Mk. II Gun Overview

Introduction

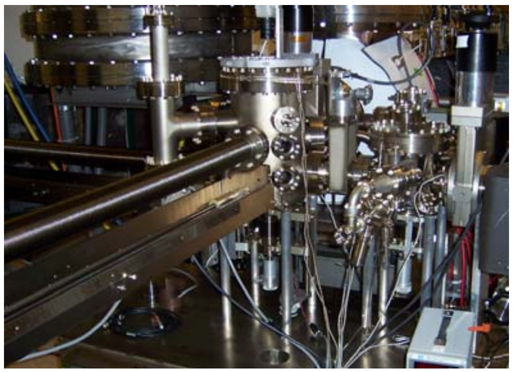
- Walk though of the gun systems and mechanical design
- Try to identify issues of interest, alternatives to proposed designs, point out where details will come from later talks

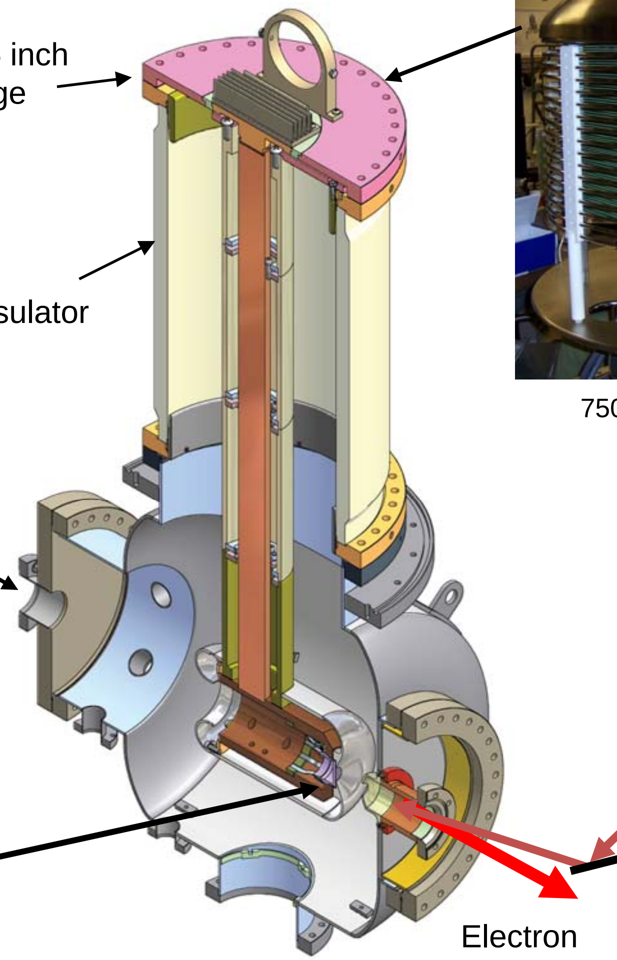
100mA at 750kV, 1.3 GHz, 2-3 ps pulse, 77 pC/bunch

- Current gun
- Issues not covered
- Overview of Mk. II gun design and status
- Detailed topical talks

Mk. I Gun Currently in Operation

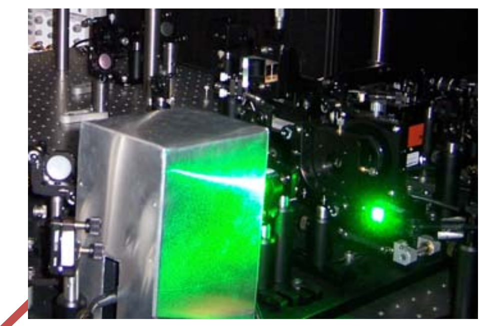
Cathode Preparation and Load Lock





750 kV, 100 mA HVPS

Drive Laser

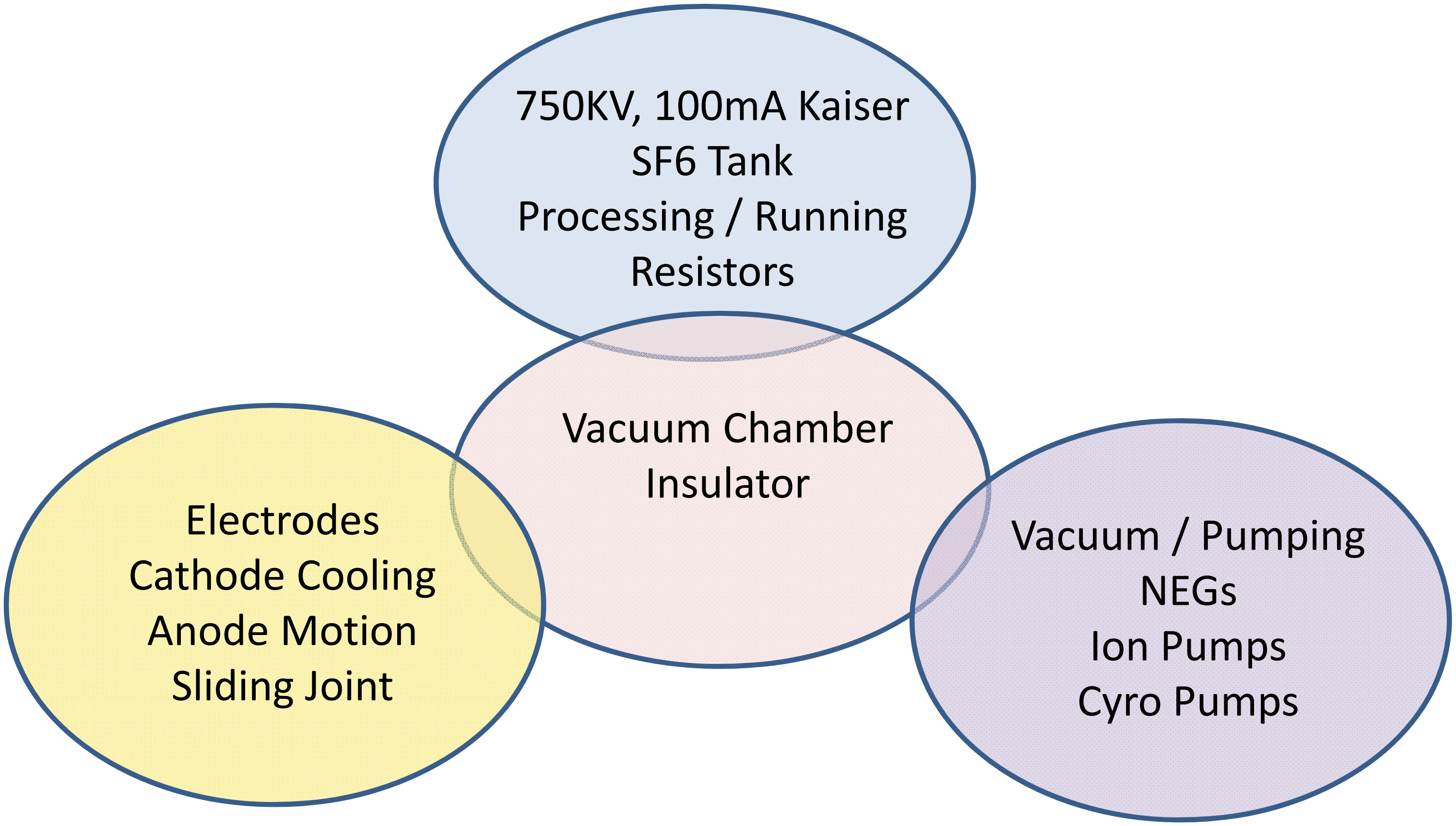


Focusing electrode,
Cathode support

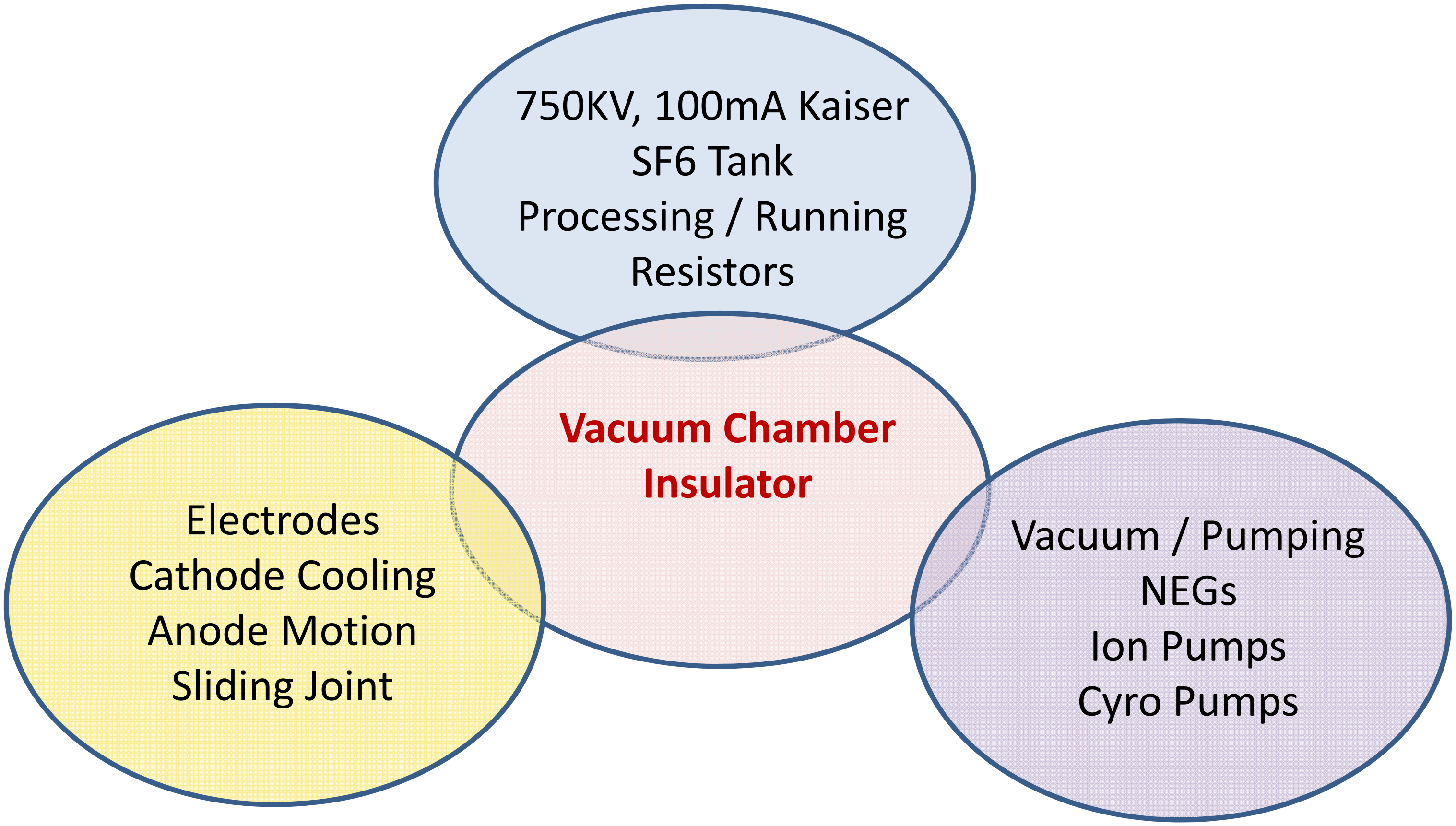
Issues Not Covered

- Laser system – still poses significant challenges
- Controls
- Cathode Transfer System (from Prep to gun)
- Details of GaAs preparation chambers – will be similar to existing
- Offline test systems such as GaAs QE chamber, new high voltage, large area field emission test chamber

System Diagram



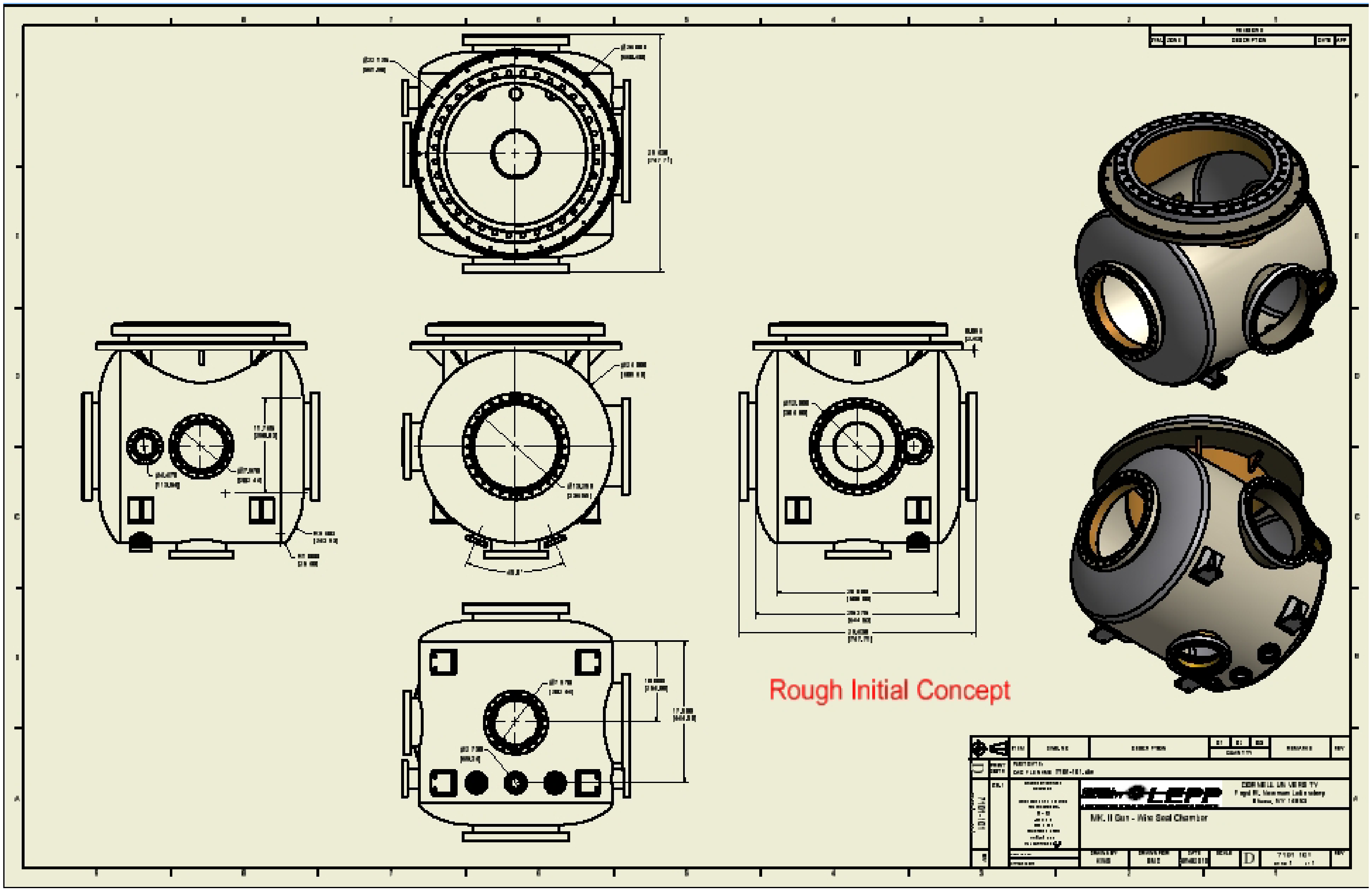
System Diagram



Chamber

- 316L UHV vacuum chamber
- All Conflat flanges except for Insulator (22.125" Commercial wire seal flange, specially manufactured in 316L (at great expense)
- Large insulator flange allows electrode assembly to be lowered into chamber easily
- Larger diameter to reduce field strength, allow more room for internal NEG modules
- Instrumentation and feedthru ports TBD

Chamber



Chamber / Wire Seals

- No prior experience with wire seal flanges. Much experience with Au and Al *compressed* wire seal flanges within CHESS for large optics enclosures.
- Commercial flanges: Seal itself generated by extrusion of copper wire, “knife edges” do not bite into gasket but define extrusion opening.
- Wire seal flanges have been extensively tested over past year: test chambers built and thermal cycled ~10 times to 250’C without any leaks in both 18” and 22” size.
- Companies do not make a lot of these, don’t stock gaskets, and are definitely not well standardized. Have had problems even with pairs ordered from same company.

Chamber / Pumping

Chamber designed to accommodate both internal and external pumping:

- Side Port for Cryopump (12” CF)
- Side Port for NEG Bundle (8” CF) (5+ unit NEG)
- Bottom Port for 400l/s Gamma Vacuum ion pump with 4-5 unit NEG insert
- Internal NEG modules (16 modules Mk. I)
- NEG Coating of chamber surfaces

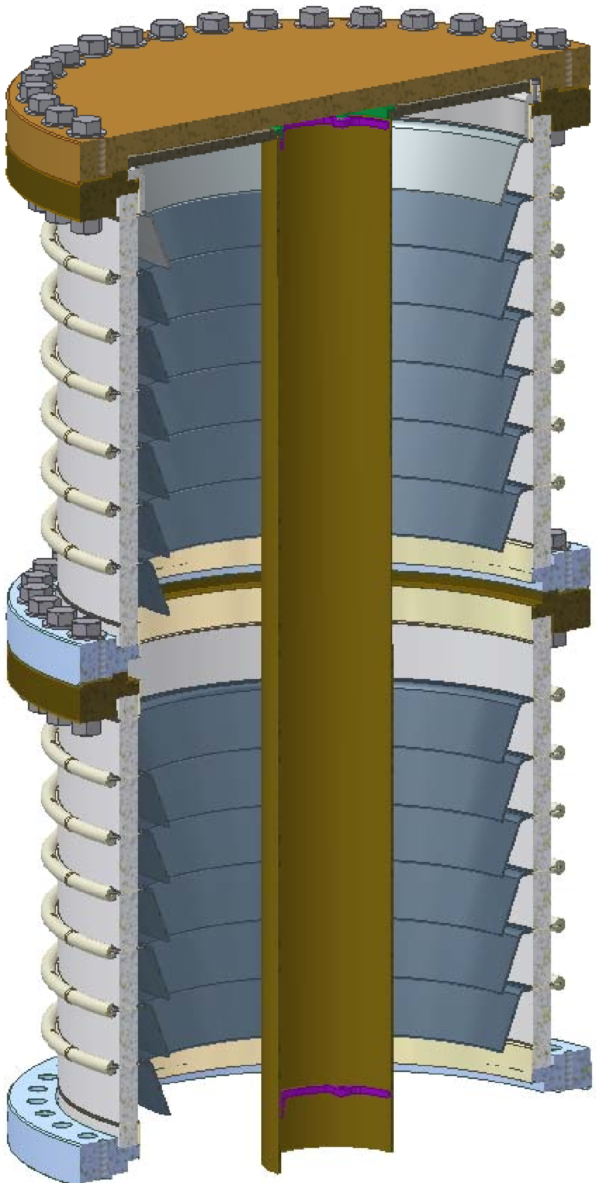
Chamber / Instrumentation

- SRS RGA
- Leybold extractor guage
- NEG power feedthrus
- This time will not ground modules, but have feedthru for both ends of chain. Currently a short between NEG module and ground limits our ability to fully activate one bank of modules.
- Some viewports (arc detection, inspection)

Segmented Insulator

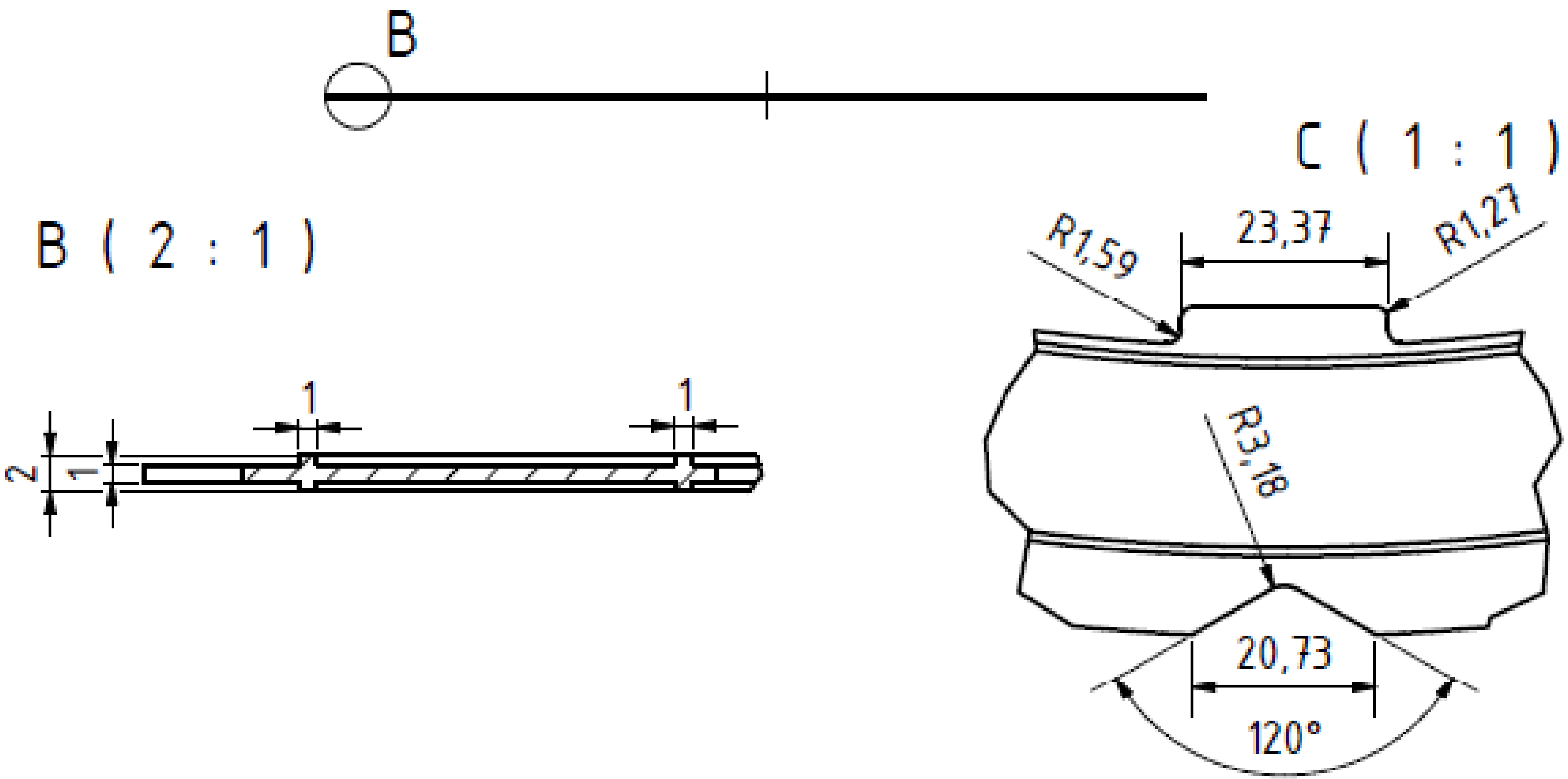
Segmented insulator will be covered in more detail this afternoon

- Frustration with punch through issues with CPI and Morgan / Kyocera ceramics. Conductive ceramic did not perform as well as expected
- Segmented insulator will be two part each capable of 375kV, this could allow for a short / small initial test gun - also allows for easy connection at half voltage with double stacked configuration for intermediate electrode.

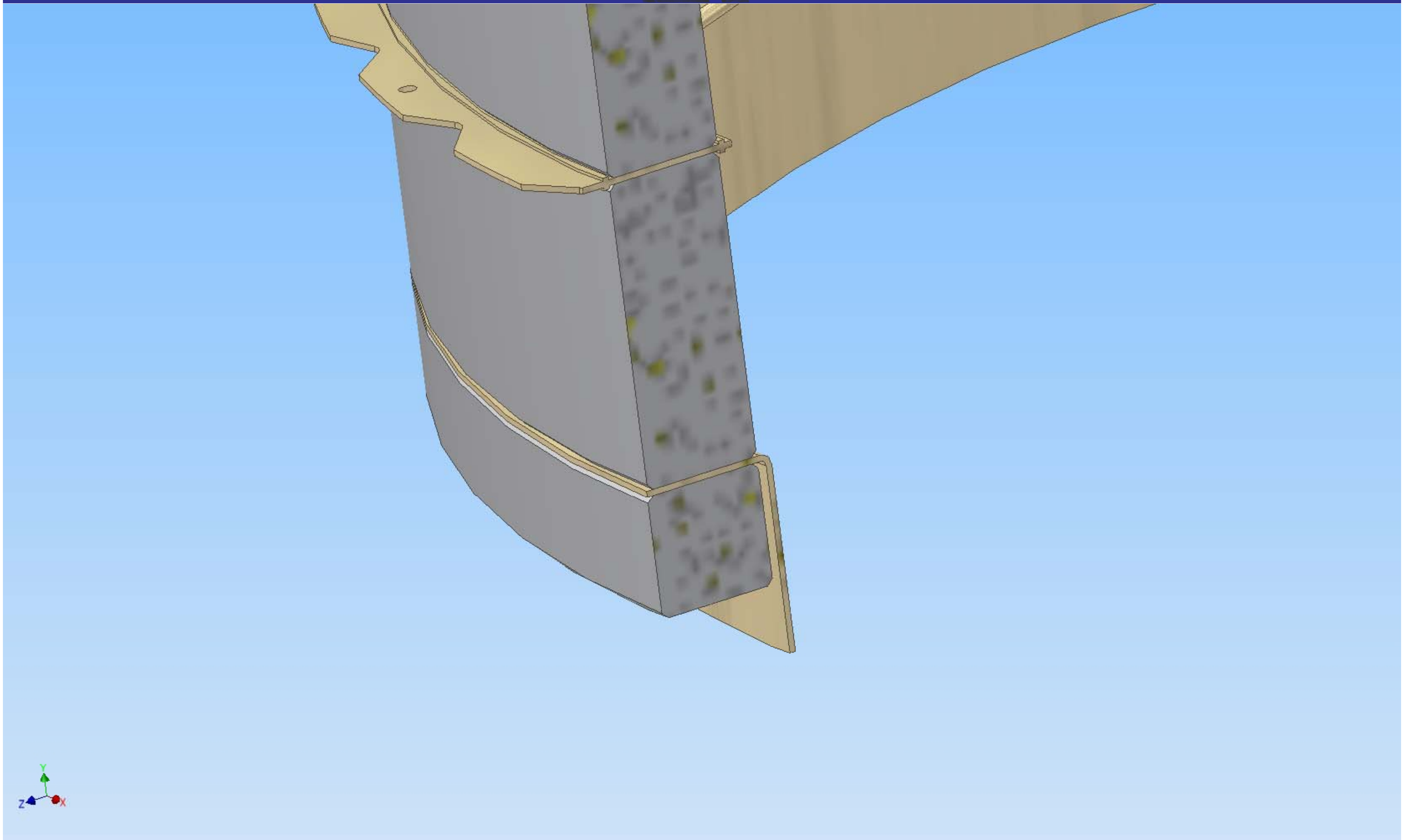


Braze Joint Design

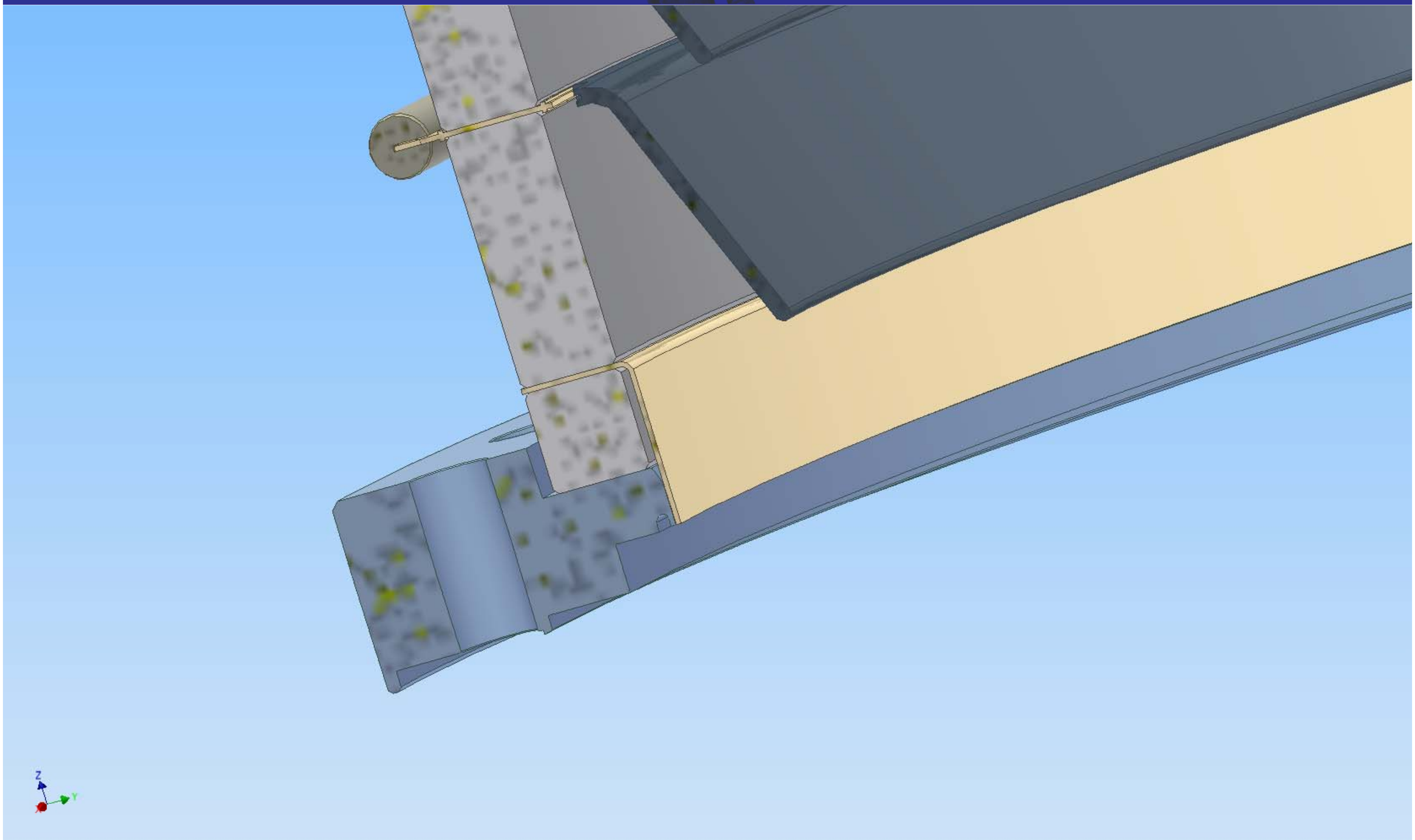
- Kovar interlayer design
- Locating steps for ceramic rings
- Internal tab for support of protection rings



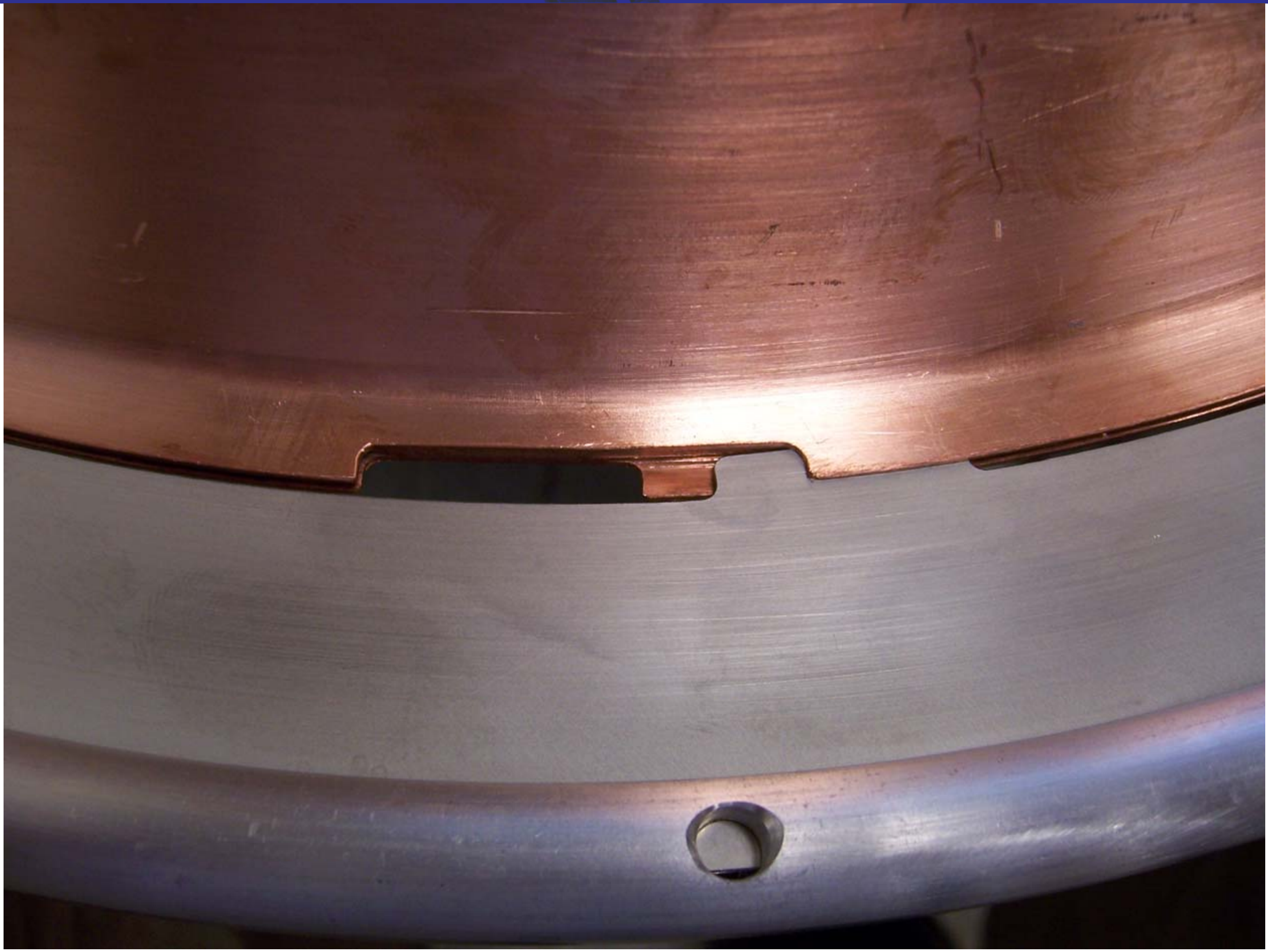
Braze Joint Design



Braze Joint Design



Ring Support Design



Insulator Vendors

- Pool of vendors (Friatec, SCT, Kyocera, ~~Hitachi~~)
- Hitatchi built JAEA / KEK gun segmented insulator
- Kyocera has been extremely efficient and inexpensive on the Mk. I Gun insulators (2+1) but extremely expensive on this insulator (???)
- SCT and Friatec roughly equivalent in experience and capability. Friatec made a low ball offer, admittedly below their normal price. They have no prior "scientific" ceramics in the US market. US staff do not have ceramics background.
- 150k$ for 4 units, including all protection rings

Insulator / Status

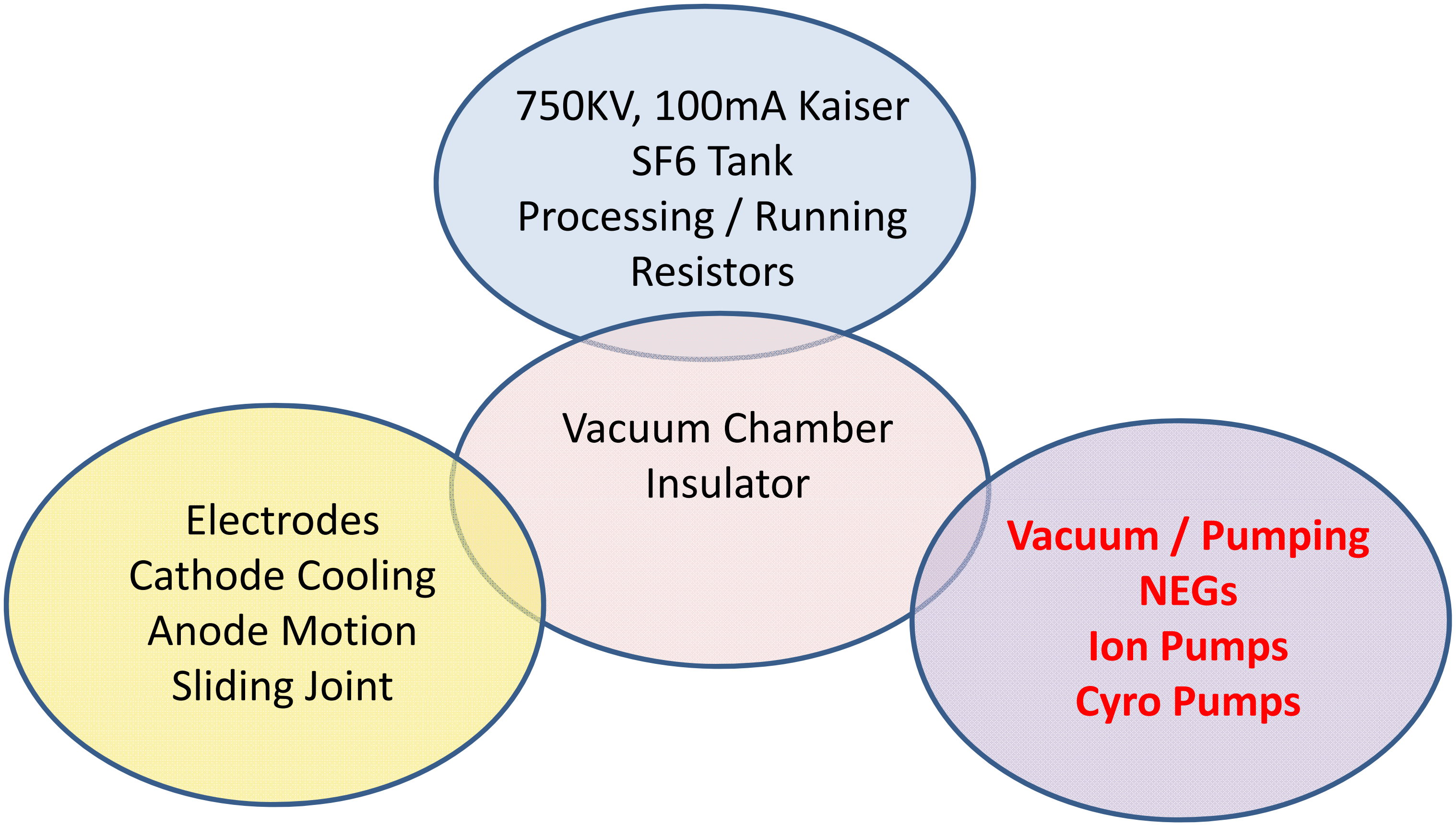
- On track! (?)

Status	Time frame
Ceramic rings for 5 Guns pressed, green machined and sintered.	Completed week of Nov. 29, 2010
Metal parts for 5 guns ordered, production ready	Week of Dec 6, 2010
Brazing of first gun	Jan 17, 2011
Welding of the flanges (Cornell part) for the first gun	Week of Jan 31,2011
Decision from Cornell needed if assembly of part 5 should be continued	February 7, 2011
First gun completed, bake out	February 14-18, 2011
Parallel to the production of part 1, brazing of the 3 other parts start, provided that part 1 is ok.	Week 5 / 2011
Welding of the flanges	Week 8 /2011
Final 3 parts ready for shipment	Week 10 /2011

Chamber / Insulator Summary

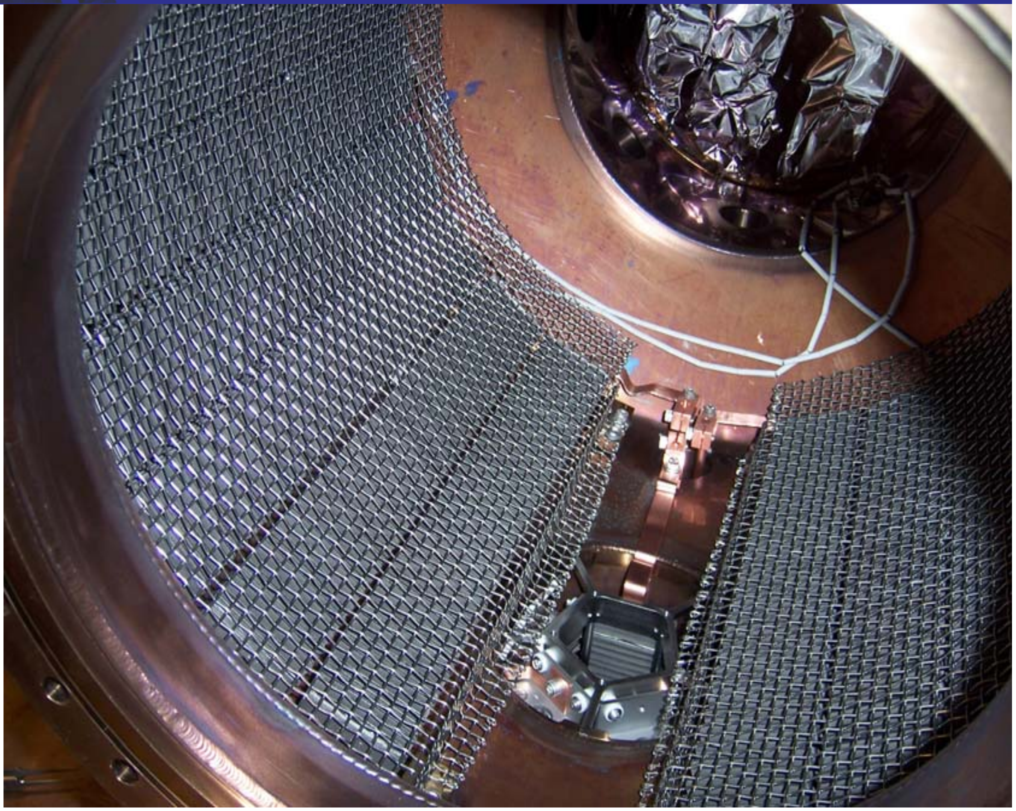
- Tests / simulations that should be performed?
- Chamber is next critical path item!

System Diagram



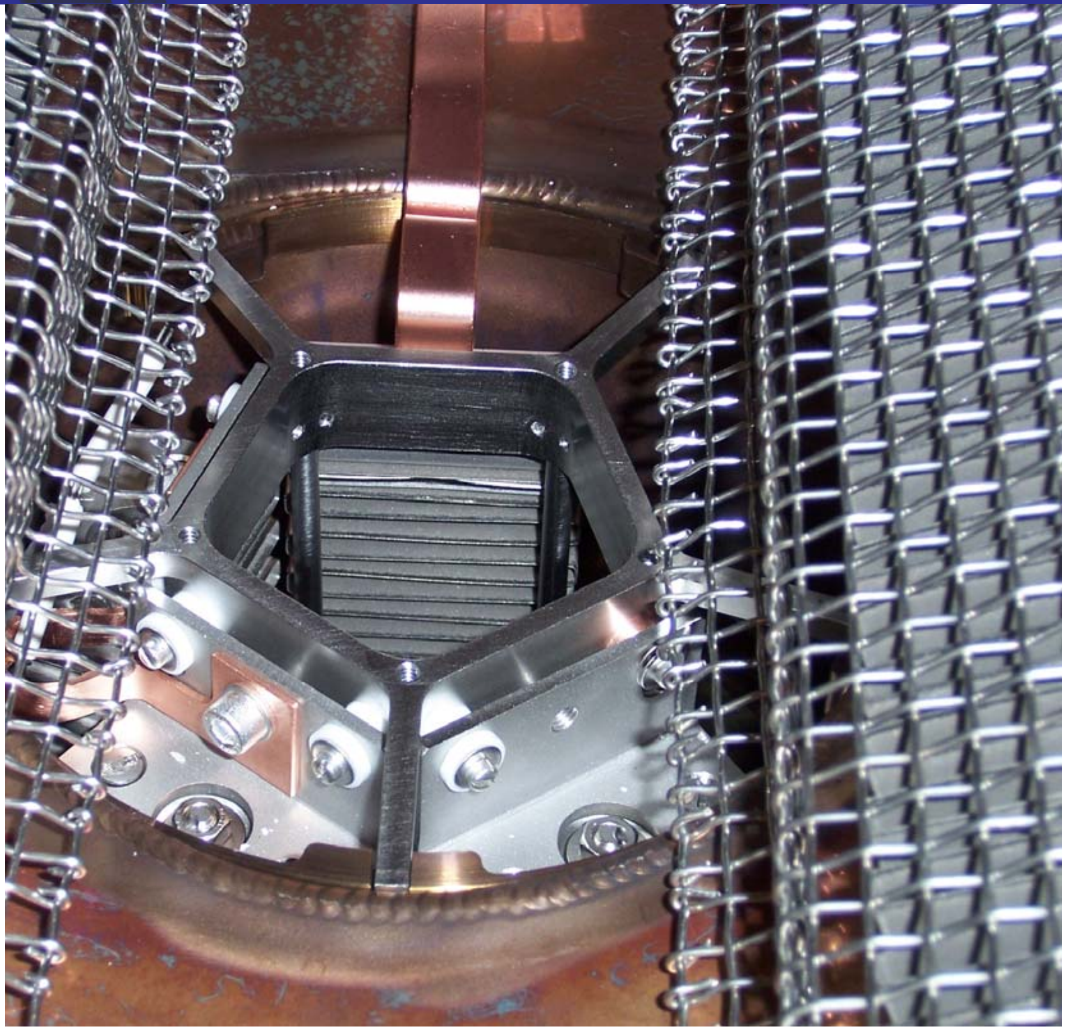
Vacuum

- 400 l/s Perkin-Elmer ion pump
- Massive NEG pumping for H_2 - using 20 modules of WP1650 – ST 707. (740 l/s x 20) ~ 15,000 l/s
- 400°C air firing of vessel and internal components, followed by 160°C bakeout*
- 5 x 10^{-12} Torr typical static pressure
- Currently investigating Cryopumping options



**** Reduction in hydrogen outgassing from stainless steels by a medium-temperature heat treatment***
J. Vac. Sci. Technol. A 26 (5), Sep/Oct 2008

NEG Pumping



Chamber / Alternatives

- Thought about thin internal double walled chambers for further reductions of hydrogen outgassing
- Large flanges probably pose too large of a source for this to be worthwhile
- Consider modest cooling of chamber (external refrigeration) – limited by SF6, liquifies at -60C
- Titanium chambers on hold for now (Ti Flanges developed and cycled), forming very difficult.

Vacuum Open Issues

- Started testing bakable cryopump - no preliminary results.

- Need to investigate “outgassing” of ceramic surfaces (trapped volume evolution) due to huge ceramic surface areas / porosity

- Introducing large surface area of copper (protection rings) – Proper pre-bake processing

Chamber / Processing

Material	Surface treatment	Outgassing rate (Pa m s^{-1})	Reference
Stainless steel	Glass bead blasted + vacuum fired at 550°C /3 days + baked at 250°C/24 h.	1.6×10^{-13}[H_2]	[59]
Stainless steel (304L)	Air fired at 400°C/38h + baked at 150°C/7 days. Air fired 390°C/100 h + baked at 150°C.	1×10^{-12} [H_2] 5×10^{-12} [H_2]	[54] [53]
Stainless steel	Vacuum fired at 960°C/25 h +baked at 180°C /6 h.	1×10^{-12} [H_2]	[60]
Aluminium	Vacuum fired at 960°C/25 h +baked at 180°C /6 .	9×10^{-13} [N_2]	[58]
Copper (OFHC)	Vacuum fired at 550°C/3 days + baked 250°C/24 h	6×10^{-14} [H_2]	[59]
Copper (OFHC)	Baked at 525°C	2×10^{-13} [N_2]	[58]
TiN on stainless steel.	Vacuum fired at 430°C/100 h and 500°C/ 100 h.	1×10^{-13} [H_2]	[61]
Aluminosilicate glass	Baked at 500°C/18 h + 600°C/2 h + 700°C/2 h/500°C/10 h.	2.5×10^{-13} [N_2]	[62]

***EXTREME HIGH VACUUM,** *P.A. Redhead*

Chamber / Processing

- "Standard" Cornell air bake [1]
- Considering TiN diffusion barriers on stainless components [2]
- Considering NEG coating all surfaces possible
- All techniques available in house

[1] Reduction in hydrogen outgassing from stainless steels by a medium-temperature heat treatment
J. Vac. Sci. Technol. A 26 (5), Sep/Oct 2008

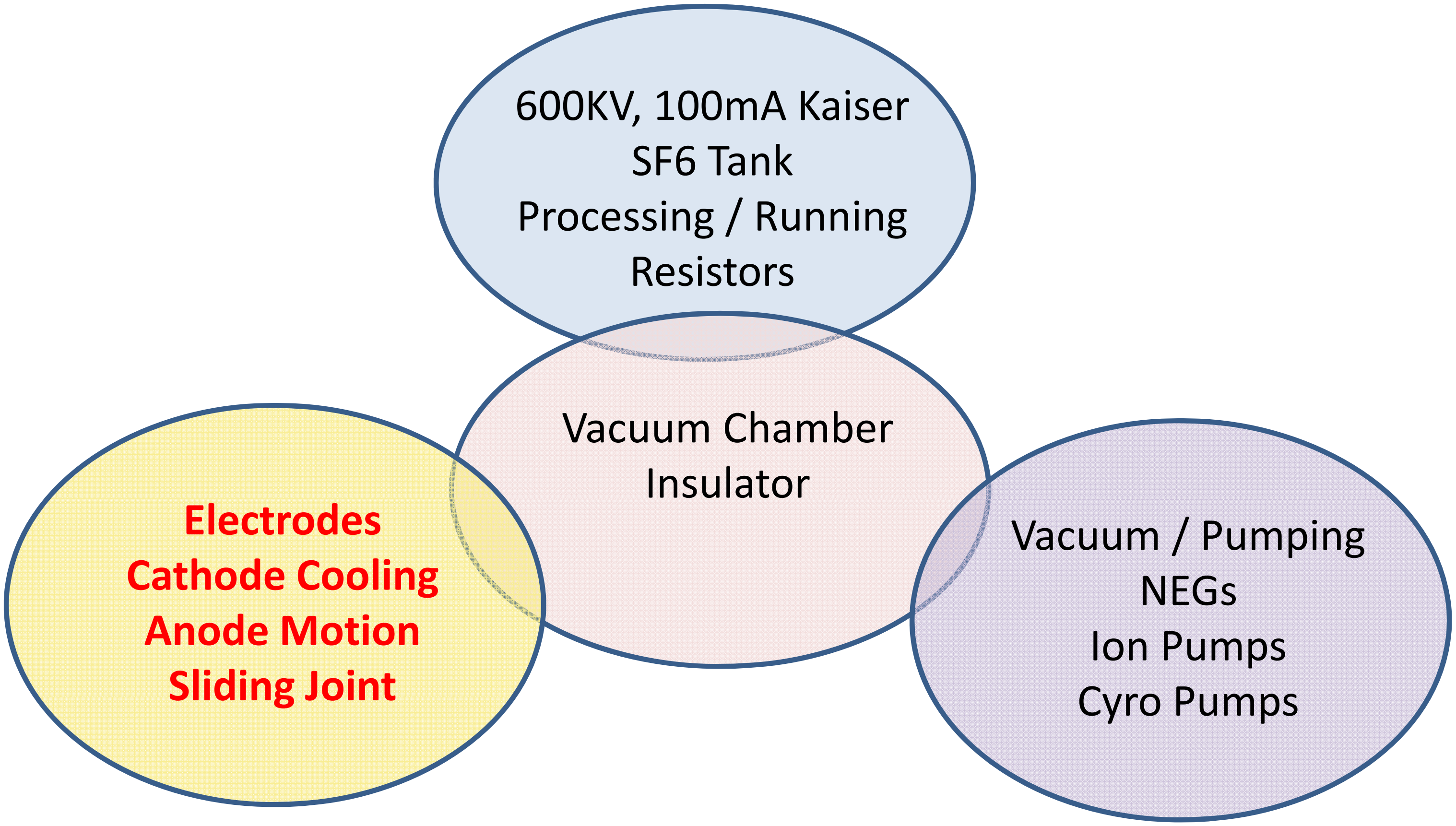
[2] TiN thin film on stainless steel for extremely high vacuum material
K. Saito, S. Inayoshi, Y. Ikeda, Y. Yang, and S. Tsukahara
J. Vac. Sci. Technol. A 13, 556 (1995)

Vacuum Summary

- ❑ Best path from 5e-12T to 1e-13T?
- ❑ How much further do we have to push?
- ❑ Is ion back bombardment dominated by ions coming from outside the gun?

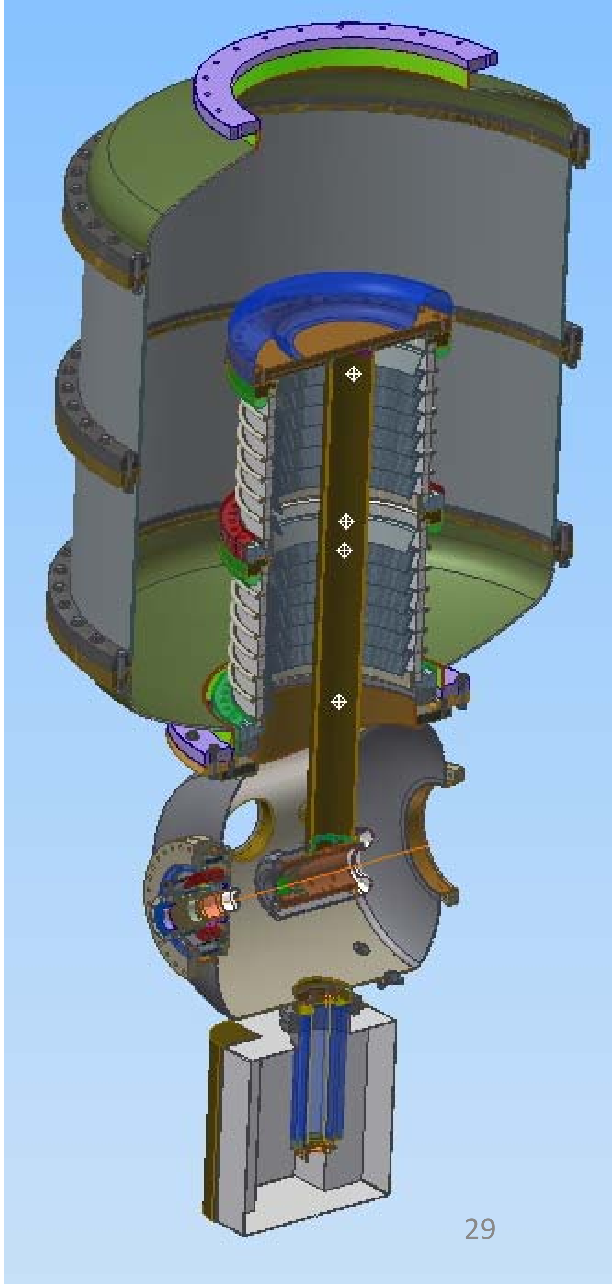
- Improvements to vacuum outside gun *(Yulin)*
- Ion tracking simulations *(Jared)*

System Diagram



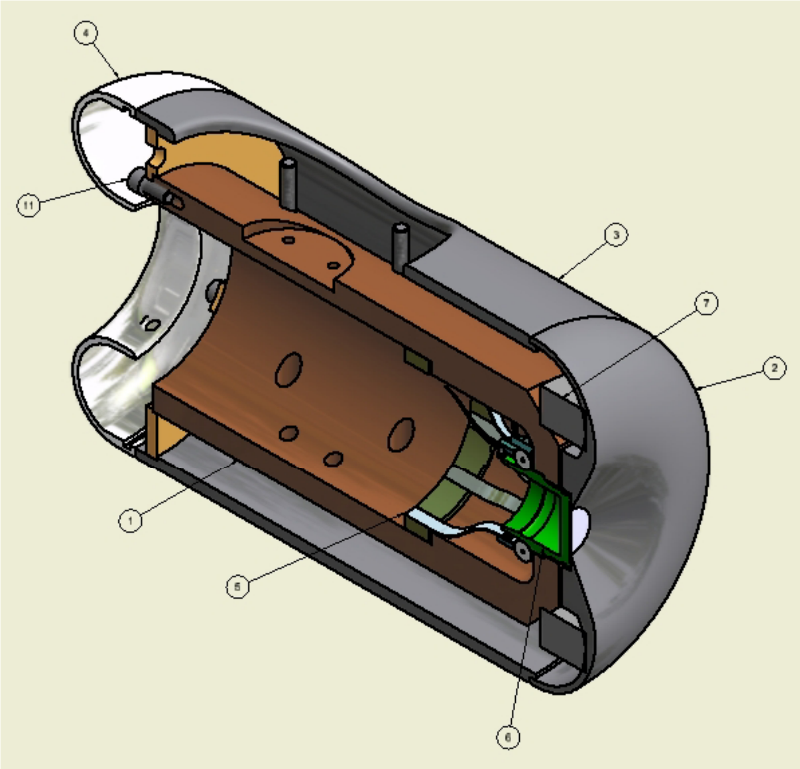
Electrode Structure

- Electrodes are supported by ~1m long stalk
- Stalk is mounted to adjuster plate bearing on top flange of upper ceramic
- Electodes broken into 3 pieces:
  - Front Pierce electrode
  - Central barrel
  - Rear Torroid
- All electrodes mounted to inner copper structure which traps the puck and provides thermal path to stalk conductor (NOT shown)



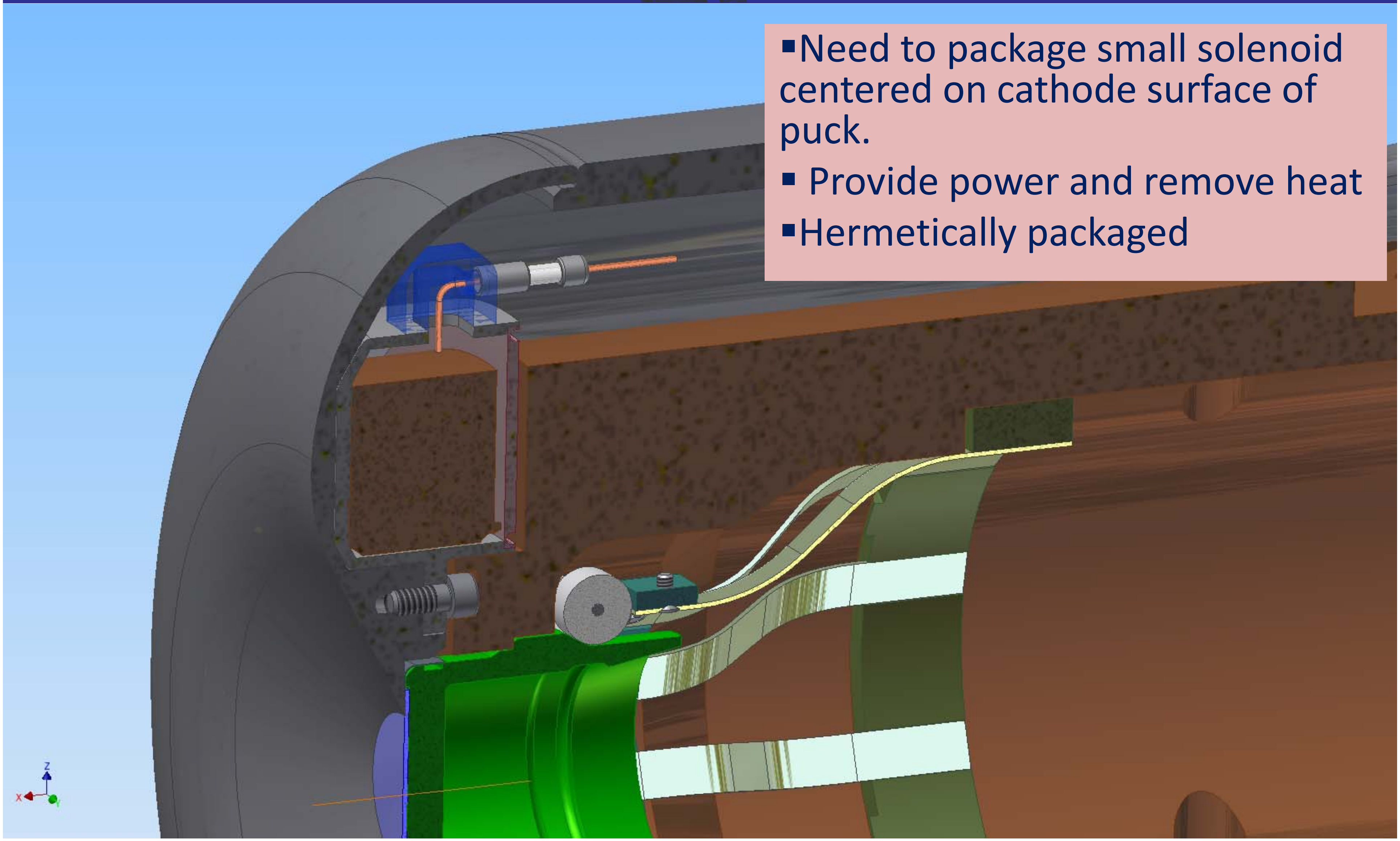
Cathode Electrode

- Electrode shape optimization – Jared
- Any profile possible
- Electrode 316LN material on hand, enough for 2 sets of electrodes. Nearly impossible to get without mill run purchase
- Polishing procedure:
  - Initial hand polishing
  - Electropolishing
  - Air firing (degassing)
  - 4hr. HPR
  - Cleanroom assembly



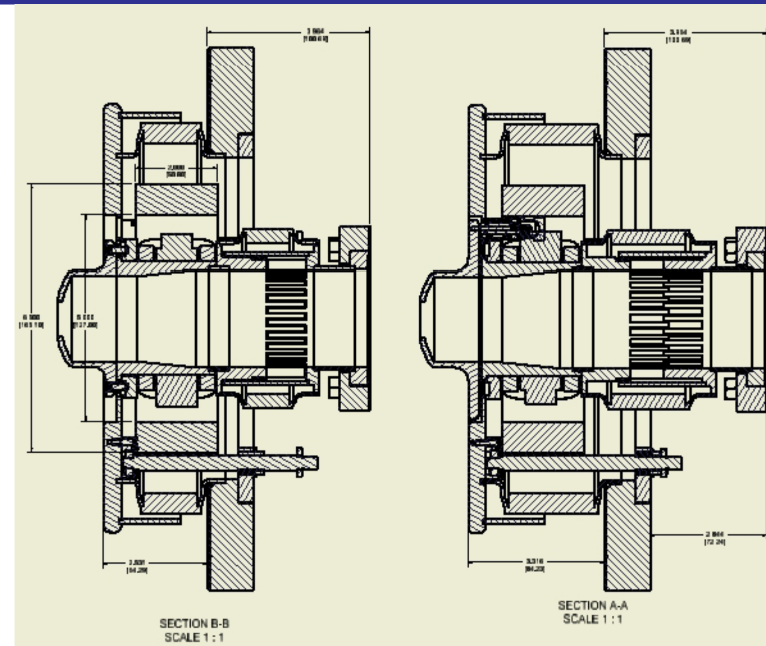
Cathode Electrode Solenoid

- Need to package small solenoid centered on cathode surface of puck.
- Provide power and remove heat
- Hermetically packaged

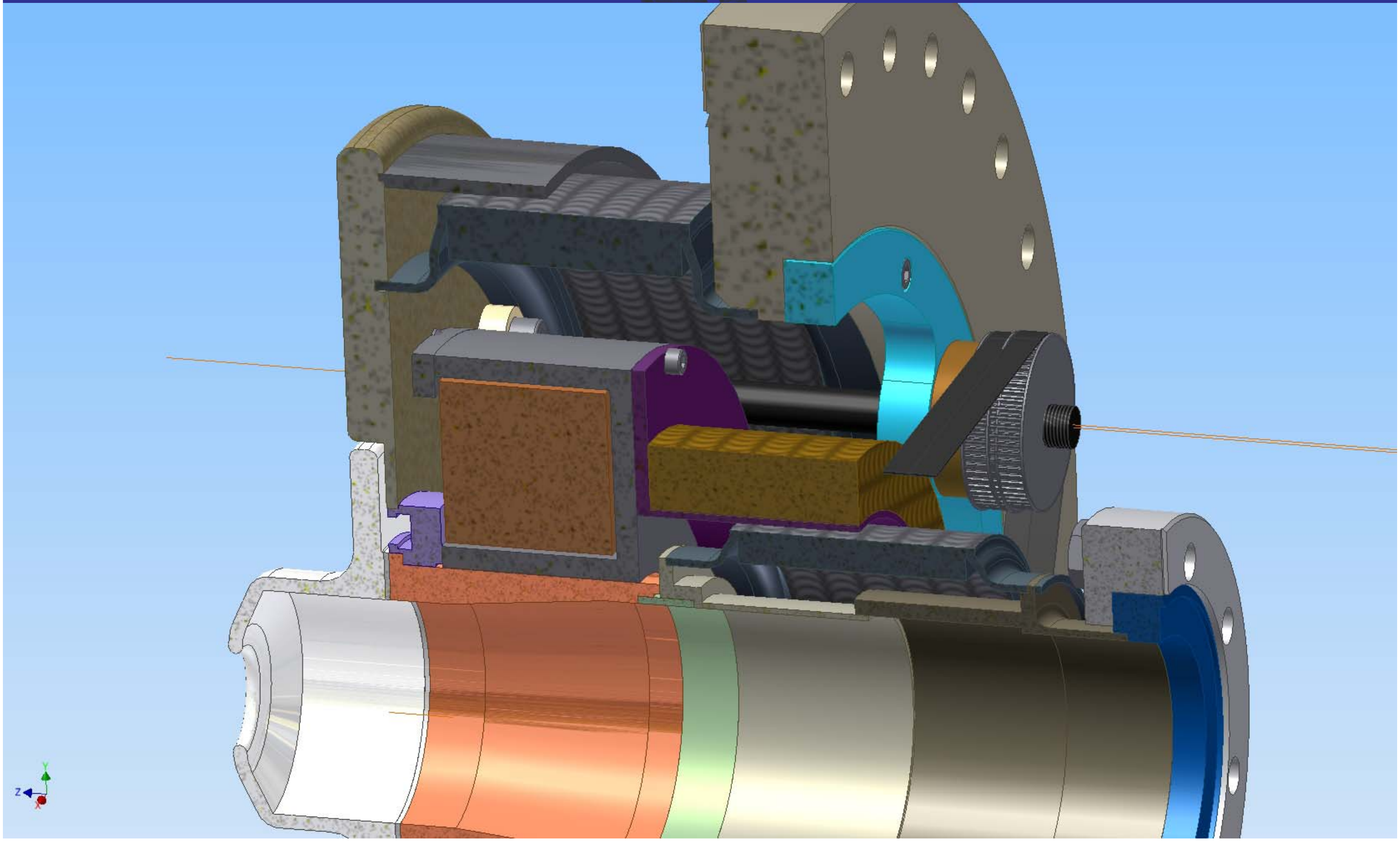


Anode Electrode

- Movable Anode – 35mm motion = (55 to 20mm gap). Mk. I gun gap is 50mm. Sliding joint makes larger motions difficult
- Would allow for processing at higher field, then retract to operational position
- Floating anode? – robust electrical connection, what voltage required?
- Remote drive and readout of gap
- Corrector pair / solenoid packaging in early stages of design
- Anode Material – Beryllium again?

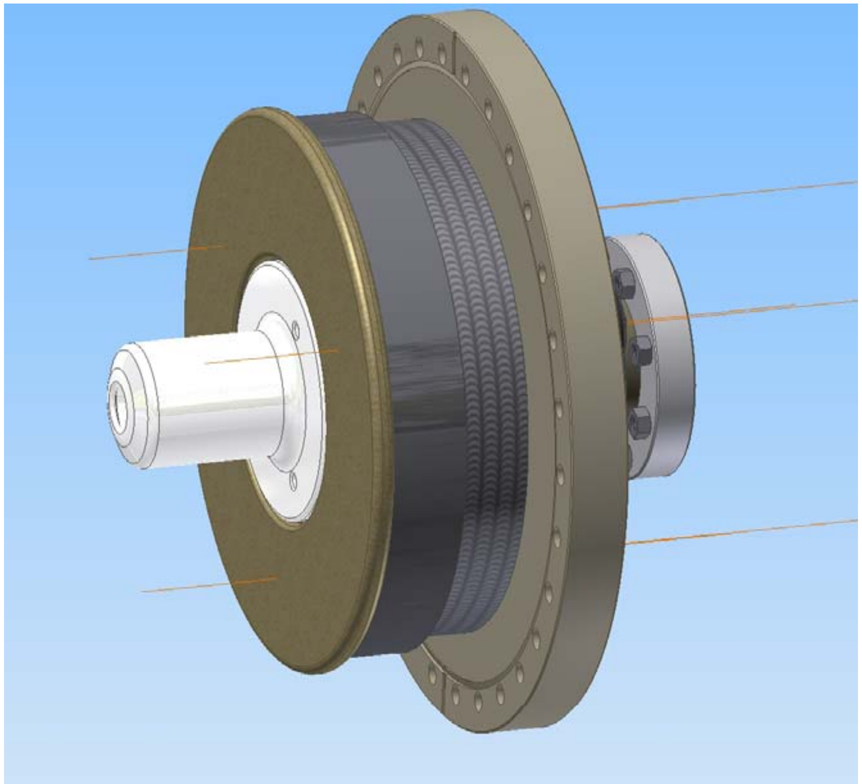


Anode Electrode



Mind the Gap

- A large range of gaps is being considered (20mm – 100mm) by optimizers
- My designs assume a baseline gap of 50mm
- Gap set by changes to the cathode electrode body
- Or easy changes to extend the Anode, much less work to switch … *(pushes solenoid further away)*

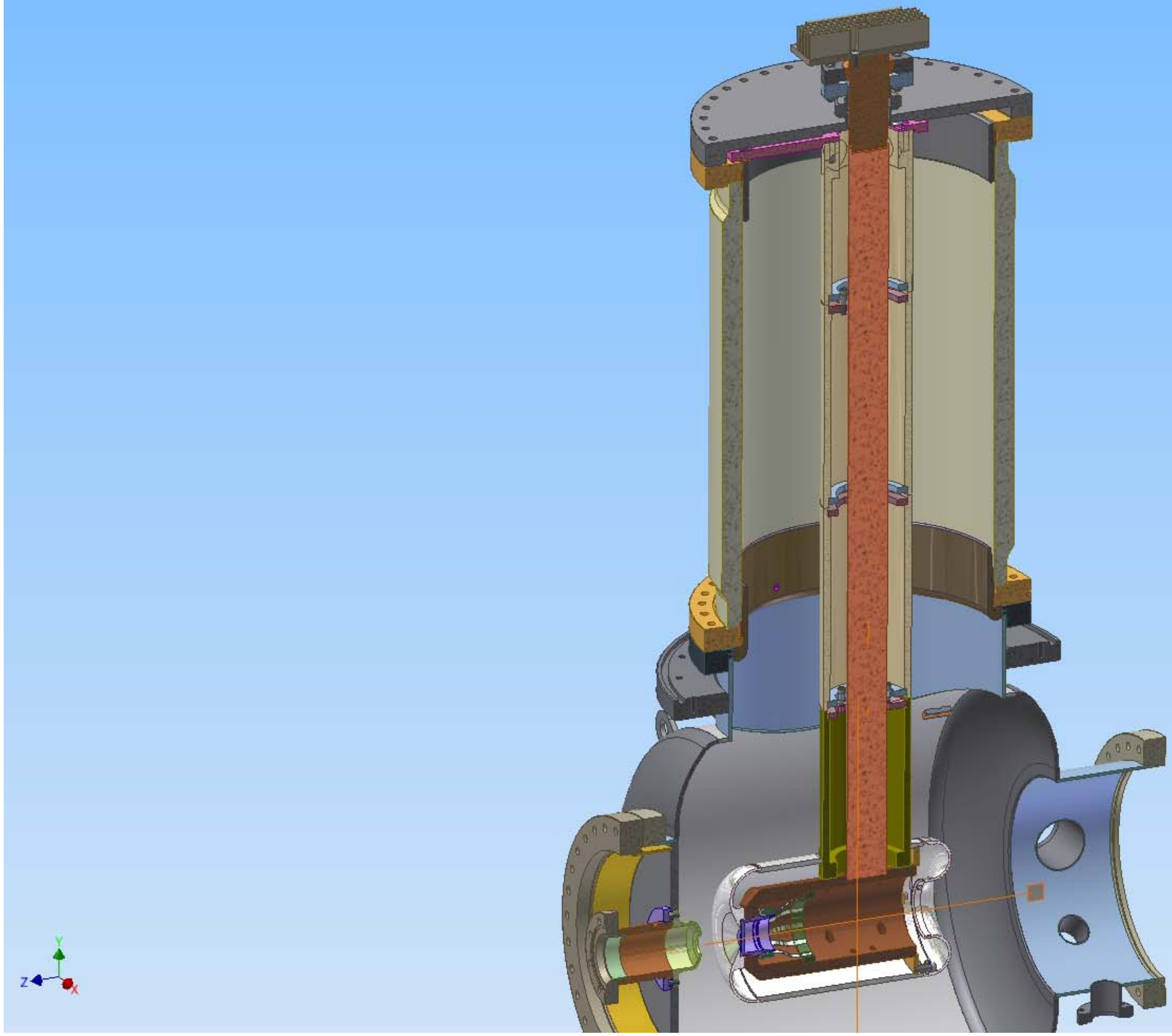


Cathode Cooling

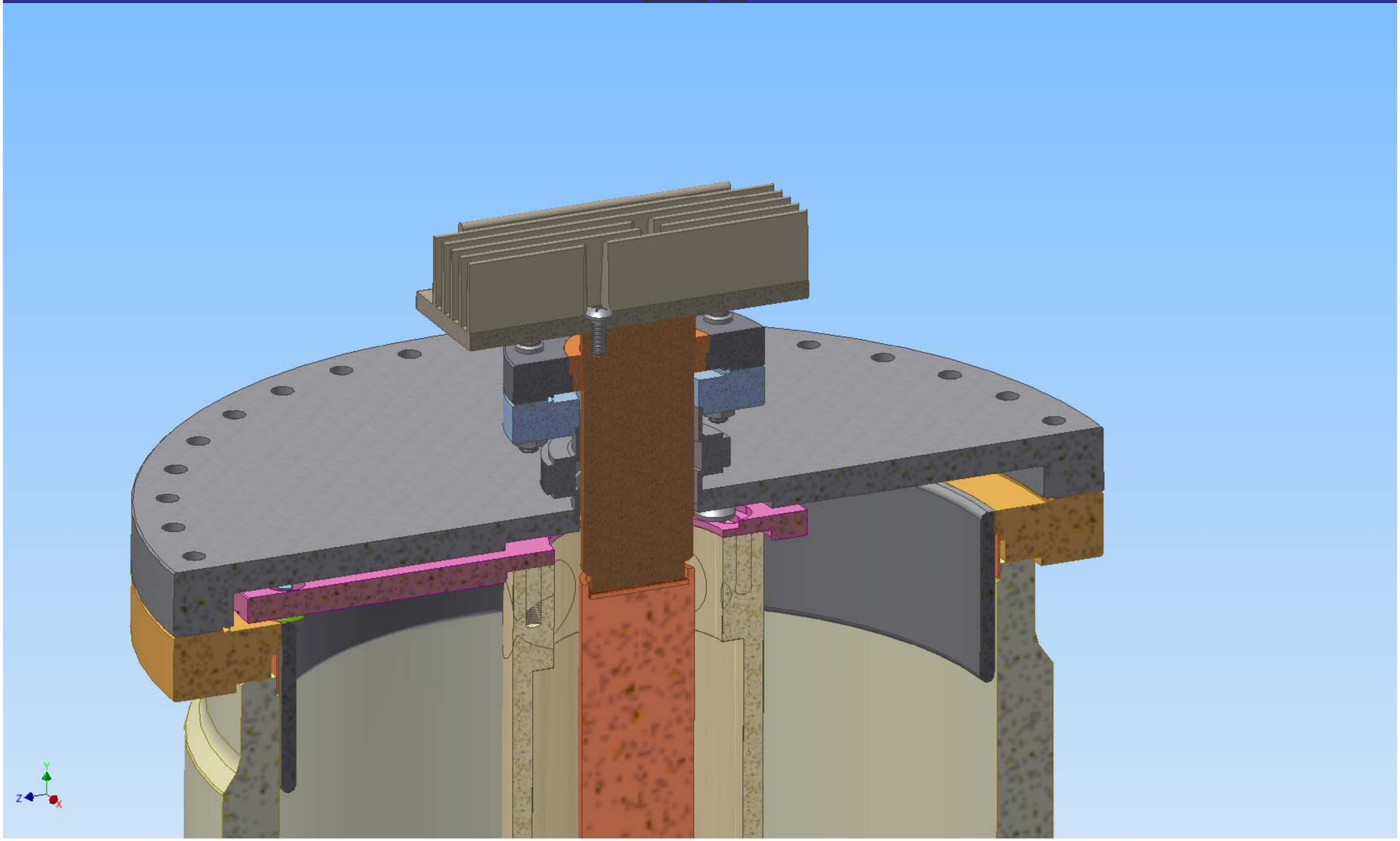
- Mk. I gun uses 50mm diameter copper rod solidly mounted to electrode inner structure within stalk to dissipate heat via finned heat sink in SF6
- Assumed ~10W from laser power, perhaps 60W from solenoid!

- Options:
  - Pass coolant (SF6?) into copper rod
  - Copper rod is replaced by heat pipe
  - Peltier cooling of cathode locally, waste heat removed by copper rod (want thermocouples and controls)

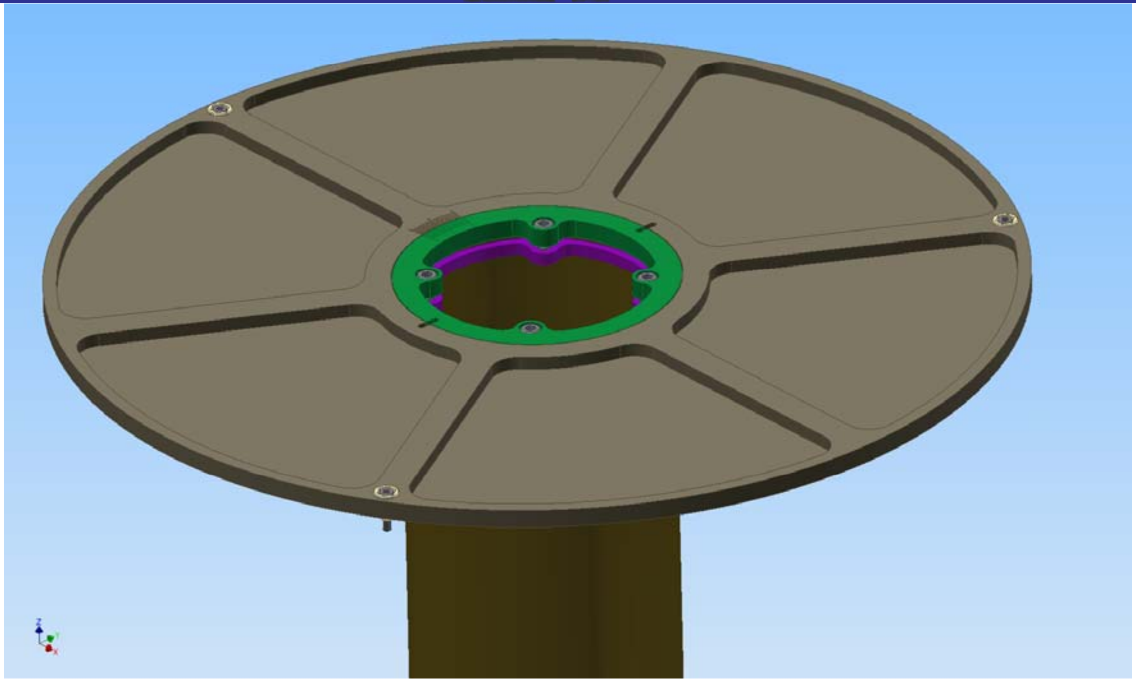
Cathode Cooling



Cathode Cooling

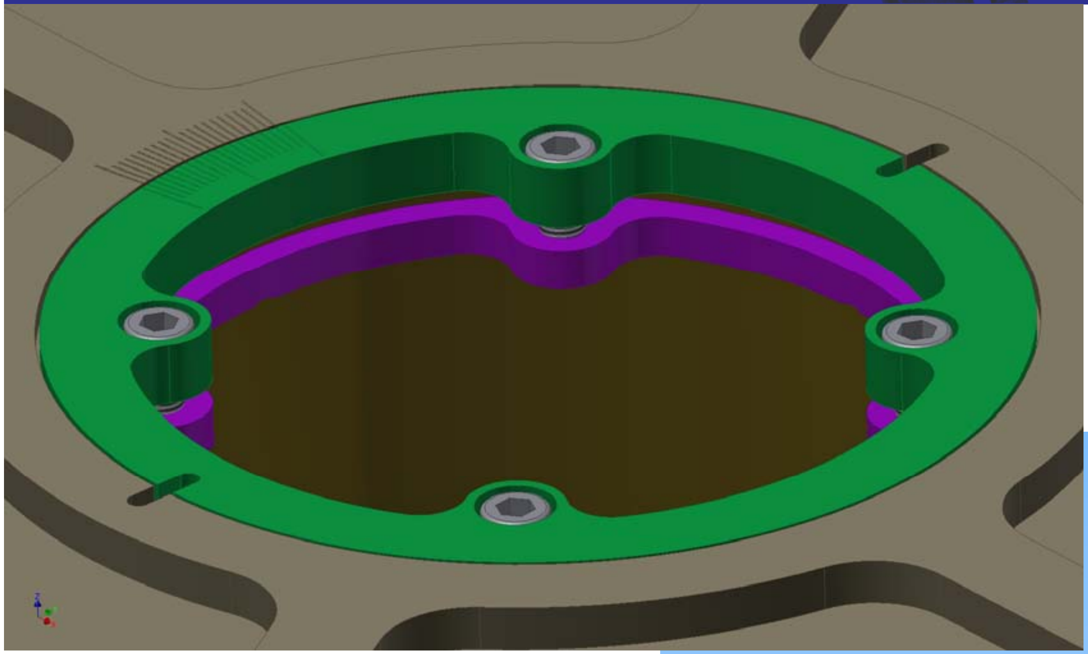


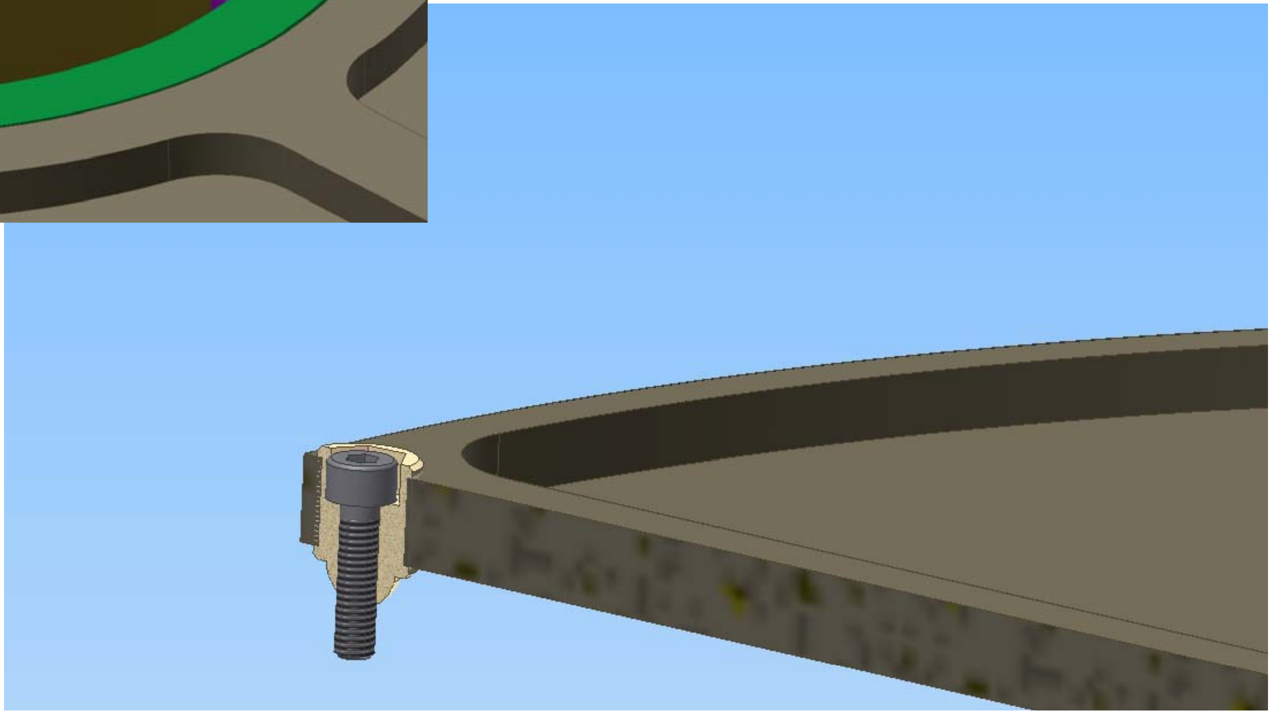
Alignment / Adjusters



- Optical survey (laser tracker, theodolite) to position electrodes
- Stalk support plate provides: θ (rotation), Z (height) and XY adjustments on arced path, corrections tend to be small (1-2mm) so angles generated by arced path are negligible. Final errors about 0.2mm
- Larger adjuster screws to reduce loads, titanium on stainless to reduce galling problems.

Alignment / Adjusters

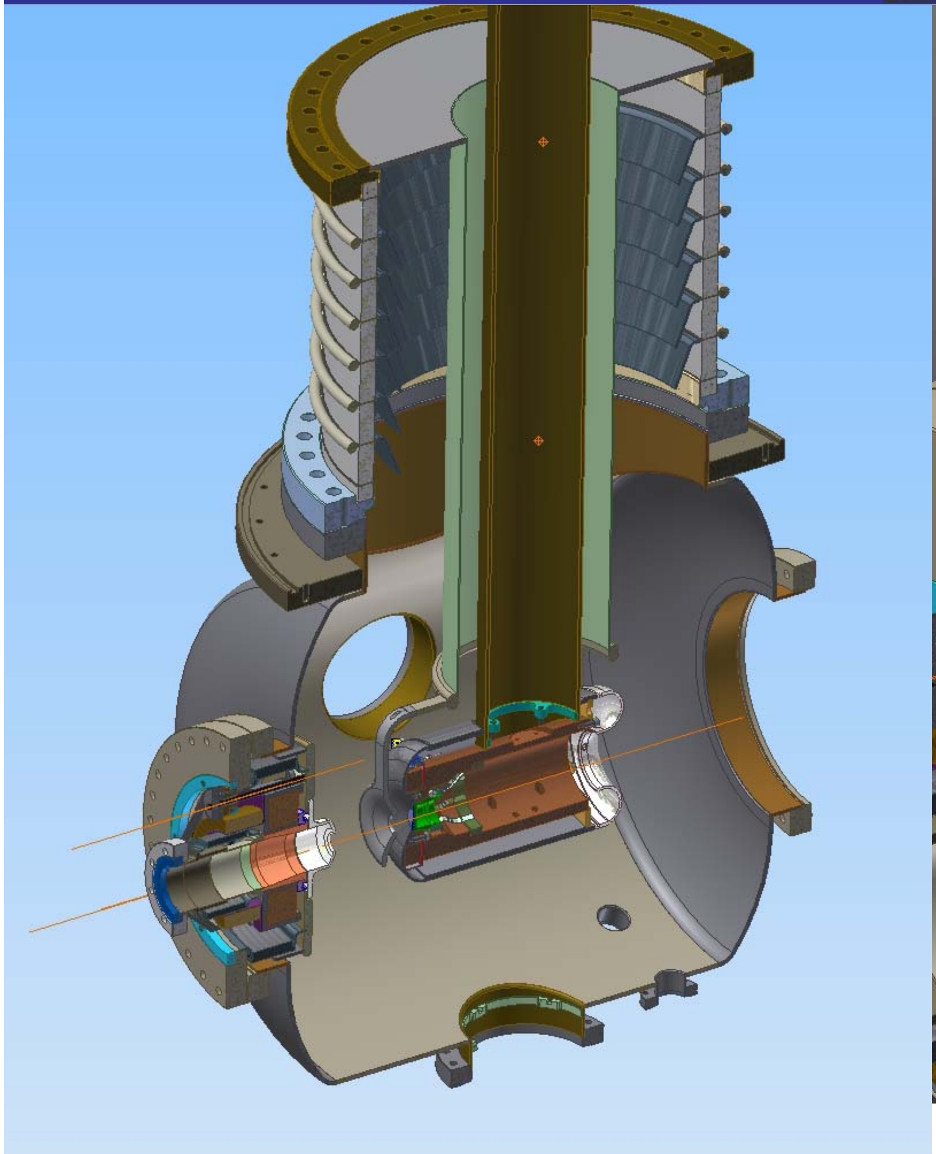


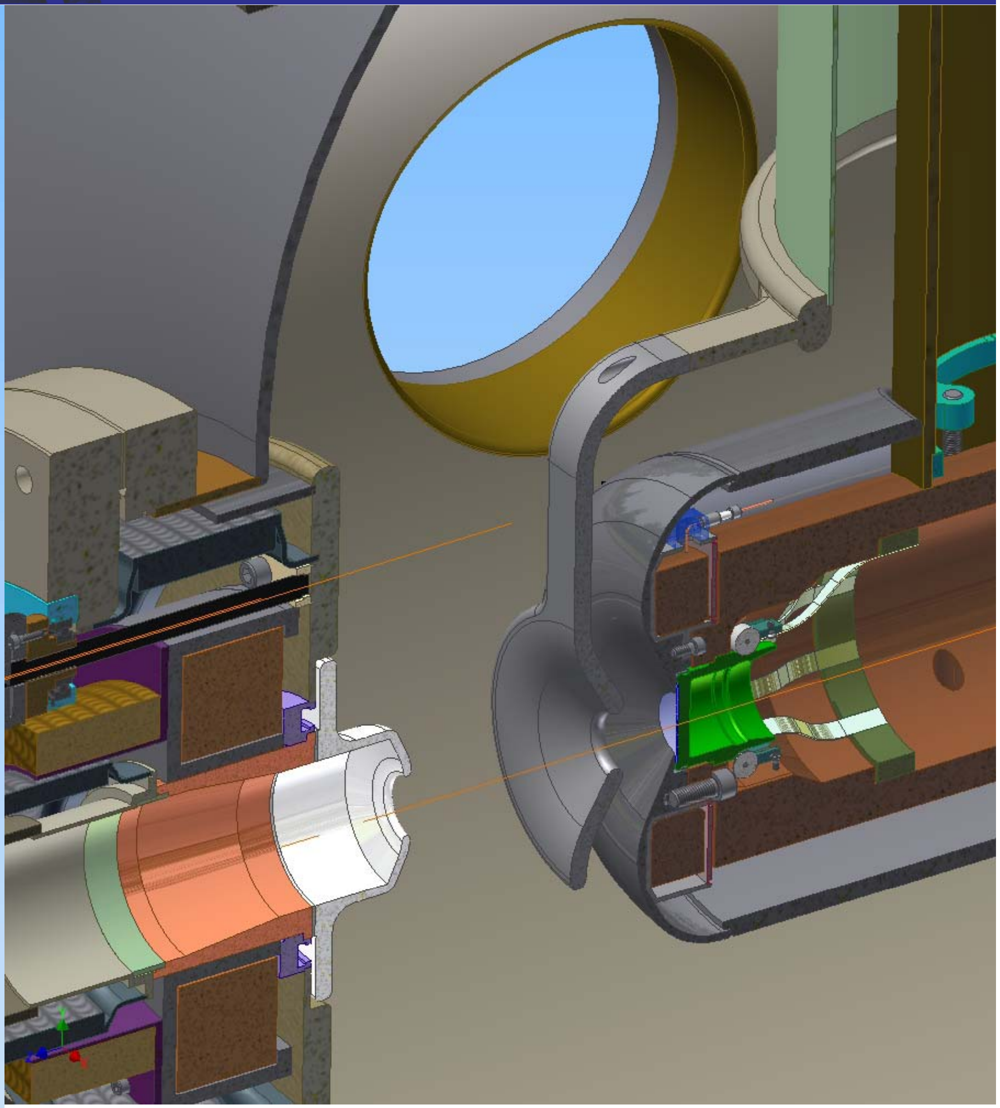


Dual Gap Gun

- Dual gap gun may provide a high field at the cathode surface (primary gap) along with a high energy at the anode (secondary gap)
- Mechanically difficult, electrostatic asymmetry
- Jared to discuss simulations tomorrow

Dual Gap Gun

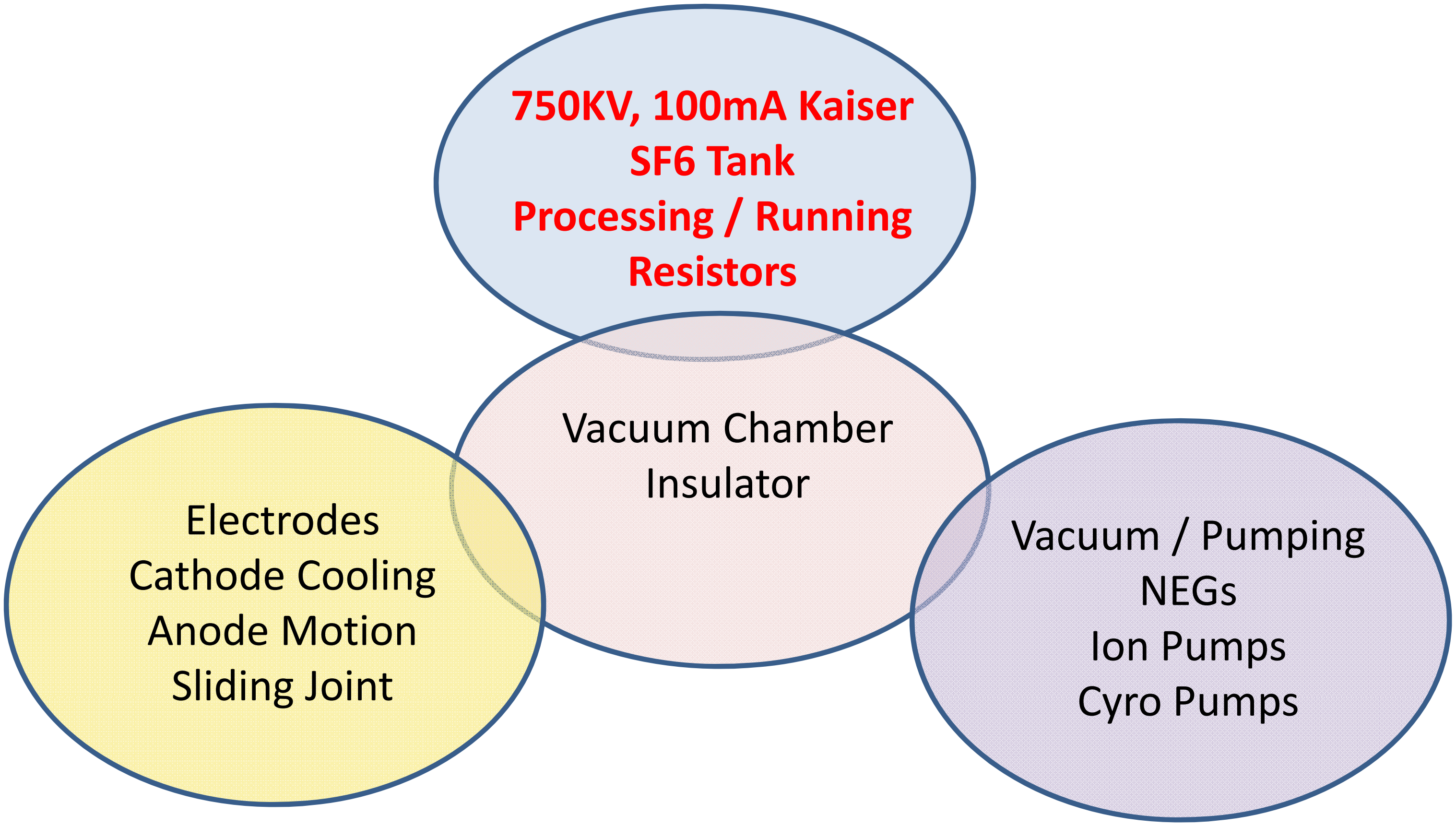




Electrode Summary

- ❑ Establish a baseline electrode configuration
- ❑ How to prioritize experiments with wide range of gaps, intermediate electrodes, etc.

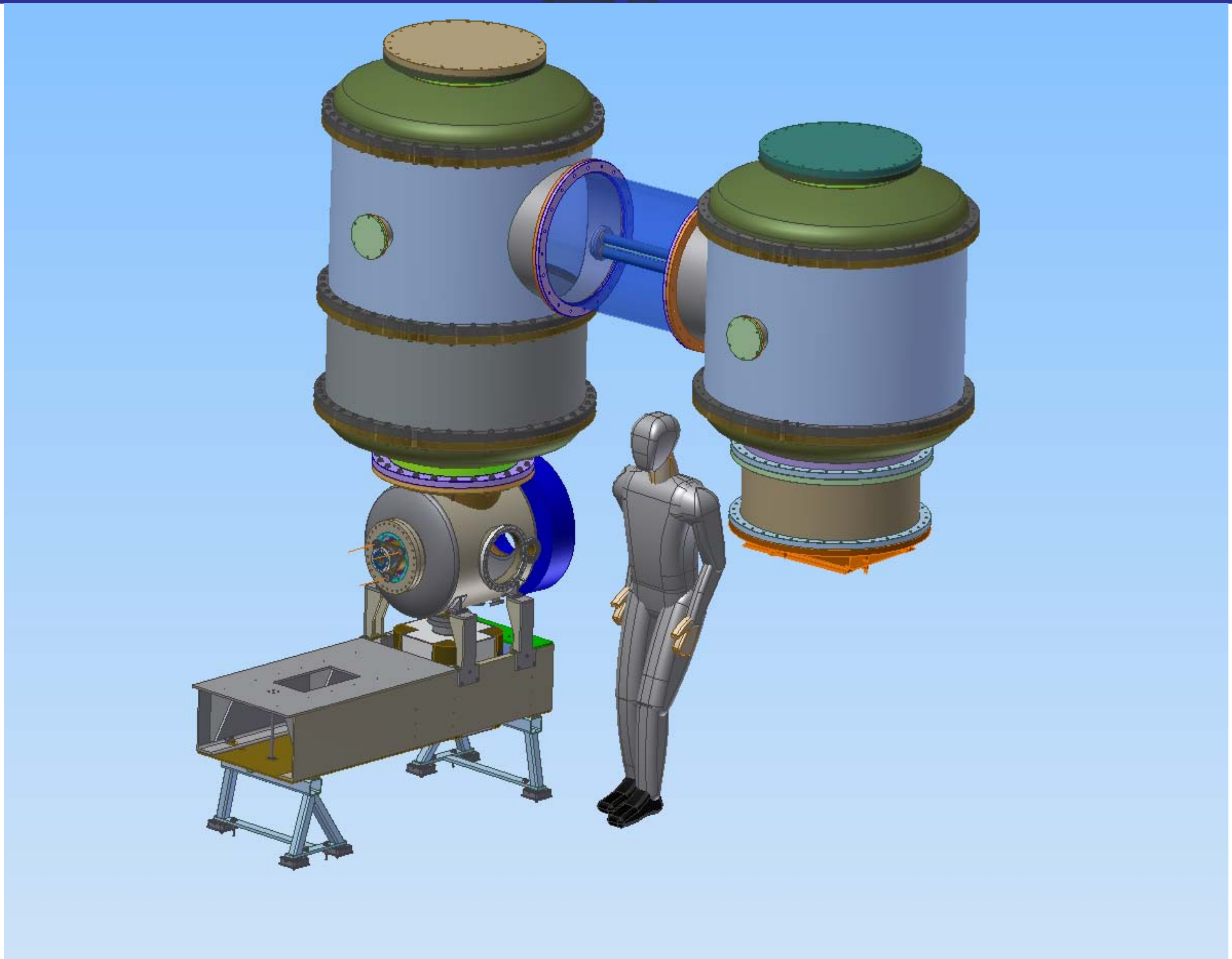
System Diagram



HVPS / SF6 PV Overview

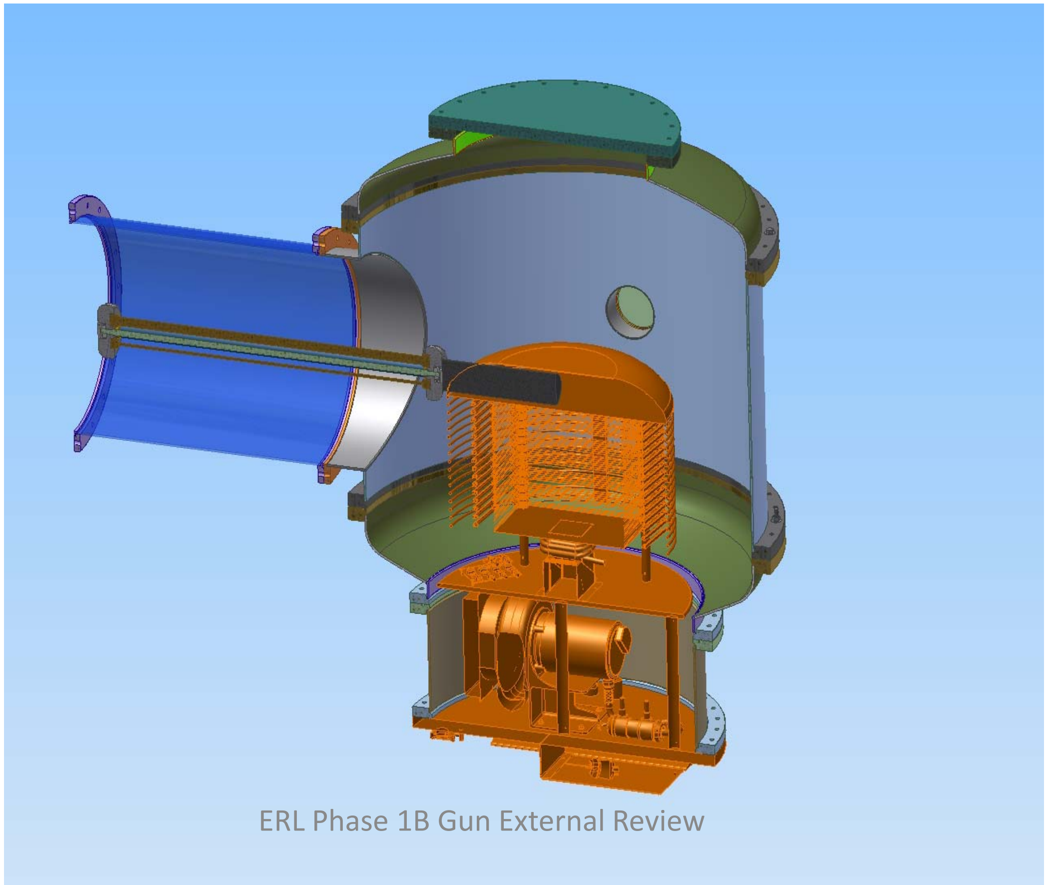
- Larger diameter SF6 pressure vessel, upright and cylindrically symmetric. Separate PV for HVPS and gun.
- Based on commercially available PV heads and tubes, 48 inch diameter. PV calculations to follow. Local fabrication with proven low cost / high quality suppliers
- Space limited for laser and cathode preparation systems, separate tanks allows for HVPS to be installed above gun, further away, or on a level above laser table (for example)
- New Scheme for tank removal / assembly required

HVPS / SF6 PV Overview

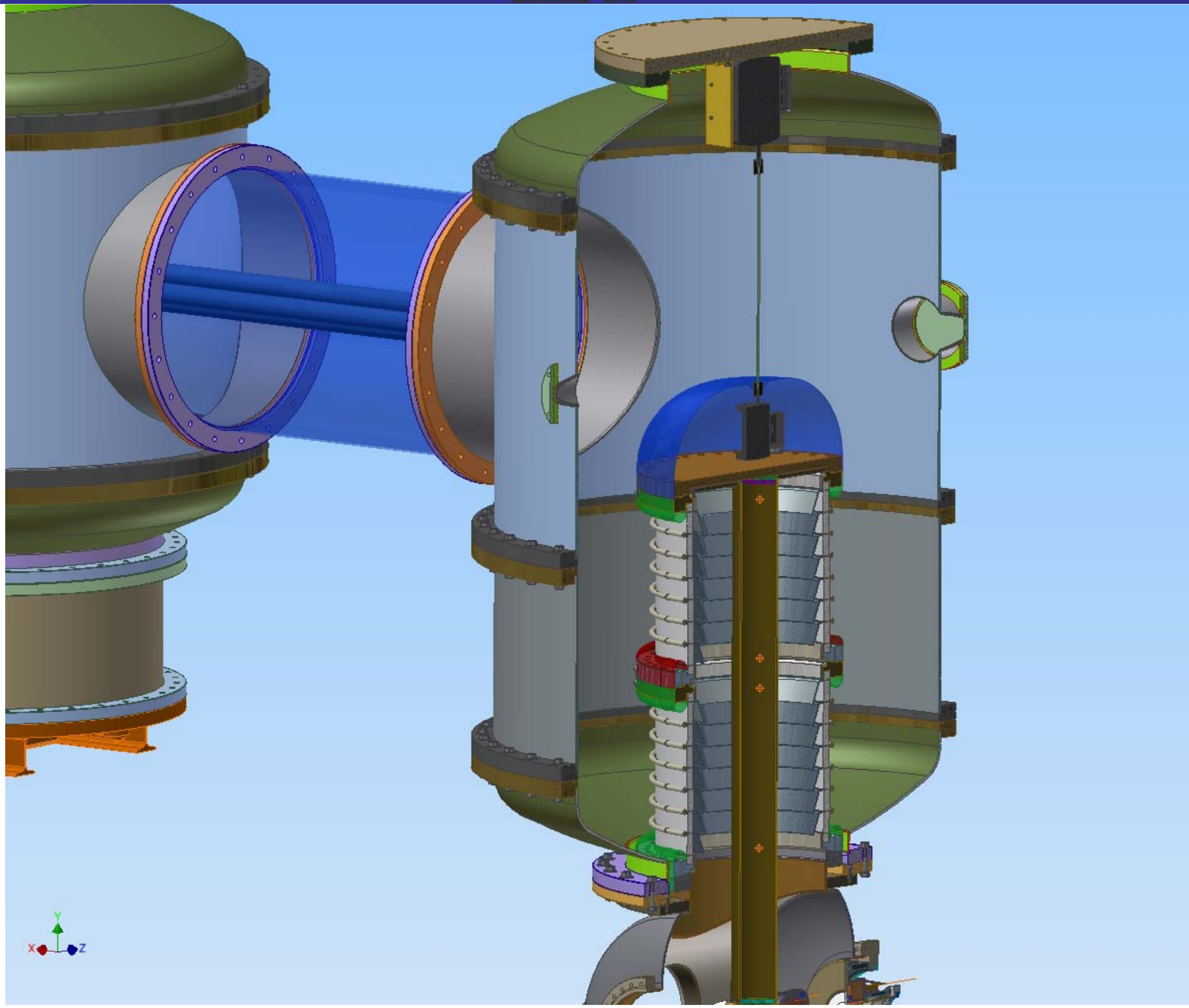


HVPS SF6 PV Overview

- Original prototype Kaiser 300kV supply rebuilt and upgraded to 600kV, will be used at first for this gun during experimental phase
- Kaiser 750kV supply would be available for operation



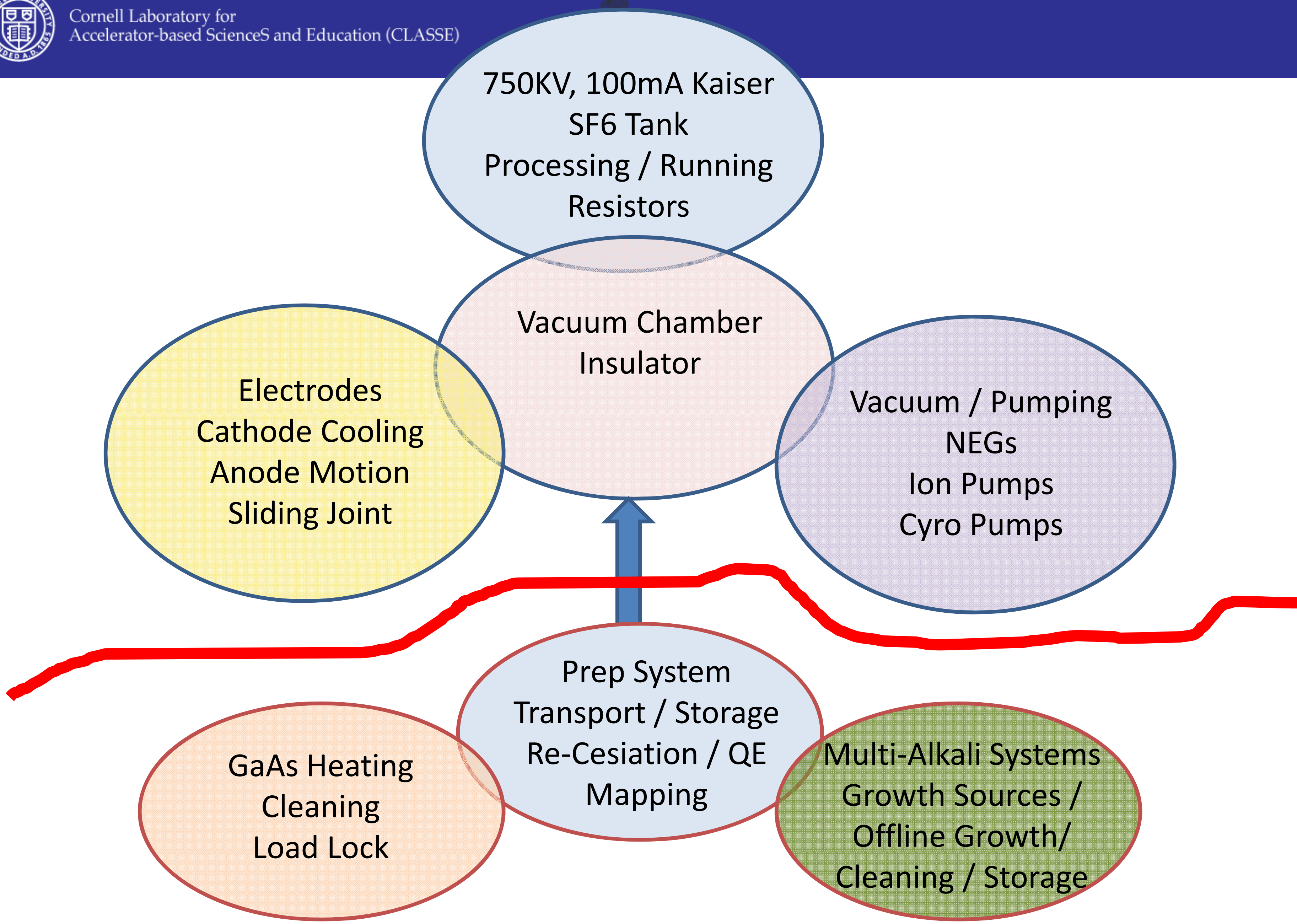
Gun SF6 Tank



HVPS / SF6 PV Overview

- Connection tube between HVPS and Gun
- Running / processing resistors
- Power to cathode solenoid *(Later)*
- Current monitoring, temperature sensors, power supply within HV dome

- ❑ Ability to change resistance without disassembly?


750KV, 100mA Kaiser
SF6 Tank
Processing / Running
Resistors
Vacuum Chamber
Insulator
Electrodes
Cathode Cooling
Anode Motion
Sliding Joint
Vacuum / Pumping
NEGs
Ion Pumps
Cyro Pumps
Prep System
Transport / Storage
Re-Cesiation / QE
Mapping
GaAs Heating
Cleaning
Load Lock
Multi-Alkali Systems
Growth Sources /
Offline Growth/
Cleaning / Storage

More Details