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Sandia National Laboratories

DIODE DESIGN FOR INCREASED RADIATION DOSE IN HERMES III FAR-FIELD

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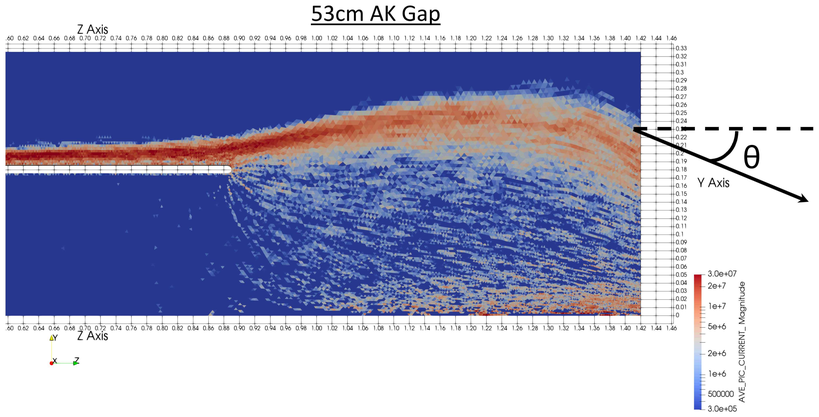
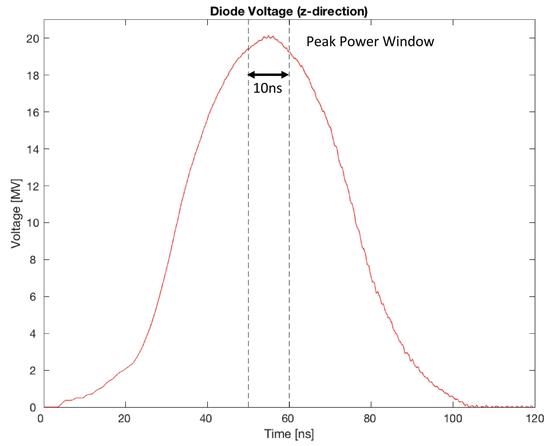
Abstract

Increasing radiated dose in the HERMES III far-field region is both a matter of mitigating current loss in the MITL and electron incident angle on the Bremsstrahlung converter. The self-magnetic field of the high currents in the diode causes the electrons to pinch at steep angles once the radial electric field drops to zero near the converter. Since a lower incident angle (closer to norm) increases the dose nonlinearly, diode design should minimize this pinch angle. Designs include extended and indented anode configurations. Indented anode designs are compared with results shared by T. Renk and P. F. Ottinger (using LSP) as well as older results from Sanford (using MAGIC). All designs are reported along with their associated simulation results.

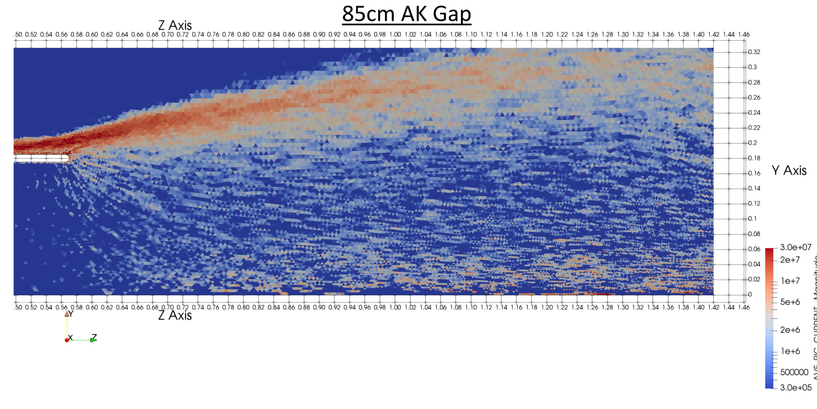
Planar Diode

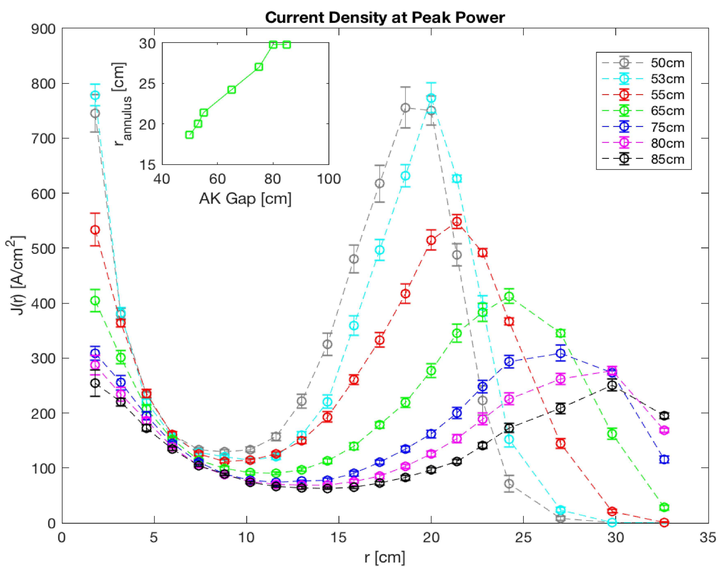
53cm AK Gap

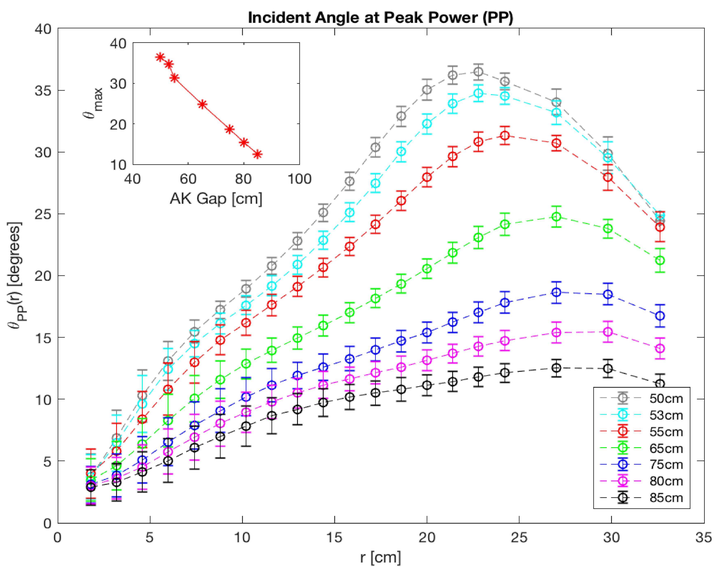


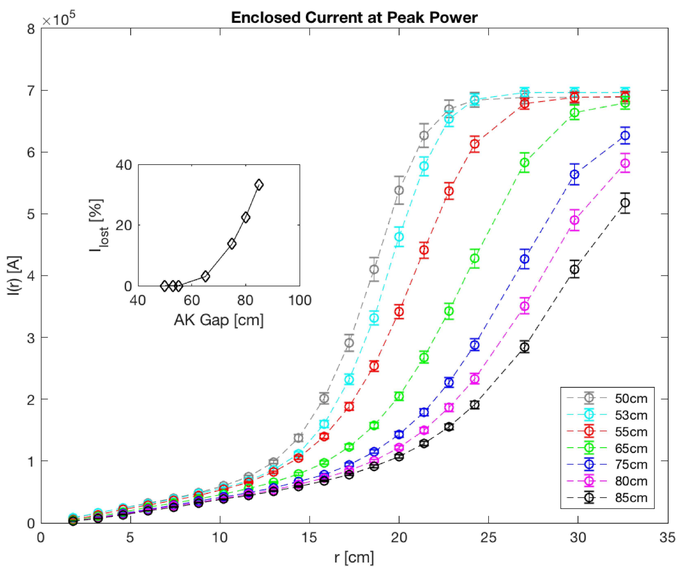


85cm AK Gap









Problem

Want to increase radiation dose by decreasing incident angle of electrons (θ).

$$\text{Dose} \propto I * V^{x};\ x = x(\theta)$$

Sanford [1,2] proposed that a lengthening of the anode-cathode (AK) gap (planar-diode case) or increasing D2 (indented-anode case) will decrease this incident angle.

It is the goal of this work to test this hypothesis and compare across codes (LSP, MAGIC, and EMPHASIS) and validate the results via experiment.

Observations

An unfortunate side-effect is that as the AK gap is increased, the beam spreads radially and eventually begins losing current to the outer anode wall. This can be an optimization problem that will need experimental measurements and model improvements to be resolved.

These results match up well with MAGIC calculations done by Sanford [1].

Current loss becomes significant around 65cm (Sanford predicted 70cm), though in experiment it was shown to occur after 80cm.

Annulus radius increases with AK gap while incident angle decreases.

Conclusions and Future Work

Extending the planar diode to larger AK gaps does indeed reduce incident angle.

Need “knock-on” ions to match experimental data more closely.

Predict at which AK gap loss becomes significant with ions.

Compare to experimental data on HERMES III.

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References

[1] - Sanford, T. W. L., Halbleib, J. A., Poukey, J. W., Baldwin, G. T,. Carlson, G. A., Stygar, W. A., Mastin, G. A., Sheridan, T., Mock, R., Alexander, J. A., Brock, E. R., and Landron, C. O. *Dynamics of Electron Flow in Extended Planar-anode Diode Operating at 19MV and 700kA.* J. Appl. Phys. 67 (3). 15 February, 1990

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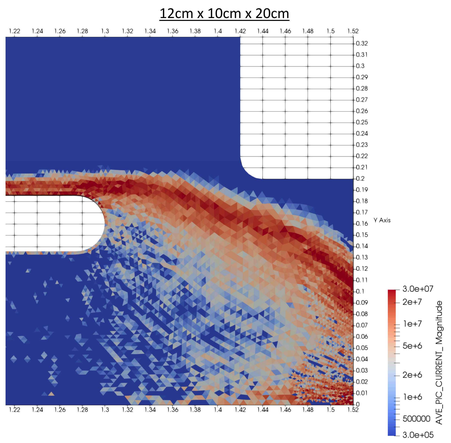
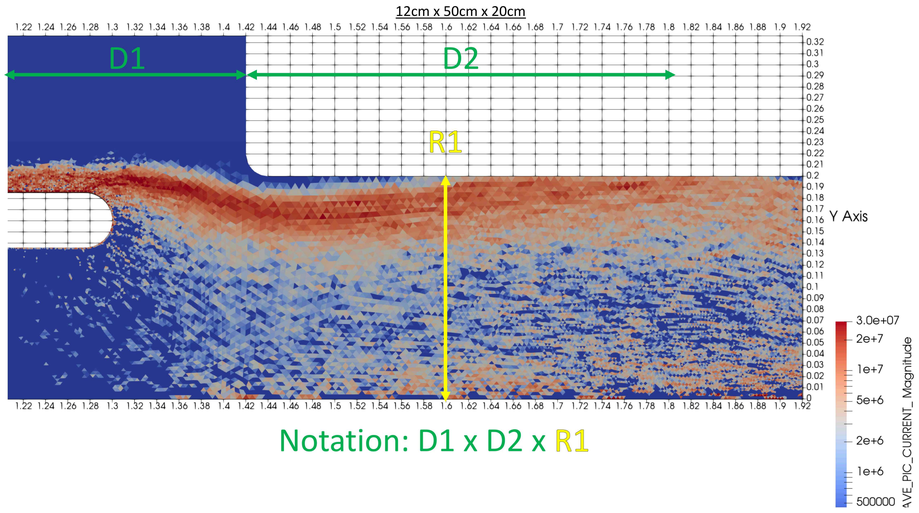
Indented Anode





Notation: D1 x D2 x R1

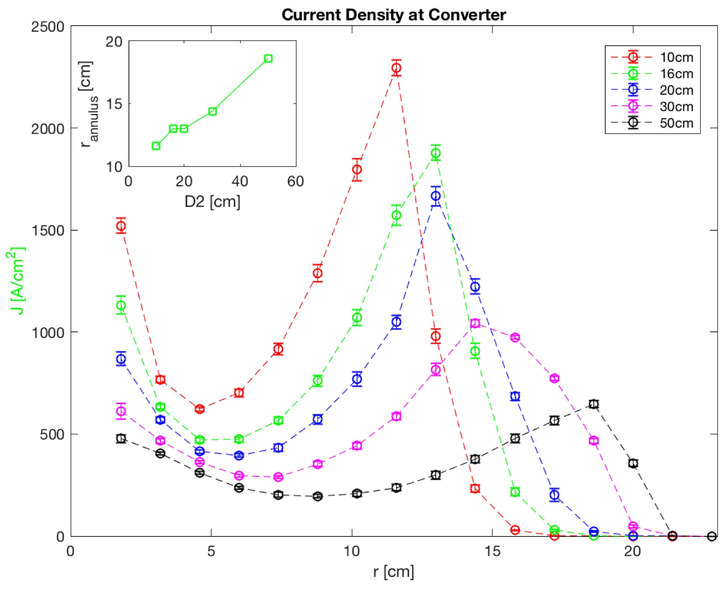
Observations

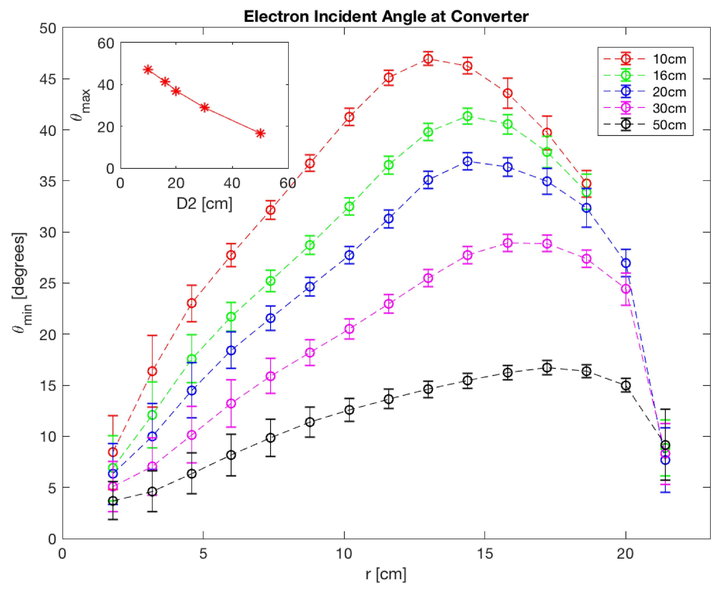
Using an indented anode shows similar behavior in terms of incident angle and current density as compared to the extended planar diode.

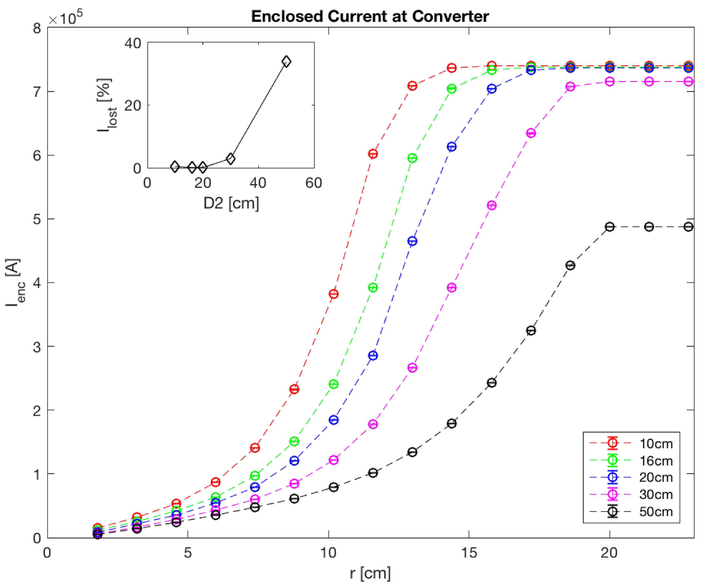
The indented anode provides a degree of tunability by using D1+R1 to control the effective diode impedance while D2 controls the pinch angle[2].

Current loss becomes significant for D2 values larger than 30cm. This will vary as well with R1.

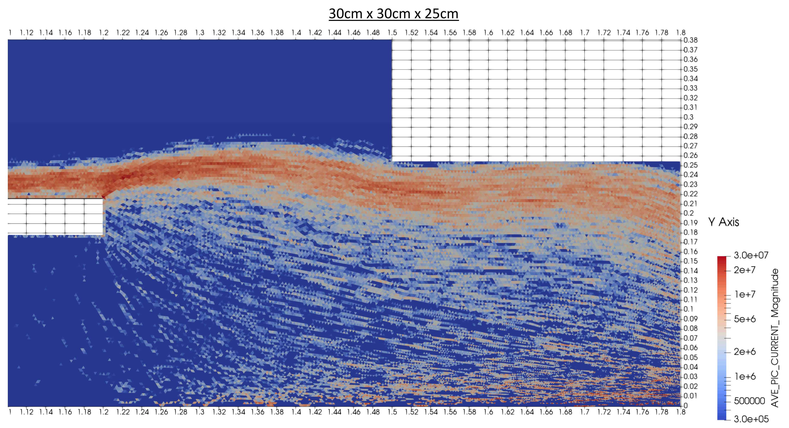
Annulus radius increases with D2 while incident angle decreases.

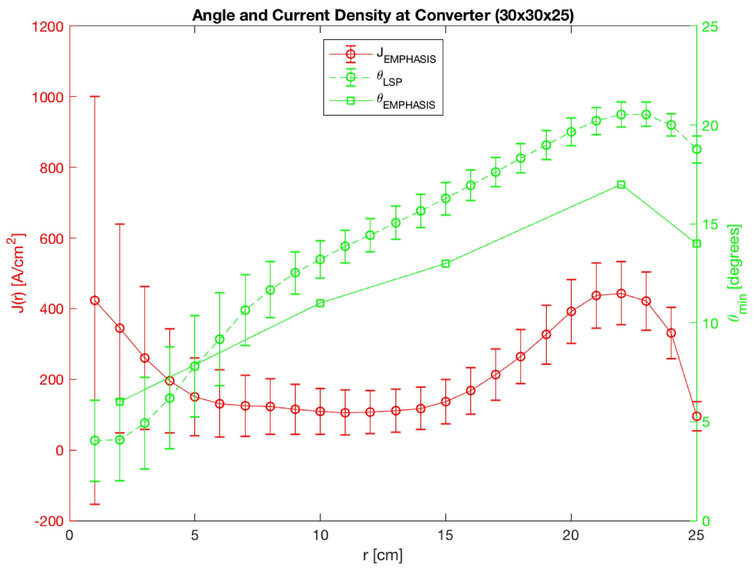






Renk-Ottinger Study





Conclusions and Future Work

Extending D2 does indeed reduce incident angle.

Both LSP, MAGIC, and EMPHASIS predict reduced incident angles for an indented-anode geometry.

Need “knock-on” ions to match experimental data more closely.

Predict at which D2 value loss becomes significant with ions.

Show tunability more explicitly by varying D1 and R1 as well as D2.

References

[2] - Sanford, T. W. L., Poukey, J.W., Wright, T. P., Bailey, J., Heath, C. E., and Mock, R. *Impedance of an Annular-cathode Indented-anode Electron Diode Terminating a Coaxial Magnetically Insulated Transmission Line.* J. Appl. Phys. 63 (3). 1 February, 1988

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