

Dynamic Surface Tracking for Velocimetry Systems STL-008-16, Year 1 of 1

E. Kirk Miller, Gene Capelle, Tom Keenan, Kevin Lee, Mike Grover

Acknowledgments:
TAG Optics, Inc.
Epolin, Inc.
Paradigm Optics, Inc.

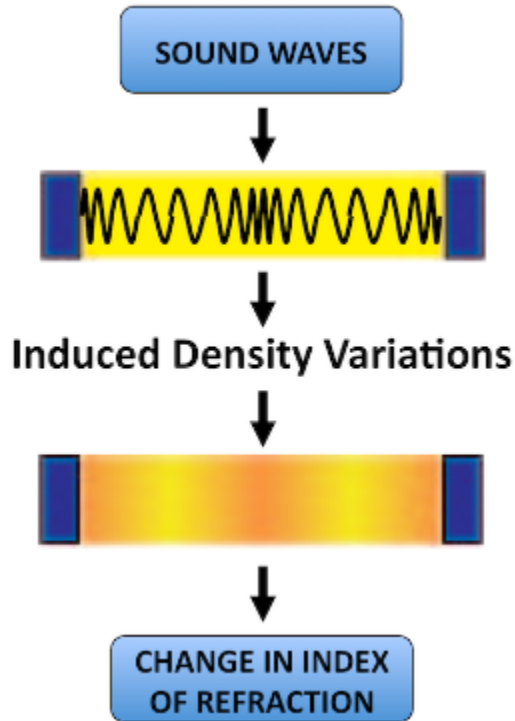
This work was done by National Security Technologies, LLC, under Contract No. DE-AC52-06NA25946 with the U.S. Department of Energy and supported by the Site-Directed Research and Development Program.



Photonic Doppler Velocimetry (PDV): Dynamic Range Challenges and Concepts

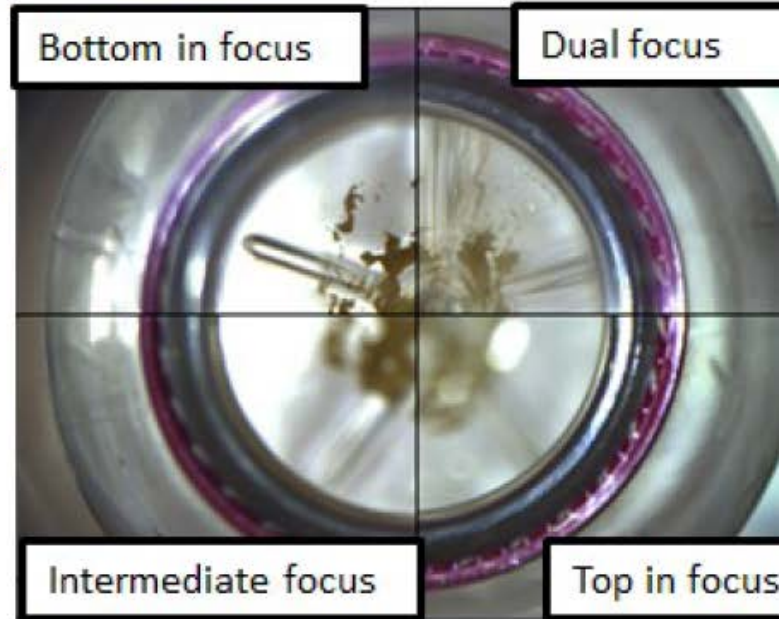
- Challenge:
 - Upcoming experiments will have ejecta occluding the surface
 - Experimenters are asking for increased dynamic range to see through cloud
- Current solutions:
 - (M)PDV probes focused near infinity
 - Collection: OK
 - Experiment tracking: full duration
 - (M)PDV probes focused in front of starting surface
 - Collection: Better, as surface passes through focus
 - Experiment tracking: limited duration
- Our concept:
 - Dynamically refocus the probe to “track” the surface, based on expected velocity vs. time profile.
- Two approaches:
 - Piezo-actuated, resonantly driven liquid-filled GRIN lens
 - Optically actuated lensing

Technique #1: TAG Optics Dynamic Lens

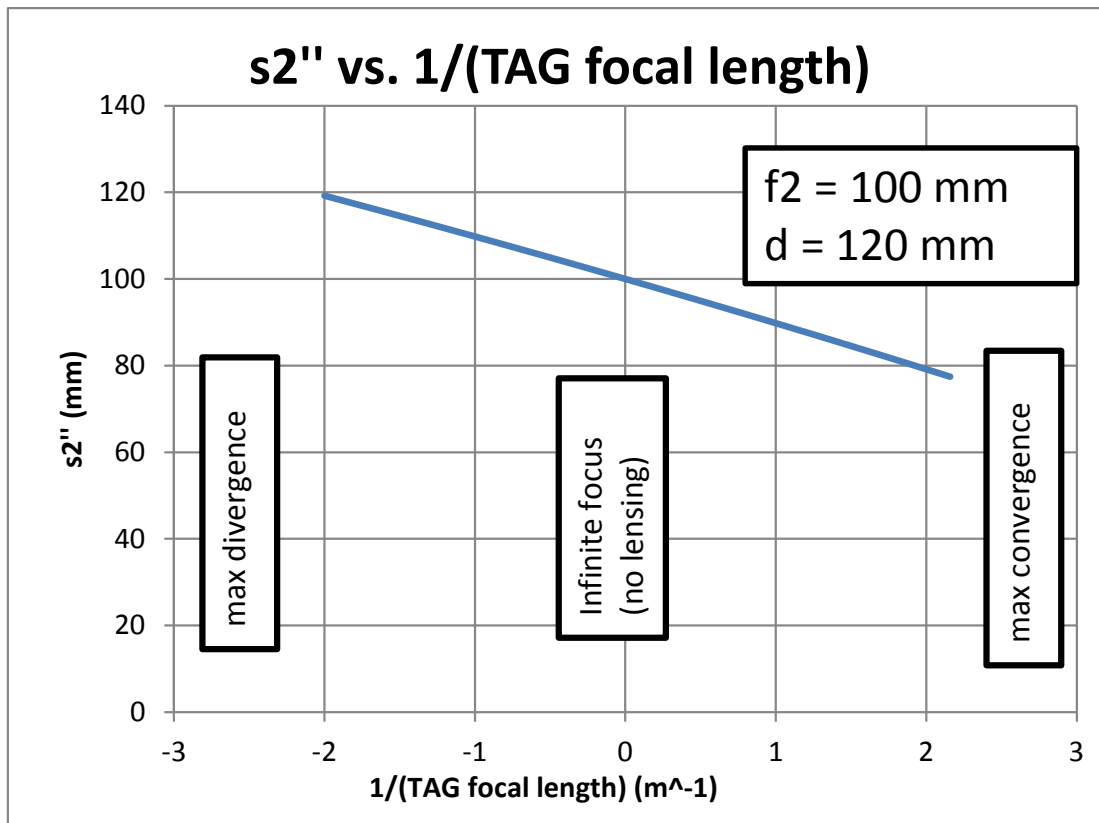
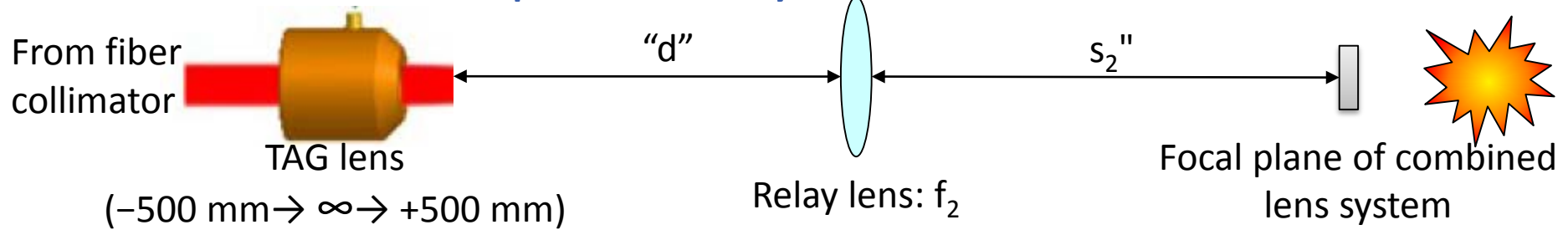


Source: tag-optics.com

Lab demo with juice bottle



Optical Relay for TAG Lens

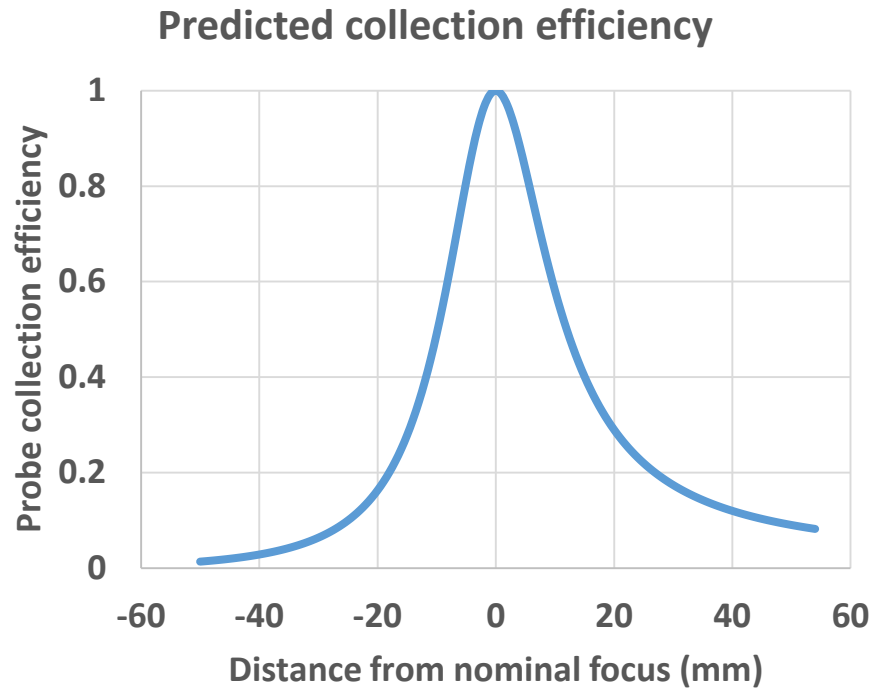


For this configuration:

- Focal point slews between 75 mm and 120 mm from relay lens
- Demonstration shots will use right-angle pellicle to protect fixed optical system

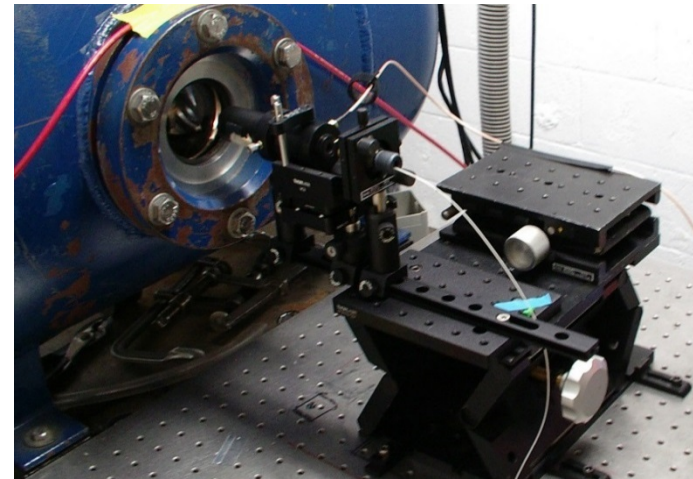
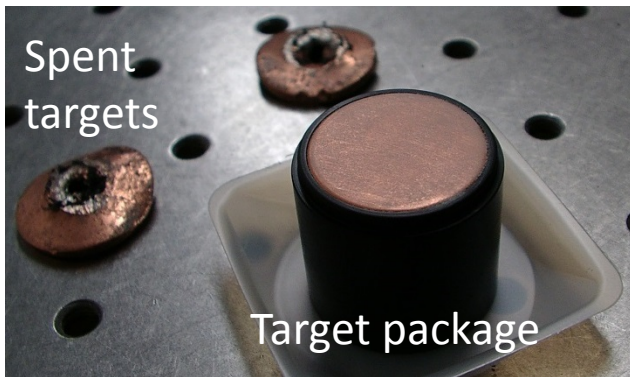
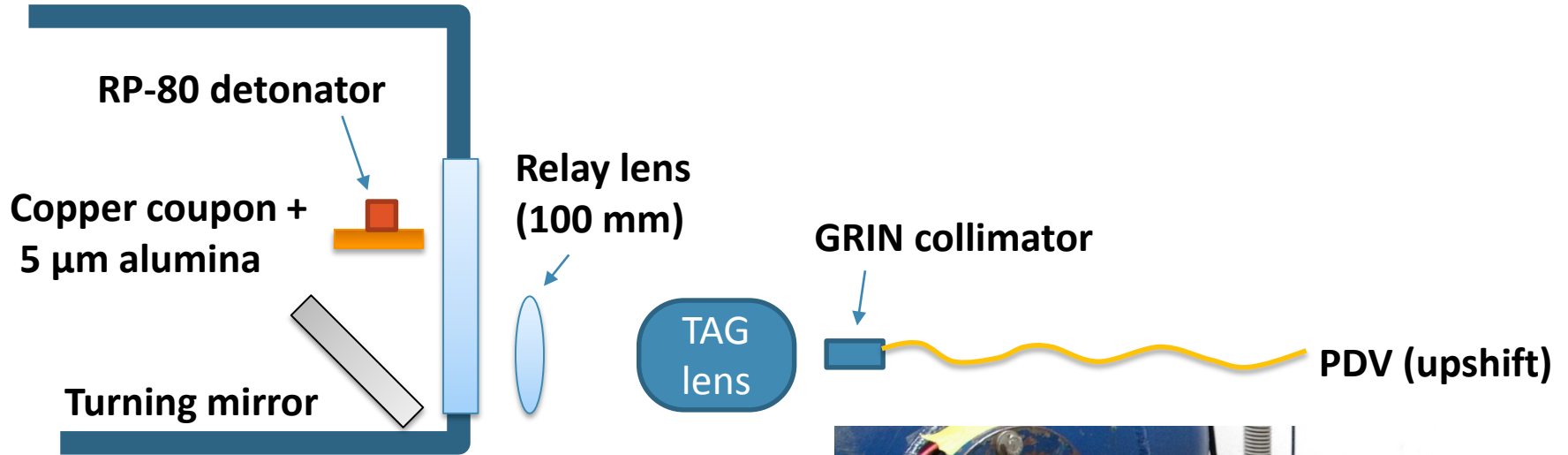
Expected Optical Performance

- Predictions are for 5–10 dB rejection of objects 20 mm from nominal focus
- Should improve tracking of surface behind ejecta



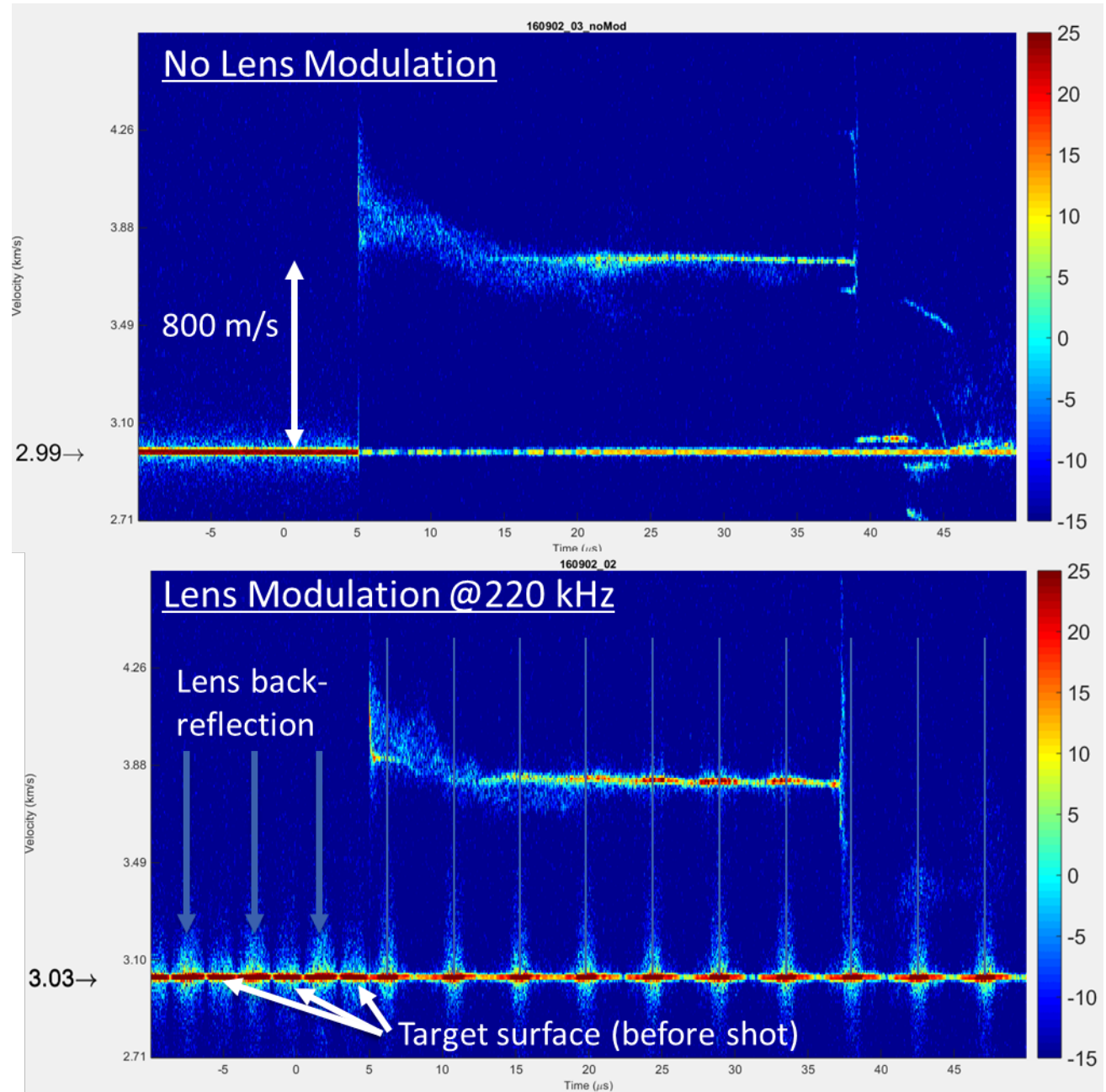
Demonstration Shots: Alumina Ejecta / Copper Coupon

Small Containment Chamber ("Boom Box")



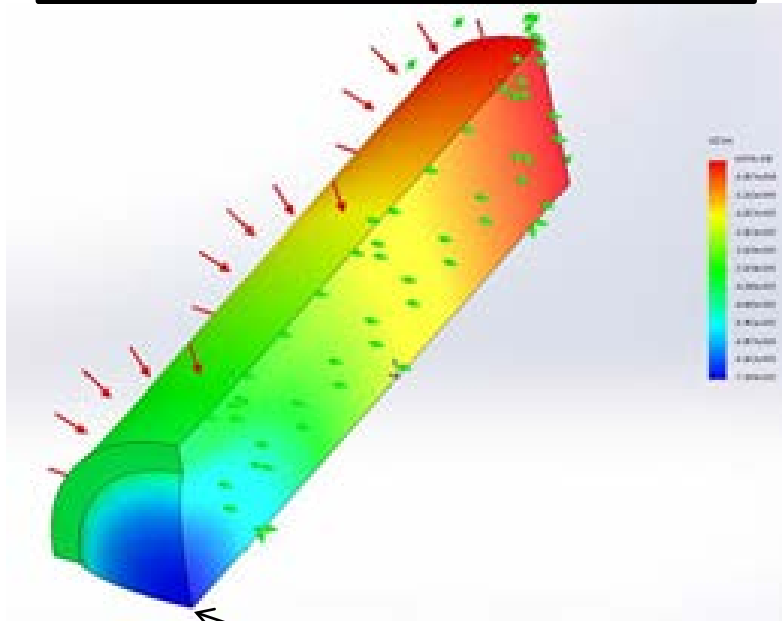
Boom Box Shot Data

- With no modulation, surface invisible for $\sim 5 \mu\text{s}$
- With 220 kHz modulation, early surface can be seen behind ejecta
- Note phasing of the intense surface return



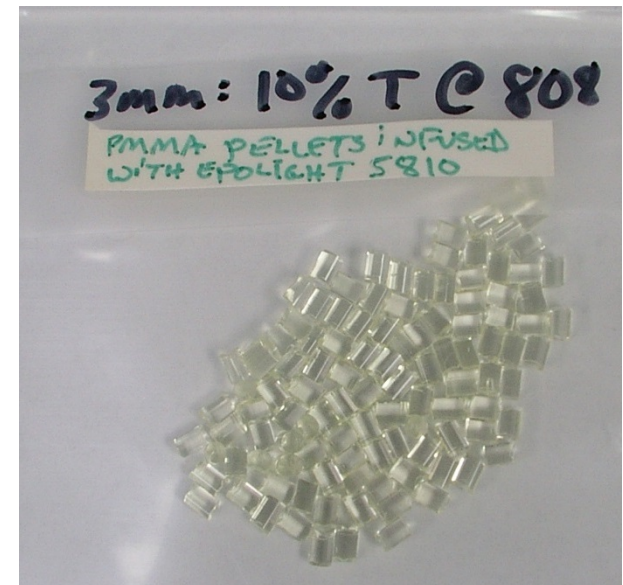
Optically Actuated Lens Scheme

100 μm polymer fiber in steel tube



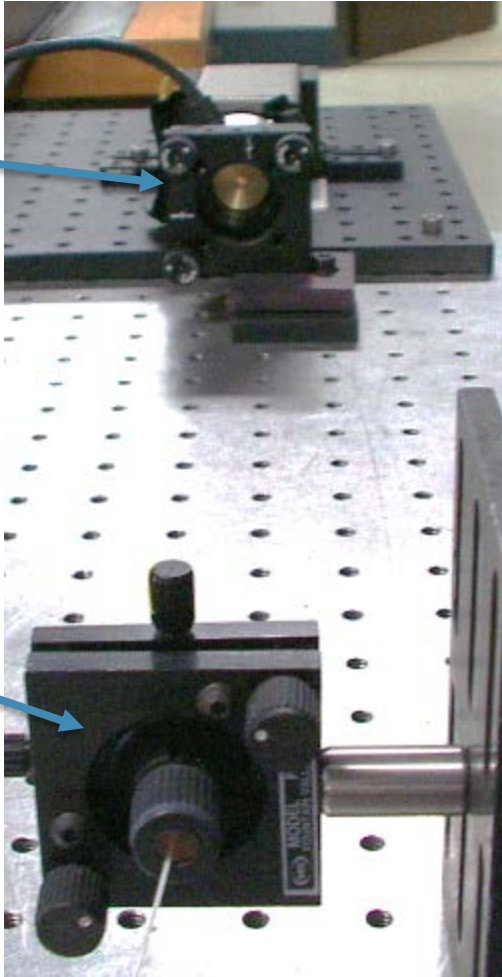
Polymer expansion (+30°C)
causes deformation at end.
Focal length ~ 40 mm

- Dye-doped PMMA pellets received from Epolin
- Paradigm is drawing the material into a “monofilament” (fiber)
- We will test the fiber using optical heating in September



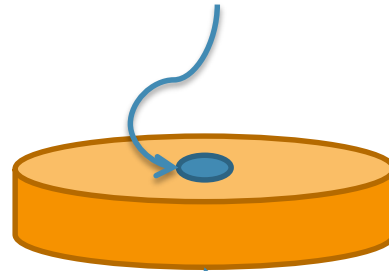
Lab Data: Static Heating

Plastic fiber in brass chuck and heater

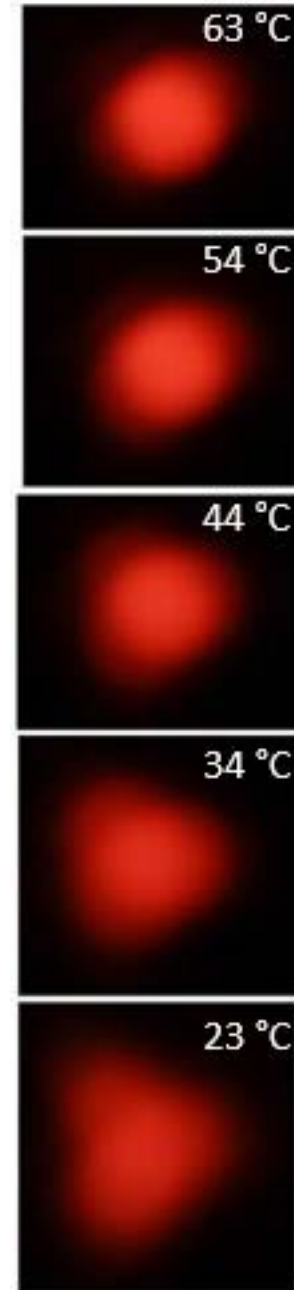


Collimated light from fiber

PMMA fiber glued into brass holder



Brass holder fits into Thorlabs lens heater



Decreasing spot size

Physical Feasibility

- Material: PMMA
 - Volume $\sim 0.012 \text{ mm}^3$
 - Mass $\sim 14 \text{ } \mu\text{g}$
 - Energy to heat by $10^\circ\text{C} \sim 0.2 \text{ mJ}$
 - Power in $20 \text{ } \mu\text{s} \sim 10 \text{ W}$
-
- Use current-pulsed, high-power laser diodes
 - Use cladding-pumped fiber to deliver pump + signal

Impact

- Optically actuated lens:
 - Invention disclosure
 - Provisional patent filed 6/7/16
- Full project presented as part of plenary talk at June 2016 PDV Workshop in Livermore

Team

- Gene Capelle
 - Optics / Laser design
 - Lead for optically actuated lens
- Tom Keenan
 - FEA analysis of polymer deformation
- Kevin Lee
 - Electronics and experimental support
- Mike Grover
 - Experimental setup and shot execution, plastic-fiber assembly and polishing