

Thor: a pulsed-power driver optimized for material-physics experiments

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Pulsed power and dynamic material physics experiments

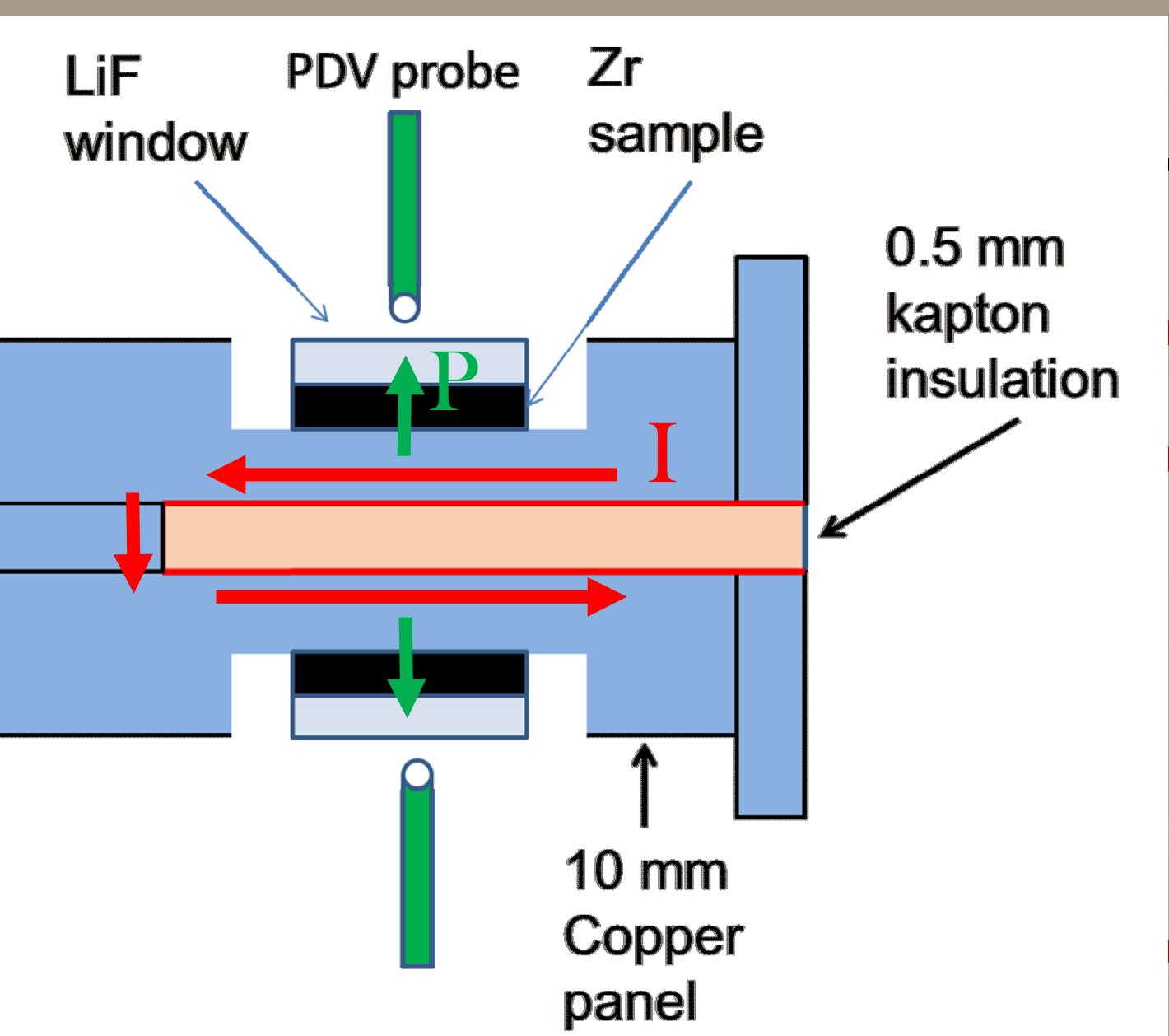
- Electrical currents generate magnetic fields, which are used to drive acoustic pressure waves for dynamic material physics experiments.
- This technique is unique in its ability to conduct tailored shockless experiments at high pressures.

$$P_{\text{magnetic}} = \frac{\mu_0 I^2}{2 w^2}$$

I = current
w = width of the conductor

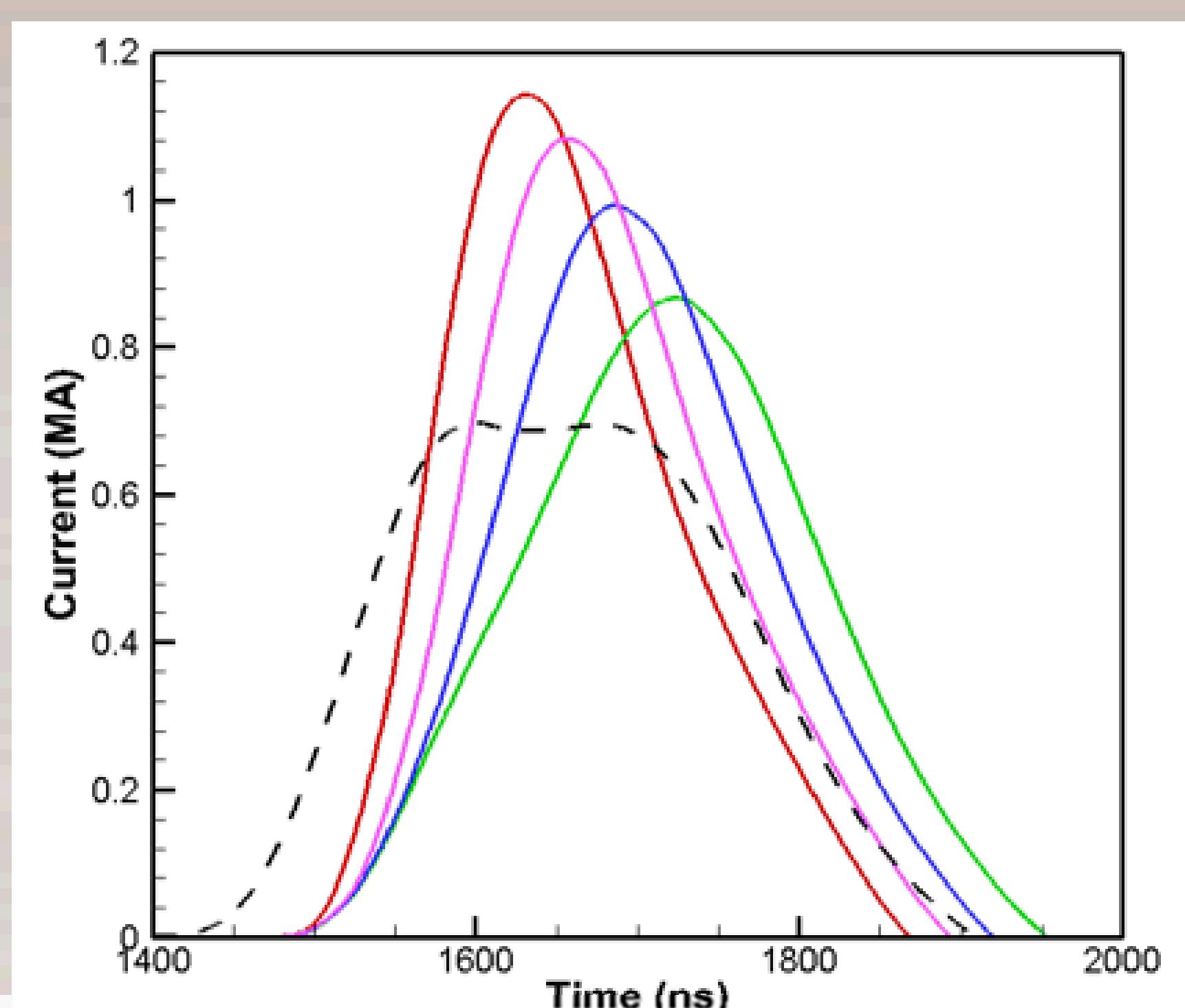
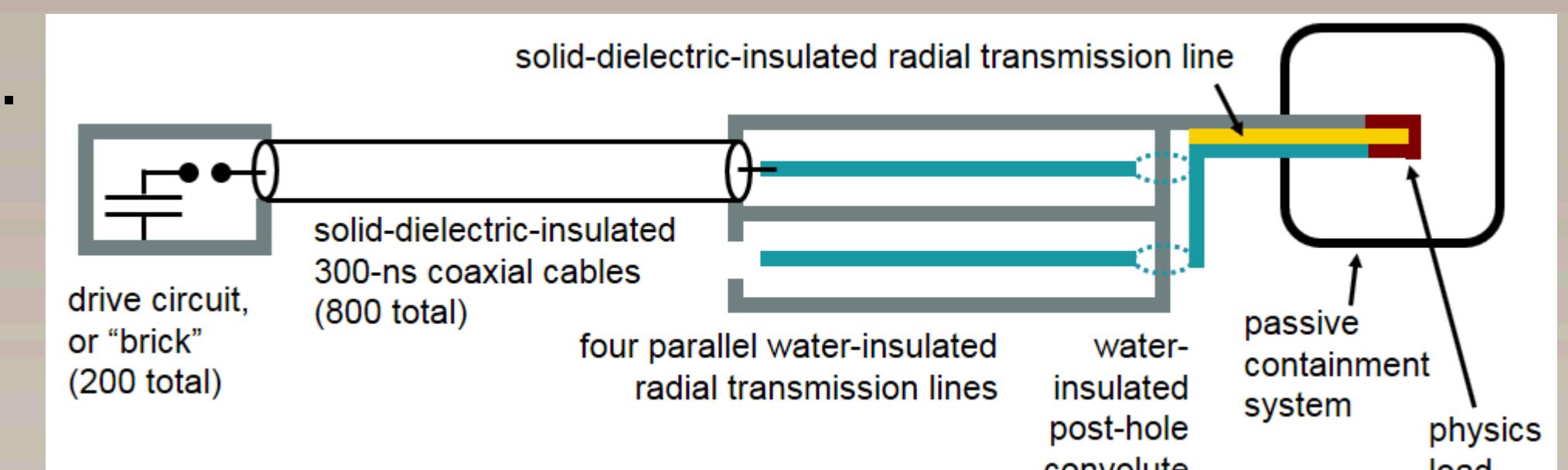
Thor design concept

- Electrical energy is stored in many small energy storage units called "bricks". Thor 48 consists of 48 bricks.
- The brick switches are triggered to launch 100 ns pulses into long cables that provide transit time isolation between the bricks.
- The pulses are then summed together at the load to generate a tailored magnetic/acoustic pressure wave.



Advantages of the Thor concept

- Precision control and tailoring of pulse shape.
 - The 250 ns long cables provide a 500 ns window over which we can easily control the sample pressure.
- Less damage from faults in the system.
 - More isolation between energy storage units.
- The modular design can be operated from Thor 8 to Thor 72.
 - Allows for the gradual build up of capability.
- Low experimental cost (~\$1 k per shot) and high shot rate (~8 per day).
 - Makes it ideal for campaigns which are too costly to run on Z.
- Engineered safety.
- Economies of scale.



Thor 48: recent experimental results

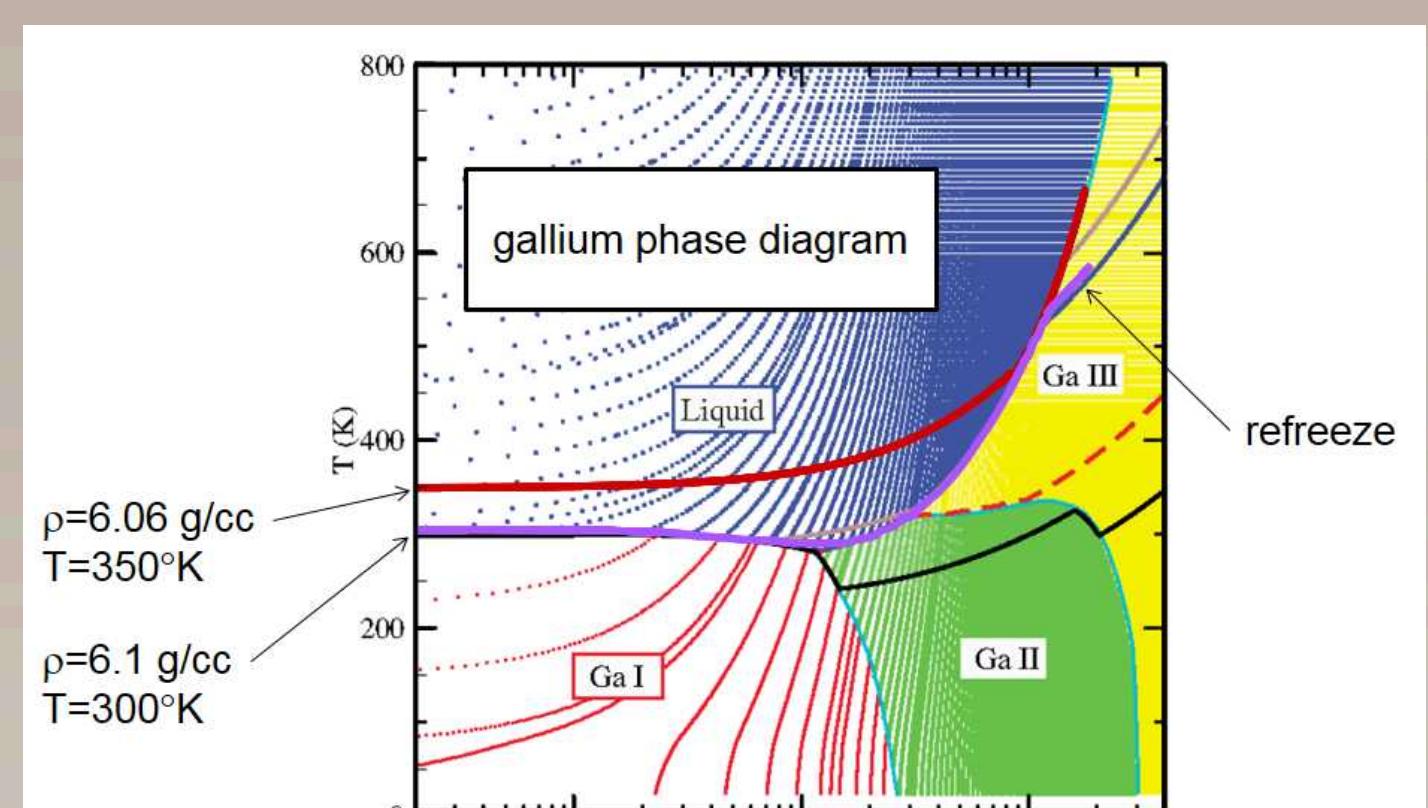
- We completed the assembly of Thor 48 on April 11th 2017.
- Thor 48 has conducted experimental shots at a charge voltage of 80 kV, which reached peak currents as high as 2.16 MA and peak pressures as high as 250 kbar.
- We observed a phase change in zirconium at ~80 kbar.
- We conducted strength experiments in copper at pressures as high as 100 kbar.

Thor 72 in FY-18

- We expect to assemble and commission Thor 72 in FY 2018.
- Thor 72 will achieve currents as high as 3 MA, and pressures in the 600 kbar range on an 8 mm wide panel with a synchronous pulse.

Materials of interest in the 100-600 kbar range FY-18:

▪ Cerium	▪ Additively manufactured materials
▪ Zirconium	▪ Calcium Fluoride
▪ Gallium	▪ PZT
▪ Titanium	▪ Aluminum
▪ Iron	▪ Copper
▪ Water	▪ Xenon



Thor is an ideal platform for the development of advanced physics-load and diagnostic concepts

▪ X-ray diffraction	▪ VISAR development	▪ Pyrometry
▪ PDV development	▪ Emission/reflectance	▪ Ellipsometry spectroscopy

