Issue 4
April 2014

The Fourth State

Newsletter of the Institute For Plasma Research, Gandhinagar, Gujarat (India)

From the editorial desk

The editorial committee of the IPR newsletter wishes to thank all the IPR staff members for their encouragement and support that they have given to the revived newsletter. We hope that this will continue for all the forthcoming issues of "The Fourth State". Please feel free to send any comment / suggestion to the committee at <newsletter@ipr.res.in> for improvement of the look and contents of the newsletter. Thank you..

SST-1 News

SST-1 is gearing up for Campaign-VIII during April-May 2014. In this campaign, focussed plasma experiments on breaking down the pre-fill gas assisted with ECH in fundamental mode and start-up scenarios of plasmas in 1.5 T of toroidal field have been planned. The SST-1 toroidal field controls have now been successfully programmed towards dynamically lengthening the pulse length and altering the current plateau values without discharging the magnet. Apart from parametric studies, coupling of ohmic plasma with Lower Hybrid Power has also been planned during campaign-VIII. The cooling down of SST-1 has now scheduled to begin in the third week of April. As a part of SST-1 up-gradation, intermediate superconductor MgB2 based strands have been experimentally validated in a race track winding and scaled down Edge Localized Mode (ELM) winding pack and have now qualified towards its potential usage in a cold gas cooled heat exchanger in novel SST-1 current leads.

ITER-India News : Cryostat Workshop Construction at ITER Site Nearing Completion

The construction of the Cryostat Workshop (110 meters long, 44 meters wide and 27 meters high) is nearing completion at ITER site, Cadarache, France. The 54 modules of Cryostat manufactured in India will be brought to the ITER site, which will be fabricated further in this workshop into 4 main sections for assembly in the Tokamak pit. The above photo is an early morning view dated 8th April 2014. A gantry crane of capacity 200 tonnes (inset) has also been installed in this workshop. The ITER Cryostat package comes under the responsibility of ITER-India. *Photo Credits:* ITER Organization

Somewhere, something incredible is waiting to be known…. Carl Sagan

HOLI Celebrations @ IPR

IPR celebrated the most colorful festival of India, **HOLI** with immense enthusiasm and fun with bright colors of *Gulal* at IPR Lawn on 16th April, 2014. Employees happily participated in the Fish Pond Game. Adding to the celebration, *Dahi Wada* and delicious *Gujia*, a Holi special cuisine of North Indians, was also served after the celebrations along with glasses of *Thandai*.

N C Gupta hosting *Fish Pond*

IPRites gathered in lawn to enjoy interesting comments for their dear colleagues

Research Scholars enjoying the North Indian delicious feast of *Gujia, Dahi Wada* and Holi special *Thandai*

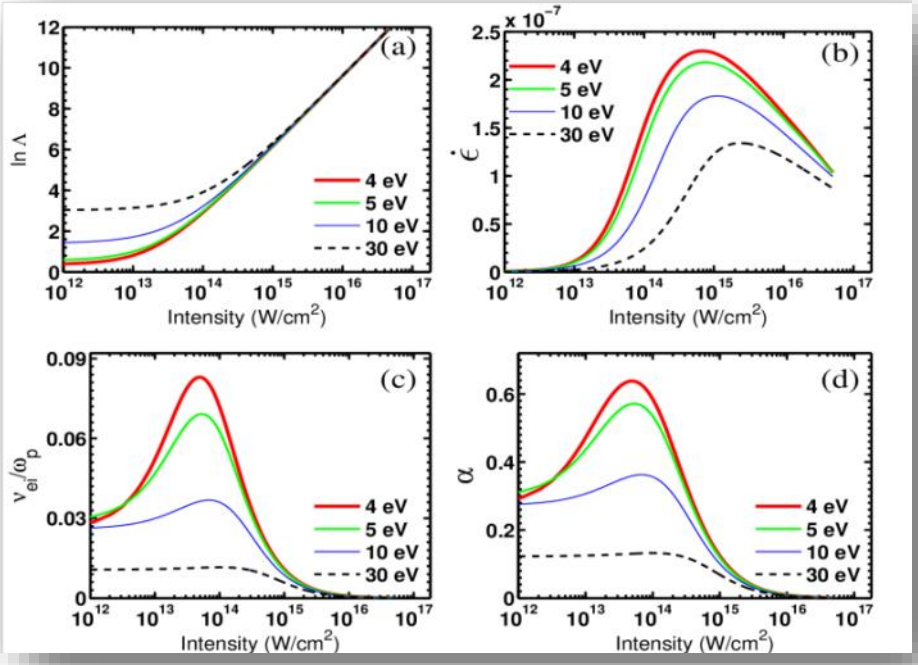
Indian Community at ITER-France Celebrates Holi

Indian Officials along with their families and friends also celebrated the festival of colors, Holi at ITER-France. On Sunday, 16 March near Manosque, nearly 50 people of ITER staff from India, friends and families gathered to celebrate this most colourful holiday.

-Courtesy ITER newsletter

Anomalous Collisional Absorption of Light Waves in Under-Dense Plasma

- Collisional absorption occurs when laser photon energy is transferred to the plasma mainly via the electron-ion collisions. In this case electron-ion collision frequency ν plays the role for the laser absorption. The most simplest classical model of ν incorporates a factor known as Coulomb logarithm which is conventionally assumed to be independent of the electron-ponderomotive velocity.
- According to this conventional model, the frequency ν and the corresponding fractional laser absorption α remain almost constant up to a value I_c of the peak intensity I_0 of the laser pulse, and then decrease when I_0 is increased beyond I_c (irrespective of temperature of the plasma).
- When a strong laser field is applied the Coulomb logarithm should depend on the total velocity, not the thermal velocity only. The consequence is shown in below.

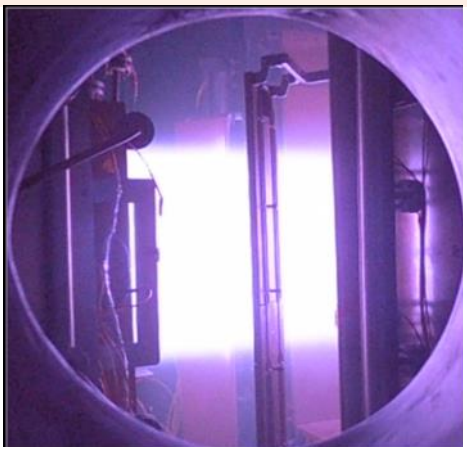


- Below some temperature <10-15~eV, with a total-velocity (thermal velocity plus the ponderomotive velocity) dependent Coulomb logarithm, it is found that ν and α grow hand in hand up to a maximum value around I_c followed by the conventional decrease when $I_0 > I_c$. Such a non-conventional anomalous variation of fractional absorption versus the laser intensity was observed in some earlier experiments, but no explanation has been given so far. The modified Coulomb logarithm may explain those experimental observations. With increasing temperature (e.g, at 30 eV) and density, the anomalous behavior is found to disappear even with the modified Coulomb logarithm, and the variation of ν and α with intensity approach to the conventional scenario.

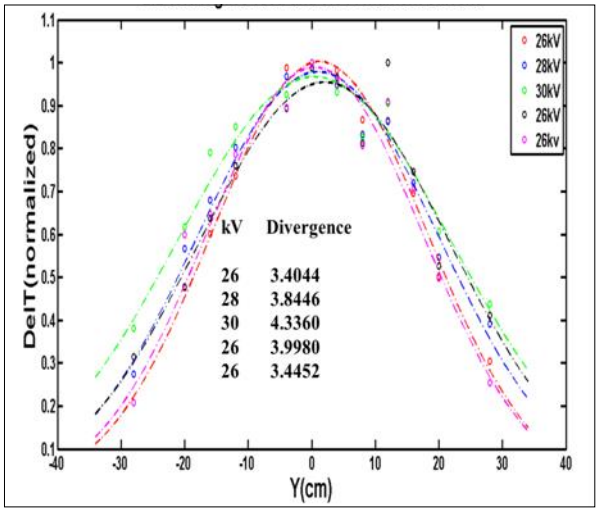
Recent Results From the NBI Test Stand: Enhancement of Operation Parameters

The NBI (Neutral Beam Injector) on Test Stand has been in routine operation with output parameters of ion beam current ~ 8A and beam acceleration energy ~ 20 keV. From a recent campaign, an enhancement of the extracted ion beam current up to 18A and energy up to 40 keV has been reported. Stable operations have been achieved around this parameter regime. Beam angular divergence was measured by three methods, namely, an array of K-type thermocouples mounted on the beam dump, IR thermography and from the line width of Doppler shifted Ha spectral lines. Higher beam divergences of 3° – 3.5° were observed even for the optimized perveance conditions. The ionic species fractions H+: H2+: H3+ measured by DSS were estimated to be 38:52:10. Experiment is planned for further improving the extracted power by operating the PINI in combination with cryo condensation pumps.

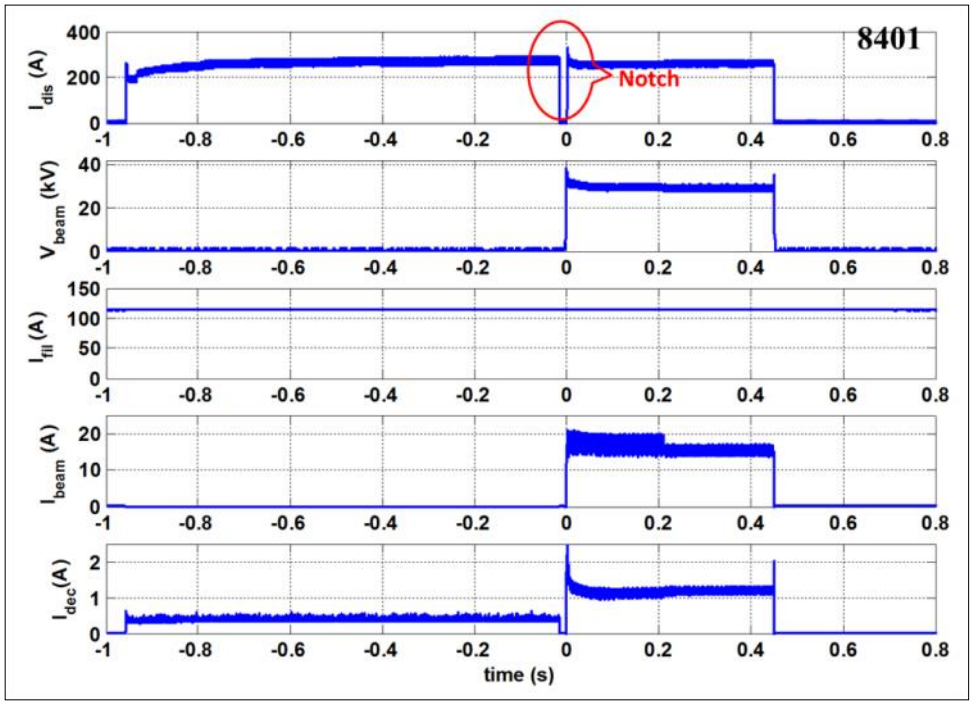
Plug-In Neutral Injector (PINI) mounted on NBI test stand.



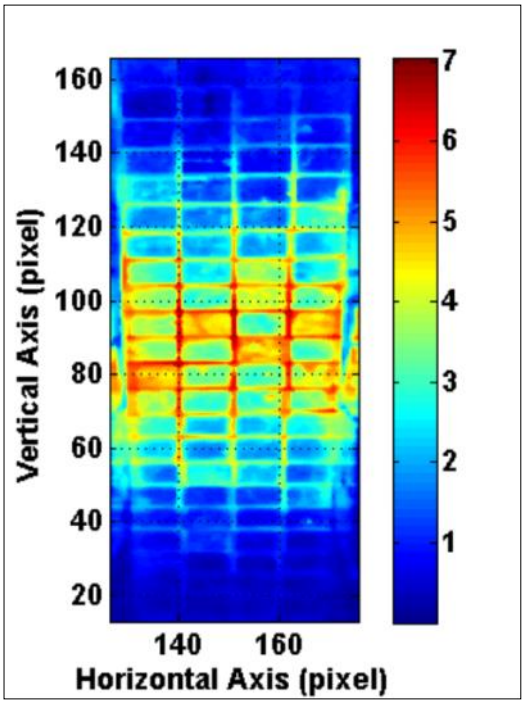
Side view of the ion beam extracted from PINI (beam propagation is from left side to right side)



Beam's thermal profile measured by the array of thermocouples.



Measured electrical parameters of the extracted ion beam. Parameters: Plasma discharge current, Idis, Beam energy, V_{beam}, Filament current, I_{fil}, Beam current, I_{beam}, and decel current, I_{dec}.



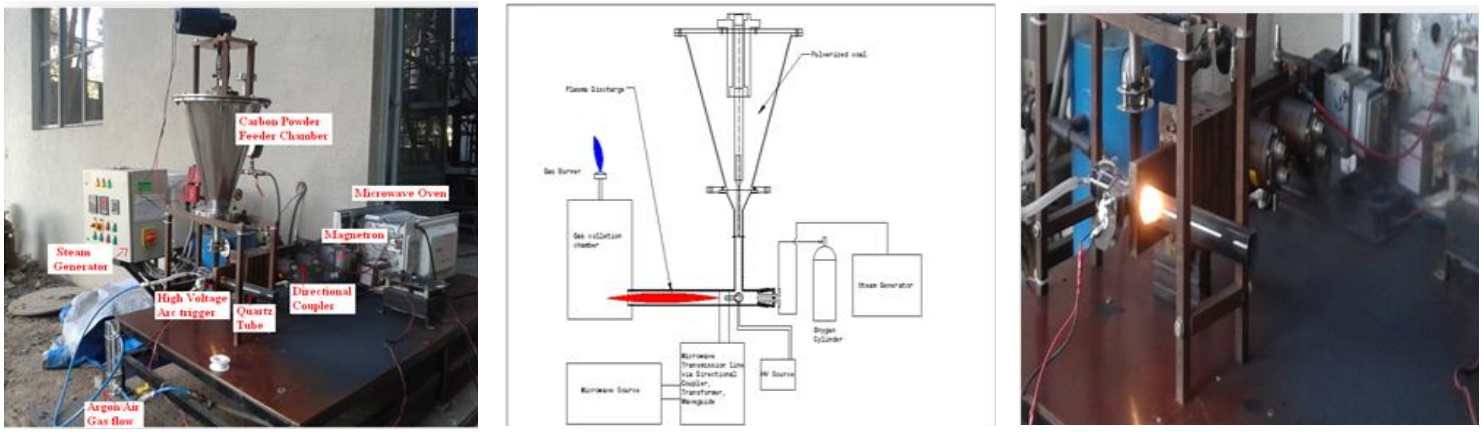
2D thermal footprint of the ion beam obtained by using IR camera.

कंप्यूटर पर हिन्दी का सरल प्रयोग

दि. 28 मार्च, 2014 को सभा कक्ष में **कंप्यूटर पर हिन्दी का सरल प्रयोग** विषय पर **श्री सुनिल मिसाल** एवं **श्रीमती रेखा सिंह** द्वारा वार्ता का आयोजन किया गया। वार्ता के दौरान संस्थान में उपलब्ध ISM 2000 - **सोफ्टवेअर** को कंप्यूटर पर कैसे संस्थापित करना है और इसे कैसे प्रयोग में लाना है इस विषय पर विस्तृत जानकारी दी गई। संस्थान के कई कर्मचारी इससे लाभंवित हुए और हिन्दी में काम करने की उनके संकल्प को दृढता मिली।

Development of 1kW Microwave Plasma Arc System for Coal Gasification at FCIPT

- Plasma arc is useful in many thermal plasma applications as it provides very high temperature by efficient conversion of electrical energy to thermal energy.
- Plasma arc is generated between electrodes that are consumable and its replacement is very complex procedure. In many applications, it is advised not to open the reactor quite often. Hence, Microwave plasma arc is a good solution for such applications because it is electrode-less plasma arc system.
- FCIPT has successfully worked on generating 1kW microwave plasma arc using commercial microwave oven. This microwave arc discharge is generated in a tube made of fused quartz that can with stand up to 3500 deg C.
- The coal powder is fed from the top in this tube into the arc discharge region with steam and Argon gas from the rear carries the carbon powder in the plasma arc region. The experiment is on to optimize the process for achieving coal gasification.
- Figure below shows the schematic and the experimental set up at FCIPT.



Microwave plasma arc system at FCIPT and its Schematic

Salient features:

- Electrode-less arc
- Uniform high temperature column over a large area
- Very high electrothermal efficiency (more than 90%)
- It allows even low grade coal gasification
- More Hydrogen generation possibility in syn-gas
- Environment friendly technique
- Many tailored application like toxic gas de-fragmentation, synthesis of carbon nano powder etc

Phase 1 of Crisis Management Plan - Tape Vaulting Service

The data storage vault installed at FCIPT

The Storage of data in off-site is known as **Vaulting**. The storage can be on Tapes/CD/DVD/USB media, vaulted in fire proof cabinet in a temperature controlled environment. This service offered by Computer Center to all groups is part of the Crisis Management Plan with more stringent security requirements with maximum data protection solution in the event of crisis like natural disaster, data loss or theft.

After storing the critical data, Individual groups can brings the tapes/CD/DVD/HDD (sealed by themselves) to Computer Center, which will be placed by the Computer Center person in the Fireproof Cabinet (installed at FCIPT-Gandhinagar). The Individual groups can recycle the tapes stored in the Fireproof Cabinet as per their requirements.

This facility is part of the IT Disaster Recovery plan for IPR

Support by Computer Center:

- Proper Logs will be maintained for the movement of media. A separate register will be maintained at FCIPT security personal.
- Monthly Backup : Every second working day of the month, a Computer Center personnel would go to FCIPT for vaulting the tapes. Other groups can submit their backup media (properly sealed) to Computer Center by first working day of the month (for monthly backup).

Various groups in IPR are requested to make use of this facility.

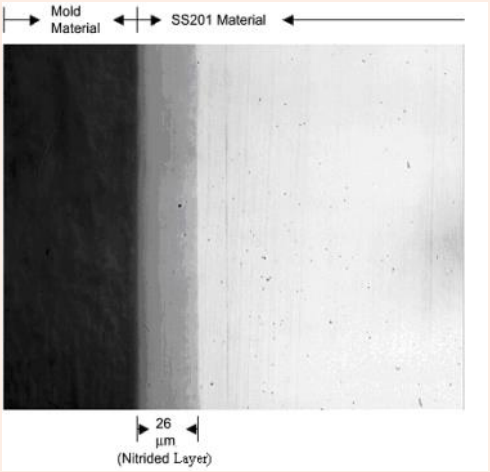
For further queries, please contact <computer.center@ipr.res.in>

Data is a precious thing and will last longer than the systems themselves - Sir Timothy John "Tim" Berners-Lee

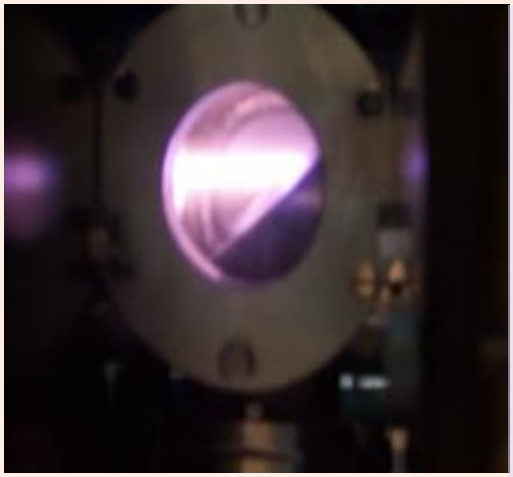
High Density Plasma / Neutral Beam for Surface Treatment

Low energy (1-100 eV) ions and neutrals interacting with various kinds of surfaces have relevance in many applications such as plasma processing, satellites placed in low earth orbits and plasma-wall interaction in fusion reactors. A facility for carrying out such studies have been developed at IPR. It includes indigenously developed high density (> 1013 cm-3) microwave powered continuous / pulsed plasma beam. Neutral beam is produced as a consequence of reflection of ions by a biased neutralizer (high-Z metal) plate. Ion/neutral energy of interest is selected by appropriately biasing the neutralizer plate.

This versatile facility can provide ion flux in the range of 1018 – 1019 cm^2/s and neutral flux in the range of 1015 – 1016 cm^2/s. Experiments carried out using the high density plasma beam have produced accelerated surface kinetics (e.g. high surface hardness, case depth) not observed earlier using conventional plasma sources anywhere.



Cross-section of a high density plasma beam nitrided steel (SS201) surface.



High density plasma beam falling on a neutralizer plate.

Key features:

- Continuous - pulsed microwave power supply.
- On / off period and frequency can be adjusted.
- **Highest plasma density ever achieved in a continuous plasma source in the country.**
- High case depth possible in a short period due to accelerated surface kinetics.
- **Incorporates a new kind of energy efficient electro-magnet developed for the first time in the country.**
- Low energy (1-100 eV) ion and neutral – surface studies can be carried out in the same experimental setup.

Environment Day "Everyday" !

For most of us, its only on the "Environment Day" that we think of plants and trees.. However, for this senior IPR staff, every day is an environment day !

Right opposite to the Blind Men Association near IIM in Ahmedabad there are some 30 tree saplings along the roadside pavement looking green and healthy… In a few years time, they would probably become the landmark of the place and give much needed shade and greenery to that area. The hard work involved in protecting and nurturing them with no assistance whatsoever even from those who promised it first, is being relentlessly carried out by a one man army named "**Raj Singh**". Every day, this senior RF engineer from IPR would carry a minimum of 4 canisters of water in his car on his way back home from office and spend time watering and tendering to these plants. Actually, most of the plants that he had originally planted had to be replaced with those that were less attractive to the wandering cows. He also made it a point to replace the sandy soil with fertile one and also taking steps in protecting the saplings. Apart from these saplings, he also has planted and is taking care of saplings planted at various other locations outside as well as inside IPR campus.

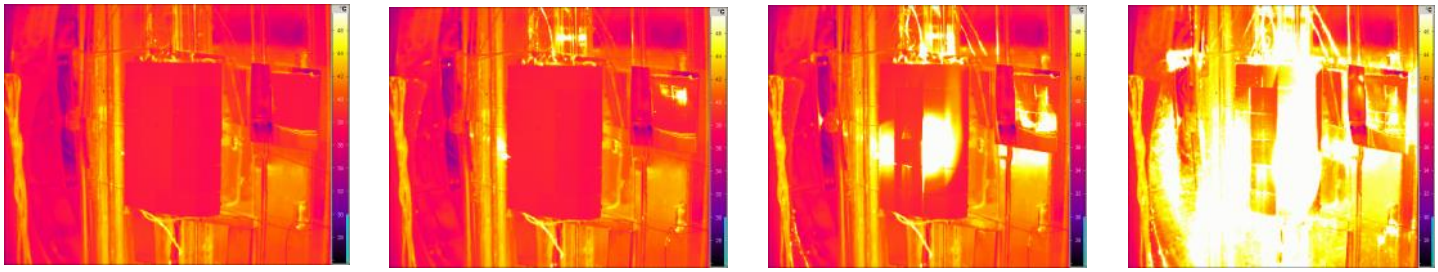
The IPR Newsletter applauds Shri. Raj Singh's outstanding service to the environment and we sincerely wish that more of IPR staff would try and emulate his example. As the famous poet Kahlil Gibran once said, "*Trees are poems that the earth writes upon the sky*"…. So lets all try and help Mother Earth write more poems for us !!!

IPR's own "Environmental Man" at work tending to the saplings on the 132' ring road near IIM

What we are doing to the forests of the world is but a mirror reflection of what we are doing to ourselves and to one another - M. K. Gandhi

Infrared Limiter Thermography for SST-1

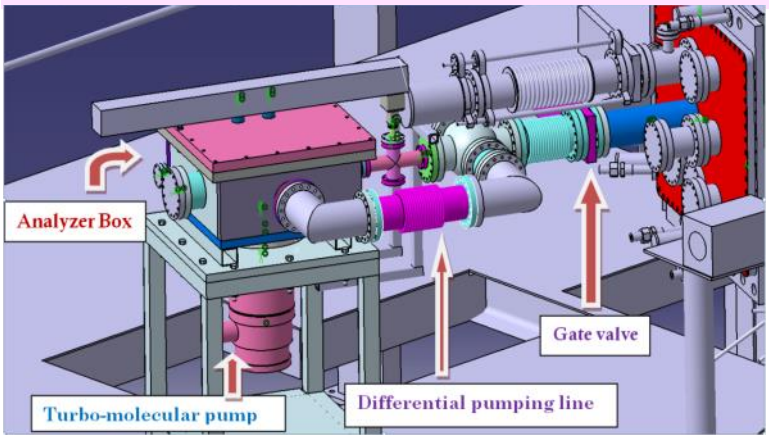
Infrared Thermography (IRT) of Plasma Facing Components (PFCs, namely Limiter, Diverter etc.) has an advantage of real time monitoring of the surface temperatures remotely with wide field of view (FOV). Infrared imaging system provides information on excessive temperature of component or power deposition profile on the PFCs.



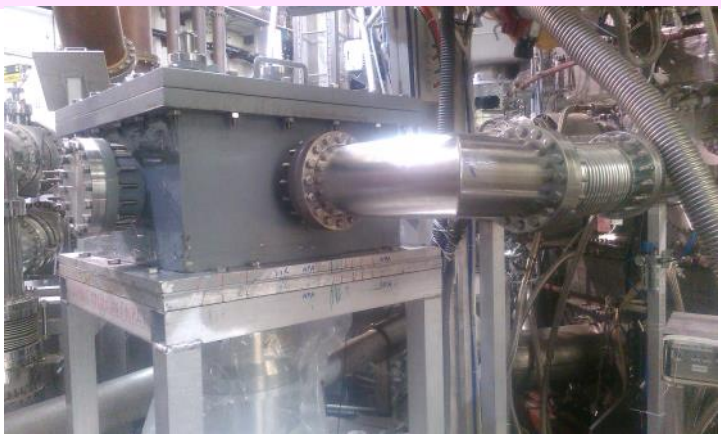
IR Thermographic images of the SST-1 Limiter, observed during the plasma **shot no. 4934. B_r=0.75, $I_{p\ max}$ = 51.47kA,** Frames are for **t = 0ms, 65ms, 115ms & 175ms**.

Neutral Particle Analyzer (NPA) Diagnostics for SST-1

The neutral particle analyzer [NPA] based charge exchange diagnostics on SST-1 aims to estimate the core ion temperature of ohmic plasma. The diagnostics system for SST-1 comprises of a drift tube which connects with the SST-1 radial port no. 15 using an isolation pneumatic gate valve and a DC break. The other end of this drift tube is connected with a 35 CF cross chamber (stripping cell of 200mm length). This cell is further connected to the Analyzer box (460mm × 460mm × 275mm, outer dimensions) which consists of parallel plate assembly (a set of plates) where a retarding electrostatic field is applied, on the ions emerging out of the stripping cell, between the top (positively biased) and the bottom plate (grounded). This box is evacuated using a 1200 ltrs/sec TMP through the port available at the rear plate of the Analyzer box. The whole assembly is evacuated with the same pump using a differential line. The analyzer box is placed over a support structure (~500mm×500mm×1460mm) which is capable of bearing the load of ~200 kg.



CXD System layouts with SST-1 at radial port no 15.



CXD System with SST-1 at radial port no. 15.

Optical Imaging Diagnostics on SST-1

The current set up of Optical Imaging Diagnostics on SST-1 provides information about plasma shape, vertical position, plasma movement in vertical direction. In figure -1 the plasma image taken during current campaign (campaign VII) is shown and figure-2 shows the planned view of the diagnostics. In figure-1, the plasma can be seen at correct location (geometrical center of the machine) and diameter of the plasma to be around 50-55cm.

The camera used in the current set up is a 640 x 480 pixel CCD camera which is directly mounted on the machine. The viewing angle of this camera is around 70^{o} which covers nearly 60 % of the vacuum vessel. The camera signal is transported through optical fibre to diagnostics lab where it is acquired through imaging card mounted in the PC. This PC is mapped in the SST-1 control room where the plasma images are displayed live.

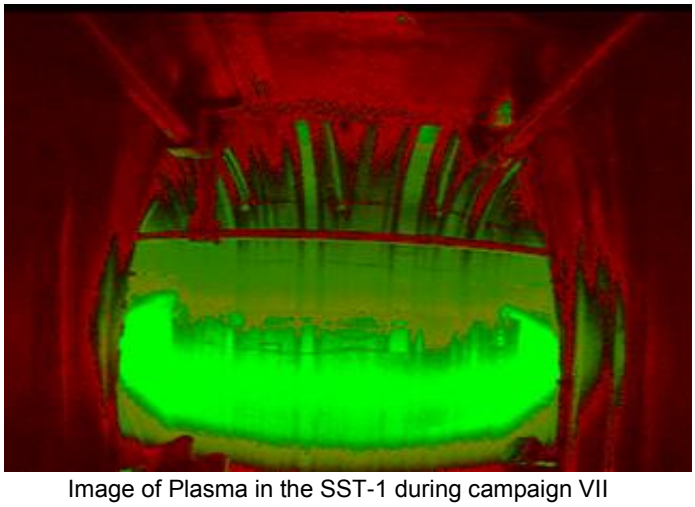
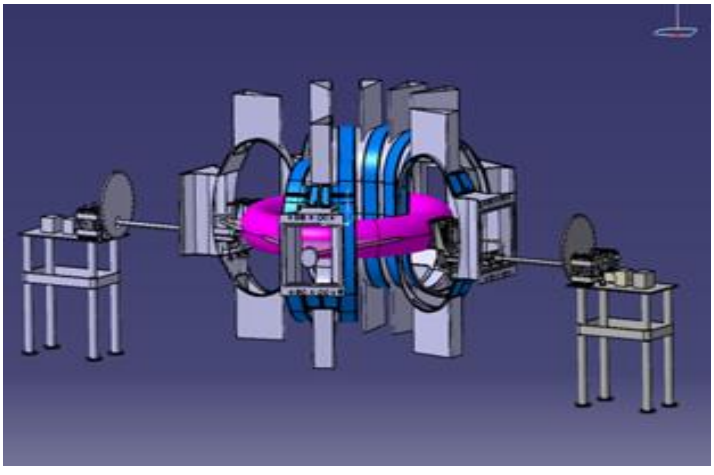


Image of Plasma in the SST-1 during campaign VII



Schematic of the proposed wide angle camera on SST-1

IPR & International Collaborations

No.	Title of the MoU / Agreement	Major Areas of collaborations	Country	Duration
I. Indo-EU collaborations				
1	Agreement for cooperation between the Govt. of India and the European Atomic Energy Community in the field of Fusion Energy Research	Tokamaks, alternative concepts for present and next generation, magnetic fusion technology, plasma theory & applied plasma physics,	EU	Since Nov 2004
2	IPR-CEA agreement	Plasma operation & control, heating & current drive and related technology, fusion grade material and divertor technology, advanced diagnostics, fueling and pellet, injection , fusion theory and simulation, data mining	France	Since Mar 2007
3	IPR-JET collaborations	JET RMP coils, Operation of large tokamak experiments control related diagnostics and technologies	UK	Since Apr 2012
4	IPR-ENEA collaboration	Tokamak design & prototyping, neutronics, tritum technology	Italy	Since Oct, 2013
5	IPR-KIT collaboration	Helium cooling systems and access to KIT facilities, fusion fuel cycle related activities, neutronics related activities for fusion blanket development, liquid ceramic pebble bed characterization	Germany	Since Jan 2014
II. Indo-US collaborations				
1	IPR-GA collaborations	Plasma operation and scenario development, integrated modeling, participation in DIII-D experiments, operation and development of diagnostics,	USA	Since Dec 2013
2	IPR-UCLA collaborations	Development of liquid metal diagnostics, thermofluid MHD experiments & simulations, solid breeder blanket design,	USA	Since Sept 2013
III. Other Collaborations				
1	IPR-NFRI collaboration	Joint research activities on fusion science and technology, such as plasma operation and control, heating & current drive, diagnostics	South Korea	Since Apr 2013
2	IPR-ISEM collaboration	Development of process and technology for superconducting magnet, fusion grade high current CICC , current lead and magnets for tokamaks,	Australia	Since May 2013

For any further information regarding IPR International collaborations, please contact Dr. Daniel Raju <raju@ipr.res.in>

Silver Stars of IPR

Prof. Ratneshwar Jha joined IPR in 1987 and has been working with the Plasma Diagnostic Group for various tokamak experiments in Aditya and SST-1. Presently, he is Dean of the Institute.

Mr. Kiran R. Padia joined Air conditioning and Water Cooling division of IPR in 1986 and is presently involved in its general operation and maintenance for various systems at IPR and FCIPT including Aditya and SST-1.

Mr. Vipulkumar K. Panchal joined IPR in 1986 and presently looks after PC based data acquisition system operation as well as development of data acquisition/ analysis programs for Aditya.

Past Events @ IPR

- **Ms. Ranjana Gangradey**, Institute for Plasma Research, Gandhinagar, gave a talk on "*Technical progress and achievements in Development of Cryoadsorption Cryopump*" on 12th March 2014
- **Dr. Sastry Pamidi**, Florida State University, gave a talk on "*High Temperature Superconducting Power Systems Research at The Florida State University Center for Advanced Power Systems*" on 18th March 2014
- **Mr. Hemen Dave**, JRF, FCIPT, gave a talk on "*Study of Plasma Surface Modification of Polymers, Biomaterial and their Characterization*" on 18th March 2014
- **Dr. Brent Covele**, University of Texas at Austin, gave a talk on "*Modeling the SST-1 Divertor and X-Divertor Performance with SOLPS 5.1*" on 19th March 2014
- **Dr. Arpan Banerjee**, National Brain Research Centre, Haryana, gave a talk on "*Neuro Cognitive Network Dynamics Underlying Action and Perception*" on 19th March 2014
- **Dr. Swadesh M Mahajan**, Professor, Dept. of Physics, University of Texas at Austin, gave a talk on "*Nonlinear Effective Quantum Mechanics – A Theory of Fluidons*" (Colloquium #231) on 21st March 2014
- **Dr. Prahlad Vattipalle**, Institute for Plasma Research, Gandhinagar, gave a talk on "*Recent Results from the NBI test stand: Enhancement of operation parameters*" on 21st March 2014
- **Ms. Kamya Chandrasekhar**, Nuclear Engineering Department, University of Wisconsin, US, gave a talk on "*Effective Variance Reduction and other MCNP Techniques for Deep Penetration Shielding Problems in Nuclear Fusion*" on 1st April 2014
- Workshop on Prevention and Response to Nuclear/Radiological Emergency, 2-4 April 2014

Upcoming Events

- 15th International Vacuum Electronics Conference (IVEC 2014), Monterey, California, 22-24 April 2014 http://ivec2014.org/
- 18th Joint Workshop on Electron Cyclotron Emission and Electron Cyclotron Resonance Heating (EC-18), Nara Prefectural New Public Hall, Nara, Japan, 22-25 April 2014 http://ec18.nifs.ac.jp/
- The International Middle East Plasma Science (IMEPS) conference, Antalya, Turkey, 23-25 April 2014 http://imeps.org/
- 4th International Workshop on Numerical Modelling of High Temperature Superconductors, Bratislava, Slovakia, 11-14 May 2014 http://www.elu.sav.sk/htsmod2014/
- 10th International Conference on High Energy Density Laboratory Astrophysics, Bordeaux, 12-16 May 2014 http://hedla2014.sciencesconf.org/
- 41st IEEE International Conference on Plasma Science (ICOPS) and the 20th International Conference on High-Power Particle Beams (Beams), Marriott Wardman Park, Washington DC, on 25-29 May 2014 http://www.ece.unm.edu/icops-beams2014/
- 21st International Conference on Plasma Surface Interactions, Ongaku-do, Kanazawa Ishikawa, Japan, 26-30 May 2014 http://psi2014.nifs.ac.jp/

From the IPR Archives

The fast changing landscape of IPR : The view from the window of BETA lab presented a green canvas back in 1995. The spot just outside this window is where the new Basic Experiments Lab came up in late 90's. The land beyond the lab is an area where deep excavations were carried out to build the gigantic water chilling plants for SST-1.

The Newsletter Team

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