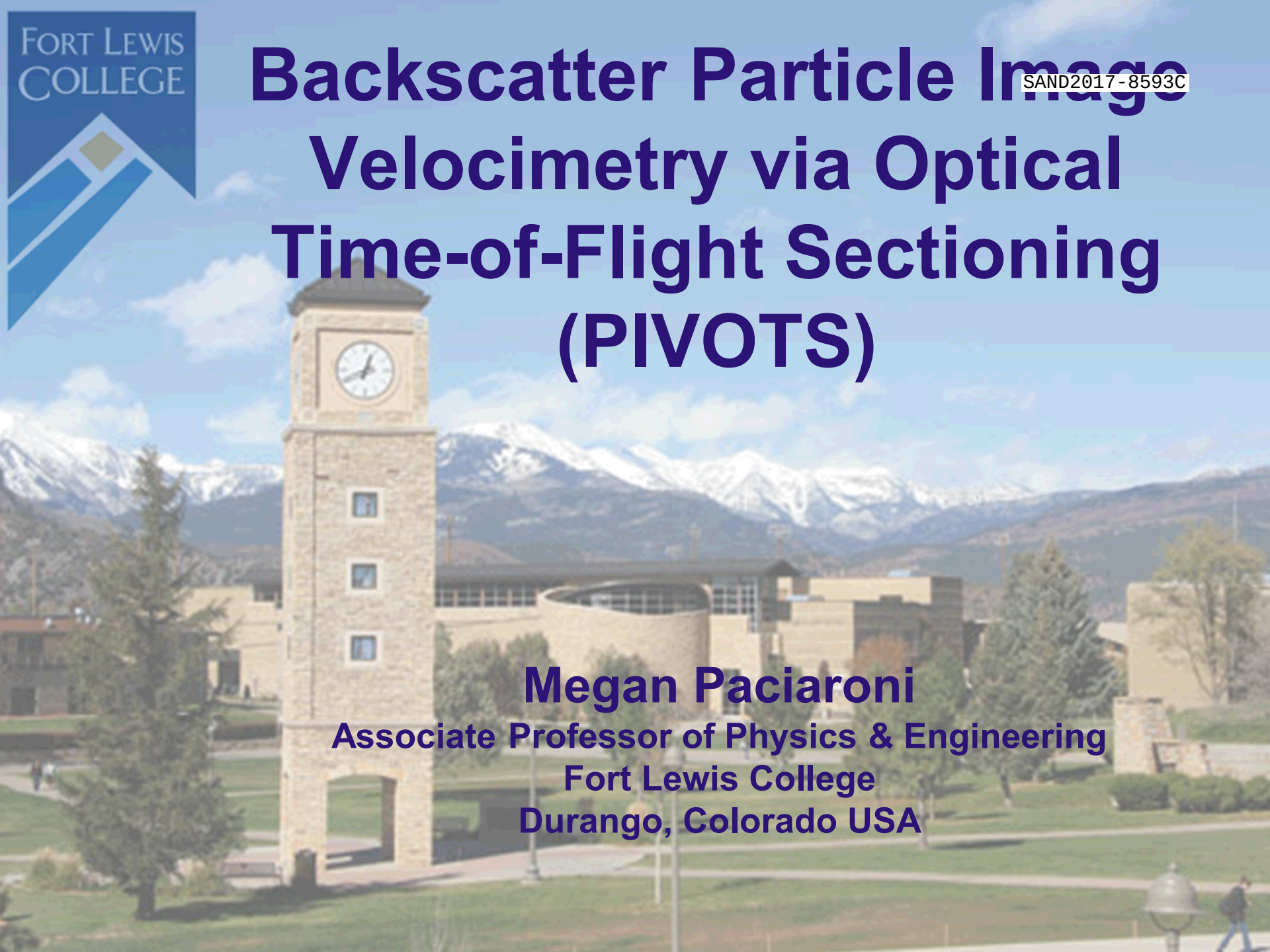
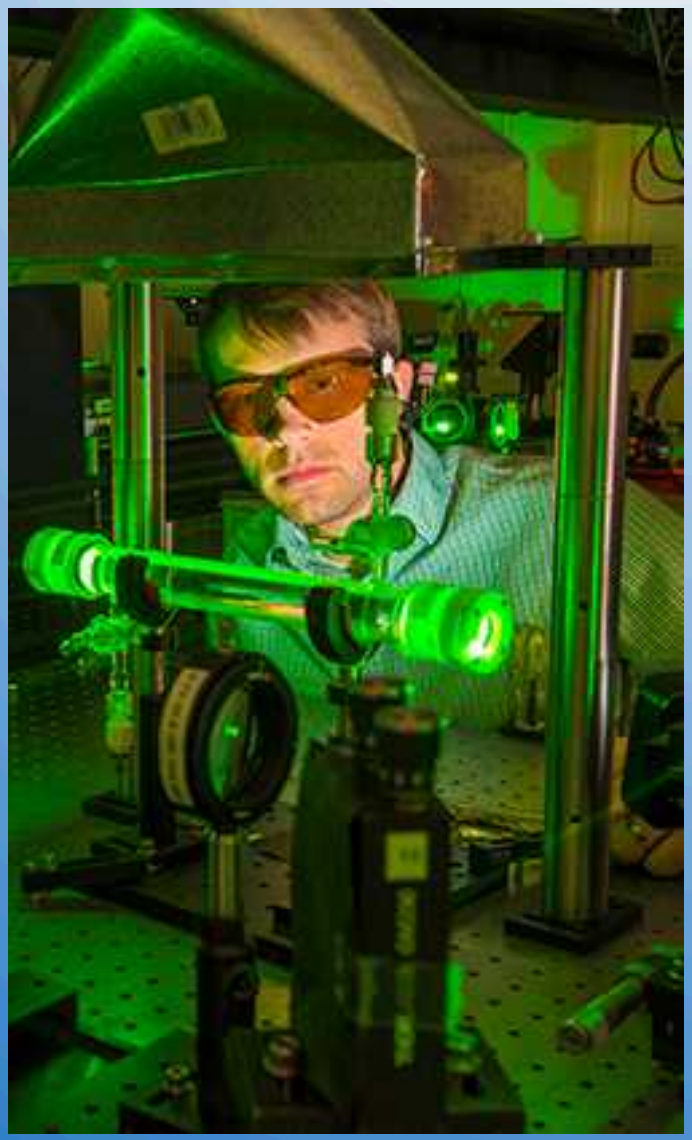


Backscatter Particle Image Velocimetry via Optical Time-of-Flight Sectioning (PIVOTS)

SAND2017-8593C

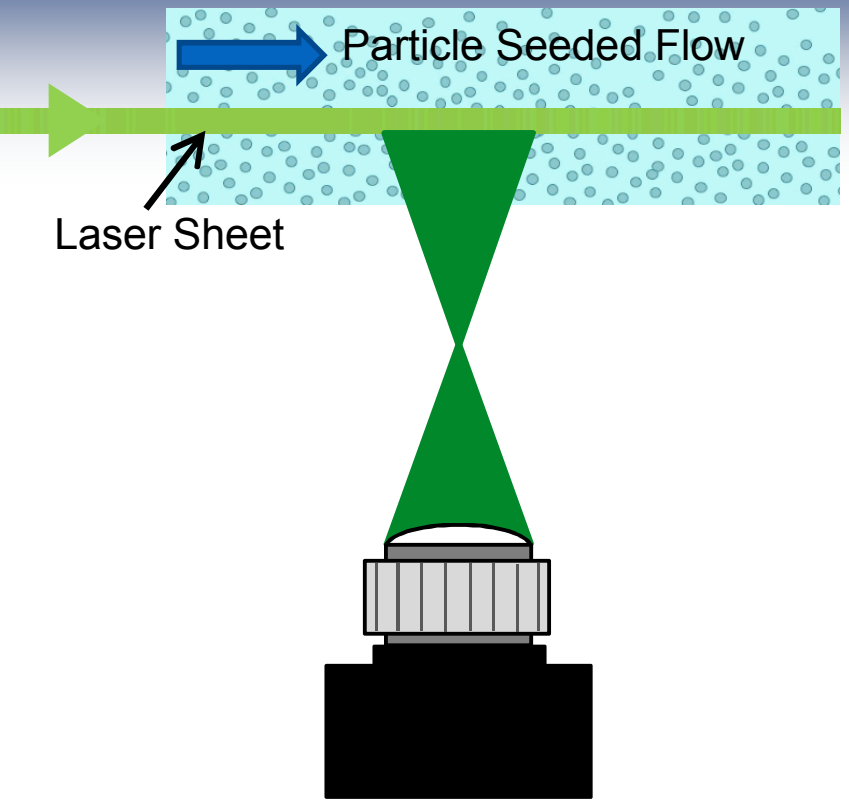
Megan Paciaroni
Associate Professor of Physics & Engineering
Fort Lewis College
Durango, Colorado USA

The Team



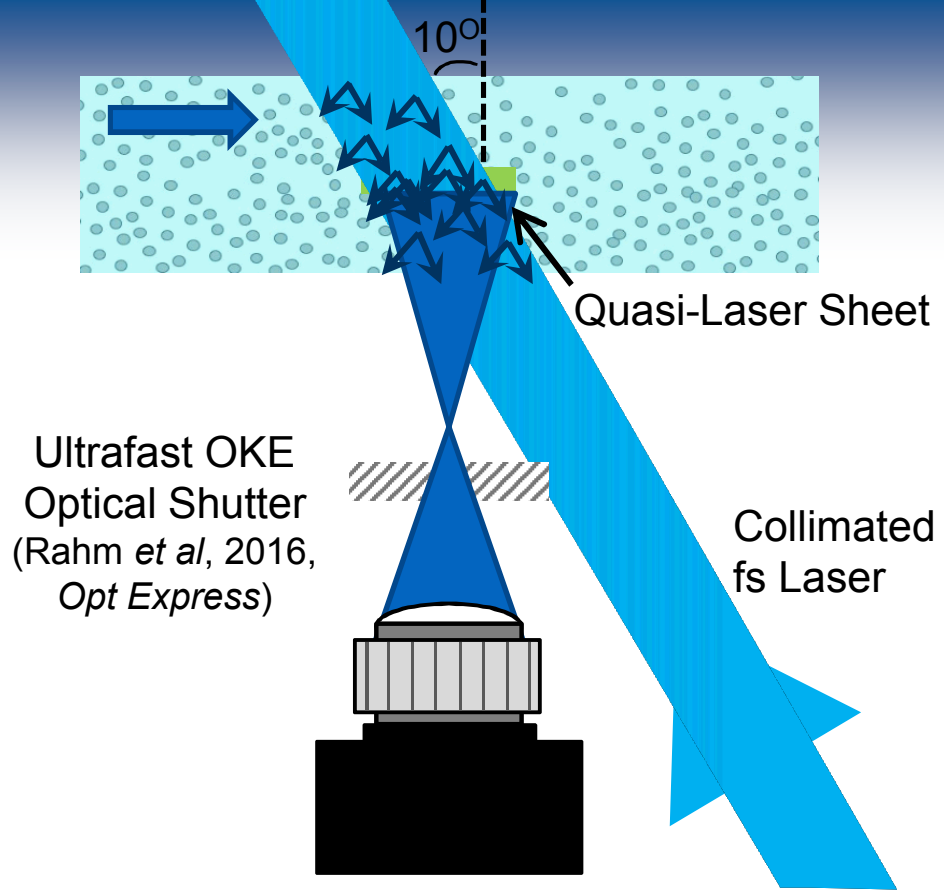
Dan Guildenbecher

Yi (Ellen) Chen



Conventional Particle Image Velocimetry (PIV)

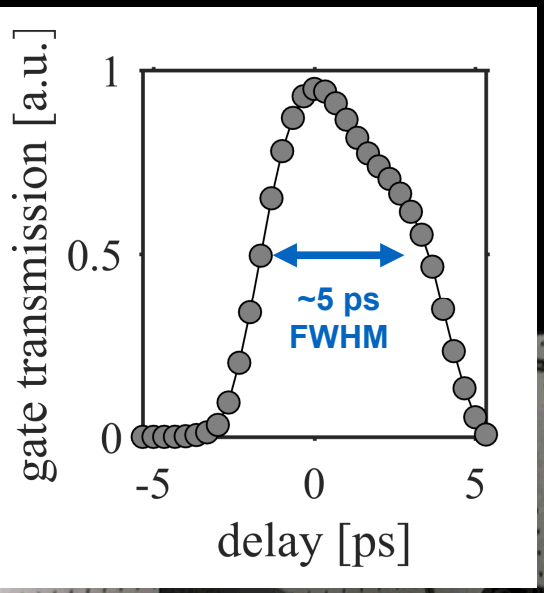
- Well established and robust flow diagnostic with many applications
- Challenges near walls and other scattering surfaces
- ***Requires two orthogonal optical access ports***



Particle Image Velocimetry via Optical Time-of-Flight Sectioning (PIVOTS)

- Inspired by backscatter OKE sectioning of Rahm *et al*, 2016
- Time gate eliminates signal from outside the effective imaging plane
- ***Requires one optical access port***

Experimental Setup



Spectra-Physics Solstice
2.5 mJ, 1 kHz, 800 nm, 80 fs

Delay Stage

α-BBO

Crossed Polarizers

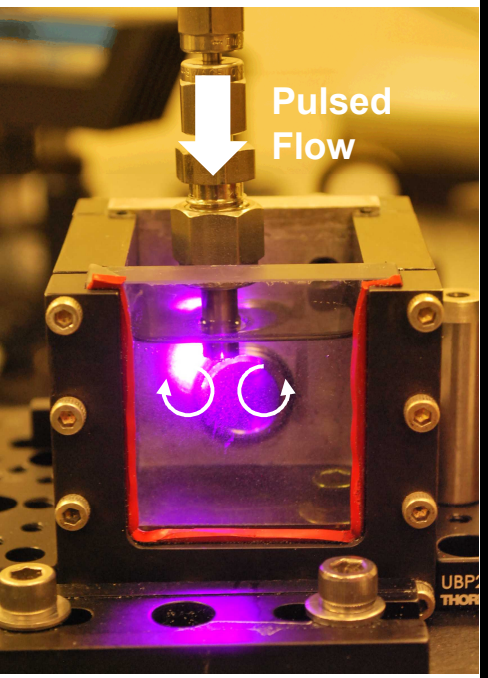
f = 200 mm

CS_2 Cell
(1 cm OPL)

Intensifier and Imager at 1 kHz

Test Cell with One Optical Window

FORT LEWIS COLLEGE



Water Seeded with
40 μm neutrally buoyant
particles

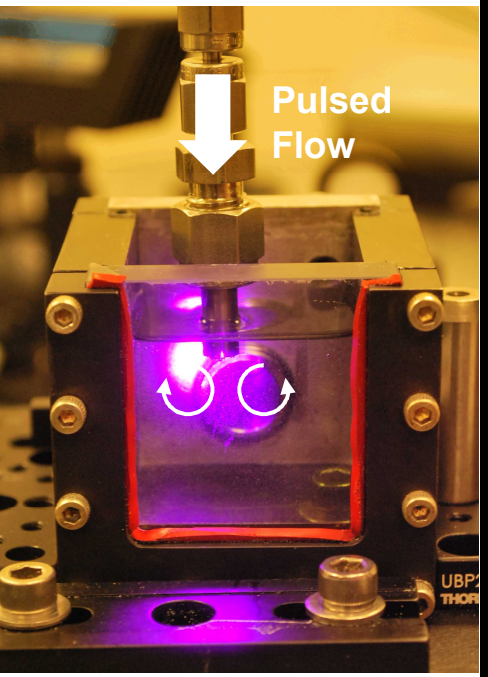
$t = 1.0$ ms

Scattering
from tube
and cell
walls

1 mm

Without OKE gate

FORT LEWIS COLLEGE



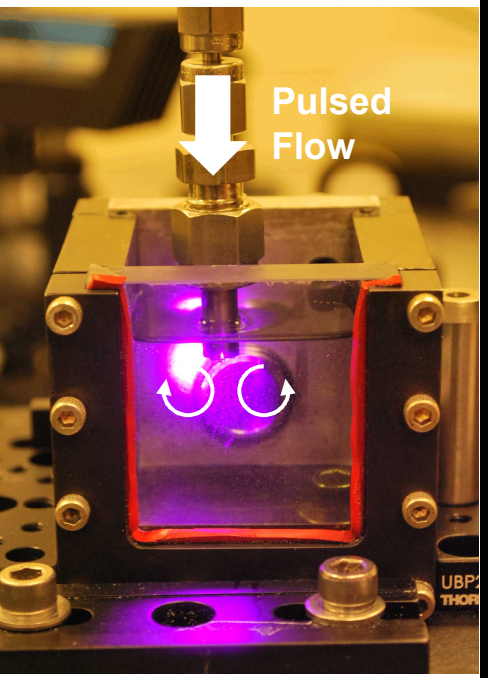
Water Seeded with
40 μm neutrally buoyant
particles

$t = 1.0$ ms

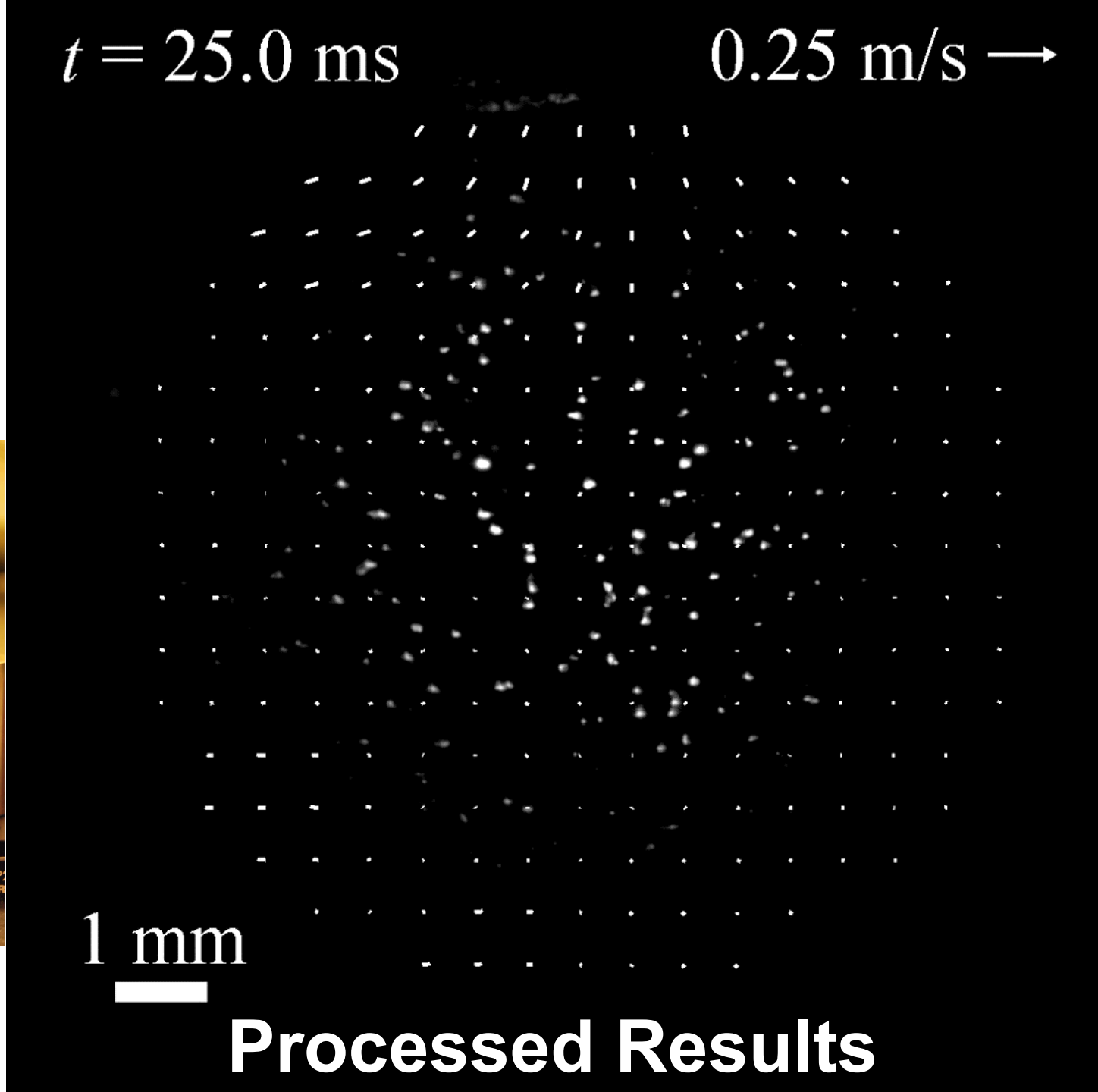
1 mm

With OKE gate

FORT LEWIS COLLEGE

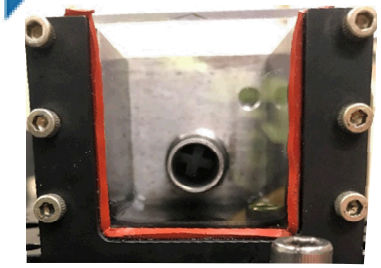


Water Seeded with
40 μm neutrally buoyant
particles

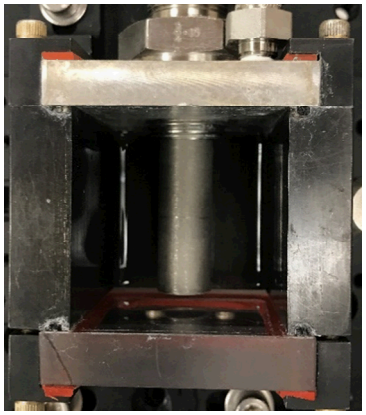


Processed Results

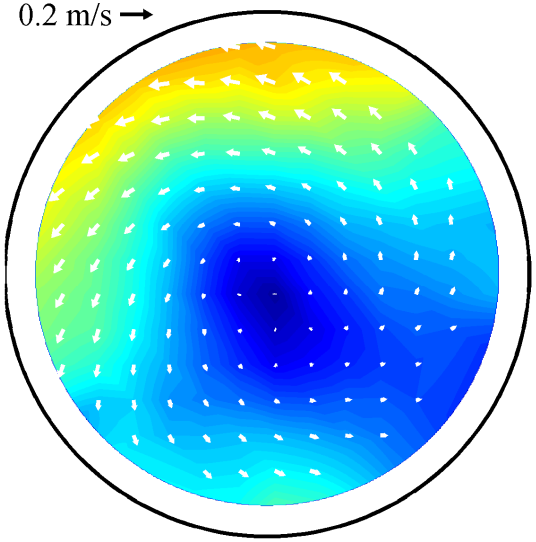
Measuring Internal Flow



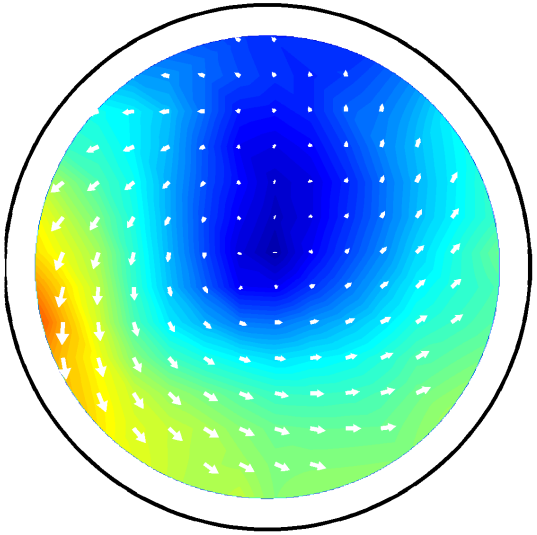
Test Cell with Tube and Flow Swirler



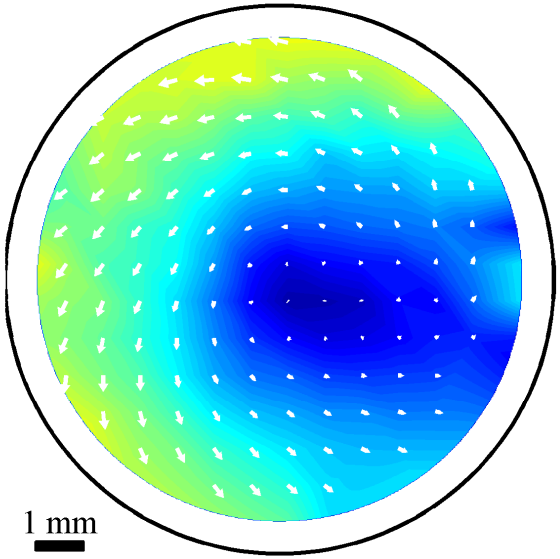
Top Down View of Test Cell



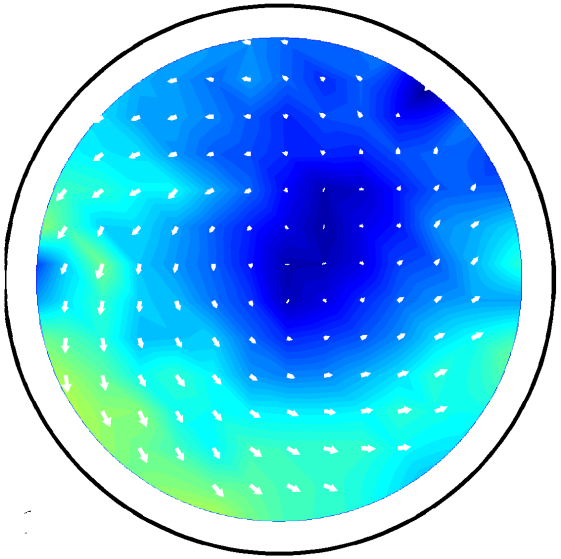
AT TUBE EXIT



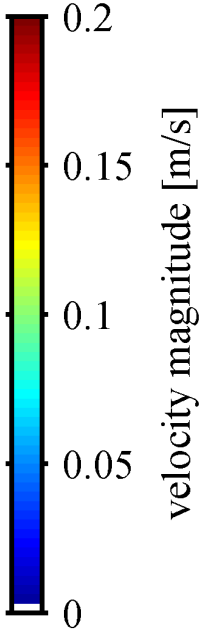
3 mm INSIDE TUBE



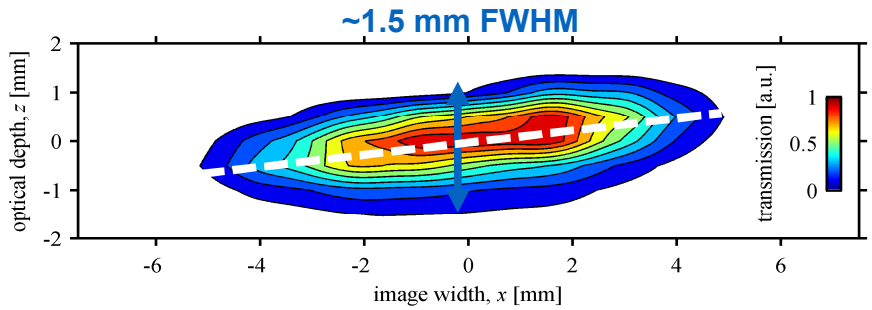
5 mm INSIDE TUBE



7 mm INSIDE TUBE



Characterizing the Measurement Volume

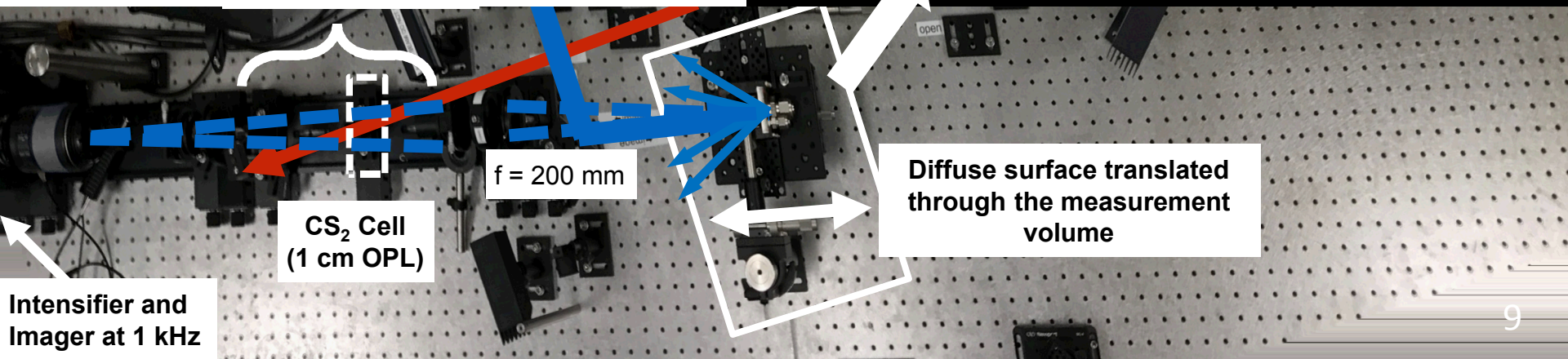


Top Down View of the Effective Measurement Volume

- FWHM in *z* (~1.5 mm) is determined by the OKE gate duration (~5 ps)
- Slight tilt due to off-axis switch beam

z = -2.0 mm

1 mm

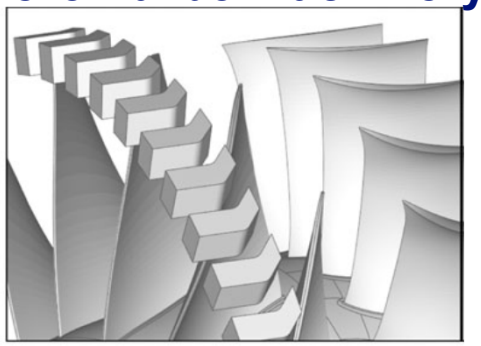


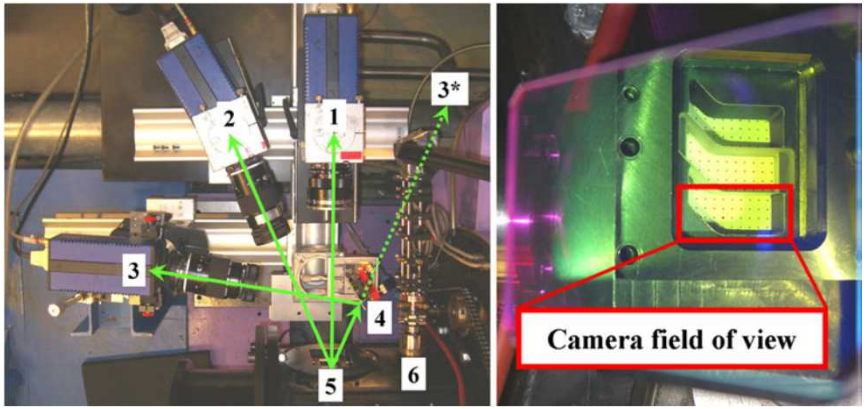
Future Applications??

This work is a *proof-of-concept* of Backscatter Particle Image Velocimetry via Optical Time of Flight Sectioning (PIVOTS)

- Extensions of this technique may eventually benefit *applications with extremely limited optical access*

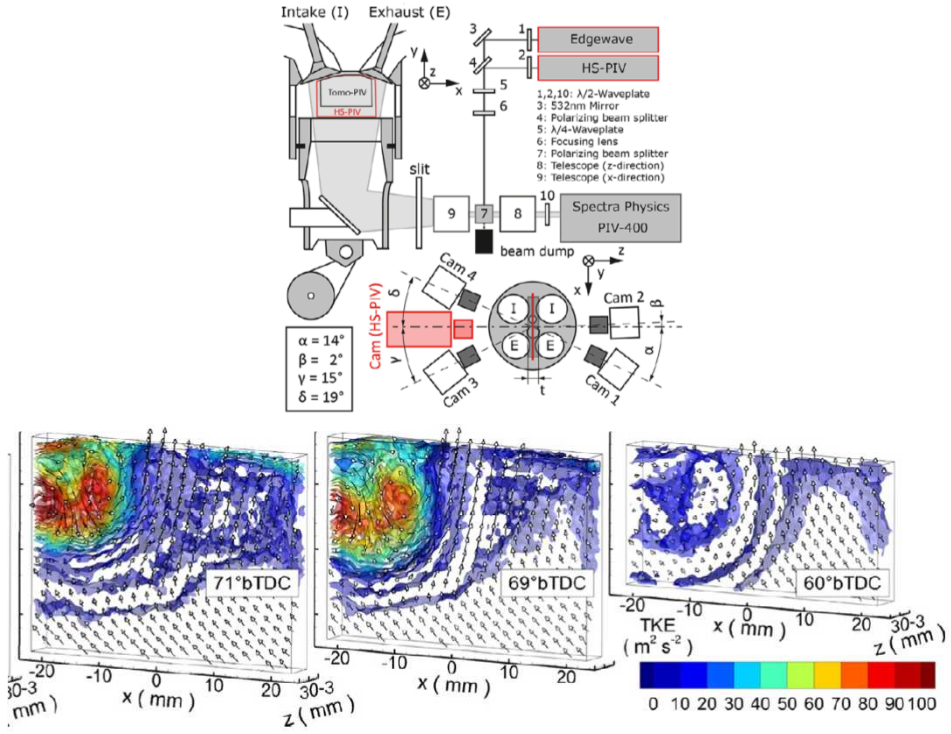
Aero Turbo Machinery





Voges *et al*, 2012, *Exp. Fluids*

Internal Combustion Engines



Paterson *et al*, 2017, *Proc. Combustion Institute*

Potential Future Improvements

- S/N may be dramatically improved with cameras and intensifiers better suited to the imaging wavelength
- An in-line configuration between the imaging and gating beam (e.g. Purwar *et al*, 2014, *Opt. Express*) could eliminate tilt in the measurement volume
- Optical system could be optimized to increase S/N and match DOF with OKE gate
- Additional fs amplifiers would allow variable Δt (e.g. Sedarsky *et al*, 2016, *Opt. Letters*)

Acknowledgements

- Megan Paciaroni gratefully acknowledges the support of the *Department of Energy Visiting Faculty Program* while at Sandia National Laboratories during the summer of 2017
- *Sandia National Laboratories* is a multimission laboratory managed and operated by National Technology and Engineering Solutions of Sandia, LLC, a wholly owned subsidiary of Honeywell International, Inc., for the U.S. Department of Energy's National Nuclear Security Administration under contract DE-NA0003525.

Questions?