

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

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## Pulsed power and dynamic material physics experiments

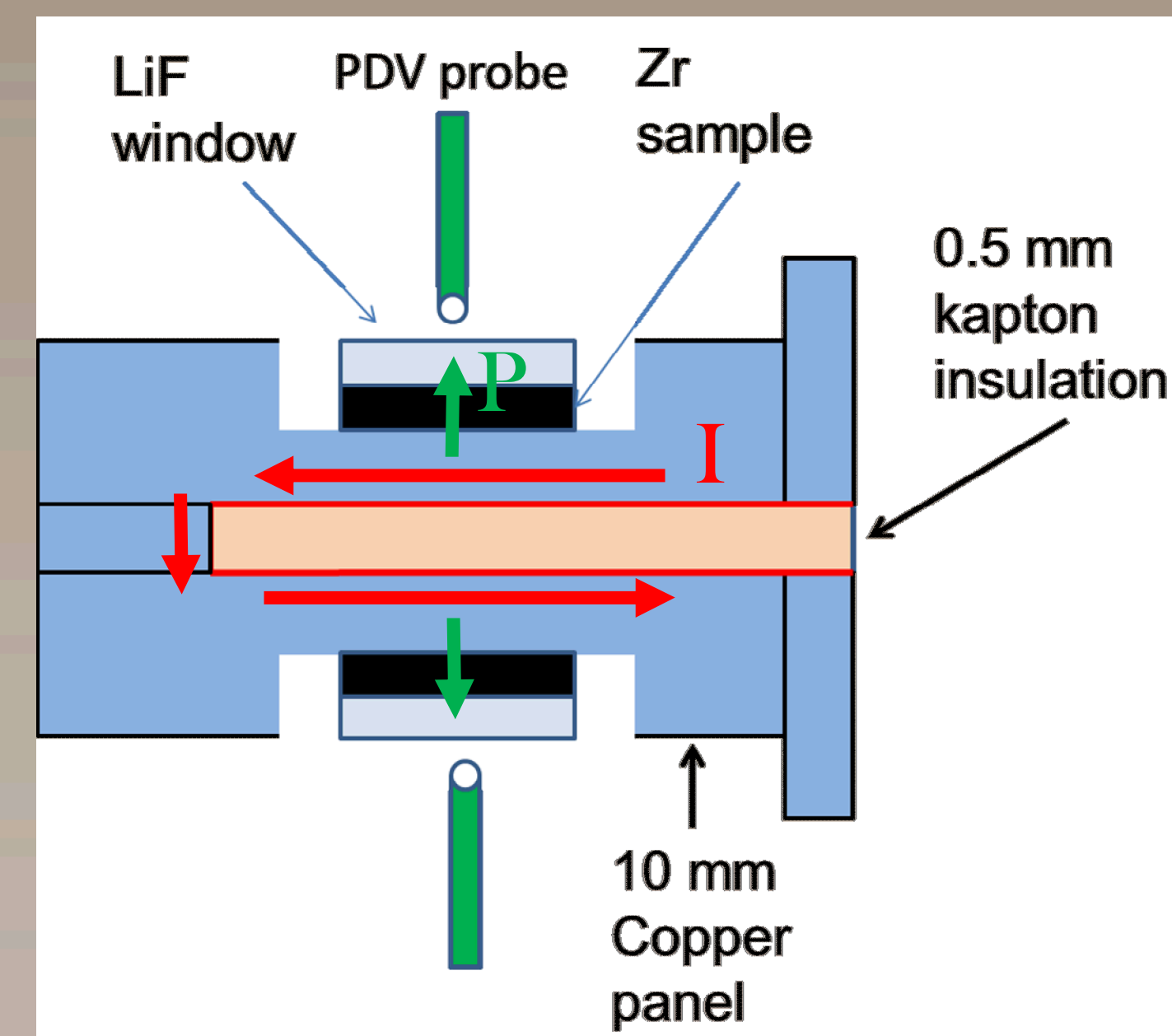
- Electrical currents generate magnetic fields, which are used to drive acoustic pressure waves for dynamic material physics experiments.
- This technique is unique in its ability to conduct tailored shockless experiments at high pressures.

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

$I$  = current  
 $w$  = width of the conductor

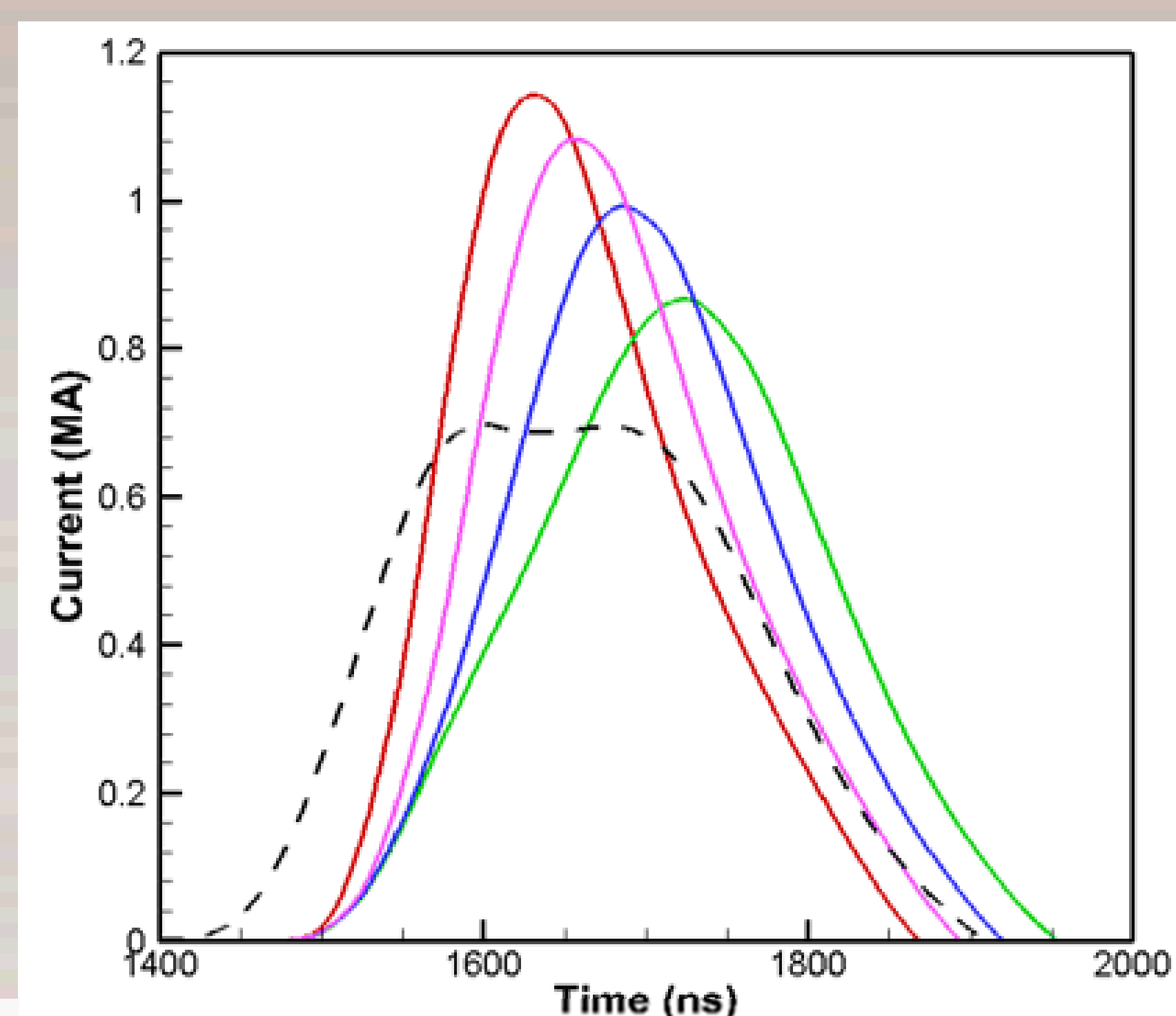
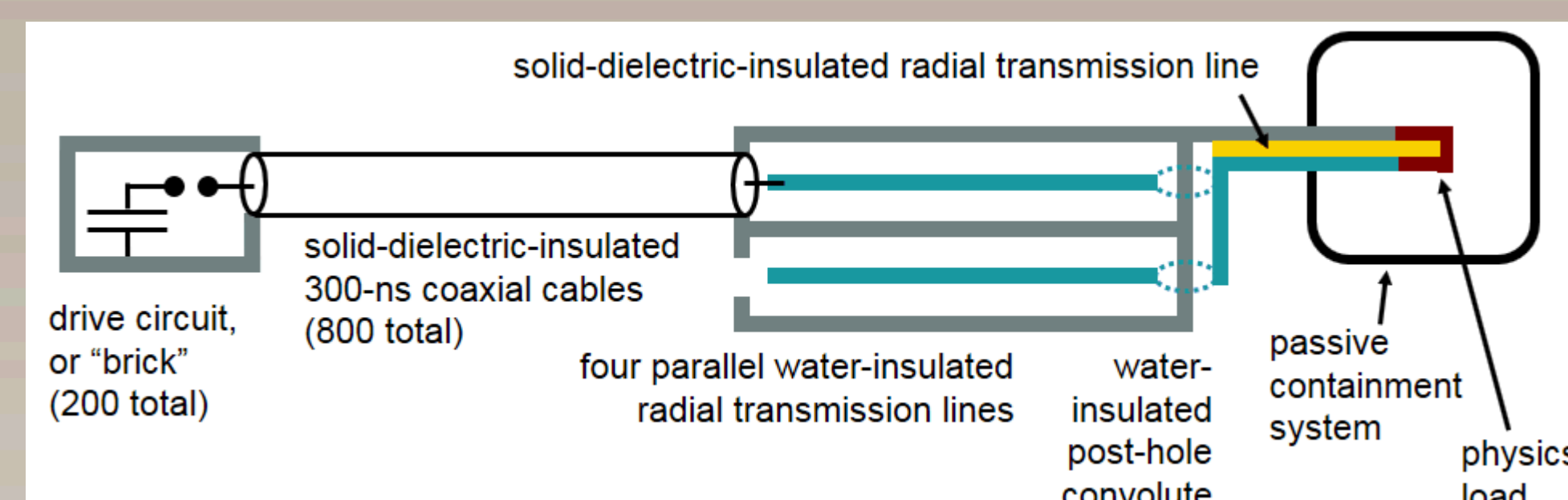
## Thor design concept

- 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

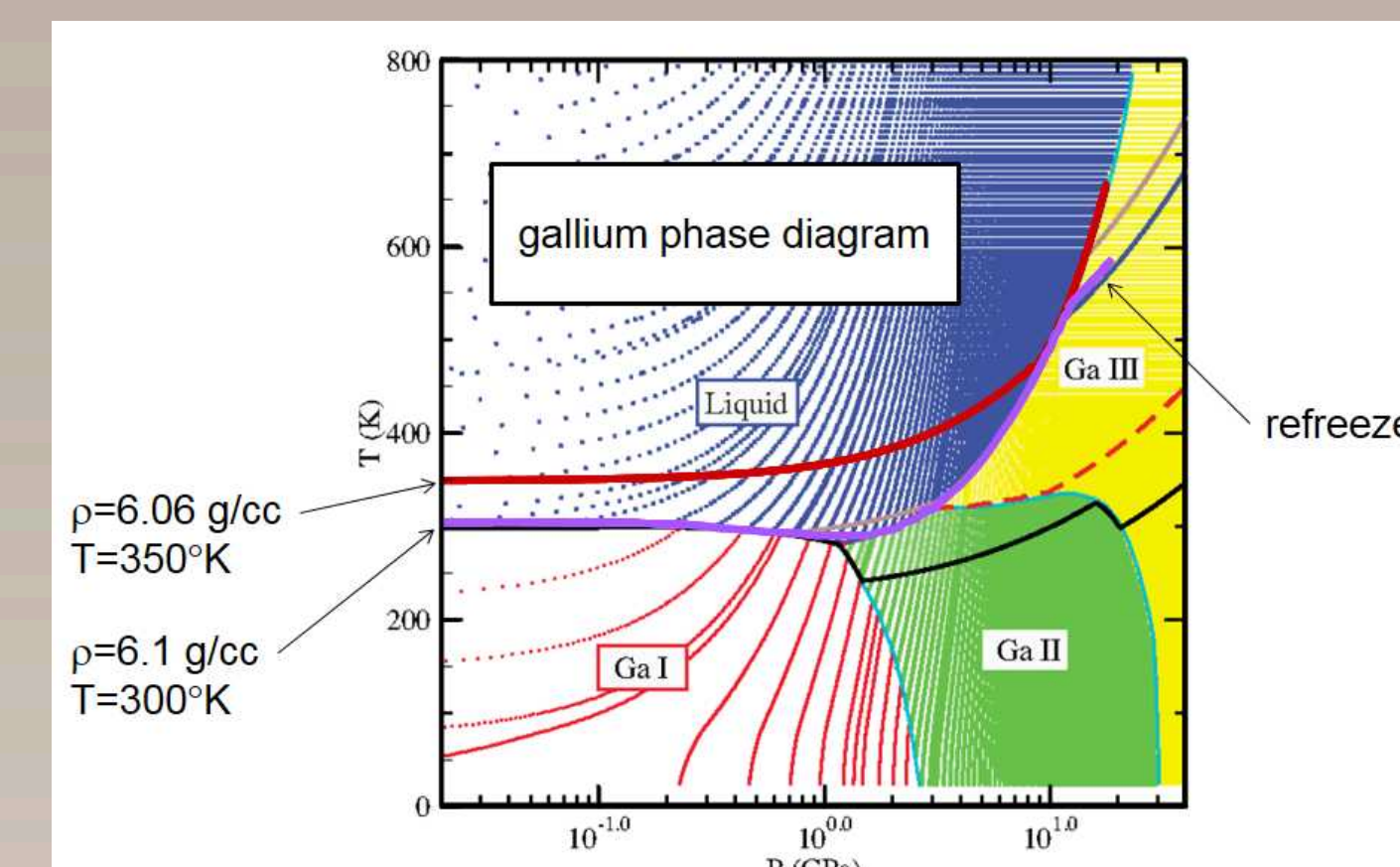
- We completed the assembly of Thor 48 on April 11<sup>th</sup> 2017.
- Thor 48 has conducted experimental shots at a charge voltage of 80 kV, which reached peak currents as high as 2.16 MA and peak pressures as high as 250 kbar.
- We observed a phase change in zirconium at ~80 kbar.
- We conducted strength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

