

# Noise Characterization of ATLAS Tile Calorimeter Readout System

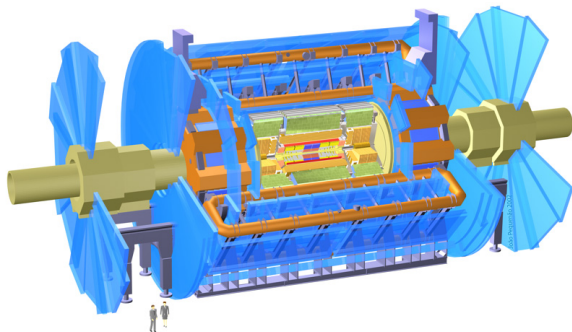
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# Introduction

- ▶ ATLAS at the Large Hadron Collider (CERN, Switzerland)
- ▶ Detector



Greenish section is the Tile Calorimeter

After a collision:

- ▶ Hadrons absorbed in tile calorimeter
- ▶ Alternating layers of steel and plastic scintillator tiles
- ▶ Deposit energy in steel, scintillator samples energy of hadron shower
- ▶ Fiberoptics takes light from energy deposits to Photo Multiplier Tubes (PMTs)
- ▶ Dynamic range approx.  $1 \text{ GeV/tile} \rightarrow 2^{-16} \times 1\text{GeV}$ 
  - ▶ Minimum ionizing particle
  - ▶ Calibration with  $\text{Co}^{60}$  source

# Tile DAQ Calorimeter Output

Consists of 4 main steps:

- ▶ Photo Multiplier Tube
- ▶ Shaping/Amplifying in 2 gain ranges (done in 3in1 card)
- ▶ 10-bit Analog to Digital Conversion (ADC)
- ▶ Serialize data from all channels, read out

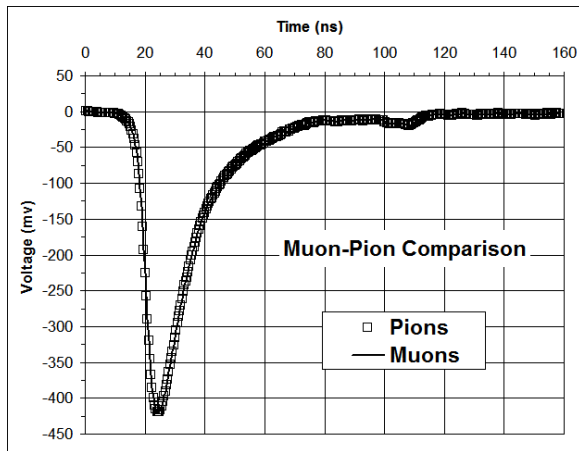
## Incoming Signal:

- ▶ PMT pulse **NOT** pretty
  - ▶ Jagged from photo-electron statistics
  - ▶ 5.5 ns rise time
  - ▶ 11 ns decay time
- ▶ Shaped so that:
  - ▶ Smooth (integrate over photo-electron statistics)
  - ▶ Wide enough to curve-trace at 40 MHz
    - ▶ 25 ns sampling rate
    - ▶ allows checking for “normal” event
  - ▶ The full width half max (FWHM) is 50 ns
- ▶ Lo or Hi gain amplification (depending on signal size)
- ▶ Differential driver to ADC a foot away
- ▶ **Done by 3in1 Card**

## Outgoing Signal:

- ▶ Get 5 discrete points at 40 MHz (25 ns intervals)
- ▶ Fit standard curve

## Sample Shaped Pulse

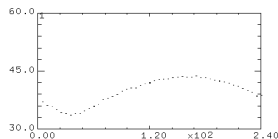
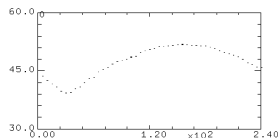


# (Simulated) Signal

Need to test system with known input information

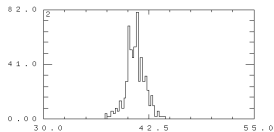
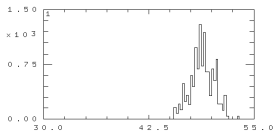
- ▶ Snake  $\text{Co}^{60}$  source to calibrate
- ▶ Inject 800 nC of charge to simulate PMT

→ First adjust ADC timing offset



# (Simulated) Signal

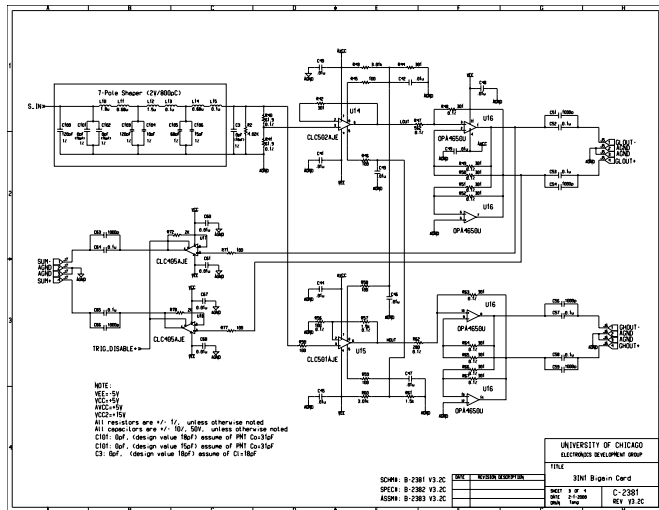
- ▶ Next histogram  $\Delta V = V_{peak} - V_{pedestal}$  to evaluate pulse shape, noise, gain. Below shows  $\Delta V$  for channels 24 and 25.



- ▶ **This is important for accurate measurement of energy in tile calorimeter!**

# 3in1 Card

## Schematic of 3in1 Card



## Main Tasks:

1. Measure parameters with lab bench prototype of old system (**DONE**)
  - ▶ Shaper variation
  - ▶ ADC variation
2. Design new differential driver (**DONE**)
  - ▶ Identify new components (should be more radiation tolerant)
  - ▶ Design new ADC and driver circuit
  - ▶ Simulate driver using Design Architect
3. Design noise filter
  - ▶ Design noise filter circuit
  - ▶ Simulate circuit using Design Architect
4. **Prototype new design with noise filter**
5. Measure effect on noise (tighten  $\Delta V$ )
6. If time, evaluate changes to shaper

- ▶ Super LHC (sLHC) will have increased luminosity
- ▶ Upgrading, why not increase the ADC to 16-bit?
  - ▶ Noisy
  - ▶ Expensive!
- ▶ Instead upgrade to 12-bit
  - ▶ Cheaper
  - ▶ Continue using dual gain setup
  - ▶ Explore noise effects on system