Design of a 200 kV DC Cryocooled Photoemission Gun for Photocathode Investigations

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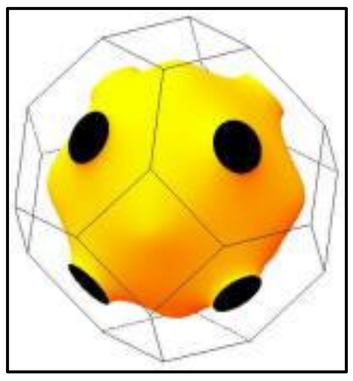
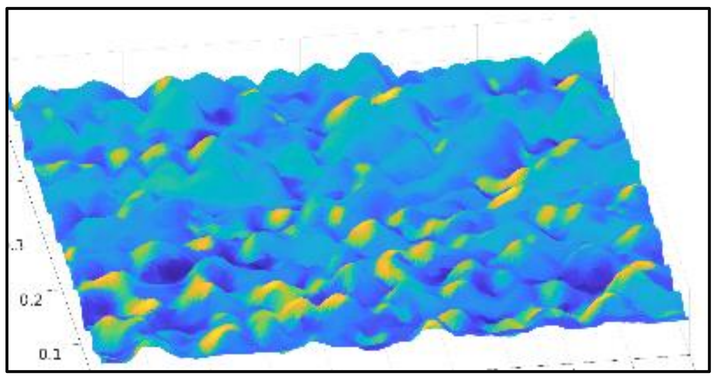
Introduction

- **Intrinsic emittance** of photocathodes limits the electron **beam brightness produced** from photoemission guns.
- Compared to their polycrystalline counterparts, **single crystalline ordered surface** materials can produce an **order of magnitude improvement** in intrinsic emittance at cryogenic temperatures.



Cu(100): 4 meV



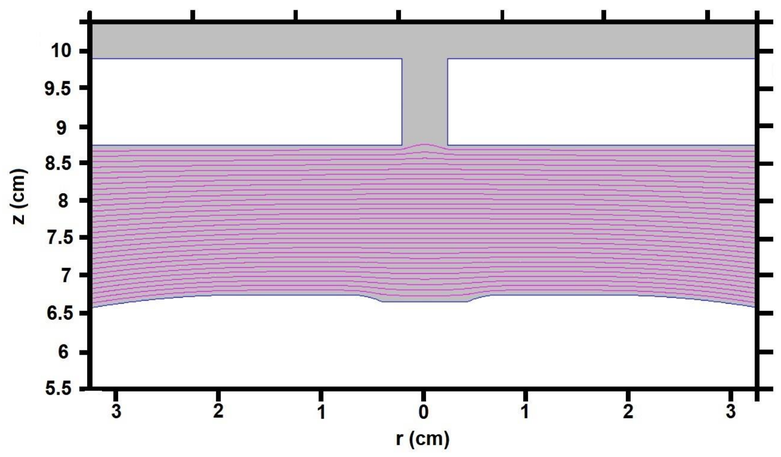
Alkali-Sb: 20+ meV

- Existing electron guns aren't designed for single crystal photocathodes.
- In this work we report on the design of a 200 kV DC cryocooled electron gun, based off the Cornell DC cryogun, which
  a) can use the omicron paddle-shaped photocathode holder enabling easy cathode characterization in standard surface science instruments,
  b) allows for a large flexibility in terms of the cathode shape and size,
  c) easily allows for the study of numerous commercially available, epitaxially grown single crystal materials.

Electrostatics Calculations

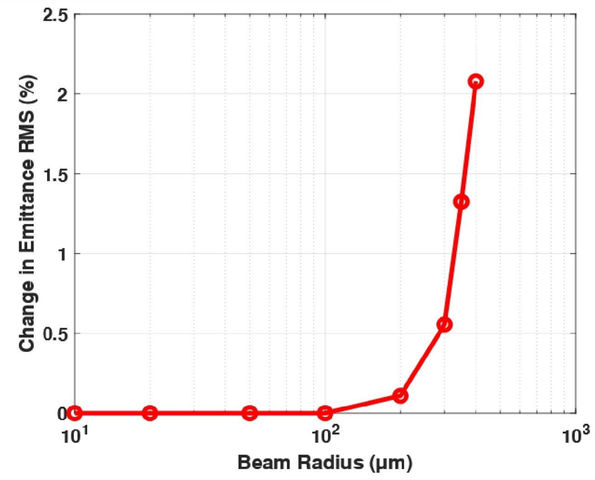
Poisson calculation of the electric fields at the spherical electrode:

- Cathode surface fields are **~76% of the max field magnitude E_{max}.**
- Field ratio is comparable to the Cornell's DC Cryogun

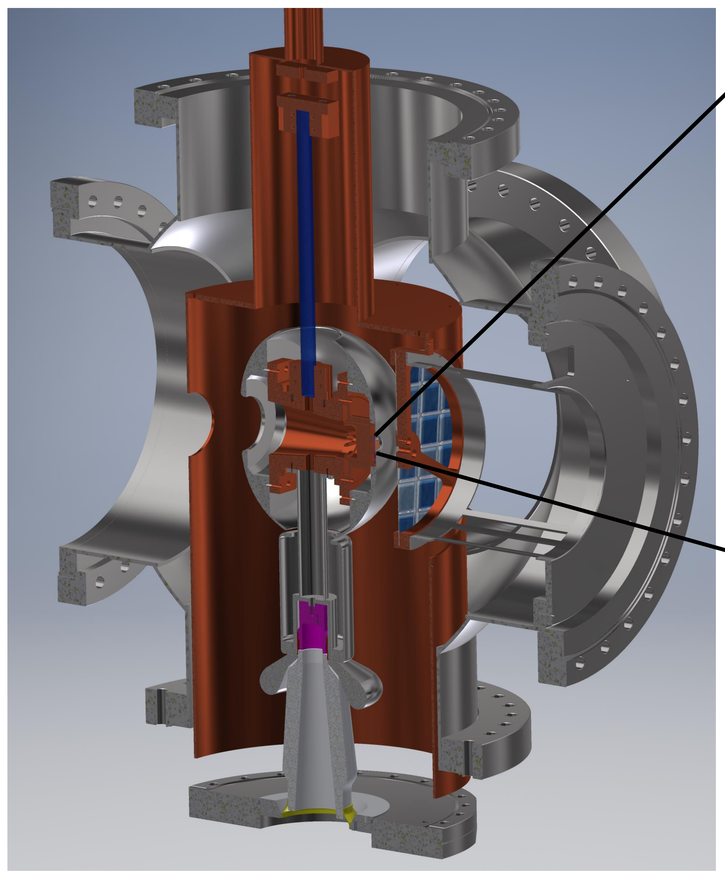


With V = -200 kV applied to the electrode, we find that E_{max} = 11.05 MV/m on the shell.

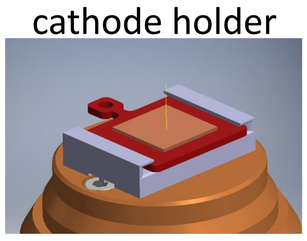
Change in emittance of the beam as it passes the anode as a function of increasing beam size. Non-linear effects, due to pierce electrode focusing fields, become prominent at beam sizes above 200 μm. The non-linear effects are negligible for $\boldsymbol{\sigma_{rms} \leq 100\ \mu m}$.



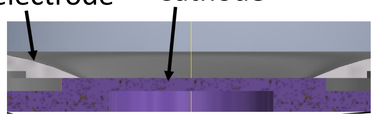
Mechanical Design



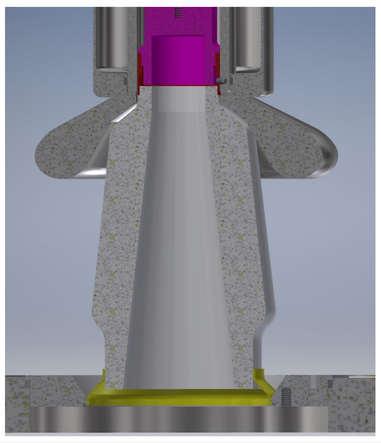
Omicron paddle cathode holder



Pierce electrode — Cathode



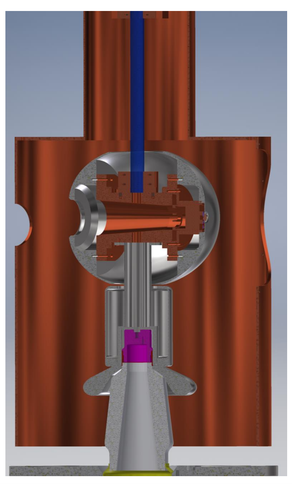
- Pierce electrode with **pierce angle 31.1°**
- Outer chamber sized with 13 inch flanges
- Cryoshield diameters 9.5 inch and 5.5 inch



Stainless Steel collar shielding the thin ceramic.

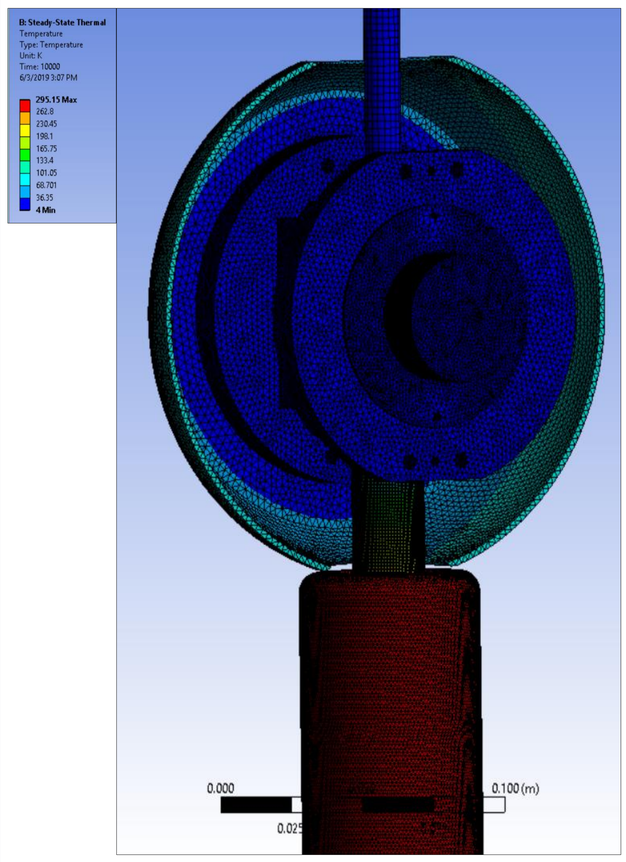
- Cryoshield added to reduce radiation heating
- Cathode can reach 20 K cryogenic temperatures.

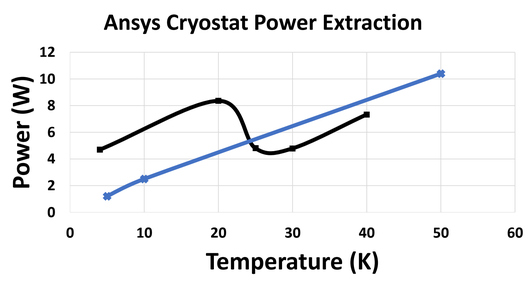
- Stainless steel collar added to the Triple Point Junction (TPJ)
- Protects thin ceramic from stray emission



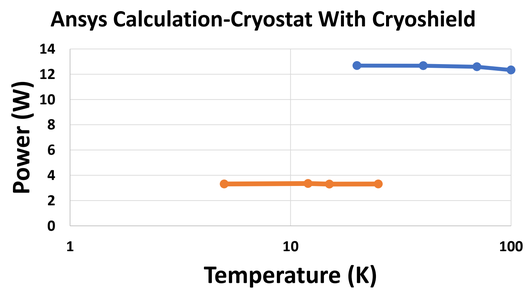
Cryoshield surrounding the electrode.

Thermal Calculations





No shield, cryostat power extraction comparison. Cathode temperature reaches 40 K.



Shield added, Ansys calculation of cryostat cooling required. Cathode temperature reaches 15 K.

Acknowledgements

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References

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