

High Resolution Optical Measurements for sCO₂

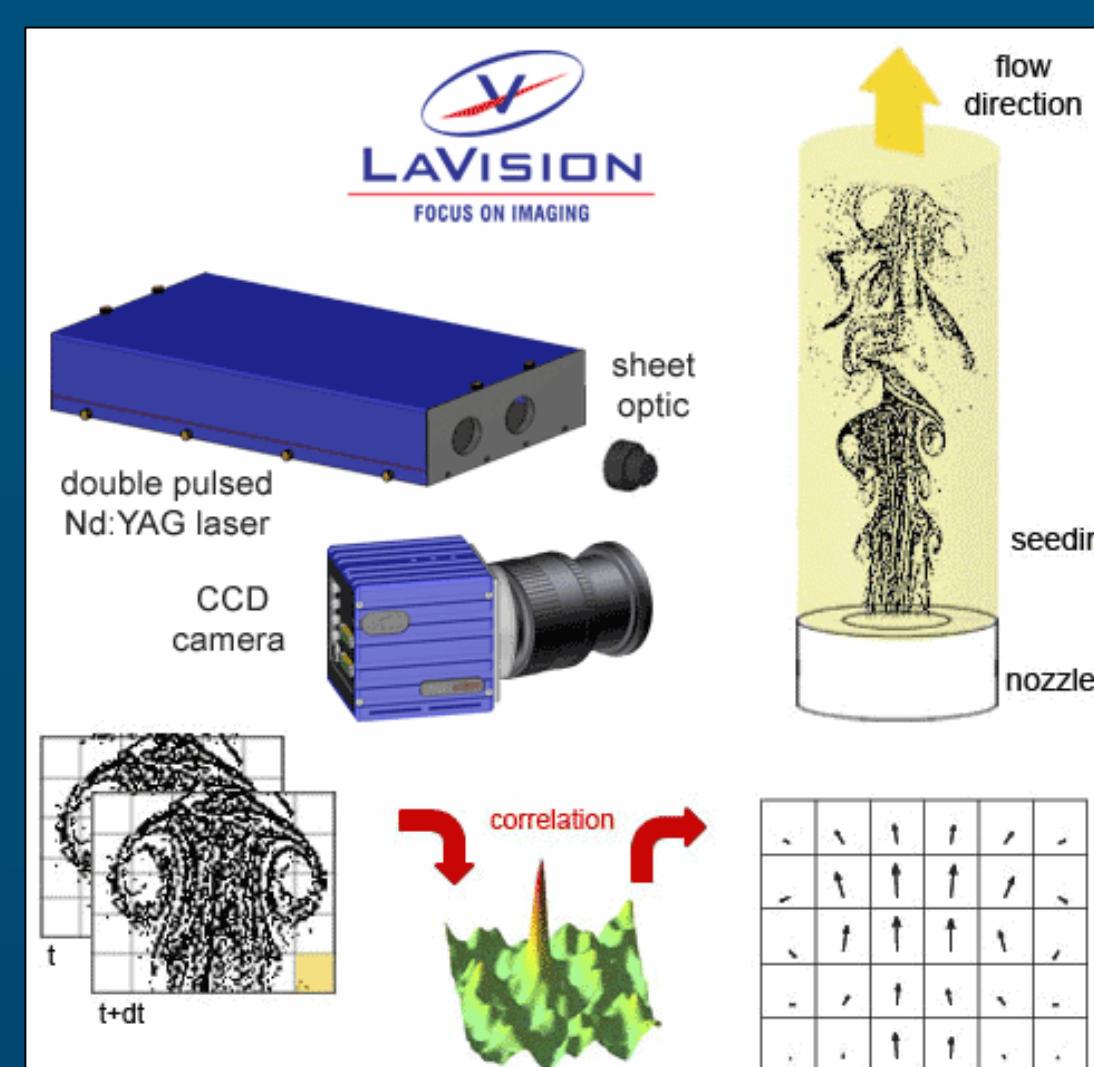
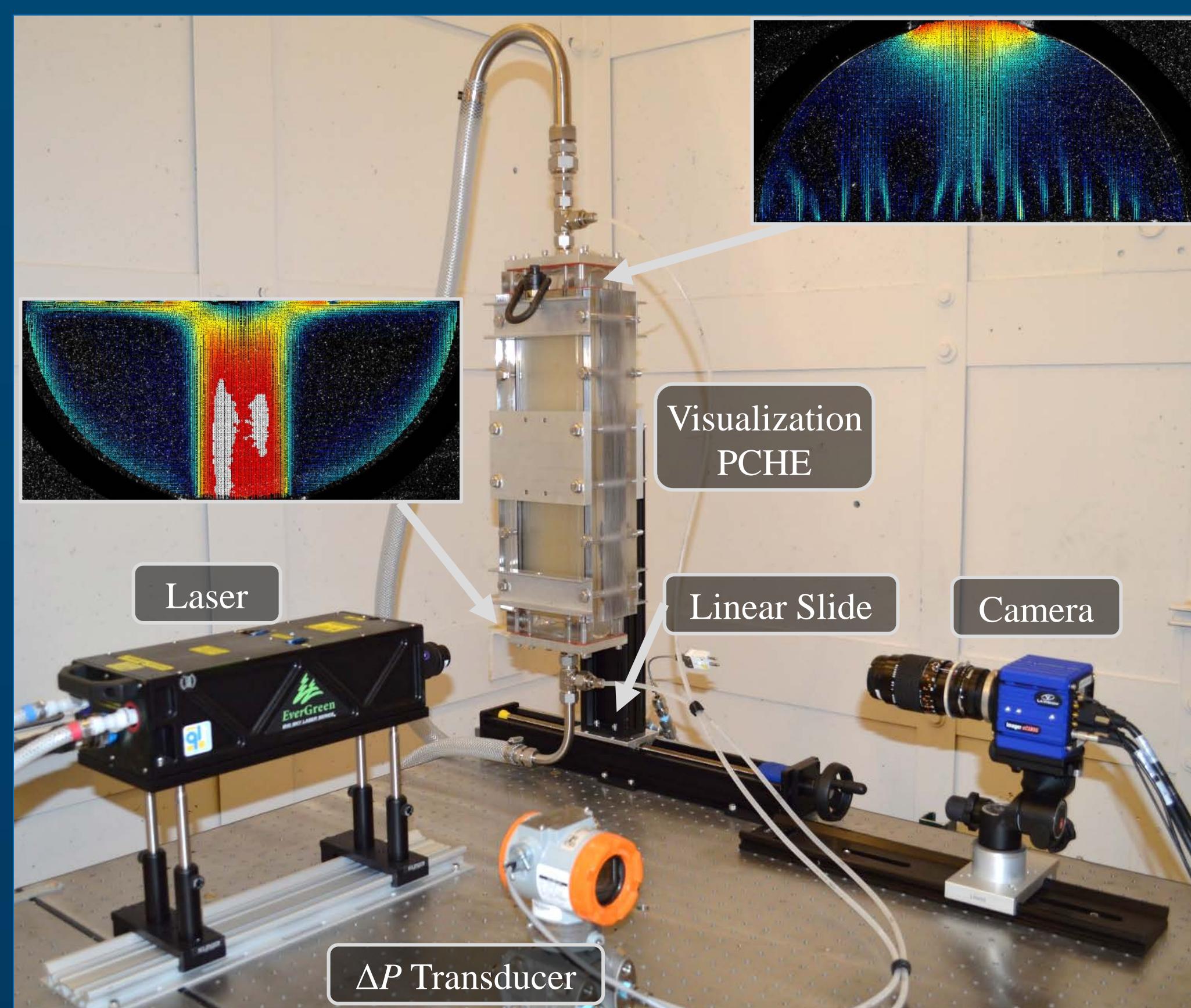
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Purpose:

To enable high resolution optical measurements for sCO₂ power cycles to provide fundamental understanding of fluid, thermal, and mechanical conditions

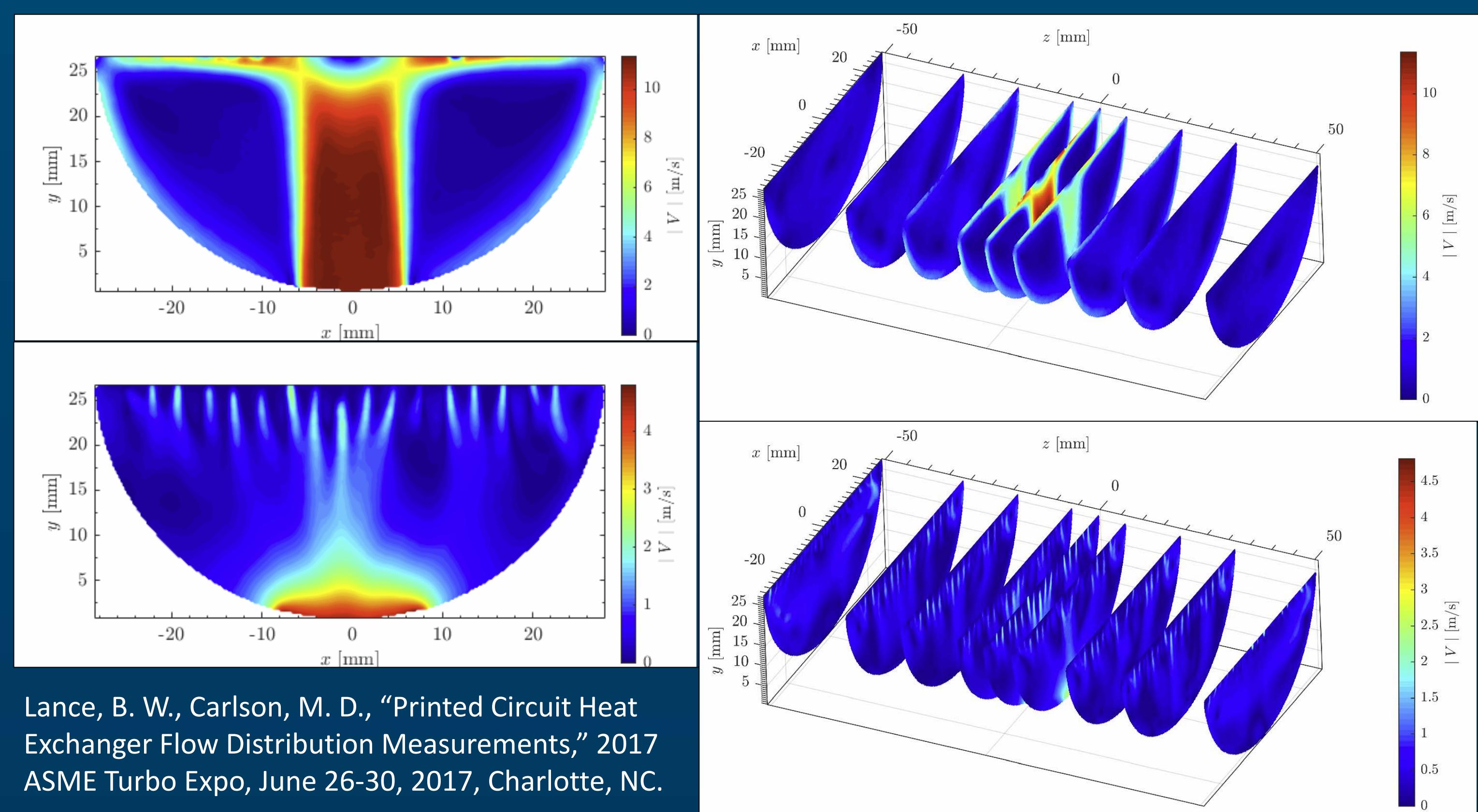
PIV and PTV:

- Particle Image Velocimetry (PIV) and Particle Tracking Velocimetry (PTV) for optical flow field measurements
- Modern system includes high energy laser, scientific camera, and accurate timing unit
- Applies to liquids, gases, and sCO₂
- Works with velocities from creeping flows to supersonic, from meter to millimeter scales
- ✓ Application: PCHE prototype flow distribution



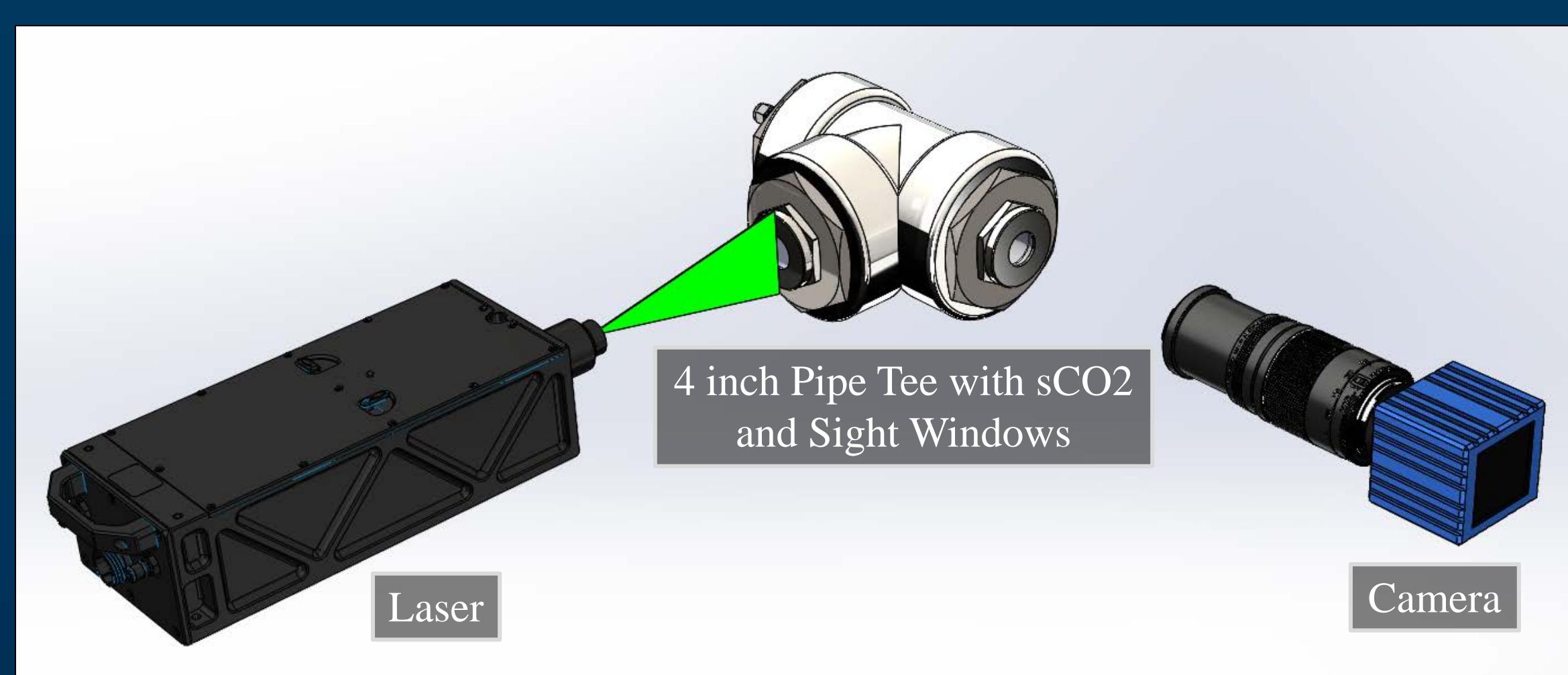
PIV Operating Principles

- Seed particles follow flow
- Laser beam formed into sheet to illuminate particles
- Camera records two images
- Cross-correlation performed on image divided into regions
- Distance of correlation peak from center is most likely particle group displacement
- Velocity is determined by scaling displacement in pixels by calibration and dividing by time interval between images

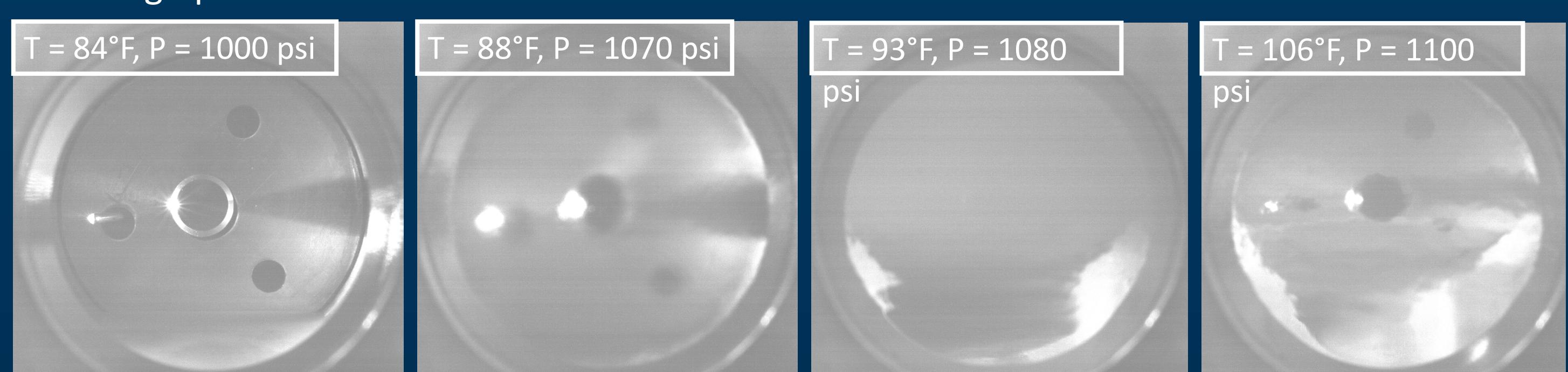


Lance, B. W., Carlson, M. D., "Printed Circuit Heat Exchanger Flow Distribution Measurements," 2017 ASME Turbo Expo, June 26-30, 2017, Charlotte, NC.

- ✓ Application: Performing the first known quantitative optical measurements in sCO₂

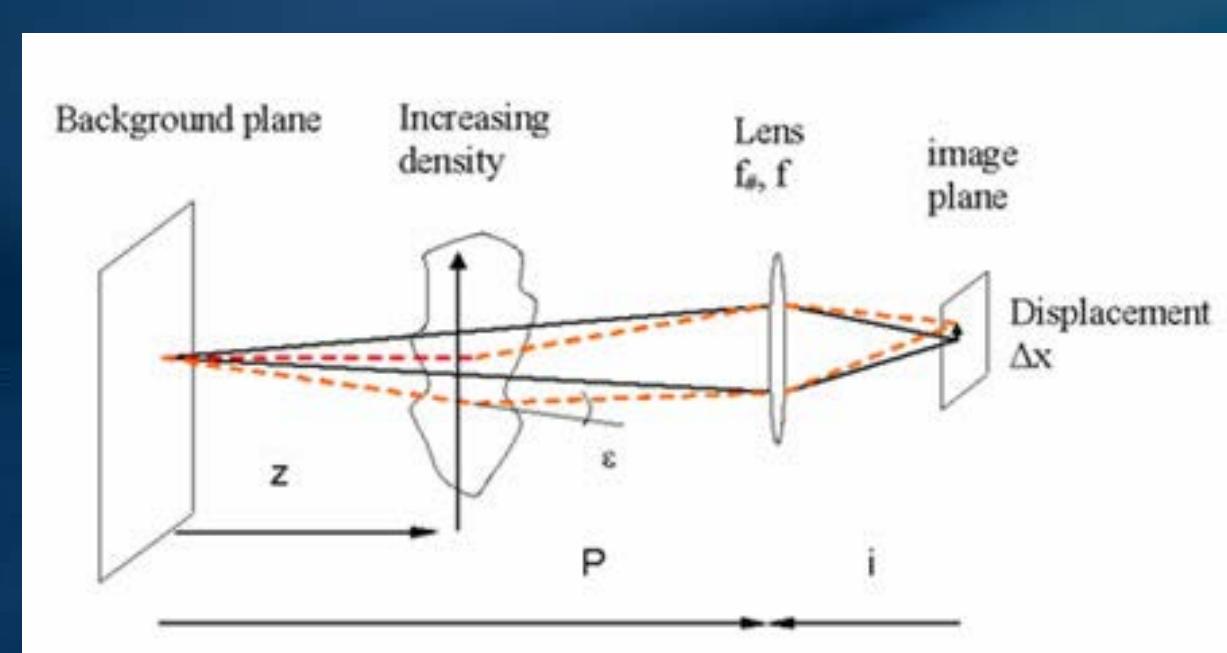


Optical quality of CO₂ improves as temperature and pressure increase over the critical point, enabling optical measurements

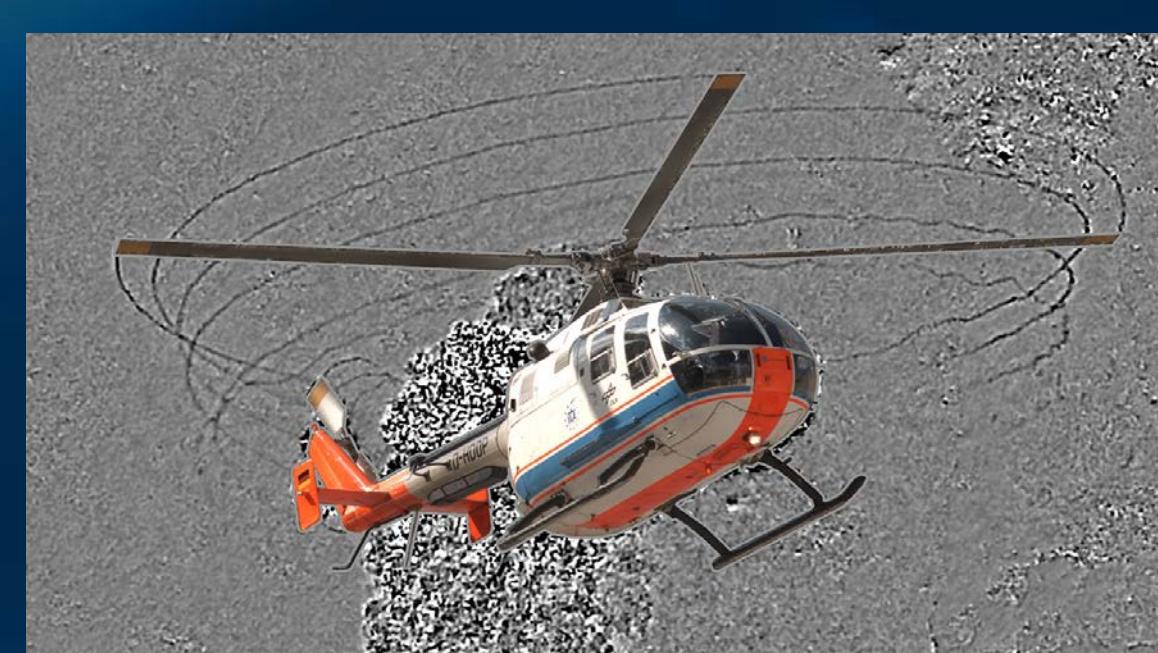


BOS:

- Background Oriented Schlieren (BOS) for density/temperature field measurements
- Simple method that detects density changes by refraction between the background random dot pattern and camera



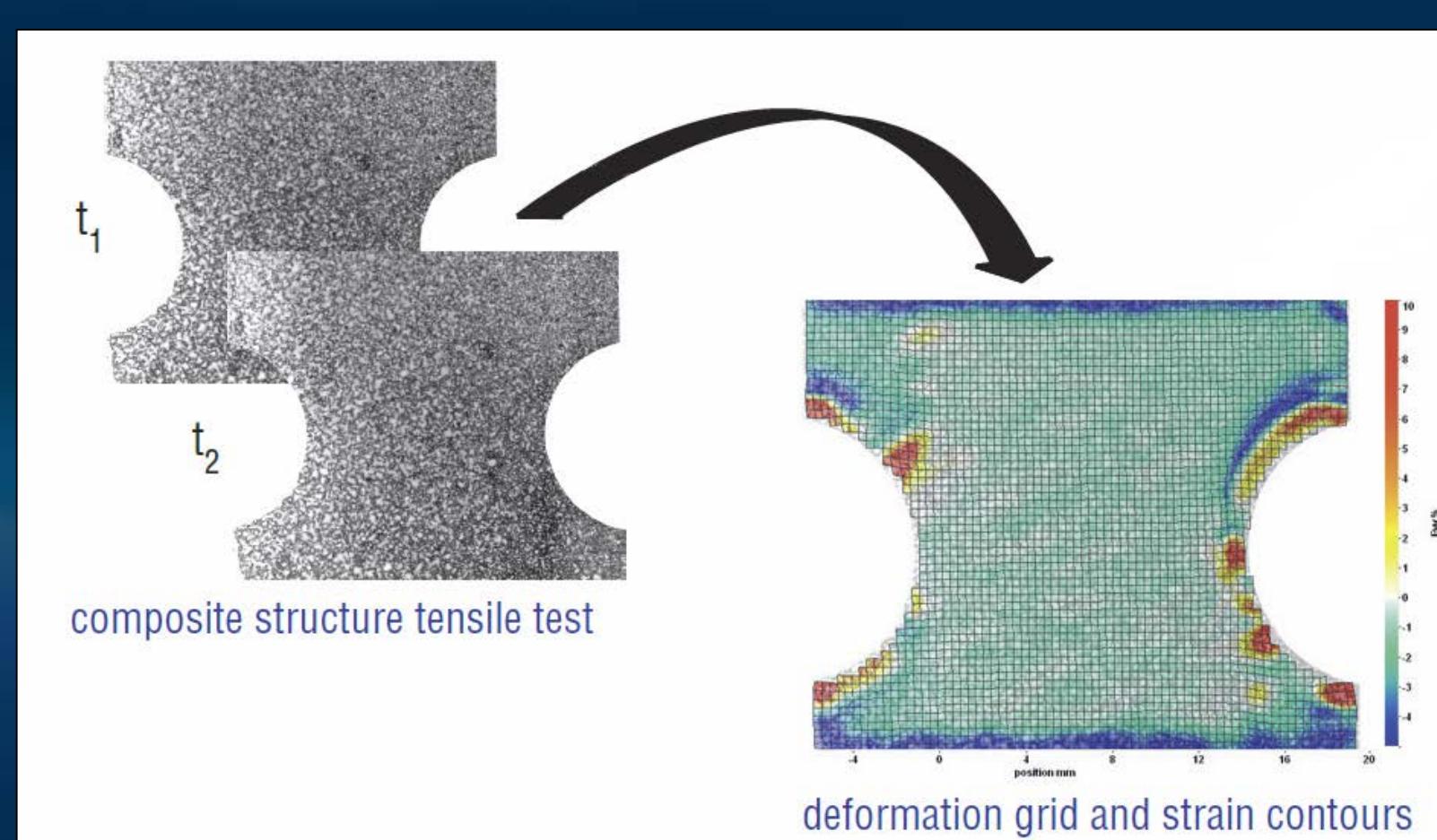
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<http://www.dlr.de/dlr/en/desktopdefault.aspx/tabid-10471#gallery/13349>

DIC:

- Digital Image Correlation (DIC) for strain field measurements
- Detects deformations on random dot pattern in two dimensions
- Equivalent to thousands of strain gages, can detect 3D deformations



<https://www.lavision.de/en/applications/materials-testing/stereo-dic/index.php>