

# Embedded Fiber Optic results: Recent progress measuring detonation speed using Heterodyne Velocimetry

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Prepared for the PDV Workshop 2007 at LLNL  
8/16/07

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Operations

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Jim Van Lewen

Don Burns

Handling and Ramrod  
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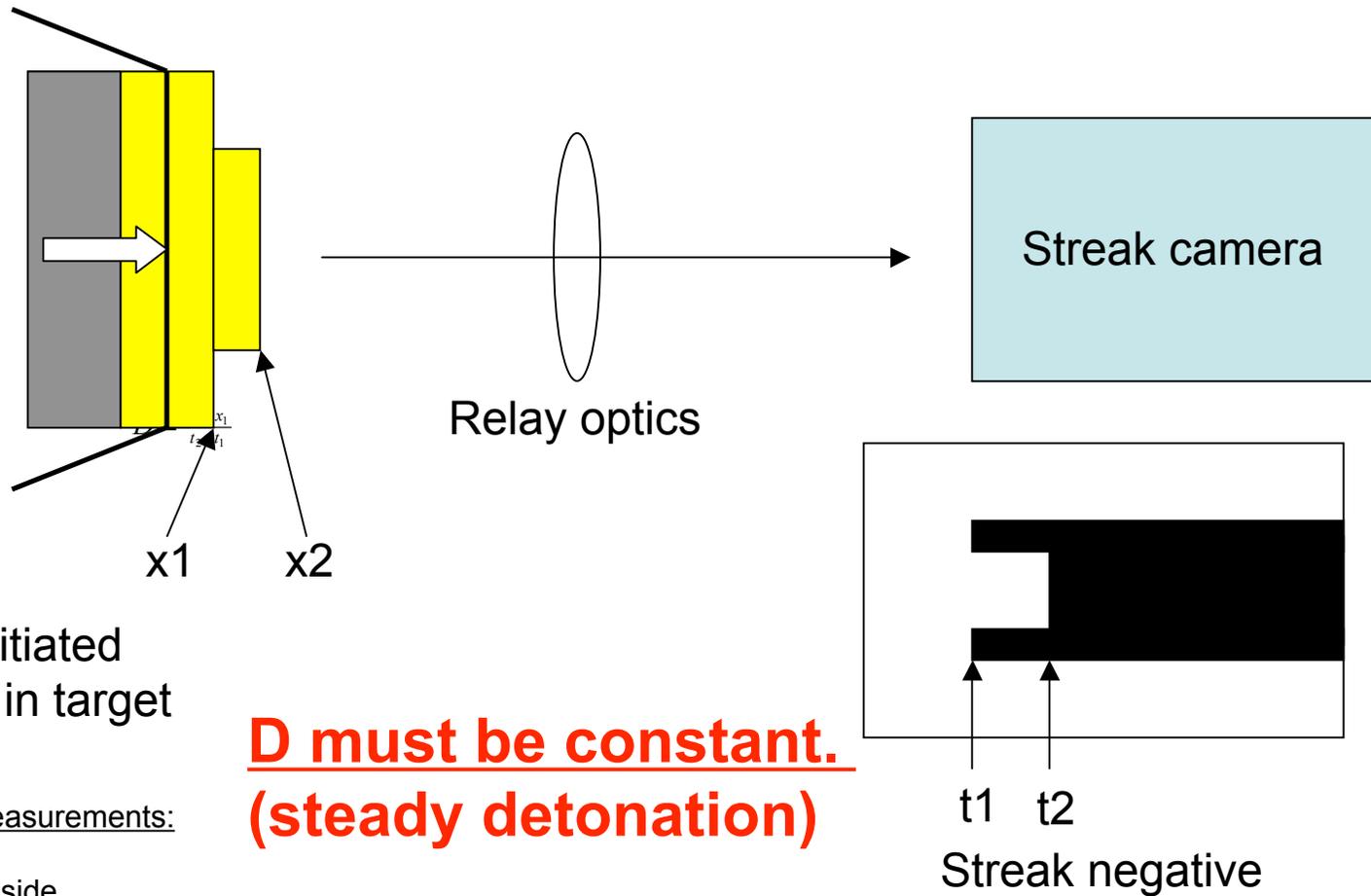
Fast oscilloscope usage

Paul Wilkins (10 GHz)

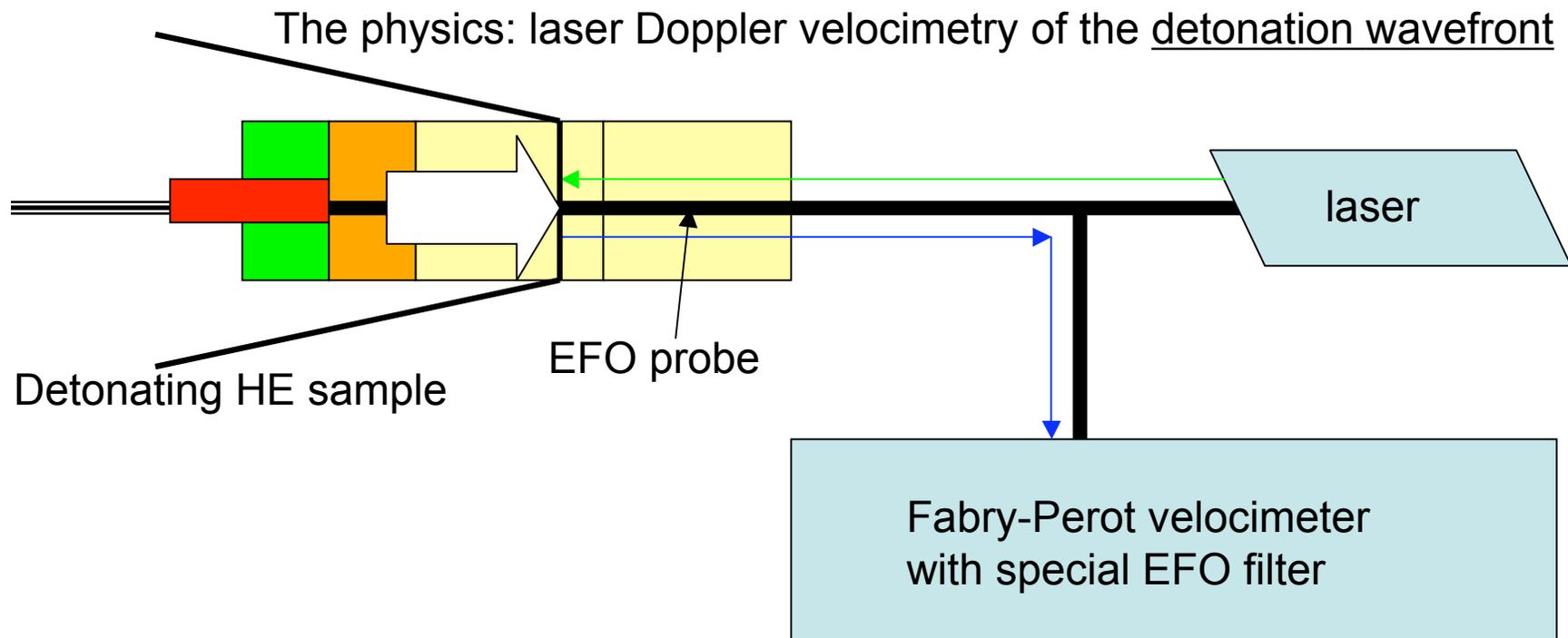
NSTec Los Alamos  
operations (16 GHz)

Tektronix, Inc (20 GHz)

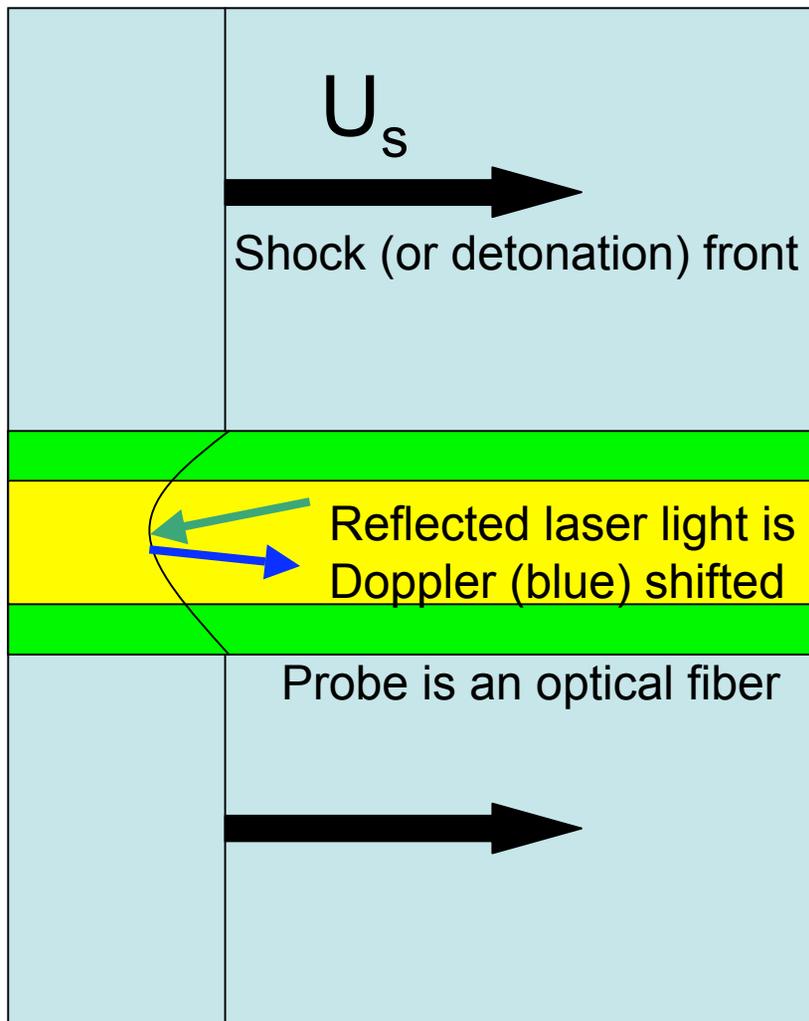
# Traditional detonation speed measurements are $\Delta x/\Delta t$ measurements



The EFO probe can measure instantaneous detonation speed versus time

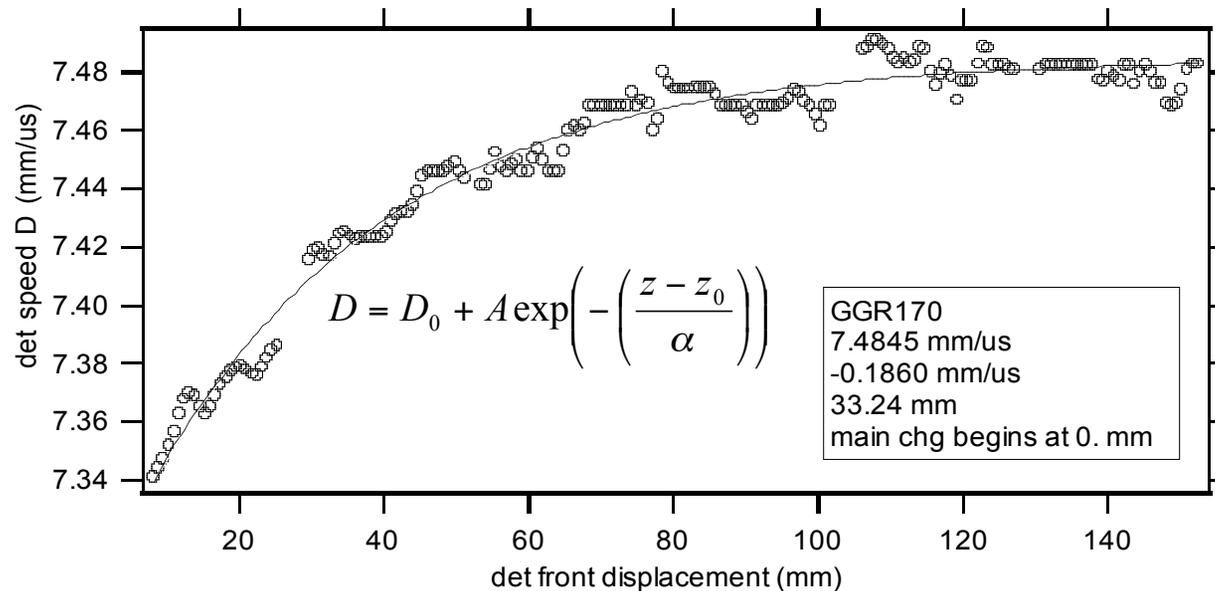


# How the EFO probe works:



- Shock wave creates / maintains a refractive index discontinuity in probe core
- Index discontinuity:
  - Reflects laser light
  - Imparts a Doppler shift because it is moving
- In the case of steady flow:
  - The Doppler shift should be exactly the same as the steady shock or steady detonation speed

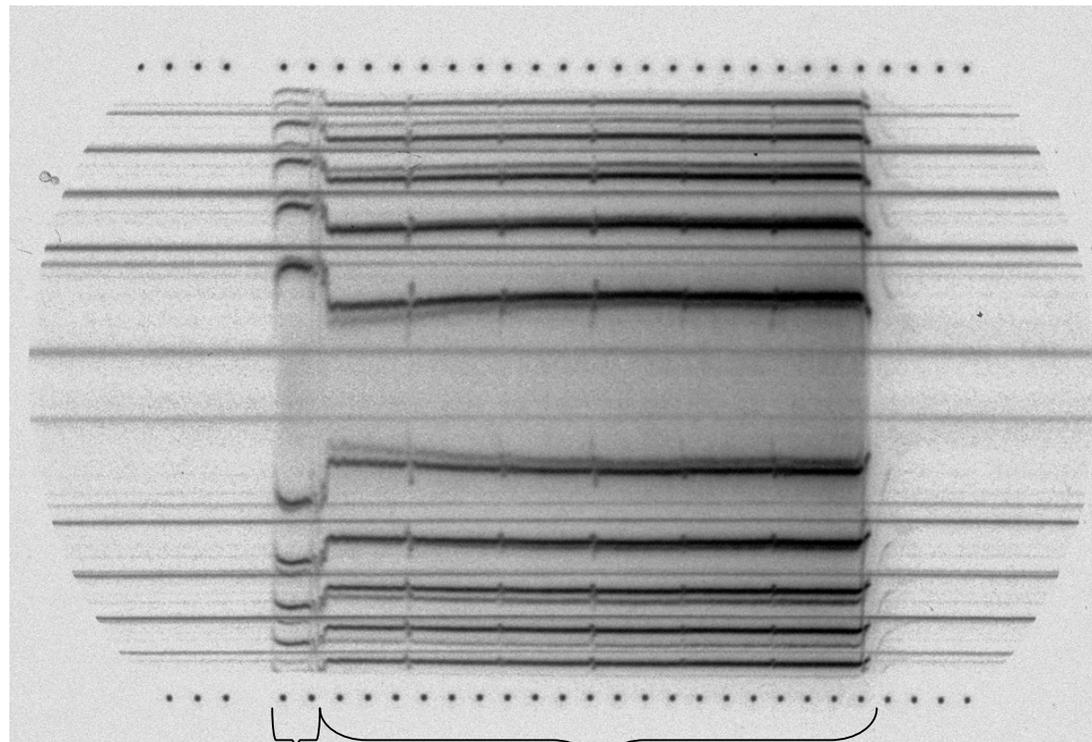
# The EFO (Embedded Fiber Optic) technique can measure time-dependent or steady detonation speed



**EFO data showing rise to steady D in long LX-17 column**

Our previous EFO measurements have used a  
Fabry-Perot velocimeter almost exclusively  
FP fringe history for a long column shot

FP velocimeter  
James T. Wade  
Denise Grimsley

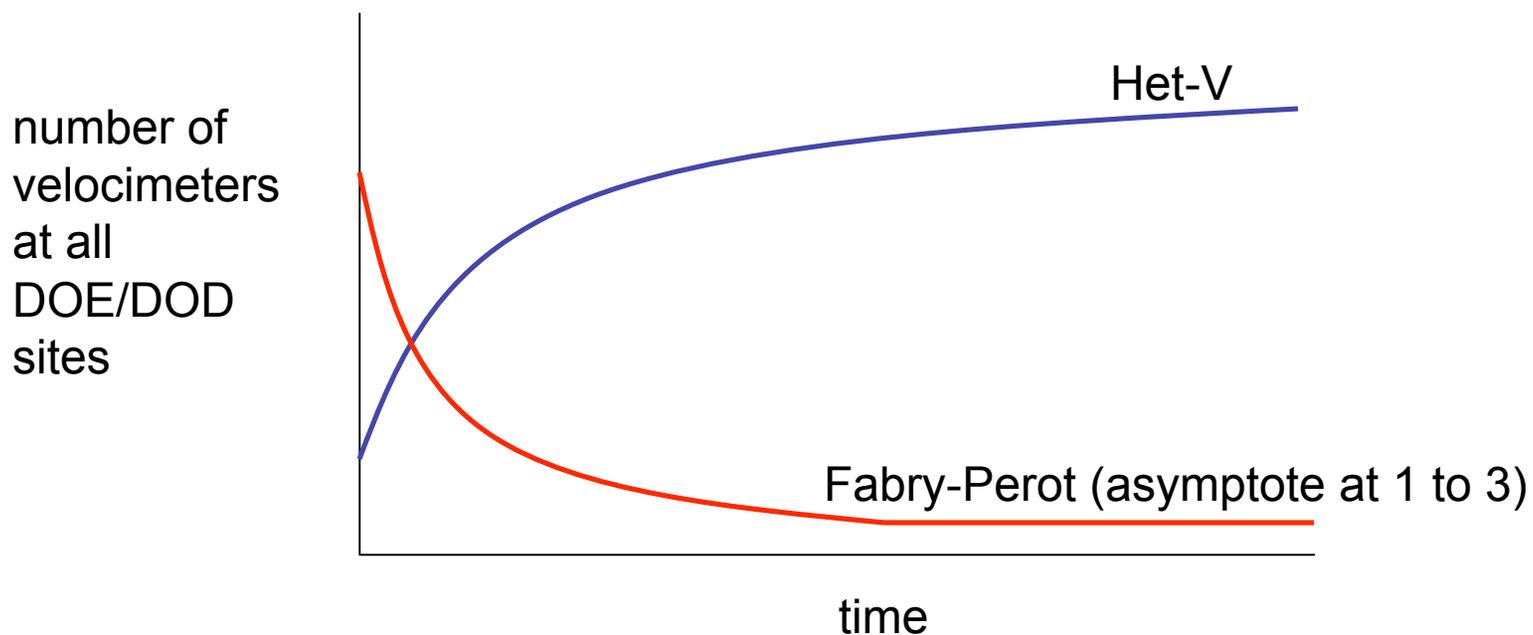


booster LX-17 or 9502 column

FP easily resolves multiple velocities  
VISAR does not

FP easily records high velocities  
This has been (?) a challenge for Het-V

# Why it is worthwhile to get EFO and Het-V to work and play well together:

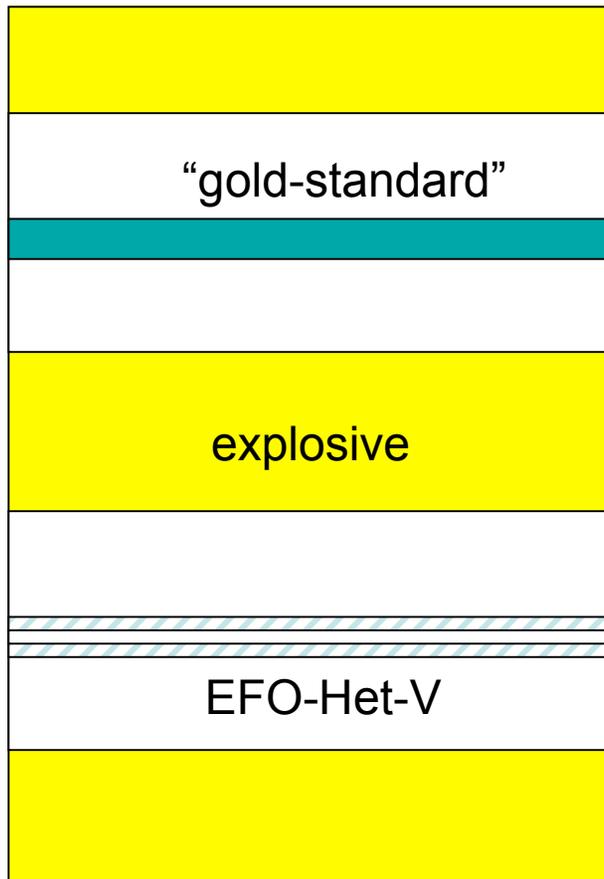


It is not likely that someone will build a FP velocimeter just to measure detonation speed

# The challenges we faced

- How to make a probe that is compatible with Het-V requirements.
- Detonation speed measurement requires previously-unattainable bandwidth

# EFO-FP and EFO-Het-V probe design: compare and contrast



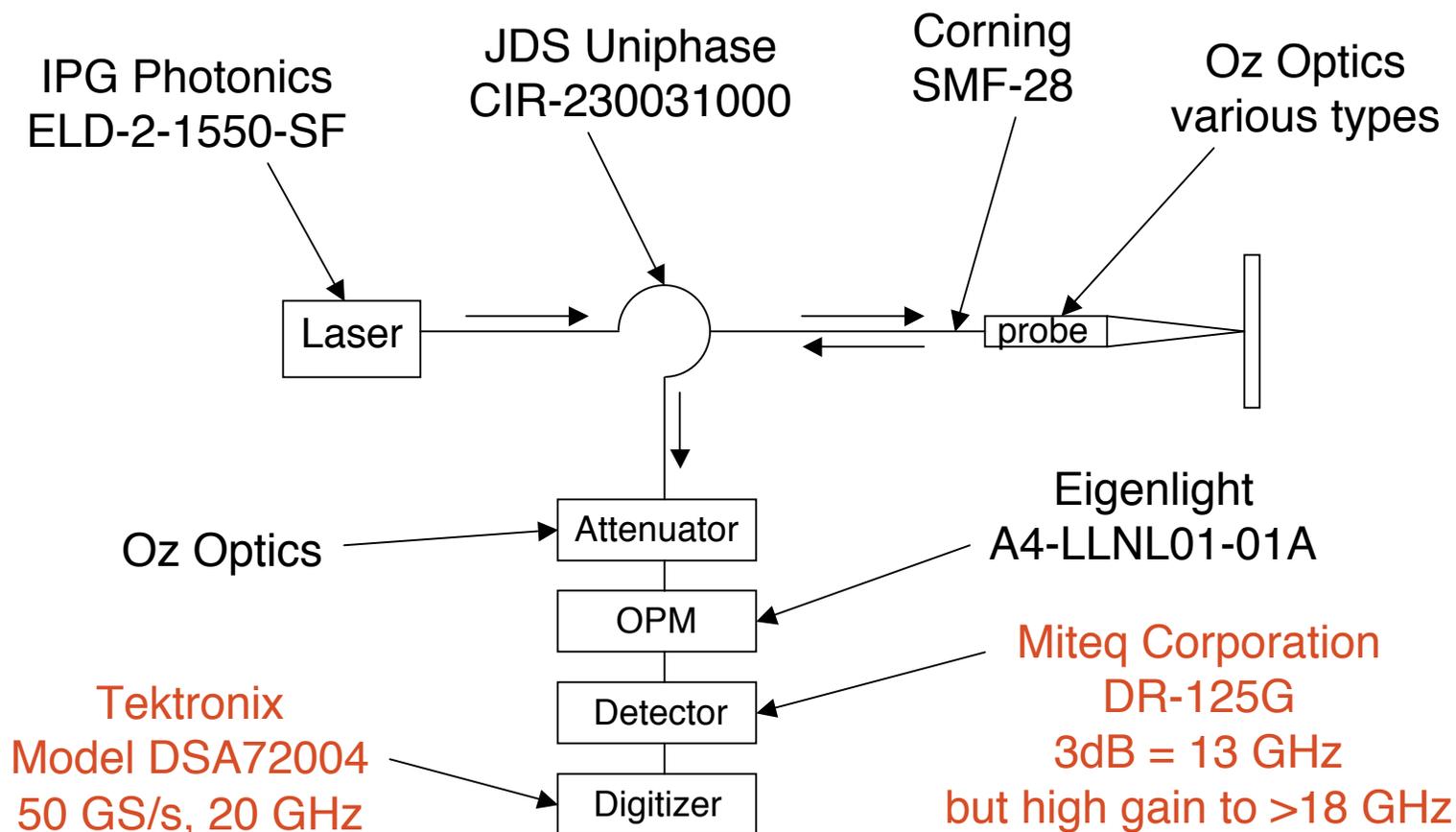
## EFO-FP "Gold-standard" probe

- Used with FP velocimeter, 532 nm
- PTFE (teflon) cladding (1.6 mm OD)
- Aqueous CsCl soln core (125  $\mu\text{m}$  OD)
- Will measure wave speeds  $> 1.9$  km/s

## Our EFO-Het-V probe

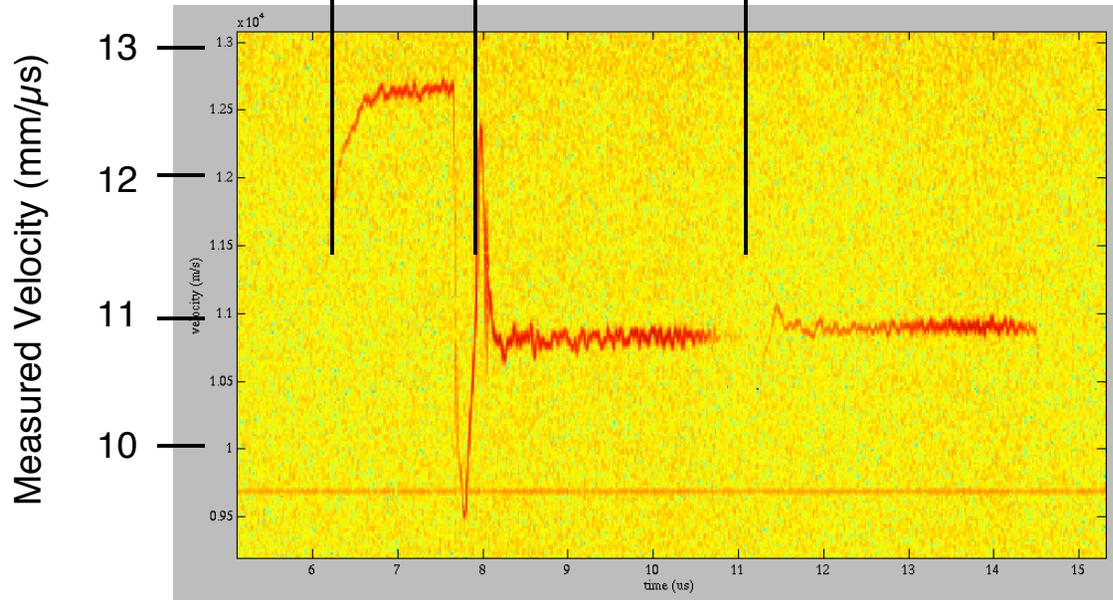
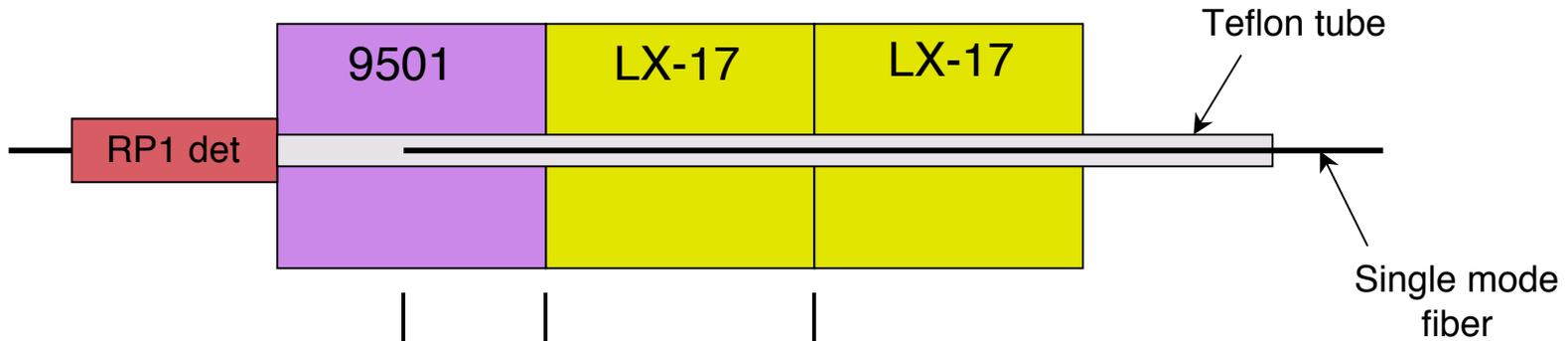
- Use with 1550 nm heterodyne velocimeter
- PTFE jacket (1.6 mm OD)
- Heart is a single-mode telecom fiber (125  $\mu\text{m}$  OD)
- Should measure wave speeds  $> 5$  or  $6$  km/s

We borrowed the latest digitizer from Tektronix and along with Miteq detectors from LANL



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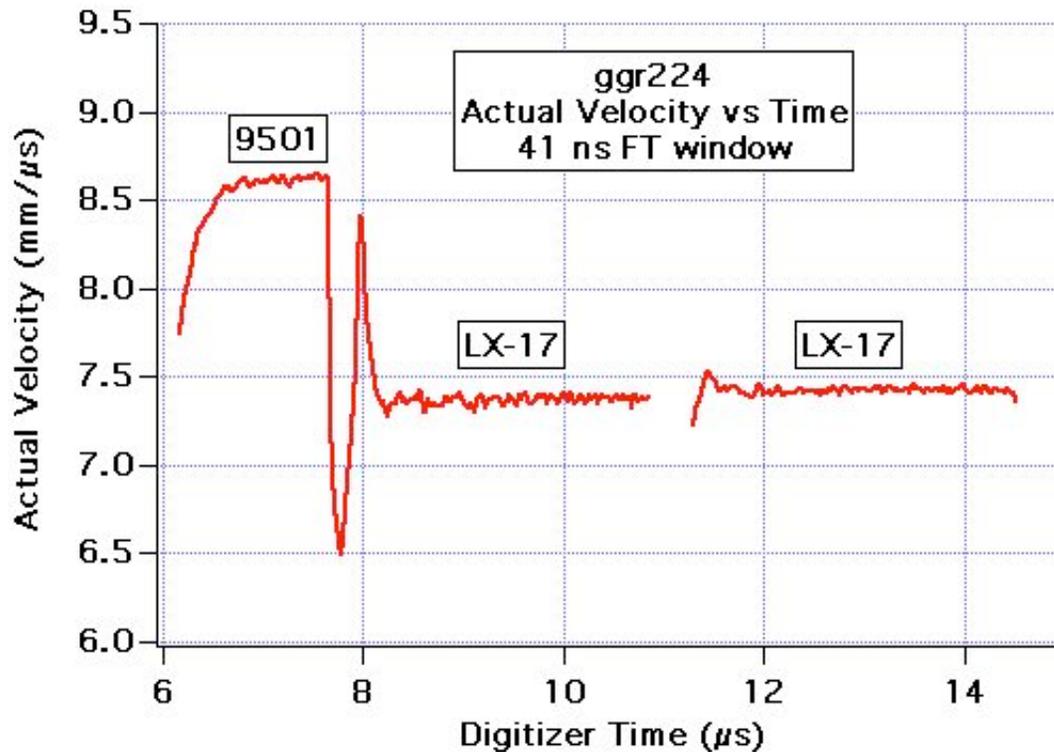
We have measured detonation speeds in solid HE's using the heterodyne system



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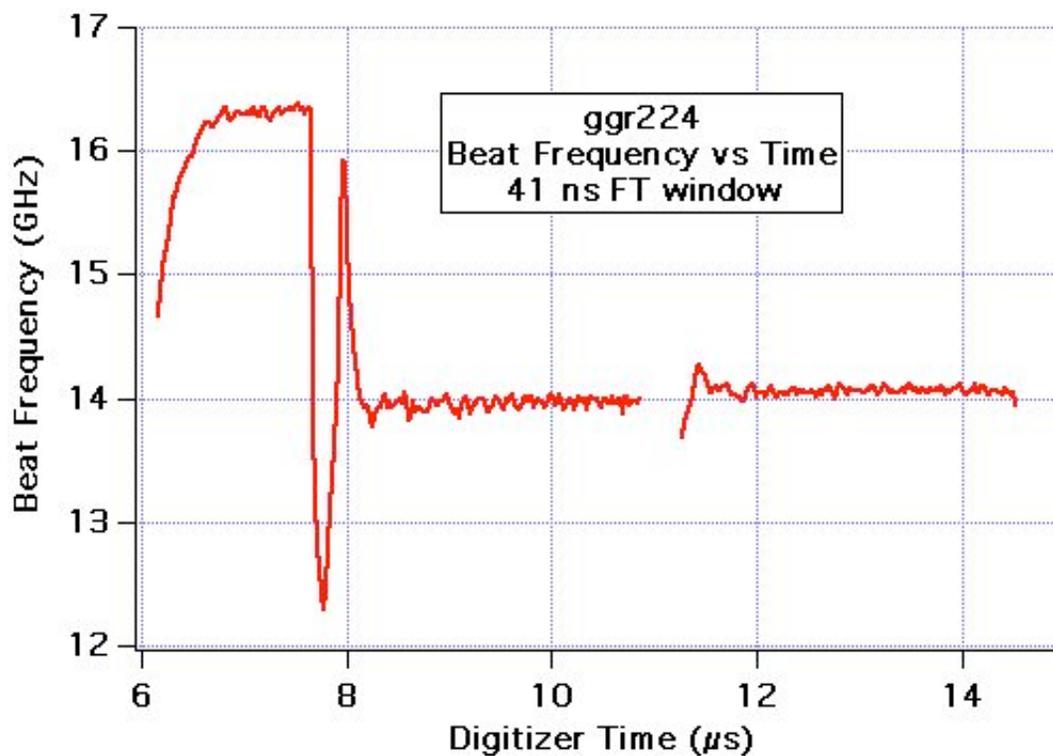
This data shows the time history of the HE detonation speeds



Many thanks to  
David Holtkamp  
of LANL  
for assistance  
with these  
experiments

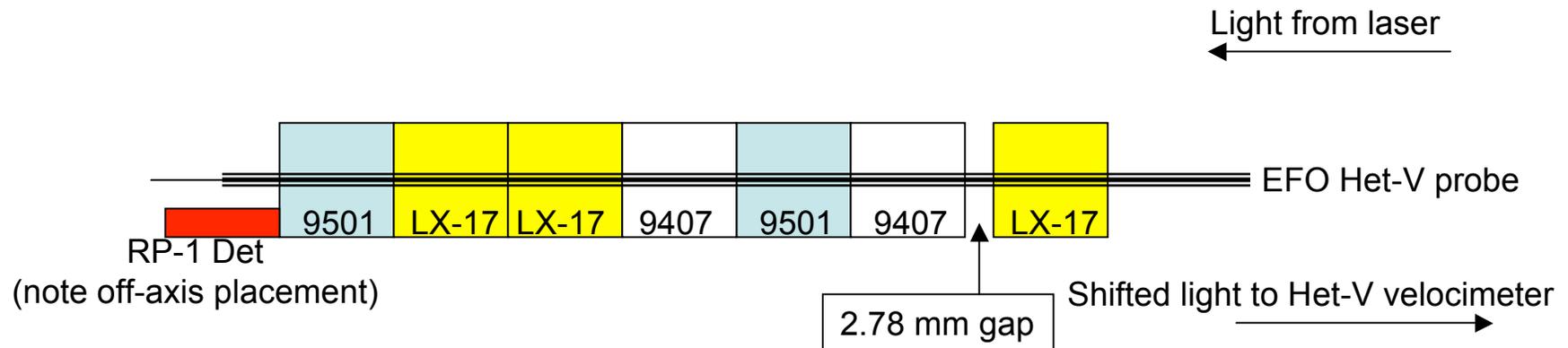
This data has been corrected for the fiber index = 1.4682

These measurements involve  
beat frequencies  $> 16$  GHz



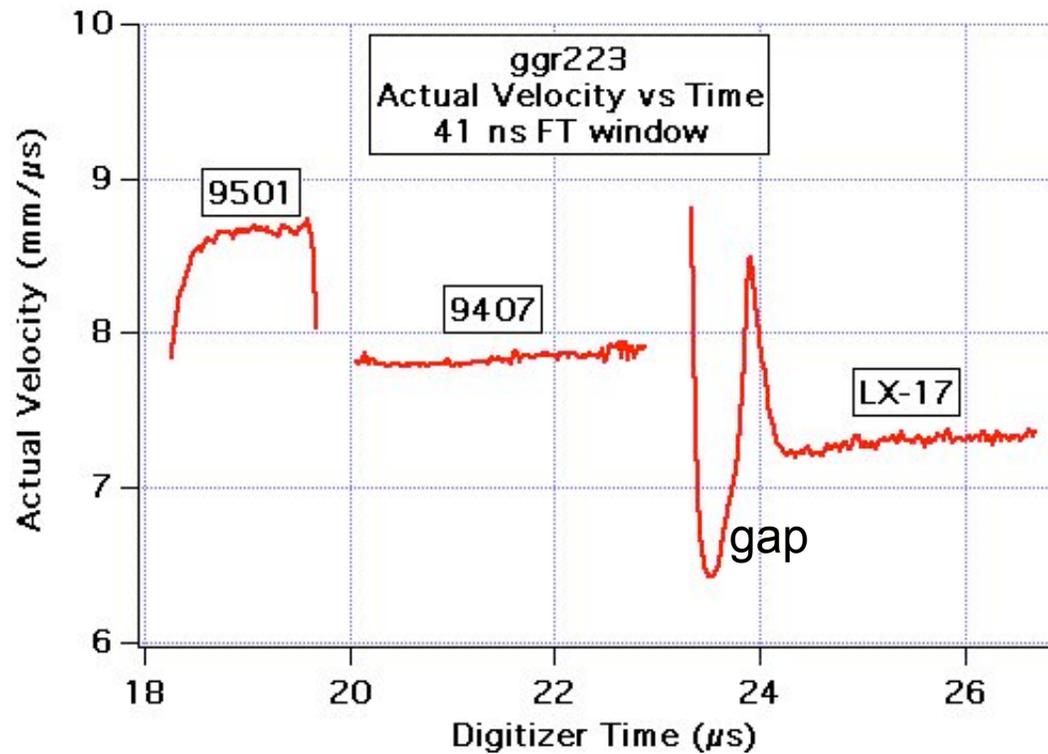
# Shot GGR223: cross-a-gap shot

- Verify rough quality of PBX-9407 at 1.6 g/cc data (90% TMD)
- Cross a gap and re-initiate LX-17. gap test in real time



Our thanks to Dr. Clark Souers for suggesting the gap width

# Did it go, or did it fail??



**The difference between doubling the speed of a computer and doubling the speed of an oscilloscope can be striking!!!!**

- Twice as fast for a desktop PC means you can do the same computation in half the time.
- Twice as fast for a Het-V detection oscilloscope is the difference between “0” (no data) and “1” (data)

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Fast Oscilloscope  
usage

Paul Wilkins 10 GHz

NSTec Los Alamos  
operations 16 GHz

Tektronix, Inc 20 GHz