

Calorimetry Precision Timing (CPT)

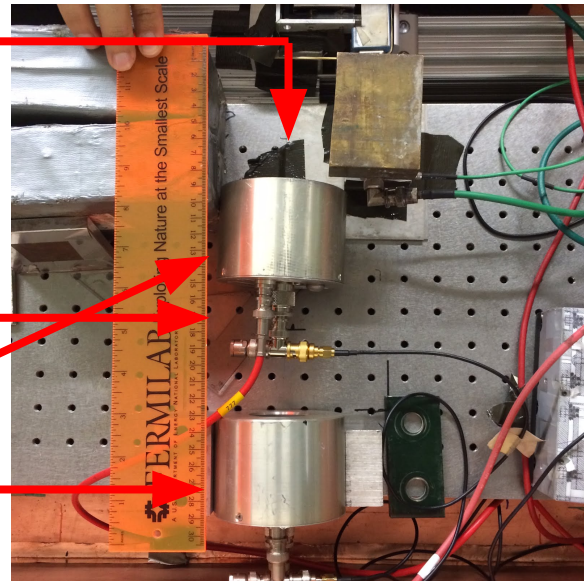
Caltech Group, CMS, CERN
Taylor Brunton Smith, 17-07-2014

Analysing test beam data from Fermilab May
Small xtal electron runs at various energy (8, 16, 32 GeV)

Electron beam from here

Small LYSO crystal here

Photek photodetectors here



Pulse Selections

Need to make cuts on pulses to ensure that we are analysing “good pulses”
(to circumvent impurity of electron beam, showering effects, saturation, etc)

Current Selection Criteria on Events

0.02 V < Cerenkov Detector Amplitude < 0.49 Volts - (Low end: ensure we're measuring electrons, high end: avoid saturation)

Photodetector Pulse Amplitude < 0.49 Volts - (Avoid readout saturation at 0.5 V)

Photodetector Histogram Integral > 4000.0 V*ps (i.e. 20.0 in natural histogram units) - (Justification to follow)

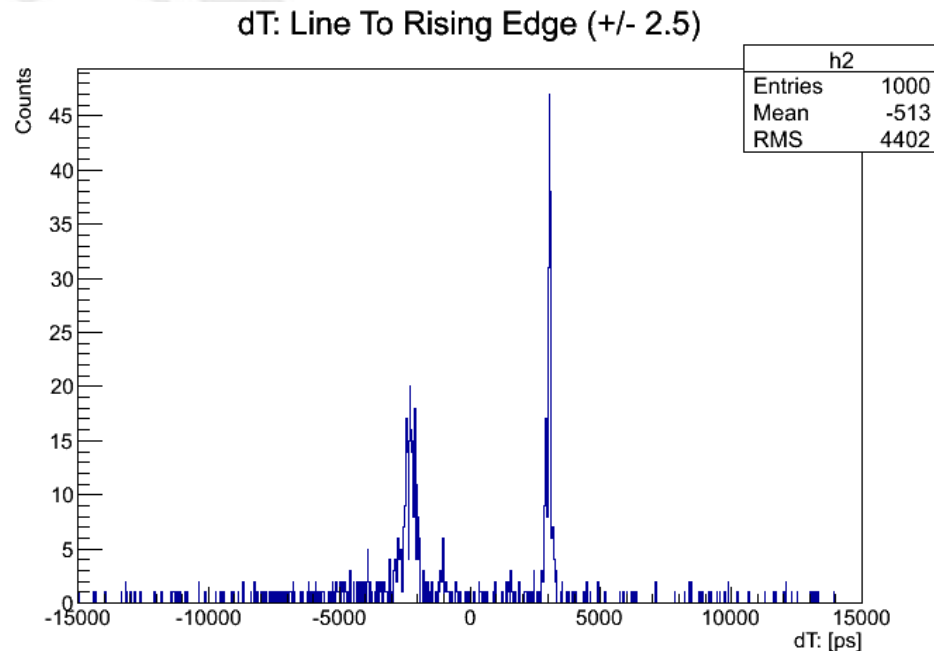
Pulse Selections

dT distribution for fitting a line to rising edge, no cuts applied

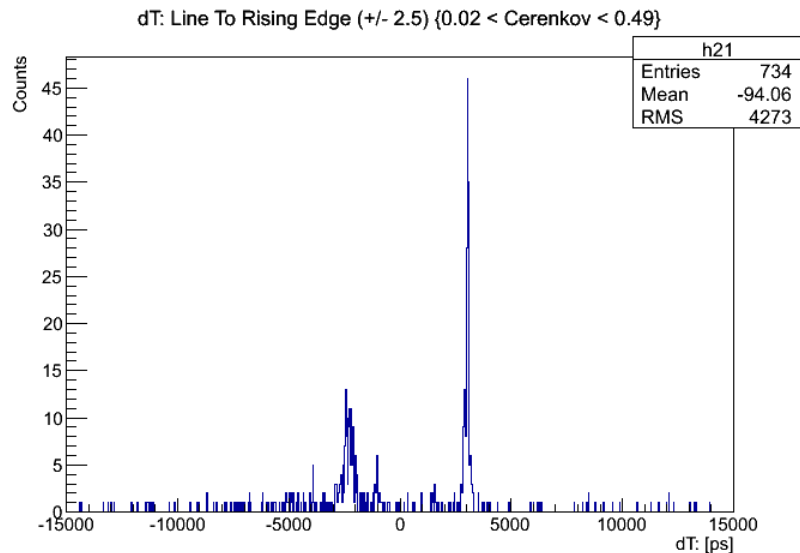
Pretty Terrible:

- Two Peaks,
- Long tailed background

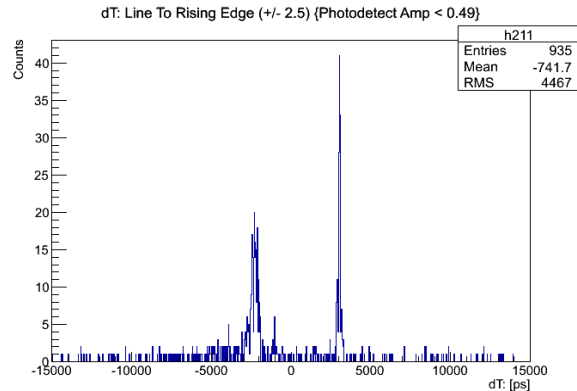
Lets add our cuts and see how they affect the dT distribution



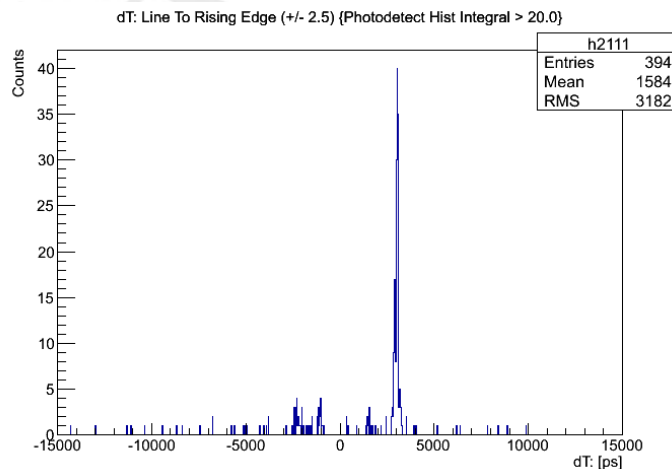
Pulse Selections



Cerenkov Response Cut



Anti-saturation Cut on Photodetector Pulse Amplitude

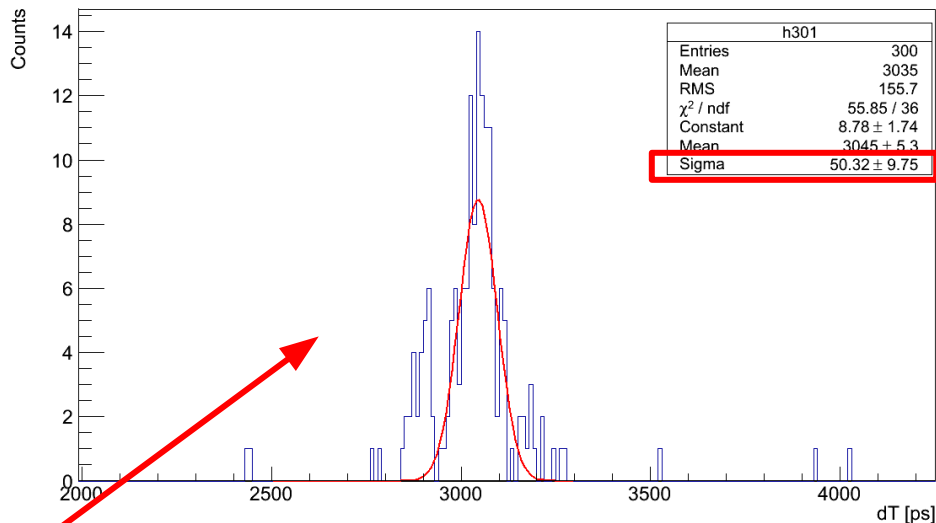


Photodetector Hist Integral Cut

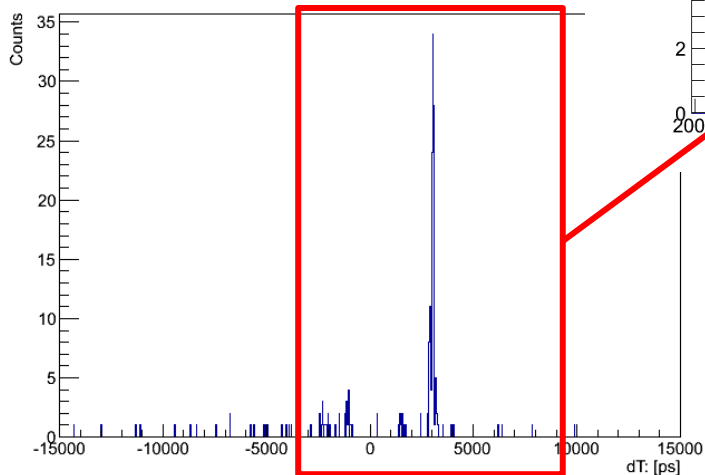
Pulse Selections

After full cut ensemble

dT: Line To Rising Edge {0.02 < Cher < 0.49 && Pulse Integral > 20.0 && Pulse Amp < 0.49}



dT: Line To Rising Edge (+/- 2.5) {Full Ensemble}



Rough time resolution ~50ps
Think we can do better!

Ensemble of Fits

Line to Rising Edge - Find max amplitude. Find half amplitude about baseline. Fit line here (+/- 500 ps)

Landau - Fit Landau distribution to full pulse shape

Exp Mod Gauss (Full) - Fit Exponentially Modified Gaussian (http://en.wikipedia.org/wiki/Exponentially_modified_Gaussian_distribution) to the full pulse shape

Exp Mod Gauss ($0 < t < 600$) - Fit Exponentially Modified Gaussian from 0 to 120 ns (t in pulses is often measured in units of 0.2 ns)

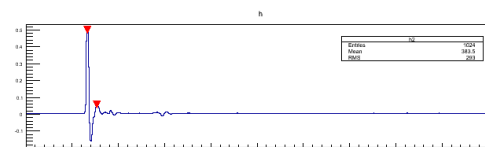
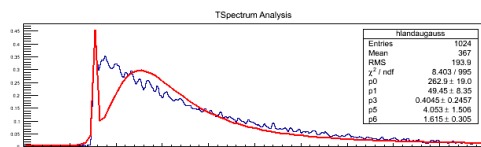
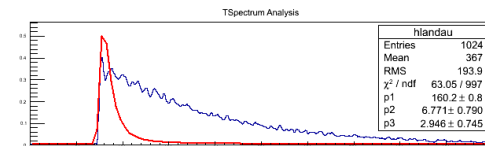
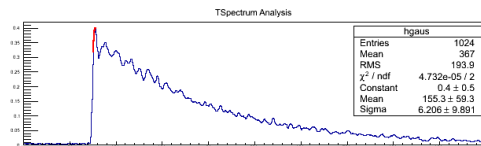
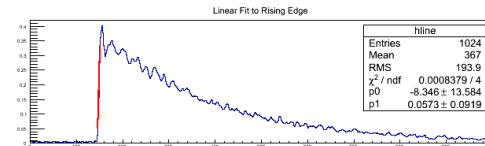
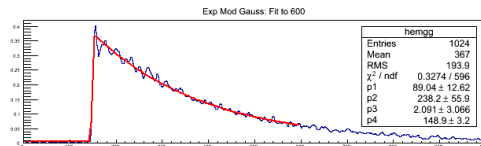
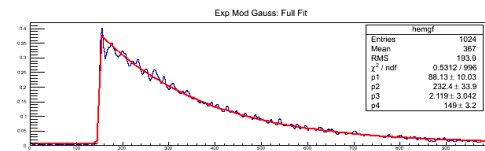
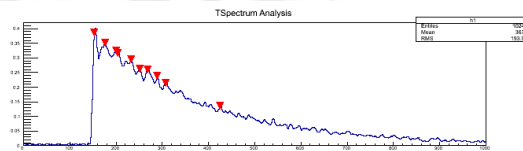
Landau / Gauss - Fit superposition of Landau and normal distributions to full pulse shape

Gauss_3 - Fit Gaussian to largest peak (+/- 0.6 ns)

Ensemble of Fits

Interested in:

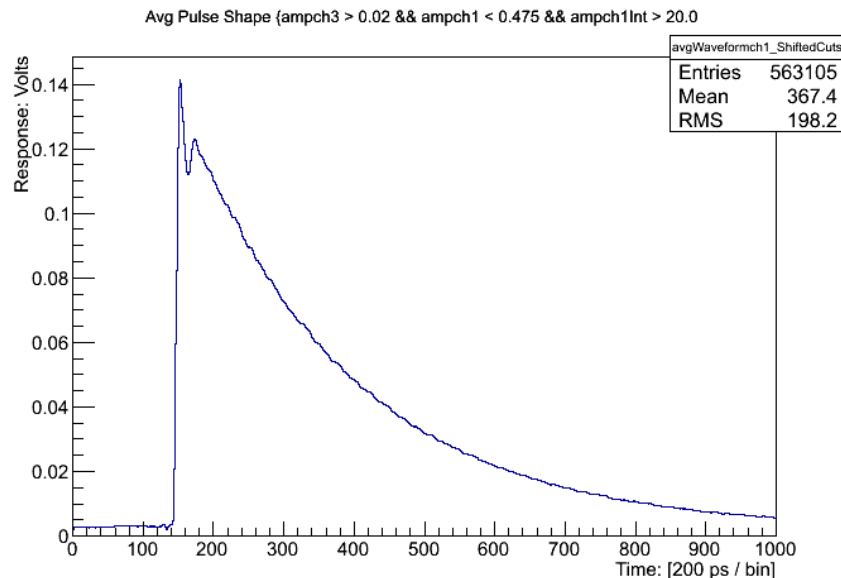
- Good time resolution
- Good energy resolution
- Robustness (does fit work well for all energies, setups)
- Reliable
- Quality factors



Need to tweak some fit parameters see effect on time resolution, next time!

Complex fits are very sensitive to
initial parameters

Can tune them on average of “good”
pulse shapes to get better IPs



Moving Forward:

- Understand wings in shown dT distribution
- Tweak all initial fit parameters to better fit the average pulse shape, study effect
- Tweak Landau / Gauss (don't give up too early!)
- Check other energy electrons, protons of same setup
- Move onto data from different experimental setup, different xtal geometry

Bonus Prizes for:

- Definitely understanding characteristic “two peak shape”
- Definitely understanding tail “wiggles”

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Piazza Venezia, Roma



Deutschland ist Weltmeister! Freiburg im

The background of the slide features a large, faint, light-gray watermark of the Rutgers University seal. The seal is circular, with a sunburst design in the center and the words "RUTGERS THE STATE UNIVERSITY OF NEW JERSEY" around the perimeter.

RUTGERS

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BACKUP SLIDES

Glossary

Pulse - The voltage vs time profile read out by the DRS boards, (See Fig 1.a)

Photodetector Pulse - Pulse profile of photodetector (either Hamamatsu or Photek) which reads out from the crystal

Reference Pulse - Pulse profile of photodetector which reads out from the reference (ie. nothing attached to it)

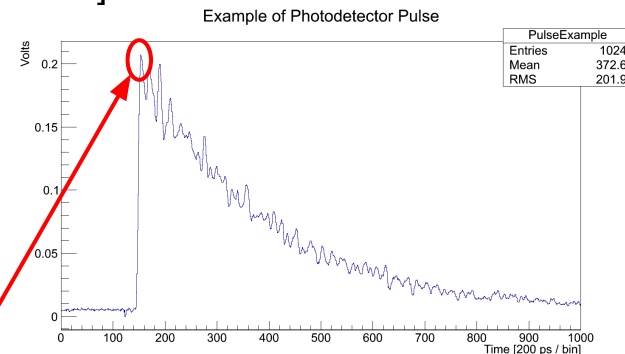
Cerenkov Pulse - Pulse profile of photodetector positioned at electron's Cerenkov angle in experimental setup (used to ensure that photodetector pulses are indeed due to electrons)

[Name of Pulse] Amplitude - Peak voltage attained by [Name of Pulse] in the measurement
(Fig 1.a)

Fig 1.a:

An example of a photodetector pulse

Photodetector pulse ampli



Glossary (cont)

Rising Edge - The steep rise in voltage characteristic of when the pulse “arrives” (See Figure 1.b)

Peaks - The small crests in voltage fluctuation (See Figure 1.b)

[Name of Pulse] Histogram Integral - Value of sum of bins in [Name of Pulse]

[Name of Pulse] [Name of Fit] Integral - Value of integral of [Name of Fit] function which has been fit to the shape of [Name of Pulse]

Time Resolution - Standard deviation gaussian fit to the distribution of time differences between amplitude of reference detector and the extracted time of pulse (See Figure 2)

[Name of Fit] Energy Resolution - Determined by correlation of Histogram Integral and [Name of Fit] Integral

dT: Line To Rising Edge {0.02 < Cher < 0.49 && Pulse Integral > 20.0 && Pulse Amp < 0.49}

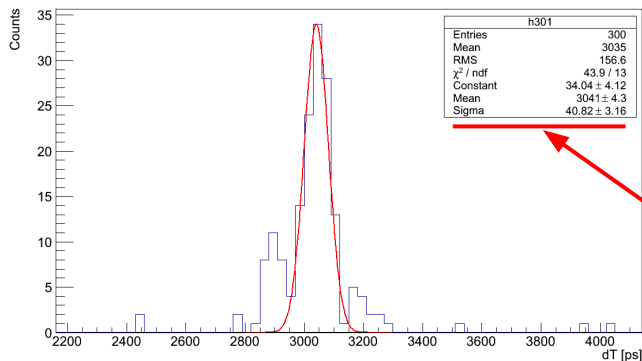


Fig 2:

Distribution of dT
for a specific time
extraction

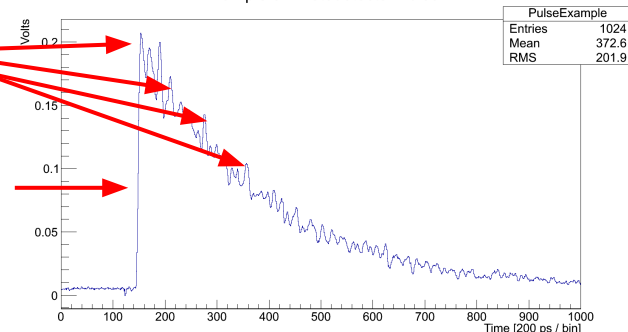
Time resolution

Fig 1.b

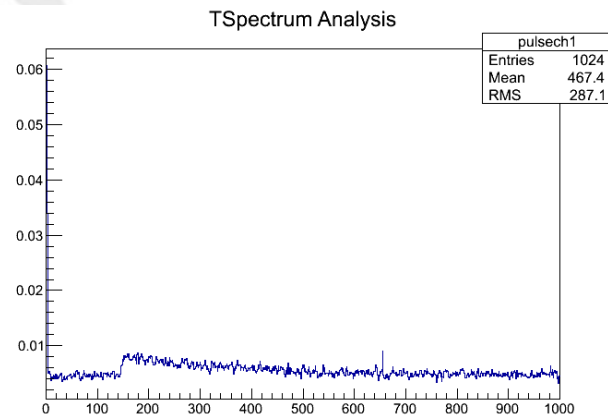
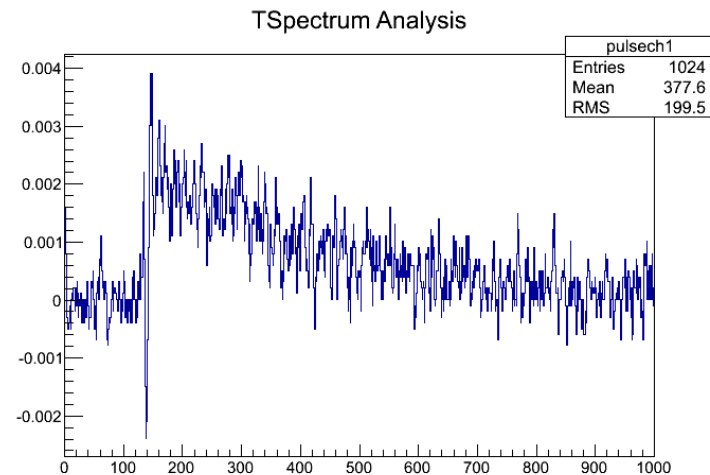
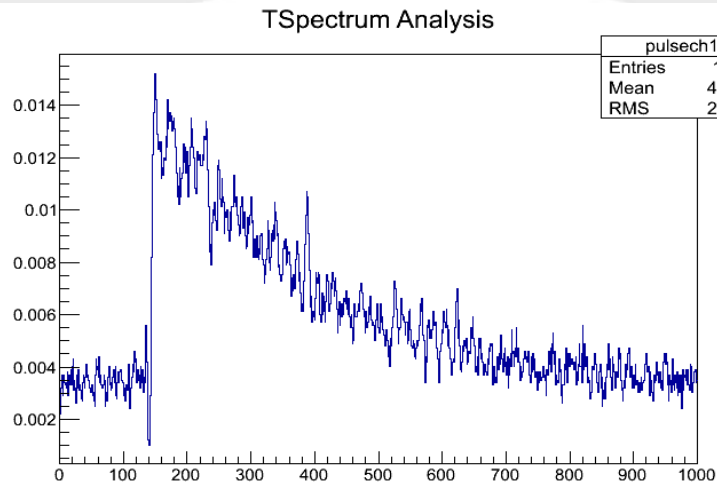
Peaks

Rising Edge

Example of Photodetector Pulse

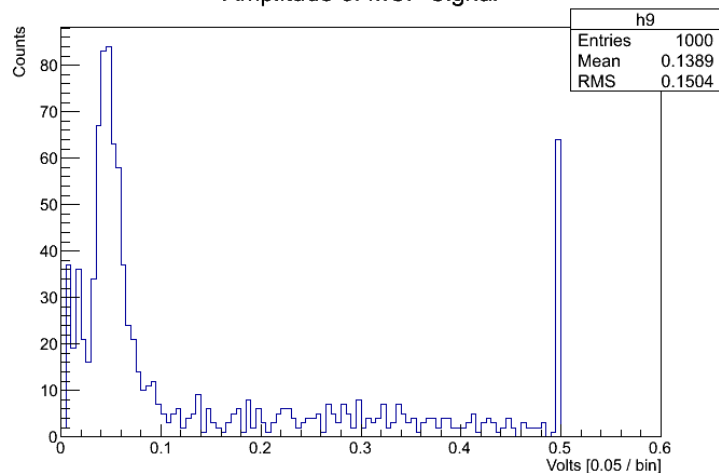


Some Bad Pulse Shape Examples:

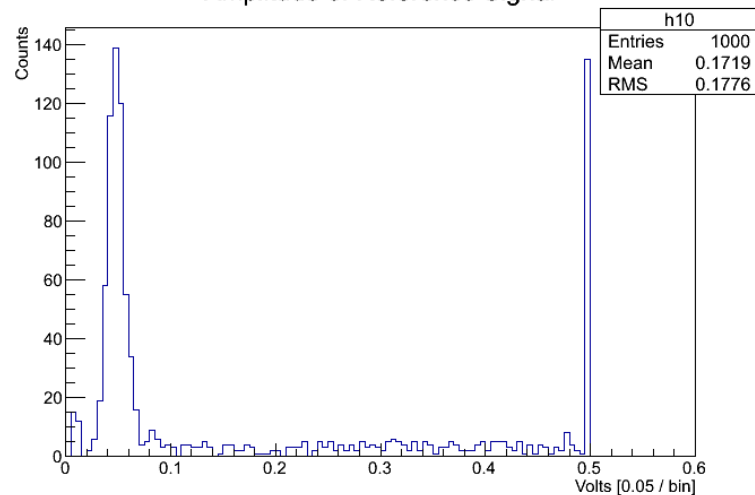


Run 082: 16 Gev electrons, small xtal

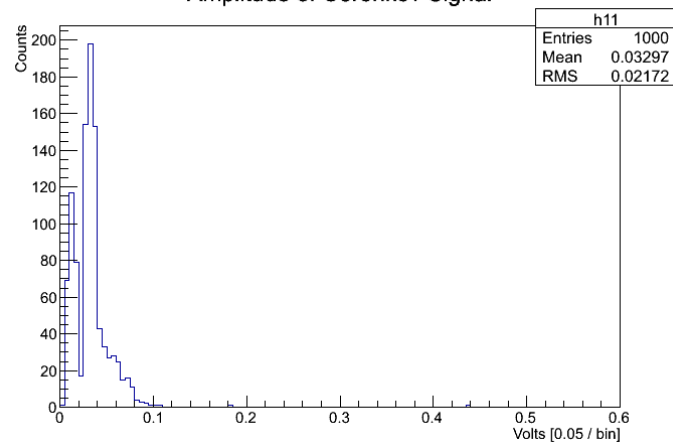
Amplitude of MCP Signal



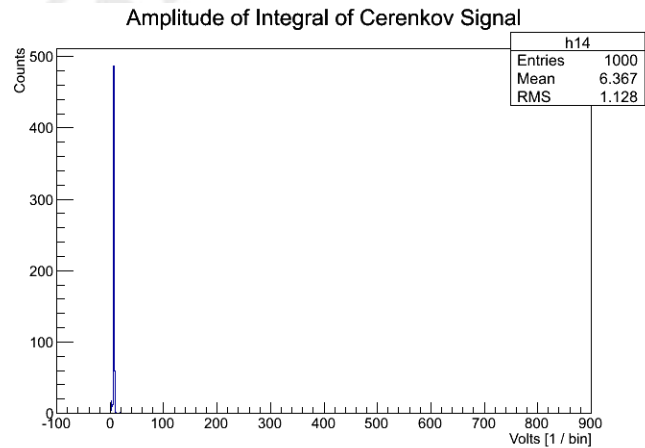
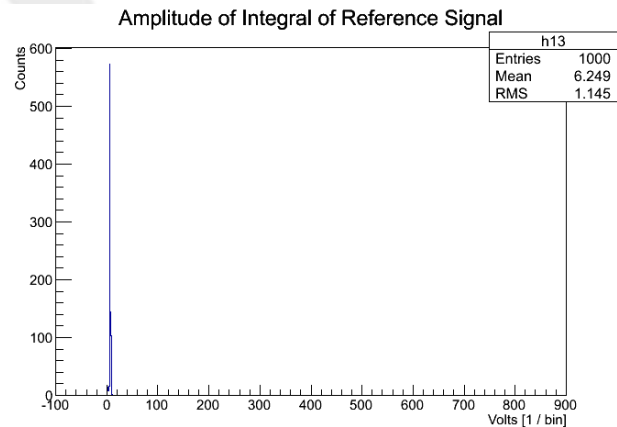
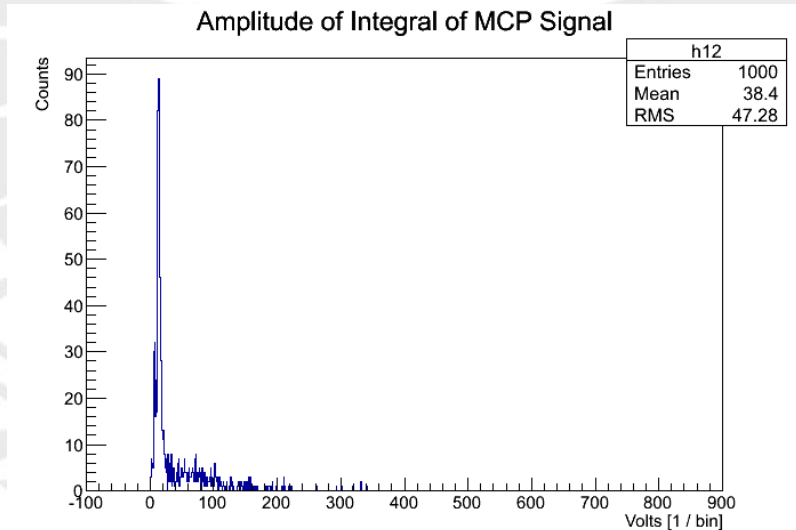
Amplitude of Reference Signal

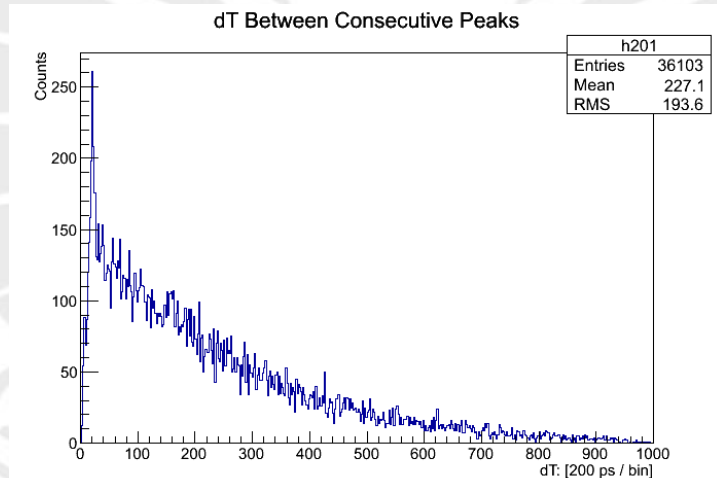


Amplitude of Cerenkov Signal

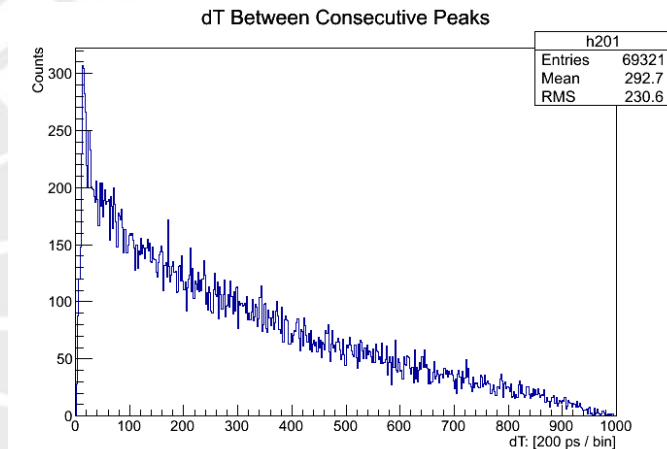


Run 082: 16 Gev electrons, small xtal





Run 082: 16 Gev electrons, small xtal



Run 091: 8 Gev electrons, small x tal

Nota Bene: EACH TICK IN TIME IS 200 ps