SAND2024-12940C

Development and Preliminary Results on a Uniform Field Test fixture for Power Flow Experiments

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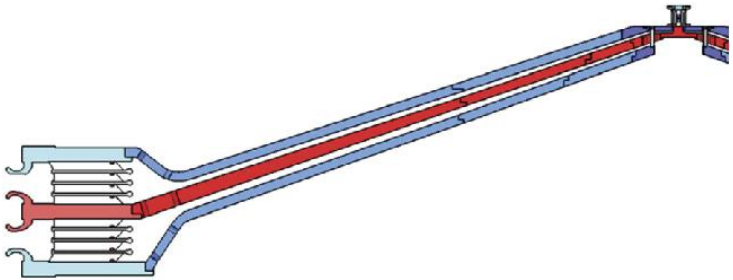
University of Rochester
Laboratory for Laser Energetics

Euro-Asian Pulsed Power Conference

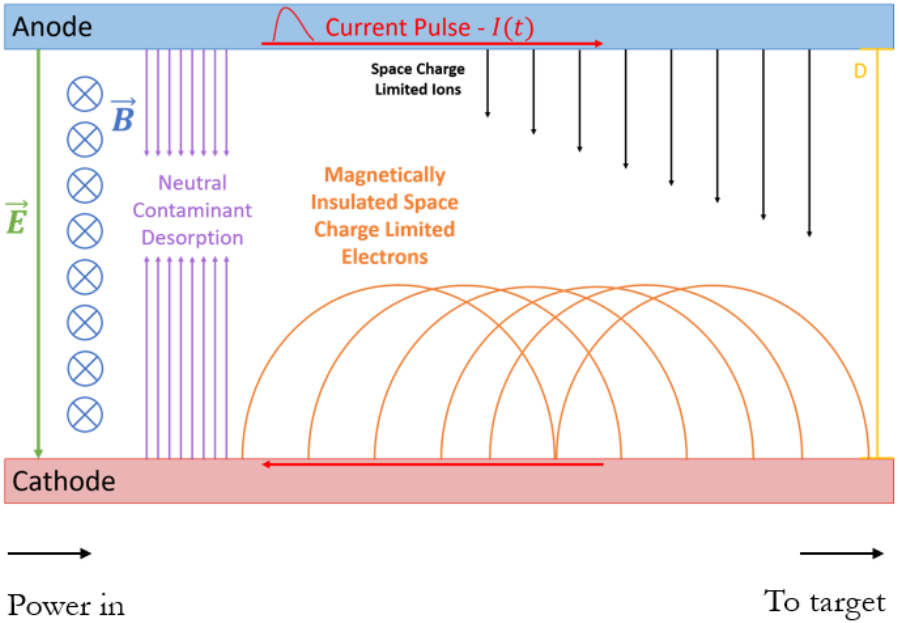
September 22-26, 2024

Vacuum Power Flow



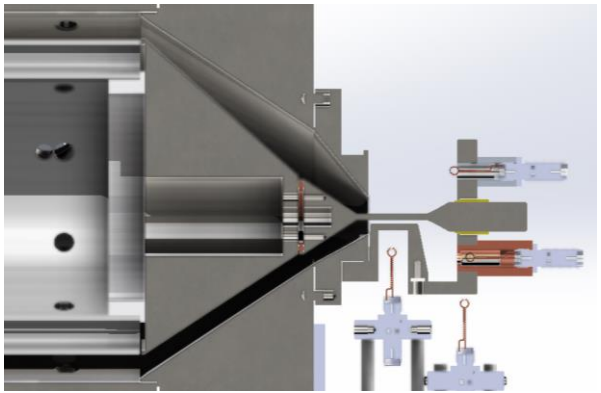
$$V \approx Z_0(I_a^2 - I_c^2)^{1/2} - \frac{gmc^2}{2e}\frac{I_a^2 - I_c^2}{I_c^2}$$

$$Z_0 = \frac{c\mu_0 d}{w} = \frac{E_a d}{(I_a^2 - I_c^2)^{1/2}}$$



Power Flow Experiments on the Mykonos Accelerator

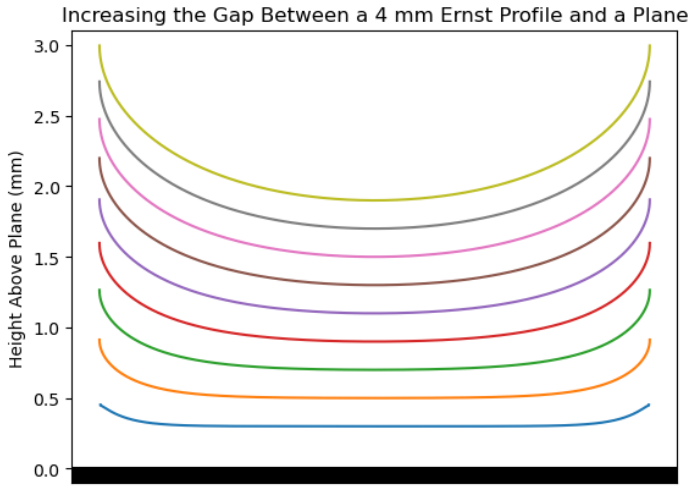
- **To improve vacuum power flow, several material modifications are being explored in addition to probing the fundamental physics**
  - **Material Treatments**
  - **Plasma Discharge cleaning**
  - **Electropolishing/Dry Electropolishing**
  - **Coatings**



D. C. Lamppa *et al.*, "Assessment of Electrode Contamination Mitigation at 0.5 MA Scale," Sandia National Laboratories, Albuquerque, NM, SAND2021-12691, Oct. 2021

Improving Load Geometry: Introducing Uniform Field Electrodes

- **The Ernst profile is an improvement on the better-known Rogowski profile:**
  - $\xi = w + k_0 sinh(w) + k_1 sinh(2w) + \cdots$
    - $\xi = x + iy$
    - $w = u + iv$
- **From this, we can find our x and y coordinates to be:**
  - $x = u + k_0 \cos(v) \sinh(u) + k_1 \cos(2v) \sinh(2u) + \cdots$
  - $y = v + k_0 \sin(v) \cosh(u) + k_1 \sin(2v) \cosh(2u) + \cdots$

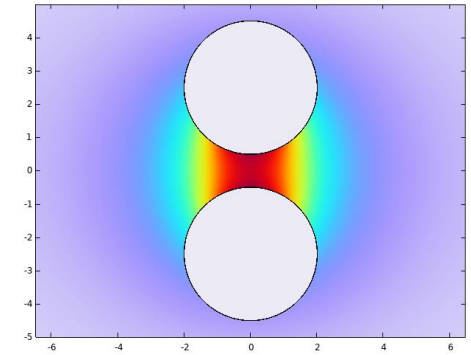


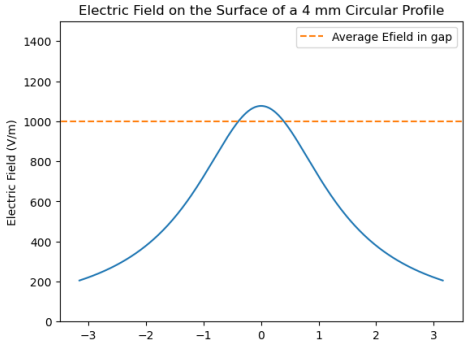
- **Using u as a running variable, we can find values of k and v that yield a profile for a desired aspect ratio (height and width of electrode). The field can be optimized with the expression below for electric field strength**
  - $E^{-2} = \left|\frac{d\xi}{dw}\right|^2$

Chang, T. Y. *Review of Scientific Instruments* 44, no. 4 (1973): 405-407.
Ernst, Gerard J. *Optics communications* 49, no. 4 (1984): 275-277.

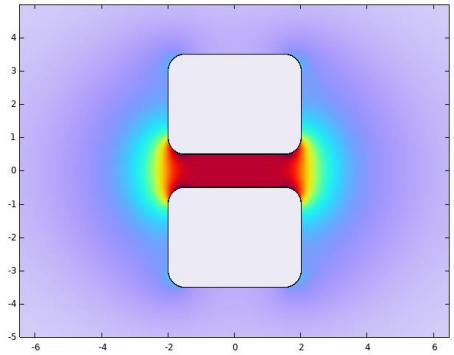
Electric Fields on the surface of the Electrodes

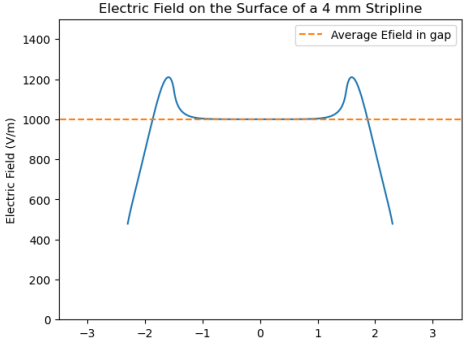
Circle
FEF = 1.08



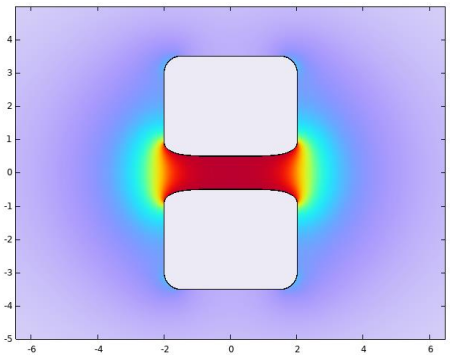


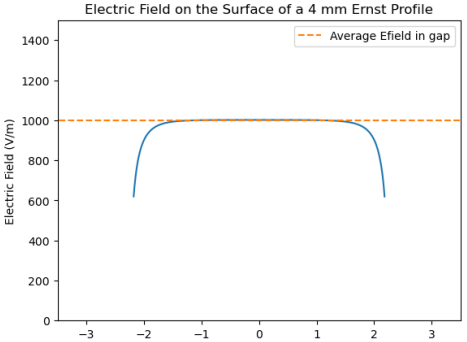
Stripline
FEF = 1.21





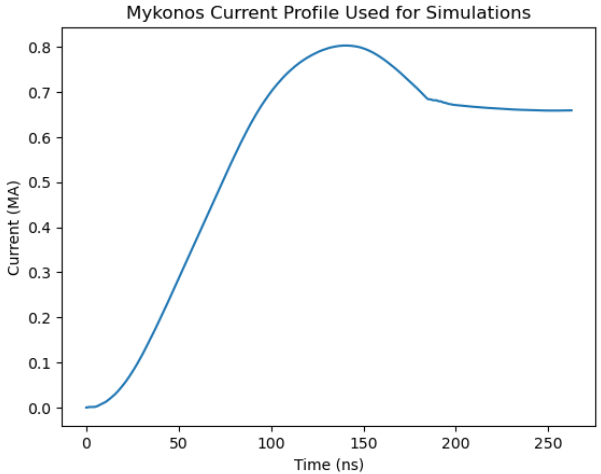
Ernst
FEF = 1.002

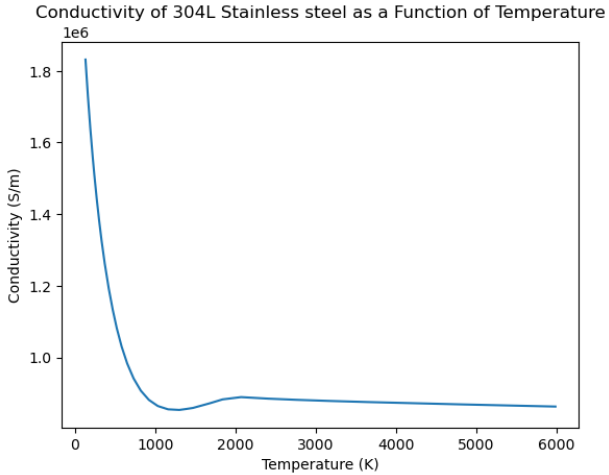




COMSOL Simulations

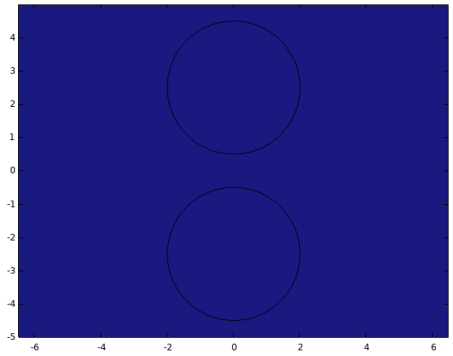
- Heat Transfer in Solids *(ht)*
  - Solid 1
  - Initial Values 1
  - Thermal Insulation 1
  - Fluid 1
- Magnetic and Electric Fields *(mef)*
  - Ampère's Law and Current Conservation 1
  - Magnetic Insulation 1
  - Initial Values 1
  - Gauge Fixing for A-field 1
  - Electric Potential 1
  - Ground 1
  - Single Conductor Coil 1
  - Single Conductor Coil 2
- Electrical Circuit *(cir)*
  - Ground Node 1 *(gnd1)*
  - Current Source 1 *(I1)*
  - Load Hardware Inductance *(LH)*
  - Load Inductance *(LI)*
- Surface-to-Surface Radiation *(rad)*
  - Diffuse Surface 1
  - Initial Values 1
- Multiphysics
  - Electromagnetic Heating 1 *(emh1)*
  - Heat Transfer with Surface-to-Surface Radiation 1 *(htrad1)*

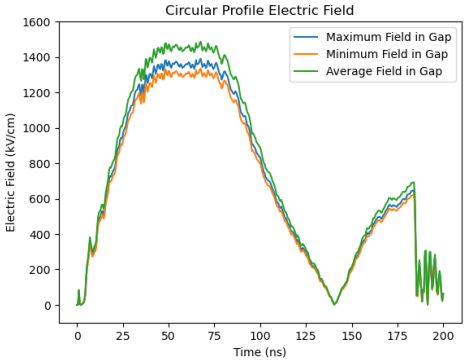




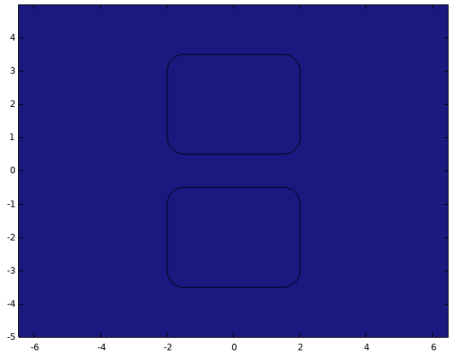
Electric Fields

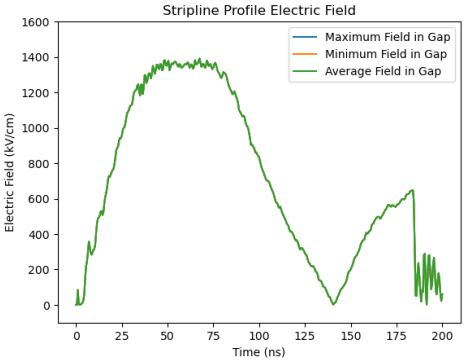
Circle





Stripline





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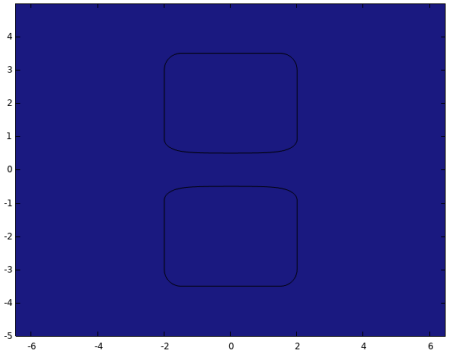
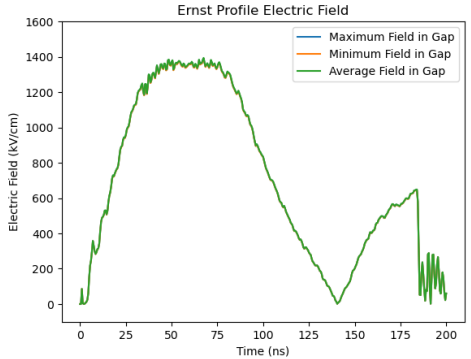
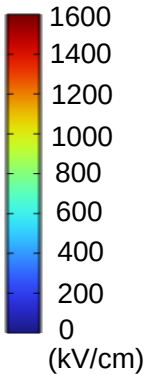
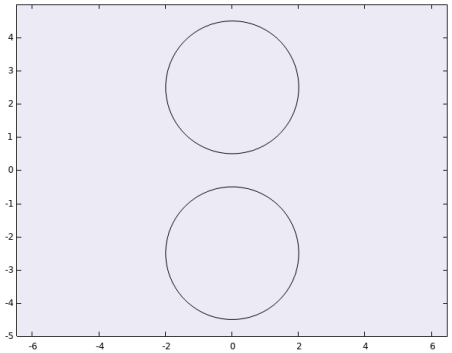






Magnetic Flux Density

Circle



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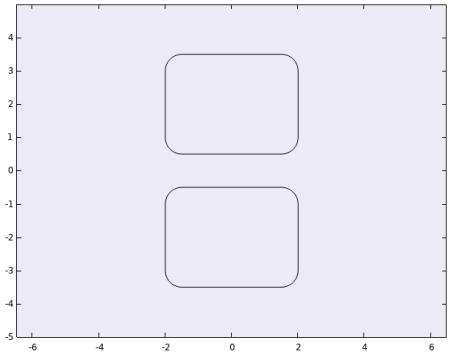

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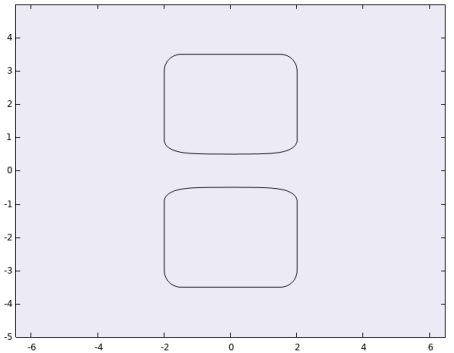
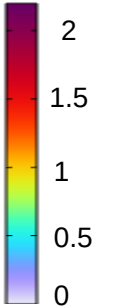
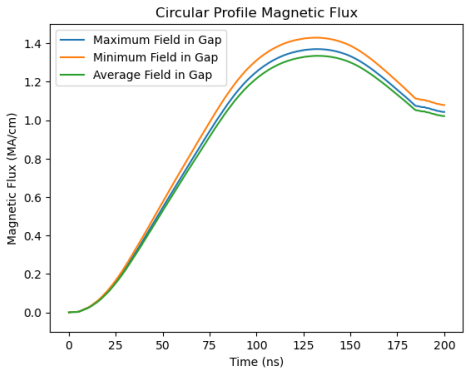
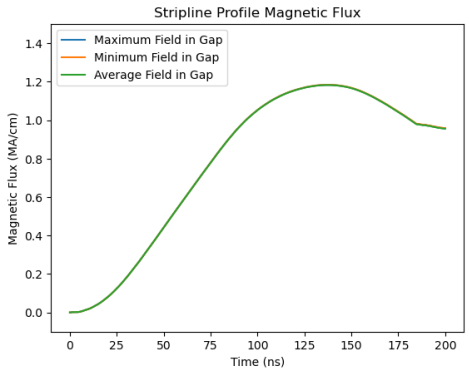
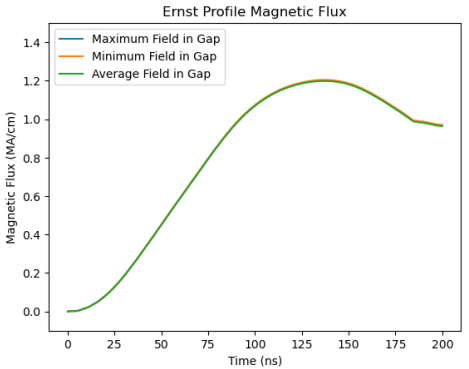




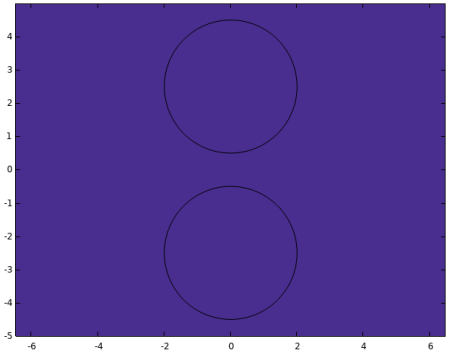




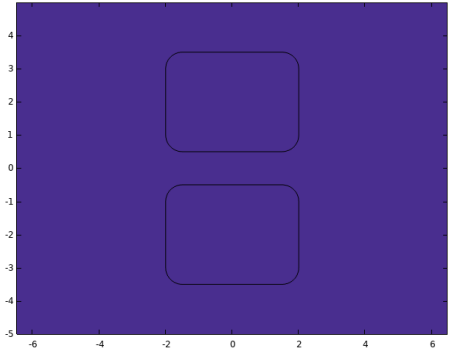


Temperature

Circle



Stripline



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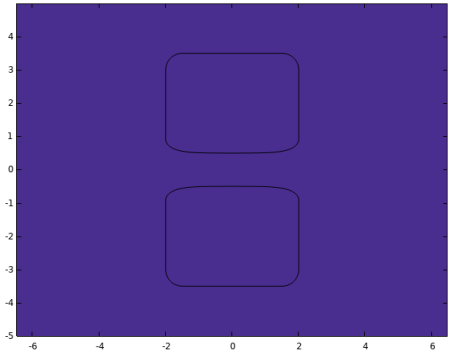
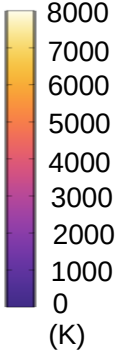
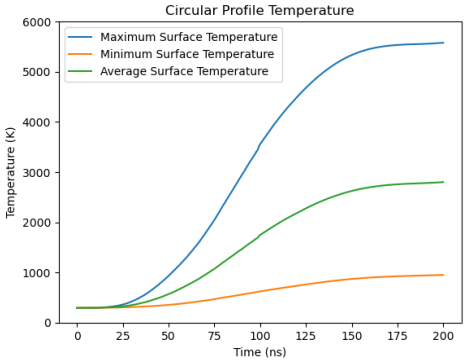
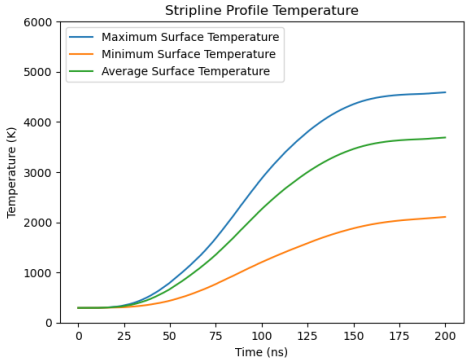
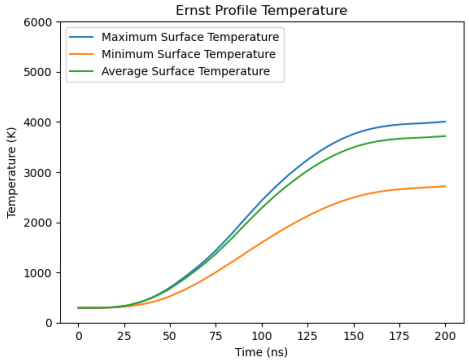




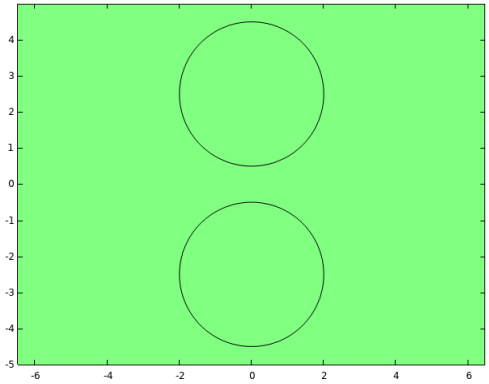




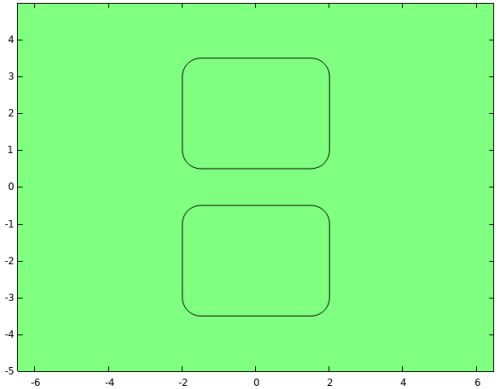


Current Density

Circle



Stripline



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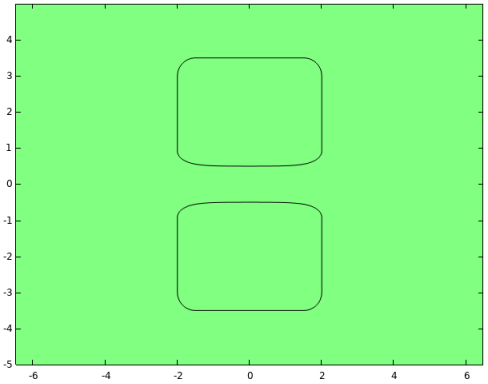
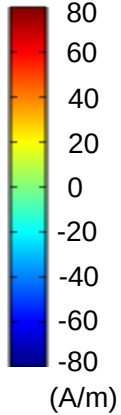
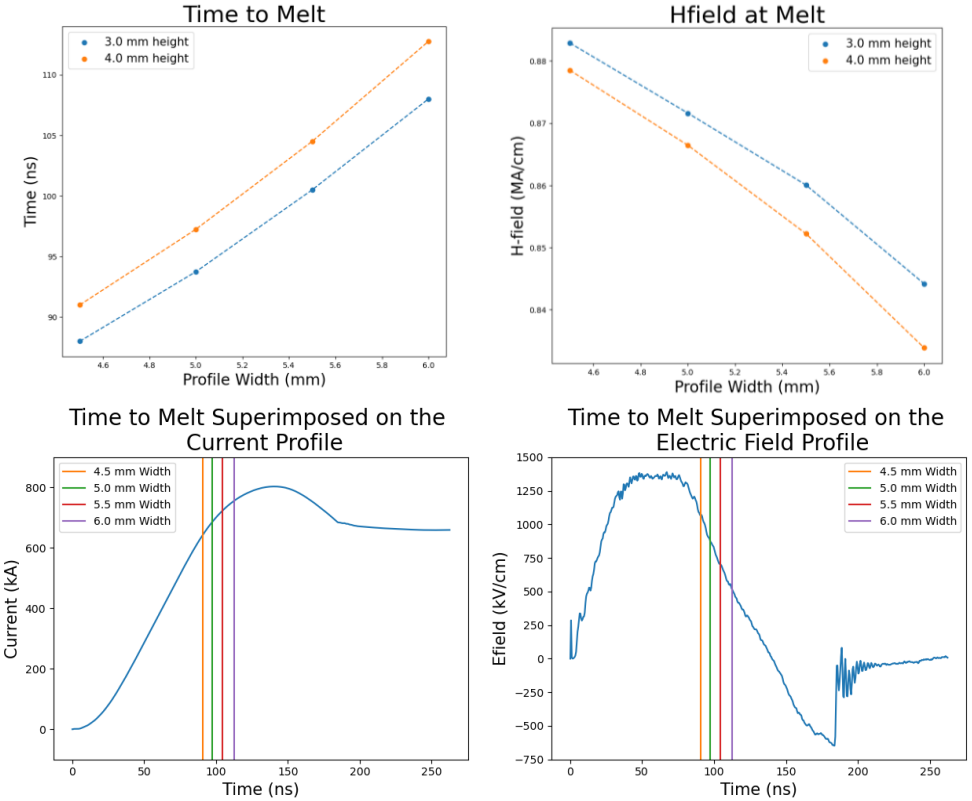
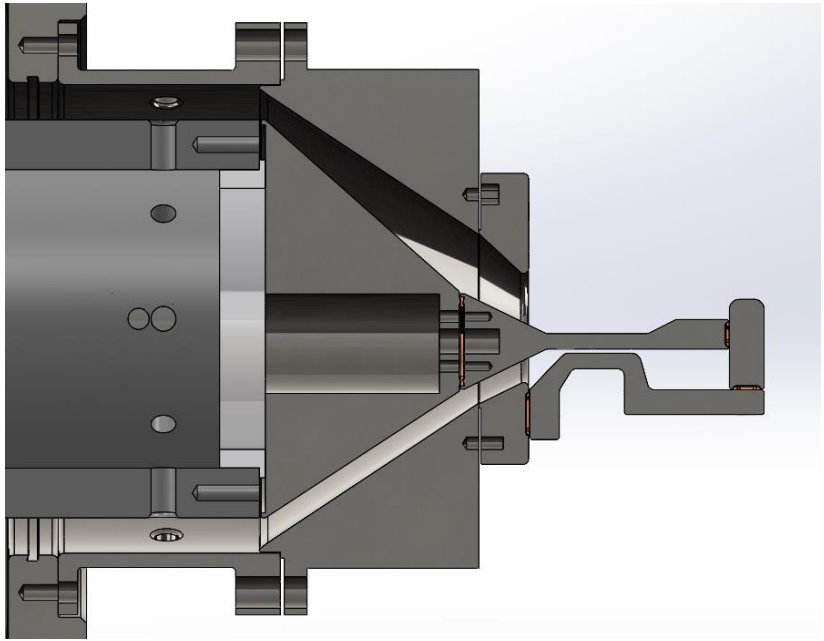


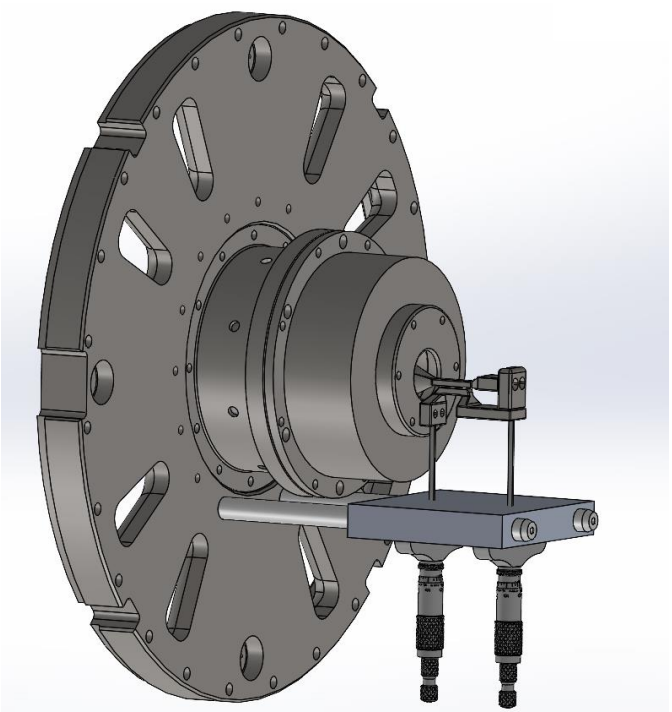


Determining Optimal Dimensions of Ernst Profile

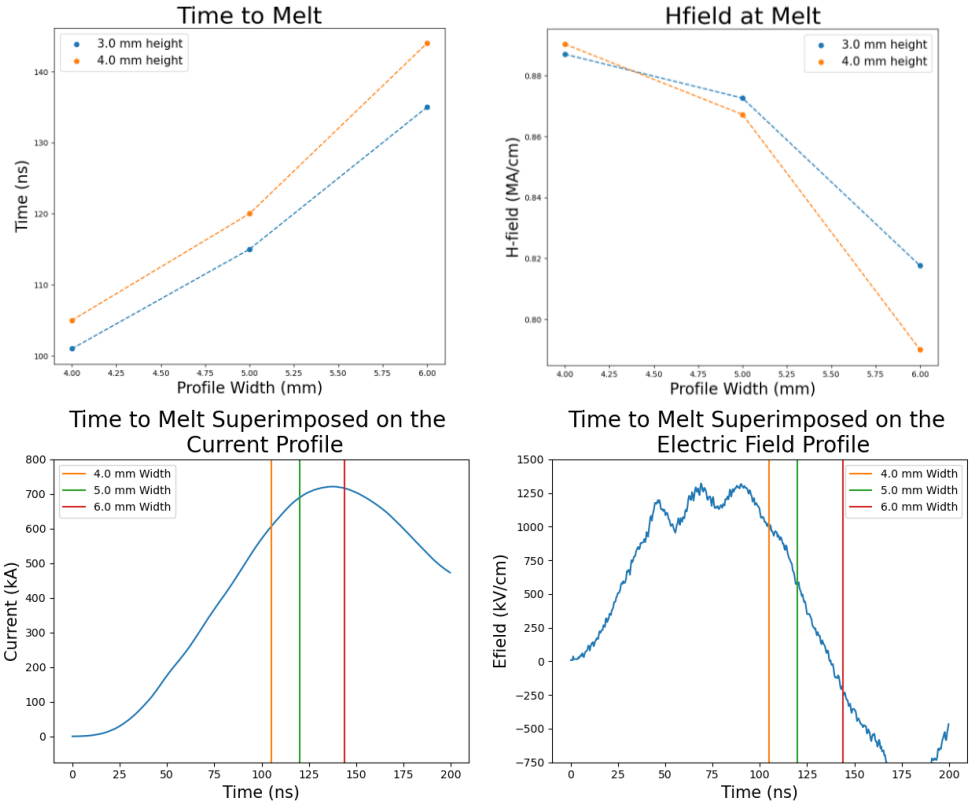


Uniform Field Mykonos Parallel Plate Platform

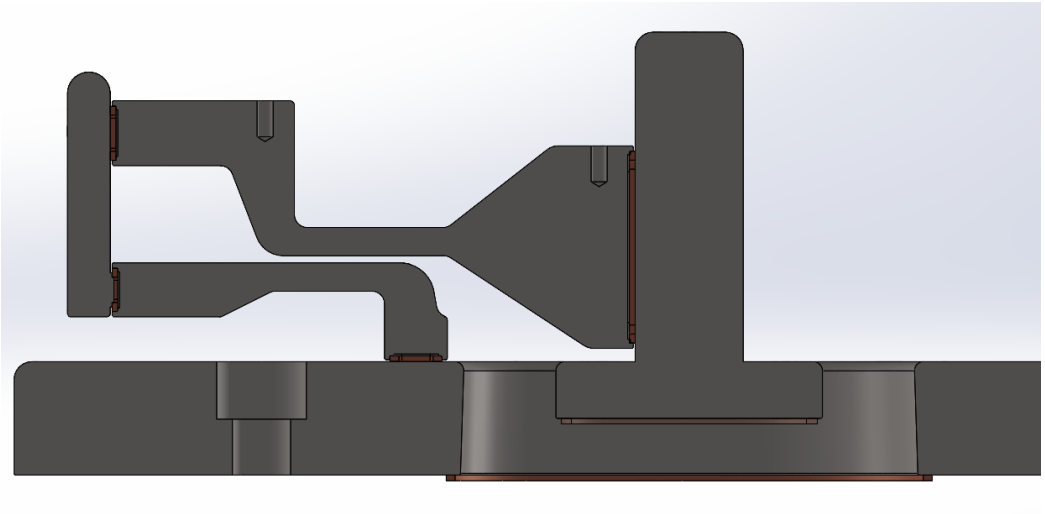


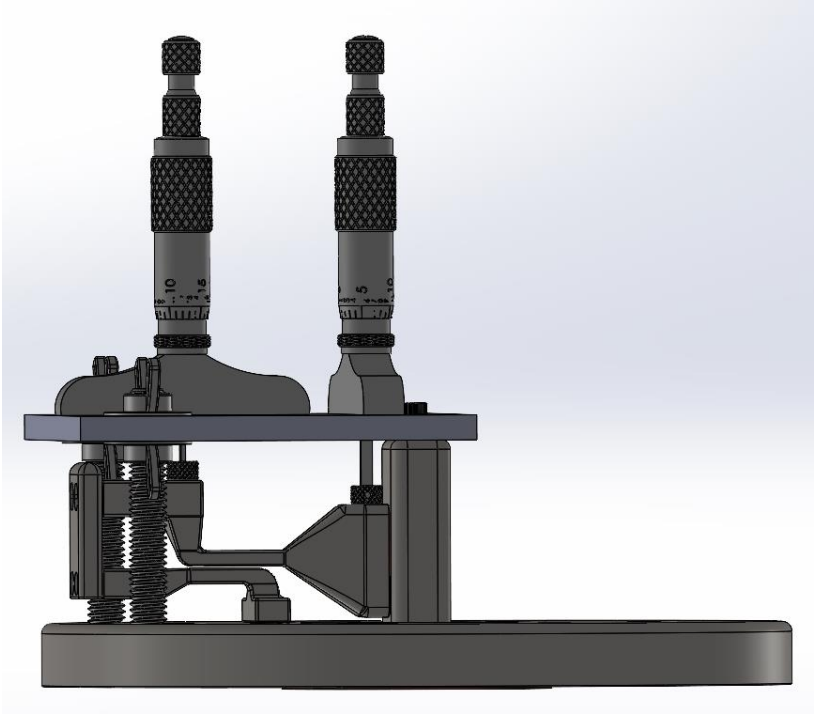


Determining Optimal Dimensions of Ernst Profile for the COBRA Accelerator

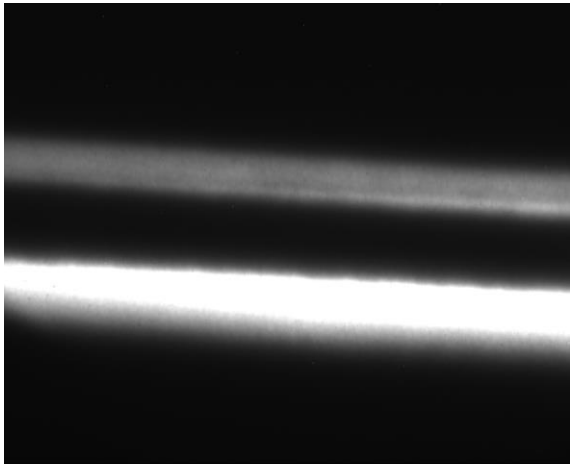


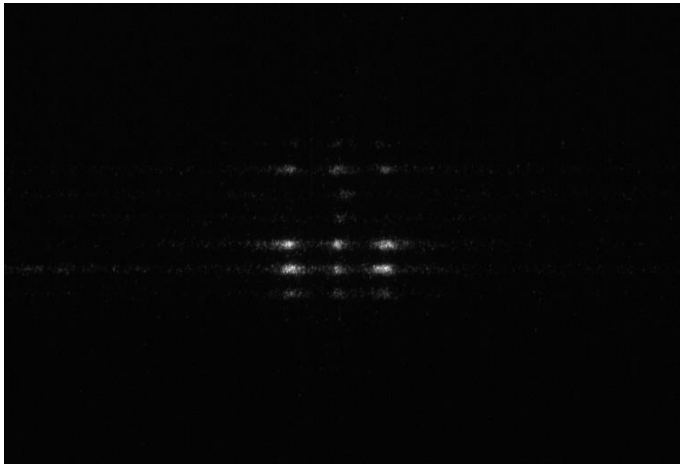
Uniform Field MP3 Adapted to COBRA (Uniform Field CP3?)





Priliminary Experimental Results





Collaborators And Funding Statement

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Thomas Mundy

Imperial College London

This work was funded by the laboratory directed research and development program at Sandia National Laboratories.
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