THE SAFIRE PROJECT

ELECTRIC UNIVERSE UK

INTERNATIONAL CONFERENCE & SYMPOSIUM

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SOMERSET, UK

SAFIRE PROJECT 2018 REPORT

WITH

MONTGOMERY CHILDS DR. MICHAEL CLARAGE

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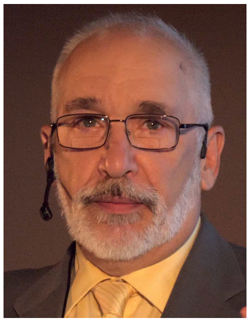


Montgomery Childs & Michael Clarage

SAFIRE 2018

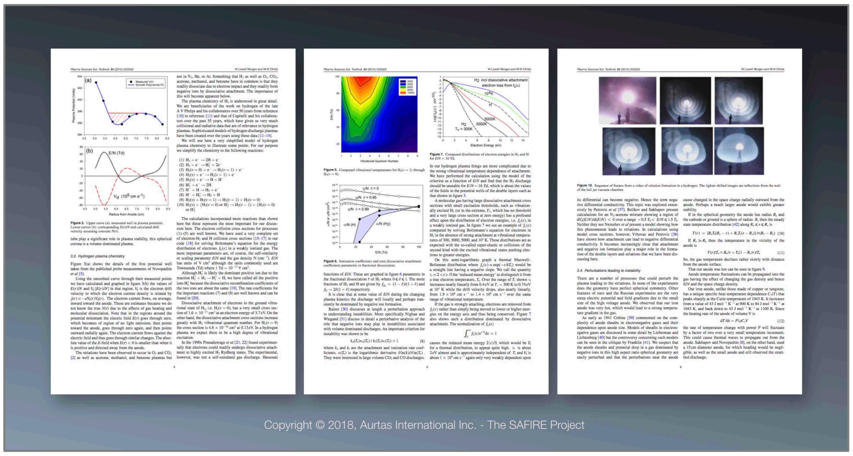
Electric Universe UK Conference
7th July 2018

Montgomery Childs: I want to thank Lucy and Adrian for inviting us. We do empirical science. We are not theoretical physicists, although we do use a lot of theoretical math to develop and design and build SAFIRE. The purpose of SAFIRE is to test the Electric Sun – the Electric Universe model. Back in 2011 I was approached by folks from the Electric Universe community to see if there would be a way to test the model. I did an evaluation and we're going to be talking quite a bit about what's called Design of Experiments: it's a methodology by which you can filter a hypothesis to see if it's testable. That's what happened. SAFIRE got started in 2013. SAFIRE has proven that it is capable to contain, control, and stabilize high-energy dense plasma. We're seeing chemistry changes. We are slowing the speed of light. We are getting variations in electron density comparable to the photosphere, the heliosphere and nuclear bombs, and we're getting electrical confinement of high energy photons. When you break the model down, it's due to charged plasma effecting matter of a different electrical potential and that's it. It doesn't mean that there aren't other factors, but those are the two primary factors and it looks like it's testable.

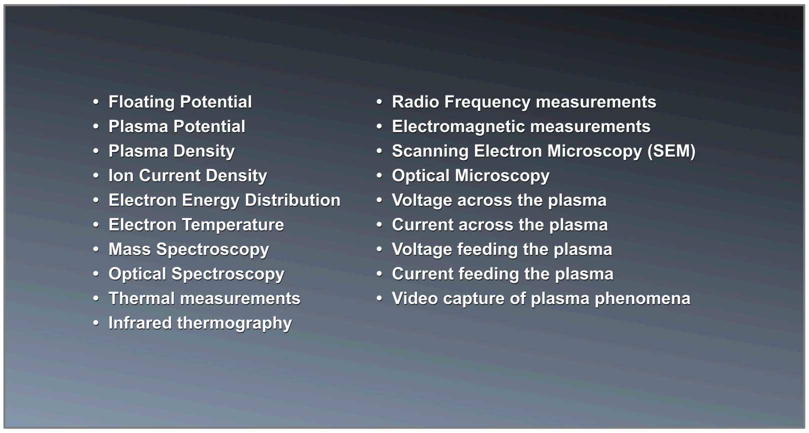
RESEARCH OBJECTIVES

SAFIRE stands for *Stellar Atmospheric Function in Regulation Experiment*.

We have one peer review paper that was published a year and a half ago. It's a study of striations and spherically symmetric hydrogen discharge. What we discovered is that in the double layers that you saw in the video electrons and ions are being trapped. We call them plasma walls or we call them double layers. It is in those double layers where the matter is actually being contained. The double layers are sequestering material into the core just above the surface of the anode. We have four other papers that we're working on. We may get them ready for publication this year, I hope, a lot of work to do.



TECHNOLOGY IN SAFIRE

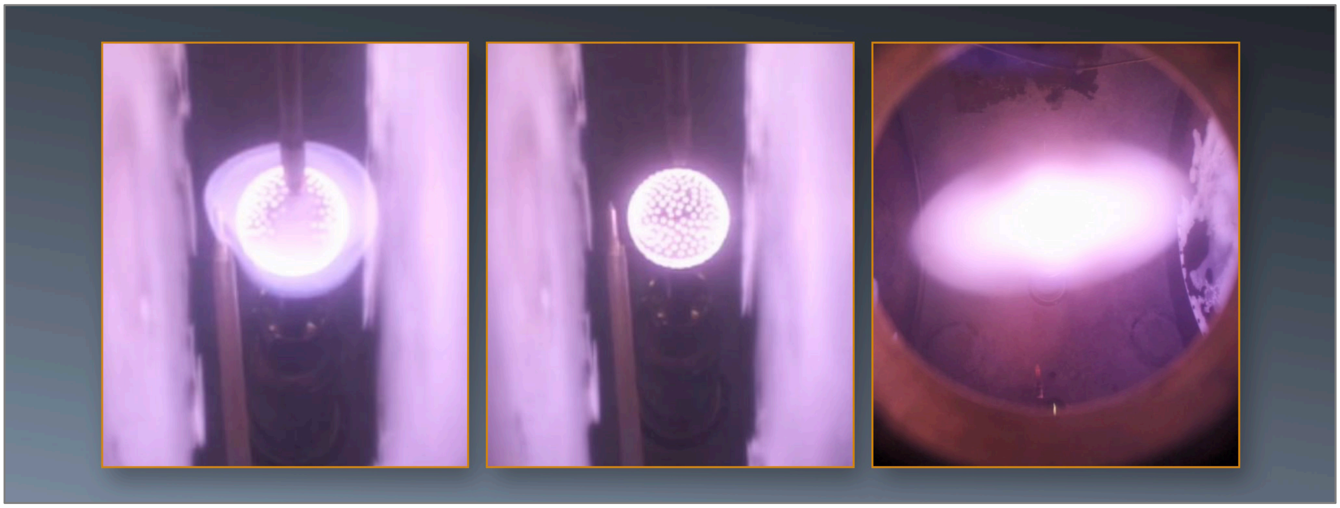


- **Floating Potential**
- **Plasma Potential**
- **Plasma Density**
- **Ion Current Density**
- **Electron Energy Distribution**
- **Electron Temperature**
- **Mass Spectroscopy**
- **Optical Spectroscopy**
- **Thermal measurements**
- **Infrared thermography**
- **Radio Frequency measurements**
- **Electromagnetic measurements**
- **Scanning Electron Microscopy (SEM)**
- **Optical Microscopy**
- **Voltage across the plasma**
- **Current across the plasma**
- **Voltage feeding the plasma**
- **Current feeding the plasma**
- **Video capture of plasma phenomena**

Technology in SAFIRE. These are just a few of the things that we're measuring in SAFIRE. It is quite an instrument. It's not like it's an apparatus and we're just firing it up. We have a variety of different instrumentation that we measure in real time, and then you'll see later on – after we do those measurements, we collect the data in real time. We're working on doing an overlaying of the data in real time; so mass spectroscopy, optical spectroscopy, oscilloscope readings, and RF are getting recorded, and then we place them over top of each other, think of it as a real time indication of these measurements as they relate to each other. I don't know that it's ever been done before. I mean maybe a couple of things, a couple of instruments, but not to this degree. And then we have post experimental analysis that we do as well, and we'll be getting into that. In the chamber we contain, control, and measure the plasma in real time. We then also do further post-experimental analysis on the data collected.

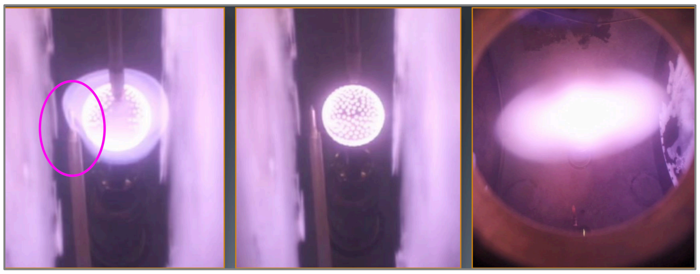
OPTICAL SPECTROSCOPY

Michael Clarage: Optical spectroscopy is one of our methods for analyzing what's going on in the chamber. What you're seeing here is three different settings or intensities of the discharge.



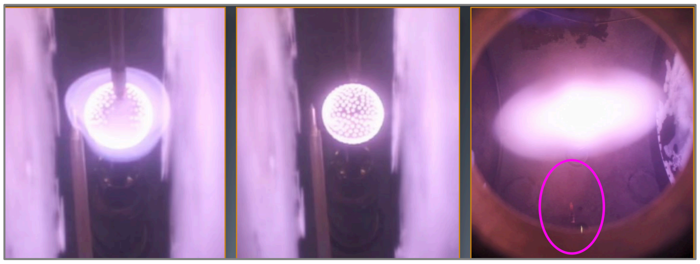
The anode there is the center glowing ball and then we place fiber optics to take in primarily visible but a little bit into the IR and UV also light.

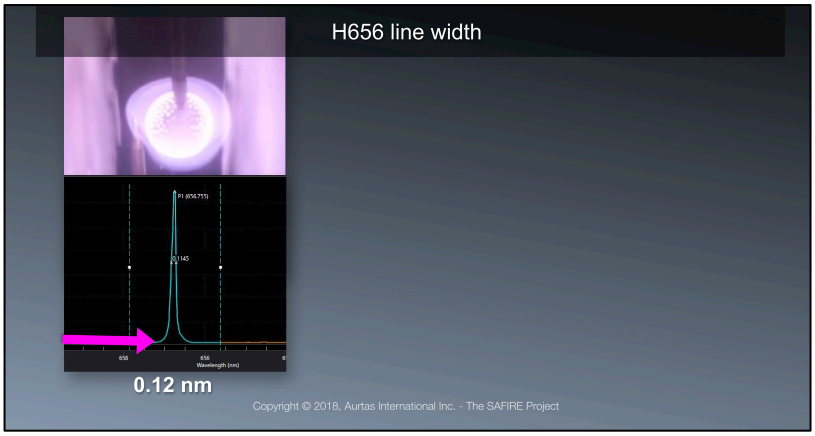
You can see in this case the fiber is placed inside of one of those striations.



The next one, we pointed away from any striation so just into the side if you will of the discharge.

And then in this last one we turned all the dials up to 11 and got the most we could, and measured the light coming from that discharge.





H656 line width

0.12 nm

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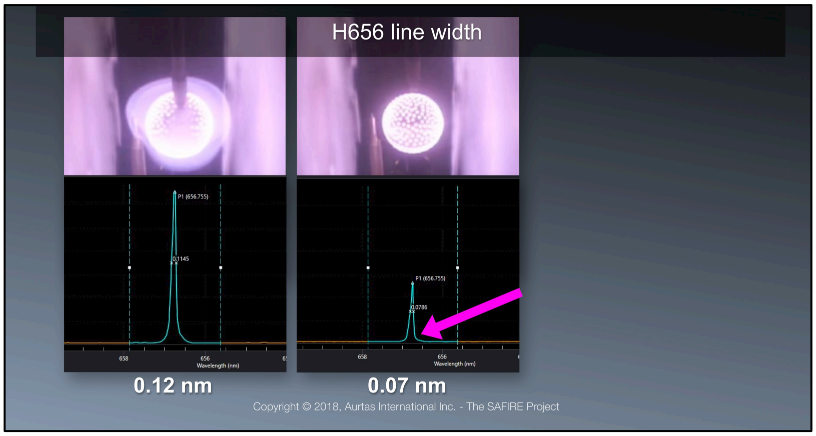
What we’re focused on often with the optical spectroscopy is the width of the line. So, light as we know is in colors. A lot of times for optical spectroscopy we’re looking at just one color, one emission line from a substance. This is a sort of data we see from our spectrometer. This is the intensity of the light as a function of wavelength and you can see it centered on about 656nm, that’s a very famous hydrogen emission line and it has a certain width to it.



H656 line width

0.12 nm 0.07 nm

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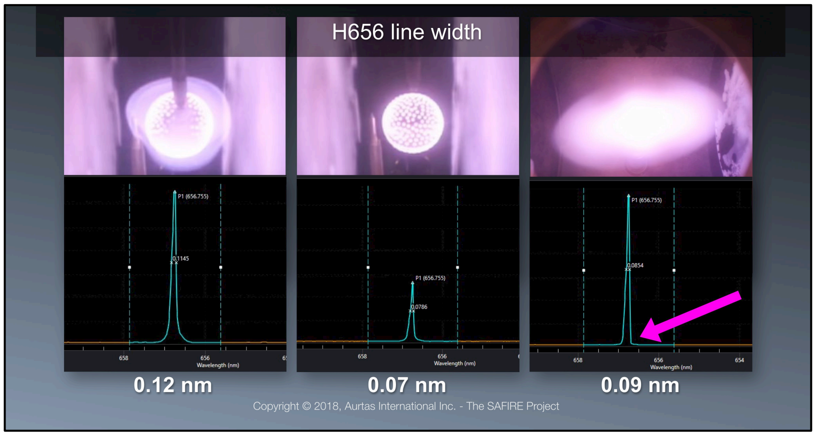
We look at the second case where we move the optical fiber a little bit off to the side. We do the same measurement. We see there’s a different width to the line.



H656 line width

0.12 nm 0.07 nm 0.09 nm

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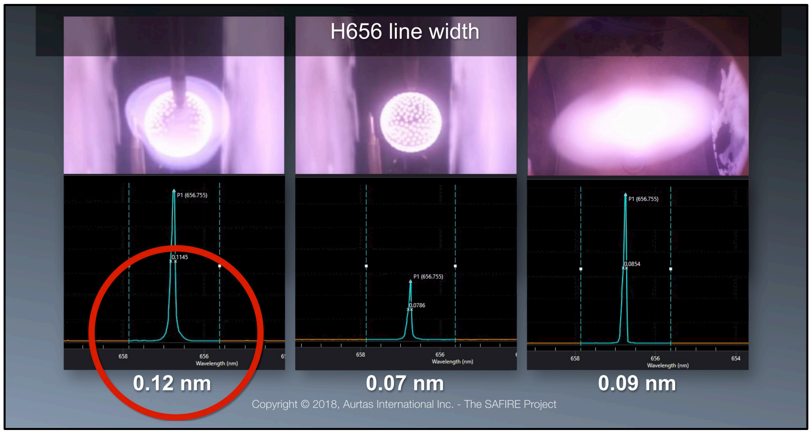
And then the third case again same measurement, a different width for there.

The width can tell us a lot of things about what’s going on in the plasma. The width of the spectral lines is one of the main ways that and astronomers use to measure temperature in the sun. There are other methods also, but this is one of the main methods and one of my jobs for SAFIRE is to take whatever methodologies are being used by NASA and ESA and use the same methodologies in our chamber. So, we can do apples to apples in the comparison. If I show this data to a solar physicist, he or she would interpret it as temperature readings or of electron density variations. I won't go into how he would distinguish the two, right now. We're going to look at the electron density variation aspect of what these lines are telling us.



H656 line width

0.12 nm

0.07 nm

0.09 nm

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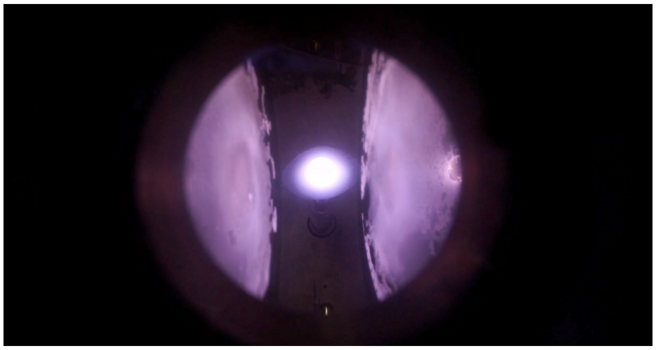
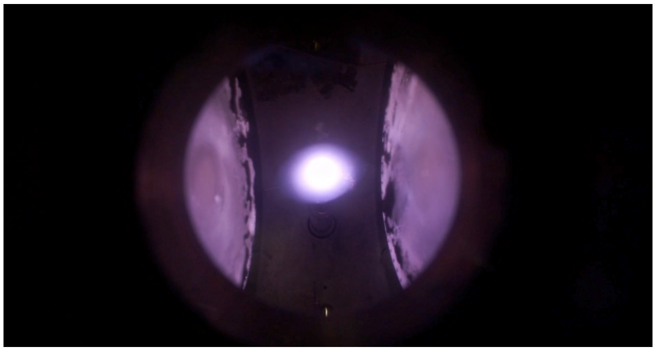
What do those line widths mean when you work back as a solar physicist would? You would say that variation of just 0.05 nm in the line width means that we have variations of electron density in our chamber 50 to 100 times. We don't know the absolute value from these numbers. We know how much it's changing, how much the variation is. And within those three different discharges that we showed you, that variation electron density, there is a hundred-fold variation in that density.

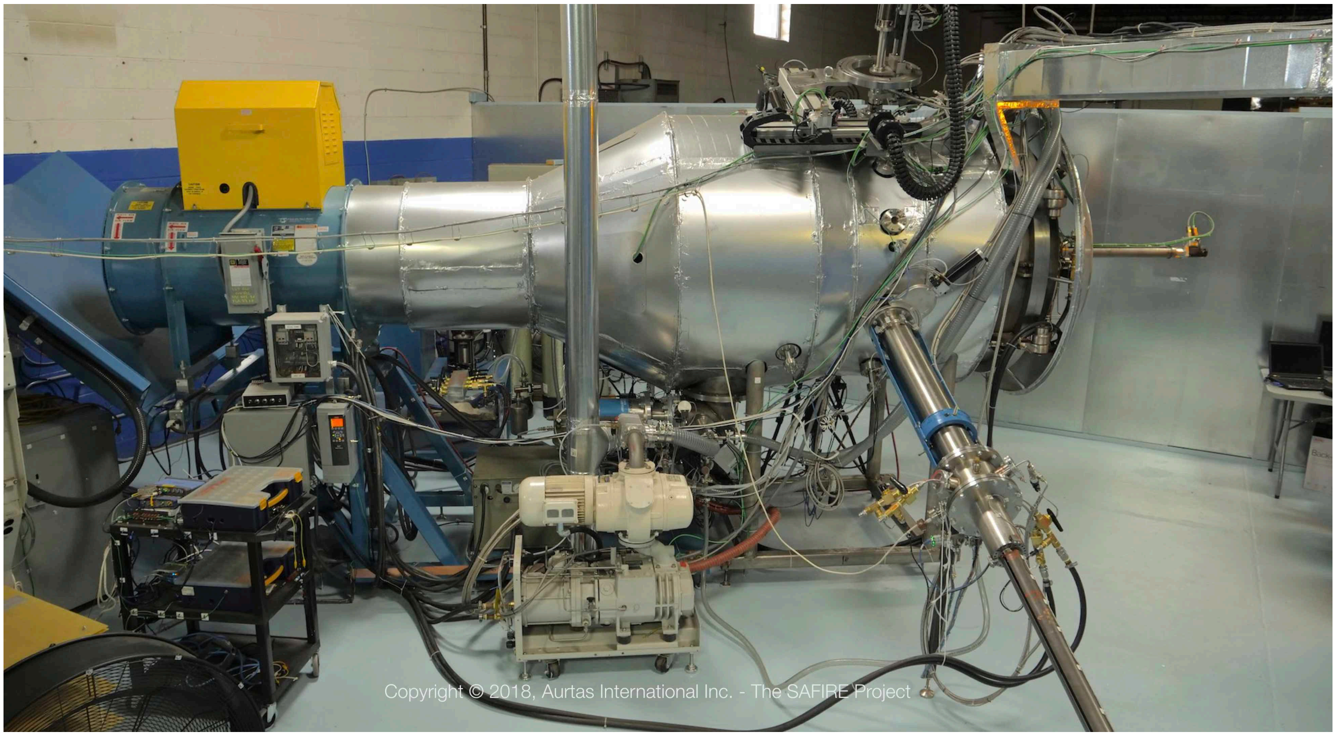
This was very exciting for us, because that's one of the main difficulties in explaining the photosphere electrically. How would you reproduce that size of electron density variation? We didn't know we were going to get this. We had no idea. But those density variations are exactly what one sees in the free electron variations off the photosphere. Voyager going through the heliosphere sees similar variations in free electron density. So, again, this is all in line of us reproducing astronomical observations in our chamber.

SAFIRE SYSTEMS

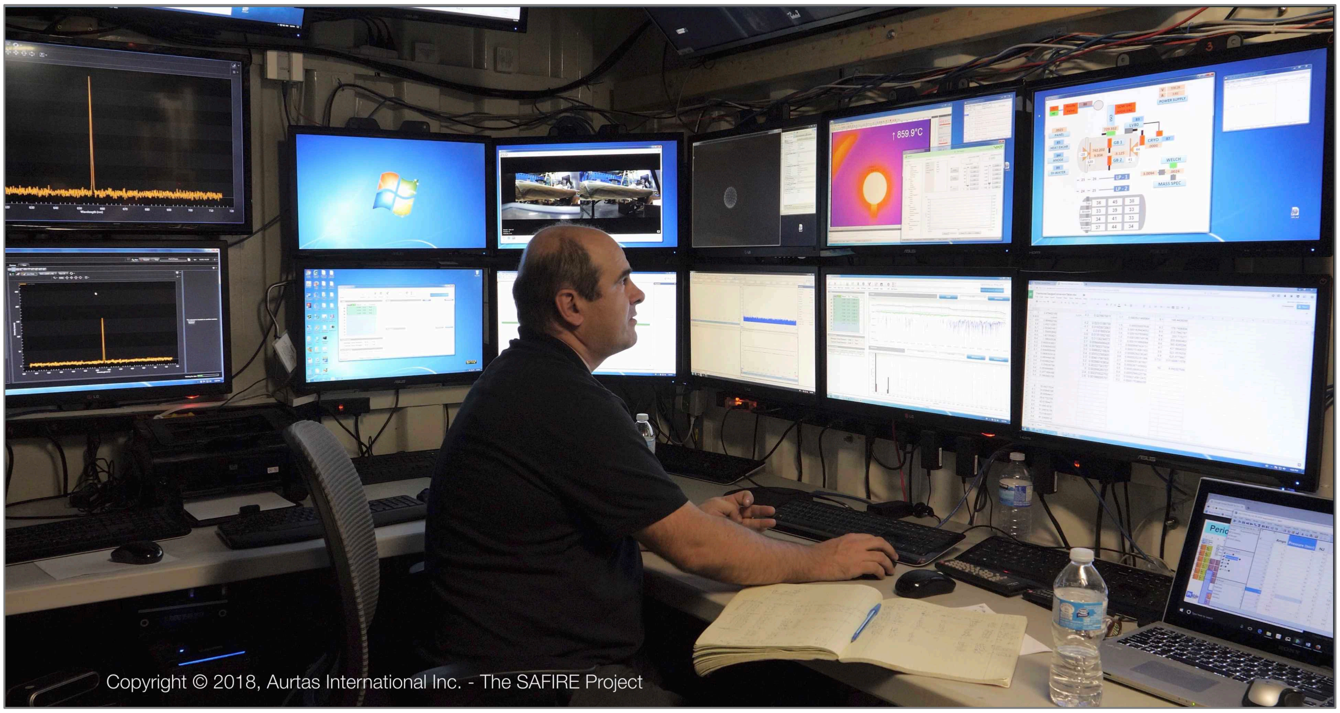
Montgomery Childs: And now, I have to start talking for Paul. And Paul is … Paul is different. He's a chemist. I'm a mechanical guy, Don Scott's a *sparky*, I'm a *cranky*. In any case, Paul is not here. I'm going to attempt to explain what a Design of Experiments is, how they're used, and to date I don't think we've been super successful in explaining them, because they are complex. We'll try and then you can give me some feedback afterwards to see whether or not we've been successful. This is just a cool little video *(images below)* to give you an indication of the control that we have over the cathodes.



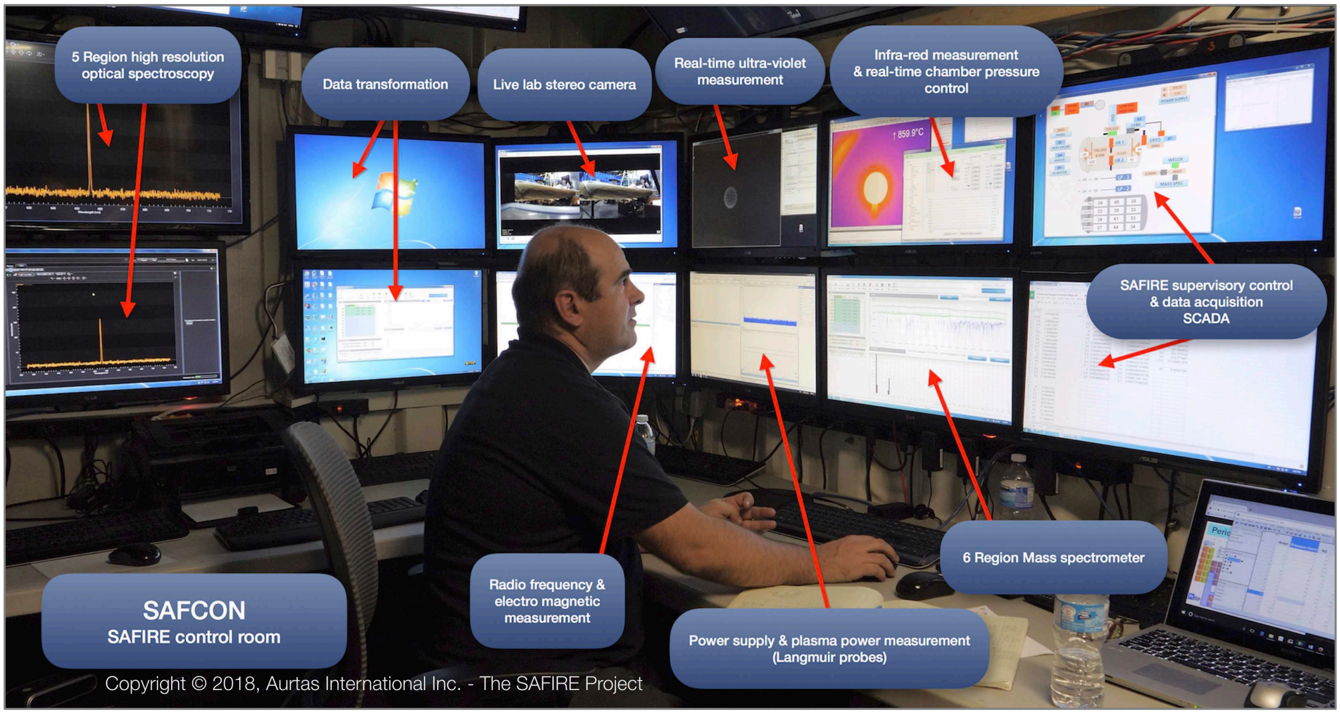




This is SAFIRE, the reactor. Complicated. We could fit probably 10 people inside the chamber. Looks like a jet engine. Once we fire it up to keep the chamber cool it sounds like a jet engine. The fan at the back will do 14,000 cubic feet of air per minute.



This is SAFCON – the SAFIRE control room. That’s Jano, one of our techs.



Five region high resolution optical spectroscopy. SAFIRE has the capability of measuring five different regions within the plasma. We have two long probes that come in. We can move them around in 3D anywhere in the plasma. We can put them right into the double layers, move them over in different regions; but five different regions at the same time. And it measures at the rate of a megahertz, that means basically a million measures per minute, *(turns to Michael)*, right? **Michael:** Per second. **Montgomery:** Per second, right, I'm sorry. So, that's per second. A million measurements per second. We can pick up change in the optical spectroscopy very quickly. It's very sensitive.

Data transformation. We can do overlays of all the data. We collect it all. It goes into one computer system. Then we start to do overlays of the data graphically, so if you look at numbers like me, I can't make sense of numbers, but if I look at a graph, I can start to relate to it.

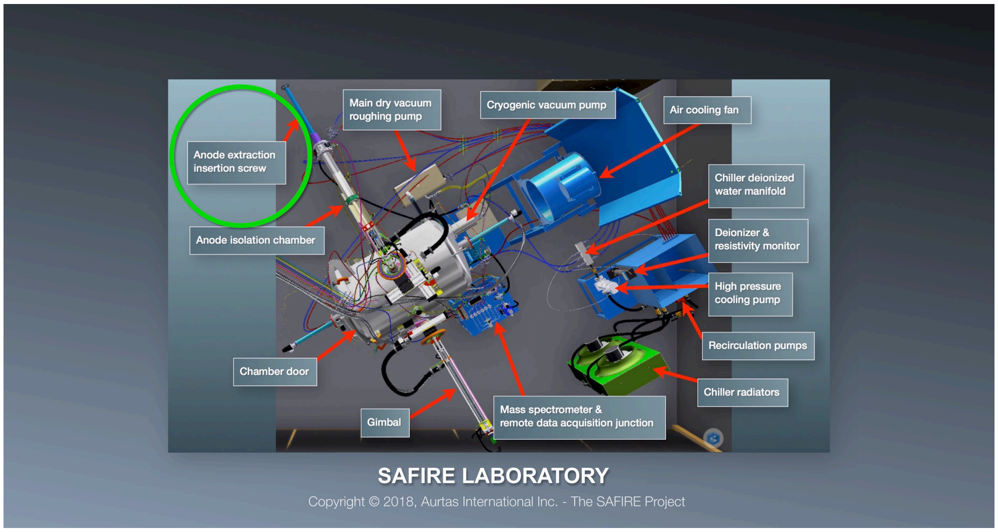
Live lab stereo camera. Just in case somebody's out there. It's for safety. But it also gives us an opportunity to see some of the manipulation. When we're running SAFIRE, nobody's allowed out in the chamber area.

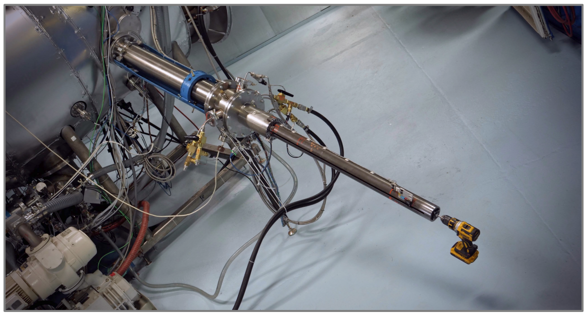
Real-time ultraviolet light measurement. Infrared – we do that to monitor temperature of course.

Supervisory control and data acquisition, *SCADA*. This will probably be new to many of you. But it allows us to gather the data back from what is happening in the chamber. We already have pre-settings, as to how we want the chamber to run. So, it's supervisory control, which means that the computers themselves can control, let's say pressure, as an example, or a vacuum. We set the vacuum to be a certain pressure and, using cool technology, link Servo motors and butterfly valves, and the computers can maintain the pressure in the vacuum within the chamber.

Six region mass spectrometer. The mass spectrometer is on the two probes with the optical spectrometers; so, we have both optical, mass, and floating potential probe, in one probe. We're measuring all three at once. And we can move it anywhere into the chamber. We're looking for any chemistry changes. Voltage probes, as Don *(Scott)* pointed out, are used to measure the e-field, plus many other things. It tells us a lot about what's going on the plasma. Michael is going to get into the analysis, which is pretty amazing stuff.

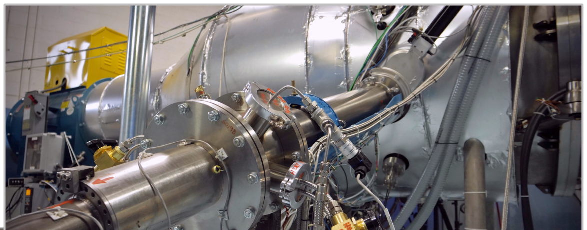
Radio frequency, and many more things; but that's SAFCON. I think we have 15 computers in there, plus servers. Some of them are monsters. There is a lot of data to process.

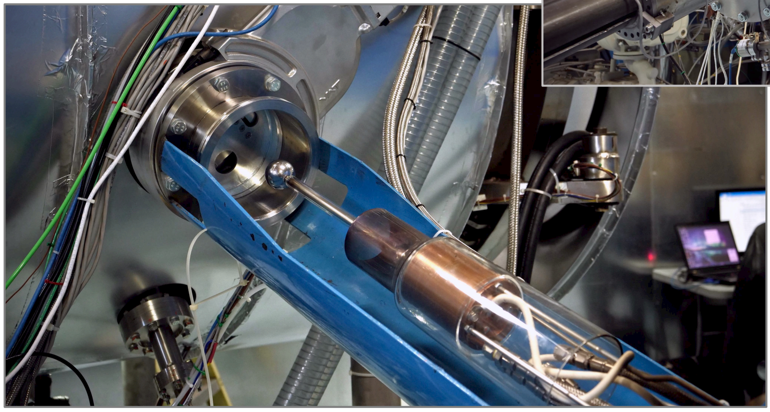


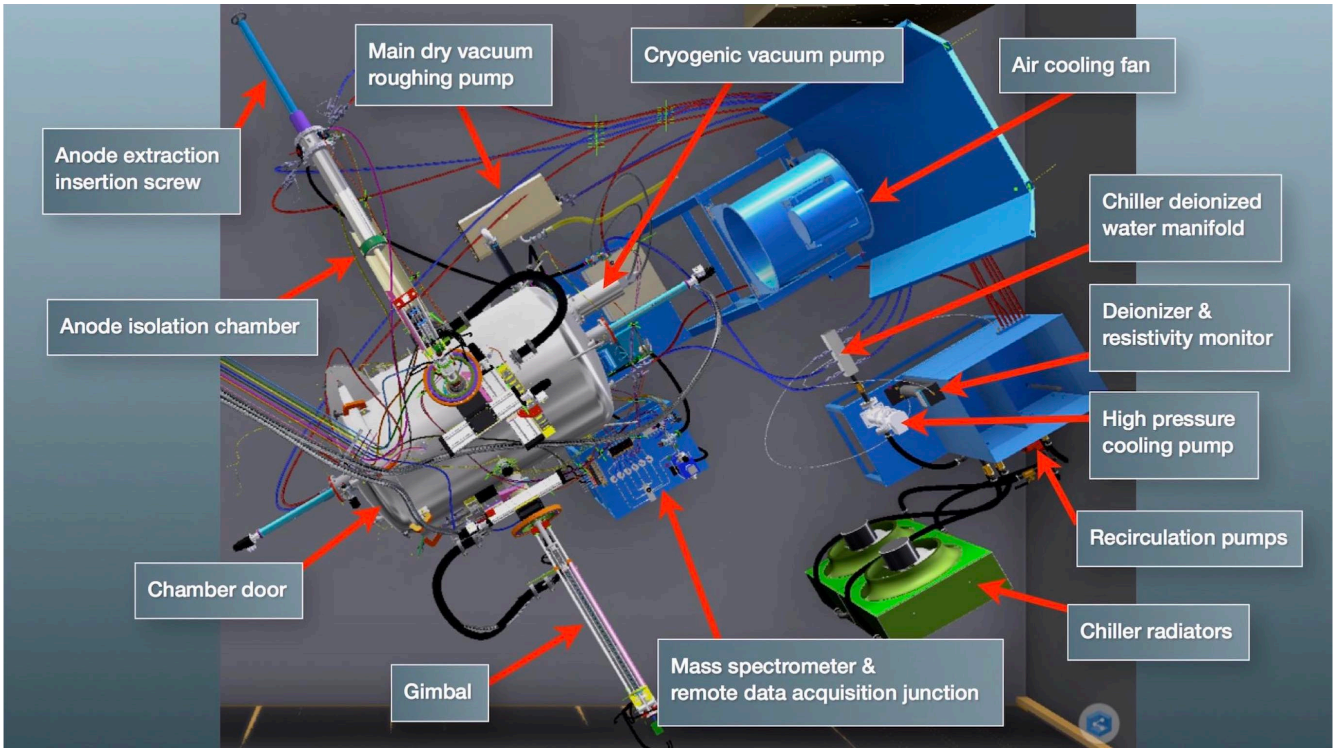


This is an overview of an *anode extraction insertion screw*. It allows us to take the anode out of the chamber without compromising the chamber gas. It might take two or three days sometimes to get all the impurities out of the chamber.

In this small isolation area we have valves that open or shut. We can pull the anode out, then seal off the chamber. We can change the anode or change different things. Then we reinsert the anode, close up the isolation area, evacuate it, and slide the anode back into the chamber, without disturbing the conditions (vacuum & gas) of the chamber. It allows us to do a lot of different experiments very quickly.

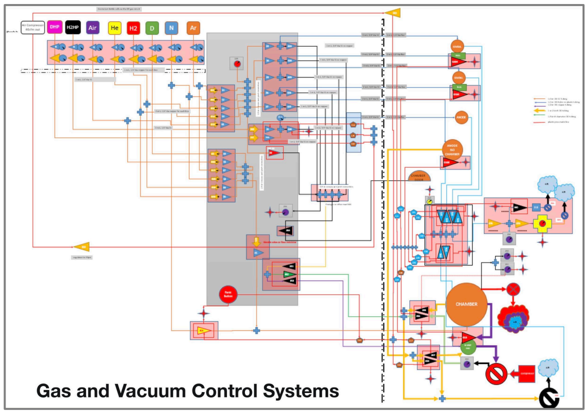






Vacuum pumps – because you need vacuum pumps to get vacuum. *Cryogenic*; *Air cooling*; *Chiller* – the reason why we have a chiller is because we actually cool the core; we use deionized water, which doesn't conduct electricity, and we pump it up through the core and through some of the anodes, the hollow ones, so we can cool them down. This is so we don't melt things. *Mass spectrometer & remote data acquisition junction; Gimbal; Chamber door* – we have a big chamber door we can open it up, so we can get in.

This is just a basic circuit here. It gives you an idea of the gas and vacuum control. Now I don't expect you to understand what you're looking at, it's complex. If we are putting gas into the chamber, we need to maintain pressure. We have to be able to control that. We have to know how much gas we're putting in; how much we're taking out. Hydrogen is going into the chamber and of course nothing ever bad happened mixing hydrogen with other elements, especially at the temperatures that we have *(audience laughing)*. So, we have to monitor not only how much hydrogen we put into the chamber, but if you're pumping it out through your exhaust system, it's not a good idea to blow the factory up because you've got raw hydrogen going out the exhaust pipe, okay? So, we diffuse it with nitrogen and we monitor all those gasses in real-time to make sure they're within safe levels, and we run different tests and pretests. Have you ever seen a checklist for a pilot flying a 747? It's a book. It might have about 200 or 300 items on the checklist before you can actually fire up the engine. It's very much like that. We have to go through them item by item. We're always looking for ways that maybe we've missed something in the engineering, or in our process, so we don't end up on the evening news. Well, we'd like to be on the evening news, but not because we've left a black hole in the middle of Mississauga.

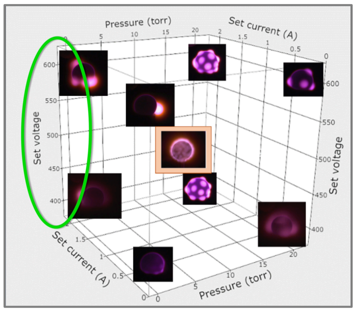


DESIGN OF EXPERIMENTS

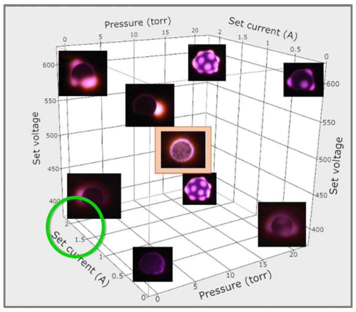
Design of Experiments – what I’m going to recommend is that you Google ‘Design of Experiments’, after you’ve heard my talk. It’s not designing an experiment. It’s not designing SAFIRE. It’s how you *conduct* the experiment.

SAFIRE regimes – the picture here is typical of what you call Design of Experiments design space, and Paul has attempted to explain this a few times. The feedback we get is that we haven’t been so successful.

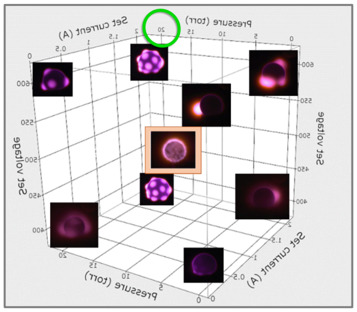
I told you if we increased the voltage from 400 to 600,



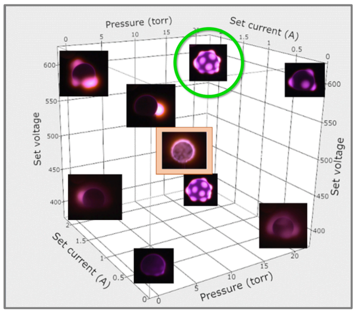
… and set the current from 1.5 or a 2,



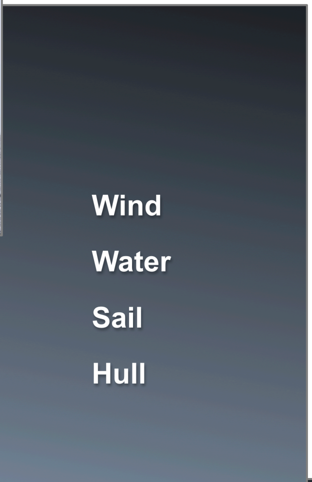
… and then set the pressure torr up to 20,



… we’d get the top middle plasma regime. Now the eyes start to gloss over. So, we decided that we’d talk about something that maybe people can relate to.



I love sailing, and some of you know that I've done a lot of racing, and I've sailed America's Cup and Canada's Cup and the Admiral's Cup. That was our racer back in 2004, a fast boat. It was designed by Steve Killing who is America's cup designer. It's a prototype.



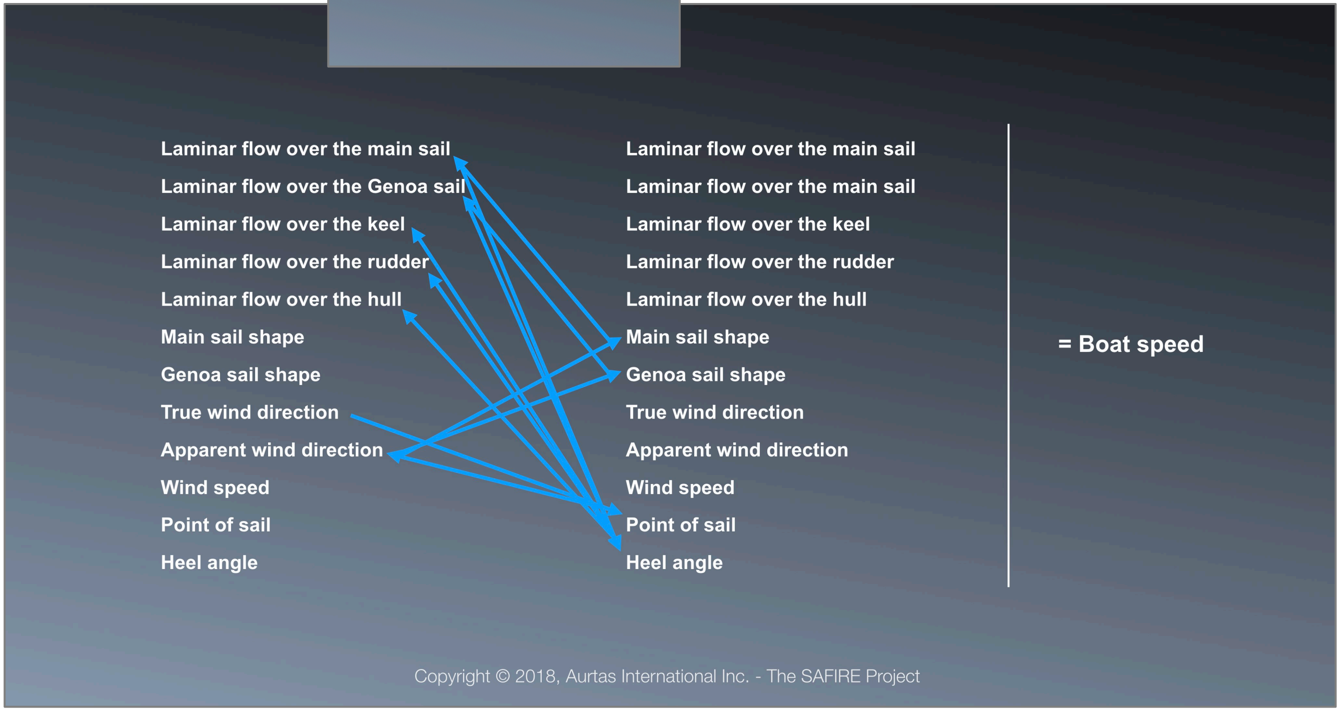
Wind

Water

Sail

Hull

With sailing you have four primary factors. You have wind, water, your sail and your hull.



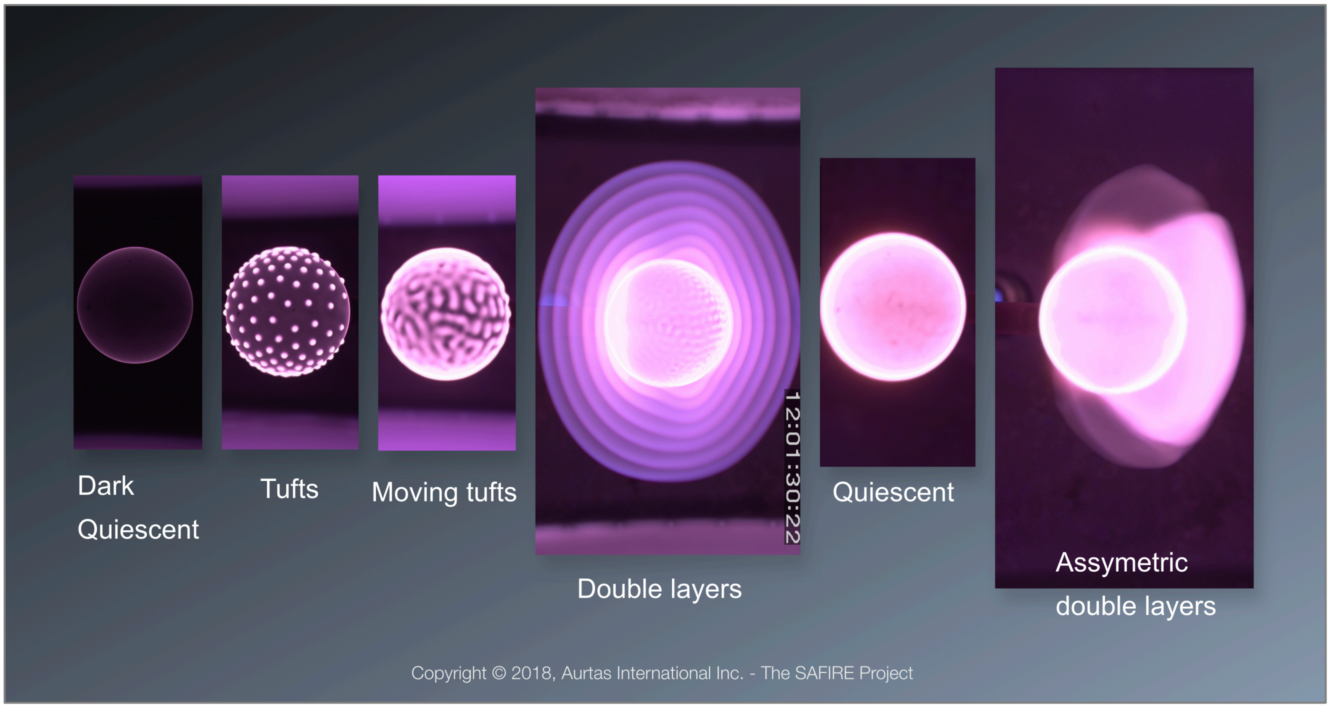
Laminar flow over the main sail
Laminar flow over the Genoa sail
Laminar flow over the keel
Laminar flow over the rudder
Laminar flow over the hull
Main sail shape
Genoa sail shape
True wind direction
Apparent wind direction
Wind speed
Point of sail
Heel angle

Laminar flow over the main sail
Laminar flow over the main sail
Laminar flow over the keel
Laminar flow over the rudder
Laminar flow over the hull
Main sail shape
Genoa sail shape
True wind direction
Apparent wind direction
Wind speed
Point of sail
Heel angle

= Boat speed

Then you have interacting factors. These aren't all of them. These are just the ones that you should know about if you are a sailor. If you're designing a sail boat, you can probably multiply that by 10. We first start off with the true wind direction – where is the wind coming from? If the wind's coming from over here, I want to get what's called point-of-sail, but I want to go over there. I can't go into the wind but I can get off to the wind. So, you select your point of sail. Then you have what's called apparent wind, which is actually the wind coming into your sail once you've set your point. Then you have to set you main sail shape and your Genoa shape. Those are the two sails, the one in the front, one in the back, and the shape what we're talking about is the actual foil

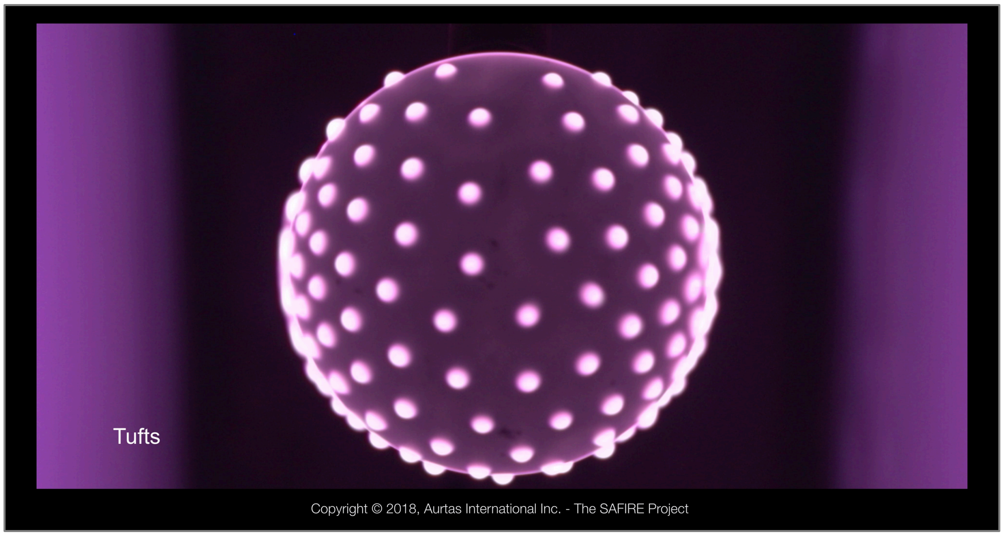
There are lot of similarities between flying and sailing – those sails are wings and you want to get a low-pressure system on the wing of your sail. It pulls the boat along. It's another factor. So, you have to deal with the shape and that's what we would call it *variable* because you can change that. You're not going to change the true wind speed because that's a *categorical* factor. The main sail, and Genoa shape, they are *variable* factors. And once you do that, then you factor in laminar flows over the mainsail and the Genoa sail. It's the laminar flow that gives you lift. Once you've got that set up and your boat starts to sail, it starts to heal. When it starts to heal, this changes all the factors, and you have to set your point-of-sail again. That would be like a second order interaction: the effect of all these changes on the boat causes your sails to change. Now you have to adjust them because the boat is starting to heal over, which changes the laminar flow over the keel, the rudder and the hull. And if you get it just right, you can start winning races. It's called being in the groove. And all that equals boat speed. The ultimate objective is to get boat speed. You have to consider all these factors and more if you're a sailor and if you're going to win races. If you don't consider these things here and you're a sailor, okay, the stress level goes up and you don't consider all the factors, this is basically what happens …



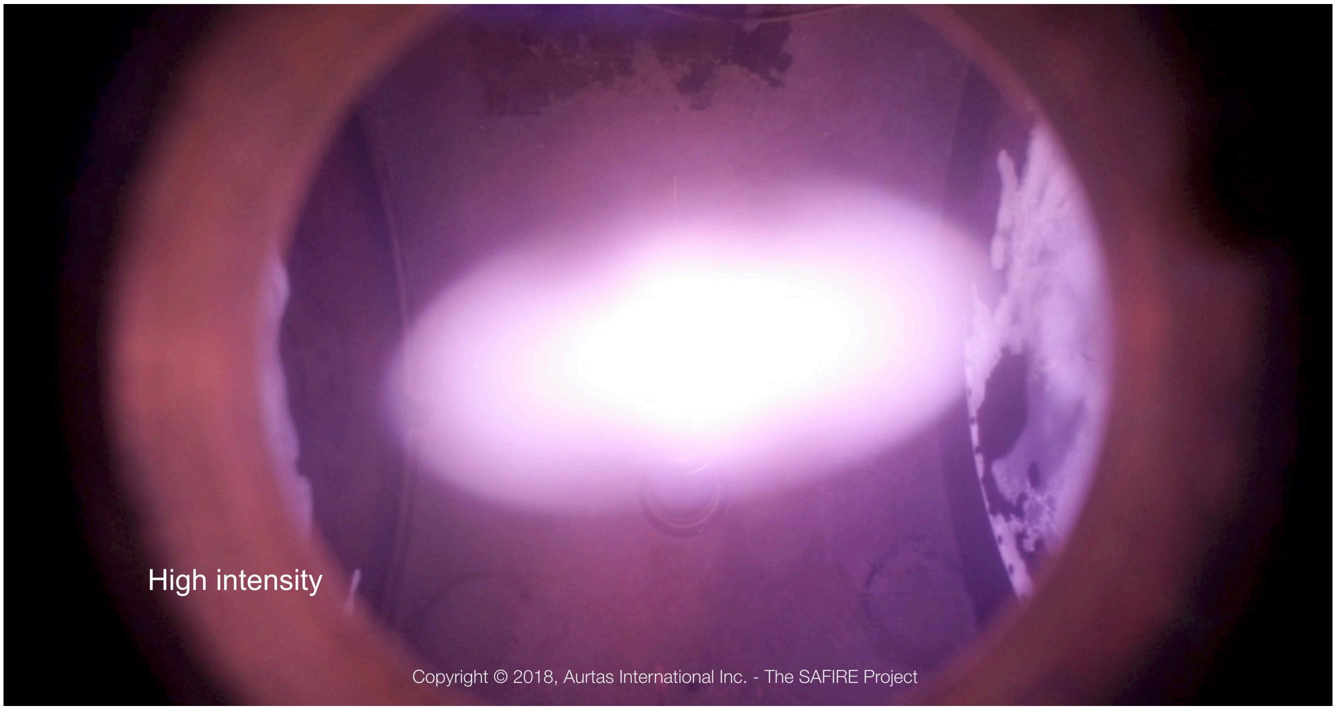
These are some of the regimes that we get. We get quiescent. We get tufting. This is more of an active plasma. You don't see the movement in this still picture. Obviously, the famous double layers that we get, this again is more intense. They're asymmetric double layers, but we haven't really looked at the last one very much.

What we're doing is we're trying to classify these regimes, to categorize them within groups so that if you came to us asking, 'can you give us double layers?', we can turn around and say – here's a check-list, yes, and we can dial it all in now, and we can say – here's your 'double layers'. And we can do this as much as you want for as long as you want. So, we have very good control over the plasma in there. It's not out of control, which is often typical of plasmas.

They're beautiful. We get to watch this stuff all the time. It's such a tough job.

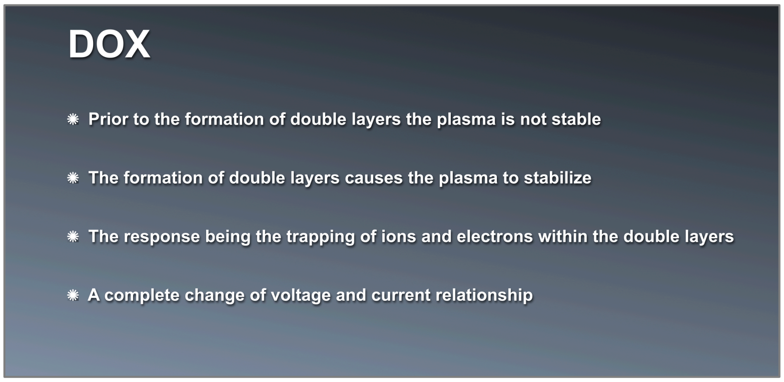


These tufts you see, are actually not sitting on the surface. You might be able to just pick it up here on the top left. You can see this just actually over top of the surface of the anode, and that's going to become important little bit later on when we talk about the voltage drop.



This here – was dialed to 11. Anybody ever seen *Spinal Tap?* 11, okay? Well anyway, forget it. You can't see it on this picture, but actually there are double arrows all within there – that's the most intense plasma that we have right now. Well, it's the dials are at 11.

We use *Design of Experiments* to understand the interactions between all the factors and the systems in order for us to be able to get these plasmas.

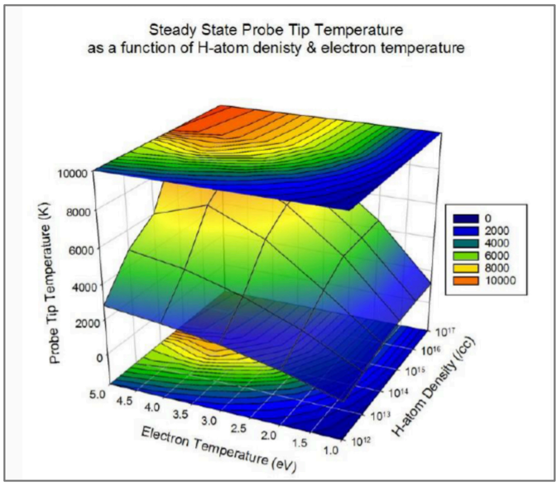


DOX

- Prior to the formation of double layers the plasma is not stable
- The formation of double layers causes the plasma to stabilize
- The response being the trapping of ions and electrons within the double layers
- A complete change of voltage and current relationship

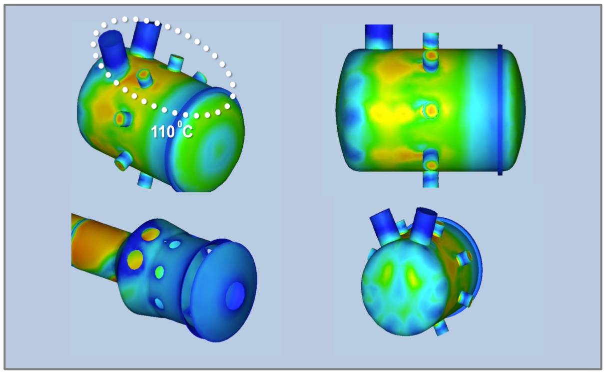
Prior to the formation of double layers, the plasma is not stable; Michael is going to show you the analysis on this later. The formation of double layers causes the plasma to stabilize. Once the double layers form, we see a voltage drop, and SAFIRE is saying 'I'm good'. It just it doesn't want any more voltage. It says, 'I'm satisfied with what I've got'. You could turn it to whatever you want, it doesn't matter, doesn't want it, which is a quite profound. The response is the trapping of ions and electrons within the double layers. And once that happens, it stabilizes. So, that's like I said – second order reaction or response, a complete change of the voltage and current relationship. Michael will talk about that. Radiation hydrodynamics, like I said before you get all the fun stuff.

RADIATION HYDRODYNAMICS



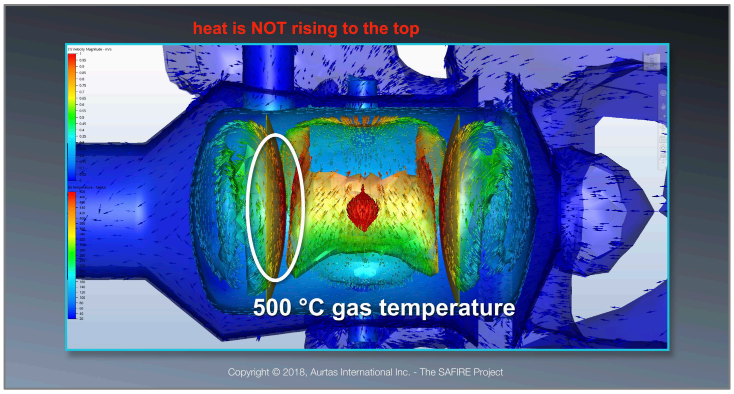
Michael: This is a good example of how the physics we inherited, so to speak, may not be always so predictive. We use our chamber as a laboratory to observe phenomena. Then sometimes we can go back and fill in some gaps like – how did this happen from a physicist's point of view? As Monty will soon say we destroyed quite a bit of equipment in our chamber; and it wasn't so clear to us how it could be happening, because there didn't seem to be enough energy present to do some of the damage that we were seeing. Lowell Morgan went back and did the radiation hydrogen dynamic analysis of it. And what came out of that, which was a surprise to all of us and quite wonderful, is that the discharge in the chamber is slowing down the passage of ultraviolet light. Optical light just goes straight through, no problem, but there's a particular frequency, at 10-electron volt, which is a high energy ultraviolet light that gets passed on very slowly from atom to atom. Even though it's not a dense plasma, the cross section is so high that a photon is emitted and is immediately absorbed by another hydrogen atom; which means if you are an ultraviolet photon, it takes you 60,000 times longer to get out of our chamber than if you're an optical photon. That sort of slowdown in the velocity of light is something that is often attributed to what we think we know about the sun, but to see it in our chamber here is a pretty exciting result. And the amount of energy that is stored, if you remember the discharges, you have to think about those layers, the discharge, that's what your eye is seeing. What our eyes can't see is this hidden or trapped or stored very high frequency energy that's just waiting there in the plasma for something like an unsuspecting piece of equipment to encounter it and then destroy it. Monty will tell you about that.

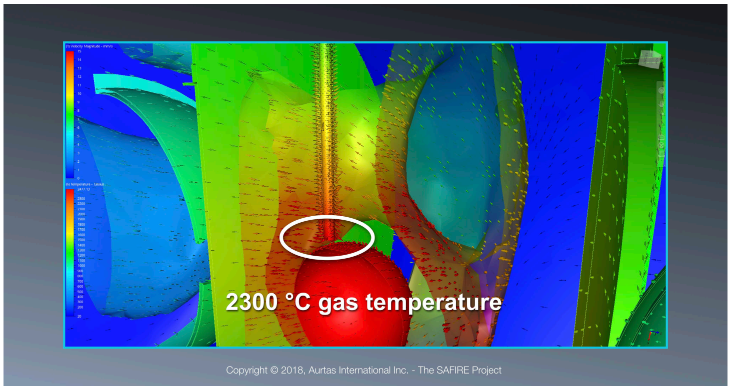
PREDICTIONS – THERMODYNAMICS



Montgomery: Predictions and thermodynamics. Some of you may be familiar with what's called computational fluid dynamics. We use it in thermodynamics. We use it in gas flow. We treat liquids and gases similarly. It's used for optimizing the speed of sailboats. It's used for laminar flow calculations over fins on high speed fighter aircraft. It's used for those kinds of things which are fluid you might say, or what we call boundary conditions. A lot has been learned over the years in thermodynamics, and being able to create modelers that can very accurately predict what is going to happen under certain conditions. The calculations we did show that the predicted responses that we got on the chamber, were accurate. We have thermocouples all way around the chamber to measure the temperature. These numbers are pretty accurate. In other words, we created a model, we run SAFIRE for a period of time, we should start seeing temperatures like this – and we do. So, we're happy.

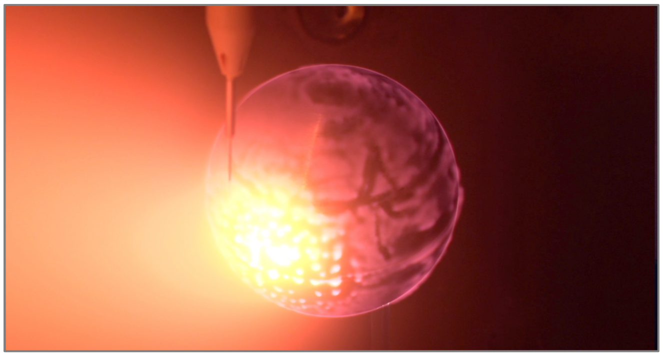
This is called gas flow. We are able to accurately predict that the gas flow inside the SAFIRE is very, very slow. It's not suffering from any kind of thermal buoyancy. When you're looking at SAFIRE it doesn't appear as if it's suffering from gravitational forces. It's a big deal.

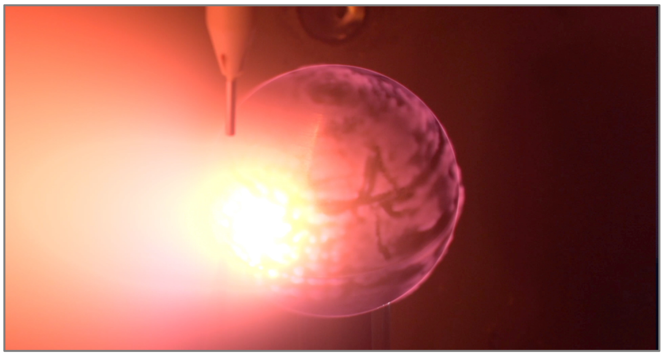


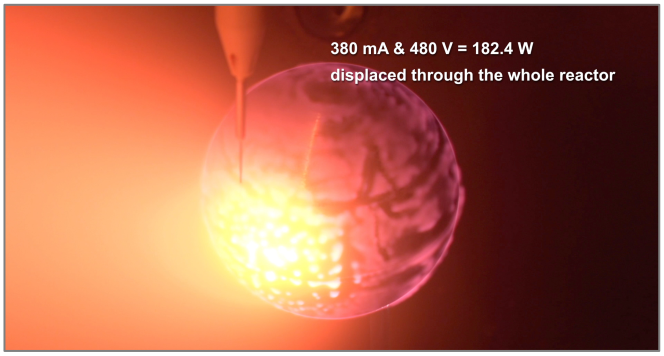


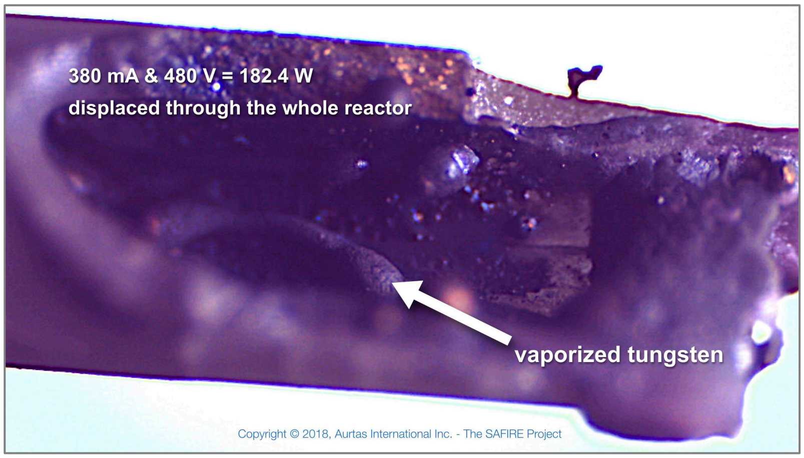
Temperature, that's a good one. We have a probe in there. We want to make sure that the temperatures are good. 2300 degrees Celsius is what the CFT is predicting based on all the information we put in there.

But what really happened? We put the probe in and we we're measuring the plasma and things seem to be fine. Just look for a little *(images below)*. And suddenly it's no longer there! It was not a magic show. One moment you see it … and then you don't. This here was approximately 182 watts. You saw the size of the chamber; that's 182 watts of energy displaced for that whole chamber.

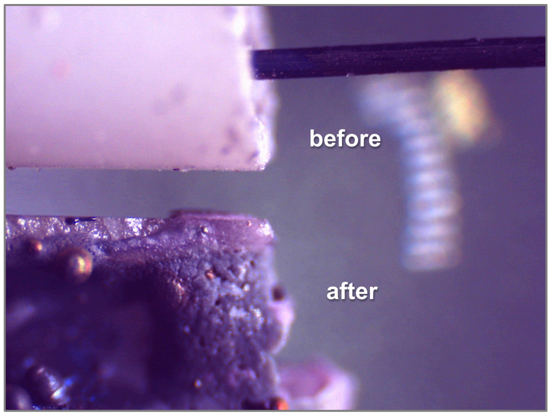






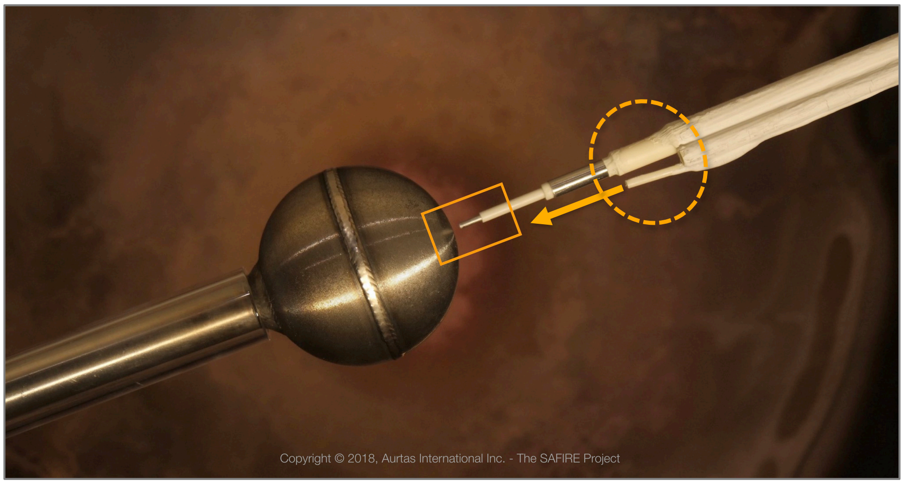


And that's what it looked like afterwards. We said there's something wrong. It shouldn't be doing this. Tungsten shouldn't even be reaching thermal temperatures to vaporize like that. But we did it with 182 watts. Some people have 200-watt light bulbs; well this is a 182-watt light bulb. And by the way, the probe isn't grounded, it's floating. Meaning, if you ever plugged something like say a paperclip into a light socket, you'd find out very quickly what happens when you have something that gets grounded. Something's going to light up. But this isn't that. This is floating, what we call floating potential, but it happened.

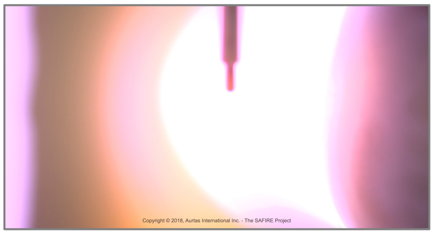


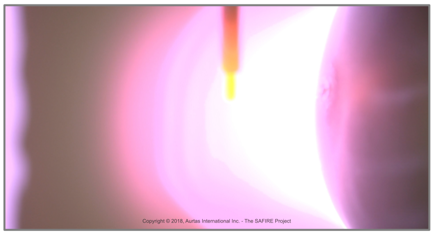
Before. And after. We went through a number of these. We call our supplier and he says: 'Well, your plasma is too hot.' But it was designed for *this plasma*! So, we had to create new-and-improved more robust voltage probes.

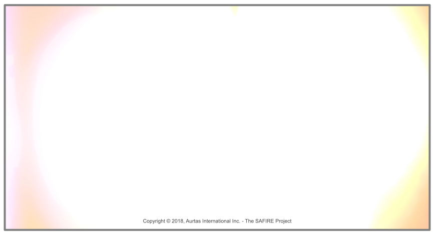
That's it *(image on right below)* and at the tip over here, underneath it we have two sets of fiber optics, but one is actually pointing to intersect with the tip. We're looking right down at the tip of the voltage probes. When we put the tip into the plasma, we're also looking at what's going on in that tip, not just electrically, but optically as well; and further back right beside it is the mass spectrometer. We're actually sucking gas out of that area too as well. We're pretty happy with that. We thought, okay, we're ready to go again.

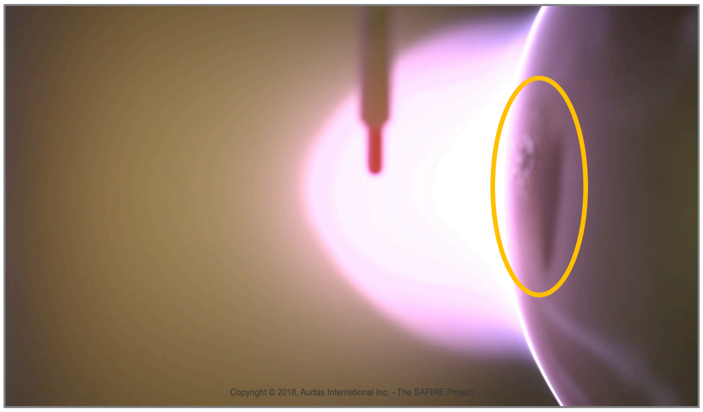


We were able to capture this. As you can see if it's white, it means it's hot. And we said, okay, well let's put the probe in and let's just see. We're getting measurements, and we're happy because the numbers are coming back, you know and we're saying, okay, what, what *(the bright light starts to take over, the audience is chuckling)*



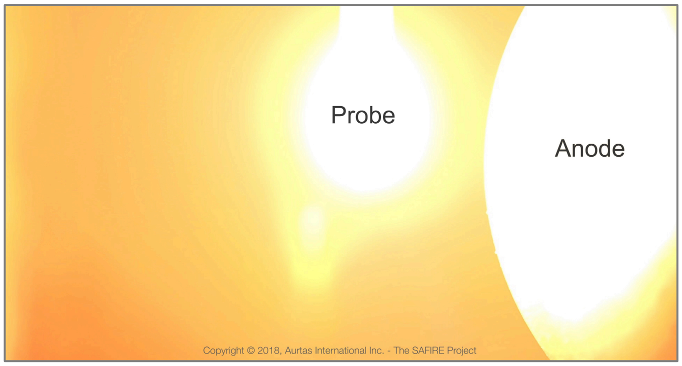




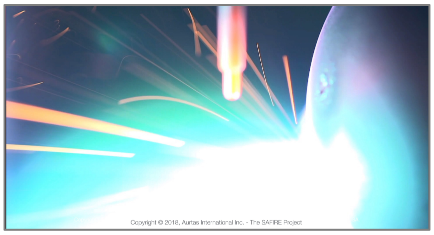


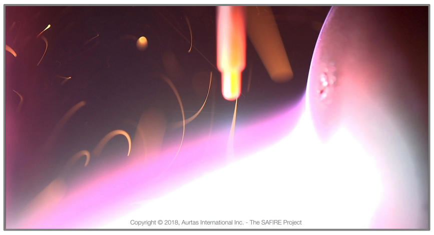
We didn't change anything in the chamber. It's just this is the response and we're like: "So we just smoked two weeks' worth of work, about $10,000 or so." What's interesting is that the probe survived. But you notice the crater on the side of the anode; we're going to come back to that in a minute.

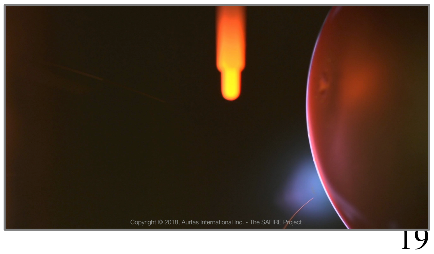
This time I'm going to show you thermionic emissions, which you get from a light bulb. Remember, the probe is sitting in a floating potential, it's not part of the electric circuit; but the anode is. So, I look at this and say – that big ball there is thermionic emissions. Okay, why is the probe so bright compared to the anode? We're starting to ask questions; it really shouldn't be doing this.



We get some really cool artwork. I'm thinking what we should do is get this printed and frame it, it's just beautiful. Like I said, it cost $10,000 so maybe we should (*audience member says "T-shirts"*). T-shirts, yeah.

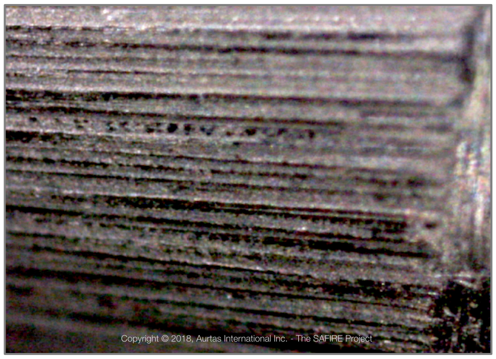




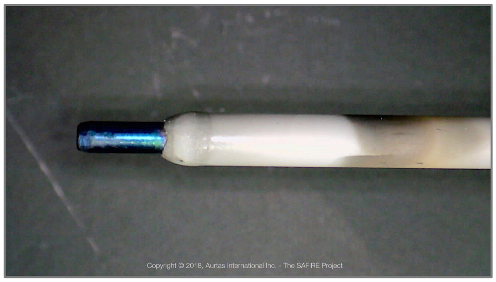


VOLTAGE PROBE – TUNGSTEN TIP

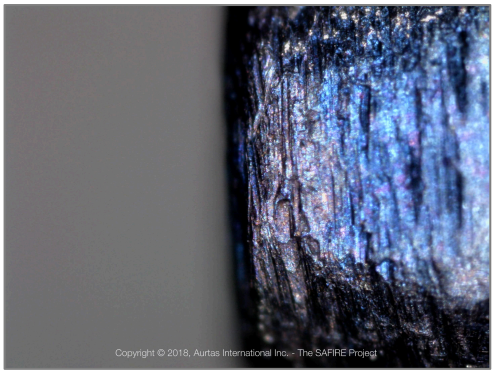
We finished with the test and we decided, so this is what tungsten looks like. It has a sintered look, before …



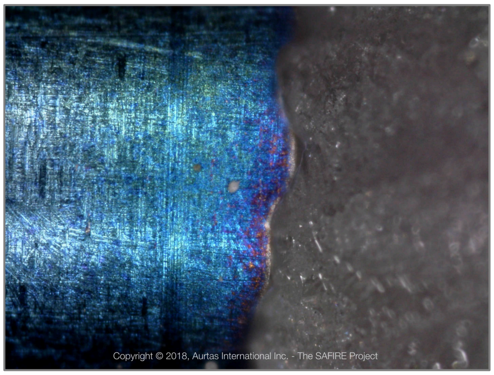
And after. And the blue, I thought, okay, I've seen this kind of thing before, where you thermalize materials and they can change color …



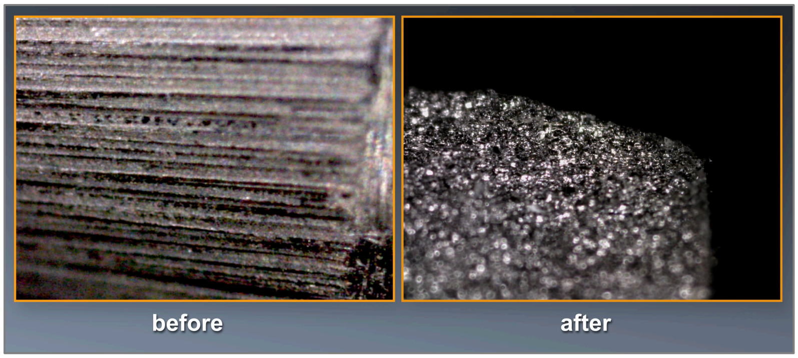
It didn't look like it suffered because those vertical marks are really from a diamond wheel. I recognize those and there doesn't appear to be any degradation.



The alumina probe shaft, it looks like it got melted; so, I know, okay, well it's pretty hot.

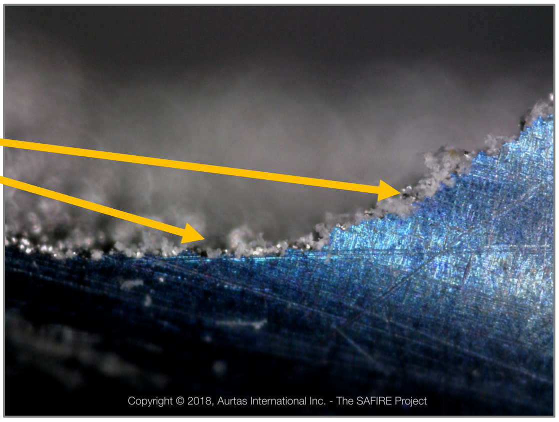


Then I tried to pull the probe tip out with my pliers and it just crumbled in my hand. It was really weird because you can have arc welding at 19,000 degrees, and TIG *(tungsten-electrode inert gas*) welding, those are incredibly hot temperatures, but those tips will last 20, 30 minutes before you have to take over and grind them. They don't just crumble.

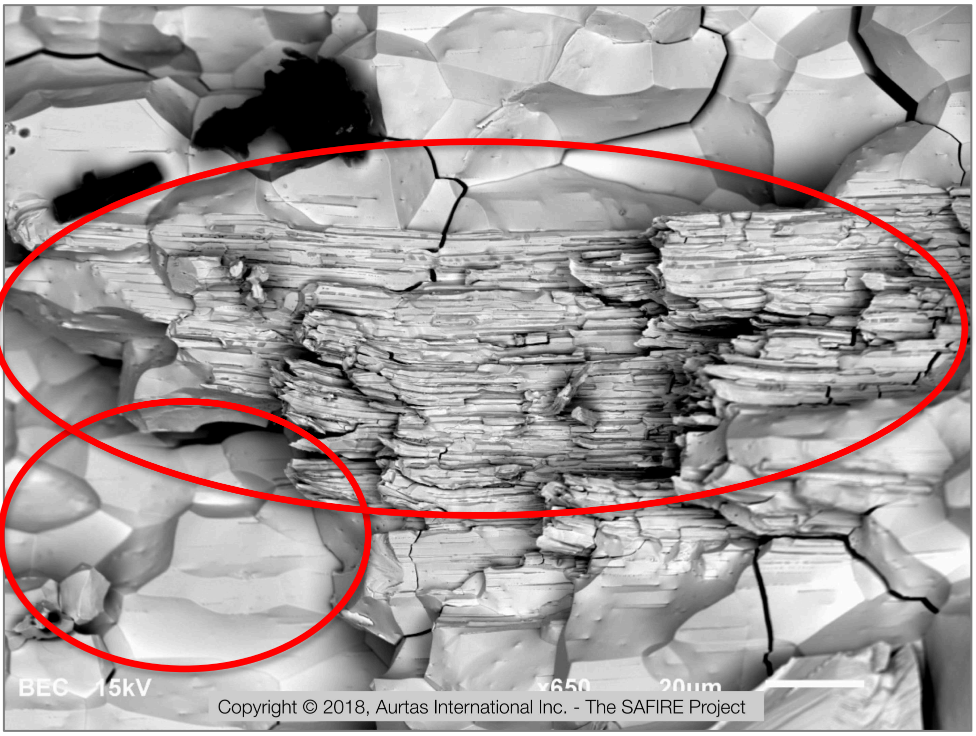


Here’s the difference between the two. I looked at that and I thought, well that’s a really strange crystalline structure.

I don’t even know what this white stuff is. Never seen this before.



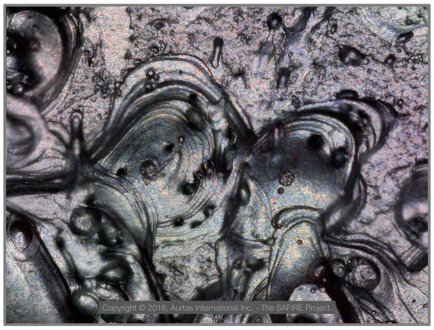
We decided to take it down the University of Toronto and do some scanning electron microscopy. This is what we found on the inside of the probe tip *(image below)*.

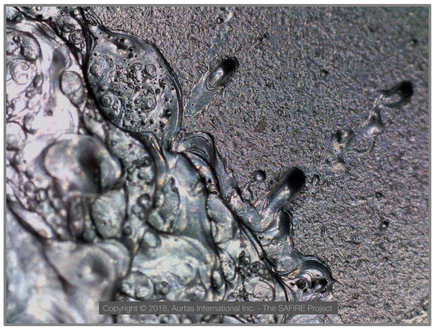


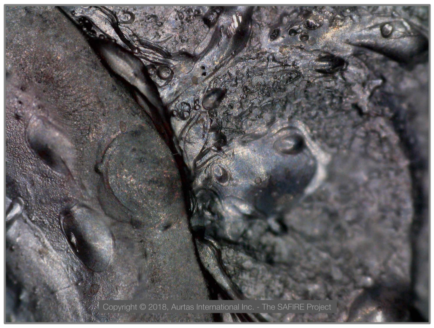
We’re calling this shale. We’re not sure what it is.

This is tungsten.

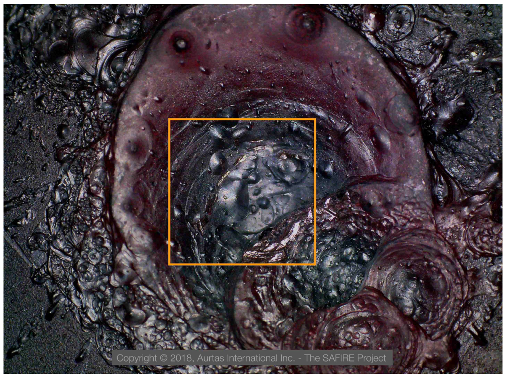
ANODE (optical microscopy)



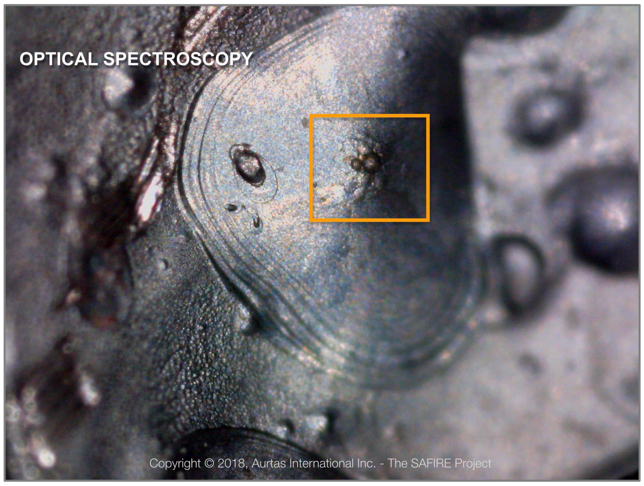


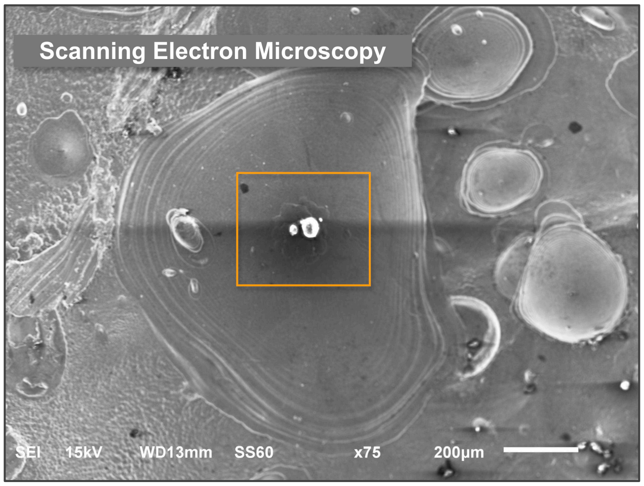


Then we took a look at the anode. This is where the crater was. And I've said before, it makes for great artwork. These are the true colors by the way.



We thought that this was copper *(image above)*; but it's not copper, it's an iron oxide. I decided to just pick a spot. I said, that's interesting, the top of that little mountain there *(images below),* I went in to take a look. I saw these little nodules, which I thought were strange, and then put that under the SEM.

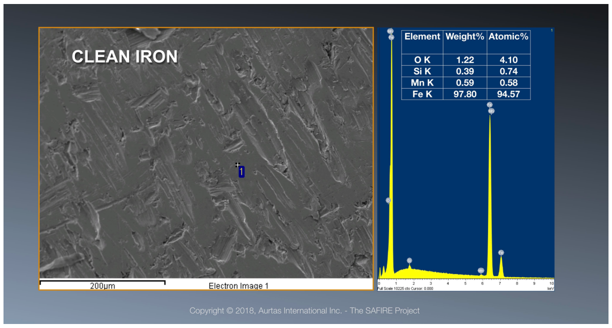




And if anyone knows anything about Scanning Electron Microscopy, normally when you see a bright spotlight that means it's usually a fairly heavy element.

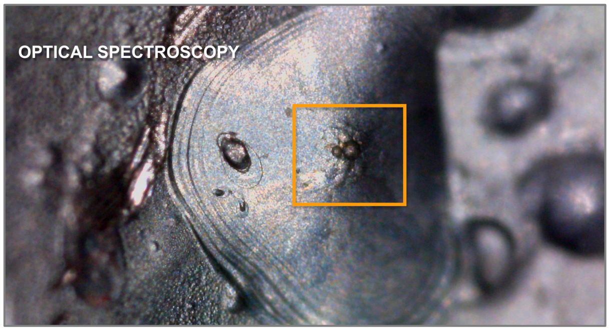
Scanning Electron Microscopy (SEM)
Energy Dispersive Spectroscopy (EDS)

With *Scanning Electron Microscopy* this normal iron.

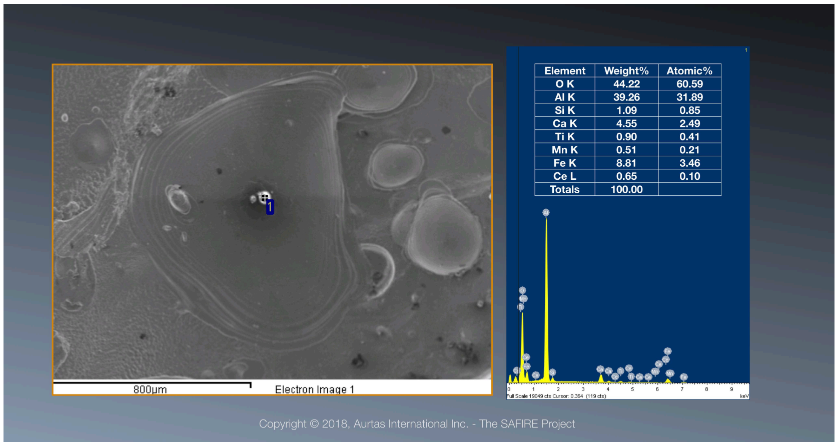


Element	Weight%	Atomic%
O K	1.22	4.10
Si K	0.39	0.74
Mn K	0.59	0.58
Fe K	97.80	94.57

This is the top of the mount on the anode.

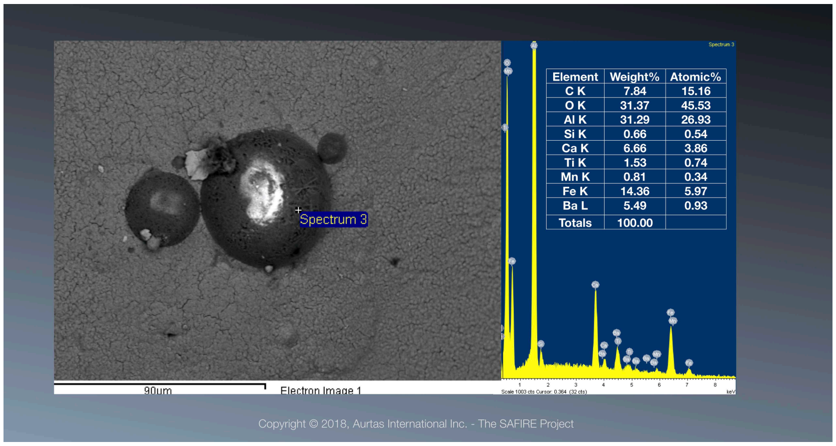


These are some of the things we're seeing. These elements were not present in the initial iron.



Element	Weight%	Atomic%
O K	44.22	60.59
Al K	39.26	31.89
Si K	1.09	0.85
Ca K	4.55	2.49
Ti K	0.90	0.41
Mn K	0.51	0.21
Fe K	8.81	3.46
Ce L	0.65	0.10
Totals	100.00	

And it certainly doesn't have *this* chemistry. We don't know where the barium, the titanium and the calcium came from. We have some ideas about maybe the carbon, but these elements were not there before, and what we don't know is why they're there in the anode afterwards.

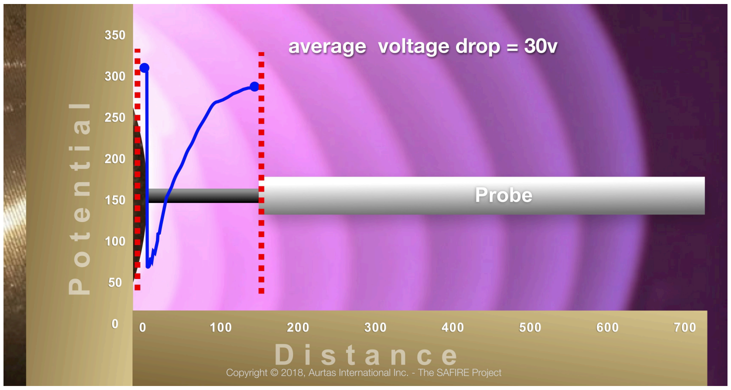


Element	Weight%	Atomic%
C K	7.84	15.16
O K	31.37	45.53
Al K	31.29	26.93
Si K	0.66	0.54
Ca K	6.66	3.86
Ti K	1.53	0.74
Mn K	0.81	0.34
Fe K	14.36	5.97
Ba L	5.49	0.93
Totals	100.00	

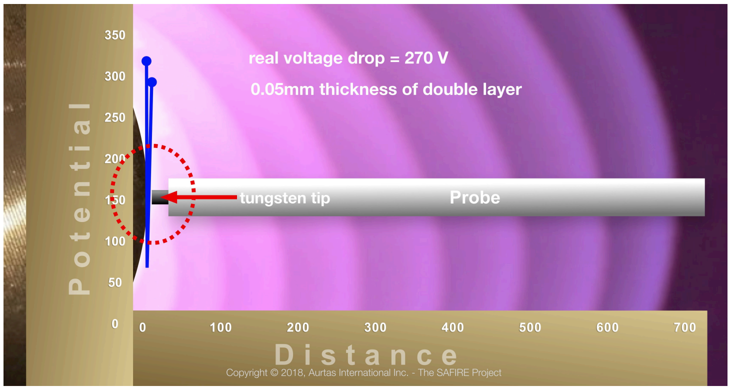
NEW VOLTAGE PROBE

We built a new probe after all that. This one did survive, and we're working on understanding the voltage drop off the anode. Don Scott was predicting it should be extremely high voltage drop just off the surface of the anode. We didn't know. We made no judgment. We were just taking a theorist's position at face value. We went in and we explored these things.

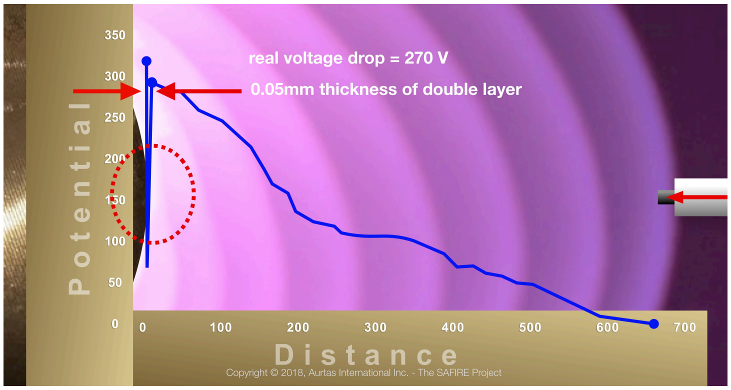
The first probe had a long tip. With this tip we got an average voltage drop off the surface of about 30 volts.



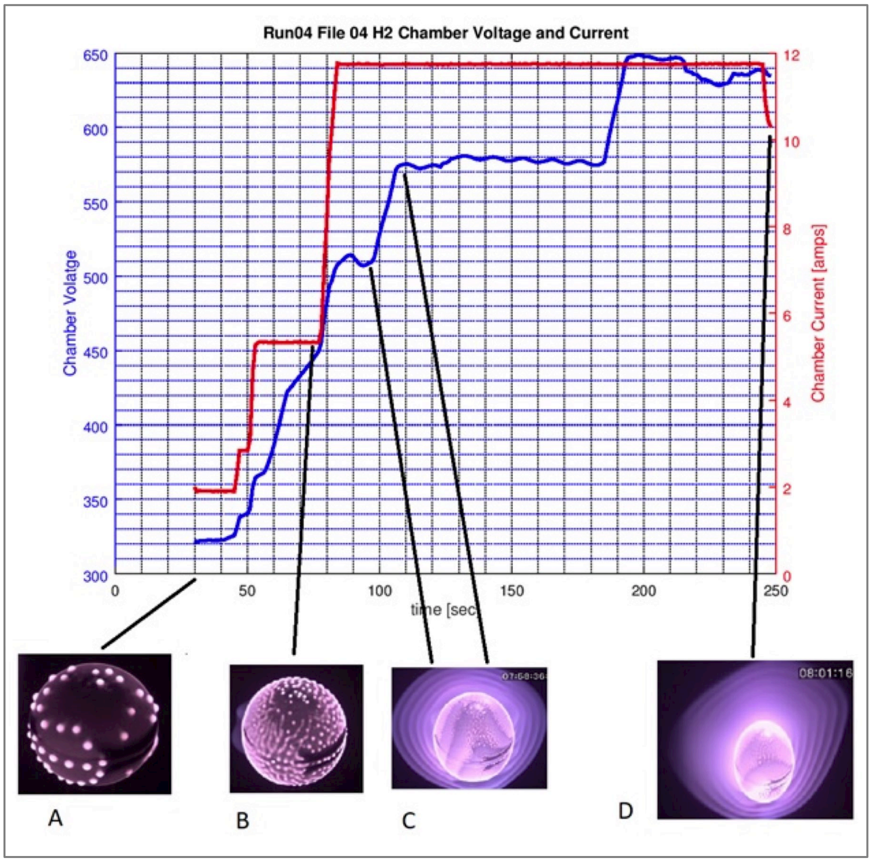
We discussed how we're going to deal with this. What if we made the tip really, really short? So, we did. That's the short tip and we were able to get closer to the plasma and we measured a 270 volt drop (as predicted by Don). And then it came right back up.



Now these aren't absolute numbers which we are looking at as the delta or the change, it's what we were able to measure. It could be higher. Then we pulled the probe tip out with our Gimbal – and Michael will show you what his analysis says about all of this.

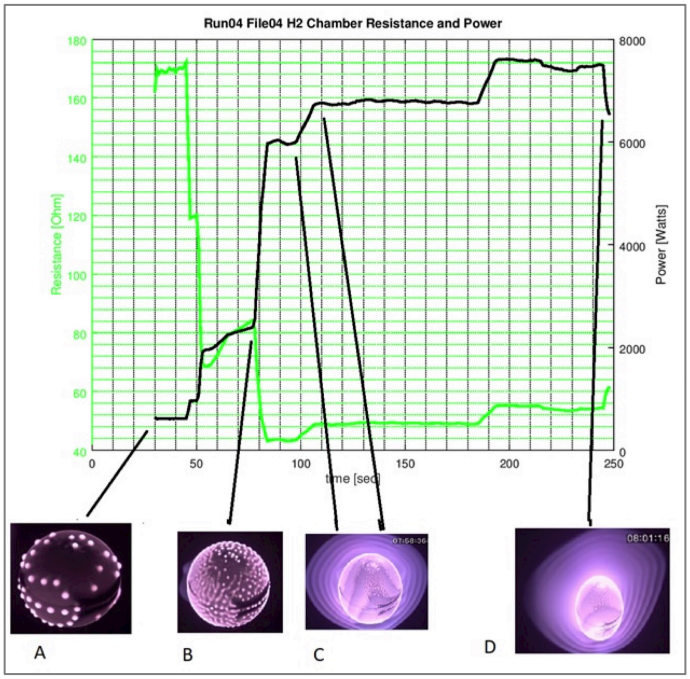


Michael: Here are several charts looking at overall chamber parameters. One of the reasons we're doing this is because, who was it, Wal or Don, who said that all electrical engineers should be astronomers and vice versa? Part of our mission is to forge that bridge, to give that crossover, and ways for each camp to think about the other's data.

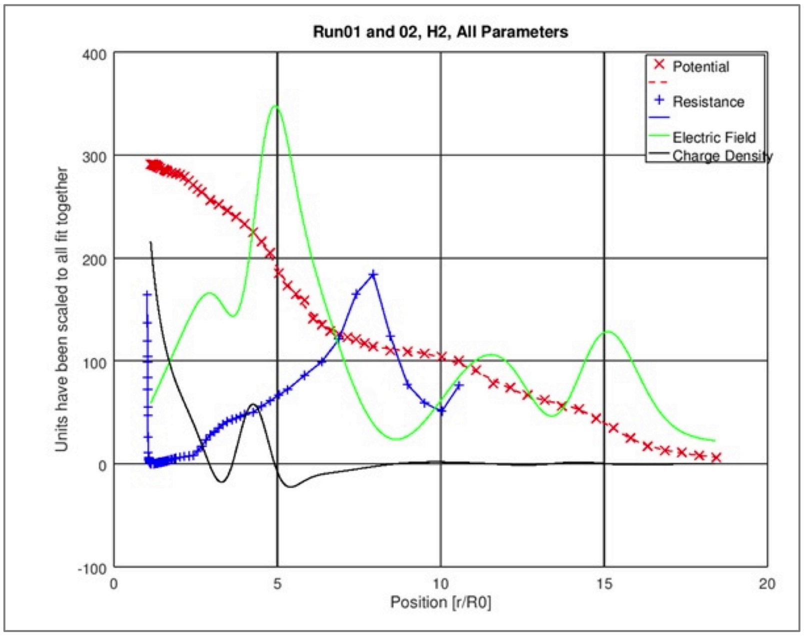


What we're looking at here are the measurements in the chamber. You can see on the bottom, there are four different regions of discharge that I'm mapping out here (A–D). The red line is the electric current. In this experiment current is our driver, that's the lever that we are turning to change the situation; and the current is going to go from about 2 amps up to about 6 amps. In response to that the blue line is the voltage across the chamber, across the entire discharge. And that voltage rises from about 300 to 450 volts. And the nature of the discharge changes. You can't see it in picture B, there is actually a lot of movement in that second picture, very complicated pattern changes.

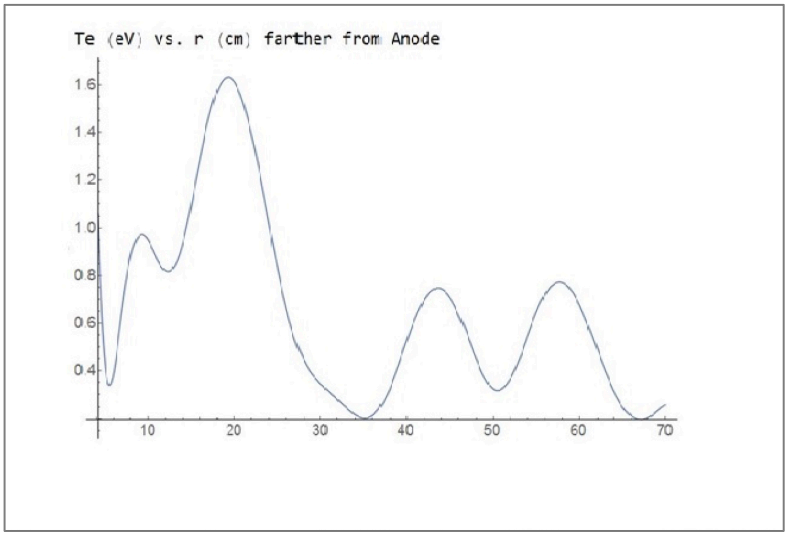
Crank up the current some more, up to about 12 amps – new response from the chamber. Looking at just the voltage piece of it, you can see the voltage goes through a couple of different changes. All of that is the plasma creating those double layers. It's changing the nature of the discharge to accommodate the extra current, the extra energy it has to process. The wiggle, we don't know about the wiggle, that's to be discussed later. It's not the power supply, it's the plasma, but we don't know why it's doing that right now. The far right of the graph that is pushing over the edge *(image D)*, past this stable region into a discharge, arc discharge.

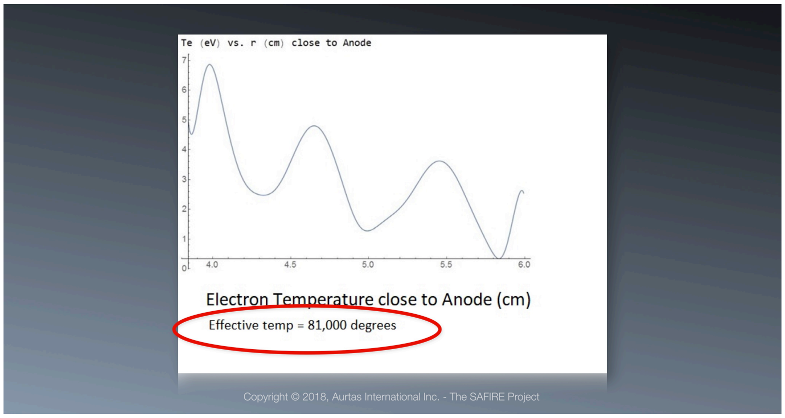


If we look at the resistance of the discharge and the power being consumed by the discharge, this is a different lens we can bring to the situation. The green line is the resistance in the chamber discharge. The black line is the power. Same regime, same experiment, but now just looking at these two other variables. And you can see that from the first phase to the second phase, the resistance goes way down. This change the plasma does is a way to bring down the resistance in the chamber. The power goes way up. It's a way that the plasma adjusts itself in order to process more power to allow you to put more energy through it. The resistance goes down even more heading towards the double layers, and the power consumption goes way up. So, what does all that mean? Well that's what we're thinking through. In basic terms, the plasma adjusts itself to an enormous range of stability. We can go from 1000 watts to 20,000 watts and the discharge is happy, it's fine, and it's changing itself constantly to be able to accommodate that power, whatever power you give it. It's a very stable system.



This is looking at the voltage probe when we pulled it out from the anode. The red line is the change in potential. It goes from about 300 down to 0 as you move away from the anode. From the changes in voltage we can calculate the strength of the electric field. – which is the green line. In this particular run about 8000 volts per meter for an electric field, which for any astronomer who says that space can't support strong electric fields, this is an example we can say – well plasma of our design can support very strong electric fields without discharging, without arcing. It's happy to keep them there in a stable state. The black line is the charge density. This data didn't get us in close to the anode, but the charge density drops way down negative. It goes off the graph, the charge density. The blue line is the resistance which we measured with our probe. I don't think anybody has ever measured the resistance of a plasma in discharge like this. This is the data we got. What does it mean that it follows that particular path, which seems kind of related to the other parameters we don't know yet? This is new data, breaking new ground here.





Electron Temperature close to Anode (cm)

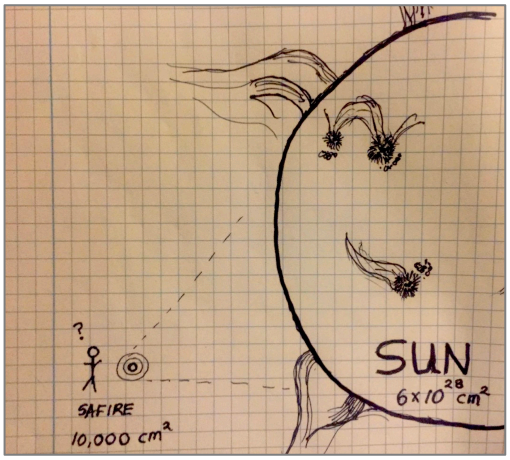
Effective temp = 81,000 degrees

Electron temperatures. You can see that the electron temperature goes up as we move away from the anode. This was back in the beginning. This was one of the classic questions, right, the temperature inversion, the temperature anomaly; why would the sun's atmosphere get hotter as you move away from it? Is there any way to explain this? We didn't set out to prove it. We simply took this electric sun model, lit it up, and then we measured the temperature. And our electron temperature – the temperature of electrons in the chamber – goes up considerably as you move away from the anode. Why does that happen from an electrician's point of view? We're not so sure yet. But the fact that we see it right out of the box is very exciting. That temperature close to the anode corresponds to 81000 degrees. If I were an astronomer and I saw this, the system, I would say, oh, the temperature of your corona just went up to 81,000 degrees! We have that in a stable state in our chamber. What 81,000 degrees means we talk about temperature a lot --

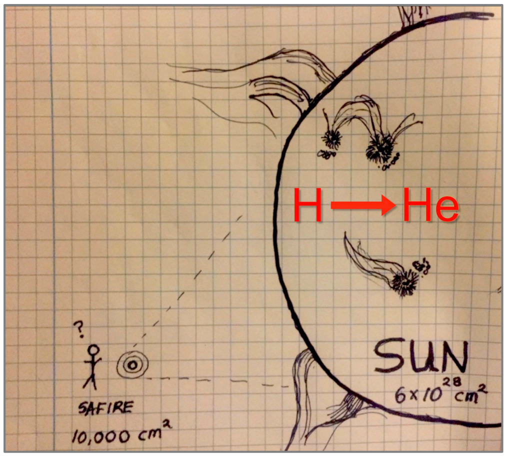
Montgomery: Yeah.

Michael: And we all realize the temperature was developed to describe steam engines. And it does a great job describing steam engines. Can we take that idea and bring it to the solar world? This is one of our afterhours discussions and it goes on for quite a bit.

PREDICTING THE SIZE OF THE SUN

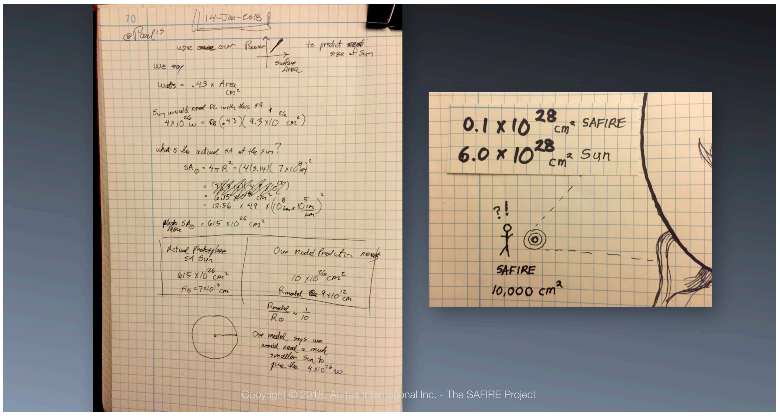


You may have heard that there are certain problems with the nuclear fusion model for the sun, like it predicts almost nothing about how the sun behaves. The fusion model may not be able to predict sunspots or coronal loops or the relative abundances of the elements in the photosphere. It may not be able to predict the 11-year cycle of the magnetic field or the amount of convection underneath the photosphere or the existence of a photosphere. It may not be able to predict the existence of a chromosphere or corona or the temperature profile of the sun's atmosphere …



But if you assume that hydrogen is fusing into helium inside the sun, then you can predict how much energy the sun will give off and that is good. That is *really* good. So good in fact that no other physics model for why the sun shines has been so good at predicting this one basic aspect of the sun's behavior. So the fusion model for the sun will have egg on its face all day long, but until some other physics model can quantitatively describe the basic energy output of the sun, then no one is going to be changing any physics textbooks.

As you know the SAFIRE project is investigating the Electric Sun model. Here is just one of the many questions we are investigating. Again, small chamber, big sun *(see image above left)*. The surface area in the SAFIRE chamber is about 10,000 square centimeters. Can we use this to predict what the size of the sun should be if it were an electrical discharge? That would be fun because no one in 100 years has done such a thing successfully. We're going from 10,000 square centimeters to six times 10 to the 28th square centimeters. That is a very big leap, okay, to add 24 zeros on to anything you're doing in the laboratory. That's pretty bold.



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14-Jan-2018

@Paul's

use ~~the~~ our Power / Surface Area to predict ~~rest~~ size of Sun

We ~~say~~

Watts = .43 × Area cm²

Sun would need DL with this SA: 4×10^{26} w = (.43)(9.3×10^{26} cm²)

what is the actual SA of the sun?

$SA_\odot = 4\pi R^2 = (4(3.14)(7\times10^8\,km))^2$

$= 12.56 \times 49 \times (10^8\,km \times 10^5\,cm/km)^2$

Photo sphere $SA_\odot = 615\times10^{26}\,cm^2$

Actual Photosphere SA Sun	Our model Prediction needs
$615\times10^{26}\,cm^2$	$10\times10^{26}\,cm^2$
$R_\odot = 7\times10^{13}\,cm$	$R_{model} \approx 9\times10^{12}\,cm$

$R_{model}/R_\odot \sim 1/10$

Our model says we would need a much smaller Sun to give the 4×10^{26} w

Montgomery, "I think so."

Michael, "Okay."

Montgomery, "Three minutes. We have three minutes."

Michael, "You can do it."

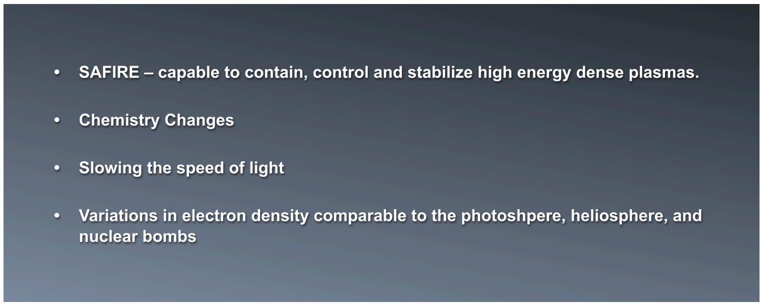
Montgomery, "Yeah, I can do it. Presentation summary, wow. We're there, okay, quickly. SAFIRE – can contain, control, stabilize energy dense plasmas, chemistry changes, I forgot to go back to that slide."

Michael, "Tomorrow."

Montgomery, "We'll do that tomorrow.

PRESENTATION SUMMARY

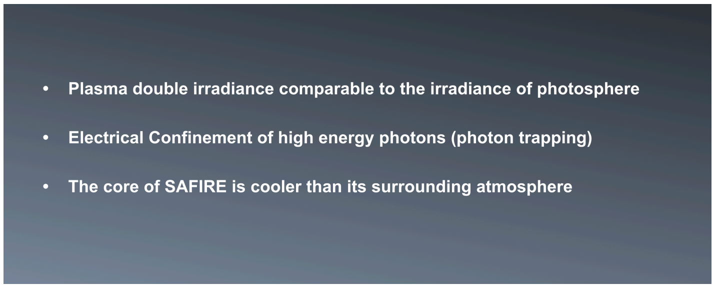
Montgomery: We're seeing some really interesting chemistry in there. And there is significant atomic mass of three. We don't know what it's about. But it's there. That's a big deal.



- SAFIRE – capable to contain, control and stabilize high energy dense plasmas.
- Chemistry Changes
- Slowing the speed of light
- Variations in electron density comparable to the photoshpere, heliosphere, and nuclear bombs

Chemistry changes, slowing the speed of light, variations in electron density comparable to the photosphere, heliosphere and nuclear bombs, – that was great work, Michael."
Michael, "Thank you."

Montgomery, "When we heard this back from Michael, Paul and I texted, Paul said: "Monty! You got to see what Michael did!"



- Plasma double irradiance comparable to the irradiance of photosphere
- Electrical Confinement of high energy photons (photon trapping)
- The core of SAFIRE is cooler than its surrounding atmosphere

Confinement of high energy, photons, the core of SAFIRE is cooler than its surrounding atmosphere. Isn't that interesting, because the further we look into the sun, the colder it gets, the same behavior in SAFIRE. We turned the volume up here about a thousand *times (referring to anode in chamber, image below)*. Let's freeze this just for a second.

Lowell had predicted that at some point in time we may not need cathodes in SAFIRE. I know there are some electrical guys that really have an issue with this, but what you're looking at here is the cathode on the left has gone dark. Most of the electrons that we are feeding the plasma are normally coming from copper cathodes. Those cathodes are pretty big. But we're discovering, as Lowell predicted, that the electrons being trapped in the double layers are actually feeding the anode. We're going to explore that this year. There is a theoretical side to this of course, but we're actually seeing that the majority of electrons that are feeding this plasma here are coming from the plasma itself in these double layers; it's pulling material into the core. So, just something we're looking at. And that's it.