Jlab FEL Photoemission DC Guns

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On behalf of the FEL team

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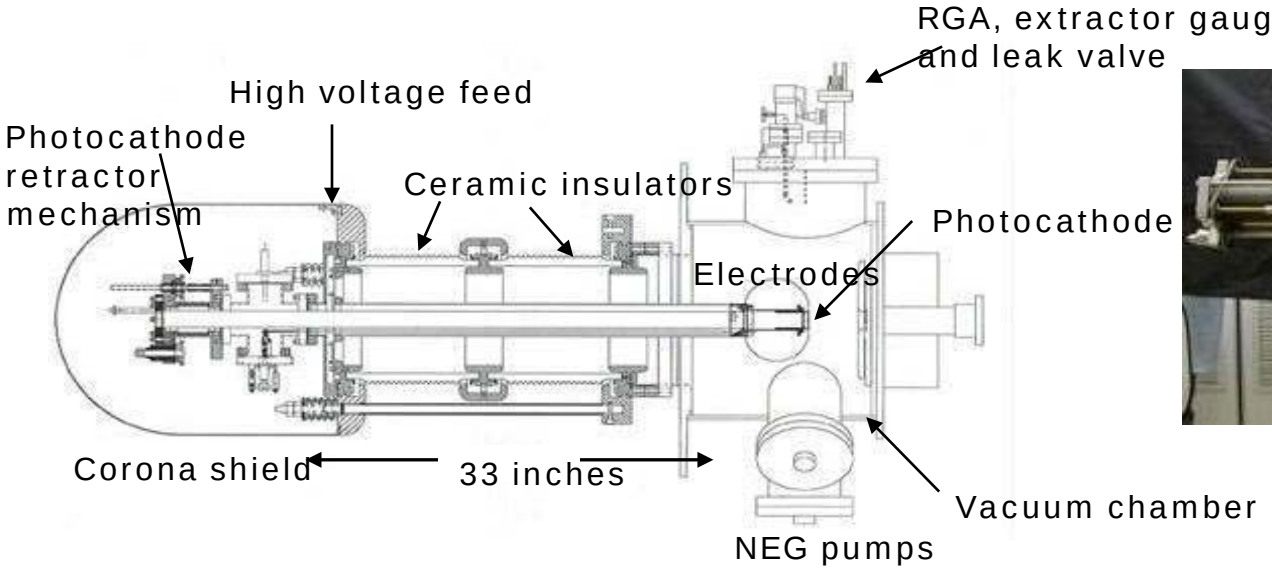
2 Operational Guns

2. Backup gun, test stand with beam characterization beamline

FEL Gun

- Nominally operates at 350kV, can deliver up to 10mA CW at 75MHz
- GaAs cathode (0.5hr re-Cs, 2 day heat clean/activation)
- Kr processing speeds up the HV conditioning
- Gun needs 3 week bake after venting e.g. cathode replacement, ceramic leak



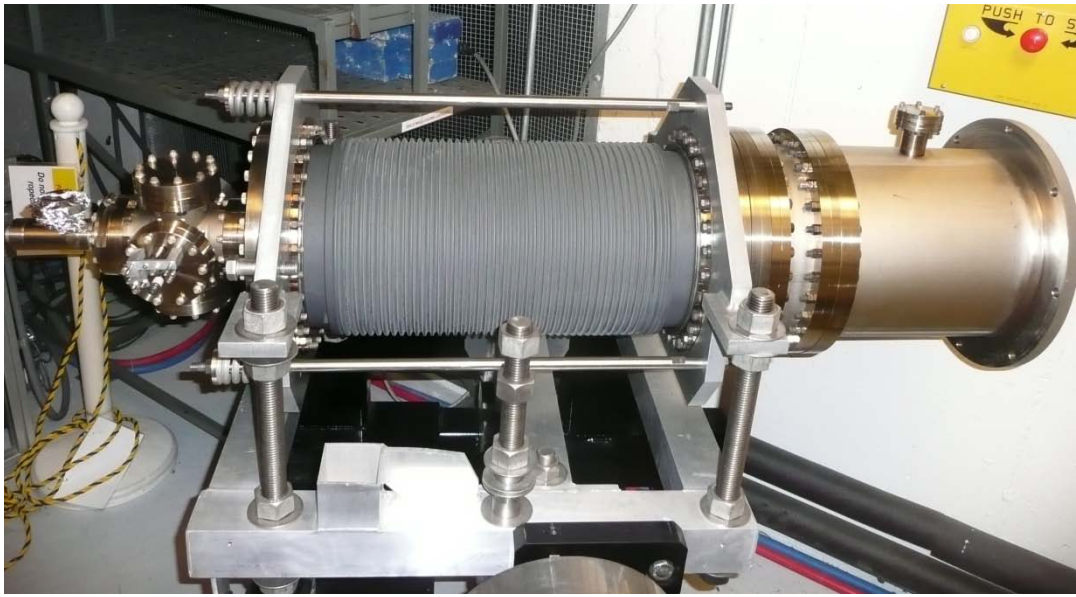
- Great for R&D machine, not acceptable for 24/7 User Facility.

FEL Gun Status

Date	Event
May 2007	Conclusion of 3 years of operations at **350** kV with a single GaAs wafer delivering over ***7000 Coulombs and 900 of CW beam time*** . Opened flange leak at 405kV while testing gun for higher charge studies
Mar. 2008	Punctured insulator at 398kV during conditioning of refurbished gun
Sept. 2008	Rebuilt gun with new insulator, but observed >100 uA of F.E. at 150kV
Oct. 2008	Krypton processed to 375 kV, but too much F. E. from cathode
Nov. 2008	Replaced cathode, F. E. reactivated at 320 kV after gun bake, Kr proc. again
Dec. 2008	No F. E. from cathode, but field emitter re-activated after cathode heat clean.
Up to date	Gun operational at 350kV but with few uA of F. E., lifetime ~10 operational hours. Motorized cathode retraction system cut down re-cesiation time from 3 to 0.5 hours

GTS Gun

- Back-up to FEL in case of catastrophic failure
- Electrostatics the same
- Used for testing



Modified

–Single insulator

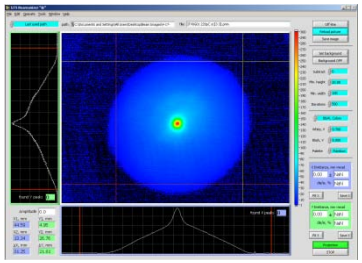
–Laser ports on gun chamber (no light box)

–Bulk resistivity insulator (shown, but not yet electrically tested)

–Semi-load lock (in manufacture – no gun bake required for cathode change)

–Electrodes have F.E. suppression coating

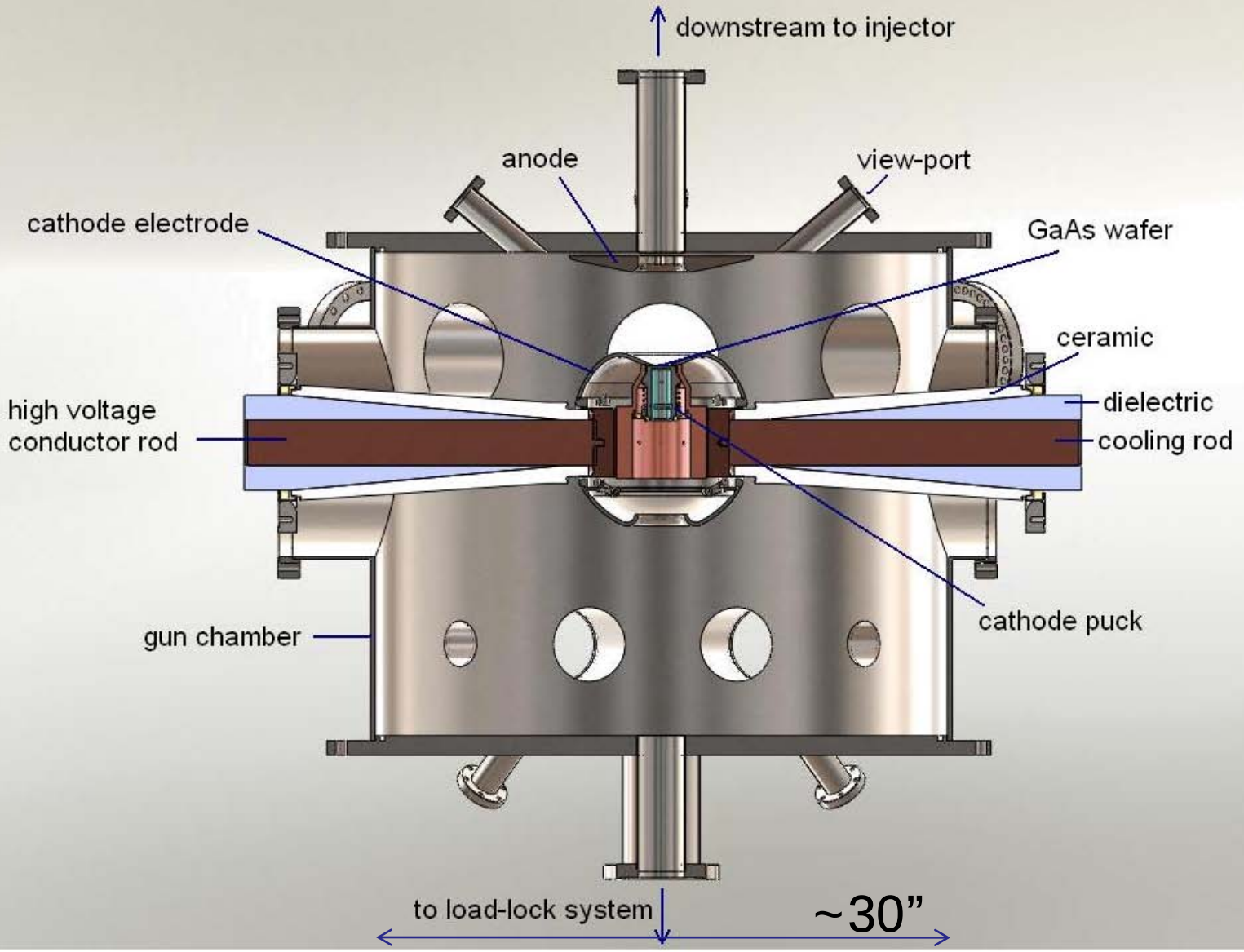
GTS Gun Status

Date	Event
12/06/2007	Started HV conditioning, achieved 85 kV the first day
02/01/2008	Achieved 485 kV after **528 processing-hours**. At 486kV punched-through ceramic insulator
02/28/2008	Fixed ceramic leak and ensured gun performance at **460 kV**. Declared HV conditioning done
03/14/2008	First beam at 300kV 
Spring 2008	Extracted beam up to 375 kV and observed indications of surface charge limit. **1nC demonstration**
2009 - 2010	Multi-slit, second solenoid, kicker cavity ready for installation in expanded diagnostic beam line Semi-Load-Lock installation, Bulk resistivity ceramic testing

GTS Program

- Install emittance measurement diagnostics
- Experiment with Kr processing after short bake
  - Generally bake for 3 weeks then process, save time with 1 week bake and Kr process as good vacuum is not required. Ion pumps don't pump the Kr, but will pump residual gases
- Demonstrate operation of bulk resistivity ceramic
  - Has been baked, no leaks
- Repeat charge extraction experiment with different dopant GaAs cathodes

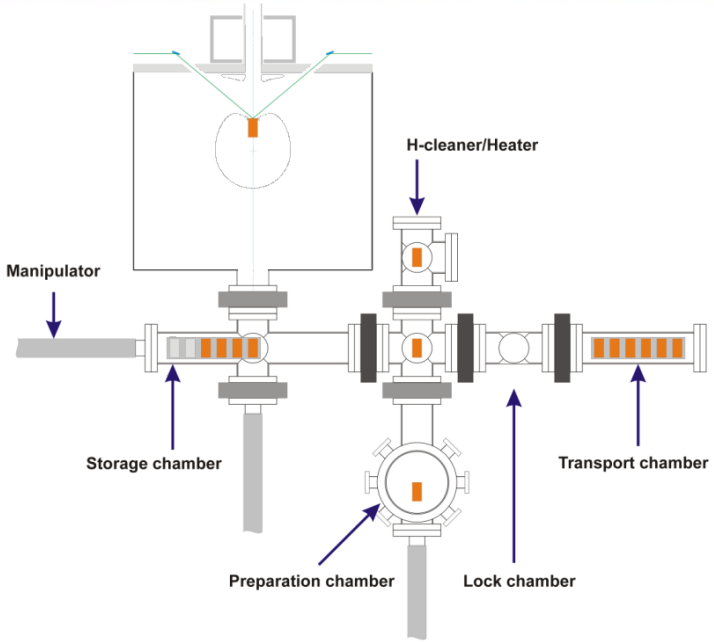
Inverted Gun

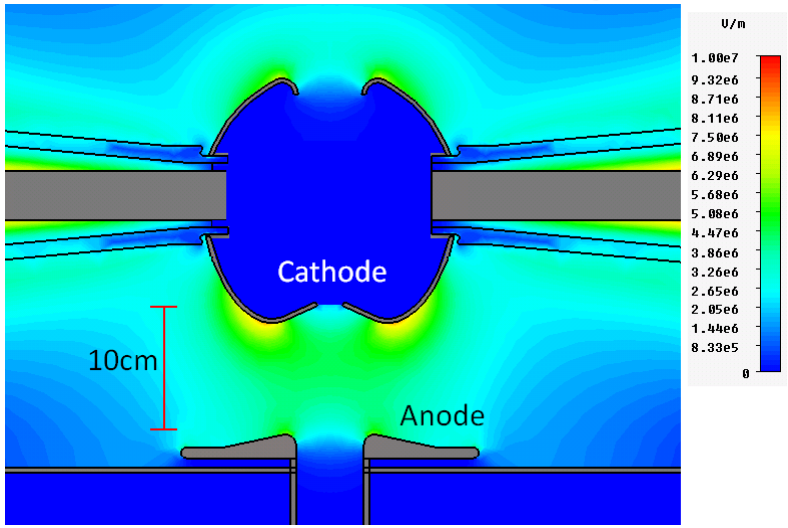


Inverted Gun

Features

- Large electrode area to reduce surface gradient, higher operating voltage
- Niobium electrodes (take advantage of SRF processing techniques)
- Bulk resistivity ceramic
- Load lock (various cathode types)
- Massive pumping for good vacuum
- Focusing geometry
- Light-box free operation
- Isolated anode for bias

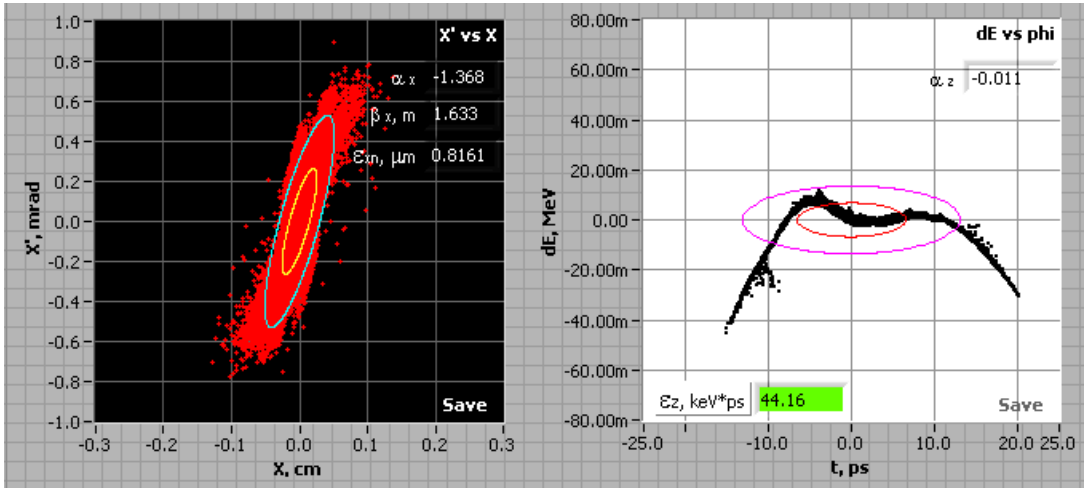




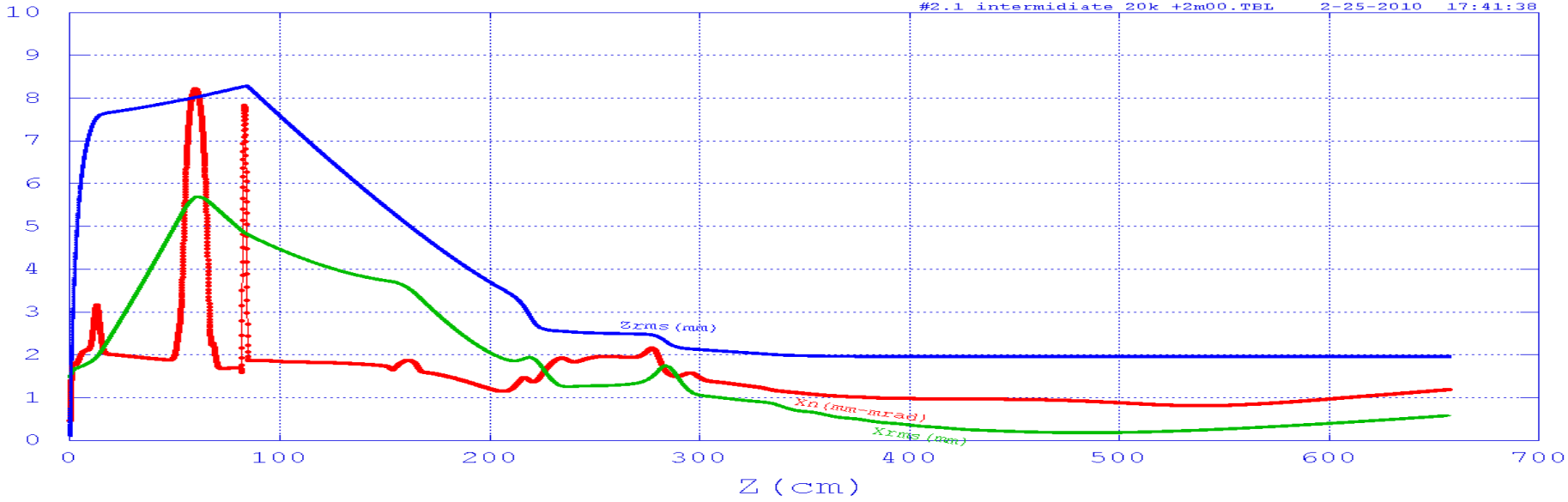
Simulations

500kV Gun and injector

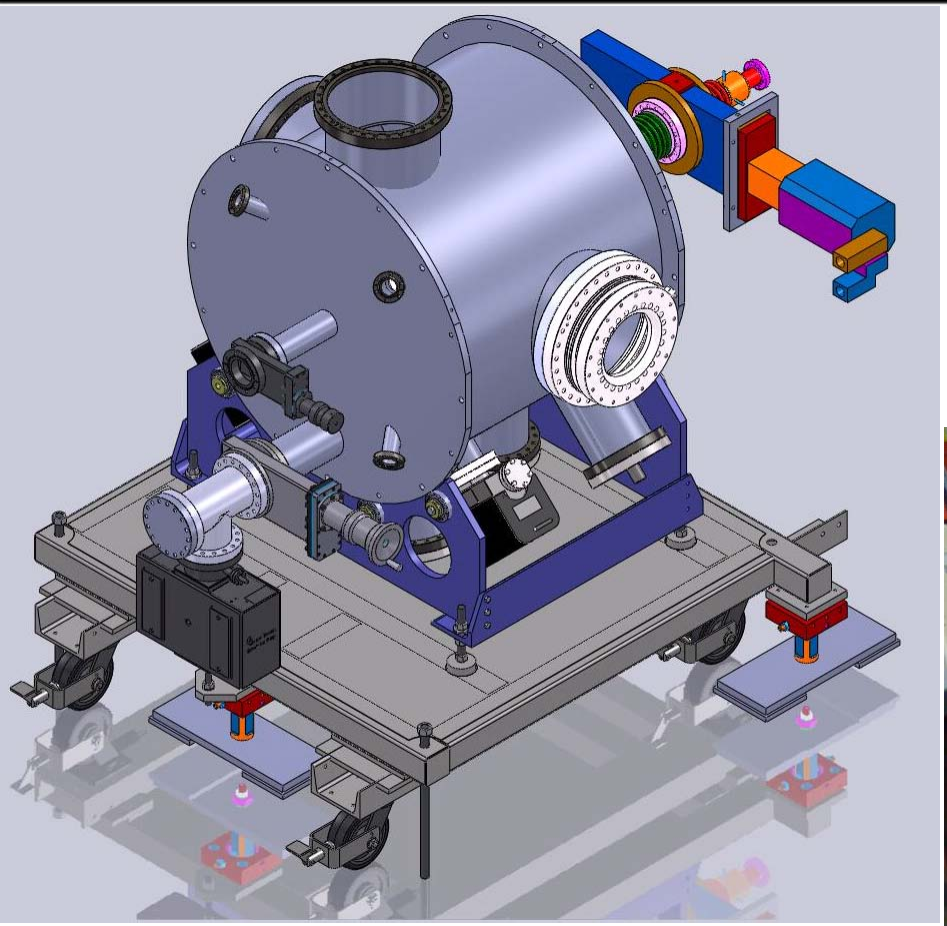
200 pC, 100ps FWHM (made of 8 Gaussian pulses superimposed to provide a flat top distribution). The thermal emittance included.
6mm diameter spot on cathode center



Preliminary results: factor 20 6D brightness

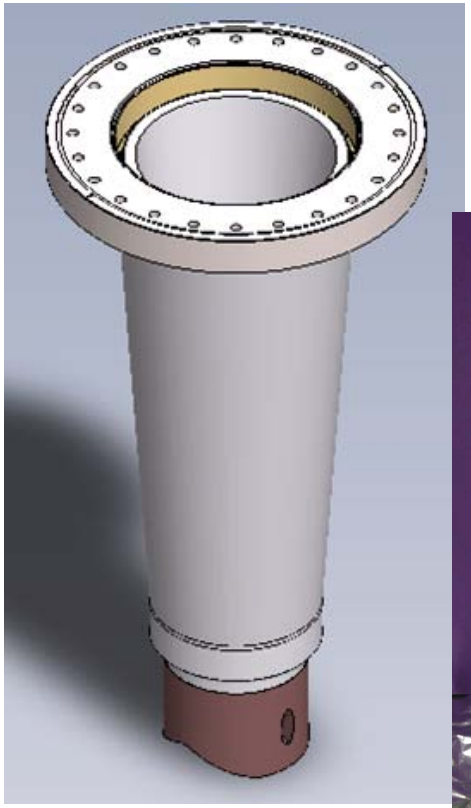


Status



Gun chamber arrived

Status



Dielectric plug test pieced delivered

Ceramics ordered

Conclusion

Potential benefits

Higher operating voltage

Lower emittance for given charge

Good vacuum (better lifetime)

Fewer bakes/ less down time

Load-lock cathode opportunities

Risks

Ions bombarding the ceramics

HV breakdown in dielectric plug/

along ceramic interface/

tracking along surface

Use of niobium

Goal

200pC, CW operation 2.33MHz,
<1um emittance @ 500kV