
SAFIRE

SAFIRE

PROJECT REPORT

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

The SAFIRE PROJECT generates the same energy densities as the sun’s photosphere and nuclear bombs . . .

. . . in a laboratory on Earth.

The SAFIRE sun, photographed in the SAFIRE lab, Mississauga, Ontario, Canada, June 15, 2016

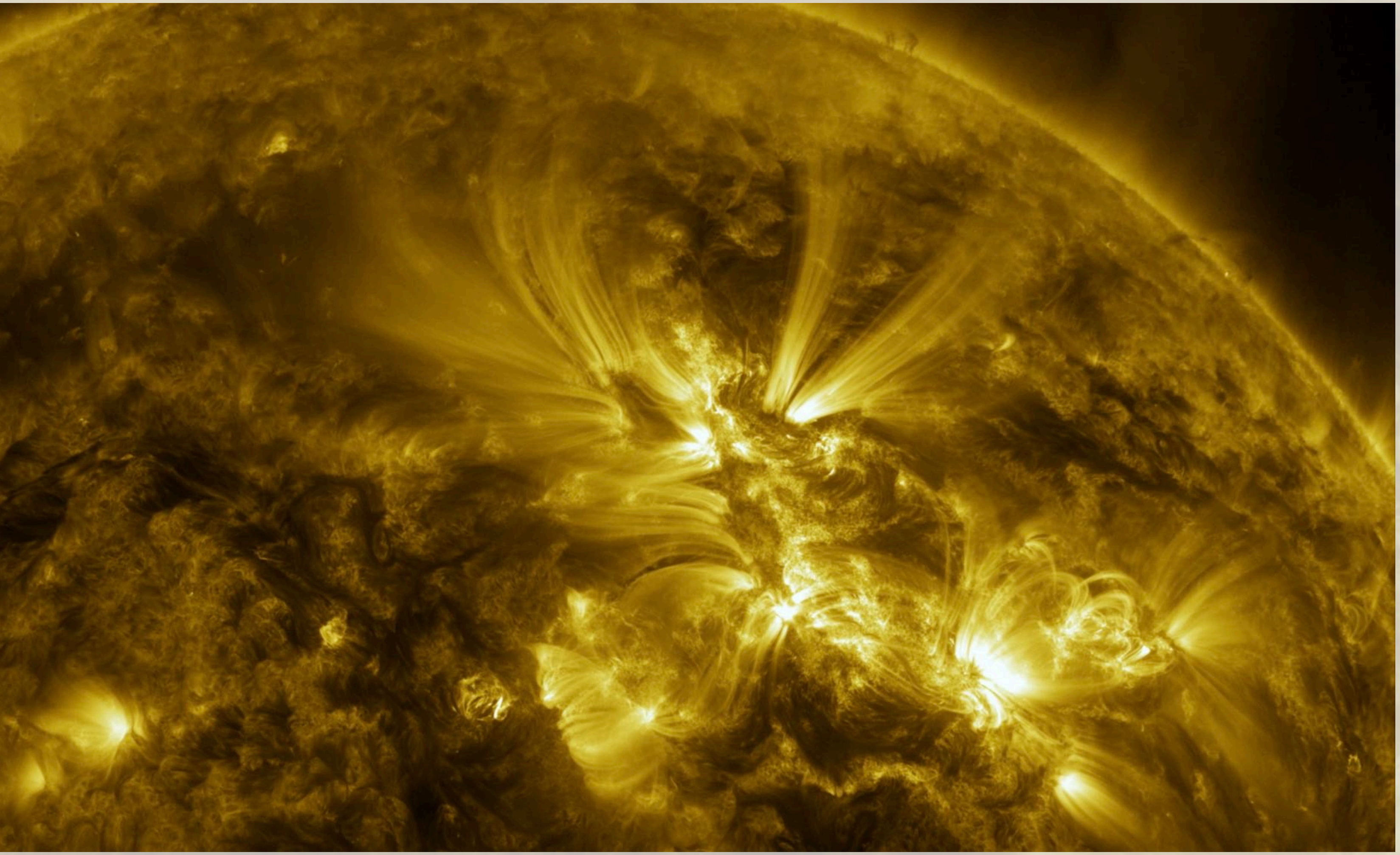
ORIGINS

In 2011 engineer Montgomery Childs was researching photovoltaic energy production systems when he noticed that aspects of the Sun's behavior appeared to contradict expected behavior predicted by the standard model of solar physics.

Childs discovered the work of a group of scientists investigating the role of electricity in the functioning of the Sun's atmosphere. The group had been developing a hypothetical model that they called 'The Electric Sun' (ES).

The model is not without precedent. Some of the most illustrious explorers in the history of the sciences have long proposed that electricity plays a much more important role in the heavens than has been acknowledged – Benjamin Franklin, Michael Faraday, James Clerk Maxwell, Sir William Crookes, Kristian Birkeland, Nicola Tesla, Irving Langmuir, Hannes Alfvén, to name only a few.


Benjamin Franklin
Michael Faraday
Kristian Birkeland
James Clerk Maxwell
Sir William Crookes
Nicola Tesla
Hannes Alfvén
Irving Langmuir



Montgomery Childs did not immediately find answers to his questions about photovoltaic energy, but he was so intrigued by the possibilities of the ES model that it started him on a new line of inquiry.

“If you want to test something, you have to know it is testable.”

Childs conducted a preliminary evaluation to determine if the ES model might be testable. He employed the powerful Design of Experiments (DOE) methodology. DOE are used throughout industry to illuminate even the most obscure factors responsible for the outcome of a process. That’s how an auto manufacturer can make 120 million brake sets a year without a single failure.

This evaluation led Childs to a particular insight. There are billions of stars in our galaxy. Throughout human history their luminosity, spectral nature, and thermal characteristics have remained relatively constant (a super nova or a pulsar is so rare an event as to be considered an ‘outlier’, and not that relevant to the overall equation). In industry, something as statistically stable as the stars suggests a relatively simple process. But what would that process be?

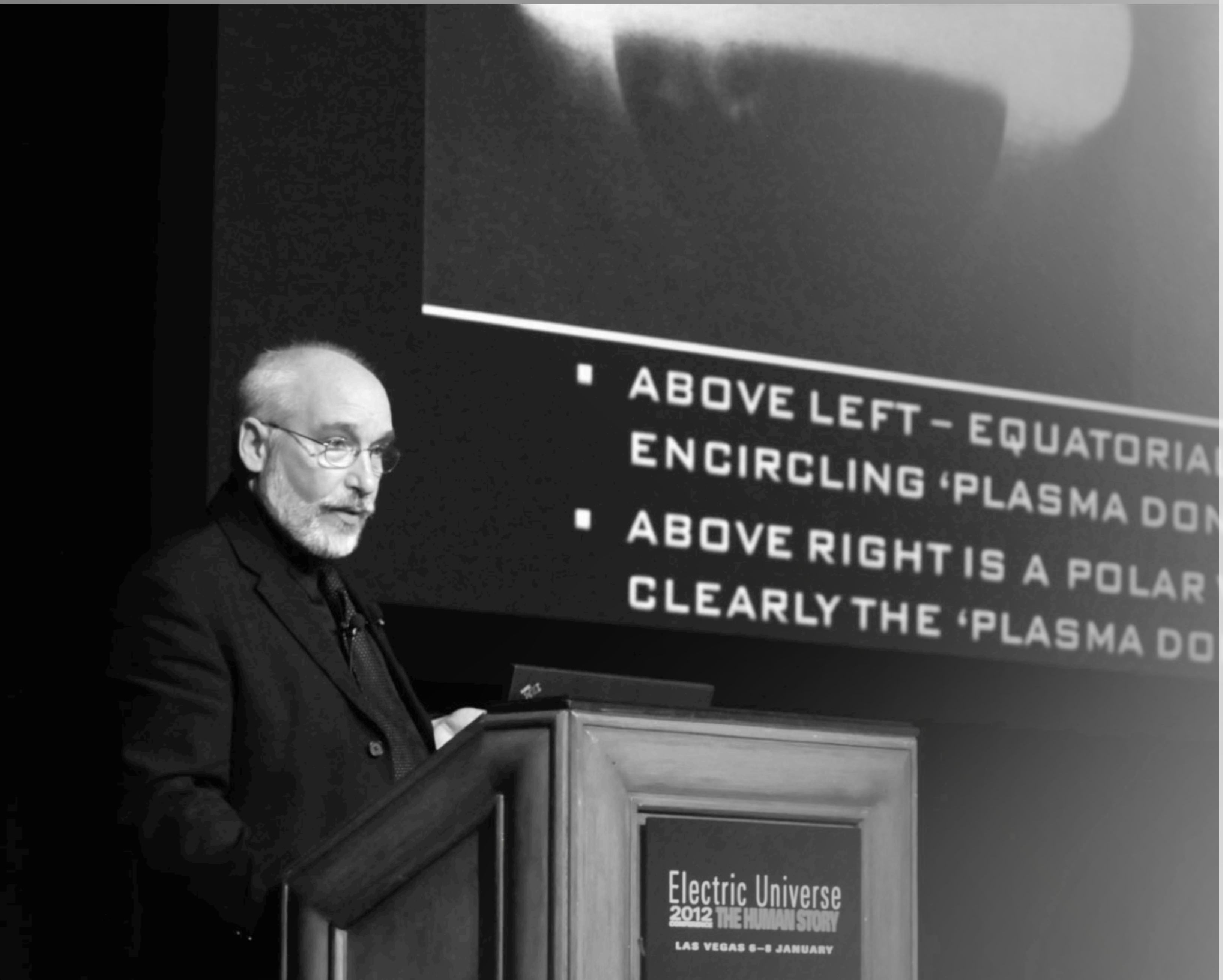
Exploring the work of William Crookes, Childs was struck by one of Crooke's famous experiments. Crookes placed rubies in a vacuum tube filled with an electrically charged rarified gas. Although the rubies were not part of the electrical circuit they mysteriously started to glow.

Based on their spectral emissions, it is known that stars differ in their makeup.

The ES model, Crookes work, and Childs' DOE statistical analysis, indicate it is not of primary importance what a star is made of, only that it interacts electrically with its environment. He began to see where the premise of an Electric Sun (ES) model could be boiled down to *a fundamental process of charged plasma affecting matter of a different electrical potential*.

And this is a process that can be created and tested in a lab.

"A fundamental process of charged plasma affecting matter of a different electrical potential."



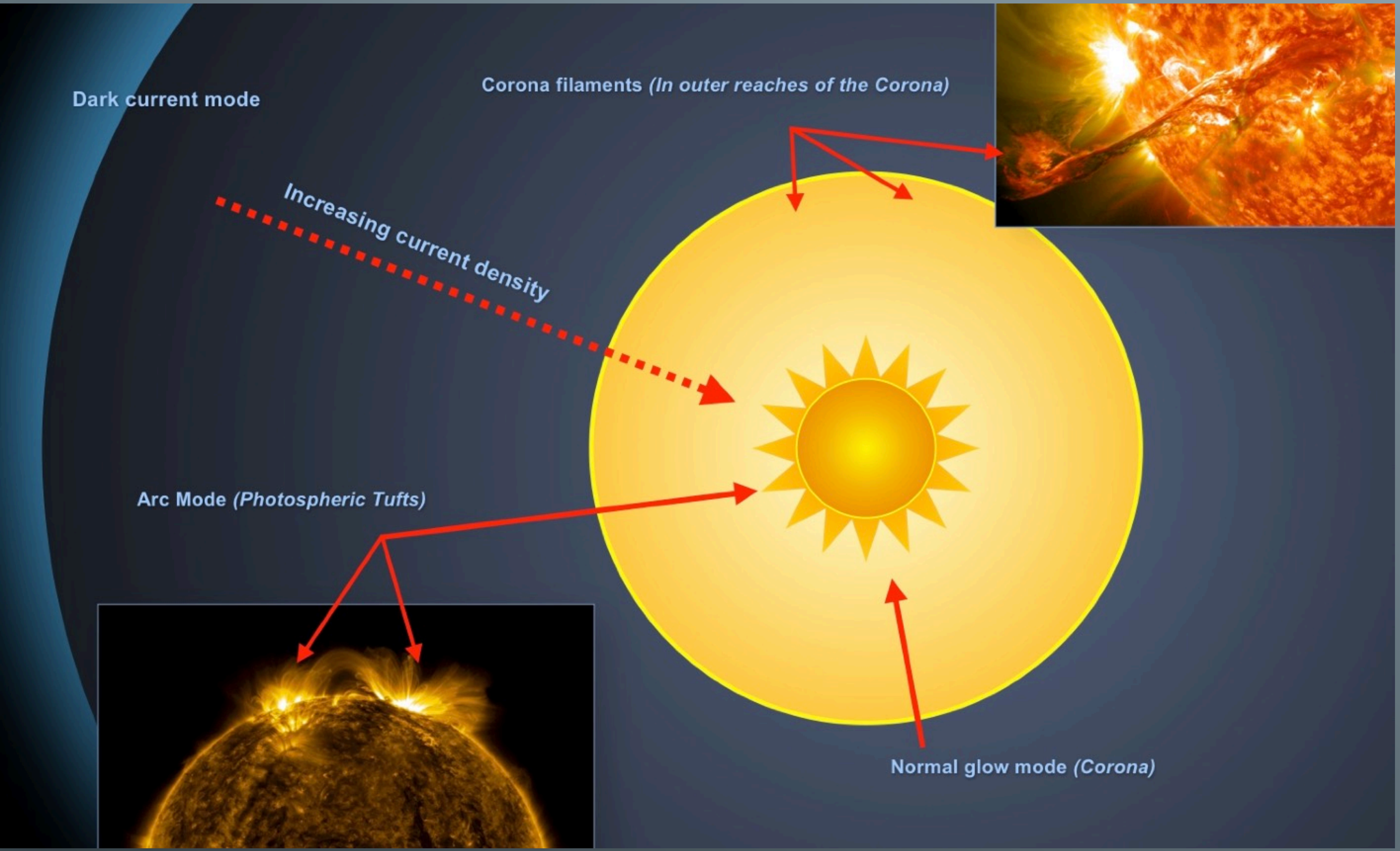
When he proposed the model might be empirically tested in a laboratory, Childs was invited to present his ideas at conferences exploring the role of electricity in nature.

In 2012 he stressed the fact that he had used the (DOE) to evaluate the model and it showed that it was, in fact, testable. He also stated that the robust DOE analysis would be used to direct the design of an experimental apparatus to model solar dynamics.

After his second presentation at a 2013 conference, a small group of interested people convened and discussed in more detail the possibility of building an apparatus to test the hypothesis.

Funding for an initial test was promised by the Mainwaring Archive Foundation, to be administered by the International Science Foundation. Scientists with backgrounds in plasma physics, astrophysics, electrical engineering, and chemistry joined as a core team.

The Stellar Atmospheric Function in Regulation Experiment (SAFIRE) was initiated. Its objective was to test the Electric Sun model.



The standard scientific technique for testing a model is to use the premise of the model to construct an apparatus that can challenge the model's predictions and provide evidence that will disprove or *falsify* the model. Or provide evidence that supports the claims.

There is a great danger in overstating the potential of a scientific experiment in the public forum, so the SAFIRE team agreed that any public discussion of the project would restrict itself to this one pragmatic objective: to test the model.

THE ELEPHANT IN THE ROOM

But right from the start there was *an elephant in the room*.

What if the Electric Sun model could not be falsified? What if the evidence revealed it was actually a viable model?

This was a very large elephant.

Photo: Lara Zanarini

PHASE ONE

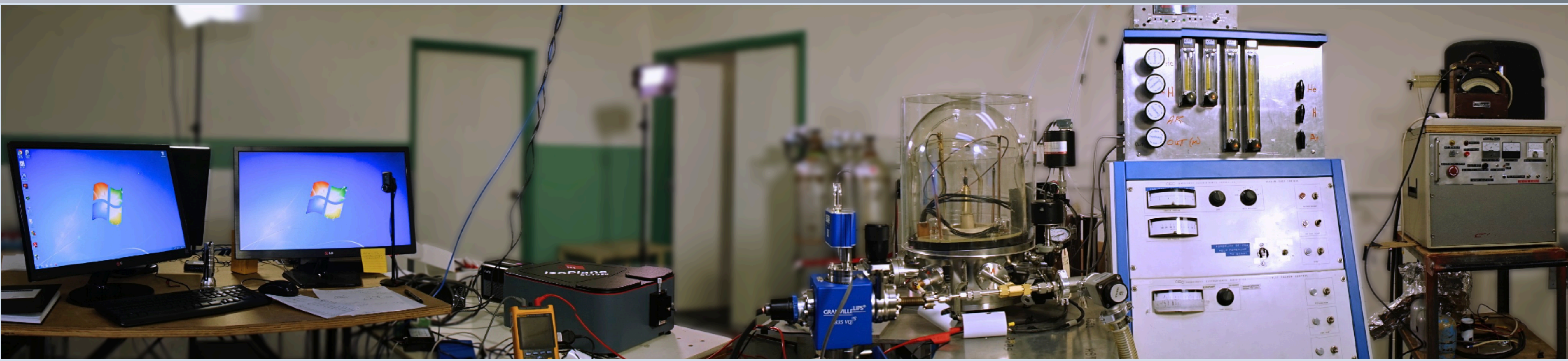
Anode

Proof of Concept: Bench top testing

The Sun's atmosphere is a stable plasma existing in the vacuum of space. The SAFIRE apparatus had to both create the plasma and gather and store data about its nature and characteristics. These lab data and observations could then be compared with similar data from actual solar observations.

After many conference calls among team members, literature searches, and meetings with vendors, a design was completed, lab space rented, equipment bought, borrowed, rented, and in early 2014 a small apparatus was constructed.

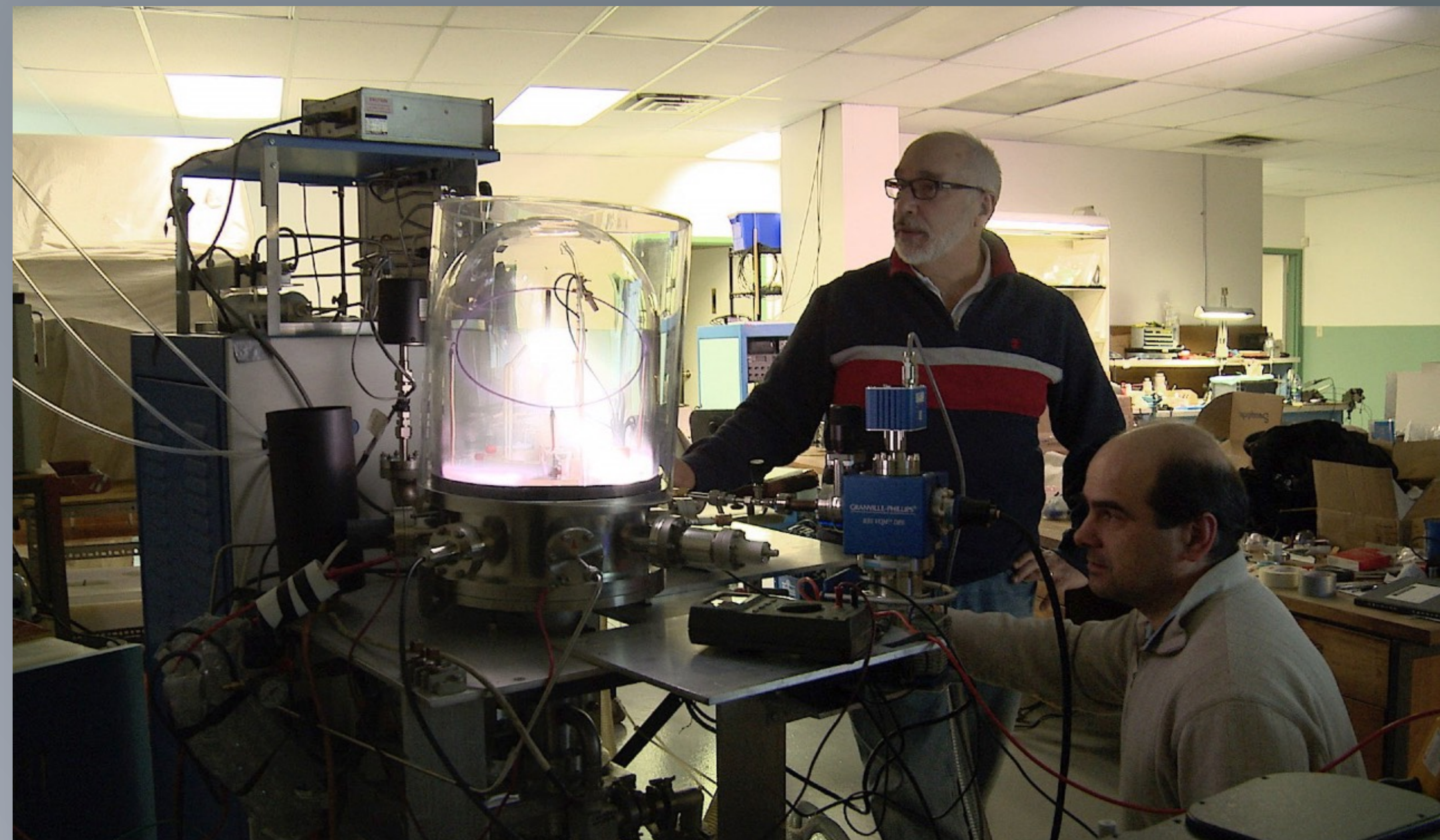
Michael Clarage, Montgomery Childs, Wal Thornhill, Paul Anderson at the University of John Hopkins



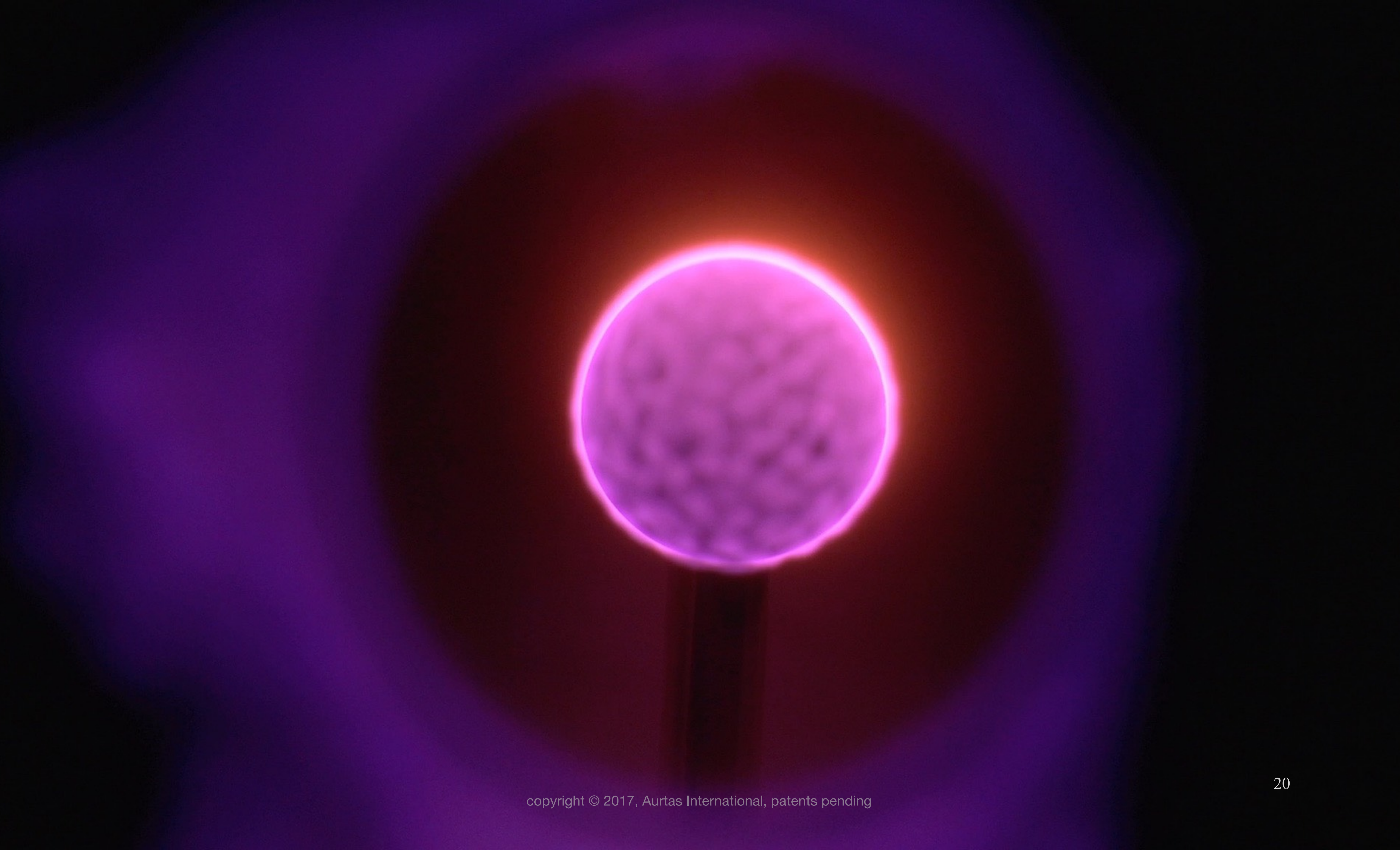
Phase I Lab with small bell jar to the left of the gas / vacuum control console

It consisted of a spherical metal anode; a variety of interchangeable copper cathodes inside a glass bell jar; pumps to create the vacuum; and an 1,800-watt direct current power supply to provide power to the anode. High speed and still cameras; an oscilloscope; and both an optical and a mass spectrometer would gather data.

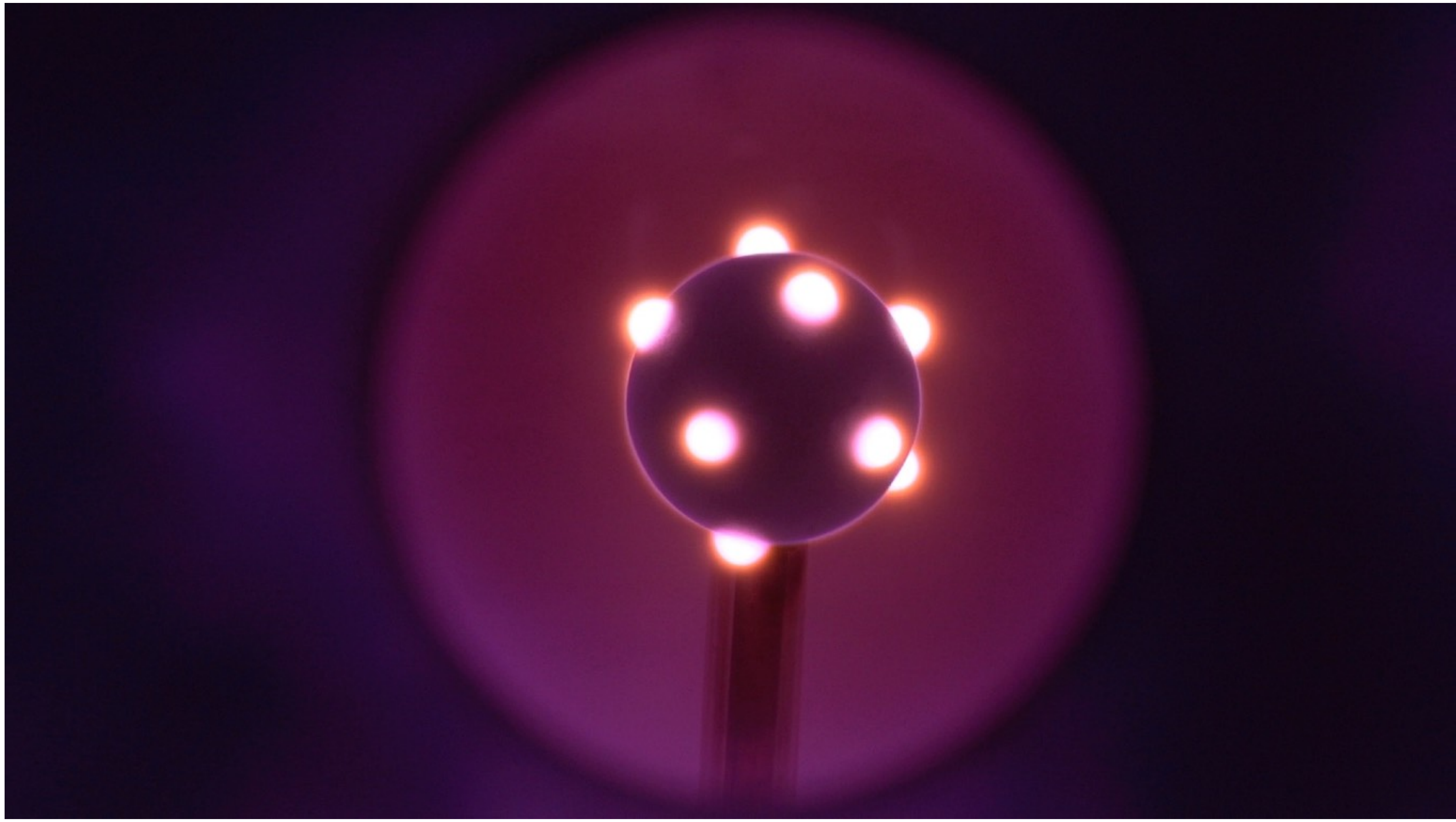
The prediction was that this rather simple combination of a positively charged anode in a negatively charged environment would produce a spherical plasma around the anode. And, it did just that.

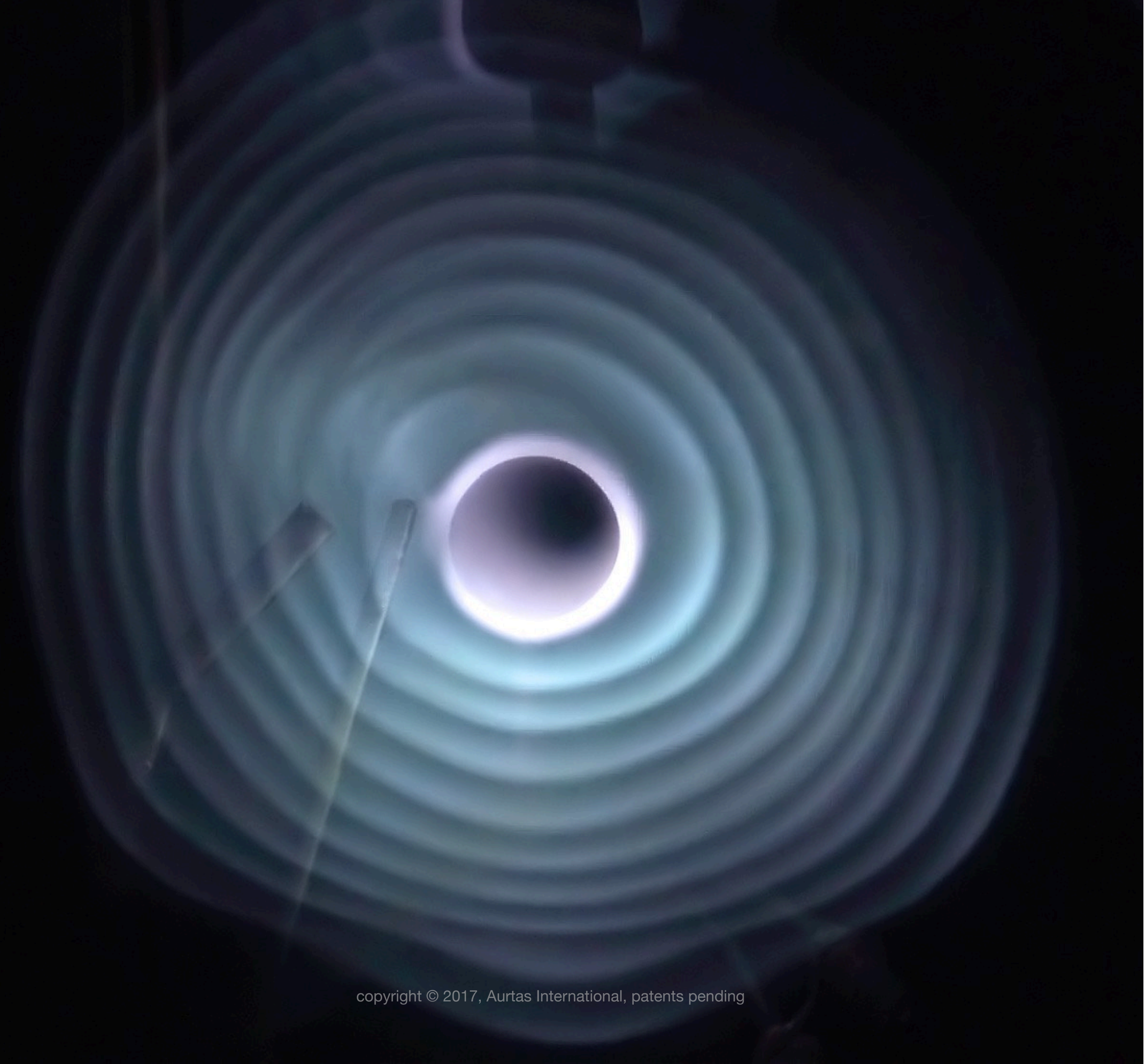


Montgomery Childs and Jan Onderco working with first proof-of-concept bell jar setup.



The first evidence of plasma phenomena were small, round tufts appearing on the surface of the anode. The tufts were in constant motion as they sought to maintain an equal distance from one another. Their numbers multiplied as the electric current supplied to the anode increased. When new tufts materialized in an empty space on the anode all the tufts jostled for an equidistant position from each other.



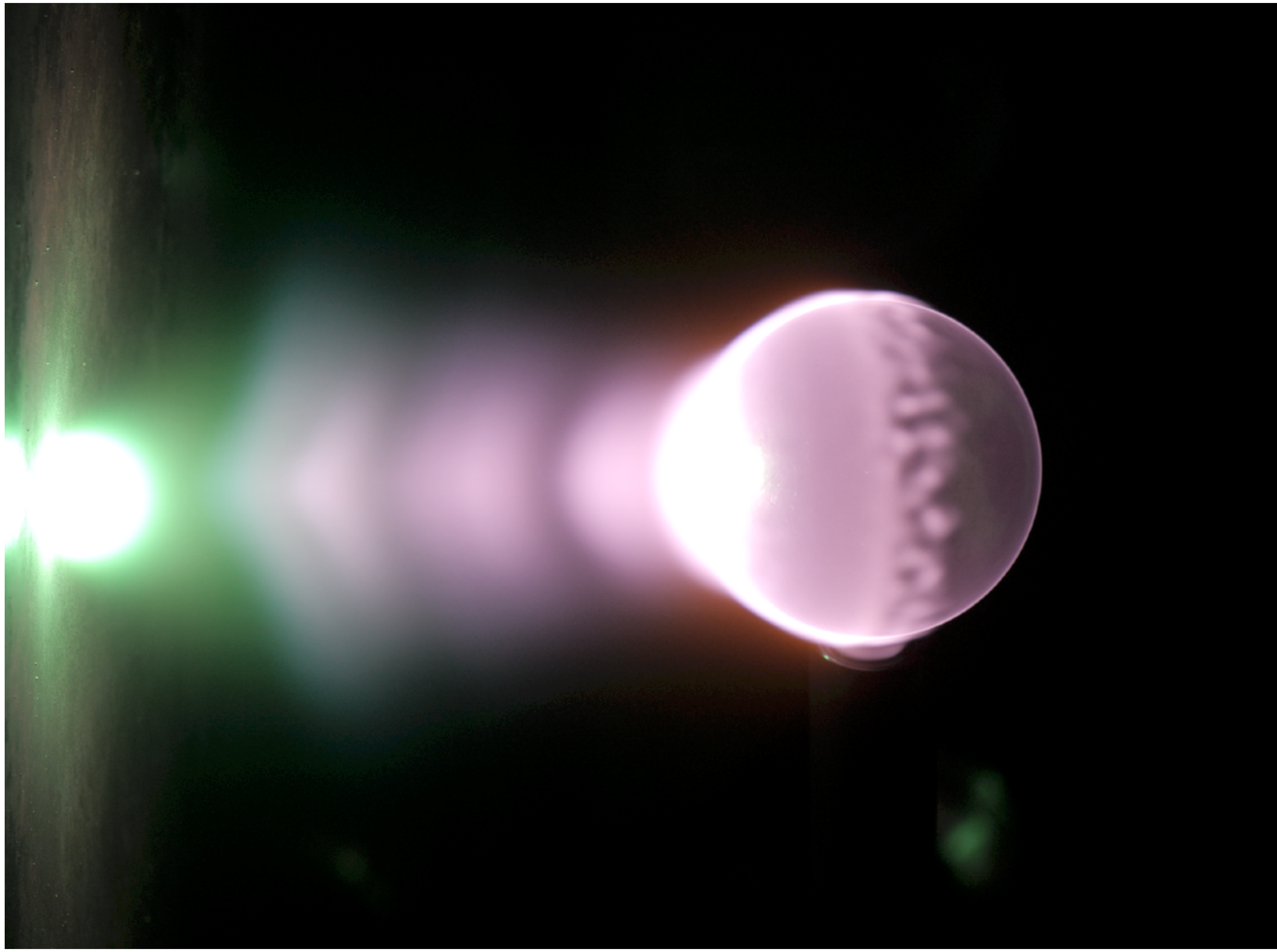


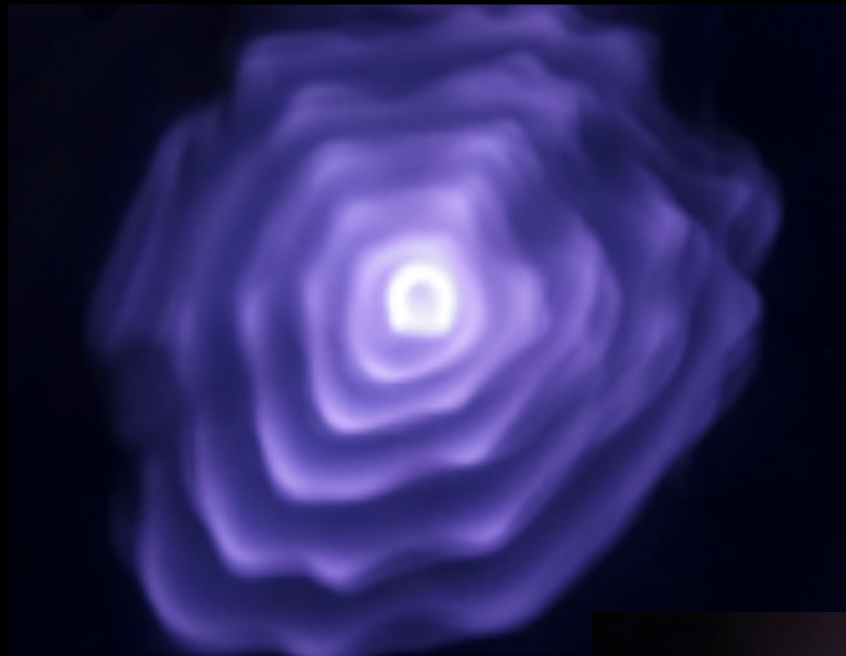
With the addition of power to the anode a spherical plasma shell appeared around the anode, obscuring the tufts. Whether the tufts formed this layer or remained on the anode beneath the dense plasma layer was unknown.

More plasma layers soon appeared around the first – forming many onion-like spheres. Each of these spherical shells had a distinct color and rotated independently of the others. These shells are known in the plasma physics community as Double Layers, because they have alternating layers of segregated positive and negative charges.

The discovery was made that the plasma double layer shells were self-organizing; and worked as high-energy containment fields for the dense plasma within.

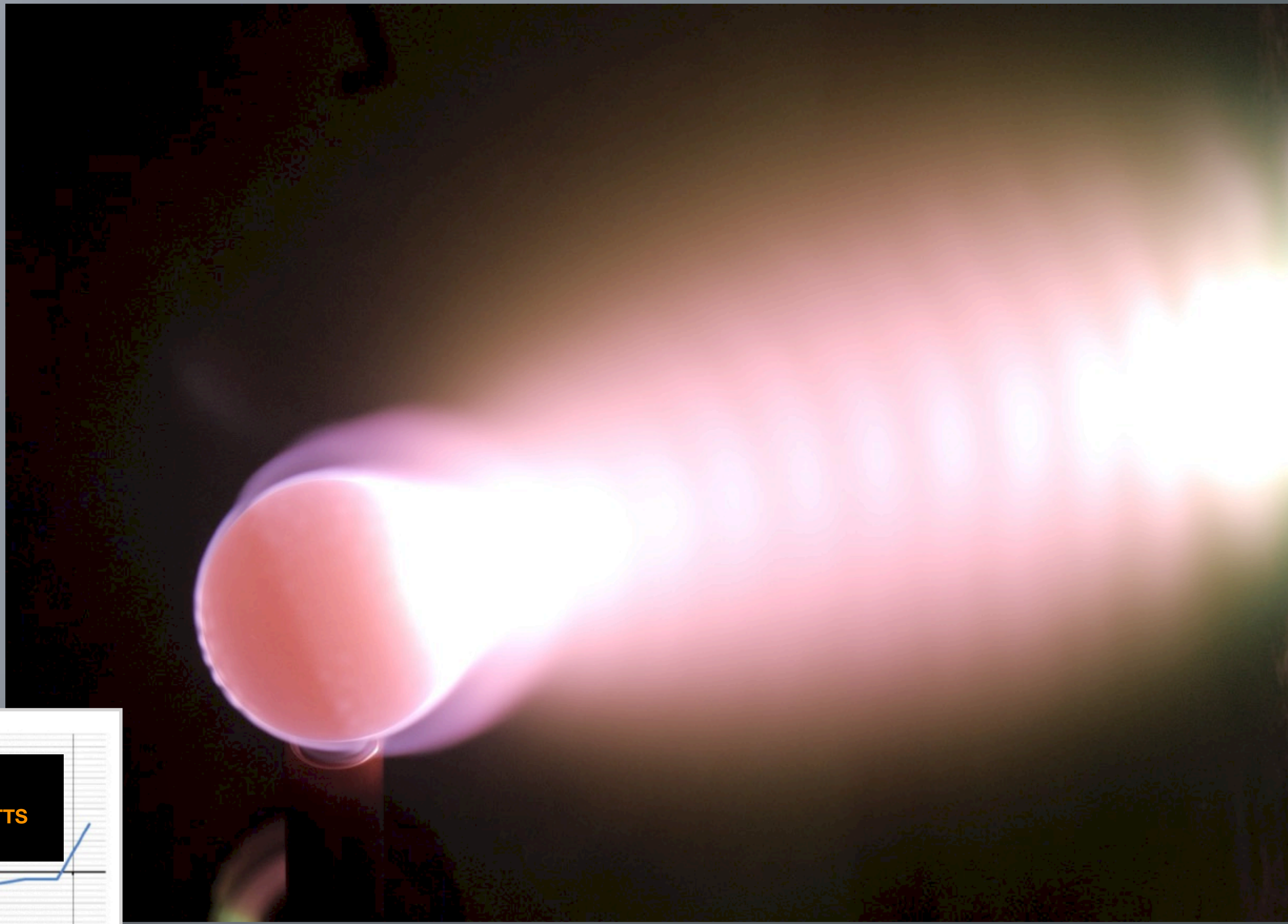
Also measured were sudden, short-lived releases of high energy. Even though the power supply could only input 1,800 watts, the oscilloscope showed transient discharges of 2,000,000 to 10,000,000 watts.

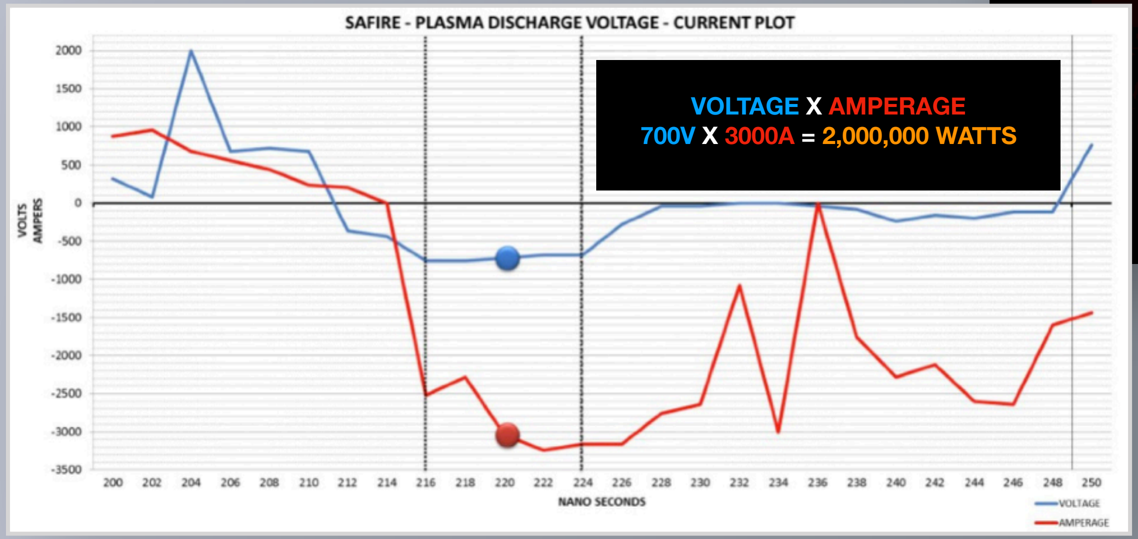


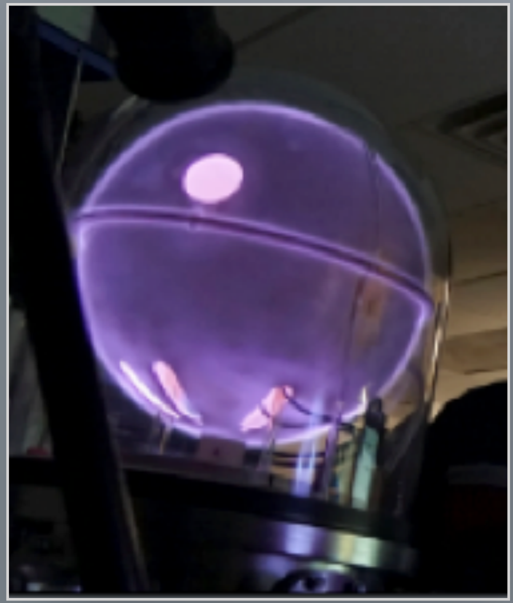


Each of these spherical shells had a distinct color and rotates independently of the others

Experiments revealed that changing the size of the anode or altering the configuration or shape of the cathode did not produce changes in plasma behavior or structure. But if the size of the anode increased, so did the size of the plasma spheres. In either case the same nested spherical double layer shells formed.







Three types of cathodes used during DOE testing

This Phase I apparatus had the capability to consistently produce stable plasmas, but two issues indicated it was time to scale up to Phase II: there was a lack of interior space for diagnostic instruments; and the large amount of heat being produced limited run times and thus required the need for cooling systems.

The bench top had achieved its purpose; a sun-like spherical plasma could be created, sustained within a vacuum chamber, and analyzed in a laboratory.

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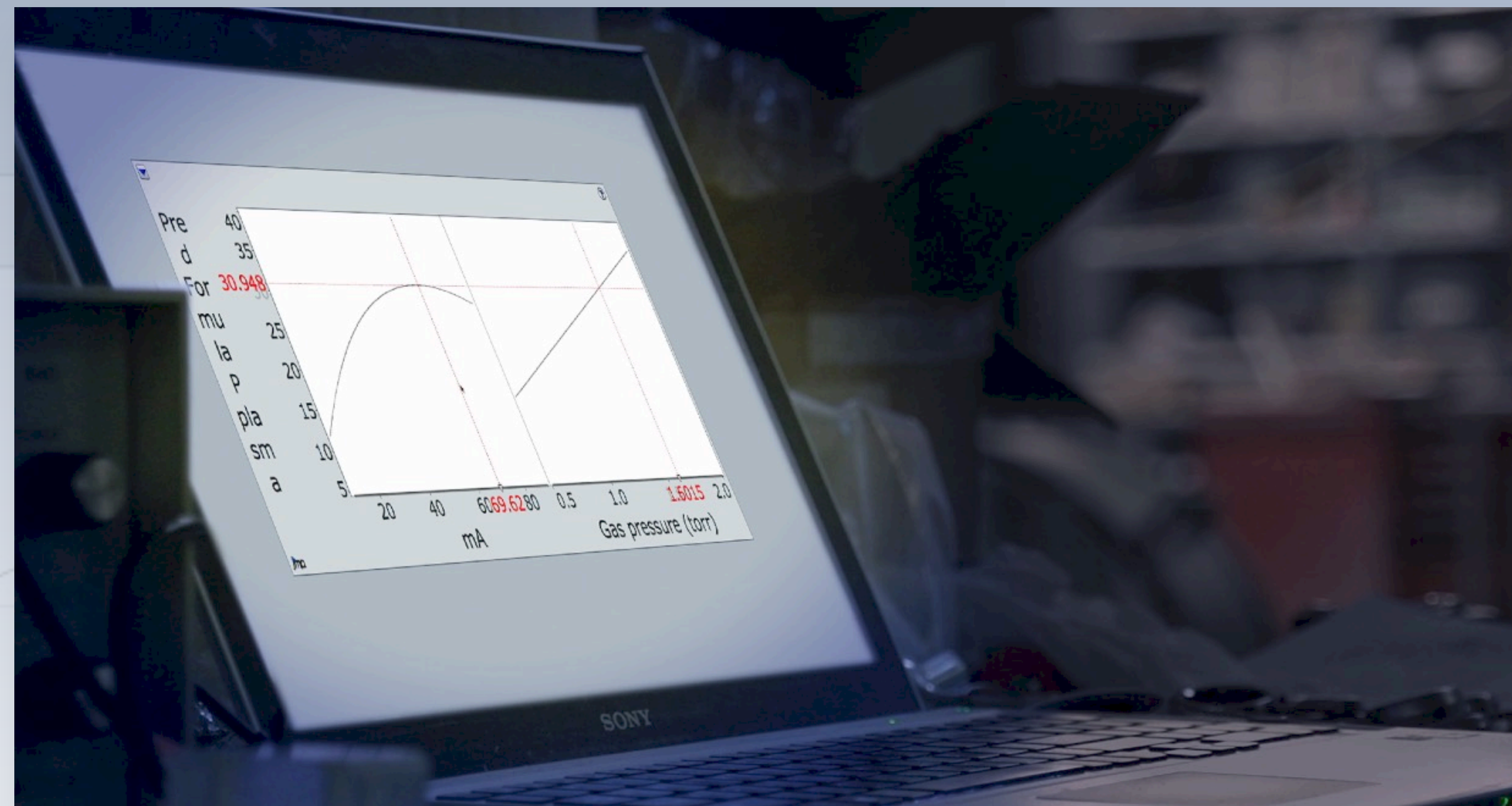
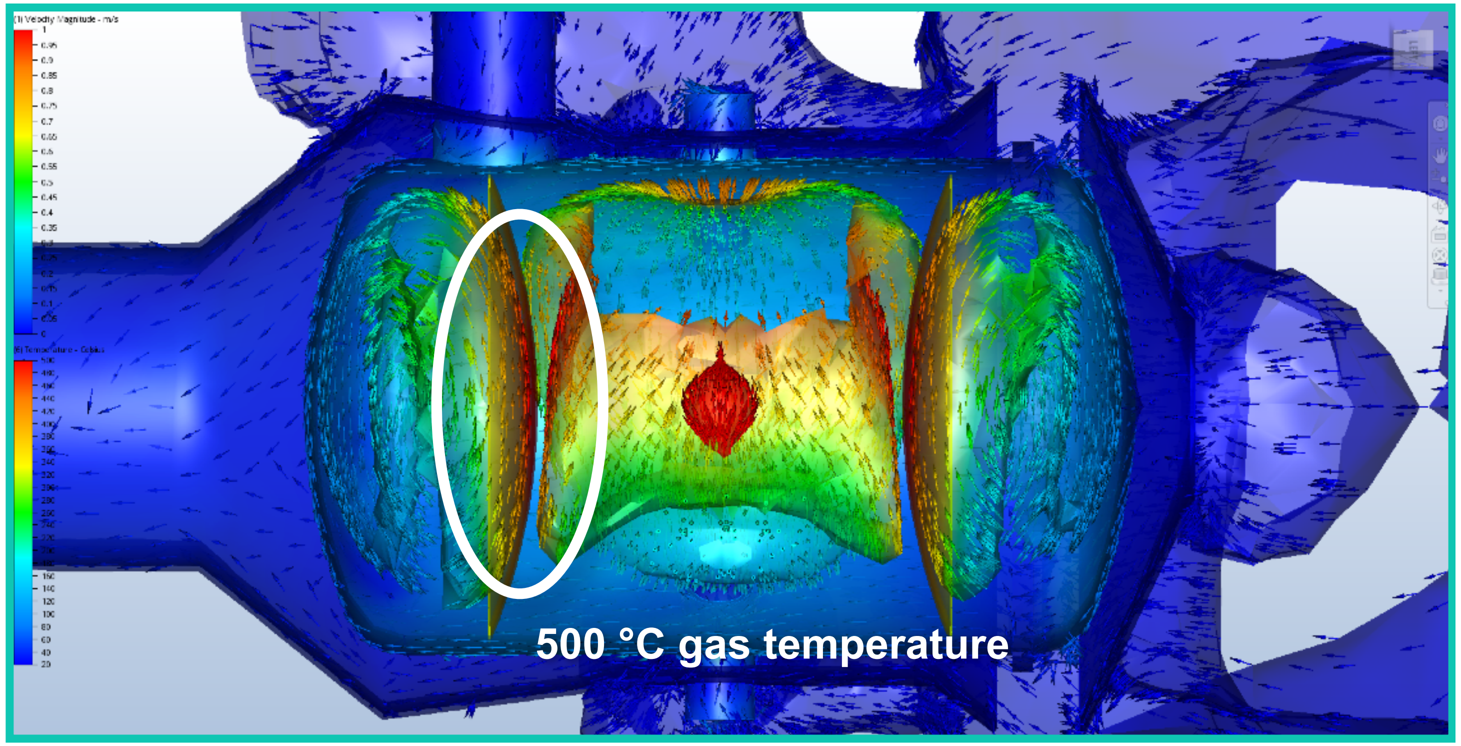
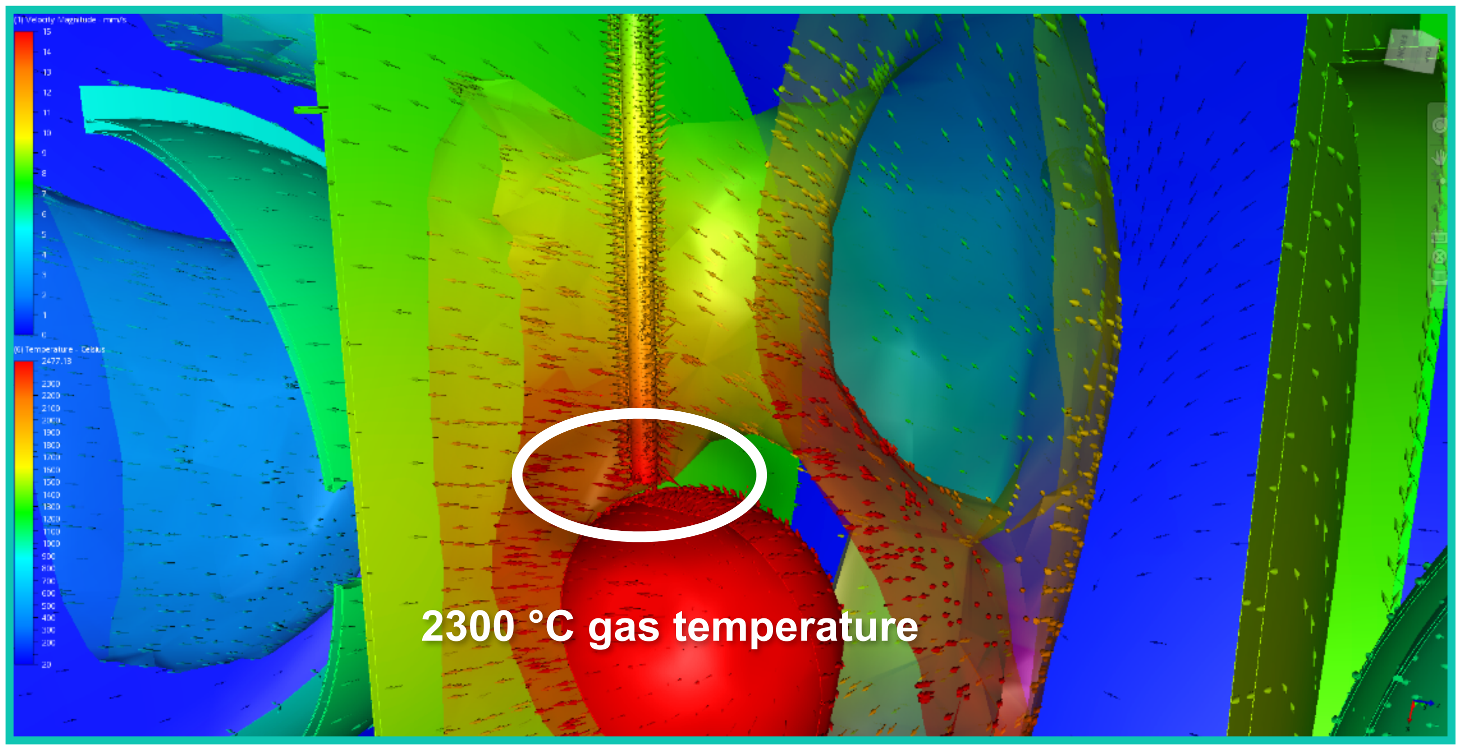
As has been throughout the project, the Design of Experiments method was employed in planning and engineering the new equipment. Systems control, enhanced data acquisition, and functionality were just three of the many capabilities taken into consideration.





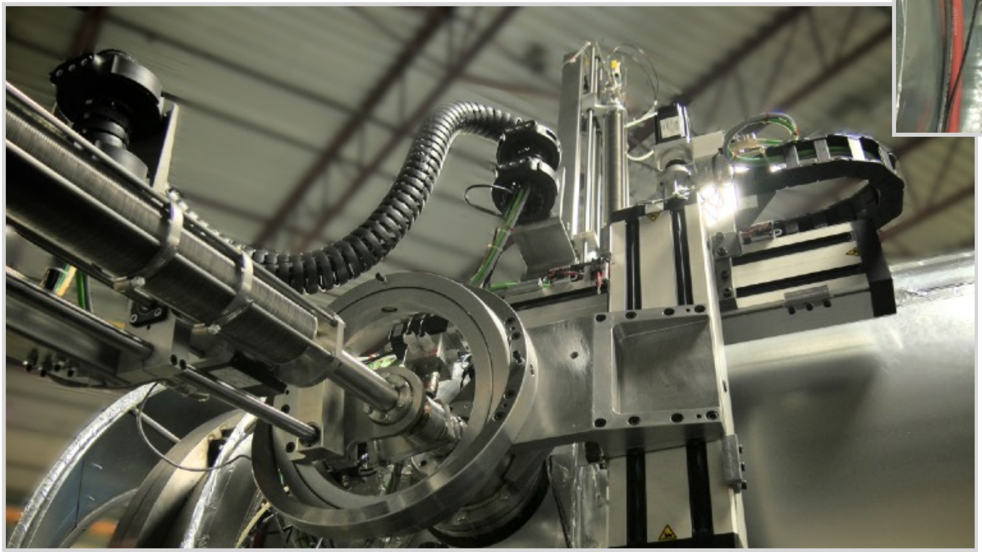


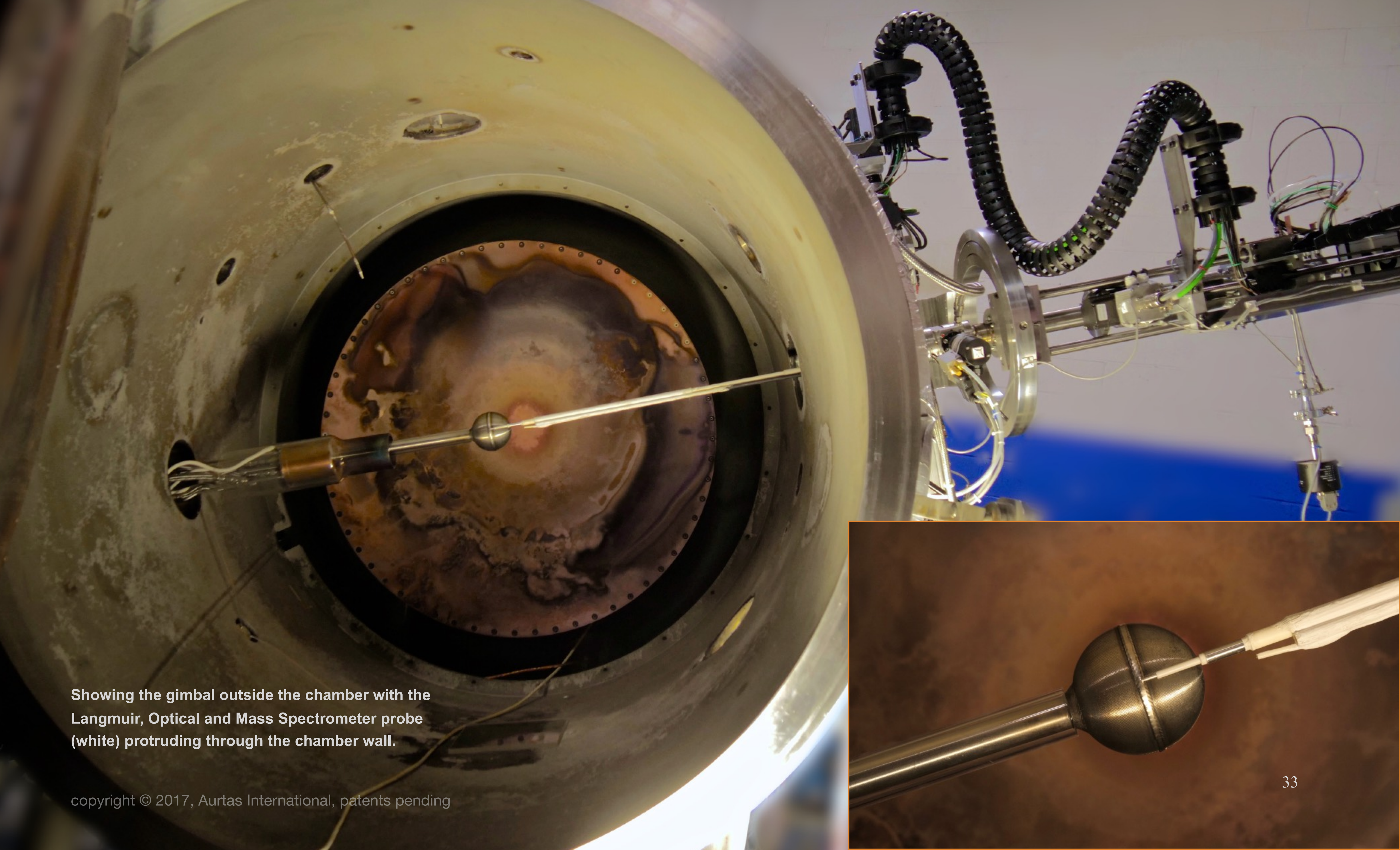
Also used were software programs for computer aided design, computational fluid dynamics, and finite element analysis.

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

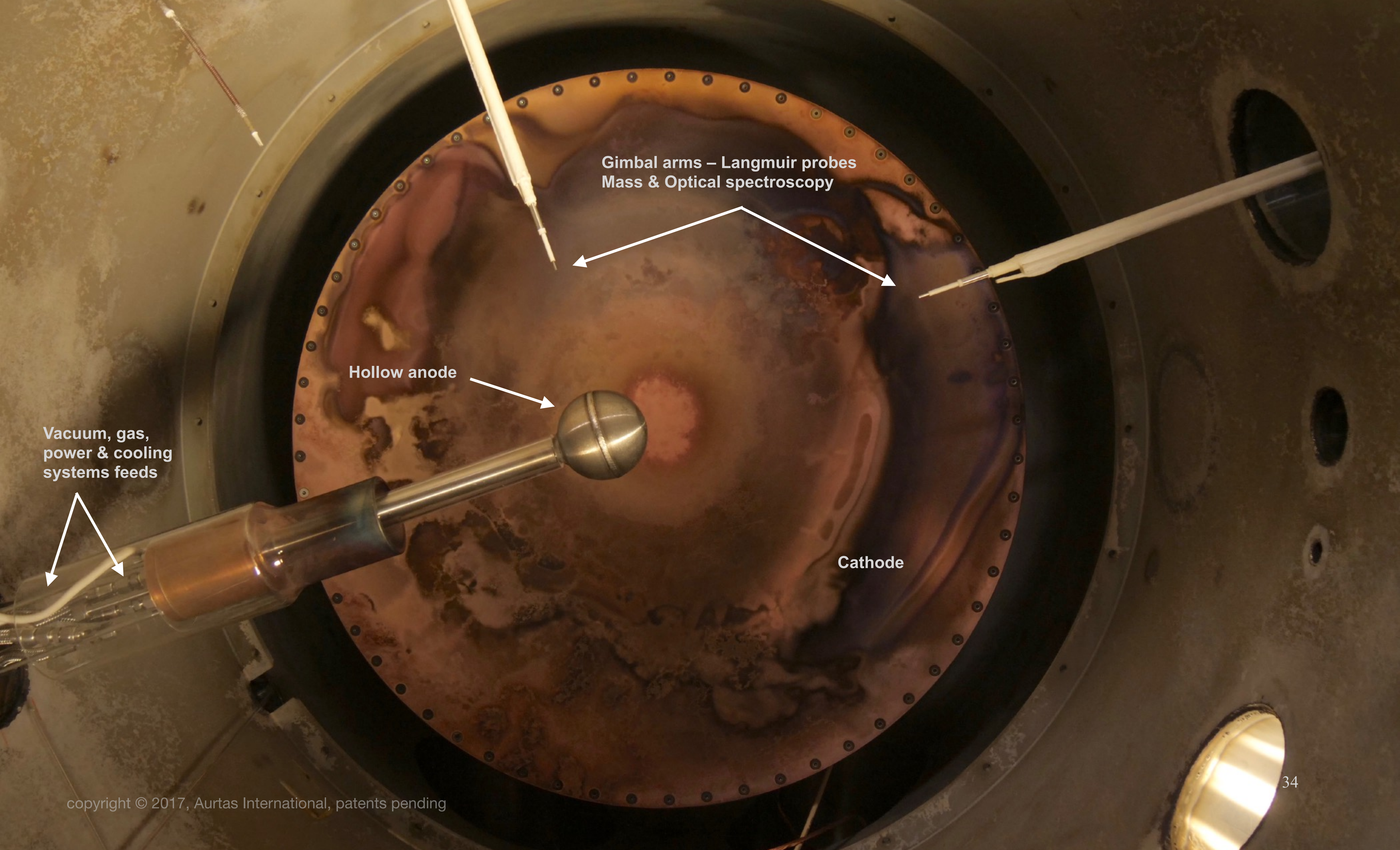
Particular attention was paid to the parts of the apparatus that would probe the plasma and gather data about it.

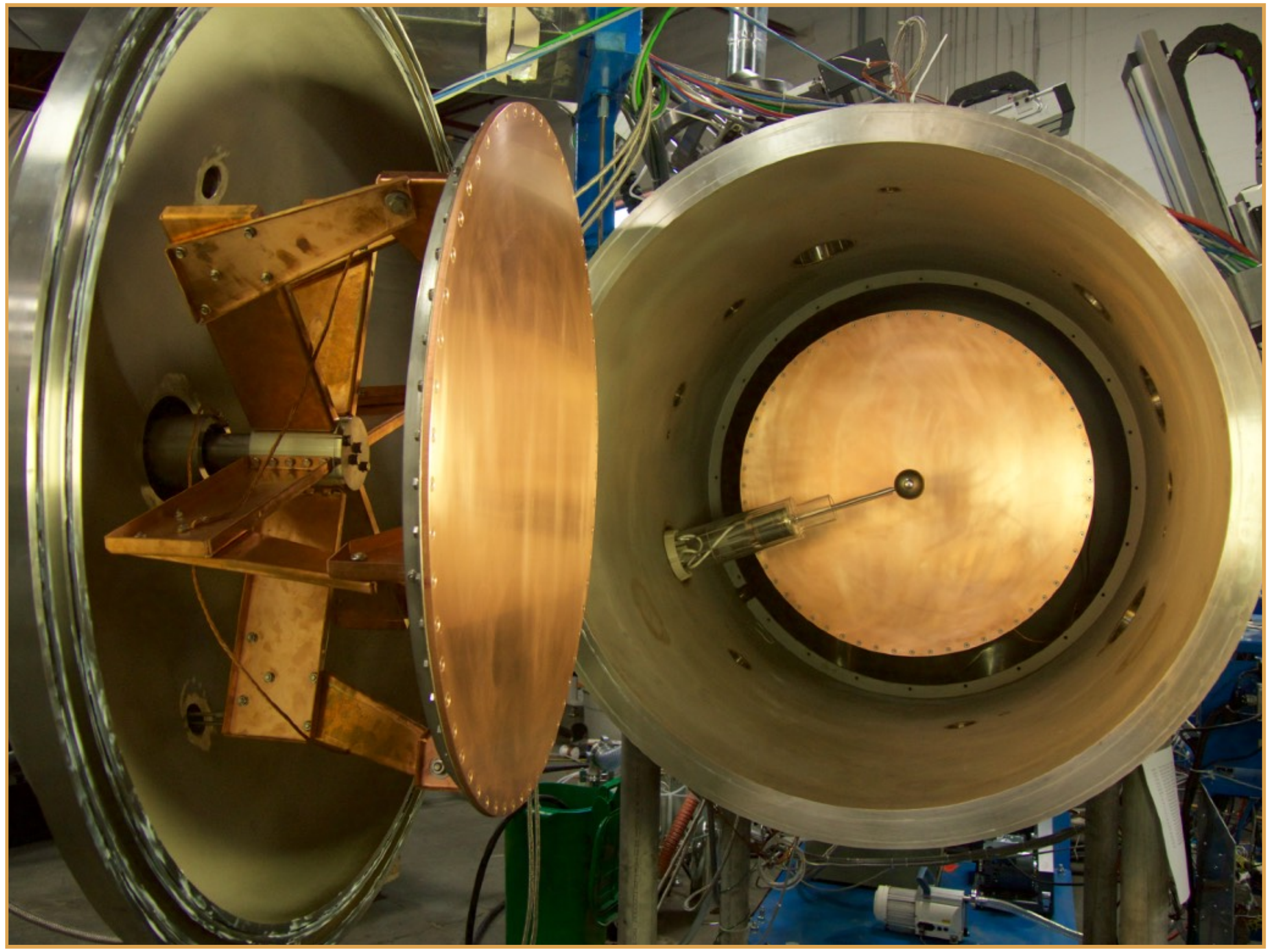
The team designed a manipulating arm to mount a Langmuir probe and mass and optical spectrometer sensors. The arm is unique in design as it employs the characteristics of a gimbal with a multi-axis computer-numerically-controlled servomotor system. There are two independently directed gimbals that provide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



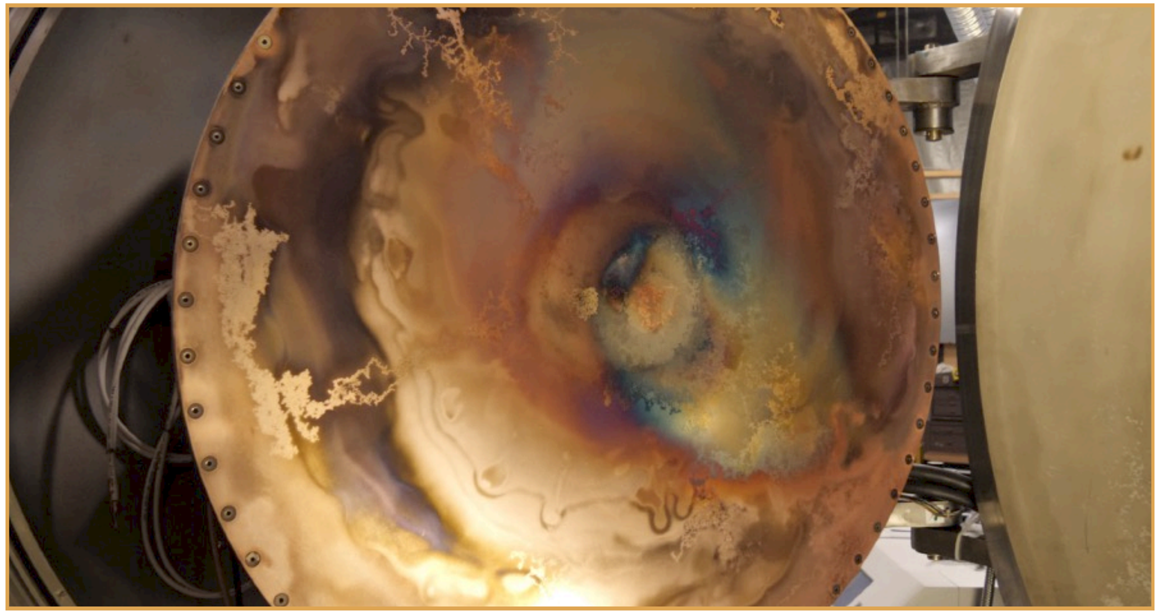


Showing the gimbal outside the chamber with the Langmuir, Optical and Mass Spectrometer probe (white) protruding through the chamber wall.


Gimbal arms – Langmuir probes
Mass & Optical spectroscopy
Hollow anode
Vacuum, gas,
power & cooling
systems feeds
Cathode



Cathode before

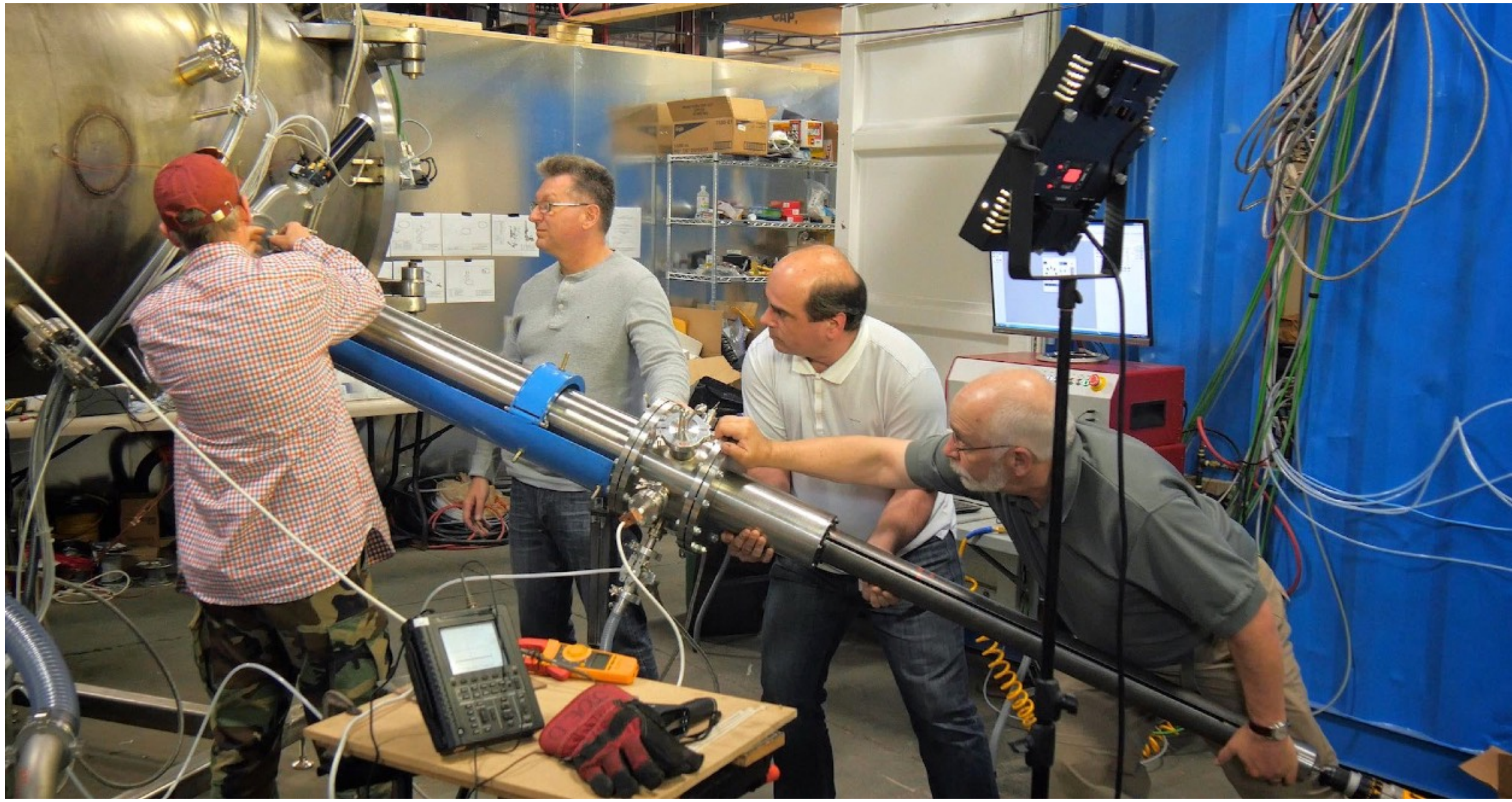


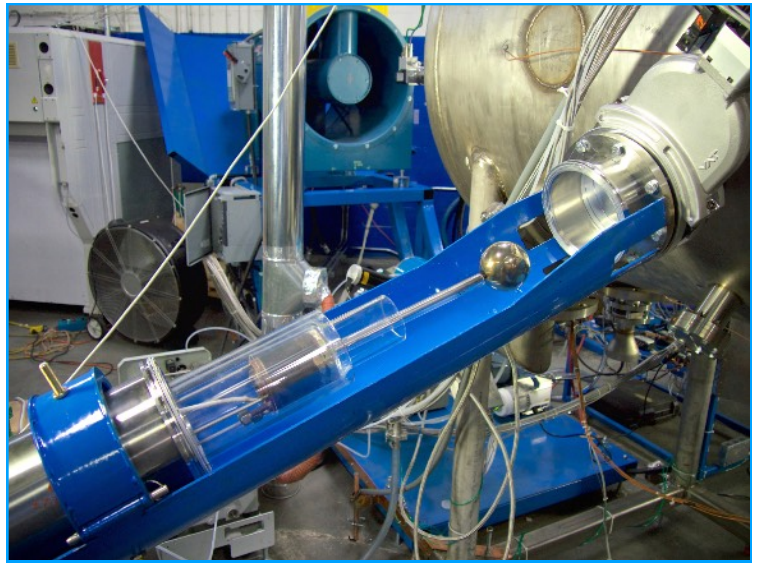
Cathode during experiments

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

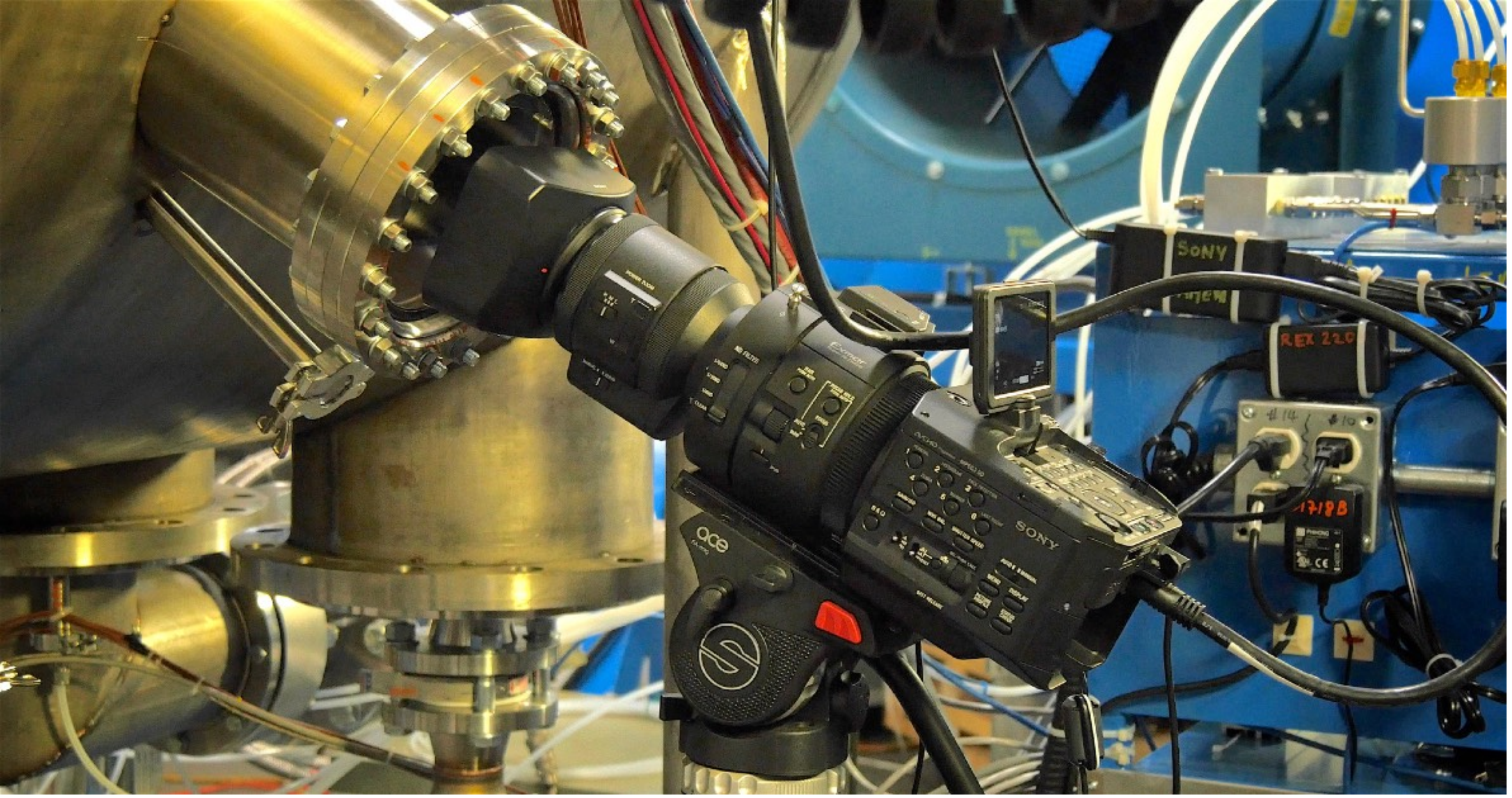
Showing the Servo Computer Numerically Controlled cathode actuator mounted on the chamber door with surrounding cooling shroud.

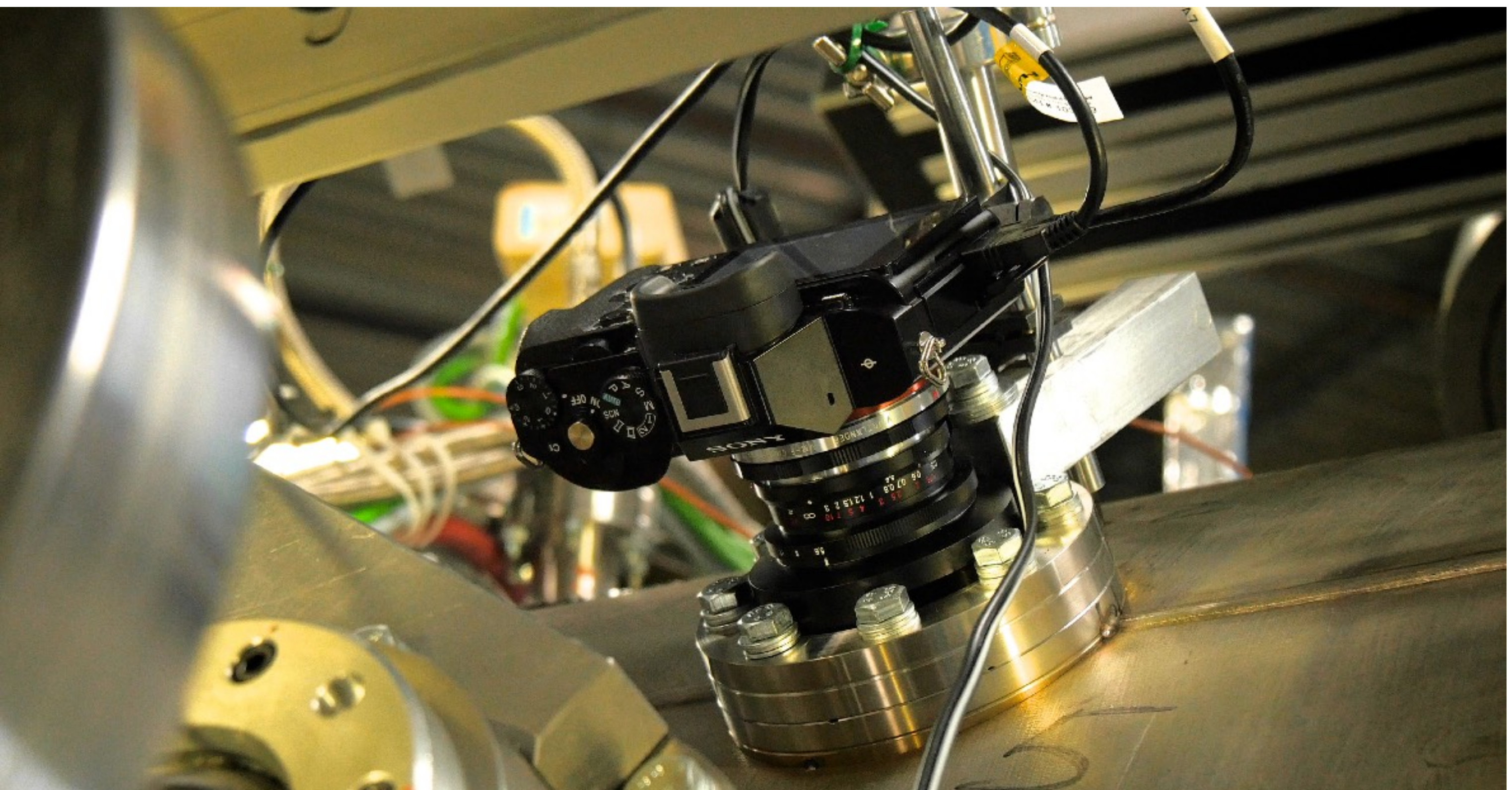
The anode itself can be withdrawn into an airlock and replaced without substantially affecting the vacuum in the chamber.



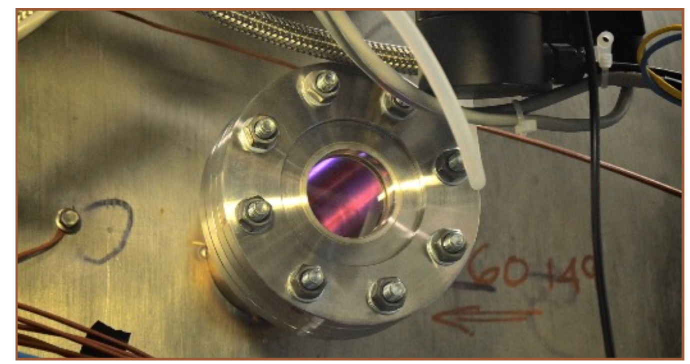


Leighton Macmillan, Joe Palermo, Jan Onderco and Montgomery Childs loading the anode into the reactor chamber





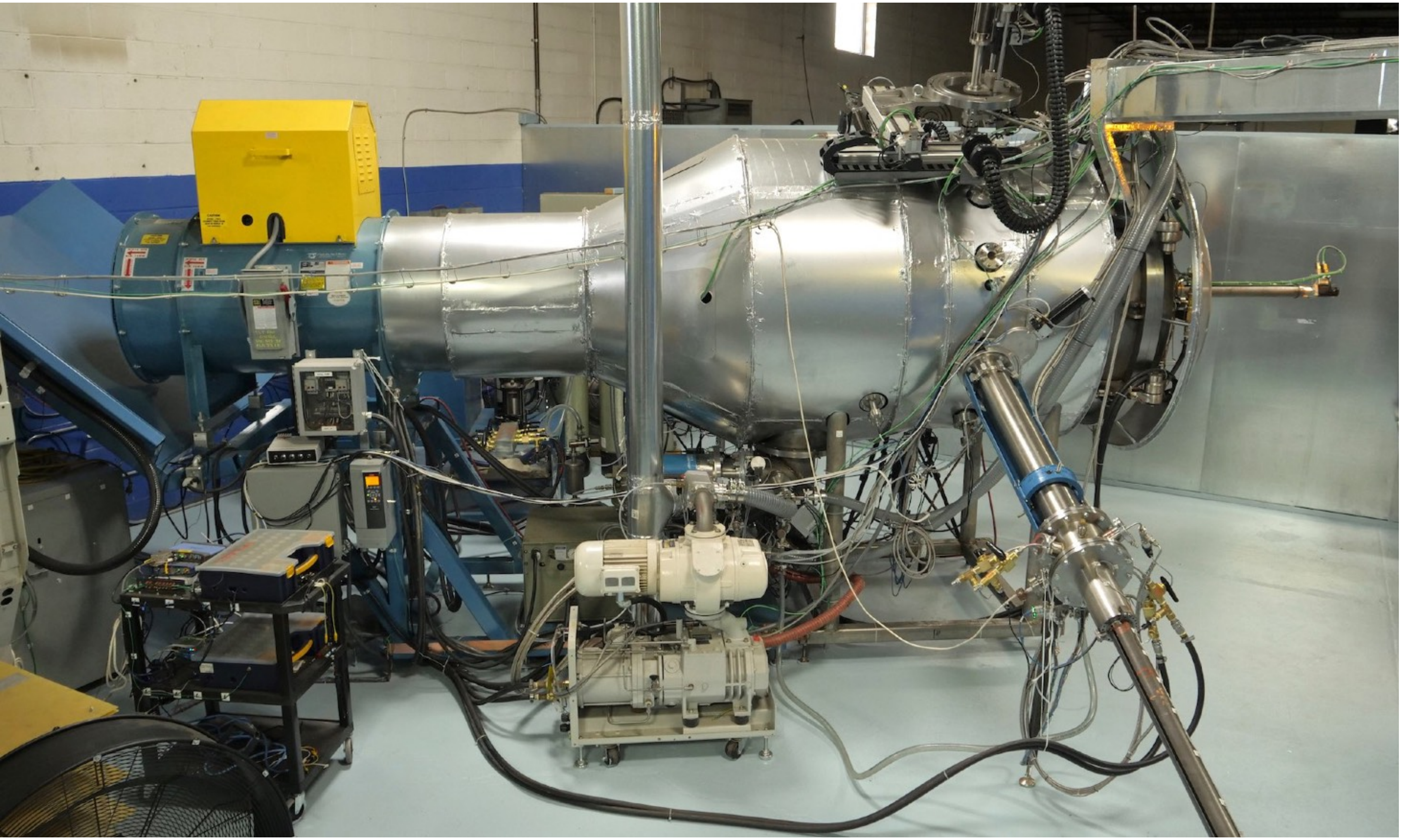
There are viewports into the chamber allowing for the external mounting of still, high-speed, infrared, and ultraviolet cameras. Antennas for measuring radio and electromagnetic signals are mounted on the inside of the chamber.



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.

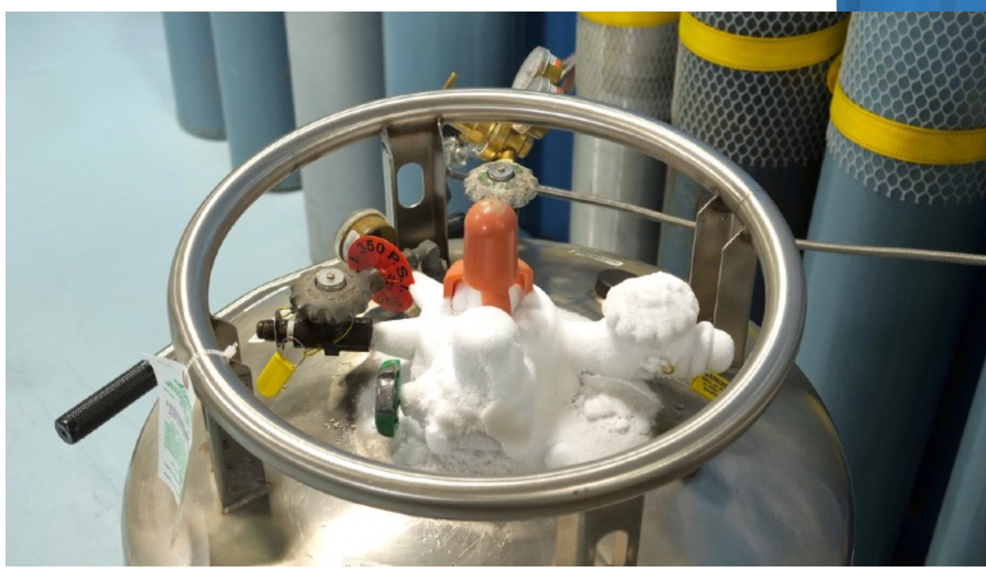
Primary controller

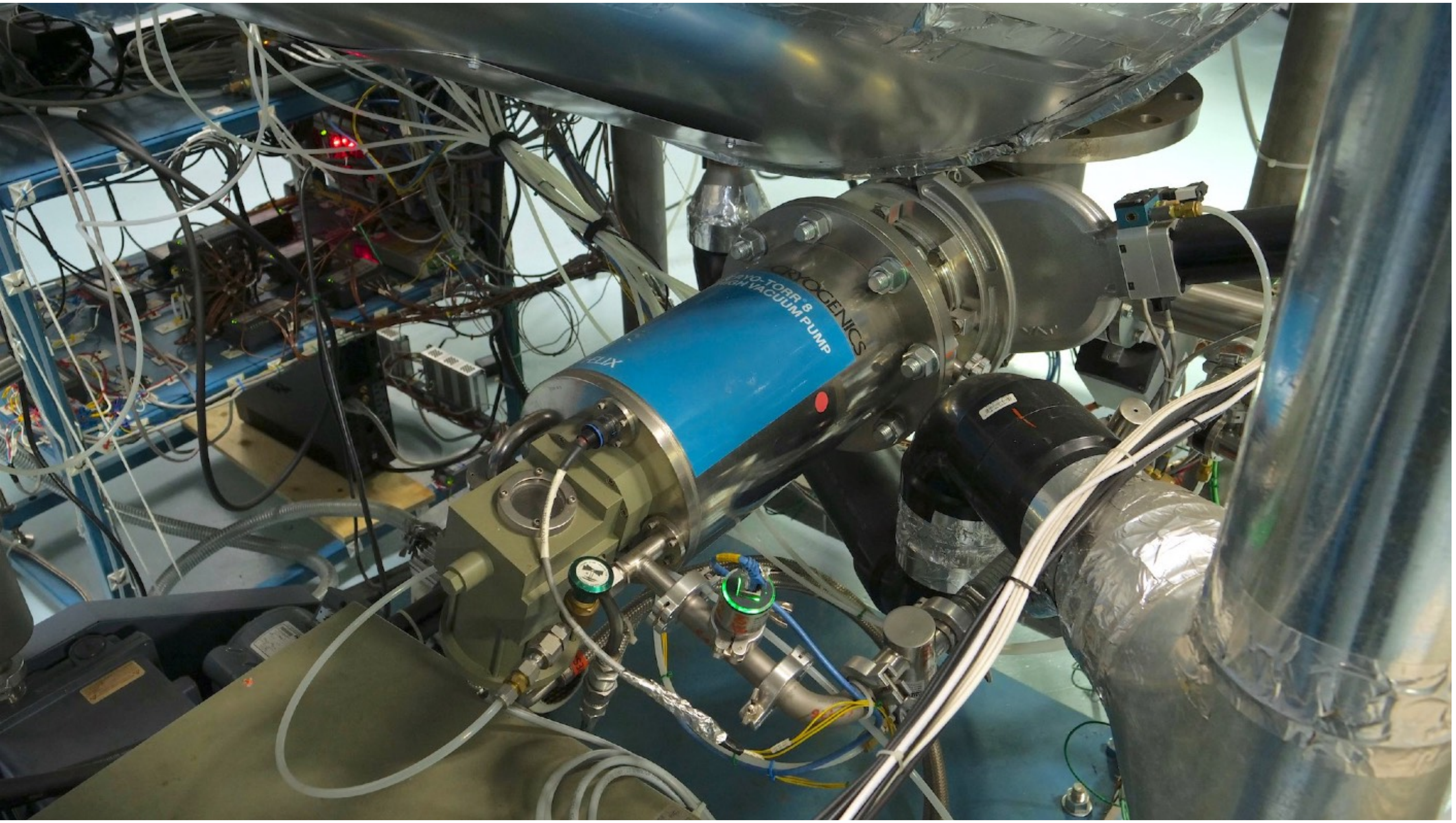
Primary transformer



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.

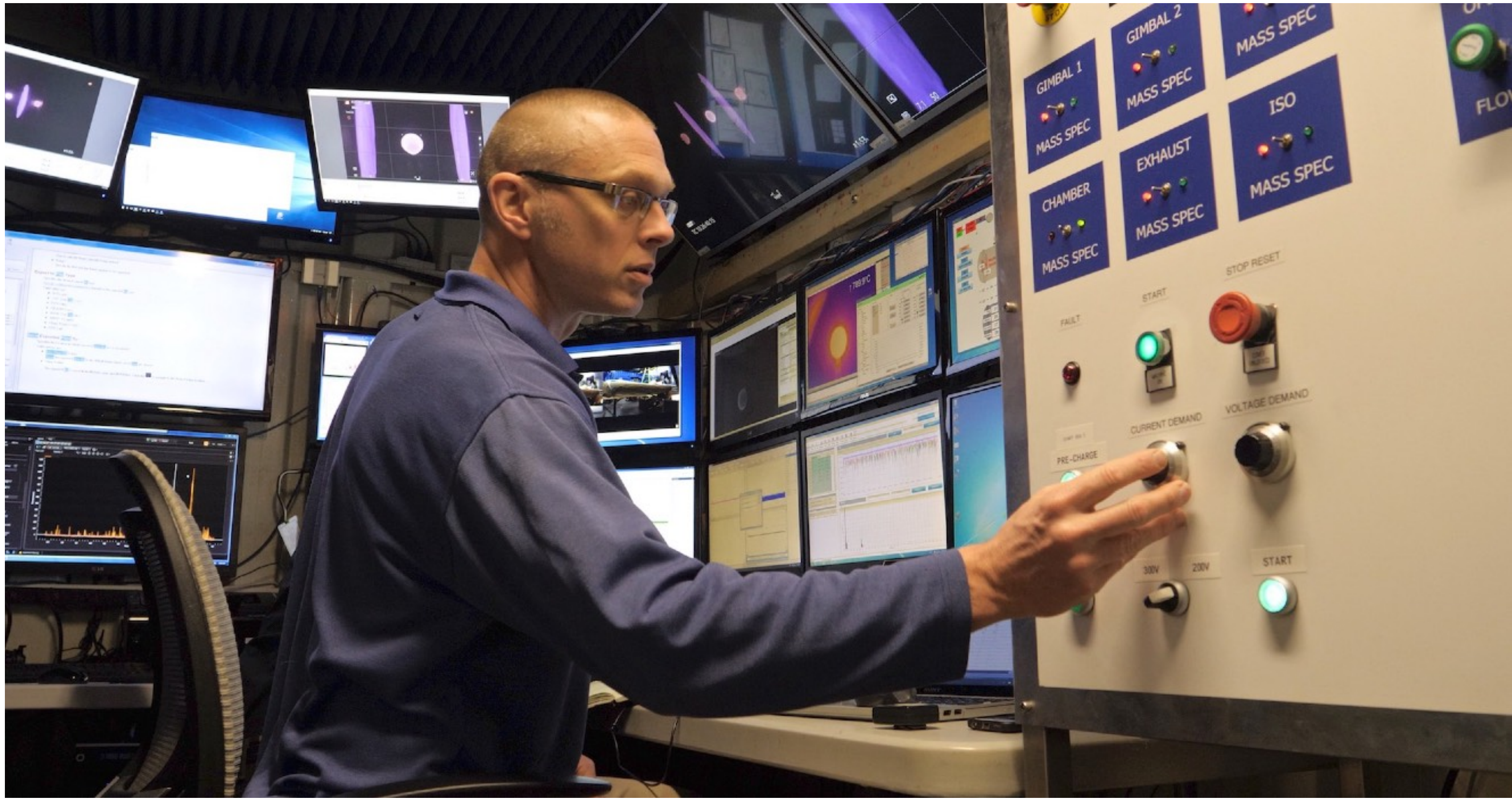
Gases, such as hydrogen or deuterium, can be introduced into the chamber so experiments may take place in different atmospheres. Vacuum pumps lower the pressure within the chamber to 0.1 micron.





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.

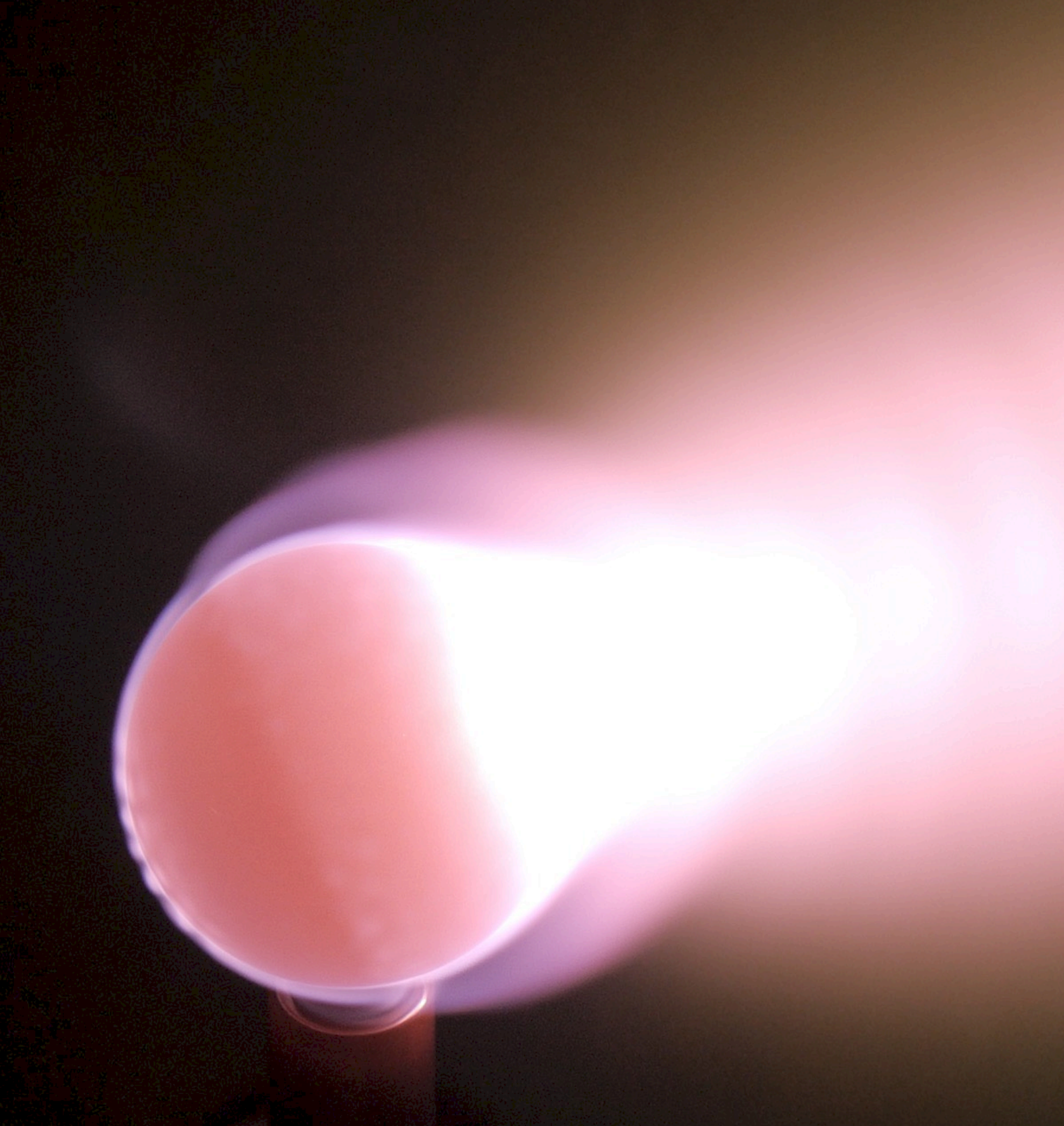
Information from the experimental data gathering, safety, and apparatus operating systems, with all of its valves, gauges, pumps, and sending units, are fed into computers in the main control room where it is displayed on numerous monitors. All that gathered information, regardless of its source, goes 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.

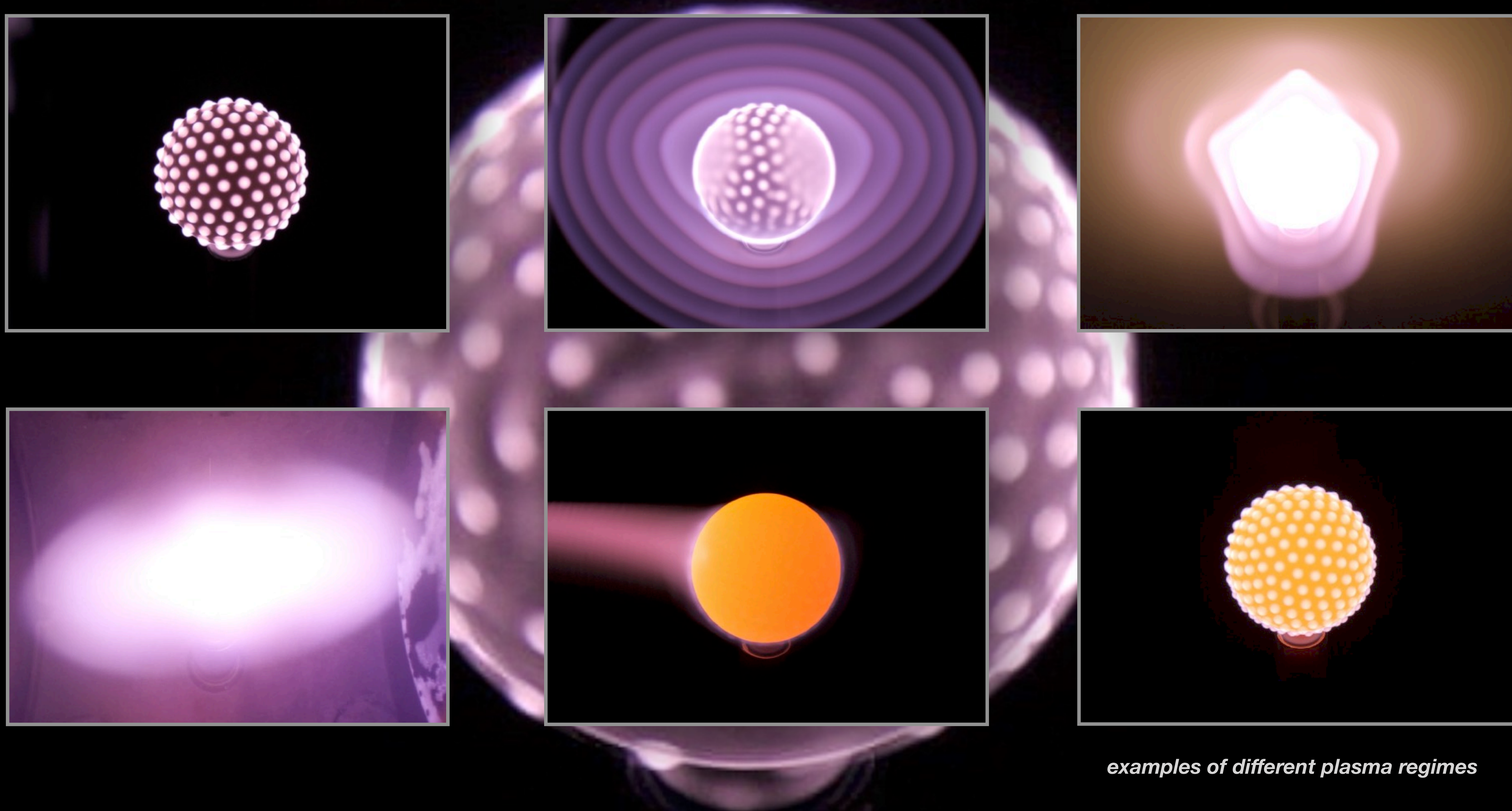
The SAFIRE reactor is made up of 40,000 parts.



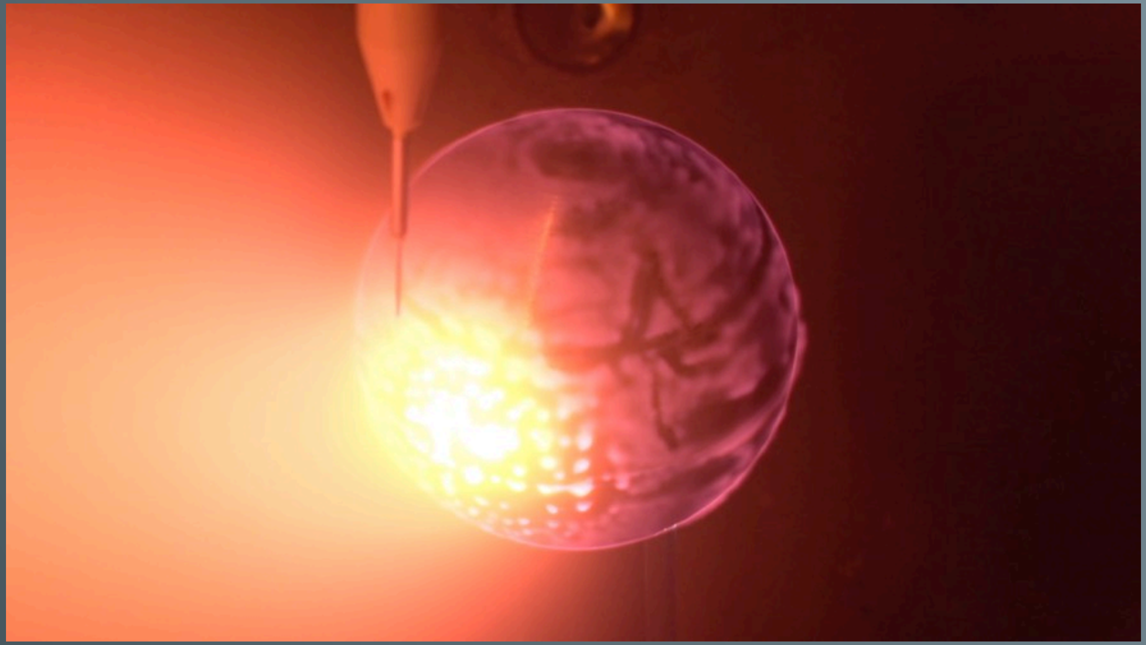
DISCOVERIES

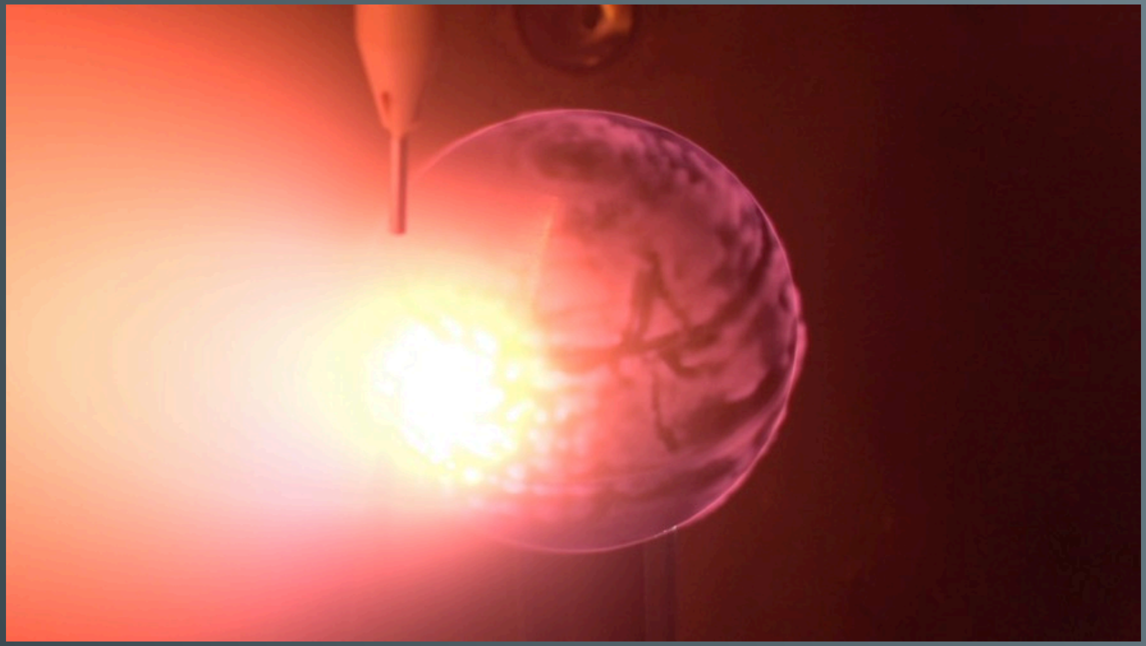
Experimental Results

The primary notable achievement of this apparatus is its ability to produce a stable, sustainable plasma which consists of multiple spherical double layers surrounding the anode.



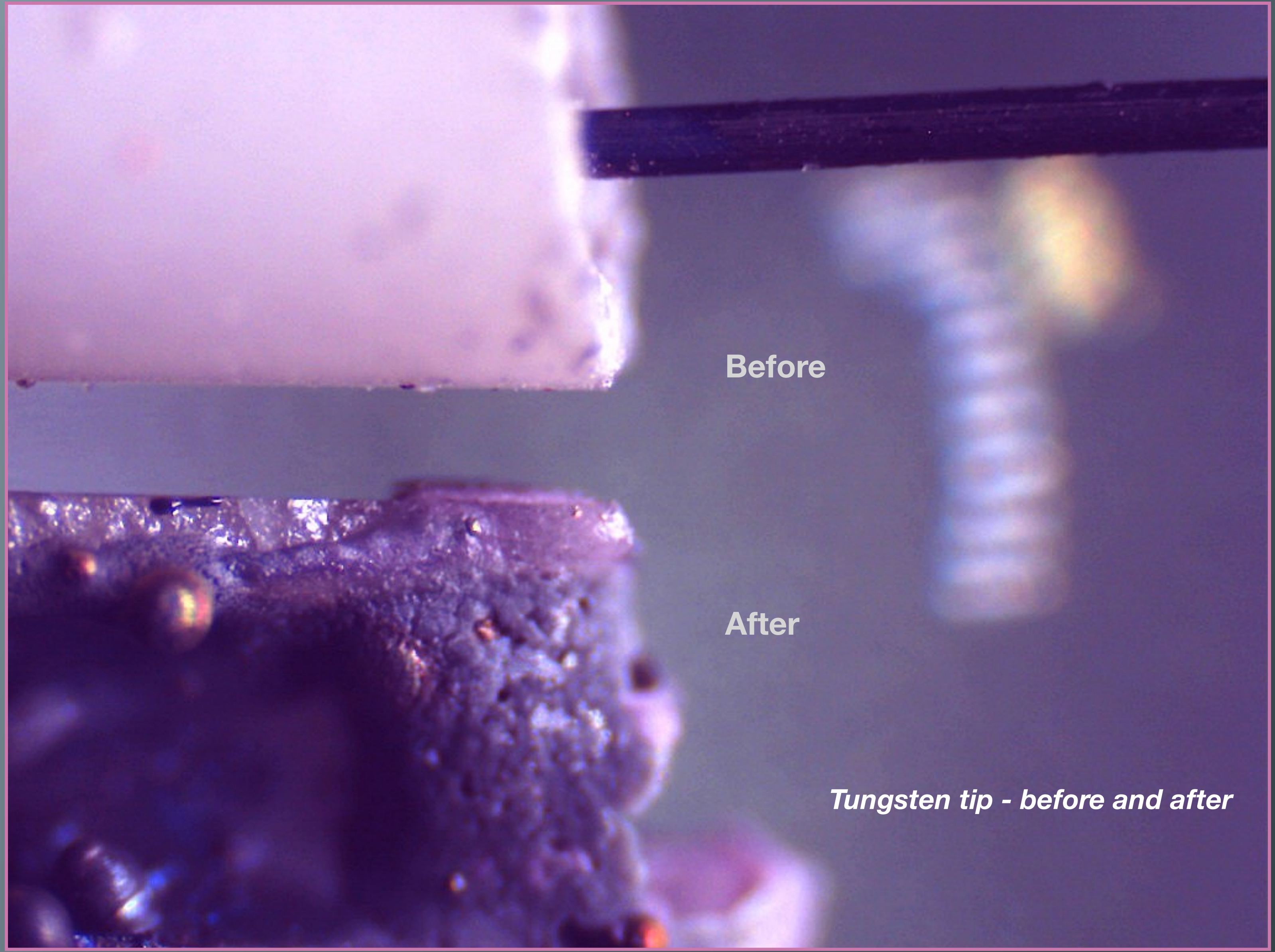
examples of different plasma regimes



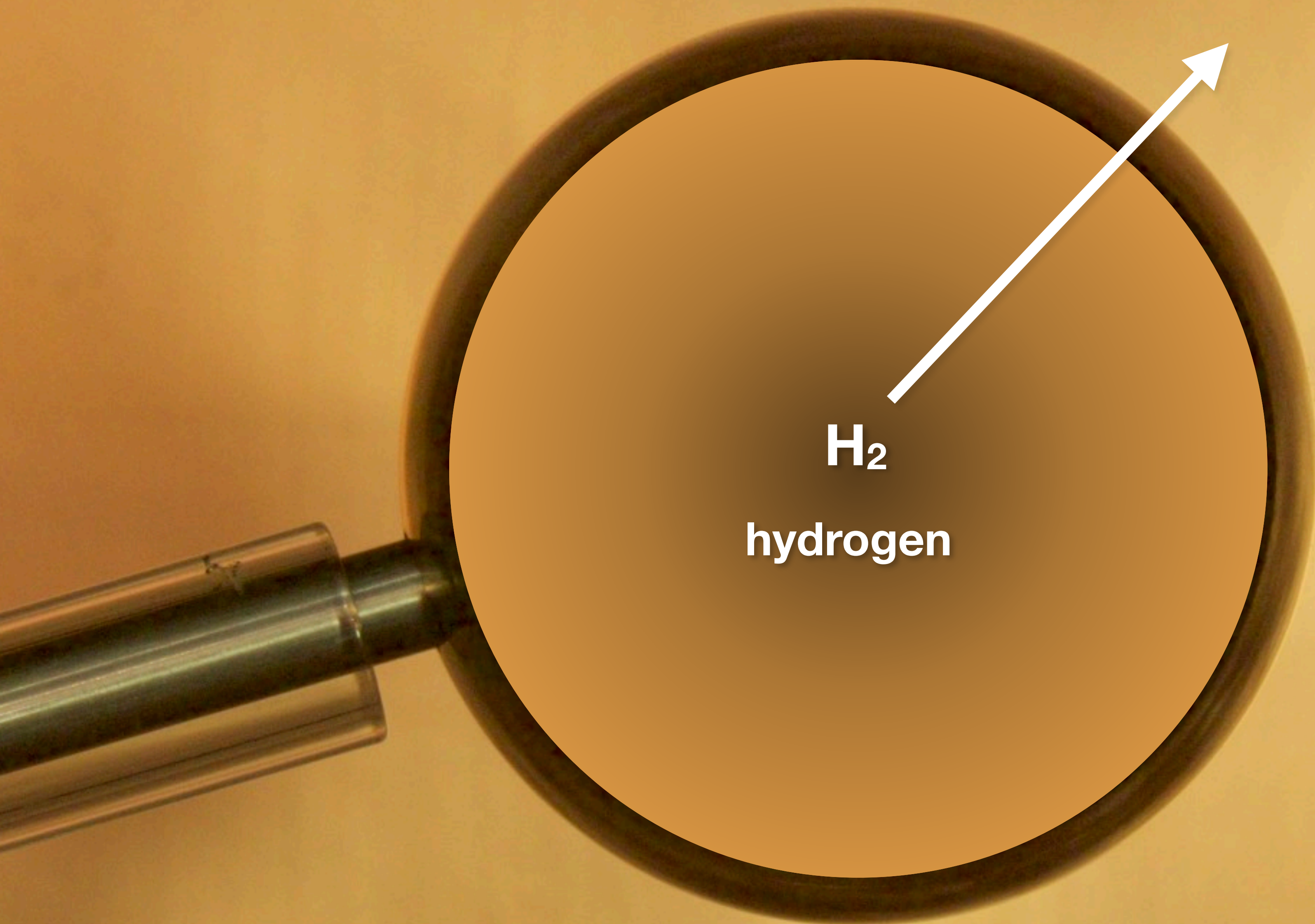


Any project that attempts to build a working model of the Sun will be dealing with high temperatures because plasmas are known to be extremely hot. In an early test to calibrate the telemetry of the gimbal mounted Langmuir probe, a tungsten wire was attached to the tip. Watching a video of the chamber, an operator maneuvered the probe toward the outermost layer of visible plasma. The plasma was being sustained by an input power of 182 watts to the anode. Before it even reached what appeared to be the edge of the plasma, the end of the tungsten tip vaporized and the remaining alumina insulator appeared to melt.

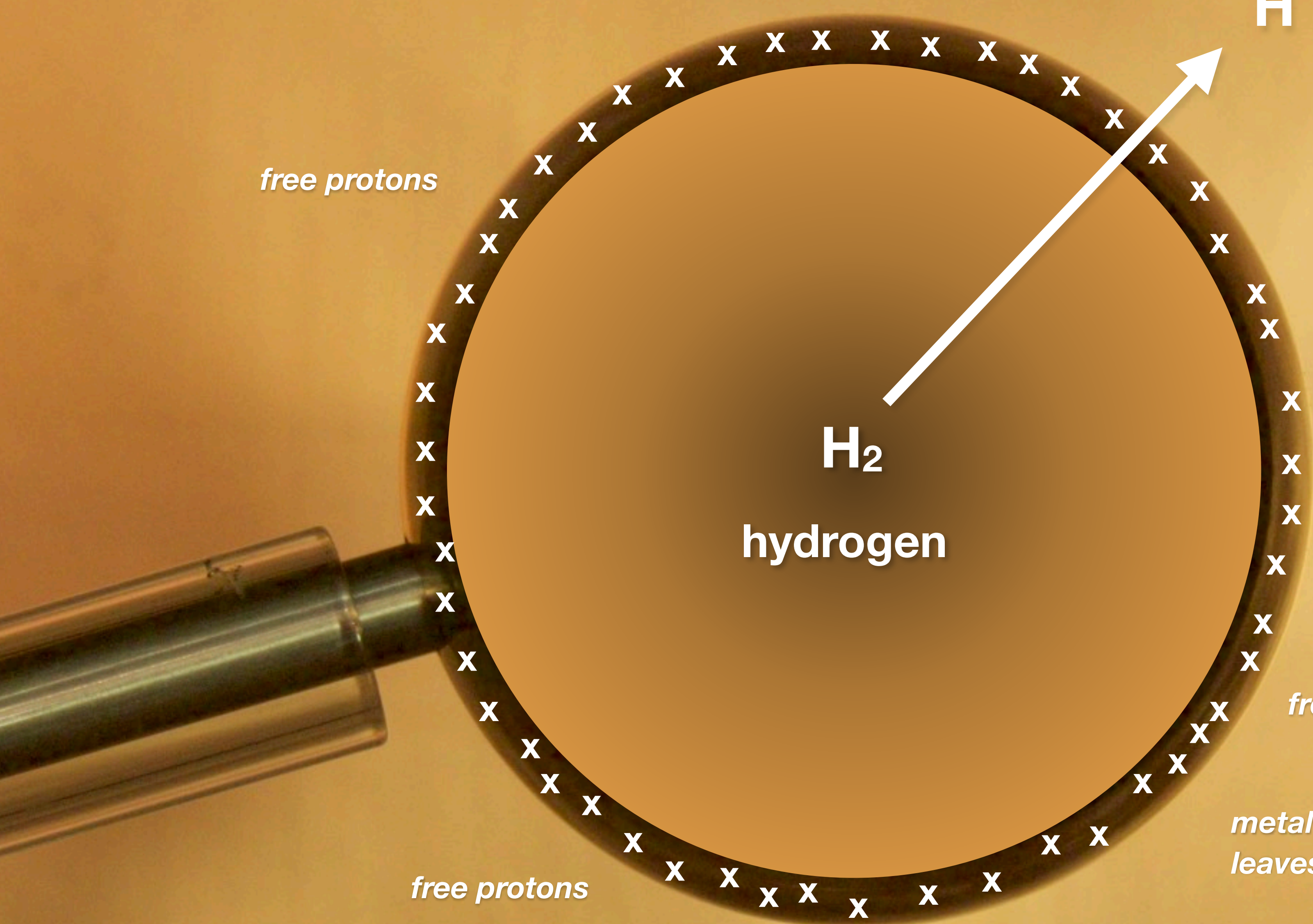
Thermodynamics analyses made during the design phase indicated that the plasma would have a maximum temperature of around two thousand degrees Celsius. Fifty-five hundred degrees Celsius is necessary to vaporize tungsten. How hot was the plasma? This strange anomaly was a cause of much excitement among the team. The unexpected vaporization of the tungsten tip required a redesign and rebuild of the Langmuir probe. *The new tungsten tips are twenty times the size of the first.*



Tungsten tip - before and after



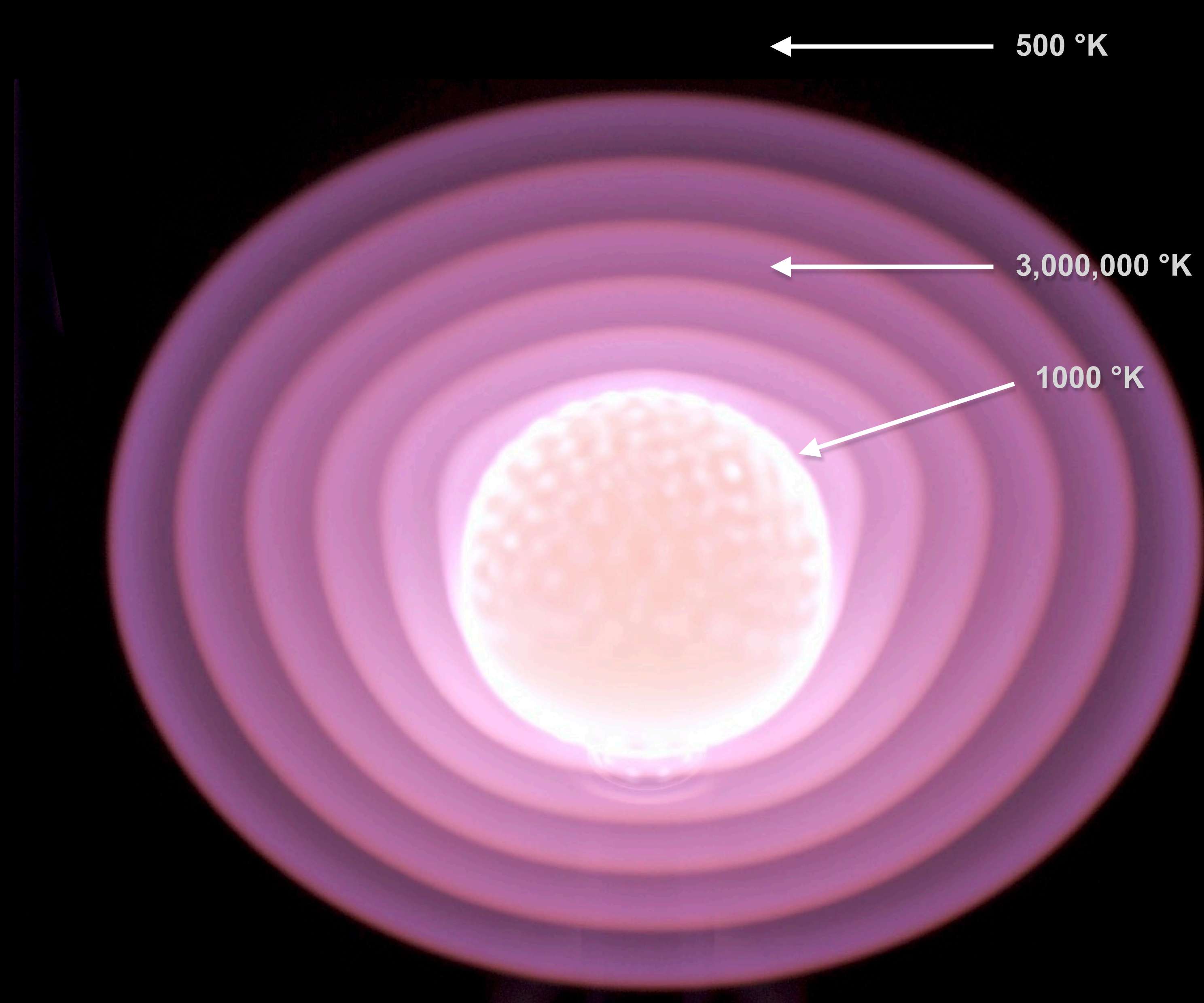
The anodes used in the experiment can be replaced easily and quickly. The standard anode is solid metal alloy, but it can be substituted with a hollow one. This hollow anode is mounted in a way that permits its core to be pressurized with hydrogen and other gases. The differential between the pressure in the anode and that in the larger chamber allows the gas to escape the anode through the crystalline lattice. The resulting plasma may more accurately model the Sun's atmosphere in the vacuum of space than one created in a gas infused atmosphere.



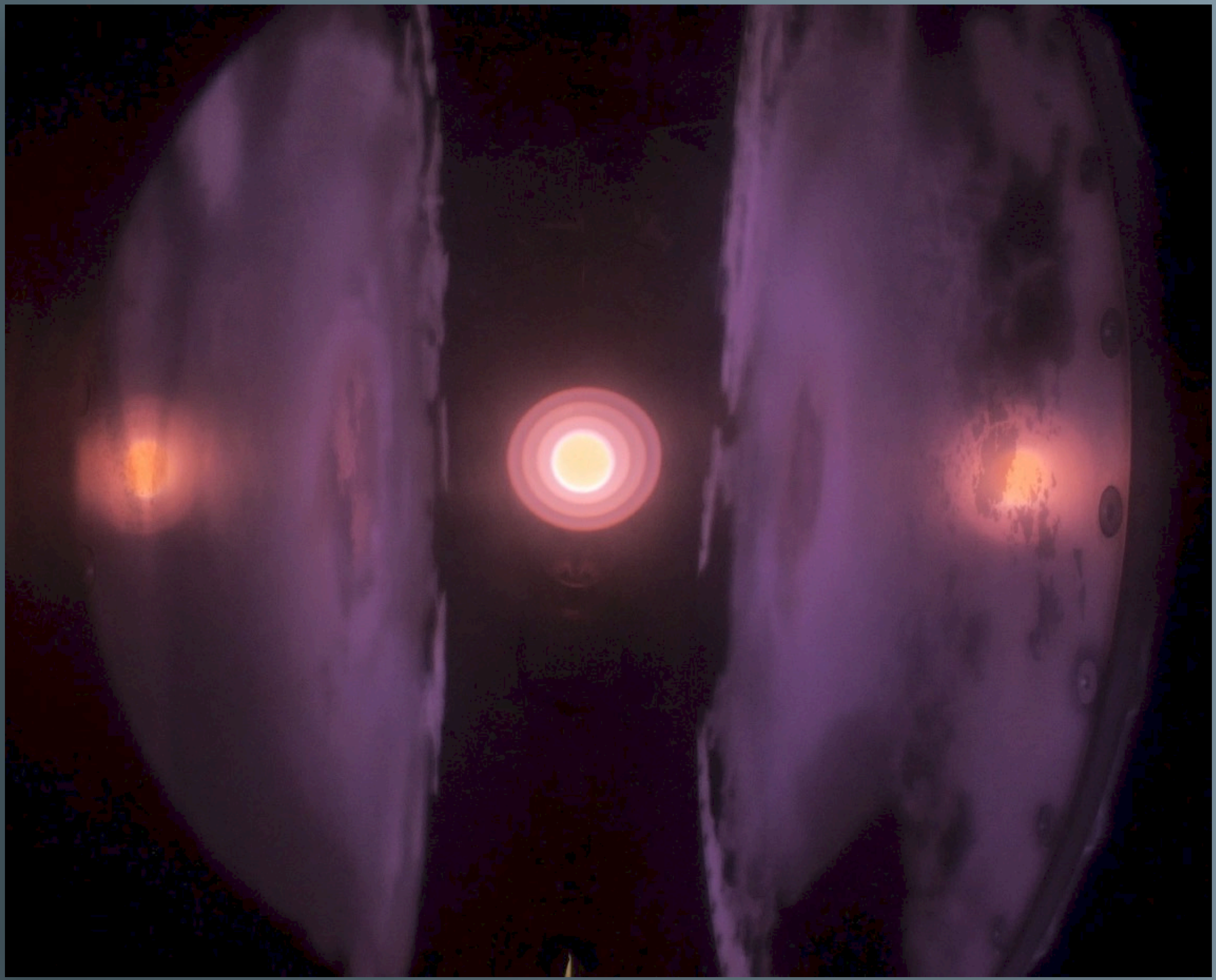
Early experimental runs with this setup produce copious amounts of monatomic hydrogen raised to unexpectedly high-energy states in the chamber. Although the process at work here has not been studied in detail, the electrically charged metal alloy matrix splits the molecular hydrogen H2 into monatomic hydrogen H. Concurrently it strips electrons from the H, leaving free protons. This is a possible process by which Low Energy Nuclear Reactions (LENR) - transmutation of elements - might occur.

A major discovery is that of an electro chemical catalytic process between hydrogen and other trace elements. It has been found to be the primary reason for the formation of the stable spherical plasma double layer shells.

The formation of these shells causes the plasma to behave as a transforming capacitor. These extremely powerful electromagnetic shells are responsible for the trapping of high energy electrons, ions and photons.



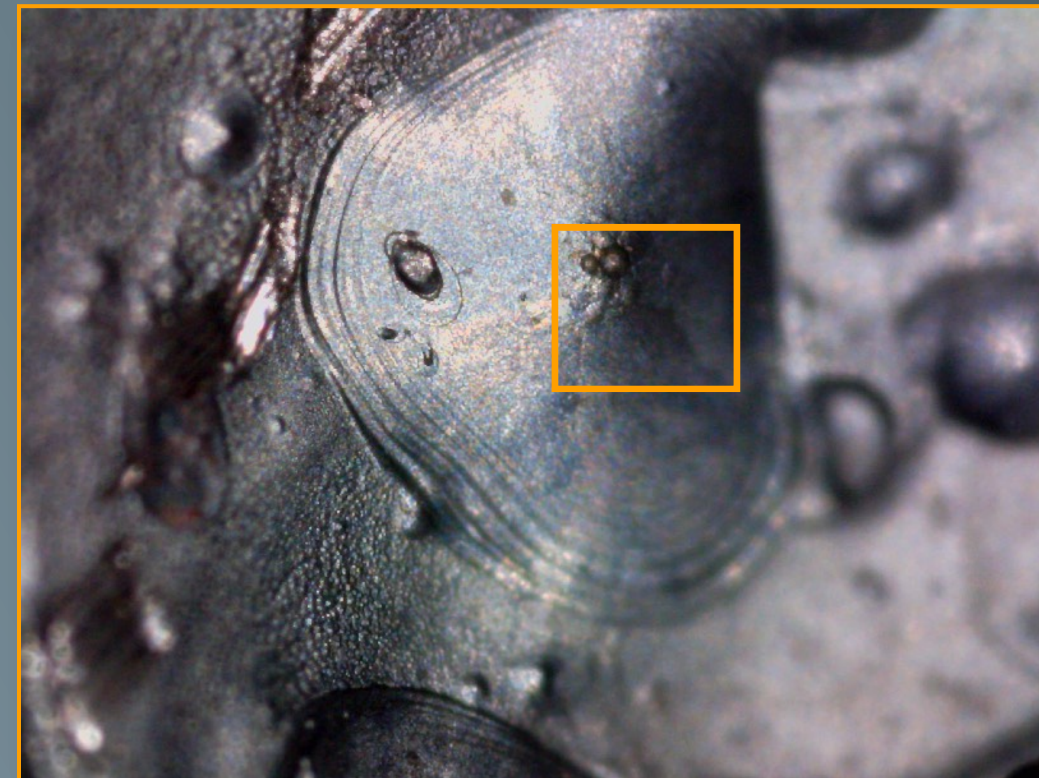
High temperature energy is *contained* within the plasma double layers



The trapping prevents the ions from flying out and smashing up against the cathodes and the steel walls of the chamber. It keeps the high energies contained within the plasma, energies that would otherwise destroy the apparatus.

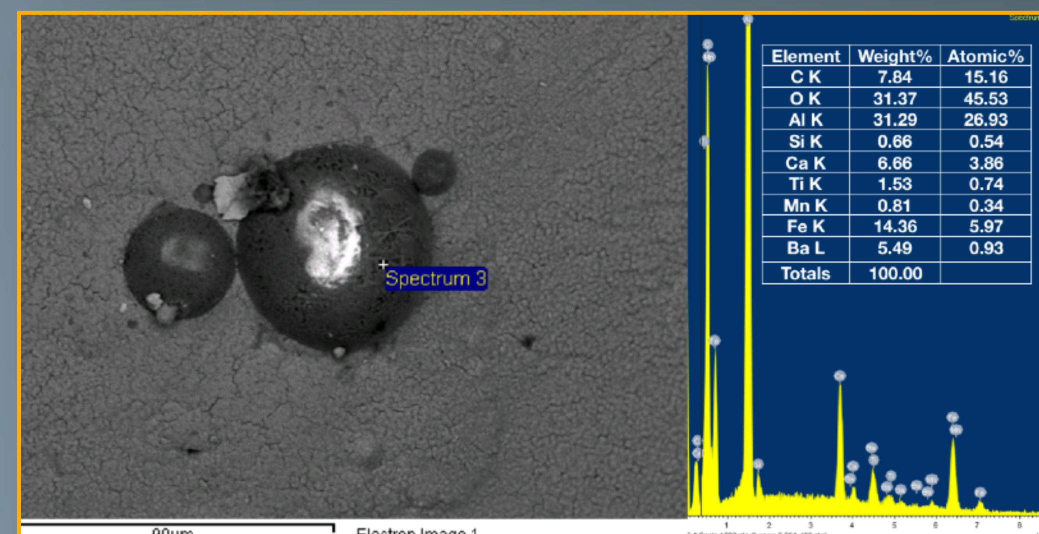
The spherical plasma double layer shells show no sign of being affected by gravity – they are spherical and would require little or no inertial damping. This is enormously significant.

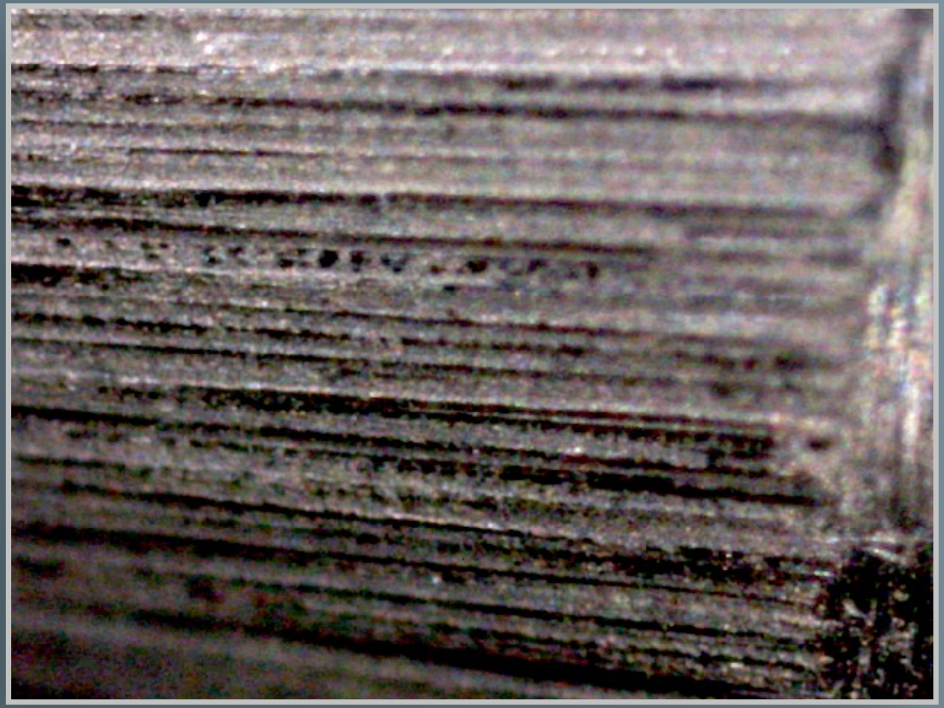
Optical microscopy



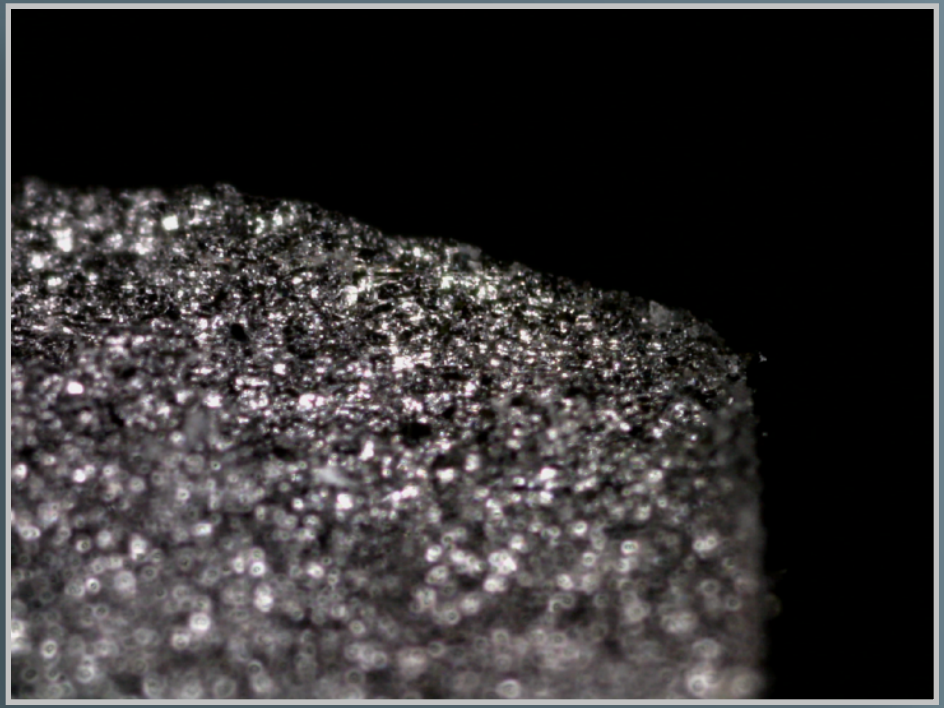
After these test runs the metal alloy anode exhibited visual changes on its surface. Scanning electron microscopy (SEM) showed new concentrated elements in small pits or atop ridges formed during testing – elements which were not present in the original metal alloy. Among them were titanium, barium, and calcium. It is uncertain at this time why these elements came to be there.

SEM analysis of nodule (Barium, Titanium, Calcium and others)





Optical microscopy of virgin tungsten

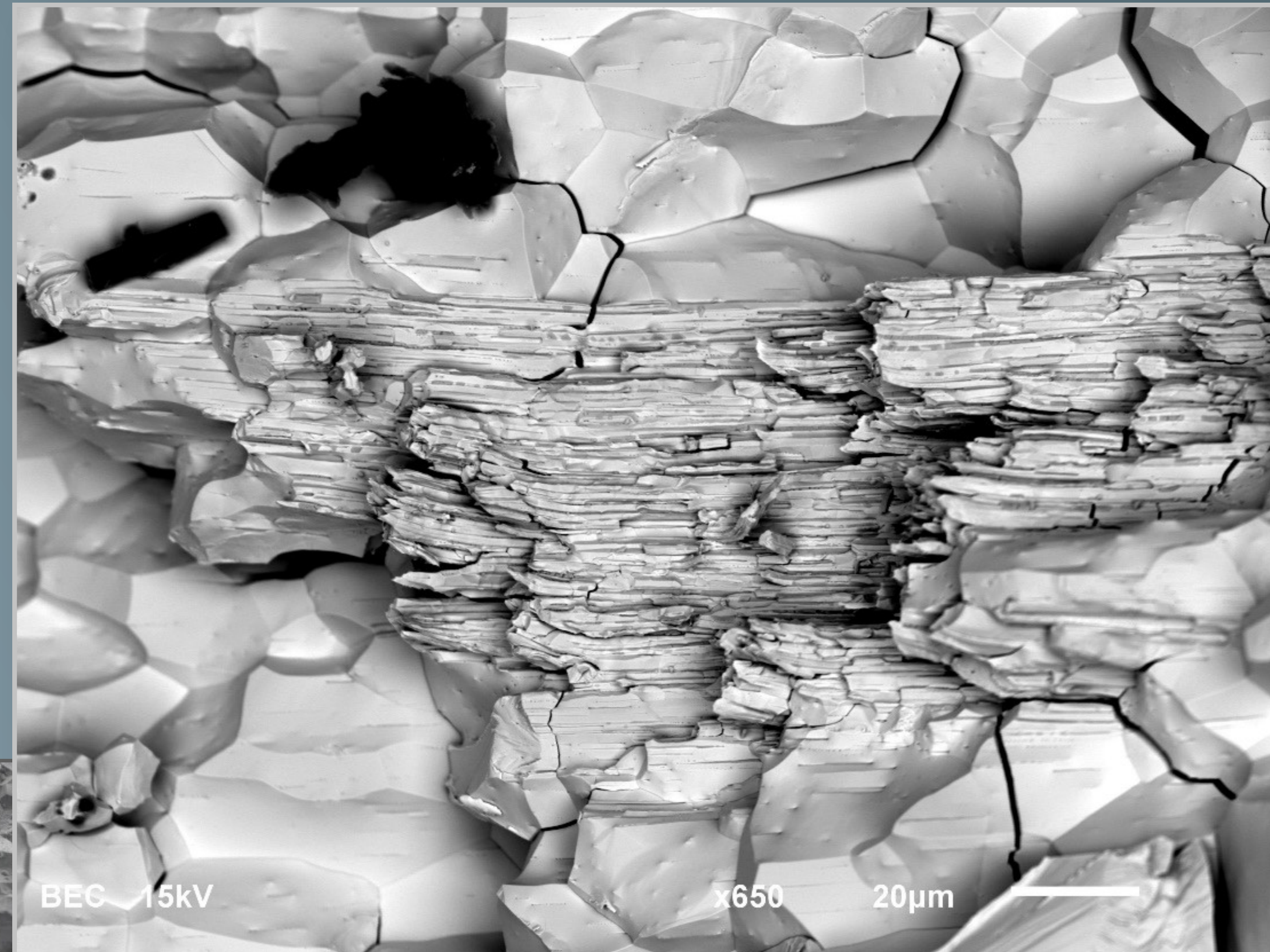


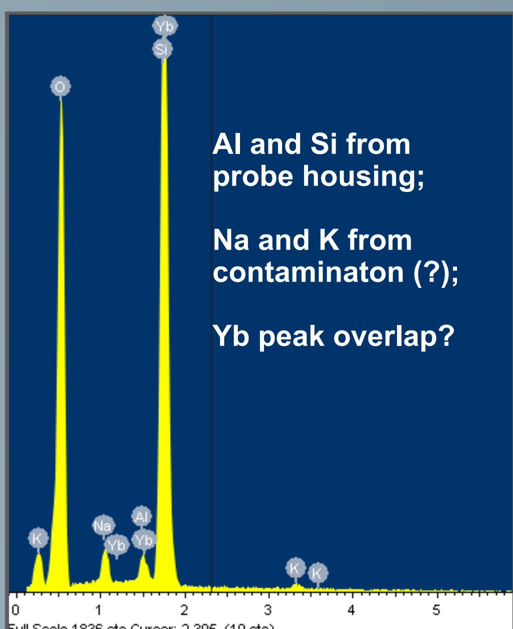
Crystalline changes after plasma exposure

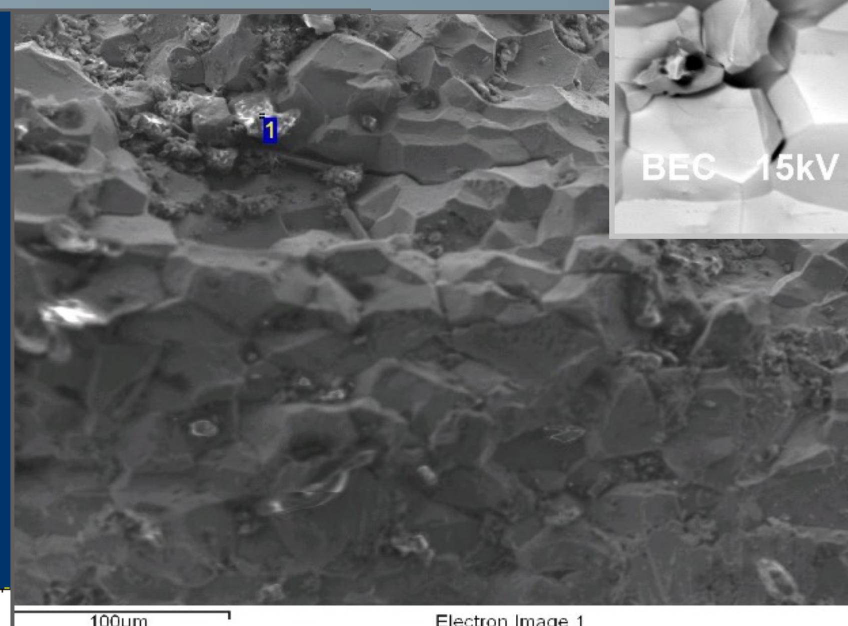
The tungsten probe tip used during these metal-hydrogen tests also displayed odd changes. The tungsten did not show melting or boiling on the surface, but the material was very brittle. It was possible to break the metal apart and examine it in longitudinal sections.

Optical microscopy revealed the tungsten had melted in the interior while leaving the surface in its original crystalline condition. The exterior only showed discoloration, which is expected from exposure to a hot plasma. The interior of the tungsten also showed new chemistry, with concentrations of elements not seen in the tip before exposure to the chamber discharge, a true mystery.

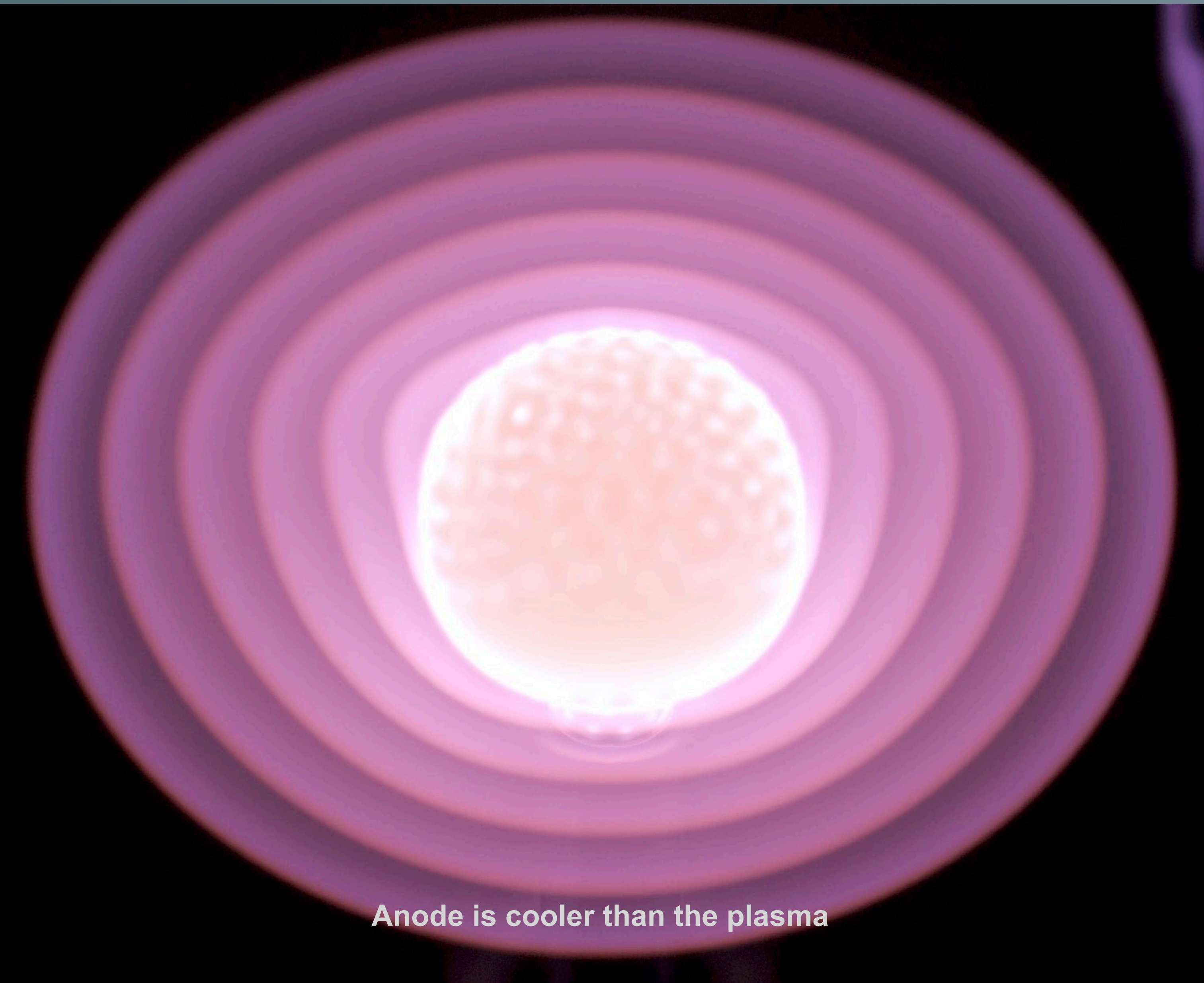
SEM showing changes of the crystalline structure on the inside of the tungsten





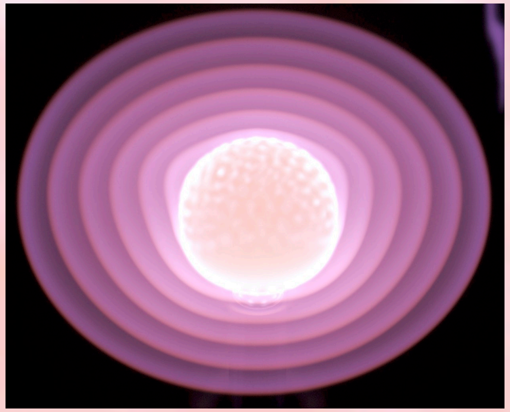


Various other new elements



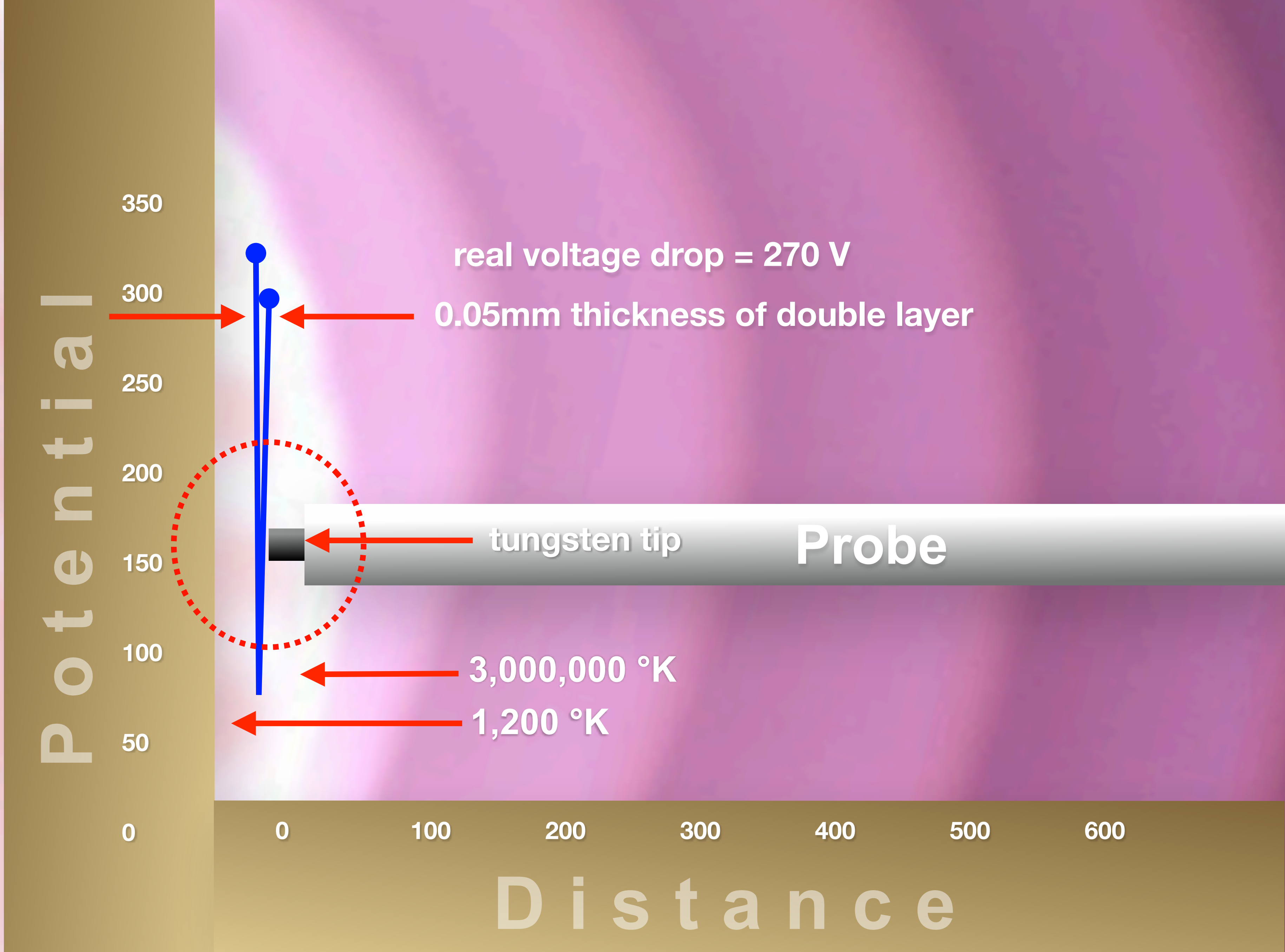
Another surprise: both solid and hollow anodes are cooler than the plasma – defying the laws of thermodynamics. Although there was H being diffused through the hollow anode the temperatures of both the solid and hollow anodes were similar.

These responses may be due to the extremely thin but powerful plasma double layer forming just off the surface of the anode. This limits electrons from impinging on the anode surface that would otherwise heat the anode to higher temperatures.

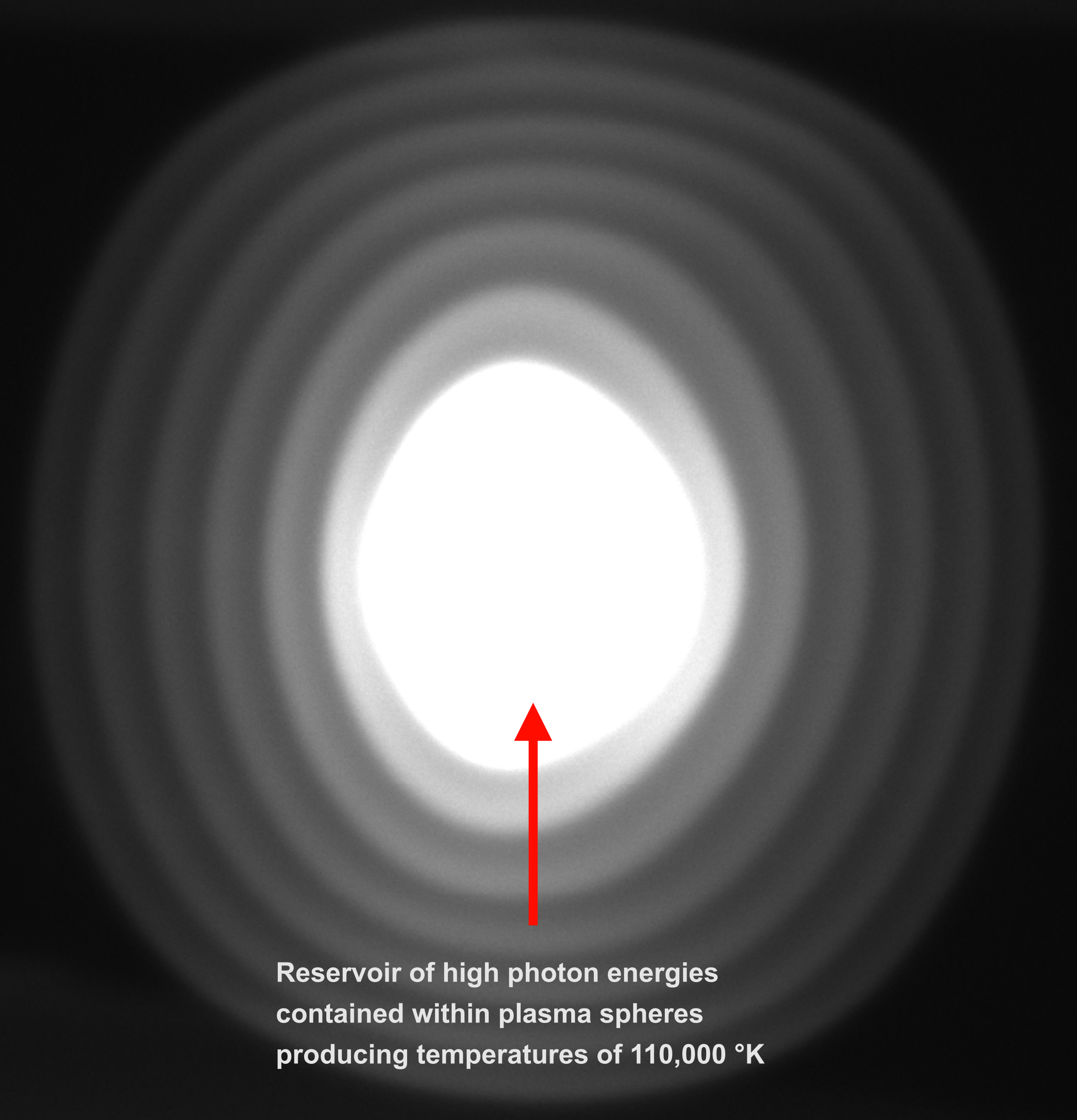


The voltage drop of 270 volts very close to the chamber anode, if converted entirely into temperature, would equate to 3,000,000 K, which, remarkably, is the same temperature increase seen when moving from the Sun's chromosphere to its lower corona.

The high temperature and high density of the plasma inside the double layers shows the spherical double layer shells are creating a force field of some kind, responsible for there being a higher pressure inside than outside the double layers.



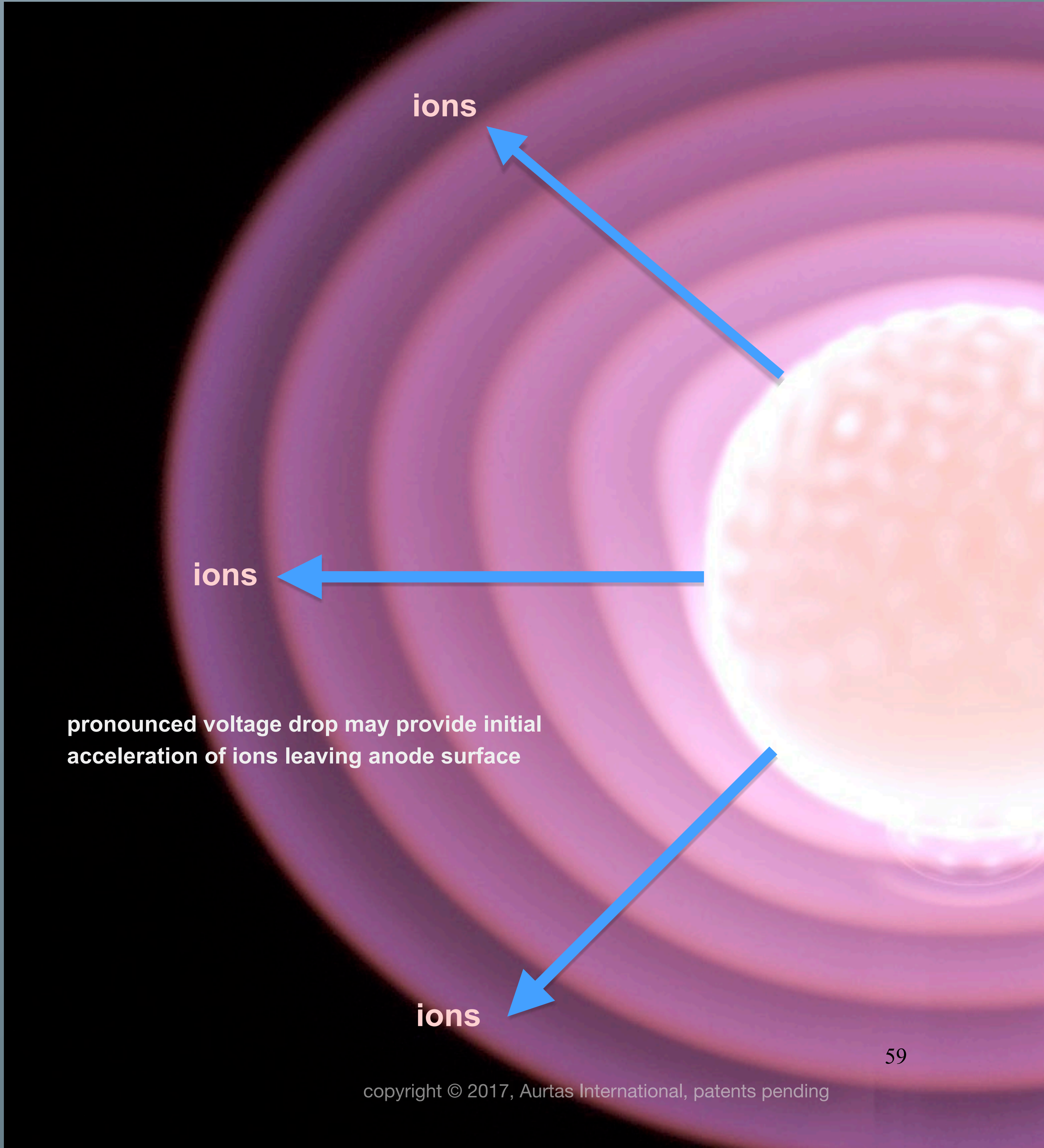
Plasma produces highly energized ultraviolet photons



It is not known at this time if the experimental plasma produces x-rays or gamma rays. However it does produce highly energized ultraviolet photons. From the visible Balmer lines obtained through optical spectroscopy it is deduced that the hydrogen is creating copious amounts of 10.2 eV Lyman Alpha photons, indicating that there is a reservoir of high photon energies contained within the plasma spheres. This is producing a temperature of 110,000 Kelvin when the tungsten is exposed to it, and may account for the deformation and chemical changes of the tungsten probes, which happens in seconds, or possibly even picoseconds.

Ultraviolet light camera

Much is to be learned as to how the experiment brings particles to such high velocities and energy states. One significant discovery is that the pronounced voltage drop may provide the initial acceleration of ions leaving the anode surface and the boost needed to drive the ions across subsequent layers, acquiring even more energy as they traverse electric fields contained within the surrounding plasma.



The energy densities being produced by these experiments are far greater than predicted. Energies of this magnitude are found in two other places – the Sun's photosphere …

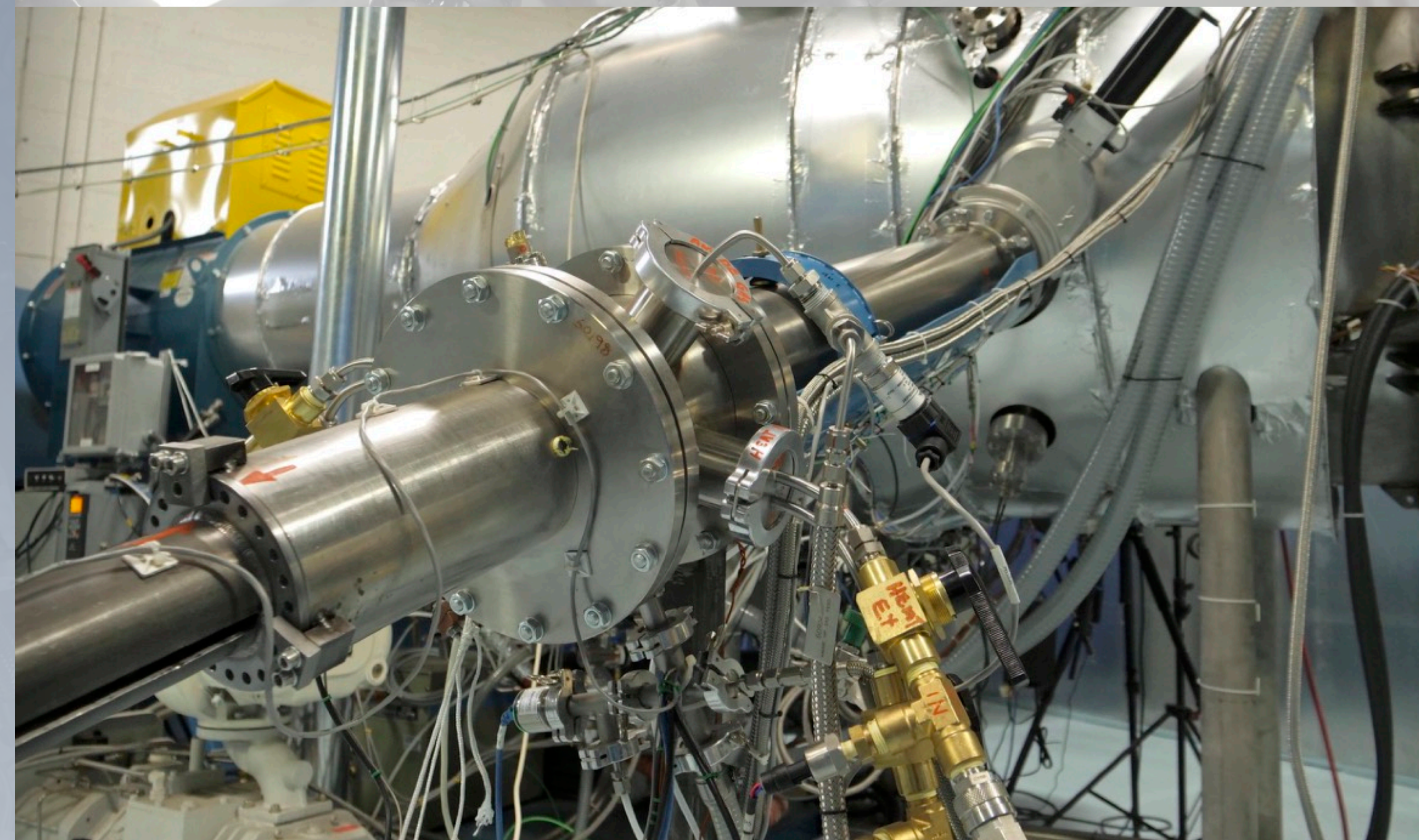
… and nuclear bombs.

SUMMARY

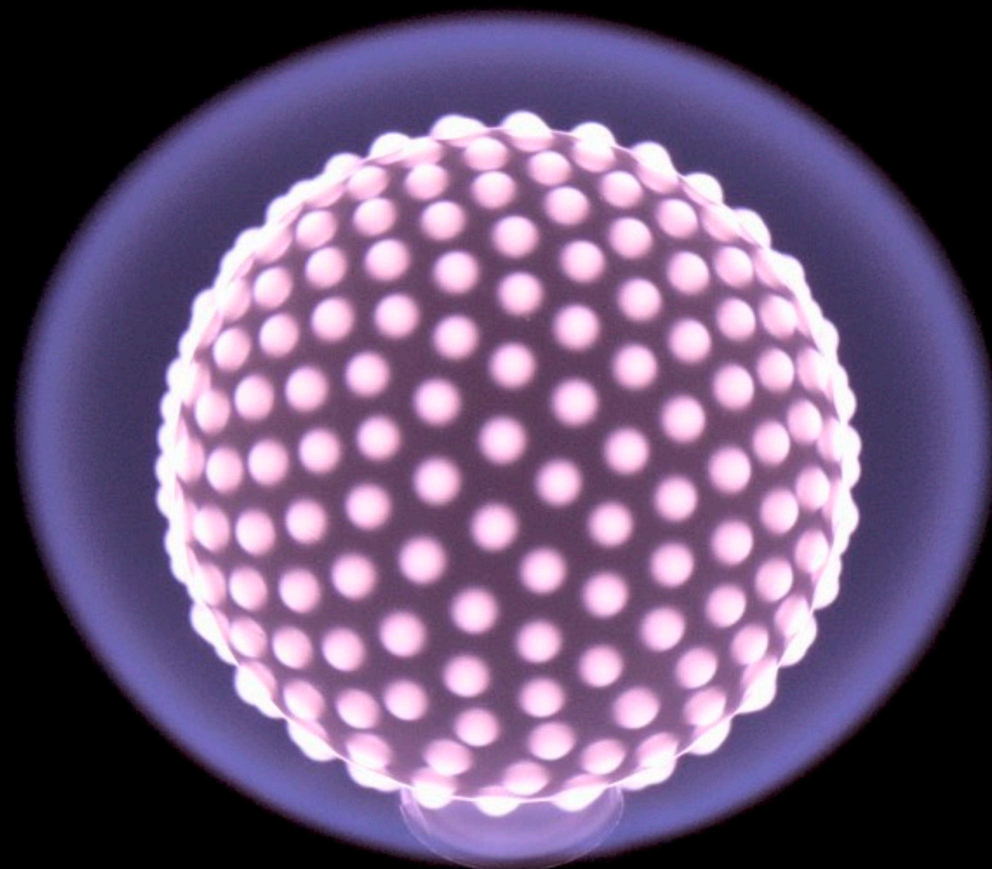
In summary the SAFIRE experiment is capable of:

- DOX – Design of Experiments Methodology.
- Creation of exothermic plasma reactions – the key to unlocking the reactions that cause powerful electromagnetic spherical plasma double layer shells to form.
- Creating a variety of spherical plasma discharges.
- Containing, controlling and stabilizing high-energy dense plasmas.
- Producing copious amounts of atomic hydrogen.
- Producing free protons within the anode metal alloy matrix.
- Producing 10.2eV vacuum ultra violet light.
- Electrical confinement of high-energy photons (photon trapping).
- Producing variations in electron density comparable to the photosphere, heliosphere, and nuclear bombs.
- Potential of Low-Energy Nuclear Reactions (LENR).
- Accelerating ions through the spherical plasma double layers to ballistic velocities.

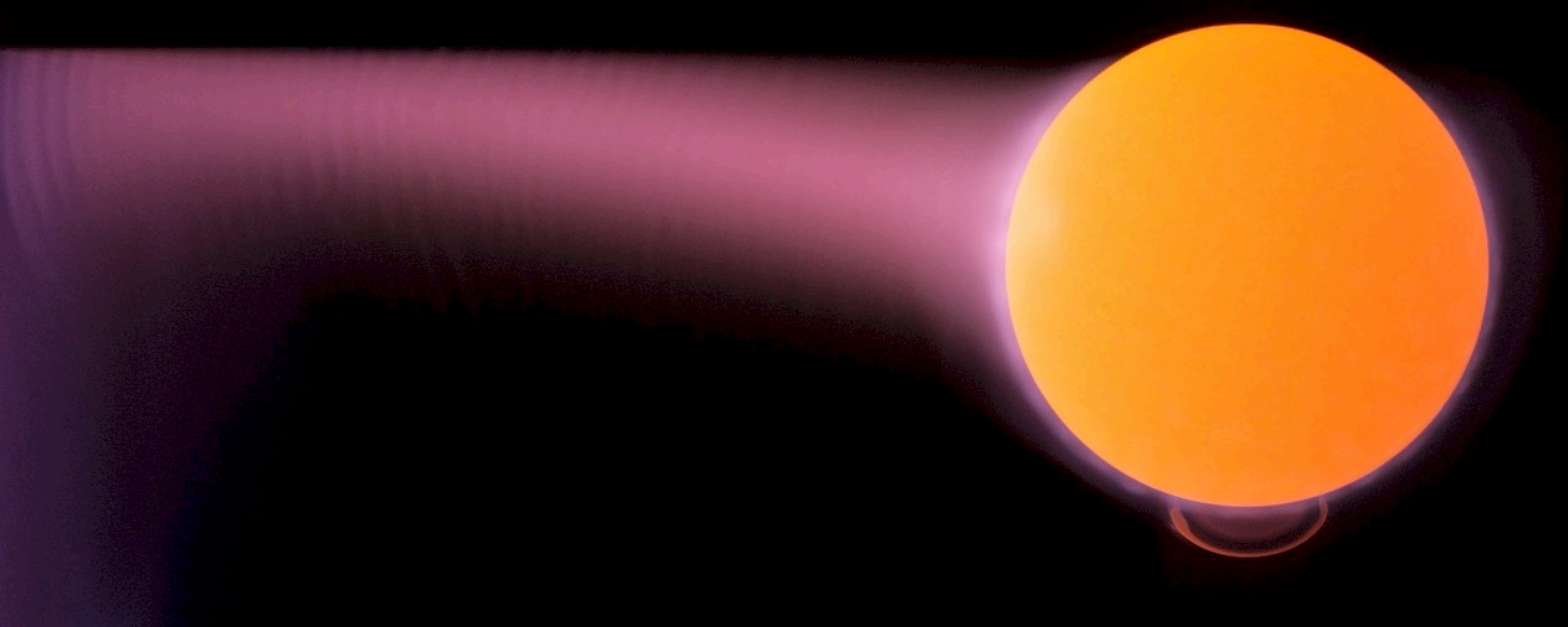
- A condition where the anode is cooler than its surrounding atmosphere.
- Systems control and data acquisition.
- Moving many measuring instruments freely through the plasma atmosphere.
- Obtaining many and varied instrumentation data sets.
- Compiling and transformation of data for post experimental analysis.
- The ability to gather data at extremely high rates – Pico Seconds.
- Correlating and generating graphical overlays of all the data.
- Synchronizing all data streams in real time.
- Obtaining high-resolution video and still images.
- Materials testing.
- Material deposition and erosion tests.
- Langmuir Probe Analysis.
- Optical Spectroscopy.
- Near Ultra Violet light measurements.
- Infrared measurements.
- Polarimetry.



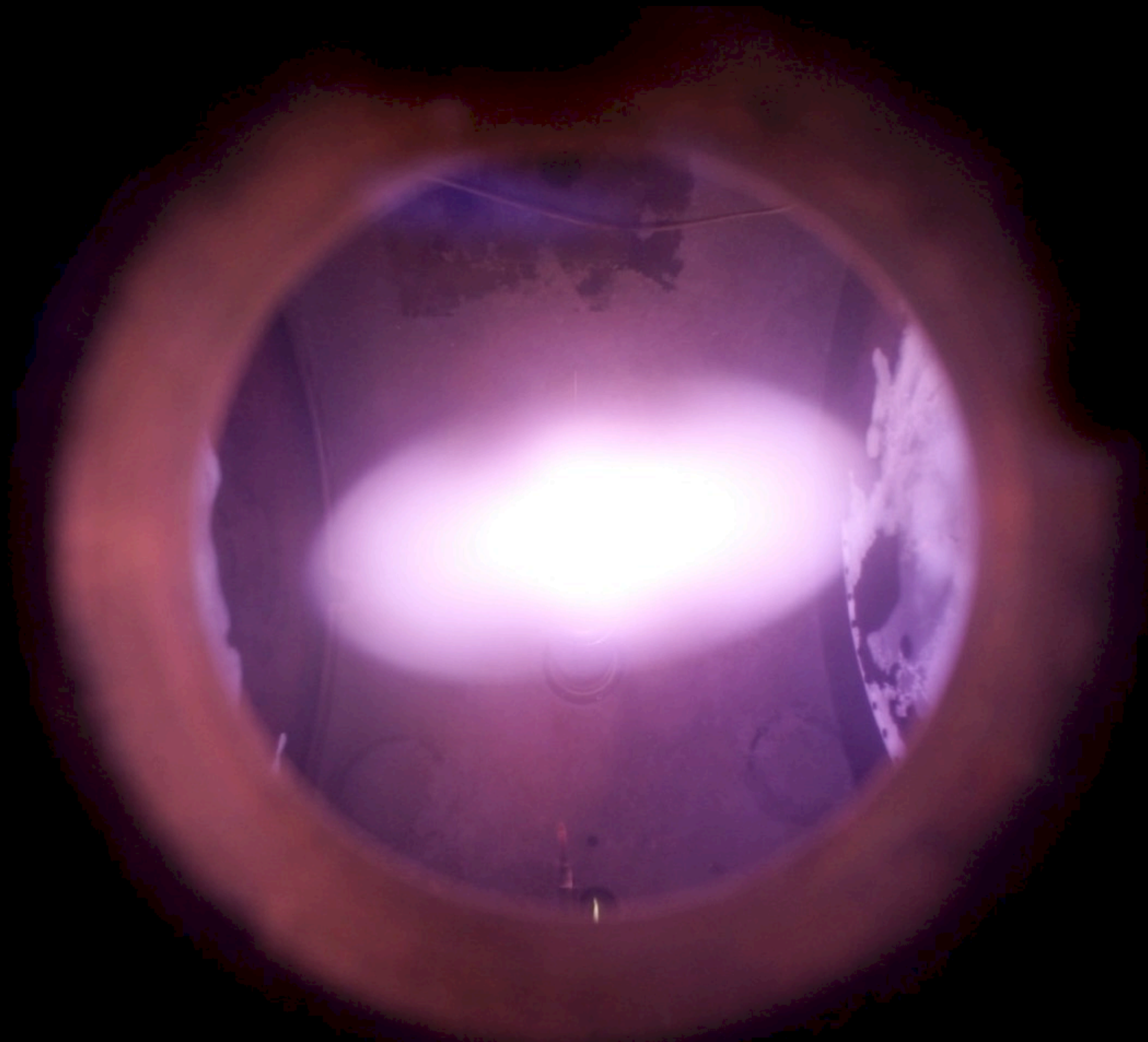
THE FUTURE



The key objective moving into the future:



Basic Research



Basic Research

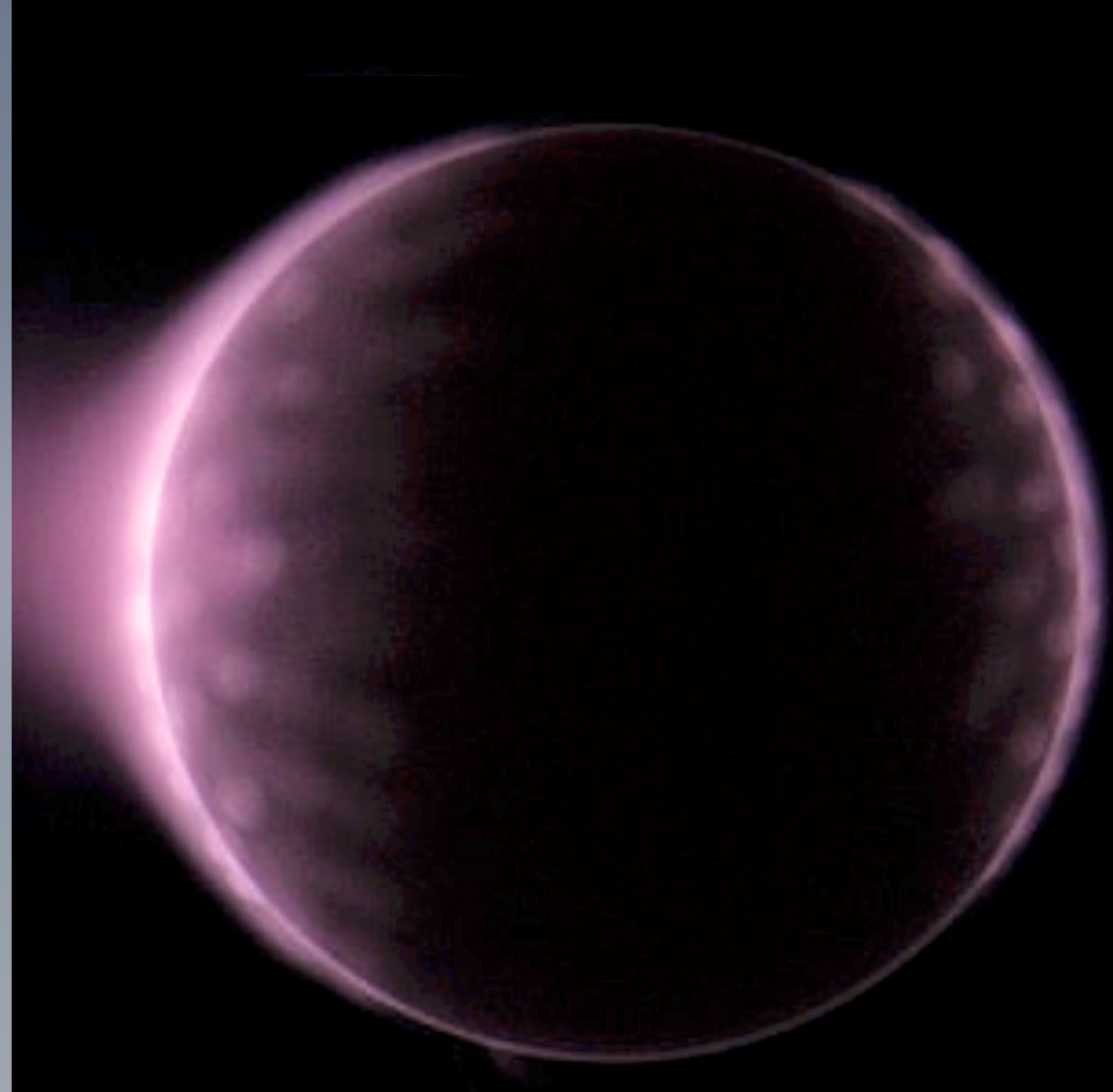
This new advancement in plasma science demonstrates a process that consistently creates, contains, and controls the plasma double layers in stable exothermic plasma reactions.

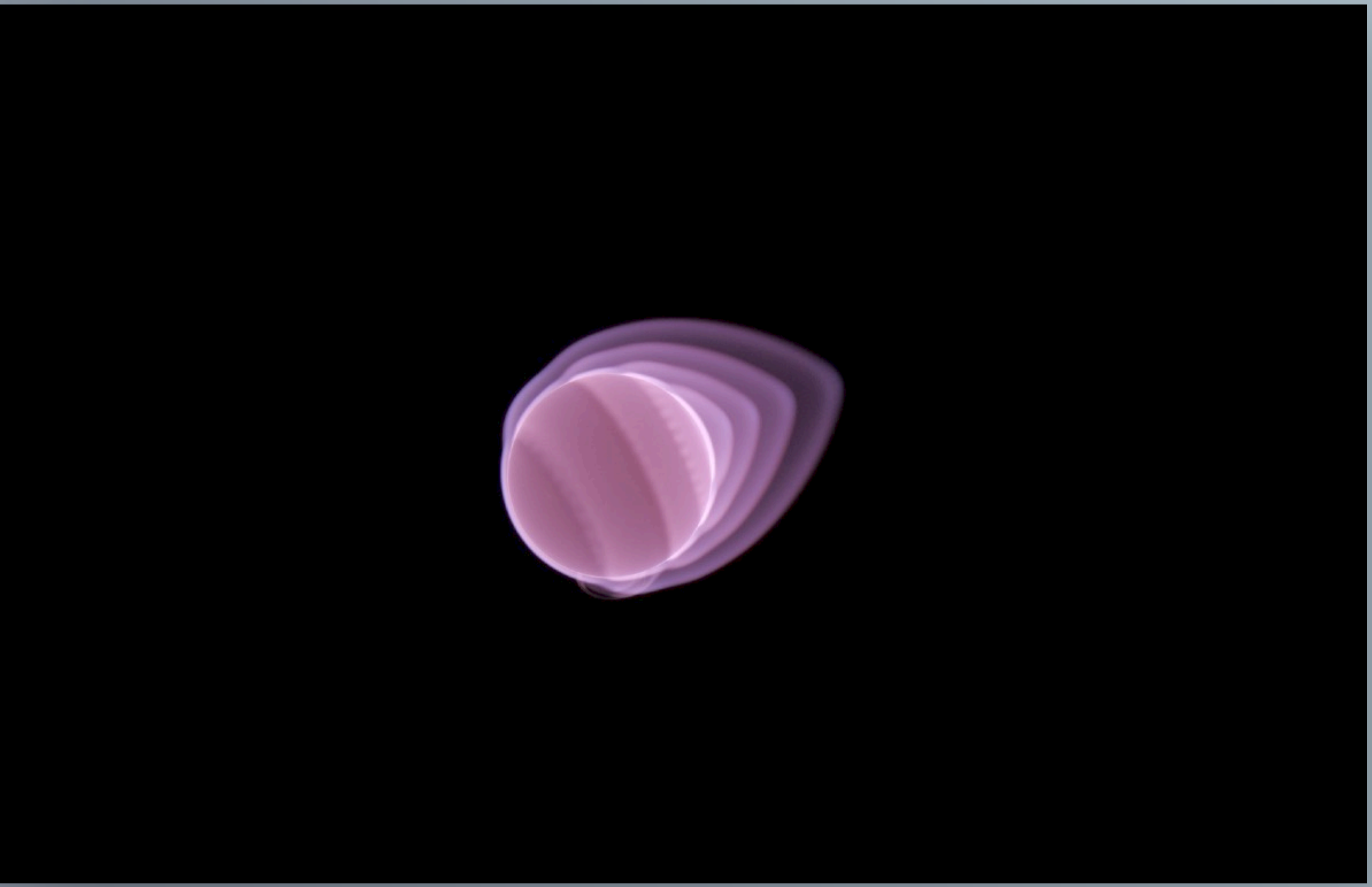
Although the energies and densities are comparable to the sun's photosphere and nuclear bombs the data shows no harmful side effects such as radioactivity.

But the science of what is actually happening at the molecular and atomic levels is not yet fully understood.

Understanding these reactions will give valuable insight into the way the sun’s atmosphere functions, and provide the foundation by which theses energies can be beneficially harnessed.

This research will be the top priority of 2018.





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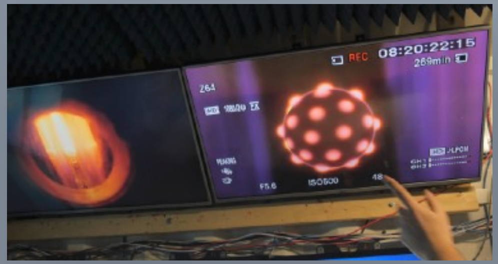

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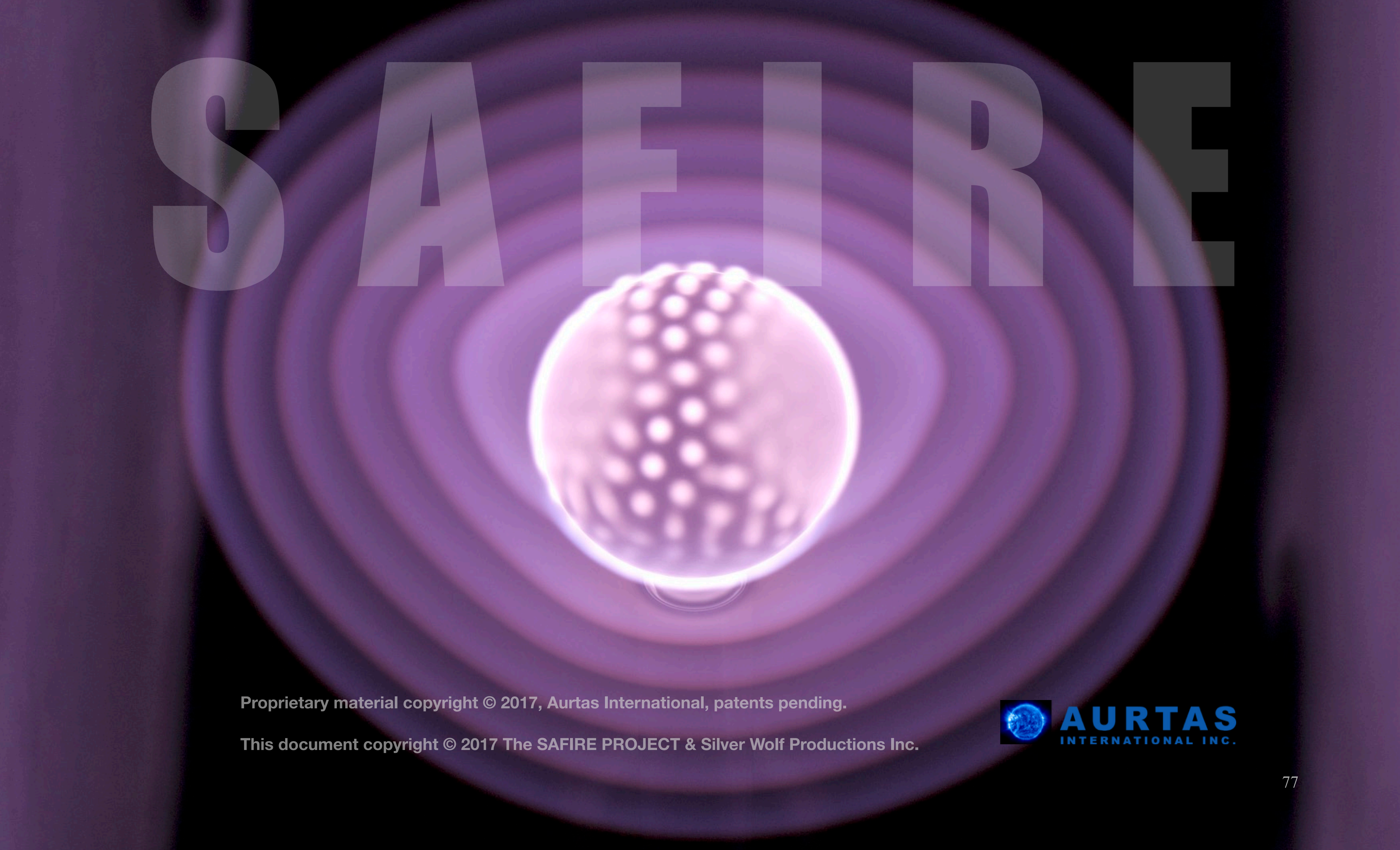
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