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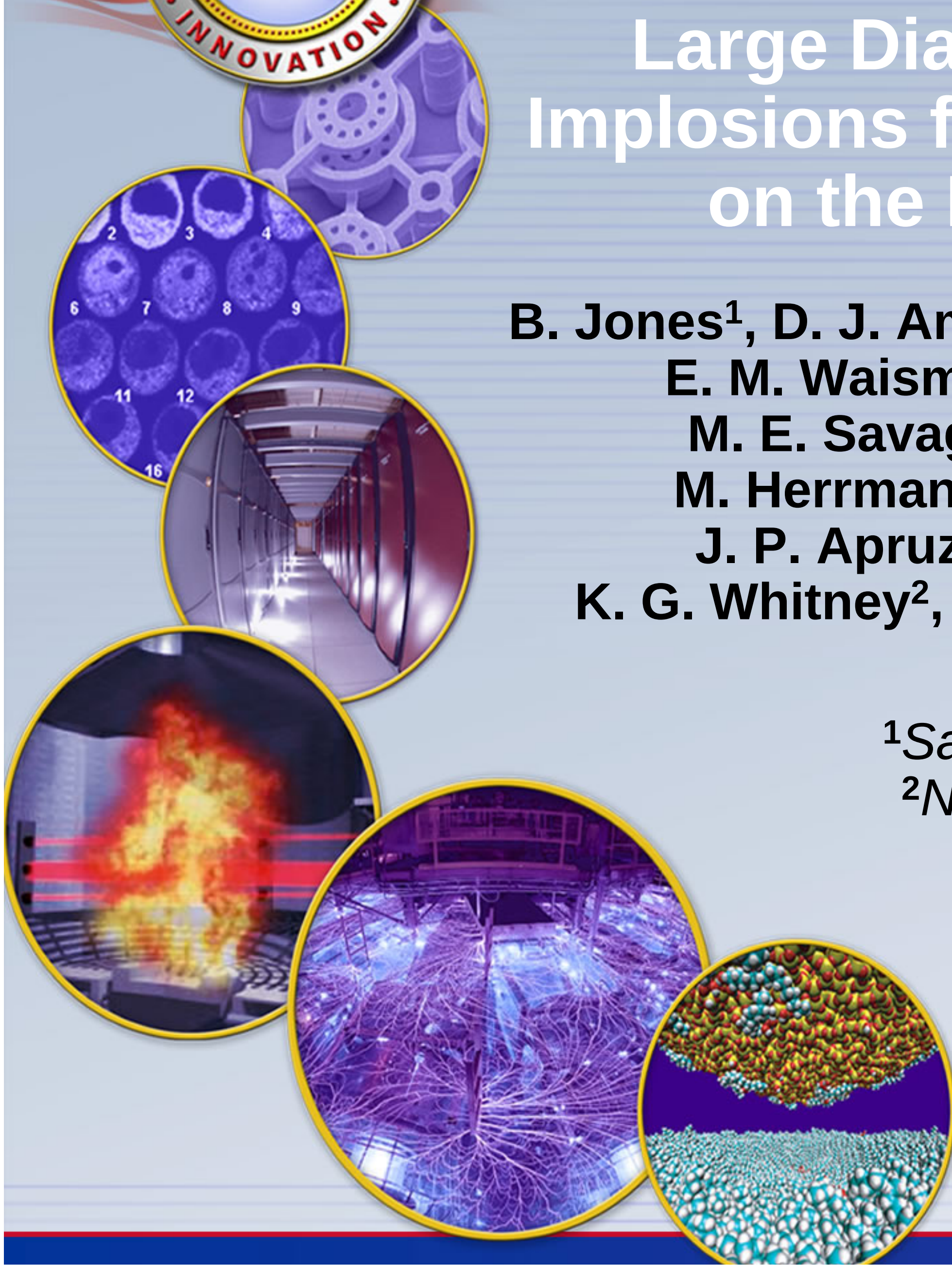

Large Diameter Copper Wire Array Implosions for K-Shell X-Ray Generation on the Refurbished Z Machine

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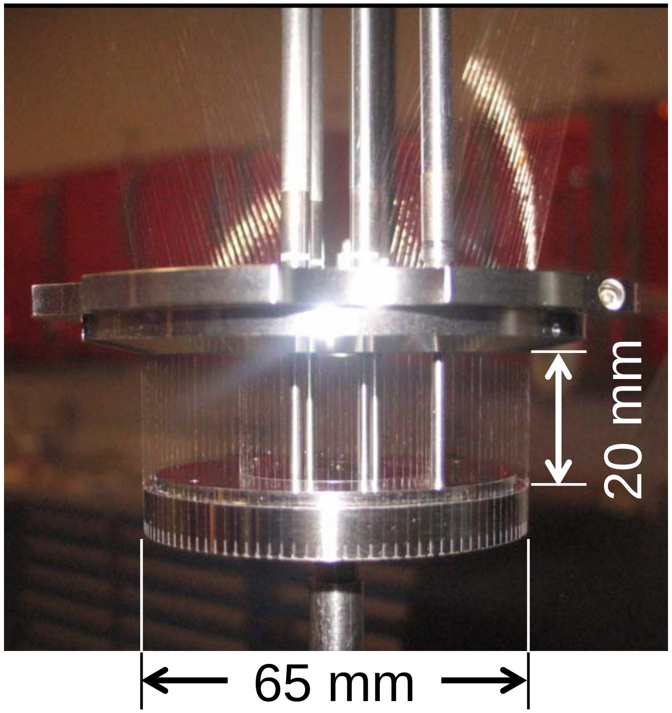
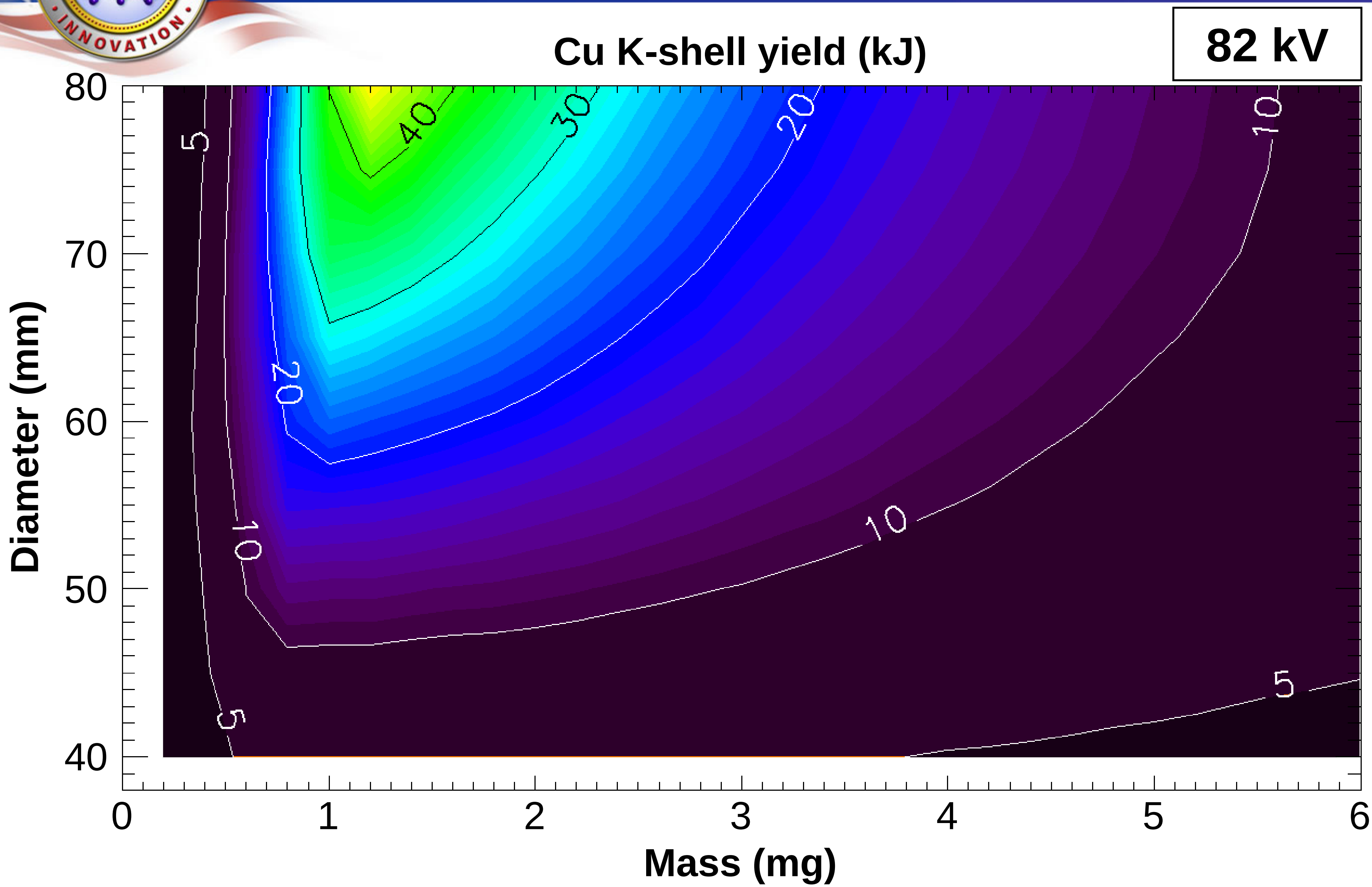
Outline

- Our goal with Cu sources on Z is to achieve 50 kJ K-shell yield with 2 ns rise
- NRL K-shell scaling model has guided our initial experiments on the refurbished Z machine
- Recent Z experiments have produced up to 30 kJ Cu K-shell
- Looking ahead, we will focus on load optimization and coupling to the generator

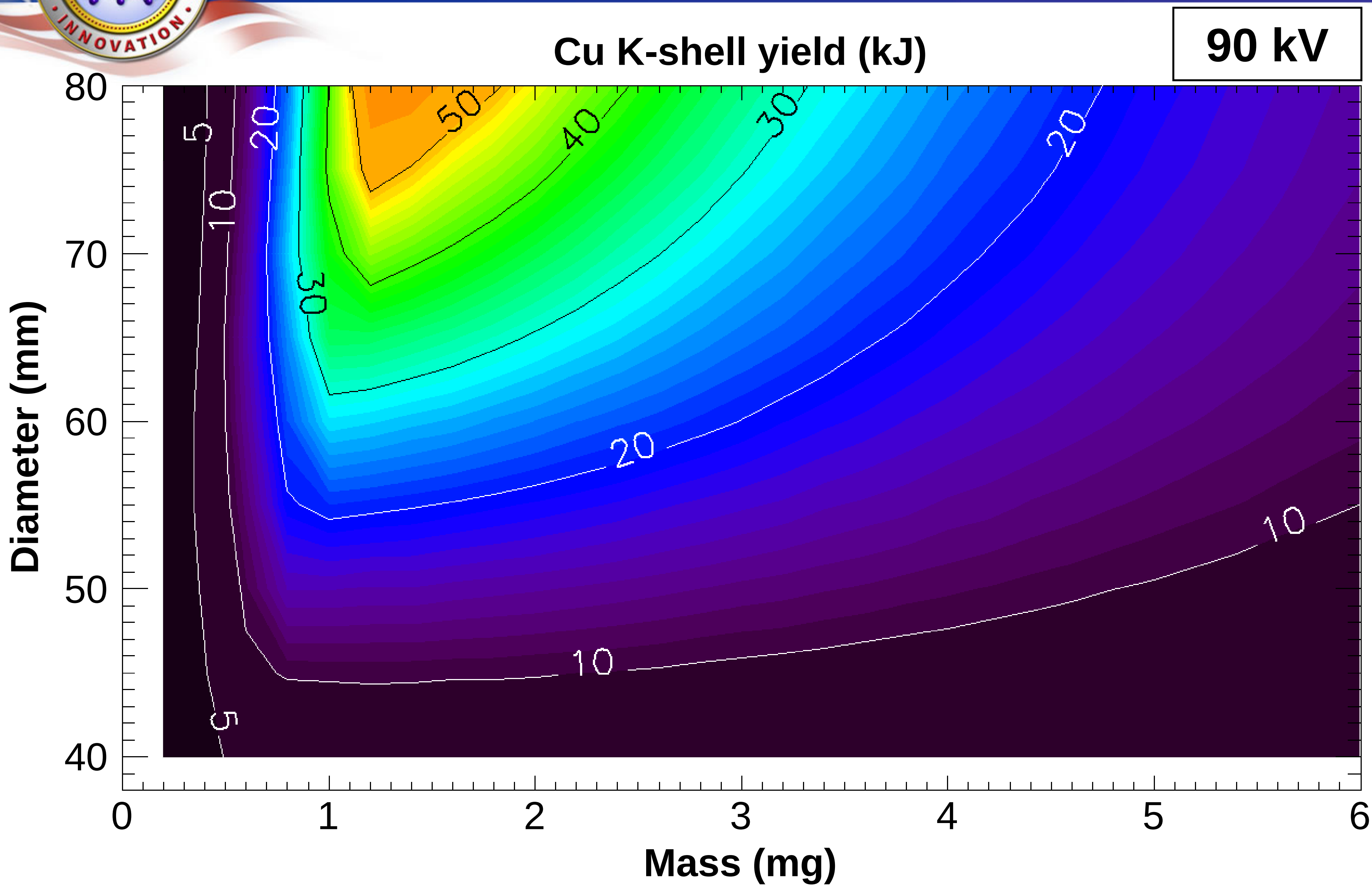


Initial Cu loads on refurbished Z planned with guidance from K-shell yield scaling model



J. W. Thornhill *et al.*, IEEE T. Plasma Sci. **34**, 2377 (2006).

Future increase of Marx charge voltage on Z is expected to enhance K-shell yield



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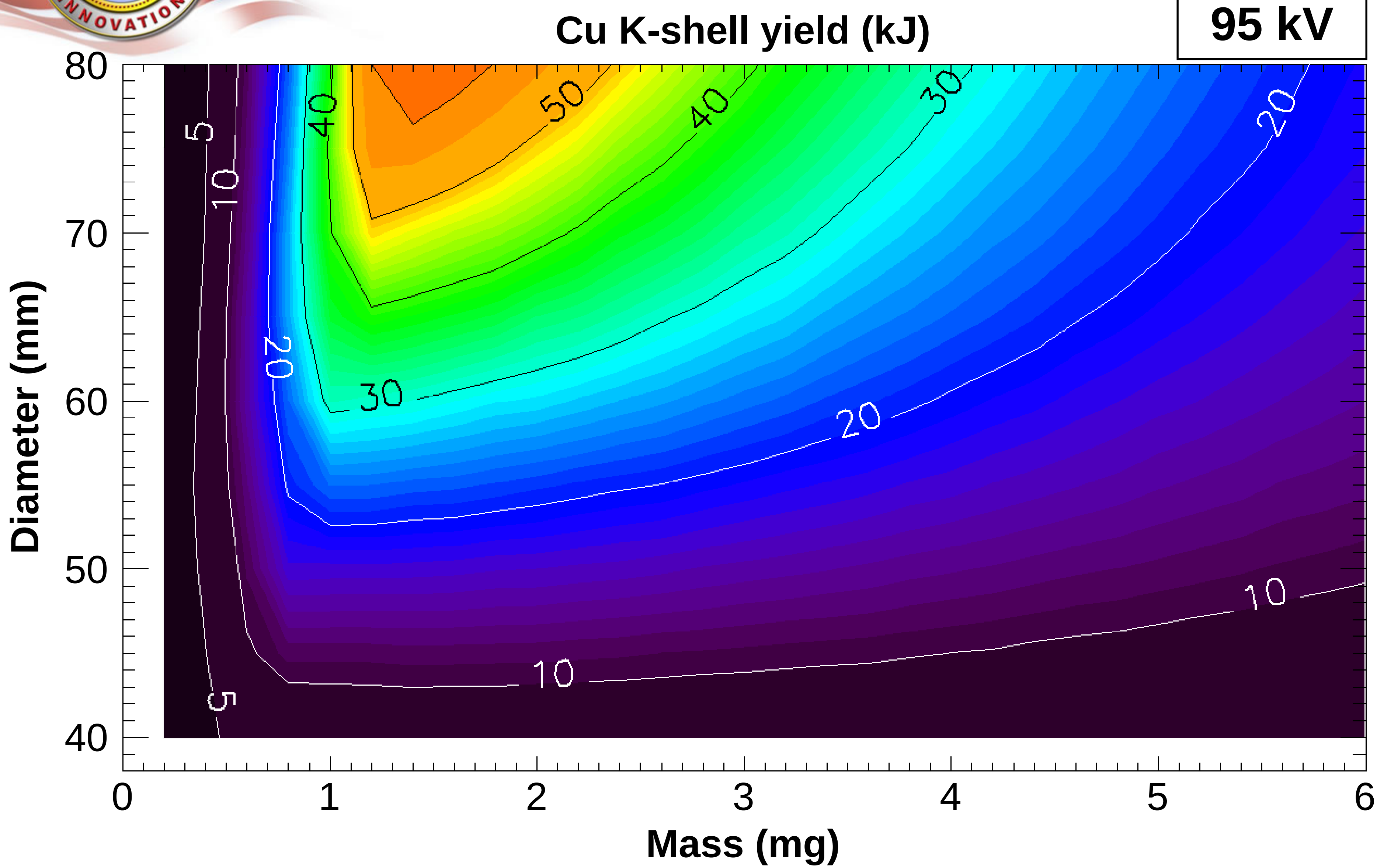
Future increase of Marx charge voltage on Z is expected to enhance K-shell yield

95 kV



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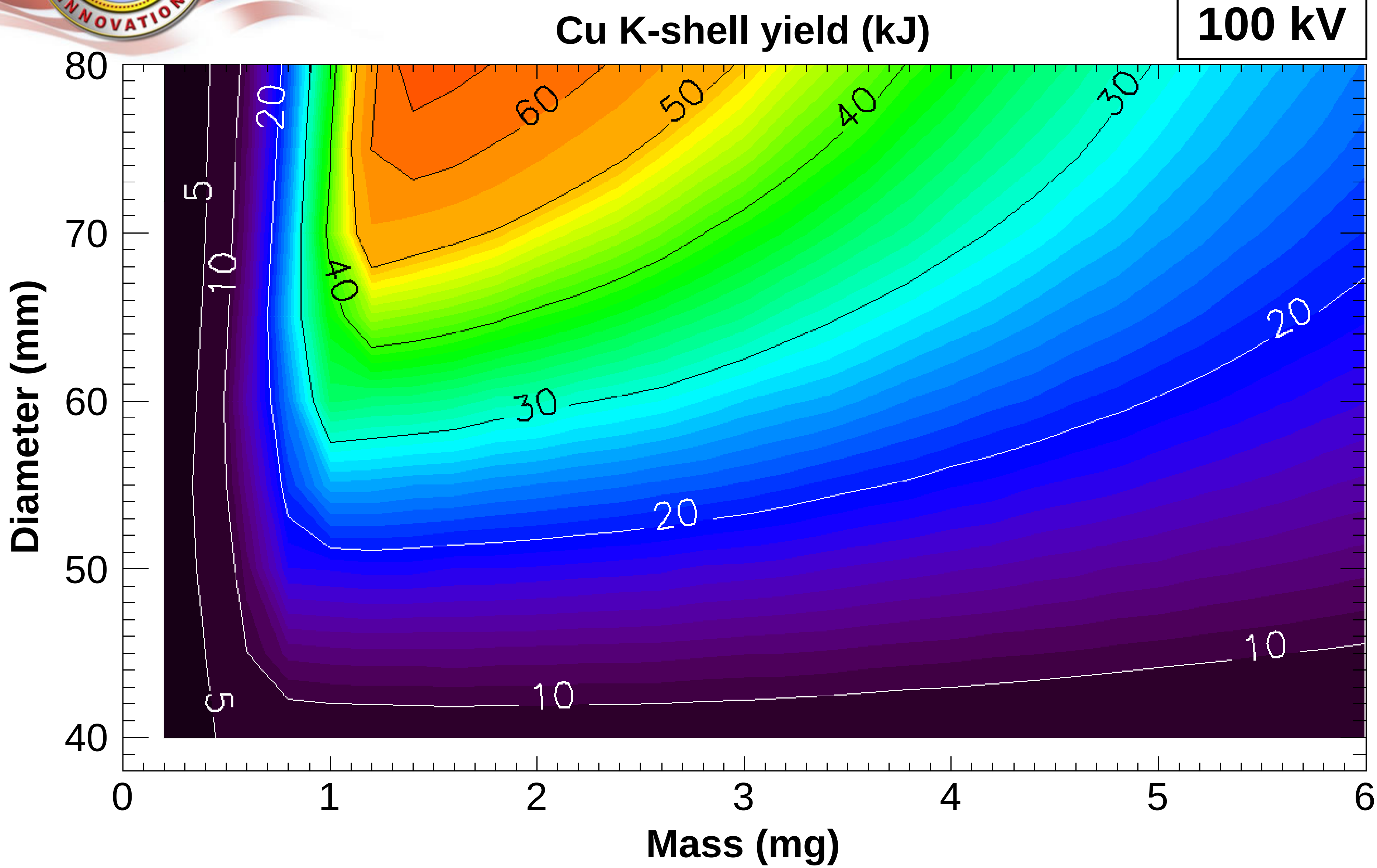

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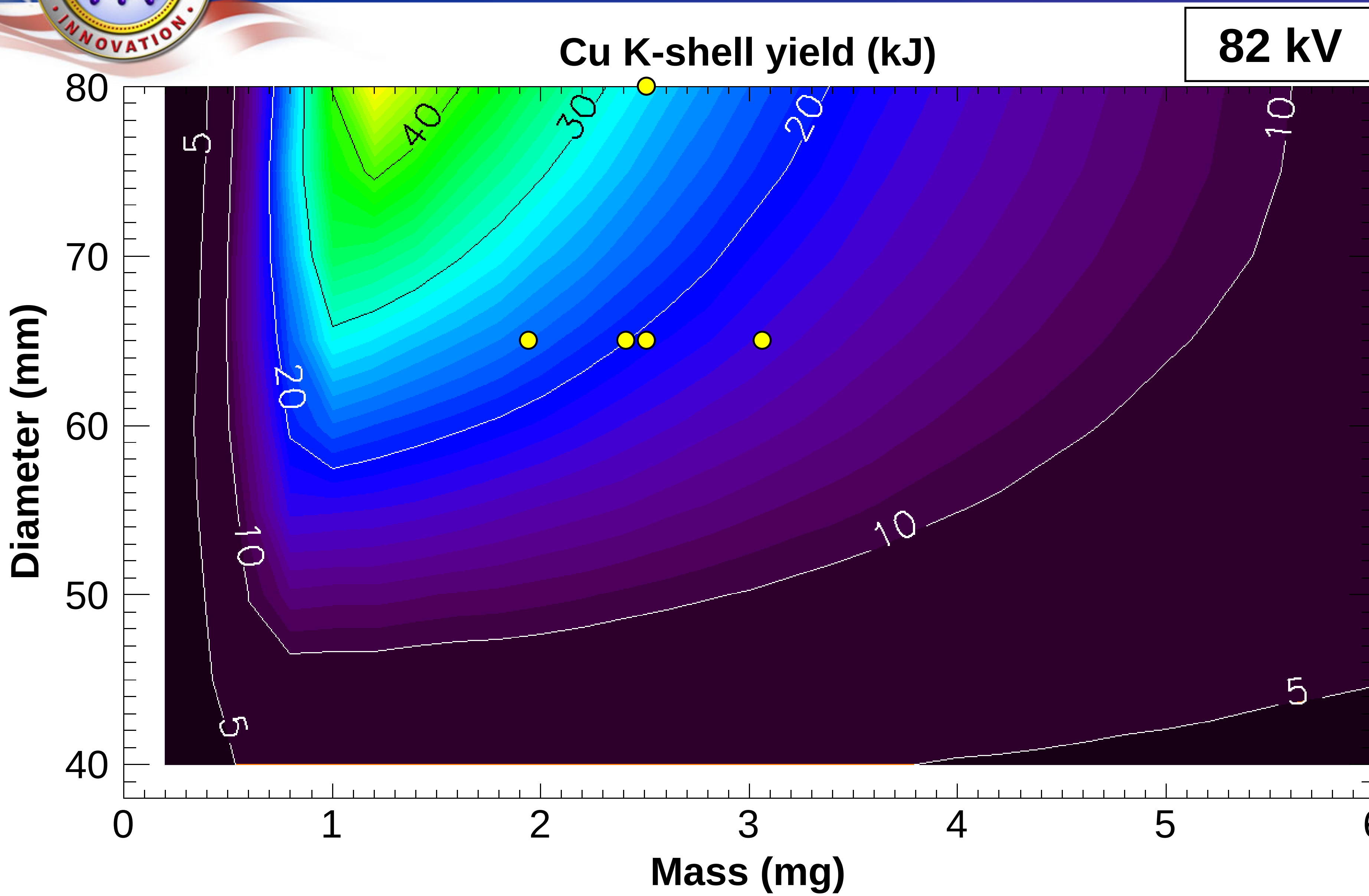
Cu experiments in 2008 seek to evaluate trends per the K-shell yield model predictions



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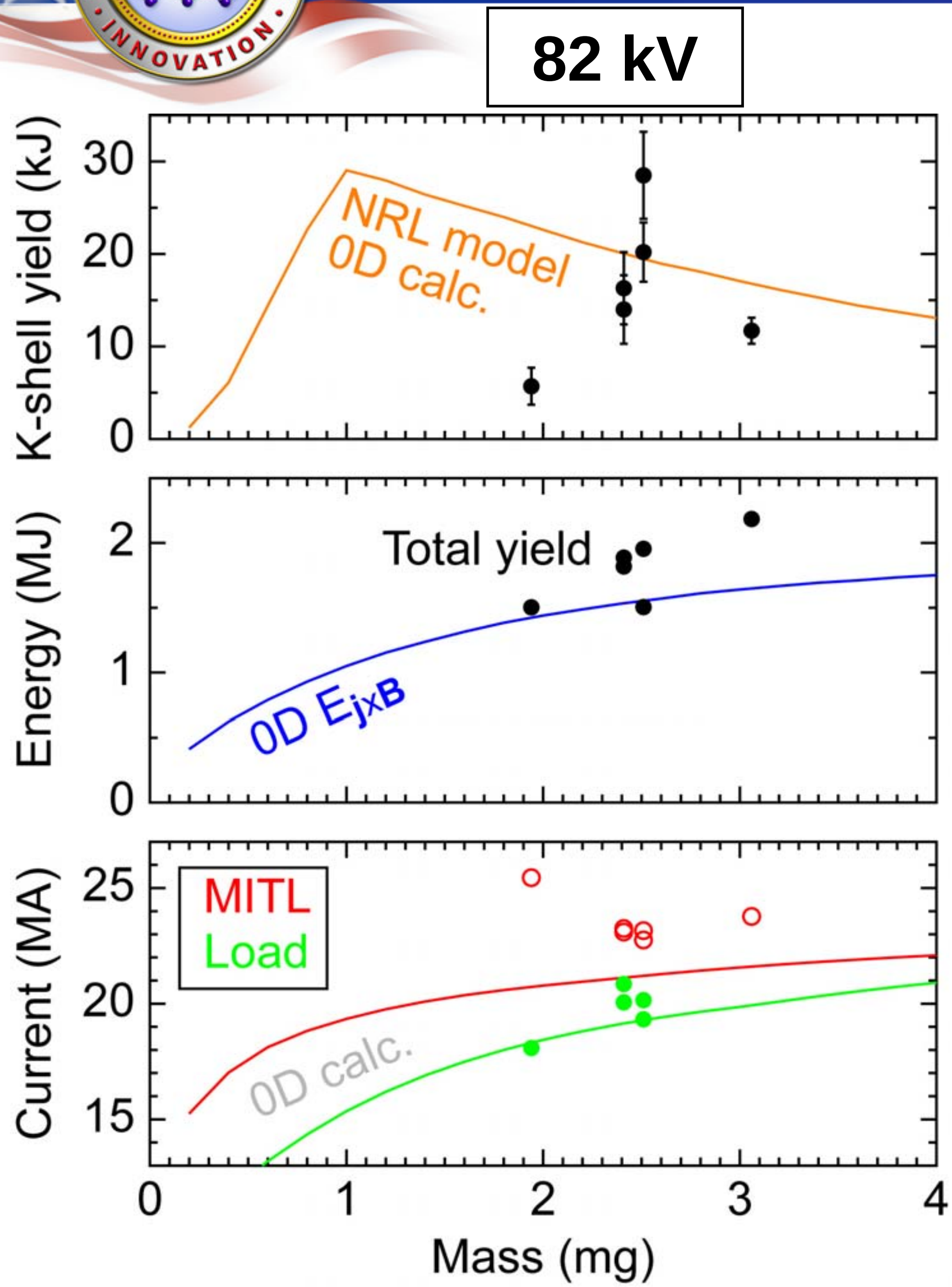
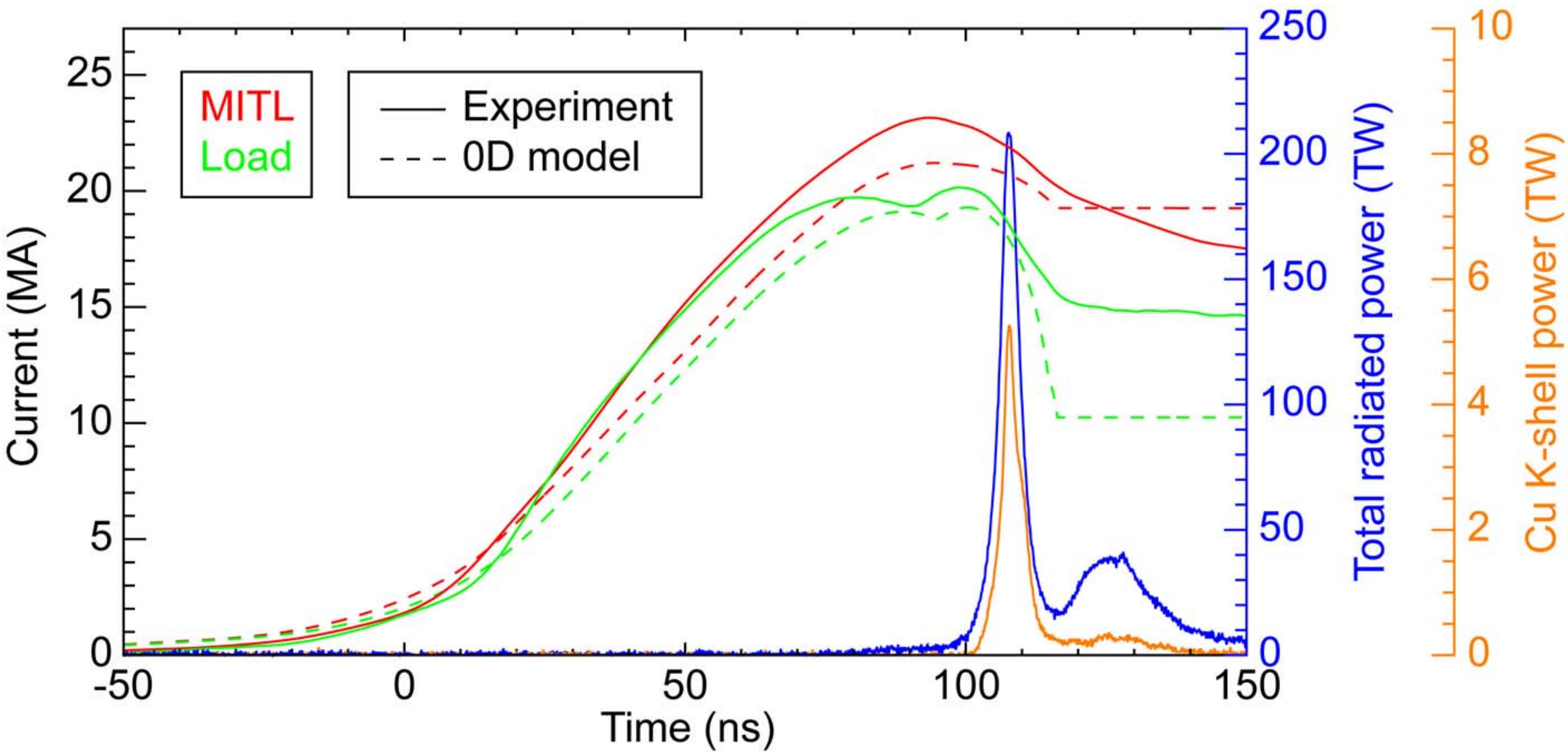
Cu mass scan shows significant deviation between experiment and model at lower mass



- Significant shot-to-shot variation is apparent at ~2.5 mg
  - May result from bright spot emission of Cu K-shell x-rays
- Drop in K-shell yield is expected at higher mass due to reduced η and radiative cooling
- Drop in K-shell yield at lower mass disagrees with scaling model
  - Seen also with SS loads pre-refurbishment, but less severe
- Convolute losses are large
- Circuit model used for 0D calculations needs improvement
  - Comes close on load current but not on MITL current

0D model comes close on predicting load current, but rise is not correct

- **Circuit model dates to early commissioning shots, requires revision for these large diameter arrays**
- **Model and experiment both show dip in load current due to L-dot at time of nested array interaction**



Ø65mm nested wire array, 2.5 mg Cu

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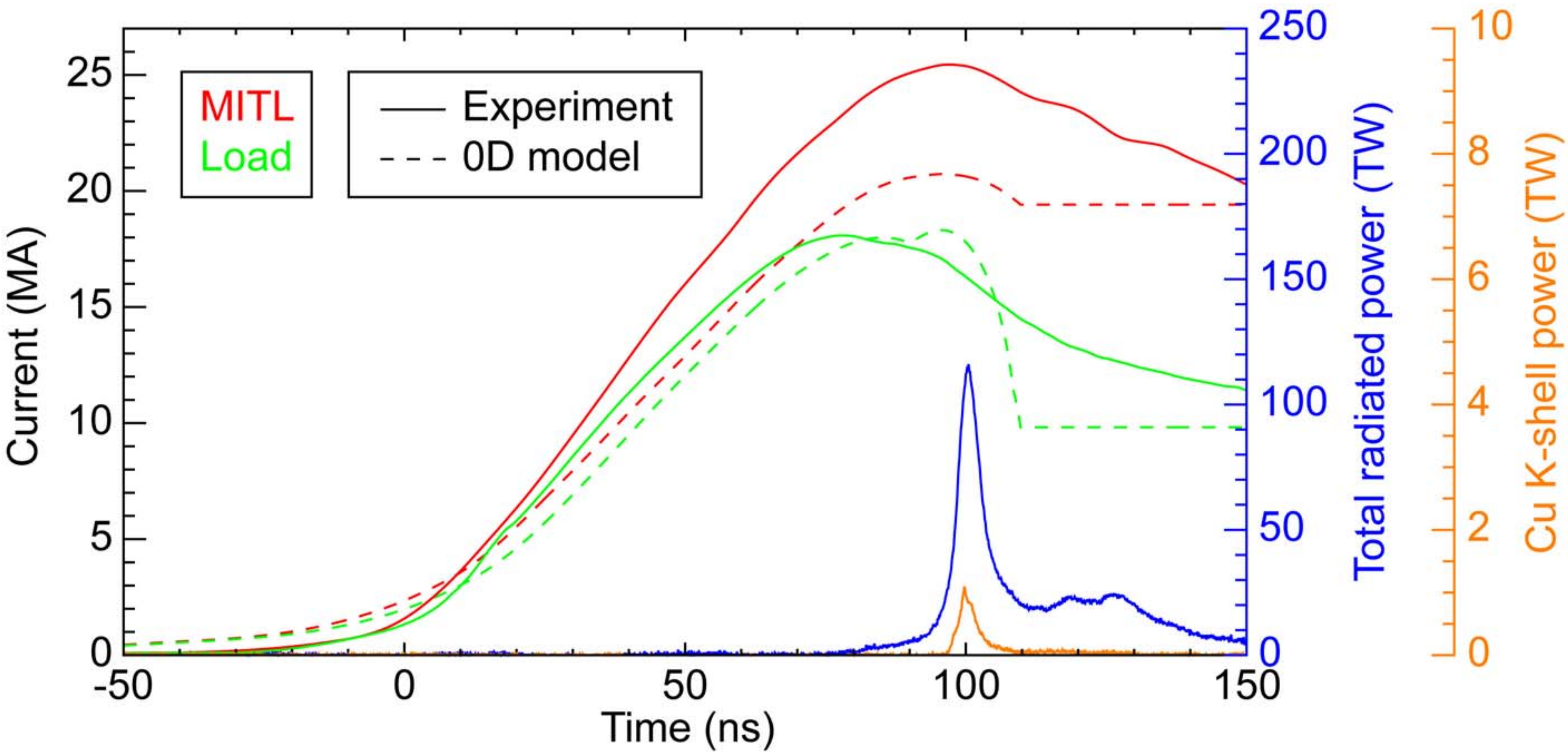
Lightest load with 100 ns implosion time shows >7 MA convolute loss

- **Improved convolute design is desirable to reduce convolute loss for these high velocity, high L-dot loads**
- **Circuit model must capture this loss if load design is to be predictive (see C. A. Jennings, IO3C-1)**



Ø65mm nested wire array, 1.9 mg Cu

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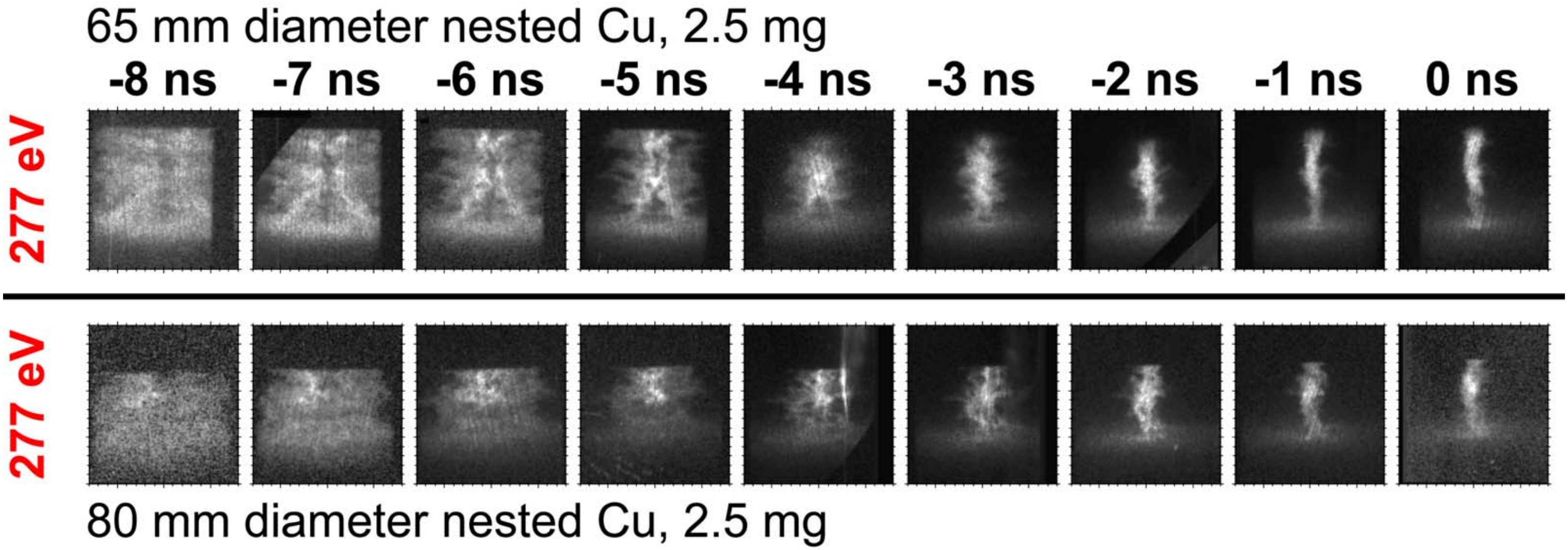
Larger diameter (80 mm) nested wire array had reduced yield, less uniform implosion

	K-shell		Total radiation	
Diameter (mm)	Power (TW)	Yield (kJ)	Power (TW)	Yield (kJ)
65	5.3	28.5	210	1950
80	1.9	9.6	150	1980



- Large diameter wire arrays with large interwire gaps may suffer from severe magnetic Rayleigh-Taylor instability
- 3D MHD modeling may help identify nesting geometries with improved MRT mitigation (J. P. Chittenden, C. A. Jennings)

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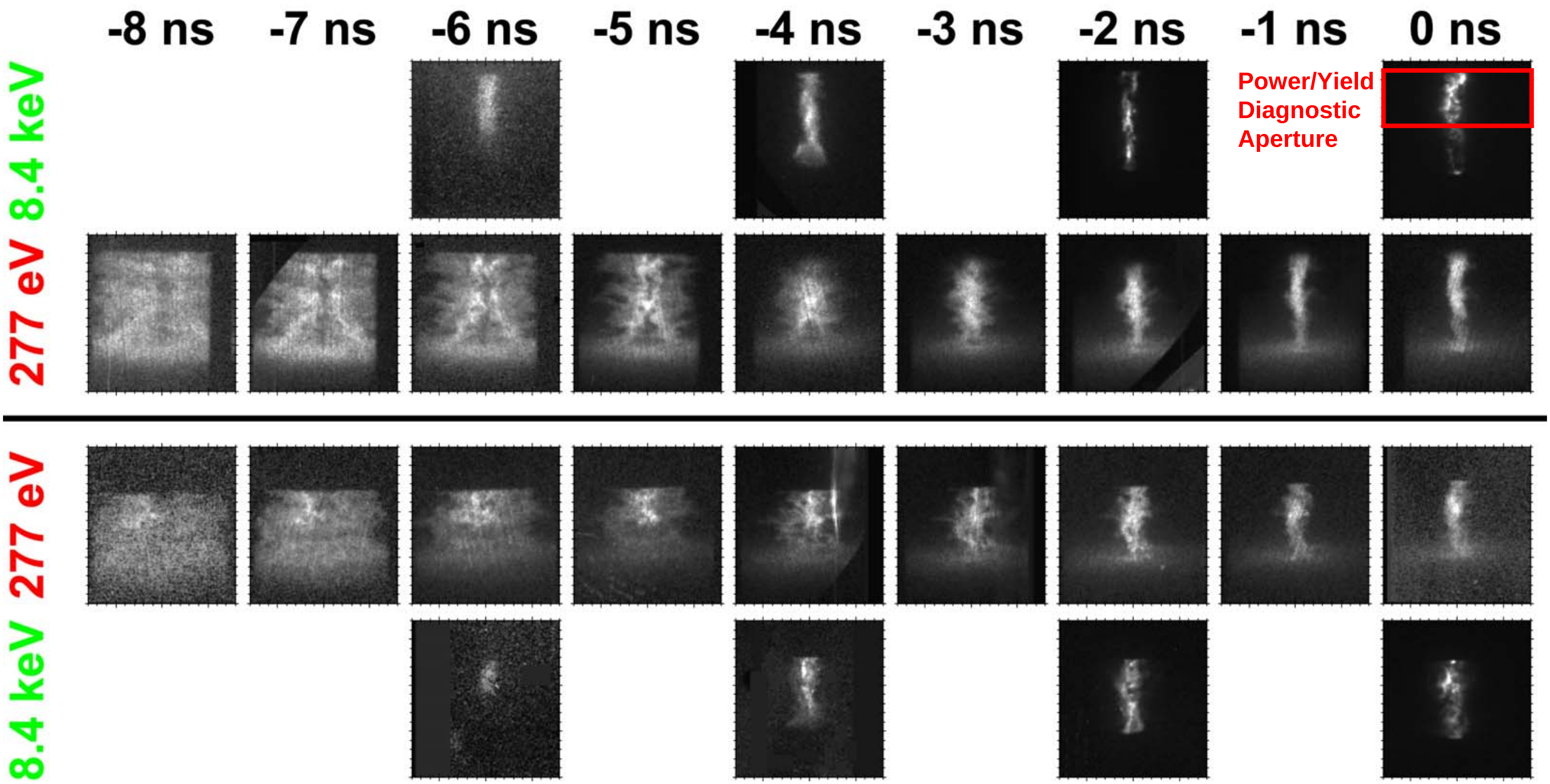
Bright spots may dominate Cu K-shell emission even for the better performing loads



- It is difficult to ionize to He-like Cu, and the charge state will be sensitive to local plasma conditions

Summary

Goal: 50 kJ of 8.4 keV Cu K-shell radiation on Z

Difficulty	Potential solutions
Load current is too low, especially given significant convolute losses for these large diameter, high velocity loads	• Increase Marx charge voltage • Improve convolute design • Reduce L and L-dot (smaller gaps, shorter load) • Larger diameter loads with longer implosion times
There is significant magnetic Rayleigh-Taylor instability for large diameter implosions	• Load optimization (vary initial radius) • Improve nesting geometry based on 3D MHD modeling
K-shell yield scaling is not fully understood (large diameter implosion quality, bright spots for Cu)	• 1D, 2D, 3D RMHD modeling to assist in load optimization • Continued benchmarking against experiments • Spectroscopic study of plasma conditions