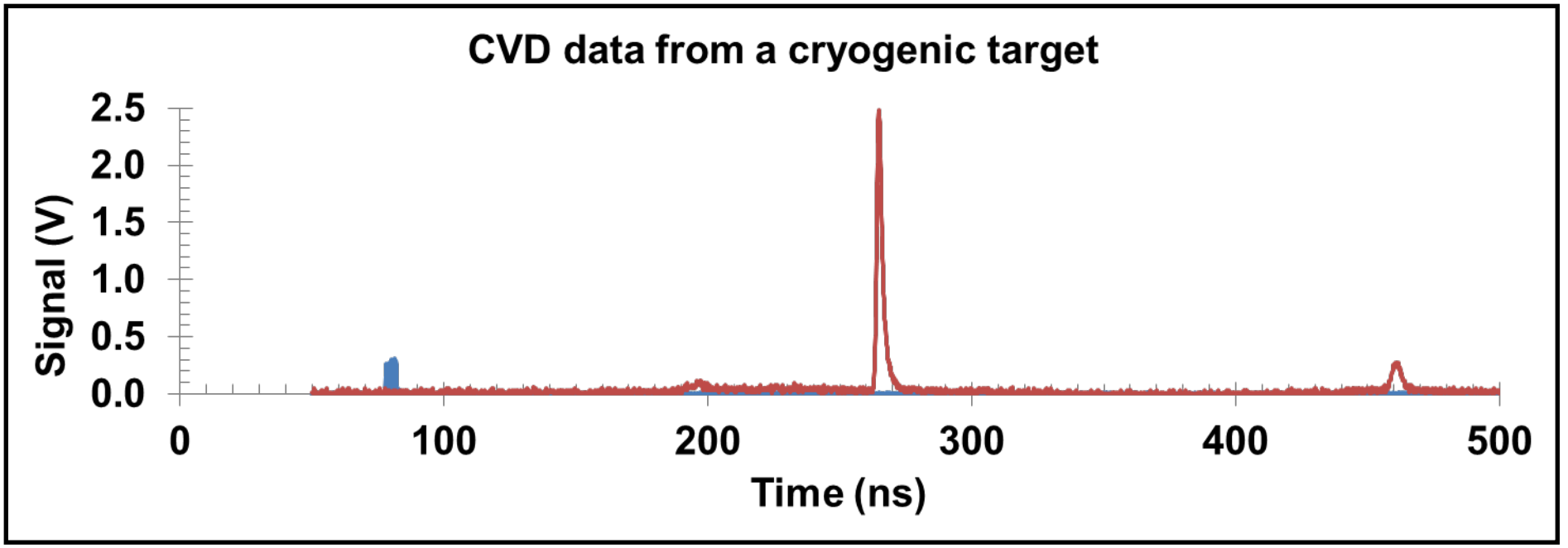
OMEGA 3dNTOF Project



J. P. Knauer
University of Rochester
Laboratory for Laser Energetics

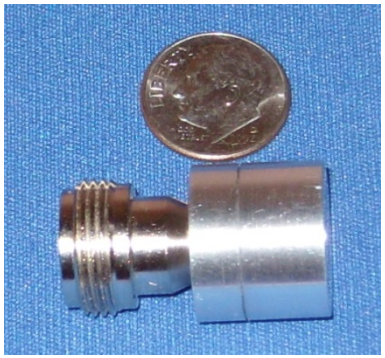
National ICF Diagnostics
Working Group Meeting
Los Alamos National Laboratory
Los Alamos, NM
6-8 October 2015

Summary

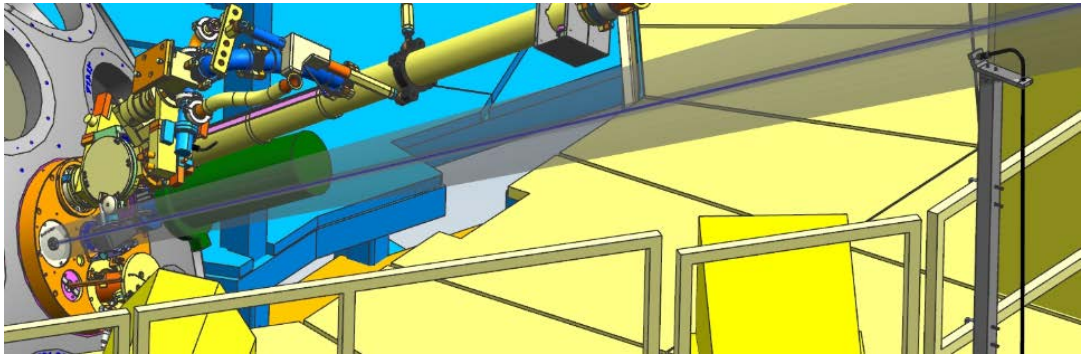
3dnToF is a Center-of-Momentum velocity measurement project

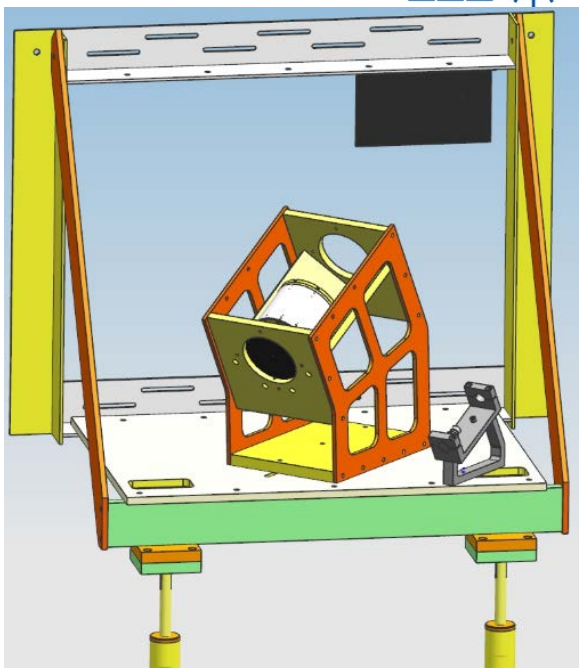
- **Proof-of-principle demonstrated in FY15**
  - **Single axis demonstration**
  - **Timing fiducial and data recorded on single digitizer**
- **Detector responses measured with x rays**
- **Asymmetric Drive experiments demonstrated feasibility of measurement**
- **Multi-layer geometries may extend the dynamic range of CVD detectors**

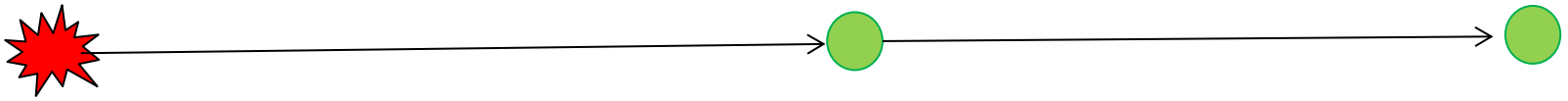
CVD diamond detectors are located at 5.8 m and 15.8 m from the center of the target chamber



Two 10x1 mm CVD







Distance uncertainty of 1 mm
Timing uncertainty of 20 ps ⇒ **Velocity resolution of 9 km/s**

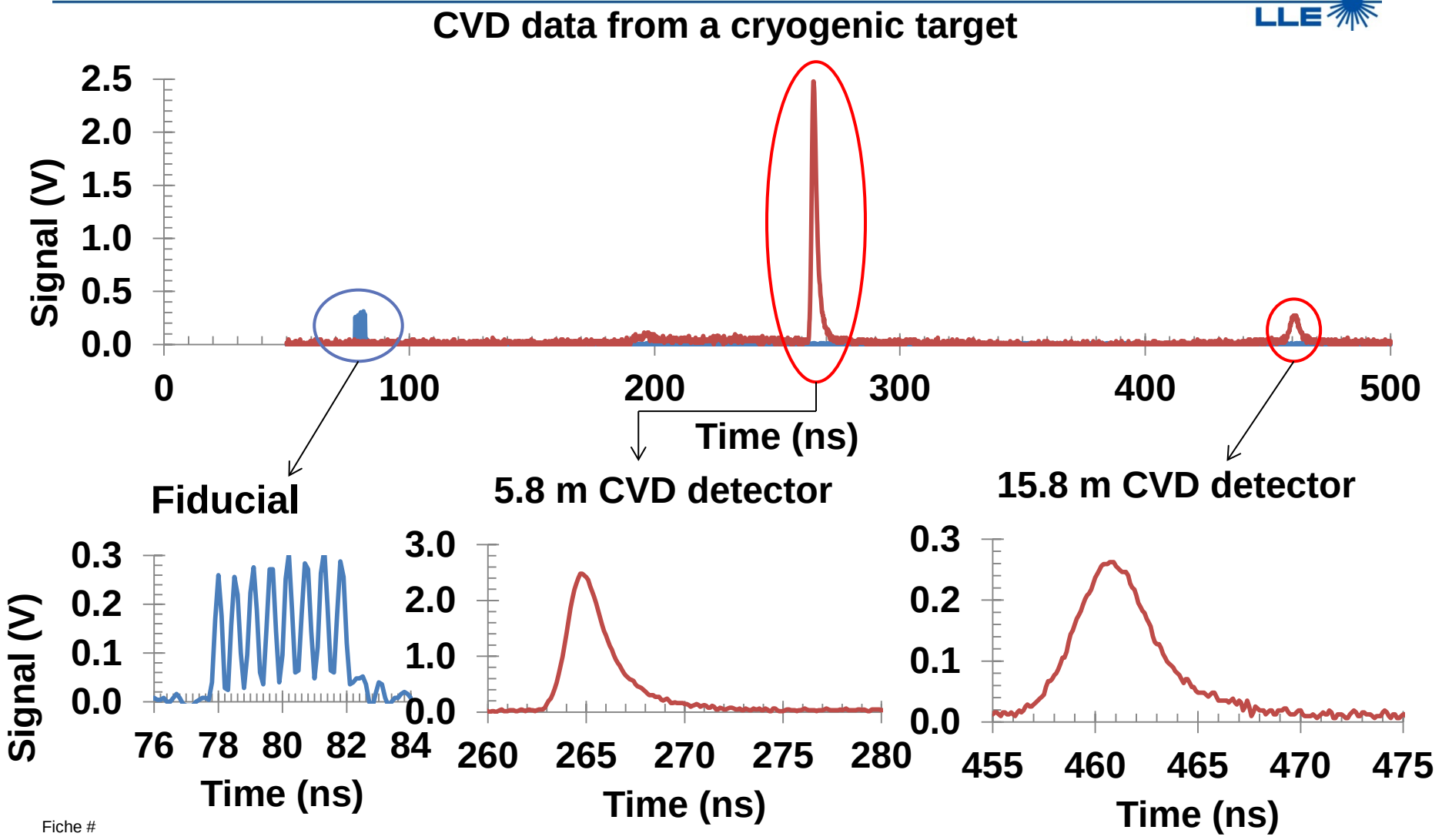
CVD detectors are aligned along the same line-of-sight as an existing nToF scintillator 15 m from tcc

Transit times for photons, DT neutrons, and DD neutrons allow for separation of the peaks

Detector - Radiation	Transit time (ns)
3dp2-1 (5.8 m) - photon	19.495
3dp2-1 (5.8 m) – DT neutron	114.078
3dp2-1 (5.8 m) – DD neutron	270.560
3dp2-2 (15.9 m) - photon	52.873
3dp2-2 (15.9 m) – DT neutron	309.383
3dp2-2 (15.9 m) – DD neutron	733.771

DT neutron transit difference between detector locations is 195.306 ns

A timing fiducial and signals from both detectors are recorded by a single digitizer

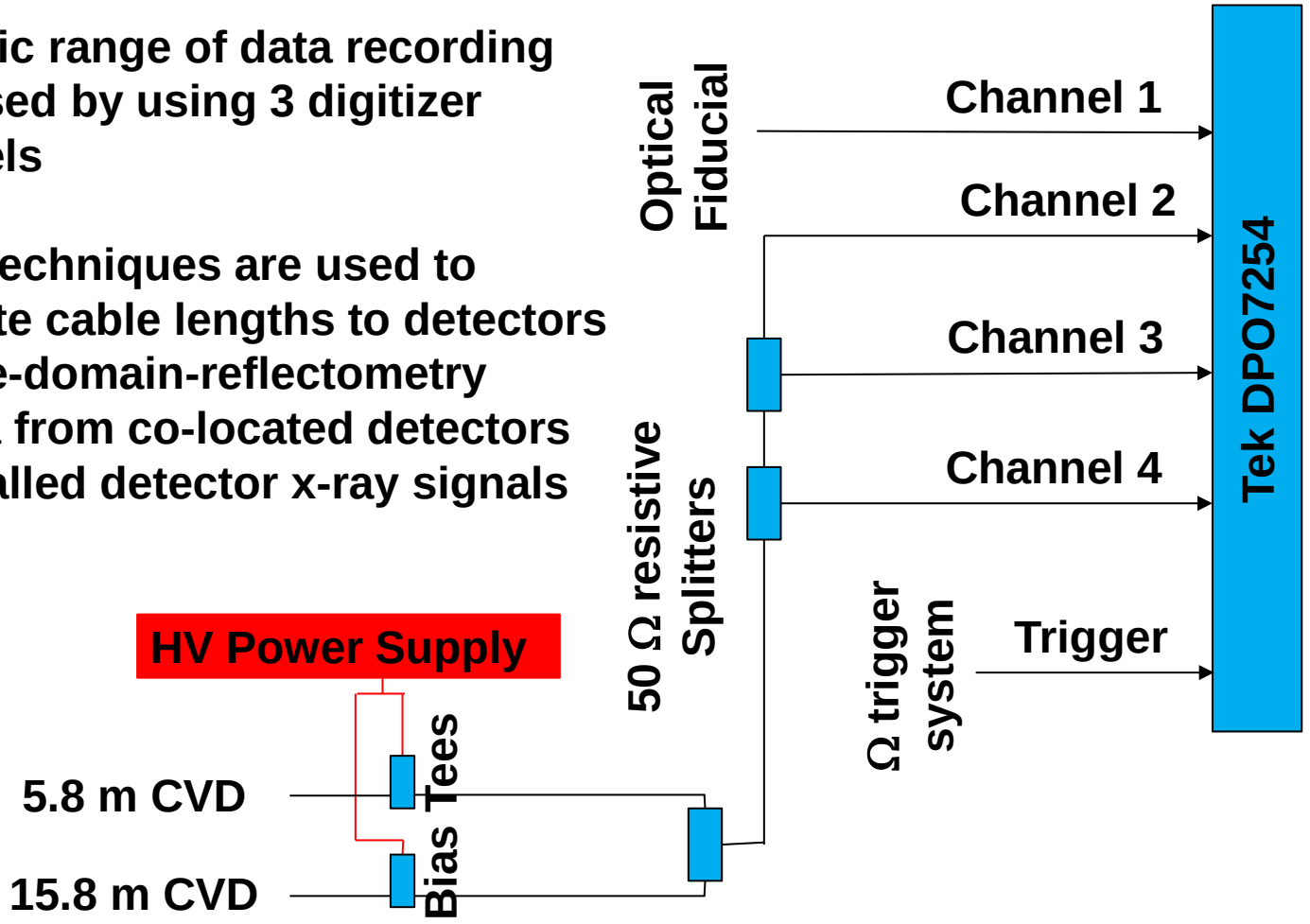


Timing fiducial uses channel 1 and data from CVD detectors use channels 2 - 4

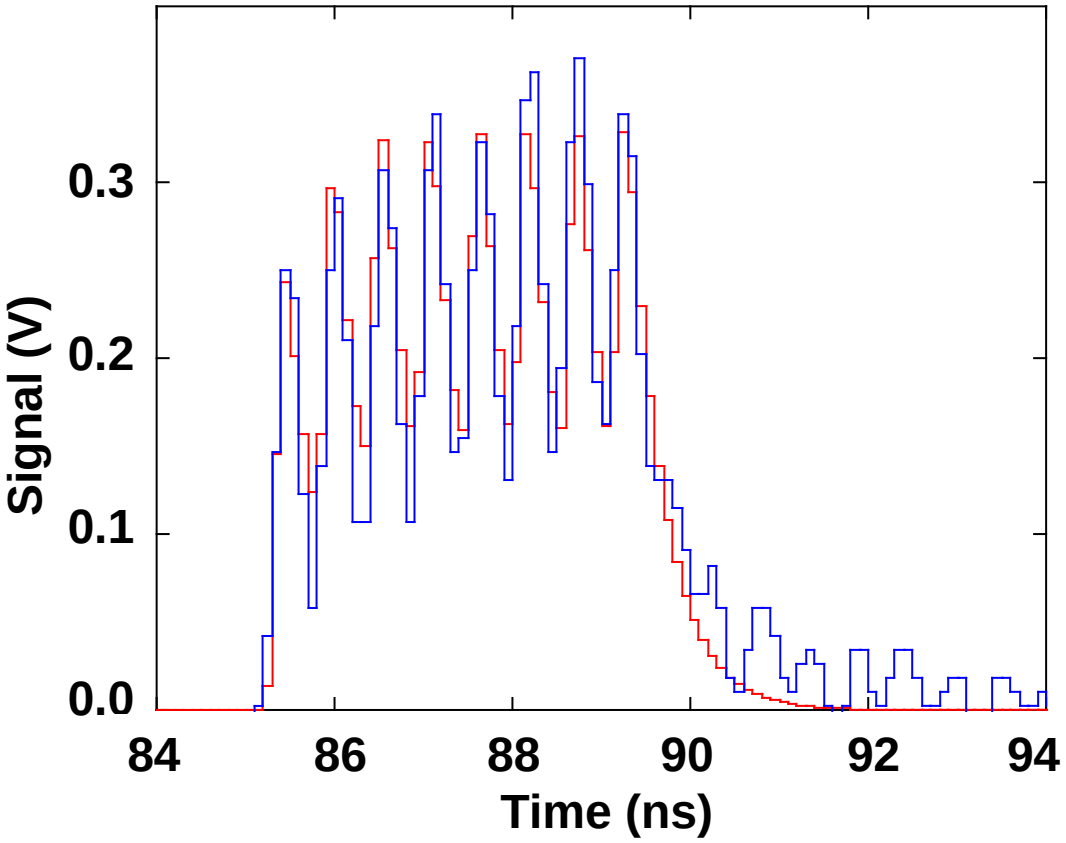
Dynamic range of data recording increased by using 3 digitizer channels

Three techniques are used to calibrate cable lengths to detectors

- **Time-domain-reflectometry**
- **Data from co-located detectors**
- **Installed detector x-ray signals**



A functional form for the fiducial is fit to the data to determine t_{fidu}

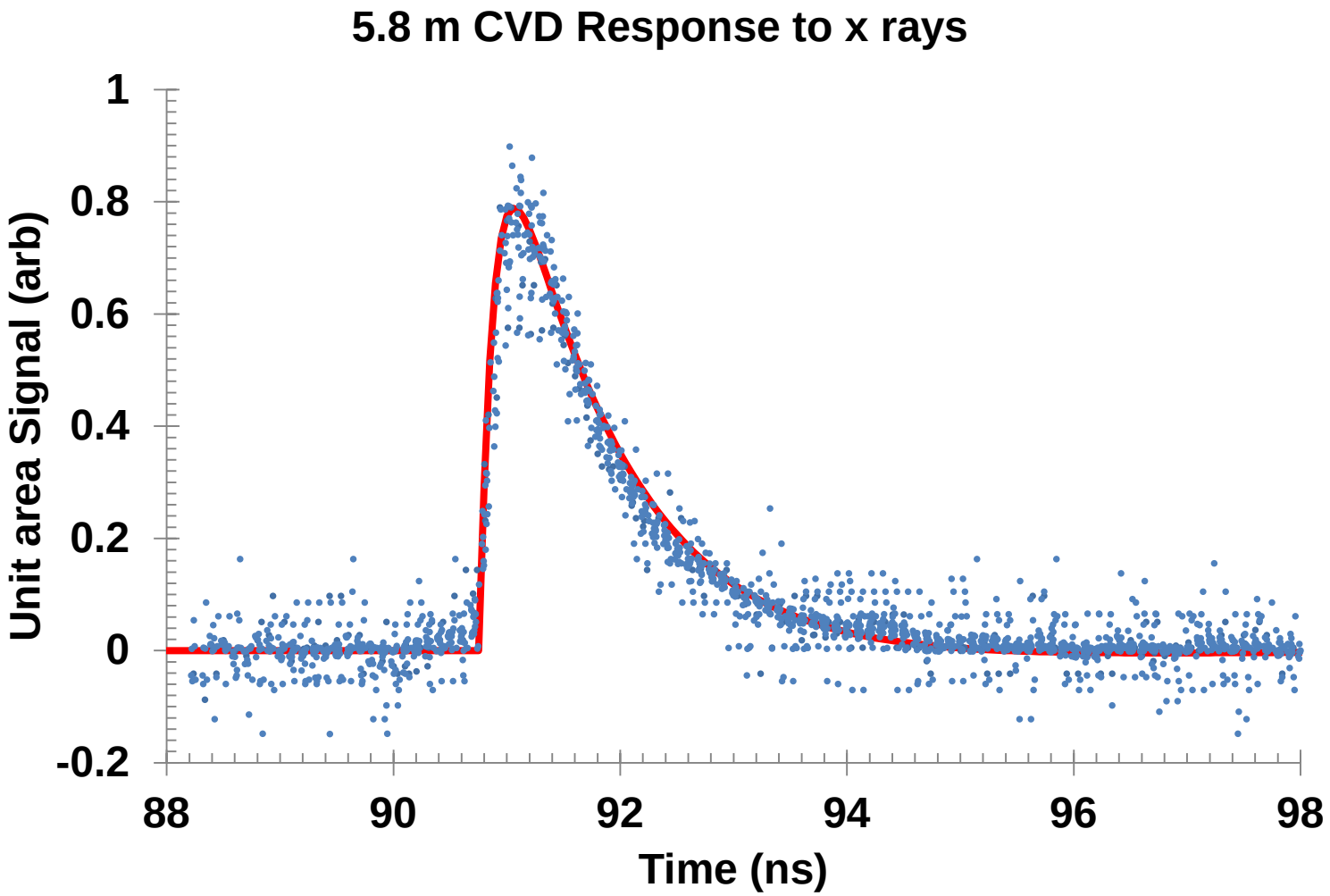


Data in blue

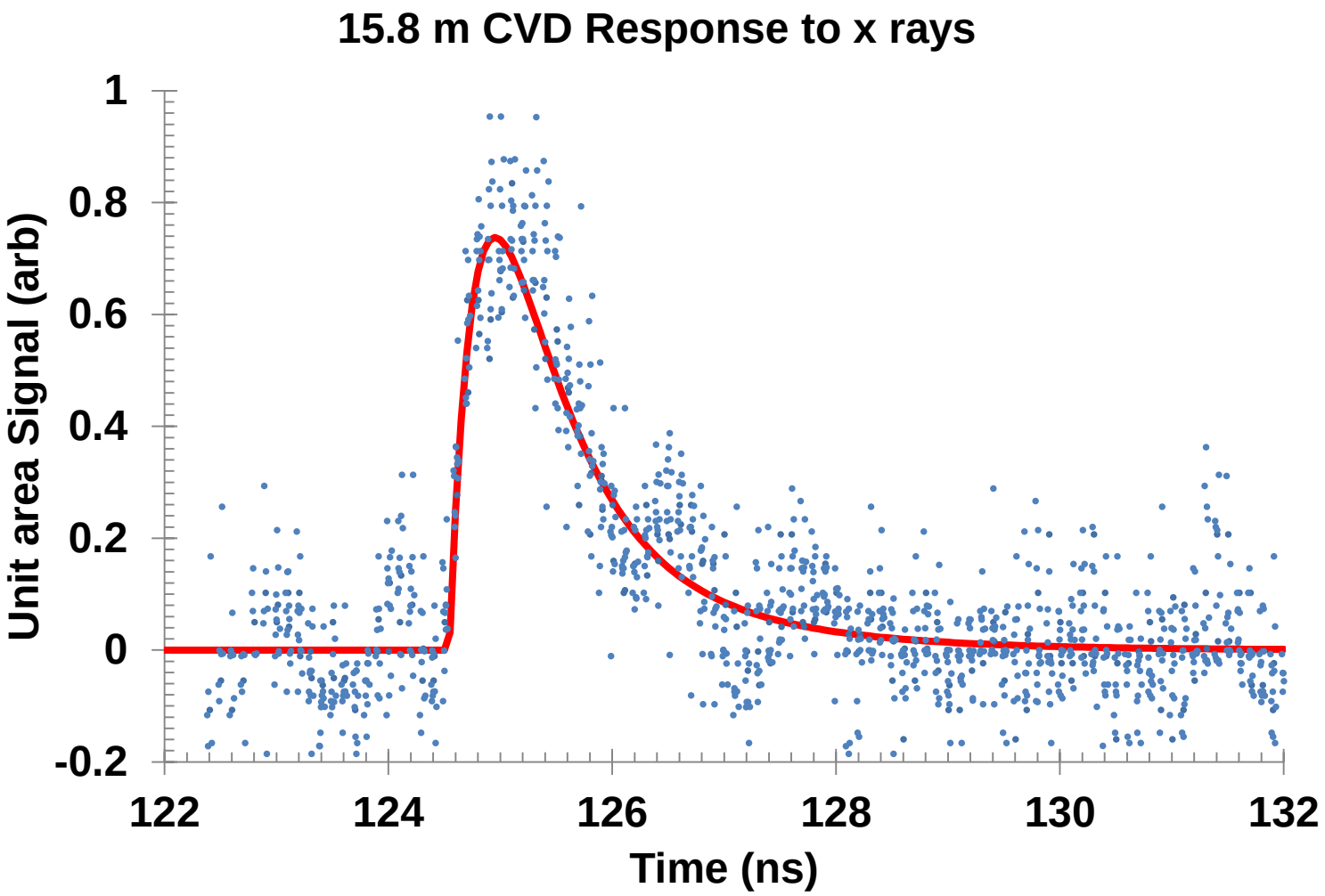
Fit in red

Fiducial model is a sum of 8 Gaussian peaks separated by 548.25 ps convolved with an exponential

X rays were used to characterize the Instrument Response Function (IRF)



X rays were used to characterize the Instrument Response Function (IRF)



Statistical errors are well determined and systematic errors are being quantified

- Statistical errors
  - Error from timing and distance = 11 km/s
  - Error from kT uncertainty of 0.4 keV = 3 km/s
  - Error from peak fit = 10 km/s
  - Total statistical error = 17 km/s
- Systematic errors
  - Minimized by recording a multiplexed signal
  - Cable differences measured
  - IRF shape dominates the unknown part of the systematic error

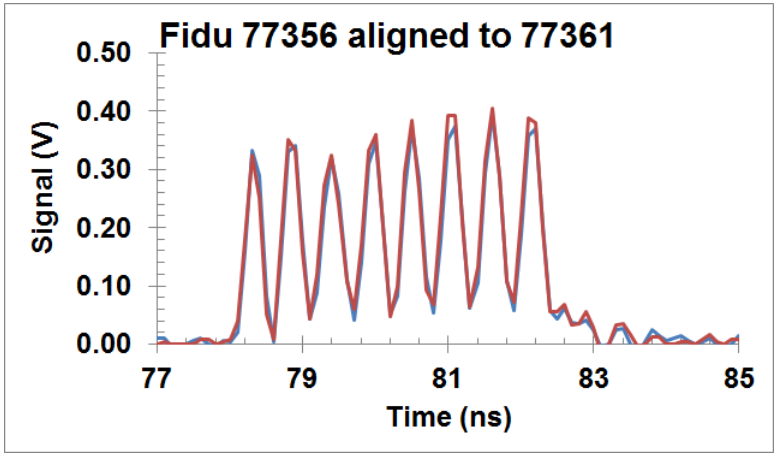
A series of three asymmetric drive implosions were used to test the “bulk velocity” measurement

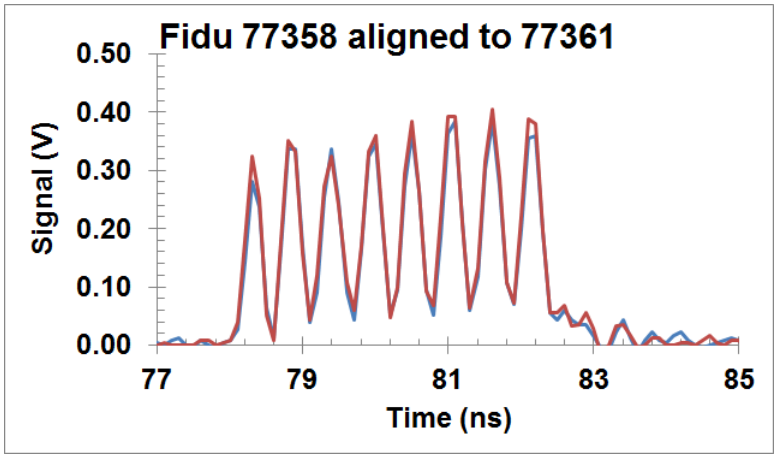
- **High yield Exploding pusher targets were used**
- **Drive asymmetry imposed by reducing laser energy on one side of the target**
  - **Shot 77365 energy reduced on side of target facing detectors**

  - **Shot 77358 energy reduced on side of target opposite detectors**

  - **Shot 77361 symmetrically driven target**

Timing fiducials were aligned to symmetrical drive shot 77361

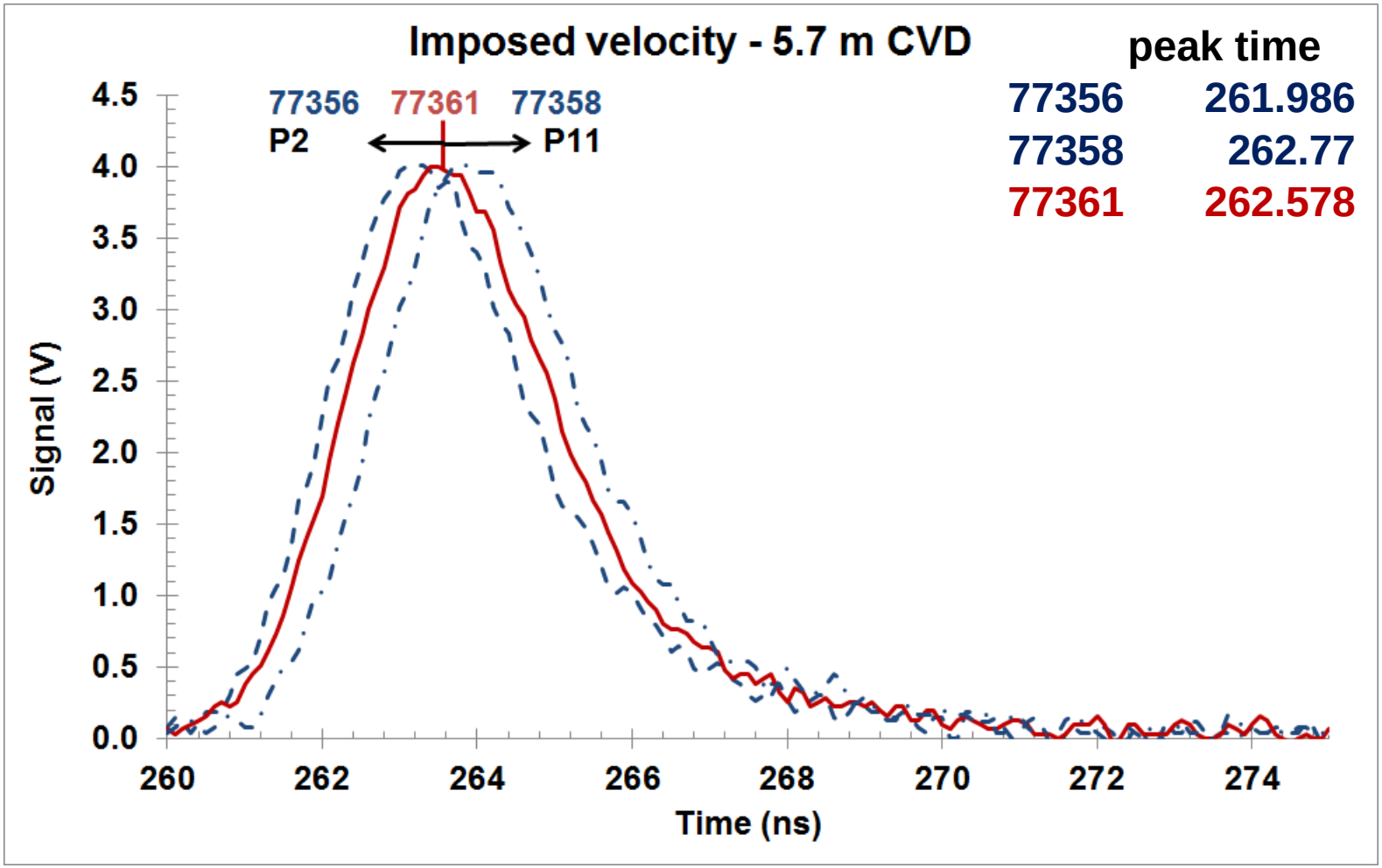




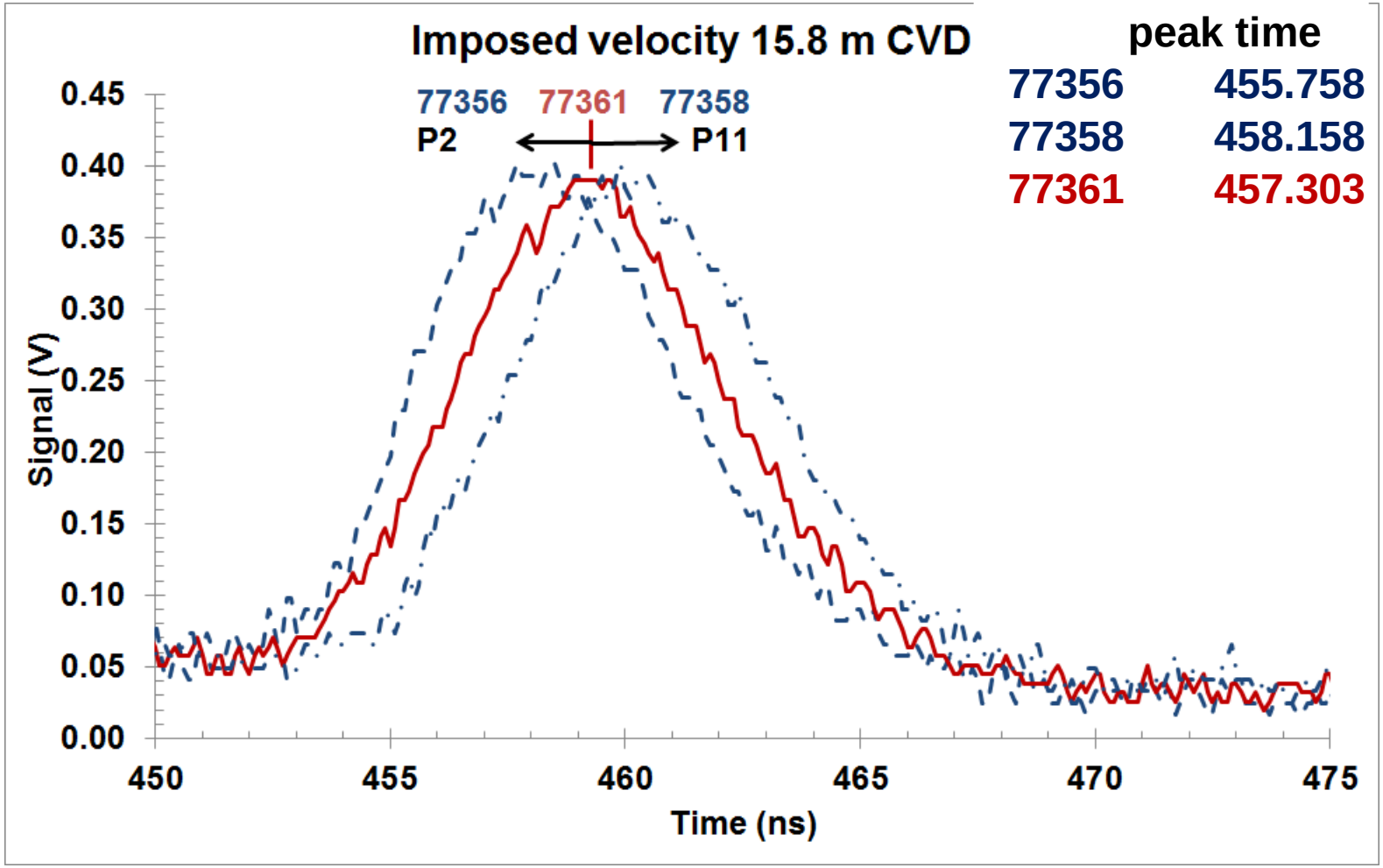
77356 - energy of beams around P2 reduced
77358 - energy of beams around P11 reduced

Timing fiducials aligned to remove trigger jitter no more than ± 100 ps (1 sample)

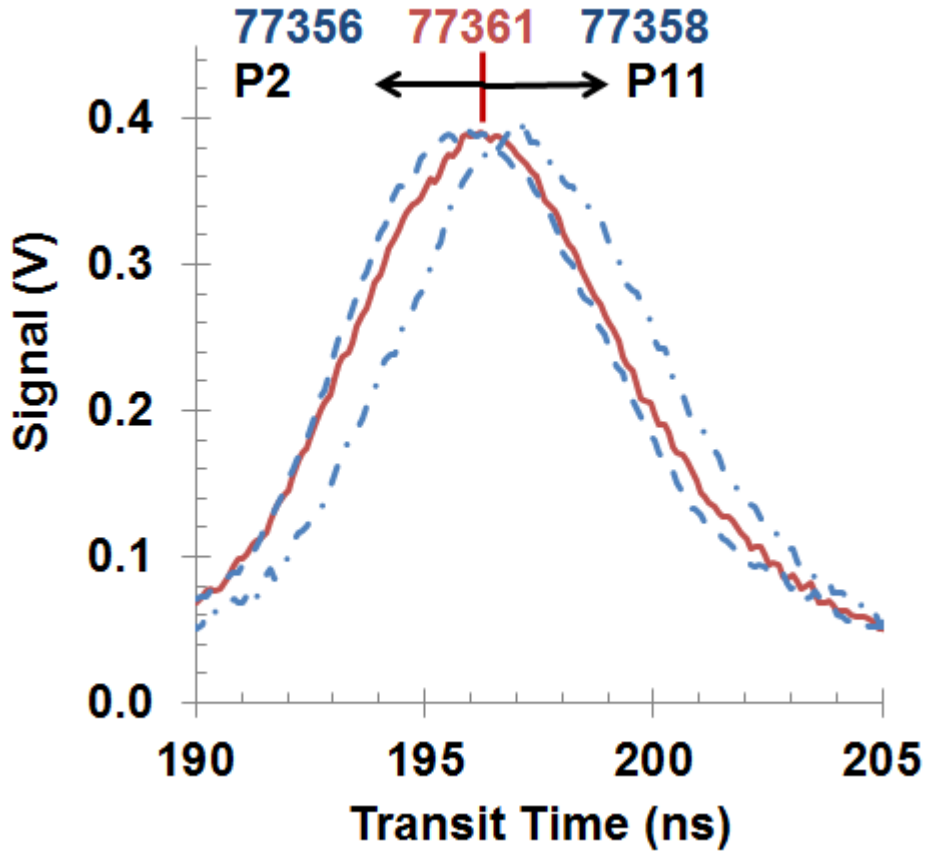
CVD diamond detector at 5.7 m shows Doppler shift with illumination perturbation



Temporal shift is larger for the 15.8 m CVD detector



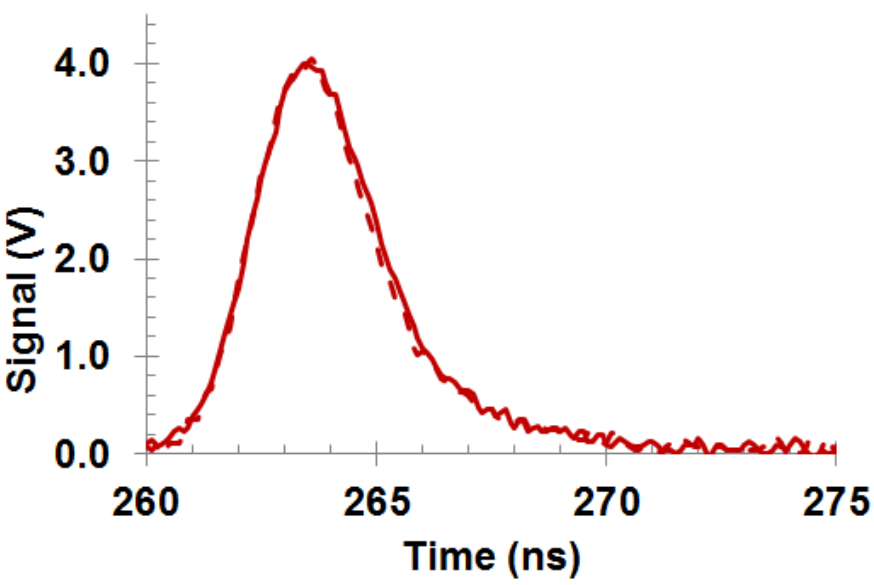
Transit time difference used to measure relative speed along P2 – P11 axis

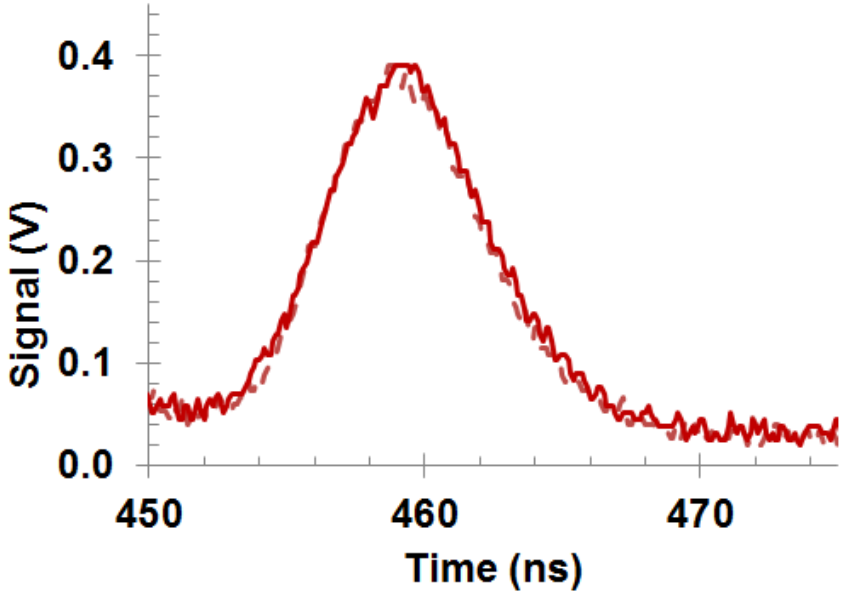


	Transit Time (ns)	Relative Speed (km/s)
77356	193.772	265
77358	195.388	-179
77361	194.725	0

No Doppler shift is seen when symmetrical illumination is used

Dashed curve – 77363
Solid curve - 77361

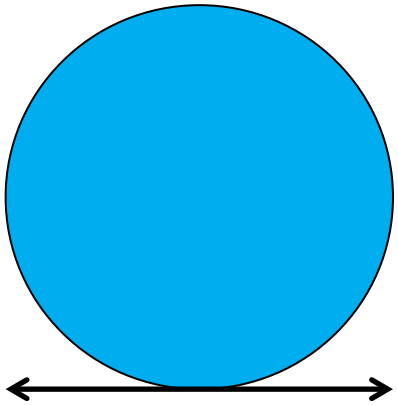




If all symmetrical shots are identical, then timing error for transit is ± 85 ps ~ ± 22 km/s (more work to be done on timing error)

CVD diamond detector concepts

- Keep total diamond thickness constant at 1 mm
- Keep detector diameter constant at 10 mm
- Vary number of layers



2 - 0.5 mm CVD layers

3 - 0.33 mm CVD layers

4 - 0.25 mm CVD layers

CVD diamond

Conductive layer

Typical 1mm CVD detectors have been built with N type connectors

CVD diamond

Conductive layer

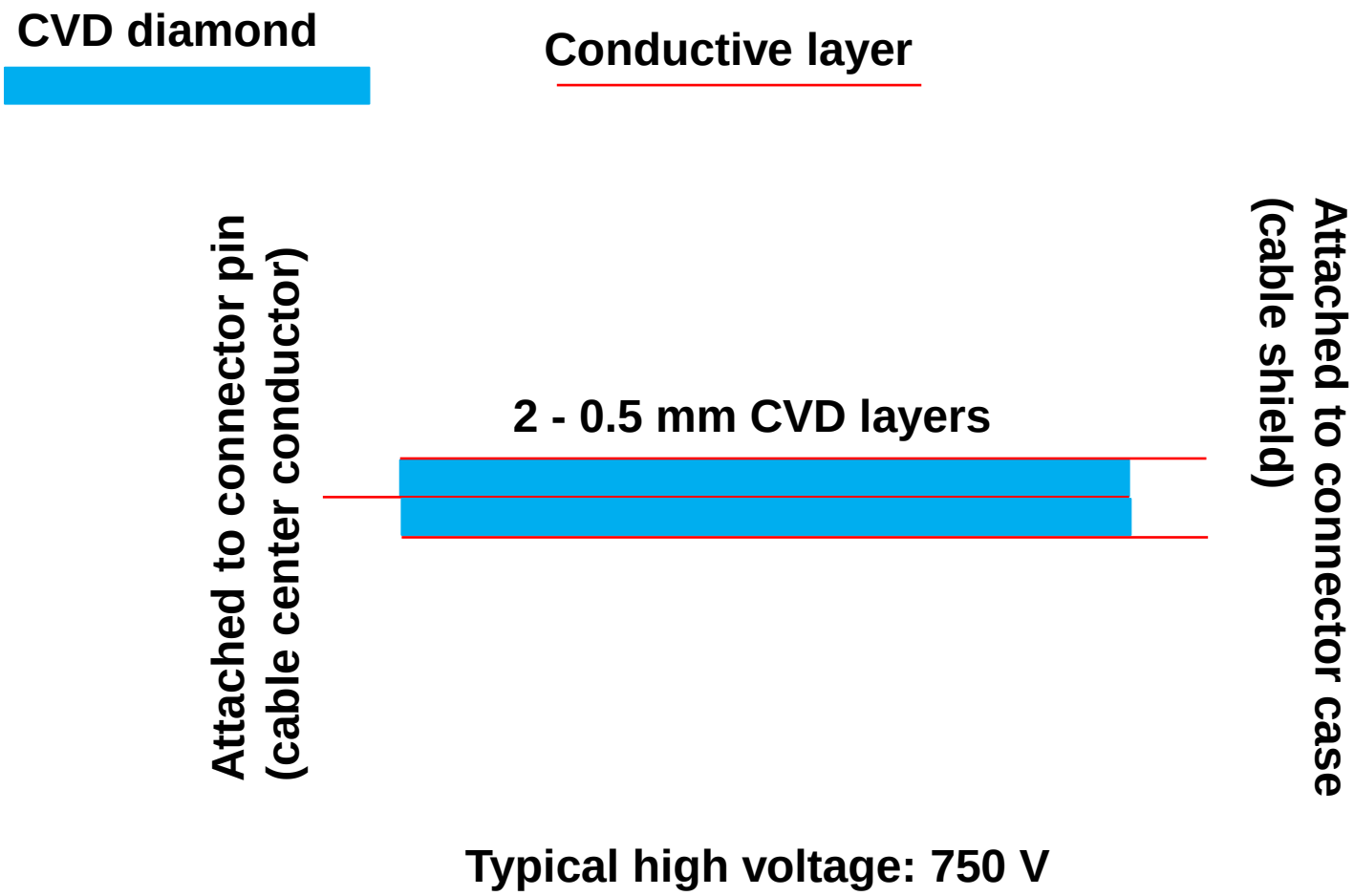
Attached to connector case (cable shield)

1 mm

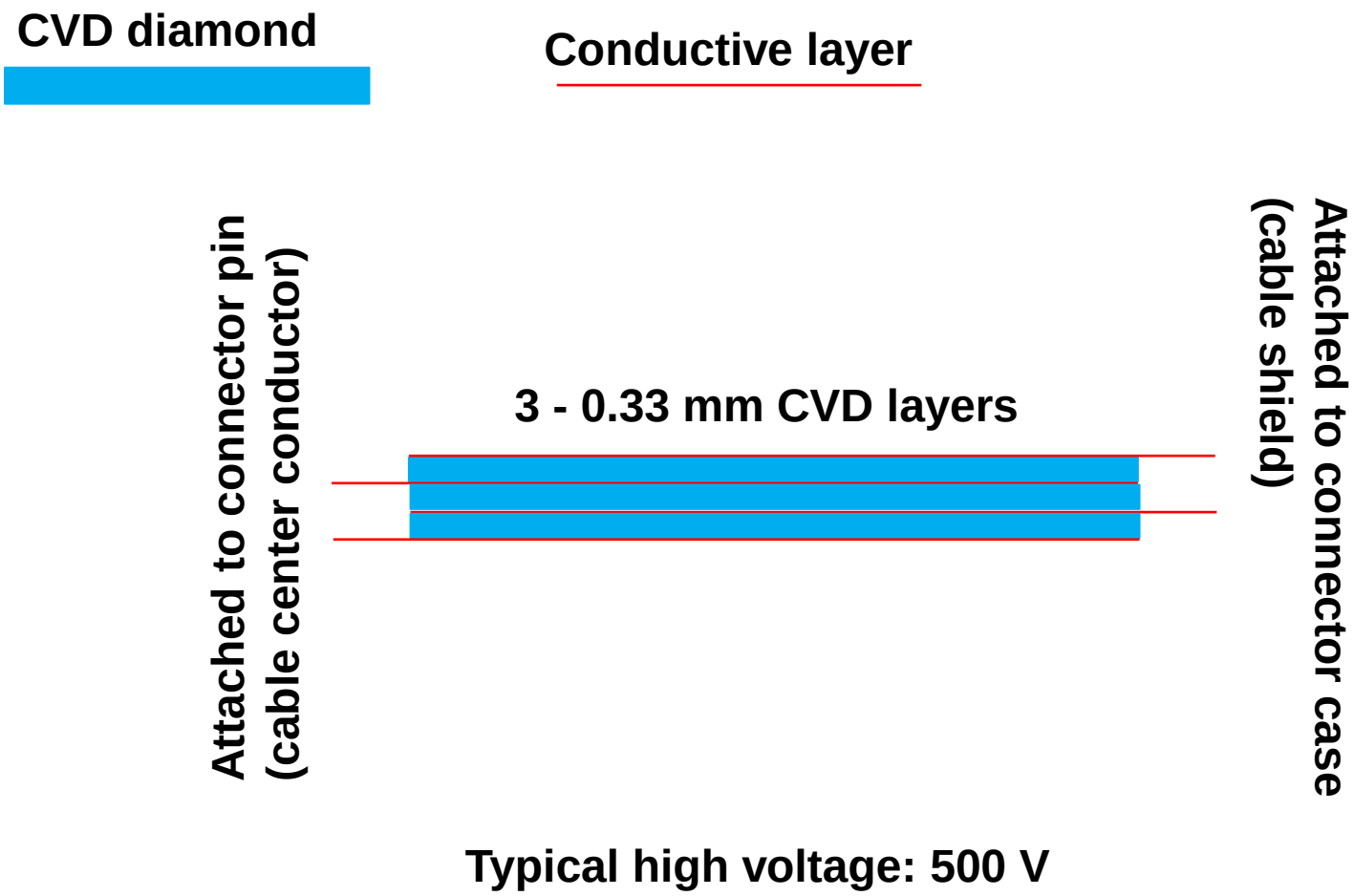
Attached to connector pin (cable center conductor)

Typical high voltage: 1500 V

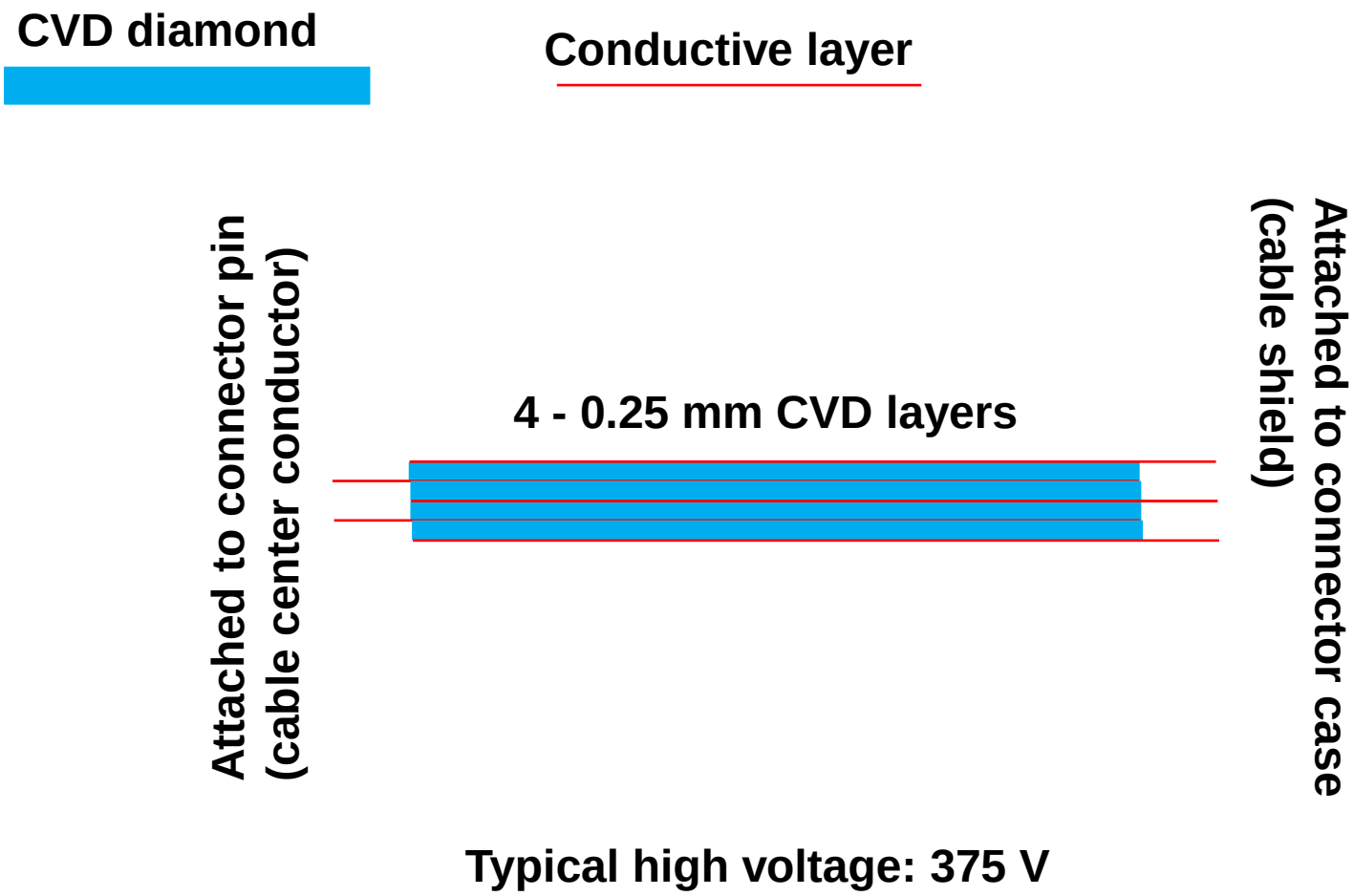
Multilayer concepts will need a new style mount



Multilayer concepts will need a new style mount



Multilayer concepts will need a new style mount



3dnToF is a Center-of-Momentum velocity measurement project

- **Proof-of-principle demonstrated in FY15**
  - **Single axis demonstration**
  - **Timing fiducial and data recorded on single digitizer**
- **Detector responses measured with x rays**
- **Asymmetric Drive experiments demonstrated feasibility of measurement**
- **Multi-layer geometries may extend the dynamic range of CVD detectors**