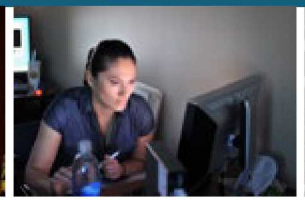
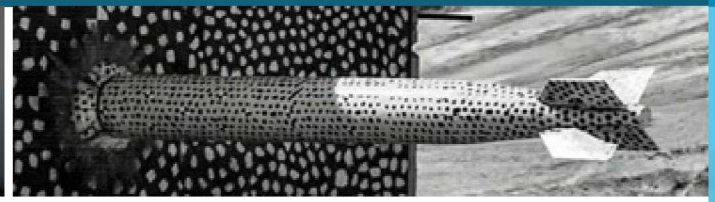
Sandia National Laboratories

SAND2020-2244PE

Uniformity of magnetic-pressure loading on Thor stripline targets





Presented by

Jean-Paul Davis

Thanks to Brian Stoltzfus, Josh Usher, Kevin Austin, Randy Hickman, Bob Campbell, others…

Thor Workshop, 18 February 2020

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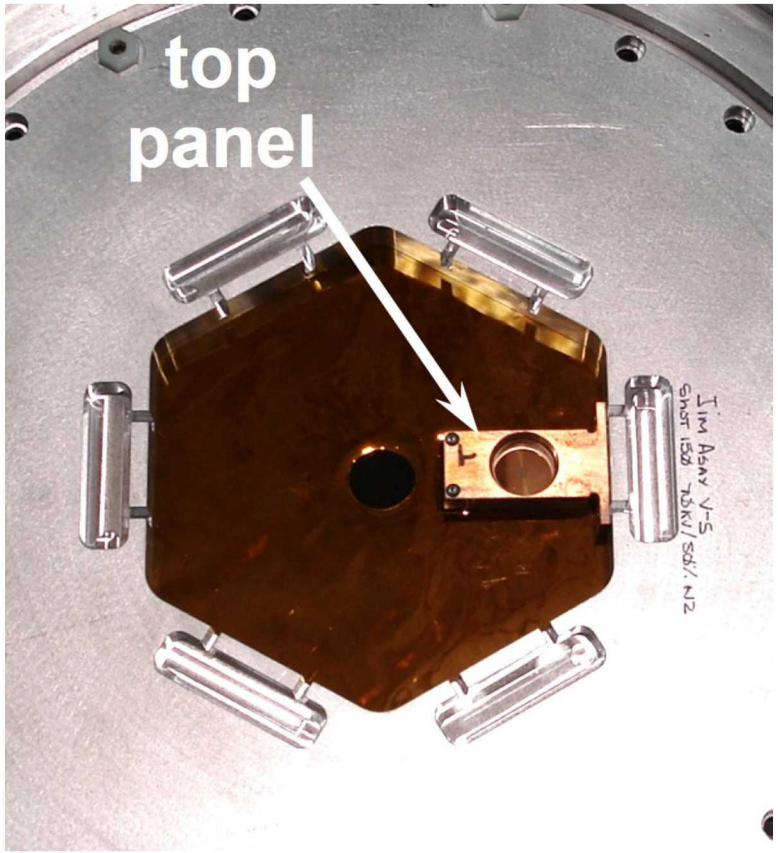
Confidence in uniformity of loading across sample dimensions is derived from previous work on Veloce

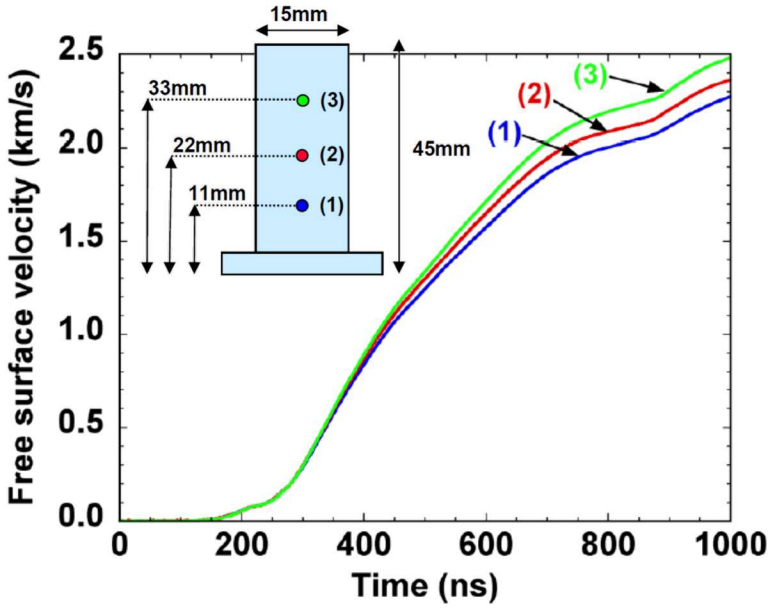
- "Standard" Veloce panel is 15 mm wide × 30 mm long (35 mm in old terminology)
- Featureless, non-tapered panels offer only marginally acceptable uniformity



$$u \sim P \sim B^2$$

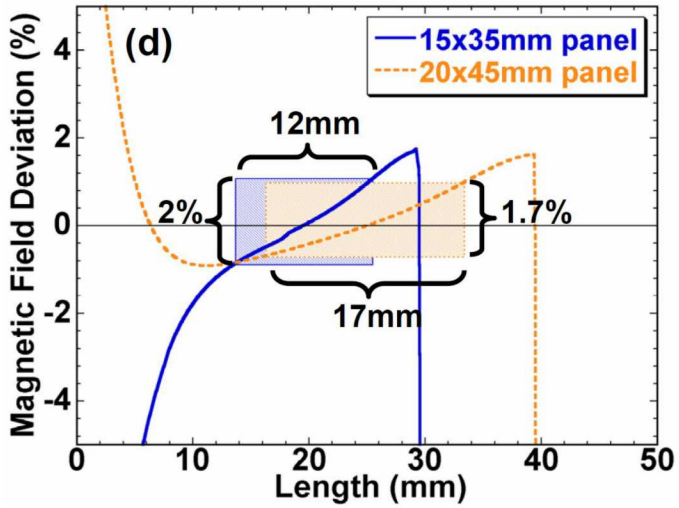
3-D MHD

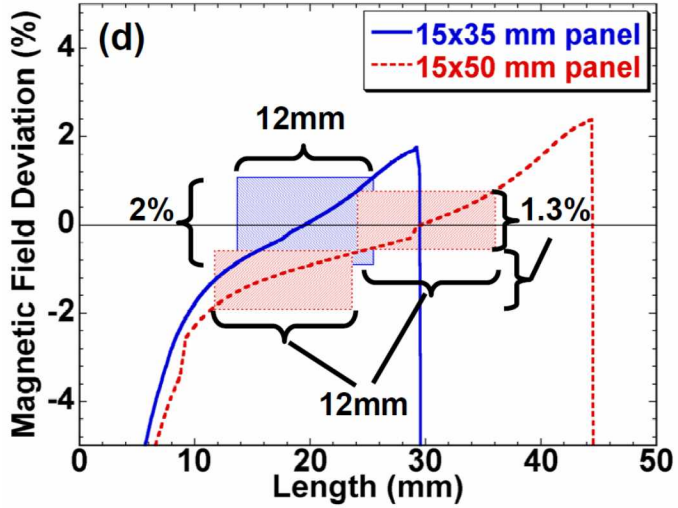
experiment



*T. Ao et al, Rev. Sci. Instrum. **79**, 013903 (2008)*

4% in P_{mag} across 12-mm sample

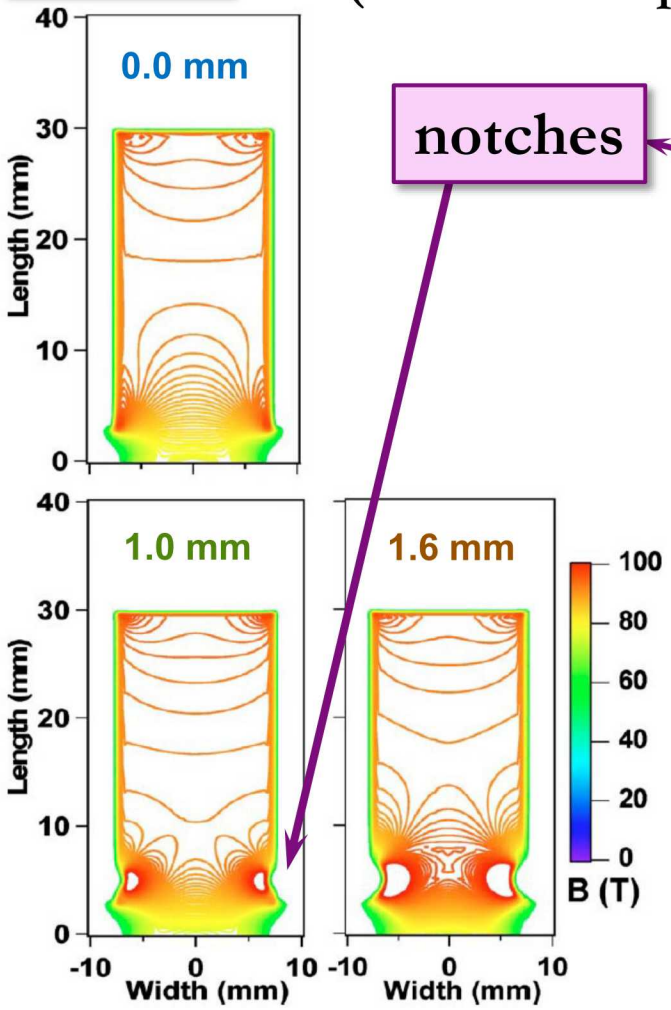




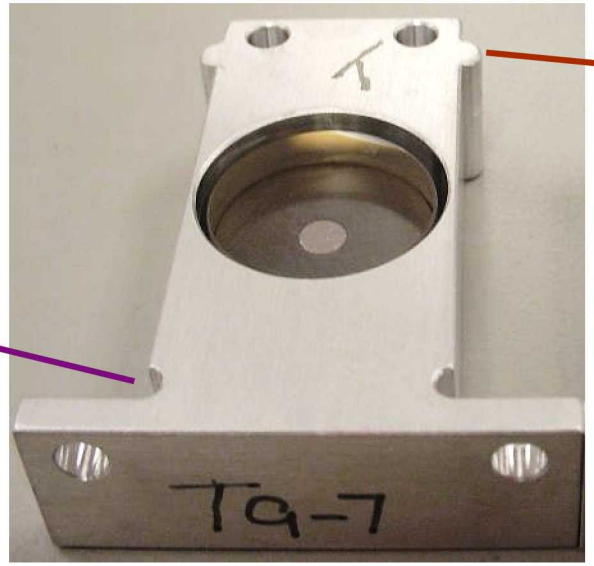
Veloce panels settled on "notches and ears" design

1% in P_{mag} across 12-mm sample (deemed acceptable)

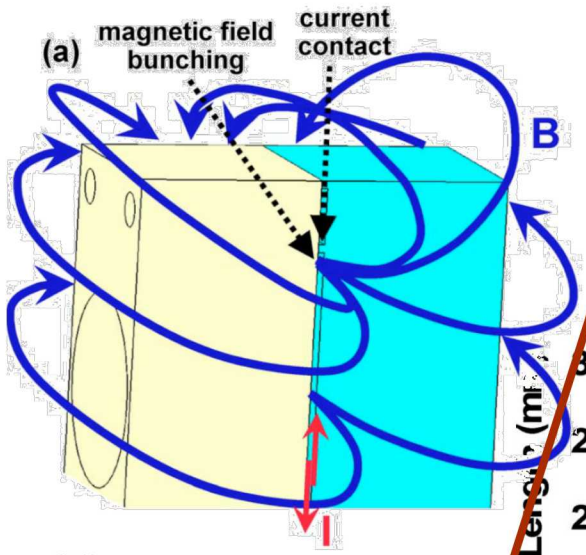
3-D MHD

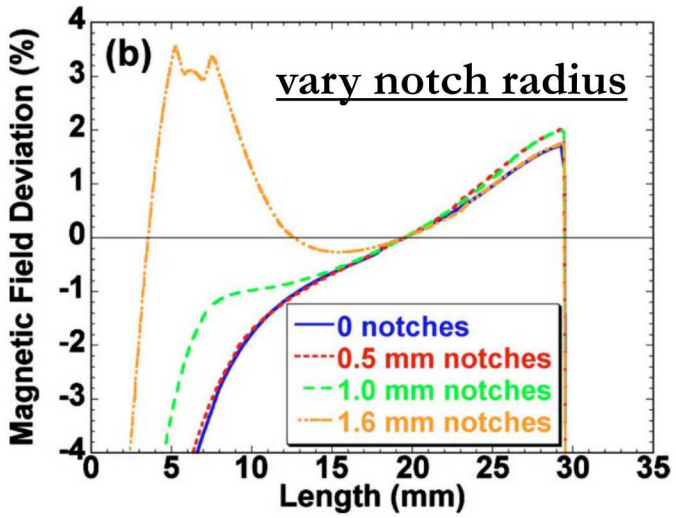


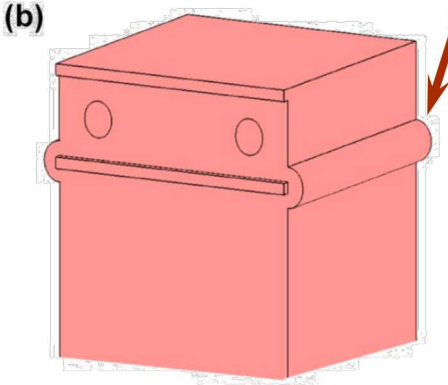
notches



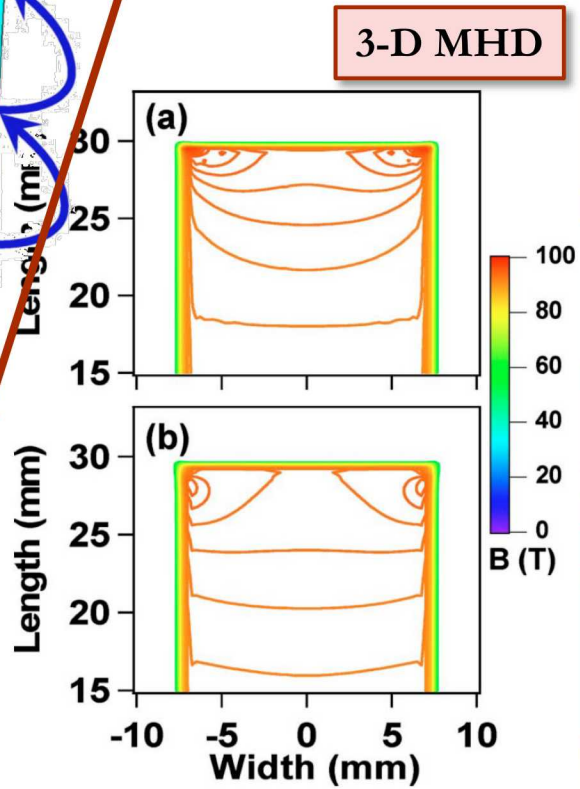
ears





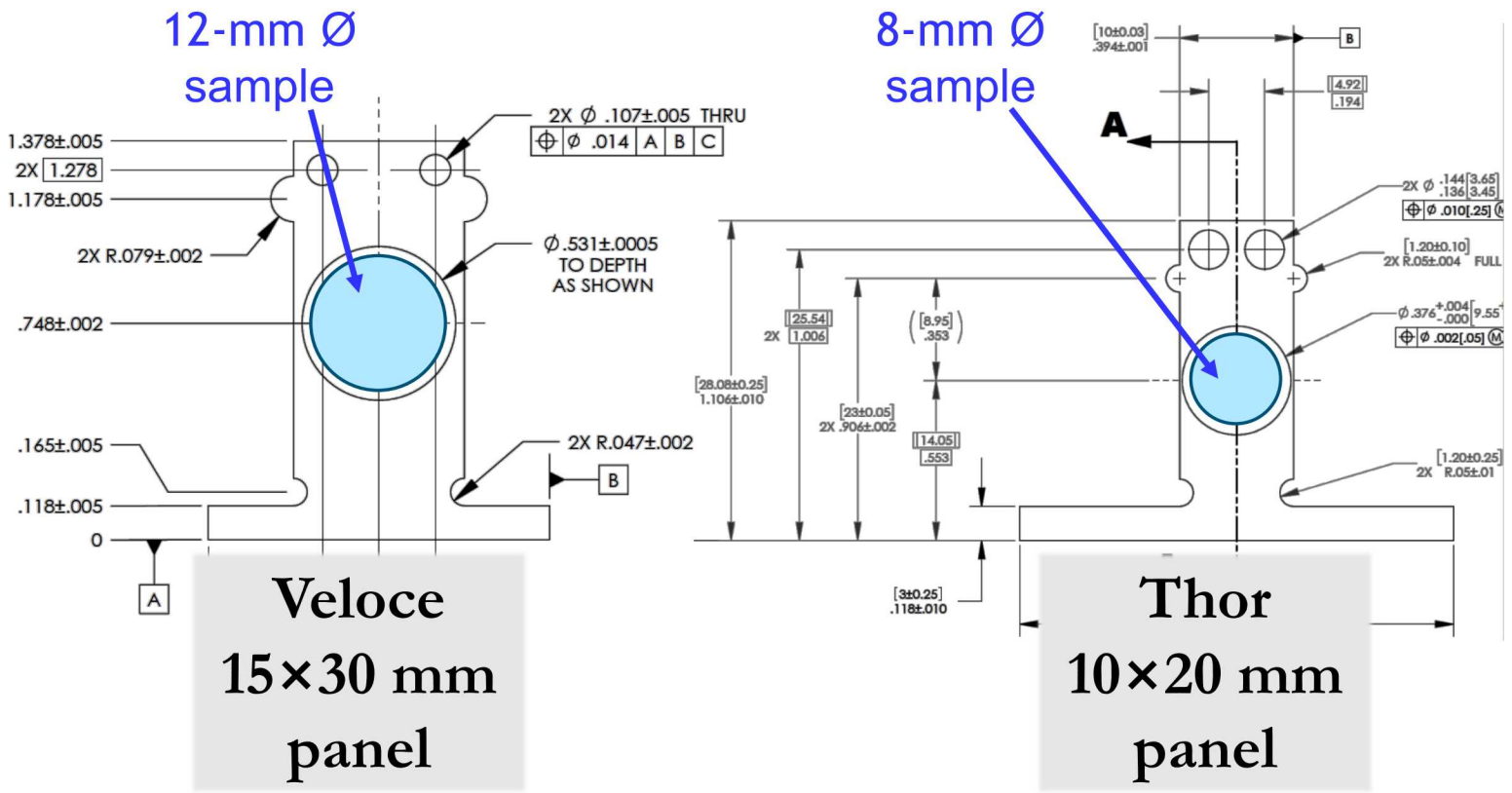


3-D MHD

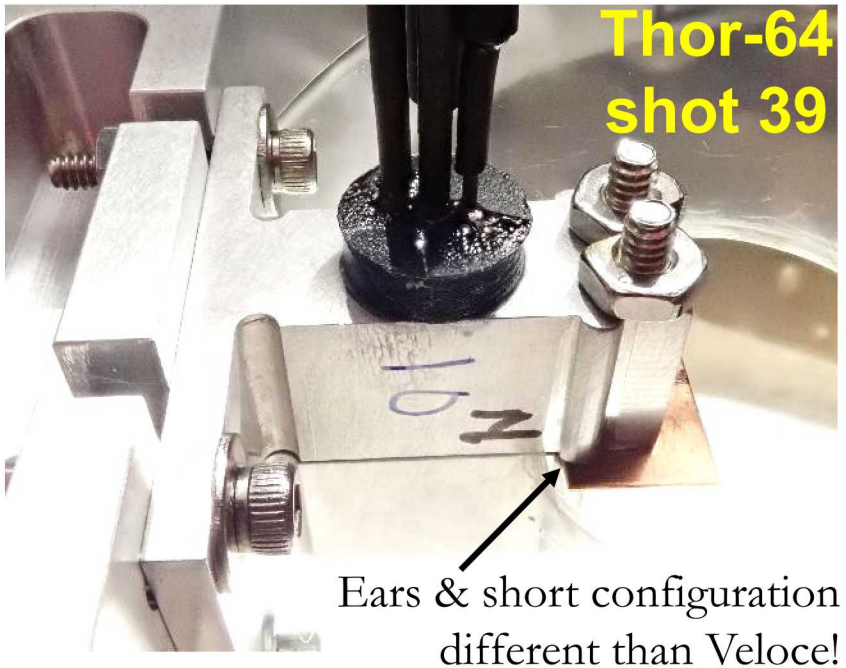


T. Ao et al, Rev. Sci. Instrum. ***79****, 013903 (2008)*

Standard 10×20-mm Thor panel scaled from Veloce 15×30-mm

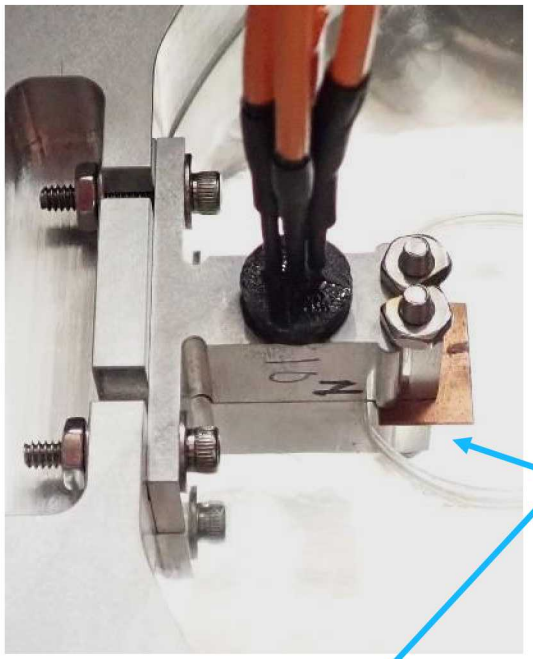


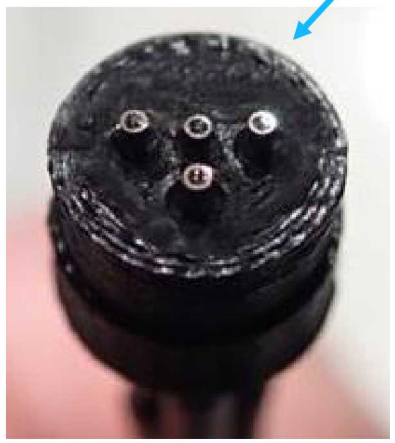
Keep 0.5" (~13-mm) panel thickness



- Maintain 2:1 aspect ratio; does longitudinal spatial gradient of B-field scale self-similarly?
  - Goal is to maintain 1% variation in magnetic pressure across sample (8 mm on Thor 10-mm panel)
- Thor 2:1 panels also available in widths of 6, 8, and 15 mm
  - Smaller samples for higher pressure, larger samples at lower pressure

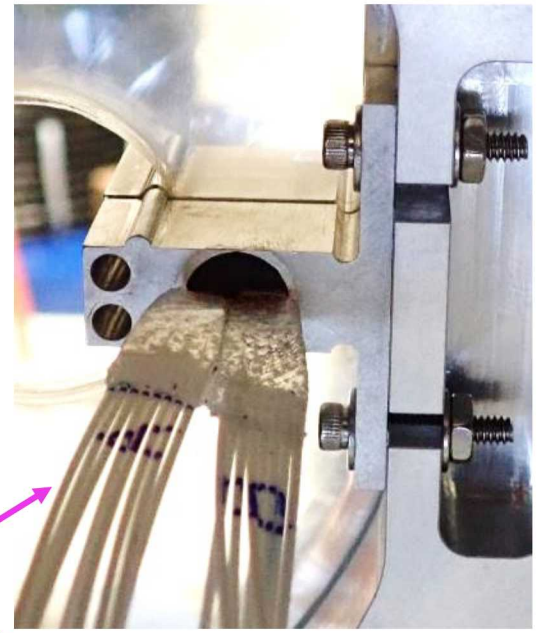
Uniformity measurements use new capabilities at Thor: 8-channel VISAR & PDV systems, custom 3-D printed probe holders

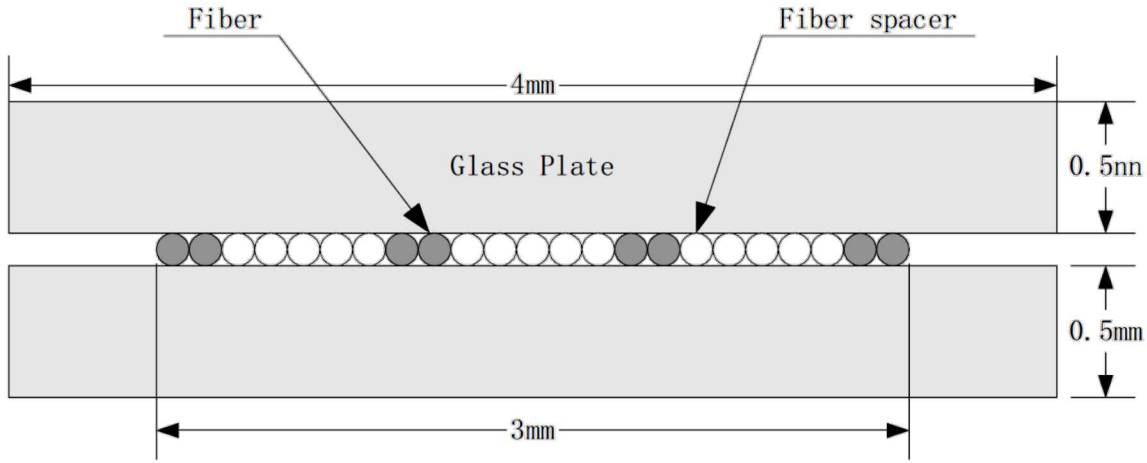




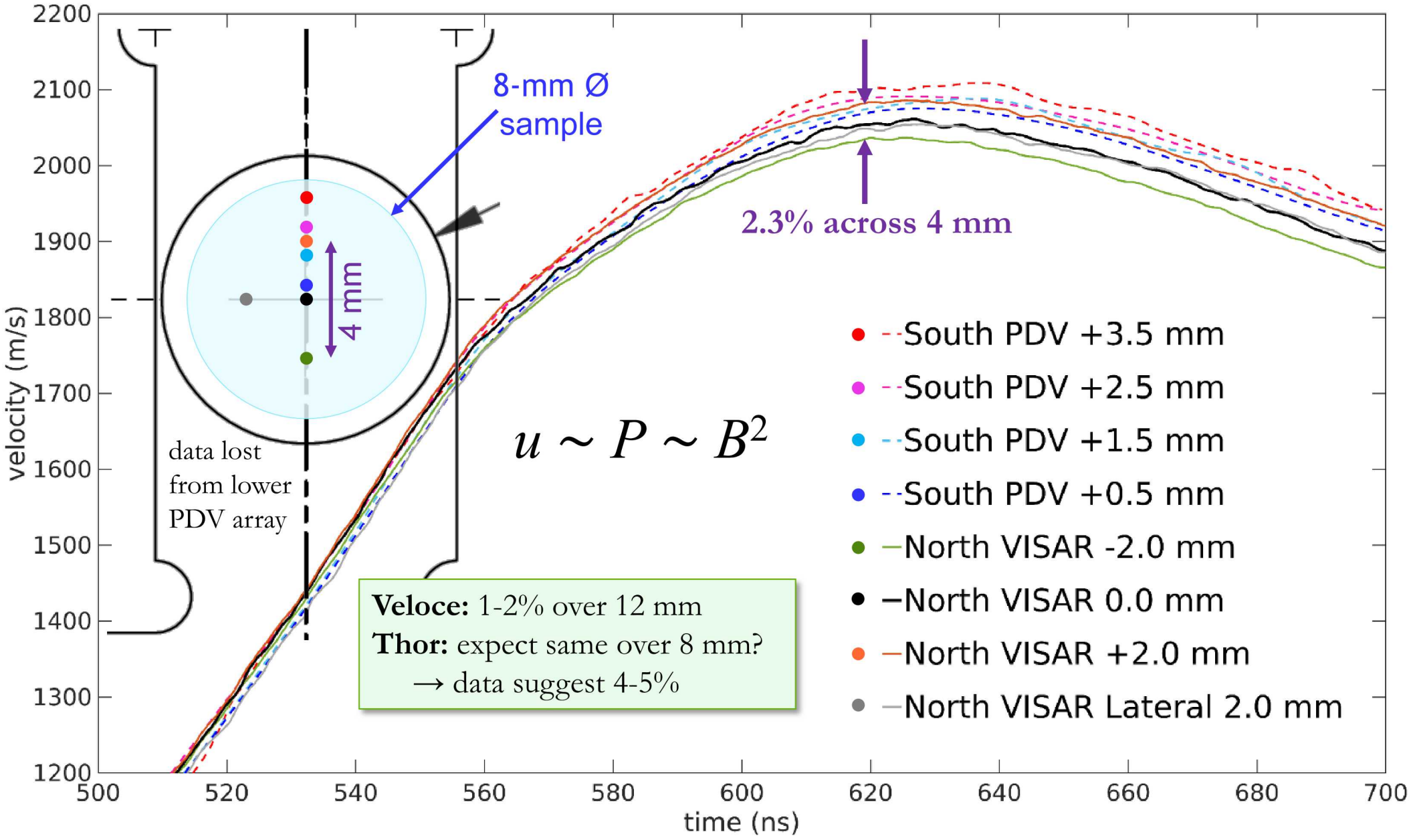
Uniformity 01 experiment (Thor-64 shot 39)

- Standard 10×20-mm stripline, aluminum panels
- 1.0-mm thick electrode floor, no windows
- ~2-MA peak current with 230-ns rise time
- **North panel:** 4 VISAR "hypo" probes (each with 1 send & 2 receive fibers) arranged in ±2-mm "T" formation
- **South panel:** 2 Ascentta linear PDV arrays (each with 4 send/receive fiber pairs) abutted end-to-end to form single line of 8 spots with 1-mm spacing





First data on Thor suggest gradient larger than scaled from Veloce

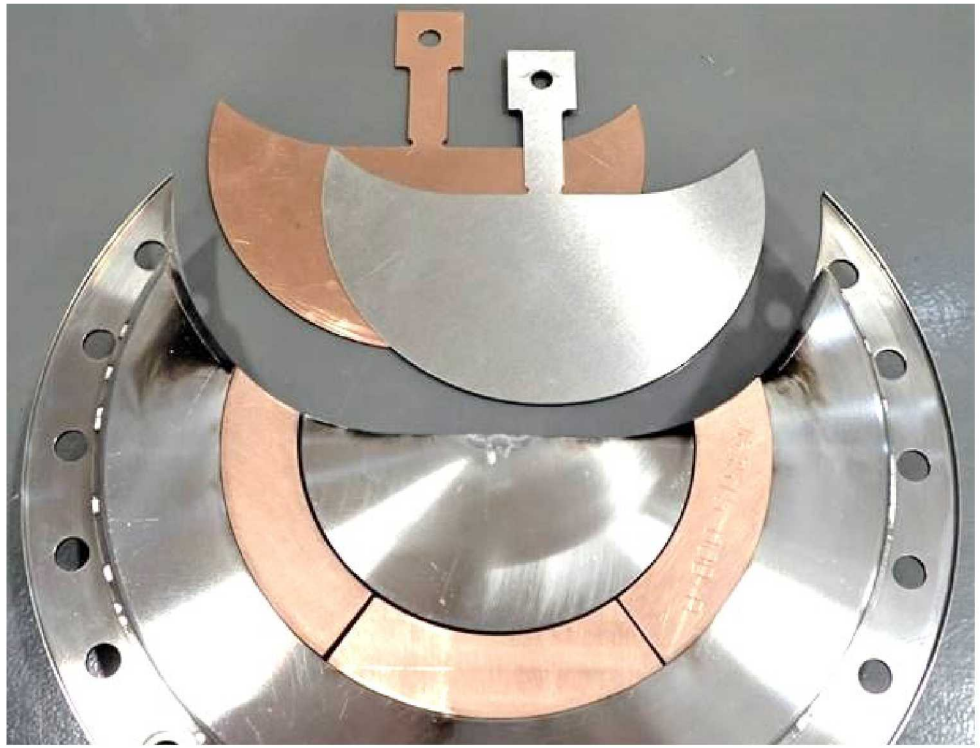


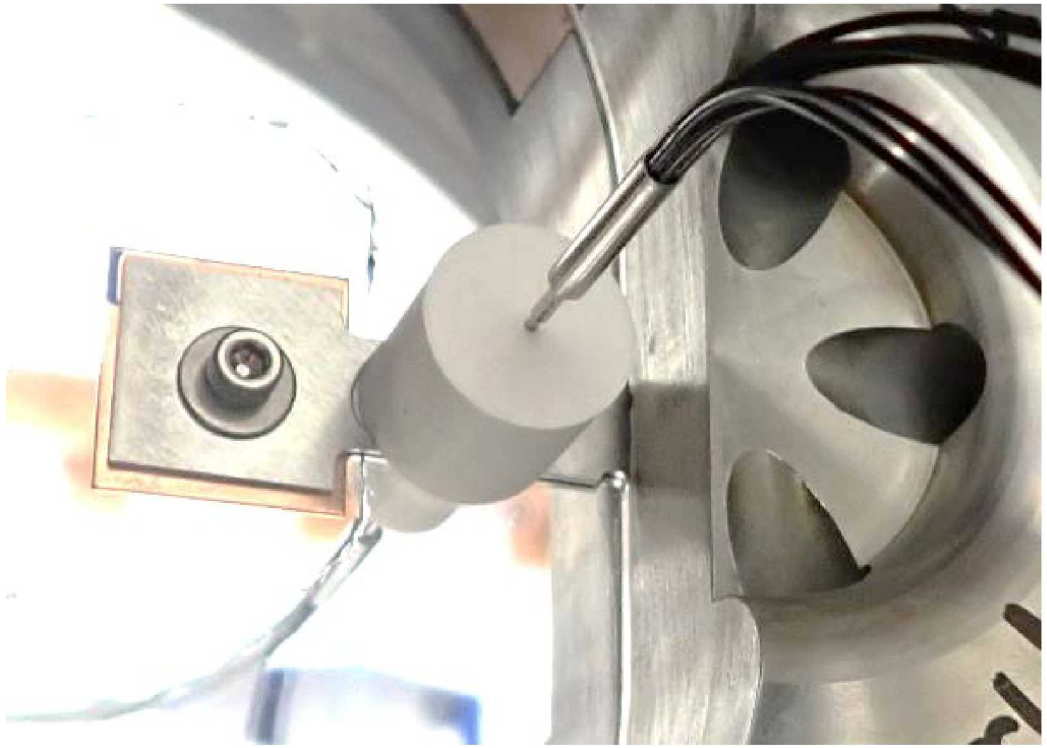
“Sheet” panels water-jet cut on site offer flexibility and low cost

Entire panel is one thickness

Geometry tested thus far is 10×25 mm, with 20-mm wide short (instead of ears)

- Longer panel increases inductance (reducing peak current) but should improve uniformity

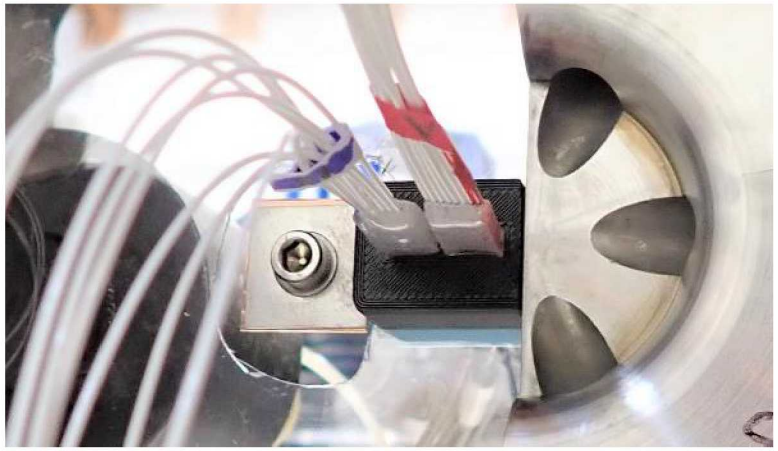


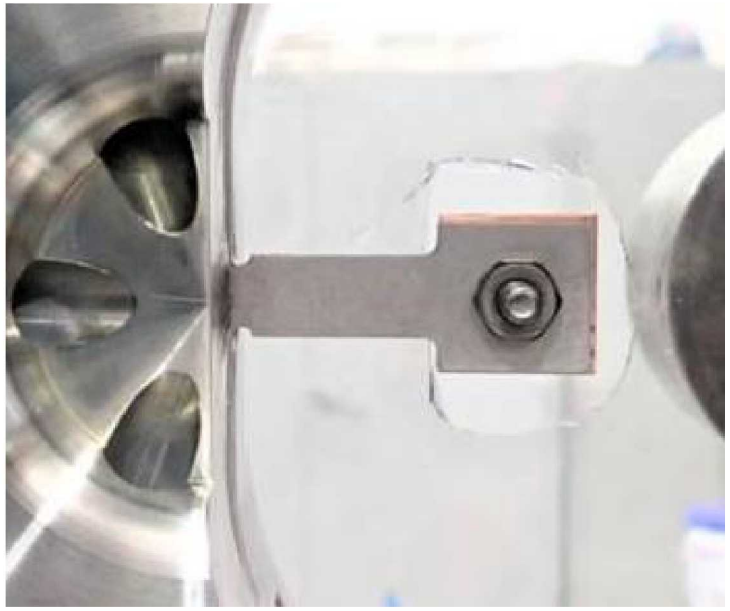


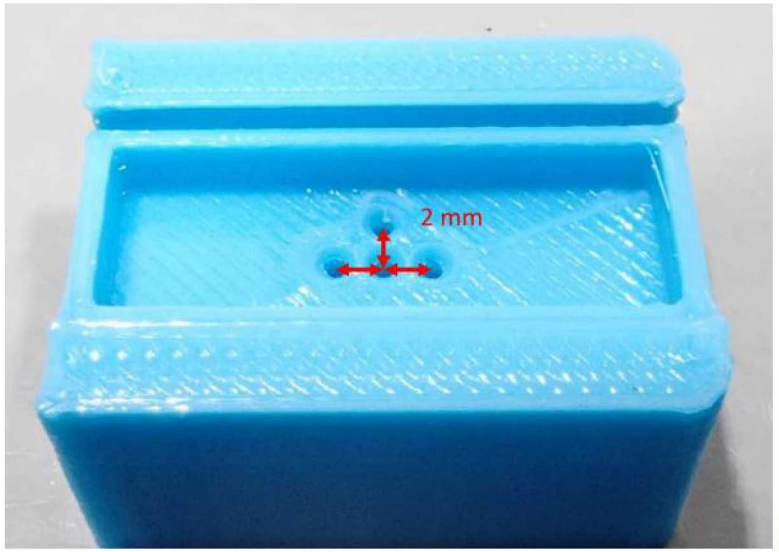
Uniformity measurement on sheet panel required new multi-point probe holders

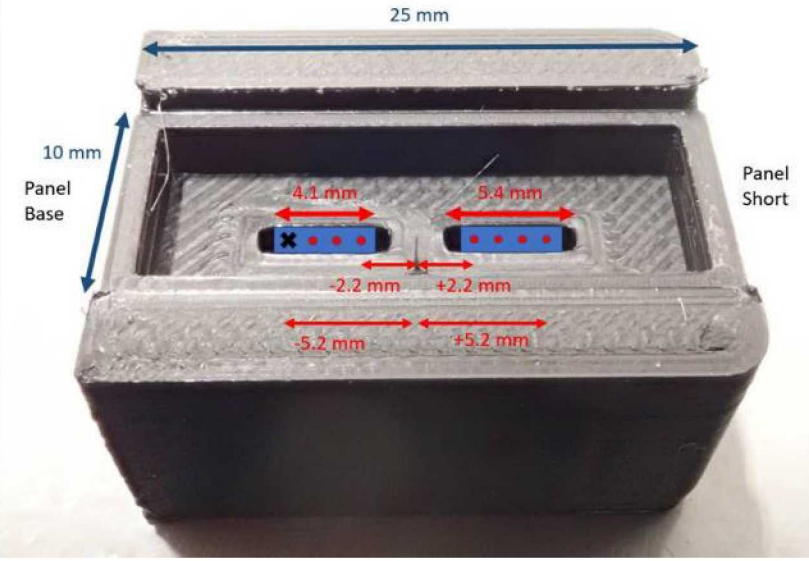
Uniformity 02 experiment (Thor-64 shot 51)

- Aluminum 10×25-mm sheet-panel stripline, 1.0 mm thick, no windows
- Same pulse shape as Uniformity 01 (lower peak due to inductance)
- **North panel:** 4 VISAR "hypo" probes in ±2-mm "T" formation
- **South panel:** 2 Ascentta linear PDV arrays along centerline with closest spots at ±2.2 mm

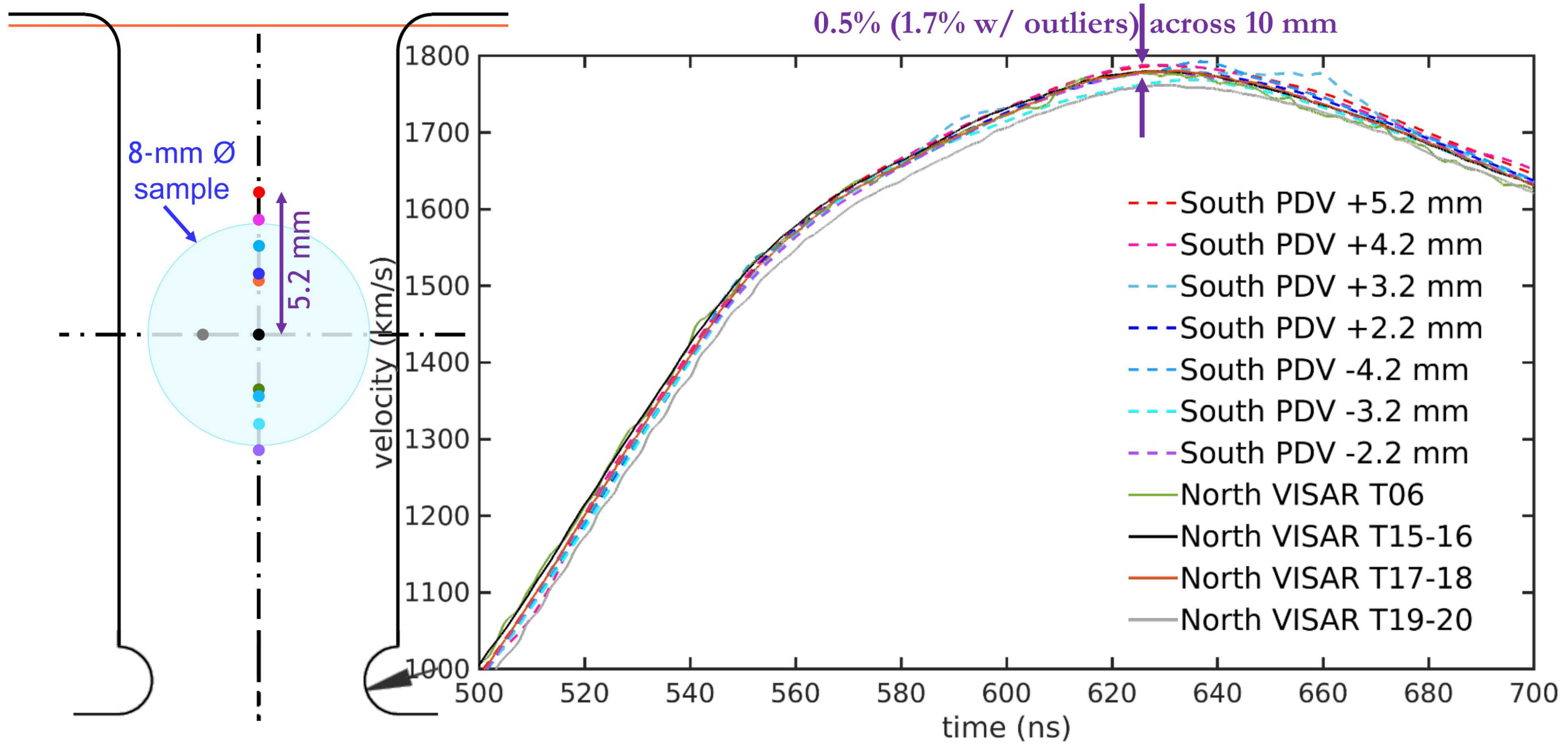




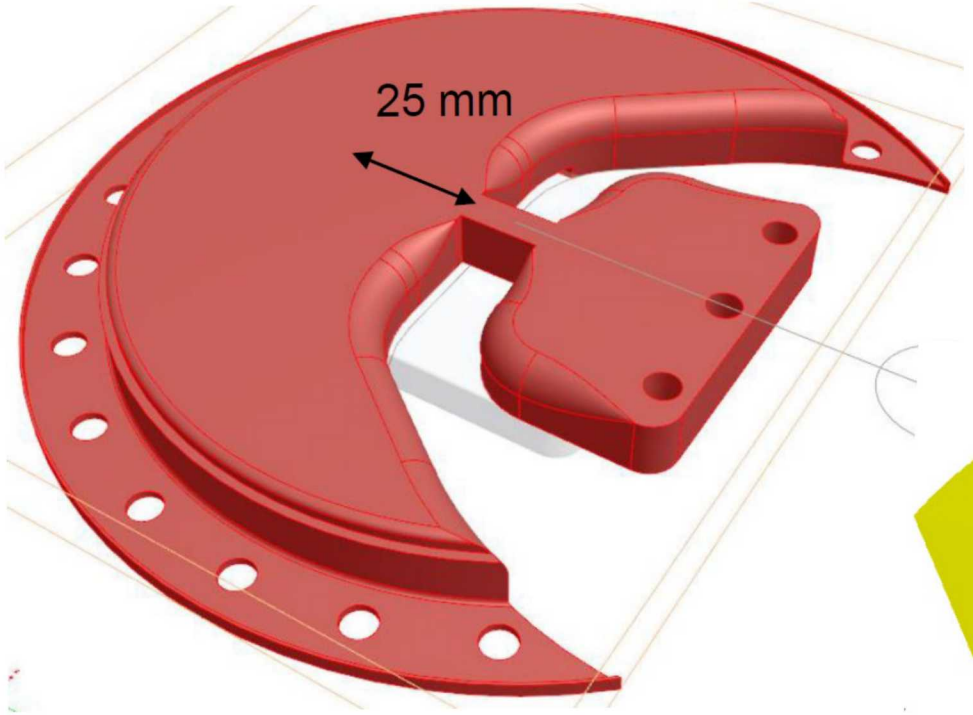




First data on sheet panel indicates improved uniformity



"Symmetric" design mirrors current flow into and out of panel

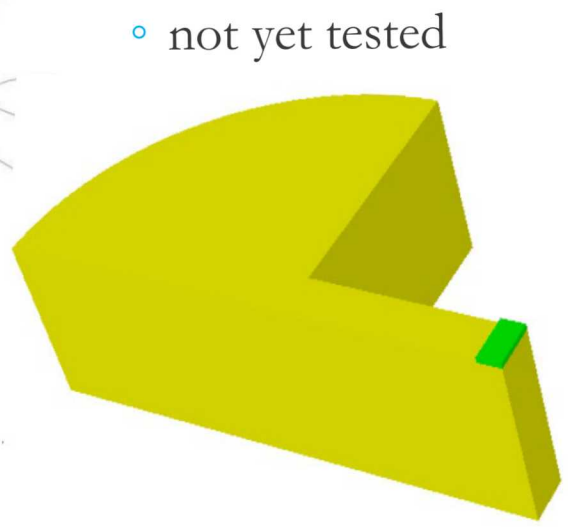


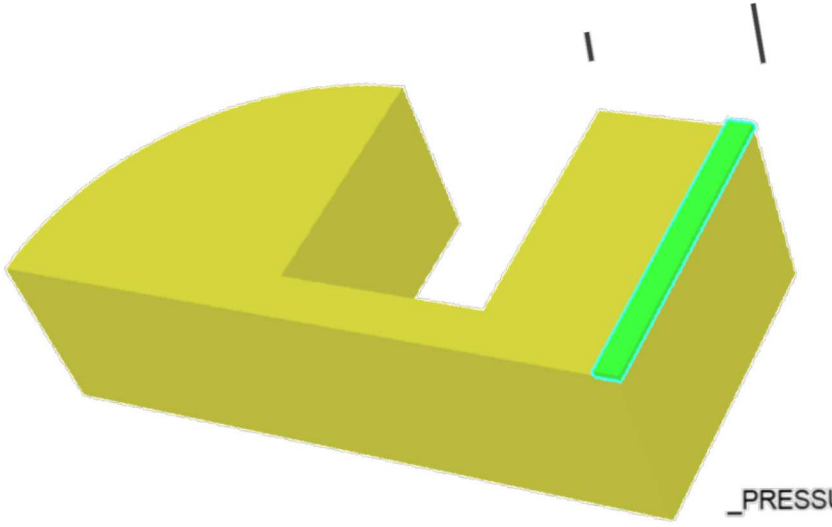
Initial 3-D MHD work by Bob Campbell (retired)

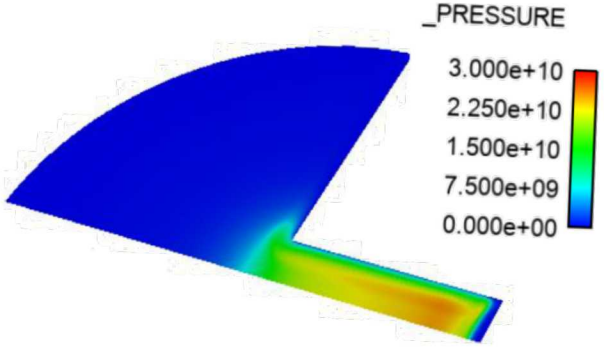
- Significantly improves uniformity
- Increased inductance means this is traded against peak current

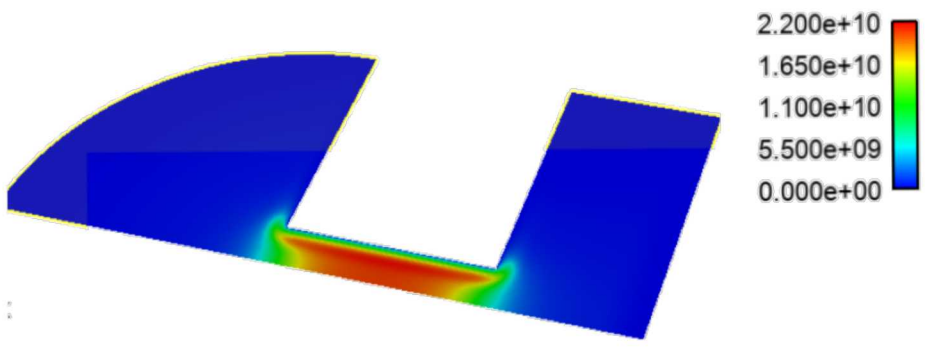
Hardware on hand for 6, 8, 10-mm wide panels

- not yet tested



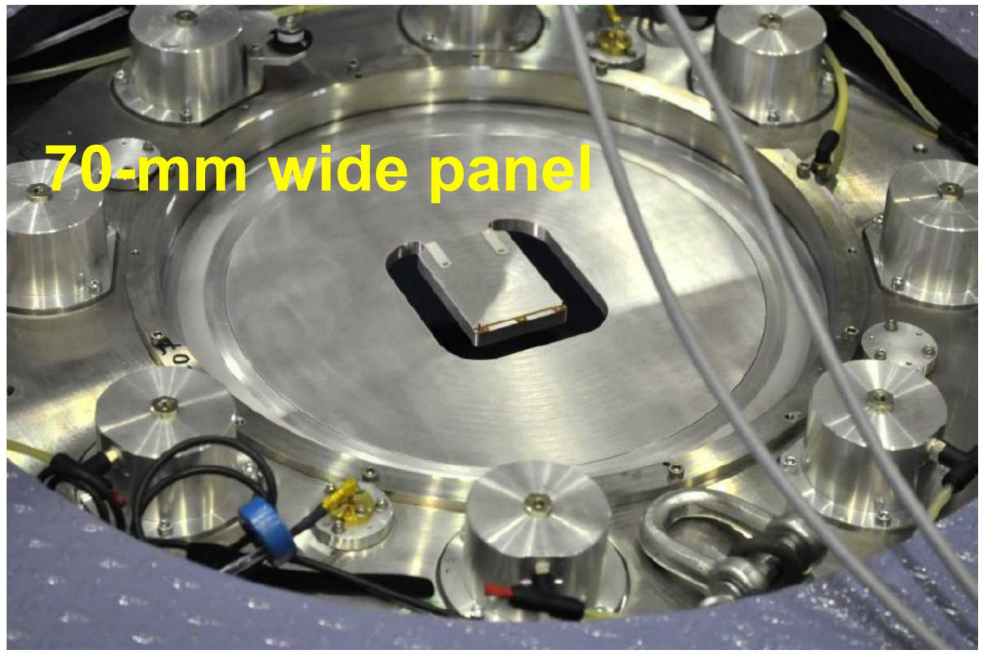


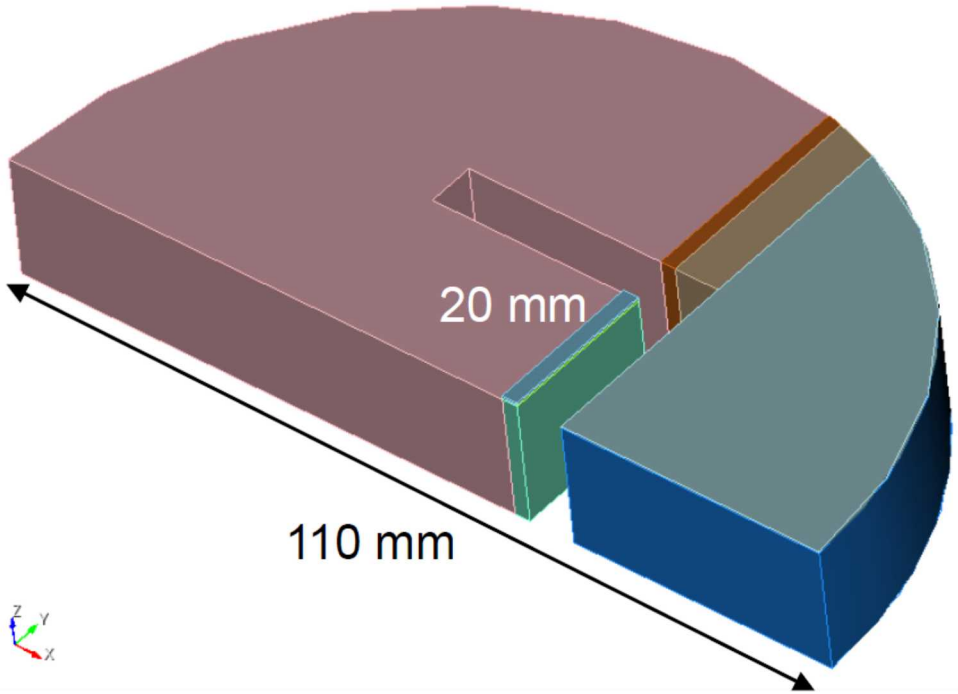


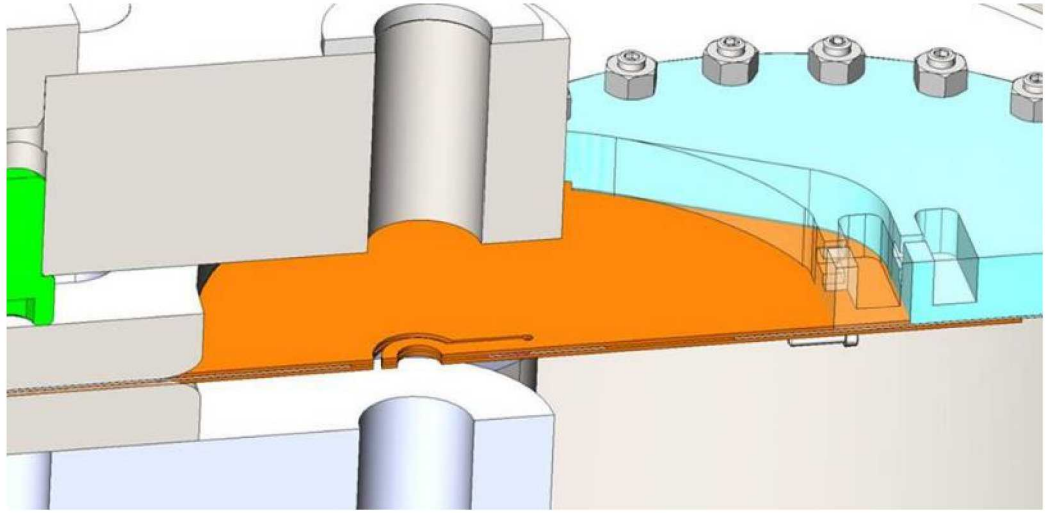


Implement this geometry with sheet panels?

CEA/Gramat (GEPI, ICE16) brings electrodes close to panel edges







CEA claims this improves uniformity

Initial 3-D MHD of simplified geometry (Campbell)

- Reduced peak current in panel (opposite currents cancel)
- Uniformity **not** improved

New concept based on this idea (not yet fabricated)

- Reduced inductance should increase peak current

Lots more work to do

Verify present results for standard and sheet panels

Measure effect (if any) of adding windows, longer/shorter pulses, aluminum vs. copper

Test non-standard panel widths (6, 8, 15 mm)

Test “symmetric” panels, wrap-around panels

New higher-resolution 3-D MHD simulations (Jeremiah Boerner)