SPHENIX INNER HADRONIC CALORIMETER GAIN TRACKING

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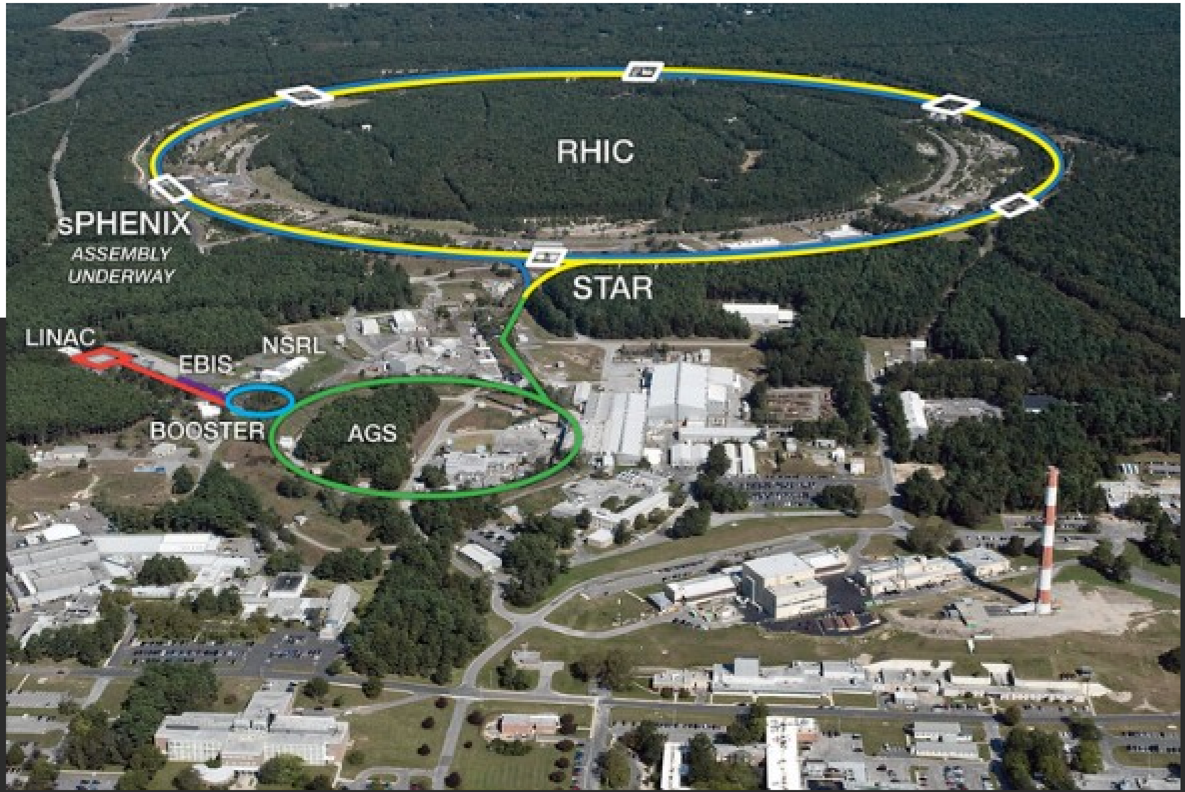
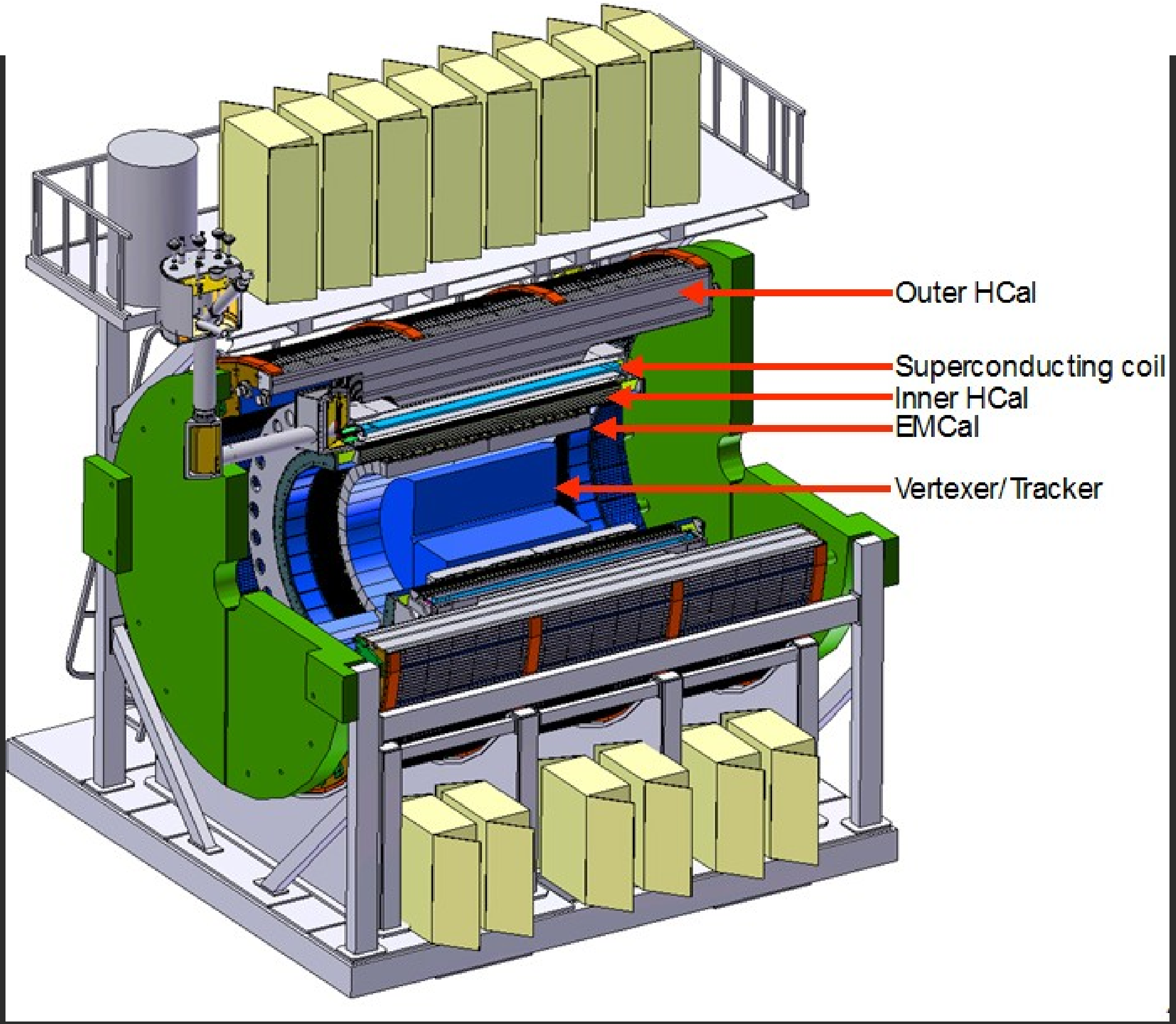
SPHENIX DETECTOR



- The Super Pioneering High Energy Nuclear Interaction eXperiment (sPHENIX) is a collaboration and detector experiment at the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Lab (BNL)
- sPHENIX will have a focus on the study of hadronic jets

SPHENIX DETECTOR

- Comprised of six main parts, the Vertexer, tracker, the EMCAL, the Inner HCAL, the solenoid, and the Outer HCAL
- EMCAL measures the energy of electrons and photons
- HCAL measures the energy of hadrons
- Assisted with the Inner HCAL assembly, testing, and calibration while at BNL

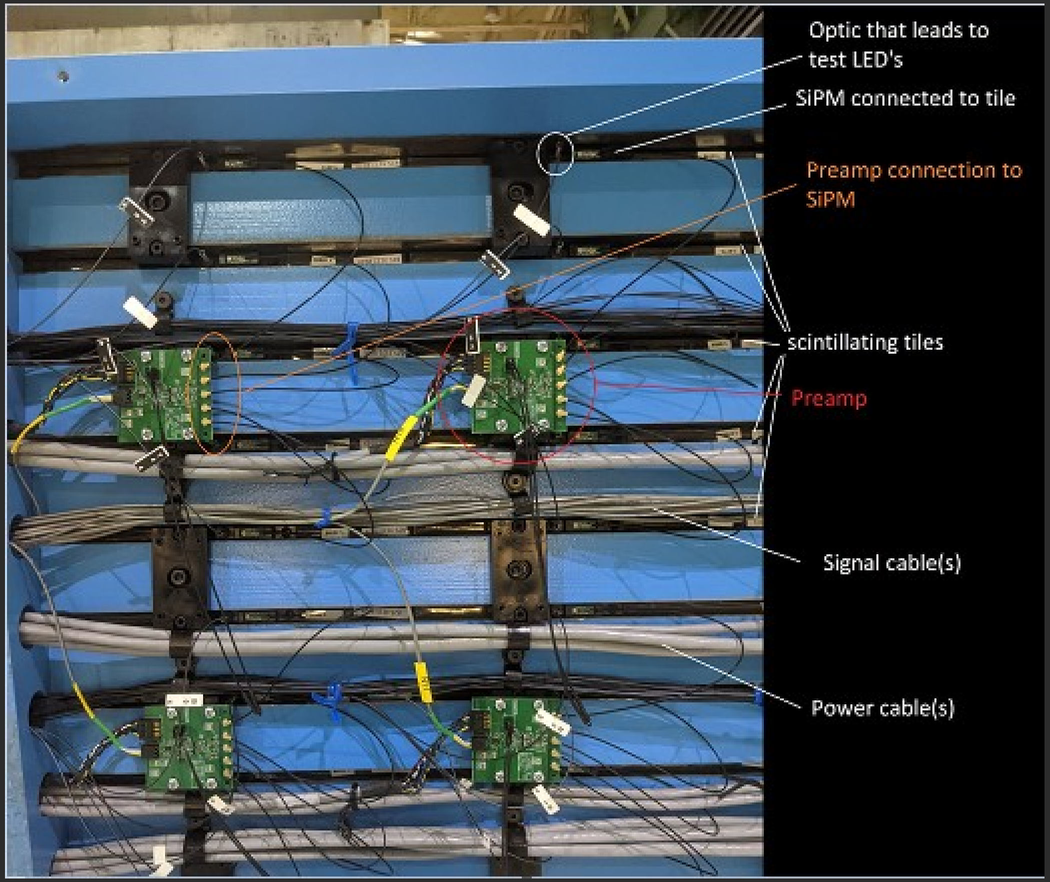


INNER HCAL

- Comprised of 32 “sectors” in circular pattern
- Each sector is a 6.4m long aluminum structure comprised of aluminum sheets with 9mm slits between to allow the placement of scintillating tiles
- Either end contains the electronics for signal and power as well as the test LEDs

INNER HCAL HARDWARE

- Scintillating tile, silicon photo multiplier (SiPM), and preamp
- Four tiles with SiPM's combine at a preamp to form a 'tower'
- Inner HCAL sectors have 48 total towers
- Signal cable, power cable, and optic cable to the test LED
- Test LEDs carried by fiber to tiles
- 4 test LEDs, a different one for each tile of the tower



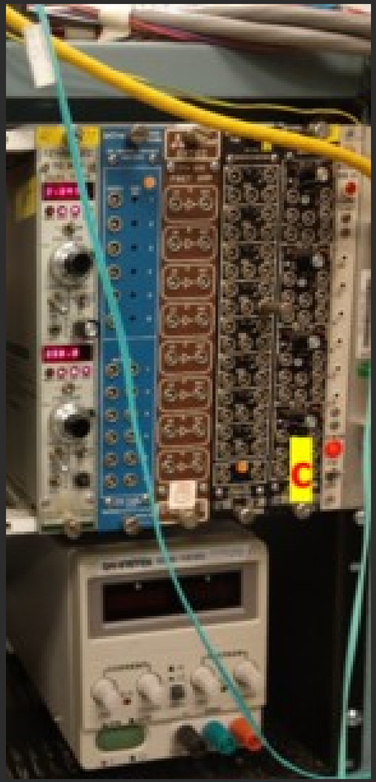
HCAL TESTING

- Test HCAL to ensure all towers are functioning and to calibrate
- Use DAQ (Data Acquisition) machine to run tests
- DAQ machine controls the bias voltage of the SiPMs, the test diode voltage, test pulse, triggers, and converts the signal voltages into ‘ADC’
- The DAQ machine has three main tests:

  -LED test to test if each SiPM is responding

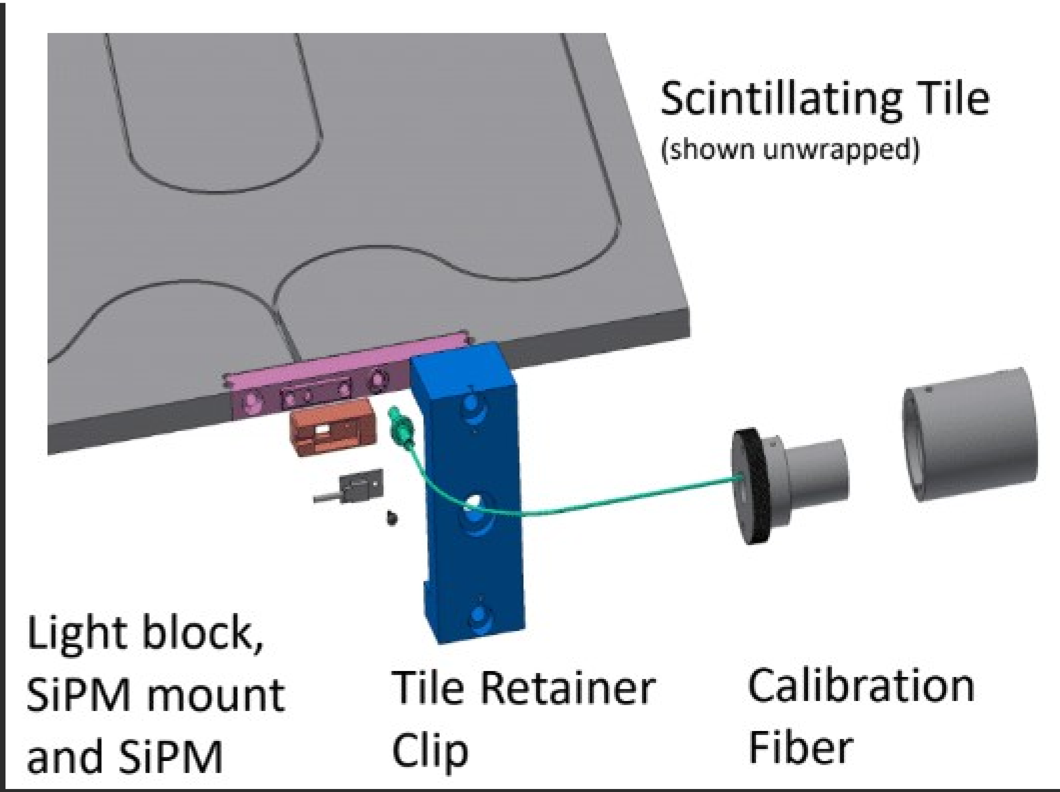
  -Cosmics which gather cosmic ray events for calibration

  -LED scan which runs the LED test at varying diode voltages



LED TEST

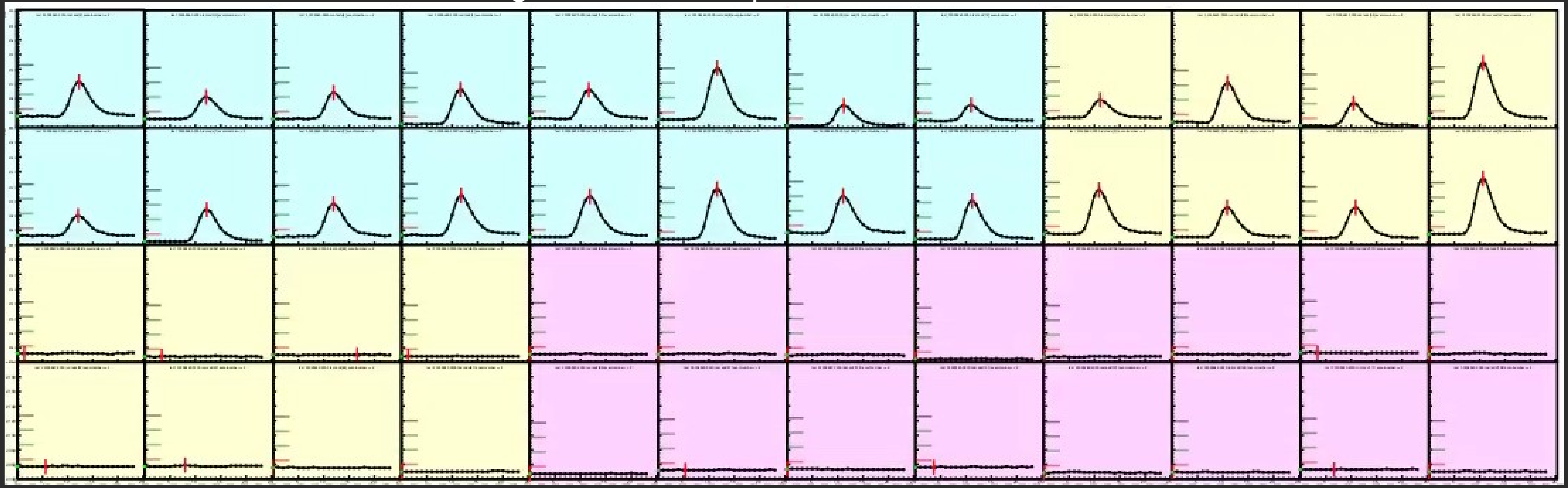
- Test LEDs are powered to a DAC value one at a time
- Test LEDs are located on the ends of the sector
- Light from LED is split to all scintillating tiles via fiber cables
- LED light is measured directly from the PIN diode
- Light from LED is injected into tile
- SiPM responds to this light as a distribution in ADC units
- Test quickly shows if tiles, preamp, or test LED are functioning correctly



LED TEST

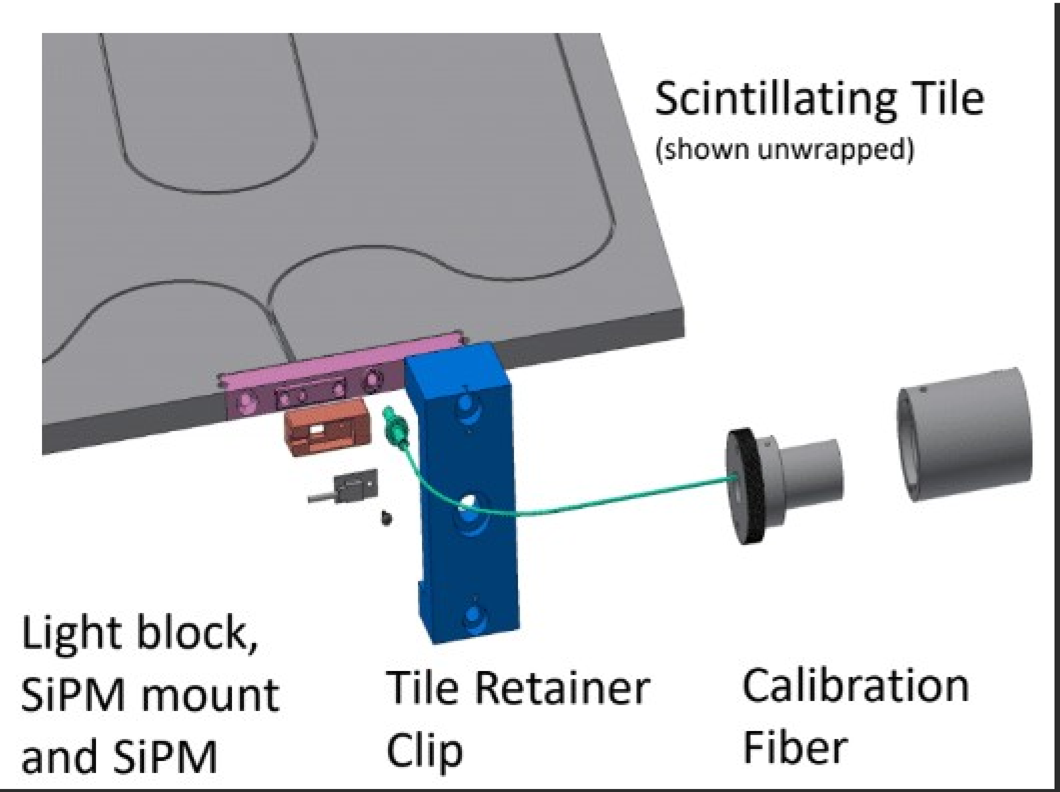
When performing LED tests we can quickly identify when parts are not working properly, as the test below shows

Histogram of LED 2 response for entire sector



LED SCAN

- Same function as LED test
- During a LED scan the DAQ machine incrementally increases each LED's diode voltage
- DAQ machine starts with DAC value of 1600 and increases by 100 DAC after each LED is injected
- Total of 7 different DAC values



LED SCAN

- The gain of the SiPM's will change due to temperature, radiation damage or other unknown factors
- Tracking this gain change is essential to understanding the physics signal from the detector
- The change in SiPM gain should be a factor determined by or
- Where ADC is our physics signal, LED is the SiPM response to the test LED, and PIN is the signal of the Pin diode, is when the detector is calibrated, and t is some later time

LED SCAN

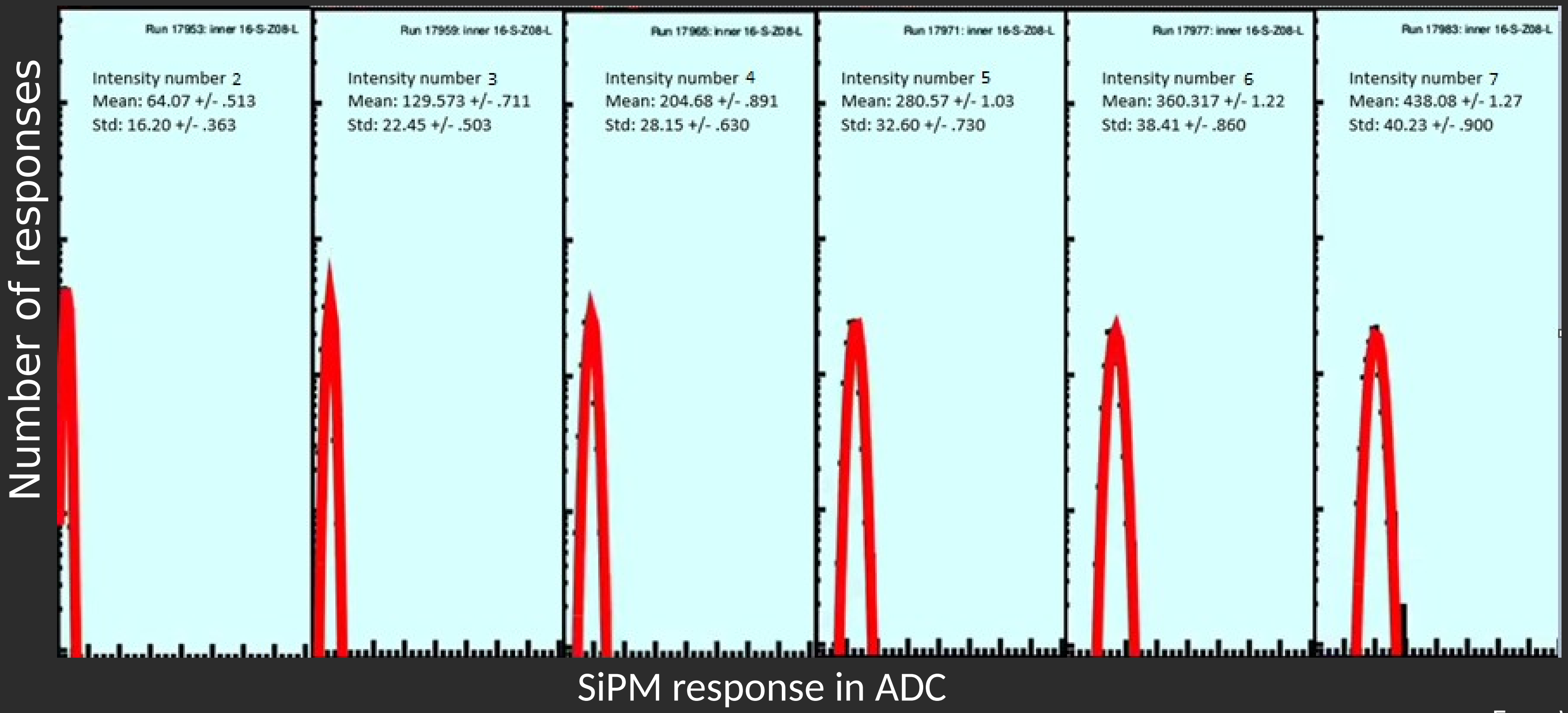
- From this, would track the change in SiPM response, assuming the LED is stable
- would track the LED luminosity
- To understand the gain change we must understand how the SiPM's response to the test LED changes as the PIN diode changes

METHOD

- During LED scan DAQ machine outputs the PIN diode information as well as the SiPM response in log file for each different LED intensity
- Developed macros in C++ that can be processed in root to extract desired data
- SiPM response as distribution in ADC
- PIN diode is a single peak value response
- Used one macro to obtain the mean response for each SiPM during LED scan and other macro to process this data with the PIN diode data

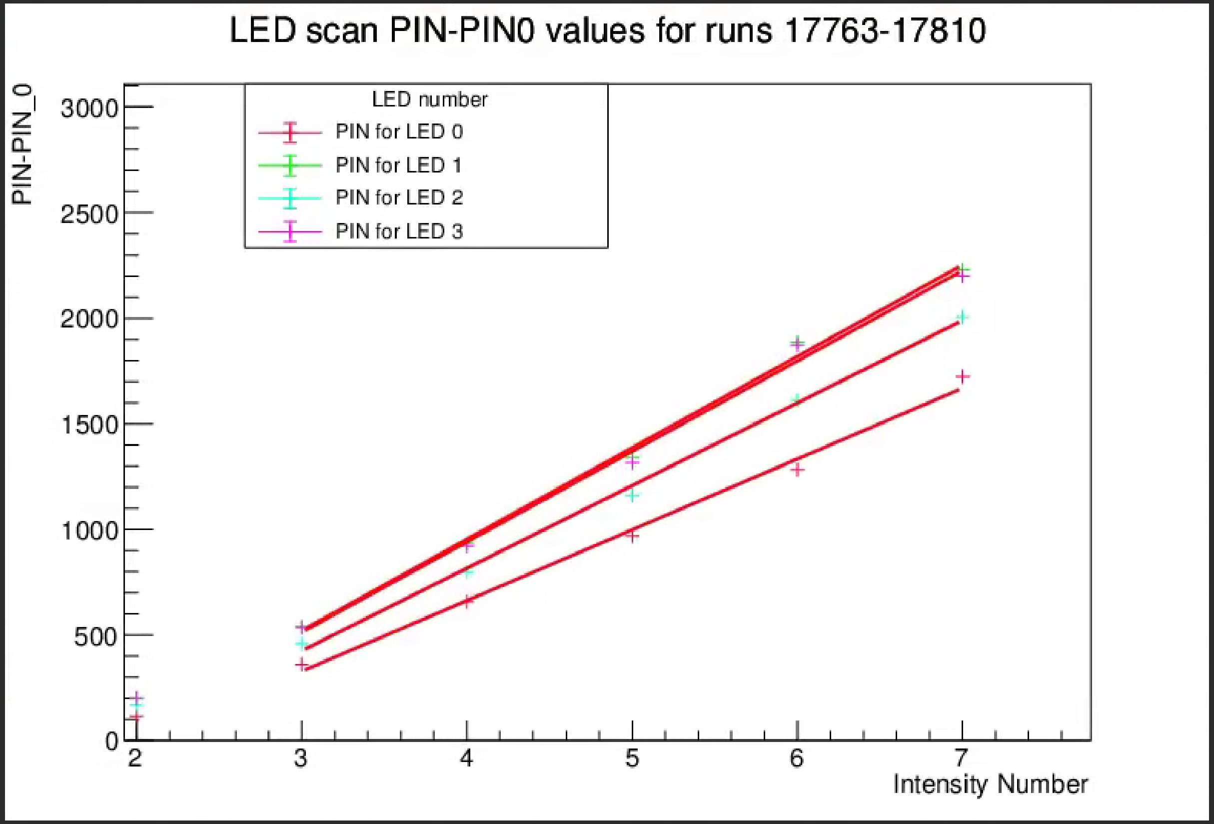
SIPM RESPONSE TO LED

- Distribution of SiPM response to test LED 0 for tower 9
- Each tile was fit with a gaussian around the peak to extract the mean and error



PIN DIODE VS INTENSITY NUMBER

- Extracted PIN diode value for each differing intensity and linear fit to line



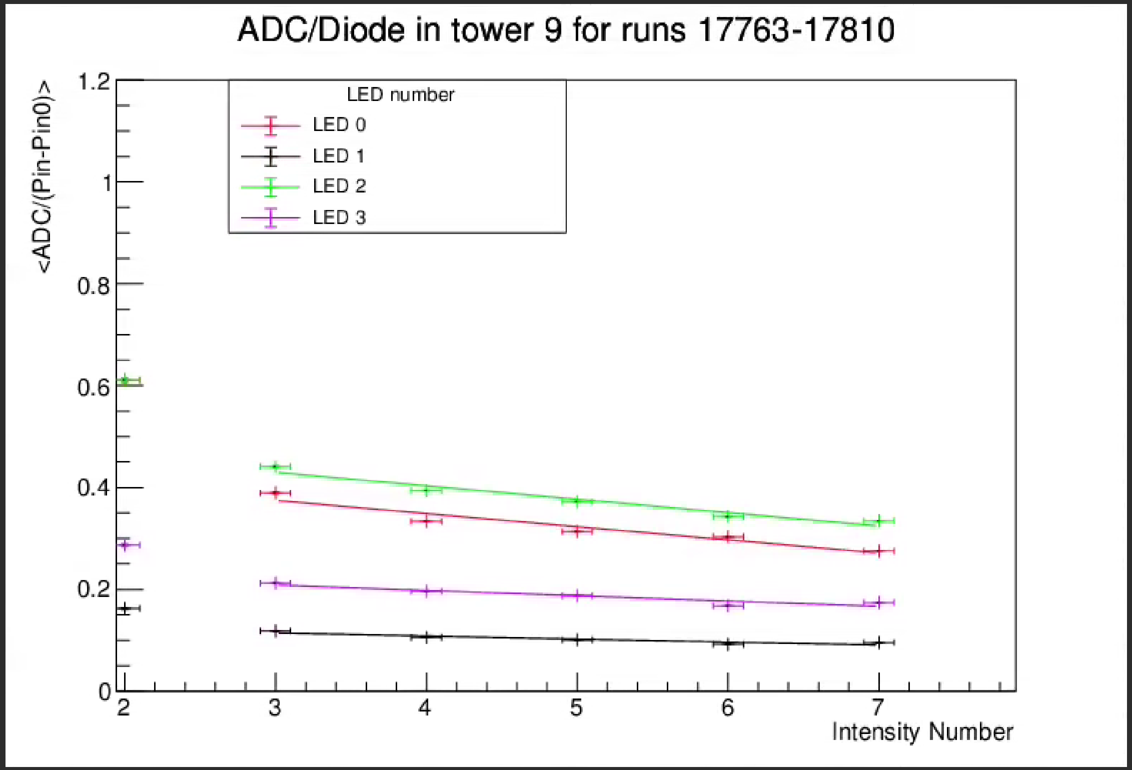

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =       7539.6
NDf                       =            3
p0                        =         -678   +/-    82.375
p1                        =        335.2   +/-    15.8531

****************************************
Minimizer is Linear / Migrad
Chi2                      =       8039.6
NDf                       =            3
p0                        =         -778   +/-    85.0626
p1                        =        432.8   +/-    16.3703

****************************************
Minimizer is Linear / Migrad
Chi2                      =       4050.7
NDf                       =            3
p0                        =       -748.7   +/-    60.3791
p1                        =        391.1   +/-    11.62

****************************************
Minimizer is Linear / Migrad
Chi2                      =      10093.6
NDf                       =            3
p0                        =         -772   +/-    95.3113
p1                        =        428.2   +/-    18.3427
```

LED/PIN VS INTENSITY VALUE

- To track the gain change we need to know how SiPM response to the LED changes as PIN changes
- If in linear region, LED/PIN vs intensity value would yield a 0 slope line
- Took each SiPM peak mean value for tower 9 and then divide by its corresponding PIN value
- Removed pedestal value for PIN
- Intensity value 1 has too low of an input that the LED does produce light, plots start at intensity value 2 for that reason
- Then used a linear fit to a line

ADC/PIN VS INTENSITY VALUE

- Since at intensity value 2 we are still in non linear region, fit for values 3-7



LED 0

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  0.000589076
NDf                       =            3
p0                        =     0.477835   +/-   0.027316
p1                        =   -0.0258166   +/-   0.00443124
```

LED 1

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  6.74111e-05
NDf                       =            3
p0                        =     0.137802   +/-   0.00924053
p1                        =  -0.00590495   +/-   0.00149901
```

LED 2

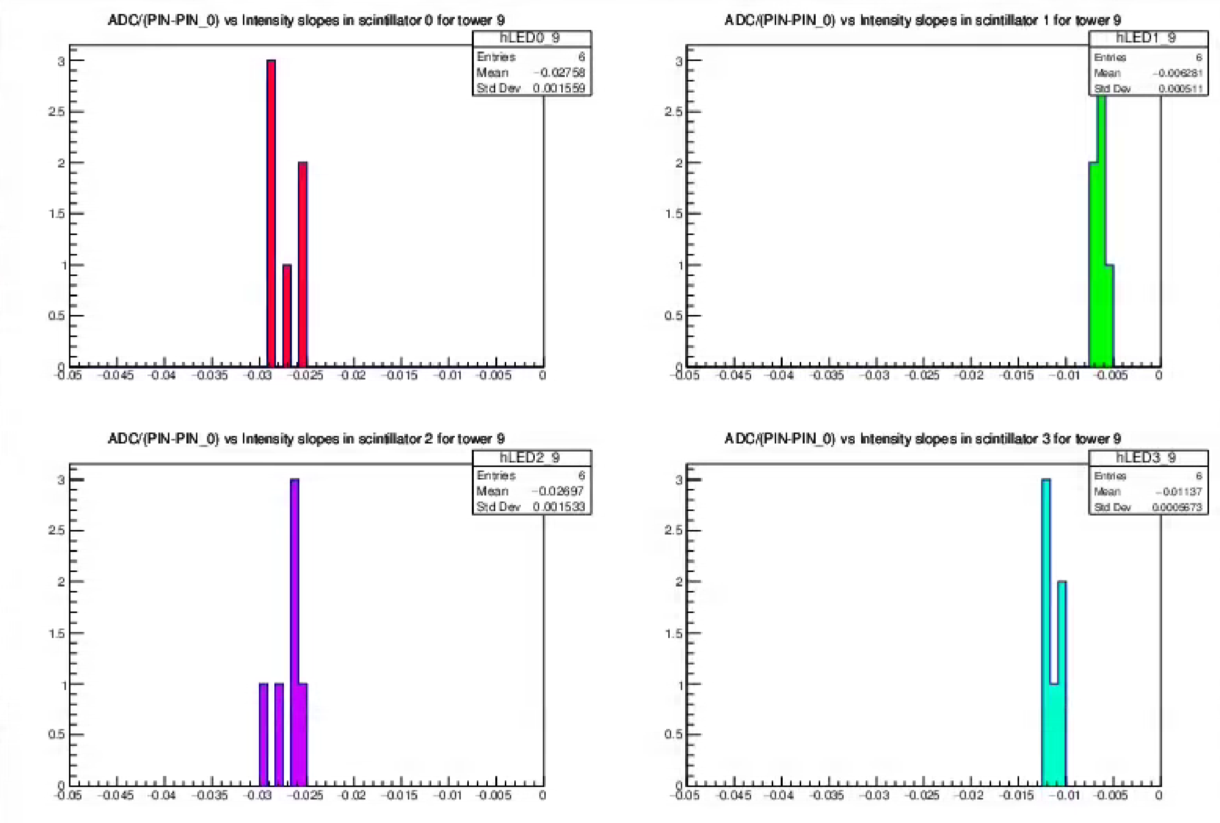
```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  0.000405435
NDf                       =            3
p0                        =     0.535071   +/-   0.0226617
p1                        =   -0.0263472   +/-   0.00367621
```

LED 3

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  0.000161485
NDf                       =            3
p0                        =     0.250213   +/-   0.014302
p1                        =   -0.0104443   +/-   0.00232009
```

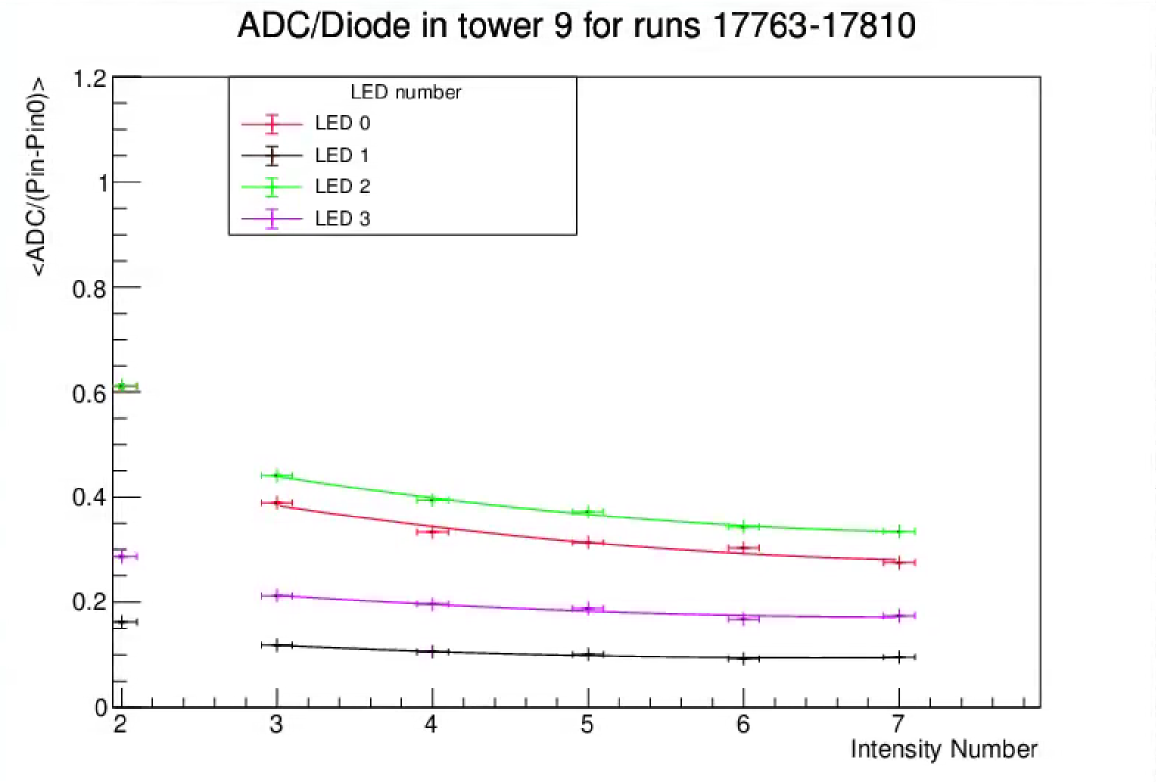
ADC/PIN VS INTENSITY VALUE SLOPES

- Histogram of the slopes from a line fit on each intensity scan (6) for each LED (0-3)



SIPM/PIN VS INTENSITY VALUE

- Since in non-linear region, fit to quadratic instead



LED 0

```
Minimizer is Linear / Migrad
Chi2                      =  0.000280594
NDf                       =            2
p0                        =     0.637434   +/-   0.11008
p1                        =   -0.0821457   +/-   0.0381718
p2                        =   0.00469409   +/-   0.00316563
```

LED 1

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  1.07653e-05
NDf                       =            2
p0                        =     0.206193   +/-   0.0215617
p1                        =   -0.0300429   +/-   0.0074768
p2                        =    0.0020115   +/-   0.00062006
```

LED 2

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  5.67642e-05
NDf                       =            2
p0                        =     0.704748   +/-   0.0495116
p1                        =   -0.0862332   +/-   0.0171688
p2                        =    0.0049905   +/-   0.00142383
```

LED 3

```
****************************************
Minimizer is Linear / Migrad
Chi2                      =  7.94861e-05
NDf                       =            2
p0                        =     0.332498   +/-   0.0585889
p1                        =   -0.0394859   +/-   0.0203165
p2                        =   0.00242013   +/-   0.00168487
```

CONCLUSION

- With a non-zero slope present it is evident that the tile output is not linear vs the DAQ setting
- Since PIN vs intensity number is linear, the negative correlation between LED/(PIN-PIN_0) is most likely caused by the efficiency of the tiles decreasing
- However, the quadratic fit is strong for the LED/(PIN-PIN_0) suggesting we can use this correlation to calibrate our gain change function

QUESTIONS?