Design and Implement of the Front End Electronics for the CDF-II Time-of-Flight System

Chunhui Chen

Department of Physics and Astronomy
University of Pennsylvania
Philadelphia, PA 19104-6396

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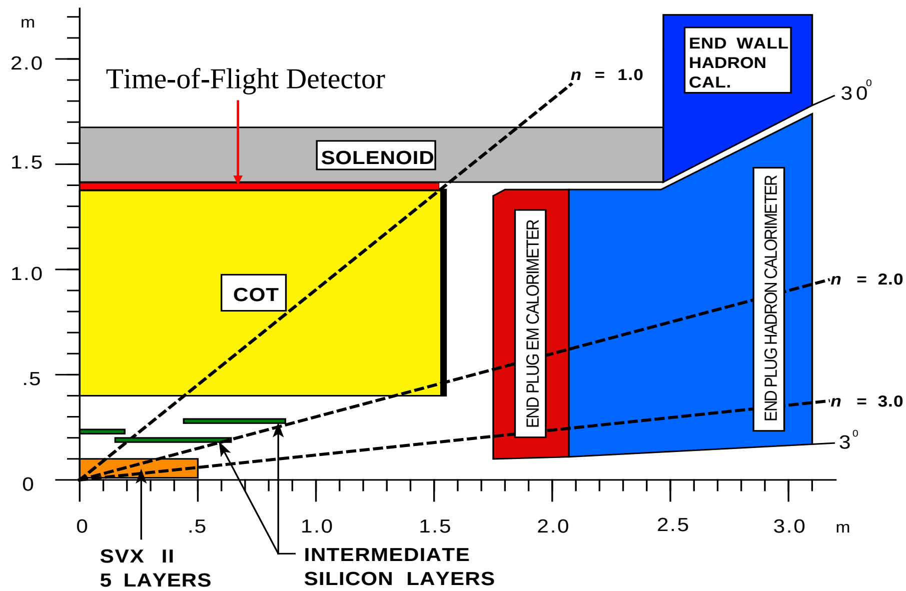
TOF Development at Penn

Chunhui Chen,
Matthew Jones,
Walter Kononenko,
Joseph Kroll,
Godwin Mayers,
Mitchell Newcomer,
Rolf Oldeman,
Denys Usynin,
Richard Van Berg

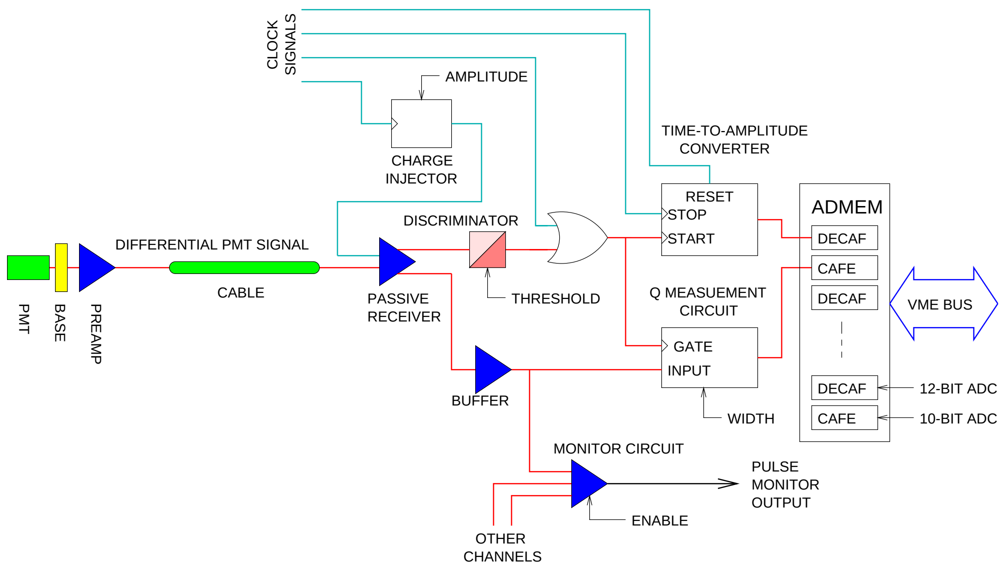
Department of Physics and Astronomy
University of Pennsylvania
Philadelphia, PA 19104-6396

Overview of TOF Electronics



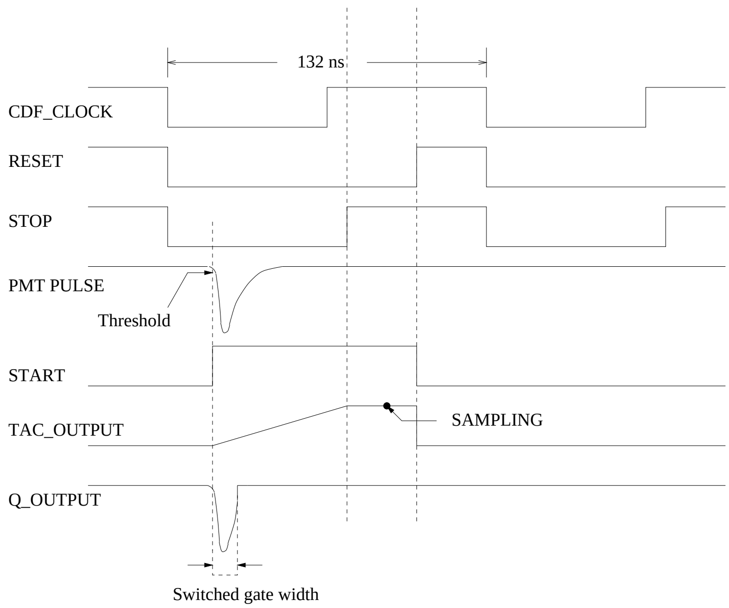
- TOF purpose: charge particle identification
- 216 Bicron BC-408 bars just outside COT
- Hamamatsu R7761 on both ends
- 432 electronics channels
- Expect time-of-flight resolution: 100 ps
- Electronics contribution: < 25 ps
- Data Acquisition rate: 7.58 MHz

One TOF Channel



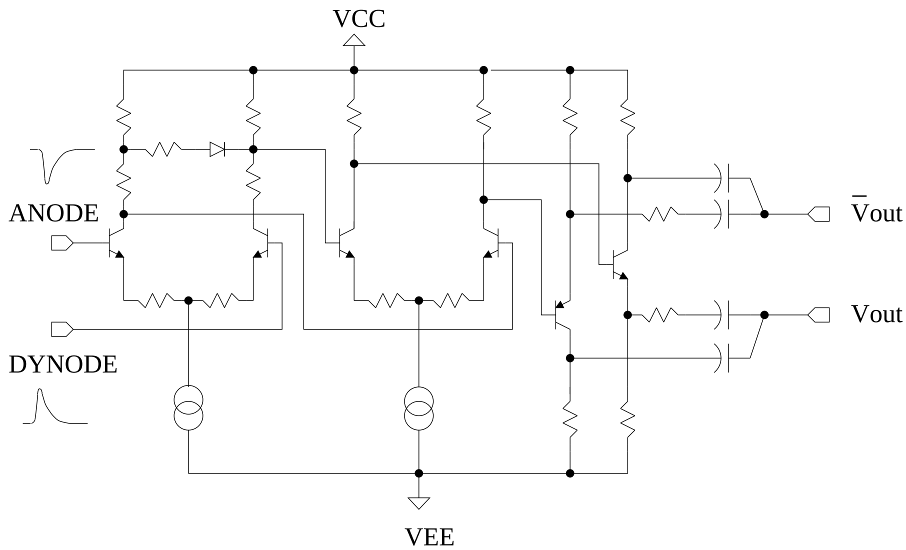
- $50\,\Omega$ termination between anode and dynode
- Differential PMT output signal
- Preamplifier drives 13 m cable
- Signal path split after receiver
- Timing to amplitude converter
- Charge measurement circuit

One TOF Channel



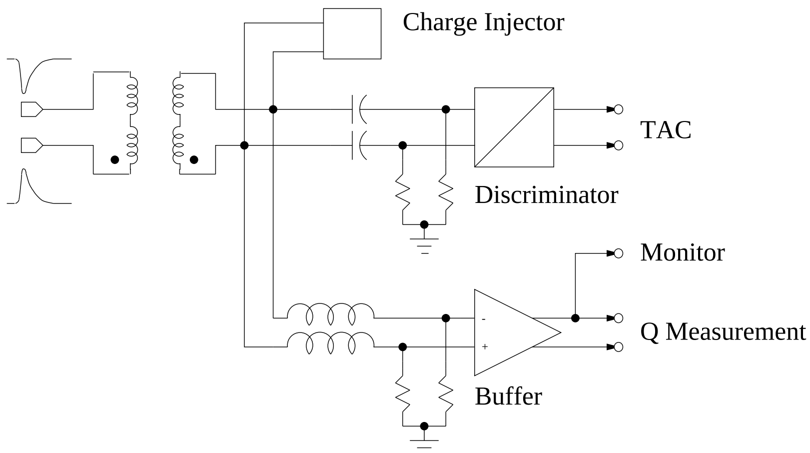
- Timing information read out by DECAF
- Charge measurement read out by CAFE
- ADMEM interface board with CDF data stream

The Preamplifier



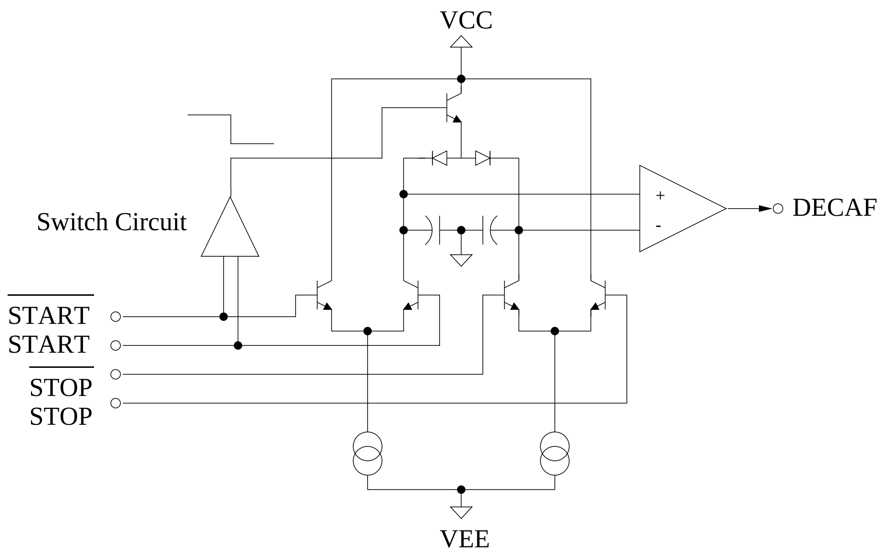
- Mounted directly behind the PMT base
- A nearly differential input from anode and last dynode
- Two differential amplifier stages and a bilinear gain
- A balanced zero-offset differential output stage with unity gain

Receiver and Discriminator



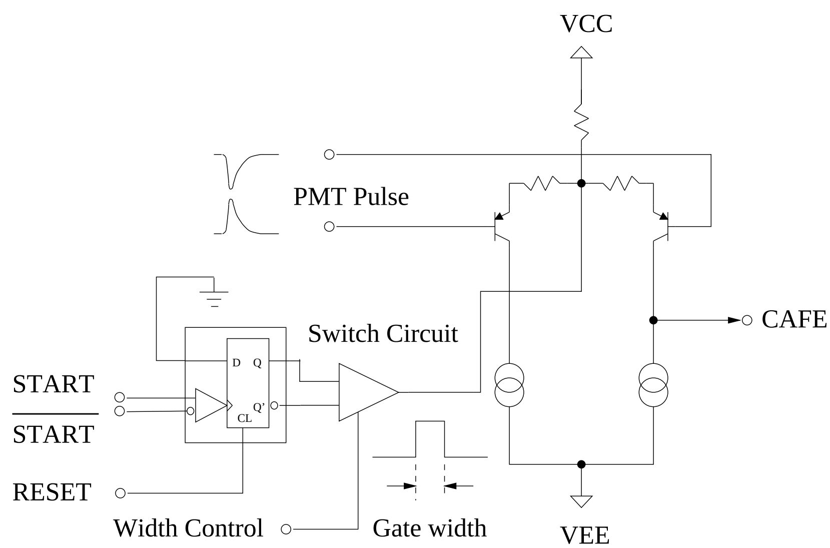
- The cable impedance matched by a parallel network
- Splits the signal into two paths
- Timing path:
  Good leading edge timing for discriminator
  Fast setting time to the baseline
- Charge path:
  A bandwidth limited version of the PMT signal
  Signal delayed to open integration gate
- Cancellation of the imaginary components of the complex termination impedance

Time Measurement Circuit



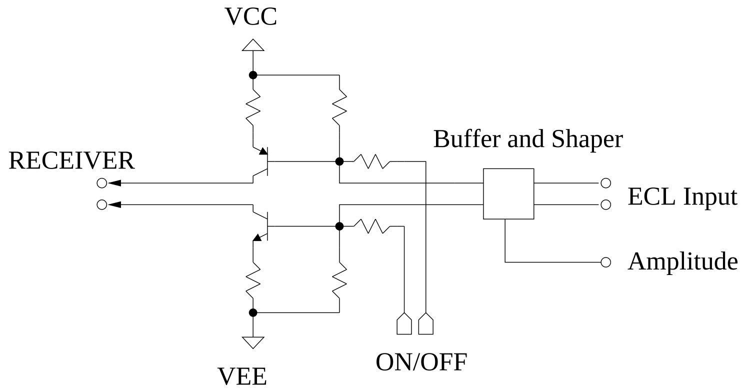
- A common stop time to amplitude converter (TAC).
- Differential ECL START signal from discriminator
- Differential ECL STOP clock signal
- High speed instrumentation amplifier output stage
- Single ended voltage output proportional to time

Charge Measurement Circuit



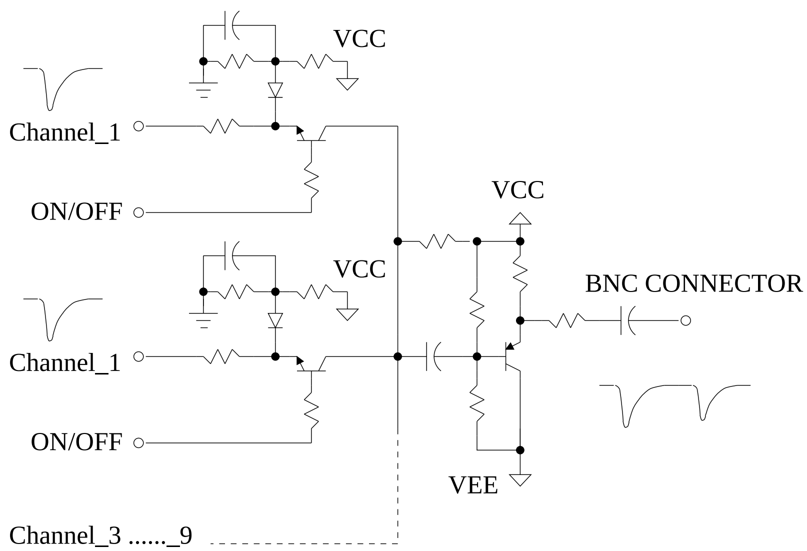
- Correct the pulse height dependence for TAC
- A trigger for highly ionizing particles
- Differential PMT input
- Single ended current output
- Initialized by the TAC START
- Switched gate with adjustable width

Calibration

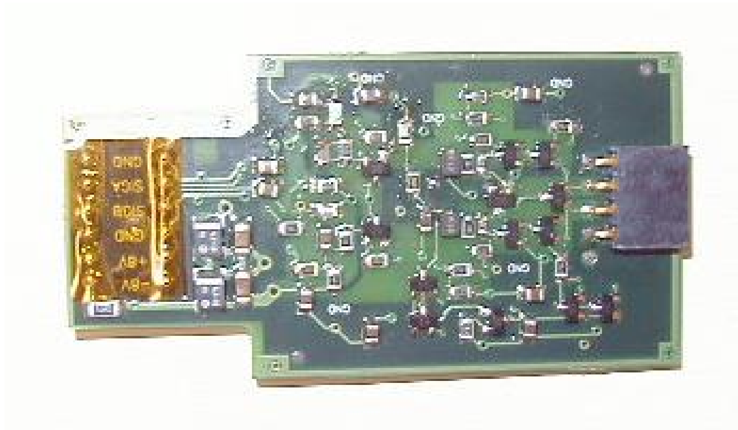


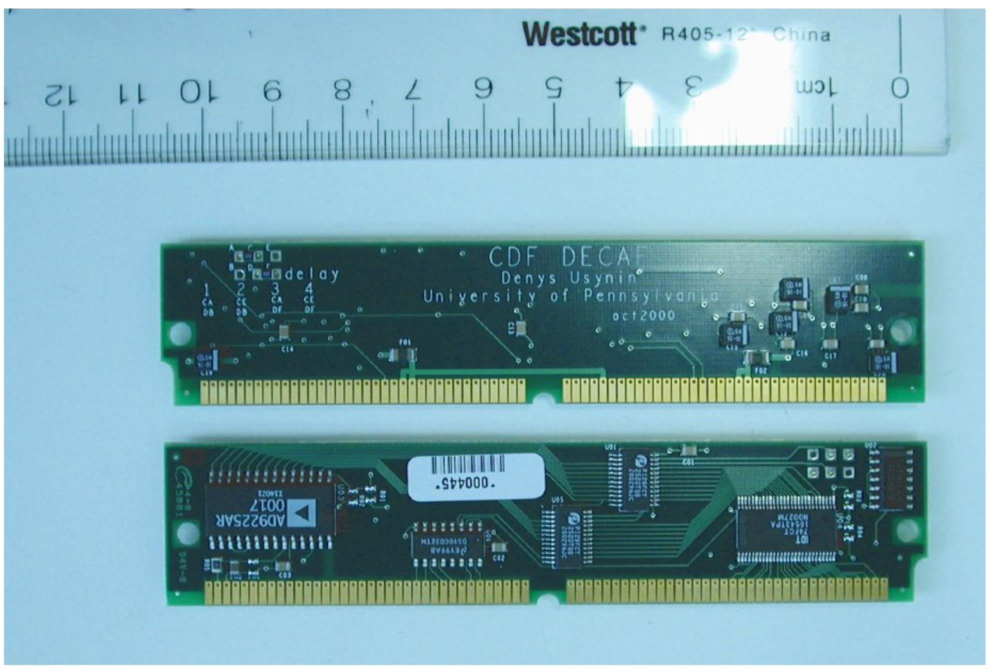
- Calibration mode 1:
  A differential ECL calibration pulse
  Start the TAC, bypassing the discriminator
  Adjustable delays with respect to common stop
- Calibration mode 2:
  Same differential ECL calibration pulse
  A charge injector to send pulse into the receiver stage
  Adjustable amplitude and phase

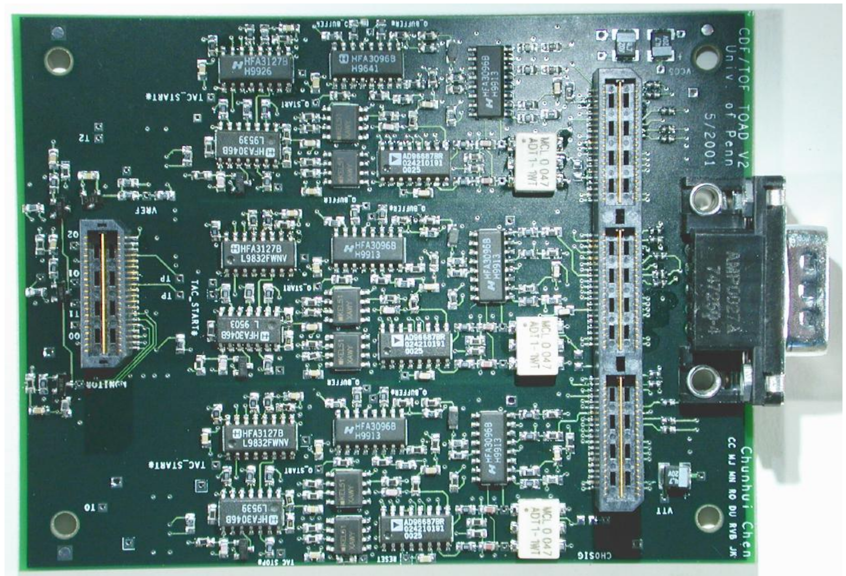
Remote Monitoring

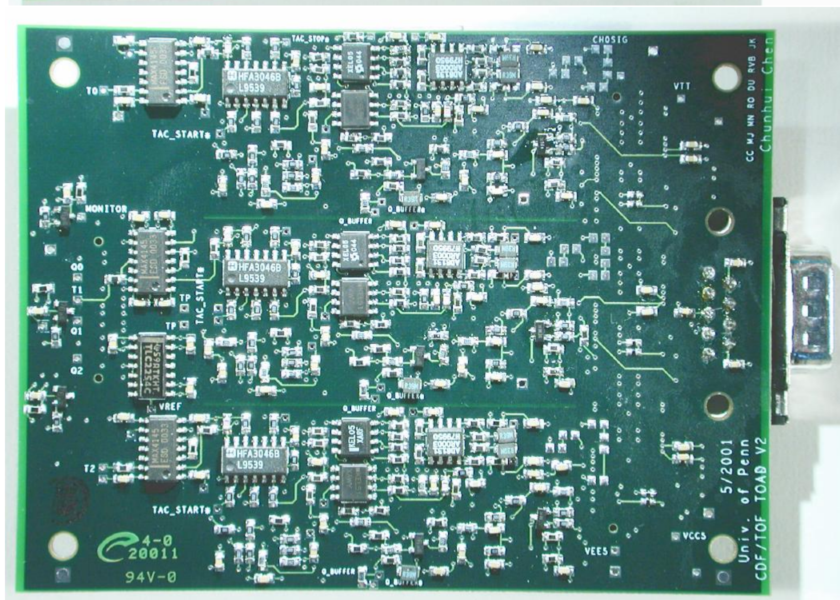


- A common base current summation circuit
- Monitor single or multiple PMT channels at any time
- Monitor single or multiple clock channels at any time




Westcott R405-12" China
CDF DECAF
Denys Usynin
University of Pennsylvania
oct2000
delay
AD9225AR
0017
000445

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Timing Performance

- Cable Delay Test:
  A fixed length cable generates the common stop signal delayed with respect to a calibration pulse.

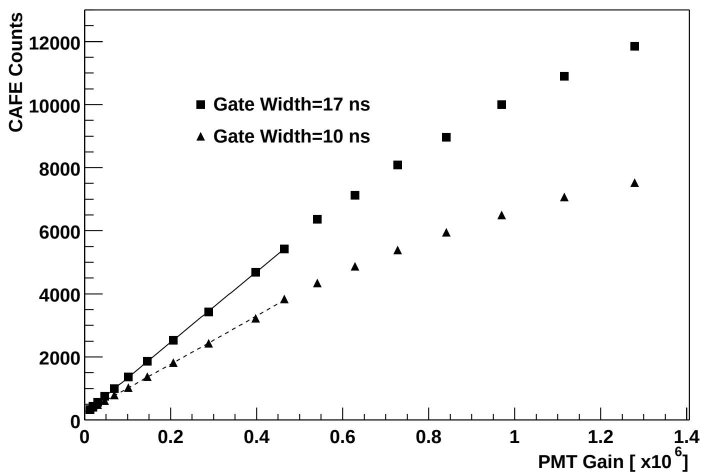
$$\begin{aligned} \text{RMS} &\leq 8.5\,\text{ps} \\ \text{Drift} &\leq 9.0\,\text{ps} \quad \text{over} \quad 40\,\text{hours} \end{aligned}$$

- The DDG Test:
  Study the response of the TDC to a sequence of known delays generated by a DDG that has been calibrated by a digital oscilloscope.

$$V_{\text{TAC}} = \beta(1 + \gamma e^{-t/\tau})t$$

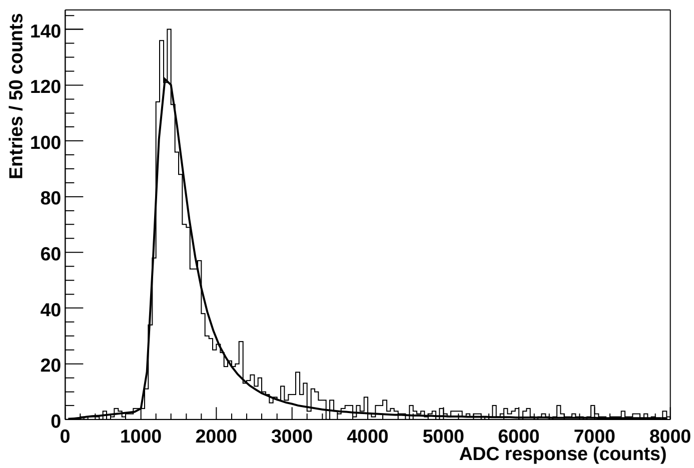
  where β, γ and τ are parameters determined from a fit to the set of generated delays. The deviation of the measurements from the fitted curve are Gaussian distributed with a width of 5.1 ps. This parameterization adequately describes the response of all 432 channels in the system.

Charge Measurement Performance



- Test PMT pulse generated by laser
- Adjust PMT tube HV
- Two different gate setting
- ADC response as a function of PMT gain

Charge Measurement Performance



- ADC response due to tracks recorded at CDF
- PMT gain at 3×10^4 in the magnetic field
- Gate width of 17 ns
- 1000 ADC counts for 1 MIP
- Larger than 12 MIP's dynamic range