Issue 086

September 2020

The Fourth State

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

150 YEARS OF CELEBRATING THE MAHATMA

74th Independence Day @ IPR

The 74th Independence day was celebrated at IPR by hoisting the national tricolor at the IPR main campus. The National flag was hoisted by Dr. Shashank Chaturvedi, Director, IPR. This was followed by the national anthem and guard of honour to the Director by the security personnel. On this occasion of the 74th Independence Day the director conveyed a speech covering the scientific / technical / social outreach achievements & contribution by institute in this year. Due to the prevailing COVID-19 pandemic, careful social distancing was observed during the event and IPR Staff Club did not organize any culture/ recreation/ seminar/ sports activities in IPR campus. The event ended with tea and snacks for IPR staff and their family members who attended the function.

Images from the flag hoisting ceremony held at IPR campus on 15 August 2020

74th Independence Day @ CPP-IPR

Prof. B. K. Saikia, Center Director, CPP-IPR hoisting the national flag at CPP-IPR

Dr-Ing. Suryakant Gupta of FCIPT was nominated to the sub-committees of LEO, MEO, GEO and Lunar Environments & Laboratory Simulation of Space Environment (Space Environments) of the of American Institute of Aeronautics and Astronautics (AIAA).

Dr. Devendra Sharma has been recognized as an Outstanding Reviewer for the IOP Journal "Plasma Research Express" for the year 2019.

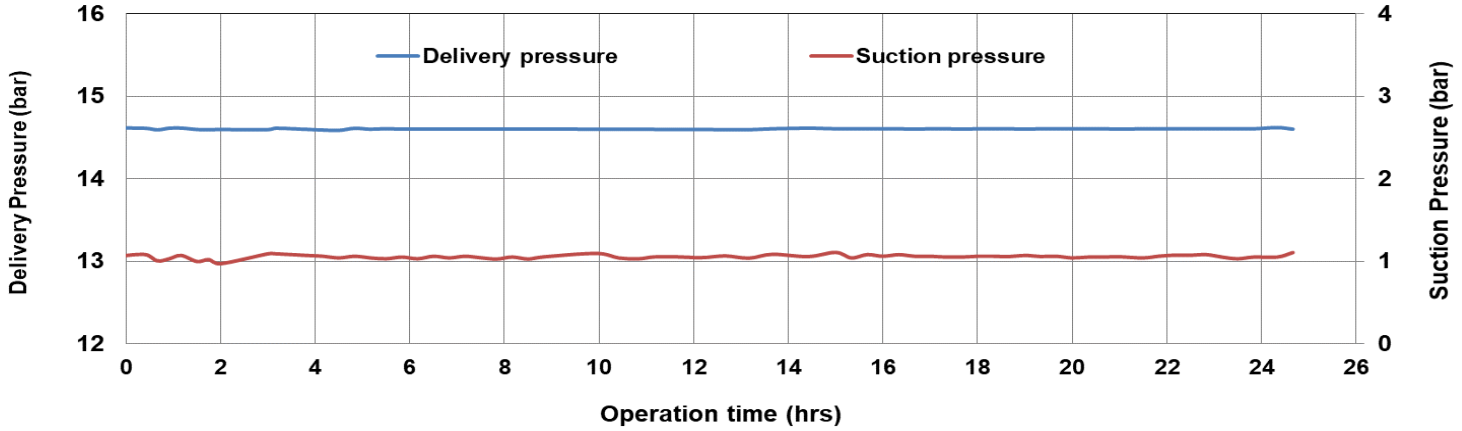
Compressor System for Helium Refrigerator/Liquefier Plant @ IPR

IPR has successfully developed an industrial scale helium compressor, a critical component in the ongoing indigenous development of a helium refrigerator/liquefier (HRL) plant at IPR. This has been achieved by modifying an industry-scale air compressor, which is the first instance in India. This is a part of the currently ongoing project of development of HRL plant at IPR. In such plants, two major systems are involved ; the cold box which contains the cold components and the compressor system which provides pure and pressurized (~14 bar) helium gas at about room temperature to the cold box for production of liquid helium at 4.5 K (-268.65^{0}C). The most difficult gas to liquefy is helium. More than 90% of this helium gas returns back to suction of compressor system at little higher than atmospheric pressure (~1.05 bar) at around room temperature. Thus, helium is circulated in a closed loop. The compressor systems required for HRL plant are oil injected screw compressor type. This type of air compressors are also used where medium pressure and high air flow rates are required.

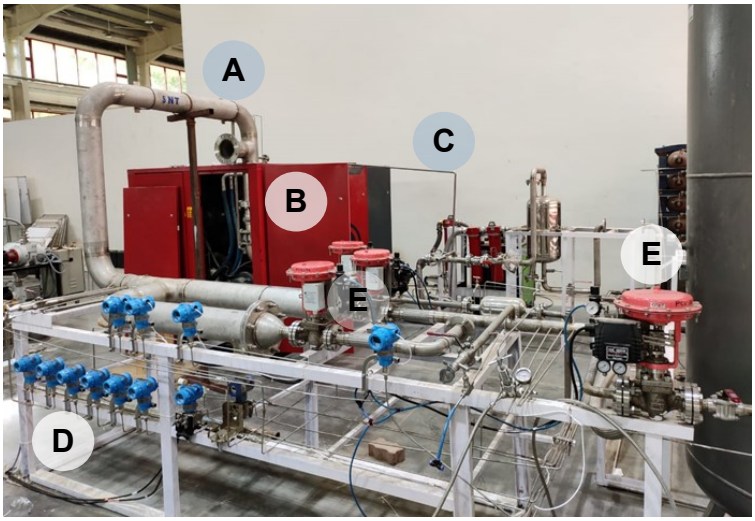
For making helium compressor, a commercial air compressor was procured from local market and then modified. Compared to air compressor, compressor of HRL plant involves significant critical design aspects, like; the oil content in the delivery helium should be few tens of PPB (parts per billion), the system should be able to operate continuously for a few days (few weeks in some cases), should have high helium leak tightness, closed-loop operation with controlled start-up and shut down. All the above design aspects have been implemented indigenously. The cost of a commercially available helium CORS of similar capacity is currently ~ Rs.4 crores, while the one indigenously developed by IPR costs ~ Rs. 60 lakhs. This system is currently being operated in semi-automatic mode and the LCPC (Large Cryogenic Plant and Cryo-system) division Is working towards making it fully automatic. The delivery pressure remained nearly constant (14.6 bar) during a 24 hour operation even when the suction pressure was intentionally varied.

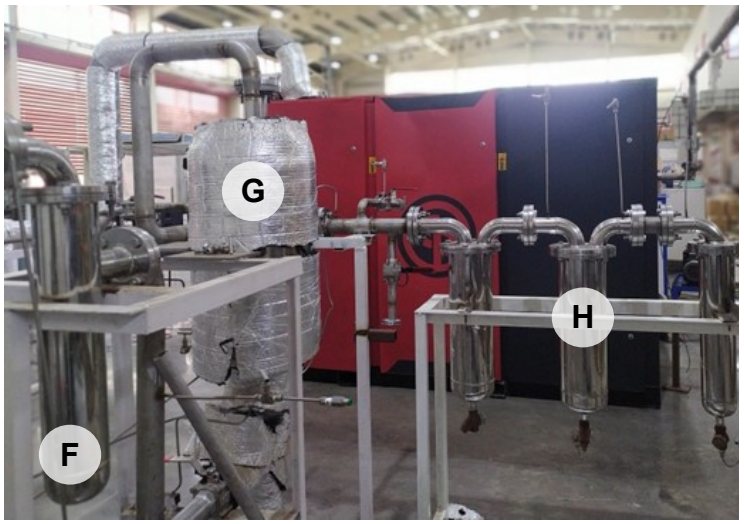
Compressor System for Helium Refrigerator/Liquefier Plant at IPR

Features	Tested values	Features	Tested values
Helium flow rate	60 g/s	Oil content in the delivery gas	~50 PPB
Delivery pressure	14.5 bar	Helium flow rate at suction	760 m^3 per hour
Suction pressure	1.07 bar	Helium leak tightness	0.04 m^3 per day
Electrical power consumption	177 kW	Cooling provision	Ambient air, no water-cooling

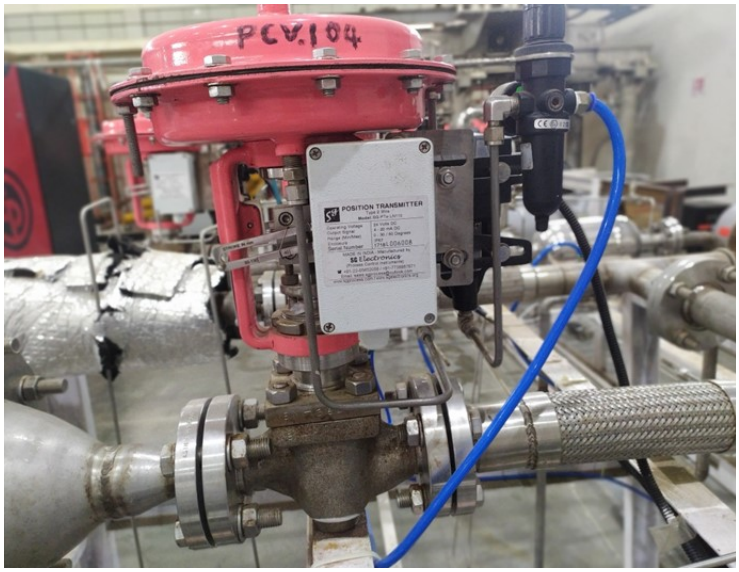


The variation of the delivery and suction pressure over a 24 hour testing period





(Left) Helium compressor system (**A**) Suction line (**B**) Enclosed compressor (**C**) Discharge pipe line (**D**) Pressure monitors (**E**) Pressure control valves (Right) Secondary oil removal system (**F**) 20μ SS filter (**G**) Oil adsorption purifier (**H**) Triple coalescers for oil removal.

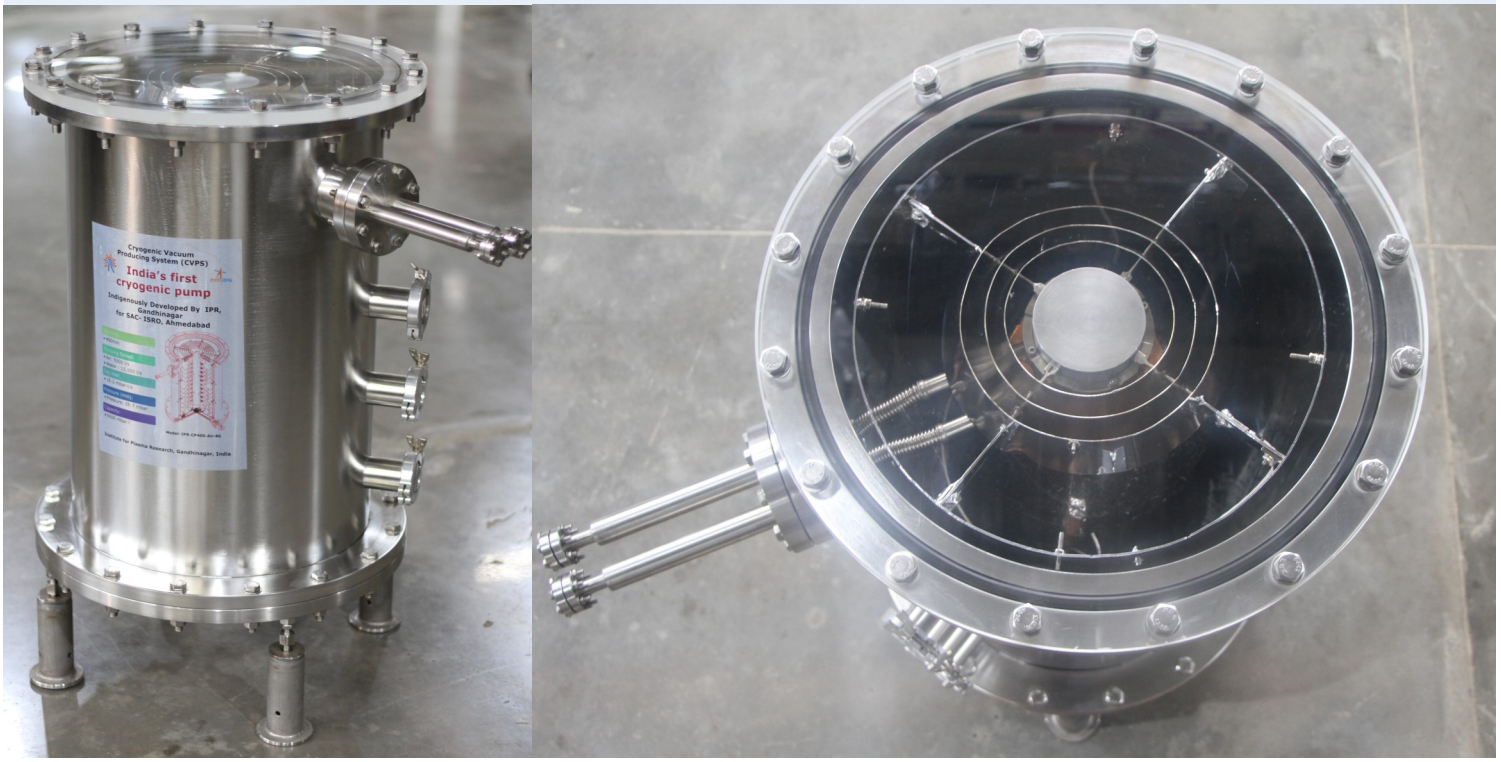


Indigenously developed (L) Oil content measuring instrument capable of PPB levels and (R) Pressure control valve for helium service with high leak tightness

Indigenously Developed Cryo-Pump by IPR Installed at SAC, ISRO, Ahmedabad

Institute for Plasma Research has developed cryopumps using indigenous technology. The concept, materials used, design and fabrication involved and its successful testing had a theme of “Make in India” concept. Cryogenic vacuum producing system (CVPS) with openings of 300 mm and 400 mm have been developed for various applications. It is based on the principle of physiosorption. The novelty of the pump is that it pumps nitrogen at liquid nitrogen temperature, it has no moving parts, thus no wear and tear and hence minimum maintenance requirement. It also does not require any electrical power for operation.

Apart from fusion, CVPS is extremely useful to evacuate the nitrogen and water vapor gas loads in space simulation chambers, which are meant to test the space-vacuum compatibility of all the components that go into making a satellite. In this connection, IPR and SAC ISRO Ahmedabad signed an MOU on 1st Sept 2017. The work plan document focused on delivering three cryopumps made by IPR to SAC. The first prototype cryo-pump of 400 mm opening with cryo temperature provided by cylindrical bath at its center with cryo-panels attached to it, which provides pumping speeds of ~ 5000 *l/s* for Air/N2 (at liquid nitrogen temperature) and a pumping capacity of ~6000 *mbar*-l, was delivered to SAC, Ahmedabad on 13th July, 2020 and was subsequently installed on one of their Cryovac chambers.

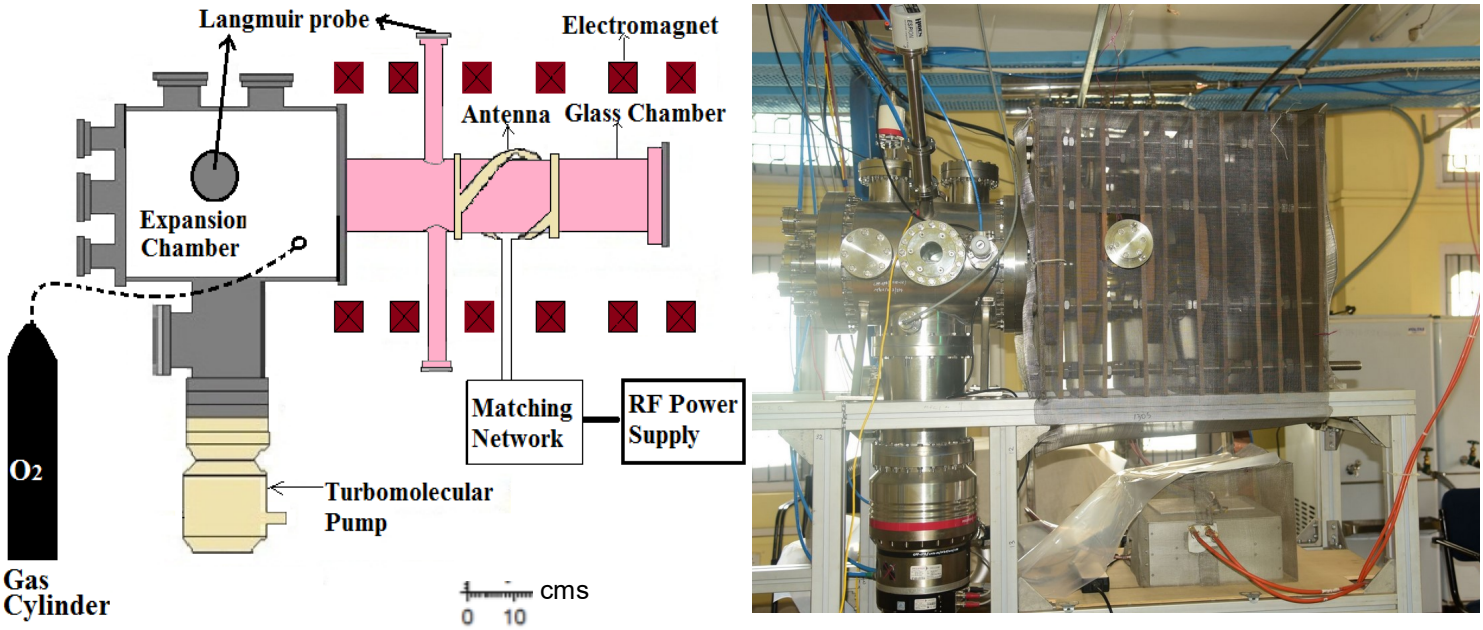


Front and Top views of one of the cryo-pumps with 400mm opening that was delivered to SAC-ISRO

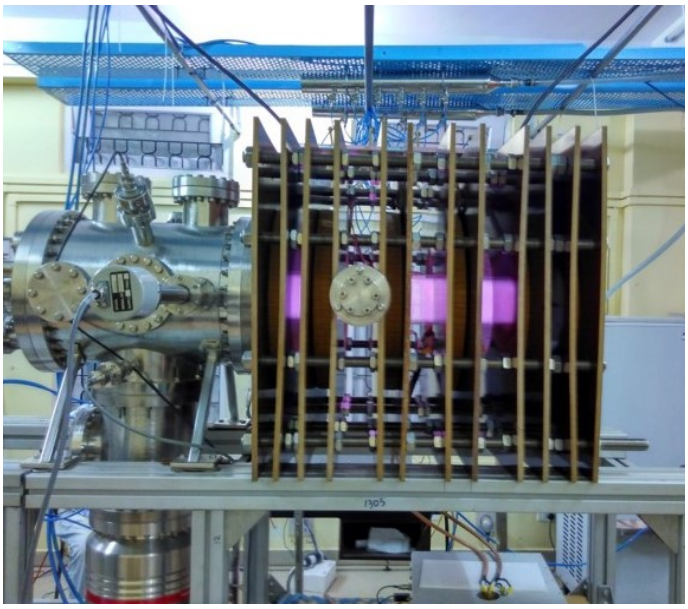
Teams from SAC-ISRO and IPR during the performance test of the Cryo-pump

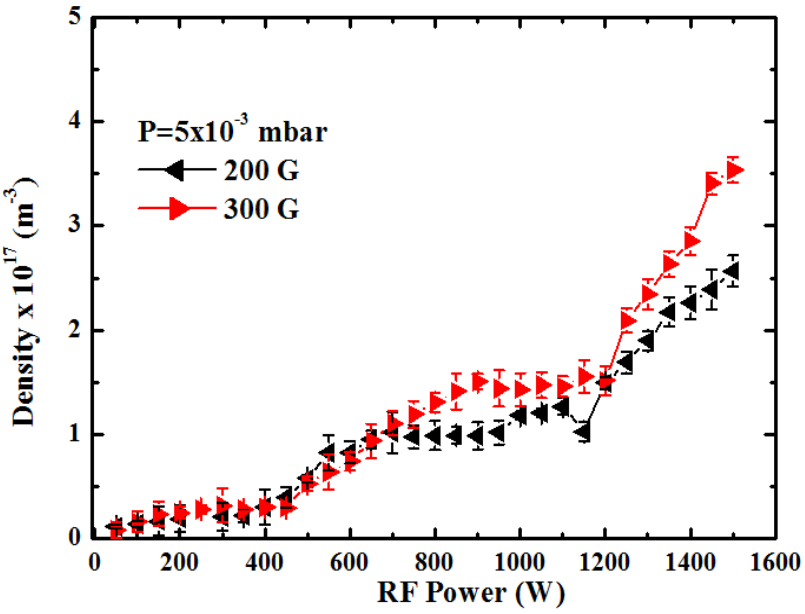
Helicon Mode Transition in Oxygen Plasma in HeliPS @ CPP-IPR

The Helicon Plasma Source (HeliPS) Laboratory at CPP-IPR is actively engaged in performing experiments in various gases such as Argon, Oxygen, Hydrogen etc. In an experimental work performed in a 13.56 MHz RF source and published in IOP Publishing's journal Plasma Research Express, 2 (2020) 015005, titled “Discharge properties of helicon oxygen plasma in the source and expansion chambers”, we presented the detailed report of transition from capacitive (E) to inductive (H) and finally to helicon (W) mode for Oxygen discharge in this set-up. Literature survey indicates this to be the first detailed report of helicon mode transition in Oxygen discharge. Mode transitions were also confirmed by studying the radial density profile and by external matching circuit parameters measurement.



(L) Schematic of the HeliPS system (R) Image of the system.





(L) Plasma inside the glass chamber of the HeliPS system (R) The mode transition profile in the system.

Follow Steps

STOP CORONAVIRUS

Stay Safe

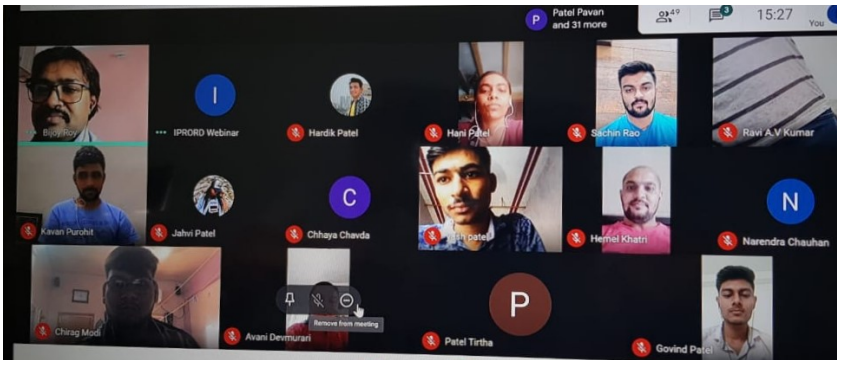
Wash your hands frequently with soap
Maintain social distancing
Avoid touching your eyes, nose and mouth
Practice respiratory hygiene
If you have fever, cough and difficulty in breathing, seek medical care early
Stay informed and follow advice given by your healthcare provider

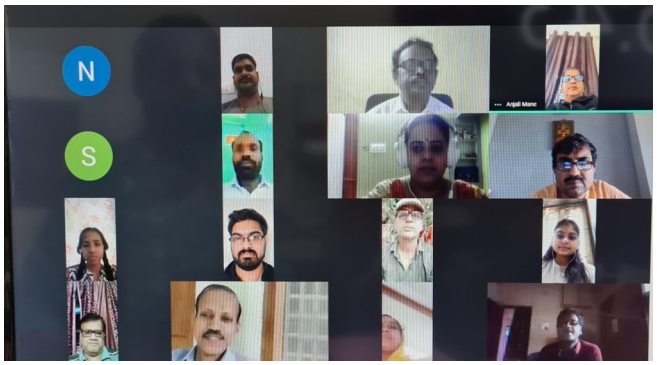
Download and use “Arogya Setu” app of the Government of India to fight the Covid-19 pandemic.

Outreach webinar programmes conducted during the month of August 2020

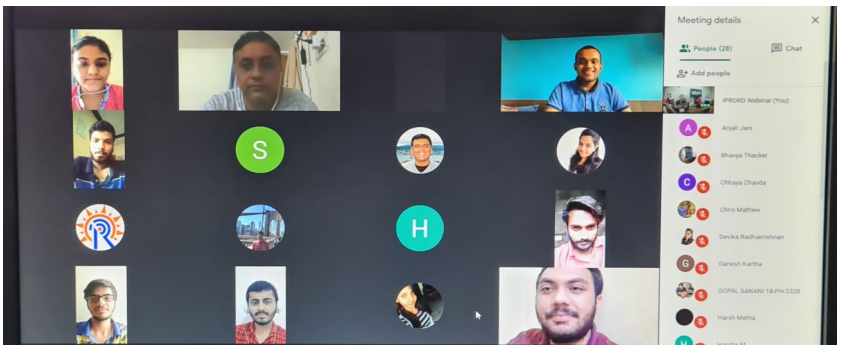
Apart from webinars for students of educational institutions, due to popular demand, IPR Outreach conducted the first webinar for teachers, students and general public, and due to the overwhelming response, it is decided that such a webinar programme for general public will be organized once a month.

Date	Institution	Programme	Participants
30-31 Jul, 2020	Ganpat University, Mehsana	2-Day webinar on plasma & its applications	54 students of BSc/MSc Physics students and 6 faculty members
6-7 Aug, 2020	MG Science Institute, Ahmedabad	2-Day webinar on plasma & its applications	49 students of BSc Physics students and 2 faculty members
13-14 Aug, 2020	St. Xavier's College, Ahmedabad	2-Day webinar on plasma & its applications	36 students of BSc Physics students and 1 faculty member
19-Aug, 2020	General Participants	1-day (4 hours) webinar on plasma & its applications	31 school / college teachers, students and general public

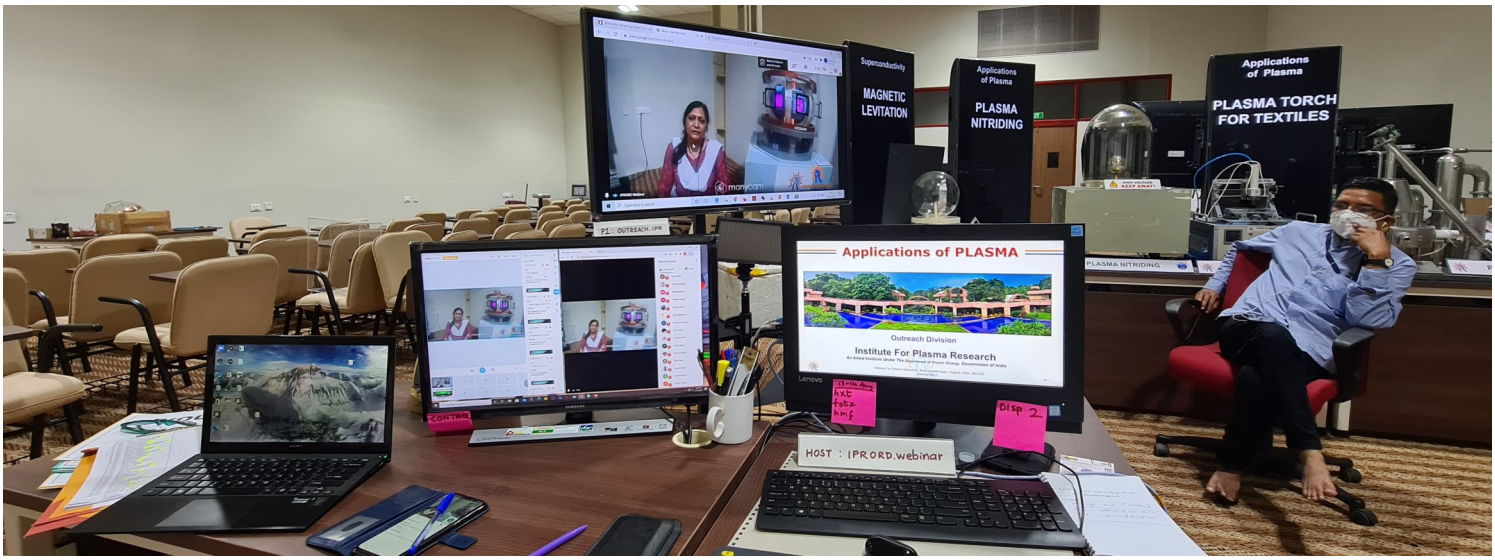




Images from the webinar organized by Outreach Division for (L) Ganpat University (R) General Participants



(L) Participants from St. Xaviers' College Ahmedabad (R) Demonstration of plasma based experiments during the webinar



The webinar session in progress

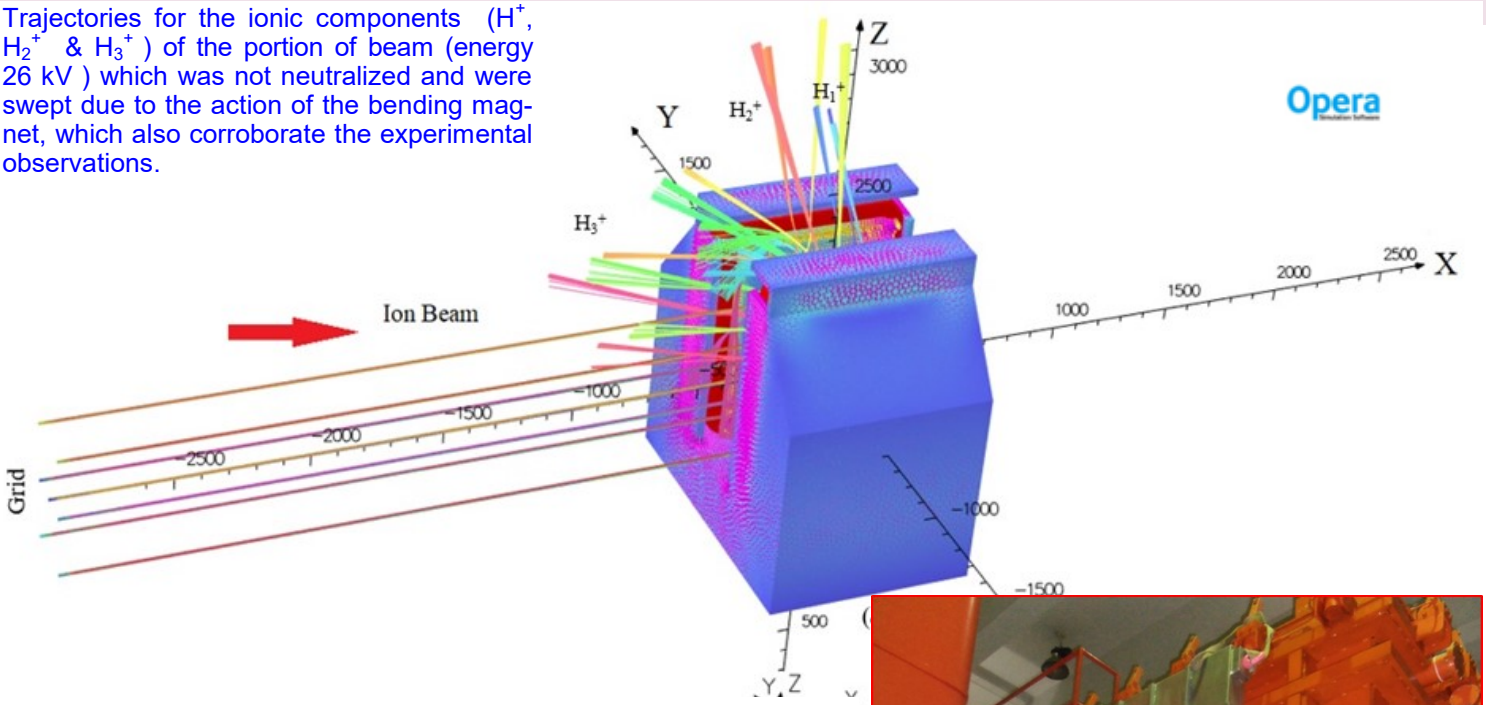
Experiments on Long Pulse Operation of the +ve Ion Source in the SST-NBI Test Stand

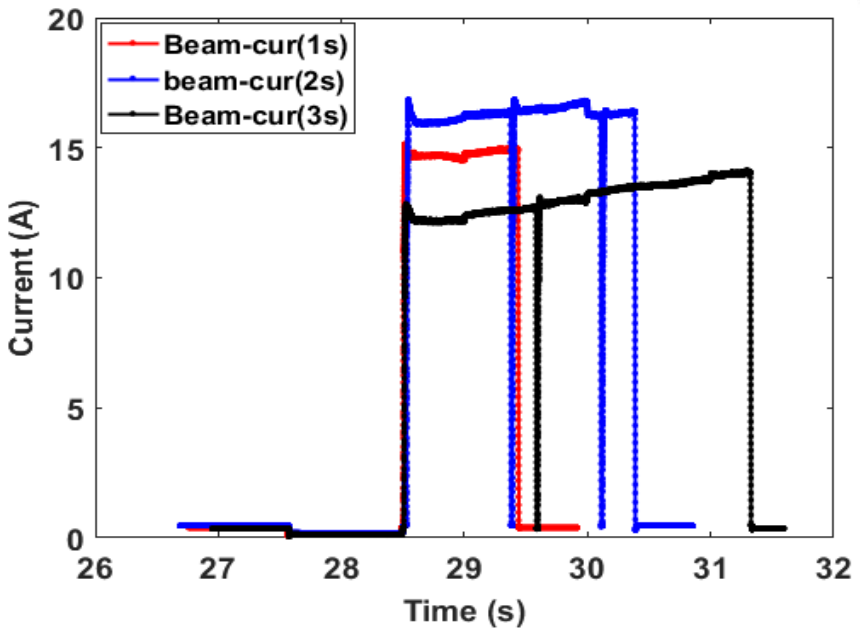
A neutral beam system for producing hydrogen ion beam current up to 90 A at energy of 55 keV was designed and developed at IPR. The system was designed to deliver 1.7 MW neutral beam power to SST-1 tokamak for the purpose of providing auxiliary heating and current drive to the plasma of the SST-1 tokamak. The Test Stand for the (positive) Neutral Beam Injector (NBI) system was established to commission the NBI system on test mode and fully characterize along with all subsystems before integration with SST-1. The test stand comprises of (a) The positive hydrogen ion source, (b) The filament & arc power supplies for production of the plasma in ion source (c) The regulated high voltage power supply (RHVPS) system, and controls required for extraction-acceleration of ion beam, (d) The liquid helium cryo-condensation pumps required for handling large amount of H_2 or D_2 gas, (e) heat transfer elements for removing heat produced by beam during its transmission from source to plasma, (f) a large bending magnet for removing the un-neutralized beam particles and (g) diagnostic systems for monitoring the performance of neutral beam.

The system achieved operation up to 18 A/38 kV of Hydrogen ion beam. However, for all these experiments, where increasing the beam current/ acceleration voltage being the primary goals, the time duration (pulse) of beam operation were restricted to a maximum of 1 second. As a result of the recent experimental campaign, consistent long pulses of duration extending to 3 seconds were achieved, combined with further improvement in beam energy up to 40 keV and ion current up to 20 A. Long duration pulses is significant because it enables a precise observation of the beam's characteristics.

Significant improvement has also been achieved in the signal-to-noise ratio of the thermal diagnostics thereby improving the accuracy for the beam's calorimetric measurements. Apart from this, the NBI group successfully characterized the action of the bending magnet on the ionic components (H^+, H_2^+ & H_3^+) of the beam, which helped in recording the magnet's characteristic performance. An attempt to simulate the action of bending magnet was carried out by the software OPERA. Presently, the group is making efforts to resume the operation of the cryo-condensation pumps which is necessary for making a further improvement in the output beam current.

Trajectories for the ionic components (H^+, H_2^+ & H_3^+) of the portion of beam (energy 26 kV) which was not neutralized and were swept due to the action of the bending magnet, which also corroborate the experimental observations.





(L) Extracted beam current variation during long pulses (R) The hydrogen positive ion source on the SST-1 NBI test stand.

Completion of Manufacturing of ITER In-Wall Shielding Assembly

ITER-India achieved a major milestone related to the completion of manufacturing of the one of the nine procurement packages in active collaboration with M/s Avasarala Technologies, Bengaluru. The package termed as “in-wall shields” is a complex assembly of ~9000 borated steel blocks. The supplied shields are sandwiched between the double walls of the vacuum vessel of the ITER machine and perform the important function of shielding the components from neutrons and contribute to plasma performance by limiting perturbations due to toroidal field ripple.

This is the third milestone achievement by India in a short span of less than year and speaks volumes of the dedication and devotion of all involved in spite of the existing pandemic conditions. The previous two milestones related to the handing over of the base section of the cryostat to ITER and its subsequent installation in the tokamak pit at ITER and the flag off of the final top lid segments of the cryostat from the premises of the M/s L&T Hazira. All components delivered to ITER meet the desired standards of safety and quality as per requirements defined by the French Nuclear Regulators. Indigenous development demonstrated the ever growing self-reliance related to the development of fusion technologies within the country for which both the industry and the scientists and engineers of ITER India, Institute for Plasma Research deserve an applause.

In this context, a video televised ceremony was organized. Speakers on the occasion included eminent scientist Dr. Anil Kakodkar, as the chief guest, Dr Bernard Bigot, Director general ITER organization, Dr. R.B. Grover. Shri K.N. Vyas, Chairman, Atomic Energy Commission conveyed his congratulatory message through Dr. Shashank Chaturvedi, Director IPR.

ITER is currently under construction in south of France at a nuclear site Cadarache is aimed at exploring and demonstrating a clean green economically viable alternate source of energy through nuclear fusion. The assembly activities are in full swing and the first plasma is expected in December 2025.

The video-telecon ceremony (L-R) The ATL team, Dr. Shashank Chaturvedi (Director, IPR) delivering the address on behalf of Shri. K.N. Vyas, Chairman Atomic Energy Commission; Dr. Bernard Bigot (Director General, ITER-IO); Chief Guest of the function, Dr. Anil Kakodkar, Member, Atomic Energy Commission and Ex-Chairman, Atomic Energy Commission.

(L) 3D CAD model of the In-Wall Shield assembly; (M) The manufactured borated steel plate assemblies at M/s Avasarala, Bengaluru and (R) assembled in vessel sectors for ITER manufactured in Korea

The final consignment of in-wall shields leaving the premises of M/s ATL, Bengaluru for ITER, France on 24th July, 2020

Past Events @ IPR & Webinars Talks

- ***Ms. Devshree Mandal*** gave a Webinar talk on "*Spontaneous Generation of Magnetic Dipole Structures in Overdense Plasma*" at the 15th Kudowa Summer School "Towards fusion energy", Virtual Edition, Institute of Plasma Physics and Laser Microfusion, Poland, 29 June - 3 July 2020
- ***Ms. Ayushi Vashistha*** gave a Webinar talk on "*Absorption of Laser Energy by Generation of an Electrostatic Mode in Plasma" at the 15th Kudowa Summer School "Towards fusion energy*", Virtual Edition, Institute of Plasma Physics and Laser Microfusion, Poland, 29 June - 3 July 2020
- ***Dr. Mariammal Megalingam,*** Vellore Institute of technology, Chennai, gave a talk on "*An Experimental Investigation of Oscillating Plasma bubbles and its Nonlinear Structure (evolution and effects) in a Magnetized Plasma System*" on 24th July 2020
- ***Dr. S.R. Mohanty*** gave a Webinar talk on "*Research Challenges and Mental Health of Researchers during COVID-19 Pandemic*" organized by Central Institute of Technology Kokrajhar (Deemed to be University), Assam in Collaboration with Rajeev Gandhi Memorial College of Engineering and Technology (Autonomous), Nandyal, Andhra Pradesh, 26 July 2020
- ***Dr. Mithun Karmakar,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Excitation of plasma wakefields by intense ultra-relativistic proton beam*" on 29th July 2020
- ***Dr. Rudrashish Panda,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Pulsed laser deposition of functional materials using high power lasers for photonics and industrial applications*" on 29th July 2020
- ***Dr. Avijit Dewasi,*** Indian Institute of Technology, Roorkee, gave a talk on "*UV-Visible Photodetection Properties of Pulsed Laser Deposited TiO_2 and Nb:TiO_2 Thin Films Grown on Si Substrate*" on 3rd August 2020
- ***Dr. Mahesh Saini,*** Institute of Physics, Bhubaneswar, gave a talk on "*Nanoscale functionalization of ion-beam fabricated ripples and facets*" on 11th August 2020
- ***Dr. Rohan Dutta,*** Indian Institute of Technology Kharagpur, gave a talk on "*Cryogenic Processes for Sustainable Power Generation and Energy Storage Systems*" on 18th August 2020
- ***Ms. Priti Kanth,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Nuclear Activation Studies in Fusion Systems: New Methods and Algorithms*" on 20th August 2020
- ***Mr. Dheeraj Sharma,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Determination of Residual Stresses in Ceramic-Metal Brazed Joint Using FEA and Experimental Validation of the Results*" on 21st August 2020
- **Mr. Rajiv Sharma,** Institute for Plasma Research, Gandhinagar, gave a webinar talk on "Structural Analysis, Design and Implementation of Safety Access to High Pressure Helium Gas Storage Vessels at IPR in the International Conference on Recent Advances in Mechanical Infrastructure (ICRAM-2020) at IITRAM, Ahmedabad during 22-23 August 2020
- ***Dr. Abhinav Kumar,*** Lovely Professional University, Punjab, gave a talk on "Mechanical, Electrical, Magnetic and Thermal Analysis on High Temperature Superconducting Magnet used for Power Grid Applications" on 25th August 2020

Upcoming Events

- International e-Conference on Plasma Theory and Simulations (PTS-2020), Bilaspur, 14-15 September 2020. https://forms.gle/VxunyzuEwDSKNMiQ6
- 31st Symposium on Fusion Technology (SOFT2020), Virtual Edition, 20-25 September 2020. https://soft2020.eu/
- 7th International Congress on Energy Fluxes and Radiation Effects (EFRE 2020), Tomsk, Russia, 20-26 September 2020. http://efre2020.hcei.tsc.ru/
- Karlsruhe International School on Fusion Technologies, Online Version, 30 September-08 October 2020. http://summerschool.fusion.kit.edu/index.php

Know Your Colleague

Mr. Hiteshkumar Mandaliya joined IPR in June 2006 and is currently working as Scientific Officer –E in the Electronics and Instrumentation Division. Before joining IPR, he had worked as Project Engineer at PRL for CHANDRAYAN-1 satellite payloads development. He had obtained his B.E. and M.E degrees in Electronics and Communication engineering before joining IPR. His area of interest is digital logic design for Digital Signal Processing and Data Acquisition. He is proficient in mixed signal circuit design and writing embedded C/VHDL firmware. Some of his contributions to IPR are SST-1 Diagnostics electronics monitoring software in LabVIEW, Aditya SBC-64 channel data acquisition system, Infrared camera electronics developments etc. He was deputed to ITER from 2015 to 2019, and he contributed for Tokamak Cooling Water System I&C design involving more than 5000 sensors and actuators. He took initiative to develop in-house the CODAC/PLC code for secondary cooling water system software at ITER which saved ITER more than 1 Million Euro. His work was recognized by ITER and he was awarded for this contribution.

The IPR Newsletter Team

Ritesh Srivastava	Tejas Parekh	Ravi A. V. Kumar	Priyanka Patel	Dharmesh P	Mohandas K.K.	Supriya R
Suryakant Gupta	Ramasubramanian N.	Chhaya Chavda	Shravan Kumar	B. J. Saikia	Harsha Machchhar	

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

प्लाज़्मा अनुसंधान संस्थान
Institute for Plasma Research

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