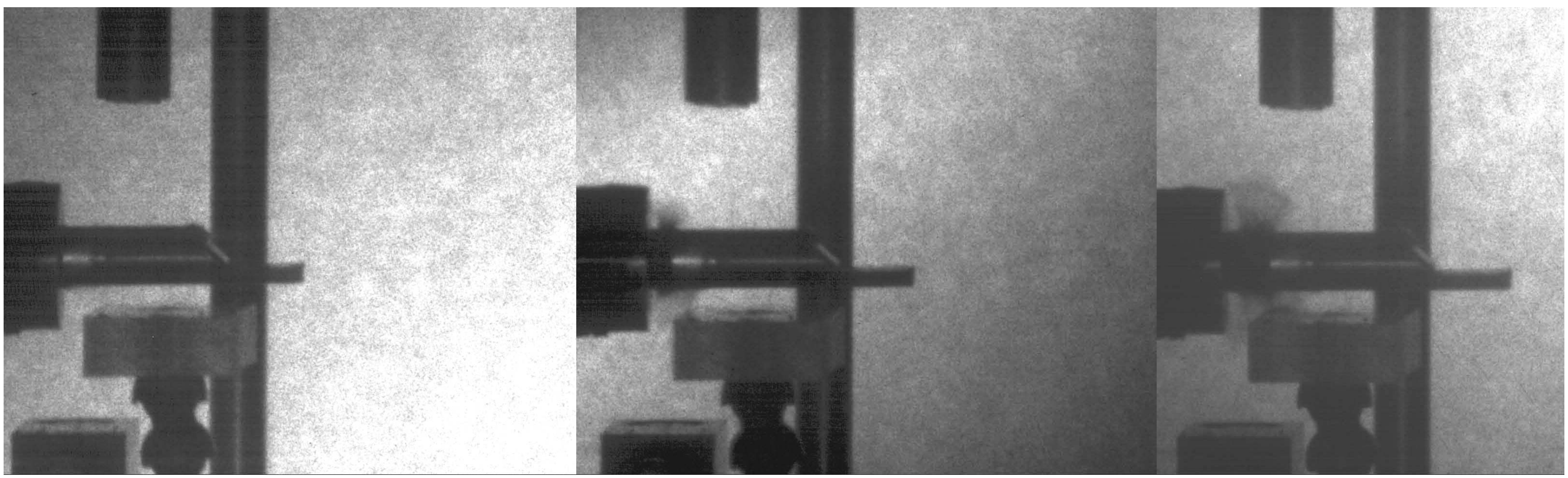
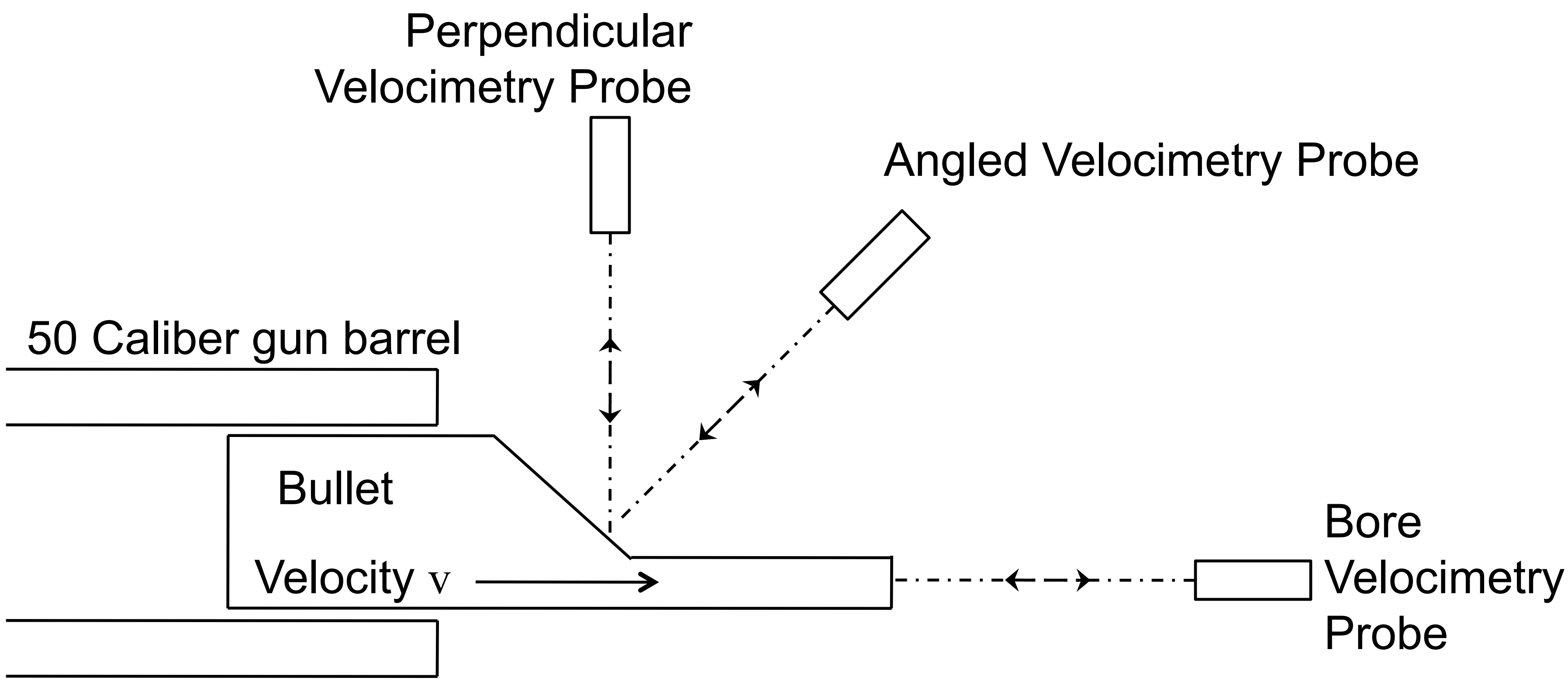
Velocities measured obliquely from funny shaped bullets

- Experiment: Steve Hare, Mike Archuleta, Mike Shinas, John Echave, Rudy Archuleta, Matt Briggs, Jim Faulkner, Larry Hull.
- Interpretation discussions: David Holtkamp, Dan Dolan, Jim Faulkner, Mike Shinas, Willard Hemsing, Larry Hull.
- Beer owed to: Willard Hemsing.

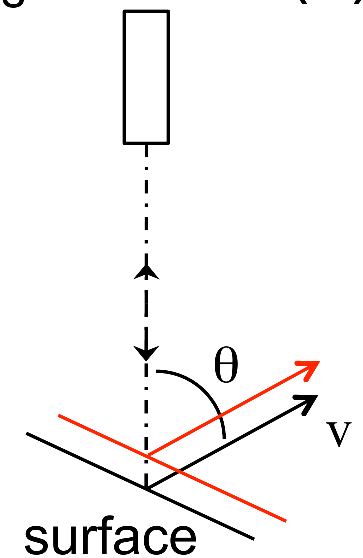


Velocity measured from 3 angles

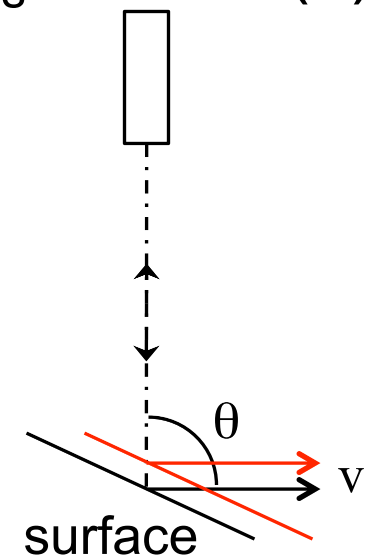


Goosman (1983): Fabry-Perot measures particle velocity

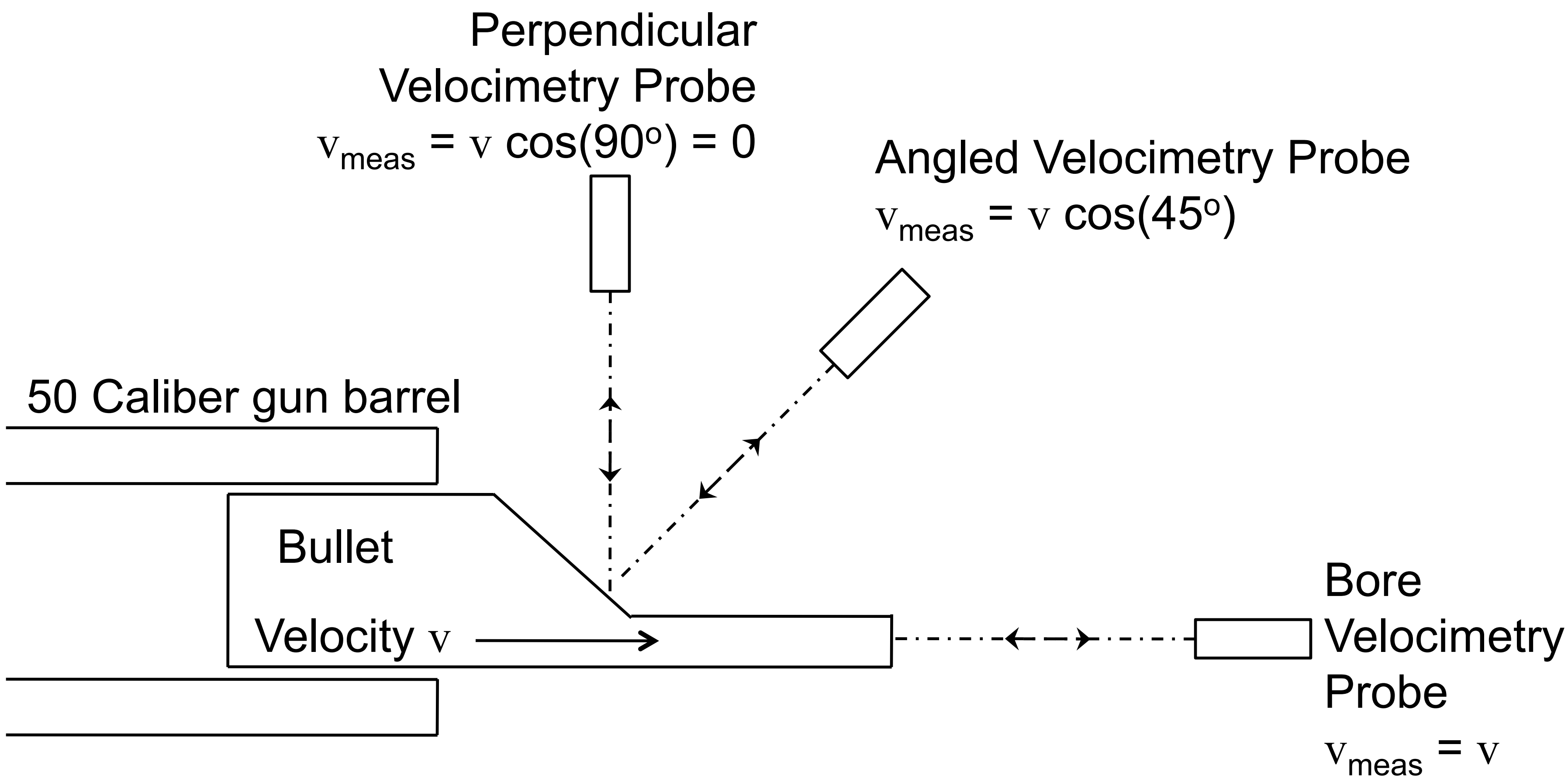
$v_{meas} = v \cos(\theta) > 0$



$v_{meas} = v \cos(\theta) = 0$

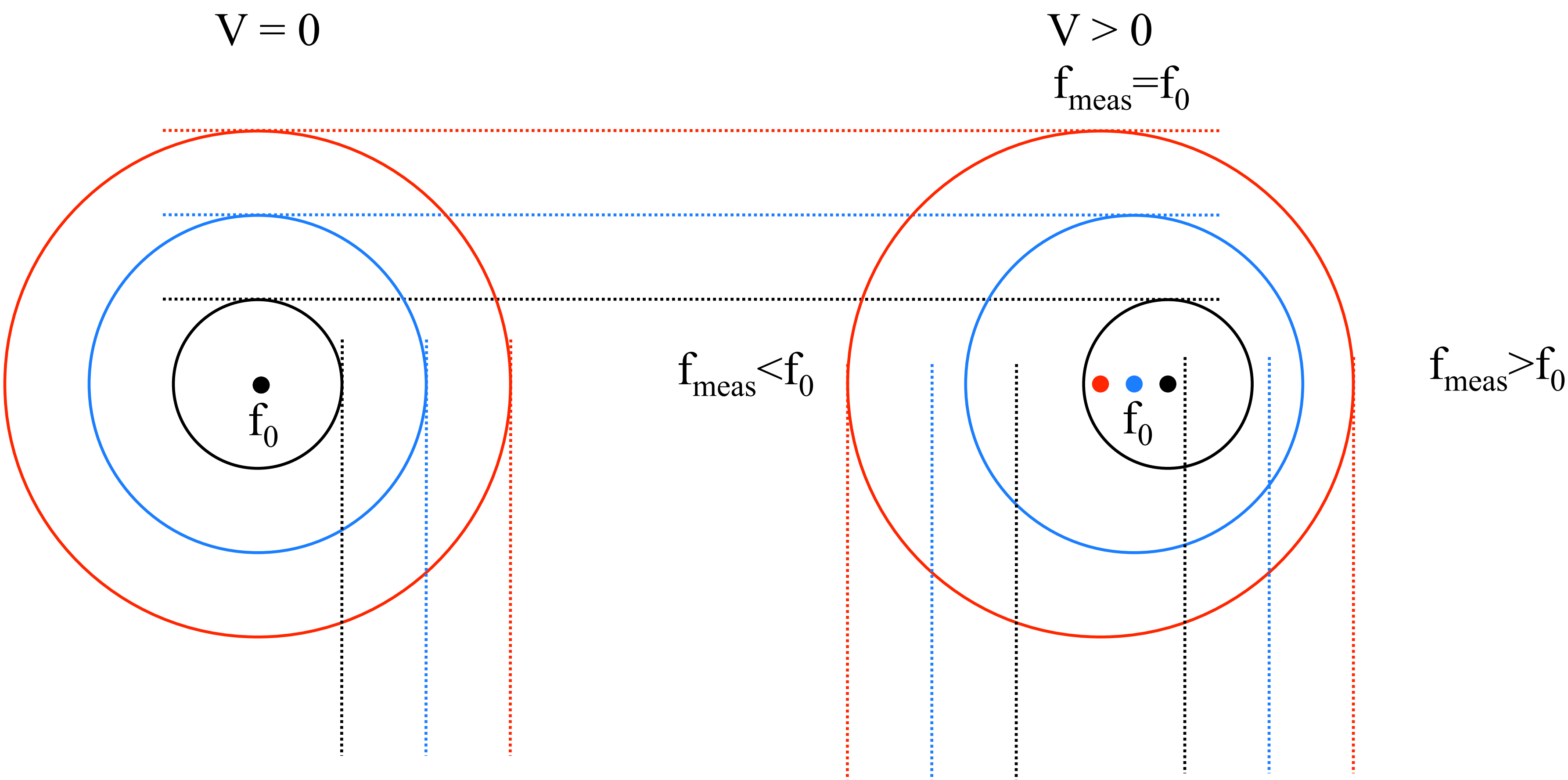


Velocity results expected from the Doppler shift

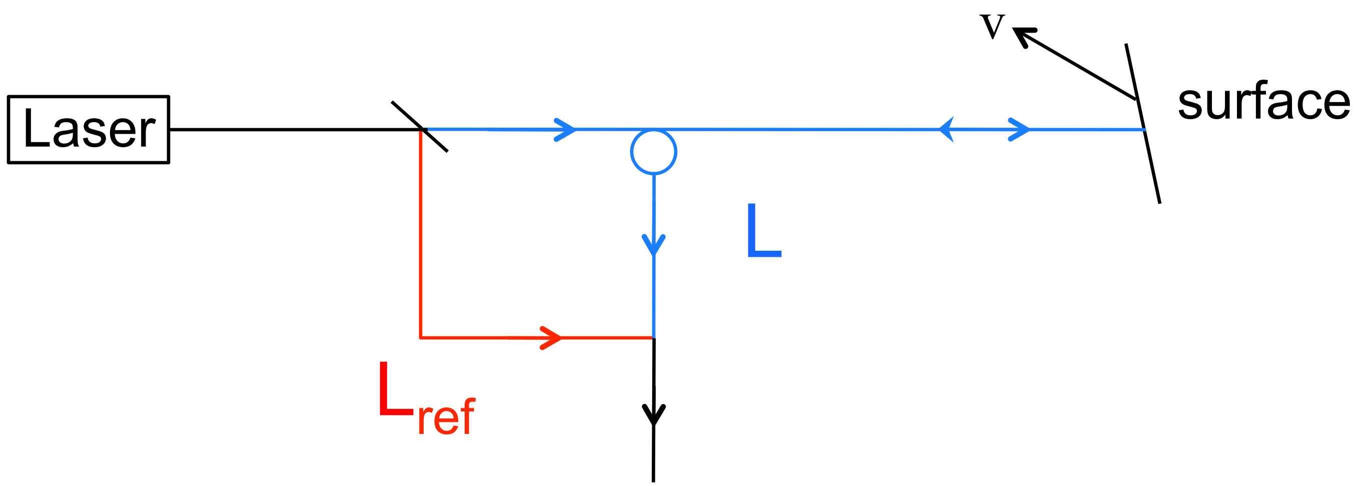


Classical explanation

For F-P, VISAR: $\Delta\phi_{meas} \sim \Delta f \tau_{delay}$; no frequency shift, no change in signal.



PDV is a displacement interferometer…



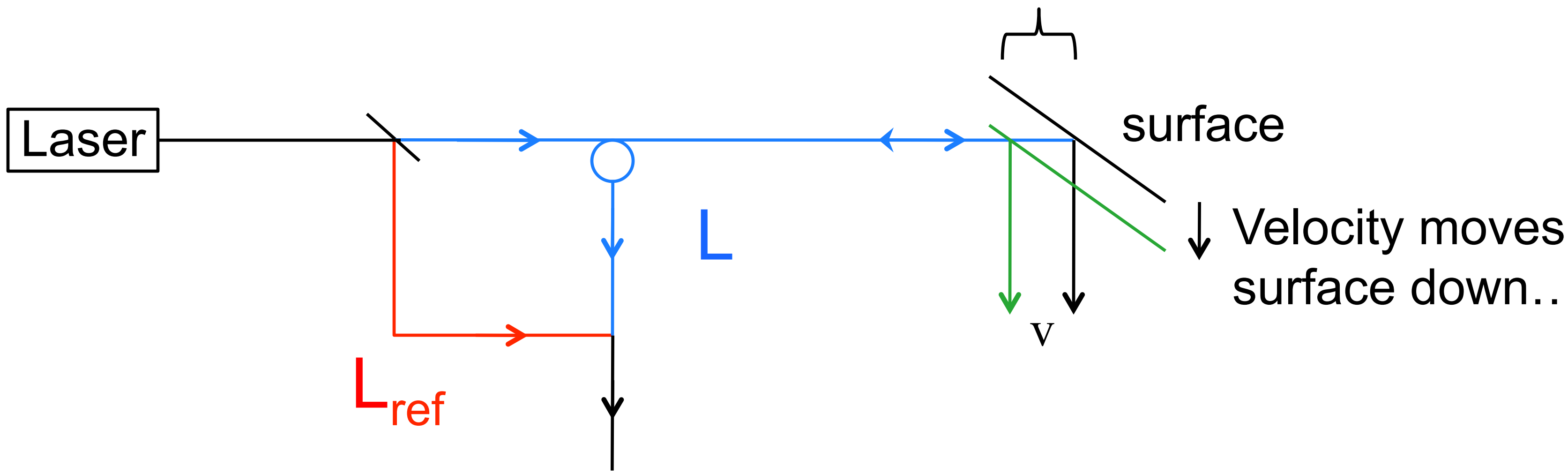
PDV signal

$\Delta\phi_{meas} \sim \Delta(L - L_{ref})/\lambda$

A change in the path length causes a change in phase.

Will Goosman's experiment be different for PDV?

F-P, VISAR would report velocity = 0, but the beam motion up the angled surface means $\Delta\phi_{meas} \neq 0$

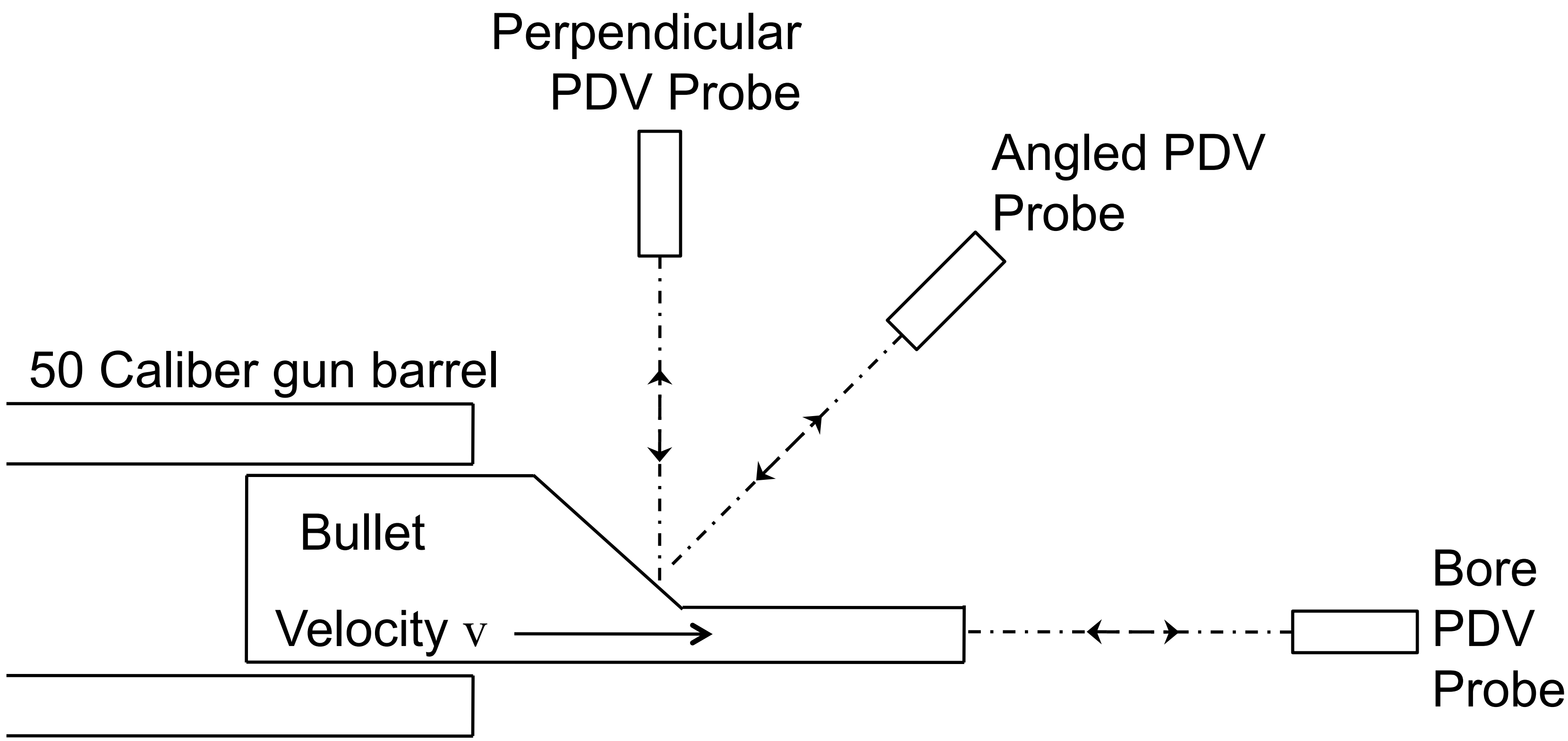


PDV signal

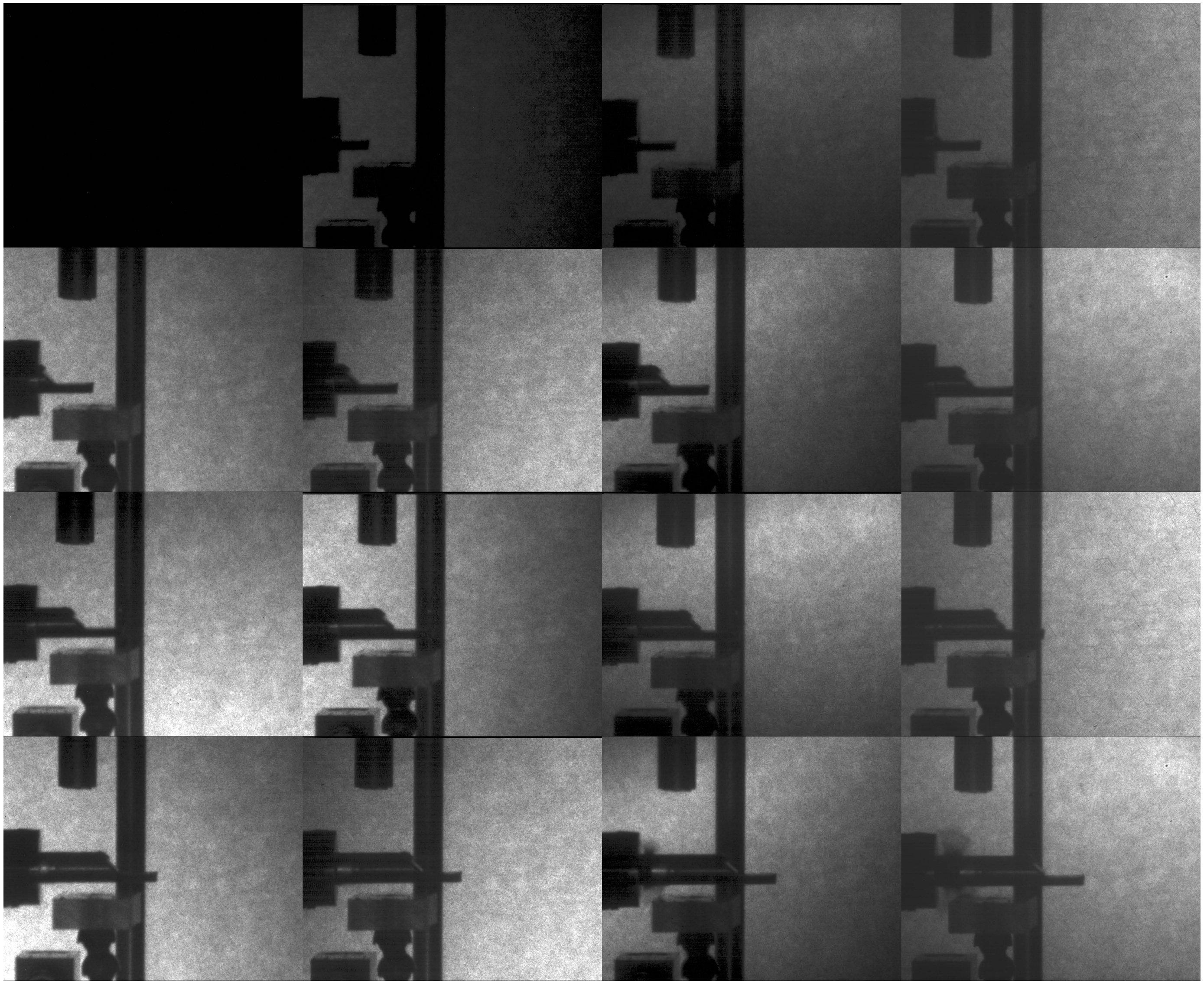
$\Delta\phi_{meas} \sim \Delta(L - L_{ref})/\lambda$

A change in the path length causes a change in phase.

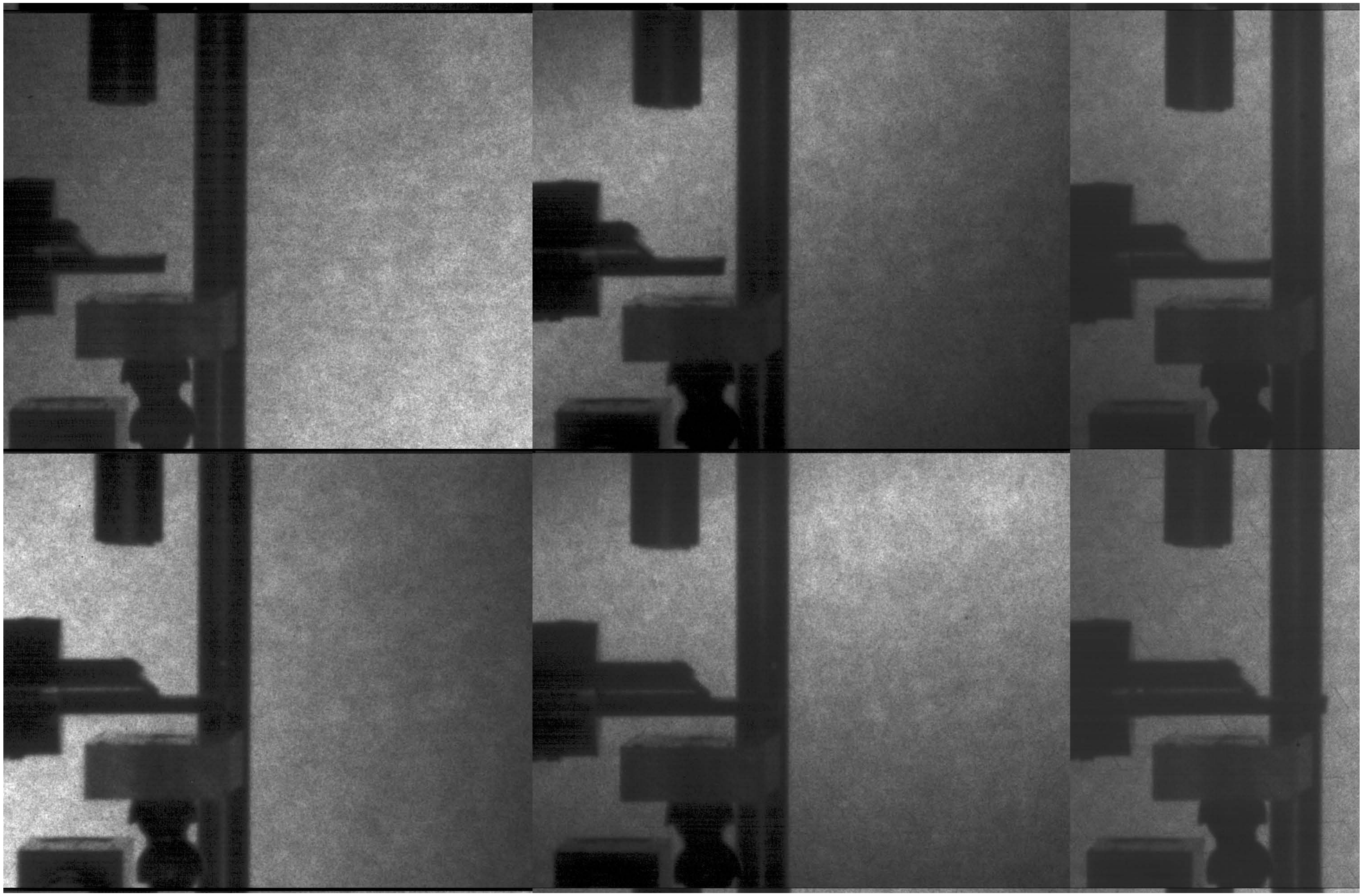
PDV experiment



The bullet came out in the correct orientation



The beam interrogates the bullet



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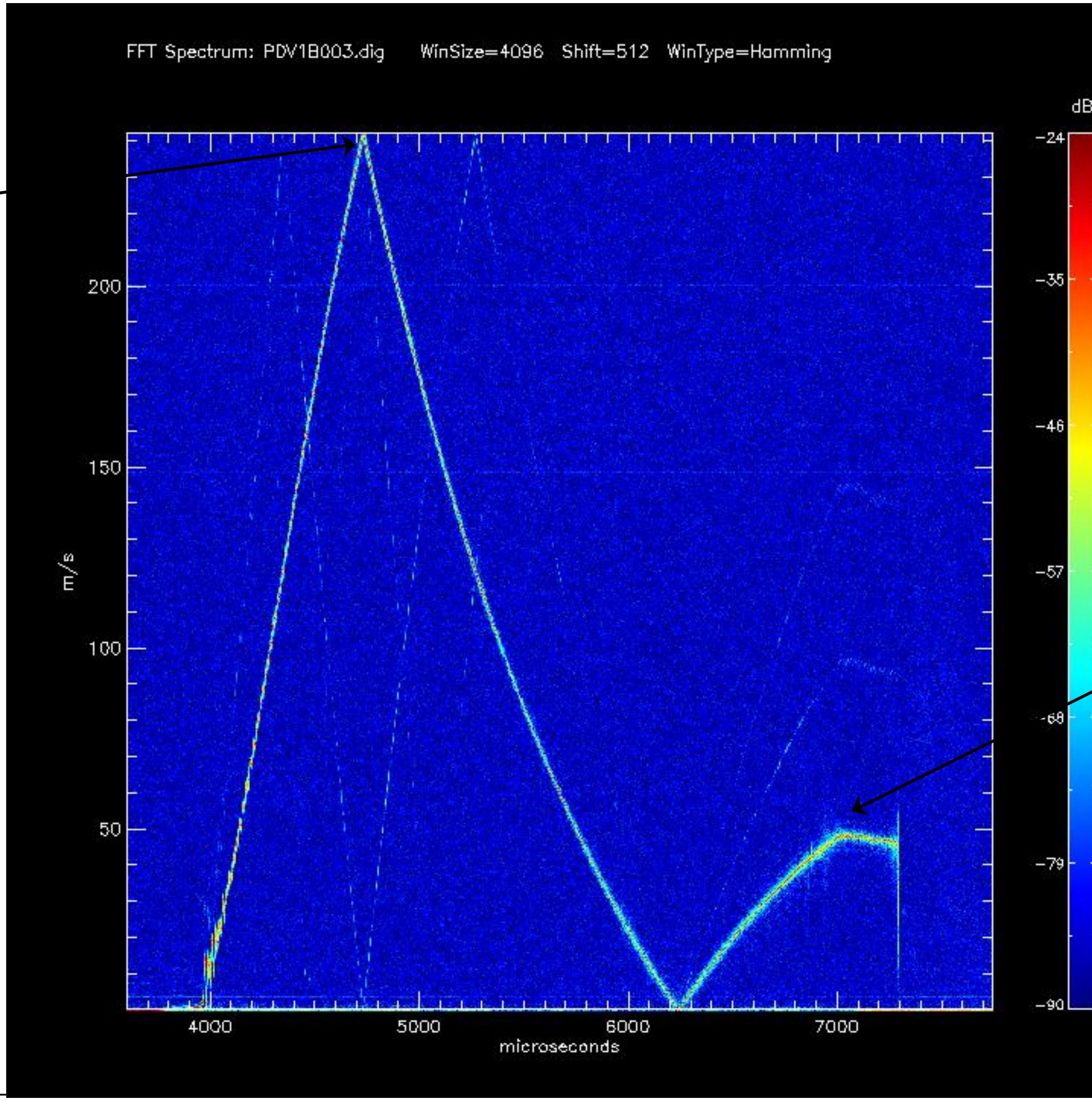
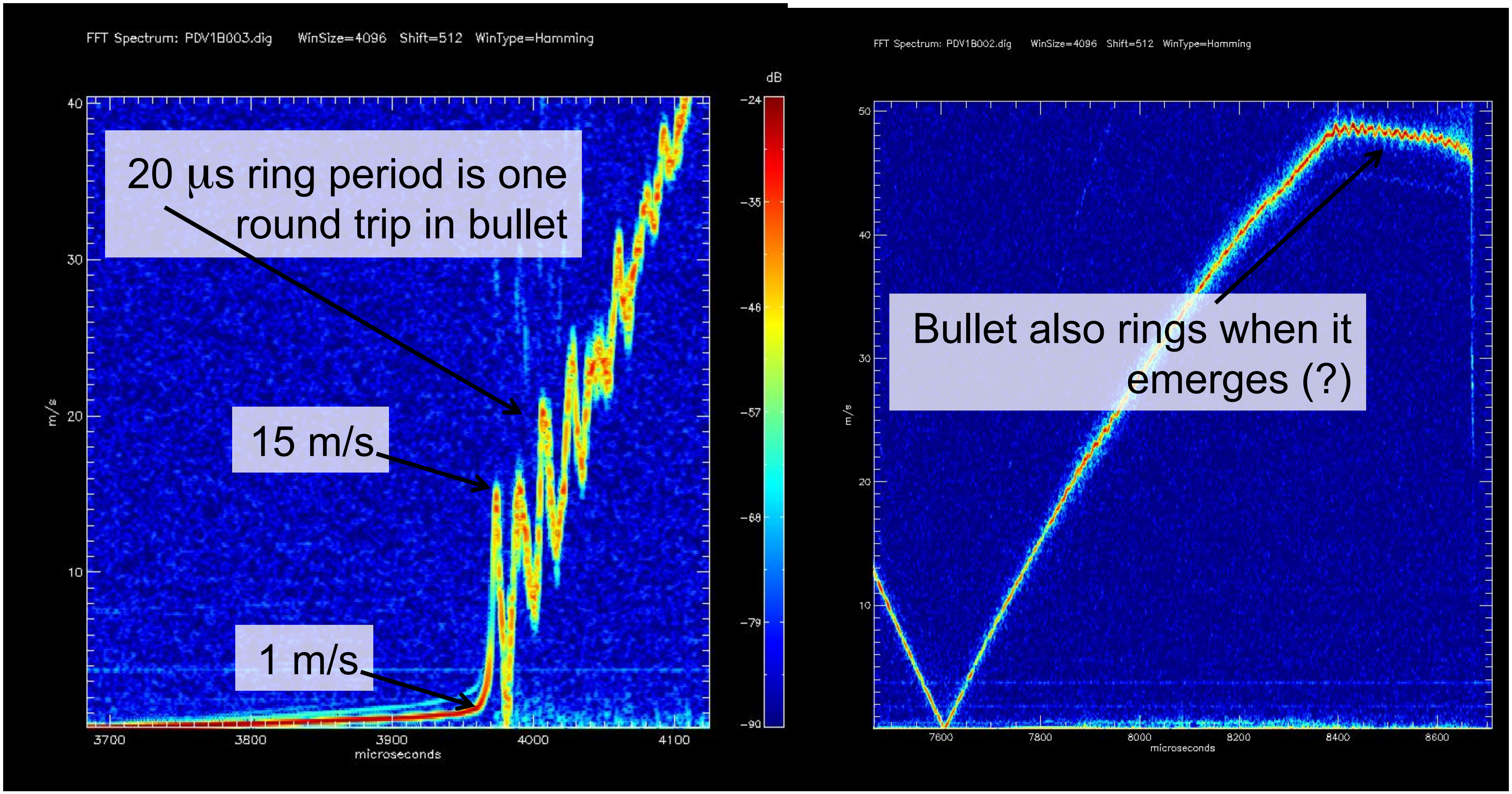
Motion along barrel

Nyquist limit 242 m/s (625 MS/S)



532 m/s end of bore, 530 final speed

Start of motion and end of motion, end-on

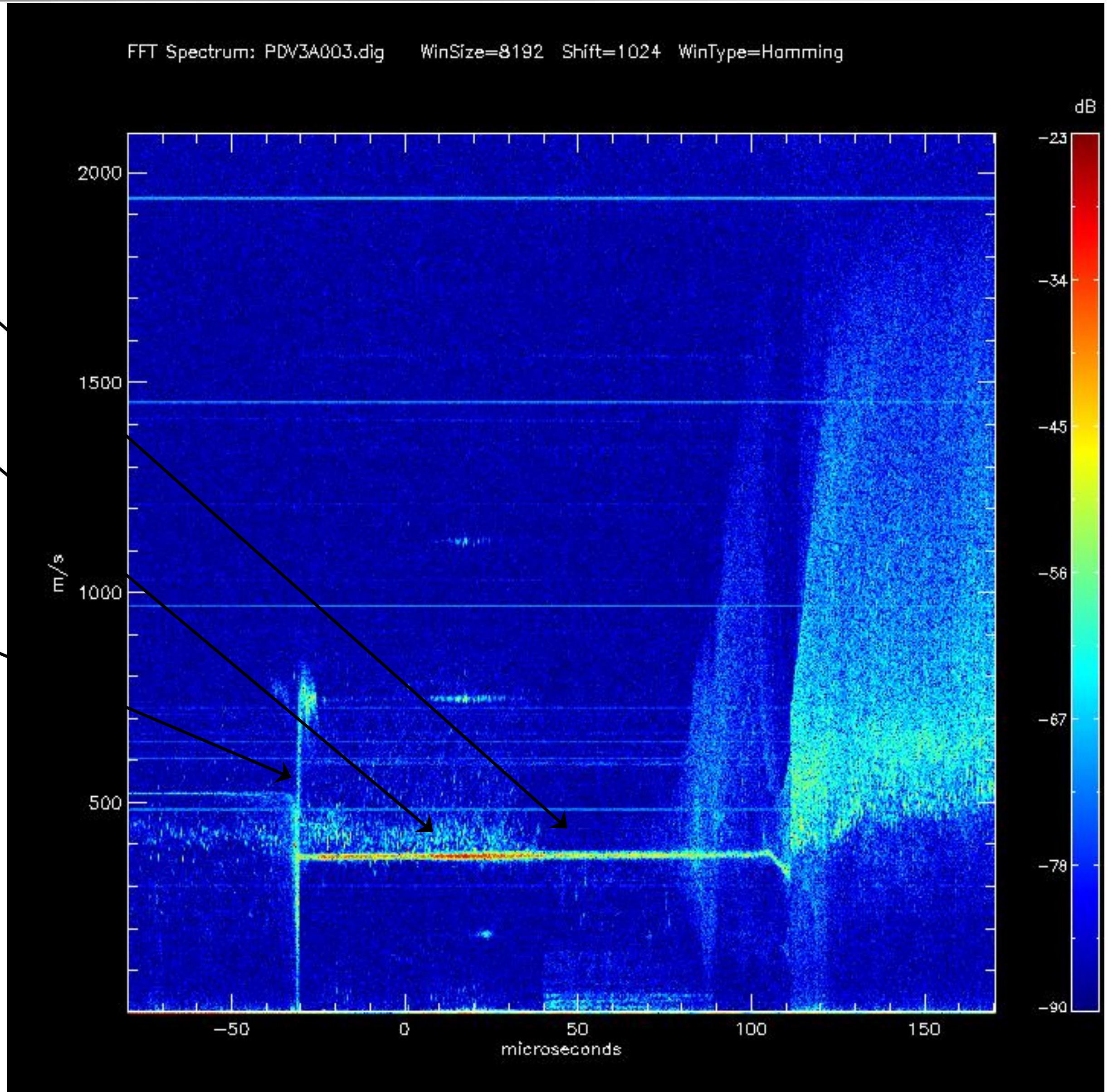


Looking down at the bullet from 45°

Top of bullet

45 degree surface

Bullet moves in front of probe beam



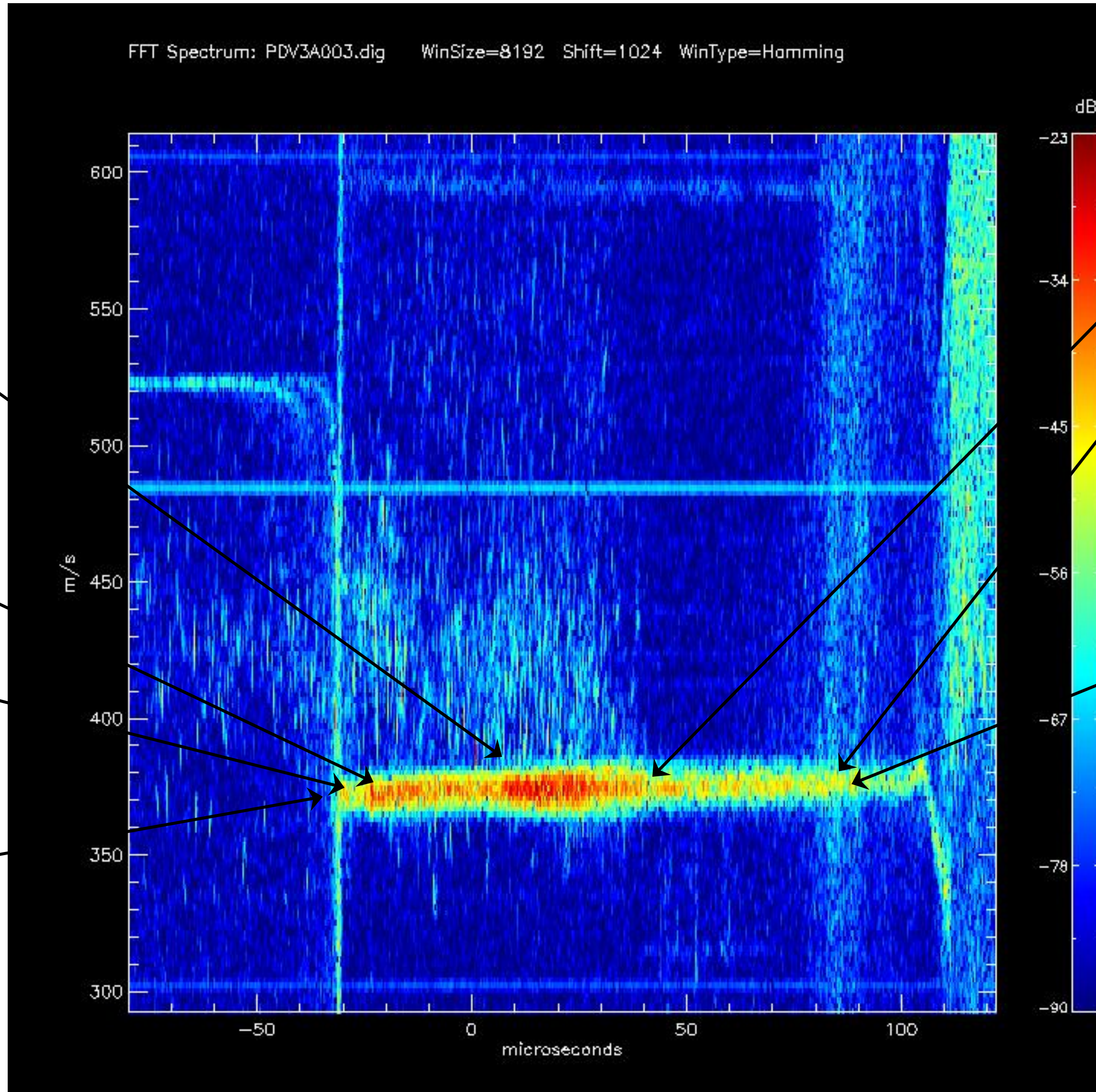
Zoomed look at the bullet from 45^o

45 degree surface

Horizontal flat at front of bullet

Front of Bullet

Bullet moves in front of probe beam



Top of bullet

Sabot

532cos(45) = 376 m/s

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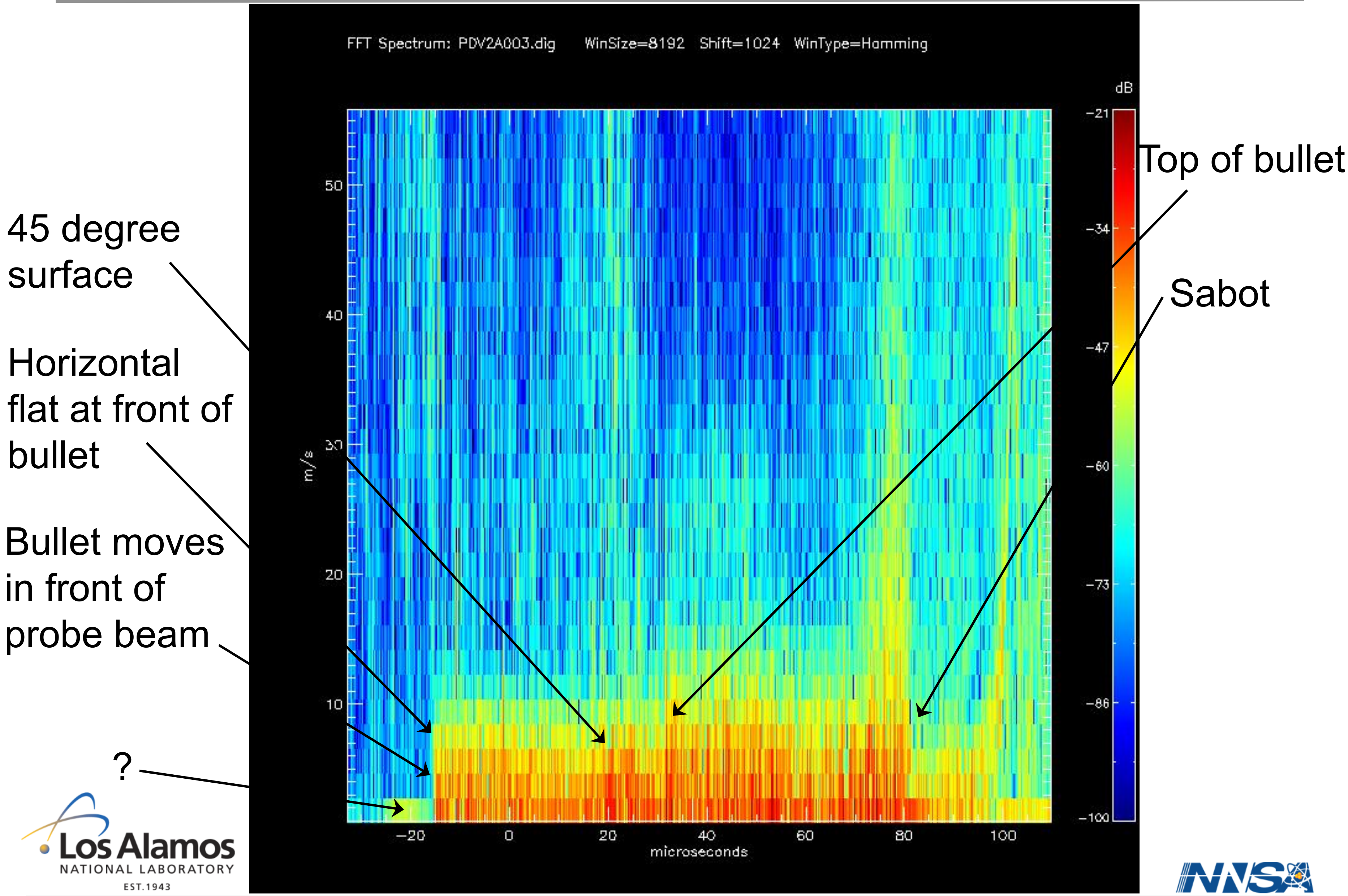
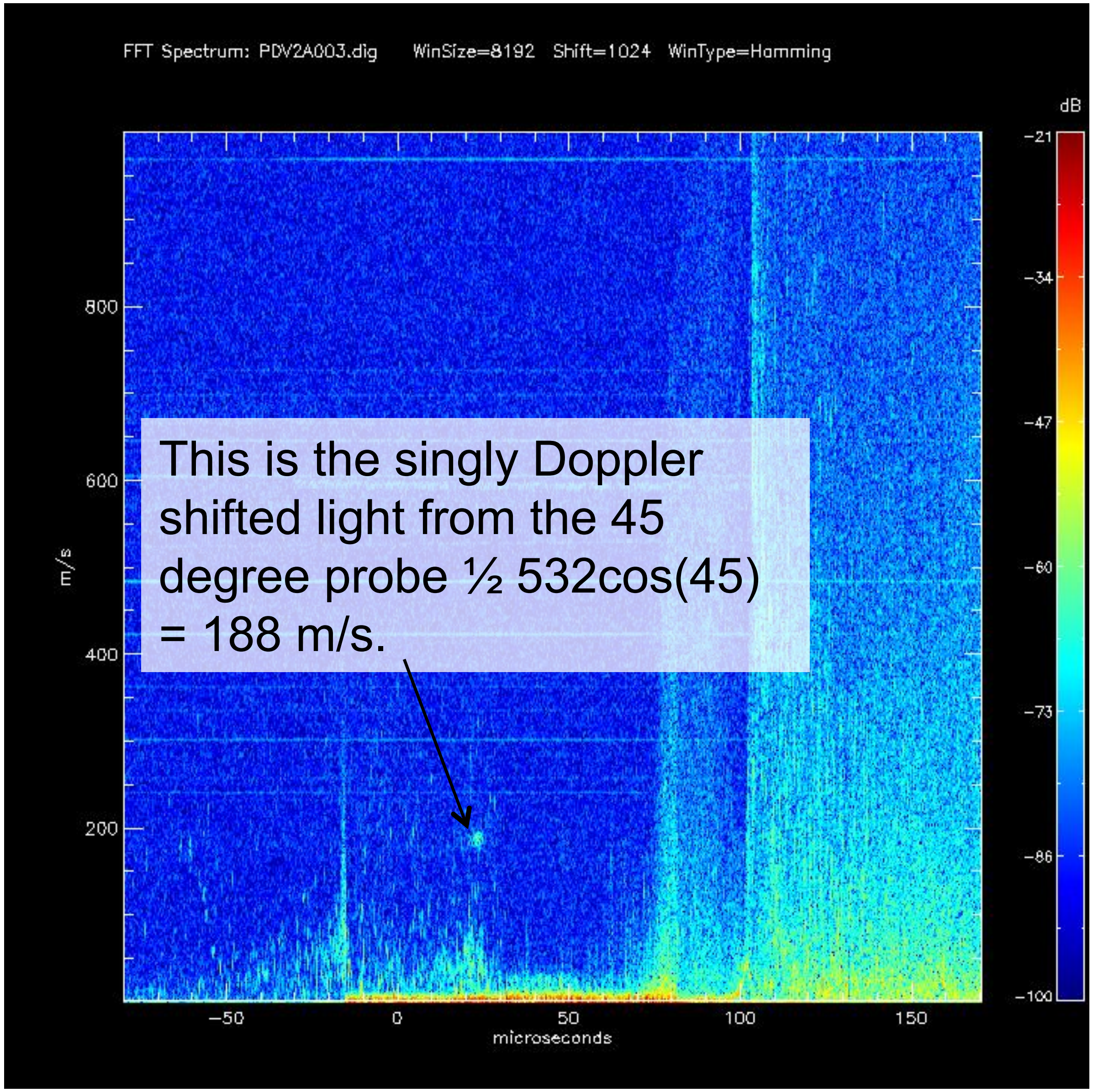
Zoomed look straight down on bullet

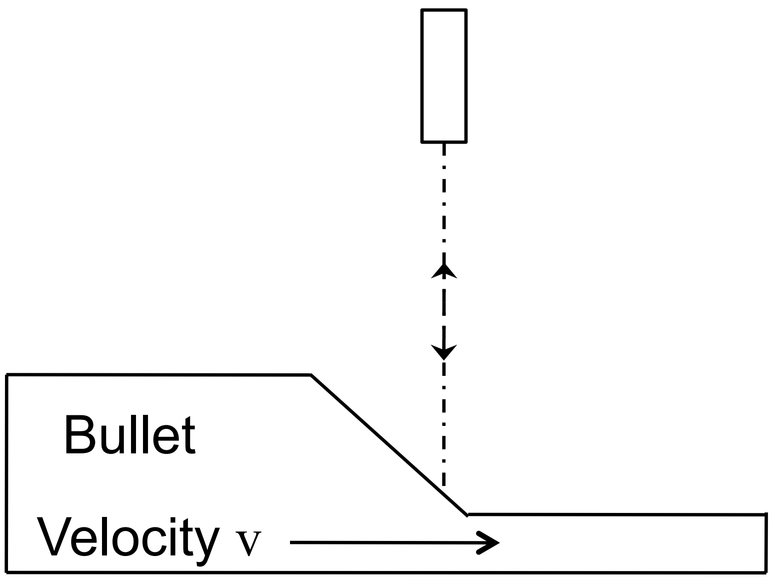


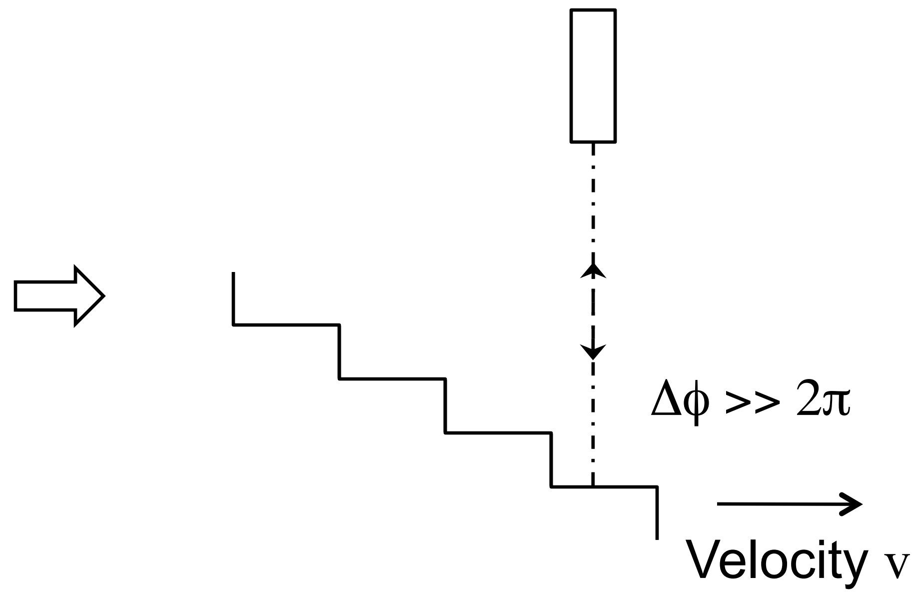
Looking straight down on Bullet



Why do we see zero velocity despite $\Delta L \neq 0$?

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.





A finite beam size has the same effect, $E_{det} = E_1 e^{i(\omega_d t - kz + \phi_1)} + E_2 e^{i(\omega_d t - kz + \phi_2)} + \ldots = (E_1 e^{i\phi_1} + E_2 e^{i\phi_2} + \ldots) e^{i(\omega_d t - kz)}$, adding new facets at random phase and loosing existing ones as the bullet moves.

But we know that we can measure even in shear

It is good that we are not mislead by surface angle, but how do we ever see motion in experiments with shear motion, if ΔL is always washed out?

The Doppler shifted frequency of the return light will beat against the reference frequency with a frequency Δf, giving:

$$\Delta\phi_{meas} \sim \Delta f \Delta t,$$

Where Δt is the duration of the Doppler shift Δf. Apparently, the phase discontinuities from new scatterers moving in and out of the beam cause base-line noise, but do not destroy the velocity information contained in Δf.