Factors to Consider When Choosing a Probe for PDV

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Ouline -- Factors to Consider When Choosing a Probe

WCI WEAPONS AND COMPLEX INTEGRATION

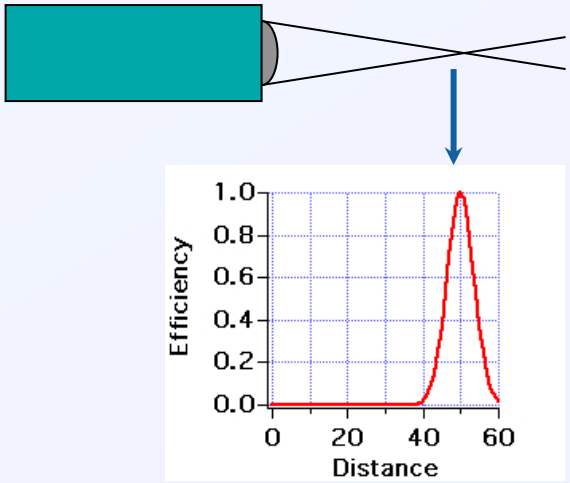
- Factors to consider
- Probe types commonly used at LLNL
- Conclusions

Factors to consider--initial stand-off

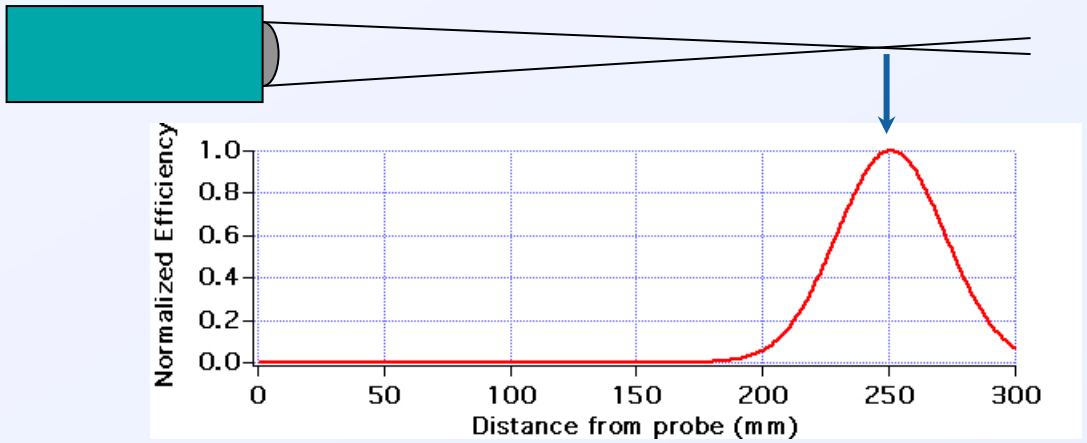
How far do you need to follow the surface?

A longer stand-off allows the probe to follow the surface a longer distance.

This is probably the single biggest factor.



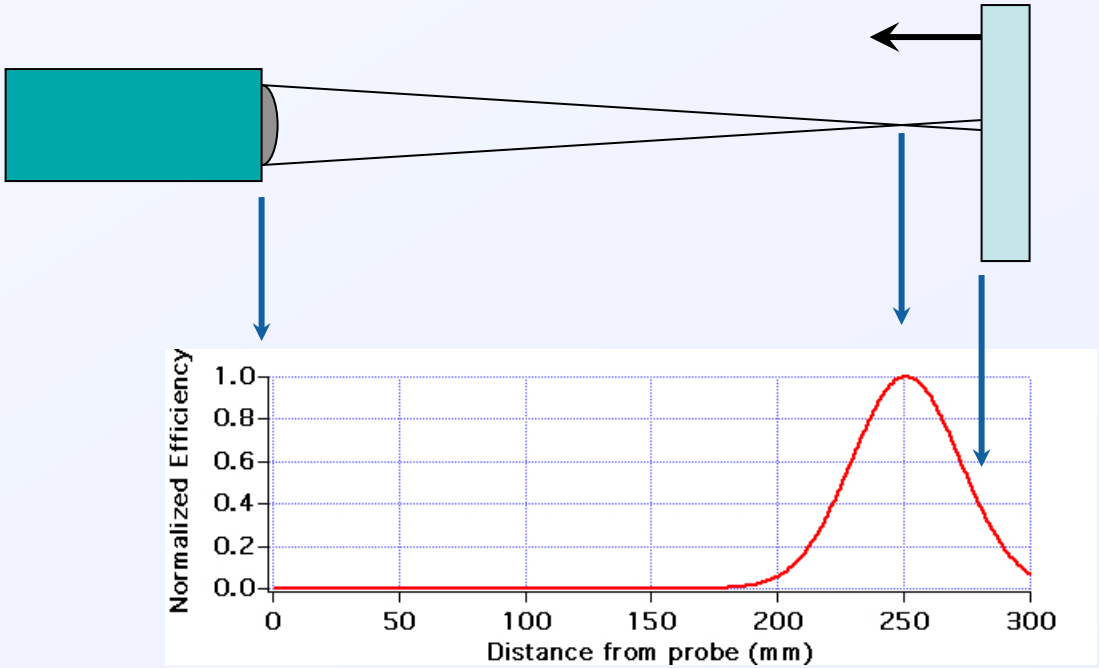
Narrow FWHM



Broad FWHM

Factors to consider--initial stand-off

Focusing probes have an efficiency curve that limits the depth of field.



We usually set the initial probe-to-surface distance with the focal point in front of the surface. This allows us to follow the surface a longer distance.

Factors to consider--initial stand-off

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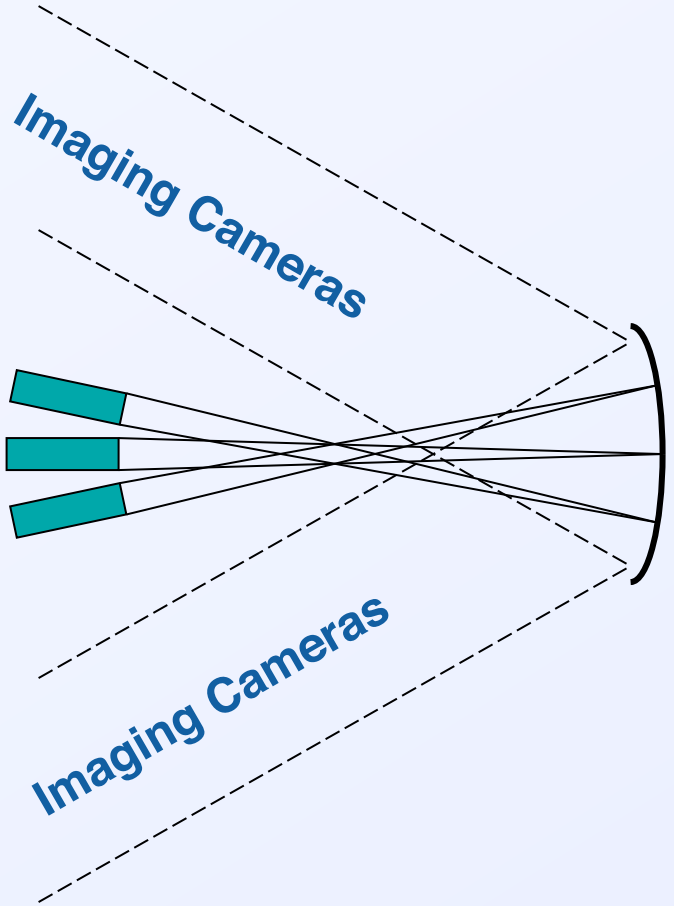
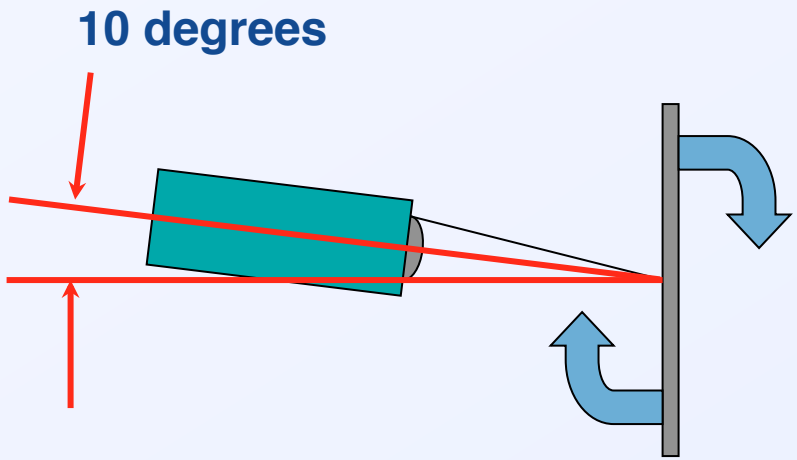
Long stand-off probes allow access for other diagnostics.



Factors to consider--surface tilt

We will initially install the probe at an angle to the surface normal if we know the surface will tilt during the measurement.

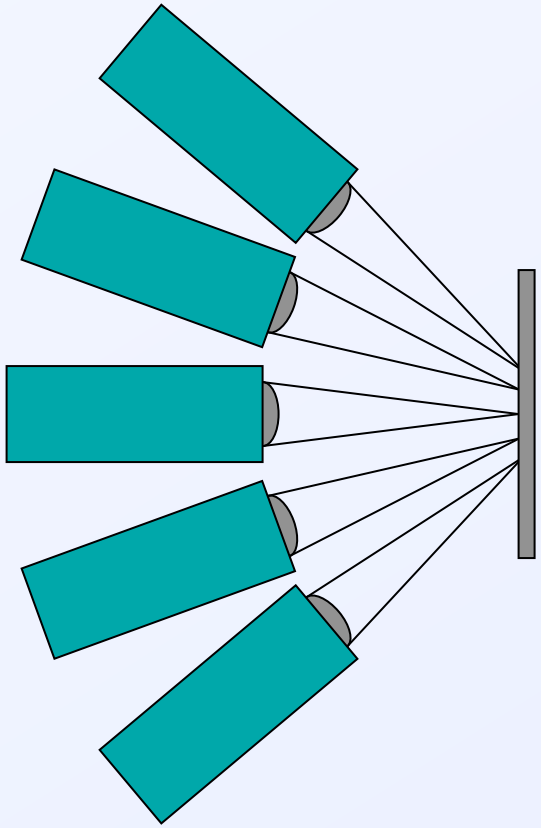
We generally try to stay within 10 degrees of the surface normal. We need a diffuse surface for this technique.



Place the probe so that the surface normal sweeps through the probe during the measurement.

Factors to consider--physical space

Short stand-off probes will not allow closely-spaced measurements if we do not exceed 10 degrees.



Factors to consider--physical space

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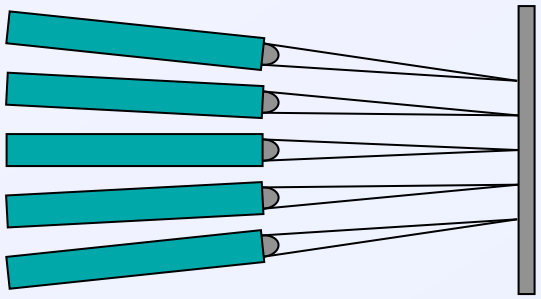
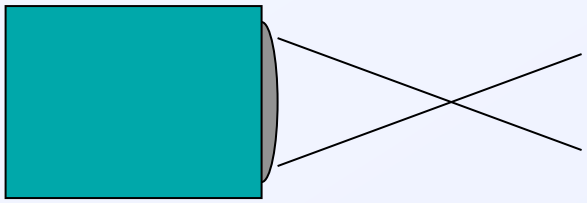
Smaller diameter probes will fit into a smaller space but have lower efficiencies, which means less signal.

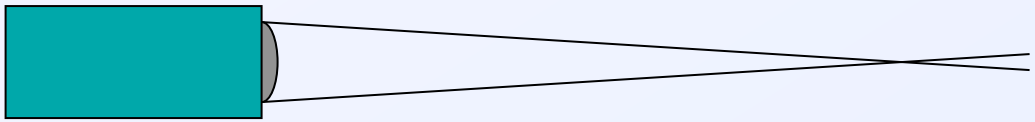


Factors to consider--solid angle

A large solid angle collects more light, which means less laser power or compensates for low surface reflectivity



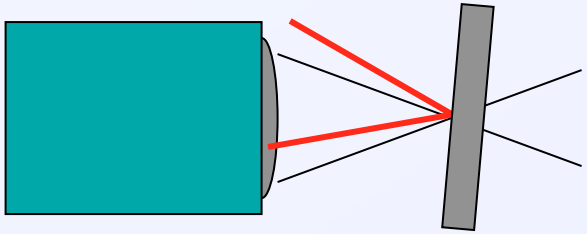
Large solid angle



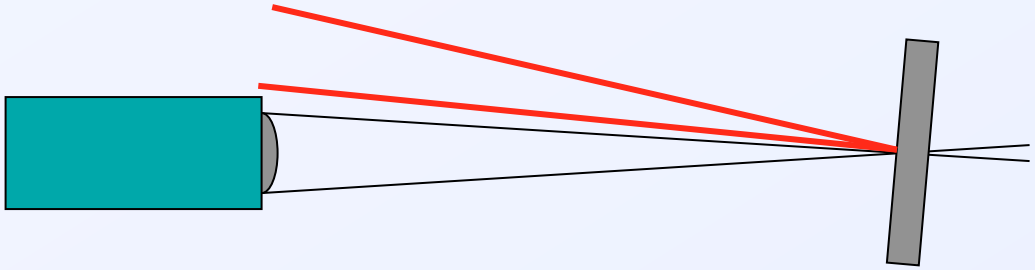
Small solid angle

Factors to consider--solid angle

A large solid angle allows more tilt



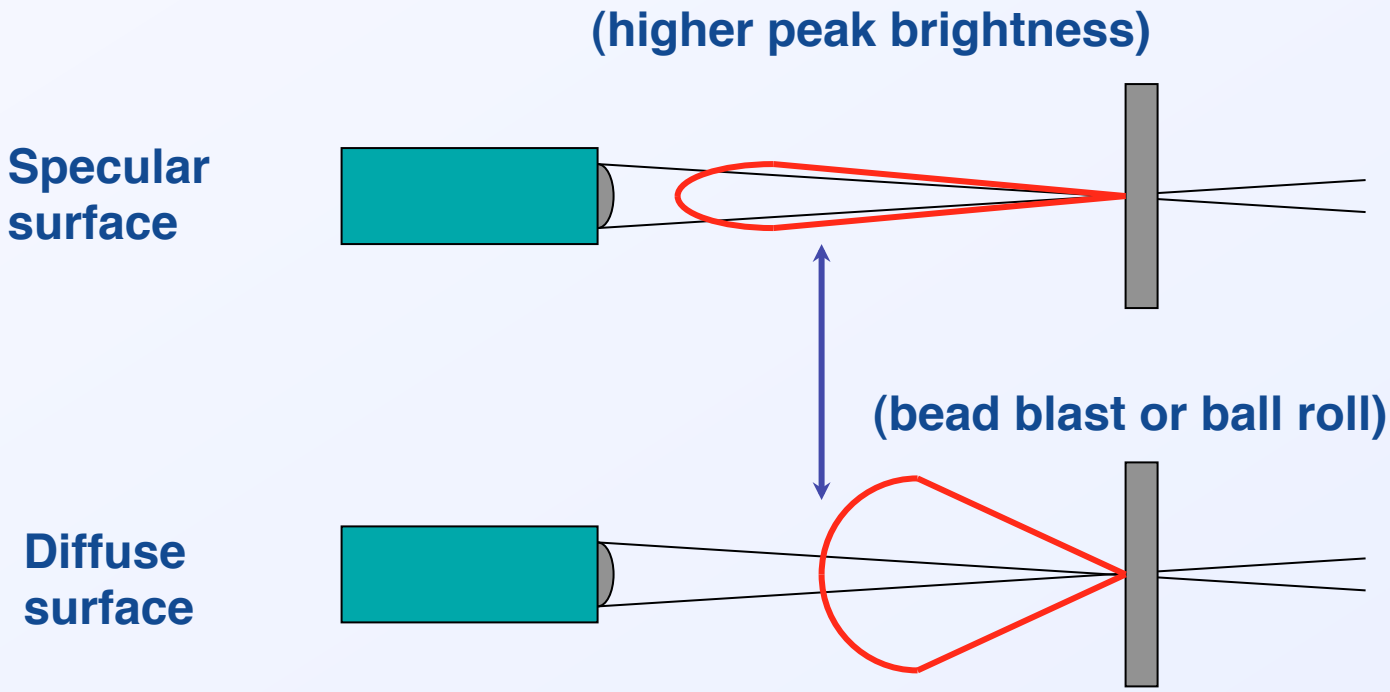
Large solid angle



Small solid angle

The red rays show the case for a specular surface, but the same principle applies to a diffuse surface.

Factors to consider--surface preparation



Specular surfaces generally go diffuse when shocked, so we often make a diffuse surface initially to avoid large drops in the signal returned to the probe.

This also helps with surfaces that tilt during the measurement.

Factors to consider--spot diameter

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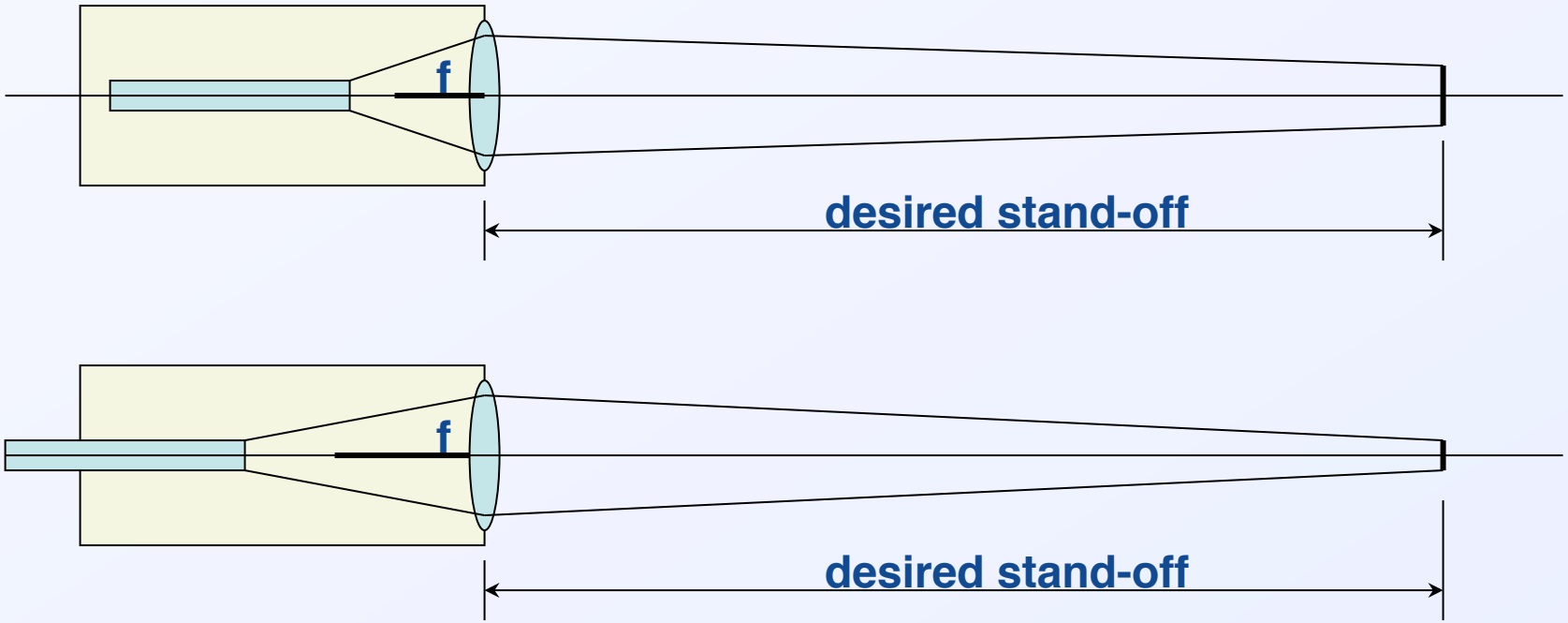
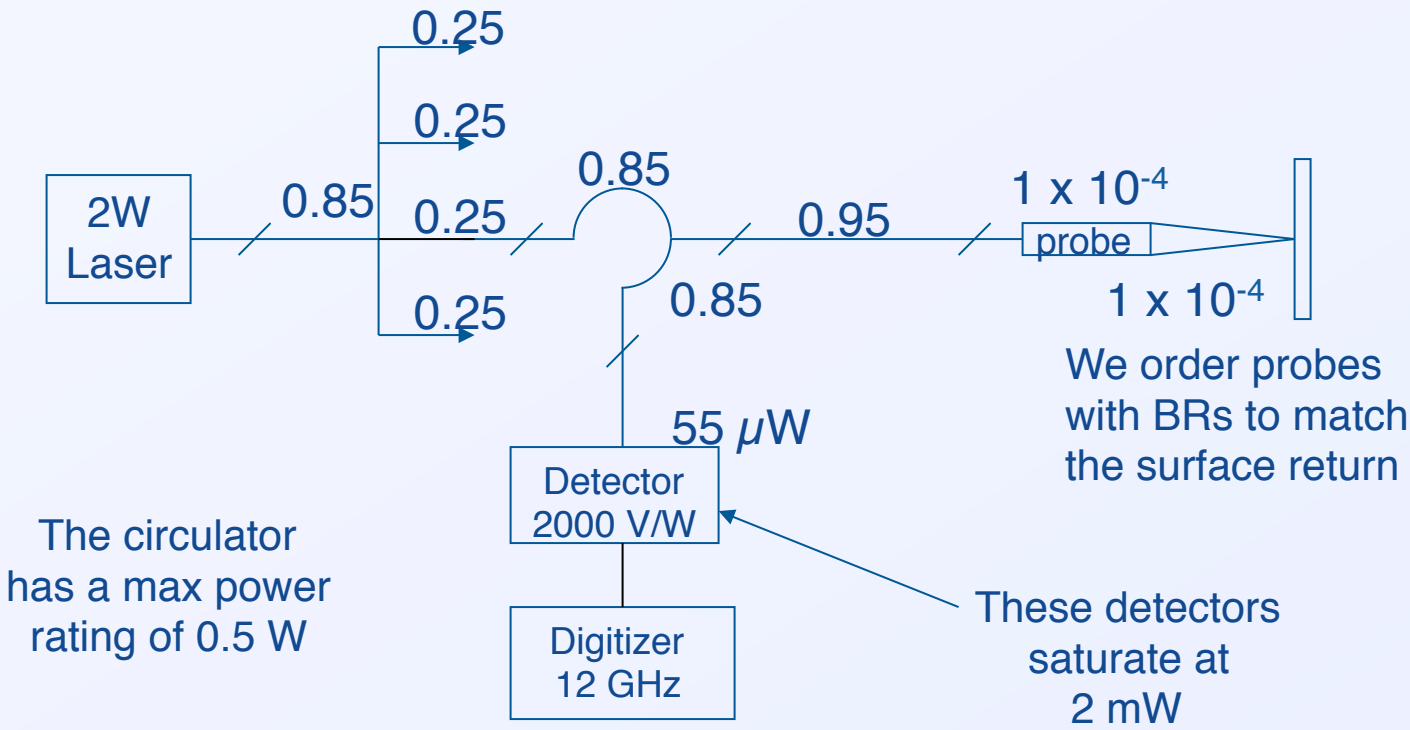
The focal length of the lens affects the spot size.



Some measurements require high spatial resolution at shock arrival, which means you want a small spot diameter.
Place the surface at the focal point to start the measurement.

Factors to consider--power budget

Historically, we use probes with 10^{-4} efficiency



The power budget for PDV is sufficient for probes with 10^{-4} efficiency

Factors to consider--probe back reflection

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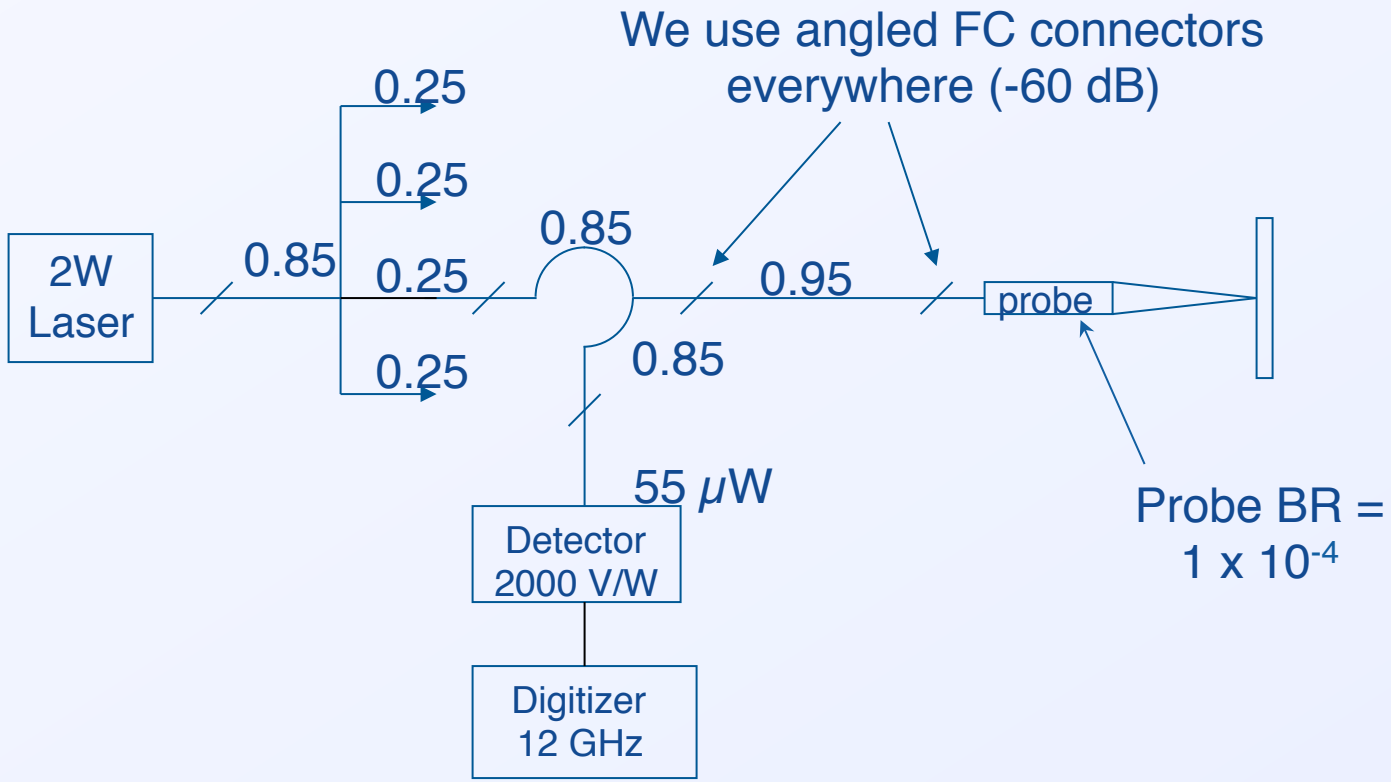
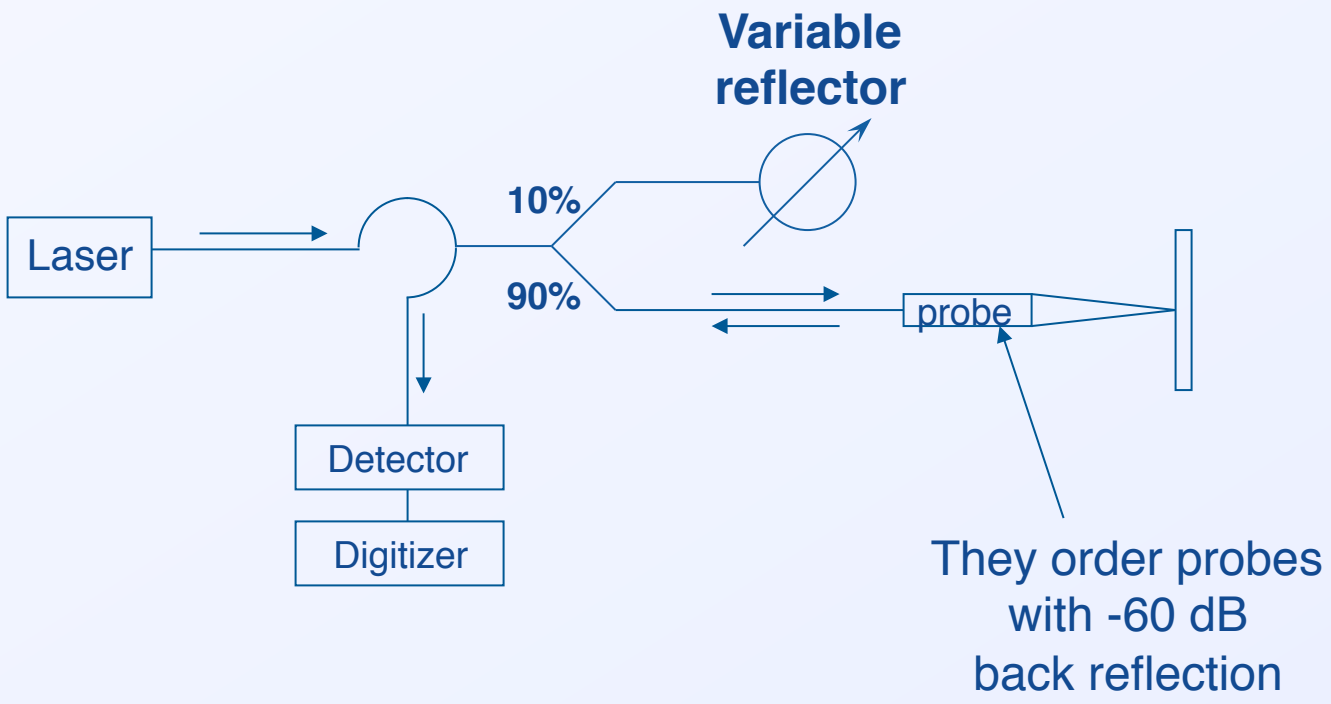
It is important to have only a single source of undoppler-shifted light



We have used probes with BR ranging from 0.04 to 10^{-4}

Factors to consider--probe back reflection

LANL uses probes with very low back reflection and an external variable source of undoppler-shifted light.



240-mm focusing probe

Oz Optics designed and built a custom probe that matched the physical dimensions and optical efficiencies of our FP probes

We quickly realized the advantage of buying probes rather than building them

Initial stand-off is usually 250 mm.

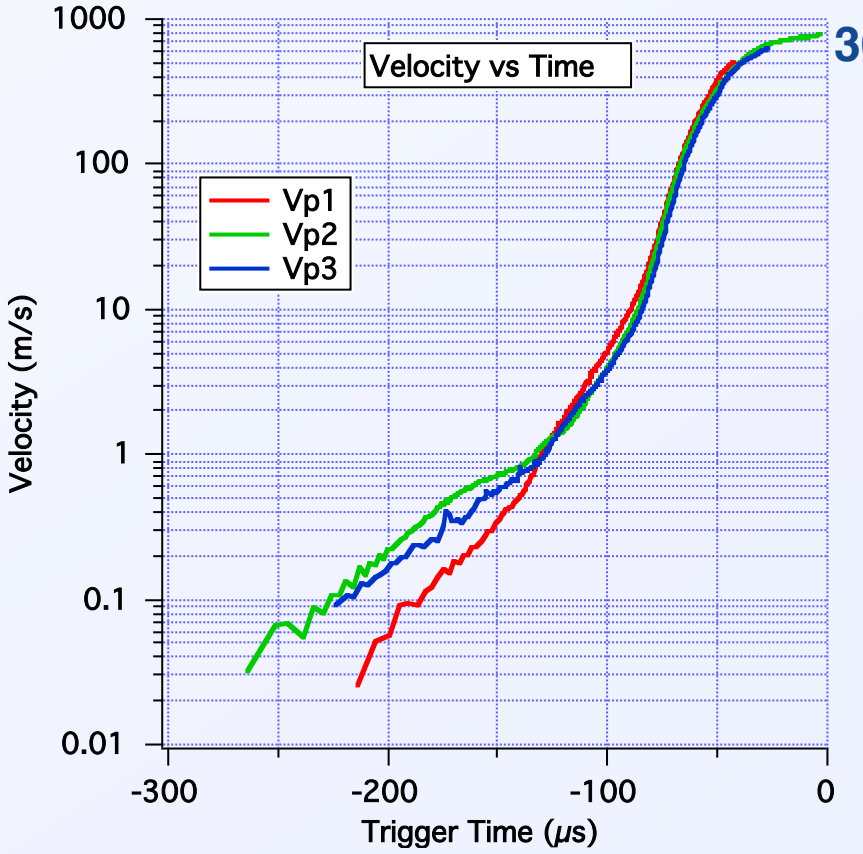
Probe body is 15 mm dia x 40 mm

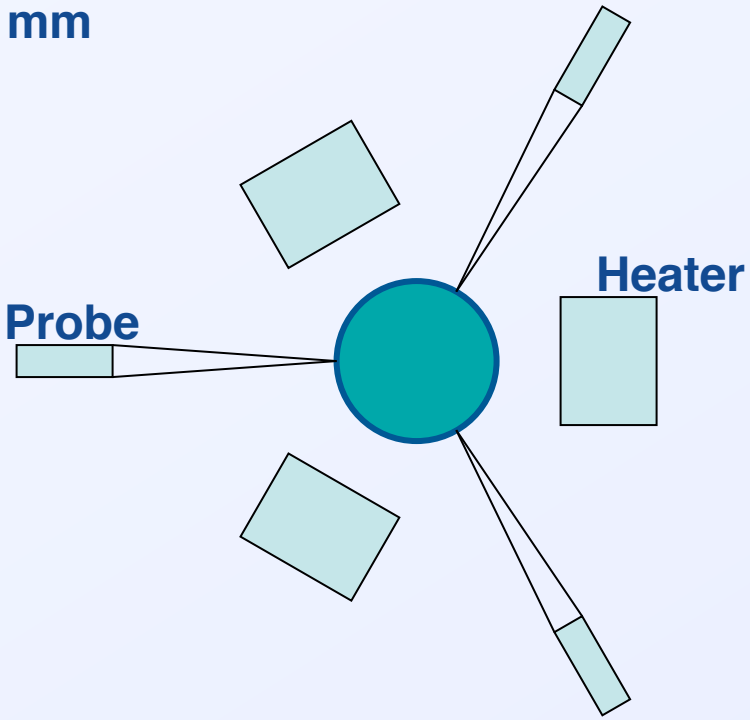
Lens dia = 12.5 mm
Focal length = 240 mm
Efficiency = 1.1 x 10^{-4}
BR = -40 dB
Spot dia = 90 μm

Oz Optics Part # LPF-OSP-1300/1550-9/125-S-8.7-240-25AC-40-3A-3-5

240-mm focusing probe

We use the 240-mm probes for cook-off experiments.
250-mm stand-off keeps the probes outside the heaters.





97-mm focusing probe

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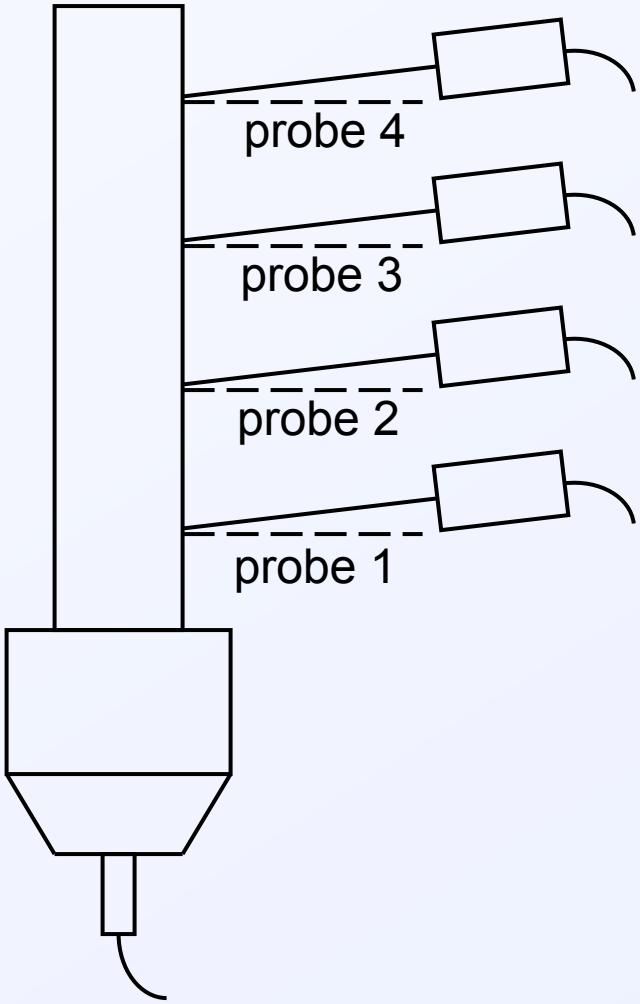
We use more 97-mm probes than any other size or type.
We usually set the initial distance at 102 mm from the surface.

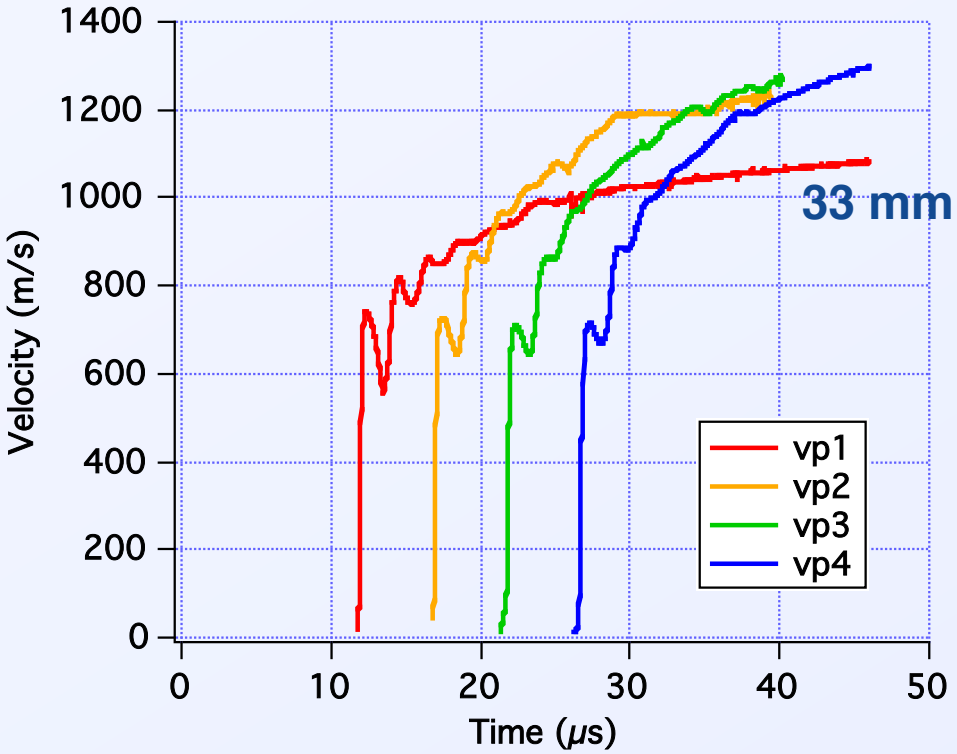
Probe body is
8 mm dia x 19 mm long

Lens dia = 5 mm
Focal length = 97 mm
Efficiency = 0.38 x 10^{-4}
BR = -40 dB
Spot dia = 150 μm

Oz Optics Part # LPF-04-1550-9/125-S-15-97-6.2AS-40-3A-3-5

97-mm focusing probe





5.5-mm focusing probe

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We sometimes have very small packages that require many probes

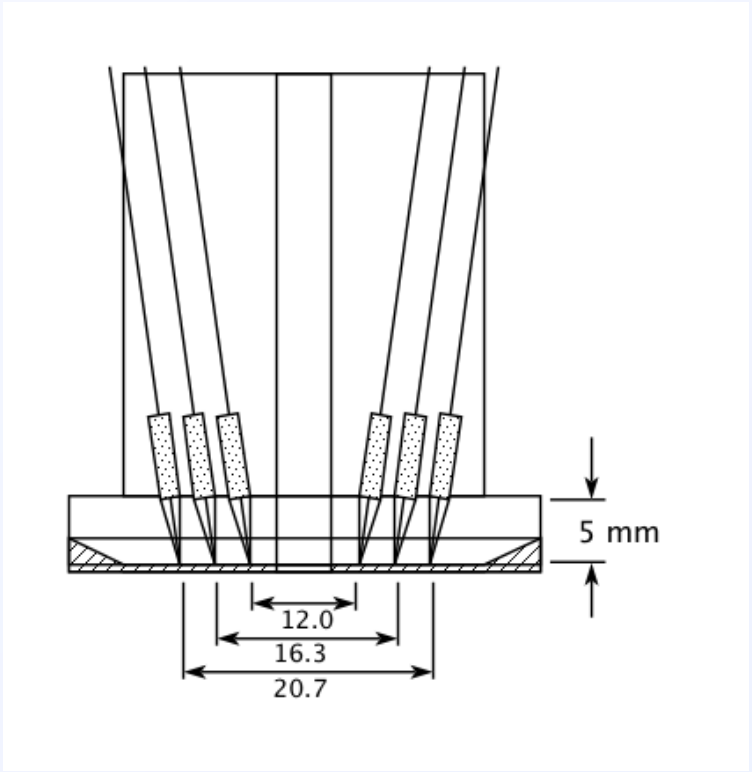
Probe body is
1.5 mm dia x 10 mm long

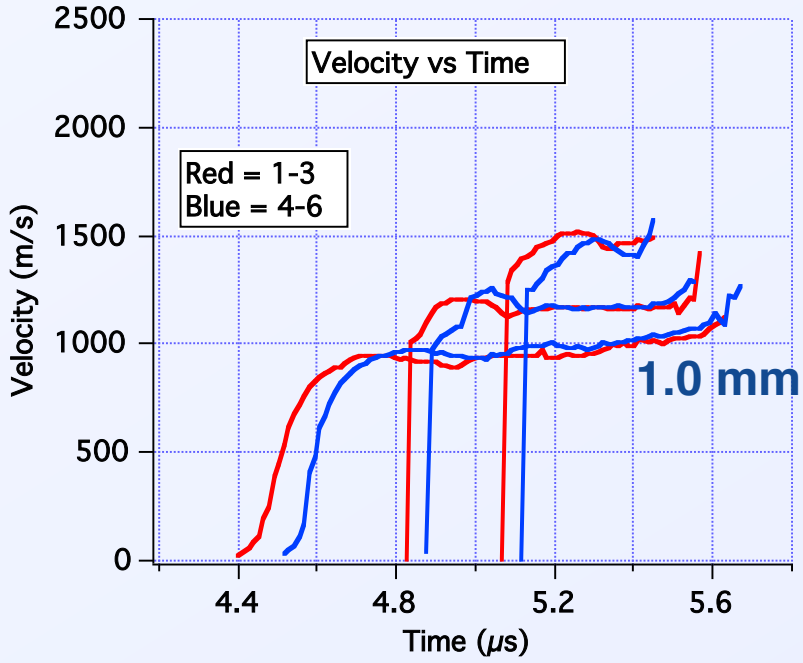
Lens dia = 1.0 mm
Focal length = 5.5 mm
Efficiency = 4.1 x 10^{-4}
BR = -15 dB (= 4%)
Spot dia = 50 μm

Oz Optics Part # LPF-07-1550-9/125-S-5-5.5-1.01GR-15-3A-1-2

5.5-mm focusing probe

This experiment required 6 measurements within 21 mm





0.5-mm proximity probe

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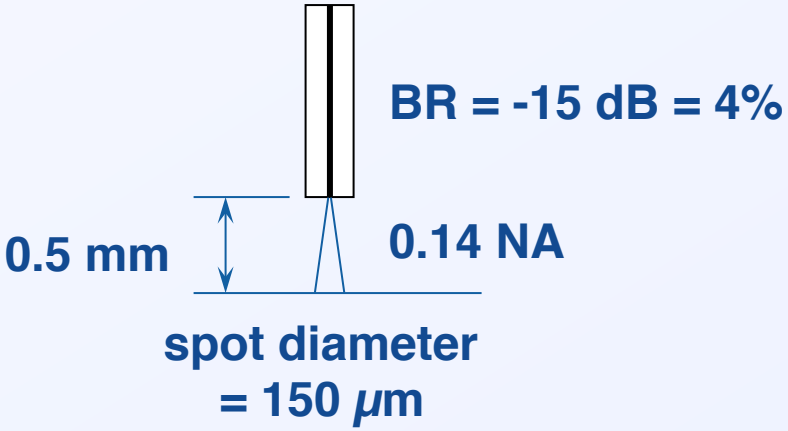
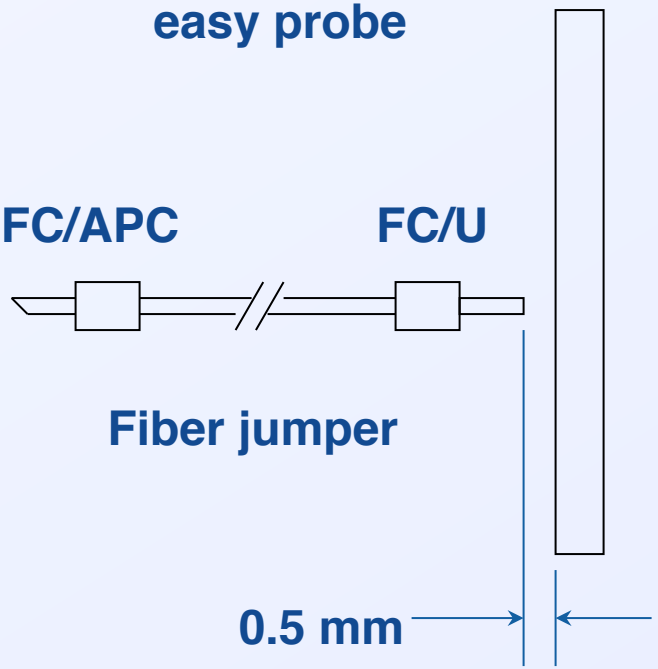
A bare fiber makes an effective probe for short-distance measurements



Efficiency = 0.33×10^{-4}

A simple fiber connector makes a quick and easy probe



0.5-mm proximity probe

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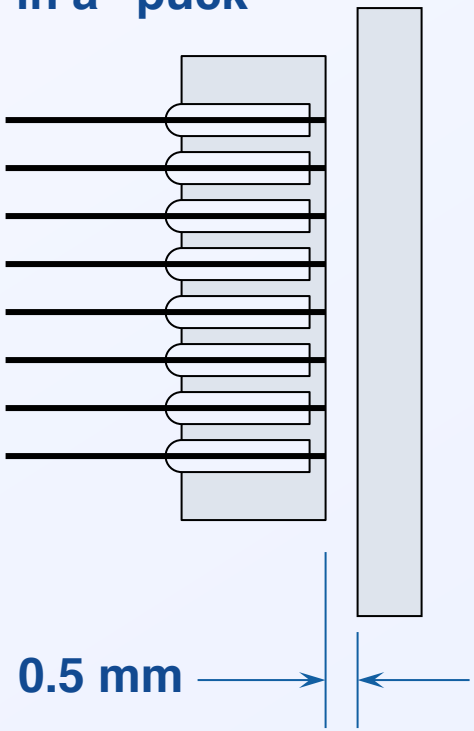
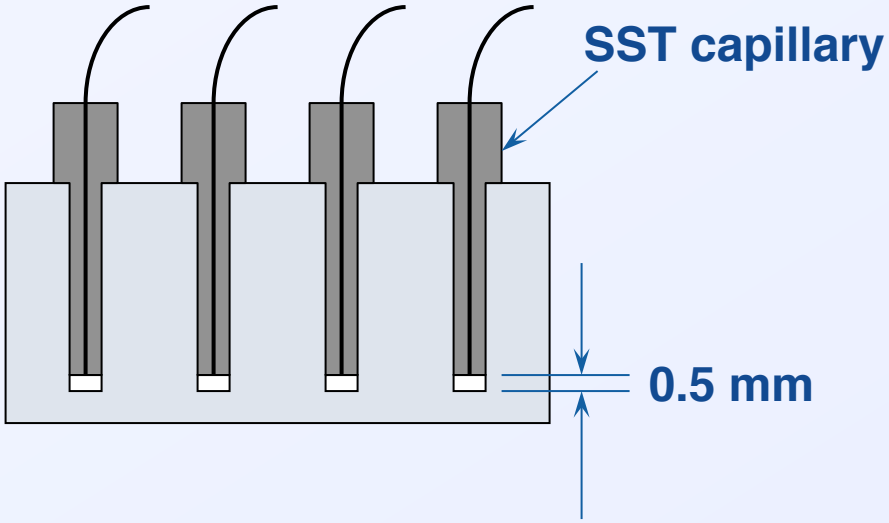
Glue the fibers into different assemblies and polish the ends

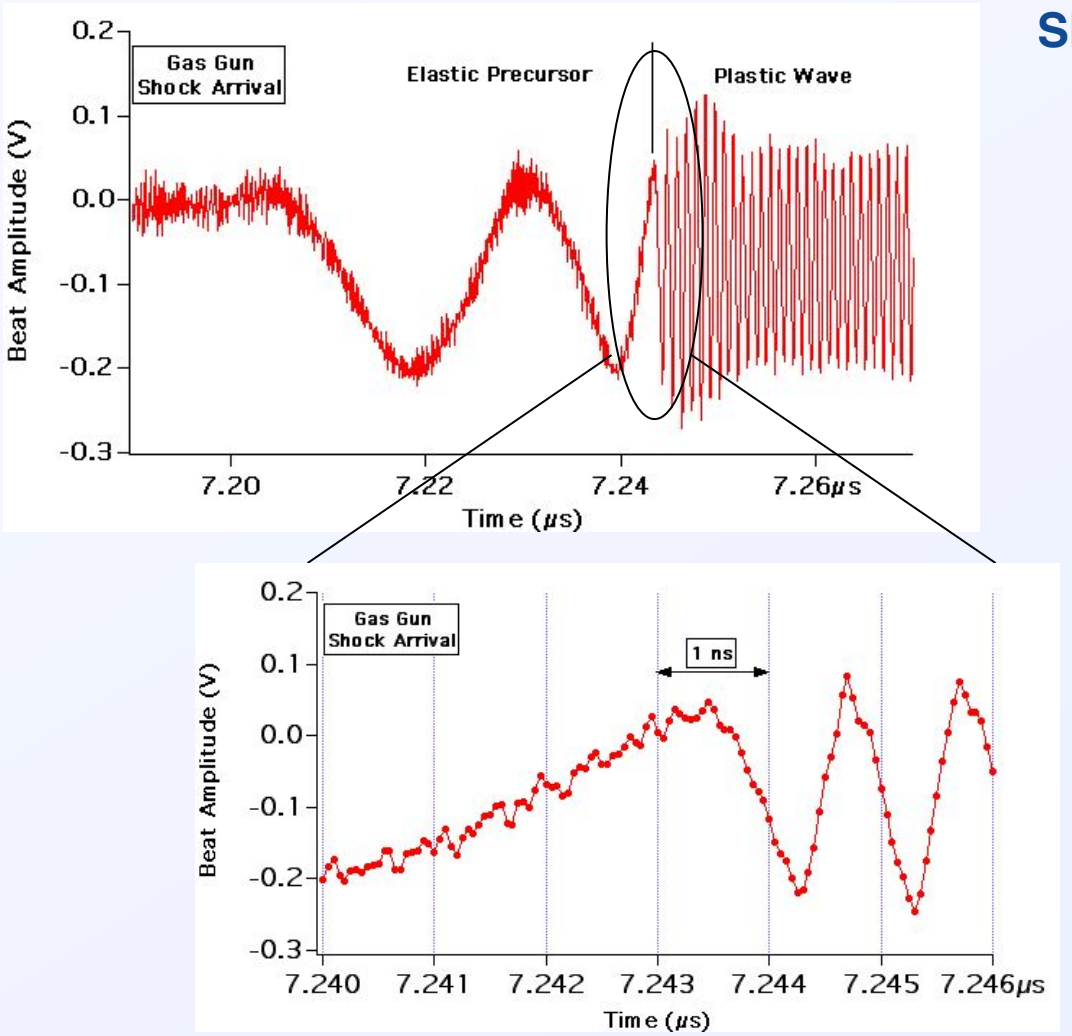
Multiple fibers in a "puck"



Individual fibers glued into holes

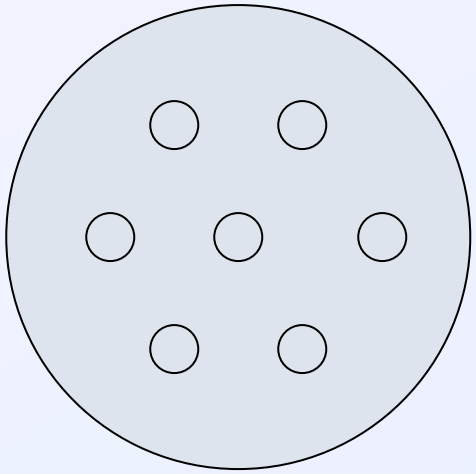


0.5-mm proximity probe



Shock arrival measurement on a gas gun

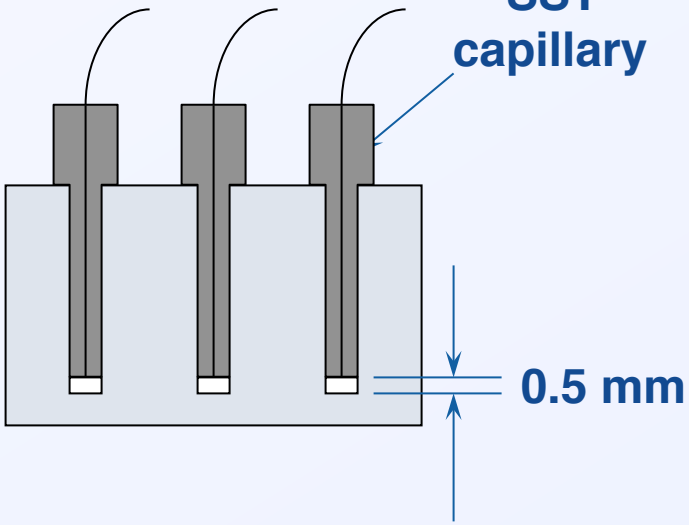
7 fibers glued into a puck



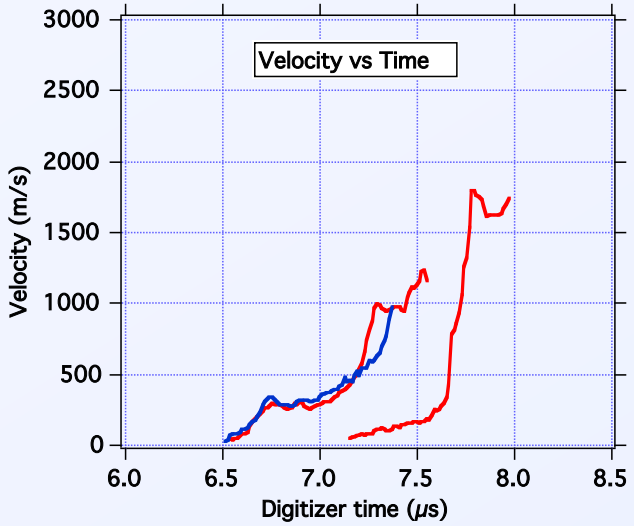
100 ps standard deviation among 7 probes

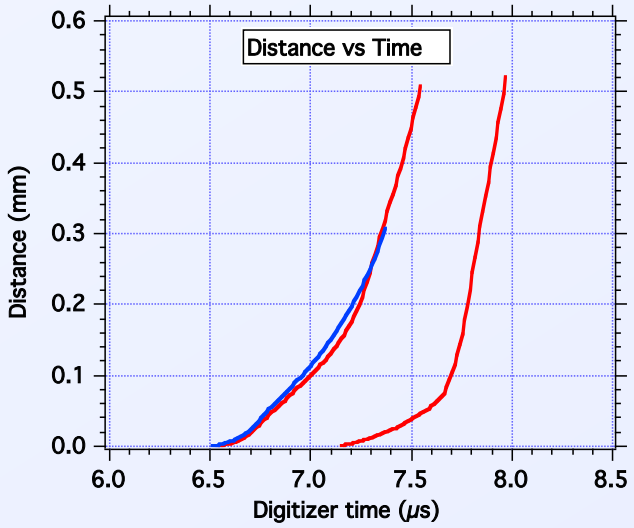
0.5-mm proximity probe

Individual fibers glued into holes



Capillaries are made by Vita Needle Company 1/16” OD x 0.020” wall thk





Summary and Conclusions

WCI WEAPONS AND COMPLEX INTEGRATION

Factors to consider include: distance to follow surface, surface tilt, physical space, surface preparation, power budget

We use a wide variety of commercially-available probes for PDV
240 mm, 97 mm, 5.5 mm

A bare fiber at a distance of 0.5 mm makes an effective probe

Focusing probes can usually follow the surface for 15 - 30% of the initial probe-to-surface distance