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INSTITUTE FOR PLASMA RESEARCH

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EXECUTIVE SUMMARY

Established in 1986, the institute has been growing steadily in its research activities in the various areas of plasma physics. The requirement to initiate research activities in all the necessary physics and technology requirements for a fusion power plant has made the institution to grow in a lot of new directions of basic science and technological programmes.

Under fusion plasma experiments, activities on two machines, namely Aditya and Superconducting Steadystate Tokamak-1, were continued with the same vigor during the last one year. Aditya was being operated regularly at lower rating (30kA, 30 ms) using the capacitor bank. Meanwhile, work for patch panel implementation, integration of new diagnostics, elaborate error field measurements, repositioning suitable correction coils have been carried out. The various components of the heating systems were upgraded with new designs and testing for the improvements made in the integrated system is being continued. Efforts were made to explore the physics from old as well as new data by developing new models and setting up numerical codes available for Aditya discharges. The studies on fluctuation suppressions induced by gas puff were continued as a lot of interesting results have started to come.

In SST-1, after analyzing the initial commissioning problems and other experiences, a Standing Expert Committee (SEC) was constituted with experts from other organizations. A number of meetings were held with this SEC and the IPR team. The main problems identified were leakages in the cryogenic circuits and the temperatures in some of the liquid Nitrogen cooled thermal shields. After a complete overview of the status, IPR team convinced the SEC to dismantle the SST-1 completely and did the dismantling.

Work on the failed components has started. The dissimilar material joint between the SS conduit of the superconductor and the copper terminations have been redesigned and the evaluational test done, has been found to be encouraging. After evaluating isolators procured from China, the design specifications have been reviewed and new suppliers are being contacted. For the thermal shield problems, Bubble type panels have been suggested. To procure these panels, revised technical specifications have been generated and tender documents have been finalized with detailed acceptance test for these thermal shields.

Under the eleventh five year plan, many fusion relevant technological developments have been started. A prototype divertor cassette development has been started by focusing on material and its related technologies. Fusion relevant superconducting strands are also being developed through a prototype magnet. Activities related to pellet injector system, prototype vessel sector and Cryopump systems have also been started. Research and development on negative ion source has been programmed to develop the indigenous expertise on the production of negative ion and operation. This programme will also provide support to the ITER-DNB programme which would be built by India.

In the ITER mission, testing of breeding blanket module concept is also one of the main tasks. To utilize this unique opportunity, India has also proposed to build one Test Blanket Module (TBM). This proposal has been accepted for testing in ITER.

In the basic experimental programme, work has continued in the toroidal assembly machine (BETA), the Large Volume Plasma Device (LVPD), and on non-neutral plasmas. New experiments like Interaction of low energy ion and neutral beams with surfaces, Plasma wake-field acceleration experiment, Microwave plasma experiment and flowing plasma experiment have been proposed and constructions of the above experiments are underway.

In theoretical and computational front, many phenomena in tokamak plasmas like excitation of Geodesic Acoustic modes (GAM), turbulent transport, ELM mitigation, Nonlinear dynamics of multiple NTMs etc., have been actively pursued. The collaboration with TIFR for the studies on laser plasma interaction has continued. Various nonlinear phenomena were simulated using KSLAB.

Through FCIPT, a good running relation with the industries has been maintained with the latest technological developments. ITER-India, the domestic agency for ITER has been formally established and a new office building has been taken on lease. From this new building work has been started in full swing for the ITER commitments.

Director, IPR

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After more than two decades of research in plasma physics with the emphasis on the physics of magnetically confined plasma, the time for realizing fusion power is fast arriving in India. The Institute for Plasma Research is now spreading its wings to acquire expertise in all the relevant scientific and technological requirements for controlled thermonuclear fusion. The National Fusion Programme (NFP) and the Fusion Technology Development Programme which have been launched under the Eleventh Five Year plan of Government of India are expected to provide the impetus for demonstrating the fusion power in India in the near future. While NFP is for the participation of other institutions in India, the latter is within the institute.

A. SCIENTIFIC AND TECHNOLOGICAL PROGRAMMES

Broadly the scientific and technical programme of the institute can be categorized into four areas : 1) fusion plasma experiments, 2) fusion technology development, 3) basic experiments and 4) theoretical and computational physics.

A.1. Fusion Plasma Experiments

A.1.1. Aditya Tokamak

A.1.1.1. Status of the Device

In the last one-year, various activities have been carried out on Aditya. It has been being operated regularly at lower rating (30 kA, 30 ms) from a capacitor bank. The main high voltage transformer necessary for converter operation is expected to come into operation only by the end of year 2008. So a major vacuum opening has been initiated to accommodate various needs. The port reallocation and necessary work to implement reallocation has been carried out. For efficient utilization of number of channel, the concept of a patch panel has been introduced, through which the data would get transferred from the diagnostic sites near the machine to the Aditya control room. A detailed measurement of error field has been started. Based on these measurements different correction coils would be repositioned.

A.1.1.2. Technological Developments

For efficient startup of tokamak discharge a good quality null is needed at the center of the vessel. Recent measurement of error fields indicated the null was found to be away from center and towards outboard side. Simulated results, matched reasonably well with experimental measurements, pointed out this shift in null was because of one turn error field correction loop. Guided by the same simulation a new error field correction coil has been designed and got fabricated. This would help to get the null at the center of the vessel. It is expected that null in the center would lead to a improvement not only in the breakdown window of Aditya discharges, but also would help to control the plasma better. New error field correction coils has been placed and will be tested when APPS comes back into operation.

For an efficient analysis of ADITYA discharges, an electronic database has been developed using Matlab. This database can be used by the researchers for getting information about various plasma parameters, status of Hard X-ray and quality of discharges.

A Patch panel has been developed and installed in the Aditya hall for easy maintenance of acquisition cables by rerouting. Signal and Trigger cables would also be rearranged in the acquisition rack kept at the control room. A intranet web page for Aditya Data acquisition system is being developed.

A.1.1.3. Diagnostics Developments

Diamagnetic loop

A new compensated diamagnetic loop to calculate the stored energy has been installed. By reinstalling the magnetic probe array, position and fluctuation measurements have been made operational with full capability. Another set of sine-cosine coil has also been installed to measure plasma position. Normal and grazing incident monochromators have been relocated to other ports to accommodate some other diagnostics. Microwave reflectometry (fixed frequencies, 22GHz and 35 GHz) has been successfully operated to measure edge and core density fluctuations.

Neutral particle analyzer

Neutral particle analyzer diagnostics has been calibrated and ready for operation. Introduction of magnetic analyzer in the analyzer box (replacing the originally used electrostatic plates, figure A.1.1.3.1) in Aditya charge exchange diagnostics was made in order to avoid the vacuum ultraviolet reflections coming from the analyzer plates on to the CEMs mixing with the counts generated by hydrogen ions. However, the problem sustained and considerable counts due to such VUV reflections were seen even with the magnetic analyzer arrangement. The reflections were coming from the walls of the analyzer box and components of analyzer magnet even after the electrostatic plates were removed.

The charge exchange systems used in various other tokomaks suggested the use of xylan coatings all inside the walls and flight tube as well as the use of several collimating devices and radiation dumps to minimize such reflections and hence the spurious signals. Our system was modified accordingly using collimators in the drift tube and radiation dumps with the analyzer box (additional and modified components shown in the figure A.1.1.3.2). The drift tube, collimators and the radiation dump were coated with Xylan paint at their inner surfaces. The coated components were found to be compatible with 10^{-6} torr range of vacuum. The suppression of VUV reflections was tested with a standard VUV source (a deuterium lamp) attached at the mouth of the drift tube and the counts on CEMs were recorded with and without the components, which were xylan coated. A series of comparative experiments were carried out and the conclusion was the suppression up to 90 % of the reflected counts with xylan-coated configuration.

Visible Spectroscopy

Optical diagnostics often suffer from the reflection from the wall surface at the termination of the field of view. A scheme has been devised to account for this wall reflection in the code.The simulated images on the camera chip 'with' and 'without' wall reflections are shown in the figure A.1.1.3.3 for comparison. Here wall reflectivity R was taken to be 0.8 and the wall surface emissivity S_w has been assumed to be equivalent to 80 percent of the average light flux on the wall from the plasma. It seemed that the wall contribution amounts to 15 percent of the flux impinging on the bright detectors and as much as 150 percent at the dark ones, under the assumed conditions.

Acquisition of tangential images of Aditya plasma

A metallic mirror has been installed inside the vacuum vessel of Aditya for acquiring tangential image of the plasma. Field of view of the camera, with respect to the mirror, has been calibrated and tangential images of the plasma shots have been captured as shown in the figure A.1.1.3.4.

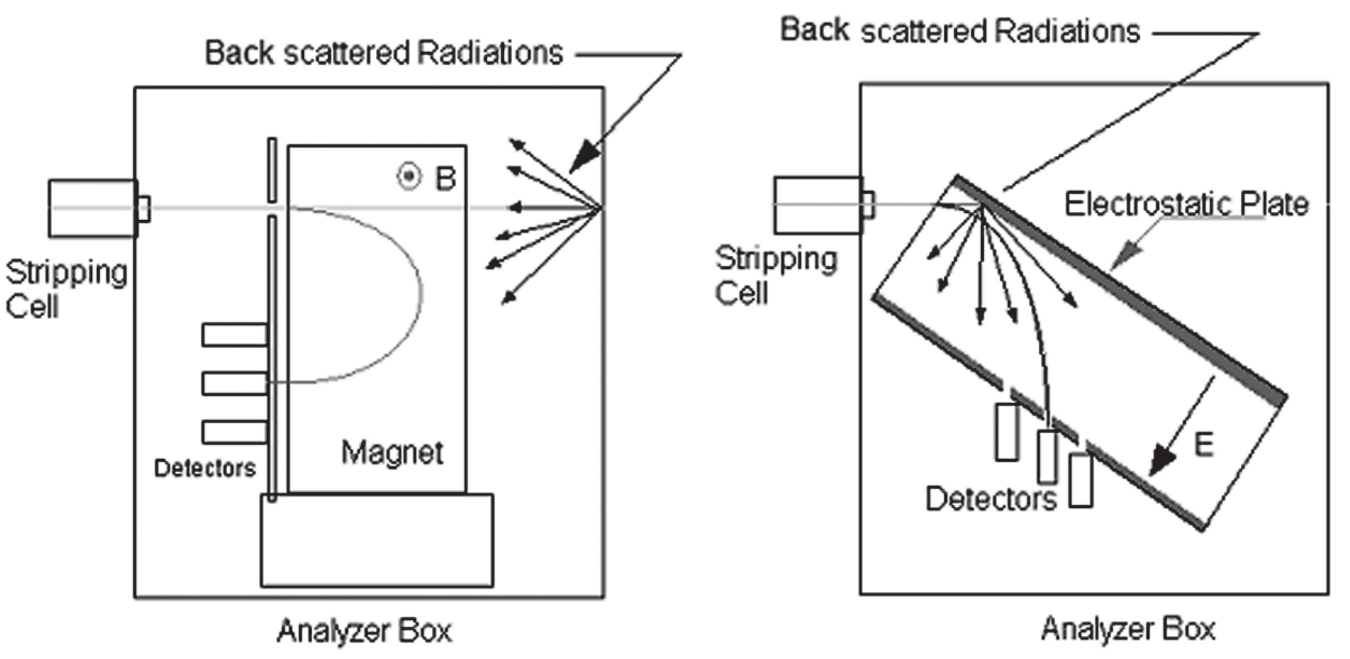


Figure A.1.1.3.1 (a) and (b). Back scattered radiations in Magnetic and Electrostatic Analyzers.

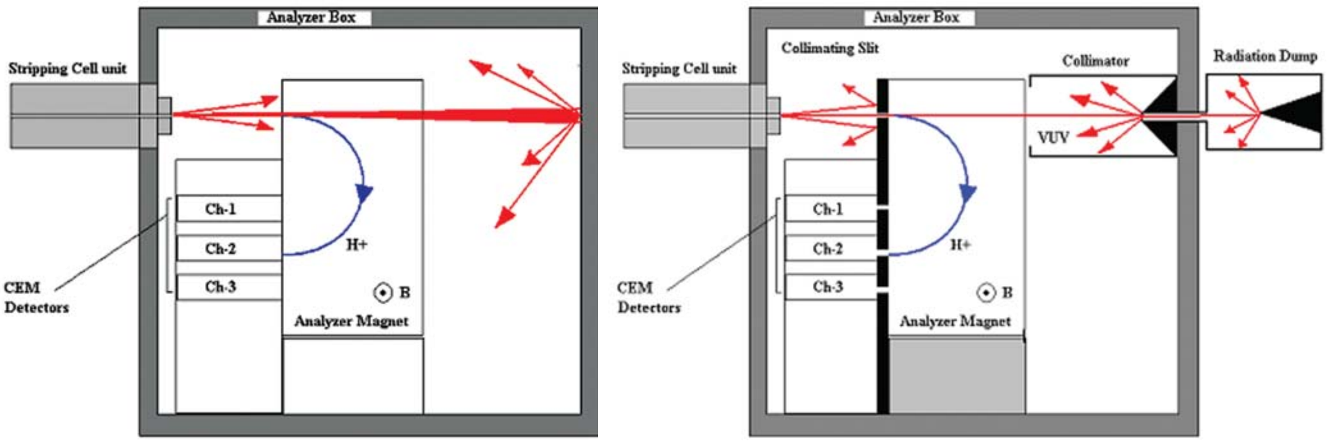


Figure A.1.1.3.2 (a) & (b). Schematics of radiation reflections and absorptions inside the Analyzer box in Aditya CXD.

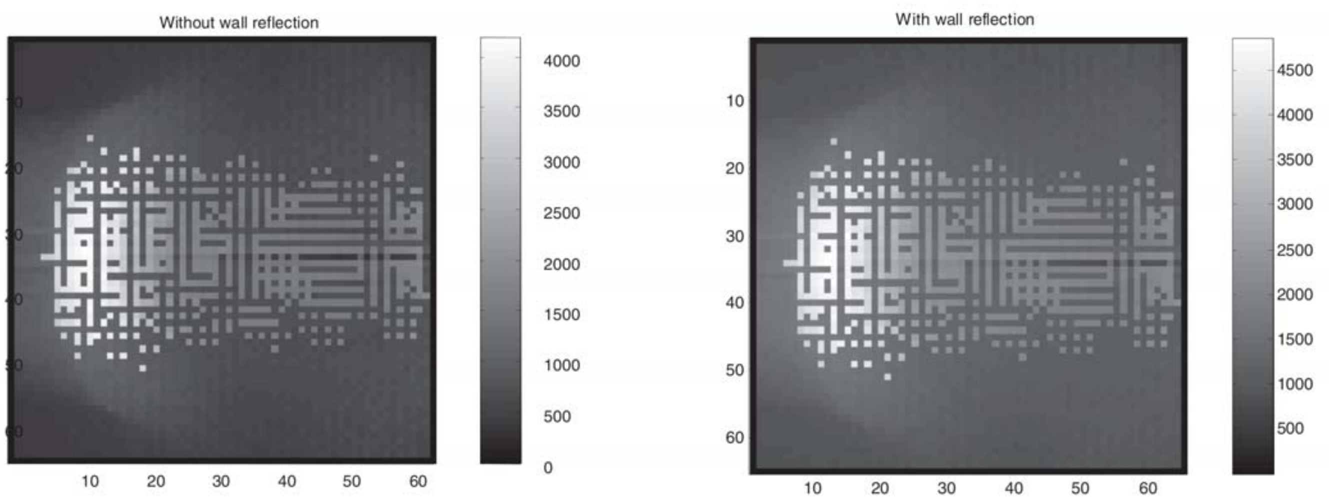


Figure A.1.1.3.3 Comparison of simulated images on the camera chip 'with' and 'without' wall reflections.

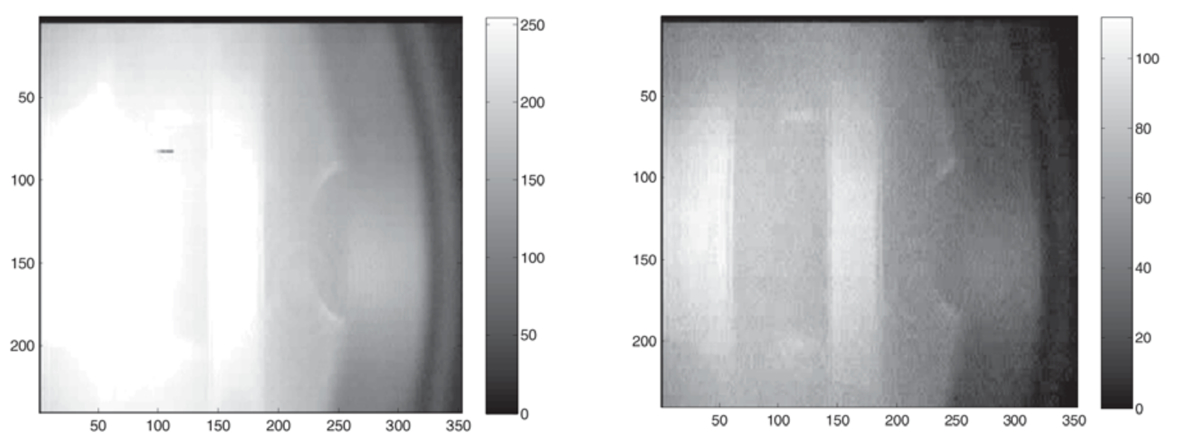


Figure A.1.1.3.4 First and second frame of Aditya capacitor shot number 97758

A.1.1.4. Heating and Current drive systems

ICRH System

It was felt necessary to upgrade the Aditya ICRH system. Antenna interface, probe section of transmission line etc. was dismantled and some of the components like gas barrier etc. were replaced and the inner conductor design of the interface was modified. The complete system was tested. In order to make ICRH systems of Aditya and SST-1 tokamaks independent, many power supplies were required. These power supplies are in the process of fabrication and procurement and soon it would be possible to operate many systems simultaneously.

LHCD System

During the recent vessel opening of ADITYA tokamak, the positioning of the LHCD antenna on ADITYA tokamak has been experimentally verified employing a unique mechanism.

Since the ports adjacent to LHCD antenna (placed in port no. 14) were inaccessible, the measurements were carried out from port no. 7. Normally the machine and LHCD antenna are on different ground and both are isolated. A long metallic plate was placed on the LH-port wall inside tokamak and antenna was pushed inside the machine till the antenna flush with the metallic plate, touching the vessel wall (see figure A.1.1.4.1). At this point, both the grounds (antenna and vessel) were in contact and isolation was lost (the multimeter between the two grounds show continuity). As the position of inner wall was accurately known, the reference position of the antenna, was established at this location.

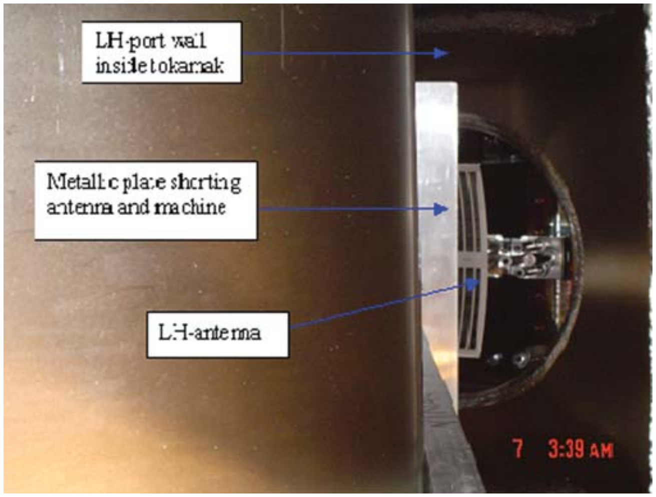


Figure A.1.1.4.1. Scheme showing the measurement technique to experimentally verify the LHCD antenna position in ADITYA tokamak.

Previously the LHCD system was operational and capable of delivering up to ~40 kW of rf power into tokamak. The available power was limited due to (1) available HVDC power supply, (2) limited dynamic range of operation of rail-gap crowbar system, (3) large rf losses due to long transmission line between the source and antenna. To address these issues, a new lab has been proposed adjacent to ADITYA hall (between SST1 hall and ADITYA building).

The transmission line losses are expected to get reduced as the length of the transmission would be reduced with this new lab. This new is expected to be completed by December 2009 and klystron set-up would be made operational by June, 2010. Further new HVPS along with new crowbar system is being procured to operate klystron at rated power in SST1 hall rf bay. This klystron would feed existing ADITYA LH system and LH experiments might be carried out at higher power. This system is expected to come up by March 2009 and would be ready for full power LHCD experimental campaign.

Electron Cyclotron Resonance Heating (ECRH) system

Preionization experiments were being done in Aditya tokamak using 2.45GHz/~1kW magnetron source. Through this, a low loop voltage (E ~ 1.5V/m) operation has been achieved for plasma current being at 10kA, the pressure window has been enhanced with reduced generation of hard X-rays. This ECRH system would be made ready for pre-ionization, start-up and heating experiments on Aditya. The ECRH power launched to the tokamak would be around 100 – 150kW. The power would be launched with variable pulse lengths from 30ms to 100ms.

A.1.1.5. Experimental Results

Runaway study

Aditya discharges were prone to various types of runaway phenomena. Previously, different kind of runaway discharges were observed in Aditya. In one of the type of runaway discharges, loop voltage spikes, negative spike followed by a positive spike was observed. These spikes, which were always accompanied by hard x-ray bursts, were caused by sudden loss of runaway electrons. It was believed that the radially outward movement of the runaway electron beam, during its extraction from inside, the plasma induced both positive and negative electric fields at those locations. An 1-D toroidal electric field diffusion model was developed to estimate these induced electric field values at the plasma boundary, which matched quite well with the observed spikes in loop voltage, in both magnitude and time response.

Reflectometry

A Two-point Correlation Reflectometer was designed and developed to study plasma density fluctuations in Aditya Tokamak. Two microwave sources, at fixed frequencies 22 GHz ($n_c = 6.0 \times 10^{12}$ cm^{-3}) and 22.5 GHz ($n_c = 6.12 \times 10^{12}$ cm^{-3}), were used in this reflectometer. The spatial and temporal resolution of the system was found to be ~ 1 cm and 10 ms respectively. Density fluctuations were observed to be present in the plasma. Initial analysis showed that a broadband fluctuation in the phase as well as a coherent mode at 70 – 85 kHz was present. This coherent mode corresponded to the ELMs like structures in H_α signal and pointed towards very sharp gradient in plasma density profile at the same time. This phenomena was also observed with the gas puff.

Spectroscopic studies

In ADITYA tokamak, the recorded spectrum around 228 *nm* showed the two features of CV (at 227.1 and 227.7 *nm)* and of CIII at 229.7 *nm*. The ratios of the two CV lines were seen to differ from the value, expected from the statistical weight ratio. Using the STRAHL code, it was tried to match the observed CV/CIII ratio using ionization balance and transport and it was found that it required a rather high diffusion coefficient to be assumed. With a reasonable diffusion coefficient, the simulated CV/CIII ratio (figure A.1.1.5.1) was found to match the experimental values better by including charge exchange contributions.

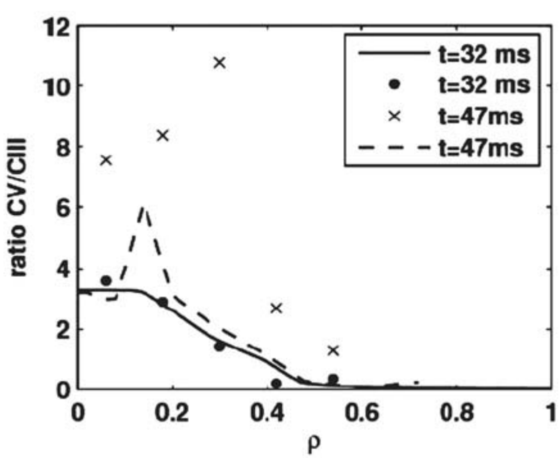


Figure A.1.1.5.1. CV/CIII ration profiles (experiment-symbols, lines-calculations)

This transport modeling seemed to indicate that the charge exchange processes might be playing an important role in the ionization stage distribution in Aditya and the relative intensities of emission.

The radial transport studies of Be-I like oxygen impurity were also performed using typical temperature and density profiles. The radial emissivity profile of OV emission at 6500.24 A was measured with different viewing chords placed at different major radius. The simulated emission profile (figure A.1.1.5.2.) using 'STRAHL' code was compared with the experimental profile to obtain diffusion coefficient. The obtained diffusion coefficient, D = 0.5 m^{2}s^{-1} matched well with the theoretical value.

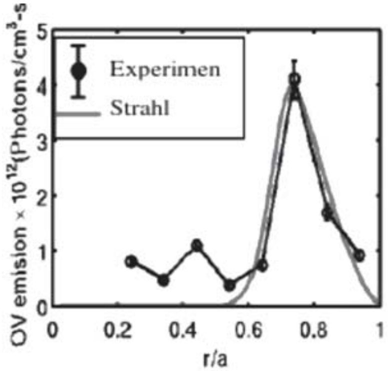


Figure A.1.1.5.2. Radial emissivity profile of OV emission

Fluctuation studies in ADITYA

Understanding of the causes of gas puff induced fluctuation suppression and transport reduction in ADITYA tokamak was not fully achieved. This experiment was carried out by introducing a short puff of the working gas into the flattop phase of ADITYA discharge using a piezo-electric valve. The amount of injected gas was controlled in such a way that there was no significant change in plasma current and its equilibrium position, yet the transport reduction was achieved [See figure A.1.1.5.3)]. The calibration experiment showed that the gas puff introduced approximately 10^{18} molecules of hydrogen gas into the plasma. Figure A.1.1.5.3 shows the changes seen in various diagnostic signals simultaneous with the gas-puff. The chord-averaged central plasma density shows a sharp rise from the baseline density n_{e0} to the peak value, n_{emax}, followed by a slower fall up to n_{e0}. The nature of the density fall indicates that the wall-recycling coefficient is less than unity. Similarly, the soft x-ray signal indicates increase of central temperature (also measured separately). The bolometer pinhole camera measurement shows that the radiation brightness from the edge chord increases significantly during the gas puff indicating a

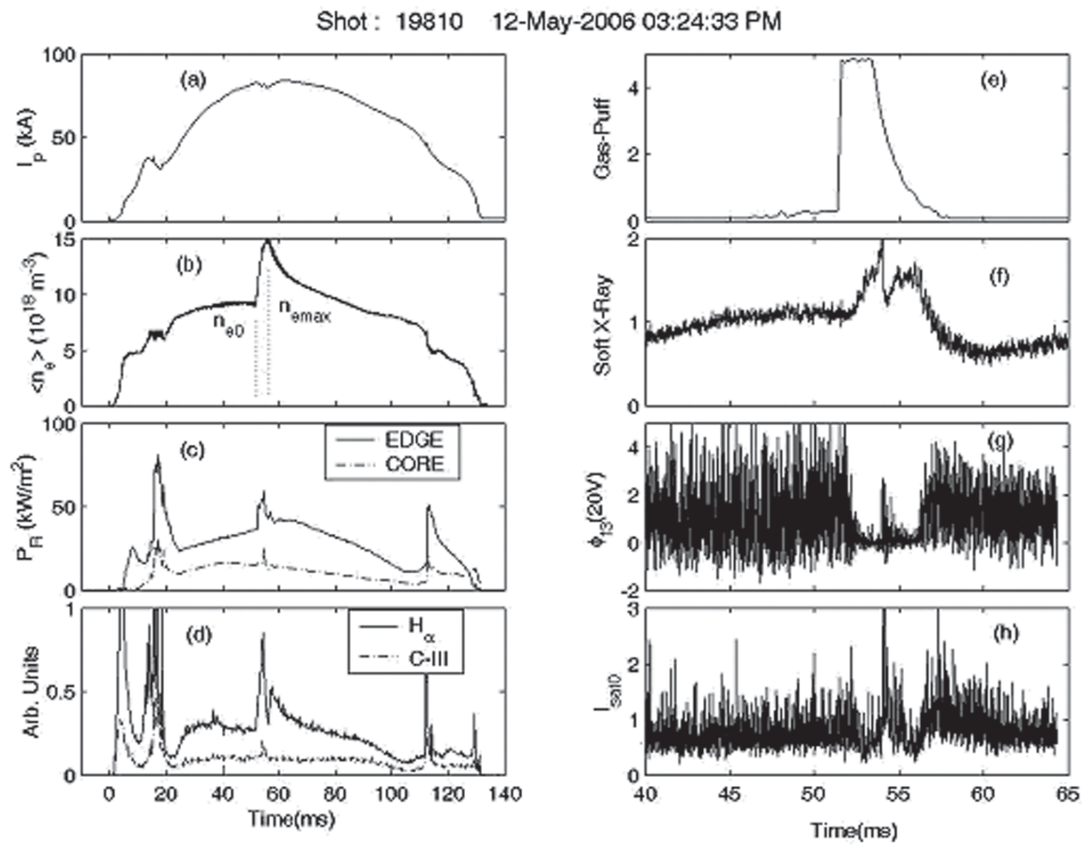


Figure A.1.1.5.3 Time-series of (a) plasma current, (b) chord-averaged plasma density, (c) bolometer signal and (d) H_α and C-III signals. The vertical dotted line indicates the time when gas-puff valve is opened. The blocks on the right shows: (e) Voltage on the gas-puff valve, (f) Soft X-ray, (g) floating potential and (h) ion-saturation current.

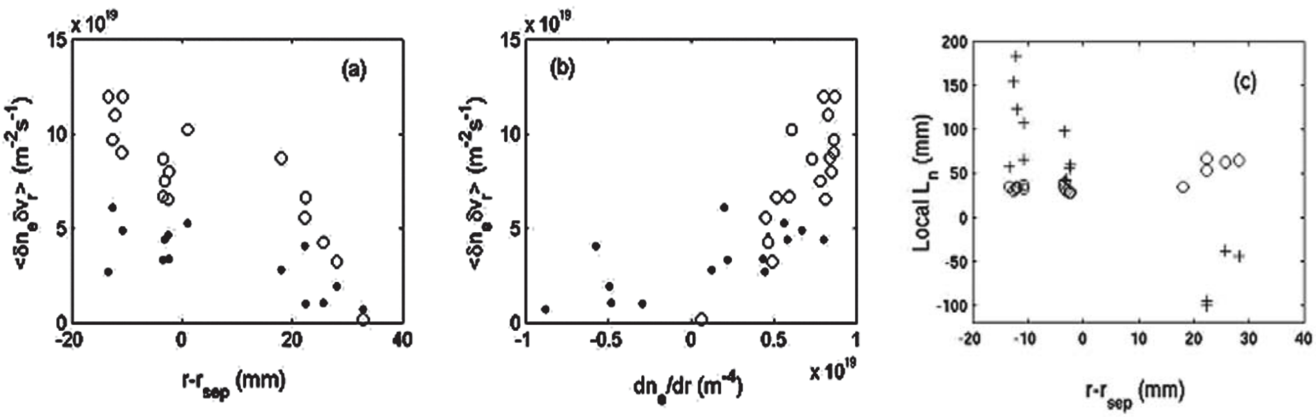


Figure A.1.1.5.4 Radial particle fluxes as a function of (a) radial position of central pin (P0) from the separatrix, (b) local density gradient in discharges with gas-puff (bullets) and without gas puff (open circles), and (c) local density gradient scale length, $L_n=n_e(dn_e/dr)^{-1}$ [open circle for normal discharge and + symbol during the gas puff].

prominent role for the edge impurity radiation. The edge plasma parameters and their fluctuations were measured by Langmuir probes and radial profiles are presented with respect to the last closed flux surface or the separatrix (r_{sep}). The radial profiles of mean floating potential showed that fluctuation got suppressed everywhere in the plasma edge. The measurement of auto-correlation time showed that mainly high frequency components were suppressed. Similarly the measurement of Reynolds stress showed that shear suppression was not a likely mechanism.

Since the transport reduction is directly related to confinement improvement, we have measured the particle flux, $\Gamma = \langle \delta n_e \delta v_r \rangle$, in both discharge conditions (i.e., before and during the gas puff). The flux is measured in terms of the fluctuations in density ($\delta n_e \sim \delta I_s$) and radial velocity ($\delta v_r \sim \delta E_\theta / B_T$) and the result is presented in figure A.1.1.5.4. The radial profile of particle flux indicates that the transport reduction is not confined to the gradient region alone but is spread over both the SOL and the edge regions [see figure A.1.1.5.4 (a)].

The probe configuration allowed a simultaneous measurement of the particle flux, the local density gradient and its scale length, $L_n = n_e \Delta r / \Delta n_e$, where Δr is the radial probe separation and Δn_e is the density difference. The particle flux was first presented as a function of the density gradient, $\Delta n_e / \Delta r$. It was observed that the particle flux increased approximately linearly with the density gradient in different discharges [see figure A.1.1.5.4 (b)]. The particle diffusion coefficient could be determined from the slope of this variation and it is ~10 $m^2 s^{-1}$ in a normal discharge. This value was approximately twice the Bohm diffusion coefficient (D_B~5 $m^2 s^{-1}$, for B_T= 2 kG and edge electron temperature ~15 eV). It should be noted that particle diffusivity of the order ~10 $m^2 s^{-1}$ is not uncommon in the periphery of fusion plasma devices.

The gradient scale lengths are important parameters that determine the growth rate of plasma instability. One such parameter is the local density gradient scale length, L_n, which have been measured in a normal discharge as well as during the gas puff [see figure A.1.1.5.4(c)]. It was observed that L_n was in the range of 20-50 mm during a normal discharge, but it increased by several factors during the gas puff. Thus the gas puff caused a flattening of the local density gradient that might be expected when an additional density source was introduced at the plasma edge.

In order to determine the level of confinement improvement, an estimate of the particle confinement time was made before the gas puff and that at the density peak following the gas puff. The particle content in a typical discharge at these two instants, namely before and during the gas puff, were estimated to be $N_e = 1.3\times10^{18}$ and 1.8×10^{18} respectively. The particle confinement time could be estimated from the equation:

$$\tau_p = \frac{N_e}{(dN_e / dt)_b} \quad \text{.... (1)}$$

where $(dN_e/dt)_b = 4\pi^2 a R_0 \Gamma \approx 6.7G$ (in MKS units) is the particle loss rate across the plasma boundary surface. It was implicitly assumed in the above equation that the particle loss from the boundary was being replenished by the same amount to maintain a certain constant density. Our measurements [see figure A.1.1.5.4 (a)] showed that the particle fluxes (Γ) across the boundary surface were 10^{20} $m^{-2}s^{-1}$ and 5×10^{19} $m^{-2}s^{-1}$ before and during the gas puff respectively. Thus, the estimated values of τ_p before and during the gas puff were ~2 ms and 4-5 ms respectively. A range of τ_p values have been given during the gas puff because the density did not reach a steady state but remained in a certain range above the baseline density. These measurements indicated a significant improvement in particle confinement time (by a factor of 2-2.5).

We now address the issue of fluctuation suppression mechanism. The collapse of the floating potential profile and Reynolds stress profile (not shown for brevity) point to the fact that velocity shear did not play a role in fluctuation suppression. Similarly, the fact that fluctuation suppression was observed throughout the edge and the SOL plasma instead of the narrow gradient region, lends further credence to the ineffectiveness of the shear suppression mechanism. Therefore, we looked for the other possible mechanisms. In fact the experimental features, in particular, the broad spatial extent of the fluctuation suppression region and transport reduction (figure A.1.1.5.4) were similar to those observed in radiation improved RI-modes seen on other tokamaks (e.g., ASDEX). Thus, we looked for an explanation that was based on a radiative cooling mechanism that could be operational at the plasma edge.

To ascertain the involvement of any radiative mechanisms, the radial profile of the total radiation brightness (P_{RAD}) have been measured during and before the gas puff in some typical ADITYA discharges [see figure A.1.1.5.5] using a pinhole bolometer camera. The sensitive spectral range was from 2000 Å to 4 Å and the radial distances indicated the perpendicular distance of the chord (line of sight) from the plasma center. It

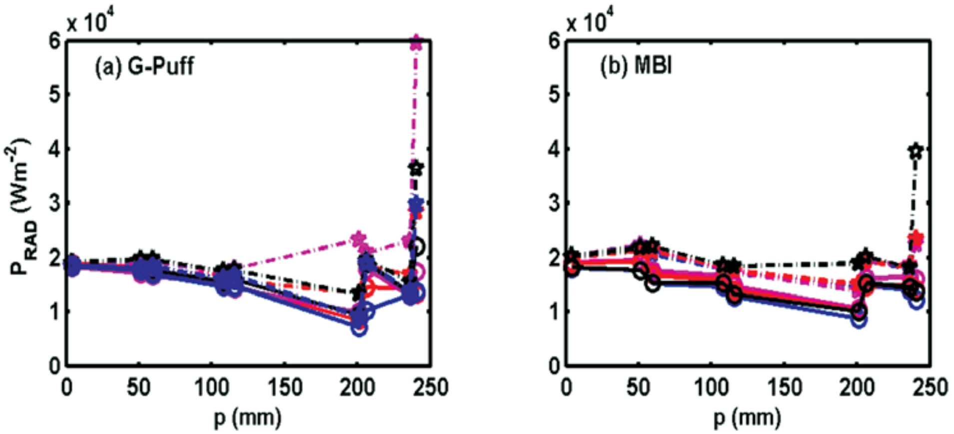


Figure A.1.1.5.5. *Spatial profiles of radiation brightness (P_{RAD}) before (open circle joined by solid line) and during gas puff peak (pentagon joined by dash-doted line) in five similar discharges. Here p is the perpendicular distance of the viewing chord from the plasma centre.*

was observed that during the gas puff the brightness becomes peaked near the plasma edge. The total radiated power was determined by integrating along the radial and toroidal directions. The radiation power was approximately 20% of the input power in a normal discharge, which increased to 40% during the gas-puff. The increase was predominantly from the edge chords. Therefore, the radiation cooling of edge plasma in our experiment was expected to play an important role in the fluctuation suppression mechanism.

The interchange instability was widely accepted as one of the

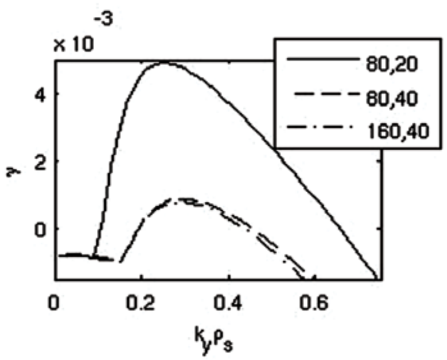


Figure A.1.1.5.6 The growth rate, γ (normalized by ion Larmor frequency) of interchange instability for different values of density and electron temperature gradient scale length (L_n,L_T) as shown in the legend. These scale lengths are normalized to the ion Larmor radius(~ 0.6 mm).

primary sources of turbulence in the edge and scrape-off layer regions of tokamak plasma. The growth rate of this instability depends on the density gradient and the toroidal curvature of the magnetic field. In a recent theoretical study Bisai *et al.* [2004] have included the effect of electron temperature dynamics on the interchange instability and found that linear growth rate increases with the density and the temperature gradients. They have also demonstrated that the radial electric field, E_r, is proportional to the mean temperature gradient and hence the reduction of E_r in our experiment might also be interpreted as coming from a reduction of the temperature gradient. Thus, the gas puff appears to lead to a reduction in the temperature gradient. Similarly the data presented in figure A.1.1.5.4(c) indicate that there was also a local flattening of the density profile. Such changes in the gradient scale lengths might be directly responsible for attenuating the interchange instability and thereby bring about the observed fluctuation suppression. To estimate the magnitude of the growth rate reduction the linear growth rate of the instability was calculated for different scale lengths. For this purpose, the dispersion relation given in Bisai *et al.* [2004] had been solved numerically and the results were presented in figure A.1.1.5.6. A density scale length, L_n=50 mm was used and a temperature scale length L_T=12 mm, which were values typical of a normal discharge in our experiment. In the normalized units of the ion Larmor radius (ρ_s ~0.6 mm), it was (L_n,L_T)=(80,20). Similarly, during the gas puff, it was (L_n,L_T)=(160,40). Figure A.1.1.5.6 clearly shows that the growth rate of the interchange instability during the gas puff gets reduced drastically because of the flattening of the density and temperature gradients. Because $L_n > L_T$, the dominant effect comes from the latter. This reduction in the growth rate concomitantly leads to a reduction of the particle flux.

A.1.2. Superconducting Steady state Tokamak - 1

A.1.2.1. Status of the Device

After concluding the initial commissioning attempts and analyzing the results during the last year, it was felt that the systems which have problems and coming in the way of successful commissioning of SST-1 needed to be thoroughly analyzed and understood to avoid any future problems. A Standing Expert Committee (SEC) consisting of experts from other organizations was constituted to recommend procedures to be followed in the evaluation of the status and future course of action. In a number of meetings held with the SEC, IPR team has explained the problem areas and possible causes and solutions of the same. The main problems identified were leakages in the cryogenic circuits (liquid Nitrogen and super critical Helium) and higher than the allowable temperature on some of the liquid Nitrogen cooled thermal shields. With partial disassembly of SST-1, leak testing confirmed that the major leakages in the Helium circuit are at the terminations and joints. The leakages in the Nitrogen circuit are at the isolator joints. Considering that the large numbers of leakages are at locations which are difficult to access it was clear that in-situ repair has been ruled out. The other problem of higher temperature on the thermal shields is due to flow imbalance in different circuits. After a complete overview of the status, IPR team has convinced the SEC that repairing of the major leaks on the magnet system needs complete dismantling of SST-1. With SEC's concurrence and suggestions, dismantling of SST-1 was undertaken and completed.

In Parallel, we have started working on the failed components and subsystems so as to understand and improve the same. In this connection one of the major failed components is the dissimilar material joint between SS conduit of the superconductor and the Copper terminations in the magnet system. A new joint with prefabricated SS-Copper joint and conduction cooled termination has been evaluated as an alternative and the laboratory testing has given encouraging results in terms of low electrical resistance. This will be further validated at coil level tests by implementing these joints in the spare TF coil. As the magnet system is one of the critical systems of SST-1 with little maintainability, a panel of experts from abroad will review the superconducting magnet system with new joints.

The other subsystems of SST-1, which have shown problems and hampering the commissioning also were reviewed by the SEC. Following its observations, suitable corrective actions have been initiated. These included replacing the thermal shields and the electrical isolators. We have identified suppliers of these components and detailed specifications are being generated to procure the same. One of the important recommendations of the SEC was to test all the systems at the normal operating conditions to the extent possible before integration so as to assure integrated SST-1 operation. This has been taken seriously and we will be testing many of the systems, particularly those with little maintainability before reassembly. Other subsystems, which were not tested earlier, are also being completed and tested so that we will be able to commission SST-1 with all the subsystems.

The SST-1 disassembly was a major task, as it needed removing the weld joints of hundreds of metes by grinding. As all the systems that were removed needed to be reused after suitable modifications, extra care also was needed during the disassembly. A team of a few people was employed in this task that have completed the disassembly without any damage to the subsystems. The subsystems that need modifications and improvements including the new joints for the superconducting magnets are being developed. These are given in the following sub-sections.

A.1.2.2 Technological Developments

Magnet division

Design and development of low resistance leak proof terminations and joints on the superconducting magnet winding packs of the Steady State Tokamak (SST-1) within the geometry and space constraints as a creditable alternative to the existing leaky joints had been one of the primary activities of the division. As a result of these efforts, a conduction cooled termination and joint had been designed and experimentally validated extensively. All the process parameters as well as the technologies associated with fabrication that ensures repeatable joints performances have been established together with detailed QA & QC measures. These new joints have shown remarkable joint resistances in the range of 0.5-1.5 nΩ with transport currents ranging from 100 A to 17 kA (figures A.1.2.2.1 and A.1.2.2.2) under laboratory conditions ensuring a vacuum leak better than 10^{-9} mbar lit s^{-1} at 4.5 K. As a final validation, a SST-1 Toroidal field magnet with these new terminations and joints are planned to be tested in representative conditions during Apr-June 08 before the new joints are extended to the SST-1 superconducting magnets. In the course of these activities, front-end electronics and signal conditioning cards suitable for nano-ohm resistances involving superconductors had also been developed in-house (figure A.1.2.2.3). A detailed finite element analysis of the SST-1 joints as well as the magnet winding packs from thermo-mechanical and magneto-structural aspects have been completed. Suitable hardware for magnet termination profiling have also been designed, fabricated and validated.

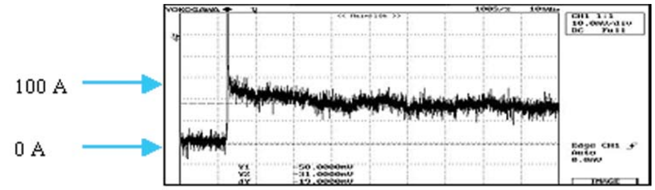


Figure A.1.2.2.1 Joint Resistance at Low current (0.5 nΩ)

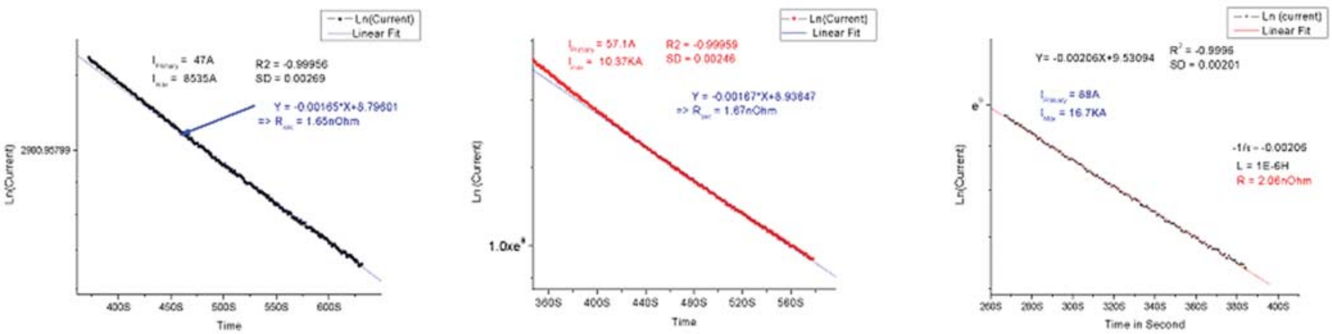


Figure A.1.2.2.2. Joint resistance with Induced currents in CICC (a) 8.5 KA (b) 10.37 KA and (c) 16.7 KA

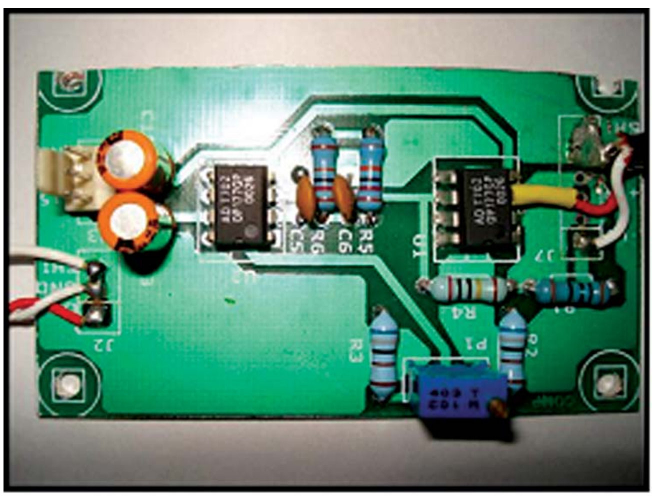


Figure A.1.2.2.3: In-house developed Signal Conditioning Cards for the nΩ resistance measurements in cryogenic conditions.

Vacuum division

SST-1 cryostat is a high vacuum (HV) chamber that encloses superconducting magnetic field coils at ~ 5 °K and the liquid nitrogen cooled panels at ~ 77 °K. Both BA gauge and a Quadrupole Mass Analyzer (QMA) are used for the total and partial pressure measurements in the cryostat. These gauges are calibrated for nitrogen gas at room temperature. As they are exposed to low temperature, the calibration needs to be validated to this condition. An experiment was designed to study the effect of temperature on these gauges. The experiment has been done for different gases.

The experimental setup is shown in figure A.1.2.2.4. A copper enclosure with brazed copper tube for cooling is connected at one end of the UHV chamber and QMA / BA gauge to be studied is mounted inside this copper enclosure. A reference BA gauge is connected to the test chamber identically opposite to the test QMA / BA gauge. Different gases are fed inside the cold surface through a copper tube connected to a variable leak valve. Three Pt-102 temperature sensors are mounted at three different locations, two of them near the two gauges and one inside the copper enclosure.

The test chamber was pumped down to 1.0×10^{-7} mbar as measured with the reference B.A. gauge. A minimum gas temperature of 150 °K was achieved by flowing liquid nitrogen through the copper tubes when the gauges were switched off. After switching on the filaments of the two gauges, the minimum gas temperature rose to 220 °K. Different gases like Nitrogen, Helium and Argon were fed into the test chamber and their temperatures were maintained at 325 °K, 300 °K, 273 °K, 250 °K and 220 °K respectively by flowing LN_2 into the

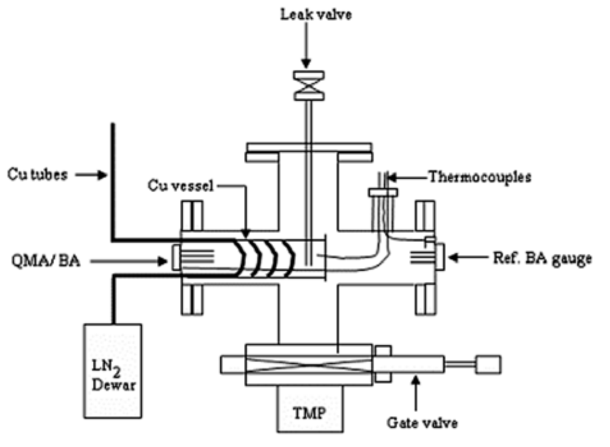


Figure A.1.2.2.4 Experimental setup to study the behaviour of gauges at low temperatures.

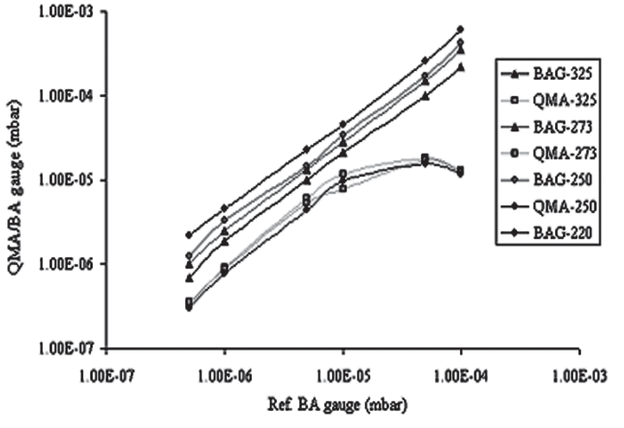


Figure A.1.2.2.5 Variation of test gauge pressure as a function of reference gauge pressure for Nitrogen gas.

copper chamber. For each gas temperature, the gas pressure was varied from 5.0×10^{-7} mbar to 1.0×10^{-4} mbar and the pressure readings were recorded with respect to the reference and test BA gauges. The same procedure was repeated for QMA.

The test gauge pressure is plotted as a function of the reference gauge pressure as shown in figure A.1.2.2.5 for all the five temperatures for nitrogen gas. At theses five temperatures, it was observed that the test BA gauge pressure varied linearly with the reference gauge pressure over the entire pressure range whereas the QMA has shown non-linearity above 1.0×10^{-5} mbar. This non-linear behaviour of QMA above 1.0×10^{-5} mbar is due to the ion space charge effect in the ion source of the QMA. The difference in the behaviour of the QMA and the BA gauge arises due to the difference in their ion source geometries. The same effect is observed for the Helium and Argon gases.

From the above experiment, it is observed that a quadrupole mass analyzer is not reliable at the pressures above 1.0×10^{-5} mbar whereas a BA gauge shows reliability up to 1.0×10^{-4} mbar. These effects are independent of the variation in gas temperature. Since there is no much variation in the pressure readings with gas temperature, it is concluded that the temperature correction for the sensitivity is not required for both BA gauge and QMA.

Cryogenics division

Year 2007 - 2008 had been a year of actions for providing reliable engineering solutions at the components and sub-system level for the cryogenic of SST-1. Recalling the experience from last cool-down of SST-1 machine during November 2006, many investigation and analysis were required to understand the limitations. The machine was open to analyze more in details components viz. Electrical Isolators and LN_2 panels (80 K Thermal shield) for SST-1. The results and out coming of the analysis were time to time presented in presence of Standing Executive Committee (SEC).

Solutions to Isolator problems encountered during commissioning

The function of Helium electrical isolators is to isolate the magnet system electrically from the helium distribution system at desired voltage level of 5 kV (maximum). The total 350 numbers of such electrical isolators for Helium service were installed in SST-1 machine for the magnets and associated auxiliary sub-systems. The functional requirements of Helium isolators are discussed below,

(i) Working condition: 4 bar (a) / 4.5 K with supercritical Helium (inside)

(ii) Compatible to vacuum: 10^{-5} mbar (outside)

(iii) Design pressure: 40 bar

(iv) Helium leak tightness at operating conditions: less than 10^{-8} mbar-l/s

(v) Electrical isolation: 5 kV (maximum)

The materials used for the manufacturing of Electrical isolators (figure A.1.2.2.6) were SS 304 L feed tubes, Stycast 2850 GT (epoxy) and G-10 (CR) tubes.

Figure A.1.2.2.6 Electrical Isolators assembly in parts

During the commissioning attempts of SST-1, the failure observed on Electrical isolators in the Helium circuit was much less than 1% including leak at the stycast joint and two of the helium Isolators have shown body crack of G-10 composite materials out of total 400 isolators and few has shown color change (White patches on Insulator body) as shown in figure A.1.2.2.7. In this regard, we have contacted composite experts within India (M/s. FRP Institute, Chennai). The expert suggested that the cause of such problems might be due to incomplete polymerization during the curing process of composite materials.

Figure A.1.2.2.7 De-colorization of Isolator

The Helium isolators went through all the necessary functional tests under laboratory conditions as mentioned in section (observation). To be more precise, as a part of leak validation of Helium isolators, 12 numbers of randomly selected in-housed developed isolators were tested at 5 bar (a) and 11 K. The integrated leak rate of 12 isolators has been measured as 1.8×10^{-7} mbar-l/s. The temperature sensors were mounted on the SS feed tube surface and middle of the G-10 surface in the experimental set-up. This reveals that from the leak tightness point of view, in-housed developed Helium isolators may be acceptable for using in SST-1 machine but material quality point of view it is not acceptable.

For Evaluation purpose, we procured 15 numbers of Electrical Isolators from Chinese Academy of Sciences, Hefei, China for Helium services and similar Experiment was repeated in order to achieve the further lower fluid temperature. Next campaign, we shall use the Pre-cooling He gas stream using LN_2 Heat exchanger and insulated tube before it enters into LHe Dewar. The test shown helium leak tightness of 3.4×10^{-8} mbar-l/s at 6 K and 5 bar (g) He gas pressure (figure A.1.2.2.8).

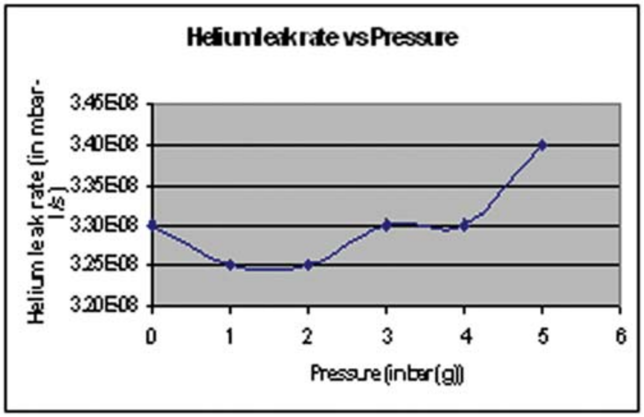


Figure A.1.2.2.8 Helium leak test vs. Pressure Summary of the test results

- Controlled cool-down was carried out from 300 K - 6 K in 18 hrs.
- The experimental results show that the Chinese Isolator was subjected to 5 bar (g) - 12 bar (g) pressure at minimum temperature of 6 K and maximum temperature of 10 K, the He leak rate was remained of the order of 3.3×10^{-8} mbar-l/s.
- During the total test duration of 18 hrs, isolator loop was pressurized to 5 bar (g) constant pressure.
- At elevated pressure, from 5 bar (g) to 12 bar (g), the leak rate was found to be 5.6×10^{-8} mbar-l/s at 20 K.

Allowable Installation condition for Electrical Isolators

During the welding, it is safe that the typical end connections length is more than 100mm to ensure the maximum temperature near the GFRP is below 353K. The allowable bending/Tensile force is less than 200NM/100Kg (for ID/OD of 10/12 mm of He feed tubes) and 500 NM / 250 Kg (for ID/OD of 6/8 mm of He feed tubes) by which the stainless steel ends is flexible. The impact should not be permitted while handling the Isolators.

Looking at the limitation of repair attempts and complexity of SST-1 machine, where on line maintenance or repair of isolators is not possible, we have not been able to develop enough confidence on to use the in-house developed isolators. Therefore, a management decision has been made to use the established and well-proven electrical isolators with similar operational conditions like SST-1. In this regard, we have contacted few established parties who can supply us proven and tested electrical isolators, which can meet our technical specifications and they have established technology and know how.

Solutions to 80 K Thermal shield problems encountered during commissioning

Observed Problems

1. Improper Flux material used in fabrication of Panels, which led to corrosion of brazed elements
2. Non-uniform temperature distribution on the panels
3. Hydraulic imbalance due to tube layout led to higher temperature of some of the panels in which at the outlet unused liquid was coming out
4. Two phase flow
5. Plates / Baffles bolted to the Outer Cryostat side plates, which were at higher temperatures - No active cooling
6. Direct room temperature view on SCMS surface at 4.5 K - No active cooling of Radiation guard present between neighboring panels

Solution to the problems

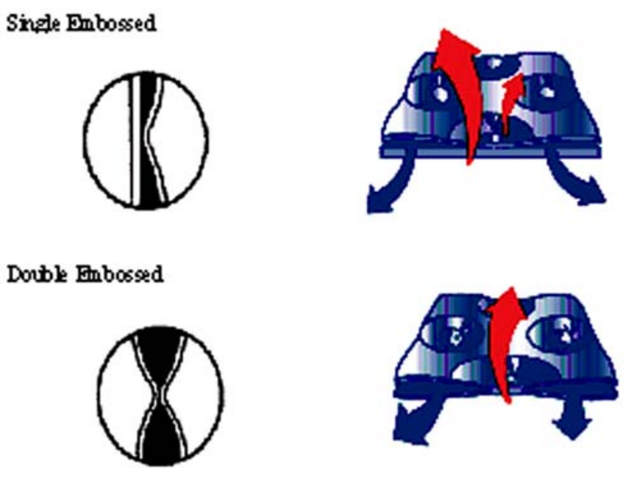


Figure A.1.2.2.9 Concept of Bubble / Embossed panels

After discussions with Space Application Center, Ahmedabad and ITER Cryo pump experts, it was suggested that the Bubble type (figure A.1.2.2.9) of panels could solve the above-mentioned problems. In this line, we have contacted the vendors who have established technology in order to provide such engineering solutions.

Many technical meetings have been carried out after interaction with the vendors and technical specifications have been generated and Tender document has been finalized. Revised heat loads calculations; liquid nitrogen (LN_2) flow requirements have been worked out and finalized. The end connections details along with header sizing have been worked out as a part of reference tentative design inputs to the vendor. Other than these panel requirements, the re-grouping of LN_2 hydraulics has been worked out. Final acceptance criteria for bubble panels have been worked out.

Acceptance Tests criteria for Bubble panels

Thermal shields shall be interfaced with existing LN_2/GN_2 mode cooling. High vacuum (< 10^{-4} mbar) shall be created in which this facility is installed. Cooling of embossed bubbled panels shall be accomplished with existing LN_2/GN_2 mode cooling. Following tests should be carried out as part of acceptance.

(i) Review of the materials test certificates

(ii) Qualified weld procedure

(iii) Factory site QA /QC

(iv) Helium leak tightness at 300 K and 80 K

(v) Hydro pressure tests (10 bar)

(vi) Temperature distribution on to the panel surface

(vii) Pressure drop measurements

(viii) Thermal shock test at LN_2 temperatures (~ 10 cycles)

Laboratory Tests Activities

As a part of Laboratory test activities, following tasks were carried out.

(1) Contribution in Joint validation test experiments

(2) Electrical Isolators validation test experiments

(3) Acceptance of LHe level sensors (20 nos.) at IPR

Acceptance of LHe level sensors

To monitor the level inside the LHe can of current lead we have selected off the shelf available superconducting wire (NbTi filament) based LHe level sensor. We have bought 20 nos. of LHe level sensor stick and level monitor model LM-500 from M/s Cryo Magnetics, USA. This LHe level instrument provide local display as well as it generates 4-20mA self powered current loop output for remote data acquisition system. The control logic for SST-1 cryogenic sub-system has been implemented using Programmable Logic Controller (PLC) and Supervisory Control And Data Acquisition (SCADA). Self-powered current loop output, which is linearly proportional to LHe level measured by LM-500, is most compatible for PLC based control system as its analog input module readily accepts 4-20mA current. In this report we present our experience with this instrument and test result data for quality and performance checking.

Data acquisition system has logged reading of 20 Cryo-magnetics level monitors and one AMI level monitor at scanning rate of 10 sec every channel. Data file is stored in text file in column wise channel data. From all this data we have seen that ch-9 has maximum similarity in reading with AMI level monitor. Keeping this in mind we have prepared ch-9 Vs other remaining channels plot.

Soft-starter Installation and test activities for LHe plant

The superconducting magnet system of SST-1 Tokamak is cooled with 1.3 kW helium refrigerator/liquefier (HRL). To meet this cryogenic load 3 numbers of oil injected Helium Screw Compressors (02 operational + 01 redundant) are required. The normal mass flow rate from each compressor is 70 g/s at 14 bars. Each compressor is coupled with three-phase induction motor of rating 315 kW. The soft starter reduces the starting torque and also stress on electrical supply. This will ensure the life of motor as well as reliability of operation under DG mode. The installed soft starter was optimised for different starting in-rush current with respect to different parameters and it has shown initial reduction of starting current from 3000 A to 1600 A. It also offers smooth starting of electric motor by controlling motor torque, voltage and current during the accelerating period

Testing with Screw Compressors (A, B, C)

- Individual testing of compressors with and without DG set carried out at maximum load.
- Initially, single compressor has been started with Soft-Starter. After successful starting, Soft-Starter has been by-passed. Same sequence is repeated for starting second compressor.
- Compressor Sequence logic and Soft-Starter performance checked by operating different sequence modes of the compressors like A-B-C, A-C-B, B-A-C at maximum loads capacity with and without DG set.
- Each time, while testing of compressors with Soft-Starter, temperature at cable, Soft-Starter and entire panel temperature have been measured and found to be under acceptable limits.

Pneumatic testing of the Helium gas Storage tanks at IPR

During last week of December 2007, the pneumatic pressure testing of the Helium gas storage tanks activities have been carried out as a part of Controller of Chief of Explosives (CCE) license approval.

Periodic testing of pressure vessel in service

1. All vessel shall be hydraulically tested by the competent person at a pressure marked on the vessel at intervals of not more than five years after the date of first test, provided that in the case the vessels, containing corrosive or toxic gases, the periodic testing shall be done at an interval of two years. In case of vessel which are designed, constructed or supported that they cannot be safely filled with water or liquids for hydraulic testing or which are used in service where traces or water cannot be tolerated, the chief controller may permit pneumatic testing along with non destructive test instead of hydraulic testing as per procedure laid down in the vessel fabrication code; after satisfying the adequacy of the safety precaution undertaken.
2. The competent person carrying out the test as required shall issue a certificate of test in the prescribed Performa.

Codes Compliance

As per Rule 19 of the SMPV Rules, the periodic testing of these vessels has become over-due. Under SMPV Rules (1981) issued and under practiced by CCE rule No. 19 Clearly states that for CODE COMPLIANCES

1. Test Procedure Compliance Code:
   SMPV Rules 1981
2. MP Vessel Fabrication code:
   ASME Sec VIII Div. 1 1998 Addenda 99
3. HP Vessel Fabrication code:
   ASME Sec VIII Div. 2- 1995, Incl. A 97

Following test procedures were worked out

Procedure for HP vessels [Multi layered vessel]

1. Physical examination of the vessel surfaces, welds etc.
2. Ultrasonic flaw Detection of the dish ends and welds of dished end with Shell.
3. Dye Penetration Testing at Nozzle necks, Man Holes and other openings
4. Pressure Testing of the Vessel using He Gas at 110% of the Design Pressure i.e. 179 kg/cm^{2}. Pnematic test pressure shall be reached gradually increasing the pressure to ½ of the test pressure. Thereafter it shall be increased in the steps of 1/10th of the test pressure until the required test pressure is reached. The pressure shall thereafter be reduced to 4/5th of the test pressure immediately and held for the sufficient time to permit the inspection of the vessel for leaks.

Procedure for MP vessels

1. Physical examination of the vessel surfaces, welds etc.
2. Ultrasonic flaw Detection of the dish ends and welds of dished end with Shell.
3. Dye Penetration Testing at Nozzle necks, Man Holes and other openings
4. Magnetic particle test of the welds from outside.
5. Pressure Testing of the Vessel using He Gas at 110% of the Design Pressure i.e. 19.8 kg/cm^{2}.

TEST RESULTS

- ***For MP tanks (4 Nos.)***

1. NDT testing covering Dye penetration test, Ultrasonic testing and Magnetic particle (only for three tanks) test has been done and found satisfactory as witnessed by the CCE authorized representative for all MP Tanks.
2. Pneumatic testing of all the tanks has been done using helium gas as per procedure approved by CCE and found satisfactory as witnessed by the CCE authorized representative for all MP Tanks.
3. All MP tanks were tested for maximum pressure of 18 bar using Helium gas successfully for holding it 10 minutes.

- ***For HP tanks (2 Nos.)***

1. NDT testing covering Dye penetration test, Ultrasonic test has been done and found satisfactory as witnessed by the CCE authorized representative for all HP Tanks.
2. Pneumatic testing of all the tanks has been done using Nitrogen gas as per procedure approved by CCE and found satisfactory as witnessed by the CCE authorized representative for all MP Tanks.
3. All HP tanks were tested for maximum pressure of 160 bar using Nitrogen gas successfully for holding it 10 minutes using cryogenic evaporator and pressurization system.

Operation and Control Division

This division is responsible for monitoring and control of SST-1 tokamak, which includes monitoring and control of plasma experiment in real time, event distribution in real time to all the subsystems, time synchronization of all the systems on SST-1 LAN, protection of man and machine, to provide user friendly access to centrally archived machine data and experiment data, control room facilities, remote experiment facility and to maintain central information repository for SST-1.

The in house developed software- Machine Control System (MCS) monitors all SST-1 subsystems and synchronizes them to make SST-1 ready for operation. At any instance, the software reflects the integrated view of all the subsystems' status and maintains software interlocks for them to proceed safely. The real time monitoring and control of plasma operation demands specialized hardware and software. To fulfill the demand of 100 msec closed feedback plasma position control we have procured hardware and developed the real time control software to meet the requirements.

Various distributed controls need to be operated simultaneously for the integrated plasma control. This requires real time distribution of events to all the subsystems. The group has designed and developed VME based timer modules. The modules have been tested successfully and give the latency of less than 4 msec.

The previous SST-1 campaign showed that time stamping of data acquisition systems of individual SST-1 subsystems depended on the local clock of their own controller and there is no correlation among the data acquired by individual subsystems. To overcome this problem we have tested the network time synchronization software on few PCs and received the time synchronization of the order of 10th millisecond. Soon all the systems

[PCs, VME, PXI] on SST-1 LAN will be synchronized. We have installed 4 cameras for SST-1 tokamak surveillance and 12 cameras at the subsystems controller end. We have also installed a CCTV network between central control room and various users in IPR to view any of these camera views.

This group has developed a web based central information repository system for SST-1 as shown in figure A.1.2.2.10. It serves as a single point access to all the SST-1 subsystems information such as technical reports, operation manuals, publications, assembly videos, test results etc. With the click of a button one can add information to the repository. As the system is web based, one can add, modify and retrieve the information from any PC over the IPR LAN. With built in search engine, the information retrieval becomes easy and fast. The system also provides collaborative writing of a document.

Presently the SST-1 subsystems are individually archiving their plant specific data to their own storage system. In this scenario each subsystem has to maintain the spare storage requirement, needs the backup software and policy and develop the expertise for backup/restore. To overcome these problems, we have planned for network based centralized modular storage system for SST-1. The system will have sufficient redundancy and 24X7 availability. A periodic backup will assure availability of SST-1 data through out its life cycle.

Data Acquisition division

This division is engaged for the development of data acquisition hardware and software to fulfill the data acquisition needs of SST-1 plasma diagnostics. These requirements are being fulfilled by PXI based system and by indigenously developed CAMAC based system. To overcome the distance limitations offered by ISA as well as parallel port CAMAC crate controller, we have developed Embedded PC 104 based CAMAC crate controller with Ethernet connectivity. As a part of progress in building in-house CAMAC digitizer we have developed a single width 6-channel 12-bit CAMAC transient digitizer with Multi-layer PCB as shown in figure A.1.2.2.11.

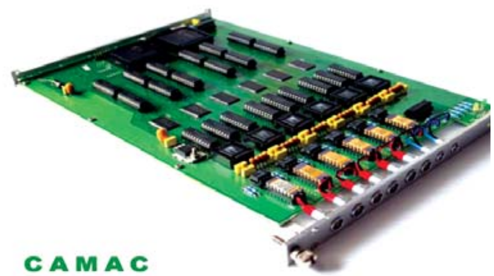


Figure A.1.2.2.11 Six-channel 12-bit CAMAC Transient Digitizer

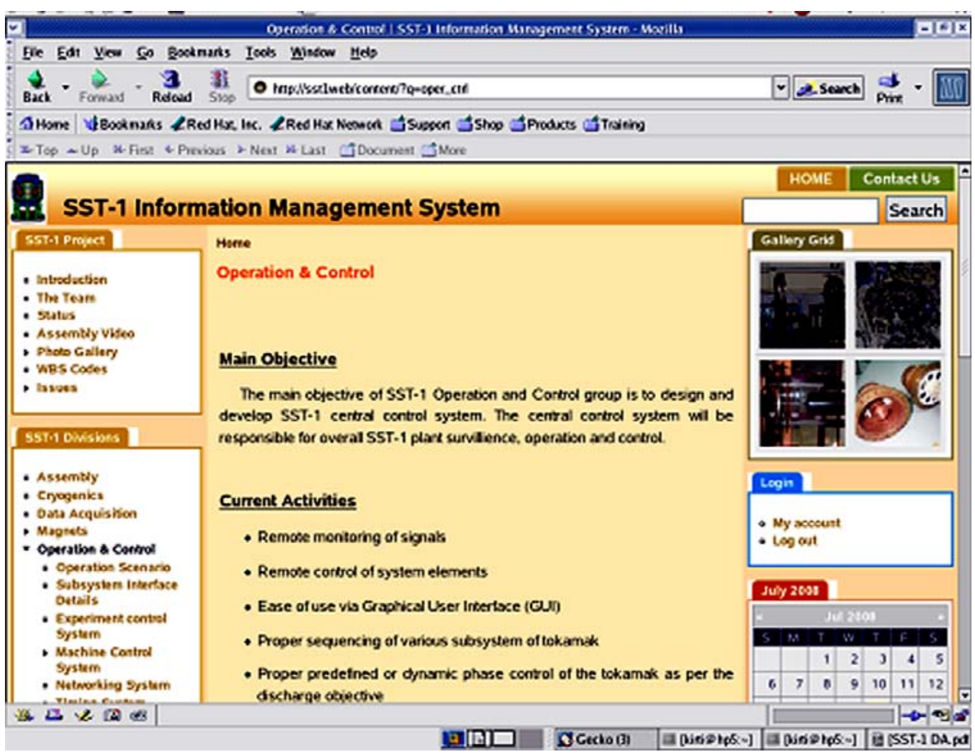


Figure A.1.2.2.10. SST-1 Information management system (SIMS)

With this we can accommodate more number of channels per CAMAC crate. The designed module is a transient digitizer, which has been designed to operate in either Burst mode or Pre/Post Trigger Mode. The module has six differential input channels with dedicated 12-bit ADC per channel providing maximum sampling rate 3MSPS per channel. Pre-trigger and Post-trigger intervals are programmable. The developed module has been tested in CAMAC data acquisition system with precise test and measurement equipments. The testing has been performed with GUI developed in LabVIEW as well as LabWindows/CVI application software. We have tested for the acquisition phase shift between channels and found no phase shift between channels. We have configured the module through software commands for different pre/post trigger samples and then verified the plotted acquired data for these exact pre/post trigger numbers. We are developing Test Generator CAMAC Modules using micro-controller/Re-configurable devices for testing of data acquisition system.

A Network Storage server with a capacity of 1Terabytes has been procured towards a centralized Data Storage Server for SST-1 Diagnostics. It has been installed and tested in integration with our continuous data acquisition system for 1000 sec. using PXI based system through LabVIEW application software. Consequently the data so archived was plotted for offline data analysis using Matlab. This utility for offline transmission of 32 channels data, reads the data from Flat file system (Binary files) on network server, which can be plotted for data analysis. Further it can also save data on local hard disk for future reference.

A.1.2.3. Diagnostics Developments

Far Infrared Interfero/Polarimeter for SST-1

A schematic layout of the multiview, multichannel far infrared interferometer is shown in figure A.1.2.3.1. The radiation source for interferometer, a twin far infrared (FIR) laser, is housed in a clean room FIR interferometry lab adjoining the SST-1 hall. The erection of clean room has been completed during this year and the laser was shifted to the same. The oversized dielectric waveguides for propagating laser beams from laser output couplers in the lab to SST-1 tokamak were installed and aligned using He-Ne laser. The waveguided transport ends near the tokamak and the beams will be transported in free space. The free space propagation involves steering, focusing and manipulating the beams using around 70 optical components mounted on a support structure.

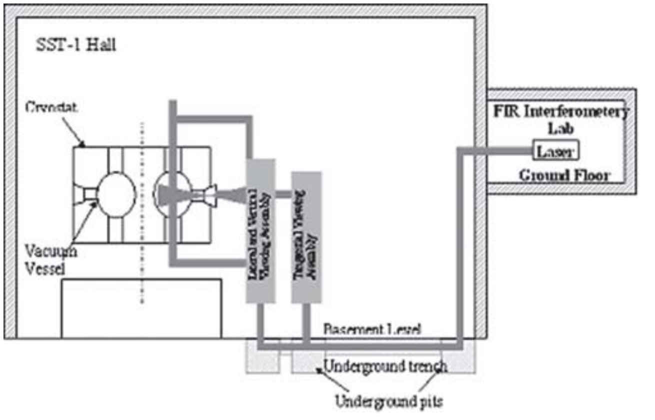


Figure A.1.2.3.1. General Layout of FIR Interferometer for SST-1

The interferometer support structure assembly (shown in figure A.1.2.3.2) consists of (i) a rigid frame with stainless steel pipe columns anchored to the basement floor slab; (ii) vibration isolators supported on these pipe columns and (iii) a modular support structure. The 3-D assembly drawing of the system was completed during the year. The fabrication drawings for the rigid frame and all the 13 modules of modular support structure were completed and the vibration isolators were procured during the year. The procurement of the complete support structure assembly was initiated. Further the conceptualization of the radiation source for lateral viewing option has also been initiated during this period.

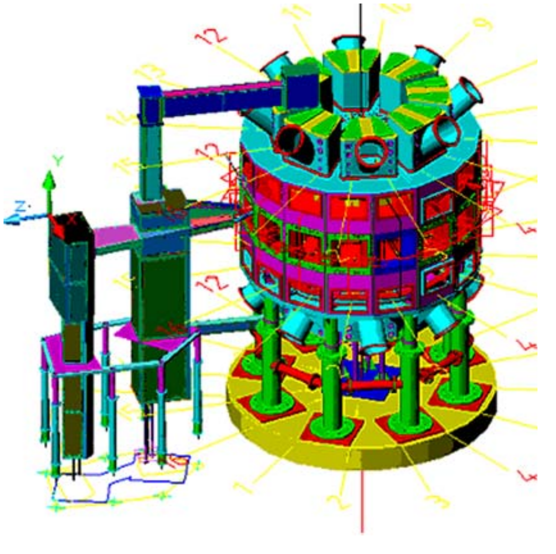


Figure A.1.2.3.2 Interferometer Support Structure Assembly for SST-1

A.1.2.4. Heating and Current drive systems

ICRH System

Work for automatic on-line matching of SST-1 plasma impedance with antenna impedance completed successfully and now the testing of the second transmission line-antenna system is going on. We could match the variable load impedance with the help of variable capacitors and stubs in less than 40 ms, which is better than that of many other tokamaks. Complete ICRH system from 1 MW rf generator up to tokamak SST-1 including hybrid coupler, vacuum interface etc. is planned and is being executed.

RF group is developing 180 kW, 1 MHz rf generators for NBI Group. The conceptual design completed. All the components finalized and many important indents have been raised. The engineering design of the rf generator is in progress.

In order to have 1.5 T operation of SST-1, 45.6MHz at 1 MW is required. The development of 100kW rf generator is in process. The required power supply system is conceptualized and generated specifications for the supply system. Indent has been raised and purchase process in progress

Development of 70kV, 22A HVDC facility for testing high power microwave devices is in progress. It consists of 11 kV voltage variation system, solid state crow bar system and HVDC rectifier system. The 11kV Voltage Variation system of rating 2MVA has been tested successfully and arrived at IPR. The solid state crow bar system is finalized and indent raised and is in the stage of placing order. The technical specifications for the HVDC rectifier unit have been generated, indent has been raised and the unit is in the stage of doing factory acceptance tests.

Rigid co-axial transmission line components like 6" TEEs, reducers, directional couplers to be used at 350 MHz, 120 kW power for BARC are fabricated, tested and supplied to BARC, Mumbai. Figure A.1.2.4.1 shows the photograph of the directional coupler developed indigenously for high power measurement and supplied to BARC, Mumbai.

Figure A.1.2.4.1 Directional coupler for high power measurement

Fast Ferrite Tuner 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. In addition, power delivered by tetrode-based amplifier is a strong function of SWR at its position. Thus impedance matching plays very important role in ICRH scheme. Minimum response time achieved by using methods other than Fast Ferrite Tuner (FFT) is 40-50 ms. FFT is designed for input power of 600 kW, Insertion loss < - 0.15 dB, Return loss > 25 dB, Response time for matching ($\rho \leq 0.65$) with active feed-back ≤ 6 ms. Its accessible mismatch region is reflection coefficient $\rho \leq 0.65$ with all phases.

FFT will be used in double stub configuration. First one-stub of FFT (FFT-1) will be tested for all required parameters and after its successful testing, second FFT stub (FFT-2) will be made and tested. It consists of a RF strip-line (figure A.1.2.4.2) partially filled with magnetized ferrites. The ferrites are placed on the inner conductor, where rf magnetic field is the strongest. Those are perpendicularly biased by combination of permanent magnet and electromagnet yoke assembly (figure A.1.2.4.3). The

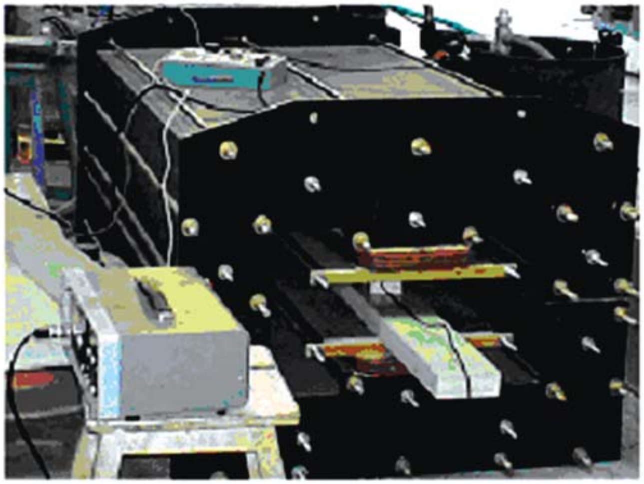


Figure A.1.2.4.3 Electromagnet yoke assembly permanent magnet is used to set bias point of the ferrite in low loss region. An electromagnet yoke assembly is used to change permeability of ferrites around the bias point, which in turn leads to change in reactance of partially filled strip-line. As a result, change in reactance is achieved just by changing an electromagnet current, enabling to achieve low response time.

Its electromagnet yoke assembly consists of electromagnet coils and H-type of yoke. It is designed to give uniform flux of 500 G in the area of 230 mm×1500 m. As it will operate on time-scale of 6ms, it is made up of CRNGO stampings. Weight of the yoke assembly is about 5 ton. Up to 300 A DC and AC current are passed through electromagnet coils and magnetic flux measurements are done. Flux density and flux uniformity is as per our calculations. Its RF assembly consists of a strip-line and strip-line to 9 inch coaxial line adapters (figure A.1.2.4.2). Its testing is in progress.

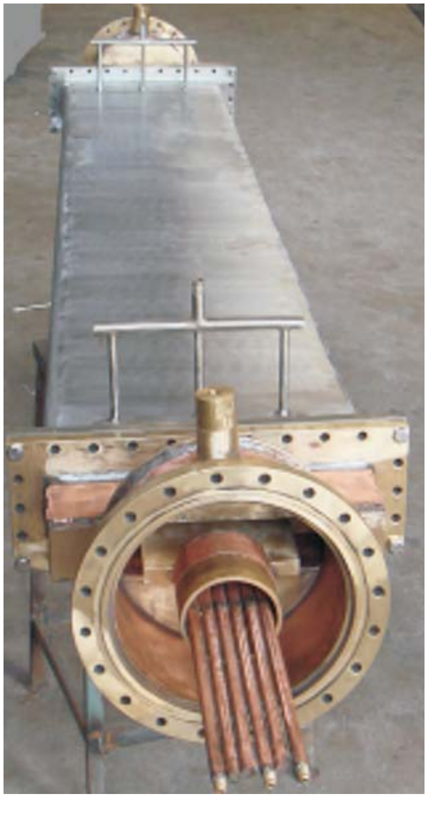


Figure A.1.2.4.2 FFT mechanical assembly

Two (1 kW, 13.65 MHz) RF generators have been fabricated, tested and been supplied to BARC and Defense laboratory. The testing of the 30 kW rf generator to be supplied to IUAC is in final stages of completion.

LHCD System

The activities related to up gradation of LHCD power from 1 MW to 2 MW have been initiated. Two more klystrons each of 500 kW would be augmented with existing two klystrons in the existing LHCD high power source section in SST-RF bay. Based on the space constraint, a new support structure has been designed on which all the four klystrons would be erected. The high power rf components would be mounted on a platform beneath which network of all the cooling lines would be installed. The scheme for the support structure is shown in figure A.1.2.4.4.

A detailed cooling layout scheme for the new high power klystrons setup has also been designed. Data acquisition and control system for new klystrons is also being pursued. Auxiliary power supplies for the additional klystrons are under fabrication.

In collaboration with CEERI, Pilani, the activities for the brazing of second proto-type window having eight ceramics in a single titanium alloy frame has been initiated. The flange is mechanically prepared and slots using wire-cut machine has been made. The ceramics have been fitted into the titanium alloy flange. The brazing of the assembly has been carried out.

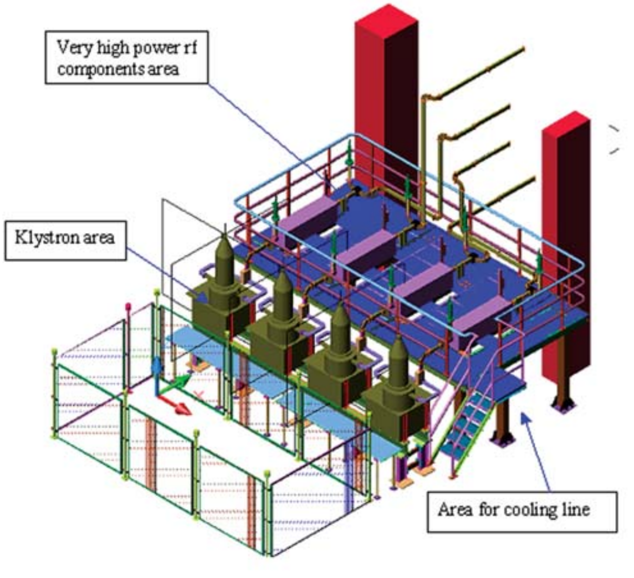


Figure A.1.2.4.4. Schematic of new support structure, which will house all the four klystrons. High power rf components are placed on platform whereas cooling line network is placed beneath it.

To characterize the rf performance of the milled plate module and in vessel module together, a support structure has been fabricated. Both, the milled plate module and in vessel module have been installed on the structure and alignment of the both the modules are being carried out.

The main 64-channel rf window has been sent back to PPPL for repair. The contractual procedure for the procurement of new klystrons is underway.

Optical signal communication between DAC (LHCD) and RHVPS established for final operation of klystrons using RHVPS and the planning for wire burn test is in process

ECRH System

The subsystems for the operation of 82.6GHz Gyrotron have been tested for its readiness for the gyrotron testing at IPR. The data acquisition and control (DAC) system has been upgraded by incorporating the new interlocks like silence of gyrotron. Rogowski coils are designed for dI/dt interlock for gyrotron and checked for its performance and reliability. The DAC software has been upgraded for MDS plus based data visualization.

The 82.6GHz gyrotron was tested for ~200kW/1000s operation into a calorimetric dummy load at M/s. Gycom Russia in the presence of IPR representatives. Figure A.1.2.4.5 shows the gyrotron test set-up used for 200 kW, 1000 second operation at Gycom, Russia.

The indigenously developed series ignitron based crowbar protection system to be used above 50 kV for Gyrotron and Klystron is currently being redesigned to incorporate the snubber circuits in the protection scheme.

The scheme of current monitoring of magnet current of 28GHz Gyrotron was modified and current is monitored directly from shunt in the power supply.

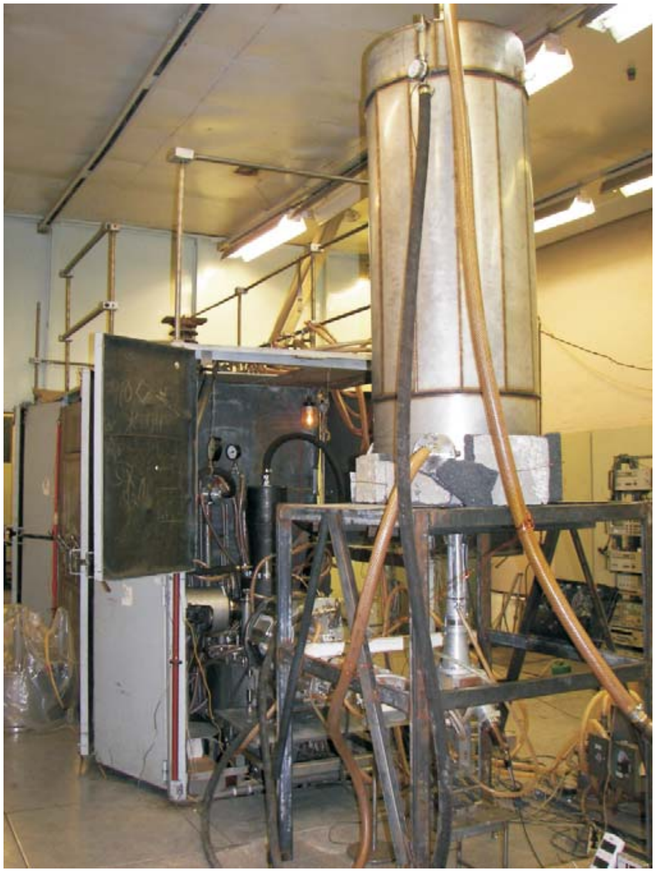


Figure A.1.2.4.5 High power Gyrotron test with Calorimetric dummy load

Design and study of quasi-optical mode converter and phase correcting mirrors systems has been undertaken under the National Fusion Program.

FPGA based interlock system is designed and tested for 8 channels system. Micro-controller based delta T measurement has been developed and tested for temperature monitoring in cooling system which is planned to be used in high power gyrotron systems.

A.1.2.4.2 Neutral Beam Injection

Operational integration of the ion source with the power supply and data acquisition and control system to extract ion beams for the SST-1 NBI formed the focus of the on going commissioning activities in this system. Ion beam current up to 10 A have been extracted at 25 kV beam voltages from a prototype ion source specially designed for this objective. Essential diagnostics (Doppler shift spectroscopy, thermocouple based data etc.) and other operational systems (RHVPS, HV Deck, Data Acquisition & control system, gas feed system, power supply, and power transmission system) have been qualified and integrated as functional systems. Further control systems (and algorithm) in the form of over current protection and re-application of high voltage following a break down have also been qualified. These have enabled the possibility of operation of the 5 MW PINI ion source on the Test Stand, which forms the next milestone.

A brief description of the experimental system and major results are presented below. This is followed by a short report on the assembly activities on the PINI ion source, where reassembly of the ion source has been successfully completed within the prescribed alignment accuracies.

Beam extraction activities

The beam extraction from a prototype ion source was to carry out tests and qualify the various subsystems, namely the RHVPS, HV Deck, Data Acquisition & control system, gas feed system and diagnostics (spectroscopic and calorimetric). The experiments were carried out with the following objectives a)Operating integrated neutral beam system and b) test the subsystems such as Power supply, Power transmission system, diagnostics, data acquisition and Control Systems, gas feed system compatibility with high voltage and operational and control algorithms.

Experimental set up for the beam extraction

The experimental setup primarily consists of a vacuum vessel, the prototype ion source, the RHVPS, HV Deck and Data Acquisition and control system, gas feed and diagnostics. A schematic view of the setup is shown in figure A.1.2.4.2.1. The salient features for each of the subsystems are described. All the major subsystems are described below. Also, the operational experience and the results obtained are presented.

The prototype ion source

The prototype ion source primarily consists of a plasma vessel and an ion extractor system. Hydrogen plasma of density 10^{11} /cm3 is produced in the plasma vessel by using hot tungsten filaments for electron emission and then striking an arc discharge. The hydrogen ions of the plasma are extracted and accelerated to required voltages of 10 - 25 kV by the ion extractor system. The plasma vessel is a cylindrical water cooled chamber of length 43 cm and of diameter 45 cm.

Magnetic confinement of plasma is required to enhance plasma density and thereby improve beam current. The present ion source has a magnetic multi-pole line cusp configuration for plasma confinement. This configuration is achieved by surrounding the exterior of the vessel wall with samarium cobalt magnets in continuous line cusp geometry (figure A.1.2.4.2.2.). The samarium cobalt ($SeCo_5$) magnets were used due to their high surface magnetic field (Bmax > 4 kG) and high curie temperature (7500 °C) suitable for a safe operation at higher temperatures.

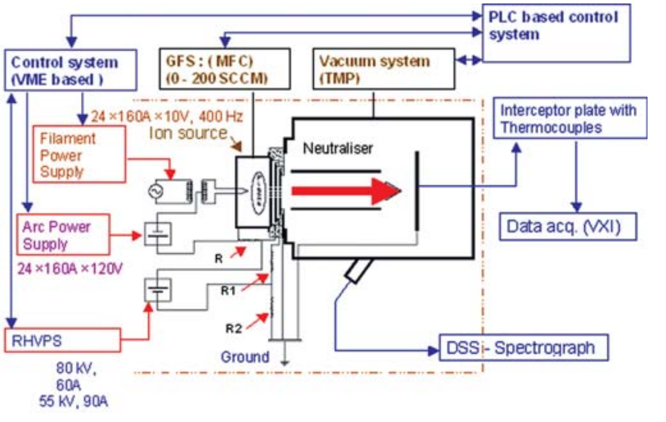


Figure A.1.2.4.2.1 Schematic of the experimental setup

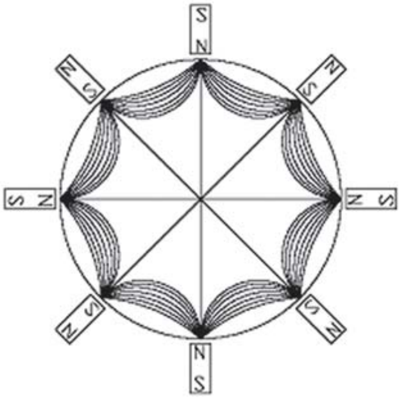


Figure A.1.2.4.2.2: Schematic cusp field configuration

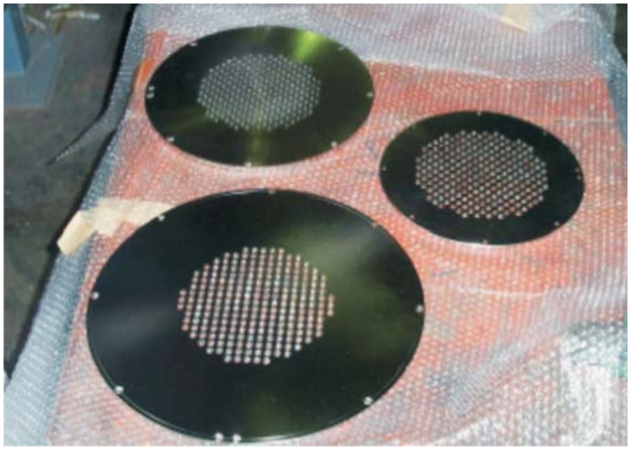
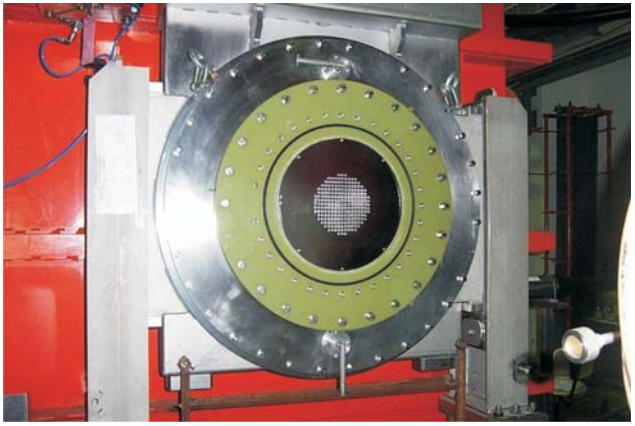
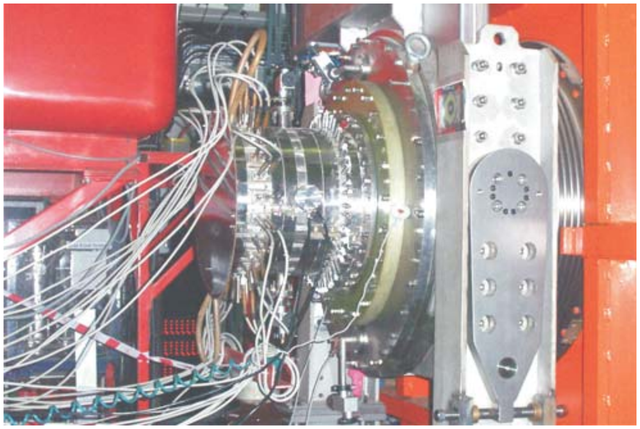


Figure A.1.2.4.2.3 (a) Three grids of the extractor system



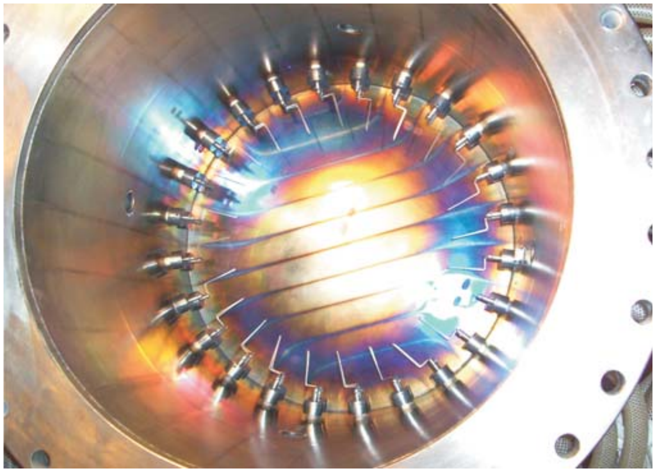
(b) Extractor system mounted on the test stand



(c) Prototype Ion source on the test stand

Extractor System

The ion extractor system was fabricated for the purpose of generating a 5-10 ampere H^+ beam at acceleration voltages of



(d) Inside view of the ion source

10 - 25 kV. The extractor system has three grids namely; the acceleration (plasma) grid, a deceleration grid and an earth (ground) grid. All the three grids are mounted on a 50 mm thick G10 block. There are 217 numbers of apertures on each of these grids with aperture size of 8 mm. The total grid transparency is 7 % resulting in an extraction area is 110 cm^2.

Configuration :Magnetic multi-pole line cusp ion source
Total cusp length : 1360 cm
Magnet used : Samarium Cobalt ($SeCo_5$)
Total number of filament : 24 (tungsten)
Total number of filaments used in the experiment : 9
Filament diameter : 1.6 mm and length : 16 cm
Chamber pressure : 1×10^{-3} torr (H_2)
No Active Cooling
Extraction system : triode type
Number of aperture in grid : 217
Dia. Of the grid holes : 8 mm
Extraction area : 110 cm^2 (Grid transparency : 7%)
Total loss area : 3000 cm^2
Discharge Voltage : 120 V
Grid biasing: Plasma grid biased with plasma box via 5 Ω resistance

Table A.1.2.4.2.1. The salient parameters of the prototype ion source

NBI power supply system

This system consists of Regulated High Voltage Power Supply (RHVPS), Discharge power supply and filament power supply. The system is operated by VME based control system. The schematic of the power supply system is shown in figure A.1.2.4.2.4. The system's specifications are as follows:

Component	Specifications
Regulated HV power supply for acceleration	80kV, 75A, modular switching topology, rise/fall time 10ms-100ms, regulation 1%
Discharge power supply	24 x 160V, 100A switching converter, rise time less than 5 µs
Filament power supply	8 x 7kVA, 15V, 155A, 400Hz inverter, 20s Soft start
HV deck	Air insulated 4×4×9m
Snubber deck	Air Insulated 4×4×4m

Table A.1.2.4.2 2. Power supplies (RHVPS & HV Deck)

Data Acquisition and Control system (VXI + VME)

The NBI Data Acquisition and control system was built by using a combination of the standard VME and VXI systems. The schematic of the control and its interface with the NBI sub-systems are shown in figure A.1.2.4.2.5 (a). The operation and timing sequence is shown in figure A.1.2.4.2.5 (b).

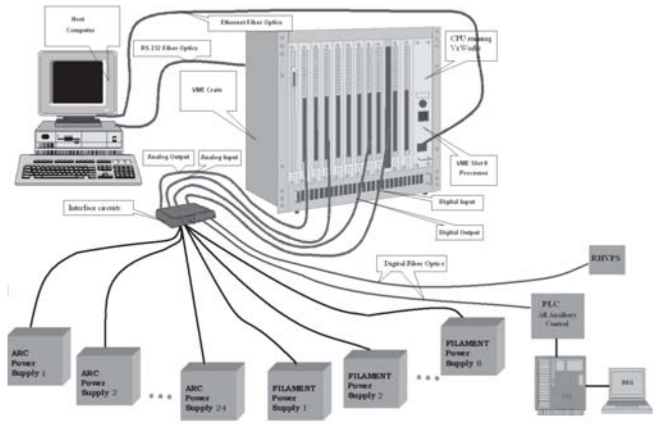
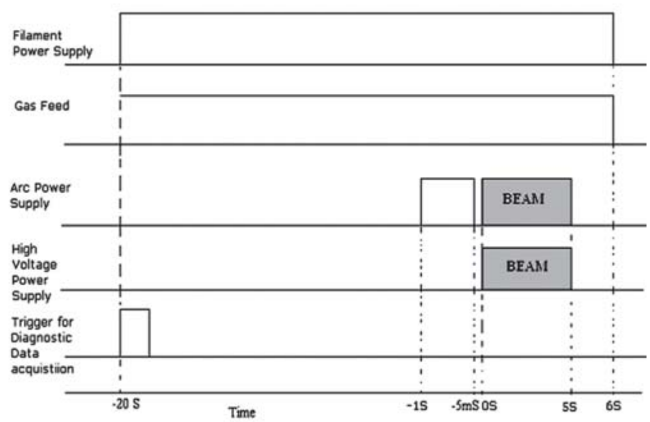


Figure A.1.2.4.2.5 (a) Data Acquisition and Control system and its interfaces with the NBI subsystems.



(b) The timing sequence of the NBI Control system.

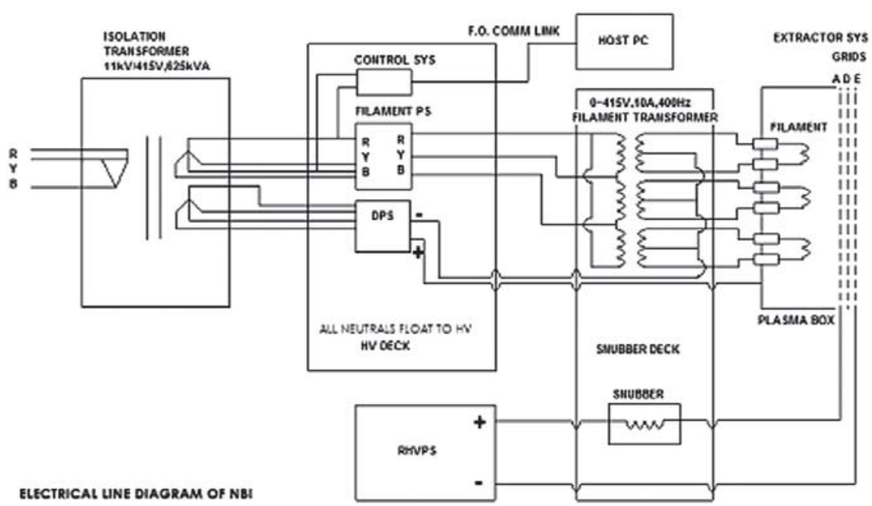


Figure A.1.2.4.2.4: Schematic of the NBI power supply system

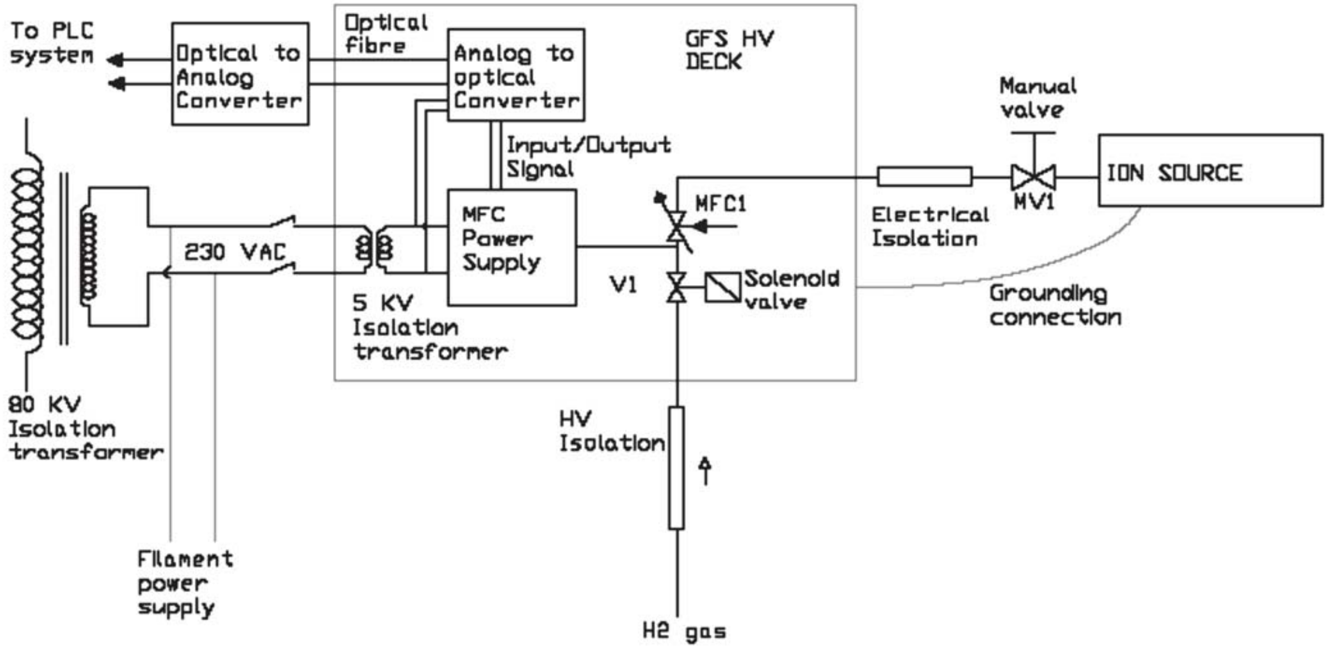


Figure A.1.2.4.2.6. The electrical diagram of mass flow controller for feeding gas to ion source

For extraction of Hydrogen ion beam from a plasma box, the Arc, filament and High voltage power supplies have to be applied in a predefined sequence. This operating sequence is controlled by a VME system, which receives the signal for initiating action from the PLC system already available with the main control of the injector. Additional tasks of control system are: 1) provide various interlocks with water, gas and pressure level of the, beam line, 2) take necessary protective action when breakdown occurs in the ion source and for reapplication of the RHVPS for reinitiating the process of beam extraction, 3) set the limits on number of allowed breakdown in a given beam pulse, 4) maintain constant arc current during the beam pulse by controlling filament heater current. Signal exchange with different module of control system has been provided by fiber optic link.

Gas Feed System

The purpose of the gas feed system is to supply hydrogen gas to the ion source. The system comprises of a set of Mass Flow Controllers (MFC). As the gas feed system is directly connected to the ion source it is provided with an electrical isolation for 55 kV and is operated by means of fiber optic based control system (figure A.1.2.4.2.6). The system is designed to supply H_2 gas for the flow rates of 0 - 100 torr/s and also to control the flow to an accuracy of about 1 %.

The Diagnostics

The diagnostics comprises of a Doppler shift spectroscopy system (DSS) and a differential calorimeter. The DSS continuously monitors the ion species fraction of the prototype ion source and is also used for estimating the divergence of the beam. The DSS consists of 1-m visible spectrograph that records the Doppler shifts in the H_α (656.3nm) produced by the beam. A differential calorimeter was fabricated by stacking copper blocks of size (4cm×4cm) (figure A.1.2.4.2.7 (a)). Each of these blocks were instrumented with K-type thermocouples to record the beam power incident on each of these blocks. This data is then used to obtain power density profile of the beam (figure A.1.2.4.2.7 (b)).

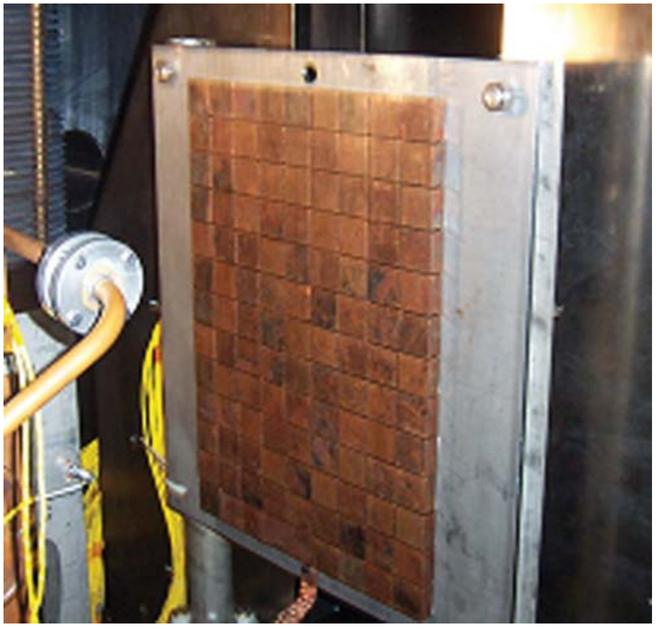


Figure A.1.2.4.2.7(a) The front view of the differential calorimeter

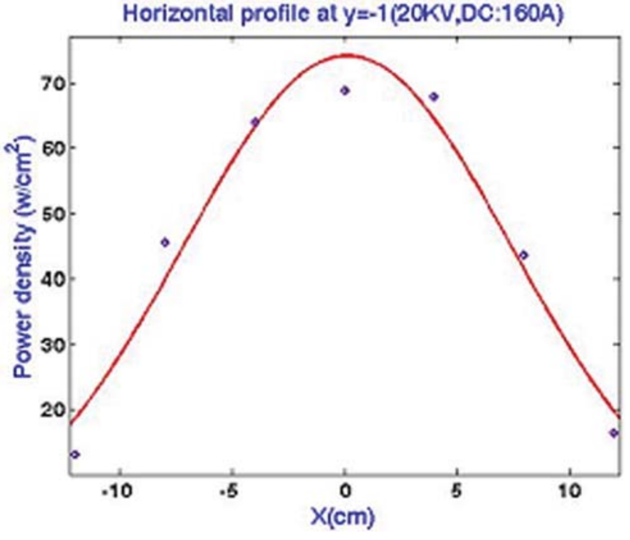


Figure A.1.2.4.2.7 (b) A typical horizontal power profile obtained using the differential calorimeter.

Results

The results obtained during the operation of the NBI system are comprises of the output data obtained from the electrical, spectroscopic and thermal diagnostics. They are presented below.

Discharge Study in plasma box

The discharge study was performed to optimize biasing resistance of the plasma grid and also to establish the appropriate parameter space of operation. The biasing of plasma grid is done to increase the plasma confinement and thereby

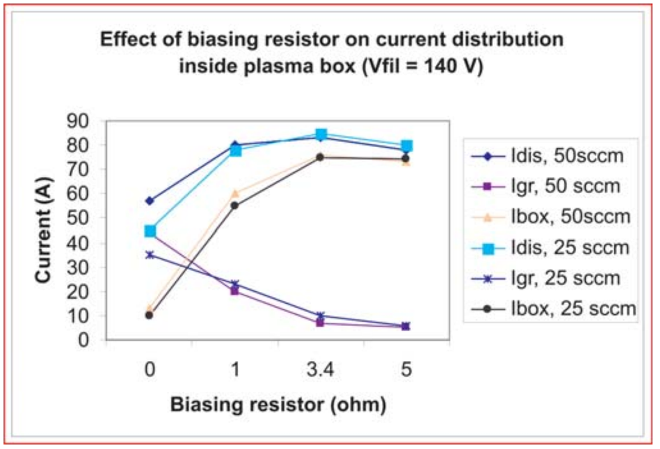


Figure A.1.2.4.2.8: Variation of grid current with biasing resistor

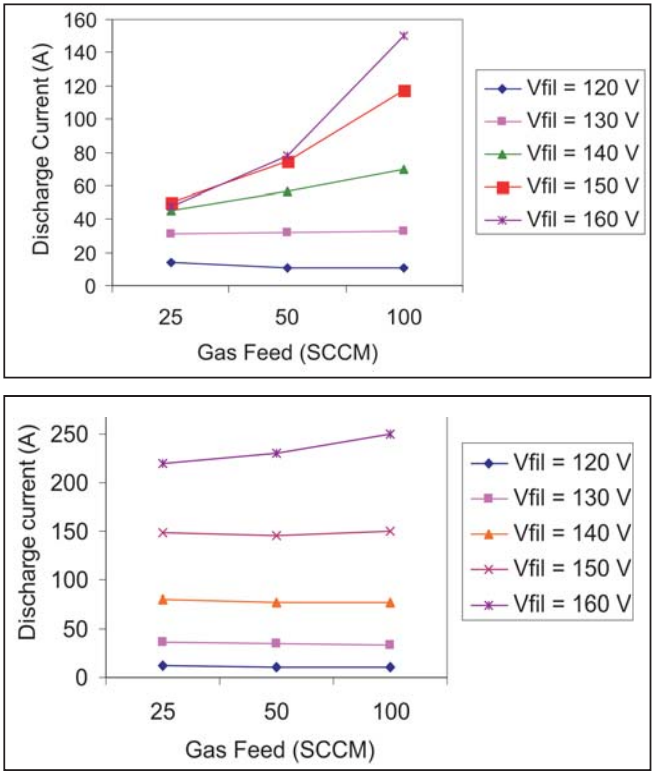


Figure A.1.2.4.2.9.Variation of discharge current with gas feed with (a) zero biasing resistance (b) biasing resistance of 5 Ω.

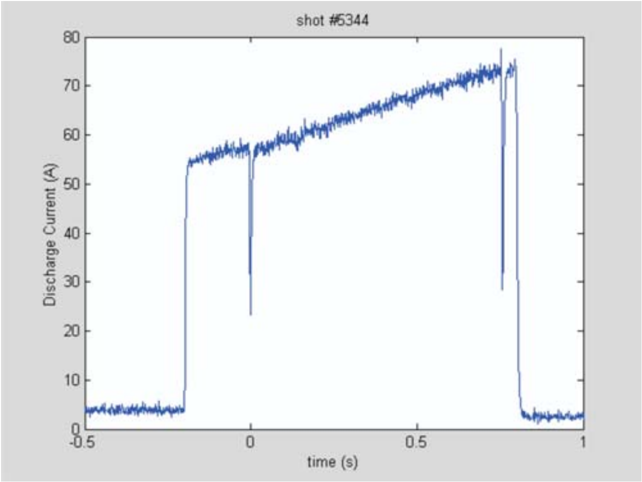


Figure A.1.2.4.2.10 (a) Variation of discharge current

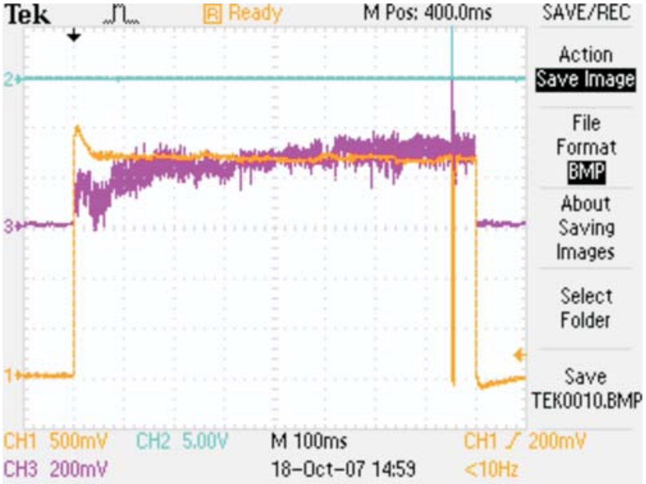


Figure A.1.2.4.2.10 (b) Variation of beam current

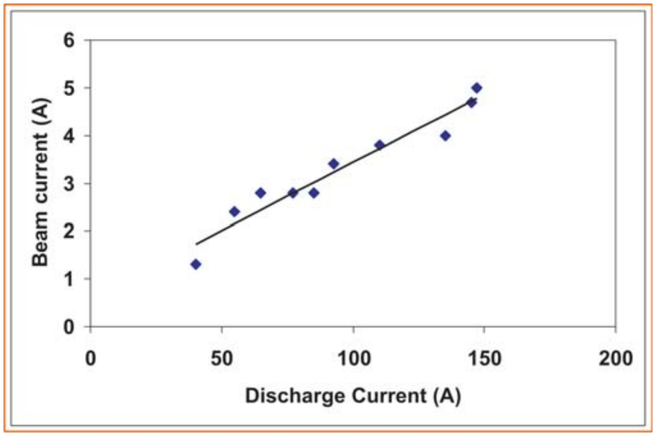


Figure A.1.2.4.2.10(c) Variation of beam current with discharge current

enhance the plasma density. It has been observed that the total discharge current rises with an increase of biasing resistance but saturates beyond 5 Ω.

Behaviour of discharge current with gas flow

When, the plasma grid is electrically shorted with plasma box, it was observed that the total discharge current rises with the increase of the gas feed. However, when the plasma grid is connected with the plasma box through the biasing resistor, the variation in gas flow did not have any effect on the discharge current (< 200A). This is due to the complete confinement of the primary electrons. But beyond 200A, discharge current again rises with the gas feed possibly due to the increase in the number of available primary electrons for ionization.

Electrical measurements:

Typical discharge current and beam current are shown in the figure A.1.2.4.2.10 (a,b). Operating parameters during above shots: Acceleration Voltage = 20 kV, Discharge Voltage = 120 V, Gas Feed = 50 SCCM, Resulted I_d/I_b ratio ~ 30. Figure A.1.2.4.2.10(c) shows the variation of beam current with discharge current.

Doppler Shift Spectroscopy

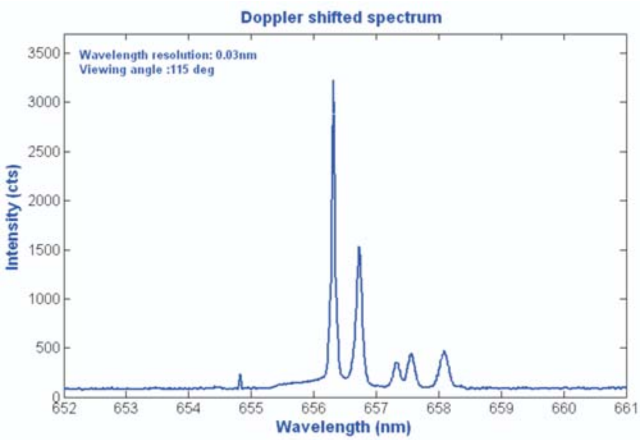


Figure A.1.2.4.2.11. A typical Doppler shifted spectrum of the hydrogen beam. The three small red shifted H_α spectral peaks are due to the three energy component of the beam. The largest peak is due to the un-shifted H_α spectral peak emitted by the background. The second largest peak is due the residual water vapor.

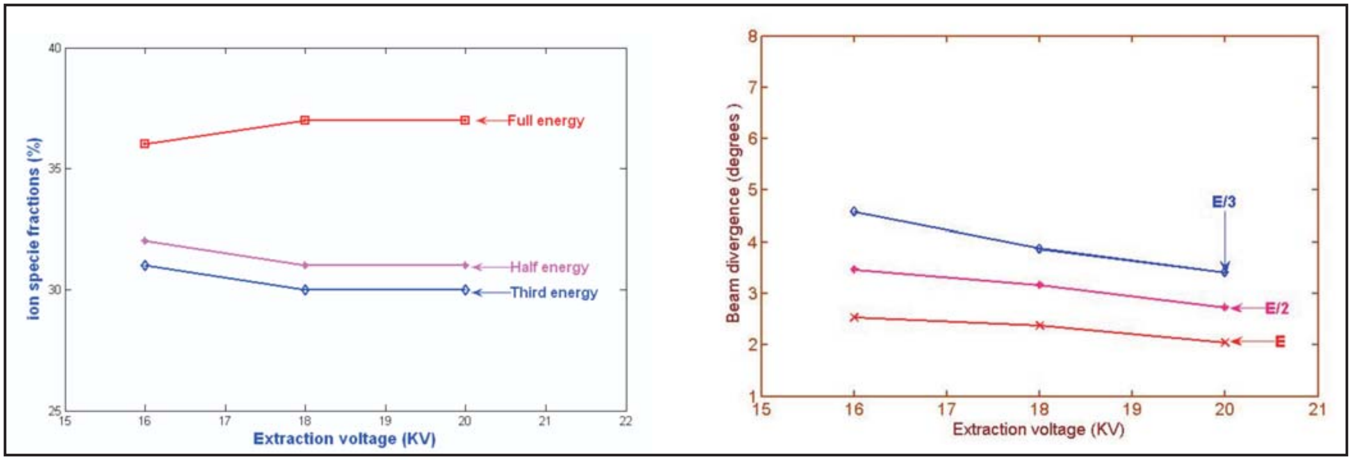


Figure A.1.2.4.2.12. Using the Doppler shifted spectral data; the ion species fractions (a) and beam divergence (b) are estimated as a function of extraction voltage.

PINI assembly at SST-1 NBI Laboratory

The following assembly activities have been carried out for the PINI in a clean assembly environment:

(a) Mounting of Main insulator assembly on assembly jigs.

(b) Assembly of extractor system on the extractor assembly jig (figure A.1.2.4.2.13) and integration of extractor assembly inside main insulator assembly, Turning of assembly jigs by 1800 to fix neutralizer and the support tube.

(c) Checking Plasma box separately for leak tightness and mounting on HV flange of the extractor system using crane.

(d) Testing assembly for leak tightness and electrical isolation and integration of filament transformer as shown in figure A.1.2.4.2.14.

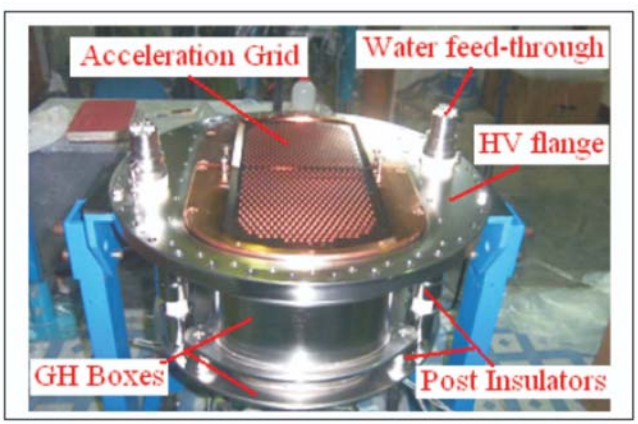


Figure A.1.2.4.2.13. Assembled extractor system with acceleration grid at top

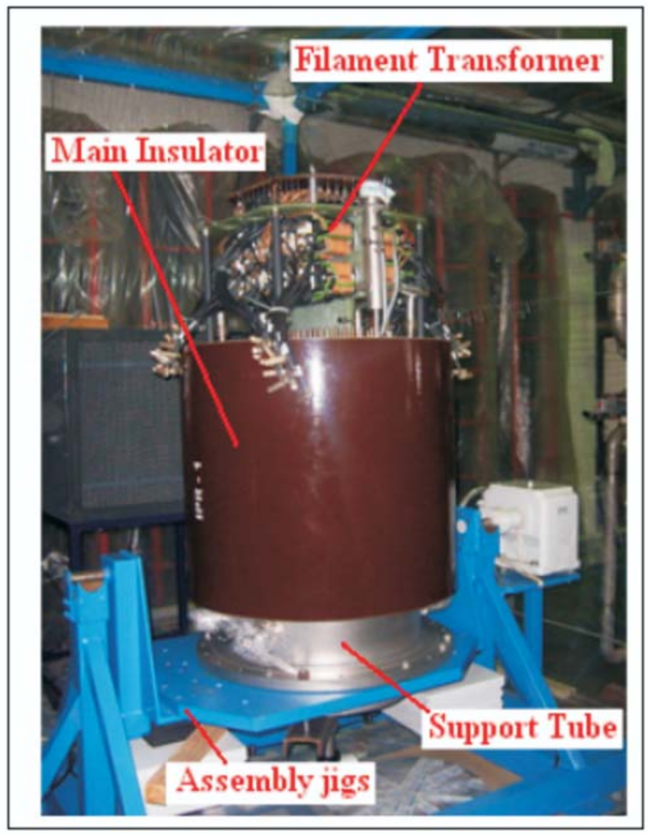


Figure A.1.2.4.2.14. Assembled PINI ion source at SST-1 NBI Laboratory

A.2. Fusion Technologies development under X1th five year plan

A.2.1. Prototype Divertor Cassette Development for Fusion Grade Tokamaks

This is a new 11th five year Plan Project started in year 2007-08. It is focused on Research and development activities of materials and technologies to fabricate divertors of a future fusion grade tokamak to be built in India.

Major activities initiated during 2007-08 for divertor prototype development are as follows:

(a) Planning overall activities of the division for 11th five year Plan Period. This includes planning of scientific, engineering & technical activities as well as infrastructure and utilities related activities.

(b) Conceptual design of divertor cassette;

(c) Understanding Remote Handling Techniques and relevant interface issues for design and handling of divertor cassette;

(d) Procurement of plasma facing materials needed for fabrication of divertor targets;

(e) Visits to various organizations & industries in India for discussions and exploring possibilities of their active participation in R&D work needed for the project;

Apart from above mentioned activities, some members of the division also actively participated in ITER related activities such as:

(1) Participation in design review meetings for in-vessel components of ITER;

(2) Design study of Baseline Transporter Systems (remote Handling Systems) for ITER Divertors such as Cassette Multifunctional Mover (CMM), Cassette Toroidal Mover (CTM) and In-Vessel Transporter (IVT) systems;

(3) Mapping route of Remote Handling Transfer Cask in ITER Hall;

(4) Study of ITER Maintenance Management System;

Status of related work at other organizations

(a) Brazing Technology Development for Plasma Facing Components by National Aerospace Laboratories (NAL, Bangalore): Brazed joints of Pure Tungsten, Graphite and CFC materials with CuCrZr Copper Alloy are produced using two different brazing filler alloys viz. TiCuNi and CuMnNi. Micro structural analysis, ultrasonic flaw detection and mechanical strength measurements conducted on test samples indicates good quality of joint. Experiments on restoration of copper alloy strength after brazing cycle are done to confirm the recovery of strength. Thermal-Hydraulic computations using COSMOS Flow-works 2007 software and fabrication of test mock-ups for high heat flux testing are currently going on.

(b) Development of cascaded thermal plasma torch as high heat flux source at Center of Plasma Physics (CPP, Guwahati): Plasma torch available at CPP is being redesigned and upgraded for its utilization as high heat flux source for cyclic thermal load tests of PFC test mockups up to $10 MW/m^2$ heat flux. Design and Fabrication of major components has already been completed. Assembly and integration is in progress.

A.2.2. Fusion Relevant Prototype Magnet Development

Under XI plan, Fusion relevant prototype magnet development has been aggressively pursued. Fusion relevant superconducting strands involving NbTi, successful twisting of the multi-filamentary multiply stabilized superconducting strands(figure A.2.2.1), pulling through techniques of the cabled strands and the duplex swaging and roll-forming of the twisted cables resulting in a cable-in-conduit conductors of 20 kA indigenously designed and developed CICC in association with Atomic Fuels Division, BARC had been realized (figure A.2.2.2). Mechanical, metallurgical and superconductivity associated characterizations are presently being carried out.

A 10 T high field facility procurement for strand characterization is in its final stage. Indigenous development of Nb3Sn based fusion grade superconducting strand and cable have also been taken up. Design of the strands and its fabrication following internal-tin route are currently being taken-up where billets and multi-stalking processes have been designed and fabricated. Development of superconductor grade high homogeneity niobium raw materials have also been initiated as a joint initiative. Special purpose precision winding machine concepts meant for fabricating large size prototype Toroidal Field magnets and central solenoid magnets have also been initiated.

Prototype magnets of half of the size of the SST-2 device (figure A.2.2.4) and one-third of the SST-2 central solenoid had been

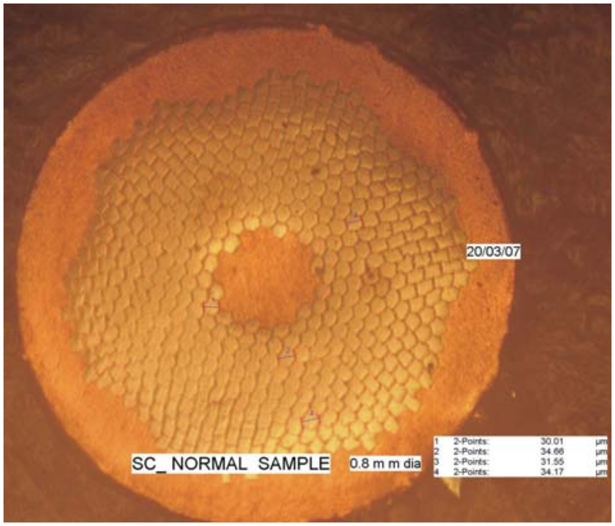


Figure A.2.2.1. Fusion Grade NbTi strands developed as a joint initiative of Magnet Division, IPR and AFD, BARC.

Figure A.2.2.2. 20 kA hybrid twisted cable

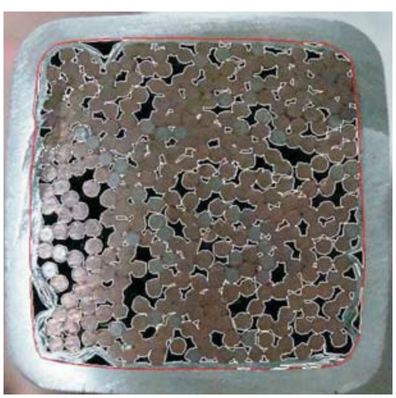


Figure A.2.2.3 20 kA hybrid Cable-in-Conduit Conductor

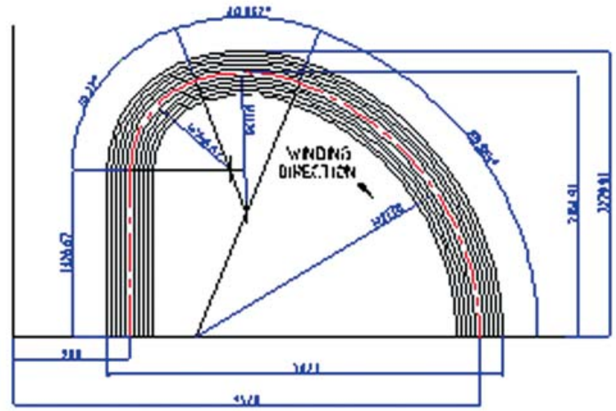


Figure A.2.2.4 Prototype TF magnets designed to be realized during the XI plan

designed already. A 30 kA, 30 kV power supply specifications for testing these magnets have also been finalized. Several diagnostics involving flow reversal measurements following a quench, measurements of cold mass displacement during cool-down and warm-up based on strain gages, measurements absolute and differential pressures in a forced flow facility etc have also begun.

Magnet division further has completed the design and trials towards realizing high homogenous magnets needed for an in-house electron-positron plasma experiments trap as well as for a DST sponsored multi-institutional project on the design and development of a magnet system suitable for a 42 Ghz, 200 kW CW gyrotron.

In laboratory scale, winding technologies with high Tc BSCCO and YBCO as well as MgB_2 have been realized. The critical characteristics of these superconductors in both tapes as well as in wound magnets have been investigated. Winding geometry induced degradations have been studied. The AC loss characteristics of these superconductors have been experimentally investigated too. High Tc current leads designs involving these tapes up to nominal currents of 10 kA and 30 kA have begun along with intermediate prototypes.

A.2.3. Prototype Vessel sector, Cryopump development and Pellet Injector Project

Pellet Injector System

The main stages of pellet injection system are freezing of hydrogen pellet, acceleration of pellet by high pressure helium gas as propellant, differential pumping for removing the propellant accompanying the pellet, diagnostics to view the pellet flight. On the section comprising differential pumping system and injection line there are NO (normally open) valves. And with these valves photodiodes are arranged in series in a way when photodiode senses pellet flight by blocking of light, valves must be closed and the propellant captured in the chamber in line gets pumped out. On the test chamber are CCD camera to view the pellet and a shock accelerometer to register the shock.

Data acquisition and control system was configured for Pellet injection system based on signal analysis using PXI as the data logger system with Lab view as front end for GUI and control applications. The work done includes image capturing and measurement of dimensions of moving objects using CCD camera and CAPTURE PLUS software. The testing of cards of PXI system was done. Digital isolation card was made and isolation card tested. Graphical User interface (GUI) was made for all PXI cards.

Fast closing valve on the Pellet Injection system have opening time less than 2 ms and can work in 0.1 to 15 MPa pressure range. Valves were tested by giving TTL voltage (3.3 to 5 V dc) by PXI and also by parallel port. Digital card's inputs were tested by giving 5V DC supply and output is tested through LED's and also with fast opening valve. Analog card is tested by giving data from variable 5 V DC and also by temperature sensors. GPB was made to give analog inputs, 24 digital outputs, RS - 485 data, and frequency input by frequency generator.

Also a project of remote handling of PXI system from user PC to host PC through internet was done. The project work included

Figure A.2.3.1 A GPB FOR ALL SIGNALS

the development of a suitable software system for control and data acquisition of the Pellet Injection System with the capabilities of (1) Design - Data handling, Logging (refers to collecting all the data from all the accessory Systems), (2) Monitoring (refers to making the logging data available to applications), (3) Displaying (refers to providing the data being monitored on screens), (4) Archiving (refers to the coordinated permanent storage of the data) and (5) Data access (refers to making the archived or live data available to a user or application). The remote collaboration interface uses JAVA, MYSQL and the Data Acquisition and control is carried out by PXI hardware system with Lab View software for all GUI applications.

Apart from the above fabrication and installation of injection line, assembly and testing of the differential pumping system was done. Test experiments on shock accelerometer were performed. Steel balls of varying mass and size were used to produce shock by dropping them from varying height. The setup consisted of shock accelerometer transparent acrylic pipes of height 5cm, 10cm, 15cm and 20cm, steel balls of weight 1.06gm, 0.45gm and 0.28gm.

Prototype Cryopump Development

In the Cryopump Development project basic thermodynamic calculations were done with ITER Cryopump as a case study. Methodology for CFD analysis of flow of Liquid nitrogen at 80K through radiation shield and liquid helium at 4.5 K through cryopanels of Cryopump was established. Radiation shield and cryopanel studied have double embossed design with the advantages of maximizing heating - cooling efficiency, reduces condensate build up, free flow pattern reduces fatigue failure , larger flow path. Theoretical calculations were done and compared with the CFD results. The results for velocity, pressure drop and fluid coefficient were found to be in good agreement with theoretical results (figures A.2.3.1 & A.2.3.2).

Prototype vessel sector project

Small scale trial welding experiments, in context of field joint of vacuum vessel, were planned to perform on different plate thicknesses of SS. Experiment were done with AISI 304, which is available at IPR. The various plate thicknesses chosen were 10 mm, 20 mm and 30 mm. Generally, TIG welding is not a preferable process for higher plate thickness because of its lower productivity and higher heat input which results in distortion. The main aim was to see the behavior of manual TIG welding in thick plate of stainless steel, especially with single-sided narrow U-joint.

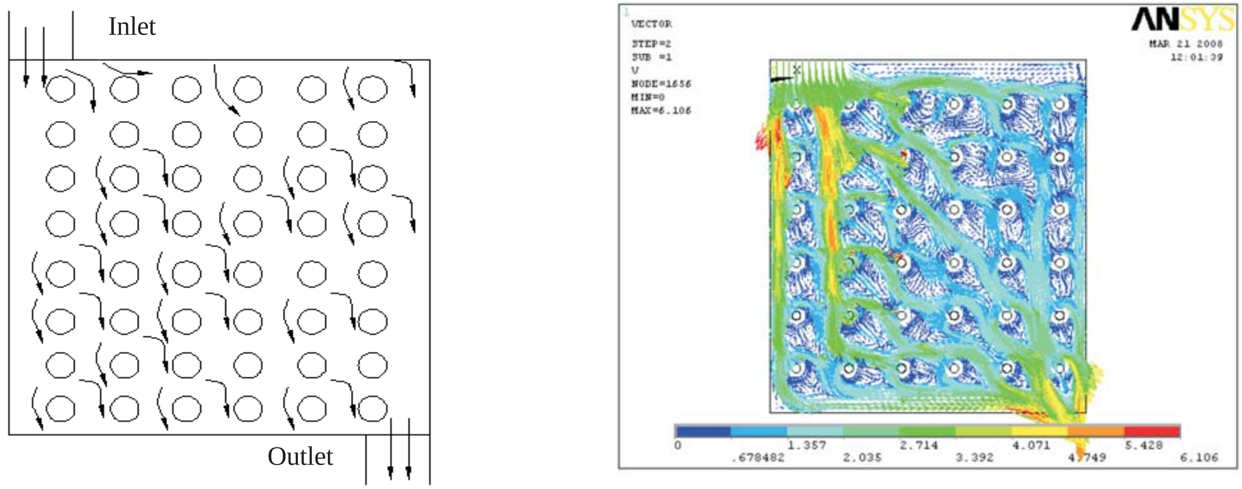


Figure A.2.3.1Velocity Nodal Plot through radiation shield for liquid nitrogen at 80 K

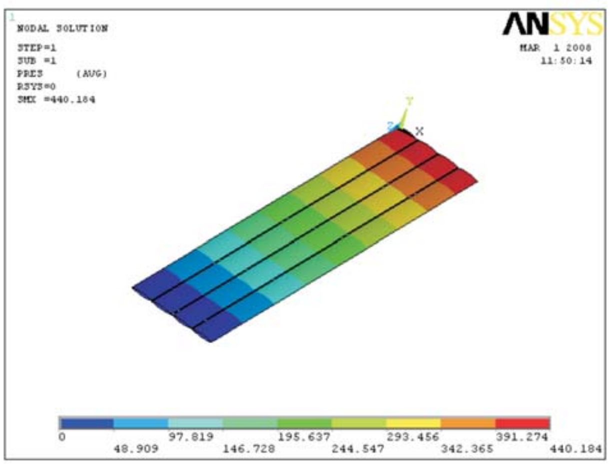


Figure A.2.3.2 Pressure Plot of the Cryopanel (Inlet- red, outlet-blue)

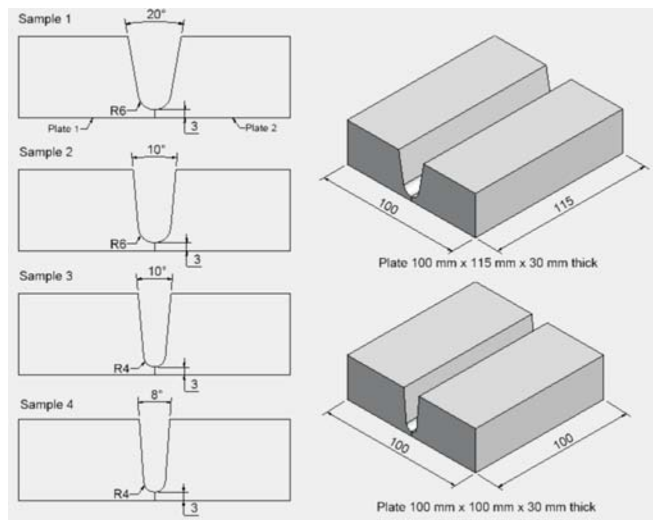


Figure A.2.3.3 Weld joint config. for 30 mm thick plate

The welding procedure for a sample having the lowest groove angle is described here. The root pass was carried out with 185 Amp. The four intermediate passes have been performed with 160, 145, 145 and 145 Amp respectively In the case of 30 mm plates mass of filler metal was 198 gm, total time of welding 10minutes with a deposition rate 19 gm/min in groove area 390 mm2 with net heat deposition 12184 j/mm. The shrinkage observed was about 4.2 mm (figure A.2.3.3). Also the NDT test of the welded tokens was performed.

A.2.4 Test Blanket Module

India is one among the seven full partners of International Thermonuclear Experimental Reactor (ITER), which is a fusion reactor, based on Tokamak concept. One of the ITER missions is that "The ITER should test tritium breeding blanket module concepts that would lead in a future DEMO fusion reactor to tritium self-sufficiency, the extraction of high grade heat and electricity production". ITER is a unique opportunity to test the blanket mock-ups in real fusion environment. All ITER Parties have defined DEMO breeding blanket designs in both solid and liquid type blankets and are performing R&D program leading to the fabrication of blanket mock-ups, called Test Blanket Modules (TBMs), and to their installation and testing in ITER.

India has also expressed its interest to evolve a new type of TBM program and proposed its own concept, namely, Lead-Lithium cooled Ceramic Breeder (LLCB) (half-port size). This

TBM concept consists of lithium titanate as ceramic breeder material in the form of packed pebble beds. The structural material is ferritic steel and is cooled by helium gas. Our LLCB TBM is very different from the other type of TBMs, in the fact, that it has features of both solid and liquid type concepts. One of the novelties of this concept compared to other solid breeder concepts is that it is beryllium free, whereas a typical solid breeder fusion reactor blanket needs tons of beryllium which is highly toxic in nature, has difficulty in reprocessing as well as has globally limited resources. In our concept, the beryllium is replaced by the Pb-Li eutectic, which acts as multiplier and an additional tritium breeder. The Pb-Li eutectic liquid, flows separately around the lithium ceramic breeder pebble bed as a coolant. The Pb-Li flow velocity should be high enough such that its own self generated heat and the heat transferred from ceramic breeder bed is extracted effectively. The preliminary engineering design of the LLCB concept has been completed and its first version of Design Description Document (DDD) has been submitted to ITER Team during April 2008. The ITER-Test Blanket Working Group (TBWG) has reviewed the concept and accepted the Indian proposal for testing in ITER. 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.

A joint team Scientists and Engineers from IGCAR and IPR participated in 8th International Symposium on Fusion Nuclear Technologies (ISFNT-8) during 30 Oct - 3rd Nov. 2007 at Heidelberg, Germany. A joint team of BARC, IGCAR and IPR scientists and engineers participated in the 13th International Conference on Fusion Reactor Materials (ICFRM-13) at Nice, France and presented the Indian programme on Fusion Materials and Technologies.

A.2.5. Negative Ion Beam Source

Research and Development on negative ion source is programmed to develop the indigenous expertise in the operation and negative ion production and to provide domestic support to the need for R&D of the negative ion based DNB for ITER.

Principal objectives of this program include R&D and personnel training, technology development. Consolidation of collaborations, and planning for procurement of hardware necessary for establishing a fully equipped R&D set-up for experimental program on negative ion R&D formed the primary focus of activities on the negative ion R&D program. Summary of these activities are presented below:

Collaboration

A license agreement between IPP-Garching and IPR has been signed, wherein, a technology and know-how transfer has been agreed for the RF based BATMAN ion source. The collaboration also provides for personnel training and participation of IPP Garching in the commissioning of the BATMAN source in IPR.

Procurement

On the basis of the collaboration agreement a procurement contract has been launched for the manufacturing of the BATMAN source, with technology support form IPP-Garching. Further, procurement contract has also been launched for a 1 MHz, 100 kW RF generator which shall provide the input RF power for plasma production in BATMAN. Further, procurement activities for power supply systems, data acquisition and associated electronics, have been initiated. Present procurement planning ensures availability of minimal system operation hardware to initiate experiments by Q1 2009.

Training on the BATMAN system has been initiated and 4 scientists and engineers have been deputed to IPP-Garching for information sharing and consolidation of experimental layout for BATMAN. Laboratory space has been made available, and work is presently ongoing on the arrangement of experimental layout based on the IPP inputs.

A.2.6 Neutronics

Simulations & Modeling

- Preliminary blanket studies for Indian DEMO: Rudimentary nuclear analysis of the DEMO reactor have been carried out from the perspective of the tritium breeding capability and self sufficiency, with the LLCB concept and solid breeder concept.
- Benchmarking of the ITER neutron source: The peak and average neutron wall loading in case of ITER have been calculated with a source model which was made here and were matched to the published ones.
- Integrated Test Blanket Module related hot cell requirements in ITER were generated.

- Understanding of activation mechanisms in nuclear fusion environment has been acquired and is specifically related to the EASY activation package.
- Consolidation of our previous efforts in designing fusion blankets to evolve the blanket concepts (LLCB and a solid concept) for Indian DEMO and to further test that concept in ITER as a test blanket module is underway.
- In the coming 3months, we plan to do a parametric study of the two blanket concepts in the DEMO environment and freeze the concept, which is intended to be tested in ITER.
- Activation and decay heat calculations for the materials used in the fusion reactor shall also be performed with the EASY code.

Experiments:

- A calibration of the High Purity Germanium detector (HPGe)-HPGe spectrometer has been installed in the Neutronics Laboratory. Energy linearity was checked using standard gamma-ray radioactive sources. Efficiency calibration of the spectrometer was carried out with a calibrated 60Co source.
- 14 MeV neutron source was installed and test runs were taken. Experiments have been initiated to generate data required for the preparation of document to be submitted for AERB clearance and license. Preparations are on to start activation experiments for short irradiations first and then extend it to longer irradiation. Standard activation foils will be tried out first later composite materials & alloys would be activated.

A.3. Basic Experiments

A.3.1. Basic Experiments Toroidal Assembly

Role of energetic electrons in BETA Machine

Since 2006-07, a new experimental campaign to understand temperature gradient related studies in current less devices as against Tokamak with current was initiated in BETA Device at IPR. Multiple hot filaments discharges are being considered to control the gradients of temperature and density of BETA plasma.

This year, the focus has been to understand experimentally the role of energetic electrons emitted during the plasma production due to hot filament discharge. We have developed Retarding Field Analyzers to investigate the energetics of electrons and have decisively identified the spatial extent to which energetic electron populations proliferates the bulk plasma. Initial analysis of data obtained shows that the energetic electrons are localized close to the radial filament. Several scaling studies using Langmuir Probes and Retarding Field Analyzers for various values of magnetic field, gas pressure has been performed.

A.3.2. Large Volume Plasma Device

The continuation of Electron Temperature Gradient (ETG) driven turbulence study in high beta ($\beta \geq 1$) plasma has been the main emphasis of LVPD during last year. Turbulence driven by Electron Temperature Gradient (ETG) has direct relevance to the plasma transport in fusion devices, space and laboratory plasmas. A direct experimental investigation on ETG turbulence has been very difficult owing to small- scale length of the instabilities in tokamaks. The capability of producing high density plasma at very low applied ambient field has made it possible to measure the ETG instability experimentally for the first time in Large Volume Plasma Device (LVPD).

Investigations on ETG turbulence have been carried out in LVPD using two different source functions, viz., Narrow (4.5 cm x 12cm) and Broad (60cm$\times$60cm) respectively. Results from these have provided experimental evidence of ETG turbulence but as the experimental setup does not have a control on electron temperature and its gradients, so a controlled investigation of ETG turbulence remains a desired dream.

Plasma discharge variable such as pressure, discharge current, magnetic field etc. modify plasma density and its gradients. In this device plasma with and without electron temperature gradient can only be produced by varying source function of primary ionizing electrons. To change electron temperature and its gradient, the possible methods are to carryout local/ global electron heating/ cooling. For this experiment, the method of cooling has been adopted for controlling electron temperature in LVPD. In pursuance of this, a Low Energy Electron Source (LEES) was designed, fabricated and has been augmented to LVPD. This source will provide a validation of concept of controlling electron temperature and its gradient for experimental investigation of turbulence excited by electron temperature gradient

The LEES will be used as an electron emissive source for plasma cooling investigations. An electron emissive source is usually realized by tungsten or thoriated tungsten heated to the necessary temperature (white glow). The LEES consists of

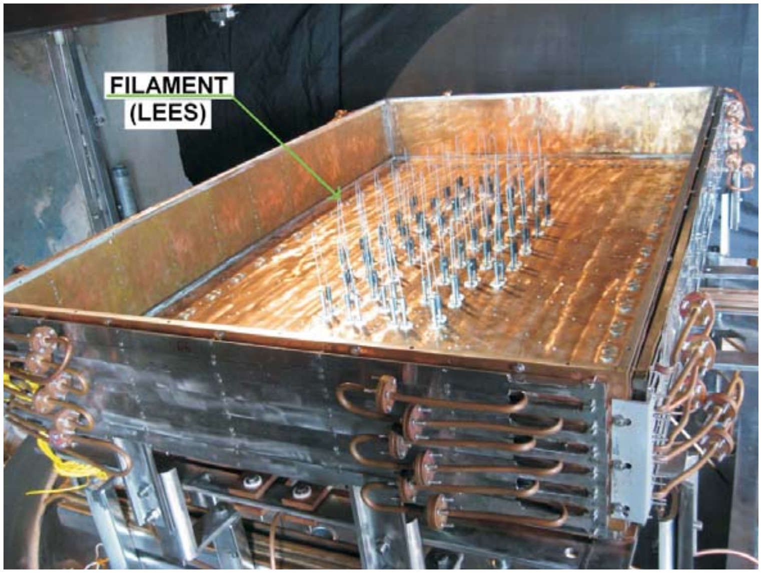


Figure A.3.2.1. The view of (a) assembled LEES in LVPD and (b) the filament assembly in the LEES. There is provision for two sets of filament configurations. Presently the inner set is configured.

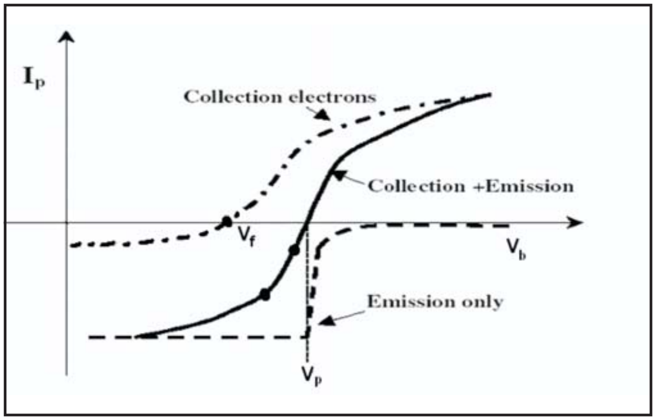


Figure A.3.2.2: Schematic diagram showing ideal characteristics of cylindrical wire immersed in plasma

large number of filaments (N = 48, each of diameter 1.6mm, emission area ~578 cm^2), distributed over a cross section of 1600 cm x 1000 cm and is well immersed into the plasma produced using a separate source of primary ionizing electrons. The designed LEES has a capability of injecting electron current of 750 A at 2600 K. The estimated current density for LEES at 2 eV is 0.18 A/cm^2. The typical operations emission current will be about 55 A.

When such a source is put into plasma, an emission current can flow as long as the bias of the source is more negative than

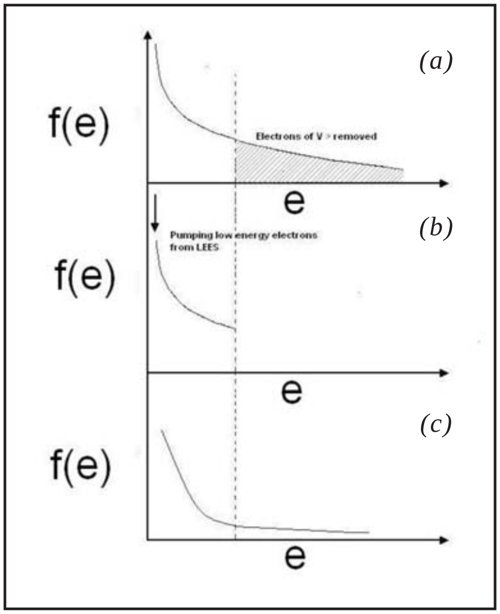


Figure A.3.2.3: Schematic describing the analogy for the exchange of electrons with LEES

the plasma potential. For increasing source heating, the current on the left- hand side of the source characteristics (figure A.3.2.2) increases while the floating potential of the source shifts to the right hand side towards the plasma potential. Consequence of this phenomenon is that injected electrons at lower energy by the emissive source replace energetic electrons in the plasma. The electrons emitted by the emissive source do not participate in plasma production. This leads to lowering of plasma electron temperature. It has been assumed that any large emissive source behaves like a typical emissive probe and therefore theory related to determination of probe characteristics can be applied.

The differences in energy is given by the expression, $\Delta E = T_e \ln [(I_{is} + I_{em})/ I_{is}]$, where, T_e and I_{is} are the electron temperature and ion saturation current of the plasma and I_{em}, the emission current of the LEES.

It has been tried to give a physical picture to the concept of plasma cooling using an emissive probe. Figure A.3.2.3 shows the process of collection of plasma electrons and injection of low energy electrons: (a) shows removal of high-energy electrons (V>) from the plasma, leaving a truncated energy distribution function; (b) shows injection of low energy electrons by LEES; (c) shows that the combined distribution function evolves into plasma with a lower electron temperature over a time scale less than the confinement time of plasma. The evolution to new distribution function is brought about by collision of injected low energy electrons with bulk electrons of the plasma and/ or any fast scattering process caused by instabilities excited in the plasma. A gradient in electron temperature may be obtained by varying spatially the amount of injected emission current and sustained by the same processes, which supported electron temperature gradient in LVPD plasma

During last year, an attempt was also made in LVPD to study high beta turbulence driven by density gradients. A floating limiter ring of (ID = 60cm, OD = 180cm) is inserted in the plasma produced using a narrow source. A sharp density gradient is observed in the shadow region of the limiter. Analysis of the turbulence data collected from this investigation is underway and will be reported later.

A.3.3. Electron-positron plasma

Injection of electrons into Cylindrical RF Trap

Electrons were injected in the trap by carefully mounting W-filament with different geometries (spiral, hairpin and helical). Trap was assembled and integrated with the LN_2 cooled baffle vacuum system (~ 10^{-7} mbar). This was followed by emission current measurement experiment and its comparison with theoretical estimations. Figures drawn below (A.3.3.1 and A.3.3.2) shows one of the experimental results of emission current measurement

Scheme worked out for pure electron plasma in a Cylindrical RF Trap

Electrons from a Tungsten filament will be accelerated through a potential difference ~ 50V (primary electrons) and introduced in to the trap whose end cap has a mesh. These primary electrons will impinge upon the other end cap and cause emission of secondary electrons from it (figure A.3.3.3). The toggle switch applies appropriate bias to the grid in order to stop or allow primary electrons entering the trap. The energy of secondary electrons from a copper end cap is expected to be 2eV - 5eV.

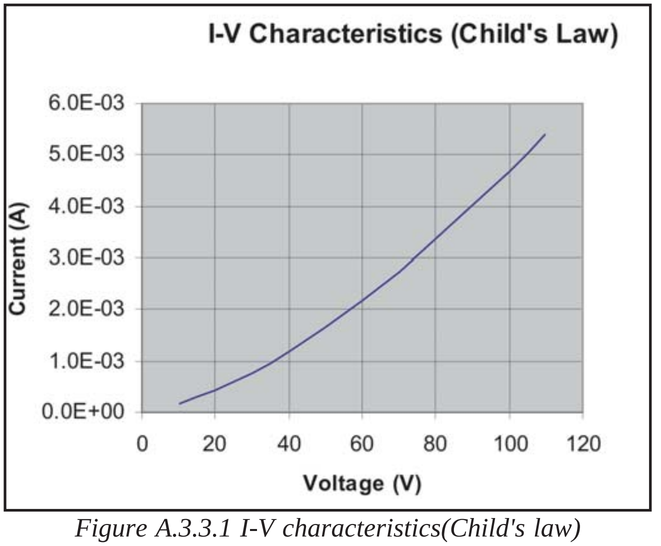


Figure A.3.3.1 I-V characteristics(Child's law)

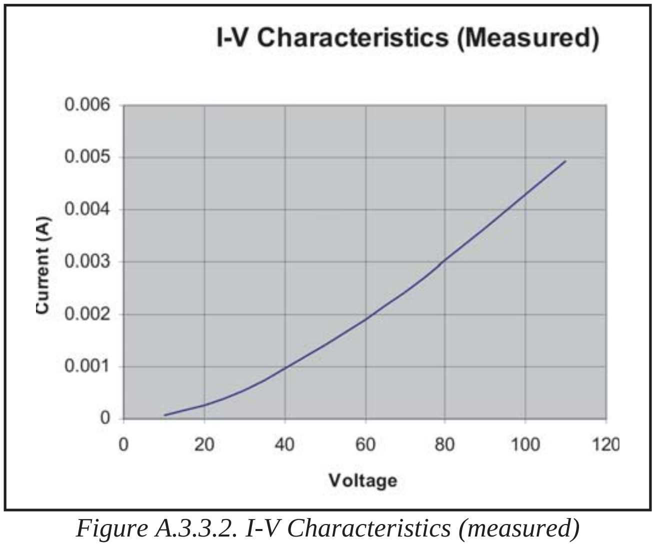


Figure A.3.3.2. I-V Characteristics (measured)

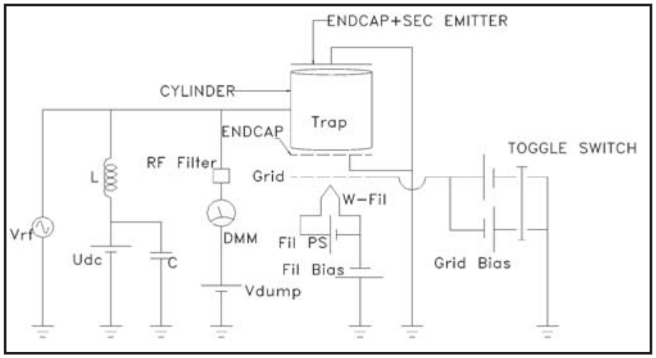


Figure A.3.3.3 Equivalent circuit diagram with the toggle switch

A.3.4. Non-neutral Plasma

Small Aspect Ratio Toroidal Experiment (SMARTEX-C) for pure electron plasmas is being carried out in a C-shaped trap in IPR. The trap has achieved considerable success in improving the confinement time to millisecond-order and has brought forth quite a few interesting physics peculiar to small aspect-ratio toroidal clouds. The lifetime of the plasma, has been rather limited by the duration of the magnetic field, which was so far restricted to 2 ms (flat-top). SMARTEX-C is being now equipped with a new Pulse Forming Network, which will allow time-independent B field of 10 ms. Concurrently a new Tf coil

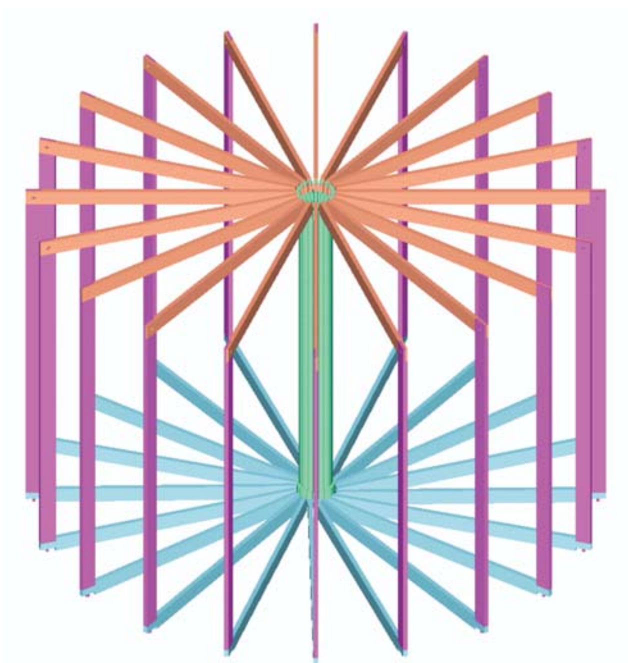


Figure A.3.4.1. New TF coil design

(figure A.3.4.1) has been designed, which, together with a 50V, 5 kA power supply will allow us to have a steady-state B field for a second. The design is capable of carrying ~4 kA and allows twenty turns of copper bus-bars in series without compromising the small aspect-ratio of the trap. The magnetic stress has been taken care of by appropriate design (figure A.3.4.2), especially of the mating on the inner joints. The steady state B field of 1 kGauss for ~1 sec (figure A.3.4.3), will allow us to accurately determine theconfinement time and also make it possible to automate and repeat injection-hold-dump cycles, in future experiments.

A.3.5. Interaction of Low Energy Ion and Neutral Beams with Surfaces

Low energy (1-100 eV) ions and neutrals are the active species in many physical and chemical processes. For example, in plasma processing both ions and active neutrals (radicals) are responsible for the growth of thin films (plasma CVD) and also

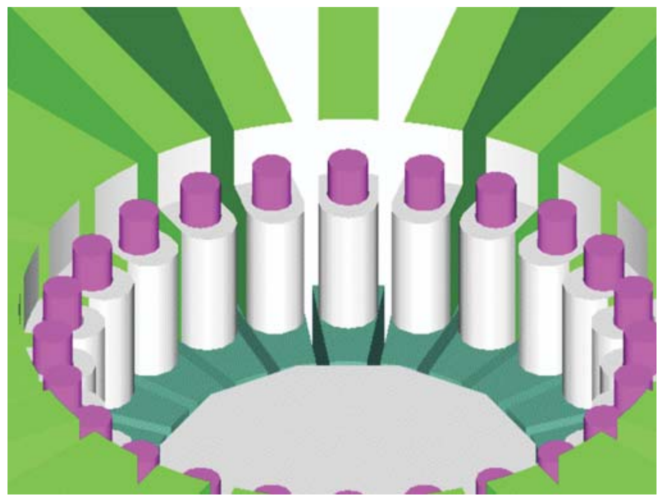


Figure A.3.4.2. Close-up of inner mating of busbars

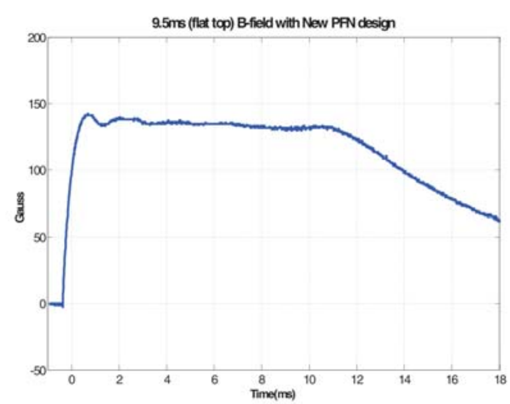


Figure A.3.4.3. 9.5 ms (flat-top) B- field with new design

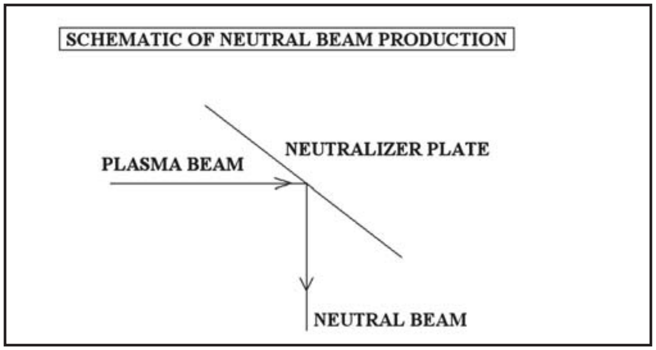


Figure A.3.5.1. Schematic of the neutral beam production mechanism

in diffusion coatings (plasma nitriding, etc.). In space, an orbiting satellite at low earth orbit (LEO) is bombarded with 5 eV ("hot") O atoms which severely erode its surfaces. In fusion devices, wall materials are sputtered by particles with energies which range from tens of eV to hundreds of eV. Hence it is desirable to study such reactions in controlled laboratory environment, i.e. interaction of surfaces with ion / neutral beam of specific energy (low energy spread).

It is with this objective a microwave based pulsed plasma / neutral beam set-up has been developed (figures A.3.5.1 and A.3.5.2). The plasma source consists of a stainless steel tube of 26 mm internal diameter and length 134 mm. Microwave power (1 KW) is coupled to this source from a pulsed microwave power supply via a coaxial antenna (SS) of diameter 5 mm. The discharge frequency, on-period and off-period are all adjustable. Presently we are using, 100 Hz, 1 ms on period and 9 ms off period, thus an average of 100 W is being used. The whole plasma source is immersed in an axial magnetic field (436 Gauss) produced by a pair of Helmholtz coils. The threshold value for plasma generation is 390 Gauss. The plasma particles travel towards a reflector plate in a "beam" form (diameter 26 mm) with the help of the axial magnetic field. The neutral beam is produced as a consequence of charge neutralization (of ions) at the biased reflector plate. [The source has been tested for hours of operation without interruption.]

The plasma beam (nitrogen discharge) has been characterized for its density across the beam. The density is 1.1×10^{12} cm^{-3} at the center, 5×10^{11} cm^{-3} at 4 mm from the center and $1x10^{11}$ cm^{-3} at 9 mm from the center. The total ion current collected by the biased neutralizer plate is approximately 50 mA. We are in the process of treating steel samples of various grades with neutral as well as ion (plasma) beams. In future it has been planned to increase the duty cycle, in stages, to 50% or higher from the present 10%. Presently a neutral beam diagnostic system is

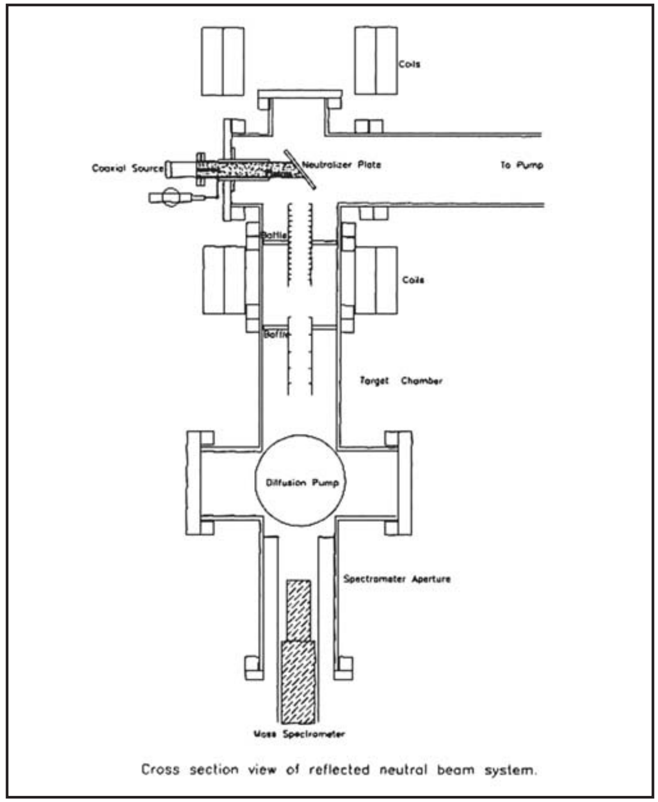


Figure A.3.5.2 Cross-sectional view of reflected neutral beam system.

been developed for which a mass spectrometer has already been procured. An energy analyzer is being developed which together with the mass spectrometer will provide quantitative values of fluxes of the neutral particles intercepted by the surfaces. In future there are plans to include spectroscopic techniques also for diagnosing the plasma beams.

A.3.6. Plasma Wakefield Acceleration Experiment (PWFA)

This multi-institutional project involving IPR, RRCAT and BARC will set up experiment to accelerate short bunch electrons using the high acceleration gradients of PWFA scheme. IPR will develop the plasma source which will be a 1 meter long, laser photo-ionized, Lithium vapor plasma having density of ~ 10^{14}/cc. The electron beam will be provided by RRCAT and the theory/simulation support will be from IPR/BARC. The project was funded this year and initial design of the plasma chamber has been carried out and the development of the laboratory for setting up the plasma source is currently underway.

A.3.7. System for Microwave - Plasma Experiments (SYMPLE)

"SYMPLE" is an experimental system recently conceived to investigate the physics of interaction of extremely intense electromagnetic (e.m.) wave with an over dense (plasma frequency fp > wave frequency fw) plasma. When their amplitude is low (eE/mω << c), it has been established theoretically and experimentally that low frequency (fw << fp) e.m. waves can not propagate in an unmagnetized plasma. However, as the intensity goes very high, to the extent that the relativistic parameter $\nu = eE/m\omega c \geq 1$, interaction of the waves with plasma leads to their absorption plasma. Physics of these nonlinear wave-plasma interactions covers issues that can be broadly divided into three: (i) mechanism of energy transfer from the wave to plasma, (ii) generation of fast electrons at the critical plasma surface and (iii) propagation of the fast electrons in the plasma that drive the plasma unstable. These issues have not been subject to detailed experimental exploration as waves with such high power required to satisfy the above condition were not realizable till recently, except in the field of lasers. Experiments on high power laser-plasma interaction, however, face severe constraints in terms of diagnostics.

The advent of high power (~ a few GW) microwave sources now open up a new arena of experimental investigations. Experiments on these waves could prove advantageous to laser-plasma experiments in many ways as plasma with much lower range of density (10^{17} - $10^{19}/m^3$), yet remaining over-dense to microwave can be chosen. This in turn leads to a reduced growth rate and larger spatial scales of instabilities, rendering easier diagnostic access.

The proposed experiments on "SYMPLE" aims at coupling a "VIRCATOR" (Virtual CAthode oscillaTOR) based, pulse (10-30 ns) powered microwave source to a plasma column. While the microwave frequency (f_μ ~ 9-10 GHz) sets the plasma density (ne) requirement, the axial and radial extents are determined by the parameters such as the growth rate (γ) and scale length predicted for the instability driven by the fast electrons. Model calculations show that the plasma should have a uniform extent of about 15 cm and 150 cm in the radial and axial extents respectively. A yet another critical criterion is steep axial gradient ($L_n \sim \lambda_\mu$) in the plasma required at the wave interaction regime.

These experiments compliment laser-plasma interaction studies, scaling the laser wavelengths to microwave region, and micron-scale targets to meter scale lengths. The investigations address various key issues relevant to inertial confinement fusion and table top particle accelerators. This project has been taken up in the 11^{th} five year plan and the development of the system is presently under way.

A.3.8 Flowing Plasma Experiment

The properties of the flowing plasma in a diverging and/or converging magnetic fields is poorly understood. This phenomenon happens in experiments like double layer, supersonic and super-Alfvenic flow generation, detachment and reconnection etc. Recently double layers have been observed within an expanding plasma in a diverging magnetic field. These double layers are formed in current less environment and the role of the magnetic field in the formation of double layers is not understood. To understand this phenomena a new experiment has been proposed to study the formation of current free double layer in a flowing plasma. The diagnostics planned for this experiment consists of microwave interferometry and Laser-induced fluorescence (LIF). A detailed planning has been done and the execution of the project is underway with procurements and fabrications.

A.4. THEORETICAL AND COMPUTATIONAL PLASMA PHYSICS

A.4.1 Tokamak Plasmas

Excitation of GAMs

Nonlinear excitation of zonal flows and backs reaction on drift wave as an important mechanism contributing to drift wave saturation. In recent years, the geodesic acoustic modes (GAMs) have attracted attention due to their similarity with zonal flows. We have developed two mode-coupling analyses for the nonlinear excitation of GAMs in tokamak plasmas by in the background of drift wave turbulence. The first approach is a coherent parametric process, which leads to a three-wave resonant interaction. This investigation allows for the drift waves and the GAMs to have comparable scales. The second approach uses the wave-kinetic equations for the drift waves, which then couples to the GAMs. This requires that the GAM scale length be large compared to the wave packet associated with the drift-waves. The relationship of the two approaches is clearly established. Recent global numerical simulations of ITG modes show excitation of GAMs and indicate that the radial wave number of the excited GAMs scales inversely as the ion Larmor radius. Also the modes are excited dominantly in the edge region of the device. Furthermore there is a nonlinear downshift of the GAM frequency compared to the predicted linear mode frequency. The mode coupling analysis presented in this paper provides an explanation of the scaling of the radial wave number; the preferential excitation of GAMs in the outer half of the plasma and the nonlinear downshift of the frequency of GAMs.

On turbulent transport of toroidal momentum

On turbulent transport of toroidal momentum, a self consistent model of turbulence driven transport of toroidal momentum in magnetically confined plasmas has been developed. The model incorporates the effects of momentum diffusion, a so-called momentum "pinch" (i.e. an inward advection of mean momentum and additional off-diagonal flux driven by, and proportional to, the radial shear. It has been shown that part of the pinch term actually comes from the fact that particles can convect momentum and so is related to the particle pinch. On the other hand, shear driven off-diagonal term comes mostly from the advection of parallel flow and perpendicular flow, and requires symmetry breaking. This simple model can describe the formation of toroidal velocity profiles along with those of density and pressure, and shows the "spontaneous generation" of toroidal momentum via conversion strong edge density and pressure gradients to edge momentum by the fluctuation- driven torque density.

A model to estimate the particle and energy losses caused by type I Edge Localized Modes (ELM) is proposed. This model is based on the assumption that the increase in transport caused by ELM is due to flows along magnetic field lines perturbed by ballooning-peeling MHD modes. The model reproduces well the experimentally found variation of these losses with the plasma collisionality, namely nearly constancy of the particle loss and significant reduction of the energy loss with increasing collisionality. It is demonstrated that the electron parallel heat conductivity is dominant in the energy loss.

ELM mitigation using external magnetic field perturbations

Particle and energy transport in the tokamak edge transport barrier is analyzed in the presence of magnetic field perturbations from external resonant coils. In recent experiments such coils have been verified as an effective tool for mitigation of the edge localized modes of type I. The observed reduction of the density in plasmas of low collisionality is explained by the generation of charged particle flows along perturbed field lines. The increase of the electron and ion temperatures in the barrier are interpreted by the reduction of perpendicular neoclassical transport in the barrier with decreasing density and non-locality of parallel heat transport. The found modification of the pressure gradient in the barrier implies the stabilization of peeling-ballooning-MHD modes responsible for type I ELMs.

Studies of SOL turbulence from three different models

Two-dimensional (2D) SOL turbulence based on interchange instability has been studied comprehensively using three different SOL models analytically as well as numerically. The models have the following distinguishing features. In the two-field (2F) model, coupled density and potential equations are investigated with the assumption of uniform electron temperature and zero ion temperature. In order to study the effect of electron temperature gradients, a three-field (3F) model that includes dynamics of electron temperature with the coupled equations for density and potential fields is used. Dynamics of coherent structure in the presence of electron temperature has been studied and compared with experiment. Four-field (4F) model, in which ion temperature dynamics is included, has also been investigated in this thesis. Ion temperature modifies the SOL turbulence by decreasing radial electric field and SOL thickness as compared to the 3F model. Particle and energy fluxes, and decay of plasma `blobs' obtained from these 2F, 3F and 4F models have been compared.

Nonlinear dynamics of multiple NTMs in tokamaks

Neoclassical tearing modes are one of the most serious concerns for operation of next-step fusion devices such as ITER. Recent experiments in ASDEX, JET etc. have shown that multiple NTMs can get coupled and the presence of one NTM can influence the growth of the other NTM. Though there have been a few studies investigating the dynamics of multiple NTMs, the phenomenon is far from being well understood. We have carried out numerical simulations investigating the interaction of co-existent 2/1 and 3/1 NTMs using a 3D toroidal code6 based on a set of generalized reduced MHD equations. The results show that the coupling between these NTMs can lead to oscillations in their energies. These oscillations are observed in the presence of a finite neoclassical electron stress tensor term in the Ohm's law. Concomitantly the flow energies become larger than the magnetic energies of the modes. The perpendicular flows are found to spread out from the resonant surfaces and to get coupled between the different modes. These oscillations apparently possess some properties close to GAMs but the exact nature of the nonlinear excitation mechanism is remains to be explored in depth. However, it does point towards a distinct coupling mechanism between NTMs even when the resonant surfaces of the modes are far apart. These results may be useful to understand the experimental observations of strong nonlinear mode coupling associated with the evolution of neoclassical tearing modes.

Gyrokinetic Simulation of non-adiabatic passing electrons

Electrostatic Ion Temperature Gradient Driven modes (ITGs) have been traditionally studied by assuming that electrons form an adiabatic (instantaneously responding) quasi-neutral background. By including the effect of non-adiabatic untrapped/passing electrons in a Tokamak geometry in the code EMGLOGYSTO, we have demonstrated that non-adiabatic passing electrons play a crucial role in changing the nature of ITGs for small toroidal mode number n. Effects appear to be more pronounced near the mode rational surfaces.

Gyrokinetic Theory, Simulation and Fast particles

In 2006-07, the MPI-scaling ability of linear gyro-kinetic spectral code EMGLOGYSTO with several number of CPUs was tested in 32-CPU cluster. The code was ported to the newly obtained CRAY-x1e supercomputer. In the same year, we also reported initial studies using local stability analysis, the effect of fast particles on Kinetic Ballooning Modes and Toroidal Alfven modes. Radially local stability analysis showed results consistent with past works done in fast particle physics. In 2007-08, effect of including energetic particles in the global code and its coding has been completed. Effect of fast ions with energy range of 1MeV distributed as a local Maxwellian has been tested. Parameters were so chosen that a global Kinetic Ballooning Mode (low n) is unstable. Preliminary results show that hitherto unseen "global" effect of fast particles population on electromagnetic mode can be studied using our formulation.

A.4.2 Laser Plasma Interactions

TIFR Collaboration

As a part of our collabortion with TIFR, this year, we have worked on modeling of self-generated magnetic fields in ultrashort (~ 100 fs) ultraintense (~10^{16} W/cm^2) laser-solid interaction. The experiments were performed with two sets of targets viz. one micron thick coating of Cu and Ag on BK7 glass. These targets were irradiated with a laser pulse (100 fs, 10^{16} W/cm^2) and temporal evolution of the magnetic field generated near the critical surface was measured with femto-second time resolution using polarimetric methods. The temporal evolution of the magnetic field was theoretically described using the model of Bell et. al. (Plasma Phys. Control Fusion **39** 653, 1997).

Phase mixing of a relativistically intense wave in a cold homogeneous plasma

We report on spatio-temporal evolution of relativistically intense longitudinal electron plasma waves in a cold homogeneous plasma, using the physically appealing Dawson sheet model. Calculations presented here in the weakly relativistic limit clearly show that under very general initial conditions, a relativistic wave will always phase mix and eventually break at arbitrarily low amplitudes, in a time scale $\omega_{pe}\tau_{mix} \sim [(3/64)(\omega_{pe}^2 \delta^3 /c^2 k^2)(\Delta k/(k+\Delta k))(1 + 1/(1+\Delta k/k))]^{-1}$. We have verified this scaling with respect to amplitude of perturbation δ and width of the spectrum $\Delta k/k$ using numerical simulations. This result may be of relevance to ultra-short, ultra-intense laser pulse-plasma interaction experiments where relativistically intense waves are excited.

Superluminal coupled nonlinear stationary waves in cold relativistic electron-ion plasmas

Recently there has been a revival of interest in the interaction of super intense electromagnetic waves with plasmas such that the laser driven motion of both electrons and ions are in the relativistic regime. We investigate a general class of superluminal nonlinear stationary solutions in such a regime using a model consisting of relativistic electron and ion fluid equations coupled with Maxwell's equations. The present study is a generalization of a past work carried out for the Akhiezer-Polovin model equations and explores the effect of ion dynamics on the nature of various types of traveling wave solutions. The solutions examined include periodic, quasi-periodic, chaotic as well as special coupled soliton solutions.

A.4.3 Non-Linear Phenomena

Vlasov Simuation studies using KSLAB

Kinetic Vlasov simulations of hot collisonless plasma are being performed using the parallel code Kinetic Simulation Lab (KSLab) which utilizes the high performance computing facilities powered by the Cray-X1E supercomputer and a cluster of Linux machines implemented by the IPR computer center. The code KSLab is presently being implemented to analyze the process of nonlinear Landau damping of large amplitude ion acoustic waves and associated coherent structures in a plasma with finite ion temperature. The Landau damping of plasma waves in a finite temperature collisionless plasma results from resonant energy exchange between waves and plasma particles. As compared to the physics of linear Landau damping of the plasma waves, many aspects of the process of nonlinear Landau damping remain less understood and are subject of active research. For a finite amplitude wave, particles which are near resonance with the phase velocity of the wave are trapped by the wave potential. Since the kinetic energy of these trapped particles is less than the potential barrier created by the wave in the frame moving with the phase velocity, they suffer multiple reflections between sets of turning points and constantly exchange energy with the wave. Over the times exceeding the bounce period of resonant particles, the linear estimates of damping therefore fail to describe the evolution of various quasistationary nonlinear structures and waveforms. The present Vlasov simulations using the code KSLab are being applied to study the evolution of finite amplitude nonlinear ion acoustic waves that give rise to coherent solitary waveforms. The kinetic effects, like the trapping of ions in the nonlinear ion acoustic wave potential and their reflection from the coherent soliton like structures, are seen to modify the estimates obtained from the linear analysis of the processes such as resonant wave particle interaction and collision-less damping of the plasma waves. The present computer simulations are aimed to investigate the nonlinear processes that also lead to effects like trapped particle instability in presence of large amplitude plasma waves and a modulational instability that can develop in the limit of $k\lambda_D>1$, where the ion acoustic waves are likely to show existence of envelop solitons governed by the nonlinear Schroedinger equation apart from the existence of conventional KdV solitons. A multispecies version of KSLab is also being applied to investigate the formation of a current-free double layer between the regions of plasma separated by a sharp gradient in the electron temperature. The front cover page shows a typical figure from the KSLAB simulation of the phase space of a non-linear wave in a hot plasma done in CRAY-X1E Supercomputer.

Generalized EMHD model

A generalized Electron Magneto-hydrodynamic (G-EMHD) model was developed to study the propagation of magnetic structures due to electron currents in electron time scales in an inhomogeneous plasma. The model has relevance in the fast ignition physics. In 2-D the model can be written in terms of two scalar fields (the magnetic field and the vector potential component along the symmetry direction). A numerical finite difference code in 2-D was developed to study the nonlinear evolution of magnetic structures through G-EMHD for various inhomogeneous plasma density profiles. The simulations demonstrate certain novel effects described below.

Shock formation and anomalous energy dissipation

An electron current pulse structure producing a magnetic field structure of the form of dipole upon entering an inhomogeneous plasma density region produces shocks. The generation of shock structures leads to rapid dissipation of energy from the electron current pulse. The energy dissipation is found to be anomalous and is independent of classical dissipative mechanisms. The observation of anomalous dissipation mechanism through shock fornation in an inhomogeneous plasma is ideal and desirable for the success of fast ignition (FI). In FI the creation of hot spot in the compressed target core depends on the rapid dissipation of energy from fast electrons created by the ignitor laser pulse.

Trapping in high density region

The shock formation and the subsequent energy dissipation leads to a novel time irreversible phenomena. A dipolar magnetic structure with electron current configuration corresponding to a spatially separated forwrad and return shielding currents is oberved to enter a high density plasma region. But once inside a high density plasma region it continues to remain trapped in the high density region.

Toroidal Electron Plasma

During 2005-06 and 2006-07, we had reported theoretical and simulational studies using Montecarlo and Fluid simulations for pure electron toroidal plasmas trapped by toroidal magnetic field. In 2007-08, a study of electron plasmas using a 5D particle-in-cell (PIC) simulation technique has been initiated. Several studies for varying Magnetic field, Neutral Pressure and Initial Electron Densities have been carried out. Time dependent fluid simulations, Montecarlo simulations and PIC simulations confirm the basic nature of the oscillations seen in the experimenal device SMARTEX-T at IPR.

A.4.4 Physics Modeling

Transport studies using (Non)equilibrium Molecular Dynamics methods

For finite sized systems, such as a nano-tube, equilibrium and non-equilibrium features tend to mar a credible comparison with experimental estimates. Possible examples range from lab grown nano-stuctures to bounded dusty plasmas. This new area of research started during early 2007. Following are the major milestones achieved during this year.

- Development of a 3D molecular dynamics (M.D.) code to model such finite sized systems for a modular interaction potential. Separate modules for "equilibrium" studies exploiting autocorrelation function formulation and "non-equilibrium" studies have been developed.
- Three widely different systems studied in our work are (i) Lennard Jones potential (ii) Yukawa Potential (iii) Tersoff Reactive Bond Order Potentialfor Carbon Nanotubes. Transport coefficients are calculated using both Einstein and Green Kubo formalism.
- All the modules have been separately benchmarked against known results.

Interesting new findings for Carbon Nanotubes include numerical determination of thermal conductivity using equilibrium heat current autocorrelation function formulation and using nonequilibrium methods. Also, a qualitative verification of Fourier Heat Law for CNT has been obtained using multiple-heat baths.

B. OTHER ACTIVITIES

B.1. FCIPT activities

B.1.1 Projects Completed

SPIX Project

FCIPT and ISAC, Bangalore had entered into an Memorandum of Understanding (MOU) for study of space plasma interactions with solar panels vide a project 'SPACE PLASMA INTERACTION EXPERIMENTS' (i.e SPIX) worth Rs. 97 Lacs. The final project report has been submitted on 28th November, 2007 to ISAC. Owing to the exciting results from the study, a second phase of the SPIX study is being worked out between ISAC & FCIPT which shall be materialized into a project in 08-09.

DST State S&T Systems (AP)

DST had funded for setting up demonstration scale plasma pyrolysis plants at Andhra Pradesh, Uttar Pradesh, Haryana and Tripura. Out of these sites, 2 systems have already been installed at sites, one at Agartala, Tripura and one at Hyderabad, Andhra Pradesh. The systems for other two sites shall be installed in upcoming couple of months. These systems shall generate techno-economic data of safe disposal of medical & plastic wastes and shall pave the way for an eco-friendly waste processing in India.

B.1.2 Projects Undertaken

MOU with CPCB

FCIPT and Central Pollution Control Board (CPCB) have signed an MOU for study and performance assessment of plasma pyrolysis technology for proper disposal of plastic waste, worth Rs. 13.63 Lacs. Under this project, the present plasma pyrolysis technology shall be tested for safe disposal of various types of plastic wastes (soiled plastics, metallized plastics etc.) under the presence of CPCB, GPCB and FCIPT representatives. The report on the emissions from plasma pyrolysis and its eco-friendliness shall be validated through this project.

Lab Scale Glow discharge System to Delhi University

Under an IPR funded project, FCIPT shall develop and demonstrate a lab scale glow discharge plasma system for Delhi University, which will enable DU to generate skilled manpower in the field of plasma physics.

B.1.3 Ongoing Projects

India's first Plasma based Angora Wool Treatment system installed at Kullu, H.P.

Under a DST funding, FCIPT along with NID had undertaken a project on development of atmospheric pressure plasma processing system for angora wool processing. The first of its kind, angora wool processing system has been installed in CWDB, Kullu, Himachal Pradesh.

Figure B.1.3.1 Atmospheric pressure plasma processing system for Angora wool installed at CWDB, Kullu, Himanchal Pradesh, India.

Feasibility studies of Al-coating on textile for Fire Resistant Application

Funded by Centre for Fire, Explosives and Environment Studies (CFEES), Timarpur, DRDO, New Delhi. The objective of the project was to develop infra-red reflective Aluminium coating on two kinds of fabrics, namely glass-wool fabric and meta-aramide based fabric, both provided by CFEES, for the purpose of developing Fire Resistant Textile. The coating was required to pass several stringent tests designed for considering the fabric suitable to Fire resistance application. A DC magnetron sputter coating system and the associated vacuum system are integrated and made functional to the required parameters. Al coating from the moderate purity Al target has been optimized for fast rate and purity of the deposition. Al coating on glass-wool and meta-aramide based fabrics were prepared and tested at CFEES for the required properties such as heat reflectance, etc. The results of the tests on both types of bare fabrics were not encouraging. The atomic deposition of Al in the process could not give a reflective and heat-opaque layer on the rough texture of fabric. So we found out a suitable 15 micron thick PI film, which has properties of withstanding to high temperature and low-friction (smooth) surface, to laminate over the fabrics and subsequently carried out the Al deposition. The prepared samples passed the stringent requirement such as low stiffness, no cracking at low temperature, abrasion resistance, heat reflectance, etc. Figure B.1.3.2 shows the XRD pattern of Al deposited on Si wafer placed along with the fabric.

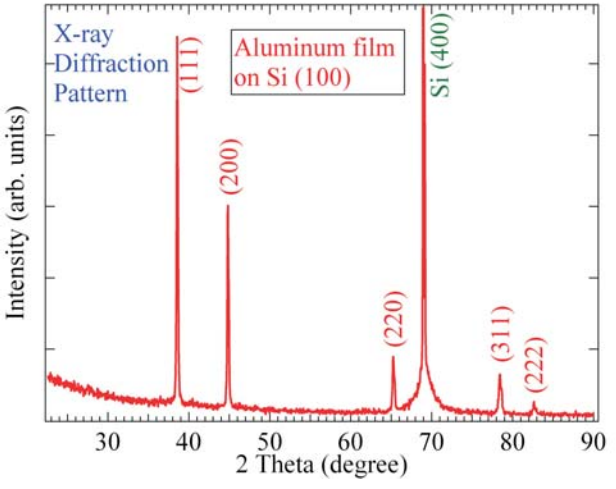


Figure B.1.3.2 Al coating on Si (100) wafer

Antifriction Teflon-like coatings on 2 m diameter SS shells using PECVD

Teflon (PTFE) is known for its unique properties such as low coefficient of friction, super-hydro-phobicity, biological compatibility etc. Teflon like coatings with good antifriction properties has good demand in the industry. Conventionally these Teflon like coatings are deposited by thermal spraying followed by high temperature (250 to 350 ° C) curing. However, this high temperature curing can lead to problems such as deformation in the case of large, bulky industrial components. In such cases, a technique which deposits Teflon like coatings at or close to room temperature has to be used. Plasma Enhanced Chemical Vapor Deposition (PECVD) is one such process.

In a project of national importance, from Indira Gandhi Center for Atomic Research (IGCAR), we have deposited thick and adherent Teflon like coatings on an industrial size component made of stainless steel (SS) at FCIPT. The component is a SS shell and is 2 m in diameter. We have deposited Teflon like coatings of minimum 5 μ thick with 2 - 4 M Pa adhesive strength, using PECVD. The deposited coating is observed to be uniform.

PECVD is a CVD technique that can deposit a variety of high quality films at or close to room temperature. Here, in order to deposit Teflon like coatings, the fluoro carbon precursors were generated by pyrolyzing the cleaned Teflon scrap/ powder at 450°C. These precursors, along with a carrier gas, are admitted into a capacitively coupled plasma discharge. The discharge was activated with a combination of pulsed dc and radio frequency (RF) power sources. The precursors are fragmented in the discharge and are then transported on to the surface of the substrate to build up the necessary coating. In order to deposit the Teflon like coatings on the inner surface of the SS shell, we have developed a special vacuum compatible box coater. This box coater houses the curved shower-head cum live electrode and all those connectors necessary for electrical and gas connections. In a batch, typically, 800 X 120 mm^2 surface area of the shell was coated. After finishing of a batch, the box coater is shifted to the adjacent region and like wise the entire shell is deposited with the coating. Proper care was taken to minimize the overlapping problems at the junction of the two adjacent regions. XPS study was used to confirm that the deposited coating was Teflon like.

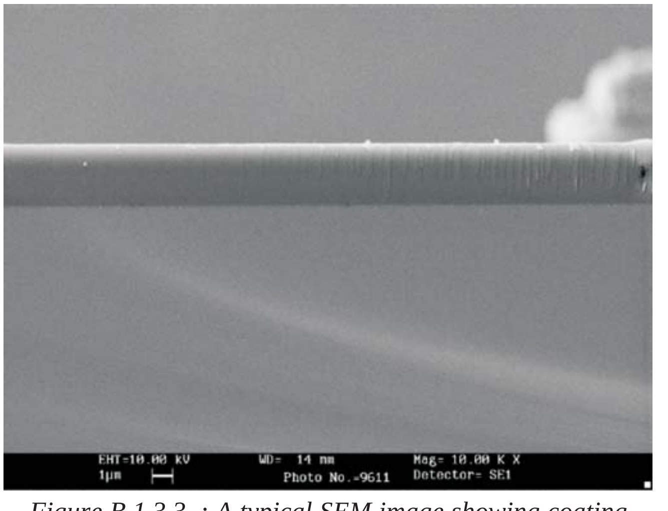


Figure B.1.3.3. : A typical SEM image showing coating

Figure B.1.3.4 The coated shell the uniformity of the coating

Figure B.1.3.5 SiO2 coated Brass articles

Eco-friendly Plasma Polymerization SiOx Coating on Brass Articles for Metal Handicraft Service Center (MHSC), Moradabad

Plasma Polymerization is eco-friendly method for protection of brass handicraft decorative objects from environment tarnishing and can be used as an alternative to lacquer spray method, which is hazardous.

In this project, a plasma polymerization system is set up at FCIPT. Process has been optimized here for coating in large area (80 cm x 80 cm) with Radio Frequency (RF) glow discharge. Process is also optimized for running deposition process in two stacks together in large area RF discharge. Process gives transparent coating on nearly flat 3D articles and optimization is underway for complex 3D shaped articles. Coated articles have been tested here for corrosion resistance and they have passed more then 96 hours in ASTM B 117 test (a standard corrosion test in 5% NaCl spray)

A comprehensive Training Program was held at FCIPT to train the MHSC Personals on "Understanding and Operation of Plasma Polymerization System". This project has drawn attention of Delhi Doordarshan and a brief coverage of MHSC Project for their Scientific Series, Turing Point is to be telecast shortly. System will be shipped to MHSC by October 2008.

Plasma based coatings for rocket applications

FCIPT had entered into an MOU with LPSC, Trivandrum for developing plasma based surface engineering technologies, viz. TiN coating and Teflon like coating on specific grades of SS. The first round of qualification trials on TiN and Teflon like coating have been completed and affirmative results have been obtained. The project is estimated to be completed by December 2008.

Energy Recovery project for CFEES, New Delhi

FCIPT had demonstrated the energy recovery concept from plasma pyrolysis of combustible wastes (cotton+plastic waste) by integrating it with gas generator. Further optimization of the process would lead to establishment of the energy recovery concept using plasma pyrolysis technology, which shall be completed by August 2008.

Installation of 50 kg/hr capacity plasma pyrolysis plant

The upgraded version of the 50 kg/hr plasma pyrolysis system is in the final stages of commissioning and will be demonstrated at FCIPT by September 2008. This shall be a milestone in the technology development and shall further pave the way for future upscalation.

Laboratory Scale Plasma Nitriding system installed at MNIT, Jaipur

The Lab scale plasma Nitriding system with langmuir probe plasma diagnostics had been installed and demonstrated to Malviya National Institute of Technology, Jaipur on 8th February, 2008.

Supply of Rigid Co-axial Transmission Line components to BARC

BARC had placed orders on FCIPT for supply of Rigid Co-axial Transmission Line Components. The RF Group at IPR had designed and fabricated the RCTL components and supplied the same to BARC.

Installation of Eco-friendly Plasma Nitriding Facility at IGTR, Ahmedabad

FCIPT has facilitated the installation of Eco-friendly plasma Nitriding facility at Indo German Tool Room, Ahmedabad under a project funded by DST New Delhi. The plasma Nitriding system installed at IGTR is in final stages of commissioning and shall be operational by September 2008 for routine jobwork. This shall help reduce the practice of polluting technologies and divert industries to adopt this eco-friendly technology.

B.1.4 Ongoing Projects under Collaboration

Projects under BRFS (National Fusion Program)

1. Radiation induced segregation and micro-structural modifications in irradiated FMS at different DPA and He appm / DPA (Mumbai University, Mumbai).
2. Development and Characterization of Carbon and SiC based Composites. (Sardar Patel University, Anand, Gujarat).
3. Preparation and Characterization of Lithium Titanate for Blanket Application in Fusion Reactor (BITS, Patna).

Projects for CPP, Assam

1. Studies on hydrogen and noble gas implantation on Materials of interest in tokamak reactor.
2. Development of a cascaded thermal plasma torch assisted system as a 1-10 MW/m^2 level tailored heat source, to be used for high heat flux testing of a Test Mock-up.

B.1.5 Activities at Surface Characterization Laboratory

Commercial Activities

Commercial activities such as characterization and analysis of various materials for composition, structure and property determination and failure analysis with the help of X-ray diffraction, Scanning electron Microscopy and EDX have been carried out for various customers including Pharmaceutical companies, Ceramics companies, Researchers from Universities and R&D organizations.

Samples like various drugs formulation powders, heat treated ceramic powders, metal, metal oxide and nitride films, wire meshes, rods, different bacterial and yeasts pellete, teeth, powders, bilayer resists, various coatings on substrates, nano particles and grains textile fibres, analysis of different defects in products (for quality control) were analyzed. Some of the important activities are given below:

Failure Analysis

The samples with micro cracks developed during the production were analyzed with SEM-EDX for the trapped elements (Sr) in the crack for 'Viraj Alloys ltd'. Hot rolled and cold rolled standard ETP copper bus bars from Omega Rolling Mills have been examined for the micro cracks and their development while bending ~90 ° C. Fractured SS 446 (ASTM A276) samples from 'TEMPSENS Instruments' have been analyzed for studying the micro crack formation as well as type of fracture occurred.

Analysis of Thin films and structures

Thin film samples of different Gadolinium oxides and Ytterbium oxides doped with Europium from Dept. of Optoelectronics, Univ. of Kerala, have been analyzed for their structural identifications in grazing incidence X-ray diffraction mode. AlN thin films grown on sapphire substrate were analyzed for structural identification, purity and preferentially oriented growth in (002) direction. The work was aimed at developing SAW devices using AlN films by Space Application Centre, Ahmedabad.

Various other samples such as Electrodeposited Cu strip, Ta wire mesh with unknown coating, patterned Silicon wafer samples have been analyzed for the grain size, composition and microstructure. Test pattern on a bi-layer resist (PMMA) for the device has been examined for the thickness and quality of the deposition on the quartz wafer.

Nanoparticles and structures have been analyzed for their nano-size identification, shapes, etc for industries and research organizations. This includes different types of dyes used in the ink for printer and paints and magnetic ferrite nanoparticles with surfactant and without surfactant.

Surface characterization of specimens from bio and health care research organizations

Bacteria viz., Staphylococcus aureus from Indian Institute for Advanced Research (IIAR), Gandhinagar were analyzed for their surface morphology and sizes by SEM imaging. Different bacterial pellets of acidothiobacillus from Department of Microbiology, Gujarat University have been examined for the study of the Cr (IV) reduction and Cr/Cu bioaccumulation, under different aerobic and anaerobic conditions.

Investigation of the effect of XeCl excimer laser on smear layer covered dentine of extracted human teeth has been done for the Dental College, Civil Hospital, Ahmedabad. SEM analysis has been performed to identify the presence of smear layer and dentinal tubular openings. The craters, fissures, melted dentinal surface, or modification of smear layer are identified and examined.

Internal Activities

- Powder X-ray diffraction analysis of TiN coating on 410 C steel in order to optimize the deposition quality is carried out from time to time for one of the external projects taken up by FCIPT.
- Analyzed Copper coating on glass to support a study on power frequency/pulse dependence of the coating and coating process in a sputter magnetron deposition system.
- Carried out Grazing incidence diffraction analysis of thin Copper and TiN depositions on Si wafer to aid a basic research project.
- Provided X-ray diffraction analysis of TiAl composite coatings on Si wafer grown by dual magnetron sputtering system to aid the basic research project.
- Plasma nitrocarburizing on boiler quality steels are performed to increase its hardness and corrosion resistance simultaneously. Powder XRD was employed to verify the hardness improvement of such samples by identifying the nitride phases on the treated surfaces.

Up-gradation of X-ray Diffraction facility

X-ray diffraction facility up-gradation program has been executed. Measurement and analysis software and associated hardware up-gradation has been done due to redundancy of the older version of the software and new features of the newer version, which are advantageous for various XRD applications, data analysis and parallel functioning.

B.1.7 ISO Certification

FCIPT has got ISO 9001:2000 certifications from TUV South Asia for compliance to Quality Management System (QMS). The Certification audit was performed by TUV on 19-July-2007 by their lead auditors and FCIPT had been rated 'Excellent' in the result of audit.

ISO 9001

QM011

B.1.8 Plasma Science Popularizing Meet

FCIPT had conducted a plasma popularizing meeting under DST funding to attract plasma based novel proposals leading to cross disciplinary technology developments. The meeting had been successful and appreciable amount of quality proposals had been generated by proposers from across India.

B.2 National Fusion Programme

It has been proposed to set up a board named as 'Board for Research on Fusion Science and Technology (BRFST)' to overview the activities of the National Fusion programme (NFP). This board will get ratified in the next possible meeting. During the year 2007 – 2008 an ad-hoc committee had been setup by IPR under the National Fusion Programme (NFP). This committee approved 18 projects totaling 4.3 Crores in three years after a formal review. First Year installment for all the projects (i. e ~ 3.0 Crores) have been sanctioned. Seven National and International conferences/symposia/workshops have been funded with a budget of Rs 7.2 Lacs during the year.

Proposed Workshop for taking the Resources Base in the Industry

After the academic and research institutions, the industry in India is potentially the largest untapped manpower source for basic research and development. It is essential for the growth of scientific R&D in India that the industry be actively involved in R&D that is not necessarily specific to its product line. With this in mind and keeping the goals of NFP in focus it has been decided to involve industry in NFP funded R&D schemes. It has been planned to arrange this workshop in a near future.

B.2.1 Internship Scheme

After successful operation of ITER, the country shall be able to take up designing and building a demo reactor. To achieve this, it has been realized that a long-term programme aimed at developing competence in all aspects of fusion science and technology within the country, needs to be started. Keeping these in mind, an Internship scheme has been initiated at IPR under National Fusion Programme (NFP), which would be helpful in generating manpower for future requirements of the country in this field.

Under this scheme, Post Graduate Students interested in research areas related to science & technology of Fusion research/ Plasma physics are encouraged to apply for undertaking projects at IPR on various topics under the supervision of IPR scientists/engineers. A stipend of Rs 5000/- per month is paid to the students who are not getting any financial support. Students can start their projects from semester beginning either around July or around January, depending on the schedule of their curriculum.

Internship scheme received good response and meritorious students were selected to take up projects at IPR; in the very first batch eight students joined in July 2007 semester while one student joined in Jan 2008 semester. These students are completing their projects successfully and would be submitting the reports on following topics

1. Parallel Programming with MPI & BLACS
2. Design of High Power Microwave Components for Gyrotron
3. Design and Development of IR Camera Interfacing Link
4. Eddy Current Analysis of Large Scale Vacuum Vessel of Fusion Grade Tokamak
5. Engineering design of first wall and box structure for Test Blanket Module
6. MHD Analysis for Liquid Metal Flows in Components of Fusion Grade Tokamaks
7. Design and Analysis of Cryoshields of Cryopump for Fusion Grade Tokamaks
8. Design and Transient Dynamic Analysis for Electromagnetic Loads on Vacuum Vessel for Large Scale Fusion Grade Tokamaks
9. Feasibility Study of Advanced Welding for Double wall vacuum vessel for Fusion Grade Tokamaks

B.3. ITER-India

(Note: In the report below IN refers to the Indian domestic agency (DA), namely ITER-India and IO refers to the ITER International Organisation, similarly KO, CN, EU etc refer to Korean, Chinese, European DAs respectively)

ITER-India, the Indian domestic agency for ITER, was established formally on 16 Nov, 2007 at the first meeting of the ITER-India Empowered Board, a governing body for looking after the program of Indian participation to ITER. Director, IPR will remain the Chief Scientist of ITER-India, while Dr. Shishir P. Deshpande was appointed as the Project Director. Figure B.3.1 (page 50) shows the Organisation Chart of ITER-India.

Initially 31 existing staff members of IPR joined ITER-India, with another 20 to be freshly recruited in IPR and transferred to ITER-India. In the second Empowered Board meeting held on March 14, 2008, additional 70 new positions were approved by the empowered board, to be advertised shortly. Thus the total approved strength of ITER-India at present is 120.

The new ITER-India office building, located in GIDC, Electronics estate, Gandhinagar, was taken on lease since October'07, significant renovation and furnishing was carried out for creating a very conducive environment for the ITER-India personnel. The ITER-India personnel have since shifted from IPR to the new office.

Due to the nature of work in ITER demanding a high network bandwidth, ITER-India will have a 10 Mbps Internet bandwidth and a 45 Mbps, dedicated leased line link to ITER through ITER-India-TIFR(Mumbai)-ITER route. A 1Gbps leased line from TIFR to CERN has already been established by DAE and ITER-India-TIFR link will be upgraded to 1Gbps as and when required. The contract for the network was awarded through standard tendering process to M/s Bharti Airtel.

A dedicated R&D lab to support ITER-India activities will be constructed inside IPR campus, which will need to share the existing facilities like cryogenics, power supplies etc in IPR. Figure 2 shows an Architectural view of the Lab building. This lab building will be constructed by mid-2010.

The ITER-India website and document servers are operational for the last one year which can be accessed at https://www.iter-india.res.in/. The documentation system called INDUS is being extensively used for ITER-documentation.

For carrying out various engineering design and analysis work related to ITER, a CAD station has been established with 15 CATIA licenses. Engineering services support from various Indian Engineering Industries has been started through contractual agreements for various urgent ITER package related work.

ITER related activities

Pre-procurement activities are ongoing in the various ITER packages in India's scope. Following is a brief status report on these:

- **WBS 1.5: In-wall shield**

1. Contract for conceptual design, Finite Element analysis (structural, thermal, electro-magnetic and coupled) and final engineering design of ITER Vacuum Vessel In-Wall Shields (VV-IWS) for vessel sector # 1 has been placed with an Indian Engineering farm (M/s Altair Engg. India Pvt. Ltd.; Bangalore) through a contractual agreement. Altair has completed bench-mark structural analysis problem and matched results earlier carried out by IO. This has established a procedure to setup a general model, carry out meshing and apply appropriate boundary condition. Altair results have been sent to IO for review.

2. Segmentation of VV-IWS blocks and generating their (about 6000) numbering scheme have been started. Each block and each plate of block will have unique number which will identify the location of block on ITER vacuum vessel.

3. Preliminary 3-D models have been generated for Finite Element Analysis based on data given by ITER IO. IO gave the revised and final data / 3-D vessel models in March 2008. Based on these data actual FEA and design activities for VV-IWS blocks have been started.

4. Material requirements and specifications for VV-IWS were obtained from IO for IN to detail out the requirements of different materials for VV-IWS. ITER-India has raised advertisement for EOI for material procurement on 03/03/2008. IN has contacted worldwide potential material suppliers and working out detailed schedule for material procurement.

5. Corrosion study of VV-IWS materials under normal and off-normal operating conditions of vessel cooling is an important issue. India is responsible for carrying out crevice corrosion study of SS 304 B4, SS 304 B7 and SS 430. ITER-India has involved M/s TCR, Mumbai for this study. At present fabrication of Autoclave systems and material samples is in progress.

6. Fabrication and delivery schedule for VV-IWS has been prepared and being discussed with IO, EU and KO. IO, EU and IN members attended two meetings at Cadarache between 17-19 Dec, 2007 and 12-14 Mar, 2008 to resolve interface issues.

- **WBS 2.4: Cryostat & VVPSS**

1. Cryostat: Detailed design, analysis and other R & D work are being carried out with the ITER-India Engineering Services Contractor. Two major Task Agreements (TA) has been signed with IO in this regard.

2. Analysis, design, manufacturing study & qualification of port metallic bellows are being carried out.

3. Cryostat structural analysis and analysis task related to Design review, DCR-40 & DCR-70 was reported to IO.

4. System requirement document for Cryostat & Vacuum Vessel Pressure Suppression System is being reviewed. A team of experts with a chairperson, Project Manager, Cryostat&VVPSS has been defined by IO.

5. Planning & Scheduling for Cryostat & VVPSS procurement activities has been identified and detailed schedule is submitted to IO.

- **WBS 2.6: Cooling Water System**

1. The detailed Planning & Scheduling (P&S) was submitted in which IN & IO activities have been projected based on 2nd ITER P&S meeting. The detailed P&S was submitted to IO

2. The other draft documents to proceed for PA are under study along with IO.

3. The necessary documents (especially Functional Specifications) from IO to proceed for detailed engineering design are awaited. Various draft documents to proceed for PA are under study along with IO.

4. Effects of DCR 154 & 159 on cost impact are being studied.

- **WBS 3.4: Cryo-distribution & Cryo-lines**

1. Detailed P&S has been submitted and integrated with ITER Integrated Project Schedule (IPS).

2. Task Agreement for design of torus, cryostat and NB cryo-line has been signed and all sub-task reports have been submitted.

3. The technical details of the cryo lines have been worked out. Assembly and integration plan for the torus and cryostat cryo line at B2M level of tokamak building has been worked out.

4. Detailed design of the prototype cryo-line along with cold test work plan has been finalised and submitted to IO for approval. Test facility for the prototype cryo-line has been conceptualised and discussed with IO.

5. Task Agreement on detailed design of the main transfer line from cryo-plant building to tokamak building has been signed. Two engineers were deputed at Cadarache by IN for a month to work with IO for detailed analysis.

- **WBS 4.2: Power supplies (DNB, IC, EC start-up)**

1. Ion Cyclotron (IC) power supplies conceptual design has been completed.

2. Conceptual design of DNB Power Supply System has been completed.

- **WBS 5.1: Ion Cyclotron (IC) Heating & Current Drive Sources**

1. Conceptual design of the IC system has been completed. Detailed engineering design, analysis and R&D work are being carried out.

2. Monitoring & Control scheme for the source and power supply system has been finalized.

3. For R&D unit, contacted potential vendors in the areas of low & high power RF sections & Data Acquisition and Control (DAC) system.

4. Procurement activity for some of the components for R & D unit initiated.

5. Component level design of Pre-driver stage completed, mechanical design ongoing.

6. Specification for Auxiliary power supplies for pre-driver stage has been completed.

7. The detailed Planning & Scheduling was submitted in which IN activities have been projected based on 3rd P&S meeting breakout session.

8. Task agreement “Support to ICRH antenna & system design”completed and final report has been submitted to IO.

- **WBS 5.2: Start-up Electron Cyclotron (EC) System**

1. Conceptual design is presently ongoing.

2. Preparations for the IPS scheduling workshop and subsequent submissions of schedules have been completed.

3. Work towards the ITA task (Report preparation etc), which is due by Apr-08 is in progress.

4. Effect of DCR 160 on change in frequency of the Startup EC system from 127 GHz to 170 GHz is being analyzed. In this context a re-definition of the Procurement package is being negotiated with ITER-IO.

5. Efforts are being made to bring out synergies with the domestic gyrotron developmental activities.

6. Possible collaborations with other organizations viz.ECIL are currently being perceived

7. Plans are being worked out to host a IAEA TM, in 2009 , the subject matter of which is closely relevant to the package deliverables

- **WBS 5.3: Diagnostic Neutral Beam (DNB) System**

The DNB as a system is mandated to deliver ~17–20 A of Neutral Beam current into ITER at 100 keV beam energy, for the purpose of He ash diagnostics, one of the most important diagnostics for fusion plasmas. Except for the beam energy, configuration of DNB is similar to the Heating and current drive NB, with an ion source which is exactly identical. The baseline design of DNB was however not complete, and following the allocation of DNB to IN, major emphasis has been to consolidate the design and help ITER in generating the BTP specifications for the system.

Following are the highlights of the activities and the major realizations over the past one year:

1. First level of optimisation of beam line configuration, component sizing and preliminary thermal hydraulics assessment of actively cooled components have been carried out, report has been completed and submitted to IO. Several options have been studied to explore the feasibility of a more compact beam line for DNB. This has led to a few changes in DNB configuration over the DDD 5.3 proposals. The TA report has been reviewed and accepted.

2. Design of DNB extractor is an ongoing task and is being carried out in collaboration with CEA for the physics design and with RFX for the mechanical design. The first proposal for the DNB grids is ready and is being considered for adoption for the ISTF accelerator configuration.

3. Proposal for DNB ion source development in collaboration (IN, EU and JA) has been finalized, under a framework that

the low voltage tests for the DNB would be carried out at 100 kV Hydrogen, to integrate the needs for DNB. Present understanding is that the tests shall be carried in the ISTF facility created under the NBTF establishment.

4. Action on the IN R&D plans - contract placement for procurement of BATMAN and RF generator in final stages, collaboration with IPP has started, under a domestic program, approved for the negative ion R&D.

5. Finalization of engineering contract (CAD, Analysis, Design) for engineering of DNB component and injector system, has been completed. Design activities are ongoing with active participation of IO.

6. Information exchange & training for BATAMAN negative ion source has been initiated under the domestic R&D programme. 4 IN scientists and engineers have visited IPP Garching and have undergone the first phase of training,

7. Discussions were held with the IO Drawing Office working on DNB layout and for transfer of engineering design drawings of DNB components. The transfer protocol, now established is being used extensively for the design data exchange.

8. 3 task agreements have been signed with IO for the completion of the engineering design, development of prototypes and for design inputs into the ISTF work. These are in progress,

9. Discussions have been initiated for the preparation of the Procurement Arrangement for DNB, which is now scheduled to be signed in June 2009.

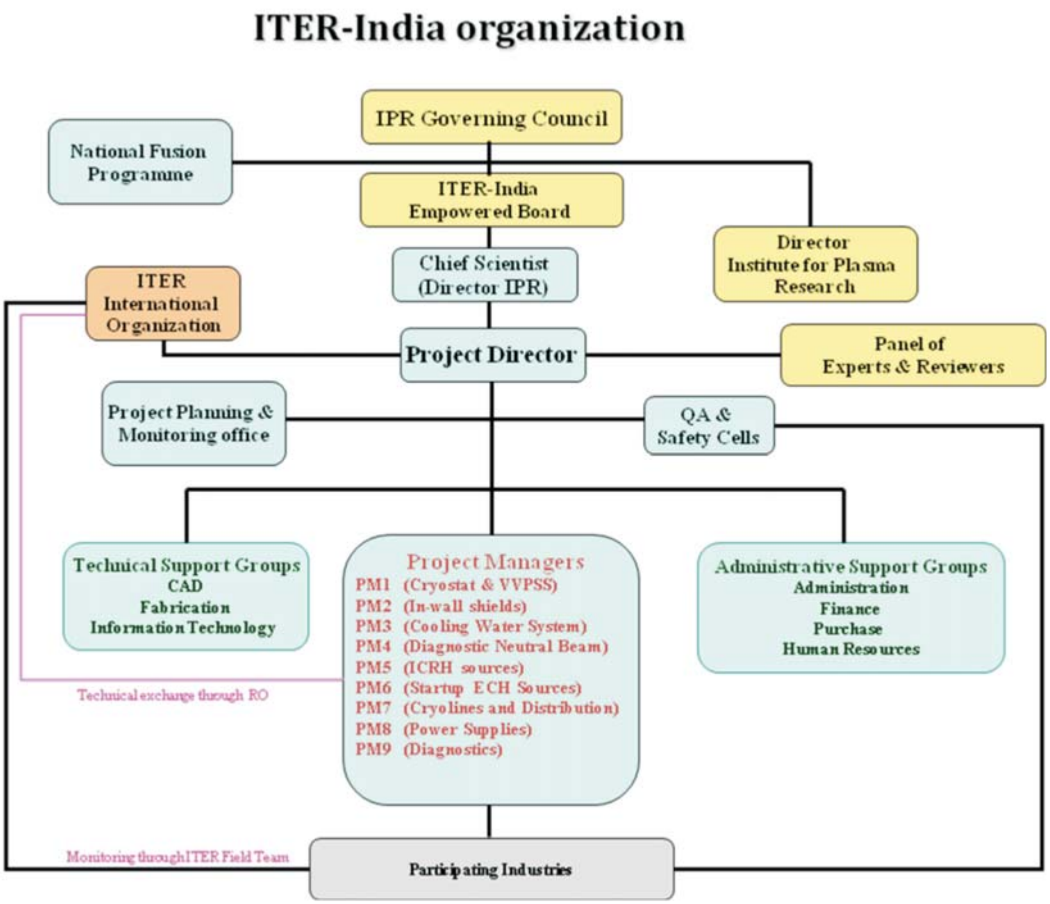


Figure B.3.1. ITER-India Organisation Chart

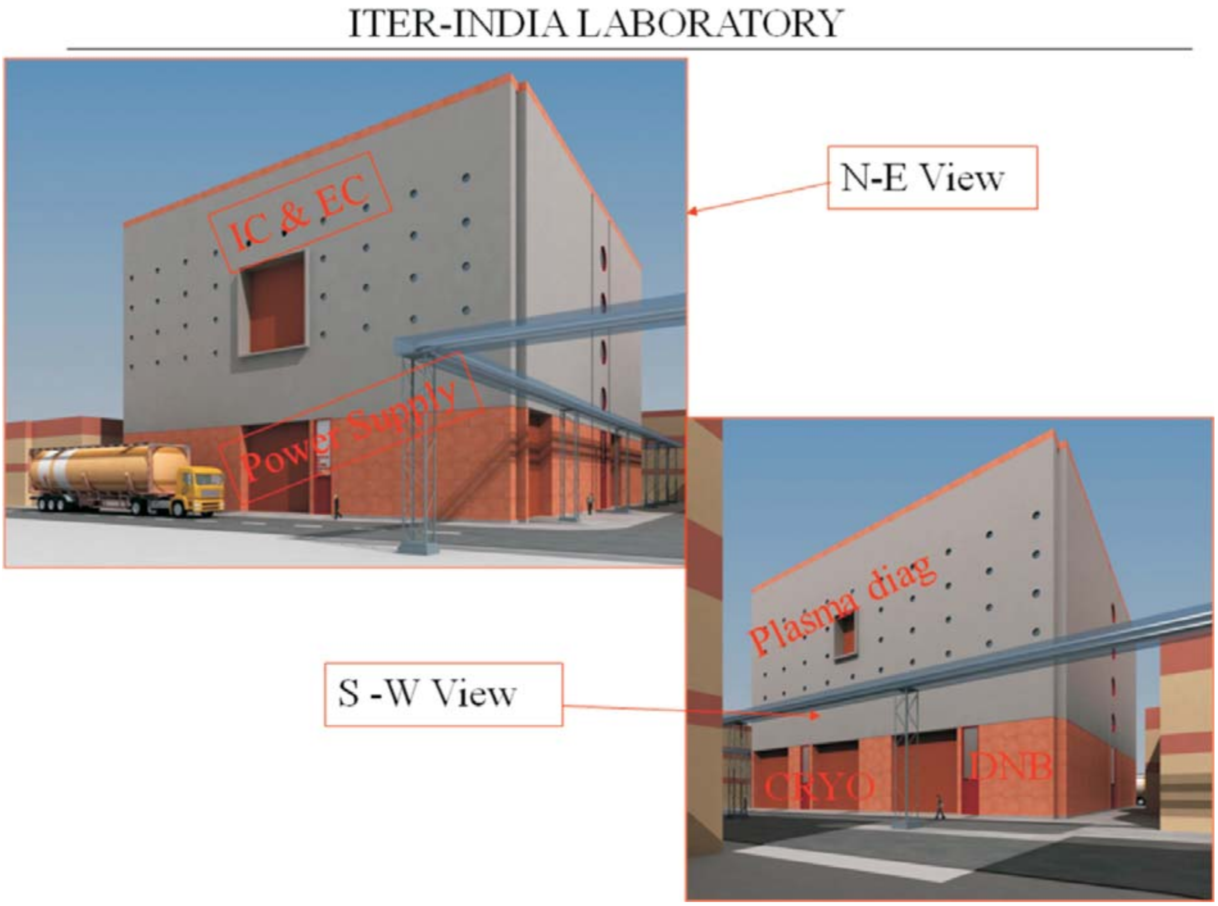


Figure B.3.2. Architectural view of new ITER-India Lab to be constructed

- **WBS 5.5: Diagnostics**

1. IN-diagnostics package is being integrated with ITER diagnostics.
2. Task on port plug design and analysis has been completed and submitted to IO. One IN engineer spent 3 months in ITER to carry out this analysis.

Other ITER Related Work

Magnet QC

Finalization & detailing of Magnet QC items for procurement and assembly was carried out.

CODAC

Subtask 1 (C45TD03FI) on Modeling of CODAC to Plant System Host Data exchanges has been completed and approved by IO.

R&D Tasks

- Some non-credit task agreements completed and reports have been submitted to the IO. Other non-credit task agreements are proceeding according to schedule and to be completed as planned
- Two major task agreement draft documents related to detailed design & R & D for Cryostat (WBS 2.4) have been received from IO and task agreement are being finalized by IN.
- In diagnostic package, work related to port plug is in progress and one engineer is already stationed at Cadarache to work o this.
- One engineer has worked for 4 months in the Remote Handling group on a visiting short term assignment.

- Corrosion study of VV-IWS materials: Manufacturing of four autoclaves completed and tested for 210 deg. C water temperature and 24 bar water pressure. Manufacturing of test coupons and their holder completed. Water of required ITER chemistry prepared and tested.

Other ITER activities (Design Review, STAC Issues etc)

Design Review: IN scientists and Engineers actively participated in the ITER Design review held in 2007. Significant amount of analysis and many discussions were held by the 13 design review working groups in most of which IN had its participants.

STAC Review: The Science and Technology Advisory Committee (STAC) of ITER, with Prof. Kaw as the present Chair, held a detailed Physics and Engineering design review of ITER in 2007-2008. The STAC-1 and STAC-II meetings were held in September and November, 2007 respectively. As a result of the STAC review (the so called *STAC issues* in ITER), ITER design underwent significant changes for necessary improvements in its design, e.g., addition of in-vessel ELM control coils, improvement of poloial field coil capabilities, improvement of RH and Hot cell specifications etc. All of the STAC suggestions are being incorporated in the new ITER baseline design.

MAC Meetings: The Management Advisory Committee (MAC) of ITER similarly held detailed review of the ITER management policies like funding, budgetary and manpower resource optimization and various other critical issues.

IO-DA Meetings: The IO-DA coordination meetings, which earlier (till November 2007) used to be called the (Participant Team Leader) PTL meetings are held every month, with alternate meetings now being held at Cadarache, while the in-between ones hosted by one of the DAs. These meetings are aimed specifically for increasing coordination between the IO and all the DAs, especially for resolving critical technical and management issues for a smooth execution of the ITER Project.

ITER CODAC activities

IPR has decided to pro actively work for ITER CODAC (Command Data Access and Communication) software package and hence a CODAC division has been set up. When India joined the ITER Project IPR tried to acquire CODAC as a package to be supplied in kind. But since ITER has kept it in fund, it was not allocated to any Domestic Agency (DA) party. Being the heart of ITER project all DA parties are showing interest in contributing to the CODAC. Since it's a software development package, it can easily be executed by Indian IT industries as and when such work is floated by ITER IO. Keeping this in view during the year an awareness was generated within IT industries about the CODAC. For this a meeting and a work shop were conducted with Indian IT industries through which the requirements of CODAC was introduced with some basic understanding of Tokamak too. Leading industries like Infosys, TCS, Wipro, Patni computers, CMC and many more participated in the meeting and in the subsequent workshop.

To involve the Indian IT industries with CODAC joint working model of ITER CODAC group, IPR and Indian IT industries to ITER CODAC was proposed. Based on this model ITER IO proposed a task of Modelling of Data exchange between CODAC and Plant system to all DA parties (US, CN, Korea, EU, JP, RS, IN). **Against this competitive bid IPR has been successful in getting the task at 3,50,000 Euros (Rs. 2.20 Crores.)**

For this task TCS has been shortlisted to provide software experts and they have worked with ITER IO CODAC team for seven months at Cadarache, France. The team was consists of two of TCS engineer and two IPR Engineer. The task was distributed in three phases. Phase I: Analysis, Phase II: Define and Design of GPI and Phase III: Prototype Implementation Under Phase I, the works carried out are the Requirement Analysis, Functional analysis, Architectural analysis using Rhapsody UML tool. Second phase was devoted to define the interactions between COADC and Plant system and design of interface. In the third phase prototype was developed in JAVA making use of OPC server, Client, State Machine and Rule based engine and demonstrated the same. The work was completed in the given time as per the quality requirements and has paved the way for further tasks.

C. ACADEMIC PROGRAMMES

C.1 DOCTORATE PROGRAMME

In the Ph.D. programme conducted by the institute **twenty-six (26)** research scholars have been enrolled at present. Out of them**, thirteen (13)** are working in theoretical and simulation projects while **six (6)** are engaged in experimental projects. **Seven (7)** 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 (during April 2007 - March 2008)

Investigation of Toroidal RF Plasmas
Manash Kumar Paul
Gujarat University, Ahmedabad, 2007

Study of High Beta Plasma in Laboratory
L.M. Awasthi
Gujarat University, Ahmedabad, 2007

Study of RF Produced Plasma Columns
Rajneesh Kumar
Gujarat University, Ahmedabad, 2007

Studies on Electron Cyclotron Emission from Fusion Plasma
Hitesh Kumar Pandya
Devi Ahilya Vishwa Vidyalaya, Indore, 2008

C.2 SUMMER SCHOOL PROGRAMME

Twenty-five (25) 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.

C.3 BASIC PHYSICS LABORATORY FOR STUDENTS

A plasma physics experimental programme had been proposed to train the Ph.D. Students. Under this programme a laboratory is being created with some basic experimental devices. During their course work the students will be asked to do some projects in this devices, for which the students will be given extra credits to pass through their course work. It is expected that this programme will help students to get acquainted with experimental plasma physics and motivate them to do their experimental research work later. Faculty and research staff at IPR will give additional lectures and help devise new experiments also in future. This laboratory programme will be integrated into the existing research curriculum. Course modules will be designed in such a way that it could supplement what is taught in the plasma physics classes. The students will help construct the device and plan the experiments. The initial experiments, which are being planned, are: glow discharge experiment, RF plasma experiment and microwave plasma experiment. Two experimental systems and its diagnostics are already operational and vacuum chambers for the other two are in the fabrication stages.

D TECHNICAL SERVICES

D.1 Engineering Services

D.1.1. Air conditioning and water cooling

The Air conditioning and Water cooling group supplied chilled water with required conductivity, temperature, pressure and flow rate to the testing of NBI- helium plant. Also the chilled water of required parameters has been supplied during the regular operation of Magnet-helium plant and the turbo-molecular pumps. The frequent regeneration of water treatment plants has been carried out to maintain the required conductivity. The Variable frequency drives have been installed for RF and NBI systems process cooling pumps. The piping for the cooling of new LHCD systems has been designed. The various valves, instruments, etc have been procured. The piping work to supply chilled water to additional klystrons will start soon. The paining of tanks, piping, structure, etc has been carried out.

The air-conditioning of Administration annexure building has been carried out. Air handling units have been replaced with new ones in Aditya Hall, Seminal Hall & Beta Lab. The replacement of fan coil unit drain pans has been carried out in first floor rooms. Split air conditioners have been installed in ITER India building, new RF lab, Pulse Power lab, Electron Positron lab, etc. Split air conditioners also have been installed in Director's office, Dean's office, committee rooms, etc.

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

D.1.2. Drafting Services

- Drawing section caters to different scientific groups of the institute in generating the Engineering / fabrication drawings.
- During this year they have helped users in getting number of systems fabricated from within Institute's workshop as well as from outside manufacturers.

- Our drawing section is currently using MDT software for generating 2D drawings and 3D models. But now intend to migrate to CATIA software which will facilitate in improving our section output and as well as take up more complex job which can be generated in CATIA with ease.

D.1.3. Mechanical Workshop

- In the workshop a procedure has been established to enable user to get their items, systems manufactured and fabricated in minimum possible time. The skill sets have been identified and work distribution is being done accordingly so as to make the work is done in less time.
- Different groups also get additional support from members of workshop to solve their technical problems in their laboratory related to mechanical assemblies, mechanical instruments etc.
- It has already started to use latest tools and related item to improve upon the quality of machined components and minimize the time spent.
- Recently manufacturing of JIG and fixtures have been done for the items that are repeatedly made by the user.

D.2. Computer Services

The computer center was actively involved in expanding and maintaining the IT infrastructure of the institute through network management and troubleshooting, Internet services management, software support, website maintenance, bandwidth reservation and monitoring during videoconferencing sessions, hardware and software procurements.

The campus network was expanded to include the newly built guest house and hostels. Each hostel was provided with pre-configured systems loaded with all required software and printing facility. Apart from browsing and other Internet facilities, the computational resources of the institute have been made accessible to the hostellers.

Technical support for international conferences APFA 2007, APPTC 2007 and Winter School on Hands-on Research on Complex Systems was provided by the center by developing interactive web sites and installing and configuring all necessary hardware, software required for the same.

FCIPT's website, www.plasmaindia.com was hosted in our own webserver along with our own website. The Internet bandwidth of the institute was upgraded to 4 Mbps. Troubleshooting and administrative tasks related to the Cray supercomputer, the 34 node compute cluster, various Internet servers and computational workstations were undertaken. Softwares developed by the center for visitors' management, cafeteria accounting, salary/tax computations and E-office applications were supported and modified as needed to incorporate necessary changes.

D.3. Library Services

IPR Library is moving on and contributing **significantly** towards the Institutes' **success** by working in **synergetic** manner. Library is **strengthening** in resources, both electronic and print. Though emphasis is more towards electronic resources in this digital era, it **shapes** out to be a perfect example of a Hybrid library.

Application of ICT to provide **cutting edge services** to the scientific community is always a priority for the experienced library staff. They are adding value to the scientific knowledge and facilitating research in Plasma physics and Fusion technology.

Library continued to provide services not only to Plasma Physicists working at IPR but also to scientists working in the novel projects such as ITER-India, Pulsed Power Project, Plasma Pyrolysis Project of FCIPT, etc. and other Institutes and Universities across India.

Collection and Services

Library added 764 Regular Books, 62 Technical Reports, 35 Pamphlets, 176 Reprints, 38 IPR Publications and Downloaded 153 Thesis, 61 Reports, 55 Reprints and 3 Books.

Library has issued 6241 Books; 39 Journals; 5 Standards; and 322 Reports and provided 114766 photocopies.

Satisfied 87.65% Inter Library Loan requests by borrowing documents from other libraries and satisfied 94.68% requests received from other libraries.

Library continued to provide access to e-resources, like e-journals including ScienceDirect, PROLA, IOP Historical Archive, and subscribed to Engineering Village which includes online access to INSPEC and COMPENDEX with supplementary access to SCOPUS for six months. It has been continued to update library's web site to include new information and resources, bibliographies of senior scientists, Virtual Tour, etc.

Developed an E-Resource Management Software for managing full-text e-resources, with browsing and search facility. Also implemented Institutional Repository software to manage e-documents of BARC project, more than 2000 reports have been entered and now available online.

Infrastructure

Reports section has been reorganized with addition of 2 Racks and 2 Cupboards. An additional Bar code scanner was added to the library infrastructure.

E. PUBLICATIONS AND PRESENTATIONS

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

Intrinsic Rotation and Electric Field Shear
O. D. GURCAN, P. H. DIAMOND, T. S. HAHM, and R. SINGH
Physics of Plasmas, ***14***, *042306, 2007*

Wave Induced Barrier Transparency and Melting of Quasi-Crystalline Structures in Two Dimensional Plasma Turbulence
AMITA DAS
Physics of Plasmas, ***14***, *042307, 2007*

Design of Multipulse Thomson Scattering Diagnostic for SST-1 Tokamak
AJAI KUMAR, CHHAYA CHAVDA, Y. C. SAXENA, RANJEET SINGH, ARUNA THAKAR, JINTO THOMAS, KIRAN PATEL, KAUSHAL PANDYA, and VIJAY BEDAKIHALE
Review of Scientific Instruments, ***78***, *043507, 2007*

Theoretical Study of FCC–HCP Phase Coexistence and Phase Stability In Al By FP-LAPW Method with GGA for Exchange and Correlation
VINAYAK MISHRA and S. CHATURVEDI
Physica B: Condensed Matter, ***393,*** *278, 2007*

Coherence resonance in an excitable system with time delay
GAUTAM C. SETHIA, JURGEN KURTHS and ABHIJIT SEN
Physics Letters A, ***364***, *227, 2007*

Pulsed Plasma Production for Applications in Plasma Immersion Ion Implantation and its Implications
S. MUKHERJEE, M. RANJAN, R. RANE, N. VAGHELA, A. PHUKAN and K.S. SURAJ
Surface and Coatings Technology, ***201***, *6502, 2007*

A Model for Particle and Heat Losses by Type I Edge Localized Modes
M Z TOKAR, A GUPTA, D KALUPIN and R SINGH
Plasma Physics & Controlled Fusion, ***49,*** *395, 2007*

Deposition of Superhydrophobic Nanostructured Teflon-Like Coating Using Expanding Plasma Arc
A. SATYAPRASAD, V. JAIN and S.K. NEMA
Applied Surface Science, ***253,*** *5462, 2007*

Plasma Nitriding of a Low Alloy – High Carbon Steel
A. BASU, J. DUTTA MAJUMDAR, J. ALPHONSA, S. MUKHERJEE, and I. MANNA
Transactions of the Indian Institute of Metals, **60,** 471, 2007

Characterization of the Plasma Properties of a Reverse Polarity Planar Magnetron Operated as an Ion Source
MUKESH RANJAN, KISHOR K. KALATHIPARAMBIL, NARESH P. VAGHELA, and SUBROTO MUKHERJEE
Plasma Processes and Polymers, ***4,*** *1030, 2007*

Modification of Edge Current Profile and Improved Confinement Induced by Biased Electrode in The Very Low Qa (VLQ) Discharges of SINP - Tokamak
JOYDEEP GHOSH, RABINDRANATH PAL, P.K. CHATTOPADHYAY, and DEBJYOTI BASU
Nuclear Fusion, ***47***, *331, 2007*

Zero-dimensional model for magnetic curvature driven Rayleigh Taylor turbulence simulations
SARVESHWAR SHARMA, AMITA DAS, PREDHIMAN KAW and ABHIJIT SEN
Physica A: Statistical Mechanics and its Applications, ***378***, *211, 2007*

Role Of Ambient Gas and Laser Fluence In Governing The Dynamics Of The Plasma Plumes Produced by Laser Blow Off of Lif–C Thin Film
R. K. SINGH, AJAI KUMAR, B. G. PATEL, and K. P. SUBRAMANIAN
Journal of Applied Physics, ***101,*** *103301, 2007*

Nonlinear Excitation of Geodesic Acoustic Modes by Drift Waves
N. CHAKRABARTI, R. SINGH, P. K. KAW, and P. N. GUZDAR
Physics of Plasmas, ***14***, *052308, 2007*

Quasisteady State Interpulse Plasmas
SUDEEP BHATTACHARJEE, INDRANUJ DEY, ABHIJIT SEN, and HIROSHI AMEMIYA
Journal of Applied Physics, ***101,*** *113311, 2007*

Surface Modification of Angora Rabbit Fibers Using Dielectric Barrier Discharge
N. DANISH, M.K. GARG, R.S. RANE, P.B. JHALA and S.K. NEMA
Applied Surface Science, ***253***, *6915, 2007*

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MANOJ SINGH, KUMAR RAJNISH, RAMESH JOSHI, H.M. JADAV, SIJU GEORGE, RAJ SINGH, RITESH SUGANDHI, D. PUROHIT, S.V. KULKARNI and ICRH Group
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ARUN PRAKASH. A, S. KHIRWARDKAR and FIRST WALL GROUP
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E.3. CONFERENCE PRESENTATIONS

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J. Alphonsa, B.A.Padsala, B.J.Chauhan, G.Zala, P.A.Rayjada, N.Chauhan, S.N.Soman, and P.M.Raole

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Kinetic Simulation of Plasma Heat-flux Behavior in Colissionless Long Mean-free-path Limits
Devendra Sharma, P. K. Kaw and A. Sen

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Devendra Sharma, A. Sen and P. K. Kaw

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India’s Contribution to ITER CXRS-BES: Status
P. Vasu and Vinay Kumar

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P. Vasu and Vinay Kumar

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Article No.1-2, pp.39

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Adopted Methodology for Cool-down of SST-1 Super conducting Magnet System: Operational Experience with the Helium Refrigerator
A. K. Sahu, B. Sarkar, P. Panchal, J. Tank, R.Bhattacharya, R. Panchal, V. L. Tanna, R. Patel, P. Shukla, J. C. Patel, M. Singh, D. Sonara, R. Sharma, R. Duggar and Y. C. Saxena

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P. Panchal, D. Sonara, B. Sarkar, R.Bhattacharya, R. Panchal, R. Patel, J. Tank, M. Singh,
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Tomographic Reconstruction of Emissivity Profile for both Main and Divertor Plasma from Tangentially Viewed Images using Pixel Method
Santanu Banerjee and P. Vasu

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Sarveshwar Sharma

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Digitization of In-house Publications at Institute of Plasma Research
S. Shravan Kumar and Saroj Das

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Saroj Das and S. Shravan Kumar

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Deposition of Teflon-like Coatings using Pulsed DC and RF Discharges and their Comparison
Satyaprasad Akkireddy, A.Sarma and S.K.Nema

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C. Jariwala, A. Chainani, R. Eguchi, M. Matsunami, S. Shin, S. Bhatt, P. Kikani, V. Dalal, and P.I. John

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Amita Das and Sudip Sengupta

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Generation of energetic neutral lithium by Laser-Blow-Off technique
Ajai Kumar, R. K. Singh and V. Prahlad

Multipulse Thomson scattering on TEXTOR
M.Yu Kantor, A.J.H. Donne, R. Jaspers, D.V. Kouprienko, H.J. Van Der Meiden, T. Oyevaar, A. Pospieszczyk, G.W. Spakman, S. K. Varshney, E. Uzgel and TEXTOR Team

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Development and performance studies of Penning type Ion Source
Basanta Kumar Das and Anurag Shyam

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E.Rajendra Kumar, C.Danani, I.Sandeep, Ch. Chakrapani, N.Ravi Pragash, V.Chaudhari, C.Rotti, P.M.Raole, J.Alphonsa, and S.P.Deshpande

Strategy for Indian Demo design
S.P.Deshpande, R. Shrinivasan, P.M.Raole and Indian Demo Team

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P. M. Raole, S. P. Deshpande and DEMO team

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V. Jain, S. Mukherji, and S.K. Nema

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Measurement of Ion Pfirsch-Schluter Flows in the Edge Region of the Aditya Tokamak
J. Ghosh, Vinay Kumar, P. Vasu, Santanu Banerjee, R. Manchanda, Bhooshan Paradkar, R.L. Tannna, P.K. Chattopadhyay, R, Jha, D. Raju, Y.C. Saxena and ADITYA team

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On Residual Gas Analysis during High Temperature Baking of Graphite Tiles
A.Prakash, P.Chaudhuri, S.Khirwadkar, D.Chenna Reddy and Y.C.Saxena

Automation of An Electro Pneumatic Gate Valve Isolating A Cryopump from the Vacuum Vessel of SST-1
P L Thankey, K R Dhanani, Y G Yeole, H A Pathak, F S Pathan, K S Joshi, P Semwal, D C Raval and Ziauddin Khan

Quantitative Study of Sniffer Leak Rate and Pressure Drop Leak Rate of Liquid Nitrogen Panels of SST-1
F.S. Pathan, Ziauddin khan, P.Semwal, D. C. Raval, K. S. Joshi, P. L. Thankey and K. R. Dhanani

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P. Semwal, K. S. Joshi, K. R. Dhanani, F. S. Pathan, P.L. Thankey, D. C. Raval, Z. Khan, Rajiv Sharma, Dasarath Sonara, H. A. Pathak and D. Chenna Reddy

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Ion Extractor System for SST-1 Neutral Beam Injector
M. R. Jana and S. K. Mattoo

First Beam Extraction Results with Prototype Ion Source in SST-1 NB System
S. K. Sharma, V. Prahlad, P. Bharathi, M. R. Jana, N. P. Singh, P. J. Patel, S. Rambabu, V. Tripathi, B. Prajapati, V. Patel, Karishma, L. K. Bansal, L. N. Gupta, D. Thakkar, B. Sridhar, B. Chokshi, S. Parmar, N. Contractor, A. K. Chakraborty, U. K. Baruah and S. K. Mattoo

Commissioning and Initial Experience of SST1-NB Power Supplies, Data Acquisition & Control System with Prototype Ion Source
N P Singh, P J Patel, V Patel, S K Sharma, B Prajapati, V Prahlad, V Tripathi, L N Gupta, D Thakkar, L K Bansal, Q Karishma, M R Jana, S Rambabu, P Bharathi, B Sridhar, B Choksi, S Parmar, N Contractor, A K Chakraborty, U K Baruah and S K Mattoo

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High Voltage, High Current Regulated Power Supply for Neutral Beam and RF Multimegawatt Power Sources
P. J. Patel, N. P. Singh, L. N. Gupta, D. P. Thakkar, U. K. Barua, S. K. Mattoo and NBI Team

RF source package for ITER Ion Cyclotron Heating and Current Drive system: Indian Contribution
Aparajita Mukherjee, Raghuraj Singh, Kumar Rajnish, R. G. Trivedi, Anil Bhardwaj, Mahesh Kushwah

Design of Ion Acceleration and Extraction System for Prototype Ion Source Experiment of SST-1 Neutral Beam Injector
M. R. Jana, M. Bandopadhyaya, N. P. Singh, S. K. Sharma and S. K. Mattoo

PXI and CAMAC based Data Acquisition System for SST-1
Amit Kumar Srivastava, Rachana Rajapal, Manika Sharma, A. L. Sharma and H.D. Pujara

Nonresonant Current Drive by Helicon Waves
Manash Kumar Paul

Selection of Proper Plasma Electrode Geometry for a Compact Size Penning Ion Source
Basanta Kumar Das, Anurag Shyam

Investigation of Symmetric Line Shapes of Balmer-A in An Abnormal DC Glow Discharge
P. Bharathi, K. S. Suraj, S. Mukherjee and P. Vasu

Transient Model Analysis of Creeping Wave Modes Around an Uncoated and Plasma Coated Cylinder
B. Chaudhury and S. Chaturvedi

Interaction of High Power Microwave with Plasma
Anitha V. P., Pankaj Deb, Amita Das, Anurag Shyam, Y. C. Saxena and P. K. Kaw

Super-Penetration of Laser Energy Via Solitary Pulses
Vikrant Saxena, Amita Das, Abhijit Sen and Predhiman Kaw

Interaction of Low Energy Neutral Beams with Surfaces
P. Ganguli

Inhomogeneous Electron Emission from A Hot Filament in Toroidal Magnetic Field
Rajwinder Kaur and S. K. Mattoo

Studies of Plasma Turbulence in the Large Volume Plasma Device
L. M. Awasthi, S. K. Mattoo, R. Jha, R. Singh and P. K. Kaw

Response of Initially-Stable Target Plasma To Liner Instabilities in A Magnetized Target Fusion (MTF) System
P. V. Subhash, S. Madhavan and S. Chaturvedi

Design and Validation of New Joints in SST-1 Superconducting Magnets
S. Pradhan, A. N. Sharma, U. Prasad, K. Doshi, Y. Kureshi, S. Kedia, P. Nayak, V. Amin, V. L. Tanna, J. C. Patel, R. Sharma, B. Sarkar, D. Sonara, Dipak Patel and D. Chenna Reddy

Simulation of SST-1 CICC Using Gandalf
A.N. Sharma, S. Pradhan, U. Prasad, J. L. Duchateau

Observations of Mirnov and Saw-Teeth Oscillations in Visible Emissions from Aditya Tokamak
R. Manchanda, M.B. Chowdhuri, Santanu Banerjee, Vinay kumar, H. Joshi, Ketan M. Patel, J. Ghosh, P. Vasu, N. Ramasubramanian, R. L. Tanna, B.Paradkar, P. S. Bawankar, R. Narayanan, S. B. Bhatt, D. Raju, R, Jha , P. K. Chattopadhyay, P. K. Atrey, C. V. S. Rao, S. Joisa, Y. C. Saxena and Aditya Team

Surface Modification with Non-Equilibrium Plasmas
S. Mukherjee

Study of Defect Sizes Between AMC and CFC Tiles for W7-X Target Element by ANSYS Simulation
Paritosh Chaudhuri, H. Greuner, B. Boeswith

Design and Development of Embedded CAMAC Crate Controller for SST-1 Data Acquisition System
Rachana Rajpal, A. L. Sharma and H. D. Pujara

PXI Based Control System for SST-1 Thomson Scattering Diagnostic
C. Chhaya, Visnu Chaudhary, K. Patel, Ranjeet Singh, T. Aruna, Jinto Thomas, Kaushal Pandya and Ajai Kumar

Production of Neutrals in Laser-Blow-off of Lif-C Thin Film
R. K. Singh, Ajai Kumar, V. Prahlad, H. C. Joshi

Performance Behavior Study of Superconducting Cable-in-Conduit Conductor using Simulation Codes
Renu Bahl, B. Sarkar and Y.C.Saxena

Applications of Striations as Antenna Elements
Rajneesh Kumar and Dhiraj Bora

Molecular Dynamics Study on the Effect of Law Energy Hydrogen Bombardment on Hydrocarbon Codeposits
P.N. Maya and Udo von Toussaint

An Overview of Gyrotron Source System for ECH Start-Up on ITER
S. L. Rao, Mahesh K., Rajnish K., Ujjwal B., Sathyanarayana K., Shishir D.

Engineering Design, Fabrication and Performance Testing of A105 I/S Cryo Condensation Pumps
S.K.Sharma, Ch.Chakrapani, B. Sridhar, S.Rambabu, A.K. Chakraborty, M.J. Singh, M. Bandhopadhyay, B. Prajapati, V. Patel, B. Choksi, V. Prahlad, U.K. Baruah and S.K.Mattoo

Finite Element Analysis of SST-1 Magnet Winding Packs
A.Amardas, S. Pradhan and Pradeep Chauhan

Network Based Centralized Modular Data Storage System for SST-1
Hitesh Gulati, K. Mahajan, K. Patel, Aveg Kumar, M. Bhandarkar, Hitesh Chudasama

FE Analysis of SST-1 Vacuum Vessel and Cryostat Using ANSYS
Prosenjit Santra, Tata Ranganath and D. Chenna Reddy

Liquid Nitrogen Thermal Shield for SST-1
Manoj Kumar Gupta,Vijay Bedakihale, T. Rang Nath, Ziauddin Khan, V. L. Tanna and D. Chenna Reddy

Performance Test on Commercial Liquid Helium Level Sensors and Transmitters
D. Sonara, R. Panchal, R. Patel, S. Saradha, R. Sharma, P. Shukla, V. L. Tanna and D. Chenna Reddy

Structural Design of NB-Torus Duct for SST-1
S. Rambabu, S.K. Sharma, V. Prahlad, Mainak Bandyopadhyay, S.K. Sah, A.K. Chakraborty, S.K. Mattoo and NBI Team

Demonstration of Measurement of Neutron Spectrum in DT-Discharges Using Activation Techniques
C.V. S. Rao, Shrichand Jakhar, Anurag Shyam and I. Sandeep

Material Joining Studies for Diverter Fabrication
S. S. Khirwadkar, N. Chauhan, P. M. Raole

Development of Pulsed Power Supplies and State of the Art Instrumentation for Plasma Nitriding and Plasma Source Ion Implantation Facilities
S. B. Gupta, K. Kalaria, N. Vaghela, and S. Mukherjee

Deposition of High Quality Films using Plasma Polymerization Method for Various Industrial Applications
Purvi Kikani, Ravi Dixit, C. Jariwala, P. M. Raole, N. Jamnapara and S. K. Nema

Study of Titanium Nitride Coatings Deposited by Plasma Assisted-Physical Vapor Deposition
Kishor Kumar K, S. Mukherjee

Study of Atmospheric Pressure Plasma Surface Modification of Non-woven Fibers
N. Tanwani, R. Rane, S. K. Nema and P. B. Jhala

Hydrogenated Silicon Thin Films grown by Multi-hole-cathode Very High Frequency-Plasma Enhanced Chemical Vapor Deposition
C. Jariwala, A. Chainani, S. Bhatt, R. Eghchi, M. Matsunami, S. Shin, R. Rane, K. R. Rane, K. R. Murali, Girish M Gouda, V. Dalal and P. I. John

Industrial Applications of Plasma Nitriding Process
J. Alphonsa, G. Jhala, S. Mukherjee and P. I. John

SMARTEX-C: New Insights into Toroidal Physics of Electron Plasmas
S. Pahari, R. Ganesh, H. S. Ramachandran, P.I. John

ITER-Cooling Water System: ITER-India Contribution (Component Cooling Water System, Chilled Water Cooling Water System, Heat Rejection System)
Gaddam Govardhan

ITER-DNB- the Indian Program
A.Chakraborty, M. Bandopadhyay, M. J. Singh, U. K. Barua and C. Rotti

An Overview of ITER Cryostat and the Present Status of Design & Analysis Activities Towards Finalization of Procurement Specifications
Bharat Doshi, Girish Gupta

Lithium Wall Conditioning in Aditya Tokamak
Manoj Kuamar, Ajai Kumar, S. B. Bhatt and Aditya team

Magnetic Fields Measurement in ADITYA Tokamak
R. L. Tanna, Gattu Ramesh Babu, Snehal P Jayswal, S. B. Bhatt, P. S. Bawankar, M. B. Kalal, D. S. Varia and D. Chenna Reddy

Studies of Nonlinear Interaction During Fluctuation Suppression in ADITYA Tokamak
D. Raju, R Jha and ADITYA team

Study of Plasma Density Fluctuations by Using 2-Points Correlation Reflectometer in ADITYA Tokamak
P. K. Atrey, N. Y. Joshi, R. Manchanda, R. Singh and Aditya Team

Plasma Disruption in ADITYA Tokamak
Y. Shankara Joisa, D. Raju, Jtothi Shankar Misra, R. Manchanda, C. V. S. Rao and ADITYA Team

Measurement of Ion Pfirsch-Schluter Flows in the Inboard and Outboard Regions of the Aditya Tokamak
J. Ghosh, Vinay Kumar, P. Vasu, S. Banerjee, R. Manchanda, Bhooshan Paradkar, R. L. Tanna, P. K. Chhattopadhyay, R. Jha, D. Raju, Y. C. Saxena and the Aditya team

Studies of Negative and Positive Loop Voltage Spikes in Aditya-Tokamak
Bhooshan Paradkar, J. Ghosh, R. L. Tanna, P. K. Chattoapadhyay, D. Raju, S. B. Bhatt, S. Joisa, C. V. S. Rao, R. Jha, P. K. Atrey, P. Vasu, Y. C. Saxena, I. Bandopadhyay, P. K. Kaw and Aditya Team

Studies of Impurity Transport in ADITYA Tokamak
R. Dey, J. Ghosh, P. Vasu, N. Ramasubramanian, Vinay Kumar, Santanu Banerjee, R. Manchanda, H. C. Joshi, K. M. Patel, P. K. Chattopadhyay, R. L. Tanna, B. Paradkar, D. Raju, R. Jha, P. K. Atrey and Aditya Team

Radiation Power Measurement on ADITYA Tokamak
Kumudni Tahiliani, Ratneshwar Jha, M. V. Gopalkrishana, Kalpesh Doshi, Vipul Rathod and Chandresh Hansalia

22nd National Symposium on Plasma Science & Technology (PLASMA 2007), Institute for Plasma Research, Gandhinagar, Gujarat, India, December 06th-10th, 2007

Anomalous Heat-Flux in Collisionless Plasma with Electrostatic Turbulence
D. Sharma, P. K. Kaw and A. Sen

Molecular Dynamics Modelling of Erosion of Hydrocarbon Films
P. N. Maya and Udo Von Toussaint (**Buti Award**)

In House Experience of Ion Source Assembly for SST-1 Neutral Beam Injector
M. R. Jana, S. K. Sharma, S. Rambabu and S. K. Mattoo

Instrumentation and Control Aspects for ITER Cryo-Distribution System
R. Bhattacharya, B. Sarkar, H. Vaghela, S. Badgujar and N. Shah

Development of Compact, Portable Pulsed Power Generator for Plasma Discharge Studies
J. G. Jamnani, D. R. Patel, A. Shyam, R. Verma and P. Banerjee

Modified Brazing Technique for Brazing of Cooling Channels to Meter Sized Thin Copper Plates
S. J. Jadeja, M. Prajapati, P. Jaiswal, A. K. Sanyasi, P. K. Srivastava, L. M. Awasthi, V. M. Bedakihale and S. K. Mattoo (**Best Poster Award**)

Stree Analysis of Cryo-Line for Torus and Neutral Beam Cryopumps for ITER
H. Vaghela, S. badgujar, N. Shah, R. Bhattacharya and B. Sarkar

80 K Helium Generation System for Thermal Shield Cooling of ITER Prototype Cryo-Line
N. Shah, S. Badgujar, H. Vaghela, R. Bhattacharya and B. Sarkar

Design of Distribution Valve Boxes for Prototype Testing of ITER Torus and NB Cryo-Line
S. Badgujar, H. Vaghela, N. Shah, R. Bhattacharya and B. Sarkar

Test Bench for Vapor Cooled Conventional Current Leads of SST-1
N. C. Gupta, P. Shukla, D. Sonara, P. Panchal, R. Panchal, M. Singh, A. Vardharajulu, V. L. Tanna and D. Chenna Reddy

New Joints Design for SST-1 Magnets and their Validations
S. Pradhan, A. N. Sharma, U. Prasad, K. Doshi, Y. Krishti, S. Kedia, P. Nayak, V. Amin, V. L. Tanna, J. C. Patel, R. Sharma, B. Sarkar, D. Sonara, Dipak Patel, Dinesh Patel and D. Chenna Reddy

Development of Gauge Controller Using Micro Controller for Bayard-Alpert Ionization Gauge
Bharat Arambhadiya, S. B. Bhatt, M. S. Khan and J. M. Sonara

Operational Experience of the Mass Flow Controller Based Gas Feed System for the Neutral Beam Injector
S. K. Sharma, B. Prajapati, B. Choksi, L. K. Bansal, N. P. Singh, L. N. Gupta, V. Prahlad, M. R. Jana, A. K. Chakraborty, U. K. Baruah, S. K. Mattoo and NBI Team

Web Based Content Management System (CMS) for SST-1
Manisha Bhandarkar, Hitesh Kumar Gulati, Kirti Mahajan, Kirit Patel, Aveg Kuma, Hitesh Chudasama and D. Chenna Reddy

Development of CAMAC Controller with Single Board Computer for SST-1 Data Acquisition System
Rachana Rajpal, A. L. Sharma and H. D. Pujara

Present Status of 2.45 GHz Electron Cyclotron Resonance Ion Source for Neutron Generator
Surender Kumar Sharma, E. Salzborn and Pulsed Power Group

Experimental Studies of Radial Position Shifts and Plasma Current Control in ADITYA Tokamak Operation
C. N. Gupta, R. L. Tanna and ADITYA Team

Operational and Maintenance Experience on Utility Power Distribution for Aditya and SST-1 Tokamaks
V. Balakrishnan, D. Paul Christian, H. D. Parekh and B. N. Buch

Commissioning of Hot Nitrogen Gas Heating and Supply System for SST-1 Tokamak
F. S. Pathan, Prashant Singh, K. R. Dhanani, K. S. Joshi, P. L. Thankey, P. Semwal, D. C. Raval and Ziauddin Khan

In House Development of Arbitary Square Wave Generator Using Programable Microcontroller
Narendra Patel, Chhaya Chavda, S. B. Bhatt and Y. C. Saxena

Finite Element Analysis of SST-1 Magnet Subsystems
A. Amardas and S. Pradhan

Simulation of Defect Sizes Between AMC and CFC Tiles for W7-X Target Element
Paritosh Chaudhuri, H. Greuner and B. Boeswirth

Evolution of Aditya and APPS Data Acquisition and Control System
Chhaya K. Chavda, Y. C. Saxena and Aditya Group

Flexibility Analysis: An Essential Requirement in Cryogenic Transfer Lines
N. C. Gupta and R. N. Mehta

Design Validation of the Heat Exchanger of 10kA Conventional Type Helium Vapor Cooled Current Leads
N. C. Gupta and R. N. Mehta

Simulation and Experimental Results of Cryostat LN2 Panels for SST-1
V. L. Tanna, A. K. Sahu, S. Badgujar, G. Gupta, R. Bhattacharya, D. Sonara, J. C. Patel, P. Shukla, P. Semwal, P. Thankey, F. P. Khan, K. Joshi, B. Sarkar and D. Chenna Reddy

Design Optimization and Analysis of Controlled Cool-Down System for SST-1 Thermal Shield
Manoj Kumar Gupta, B. V. Dave, A. K. Sahu, V. L. Tanna, B. Sarkar and Y. C. Saxena

Performance Test on Commercial Liquid Helium Level Sensors and Transmitters
D. Sonara, R. Panchal, R. Patel, S. Saradha, P. Shukla, V. L. Tanna and D. Chenna Reddy

Upgradation of Liquid Nitrogen Distribution System for SST-1
R. Duggar, P. Shukla, N. C. Gupta, R. Panchal, J. C. Patel, V. L. Tanna and D. Chenna Reddy

Calibration of SST-1 Venturi Flow Meters
Vikas Amin, Yohan Khristi, A. N. Sharma and S. Pradhan

Signal-Conditioning Card for Low Level Voltage Measurement
Yohan Khristi, Kalpesh Doshi, Vikas Amin and S. Pradhan

Study of Strain Gauge Based Displacement Transducer in Cryogenic Temperature
Dipak Patel, Firoz Khan Pathan, Yohan Khristi, A. N. Sharma, Upendra Prasad and S. Pradhan

Low Resistance Measurement of Cryogenic Temperatures
Kalpesh Doshi, Yohan Khristi, V. Amin, A. N. Sharma, Pramod Nayak, S. Kedia and S. Pradhan

Resistance Measurements in Joints with Cable-In-Conduit Conductors by Current Decay Method
S. Kedia, V. Amin, Y. Khristi, A. N. Sharma, Upendra Prasad and S. Pradhan

Fabrication and Characterization of High Tc Magnet made up of Double Pancake and Helmholtz Coil configuration
P. K. Nayak, U. Prasad, A. N. Sharma, S. Kedia, Y. Khristi, V. Amin, K. Doshi and S. Pradhan

Measurement of AC Losses in Bi (2223) MgB2 Tapes Using AC Susceptibility Technique
P. K. Nayak, U. Prasad and S. Pradhan

Signal-Conditioning Cards and Data Acquisition System of 42GHz Gyrotron Magnets
A. N. Sharma, K. Doshi, Y. Khristi, V. Amin and S. Pradhan

Quench Propagation in High Temperature Super conducting Tapes
A. N. Sharma, U. Prasad P. Nayak, D. Patel, Y. Khristi, V. Amin, S. Kedia and S. Pradhan

Simulations of SST-1 CICC Quench Using Gandalf
A. N. Sharma, S. Pradhan, U. Prasad and J. L. Duchateau

Performance of SST-1 Quench Detection Circuit
A. N. Sharma, Y. Khristi, U. Prasad, V. Amin, K. Doshi and S. Pradhan

Precision Tools Development for SST-1 Magnets Pre-Assembly Preparations
Pradeep Chauhan and S. Pradhan

Characterization of BSCCO-2223 High Tc Tapes and Magnets
Upendra Prasad, A. N. Sharma, Pramod Nayak, S. Kedia, Y. Khristi, V. Amin and S. Pradhan

Magnetic Field Profile Design Using M'C Code
Upendra Prasad, A. N. Sharma and S. Pradhan

Upgradation of Starting Method for Large Scale Helium Compressor for SST-1 LHe Plant
J. Tank, M. Singh, R. Panchal, R. Patel, J. C. Patel and V. L. Tanna

Design and Development of 1.5kV 2A, Floating DC Screen Grid Power Supply for 200kW, 91.2 MHz ICRH System for SST-1 Tokamak
Agrajit Gahlaut, N. Rajam Babu, Azad S. Makwana, Y. S. S. Srinivas, S. V. Kulkarni and RF Group

Design of Regulated DC Filament Power Supply for 200 kW, 91.2 MHz ICRH System for SST-1
Azadsinh Makwana, Pankaj L. Khilar, Y. S. S. Srinivas and S. V. Kulkarni

Optimization of 4 KV 0.5 Ampere DC Power Supply System for 1kW, 13.56 MHz CWRF Source
Bhavesh R. Kadia, Y. S. S. Srinivas, Sunil Kumar, Atul Varia, S. V. Kulkarni and RF Group

Development of 6 1/8" Coaxial Tee Section for High Power RF Transmission Line
Sunil Dani, Raj Singh, S. V. Kulkarni and RF Group

Low Ripple, Fast Response V-F and F-V Fiber Optic Link for LHCD DAC System
Chetan Virani, Kumar Rajnish, K. K. Ambulkar, P. K. Sharma and LHCD Group

Fast Acquisition System for Fault Tracing in High Power RF System Operation
P. K. Sharma, Ritesh Sugandhi, Chetan Virani, Nirav Patel, Y. C. Saxena, S. V. Kulkarni and LHCD Group

Development of Control Electronics for Regulated AC Power Supply for Filament of 500 KW, CW Klystrons
Jignesh Soni, Pankaj Khilar, Chetan Virani, P. K. Sharma, S. V. Kulkarni and LHCD Group

Emissivity Measurement of Various Materials with IR Camera
A. Sarada Sree, P. K. Sharma, S. V. Kulkarni and LHCD Group

Indigenously Developed Multi-Ignitrons Series Crowbar System
Mahesh Kushwah, Y. S. S. Srinivas, K. Sathyanarayana, B. K. Shukla, Rajan Babu, Agrajit Gahlaut, K. G. Parmar, A. R. Makwana, B. R. Kadia, K. M. Parmar, S. V. Kulkarni and RF Group

Development of Coaxial Two-Way Switch for ICRH Transmission
Raj Singh, Sunil Dani, S. V. Kulkarni and RF Group

Pressurisable Directional Coupler for ICRH Transmission
Dharmendra Rathi, Raj Singh, S. V. Kulkarni and RF Group

Quasi-Optical Transmission Line for ECRH System
B. K. Shukla and S. V. Kulkarni

Design, Fabrication and Testing of 7/8” Transmission Line for High RF Power Transmission for Tokamaks
Siju George, Raj Singh, S. Dani, S. V. Kulkarni and RF Group

Common Anode Power Supply for Driver and Output Stages of 1.5MW, ICRH Systems: Feasibility Study
Y. S. S. Srinivas, R. Singh, R. G. Trivedi, K. Rajneesh, A. Mukherjee, D. S. Bhattacharya, S. V. Kulkarni and ITER – India Team

13.56MHz 1KW CWRF Oscillator Source
Sunil Kumar, Y. S. S. Srinivas, B. R. Kadia, Atul Varia, S. V. Kulkarni and RF Group

Design of 1MHz, 180 KW CWRF Source
Sunil Kumar, S. V. Kulkarni and RF Group

Preionization Experiments in Antenna Test Facility
Gayatri Ashok, R. A. Yogi, Sunil Kumar, S. Dani, Bhavesh Kadia, H. Jadhav, Y. S. S. Srinivas and S. V. Kulkarni

Design and Testing of 7.5kV, 6Amp DC Power Supply for 20kW Stage 91.2 Mhz ICRH Amplifier for SST1
K. M. Parmar, N. Shah, B. R. Kadia, Rajan Babu, Y. S. S. Srinivas, S. V. Kulkarni and RF Group

Electrostatic and Electromagnetic Field Measurements of IBW Antenna
Gaurav Shukla, R. A. Yogi, S. V. Kulkarni, D. Bora and RF Group

Optimal Beamline Component Dispersion and Beam Transmission for ITER DNB
M. Bandyopadhyay, M. J. Singh, S. K. Shah, C. Rotti and A. K. Chakraborty

Safety Solution for TF Converter Power Supply Using Timer Circuit
R. K. Sinha, R. L. Tanna, V. K. Patel, M. N. Makawana, J. H. Patel and R. B. Mishra

Design and Development of PC Controlled Electronic Triggering System for IR Camera
Jignesh Patel, C. J. Hansalia, Harish Masand, Hitesh Mandalia, Praveen Lal E. V., Vipal Rathod, Praveena, Pramila, Minsha Shah and Electronics Group

CCTV Network for SST-1 Monitoring
Kirit Patel, H. Chudasama, K. Mahajan, H. Gulati, Aveg, M. Bhandarkar and S. V. Kulkarni

FPGA Based Digitizer with Real Time Processing (**PSSI - Best Poster Award**)
Amit Kumar Srivastava, Atish L. Sharma, Tushar Raval and H. D. Pujara

Real-Time Loss-Less Data Compression and Decompression for Long- Pulse Operation of SST-1
Manika Sharma and H. D. Pujara

Monitoring and Control of Steady State Super-Conducting Tokamak (SST-1) Parameters Using SOA and Web Services
Hitesh Gulati, K. Mahajan, K. Patel, A. Kumar, M. Bhandarkar, H. Chudasama and S. Kulkarni

Three-Axis Probe Drive System for Large Volume Plasma Device
Siddarth Sheth, Anitha V. P., M. Rao, G. B. Patel, Bharat Doshi, P. K. Srivastava, A. K. Sanyasi, L. M. Awasthi and S. K. Mattoo

CAMAC Based Multi-Channel High Speed Transient Digitizer
Amit Kumar Srivastava and Nilay N. Bhuptani

Micro-controller Based Programmable High Voltage Power Supply for APD Biasing for SST Thomson Scattering Diagnostic
Kiran Patel, Chhaya K. Chavda, Aruna Thakkar and Ajai Kumar

Design and Development of Charge Exchange Counter
Hitesh Mandliya, C. J. Hansalia, Praveenlal E. V., Pramila, Vipal Rathod, Praveena Kumari, Minsha Shah, Jignesh Patel, Harish Santosh Pandya, Govindarajan and Electronics Division

Design of Infrared Camera Based on Microbolometer Detector
Hiral Rao, C. J. Hansalia, Hitesh Mandliya, Praveenlal E. V., Pramila, Vipal Rathod, Praveena Kumari, Minsha Shah, Swetang Pandya, J. Govindarajan, Chenna Reddy & Electronics Division

Remote Power ON/OFF System for SST-1 Electronics Using CAN Network
Pramila, C.J.Hansalia, Praveen Lal E.V., Hitesh Mandaliya , Vipal Rathod, Praveena , Minsha Shah, Chenna Reddy & Electronic Division

Microcontroller Based Simultaneous and Sequential Timing Signal Generator for Pure Electron Plasma in Penning Malmberg Trap Experiment
Praveenlal E.V., Hitesh Mandaliya, C.J. Hansalia, Pramila, vipal Rathod, Praveena Kumari, Minsha Shah, Santosh Pandya, Govindrajan, Chenna Reddy and Electronics Division

Design and Development of Analog Signal Conditioning Electronics System for Electron Cyclotron Emission Diagnostics System in Aditya Tokamak
Praveena Kumari, V.Patel, M.Patel, K. Doshi, H. Masand, Praveen Lal E.V., Yohan, Vipal, Pramila, L.K. Bansal, C.J. Hansalia, H.Mandliya, H.Pandya, P.K.Atrey,Chenna Readdy and Electronics Division

Design and Development of Electronics for the Measurement of Charge Density of Pure Electron Plasma in Penning Malmberg Trap
Vipal Rathod, H.Mandalia, Praveen Lal E.V., C.J.Hansalia, Praveena, Pramila, Minsha, S.Pandya, L.Lachhvani, J.Govindrajan, Chenna Reddy and Electronics Divison

Optical and Mechanical Arrangement of Tangential Far Infrared Interferometer for SST-1
Rajwinder Kaur, B. Shrishail, Padasalgi and Asha Adhiya

Design Simulation and Development of Battery Operated 140 kV DC Power Supply to Study Electrical Breakdown and Streamer Discharges
J. G. Jamnani, A. V. Shah, A. Shyam, R. Verma and P. Banerjee

Design and Development of A Coil Gun for Use in Fast Opening Switches
S. Pahari and S. Chaturvedi

Temperature Diagnostics in A Plasma Nitriding Reactor
K. R. Kalaria, N. P. Vaghela and S. B. Gupta

30-50 KHz, 2 kW Bipolar Pulsed DC Power Supply for Sputtering of Dielectric Material
N. P. Vaghela, K. R. Kalaria and S. B. Gupta

Molecular Dynamics Simulations of A Carbon-Nanotube Based Motor
S.Negi , M. Warrier , S. Chaturvedi and K. Nordlund

Wave-Induced Helicity Current Drive by Helicon Waves
Manash Kumar Paul

Transient Analysis of Azimuthally Propagating Wave Modes Around An Uncoated Cylinder
Bhaskar Chaudhury and Shashank Chaturvedi

Study the Effect of Electron-Wall Collision in Hall Thruster
Deepti Sharma and R. Srinivasan

A Study of Fast Particle Effects on finite-Beta Modes Using Global Gyrokinetic Formalism
J. Chowdhury & R. Ganesh

Study of Electron Response in Pulsed Ion Sheath
Satyananda Kar and S. Mukherjee

Measurement of Plasma Parameters in BETA
T. Shekhar Goud, R. Ganesh, D. Raju, K. Sathyanarayana and BETA Team

Kinetic Effects on the Propagation of Ion-Acoustic Solitons in a Collisionless Plasma with Warm Ions
D. Sharma, P. K. Kaw and A. Sen

Improved Confinement and Control of Diocotron Mode in SMARTEX-C
S. Pahari and R. Ganesh

First Experimental Observation of Whistler-Electron Temperature Gradient (W-ETG) Mode in Laboratory Plasma
L. M. Awasthi, S. K. Mattoo, R. Jha, R. Singh and P. K. Kaw

Observation of Sheared Poloidal Flows in the Large Volume Plasma Device
L. M. Awasthi, R. Jha and S. K. Mattoo

Low Energy Electron Source (LEES)
L. M. Awasthi, A. K. Sanyasi, P. K. Srivastava and S. K. Mattoo

Exciter for Whistler Wave Experiments in LVPD
P. K. Srivastava, A. K. Sanyasi, S. P. Banerjee, L. M. Awasthi, Anitha V. P. and S. K. Mattoo

Characteristics of Plasma in LVPD with Line Source Function for Primary Ionizing Electrons
A. K. Sanyasi, L. M. Awasthi, P. K. Srivastava, R. Jha and S. K. Mattoo

Excitation of Dust Acoustic Waves by Different Means
Pintu Bandyopadhyay

EMHD Response of the ELB Plasma in a Large Volume Magnetic Bubble
Anitha V. P., S. P. Banerjee and S. K. Mattoo

High Power Microwave- Plasma Interaction
Anitha V. P., Pankaj Deb, Amita Das, Anurag Shyam and Y. C. Saxena

Design Parameters Optimization of Superconducting Cable-In-Conductor for Fusion Applications
Renu Bahl, B. Sarkar, Priyavandna Rathod and Y. C. Saxena

Studies of Fluctuation Suppression with Gas Puff in ADITYA Tokamak
R. Jha, P. K. Atrey, S. B. Bhatt, N. Bisai, P. K. Kaw, A. Sen and the ADITYA Team

Establishing Hot Iso-Static Press (HIP) Facility at IPR
Prosenjit Santra and Arun Prakash

Thermal Quench in ADITYA Discharges
Y. Shankara Joisa, D. Raju, Jyothi Shankar Misra, R. Manchanda, C. V. S. Rao and Aditya Team

Measurement of Parallel Flows in the ADITYA SOL Plasma
Deepak Sangwan, Ratneshwar Jha, M. V. Gopalkrishna and the Aditya Team

Filament Preionization Assisted Breakdown and Start-Up Studies in Capacitor Bank Discharges of ADITYA Tokamak
R. L. Tanna, Bhooshan Paradkar, K. A. Jadeja, S. B. Bhatt, J. Ghosh, P. K. Chattopadhyay and Aditya Team

ADITYA Data Handling Using MDSplus
V. K. Panchal, Chhaya Chavda, V. K. Patel, Aruna Thakar, N. C. Patel, P. K. Chattopadhyay and ADITYA Team

R.F. / R. F. Assisted Glow Discharge Cleaning Studies in An Experimental Set-up
J. M. Sonara, K. M. Patel, S. B. Bhatt and K. Sathyanarayana

Study of Plasma Interactions in a Multi Magnetron Co-Sputter Deposition setup
Kishor Kumar and S. Mukherjee

Study of Copper Oxide Nanoparticle Produced by Exploding Wire Method
Rashmita Das, T. Prabaharan with Anurag Shyam

Role of Atomic Hydrogen in Deciding the Surface Properties of Plasma Deposited Hydrocarbon Films
P. N. Maya and S. P. Deshpande

Formation of Nano-Structured Features on the Surface of Angora Fibers using Dielectric Barrier Discharge to Improve Processing
R. Rane, N. Tanwani, N. Chauhan, G. A. Gandhi, A. Sanghariyat, P. B. Jhala, S. Mukherjee and S. K. Nema

Plasma Nitrocarburising of Sa 515A Grade#70 Steel to Improve Corrosion Resistance
J. Alphonsa, Nirav Jamanapara, G. Jhala, P. A. Rayjada, P. M. Raole and S. Mukherjee

Automatic Stabilization of Plasma Arc for Pyrolysis Application
Vishal Jain, S. K. Nema, and K. S. Ganesh Prasad

Plasma Pyrolysis of Plastic Waste and Energy Recovery Possibilities
A. C. Ratnu, V. Chauhan, C. Patil, A. Sanghariyat, V. Jain, S. K. Nema and P. I. John

Ground Experiments Related to Arcing Events on Solar Cells in LEO Like Plasma Conditions
Bhoomi Mehta, S. Mukherjee, S. P. Deshpande, M. Ranjan, N. Vaghela, V. Acharya, E. P. Suresh, M. Sankaran and M. Sudhakar

Design and Thermal Analysis of 8 nF Cylindrical Capacitor for High Frequency and High Current Amplifier Cavity
A. K. Bhardwaj, Raghuraj Singh, Mahesh Kushwah, Aparajita Mukherjee, R. G. Trivedi and Kumar Rajnish

Amplitude Control Loop for ITER ICH & CD Source
Kumar Rajnish, R. G. Trivedi, Aparajita Mukherjee, Raghuraj Singh, Anil Bhardwaj, Mahesh Kushwah and ITER-India IC Team

Local Control Unit for ICH & CD Source
Kumar Rajnish, Raghuraj Singh, R. G. Trivedi, Aparajita Mukherjee, Anil Bhardwaj, Mahesh Kushwah and ICH & CD ITER-India Team

Influence of Voltage Standing Wave Ratio (VSWR) on Operating Point of High Power Tetrodes
Raghuraj Singh, R. G. Trivedi, Kumar Rajnish, Mahesh Kushwah, Anil Bhardwaj, D. S. Bhattacharya and Aparajita Mukherjee

Design of 20kW Pre-driver Amplifier for ITER IC System
R. G. Trivedi, Raghuraj Singh, Kumar Rajnish, Mahesh Kushwah, Anil Bhardwaj, D. S. Bhattacharya and Aparajita Mukherjee

Design Concept of Multi-megawatt RF Sources for ITER Ion Cyclotron Heating and Current Drive System
Aparajita Mukherjee, Raghuraj Sing, Kumar Rajnish, R.G. Trivedi, Anil Bhardwaj, Mahesh Kushwah, D.S. Bhatacharya,

Application software based remote setting of refractive index of ADITYA Tokamak LHCD System
P. K. Sharma, Ritesh Sugandhi, K. Ambulkar, S. V. Kulkarni and LHCD Group

Development of non-standard Waveguide adapter for RF characterization of LHCD transmission Line
P.K. Sharma, K.K.Ambulkar, K.K.Ramella, S.V.Kulkarni and LHCD Group

A Spectroscopic Diagnostic Method Using UV OH Spectrum as a Molecular Pyrometer and Exploring its Applicability for Temperature Measurements of Penning Discharge Plasma under Varied Conditions
Santanu Banerjee, R.Manchanda, Vinay Kumar, K.M.Patel, J.Ghosh, Ritu Dey, N. Ramasubramanian, H.C.Joshi and P.Vasu

Complex Ginzburg-Labdau Equation
Gautam C. Sethia and Abhijit Sen

Pulsed Electron Beam Generation and Observation of Ionizing As Well As Non-Ionizing Radiation
Rohit Shukla, S.K. Sharma, A.Shyam, S.Chaturved

Sub-Lambda Gratings,Surface Plasmons, Hotter Electrons and Brighter X-Ray Sources: Enhanced Absorption of Intense, Ultrashort Laser Light by Tiny Surface Modulations
Subhendu Kahaly, G..Ravindra Kumar, S.K.Yadav, S.Sengupta, A.Das, P.K. Kaw

Investigation of Oxygen Impurity Transport in ADITYA Tokamak
R.Dey, J.Ghosh, P.Vasu, Vinay Kumar, Santanu Banerjee, R.ManChanda, N.Ramasubramanian, H.C.Joshi, K.M.Patel, P.K.Chattopadyay, R.K.Tanna, B.Paradkar, D. Raju, R.Jha, P.K. Atrey, and Aditya Team

Application of the Line Intensity Ratio Method on Different Charged States of Oxygen for the Measurement of Electron Density and Temperature Profiles for ADITYA Plasma
Santanu Banerjee, Ritu Dey, J. Ghosh, R. Manchanda, Vinay Kumar, K. M.Patel, N. Ramasubramanian, H. C. Joshi, P. Vasu and ADITYA Team

Design Development of X-Ray Crystal Spectrometers for ITER
S. K. Varshney and R. Barnsley

Effect of Edge Signal to Noise Ratio on Tomographic Reconstruction of Soft X-ray Emission in Tokamak
Arun Anand, Asim Kumar Chattopadhyay and C. V. S. Rao

Plasma Imaging in Aditya Using CCD Camera
Manoj Kumar, Vishnu Chaudhary and Ajai Kumar

Plasma Current Measurement on Tokamak ADITYA Using Faraday Effect Fiber Optic Sensor
Sameer Kumar, D. Raju, R. Jha, Aruna Thakar and FOCS Contributors

Design and Calibration Technique of Time of Flight Low Energy Analyzer for Neutrals from Aditya Tokamak
Santosh P. Pandya, Kumar Ajay, C. Chhaya and J. Govindarajan

Study of the CEM Responsivities in Magnetic Field of Neutral Particle Analyzer
Santosh P. Pandya, Ketan M. Patel, Kumar Ajay and Ranjana Manchanda

Discharge Characteristic of a Penning Ion Source
Basanta Kumar Das and Anurag Shyam

FPGA Based Multi-Channel Digitization and Digital Data Transmission Using Low Voltage Differential Signaling
L. K. Bansal, C. J. Hansalia and N. N. Bhuptani

Temperature Dependence of Detector's Performance for SST-1 Thomson Scattering System
Aruna Thakar, Jinto Thomas, Ajai Kumar and Chhaya Chavda

Study of Plasma Density Fluctuations in ADITYA Tokamak Using Fixed Frequency Reflectometer
P. K. Atrey, N. Y. Joshi, R. Manchanda, R. Singh and Aditya Team

Optical Windows for Far Infrared Interferometer of SST-1
Asha Adhiya and Rajwinder Kaur

Effect of Liner Non-Uniformities on Overall Stability of an MTF System
P.V. Subhash, S.Madhavan and S. Chaturvedi

Calcution of Transport Coefficents Using Non Equilibrium Molecular Dynamics (NEMD)
Ashwin Joy, Rajaraman Ganesh and Manoj Warrier

3 Dimensional PIC Simulation of Virtual Cathode Oscillator
Gursharn Singh and Shashank Chaturvedi

Numerical Modeling of A Non-Transferred Plasma Torch
N.Sakthivel, and S.Chadturvedi

Optimization of Reactive force Field Potential Using Genetic Algorithm
Poonam Pahari and Shashank Chaturvedi

A Method for Handling Multi-Material Equation of State in a 2-D Eulerian Code for Simulation of MTF Systems
S. Madhavan, P. V. Subhash, and S.Chaturvedi

Parallel Finite-Difference Time Domain Methods for Electromagnetic and Particle in Cell Simulation Codes
Sijoy C. D., Gursharn Singh and Shashank Chaturvedi

Smoothed Particle magnetohydrodynamics in one Dimension
V. Mehra and S. Chaturvedi

Design Modification in Soft X-ray Diagnostics: Hot Plasma to Burning Plasma
I. Sandeep, Shrichand Jakhar, C. V. S. Rao and C. Danani

Computer Simulations for High Energy Density Systems
Shashank Chaturvedi

Particle-In-Cell Simulation of Large Amplitude Ion-Acoustic Solitions
Sarveshwar Sharma, Sudip Sengupta and Abhijit Sen

Experiment to Study the Counting Efficiency of Channel Electron Multiplier in Presence of Magnetic Field
Santosh P. Pandya, Ketan M. Patel, Kumar Ajay, Ranjana Manchanda and J. Govindarajan

8th Asia Pacific Plasma Theory Conference (APPTC 2007), Institute for Plasma Research, Gandhinagar, Gujarat, India, December 11 – 13, 2007

Ion Acoustic Solitons in a Collisionless Warm Ion Plasma
D. Sharma, A. Sen and P. K. Kaw

Destabilization of Envelope Solitons in a Plasma due to Ion Response
Vikrant Saxena, Amita Das, Abhijit Sen and Predhiman Kaw

A Comprehensive Study of Scrape-Off-Layer Plasma Turbulence
N. Bisai, R. Singh and P. K. Kaw

Simulations of Major Disruptions in ITER using TSC
I. Bandyopadhyay, Y. Nakamura, M. Sugihara, H. Fujieda and A. Sen

Investigation of Correlation Effects on Low Frequency Collective Modes in Strongly Coupled Dusty Plasmas
P. Bandyopadhyay, G. Prasad, A. Sen and P. K. Kaw

Studies in Toroidal Helicon Plasma Device
Manash Kumar Paul, P. K. Chattopadhyay and D. Bora

Studies on the Effect of Energetic Ion Bombardment in Deciding the Surface Properties of Amorphous Hydrocarbon Films
P. N. Maya

Metal Plasma Formation at the Surface of a Magnetized Target Fusion (MTF) Liner: A Computational Study
P. V. Subhash, S. Madhavan and S. Chaturvedi

Numerical Simulation of Steady State Charging of Spherical Body in GEO Plasma Environment
Bhoomi Mehta, S. P. Deshpande, S. Mukherjee, M. Ranjan, N. Vaghela, V. Acharya, E. P. Suresh, B. R. Uma, M. Sankaran, and M. Sudhakar

Analysis of Stationary Striations in Surface Wave Produced Plasma Column of Argon
Rajneesh Kumar

Probe Diagnostics of a Three Magnetron Co-Sputter Deposition Setup
Kishor Kumar K, S. Mukherjee

International Conference on SENSORS and related networks (SENNET 2007) at VIT University, Vellore, December 12-14, 2007

Thermal Data Acquisition System for Plasma Facing Components of SST-1 Tokamak
A.Prakash, S.S.Khirwadkar, Y.C.Saxena and First Wall Group

7th DAE-BRNS National Laser Symposium (NLS-07), Vadodara, December 17-20, 2007

Optical Emission in Laser Induced Breakdown of Li in Transverse Magnetic Field
V. J. Dann, R. K. Singh, Ajai Kumar, V. P. N. Nampoori

International Conference cum Workshop on Nanoscience and Nanotechnology, at Ansal Institute of technology, Gurgaon, December 17-21, 2007

Study of the Distribution of Copper Oxide Nanoparticles Produced by Pulse Wire Discharge Method
Rashmita Das, T.Prabaharan, and Anurag Shyam

Indo-Australia Symposium on Multifunctional Nanomaterials, Nanostructures and Applications 2007 (MANNA-2007), Department of physics and Astrophysics, University of Delhi, December 19-21, 2007

Parametric study of the distribution of metal nanoparticles produced by exploding wire method
Rashmita Das, T.Prabaharan, and Anurag Shyam

Topical Conference on Atomic and Molecular Physics "TC2008", Department of Physics, Sardar Patel University, Vallabh Vidyanagar, Gujarat, January 3-5, 2008

Studies of Oxygen Impurity Transport in ADITYA Tokamak Using STRAHL Code.
R. Dey, J. Ghosh, P. Vasu, N. Ramasubramanian, Vinay Kumar, Santanu Banerjee, R. Manchanda, H.C. Joshi, K.M. Patel, P.K. Chattopadhyay, R.L. Tanna, B. Paradkar, D. Raju, R. Jha, P.K. Atrey, V. Balakrishnan, S.B. Bhatt, D. Bora, B.N. Buch, C. Chavda, C.N. Gupta, C.J. Hansalia, P.I. John, P.K. Kaw, A. Kumar, S.K. Mattoo, H.A. Pathak, H.D. Pujara,C.V.S. Rao, K. Satyanarayana, Y.C. Saxena, G.C. Sethia and A. Varadharajulu

Development of Surface Ionization Detector for Lithium Beam
B.K. Das, K.M. Patel and S.B. Bhatt

Electron Impact Single Ionization of He with Large Energy Transfer
R. Dey, A.C. Roy and C. Dal Cappello

Measurements of Electron Temperature and Density for Multi-Component Plasma Plume Formed by Laser-Blow-Off of LiF-C Film
Ajai Kumar, S. Sunil Kumar, R.K. Singh, B.G. Patel and K.P. Subramanian

IAEA International Workshop on Challenges in Plasma Spectroscopy for Future Fusion Research Machines, (CPS-08 Proceedings) held at BIT, Mesra, Ranchi Extension Centre Jaipur, India, February 20-22, 2008

Production of Fast Neutral Lithium Atoms by Laser-Blow-Off Technique
Ajai Kumar, R.K. Singh, V. Prahlad and H.C. Joshi

Interference Filter Polychromator for SST-1 Thomson Scattering System
Jinto Thomas, Ajai Kumar and Kaushal Pandya

Wall Reflection Calculations for the Tangential Image Tomographic Reconstruction (TITR) Code
Santanu Banerjee and P. Vasu

(e,2e) Momentum Profiles of Helium
R. Dey and A.C. Roy

Electron Density Measurement of the Edge Region of ADITYA Tokamak using Laser-Blow-Off Diagnostic
S. Sunil and Ajai Kumar

Ray -Tracing of ITER X-ray Survey Spectrometer
Sanjeev Varshney and R. Barnsley

Impurity Transport Studies in ADITYA Tokamak Using Spectrometric Data and STRAHL Code
R. Dey, N. Ramasubramanian, R. Manchanda, Santanu Banerjee, J. Ghosh, P. Vasu, Vinay Kumar and ADITYA Team

Subsystem Testing of SST-1 Thomson Scattering
Ajai Kumar, Jinto Thomas, Ranjeet Singh, Chhaya Chavda, Aruna Thakar, Kiran Patel, Vishnu Chaudhary and Kaushal Pandya

A Fast Data Acquisition and Control System
Chhaya Chavda, Ajai Kumar, Aruna Thakar and Kiran Patel

Fast Signal Conditioning Electronics for Laser Based Spectroscopic Measurement
Aruna Thakar, Ajai Kumar and Jinto Thomas

Spectroscopic Investigation of Laser-Blow-Off Experiments
H.C. Joshi, Ajai Kumar, R.K. Singh and V. Prahlad

Feedback Alignment Control System for SST-1 Thomson Scattering Diagnostics
Ranjeet Singh, Kiran Patel and Ajai Kumar

Li Atomic Beam Diagnostics for Characterization of Edge Plasma in Aditya
Manoj Kumar, Vishnu Chaudhary, Ajai Kumar and Aditya Team

Design and Development of Tangentially Viewing Camera System for SST-1
Manoj Kumar, Vishnu Chaudhary, and Ajai Kumar

Observation of Fast Neutrals in the Interaction of 10 -20 KeV Hydrogen Neutral Beam with a Copper Target
V. Prahlad, P. Bharathi, S.K. Sharma, M.R. Jana, N.P. Singh and A.K. Chakraborty

Measurement of Relative Densities of Ion Species in a 10 – 20 KeV Mixed Beam by Doppler Shift Spectroscopy
P. Bharathi, V. Prahlad, S.K.Sharma, S. Rambabu, M.R.Jana, N.P. Singh, Paresh Patel, Vishnu Patel, U K Baruah and A.K.Chakraborty

15th National Space Science Symposium (NSSS-2008), Radio Astronomy Centre, Ooty, February 26-29, 2008

Absorption Cells for Hydrogen Isotope Measurement
Prahlad Vattipalle

E.4. INVITED TALK DELIVERED BY IPR STAFF

P. K. KAW

Gave an invited talk at the International Conference on Frontiers of Nonlinear Physics, held at Nizhny Novgorod, Russia, during July 2-10, 2007

Delivered a talk at the 174th Meeting of the American Association for the Advancement of Science, Boston, MA, USA, during February 14-18, 2008

ABHIJIT SEN

Delivered a talk at the ITPA, Workshop on MHD, held at General Atomics, San Diego, USA during May 21-26, 2007 and carried out Joint Research work with Dr Rob La Haye, on the Analysis of D-III-D Data for Assessing the Impact of Plasma Rotation on NTMs during May 15-20, 2007

Delivered a talk at the SIAM Conference on Applications of Dynamical Systems (DS07), held at Snowbird, Utah, from May 28 to June 1, 2007 and also made a Scientific visit to the Plasma Fusion Center, MIT, U.S.A.

AMITA DAS

Gave an invited talk entitled "Self Organization and Wave Induced Melting of Quasi Crystalline Patterns in 2-D Plasma Flows" at International Conference on Frontiers of Nonlinear Physics, Nizhny Novgorod on July 3-9, 2007

Gave an invited talk entitled "Inverse Cascade and Kelvin Helmholtz Instability" at Workshop on Festival de Theorie: Bifurcations, Fronts and Boundary Layers in Fusion and Astrophysical Plasmas, Aix en Provence, France on July 10-22, 2007

Gave an invited talk entitled "Theoretical Description of Electron Transport and Stopping in Fast Ignition" 1st NILES International Workshop on Lasers and Plasmas joined with 10th Easter Plasma Meeting, NILES, Cairo University, Cairo, Egypt on March 15-19, 2008

AJAI KUMAR

Gave an invited talk entitled "Thomson scattering diagnostics for tokamak plasma" at IAEA Workshop "Challenges in Plasma spectroscopy for Future Research Machine", Jaipur on February 20-22, 2008

C. V. S. RAO

Gave an invited talk entitled "Tomography for Burning Plasmas" at International conference on Computer-aided Tomography, "Tomography Confluence", I.I.T., Kanpur on February 15-17, 2008

S. K. NEMA

Gave an invited talk entitled "Research Perspectives in Plasma Pyrolysis of Waste" at New Research Directions in the use of Power Beams for Environmental Applications (RPDM-PBEA – 2007), BARC, Mumbai, India on September 18, 2007

Gave an invited talk entitled "An Innovative Approach to Modify Surface Properties of Material using Plasmas" at National Conference on Recent Advances in Innovative Materials (RAIM-08), National Institute of Technology (NIT), Hamirpur, H.P., India on February 16-17, 2008

Gave a talk entitled "Plasma Surface Modification- Commercial Capabilities in India" at Procter & Gamble, Cincinnati, USA, on August 26, 2007

S. K. GUPTA

Gave an invited talk entitled "Water Disinfection by Pulsed Underwater Corona Discharges: A Chemical Free and Environmental Friendly Technology" at Conference on Non-Chemical Disinfection Technologies: 5th Everything About Water Expo 2008, Goregaon, Mumbai, India, 30 January - 1 February 2008

N. I. JAMNAPARA

Gave an invited talk entitled "Socio-Economic Applications of Plasma Technologies" at XIV Regional Meeting of State S&T Councils & Departments (Eastern Region), BIT, Mesra, Ranchi, Jharkhand, India on April 10, 2007

Gave an invited talk entitled "Plasma Assisted Coatings" at Industry-Interaction Meet, ERDA and NRDC Ltd., Vadodara, India on January 9, 2008.

N. I. JAMNAPARA, S. K. NEMA and S. MUKHERJEE gave an invited talk entitled "Industrial Plasma Technologies" at Workshop on Venture Funding in Technology & Innovation, Confederation of Indian Industries (CII) and Technology Development Board (TDB) Ahmedabad, India on July 20, 2007

M. R. JANA and S. K. MATTOO gave an invited talk entitled **"**Criticality in the Fabrication of Ion Extraction System for SST-1 Neutral Beam Injector" at DAE-BRNS National Symposium of Ion Beam Technology and Applications (SIBTA-2007), Bhaba Atomic Research Centre (BARC), 19th - 21st September 2007.

P. J. PATHAK

Gave an invited talk entitled "Collection Development of e-products" at Refresher Course, Academic Staff College, Saurashtra University, Rajkot on February 4, 2008.

SAROJ DAS

Gave an invited talk entitled "E-Resources" at ADINET Abridged Course on Information Technology Library & Information Science, organized by INFLIBNET & ADINET on May 8, 2007.

Plenary & Invited talks given at 22nd National Symposium on Plasma Science & Technology (PLASMA 2007), Institute for Plasma Research, Gandhinagar, Gujarat, India, December 06th-10th, 2007.

RATNESHWAR JHA on "Advances in Plasma Diagnostics" *(a Plenary talk).*

AMITA DAS on "Two Dimensional Plasma And Hydrodynamic Fluid Flow System" *(a Plenary talk).*

P. M. RAOLE gave an invited talk entitled on "Low-Temperature Plasma Processing of Materials for Industrial Applications".

SUDIP SENGUPTA, VIKRANT SAXENA, PREDHIMAN K. KAW, ABHIJIT SEN and **AMITA DAS** gave an invited talk entitled on "Phase Mixing of Relativistically Intense Waves in a Cold Homogeneous Plasma".

P.K. CHATTOPADHYAY gave an invited talk entitled on "RF and Microwave Diagnostics in Plasma".

Invited talks given at 6th Conference of Asia Plasma & Fusion Association (APFA-2007), Institute for Plasma Research, Gandhinagar, Gujarat, India, December 3-5, 2007.

B. SARKAR, H. VAGHELA, S. BADGUJAR, N. SHAH, R. BHATTACHARYA, V. KALININ and Y. H. KIM gave an invited talk entitled on "Engineering Approach and Implementation Plan for Cryo-Distribution and Cryo- Lines of ITER".

D. CHENNA REDDY and SST-1 TEAM gave an invited talk entitled on **"**Present Status of SST-1 Tokamak".

P. I. JOHN gave an invited talk entitled on **"**Industrial and Environment Applications of Plasmas".

P. K. CHATTOPADHYAY gave an invited talk entitled on "Recent Results from Aditya tokamak".

R. GANESH, W. W. LEE, S. ETHIER, and J. MANICKAM gave an invited talk entitled on **"**Self-consistent profile-relaxation effect in Gyrokinetic Particle simulation of Fusion Plasmas".

S. K. NEMA, V. JAIN, K. S. GANESHPRASAD and P. I. JOHN gave an invited talk entitled on "Plasma Pyrolysis Technology and its Evolution at FCIPT, Institute for Plasma Research".

Invited talks given at 8th Asia Pacific Plasma Theory Conference (APPTC 2007), Institute for Plasma Research, Gandhinagar, Gujarat, India, December 11 – 13, 2007.

SUDIP SENGUPTA, VIKRANT SAXENA, PREDHIMAN K. KAW, ABHIJIT SEN and AMITA DAS gave an invited talk entitled on **"**Spatio-temporal evolution of Relativistically Intense Waves in a Cold Homogeneous Plasma".

A.CHAKRABORTY, M.J. SINGH, MAINAK BANDYO-PADHYAY, C. ROTTI and S. K. SAH gave an invited talk entitled on **"**Negative Ion Based Neutral Beams in Fusion Research – the ITER Perspective".

S. MUKHERJEE gave an invited talk entitled on **"**Ion Sheaths and Its Use in Low Pressure Industrial Plasma Applications".

E.5. TALKS DELIVERED BY DISTINGUISHED VISITORS AT IPR

Dr. Sanjoy Roychowdhury, Physical Research Laboratory, Ahmedabad, India gave seminar on "Interferometric Investigation of Optical Beams with Phase Singularities".

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Dr. S. R. Mohanty, Centre of Plasma Physics, Guwahati, Assam, India gave a talk on " Discharge Produced Plasma Source for EUV Lithography"

Dr. Ravi Samtanrey, Computational Plasma Physics Group, Princeton Plasma Physics Laboratory, Princeton University, gave a talk on "Simulations of Pellet Injection into Tokamaks"

Mr. Amuthan Ramar, Research Scholar, EPFL-CRPP, Switzerland gave a talk on " Understanding the potential of ODS EUROFER97 steel for its application in the future Fusion Reactors".

CEO of Telops Inc. Canada has presented demo cum talk on " Introduce Telops and key achievements - Aerospace optical systems, - Defense optical systems and introduce Telops R&D Expertise and related engineering services".

Mr. Vishveshwar Mantha gave a talk on "Studies of high-density liquid metal flows in the Simulated Spallation Target configuration of Accelerator Driven System" .

Dr. Ashish Chainani gave a talk on "Evidence for charge-order maximized momentum-dependent superconductivity: Angle-resolved Photo-emission spectroscopy of 2H-NbSe2".

Dr. Toshinori Yabuuchi, Institute of Laser Engineering, Osaka University, Japan gave a talk on "Behaviour of Hot Electrons in Self-Excited Fields at Target Rear".

Mr. Deepak Pingle and Mr. Abhijit Madalgi , Advanced Micronic Devices Ltd ,Mumbai gave a demonstration of Cadence - Orcad - EDA tool. (the latest version of Orcad tools).

Dr. Mayur Kakati, Thermal Plasma Processed Materials Laboratory, Centre of Plasma Physics, Guwahati 782 402 gave a talk on " Thermal Plasma Assisted Materials Processing at CPP".

Dr. Bipul Jyoti Saikia, Centre of Plasma Physics, Guwahati gave a talk on "Simulation of Jeans Instability of Dusty Plasma" .

Prof. Jean-Pierre BOEUF, Director de Recherches ou CNRS (GREPHE/LAPLACE), University of Toulouse, France gave a talk on " Physics of Hall Effect Thrusters for Space Propulsion".

Dr. R. Sakamoto, National Institute for Fusion Science, Japan gave a seminar on "Pellet Injection and Internal Diffusion Barrier Formation in the LHD Plasmas" .

Dr. Hans-Werner Bartels, Head, ITER Information Technology gave a talk on "ITER Information Technology: objectives, status and challenges"

Dr Dhiraj Bora, gave a talk on "ITER Heating & Current Drive Plans: An Overview"

Prof. Frank Verheest, University of Gent, Belgium, gave a talk on " Large Nonlinear Solitary Waves and (Dusty) Plasmas"

Mick Pont, Principal Technical Consultant at NAG gave a presentation on "NAG Libraries"

Dr. Y. Peysson, TORE SUPRA, CEA-Cadarache, France, gave a talk on " The Few Ray Approach for Simulating The Lower Hybrid Current Drive in Tokamak" .

Prof. Swadesh Mahajan, Institute for Fusion Studies, University of Texas, USA gave a talk on " High Power Density(HPD) Fusion Machine Prelude to HPD Reactors"

Prof. Swadesh Mahajan, Institute for Fusion Studies, University of Texas, USA gave a talk on " Classical Superconductivity".

Mr. Rajiv Pillai and Mr. Rishi Ganguly, Apple India (P) Ltd., Ahmedabad, India gave a talk on " Apple Technology with 8 Core Technology Machine, Apple 64 Bit Operating System - Leopard and Cluster Nodes".

Acharya Sri Raghunath Bhatt, Ahmedabad gave a seminar on "Hindi Grammar".

Prf. Hari om Vats PRL, Ahmedabad gave a scientific talk in hindi on "Scientific Analysis of a bird's view of Maitri".

E.6. COLLOQUIA PRESENTED AT IPR

Prof. N Vedachalam, Distinguished Professor, Vikram Sarabhai Space Centre, ISRO, Trivandrum, India given a talk on "Challenges in Cryogenic Rocket Propulsion System" (Colloquium #198).

Mr. Ravisankar, HRDD/PPG, Space Application Centre, ISRO, Ahmedabad, India given a talk on "Demystification of Soft Skill" (Colloquium #199).

Dr. Serge Claudet, Leader, LHC Cryogenics operation team, CERN, Accelerator Technology Department, Geneva, Switzerland given a talk on "CERN and LHC Project" (Colloquium #200)

Prof. Minh Quang TRAN, Director, Centre de Recherches en Physique des Plasmas, Association Euratom- Confederation Suisse, Switzerland on "Fusion Technology at the CRPP" (Colloquium #201)

Dr. Ranjan Gupta, IUCCA, Pune, India, on "ANNs and Application to upcoming Satellite Missions" (Colloquium #202)

E.7. SCIENTIFIC MEETINGS HOSTED BY IPR

Report on the Fusion Neutronics Workshop FNW-2007

The workshop was held from 20 – 22 of November'07. There were totally 45 participants who attended the workshop. There were 15 experts in the field of fusion neutronics 5 from abroad Drs. Ulrich Fischer from FZK, Karlsruhe, Germany. Paola Batistoni and L. Petrizzi from ENEA, Italy, C.Konno and S.Sato from JAEA, Japan. There were 10 experts from BARC, IGCAR and University of Hyderabad.

About 17 presentations were there which covered topics like Fundamentals of fusion neutronics, neutron interactions, neutron and photon transport – theory and models. Nuclear heating, nuclear design analysis, tritium breeding, nuclear power production, radiation shielding, radiation loads on Superconducting magnets, and blanket design for DEMO reactors.

Overviews of experimental neutronics from FNS, JAEA, Japan and FNG, ENEA, Italy, Integral & mock-up experiments, benchmark experiments, comparison of Attila and Monte Carlo codes, nuclear analysis of ITER, activation & Transmutation of fusion reactor materials & components, nuclear data reliability its impact on reactor design aspects, and future development needs of nuclear data for fusion technology.

6th General Scientific Assembly of the Asia Plasma and Fusion Association (APFA 2007), 3-5 December 2007
~ 50 participants, 30 from Asian countries, 20 from India

22nd National Symposium on Plasma Science & Technology (PLASMA 2007), from 6-10 December 2007
250 participants, 140 from outside

8th Asia Pacific Plasma Theory Conference (APPTC-2007), from 11-13 December 2007
~35 participants

Hands-on Workshop on Non-Linear Dynamics, 5-25 January 2008
50 participants