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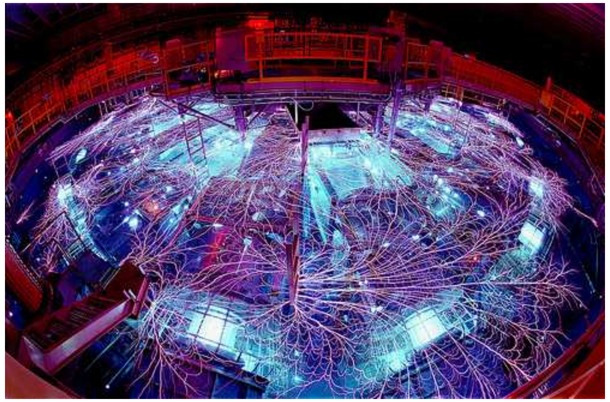

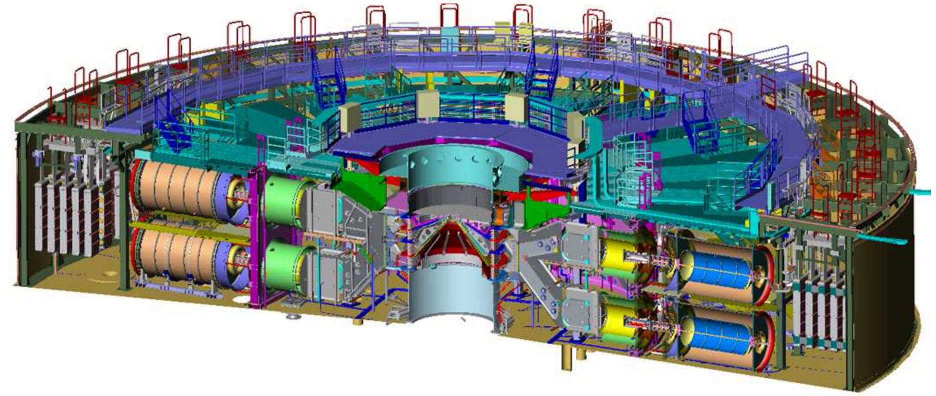

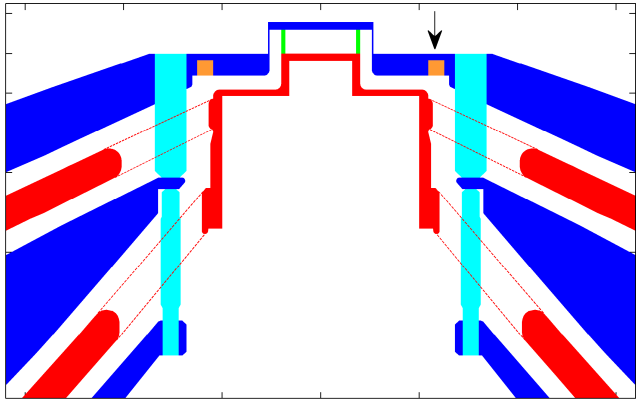

Understanding current loss in the Z machine double post-hole convolute

M. R. Gomez, R. M. Gilgenbach, M. E. Cuneo, C. A. Jennings, R. D. McBride, E. M. Waisman, B. T. Hutsel, W. A. Stygar, D. V. Rose, Y. Maron

Presented at EAPPC-BEAMS-Megagauss, 2016 September 19-22

U.S. DEPARTMENT OF ENERGY

National Nuclear Security Administration

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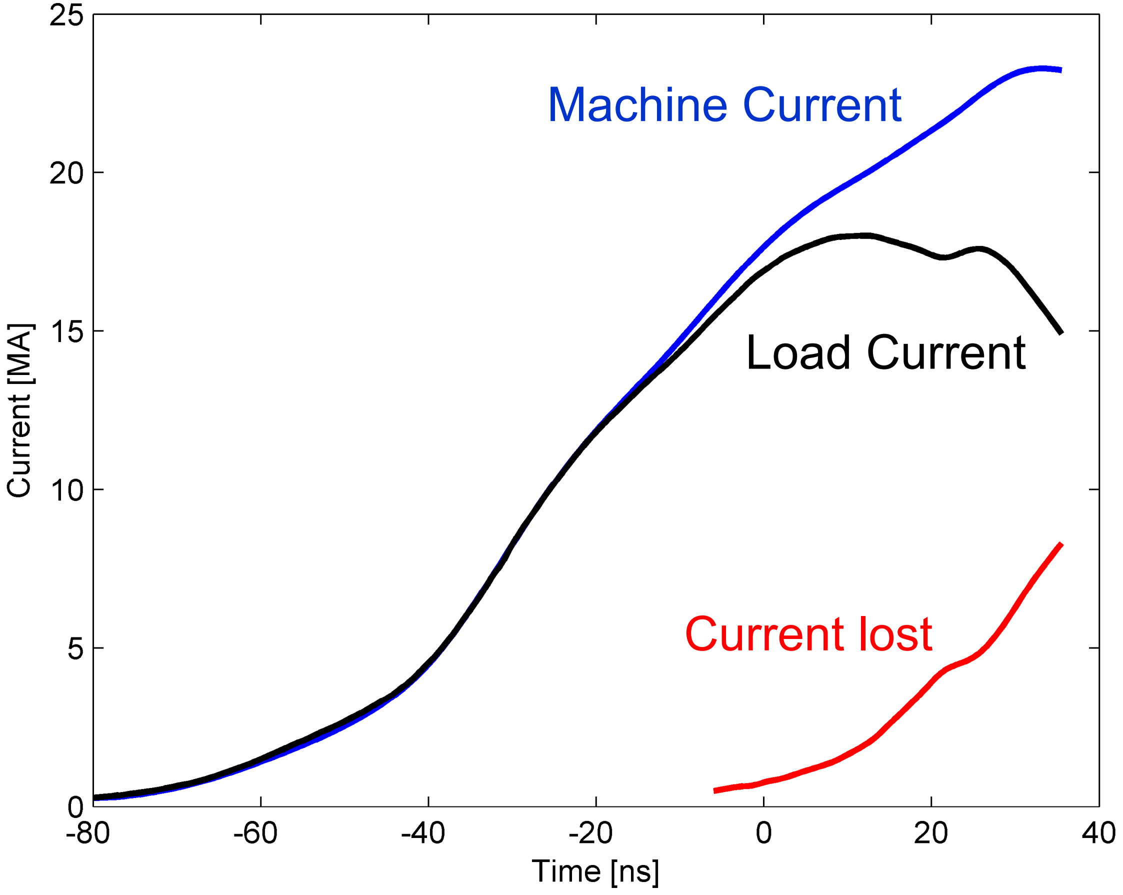
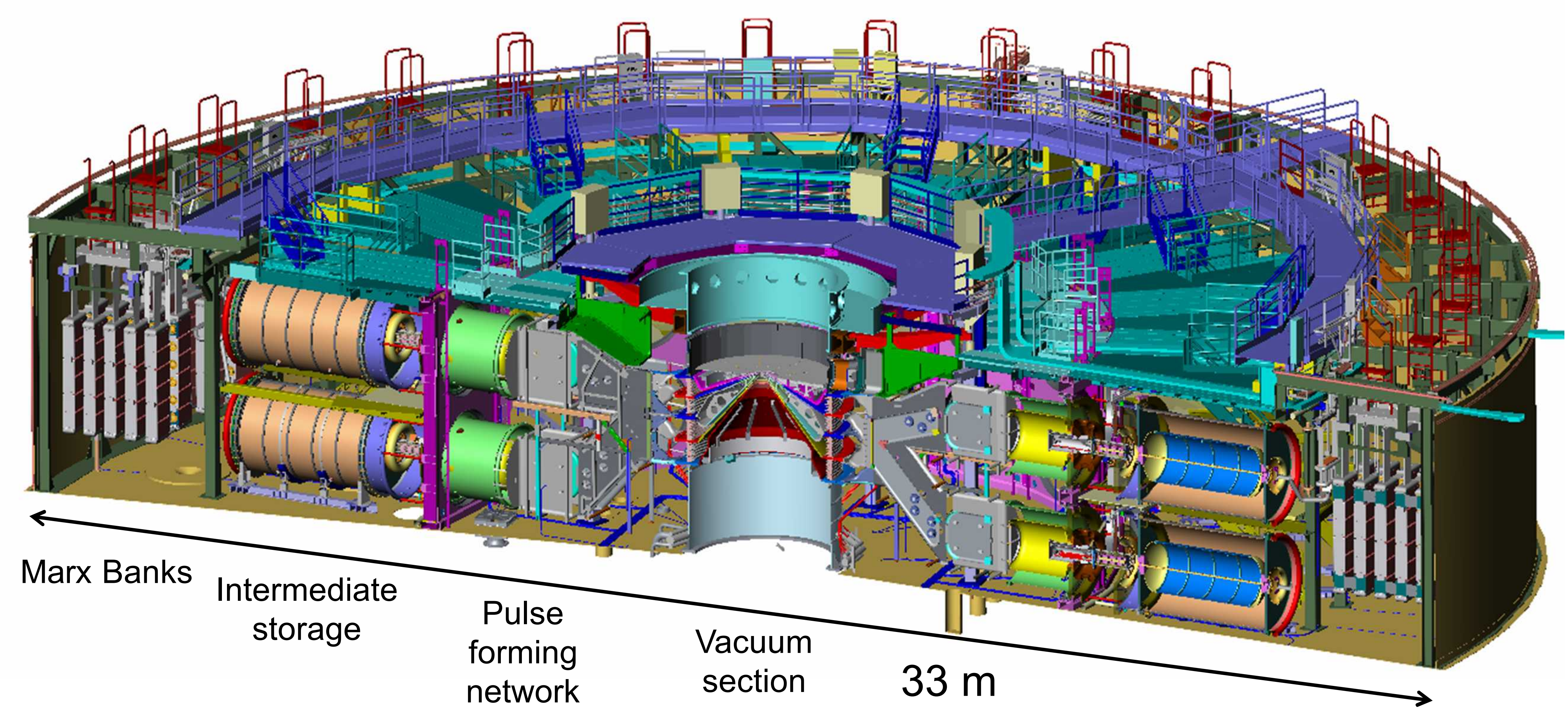
Significant current losses have been observed on the Z machine

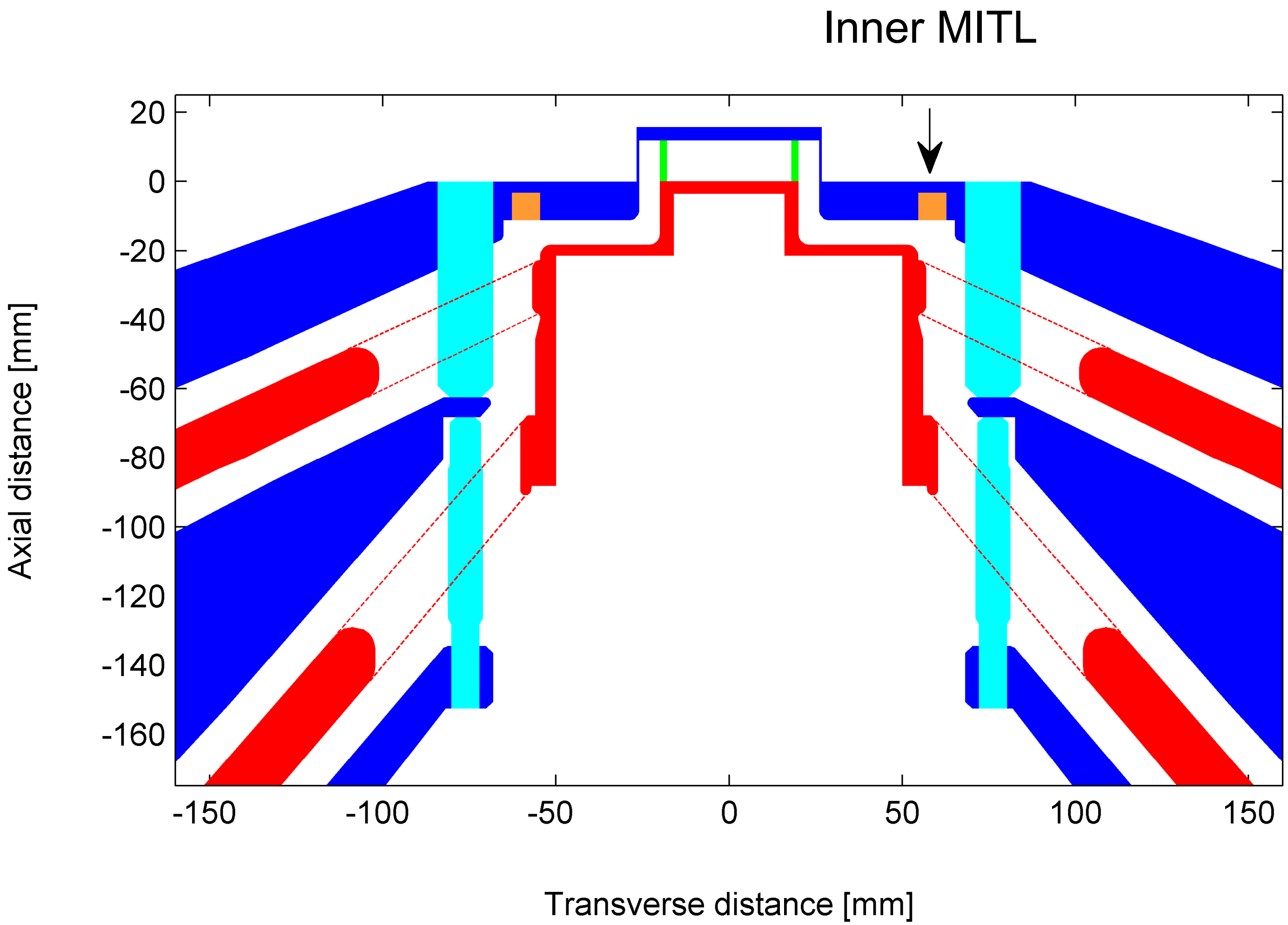


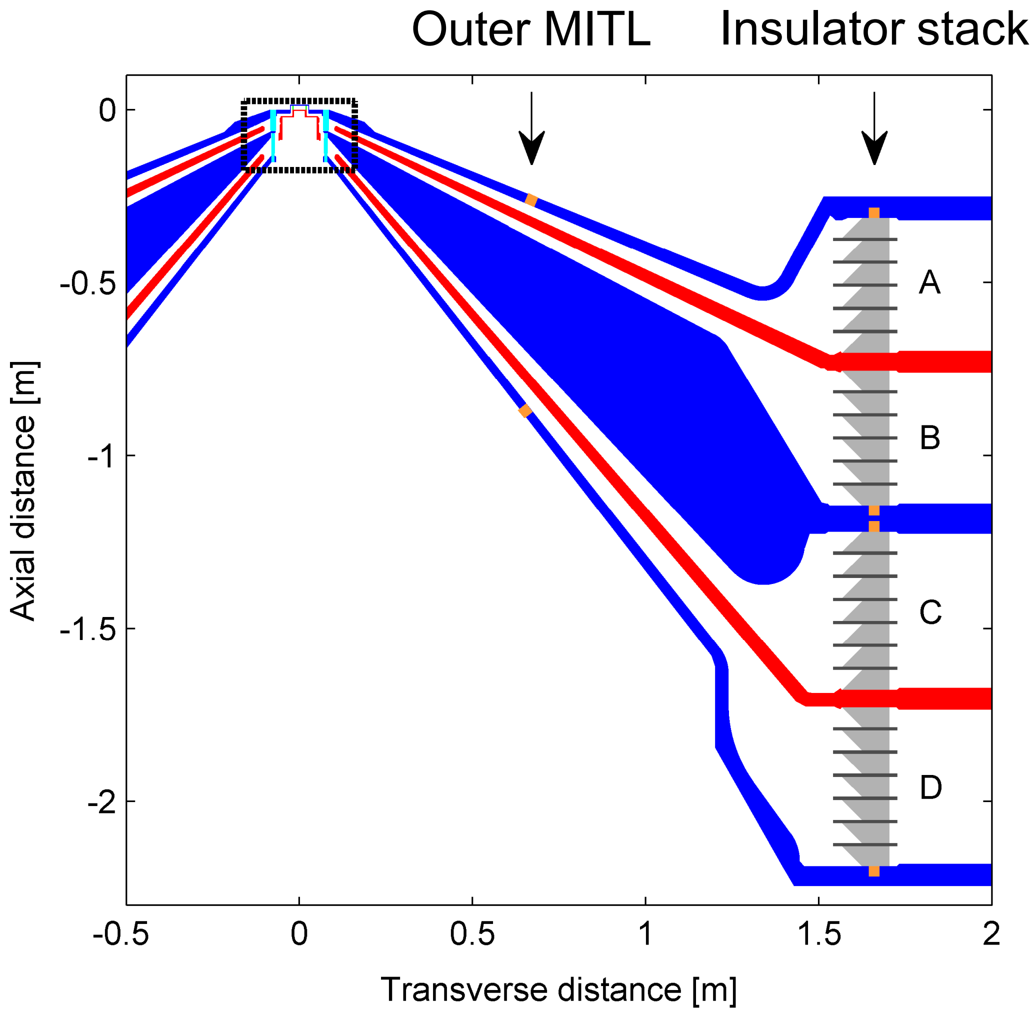
- Substantial losses are only observed on some types of experiments
- Magnitude of loss seems to be consistent for nominally identical experiments
- Losses are attributed to inefficient post-hole convolute performance

The Z machine stores 20 MJ of energy and can deliver more than 25 MA to the load

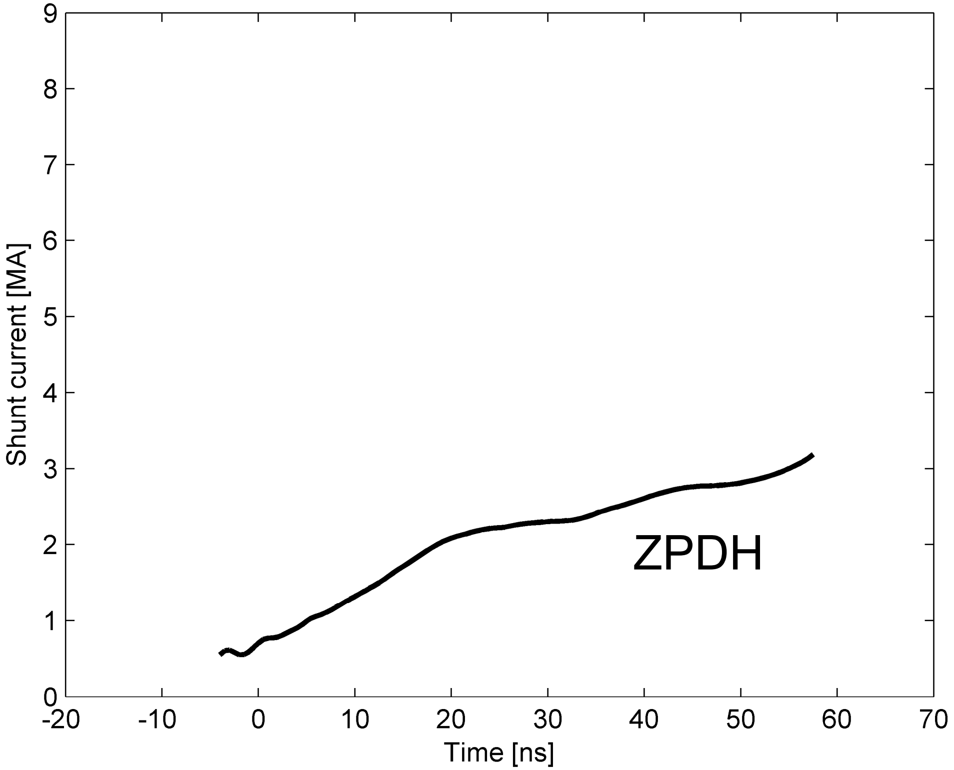


Current monitors throughout the vacuum section help identify the location of losses



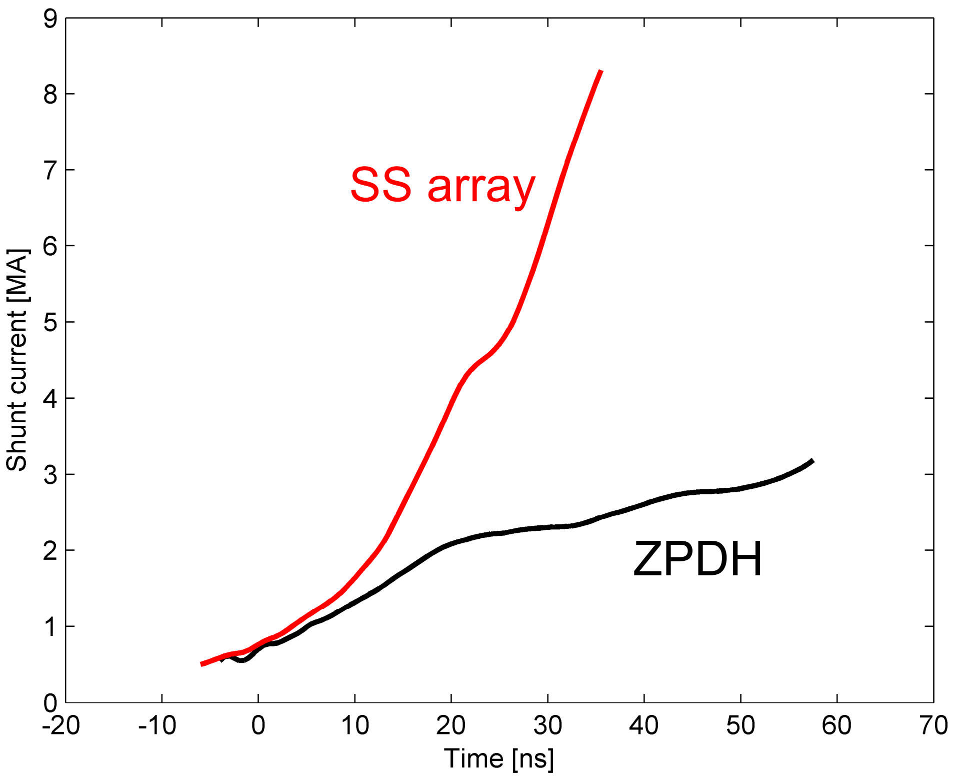


Not all experiments experience the same amount of loss



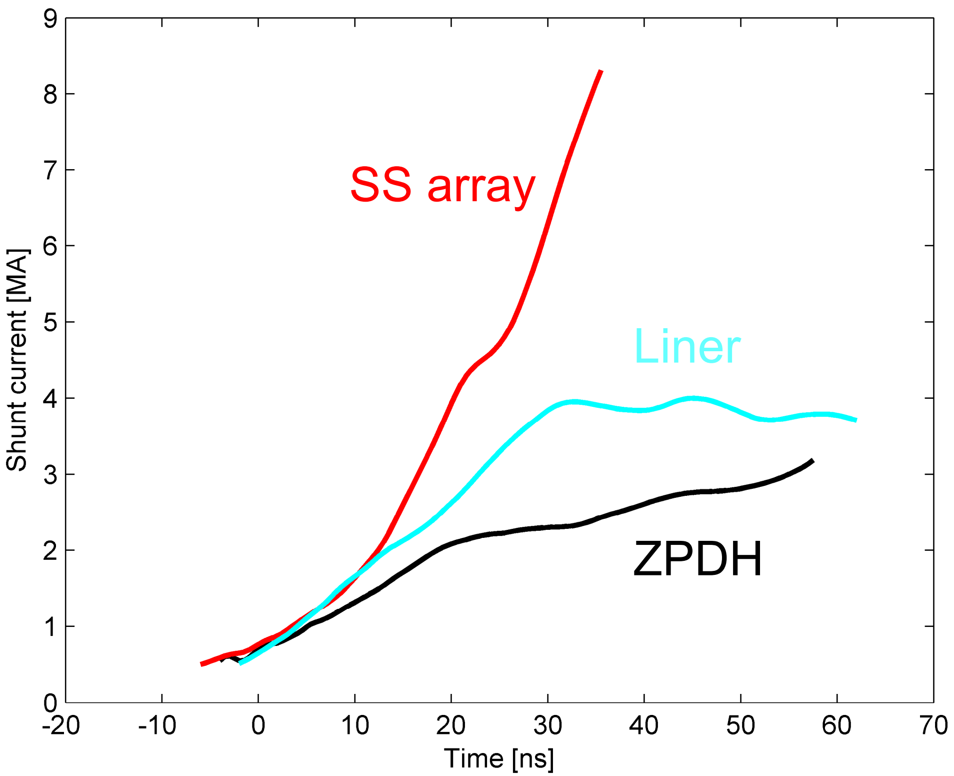
- Z-pinch dynamic hohlraum
  - L_0 = 2.7 nH
  - Peak dL/dt = 1.4 nH/ns

Not all experiments experience the same amount of loss



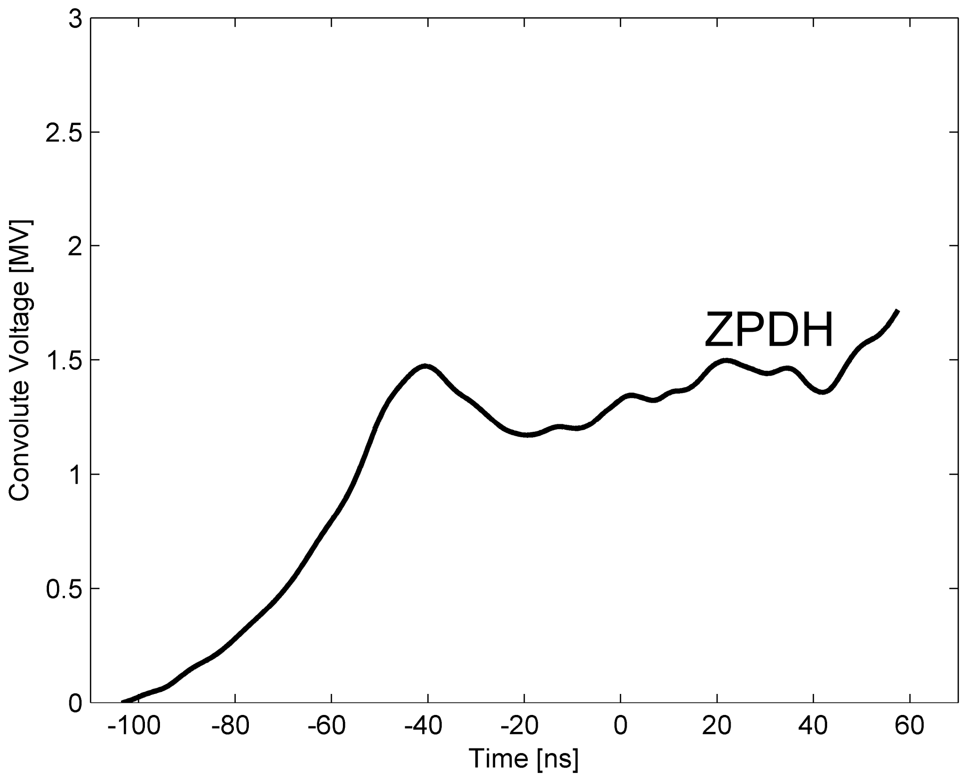
- Z-pinch dynamic hohlraum
  - L_0 = 2.7 nH
  - Peak dL/dt = 1.4 nH/ns
- 70 mm SS wire array
  - L_0 = 1.8 nH
  - Peak dL/dt = 8 nH/ns

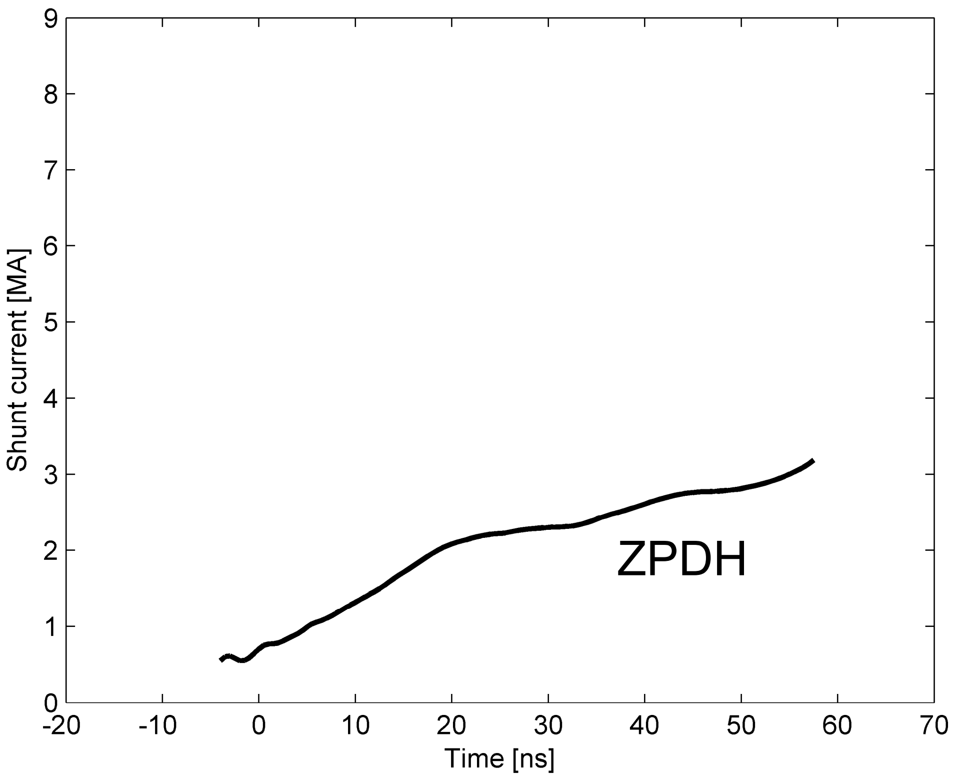
Not all experiments experience the same amount of loss



- Z-pinch dynamic hohlraum
  - L_0 = 2.7 nH
  - Peak dL/dt = 1.4 nH/ns
- 70 mm SS wire array
  - L_0 = 1.8 nH
  - Peak dL/dt = 8 nH/ns
- Solid beryllium liner
  - L_0 = 4.3 nH
  - Peak dL/dt = 0.26 nH/ns

There appears to be a relationship between convolute voltage and current loss





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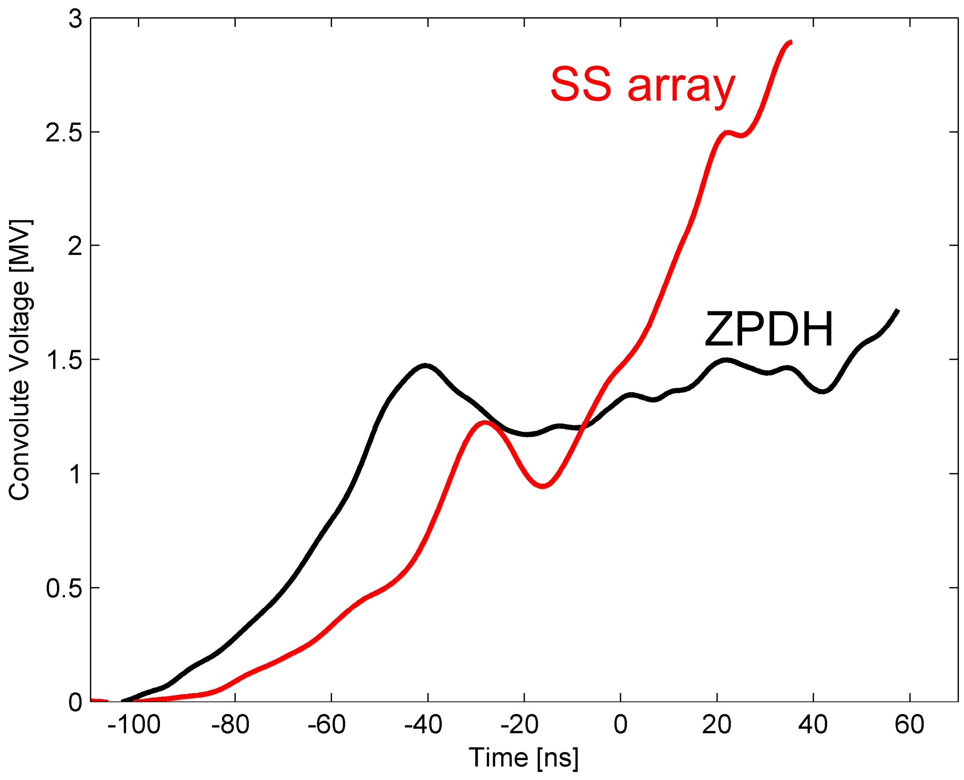

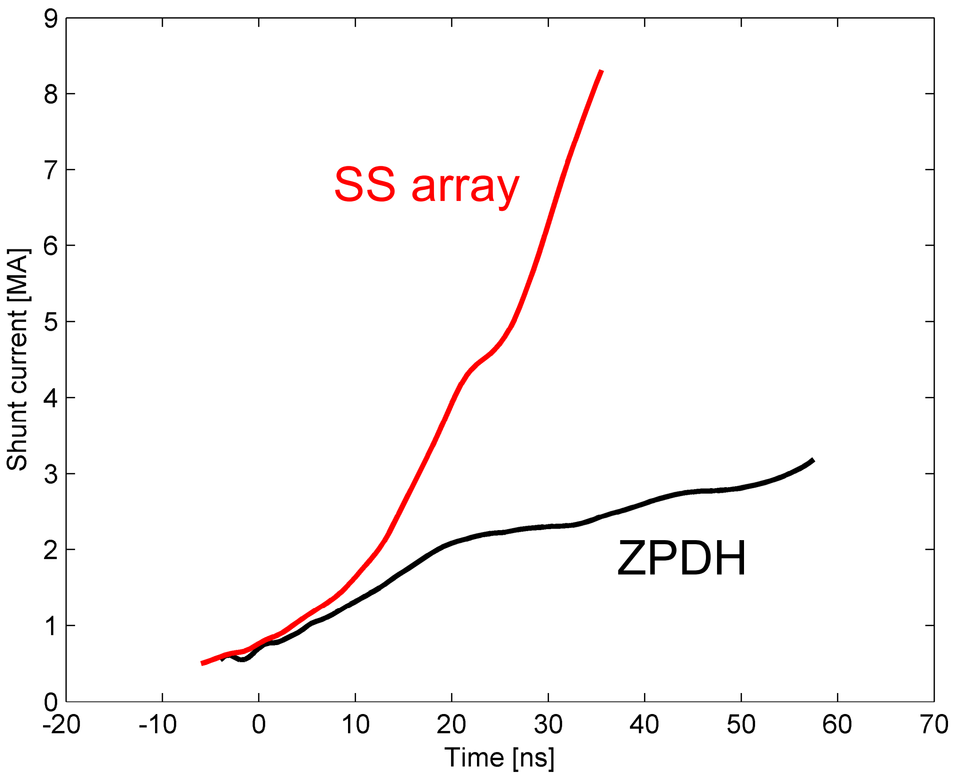

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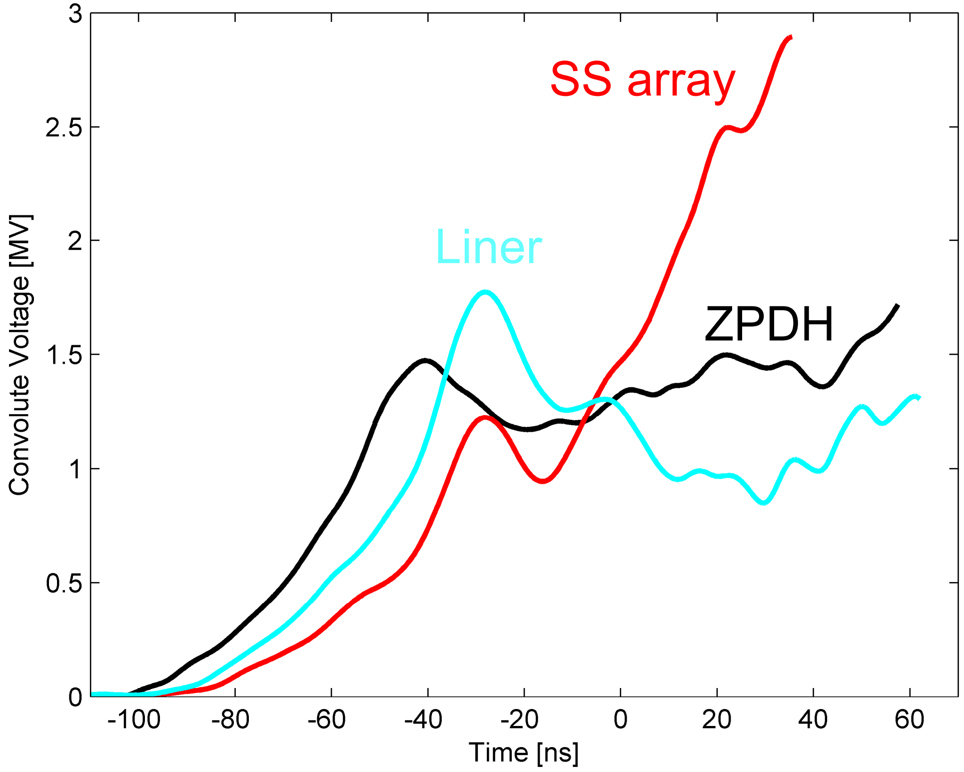
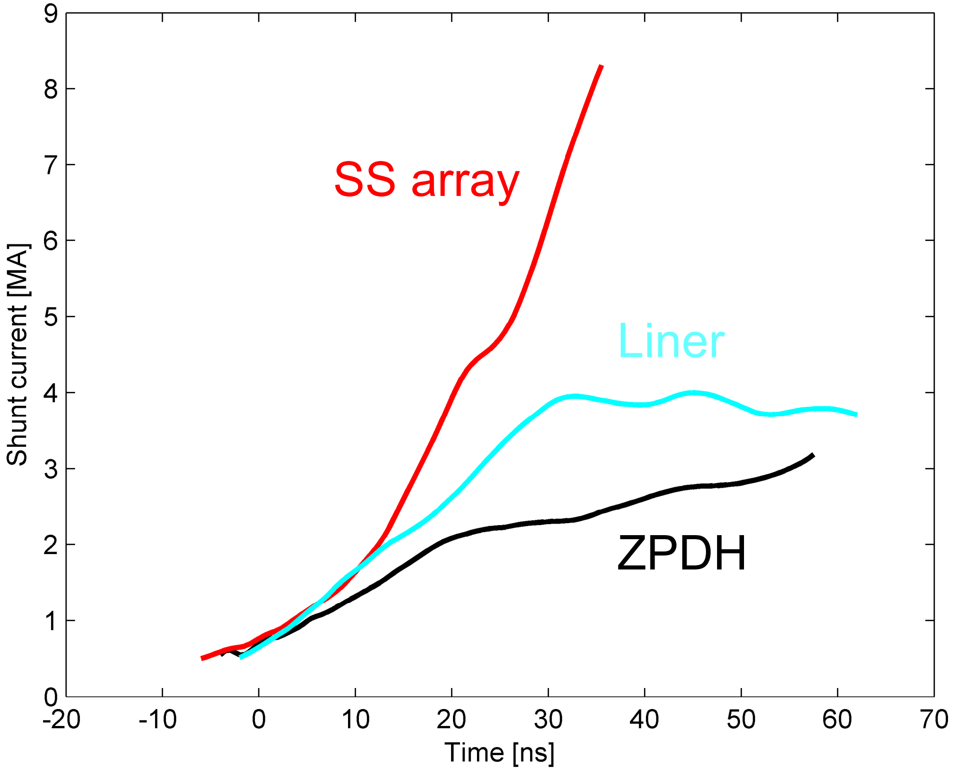
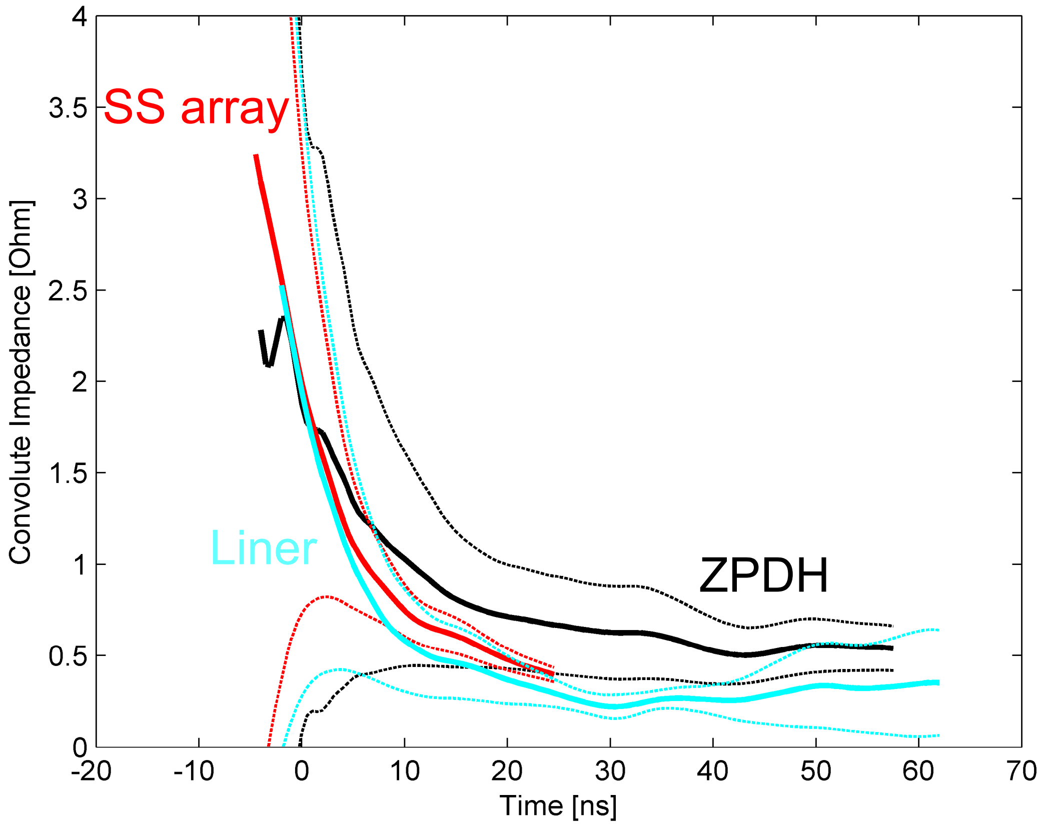


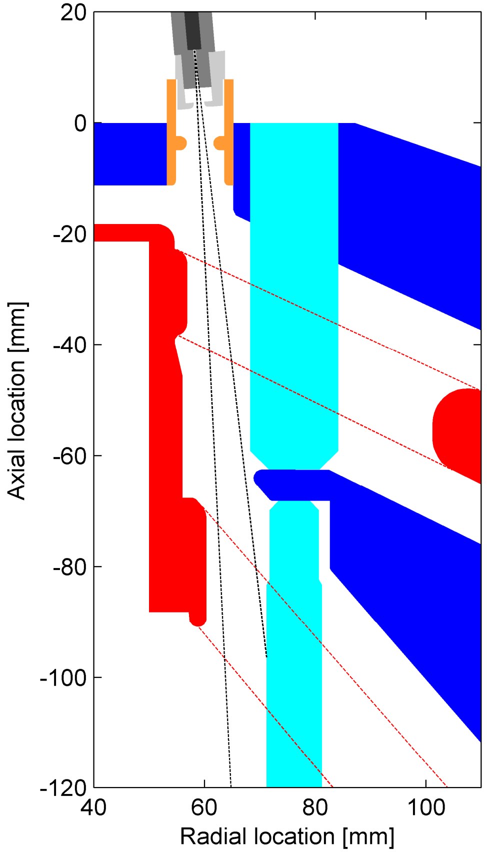


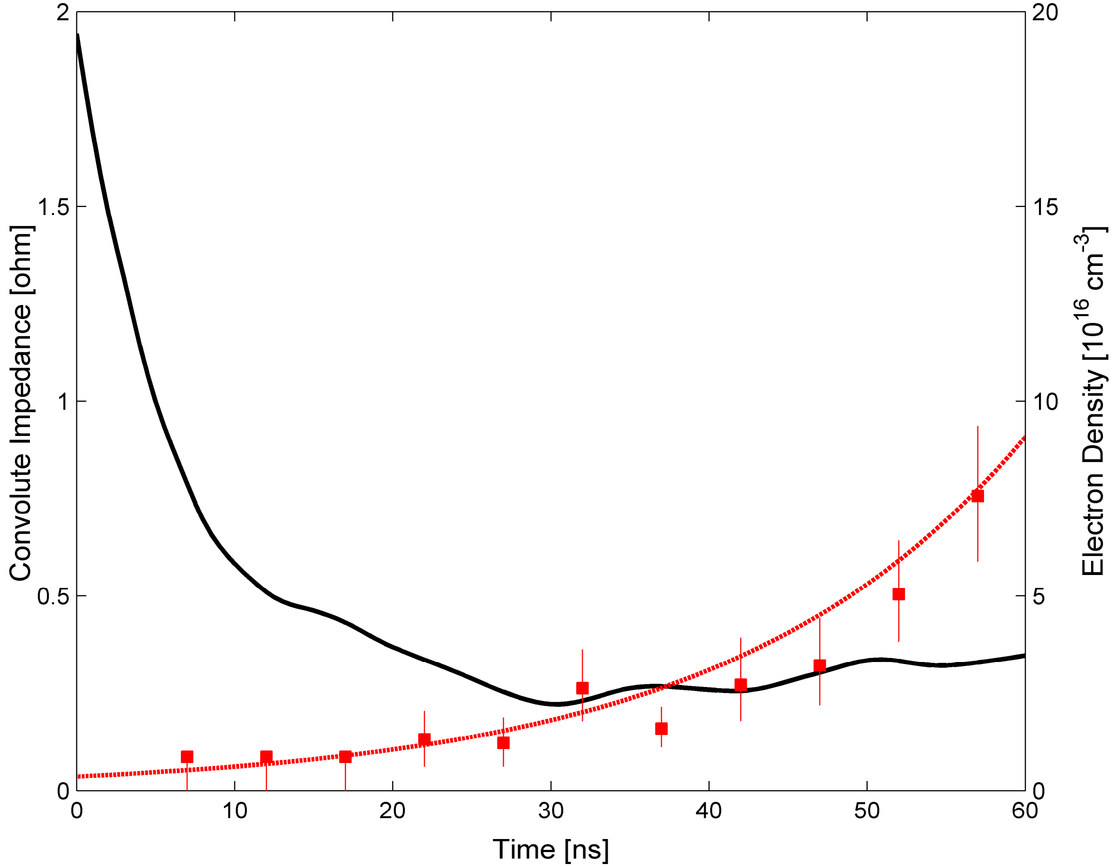
Experiments with dramatically different losses have relatively similar convolute impedance



- Convolute impedance is defined as voltage applied across divided by current shunted through
- Convolute impedance rapidly drops from effectively infinite to around 0.5 ohm
- **What causes the impedance collapse?**

Plasma is observed in the convolute region around the time of impedance collapse

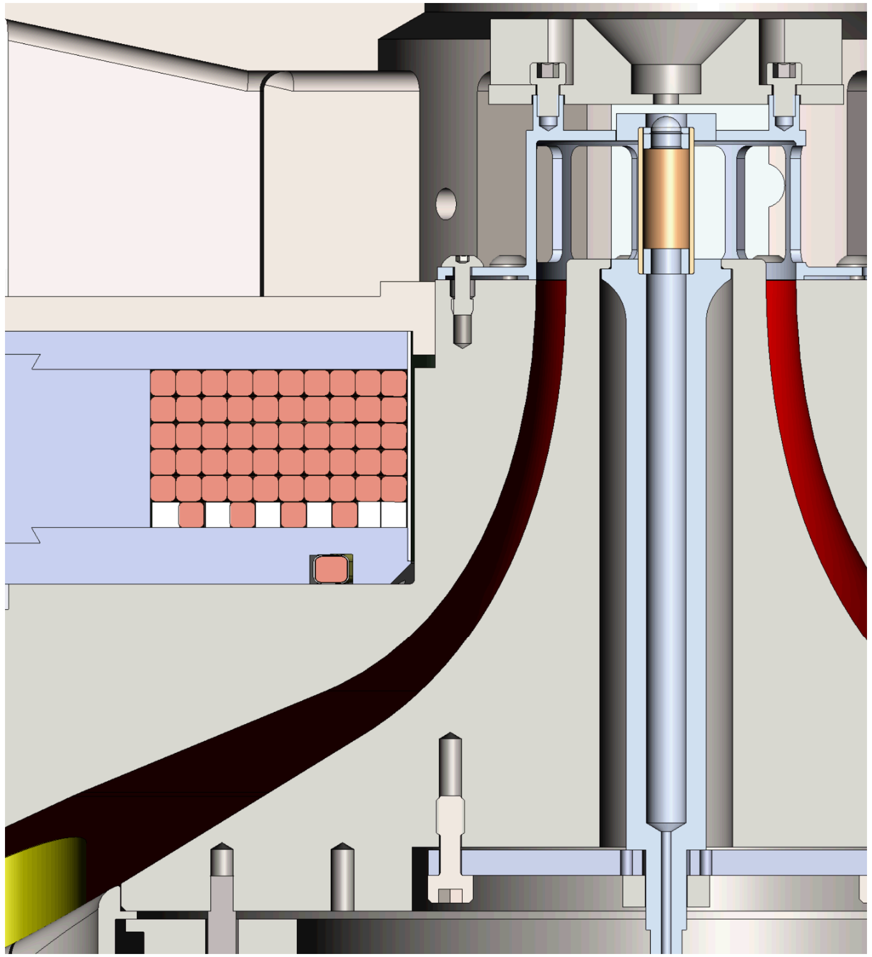




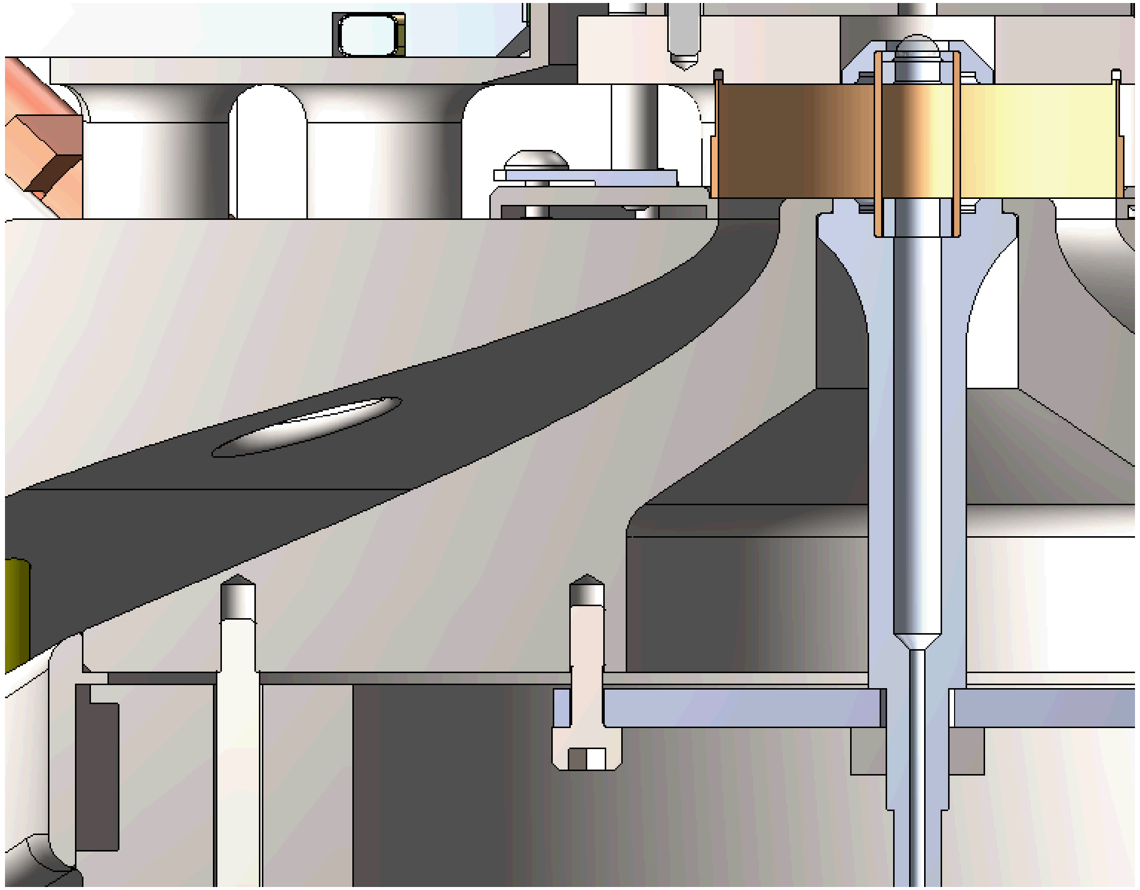
- As the impedance drops, the plasma density exceeds 1e16 cm^{-3}
- The density rapidly rises to 1e17 cm^{-3} by stagnation
- A similar trend is observed for all load types

To improve current delivery in ICF experiments, we have significantly reduced inductance

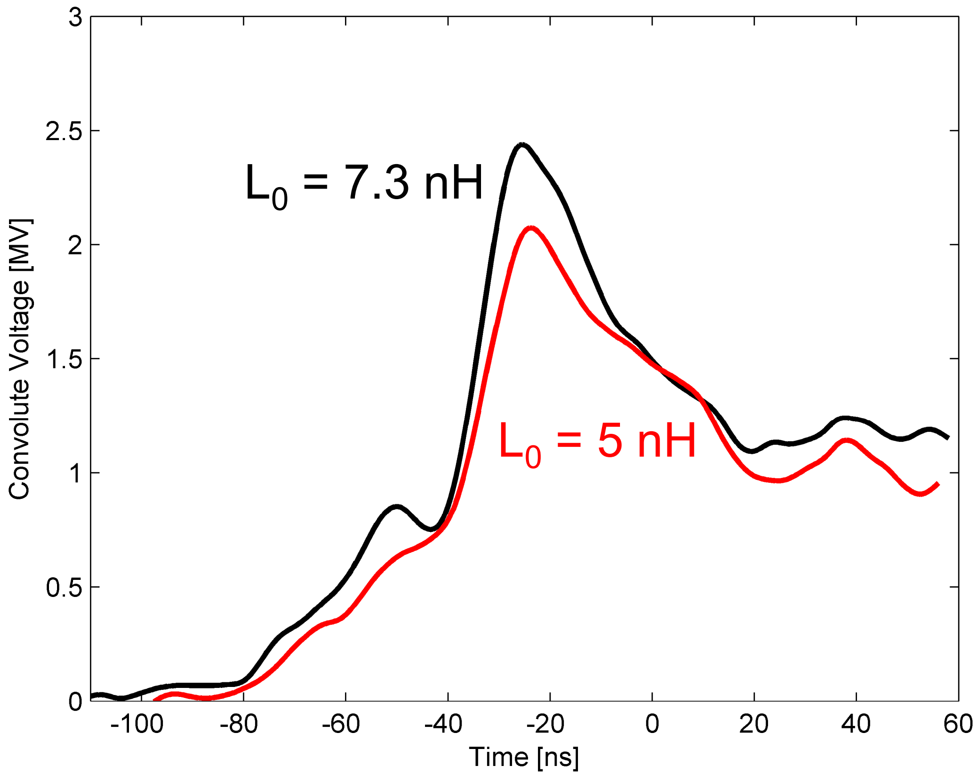
Old design: L_0 = 7.3 nH

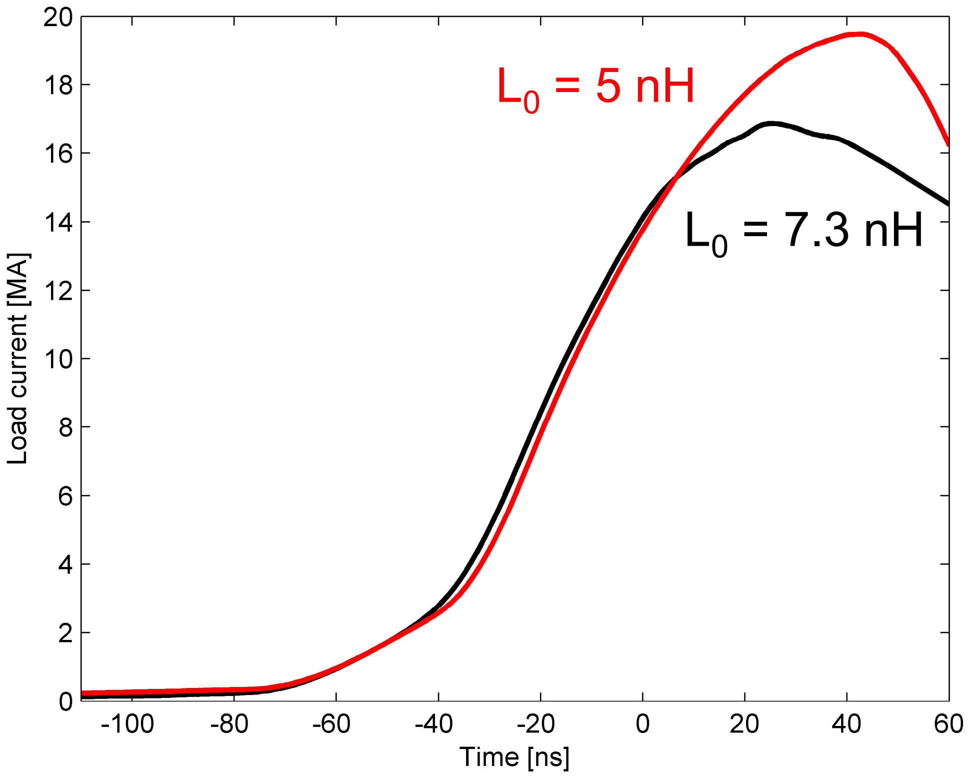


New design: L_0 = 5 nH



The lower inductance design reduces convolute voltage and consequently current loss





Peak voltage dropped from 2.4 to 2 MV

Peak current increased from 17 to 19.5 MA

Conclusions

- Substantial losses are observed in some experiments on Z
- Plasma formation in the convolute is correlated with the observed current losses
- The convolute appears to behave very similarly on all experiments
  - Experiments with higher voltages drive greater losses
- Lower inductance designs have demonstrated improved load current delivery

* The results of this study were recently submitted to Phys. Rev. Accel. Beams