Can we fake a signal with gratings, and what happened to $1/r^2$?

Experiments: Steve Hare, Mike Shinas, Matt Briggs

Interpretation discussions: David Holtkamp, Dan Dolan, Jim Faulkner, Mike Shinas, Willard Hemsing, Larry Hull.

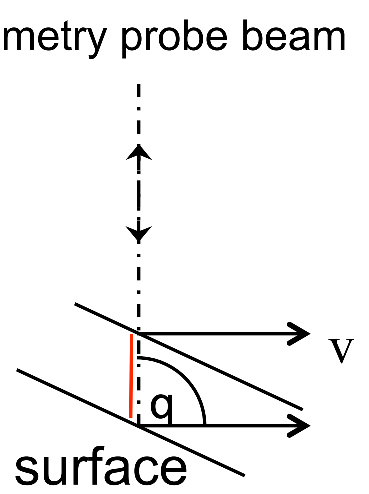
Abstract

Although PDV is a displacement interferometer, PDV does not see motion from a diffusely scattering surface approaching the probe if the motion is due to transverse motion of an angled surface. We reported this result at last years PDV workshop in Sandia. Our initial speculation of the cause was that surface roughness is randomizing the phases. Since then, this notion has been bolstered by Dan Dolan's analysis and experiments. By considering a phasor picture, it appears we should be able to trick PDV into measuring a signal with a stepped surface moving transversely. We report on our first attempts to do this using our Pea Shooter. We also update Mike Shinas report from last year on probe efficiencies, and note an apparent problem in the results.

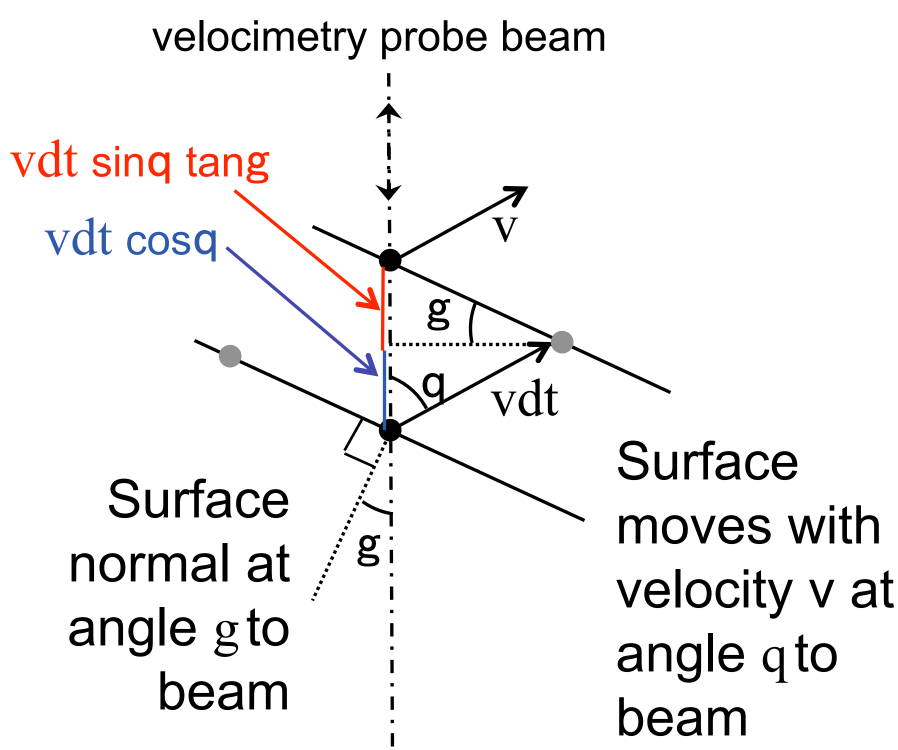
PDV: only the component of velocity along beam

Our bullet shots from last year showed that PDV measures only the component of velocity along the beam; despite being a displacement interferometer, it fails to observe the displacements shown in red.

$$v_{\text{observed}} = v\cos q = 0$$

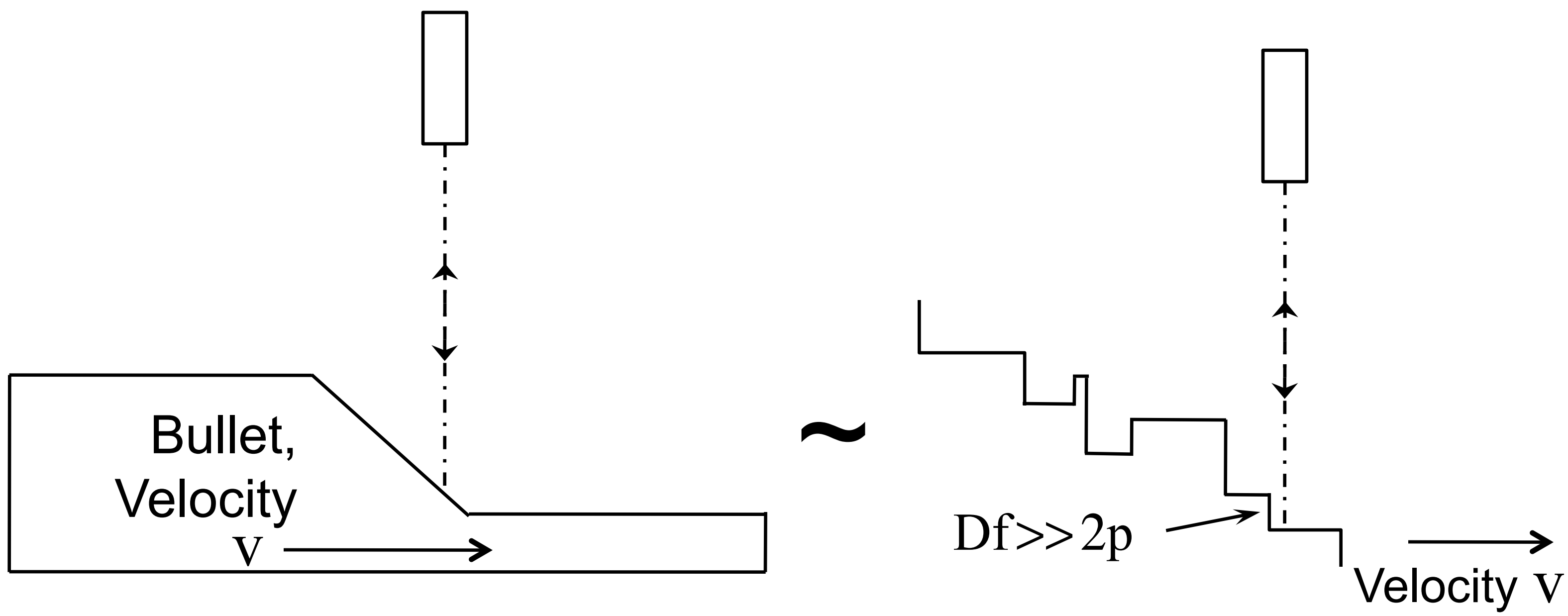


$$v_{\text{observed}} = v\cos q$$



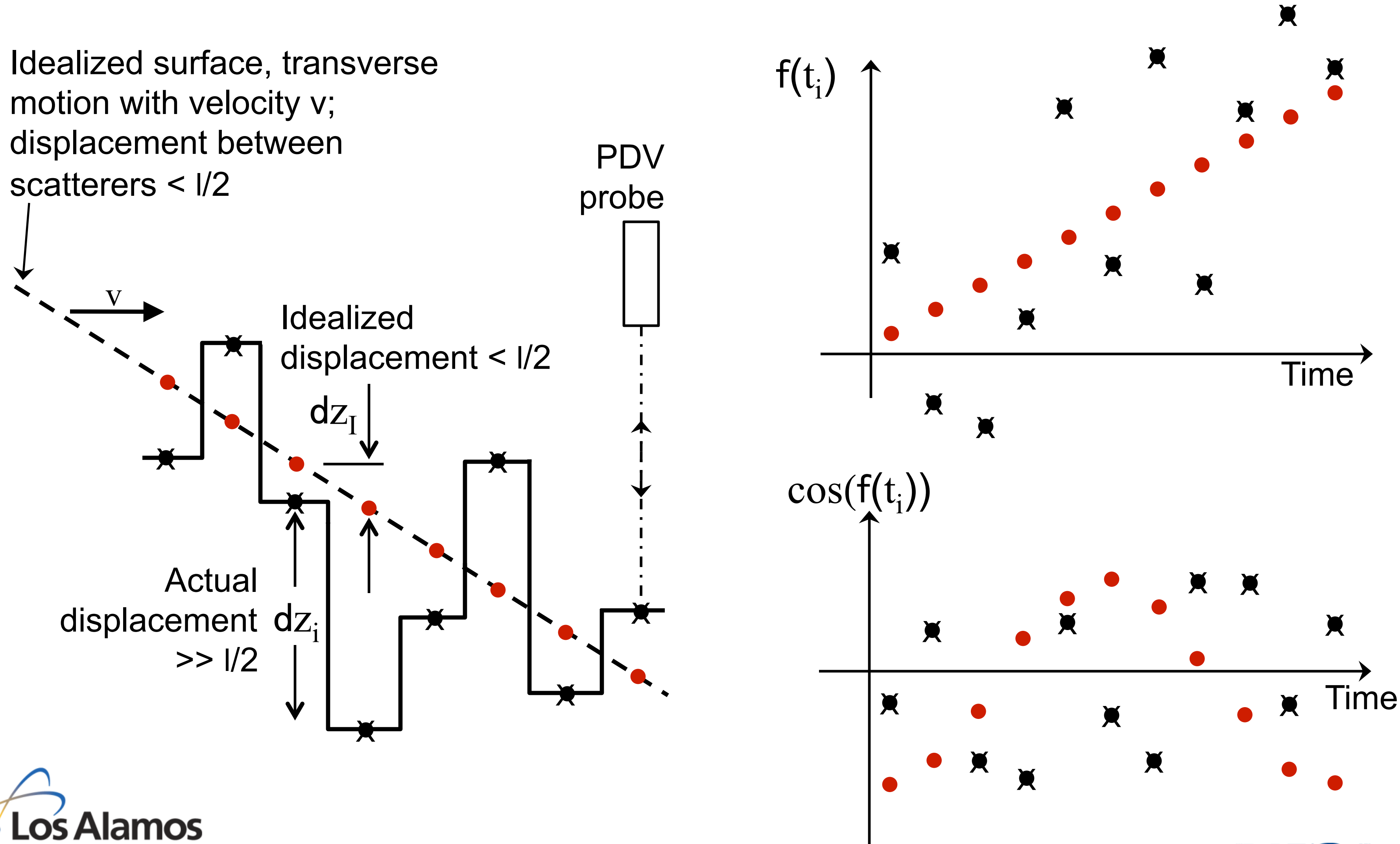
Why do we see zero velocity despite DL ≠ 0?

Idealized, the light we see comes from a series of facets that make up the sloping bullet surface. For a real surface, the jumps are >> 1550 nm, so the phase will appear to bounce around at random.



Compare Idealized to Realistic Surface

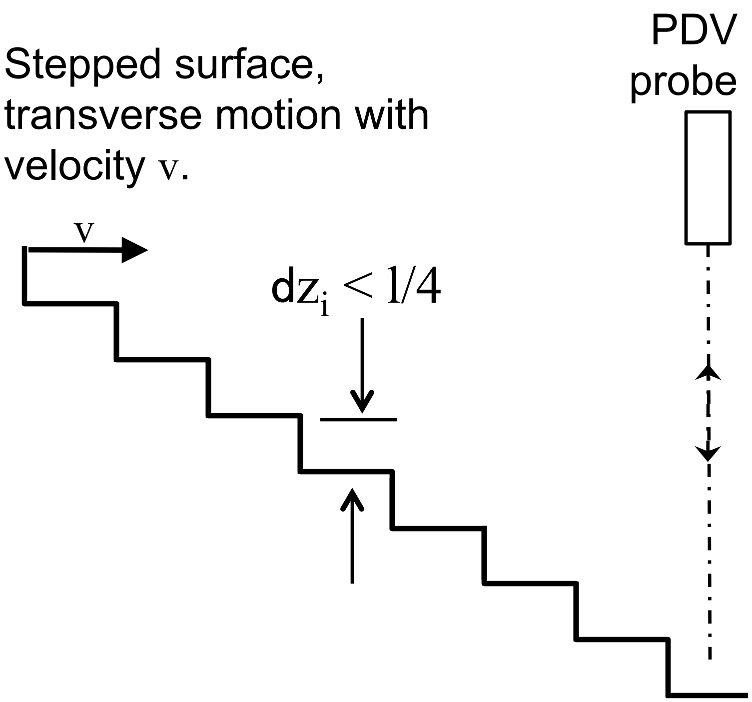
PDV Signal ~ $\cos(f_{target}(t))$; Narrow Beam $f(t_i) = 4pz_i/l$; l = 1.5 mm.

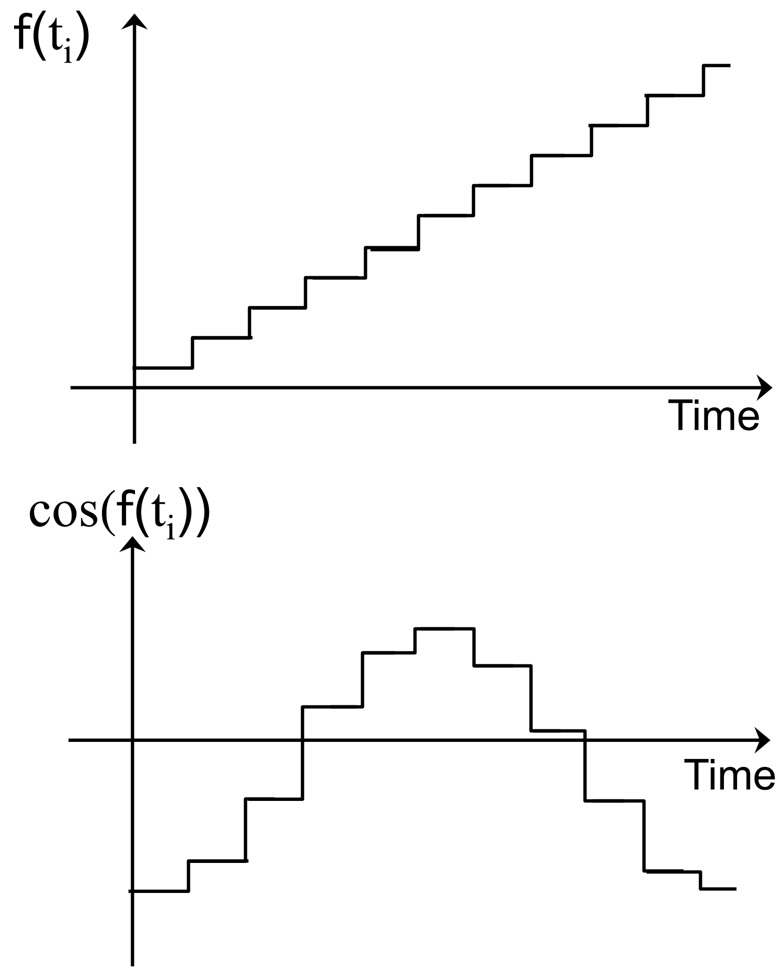


PDV from transverse motion of a stepped surface?

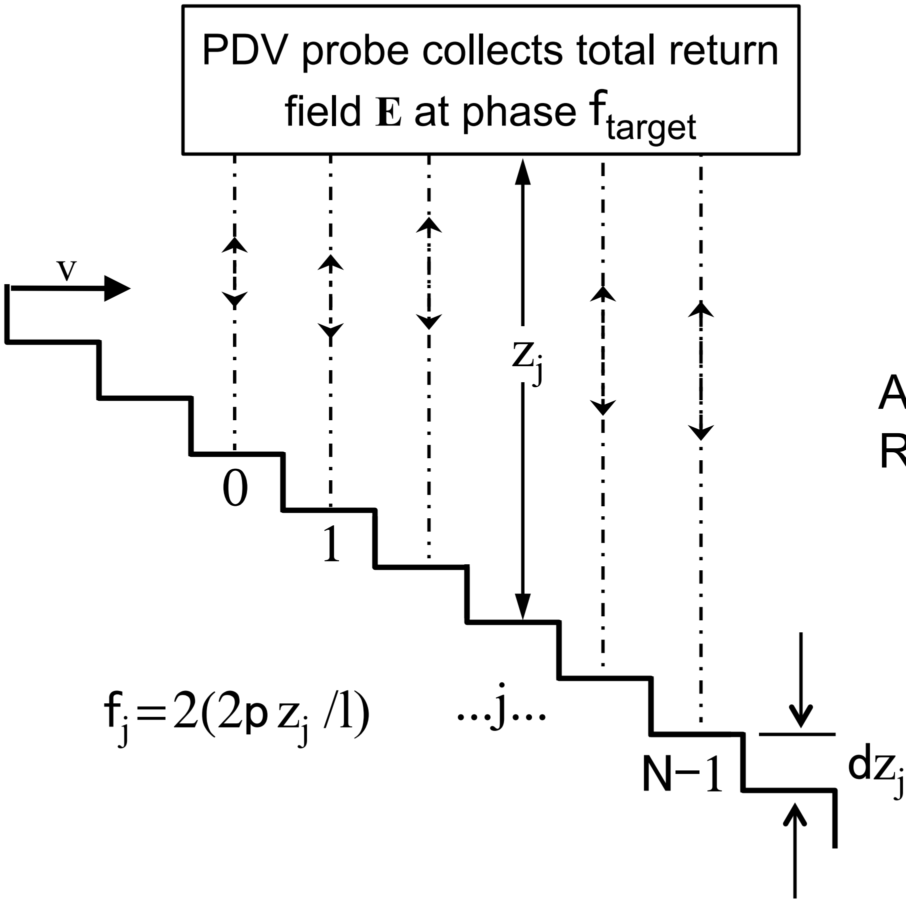
PDV Signal ~ $\cos(f_{target}(t))$; Narrow Beam $f(t_i) = 4pz_i/l$; l = 1.5 mm.

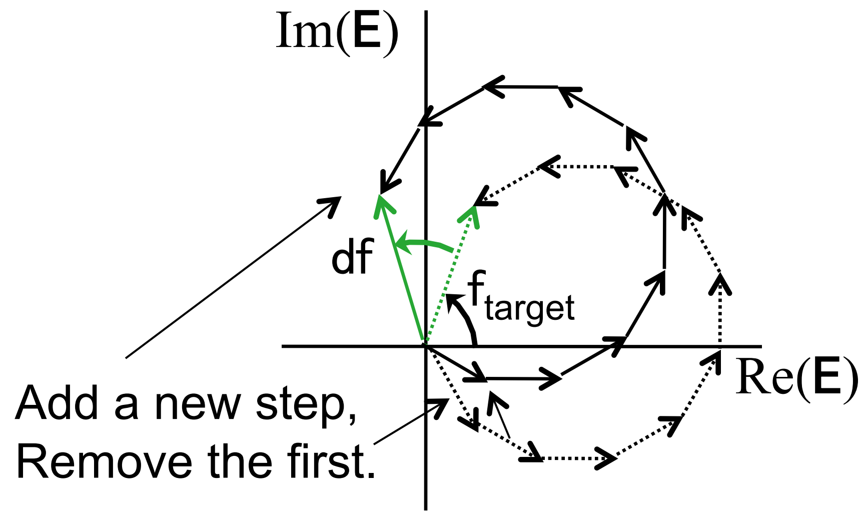
Stepped surface, transverse motion with velocity v.





It might be OK that beams are not so narrow

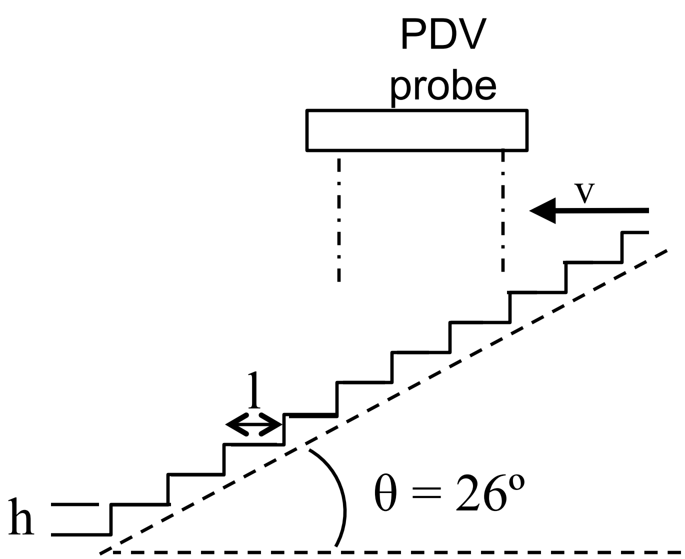




$$\mathbf{E} \sim \Sigma_j\, e^{-2ik\,z_j(t)}$$
$$= \Sigma_j\, e^{-2ik\,(z_0(t)\,+\,j dz)}$$
$$= e^{-2ik\,z_0(t)}\,\Sigma_j\, e^{-2ik\,j dz}$$
$$= e^{-2ik\,z_0(t)}\,\Sigma_j\,(e^{-2ikdz})^j$$

$$= e^{-2ik\,z_0(t)}[\sin(Ne/2)/\sin(e/2)]$$
(with e = 2kdz)

Will [sin(Ne/2)/sin(e/2)] allow a signal?



Grating: 1200 steps/mm, 26º blaze
Beam: 30 μm diameter at grating; 40 steps

l = cos(26º)/1.2 steps/μm = 0.75 μm;
h = sin(26º)/1.2 steps/μm = 0.37 μm

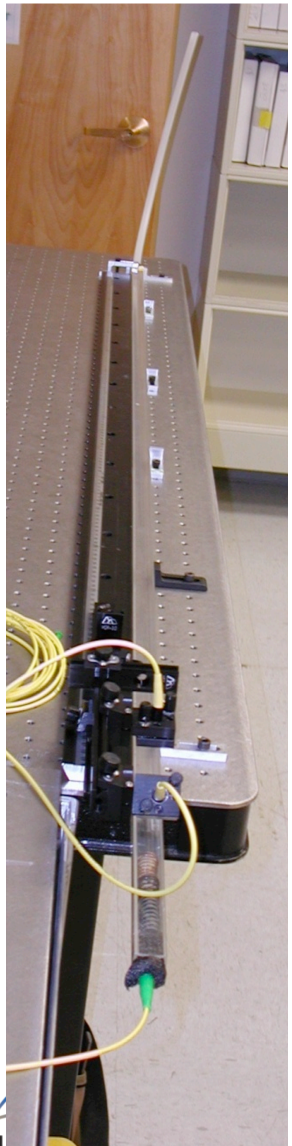
$\boxed{h = 0.24*l}$

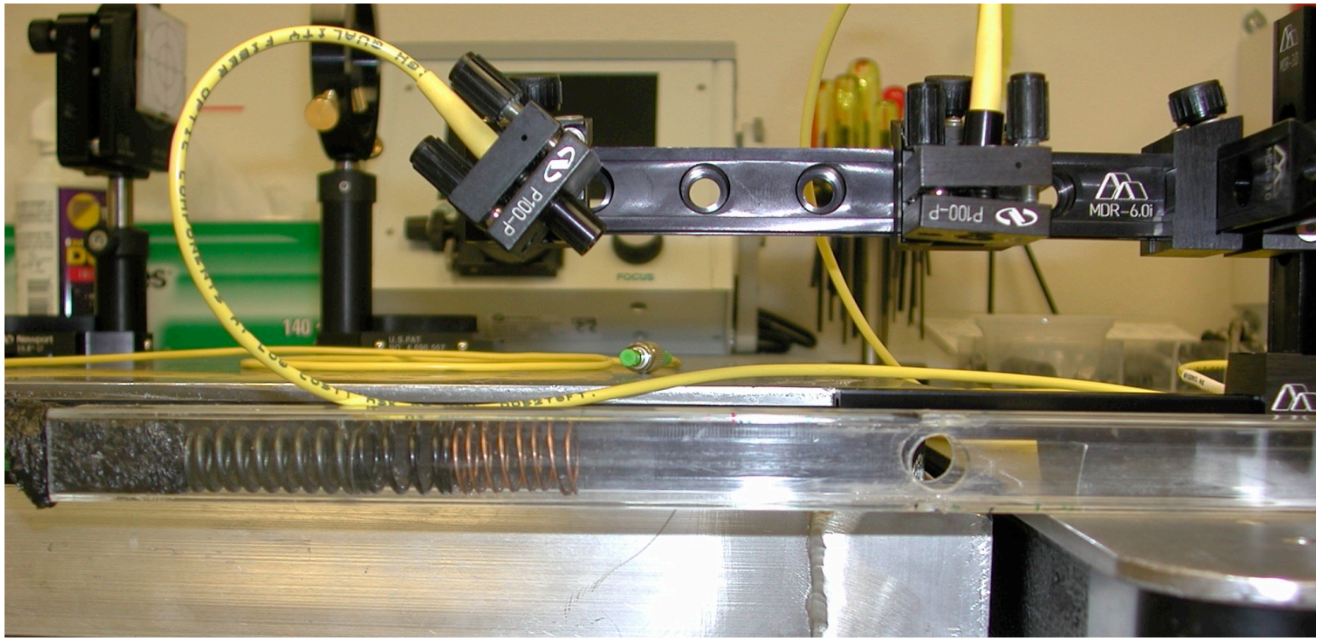
e = 4ph/l= 3.0 rad; N = 40

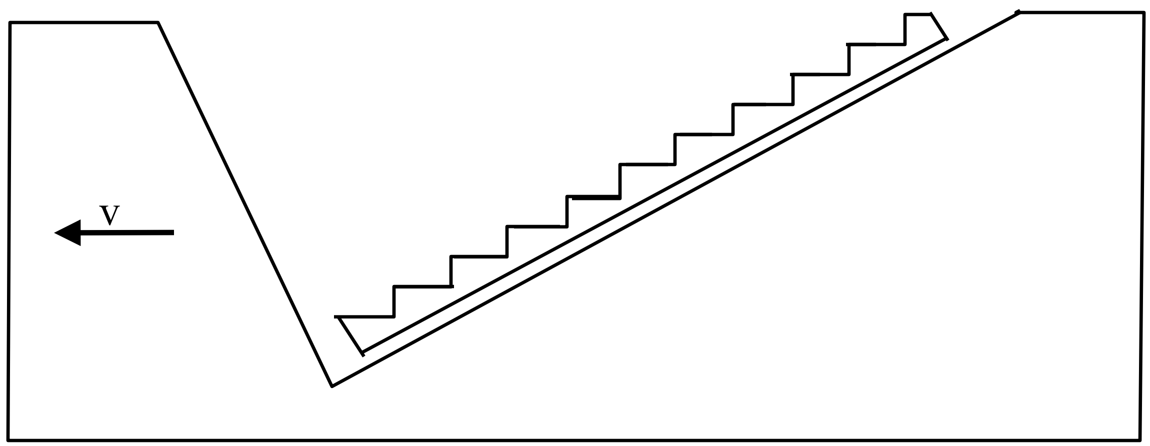
sin(Ne/2)/sin(e/2) = 0.31 (~ 1/100 of diffraction peak)

Velocity measured = v*tan(26º) = 0.5 v ?

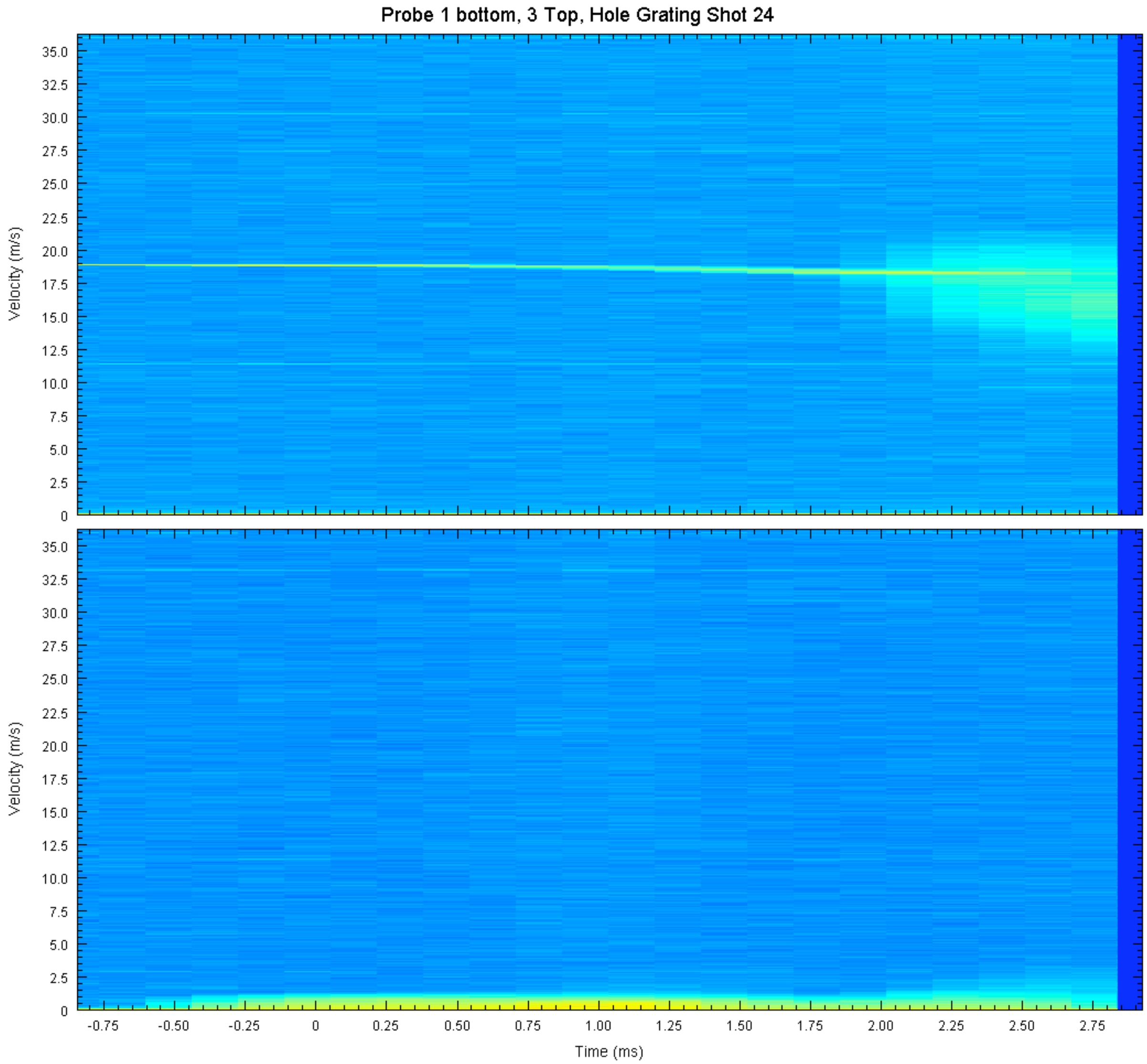
Pea Shooter







Grating Result: velocity not seen



Update on PDV probe efficiency study using the Luna Optical Backscattering Reflectometer

PDV Workshop
November 5th & 6th 2009

Presented by: Michael A. Shinas
LANL, HX-4

Michael Shinas, Matt Briggs, Steve Hare

Abstract

This PDV probe efficiency study collected plots of back reflection vs. distance on many different type of PDV probes used at HX-4. An optical test stand was constructed for this work, which consisted of a probe holder, translation stage, opal diffuser and an Optical Frequency Domain Reflectometry (OFDR). Four new probes were evaluated on this test stand in 2009. The plots presented in this talk were created by taking backscatter measurements off an opal diffuser at a 3° wedge and then moving to new locations and repeating the backscatter measurement. The diffuser was measured to have a uniform diffuseness of ± .5 dB.

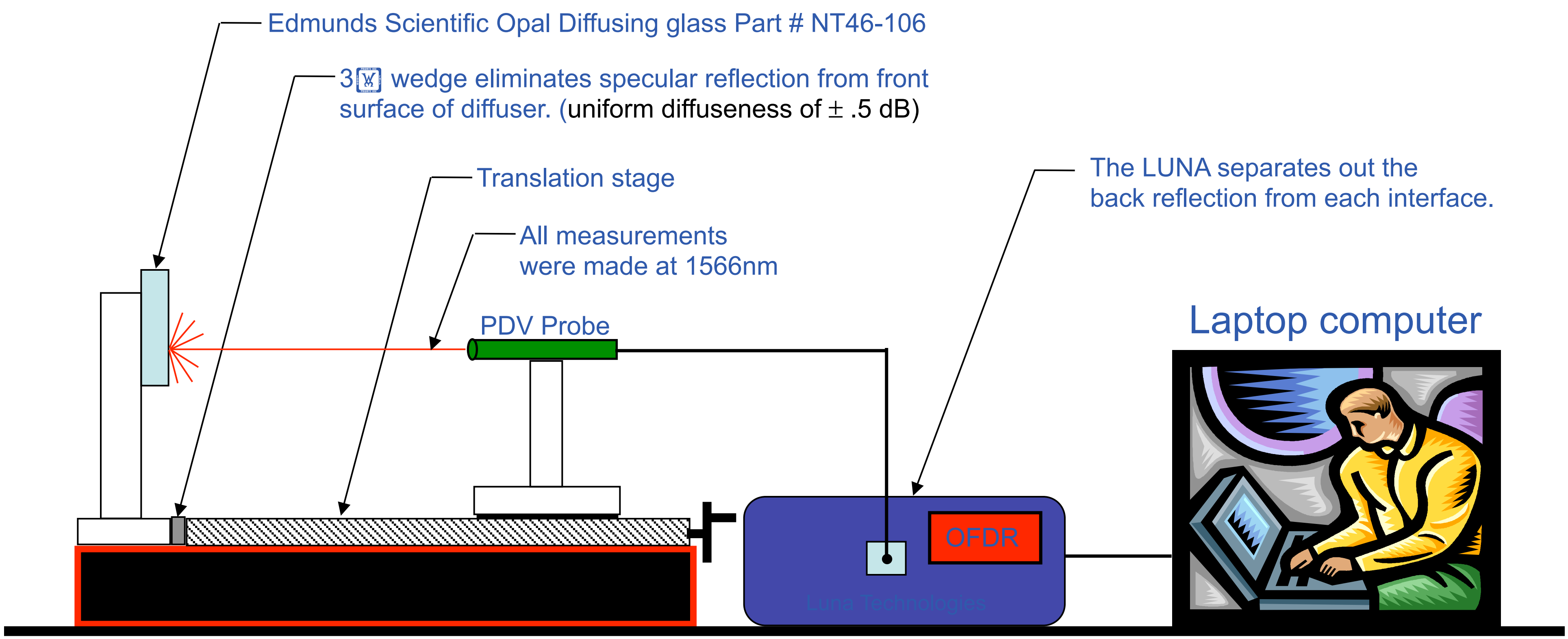
Outline

- Goal
- Describe the Probe test stand
- Show some examples of the Luna Analysis software
- Types of PDV probes tested
- Present Data

Goal

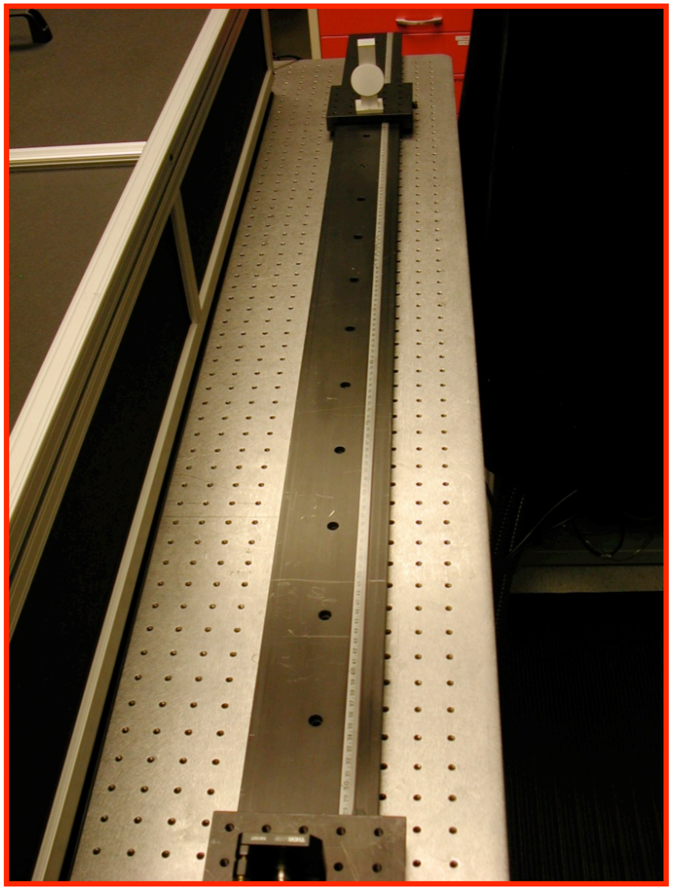
- The goal of this study is to compare the collection efficiency of different PDV probes using the same uniform diffuse surface.

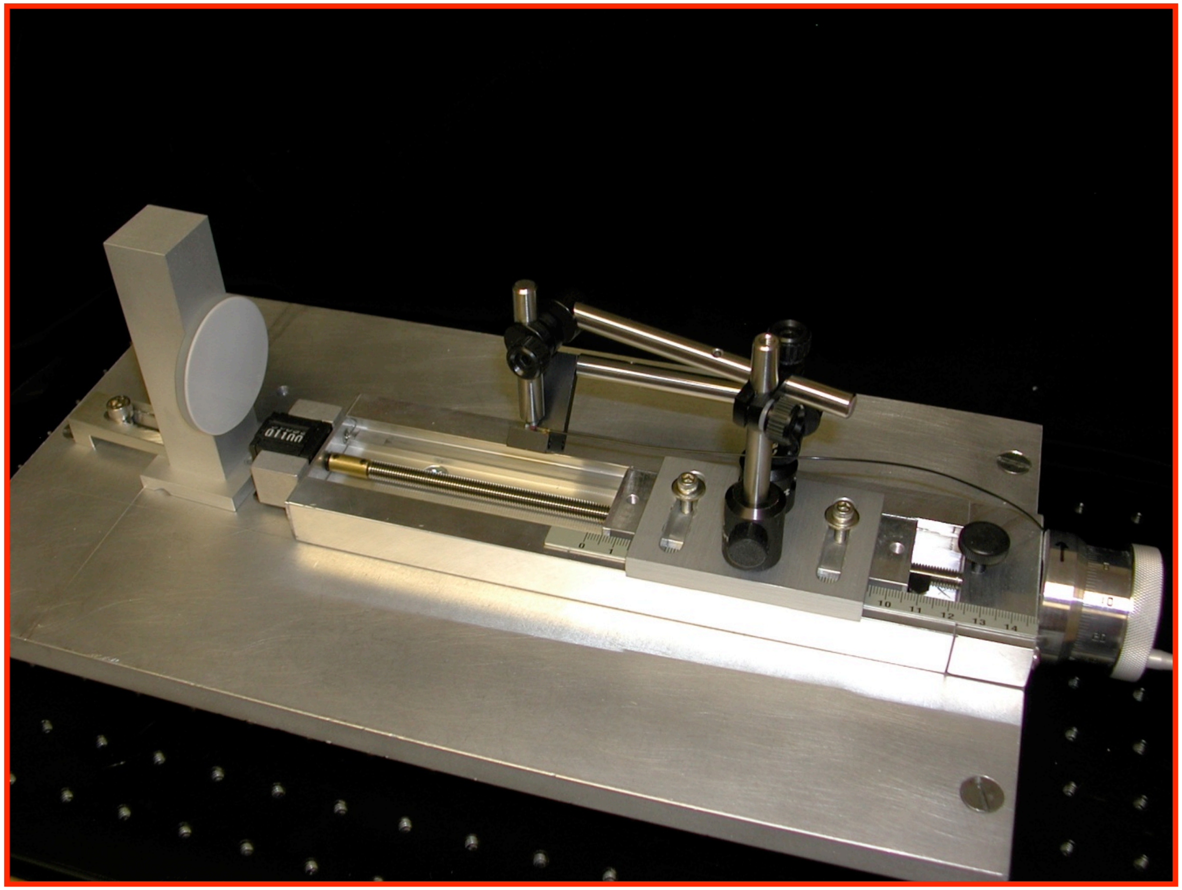
Schematic of Probe Test Stand



Los Alamos NATIONAL LABORATORY EST. 1943

Photos of probe test stand.





Luna Desktop Analysis software

Backreflection From fiber

Back of lens

Front of lens

Scan from a 8 mm OZ probe 50mm WD

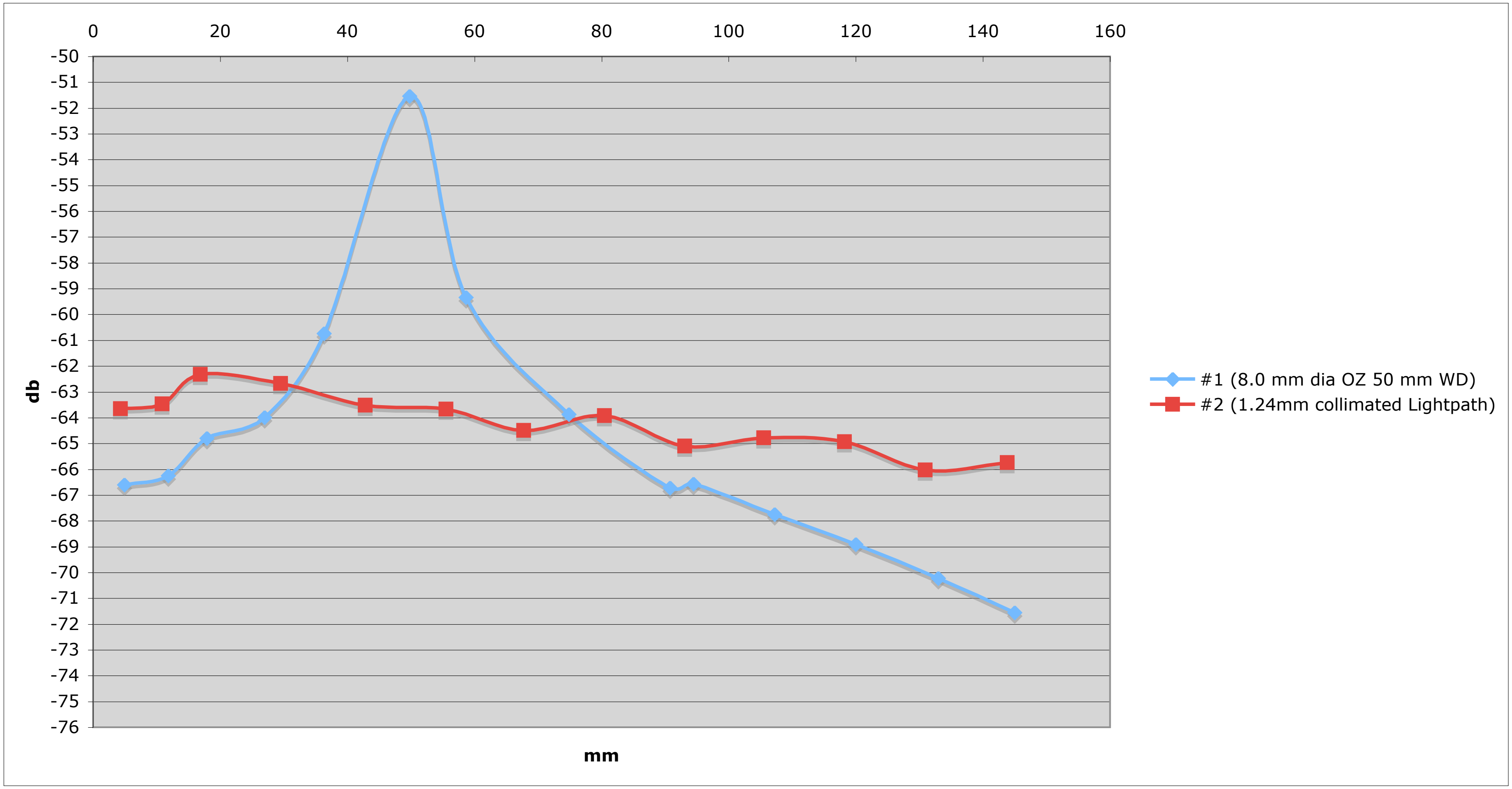
dX

Loss

Diffuser

A calibration gold metal reflector measured -.68 dB at the beginning of test.

Typical curves



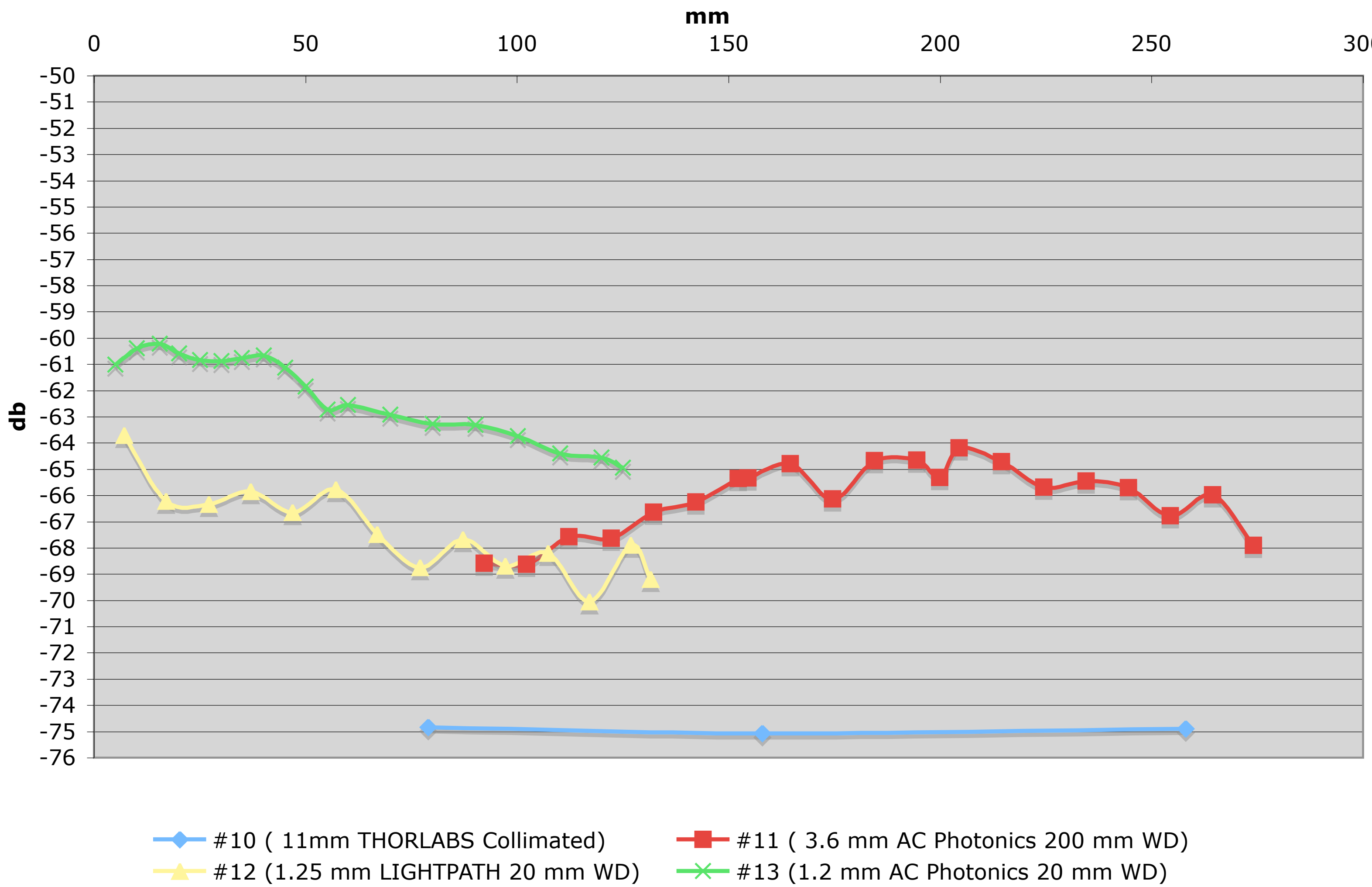
Types of PDV probes tested in 2008

Probe Number	Collection Optic OD mm	Probe OD mm	Manufacture	Manufacture part #	Working Distance mm
1	1.95	2.4	OZ	LPF-05-1550-9/125-S-12-75-5AS-60-3A-3-5	75
2	1.95	4.0	OZ	LPF-01-1550-9/125-S-12-75-5AS-60-3A-3-5	75
3	7.12	8.0	OZ	LPF-04-1550-9/125-S-6-75-11AS-60-3A-3-2	75
4	1.8	2.4	AC Photonics	1CL15P100CC01-CL	100
5	1.25	1.24	Light Path	T1005Y0S1	Collimated
6	1.8	2.4	AC Photonics	1CL15P20LSC01-3M	20
7	NA	1.5	NSTec	Drawing # 311235-04 Polished 8[illegible]	< 5
8	7.12	8	OZ	LPF-04-1550-9/125-S-7.4-50-6.2AS-60-3A-3-2	50
9	6.4	11	THORLABS	F260FC-1550	Collimated

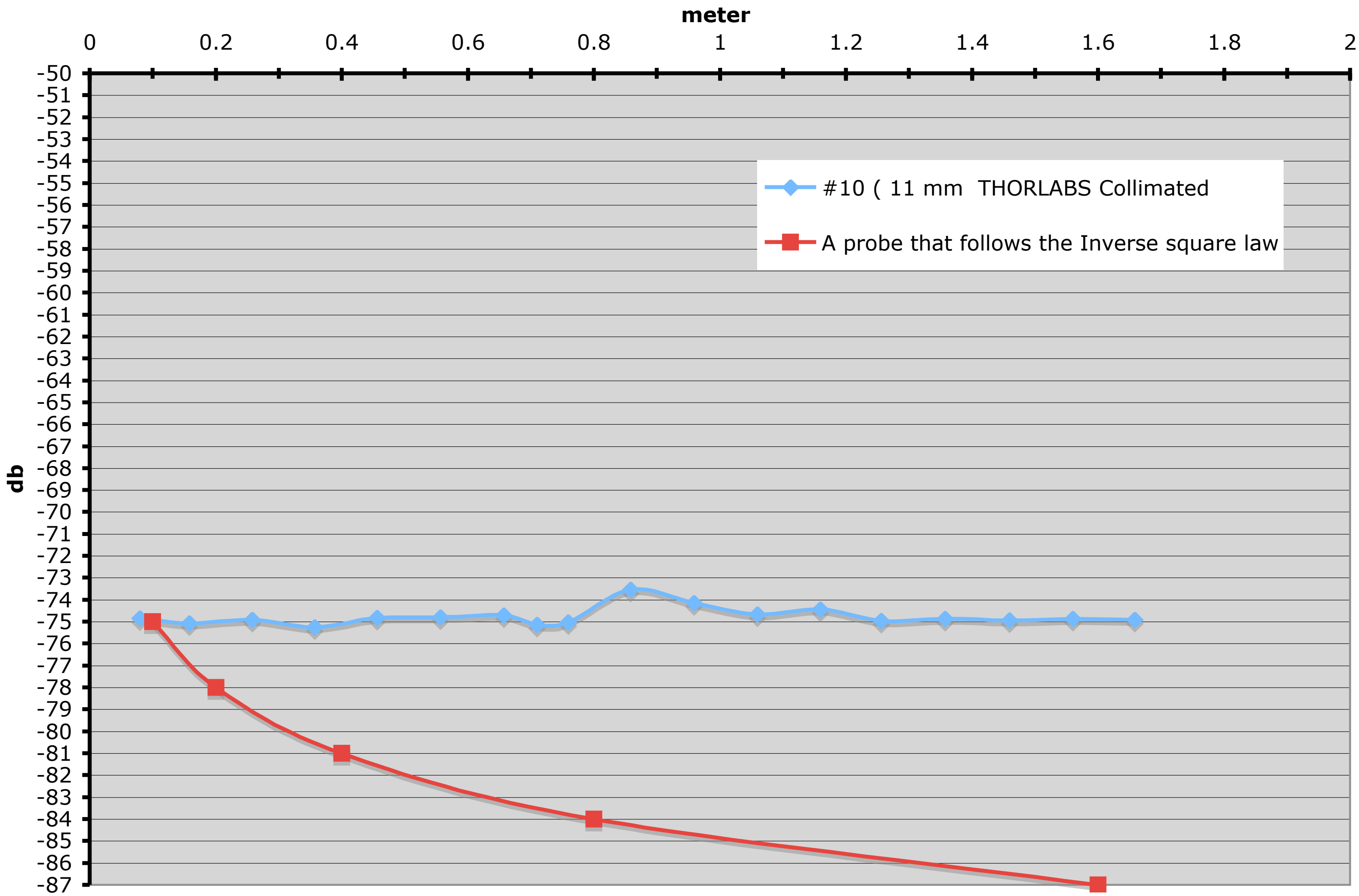
New probes tested in 2009

Probe Number	Collection Optic OD mm	Probe OD mm	Manufacture	Manufacture part #	Working Distance mm
10	6.4	11	THORLABS	F260APC-1550	Collimated
11	2.79	3.6	AC Photonics	1CL15P200LCC01-FC1	200
12	1.25	1.25	LIGHTPATH	T1005Y0S1-50A	20
13	1.2	1.2	AC Photonics	1CL15P020LxH01-BLK	20

Plots of back reflection vs. distance 2009



Plots of back reflection vs. distance THORLABS Collimated



Plots of all Probes