

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

Plasma parameters in SST-1 have been further improved in Campaign-X which concluded on June 24, 2014. In this short experimental campaign, plasma currents exceeding 60 KA were obtained for a total duration exceeding 400 ms at a field of 1.5 T (Fig-1)in plasma centre where the pre-ionization was carried out with ECH in fundamental mode. Similarly, plasma currents exceeding 41 KA could also be achieved exceeding the duration of 400 ms at a field of 0.75 T (Fig-2), where the pre-ionization was carried out in second harmonic mode. Campaign-X in SST-1 had undeniably demonstrated that it is capable of sustaining ohmic plasmas for such long durations once appropriate pre-ionization is done with ECH. Having achieved these, immediate future campaign would focus on coupling of externally launched Lower Hybrid power that has the exciting possibilities of influencing plasma densities as well as lengthening the duration of plasmas in SST-1.





41 kA plasma current obtained for > 400 ms for 0.75 T



SST-1 team during the Campaign-X of July 2014

Magnet Technology Division has successfully fabricated a sub-size prototype fusion relevant magnet. This prototype comprises of eight turns of indigenously developed NbTi/Cu based cable-in-conduit-conductor of 30kA rating wound in a single layer configuration.

| Shape | Modified `D' shaped |
|------------------|---|
| Size: | Major dia : 5.4m; Minor dia : 3.8m |
| Base conductor | NbTi/Cu |
| Conductor type | Indigenously developed Cable-in-Conduit (CIC) |
| Conductor rating | 30kA @ 5.5 T & 5 K |
| Insulation | Bisphenol based epoxy with Fibre glass |
| Case material | Non-magnetic SS 304 L |
| Weight | Winding : 240 kg ; Full magnet : 340 kg |



| Ampere turn (KA-t) | 240 | |
|--------------------|---------------|--|
| Winding type | 8 turn single | |
| which g type | solenoid | |

Bolometer Diagnostics in SST-1

The objective of bolometer diagnostic is to measure the total radiation power loss from the plasma which is a significant fraction of the input power (20%-100%). A single channel is required that has a 2π view in the poloidal cross-section. To determine the spatial distribution of radiation, arrays of bolometers are required. These also give the radiation power loss. The SST-1 bolometer diagnostic consists of four pin-hole cameras of 16 channels each for main plasma. These provide a spatial resolution of 2cm at the plasma mid-plane. Six pin-hole cameras of 20 channels have been designed for diverter viewing. These provide spatial resolution of 0.7cm-1cm. For the present campaigns, one camera is installed on radial port no. 15. The system and the results from shot no. 5322 of campaign IX are shown below.



The schematic of the bolometer and one of the arrays of camera



The radiation power loss and brightness profile as measured by the bolometer.



Mr. Natvarlal P Sadariya joined the workshop in 1987, and has hence been involved in the precision engineering fabrication of different systems and components of many working systems at IPR.

Silver Stars of IPR



Dr. V. Balakrishnan joined IPR in 1987. His early work included design and commissioning of ADITYA Pulsed Power and later on power supplies for different experiment Systems. Presently he heads IPR electrical maintenance section.



Mr. Vishnubhai R. Prajapati joined the engineering drafting section in 1987. He was involved in drafting major structures and diagnostics for SST-1 and Aditya and other experimental systems. Recently he worked for ELM coils at Culham Science Centre, UK.

Measurement of Pulsed Neutron Energy - CPP

The measurement of neutron energy from a pulsed neutron source is an important parameter to know the emission properties of the source. One of the best known techniques to measure neutron energy is called "Time of Flight" (TOF) technique. Extensive studies on neutron emission from a pulsed neutron source, called the plasma focus (PF), have been carried out in deuterium medium at CPPIPR. The device (i.e. PF), producing the pulsed neutrons, has a coaxial electrode system and the studies were carried out in three different shaped central electrodes (anode) namely oval, converging and cylindrical. For neutron energy measurement with TOF technique, a photomultiplier tube (PMT) in combination with scintillator has been used for measurements in axial and radial directions. The energy of the neutrons is determined by taking the hard X-ray pulse (X-rays are also simultaneously emitted from the source) as the reference. The average energy of neutron is found to be around 3 MeV and 2 MeV in the axial and radial direction respectively.





Typical neutron signal captured with a cylindrical anode

ploring Advanced Divertor Configuration In SST-

One of the critical issues in developing tokamak fusion reactor is the high heat flux exhaust. The excessive heat flux will erode and possibly melt materials from the plasma facing components (PFC), thereby limiting the lifetime of these components and also increase the impurity contamination of plasma core. The peak plasma heat exhaust consists of two phenomena namely (1) continuous flow of power to the divertor plates which is limited to 10-20 MW/m² for the present technology, (2) the transient peak-heat flux that can be allowed before the ablation/melting of surface occurs. The transient heat flux can be reduced by mitigating the Edge Localized Modes (ELM) using various schemes. However, the steady state heat flux on the divertor has to be tackled for fusion reactors like ITER and DEMO.

The heat flux on the divertor can be reduced by either flaring the field lines at the strike point (field line hit the divertor target) or moving the strike point radially outward, there by increase the wetted area. The divertor index (DI) is the measure of field lines flaring. In the standard divertor configuration, there exists one x-point (magnetic null) which limits the plasma region. In the recent past, advanced divertor configurations are proposed by creating a secondary x-point very close to the 1-st x-point which in turn increased flaring near this 2-nd x-point (Snowflake with DI < 1). Many experiments have been carried out with snowflake configuration and thoroughly investigated for its divertor performance. For reactor like devices, this configuration may not be very attractive compared to X-divertor (DI > 1). In the X-divertor configuration, the 2-nd x-point can be formed at a location far away from the 1-st x-point which allows to have the target plate at a larger radial location. The experimental exploration of this configuration is not yet done. In this regard, a feasibility study has been carried out to have X-divertor configuration in SST-1.

The SST-1 standard divertor has DI around 2.69 thereby includes some effects of x-divertor. This is due to coils kept at a larger height from the plasma allowing them to form 2-nd x-point like situation. However, for large DI values (~6.8), an additional coil carrying current 30 kA for the plasma current of 220 kA is needed. This figure shows the X-divertor configuration. The preliminary study shows that this may be feasible for SST-1 without changing the present divertor targets. This configuration can allow us to operate SST-1 with an input power much higher than 1 MW which is the designed value of SST-1. The detailed assessment is in progress.



Different types of anode used in the experiment

Football - No Ordinary Game This Is !



The IPR team, under the captaincy Prof. Dhiraj Bora, after it won the

Vikram Sarabhai Runners Up Football Cup in 1986. Back Row: (L-R): V.N

Football is a game that demands extreme physical fitness, the fastest of the reflexes and an almost never exhausting stamina, all of which need to be put into use and displayed simultaneously by a bunch of high spirited teammates in accurate rhythm. IPR always had a very active football playing group right from the mid 80's to now. We may not win the world cup, but we sure will win the hearts of IPR'ites !!



The IPR team, during one of their practice sessions at IPR in1997-98.

Rai, Robin Pal, D.P Mahapatra (in front of Robin Pal), Mohandas K.K, P.C Abraham, S C Bhoi, Dhiraj Bora, First Row (L-R): Madanlal Kalal, S.K. Mattoo, A.K. Sharma. Those not in the photo: C.V.S. Rao, Avinash Khare, C.N. Gupta and B.R. Tiwari.

Excepts from the IPR newsletter Vol.3 (1986) ; Sports & Cultural Round-up - A Moment to Rejoice (Vikram Sarabhai Cup Football Tournament, June 1986) by R. Pal

It was just another Saturday in the month of June. Nothing special. But I woke up on the morning with a painful memory in my mind and a chilling, realization: 'My God'. The football game is today; Our game with arch rival Rest of PRL; I still have that bitter taste in my mouth of their humiliating 6-0 handling of us last year. The 'revenge' made me jump out of bed.

Veteran player, Dhiraj Bora, I was sure, had the same feeling. I chose him as the captain. We coaxed Mahapatra, always complaining about a weak knee, to keep the goal-the most vital job (what a selection was that;) Strongman A.S. Sharma (I heard five yards around him is a 'danger Zone' and anybody who goes into it either comes out limping or relax lying on the ground) agreed to play in the key position of last defensive back. Other backs were CVS Rao. (who always takes a strong and prompt kick, no matter whether there is any opponent in his neighborhood or not). S.K. Mattoo (who may seem to be more eager to protect goalkeeper by running to-wards him and blocking him and his view whenever any opponent player comes with the ball), 'sticking-Plaster' Avinash (some people say you may be able to get rid of your shadow, but you cannot shake him off) and I (everybody thinks he can run over me.) So we had a solid back Line: C.N. Gupta (he is there wherever the ball and tackling), MVVS Rao (a tennis player who vows he never touched a football) and guiet Madanlal, (not the well known one) were half-backs. Lean B.R. Tiwari was ouf 'star' forward, and of course, Dhiraj was there-strong, steady, athletic and 'highly Pressurized'. Other forwards were Mohandas (People say if ball goes to him he will dribble and dribble and dribble until somebody obliges him by tackling the ball away from him), S.C. Bhoi (the most bubbling enthusiast) and smiling P.C. Abraham. On card, we had a 'reasonably' good team. Any way, we arrived at the IIM ground, all booted and psyched up. The game started. Everybody was doing his job remarkably well. However, suddenly may be, in going to protect the goalkeeper from a high, soft, outgoing shot Mattoo handled the ball in the red zone. Referee did not appreciate it and said it was 'football' game and awarded a penalty. God did not like the decision, and apparently understood Mattoo logic; so he pulled the shot towards him. We survived. Rest of PRL was furious. Ball was in our half almost all the time. We were damn tried, but still somehow defending. Ultimately, they cracked into the goal (0-1). we were down. Enthusiasm started leaking out. Suddenly, the 'revenge' started banging into my head. I switched position with Madanlal and went forward. Within a few minutes somehow Tiwari got the ball in a favorable position. He was running with the ball, I prayed; Tiwari dodged one defender, then the goalkeeper and then softly placed the ball into the far corner of the goal (1-1). Oh boy ! Everybody was up. Coming back from behind, who could imagine; The regular time lapsed. Extra time too. Finally penalty shoot-out time. Sharma and I let our team down. But Mahapatra compensated for our failure and saved our grace. It was 4-4. Now 'sudden-death' Excitement was running higher and higher after each shot. CVS Rao converted the first shot. We started jumping. They replied; they went crazy; Then our captain took a tactical move; He sent Mahapatra to take shot, and Mahapatra obliged (6-5). He went to defend, we held our breath. He blocked the shot, and what; The ball slipped out of his hand, and was rolling towards the goal line; Oh no! It was all in front of me! I felt like jumping on the ball! But Mahapatra did it in the second attempt! We tore the sky! We won! We won!! We could not believe it! We went out of our minds!! It was a moment to rejoice! Totally exhausted, limping, finally we headed home.

Next morning I opened my eyes, felt the aching all over, painfully remembered today was our final game against evergreen PRL juniors in the Vikram Sarabhai Football Tournament. However, I did not find the word `revenge 'in my mind. I still had that sweet taste of yesterday. I took my time and helped myself up slowly.

P.S. We lost final only 0-4. The ball was inside our half-back line almost throughout the game. But then, who cared?

Dedicated Services and Facilities at IPR

IPR has established the following dedicated services and facilities for the staff members, IPR staff may contact them as and when required.

| Service/Facility | Concerned Person | Contact Information (Extn. No / Email-Id) |
|------------------------------|----------------------|---|
| Accounts | Mr. H.K. Sharma | 2003,hsharma@ipr.res.in |
| Campus Maintenance | Mr. Subodh M. Patel | 4023,smpatel@ipr.res.in |
| Computer Centre | Dr. Ravi A V Kumar | 2181, ravi@ipr.res.in |
| Electrical Maintenance | Mr. V. Balakrishnan | 4183,balakris@ipr.res.in |
| Foreign Travel | Mr. M. Vartak | 2016, vartak@ipr.res.in |
| IPR Security and Canteen | Mr. H. S. Chamunde | 2013, chamunde@ipr.res.in |
| Library | Mr. S. Shravan Kumar | 2033,shravan@ipr.res.in |
| Local Transport, Guest House | Mr. Hitesh Mehta | 2018,hmehta@ipr.res.in |
| Medical Services | Mr. Dinesh Nair | 2015. dnair@ipr.res.in |
| Purchase (Foreign) | Mr. BKBS Rao | 2022, bkbsrao@ipr.res.in |
| Purchase (Local) | Mr. D. Ramesh | 2021, ramesh@ipr.res.in |
| Stores | Mr. R.U. Pandya | 2260,rashmi@ipr.res.in |
| WC and A/C Maintenance | Mr. Prashant Singh | 4007, prashant@ipr.res.in |
| Workshop, Drafting/Drawing | Mr. Vijay Patel | 2256, vijaypatel@ipr.res.in |

Aditya Upgrade Programme

After more than 25 years of successful operation of the Aditya Tokamak, it was decided to upgrade this machine in the current plan term. The main technical objectives of the Aditya upgrade are (1) study of diverted plasma operation, (2) Demonstration of advanced integrated control of plasma, (3) Graphite/ Tungsten divertor plates/first wall, (4) Demonstration of multiple fast gas injection, (5) molecular beam injection, pellet injection etc.

The scientific objectives of Aditya Upgrade are (1) Low loop voltage start-up with strong pre-ionization, (2) disruption mitigation studies relevant to future fusion devices, (3) runway mitigation studies, (4) demonstration of Radio-frequency (RF) heating and current drive (CD) etc.

The Aditya Upgrade machine will have more physical accessibility to the plasma as compared to SST-I and will be very useful for generation of technical and scientific expertise for future fusion devices. The upgrade is slated to be completed by March 2015



The original vacuum vessel of Aditya during its construction in 1988

3-D image of the proposed Aditya upgrade vacuum vessel

Our scientific power has outrun our spiritual power. We have guided missiles and misguided men... Martin Luther King, Jr.

Summer School Programme - 2014

The six week long Summer School Programme-2014 was concluded on 11th July 2014. As a part of this program, lectures, scientific projects, visits to IPR labs and to the ISRO Space Applications Center were arranged. A pleasure trip to the forests of Polo in the Sabarkanta district of Gujarat was also arranged. A poster presentation was arranged for the SSP students to showcase the project work carried out by them as part of the programme, and six prizes were awarded to the best posters.

| Student | Title of the project | Affiliation of the Student |
|--------------------|--|---|
| Divya Sharma | Trajectories of charged particles in 2D-A numerical study. | Punjab university |
| Maitreyi Sangal | Collisional absorption sub-cycle laser light in under-dense plasma | Symbiosis Institute of Technology |
| K Shravana Shankar | Design, analysis and optimization of flat plate for vacuum | NMAM Institute of Technology |
| Richa Chauhan | Experimental characterization of complex plasma. | University of Delhi |
| Atanu Mandal | Study the working principle of triple Langmuir probe to measure electron temperature and density of radio frequency plasma | Ramakrishna Mission Residential College, West Bengal |
| Gangandeep Kaur | Development of Magnetic Field Probes of High Frequency Response | Guru Nanak Dev University |



Professor Abhijit Sen addressing the participants of SSP-2014 during the concluding session



The participants of SSP-2014 during their trip to Polo Forest



The participants of SSP-2014 with the organizing members

Power Supply Group Activities at ITER-India Lab

The Industrial Prototype of High Voltage Power Supply (27kV/18kV, 3MW) have been supplied by ECIL and commissioned at ITER-India lab. These power supplies are prototypes and of the same specifications that will be used for the ITER Ion cyclotron high voltage power supplies (ICHVPS) to power ICRF heating systems on the ITER machine. ECIL is the Indian industry that is manufacturing these power supplies under the Indian scope of power supply contribution to ITER comprising of DNB, EC and IC power supplies. The testing of this power supply at ITER-India lab demonstrated rated voltage of 27kV at lower power, and is presently being organised for other performance parameters .





The front view of the IC HVPS power supply



Input voltage of the IC HVPS22kV +10% -10%,
50Hz ± 3 %, 3-phaseMax Total continuous power required by one amplifier chain from single HVPS3000 kWMax pulse duration3600 sDuty cycle1/4

The transformers for the IC HVPS power supply

| HVPS output for End stage | | |
|---|-----------|--|
| Voltage range | 10 -27 kV | |
| Maximum current to one end stage tube | 170 A | |
| maximum output continuous power to one end stage tube | 2800 kW | |
| Voltage rise time (10% to 90% of flat top value) | 50 ms | |
| Transient response from 18 kV to 27 kV | 5 ms | |

| HVPS output for Driver stage | | | |
|---|---------------------------|--|--|
| Voltage range | 8 -18 kV | | |
| Maximum current to one Driver stage tube | 20 A | | |
| maximum output continuous pow- er to one Driver stage tube | 250 kW | | |
| Voltage rise time (10% to 90% of flat top value) | 50 ms | | |
| Ripple of driver stage voltage | ± 1% of the maximum value | | |

Basic Plasma Group Meeting @ IPR



The annual meeting of the Basic Plasma Group of IPR was held on 3rd July. The meeting, led by Dr. Prabal Chattopadhyay and organized by Dr. Pintu Bandhopadhyay, had presentations and detailed discussions related to the various subprojects under this group.

Prof. Dhiraj Bora, Prof P.K. Kaw and Prof Amita Das attended the meeting and gave their valuable comments and suggestions.

- Mr. Braj Kishore Shukla, Institute for Plasma Research, gave a talk on "Studies on quasi-optical launchers (QoLs) for Gyrotron based ECRH systems and its application to Plasma" on 4th July 2014
- Dr. Kushal Shah, Assistant Professor, IIT Delhi, gave a talk on "Plasma Dynamics in Paul Traps" (Colloquium #232) on 8th July 2014
- Dr. Deepak K Gupta, Tri Alpha Energy, California, USA, gave a talk on "Progress on C2 Field Reversal Configuration (FRC) Plasma Device" on 10th July 2014

Upcoming Events

- Plasma Processing Science: Many Scales, Many Applications, One Discipline (Gordon Research Conference), Smithfield, Rhode Island, USA, 27 July - 1 August 2014 http://www.grc.org/programs.aspx?year=2014&program=plasmaproc
- 40th Scientific Assembly of the Committee on Space Research (COSPAR 2014), Moscow, Russia, 2 10 August 2014 https:// www.cospar-assembly.org/
- 9th International Conference on Dense Z-Pinches (DZP 2014), Napa, California USA, 3 7 August 2014, http://www.dzp2014.com/
- Joint ICTP-IAEA College on Advanced Plasma Physics, Trieste, Italy, 18 29 August 2014 http://cdsagenda5.ictp.it/full_display.php? ida=a13216
- 21st International Workshop on ECR Ion Sources (ECRIS 2014), Nizhny Novgorod, Russia, 24 28 August 2014 http:// ecris14.iapras.ru/
- ♦ 36th International Free Electron Laser Conference (FEL 2014), Basel, Switzerland, 25 29 August 2014 http://www.fel2014.ch/
- ITER International School: High Performance Computing in Fusion Science, Aix-en-Provence, France, 25 29 August 2014 http:// iterschool.univ-amu.fr/
- 27th Summer School and International Symposium on the Physics of Ionized Gases (SPIG 2014), Belgrade, Serbia, 26 29 August 2014 http://www.spig2014.ipb.ac.rs/

Welcome to New IPR Staff

On behalf of IPR, we wish to extend a very hearty welcome to all the new staff members who have joined IPR in various permanent positions during May-June 2014. We wish them all the very best in their career !





Dr. V. Sivakumaran Scientist – SE DOJ: 09.06.2014

Mr. Kartik J. Dave Tech. Asst.-B DOJ: 21.05.2014



Mr. Gaurav Purwar Tech. Asst.-B DOJ: 15.05.2014



Mr. Sharad Jash Sci. Asst. – B DOJ: 30.05.2014

Obituary



yur P. Suthar Mr. Na





Mr. Mayur P. Suthar Mr. Office Clerk – A DOJ: 23.05.2014 D

Mr. Nagarji C Thakor M Tradesman – A DOJ: 12.06.2014

Mr. Vijay K Vasava Tradesman – A DOJ: 30.05.2014



Professor Ram Kumar Varma (March 31, 1935-May 14, 2014)

Professor Ram Kumar Varma, former Director, Physical Research Laboratory, Ahmedabad, passed away on May 14, 2014. He was 79. Prof. Varma joined Physical Research Laboratory (PRL), Ahmedabad, in 1968 and initiated plasma physics activity that later led to provide the nucleus for the formation of Institute of Plasma Research (IPR). He served as the Director of PRL from 1987 to 1995. During this period, he initiated numerous new activities, and carried out reorganization of research areas which laid the foundation of a long lasting vision for PRL. After his superannuation from PRL, he continued to remain active as an Emeritus Scientist and Honorary Fellow. Prof. Varma earned recognition for his work from many quarters. He was elected as the fellow of Indian Academy of Sciences, Indian National Science Academy and National Academy of Sciences. He was awarded the H.C. Shah Gold Medal in 1977. He was also the Founder-President of the Plasma Society of India (1978-92).

| The Newsletter Team | | | | |
|---------------------|----------------|--------------------|-------------------|--------------|
| Chhaya Chavda | Mohandas K.K. | Ramasubramanian N. | Ritesh Srivastava | Swati Roy |
| Hiral B. Joshi | Priyanka Patel | Ravi A. V. Kumar | Shravan Kumar | Tejas Parekh |

Institute for Plasma Research Bhat, Near Indira Bridge Gandhinagar 382 428, Gujarat (India)



Web : www.ipr.res.in E-mail : newsletter@ipr.res.in Tel : 91-79-2396 2000 Fax : 91-79-2396 2277