

LCWS 2021

500kV inverted insulators for polarized photoguns

Carlos Hernandez-Garcia
Jefferson Lab

Motivation: Develop a robust high voltage system that can be implemented in a future photogun for delivering spin polarized beam from GaAs photocathodes at **350 kV** with **no field emission**. This photogun design could then be used for generating **high bunch charge spin-polarized electron beams** for the **EIC**, **ILC** and **positron** beam production at **JLab**.

Objective: Demonstrate an inverted insulator + high voltage cable assembly that can be used to reliably apply **500 kV** bias voltage to a test electrode, with no high voltage breakdown inside or outside the vacuum chamber.

Monday, March 15, 2021

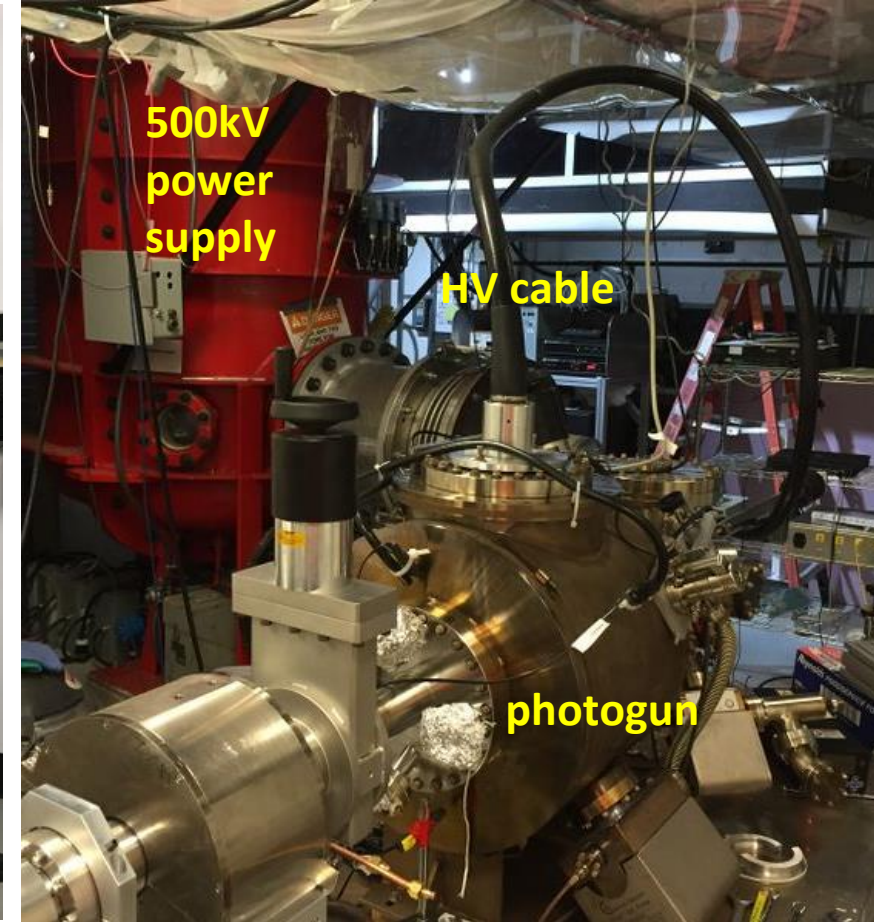
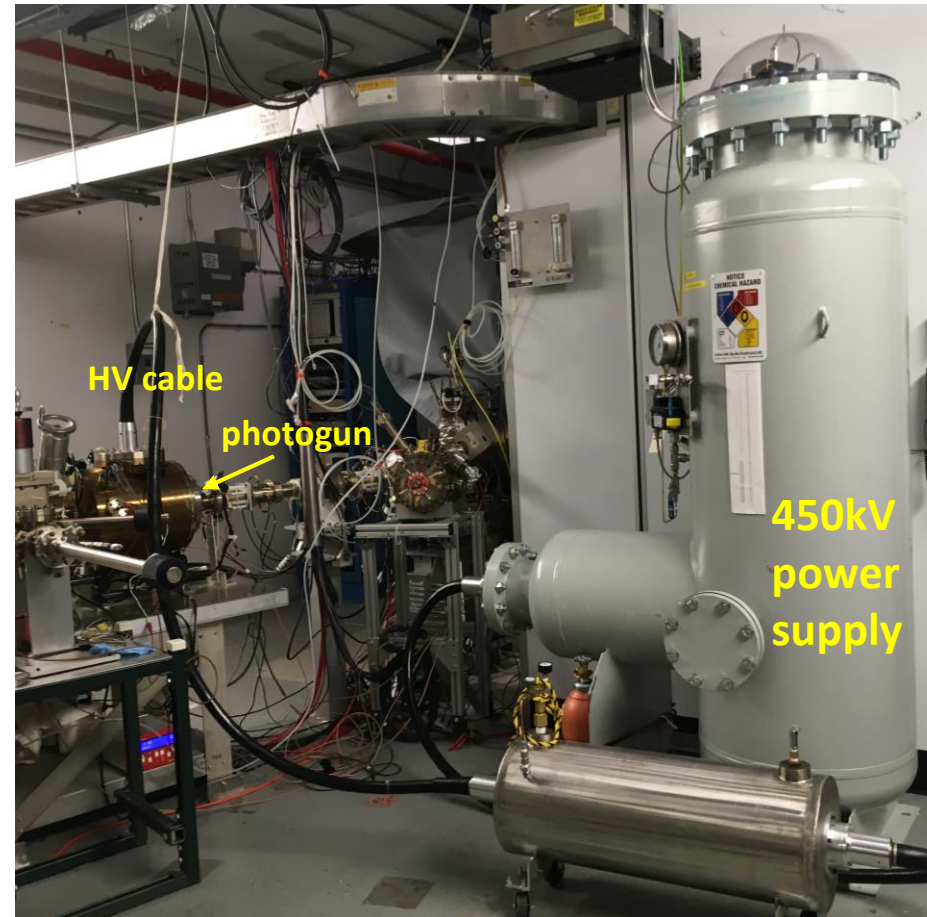
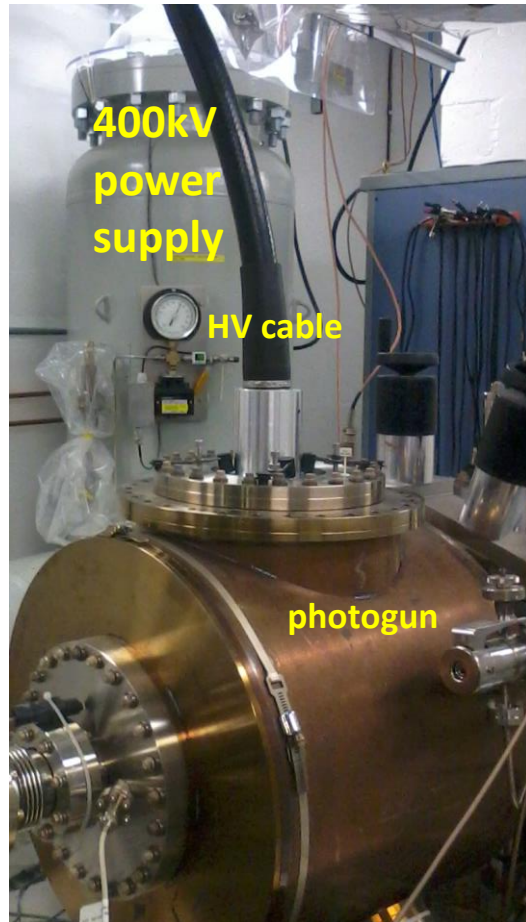


JLab inverted insulator photoguns use commercial high voltage cables mated to custom ceramic insulators made by SCT Advanced Technical Ceramics (France)

UITF 200 kV

CEBAF 200 kV

GTS 300 kV



The approach is an evolution from our experience developing and operating high voltage inverted insulator photo-guns connected to power supplies using commercial components

CEBAF
200 kV R28

300 kV R30

Next step: 500 kV

We have 6 of these customized insulators, but they do not fit to the cable shown below

Conceptual approach: modify commercial epoxy receptacle designed for 350kV cable to mate with inverted insulator

R28

R30

12"

Insulator

Cable plug

Receptacle

Insulator

Cable plug

Receptacle

350kV commercial cable

Based on scaled up CEBAF gun design, we developed an insulator/cable/electrode solution for 350kV kV without insulator arcing

418 C. Hernandez-Garcia et al.: High Voltage Studies of Inverted-geometry Ceramic Insulators for a 350 kV DC Polarized Electron Gun

High Voltage Studies of Inverted-geometry Ceramic Insulators for a 350 kV DC Polarized Electron Gun

C. Hernandez-Garcia, M. Poelker, and J. Hansknecht

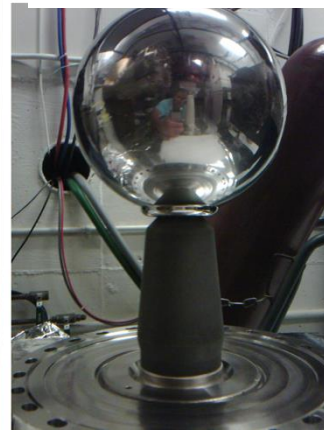
Thomas Jefferson National Accelerator Facility
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Newport News, VA 23606, USA



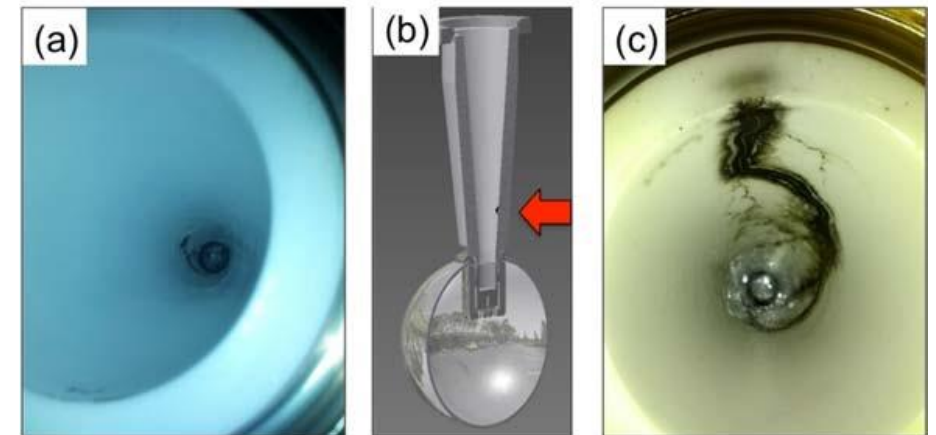
R30 with shielding electrode reached 375 kV



R30 with no shield arced at 325 kV

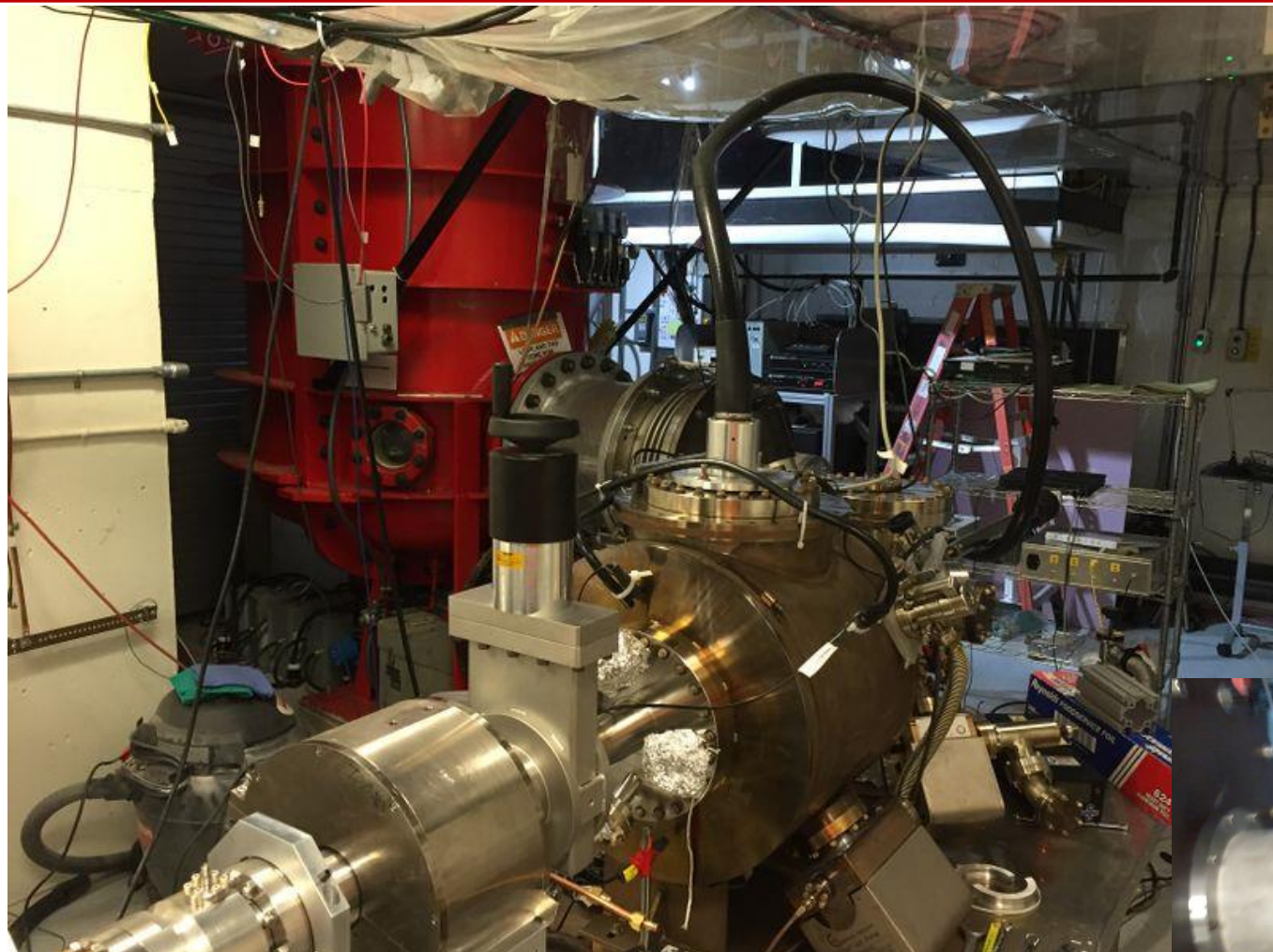


R28 with no shield reached 360 kV (large electrode might have served as shield) ⁴



R30 insulator without shielding electrode sometimes punctures through, some other times arcs all the way to ground ~ 325 kV

We use our Gun Test Stand housing a 500 kV 5 mA DC power supply for HV tests



The red tank is filled to 10 psig of SF6 and houses the Glassman HVPS

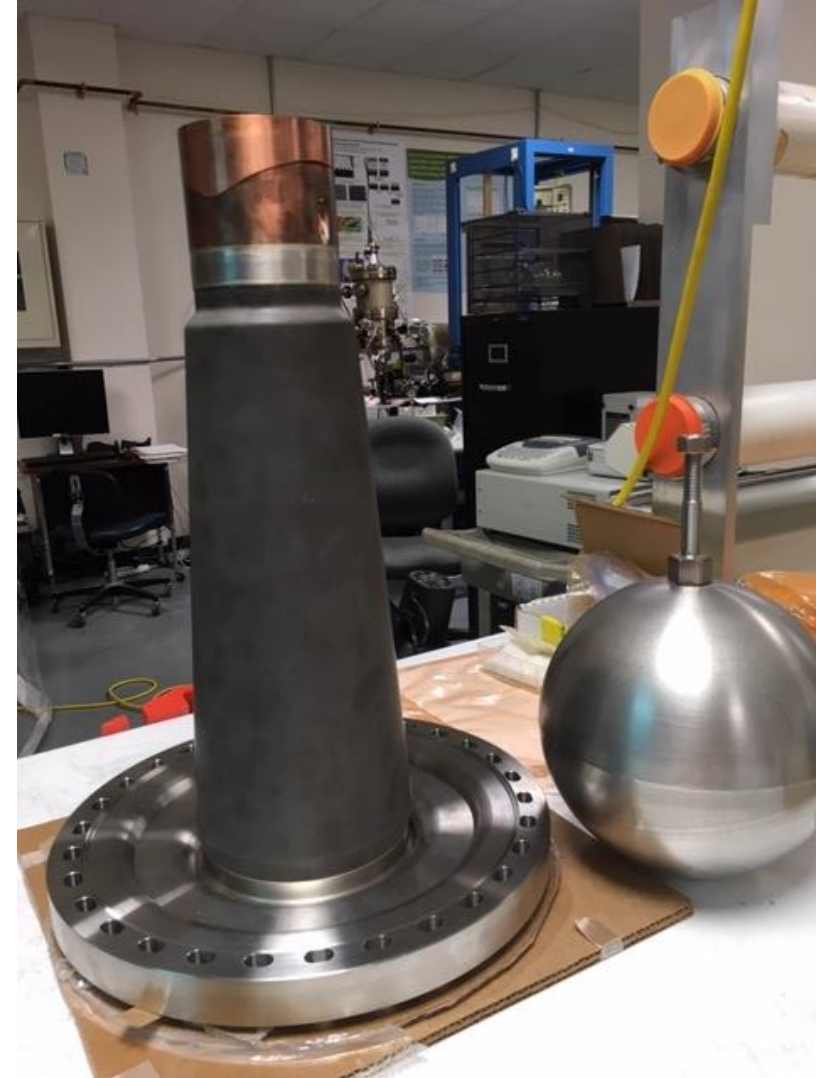


Start with available inverted insulators from JLab FEL gun using test spherical electrode

- We will design a custom triple junction shield electrode

* With screening electrode	R28	R30	JLab FEL
Pure Alumina			N/A
Voltage Achieved	280 kV	325 kV 375 kV *	
Semi-conductive			
Voltage Achieved	360kV	365 kV *	TBD
Commercial Cable	Y	Y	N

*Achieved using triple junction shielding electrode



We received a two-year DOE FOA grant for developing a robust 500 kV inverted insulator

DOE COVER PAGE

High Voltage Insulators and Electrodes for 500 kV DC High Voltage Photogun with Inverted Insulator Design

Carlos Hernandez-Garcia (PI) and Matt Poelker (co-PI)
Thomas Jefferson National Accelerator Facility

PROJECT NARRATIVE

Background/Introduction

Soon after the first demonstration of spin polarized electron beams from GaAs, DC high voltage photoguns were built to conduct nuclear physics experiments at SLAC, MIT-Bates, the

Project Title:

High Voltage Insulators and Electrodes for 500 kV DC High Voltage Photogun with Inverted Insulator Design

Applicant/Institution:

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DOE National Laboratory Announcement Number: **LAB 20-2310**

DOE/SC Program Office: Nuclear Physics

DOE/SC Program Office Technical Contact: Manoucheher Farkhondeh

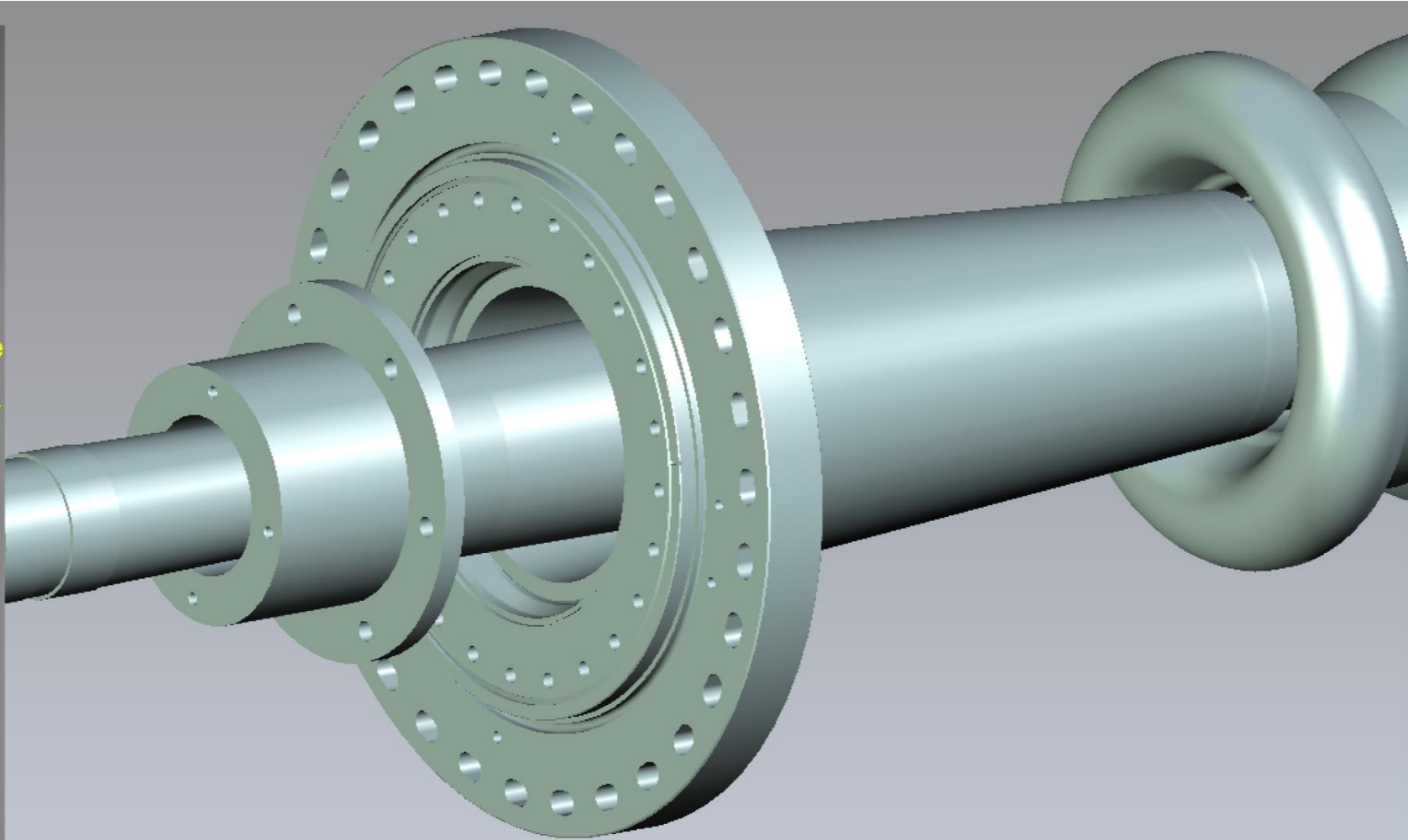
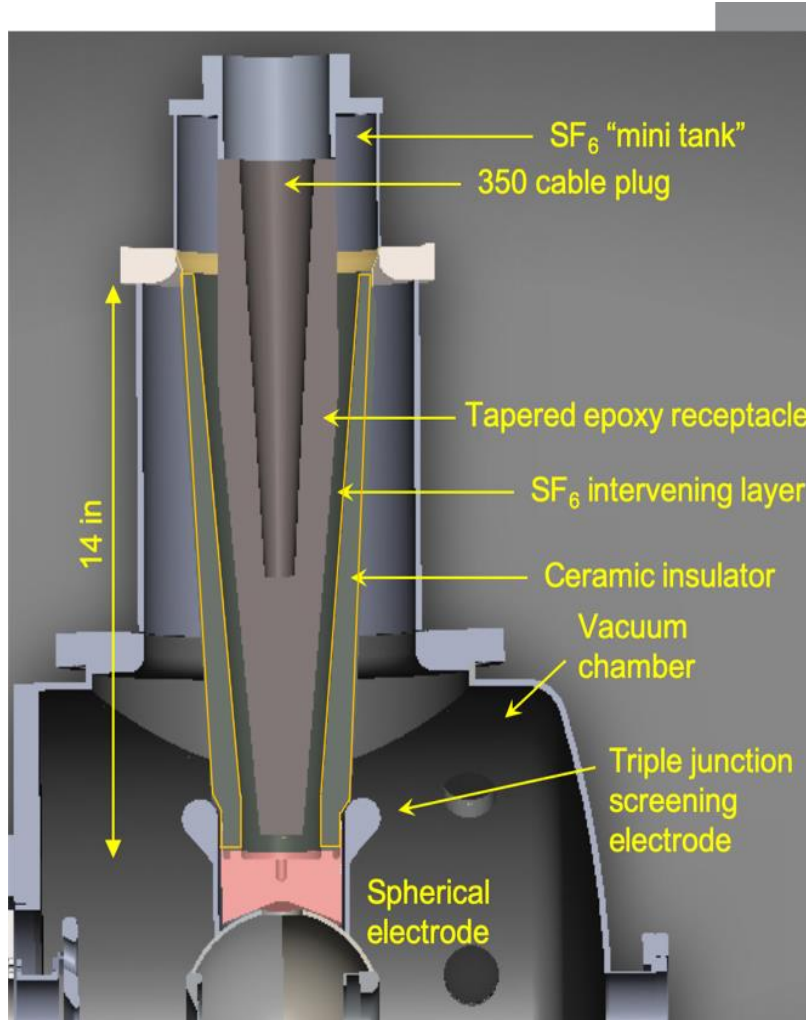
PAMS Letter of Intent Tracking Number: N/A

Research area (site) identified in Section I of this Announcement:

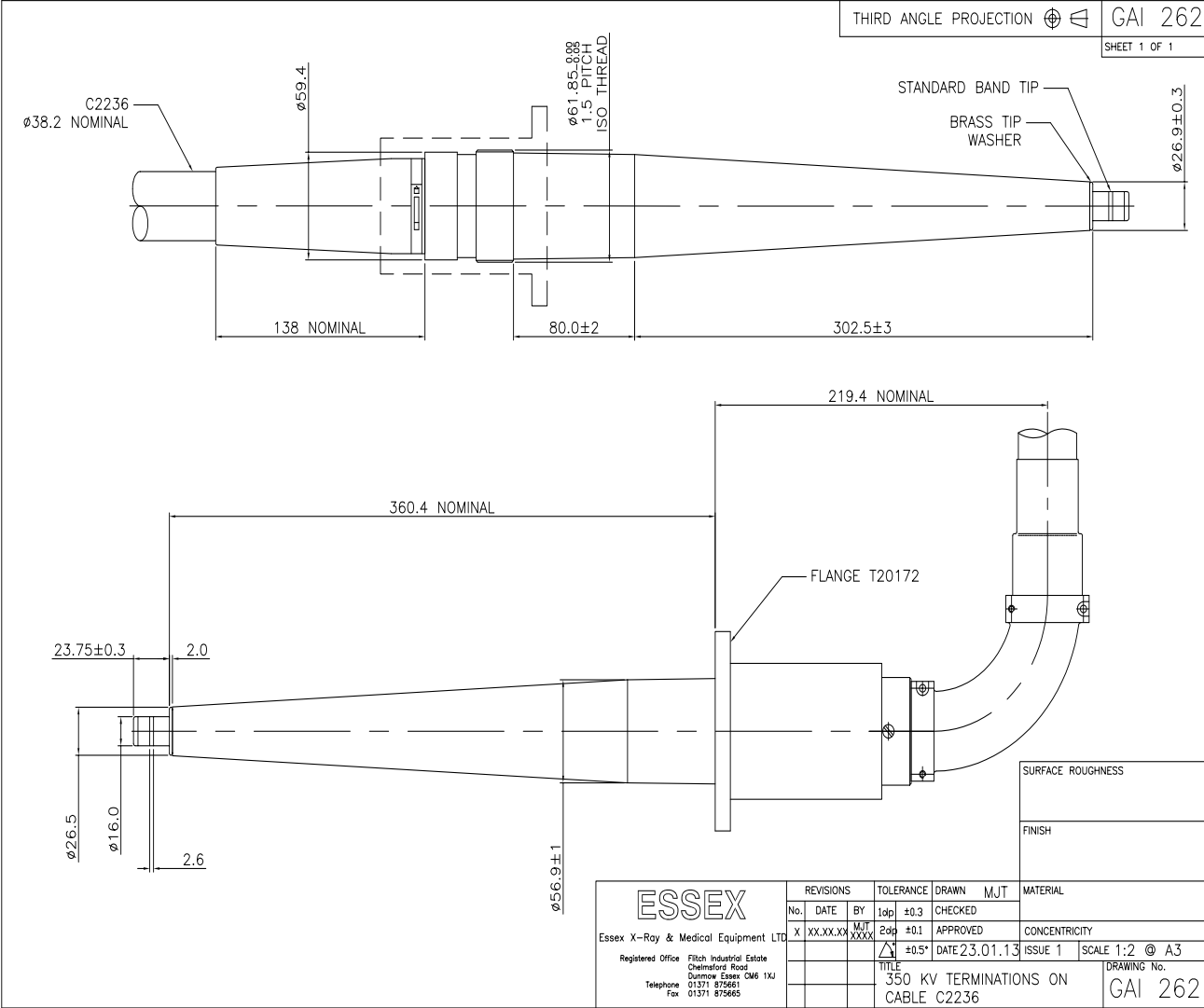
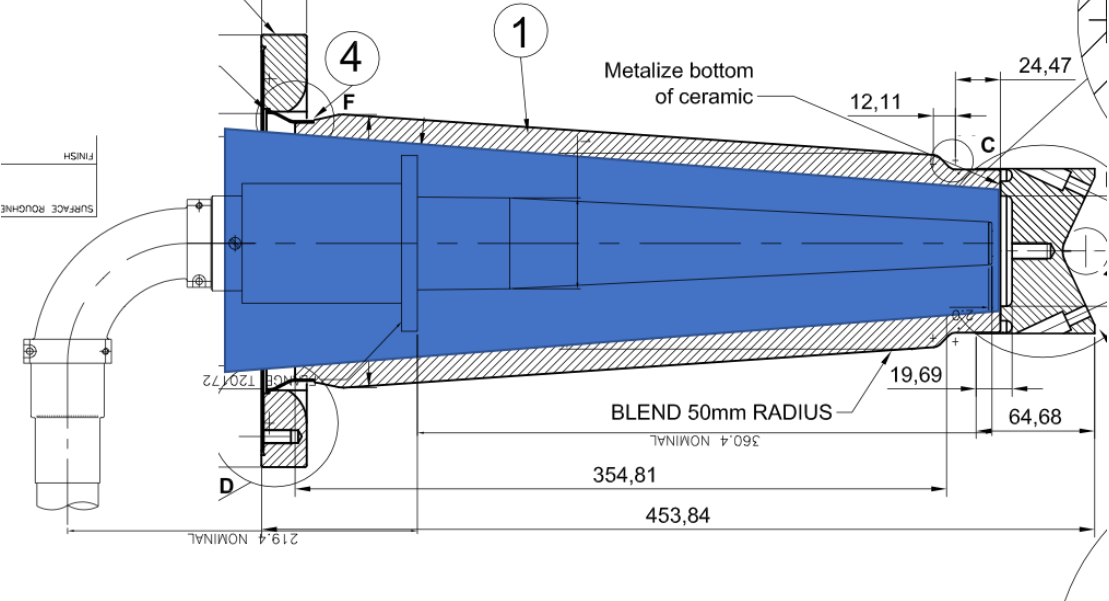
Transformative accelerator R&D in next generation ion and electron sources.

The first concept to be designed & tested:

- Tapered EPOXY receptacle compatible with 350 kV cable plug
- Intervining SF₆ layer between receptacle and insulator



The second concepts is based on collaborating with Dielectric Sciences to make custom 350 kV cable plug to mate with FEL-style inverted insulator

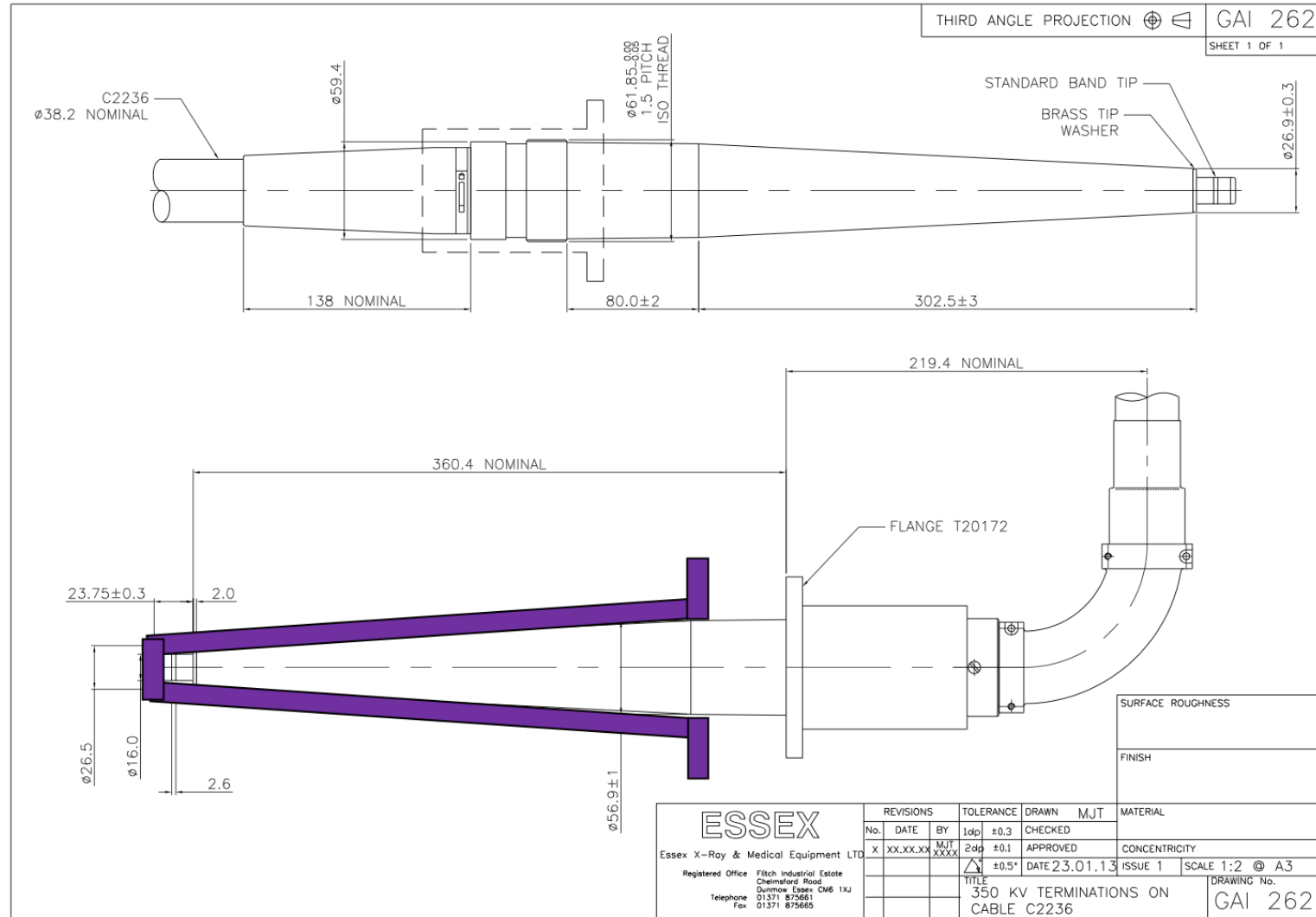


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ESSEX Essex X-Ray & Medical Equipment LTD Registered Office: Fitch Industrial Estate, Chelmsford Road, Gurrrow, Essex CM6 1XJ Telephone: 01371 875661, Fax: 01371 875665					CONCENTRICITY SCALE 1:2 @ A3 DRAWING No. GAI 262
TITLE: 350 KV TERMINATIONS ON CABLE C2236					ISSUE 1

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The ultimate goal is to design a custom insulator that fits commercial 350 kV cable

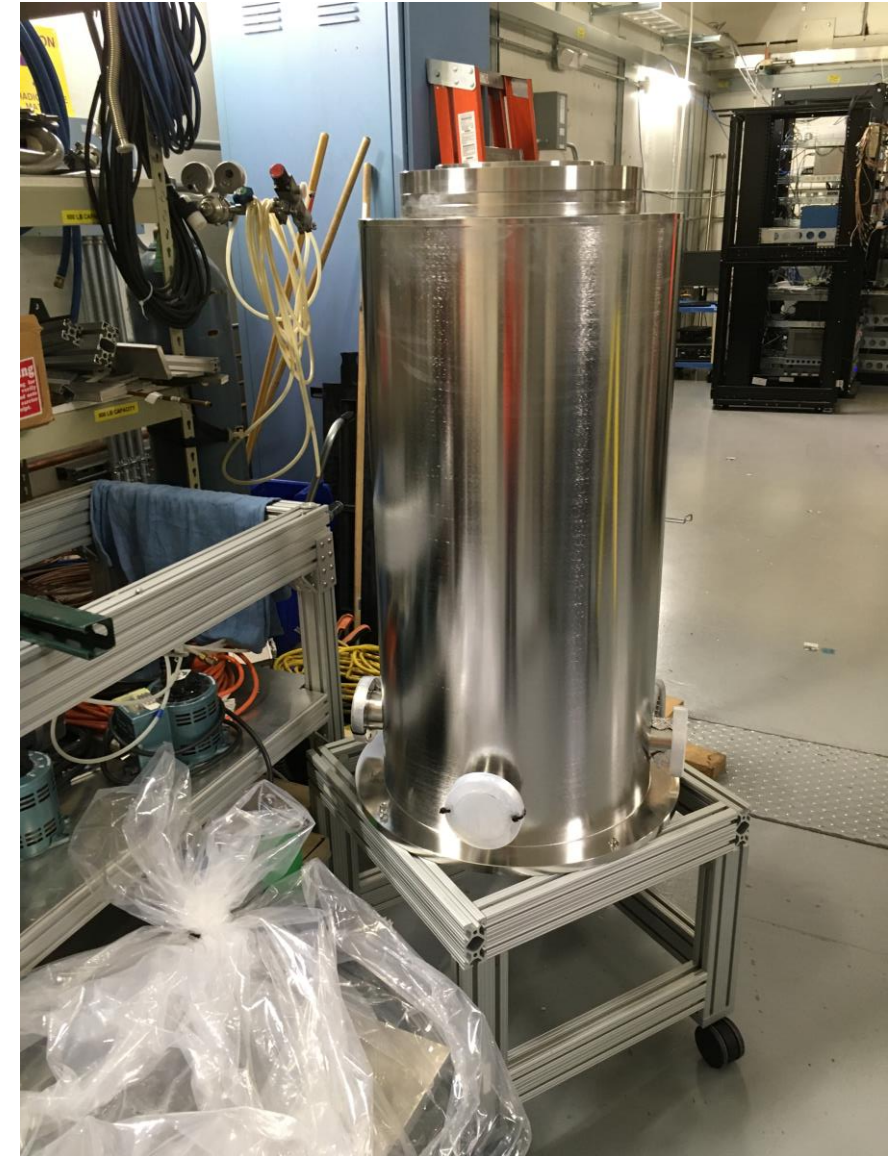


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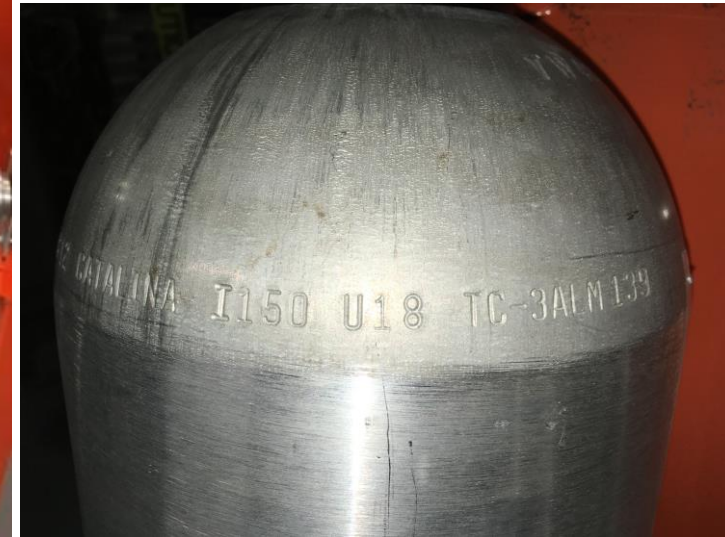
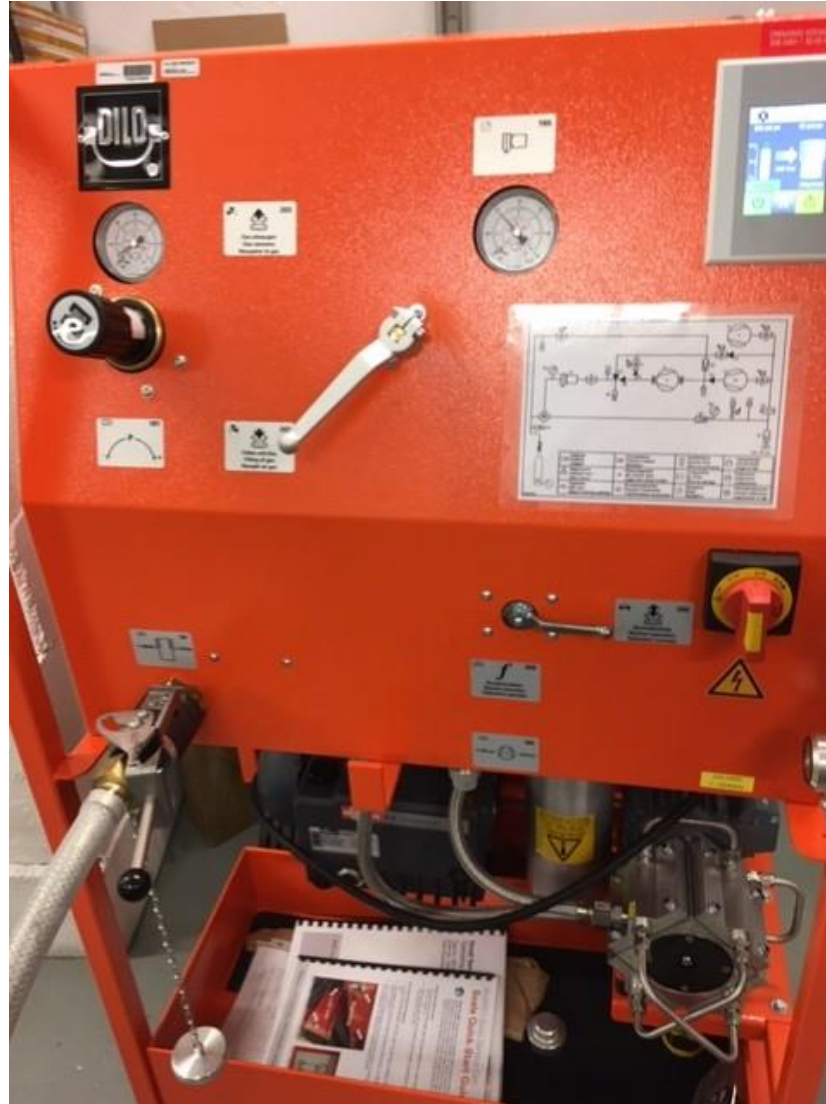
The insulator/electrode assembly will be tested in a custom-made vacuum chamber filled to 10 psig of SF₆

- The reason to test in SF₆ is to avoid dealing with field emission and thus concentrate on the electrical assembly robustness to 500 kV.
- The chamber can be evacuated and SF₆ backfilled using a commercial filling/recovery system.
- The insulator/electrode test assembly will be mounted using the top 13.25" CF flange.



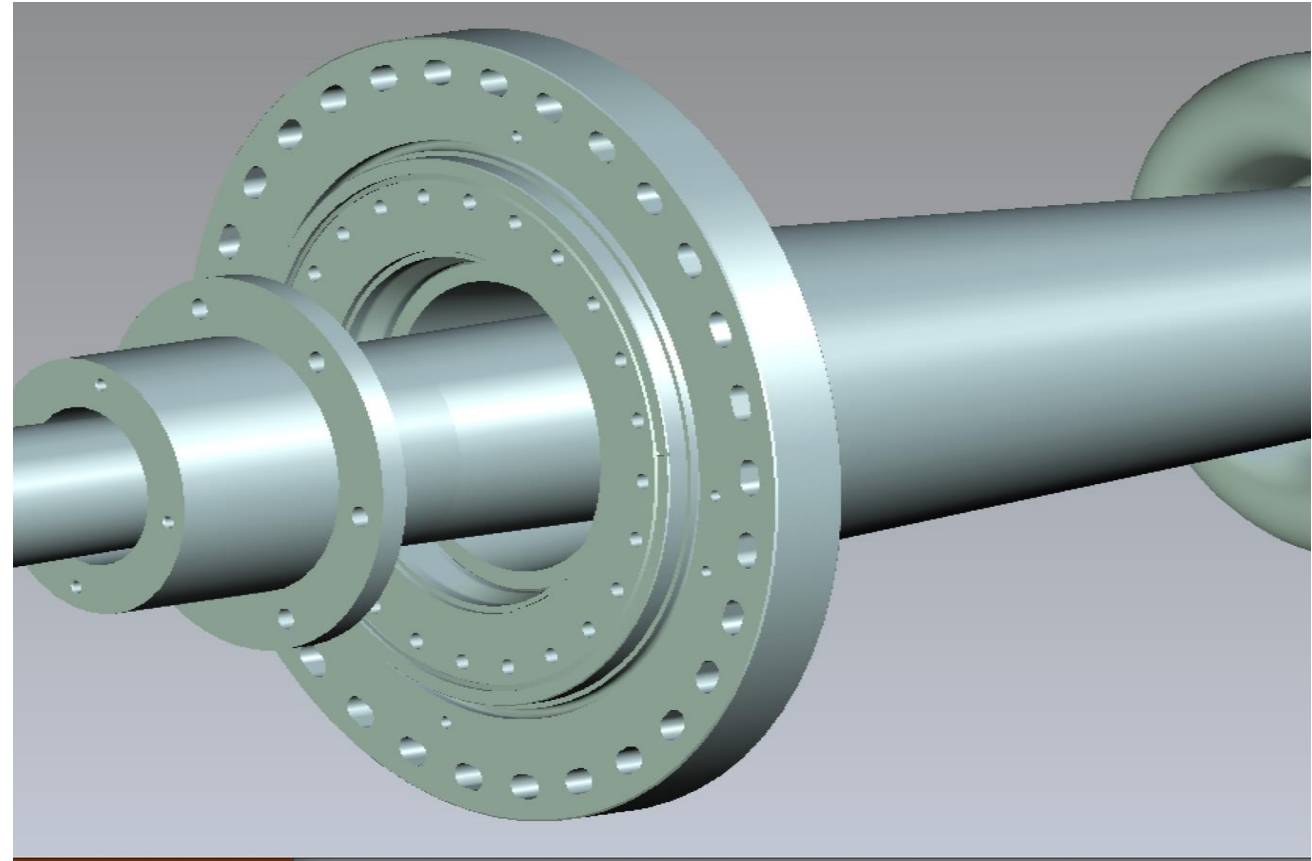
This is the commercial SF6 recovery system from DILO.

- The cart has a vacuum pump to first evacuate the test chamber
- SF6 is stored in aluminum bottles
- SF6 is transferred to the test chamber by means of a compressor, moving gas from the bottles, through a regulator and onto the chamber
- SF6 is transferred back to storage bottles when test is done by means of the compressors.



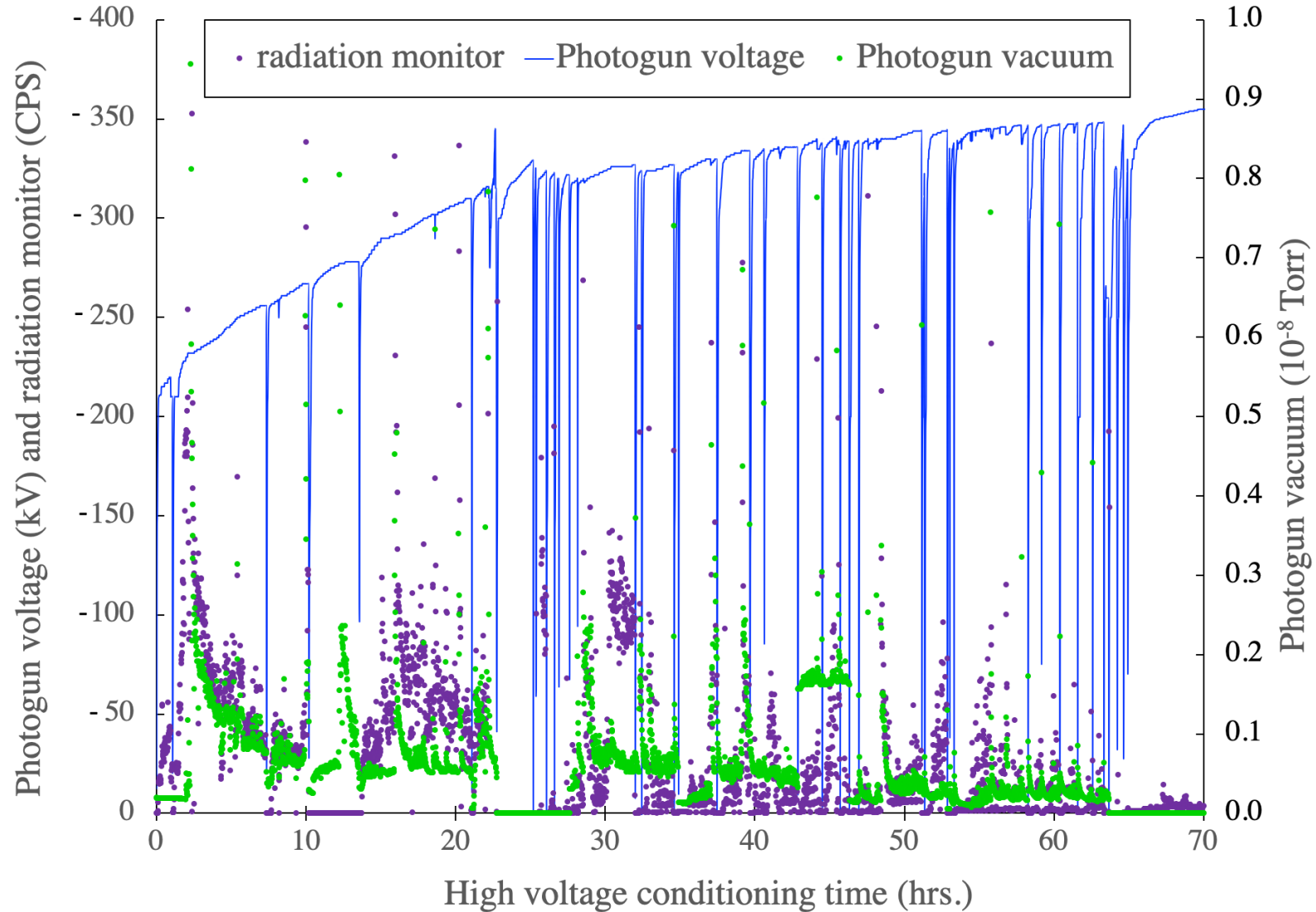
Thank you! Questions?

- FOA project relies on hiring postdoctoral appointee
- Objective: Design & test 500kV insulator/cable system
- Deliverables:
 - **Robust system** approach for **350kV** gun w/o field emission or breakdown
 - **Prototype insulator** design that fits commercial cable for potential SBIR with US insulator manufacturer



Backup!

The plan is to perform HV test in SF6 rather than in Vacuum to avoid dealing with field emission.



*M. BastaniNejad, A. A. Elmustafa, E. Forman, J. Clark, S. Covert, J. Grames, J. Hansknecht, C. Hernandez-Garcia, M. Poelker and R. Suleiman, Nucl. Instr. and Meth. in Phys. Res. A, Vol. **762**, pp. 135–141, 2014

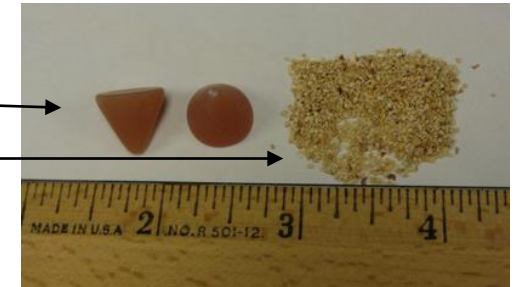
Polish electrodes

- Diamond paste polishing is a labor intensive process that takes about 3 weeks
- Implementing centrifugal barrel polishing has reduced polishing time from weeks to hours
- Profilometry measurements shows surface rms roughness is comparable between the two polishing methods

From machine shop



After barrel polishing
60 min. plastic cones
60 min. crushed **corn** cob



Barrel polishing
machine at JLab SRF



* C. Hernandez-Garcia, D. Bullard, F. Hannon, Y. Wang and M. Poelker, Review of Scientific Instruments **88**, 093303 (2017)