

**Bechtel Nevada Los Alamos Operations
Fiber Optic Probe Workshop
Tuesday, March 28, 2006**

Excellent Probes Give Excellent Data

Good Probes Give Good Data

Bad Probes Give Bad Data

Acknowledgements

NSTec LAO

Douglas DeVore

Adam Iverson

Bart Briggs

Brent Frogget

Vincent Romero

David Esquibel

Richard Thompson

Don Rosenberry

NSTec STL

Bruce Marshall

Gerald Stevens

Dale Turley

Mike Grover

NSTec Las Vegas

Scott Meyers

Mandy Hutchins

Barbara Begley

LANL

David Holtkamp

Leonard Tabaka

Patrick Rodriguez

David Clark, Sr.

Terry Salyer

Mike Shinas

Introduction

This workshop covered the following topics:

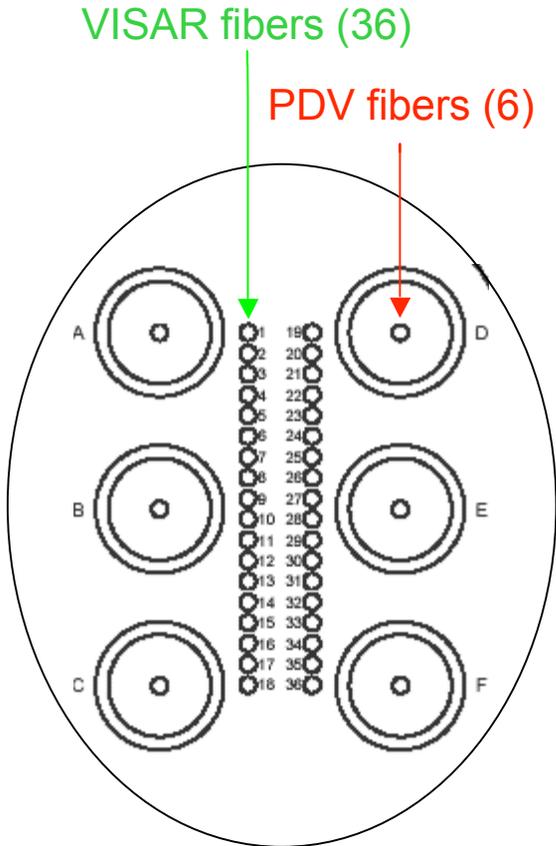
- Existing probe designs
- Existing testing methodologies and data collection
- The desire to achieve universal standards for
 - Target material
 - Target shape
 - Pointing accuracy
- Future probes
 - Designs and capabilities
 - Testing requirements
- Connector issues and requirements
 - Standardized connectors

Existing Probes

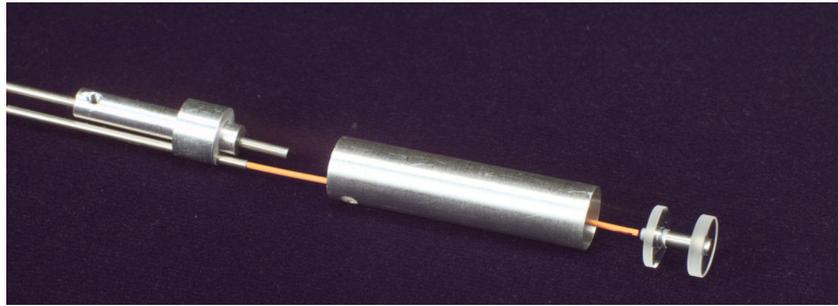
Existing Probes: Overview (Frogget, NSTec LAO)

- 3/8-inch Diameter VISAR Probe (“Frogget” Probe)
 - Other Diameters 1/4-inch, 5/8-inch, 7/8-inch
- 7/8-inch Combination Pyrometry/VISAR Probe
- New 5/8-inch Diameter VISAR Probe
- Long GRIN lens multipoint Unicorn Probe
- “Cata” Probe (collimators - six around one)
 - Mini Cata Probe (two collimators)
- “Winkler” Probe (fibers - six around one)
- Other Probes
 - OZ Optics Collimators, Bare Fiber, Line-Imaging VISARs

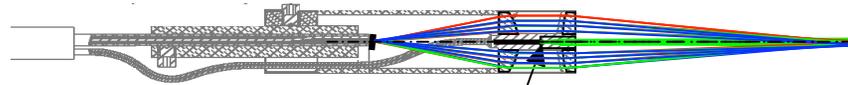
Existing Probes, samples



Array pattern of Unicorn Probe



3/8-inch diameter VISAR Probe

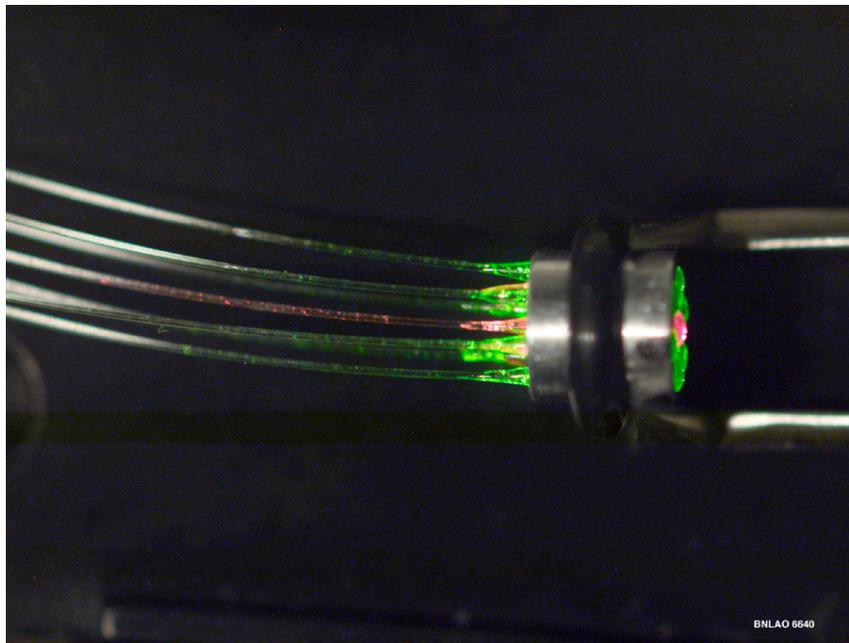


NSG GRIN collimator
w/50µm core fiber

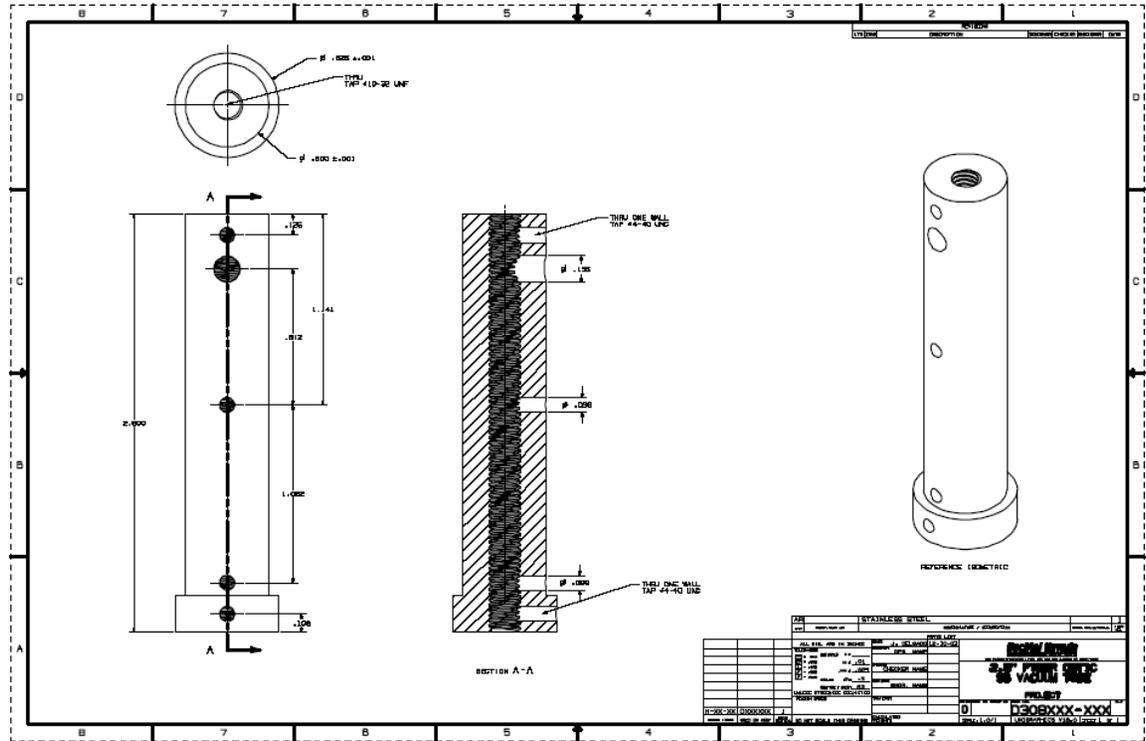
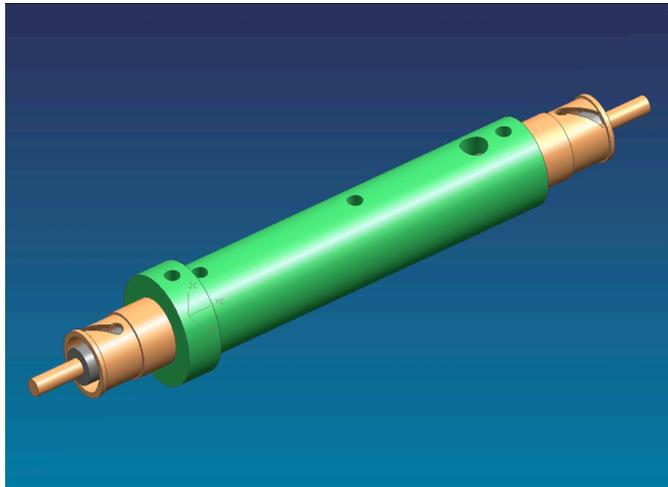


Combination
Pyrometry/VISAR
Probe

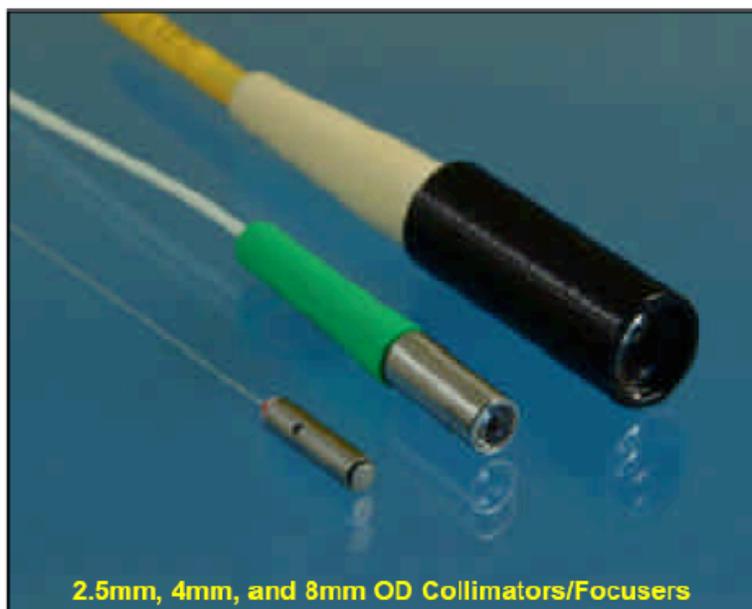
Existing Probes: Cata 6-around-1



Existing Probes: Vacuum seal tube assembly



Existing Probes: OZ and Lightpath (Holtkamp)

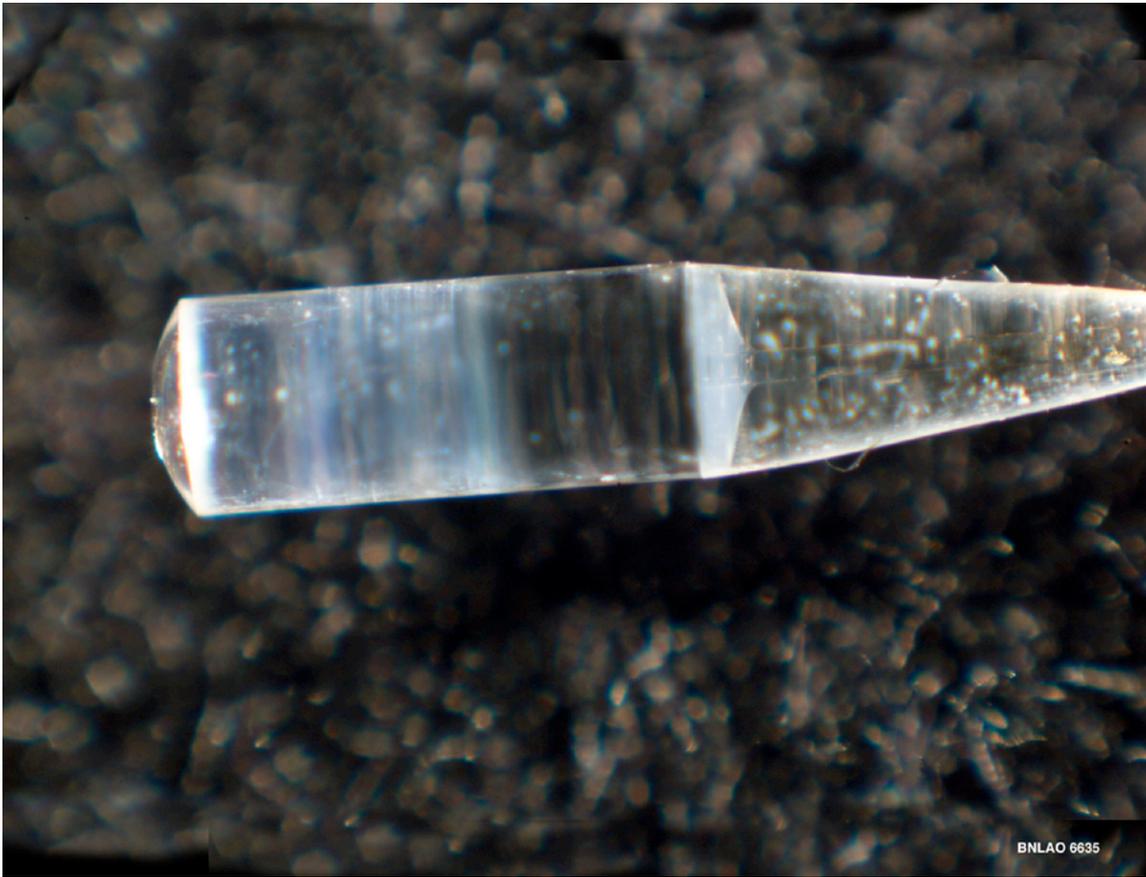


Oz Optics Probes

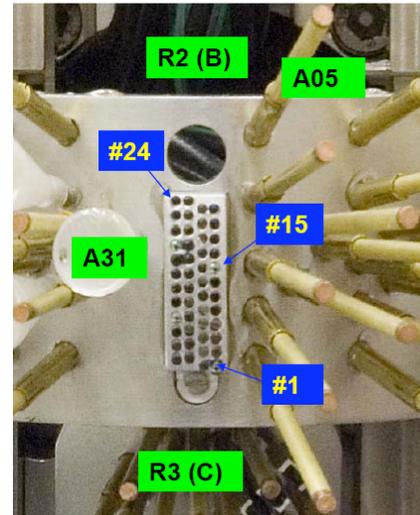
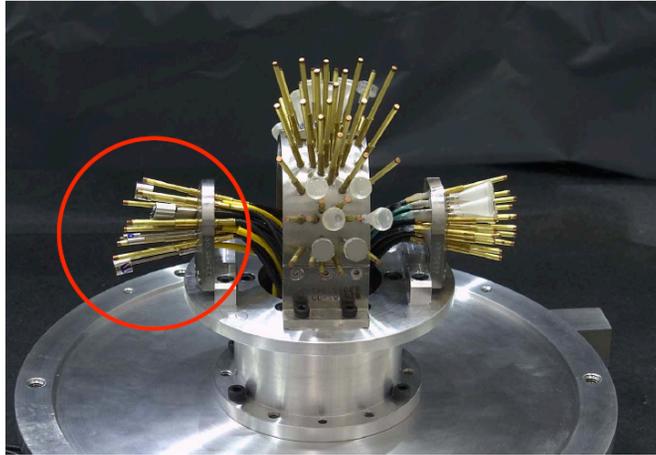


- Trying to standardize on bare fiber (& Lightpath) probe tube diameters, length, etc for multiple users

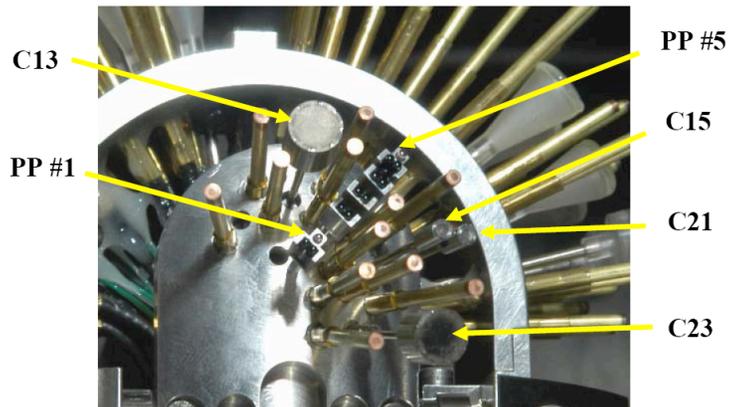
Existing Probes: Lightpath collimator



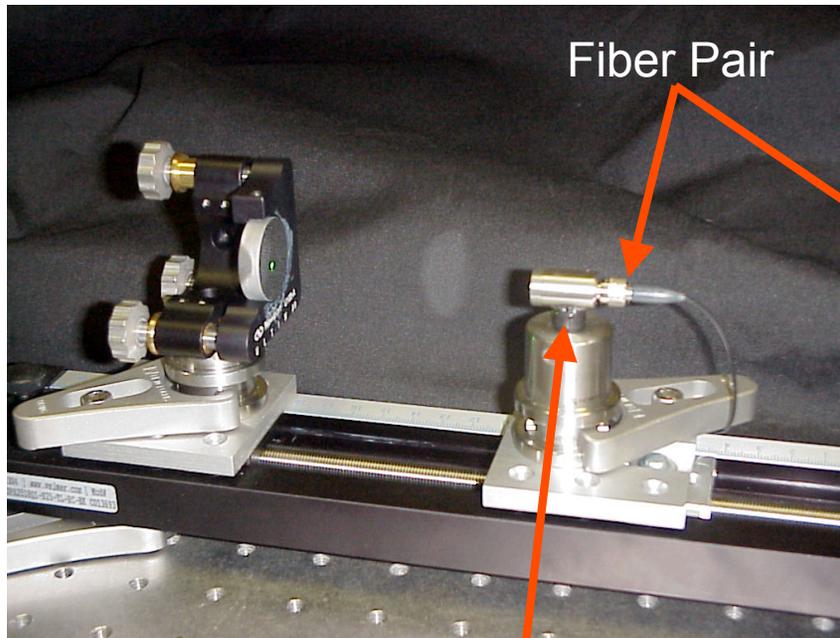
Existing Probes: Probes on Kerenei and Krakatau (Holtkamp)



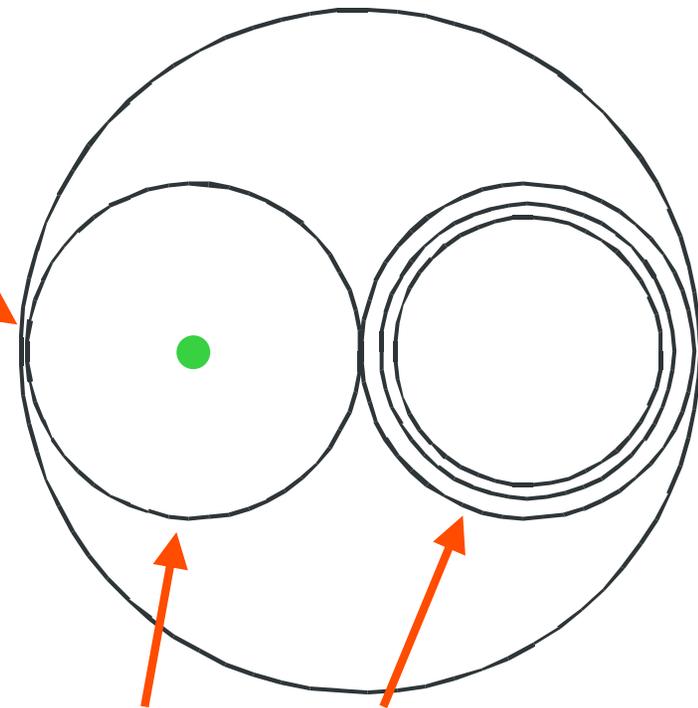
R2 (B)							
22	16	10	0	10	16	22	28
A06				A05		A04	70.0
							78.0
A17				A16		A15	80.0
							83.5
	A26				A25		84.5
A32		A31	18			A30	87.5
							88.5
			15	A39		A38	90.0
	A50				A49		87.0
A52							86.0
							85.0
			8	A57		A56	82.5
							81.5
A67			1	A66		A65	75.0
R3 (C)							



Existing Probes: Thorlabs VISAR (Stevens, NSTec STL)



\$125 Thorlabs Collimator

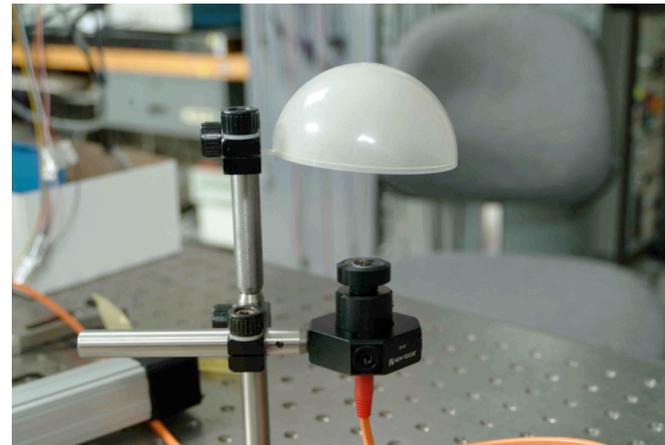
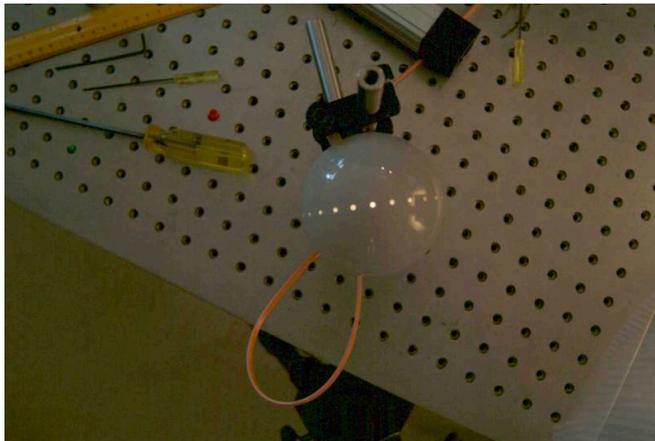
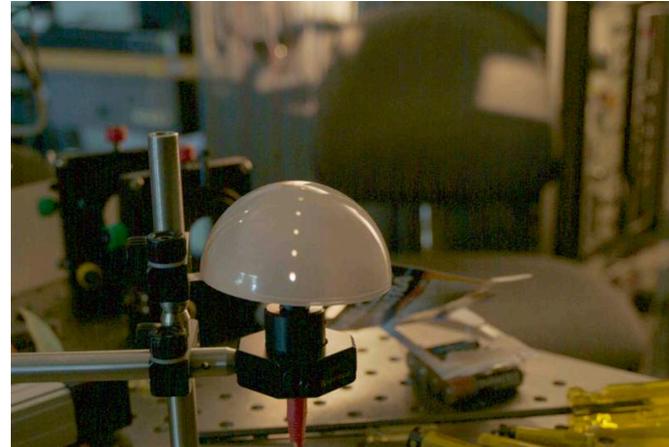
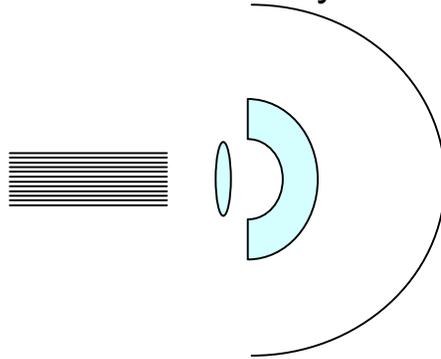


SMF28 & 100/110/125
IN 255 MICRON HOLE (#85-86)

continued

Existing Probes: Fisheye VISAR or PDV Probes (Marshall, NSTec STL)

- MTP 12-fiber connector (62.5 μm core) projected thru 190° fisheye lens



Existing Testing

Existing Testing: VISAR Probe Test Bench



Existing Testing: Overview

- Compatibility with VISAR is crucial: combined PDV/VISAR probes will continue to be used
- Lambertian source evaluation of probes
 - Measure the efficiency
 - Experiment with the quality of the target surfaces:
 - Bead-blasted aluminum
 - Mirrored
 - Reverse side of aluminum foil
 - Characterize for angular dependence and distance
- Objective: to be able to repeat probe testing and get the same results—repeatability
 - One means is to standardize the target material

Existing Testing: An Automated Test Bed for VISAR Probe Characterization

Existing Testing: An Automated Test Bed (Salyer, LANL)

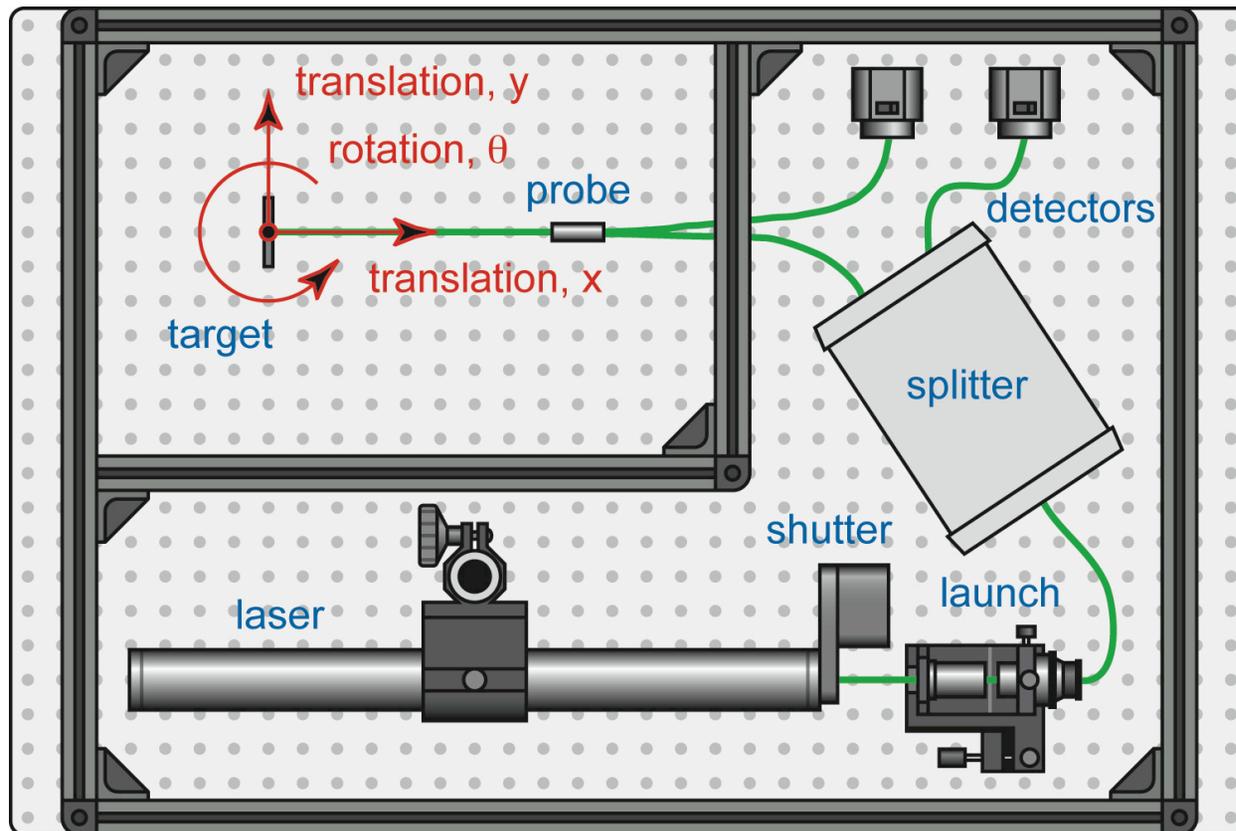
Compact desktop setup



continued

Existing Testing: An Automated Test Bed

Optics breadboard schematic

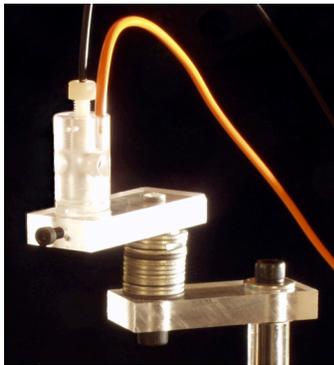


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Existing Testing: Automated Test Bed

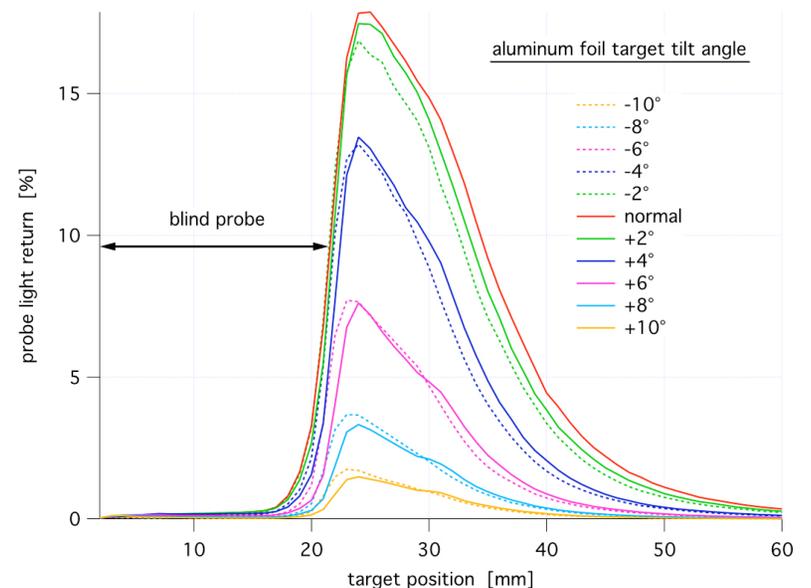
Sample Probe Characterization: Axial Response and Target Angle Sensitivity

- Response halved at roughly 5° target tilt.



Sample Probe:

Valyn 30 mm target focus
(#FOP-1000)



continued

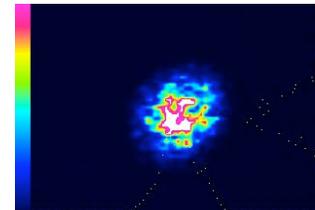
Existing Testing: Automated Test Bed

Sample Probe Characterization: Illumination Beam Characteristics

- Expanding spot size with increasing target distance.

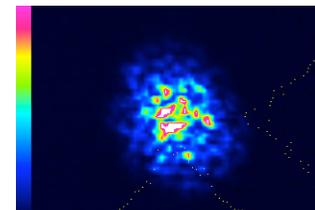
Target 15 mm from end of probe.

	Horizontal		Vertical	
	Beam	Gaussian	Beam	Gaussian
Centroid (μm)	2778.63		2120.11	
Beam Peak (μm)	2715.45	2778.63	2091.60	2120.11
Width (μm) (80.0%)	131.24	126.97	63.96	106.67
Width (μm) (50.0%)	229.93	223.78	176.11	188.00
Width (μm) (13.5%)	367.74	380.36	331.87	319.55
Correlation (%)	87.29		83.29	
Power (mW)	-----			



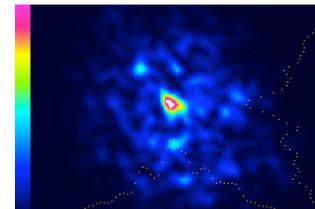
Target 30 mm from end of probe.
(Probe design target distance.)

	Horizontal		Vertical	
	Beam	Gaussian	Beam	Gaussian
Centroid (μm)	2762.55		2065.45	
Beam Peak (μm)	2715.45	2762.55	2075.00	2065.45
Width (μm) (80.0%)	74.58	147.07	49.60	141.58
Width (μm) (50.0%)	265.60	259.21	207.32	249.54
Width (μm) (13.5%)	474.44	440.57	490.99	424.13
Correlation (%)	83.65		80.33	
Power (mW)	-----			



Target 45 mm from end of probe.

	Horizontal		Vertical	
	Beam	Gaussian	Beam	Gaussian
Centroid (μm)	2761.13		2011.26	
Beam Peak (μm)	2733.55	2761.13	2058.40	2011.26
Width (μm) (80.0%)	100.47	191.56	65.66	179.95
Width (μm) (50.0%)	254.10	337.61	154.28	317.15
Width (μm) (13.5%)	740.92	573.84	745.52	539.06
Correlation (%)	75.23		65.06	
Power (mW)	-----			



Data Collection and Retrieval

Data Collection and Retrieval (Briggs, NSTec LAO)

Optical Probe Characterization System (OPCS)

Database automated for consistency and accuracy

Measurement configurations as well as the data collected are packaged in XML transactions by the Web-enabled LabVIEW application. The transactions are transmitted to the Instrumentation Web-Service and stored in the Instrumentation database. Setup information from previous configurations can be retrieved from the Web service and used to configure successive measurements.

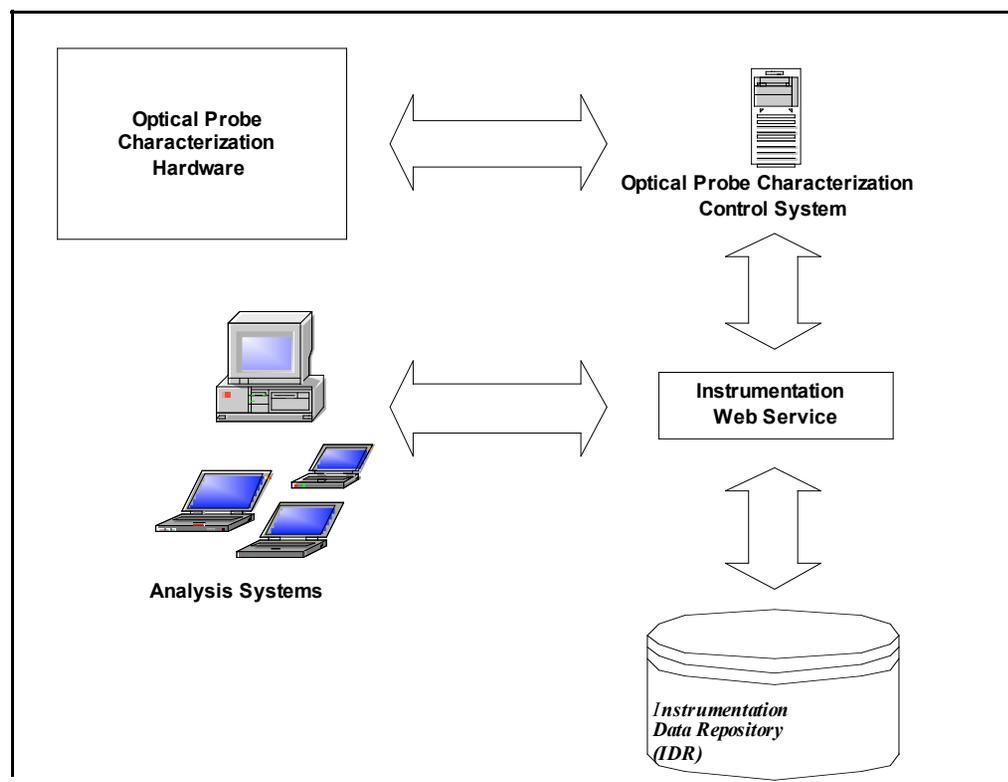
Instrumentation Web-Service (IWS)

This Web service responds to XML Instrumentation transactions and is responsible for acknowledging, validating, storing and retrieving transaction data from the Instrumentation database.

Could this be linked with other databases for cross-comparison of probes at different locations?

Data Collection and Retrieval, continued

Optical Probe Characterization

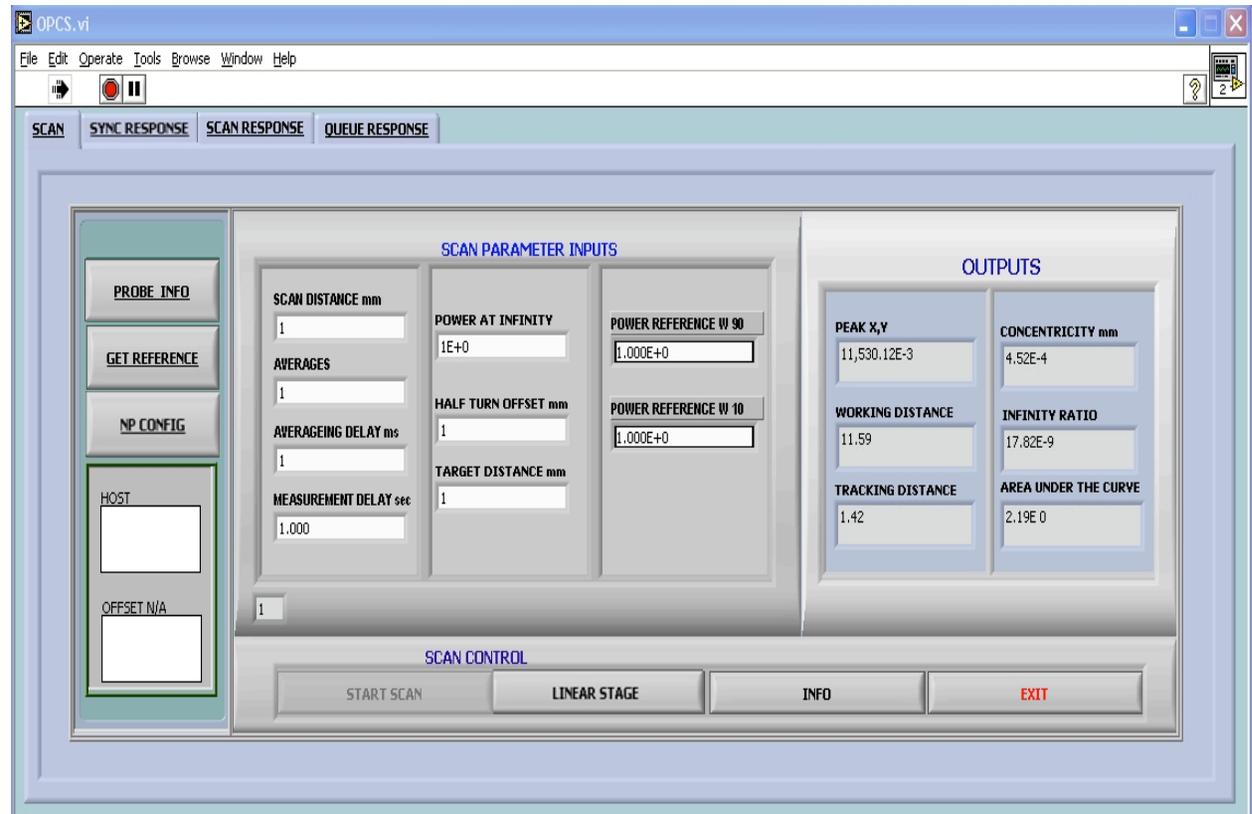


Data Collection and Retrieval, continued

OPCS main user interface screen

- DESCRIPTION

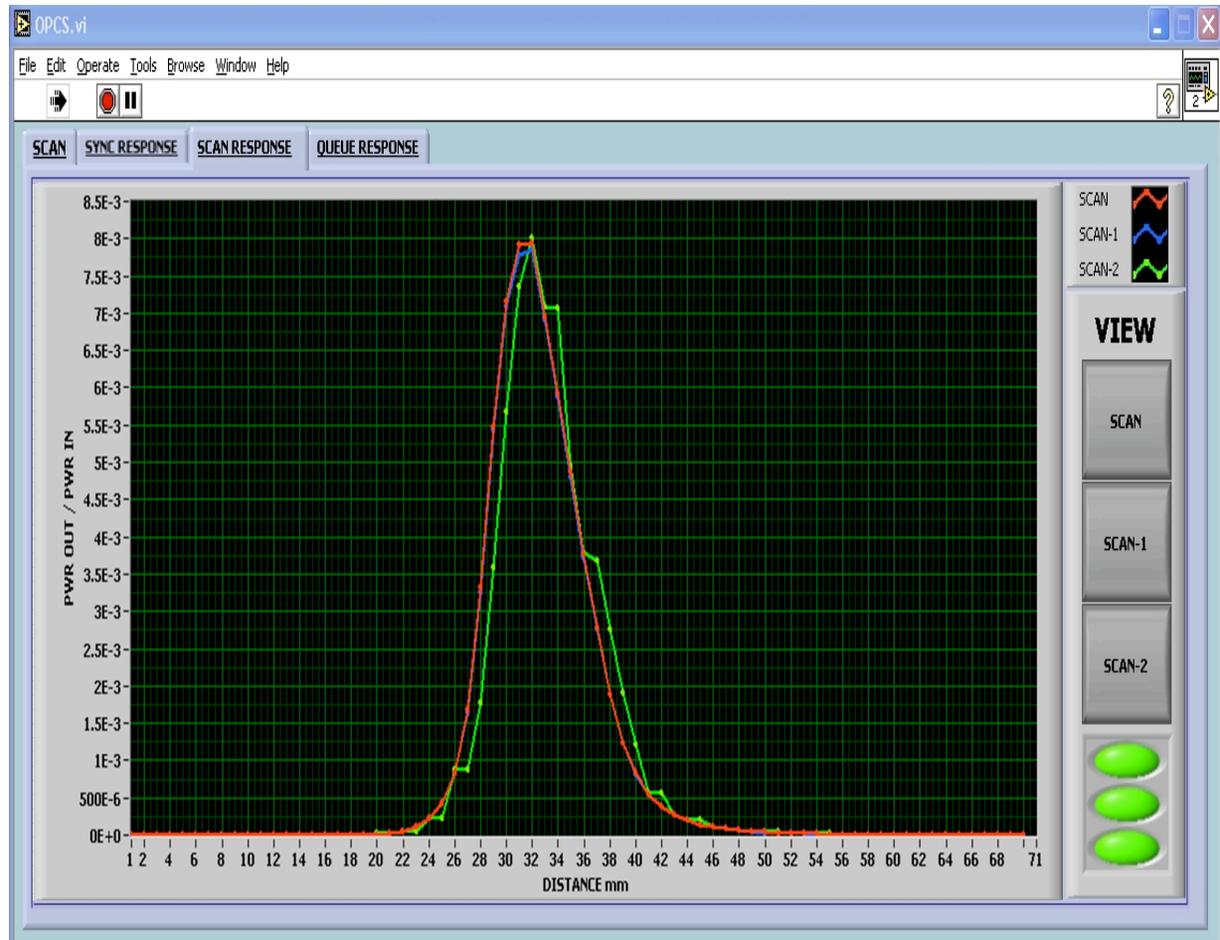
- The “scan” tab controls the flow of most functions throughout the program.
- All probe information is acquired from this tab or called from this tab.



Data Collection and Retrieval, continued

OPCS Scan Response tab

- DESCRIPTION
 - This tab displays the last three responses that were acquired, for comparing different probes or the same probe.
- GREEN RESPONSE
 - Averages=0
 - Averaging delay=0
 - Measurement delay=0
- BLUE RESPONSE
 - Averages=2
 - Averaging delay=100ms
 - Measurement delay=1 sec
- RED RESPONSE
 - Averages=4
 - Averaging delay=200ms
 - Measurement delay=2 sec



Developing Universal Standards

Developing Universal Standards (Rosenberry)

- Work together to get the same repeatable results
- Probe specifications
- Production specifications
- Testing standards, including standardized targets

Bead-blasted aluminum is fairly uniform over time—could this be the standard target?

Or could there be several standard surfaces: mirror, diffuse side of aluminum foil, bead-blasted aluminum, etc.

Need to characterize the angular dependence and distance

Surface flat or curved?

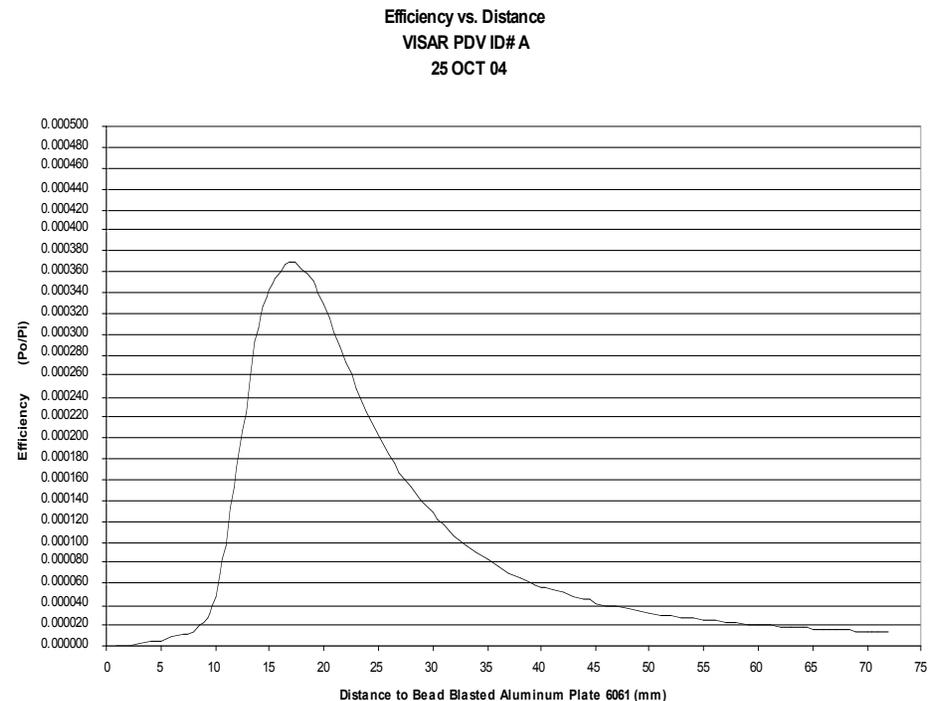
- Goal: Standardization across the board

Future Probes

Future Probes: Probe configuration and capabilities (Iverson, NSTec LAO)

Probes are getting more precise and smaller, leading to difficulties in production and in testing.

- Improve upon existing probe designs
 - Increased efficiency
 - Smaller footprint
 - Longer tracking distances
 - Improved optical design
 - Improved mechanical design
 - Improved fabrication
 - Improved metrology



Future Probes: Developing new probe concepts

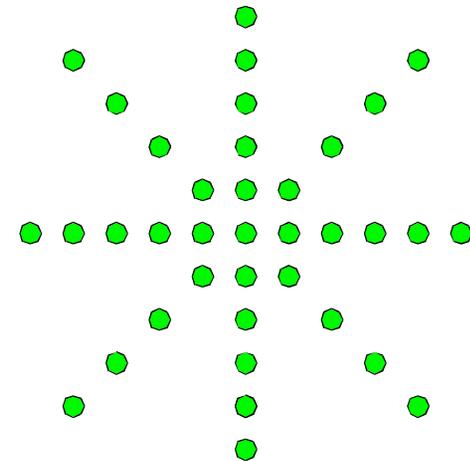
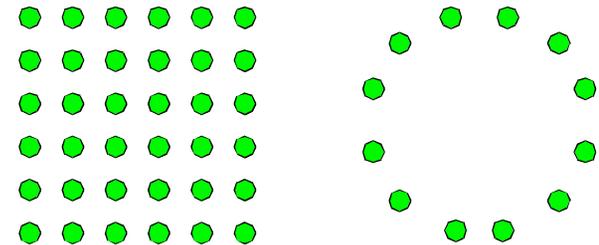
- Probe geometry

 - Linear geometries

 - Krakatau (24x along a line)
 - Unicorn (36x along 2 parallel lines)

 - Spherical geometries

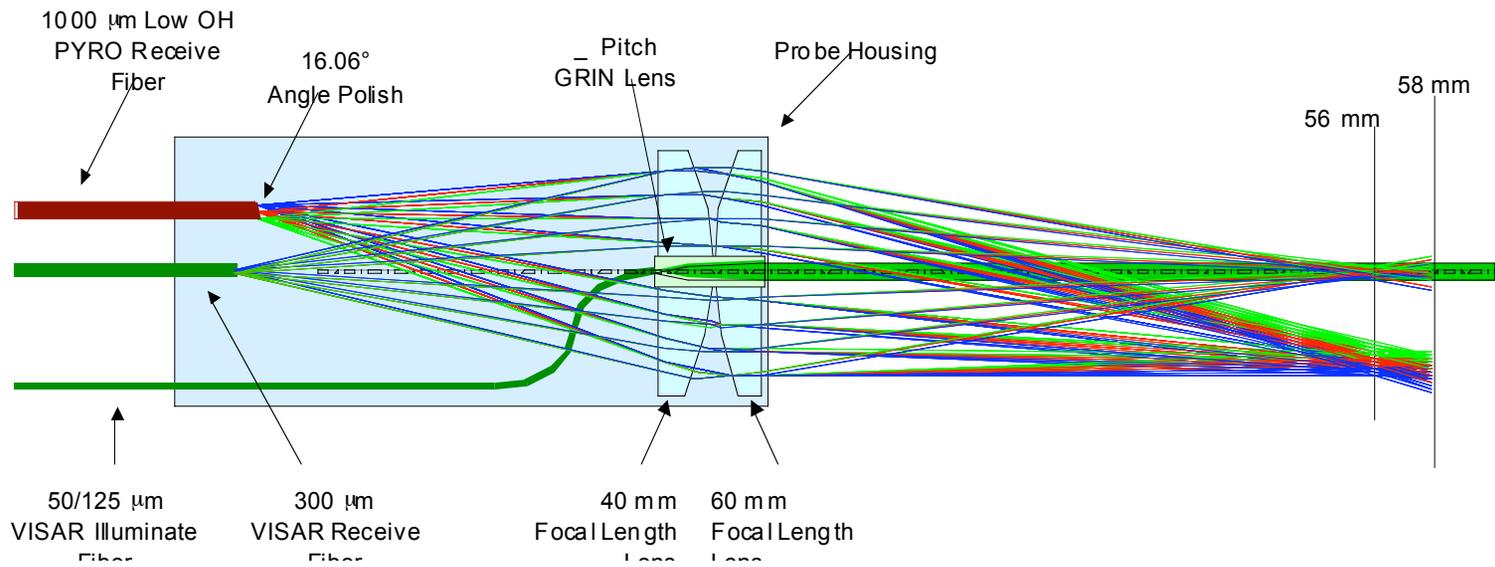
 - PDV/VISAR Pin Dome



continued

Developing new probe concepts, continued

- Hybrid probes (Past & Present)
 - Armando Single-Point VISAR
 - Pyrometry added to optical system



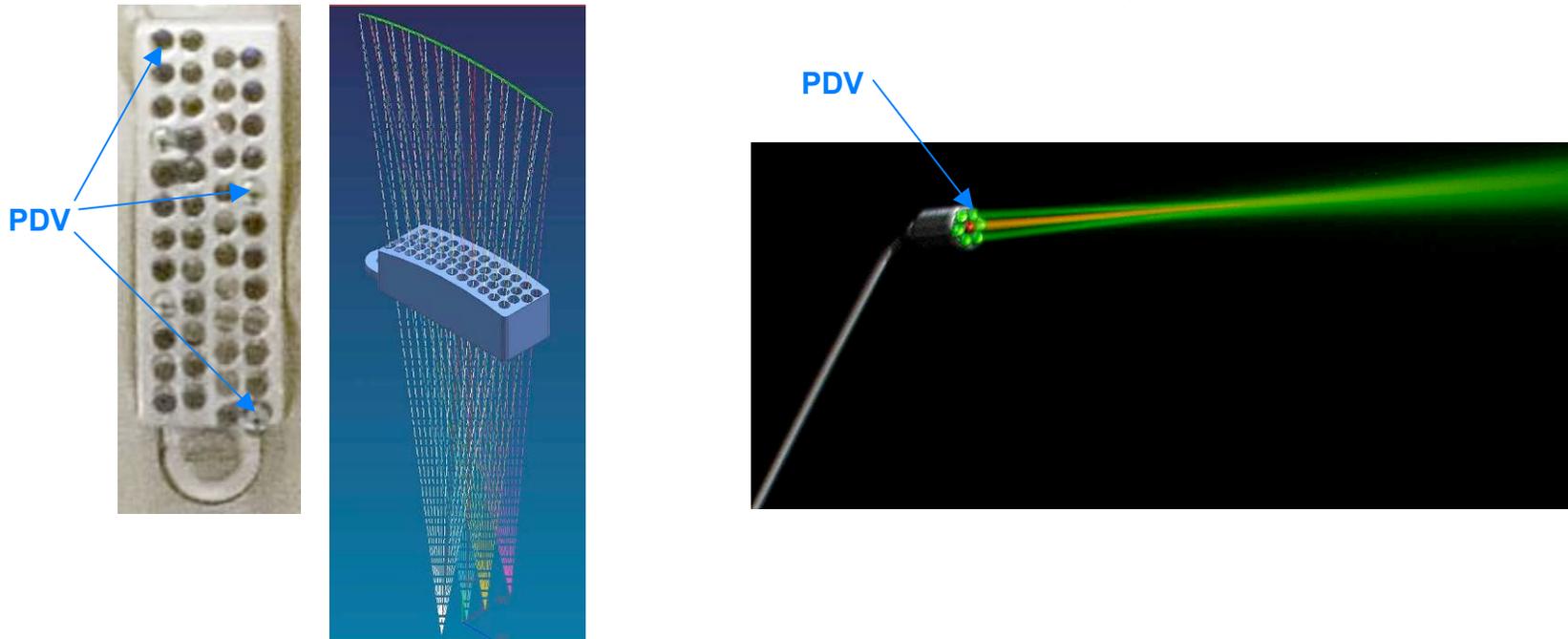
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Developing new probe concepts, continued

- Hybrid probes (Past & Present)

Krakatau Multi-Point VISAR & Unicorn Single-Point VISAR

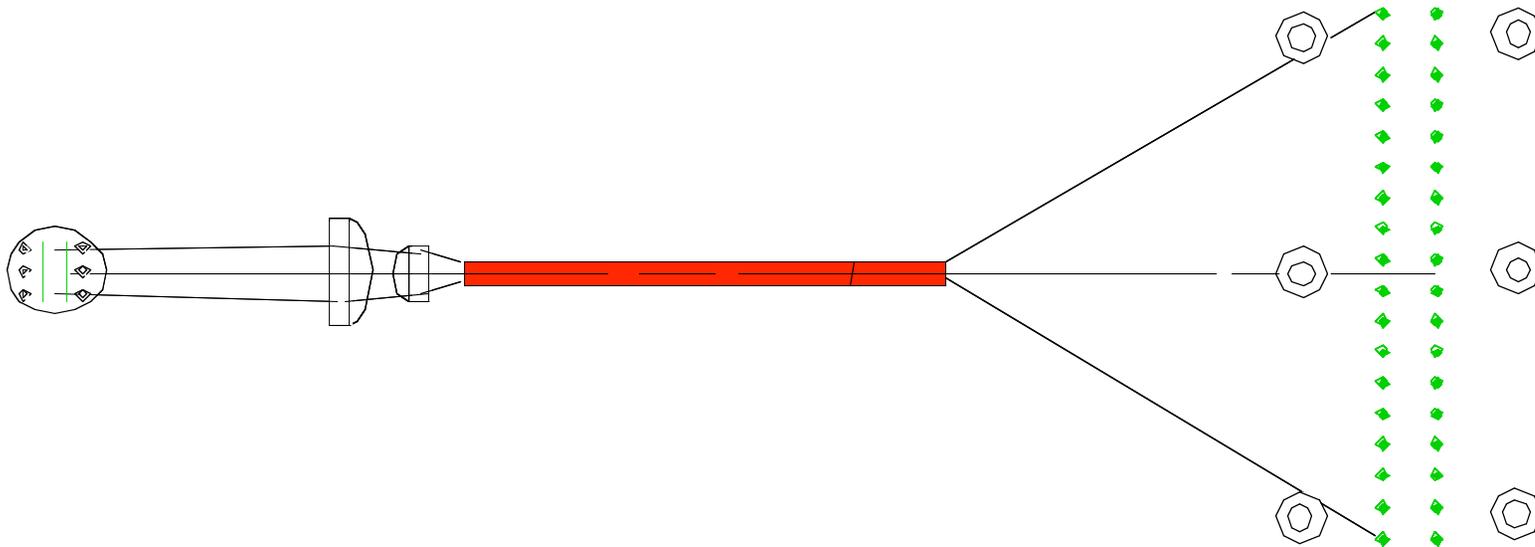
- Replaced VISAR illuminator(s) with PDV probe



continued

Developing new probe concepts, continued

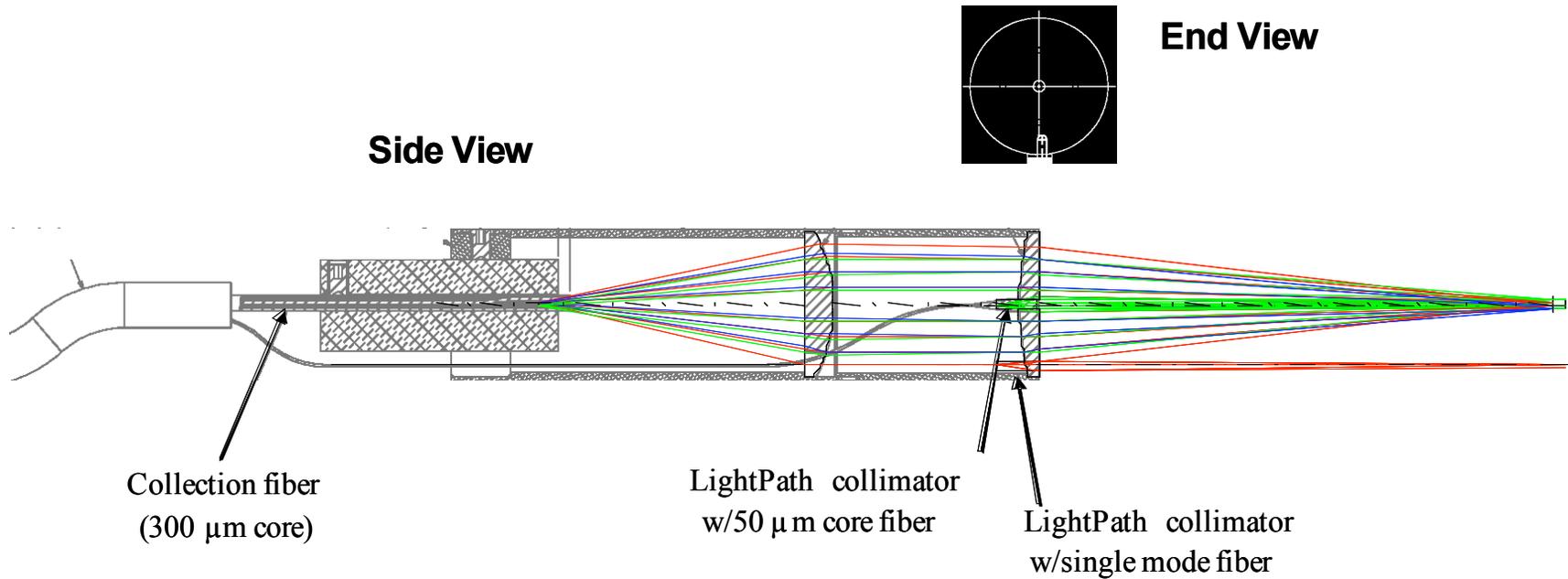
- Hybrid probes (Past & Present)
 - Unicorn Multi-Point VISAR
 - Added PDV probes to optical system



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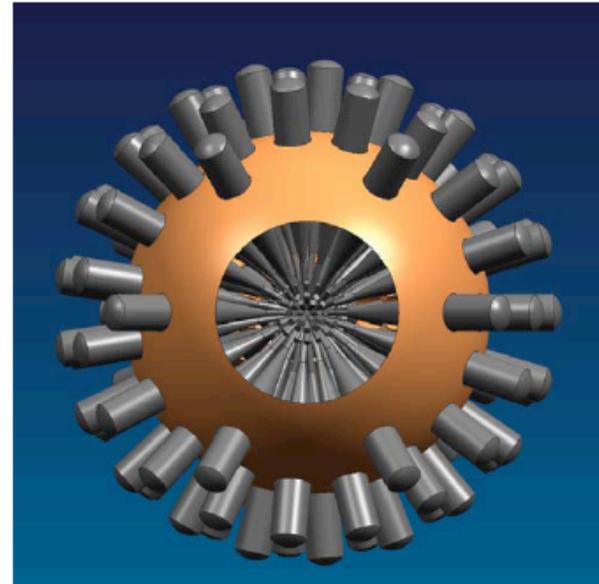
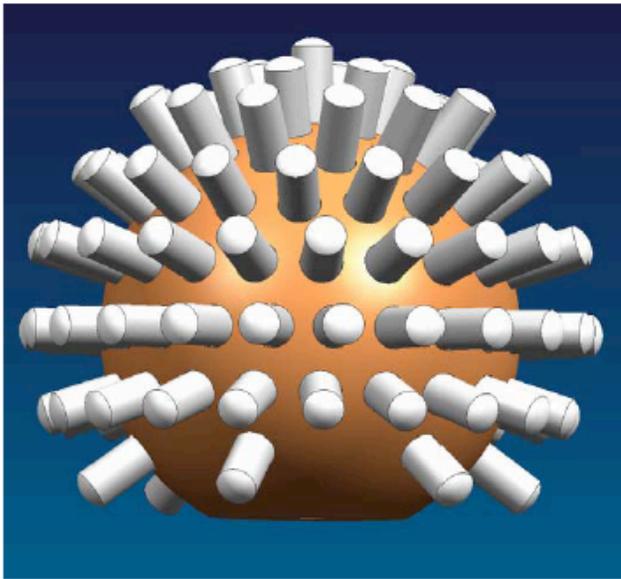
Developing new probe concepts, continued

- Hybrid probes (Future)
 - High interest in adding PDV
 - Single-Point VISAR + PDV



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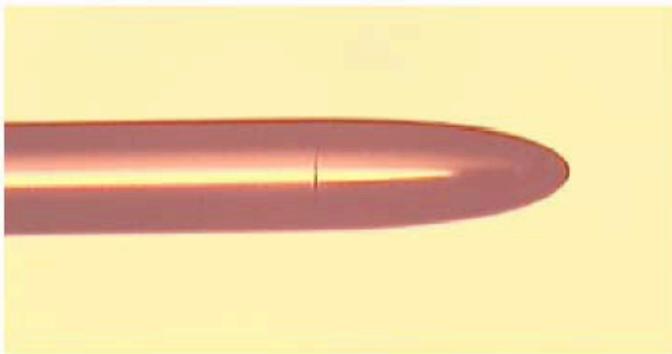
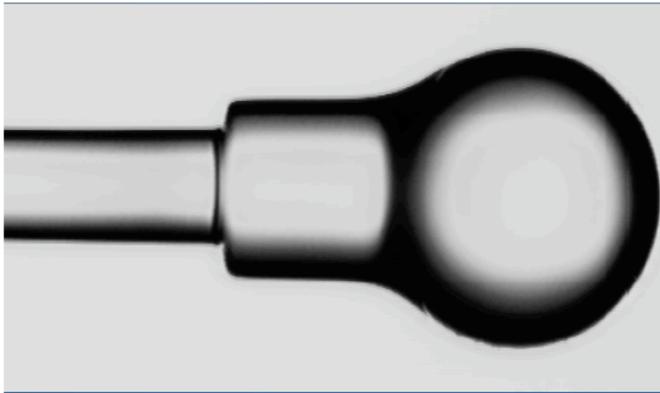
Future Probes, continued



- Memo coauthored with Vince Romero
- Complimentary to current multipoint VISAR
- 0.7" (< 18 mm) tip-to-tip probe diameter (above is 1/2" ball; really likely to be 5/8" for practical reasons)
- Interferometric OTDR to locate probe tip and target surface (each) to few microns

Future Probes, continued

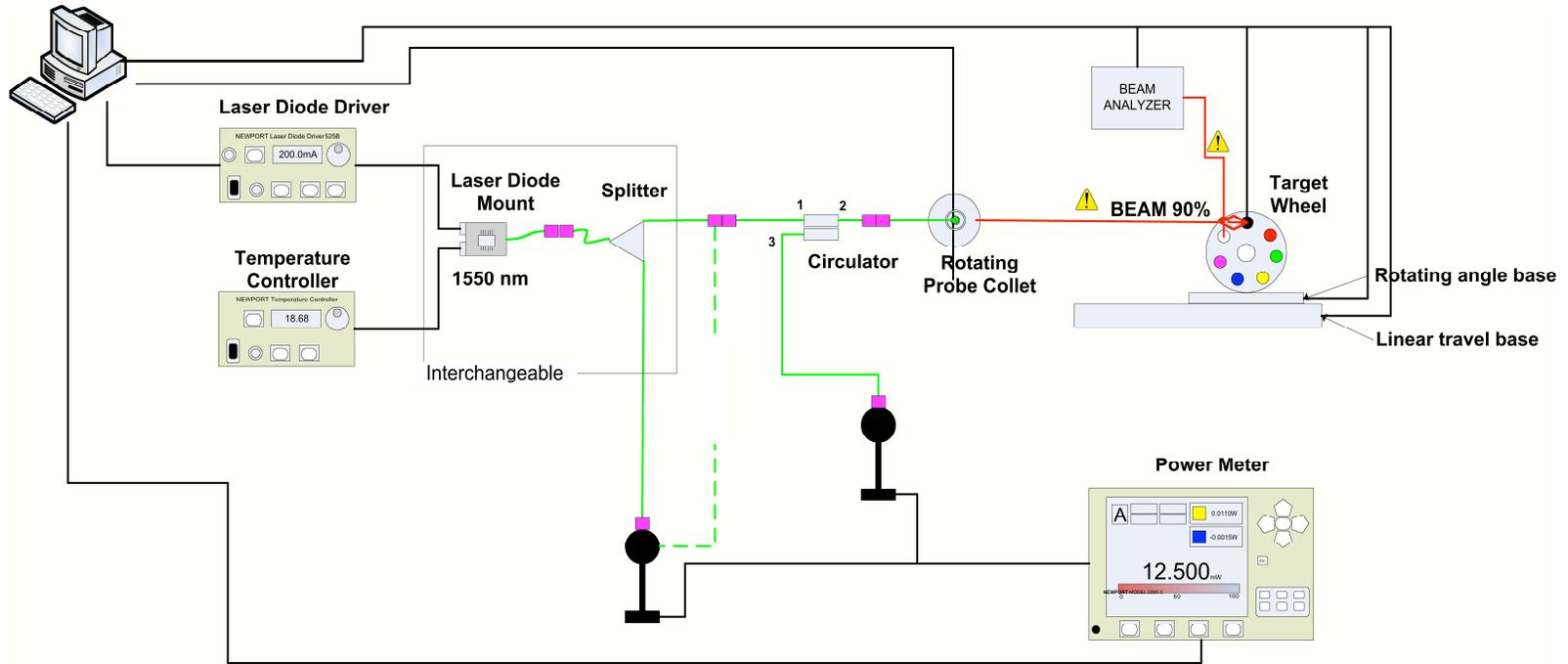
Ultra-miniature Probes



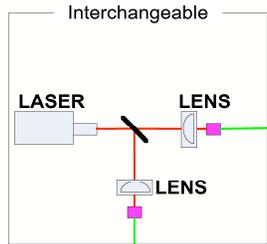
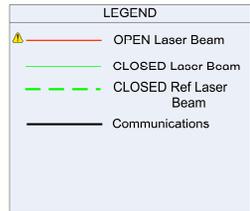
- Corning “Optifocus”
- Monolithic collimator
 - Fusion spliced
 - No epoxy
 - Single AR coated surface
- Low cost (\$40-50 ea)
- Concerns
 - Efficiency
 - Alignment accuracy to probe assembly

Future Probes: Probe testing (Romero, NSTec LAO)

- Really small spot sizes (5-10 microns): precision becomes vital
 - Really fast, with narrow depth of field
 - Sub-nanosecond resolution
 - Different wavelengths
 - Pointing accuracy
 - Need velocity requirement of 1% accuracy
 - Low-coherence light
 - Test *in situ*
 - Quadrant detector for defining rays of certain configurations
- Testing at these tiny sizes: temperatures, angles, humidity will all affect measurements



- Probe Types
- PDV
 - Cata Probe
 - Frogget Probe
 - Winkler Probe
 - OZ Optics
 - Collimators
 - Bare Fiber
 - VISARs



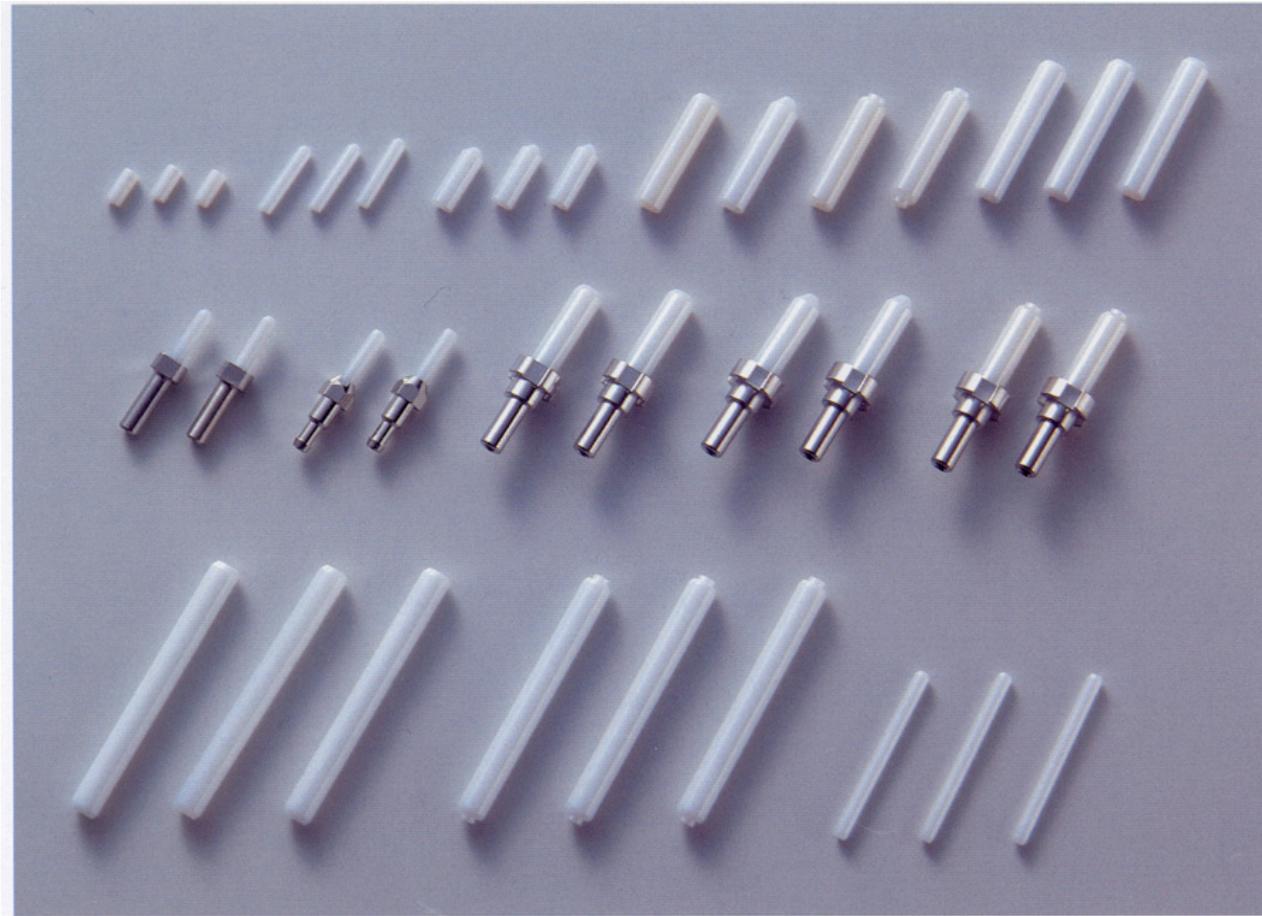
Fiber Calibration Layout
 Rev 1.0 A. Tibbitts July, 18 2006

Connectors

Connectors (DeVore, NSTec LAO)

- Need standardized connectors
- FC/APC connectors up to 5-6 dB (Connector problem)
 - Tolerance issue and radius issue
- Probes in different conditions (vacuum, pressure, high temperature, radiation) need fiber protection
- Standard AC, but proprietary “recipes” prevent uniformity, so need a universal standard
- May have found a connector to be the standard: the Diamond E-2000
 - Actively aligns core to center
 - Fuse it to your fitting
 - Field-ready, pre-polished—good for field where you don’t have equipment
 - Still need back reflector, interferometer (\$75,000)
- Need one brand name for connector, one for feed-throughs—standardize!
- Need a source for high-powered connectors
 - We make our own—could we outsource?

Connectors: Ferrules



Connectors: Endfaces

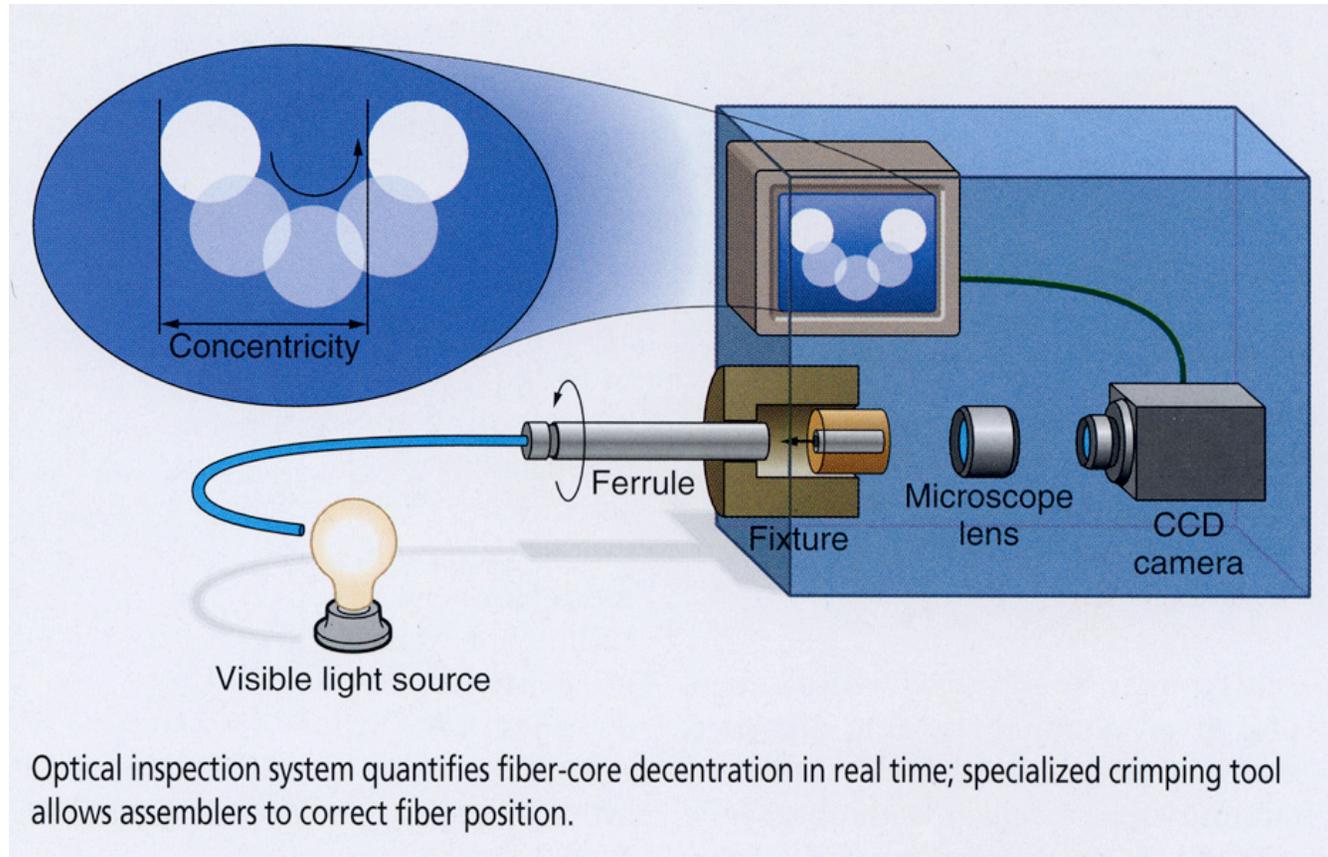


Follow-up report:

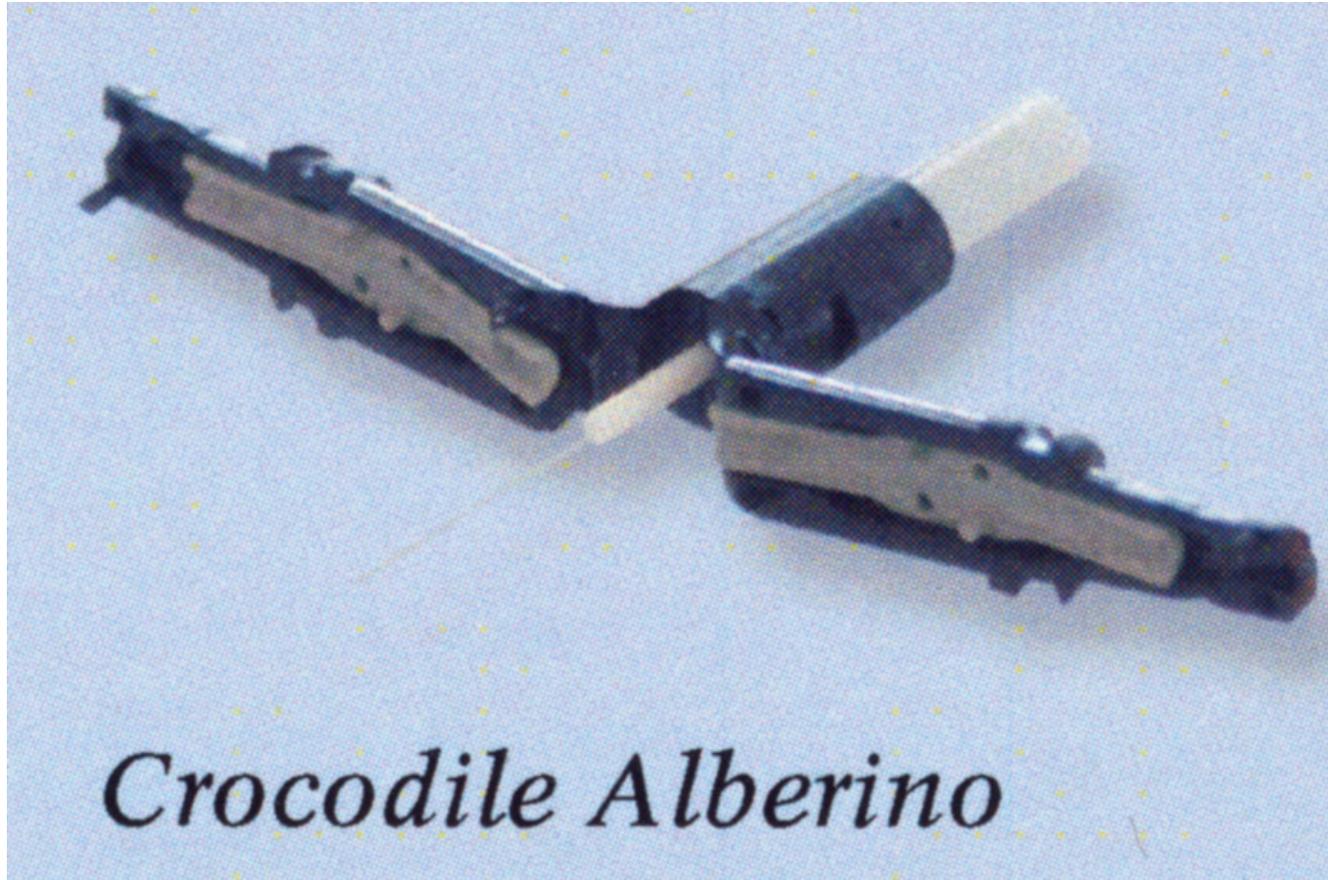
Study for the FC/ APC (Angled Physical Contact) connector only.

Available from Douglas DeVore devoredo@nv.doe.gov

Connectors: Optical inspection system



Connectors: Crocodile Alberino



Connectors: Standardization follow-up (Marshall)

A combination of solutions would allow the most flexibility:

1. Choose a set of specifications to standardize on.
2. Identify one or more sources for acceptable connectors that meet these specifications.
3. Give everyone who installs connectors a written procedure and list of equipment needed to do it correctly. Also, a way to check a connector to verify that the installation is ok.
4. Identify one or more sources for connectorized jumpers that are properly assembled. These could be welded when it is feasible to do so.

Update July 17, 2006: Standard connector has been found: 3M FC/APC

Connectors: FIS Bulk Prices for 3M FC/APC

QTY.	PART NUMBER	DESCRIPTION	UNIT PRICE	EXTENDED PRICE	LEAD TIME
500	AEXGBO (8206FCAPC900)	3M FC/APC Singlemode Connector with (green) 900um boot.	\$4.95	\$2,475.00	Stock to 1 week
1,000	AEXGBO (8206FCAPC900)	3M FC/APC Singlemode Connector with (green) 900um boot.	\$4.25	\$4,250.00	Stock to 1 week
500	AEXGL3 (8206FCAPC)	3M FC/APC Singlemode Connector with (green) long 3mm boot.	\$4.95	\$2,475.00	Stock to 1 week
1,000	AEXGL3 (8206FCAPC)	3M FC/APC Singlemode Connector with (green) long 3mm boot.	\$4.25	\$4,250.00	Stock to 1 week

3M FC/APC 8206 field-ready connector versus
3M FC/APC bulk-priced connector.

Connectors: Quality issues and solutions

- Bought an interferometer
 - Changing radius changes centering of the fiber
 - Interferometer will measure the radius as well as the angle of the connector
 - The angle of the PDV probe can also be measured using the interferometer
- Dornier pneumatic polisher versus hand polish
 - Polishing procedures
 - Derometer of polishing pad
 - Customized FC/APC polishing puck with specifications from 3M
 - 3M will help customize polishing procedures
- Connector loss (-0.1dB)
- Back reflection versus return loss reflection

Summary

Summary (All)

- Best to use our talents for designing what we cannot buy
- Committees formed to study the need for standardization of
 - Testing methodology
 - Target material and surface
 - Data collection and retrieval:
 - Expand database to include targets of all materials used by everyone involved
 - Combine or connect databases
- Connectors
 - Update July 17, 2006: Standard connector: 3M FC/APC

These committees could use your input; to volunteer, contact Douglas DeVore at devordo@nv.doe.gov or 505-663-2037