TECHNOLOGIES FOR
NEW INDIA@75

The Fourth State

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

Issue 098

September 2021

75 Azadi Ka Amrit Mahotsav

75 आज़ादी का अमृत महोत्सव

75th Independence Day Celebrations @ IPR

The 75th independence day was celebrated at IPR main campus on 15th August, 2021,observing/following covid protocols. Director, Dr Shashank Chaturvedi hoisted the national flag, which was followed by singing of the national anthem by the staff members present at the occasion. Dr. Shashank Chaturvedi addressed the gathering and spoke in detail about scientific achievements and technologies developed by IPR despite of testing times of COVID -19.

The flag hoisting ceremony at IPR main campus

75th Independence Day Celebrations @ IPR

Director, IPR addressing the gathering at IPR main campus after hoisting the national flag.

Prof. B. K. Saikia, Acting Centre Director, CPP-IPR hoisting the national flag at CPP-IPR campus.

"Make in India" Cryolines for ITER project: Flag off Ceremony of Cryolines

ITER employs a magnetic "cage" to contain the hot plasma. This cage makes use of superconducting magnets, which must be cooled to -269^{0}C, just 4^0 above absolute zero. ITER will employ the biggest cryoplant in the world coupled to a Nuclear Facility, and the liquid helium & nitrogen produced by this plant will be distributed to the magnets through a massive network of "cryolines".

Approximately 4 km of Cryolines, operating at temperatures ranging from -269^{0}C to -193^{0}C, and about 6 km of return lines for warm gases, have been manufactured by M/s INOXCVA in India and then dispatched to the ITER Worksite in France. The last consignment of these lines was flagged-off on 29th July'21 at M/s INOXCVA's factory in Kalol village, near Vadodara in Gujarat.

These Cryolines are made to stringent Nuclear standards. These are 'first of a kind systems' in terms of large size (diameter up to 1 m), and include multiple process pipes with very low heat loss and complex layout. ITER-India and M/s INOXCVA established the design through meticulous prototyping and qualification before starting production.

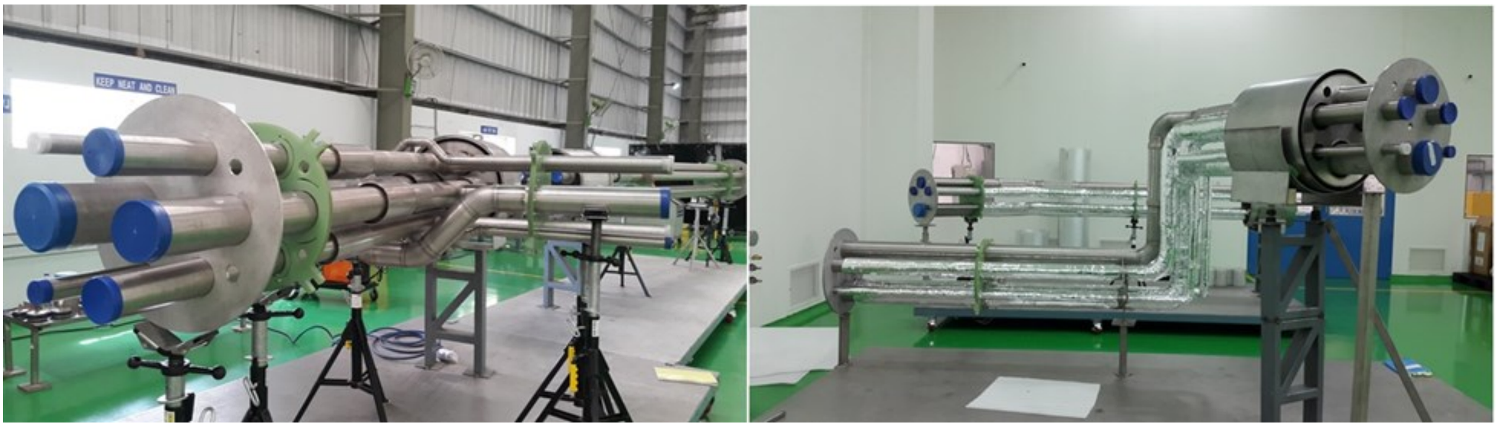
ITER-India, DAE and M/s INOXCVA are proud that India has demonstrated its ability to develop a hi-tech, first-of-a-kind product in Cryogenics, at par with the best in the world, a good illustration of *Atmanirbhar Bharat.*

The ceremony was remotely attended by Sh. K.N. Vyas, Secretary, DAE and Dr. Bernard Bigot, Director General of ITER Organization, Dr. Bigot applauded the engineering & manufacturing capabilities of INOXCVA and the quality and promptness of project related deliveries. Addressing the audience Sh. Vyas said, "*I am happy to see M/S INOXCVA as one such industry which has made its presence felt globally in a short span of 5 years in cryogenic lines at 4K temperature level, and I congratulate them for this*".

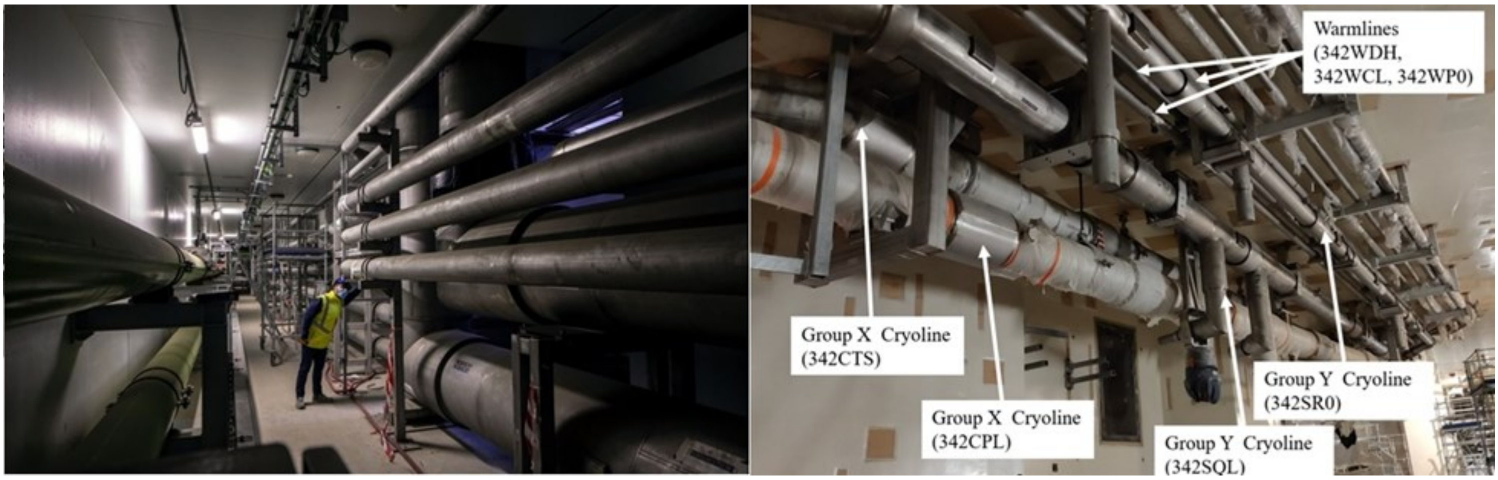
(L) Shri K N Vyas, Chairman DAE and (R) Dr Bernard Bigot Director General ITER France addressing the audience remotely

Final shipment flagged off by the dignitaries at M/S INOXCVA, Vadodara, on 29th July 2021

"Make in India" Cryolines for ITER project: Flag off Ceremony of Cryolines



Multi-process pipe cryoline under manufacturing and assembly at M/S INOXCVA , Vadodara



Cryolines and Warmlines manufactured by M/S INOXCVA under installation at ITER site

Obituary

Shri. Kirit Vasava

(17 April 1972 – 23 July 2021)

Shri. Kirit R. Vasava joined IPR in July 1998 as Draughtsman-A in the Drafting Section and later moved to MESD Division (Drafting Section) and was a valued member of the team.

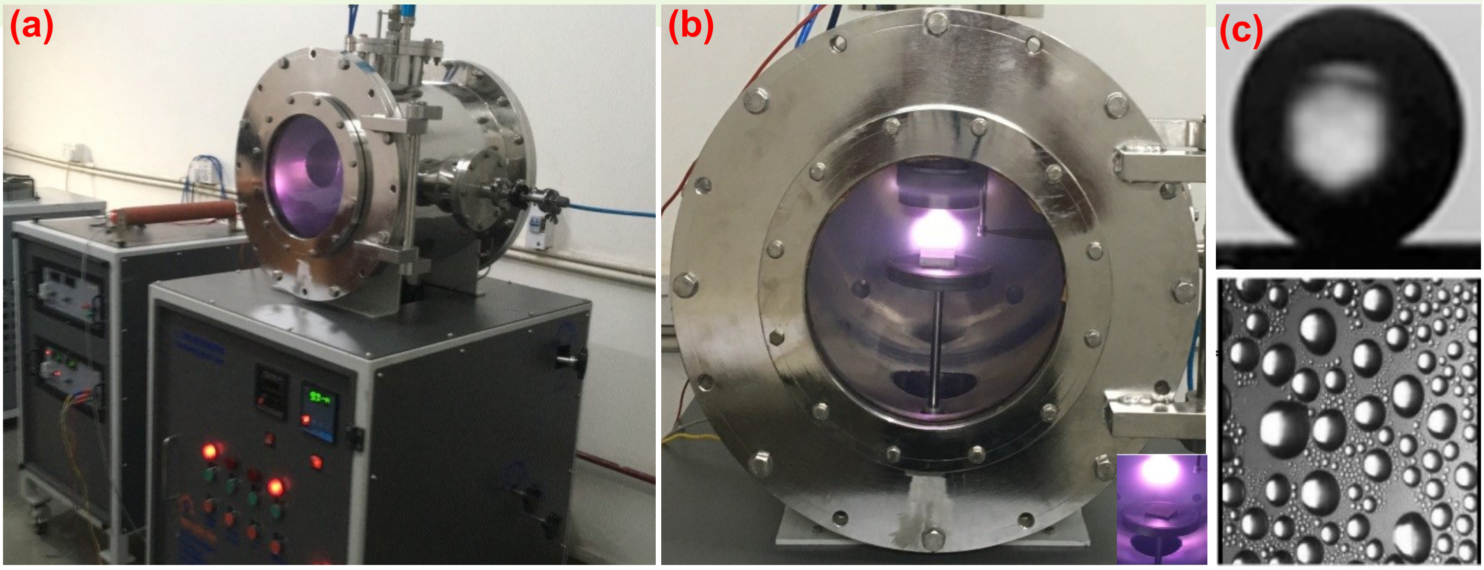
He had contributed substantially to the SST-1 in commissioning and refurbishment phase. He was one of the active member in device integration team and also contributed in ELM coil collaboration work with JET. His dedication to wok was commendable in many ways, he was active, adaptive and always keen to learn new things. He was a very gentle, humble and sincere toward his duties.

Shri Vasava left for his heavenly abode on 23/July/2021. IPR has lost a very dedicated and experienced staff and Shri Vasava will always be missed. He is survived by his wife Smt. Ranjanben Vasava and son Jay Vasava

On behalf of all the staff members of IPR, ITER-India, FCIPT and CPP-IPR. We all pray that the departed soul rests in eternal peace. We also express our heartfelt condolences to the sorrowing family.

Development of Plasma System for Surface Texturing

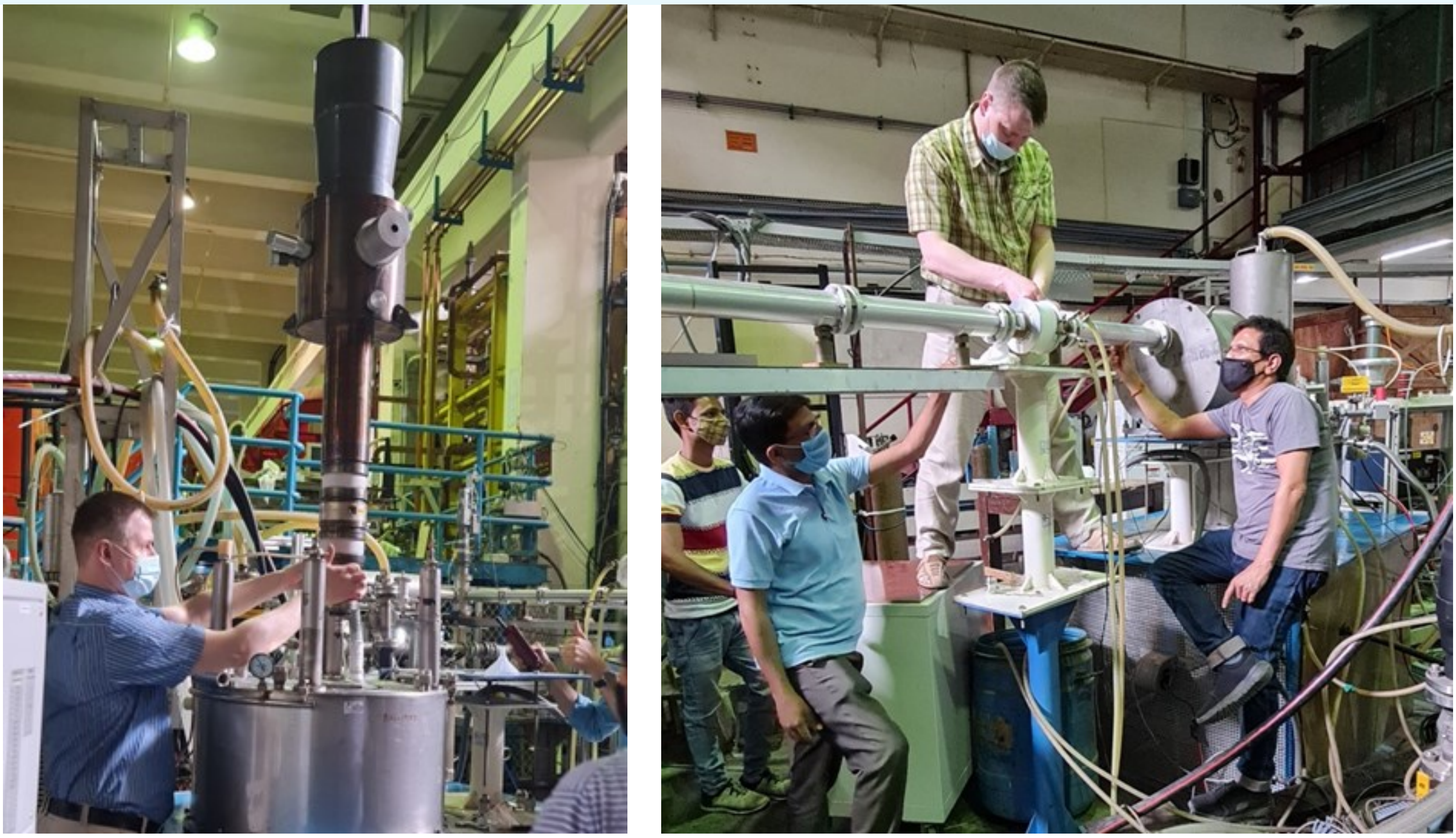
Under the collaborative BRNS project funding awarded to Prof. Basant Singh Sikarwar, Amity School of Engineering and Technology, Noida, the Plasma Surface Engineering Division (PSED) of IPR has developed a system using plasma fireball concept for surface texturing. In this work, plasma treated metal surface will be functionalized for making superhydrophobic surfaces. These surfaces will be further utilized for water harvesting via droplet condensation from a moist air. A superhydrophobic surface helps for water droplet rolling and to enhance the efficiency of water collection. This system was recently installed at Amity University, Noida as part of the BRNS project and experiments for the water condensations are currently being carried out. The IPR collaborators of this project are Dr. Mukesh Ranjan, Mr. Sooraj KP, Mr. Akshay Vaid and Mr. Vivek Pachichigar.



(a) The plasma system developed by PSED Division (b) Plasma treatment of sample (c) Water droplet condensation.

Commissioning of a New, 42GHz Gyrotron for ECRH System for SST-1 and Aditya-U

A new 42GHz - 500kW - 500ms Gyrotron has been commissioned for Electron Cyclotron Resonance Heating (ECRH) system in SST-1 and Aditya-U. The system is used in both the tokamaks for plasma start-up and heating. This new 42GHz Gyrotron has replaced the old Gyrotron which has been used since 2013 and completed its life. This 42GHz Gyrotron delivers 500kW power for 500ms duration at beam voltage of ~ -50kV, beam current ~20A and anode voltage +20kV. This Gyrotron is commissioned on existing cryomagnet and output is coupled with the existing matching optic unit (MOU) of the transmission line.



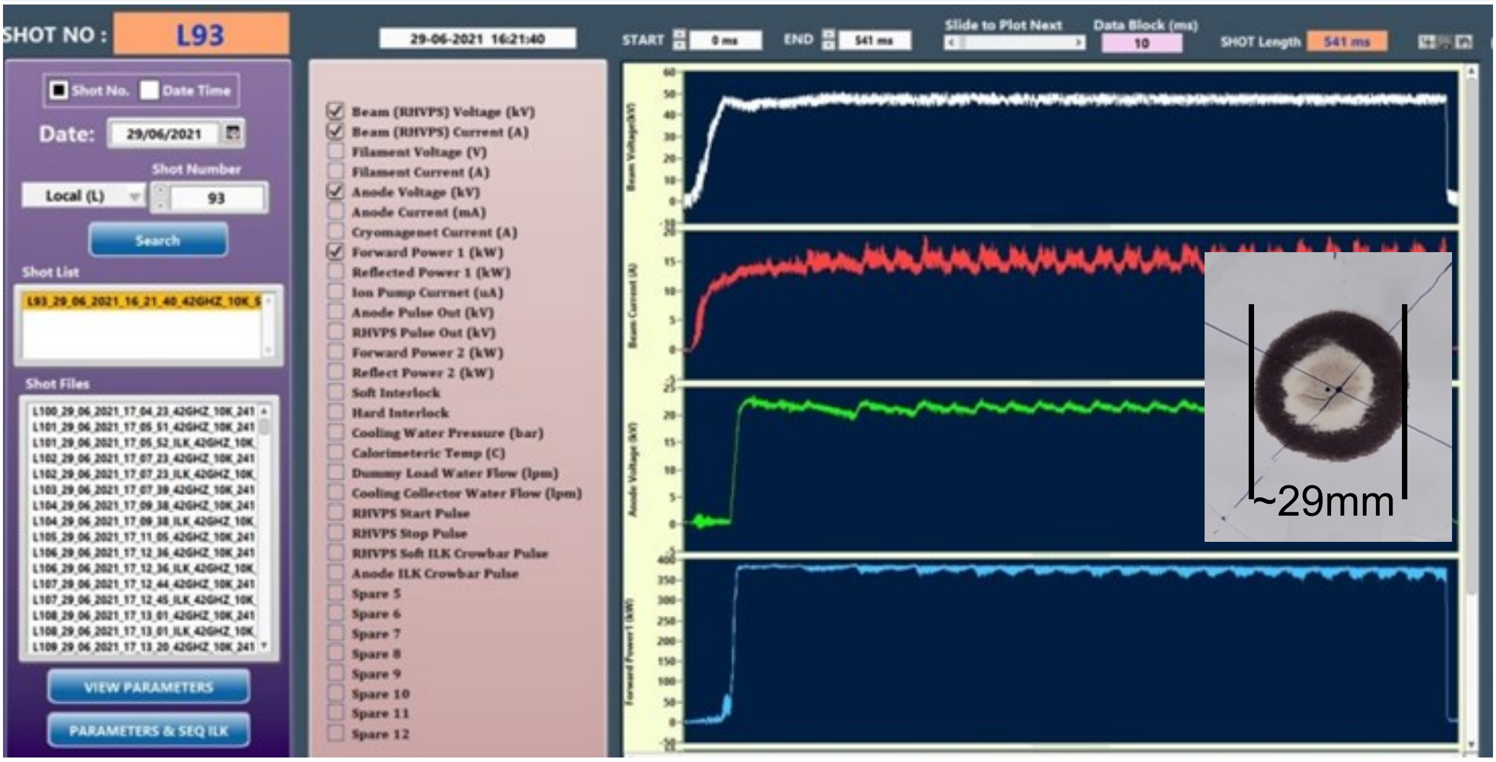
(L) The Gyrotron being installed (R) Connecting the Gyrotron to the transmission line

Commissioning of a New, 42GHz Gyrotron for ECRH System in SST-1 & Aditya-U

After making all electrical and cooling connections, the high voltage protection is demonstrated. The out beam quality of Gyrotron is checked by taking burn pattern at the exit of matching optic unit. In order to achieve the burn pattern, the Cryomagnet is maintained at 28.3A and filament is 20.9V and filament current 33.5A. The thermal paper is installed at the mouth of matching optic unit. A small pulse of 15ms is applied to the Gyrotron with Beam voltage: ~-45kV, Beam current ~15A, Anode voltage: ~17kV. The burn pattern shows a good Gaussian output at the exit of MOU.

High Power test of Gyrotron: In order to achieve full 500kW power from the Gyrotron, the filament is set to get beam current close to 20A (Filament voltage:20.8V, Filament current:33.4A), the Cryomagnet current is 28.4A and Cathode coil current: 1.0A. The high power test of Gyrotron was initiated, the beam voltage of Gyrotron is gradually increased up to - 48kV, the beam current is 15A (transient beam current in pulse condition for ~150ms up to 19A) and the anode voltage increased up to +22kV. The maximum power is measured at the dummy load calorimetrically; the power at the load is measured 478kW, considering the total loss in the transmission line around 5% (MOU around 3%, DC break, bend switch and line ~2%), the total power at the Gyrotron is 502kW. For the 500ms operation of the Gyrotron, the high voltage parameters were gradually increased with beam voltage up to -46kV and anode voltage +22kV and beam current maintain up to 15A for the stable operation of power supply. The Gyrotron output power was measured calorimetrically on a dummy load in various shots, the average power in most of the shots was around 425kW which corresponds to 450kW power for full duration 500ms at the exit of Gyrotron.

The efficiency of Gyrotron is more than 50% as 500kW power is achieved at ~49kV beam voltage and beam current is ~19A. The Gyrotron has been successfully commissioned and initial ECRH experiments have been carried out on Aditya-U and system is performing well on SST-1 tokamak.

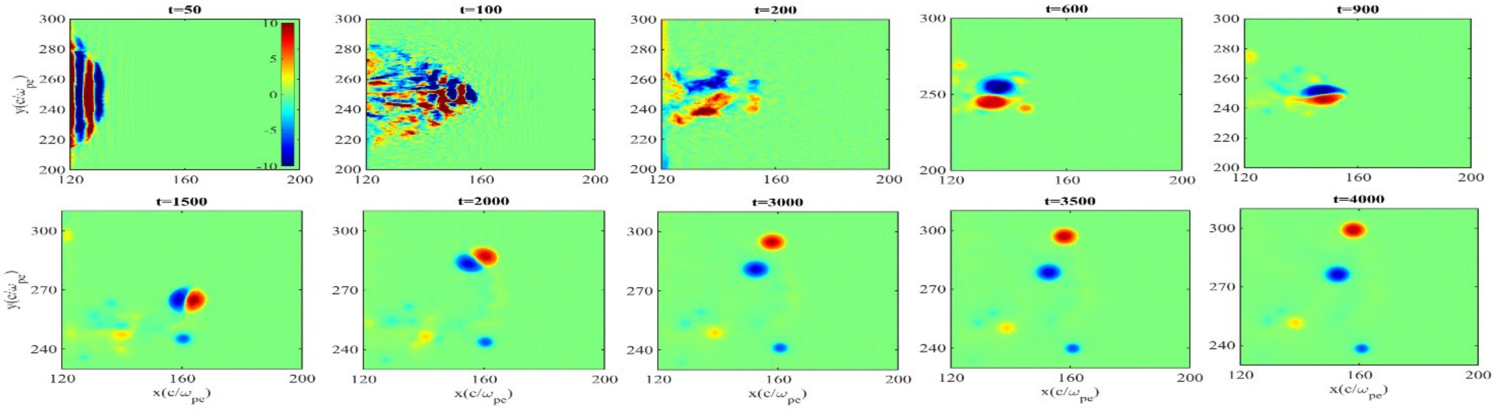


Traces of the 500ms shot of the Gyrotron (Power ~ 438kW) . (Inset : Burn pattern at The exit of MOU)

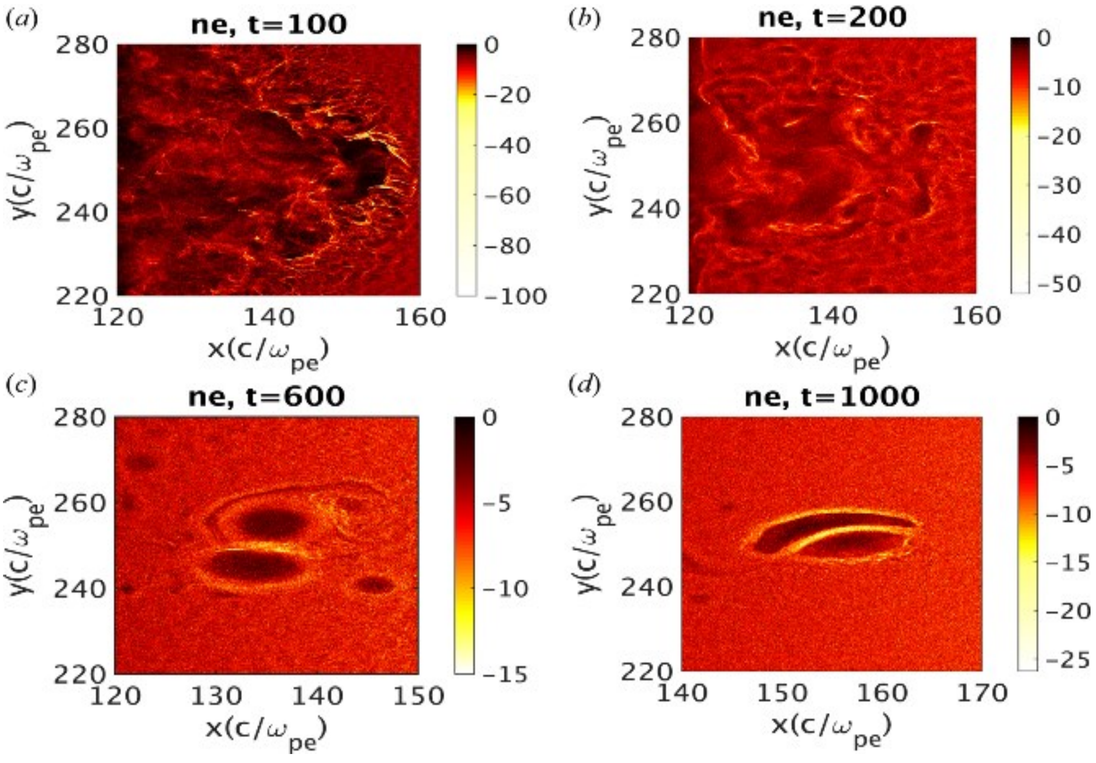
The IPR and Gycom (Russia) team during the Gyrotron Installation

The study of nonlinear coherent structures which are ordered and robust for several temporal scales of the system has always been pursued keenly in several physical contexts. The richness of nonlinear interactions in laser plasma interaction provides a fertile ground for the formation of such structures. Coherent structures can be important as they can serve in the transport of physical entities like charge bunches, electromagnetic energies and fields, kinetic energy of particles. In this work, by tailoring plasma density and choosing appropriate laser parameters, we have analyzed the stability and propagation characteristics of these coherent structures which are formed due to the intense laser interaction with solid density plasma.

When the laser frequency (ω_l) is less than plasma frequency (i.e. Fundamental frequency of unmagnetized plasma, ω_{pe}), the laser reflects from the critical surface. But in a scenario where a_0 parameter ($a_0 = eE_0/m\omega_l c$) is greater than unity then plasma dynamics are relativistic and electrons are pushed into the plasma in the manner of forward current while plasma responses by generating a return current inhibiting the propagation of this energetic current profiles. These spatially separated current profiles are unstable and they produce a magnetic field in the perpendicular plane. Now due to various instabilities, these current profiles get filamented and magnetic field structures merge and form bigger structures as they are left to evolve. If the conditions are appropriate such that these structures can balance particle kinetic energy pressure with electromagnetic field pressure, one can observe these coherent structures to become stable and robust. Additionally, if magnetic field structures of opposite polarities come together within a skin depth, their dynamics will be coupled. The fascinating property that we have observed about these structures is that they are not formed behind a wake field, formed by a laser but they are formed spontaneously in overdense plasma where the laser has been reflected. And these structures can propagate into those regions of plasma that are not accessible by powerful lasers. We have characterized these coherent structures and found their dependency on plasma inhomogeneity. We have found them to entrap 78% of the electromagnetic energy of the system and that makes them compact sources of energy which can be useful in electromagnetic energy transport in the overdense plasma.



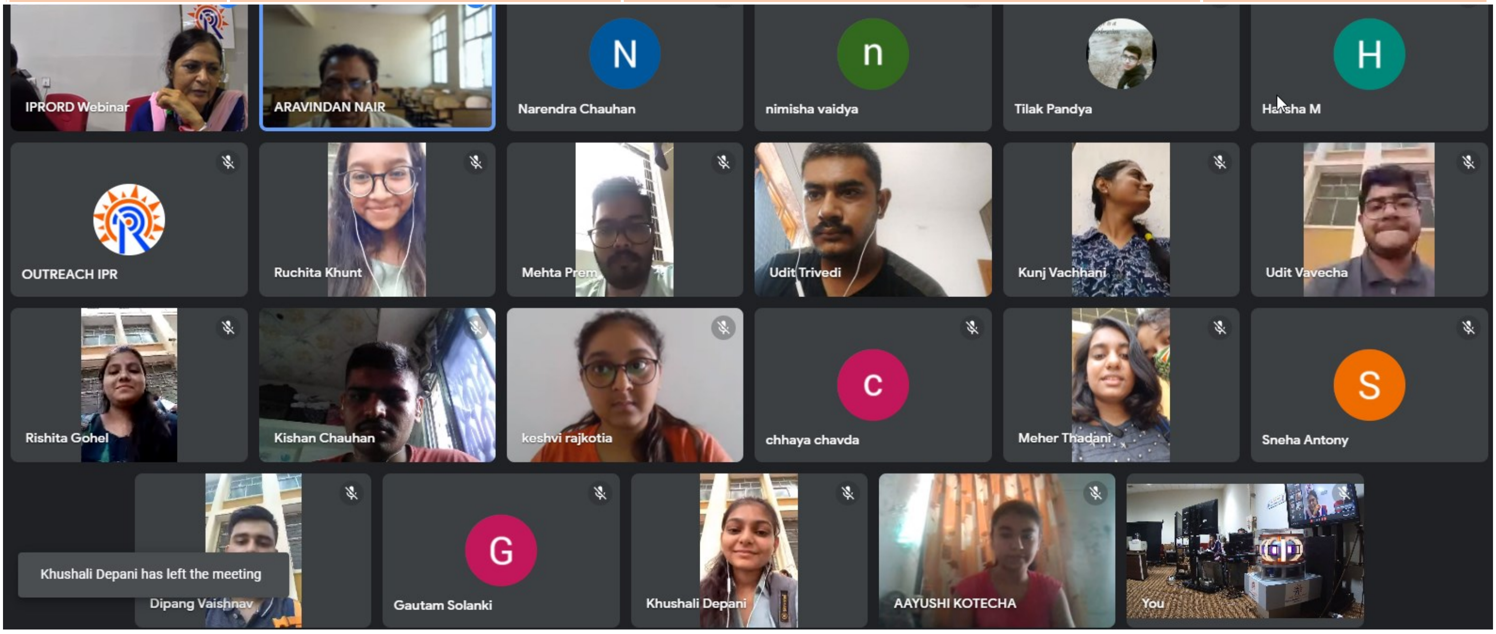
The result from PIC simulation with OSIRIS code performed in ANTYA; The evolution of B_z as current profiles were in X-Y plane. In this study we have used a p-polarized laser pulse of 1 μm wavelength and intensity 10^{21} W/cm^2 and it is made to interact with an overdense inhomogeneous plasma. These snapshots shows the generation of B_z inside the plasma (t=50), filamentation of current sheets (t=100), organization of magnetic fields into a coherent structure (t=200, 600), propagation into denser plasma (t =900), turning its trajectory and separating into monopole coherent structures (t=1500-4000). For more details about this work click here.

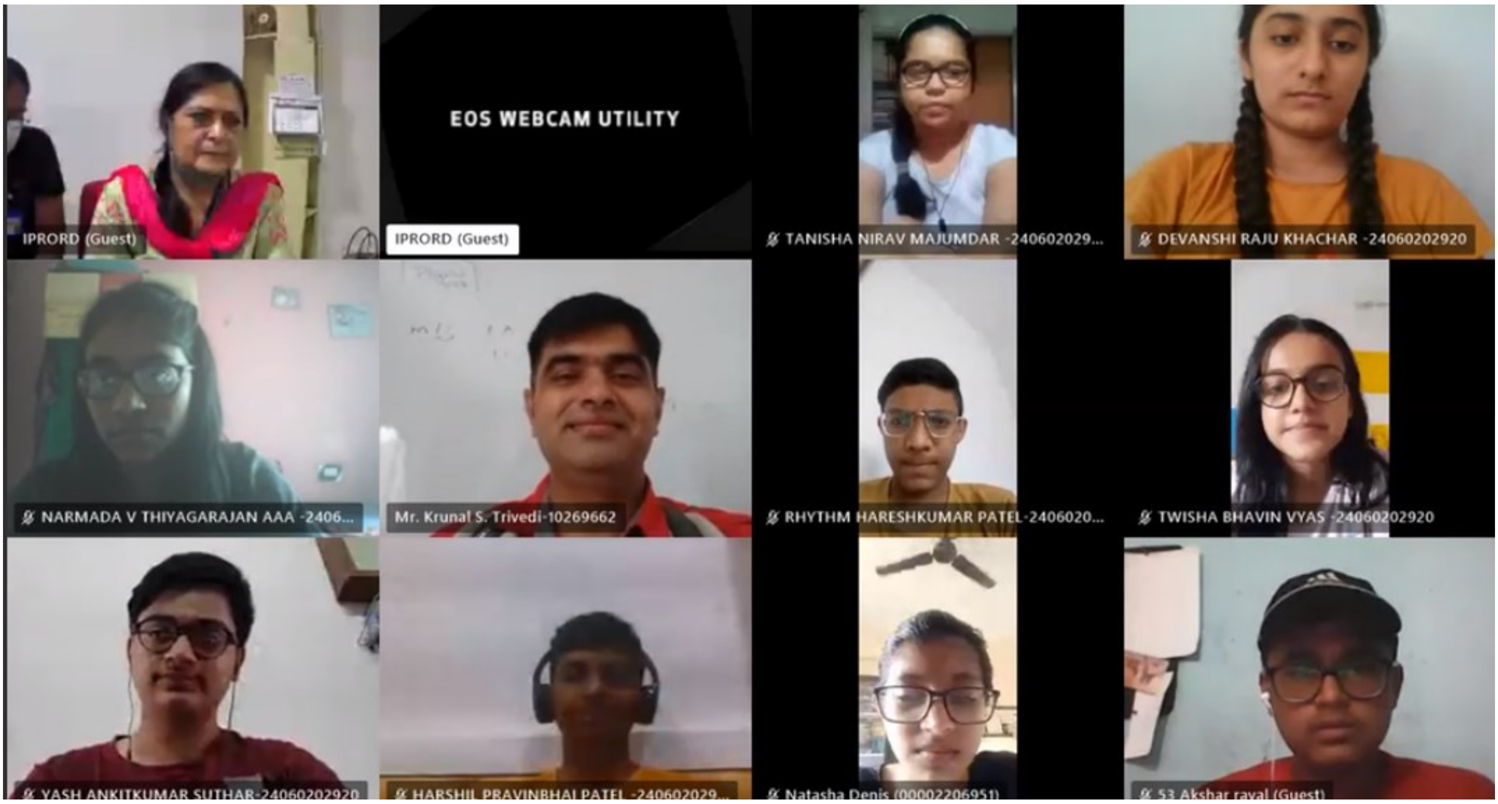


Electron charge density evolution when an intense laser (I = 10^{21} W/cm^2) interacts with an overdense plasma. Such an intense laser will violently disturb the plasma that can be observed in (a) where electrons have been pushed inside the plasma in the shape of laser Gaussian waveform. After most of laser has been reflected electrons will start rearranging themselves according to self-generated fields. While doing so they can form these structures if local kinetic energy pressure of structure is equivalent electromagnetic field pressure of that region (progress of this event is observed in (b, c, d)). 't' is normalized by plasma frequency 10^{15} Hz.

The webinar Programmes conducted by Outreach Division during the month of August 2021 under the auspices of 75 years of Independence are as follows;

Date	Institution	Programme	Participants
30-Jul-2021	Mount Carmel School, Gandhinagar	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	68 students and 2 teachers
4-5 Aug, 2021	Christ College, Rajkot	2-day,4 hour webinar Plasma & its applications for BSc Physics students	22 students and 2 teachers
12-13 Aug, 2021	Kadi Sarva Vishwavidyalaya, Gandhinagar	2-day,4 hour webinar Plasma & its applications for BSc Physics students	80 students and 2 teachers
20-Aug, 2021	Delhi Public School, Bopal, Ahmedabad	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	15 students and 1 teacher
26 Aug, 2021	KIIT School - I, Bhubaneswar	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	68 students and 2 teacher
27-Aug, 2021	KIIT School - II, Bhubaneswar	1-day, 2 hour webinar Plasma & its applications for class 11-12 students	108 students and 3 teacher





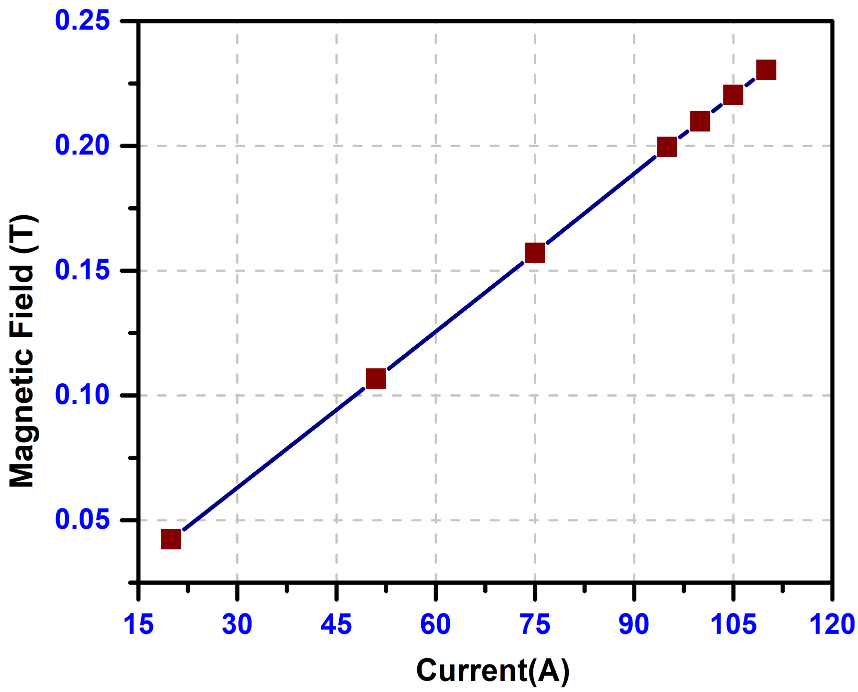
Participants from (Top) Christ College, Rajkot and (Bottom) Mount Carmel School, Gandhinagar attending the webinar

Sapling Distribution & Tree-Planting @ IPR

Trees are one of the most essential parts of our ecosystem and are necessary for our own existence. Recently, IPR campus lost quite a few number of trees due to cyclone *Tauktae* during 14th-19th May 2021. In order to make up for the loss and maintain a green campus, IPR staff club organised Tree Plantation drive on 30th of July 2021, where Staff members of IPR, FCIPT and ITER India campuses got together and planted more than 80 different tree saplings in IPR, ITER-India and FCIPT campuses. The trees consisted of *Kadamb, Amla, Banyan, Mango, Setur, Bili, Parijat* etc. The IPR staff club also distributed around 300 different saplings of Ixora plant, Double Chandni, Mogra and Rose to staff members.

Fabrication & Testing of High Temperature Superconducting Solenoid Coil

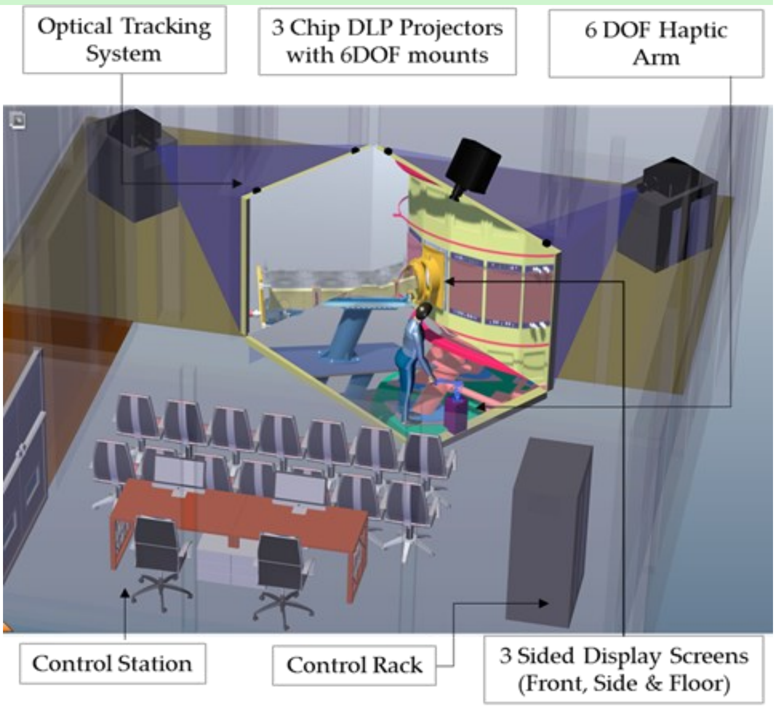
High temperature superconductors (HTS) are promising candidates for the next generation high field compact magnets. Winding, inter-pancake and terminal joints are challenging technology for the fabrication of HTS tapes based high field magnets. Magnet System Division (MSD) has fabricated a HTS solenoid coil of Room Temperature (RT) bore 50 mm having 21 double pancakes, 20 inter-double pancake joints, 576 nos. of turns and length 230 mm. This solenoid coil has been charged up to 110 A current per turn at 64.5 K and generated steady magnetic field of 0.23 T at the center of RT bore. The generated magnetic field was measured with Hall probe mounted at its center.



(L) The HTS coil during testing with its housing cryostat (R) Measured Magnetic field at operating currents

Virtual Reality CAVE Facility @ IPR

A 3-sided, fully immersive integrated Virtual Reality CAVE facility has been commissioned, tested and demonstrated successfully at the Remote Handling and Robotics Technology Development (RHRTD) Division, IPR. The facility is seamlessly compatible with various design and modelling software, *viz.,* CATIA v5, Solidworks and 3DVIA composer. The users can load the 3D models of any machines/systems in the VR facility, instantly view these models as 3D immersive models using the stereoscopic glasses, and feel as if they are actually present in the actual environment. The facility has in-built head/hand tracking and the haptic arm for navigation and interaction within the virtual environment. Various features include virtual assembly, collision detection, animations, navigation, zoom in/out, fly through, cutting planes, and snapshots, etc. VR is extremely useful in remote handling as remote operations require an accurate perception of a dynamic environment. The facility gives the operators the same unrestricted knowledge of the task scene as would be available if they were physically located in the remote environment.



Virtual Reality CAVE Facility @ IPR

Components of the VR CAVE system

Hardware

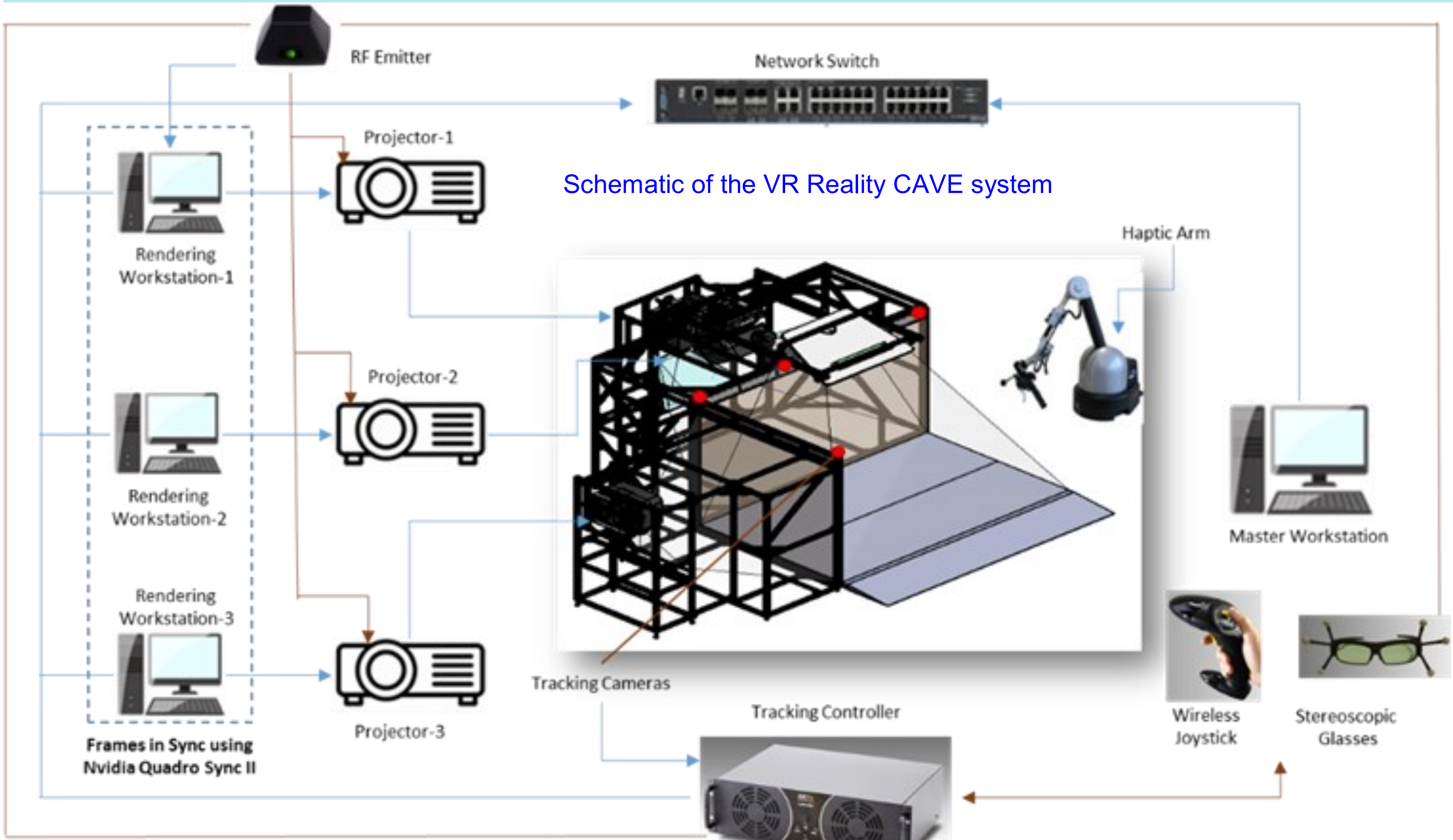
1. 3D Laser phosphor Projection systems
2. 6-DOF Haptic Force feedback arm
3. 6-DOF optical tracking system, wireless joysticks, stereoscopic glasses, RF emitters
4. 03 Nos. High end GPU workstations (with Nvidia RTX6000 & Nvidia Sync II cards) for graphic rendering
5. 01 No. Master node (with Nvidia RTX 6000 graphics card) for running the various design software

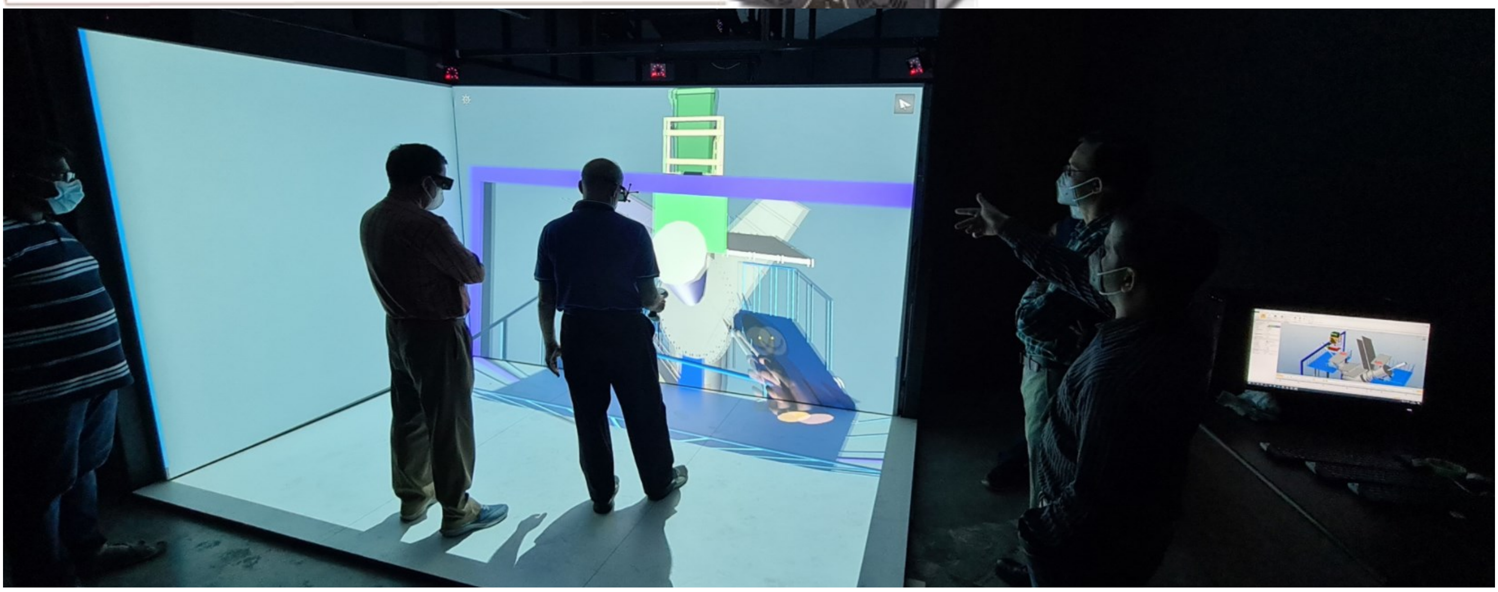
Software

1. Techviz middleware software for immersive visualization

Major Applications of the VR facility

1. 3D virtual interactive walkthroughs of machines/systems
2. Rapid prototyping - eliminating need of physical prototypes
3. System interface, design & integration studies
4. Real-time monitoring and remote control of RH operations
5. Customized training by simulating different scenarios, etc.





तकनीक के साथ विज्ञान की बात

'तकनीक के साथ विज्ञान की बात' की श्रृंखला-2 में **श्रीमती हिरल जोशी**, वैज्ञानिक सहायक - सी द्वारा 2 अगस्त 2021 को दोपहर वेबिनार के माध्यम से "अप्रतिध्वनिक चैम्बर (Anechoic Chamber)" विषय पर व्याख्यान दिया गया। अप्रतिध्वनिक चैम्बर क्यों और कैसे बनाया जाता है तथा इसकी आवश्यकता के बारे में चर्चा की। इस चैम्बर का उद्देश्य किसी अनुप्रयोग के दौरान बाहर से आती विद्युत चुंबकीय किरणों को चैम्बर के अंदर प्रवेश करने से रोकना है, ताकि बिना किसी व्यवधान के प्रयोग किये जा सकें। उन्होने बताया कि अप्रतिध्वनिक चैम्बर को बनाने से पहले उसकी लंबाई, चौडाई, ऊँचाई, आवृत्ति आदि पहलुओं पर विशेष ध्यान देना जरूरी है। इस चैम्बर में NRL आर्च पद्धति से प्रयोग किये जाने की व्यवस्था की गई है। नव निर्मित तकनीक पर सरल हिंदी भाषा में प्रस्तुत व्याख्यान से सभी श्रोतागण लाभान्वित हुए।

आज़ादी का अमृत महोत्सव

At 12:30hrs on 13th August, 2021, rendering of National Anthem was done by over 600 members of the Indian Scientific Fraternity across the nation. This online function was organized as part of the *Azadi Ka Amrit Mahotsav* at the Mahika Hall, Ministry of Earth Science, Prithivi Bhavan, New Delhi. Due to covid restrictions, only six faculty members from IPR participated in the event.

Past Events @ IPR

- ***Dr. Nirmal K Bisai,*** gave a talk on "*Plasma blob formation mechanism in SOL using 3D simulations and its experimental validation*" at 30th ITPA meeting of TG SOL and divertor physics, 5th July 2021
- ***Mr. Naveen Rastogi,*** gave an invited talk on "Virtual reality applications in remote handling" at AICTE sponsored Faculty Development Program on "*AR VR in Robotics*" organized by Vimal Jyothi Engineering College, Kannur, Kerala, 15th July 2021
- ***Mr. Rajiv Sharma,*** gave a talk on "*Indigenous Development of Epoxy Resin system for Cryogenic Services and Fusion Application*" at 23rd Cryogenic Engineering Conference and International Cryogenic Materials Conference (CEC-ICMC 2021), (Virtual), Louisville, Colorado, USA, 19-23 July 2021
- ***Dr. Isheta Majumdar,*** Helmholtz-Zentrum Berlin für Materialien und Energie (HZB), Germany, gave a talk on "*Photoelectron spectroscopic studies of solar cell absorber materials*" on 26th July 2021
- ***Dr. Milind Kumar Singh,*** Banaras Hindu University, Varanasi, gave a talk on "*Experimental and first principal studies on hydrogen desorption behaviour of graphene nanofiber catalyzed* MgH_2" on 30th July 2021
- ***Ms. Ayushi Vashistha,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Study of laser interacting with magnetized plasma*" on 3rd August 2021
- ***Ms. Devshree Mandal,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Some studies on Interaction of laser with overdense plasma*" on 4th August 2021
- ***Mr. Vaibhav Ranjan,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Design & Analysis of Pulse Power Supply for Diverter Coils in Aditya U Tokamak*" on 5th August 2021
- ***Dr. Rinku Mishra,*** CPP, Institute for Plasma Research, gave a talk on "*Wave Propagation along Plasma and Dusty Plasma Interfaces*" on 6th August 2021
- ***Dr. Jyoti Pandey,*** ITER-India, Institute for Plasma Research, Gandhinagar, gave talk on "*Nuclear Analysis for ITER deliverables from IN-DA*" on 6th August 2021
- ***Dr. Akanksha Gupta,*** IIT Kanpur, gave a talk on "*Study of turbulent and shear flows in viscous and viscoelastic fluids*" on 13th August 2021
- ***Mr. Tanmay Macwan,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*Effect of Short Gas-puff Pulses and Biased-electrode on Transport, MHD Instabilities, Plasma-Wall Interaction and Runaway Electrons in ADITYA-U Tokamak*" on 17th August 2021
- ***Dr. Mahesh Saini,*** Institute for Plasma Research, Gandhinagar, gave a talk on "*SERS-based detection of adulterants in spices and fruits*" on 24th August 2021

Upcoming Events

- Virtual Turbulent Dynamics of Tokamak Plasmas (TDoTP) Advanced Graduate School, 3 September 2021. https://www.tdotp.ac.uk/news-and-events/advanced-graduate-school-2021/
- 15th European Conference on Applied Superconductivity, Russia, 5-9 September 2021. https://www.eucas2021.org/programme
- 58th Culham Plasma Physics Summer School, Culham Science Centre, Oxfordshire, 6-17th September 2021. https://culhamsummerschool.org.uk/
- Online School-cum-Workshop on Ion Beams in Sensor Development, Inter University Accelerator Centre, New Delhi, 7-8 September 2021. https://gate.iuac.res.in/IBSD-2021/
- 13th International Conference on Plasma Assisted Technologies (ICPAT 2021), China, 7-11 September 2021. http://www.plasmacombustion.com/iwepac.html
- 48th IEEE International Conference on Plasma Science (ICOPS 2021), Nevada, 12-16 September 2021. http://ece-events.unm.edu/icops2021/index.html
- 18th International Workshop on Plasma Edge Theory in Fusion Devices (PET21), EPFL Swiss Plasma Center, 13-15 Sep tember 2021. https://www.epfl.ch/research/domains/swiss-plasma-center/news/pet21/
- 14th Carolus Magnus Summer School on Plasma and Fusion Energy Physics, 20 September - 1 October 2021. http://www.carolusmagnus.net/
- 5th Asia Pacific Conference on Plasma Physics (AAPPS-DPP2021), Division of Plasma Physics, 26 September - 1 Octo ber 2021. http://aappsdpp.org/DPP2021/index.html

Know Your Colleagues

Mr. Pankaj P Varmora joined IPR as an Engineer-SC (Electronics & Communication) in October 2007 in the Magnets Division. Some of his major contributions from 2007 to present for the SST-1 Tokomak include refurbishment project for the cryogenics sensors and instrumentation & data acquisition (DAQ) system for SST-1 superconducting magnets. He has also contributed in several superconducting experiments in the magnet system division. Currently, he is working in the SST-1 operation division as a Scientific Officer - E and plays a major role in the operation of superconducting SST-1 magnet system sensors, instrumentation, TF and PF quench detections system, and DAQ system.

His current research interests include sensors and instrumentation and design of new DAQ system for laboratory-scale and large-scale superconducting experiments.

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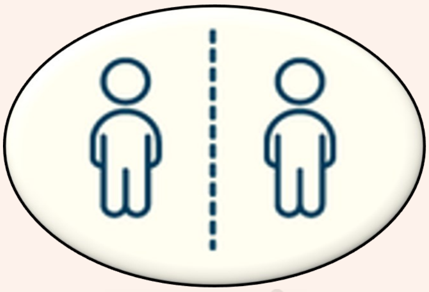
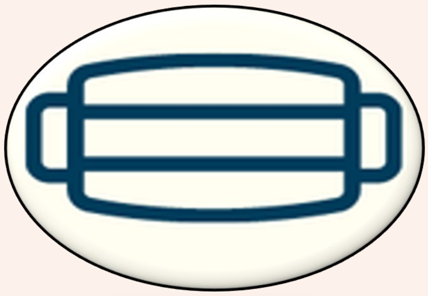
Help Fight The Covid-19 Pandemic


Wash Your Hands frequently
With Soap


Ensure Social Distancing
At ALL times


Always WEAR a Mask
When you go outside

- 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 - Social Distancing : Mask : Soap/ Sanitizer
- Strictly follow social distancing while outdoors, especially at work.

Please get yourselves vaccinated against Covid-19

कृपया अपने आप को कोविड -19 के खिलाफ टीकाकरण करवाएं

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

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