

Issue 091

February 2021

# The 4<sup>th</sup> State

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



## 72<sup>nd</sup> Republic Day @ IPR

The **72<sup>nd</sup> Republic day** was celebrated at IPR by hoisting the national tricolour at the IPR main campus 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, the director delivered a speech which briefly described the scientific / technical / social outreach achievements & contributions by institute in this year. Due to COVID-19 pandemic, IPR Staff Club did not organise any culture/ recreation/ seminar/ sports activities in IPR campus. The event ended with tea and coffee for IPR staff and their family members who attended the function.



Images from the Republic day flag hoisting ceremony at the IPR main campus



The 72nd Republic Day at CPP-IPR was celebrated with the unfurling of the national tricolor by Dr. S. R. Mohanty, Associate Prof. F. in the presence of select staff members and the security personnel. Due to the Covid-19 pandemic situation, other programmes were not organized.



Images from the Republic day flag hoisting ceremony at CPP-IPR campus

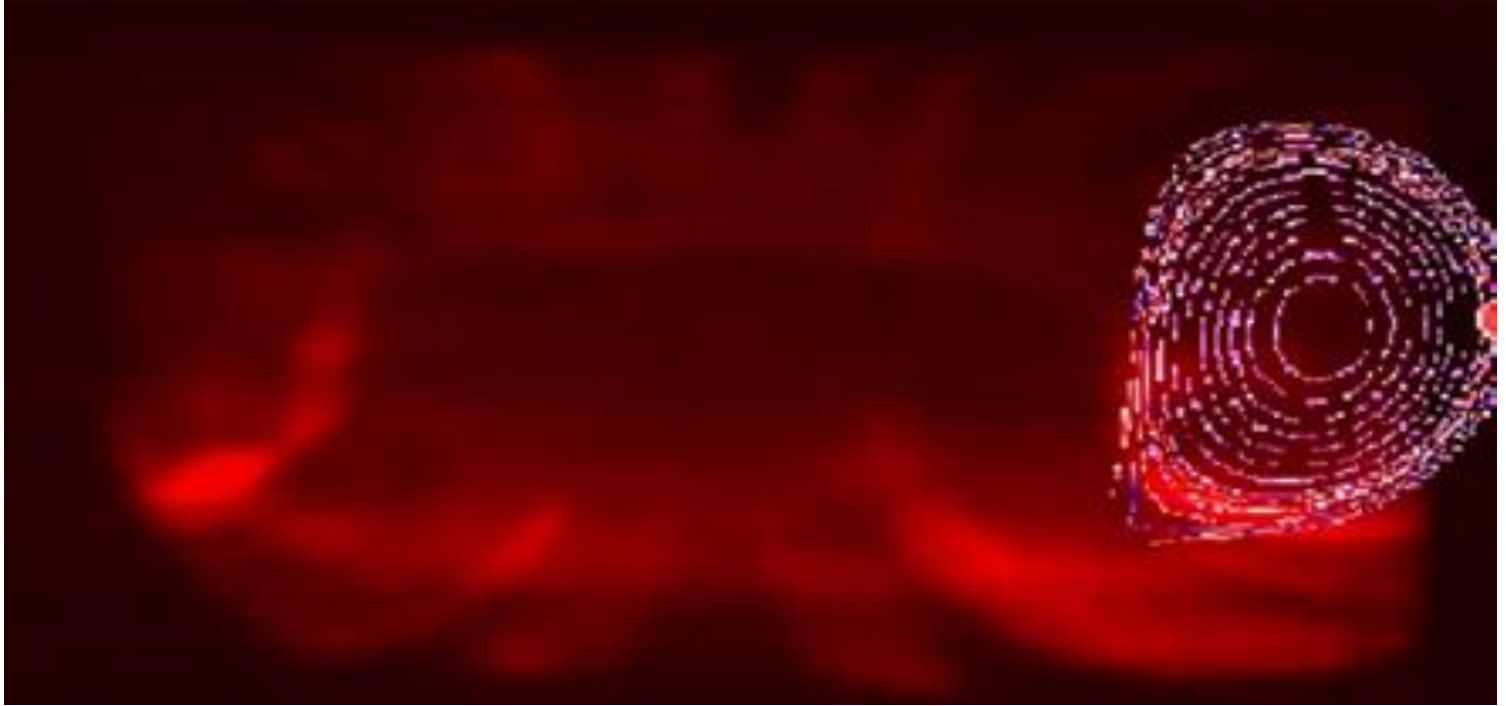
### विश्व हिंदी दिवस समारोह 2021

विश्व हिंदी दिवस के उपलक्ष्य में 11 जनवरी 2021 को तकनीकी व्याख्यान का ऑनलाइन माध्यम से आयोजन किया गया। इस अवसर पर यू आर राव उपग्रह केन्द्र बैंगलोर के उत्कृष्ट वैज्ञानिक डॉ. आलोक श्रीवास्तव को 'मंगल यात्रा वृत्तांत - इसरी: कल, आज और कल' विषय पर हिंदी में व्याख्यान देने हेतु आमंत्रित किया गया। कार्यक्रम के प्रारंभ में डॉ. प्रवीण कुमार आत्रेय, डीन आर एंड डी ने डॉ. आलोक श्रीवास्तव की परिचय दिया। इसके पश्चात् डॉ. आलोक ने अपने वक्तव्य में मंगल अभियान पर प्रकाश डालते हुए मंगल यात्रा की जटिलता, पृथ्वी और मंगल के वातावरण व वायुमंडल की तुलना, मंगल ग्रह के जल सिद्धांत, वहाँ पर खनिजों की उपस्थिति, मंगल ग्रह पर जीवन की खोज आदि पर विस्तारपूर्वक एवं रोचक जानकारी सभी श्रोताओं को उपलब्ध कराई। चित्रों एवं विडियो के साथ इन जानकारियों को साझा करते हुए बहुत ही सरल और स्पष्ट हिंदी भाषा में उन्होंने इस महत्वपूर्ण तकनीकी विषय को रोचकता से समझाया। सभी श्रोताओं के लिए मंगल की यात्रा करना वाकई में एक नया अनुभव रहा।

अंत में श्री राज सिंह, उपाध्यक्ष, राजभाषा कार्यान्वयन समिति द्वारा सभी को धन्यवाद देने से साथ यह कार्यक्रम समाप्त हुआ।



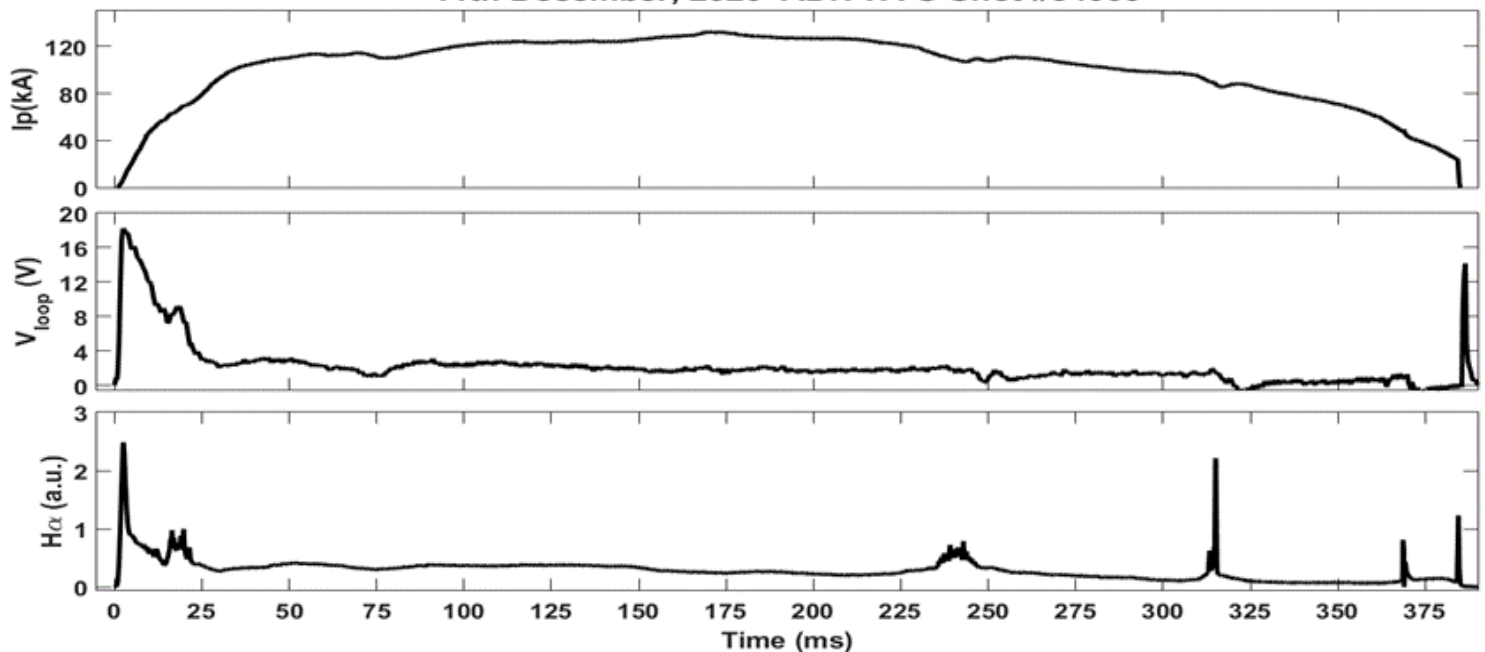
डॉ. आलोक श्रीवास्तव के व्याख्यान के दौरान साझा किये गये चित्र | इनसेट : डॉ. आलोक श्रीवास्तव, उत्कृष्ट वैज्ञानिक, यू आर राव उपग्रह केन्द्र, बैंगलोर



The image of Aditya-Upgrade plasma discharge with divertor coil operation showing strike points on the bottom side

After the Diwali holidays and installation of ICRH transmission line, ADITYA-U resumed operations from 24<sup>th</sup> November, 2020 and continued till 18<sup>th</sup> December, 2020. Almost 227 discharges were obtained with varied toroidal magnetic field ( $B_\phi$ ) from 0.9 Tesla to 1.07 Tesla. The extensive wall conditioning with Hydrogen GDC as well as combination of Argon + Hydrogen GDC showed substantial reduction in various impurities mass species like  $H_2$ ,  $O_2$ ,  $CO$ ,  $N_2$ ,  $CH_4$  and reduction in Hydrogen recycling. The real-time horizontal plasma position control was operational throughout the operation. The longest ever ADITYA-U discharge of  $\sim 386$  ms with  $\sim 134$  kA of peak plasma current (Shot #34009) has been achieved by using 70% of available Volt-Sec at  $\sim 19$  V of peak loop voltage. The discharge was obtained at toroidal field of  $\sim 1.07$  Tesla and in absence of any strong pre-ionization.

11th December, 2020 ADITYA-U Shot #34009



The plasma discharge with long duration of  $\sim 386$  ms in the Aditya-Upgrade Tokamak

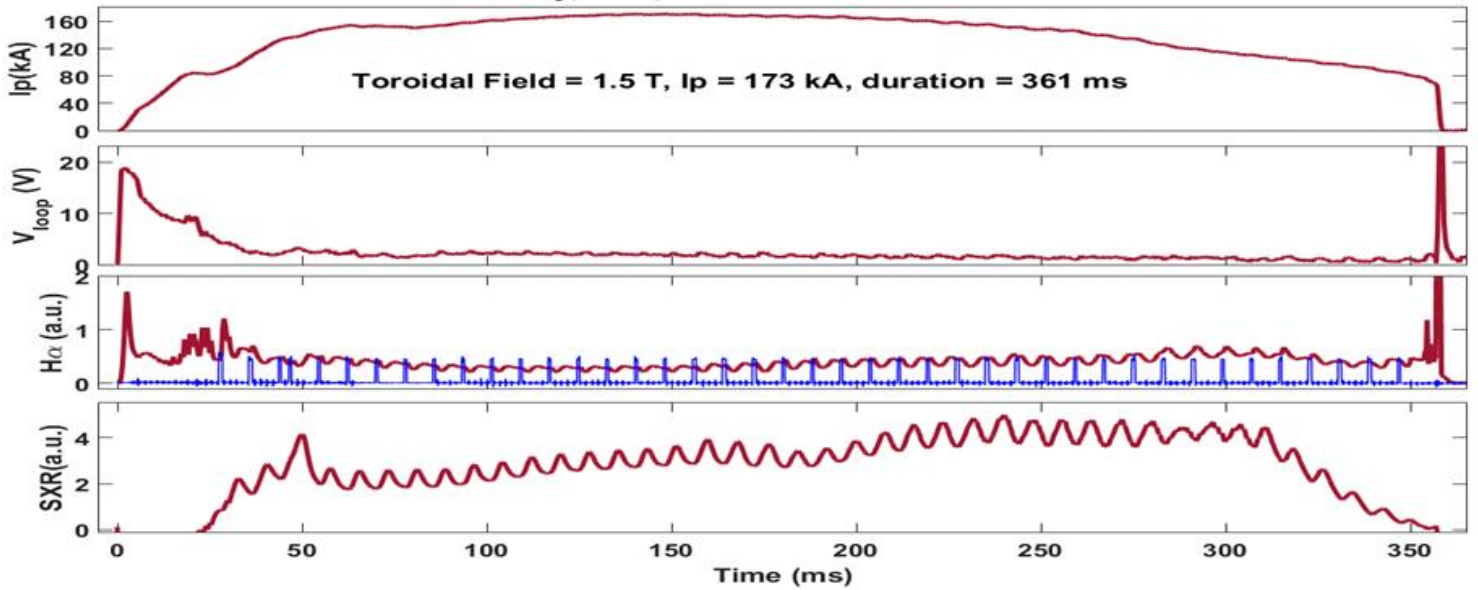
Further, after installation of new auxiliary transformer by APPS Division, ADITYA-U operation resumed from 4<sup>th</sup> January, 2021. ADITYA-U operation was planned for ECRH experiments with two pulse operation (one for low loop voltage start-up and other one for ECR heating simultaneously) in a single shot.

The ECRH group plans for 42 GHz fundamental harmonic ECRH experiment with  $\sim 1.5$  Tesla toroidal magnetic field at the plasma centre. The ADITYA-U Operations Division (AOD) has systematically raised the toroidal magnetic field in steps starting from 1.07 T to 1.28 T to 1.36 T to 1.44 T to finally 1.5 T.



For the first-time, AOD has successfully demonstrated the 1.5 T toroidal field operation (100% design parameter of toroidal field) and achieved ~ 173 kA of peak plasma current with a discharge duration~ 361 ms (Shot #34167).

20th January, 2020, ADITYA UPGRADE SHOT # 34167

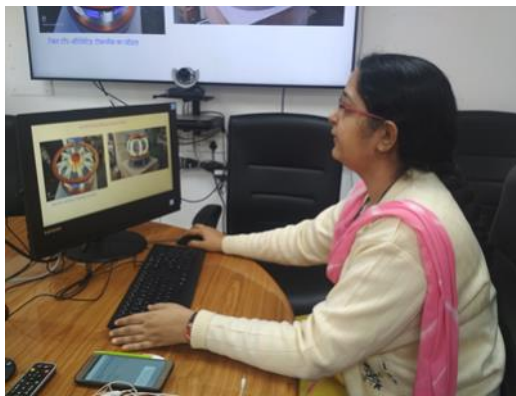


. The time evolution of ADITYA-U shot (#34167) demonstrating 1.5 T toroidal field operation.

## “आत्मनिर्भर भारत की उड़ान-विज्ञान एवं तकनीकी का योगदान” – वेब संगोष्ठी में आईपीआर की प्रतिभागिता

IGCAR, कलपाकम द्वारा 11-12 जनवरी, 2021 को ‘आत्मनिर्भर भारत की उड़ान-विज्ञान एवं तकनीकी का योगदान’ विषय पर अखिल भारतीय हिंदी वेब संगोष्ठी का आयोजन किया गया। इस वेब संगोष्ठी में परमाणु ऊर्जा विभाग की विभिन्न इकाईयों/उपक्रमों/संगठनों के प्रतिनिधियों ने भाग लिया। इस द्वि-दिवसीय वेब-संगोष्ठी के दौरान ‘आत्मनिर्भर भारत की उड़ान- विज्ञान एवं तकनीकी का योगदान’ शीर्षक के अंतर्गत विभिन्न विषयों पर 2 आमंत्रित एवं लगभग 26 मौखिक प्रस्तुतियाँ हुईं। आईपीआर की ओर से इस वेब संगोष्ठी में तीन वैज्ञानिक अधिकारियों ने भाग लिया एवं विभिन्न विषयों पर प्रस्तुतिकरण दिये।

- “आत्मनिर्भर भारत हेतु प्लाज्मा तकनीक का संभावित योगदान” - डॉ. सूर्यकान्त गुप्ता, वैज्ञानिक अधिकारी-जी
- “क्रायाोजेनिक संयंत्र एवं घटकों का स्वदेशीय विकास - नाभिकीय संलयन द्वारा भविष्य ऊर्जा स्रोत की दिशा में भारत की आत्मनिर्भरता” - श्री राजीव शर्मा, वैज्ञानिक अधिकारी-डी
- “प्लाज्मा के क्षेत्र में भारत की आत्मनिर्भरता” - सुश्री प्रतिभा गुप्ता, वैज्ञानिक अधिकारी-एफ

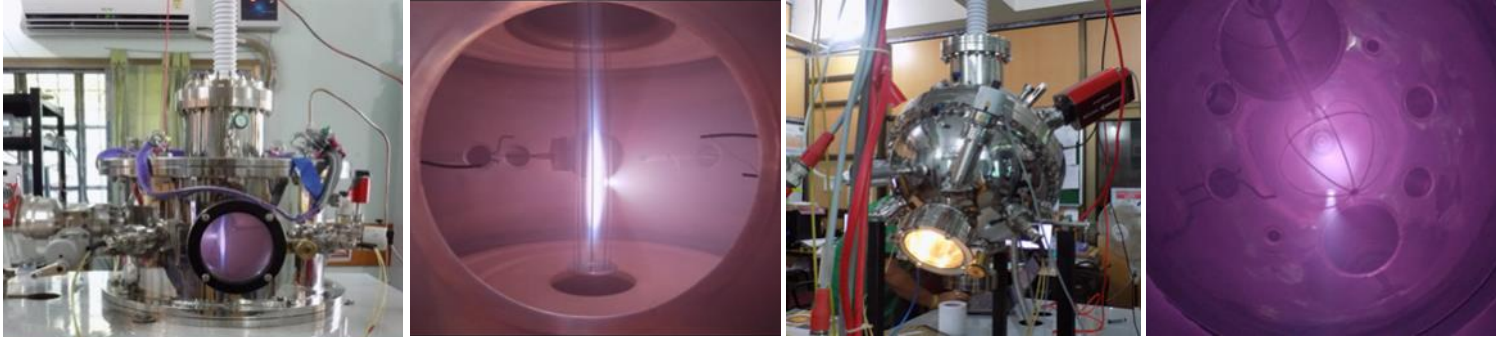


(L) डॉ. राजीव शर्मा, (M) सुश्री प्रतिभा गुप्ता (R) डॉ. सूर्यकान्त गुप्ता, अपने व्याख्यान देते हुए

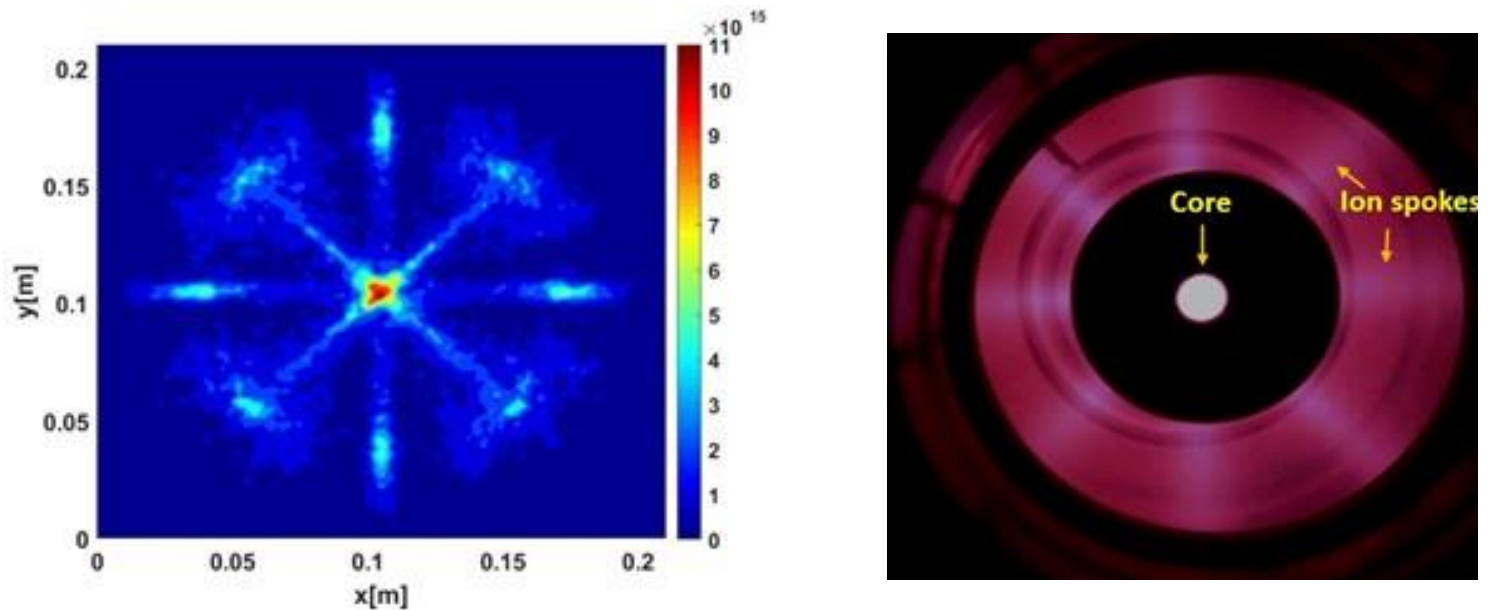


Panoramic view of the “Antya” HPC system in the IPR data center

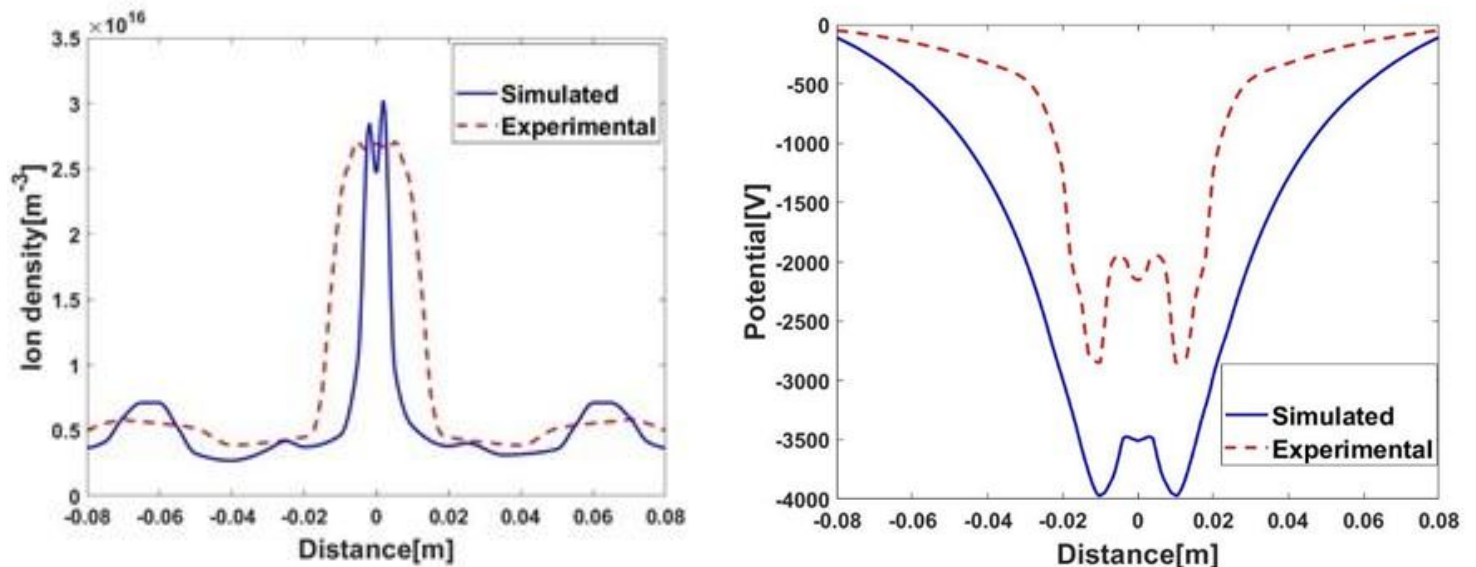
Kinetic simulations have been performed using particle-in-cell method to analyse the behaviour of ions inside a cylindrical inertial electrostatic confinement fusion (IECF) device which is being developed as a table top neutron source at CPP-IPR. The ion recirculation across the gridded cathode, ion density and potential well profiles are investigated in a discharge plasma using XOOPIC (X11- based object-oriented particle-in-cell) code. The simulated results are also compared with the experiment to benchmark the results. The recirculation of the ions can be visualised from the phase space during runtime. The simulation contour plot of ions during -1 kV cathode voltage clearly indicates the signature of recirculating ions across the cathode grid openings. This compares well with the photograph of the actual experiment. Ion spokes or channels can be observed to be coming out from the central core region. Ion density profile was measured along with experimental profile using Langmuir probe, and a maximum ion density is found to be  $\sim 10^{16} \text{ m}^{-3}$  during -5 kV operation. The potential profile indicates the formation of multiple or double well structures during -5 kV cathode voltage operation.



(L) The Cylindrical IEC fusion device and its plasma (R) The spherical ICE fusion device and its plasma at CPP-IPR



(L) Contour plot of ions, (R) actual experimental photograph, showing ion recirculation across the cathode openings.

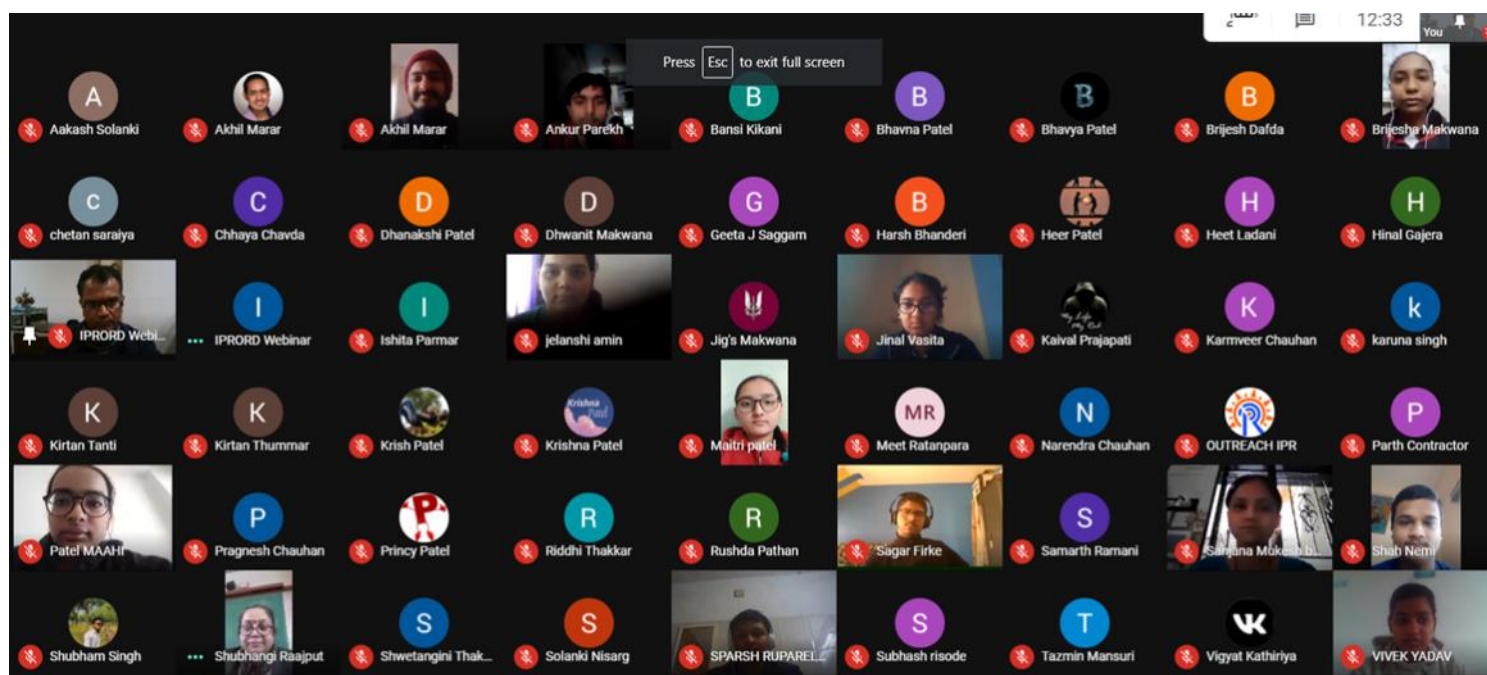
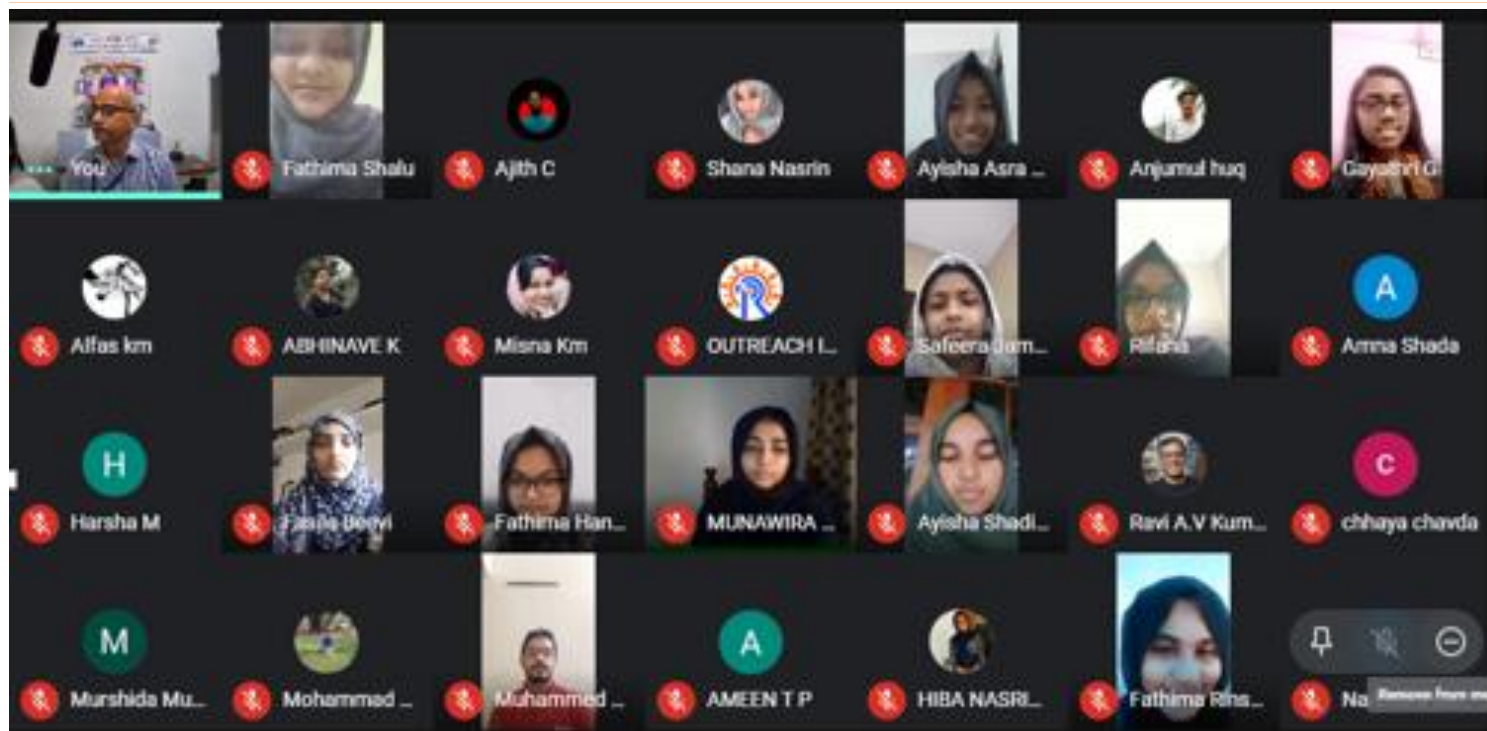


(L) Ion density profile, (R) double potential well structure, during -5 kV cathode voltage operation.



## Outreach webinar programmes conducted during the month of January, 2021

Date	Institution	Programme	Participants
6-Jan-2021	Adani Vidya Mandir-Ahmedabad	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	60 students of 12th standard and one teacher
7-8 Jan, 2021	M A M O College, Manassery, Calicut, Kerala	2-day,4 hour webinar Plasma & its applications for BSc Physics students	35 BSc physics (3rd year) students and 1 teacher
11-12 Jan-2021	KKTM.Govt.College, Pullut, Kerala	2-day,4 hour webinar Plasma & its applications for BSc Physics students	66 BSc physics (3rd year ) students and 1 teacher
13-Jan-2021	Amrita Vidyalayam, Ahmedabad	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	20 students of 12th standard and 2 teachers



Students of (Top) M A M O College, Calicut, Kerala and (Bottom) Adani Vidya Mandir-Ahmedabad attending the webinar.



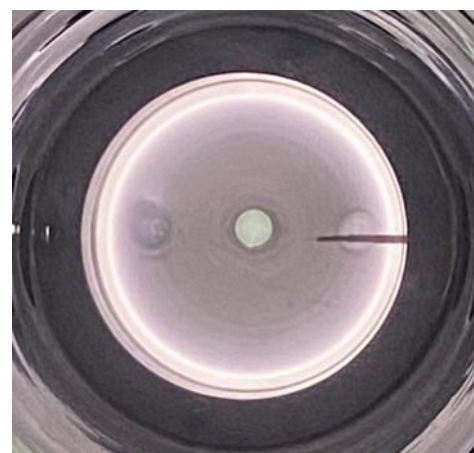
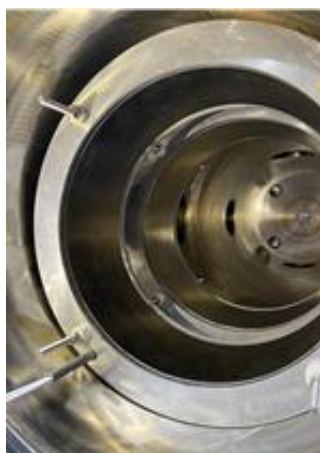
Scientists reckon that plasmas confined by toroidal magnetic field is a viable mechanism to achieve controlled thermonuclear fusion in laboratories from which abundant electricity can be produced. As the ITER fusion device is reaching towards achieving its first plasma, the nation is concurrently building technologies that will be required to indigenize a fusion reactor. From both physics and engineering perspective, the laboratory experiments are highly needed to perfect the underlying technologies, create the absolute knowhow and generate relevant experimental data for benchmarking the modelling results associated with these complex machines.

In the Magnetized Plasma Development Laboratory, a Basic Experimental setup with Axial Magnetic field (BEAM) has been developed in which rigorous experiments are carried out on positive and negative ion beams produced by diverse discharge configurations; with primary focus on their interactions with electrodes in magnetized plasma. The BEAM setup is equipped with a quadrupole mass and energy analyzer system for diagnostics. Using this setup, energy distribution of plasma ions, multi charge ionic species, energetic neutrals that may be generated using different types of plasma sources such as hall thruster, high voltage sputtering magnetron discharge, ion extraction using plasma grids *etc.* can be characterized. The device is also equipped with a suite of indigenously developed electric probe diagnostic system that provide accurate measurement of plasma parameters at various axial and radial location inside the BEAM setup.



The BEAM experimental device

Recent experiments in the BEAM demonstrates a remarkable mechanism of controlling the radial electron temperature and plasma uniformity inside cylindrical plasma column by a combination of external plate biasing and diverging magnetic field. This effect is highly promising for applications in industries, where homogeneous plasma is required for the treatment of large area substrates. The uniform plasma is also required in plasma based ion sources to minimize the beam divergence and spatial energy distribution of ions extracted from the source. Controlling the electron temperature is also important for the production of negative ions. This has been achieved in the BEAM by a suitable combination of electrode geometry and axial magnetic field. Due to high neutralization efficiency, negative ions are used for the neutral beam generation for applications ranging from plasma thruster to neutral beam heating in fusion device, and also for weapons. Presently studies on charge particle transport across magnetic field lines, wake creation in a flowing/ non- flowing magnetized plasma, investigation of radio-frequency magnetized sheaths and plasma surface interactions are some of the work being carried out using this device. In the future, it is planned to install a new set of electro-magnets in the BEAM to achieve peak magnetic field of 300 Gauss. The facility will lay emphasis on development indigenous ion beam sources.



(L) Electrode assembly of Capacitive-Coupled RF discharge (M) Inside view of BEAM setup showing the cylindrical discharge electrodes (R) Ring-shape hot plasma produced by cylindrical RF discharge with axial magnetic field.

- ◆ **Mr. Hitensinh Vaghela**, gave a talk on “Thermal-hydraulic analysis of Cable-In-Conduit Superconductor: A CFD approach” at International Conference on Recent Innovations in Engineering and Technology-2020 (ICRIET-2020), Nandha Engineering College, Erode, on 5th December 2020
- ◆ **Mr. Bharat Singh Rawat**, gave a talk on “Characteristics performance of a multi-aperture ion source for its application in ion thruster and material processing” at International Conference on Plasma Sciences (ICOPS-2020), IEEE- NPSS, Singapore, on 6th-10th December 2020
- ◆ **Mr. Basanta Kumar Parida**, gave a talk on “Low energy ion irradiation on BN-composite materials” at 6th International Virtual Conference on Ion Beams in Materials Engineering and Characterizations. (IBMEC 2020), IUAC, New Delhi, 8th-11th December 2020
- ◆ **Dr. Mukesh Ranjan**, gave an invited talk on “Plasmonics for SERS and Solar Cell Application” at Recent Advances in Optical and Magnetic Materials, NIT Uttarakhand, 14th-18th December 2020
- ◆ **Dr. Amreen Ara Hussain**, gave a talk on “Comparative Study of Mixed Metal Cation Lead-Free Perovskites for Visible Light Photodetection” at National Conference on Physics and Chemistry of Materials (NCPCM 2020), Govt. Holkar Science College, Indore, on 15th December 2020
- ◆ **Mr. Samiran Mukherjee**, gave a talk on “Hydrogen outgassing and permeation in stainless steel and its reduction for UHV applications” at 11th International Conference on Material Processing and Characterization, IIT Indore, 15th-17th December 2020
- ◆ **Dr. A. Sarkar**, gave a talk on “Investigation on hydrogen adsorption on different kinds of activated carbons” at 4th International Conference on Soft Materials (ICSM 2020), Malaviya National Institute of Technology (MNIT), Jaipur, on 18th December 2020
- ◆ **Dr. P.N. Maya**, gave an invited talk on “Magnetic trapping of charged particles and the pursuit of fusion energy on Earth” at CAPSS Seminar series - 'Nature as we unfold it', Center for Astroparticle Physics and Space Science, Bose Institute, Kolkata, on 26th December 2020
- ◆ 13th International Conference on Plasma Science and Applications (ICPSA 2020), Ravenshaw University, Cuttack, Odisha, on 26th-28th December 2020
  - **Dr. Mukti Ranjan Jana**, gave an invited talk on “Development of Technology for PINI Ion Source Back Plate and Ion Extractor Grids for Tokamak Plasma Heating”
  - **Dr. S.R. Mohanty**, gave an invited talk on “Inertial electrostatic confinement fusion device and its applications”
  - **Dr. Mayur Kakati**, gave an invited talk on “ITER relevant plasma surface interaction studies in the CPP-IPR CIM-PLP-PSI Device, recent irradiation experiments with India specific reduced activation ferritic martensitic steel (IN-RAFM)”
  - **Dr. Suramoni Borthakur**, gave a talk on “Gas injection system and its use in pulsed plasma accelerator”
  - **Mr. Ayan Adhikari**, gave an invited talk on “Pressure Gradient Induced Electrostatic Plasma Turbulence in LVPD”
  - **Ms. Asha Adhiya**, gave a talk on “Bench test Experiments on Fiber Optic Current Sensor for Aditya Tokamak”
- ◆ **Dr. Niraj Kumar Rai**, Banaras Hindu University, Varanasi, gave a talk on “Role of nuclear dissipation in heavy ion fusion-fission reactions” on 30th December 2020
- ◆ **Dr. Shivam Gupta**, Indian Institute of Technology Roorkee, gave a talk on “Spectroscopy modeling of laboratory plasma through a detailed plasma model using the reliable electron impact excitation cross-sections” on 08th January 2021
- ◆ **Dr. Uttam Kumar Goswami**, Institute for Plasma Research, Gandhinagar, gave a talk on “Investigation of TM01 mode analysis in circular waveguide for High power microwave plasma interaction applications and other activities” on 12th January 2021
- ◆ **Dr. Meenu Kaushik**, CSIR-Academy of Scientific and Innovative Research, Ghaziabad, gave a talk on “Electromagnetic Analysis of Electron Gun and RF cavities for Inductive Output Tube” on 12th January 2021
- ◆ **Ms. Pratibha Gupta**, gave a talk in Hindi on “प्लाज़्मा के क्षेत्र में भारत की आत्मनिर्भरता” at All India Hindi Scientific webinar on “Journey Towards Self-Reliant India - Role of Science & Technology”, IGCAR, Kalpakkam, 11-12 January 2021
- ◆ **Mr. Zubairuddin**, Institute for Plasma Research, Gandhinagar, gave a talk on “Thermo-mechanical analysis of GTA welding of Mod. 9Cr-1Mo steel considering the effects of phase transformation, Pre heating and Post heating” on 16th January 2021
- ◆ **Dr. P.N. Maya**, Institute for Plasma Research, Gandhinagar, gave a talk on “Studies on the Energetic Particles in Tokamak Plasma-Wall Interactions” on 19th January 2021

## Upcoming Events

- ◆ 29th DAE-BRNS National Laser Symposium (NLS-29), Shri Vaishnav Vidyapeeth Vishwavidyalaya (SVVV), Indore, 12th-15th February 2021 <https://ila.org.in/nls29>
- ◆ 13th International Symposium on Advanced Plasma Science and Its Applications for Nitrides and Nanomaterials and 14th International Conference on Plasma-Nano Technology & Science (ISPlasma2021/IC-PLANTS2021), 7th-11th March 2021 <http://www.isplasma.jp/>

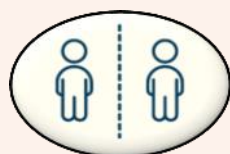


Title	Page No
RD Celebration @ IPR	01
RD Celebration @ CPP-IPR	02
विश्व हिंदी दिवस समारोह 2021	02
Aditya-Upgrade Tokamak Operation	03,04
“आत्मनिर्भर भारत की उड़ान-विज्ञान एवं तकनीकी का योगदान” – वेब संगोष्ठी	04
Validation Of Ion Recirculation In CPP-IPR IECF Device Using XOOPIC Code	05
IPR Outreach Activities	06
The BEAM Experimental Facility @ IPR	07
Past & upcoming events	08
Know Your Colleagues	09

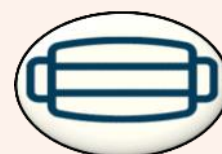
### Help Fight The Covid-19 Pandemic



**Wash Your Hands  
With Soap**



**Ensure Social  
Distancing**



**Always Wear  
Mask**

- ◆ Avoid touching your eyes, nose and mouth
- ◆ If you have fever, cough and difficulty in breathing, seek medical care early
- ◆ Stay informed and follow advice given by your healthcare provider

- ◆ Inform Office immediately if you or any family member tests positive
- ◆ Follow SMS - **S**ocial Distancing : **M**ask : **S**oap/Sanitizer
- ◆ Strictly follow social distancing while outdoors, especially at work.

**For your safety and for the safety of your co-workers, ensure that you always use  
Arogya Setu App**

### Know Your Colleagues



**Ramasubramanian N.** came to IPR in 1994 as a research scholar and completed the submission of thesis in 2001, under the guidance of Dr. P. Vasu. He then spent 4 years at the Max-Planck-Institut für Plasmaphysik, Garching/Griefswald, Germany as a Post-doctoral fellow. He returned to IPR as a Scientist-SD in Jan 2005 to work for divertor diagnostics of SST-1. From 2007, he is working on the Multi-Cusp Plasma Experiment System in Basic Plasma Physics group. He has interests in Tokamak edge plasma physics, laboratory plasma discharge physics and plasma diagnostics. He contributes to the Publication and Newsletter committee by preparing the Annual report of the institute as well as the matter contributed to the DAE annual report. He guided one student to the PhD degree and two more are there in the final stages of their degrees. He teaches Basic plasma physics or Plasma production and measurements in the course work period of Ph.D. students. He enjoys talking about the plasma to different kind of audiences.

### 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)



Web : [www.ipr.res.in](http://www.ipr.res.in)  
E-mail : [newsletter@ipr.res.in](mailto:newsletter@ipr.res.in)  
Tel : 91-79-2396 2000  
Fax : 91-79-2396 2277