

Tests of ProtoDUNE beam-line ToF detectors

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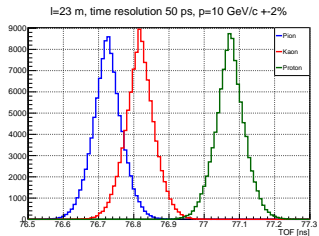
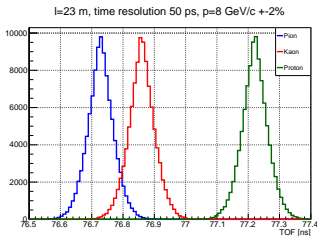
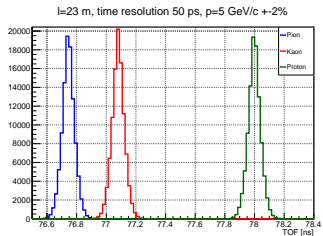
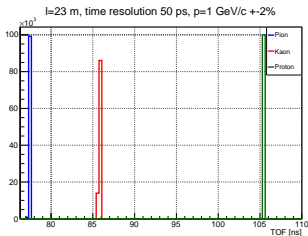
Supervisor: Jonathan Paley

Final Report
Summer Internship in Fermilab 2016

- Overview and simulations of particle separation
- Tests and technical troubles
- Installing pLAPPDs into muon telescope
- Analysis of pulse shape measurements

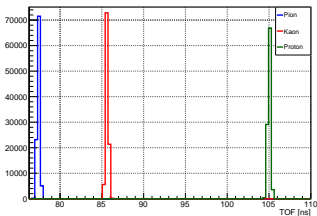
- p , π , K , e present in charged-particle beam
- Separation: all over the beam momentum range (1-10 GeV/c)
- Time of Flight Measurements (ToF) with high timing resolution
- Distance between ToF detectors 23 m
- Time resolution below 100 ps required

Particle Separation - time resolution 50 ps, uncertainty in momentum 2 %

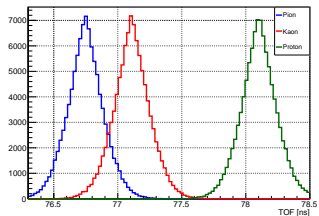


Particle Separation - time resolution 170 ps, uncertainty in momentum 2 %

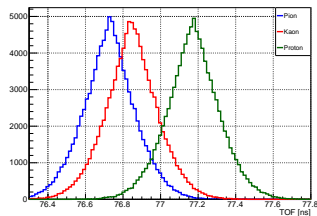
$l=23$ m, time resolution 170 ps, $p=1$ GeV/c +2%



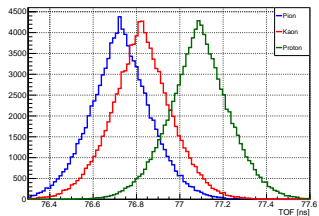
$l=23$ m, time resolution 170 ps, $p=5$ GeV/c +2%



$l=23$ m, time resolution 170 ps, $p=8$ GeV/c +2%

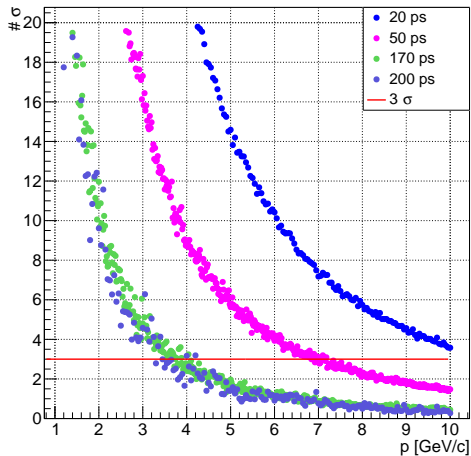


$l=23$ m, time resolution 170 ps, $p=10$ GeV/c +2%



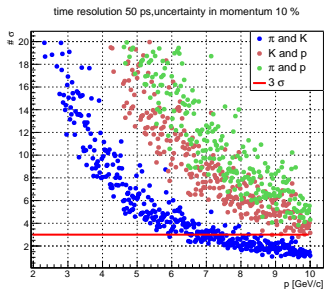
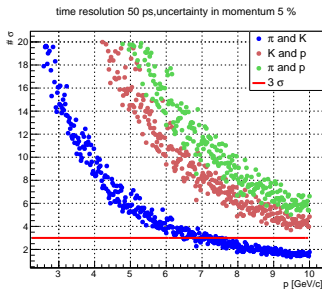
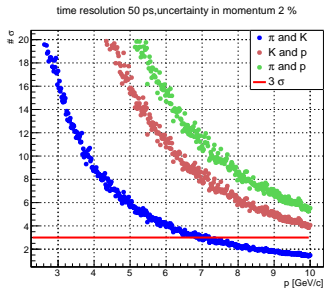
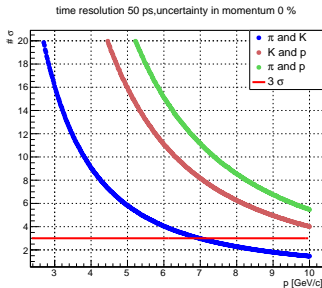
Pion and Kaon Separation

Separation of π and K for different time resolution

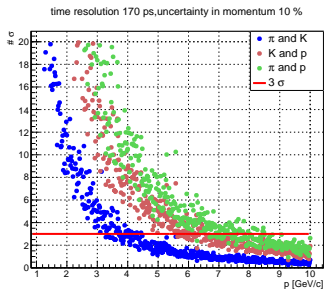
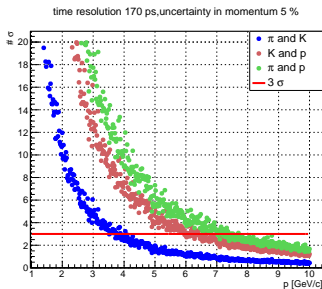
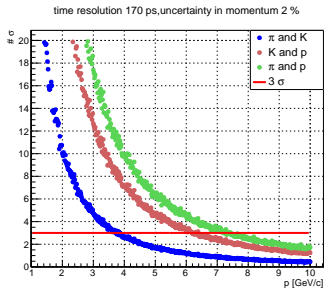
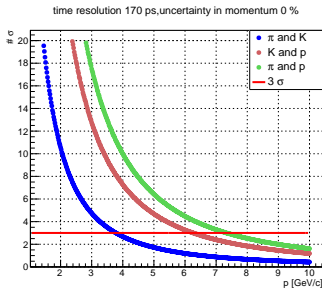


$$\# \sigma = \frac{\Delta TOF}{\sqrt{RMS_1^2 + RMS_2^2}}$$

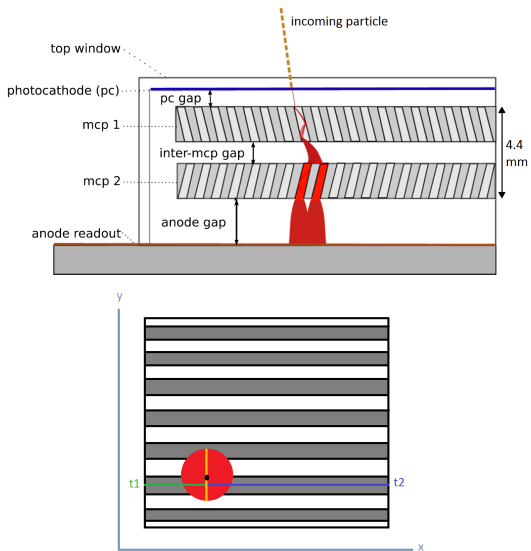
Particle Separation - time resolution 50 ps



Particle Separation - time resolution 170 ps

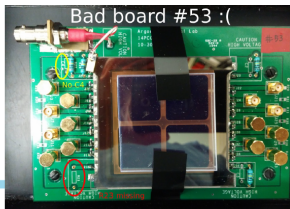
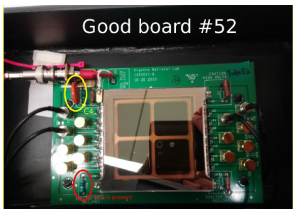


pLAPPD - prototype Large Area Picosecond PhotoDetector



Testing pLAPPDs from Argonne Lab: troubles and malfunctions

- 2 pLAPPDs $6 \times 6 \text{ cm}^2$ mounted on readout boards
 - “board #52 and board #53”
- Testing pLAPPD in the LArLAT beamline in the Fermilab Test Beam Facility (FTBF)
 - the test started just few days before the planned summer accelerator shutdown
 - the board #53 was missing resistor and capacitor $\rightarrow \text{☹}$



Testing pLAPPDs from Argonne Lab: troubles and malfunctions

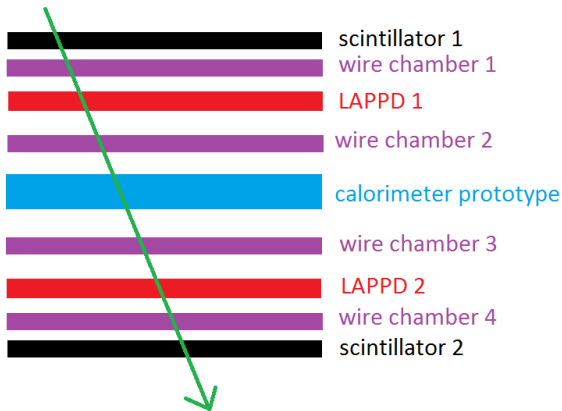
- Testing “good board” #52 with digital oscilloscope → 😊
 - read out single photoelectron (SPE) noise
 - pulse shapes from each channel and with different cable lengths
- Board #52 began misbehaving in the end of the measurements → ☹️
- Both boards sent to Argonne for repairing and checking
- Board #53 repaired, board #52 supposed to be alright after replacing resistor...

Testing pLAPPDs from Argonne Lab: troubles and malfunctions

- Problems with HV supply → ☹
 - board #53 broken
 - sparks in board #52 when HV is above 2 kV
 - unable to finish test with oscilloscope
- Preparing installation into muon telescope → 😊
- The installation was delayed because of troubles with both boards → ☹

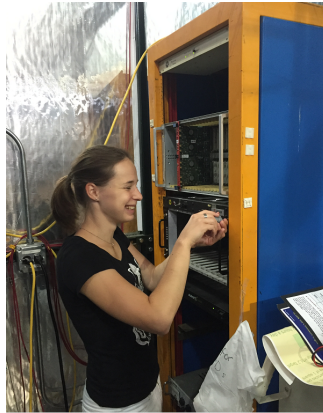
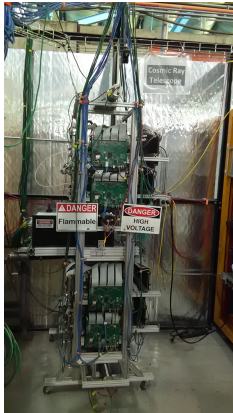
Installing pLAPPDs into muon telescope

- Determine pLAPPD efficiency vs. position
- Determine pLAPPD position resolution



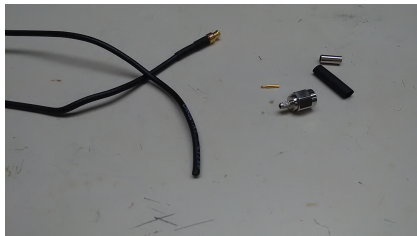
Installing pLAPPDs into muon telescope

- Mounting VME crate with CAEN V1751 digitizer
- Mounting NIM crate with power supply



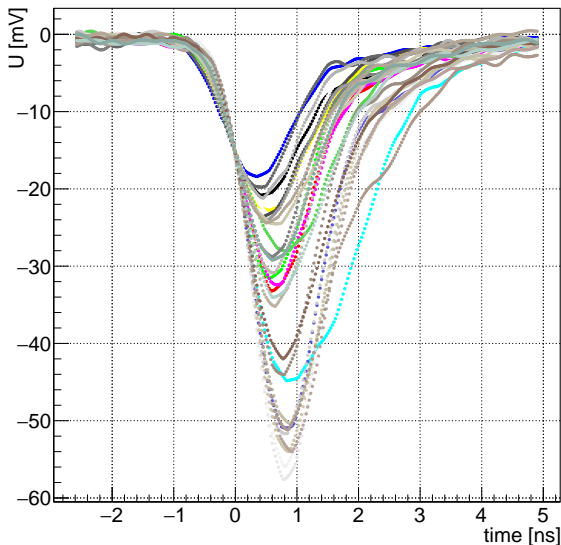
Making cables for redout from muon telescope

RG-174U signal cables with SMA and MCX connectors



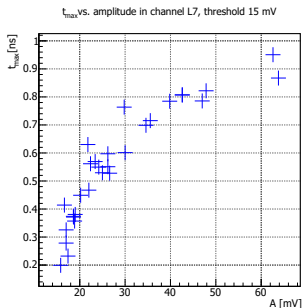
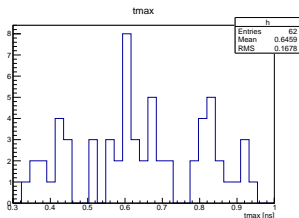
Back to the pulse shape analysis

Pulses: threshold 15 mV, Channel L6



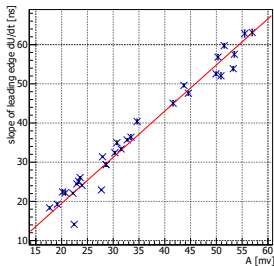
Distribution of pulse centroid t_{max} (threshold 15 mV)

- Pulse amplitudes depends on where the SPE from spontaneous thermal emission is emitted
- Location of pulse maximum depends on the amplitude
- Based of the distribution of t_{max} the resolution is about 170 ps
- In real meausurements we can correct for the effect of amplitude → the resolution would be improved

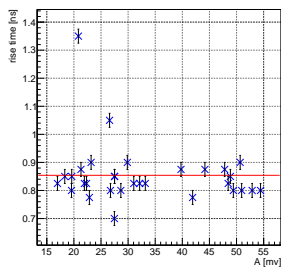


Rise time and slope of leading edge

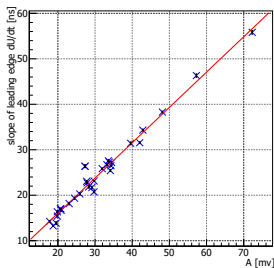
Slope vs. Amplitude in Channel L6



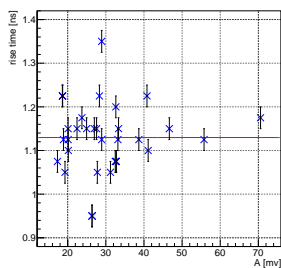
Rise time vs. Amplitude in Channel L6



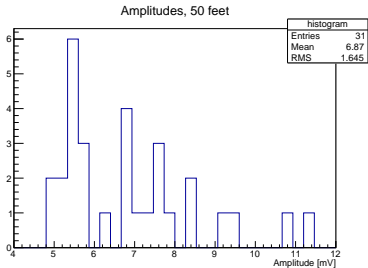
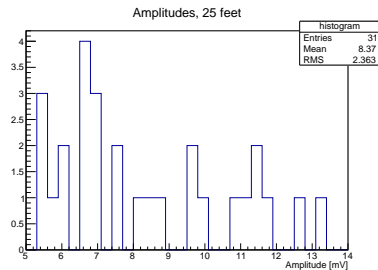
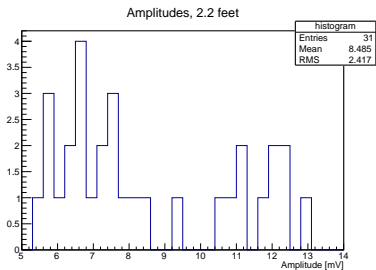
Slope vs. Amplitude in Channel R6



Rise time vs. Amplitude in Channel R6



Amplitudes for different cable lengths (threshold 5 mV)



Thank you for attention!

