Center for BRIGHT BEAMS
A National Science Foundation Science & Technology Center

Arizona State University

Commissioning of the ASU Cryocooled 200 kV DC Electron Gun

Gevork S. Gevorkyan, C. A. S. Cardenas, A. H. Kachwala,
C. Knill, T. J. Hanks, S. Karkare,

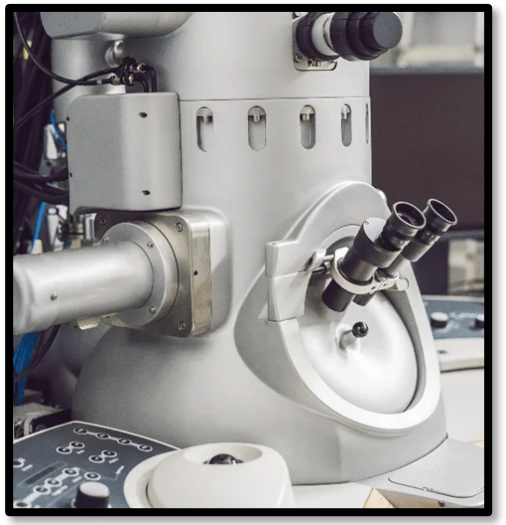
August 2022

Ggevorky@asu.edu

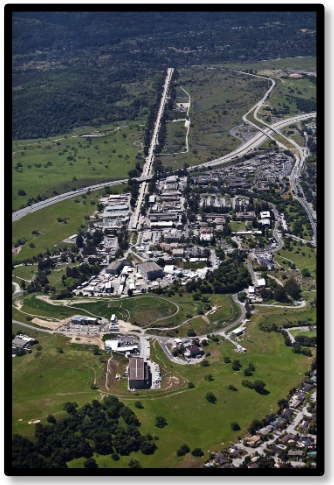
Electron Guns and Science

Research conducted with electron guns

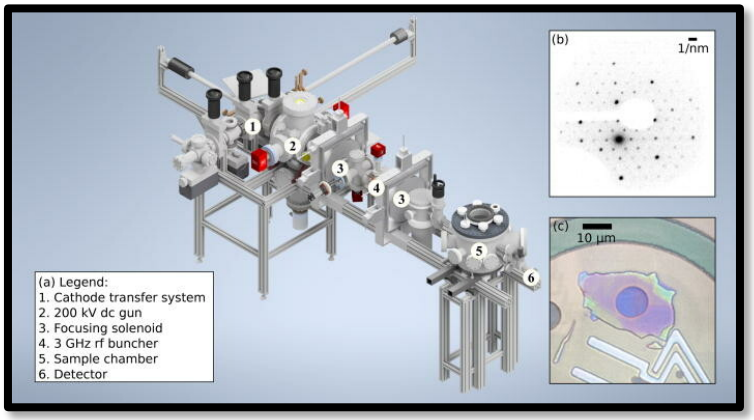
Many more…



UEM



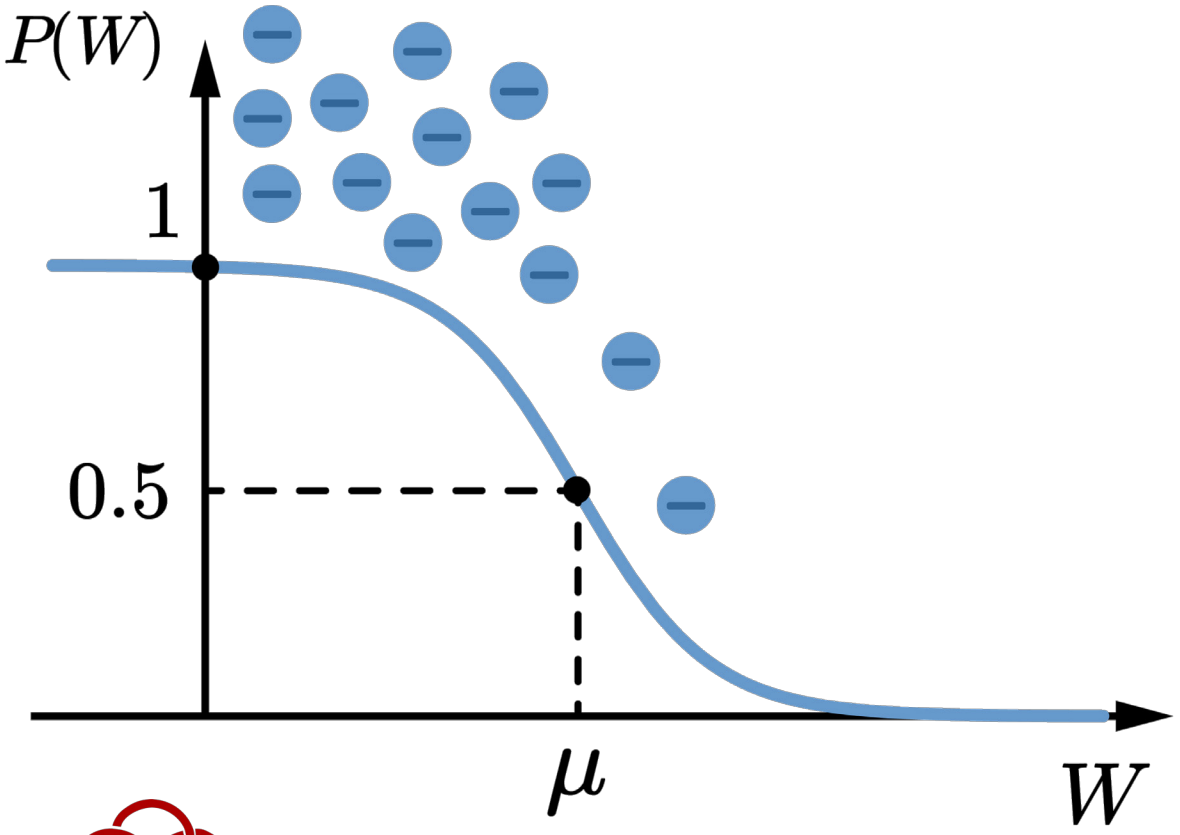
XFEL



UED

P. Musumeci, et al, Nucl. Instrum. Meth. A, 907, 209 (2018)
W. H. Li, et al, Structural Dynamics 9.2 024302 (2022)

Photocathode and Emittance



$$\boldsymbol{B_{4D}} \propto \frac{E_0^n}{\mathbf{MTE}}$$

$$\varepsilon_n = \sigma_x \sqrt{\frac{\mathbf{MTE}}{m_e c^2}}$$

D. H. Dowell, J. F. schmerge, Phys. Rev. STAB, 12, 074201 (2009)

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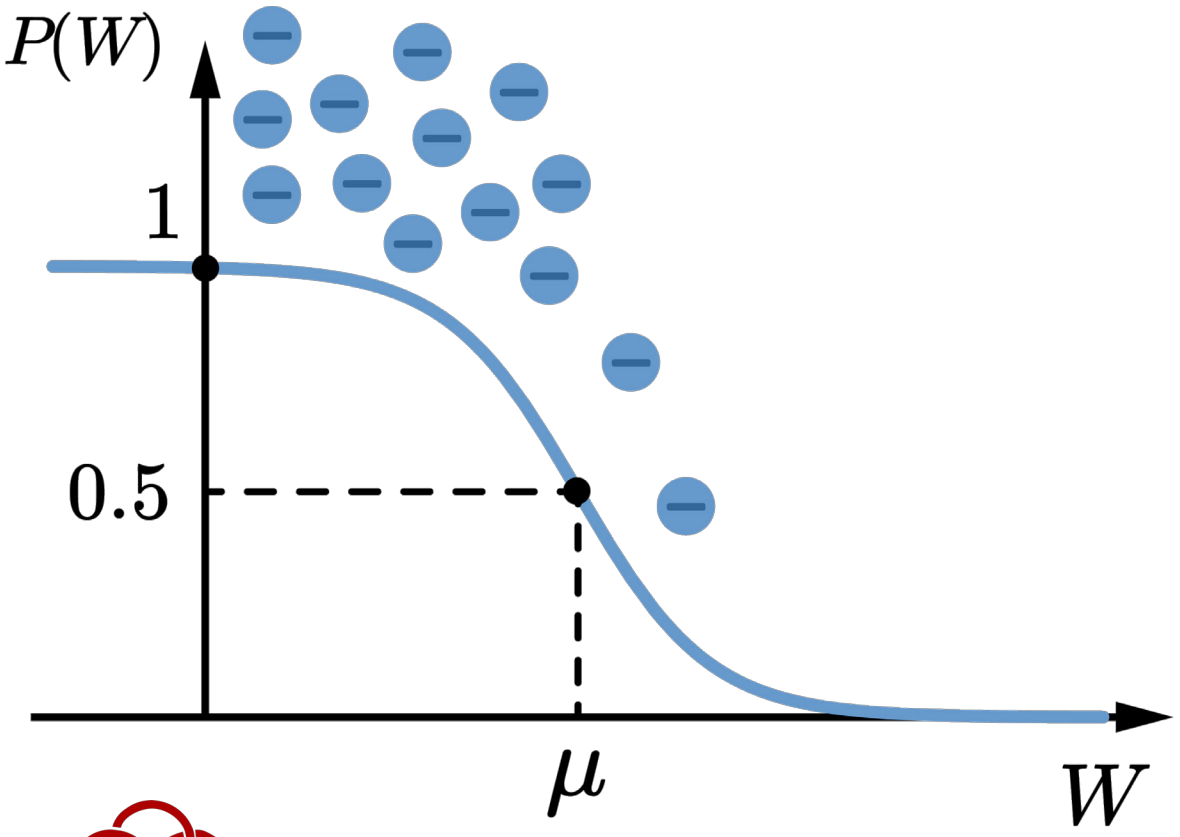
Photocathode and Emittance

$$E_{excess} = hf - W$$



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Photocathode and Emittance

$$E_{excess} = hf - W$$

$$\mathbf{MTE} \approx \frac{E_{excess}}{3}$$

(100s of meV)

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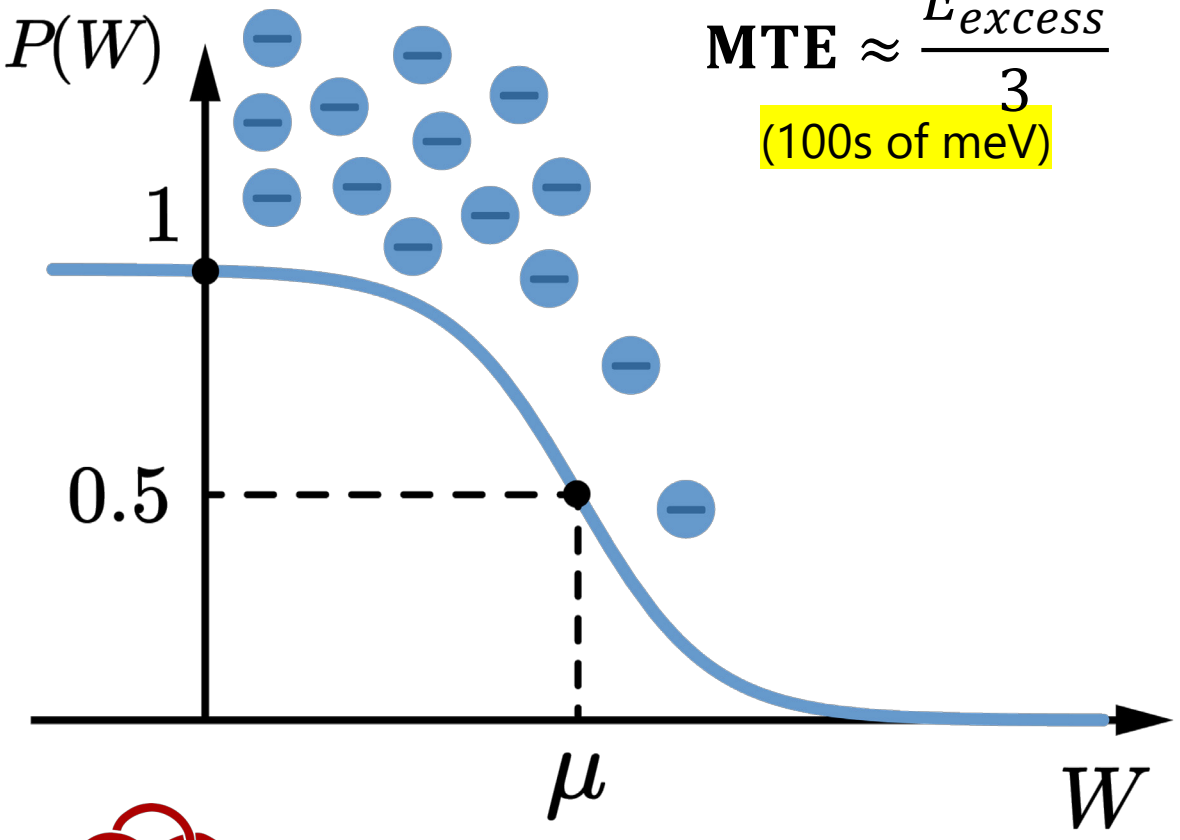

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Photocathode and Emittance

$$E_{excess} = hf - W$$

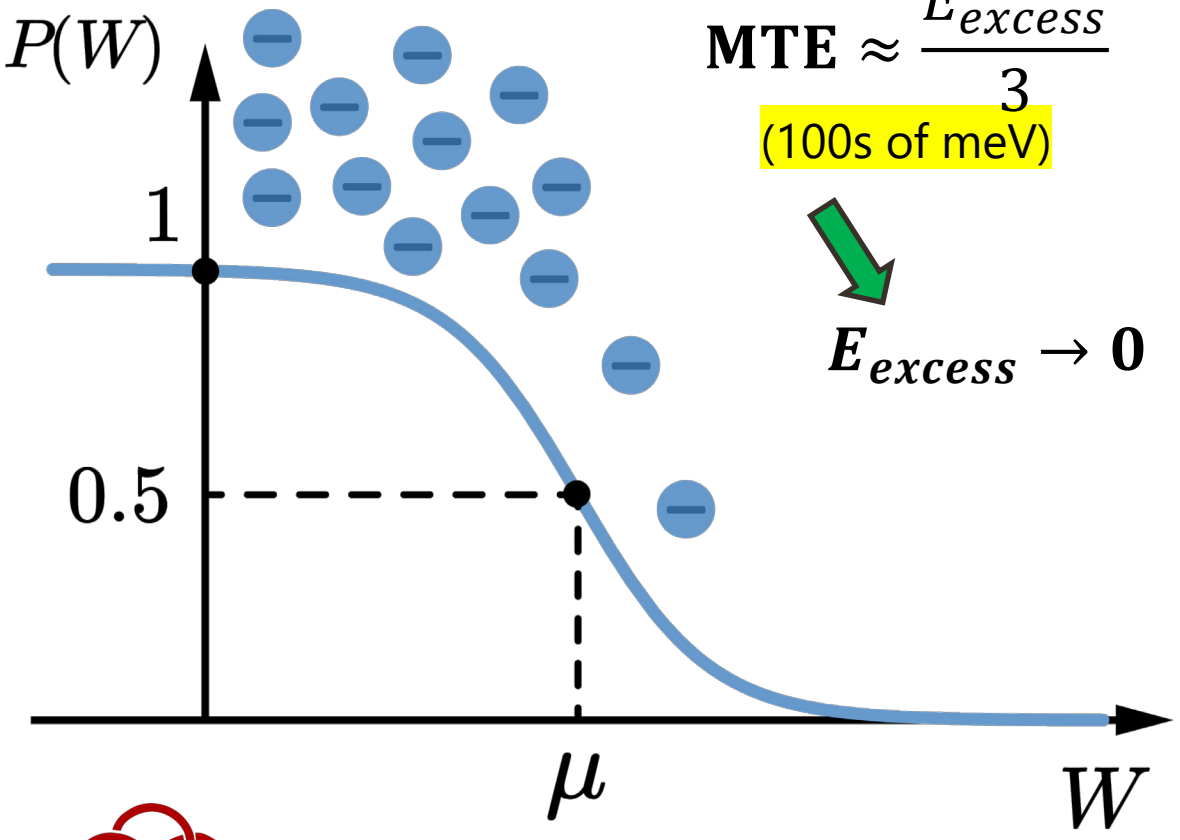
$$\mathbf{MTE} \approx \frac{E_{excess}}{3}$$

(100s of meV)

$$E_{excess} \to 0$$

$$B_{4D} \propto \frac{E_0^n}{\mathbf{MTE}}$$

$$\varepsilon_n = \sigma_x \sqrt{\frac{\mathbf{MTE}}{m_e c^2}}$$



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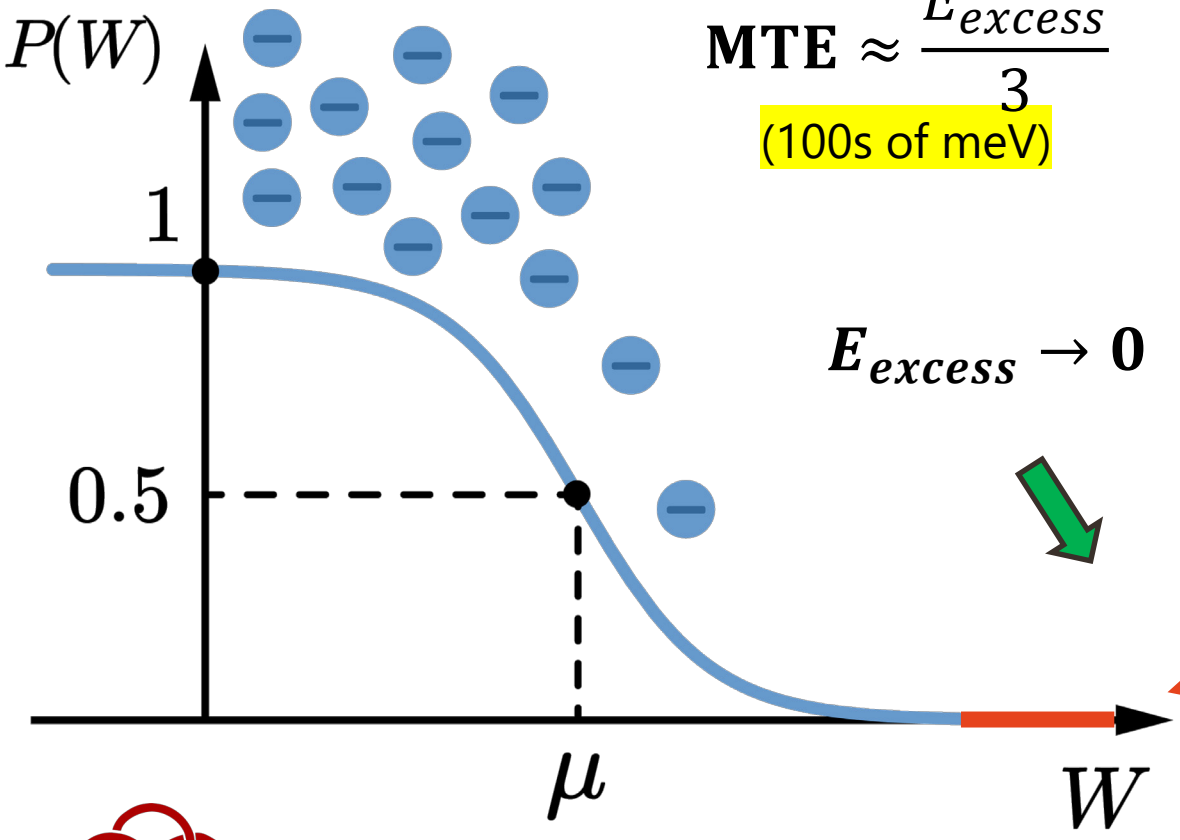

$$E_{excess} \to 0$$

$$\mathbf{MTE} \sim k_b T$$

(25.8 meV)

D. H. Dowell, J. F. schmerge, Phys. Rev. STAB, 12, 074201 (2009)

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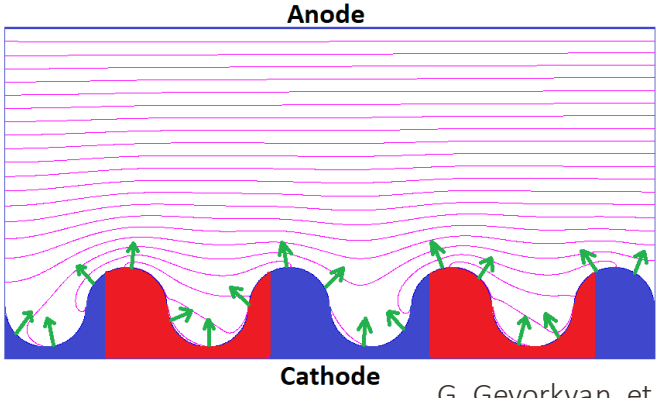
Photocathode and Emittance

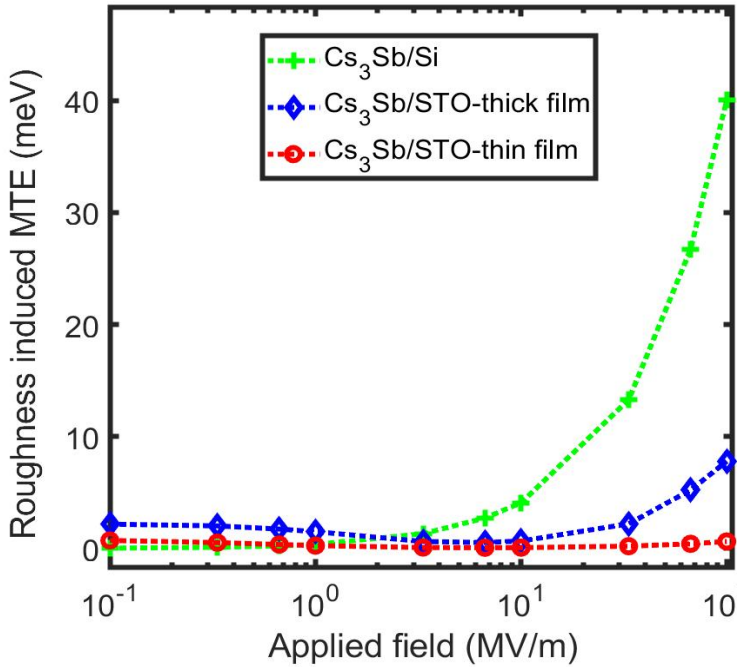
$$B_{4D} \propto \frac{E_0^n}{\mathbf{MTE}}$$

- Non-linear Photoemission
- Thermal Effects $\mathbf{MTE} \sim k_b T$
- Physical Roughness $\mathbf{MTE} \propto E_0$
- Chemical Roughness $\mathbf{MTE} \propto E_0^{-1}$
- …

Photocathode Cartoon



Rough vs Smooth Cs_3Sb



Need atomically ordered surface, cold photocathodes!

G. Gevorkyan, et al. Phys. Rev. STAB, 21, 093401 (2018)
P. Saha, et al., Appl. Phys. Lett. 120, 194102 (2022)

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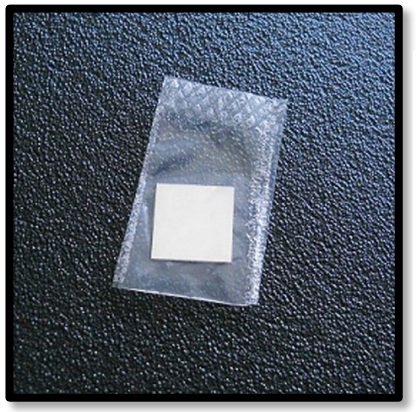
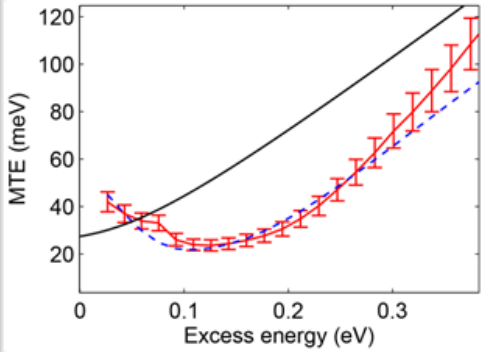
Photocathode and Emittance

Ag (111)



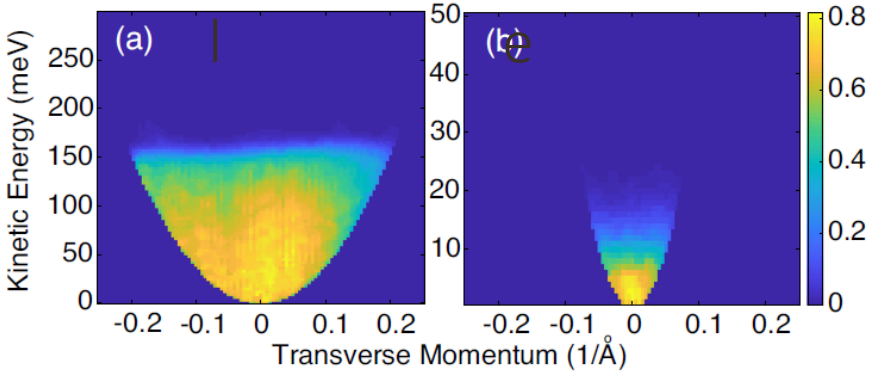
MTE 25 meV

QE: 10^{-4}



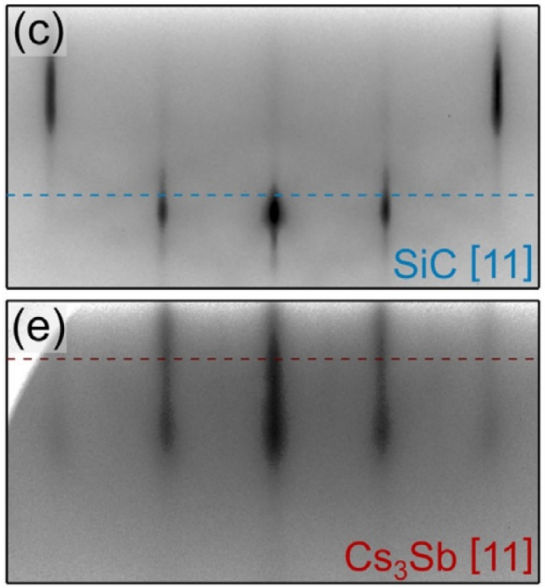
Cu (100)

Tota Transvers



MTE 5 meV | QE: 10^{-8}

RHEED Cs_3Sb (SiC)



MTE expected 25 meV at 300 K

QE: 10^{-3}

S. Karkare, et al, Phys. Rev. Lett., 118, 164802 (2017)
S. Karkare, et al, Phys. Rev. Lett., 125, 054801 (2020)
A. Galdi, et al, Phys. Rev. Lett. 128, 114801 (2022)

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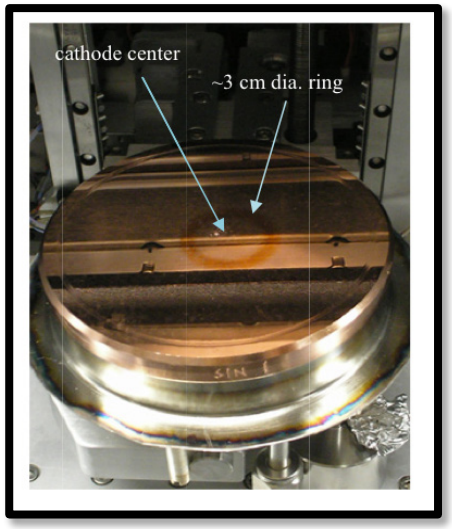
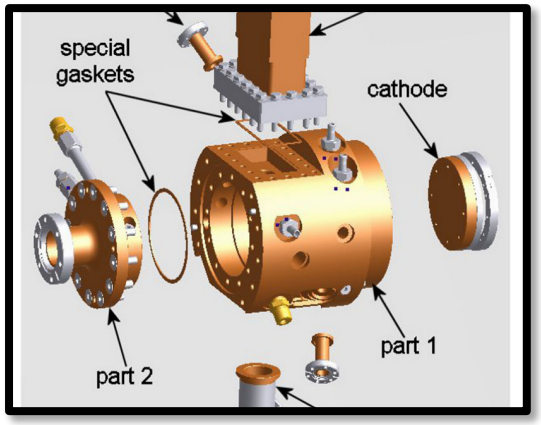
RF and DC Electron Guns

RF Guns





DC Guns

Emission from backplate (copper)

INFN Cathode

D. Alesini, et al, Phys. Rev. Lett. STAB, 18, 092001, (2015)

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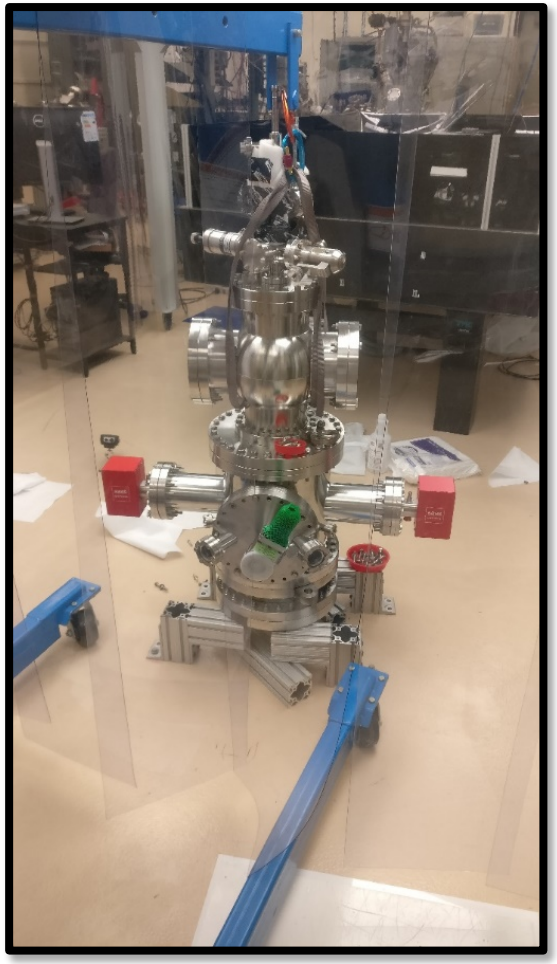
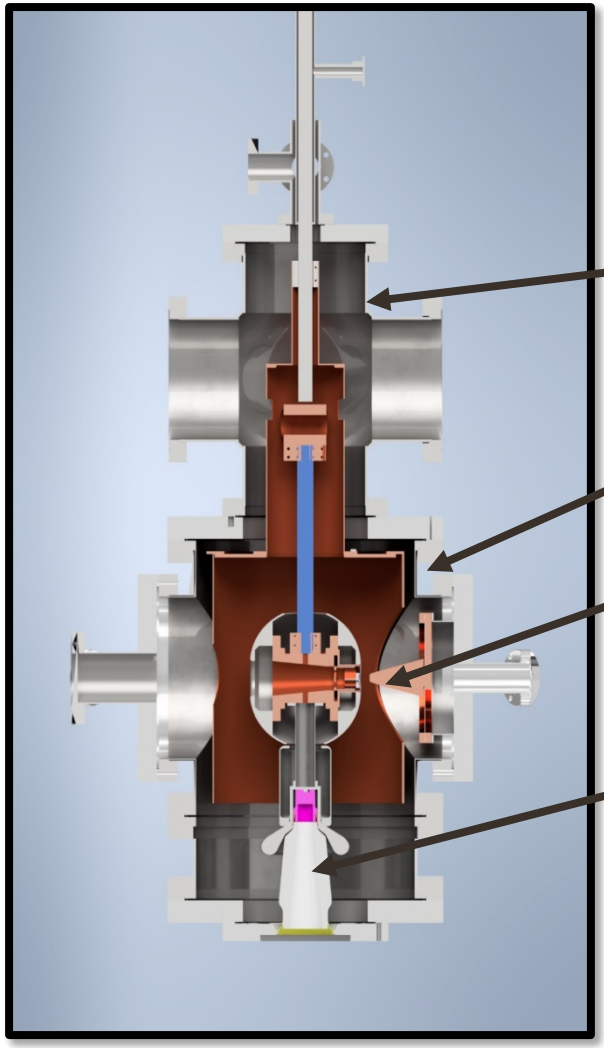
ASU Cryocooled DC Electron Gun





Based on Cornell's Cryogun Design

Cryostat

Cryoshield

Cathode - Anode

HV plug and ceramic

H. Lee, et al, Rev. Sci. Instrum., 89, 083303, (2018)
G. Gevorkyan, et al, Proc. NAPAC'19 OPLM16 (2019).

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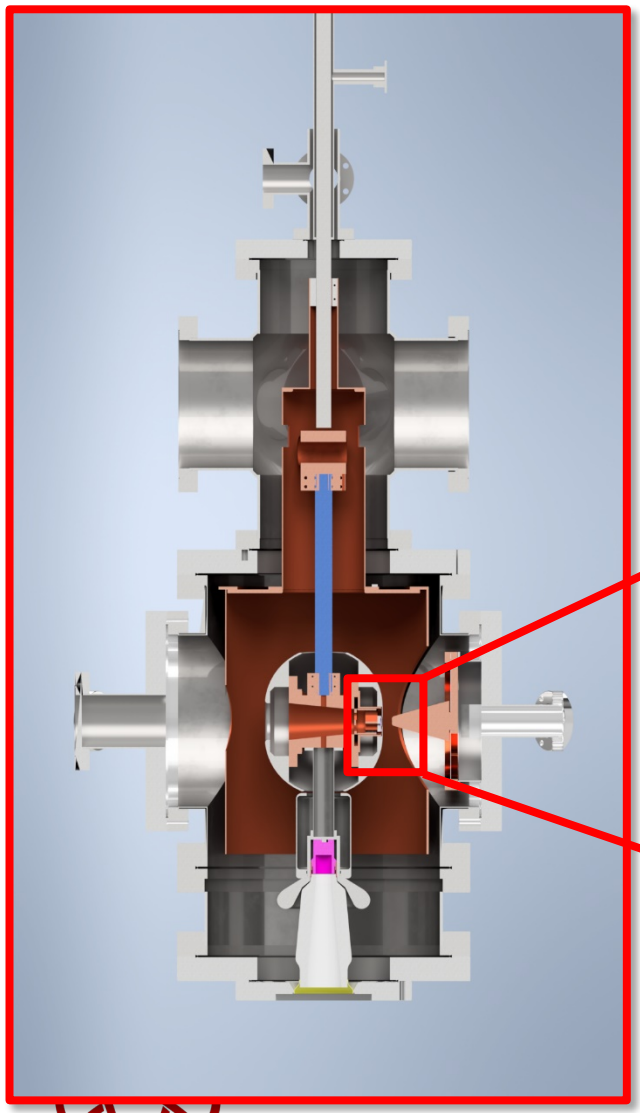
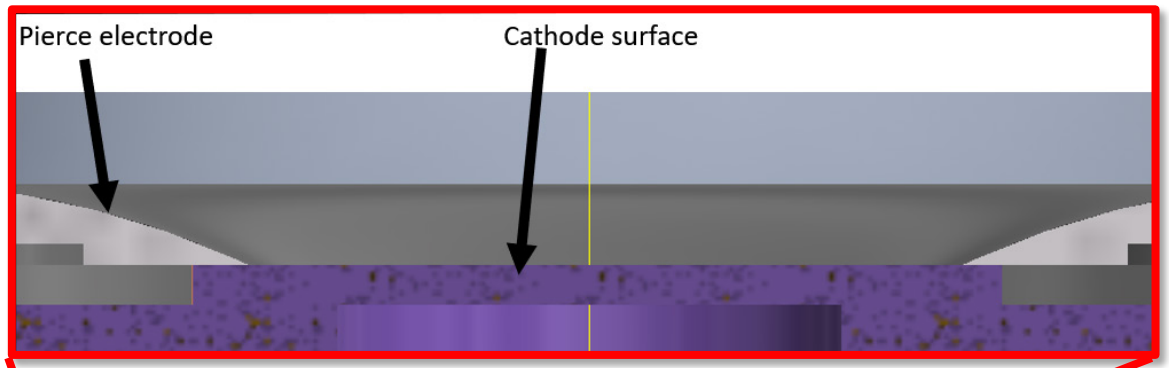
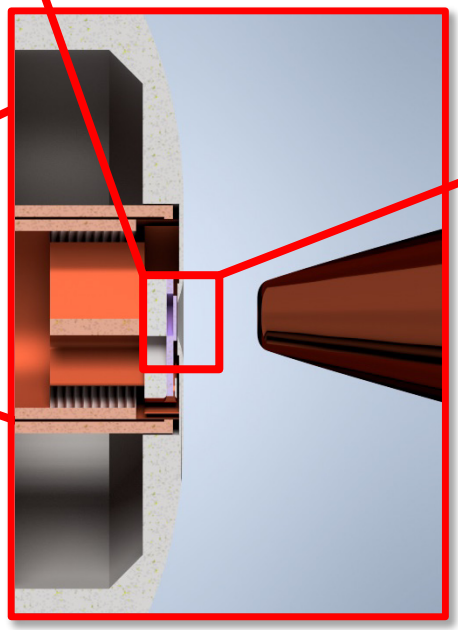
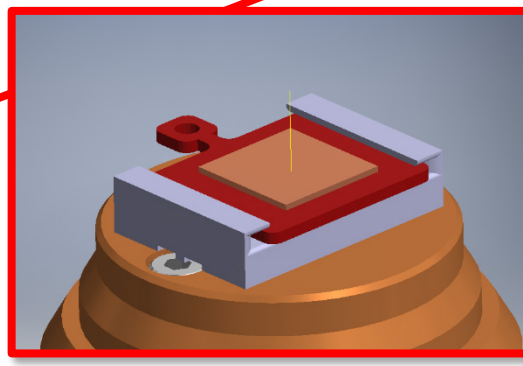
ASU Cryogun - Cathode









Omicron Paddle

8 MV/m at 200 kV

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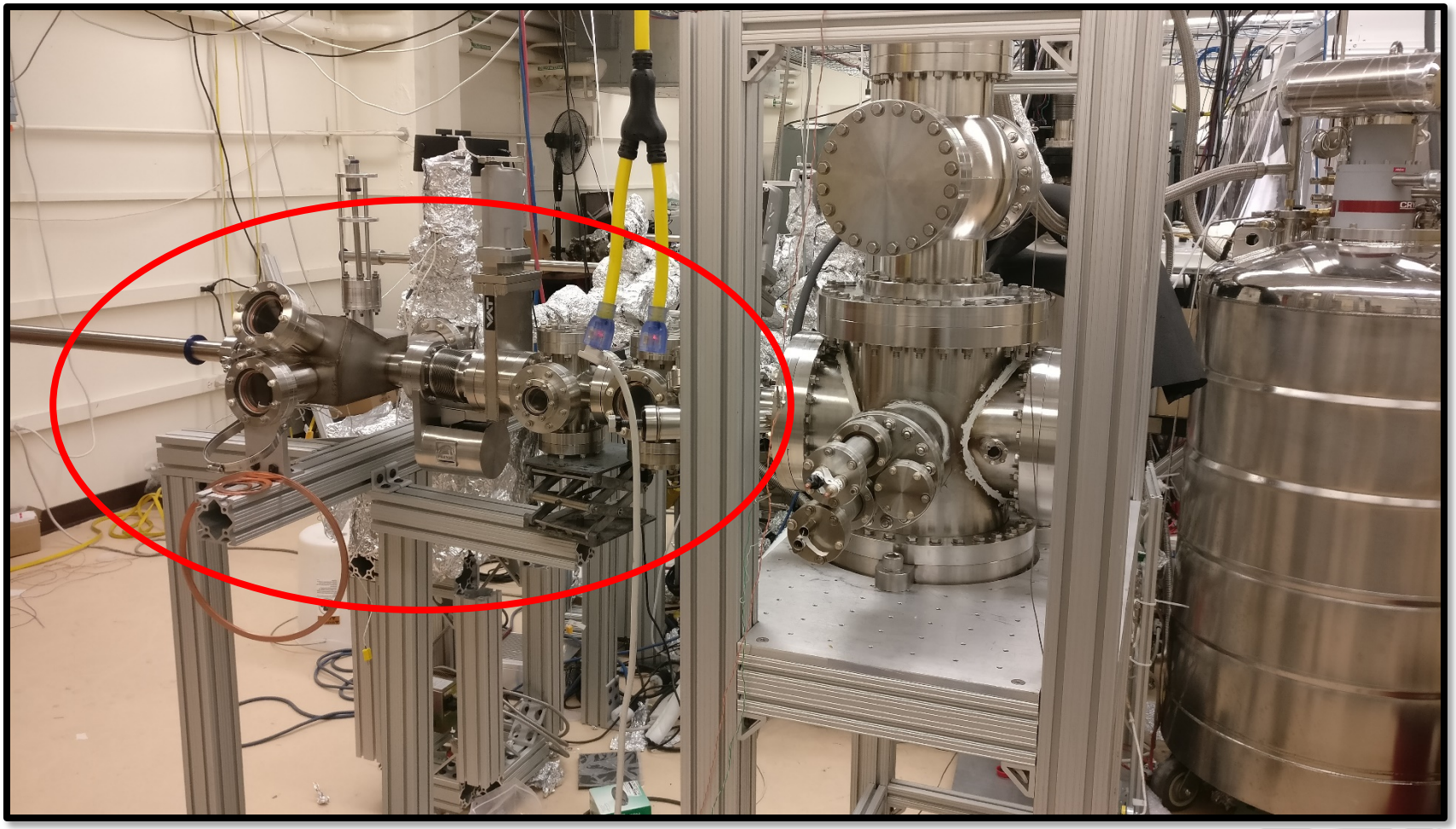
ASU Cryogun - Cathode



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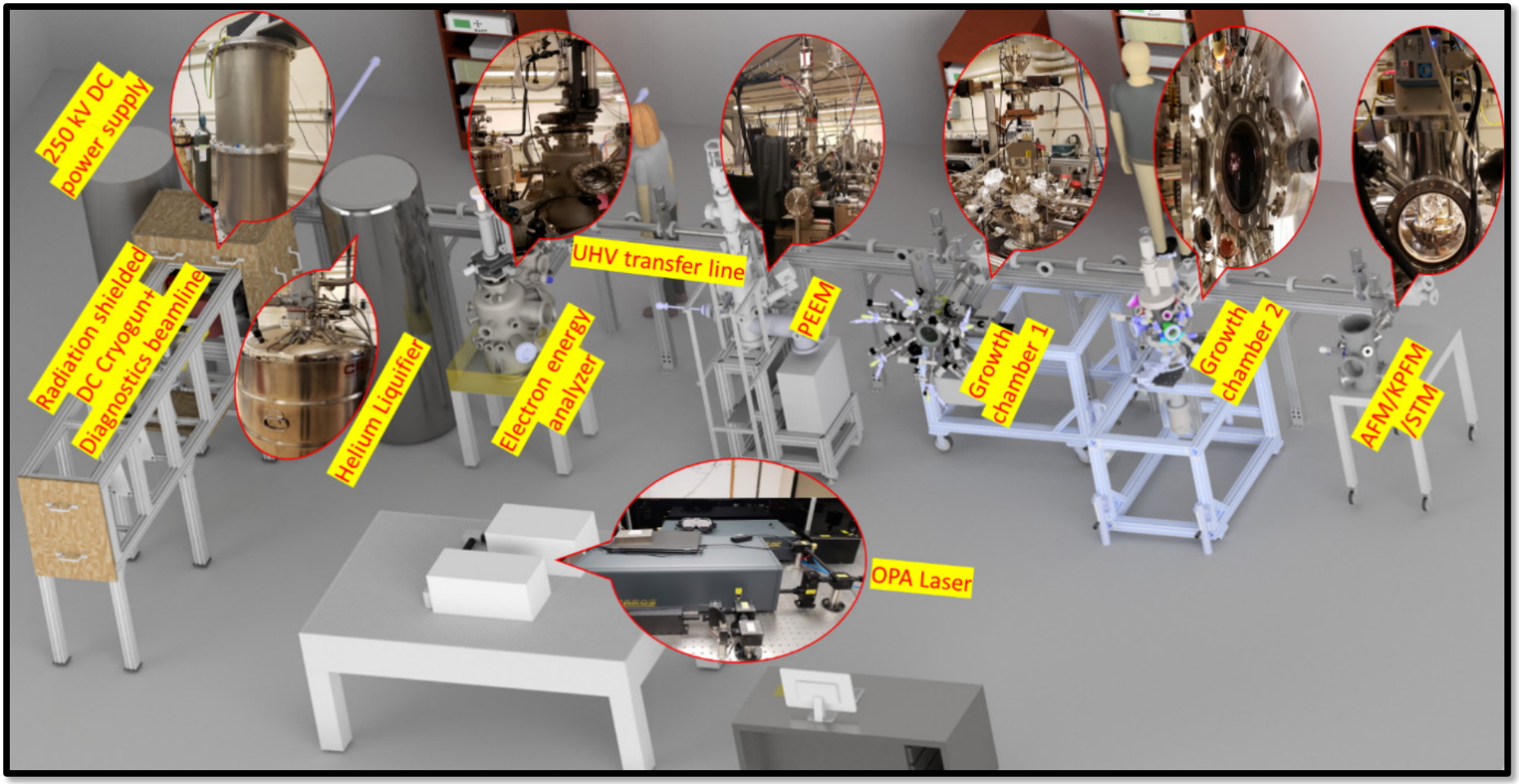

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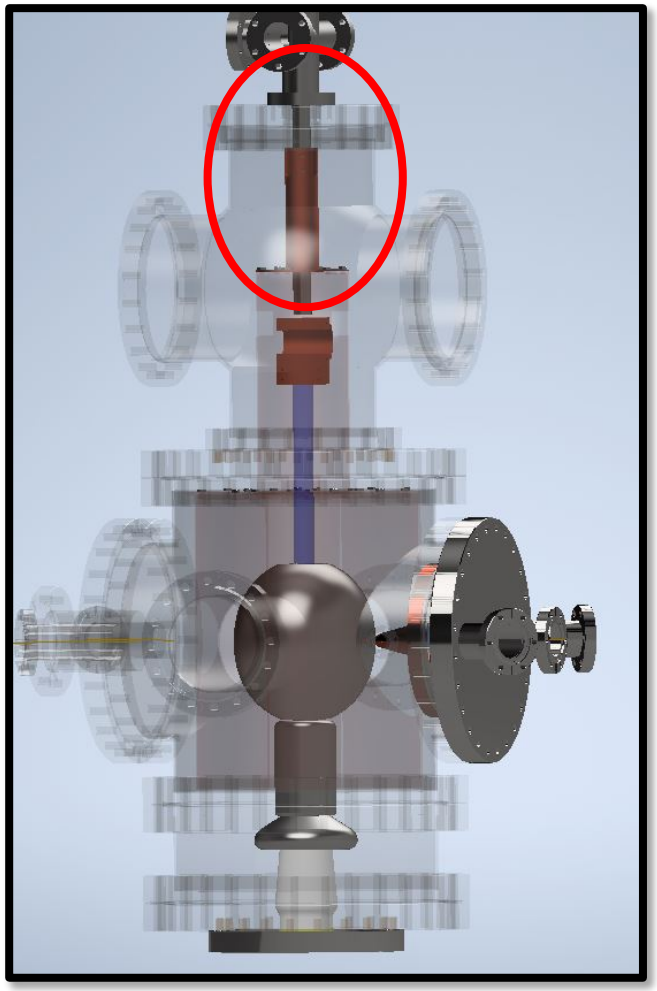
Cryocooling of the Gun



Helium Liquifier Plant

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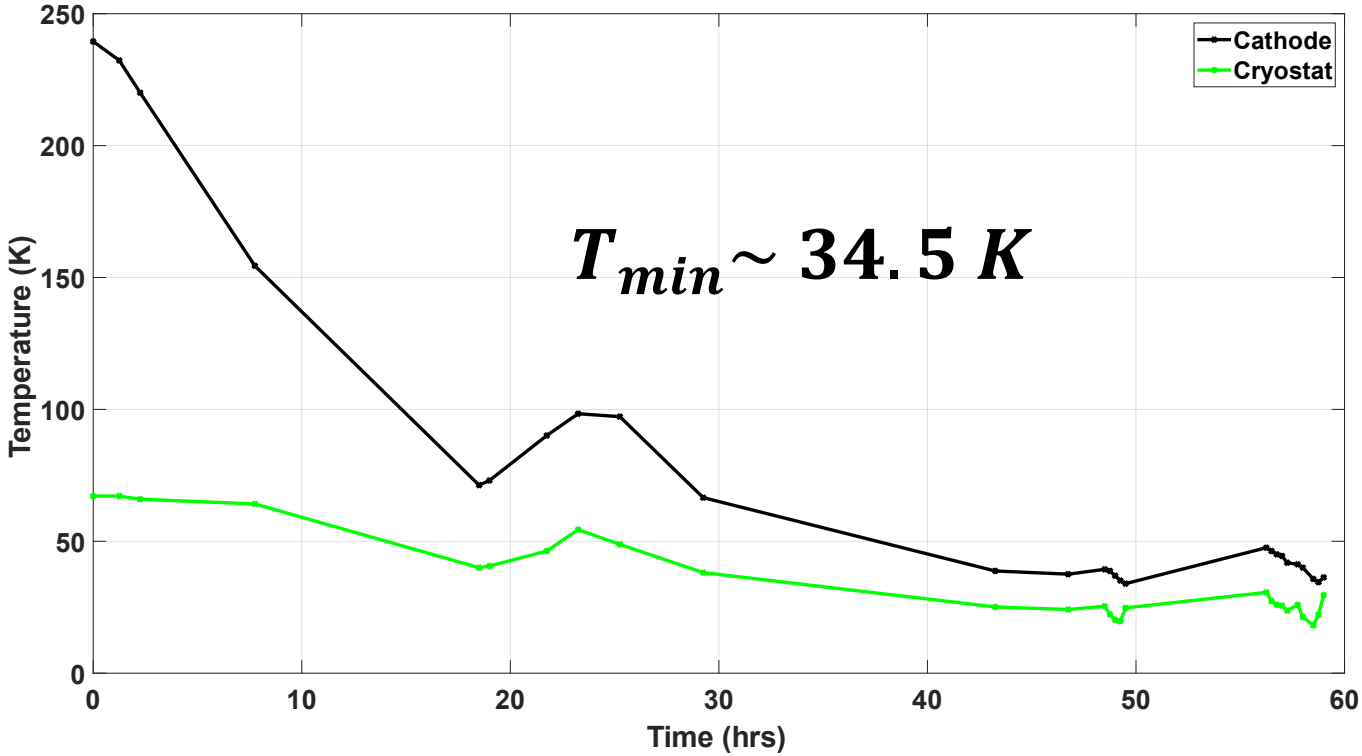
Cryocooling of the Gun

Calibration – Cathode Temperature vs Time



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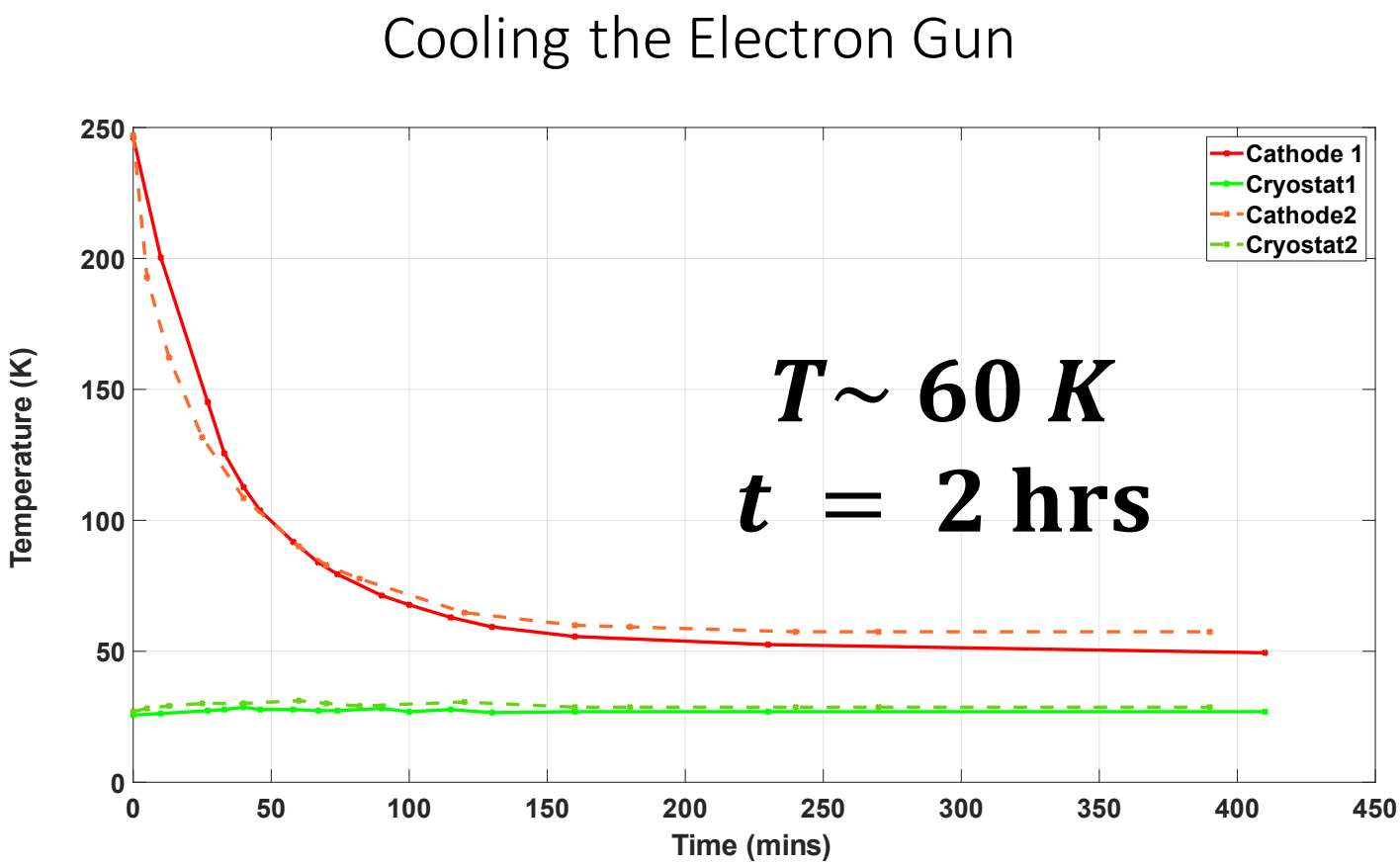
Cryocooling Calibration of the Gun



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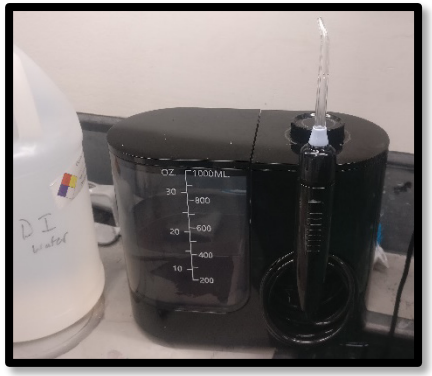
Surface Preparation and Assembly

Rotary tumbler polishing



Water flosser HPR

Ultrasonic

CO2 Snow-jet cleaning

120+ °C for 50 hours
Activated NEG Pumps
P ~ 10^{-10} Torr

C. Hernandez-Garcia, et al, Review of Scientific Instruments, 88.9, 093303 (2017)

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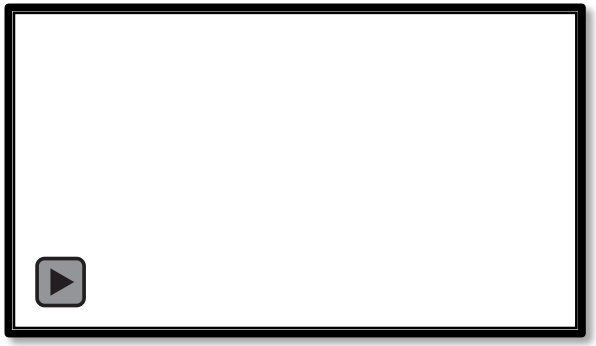

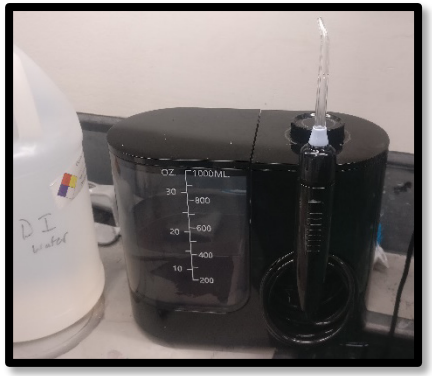

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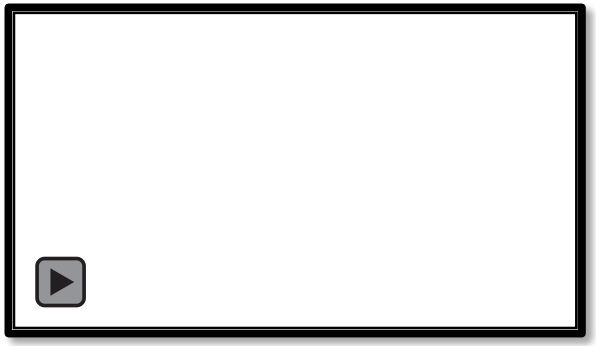

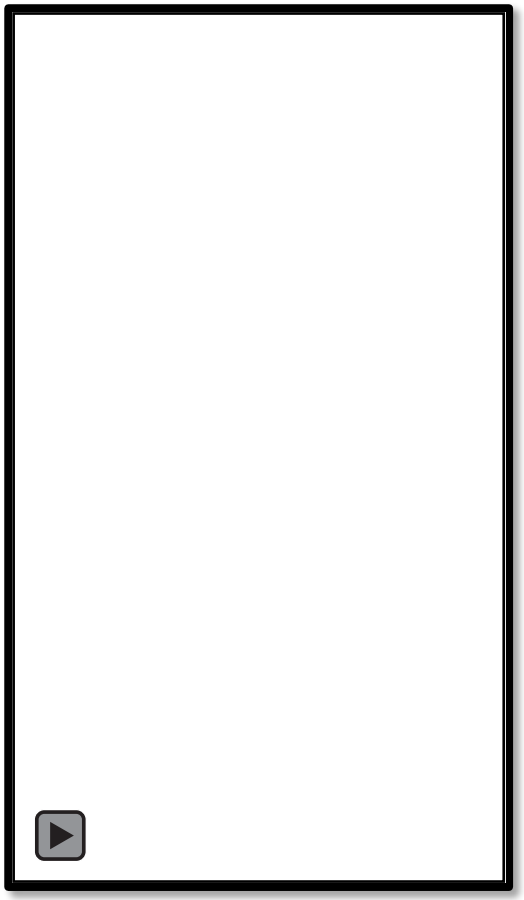

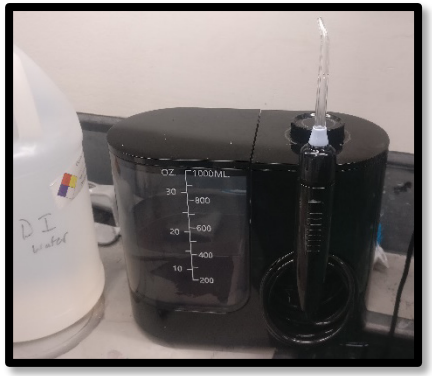

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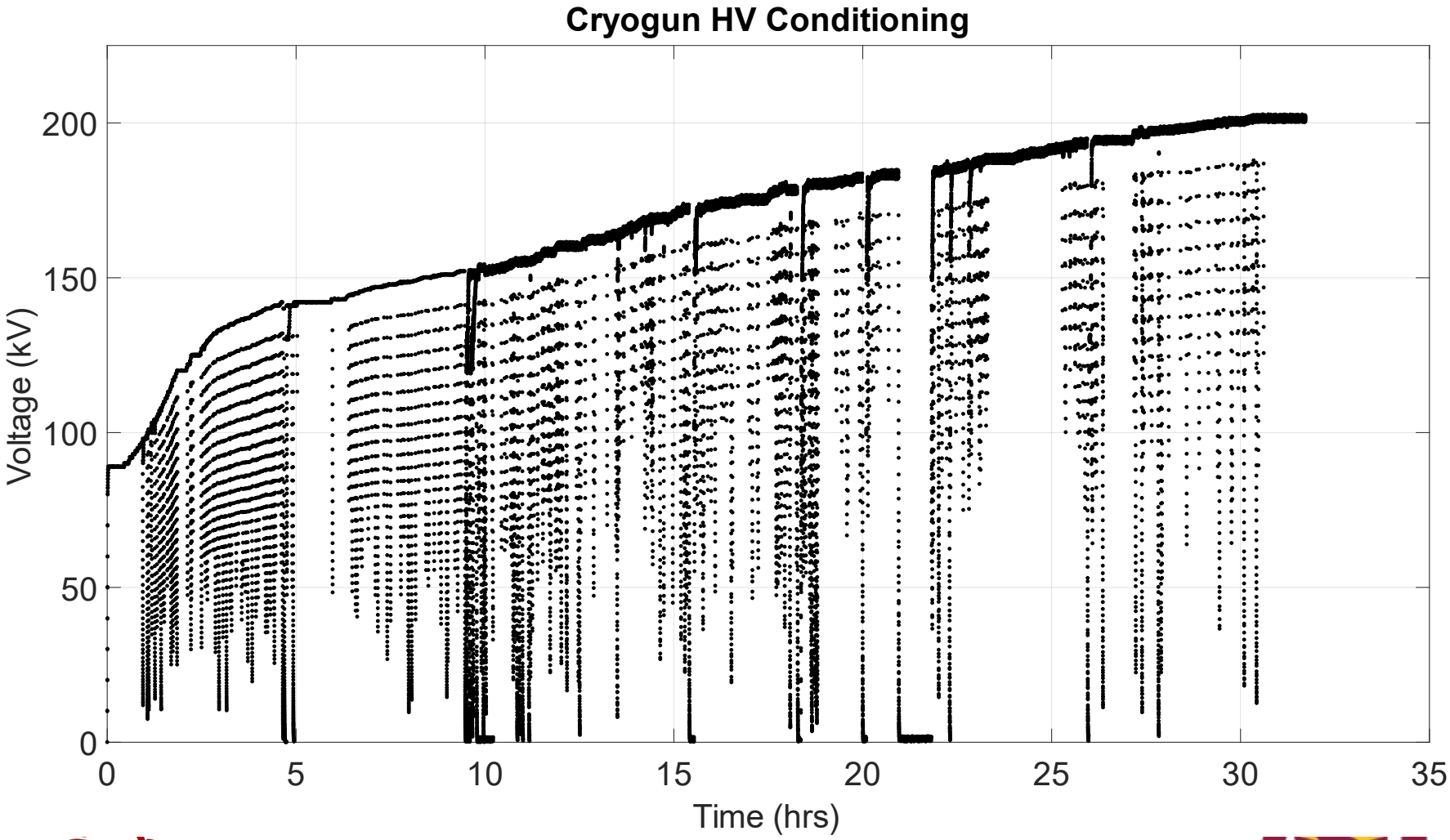
HV Conditioning Status



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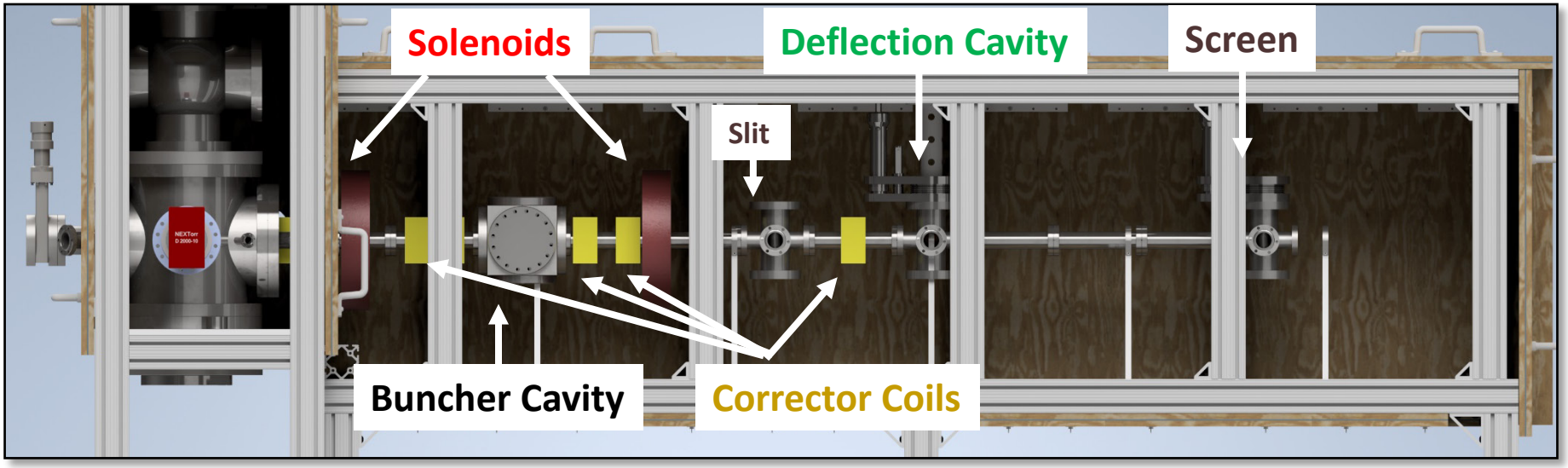
Future work



- Pinhole scan technique for 4D phase space mapping
- Solenoid scan emittance measurements
- 3.0 GHz deflection cavity for time response

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Acknowledgements

Carlos Hernandez Garcia

Jared Maxson
Ivan Bazarov
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Pallavi Saha
Endy Gonzalez
Priyadarshini Bhattacharyya

Thank you!

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