An overview of the Dynamic Hohlraum source at Sandia National Laboratories

SAND2006-7341C

T. Sanford D. Bliss M. Cuneo
R. Leeper T. Nash S. Rosenthal W. Stygar
*Sandia National Laboratories**

G. Sarkisov R. Mock
Ktech Corp., Albuquerque NM

P. Sasorov
Institute of Theoretical and Experimental Physics, Moscow

J. Chittenden M. Haines C. Jennings
Imperial College, London UK

D. Peterson
Los Alamos National Laboratory

J. Apruzese
Naval Research Laboratory, Washington DC

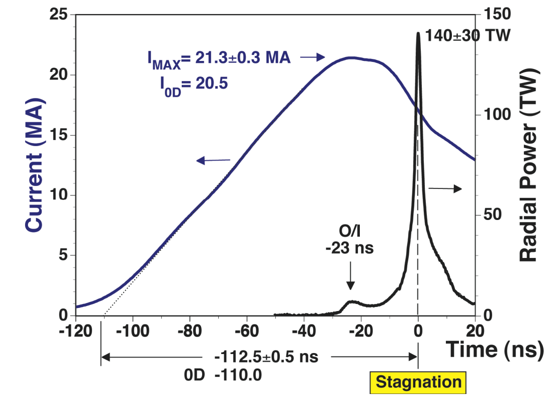
Z Generator

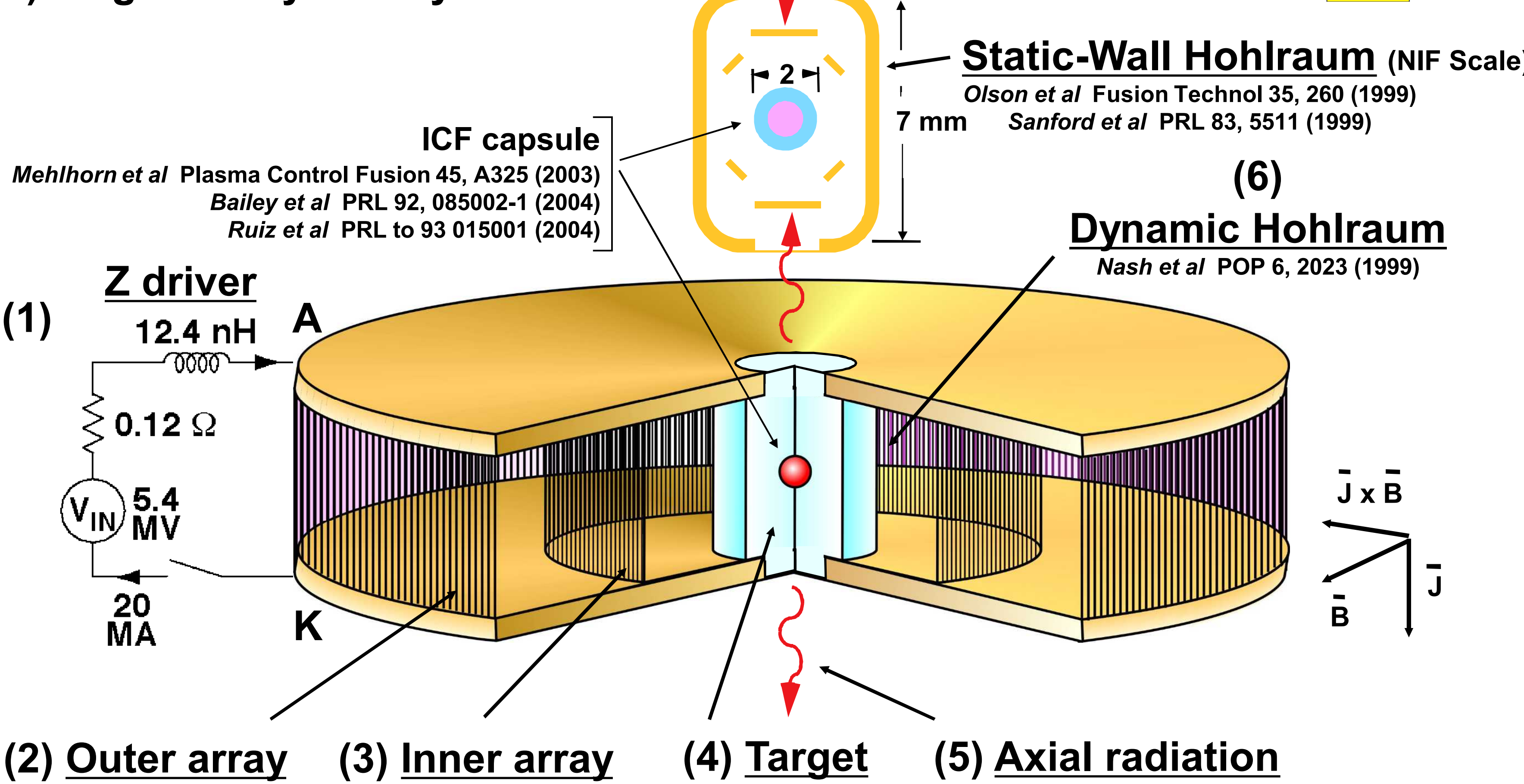
*Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy under contract DE-AC04-94AL85000.

Sandia National Laboratories

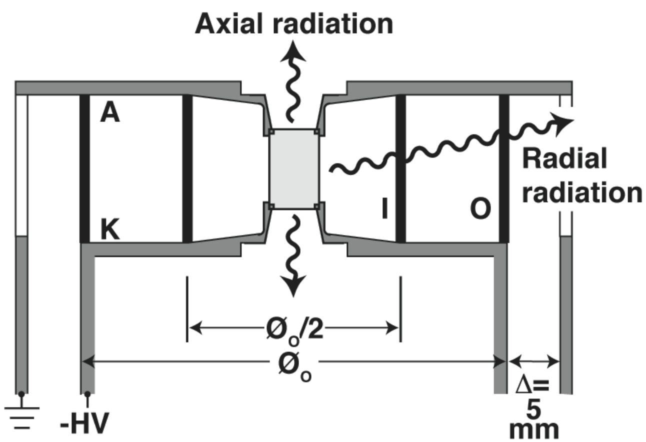
DH is used for high-temperature radiation flow and ICF experiments.

Outline:
1) Optimization of arrays
2) Collision of O with I array
3) Implosion of target
4) Asymmetry in radiation
5) Origin of asymmetry





Radial power is maximized using an outside array diameter of 40 mm containing 240 wires.

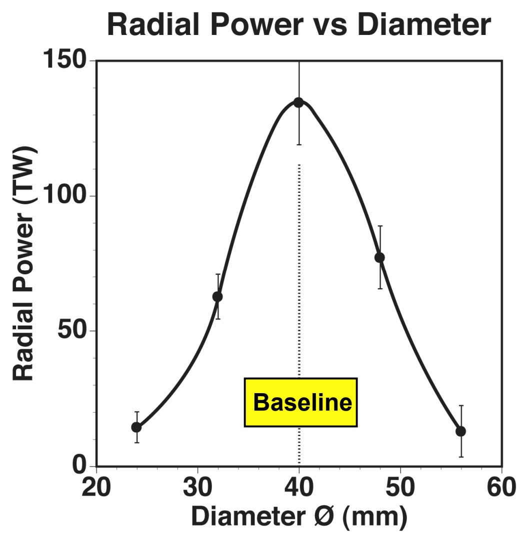


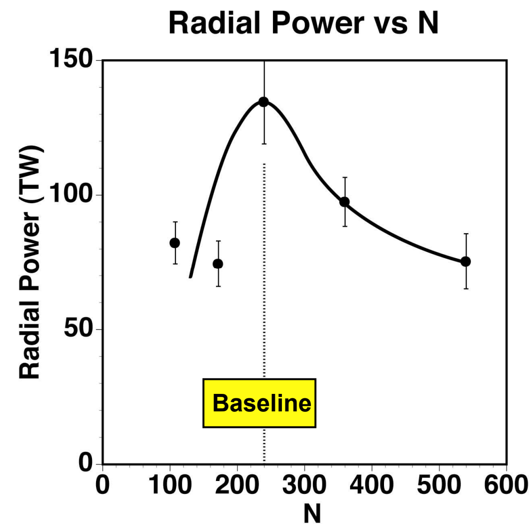
$$M_I = M_O/2$$

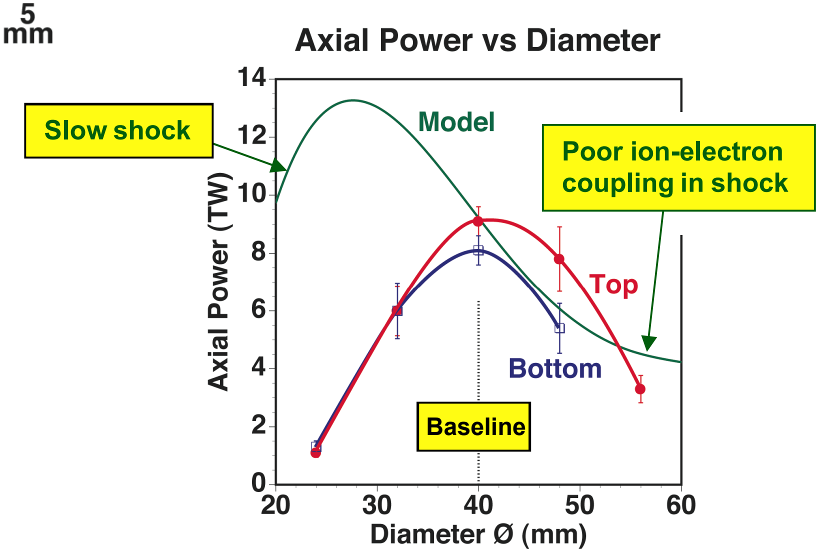
$$Ø_I = Ø_O/2$$

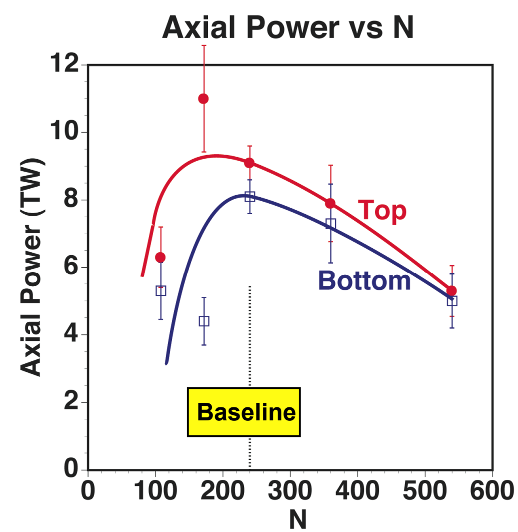
$$N_I = N_O/2$$

$$M_T = M_O + M_I$$

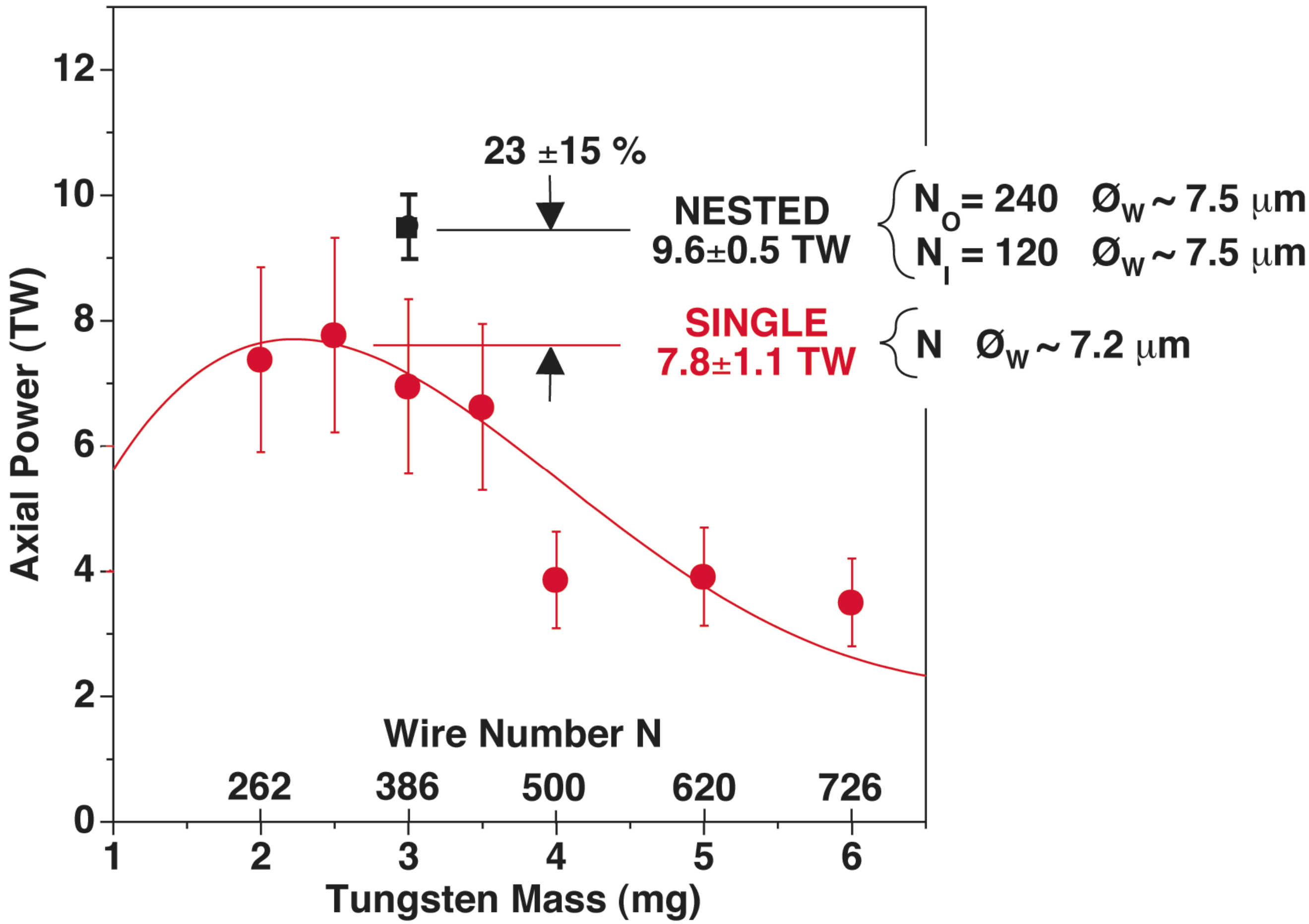








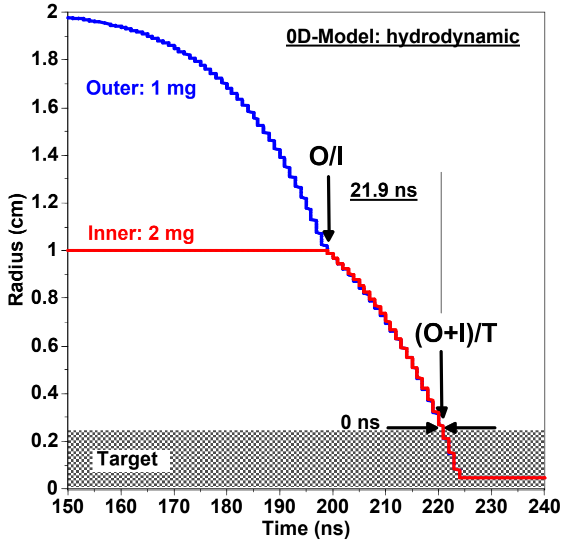
Adding inner array increases axial power by only 23±15% in contrast to RMHD simulations which predicted factor of 2-3 increase.

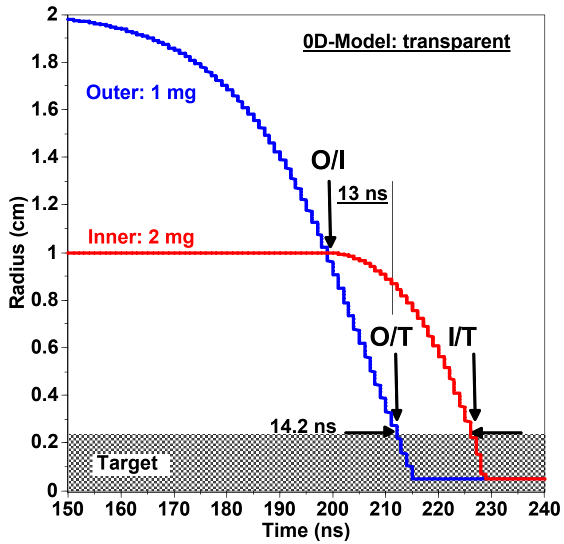


Simulation assumes O/I collision is hydrodynamic

Measurements suggest outer array passes through inner array with current switching from outer to inner.

Outer = 1 mg   Inner = 2 mg

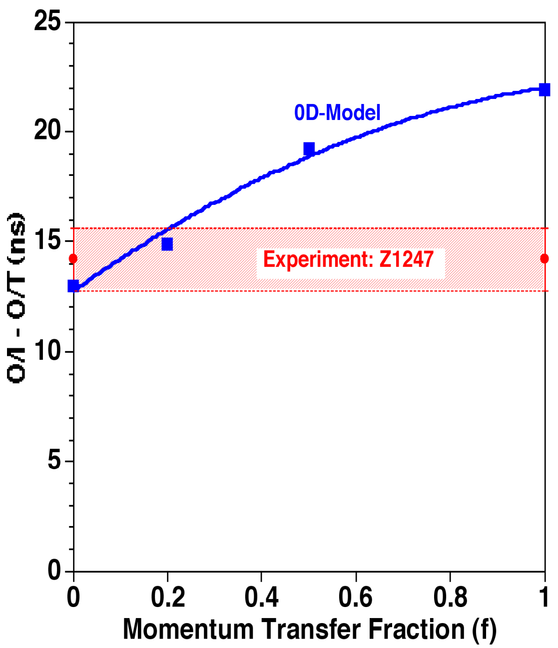




Simulations show dynamics same if mass of O and I is reversed.

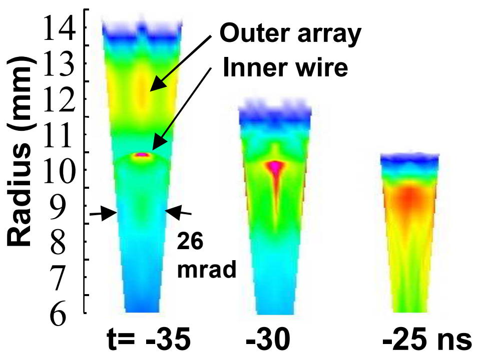
Permits hydrodynamic to be distinguished from transparent mode.

Time between outer hitting inner array and outer hitting target agrees with transparency

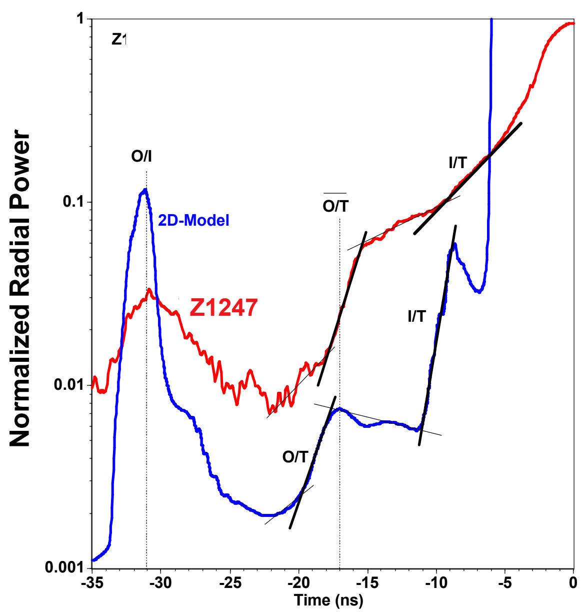


2D xy model (Chittenden)

Z1247 1x2

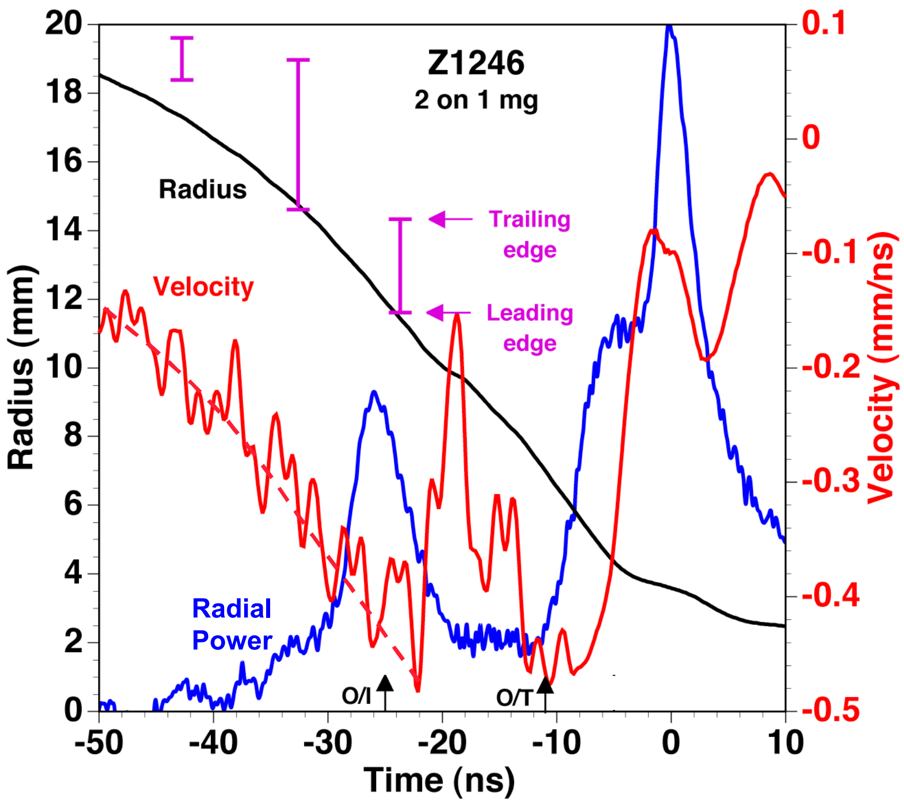


2D xy model qualitatively tracks measured radial power

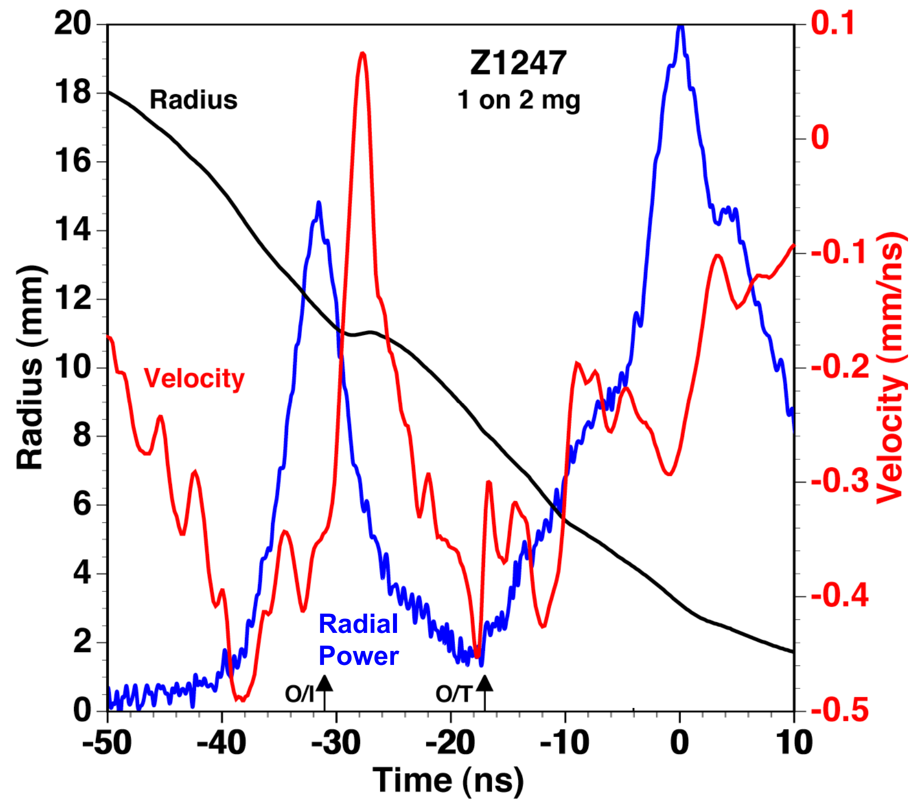


Comparison of radiation with current radius suggests current switching from O to I occurs after O/I collision begins.

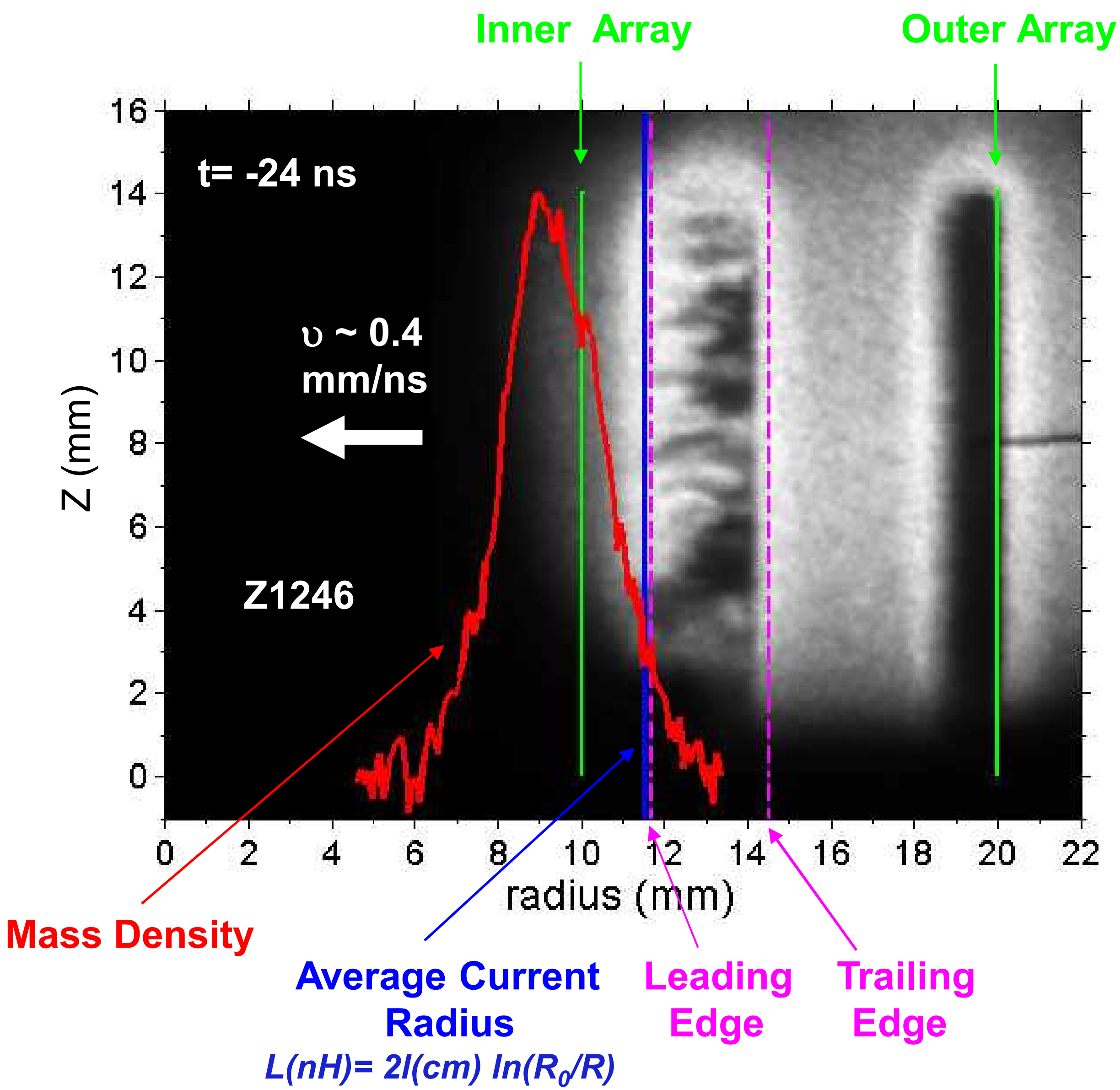
Only slight inflection in current radius when *heavy* outer array passes through *light* inner array and current switches to inner.



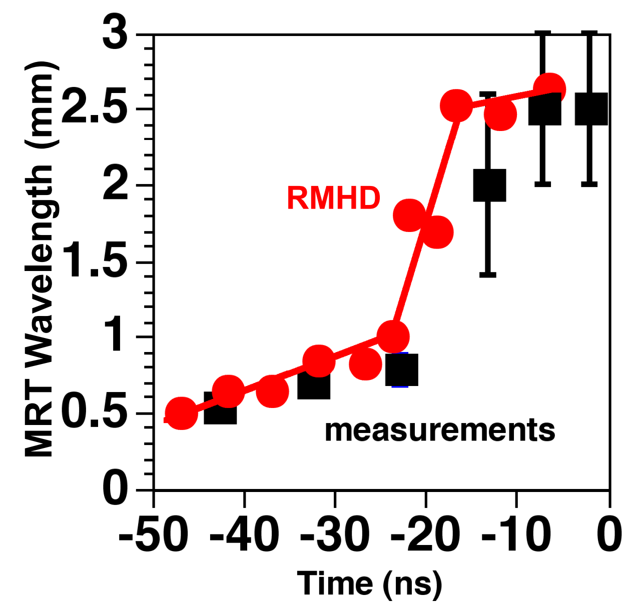
Significant inflection in current radius when *light* outer array passes through *heavy* inner array and current switches to inner.



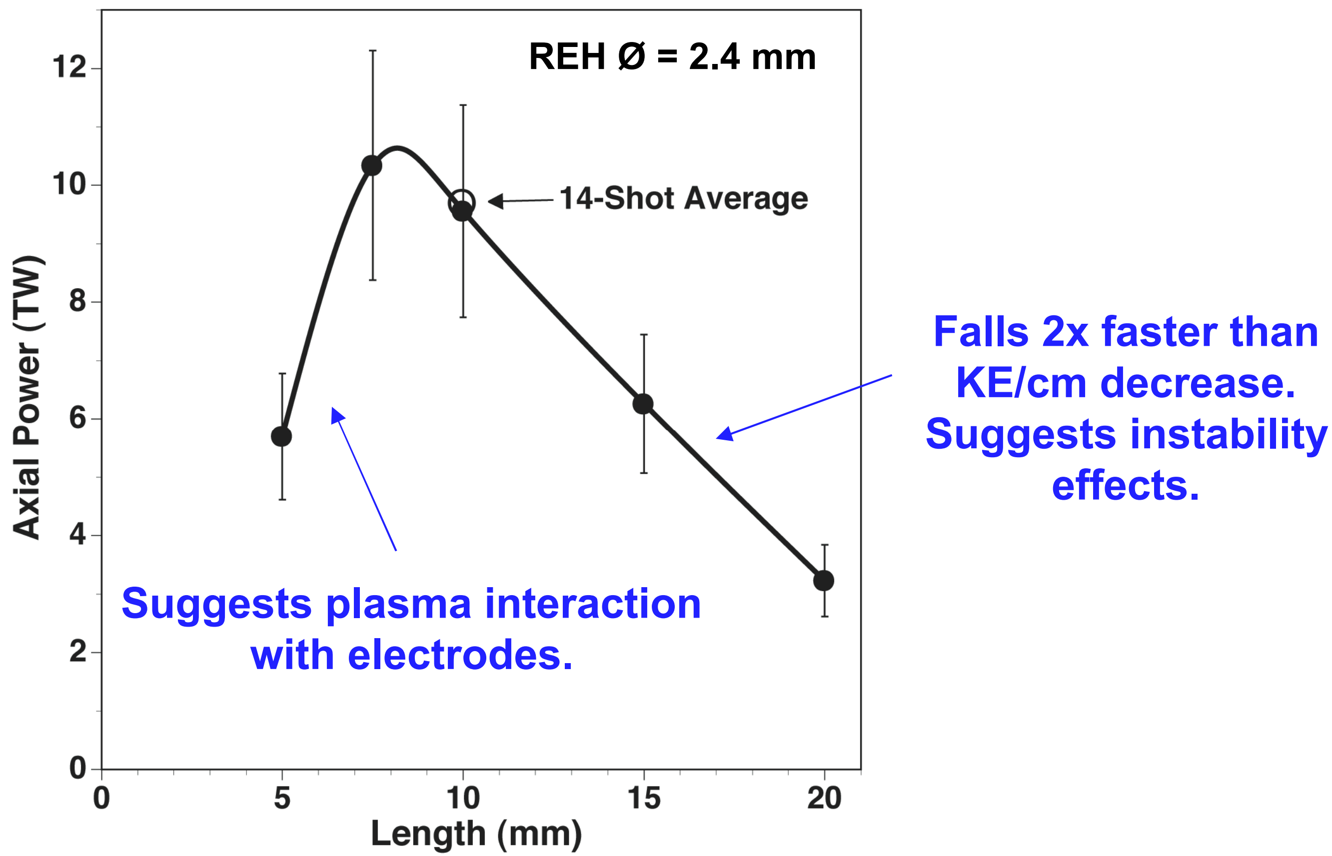
Average current follows leading edge of MRT instability with main mass distribution ~3 mm ahead for baseline.



RMHD wave lengths agree with measured

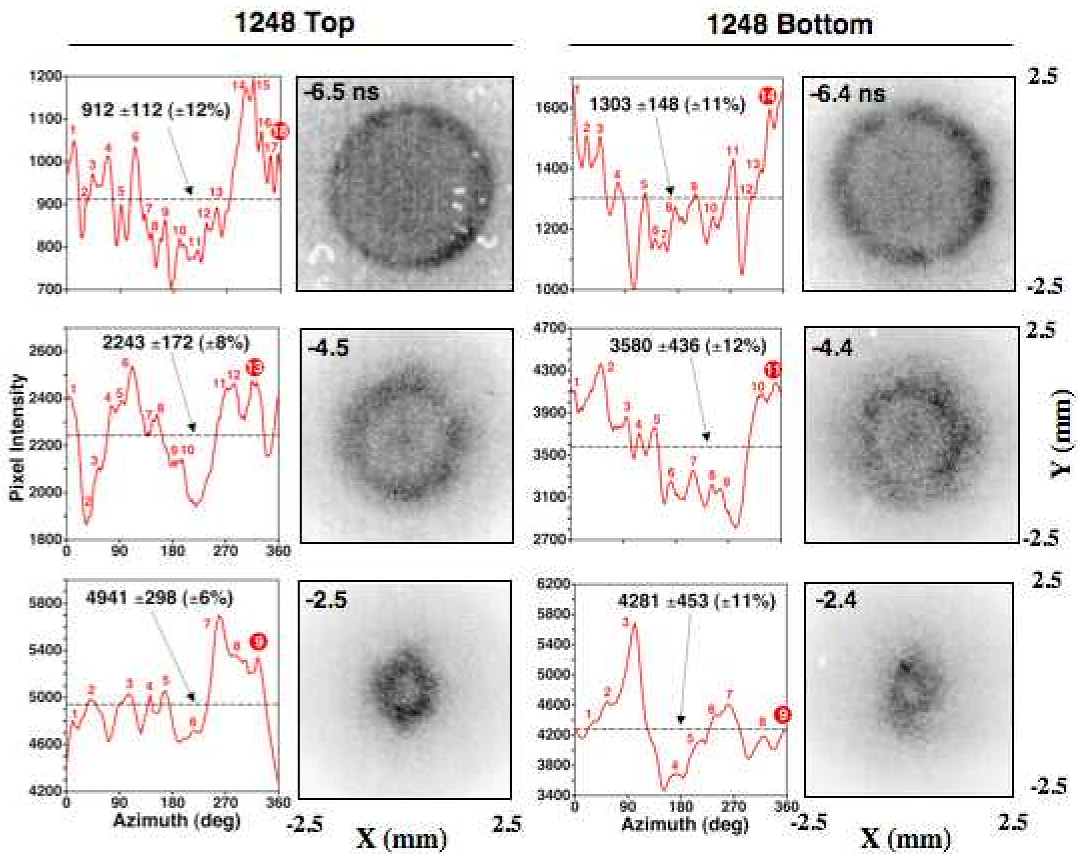


8-mm target length maximizes axial power: bounded by wire-electrode effects for L < 7 mm and reduced KE/cm and increased instabilities for L > 10 mm.

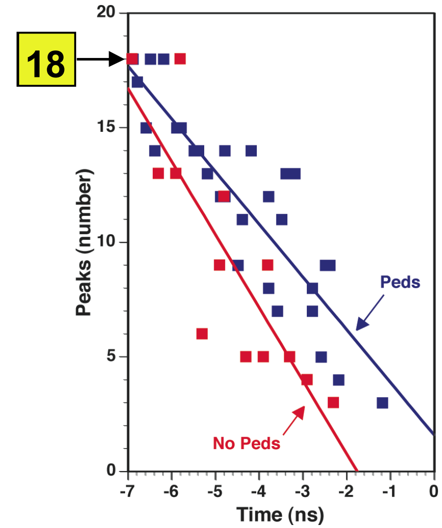


18 viewing slots imprints on developing shock.

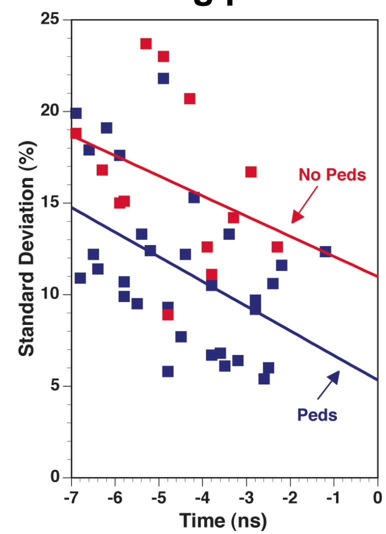
Developing shock

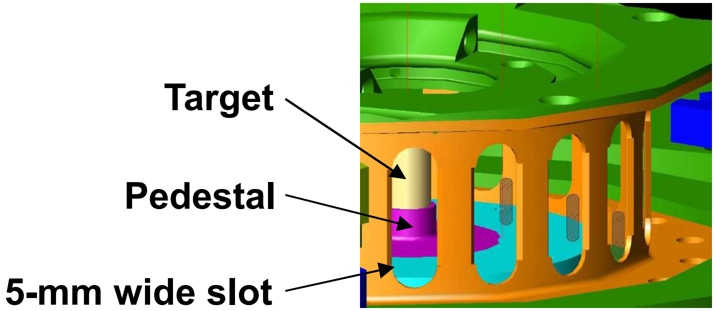


18 peaks measured azimuthally just when shell impacts target.



Azimuthal variation is less when using pedestals.

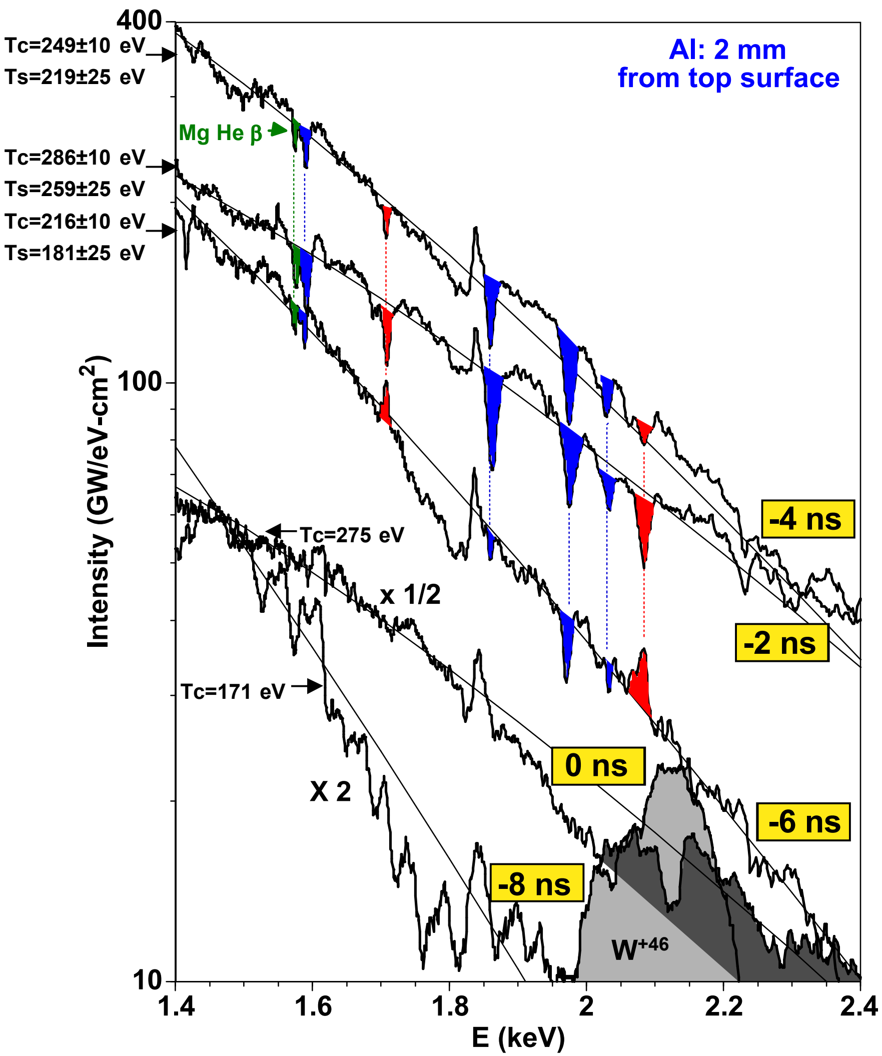




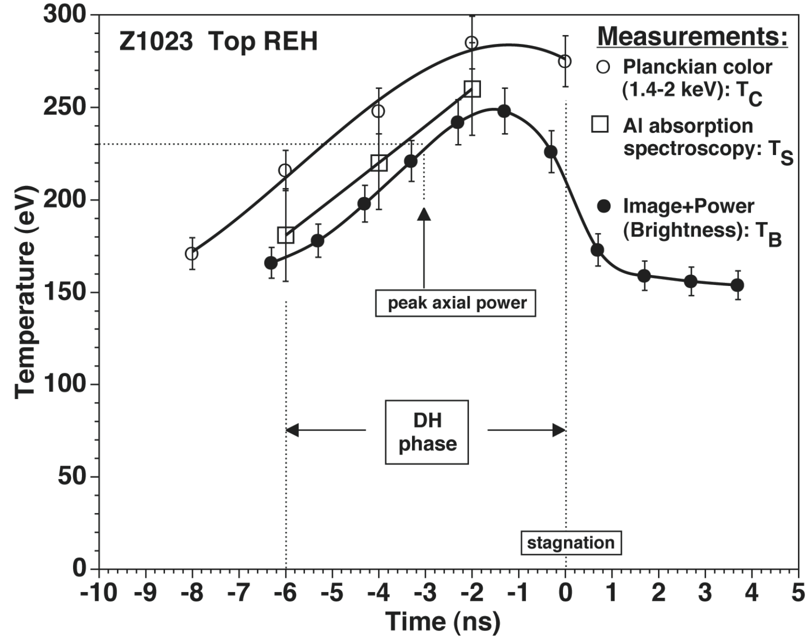
DH temperature reaches ~230 eV at peak axial power.

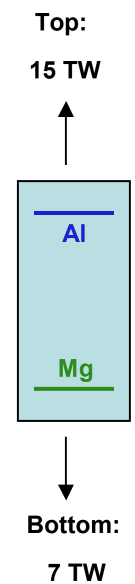
**(Apruzese et al POP 12, 1, 2005)*

Al K-shell spectra vs time



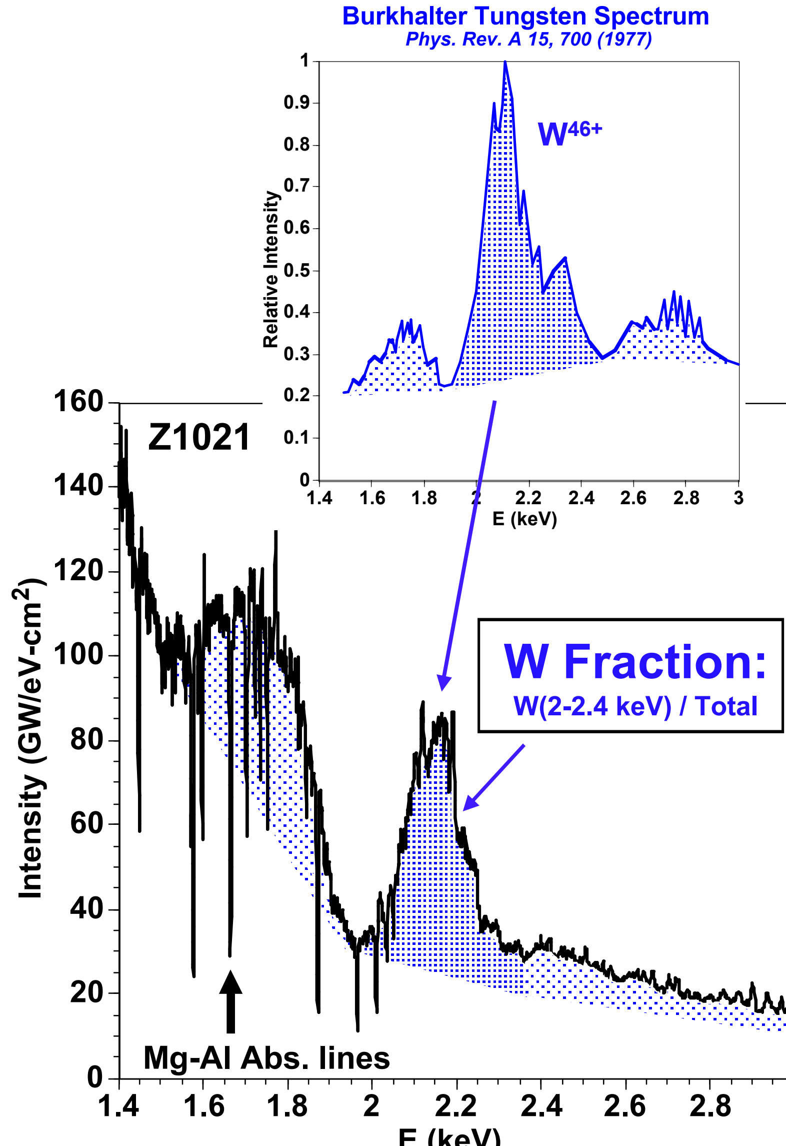
T extracted from K-shell spectra are consistent with brightness and color temperature



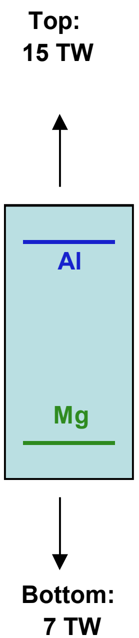


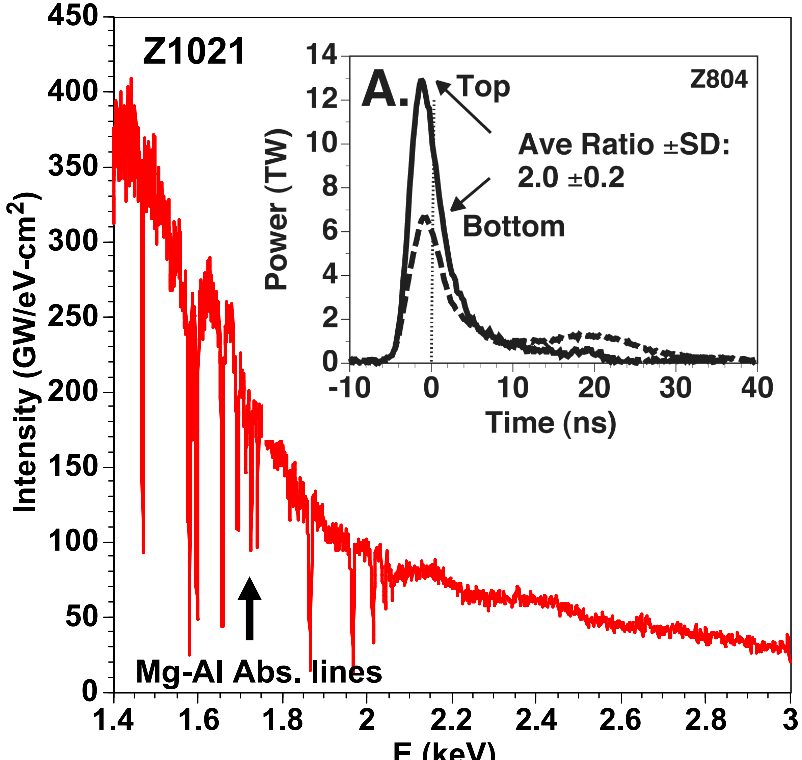
More tungsten present in bottom REH explains top/bottom axial power asymmetry.

Bottom: Time Integrated Spectrum



Top: Time Integrated Spectrum

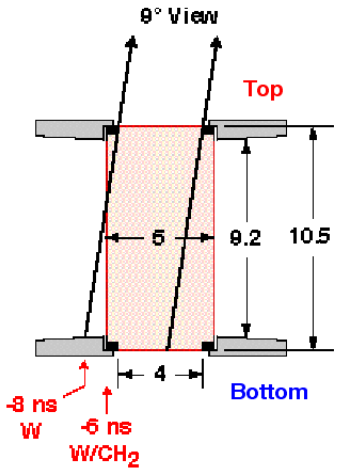




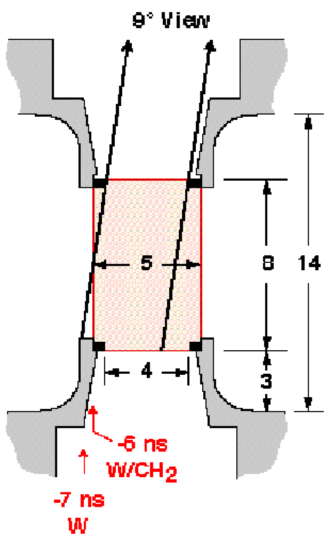
Annular pedestals eliminate early-time tungsten plasma and roughly equalize axial powers.

Target

Baseline

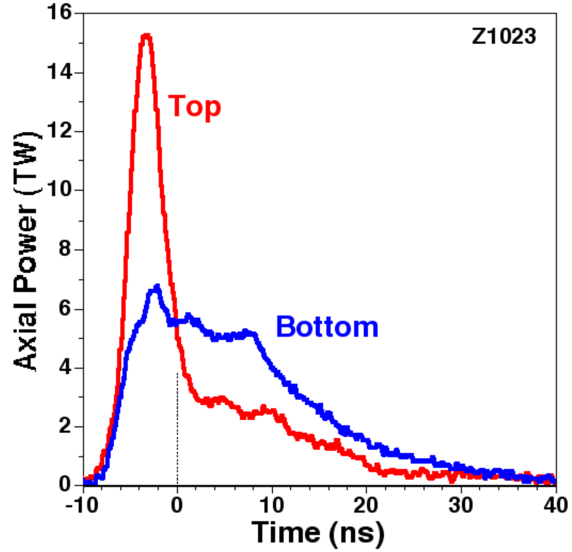


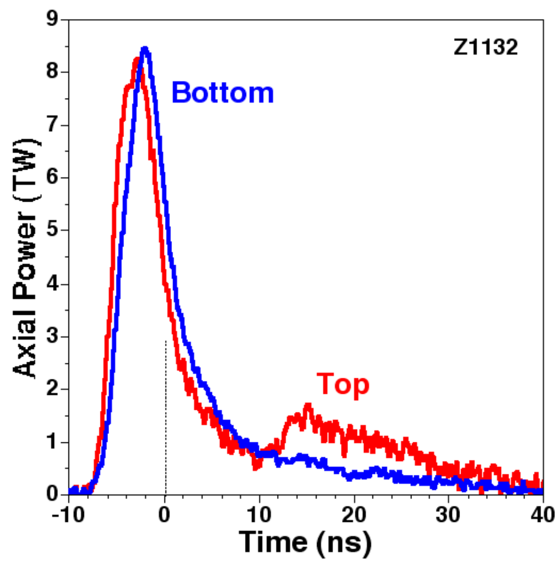
Pedestal



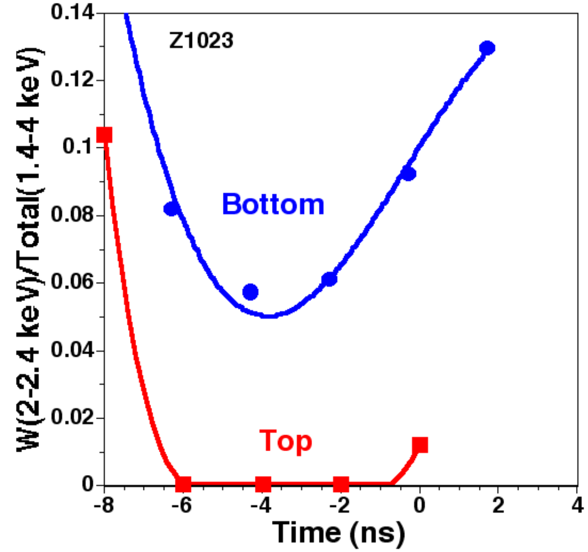
(Dimensions in mm)

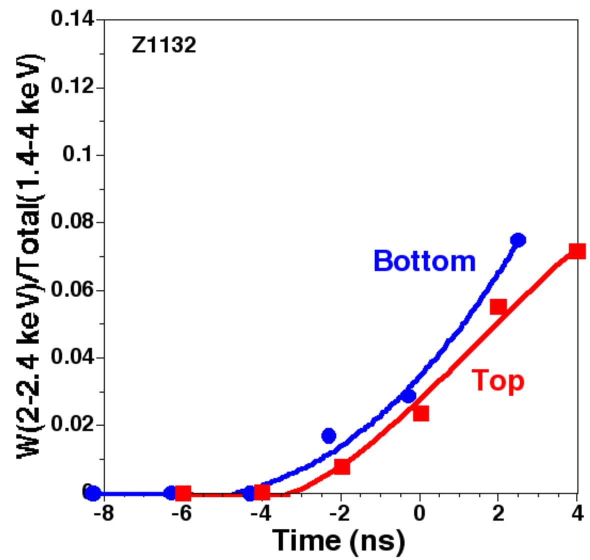
Axial power



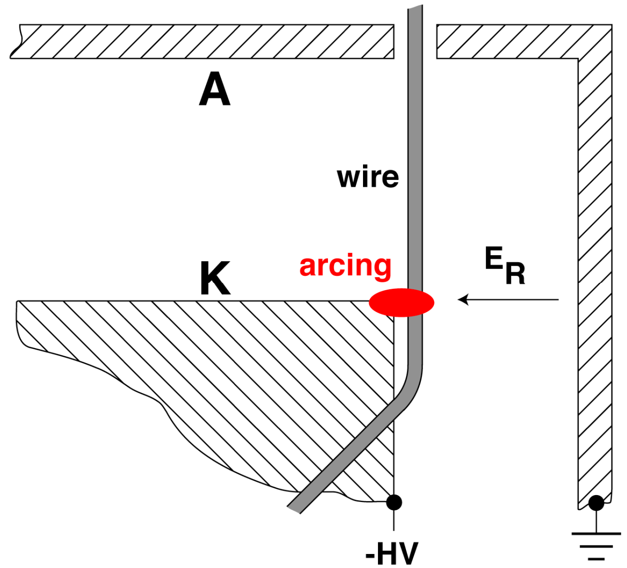


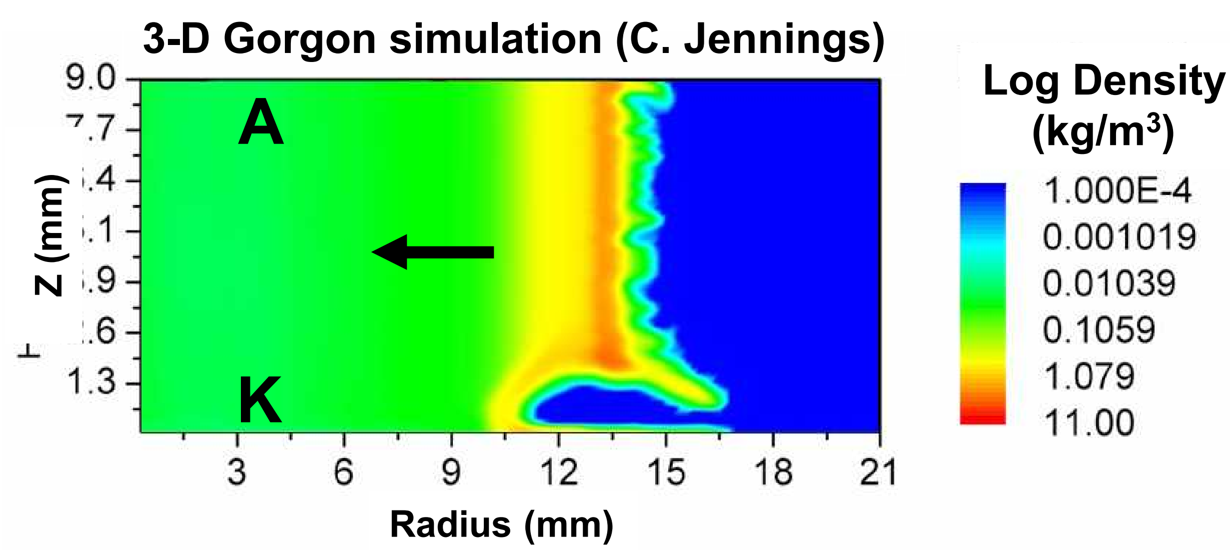
Tungsten fraction

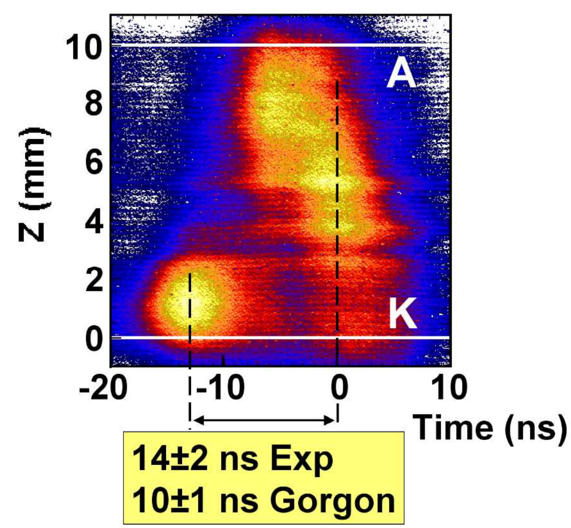




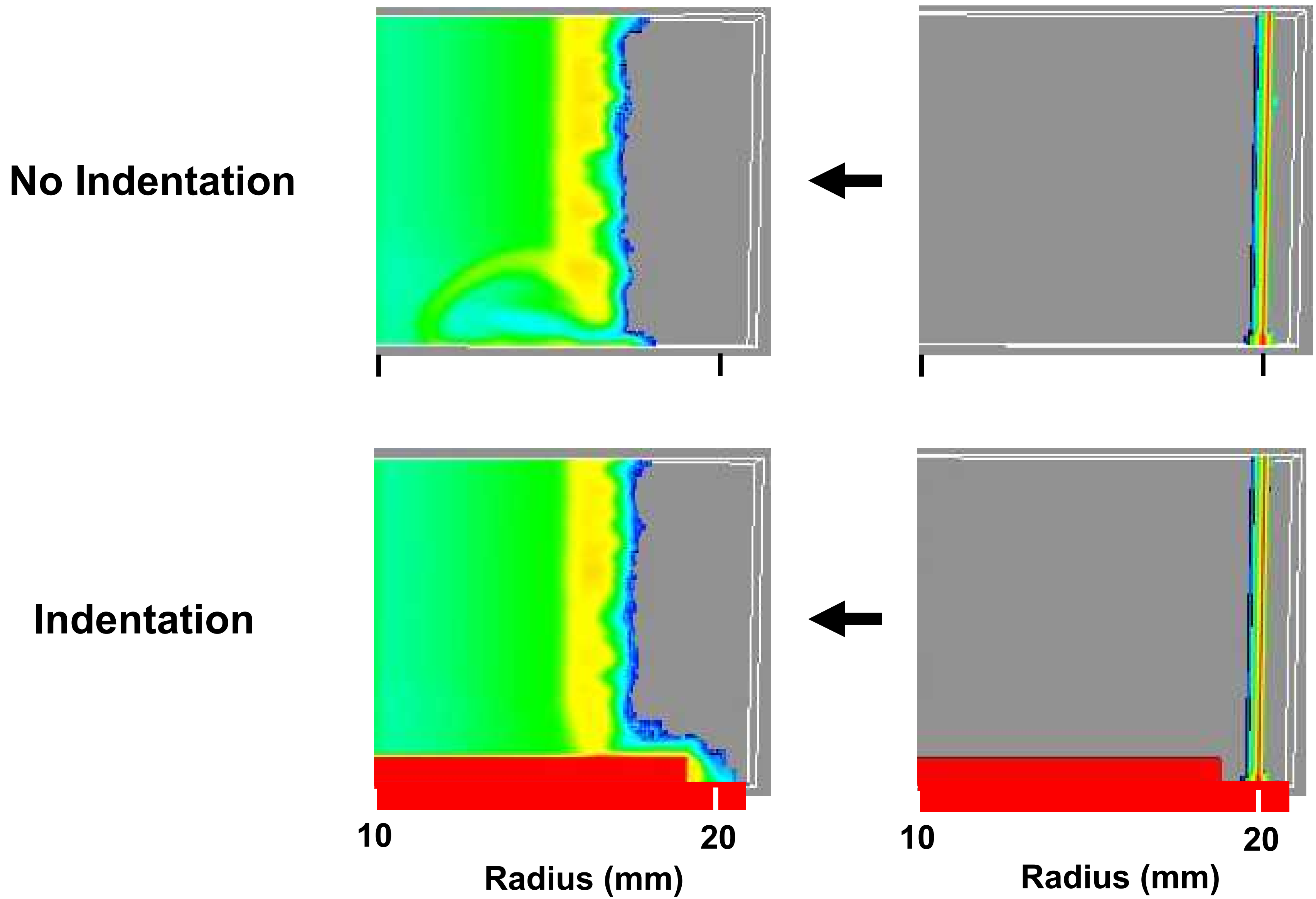
The early tungsten near the cathode may be due to arcing between the wires and cathode.



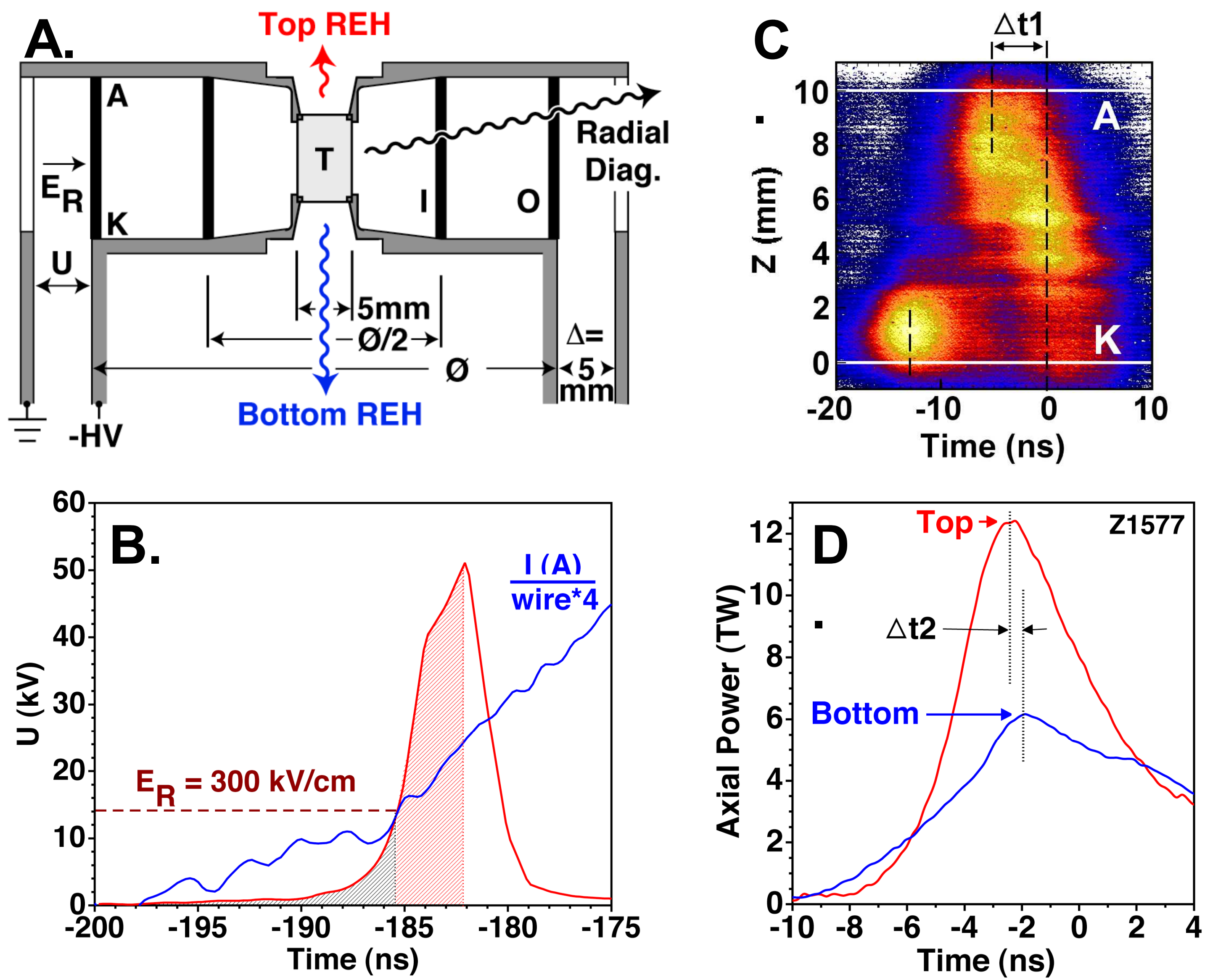




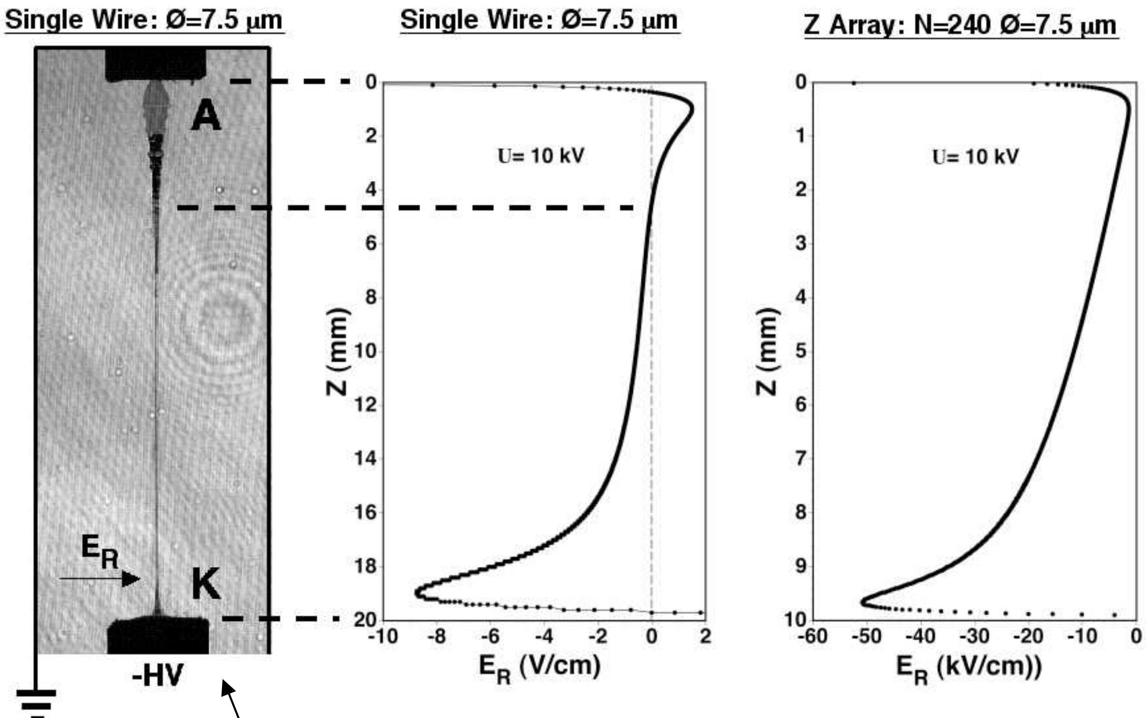
Gorgon simulation using cathode indentation shows W precursor from arcing is eliminated at target.

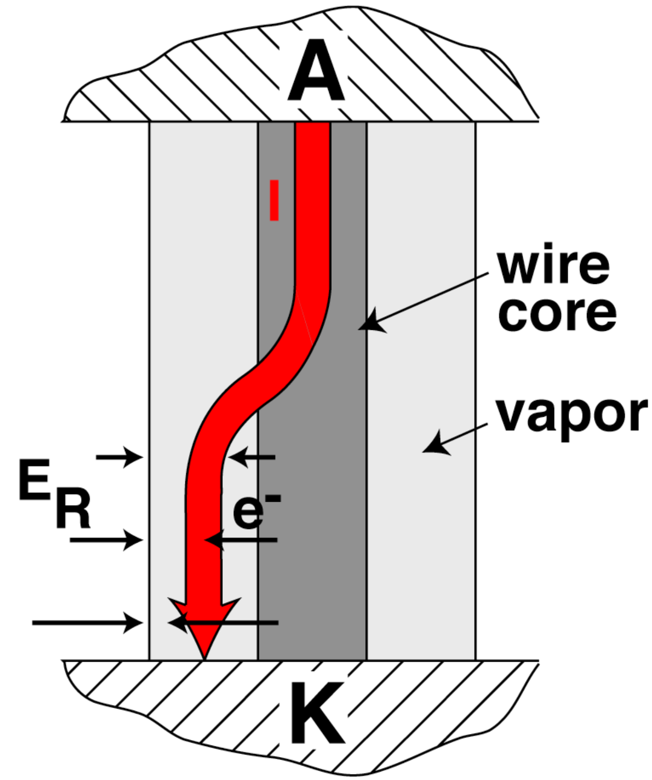


Axial zippering at target leads to further axial radiation asymmetry.



Radial electric field E_R modulates current shunting in wires.

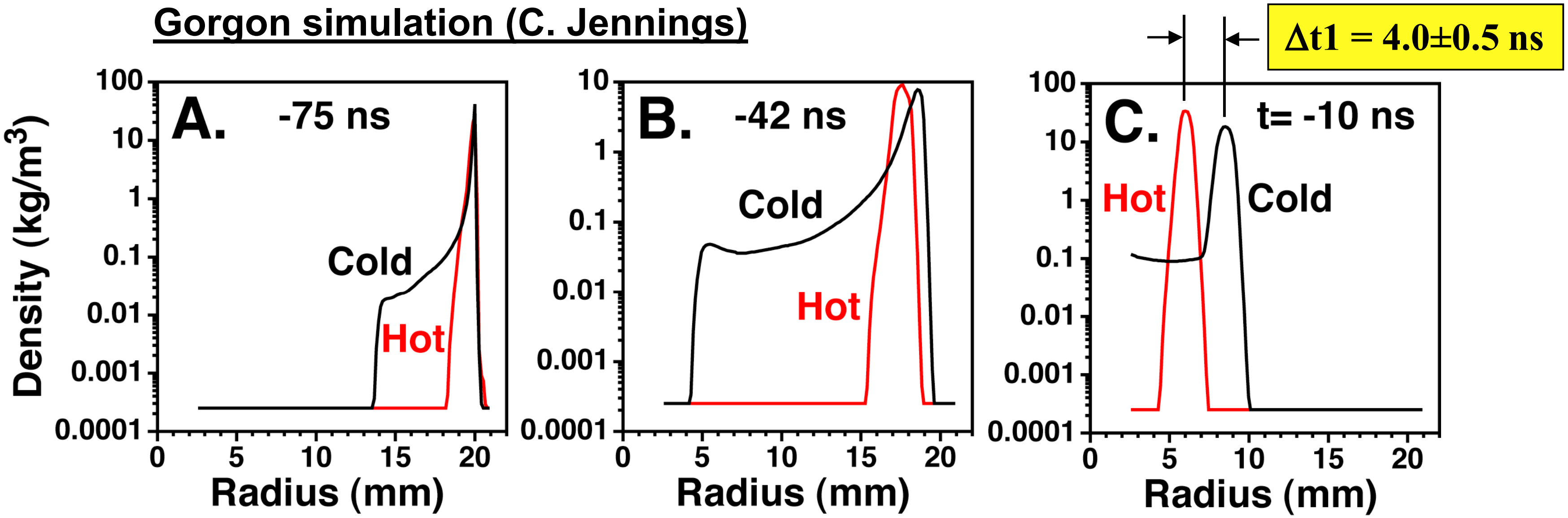


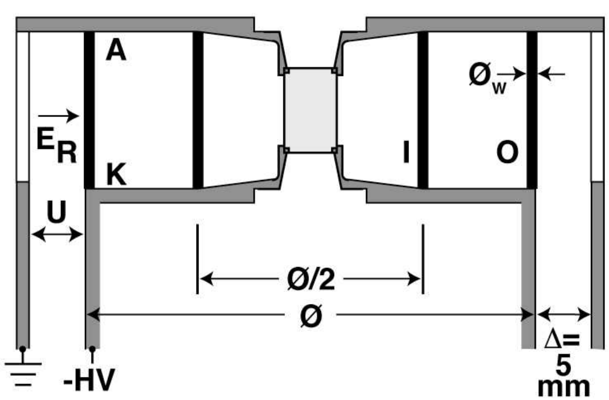


G. Sarkisov, etal, Phys. Rev. E **66**, 046413 (2002)

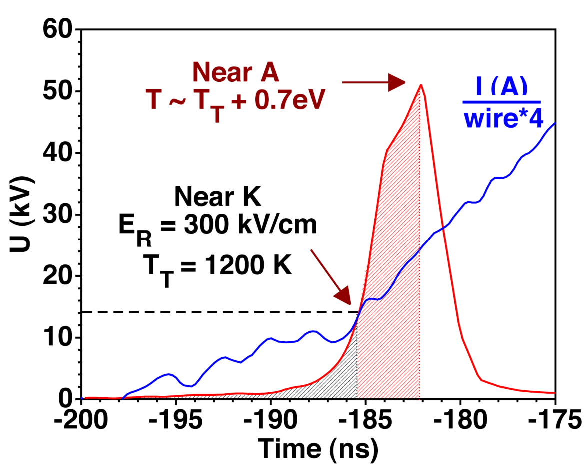
Simulated time difference of zipper Δt1 is in agreement with measured difference.

Gorgon simulation (C. Jennings)

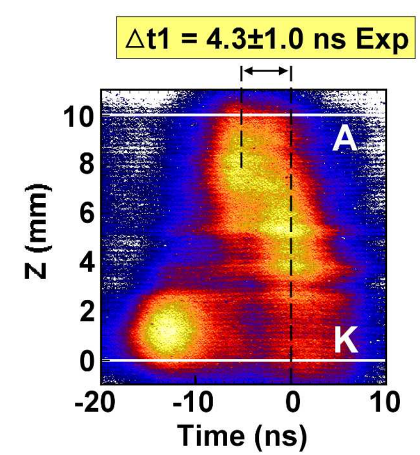




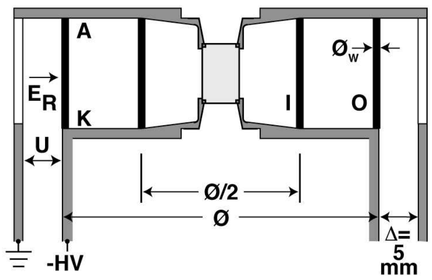
AK voltage (S. Rosenthal)



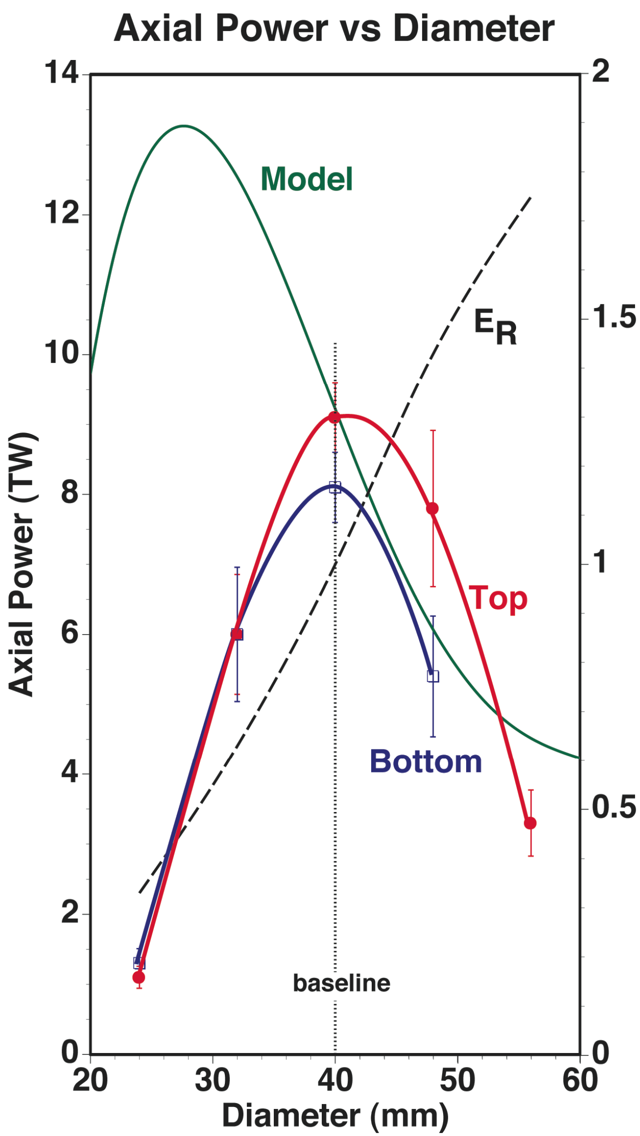
X-ray streak camera image

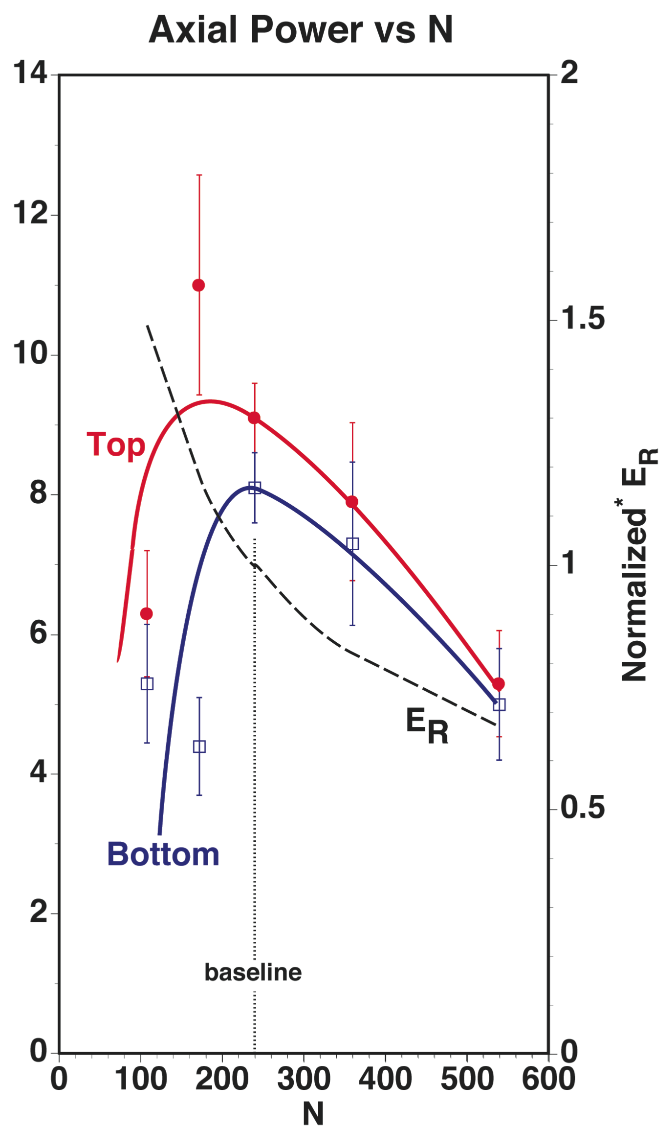


Top / bottom axial power asymmetry increases with E_R.



$$E_R = \frac{U}{2\Delta} \cdot \frac{Ø}{Ø_w N}$$



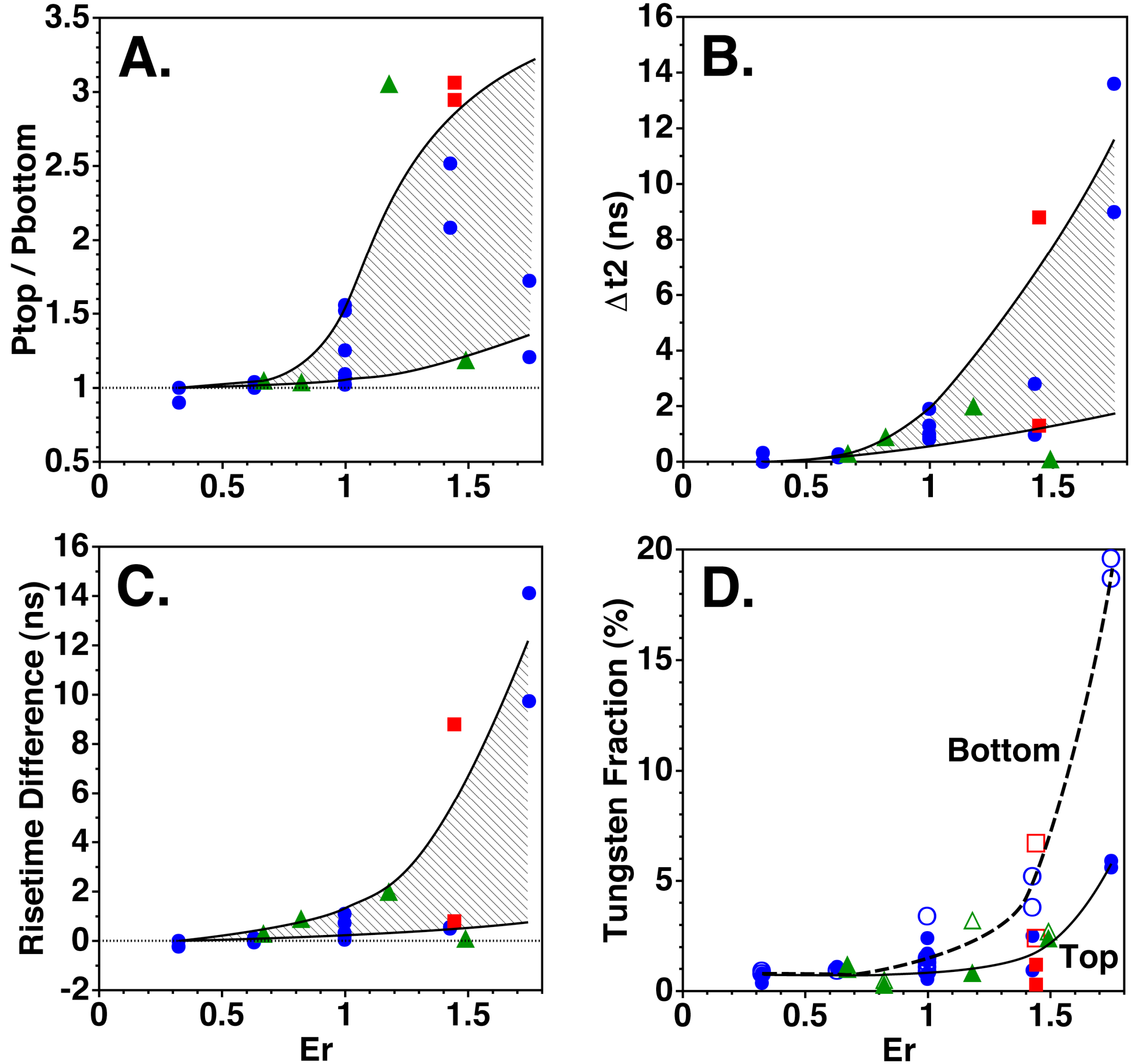


* E_R normalized to baseline E_R

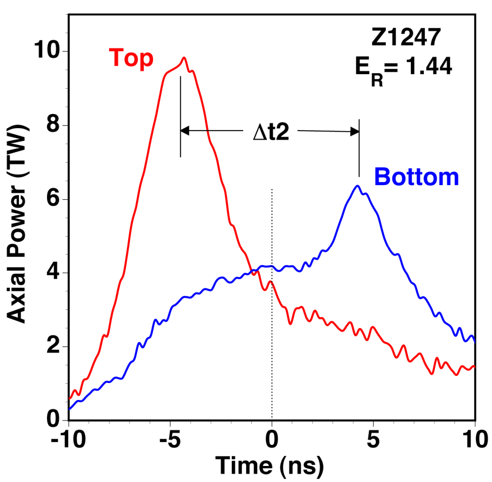
Data suggests keeping relative radial electric field E_R below ~0.8 for axially symmetric implosion.

Table I. Outer wire array parameters.

Symbol	Array Ø (mm)	N	Wire Ø (μm)	Er
●	56	288	5	1.75
	48	240	6.3	1.43
	40	240	7.5	1
	32	256	8.9	0.63
	24	332	10	0.33
■	40	240	5.2	1.44
▲	40	108	11.2	1.49
	40	172	8.9	1.18
	40	360	6.1	0.82
	40	540	5	0.67



Reverse-mass configuration



Summary

I. Axial power is maximized using an outer array diameter of 40 mm containing 240 wires and using a target height of 8 mm.

II. The O/I collision is transparent like.

III. The viewing slots result in imprinting on the developing shock within the target.

IV. Pedestals remove the bulk precursor plasma *(due to arcing at wire-electrode contact)* crossing the REHs thus improving axial radiation symmetry.

V. Residual axial radiation asymmetry ma be controlled by the axial uniformity of the initial energy deposition into the wires, which is correlated to the magnitude of the negative radial electric field along the wire surface.

Sandia National Laboratories