



# **SAFIRE**

## **PHASE TWO**

# SAFIRE

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*Note: all photographs of experiments are exactly as seen by the eye, no Photoshopping has been done.*



# PHASE TWO



## Phase II: Bigger with More Data

The central feature of the experimental apparatus is a stainless-steel cylinder four feet in diameter and seven feet long.

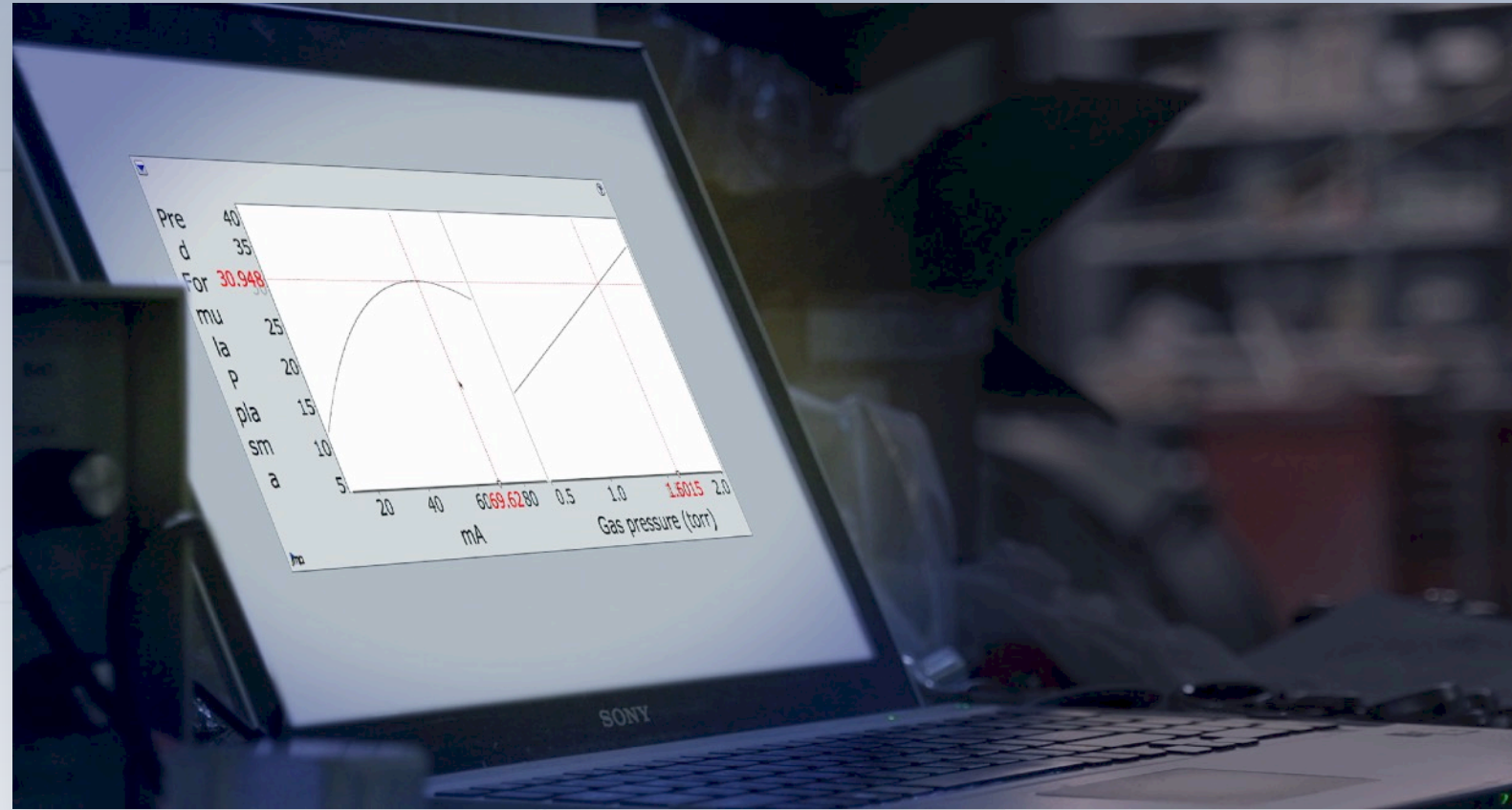
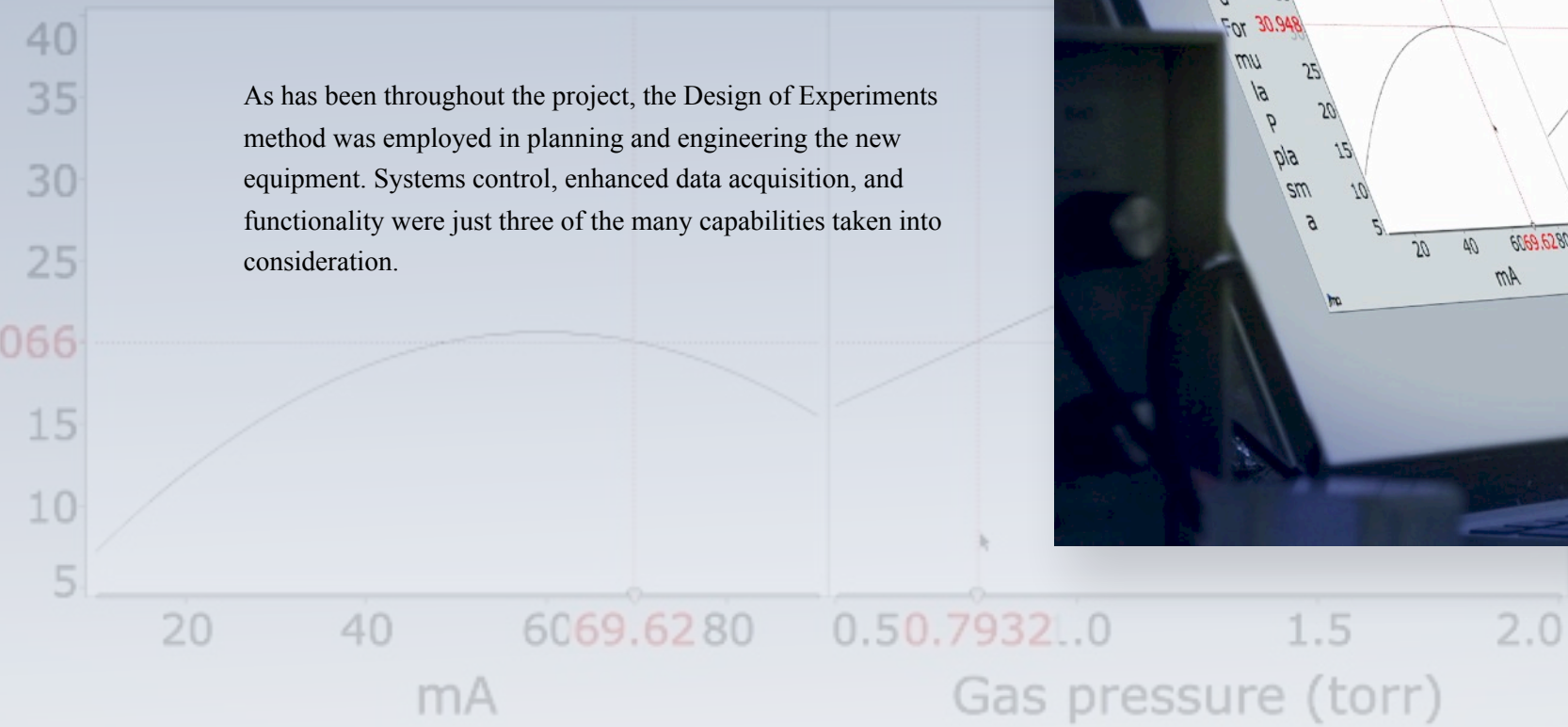


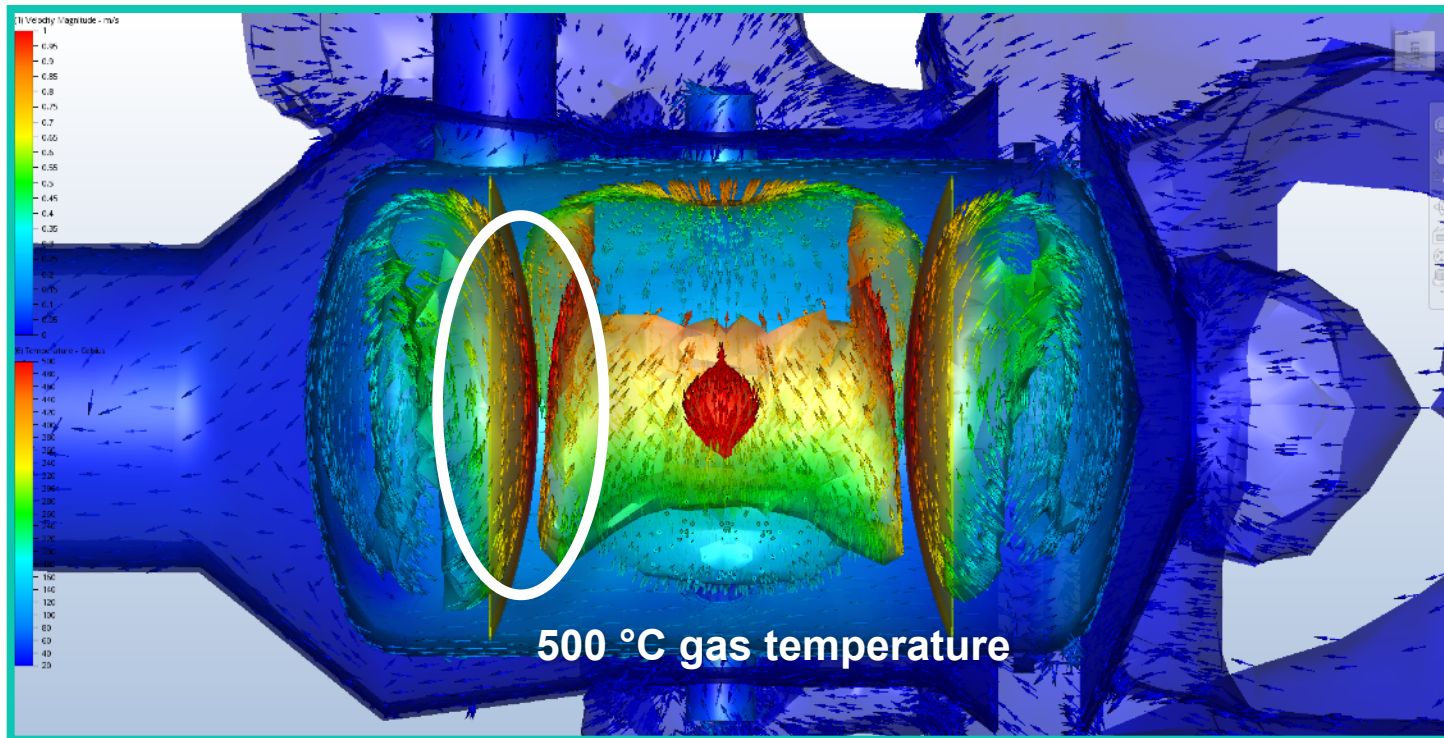
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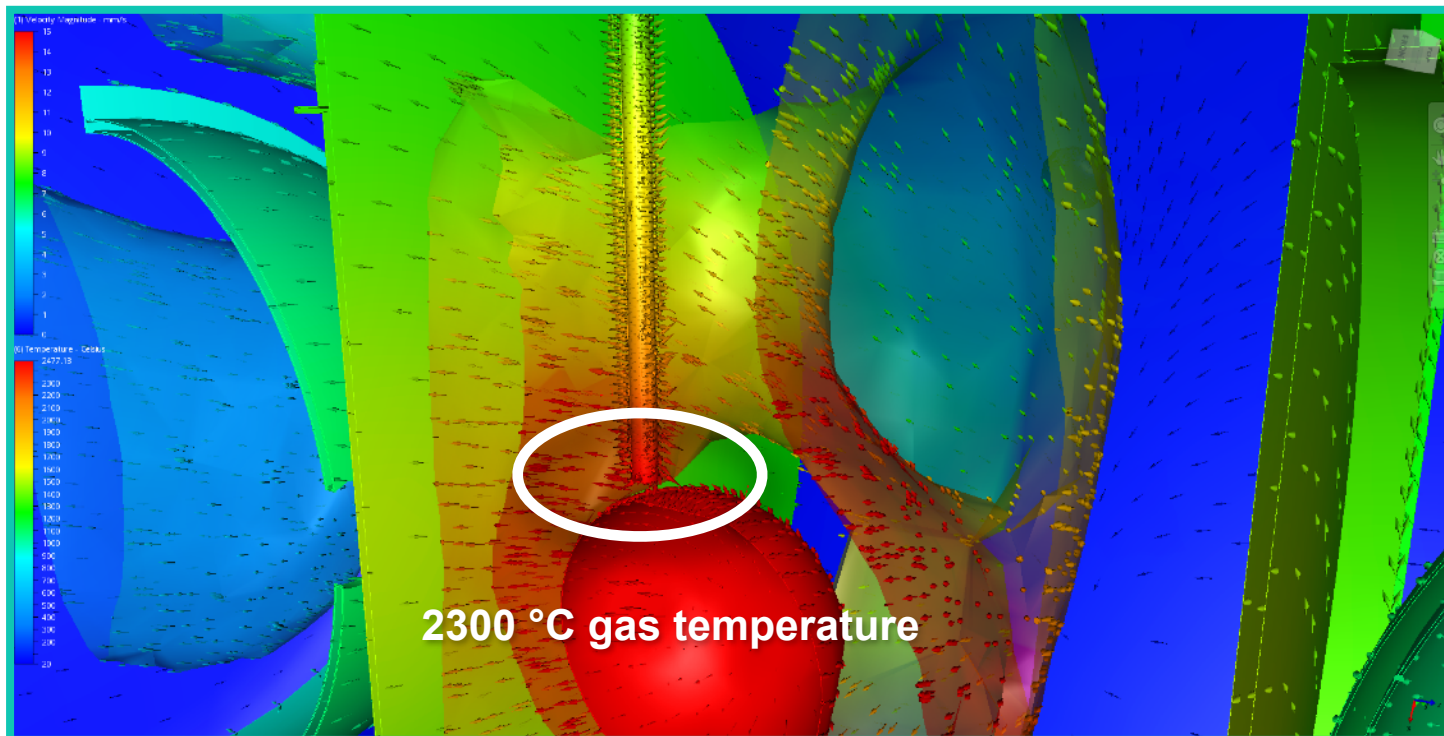


As has been throughout the project, the Design of Experiments method was employed in planning and engineering the new equipment. Systems control, enhanced data acquisition, and functionality were just three of the many capabilities taken into consideration.





Also used were software programs for computer aided design, computational fluid dynamics, and finite element analysis.

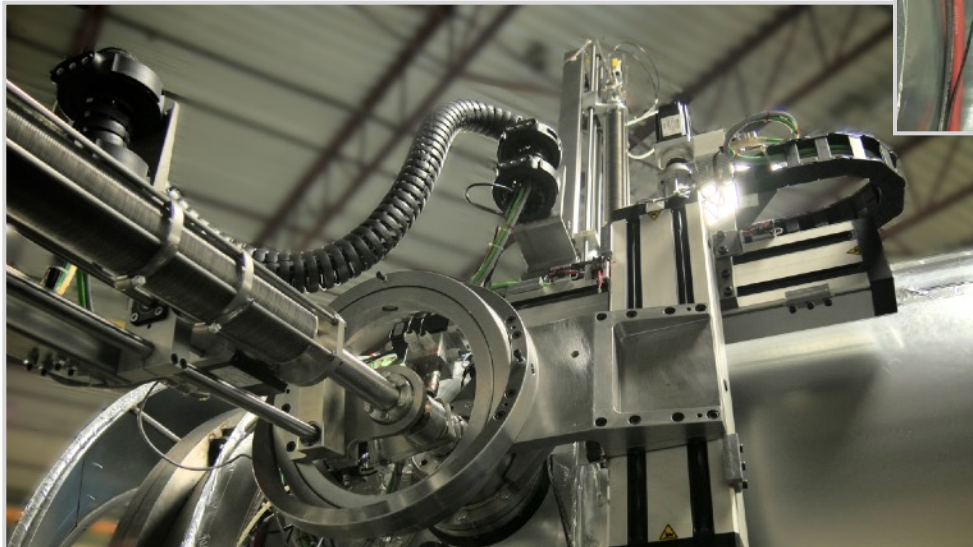


*Computational Fluid Dynamics showing thermal stress distribution and gas flow inside the chamber as a result of intense radiation emissions.*

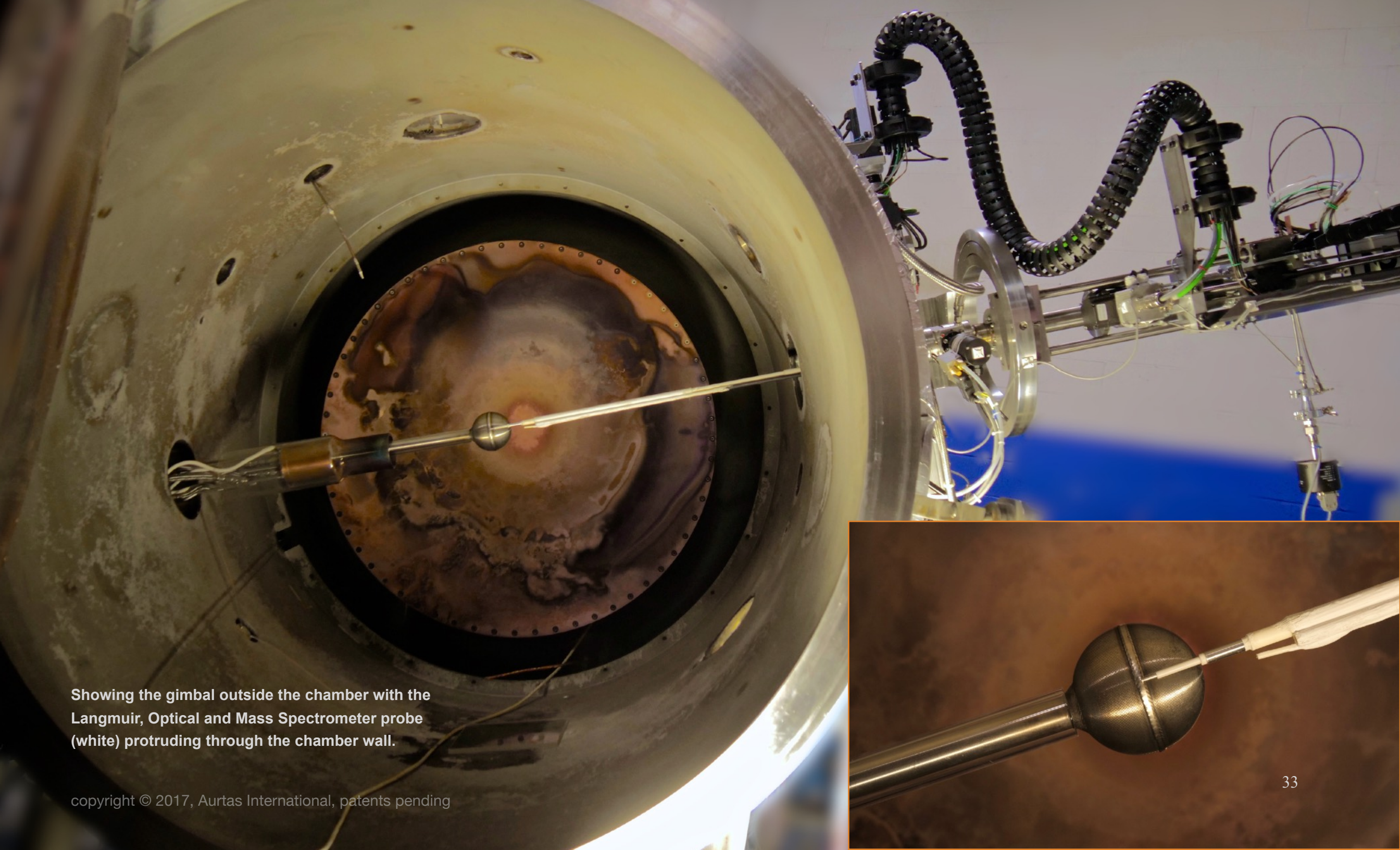


Particular attention was paid to the parts of the apparatus that would probe the plasma and gather data about it.

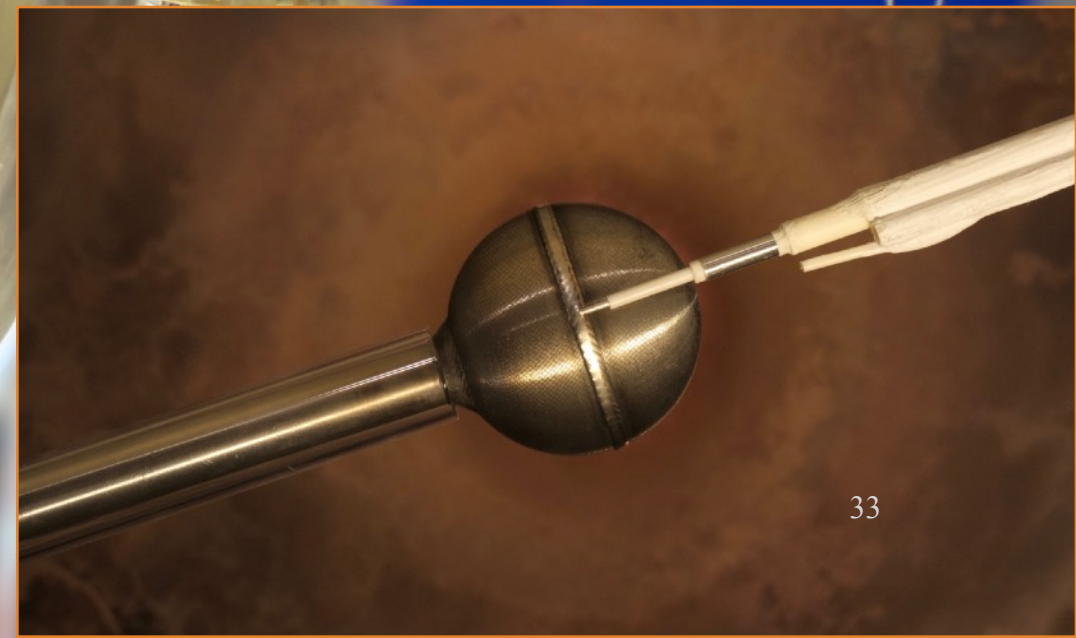
The team designed a manipulating arm to mount a Langmuir probe and mass and optical spectrometer sensors. The arm is unique in design as it employs the characteristics of a gimbal with a multi-axis computer-numerically-controlled servomotor system. There are two independently directed gimbals that provide 5 degrees of freedom to simultaneously move each probe with a positional accuracy of 0.01mm.



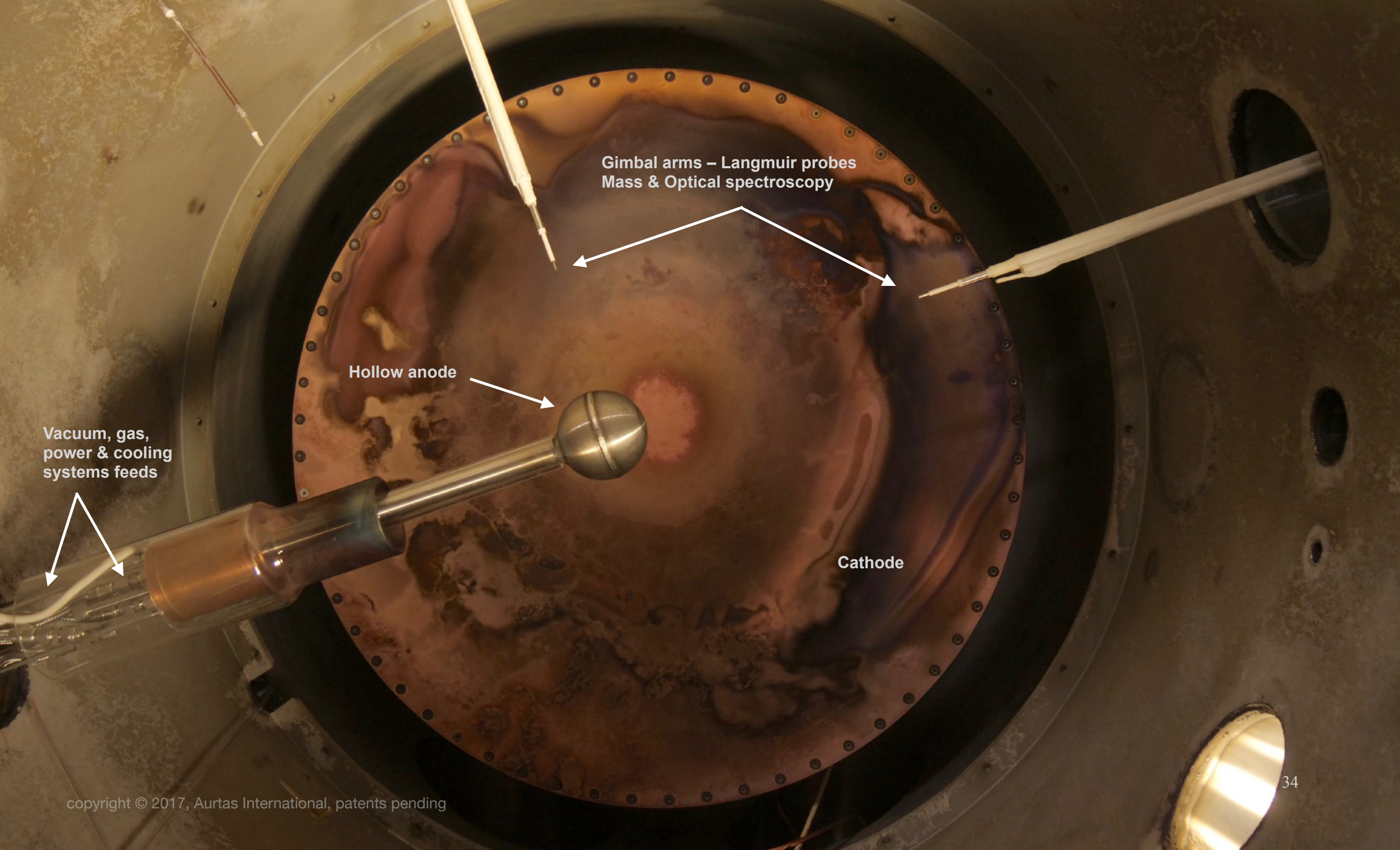




Showing the gimbal outside the chamber with the Langmuir, Optical and Mass Spectrometer probe (white) protruding through the chamber wall.







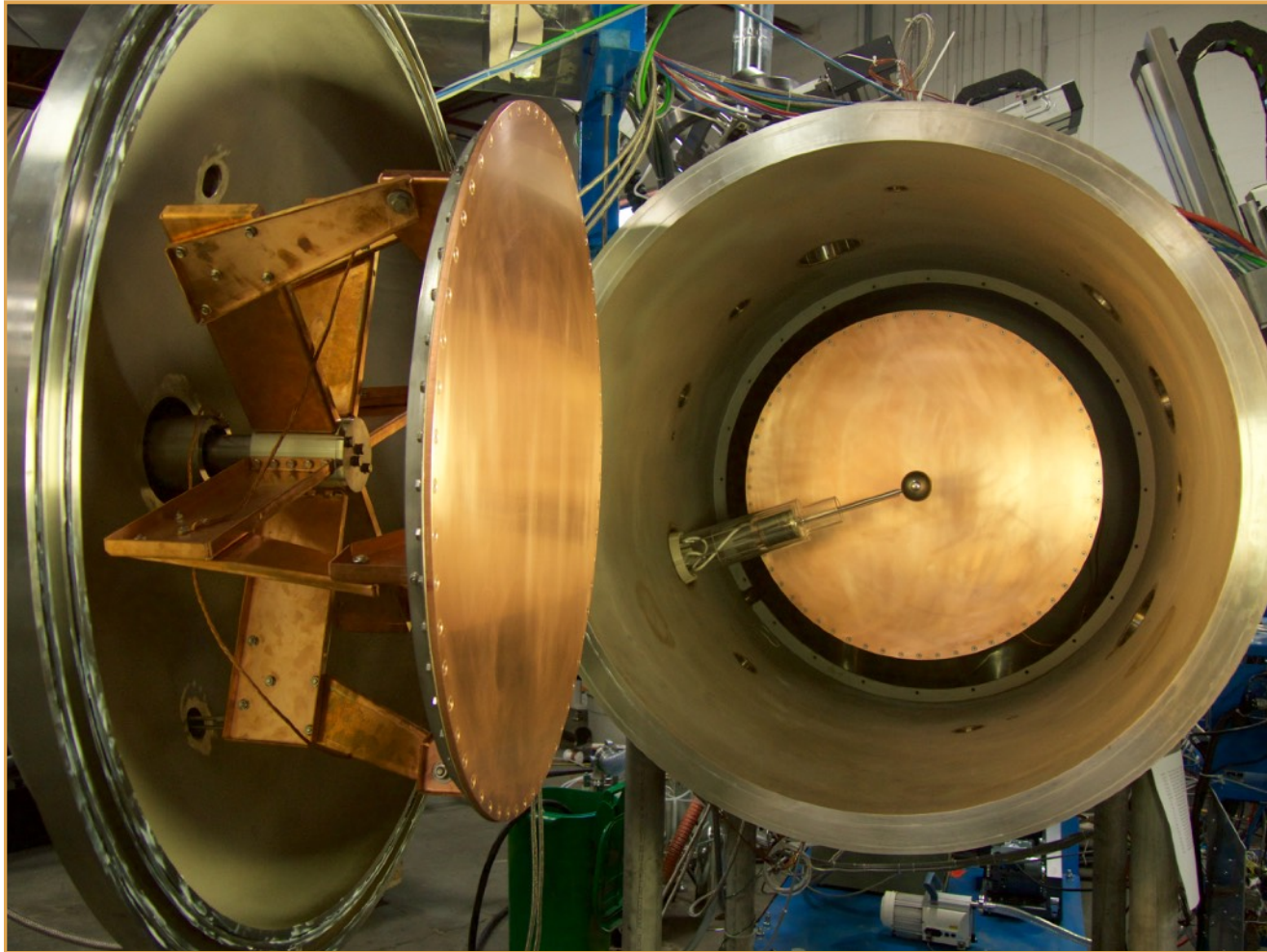
Gimbal arms – Langmuir probes  
Mass & Optical spectroscopy

Hollow anode

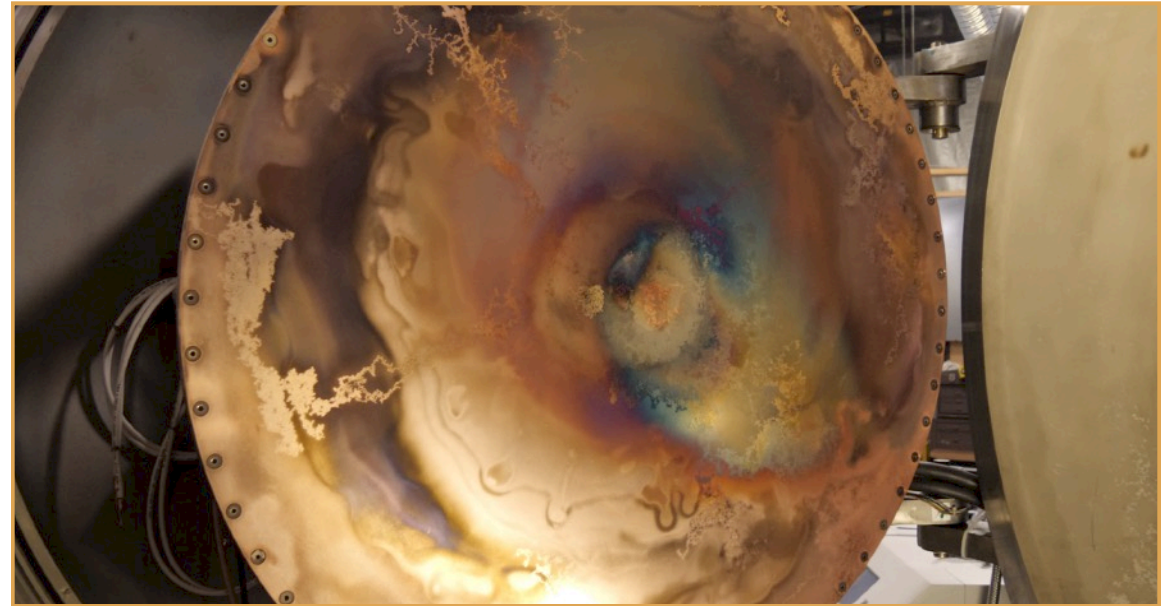
Cathode

Vacuum, gas,  
power & cooling  
systems feeds





*Cathode before*



*Cathode during experiments*



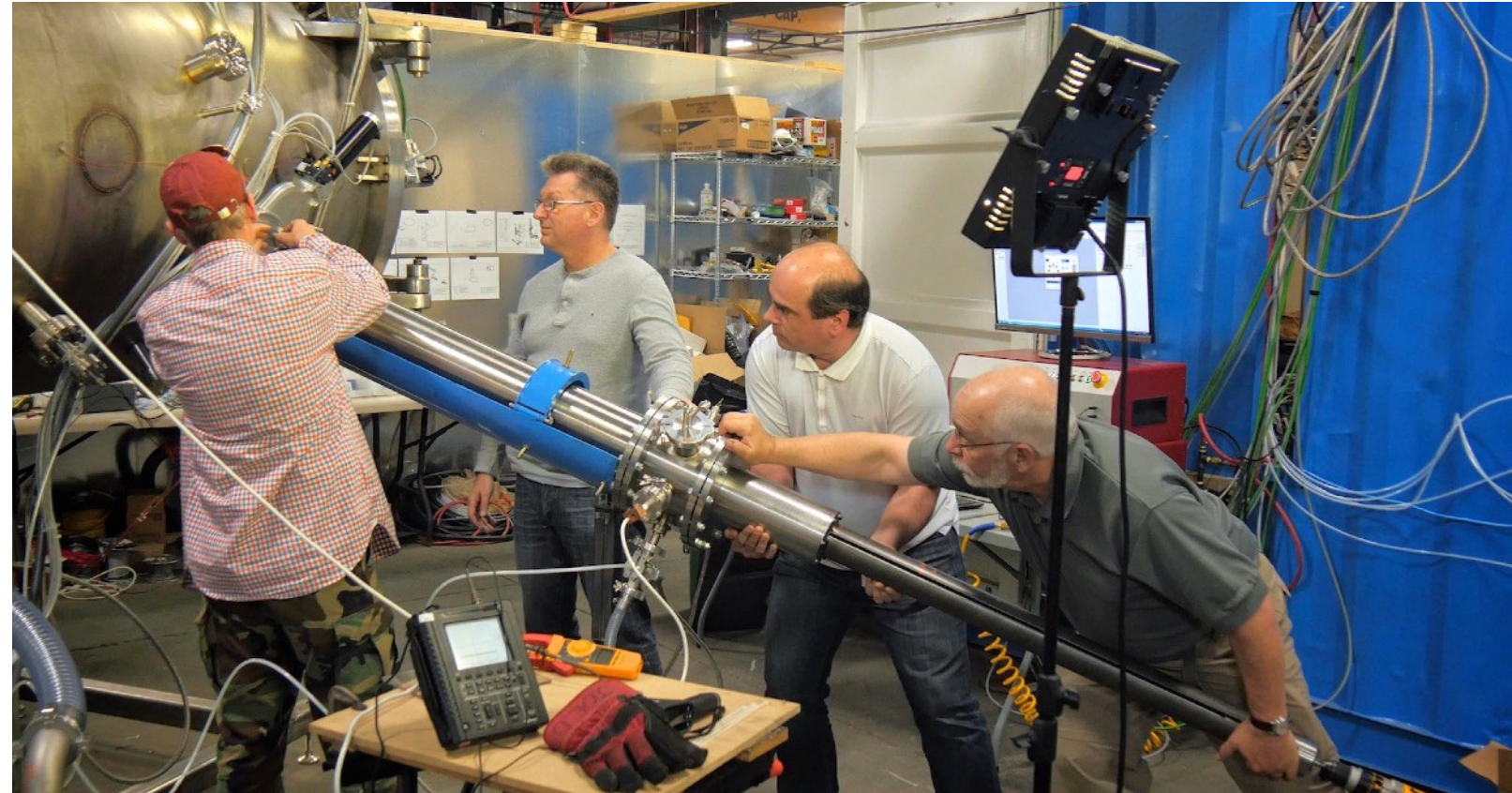
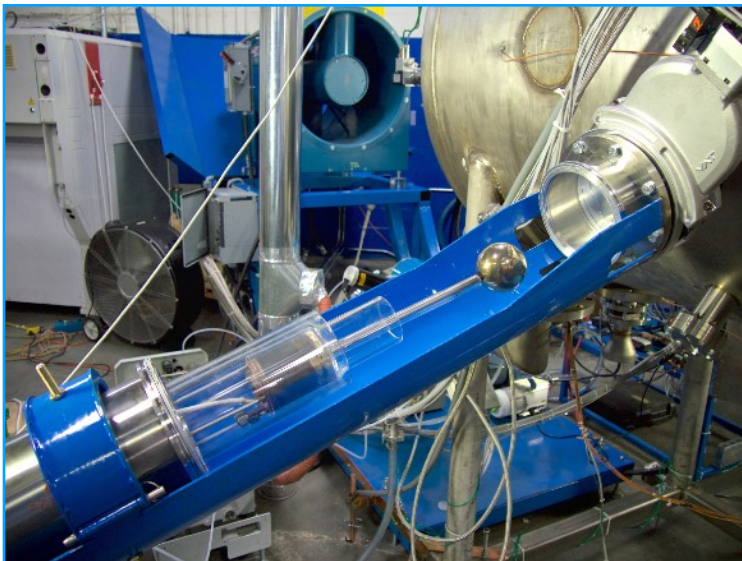


The cathodes are also servomotor controlled and can be moved closer to or further from the anode in an accurately measured manner.

*Showing the Servo Computer Numerically Controlled cathode actuator mounted on the chamber door with surrounding cooling shroud.*

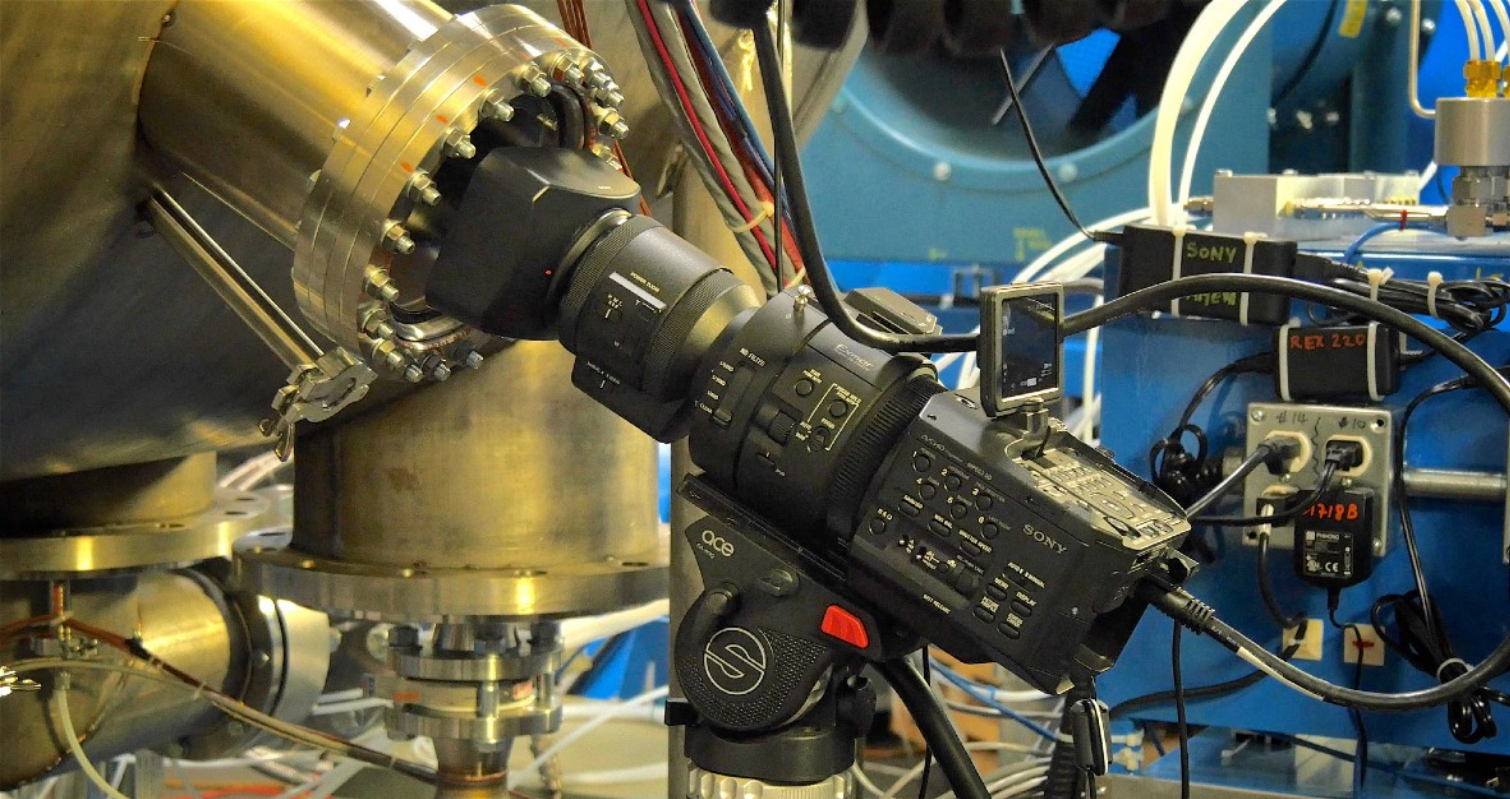


The anode itself can be withdrawn into an airlock and replaced without substantially affecting the vacuum in the chamber.

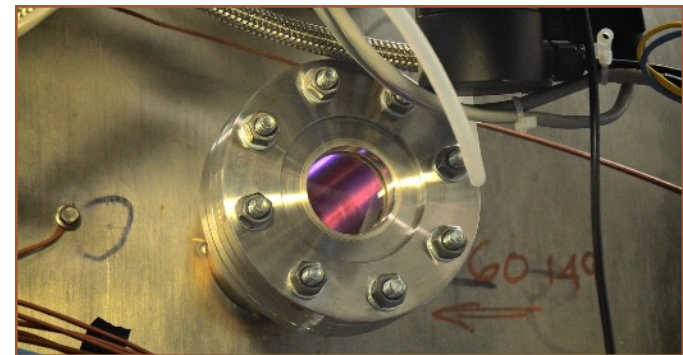
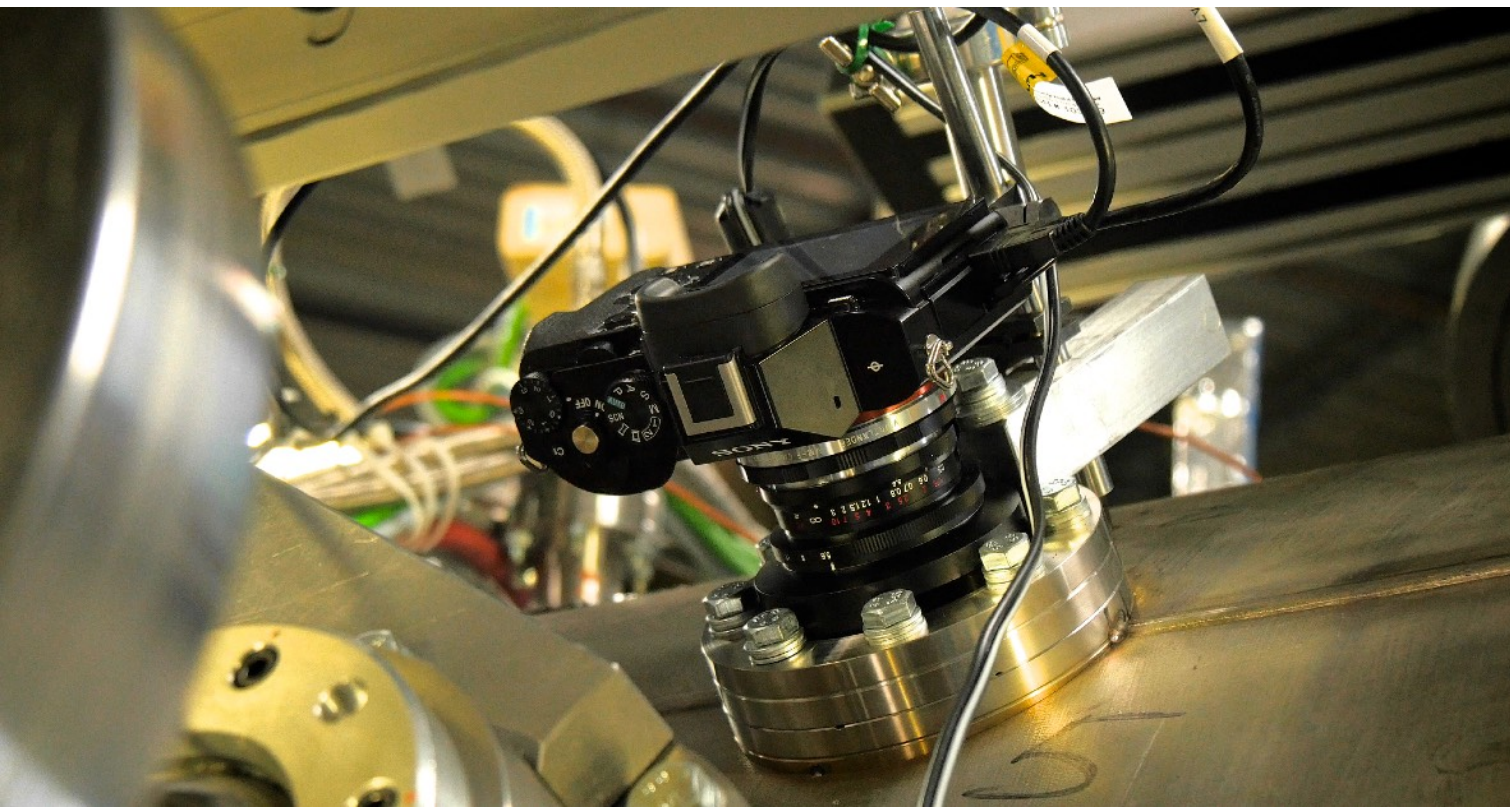


*Leighton Macmillan, Joe Palermo, Jan Onderco and Montgomery Childs loading the anode into the reactor chamber*





There are viewports into the chamber allowing for the external mounting of still, high-speed, infrared, and ultraviolet cameras. Antennas for measuring radio and electromagnetic signals are mounted on the inside of the chamber.





A power supply capable of producing 200kW of clean, continuous, direct current and voltage was constructed for the project. Both voltage and current delivered by the power supply can be varied and monitored independently.

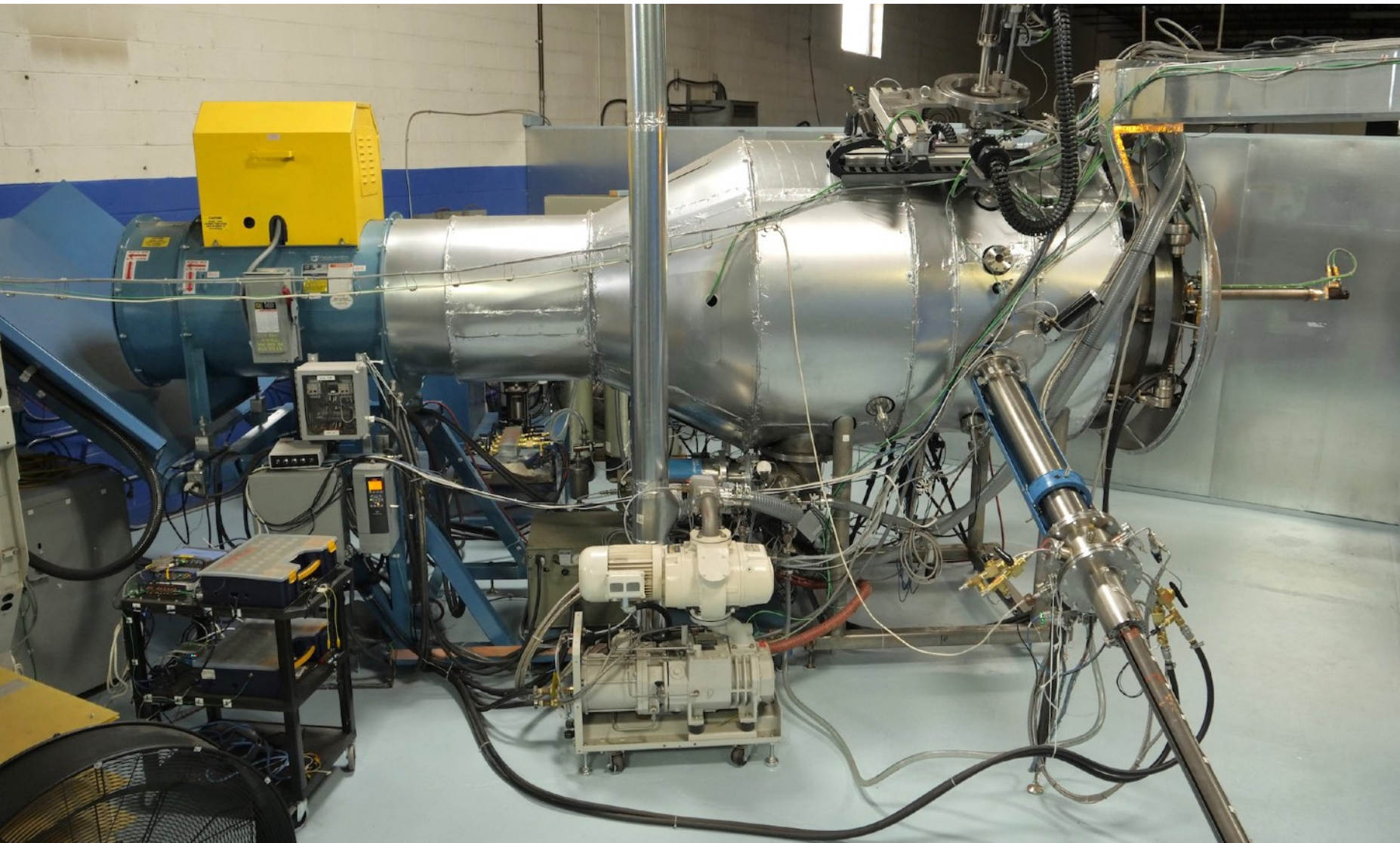


*Primary controller*



*Primary transformer*





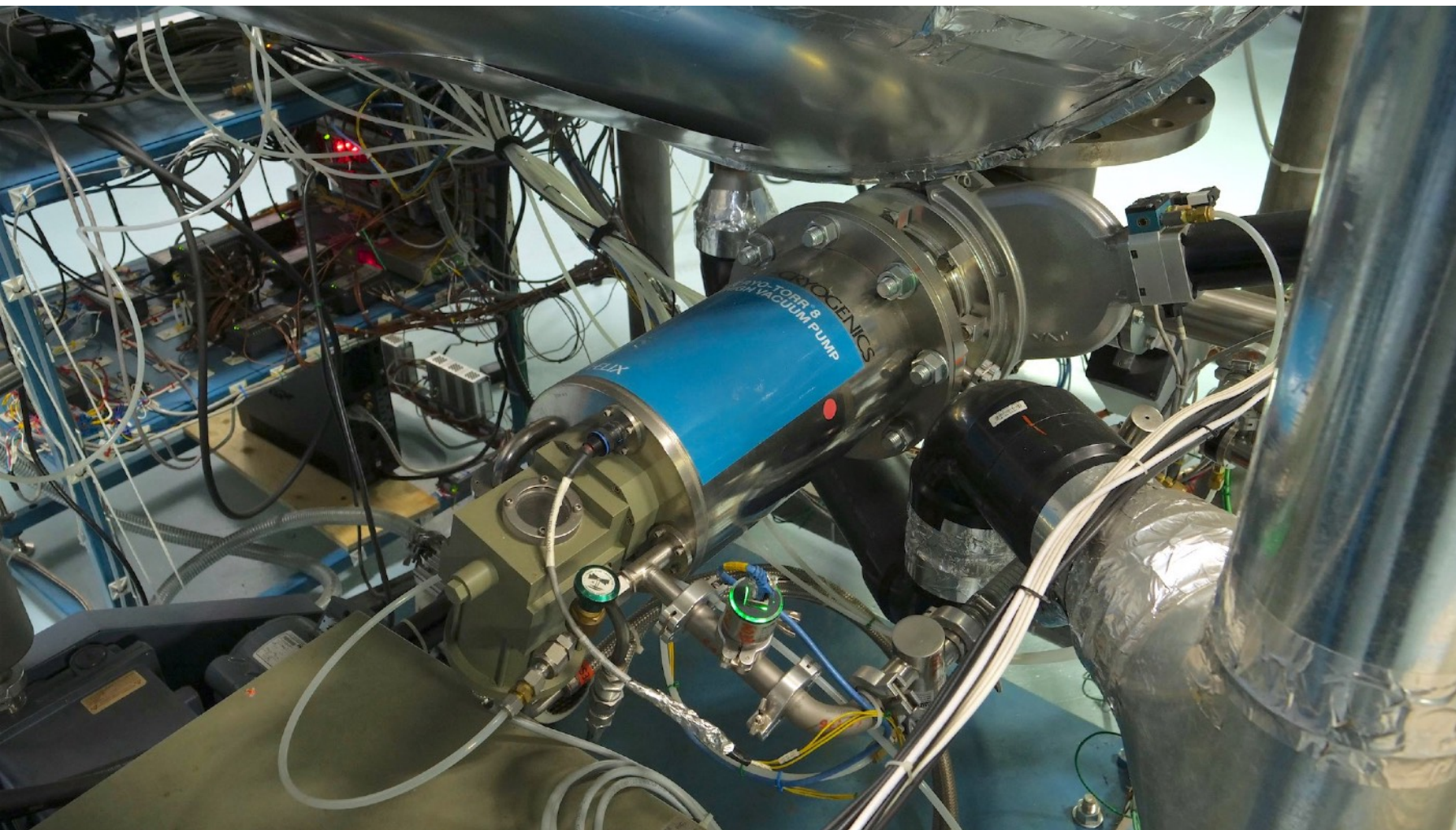
To solve the problem of excess heat: a metal shroud surrounds the apparatus chamber; a high-volume – high pressure fan blows air under the shroud; the gimbal-mounting probe assemblies are cooled by a pressurized nitrogen gas system; circulating de-ionized water cools the anode, vacuum pumps and other equipment. These cooling systems allow for much longer experimental run times than were possible with the small bell jar. Unanticipated excess heat remains a problem.



Gases, such as hydrogen or deuterium, can be introduced into the chamber so experiments may take place in different atmospheres. Vacuum pumps lower the pressure within the chamber to 0.1 micron.







A cryopump provides additional assistance in controlling the atmosphere within the chamber, in particular by removing water vapor. As a safety measure, the chamber can be rapidly flooded with nitrogen.



Information from the experimental data gathering, safety, and apparatus operating systems, with all of its valves, gauges, pumps, and sending units, are fed into computers in the main control room where it is displayed on numerous monitors. All that gathered information, regardless of its source, goes into a data acquisition transform engine where it is sorted and filed on a Linux server. This information system allows for concise post-experiment data mining and analysis.



*Paul Anderson running tests in the SAFIRE control room (SAFCON)*





The off-the-shelf availability of most of the components of the experimental system is a relatively recent development. This has allowed the team to build and operate a robust, sophisticated, and comparatively low-cost device in a way that could not have been accomplished just a few years ago.

*The SAFIRE engine is made up of 40,000 parts.*



THE SAFIRE PROJECT Team

Montgomery Childs

*Principal Scientist, Design Engineer*

Dr. Michael Clamage

*Astrophysicist*

Dr. Paul Anderson

*Design of Experiments, Chemist*

Dr. Lowell Morgan

*Applied Physicist*

Wallace Thornhill

*Cosmologist Electric Universe*

Dr. Donald Scott

*Plasma Electrodynamics*

Jan Onderco

*Computer Science and Data Acquisition*

Jason Lickver

*Systems Engineering and Telemetry*

Leighton MacMillan

*Mechanical and Electrical Technician*

Ben Ged Low

*Cinematography, Optics, Video Capture*







SCIENCE REVIEW Team

Dr. James Ryder

*Chairman  
International Science Foundation*

Harold Puthoff, PhD

*Director, Institute for Advanced Studies at Austin*

Eric W. Davis, Ph.D.

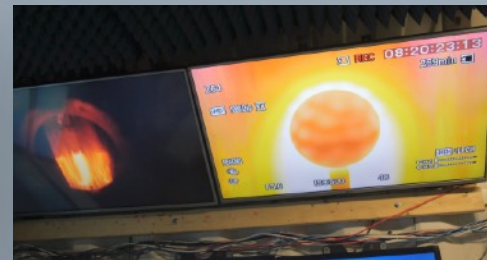
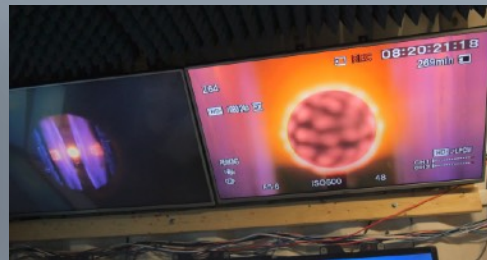
*Chief Science Officer  
Institute for Advanced Studies at Austin, Austin, TX*

William A. Gardner

*Professor Emeritus  
University of California*

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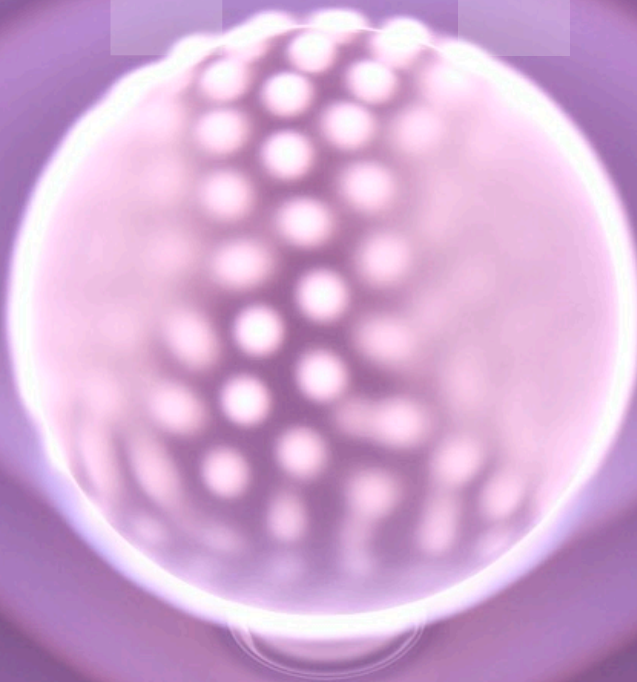
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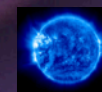


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