sPHENIX EMCAL LED System

C. Woody & S. Stoll
BNL

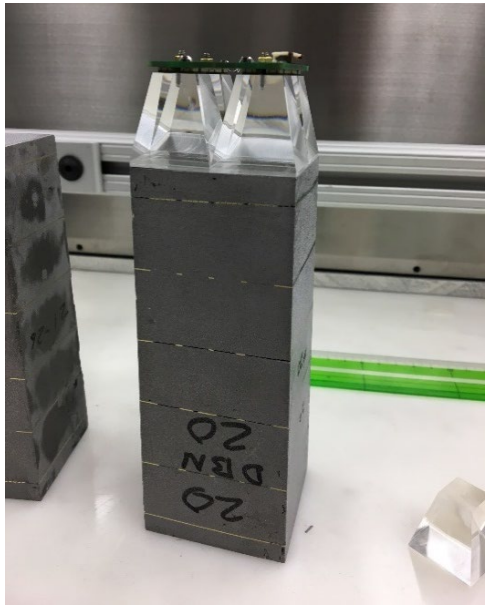
ePIC Calorimeter Working Group Meeting
December 13, 2023

Overview and General Comments

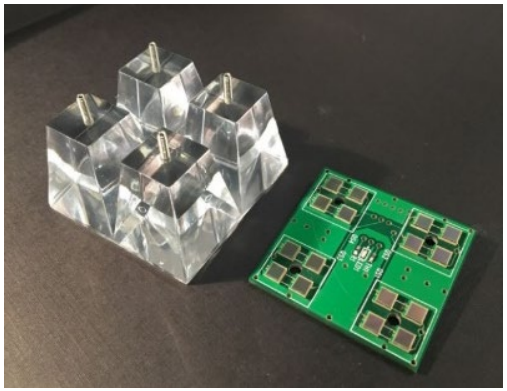
- The LED and Test Pulse systems for the sPHENIX EMCAL and HCAL were originally designed to simply provide a live channel map for both calorimeters.
- We later realized that we needed to rely on the LEDs for more precise gain measurements and gain monitoring, particularly as a result of the effects of radiation damage to the SiPMs.
- The system was designed using a digital driver/fanout system that allowed us to vary the pulse width of the drive pulse to the LEDs but not its amplitude.
- Even after a number of improvements to the driver system, it was found that the amplitude of the LED pulses as measured by the SiPMs in the calorimeters was very sensitive to the width of the drive pulse.
- We also learned that due to variations in the way the light was delivered and viewed by the SiPMs, there was a large variation in the amplitude of all the LED signals for a given pulse width (i.e., no single pulse width could be used to put the LED signal within its useful dynamic range for each channel simultaneously).

LEDs for the EMCAL

Each calorimeter module (6144 total) consists of 4 towers, each with its own light guide which is read out with four 3x3 mm^2 SiPMs (Hamamatsu S12572-015P)

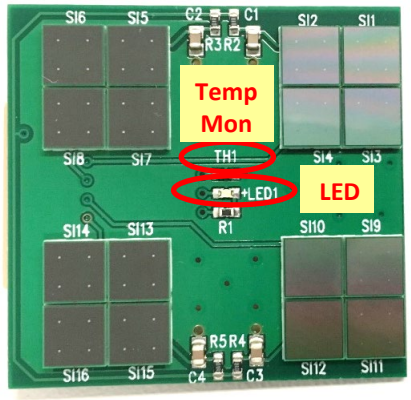


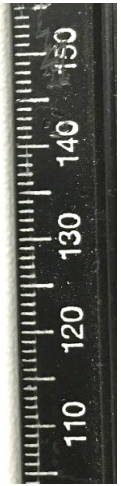
Calorimeter module consisting of one calorimeter block and 4 independently read out towers



4 readout towers
each with a 1” light guide and
a 2x2 array of SiPMs

SiPM Daughter Card

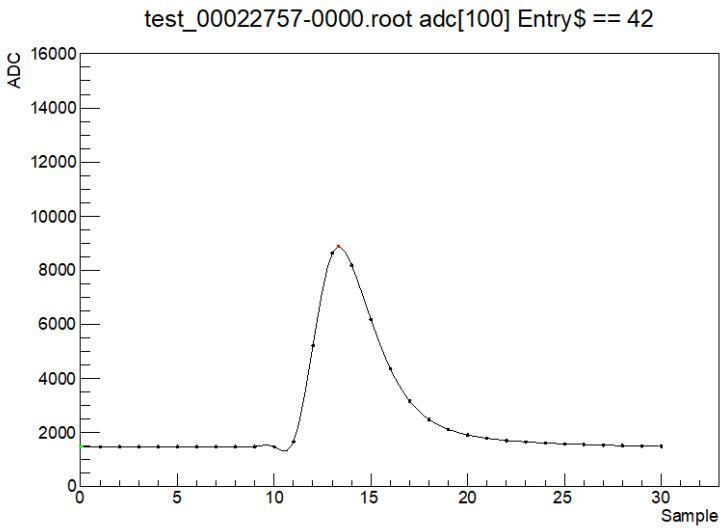


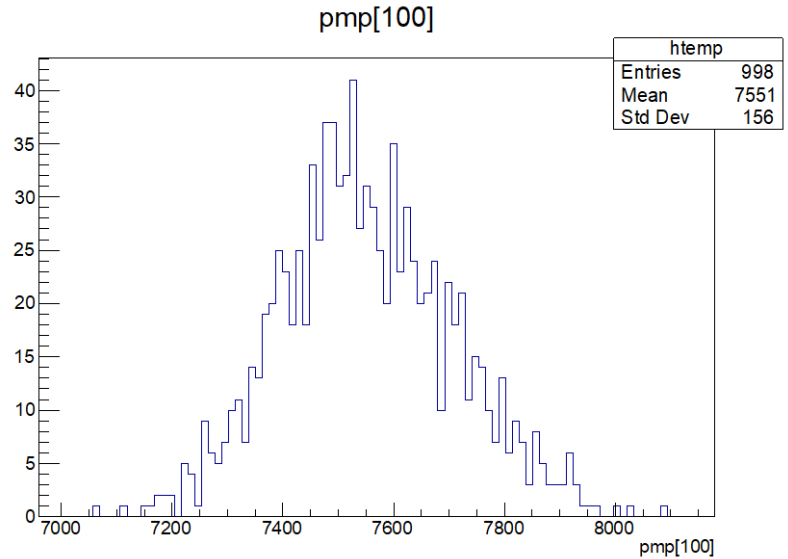


Note: The LED is facing downward into the gap between the light guides, which does not necessarily provide a uniform light distribution to the 4 towers. LED light output can also vary from module to module.

LED Signals

LED pulses look pretty much like normal SiPM signals from light produced in the calorimeter except that the pulse length can be longer

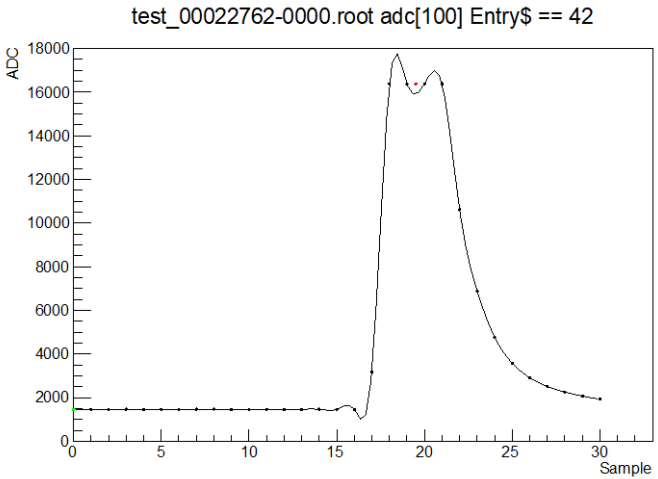




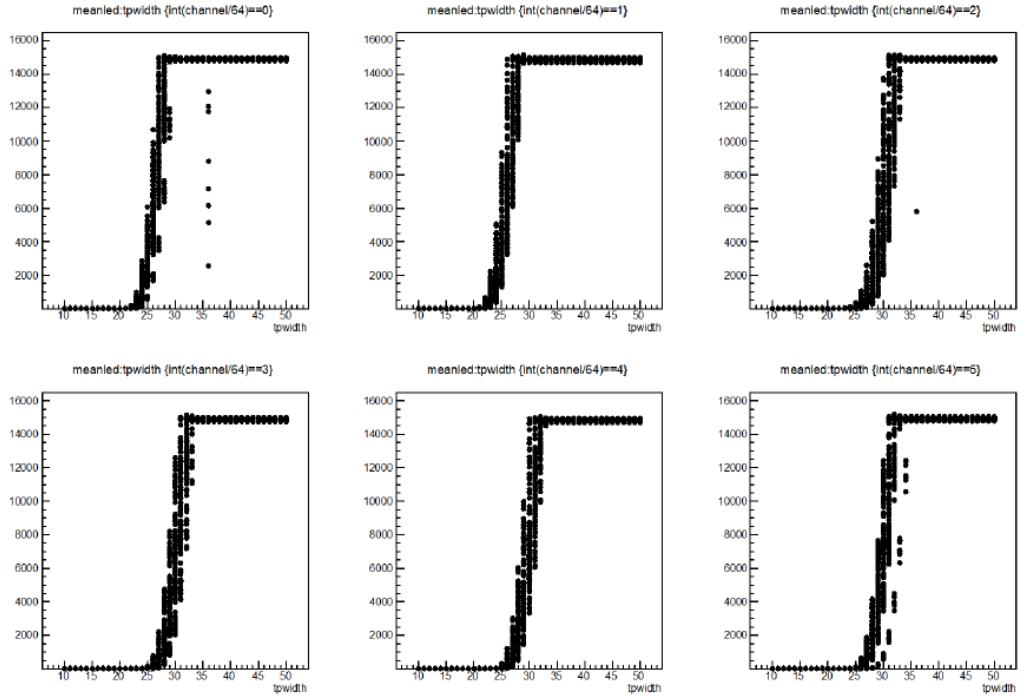
J.Haggerty sPHENIX EMCAL Meeting 7-25-22

Saturated LED pulses

Saturated LED pulse in SiPM



Typical turn-on and saturation behavior for LED pulses



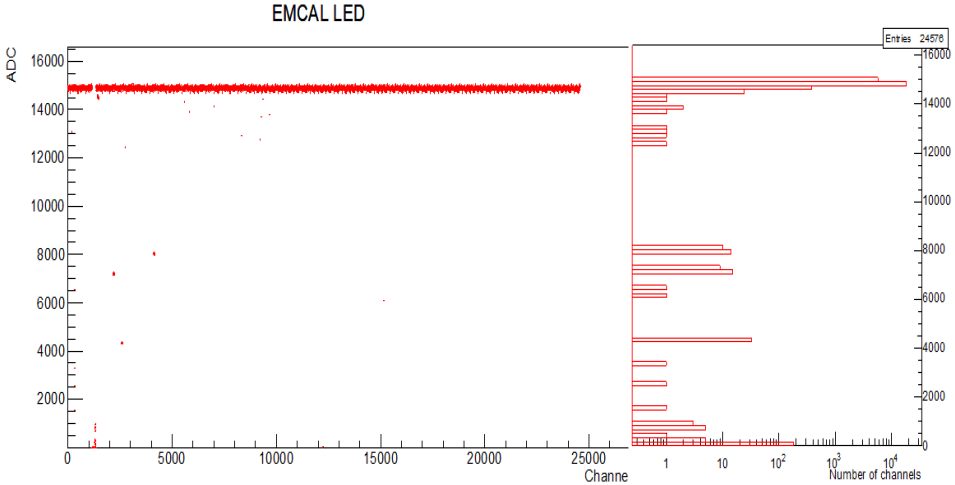
J.Haggerty sPHENIX EMCAL Meeting 7-25-22

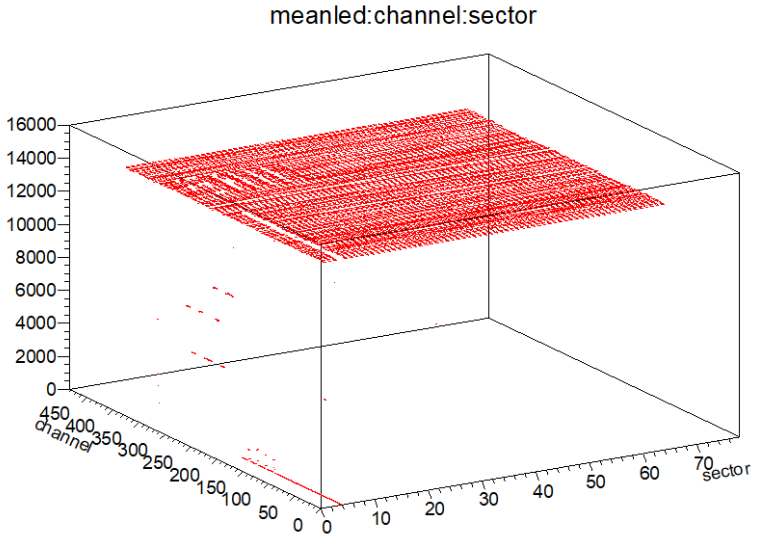
Key Performance Parameters (KPPs)

We used our LED system to satisfy one of the Key Performance Parameters for the EMCAL system

KPP 1: > 95% live channels based on LEDs

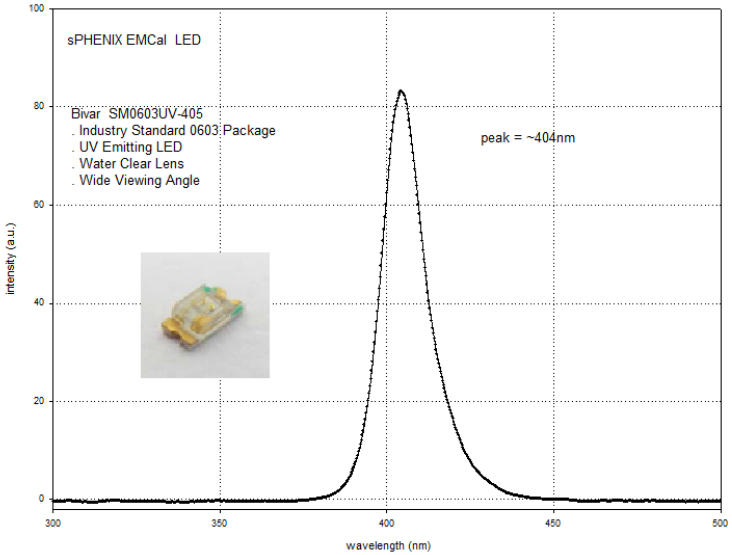
All signals saturated

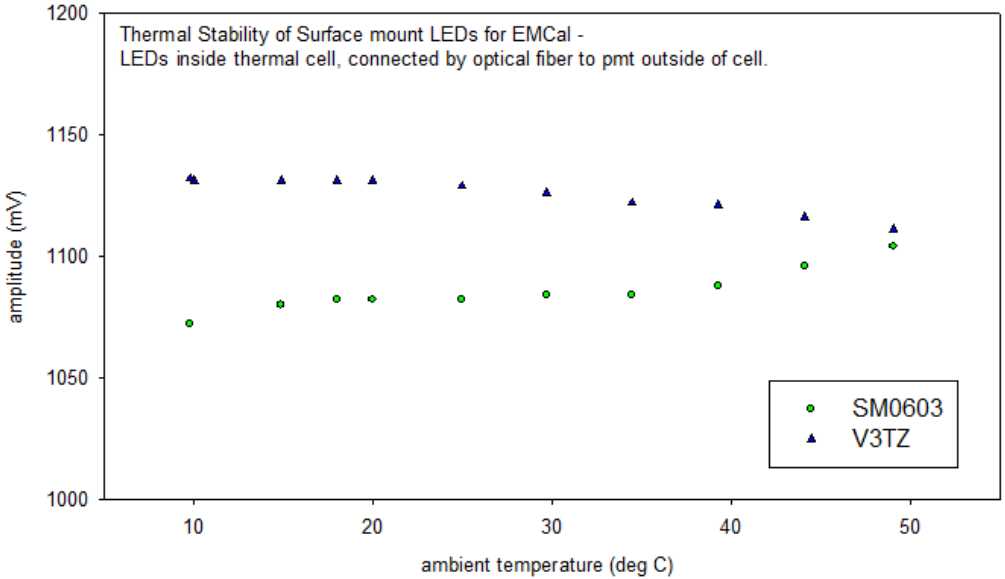




J.Haggerty sPHENIX EMCAL Meeting 7-25-22

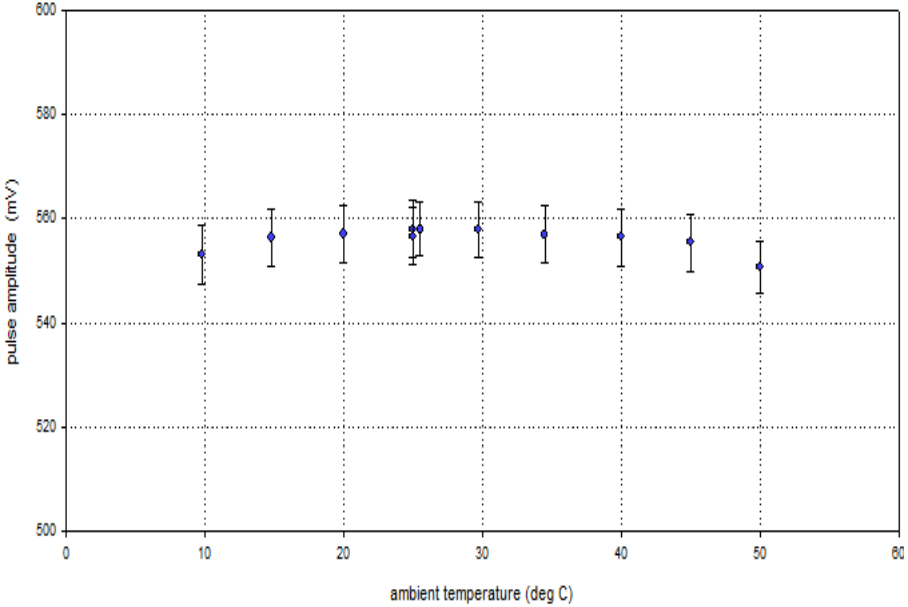
LED Temperature Stability

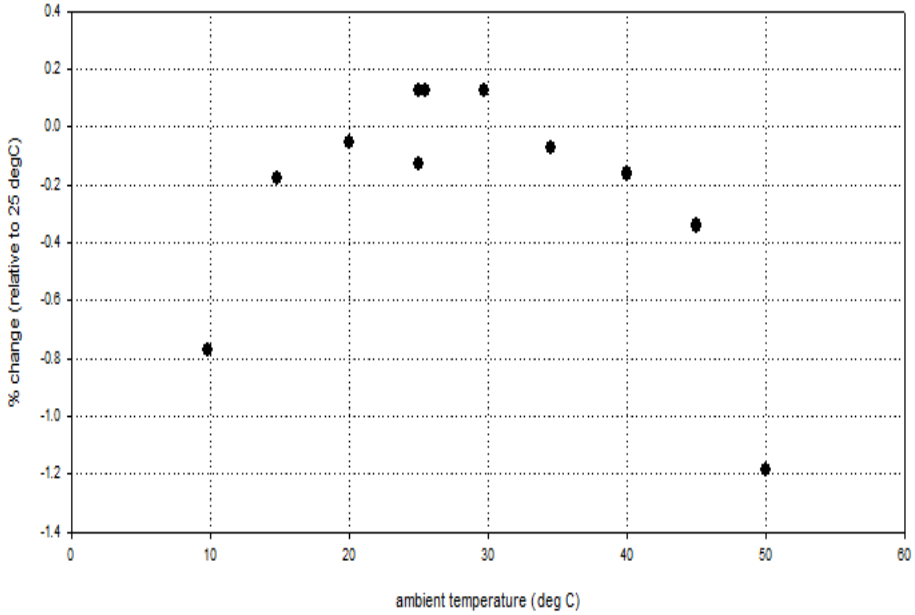




LED Temperature Stability

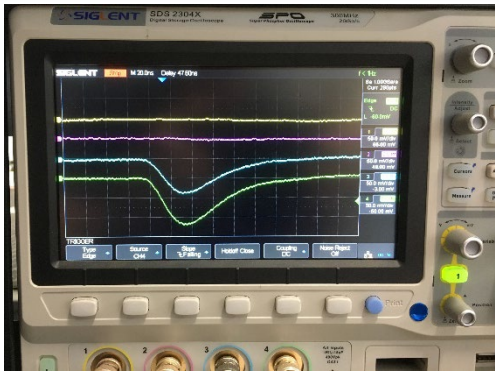
Temperature dependence of sPHENIX LED emission amplitude.
(Trigger pluse: 3.3V x 50ns) LED positioned inside thermal cell connected by optical fiber to pmt outside cell.



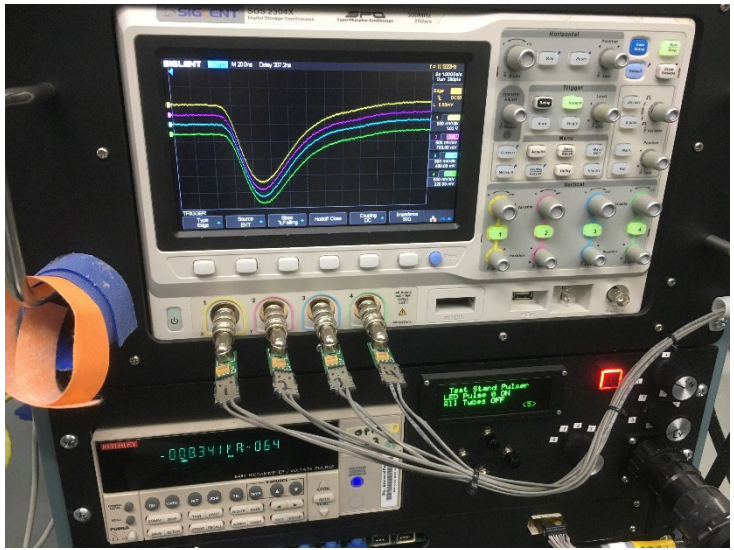


Sector Testing and Commissioning

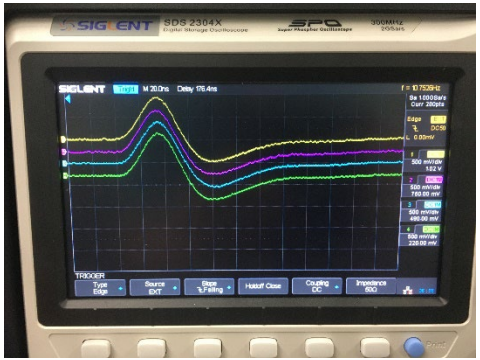
LEDs and Electronic test pulses used to check sector functionality during production. LEDs were used as an assessment tool during sector assembly and installation to test the entire signal chain.



LED pulse signals (4 towers on 1 block).
2 “bad” towers. Cable issue.



Typical LED signals from 4 towers on 1 block (same LED).
Viewed using portable test stand.

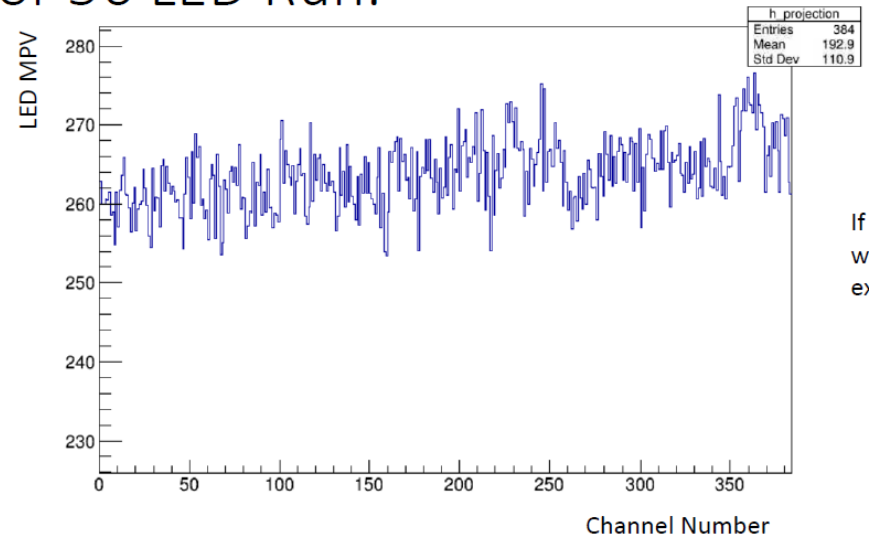


Electronic test-pulse signals (4 towers on 1 block)
Charge injected at preamp.

Sector testing during burn-in and cosmic ray testing

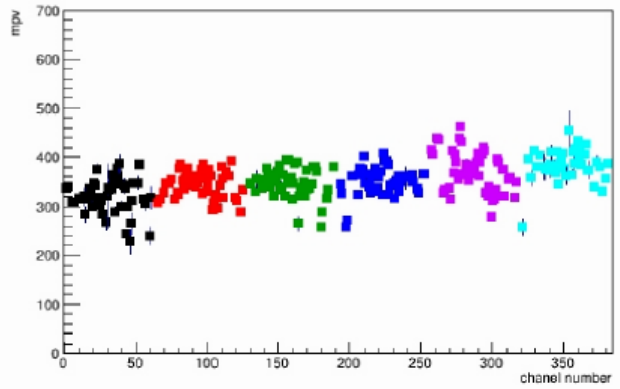
Using the DAQ system, full sectors were read out.
LED data was taken along with Cosmic ray data.

Sector 56 LED Run:

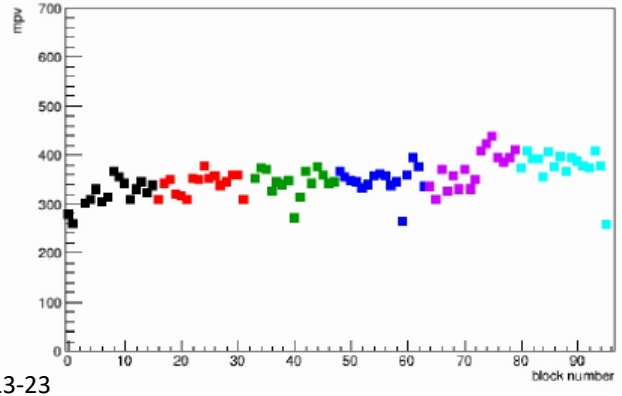


If
w
e)

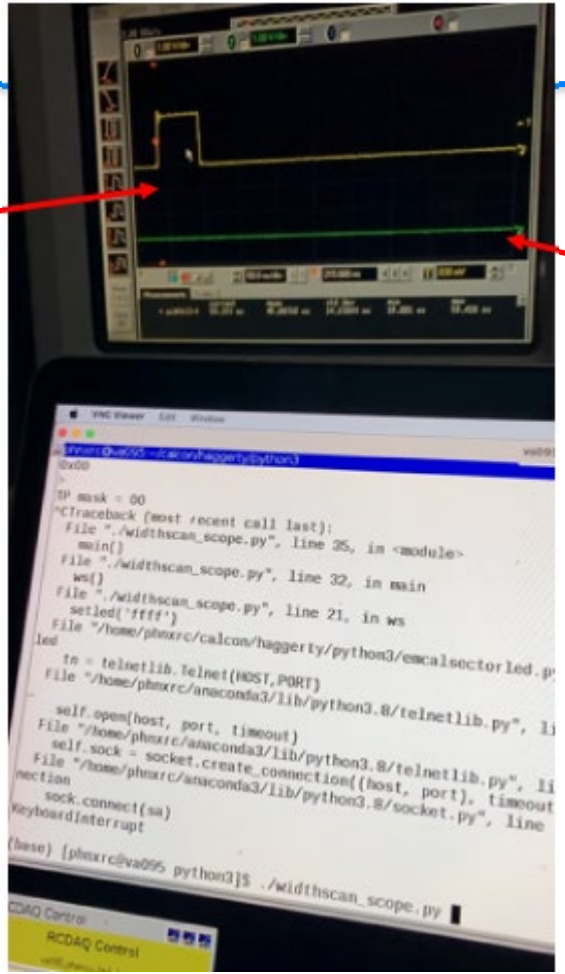
Per Channel MPVs



Block averaged MPVs

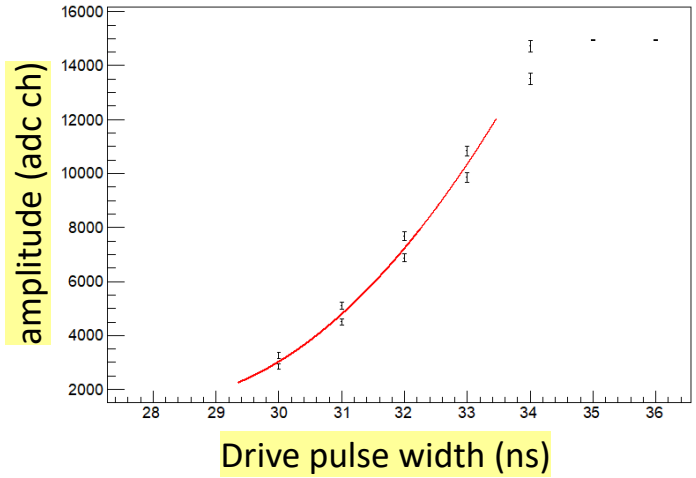


LED widthscan (video)



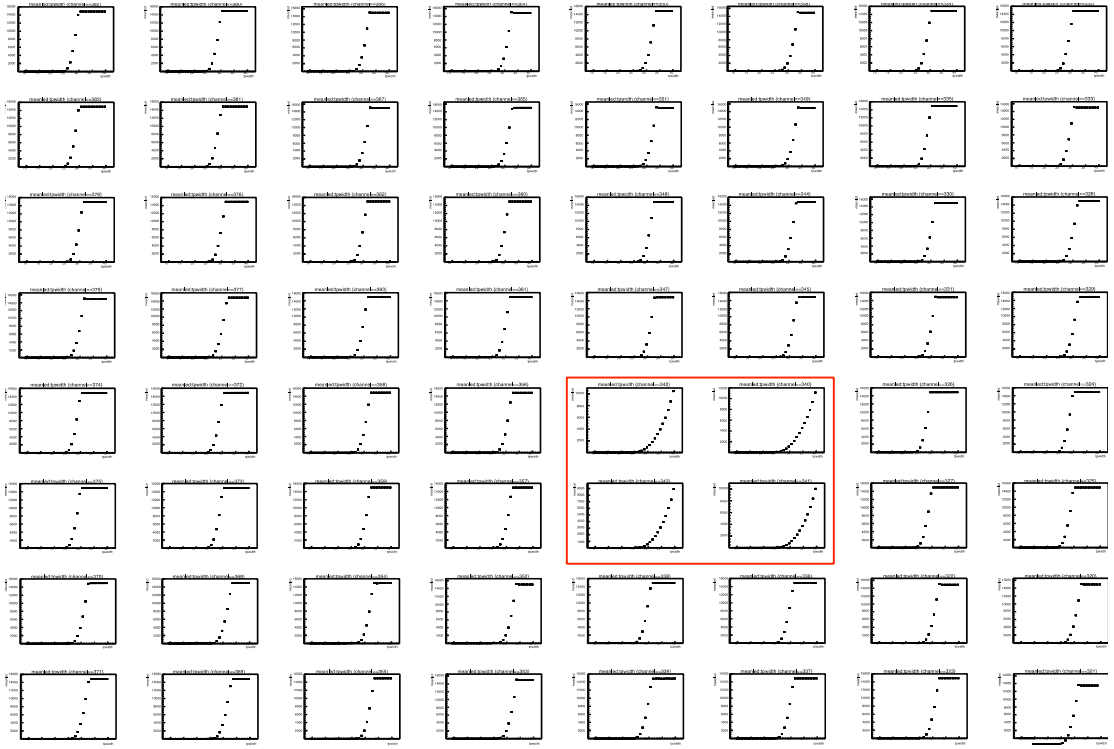
Limited precision/control in LED pulsing.

- Full dynamic range of pulse amplitudes is covered by ~5 ns of variation of the trigger pulse width.



Sector 53 IB 5

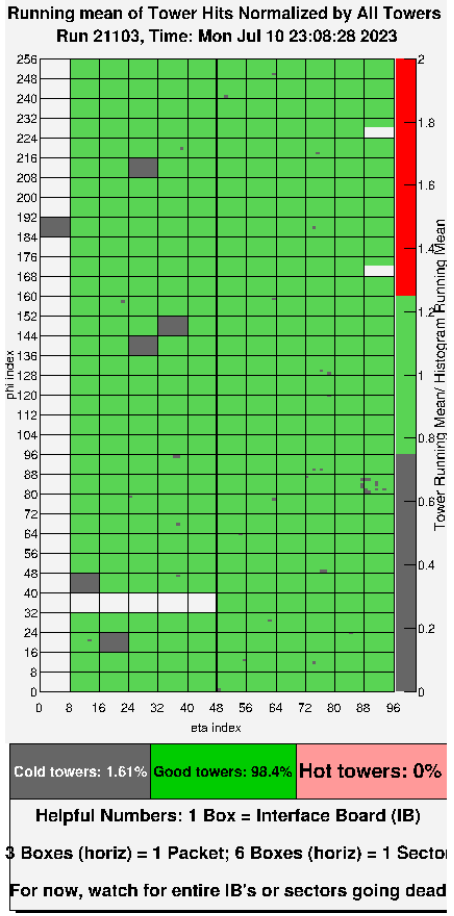
LED “turn-on” curves
from one interface board
(64 towers)



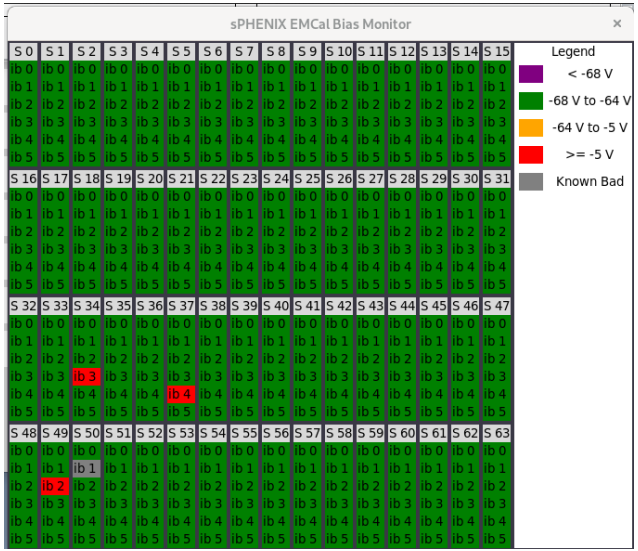
J. Haggerty - sPHENIX EMCAL Meeting 2022-02-04

Run 2023 Monitoring

Online monitoring plots for the Shift Crew to monitor detector performance focused on relative physics signals:
single channel / detector avg



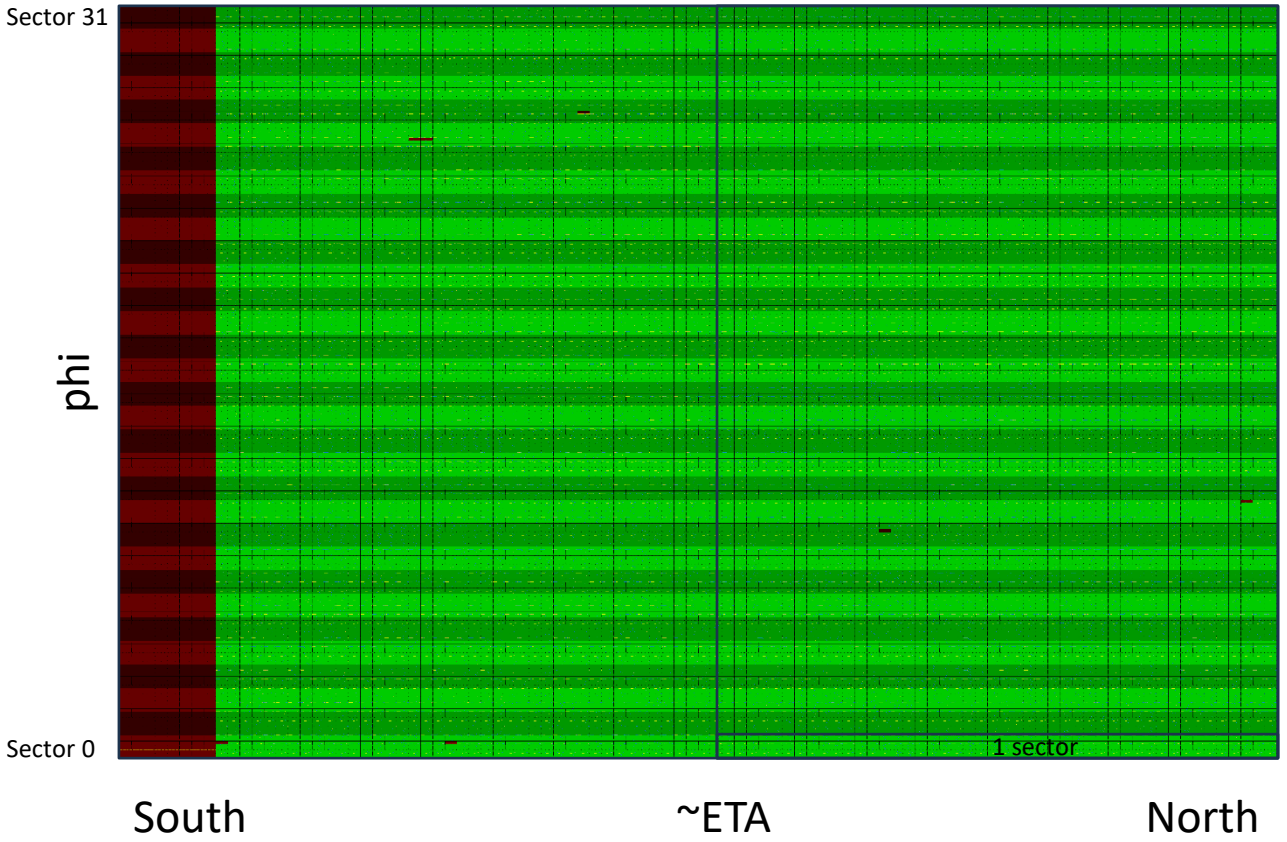
And SiPM bias current trips



Run 2023 Monitoring

LED monitoring plot
From start of Run 2023.

LED data was used by EMCal experts to monitor detector health and troubleshoot problems.



Summary

- Our LED system was used not only for a live channel map but also for calibration and testing during construction and assembly and for gain monitoring during the run. It's been a vital system to have for both purposes, but better precision could have been built in at an early stage of its design.
- The LED pulser/driver system delivers fixed amplitude pulses and the intensity is varied by changing the pulse length. This led to certain limitations and sensitivities.
- There was a large variation in the SiPM LED signals across the entire detector due to variations in the LED intensities and light distribution within the modules.
- Drive Pulse widths are controlled at the "Interface Board" level (64 towers). We don't have the ability to set the LED amplitude for individual towers (or blocks of 4 towers) independently, so we use LED scans to see optimal LED signals from all towers.
- Some dedicated LED runs were taken during Run 2023, but the data has not been used thus far for actual calibration or monitoring.