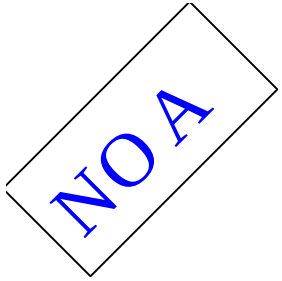

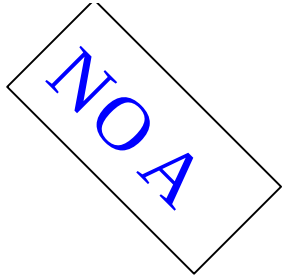

APD and Electronics Testing

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University of Minnesota

May 15, 2004

With Contributions from John Oliver

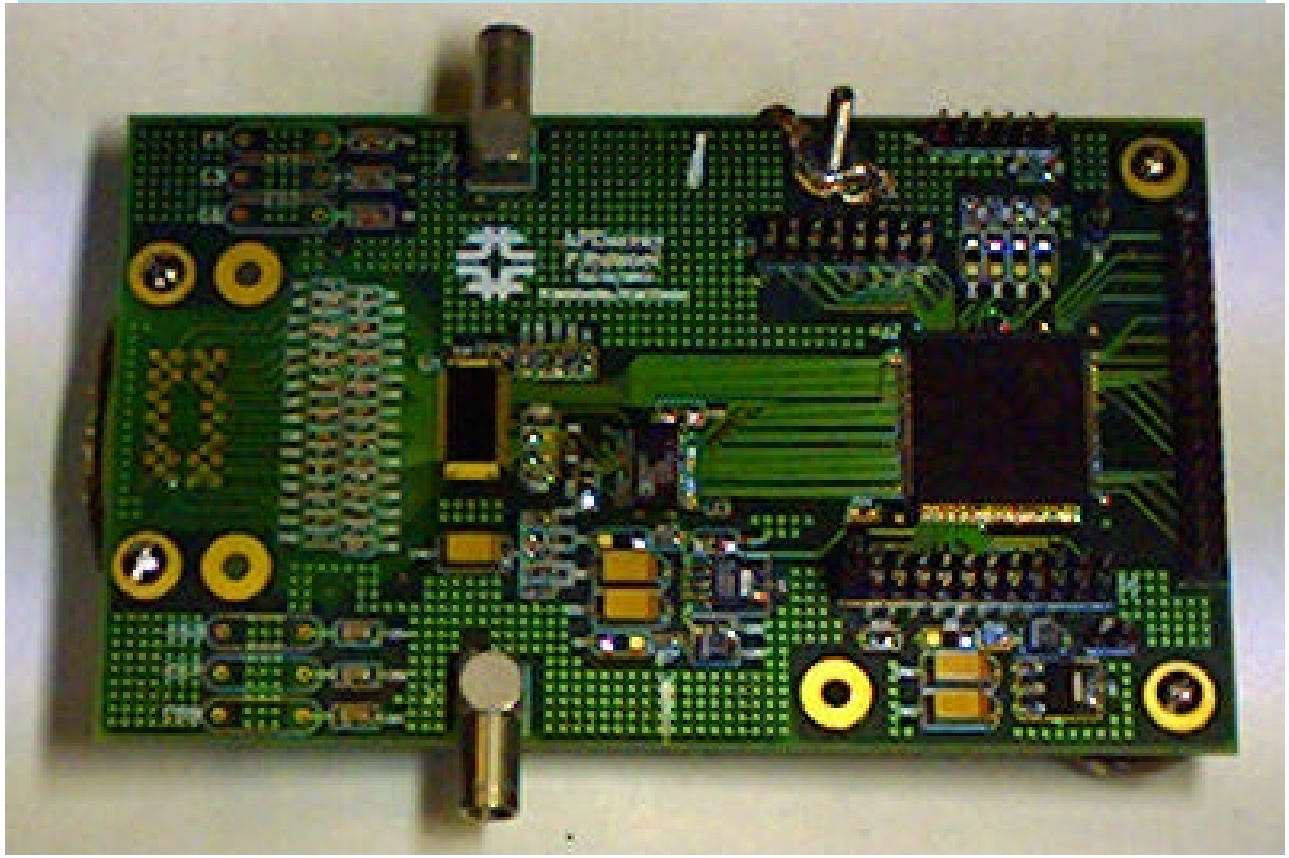
Current Activities

- **Fermilab/Minnesota**
  - **Masda Prototype boards**
  - **Goals:**
    - **Measure achievable noise limits**
    - **Measure APD properties**
      - **Noise vs. T**
      - **Gain**
      - **Signal response**
    - **Measure Detector Properties:**
      - **Light output vs. Position**

- **Harvard**
  - **Harvard Prototype board(s)**
  - **Goals:**
    - **Demonstrate noise reduction with decreased capacitance**
    - **Demonstrate effectiveness of MCS technique**

New MASDA Prototype Board

- Equivalent noise performance
- Experience of version 1 incorporated:
  - Low noise voltage regulator
  - designed in additional filtering/bypassing



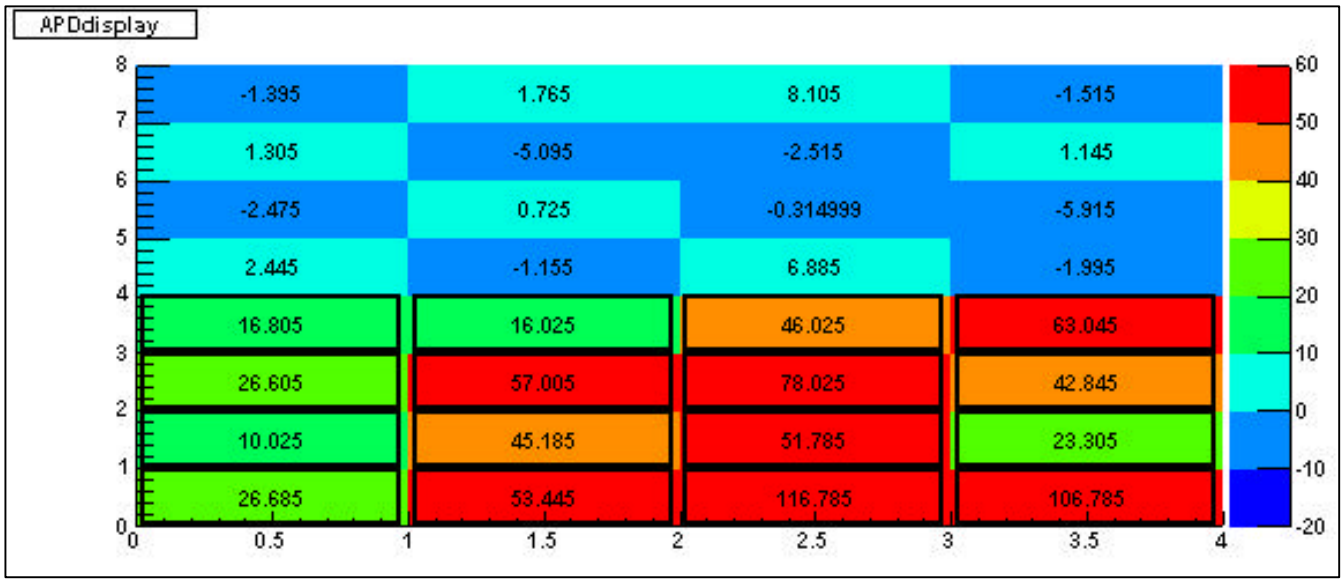
Improvements to Prototype boards

- **Firmware re-written with two major corrections**
  - **Installed a triggered mode to work with external coincidence trigger – Air shower particles, or pulser**
  - **Reduced the noise by about 10% with a couple of fixes**
    - **Lengthen hold time for the "before" sample ~5%**
    - **Add multiple samples of MASDA analog output**
      - **Effectively averages out noise in the analog output to reduce noise by about 5%**
  - **Noise level at operating point of APD: M=100,T=-15C reduced to 360e^- from 400 reported previously.**

Triggered Scintillator Tracker

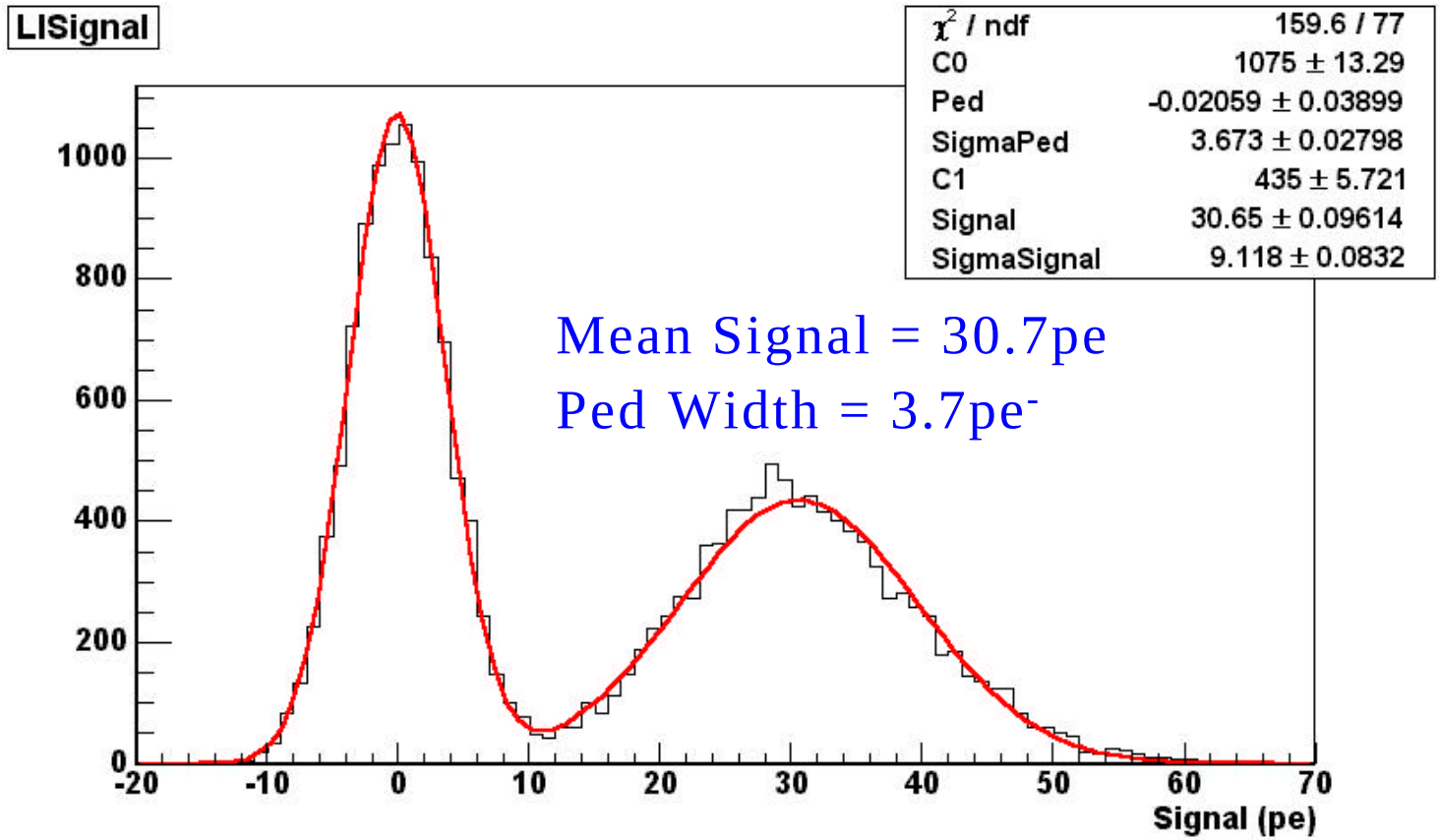
- Provides realistic signals from scintillator/fiber strips
- 2 trigger arrays:
  - 8-wide x 4-thick with
  - standard PMT readout
  - NIM logic generates coincidences
- 1 scintillator test array:
  - 4-wide x 8 thick
  - APD readout

Light Injection Signals

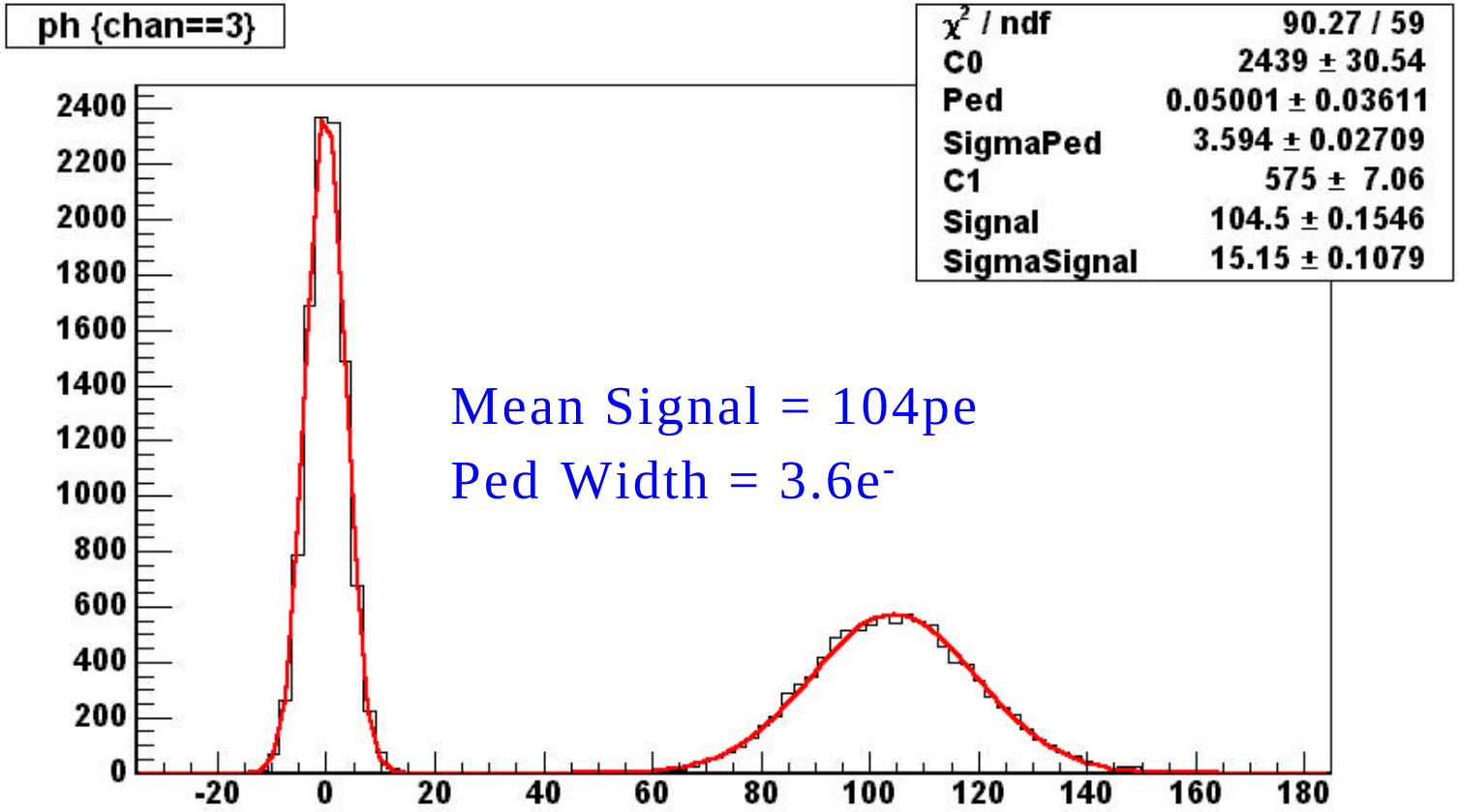


Calibration/testing system can inject light into the fibers of the bottom half of the test array with a blue LED and a pulse generator. Half left undisturbed to facilitate common mode subtraction.

Light Injection Signals

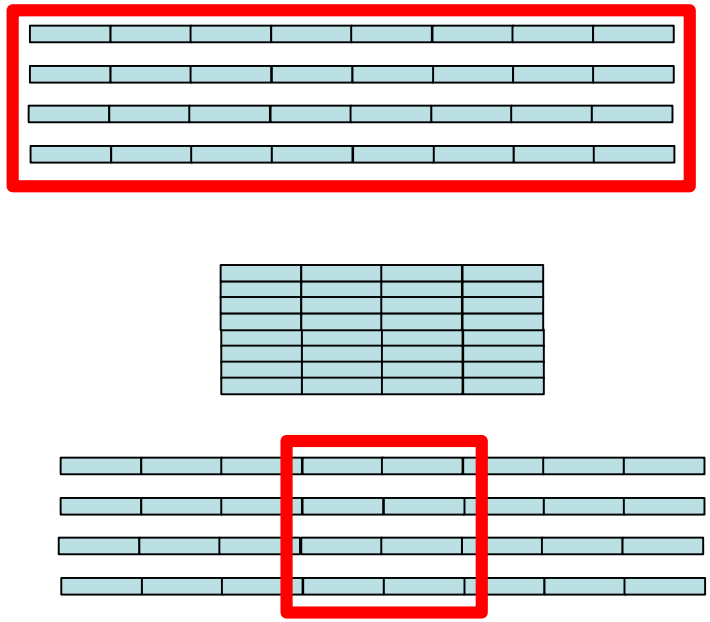


Light Injection Signal

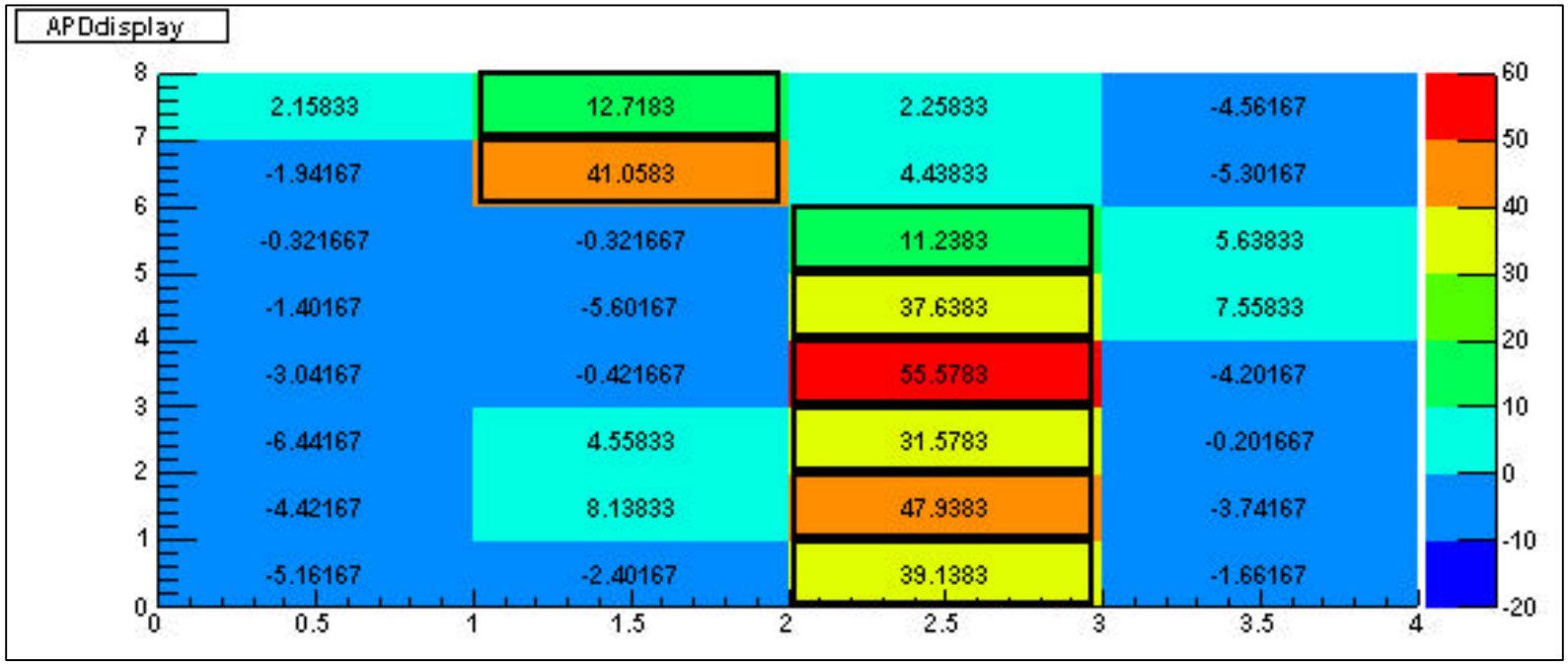


Triggered Mode Signals
Search for Tracks

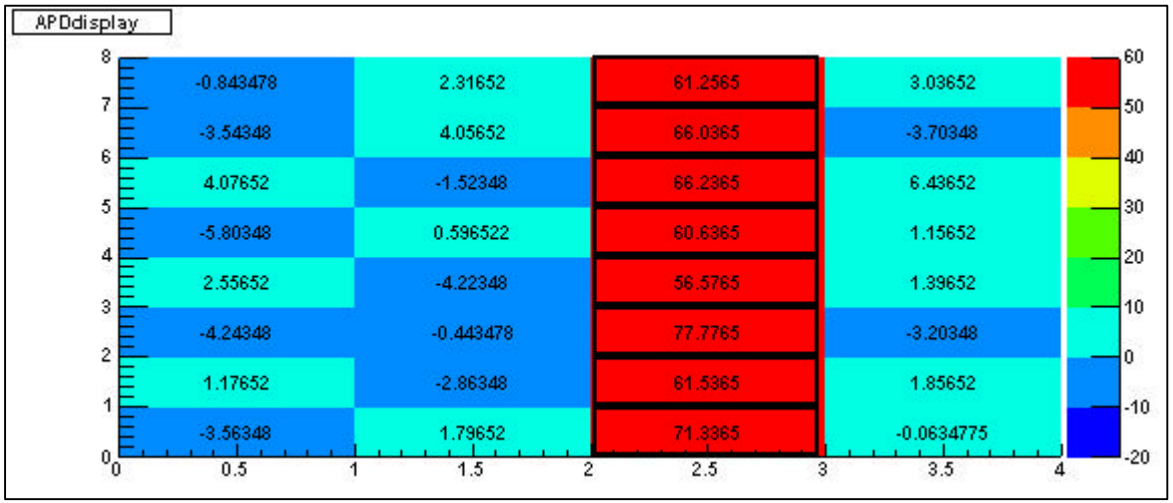
- Use entire upper trigger array.
- Use 2 columns of lower trigger array.
- Generate coincidence gate from PMT signals and the usual NIM Discriminator and logic modules.

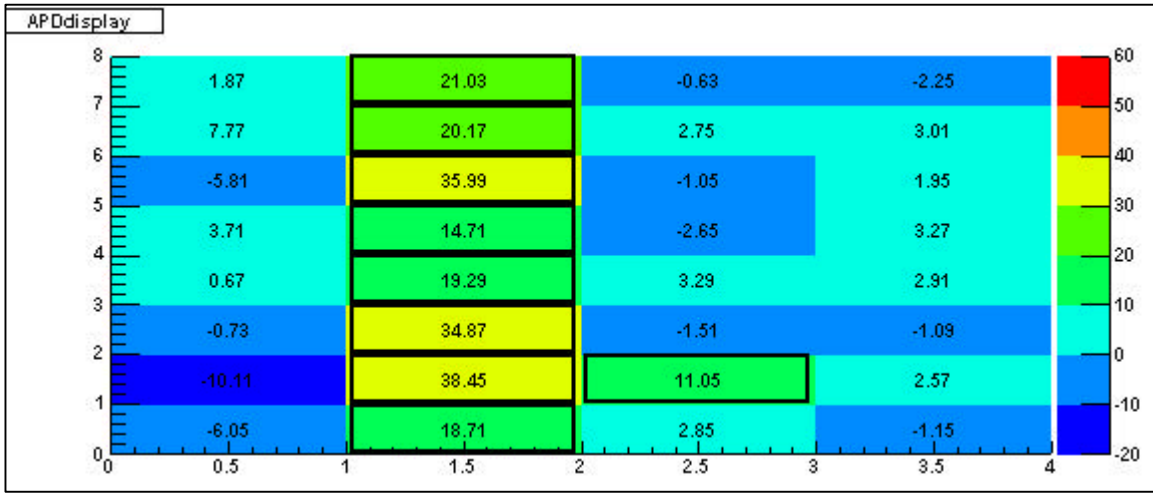


Sample Track (1)

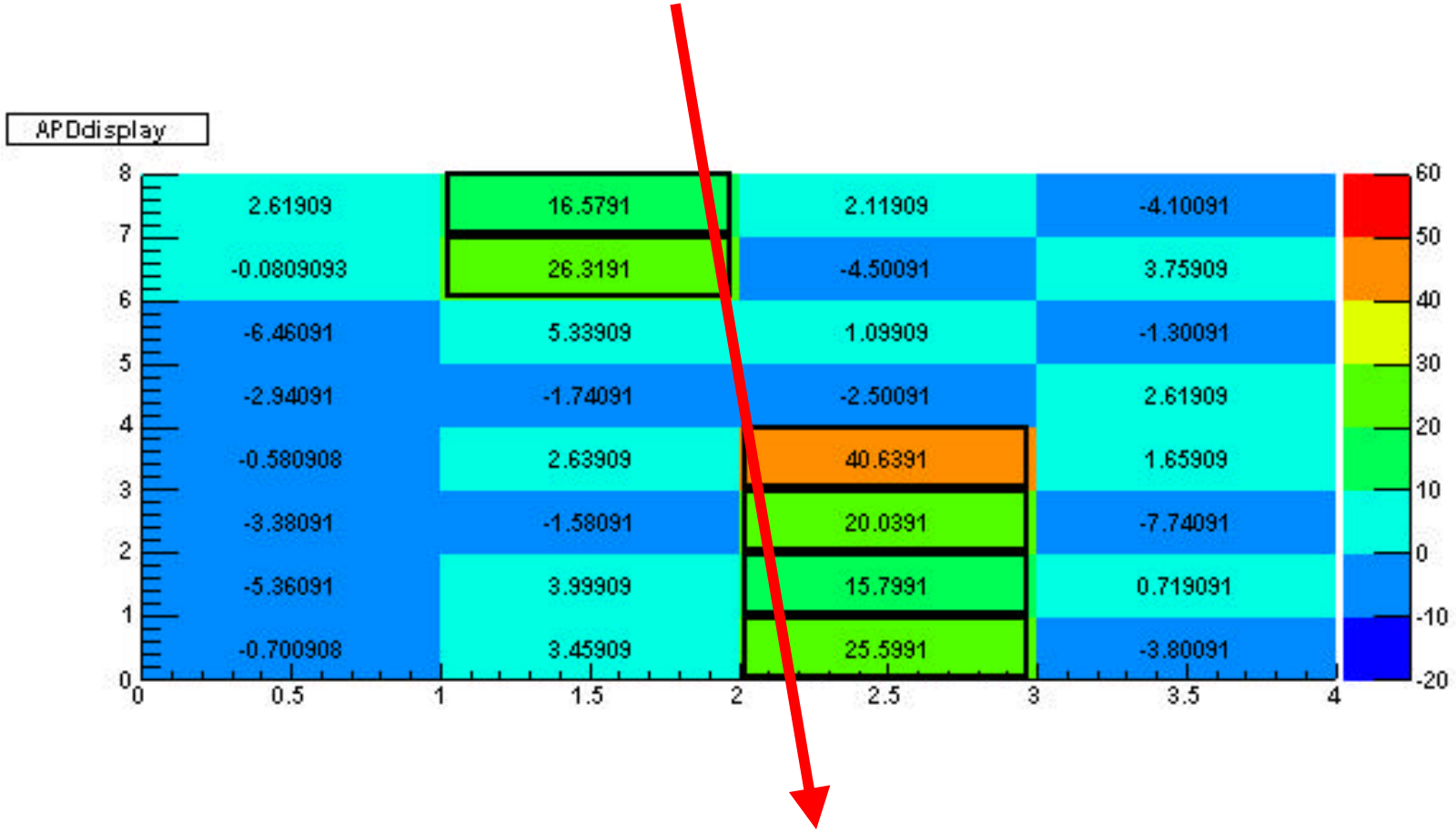


Sample Tracks (2,3)

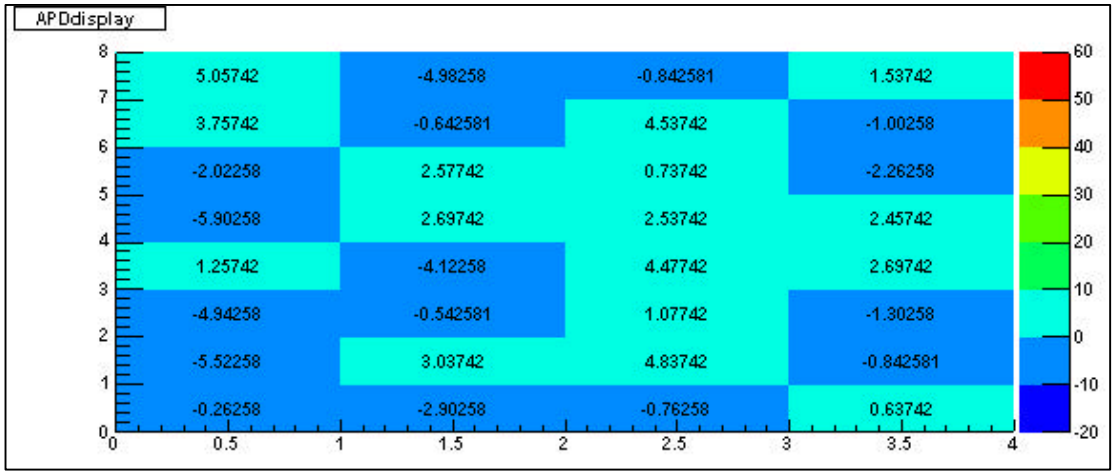




Sample Track (4)

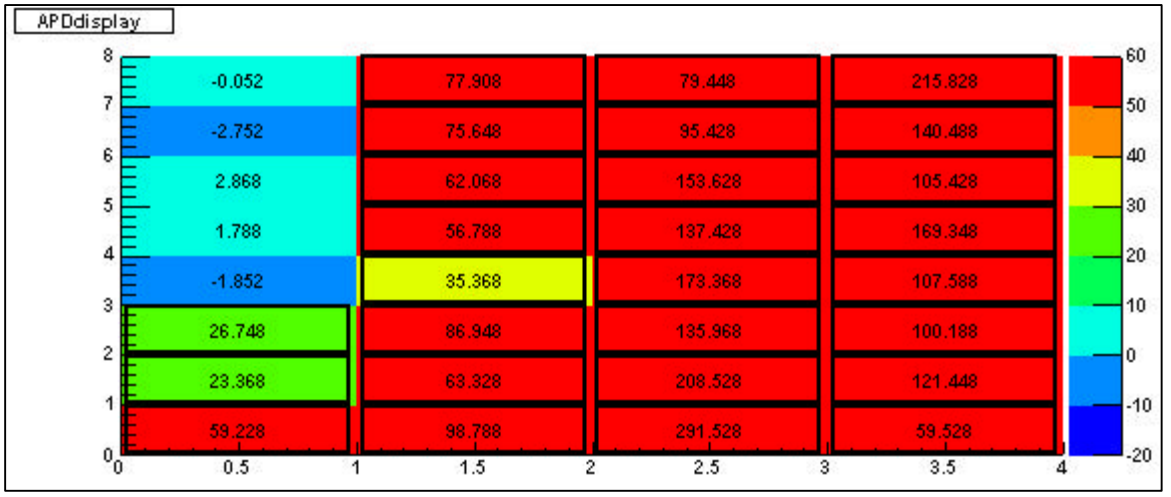


Other Samples

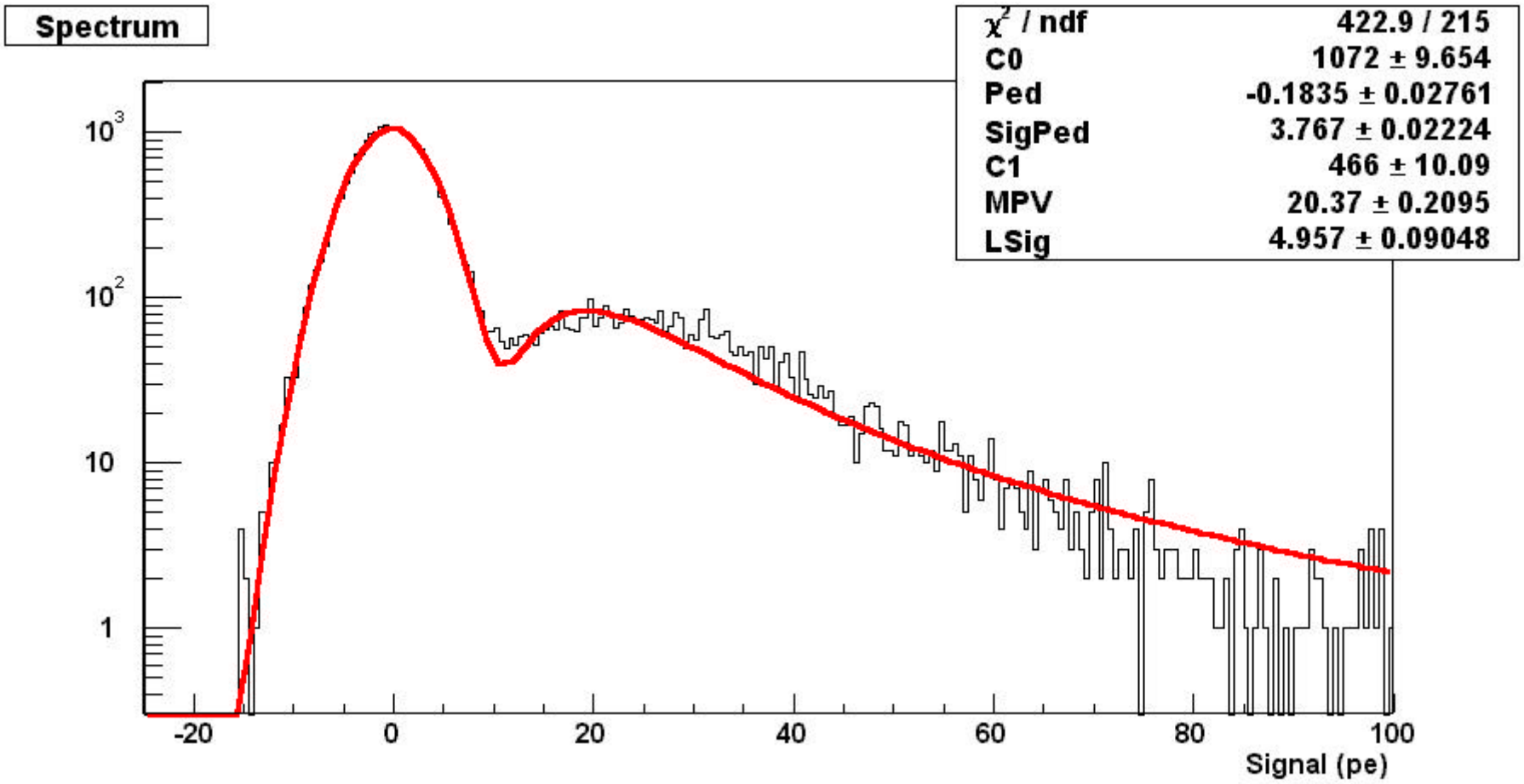


Of course you get
Some misses.

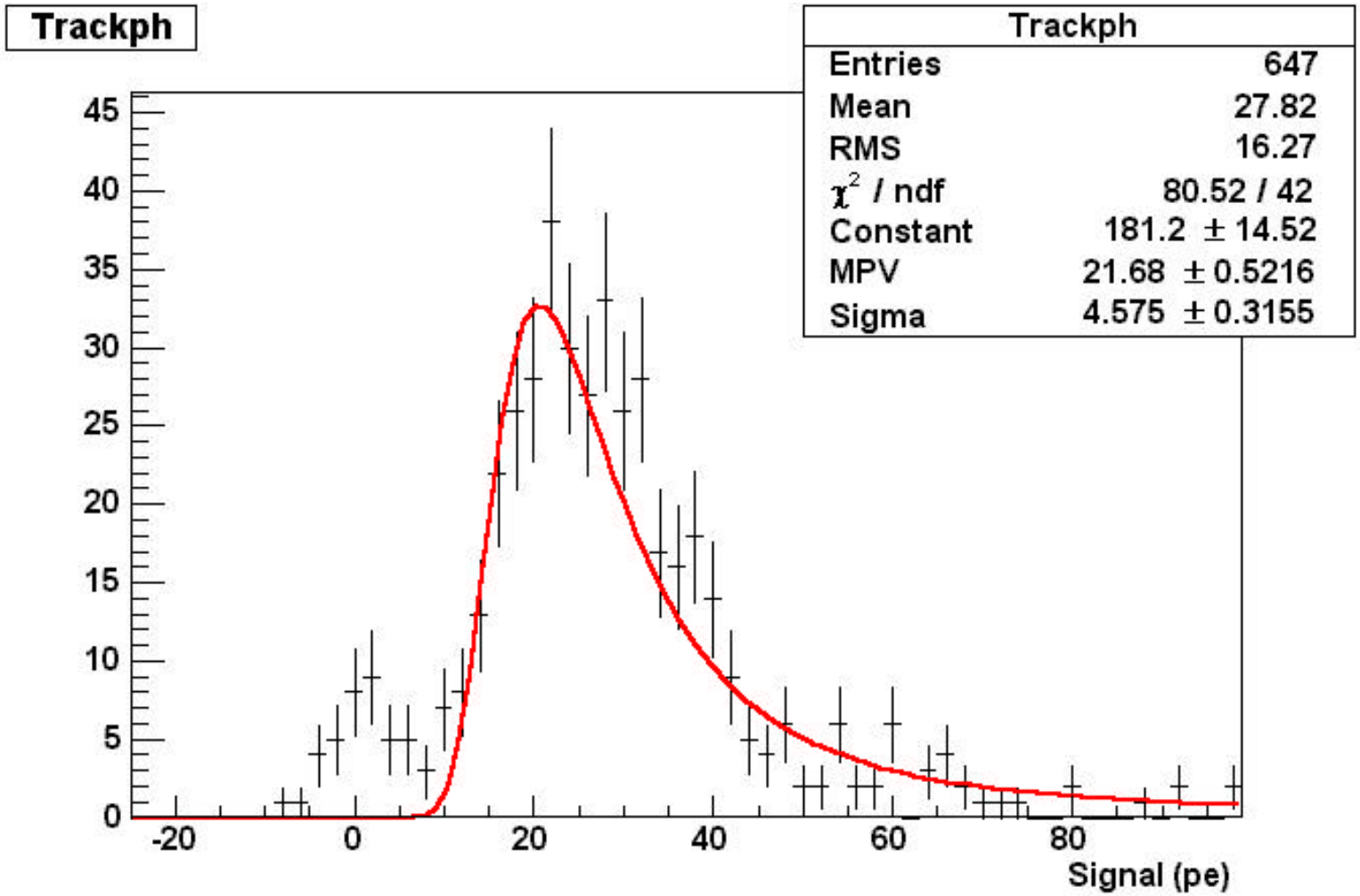
You get Showers Too!



Signal Distribution for all triggers



Signal distribution for track selected strips

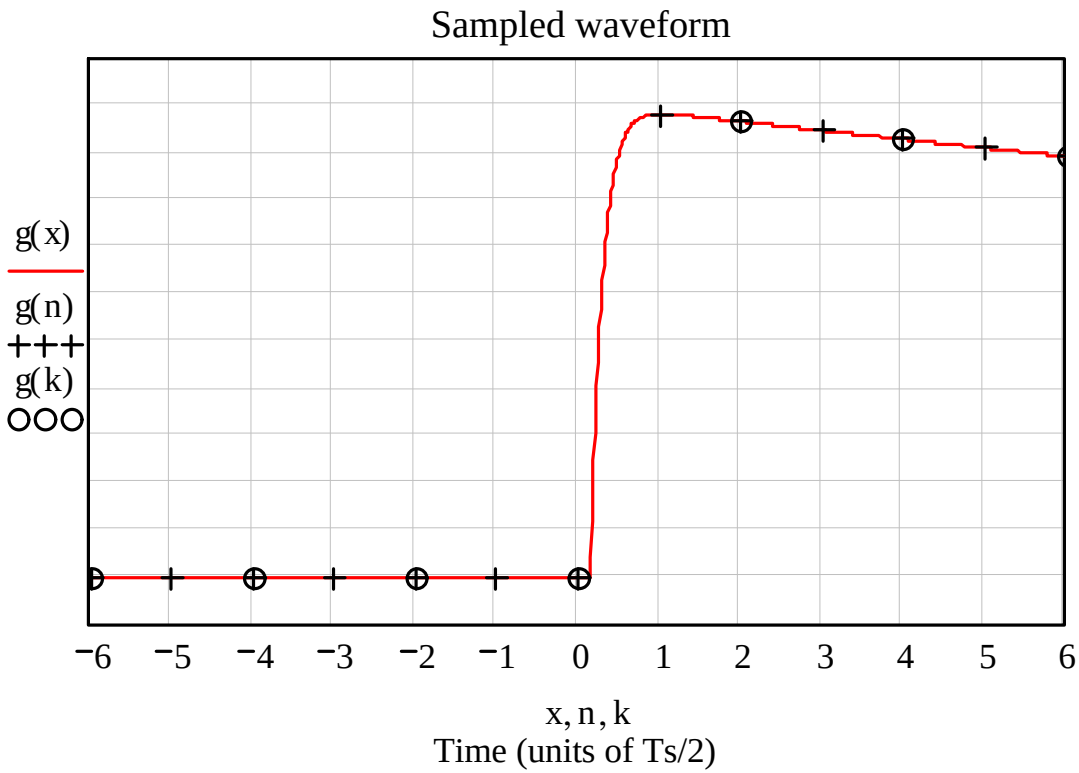


APD Readout Prototype Board
-Noise Optimization-

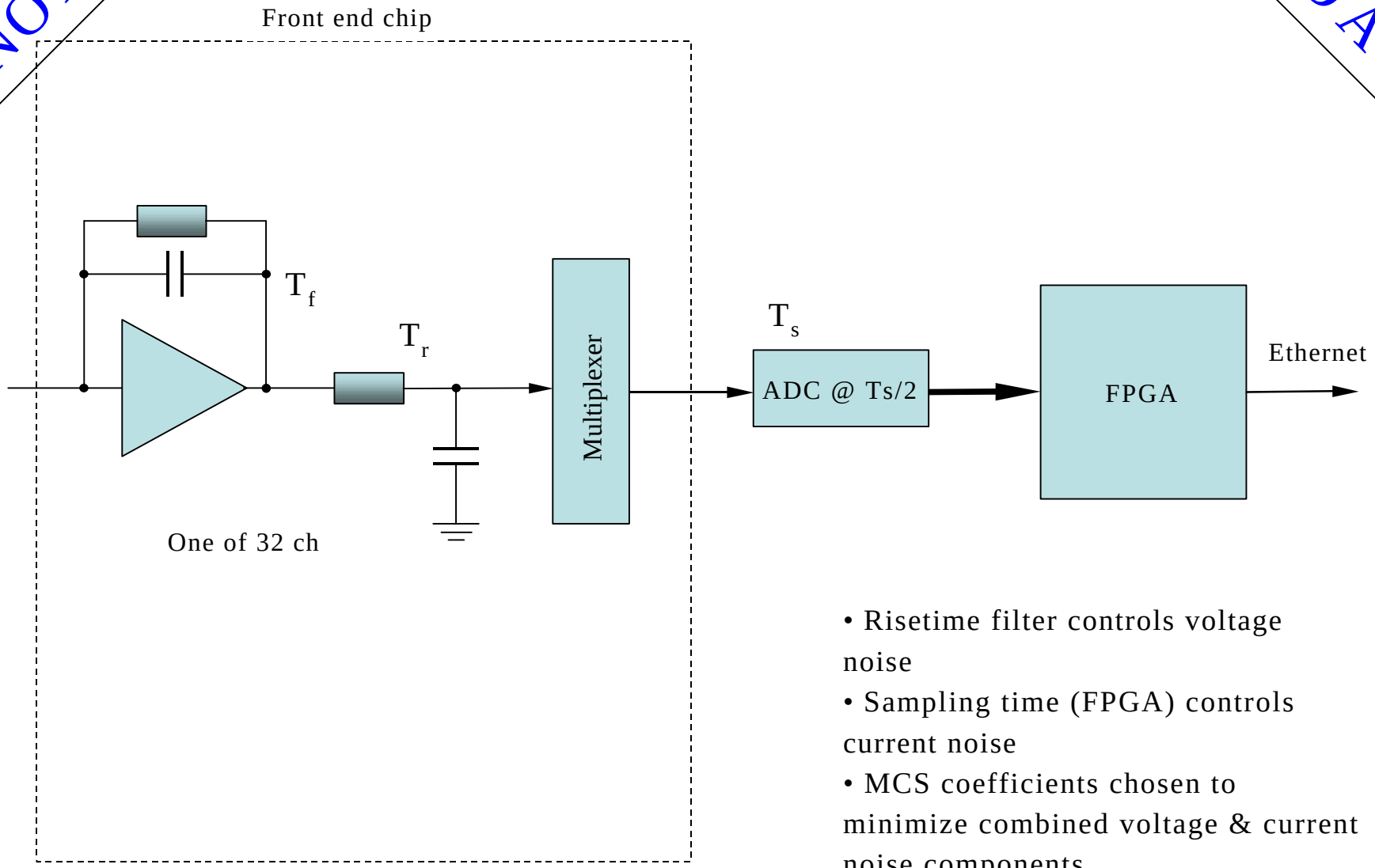
Objectives

- Dual Correlated Sampling has been shown (MASDA) to yield noise performance down to ~ 360 e rms
- Low data rate from APD allows use of more than two samples to further reduce noise. (Multiple Correlated Sampling – MCS)
- Perform sampling function after digitization in FPGA.
  - Dedicated multipliers + adders can implement Multiple Correlated Sampling with downloaded coefficients.
  - Coefficients to be optimized for best noise performance
  - Noise goal with 10pf APD : 200 e rms

Sample Waveform



DAQ Schematic



- Risetime filter controls voltage noise
- Sampling time (FPGA) controls current noise
- MCS coefficients chosen to minimize combined voltage & current noise components

Protoboard test

- Preamp shaper implement in custom hybrid -- in fabrication
- Hybrid allows modification of risetime by capacitor replacement
- Proto board will use 4 hybrids with commercial multiplexer to test noise minimization
- Board expandable to 16 channels for APD vertical slice test
- Ethernet not implemented (CCLRC has done it)→ RS232 & USB interfaces
- Board status → in layout

- Secondary goal : Test extraction of leading edge timing by "over-sampling" or utilizing several samples on pulse risetime & fit to known exponential function → increased timing resolution
- This should be possible by choosing longer risetime (eg ~ 300 – 400 ns) while maintaining ~ 500ns sampling. → Optimum to be determined

Status Summary

- Working APD readout prototype board
- Scintillator test stand for cosmic ray signals – tested with solid scintillator, ready for liquid scintillator test modules.

- Optimized hybrid front-end circuit in fabrication.
- Protoboard for Continuous readout/MCS designed and in layout
- Designed as drop-in replacement for MASDA prototype board (with 16 instead of 32 channels
- Readout system can be interchanged with same scintillator modules.