Historical Perspective on the Evolution of MPDV Probe Designs

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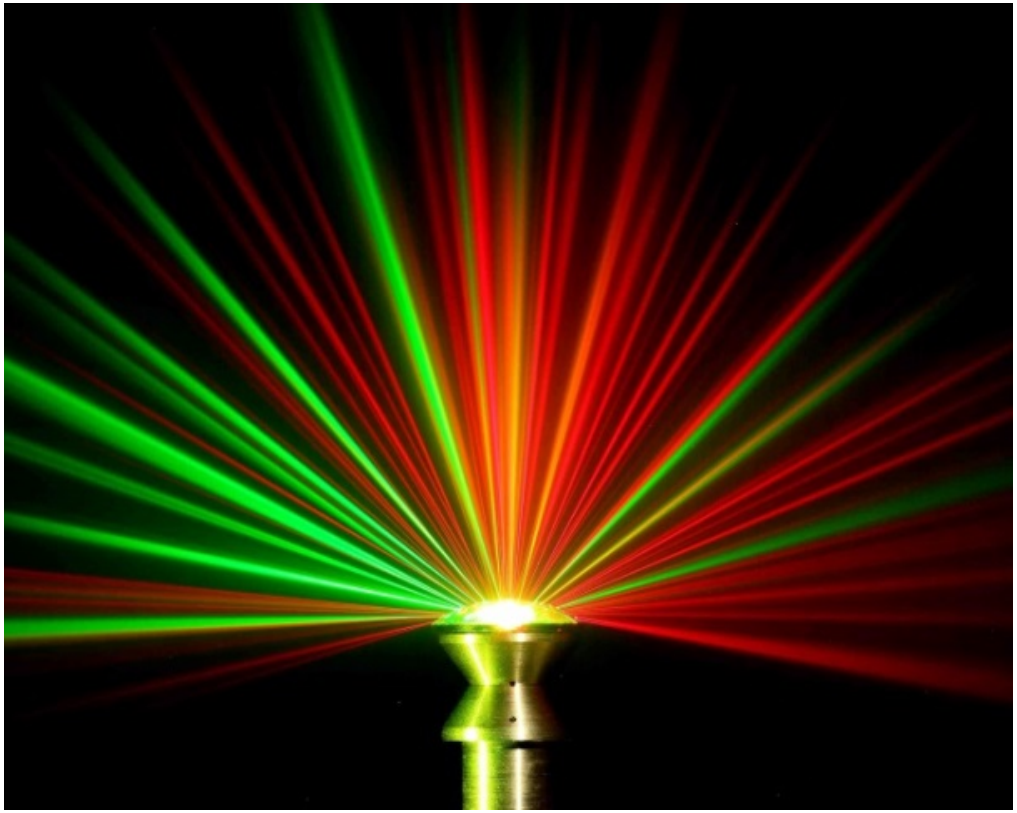

9th Annual PDV Workshop
June 6–9, 2016
Livermore, CA

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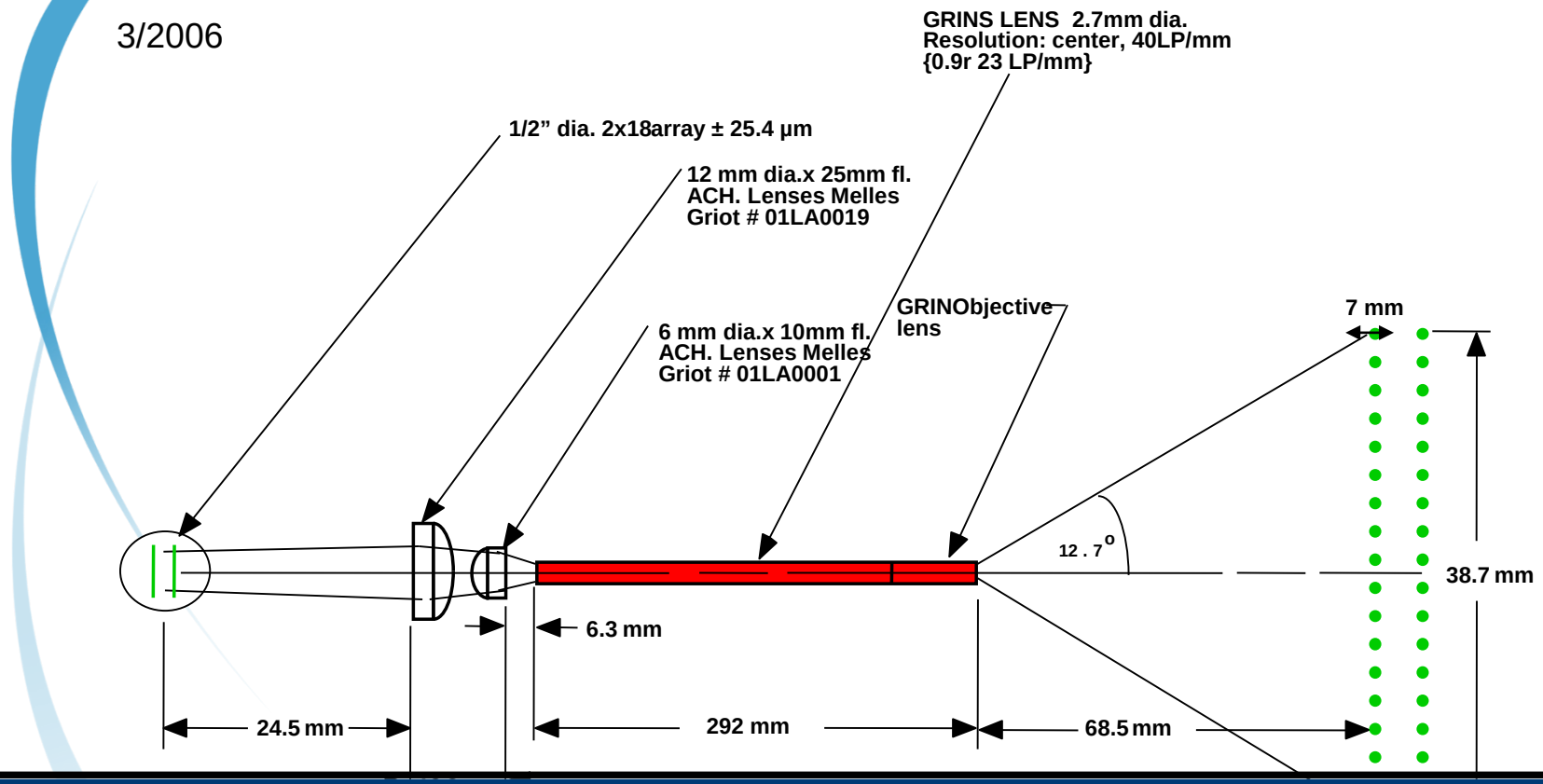
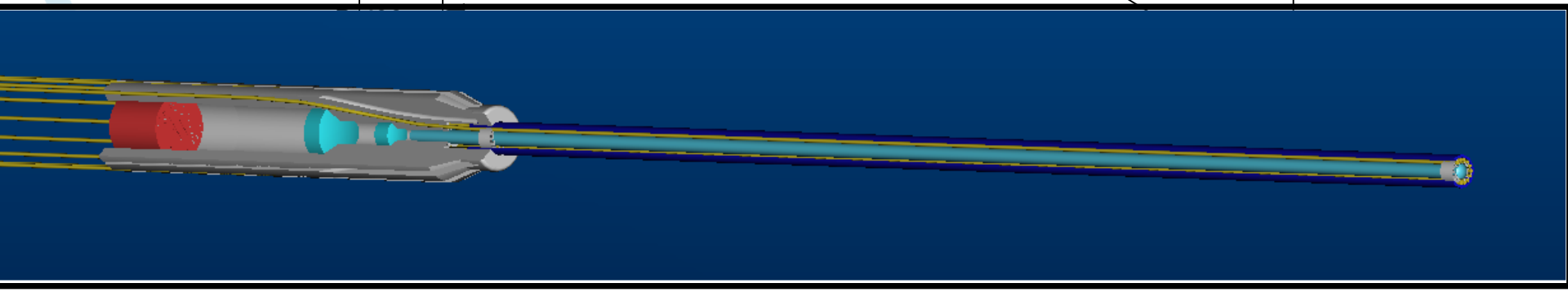
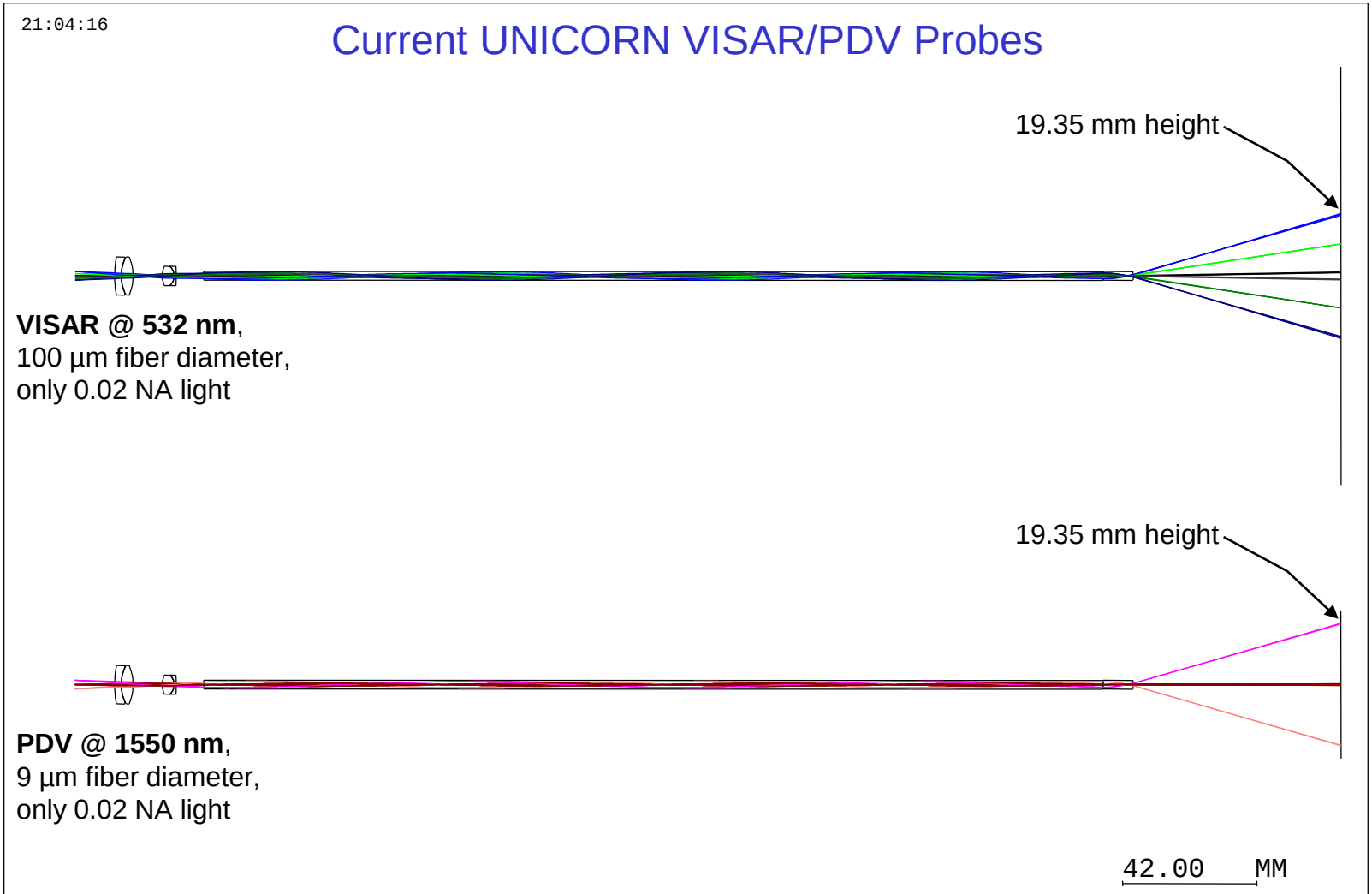
GRIN (Gradient Index) VISAR/PDV probe collection system for UNICORN

3/2006





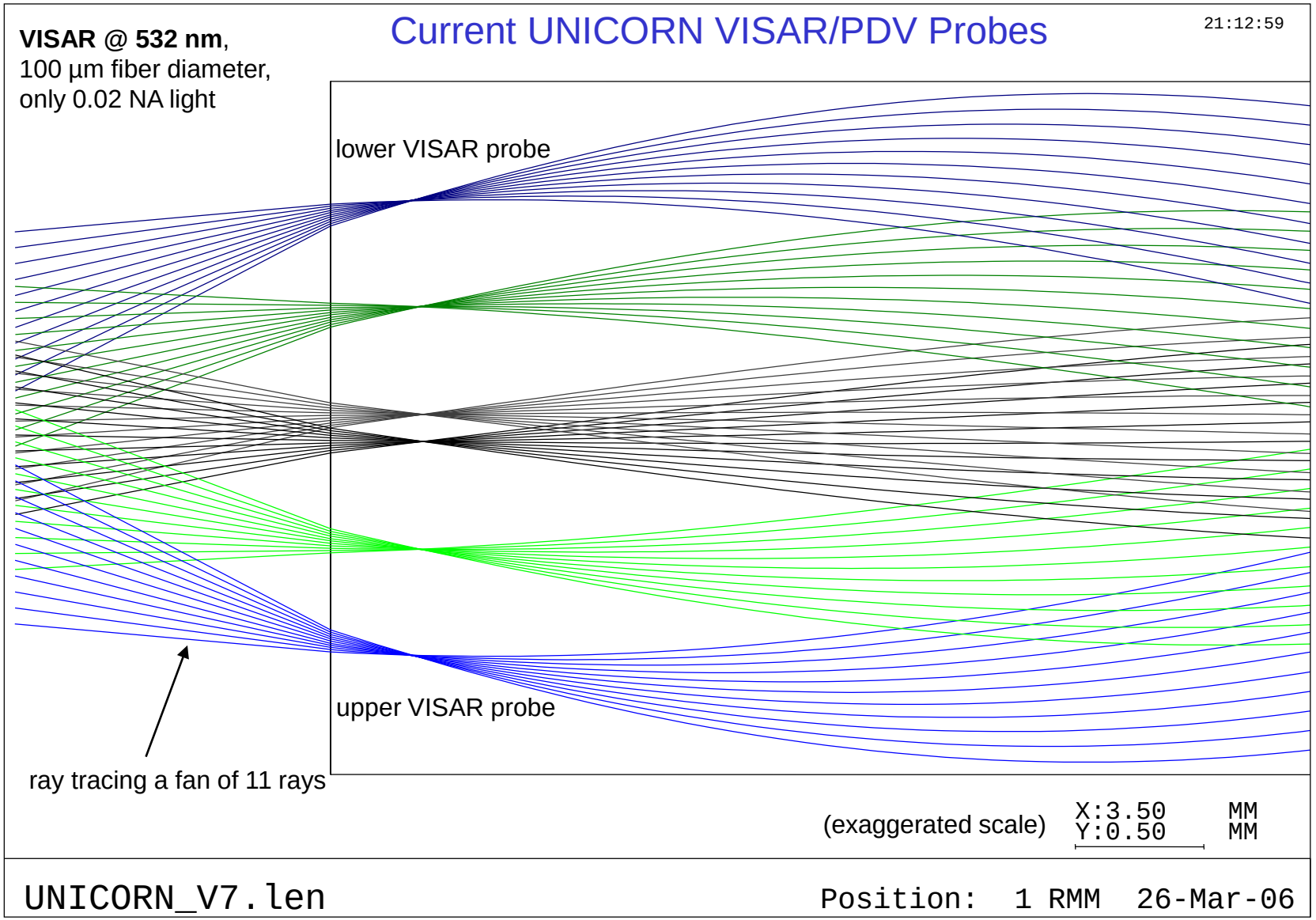
Current UNICORN VISAR/PDV Probes



VISAR @ 532 nm,
100 µm fiber diameter,
only 0.02 NA light

PDV @ 1550 nm,
9 µm fiber diameter,
only 0.02 NA light

Current UNICORN VISAR/PDV Probes



Current UNICORN VISAR/PDV Probes

PDV @ 1550 nm,
9 µm fiber diameter,
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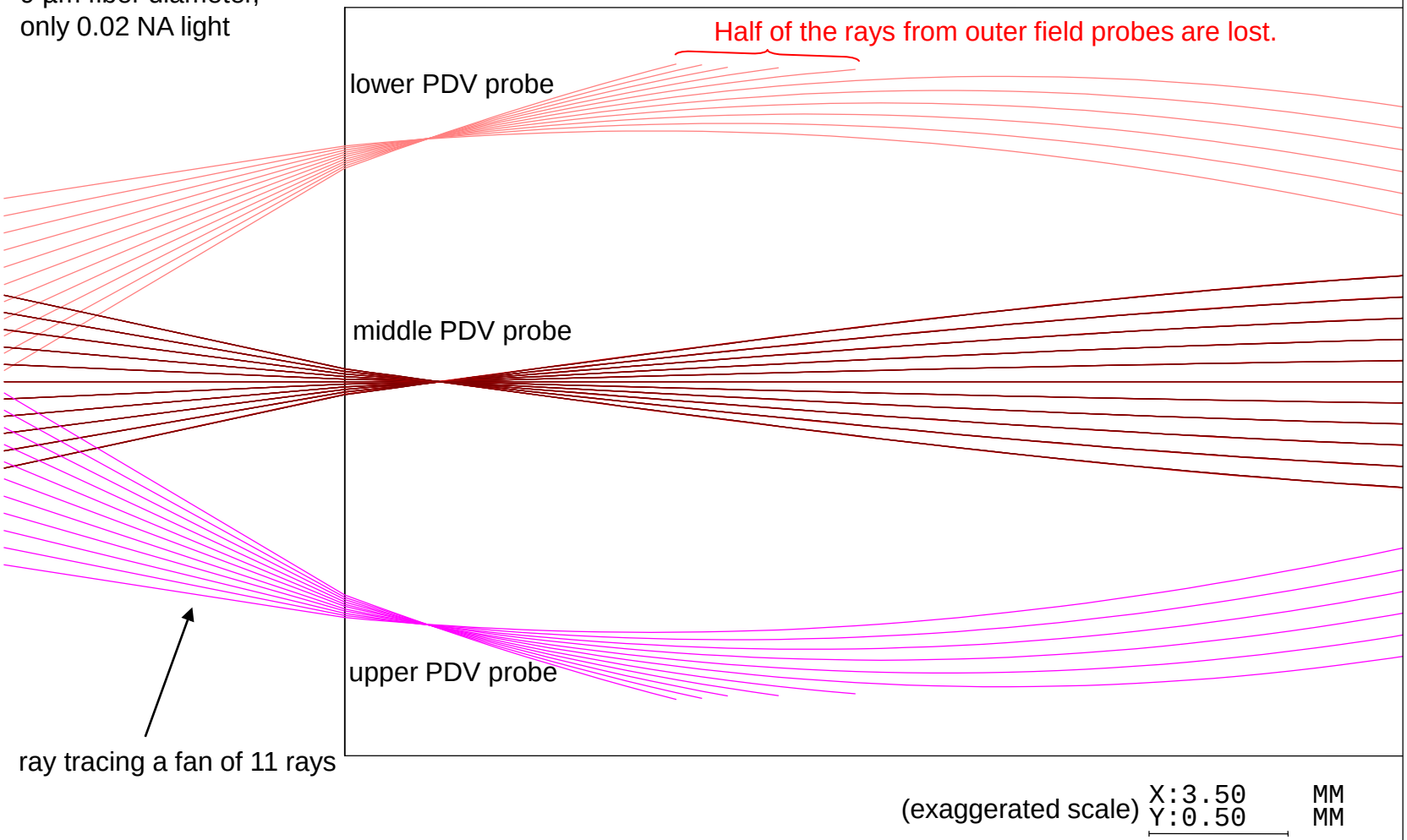
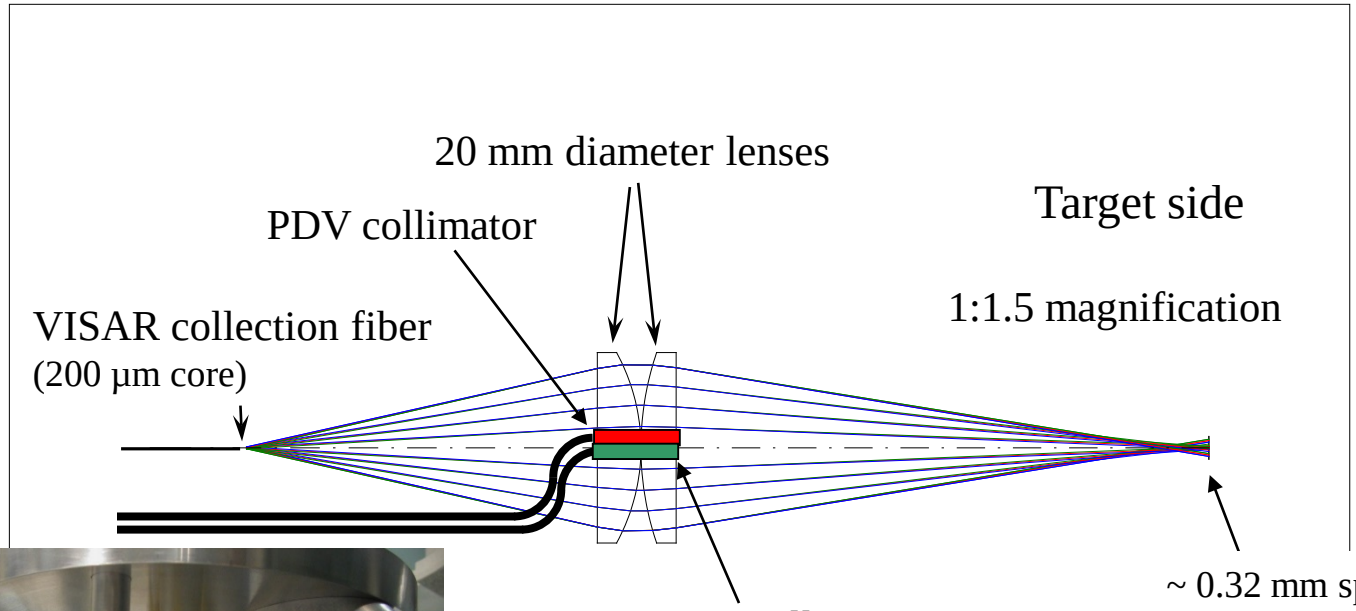
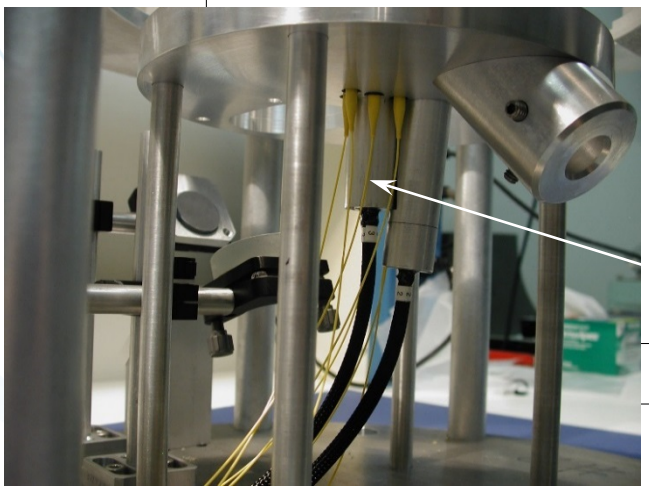


Graded Index Rod Lenses

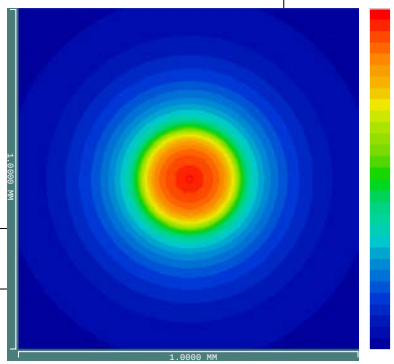
Barolo pRad 40-60 VISAR probe ray trace





40-60 VISAR probe

Barolo_setup_DSCN4190.JPG,
12/14/06

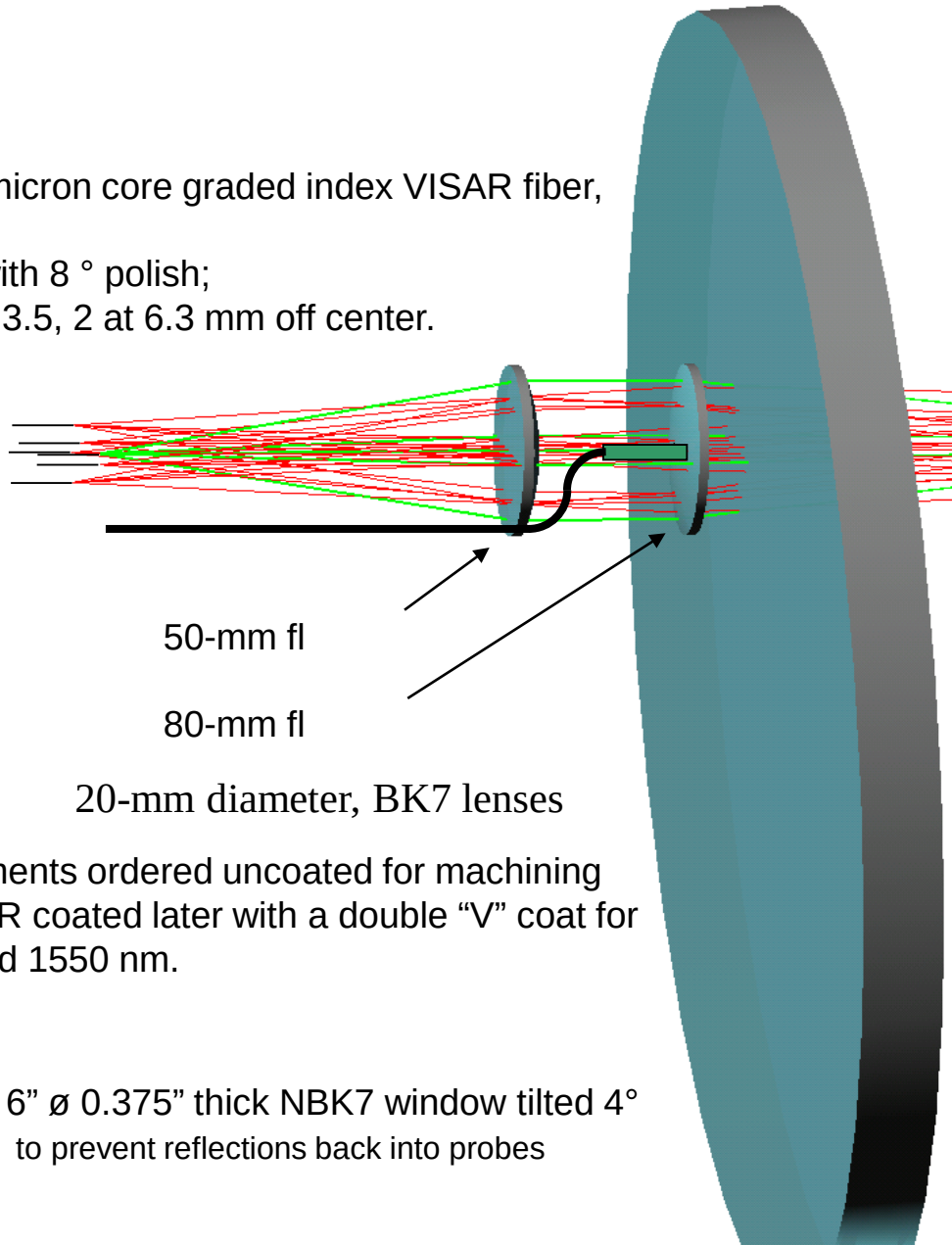


Combination VISAR/PDV probe for Barolo, 2007

Center 200-micron core graded index VISAR fiber,

PDV fibers with 8 ° polish;
1 at 0.7, 2 at 3.5, 2 at 6.3 mm off center.

PDV to be focused using 670 nm light.

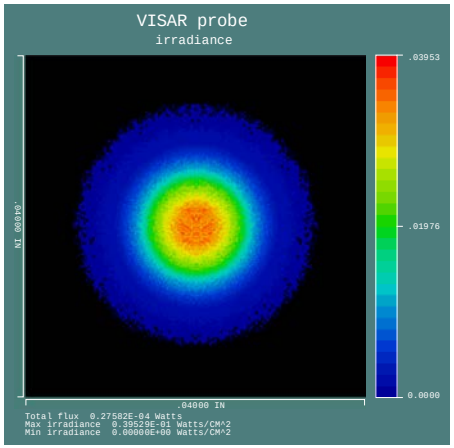


50-mm fl

80-mm fl

20-mm diameter, BK7 lenses

~ 0.29-mm VISAR spot

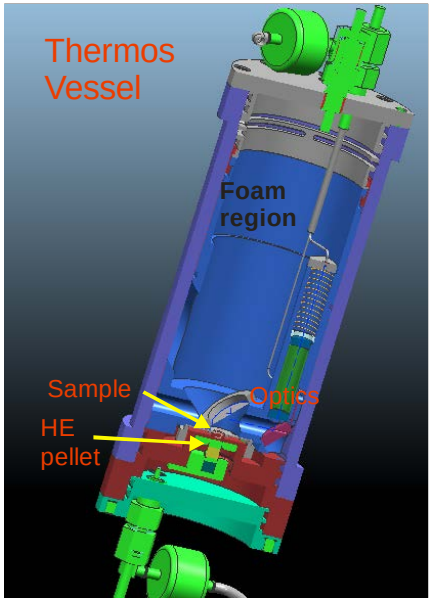


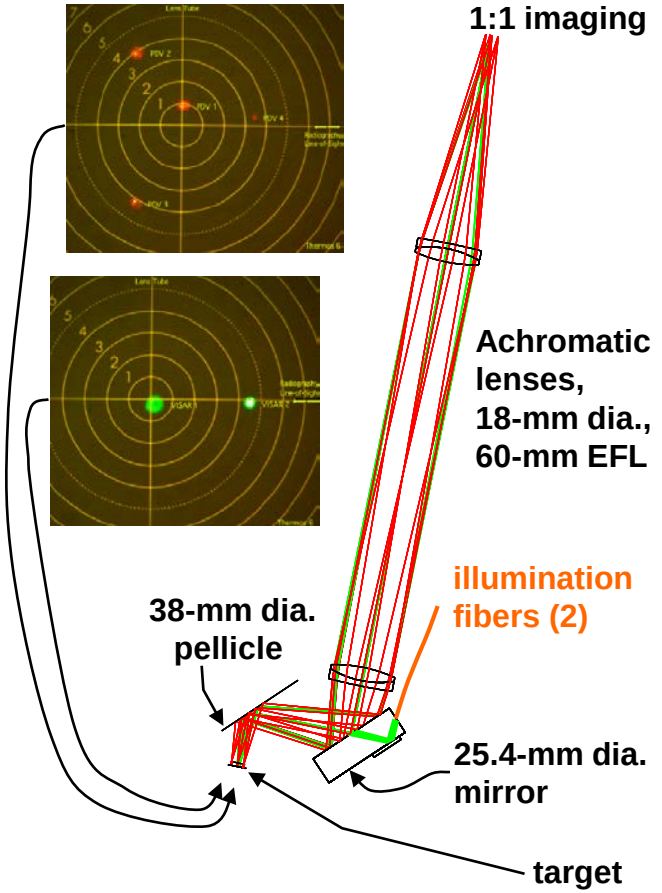
Optical elements ordered uncoated for machining holes and AR coated later with a double “V” coat for both 532 and 1550 nm.

6” ø 0.375” thick NBK7 window tilted 4°
to prevent reflections back into probes

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 ½ sample radius. The VISAR sampled near the center and at 1 position at ½ sample radius.





PDV

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VISAR

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NSTec

Morris Kaufman

Brent Frogget

Bart Briggs

Adam Iverson

Vincent Romero

Bob Malone

Greg Lare

Dave Esquibel

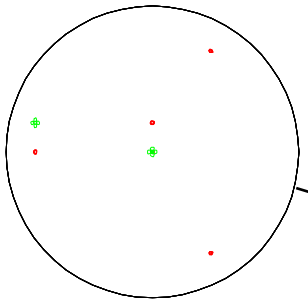
2006-2007

THERMOS VISAR and PDV imaging

VISAR and PDV fibers have different heights within the fiber array

doublet achromat lenses,
(special AR coatings for both 532 and 1550 nm),
60 mm EFL, 16.2-mm diameter aperture,
SSK4A & SF8 glasses

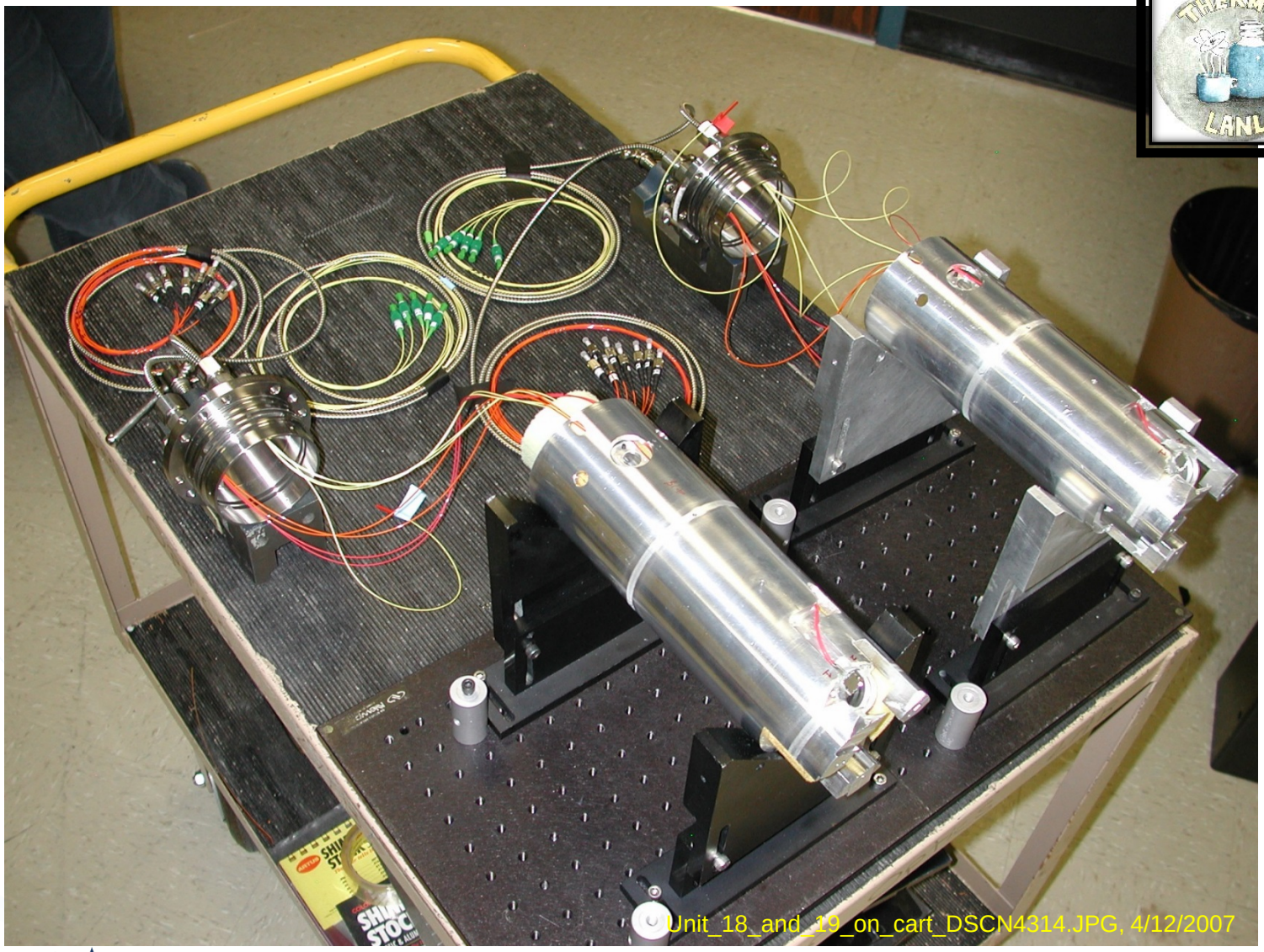
Mirror,
25.4-mm diameter, 8-mm thick,
offset 0.25 mm, 1.651 ID holes,
18-mm diameter aperture,
with small back mirror,
9 x 9 x 1 -mm, offset 6.5 x 1 mm



View of VISAR and PDV locations looking at the target

Pellicle, 38-mm ID,
silver coated
(4 mm offset)

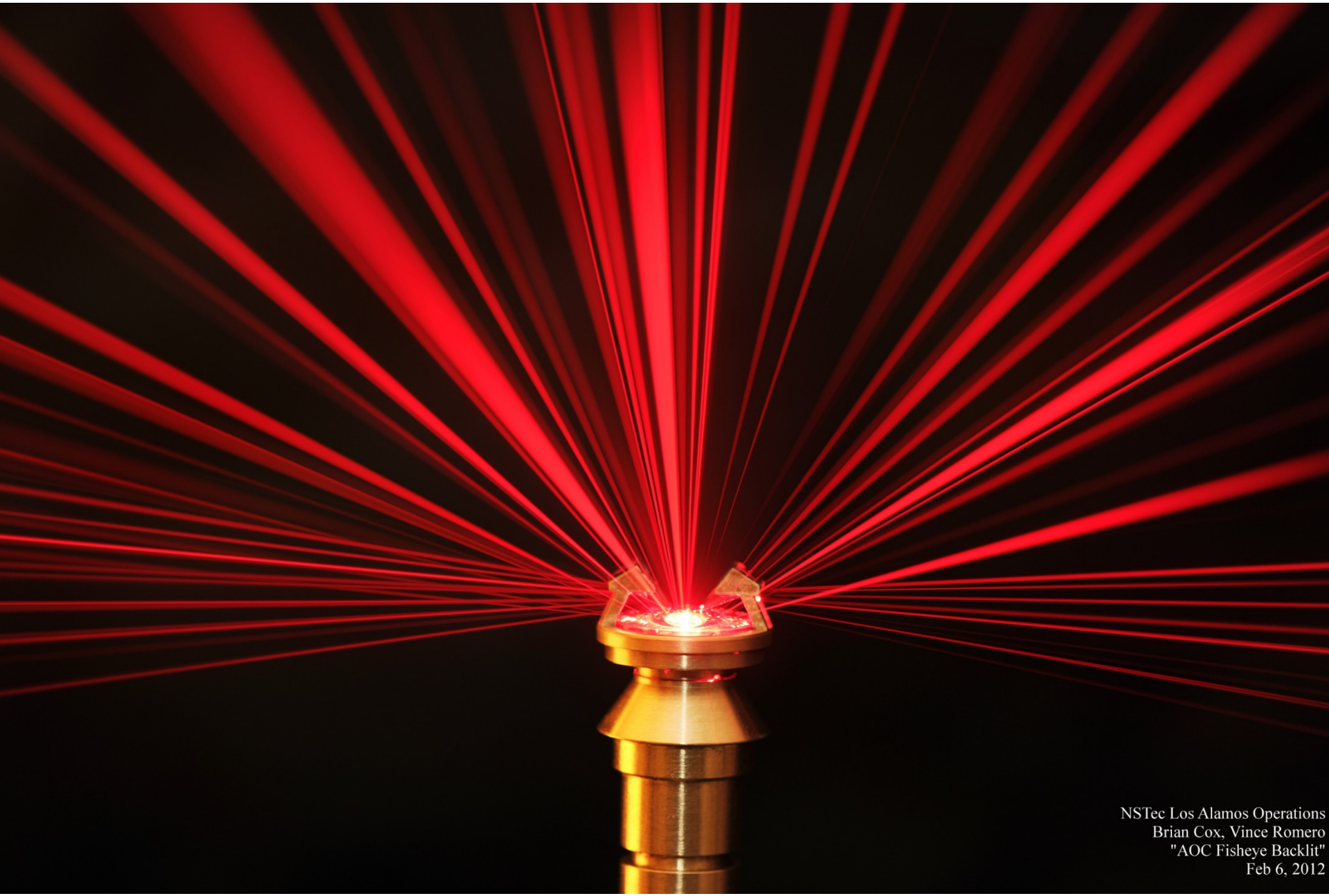
THERMOS packages being prepared for shipment



Unit_18_and_19_on_cart_DSCN4314.JPG, 4/12/2007

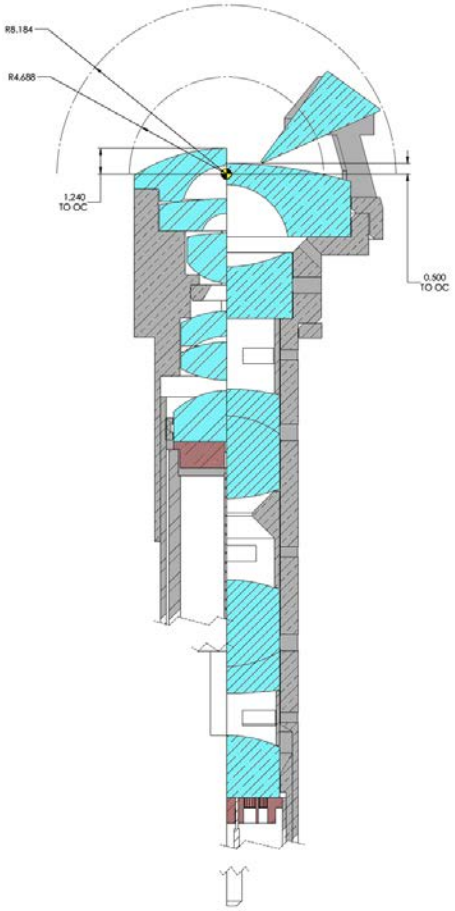
Soft Catch

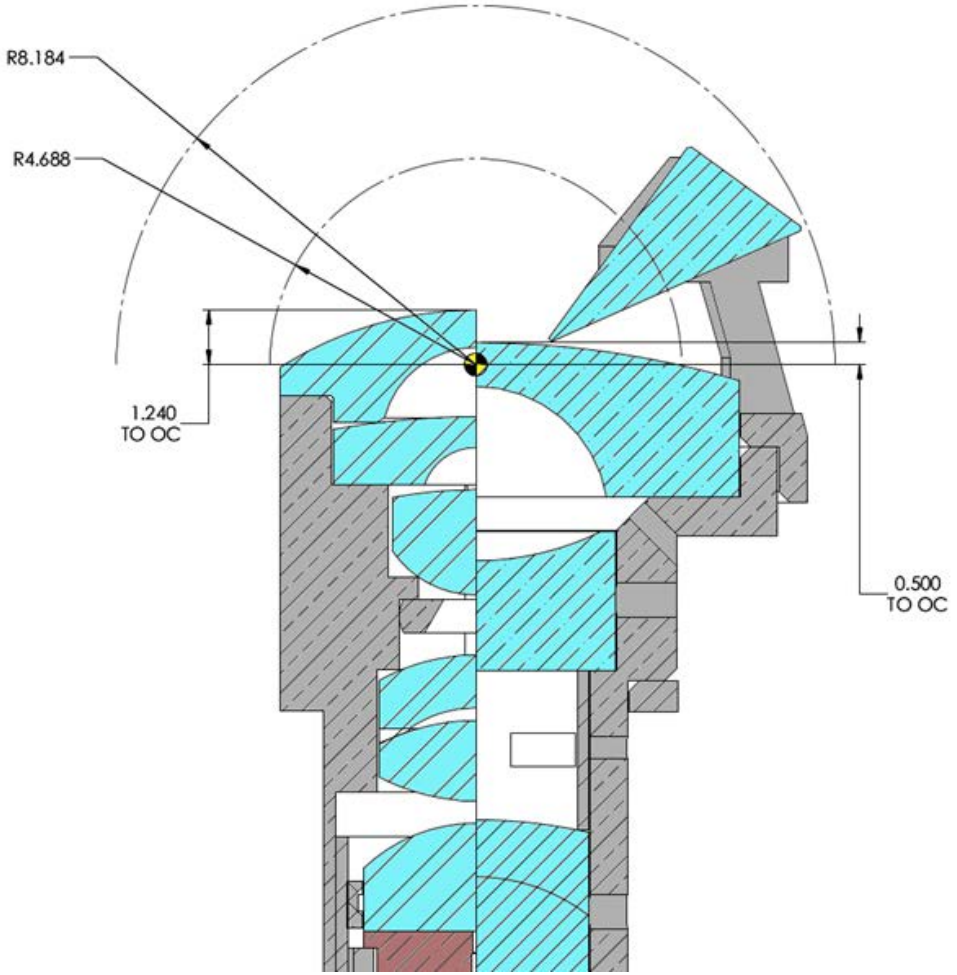
- It was discovered experimentally that commercial 3.5 lb/ft^3 foam will stop the projectile without incurring further damage.
- Later, due to a different HE configuration, the design was changed to specify a 5 lb/ft^3 foam.


NSTec Los Alamos Operations
Brian Cox, Vince Romero
"AOC Fisheye Backlit"
Feb 6, 2012

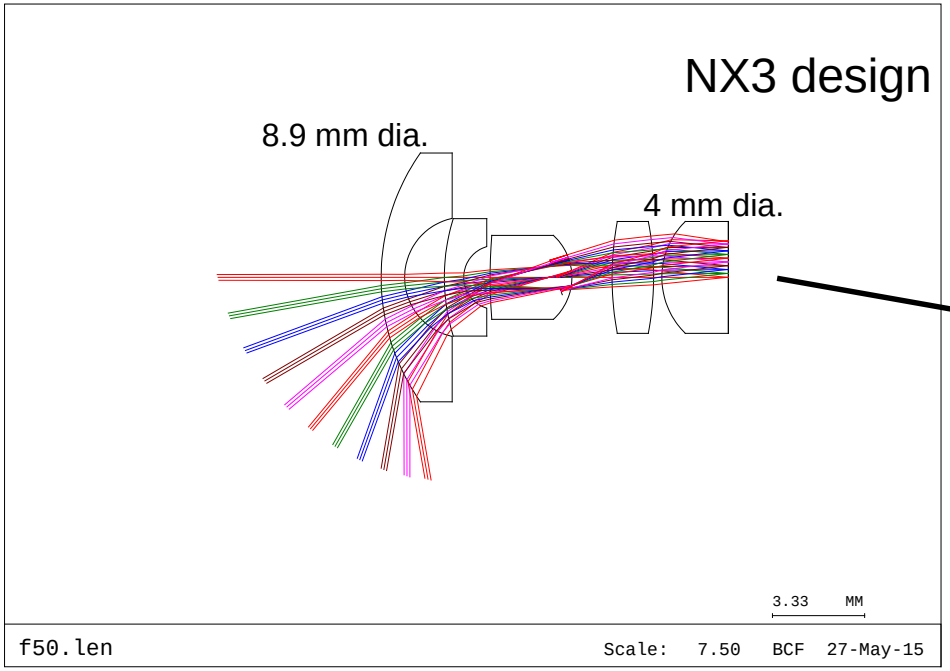
Size comparison

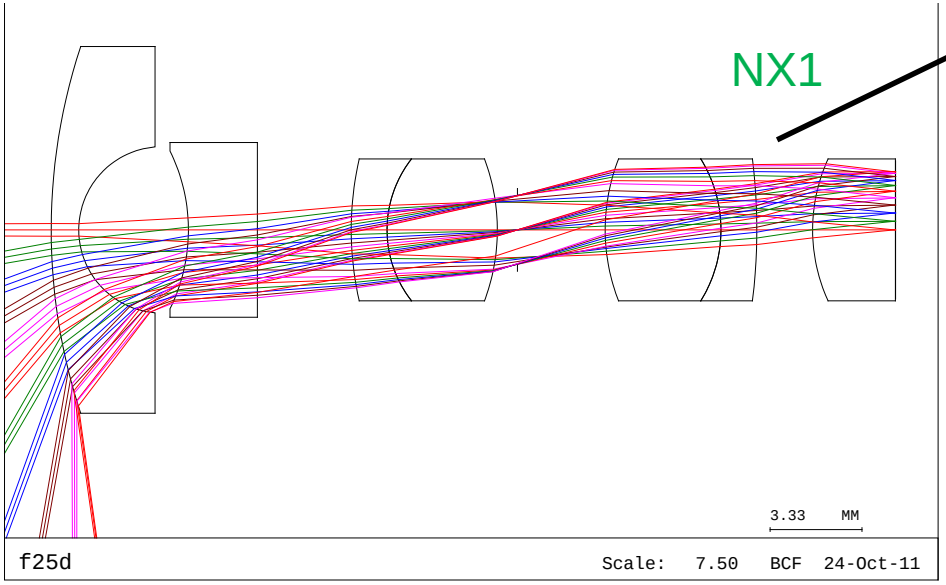
NX3b to NX1

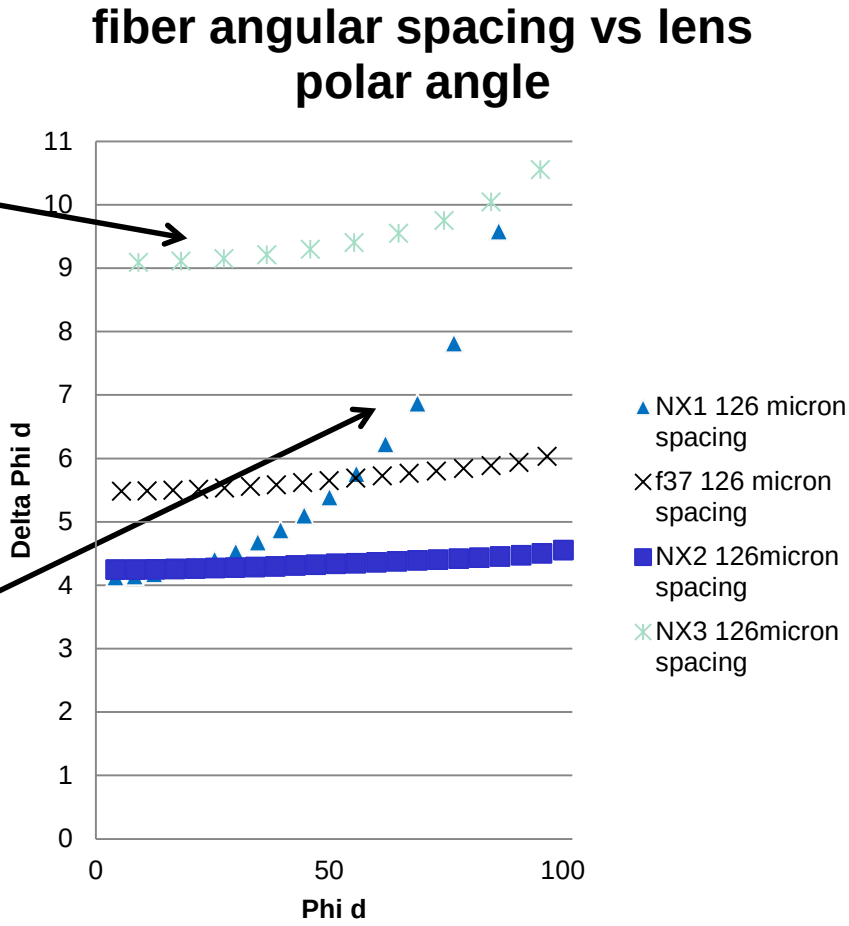




Fisheye Lens Designs

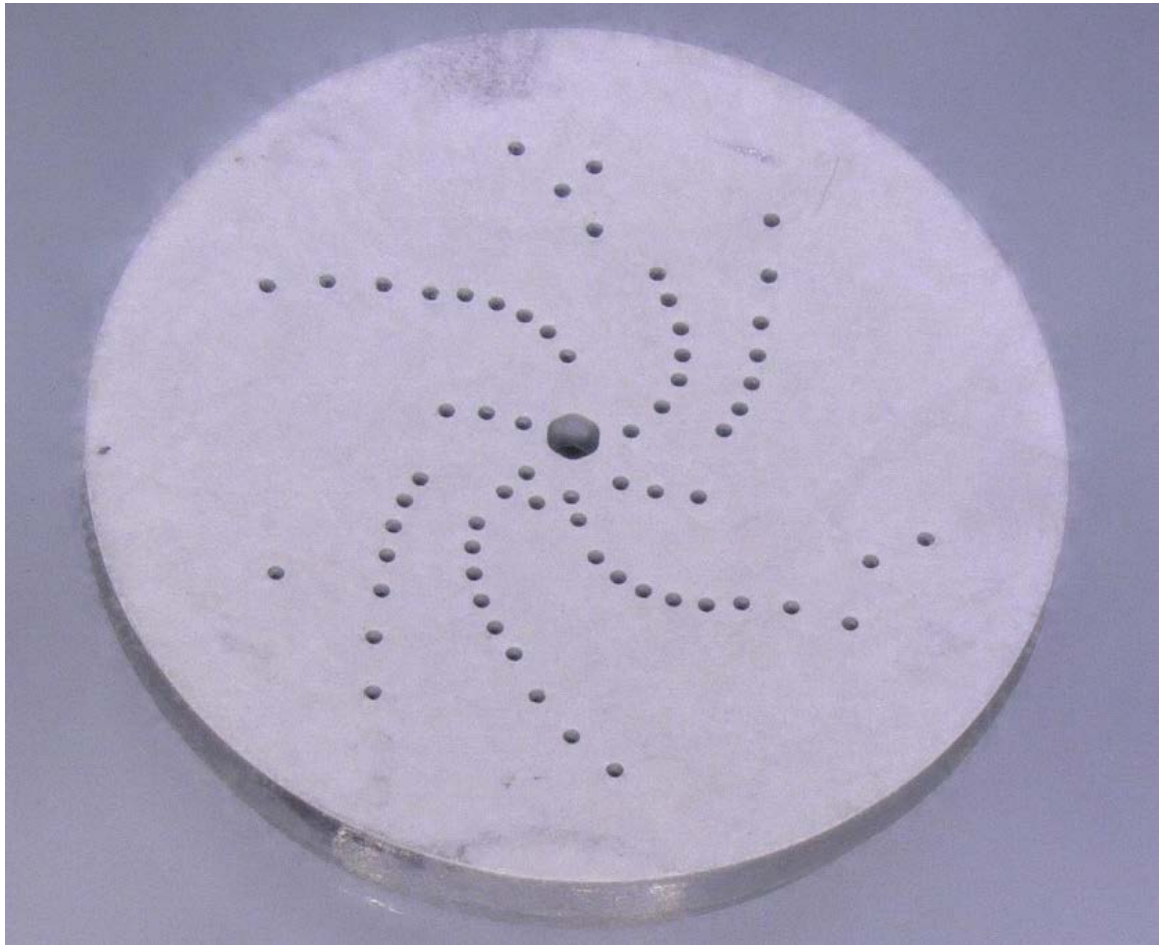




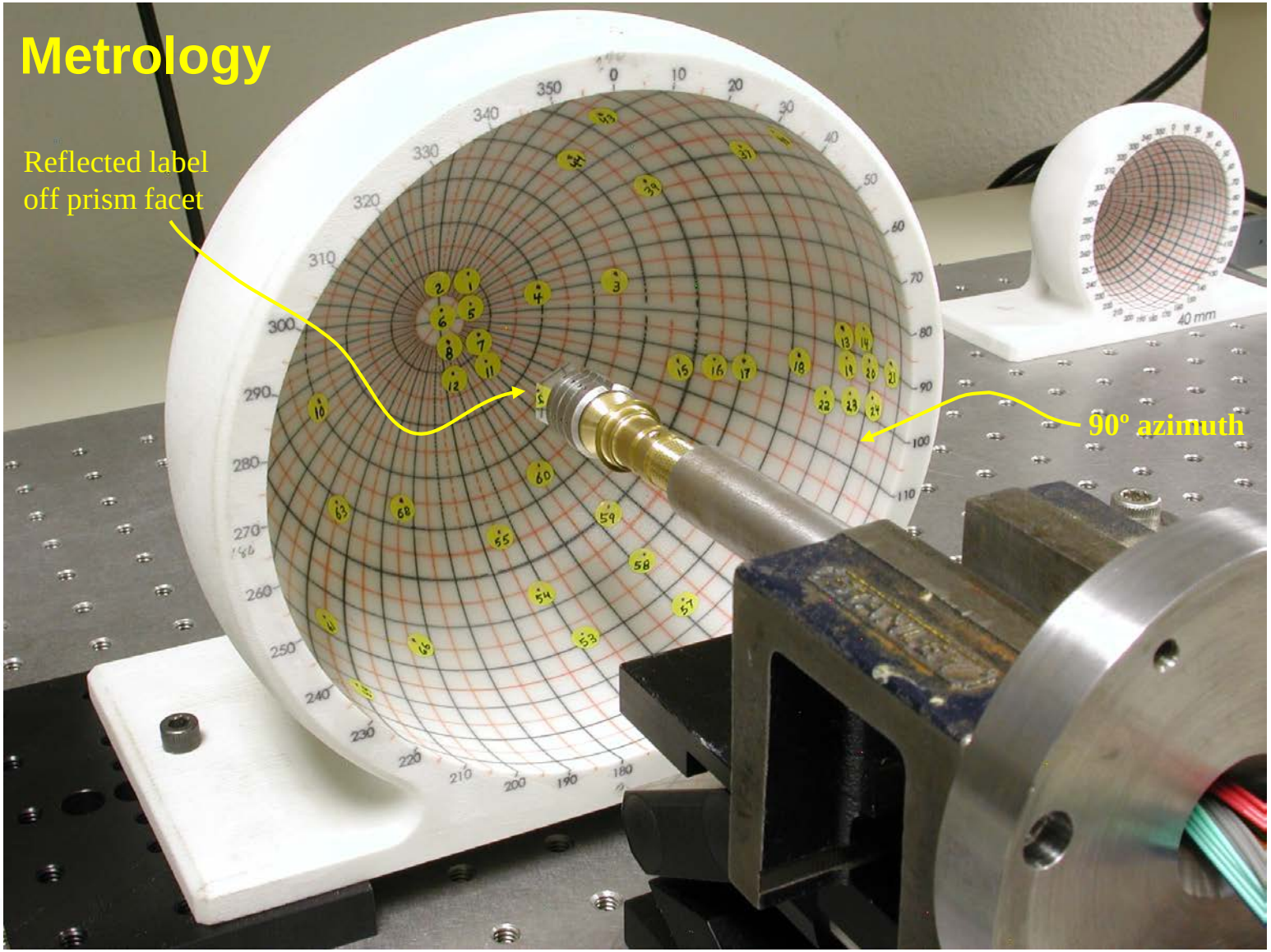


PDV Details

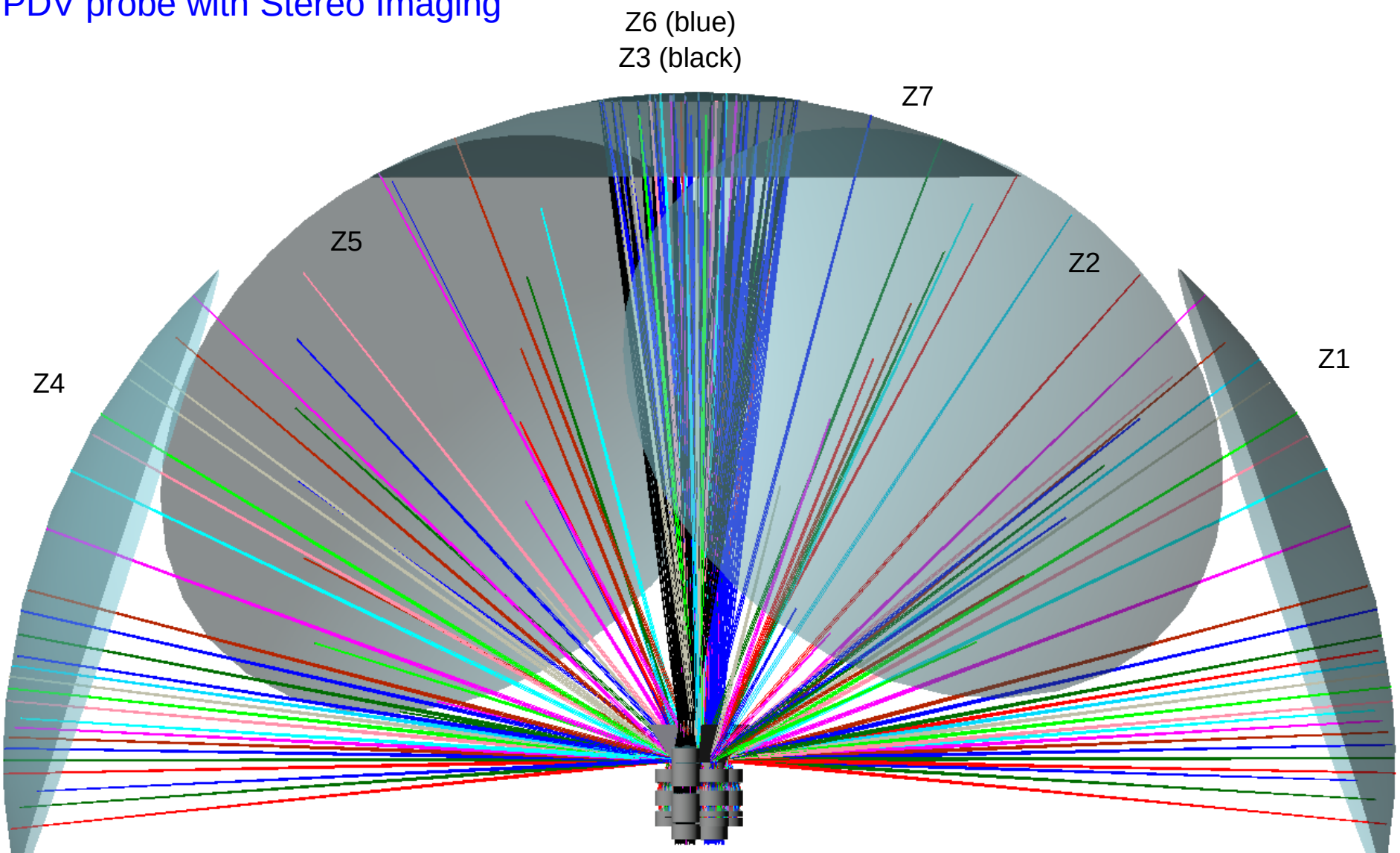
Ceramic mask for fiber arrays
(Photoveel II)
8 mm diameter,
1.5 mm thick,
126 µm tapered holes



Metrology

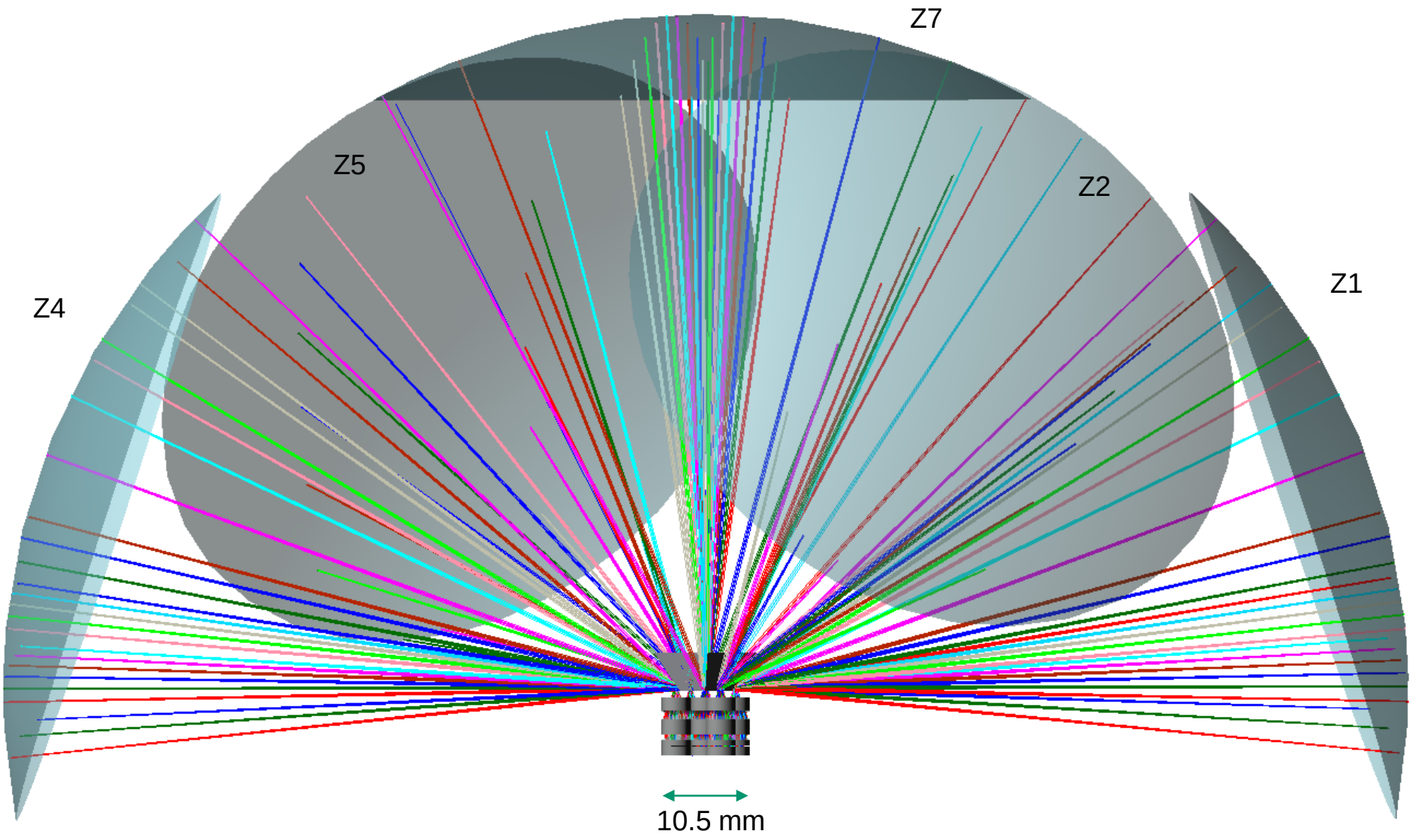


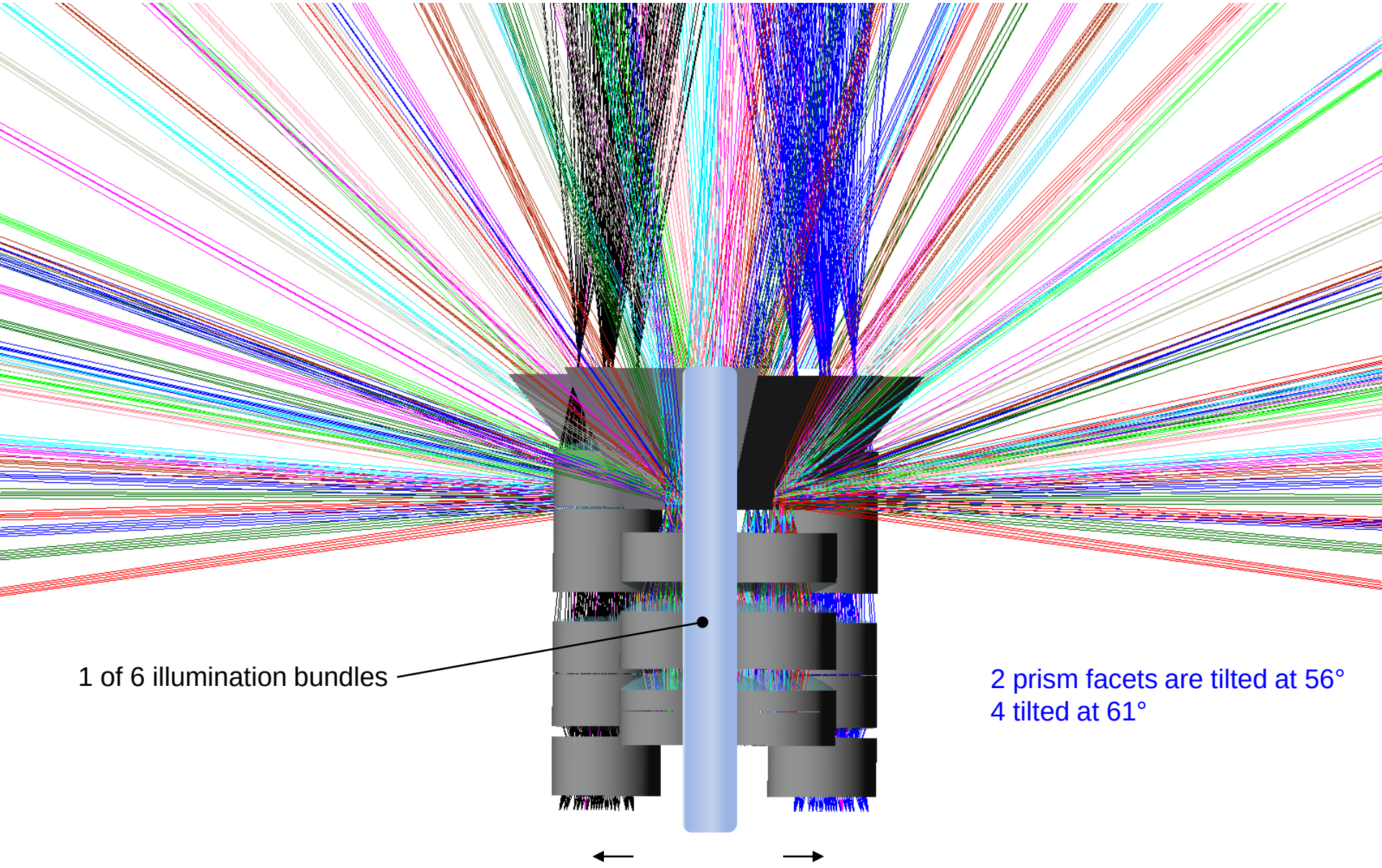
PDV probe with Stereo Imaging



PDV fiber arrays are index matched to first fused silica lens

PDV probe (Stereo Imaging hidden)




1 of 6 illumination bundles
2 prism facets are tilted at 56°
4 tilted at 61°
Coherent bundles offset to allow overlap imaging

Zones 3 & 6 are used for stereo imaging

The stop diameter determines the NA of collected light and also the depth of focus

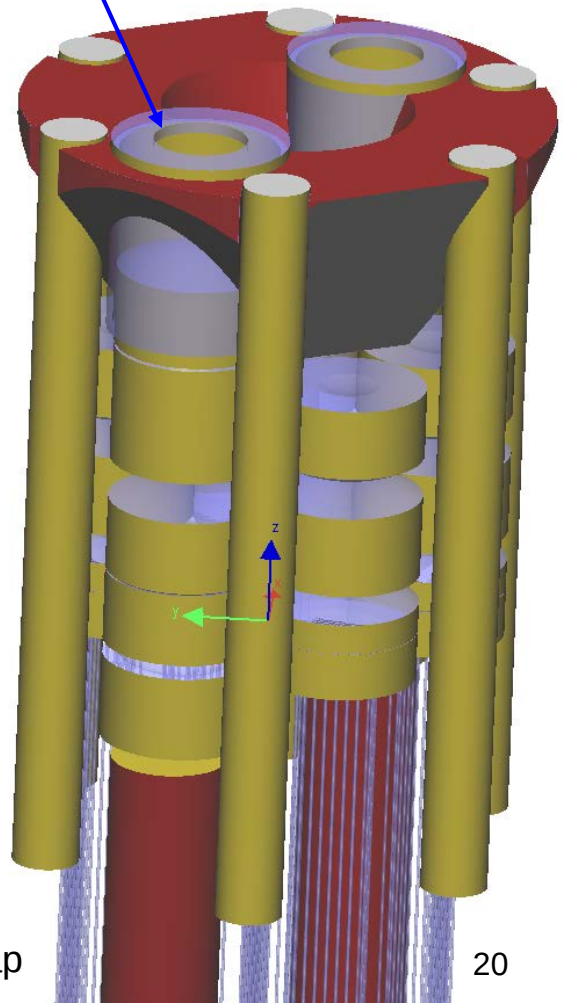
(Perspective has been rotated)

Z6 (blue)
Z3 (black)

24 mm diameter zone for imaging (blue & black rays); 10x magnification

F/# of surface collected light is 36

Imaging stop (2.1 mm dia.)



5º stereo angle

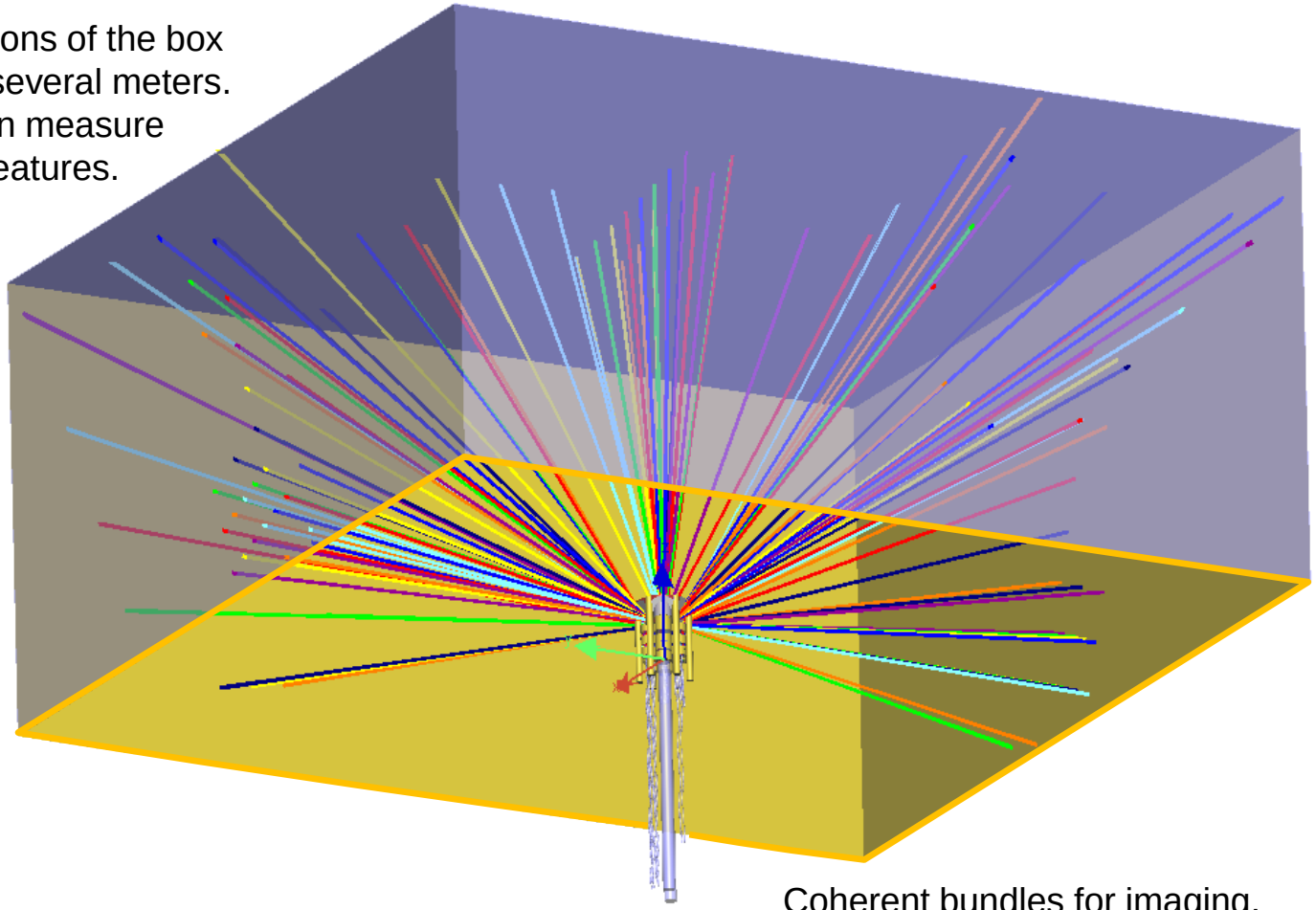
Assuming 24 mm diameter FOV at surface and 2.4 mm diameter bundle at 50 lp/mm. Resolve 200 µm at surface (5 lp/mm).

2 thin stop "washers" rest on top of prism

Coherent bundles are translated 0.314 mm, so that the image areas overlap

Probe can be configured to measure dimensions of an unknown shape using an Optical Backscatter Reflectometer (OBR) in static mode, and then measure the velocity of the wall movements in dynamic mode. (Not shown are the two imaging zones.)

Dimensions of the box can be several meters. OBR can measure 10 µm features.

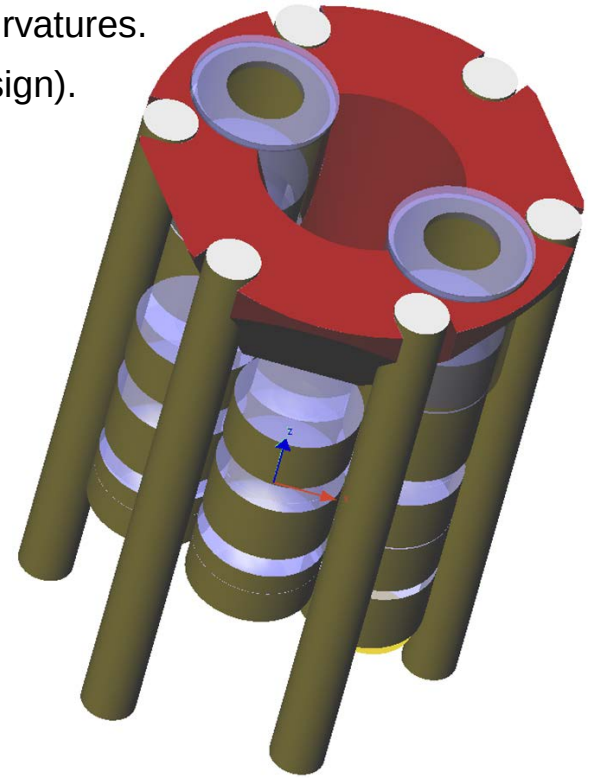


Coherent bundles for imaging. Fibers for PDV.

PDV Probe with Stereo Imaging

Advantages:

1. Accommodates imaging along with the PDV channels. Imaging does not have to be used for dynamic recording, it could also serve as a surface inspection tool. We have a 1550 nm converter for visible cameras allowing images of surface features surrounding a PDV spot.
2. Each of the 5 fiber arrays can have different rotations to change area coverages.
3. Each mirror facet can have different tilts to change area coverages. Currently using 56º and 61º.
4. AR coatings more efficient than fish-eye, because of fewer curvatures.
5. Each lens stack can have different focal lengths (modular design).
6. This probe accommodates several hundreds of fibers.
7. Data recorded down to 6.5 mm from the zero crossing.



Disadvantages:

1. Zero crossings are shifted ~2.5 mm for 4 of the 5 zones.
2. Must show that imaging is cheap and easy to perform.

US 9,121,861 B2 Patent