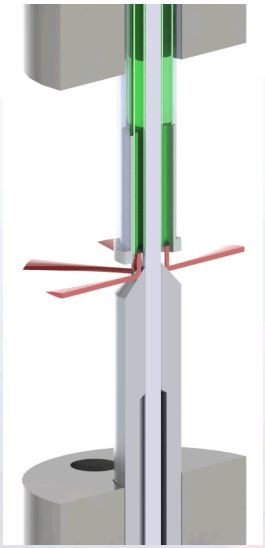
SAND2013-5399C

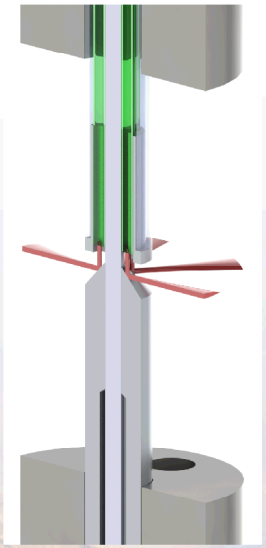
A multi-point radial photonic Doppler velocimetry (PDV) diagnostic for cylindrical implosion experiments

Devon G. Dalton, Daniel Dolan, Raymond Lemke, Ryan McBride, Matthew Martin, & Eric Harding
Sandia National Laboratories

Brent Blue
General Atomics

Scott Walker
National Security Technologies





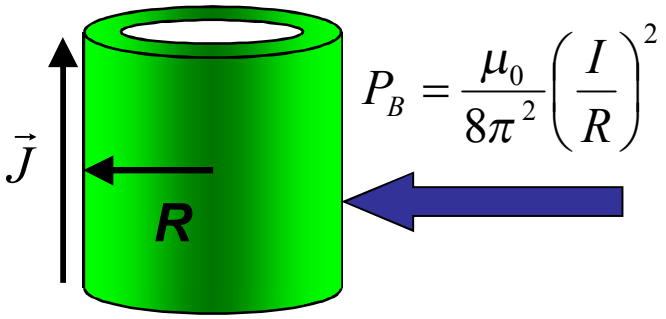
APS-SCCM / AIRAPT Meeting
Seattle, Washington
July 7-12 2013

Sandia National Laboratories is a multi-program laboratory operated by Sandia Corporation, a wholly owned subsidiary of Lockheed Martin company, for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

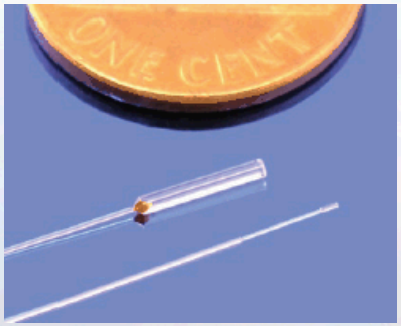
Sandia National Laboratories

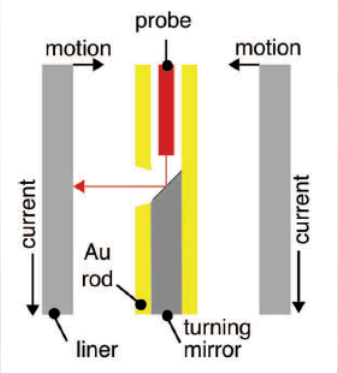
Z Cylindrical Experiment Motivation and Challenges

- Quasi-isentropic compression to peak stresses ≈20 Mbar
- 3-4 times higher pressure than can be achieved in planar geometry
- Shockless compression achieved by shaping current
- Diagnosing the compressed state is the key challenge



I=20 MA; R=0.1 cm;
P_B≈64 Mbar.



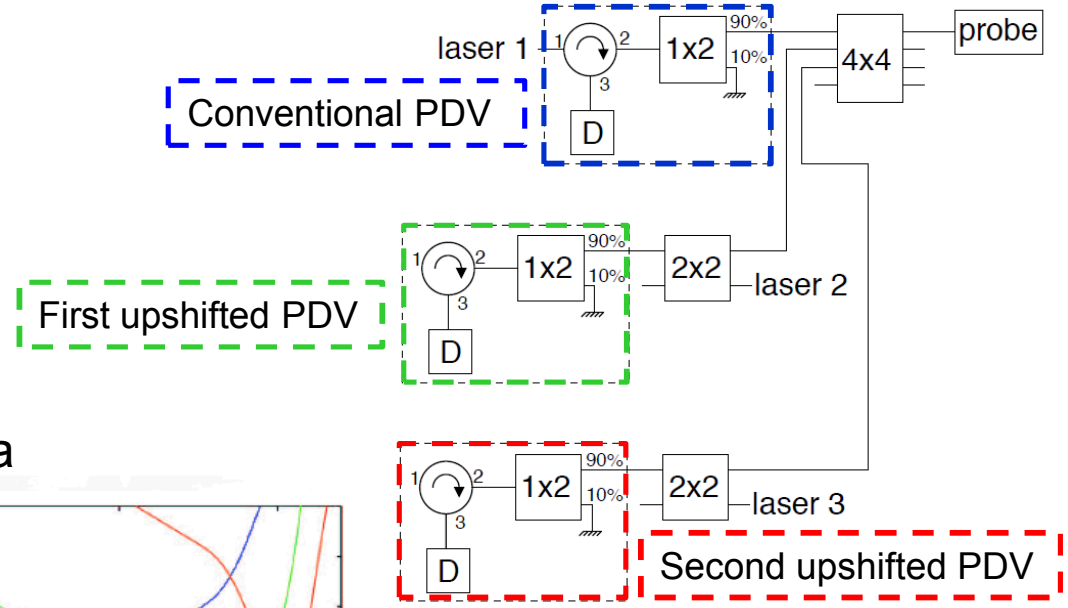


- Very limited space due to design constraints
- Velocities beyond 40 km/s
- Cylinder wall surface finish concerns
- PDV has achieved success where VISAR has failed

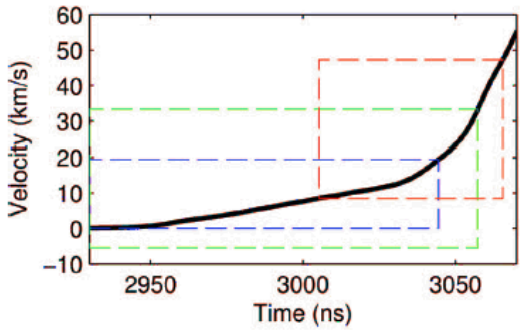
Leapfrog* PDV Technique is the Key

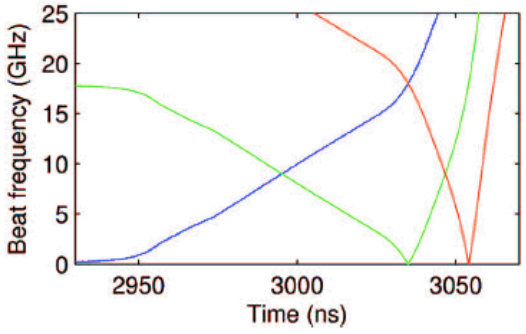
$$B = \left| \frac{c}{\lambda_1'} - \frac{c}{\lambda_2} \right| \approx \left| \frac{c}{\lambda_1} - \frac{c}{\lambda_2} + \frac{2u}{\lambda_1} \right|$$

B = beat frequency
u = reflector velocity
c = speed of light



Conceptual Data



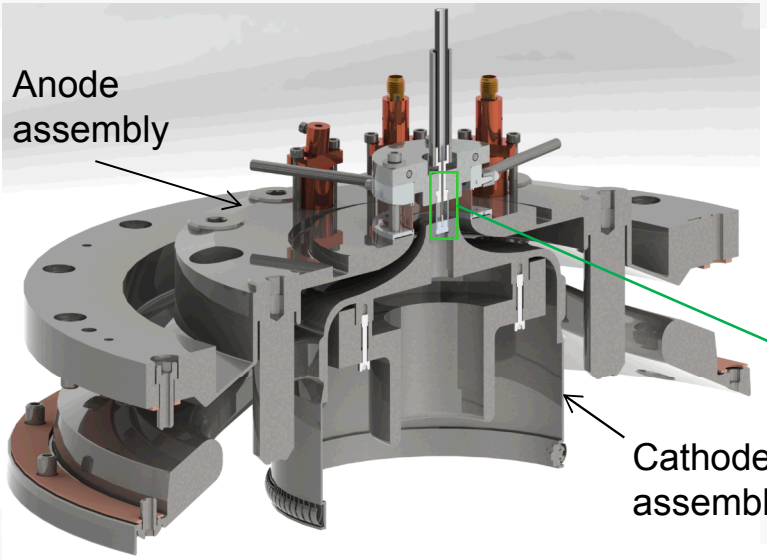


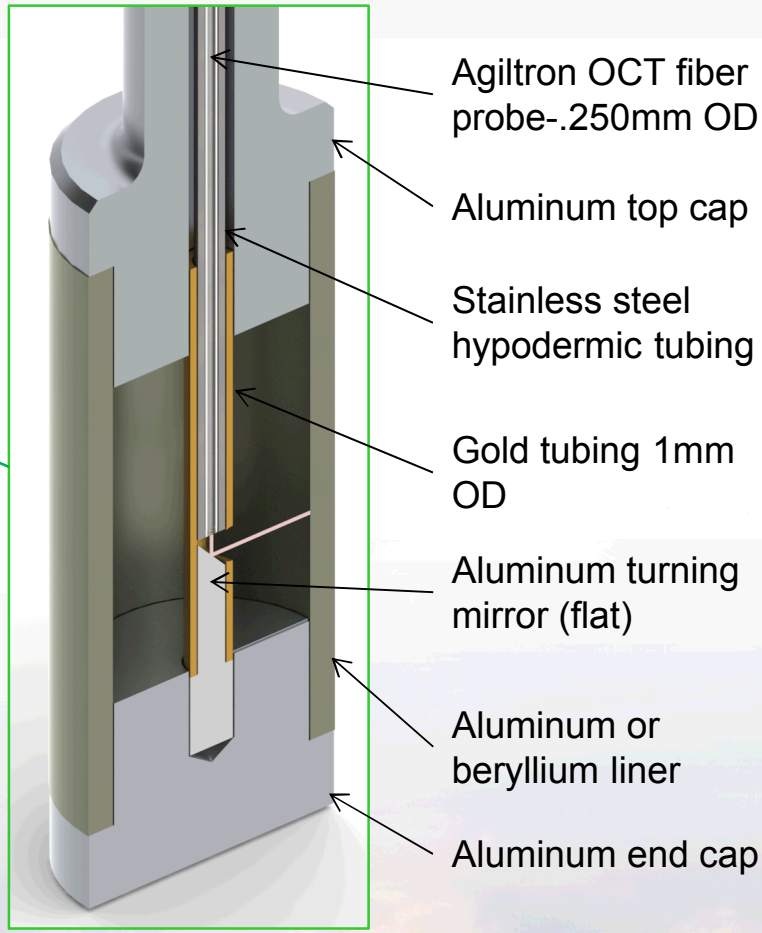
1GHz in beat frequency = 775 m/s

- Three-channel system could measure up to 97 km/s
- Channel overlap used to eliminate null point ambiguities- 48 km/s

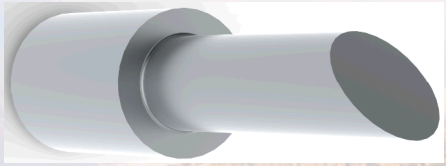
*D.H. Dolan, R.W. Lemke, R.D. McBride, M.R. Martin, E. Harding, D.G. Dalton, B.E. Blue, and S.S. Walker, Rev.Sci. Instrum. 84, 055102 (2013).

Initial Radial PDV Design Provides Velocity Profile for a Single Location





- Radial Velocity Hardware
- 17.1-19.7 MA Load Current
- >45 km/sec Liner Velocity

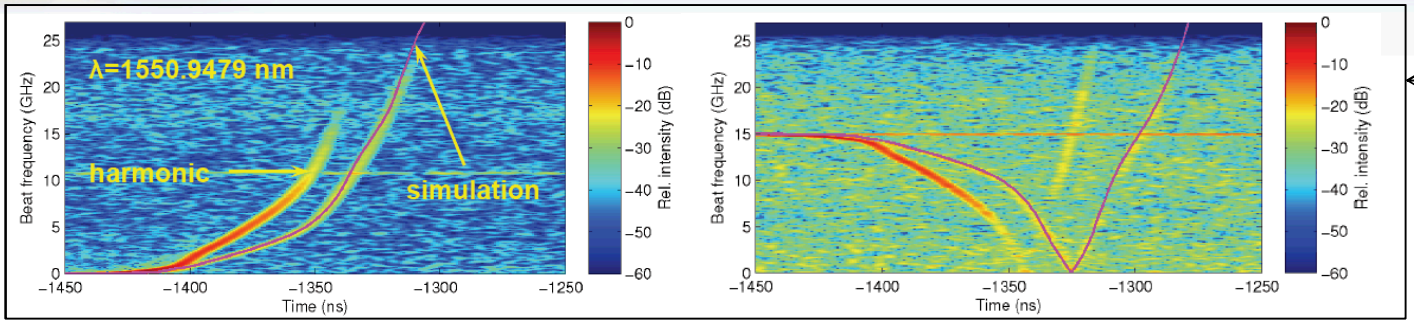


Flat mirror design

Static pre-shot radiograph of target assembly

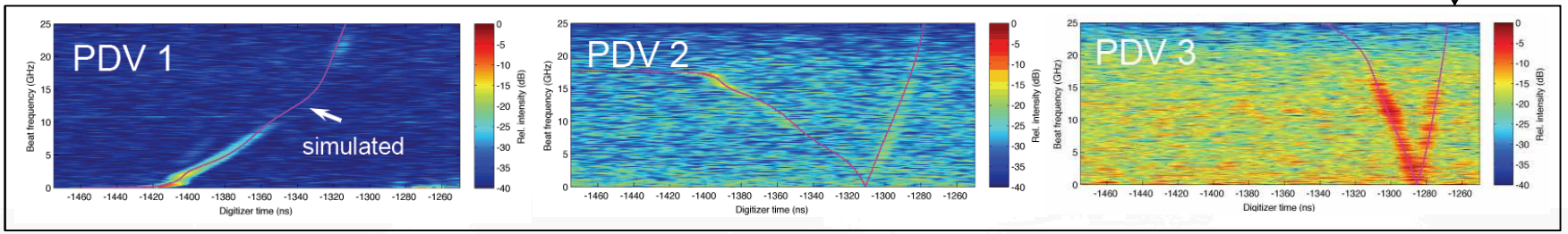
Sandia National Laboratories

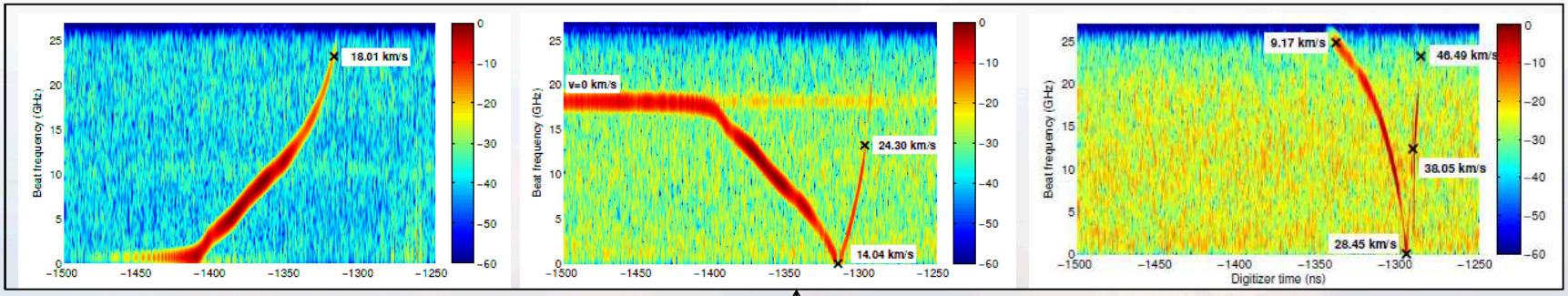
Single-point Radial PDV Results were Encouraging



1st attempt- Al liner

2nd attempt- Al liner

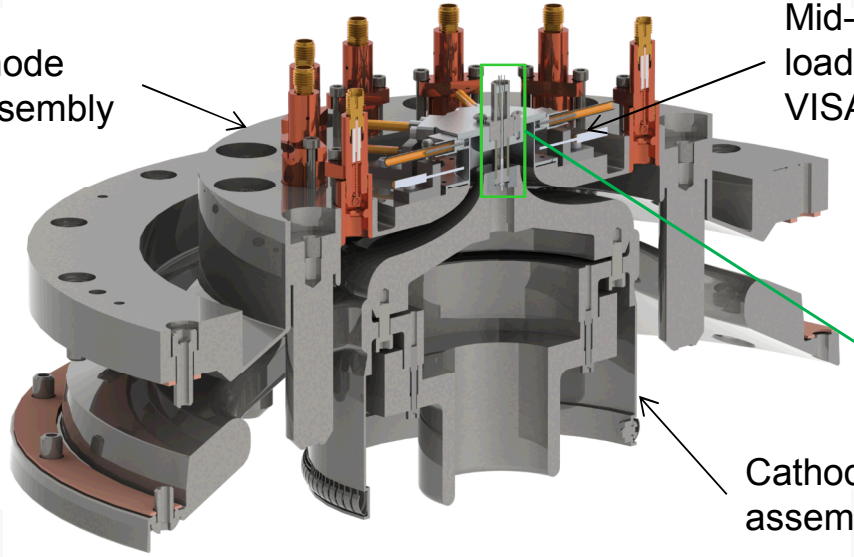


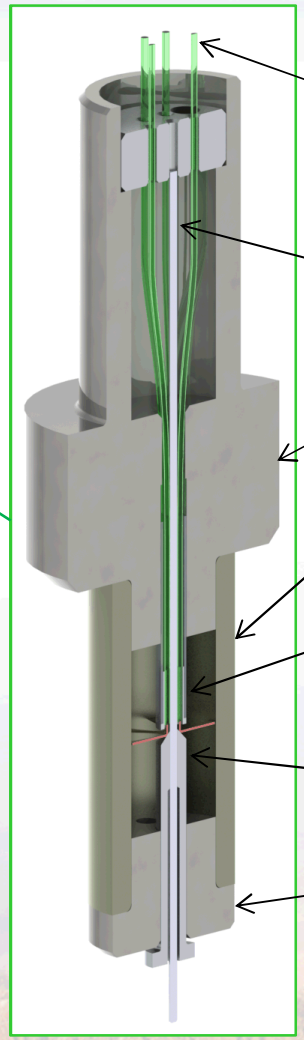


Final attempt- Be liner

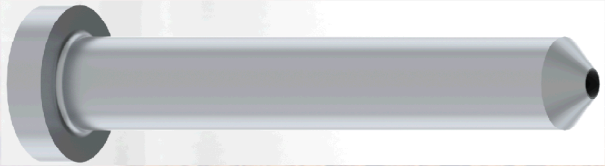
Sandia National Laboratories

Multi-point Radial PDV Design to Evaluate Implosion Symmetry



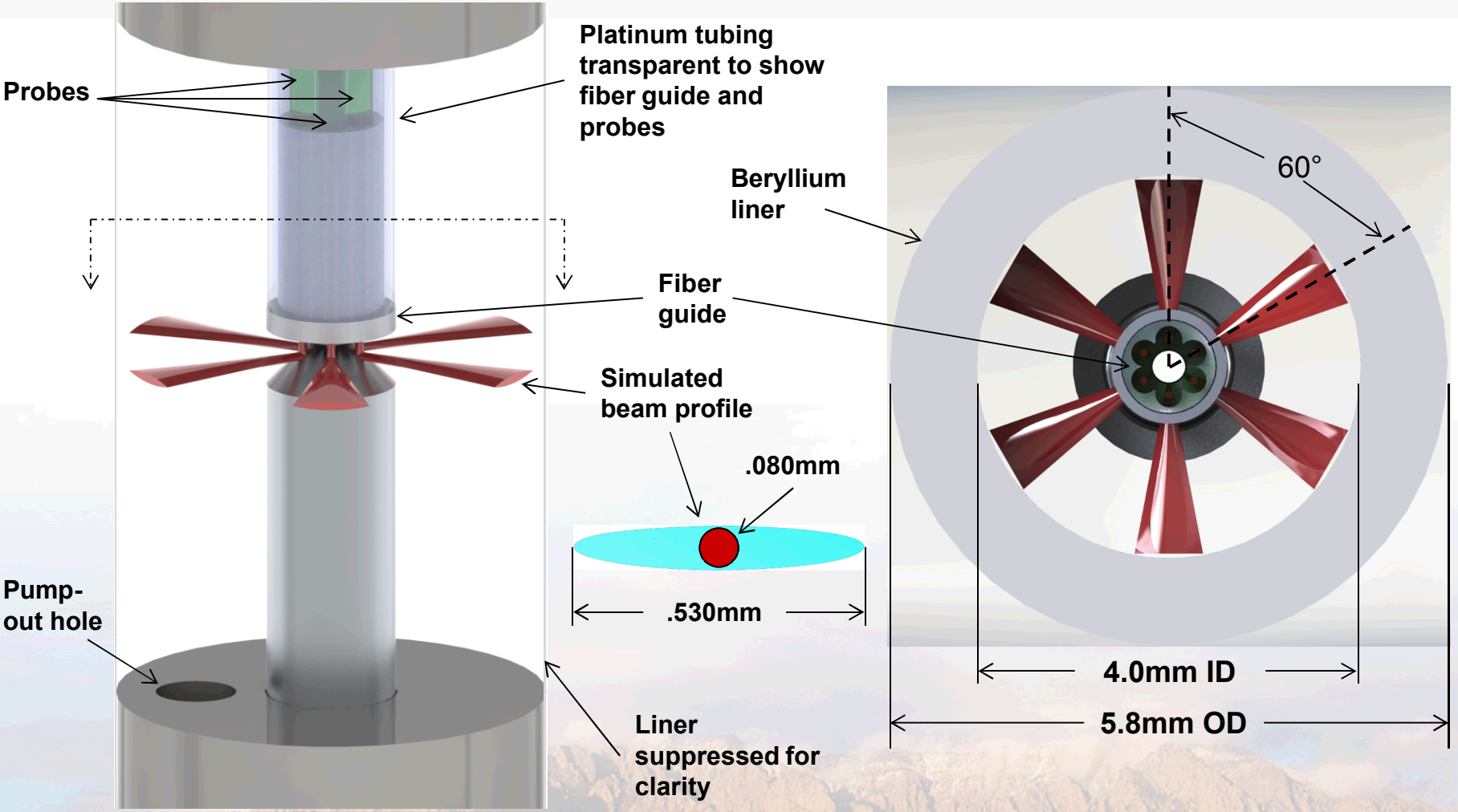


- Union IV Hardware
- ≈18.6 MA Load Current
- >42 km/sec Liner Velocity

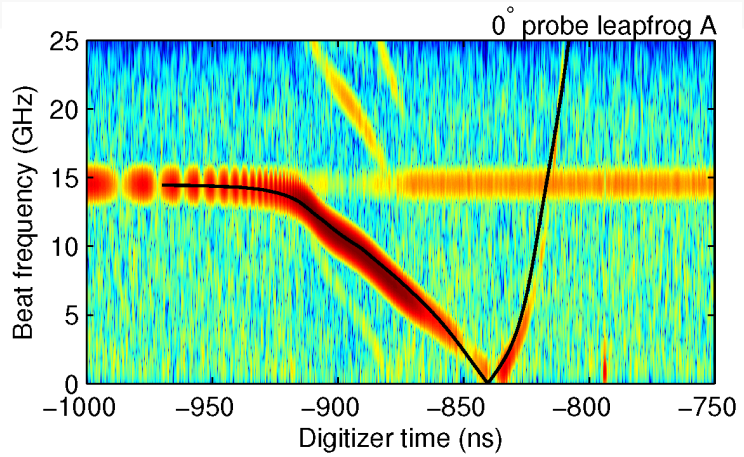


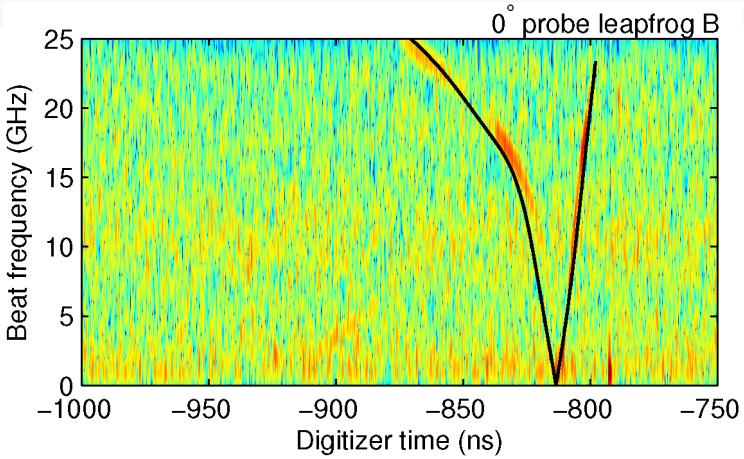
Conical mirror design

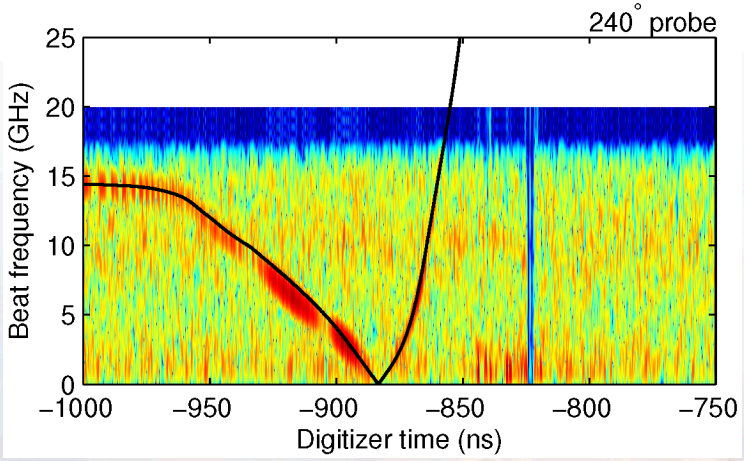
Multi-point Radial PDV Target Design Can Provide Six Simultaneous Velocity Profiles

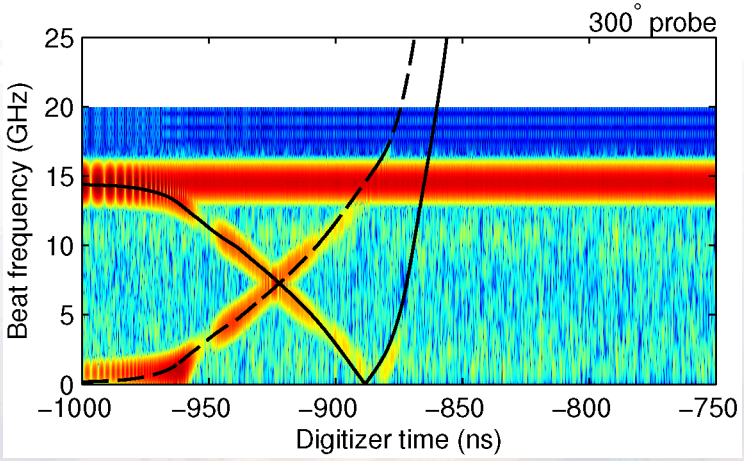


4 out of 6 Probe Locations Returned Data on Initial Attempt



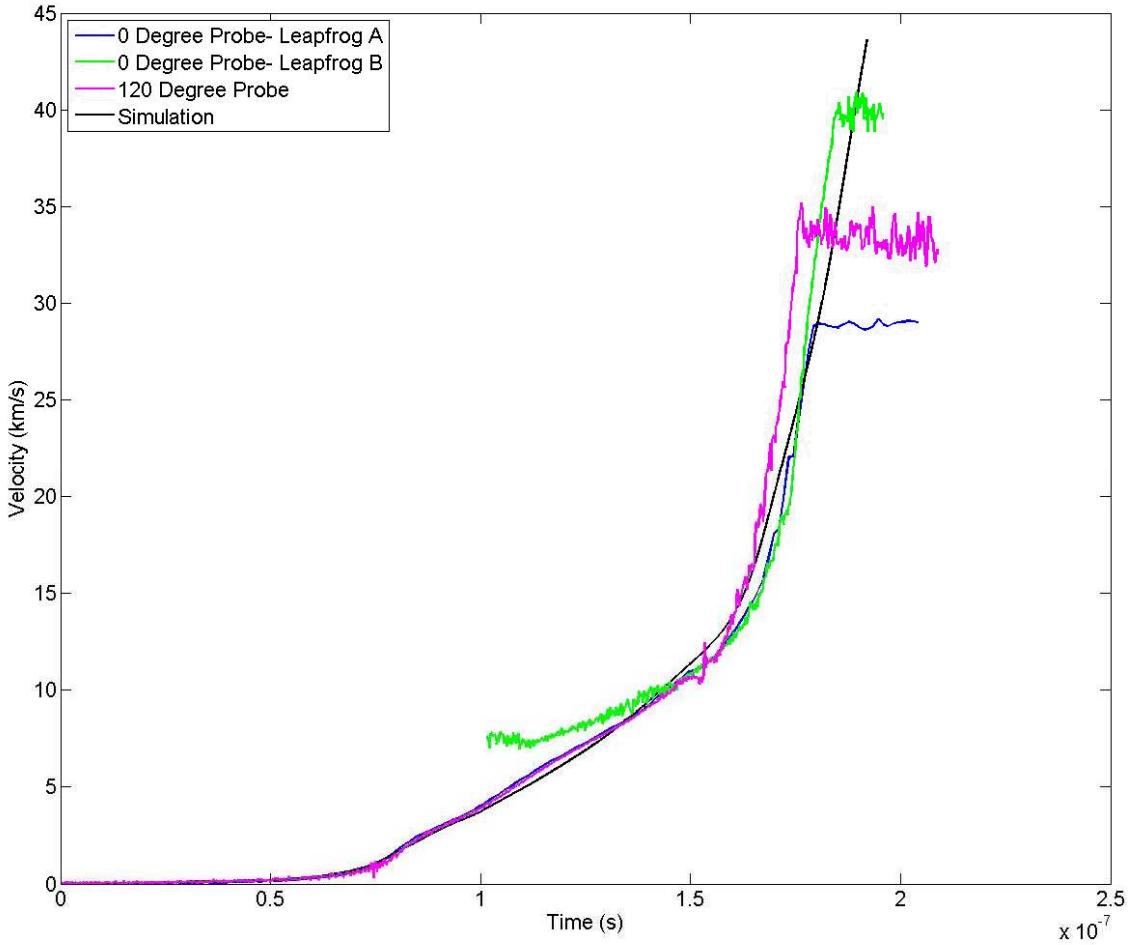






Simulated PDV velocity based on load current VISAR measurements in black

Extracted Velocity Profiles Demonstrate Reasonable Agreement with Load Current Unfold Simulation



Next Steps for Multi-point Radial PDV

- Time synchronization of data channels
- Time-domain multiplexing to increase velocity range
- Evaluate smaller probe diameters- 100μm available
- Additional experiments across a broad range of materials
- ZEMAX analysis for optimizing mirror and fiber lens design
- Cylinder ID surface finish evaluation

Special Thanks

- **Target Fabrication Group-** General Atomics
  - Robert Stamm
  - Diana Schroen
  - Kurt Tomlinson
  - Jerry Taylor (Raytheon Ktech)
  - Randy Holt (Raytheon Ktech)
- **Dynamic Material Properties- Sandia National Labs**
  - Charlie Meyer
  - Anthony Romero
  - Dustin Romero
- **Sandia Z Facility Operations Staff and Crew**
- **Z Load Hardware Assembly and Design**
  - Daniel Sandoval