F2F: FEE Board Attenuator Study

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University of California Riverside

April 27, 2021

Introduction

- In this brief talk, I will share the results of an analysis performed on the Fee Boards, specifically referring to the attenuator settings.
- Data taken on day 26, runs 1106918 and 1106919, which are distinguished by their "Attenuator setting in 'default file' for Ecal" being "0 (0db)" and "12 (6db)", respectively.
- Can take the led data between the two runs and compute a ratio (G(12)/G(0)). From here, we can identify anomalous channels.

ECal LED Ratio Distribution

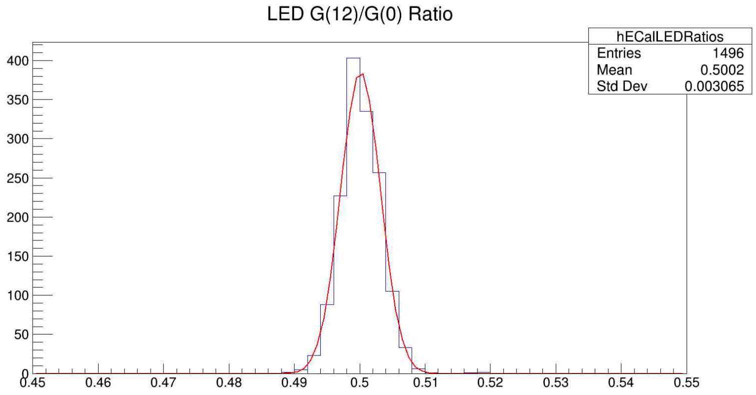


Figure 1 - Histogram of LED ratios within ECal. The expected attenuation is around 0.5. All functioning channels were within reasonable limits of this value.

Conclusion

- The takeaway: Outside of channels which threw flags during one or both runs (13 channels in ECal out of 1496), all systems were nominal.
- The attenuators are working, at least within the confines of this analysis.
- The study may be conducted on future attenuation settings, if needed.

Backup: The FEE Boards

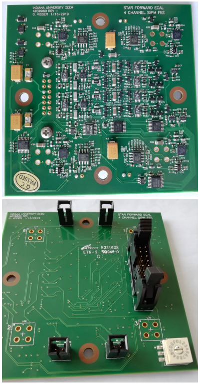


Figure 1 - The FEEBoards as they appear on the ECal.

The 374 4-channel (260 2-channel) FEE Boards on ECal (HCal) are controlled using DEP control branches. Control is done by row, multidrop I2C, using 17 (10) DEP control branches per half north/south. LV power is done by groups of 3 rows, using 6 (4) MPOD power groups. Notably, the attenuation settings on the FEE Boards can be adjusted.

LED Voltage Scan

Forward Upgrade F2F Meeting

Cameron Racz

UC Riverside

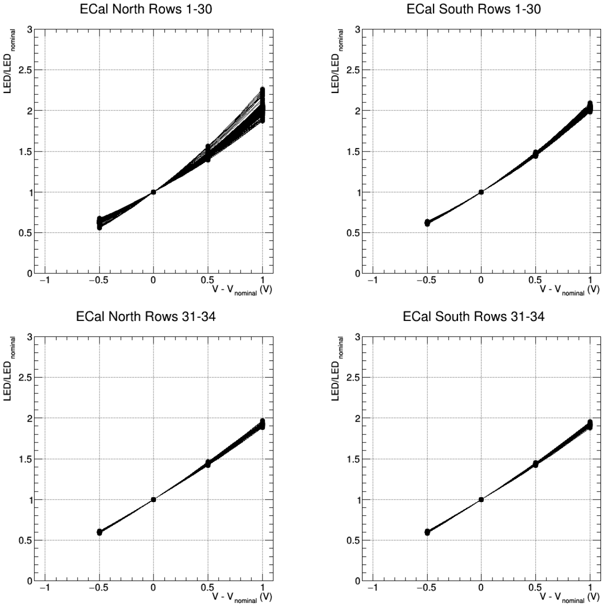
April 27, 2021

Overview

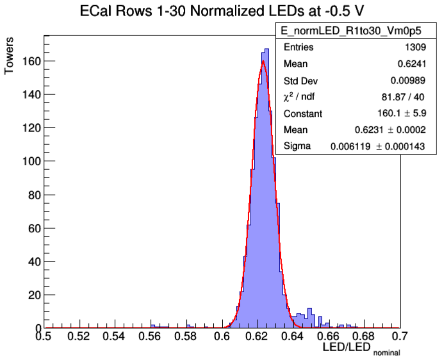
- Task: Look at ECal LED amplitude vs bias voltage for 4 settings $V - V_{nominal} = -0.5, 0, +0.5, +1$, where $V_{nominal}$ is our original calibration value.
- -1 V proved to be too low, so that is not included.
- We wanted to check the behavior of the LED signals and investigate the possibility of uniformly lowering the bias for all ECal SiPMs without losing the signal.
- Run # with ECal bias setting: 22098020 (nominal), -21 (-0.5 V), -22 ($+0.5$ V), -23 ($+1$ V).
- ECal rows $1 - 30$ and $31 - 34$ were separated since they have different SiPMs.

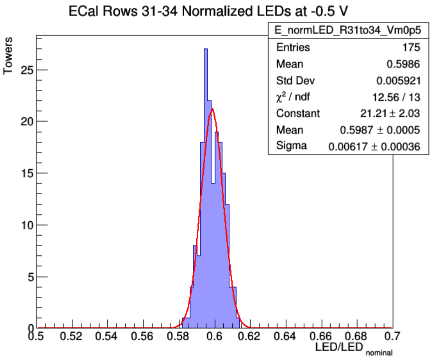
ECal SiPMs' LEDs

- SiPM LED amplitudes are shown, normalized by their nominal value, as a function of bias voltage.
- All SiPMs have the same general trend and no problems were revealed.
- No strong correlations were found between these distributions and temperature.
- The spread at -0.5 V was not large, making it a good candidate for the new bias setting.



Normalized LED Spread at -0.5 V





- Lowering the bias by 0.5 V produces a narrow spread and only reduces the LED amplitudes by about 40% of their original values.
- This study concluded that the LED amplitudes looked good and that it was safe to uniformly lower bias voltages by 0.5 V.

FCS commission summary

Xilin Liang

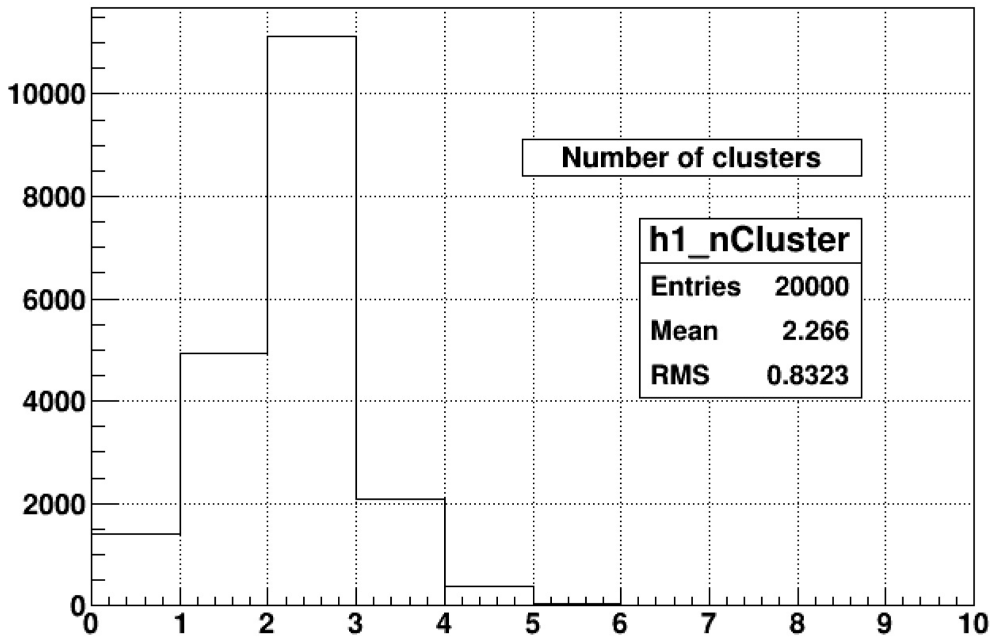
Apr. 27, 2021

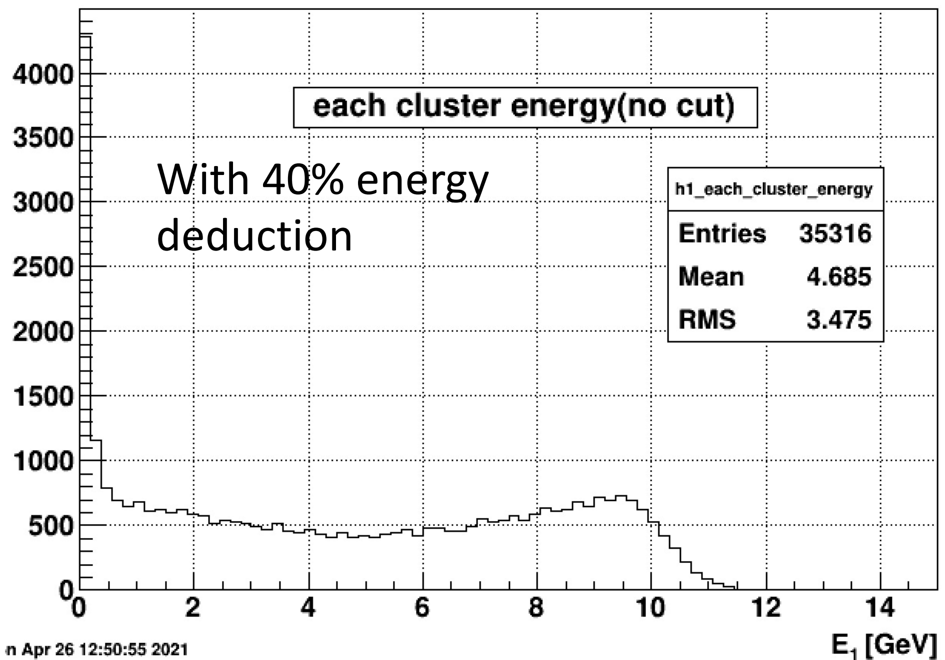
Task 1: π^0 reconstruction for HCal with MC simulation

- Goal: Sanity check of FCS HCal by using π^0 reconstruction ($\pi^0 \to \gamma\gamma$).
- If the simulation looks good (doable), we can consider using O-O 200 GeV data to calibrate HCal with this method.
- Simulation datasets: 10 GeV single π^0 event
  - 20 k simulation events
  - Turn off ECal
  - Also try 3 , 6 GeV single π^0 event as well.
- We use Cluster finder to get all the clusters as photon candidate in each event.

Clusters and cluster energy (before cut)

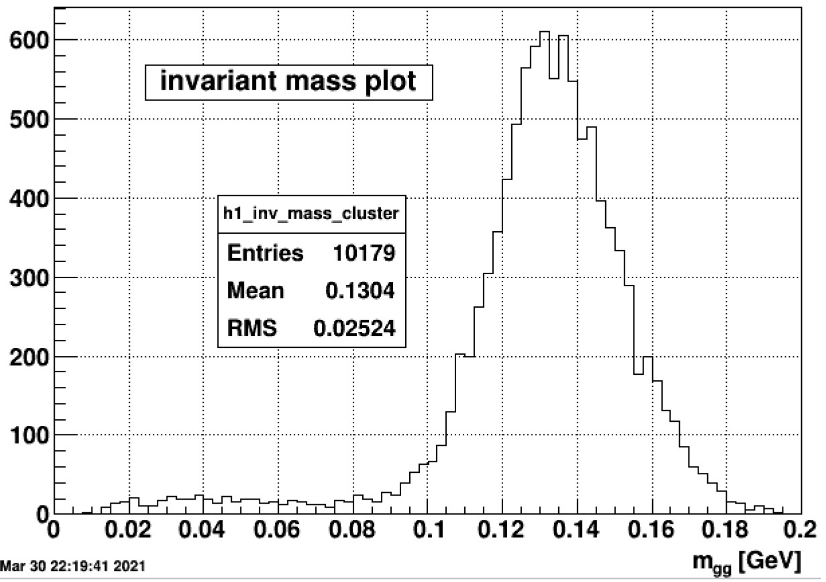
- Many events have 2 or more clusters.
  - Should be able to see some π^0
- We can consider a cut of E > 0.35 GeV.
  - Sampling fraction for EM particle in HCal is 40% higher than hadron particle in Hcal if we turn off Ecal (from Ting & Huanzhao 's study)
  - Thus we reduce 40% of cluster energy.

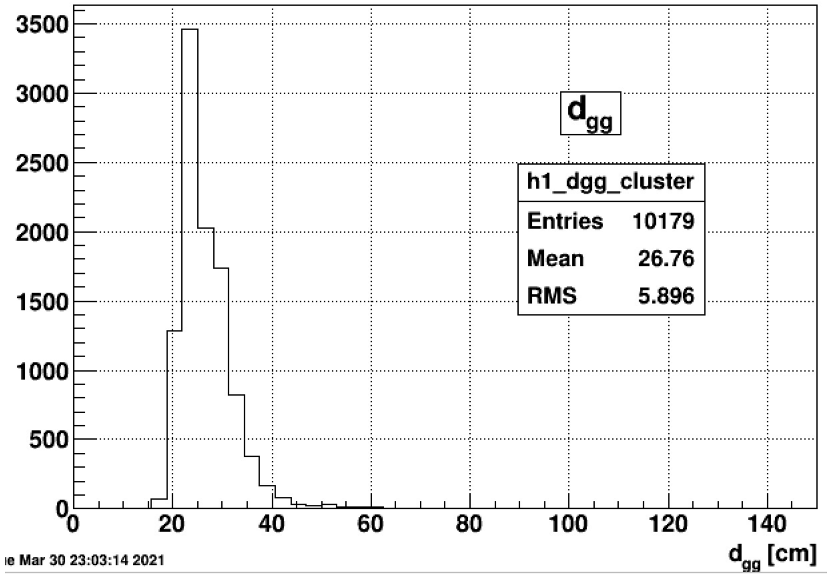




Result for 10 GeV π^0 event

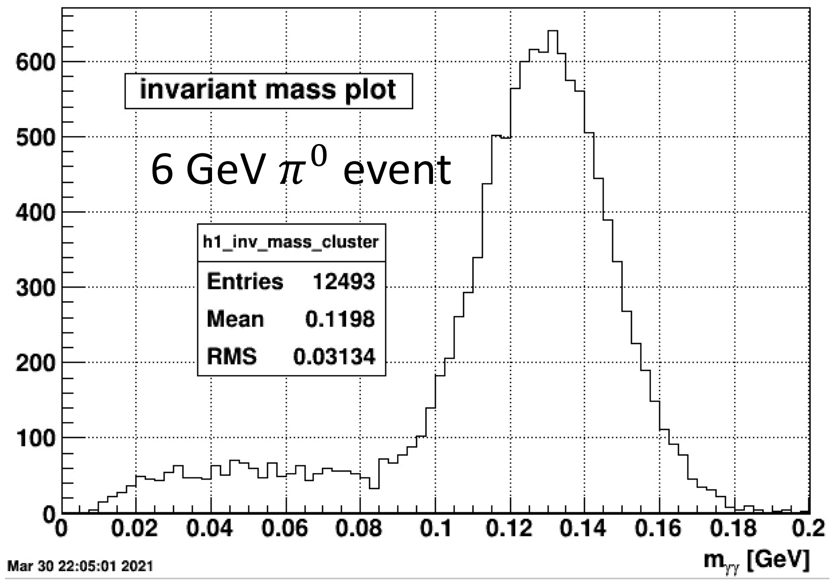
- Basic event selection (all cluster apply 40% energy reduction)
  - Each cluster energy > 0.35 GeV
  - Energy asymmetry $Z_{\gamma\gamma}$ < 0.8
- We can see π^0 peak in the invariant mass plot.
- The distance between two clusters in a good pair is within the expectation.

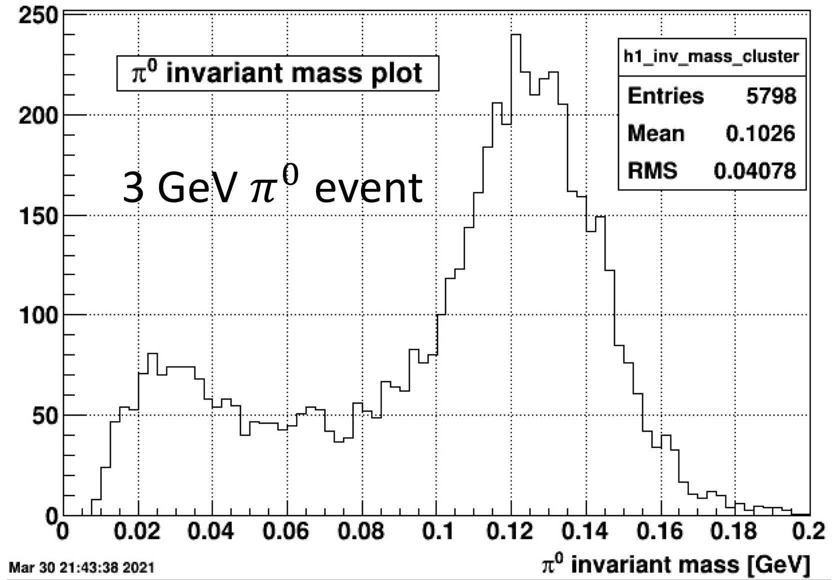




Conclusion

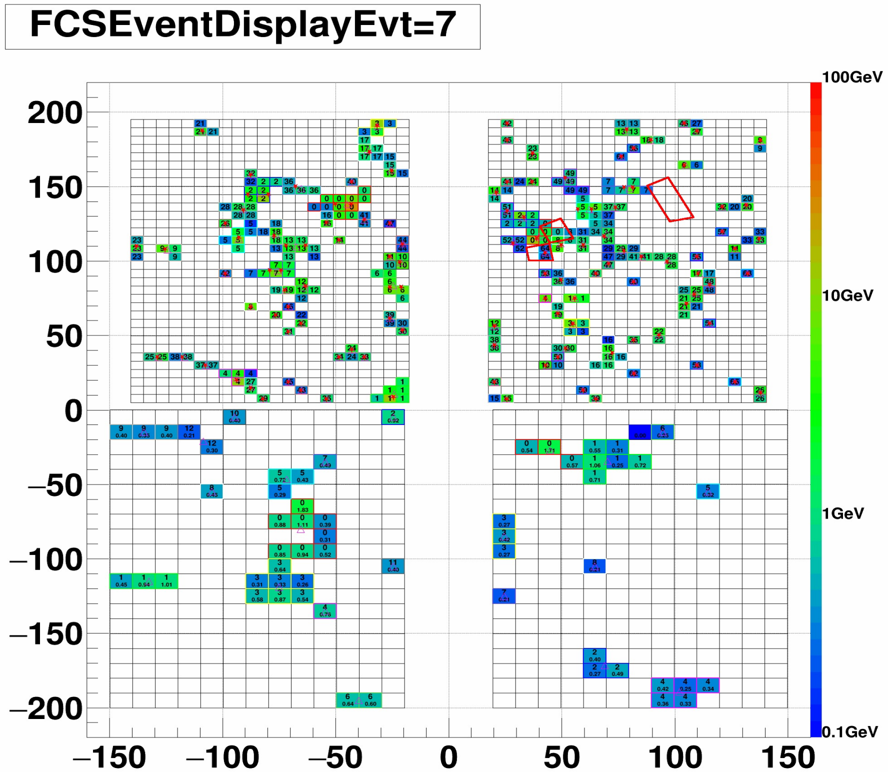
- We can see π^0 peak in the invariant mass plot for π^0 event with different energy.
- We can consider to apply π^0 reconstruction with O-O 200GeV, but require "turn off" ECal.
- Improvement: use K_s decay to analysis.



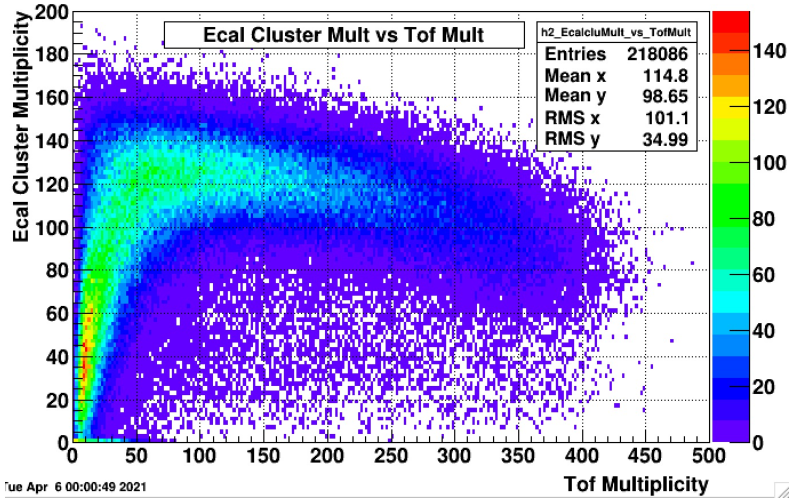


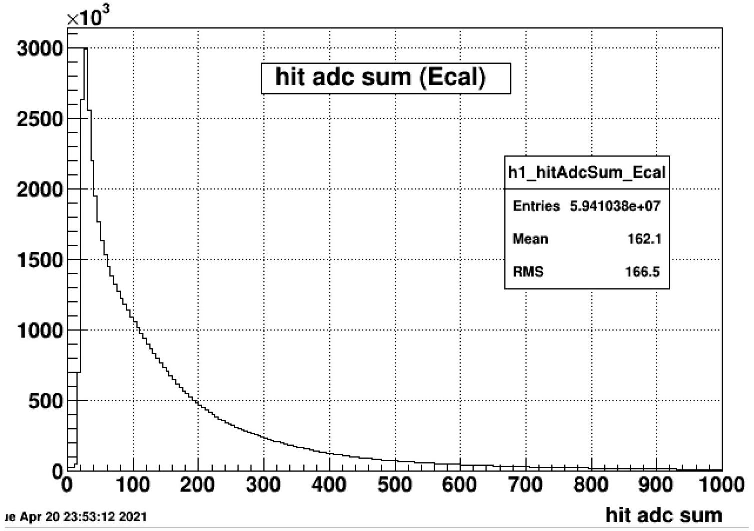
Task 2: run21 data analysis with FCS

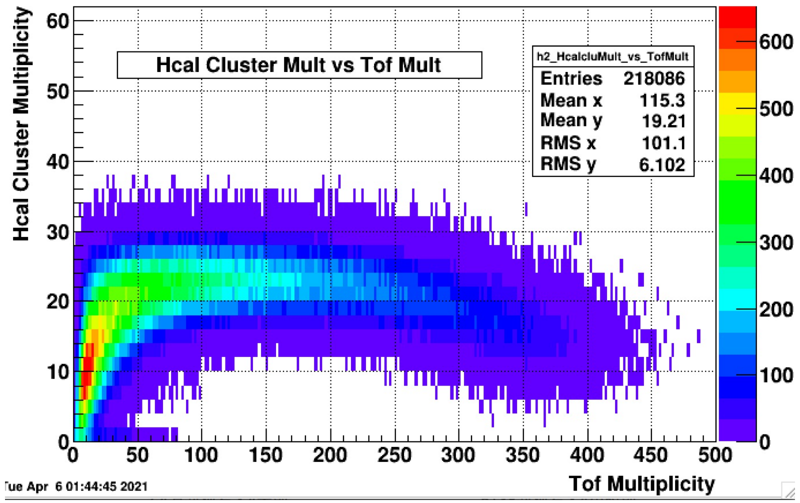
- Goal: check FCS ECal and HCal clusters in run21 data and consider to match with clusters in ECal and HCal.
- Datasets: run 22072045 , 22072046 , 22072051, 22072052 (AuAu 7.7 GeV, production_7p7GeV_2021)
  - Trigger : minbias-hlt150 (810023)
  - # of events: 218k
- Clusters are obtained by Akio's StFcsClusterMaker.

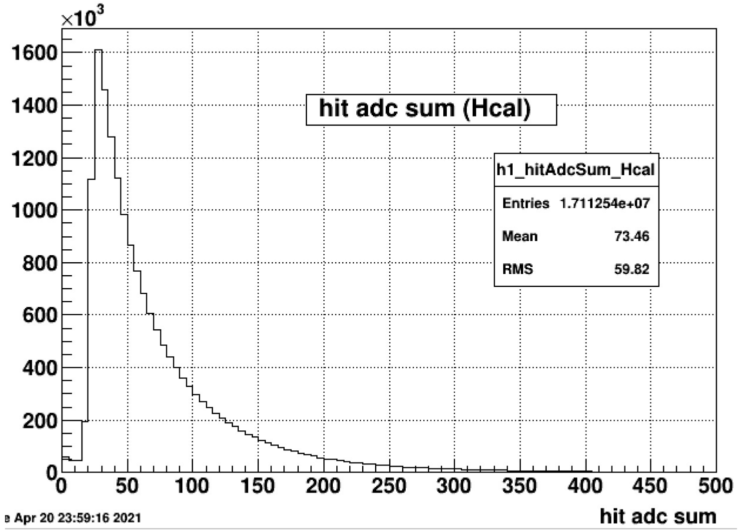


Hits and Clusters in ECal and HCal







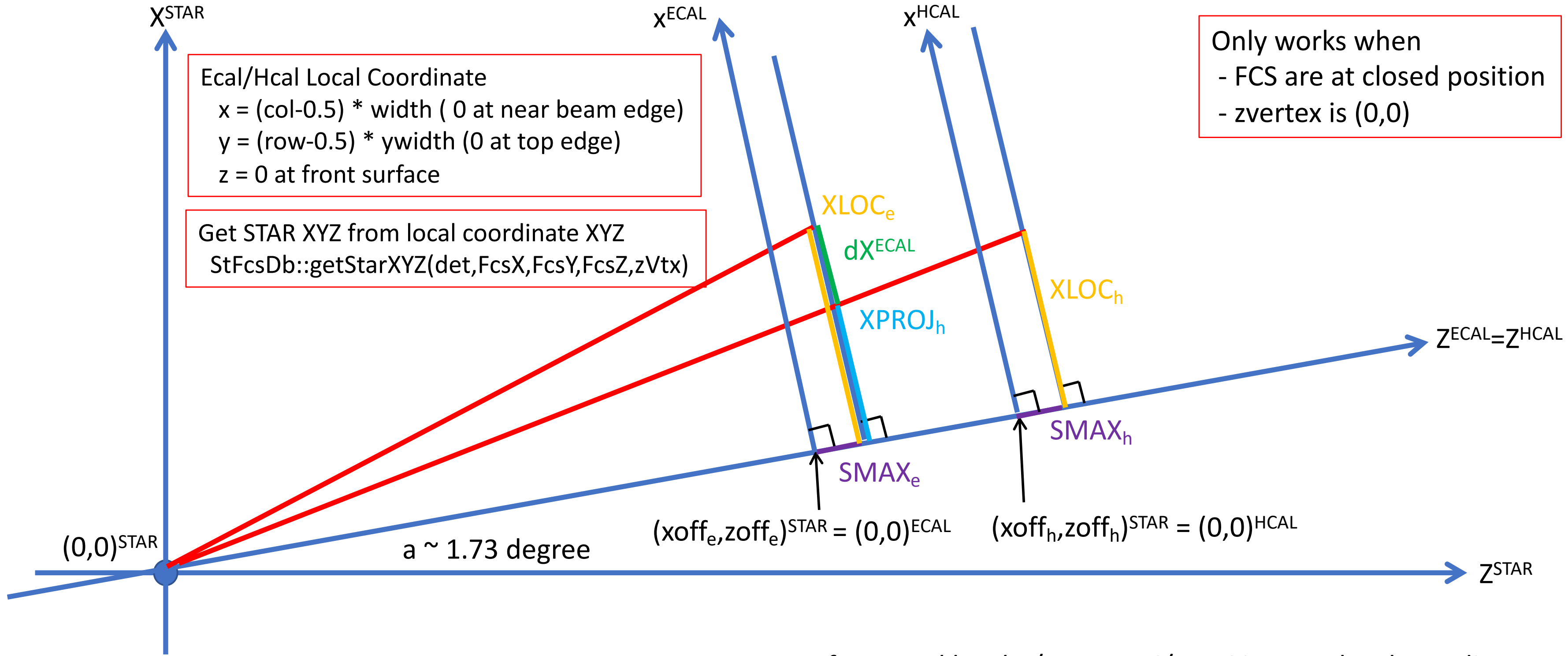


- Hit energy is related to ADC sum.
- Gain factor is not exactly determined for run21 data.
  - Currently based on previous study.
- Most hit (cluster) will be low energy.
  - MIP?

HCal cluster project to ECal

$$dR = \sqrt{(x_{Ecal} - x_{Proj})^2 + (y_{Ecal} - y_{Proj})^2}$$

- Based on Akio's DbMaker on HCal cluster project to ECal.

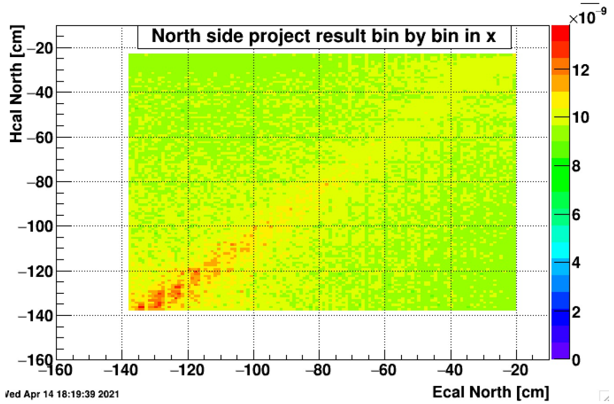


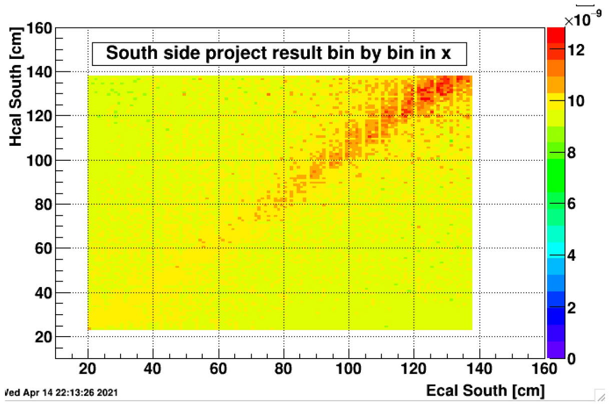
StFcsDb::getDetectorOffset() = XOFF/YOFF/ZOFF in STAR coord [cm]
StFcsDb::getShowerMaxZ() = SMAX depth (Ecal/Hcal local z) [cm]
StFcsCluster::x() [cell] * StFcsDb::getXWidth() [cm/cell] = XLOC [cm]
$D = \mathrm{sqrt}(XOFF^2 + ZOFF^2)$
$XPROJ_h = XLOC_h * (D_e + SMAX_e)/(D_h + SMAX_h)$
$dX^{ECAL} = XLOC_e - XPROJ_h$

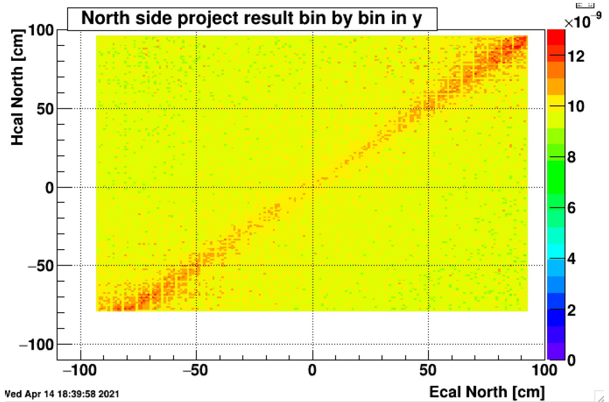
Get from Hcal local X/Y to Xproj/Yproj in ECAL local coordinate
StFcsDb::getHcalProjectedToEcalX(ns, hcallocalx,zvtx)
StFcsDb::getHcalProjectedToEcalY(ns, hcallocalx,zvtx)
Get dR (distance from Ecal cluster/point to Hcal cluster projected
StFcsDb::getHcalProjectedDistance(cluster_ecal, cluster_hcal)
StFcsDb::getHcalProjectedDistance(point_ecal, cluster_hcal)

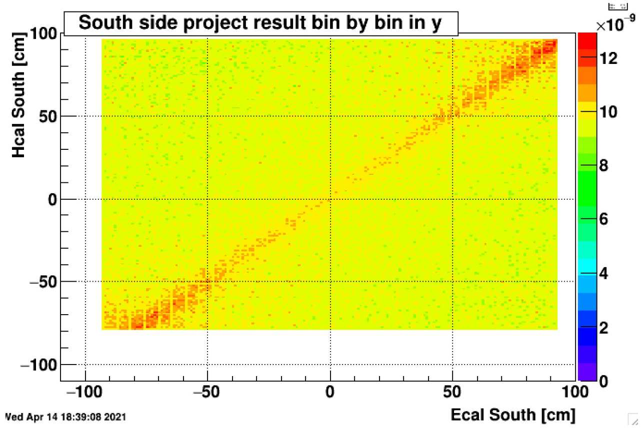
Match FCS ECal and HCal projected cluster

- Plot the distribution for all the combination of cluster in x (y) for HCal projected to ECal vs cluster in ECal first
- Project the plot in x axis (ECal) and in y axis (HCal projected to ECal) separately. (Separate south side and north side)
- Calculate ratio: $\frac{original[i,j]}{project\ to\ Ecal[i] * project\ to\ Hcal[j]}$
- So can see peak at:
- $x_{Ecal} = x_{Proj}$
- $y_{Ecal} = y_{Proj}$



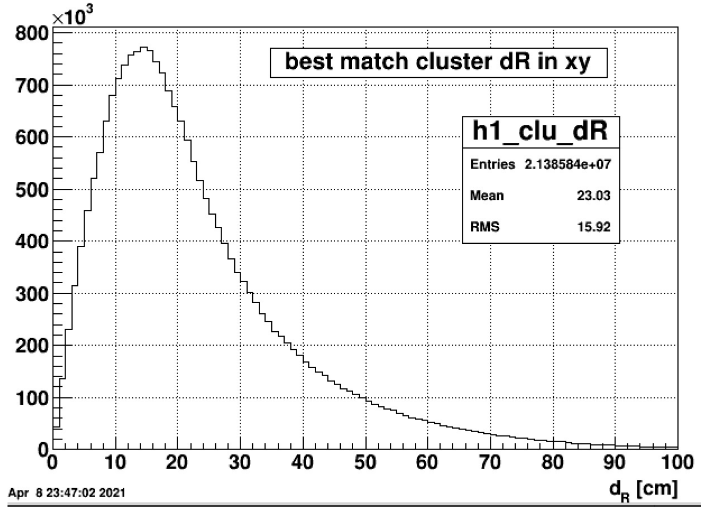






$$dR = \sqrt{(x_{Ecal} - x_{Proj})^2 + (y_{Ecal} - y_{Proj})^2}$$

For each ECal cluster, keep the min distance with HCal cluster projected to ECal. (in local XY)



Conclusion

- We can get hits and clusters from run21 data.
- HCal cluster project to ECal looks well. But might need to consider for improvement for clusters at detector edge.
- Next to do: based on dR, try on some cuts to look at cluster matching for MIP.

Update on Temp Gain Compensation Study

Navagyan Ghimire

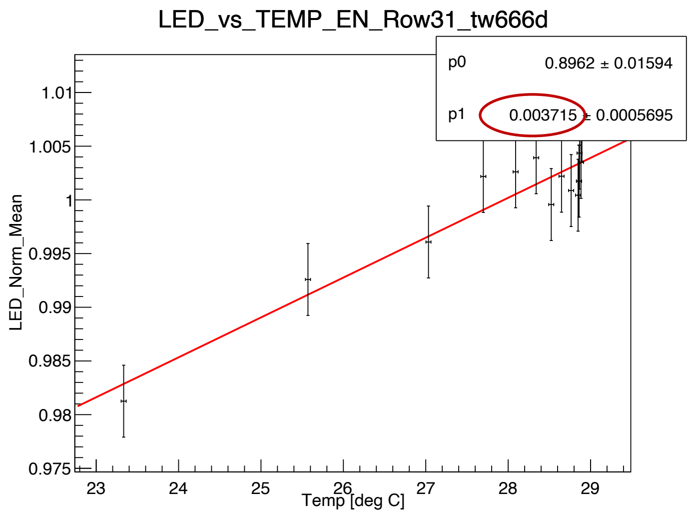
04/27/2021

April F2F Meeting

Temperature Gain Compensation Study:

Goal:

- **Study how the Gain of the FCS change with temp.**
- **Plot slope distribution of LED (normalized to mean) Vs Temp for each channel when temp is allowed to rise (by turning off fan) .**



$$LED_{Norm_{Mean(ch)}} = \frac{LED(ch)}{LED_{Mean}(ch)}$$

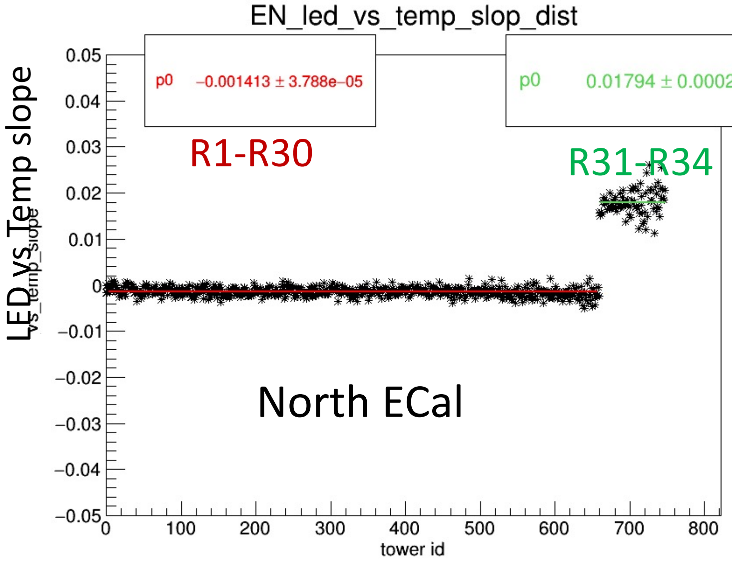
$$LED(ch)_{error} = \frac{\delta L}{LED_{Mean}(ch)}$$

$$Temp(ch)_{error} = \delta T$$

- **LED Runs 1106943-53 from 2021/2/17(stability test runs) is used to calculate Error in LED (δL) and Temp (δT).**

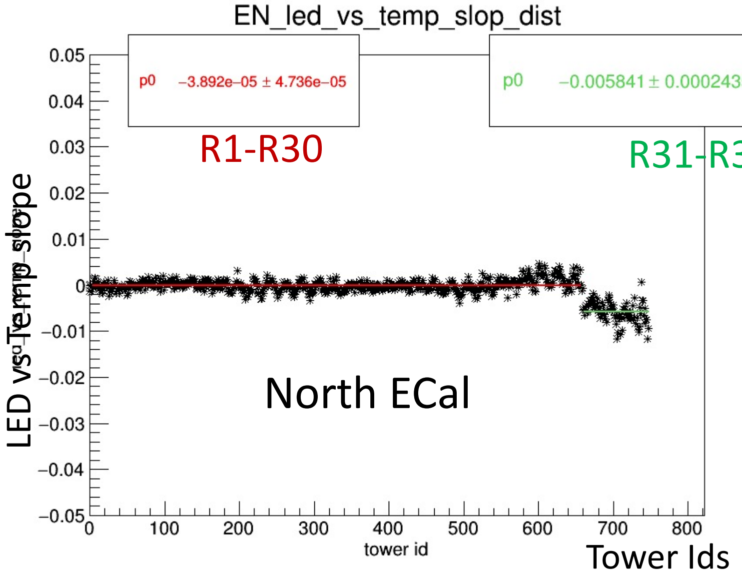
Temperature Gain Compensation Study:

Jan 28 LED Runs



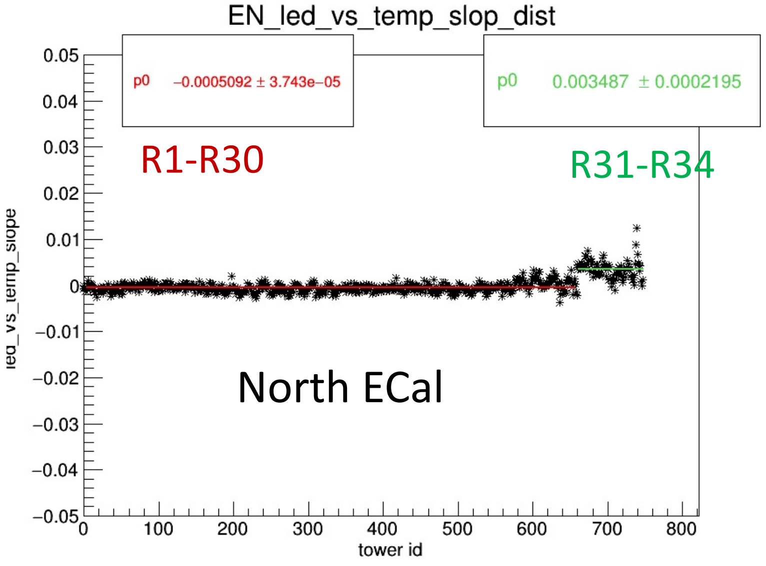
Runs= XX21-XX27
Vslope value = 63mV/C for all channels

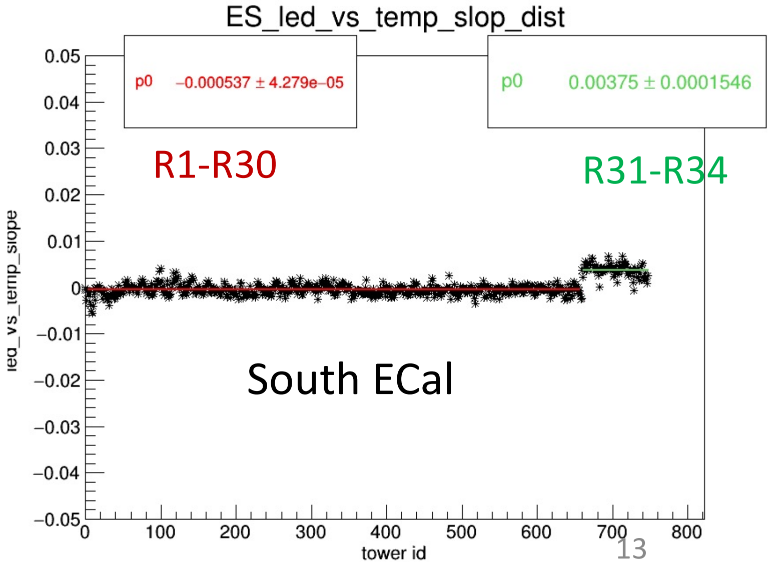
April 08 LED Runs



Runs= XX31-XX48
Vslope value = 63mV/C (R1-30)
Vslope value = 34mV/C (R31-34) recommended by HIMAMATSU

April 21 LED Runs





Runs=XX19-XX38
Vslope value = 63mV/C (R1-R30)
Vslope value = 41.10mV/C (R31-R34)based on April 08 result.

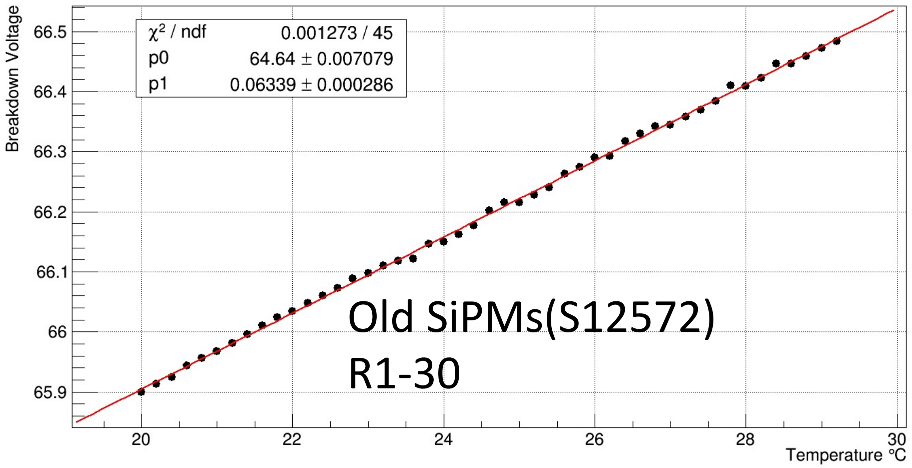
*Removed bad channels (twid 32,45,116,220,360,482,725,731)

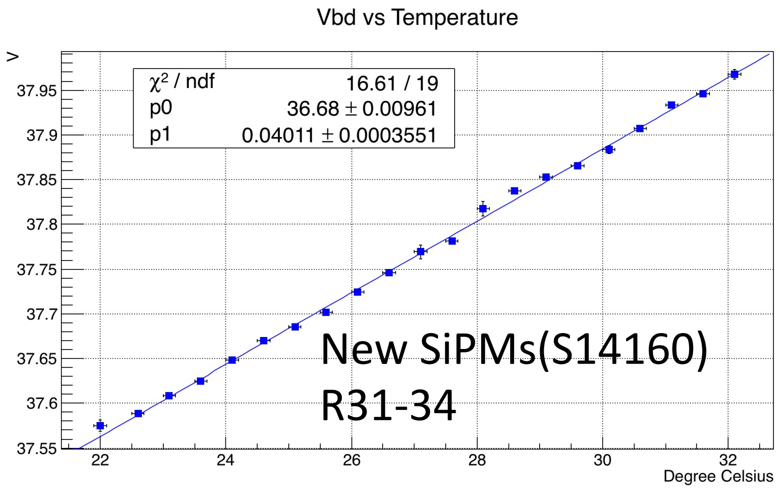
Conclusion:

- **Jan 28 data shows that channels from Row31-34 of Ecal should have different values of vslope as they uses different SiPMs.**
- **LED runs from April 08, 2021, with vslope value 34mV/C (recommended by HAMAMATSU) for Row31-34, shows slope distribution slightly over-shoot than zero.**
- **LED runs from April 21, 2021, bring slope distributions Row31-34 closer to zero. Still not perfect.**
- **Based on Vslope and p0 values from previous dataset and Oleg's Measurement, we should try with vslope 38mV/C for Row31-34.**

$$vslope = \frac{0.07667 * \$7}{4096}$$

$\$7 = 2030$ **(vslope daq value)**





Oleg's Measurement

Radiation Damage

Ananya Paul

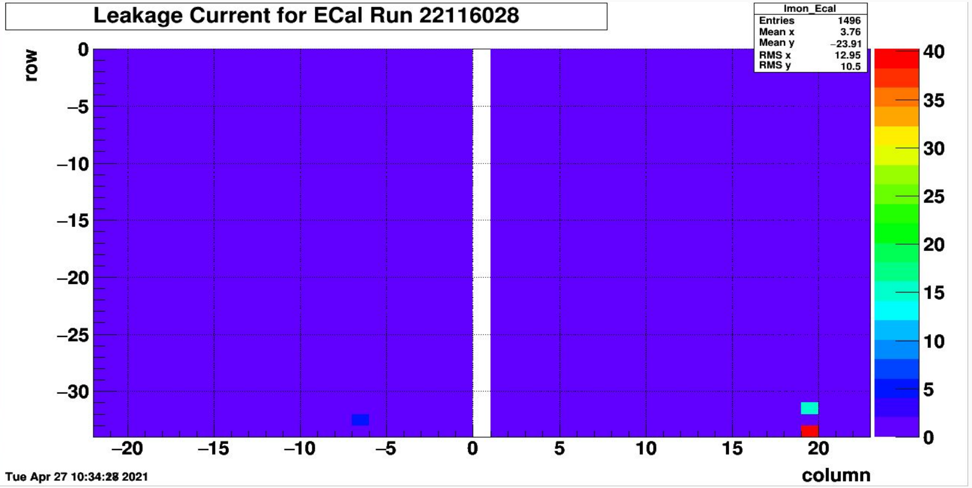
Goals

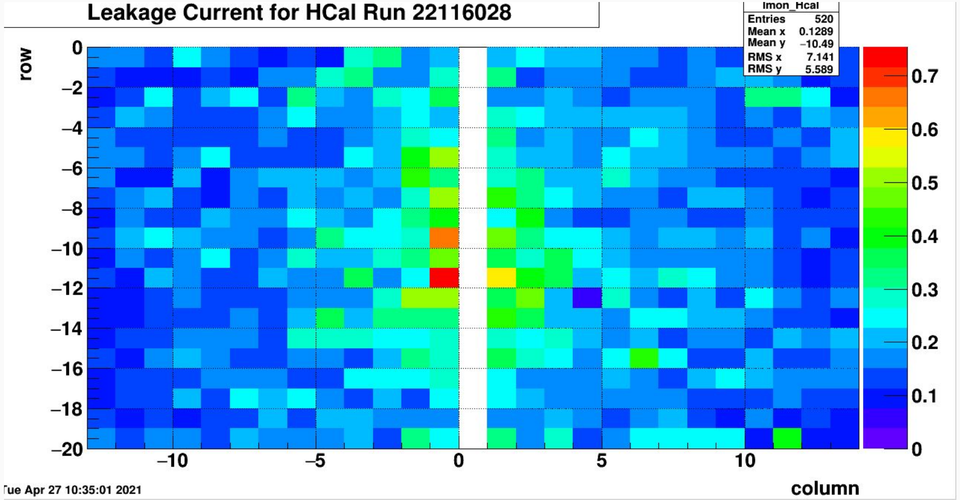
- Plotting the history of Leakage Current
- Monitoring radiation damage
- Making a webpage

Trigger: pedestal_rhicclock_clean

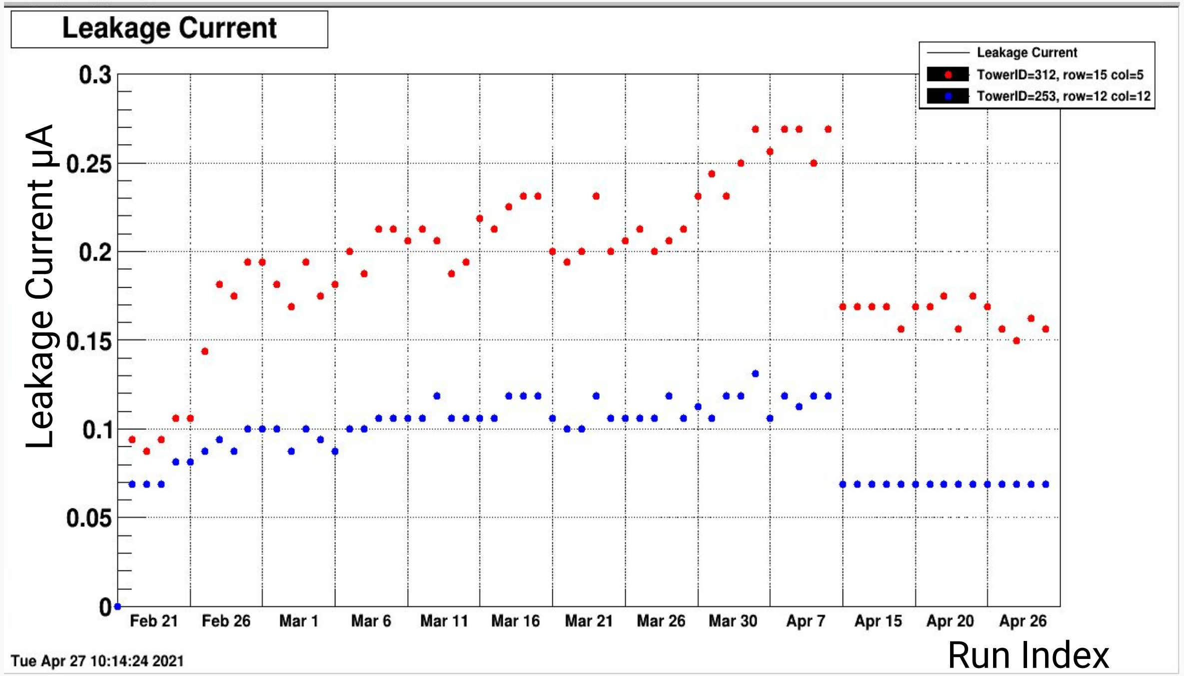
Runs: 22049019-22116028 (Feb 18 - Apr 26)

2D plot of Leakage Current for ECal and HCal

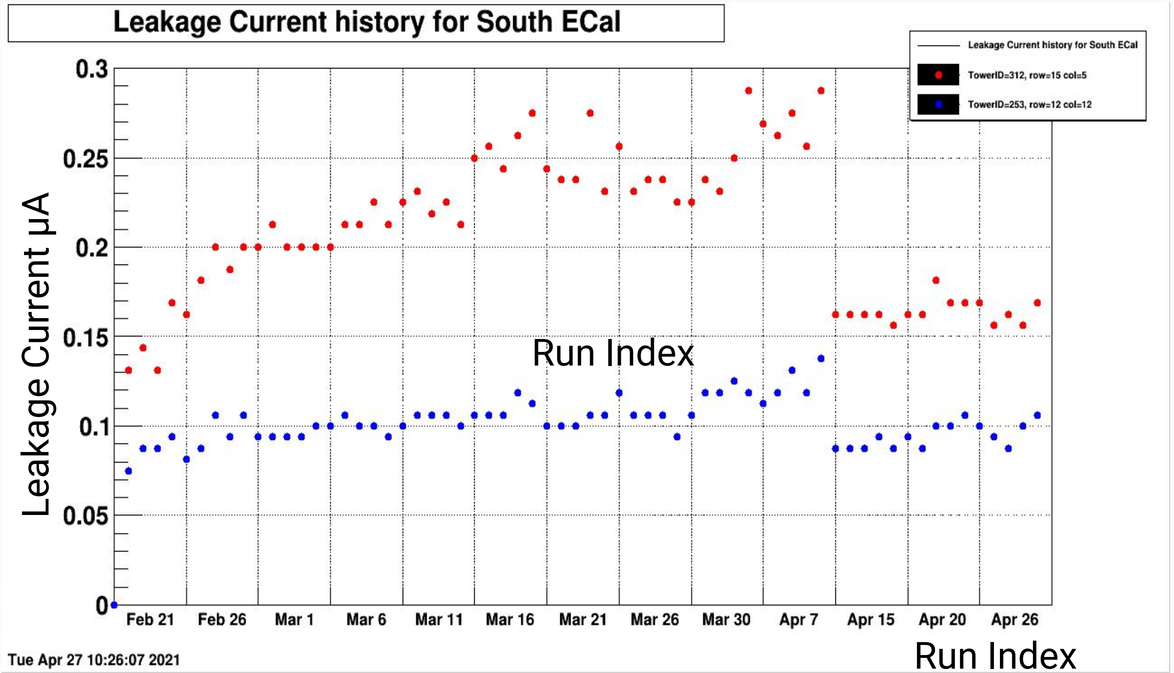




Leakage Current History for all pedestal runs for North ECal



Leakage Current History for all pedestal runs for North ECal



Waveform Fitting Study

David Kapukchyan

April 27, 2021

STAR forward upgrade F2F meeting

Goals and Status

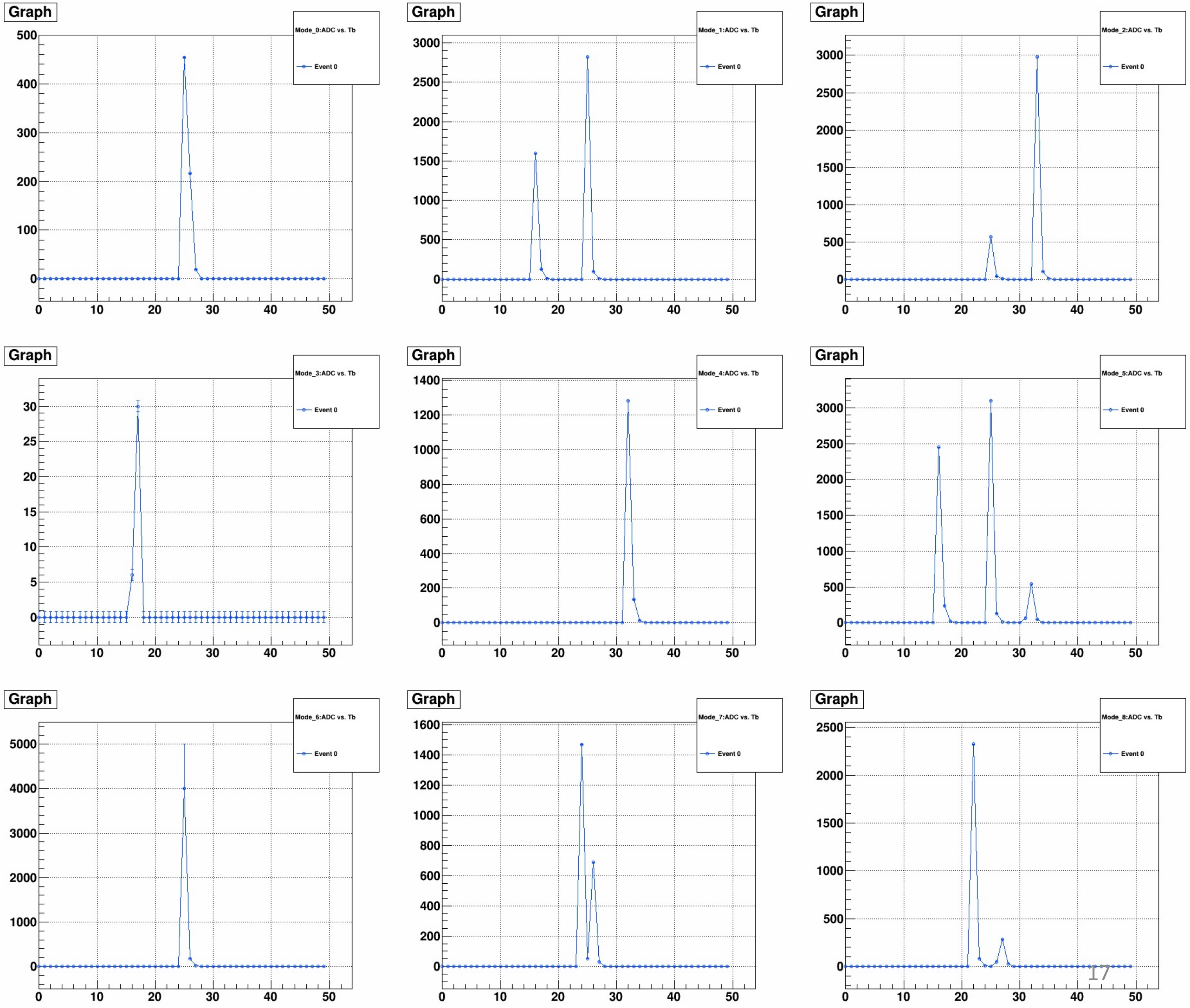
- ADC data from DEP boards are in timebins (tb) of ~12ns
- To get energy, we need to integrate ADC in the triggered crossing
- Fitting for every event for every channel may be too slow
  - One fit ~1ms so hundreds of channels ~1s per event, 1,000,000s -> 280 hours
- Use a peak simulator to test ADC integrate methods
  - Wrote a peak simulator StFcsPulseSim plus helper class StFcsDbPulse for constants and Akio's pulse shape function
  - Currently 5 summing methods are being explored excluding fitting
  - Final algorithm will determine which method to use by categorizing data
- Select best method to use for triggering

Pulse Sim Modes

- Pulse sim modes going left to right top to bottom

1. Single peak in triggered crossing
2. (1)+Peak in pre-crossing
3. (1)+Peak in post-crossing
4. Peak in pre-crossing
5. Peak in post-crossing
6. (1)+(4)+(5)
7. Peak saturates
8. Two peaks in same triggered crossing
9. Two peaks ~4tb apart in triggered crossing

- Parameters need tweeking

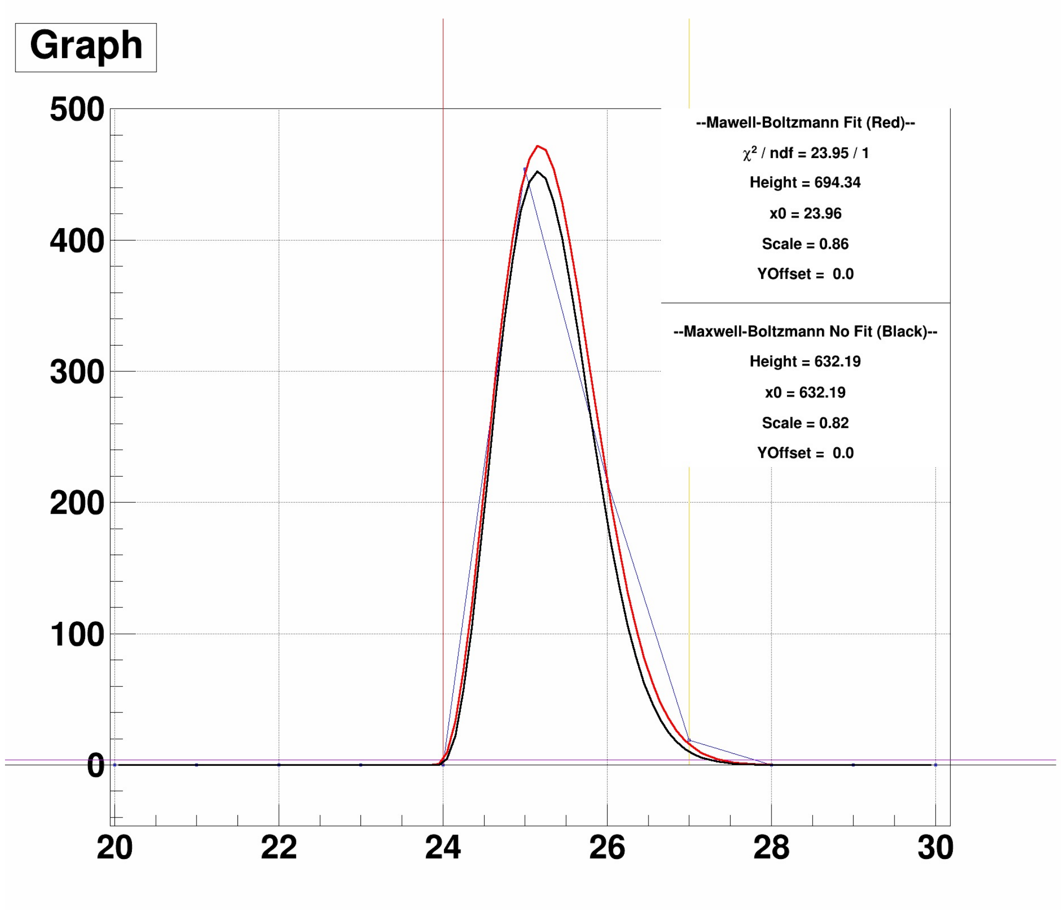


Summing Methods

- Sum 8: Sums 8 tb around triggered crossing (±4)
- Sum 16: Sums 16 tb around triggered crossing (±8)
- Hi: Sum based on value of highest ADC in triggered crossing
- Hi3: Sum highest ADC and ±1 tb around highest ADC
- Maxwell Boltzmann: Compute sum by estimating shape as Maxwell-Boltzmann distribution
  - $A * \sqrt{\frac{2}{\pi}} * \frac{(x-x_0)^2}{a^3} * e^{-\frac{(x-x_0)^2}{2a^2}} + y_0$
  - *A* is the amplitude and integral = $((y_h-y_0)*\text{sqrt}(\pi/2)*a*e)/2$, where e is the number and y_h is peak height
  - x_0 is the position peak starts to rise ("rise time")
  - *a* is the scale factor = $(x_h-x_0)/\text{sqrt}(2)$, where x_h is the peak location
  - y_0 is the y offset. Fixed to a pedestal or zero for ZS data

Maxwell-Boltzmann Approximation

- Shown on right is the result of my peak simulator and peak finder algorithm that determines the Maxwell-Boltzmann values
- As can be seen the determined values and fitted values are very close and both curves show a good approximation
- Both miss tail but can compensate



Finding Ecal MIPs: Run 19

- Data Cuts

Ecal	minbias data set
	Nearest Neighbors =0
	Towers per Cluster = 1
	Number of Hits < 50
Hcal	E_{Hcal} > 6 GeV

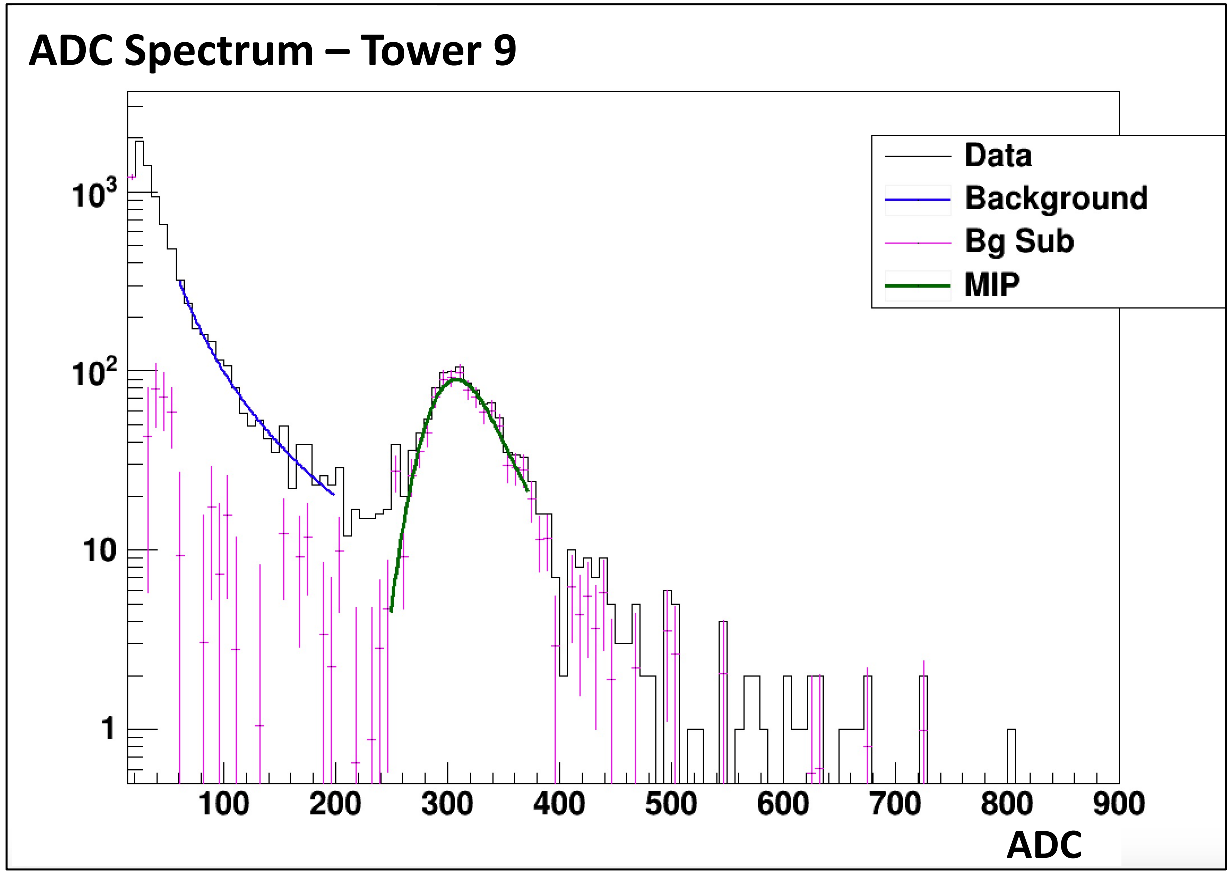
- Fit Data

Background	Ax^n	(EM shower)
'MIP' Convolution	Gaussian	(SiPM Response)
	Landau	(MIP)
Global Fit	Extracted from background & convolution	

- Background Subtraction

Subtract background fit from data

$$bgsub(x) = data(x) - bg(x)$$



Run 19
AuAu at $\sqrt{s}$= 200 GeV
1e8 events

Finding Ecal MIPs: Run 21

- MIPMaker updated to coincide with FCS Software review and software update.
  /StRoot/StSpinPool/StFcsMIPMaker

- Run 21 MIP Identification
  - Running over data provided by Xilin
    /gpfs01/star/subsysg/FPS/fcs2021/liangxl/

22055021	22072046
22066022	22072051
22066024	22072052
22072045	

<u>Triggers:</u> minbias // 810030
mb_epdcomponent // 810015

  - Trouble finding Hcal clusters

- Next Steps
  Determine isolation criteria for Run21 MIPs.
  Produce Run21 MIPs and determine if fitting parameters have also changed.
  Create How-To for other STAR users interested in running this MIPMaker.

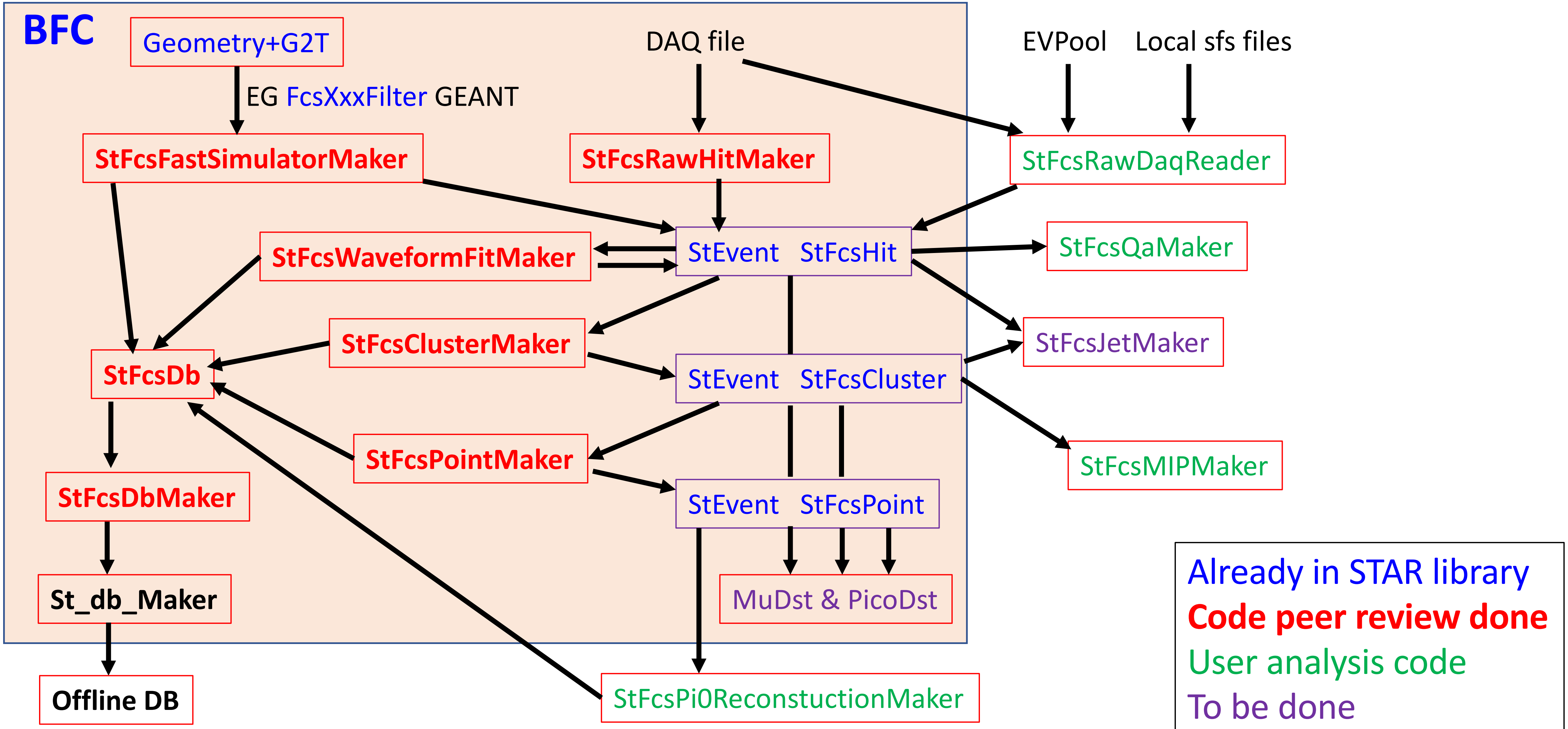
FCS in STAR software

My webpage https://www.star.bnl.gov/protected/spin/akio/fcs/index.html
How To https://www.star.bnl.gov/protected/spin/akio/fcs/index.html#howto

- Geometry xml (WcalGeo0.g, HcalGeo0.g, PlatGeo0.g)
- G2T
- StEvent (StFcsCollection, StFcsHit, StFcsCluster, StFcsPoint)
- **Offline Raw data reader (StFcsRawHitMaker)**
- **Fast Simulator (StFcsFastSimulatorMaker)**
- **Pulse Fitter (StFcsWaveformFitMaker)**
- **Cluster Finder (StFcsClusterMaker)**
- **Photon fitting (StFcsPointMaker)**
- **DB for constants/calibration/utilities (StFcsDbMaker and StFcsDb)**
- Pythia Filter for DY & Jet (FcsDYFilter, FCcsDYBGFilter, FcsJetFilter)
- New BFC chain options (StBFChain)
- Online Raw data reader (StRoot/StSpinPool/StFcsRawDaqReader)
- 2D Event Display (StFcsEventDisplay)
- Trigger Simulator & Bit checker (StFcsTriggerSimMaker)
- Online QA (StRoot/StSpinPool/StFcsQaMaker)
- Pi0 finder (StRoot/StSpinPool/StFcsPi0ReconstuctionMaker)
- MIP peak finder (StRoot/StSpinPool/StFcsMIPMaker)
- MuDst & PicoDst

Already in STAR library
STAR code peer review done
Analysis code
To be done

FCS in STAR Software Flaw Chart



Future Tasks

- uDST
  - What do we keep? What can we drop? ADC vs timebin? File size?
  - Re-create StEvent on memory for re-running analysis with newer calibration
- picoDST?
- Hcal Cluster finder
  - Currently Ecal algo with eye-tuned (100 event display) parameters
  - More systematic study & serious tuning are needed? Or adding a new algorithm?
  - Gean4star is available to use, in addition to GEANT3/Gstar
- Hcal cluster projection to Ecal plane
  - Simple version with zVtx=0 and Ecal/Hcal closed position working. More generic code needed?
- Ecal + Hcal correlation and adding Ecal + Hcal to get to hadron energy
- $K^0_{short} \rightarrow \pi^+ + \pi^-$ and other hadrons?
- MIP @ Ecal (2021)   Hannah have done for 2019, Maker in CVS
- MIP @ Hcal (2021 OO200)
- π^0 @ Ecal (2021)   Xilin have done for 2019, Maker in CVS
- π^0 @ Hcal (2021 OO200 Ecal open)
- FCS + Track correlation and association
- Jet at forward (FCS only, FCS+Tracking)
- More trigger algorithm optimization? Jet?