

Design and assembly of the PDV and VISAR diagnostics for the Thermos subcritical experiments

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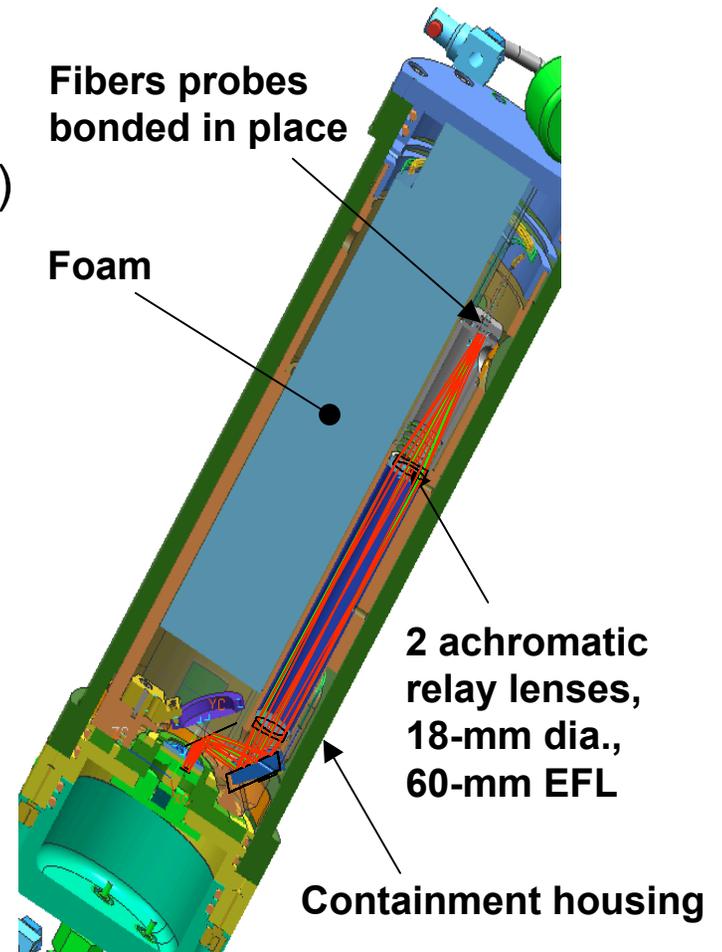
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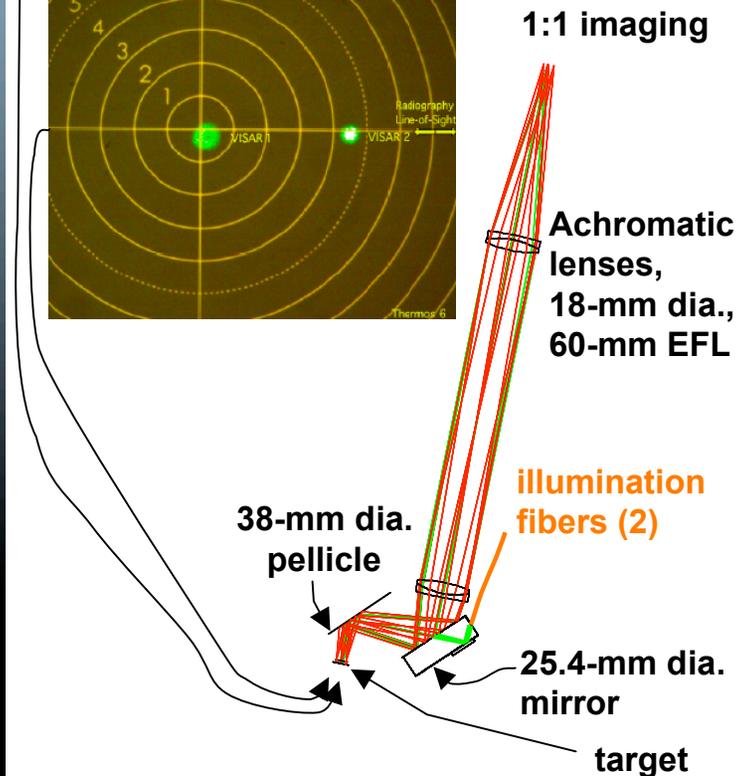
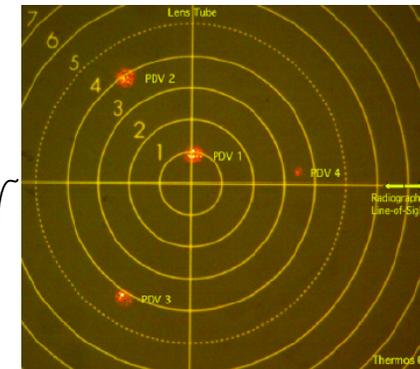
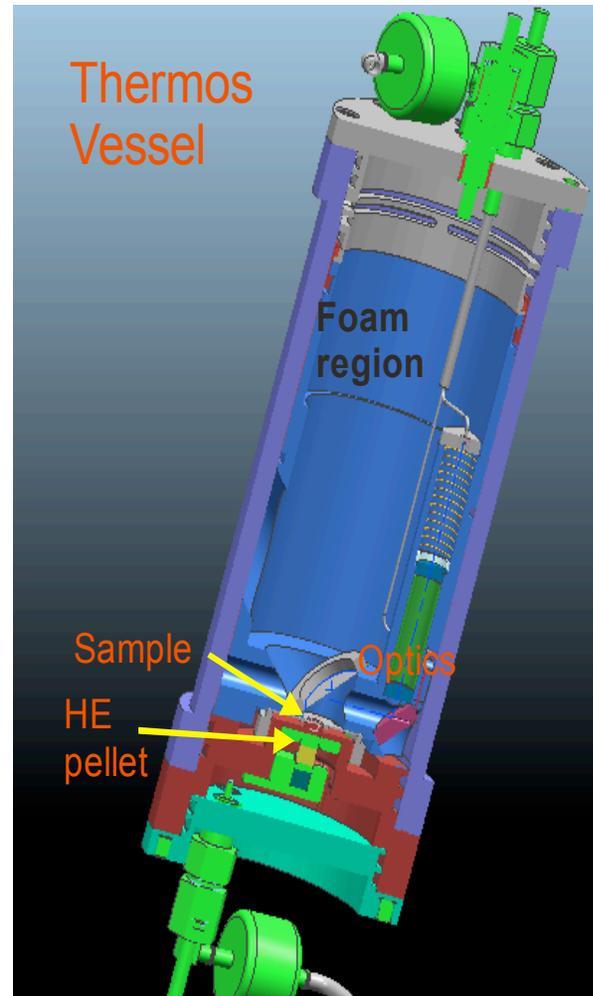
Purpose and Description of Experiment

- Validate equation-of-state material models
 - Compact instrument (~100 mm dia. x 400 mm long)
 - Compressed schedule (2 shots per week)
 - 12 experiments
- Shock target with high explosives (HE)
 - Accelerate up to 3 km/sec in a few mm
 - **Soft catch** using calibrated foam
- Perform **metallurgical** examination of shocked metal target
- **Radiography**: 2 lines of sight with Cygnus
- **Velocimetry**: 4 single-point measurements



The velocimetry system consisted of both VISAR and PDV

- NSTec designed a diagnostic canister to hold the foam and the optical diagnostics.
- A high-bandwidth VISAR was designed to resolve the rise time.
- PDV was designed to follow the velocity for a long period of time.
- The relay lens system sampled small regions of the target. A pellicle was used so the optics did not interfere with the flight of the target. The small sample spots avoided bandwidth problems from sweeping waves.
- The PDV sampled the center of the target and at 3 positions at $\frac{1}{2}$ sample radius. The VISAR sampled near the center and at 1 position at $\frac{1}{2}$ sample radius.

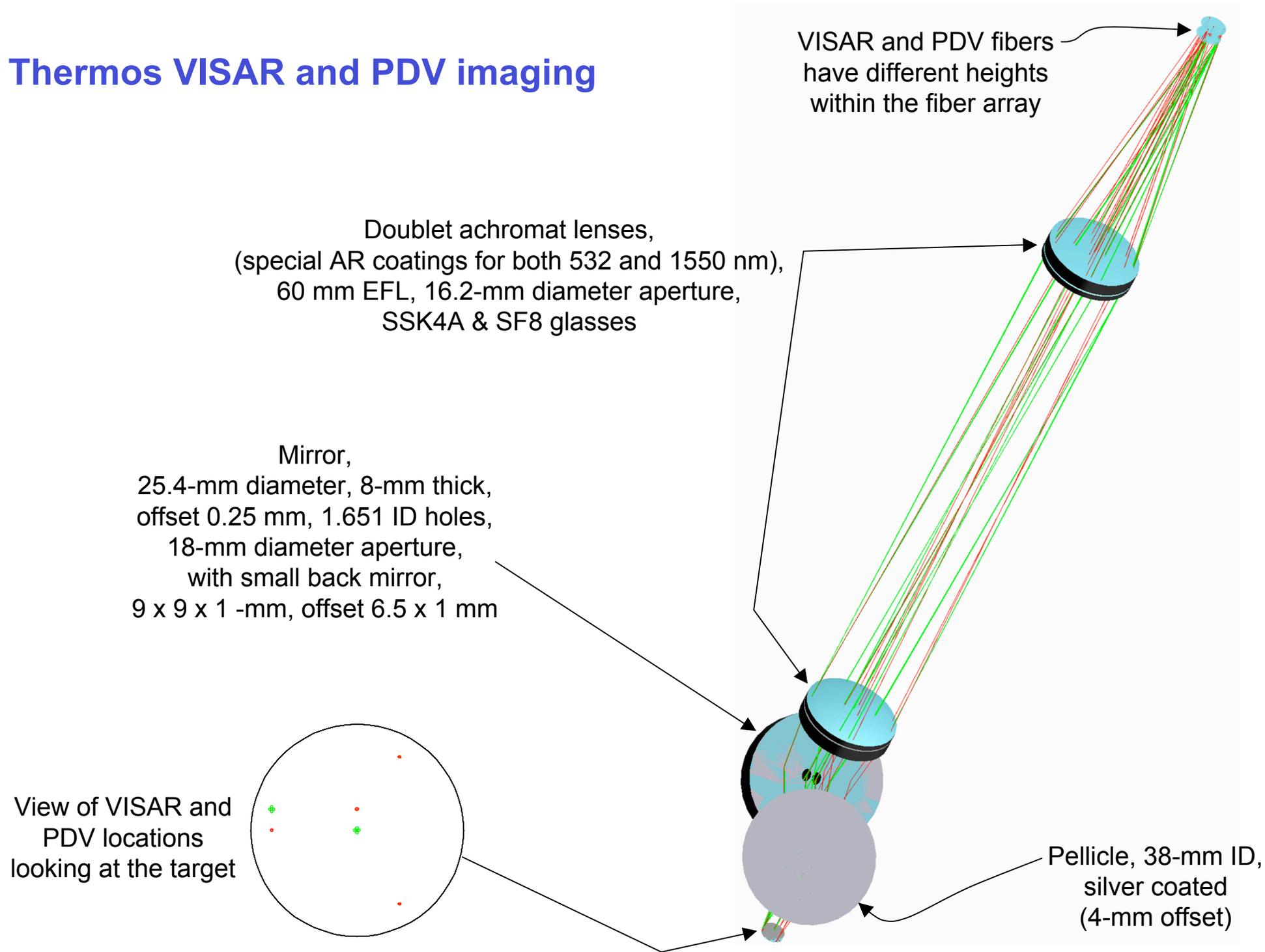


Soft Catch

- It was discovered experimentally that commercial 3.5 lb/ft³ foam will stop the projectile without incurring further damage.
- Later, due to a different HE configuration, the design was changed to specify a 5 lb/ft³ foam.



Thermos VISAR and PDV imaging

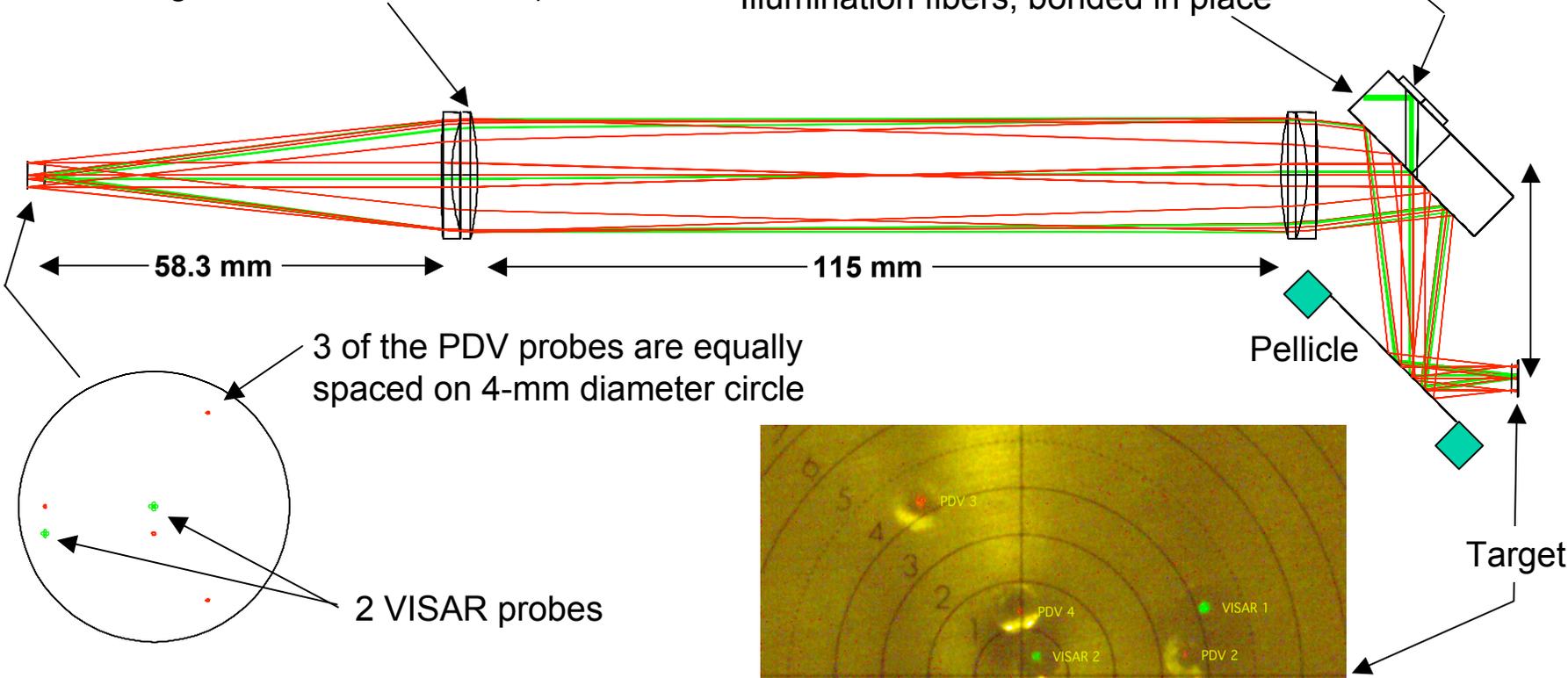


Optical System

2 doublet achromat lenses
(special coatings for 532 and 1550 nm)

Small mirror bonded to back of larger mirror

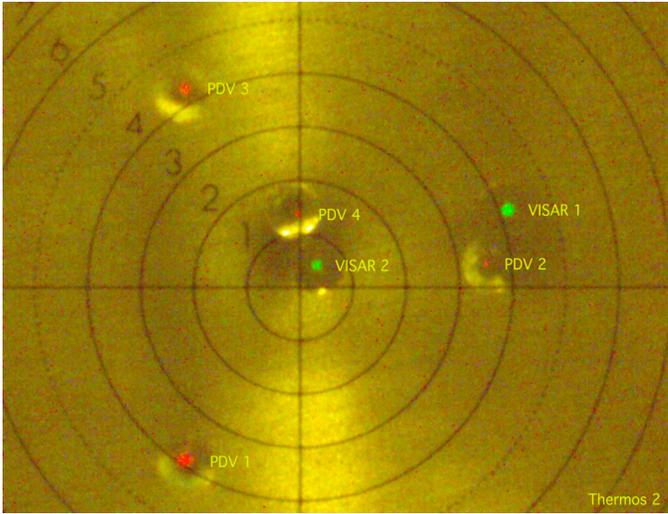
Illumination fibers, bonded in place



3 of the PDV probes are equally spaced on 4-mm diameter circle

2 VISAR probes

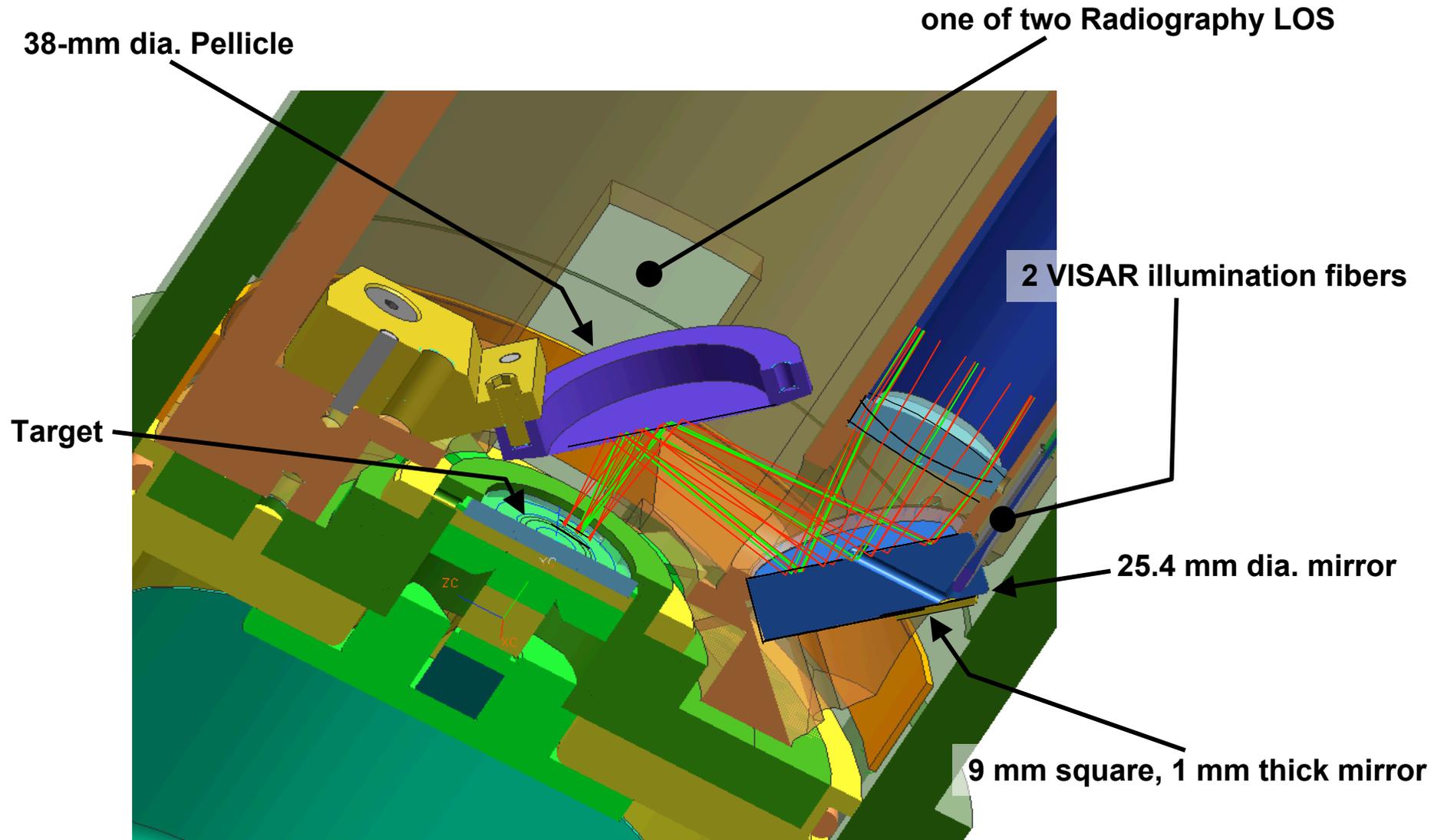
2 VISAR, and 4 PDV probes



Calibration measurement with reticle

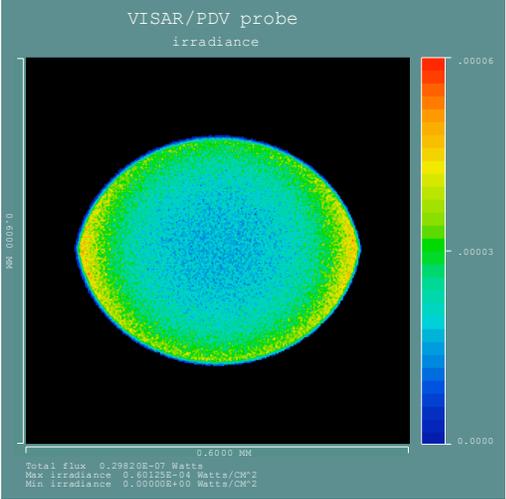
PDV works at 1550 nm, but it is aligned at 670 nm so camera can archive alignment images.

Close Up Near Target

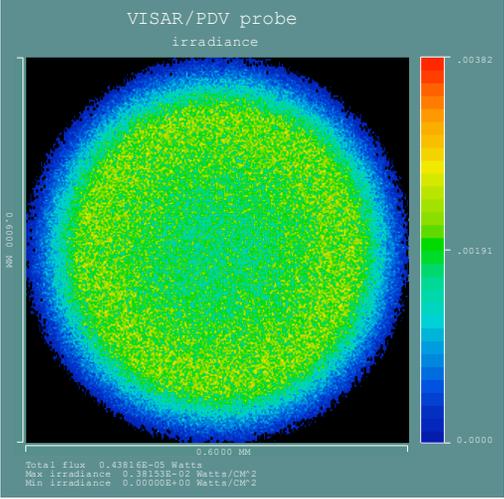


Thermos VISAR/PDV fiber spots on target after 2 mm travel toward pellicle. Note: scale change

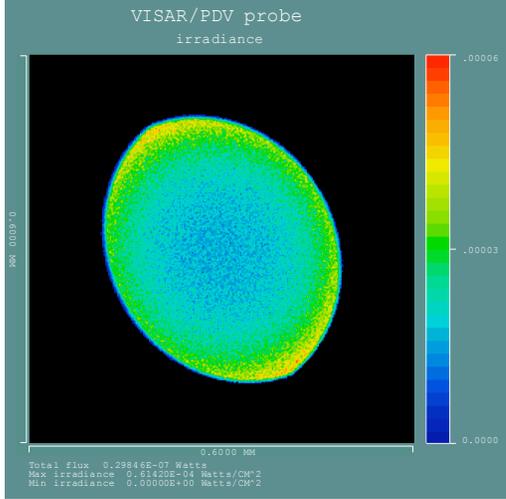
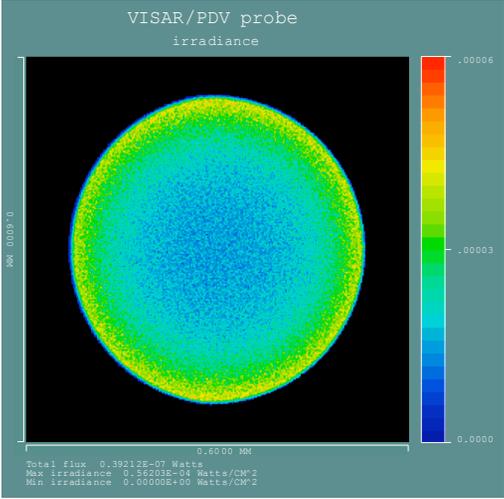
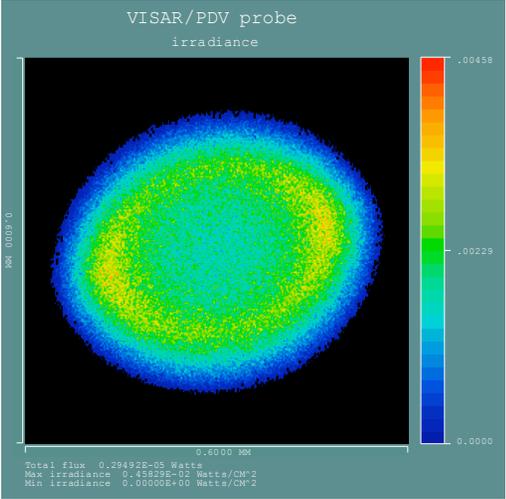
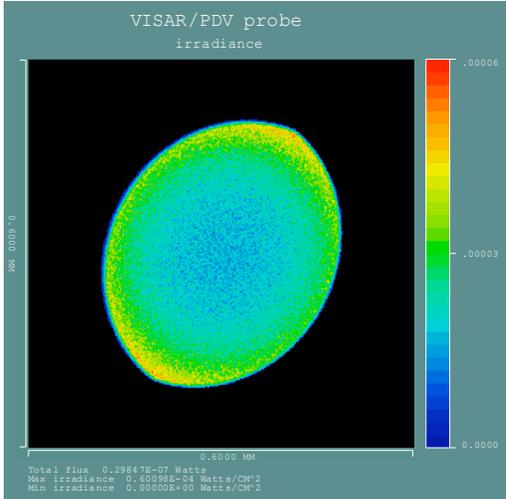
Edge



Center



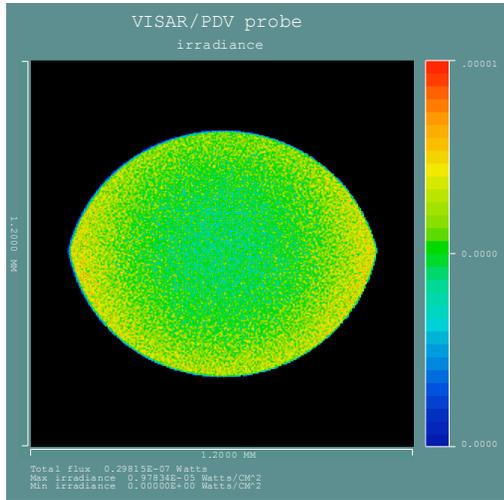
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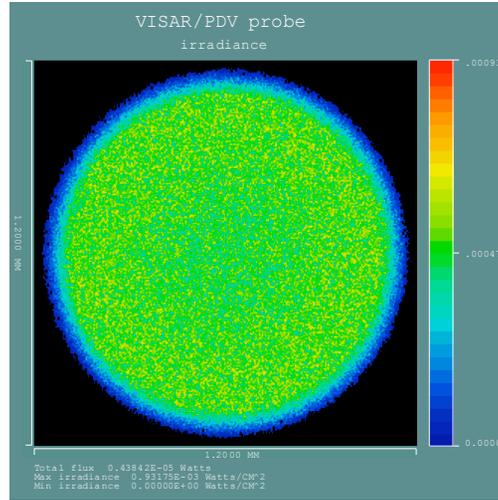
Plots are 0.6-mm square

Thermos VISAR/PDV fiber spots on target after 4 mm travel toward pellicle. Note: scale change

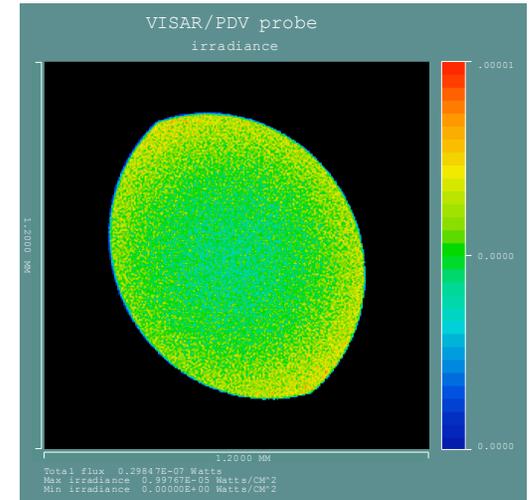
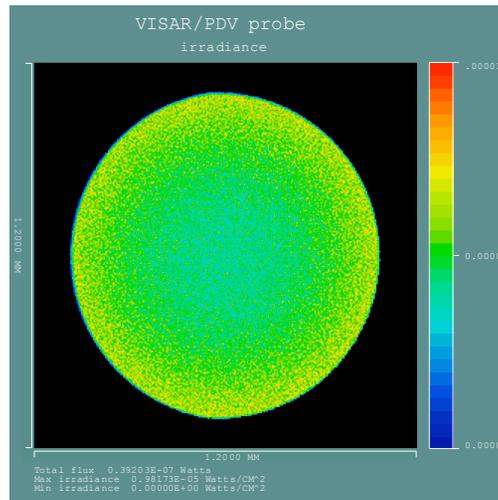
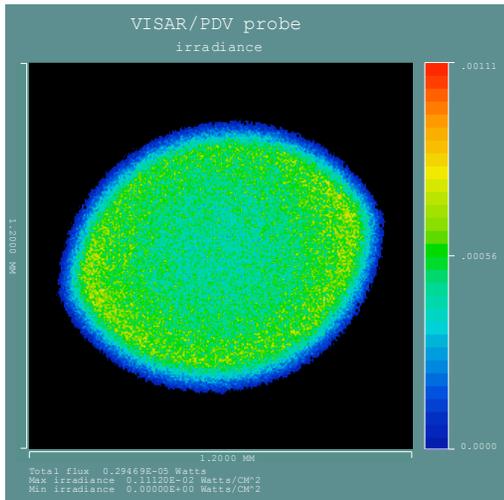
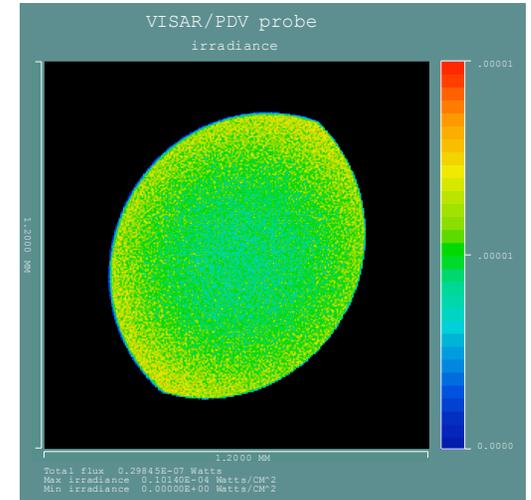
Edge



Center

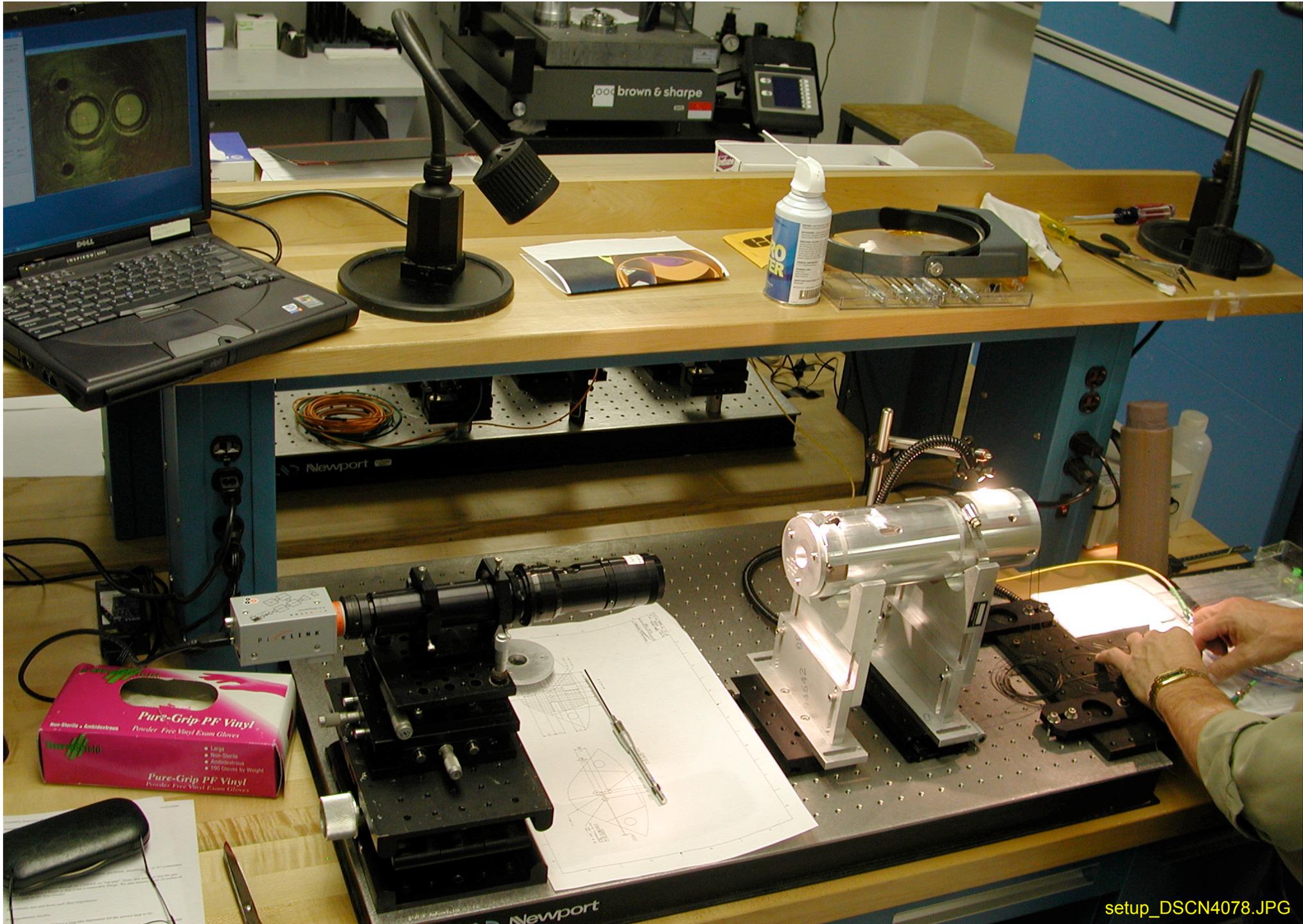


Edge



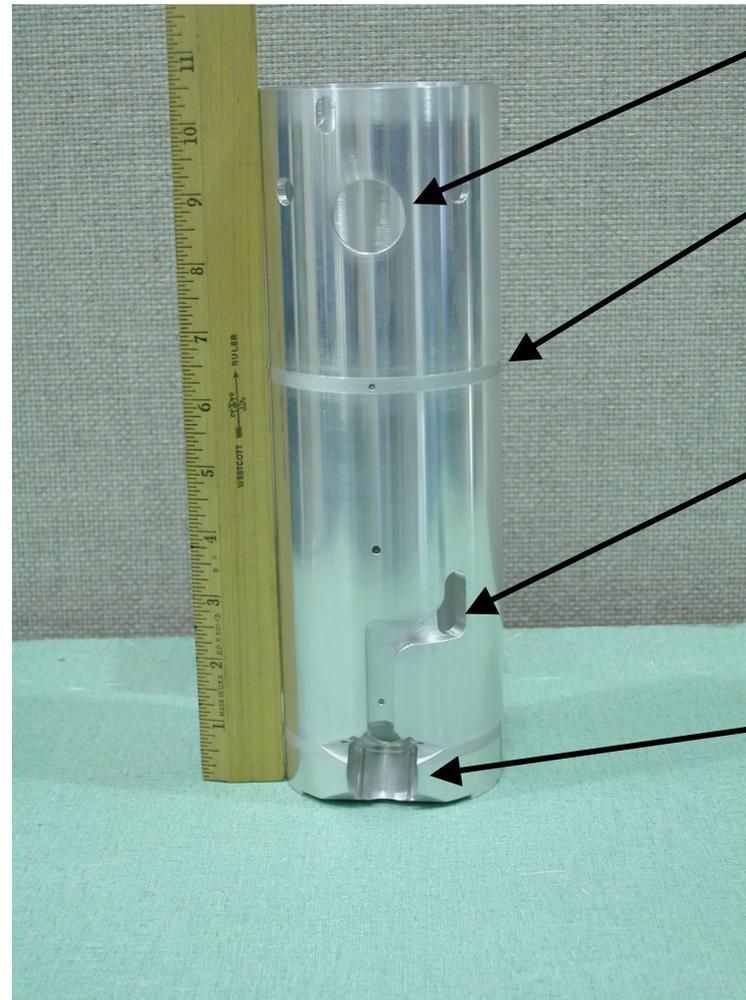
Plots are 1.2-mm square

Thermos lab setup



Aluminum "Mo-Pack" Canister

- Design considerations
 - Simplicity
 - Alignment
 - Ease of installation
- Next steps
 - Ease of manufacture
 - *Poke-yoke* design
 - New science goals



Inspection port for fibers

3 piece welded construction

Path for VISAR illumination fibers

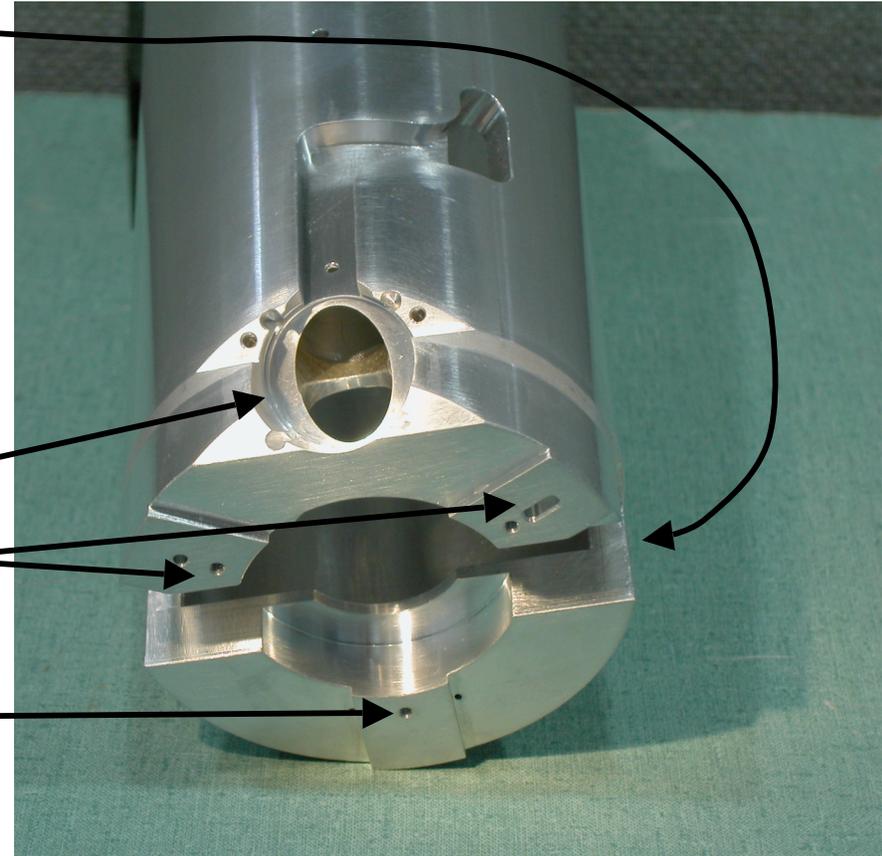
Registration for mirror

Canister

- First design iteration had only one LOS for radiography, a second LOS was added at 60 deg.

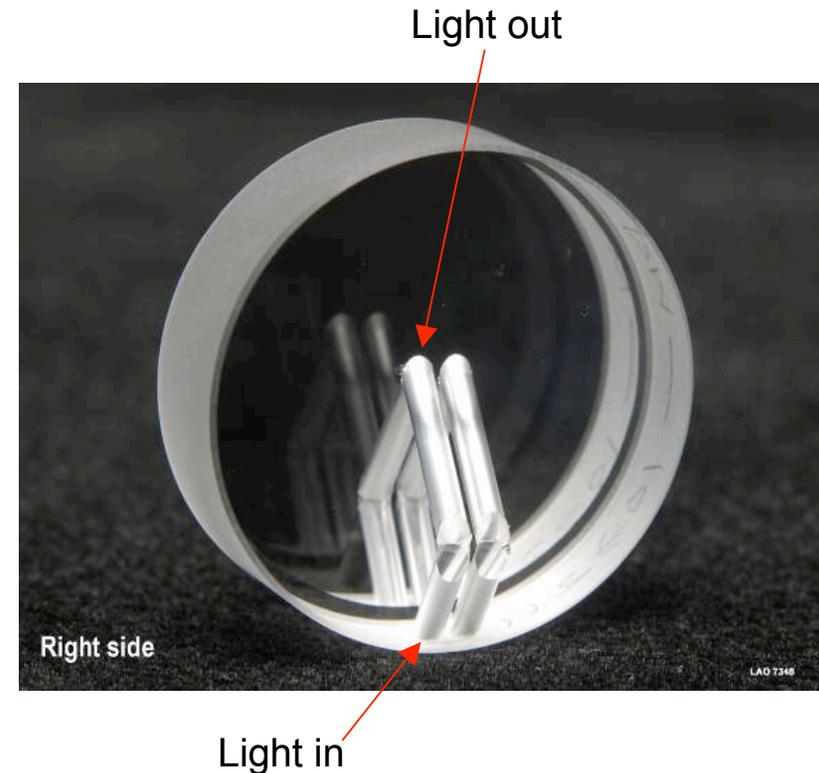
Notice:

- Mounting feature for mirror
- Alignment features (hole/slot for 2 pins)
- 3 pt mounting, threaded holes for alignment fixture



"Holey" Mirror!

- Special holes required ultrasonic drilling methods
 - Very little deviation from surface flatness (from $\lambda/10$ to $\lambda/9$)
 - Dimensional accuracy of holes within spec
 - Some chipping at mirror surface, minimized with ophthalmic tape (3M 1640 Surface Saver Blue Tape)
 - No cracking (with one exception)
 - OST/Sonic Mill provided good service: on-time delivery, vendor integration between glass procurement, drilling, optical coating

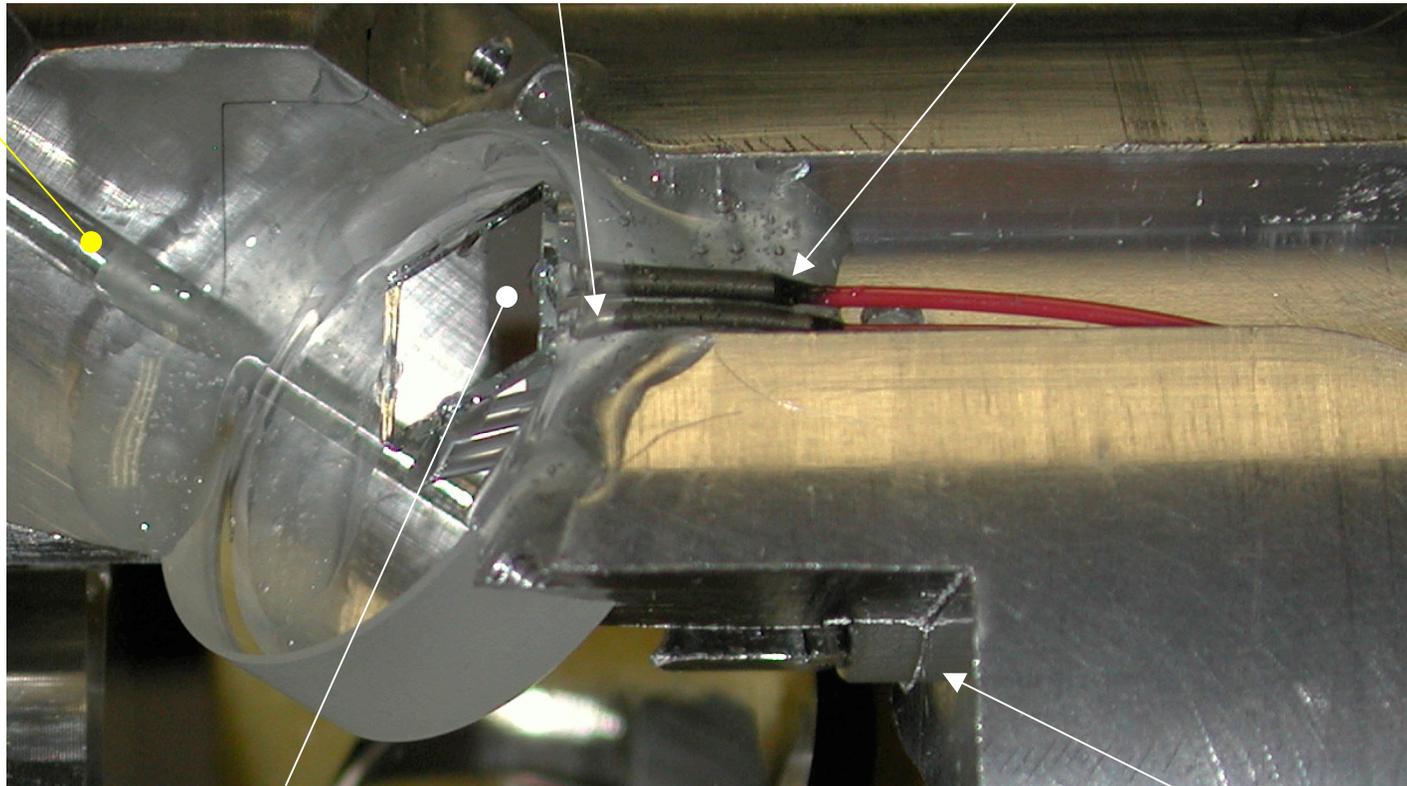


VISAR Fiber illumination

No room for radius on fibers

Multimode fibers with collimator lenses potted in .065 tubes

Bonding features



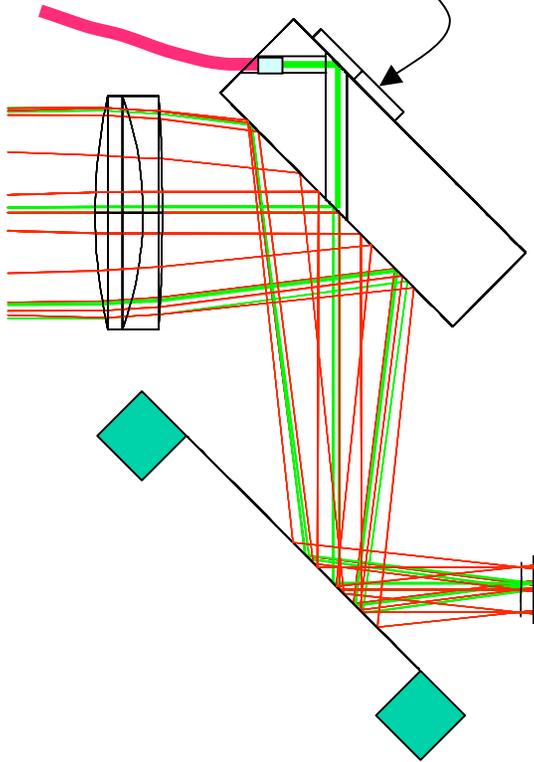
Turned light with small mirror mounted to back of "holey" mirror.

Clearance for radiometry LOS

Small mirror was shimmed and glued to align illumination spots on target.

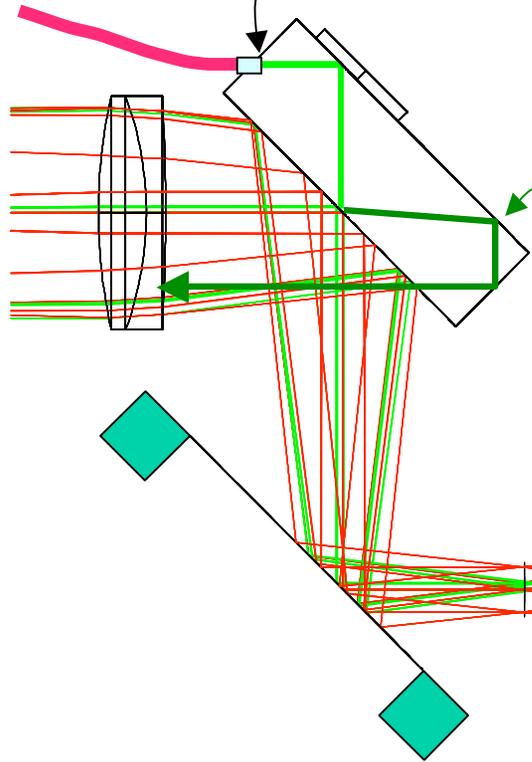
Alternative VISAR illumination schemes

Small mirror provides illumination steering
(shimmed and glued)

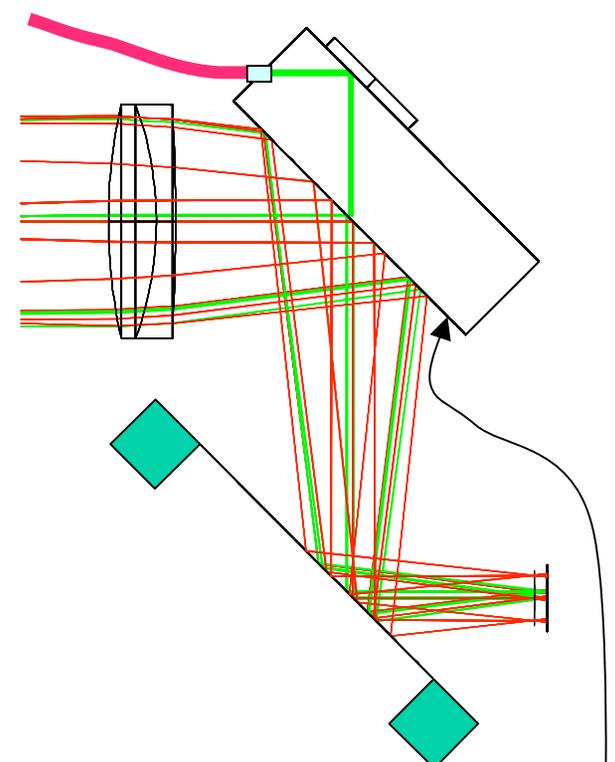


Thermos "Holey" Mirror
(don't have to worry about unshifted light)

Polished notch on mirror edge



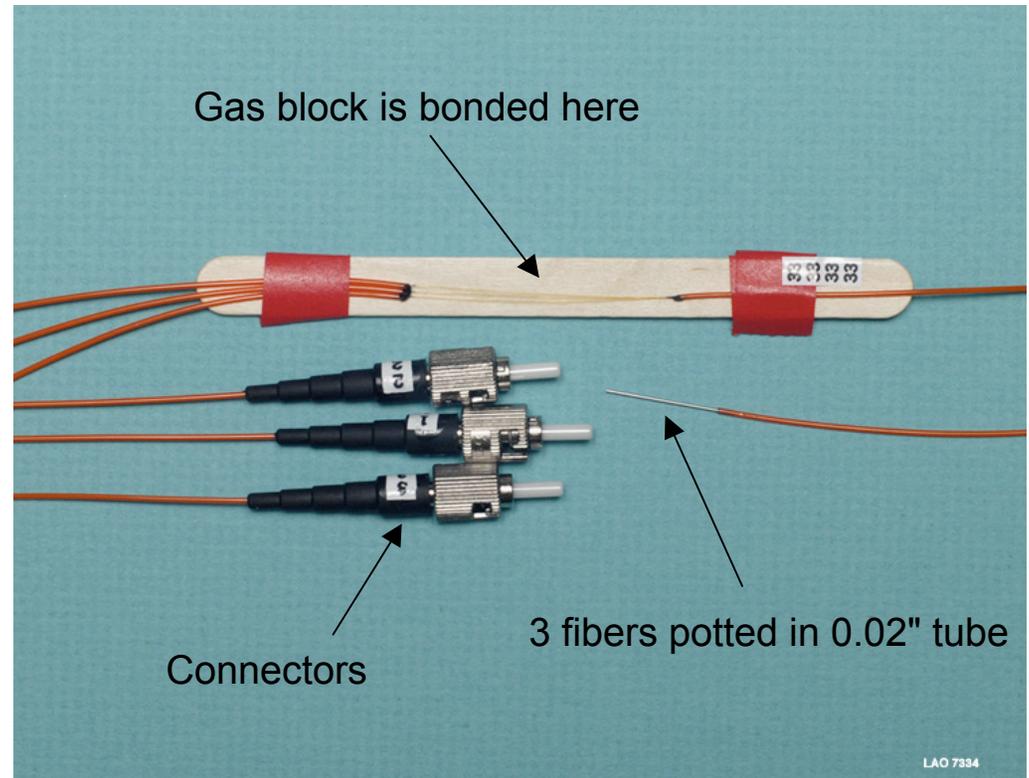
No drilled holes in mirror,
50/50 R @ 532 nm
100 R @ 1550 nm
(lose 75% of VISAR light)
(unshifted light will be a problem)



No drilled holes in mirror
Silver coating has masked clear holes
(unshifted light should not be a problem)

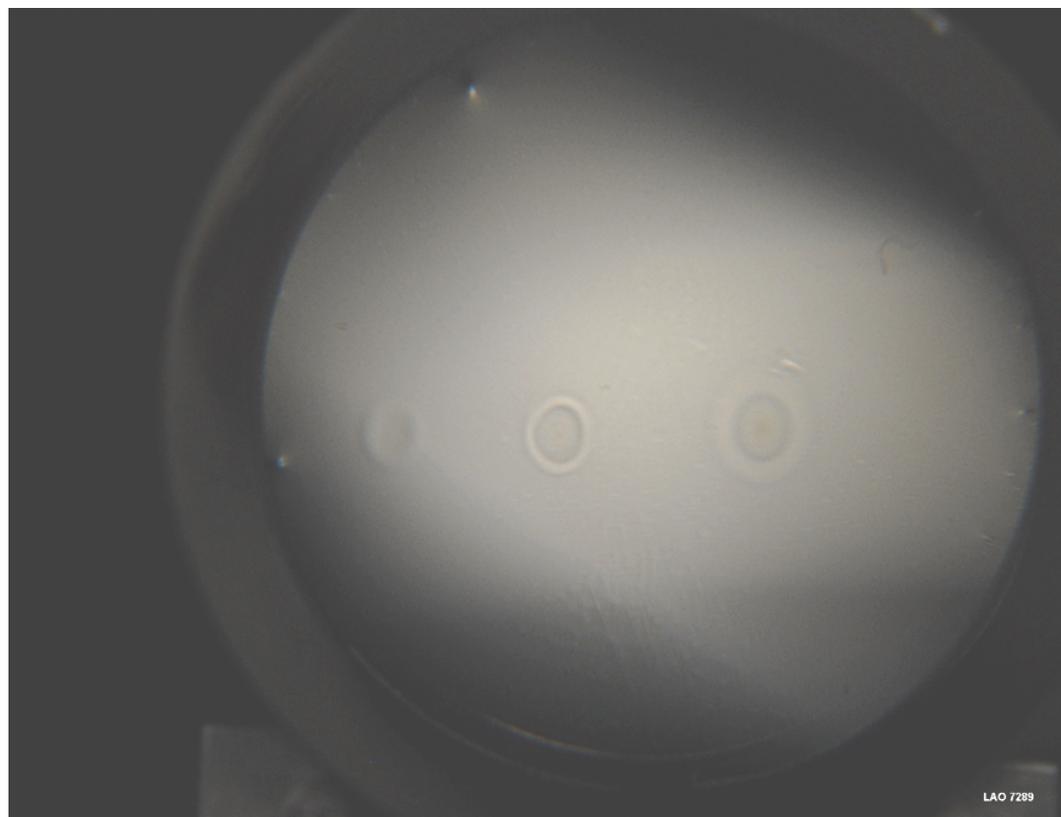
Fiber-optic probe design

- PDV: Polished and applied anti-reflective coating *after* assembly into the 0.02" dia. tubes
- Integration with gas block can damage fibers
- Put in 3 fibers per probe for VISAR to increase throughput and minimize damage



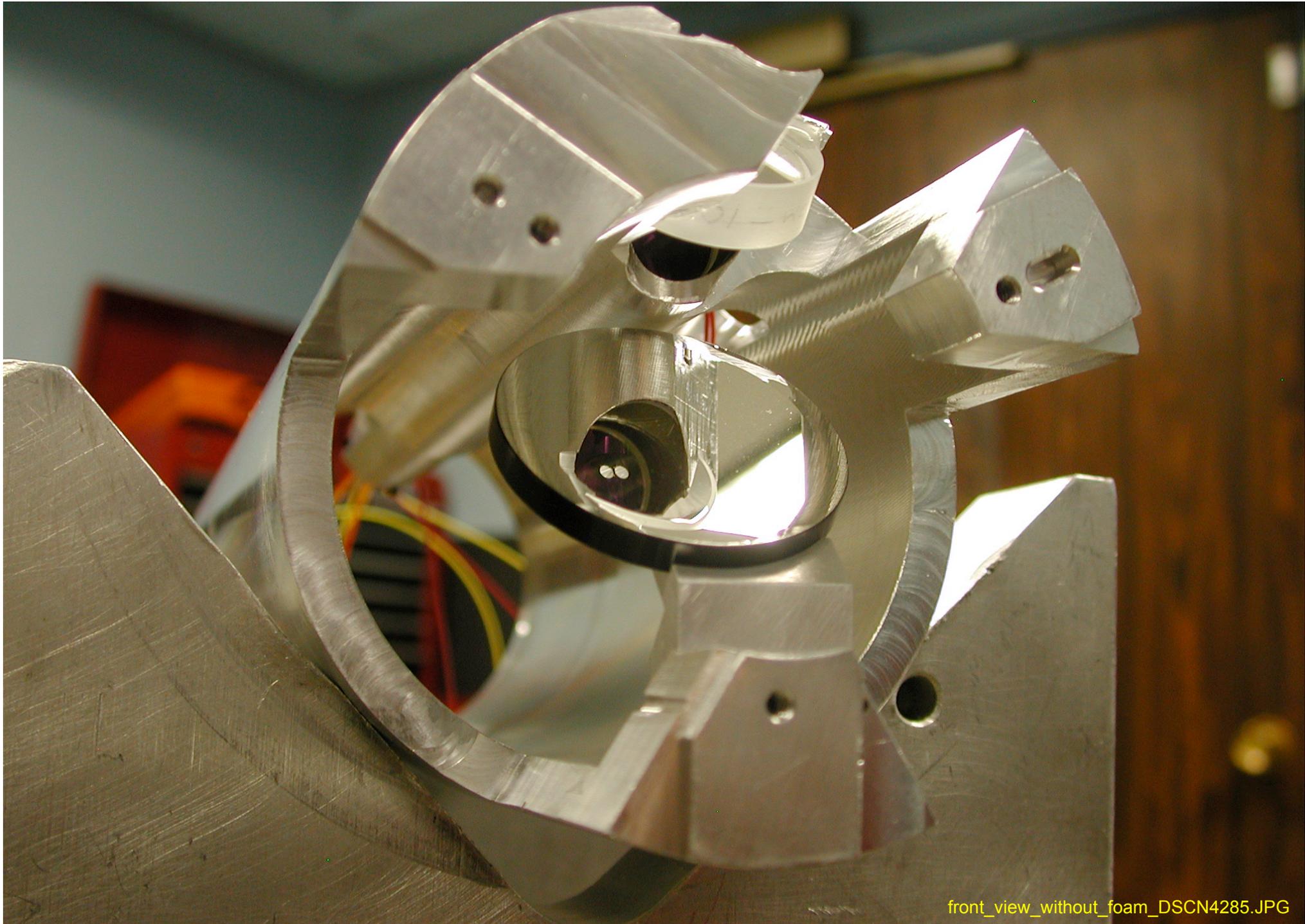
Pellicle Burn Study

- Study to establish the amount of laser illumination that would damage the pellicle
- 4 W for 1/30 sec causes visible damage
- 2.25-mm dia. spot on pellicle
- Needed Pockels cell to gate laser and mitigate damage



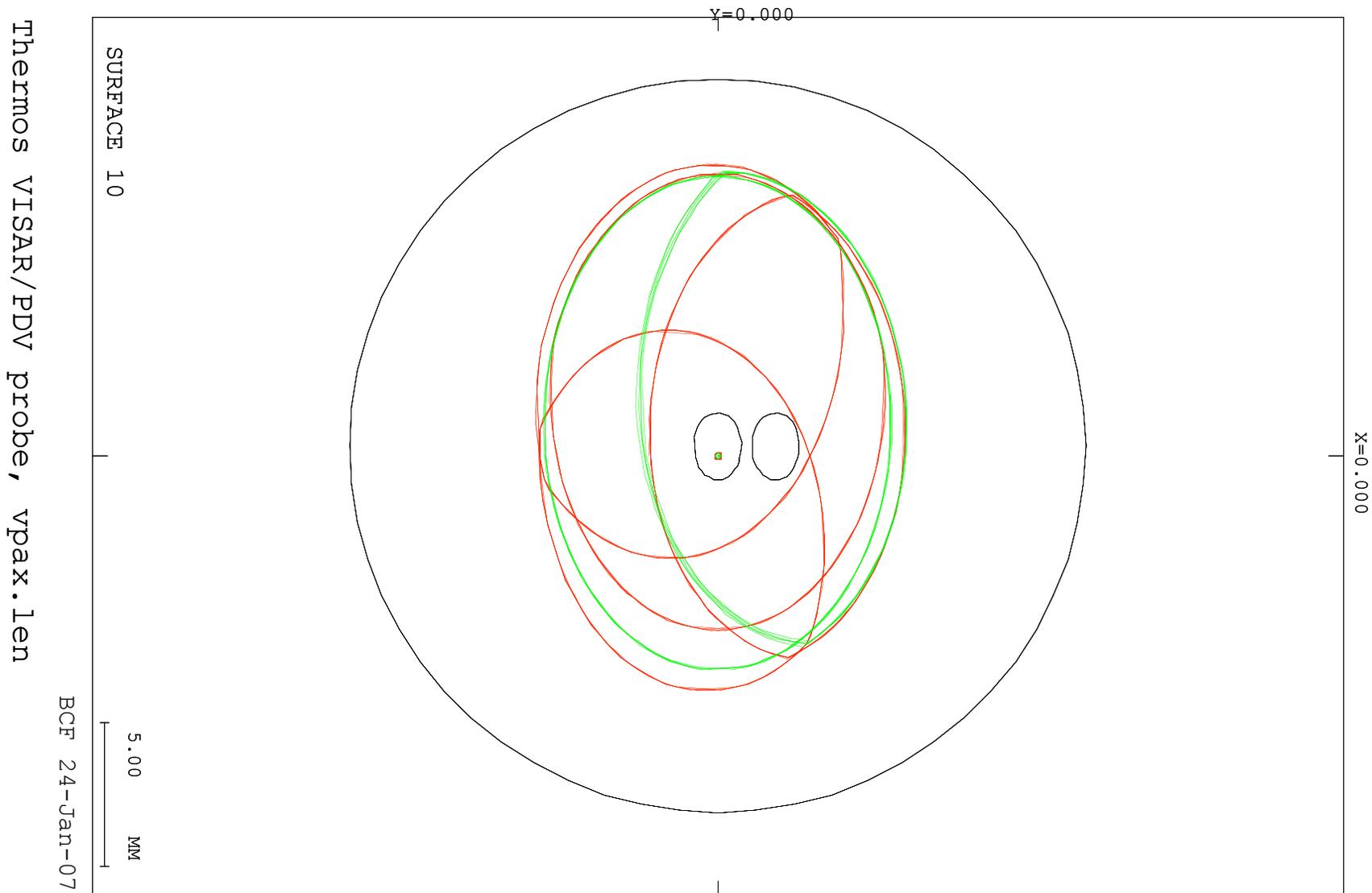
LAO 7289

Thermos installation of pellicle and mirror

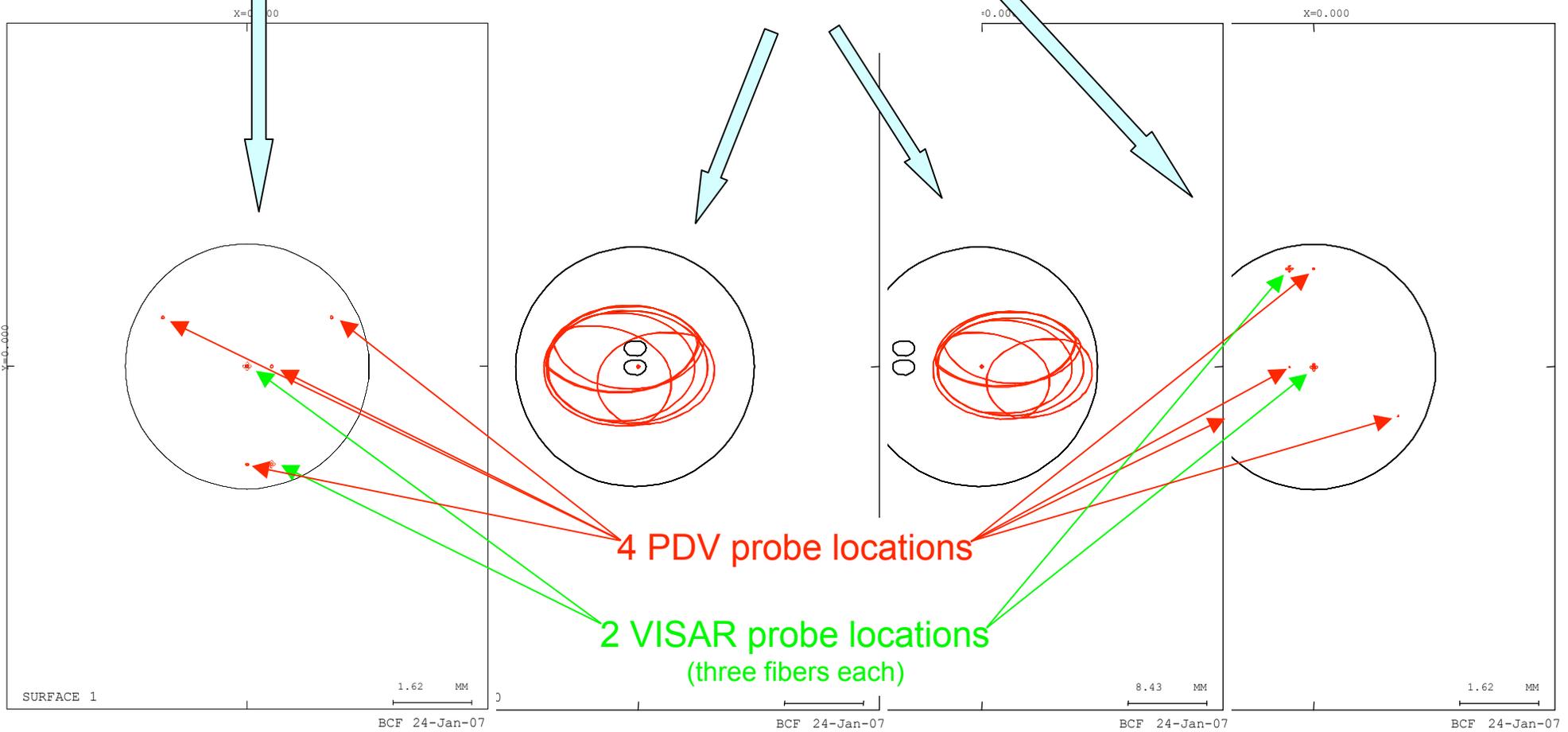
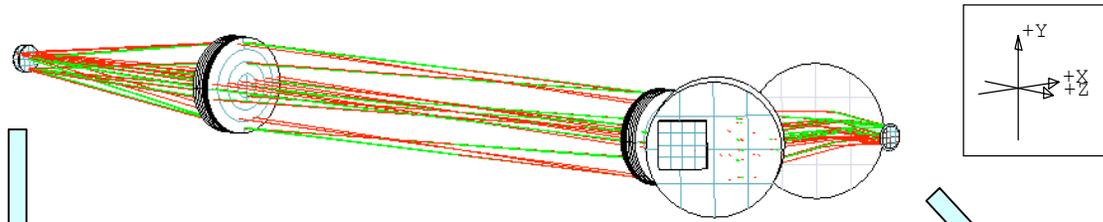


Mirror footprint

showing VISAR illumination holes 1.651 ID at 45 degrees to face,
2-mm horizontal separation, mirror 0.25-mm vertical offset,
front face as viewed through mirror from back



Footprints



4 PDV probe locations

2 VISAR probe locations
(three fibers each)

Thermos VISAR/PDV probe, vpax.len

Mirror front surface

(As viewed from behind through mirror)

Target

(As viewed by alignment camera)

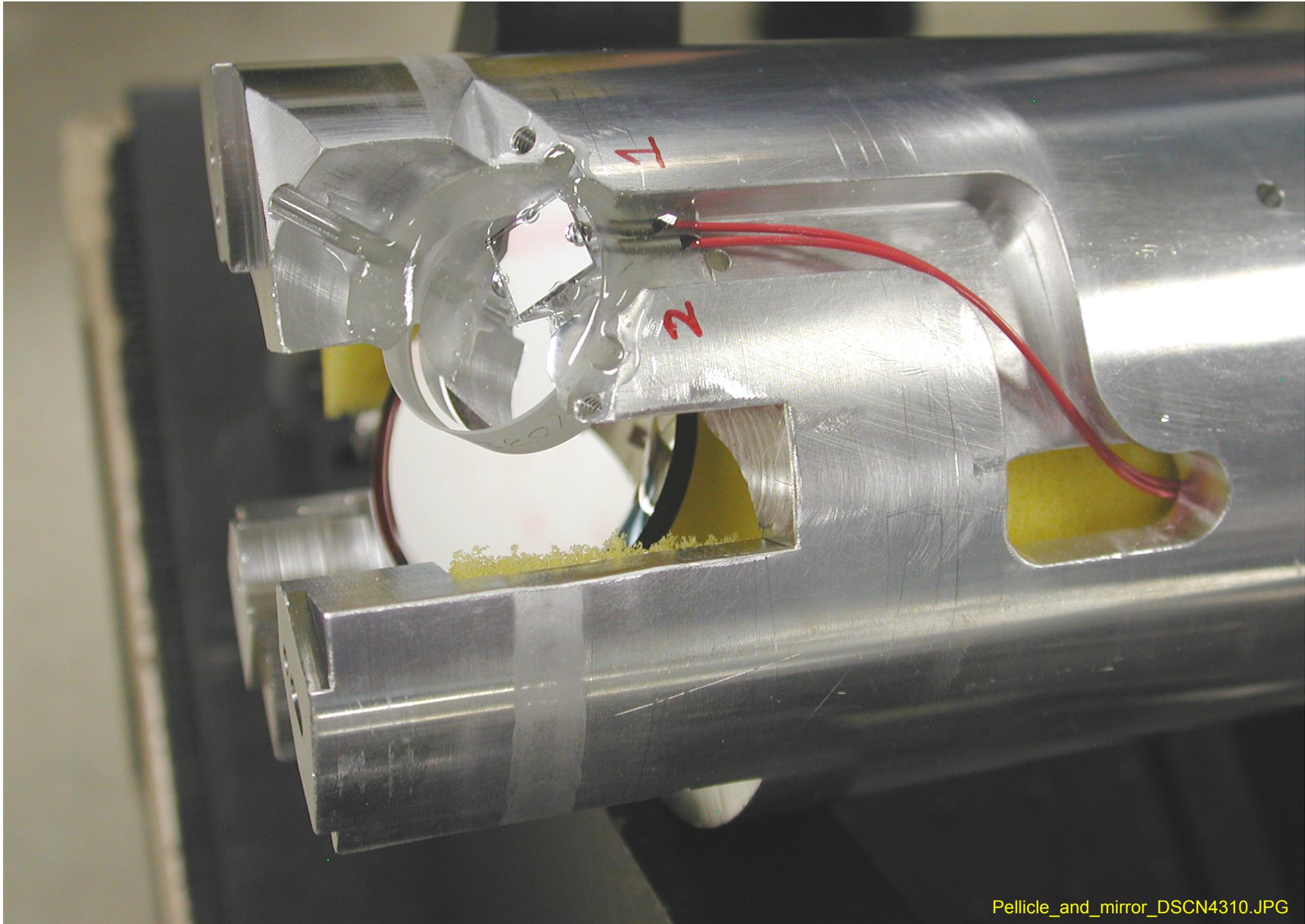
Fibers

(As viewed toward fibers)

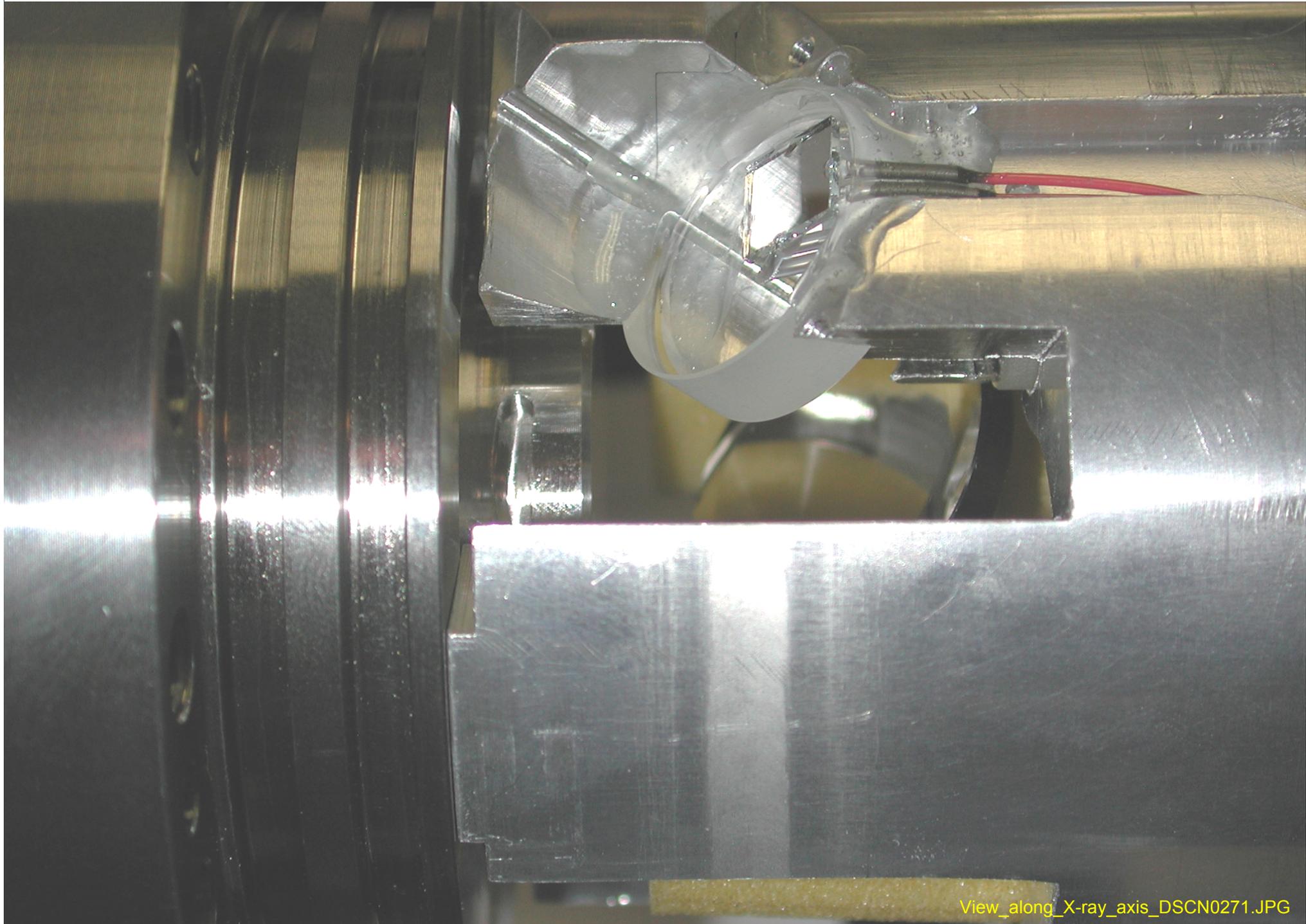
Mirror back surface

(As viewed from behind mirror)

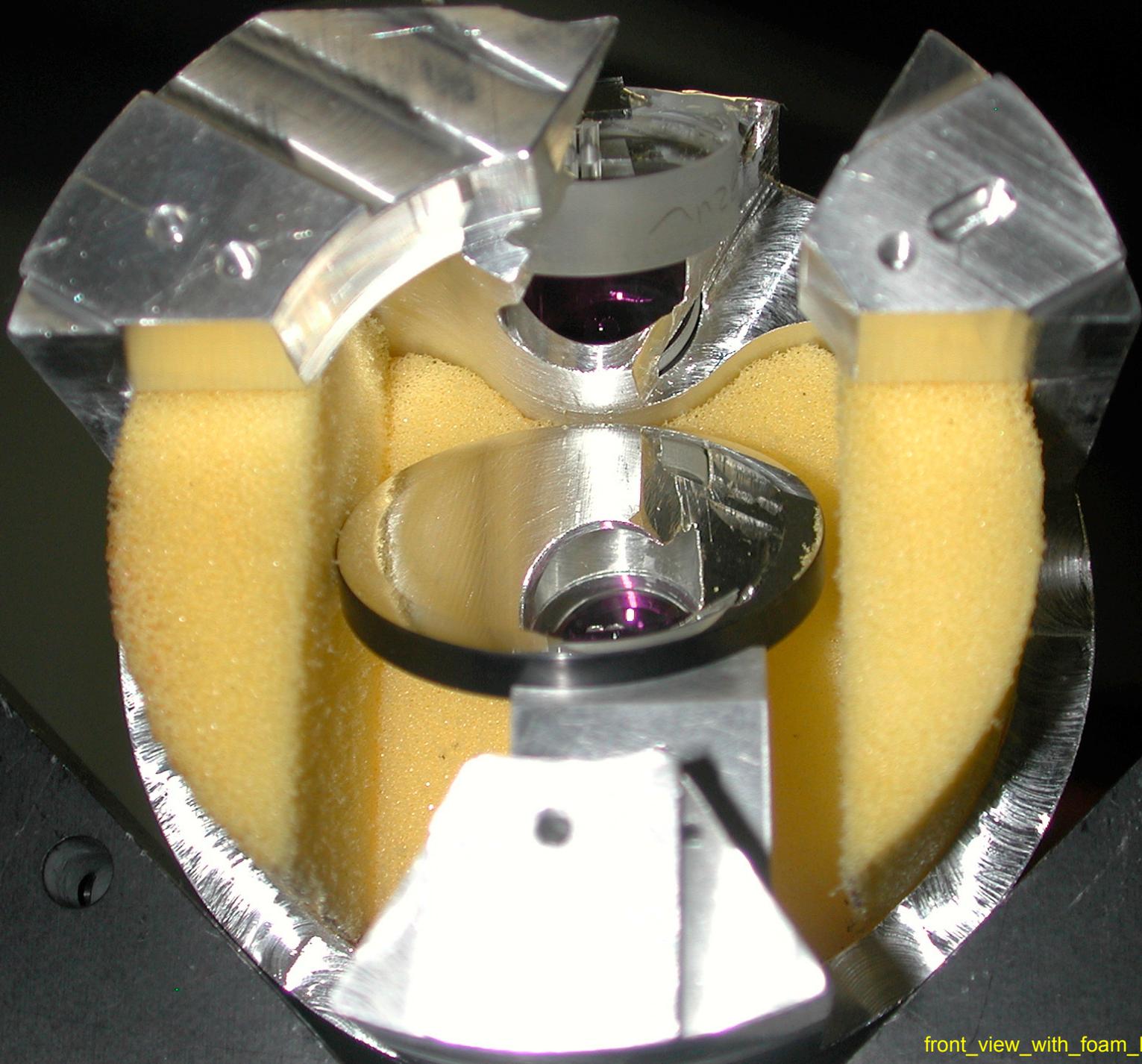
Thermos VISAR illumination fibers



Thermos view along one of the X-ray axes

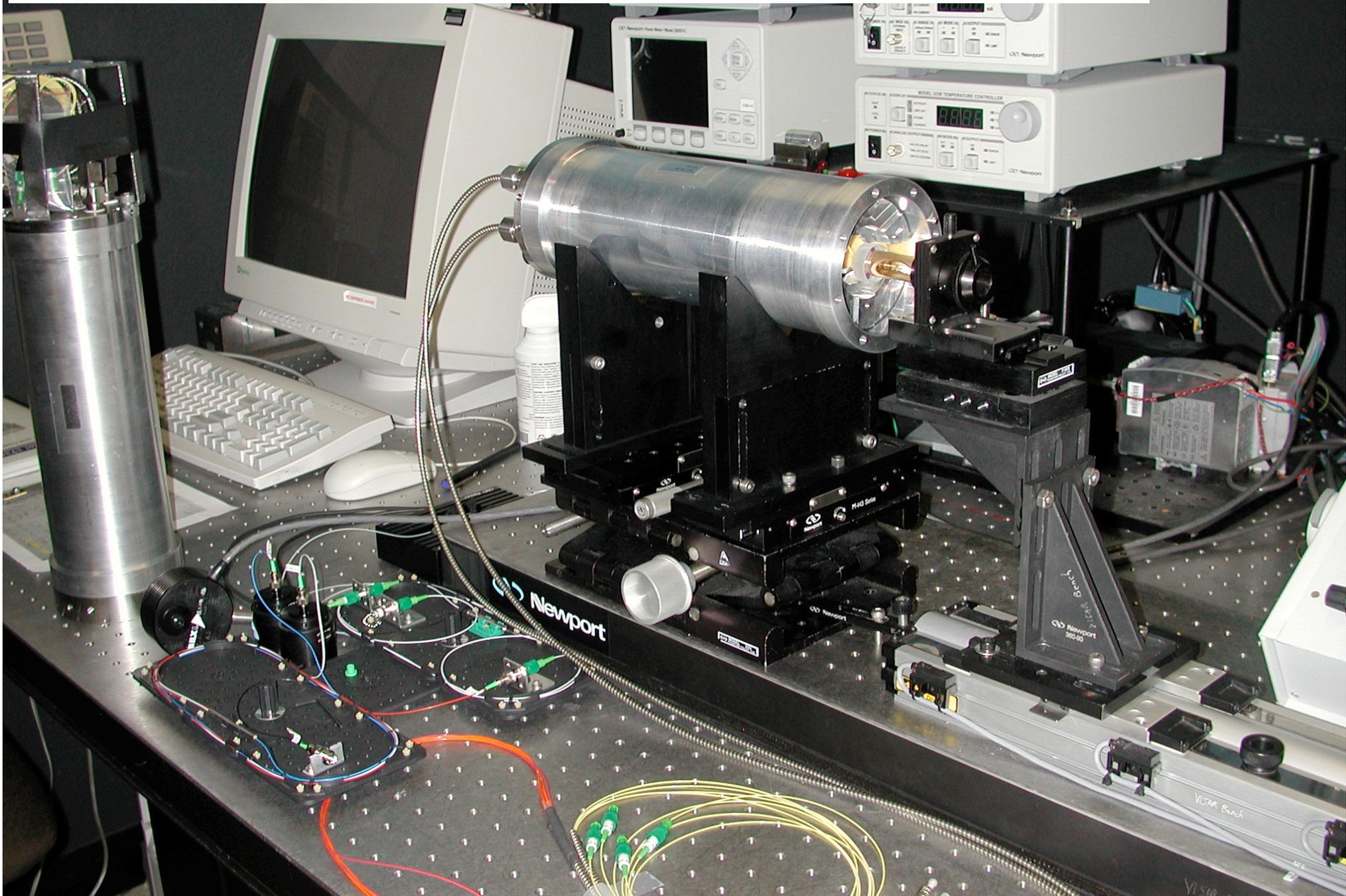


Thermos, front view of optical imaging

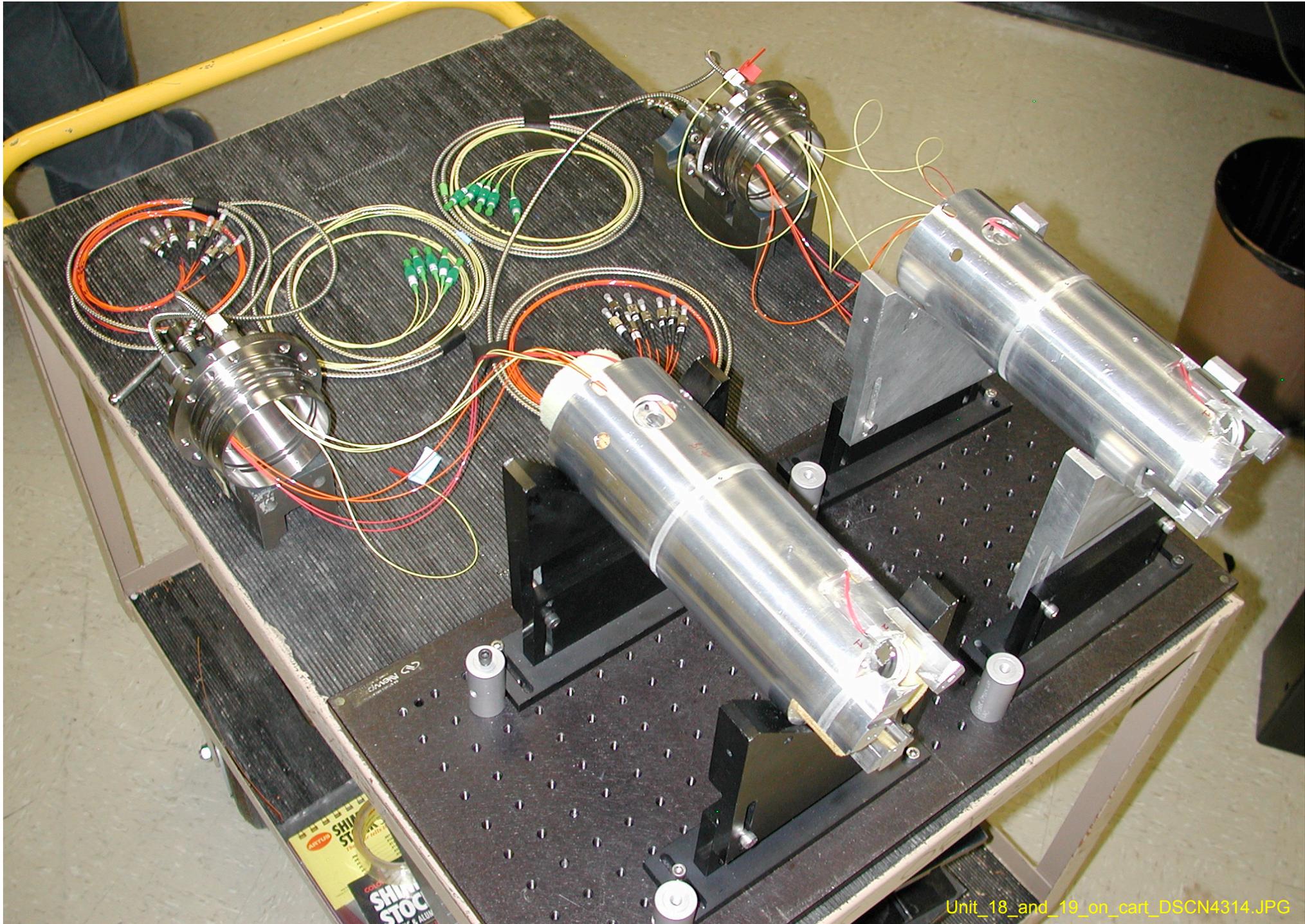


Z-Test Calibration Setup

(flat mirror moved along z-axis for reflectivity measurements)



Thermos packages being prepared for shipment



Conclusion

- Met goals for compact instrument
- Met unprecedented two shots per week schedule
- Soft catch coupled with velocimetry and radiometry is unprecedented
- High quality data from all diagnostics confirmed
- Achieved rough agreement between models and diagnostic data
- 4 packages currently being readied for pRad testing at LANL LANSCE during October (made up of spare parts)

