SAND2008-2173C

Current Scaling of Axially Radiated Power in Dynamic Hohlraums and Dynamic Hohlraum Load Design for ZR

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We present designs for dynamic hohlraum z-pinch loads on the 28 MA, 140 ns driver ZR. The scaling of axially radiated power with current in dynamic hohlraums is reviewed. With adequate stability on ZR this scaling indicates that 30 TW of axially radiated power may be possible. The baseline z-pinch load on Z is a nested tungsten wire array imploding onto on-axis foam. Data from a variety of x-ray diagnostics fielded on Z are presented. These diagnostics include x-ray diodes, bolometers, fast x-ray imaging cameras, and crystal spectrometers. Analysis of these data indicates that the peak dynamic radiation temperature on Z is between 250 and 300 eV from a diameter less than 1 mm. 1D simulations of the dynamic hohlraum implosion are presented and compared to experimental data. An analytic model for the current scaling of the axially radiated power is also presented and compared to experimental data. Both models and experimental data indicate that the axially radiated power scales roughly as the cube of the current.

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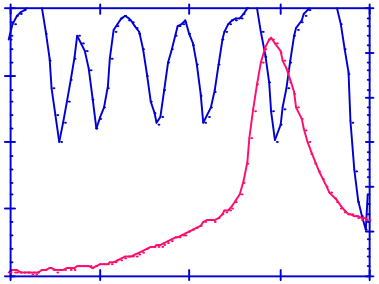
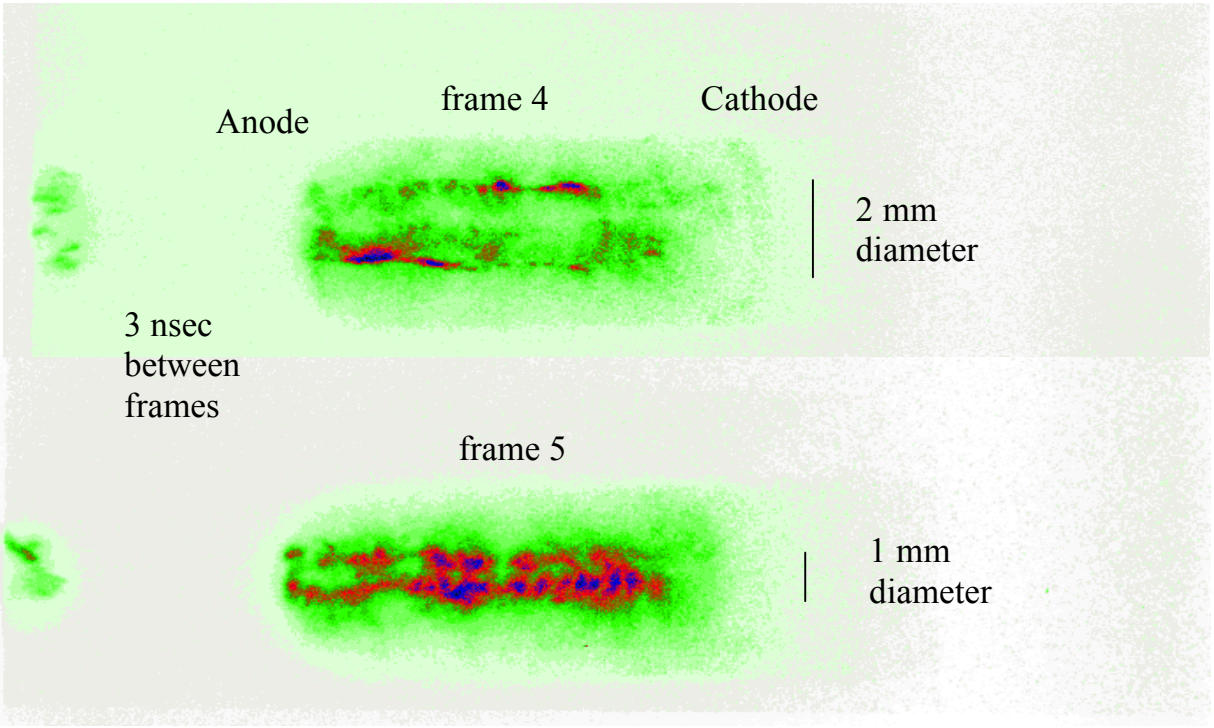
Side-on dynamic hohlraum images from the 7-MA SATURN generator

Large format images for Saturn Dynamic Hohlraum Shot 2261 show an open pinch at 1 mm diameter





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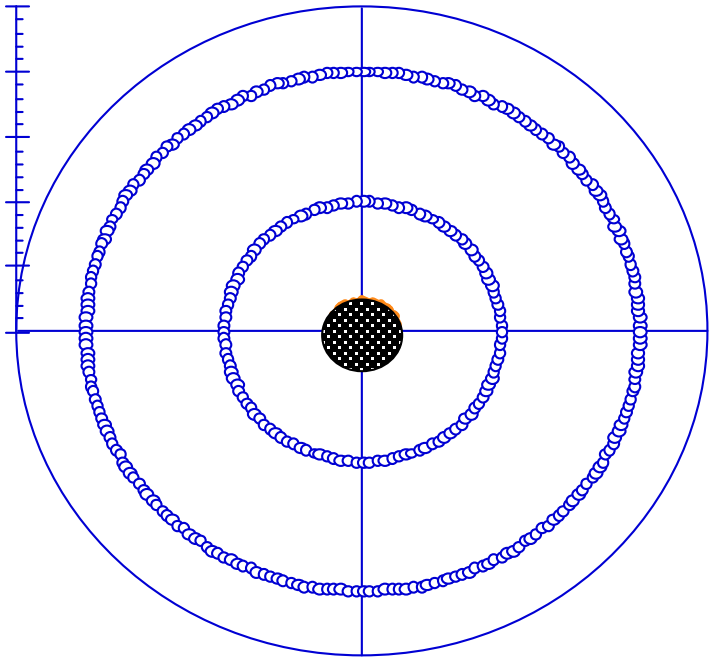
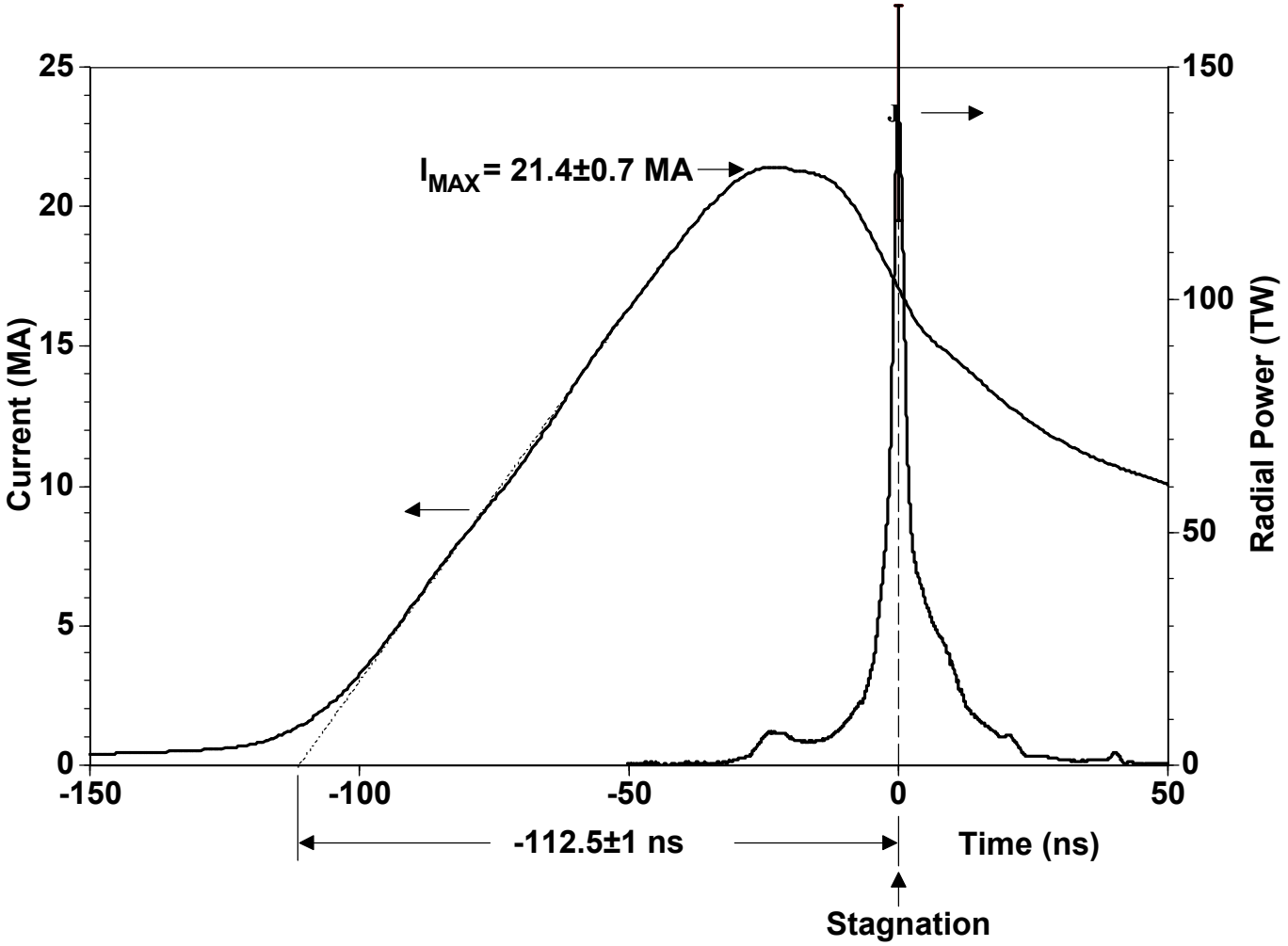
Dynamic Hohlraum Load Configuration on Z.



Load Current and Radially Radiated Power for Dynamic Hohlraum on Z.



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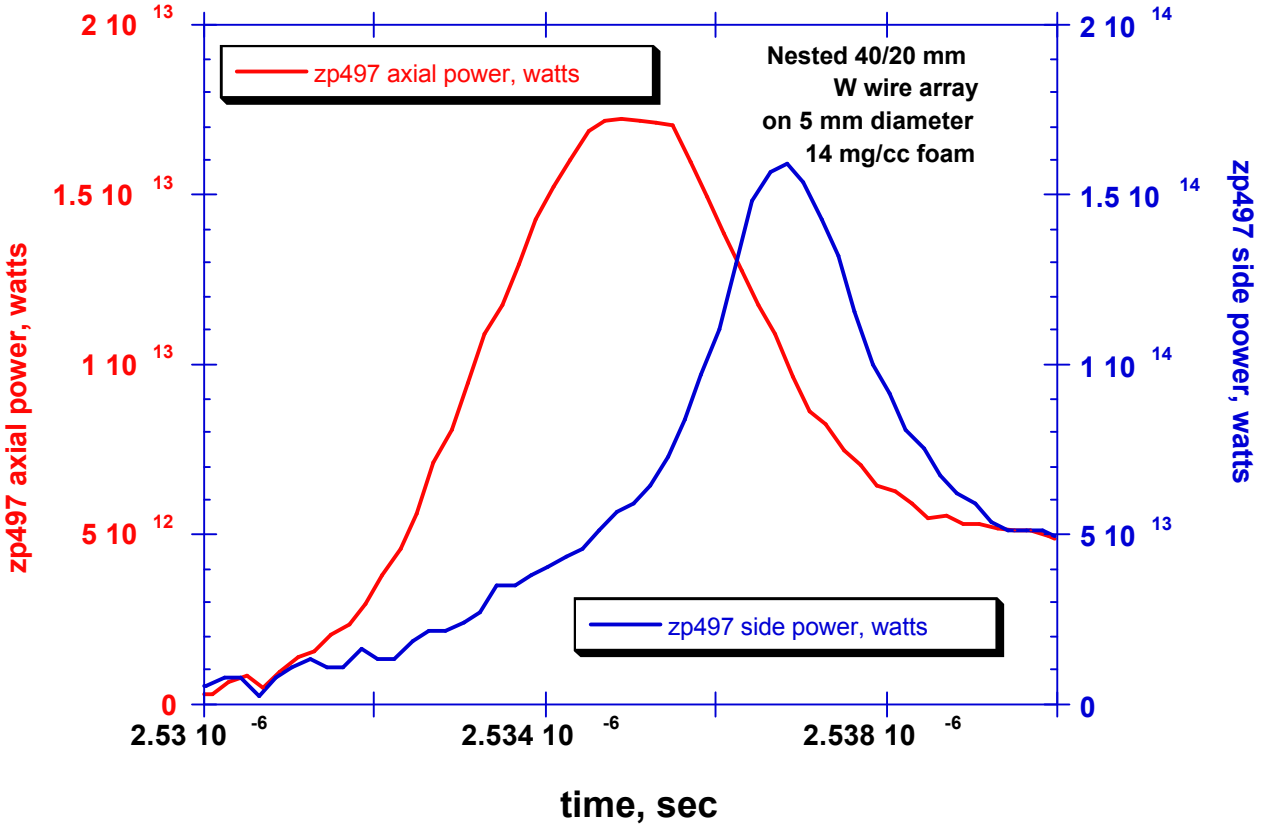
Axially and Radially Radiated Power for Dynamic Hohlraum on Z.



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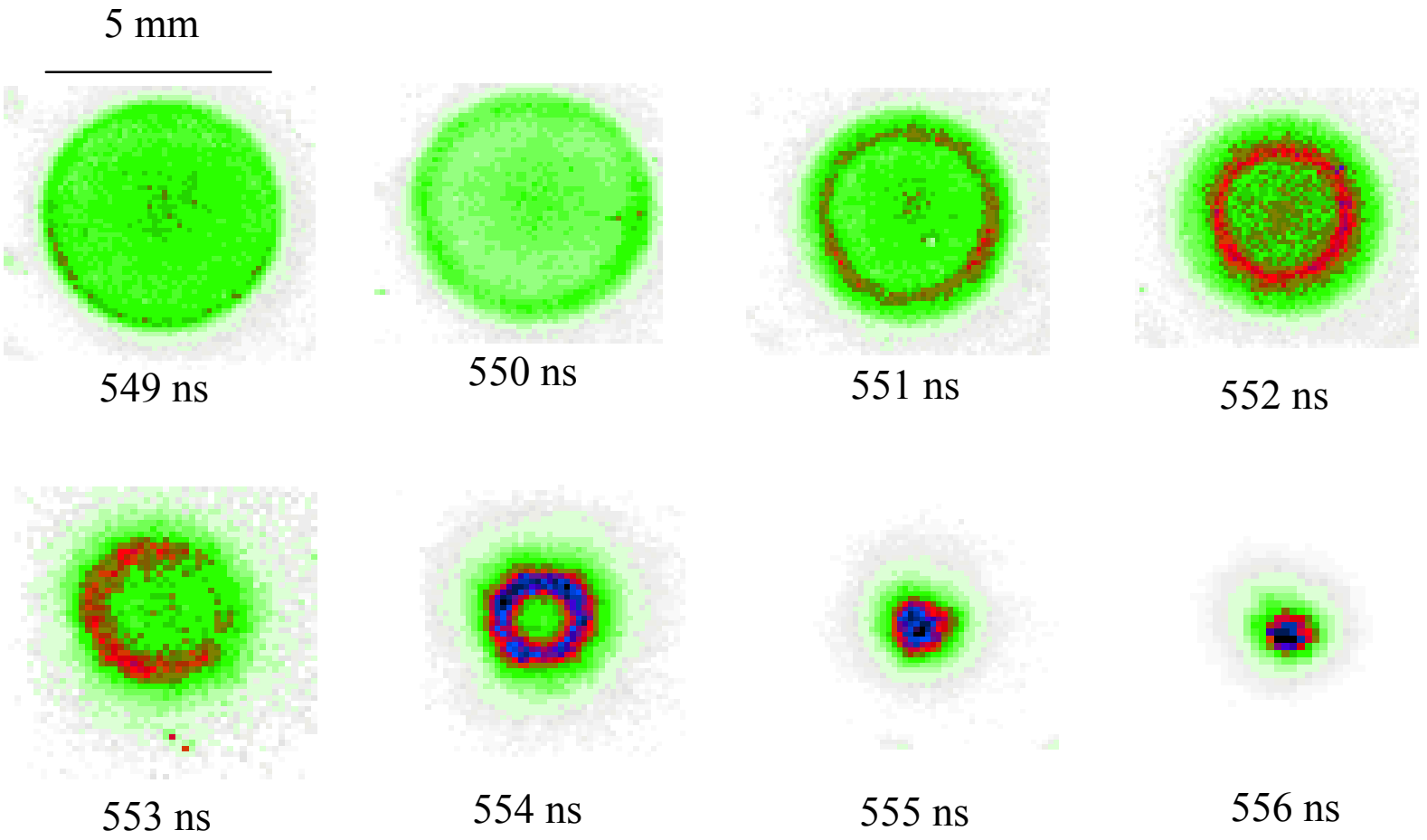
On-axis time-resolved x-ray images of imploding radiating shock wave in dynamic hohlraum on Z.



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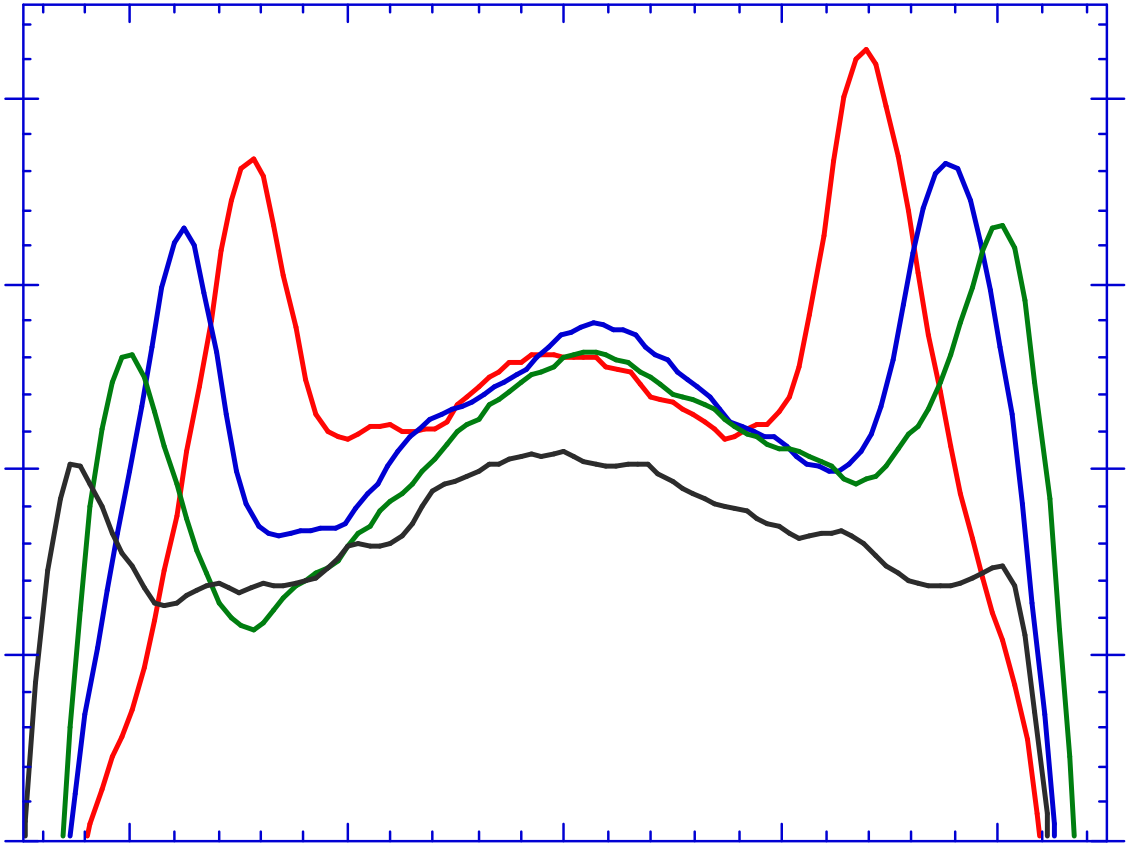
Line-outs of x-ray images normalized to radiation temperature for dynamic hohlraum on Z.



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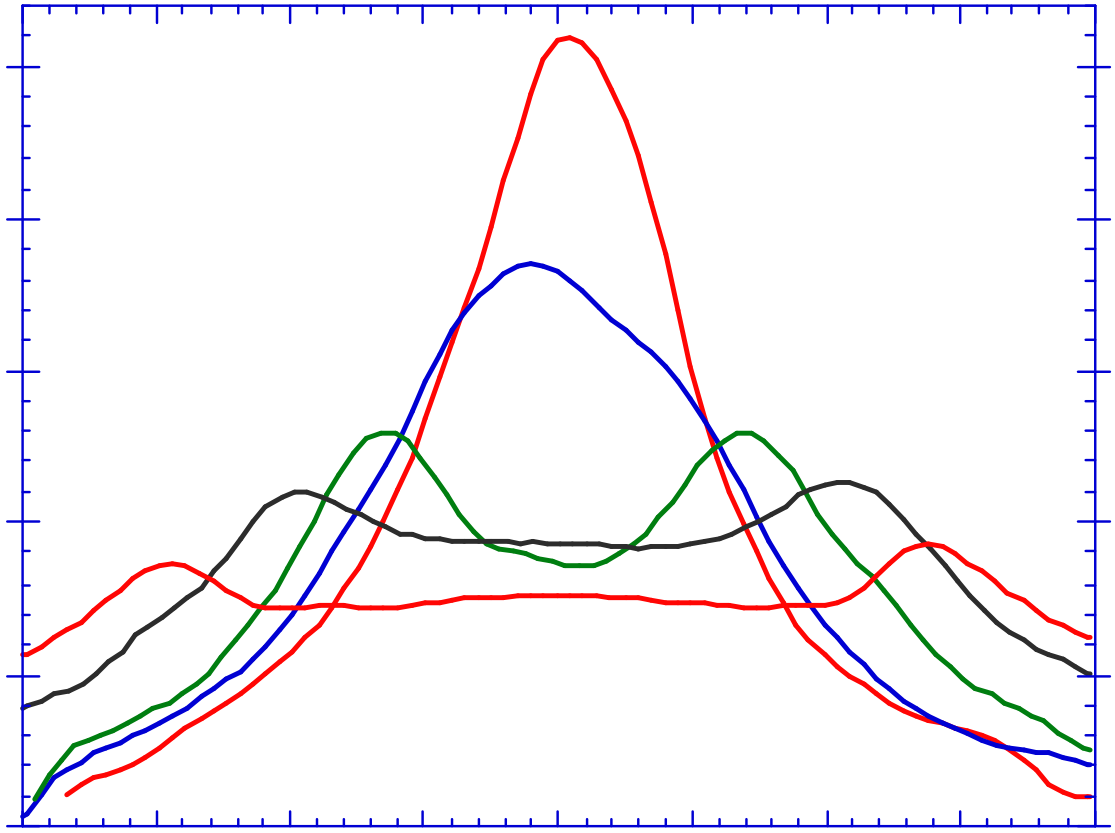
Line-outs of x-ray images normalized to radiation temperature for dynamic hohlraum on Z.



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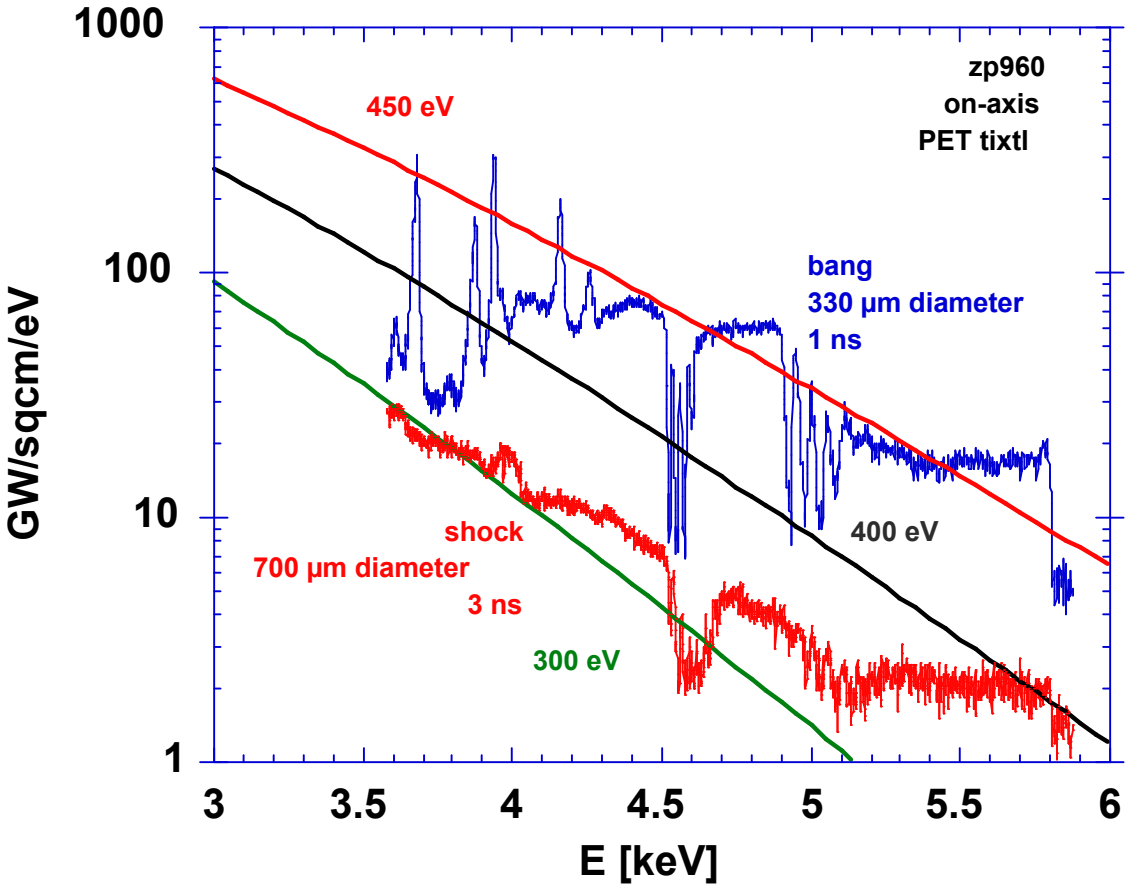
Data from spatially resolved on-axis time-integrated crystal spectrometer normalized with PCDs.



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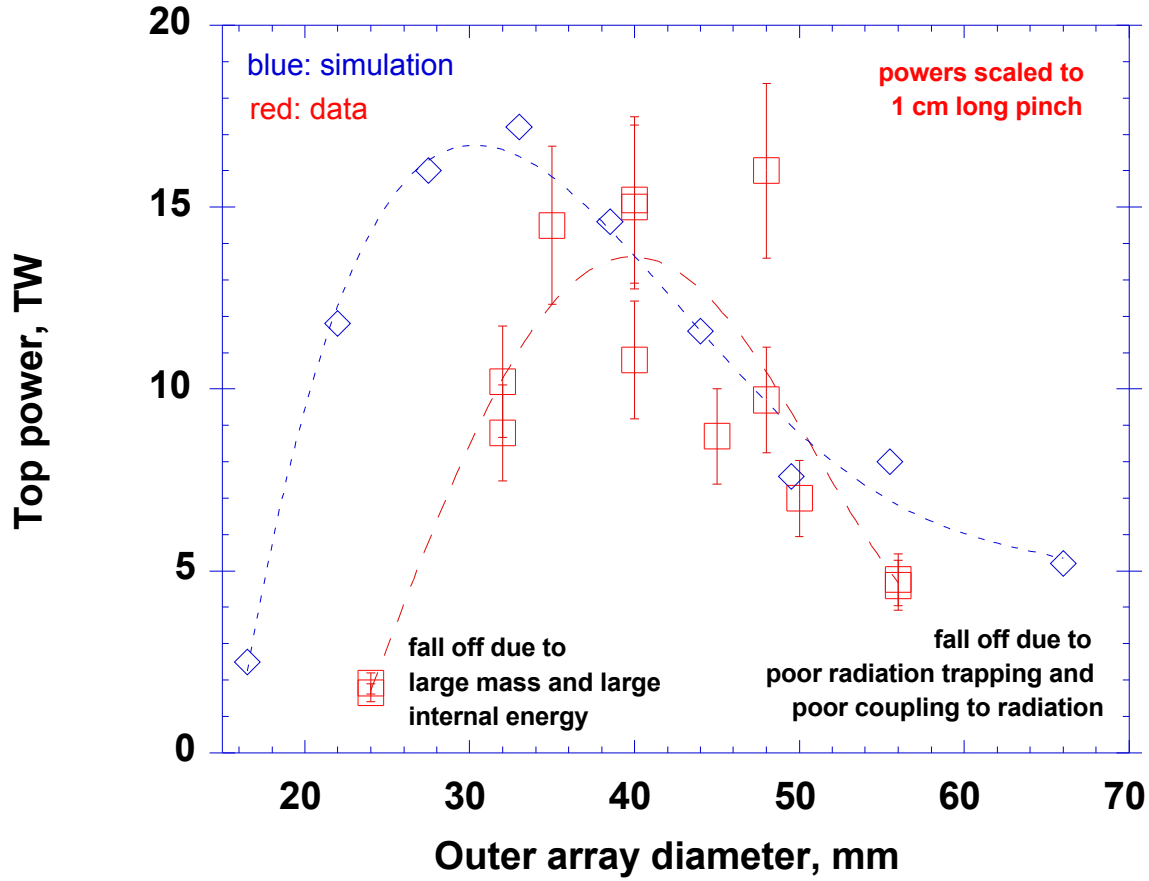
Comparison of data and simulation for fixed implosion time scan of dynamic hohlraum diameter on Z.



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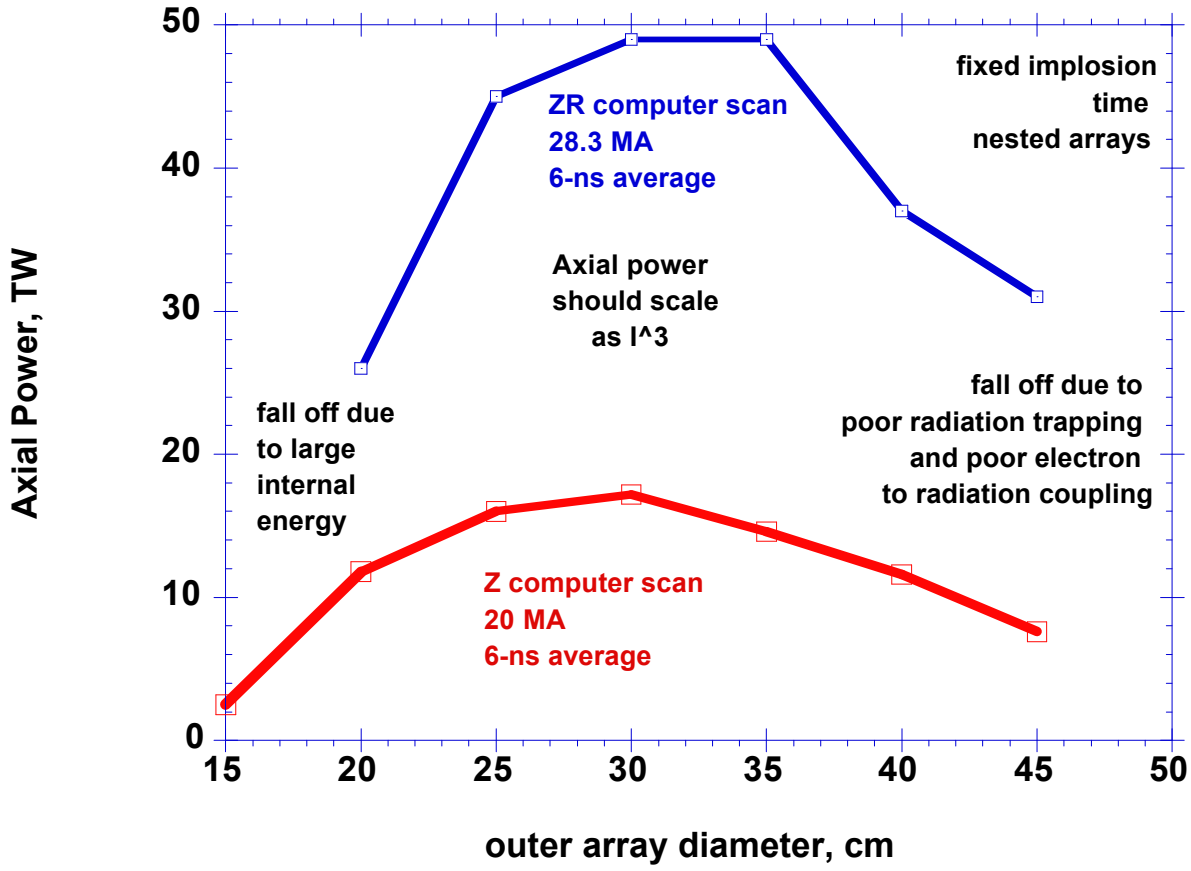
1D dynamic hohlraum simulations indicate that the axially radiated power scales roughly as the cube of the current.



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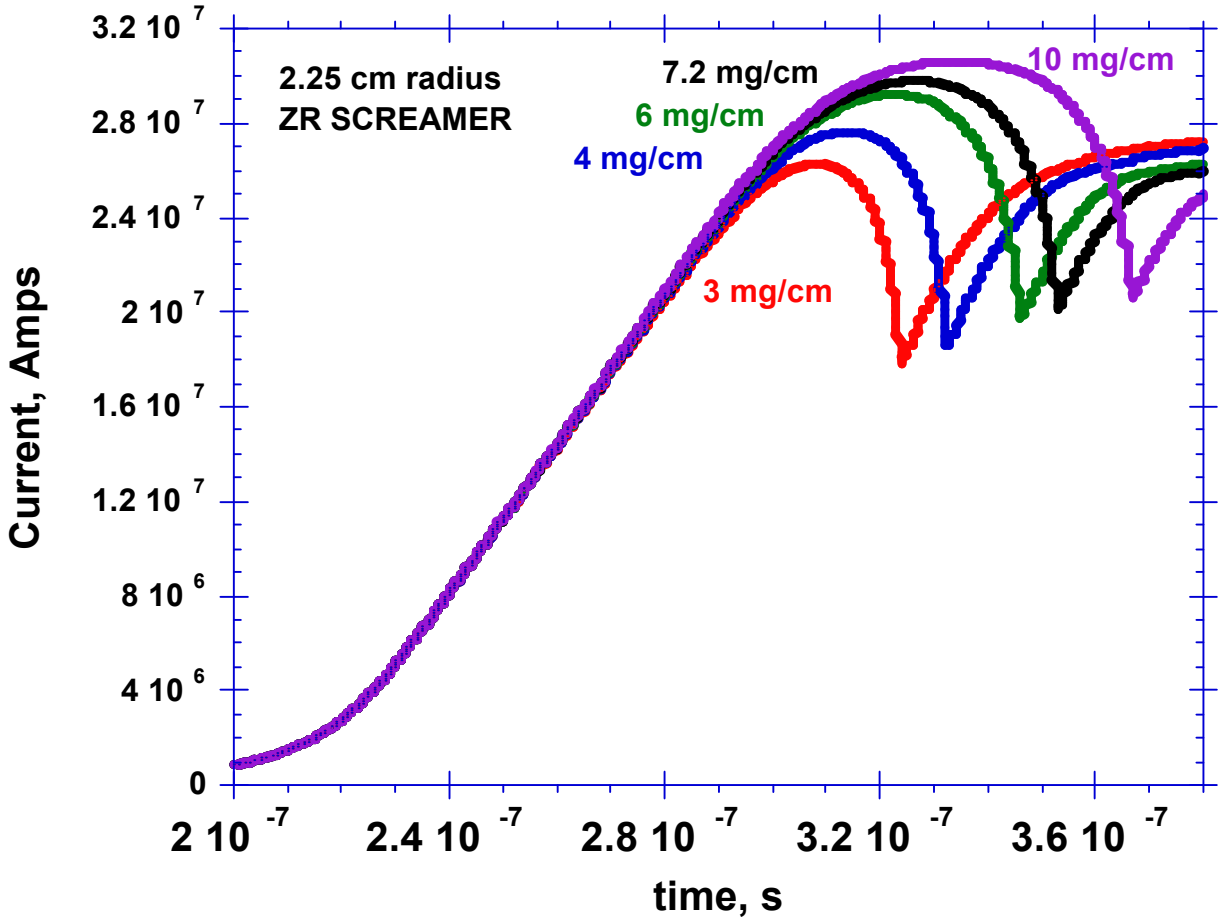
SCREAMER 95 kV Marx charge ZR results for load current vs. time for 2.25 cm radius load parametric in mass.

Note increasing peak current with increasing mass.



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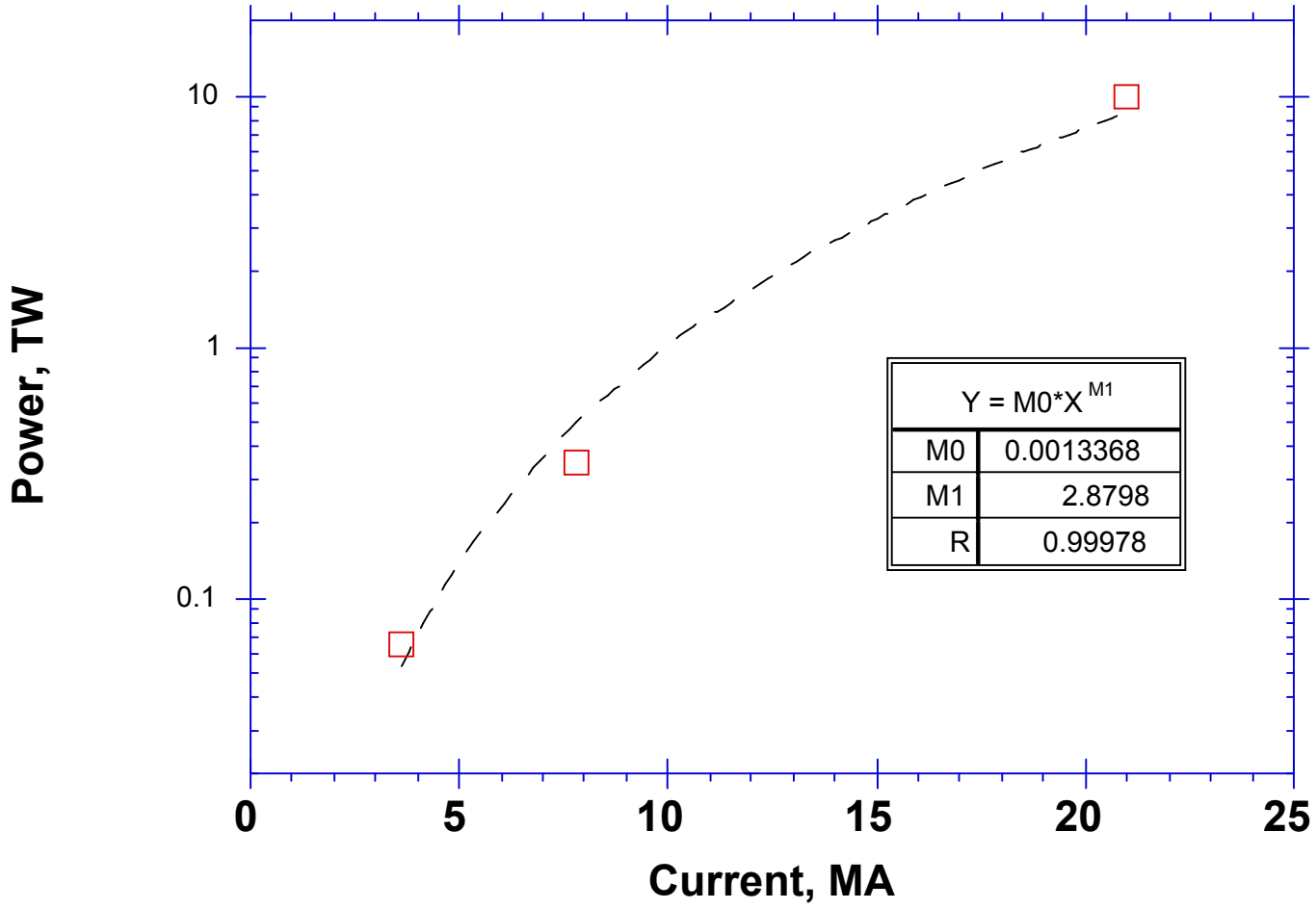
Current scaling of dynamic hohlraum axial power is nearly cubic.



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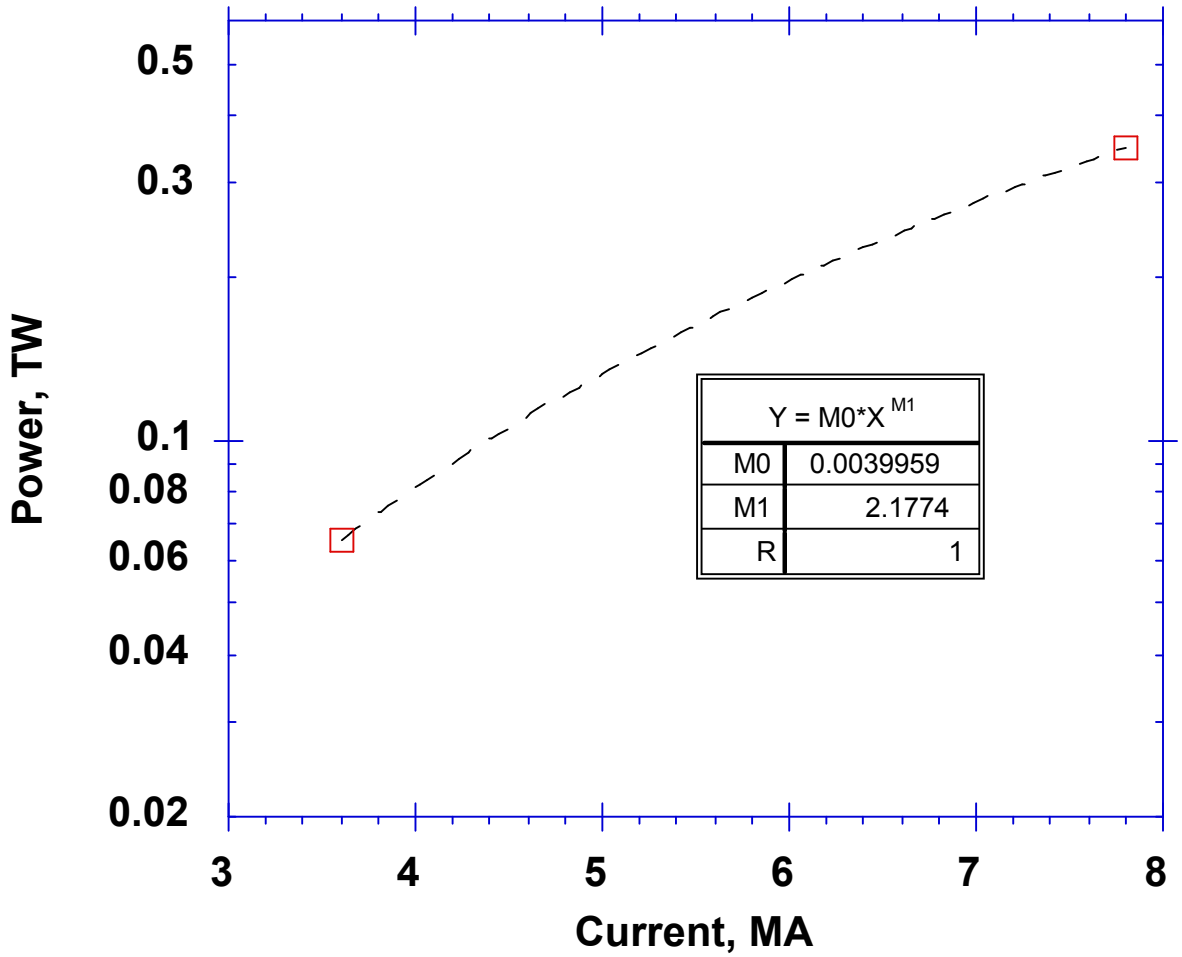
Current scaling of axial power from Angara to Saturn is little more than quadratic.



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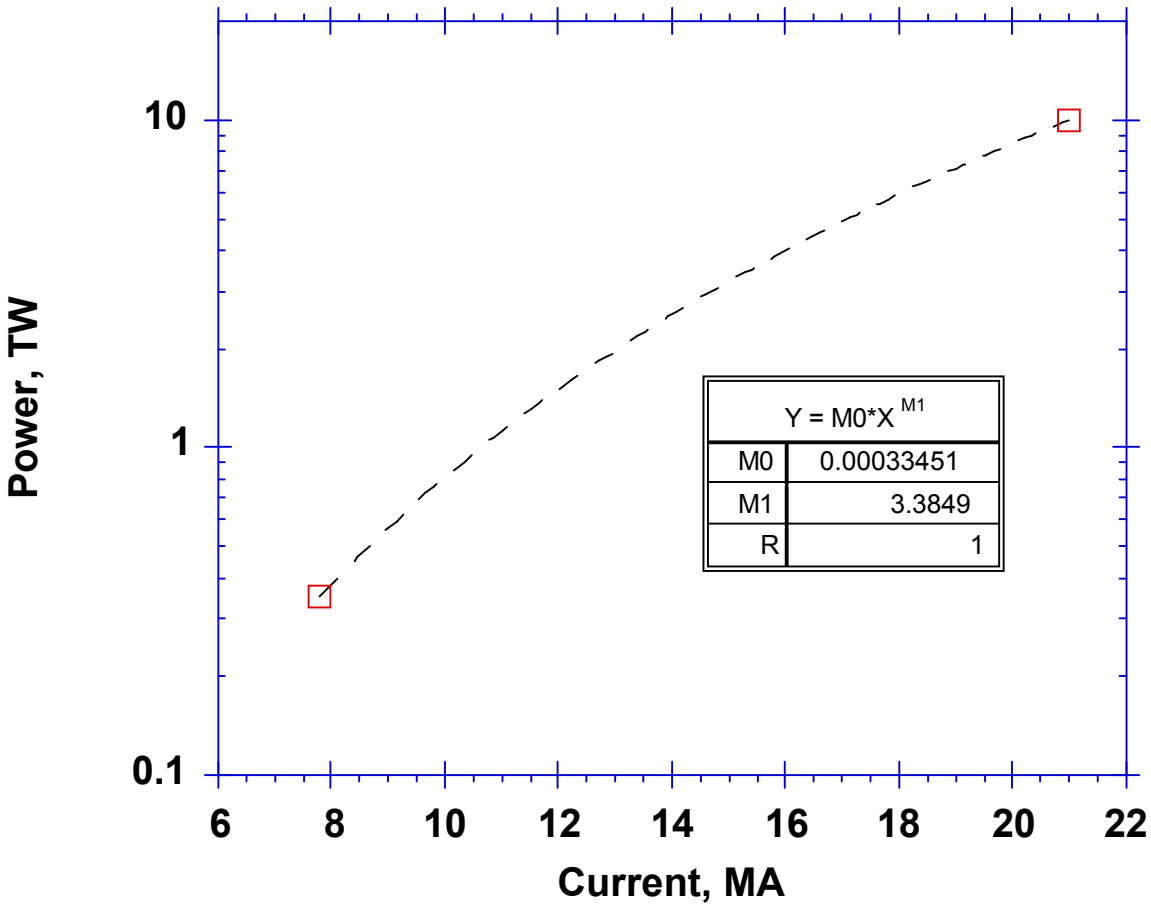
Current scaling from Saturn to Z is slightly more than cubic.



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Current and implosion time scaling of dynamic hohlraum axial power.

$$P_{ax} \propto P_{in}(OD) \propto T^4$$

$$P_{in} \propto I^2/\Gamma$$

$$(OD) \propto m^{1.3}/T^{1.5}$$

$$mr^2 \propto I^2\Gamma^2$$

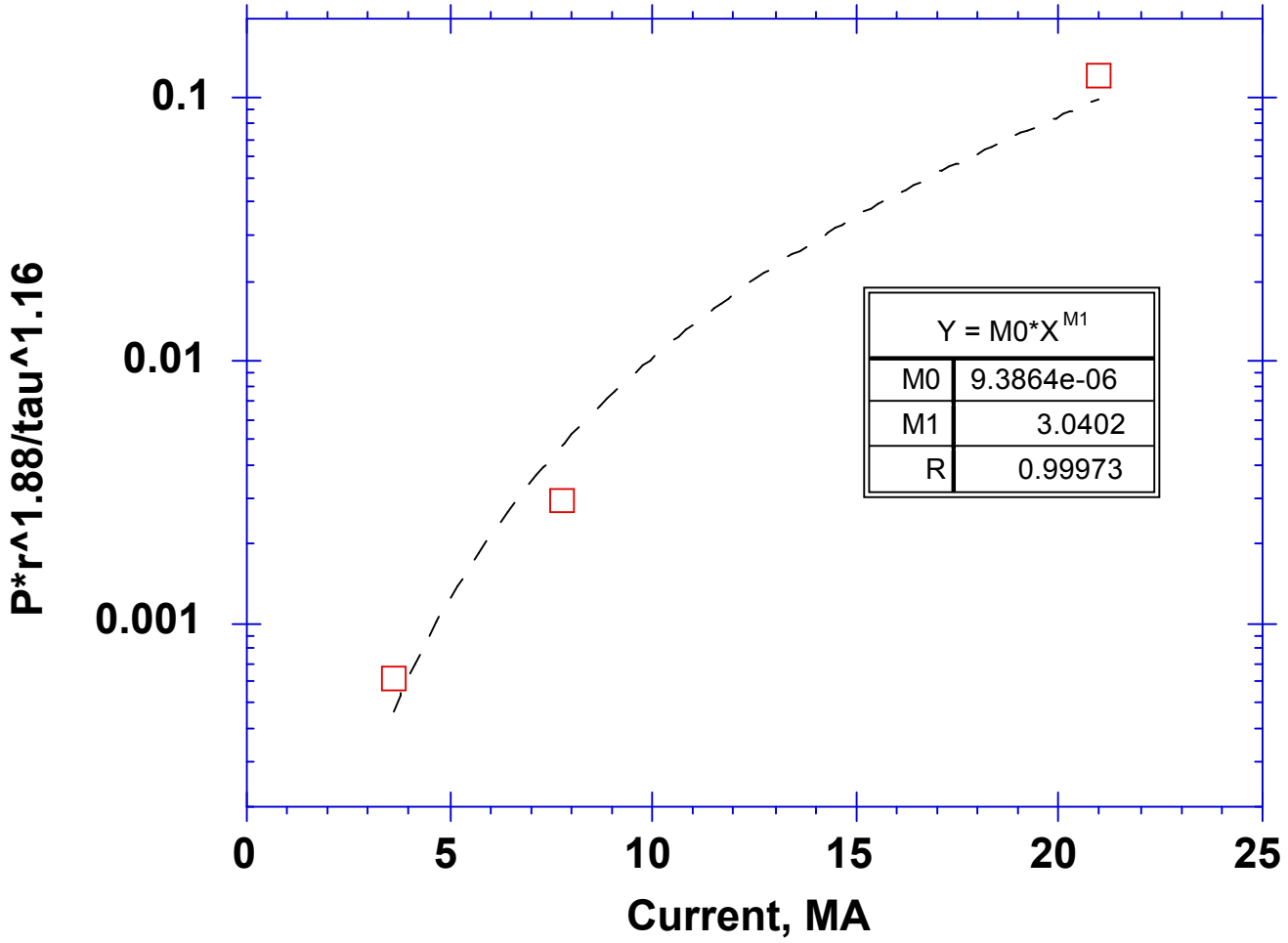
$$T^4 \propto (I^2/\Gamma)(I^{2.6}\Gamma^{2.6}/r^{2.6}/T^{1.5})$$

$$T^{5.5} \propto I^{4.6}\Gamma^{1.6}/r^{2.6}$$

$$T \propto I^{0.84}\Gamma^{0.29}/r^{0.47}$$

$$P_{ax} \propto T^4 \propto I^{3.32}\Gamma^{1.16}/r^{1.88}$$

Scaling model applied to Angara, Saturn and Z.



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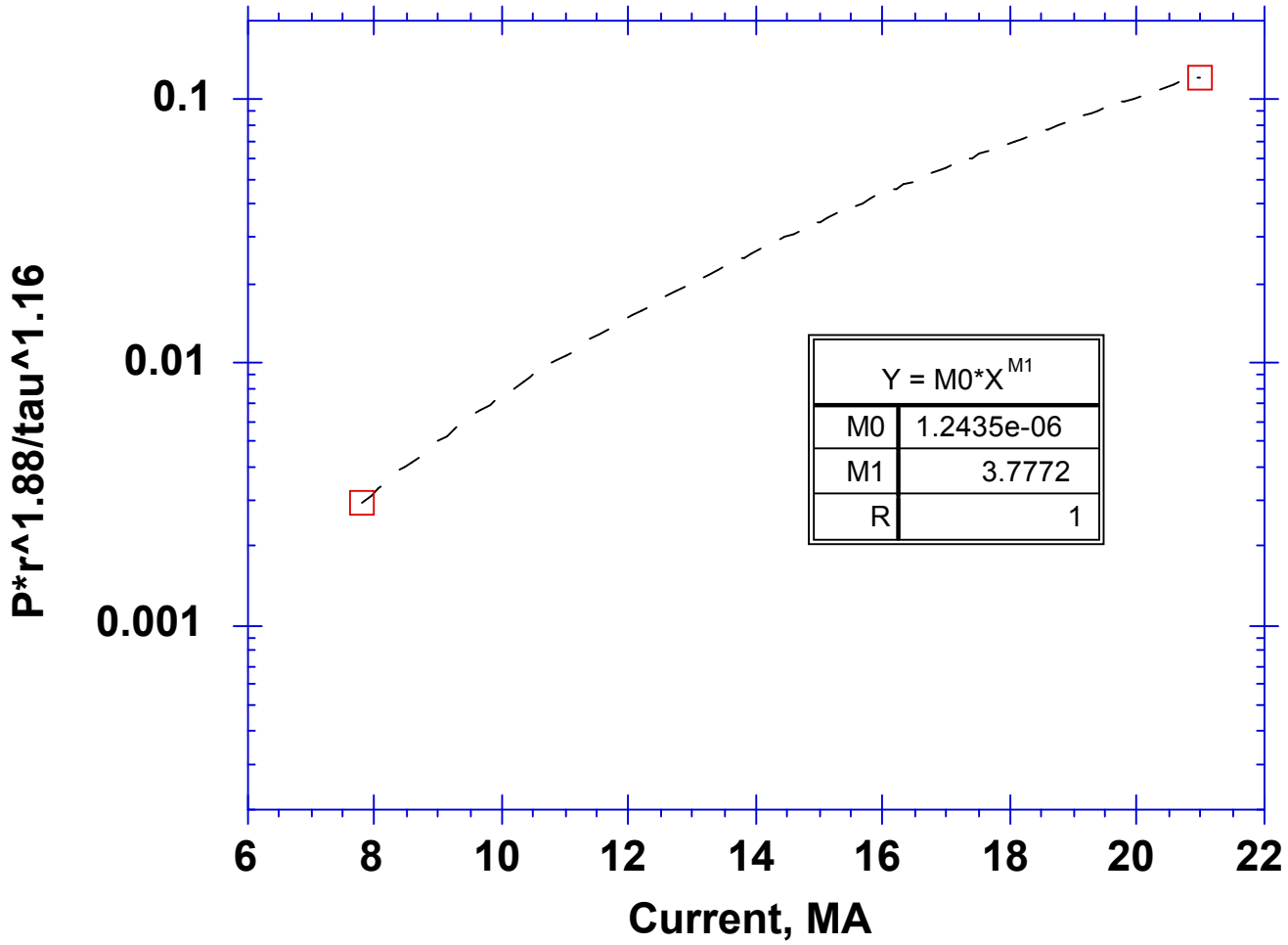
Scaling model applied to Saturn and Z.



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ZR dynamic hohlraum source development plan.

Shot	Wire Nos.	Dia mm	Wire Dia μm	Masses mg/cm	Foam rho mg/cc	Foam mass mg/cm	l mm	wire gap μm	Imp Time ns	Peak Cur MA	Foam dia mm	Marx Charge kV
1	240/120	40/20	8.9	2.81/1.40	17	4.8	10	458	119	23.8	6	85
2	240/120	40/20	10	3.55/1.77	17	4.8	10	458	125	24.75	6	85
3	240/120	40/20	11.18	4.44/2.22	17	4.8	10	458	131	25.5	6	85
4	240/120	40/20	10	3.55/1.77	17	4.8	10	458	118	26.6	6	95
5	240/120	40/20	11.18	4.44/2.22	17	4.8	10	458	125	27.65	6	95

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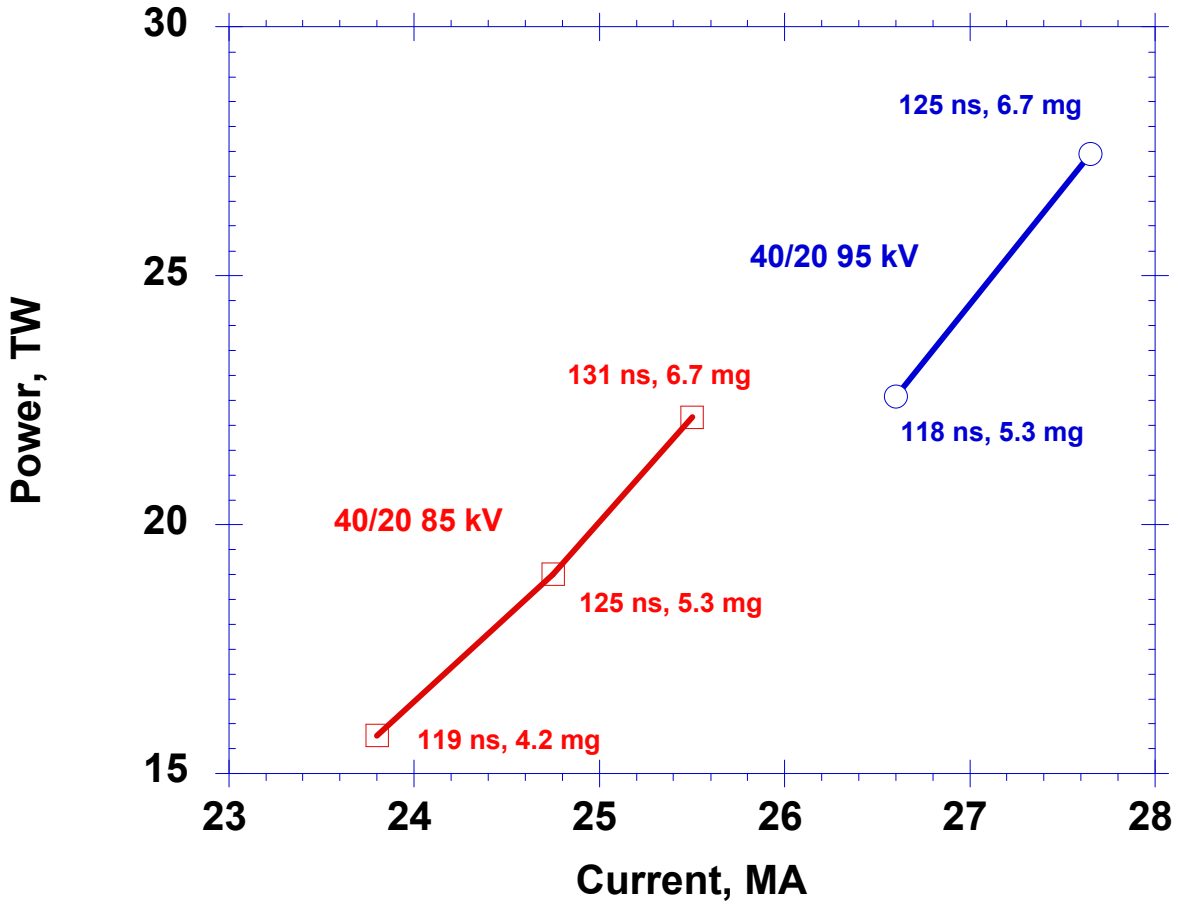
Apply the Z-normalized scaling formula to the shot plan.

$$P_{ax} = 10TW\,(I/21MA)^{3.32}(\Gamma/115ns)^{1.16}(1.75cm/r)^{1.88}$$



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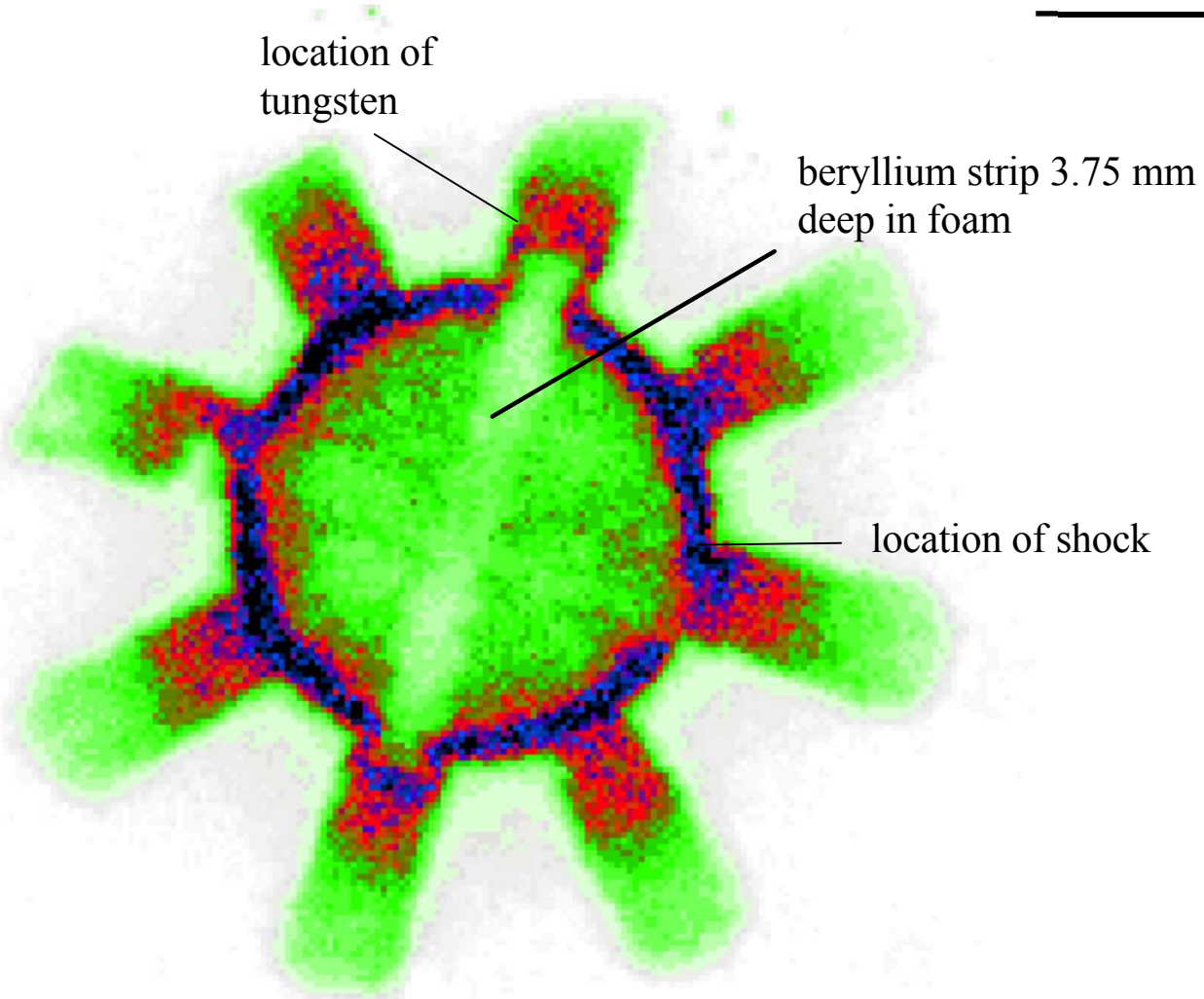
Back up Slides

On-axis x-ray image that contrasts location of radiating shock wave in foam and imploding tungsten shell.

zp799
jm2 on-axis
camera
frame 2
525.5 ns



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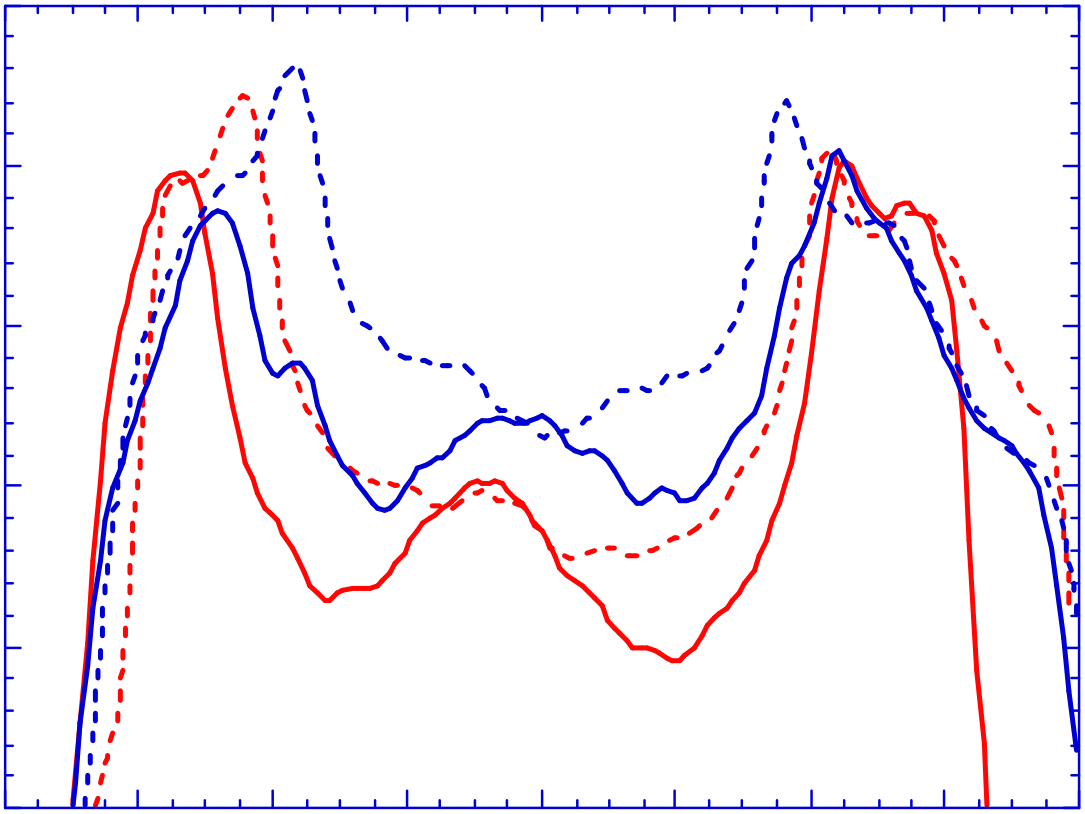
Line-outs of normalized on-axis time-resolved x-ray images that contrast the locations of the radiating shock wave in the foam and the imploding tungsten shell.



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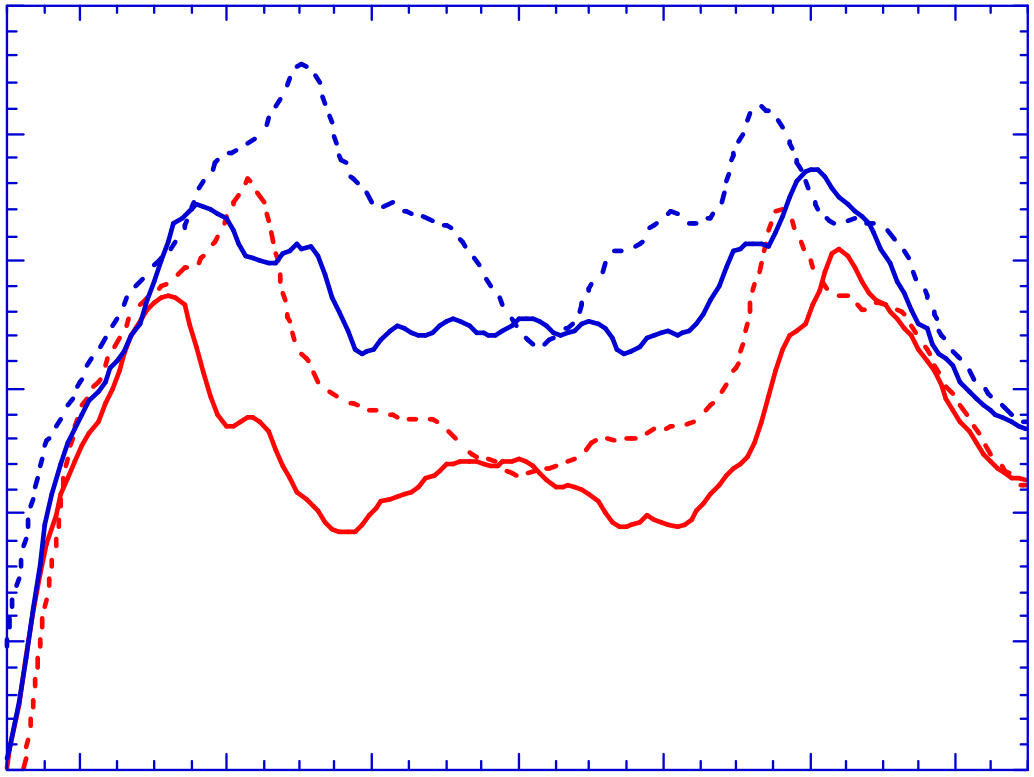

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