A 500 KV INVERTED GEOMETRY FEEDTHROUGH FOR A HIGH VOLTAGE DC ELECTRON GUN*

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Abstract

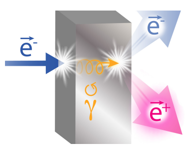
This contribution reports on the development of an unprecedented inverted-insulator with cable connector for reliably applying 500 kV dc to a future polarized beam photogun, to be designed for operating at 350kV without field emission. Such a photogun design could then be used for generating a polarized electron beam to drive a spin-polarized positron source as a demonstrator for high energy nuclear physics at JLab. There are no commercial cable connectors that fit the large inverted insulators required for that voltage range. Our proposed concept is based on a modified epoxy receptacle with intervening SF_6 layer and a test electrode in a vacuum vessel.

If photoguns with inverted insulators already deliver beam at 200 and 300 keV, why develop a 500 kV insulator?

Photo-gun	Operational voltage (kV)	Max. applied voltage (kV)	Field emission onset voltage (kV)	Photocathode type	Inverted insulator type and length (cm)	Photogun CW beam current (mA)	Charge lifetime (C)
CEBAF[1]	130	200	190	Strained super lattice GaAs	R28, 12	0.2	200-400
UITF	180	250	190	Bulk GaAs	R28, 12	0.1	~ 200
GTS[2]	300	350	300	CsK2Sb	R20, 19	4.5	~ 6000
R&D	350	TBD ~500		Expected to be Strained super lattice GaAs	Custom, 36	10	> 200

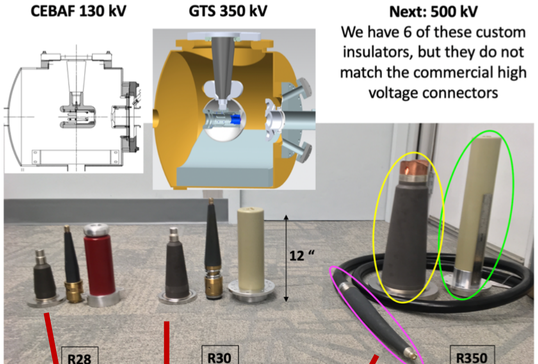
Positrons !!!

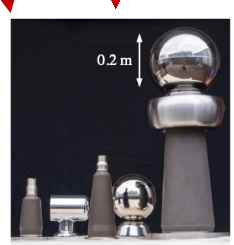
Positrons are in demand and at Jefferson Lab, we would like to make polarized positron beams using the PEPPo technique[3], where the polarization of an electron drive beam is transferred to a positron beam via pair production within a conversion target. A 10 mA CW, 0.3 nC bunch charge, polarized electron beam drive for polarized positron beams motivates the need for an inverted insulator photogun operating reliably – without field emission – at 350 kV to manage space charge and photocathode lifetime.



In the "inverted-geometry" insulator design, the insulator serves as the electrode support structure resulting in the following advantages:

- less metal biased at high voltage contributing to field emission
- smaller vacuum chamber resulting in better achievable vacuum, and
- no exposed high voltage components; and thus, a sulfur hexafluoride (SF_6) tank is not required to suppress corona discharge.





Inverted geometry insulators and electrodes utilized in JLab photoguns. From left to right: 200 kV R28, 300 kV R30, and the 500 kV assembly currently under testing.

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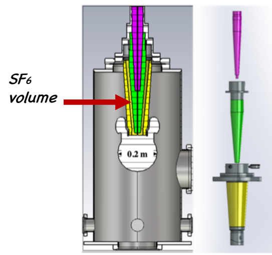
The 500 kV feedthrough concept[4] is based on a commercial epoxy receptacle that connects to a 350 kV commercial cable plug. The receptacle was machined to match the insulator taper. When inserted, the receptacle leaves ~ 1 cm gap to the wall of the insulator for an intervening SF_6 layer

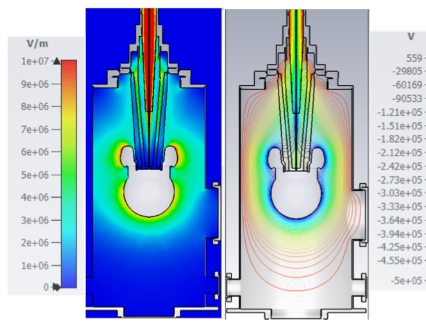


Left: Cross section of the model used for electrostatic simulations in CST EM Studio. Right:, SolidWorks exploded view of the cable plug (purple), tapered receptacle (green) and insulator (yellow) assembly (Right).

Picture of the tapered epoxy receptacle (left) next to the 500 kV doped alumina insulator with triple point junction shield and spherical test electrode.

Due to its share weight (~60 lbs), the insulator-electrode assembly was installed into the test chamber using a crane..

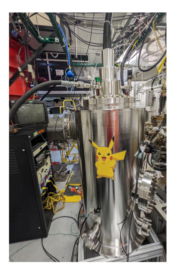
The electrodes were mechanically polished to mirror finishing in a tumbler barrel polisher[5].



CST EM electrostatic simulation of the testing apparatus at 500 kV. Left: Electric field map. Right: Equipotential lines.

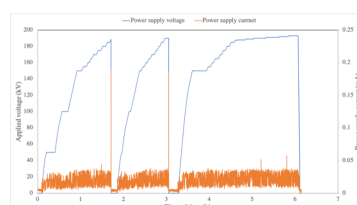
The testing apparatus consisting of the high voltage cable, modified receptacle, triple point junction shield, test electrode and vacuum chamber was modeled in SolidWorks, then imported to CST-EM Studio for electrostatic simulations and optimization aiming for 10 MV/m maximum at 500 kV.

Postdoctoral fellow Gabriel Palacios-Serrano installing the modified epoxy receptacle to the SF_6 reservoir assembly on top of the testing chamber. Inset: Close-up view of the spring attached to the end of the epoxy receptacle.



The testing apparatus has been connected to a 500 kV Cockcroft, SF6 gas insulated high voltage power supply using a commercial high voltage cable connected to the modified epoxy receptacle.

Initial HV testing: superficial insulator arcing at 190 kV was easily removed with sand paper, but power supply tripped off on over current at 20 kV.



It is likely that higher SF6 pressure is needed to achieve 500 kV. We are in the process of evaluating the system for higher pressure.

References

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Conclusions

- An inverted insulator connected to a commercial high voltage cable is being developed for a future photogun to operate at 350 kV without field emission.
- The concept is based on an SF_6 filled volume between the insulator and a modified commercial cable receptacle
- Initial HV tests show superficial insulator arcing at 190 kV. This is unexpectedly low voltage.
- It is likely that higher than 10 PSIG of SF_6 pressure is needed in the SF6 volume to achieve 500 kV.
- We are in the process of evaluating the system for higher SF_6 pressure in the insulator-receptacle volume.

* *Work supported by U.S. Department of Energy, Office of Science, Office of Nuclear Physics under contract DE-AC05-06OR23177, and by the Office of Science Funding Opportunity LAB 20-2310 with award PAMS-254442*