ANNUAL REPORT
2009-2010

Institute for Plasma Research
Bhat, Gandhinagar 382428

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EXECUTIVE SUMMARY

In the last 25 years of its existence, the Institute for Plasma Research has grown with a well-focussed research towards the realization of controlled thermo-nuclear fusion through magnetic confinement, various applications of plasmas in industry and basic plasma sciences. Active support of the Department of Atomic Energy, Government of India has been crucial for this significant growth and is a testimony to this support in making the participation of India in the ITER programme with the Institute as the nodal agency. With this support and the expertise gained in various areas of plasma sciences, the Institute has expanded its programme to include some of the technologies needed for a fusion reactor in the XI five-year plan.

The main transformer of the Aditya tokamak has been installed and tested and is now fully operational. To increase the operational pressure window of Aditya discharges, second harmonic pre-ionization, boronization and optimized glow discharge cleaning have been planned and are in the initial stages of testing. It is expected that after these become operational, many unexplored regimes without runaway electrons will also be accessible. New diagnostic systems such as charge exchange diagnostics, Thomson scattering system, diamagnetic loop and newly integrated magnetic probes have become operational. These will make the Aditya plasmas better diagnosed. The initial experiments with Ion Cyclotron Resonance Heating (ICRH) have given useful results and will encourage the Radio Frequency (RF) heating technology developments at the institute.

The work on SST-1 tokamak is progressing well. The problem areas that emerged from the last SST-1 commissioning attempt have been identified and remedial steps have been planned, reviewed and are being implemented. These include extensive consultations with domain knowledge experts drawn from both India and abroad and testing of components and sub-systems prior to assembly. The testing of each and every superconducting TF coil is being done at the operating temperature and current. These tests have increased confidence in the systems involved and have given a very rich technical experience. There has been considerable progress in other subsystems as well and the commencement of SST-1 re-assembly is expected shortly. The Gyrotron necessary for Electron Cyclotron Resonance Heating has been successfully tested and ready for integration with the machine. The commissioning and operation of the PINI (Plug In Neutral Injector) ion source on the SST1-NBI test stand has been successful.

The technology development of various systems, viz., divertor cassette, superconducting magnets, vacuum vessel sector, cryo-pump, negative ion source and neutronics for fusion grade tokamak is progressing well under the XI five-year plan. Collaboration with various institutions in the country and relevant training of manpower with these developments is complimenting the technological progress. The engineering design of Test Blanket Module (TBM) for ITER is also advancing to meet the tight time schedule of ITER. The neutronics laboratory that has been set up to study low activation materials for the future fusion machines is fully operational now.

Basic plasma physics continues to be an area where the Institute expends considerable resources to develop the necessary manpower. Apart from improvising the existing experiments, the proposed experiments under the eleventh five-year plan are also being realized. Experiments like dusty plasma, direct current glow discharge also have been planned to make use of recently developed technological improvements.

In the theoretical and computational front, the existing computing facilities at the institute are being utilized to their full potential. Electron Magnetohydro Dynamics simulations, Gyro-Kinetic simulations, Non-linear phenomena, Molecular dynamics and Multi-potential Molecular dynamics, Particle-in-Cell simulations, etc. are various methods being used for exploring and understanding many basic and complex physics problems. Simulation of Laser-Plasma interactions in collaboration with TIFR have explained many observed phenomena in the experiments.

The Facilitation Center for Industrial Plasma Technology (FCIPT) has undergone tremendous growth and has now moved to a newly constructed building with green technologies. Apart from the industrial projects, FCIPT is now catering to various educational institutions by way of building experimental facilities for the use of their students. This would certainly help in spreading the plasma physics in these educational institutes. This will also help in generating the trained manpower necessary for the ongoing and future programmes of the country.

Director,
IPR

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ANNUAL REPORT

April 1, 2009 to March 31, 2010

Since 1986 the institute has been excelling in plasma physics research with fast growing facilities and trained man power. Started with small tokamak experiments and basic plasma experiments, the institute has been acquiring expertise in all the relevant scientific and technological requirements for controlled thermonuclear fusion. The activities of the Board of Research on Fusion Science and Technology (BRFST) and the Fusion Technology Development Programme under the Eleventh Five Year Plan are giving the required growth for the capability to absorb the world's state-of-the-art technical knowledge of controlled thermonuclear fusion available through the participation of the country in the International Thermonuclear Experimental Reactor (ITER). At the same time basic experiments related to immediate plasma technology dissemination to industry through Facilitation Center for Indutrial Plasma Technology (FCIPT) forms an integral part of the programme.

A. SCIENTIFIC & TECHNOLOGICAL PROGRAMMES

Scientific programme of the institute can broadly be categorised into five main areas as following: 1) magnetically confined fusion plasma experiments 2) Fusion Technology Developements 3) Basic Experiments 4) Theoretical and Computational Physics and 5) Industrial Plasma technologies.

A.1 Fusion Plasma Experiments.

A.1.1 Aditya Tokamak

A.1.1.1 Status of the Device

The main high voltage transformer for converter operation has been repaired and installed back for Aditya operation and after some initial testing Aditya was operated regularly. New ICRH transmission line was installed in Aditya and ICRH heating experiments have been carried out. Experiments on fluctuation reduction during gas puff Gas was also continued during this time. In addition to these experiments, experiments for upgrading the machine were also carried out. A new Silicon-Carbide (SIC) limiter has been put into operation. Experiment to optimize Glow Discharge Cleaning (GDC) has been carried out. During this time it has been tried to extend the pressure window from the normal range of operation. However, it was observed at high-pressures the plasma discharge is not smooth and appear to have impurity burn-through problem. To address this issue, some new measures which include boronization, replacement of safety limiter tiles and replacement of graphite limiter to molybdenum limiter has been initiated. To elongate the discharge duration feedback controls involving density, position and current have been initiated. Charge exchange diagnostics was calibrated successfully and signals were acquired for analysis. Trouble shooting continued for of newly place magnetic diagnostics viz., Diamagnetic loop to calculate the stored energy, Sine –Cosine coil to measure the plasma position and Magnetic probe to measure the MHD activities in Aditya tokamak plasma.

Machine Operation : Aditya usually operates at pressure less than 1×10^{-4} torr. It has been observed during experiment that at low pressure lot of runaway electrons are generated leading to hard x-ray signal. Though, the discharge is long enough with reasonable high current this is unwanted as these runaway electrons might damage many in-vessel components as well as vessel itself. These runaway electrons get occasionally decreased if the machine is very clean. It is expected that at higher pressure the runaways are expected to be reduced. Hence high pressure operation was tried. Though the plasma formation and ionization were good as seen from the H_alpha signal the discharges fails because of burn through as observed from CIII signal. The burn through problem is thought to be because of the presence of excessive carbon and oxygen during discharges. Since Aditya limiter is made of graphite under present scenario it is difficult to reduce carbon influx during discharges. Boronization and/or molybdenum limiter may be needed to address this issue.

A.1.1.2 Diagnostic Developments

Spectroscopy – Tangential Imaging of Aditya : For any meaningful tomographic reconstruction from tangential images, the Field-Of-View (FOV) of the camera needs to be calibrated. This will determine the intrinsic parameters of the camera and its position. A novel technique has been demonstrated for the FOV calibration of tangential cameras on toroidal devices. Tangential view is realized through a metallic mirror at radial port number 18. A linear series of LEDs are inserted in the vessel from radial port 15. On the mirror corrected reference image 3 fiduciaries are selected. Thereafter, lighted spheres are imagined at the locations of the LEDs

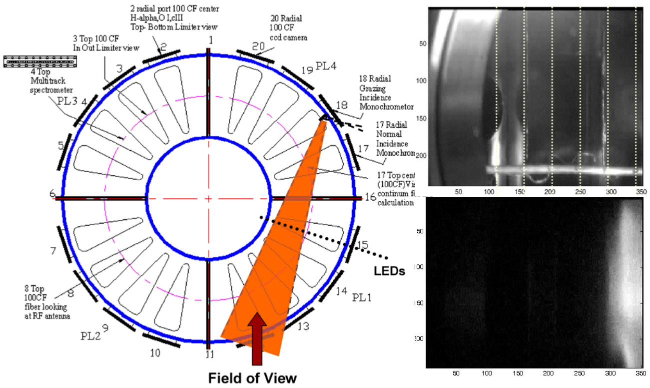


Figure A.1.1.2.1 Tangential view line shown in the torus and two typical images shown

and with an initial guess of parameters, a ray sphere intersection problem is solved for all the pixels. The simulated image obtained is compared with the reference image for the position of the LEDs to optimize the camera parameters. Finally, TV frame rate tangential images taken on ADITYA have been subjected to reconstruction through the Tangential Image Tomographic Reconstruction (TITR) code for inferring poloidal emissivity profiles. A high frame rate camera (6000 frames per second at 512 × 512 pixel resolution) along with an imaging fiber bundle is being installed on Aditya tokamak for tangential imaging of the fast evolving plasma.

Vacuum Ultra Violet (VUV) Spectroscopy : A VUV spectrograph has been installed on the ADITYA tokamak, which has the capability to record spectra in a range of 15 nm to 170 nm in a single discharge from the plasma core using a MCP based CCD attached to the spectrograph. This spectrograph has the option of using three different groove density gratings (290, 450 and 2105) and a temporal resolution of 6 ms. Spectrum recorded with all the gratings with minimum possible exposure time which proves to give sufficient signal. These gratings can be selected to give required spectral resolution or spectral coverage as per experimental requirement. A newly procured visible spectrometer is been installed viewing Tokamak mid plane with ICCD for simultaneous data acquisition in visible with VUV spectrometer to be used for absolute calibration of VUV using branching ratio method.

Neutral Particle Analyzer Diagnostics – Charge Exchange System : Charge Exchange signals have been obtained recently using the present parallel plate configuration. Charge exchange counts on all three channels could be realized during capacitor bank discharges as well as APPS shots, as a result of the drastic cut down of the reflecting spurious photons flux on CEMs. Data found to be in good agreement with the estimated and expected signal to noise ratio as the reflections of VUV photon flux coming from the plasma has highly been suppressed (~ 98%) after the modifications done.

Neutral Particle Analyzer Diagnostics – Time-Of-Flight (TOF) System : Engineering drawing for newly proposed Time of Flight Diagnostics system (ADITYA) has been finalized and fabrication of the same is now in process. Conceptualizations regarding Data Acquisition and Electronics for the Aditya Time of Flight system are in process. The Electronics of the TOF diagnostics for low energy particles has been divided mainly into three parts: (i) Trigger circuit: It triggers the electronics of the TOF system and the data acquisition system, as soon as the chopper opens for the photons to stream along with the neutrals. The Trigger circuit consists of a He-Ne LASER and a Si-PIN diode with a fast response time that responds when the LASER falls on it consequent to the opening of the chopper. The output TTL pulse will be amplified to trigger the data acquisition circuit. (ii) I to V converter: This circuit has been designed for the operation of CEM in current mode. The circuit for the same has been tested by the electronics group by a higher current source (NanoAmps). (iii) Fast Switching Power Supply Unit: Fabrication of this power supply is in process.

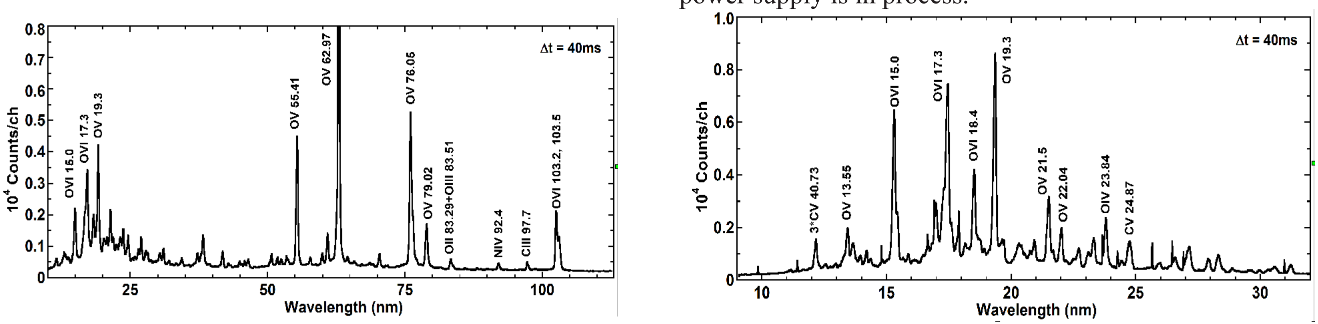


Figure A.1.1.2.2Typical spectra recoreded two different gratings (a) 450 g/mm and (b) 2105 g/mm

A.1.1.3 Heating and Current Drive Systems

Ion Cyclotron Resonance Heating (ICRH) : Fast wave heating experiments are carried out on tokamak Aditya in theion cyclotron resonance frequency range. The ICRH system consists of Radio-Frrquency (RF) generator, 100 m long 9" co-axial transmission line, two stubs and two phase shifters for matching, probe section of the transmission line for VSWR measurements, a vacuum transmission line (VTL) section to separate Aditya vacuum from RF transmission line and the poloidal shorted strip-line antenna for radiating RF power in the tokamak. The indigenously developed RF generator is of 200 kW power in the frequency range of 20-40 MHz and fast wave antenna is of poloidal nature along with the Faraday shield. The RF generator is tuned at 24.6MHz for a central cyclotron frequency corresponding to the toroidal magnetic field of Aditya and RF experiments are conducted using the 200 kW RF generator. Initially 200 kW RF generator is tested up to 120 kW power level using a matched dummy load right across the generator. Then in second phase, the whole transmission line is tested with dummy load near tokamak up to 80 kW power. In third phase, the VTL section, which is upgraded with new coaxial ceramic based vacuum window and a modified EIA standard elbow joint feeder, is conditioned using different RF power pulses with various durations and number to increase the power withstand capability of the VTL, In fourth phase, the RF power is introduced in tokamak without plasma and tuning and impedance matching of the transmission system is done up to 80 kW power. In fifth phase, the RF power is introduced when the plasma was present in the tokamak. The detected un-calibrated signal of the antenna current clearly shows that the antenna is adiating the RF power. Different diagnostics have detected the signals produced due to plasma heating. Soft X-ray diagnostics clearly shows rise in electron temperature during RF pulse. Normally, the electron temperature of Aditya plasma is around 250 eV and the temperature rise due to additional heating observed is around 70-100 eV for RF pulse of power 80 kW. The increment in electron temperature shows a linear relationship with input RF power. The diamagnetic flux as detected by diamagnetic loop is decreased with RF power from 0.5mWb to a value of 0.41mWb and recovers its original value as RF is withdrawn. The corresponding plasma beta shows an increase with RF from a value of 0.31 to 0.44. The stored diamagnetic energy content of plasma shows an increase from 630 Joules to 895 joules for an injected RF power of 40kW to the plasmawhile in case of another RF pulse, the increase in the stored energy was upto 1.6 kJ. The impurity content of plasma is monitored by CIII, OV spectral lines through spectroscopic diagnostics. It shows that the impurity level keeps on increasing with time and does not show extra increase in impurities during RF pulse, indicating the less possibility of impurity influx due to RF heating. Microwave diagnostics like interferometer shows no appreciable increase in plasma density, which is again correlated with impurity signals but preliminary power spectra analysis shows an enhancement in MHD activity.

Fast Ferrite Tuner (FFT) for on-line antenna-plasma matching: During fast wave ICRH experiments on tokamak plasmas, large and fast plasma load changes may occur. Hence a device is needed to match antenna impedance to the generator impedance on a faster time scale for delivery of maximum power. Thus impedance matching plays very important role in ICRH scheme. Minimum response time achieved by using methods other than FFT is 40-50 ms. FFT is designed for input power of 600 kW, Insertion loss less than - 0.15 dB, Return loss greater than 25 dB, Response time

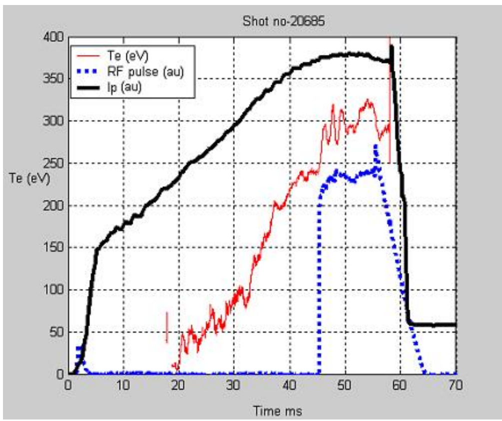


Figure A.1.1.3.1Typical ICRH pulse shot showing increase in Temperature

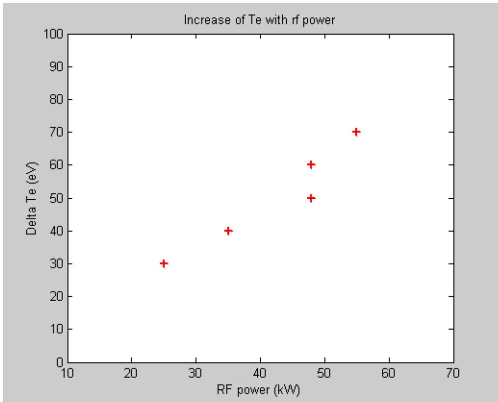


Figure A.1.1.3.2 Increase of electron Temperature with respect to RF Power for matching ($\rho \leq 0.65$) with active feed-back ≤ 6 msec. Its accessible mismatch region is reflection coefficient $\rho \leq 0.65$ with all phases. FFT consists of stripline partially filled with ferrites, which are biased by electromagnet and permanent magnets. FFT assembly completed and the coil is tested for full current of +-600 A with the a very fast ramp up rate of 1MA/sec. The specially designed power supply has arrived and is installed and tested with dummy load as well as with actual load of FFT. The response time of power supply to change from +600 A to –600 A is found to be only 2 ms and hence it is expected that fat ferrite tuner may work within the designed time of 6 ms. VME program for on-line matching for feedback control to match the plasma impedance with generator impedance in less than 6 ms is in progress.

A.1.1.4 Experiments and Results

Measurement and comparison of plasma flows by using magnetized and unmagnetized Mach probes : The Mach probe is widely used to measure plasma flow because of its simplicity and ability to provide a spatially localized flow measurement. Two types of Mach probes, namely, a magnetized Mach probe and an un-magnetized Mach probe, have been reported in literature. Although the use of magnetized probe is better understood in terms of interpretation of the data, the use of un-magnetized probe is hampered because its data interpretation is not on firm theoretical base. In spite of that, sometimes one may have to necessarily use un-magnetized probe for practical reasons. For this purpose we have carried out experiments to find empirical relation between the flow Mach number estimated from un-magnetized and magnetized Mach probes. In both cases, the Mach number, M is determined from the ratio (R) of ion saturation currents in the upstream and downstream directions M= K ln(R) where the coefficient K depends on the model used. We have carried out experiments on ADITYA tokamak in order to determine the empirical value of K for the un-magnetized Mach probe. The probe head is schematically shown in Figure A.1.1.4.1.

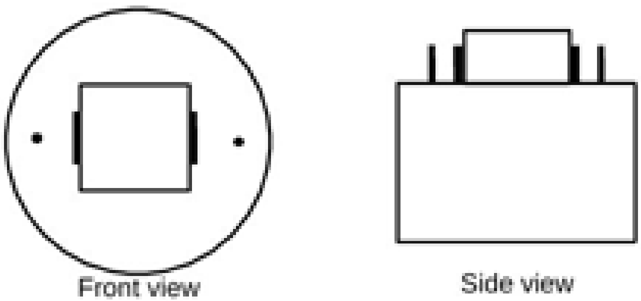


Figure A.1.1.4.1 Schematic diagram of the Mach probe head.

The magnetize Mach probe consists of a pair of molybdenum plates that measure ion saturation current in the upstream and downstream directions. The un-magnetized Mach probe consists of molybdenum wires mounted in front of plates at a distance of 3 mm. Figure A.1.1.4.2 shows the densities of ion saturation currents in the upstream and downstream directions. This measurement is being further analyzed to determine the empirical relation between K-values for the magnetized and un-magnetized Mach probes.

Diamagnetic flux measurement in Aditya tokamak : In tokamak, the plasma kinetic pressure is balanced by the sum of the poloidal magnetic pressure and any change in the toroidal magnetic pressure. Although in a purely ohmic heating case the toroidal magnetic pressure increases and, thus the tokamak plasma becomes paramagnetic, any change in the toroidal magnetic flux is traditionally referred as the diamagnetic flux. The measurement of this flux can be used to determine several quantities that are related to the plasma kinetic pressure, namely, poloidal beta (β_p) total stored energy (W_{dia}) and energy confinement time (τ_E). We have carried out measurements of diamagnetic flux in both ohmic heated and radio frequency (RF) heated discharges of Aditya tokamak. The measured diamagnetic flux in a typical ohmic heated plasma discharge is ≤ 0.6 mWb and therefore it has required careful compensation for various kinds of pick-ups. The dominant contribution comes from currents in toroidal magnetic field coils, vessel eddy currents and vertical magnetic field coils, in that order. We have also introduced compensation due to plasma current in small duration discharges, in which plasma pressure gradient is supposed to be negligible. Figure A.1.1.4.3 shows the measured diamagnetic flux in RF heated plasma. It is observed that the in the ohmic heating case the typical is β_p ~0.3 and the stored energy W_{dia}~0.6 kJ. During RF heating, β_p ~ 0.4 and Wdia is approximately 0.8 kJ. Thus

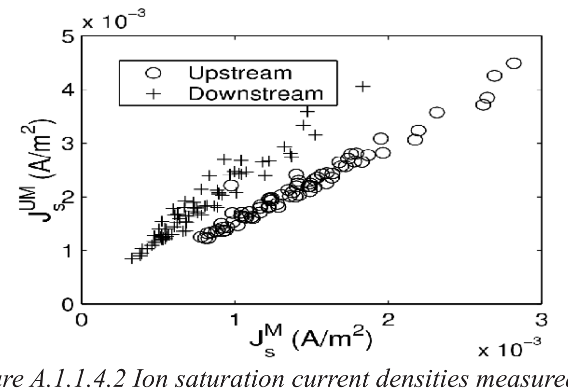


Figure A.1.1.4.2 Ion saturation current densities measured by magnetized and un-magnetized Mach probes.

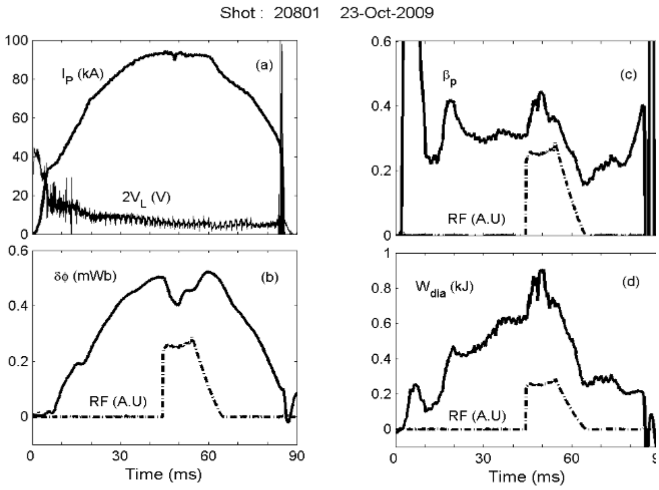


Figure A.1.1.4.3 (a) Plasma current and loop voltage in ICRF heated plasma discharge, (b) diamagnetic flux, (c) poloidal beta, and (d) stored diamagnetic energy.

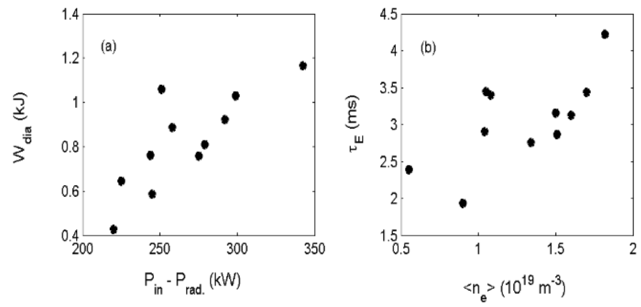


Figure A.1.1.4.4.(a) Stored energy measured with diamagnetic loop, W_{dia} , as a function of absorbed power, P_{in}-P_{rad} , at the flattop of the plasma current for various plasma discharges, where $P_{in} = I_p V_L$ is the input ohmic power and P_{rad} is the radiated power. (b) The energy confinement time τ_E as a function of chord averaged plasma density <ne> (measured by microwave interferometer).

RF heating causes approximately 30% increase in the stored energy. We have also analyzed energy confinement time in the ohmically heated plasma. Figure A.1.1.4.4 shows the variation of W_{dia} with the power absorbed by the plasma, Pin - Prad , during current flattop in some Aditya discharges. Here Pin is the input ohmic power and Prad is the radiated power, as measured by a bolometer camera. We have chosen those discharges where the flattop duration is at least 10 ms, so that estimates of both Pin and Wdia are reliable and correct. It is observed from Figure A.1.1.4.4(a) that Wdia scales linearly with Pin - Prad . We have calculated energy confinement time (τ_E) from these measurements and the result is plotted as a function of the central chord-averaged plasma density <ne> in Figure A.1.1.4.4(b). The confinement time is seen to vary linearly as a function of the chord-averaged density and it compares well with Alcator scaling.

A.1.2 Superconducting Steadystate Tokamak (SST-1)

A.1.2.1. Status of the Device

SST-1 Mission : Team comprising of the SST-1 Cryogenics Division, SST-1 Magnets Division, SST-1 Assembly Division, SST-1 Vacuum Division, SST-1 Power Systems Division, SST-1 Data Acquisition Division, SST-1 Operations and Control Division & SST-1 Plasma Control Physics Division have made significant progress during 2009-10 towards the refurbishment of the machine. All the problem areas belonging to each of these divisions that emerged from the last SST-1 campaign as well as discovered during the review of the SST-1 have been identified. Elaborated remedial plans based on sound technical and engineering bases have been firmed up and followed with domain knowledge experts drawn from both India and abroad. Remedial action plans have been focused and modular. They are primarily aimed at the process validation, technology development, testing, experimental prototyping etc. All these progresses would supplement towards the commencement of the SST-1 re-assembly. Prior to the SST-1 reassembly, all components would be tested in actual or near operating conditions. The SST-1 reassembly is envisaged to begin in June 2010 and would continue for a period of twenty four months.

A.1.2.2 Technological Developments

SST-1 Magnets Division: Development of ultra low DC joint resistances involving cable-in-conduit-conductors in the SST-1 magnet winding packs ensuring leak tightness at all operational scenarios starting from cool-down to steady state operation and in off- normal operations have been the primary achievement. A detailed process of making inter-pancake and inter-coil joints ensuring zero leaking sub nano-ohm joint resistances in transport currents up to 10000 A at 4 bar and 5 K has been experimentally validated in a repeatable fashion through experiments on actual TF magnet winding packs. The DC resistances have been measured to be sub nano ohms and are nearly an order less than the design specifications of 5 nano ohms. The resistances have been measured to be in the range of 200-700 pico ohms at 10000 A of transport current. Such low level of DC resistances involving cable-in-conduit-conductor in SST-1 winding pack has been one of the unique and spectacular achievement and is better than any DC joints

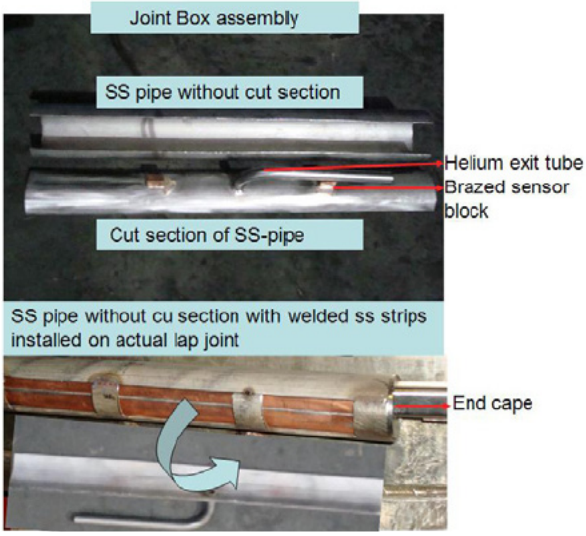


Figure A.1.2.2.1 Modified joints

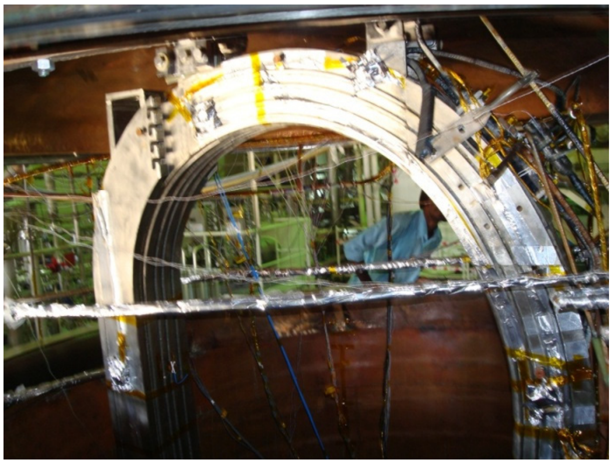


Figure A.1.2.2.2 A magnet is getting inserted into the experimental cryostat

made so far anywhere for superconducting Tokamak. An in-house indigenous measurement technique focused at measuring such low level of resistances have also been successfully developed and implemented in all the DC resistance measurements. The TF magnets cases have been locally profiled at the joints locations to avoid any likely interference with the neighboring components as well as ensuring an appropriate mounting of the joints facilitating the thermal contraction as well as electromagnetic force induced displacements. The helium inlet region in the magnet winding packs, near the double pancake inlet and outlet leads locations in the outer mid-plane have also been insulation strengthened with bisphenol-A epoxy and fiber-glass tapes. Systematic QA/QC plans and protocols have been developed for each of these activities, which are strictly adhered to, while preparing the magnets. The magnets are planned to be quality tested at several stages in the room temperature for their leak tightness, insulation integrity as well as mass flow rates and pressure drop characteristics prior to, they being tested in cold with currents. These magnet preparations have begun and are expected to take about twelve months from March 2010. The SST-1 TF magnet cold tests are expected to begin from May/June 2010. These tests would continue for sixteen months and are expected to be finished by Sep 2011. The re-assembly of SST-1 will be in parallel to these magnets tests after the first couple of magnets are tested.

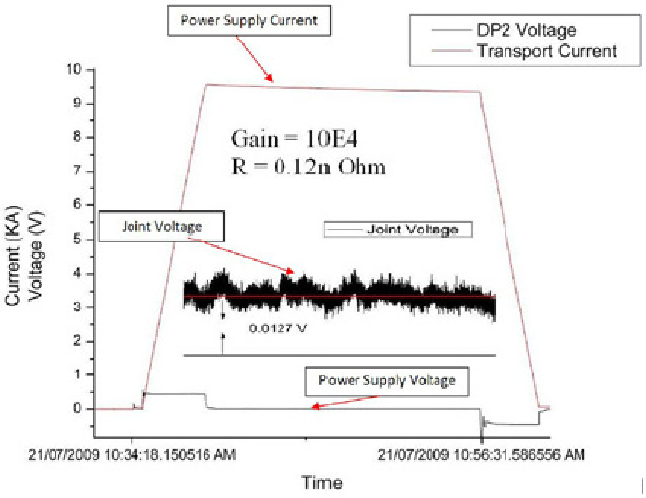


Figure A.1.2.2.3 Experimental results of extremely low DC joint resistance

SST-1 Cryogenics Division: This division has been central to maintaining the helium and nitrogen cryogenic facilities

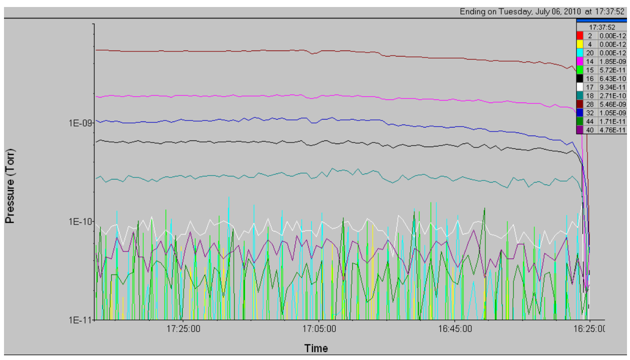


Figure A.1.2.2.4 Helium leak tightness of the Joints (partial pressure)

Compressor		LN2 Precooling		Turbine Parameter	Turbine A Parameter		Turbine B Parameter		Turbine C Parameter	
PT230	14.01	DPT433	33.45	Inlet Pressure	PT522A	13.52	PT522B	5.30	PT522C	11.57
PT218	1.05	FCV432	11.81	Inlet Temp	TE441	37.95	TE455	16.00	TE450A	9.60
PT233	3.50	TT487	81.94	Outlet Pressure	PT523A	6.16	PT523B	1.08	PT523C	4.11
FT238(g/s)	138.03	TT347(C)	-2.45	Outlet Temp	TE476	32.75	TE457	15.15	TE479	8.96
PCV225 / 229	20.10	MCD Critical Parameter		Speed	ST540A	1747.00	ST540B	1463.00	ST540C	1252.00
JT198C	440.00	PT605	1.30	Bearing Temp	TT555A	6.75	TT555B	6.85	TT555C	16.85
JT198B	1.00	TT606	5.54	Bearing Pressure	PT525A	13.47	PT525B	13.44	PT525C	11.11
PCV223	12.50	LT607(mm)	280.40	Break Pressure	PT526A	10.60	PT526B	12.03	FCV428C	35.95
COMP C	100.64	LT607(ltr)	378.50	Cold Box			FCV428A	100.00	TT031	5.90
COMP B	0.31	WT601	195.70	Outlet Temp	TT479	8.96	OTHER		TT419	4.53
TT184(C)	16.40	FCV444	15.99	Outlet flowrate(g/s)	CL_FLOW	4.00	TT463	14.15	PT419	4.06
Purifier Pressure Drop		FCV446	15.17	CC Speed in Hz	ST410	0.02	FCV435	26.93	FT419	60.50
PT706	14.09	FCV443	0.00	Return Temp	TT451	121.18	FCV436	22.03	PT396	1.03
PT715A	13.96	FCV445	63.87	Return Pressure	PT338	3.06	FCV420	100.00	TT425	271.30
DIFF	0.13	FCV447	0.00	HP Pressure	PT353	13.60	FCV421	4.00	LT449	651.70

Figure A.1.2.2.5 Supercritical Operation of the helium facility

for the tests and validations of the SST-1 components/subsystems meant for cryogenics operations. During 09-10, the focus was at increasing the reliability of cryogenics operations, establishing the various cryogenic processes and accessing their limiting characteristics and augmenting the infrastructural facilities including incorporating redundancies in critical operational components. The supercritical operation was established through the cold circulator operation for extended time with a superconducting load in the supercritical helium circuit. A complete service and maintenances of the entire helium cryogenic facility was also carried out after a gap of nine years during Oct 09-Feb 10. As a result of this activity, the refrigeration, liquefaction and the mixed mode operational limits of the plant were established. Additional gas bags were installed on the recovery lines of the plants to smoothen out the additional through out of the gas during a sudden quench of the magnet. The helium compressors were completely overhauled and re-commissioned for extended operations. The surrounding cooling of the compressor skids and the bay area have also been humidity regulated so as to enable the extra-long operation of the compressor system. The purification section of the helium facility was also changed anew to ensure the purity of the gas and increase the reliability of the turbine blades. The sensors inside the cold box and other essential diagnostics have also been calibrated for better insurances. Consequently, the helium cryogenic facility has been operated with superconducting magnet loads and have demonstrated impressive performances even exceeding the design parameters. Now, the facility is suitable for extended operations involving the tests of the SST-1 magnets. A pair of 10000 A current leads in a separate facility has also been tested for the design verifications and performances in typi-

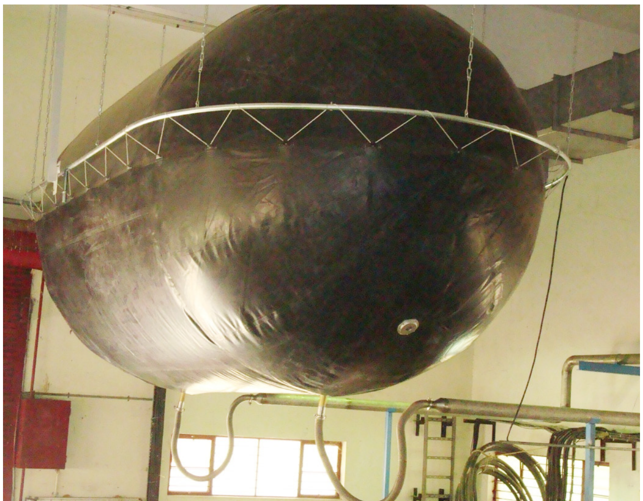


Figure A.1.2.2.6 Facility augmentation with additional gas bags in recovery section cal SST-1 TF and PF operating scenarios. The temperature uniformity and pressure drop characteristics of the fabricated bubble type 80 K thermal shield panels will also be validated by the SST-1 cryogenics division together with the Device Integration Division ensuring the dimensional and assembly appropriateness.

SST-1 Vacuum Division: This division shoulders the role of refurbishing the SST-1 vessel module and sectors especially with the baking channels as per the operational requirements as well as providing critical services on leak testing of the components. There were several leaks found in the baking channels welded onto the vessel sectors and vessel modules. Together with external domain knowledge experts and after an in-depth systematic repair procedure, the leaking baking channels were repaired following an elaborate QA/QC protocols. All these baking channels have been planned to be tested in operating baking conditions of 150 C over several hours to ensure the repair appropriateness of the baking channels. Half of the vessel modules which have been repaired have been tested in a dedicated baking chamber successfully. All these repairs have withstood the baking cycle and have remained leak tight after the baking cycle. During these exercises, the hot nitrogen baking facility of SST-1 has also been fully commissioned. SST-1 vacuum division makes the leak tests of all the vacuum and cryogenics components and also acts partially as a regulatory authority for any components prior to its commissioning on the SST-1 machine.

Figure A.1.2.2.7 A vessel module getting ready for the baking in a dedicated baking facility

SST-1 Power Supplies Division: This division is responsible for the power supplies and the controls for the entire SST-1 Magnet System. The protection of the superconducting magnets in cases of abnormal transition into resistive regime leading to the quench is also carried out by the Power Supply Division. Extended operation of the stand alone as well as together with superconducting magnets loads have been successfully carried out during 09-10. The charging of the large test magnets has been systematically done both in local and remote mode of operations. The power supplies operations and controls have been established.

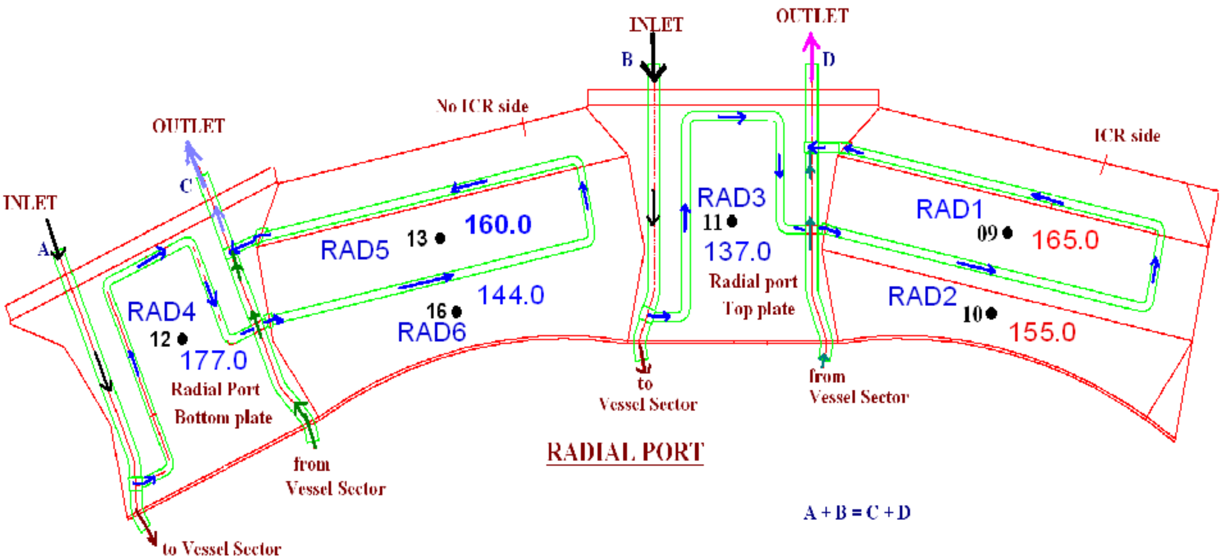


Figure A.1.2.2.8Temperature sensors along the baking channels

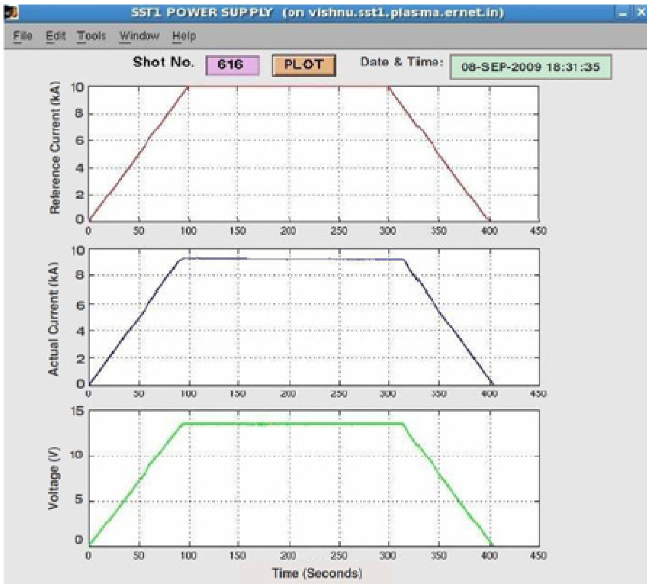


Figure A.1.2.2.9 TF Power Supply profile during the charging

SST-1 Device Integration Division: This division carried out the as-built drawings generations, sub-assembly and assembly sequences generations and metrology of the assembled components at various stages apart from assisting in the drawings and fabrication of the thermal shield and headers of the cryogenic lines. During 09-10, a basic module comprising of the vacuum vessel module, two TF magnets, 5 K shields and 80 K shields, outer inter-coil structures have been achieved for referencing purposes. The metrology and the assembly tolerances have been established in this trail as well as the critical QA/QC have been established. These references shall be followed in the actual re-assembly of the SST-1 machine shell. The interconnecting piping lay outs, the interferences with the neighboring components, the thermal and electrical isolations between the different sections, the positioning and appropriateness of the supports etc for various loadings scenarios have been established. This division will actively pursue the SST reassembly during 10-11.

SST-1 Data Acquisition Division: SST-1 DAQ Division along with SST-1 operation & Control Division and Electronics Section are coordinating integrated testing for SST-1 Phase-I Diagnostics channels measurement. Several Tasks have to be accomplished in this phase of Integrated Testing as per the established protocol. In the first task/activity, all SST-1 Phase-I diagnostic channels together have been tested to es-

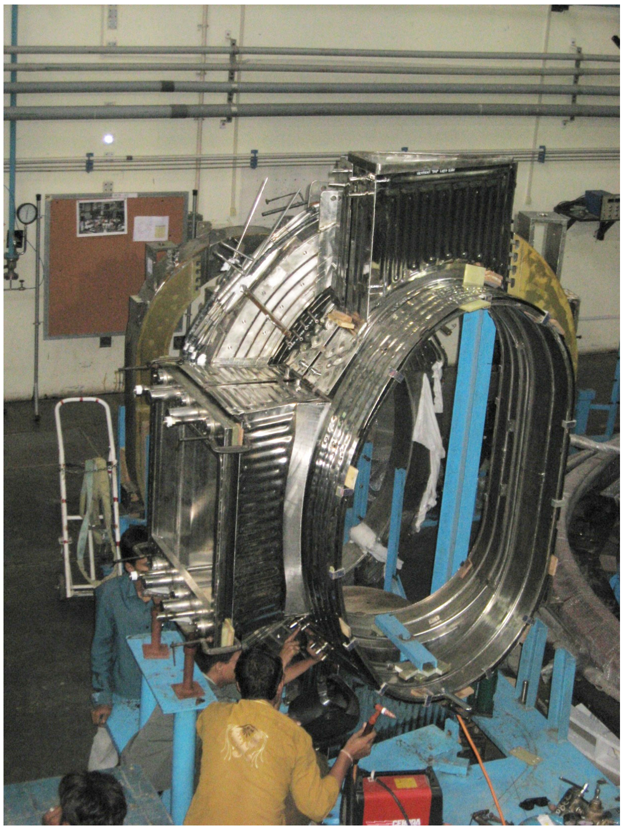


Figure A.1.2.2.10 Module assembly

tablish communication interface, during tokamak operation, among various sections, with automatic Shot number based Configurations and Data Files generations at various locations. The tests were performed for two modes of data acquisition. In first mode (Continuous Acquisition), the data was acquired continuously for certain period of time to test the acquisition window for specified parameters. In second mode (Pre/Post Trigger Acquisition), the data was acquired with reference to trigger to test the DAQ system for event-based acquisition. Post-trigger as well as pre-trigger data was stored for analysis. This mode is required to test the system close to actual Phase-I shot condition. SST-1 Operation & Control Division and Data Acquisition Division have jointly developed an enhanced communication link between each DAQ GUI and Central Control Status Monitoring GUI (Graphical User Interface) to establish the necessary communication interface to monitor the DAQ system status and to assign the shot number in automated manner during tokamak operation. The advantage of this enhanced communication interface is

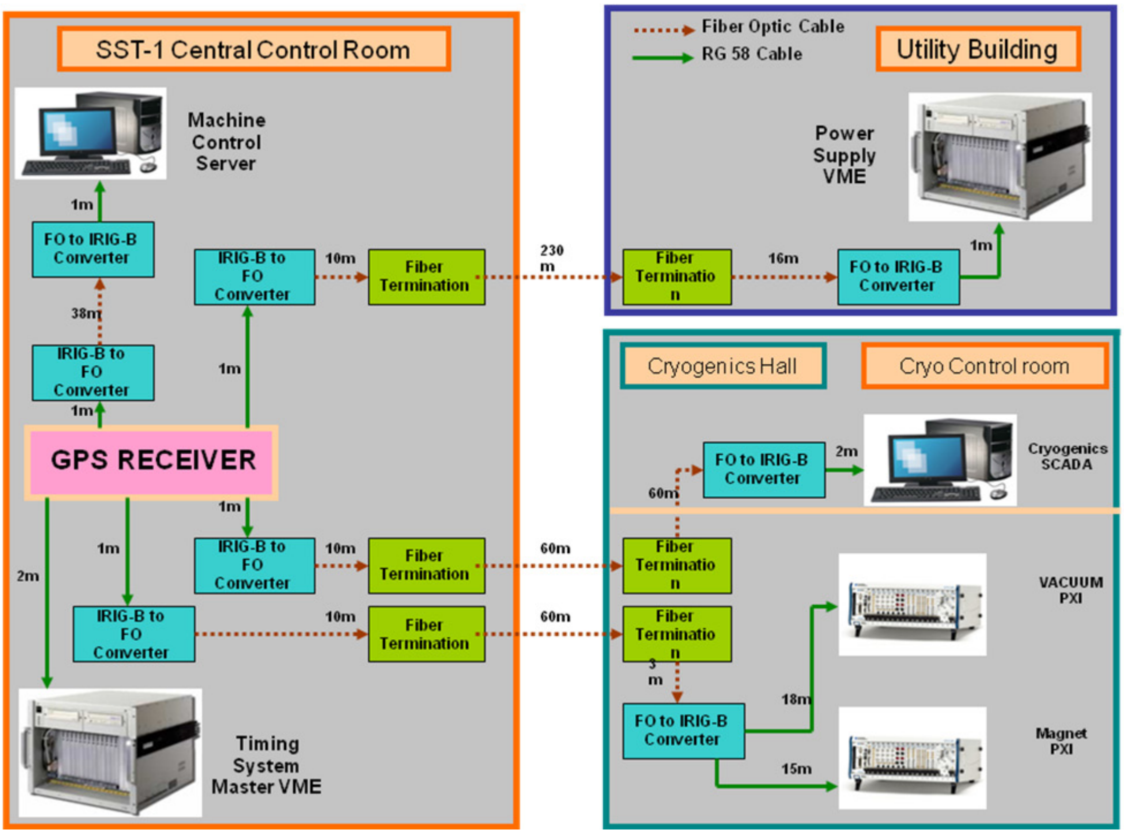


Figure A.1.2.2.11 GPS based synchronization

to facilitate integrated as well as stand-alone operation of each DAQ system as per tokamak shot requirements. This is a TCP/IP based application with Ethernet and it was successfully tested with CAMAC and PXI Data Acquisition systems at various physical locations.

SST-1 Central Control Division: SST-1 Control Division has initiated a GPS Based Time Synchronization System. The GPS unit with time receiver modules (VME, PXI, PCI) are being integrated. The VME based application of the TF power supply has been upgraded. The integration and interfacing of the convertor fault and emergency shutdown signals will be completed soon. Communication interface & Timing system interface testing during Integrated engineering validation of plasma diagnostics has established the Timing System capability of Multiple Clock & Trigger distribution. Machine Control System (MCS) connectivity with DAQ & Front End Electronics for communication of Shot No, Trigger time-stamp & Status monitoring has also been tested successfully.

A.1.2.3 Diagnostics Developments

Infrared Imaging Video Bolometer (IRVB) Diagnostic for SST-1 Tokamak : Prototype of newly invented Radiation Sensing Module has been fabricated and tested for its feasibility and found to be working well as expected. Due to the non-uniformity in Foil thickness during the fabrication process as well as non-uniformity in thermal conductivity due to the coating of high emissive layer, calibration of the Foil thermal properties and thickness need to be done. Hence, different calibration processes is investigated. Calibration procedure of IRVB is established. It has been given as a project to student Calibraiton of IRVB: (1) Free stending thin metal foil in Mask, (b) Irvb Calibration Setup and (c) 2D- thermal conductivity map of foil as a result of the claibration

Microwave and Electron Cyclotron Emission Diagnostics : Microwave Laboratory and required necessary infrastructures are now in place. Two labs one at ground floor of SST-1 building and another at first floor of SST-1 building has been developed. At ground floor lab necessary infrastructure

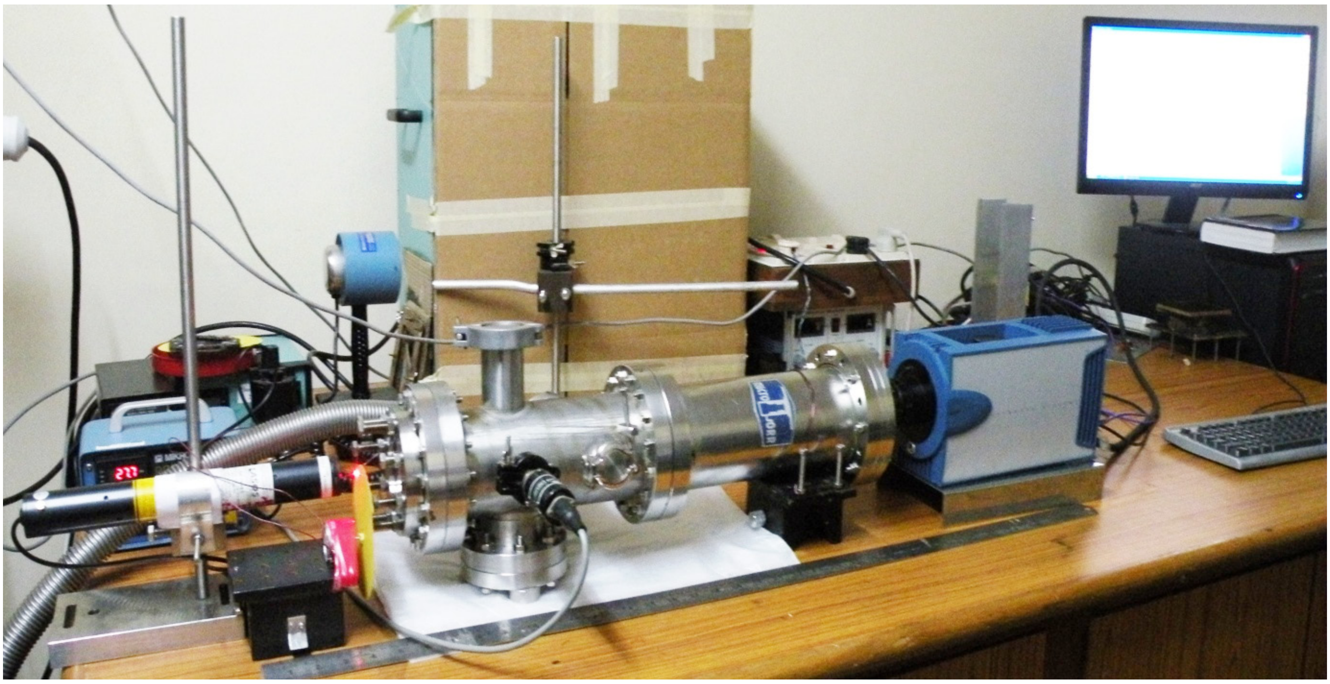


Figure A.1.2.3.1 Infrared Imaging Video Bolometer test setup

for ECE diagnostics has been developed. Experimental setup has been properly arranged to do testing of ECE Radiometry system.At first floor lab Interferometry system and Reflectometry system experimental set up has been prepared to do experiment as well as testing of the equipments and components

Thomson scattering system : the UHV windows to be used in the transport line of Thomson scattering is tested for its transmission properties under different situations. A micro controller based controller circuit is already designed and tested with one of the detector channel. The extension work for increasing the capability of the circuit to work with all the five detectors of a polychromator is under progress. On reaching this target the controlling should be done to the entire Filter polychromators (27 nos x 5 channel). This system is designed for multi point imaging (8 to 27). The measurement from each point requires monitoring and data acquisition of five detectors. A Lab view based program is developed for monitoring, controlling and setting various parameters for all the detectors. The program communicates to designed controller circuit through the RS 232 port of PC. The program is integrated with the controller and tested for one detector module. A fast integrator (20 ns) is designed for measuring the intensity of scattered photon reached one each channel. The fast integrator is tested with standard source and documented and published in Review of scientific instruments. A snapshot of the test results is shown in the attached figure. Figure shows the linear response curve for different capacitor, which modifies the gain of the integrator. A feedback alignment system based on fuzzy logic is designed and developed for the beam transport line of Thomson scattering. The feedback is applied in lab condition for beam lines having focusing optics too. With the present feedback alignment system, the laser positioning on a point is improved significantly from (± 60 μrad to ± 0.9 μrad). This will help to improve the accuracy of electron temperature and density measurement in SST-1 Thomson scattering setup.

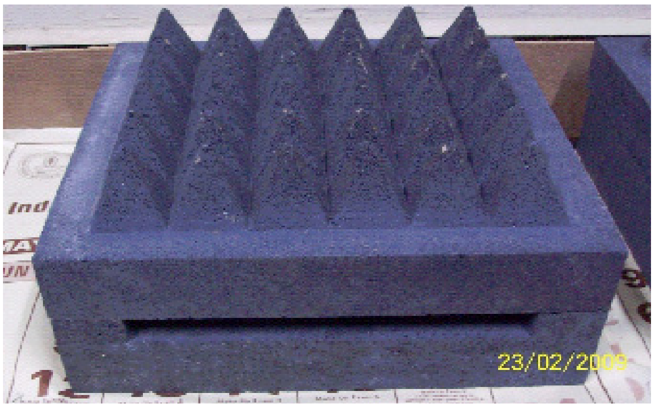


Figure A.1.2.3.2 Black body radiator for calibration

A.1.2.4 Heating and Current Drive Systems

A.1.2.4.1 Radio-Frequency based systems

Electron Cyclotron Resonance Heating (ECRH) system:
Development of Ignitron crowbar system: A crowbar system is used in electrical circuit parallel to the microwave tube, which diverts the high voltage and protects the tube in an event of fault. Two series Ignitron crowbar system is developed and tested successfully to carry out acceptance test of 82.6GHz Gyrotron at IPR. Two ignitrons (NL8900: Maximum voltage rating 35kV) are connected in series (Figure A.1.2.4.1) to operate the system up to 45kV. The RC circuit is used for static and dynamic compensation. The critical design issue with the ignitron crowbar system is its trigger module, which is designed, developed and tested in-house at IPR. This trigger module gives a pulse output ~ 4kV-2µs to conduct the ignitrons. This two series ignitron crowbar system is commissioned and high voltage tests are carried out successfully. The main requirement of for the Gyrotron is to remove the high voltage with 10µs. The system is tested up to –45kVDC, which removes high voltage successfully within 8.5 µs (Figure A.1.2.4.2).

10J wire burn test with two series Ignitron crowbar system: The maximum fault energy (critical crater energy) for the 82.6GHz gyrotron is less than 10J. Hence 10J wire-burn test is an important test to ensure that in an event of fault the energy to the Gyrotron should not exceed 10J. An experimental set-up is arranged as per the figure 3 and a 10J copper wire is connected at the place of gyrotron. In the test set-up, a fault is created by the pneumatic switch and current in crowbar path and return path is sensed by the CTs. The current transducer (CT) senses the current and triggers the crowbar system, which diverts the high voltage from wire path to crowbar path. This 10J wire burn tests are carried out at different high voltage from 20kV to 45KV and all the shots are successful and wire remains intact (safe) in all the high voltage shots. Figure 4 highlights the crowbar current and follow through ensures that all the voltage diverts to the crowbar and wire remains safe during the shot.

Solid state High voltage power supply for Gyrotron: A solid-state high voltage power (30kV/100mA) power supply is procured from M/s. Heinzinger Germany. The critical parameter for this power supply is its rise-time, which is ~25ms at 20kV. This power supply is used as a modulator for the

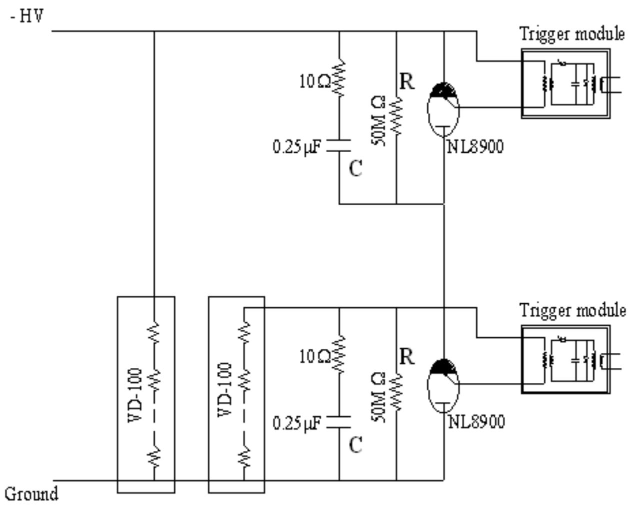


Figure.A.1.2.4.1 Two series Ignitron crowbar system
82.6GHz Gyrotron.

Gyrotron testing: The testing of 82.6GHz Gyrotron is carried out at IPR. The High power tests are carried out in presence of Russian representatives from M/s. Gycom. Before testing the Gyrotron, we carried out integrated high voltage testing to ensure the safe operation of Gyrotron. The Gyrotron delivers 200kW power at ~ –42kV DC beam voltage and ~ +19kV anode voltage. The aim of integrated testing is to establish the criteria of removing of high voltage with in 10 µs. This test is carried out successfully at –43kV beam voltage and +20kV

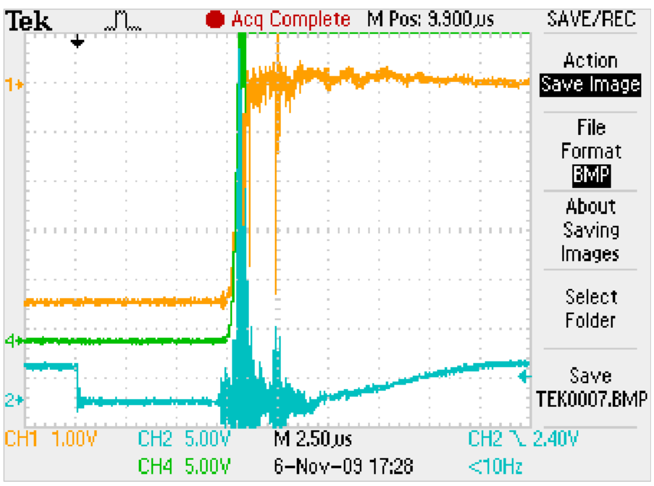


Figure A.1.2.4.2 High voltage test of two series ignitron crowbar system) anode voltage. As shown in figure A.1.2.4.2, both the voltages remove within 8 μs, which is an essential requirement for the Gyrotron testing. The Gyrotron is tested first in pulsed condition and after getting desired burn pattern at the exit of matching optic unit (Figure A.1.2.4.5) the dummy load is connected and high power CW test of Gyrotron started. CW operation of Gyrotron is started with low power ~ 65kW for 1000s. The power is slowly increased to 100kW, 130kW in various pulses of 1000s. Maximum power achieved on dummy load ~ 141kW in 1000s. Considering loss of ~ 20% in the transmission line and pre-load the Gyrotron output is around 175kW. The parameters for this operation (175kW/1000s) are beam voltage - 38kV, beam current ~ 9.5A, anode voltage + 19kV and Cryomagnet current 45.25A.

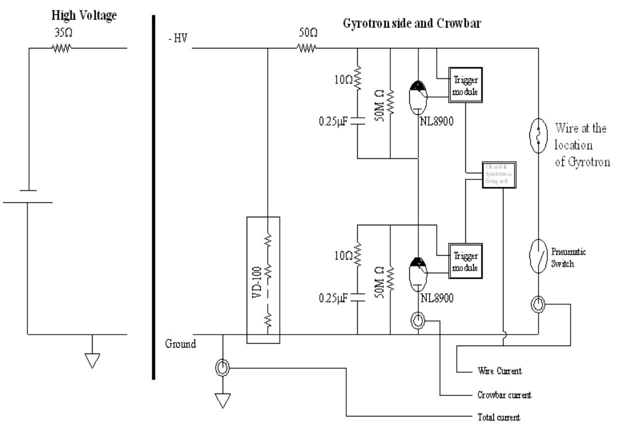


Figure.A.1.2.4.3 10J wire burn test set-up

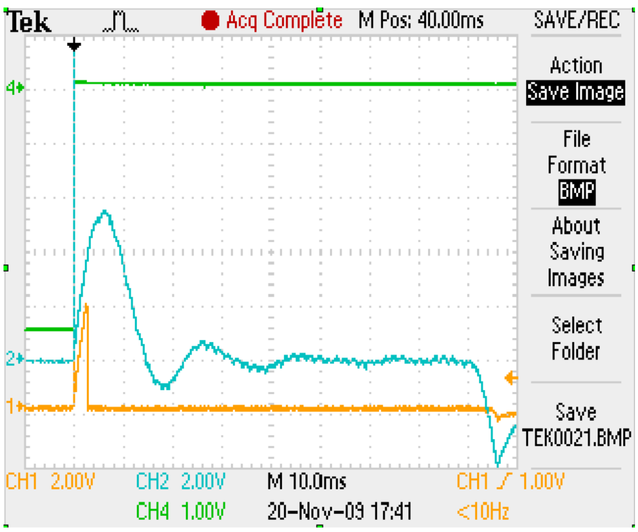


Figure. A.1.2.4.4 10J wire burn test highlights follow-through for ~ 80ms

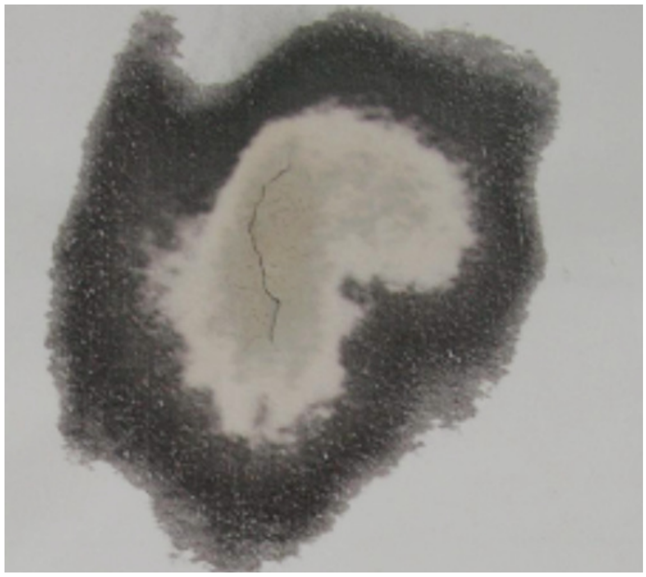


Figure A.1.2.4.5 Burn Pattern at the exit of Gyrotron

Lower Hybrid Current Drive System (LHCD): The activities related to up gradation of the LHCD/SST-1 system is in progress. The klystrons and its high power components are mounted on the new support structure. The cooling lines are modified and upgraded for 4 klystrons and tested for hydrostatic, DP test and radiography. The cooling line connection with the system is in progress. Flow-switches are procured, tested and mounted in the cooling lines. Activities related to designs and procurements for Data acquisition and control system for the new scheme has been initiated. The details provided by the supplier regarding klystron tank are studied and the tank procurement activity is started. Also there is a requirement of insulating oil for the klystron tank which has high power electrical component inside it. The procurement of oil is also going on. The Gamma spectroscopy system which consists of scintillation detector, preamplifier, amplifier, high voltage power supply, MCA and software for Pulse-Height analysis is installed in ADITYA after calibration for measuring the high energy particle coming out from the ADITYA machine during the plasma shots. The Hard X-ray data during the plasma shots are acquired for the analysis. Also the acceptance test and calibration test were carried out for recently procured CdTe detector assembly for its Count/Energy measurement. The proto-type probe diagnostics for SST1 LHCD system is being tested on existing basic experimental toroidal device in which plasma is formed by ECR technique using 2.45 GHz magnetron source. A micro-controller based ramp generator circuit is being tested for probe biasing by remotely setting the various parameters like ramp-up rate, trigger mode, no of cycles etc. through PC using RS485 serial connection. A GUI is developed for the same. The capacitor bank has been modified to obtain desired toroidal magnetic field with newly wounded toroidal magnetic coils. The 5.0GHz, 100W source with inbuilt PLL is tested for its rf performance and functionality. This source will be used to test the various microwave components at a frequency of 5.0GHz. A 13.56MHz, 2.5kW rf source is indented along with matching network to assist the experiment of helicon plasma in toroidal device. To verify the performance of this rf source a match load is required which is also in a procurement stage. Control and monitoring signals which are going to system and coming out of system and connected to DAC require analog and digital isolator for signal isolation. The procurement of these isolators is also going on. The computational studies employing LUKE code were further extended to evaluate the performance of lower hybrid waves for different SST1 scenarios. The same is being tried out with CRONOS code for temporal evolution of plasma to carry out predictive analysis. Experimental activities were carried out in collaboration with CEA to validate passive active multi-junction (PAM) antenna. Contribution is also made in ITER LHCD system through CEA EFDA task.

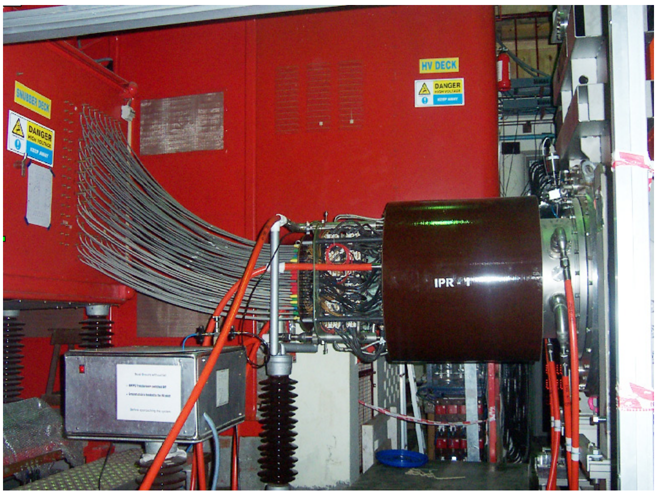


Figure A.1.2.4.6 The PINI mounted on the SST1-NBI test stand.

A.1.2.4.2 Neutral Beam Systems

During the period, an important objective was achieved i.e. the successful commissioning and operation of the PINI (Plug In Neutral Injector) ion source on the SST1-NBI test stand. For the sake of operating the PINI major modifications were made on the test stand. Some of the important modifications were the up-gradation of the H2 gas feed system, thermal hydraulics and the high voltage safety systems. The discharge and acceleration power supplies were also suitably tuned for carrying out experiments on the PINI. A study of discharge characteristics and high voltage conditioning of the acceleration grids were carried out. The commissioning of the PINI commenced with the replacement of the prototype ion source on the test stand with the PINI as can be seen in figure A.1.2.4.6. An equivalent electrical circuit diagram of the ion source is shown in figure 2. A study of the discharge characteristics and high voltage conditioning the acceleration grids were carried out. hydrogen ion beam of energy 10 –30 KeV carrying currents of 8 – 10 Amperes were extracted and characterized. The electrical traces of the ion beam as measured on the RHVPS (acceleration power supply) are shown in figure A.1.2.4.7. A Doppler shift spectrometer and a calorimeter are being used as diagnostics for studying the characteristics of the beam and the performance of the ion source. These diagnostics were used to measure the parameters such as the beam divergence, thermal power profile and beam spe-

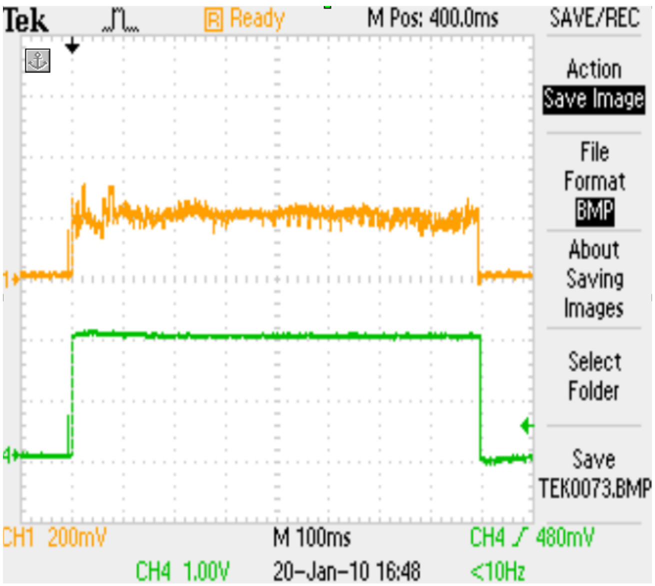


Figure A.1.2.4.7. A typical trace of the acceleration voltage and beam current of PINI. The time duration of the beam operation is ~ 1 s.

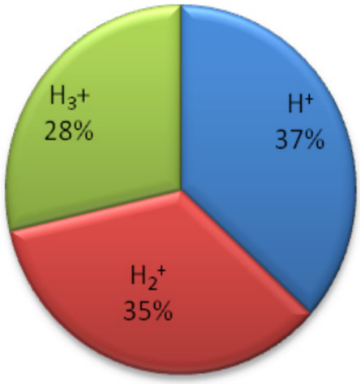


Figure A.1.2.4.8. Full, 1/2 and 1/3 energy ion species ratio for from the spectra

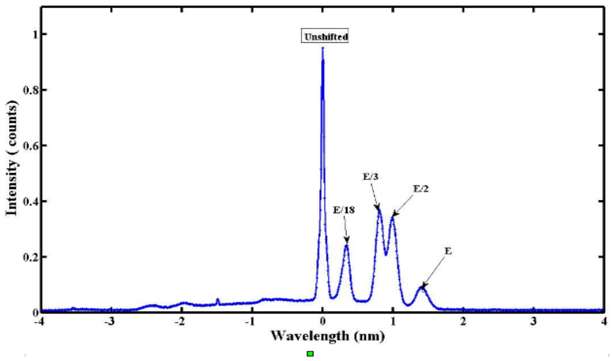


Figure A.1.2.4.9. A typical Doppler shifted spectrum of the H-α spectral line (656.3 nm)

cies fractions. Some interesting results obtained by these diagnostics are shown in the figures.A.1.2.4.8 and A.1.2.4.9. Experiments specifically aimed at studying the role of 'plasma grid bias' and the 'deceleration voltage (resistance) were carried out. Improvements were made in signal conditioning units of the thermal diagnostics (calorimeters) for eliminating the conductive and radiative (electromagnetic) noises. These improvements helped in increasing the accuracy of the data obtained from thermal diagnostics. In data analysis front: a careful examination of the excitation and emission processes in the case of NBI-DSS revealed that there is a substantial reduction in the emission due to the non-radiative collisions in the beam line. These effects were incorporated and a suitable revision was made to the existing (data analysis) model. The revised model shall improve the accuracy of measurement of source and beam parameters.Presently, efforts are being made on the test stand for increasing the beam currents up to 50 Amperes and also for increasing the beam duration > 1 sec. Also, the operation of cryo-condensation pumps is being integrated with the operation of the NBI test stand so as to improve the beam currents

A.2 FUSION TECHNOLOGIES DEVELOPMENT UNDER XIth FIVE YEAR PLAN

A.2.1 Prototype Divertor Cassette Development for Fusion Grade Tokamaks

Prototype Divertors Division of IPR deals with design and development of divertors for fusion grade tokamaks. Major activities carried out by the division during the current period were oriented towards fabrication of divertor cassette body, developing fabrication technologies for divertor targets & dome, development of new tungsten based materials, procurement of high power electron beam system & ultrasonic flaw detection system, signed agreements with various organizations for High heat flux testing of test mock-ups and materials.

Divertor target development: Tungsten monoblock development is in progress at NFTDC (Hyderabad). Experimental set-up for High Pressure High Temperature Sinterbonding of tungsten with copper is established and tested at NFTDC. The set-up is used for fabrication of Tungsten alloy mono-block and further investigations are going on to study the joint obtained and to improve its thermo-mechanical properties.

Divertor Cassette Body Development: Tender document prepared and indent submitted for fabrication of ITER-like Divertor Cassette Body and Support Structures for Divertor Vertical targets and Dome. ITER International Organization (ITER-IO, France) agreed to share relevant technical information about ITER Divertor System to IPR for assessment of manufacturing capabilities of Indian fabricators and to develop a basis for DEMO reactor relevant divertor.

Tungsten Material Development: Indigeneous development of tungsten based materials for Divertor applications is in progress at IIT-Kanpur. Material development work conducted so far includes – (a) Furnace sintering of W with 1% of Fe/ Ni/ Co. Neutronics Division of IPR performed neutronic activation analysis of these materials and suggested further reduction in Fe and Ni content below 1%. Co is not acceptable; (b) Microwave sintering at various temperatures corresponding to solid and liquid phase sintering of pure tungsten, tungsten-copper alloys and tungsten heavy alloys; (c) Experimental and Computational studies of the effect of powder particle size and as-pressed porosity on heating response of metal powder compact during microwave sintering process; (d) Effect of specimen size and conductivity on heating efficiency for microwave sintering and conventional sintering process. Compared to conventional furnace sintering process, microwave sintering process is found to reduce the total sintering time by nearly 80%, improves densification & micro-structural behavior of the sintered material that results in better mechanical strength.

High Heat Flux Testing of test mock-ups and materials: Agreements are signed with : (a) Sandia National Laboratories (Albuquerque, USA) for High Heat Flux testing of test mock-ups of plasma facing components using EB-60 Electron Beam Facility; (b) Kharkov Institute of Physics and Technology (Kharkov, Ukraine) for testing of plasma facing (tungsten) materials developed in India for their performance under transient (ELM like) thermal load conditions using QSPA Kh-50 plasma accelerator ; (c) Nuclear Fuel Complex (Hyderabad) for HHF tests of test mock-ups using 60kW Electron Beam facility. HHF experiments on graphite and tungsten brazed test mock-ups at Sandia N.L. (USA) are planned for May-2010.

Brazing technology development: Brazing technology development for plasma facing components at National Aerospace Laboratories (NAL, Bangalore) is near its completion stage. Non-Destructive Testing of test mock-ups using Infra-Red Thermography technique was performed by IR-Thermography division at IPR and IGCAR. Ultrasonic Flaw Detection tests performed at IGCAR and IIT-Madras. Tungsten and Graphite test mock-ups were subjected to thermal cyclic testing in brazing furnace at IPR by heating/cooling them under inert gas atmosphere up to 450C for several cycles. 15/15 tiles from tungsten mock-up and 10/14 tiles of graphite mock-up could withstand the thermal cyclic test. Effect of attaching fins to the test mock-ups for improving heating/cooling rate is studied experimentally. Computational Analysis was performed using ANSYS and results compared with experimental data to obtain effective heat transfer coefficient due to attachment of fins.

Development of high heat flux facility using plasma torch: Procurement of power supply with higher rating (80-100kW) for cascaded thermal plasma torch at Center of Plasma Physics (CPP, Guwahati) is in progress. Brazed test mock-ups are integrated with main vacuum vessel of the facility for thermal cyclic testing.

Procurement of materials and equipments: (a) Technical specifications for procurement of high power electron beam system is finalized and indent submitted to purchase for procurement. (b) Technical specifications for procurement of Ultrasonic Flaw Detector System is finalized and indent submitted to purchase for procurement.(c) Procurement of Infra-Red Pyrometers and IR-Camera are in progress.

A.2.2 Fusion Relevant Prototype Magnet Development

This program under the XI plan initiative had made several milestone progress and achievements during the period, focused at its mandate on the (a) designing, fabricating and testing a fusion relevant Toroidal Field (TF) and Central Solenoid (CS) (b) developing a test facility so as to carry out the tests and validations on short samples and magnet winding packs. High current carrying high field multi-filamentary NbTi superconducting strands had been comprehensively developed with high (J,B,T) parameters as a joint initiative of IPR and Atomic Fuels Division (BARC) with several kilometre long piece lengths. Technologies and processes leading to the fabrication of long lengths of NbTi based cable-in-conduit-conductor capable of carrying 30000 A of current at 5 T which had been realized during 2008-09 had been further refined including the multistage cabling and conduiting in a compact set-up with a pull through triangular set-up. Green strands of multi-filamentary Nb3Sn A-15 inter-metallic have been realized through the advanced 'Internal Tin' route after establishing the processes and techniques. For further process refinements, a dedicated set-up on precession deep hole drilling facility is being developed with an Indian industry. This facility will be dedicated to gun drill the oxygen free electrolytic grade copper billets with indexed holes for high homogeneity niobium insertions. This facility is expected to be commissioned and available for Nb3Sn strands fabrication by the end of 2010. There have been focused attempts in terms of experimental trials on developing an optimized heat treatment schedule for enabling maximum solid diffusion of high homogeneous niobium with that of tin to form the Nb3Sn phases as allowed by the metallurgical processes. The growth of the Nb3Sn layer, migration and solid state diffusion of the tin in copper matrix with niobium has been investigated as a function of heat treatment schedule parameters. These strands are also further being measured for their critical current characteristics. MgB2 strands and tapes capable of carrying 104 A cm-2 at 20 K in self field have been developed in a laboratory scale in a joint initiative with National Institute of Interdisciplinary Sciences, Trivandrum. MgB2 strands capable of carrying a Jc in excess of 105 A cm-2 up to a length of 40 cm has been achieved in a laboratory scale with additional doping and by self heating tech-

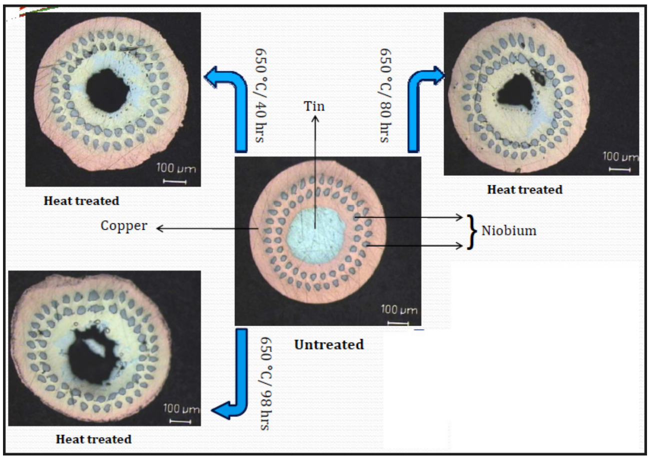


Figure A.2.2.1 Cross sectional pictures of a heat treated strand

niques. Radiation resistant insulation systems comprising of cyanate ester and bisphenol-F epoxy in aided by manganese acetyle acetonate in nonyl phenol as catalysts and co-catalysts, which are compatible to high winding pack stresses in cryogenic operating environment have been conceptualized. The chemical kinetics including the order of reactions of radiation resistant cyanate ester and epoxy based insulation systems have been completed with differential scanning calorimetry and thermo-gravimetric analysis as a function of the component ratios and physical characteristics with catalysts and co-catalysts. A laboratory scale vacuum pressure impregnation facility has been established at IPR which is capable of impregnating laboratory size magnets up to 700 mm height and 500 mm diameter with these advanced epoxy insulation systems. Similarly, winding machine capable of winding large size conductors in a precision manner have been conceptualized and is presently being developed with an Indian industry. Winding proof-of-principle trials of the large fusion relevant 'D' shaped magnet winding packs established in this special purpose winding machine development activity. Power supplies capable of testing high current carrying short samples and magnet winding packs have been conceptualised too. Technical deliberations have also begun on procuring a 30 kA, 30 V power supply for testing the fusion relevant magnets. A large experimental cryostat has been designed and fabricated. This experimental cryostat is capable of accommodating and testing fusion relevant magnets and is ~ 5 m diameter and ~ 6 m in height with nearly ~ 100 m3 of volume. It has been tested to hold a vacuum of 4 X 10-6 mbar. Specifications had been frozen towards realizing a 600 W, 6 bar, 4.5 K, > 36 g/s mass flow rate helium cryogenic system. Initiatives have been undertaken towards making high temperature superconductor based current leads of 1000 A and would be extended to several kilo ampere ranges subsequently. Characterization of high Tc tapes in short sample form and in laboratory scale magnets have been carried out. The high field 12 T 'Jc' measurement facility for the strands, is also augmented with a variable temperature insert..

A.2.3 Development of Vacuum Vessel Sector, Cryo-adsorption Cryopump

Towards the development of 20 panel Cryopump, an important step is the know-how process to design and fabricate double embossed stainless steel panels to be used as components to function inside a vacuum chamber at cryogenic conditions. Such panels have to cope up with conditions like vacuum leak tightness, cryo compatibility at 80K and 4K, its fabrication procedures, product design technology such as structural design, fluid flow design, thermodynamics, etc. So far, such panels were imported. Also the flexibility with import content was an issue apart from many other hurdles. Thus a project was undertaken to develop these panels.

Critical elements of the Project : The critical elements in the development of such panels are selection of material for a panel, weldment material, joining of 2 plates, joining of ports, flow pattern, vacuum leak tightness, performance of the panels after thermal shocks, hydro-forming / Fluid flow analysis for avoidance of dead pockets / hot zones , Pressure drop , heat transfer rate, process flow design and process parameter selection and testing of the Panels to verify its usability in operating conditions. Panels of different shape and size were designed, CFD conducted to understand its flow behavior, pressure drop, etc. and conclusions drawn on weld spacing, port size, spot gap for various burst pressure requirements and pressure drop requirements. Physical prototypes of different shapes and sizes, different bubble geometry, port connections were made and conclusions drawn process limitations, quality control points, physical behavior monitored in design for improvement in actual panels. Various processes of welding were tried its underlying theories studied and finally the process parameters were determined keeping in mind the process and product variables. Indigenously developed prototype hydro formed cryopanels within the country were successfully tested for the thermal cycling and leak tightness for application of Cryoadsorption Cryopump project. The panels were tested for thermal cycling , leak tightness.

Development of Phenolic resin based Activated Carbon Spheres (ACS) : These spheres were prepared by carboniz-

Figure A.2.3.1 Prototype Cryopanels developed for Cryosorption Cryopump Project.

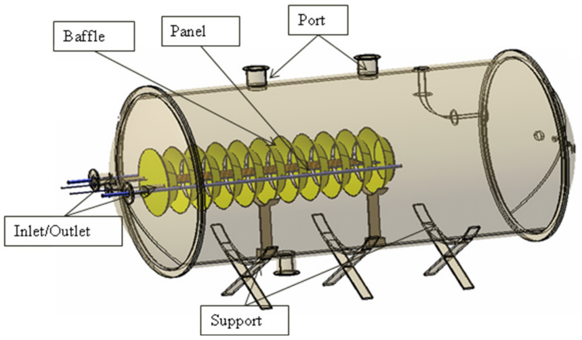


Figure A.2.3.2 Single Panel test stand for testing panels coated with different sorbents Cryopump

ing the phenolic resin spheres prepared by suspension polymerization method followed by activation of carbonized spheres. Carbonization was carried out at 800°C in an inert atmosphere and activation was carried out at 900°C in CO2 atmosphere for different length of time. Properties of ACS samples with different surface properties are shown below.

Development and Validation of Advanced Carbonaceous Adsorbents for Cryosorption Pump : This project envisages the development of an advanced sorbent material/media in self-supporting form having optimum level of functional properties, which could be incorporated on cryopanels. Self-supporting, flexible adsorbent media such as activated carbon fabric have been used for strategic applications in suits meant for whole body protection against chemical and biological agents. The aim was use to develop such a fabric for cryopump application.Activated carbon fabric developed is aimed at revolutionizing the field of cryosorption in which the sorbent forms the heart of the project. The activated carbon fabric can be fixed over the cryopanel with fixtures/mesh and the adhesive may not be required. Thus it will benefit by giving more pore surface area for adsorption of gases and thus higher pumping speed as no pores are blocked. A readily available oven dried viscose rayon fabric sample pretreated with 5 % phosphoric acid was selected in order to establish process parameters (activation parameters) to get surface area approx. 2000 m2/g. Activated carbon sphere were also developed and characterized for adsorption of nitrogen at 77K. Activated carbon prepared from synthetic precursors showed tailor-made properties with good adsorption capacity. In the present project, activated carbon was prepared from synthetic precursors i.e Viscose rayon and Phenolic resin spheres. Rayon fabric pretreated with phosphoric acid showed high carbon yield compared to untreated fabric. Overall yield and nitrogen adsorption properties of activated carbon are strongly influenced by activation parameters such as activation temperature, soaking time and flow rate of activating agent. On increasing activation temperature from 800 to 925°C, the surface area increases from 1225 to 2044 m2/gm, total pore volume increases from 0.51 to 1.12 cc/gm and overall yield decreases from 19.2 to 1.6% respectively. On increasing CO2 flow rate from 100 to 200 ml/min., the surface area increases from 1880 to 1964 m2/gm, total pore volume increases from 0.81 to 0.86 cc/gm and overall yield decreases from 14.1 to 13.5% respectively. On increasing soaking time from 15 to 60 min., the surface area increases from 1254 to 1920 m2/gm, total pore volume increases from 0.55 to 0.86 cc/gm and overall yield decreases from 21.8 to 13.5% respectively. Activated carbon spheres prepared with different processing conditions found to have surface area in the range of 858 to 2092 m2/gm and total pore volume from 0.35 to 1.16 cc/g. Three type of viscose rayon fabric i.e. Automann, flat knitted (woven knitted) and non woven samples were treated with 5% phosphoric acid, dried at 85°C and then activated at 850°C for 1 hr in CO2 atmosphere. Surface properties of different fabric sample were compared and effect of knitting pattern was observed.

A.2.4 Test Blanket Module

The establishment of the Test Blanket Module (TBM) program in ITER, has been approved at 3rd meeting of ITER council. "Mock-ups of DEMO breeding blankets, called Test Blanket Modules (TBMs), shall be inserted and tested in ITER in dedicated equatorial ports directly facing the plasma, and shall contribute to experimental data on the potential of fusion as an energy source". Since its establishment at the third ITER Council meeting, Test Blanket Module (TBM) Program was integrated into the ITER main program and was governed by a specific IO organization called TBM-Program

Committee (TBM-PC). It has been confirmed that India shall be TBM leader of Lead-Lithium cooled Ceramic Breeder (LLCB) TBM concept in Port-2.

The Indian TBM program is focusing on the development of Lead-Lithium cooled Ceramic Breeder (LLCB) (half-port size) which has the characteristics of both Solid Breeder and Liquid breeder blanket concepts. The Research and development oriented towards this concept covers major technologies development required for the future DEMO blanket. This blanket module will be tested in the ITER Radial Port no-2, the interface requirements between the TBM and the ITER machine are being worked out jointly with ITER organization, Cadarache France. The scientists and engineers from BARC, Mumbai and IGCAR Kalpakkam are actively involved in the design and development of the TBMs and the associated technologies such as, Fusion Neutronics, Fusion Engineering Design, Safety, Liquid metal technologies, Thermofluid MHD, Lithium Ceramics, Beryllium pebbles, Structural Materials, Fabrication Technologies for the TBM programme. In this regard, Memorandum of Understanding between IPR-BARC and IPR-IGCAR has been signed between the institute directors for development of nuclear technologies required for TBM delivery to ITER. For each area of development tasks and subtasks has been identified and the corresponding teams has been identified at both the centers. IPR scientists and engineers jointly working with the experts for the technologies development. The TBM, Division IPR, is collaborating with Centre for Plasma Physics (CPP), Guwahati through an Memorandum of Understanding (MoU) for TBM MHD analysis, DEMO blanket and TBM neutronic analysis.

The LLCB blanket concept consists of lithium titanate as ceramic breeder material in the form of packed pebble beds, lead-lithium as breeder and coolant. The Pb-Li flows separately around the pebble bed to extract heat from the breeder zones. The Pb-Li flow velocity is moderate enough such that its self generated heat and the heat transferred from ceramic breeder is extracted effectively. Helium is used as coolant for the external box structure. The main design objective is to obtain efficient blanket performance by limiting the structural material temperature to < 550 C, the Pb-Li to FMS interface temperatures within the corrosion limit of < 480 C, ceramic breeder temperatures window between 450 – 920 C for tritium extraction and to prevent sintering of ceramic pebbles. The figure shows the internal arrangement of the LLCB TBM. In continuation to the first level neutronic design calculations and engineering design of LLCB TBM, the auxiliary systems such as High pressure helium cooling system,

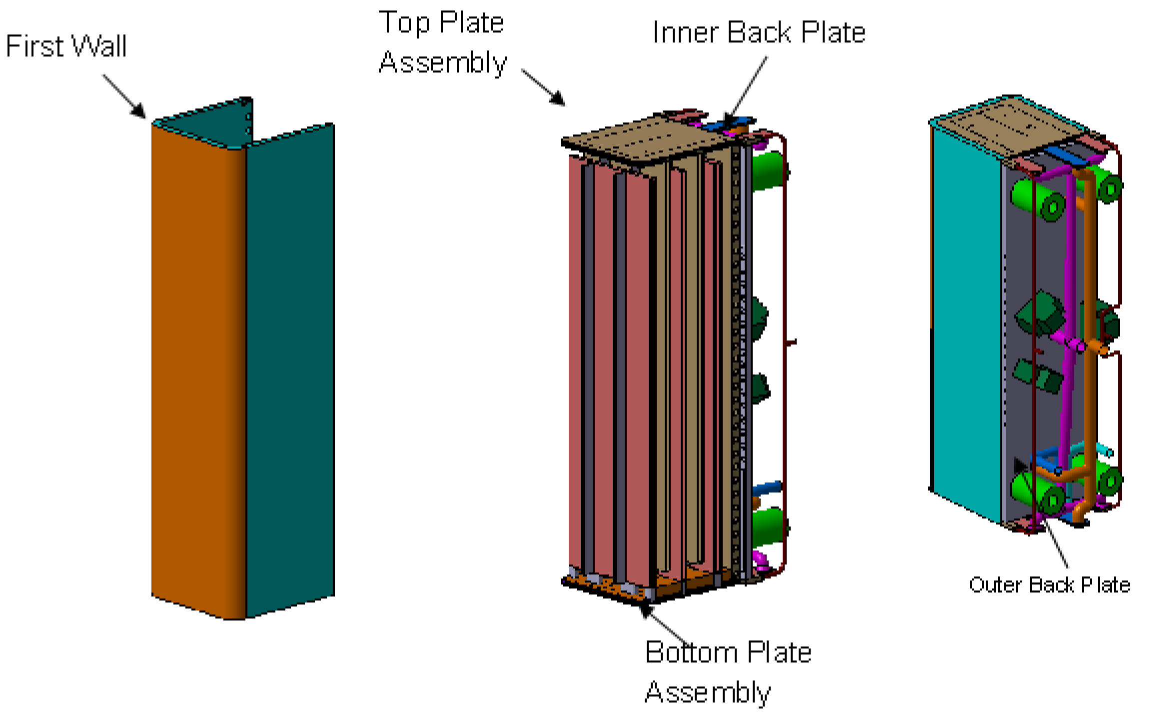


Figure A.2.4.1 CAD Model of Indian LLCB TBM

Lead-Lithium loop systems and Helium purge systems has been initiated. BARC experts play a key role in the conceptualization of these auxiliary systems and its detail engineering design is under progress with the support from engineering services. The indigenous development of Lead-Lithium eutectic alloy has been initiated in BARC. The lab scale production is successful and its characterization for purity and homogeneity is under progress.

Reduced Activation Ferritic Martensitic steel is a structural material, which is under development at MIDHANI, under the guidance of IGCAR experts. This development includes the establishment of fabrication procedures such as Vacuum Induction Melting and Vacuum arc refining. The Indian RAFM steel meets the stringent chemical composition requirements with respect to radiologically undesirable elements as well as trace and tramp elements. This melt route ensured a clean, homogeneous, and segregation free ingots. Based on detailed investigations, proper combination of normalizing and tempering heat treatments were optimized. Detailed investigations carried out on the tensile, creep and ductile-brittle transition behavior of this steel have confirmed that the Indian RAFM steel possesses the required microstructure, creep rupture strength, elevated temperature tensile strength as well as very low ductile-to-brittle transition temperature. Systematic investigations are being carried out to optimize the steel development, fabricability of the material and characterization of Indian RAFM steels for ITER-TBM program.

Thermofluid MHD studies for LLCB TBM is under progress at IPR along with the experts support from BARC, CPP for the code development. In parallel, various critical technologies such as tritium extraction systems, corrosion studies, ceramic pebble development, TBM safety, Beryllium pebbles manufacturing, full scale TBM fabrication techniques, Robotics, Instrumentation & Control systems for TBM are under progress at BARC.

In ITER collaborative work for TBM testing plans, after India submitted “Design Description Document for LLCB Blanket” Version-1.0 to ITER, the TBM Division has made a great progress on TBM and its auxiliary system development. Conceptual design of TBM and preliminary consideration of its auxiliary systems are being performed. Engineering description of IN LLCB TBM and Preliminary Description of LLCB TBM systems & list of major components were presented at the ITER-PMG-2 meeting.

LLCB TBM testing approach will follow the ITER plasma operation plans:
Non-active phase (Mar 2020 – Jun 2024) (Hydrogen/Helium discharges) : Electromagnetic TBM (EM-TBM)
DD phase (Mar 2025 – Jun 2026) (D-D discharges) : Thermal-Neutronic Module (TN-TBM)
DT-1 Phase (From Jan 2027) : Neutronic-Tritium & Thermo-Mechanical Module (NT/TM-TBM)
DT-2 Phase : Integral Module (INT-TBM)

The Scientists and Engineers from DAE, BARC and IPR participated in the ITER-TBM Program Management meetings and technical meetings with ITER Organization. A joint team of scientists and engineers from BARC, IGCAR, CPP and IPR participated in 9th International Symposium on Fusion Nuclear Technologies (ISFNT-9) during 11-16 Oct 2009 at Dalian, China and presented technical papers on TBM. Another joint team participated in 14th International Conference for Fusion Reactor Materials (ICFRM-13) during 7-11 Sep. 2009 at Sapporo Japan.

A.2.5 Negative Ion Beam Source

Neutral beam systems for tokamak machines of future shall use RF based negative ion sources for producing high energy, high current beams. A negative ion program under the XIth plan has been undertaken in order to develop the desired competence to develop, operate and maintain negative ion sources. The roadmap of this plan is to start with single driver sources similar to the one in IPP (Garching) to learn the techniques of plasma production using inductive coupling of RF power, negative ion production in a ceasiated source and extraction and acceleration of negative ion beams. The experiences so developed can then be extended to performing similar operations on multi driver RF sources like the twin and the 8 driver based source to be used on the DNB in ITER.

As a first step towards producing negative ion beams with RF based ion sources, a single driver RF source has been procured from M/S PVA Tepla, Garching, under a technical MOU with IPP Garching. The source is a replica of the BATMAN source.

Besides procurement of the source, activities under the negative ion program in this year have concentrated on developing a laboratory conducive to the needs of such a program. This involves procurement, acceptance testing and commissioning of the various equipments required for the experimental set up and inhouse development of a control and data acquisition system in order to automate and control the entire experimental set up. The year has ended with the commissioning of the ion source in the negative ion laboratory, where upto 85 kW of RF power has been coupled to the plasma. A brief description of each activity is given below:

Factory acceptance test of ion source: The BATMAN type plasma source has been acceptance tested for its mechanical, hydraulic electrical and vacuum integrity at the works of M/S PVA Tepla, Germany during 3rd to 5th August, 2009. Figure A.2.5.1 shows the complete ion source assembly undergoing He leak tests in the factory prior to its acceptance. The acceptance tests were found to be in compliance with the contract specifications.

Factory acceptance tests and Commissioning of Power distribution system : To cater the utility and experimental requirements of the ion source, an 800A distribution system has been designed and successfully commissioned at the negative ion laboratory. The complete system includes: (1)3-ph, 440v, 50Hz, 800A Main Distribution panel (MDP) housed in LT panel (2) Incomer feeder @ 800A with ACB with Microprocessor based Protection Unit having overload, Short-circuit and Ground Fault Protection. (3) Outgoing feeders one 400A, one 200A, three 100A MCCB with integrated static releases for protection against Short circuit, Overload, Earth Fault, Over-voltage and Under-voltage (4) AC Distribution Cable - Copper conductor, 1.1kV, XLPE Insulated, Cables (5)Cable routing through Hot dipped ladder type GI cable trays.

Acceptance tests for the 100 kW RF generator Since the source is RF driven, a 100kW : The 100 kW, 1 MHz RF generator, for the source, procured from M/s Himmelwerk, Germany has been installed, tested and commissioned in the negative ion laboratory using a water cooled 50 ohm dummy load. The RF generator has a built in tube based oscillator along with its power supply and a control and monitoring unit. The generator has been commissioned using the control and data acquisition system specially developed in IPR for this purpose with facilities to run the generator in a continuous or the pulsed mode with or without modulation. The PLC controlled generator was operated locally through the LCD based HMI console provided on power supply unit and also remotely by interfacing it with the central DAC system of IPR via FO links. In addition to this, hands-on training session was conducted by the vendor for the operation and maintenance of the generator by the IPR personnel.

Design, assembly and integration of Matching circuit : In RF based ion source experimental set ups a matching unit is deployed to match the source impedance to the generator impedance in order to ensure efficient coupling of the RF power supplied by the generator to the source. The circuit consists of the fixed and tunable capacitors in the shunt and the series arms of the matching unit. In addition, in order to isolate the generator from the source which is expected to be at a high voltage during the beam extraction and acceleration a ferrite based 3:1 isolation transformer also forms a part of the matching circuit. The circuit is mounted on an isolated Aluminium base with copper based electrical connections. The matching circuit is enclosed inside an Aluminium based radiation-shielding cage, with provision to terminate input coaxial RF cable and output RF connections to the RF coil

DAC system commissioning for plasma source experiments : A siemens PLC based control system and PXI based data acquisition system have been successfully developed, tested and commissioned for the remote operation, control and data acquisition of plasma source.

The DAC system is composed of:

(a) Siemens S7 400 PLC system – for fast and reliable control of the system S7 series of PLC from Siemens has been implemented. The system is constructed on a CPU 414 with input/output modules, power supply modules and control program. The program for control has been developed indigenously using Step-7 programming software. Various GUIs have been developed and implemented using WinCC SCADA software for ease of operation and control.

(b) Front end signal conditioning electronics – All the control and monitoring signals (except water supply system) are connected through fiber optic (FO) TX and RX modules. Required FO cable length of 60m length has been laid between RF Generator and the control system. Control signals of the water supply systems are connected to the control system through signal conditioning electronics having galvanic isolation (> 2.5 KV).

(c) PXI based Data acquisition system (DAQ) – A Real time and loss-less DAQ using PXI RT system (sampling rate 1ms or less, 13 bit resolution, Accuracy 0.5%) has been developed. RT and host application programs are indigenously developed in LabVIEW and the data is stored in binary format with a facility of online display of selected parameters. Mathematical calculations and report generation is performed at the end of each shot. Multi monitors configuration is used for simultaneous viewing of multiple online graphs and control windows.

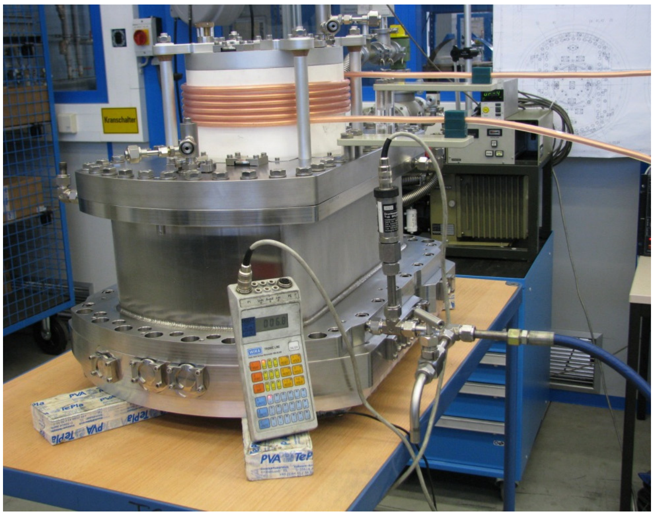


Figure A.2.5.1 He leak testing of source

(d) Workstations and Video monitoring system
Control, monitoring and acquisition of data is performed in central control room consisting of two workstations for control and DAQ respectively. A separate video monitoring system with DVR is installed to monitor and capture the real time image/video of plasma shots.

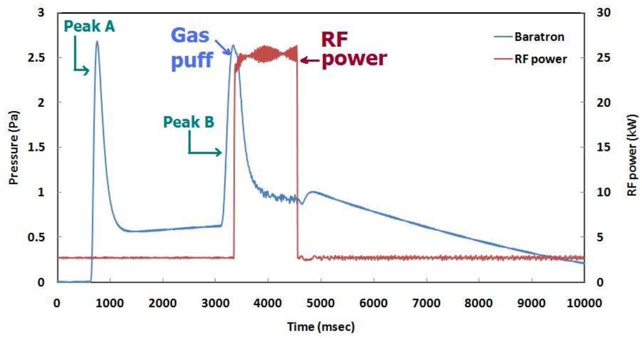


Figure A.2.5.3: Application of the RF pulse at the peak of the gas puff

Commissioning of Plasma-monitor Spectrometer : For safe and efficient operation of the ion source during the plasma shot, plasma needs to be monitored continuously using the optical signals, whose emission wavelengths are well dispersed in the spectrum window. For that purpose, a wide spectral band (200nm – 1100nm), 4-channel spectrometer is procured from M/S Plasus, Germany and commissioned

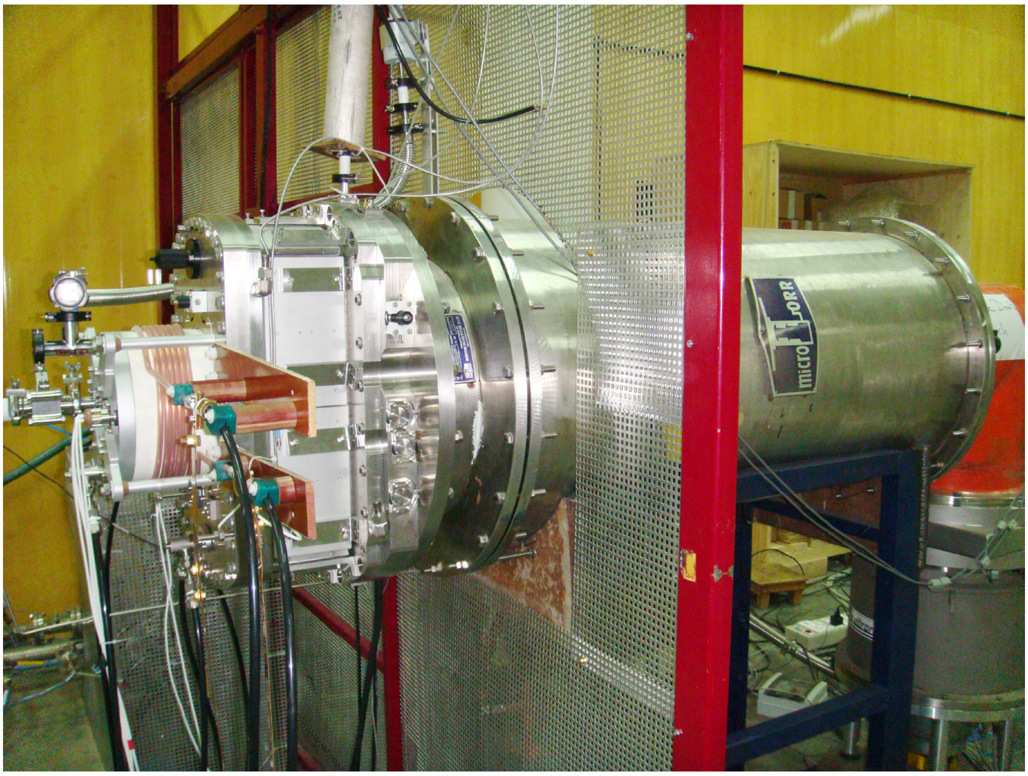


Figure A.2.5.2 : RF ion source experimental set up in the negative ion laboratory successfully and also used during ion source commissioning phase. Typical lines which normally monitored are (approximated wavelength values), H_α - 656nm, H_β -486nm, H_γ - 434nm (all lines for monitoring H- ion density); O+ - 777nm, N2 – 337nm (for monitoring vacuum leak), Cs - 852nm (for monitoring Cs evaporation); Cu - 368nm (for monitoring of any damage in source body); OH radical – 306 -309nm (for water leak) etc..

RF compensated Langmuir probe : A Langmuir probe, RF compensated at 1MHz and its 1st two harmonics has been designed and built. Bench top simulated experiment shows -20dB compensation is achieved. Performance of the probe with plasma is yet to be tested.

Assembly of the test set up and integration of the plasma source with the set up : All the components mentioned above were assembled together in order to facilitate the first phase of plasma production experiments using the RF based source. The source, Figure A.2.5.2, consists of a water cooled plasma box, a RF driver mounted on the back plate of the source and a diagnostic flange on the exit side. The RF driver consists of a water cooled 3 mm thick Farday shield surrounded by an alumina cylinder over which a 6.5 turn copper coil is wound. The water cooled coil is sleeved using a poly propylene tubing with the interspace filled with transformer oil to prevent inter turn breakdowns during operation. The Faraday shield is connected to the driver back plate which press fits the Alumina cylinder to the source back plate. The driver back plate also has provisions for mounting starter filaments, the gas feed and capacitor manometer for monitoring the driver pressure during operation. The starter filament provides the seed electrons before the application of RF power. The coil on the driver is coupled to a 1 MHz RF generator through a matching network mentioned above. Magnets are located on the plasma box and the source and the driver back plate. The inner walls of the plasma box and the source back plate have a 1 mm thick layer of electrodeposited OFHC copper for better heat conduction. The diagnostic flange houses the filter magnets and is equipped with a large number of ports for plasma diagnostic purposes. The present ion source set up does not have the extraction and acceleration system. However in order to simulate the conductance a dummy grid is attached at the diagnostic flange exit.

The diagnostic flange exit of the source is coupled to a 600 mm dia 1300 mm long cylindrical chamber through an adaptor. The arrangement is pumped using a water cooled 5000 l/s Turbo molecular pump which provides a base vacuum of 1×10^{-6} mbar. Hydrogen gas is fed into the ion source using a gas feed system. The gas feed system is a combination of needle valves, pneumatic valves backed by solenoid valves for remote operation, which are operated in a sequence to ensure that there is a gas puff, 1.6 Pa, at the beginning of each gas pulse. After the puff the source pressure during the operation pulse length varies between 0.8 to 0.4 Pa. Modifications shall be made in the gas feed system to maintain a constant pressure of 0.3 Pa during the entire pulse length. The hydraulic network set up for the present experiments supplies water to the RF generator, the various components of the source at 5.5 bar. The flow rates to the different components vary between 90 l/min for the generator to 2.2 l/min for the RF coil. The water conductivity is 1 mS at 20oC. For diagnostic purposes each hydraulic line is equipped with a flow meter and a temperature sensor. As the experiments are performed in an RF environment it is necessary to reduce the field values to 2-3 V/m near the DAC racks. This has been achieved by using an Al shielding mesh which separates the areas housing the generator and the source from the areas housing the DAC.

Plasma source commissioning : The first phase of the commissioning involved establishing suitable matching network parameters in order to produce plasma of the 0.5 – 1×10^{18} cm^{-3} density in the source through the inductive coupling of the RF power. The timing sequence of the control system was adjusted so that the RF power is applied at the peak of the gas puff, Figure A.2.5.3. This ensures proper ignition and sustenance of the plasma during the pulse. Various configurations of the matching circuit have been tried to reach the optimal matching parameters. These include variations in the transformer design, use of different kind of ferrites and modifications in the tank circuit of the RF generator by addition of capacitors. In each of this set of experiments the goal was to reach the maximum cos(Phi) with minimal circuit resistance. The matching exercise was performed at lower power levels. While the series capacitance was used to achieve the best value of cos(phi) the shunt capacitor was used to obtain the least value of the circuit resistance. Once established these conditions were seen to be repeatable for higher RF powers. In the present experiments the source has been operated at 50 kW power levels for 20 s pulse length which reduces to 6 s for 85 kW Rf power. Further experiments on this set up shall be aimed at improving upon the present experimental set up to achieve automated tuning of the capacitors, studies with a 8 turn RF coil to improve stability of matching in addition to the beam extraction and acceleration experiments without (volume production of negative ions) and with caesiating (surface production of negative ions) the source in the next phase.

The program shall be extended to developing a two driver source. This step is necessary to learn the technique of coupling power to two drivers in series from single generator. The experience so obtained shall be form a good database for operating 8 driver based large area DNB source for ITER where use of 4 generators to couple power to 8 drivers is envisaged.

Progress on the 1 MHz, 180 kW RF generator development :

Engineering drawings for 1MHz, 180KW rf oscillator, the 300 kW variable dummy load and 61/8" Transmission Line Sections, Bends and reducers have been completed. Various parts are under fabrication. The desired purchase procedures for the integrated DC Power Supply and the directional couplers have been initiated. Evaluation of quotations received is an on going activity.

A.2.6 Neutronics

ITER X-ray crystal Spectrometer Neutronic Analysis : A design work order (DWO-55-160-LBT-IN) related with the Neutronic analysis of the ITER X-ray Crystal Spectrometer Port #9 was received from ITER-IO. The port plug and X-ray system was modeled in MCNP and various nuclear parameters such as neutron & photon flux, nuclear heating, radiation damage etc. were estimated in the port plug, in the X-ray view-port and at the X-ray crystal and detector.

Tritium Breeding Experiment in LiAlO2 Assembly : A tritium breeding assembly consisting of Lithium Aluminate as breeder and high density polyethylene (HDPE) as reflector was fabricated and irradiated for 5 hours by D-T neutrons at the rate of 1010 n/s. The radial and axial distribution of tritium was measured with lithium carbonate pellet detectors. The tritium in these pellets was measured using liquid scintillation technique.

Neutron spectrum unfolding using multi-foil activation in the LiAlO2 assembly : A multi-foil pack of 12 ultra pure metal foils was irradiated inside the LiAlO2 assembly to measure the neutron spectra at L3C location shown in Fig. 4. The objective of this exercise is to estimate the tritium production from the measured neutron spectra. The gamma activity of

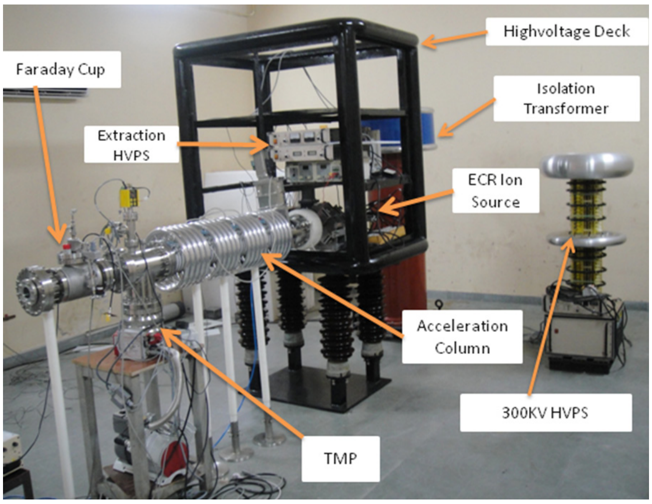


Figure A.2.6.1 Photograph of 14 MeV neutron generator assembly at IPR

each foil was measured using γ-ray spectrometer. Then, neutron spectrum was unfolded with unfolding code STAYNL. The neutron cross-section library used was IRDF-90.

Nuclear Analysis of ITER diagnostic generic upper port plug (GUPP): A design work order (DWO-55-185-SPR-IN) for nuclear analysis of ITER GUPP was received from ITER-IO. So, the neutronics analyses to assess the nuclear performance of several key parameters (nuclear heating, helium production, radiation damage, fast neutron flux, biological dose rate etc.) were conducted in support of the integration of diagnostics in to the ITER generic upper port plug. The analysis was done with MCNP by modifying the ITER reference model Alite-4.

Design of Local Shield for IPR neutron generator : The construction of 1 m thick concrete shield around the neutron lab was posing the difficulty due to foundation level difference between control room and proposed wall. So, it was decided to shield the neutron generator tube locally. A local shield consisting of HDPE and lead was designed for 14 MeV neutron generator using MCNP. The thicknesses obtained were 1.05 m thick HDPE and 2 cm thick lead on the outer surface of the HDPE. This combination was found to sufficient to keep the dose rate levels below regulatory limit of 1 μSv/hr at human occupied places. The mechanical design and analysis of the local shield is under progress.

Absolute measurement of neutron yield for 14 MeV D-T neutron generator using water activation : A project to measure the absolute neutron yield of the 14 MeV neutron generator was undertaken. The 16O(n,p)16N reaction was chosen because of reaction threshold (~11 MeV) close to source neutrons and low half-life (7.16 s) of daughter product in order to achieve high time resolution. A water loop consisting of four spiral segments around the neutron generator was designed and fabricated to flow the water around neutron generator and γ-ray spectrometer. 3"X3" NaI(Tl) detector was chosen to measure the 6.13 MeV gamma from 16N. The detector was calibrated for efficiency and energy resolution. The reaction rate on each spiral segment was estimated with MCNP. The estimation of the neutron generator yield is under progress.

Interface program for Converting CAD geometries into MCNP format : The purpose of this project is to develop an interface program to convert the CAD (Computer Aided Design) models into an appropriate Mathematical Models which can be used in various kinds of analytical calculation codes. For Example, these models can be used in Monte Carlo code (MCNP) for neutron & photon transport through a medium. The developed methodology and the software are generic and do not depend on specific CAD system or MC code. A suitable model is generated by a CAD system and is transferred through export of data via neutral file format to an interface program, where conversion is performed. The approach of this work makes use of STEP (Standard for the Exchange of Product Model Data) compliant neutral file to connect dissimilar CAD packages to MCNP through a methodology, which was designed to cover all the types of regular & irregular geometries.

Conceptual Design of a Sector Magnet for 900 deflection of a 20 keV deuteron-beam for Intense 14 MeV Neutron Generation Facility: The conceptual design of a sector magnet to separate D+ beam from various ion species was completed and the engineering design is under progress.

Neutronics Analysis of ITER TBM Correction coil : Neutronics analysis to calculate the radiation dose on the coils--conductor and insulators for two years of operation of ITER in the high-duty D-T phase and to design shielding requirement to limit the dose to acceptable values. The summary of the MCNP analysis is as follows: Neutronics analysis is carried out for with above MCNP model and iterations are carried out to decide front shield and side shield in order to make coil safe. In iterations correction coils with TBM is displaced from its default position (5cm from center of equatorial port).

A.3 Basic Experiments

A.3.1. Experimental study of control of mean profile asymmetry in Basic Experiments in Toroidal Assembly (BETA)

It is primarily for understanding fluctuations and transport in simple magnetized currentless toroidal plasma. In the present experiments argon plasma is produced using biased hot filament with a typical toroidal magnetic fields of 200-900G. Typical profiles of plasma parameters like electron temperature and density are estimated using Langmuir probes. Recently observations of plasma profiles of density, electron temperature and floating potential were made , using single / triple Lagmuir probes. Also first attempt was made for the study of a double filament produced plasma, using two 1mm filaments – one at minor axis and the other at 5cm inwards from the minor axis. During these experiments, plasma was always observed to stay in the outboard region from the minor axis. Thereafter, thorough tests were conducted to address this kind of plasma shift. It was observed later that, discharge voltage has a significant influence on the shape of plasma profiles such as density. Initial experimental observations identify a transition from nearly symmetric to highly asymmetric radial profiles for which the cause is still under investigation.

A.3.2. Large Volume Plasma Device (LVPD)

In this experiment efforts have been focused mainly on two fronts namely, 1) the interaction of electron beam with bulk plasma and subsequently its effect on electron temperature gradient over a large volume and (2) analysis of the data obtained for plasma transport in the Scrape-of-Layer (SOL) of LVPD plasma. For the first one, further, in pursuance towards producing suitable plasma for Electron Temperature Gradient (ETG) turbulence, investigations were carried out for producing plasma by scavenging energetic electrons. In teh second the focus of study was on unfolding the nature of turbulence in high beta plasma ($\beta \geq 1$) of SOL region.

Electron Temperature Gradient (ETG) : Investigations on high beta turbulence in LVPD have given clear indication that the fluctuation observed resembles the ETG turbulence. The significance of studying ETG turbulence lies on the fact that it is considered as major source for anomalous transport in tokamaks. Direct investigation of this instability there is difficult because of high temperature environment and extremely small-scale lengths. The capability of LVPD in pro-

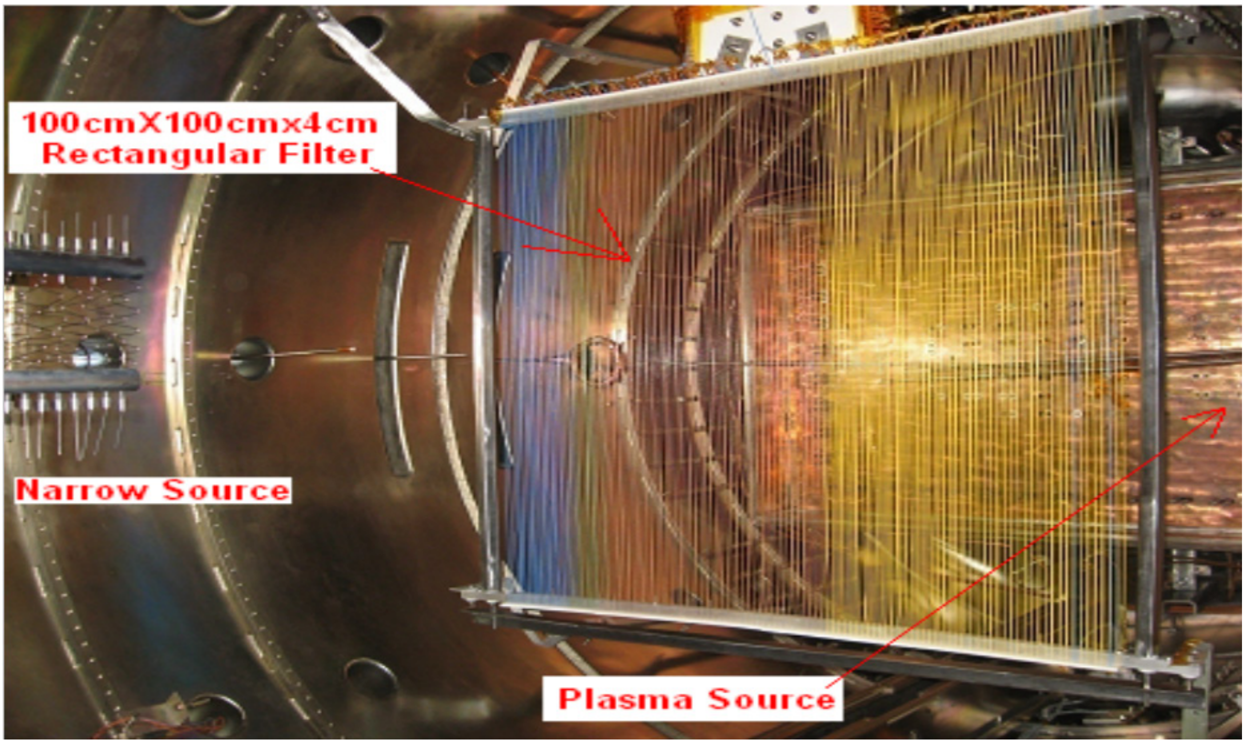


Figure A.3.2.1: The photograph showing inside view of vacuum vessel where 1m X 1m prototype rectangular filter and the filament holding assembly of the plasma source are located.

ducing high-density plasma at very low applied ambient field provides suitable conditions for the investigation of this instability. Past investigations with narrow plasma source(4.5 cm x 12 cm x 40 cm) have shown that the presence of an electron temperature gradient in the core of LVPD plasma provides necessary free energy for the excitation of high beta turbulence. Further, investigations with broad plasma source (60 cm x 60 cm x 2.5 cm) confirm these observations. These experimental observations do not provide an active control on electron temperature gradient except that of indicating electron temperature gradient as a possible source of instability. Thus, the efforts have been expanded towards finding a mechanism for studying ETG turbulence by suitably controlling gradient in the electron temperature. Our emphasis has been on two fronts for realizing this control, First by allowing the interaction of electron beam with the background plasma and secondly by making use of a suitable filter for both scavenging energetic electrons and controlling electron temperature gradient. Our results from beam-plasma experiments have shown that the presence of energetic electrons in bulk plasma makes interaction difficult even with electron beams of capacity ($I_b \sim 4 - 8$ A, $E_b \sim 2$- 80 eV). This has not shown any significant change in electron temperature gradient. These observations have raised an important issue of the requirement of plasma, free of energetic electrons and therefore excited us to look for a mechanism for scavenging energetic electrons and finally realizing a control on electron temperature gradient. In order to address this issue, few pilot experiments were conducted. Encouraging results from these have supported our hypothesis of using multi-cusp filters for scavenging of energetic electrons. This has ultimately given way for the design of a device size electromagnetic filter. Pilot experiments using permanent magnets have shown that trapping was affected but local effect has been observed in the form of density drop across magnetic field. The consequences are thus seen in the form of localized temperature gradients and large density modulation. These were unacceptable as carrying out ETG experiments are not possible in such conditions but simultaneously these observations have given enough evidence that by scaling up of magnets on large area these local effects can be nullified. This has led to a design of 1m x 1m cross-section electromagnetic filter (figure A.3.2.1.).

The presence of this filter divides LVPD plasma into two parts namely, source and target plasma. As experimental interests

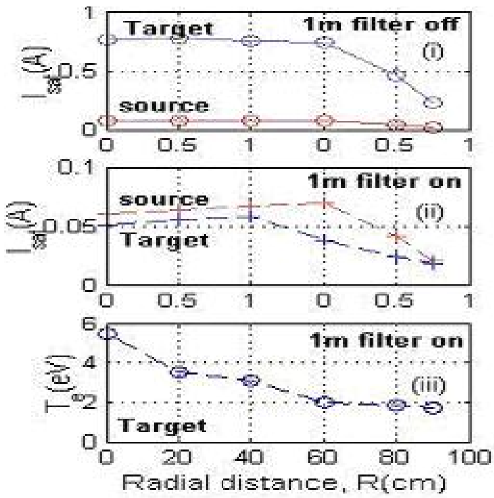


Figure A.3.2.2 The radial profile (i- ii) ion saturation current, mimics plasma density with filter in off and on state, (iii) the electron temperature in target chamber.

for carrying out ETG studies lies in the target chamber so investigations are focused mainly in the target region. Experimental observations have shown that the change in electron temperature in core is realizable as temperature has reduced to 5.5 eV from 9 eV(as reported earlier) but a significant reduction is observed in plasma density, reduces to one tenth of its initial value [Fig. A.3.2.2]. Observations have also shown

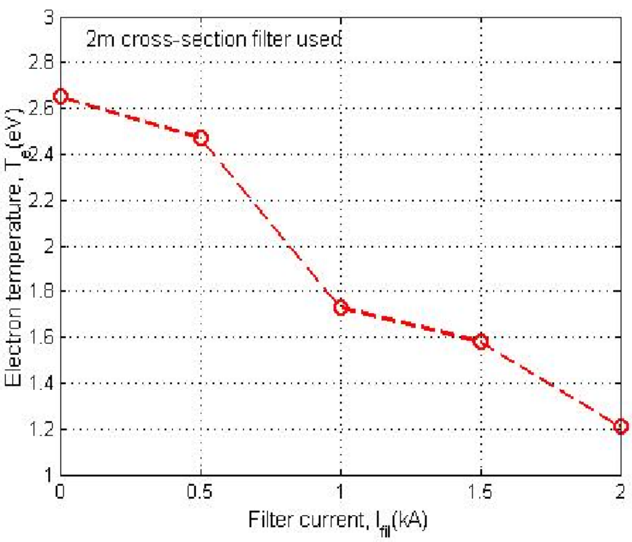


Figure A.3.2.3: The electron temperature at device centre in target chamber showing dependence on filter current and also indicating of experimental control on electron temperature.

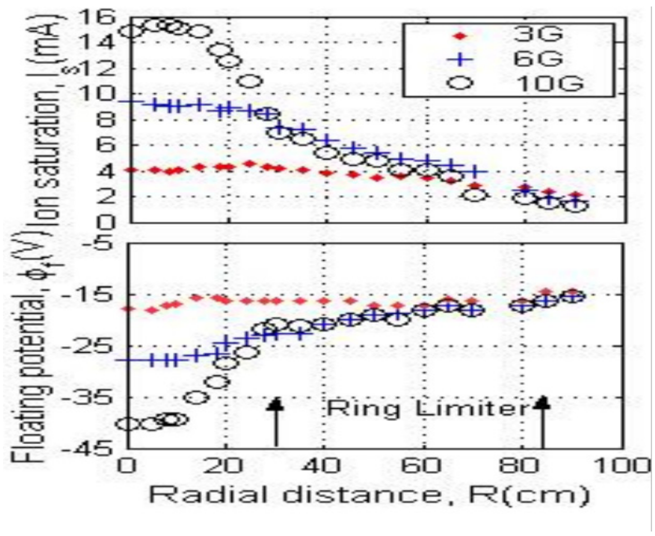


Figure A.3.2.4. The radial profiles of mean plasma parameters, density (upper) and floating potential (lower) in the source and SOL region at different applied ambient magnetic fields.

dilution of density undulations and signature of scavenging of energetic electrons. Results obtained are encouraging (flat density and temperature gradient) from the point of carrying out ETG study but still a lacuna is left in the concept i.e., the extent of the filter has been much less than the cross section of the device and this allows significant poisoning of target plasma because of leakage of unfiltered plasma from source side to target chamber. Finally, these consequences of pilot experiment have motivated us to design a 2m cross-section electromagnetic filter, which will cover the whole cross section of device (figure A.3.2.3). Presence of this filter separates distinctively LVPD plasma into two parts. This has thus allowed leakage of plasma only through filter surface. Preliminary investigations using this filter exhibit that a change in electron temperature can be realized by charging this filter to different currents. The characterization of plasma and subsequently investigating ETG turbulence by exerting control on electron temperature gradient will be a subject of future studies.

Plasma Transport in Scrape-of-Layer (SOL) : Experimental investigations are also undertaken in LVPD on understanding of plasma transport in the regions of sharp density gradients. A high beta electron magnetohydrodynamic(EMHD) plasma($\beta \sim 1.3$, ne ~ 3×10^{11} cm-3) having frequency ordering $\omega_{ci} << \omega_{ce}$, where ω_{ci} and ω_{ce} are the ion and electron gyro frequencies, is produced using a narrow plasma source. The plasma

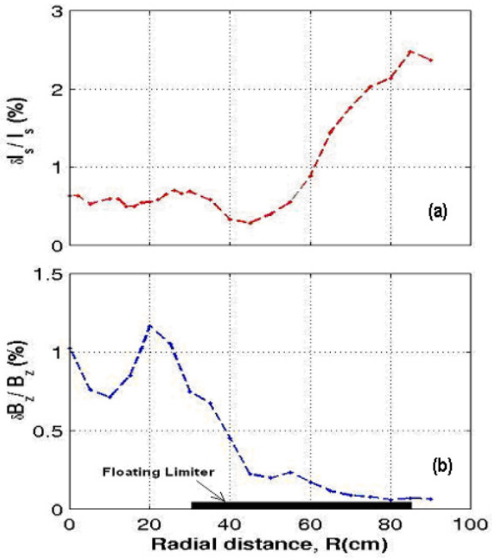


Figure A.3.2.5 Radial profile of normalized fluctuations of a) ion saturation current & b) magnetic field.

produced is divided into two regions i.e., the source region and the Scrape – of – Layer (SOL) region by placing a large floating metallic ring in front of the source.The mean plasma profiles exhibits sharp density gradient in SOL with typical density scale length, Ln ~ 45 cm. These profiles are taken at different magnetic fields where dynamics is governed by EMHD. A radial electric field, Ey ~ 80 V/m is developed in the region 18 cm < R < 40 cm. Experimental observation shows, primarily a dominant E×B rotation and Δn×B effects in the source and SOL region. Past experimental observations have also shown significant expulsion of ambient field in the core plasma whereas it is absent in the SOL region. Analysis of experimental data exhibit percentage of normalized density (Δn/n) and magnetic field fluctuations ($\Delta B_z / B_z$)in the core as typically 0.5 %, 1% and those in the SOL plasma are 2.5% , 0.15 % respectively (Figure A.3.2.5.). The turbulence is electromagnetic in the core plasma and electrostatic in the SOL plasma. The time series and the correlation function of density fluctuations are shown in the figure A.3.2.6. Experimental observation demonstrates a higher azimuthal phase velocity of density fluctuation in the core region in comparison to SOL. The Power spectrum of these fluctuations shows coherent oscillation (Δf/ f <1) in the core plasma whereas SOL plasma exhibits incoherent fluctuations (figure A.3.2.6). Thus a conclusion can be drawn from the analyzed data that the core region is dominated by plasma rotation and the free energy source associated is the strong electric field whereas the shadow plasma is mainly due to both the cross field diffusion and the density gradient. A significant observation is the excitation of coherent structures in the core region whereas SOL plasma is predominantly turbulent in nature. Future study will adhere to the identification of the instability mechanism in the two regions.

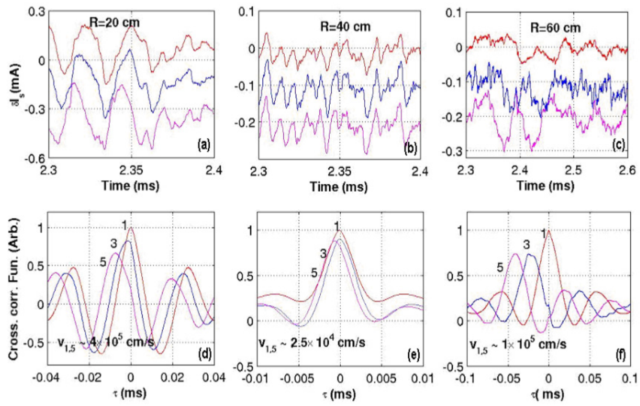


Figure A.3.2.6 (a-c) Time series of ion saturation fluctuations and (d-f) the cross correlation function showing azimuthal phase velocity at different radial locations

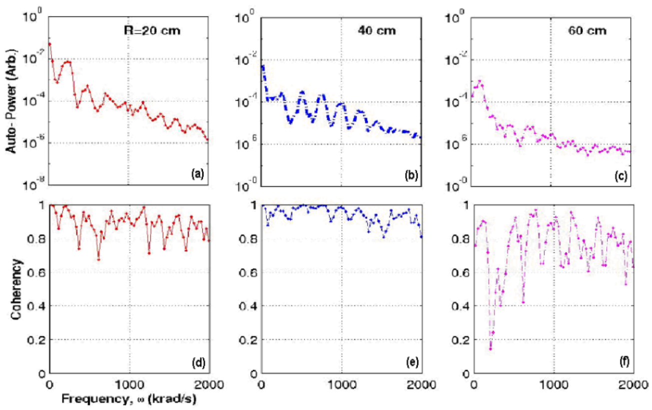


Figure A.3.2.6 (a-c) Auto power and (d-f) coherency at different radial locations of ion saturation fluctuations.

A.3.3 Interaction of Low Energy Ion and Neutral Beams with Surfaces

In continuation of this experiment, the duty cycle of microwave plasma was increased successfully from 10% to 50% in several steps. Experiments were carried out at 20%, 33% and 50% for long hours (more than four hours) continuously without any problems. Ion flux (on the average) increased proportionally (five times with 50% duty cycle compared to

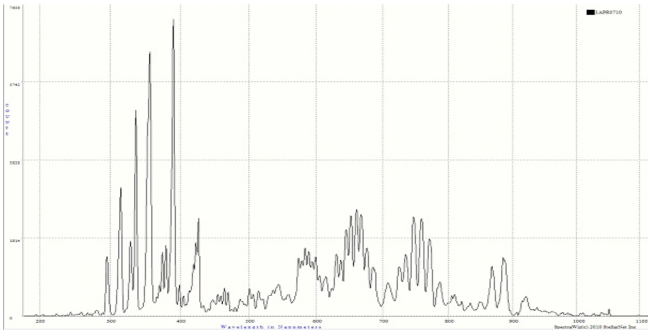


Figure A.3.3.1 Optical Spectrum of Nitrogen Plasma Beam

10% duty cycle). A differential pumping system incorporating a mass spectrometer has been successfully integrated to the main plasma chamber at 90° angle. This was necessitated because the mass spectrometer can only operate at a pressure below a few times 10^{-5} Torr while the plasma can be sustained only at above a few times 10^{-4} Torr pressure. A separation plate (stainless steel) with a small orifice between the two regions allows the differential pressures to be maintained. The small orifice allows enough neutrals to pass through to be detected by the mass spectrometer. A portable optical spectrometer has also been integrated to the plasma chamber recently. This is ideal for diagnosing the plasma. We have already started taking spectrums under various conditions. Figure A.3.3.1 show optical spectrums for nitrogen plasma beam. Future efforts will concentrate on developing an energy analyzer which will be put in front of the mass spectrometer. The mass spectrometer in conjunction with the energy analyzer will facilitate us not only to identify the neutral species but also measure its flux. An energy efficient electromagnet was also designed which will help to increase the magnetic field by a factor of four without additional power consumption for which the fabrication work will be started shortly.

A.3.4 Plasma Wake-Field Acceleration Experiment (PWFA)

The full assembly of the plasma system on its support structure has been completed and vacuum tests carried out successfully. A base vacuum of ~ 5×10^{-6} Torr was obtained. Initial temperature profiling studies in vacuum have also been completed and they compare well with the studies carried out with Ansys. Since temperature stability of the heaters was more than 10%, tests are currently on to obtain a more stable heater temperature. Once stable heater power is achieved, temperature profiling using nitrogen gas fills at 200 mTorr will be carried out before starting experiments with Lithium.

All the major equipments except the Excimer Laser and the optical multi-channel analyzer have been received. The design of the gas exhaust as well as gas feed sys-

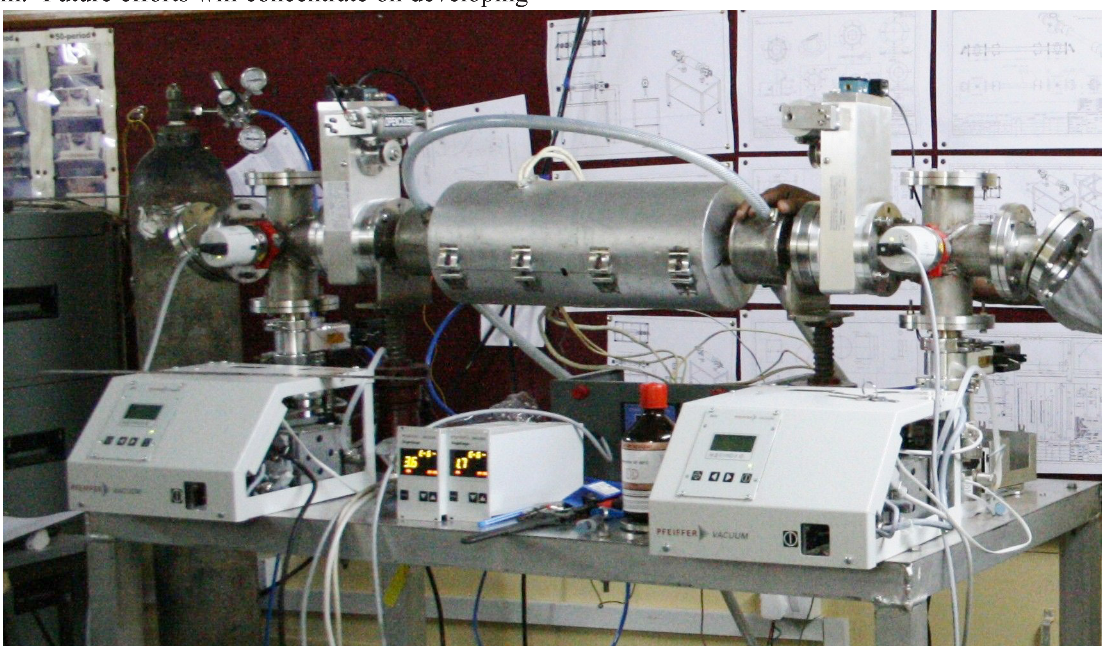


Figure A.3.4.1 The fully assembled heat-pipe oven for generation of photo-ionized lithium plasma tem for the ArF laser has also been completed and will be implemented during the installation of the laser.

A.3.5 System for Microwave Plasma Experiment

The major work carried out this year includes several improvisations on the primitive form of the plasma source discussed last year, in order to enhance or tailor the performance to suit the specific requirements of this project. Further, development of the VIRCATOR based microwave source has been initiated in a separate shed allotted to us for this purpose. A brief account of the development on the plasma front is discussed here. The washer gun based system set-up last year gave us plasma density nearly 1×10^{12} cm^{-3} close (by 5-10 cm) to the gun, followed by a steep gradient (~ scale length 10 cm) in the axial direction. The enhancements we look forward include a uniform axial extent, prior the steep gradient, of about 1 m and a radial extent of about 10 cm. Also, 5-10 times enhancement in the density is also desired. To achieve these, the improvisations sought for include, 1) use a pulse forming network (PFN) to produce and sustain the discharge for about 100 µs, 2) reduction in the working pressure to attain a less collisional plasma, 3) applicaton of an ambient magnetic field for confining the plasma and 3) use of multi-gun sources. These activities were taken up last year. A pulse forming set-up (20 KV, 100µs) has been designed and its development is nearly complete. The system is being tested

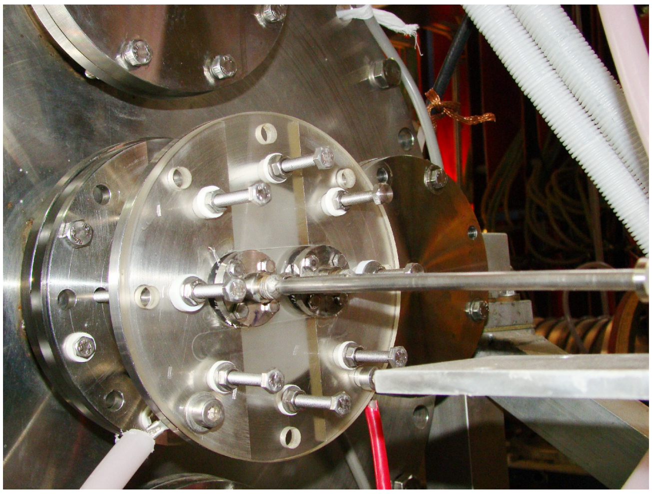


Figure A.3.5.1 The mounted double gun

with dummy loads presently. A set-up, using current carrying coils for producing a uniform DC magnetic field up to 100 G in the chamber has been made. Another set of coil produces a magnetic field up to 500 G within the plasma gun. However, with application of magnetic field in the chamber / washer gun, we could not achieve enhancement in the plasma density / uniformity, as per our requirement. Production of multi-gun plasma with voltage input from a single pulsed source connected across a few parrallel guns has been an issue of concern as even a minor mismatch in the load resistance was thought to result in preferential current flow in a single path

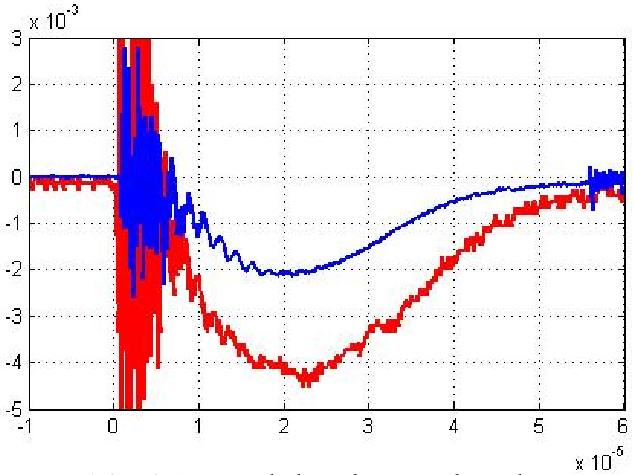


Figure A.3.5.2 A typical shot showing the enhancement in the plasma density with the use of a double gun, as indicated by the Langmuir probe ion saturation current data. The blue and red curves represent single gun and double gun results respectively.

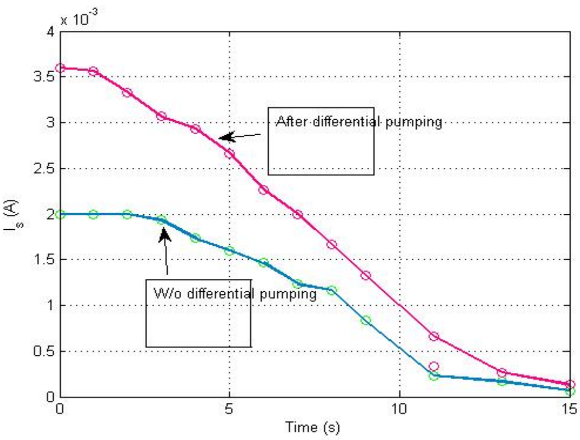


Figure A.3.5.3 Radial profile of the ion saturation current under conditions, with out (green) and with (red) differential pumping of the argon gas. The results show enhancement in the plasma density when the gas is differentially pumped out.

and producion of discharge only in one gun. As a proof of principle experiment, a double gun was designed and fabricated (shown in Figure A.3.5.1.). By carefully matching the impedance of the two paths, we could produce parallel discharges, having equal discharge current, across the two guns. The currents in the two paths were measured using two CT's. With this set-up, we could attain an enhancement in the plasma density, 2-4 times depending on the location within the device. Figure A.3.5.2. shows a comparison of the density profile between the single and double guns. This result has encouraged us to proceed with multigun structure. We have designed a 4-gun structure, the fabrication of which is under way. In order to produce the discharge, puffing of adequante amount argon gas to the gun is a prime requisite. This Ar flow into the working chamber enhances the pressure of the chamber from 5×10^{-6} to 1×10^{-1} mbar, if the whole gas was allowed to enter the chamber. This makes the plasma highly collisional. In order to improve this situation, a differential pumping arrangement has been incorporated which allows a major part of the Ar gas to be pumped out, before entering the chamber. With this arrangement, we could reduce the working pressure by two orders of magnitude ($\sim1\times10^{-3}$ mbar). With this improvisation a considerable enhancement in the plasma density could be attained, as shown in Figure A.3.5.3. The tasks presently taken up by us, with regard to the plasma source include implementation of the PFN studying the plasma performance with single as well as multigun sources. VIRCATOR development is also under way in a separate laboratory. A scheme is also being worked out for the coupling of microwave to plasma. An antenna for receiving the microwave power has been fabricated and is being calibrated against a standard antenna.

A.3.6 Flowing Plasma experiment

The study of formation of current free double layers in geometrically and magnetically expanding helicon plasma is the current aim of this experiment. For this a glass chamber is made of borosilicate glass (Source Chamber) and measures 700mm in length and 100mm in dia. This glass chamber is augmented by a stainless steel cylindrical chamber (Diffusion chamber), which measures 500mm in length and 200mm in diameter. There are 11 KF40 diagnostic ports in the diffusion chamber and 4 KF40 diagnostic ports in the transition region of the glass chamber. A diffusion pump backed by a rotary pump upto 2×10^{-5} mbar evacuates the whole system and neutral argon gas is filled in the system up to 5×10^{-3}mbar. For the Helicon waves to exist we need an axial magnetic field, as these are the normal modes of magnetized plasma.

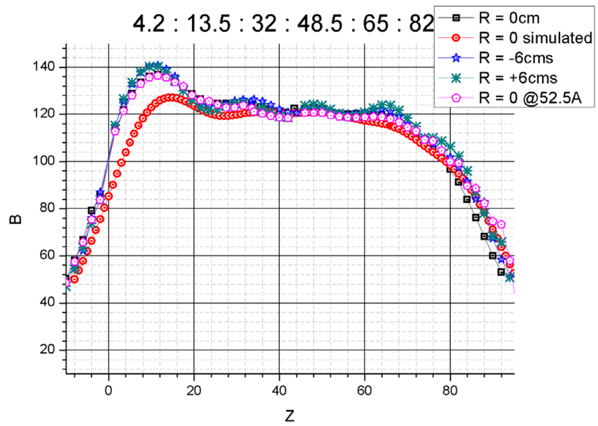


Figure A.3.6.1 Magnetic filed measured and simu lated

The magnetic field was produced by a set of 7 electromagnets made of copper tubing of internal dia 6 mm and outer diameter of 8mm and having 36 turns each. All the coils have cooling facility for high ampere operation. The magnetic field was simulated by a code and then matched with the measured data taken by a Gauss meter. The numbers on the heading of the graph (figure A.3.6.1) shows the position of the magnets whose width and height are 6cm and internal diameter of 31.5cms.

The plasma is produced by a Helicon m=+1 Helicon antenna built in our workshop having 180mm length and 108mm internal diameter. The Helicon antenna is fed RF power by an RF generator of 2500 watts intermediated by an automated matching network. The impedance of the antenna with all the shielding was measured and it was found out to be nearly 75 Ohm and having a positive phase of 15 degrees showing

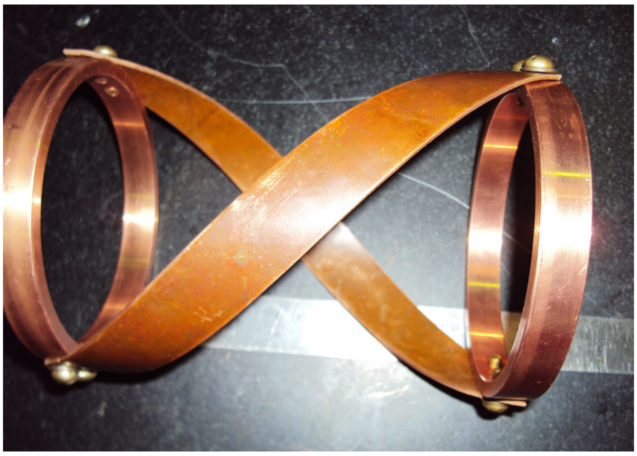


Figure A.3.6.2 Helicon antenna M=+1 having 180mm length and 108mm internal diameter

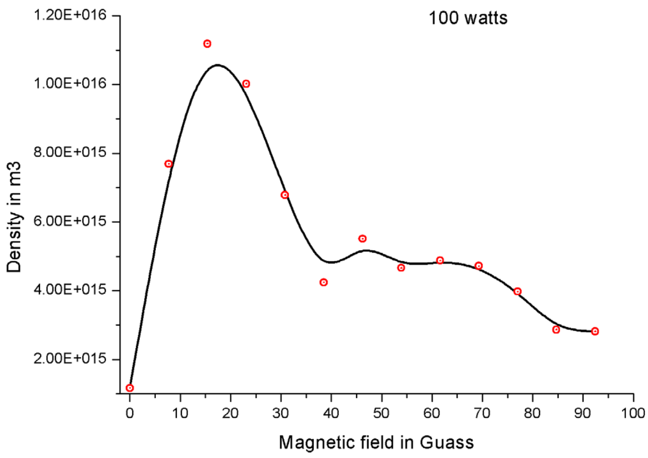


Figure A.3.6.1 Variation of density with magnetic field for a power of 100 watts

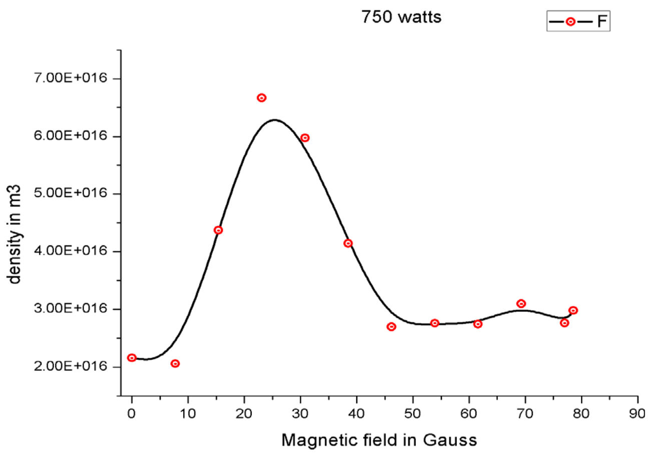


Figure A.3.6.2 Variation of density with magnetic field for a power of 750 watts

that the antenna is an inductive antenna. The total inductance at 13.56 MHz is nearly 270nH.The antenna DC resistance taking care of the skin effect is 50 mOhms. The antenna-plasma system was matched to the RF generator 50Ohm output impedance up to 100%. The plasma produced so was characterised by a triple Langmuir probe biased to 12 volts and electron temperature and density were measured for different power and magnetic field. For no magnetic field the density increased upto 400 watts and remained nearly constant there. The density and temperature showed a jump in their respective values by nearly an order for power of 100-200 watts.

Many authors working in helicon discharges have studied the low magnetic field density peak and attributed it to the electron cyclotron wave coupling. We have also seen the low magnetic field density peak for a magnetic field of 20 to 40 Gauss. The density was measured 40 cm downstream of the source at r=0 position. The detail plots are given below.

Many authors have also seen density jumps in helicon discharges where the density jumps for some power and magnetic field to an order. As we are limited by a magnet power supply we went on to see if the density jumps exist for only power increase. The graphs below show that density jumps are really there where the plasma goes from a capacitive mode to the inductive mode but it was just limited by the helicon mode where the density have increase by one order more

A.3.7 Multi-Cusp Plasma Experiment

The engineering design for the complete system is done with and the intending process for various subsystems like chamber, magnets, power supplies, vacuum pumps are in various stages of procurements. The design of the magnets with the relevant soft core are completed and the purchase indent for the soft core material has been raised. A prototype Cesium oven has been made and is being tested. A prototype of the Tungsten plate ionizer has been made with low cost material components, which will be replaced with originally designed components in the later stage. This prototype (figure D.2.1, page xx) has helped to identify some critical issues like thermal expansion and flash-over points which now have been studied well. A thermal analysis with full vacuum and real heat sources is being done. The design for the diagnostics systems has been started.

A.3.8 Laser Blow-Off Plasma Experiment

The experiments related to the characterization of laser induced plasma (for the both film ablation and solid ablation) under the different experimental condition are continuing in this period . The effect of a variable magnetic field on plasma plume produced by laser-blow-off (LBO) as well as conventional solid ablation (LPP) has been studied experimentally. Enhancement in the intensity accompanied with structures was observed for the spectral lines from neutrals, which varied with the intensity of the magnetic field. The observed results have been explained by considering various atomic processes. The atomic analysis by computing photon emissivity coefficients in the present case has revealed for the first time that enhancement in emission in the presence of the magnetic field is due to electron impact excitation. Effect of intensity profile of the ablating laser on the dynamics of laser-blow-off (LBO) plume has also been studied by fast imaging technique. Present results demonstrate that the Gaussian profile laser produces a well-collimated, low divergence plasma plume as compared to the plume formed by a top-hat profile laser. The sequence of film removal processes is invoked to explain the role of energy density profile of the ablating laser in LBO mechanism. Further, a study has been carried out to understand the influence of nature of ambient gases on the dynamics of laser-blow off plumes using an intensified CCD camera. The evolution features of LBO plume in He, O and Ar environments has been investigated with special attention on the comparison of the structure formation in the expanding plume in these ambient. Singular value decomposition (SVD) of the fast imaging data of the LBO plume is used to analyze the internal structure of the plume in presence of different ambient environment.

A.3.9 Experimental Study of non-linear plasma oscillations

The aim of this experiment is to study phase mixing and wave breaking of plasma oscillations. The plasma requirements are as follows: (1) plasma must be one dimensional and uniform with density in the range between 107/cc to 108 /cc. The length of the uniform plasma should be at least 1 m.

In order have plasma that satisfies the above requirements, a vacuum vessel, a plasma source and the associated magnet is being designed. The dimensions of the vacuum vessel has been finalised and the magnet design is complete. A total of 8 eight magnets will be used to get the primary axial uniform magnetic field. The inner diameter of the magnet is 40 cm, length along the axis is 6 cm and thickness is 13 cm. The centre to centre distance between the magnets is 18 cm. The spacing between two magnets is 10 cm. The spacing between the last two magnets is 4 cm. The variation of the axial magnetic field with distance is shown in the figure below.

The ripple was found to be less than 3.17 %. The magnets will be constructed form Cu tube. Outer diameter of the selected copper tube is 8mm and inner diameter is 5 mm. The expected weight of the Cu coil is 35.644 kg. The length of copper tube needed for making each coil is 129.873 m. The maximum rise in temperature of the coil, if 50 A current is passed for 10 minutes is expected to be round about 7.7660C. We intend to start our primary experiment with 250 G axial magnetic field. Thus 50A current will be enough. Hence the NI of each coil is 3900 Amp turn for producing 250 G axial magnetic field. The designing of the filament plasma source is almost complete. Filaments will be attached on each end flange. Permanent magnets either in chequered board arrangement or line cusp arrangement will be attached on the end flanges for axial confinement. Radial confinement will be achieved with the help axial magnetic field.

The value of the axial magnetic field must be maintained at a value as low as possible in the plane containing the filaments and also over an axial extent. This is done to ensure that the electrons emerging from the heated filament are able to randomise and thus able to produce plasma. The axial magnetic field near the filaments must be maintained at such a value such that the filament spacing must be less than the Larmor radius. In order to ensure that the magnetic field near the filaments is few gauss, two compensating coils carrying negative current are used to reduce the axial magnetic field, which is maintained at a value of 250 gauss in the main chamber.

The vessel is approximately 2.8 m long. It will comprise of three sections, two-source sections 72.5 cm long each and the main chamber 135 cm long. The inner diameter of the main chamber will be 202.72 mm. The inner diameter of the two source chambers will be 396.84 mm.

A.3.10 Experiments on Dusty Plasma

The basic objectives of dusty plasma experiment is to study waves in dusty plasma, rotation of dust particle clouds and other various phenomena like mach cones, etc. Loosely speaking, Dusty Plasmas are plasmas containing solid particles (dust) of nano or micron sized which are charged. The charge on dust particle can be positive or negative depending upon the charging mechanisms operating in the plasma. In addition to the usual waves occurring in the plasma, the dust present in the plasma, also gives rise to some modified waves and some additional waves, for example, dust acoustic waves, dust lattice waves, etc. The dust particles can also form 3D dust clouds which under the effect of a strong external magnetic field, act as rigid rotors and show rotations in a direction perpendicular to the plane containing the electric field and the externally applied magnetic field. Now the essential requirement for this rotation of dust clouds are: (1) Dust density should be sufficient enough for the interaction of the dust particles among themselves. (2) The electric field and magnetic field should be in perpendicular direction so that the ExB drift is maximum.

The experimental set up consists of the experimental chamber, vacuum system, the electrode configuration being used. Here we are using a stainless steel cylindrical chamber whose inner diameter is 31cm and length approximately equal to 50cm. It has four radial ports each having a mouth flange of outer diameter equal to 19cm and height equal to 9.5cm above the cylinder. These four radial ports can be used for different purposes like the upper radial port will act as a view port for collecting scattered light from dust particles with the help of a CCD camera, the side ports will be used in inserting feed-throughs, various kinds of electrical diagnostics like Langmuir probe, inserting gas with help of a needle valve (shut off valve) and for measuring the pressure of the chamber with the help of a pirani gauge and the bottom radial port is connected to a Diffusion pump backed by a Rotary pump. To evacuate this chamber we are using a Diffusion pump with a pumping speed 500 litre/sec and fluid charge <100 litres. Diffusion pump is connected to a Rotary pump with pumping speed 600 litres/min. Also the bottom port has two KF 25 flanges at an angle of 90°. There are two axial windows of outer diameter 39cm glass flanges. One of these glass flanges will be used for inserting laser light and another axial port will be used for collecting scattered light from dust particles, with the help of a CCD camera.

In all the experiments related to dusty plasmas, Laser beam is used to illuminate the dust particles. The dust particles will scatter the laser light falling on to them via a process called Mie Scattering. For particle sizes larger than a wavelength, Mie scattering predominates. This scattering produces a pattern like an antenna lobe, with a sharper and more intense forward lobe for larger particles. In our experiments, we will use an Nd-Yag laser of wavelength 532nm and power 25 mWatt to illuminate the dust grain particles of sizes approximately larger than 1 μm. Clearly here the light wavelength is smaller than the size of the particles so Mie scattering will predominate here over Rayleigh scattering. Shukla in his book has estimated that the laser energy flux required for the thermionic emission to take place is 300 W/cm2. In the present case, the beam diameter is 1mm2 and after that we will expand the laser beam into a sheet so that more number of particles can be traced. Let the effective cross section increases up to 20 mm2 , and then the effective laser energy flux will be 0.125 W/cm2 , which is insufficient for the heating of dust grains for thermionic emission.

In Dusty plasma, we are interested in studying the structures of dust clouds, their rotations, phase transitions and many other things like charging of dust particles, void formation etc. But for all this, we should be able to scan the particles horizontally or vertically which is not possible in case of a laser beam as it will illumination the particles which will be lying in the path of the beam (which is a straight line). So to convert this beam in the shape of a sheet, we have to use cylindrical lenses. In our experiments, we will use two types of lenses: Horizontal Cylindrical Lens and Vertical Cylindrical Lens. The horizontal cylindrical lens will convert the laser beam into a horizontal sheet of light and the vertical one will convert it into a vertical sheet of light. In the present experimental set up, a dc parallel plate electrode configuration has been used. A disc shaped anode of diameter 10 cm has been inserted from the top and a rectangular shaped plate upon which dust is placed, is acting as cathode and is grounded along with the Chamber. The separation between the two electrodes is roughly 3 cm.

Preliminary observations are made on 3D and 2D dust clouds, naturally excited excited Dust acoustic waves and mach cones. When the discharge starts, we let the discharge to occur for few minutes so that enough number of charged particles can be produced for the charging of sufficient number of dust particles. Now we will see that at pressures around 200×10^{-3} mbar, 3D dust clouds are getting formed with external voltage (Applied to the electrodes) of 350 Volts. After increasing the pressure to some higher value the dust particles present in the 3D cloud will start moving or oscillating. At higher pressures, the dust neutral collisions are very dominant. Because of large number of collisions with the dust particles, neutrals can cool the dust particles and they become stationary. When we decrease the neutral gas pressure to some lower values, the 3D dust clouds will start disappearing and at some values of pressure around 100×10^{-3} mbar, the 3D dust cloud will be completely gone and the dust particles will be suspended at the bottom of the frequently moving anode spots. When we further go on decreasing the pressure, the 2D sheets of dust particles start coming with dark and bright bands of particles which shows the occurrence of Dust acoustic Waves. What happens is that at lower pressures, the dust neutral collisions gets decreased and the ion drift comes into picture which results in the excitation of linear pattern of dust acoustic waves. On further decreasing the pressure, the 2D sheet of dust particles comes. On further decrease of pressure, the ion drift takes over the dust neutral collisions and the dust acoustic mode will try to acquire higher amplitudes. By still more decrease of pressure, we get get some particles trapped below the 2D dust sheet, moving with very high velocities which can disturb the dust particles present in the 2D sheet and hence result in the formation of mach cones.

A.3.11 Experimental study of DC glow discharge

Low-pressure breakdown conditions were studied in an evacuated glass chamber under a steady electric field. Influence of gas pressure P and geometrical factors have been studied. A spectroscopic study of argon DC glow discharge was carried out. An effort was made to study the different routes to chaos in DC glow discharge system. Experiments were carried out in a cylindrical glass chamber (borosilicate glass) filled with argon gas at a pressure ranging from 0.026 mbar to 3 mbar. The length of the tube is 1200 mm and inner diameter 155 mm. Electrodes made from SS304 and Cu was used. The distances between the electrodes were varied to study the variation of the breakdown voltage with distance.
The emission spectra of both positive column and the negative glow region and cathode glow of the DC glow discharge were studied. The intensity of lines in the cathode glow region was considerably greater than the intensity of lines in the positive column. A study of the dependence of striation on pressure and voltage was also carried out. It was observed the number of striations changed more sharply with change in voltage than change in pressure. The numbers of striations were found to increase on decreasing the discharge voltage. With pressure the striations were found to increase on increasing the pressure. Understanding the route to chaos found in nonlinear dynamical systems by varying bifurcation parameters allows one to predict the transition from regular to irregular oscillations. In our experiment we have tried to study the route to chaos. The discharge current I act as a bifurcation parameter. The discharge operation was sustained by an external voltage and discharge current I limited by a load resistor (R = 10k). The variation of the ac component of the discharge current was studied.

A.3.12 Magnetic field measurement using B-dot probe

The primary motive of this experiment is to measure a time varying magnetic field using a B dot probe. During the course of the experiment it is observed that the expected signal is accompanied by unwanted signals (noise). The other aim of this experiment lies in the fact that we are able to identify each source of noise separately and study it.
Any measuring system contains many sources of noise. Three primary sources of noise that we encountered in this experiment are circuit noise, electrostatic noise and interference noise picked up from outside the circuit. In this experiment we have concentrated on the different types of noise. Every real circuit component consists of an L, C and R. The manifestation of the real effects of the circuit components can be observed here.

In our experiment a time varying magnetic field was created by a RC discharge circuit. Two B dot probes were placed symmetrically about a straight current carrying conductor connected to the discharge circuit. The variation of the current in the straight current carrying conductor and the expected probe signal.

But the experimentally obtained probe signal did not match with the expected probe signal. An oscillatory signal was obtained as shown in figure below. This oscillation is actually circuit noise. This noise was removed by connecting a low resistance across the two leads of the coil.

Signal was acquired in the probe for both forward and reverse direction of the current i.e. signal was acquired in the probe after reversing the direction of current in the current carrying conductor also. The probe signal flipped but the inverted flipped signal did not match exactly with the probe signal for the forward direction of the current. This is so because the probe picks up an electrostatic signal along with the magnetic signal. The magnetic signal changes its direction on changing the direction of the current producing it but the direction of the capacitive coupling remains the same. The capacitive pick up can be removed by using a differential amplifier in the measuring circuit. Right now we are trying to extract the correct probe signal using a differential amplifier.
During the course of the experiment it was observed that our circuits used to get triggered when someone took a plasma shot, this problem was removed by keeping the circuits in a grounded metallic box. This was a case of noise picked up by the circuit from external sources.

A.4 Theoretical and Computational Plasma Physics

A.4.1 Laser Plasma Interations

Electron acceleration in Vacuum using Ultraintense lasers : Relativistic motion of a charged particle is studied in the field of an intense -finite duration electromagnetic pulse with intensity slowly varying as a function of space. Such variations are used to model focussing and de-focussing of electromagnetic waves/pulses. Kaw et. al (Phys. Fluids 16, 321 (1973)) had investigated a model where the intensity of the electromagnetic wave varied linearly with spatial coordinate in the focal region and had obtained optimum initial condition for maximum energy gain. In the present work we have used a more realistic model, where the intensity is chosen to vary exponentially with spatial coordinate in the focal region. This model is used to get quantitative estimate of energy gain and optimum initial conditions are obtained for maximum energy gain. It is found that the results obtained are in good agreement with the theoretical predictions made by the linear model.

A.4.2 Electron Magnetohydrodynamics (EMHD)

G-EMHD Simulations: Numerical simulations of Generalized Electron Magnetohydrodynamic (G-EMHD) equations to study the role of inhomogeneous density on fast electron time scale phenoemena was carried out in detail. It was observed that the fast electron current structures dissipate energy in the presence of plasma density inhomogeneity by forming magnetic shock layers. Furthermore, they get trapped within a high density plasma region. A complete characterization to determine the dependence on various parameters for these physical features was studied.

Free energy studies for flow shear driven modes in EMHD :The Electron - Magnetohydrodynamic model provides a fluid description for the fast electron time scale phenomena in plasmas. The heavier ions are merely treated as a stationary background. In this prescription the electron fluid flow provides for the current also in the system. There has, therefore, been an ambiguity whether to consider the flow shear and/or the current shear as responsible for the instability arising in the presence of shear in the electron flow. The flow energy has been clearly identified by us as the free energy source in the case of EMHD by distinguishing the current shear with the flow shear configuration.

Relativistic EMHD: In intense laser generated plasma system often the electrons are in relativistic regime. A simplified set of equations for a incompressible Relativistic electron fluid system has been obtained by us to study such a system. The model is then used to study the velocity shear flow Kelvin Helmholtz like instability for a relativistic electron fluid. It is observed that the shear in the relativistic mass of the electron fluid produces certain novel characteristics.

Study of Strongly Coupled Dusty Plasma System : A dusty plasma can often be in the strongly coupled regime. The study of the strongly coupled dusty plasma system has been carried out using the Generalized Hydrodynamic (GHD) fluid model. A numerical simulation code for 1-D GHD model for dusty plasma was successfully developed and tested. The code reproduces the linear wave dispersion characteristics of the GHD model equations. The nonlinear simulations at higher amplitudes show shock formation. Further studies on the interaction of localized structure with the help of the code is being pursued.

A.4.3 Non-Linear Phenomena

Nonlinear theory and Simulation of large Amplitude plasma Oscillations/Waves in a Cold Plasma : (a) An exact analytical solution describing the nonlinear evolution of an arbitrary density perturbation, which can be expressed as a Fourier series in x, is found for a cold homogeneous plasma. We have reproduced earlier known results for a pure sinusoidal perturbation in density (wave breaking limit $keE/m\omega_{pe}^2 < 0.5$) and for a pure sinusoidal perturbation in particle position (wave breaking limit $keE/m\omega_{pe}^2 < 1$), from our general solution. We have further applied our general result to several other density profiles like square wave and a triangular wave.

(b) In a recent publication Infeld et. al. (Phys. Rev. Letts. 102, 145005 (2009)) has shown that when the effect of viscosity and resistivity is included in the cold plasma model, nonlinear plasma oscillations exhibit a new nonlinear effect in the form of splitting of density peak and waves do not break even if the amplitude of perturbation $\delta n/n0 > 0.5$. Infeld et, al. has analytically derived this result using Lagrange variable method, for a specific model of viscosity as $4/3\nu_e = \nu(n_0 /n_e(x,t))$. In a realistic case however, electron viscosity has a relatively weak dependence on density through Coulomb logarithm. In our work, we first reproduce Infeld's results numerically using a uid code based on flux corrected

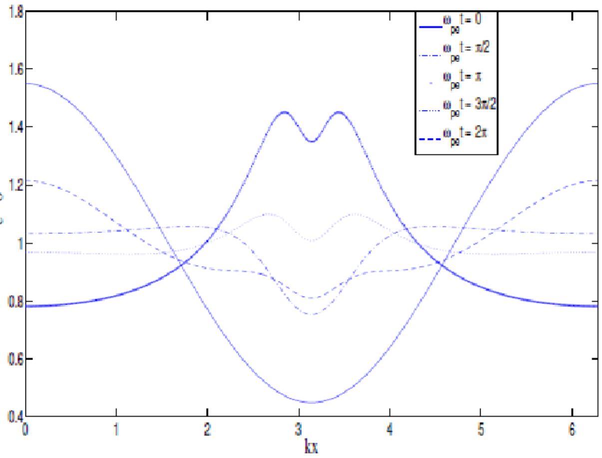


Figure A.4.3.1. The space-time evolution of electron density in a viscous and resistive plasma with $\alpha = 0$, $\Delta = 0.55$, $\nu = 0.35$ and $\eta = 2 \times 10^{-3}$. Here viscosity coefficient is independent of electron density

transport scheme (LCPFCT) and secondly extend their work for the more realistic case where electron viscosity is chosen to be independent of density. We observe that the results are qualitatively independent of the model for viscosity. Figure A.4.3.1 shows the space-time evolution of electron density in a viscous and resistive plasma where viscosity coefficient η is independent of electron density. We have further investigated an alternative electron dissipative model by substituting viscosity with hyper-viscosity, which for a specific choice of hyper-viscosity coefficient $4/3\nu_{hy} = \nu_h\ (n0\ /ne(x,t))^3$, can also be solved analytically using Lagrange variable method. We observe that the results in this case also, other than exhibiting a more pronounced splitting of density peak, are qualitatively similar to Infeld et. al. Figure A.4.3.2 shows the space-time evolution of electron density in a hyperviscous and resistive plasma.

Nonlinear interaction of electron plasma waves with electron acoustic waves : We have carried out an analysis of interaction between two temperature electron species in presence of static neutralizing ion background. It is shown that electron plasma waves can nonlinearly interact with electron acoustic wave in a time scale much longer than $1/\omega_p$ where ω_p is electron plasma frequency. A set of coupled nonlinear diff erential equations is shown to exist in such a scenario. Propagating soliton solutions are demonstrated from these equations.

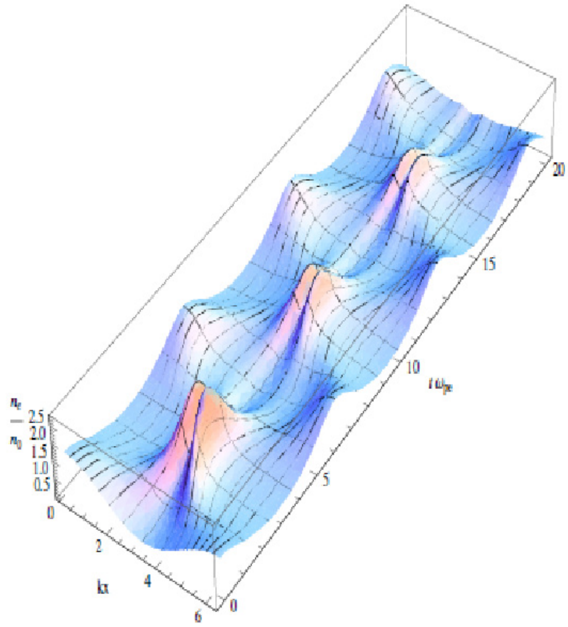


Figure A.4.3.2 Space-time evolution of electron density in a hyperviscous and resistive plasma with $\Delta=0.55$, $\nu_h = 0.03$ and $\eta = 2 \times 10^{-5}$.

A.4.4 Gyro-kinetic Simulations

Gyrokinetic Simulation of nonadiabatic passing and trapped electrons- A Linear Global Gyrokinetic Study : SWITG : The effect of trapped electrons on the Ion Temperature Gradient (ITG) mode in a regime where its wavelength is shorter than the conventional ITG mode $k_\perp \rho_{Li} \leq 1$ is studied using EM-GLOGYSTO code. Such a mode propagates in the ion diamagnetic direction with a typical scale length $k_\perp \rho_{Li} >> 1$ and is termed as the short wavelength ion temperature gradient (SWITG) mode. The effect of the trapped electrons on this SWITG mode is investigated, for the first time, using a global and local linear gyro-kinetic model. The trapped electrons are observed to destabilize the mode strongly. Comparison of the various parameter scans for the SWITG mode with and without the trapped electrons is presented. One important result obtained is that, while in the absence of the trapped electrons the mode was found to subside with increasing value of $\varepsilon_n = L_n/R$ exhibiting the character of a slab like mode, the presence of the trapped electrons has been observed to enhance the $\varepsilon_n = L_n/R$ window of existence of the SWITG mode making the mode more toroidal like. In the present work, the features of the short wavelength ion temperature gradient (SWITG) mode in the presence of the trapped electrons have been presented using a linear gyrokinetic model in the toroidal geometry, that treats both the species, namely, ions and electrons fully gyro-kinetically, taking into account all the kinetic effects. Comparison of parametric dependencies for the two cases of the SWITG mode with and without the trapped electrons is presented. In line with the global model, we also compare the results from a local gyro-kinetic model for the two cases, with and without the trapped electrons. This is for the first time where the SWITG mode is studied (a)in the presence of trapped electrons and (b) in the frame of a global gyrokinetic model. The major findings of the present work are (i) The trapped electrons have strong effect on the SWITG modes, rising the growth rate substantially. This is in contrast to the earlier conjecture that the trapped electrons may not be important for the SWITG mode (ii)Though defined as short wavelength ITG, the two dimensional mode structure of the SWITG mode has been found to be quite global occupying a considerable fraction of the tokamak cross-section for the chosen set of parameters. This establishes the necessity of a global model to study such a phenomenon. The most important observation is that, in the presence of the trapped electrons the Ln/R window for the existence of the SWITG mode gets widened (iii) The toroidicity has strong stabilizing effect on the SWITG mode in the absence of the trapped electrons. Inclusion of the trapped electrons, however, has been found to make the mode stronger against the stabilizing effect of the toroidicity. Thus, the inference from this result is that the mode acquires toroidal like nature in the presence of the trapped electrons in contrast to the slab like nature in the absence of the trapped electrons. The increased fraction of the trapped electrons with increased toroidicity is the main factor behind this flipping of the mode from the slab nature to the toroidal nature. The increased trapped fraction of the electrons with toroidicity reduces the adiabatic response of the electrons, which in turn enhances the formation of the space charge leading to a higher growth rate of the mode and hence the mode can withstand the effect of increased toroidicity (iv)The SWITG mode is an ion temperature gradient driven mode in the higher $k_\perp\backslash\rho_{Li}$ regime exhibiting a threshold in ξ_i. The mode persists even if the electrons are considered adiabatic. In the absence of the trapped electrons the mode vanishes below a critical ξ_i. But, in the presence of the trapped electrons, with the decreasing value of ξ_i, the mode does not vanish, rather it transforms itself from the dominantly ion mode to the dominantly trapped electron mode (v) The growth rate increases for lower values of τ but starts saturating at higher values of it. In the presence of the trapped electrons, the growth rate increases initially, but at higher values of τ where the electrons become hotter than the ions the growth rate falls and then saturates with the mode frequency tending to move towards the electron diamagnetic direction (vi) An estimation of the ion transport based on the mixing length theory is done. The trapped electrons rise the heat diffusivity significantly. It is found that the ion heat diffusivity peaks at lower $k_\perp\backslash\rho_{Li}$. No significant diffusivity is observed at higher $k_\perp\backslash\rho_{Li}$ where the SWITG mode is strongest for both the cases with and without the trapped electrons.

A Nonlinear Study - SWITG : The nonlinear study of the SWITG mode is carried out using the code GENE (Gyrokinetic Electromagnetic Numerical Experiment). It is a nonlinear gyro-kinetic code to study the turbulence and transport of plasma in a tokamak. The model is based on the solution of the nonlinear gyro-kinetic equation, where the fast gyromotion has been removed analytically, such that each particle species is now described by a time dependent distribution funcion in the five dimensional phase space. Solution of the Maxwell equations are required to find out the electromanetic potential, namely (Φ, A|| and B||)which are functions of position and time. The code can use circular model, s-alpha model as well as more realistic general geometry MHD equilibrum when interfaced with other codes e.g. CHEASE that solves the Grad-Shafranov equation, when one provides the plasma boundary, pressure profile and the current profile as an input. The magnetic geometry being adopted in the GENE is the field aligned non-certesian coordinates. The spirit of using such a gemetry is to take the advantage of the strong anisptropic property of the microturbulne along and across the magnetic field ($k_\parallel \ll k_\perp$). The simulation domain is a curved and sheared long box that follows a field line (the field line going through the axial center of the box) an interger number of poloidal turns around the torus. In fact, with toroidal axissymmetry, the equilibrium is two dimentional and all the variations on the flux surface can be sampled in a single poloidal turn. The various equilibrium quantitities (e.g. Density, temperature etc) and their gradients and the parameters that describe the geometry of the simulation box are considered constant, over the perpendicular cross section of the tube; only parallel variation, if any, is taken in to account. Such a flux tube approxmation is justified (i) if the size of the box in a given direction is greater than the corelation length of the phenomena under study in that direction and (ii) if the radial extent of the box is small compared to the machin size. The nonlinear study of the SWITG mode is carried out using GENE. Comparison of the results from GENE and EM-GLOGYSTO in the linear phase is studied as well. We carried two nonlinear runs for R/Ln=10 where the SWITG drive is stronger and R/Ln=5where the drive is weaker. The contribution to the heat flux from the SWITG is found to be 15% over that from the conventional ITG for the case R/Ln=10 and merely 2.3% for the R/Ln=5, where SWITG is weaker. Effect of zonal flow is also studied. Zonal flow plays a significant role in reduction of the ion heat transport. The shearing rate is found to be more than twice the growth rate of the mode.

Molecular Dynamics Simulation of Yukawa Systems : Yukawa systems are used to model complex plasmas or dusty plasmas. They are a good testbed to study various kinetic and fluid problems. In laboratory experiments dusty plasma is formed by immersing dust grains in a plasma. At low enough temperatures they can form crystalline lattices. These dust grains an be modelled through a simple Yukawa interaction potential. The screening of dust interaction potential is provided by the background plasma. Hence one can perform a molecular dynamics simulation of dusty plasma (dust grains only!) using this Yukawa potential. As a preliminary study our study we apply an external drive on a strongly coupled Yukawa solid (BCC) and perform both equilibrium and non equilibrium molecular dynamics simulations. The magnitude of external drive is small compared to average interparticle potential energy. We observe melting of the Yukawa solid with the application of external drive. Interstingly we find a critical value of external drive (Vc) below which there is no melting. The mechanism of melting in the transient state is attributed to the local heating of the system where the forces are maximum. It is shown that these local hot regions dissipate heat into surrounding regions ultimately leading to a uniform temperature throughout the system. In the next study we apply a step velocity shear profile on a two dimensional strongly coupled Yukawa liquid. At a given coupling strength Γ a subsonic shear profile is superposed on an equilibrated Yukawa liquid and Kelvin Helmholtz instability is observed. Linear growth rates computed directly from

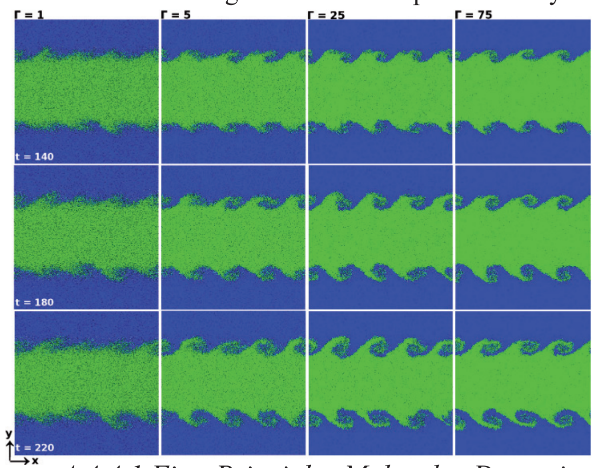


Figure A 4.4.1 First Principles Molecular Dynamics of 2D Strongly Coupled Yukawa System Demonstrating the Kelvin-Helmhotlz Instability using MPMD Code

MD simulations are seen to increase with strong coupling. Vortex roll formation in the non-linear regime is reported.

Multi Potential Molecular Dynamics (MPMD): For the above said work, MPMD, an MPI-based parallel molecular dynamics code was developed by the authors for simulating Yukawa, Coulomb and Carbon systems. The code has been exhaustively benchmarked against known results. This code handle interatomic potentials of Yukawa systems, Lennard Jones and Tersoff-Brenner. Ewald sums are employed to handle long ranged forces in the Yukawa system in the presence of periodic boundaries. MPMD can simulate various thermodynamic ensembles such as NVT, NVE, NPT by employing a Gaussian thermostat and an Andersen Barostat. In the figure A.4.4.1, Blue colored fluid moves along +x direction and green colored moves in -x. The snapshots are shown for the full system at times t = 140, 180, 220 for four different values of inverse temperature (γ), when a given mode m=4 is excited. Horizontal and vertical rows show snapshots at constant t and γ respectively. At higher γ, the mode structures are more prominent. It is interesting to note that at the highest temperature γ=1, mode structures are weak and diffusive due to high thermal agitation.

A.4.5 Particle-in-Cell Simulation

Particle-in-cell (PIC) is a powerful method to simulate dynamics of plasma particles. For a given time step Maxwell's equations are solved on the numerical grid, field components are interpolated at each particle location and then particles are moved by solving their respective equation of motion. We have written a two dimensional electromagnetic PIC code, EMPIC2D, for plasma simulation using total field/scattered field formulation and perfectly matched layer (PML) absorbing boundary conditions. EMPIC2D has provisions for S-polarized and P-polarized light at oblique incidence. Verification of EMPIC2D was done for the following cases: (i) plasma frequency, (ii) energy conservation, (iii) transmission and reflection of incident light on an underdense plasma, (iv) attenuation of incident light on an overdense plasma and reflection from skin-layer (v) laser propagation in an inhomogeneous plasma (with linear density profile), refection from critical density surface, and the formation of Airy profile. In addition to the plane wave excitation, a focused Gaussian beam can also be excited numerically in EMPIC2D. In the relativistic regime (for laser intensity > 10^{18} W/cm^2) with thin over-dense plasma slab, it is seen that as the light intensity increases more electrons are pulled from the back-side of the target due to relativistic transparency. The analysis of these results are in progress.

A. 5. Facilitation Center for Industrial Plasma Technologies (FCIPT) Activities

FCIPT (http://www.plasmaindia.com) is a division of IPR, and has a mandate to develop plasma based technologies on commercial basis. Further, it also acts as a link between the Institute for Plasma Research (IPR) and Indian industry. In the last one year, at FCIPT, the following activities were undertaken.

A.5.1 Plasma Surface Engineering

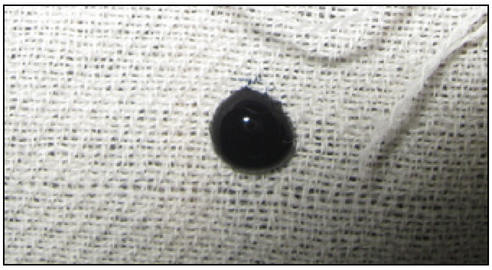
Design and development of twin magnetron plasma PVD system for IIT – Kharagpur : Plasma based magnetron sputter deposition systems are widely used for depositing metals, compounds, alloys etc. Deposition of alloy coatings is possible by using single magnetron systems; where in a single target of the same alloy would be used. However, as the sputtering yields of the alloying elements being different, it would be very difficult to obtain the coatings with the same alloy composition. Multi magnetron systems should be used in such cases. FCIPT has designed and developed a compact plasma based PVD system that could house two magnetrons in it. The system is designed such that two different targets could be sputtered simultaneously, and it could be used for depositing binary alloy coatings, and multilayer coatings. The developed system is provided with facilities to externally bias, and heat the substrate. The initial trials were carried out in the system to check for its performance and the system is ready for dispatch. A photograph of the developed system is shown in figure A.5.1 1.

Design and development of magnetron based plasma PVD system for Tata Steel, Jamshedpur : FCIPT has developed and supplied a full-fledged magnetron based plasma PVD system to M/s Tata Steel, Jamshedpur. This activity involved the design and fabrication of the vacuum chamber, procuring the pumping system, the magnetron device and other accessories, integration and demonstration of the system at FCIPT. Later the system was transported, installed & commissioned at m/s Tata Steel, Jamshedpur.

Development of atmospheric pressure plasma processing system for Wool Research Association (WRA), Mumbai : FCIPT has developed a dielectric barrier discharge (DBD) based atmospheric pressure plasma processing system to surface treat Merino wool and other such fibers, for WRA, Mumbai. The major objective of WRA is to surface treat the Merino wool in order to improve its dye uptake efficiency and to make it itch-free. The photograph of the system is shown in figure A.5.1.2. A homogenous DBD discharge can be produced, in the developed system, using Helium, Argon,

Figure A.5.1.1 : (LEFT) Photograph of the twin magnetron system
Figure A.5.1.2.(RIGHT) Photograph of the atmospheric pressure plasma processing system

Nitrogen, air, or a mixture of these gases, as plasmagen gas. The initial trials have been carried out at FCIPT, in the developed system, to see the effectiveness of the plasma treatment on the improvement of dye uptake. Samples of Merino wool fabric have been exposed to the plasma and the treated samples were tested for dye absorption. The results indicate that the dye uptake has improved very much after plasma treatment, and are shown in the photographs in figure A.5.1.3. The system was successfully installed and commissioned at WRA, Mumbai in March 2010.



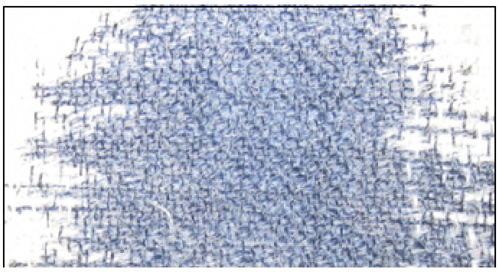


Figure A.5.1.3 Photographs showing the results of dye absorption test (TOP) Untreated Merino wool fabric ((BOTTOM) Air Plasma treated Merino wool fabric

A.5.2 Plasma Pyrolysis

Installation of Plasma Pyrolysis System at Gujarat Cancer Research Institute (GCRI), Ahmedabad : A plasma pyrolysis system of 20 kg/hr capacity was designed, developed, installed and commissioned at GCRI, Ahmedabad, in September 2009. This system was designed specifically for pyrolyzing the medical waste. After installation, test trials were carried out with the medical waste and the obtained results were satisfactory. This system was made more user-friendly, with respect to the earlier versions, by improving the design in the waste feed mechanism. Further, in this design, the graphite electrodes could be continuously fed. Studies carried out to analyze the gaseous emissions during Plasma Pyrolysis of Bio-medical waste. Experiments were carried out, using a 20 kg/hr plasma pyrolysis system, to analyze the emission levels of toxic molecules generated while the bio-medical waste was getting disposed off. Bio-medical waste of category 6 and 7, which have the maximum possibility of generating toxic molecules while getting disposed, were chosen for the trials. The objective of carrying out the experiments was to get the approval of Central Pollution Control Board (CPCB) for the above system. These experiments were done in the presence of CPCB officials and the analysis of the emitted gas was done by M/s VIMTA lab, Hyderabad. All the emissions of toxic gases were found to be well under limits, as per CPCB norms, and some of the results are shown in table A.5.2.1. The photograph of the system, operating in the presence of CPCB officials, is shown in figure A.5.2.1.

A.5.2.1. Photograph of the Plasma Pyrolysis system

Table A.5.2.1: Emissions from Plasma Pyrolysis System

Sr. No	*Type of gas molecules*	*Norms Set by CPCB*	*Actual Emission values at the exhaust (Category 6 waste + 10% PVC)*
1	CO	100 mg/Nm^3	76.2
2	SO_2	200 mg/Nm^3	76.4
3	NO_X	400 mg/Nm^3	129.7
4	SPM	50 mg/Nm^3	26.4
5	HCl	50 mg/Nm^3	<0.5
6	Cl_2	Not mentioned	<0.5
7	Dioxins & Furans	0.1 mg/Nm^3	0.0071

Studies carried out to analyze the gaseous emissions during plasma pyrolysis of plastic waste : FCIPT has undertaken a project, sanctioned by Central Pollution Control Board (CPCB), to study the gaseous emissions from plasma pyrolysis system meant for pyrolyzing plastic waste. Experiments were carried out with various types of plastic waste, including metallic plastic waste, multilayer plastic waste, soiled plastic waste, and PVC. Number of experiments were carried out for optimizing the process parameters. After optimization, all the emissions of the toxic gases were found to be well within the limits set by CPCB.

Job-Shop Activities : At FCIPT, job work is carried out regularly on commercial basis. Various jobs are received, generally, for plasma nitriding, pvd coatings, micro-hardness measurement, hardness depth profiling etc. Jobs, for plasma nitriding, are sent to FCIPT by M/s Mazda ltd., M/s Precise Industries, M/s Peass Engg. etc.; on a regular basis.

A.5.3 Research, Development and Other Activities

Development of industrial scale non-thermal atmospheric pressure air plasma processing system : An industrial scale DBD based air plasma processing system was designed and developed at FICPT for surface treating various wool and textile materials. The typical dimensions of the system are 4 m length, 1.5 m width, and 0.8 m height. The dielectric barrier (non-thermal) discharge (DBD) was used to treat the surfaces of textile fibers. These dimensions are such that this system can be directly coupled with the carting machine, in a continuous processing line, in textile industry. This system is unique in the sense that homogenous DBD could be generated over a large area (1m X 0.5 m). Further, homogenous DBD was obtained even with air as the plasmagen gas. Generally a mixture of Helium and other gases is used to obtain the homogenous DBD. Multiple electrode setups have been used in sequence to obtain the above mentioned system dimensions. This system was developed as a follow-up to the prototype system, that was developed earlier at FCIPT and installed at Kullu, Himachalpradesh, for treating Angora wool. The photograph of the developed system is shown in figure A.5.3.1. It is driven by a high voltage AC power supply, with a rated capacity of 10 kW. The system is equipped with a pair of conveyor belts and a motor drive. The sample to be treated (up to 1 m wide fibers/web/fabric) could be placed in between these belts and conveyed to the processing zone where it would be exposed to the DBD discharge. The treated samples could be collected at the other end of the system. The functioning of the system was demonstrated at FCIPT/IPR, and the experiments were carried out to treat the Angora wool. The results are as good as those obtained in the prototype system.

Development of lab scale glow discharge experimental systems for various Universities : FCIPT has developed lab scale glow discharge experimental systems for Delhi University (DU), Delhi; and Mahatma Gandhi (MG) University, Kerala. These systems were designed and fabricated as per the purchase orders received by the above universities. Two systems were developed for DU and one system was developed for MG University. These systems would be used by the Masters level students, for routinely carrying out the experiments. All the three systems were developed, tested at FCIPT and dispatched to the respective universities. The photograph of the system that was installed and commissioned at MG

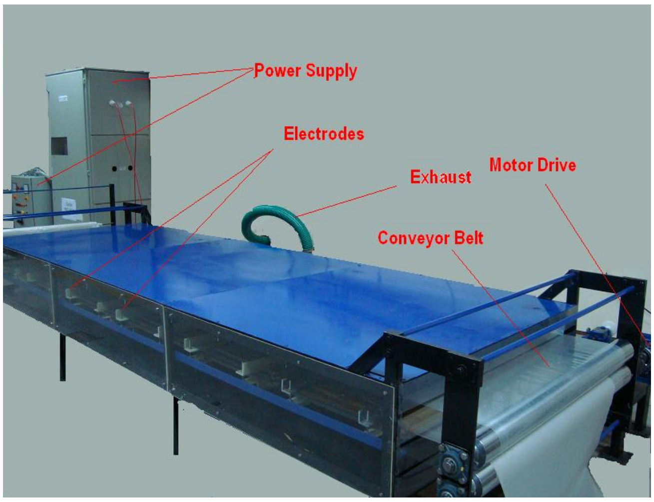


Figure A.5.3.1.Industrial scale non-thermal atmospheric pressure air plasma processing system

Figure A.5.3.2.Lab scale plasma glow-discharge system, developed at FCIPT for MG University, Kerala

University is shown in figure A.5.3.2.

Experimental study of space plasma interaction with space-craft solar arrays (SPIX) II : As a follow up to the previous SPIX project, which was successfully completed by FCIPT, ISAC (ISRO Satellite Center), Bangaluru, has sanctioned another project SPIX II, to IPR. The project is divided into two phases and the project tenure is 18 months.
In phase 1, the existing test facility at FCIPT will be up-graded and modified as per ISO standards, which requires new design finalization, specification generation, procurement and integration of subsystems including electron gun and track probe, development of necessary data acquisition software etc., so that the LEO and GEO conditions could be simulated in the existing test facility. In phase 2, the experiments concerned with the study of formation and propagation of primary and secondary arcs, analysis of the resulted data will be carried out. Finally, appropriate recommendations will be reported to ISAC.

Plasma gasification of petroleum residue and energy recovery : An MoU was signed between Bharat Petroleum Corporation Limited (BPCL) and IPR, in order to develop a plasma based gasification system for converting petroleum residue into combustible gases, and recovering energy from these gases. In the first phase, a feasibility study would be undertaken to see which type of gases are formed on gasifying the petroleum residue such as peat coke. Subsequently experiments will be carried out to recover the energy from these gases, by combusting them.

Development of Hot Dip Aluminide coating for Indian TBM : Hot dip aluminized coatings have been considered as reference coatings for mitigating liquid metal corrosion and tritium permeation problems, concerned with the Test Blanket Module (TBM) program of India. In this connection, while the required controlled atmosphere furnace and the 9Cr-1Mo steels are under fabrication/procurement stage, experiments have been initiated on hot dip aluminizing of mild steel (MS) samples using a box type furnace, built in-house, as preliminary studies.

A graphite crucible, filled with pure Aluminum (Al) blocks, was heated using the box furnace and a bath of liquid was produced. The MS samples were dipped in the liquid bath for a predetermined duration. Scanning Electron Microscope results indicate that, 200 µm thick Al layer was deposited uniformly on MS samples. Later these samples, deposited with Al, were subjected to vacuum heat treatment (under Argon environment) at 720 ^{o}C for a predetermined time scales. The cross-sections of the as hot dipped and heat treated samples have been studied using SEM. Elemental depth profiling of the cross-section, was done using EDAX technique, and the results suggest that iron and Al have inter-diffused over a depth of around 150 µm, after the heat treatment.
Studies concerned with the dependency of Al wettability on various fluxes, corrosion resistance of the inter-diffused iron aluminide coatings etc. are underway.

Mixed Phase Hydrogenated Silicon (Si:H) thin film deposition by Very High Frequency (VHF) Plasma Enhanced Chemical Vapor Deposition (PECVD) : In the present study, multi-hole cathode (MHC), very-high-frequency (VHF) have been used to get high deposition rate of Si:H thin films by tuning the process parameters. Films were grown – using VHF PECVD – on glass, silicon wafer and polished SS samples as a function of operating pressure varying from 0.5 Torr to 9 Torr, while all other parameters such as coupled power, total gas flow (Silane + Hydrogen), electrode separation, and substrate temperature were kept constant. Mixed phase Si:H thin films were successfully grown at a high deposition rate of 3-4 nm/sec at high power and high operating pressure conditions. Scanning Electron Microscope (SEM) was used for measuring the coating thickness.

Further, the VHF PECVD plasma was diagnosed using Optical Emission Spectroscopy (OES), during deposition, without disturbing the silane plasma. The line intensity of Si* (289nm) was particularly monitored during deposition, at all the operating pressures ranging from 0.5 Torr to 9 Torr. It was already established that the line intensity of Si* has direct correlation with the deposition rate of Si:H thin films. In the present case also, a systematic enhancement was observed in the line intensity of Si*, as the deposition rate increased, confirming that line intensity has a correlation with the deposition rate. Detailed OES diagnostics, to investigate the presence of radicals that are responsible for higher deposition rate of Si:H films, is underway.

Comparative Study of SnO2 thin film properties, deposited by Thermal Evaporation and Plasma Assisted Thermal Evaporation processes : Tin oxide (SnO2) thin films are of great interest in opto-electronics industry, and solar cell manufacturing, due to their interesting combination of properties.

A study was undertaken at FCIPT, to compare the properties of SnO2 thin films, deposited by thermal evaporation, and plasma assisted thermal evaporation where RF (13.56 MHz) oxygen plasma was used. Structural, electrical and optical properties of the deposited films were investigated and compared, at various substrate temperatures ranging from 200-350^{o}C, keeping all other process parameters constant. X-ray Diffraction (XRD) analysis has shown the presence of SnO and SnO2 phases in the films deposited by both the processes. Scanning Electron Microscopy (SEM) micrographs indicate that the films deposited by plasma assisted thermal evaporation are relatively more uniform. Resistivity of the films was analyzed using Four Probe method and the results confirmed that the films deposited by both the techniques are electrically conducting and the films deposited by plasma assisted thermal evaporation are relatively more conducting. Optical property measurements were carried out in the visible-infrared region and the results indicate the films deposited by plasma assisted thermal evaporation have higher transparency.

Design and development of Plasma Torch : Studies on water cooled plasma torch were initiated with an aim to develop physics and design understanding, predict thermal and electrical parameters and generate guidelines to help design reliable plasma torches for use as high heat flux sources. In this context, initially a low power 25 kW plasma torch system, along with simple diagnostics, was set up using existing infrastructure. Preliminary experiments were done to gain confidence in operation of such systems and to identify various operating regimes of the torch. Further, a two-dimensional parametric, steady state model for heat transfer analysis in a plasma torch was developed on ANSYS platform. Simplistic geometry of the torch was chosen to understand the heat transfer mechanism in different sections of the existing torch under various operating parameters and to identify safe operating regimes. And the conceptual design of an enthalpy probe diagnostic system for testing medium power plasma torches was also carried out.

A new proposal entitled "Studies on dynamics and instabilities of thermal plasma in plasma torch" was submitted for funding from XI plan under fundamental plasma physics category and subsequently got approved. Procedure for procuring the necessary infrastructure has already been initiated.

Synthesis of Nano Titania by Thermal Plasma : Synthesis of nano-titania by thermal arc plasma was done for a set of parameters. The product, in the form of powder, was analyzed using various techniques to ascertain its crystallinity and morphology. X-ray diffraction analysis showed the product to be anatase phase with small concentrations of rutile phase as well. Calculation of the average particle size (approximated from crystallite size) from the line broadening of the diffraction peak indicated the nano-titania to be 25–30 nm in size.

Scanning Electron and Transmission Electron microscopy studies indicated the particles to be spherical in shape. The particle size range analysis showed the size distribution to vary from 7–75 nm with a peak maximum at around 30 nm. The Energy Dispersive Analysis of X-rays (EDAX) showed the titanium and oxygen atoms to be in stoichiometric ratio. The Selected Area Electron Diffraction pattern indicated the product to consist of both single as well as polycrystalline particles.

Further, in order to see their self-cleaning ability, these particles were dispersed in isopropyl alcohol and ultrasonically spray coated on to cotton fabric with different weight concentrations of nano titania powder. The fabric sprayed with nano titania was stained with coffee, tea and turmeric powder, and then was exposed to an Ultraviolet (UV) lamp and sunlight separately. The stains of coffee and turmeric were observed to disappear after 4–6 hrs time due to the photocatalytic activity of nano titania.

Relocation of FCIPT to New Premises : The FCIPT division has been relocated from old rented building to permanent new premises within Gandhinagar. The entire infrastructure – including vacuum compatible plasma processing reactors, sophisticated surface characterization equipment – have been shifted to the new premises. Due to the collective and co-ordinated effort from the staff of FCIPT and the necessary support from IPR, the relocation activity was smooth and fast. The down time for some of the important projects was as less as twenty days only. The photograph of the new building is shown in cover page no. 2.

A.5.4 Surface Characterization Laboratory Activities

The surface characterization lab is engaged in characterizing various materials to aid the internal research & developmental activities and also to the external customers on commercial basis.

Internal Projects, Research and Development : The necessary characterization work associated with the internal projects, both from FCIPT and IPR, is regularly carried out. Some of the important projects where the characterization was vital are given below.

Analysis of Nb3Sn based fusion grade cable-in-conduit superconductors for Prototype MAGNET division: Development of the fusion grade cable-in-conduit superconductors for the prototype magnets has been initiated by the Prototype magnet division, IPR. The fabrication of Nb3Sn strands were carried out in collaboration with BARC by internal tin process followed by a heat treatment. Composite Nb_3Sn/ Cu strand thus prepared at various (plateau) times have been analyzed at FCIPT by SEM and EDX to study the Sn diffusion and redistribution of elements after the treatment.

Analysis of graphite/CFC-CuCrZr and W-CuCrZr brazed joints for Prototype Divertor Division: The hitherto non-existing brazed joints, being developed by divertor group for fusion applications, have been studied at FCIPT, using SEM. The cross sections of some of such joints including graphite/ CFC–CuCrZr, W–CuCrZr, Cu–graphite, Ti–graphite were studied. Typical SEM micrographs of Cu-graphite, and Ti-graphite joints are shown in figure 1.

XRD analysis of Plasma nitrided F22, F11 and A 105 steels : XRD analysis was carried out on the above steel samples after they were nitrided. The analysis of powder XRD pattern reveals that post nitrided surface of all the three samples, consists of Ferrite, Fe_3N, Fe_4N and to some extent Magnetite (Fe_3O_4). The oxide content is significantly lesser in F22 sample. On the other hand Fe_4N and the oxide concentration is maximum in A105 steel.

Powder XRD analysis of TiO_2 : Nano TiO_2, and nano ZnO powders, synthesized through thermal plasma route, were analyzed using XRD, for the phase identification. The results indicate the formation of tetragonal Anatase and Rutile phases, the former being dominant, in the case of TiO_2, and hexagonal Wurtzite phase in the case of ZnO. The typical XRD result for the TiO_2.

Further, the XRD analysis of various coatings such as TiN, Cu doped TiN, amorphous hydrogenated Si; variety of plasma nitrided steels, etc. was carried out.

Activities carried out on Commercial basis

X-ray Diffraction (XRD), Scanning Electron Microscopy (SEM), Optical microscopy were used for majority of the commercial activities. A variety of samples, ranging from ICs, drug powders, teeth & dental investment material, to bacteria were characterized. The customers are from various industries, research institutes and universities. Some of the important activities are detailed below.

XRD analysis was carried out on phosphate bonded dental investment material, for M/s Square Chemicals, Ahmedabad; to find out its content and qualitative information of the relative concentration for.
A heat isolative fabric manufactured by M/s Jagjivan Enchem Udyog Ltd, Ahmedabad, was analysed using powder XRD for the presence of any type of Asbestos as a content of it. The detailed analysis on the fabric and of the individual raw materials from which it is made, suggested that none of them contained Asbestos within the detection limit of the technique.

Kaolinite, a kind of mined clay, is heat treated in a special manner by M/s Meenal Ceramics Pvt. Ltd. to convert it into fine grained meta-Kaolinite phase. The treated samples are regularly analyzed using XRD, at FCIPT.

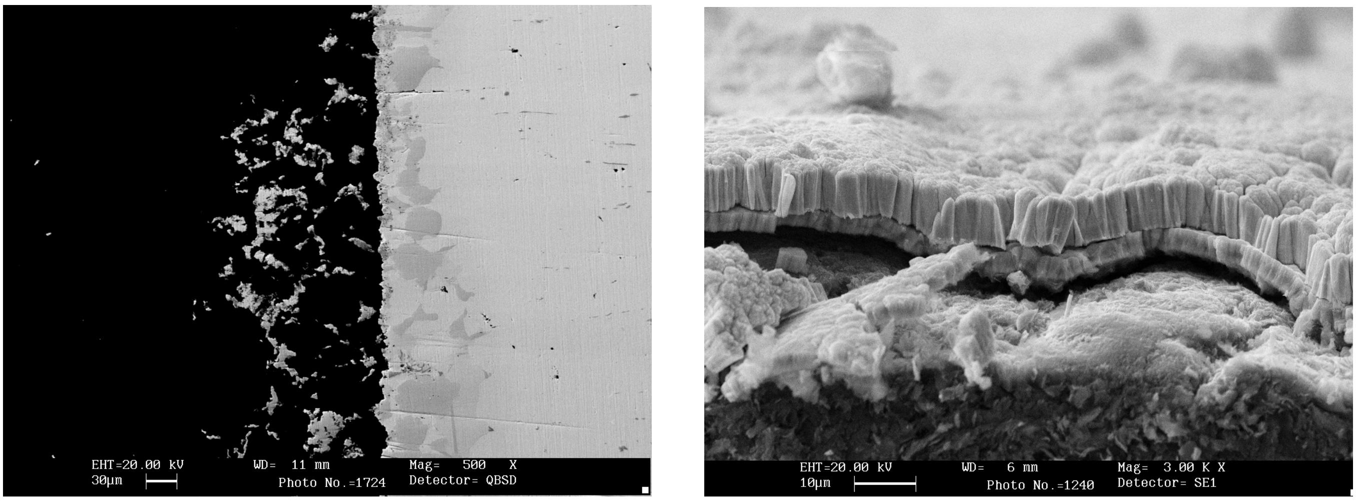


Figure A.5.4.1 (a) Cross sectional BSE Image of Cu-Graphite joint and (b) image of magnetron sputtered Ti on graphite

B. OTHER ACTIVITIES

B.1 Board of Research on Fusion Science and Technology (BRFST)

During the period of August 2007 to February 2010, a total number of 45 research projects were granted by BRFST. Of this, nine were awarded to collaborative research proposals with industry. The Board conducted its bi-annual review of projects in August 2009 and February 2010.

Major Activities of BRFST : Some of the achievements of BRFST are listed below graphically. A total number of 45 projects have been sanctioned under NFP during this period with a committed budget amount of ~ Rs.1220 Lakhs. Research projects in several areas of research important from the point of fusion science & technology have been sanctioned to both academic as well as industrial establishments. The board also supported over 20 conferences/ workshops that were related to fusion science & technology. Twenty students from various streams of science & engineering were awarded fellwowships under the NFP internship scheme.

BRFST plans to conduct contact meeting for the faculty of National Institute of Technologies as well as industry participants in near future. These meetings are aimed at exposing the NIT faculty as well as selected industry to the requirements of R&D in the area of fusion science and technology and to encourage them to take up R&D projects with BRFST.

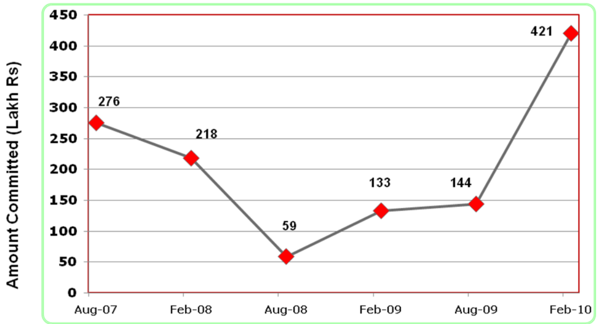


Figure B.1.1. Year-wise utilization of R&D funds between August 2007 and February 2010

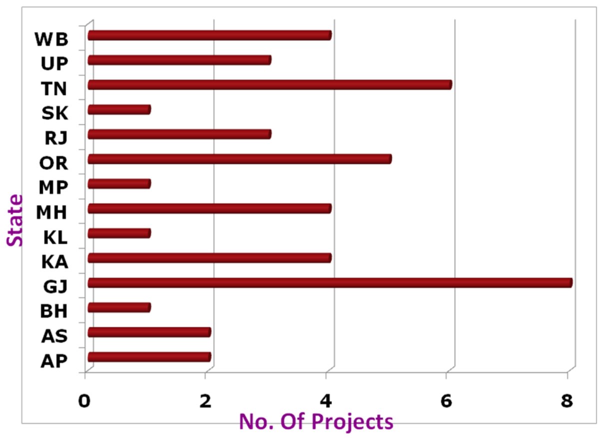


Figure B.1.2. Demographic distribution of the projects sanctioned under BRFST

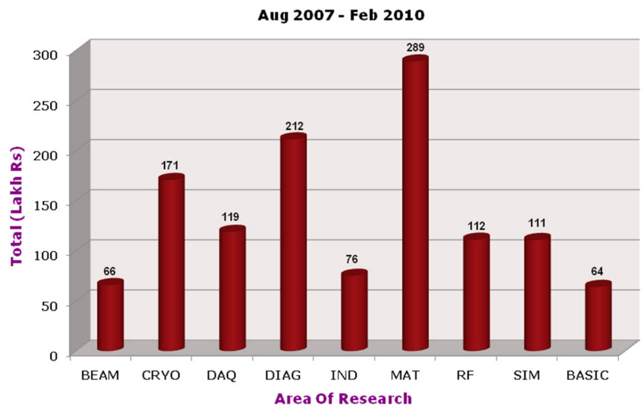


Figure B.1.3 Areas of research that have been funded under NFP.

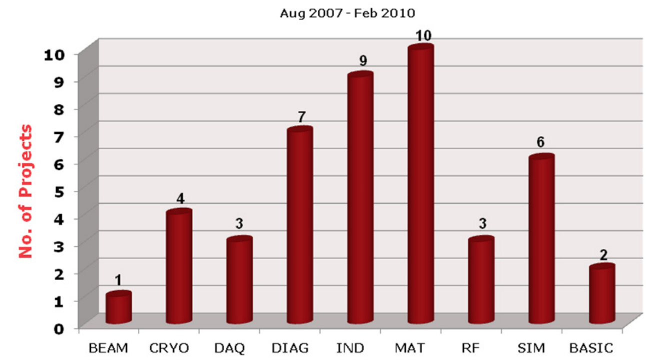


Figure B.1.4 Sanctioned amount for the projects under various areas of research

B.2. ITER-India

In 2009-2010, ITER as well as ITER-India has made significant progress in towards resolving many of the outstanding design issues and launching of the procurements. During this period ITER-India has signed the Procurement Arrangements (PAs) for the vacuum-vessel In-wall shields, the diagnostic neutral beam system (DNB) as also the high voltage power supplies for DNB system, the Ion-Cyclotron heating sources and the Cooling Water System (CWS). The others PAs are to be signed in 2010-11 or later. Design, as well as prototyping and R&D activities in all the ITER-India packages are presently ongoing. A significant amount of documentation as well as design review activities were involved towards finalizing of the PAs.

ITER-India as also IPR personnel participated actively in numerous ITER meetings to resolve many of the outstanding issues in the project. The STAC (Science and Technology Advisory Committee), MAC (Management Advisory Committee) and Council meetings, which are held twice a year, were held in May and October 2009 to resolve a host of management and technical issues in ITER. The ITER Scope, Schedule and Cost baseline is in a very advanced stage of completion and is likely to be approved by the ITER Parties in the June/July 2010 Council meetings. Thirteen IO-DA coordination meetings were held in 2009-10, almost half of which in person and the rest through Videoconferencing. The IO-DA coordination is the highest decision making body within the IO and the DAs and act as the decision making project board. Apart from these top level meetings, the ITER-India personnel were also involved in several working groups, Integrated Project Teams (IPTs), review groups etc which also have regular interactions either through regular Video Conference or in-person meetings. Several ITER-India personnel have also visited ITER, Cadarache, as also other Domestic Agencies to work actively towards finalizing of the ITER designs.

Following is a brief account of the activities in the different Procurement Package areas of ITER-India to be delivered to ITER Project :

WBS 1.5 In-Wall Shielding (IWS)

Major activities carried out by ITER-India In-Wall Shielding (IWS) Group during year 2009-2010 are mainly related to (1) finalization of Procurement Arrangement with ITER Organization (IO) and (2) tendering of IWS manufacturing and materials.IWS Procurement Arrangement was signed between IO and ITER-India on 23rd September 2009. A large number documents detailing out technical specifications and engineering drawings were prepared for PA.

Tenders were released for (1) IWS manufacturing and (2) Procurement of different materials for IWS. The first tender is to manufacture about 8424 E IWS blocks as per very stringent dimensional tolerance requirements specified in drawings. Second tender is to procure, (i) SS 304B4- 1375 ton, (ii) SS304B7-182 ton, (iii) SS430-551 ton and (iv) SS 316L(N)(IG)- 185 ton. We plan to award the contracts for these two tenders by July 2010.

WBS 2.4 Cryostat & VVPSS

ITER-India Cryostat & VVPSS group had taken various Design work order (DWO) and also working on signed task agreement (TA: C24PP14FI & C24PP15FI) between ITER Organization (IO) and ITER-India during this period. We had prepared many technical reports of Cryostat design and analysis. We have also launched tendor for Cryostat and Bellow prototyping work. We are also working with IGCAR on four Cryostat and VVPSS Annexe Tasks. We had also prepared Pre-qualification documents. During this period the following works have been completed : (i) Design work order of 'DWO-24-106-CZU-IN' (Built-up of the DA-DWO workplan for preparing the Cryostat and VVPSS detailed design work) (ii) Design work order of 'DWO-75-137-JJC-IN' (Preparation and review of the System Requirement Document of Cryostat and VVPSS ; (iii) Final Report Cryostat structural and electromagnetic analysis(C24PP14FI) -This includes detailed Global analysis of cryostat structure integrity for all the possible loading conditions and detailed analysis of the component structural states, structure aspects of penetrations. Detail Electromagnetic analysis including structural loading to check the effect of plasma disruption. (iv) Final Report Cryostat thermal analysis(C24PP14FI) - This includes analysis for overall thermal performance in operation and accidental conditions. Thermal analysis at the pedestal ring area to evaluate the temperature decrease due to heat conduction through the magnet gravity supports and the temperature rise due to heat conduction through the VV support. (v) Intermediate Report on Detailed design of cryostat components(C24PP14FI) -It includes detailed design of cryostat components including pedestal ring, column support, skirt support with anchor bolts, connecting bolts and radial support lugs. This analysis had done based on different loading conditions.(vi) Generation of updated Engineering

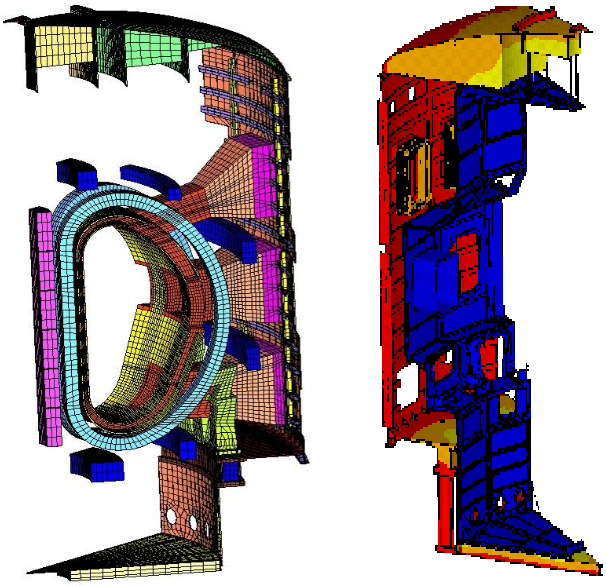


Figure B.2.1 (a) 40^o Sector used for Electromagnetic Analysis (b) Temperature distribution plot

Drawing of Cryostat as per new design and analysis results. (C24PP14FI). (vii) Intermediate Report Cryostat Bellow design and analysis tasks (C24PP15FI) It include and design and analysis of Port Duct and Port cell Bellows for Cryostat. (viii) Preparation of document for Pre-Qualification of Vendors for ITER Cryostat. (ix) Detailed Work Breakdown schedule for Cryostat and VVPSS. (x) Simulation of Single Side Full penetration Welding on SYS WELD for 25mm this SS Plates and validated with prototype (xi) Preliminary Design and Analysis of Vacuum Vessel Suppression System components. (Tank, Relief Line, By-Pass line, Rupture Disc and Bellows)

WBS 2.6: Cooling Water system

Under this package the following works have been done : (i) The System Interface Control Documents (SICDs) and Interface Sheets (IS) have been prepared. (ii) Conceptual level hydraulic network analysis was carried out. (iii) The Conceptual Design Review (CDR) of Component Cooling Water System (CCWS), Chilled Water System (CHWS) and Heat Rejection System (HRS) was held. The queries raised in the CDR were resolved. The conceptual design has been completed (iv) The Procurement Arrangement (PA) related documents like Main, Annex-A, Annex-B and Credit Allocation Schemes were reviewed. (v) The PA has been signed between ITER-IO and ITER India. (vi) The procurement schedule has been finalized and has been approved by ITER IO. (vii) The Task Description document of 'Preliminary Design of ITER CCWS, CHWS and HRS' has been prepared. (viii) The preliminary design has been initiated (ix) Effects of Project Change Requests (PCR) 187, 213 and 229 have been studied and the comments were sent to ITER-IO.

WBS 3.4 Cryo-distribution & Cryo-line

During this period three major activities have been performed to support the progress for the ITER-Cryoline and Cryo-distribution system, namely, (i) Design and analysis, (ii) Representative Prototype (iii) Documentation for preparation of procurement process

Following the development of Conceptual design of ITER Torus & Cryostat (T&C) cryoline, a representative prototype of the thermal shield of the T & C cryoline has been developed to support the thermal analysis and fabrication feasibility.

The topology of the thermal shield for T&C cryoline is C shaped with the clamps for the thermalization around the process pipe at 80 K. The detailed CATIA model and engineering drawings were prepared at ITER-India for the fabrication of the prototype thermal shield assembly.

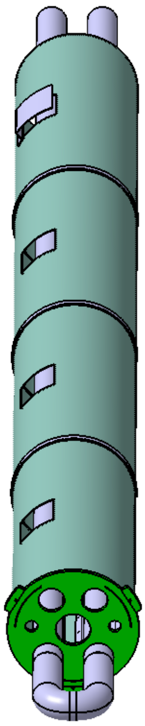


Figure B.2.2:(a) the CATIA model and (b) as fabricated prototype thermal shield assembly

Assembly of the fabricated components was carried out under the strict supervision and quality control of ITER-India cryogenic team including MLI wrapping and sensor mounting. Figure B.2.2.'a' and 'b' shows the CATIA model and as fabricated prototype thermal shield.

The testing scheme as well as P&I D for the test of the prototype thermal shield test have been developed . Following tests have been carried out as a pre-qualification at factory (i) Pneumatic pressure test with helium gas at pressure 25 bar (gauge) in room temperature (ii) Helium leak test at pressure equal to pneumatic test pressure and under vacuum(iii) Cold test . Another major milestone achieved during this year is starting of the procurement process of ITER-Cryolines and Manifolds system.

The pre-qualification process has been announced by publishing globally the expression of interest. Many cryogenic industries from India and abroad participated in the in the process of pre-qualification. ITER-India gave an overview and technical requirement of the project. An expert committee after reviewing the industry's capabilities selected the pre-qualified industries for the system of cryolines and manifold projects of ITER. ITER-India cryogenic team has established its capability of simulation of cryogenic processes by establishing the Aspen HYSYS® simulation tool. A cryogenic process model of the auxiliary cold box for magnet system of ITER, which is responsibility of supply from India, has been developed and analyzed.

WBS 5.1: Ion Cyclotron Heating & Current Drive Sources

Procurement Arrangement (PA) documents which content Main, Annex A, Annex B, CAS, detailed schedule, System-Interface Control Documents (SICD), Plant Breakdown Structure etc. were finalized through bi-weekly meetings with IO. Conceptual Design Review (CDR) related to PA was conducted on 6th May 2009, where Annex B (technical part), SICDs & schedule discussed. Chits received, reviewed, resolution of chits conducted and the same incorporated in the PA documents. All the PA documents are finalized through rigorous review mechanism at various levels and PA signed on 5th Feb 2010.

Procurement activities for different sub-system/components related to R&D unit were conducted. Most of the low power RF components, capacitors, measuring instruments and vacuum tube for pre-driver stage were received and acceptance was given after testing of the same. Contract for development of Local Control Unit (LCU) was placed.

RF design for the driver stage (~125 kW) amplifier completed. Simulation for the same has been done using high frequency software MWS & HFSS. Mechanical analysis is presently under progress. High power RF Tests of EIMAC tetrodes at 65 MHz was initiated along with ITER-IO participation at LHD, NIFS, Japan.

Indigenous development of cylindrical capacitor & disc type capacitor which will be required for pre-driver stage amplifier has been done, along with industrial partner M/s Zeonics India Ltd. Initiation of vendor development process for design/material/ manufacturing/assembly/testing activities for 1 + 8 RF source system

WBS 5.2 ECH Start-Up

After the management level agreement in the last financial year, the revised scope of the Indian ECH package is to supply 2 units of 170 GHz, 1MW, CW Gyrotron sources for ITER EC H&CD applications. In line with the ITER new schedule scenario and also due to the above scope change a revised delivery schedule has been prescribed (2018-2019). The project contractual starting point, which is known as Procurement Arrangement is foreseen towards the end of 2011. With these changes in mind, the project strategy & near term priorities have been readjusted and accordingly the domestic activity centered on the Gyrotron Test facility has been brought into the main focus. The Gyrotron Test facility would not only facilitate the integrated Gyrotron Testing and also expected to facilitate the Prototype developments of critical subsystems. A detailed management report highlighting the synergies and near term and long term benefits of such a facility has been prepared.

Towards the Gyrotron Test facility, an overall conceptual design is under preparation. A conceptual design of the Test Facility cooling distribution has been completed through a Technical Training Project. A System Requirements document for the Prototype Local control Unit has been completed and the conceptual design of the same is in progress. Also a prototype design and development of the sequence control sub-system for the LCU is ongoing through a Technical Training Project. Requirements for the Gyrotron diagnostics such as the Mode purity measurements and Frequency measurements have been studied and are in good progress. A conceptual design on the Auxiliary power supplies is also ongoing through a Technical Training Project. Other main activity towards the test facility includes utility power & cooling requirements, detailed 3D layout, Cost estimation and Schedule planning etc.

Also during this financial year, the group has actively collaborated with home project team at IPR to utilize the expertise/facilities on both sides in a productive way for mutual benefit. Under this collaboration some productive technical results have been delivered. As a part of this collaborative work with IPR, an indigenously developed Ignitron Crowbar System has been tested and made operational. A wire burn test of the conventional HVDC setup with the Ignitron Crowbar system has been successfully tested for the Gyrotron set up at IPR. This also includes re-design and development of Trigger modules for the Anode Power Supply Crowbar unit.

A noteworthy contribution under this collaboration has been the significant contribution of the group in successfully completing Gyrotron (82.6 GHz, 200 KW, 1000 s) commissioning tests at IPR including the preparatory & critical trouble shooting works such as the operationalizing of the Anode Power Supply etc. This activity not only assisted the domestic team but also provided a great training opportunity for the young members of the ITER-India team.

Also the group has successfully completed, the ITER task on RAMI analysis of ITER EC H&CD System within the stipulated schedule with due credits received. Other work includes contributions to the different technical and management meetings with ITER and other involved domestic agencies.

WBS 4.2 Power Supplies

The Group is responsible for the power supplies of the Diagnostic Neutral Beam (DNB), the Ion-Cyclotron (IC) Systems and the Start-up Electron Cyclotron (EC) Systems. These systems will be used in the Indian Test facility (IN-TF), before delivery to ITER, to test corresponding systems to full operational parameters. Subsequent to the conceptual design review of the DNB Power Supply, IN-DA and IO together worked upon the technical document, management specifications, project schedule, and credit allocations enabling the Procurement Arrangement (PA) for DNBPS system that was signed in April'2009. Monthly submission of the technical and schedule updates being done on the regular basis. A mini review of the Preliminary design for the DNBPS was carried out at IO during January'2010. Requirements at the IN-TF, particular to the interfaces and layout have been initiated. Test bench for control purpose is being developed.

Conceptual design review for the IC HVPS was carried out in May'2009 with an international review. Documentation for the technical part is under discussion with IO, this shall enable the PA signature for the IC HVPS.

Existing MoU between ITER-India and ECIL has been operative; a prototype IC HVPS (26kV, 190A) has been identified to work upon. Initial phase shall include different level of documentation converging to procurement specifications. A more intensive technical discussion on the SPIDER High voltage power supply (HVPS) was carried out with IO and RFX team during their visit in March'2010 in India. Procurement arrangement for the Indian part is under preparation in close coordination with IO and RFX team.

A major activity foreseen at the IN-TF is establishing the 22kV distribution network; essential for demonstration of power supply performance and corresponding H&CD systems. Proposed scheme includes a dedicated 22kV feeder catering to DNBPS, IC HVPS and EC HVPS requirements.

WBS 5.3 Diagnostic Neutral Beam (DNB)

Diagnostic Neutral Beam (DNB) is the probe beam under CXRS diagnostic system for measuring Helium ash content in Fusion plasma. In ITER the energy of the beam is 100keV and neutral beam current is ~ 17-20A (H atom) having divergence ~7mrad. The baseline design of ITER-DNB was not complete, hence, ITER-India DNB Group has helped ITER-IO in generating the built-to-print (BTP) design for the system in collaboration with ITER-IO and its partners. The complete design of DNB including details of its different components has been critically reviewed by an international team comprising of Neutral Beam experts and recommended for acceptance by IO. The final design review (FDR) was held on April 2009 and signature of the procurement arrangement (prepared with support of ITER-IN project office) was done on 22nd March 2010. Following are the highlights of the activities and achievements over the past one year in this regard.

Activities related to ITER-DNB Physics & Engineering:
1. Beam Source: DNB beam source consist of inductively coupled RF negative ion source and the 100kV 3-grid accelerator system. The basic model of the ion source is provided by IO as an input design. The activities related to the accelerator design and the integration of the ion source with the vacuum vessel and HV Bushing along with ion source movement mechanisms, keeping in mind the remote handling issues are described below.

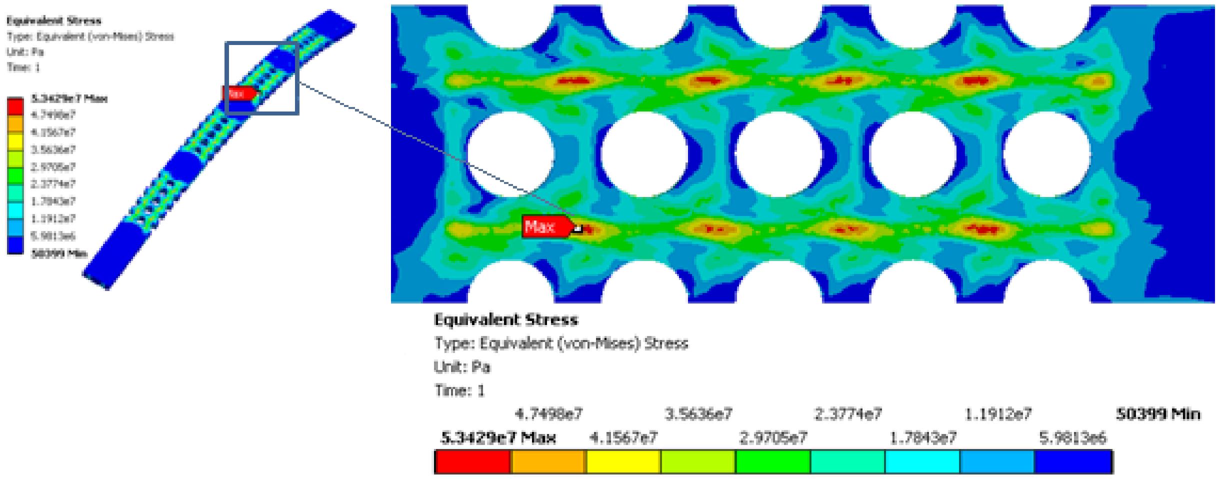


Figure B.2.3 Maximum Von Mises stress 53.4Mpa at time 46.9s (EG)

Accelerator design: The physics design for the extractor and accelerator system for the DNB, a three grid system consisting of the Plasma grid (PG), the extractor grid (EG) and the grounded grid (GG), has been completed. Each grid consists of 4 segments with each segment having 4 beam groups and each beam group having 80 apertures. The total number of apertures per grid is 1280. In addition to the use of the SLAC-CAD code for optimising the aperture shapes and voltages to get a minimal beamlet divergence, various codes have been used in the optimisation of the different parameters of the grid design. The TRACK and the EAMCC codes have been used to estimate an electron power load of 672 kW and 400 kW on the EG and the GG respectively. The maximum power density on the EG is 1250 W/cm2 for the EG and the 350 W/cm2 on the GG. 2.6% of the electrons leak from the accelerator and correspond to a power of ~ 400 W. The power corresponding to the back streaming positive ions is estimated to be 10 kW for the H+ and 50 kW for the H2+. These studies have been carried out using various possible configurations of the filter fields modelled for an □Bdl of 500 Gcm for hydrogen between the source back plate and the PG grid. FINDNB code has been used to estimate the beamlet dispersions and deflections for each of these filter field configurations. OPERA 3D code from vector fields has been used to estimate the beamlet deflection due to suppression magnets in the extractor grid, the beamlet steering constant, the deflection of the outermost beamlets due to space charge repulsion and the design of the field shaping plates also known as kerbs to cancel this deflection. The beamlet deflection due to suppression magnets in the extraction grid is estimated to be 6 mrad which can be compensated by offsetting the apertures in the GG with respect to EG using the beamlet steering constant of -7.76 mrad, for a +1 mm offset. The deflection of the outermost beamlet due to space charge repulsion of the neighbouring beamlets has been estimated to be 2.8 mrad for an aperture pitch of 22 mm in the vertical direction and 3.4 mrad for an aperture pitch of 20 mm in the horizontal direction. These can be compensated by the use of 1.3 mm thick field shaping plates at a distance of 17.5 mm and 15 mm from the periphery of the outermost aperture in the vertical and horizontal directions respectively. The interaction between the beam groups has been found to be negligible. The beamlets can be focussed in the vertical direction to the focal point located 20.67 m from the GG by geometrical aiming of the beam segments and applying the aperture offset technique. In the horizontal direction the same can be achieved by using a combination of shaping of individual segments and aperture offset. The electron power leaking out of the accelerator can be controlled by using 260 mm long dump plates termed as blinkers in the space between two vertical beam group columns. ELETRACK program has been used to optimise the blinker dump length and to estimate the power loads on the electron dumps and the other beam line components. Use of such blinker dumps helps to reduce the power to the cryopumps to an acceptable limit of 5 kW per cryopump.

Inputs from the physics design of accelerator have formed inputs to the engineering design. After the CAD design, a alignment optimisation procedure is carried out where the PG apertures pre-offset and minimum EG and GG cooling parameters were the outputs. These cooling parameters were then used in the thermo-mechanical analysis of EG and GG strip models. Results of thermo-mechanical analysis of EG strip model are given in Figure B.2.2. The thermo-mechanical analysis is by using ANSYS has been carried out and the damage verification done with the rules of Structural Design Criteria for In-vessel Components (SDC-IC).

a) Ion source integration: With the basic model of ion source available, the integration of the source with DNB HV Bushing is being designed. The interfaces are electrical, hydraulic, gas feed and diagnostics. The primary activity in this front is to generate the layout of different connections between the ion source and the HV Bushing. Layout has be designed in such a manner so that it can accommodate RH tools for maintenance and remotely operated ion source movement requirements. A depiction of the pipes and electrical bus bar layouts is shown in figure B.2.3

a) Ion source support structure and movement mechanism: The DNB source needs horizontal and vertical movements to accommodate possible mechanical misalignment and magnetic field induced beam deflection so that the beam should not interfere with any beam facing surfaces of different BLCs and the Duct. The total required horizontal angular movement is -7mrad and linear movement is ~25mm. The required vertical angular tilting is >3mrad. Apart from that a fixed tilting angle (-15mrad) is also required to align the beam axis towards the tokamak plasma due to the height difference between ion source and the duct aperture through which beam enters into the tokamak. For these reasons the DNB source support system shall be equipped with a positioning system, able to correct the possible beam misalignment through remotely operated stepper motor based link and joint system. The movement mechanism of the ion source positioning system, attached to the support structure is conceptualized and static force analysis has been carried out. The estimated weight of the ion source and the accelerator is ~ 6350kg.

b) Electrostatic shield: it is used to ensure uniform potential contour between ion source at high voltage and electrically grounded vacuum vessel to avoid breakdowns during operation.

2 High Voltage Bushing (HV bushing): HV Bushing is the vacuum transition and link (electrical hydraulic & diagnostic) between the DNB ion source and the HV transmission line coming from the HV deck. Design is optimized in accordance with safety, remote handling and manufacturing point of view. Provisions for inter-space gas circulation and its pressure monitoring have been incorporated. Shaping of the electrostatic shields is carried out to maintain stress value within allowable limits. Overall design is validated by electrostatic and structural analysis. Compatibility is checked with the vacuum vessel and the HV Transmission line. Manufacturing processes of each parts and preliminary assembly sequence is identified. Discussion with the manufacturers for the fabrication of the of the critical components like ~1m diameter ceramic ring brazed with similar diameter kovar rings at two ends, individual kovar-ceramic feed-throughs to be fitted on

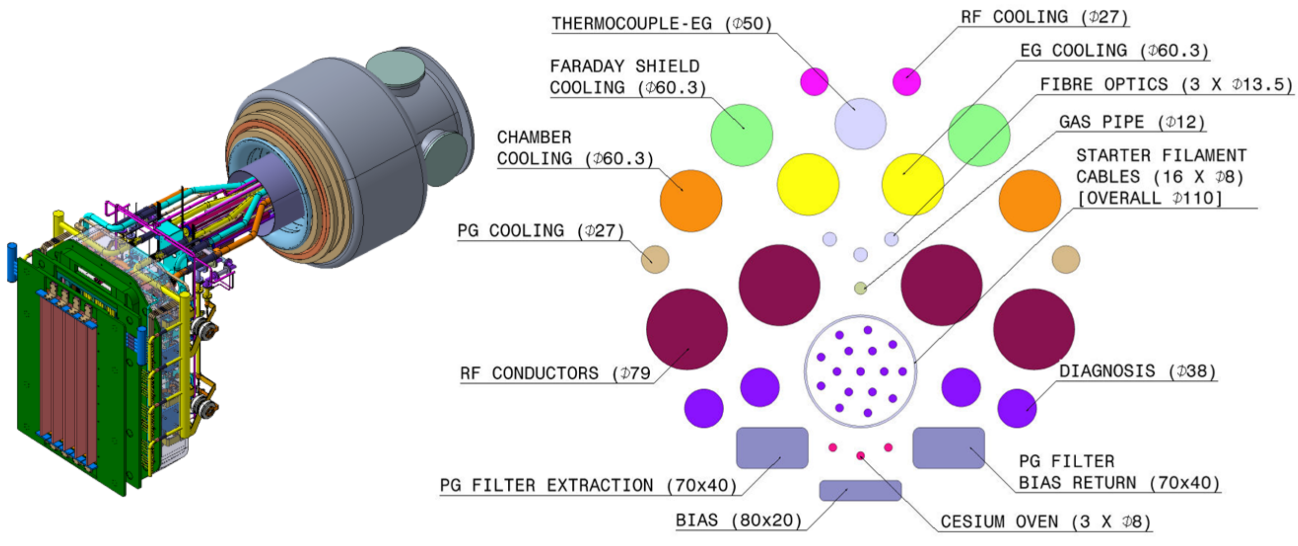
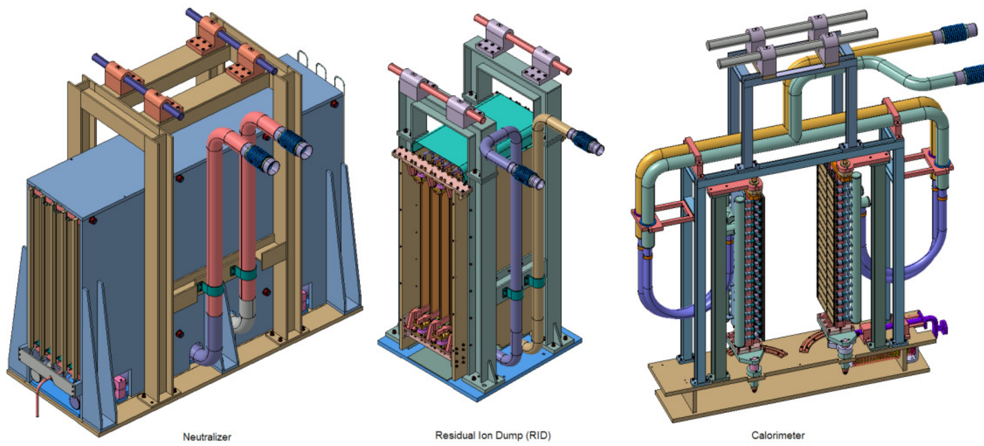


Figure B.2.3 Layout of electrical and Hydraulic lines connecting the ion source and the HV bushing

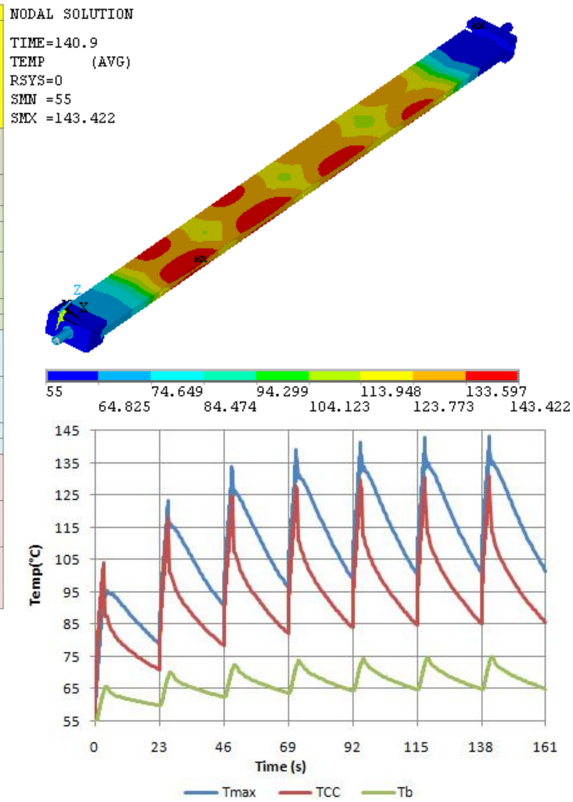


LEFT -Figure B.2.4 CAD models of Beamline components

BELOW Figure B.2.5 Thermal analysis of RID element and time evolution of surface temperature considering beam modulation.

Component	Heat loaded Component	Analysed case	Time to reach steady state (s)	Max. surface temp. (°C)	Imposed temp. Limit (°C)	Max inner wall heat flux (MW/m²)	Critical Heat Flux (MW/m²)	Von Mises Stress (MPa)	Def. - along Beam Axis (mm)	Free exp. Clearance (mm)	Def. – along Height (mm)	Free exp. Clearance (mm)	SDC IC validation
			Thermo mechanical Analysis										
Neutraliser	Front Panel	Normal Operation case	278.9	80 (average)	100	0.5	9.6	61 (Local)	0.75	2	1.43	3	Ok
	Rear Panel		278.9	89	100	0.0		73 (Local)	1.10	2	1.91	3	Ok
RID	Tube element	Normal Operation case	140.9	144	350		8.4	53	0.15	0.2	2.35	32	Ok
			163.9	109	350	0.9		56	0.11	0.2	1.65	32	Ok
		Loss of Neutralization	209.9	272	350	1.8		162			4.47	32	Ok
		LOCA1	232.9	481		0.8							Ok
		LOCA2	181.9	481		1.6							Ok
Calorimeter	Single HTE	Normal Operation case	25.9	280	350	7.6	22	297	0.5		0.14		Ok
		Loss of Deflection Voltage	25.9	390	350	9.5							Ok
		LOCA1	2.1	471	350	10.4							Ok
		LOCA2	1.8	478	350	8.5							Ok
Grids	Plasma Grid			155				4	0		0.4 (along width)		Ok
	Extractor Grid		25.9	85				53.4	0.8(out of plane)		0.38 (along width)		Ok
	Ground Grid		25.9	93				19	0.3 (out of plane)		0.38 (along width)		Ok

Table-B.2.2. Consolidated thermo-mechanical results for all the beam line components



dish head at the locations of each penetration is on-going.

3 Beamline components: After completion of the Physics design of the BLCs (reported last year), engineering design is carried out and manufacturing technologies have been established. Inputs from Indian industries are considered in this process. CAD models of each BLCs are generated during this phase, shown in figure B.2.4. The thermo-mechanical analysis of each models are carried out by using ANSYS and the damage verification is done with the rules of Structural Design Criteria for In-vessel Components (SDC-IC). Thermal result of one RID element is shown in figure B.2.5. Table-B.2.2 shows the consolidated thermo-mechanical results for all the beam line components. Manufacturing Process sheets and assembly sequence for each component is available for the next stage of vendor discussions.

4 Design of flexible bellows in DNB Systems: Flexible elements (Bellows, Braided hoses) are the components extensively used in all beamline components (BLCs), beam source and the drift duct of DNB to accommodate vibrations, misalignment etc. The design of the same to be as per the ITER specified codes and the application and selection are further subjected to the Vacuum guide lines of ITER. Unlike other components, the flexible components design is to be conducted hand in hand with manufacturer input. Generation of engineering design input was carried out for the design of coolant header bellows of BLCs & Calorimeter heat transfer elements (H.T.E) bellows and the same was provided to Witzenmann India Pvt Ltd. The design recommended by them was verified and integrated with the DNB Catia Model. Drift Duct Below is classified as the external (front end) components of DNB which absorbs the movements of main ITER vacuum vessel during various operating (Including accidental scenarios) scenarios and help to isolate DNB vessel and other front end components from such undue movements. It forms the part of ITER primary vacuum confinement as well as acts as a boundary for radioactive confinement. The design of the same was not available from ITER, except some representative geometry. The load specification of the Drift duct bellow was generated by conducting detailed studies of several ITER approved documents and preliminary design was carried out as per the ITER recommended EJMA code and the same was presented to ITER IO. In parallel the group has contacted Witzenmann India Pvt Limited for the engineering design of the same, and a Level 1 design was carried out by them based on the engineering input supplied by ITER India DNB Team. The design of the same is under optimization. F

5. Design for Remote Handling (RH) Compatibility: All DNB Components are to be maintained remotely (no human interface is allowed once D-T operation is begun) at some point of time during the life time of ITER. The frequency of maintenance is varied for different components. Hence the components are to be designed such that it should be handled by Remote Handling equipments. The design of the components for RH was not matured either at IO or DA end. Hence IO is realizing the same with the co operation of DAs. DNB group is carrying out the RH compatibility design together with Oxford Technologies Limited, U.K for the beam source components and all beam line components. ITER Remote Handling User Codes of Practice (IRHCOP) is extensively used for the design. The group has supplied necessary information to I.O for the preparation of documents necessary for establishing RH Compatibility procedures. A preliminary study of the integration of front end components (Fast shutter, Absolute Valve, Drift duct bellow) has been also carried out by the group to verify the space availability/ space reservation for remote handling of these components.

6. Activities related to Indian Test Facility (INTF):
Several concepts related to ion source and beam line component functionality and beam transport need to be tested in order to ensure a working DNB at ITER. These include plasma production in the 8 driver ion source having an extraction area of 2 m x 1m with a plasma uniformity of ~ 10%, the choice of a proper filter field, effects on the beam optics due to bending of the grids caused by power deposition of the trapped electrons, effectiveness of the aperture offset method for beamlet steering, role played by the field shaping plates in overcoming the beamlet deflections due to space charge, the effectiveness of the blinker dumps, the optimal gas pressure for the neutraliser, the behaviour of the RID in trapping the deflected ions and testing beam focussing obtained using a combination of geometrical aiming and shaping of the segments and aperture offset technuiques in the accelerator. In order to aid ITER in this venture an ITER Reviewed, Indian Test Facility (INTF) is planned at the ITER experimental building in IPR. The test facility shall be a replica of the DNB facility including the unique feature of studying the beam transmission over a transport length of 20.67 m. The facility shall consist of a vacuum vessel, a transport duct and a calorimeter at the end of the 20.67 m traversal path. The vacuum vessel shall house an 8 driver RF based ion source, the neutraliser, the residual ion dump, a calorimeter and cryopumps. The design of the components inside the vacuum vessel shall be similar to those for ITER. The experimental program on the facility has been divided into three phase with the first phase being dedicated to establishing the operational parameters of the source followed by a second phase related to the transport of the beam over the desired length. The third phase shall be dedicated to establishing the working of the beam line components. The conceptual layout of the facility and the floor loading requirement in the ITER experimental building has been worked out as shown in Figure 10. The diagnostic needs on the different components have been looked into. The shielding requirements in order to prevent large beam deflection over the 20.67 m transport length due to the earth's magnetic field have been established. The design of the vacuum vessel, the cryopumps, the calorimeter at the end of the transport length and the high voltage bushing for this facility is an ongoing activity. Interfaces with the various power supplies and the RF generators, gas feed systems, hydraulics and cryogenics are being looked into. The facility is expected to be assembled in the year 2013-2014 and operational in the first quarter of 2015.

WBS 5.5 ITER-India Diagnostics

Diagnostic items to be delivered to the ITER project by ITER-India consist of (a) Electron Cyclotron Emission (ECE) Diagnostics : Ex-cryostat transmission and receiver equipment and a set of Radiometers and a Michelson Interferometer (b) Beam emission Spectroscopy (BES): a set of ex-port-plug optical assemblies, spectrometers and 2-D array detectors (c) X-Ray Spectroscopy (XCS): A Survey Spectrometer to be mounted an Equatorial Port and one High Resolution Spectrometer, viewing the edge plasma, mounted at an Upper Port-plug along with 2D-array detectors and (d) Upper port-plug (UPP 09) : The Port-plug that would house the XCS (edge) spectrometer and other ITER specified equipment. A Design Work Order (DWO) from ITER Organization for Vibration and Thermal Hydraulic analysis of a generic design of Upper Port Plug was completed. Based on the results submitted, the scope of the DWO has been extended to perform Vibration Analysis for an updated design of the Port-Plug.

Modelling of the distortion due to welding operation to be expected during the fabrication of the Port-plug structure needed to be done. This was accomplished in collaboration with IIT-Khargpur. The distortion estimated for both Electron Beam welding and an alternative multi-pass welding process. These results were presented at the 17th meeting of the ITPA topical group on diagnostics, in Russia.

Another DWO for calculation of Neutron dose and spectrum in the Upper Port Plug was accepted and on the basis of calculations performed preliminary results were submitted to ITER. Calculations incorporating the changes in the port design is being continued. These results would be essential for the design of the High Resolution X-ray spectrometer at this port-plug.

A conceptual design of the XCS Survey spectrometer was developed. Through X-ray ray tracing an optical layout of the spectrometer was achieved, that locates the diffracting elements and the detector at the port-cell, protected from the n-γ radiations from the plasma, yet obtaining adequate signal levels. The ray tracing results have shown that with toroidaly bent crystals image can be measured with required resolution. A signal-to-noise analysis for the major impurities was carried out to evaluate spectrometer performance in ITER reference plasma scenarios. The simulated accuracy in line measurements mostly satisfy the baseline requirements of impurity concentration measurements. These results were presented at the 17th meeting of the ITPA topical of PSSI in India. Analysis using an ECE simulation code has been initiated to evaluate the X and O-mode emissivities for the reference scenario of ITER plasma and the effects of group on diagnostics, in Korea . The port-plug integrated 3-D CAD model of survey spectrometer is underway. The work on high-resolution spectrometer has been initiated.

A possible lay out for the ECE transmission lines using corrugated waveguide from the tokamak to the diagnostics area about 35 meters away (where the radiometers and the interferometer and other equipment are kept) was worked out. It appears that mitre bends would be the chief cause of attenuation during transmission. The transmission losses in corrugated waveguides and in the mitre bend is being studied theoretically and also through simulation. Preliminary results were reported at the 24th National Symposium harmonic overlapping and polarization mixing on the measurements. The reflection of light from the walls of the tokamak affecting the true light signals in all optical diagnostics, including BES is an important concern. A computer simulation code that had been developed to model this in ADITYA tokamak has been extended to evaluate the extent of reflection of Bremsstrahlung and Charge Exchange light into the detector channels meant for BES and CXRS diagnostics in ITER. Results obtained show that the spectral distortion may also need to be estimated by performing the calculations at different wavelengths.

A preliminary draft of the technical annexure that will form a part of ITER-India's Diagnostics Procurement Arrangement (PA) with ITER for all the above diagnostic equipment was prepared. Efforts are underway to collaborate with ITER for the development of conceptual design for the different diagnostics and the PA documents.

Activities of Fusion Physics and Information Technology group

In the last year we had reported activities in physics analysis and modeling of ITER disruption and vertical displacement events (VDEs) scenarios. VDEs and Major Disruptions (MDs) of the plasma current will induce large electromagnetic forces on the ITER machine. Estimation of these forces based on accurate modelling of these events is necessary for a robust ITER design. Originally the estimates for electromagnetic forces on ITER were carried out with the help of DINA simulations. However, since simulations of these events may be significantly influenced by model assumptions of a given code it was decided during the 2007 ITER design review to benchmark the DINA simulations against that using the TSC code. Thus the model comparisons for the ITER VDE and Disruption simulations were carried out as a voluntary task, the results of which were presented in the 2008 IAEA FEC. The TSC simulations even though largely showed similar plasma behaviour, had certain differences in the predictions for the plasma current quench times and halo current magnitudes. It has further been decided to update both the models after benchmarking them with experimental observations in existing tokamaks and use the updated codes to make more accurate predictions for ITER. Moreover, in the recent past, the design of the ITER vacuum vessel, the Central Solenoid (CS) and some of the PF coils as also other in-vessel components like blanket modules (BMs) incorporated certain necessary changes. These changes result in small but finite change of the electromagnetic parameters in ITER, which can potentially influence the plasma behaviour in a disrupting or VDE scenario. This has also necessitated in updating the TSC model of ITER with the new parameters and recalculation of the disruption and the VDE forces. The benchmarking and updating of the TSC code as also TSC modelling of the ITER VDE and Disruption scenarios are being carried out through three separate separate task agreements in collaboration between ITER-IO, ITER-India, Princeton Plasma Physics Laboratory (PPPL) and Japan Atomic Energy Agency (JAEA). The task agreement for ITER-India (C19TD27FI) is an in-cash task agreement worth 60 thousand Euros and is specifically for carrying out the VDE and disruption simulations for ITER with the updated TSC code. The first interim task report has been submitted to ITER and payment worth 20kEuro received for the same. The task is scheduled to be completed in October 2010.

Under the modelling activities on this task, a much more detailed model of ITER in the TSC code, than the one used during the earlier results presented in FEC 2008 has been created. In TSC the plasma equilibrium is computed on a rectangular computational domain and is evolved in time solving the time dependent coupled Maxwell equations, while the plasma temperature and density can be evolved either by solving the appropriate thermal and density transport equations or can be predefined as a function of time. The electromagnetic structures like the vacuum vessel or other conducting shells lying inside the computational domain are treated as toroidal 'wires', the currents through which are calculated self-consistently. For the structures like blanket modules which are toroidally discontinuous, a 'toroidal break resistance' can be defined by which the toroidal current can be constrained to zero. However, if these structures are defined in such a way that a continuous poloidal current path exists, then poloidal currents can flow through them. This is particularly useful in Disruption halo current modeling to allow poloidal halo currents in the plasma to flow through the structures when the plasma comes in contact with the first wall. In the new ITER model created in TSC, we have made both the inner and the outer vessel shells 'poloidally continuous' to allow poloidal currents to flow through them. Furthermore the blankets are modelled as a lumped set of 'wires' with toroidal breaks (zero net toroidal current), but having poloidally continuous current path from the blanket to the inner vessel shell. Thus, using this model, it possible to model poloidal halo currents to flow from the plasma to the blanket modules, then to the vessel and further back to another BM and finally back to the plasma. Using the data provided in, a detailed TSC model has been created.

In information technology sector, we have maintained the good quality of the network and the other IT infrastructure that were already reported earlier. We had zero unscheduled downtime of the network and the servers this year. The INDUS documentation server underwent significant up-gradation in the documentation configuration. Now the documentation system automatically assigns 7-digit alphanumeric random numbers to all documents uploaded in the system, which can then be used in search engine to track these documents. Several other changes in the features of the documentation system were also incorporated to make it more efficient.

Activities of the Project Office

1. Schedule activities of various packages are routinely updated using Primavera and integrated with ITER Organization (IO), thus IO updates Integrated Project Schedule (IPS) incorporating schedule inputs from all DAs & IO. This is being used for continuous tracking of the activities and taking corrective measures whenever negative variances are observed. Two training sessions were organised for Primavera 6.2 version to update schedule contact persons for each packages.

2. Work related to risk management started in coordination with IO to identify activities impacting the scope, cost and schedule of the project. This allows management to take mitigating actions in advance of work execution. Now at ITER-India Risk Register is being updated regularly for various packages including mitigation plans and its impacts are analyzed on the overall project.

3. To implement the change process, configuration management plan is being developed in line with IO and this helps in

tracking the changes and deviations.

4. Cost estimating templates are developed and process of cost estimates for various packages in progress.

Activities of ITER-India Design Office

Report for roles and the responsibilities of the Design office and flow chart for activities prepared as per the QA requirements. Interface reports of the major packages and support in design, analysis and drawing.

ITER-Data base replication: test run of successful ENOVIA Implementation and data replication at ITER-India site through 40Mbps collaborative network (CN). 53 DETs were exchanges between IO and DA and associated Technical support provided 5 Design collaboration implementation forms (DCIFs) have been signed with IO prior to signing of respective PA.

Meetings:
All CCB2 and TCM Meetings were attended on the behalf of ITER-India, and information affecting the packages was coordinated between IO and DA. CAD Users Meetings were organized to assess Design office resource.

Licenses:
Maintenance of CATIA, ANSYS and HYPERMESH licenses for ITER-India. Indent for leasing of two Equipment and system license (Full module of CATIA) and ENOVIA licenses procured. Block SIM and XFMEA licenses indented including the 4 laptops for running these licenses

Hardware: Server and WS management, procurement and installation of the 10 high end new workstations and plotter maintenance and management

Training:
31 staff including the IPR and FCIPT participated in the 10 days ANSYS Training arranged at ITER-India by Design office. Training held on E&S (CATIA Module) at ITER-India, prior to "CAD users training at CADARACHE".

ANSYS and CATIA Training for one week at ITER-India were arranged for TTP2009.

CODES for analysis and Standards for drawings were compiled and presentation by DO on the same to create awareness.

B.3. Center for Plasma Physics, Guwahati

B.3 Activities of Center for Plasma Physics, Guwahati

B.3.1. Thermo-Fluid MHD Modeling for Blanket Module

The above project was related to MHD and thermal modeling of LLCB-TBM. MHD and thermal analysis of the LLCB-TBM is performed by numerically solving the Navier-Stokes equation coupled with the continuity and induction equations over the cross section of a rectangular duct having transverse dimensions of the TBM to determine the pressure drop, fully developed axial velocity (u) and induced magnetic field (Bx). A control volume based iterative scheme and a Hartmann number sensitive non-uniform collocated grid is used in this study to evaluate the flow and electrical parameters for the LLCB-TBM both with and without insulation coatings. Results indicate that the application of a thin layer of Alumina as insulation to the inner portions of the LLCB channel decreases the MHD pressure drop for the current design substantially, by more than 230 times from its insulation- free value.

B.3.2. Shielding Calculations for Breeding Blankets Using Monte Carlo Code

Shielding efficiencies of various candidate-shielding materials was carried out under the above project by using Monte Carlo method. The materials considered include Eurofer, SS-316, Water, Different homogeneous mixtures of Eurofer and water (with different volume ratios), Different homogeneous mixtures of SS-316 and water (with different volume ratios), Tungsten Carbide (WC), Zirconium Hydride (ZrH_2), Titanium Hydride (TiH_2), and Boron Carbide (B_4C). A preliminary study of the shielding performance of IN DEMO (based upon LLCB blanket concept) was carried out. We used the neutronics reference model available at that time in IPR and modified the geometry to perform shielding calculations. Three different configurations of shield were studied: (1) 70% v/v Eurofer, 30% v/v Water, (2) a two component shield of Eurofer with a thickness of 15 cm followed by 5 cm shield of WC composite (tungsten carbide composed of 50% W and 50% C) cooled by 10% v/v Helium, and (3) a shield same as (2), except that this time the WC composite is cooled by 20% v/v Water. The results were compared and found that shield variant (3) is most efficient. A few variance reduction techniques for MCNP were studied during the period of this report. The techniques considered are (i) Geometry Splitting and Russian Roulette [IMP:N, IMP:P cards], (ii) Implicit Capture [PHYS:N, PHYS:P cards], (iii) Time and Energy Cut-off [CUT:N, CUT:P cards] and (iv)Weight Windows Generation [WWG cards].

B.3.3 Kinetic Vlasov simulation for heat flux and Particle transport in Scrape off Layers (SOL) region

To study the parallel transport in the Scrap Off Layer of tokamak we have developed a one dimensional Valsov code. Our code is based on time splitting and flux balance method. Vlasov code gives the direct evolution of distribution function. So we have the particle distribution function at different time and from which we have calculated the particle flux (first momentum) and heat flux (third momentum). We have assumed that the boundaries are absorbing, i.e., nothing is coming from boundaries. Physically a sheath boundary will maintain. The flux balance of electrons and ions verifies this. Next we are incorporating the secondary cold electrons emitting from the boundary (divertor) and entering into the plasma.

B.3.4 Development of a cascaded thermal plasma torch assisted system as a 1-10 MW/m2 level tailored heat source, to be used for high heat flux testing of a Test-Mock-Up.

Under this project a calorimeter has been designed and fabricated for measuring 2-D heat deposition profile. We have obtained maximum of 3.9 MW/m^2 heat load at 300 ampere current and 92 volt with 25 lpm of argon and 10 lpm of nitrogen. A pneumatically controlled pulsing system have been designed and installed for exposing the substrate with a controlled on and off time. A differential temperature detector system was designed and installed with a new circuit of AD590 temperature sensor. A steeper motor is used to change the positioned of the calorimeter with 1.25 mm resolution to measure the heat deposition on different places of the plasma jet. The plasma jet is thoroughly characterized in the entire range of plasma current and gas flow rate. The actual heat distribution of the plasma jet is computed by Abel inversion method from the measured heat load data. The Test-mockup is exposed to the plasma jet and we are trying to optimize the system for better yields of the experiment so that the temperature at the join of the surfaces increases to 400 ^{o}C. But due to the limitation of the existing power supply we are able to increase it up to 180 oC. The fatigue testing of the test mock up at low power level is going on by exposing it to the plasma beam for 100 cycles. We have successfully synthesis and characterized the nanoparticle of different ceramic materials like Titania, Titanium Nitride, Alumina with controllable size and phase having average size 10 nm to 40 nm.

B.3.5 To study the properties of a plasma having cesium (Cs) coated dust

The aim of the project was to coat Tungsten dust particles with Cesium and then to allow these dust grains to enter into the hydrogen plasma so that negative hydrogen ions could be produced in plasma volume using surface production mechanism. A dust dropper is designed to drop the dust particles into the plasma. The dust particles are dropped by agitating a mess sieve with the help of an electromagnet. A variable resistor controls the output frequency so that dust grains fall according to the required density. Effect of plasma parameters on dust charging is studied in low-pressure hydrogen plasma. The hydrogen plasma is produced by a hot cathode filament discharge method in a dusty plasma device. A full line cusped magnetic field is used to confine the plasma elements. To study the plasma parameters for various discharge conditions, a cylindrical Langmuir probe having 0.15 mm diameter and 10.0 mm length is used. An electronically controlled dust dropper is used to drop the dust particles into the plasma from the top of the vertical chamber. Tungsten powder is used as dust grains. The average size of particles is 3□m. The charge accumulated on the dust particles is calculated using the capacitance model. The dust current is measured by the combination of a Faraday cup and an electrometer.

B.3.6 Studies on plasma dynamics across magnetic filter field for negative ion source

Under this project the effect of transverse magnetic field (TMF) and the filament position on plasma parameters have been studied. Also the axial variations of plasma parameters with discharge parameters have been examined. A single fluid description of plasma is used to study the plasma dynamics across a magnetic filter. A one-dimensional numerical code is developed to solve the plasma transport equations. Spatial profiles of electron temperature and plasma density across a non-uniform magnetic filter field are obtained. The magnetic filter affects the spatial distribution of the plasma density, which decreases by an order of magnitude across the filter field. The electron cooling is observed as the electron temperature drops to 1-2 eV from 5 eV. The decrease in density and temperature depends on the magnitude of the magnetic flux.

B.3.7 Ion beam characterization and irradiation on material in plasma focus device

Under this project the temporal and spatial characteristics of the neon ion beam emissions from a plasma focus device (PF) have been studied by employing a multiple Faraday cup (FC) assembly and the CR-39 track detectors at different angular and axial positions. The characterization of the neon ion has been made for different operating gas pressures as well as angular and axial positions. The FC analysis show that the ion beam fluxes strongly depends upon the operating gas pressure as well as the angular positions. The ion beam fluxes are found to be highest at 250 angular position and 0.3 Torr operating pressure.

B.3.8 Development of Vacuum Photodiode

The absorption of photoelectrons emitted from the vacuum photodiode (VPD) in plasma focus (PF) detector is high as the pressure of the surrounding medium is higher (of the order of few torr). There are other factors such as absorption of low energy UV and ultra soft X-rays in the surrounding gas before reaching the detector from the source also have its role. We used large conical VPD and large cylindrical VPDs. The outer diameter of these two detectors was fixed according to port size of the PF chamber and the annular space between the cathode and anode as well as the diameter of the photocathode was determined according to 50-ohm impedance matching. We have been using a pinhole of few mm diameters in front of the VPD in order to restrict incoming charge particles from the pinch region of PF. We noticed that even though the diameter of the photo-cathode is large (3 cm) in large conical and cylindrical VPD, the exposed area of radiation at the photo-cathode is only of few mms of total diameter of the photo-cathode. Therefore we presumed that the use of large diameter photo-cathode would not help to improve the signal efficiency. Thus we examined the detection efficiency with cathodes of different diameters. However this observation could not produce any conclusive results of increasing the detection efficiency of VPD. Thus we checked for the other factors, which may be related to efficiency of the detector.

B.3.9 Duplex Plasma Processing Laboratory

The nitriding plasma is produced by applying a negative continuous pulsed voltage (500-700 V) to the cathode. The on and off time of the pulse can be varied by changing the duty factor from 20% to 80% while the discharge frequency can also be changed in the range 20-500 kHz. A K-type thermocouple, introduced into the cathode holder can measure the temperature attained by the stainless steel cathode due to plasma heating. Optical Emission Spectroscopic study is done by a CVI Laser Corporation make DK 480 0.5 meter monochromator and an AD 110 photo-multiplier detection unit. The grating design is Czerny-Turner, triple turret type, 68 mm x 68 mm in size with 480 mm focal length and 1200 grooves/mm. The radiation is carried out to the monochromator slit by lens, fiber and fiber-slit coupler. N2/H2/Ar flow is controlled by Digital Mass Flow controllers. We have been able to achieve cathode temperature up to 650 0C by optimizing pressure, discharge voltage and duty cycle to obtain a current density more than 1 mA/cm2. We have nitrided samples (SS304 and SS302) in different frequency conditions and have done Optical Emission Spectroscopy in the proper nitriding conditions. The XRD results have shown the presence of Fe2N3 and CrN and in SS304.

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C. ACADEMIC PROGRAMMES

C.1 DOCTORATE PROGRAMME

In the Ph.D. programme conducted by the institute twenty-three (23) research scholars have been enrolled at present. Out of them, eleven (11) are working in theoretical and simulation projects while nine (9) are engaged in experimental projects. Three (3) new students have joined this programme during the year and are going through the course work. After successful completion of this course work, they will be enrolled for their Ph.D. works.

Ph.D. THESIS SUBMITTED

Propagation of Relativistically Intense Electromagnetic Pulses in Plasmas
Vikrant Saxena
Gujarat University, Ahmedabad, 2009

High Power Ion Extraction and Acceleration System for SST Neutral Beam Injector
Mukti Ranjan Jana
Jadavpur University, Kolkata, 2009

Computational Studies of a Magnetized Target Fusion System
P.V. Subhash
Devi Ahilya Vishwa Vidyalaya, Indore, 2010

C.2 SUMMER SCHOOL PROGRAMME

Twenty-six (26) students participated in this programme, which aimed at providing an opportunity to M.Sc. students to interact actively with scientists of the institute and learn about Plasma Physics and related areas through a project and series of lectures.

Besides the above-mentioned training programme, project works are routinely offered in Computer, Electronics and Electrical Engineering for regular students as a part of their academic requirements.

D. TECHNICAL SERVICES

D.1 Engineering Services

D.1.1 Air conditioning and Water Cooling

The Water-cooling & Air conditioning group supplied chilled water with required conductivity, temperature, pressure & flow rate to SST Cryogenics plant and the various other experimental systems. The frequent regeneration of water treatment plants has been carried out to maintain the required conductivity of water. The Kitchen Basement Air conditioning System (KBAC) for Ground floor rooms, seminar Hall, Aditya Hall, Beta Lab and Library, which was 22 years old, is being replaced by energy efficient Screw Chillers Air Conditioning plant based on environment friendly refrigerant R-134a gas. The detailed engineering with Improved designs was made and a tender document was prepared for replacement of existing old air conditioning plant. The installation work of new plant consisting of 3 Nos. of 125 TR energy efficient York made Screw chillers is presently going on. The Air Handling Units are fitted with new 3-way diverting valves with DDC based temperature controllers. The entire plant will be monitored by Computerized BMS system.

The Section has carried out improvement in air-cooling in Helium Compressor Hall by installing Cellulose Pad Evaporating-cooling system in Fresh Air ventilation system of Helium Compressor hall. This has resulted ambient temperature of around 35 degree Celsius in peak summer conditions inside the Helium compressor hall. The lower ambient temperature is essential for the healthy operation of Cryogenic Compressors.

The Section has provided HDPE piping for the cooling water end connections to the high-pressure experimental system like NBI and LHCD system. This has resulted total rigid piping of cooling water unto the high voltage experimental system.

The packaged type new air conditioning systems for Negative NBI Lab and FCIPT Seminar hall were designed after considering heat loads of the building. Detailed engineering with relevant ducting design were carried out for these system. Installation works of those packaged Air Conditioning systems are going on.

Maintenance & overhauling of Motors of process pumps of cryogenic system, ECRH/ICRH system, Chilled water System and Cooling tower water system were carried out.

The maintenance of central AC plants, various package units, water coolers, split air conditioners and window air conditioners has been carried out in IPR, ITER-India, FCIPT and Hostel & Guest-house with the help of contractors.

D.1.2 Drafting Services

Drafting Section of the Institute is providing basic services in the preparation of 2D, 3D drawings, Graphs, carrying out measurements for preparation of as built drawings, conceptual design drawings for new upcoming systems. During the period the section provided the support in making drawings for the Multi-Cusp Plasma experiment chamber and its support, various systems of RF group. All the necessary drawings preparation for the start of the re-assembly of SST-1 which includes, vacuum vessel & cryostat, Magnets and Cryo-distribution lines was carried out. The following procurements were carried out in the drafting sections- (i) Two Workstations for CAD, (ii) Two Seats of Autodesk Inventor, and (iii) AutoDesk 3-D max software to enable the section to create the 3-D animations for the complex assemblies to verify the interfaces and interferences along with the assembly sequence.

D.1.3 Mechanical Workshop Services

Workshop provides the Basic services in mechanical manufacturing activities to the users in the Institute. The Institute workshop this year has undertaken many works related to Research scholars requirements. To enable them to complete their tasks, Workshop Handles job cards of Research Scholars always on priority basis. Among other major systems manufacturing of which was carried out during the period is Time of Flight Diagnostics System for Aditya Tokamak, Prototype of the Ionizer for the Multi-Cusp Cesium plasma experiment (which needed very precision machining figure D.1.3.1 (a) and (b)) . SST-1 Reassembly work is going on at the highest priority basis in the Institute among all the ongoing tasks. Workshop is providing its full support in its available resources for the manufacturing requirements. Among some of the jobs carried consist of Machining of G-10 spacers, Copper Sensor Holders, Welding of the Super-conducting Joints, Repairs of the baking channels. Other works involve the support to users in the outsourced systems for assembly of systems in their respective laboratories, technical support during factory testing and acceptance. Workshop has made arrangements to procure following machines in the workshop – (i) Miller Make 700 A Welding machine, (ii) All gear Precision lathes.

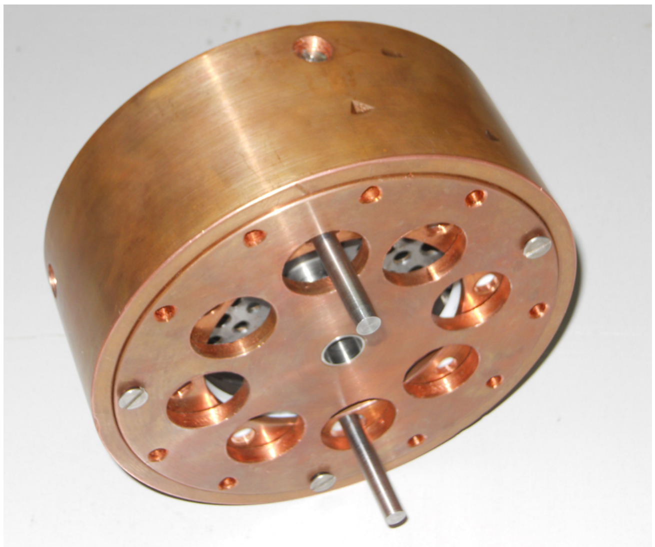

Figure D.1.2.1(a) Parts of the ionizer which were precision machined (b) Assembly of the same

D.1.4 Computer Services

Highlights of work done by the computer division in augmenting and strengthening the IT infrastructure of the institute : (i)Networking of new FCIPT building in Gandhinagar (ii) Extension of fibre network to the newly constructed Magnet lab; (iii)Re-organizing the networking of the Eastern segment of the main building; (iv) Replacing the backbone switches with latest high speed ones from Dlink; (v) Shifting of existing Ansys and Catia workstations and their administration, to the computer center; (vi) New networked Linux Computation Setup to replace the old Sun workstations; (vii) Installation of Untangled server for spam control; (viii) In-house Accounting software developed and being implemented, as per requirement of the Accounting section; (ix) Implementation of BARC provided In-house ID card generation hardware and software; (x)Payroll management, income tax, new pension scheme data management, Form-16 and PF computation; (xi) Procurement and installation of high end HP workstations for Ansys and Catia; (xii)Procurement of PCs and peripherals for the institute members and laboratories

D.2 Library Services

The hybrid IPR Library extends the breath of scholarly and cultural evidence to supports innovative research and lifelong learning. IPR library mediates between diverse and distributed information resources on the one hand and charging range of users communities on the other. It has networked online resources and services, side-by-side continuation of all traditional services. It has constantly improved techniques and technologies, expand infrastructure and acquired latest resources in print as well electronic media. IPR Library has also support and developed two divisional library of FCIPT library and ITER-India library.

Highlight of the services provided during the reporting period are as following :
This is one of the richest libraries in India in the field of Plasma Physics with the addition of 153 books, 661 bound volumes, 145 reprints, 132 reports, 133 CDs/DVDs, 21 pamphlets & Thesis the collection has reached to total 40,214 documents.

This has subscribed to total 105 journals 5 databases such as PROLA, Science Direct, SCOPUS, INIS database, IOP Archives and more than 5000 full text e-journals.

This Library issued total 5634 documents to its users and provided 1,44,471 photocopies.

This provides very efficient ILL services on request of users. During reporting period total 77% of demand were satisfied and 81 % of need satisfied from our library to other libraries.

Printed Current content of important Plasma Physics journals were provided to the 9 institutes and 15 Plasma Physicist through e-mail.

To strengthen the infra structure, library has procured new chairs for users, Laptop, Digital Camera & Colour Laser Printer. Also initiated to upgrade the present CDM Server to accommodate more e-resources and dissemination through LAN.

Orientation was given to all new comers, SSP Students, TTP Students & Research Scholars.

Physical Verification work was carried out without interrupting regular services and finished with in five working days.

Total budget of Rs.1,27,39,471/- for library, Rs.24438/- for Books grant and Rs.110,882/- for ITER India library.

Total 30 Research reports & 11 Technical reports made & sent to other libraries.

During the year, 1694 research reports were digitized and made available to users through LAN.

One of the biggest highlight here is we could found 59 + 9 FCIPT books during Physical Verification, which we declared as lost.

Current Awareness Service using Web 2.0 Tool

Started a Blog and CAS service using Web 2.0 tool by subscribing RSS feeds of core Plasma Physics Journals and Publication updates through SCOPUS

Continued to maintain and update Library Web Site on a regular basis to include new resources/information and links, removing old and dead links etc.

E. PUBLICATION AND PRESENTATION

E.1 RESEARCH REPORTS (Published in Scientific Journals and Proceedings)

Fast Imaging of Laser-blow-off Plume: Lateral Confinement in Ambient Environment
SONY GEORGE, AJAI KUMAR, R. K. SINGH, and V. P. N. NAMPOORI
Applied Physics Letters, 94, 141501, 2009

Physics of Non-diffusive Turbulent Transport of Momentum and the Origins of Spontaneous Rotation in Tokamaks
P.H. DIAMOND, C.J. MCDEVITT, O.D. GURCAN, T.S. HAHM, W. X. WANG, E.S. YOON, I. HOLOD, Z. LIN, V. NAULIN and R. SINGH
Nuclear Fusion, 49, 045002, 2009

Anomalous Energy Dissipation of Electron Current Pulses Propagating through an Inhomogeneous Collisionless Plasma Medium
SHARAD KUMAR YADAV, AMITA DAS, PREDHIMAN KAW, and SUDIP SENGUPTA
Physics of Plasmas, 16, 040701, 2009

Polarimetric Detection of Laser Induced Ultrashort Magnetic Pulses in Overdense Plasma
SUBHENDU KAHALY, S. MONDAL, G. RAVINDRA KUMAR, S. SENGUPTA,
A. DAS, and P. K. KAW
Physics of Plasmas, 16, 043114, 2009

Plasma Currents Induced by Resonant Magnetic Field Perturbations in Tokamaks
D. REISER and D. CHANDRA
Physics of Plasmas, 16, 042317, 2009

Molecular Dynamics Modeling of Chemical Erosion of Hydrocarbon Films
U. VON TOUSSAINT, P.N. MAYA, and C. HOPF
Journal of Nuclear Materials, 386-388, 353-355, 2009

Cyclic Heat Load Testing of Improved CFC/Cu Bonding for the W 7-X Divertor Targets
H. GREUNER, B. BOSWIRTH, J. BOSCARY, P. CHAUDHURI, J. SCHLOSSER, T. FRIEDRICH, A. PLANKENSTEINER, and R. TIVEY
Journal of Nuclear Materials, 386-388, 772-775, 2009

Structural Materials for Fusion Reactors
P. M. RAOLE, S. P. DESHPANDE and DEMO TEAM
Transactions of the Indian Institute of Metals, 62, 105-111, 2009

Signature of Fast H Atoms from Cathode Glow Region of a DC Discharge
P. BHARATHI, K. S. SURAJ, V. PRAHLAD, S. MUKHERJEE, and P. VASU
Physics of Plasmas, 16, 053504, 2009

Effect of the Curvature and the ß Parameter on the Nonlinear Dynamics of a Drift Tearing Magnetic Island
M. MURAGLIA, O. AGULLO, M. YAGI, S. BENKADDA, P. BEYER, X. GARBET, S.-I. ITOH, K. ITOH and A. SEN
Nuclear Fusion, 49, 055016, 2009

A Comprehensive Gyrokinetic Description of Global Electrostatic Microinstabilities in a Tokamak
J. CHOWDHURY, R. GANESH, S. BRUNNER, J. VACLAVIK, L. VILLARD, and P. ANGELINO
Physics of Plasmas, 16, 052507, 2009

Nonlocal Analysis of the Excitation of the Geodesic Acoustic Mode by Drift Waves
P. N. GUZDAR, R. G. KLEVA, N. CHAKRABARTI, V. NAULIN, J. J. RASMUSSEN, P. K. KAW, and R. SINGH
Physics of Plasmas, 16, 052514, 2009

Principal Physics Developments Evaluated in the ITER Design Review
R.J. HAWRYLUK, D.J. CAMPBELL, G. JANESCHITZ, P.R. THOMAS, R. ALBANESE, R. AMBROSINO, C. BACHMANN,L. BAYLOR, M. BECOULET, I. BENFATTO, J. BIALEK, A. BOOZER, A. BROOKS, R. BUDNY, T. CASPER, M. CAVINATO,J.-J. CORDIER, V. CHUYANOV, E. DOYLE, T. EVANS, G. FEDERICI, M. FENSTERMACHER, H. FUJIEDA, K. G'AL,A. GAROFALO, L. GARZOTTI, D. GATES, Y. GRIBOV, P. HEITZENROEDER, T.C. HENDER, N. HOLTKAMP, D. HUMPHREYS,I. HUTCHINSON, K. IOKI, J. JOHNER, G. JOHNSON, Y. KAMADA, A. KAVIN, C. KESSEL, R. KHAYRUTDINOV, G. KRAMER,A. KUKUSHKIN, K. LACKNER, I. LANDMAN, P. LANG, Y. LIANG, J. LINKE, B. LIPSCHULTZ, A. LOARTE, G.D. LOESSER,C. LOWRY, T. LUCE, V. LUKASH, S. MARUYAMA, M. MATTEI, J. MENARD, M. MEROLA, A. MINEEV, N. MITCHELL,E. NARDON, R. NAZIKIAN, B. NELSON, C. NEUMEYER, J.-K. PARK, R. PEARCE, R.A. PITTS, A. POLEVOI, A. PORTONE,M.

OKABAYASHI, P.H. REBUT, V. RICCARDO, J. ROTH, S. SABBAGH, G. SAIBENE, G. SANNAZZARO, M. SCHAFFER,M. SHIMADA, A. SEN, A. SIPS, C.H. SKINNER, P. SNYDER, R. STAMBAUGH, E. STRAIT, M. SUGIHARA, E. TSITRONE,J. URANO, M. VALOVIC, M. WADE, J. WESLEY, R. WHITE, D.G. WHYTE, S. WU, M. WYKES and L. ZAKHAROV
Nuclear Fusion, 49, 065012, 2009

Symmetry Breaking Effects of Toroidicity on Toroidal Momentum Transport
J. WEILAND, R. SINGH, H. NORDMAN, P. KAW, A.G. PEETERS and D. STRINZI
Nuclear Fusion, 49, 065033, 2009

Thermal–hydraulic and Thermo-structural Analysis of First Wall for Indian DEMO Blanket Module
PARITOSH CHAUDHURI, CHANDAN DANANI, VILAS CHAUDHARI, C. CHAKRAPANI, R. SRINIVASAN, I. SANDEEP,E. RAJENDRA KUMAR, S.P. DESHPANDE
Fusion Engineering and Design, 84, 573-577, 2009

Thermal Structural Analysis of SST-1 Vacuum Vessel and Cryostat Assembly using ANSYS
PROSENJIT SANTRA, VIJAY BEDAKIHALE, TATA RANGANATH
Fusion Engineering and Design, 84, 1708-1712, 2009

Progress in Design and Integration of the ITER Electron Cyclotron H&CD System
C. DARBOS, M. HENDERSON, F. ALBAJAR, T. BIGELOW, T. BONICELLI, R. CHAVAN, G.G. DENISOV, D. FASEL,R. HEIDINGER, J.P. HOGGE, N. KOBAYASHI, B. PIOSCZYK, S.L. RAO, D. RASMUSSEN, G. SAIBENE, K. SAKAMOTO,K. TAKAHASHI, M. THUMM
Fusion Engineering and Design, 84, 651-655, 2009

Beamline Optimization for 100keV Diagnostic Neutral Beam (DNB) Injector for ITER
M. BANDYOPADHYAY, M.J. SINGH, C. ROTTI, A. CHAKRABORTY, R. HEMSWORTH, B. SCHUNKE
IEEE Transactions on Plasma Science, 38, 242, 2010

ITER ICRF System: R & D Progress and Technical Choices
B. BEAUMONT, T. GASSMANN, F. KAZARIAN, P. LAMALLE, D. RASMUSSEN, A. MUKHERJEE, U. BARUAH, R. SARTORI
23rd IEEE/NPSS Symposium on Fusion Engineering, SOFE 2009; San Diego, 1 - 5 June 2009

Analysis of Residual Ion Dump (RID) of Diagnostic Neutral Beam (DNB) injector for ITER
C. ROTTI, K. ACHARYA, M. BANDYOPADHYAY, M. SINGH, A.K. CHAKRABORTY, B. SRUSTI, G.P. REDDY
23rd IEEE/NPSS Symposium on Fusion Engineering, SOFE 2009; San Diego, 1 - 5 June 2009

Partial Discharge in High Voltage Equipments-HV Cable
J. JAMES, S.V. KULKARNI, B.R. PAREKH
IEEE 9th International Conference on the Properties and Applications of Dielectric Materials, ICPADM 2009; Harbin; 19 - 23 July 2009

A Lower Hybrid Current Drive System for ITER
G.T. HOANG, A. BECOULET, J. JACQUINOT, J.F. ARTAUD, Y.S. BAE, B. BEAUMONT, J.H. BELO, G. BERGER-BY,JOAO P.S. BIZARRO, P. BONOLI, M.H. CHO, J. DECKER, L. DELPECH, A. EKEDAHL, J. GARCIA, G. GIRUZZI,M. GONICHE, C. GORMEZANO, D. GUILHEM, J. HILLAIRET, F. IMBEAUX, F. KAZARIAN, C. KESSEL, S.H. KIM,J.G. KWAK, J.H. JEONG, J.B. LISTER, X. LITAUDON, R. MAGNE, S. MILORA, F. MIRIZZI, W. NAMKUNG, J.M. NOTERDAEME, S.I. PARK, R. PARKER, Y. PEYSSON, D. RASMUSSEN, P.K. SHARMA, M. SCHNEIDER, E. SYNAKOWSKI, A. TANGA, A. TUCCILLO and Y.X. WAN
Nuclear Fusion, 49, 075001, 2009

Experimental Study of Neutron Emission Characteristics in a Compact Sub-Kilojoule Range Miniature Plasma Focus Device
RISHI VERMA, R S RAWAT, P LEE, M KRISHNAN, S V SPRINGHAM and T L TAN
Plasma Physics and Controlled Fusion, 51, 075008, 2009

Fully Differential Cross Section for Single Ionization of Helium by 1 Kev Electrons in the Eikonal Approximation
R. DEY, A.C. ROY
Nuclear Instruments and Methods in Physics Research Section B: Beam Interactions with Materials and Atoms, 267, 2357-2360, 2009

Diffuse Reflection Model and Noise Stabilization for Tangential Image Tomographic Reconstruction (TITR) Code
SANTANU BANERJEE and P. VASU
Nuclear Fusion, 49, 075032, 2009

Nonlinear Interaction of Electron Plasma Waves with Electron Acoustic Waves in Plasmas
NIKHIL CHAKRABARTI and SUDIP SENGUPTA
Physics of Plasmas, 16, 072311, 2009

Role of Natural Length and Time Scales on Shear Driven Two-Dimensional Electron Magnetohydrodynamic Instability
GURUDATT GAUR, SITA SUNDAR, SHARAD K. YADAV, AMITA DAS, PREDHIMAN KAW, and SARVESHWAR SHARMA
Physics of Plasmas, 16, 072310, 2009

Linearly Polarized Superluminal Electromagnetic Solitons in Cold Relativistic Plasmas
VIKRANT SAXENA, ABHIJIT SEN, and PREDHIMAN KAW
Physical Review E, 80, 016406, 2009

A Hierarchical Multi-Scale Method to Simulate Reactive–Diffusive Transport in Porous Media
A. RAI, M. WARRIER, R. SCHNEIDER
Computational Materials Science, 46, 469-478, 2009

Radiation Power Measurement on the ADITYA Tokamak
KUMUDNI TAHILIANI, RATNESHWAR JHA, M V GOPALKRISHANA, KALPESH DOSHI, VIPAL RATHOD, CHANDRESH HANSALIA and THE ADITYA TEAM
Plasma Physics & Controlled Fusion, 51, 085004, 2009

Importance of Collisions with the main Plasma Components for Impurity Anomalous Transport
S. MORADI, M.Z. TOKAR, R. SINGH and B. WEYSSOW
Nuclear Fusion, 49, 085007, 2009

Parametric Study of Expanding Plasma Plume Formed by Laser-Blow-Off of Thin Film using Triple Langmuir Probe
AJAI KUMAR, R. K. SINGH, JINTO THOMAS, and S. SUNIL
Journal of Applied Physics, 106, 043306, 2009

Short Wavelength Ion Temperature Gradient Mode and Coupling with Trapped Electrons
J. CHOWDHURY, R. GANESH, J. VACLAVIK, S. BRUNNER, L. VILLARD, and P. ANGELINO
Physics of Plasmas, 16, 082511, 2009

Nonlinear Dynamics of Magnetic Islands Imbedded in Small-Scale Turbulence
M. MURAGLIA, O. AGULLO, S. BENKADDA, X. GARBET, P. BEYER, and A. SEN
Physical Review Letters, 103, 145001, 2009

Emission Analysis of Expanding Laser Produced Lithium Plasma Plume in Presence of Ambient Gas
H.C. JOSHI, V. PRAHLAD, R.K. SINGH, and AJAI KUMAR
Physics Letters A, 373, 350-3353, 2009

Evidence of Anomalous Resistivity for Hot Electron Propagation through a Dense Fusion Core in Fast Ignition Experiments
T YABUUCHI, A DAS, G R KUMAR, H HABARA, P K KAW, R KODAMA, K MIMA, P A NORREYS, S SENGUPTA and K A TANAKA
New Journal of Physics, 11, 093031, 2009

Investigation of Gas Puff Induced Fluctuation Suppression in ADITYA Tokamak
R JHA, A SEN, P K KAW, P K ATREY, S B BHATT, N BISAI, K TAHILIANI, R L TANNA and THE ADITYA TEAM
Plasma Physics and Controlled Fusion, 51, 095010, 2009

Instability Analysis in Aditya Tokamak Discharges with the help of Soft X-ray
ASIM KUMAR CHATTOPADHYAY and ADITYA TEAM
Proceedings of the 14th International Congress on Plasma Physics (ICPP2008), September 8-12, 2008, Fukuoka, Japan
Journal of Plasma and Fusion Research SERIES, 8, 685-690, 2009

An Overview of the ITER Electron Cyclotron H&CD System
M. HENDERSON, F. ALBAJAR, S. ALBERTI, U. BARUAH, T. BIGELOW, B. BECKET, R. BERTIZZOLO, T. BONICELLI,A. BRUSCHI, J. CAUGHMAN, R. CHAVAN, S. CIRANT, A. COLLAZOS, C. DARBOS, M. DE BAAR, G. DENISOV, D. FARINA,F. GANDINI, T. GASSMAN, T.P. GOODMAN, R. HEIDINGER, J.P. HOGGE, O. JEAN, K. KAJIWARA, W. KASPAREK,A. KASUGAI, S. KERN, N. KOBAYASHI, J.D. LANDIS, A. MORO, C. NAZARE, J. ODA, I. PAGANAKIS, P. PLATANIA,B. PLAUM, E. POLI, L. PORTE, B. PIOSCZYK, G. RAMPONI, S.L. RAO, D. RASMUSSEN, D. RONDEN, G. SAIBENE,K. SAKAMOTO, F. SANCHEZ, T. SCHERER, M. SHAPIRO, C. SOZZI, P. SPAEH, D. STRAUS, O. SAUTER, K. TAKAHASHI,A. TANGA, R. TEMKIN, M. THUMM, M.Q. TRAN, H. ZOHM, C. ZUCCA
34th International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz 2009, Busan, 21 - 25 September 2009

Paul Trap for Pure Positron Plasma - A Prelude to Electron-Positron Plasma in a Laboratory
M. BAJPAI, L.T. LACHHVANI, Y.C. SAXENA
15th International Conference on Positron Annihilation, ICPA-15; Kolkata; 18 - 23 January 2009
Physica Status Solidi (C), 6, 2456-2458, 2009

Boron Spectral Line Ratios Helpful to Characterize Wall Conditioned Tokamak Plasmas
BISHU AGARWAL, RAM PRAKASH, JALAJ JAIN, VINAY KUMAR and P VASU
Physica Scripta, 80, 055505, 2009

ETG Turbulence Effects on the Evolution of an NTM
A. SEN, R. SINGH, D. CHANDRA, P. KAW and D. RAJU
Nuclear Fusion, 49, 115012, 2009

ECRH System for ITER
C. DARBOS, M. HENDERSON, F. ALBAJAR, T. BIGELOW, T. BOMCELLI, R. CHAVAN, G. DENISOV, D. FARINA,F. GANDINI, R. HEIDINGER, T. GOODMAN, J. P. HOGGE, K. KAJIWARA, A. KASUGAI, S. KERN, N. KOBAYASHI, Y. ODA, G. RAMPONI, S. L. RAO, D. RASMUSSEN, T. RZESNICKI, G. SAIBENE, K. SAKAMOTO, O. SAUTER, T. SCHERER, D. STRAUSS, K. TAKAHASHI, and H. ZOHMK
Proceedings of the 18th Topical Conference on Radio Frequency Power in Plasmas; AIP Conference Proceedings, 187, 531-538, 2009

Effect of External Drive on Strongly Coupled Yukawa Systems: A Nonequilibrium Molecular Dynamics Study
ASHWIN J. and R. GANESH
Physical Review E, 80, 056408, 2009

Lunar and Planetary Science Conference
DEEPAK DHINGRA and RAJANI DEEPAK DHINGRA
Current Science, 97, 1403-1404, 2009

Low-frequency Fluctuations in a Pure Toroidal Magnetized Plasma
P.K. SHARMA, R. SINGH, D. BORA
Pramana - Journal of Physics, 73, 1073-1086, 2009

Realization of Enhancement in Time Averaged Neutron Yield by using Repetitive Miniature Plasma Focus Device as Pulsed Neutron Source
RISHI VERMA, R S RAWAT, P LEE, S V SPRINGHAM, T L TAN AND M KRISHNAN
Journal of Physics D: Applied Physics, 42, 235203, 2009

Molecular Dynamics Simulations of Synergistic Erosion of Amorphous Hydrocarbon Films
U VON TOUSSAINT, P N MAYA, C HOPF and M SCHLUTER
Physica Scripta, 138, 014018, 009

Design of an Ion Extractor System for a Prototype Ion Source Experiment for SST-1 Neutral Beam Injector
M.R. JANA, M. BANDYOPADHAYA, N.P. SINGH, S.K. SHARMA, A.K. CHAKRABORTY, U.K. BARUAH and S.K. MATTOO
Fusion Engineering and Design, 85, 122-125, 2010

Physics Design of a 100 keV Acceleration Grid System for the Diagnostic Neutral Beam for International Tokamak Experimental Reactor
M. J. SINGH and H. P. L. DE ESCH
Review of Scientific Instruments, 81, 013305, 2010

Radial Characterization of Wave Magnetic Field Components during Helicon Discharge in a Small Aspect Ratio Torus
MANASH KUMAR PAUL and DHIRAJ BORA
Journal of Plasma Physics, 76, 39-48, 2010

Electron Velocity Shear Driven Instability in Relativistic Regime
SITA SUNDAR and AMITA DAS
Physics of Plasmas, 17, 022101, 2010

Miniature Plasma Focus as a Novel Device for Synthesis of Soft Magnetic FeCo Thin Films
Z.Y. PAN, R.S. RAWAT, R. VERMA, J.J. LIN, H. YAN, R.V. RAMANUJAN, P. LEE, S.V. SPRINGHAM, T.L. TAN
Physics Letters A, 374, 1043-1048, 2010

Analysis of Axial Neutron Emission Pulse from a Plasma Focus Device
T.K. BORTHAKUR, A. SHYAM
Indian Journal of Pure and Applied Physics, 48, 100-103, 2010

Stress, Texture and Phase Transformation in Titanium Thin Films
JAY CHAKRABORTY, KISHOR KUMAR, R. RANJAN, SANDIP GHOSH CHOWDHURY, S.R. SINGH
Diffusion and Defect Data Pt.B: Solid State Phenomena, 160, 109-116, 2010

Diagnostic neutral beam for iter-concept to engineering
A. CHAKRABORTY, C. ROTTI, M. BANDYOPADHYAY, M.J. SINGH, R. GANGADHARAN NAIR, S. SHAH,U.K. BARUAH, R.S. HEMSWORTH, B. SCHUNKE
IEEE Transactions on Plasma Science, 38, 248-253, 2010

Effect of magnetic field on the expansion dynamics of laser-blow-off generated plasma plume: Role of atomic processes
A. KUMAR, R.K. SINGH, V. PRAHLAD, H.C. JOSHI
Laser and Particle Beams, 28, 21-127, 2010

Effect of Ambient Gas on the Expansion Dynamics of Plasma Plume Formed by Laser Blow Off of Thin Film
SONY GEORGE, AJAI KUMAR, R.K. SINGH, and V.P.N. NAMPOORI
Applied Physics A: Materials Science & Processing, 98, 901-908, 2010

Kondo Scaling of the Pseudogap in CeOs4Sb12 and CeFe4P12
P A RAYJADA, A CHAINANI, M MATSUNAMI, M TAGUCHI, S TSUDA, T YOKOYA, S SHIN, H SUGAWARA and H SATO
Journal of Physics: Condensed Matter, 22, 095502, 2010

Nonlinear Wave Propagation in Strongly Coupled Dusty Plasmas
B. M. VEERESHA, S. K. TIWARI, A. SEN, P. K. KAW, and A. DAS
Physical Review E, 81, 036407, 2010

A Reconfigurable Plasma Antenna
RAJNEESH KUMAR and DHIRAJ BORA
Journal of Applied Physics, 107, 053303, 2010

Surfactant-Assisted Synthesis of Cd1-xCoxS Nanocluster Alloys and their Structural, Optical and Magnetic Properties
R. SATHYAMOORTHY, P. SUDHAGAR, A. BALERNA, C. BALASUBRAMANIAN, S. BELLUCCI, A.I. POPOV, K. ASOKAN
Journal of Alloys and Compounds, 493, 240-245, 2010

Development of CCD Controller for Scientific Application
M S KHAN, F M PATHAN, U V SHAH, D H MAKWANA and B G ANANDARAO
Journal of Physics: Conference Series, 208, 012002, 2010

Development of Cast Resin Multisecondary 1600kVA Transformer for Regulated High Voltage Power Supply- A Prototype
V TRIPATHI, N P SINGH, L N GUPTA, KAPIL OZA, PARESH PATEL and U K BARUAH
Journal of Physics: Conference Series, 208, 12005, 2010

CAMAC Based Test Signal Generator Using Re-configurable Device
A. Sharma, T. Raval, A.K. Srivastava, D. Chenna Reddy
Journal of Physics: Conference Series, 208, 012006, 2010

Performance Test Results of Ion Beam Transport for SST-1 Neutral Beam Injector
M. R. JANA, S K MATTOO and R UHLEMANN
Journal of Physics: Conference Series, 208, 012008, 2010

Operational Experience of SST1 NBI Control System with Prototype Ion Source
V B PATEL, P J PATEL, N P SINGH, G B PATEL, RAJA ONALI, V TRIPATHI, D THAKKAR, L N GUPTA, V PRAHLAD,S K SHARMA, M BANDYOPADYAY, A K CHAKRABORTY, U K BARUAH and S K MATTOO (NBI TEAM)
Journal of Physics: Conference Series, 208, 012009, 2010

Mesh Sensitivity Study and Optimization of Fixed Support for ITER Torus and Cryostat Cryoline
S BADGUJAR, H VAGHELA, N SHAH, R BHATTACHARYA and B SARKAR
Journal of Physics: Conference Series, 208, 012010, 2010

Philosophy of Stress-strain Measurement for Proto-type Cryo-line of ITER
R BHATTACHARYA, H VAGHELA, N SHAH, S BADGUJAR and B SARKAR
Journal of Physics: Conference Series, 208, 012011, 2010

Design Aspects of 13.56MHz, 1kW, CW-RF Oscillator for Plasma Production
SUNIL KUMAR, BHAVESH KADIA, RAJ SINGH, ATUL VARIA, Y S S SRINIVAS and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012012, 2010

Design and Development of 1 KW Solid State RF Amplifier
GAYATRI ASHOK, BHAVESH KADIA, PRAGYA JAIN and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012013, 2010

Generation of Multiple Analog Pulses with Different Duty Cycles within VME Control System for ICRH Aditya System
RAMESH JOSHI, MANOJ SINGH, H M JADAV, KISHOR MISRA and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012014, 2010

Automatic Impedance Matching Network for ICRH-RF Experiments on SST-1
R JOSHI, M SINGH, H M JADAV, D PUROHIT, SIJU GEORGE, K RAJNISH, RAJ SINGH and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012015, 2010

60kV, 10Amp DC Power Supply Multiple Input Control and Monitoring Provision for the Operation of Various High Power RF GenerationSystems
KIRIT M PARMAR, Y S S SRINIVAS and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012016, 2010

Conditioning Technique for High Power RF Vacuum Transmission Line Components using Multipactor Plasma
KISHORE MISHRA, D RATHI, SIJU GEORGE, ATUL VARIA, M PARIHAR, H M JADAV, Y S S SRINIVAS, RAJ SINGH, SUNIL KUMAR and S V KULKARNI
Journal of Physics: Conference Series, 208, 012017, 2010

Liquid Phase Shifter for ICRH for Long Pulse Operation at SST-1
RAJ SINGH, SUNIL DANI and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012018, 2010

Conceptual Design of Automation of ICRH Vacuum System on Aditya Tokamak
DHARMENDRA RATHI, KISHORE MISHRA, RAMESH JOSHI, H M JADAV and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012019, 2010

Development of Pre Pre-driver Amplifier Stage for Generator of SST-1 ICRH System
SUNIL KUMAR, AZAD SINH MAKWANA, Y S S SRINIVAS and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012020, 2010

Design and Fabrication of a High Tc BSCCO Based Square Helmholtz Coil
NAYAK PRAMODA K, PRASAD U, AMARDAS A, PATEL D and PRADHAN S
Journal of Physics: Conference Series, 208, 012021, 2010

CAMAC Based 4-channel 12-bit Digitizer
A.K. Srivastava, A. Sharma, T. Raval, D. Chenna Reddy
Journal of Physics: Conference Series, 208, 012022, 2010

Design of Telescopic Stub Tuner of 1 5/8'' Transmission Line
ATUL VARIA, RAJ SINGH and S V KULKARNI (RF GROUP)
Journal of Physics: Conference Series, 208, 012023, 2010

Development of Multi-Channel High Power Rectangular RF Window for LHCD System Employing High Temperature Vacuum BrazingTechnique
P K SHARMA, K K AMBULKAR, P R PARMAR, C G VIRANI, A L THAKUR, L M JOSHI AND S C NANGRU
Journal of Physics: Conference Series, 208, 012024, 2010

Measurement of LHCD Antenna Position in Aditya Tokamak
K K AMBULKAR, P K SHARMA, C G VIRANI, P R PARMAR, A L THAKUR and S V KULKARNI
Journal of Physics: Conference Series, 208, 012025, 2010

Ramp Generator Circuit for Probe Diagnostics Using Microcontroller for LHCD System
C G VIRANI and P K SHARMA (LHCD GROUP)
Journal of Physics: Conference Series, 208, 012026, 2010

Up Gradation of LHCD System for RF Power Level up to 2MW for SST1
P K SHARMA, K K AMBULKAR, P R PARMAR, C G VIRANI, A L THAKUR and S V KULKARNI (LHCD GROUP)
Journal of Physics: Conference Series, 208, 012027, 2010

Finite Element Analysis of CICC Joints in SST-1
A AMARDAS and S PRADHAN
Journal of Physics: Conference Series, 208, 012028, 2010

Experimental Determination of Radial Spread of Residual Fast Electrons in a Hot Filament Toroidal Magnetized Plasma Discharge
T S GOUD, R GANESH, K SATHYANARAYANA, D RAJU, K K MOHANDAS, C CHAVDA, ARUNA M THAKAR and N C PATEL
Journal of Physics: Conference Series, 208, 012029, 2010

Power Supply System for Negative Ion Source at IPR
Agrajit Gahlaut, Jashwant Sonara, K G Parmar, Jignesh Soni, M Bandyopadhyay, Mahendrajit Singh, Gourab Bansal, Kaushal Pandya and Arun Chakraborty
Journal of Physics: Conference Series, 208, 012030, 2010

Development of 70kV, 22A DC Power Supply for High Power RF and Microwave Tubes
Y S S SRINIVAS, RAJAN BABU, AZAD MAKWANA, KIRIT PARMAR and S V KULKARNI (RF GROUP)
Journal of Physics: Conference Series, 208, 012031, 2010

Design of Multi Limb Phase Shifter
SUNIL DANI, RAJ SINGH and S V KULKARNI (ICRH-RF GROUP)
Journal of Physics: Conference Series, 208, 012032, 2010

Influence of Surface Produced Negative Ions on Sheath Structure
SEJAL SHAH and M BANDYOPADHYAY
Journal of Physics: Conference Series, 208, 012045, 2010

Sluggish Response of Untrapped Electrons and Global Electrostatic Micro-Instabilities in a Tokamak
J CHOWDHURY, R GANESH, P ANGELINO, J VACLAVIK, L VILLARD and S BRUNNER
Journal of Physics: Conference Series, 208, 012058, 2010

System Integration of RF Based Negative Ion Experimental Facility at IPR
G BANSAL, M BANDYOPADHYAY, M J SINGH, A GAHLAUT, J SONI, K PANDYA, K G PARMAR, J SONARA and A CHAKRABORTY
Journal of Physics: Conference Series, 208, 012060, 2010

Development of Circuit Model for Arcing on Solar Panels
BHOOMI K MEHTA, S P DESHPANDE, S MUKHERJEE, S B GUPTA,
M RANJAN, R RANE, N VAGHELA, V ACHARYA, M SUDHAKAR, M SANKARAN and E P SURESH
Journal of Physics: Conference Series, 208, 012074, 2010

Surface Free Energy Analysis for Bipolar Pulsed Argon Plasma Treated Polymer Films

S. PELAGADE, N. L. SINGH, SEJAL SHAH, A. QURESHI, R. S. RANE, S. MUKHERJEE, U. P. DESHPANDE, V. GANESHAN, T. SHRIPATHI
Journal of Physics: Conference Series, 208, 012107, 2010

Surface Modification of Polycarbonate by Plasma Treatment
A. QURESHI, S. SHAH, S. PELAGADE, N.L. SINGH, S. MUKHERJEE, A. TRIPATHI, U. P. DESHPANDE, T. SHRIPATHI
Journal of Physics: Conference Series, 208, 012108, 2010

Abel Inversion of Asymmetric Plasma Density Profile at Aditya Tokamak
N Y JOSHI, P K ATREY and S K PATHAK
Journal of Physics: Conference Series, 208, 012129, 2010

Development of Calibration Set-up for ECE Radiometer Systems at Institute for Plasma Research
N Y JOSHI, H B PANDYA, VARSHA SIJU, P K ATREY and S K PATHAK
Journal of Physics: Conference Series, 208, 012130, 2010

Designing of Electrode for High Energy Charged Particle Acceleration
BASANTA KUMAR DAS and A SHYAM
Journal of Physics: Conference Series, 208, 012136, 2010

Laser Welding of Dissimilar Metals
B. VIJAY, J. SNEHAL, B. PRABAL, M. HALASWAMY
Welding in the World, 53, 347-349, 2009

Analytical Description of Poloidally Diverted Tokamak Equilibrium with Linear Stream Functions
R SRINIVASAN, L L LAO and M S CHU
Plasma Physics and Controlled Fusion, 52, 035007, 2010

Characterization of Neon Ion Beam Emitted from Plasma Focus Device
M. BHUYAN, N. K. NEOG, S. R. MOHANTY, C.V.S. RAO, P. M. RAOLE
Journal of Physics: Conference Series, 208, 012126, 2010

Studies on Plasma Profiles and its Effect on Dust Charging in Hydrogen Plasma
B. KAKATI, S. S. KAUSIK, B. K. SAIKIA AND M. BANDYOPADHYAY
Journal of Physics: Conference Series, 208, 012139, 2010

EUV Diagnostics of Pulsed Plasma Systems
S. R. MOHANTY AND E. HOTTA
Journal of Physics: Conference Series, 208, 012138, 2010

Self-Organized Transformation to Polyaniline Nanowires by Pulsed Energetic Electron Irradiation in a Plasma Focus Device
S. R. MOHANTY, N. K. NEOG, R. S. RAWAT, P. LEE, B. B. NAYAK AND B. S. ACHARAY
Physics Letters A, 373, 1962, 2009

Study of a Supersonic Thermal Plasma Expansion Process for Synthesis of Nanostructured TiO2.
M. KAKATI, B. BORA, U. DESHPANDE, D.M. PHASE,V. SATHE, N.P. LALLA, T.SHRIPATHI, S. SARMA, N.K. JOSHI AND A.K. DAS
Thin Solid Films 518, 84, 2009

Development of a Potential Based Code for MHD Analysis of LLCB TBM
P. J. BHUYAN AND K. S. GOSWAMI
Fusion Engineering and Design, 85, 138, 2010

Characteristic and Temperature Measurement of a Non-transferred Cascaded DC Plasma Torch
B BORA, N. AOMOA, M. KAKATI
Plasma Science and Technology, 12, 181, 2010

Split and Segmented-Type Helical Coils for the Heliotron Fusion Energy Reactor
NAGATO YANAGI, KIYOHIKO NISHIMURA, GOURAB BANSAL, AKIO SAGARA AND OSAMU MOTOJIMA
Plasma and Fusion Research, Volume 5, S1026, 2010

Progress on the Heating and Current Drive Systems for ITER
J. JACQUINOT, F. ALBAJAR, B. BEAUMONT, A. BECOULET, T. BONICELLI, D. BORA, D. CAMPBELL, A. CHAKRABORTY, C. DARBOS, H. DECAMPS, G. DENISOV, R. GOULDING, J. GRACEFFA, T. GASSMANN, R. HEMSWORTH, M. HENDERSON, G.T. HOANG, T. INOUE, N. KOBAYASHI, P.U. LAMALLE, A. MUKHERJEE, M. NIGHTINGALE, D. RASMUSSEN, S.L. RAO, G. SAIBENE, K. SAKAMOTO, R. SARTORI, B. SCHUNKE, P. SONATO, D. SWAIN, K. TAKAHASHI, M. TANAKA, A. TANGA and K. WATANABE
Fusion Engineering and Design, 84, 125-130, 2009
Proceeding of the 25th Symposium on Fusion Technology - (SOFT-25)

ITER Vacuum Vessel: Design Review and Start of Procurement Process
K. IOKI, C. BACHMANN, P. CHAPPUIS, J.-J. CORDIER, B. GIRAUD, Y. GRIBOV, L. JONES, C. JUN, B.C. KIM, E. KUZMIN, H. PATHAK, P. READMAN, M. SUGIHARA, YU. UTIN, X. WANG and S. WU
Fusion Engineering and Design, Volume 84, 229-235, 2009
Proceeding of the 25th Symposium on Fusion Technology - (SOFT-25)

Status of the ITER IC H&CD System
P. U. LAMALLE, B. BEAUMONT, T. GASSMANN, F. KAZARIAN, B. ARAMBHADIYA, D. BORA, J. JACQUINOT, R. MITTEAU, F. C. SCHÜLLER, A. TANGA, U. BARUAH, A. BHARDWAJ, R. KUMAR, A. MUKHERJEE, N. P. SINGH, R. SINGH, R. GOULDING, D. RASMUSSEN, D. SWAIN, G. AGARICI, R. SARTORI, A. BORTHWICK, A. DAVIS, J. FANTHOME, C. HAMLYN-HARRIS, A. D. HANCOCK, A. KAYE, D. LOCKLEY, M. NIGHTINGALE, P. DUMORTIER, F. DURODIÉ, D. GRINE, R. KOCH, F. LOUCHE, A. LYSSOIVAN, A. MESSIAEN, P. TAMAIN, M. VERVIER, R. R. WEYNANTS, R. MAGGIORA, D. MILANESIO, F. BRAUN, J.-M. NOTERDAEME, K. VULLIEZ
Proceedings of the 18th Topical Conference on Radio Frequency Power in Plasmas, AIP Conference Proceedings, 1187, 265-268, 2009

Genetic Programming Based Approach for Synchronization with Parameter Mismatches in EEG
D.P. AHALPARA, S. ARORA, M. S. SANTHANAM
Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics) 5481 LNCS, 3-24, 2009 (Book Chapter)

Amplitude Death, Synchrony, and Chimera States in Delay Coupled Limit Cycle Oscillators
A. SEN, R. DODLA, G.L. JOHNSTON, G.C.SETHIA
Understanding Complex Systems, 2010, 1-43, 2010 (Book Chapter)

Intermittency like Phenomena in Plasma Turbulence.
Amita Das, Predhiman Kaw and R. Jha
Relaxation dynamics in Laboratory and Astrophysical Plasmas, Biennial Reviews of the theory of Magnetized Plasmas, Volume 1, Edited by P. H. diamond, Xavier Garbet, Philippe Ghendrih and Yanick Sarazin, World Scientific, p. 151, 2010 (Book Chapter)

Surface Engineering with low pressure plasmas
S. Mukherjee
Surface Engineering, Edited by D.S. Rao and S.V. Joshi
Daya Publishers, Delhi, 2010. ISBN: 978-81-7035-628-8 (Book Chapter)

E 2. TECHNICAL REPORTS

Installation and Testing of a Jc Measurement Facility for Superconducting Strands with a 12T Superconducting Background Field Solenoid at IPR
UPENDRA PRASAD, A.N.SHARMA, D.PATEL, J.PARMAR, S.KEDIA, PANKAJ VARMORA , J.C PATEL, A.M. BAPAT and S.PRADHAN
IPR/TR-152/2009 (APRIL, 2009)

Design, Development and Testing of Electromagnet Yoke Assembly for Fast Ferrite Tuner for Antenna Plasma Matching in ICRH Experiments on SST-1 Tokamak
R.A. YOGI, Y.S.S. SRINIVAS, D. RATHI, S. DANI, S.V. KULKARNI, D.BORA and ICRH-RF GROUP
IPR/TR-153/2009 (APRIL, 2009)

Generation of Multiple Analog Pulses with Different Duty Cycles within VME Control System for ICRH Aditya System
RAMESH JOSHI, MANOJ SINGH, H. M. JADAV, KISHOR MISRA, S. V. KULKARNI & ICRH-RF GROUP
IPR/TR-154/2009 (JULY, 2009)

Development of PLC based System for Monitor and Control of Power Supplies of 2-200 kW RF Amplifier Stages
H. M. JADAV, MANOJ PARIHAR, RAMESH JOSHI, KIRIT PARMAR, S.V. KULKARNI & ICRH-RF GROUP
IPR/TR-155/2009 (JULY, 2009)

Nondestructive Test of Brazed Cooling Tubes of Prototype Bolometer Camera Housing using Active Infrared Thermography
KUMUDNI TAHILIANI, SANTOSH PANDYA, SHWETANG PANDYA, R. JHA and J. GOVINDARAJAN
IPR/TR-156/2009 (SEPTEMBER, 2009)

SST-1 Information Management System (SIMS)
MANISHA BHANDARKAR, HARISH MASAND, AVEG KUMAR, HITESH CHUDASAMA, KIRTI MAHAJAN, D. CHENNA REDDY, S.PRADHAN and SST-1 OPERATION & CONTROL GROUP
IPR/TR-157/2009 (OCTOBER, 2009)

Prototype of ICRH DAC Client Software using Dot Net Technology running on Linux Environment
RAMESH JOSHI, H M JADAV, MANOJ PARIHAR, S V KULKARNI & ICRH GROUP
IPR/TR-158/2009 (NOVEMBER, 2009)

Installation, Commissioning and Operation of Versatile Machine for TF Coil Winding Pack Case Modification in SST-1 Hall
UPENDRA PRASAD, A.N. SHARMA, VISHAL SUTHAR, ARUN PANCHAL and S. PRADHAN
IPR/TR-159/2009 (NOVEMBER, 2009)

Performance Study of Strain Gauge Displacement Transducer at Various Cryogenic Temperatures
DIPAK PATEL, Y. KHRISTI, F. KHAN, S. KEDIA, A.N. SHARMA, U. PRASAD and S. PRADHAN
IPR/TR-160/2009 (DECEMBER, 2009)

Study and Conceptual Design of Time Synchronization System for SST-1
HARISH MASAND, MANISHA BHANDARKAR, AVEG KUMAR, HITESH CHUDASAMA, KIRTI MAHAJAN, S. PRADHAN and SST-1 OPERATION & CONTROL GROUP
IPR/TR-161/2009 (DECEMBER, 2009)

I-V Characteristics, Minimum Quench Energy and Normal Zone Propagation Studies of Forced Flow Gas Cooled YBCO Tape
ANANYA KUNDU, PIYUSH RAJ, SUNIL KEDIA, YOHAN KHRISTI, DIPAK PATEL and S.PRADHAN
IPR/TR-162/2010 (MARCH, 2010)

Signal Conditioning Electronics for Measurement of Stresses in SST-1 TF Coil
YOHAN KRISTI, KALPESH DOSHI, SUNIL KEDIA, A.N. SHARMA, UPENDRA PRASAD and SUBRATA PRADHAN
IPR/TR-163/2010 (MARCH, 2010)

E 3. CONFERENCE PRESENTATIONS

6th National Conference of Physics Academy of North East (PANE), Tripura University, Tripura, 2nd – 4th April, 2009

Development of Diagnostics for the Studies of X-ray Emission from Low Energy Plasma focus device
N. Talukdar, T. K. Borthakur, N. K. Neog, C. V. S. Rao, and A. Shyam

Studies on ion emission from the plasma focus device by using ion collector and track detector
M. Bhuyan, N. K. Neog, S. R. Mohanty, C. V. S. Rao, P. M. Raole

8th Workshop on Frontiers in Low Temperature Plasma Diagnostics (FLTPD), Blansko, Czech Republic, 19th – 23rd April, 2009

Effect of filament position on plasma parameters in a double plasma device
M. Chakraborty, B. Das, M.K. Mishra, M. Bandyopadhyay

12th International Workshop on Plasma Facing Materials and Components for Fusion Applications (PFMC-12), Julich, Germany, 11-14 May, 2009

Characterization of SiC Coated Graphite Limiter Tiles for ADITYA Tokamak
S. B. Bhatt, Ajai Kumar, P. Santra, P. A. Rayjada, K. A. Jadeja, R. K. Singh, N. L. Chauhan, K. M. Patel, D. Chenna Reddy, P. M. Raole

Development of High Pressure Non-Thermal Argon Plasma Torch
S. Mukherjee

2nd International Conference on Ultra-intense Laser Interactions Science (ULIS-2009), Laboratori Nazionali di Frascati, Frascati, Italy, May 24 - 29, 2009

On dynamics of Flat-top Electromagnetic Solitons in a Cold Relativistic Electron-ion Plasma
Vikrant Saxena, Amita Das, Abhijit Sen, and Predhiman Kaw

23rd IEEE/NPSS Symposium on Fusion Engineering, SOFE 2009; San Diego, 1 June - 5 June 2009

Beamline Optimization for 100keV Diagnostic Neutral Beam (DNB) Injector for ITER
M. Bandyopadhyay, M.J. Singh, C. Rotti, A. Chakraborty, R. Hemsworth, B. Schunke

ITER ICRF System: R & D Progress and Technical Choices
B. Beaumont, T. Gassmann, F. Kazarian, P. Lamalle, D. Rasmussen, A. Mukherjee,
U. Baruah, R. Sartori

Analysis of Residual Ion Dump (RID) of Diagnostic Neutral Beam (DNB) injector for ITER
C. Rotti, K. Acharya, M. Bandyopadhyay, M. Singh, A.K. Chakraborty, B. Srusti,
G.P. Reddy

Diagnostic Neutral Beam for ITER - Concept to Engineering
A. Chakraborty, C. Rotti, M. Bandyopadhyay, M.J. Singh, R. Gangadharan Nair, S. Shah, U.K. Baruah, R.S. Hemsworth, B. Schunke

ITER International Summer School 2009 (IISS2009), organized by University de Provence & ITER Organization at Aix-en Provence, France, 22-26 June 2009

Aluminizing of SS410 by Magnetron Sputtering
N. I. Jamnapara, R. S. Rane, K. Bihola, V. Acharya, N. L. Chauhan, P. M. Raole,
S. Mukherjee

18th Topical Conference on Radio Frequency Power in Plasmas, Ghent, Belgium, 24-26 June 2009

Status of the ITER IC H&CD System
P. U. Lamalle, B. Beaumont, T. Gassmann, F. Kazarian, B. Arambhadiya, D. Bora, J. Jacquinot, R. Mitteau, F. C. Schüller, A. Tanga, U. Baruah, A. Bhardwaj, R. Kumar, A. Mukherjee, N. P. Singh, R. Singh, R. Goulding, D. Rasmussen, D. Swain, G. Agarici, R. Sartori, A. Borthwick, A. Davis, J. Fanthome, C. Hamlyn-Harris, A. D. Hancock, A. Kaye, D. Lockley, M. Nightingale, P. Dumortier, F. Durodié, D. Grine, R. Koch, F. Louche, A. Lyssoivan, A. Messiaen, P. Tamain, M. Vervier, R. R. Weynants, R. Maggiora, D. Milanesio, F. Braun, J.-M. Noterdaeme, K. Vulliez

DST-SERC School on Plasma Diagnostics, Institute for Plasma Research, Ahmedabad, 20-31 July 2009

Overview of Plasma with Emphasis on Inviscid Damping and Fluid Plasma Echos
R Ganesh

Fusion Plasma Physics
N. Ramasubramanian

Tokamak Physics- Overview
Joydeep Ghosh

Basic Plasma- Overview
Prabal Chattopadhyay

Interaction of Short Intense LASER Pulses with Solid Density Plasmas: An Overview of Experimental Results
Sudip Sengupta

Diagnostics- Introduction
J. Govindarajan

Diagnosing Plasma with Langmuir Probe
Ratneshwar Jha

Diagnosing plasma with magnetic probes
Ratneshwar Jha

Active Spectroscopy
N. Ramasubramanian

Emission Spectroscopic Diagnostic
N. Ramasubramanian

LASER Aided Diagnostics-1 (Laser Plasma)
Ajai Kumar

LASER Aided diagnostics-2 (Interferometry)
Rajwinder Kaur

Noise Elimination Techniques in Electronics for Plasma Diagnostics
Chhaya Chavda

Modification of Materials Surfaces with Low Pressure Plasmas
S. Mukherjee

Thermal Disintegration of Plastic Waste and Energy Recovery Using Plasma Pyrolysis Technology
S. K. Nema

Thermal Atomic Beam Assisted Plasma Diagnostics
Manoj Kumar Gupta

Microwave Diagnostics in Fusion Plasmas
Surya K. Gupta

Nuclear Diagnostics of Plasma
C. V. Srinivasa Rao

Plasma DAQ and Instrumentation
L. M. Awasthi

Introduction to Thermal Imaging Diagnostics
Shwetang Pandya

Visible Imaging of the Tokamak Plasma
Santanu Banerjee

Helicon Wave Plasma
Y. Shankara Joisa

Vacuum Techniques in Plasma Generation
S. B. Bhatt

Particle Beam Aided Spectroscopy
Prahlad Vattipalle

LAB EXPERIMENTS

Waves in High Beta Plasma of LVPD
P. K. Srivastava, U. Dhobi and L. M. Awasthi

Probe Diagnostics in DC and Pulsed Plasmas
Anita V., Renu Behl and Priyavandna R.

SMARTEX-C: Toroidal Electron Plasma Device
Lavkesh Lachhvani, R. Ganesh and S. Pahari

Measurements Using Retarding Field Analyzer In Toroidal Plasma Device BETA
T. Shekar Goud, K. Satyanarayana, D. Raju, C. Chavda and R. Ganesh

K-Band (18-26GHz) Single Channel Interferometer
P. K. Atrey, Varsha Siju

Study of DC Glow Discharge
K. K. Barada, S. Bose, J. Ghosh, P. K. Chattopadhyay

Measurement of Plasma Potential of DC Plasma by using Emissive Probe
R. Rane, V. Acharya, S. Mukherjee

Plasma Imaging Using10 kW Torch
Santosh Pandya, Shwetang Pandya, A. Satyaprasad, C. Balasubramanian, G. Ravi

LASER Optogalvanic Effect
Rajani D. Dhingra, Kumar Ajai, M. K. Gupta and Govindarajan

APPENDIX
Demonstration Experiment 1

Production and Measurement of Radioactive Nuclides Generated in Materials of the Structure Components of a Fusion Reactor by Bombardment of 14MeV Neutrons
C. V. Srinivasa Rao

Demonstration Experiment 2

Ku-Band Single Channel Reflectometer
P. K. Atrey, Varsha Siju

Laser-Blow-Off Experiment
Ajai Kumar

Brainstorming Session on Stealth Technologies, Aeronautical Development Agency, Bangalore, 1st August, 2009

Plasma - A Stealth Tool
G. Ravi

2nd International Conference on Advances in Mechanical Engineering (ICAME 2009), at SVNIT, Surat, 3-5 August 2009

Cryogenic Application of Composites Materials
Rajiv Sharma, V. L. Tanna and B.V. Dave

14th International Conference on Fusion Reactor Materials (ICFRM-14), Sapporo, Japan, 6-11 September, 2009

Synthesis of Tailored 2D SiC/SiC Ceramic Matrix Composites through ICVI
A. Udayakumar, P. M. Raole, M. Balasubramanian

34th International Conference on Infrared, Millimeter, and Terahertz Waves, IRMMW-THz 2009, Busan, 21 - 25 September 2009

An Overview of the ITER Electron Cyclotron H&CD System
M. Henderson, F. Albajar, S. Alberti, U. Baruah, T. Bigelow, B. Becket, R. Bertizzolo, T. Bonicelli,A. Bruschi, J. Caughman, R. Chavan, S. Cirant, A. Collazos, C. Darbos, M. De Baar, G. Denisov, D. Farina,F. Gandini, T. Gassman, T.P. Goodman, R. Heidinger, J.P. Hogge, O. Jean, K. Kajiwara, W. Kasparek,A. Kasugai, S. Kern, N. Kobayashi, J.D. Landis, A. Moro, C. Nazare, J. Oda, I. Paganakis, P. Platania,B. Plaum, E. Poli, L. Porte, B. Piosczyk, G. Ramponi, S.L. Rao, D. Rasmussen, D. Ronden, G. Saibene,K. Sakamoto, F. Sanchez, T. Scherer, M. Shapiro, C. Sozzi, P. Spaeh, D. Straus, O. Sauter, K. Takahashi,A. Tanga, R. Temkin, M. Thumm, M.Q. Tran, H. Zohm, C. Zucca

9th International Symposium on Fusion Nuclear Technology (ISFNT-9), Dalian, China, 11th-16th October 2009

Neutronic optimization of the Indian Lead – Lithium cooled Ceramic Breeder (LLCB) blanket for DEMO
C. Danani, H. L. Swami, V. Chaudhari and B. J. Saikia

Current Status of Engineering Design and Analysis of Indian LLCB TBM
Paritosh Chaudhuri

Preliminary studies on MHD Simulation and Heat Transfer analysis for LLCB TBM
K S Goswami, B. Dey, P. J. Bhuyan and E. Rajendrakumar

21st International Conference on Magnet Technology (MT-21), Hefei, China, 18-23 October 2009

Feasibility of High-Temperature Superconducting Coil Option for the LHD-Type Fusion Energy Reactor
N. Yanagi, G. Bansal, R. Champailler, T. Mito, S. Imagawa, A. Sagara, M. Iwakuma

62nd APS Gaseous Electronics Conference, Saratoga Springs, New York, 20 – 23 October 2009

Some Basic Experiments on Dusty Plasma with Negative Hydrogen Ion Generation
B. K. Saikia, S. S. Kausik, B. Kakati and M Bandyopadhyay

6th Space Environment Symposium, held in Kitakyushu, Japan, 29-30 October 2009

Spacecraft Plasma Interaction eXperiments (SPIX) Performed in India
Suryakant B. Gupta

Vacuum Electronic Devices and Applications (VEDA-WS-2009), on Microwave Tubes for Electronic Cyclotron Heating and Current Drive at MTRDC, Bangalore, 29-31 October, 2009

ITER Project and High Power Gyrotron Source Systems for ECH Applications in ITER
S.L. Rao

Vacuum Electronic Devices and Applications (VEDA-WS-2009), on Microwave Tubes for Electronic Cyclotron Heating and Current Drive at MTRDC, Bangalore, 29-31 October, 2009

ITER Project and High Power Gyrotron Source Systems for

ECH Applications in ITER
S.L. Rao

School on foundation of Plasma Physics and Technology for Young Researchers of North East India, Dibrugarh University, Dibrugarh, Assam, 30th October to 1st November, 2009

Langmuir Probe Diagnostics in a Discharge Tube
M. Chakraborty, S. S. Kausik and N. K. Neog

23rd International Conference on Surface Modification and Technologies (SMT23), Mamallapuram, Chennai, India, 2-5 November 2009

Plasma Nitriding-An Eco-friendly Process
S. Mukherjee, J. Alphonsa

Results of the Preliminary Experiments Conducted to Deposit Zn using Plasma Enhanced Jet Vapor Depsoition (PEJVD)
A. Satyaprasad, R. S. Rane, J. Alphonsa, N. L. Chauhan, S. Mukherjee

Effect of Surface Roughness and Operating Parameters on Plasma Nitriding of AISI 304 Steel
S. Mukherjee, G.P. Singh , J. Alphonsa , P.K. Barhai , P.A. Rayjada , P.M. Raole

51st Annual Meeting of the APS Division of Plasma Physics (DPP), held at Atlanta, Georgia, 2 - 6 November, 2009

The Negative Ion based Diagnostic Neutral Beam for ITER
B. Schunke, H. Decamps, M. Dremel, R. Hemsworth, A. Tanga, M. Bandyophadhyay, U. Baruah, A. Chakraborty, C. Rotti, S. Shah, M. Singh, N. Singh

National Conference of Advances in Atomic and Molecular Nuclear Physics at MMH College, Gaziabad, UP, India on 5-8 November 2009

Positive Ion Extraction from Plasma Source and its Application in Fusion Research
Mukti Ranjan Jana (Best oral presentation award)

Proceedings of National Workshop on Eco-friendly Plasma Applications in Textiles, at Institute for Plasma Research, Gandhinagar, 10-11 November 2009

Plasma Textile Collaborative R&D
P. B. Jhala and S. K. Nema

Use of Plasma in Textiles
S. K. Nema and P. B. Jhala

National Symposium on Vacuum Technology and its Application to Electronic Devices and Systems (IVSNS-2009), organized by Indian Vacuum Society, CEERI and BITS, at Pilani 11-13 November, 2009

The Effect of Power Failure on a Cryogenic Pumped Vacuum System
K.A. Jadeja, S. B. Bhatt, P. S. Bawankar, A.S. Prajapati

Development of Software for Operation of Vacuum Gauge
Prakash S. Bawankar, Kiran Patel, Ranjeet Singh, Kumar Jadeja, Bharat Darji, Amit Prajapati, S. B. Bhatt

4th National Conference-Texcellence-09, AMA, Ahmedabad, India, 13-14 November, 2009

How Plasma-Nanotechnology can add Value in Home Textiles
P.B. Jhala

1st Annual COMSOL Conference 2009, Bangalore, 13-14 November 2009

Magneto-structural Analysis of Fusion grade Superconducting Toroidal Field Coils
A. Amardas, Sarvagya Dwivedi

National Metallurgical Day and Annual Technical Meeting (NMD-ATM 09), Kolkata, India, 14-17 November, 2009

Co-sputter Deposition Setup with Three Magnetrons for Depositing Nano-composite Coatings
K. Kishor Kumar

Deposition of Zinc Coatings using Plasma Enhanced Jet Vapour Deposition
A. Satyaprasad, R. S. Rane, J. Alphonsa, N. L. Chauhan, S. Mukherjee

26th DAE Safety and Occupational Health Professionals' Meet at VECC, Kolkata on 16 November 2009

Safety Implementation for the Cryogenic System at IPR for Fusion Applications
B. Sarkar

6th International Conference on Maintenance, Inspection, Corrosion, Materials, Engineering and Plant Reliability (MICMEP 2009), Baroda, India, 6-8 December, 2009

Plasma Nitrocarburising Process for Corrosion resistance of Valves used in Steam Turbines
J. Alphonsa

International Conference on Environmental Issues (ICEI2009) in Emerging & Advanced Economies, Canada, India; AMA, Ahmedabad, India, 7th December, 2009

Plasma Pyrolysis Technology for Disposal of Hazardous Medical & Industrial Waste in an Eco-friendly Manner
Nirav. I. Jamnapara, S. K. Nema

24th National Symposium on Plasma Science & Technology (PLASMA 2009), National Institute of Technology, Hamirpur, India, 08-11 December, 2009

Electron Current Pulse Propagation and its Anomalous Dissipation through Inhomogeneous Plasma
Sharad Kumar Yadav, Amita Das, Predhiman Kaw and Sudip Sengupta (Buti Award)

Effect on Plasma Interactions on Sputter Yield of Planar Magnetrons in a Multimagnetron Setup
Kishor Kumar K. and S. Mukherjee (Buti Award)

One Dimensional Fluid Modeling of Plasma Transport Across Magnetic Filter
Kavita Rani Rajkhowa, M. Bandyopadhyay and M. Chakraborty

Possible Application of Ultra-Cold Plasmas as Tunable Meta-Materials for Microwave
Rajneesh Kumar and Ajai Kumar

Role of Natural Length and Time Scales on Velocity Shear Driven EMHD Instability
Gurudatt Gaur, Sita Sundar, Sharad K. Yadav, Amita Das Predhiman Kaw and Sarveshwar Sharma

Effect of Plasma Potential on Particle Diffusion across a Transverse Magnetic Filter Field in Double Plasma Device
M. Chakraborty, B. K. Das, M. K. Mishra and M. Bandyopadhyay

Study of Equilibrium and Fluctuation in Multi-Filament Currentless Toroidal Plasma
T. S. Goud, R. Ganesh, D. Raju, K. Satyanarayana, K. K. Mohandas and C. Chavda

System for Microwave and Plasma Experiments (Symple)
Anitha V. P, Renu Bansal, Priyavandna Rathod, Anurag Shyam and Y. C. Saxena

Extraction of Negative Ion Beam from the Downstream Region of a Microwave Multicusp Plasma Source
Debaprasad Sahu, Mainak Bandyopadhyay, Arun Chakraborty and Sudeep Bhattacharjee

Damped Electron Plasma Oscillations in a Growing Plasma Upon Interaction of High-Power Short-Pulse Microwaves with a Gaseous Medium
Shail Kumari, Indranuj Dey, D. P. Sahu, Sudeep Bhattacharjee, Abhjit Sen and H. Amemiya

Design of Magnets for a Multi-Cups Cesium Plasma
N. Ramasubramanian, Avani Patel, Y. C. Saxena, P. I. John and P. K. Kaw

The Influence of Displacement Current on Electron Velocity Shear Driven Instabilities in the Relativistic Regime
Sita Sundar and Amita Das

Superluminal Solitary Waves in a Cold Relativistic Electron-Ion Plasma
Vikrant Saxena, Abhijit Sen and Predhiman Kaw

Plasma Response to Transient Positive Potential Perturbation
S. Kar and S. Mukherjee

Excitation of Potential Well in BETA Device
R. Kaur and S. K. Mattoo

Life Cycle of Density Structures in Simple Magnetized Torus
R. Kaur and S. K. Mattoo

Nonlinear Evolution of an Arbitrary Density Perturbation in a Cold Homogenous Plasma
Prabal Singh Verma, S. Sengupta and P. K. Kaw

Study of Nonlinear Oscillations in a Cold Dissipative Plasma
Prabal Singh Verma, J. K. Soni S. Sengupta and P. K. Kaw

One Dimensional Focusing Model for Vacuum Acceleration of Charged Particle
Vikram Sagar, Sudip Sengupta and Predhiman Kaw

Measurement of Ion Density and Electron Temperature of Pulsed Plasma Produced Inside a Curved Vacuum Chamber using Double Langmuir Probe
N. Sasini, R. Paikaray, G. Sahoo, D. C. Patra, J. Ghosh and A. Mishra

Simon-Hoh Instability in High Beta Plasma
S. K. Singh, L. M. Awasthi, S. K. Mattoo R. Jha, P. K. Kaw and R. Singh

Development of a Photo-Ionized Lithium Plasma Source for Plasma Wakefield Acceleration Experiments
K. K. Mohandas, Ravi A. V. Kumar, Ajai Kumar and Y. C. Saxena

Washers Gun Design for Microwave and Plasma Experiments (Symple)
Renu Bansal, Anitha V. P., Priyavandna Rathod and Y. C. Saxena

Characterization of Ion Beam for the 14 MeV Neutron Generator Based on D-T Reaction
Sudhirsinh Vala, Shrichand Jakhar, C. V. S. Rao and A. Shyam

Synthesis and Characterization of Nano-Sized Li2 TiO3 for Blanket Application in Fusion Reactor
Sanjeev Kumar, S. K. Sinha and P. M. Raole

Study of Plasma Flows in Scrape-Off Layer of Aditya Tokamak
Deepak Sangwan, M. V. Gopalkrishna and Ratneshwar Jha

The Role of Gas Feed on the Discharge and Beam Currents of PINI
B. Choksi, P. Bharthi, S. K. Sharma, L. K. Bansal, Karishma Qureshi, Ch. Chakrapani, N. Contractor, S. Parmar, U. K. Barua and V. Prahlad

Experimental Studies with Newly Installed S. B. 1 Power Supply in Capacitor Bank Discharges of Aditya Tokamak
R. L. Tanna, M. B. Kalal, D. S. Varia, Deepak Sangwan, Pravesh Dhyani, K. Sathyanarayana, M. N. Makawana, S. B. Bhatt, J. Ghosh, P. K. Chattopadhyay, Y. C. Saxena and Aditya Team

Development of SCADA Application with Distributed Control for Testing of 10kA Vapor Cooled Current for SST 1
R. Patel, G. Mahesuria, R. Panchal, D. Sonara, V. Thakore, P. Panchal, N. C. Gupta, A. N. Sharma, V. L. Tanna and S. Pradhan

Improved Control Scheme of Helium Gas Recovery System of Liquid Helium Refrigerator/ Liquefier for SST 1
R. Panchal, M. Singh and V. L. Tanna

Activation and Afterheat Analyses for the LLCB Test Blanket Module in ITER
Vilas Chaudhari, Chandan Danani and E. Rajendra Kumar

Conceptual Design of Electrode Assembly and Pulsed Power Supply for Electrode Biasing Experiment in Aditya Tokamak
Pravesh Dhyani, Joydeep Ghosh, P. K. Chattopadhyay, Deepak Sangwan, K. A. Jadeja, S. B. Bhatt and Aditya Team

Design of an Experimental Set-up to Study Permeation of Hydrogen Isotopes through Structural Material of Indian LLCB-TBM
Amit Sircar, E. Rajendra Kumar, Sadhana Mohan and Kalyan Bhanja

Studies on Vacuum Brazing of Graphite & CFC with Copper Alloy to Fabricate Divertor Targets for Fusion Applications
Y. Patil, K. P. Singh, S. S. Khirwadkar, N. Chauhan, R. Rane, P. A. Rayjada, P. M. Raole and S. Mukherjee

Fabrication of Flat Tile Tungsten Mock-Up Using Vacuum Brazing Technique for Divertor Target Application
K. P. Singh, Y. Patil, S. S. Khirwadkar, N. Chauhan, R. Rane, P. A. Rayjada, P. M. Raole and S. Mukherjee

Status on ITER DNB Activities
A. Chakraborty, M. J. Singh, M. Bandopadhyay, C. Rotti, Sejal Shah, G. Roopesh, Kanan Acharya, Rajesh Surendran, Irfan Ahmed, Hemal Lakdawala and Ratnakar Yadav

Desorption Study of SiC Coated Graphite Tiles for Aditya Limiter
K. A. Jadeja, S. B. Bhatt, A. S. Prajapati, Ajai Kumar, P. Santra, D. Chenna Reddy and Y. C. Saxena

Comparison of Experimental & Simulation Methods- Experimental Verification of ANSYS Thermal- Fluid Analysis of Radiation Shield Plate for Cryopump Application
Chirag Sanghani, Ranjana Gangradey and N. Ravipraksh

Benchmark of Tritium Breeding Ratio for DEMO Breeding Blankets
Ravi Prakash N. and Niraj Badheka

Eddy Current Analysis of Vacuum Vessel of Fusion Grade Tokamak in 3–D using Finite Element Analysis
Ravi Prakash N., Rajan Babu, Ketul Patel and Ranjana Gangradey

Magneto-Hydrodynamic (MHD) Analysis for the Liquid Metal Flows in the Conducting Wall Straight Channel
Ravi Prakash N., Rajan Babu, Mahesh Patel and Ranjana Gangradey

Thermal Hydraulics of Radiation Shield of Cryosorption Cryopump
Ravi Prakash N., Sanjay Luhana, Chirag Sanghani and Ranjana Gangradey

Theoretical and Transient Thermal Analysis of an Assembly of High Pressure Gas Feed Lines for Pellet Injector System
Ranjana Gangradey, N. Ravi Prakash and Luhan Sanjay G.

Modeling of Hydrocarbon Co-Deposition and Hydrogen Retention in Steady- State Tokamaks
P. N. Maya and S. P. Deshpande

Conditioning of Antenna and Interface for High Power RF Launching for Plasma Heating in ICRF Range on Aditya
Kishore Mishra, Rathi D., Jadav H. M., Joshi Ramesh, Raj Singh, Dani S., Atul Varia, Srinivas Y. S .S., Parmar Kirit, Sunil Kumar, Yogi R. A., Kadia B. R., Gayatri Ashok, Kulkarni S. V. and Aditya Team

Study of Deposition Profile of Lower Hybrid Waves in SST1
P. K. Sharma, Y. Peysson, J. Decker and V. Basiuk

Automation of Aditya Capacitor Bank Charging System
Narendra Patel, Chhaya Chavda, P. K. Chattopadhyay and Aditya Team

Ion Beam Optics Calculation for Low Current Operation of PINI Ion Source for SST-1 NBI
M. R. Jana, S. Rambabu, S. Parmar, N. Contractor, P. Patel, L. N. Gupta, V. Patel, P. Bharathi, B. Choksi, A. Karishma, L. K. Bansal, U. K. Baruah and A. K. Chakraborty
(First prize of Z. H. Sholapurwala award in Fusion Science 2009)

Development of Dual Mode Pulse Generator for Compact Neutron Generator
Basanta K. Das, Amit K. Srivastava, Tushar Raval and Anurag Shyam

HV Discharge Switch for 100 KV Power Supply- Previous Experience and New Development
L. N. Gupta, N. P. Singh, V. Tripathi, Kapil Oza and U. K. Baruah

SST-1 NBI Data Management and Analysis Software
Vishnukumar B. Patel, P. J. Patel, L. K. Bansal, Karishma, D. Thakkar and U. K. Baruah

Maintenance Management and Control with TPM for Power System
V. Balakrishnan, H. D. Parekh and A. R. Chavda

Conceptual Design and Implementation of AC Power Distribution System for Negative Ion Source at IPR
Agrajit Gahlaut, Jashwant Sonara, K. G. Parmar, Jignesh Soni, Gourab Bansal, Kaushal Pandya, M. Bandyopadhyay, Mahendrajit Singh and Arun Chakraborty

Conceptual Design of High Voltage Power Supply (HVPS) System for Negative Ion Source at IPR
Agrajit Gahlaut, K. G. Parmar, Jignesh Soni, Jashwant Sonara, M. Bandyopadhyay, M. J. Singh, Gourab Bansal, Kaushal Pandya, and A. Chakraborty

Control and Data Acquisition System for TF Power Supply of SST-1 Machine
Dinesh Kumar Sharma, Kirti Mahajan, Harish Masand, Aveg Kumar, Manisha Bhandarkar, Murtuza M. Vora, Akhilesh Kumar Singh and Hitesh Chaudasma

Measurement of Supercritical Helium Flow in Spare TF Coil Test
A. N. Sharma, U. Prasad, P. Varmora D. Patel and S. Pradhan

Upgradation of Quench Detection System of SST-1 TF Magnets
Y. Khristi, A. N. Sharma, U. Prasad, K. Doshi, P. Varmora and S. Pradhan

Precision Signal Conditioning Card for Cryogenic Temperature Measurement
Kalpesh Doshi, Yohan Khristi, Sunil Kedia, A. N. Sharma, P. Varmora, U. Prasad, D. Patel and S. Pradhan

Data Acquisition System for Spare TF Coil Test
Pankaj Varmora, A. N. Sharma, K. Doshi, Y. Khristi, S. Kedia and S. Pradhan

Investigation of Strain Gauge Based Displacement Transducer at Various Cryogenic Temperatures
Dipak Patel, S. Kedia, Y. Khristi, K. Doshi, U. Prasad, A. N. Sharma and S. Pradhan

Quality Assurance and Quality Control for SST-1 Magnets
Pratibha Gupta, Upendra Prasad, A. N. Sharma, S. J. Jadeja and S. Pradhan

Fabrication of New Joints in SST-1 Superconducting TF Coils
Upendra Prasad, A. N. Sharma, D. Patel, S. J. Jadeja and S. Pradhan

Development of W-Band Heterodyne Interferometer System for Aditya Tokamak
Varsha Siju, Praveena Kumari, Surya K. Pathak and P. K. Atrey

An Overview of Proposed ITER-INDIA Test Facility for High Power Gyrotron System
Mahesh Kushwah, S. L. Rao, Vipal Rathod, Anjali Sharma and Ronak Shah

An Overview of Local Control Unit (LCU) for Indian Scope of Gyrotron System on ITER for Electron Cyclotron Applications
Vipal Rathod, M. Kushwah, S. L. Rao, R. Shah and A. Sharma

Characterization and Validation Test of 10kA Vapor Cooled Conventional Current Leads under Long Pulse Operation
N. C. Gupta, D. Sonara, A. Garg, R. Patel, G. Modi, S. George, R. Panchal, A. N. Sharma, V. L. Tanna and S. Pradhan

Integrated Testing and Engineering Validation of SST-1 Timing System
Aveg Kumar, Harish Masand, Kirit Patel, Kirti Mahajan, Haresh Dave, Hitesh Gulati, Manisha Bhandarkar, Hitesh Chudasma, S. Pradhan & SST-1 Operation and Control Group

Noise Mitigation in Signal Conditioning System of the Thermal Diagnostics in Neutral Beam
L. K. Bansal, Karishma Kureshi, V. Prahlad, P. Bharathi, Vishnu Patel, Dipal Thakkar and U. K. Baruah

Instrumentation Set-Up for Test of 10kA Vapor Cooled Conventional Current Leads for the Requirements of TF And PF Magnets of SST-1
D. Sonara, R. Patel, R. Panchal, V. Thakore, N. C. Gupta, A. N. Sharma, V. L. Tanna and S. Pradhan

Simultaneous Sampling 8-channel 12-bit CAMAC Transient Digitizer
Amit K. Srivastava, Atish Sharma, Tushar Raval and Imran Mansuri

Analog Fiber Optic Transmitter/Receiver Module
Kumar Rajnish, Dipal Patadia, Gajendra Suthar, Raghuraj Singh, R. G. Trivedi, Anil Bhardwaj, Aparajita Mukherjee, IC H and ITER-India Team

Status of ITER IC Source System
Aparajita Mukherjee, R. G. Trivedi, Kumar Rajnish, Raghuraj Singh, Anil Bhardwaj, Harsha Machchhar, Ajesh P., Gajendra Suthar, Dipal Patadia and Manoj Patel

Conceptual Design of Driver Amplifier for ITER IC System
Raghuraj Singh, R. G. Trivedi, Kumar Rajnish, Anil Bhardwaj, Harsha H. Machchhar, Dipal Patadia, Ajesh P., Gajendra Suthar, Yuva Kiran, Manoj Patel, D. S. Bhattacharya, F. Braun and Aparajita Mukherjee

Coupled Field Analysis for RF Components of 20kW ITER Amplifier System in 25-65 MHz Frequency Range
Paravastu Yuvakiran, Anil Bhardwaj, Raghuraj Singh, P. Ajesh, R. G. Trivedi Kumar Rajnish, D. S. Bhattacharya, Aparajita Mukherjee and ITER IC Team

Test Result of Cylindrical RF Capacitor
Mahesh Kushwah, Anil Bhardwaj, Aprajita Mukherjee, Raghuraj Singh, R. G. Trivedi, Kumar Rajnish and IC H and CD ITER-India Team
Realization of Input Wideband Circuit for 20 kW Amplifier fir ITER IC Source System
Harsha Machchhar, R. G. Trivedi, Raghuraj Singh, Kumar Rajnish, Anil Bhardwaj, Aparajita Mukherjee and ICH & CD ITER-India Team

Test Result of Wide Band Voltage Controlled Phase Shifter (0—360 Deg.) for ITER IC Source System
Harsha Machchhar, R. G. Trivedi, Raghuraj Singh, Kumar Rajnish, Anil Bhardwaj, Aparajita Mukherjee and ICH & CD ITER-India Team

Conceptual Design of the Grounding Scheme for Negative Ion Source at IPR
Jashwant Sonara, Agrajit Gahalaut, K. G. Parmar, Jignesh Soni, Gourab Bansal, Kaushal Pandya, M. Bandyopadhyay, Mahendrajit Singh and Arun Chakraborty

Conceptual Design and Implimenation of Data Acquisition and Control System for Negative Ion Source at IPR
Jignesh Soni, Ratnakar Yadav, Agrajit Gahalaut, K. G. Parmar, Jashwant Sonara, Gourab Bansal, , Kaushal Pandya, M. Bandyopadhyay, M. J. Singh and A. Chakraborty

Development and Application of Advanced Non-Destructive Evaluation Technique for Divertor Target
M. S. Khan, S. S. Khirwadkar, Santosh Pandya, Shwetang Pandya and J. Govindrajan

Overview of Design and Analysis for 100 kV High Voltage Bushing for ITER-DNB
Sejal Shah, S. Rajesh, M. Badyopadhyay, M. J. Singh, C. Rotti, Roopesh G., C. M. Deshpande, B. Srusti, Nishad Hussain and A. Chakraborty

Corrugated Waveguide Fabrication for Microwave Applications
J. V. Vihola and Panchal Tushar M.

Calculation of Energy Deposition Rate During the Fault in High Power RF and Microwave Vacuum Devices using PSCAD Software
Rajan Babu N., Sanjay Kulkarni and R. F. Group

Design and Mode Analysis of Circular Corrugated Waveguide for ITER ECE Applications
Suman Danani, Hitesh B. Pandya, P. K. Sharma

Modeling of Vacuum Vessel in MCNP Code and Estimating the Wall Thickness of Vacuum Vessel with Neutronics Calculations
Jyoti Agrawal, Ravi Prakash N., Ranjana Gangradey, T. K. Basu and C. P. Reddy

Shape Optimization for Zero Bending Moment Toroidal Field (TF) Coils
Mayur J. Malaviya and N. Ravi Prakash

Development of High Pressure Gas Feed Lines of H2 Pellet Production in Cryocooler of Pellet Injection System
Luhana Sanjay G., N. Ravi Prakash and Ranjana Gangradey

ITER DNB Power Supply –Conceptual Design
N. P. Singh, Aruna Thakar, D. Parmar, Amit Patel, Hitesh Dhola, Rasesh Dave, Sandip Gajjar, Bhavin Raval, Vikranr Gupta, B. Schunke, Hans Decamps and U. K. Baruah

Design and Analysis of Port Duct Bellow
Atik Mistry, Girish Gupta, Jagrut Bhavsar, Vipul More, Rajanikant Prajapati, Mukesh Jindal and Anil Bhardwaj

Design and Analysis of Vacuum Vessel Pressure Suppression System
Girish Gupta, Atik Mistry, Jagrut Bhavsar, Vipul More, Rajanikant Prajapati, Mukesh Jindal and Anil Bhardwaj

Friction Welding for Joining Dissimilar Metals
Jaiswal Snehal, Amit Munjani, Patel Anjana, Bedakihale Vijay and Joshi Atul

Indigenous Development of Fabrication Technology for Hydroformed Bubble Panel used as Radiation Shield for Cryosorption Cryopump
Ranjana Gangradey, N. Raviprakash, I-Design Team and Chirag Sanghani

Material and Welding R&D Involved in Fabrication of Fusion Grade Tokamak
Ranjana Ganradey, Ravi Prakash and M. Manoah Stephen

Development of RF Transmission Line Components at 350 MHz
Atul D. Varia, Dharmendra Rathi, Raj Singh, S. V. Kulkarni and RF-ICRH Group

Up-gradation of Antenna Test Facility (ATF) Coil Assembly
Y. S. S. Srinivas, Kirit M. Parmar, D. Rathi, Gayatri Ramesh, S. V. Kulkarni and ICRH-RF Group

Up-gradation of Matching Network System for Ion Cyclotron Resonance Heating System of Tokamak Aditya
Raj Singh, Atul Varia, D. Rathi, S. V. Kulkarni and ICRH-RF Group

Wire Burn Test on 35kV, 20A High Voltage Power Supply for 91.2 MHz, 200vW Stage RF Generator
K. M. Parmar, Y. S. S. Srinivas, B. R. Kadia, S. V. Kulkarni and ICRH-RF Group

Development of PLC Based System for Monitor and Control of Power Supplies of 2-220 kW RF Amplifier Stages
H. M. Yadav, Manoj Parihar, Ramesh Joshi, Kirit Parmar, S. V. Kulkarni and ICRH-RF Group

Development of Versatile Protection System analog with Isolation for High Voltage DC Power Supplies
Bhavesh R. Kadia, Kirit Parmar, Y. S. S. Srinivas, S. V. Kulkarni and RF-ICRH Group

Design and Development of Ignitron Firing Power Supply for Ignitron NL8900
Shrey Bhatnagar, Rajan Babu N. and Prabal Chattopadhyay

Development of Software for Monitoring and Control of Water-Cooling for 82.6 GHz Gyrotron
Jatin Kumar Patel, Pragnesh Dhorajiya, J. Sathyanarayan, Harshita Patel, B. K. Shukla and ECRH Group

Design and Development of Series Ignitron Crowbar System for 82.6 GHz Gyrotron
Rajan Babu N., B. K. Shukla, K. Sathyanarayana, Pragnesh B. Dhorajiya, Dharmesh K. Purohit, Pankaj Dev, Harshida R. Patel, Anurag Shyam and Y. C. Saxena

Design and Development of dI/dt Protection for 82.6GHz Gyrotron
Rajan Babu N., K. Sathyanarayana, Pragnesh B. Dhorajiya, B. K. Shukla, Dharmesh K. Purohit, Harshida R. Patel, and ECRH Group

Conceptual Design of Centralized Data Storage System for SST-1
Manisha Bhandarkar, Harish Masand, Aveg Kumar, Hitesh Chudasama, K. Mahajan and S. Pradhan

Toroidal Field Coil Fault Detection and Its Repairing in Aditya Tokamak
D. S. Varia, M. B. Kalal, Deepak Sangwan, Pravesh Dhyani, Nirav Mecwan, P. K. Chattopadhyay, S. B. Bhatt and Aditya Team

Remote Operation and Data Acquisition System for Testing SST-1 TF Coils
K. R. Dhanani, Y. G. Yeole, Ziauddin Khan, D. C. Raval, P. L. Thankey, F. S. Pathan, P. Semwal, Siju G., Gattu Ramesh and H. Bindu

Study and Conceptual Design of Time Synchronization System for SST-1
Harish Masand, Aveg Kumar, Manisha Bhandarkar, Hitesh Chudasama, Kirti Mahajan, Hitesh Gulati, Haresh Dave, Kirit Patel and S. Pradhan

Microplasmas and Applications in Photonic Crystal
Rajneesh Kumar

Role of Process Parameters in Tailoring the Surface Properties of Polymers in Low Pressure Plasma
Purvi Kikani, S. Mukherjee, Umang Patel, Bhakti Desai and S. K. Nema

Understanding the Role of Ozone and Dielectric Barrier Discharge in the Surface Modification of Polyester Film
Nisha Chandwani, Purvi Kikani, Umang Patel and S. K. Nema

Effects of Plasma Irradiation on Asymmetric Polysulfone Membrane
Yogesh, A. Bhattacharya, Payal Mehta, Neelam Ramaiya and J. Ghosh

Effects of Plasma Interactions on Sputter Yield of Planar Magnetrons in a Multimagnetron Setup
Kishor Kumar K. and S. Mukherjee

Non-Thermal Plasma Fuel Reforming and Cracking
G. Ravi

Performance of Plasma Nitrided Hot-Forging Dies and Punches in Service Condition
Ravindra Kumar, Ram Prakash, J. Alphonsa, A. Pareek, P. A. Rayjada, P. M. Raole, K. S. Suraj and S. Mukherjee

Low Energy Charge Exchange Neutral Particle Analyzer for Aditya Tokamak
Santosh P. Pandya, Rajani D. Dhingra, Kumar Ajay and J. Govindarajan

Temperature Profile of Graphite and LaB6 Materials using CO2 Laser
P. Mehta, A. Sharma, J. Ghosh, J. Govindarajan, Shwetang Pandya, Santosh Pandya and P. Chaudhuri

Tangential Visible Imaging and Poloidal Emissivity Reconstruction of ADITYA Plasma
Santanu Banerjee, R. Manchanda, Ketan M. Patel, N. Ramaiya, J. Ghosh, Vinay Kumar, M. B. Chowdhuri, P. Vasu and Aditya Team

Observation of H-alpha Emission Profiles and Study of Neutral Particle Transport in ADITYA Tokamak

Santanu Banerjee, J. Ghosh, R. Manchanda, Ketan M. Patel, N. Ramaiya, Vinay Kumar, P. Vasu, R. Jha and Aditya Team

Measurement of Ion Specie Mix, Beam Specie Distribution and Beam Divergence of Extracted Ion Beam using Doppler
P. Bharathi, V. Prahlad, S. K. Sharma, M. R. Jana, S. Rambabu, B. Sridhar, B. Choksi, S. Parmar, P. J. Patel, N. P. Singh, V. Tripathi, L. N. Gupta, V. Patel, L. K. Bansal, D. Thakkar, U. K. Barua and A. K. Chakraborty

Thermometer for Measuring Gas Temperature of Plasma Discharges
P. Bharati, K. S. Suraj, V. Prahlad and S. Mukherjee

Conceptual Design of an Infrared Imaging Video Bolometer for the SST-1 Tokamak
Santosh P. Pandya, Shwetang Pandya, N. Pandya and J .Govindarajan

Design, Fabrication, Calibration, Installation and Result of Sine-Cosine Rogowski Coils for Plasma Centroid Measurement in ADITYA Tokamak
Prakash S. Bawankar, Bhoosan S. Paradkar, Praveenlal E. V., Joydeep Ghosh, Prabal Chattopadhyay and D. Chenna Reddy

Vision Based Active Feedback Control System for the Laser Beam Alignment in SST-1 Thomson Scattering System
Kiran Patel, Ranjeet Singh and Ajai Kumar

Plasma Diagnostics for a Negative Hydrogen Ion Source
M. Bandyopadhyay, Arindam Phukan, Shiwani Pandhija, Ratnakar K. Yadav, J. Soni, M. J. Singh, G. Bansal, A. Gahluat, Kaushal Pandya and A. K. Chakraborty

Primary Current Generation System with Variable di/dt Upto~10Ma/Sec and Calibration of SST-1 Rogowski Coil
Y. S. S. Srinivas, M. V. Gopal Krishna, Sameer Kumar, S. V. Kulkarni and R. Jha

Studies of X-ray Emission from Low Energy Plasma Focus Device
N. Talukdar, T. K. Borthakur, N. K. Neog, C. V. S. Rao and A. Shyam

Analysis on the Effective use of Vacuum Photodiode in Plasma Focus Device
T. K. Borthakur, N. Talukdar, N. K. Neog, C. V. S. Rao and A. Shyam

VUV Spectroscopy in ADITYA Tokamak
R. Manchanda, Santanu Banerjee, Ketan M. Patel, N. Ramayia, J. Ghosh, Vinay Kumar, M. B. Chowdhuri, P. Vasu and Aditya Team

Absolute Intensity Calibration of Spectroscopis Systems on ADITYA Tokamak using Integrating Sphere
Nilam Ramaiya, Ranjana Manchanda, Santanu Banerjee, Payal Mehta, N. Ramasubramanian and J. Ghosh

Lab VIEW Based Graphical User Interface for SST-1 CAMAC Data Acquisition System
Tushar Raval, Atish Sharma, Imran Mansuri, Amit K. Srivastava and R. Pradhan

Design of a FPGA Based Fuzzy Logic Controller Hardware for Plasma Position Control in ADITYA Tokamak
Jigneshkumar Patel, Pooja Suratia, Rachana Rajpal, P. K. Chattopadhyay and J. Govindarajan

Design of an Uncooled Microbolometer IR Camera
Hitesh Mandaliya, Praveenlal E. V., Rachana Rajpal, Prabal Chattopadhyay, J. Govindarajan and Swetang Pandya

Prototype of ICRH DAC Software using Dot-Net Technology Running on Linux Environment
Ramesh Joshi, H. M. Yadav, S. V. Kulkarni and ICRH-RF Group

Development of the DAC Software for Remote Operation of ICRH Cooling System with Data Logger
Ramesh Joshi, Jatin Patel, Harshida Patel, Shukla B. K., S. V. Kulkarni and R.F. Group

Nonlinear Studies of Strongly Correlated Dusty Plasma System
Sanat Tiwari, Amita Das, Abhijit Sen and Predhiman Kaw

Study of Barium Laser-Blow-Off Plasma Plume Expansion Dynamics under Ambient Environment and Transverse Magnetic Field
Manoj Kumar, R. K. Singh and Ajai Kumar

Dynamics of Magnetic Field Measurement on Rear Side Target using Intense Ultrashort Laser Pulse
V. Narayanan, S. Mondal, Amit D. Lad, S. N. Ahmed, S. Sengupta, A. Das, P. K. Kaw and G. Ravindra Kumar

Improvement of Optical Transmission Characteristics of Tokamak Windows
S. Sasanka Kumar, M. K. Jayaraj, Ajai Kumar and Ravi A. V. Kumar

Ultrafast, Giant Magnetic Pulses and Their Microscopic Evolution-Signature for Relativistic Transport
S. Mondal, V. Narayanan, Amit D. Lad, S. N. Ahmed, S. Sengupta, A. Das, P. K. Kaw, Z. M. Sheng and G. Ravindra Kumar

Laser Plasma Interaction with Few-Cycle Ultrashort Focused Light Beam
M. Kundu

Pulsed Laser Deposition of Mirror Like Tungsten Thin Films
A. T. T. Mostako, C. V. S. Rao and A. Khare

Study of Q2D Turbulent Magnetohydrodynamic Flows in Channels
B. Dey, P. J. Bhuyan, K. S. Goswami, R. P. Bhattacharyay and E. Rajendrakumar

One-Dimensional Vlasov Simulation of Parallel Transport and Effect of Secondary Electron Emission in SOL Region of Tokamak
K. Saharia, K. S. Goswami, D. Sharma and P. K. Kaw

Role of Gas Feed in Scrape-Off Layer of Tokamak Plasma
N. Bisai, R. Srinivasan and R. Jha

A Novel Orthonormal Basis of 3D Vectors for Modeling Deterministic Nonlinear Dynamical System
A. K. Agarwal

Sokendai International Symposium 2009 - Constructing Sokendai Academic Networks, Hayama, Japan, December 14-17, 2009

RF based Negative Ion Experimental Facility at IPR
Gourab Bansal, M. Bandyopadhyay, M.J. Singh, A. Gahlaut, J. Soni, K. Pandya, K.G. Parmar, J. Sonara, R.K. Yadav, and A. Chakraborty

International Conference on Turbulence, IIT Kanpur, 21 -23 December, 2009

Electron Magnetohydrodynamic Simulations in an Inhomogeneous Plasma Medium
Amita Das

Seminar on Plasma and Coating on Textile, M.S. University, Vadodara, India, 24 December, 2009

Plasma Technology in Textile Processing
P. B. Jhala

Heat Treat Show, Conference and Exhibition on Heat Treatment, Worli, Mumbai, 29-31, January 2010

Design & Construction of a Compact Heater for Vacuum Heat Treatment Process
A. Vaid, J. Alphonsa, N. Jamnapara, G. Jhala

Plasma Nitrocarburizing Process for Corrosion Resistance of Valves Used In Steam Turbines
Alphonsa Joseph, Ghanshyam Jhala, R. M. Anklesaria, K. M. Anklesaria, Kelly Buchia

International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

A Novel Orthonormal Basis of 3D Vectors for Modeling Deterministic Nonlinear Phenomena
A.K Agarwal

Study of Mode Structures and Their Dynamics in Expanding Laser- Blow-Off Plume
Ajai Kumar, D. Raju, Sony George and R.K.Singh

Nonlinear Regime Of Flow Shear Driven EMHD Instability In The Presence Of In – Plane Magnetic Field
Gurudutt Gaur , Sita Sundar, Sharad K.Yadav, Amita Das, Predhiman Kaw

Electron Velocity Shear Driven Instabilities In The Relativistic Regime
Sita Sunder and Amita Das

Possible Excitation Of The Nonlinear Electron Acoustic Waves
Sayananda Kar, S. Mukherjee and G.Ravi

Study Of Pressure Driven Oscillations In Laser- Blow –Off Plasma In The Absence Of Ambient Gas
Rajneesh Kumar, Ajai Kumar, R.K. Singh and Jinto Thomas

Effect Of Magnetic Field On The Discharge Mode Of Cylindrical Electrode Confugaration
R. Rane, A.Phukan, V. Acharya,G.Ravi and S. Mukherjee

Density And Magnetic Fluctuation Studies In Magnetized Plasma Blob Projected By A Washer Stacked Plasma Gun Into A Curved Vacuum Chamber
G.Sahoo, R. Paikaray, J.Ghosh, R.singh, D.C Patra, N.C.Sasini, A.K. Sanyasi

Kinetics of Self – Consistent Collisionless Ion Acoustic Shock Pulses in Warm Ion Plasma
D. Sharma, A. Sen and P.K. Kaw

Signature of Potential Structure of Anodic Double Layers In Glow Discharges
Suraj K.S, G.Singh, Ramprakash and S. mukherjee

Nonlinear Evolution of An Arbitrary Density Perturbation In A Cold Homogeneous plasma
Prabal Singh Verma, S.Sengupta and P.K. Kaw

Study of Nonlinear Oscillations In A Cold Dissipative Plasma
Prabal Singh Verma, J. K. Soni, S. Sengupta and P. K. Kaw

Experimental Plasma Wakefield Acceleration Activities at IPR
K.K Mohandas, Ravi A.V.Kumar, Ajai kumar & Y.C. Saxena

Effects of Plasma Rotation on NTMs
D.Chandra, A.Sen, P.Kaw and M.P.Bora

Coherent Structures in Electron Plasma: Studies In SMARTEX-C
S.Pahari, L. Lachhvani, R. Ganesh

Lower Hybrid Waves in SST1 Plasmas
Pramod K.Sharma, Y.Peysson, J. Decker and Basiuk

Electromagnetic Fluctuations in High Beta Plasma of a Large Linear Device
L.M. Awasthi, S.K. Mattoo, R.Singh and P.K.Kaw

Ultrafast, Giant Magnetic Pulses and Their Microscopic Evolution – Signature For Relativistic Transport
Amit D.Lad, S.Mondal, V. Narayanan, S.N.Ahmed, Sengupta, A.Das, P.K.Kaw, Z.M.Sheng. G. Ravindra Kumar

EC Waves In SST-1: Preliminary Study on Plasma Start-UP
B.K.Shukla,R.Srinivasan, prabal chattopadhyay,Jatin Patel, Rajan Babu, Prgnesh Dhorajia, Harshida Patel, Sunil Belsare and ECRH Group

One Dimensional Model for Vacuum Acceleration of Charged Particle
Vikram Sagar, Sudip Sengupta, Predhiman Kaw

One dimensional Vlasov simulation to study the formation of nonlinear coherent structures in plasma
K. Saharia and K.S. Goswami

21st AGM of Material Research Society of India (MRSI), M. S. University, Vadodara, India, 9-11 February, 2010

Thermal Plasma Process for Synthesis of Crystalline Nanotitania
P. Macwan Dhwani, C. Balasubramaniam, P. N. Dave, P. A. Rayjada, N. Chauhan. (Best Poster Award)

Co-sputter Deposition of Nano Structured Composite Coatings of Copper Doped Titanium Nitride
K. Kishor Kumar, P. M. Raole, P. A. Rayjada, N. Chauhan, S. Mukherjee

Technical Textile Conference on Agrotech, Meditech and Coating & Lamination, Office of Textile Commissioner, MoT, GOI, MANTRA and The Institution of Engineers, Gujarat State Centre at Ahmedabad, 20 February, 2010

Plasma in Textile Coating and Lamination
P. B. Jhala

Souvenir cum Proceedings of National Level Seminar on Nanotechnology-Today & Tomorrow, at Institute of Technology, Nirma University, Ahmedabad, 8 March, 2010

Nano-Plasma Technology for Novel Functional Textile Products
P. B. Jhala

EuroGP-2009 conferenceheld at Tübingen, Germany during April 15-17, 2009

Genetic Programming Based Approach for Synchronization with Parameter Mismatches in EEG. 13-24
Dilip P. Ahalpara, Siddharth Arora, M. S. Santhanam:

PATENT APPLIED

Plasma Enhanced Jet Vapor Deposition of Metallic Films
A. Satyaprasad, R. S. Rane, J. Alphonsa, S. Mukherjee
Patent application no. 494/MUM/2010

E 4. INVITED TALK DELIVERED BY IPR STAFF

ABHIJIT SEN

Gave an invited talk entitled "Collective Dynamics of Strongly Coupled Dusty Plasmas" at International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

AMITA DAS

Gave a popular talk on "Art and Science of Fractals" at DST-SERC School on Plasma Diagnostics, Institute for Plasma Research, Ahmedabad, 20-31 July 2009

Gave an invited talk entitled "Electron Magnetohydrodynamic Simulations in an Inhomogeneous Plasma Medium" at International Conference on Turbulence, IIT Kanpur, 21 -23 December, 2009

Gave an invited talk entitled "Electron Magnetohydrodynamics Studies in an Inhomogeneous Plasma Medium: Relevance in Fast Ignition Experiments" at International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

R. SINGH, P K KAW, M.TOKAR and P.H. DIAMOND

"Synergy of Flow and Edge Plasma Turbulence In Density Limit Physics" at International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

R. JHA

"Experimental Studies of Intermittency – Like Phenomena At The Institute For Plasma Research" at International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

SHISHIR DESHPANDE

Gave a popular talk on "ITER India" at DST-SERC School on Plasma Diagnostics, Institute for Plasma Research, Ahmedabad, 20-31 July 2009

"Science & Technology Challenges In The ITER Participation" at International Symposium on Waves, Coherent Structures & Turbulence In Plasmas, Institute for Plasma Research Bhat, Gandhinagar, 12-15 January, 2010

R. GANESH, W. W. LEE, S. ETHIER, J. MANICKAM

Gave an invited Talk on "Properties of Freely Decaying and Driven Turbulence of Fusion Plasmas using Gyrokinetic Particle Simulation", at Asia Plasma Fusion Association (APFA) and Asia-Pacific Theory Conference (APPTC), Aamori, Japan, October 27-30 2009

K.S. GOSWAMI

Gave an invited talk on "Double Layers and its existence, Microseminar on Nonlinear Phenomena",
at Center for Plasma Studies, Jadavpur University, Jadavpur, Kolkata, 27th August 2009

Gave an invited talk on "Current Status of Fusion Research", The School on foundation of Plasma Physics and Technology for young researchers of NE India held at Dibrugarh University, from October 30 to November 1, 2009

P. J. BHUYAN

Gave an invited talk on "On Fundamentals of MATLAB", at School on foundation of Plasma Physics and Technology for young researchers of NE India, held at Dibrugarh University, from October 30 to November 1, 2009

S. R. MOHANTY

Gave an invited talk entitled "Discharge Produced Plasma EUV Lithography Source", at Department of Electric and Electronic Systems, University of Toyama, Japan, 28th May 2009.

Gave an invited talk entitled "EUV Diagnostics of Pulsed Plasma System", International Workshop on Plasma Diagnostics and Application (IWPDA-2009), NIE, Singapore, 2-3 July 2009

S. MUKHERJEE

Gave a popular talk on "Modification of Material Surfaces with Low Pressure Plasmas" at DST-SERC School on Plasma Diagnostics, Institute for Plasma Research, Ahmedabad, 20-31 July 2009

Gave an invited talk on “Plasma Nitriding - An Eco Friendly Process for Surface Modification” at 23rd International Conference on Surface Modification Technologies (SMT 23), Mamallapuram, Chennai, India on 2-5 November, 2009

Gave an invited talk on “Modification of Material Surfaces with Non-Thermal Plasmas” at National Metallurgists’ Day and Annual Technical Meeting 2009 (NMD-ATM 2009), Kolkata, India, 14-17 November 2009

P. M. RAOLE

Gave an invited talk on “Fusion Materials and National Fusion Program” at National Symposium for Material Research Scholars MR-09, IIT Mumbai, India, 8-9 May 2009

S. K. NEMA

Gave an invited talk on “Use of Plasma in Textiles” at National Workshop on Eco-Friendly Plasma Applications in Textile, IPR, Gandhinagar, India, November 2009

P. B. JHALA

Gave an invited talk on “Design and Development of Nano Silk Sarees by Plasma Nano Technology” for Member Secretary, Central Silk Board, and Central Silk Technological Research Institute (CSTRI) Scientists at Bangalore, India, June 16, 2009

Gave an invited talk on “Emerging Role of Plasma Technology in Textile Treatment” for South India Textile Research Association (SITRA) Scientists at Coimbatore, India, June 19, 2009

Gave an invited talk on “Emerging Role of Nano and Plasma Technology in Wool Processing” for J&K Professors and Wool Research Association (WRA) Trainee Scientists at WRA, Mumbai, India, August 13, 2009

C. BALASUBRAMANIAN

Gave an invited guest lecture on “Understanding Physics of Nanotechnology” at Nirma University, Ahmedabad, India, August 2009

Gave an invited guest lecture on “Science of Nanotechnology” at Vishwakarma Government Engineering College, Ahmedabad, India, 15 September, 2009

CHETAN JARIWALA

Gave an invited talk on “Thin Film Processing by Plasma Techniques for Photo-voltaic Applications” at AICT sponsored Staff Development Program on “OPTICS AND PHOTONICS” at Sardar Vallabhbhai National Institute of Technology (SVNIT), Surat, India, February 2010

NIRAV I JAMNAPARA

Gave an invited talk on “Plasma Technology – Applications & Business Potential” at
Extreplexus 2009, Entrepreneurship Development Institute of India, Gandhinagar, India, December 2009

P. J. PATHAK

“Indexing systems & Information Retrieval” at LISC Department, Gujarat University to teach MLISc Students 2009-10

“Communication & Reporting skill” at Skill Enhancement Training: Module-II on 4th July 2009 to working librarians, organized by ADINET, Ahmedabad

“Future Academic Libraries” at refresher course organized by Academic staff college, Gujarat University on 5th November 2009 for working Librarians.

UGC special lecture at Gujarat Granthalaya Seva Sangh seminar at Junagadh on 27th December 2009 on “Challenges & opportunities for Academic Libraries”.

“Digital Technology & Digital libraries at HCNG University, LISC Department for IRTPLA programme on 5th January 2010.

SAROJ DAS

“Strategic Searching on the Web” at Skill Enhancement Training & web bloging: Module – I on 20th June 2009, to working librarians organized by ADINET, Ahmedabad

SHRAVAN KUMAR

Gave an invited talk on “Digital Technology” at Library and Information Science Department, S. P. University, V.V. Nagar on 7th February 2010

DILIP P.AHALPARA

"Principles of Structured Programming and its Usage in Scientific Computation" on 20th April 2009 at Hedmark University College, 2451 Rena , Norway

"Overview of Evolutionary Computation based on Genetic Algorithm and Genetic Programming" on 24th April 2009 at University of Tromsø, Tromsø, Norway

"Time Series Analysis using Wavelet Analysis and Genetic Programming" on 27th April 2009 at Norwegian University of Science and Technology (NTNU), Norway

Invited talks given at National Workshop on Plasma-Surface Interactions and Processing (NWPSIP-09), Hamirpur, HP, 25-27 May 2009

Low Pressure Plasma Processing Systems and Applications
S. Mukherjee

Plasma – Materials Interaction for Fusion Applications
P. M. Raole

Environment Friendly Disposal of Solid Organic Waste using Plasma Pyrolysis Technology
S. K. Nema

High Voltage Pulse Power Sources for Plasma Processing Applications
Suryakant B. Gupta

Plasma Process for Nanomaterial Synthesis
C. Balasubramanian

Disposal of Waste and Energy Recovery using Environment Friendly Plasma Pyrolysis Technology
Vishal Jain

Hydrogenated Silicon Thin Film Processing by VHF (55 MHz) Plasma Enhanced Chemical Vapour Deposition for Photovoltaic Applications
Chetan Jariwala

Plenary & Invited talks given at 24th National Symposium on Plasma Science & Technology (PLASMA 2009), National Institute of Technology, Hamirpur, HP, December 08th – 11th 2009

S. MUKHERJEE gave Plenary and invited talk on "Plasma Surface Engineering"

S. K. NEMA gave Plenary and invited talk on "Environment Friendly Disposal of Solid Organic Waste using Plasma Prylysis Technology"

L. M. AWASTHI gave Plenary and invited talk on "Study of High Beta Plasma in LVPD"

S. V. KULKARNI gave Plenary and invited talk on "Second Harmonic Heating Experiments on Tokamak Aditya using Fast Waves in ICRF Range"

A. CHAKRABORTY gave Plenary and invited talk on "Neutral Beam Injectors-The Fusion Enablers"

E. RAJENDRA KUMAR gave Plenary and invited talk on "An Overview of the Indian LLCB ITER-TBM Program"

P. B. JHALA gave Plenary and invited talk on "Emerging Role for Plasma Technology in Textile Processing

J. GOVINDRAJAN gave Plenary and invited talk on "Fuzzy Thinking, Fuzzy Logic and Tokamaks"

SANTANU BANERJEE gave Plenary and invited talk on "Visible Imaging and Tomographic Reconstruction of Tangential Images of the Tokamak Plasma"

AJAI KUMAR gave Plenary and invited talk on "Experimental Investigation of Plasma Plume by Laser –Blow-Off of Thin Film-Structure and Dynamics in Ambient Environment"

AMITA DAS gave Plenary and invited talk on "Fast Time Scale Phenomena in Plasma"

DEVENDRA SHARMA gave Plenary and invited talk on "Simulating Kinetics of Nonlinear Electrostatic Processes in Vlasov Plasma"

E 5. TALKS DELIVERED BY DISTINGUISHED VISITORS AT IPR

Dr. Dinesh O. Shah, University of Florida, Gainesville gave a lecture on "Advances in Nano Technology".

Dr. Prashant M. Gade, Department of Applied Science, Government College of Engg, Shivajinagar, Pune gave a lecture on "Dynamics on Networks: Synchronization and Beyond".

Dr. Bornali Sharma, gave a lecture on "Experimental observation of sheath and magnetic pre-sheath in the presence of a tilted magnetic field".

Prof Ganapati Rao Myneni, University of Virginia, Jefferson Lab, gave a lecture on "Cryosorption pumping of hydrogen and helium".

Prof. A. S. Khanna, IIT Bombay, gave a lecture on "Surface Modifications Using Thermal Spray & laser based techniques".

Dr. Rajneesh Kumar, Laboratoire Plasma et conversion d' Energie Laboratoire (LAPLACE) CNRS-INPT-U.P.S Toulouse -(France), gave a lecture on "Plasmas as Metamaterials".

Mr. Carl Thomas, President AICON Germany and Mr. Jonathan Kwon, Asia Pacific
Regional Manager and Mr. Sanjeev Gandhi- Director of Geo Informatics Consultants Pvt.Ltd gave a talk on "Camera Based Handheld Photogrammetery for 3D Inspection".

Mr. Shantanu Karkari, National Centre for Plasma Science and technology and the School of Physical Sciences, Dublin City University, Dublin -9, Ireland, gave a lecture on "Application of Low Temperature Plasma Sources and Plasma diagnostics: An overview of current studies discussing the scope of fundamental research".

Prof. K. Avinash, Department of Physics and Astrophysics, University of Delhi, New Delhi, gave a lecture on "Plasma Heat Pump".

Dr. Zulfikar Najmudin, Imperial College, London, gave a lecture on "Plasma Based Accelerators".

Dr. Phanikrishna Thota, Dept of Engineering Mathematics, University of Bristol, UK, gave a lecture on "From Nose Landing Gears to Atomic Force Microscopy Engineering Application of Nonlinear Dynamics".

Dr. Mohit Adhikari, University of Bristol, UK, gave a lecture on "Studies with Delay Differential Equations".

Dr. H. Neumann, ITP, Forschungszentrum Karlsruhe, gave a lecture on "Cooling Techniques and thermal insulation in cryogenics".

Dr. Abha Rao, Computational Material Science Group, Max-Planck-Institut fur Plasmaphysik, D-17491 Greifswald, Germany, gave a lecture on "An introduction to General Purpose computing on Graphic Processing Units (GPGPU)".

Dr. J.E.Freibergs, Director, Institute of Physics, University of Latvia, gave a lecture on " Industrial production technology of lead-lithium alloy"

Dr. E. Platacis, Institute of Physics, University of Latvia, gave a lecture on "Liquid metal research activities at Institute of Physics, University of Latvia".

Dr Manfred Maitz, Leibniz Institute for Polymer Research, Dresden, Germany, gave a lecture on "Strategies of active hemocompatible surface modification".

Dr. Pinaki Pal, Senior Lecturer in Mathematics, Kabi Sukanta Mahavidyalaya, Hooghly, West Bengal, India, gave a lecture on "Onset of zero-Prandtl-number convection".

Dr.Abhijit Majmudar, University of Greifswald, Germany, gave a lecture on "Atmospheric Plasma on Gas Chemistry and Biology".

Acharya Raghunath Bhatt, Director, Rashtrabhasha College, Ahmedabad, gave a literary talk on "Jaishankar Prasad evam unka Sahityik Yogdan".

Dr. Bhavesh G. Patel, PRL Ahmedabad, gave a lecture on "On different velocity components of laser produced plasma: Their origin and isolation".

Dr. John Pasley, University of York, U.K., gave a lecture on "Recent Experiments on Energetic Electron Transport"

Dr.Vinod K, National Institute for Interdisciplinary Science and Technology, Trivandrum, India, gave a lecture on "Studies on development of MgB2 superconductor with improved in-field critical current density".

Dr. Kiran Kolwankar, Department of Physics, Ramniranjan Jhunjhunwala College, Ghatkopar (W), Mumbai, gave a lecture on "Effect of learning on network structure".

Dr. Arindam Sarkar, Scientific Officer, Ahmedabad Textile Industry's Research Association (ATIRA), Ahmedabad, gave a lecture on "Electrospinning: A special application of Electrohydrodynamics".

Dr. Swadesh Mahajan, University of Texas, Austin, USA, gave a lecture on “FUSION - FISSION Hybrids - Maturing of an old idea”.

Dr. B.K.Venkataramu, Liquid Propulsion Systems Center, ISRO, Bangalore, INDIA, gave a lecture on “Spacecraft Propulsion Systems in ISRO”.

Dr. V. Sivakumaran, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, California USA, gave a lecture on “Time-Resolved Fluorescence Spectroscopy of Molecules/Radicals Relevant to Planetary Atmospheres”

Dr. Jay Chakraborty, National Metallurgical Laboratory (CSIR), Jamshedpur, INDIA, gave a lecture on “Phase transformation in polycrystalline thin films - example Titanium”.

E 6. SCIENTIFIC MEETINGS HOSTED BY IPR

DST-SERC School on Plasma Diagnostics

DST-SERC School on Plasma Diagnostics was conducted by IPR from 20th July to 31st July 2009. Thirty Six (36) participants from various institutions from all over India participated in the school. The school consisted of introductory and advanced lectures (40 hours) in Plasma Diagnostics as well as nine hands on experiments (240 hours). Detailed lecture notes were provided to all the participants. Other than this, the school also had popular talks delivered on extra-mural topics (9 lectures) by eminent scientists from various R&D institutions in India.

“International Symposium on Waves, Coherent Structures & Turbulence In Plasmas” 12 − 15 January 2010

An international symposium was organized on the topic of “Waves, Coherent Structures & Turbulence in Plasmas” during 12-15 January 2010. The conference was organized to honour Professor Predhiman Kaw for his seminal scientific contributions in many areas of plasma science and for providing a leadership in promoting this field in India as well as in the international arena. The symposium covered a wide range of topics in the area of nonlinear phenomena in plasmas - a field of research that Prof. Kaw has been primarily engaged in during his illustrious career.

The symposium was attended by participants from India and from other parts of the world. There were around 28 invited talks and about 75 poster presentations during the four day symposium by the participants. The invited talks covered diverse topics related to waves, instabilities and turbulence in the context of astrophysical, ionospheric and laboratory plasmas (related to both fusion and basic studies). Studies on laser plasma interactions and plasma based particle acceleration concepts were also highlighted. The progress on the international magnetic fusion ITER project, Indian participation in it (which was spear-headed under the able guidance of Prof. Kaw) and the challenges ahead were discussed in some talks. Thus, there was intense scientific deliberation during the symposium, a number of novel ideas were floated and new collaborations forged for future work.

The evening of 13th January was dedicated to felicitate Prof. Kaw. A number of distinguished scientists from across the globe reminisced their association with him (both scientific and personal) and also commented upon his remarkable achievements and exemplary human qualities.