Calorimeter DQM

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Mu2e Italia
3 September 2020

Calorimeter DQM strategy

Several calo DQM processes, to be run both **online** (*otsdaq*) for a **real time monitoring** of the EMC performance and **offline** for **calibration**

1. **caloSpy** : ~ trigger independent
   - ✘ First DQM level running on raw data, at channel level
   - ✘ Monitoring of wf-baseline, noise level, occupancy, signal saturation, left/right wf_{max} ratio, noise-correlation, single channel spectra

2. **caloCosmics** : DQM for cosmics selected by the trigger
   - ✘ Higher level calo monitoring from digi, after cluster reconstruction
   - ✘ Monitoring of calorimeter illumination, energy response, timing…

3. **caloLaser** : DQM for laser triggered data while beam off
   - ✘ T_0 offsets and gains
   - ✘ Monitoring of energy/time intrinsic resolution, gain drift…
   - ✘ Outputs to be handled by EPICS for correlation studies (G vs T/beam) ?

caloSpy: online usage

1. Run inside the otsdaq framework on a subset of online raw data

2. Online calorimeter monitoring of single readout channels
   - ✘ automatic warnings if anomalous condition are detected
   - ✘ DQM histograms for Mu2e shifters
     - ➪ Histograms displayed through ots visualizer

3. Running on random trigger special runs before physics running to provide, if needed:
   - ✘ pedestals for zero suppression
   - ✘ channel thresholds
   - ✘ dead/hot mask

   ➪ Store this information in the online DB (or temporary ASCII → DB) for subsequent data taking

caloSpy: offline usage

1. Run in the offline framework on larger data sample before data reconstruction

2. Offline evaluation of:
   - ✘ residual pedestal offset
   - ✘ thresholds
   - ✘ + check of dead/hot masking

   to be upload in Condition DB and used for data reconstruction

3. Histogram output, to be displayed in an offline framework

caloSpy on DAQ machines

Current version of caloSpy on DAQ machines:

✗ DAQ fragments produced through the ots State Machine starting from MDC 2018 generated events and saved on disk

✗ DQM caloSpy module launched from terminal through a fcl file

✗ Histograms displayed through the ots Visualizer

Next steps:

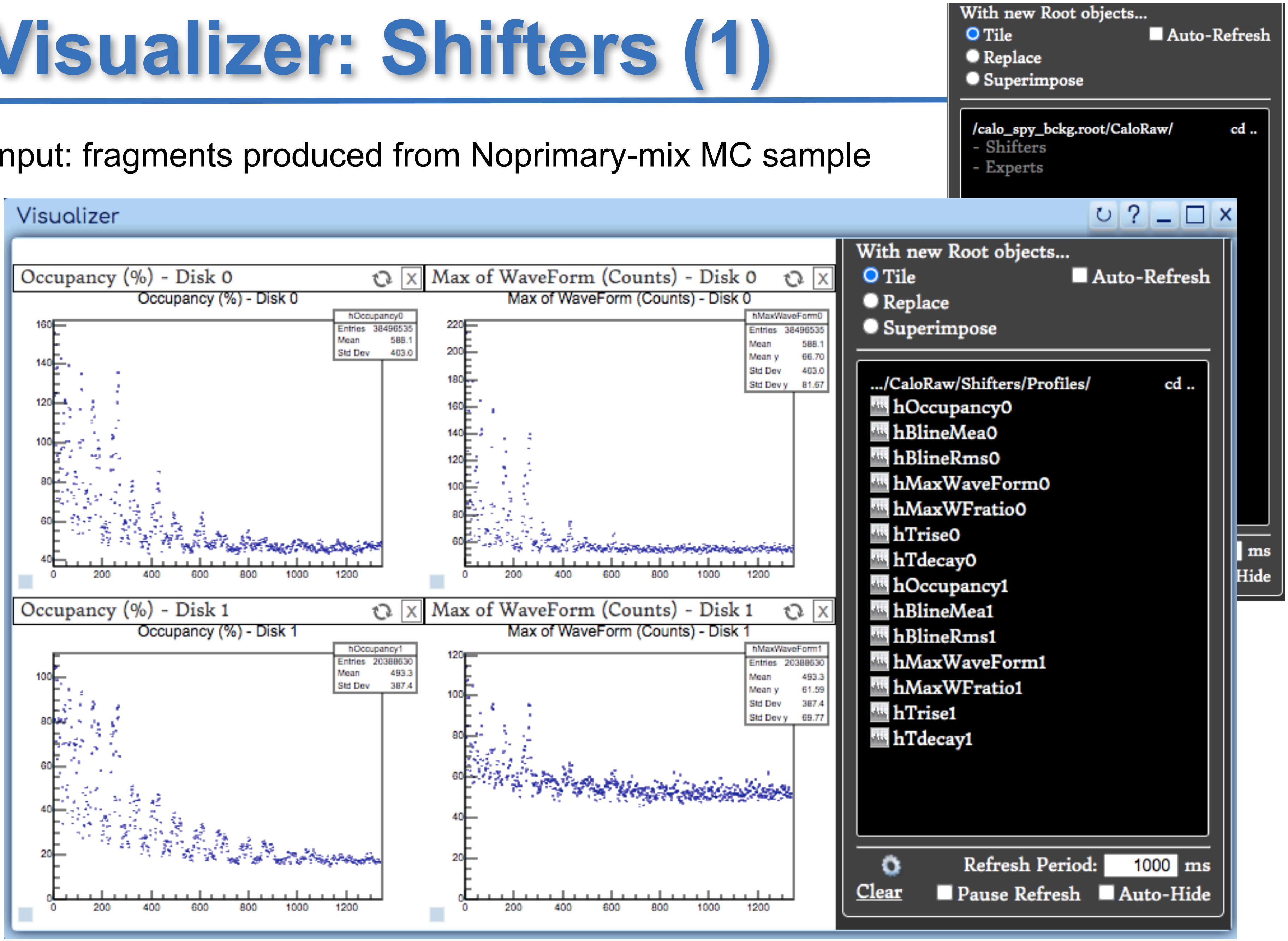
➢ Running of DQM modules inside ots

➢ Calorimeter DMAP implementation

- Waiting finalized calorimeter data packets format for digitizer

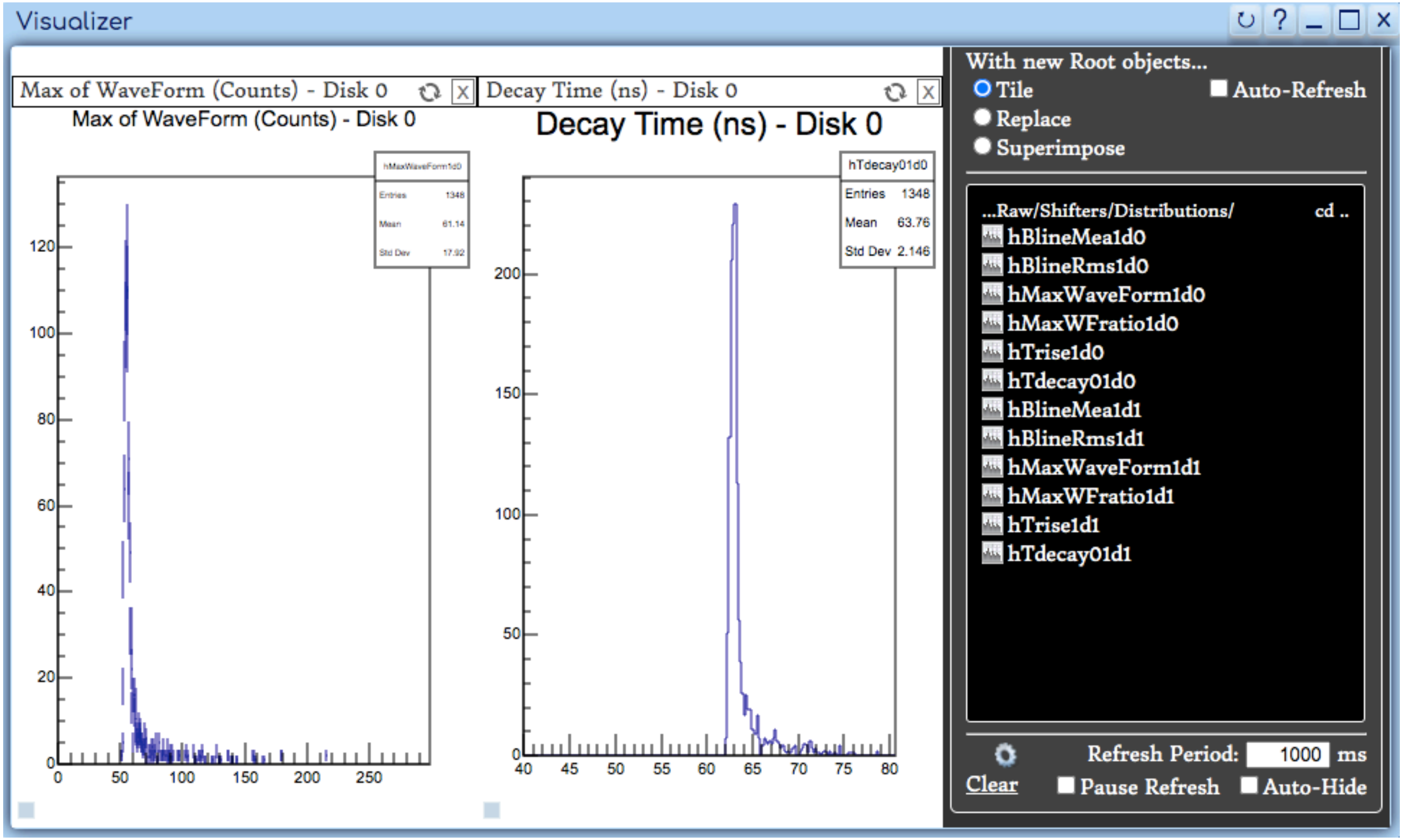
Visualizer: Shifters (1)

Input: fragments produced from Noprimary-mix MC sample



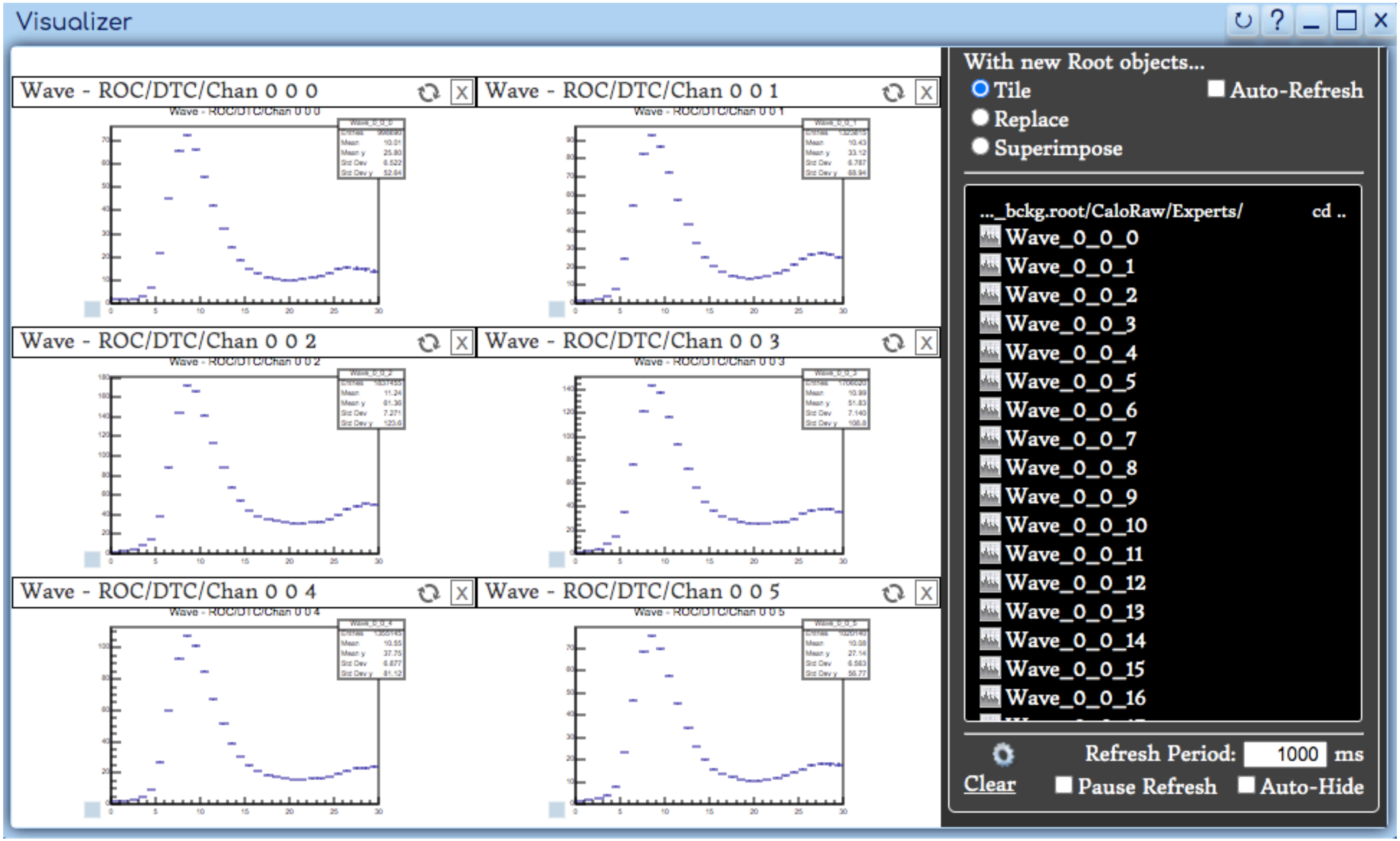
Visualizer: Shifters (2)

Input: fragments produced from Noprimary-mix MC sample



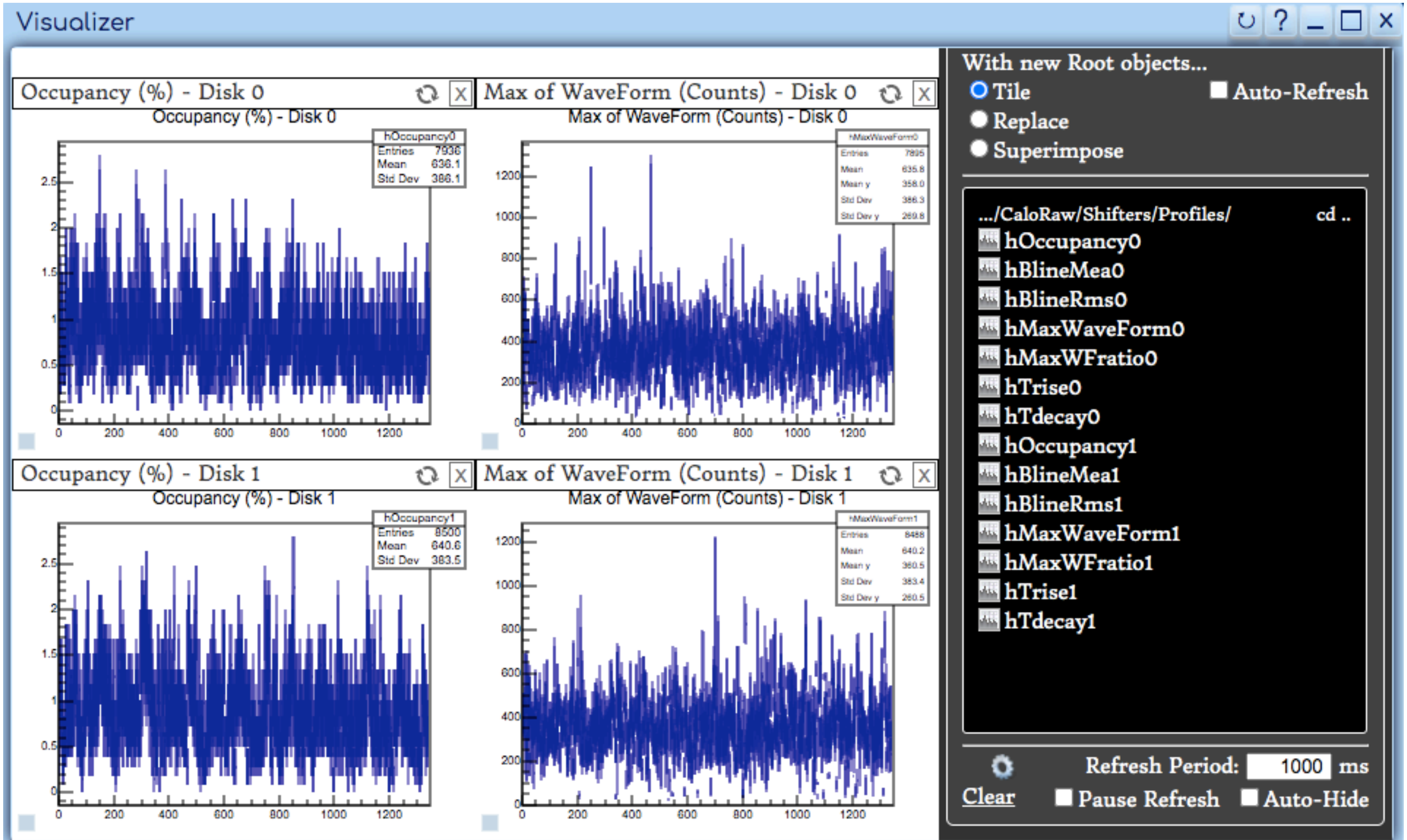
Visualizer: Experts

Input: fragments produced from Noprimary-mix MC sample



Visualizer: cosmics

Input: fragments produced from cosmics MC sample

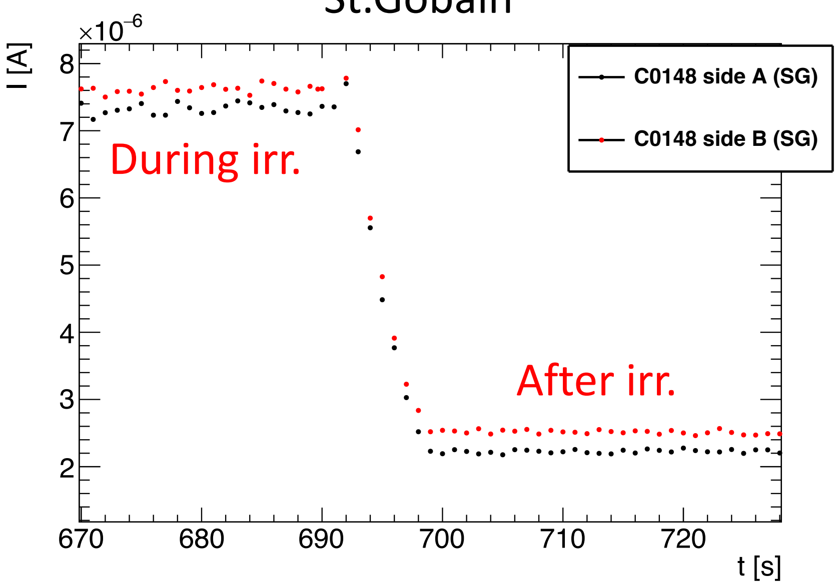


caloPED: SiPM baseline

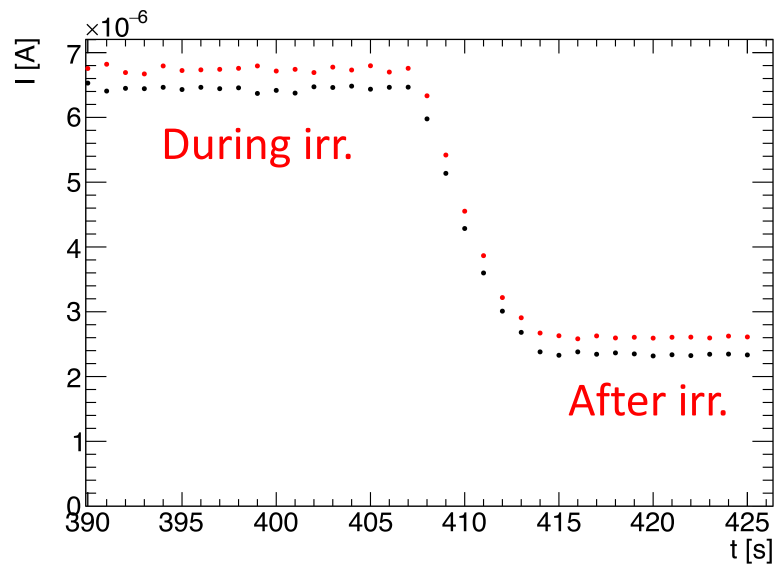
Besides monitoring the calorimeter at readout level, we propose to use calorimeter fragments to evaluated the SiPM baseline during data taking

- ✗ This allows to include the Radiation Induced Noise (from 150 to 400-500 keV) due to induced fluorescence when the beam is on
- ✗ RIN effects visible within ~ 5 seconds
- ✗ Baseline evaluation within 1 sec after beam is off provides mean value within 5-10% w.r.t. the nominal value

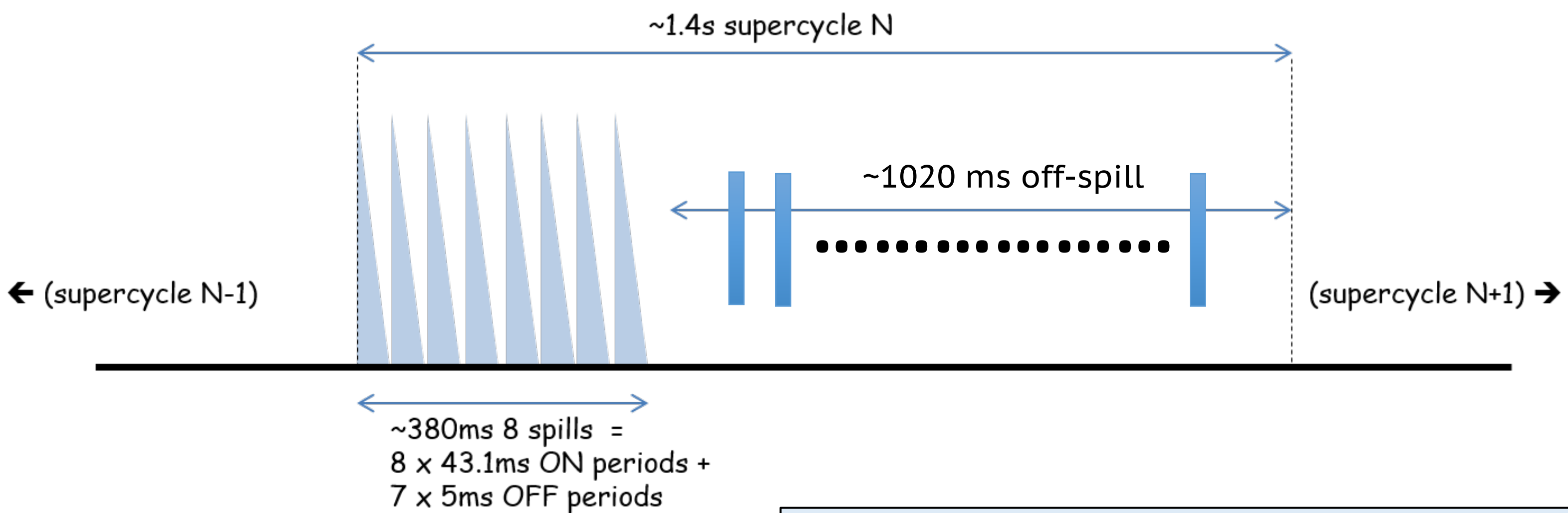
St.Gobain



SICCAS



caloPED: running mode



Event-MODE proposed:

1. Event Window Type = BASELINE
2. Beam Time = off-Spill
3. ROC-action : NO zero-suppression

- Blue blocks, 100 random events for Noise Run
- Off-spill event window, 100 μsec
- Baseline data: 1 μsec NOT-Suppressed
- 1 sec running = 100 on-spill events not suppressed
- 100 evts x 200 samples x 2796 ch x 2 Bytes = 120 MB

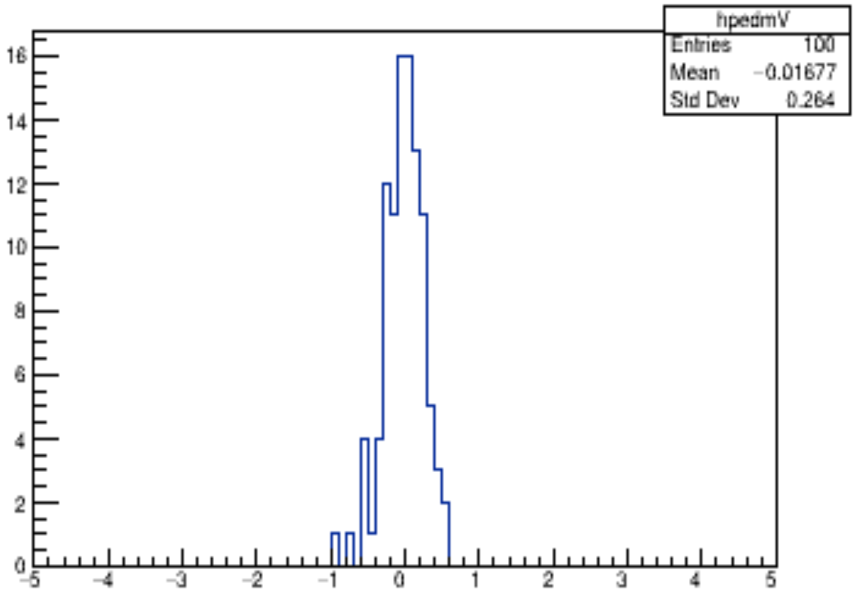
✗ **caloPED will determine baseline average and RMS** only before starting a long run i.e. as soon as beam is established

✗ Time needed: 1 sec data taking + few secs of calculation

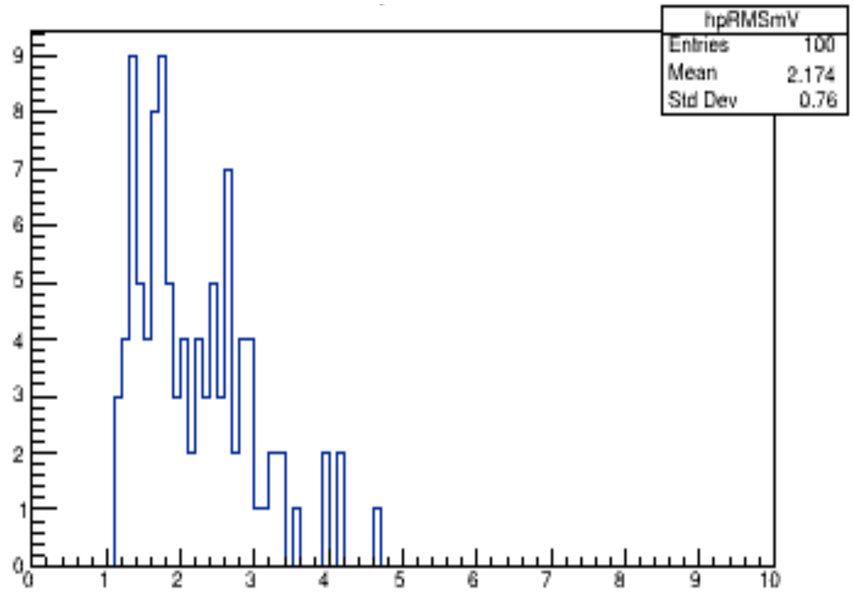
✗ Prepare table to be loaded inside DIRACs for setting average baseline and thresholds for zero-suppression

caloPED: baseline evaluation

Baseline evaluated with 100 cosmic ray events acquired with Module 0, on first 50 bins (200 ns)



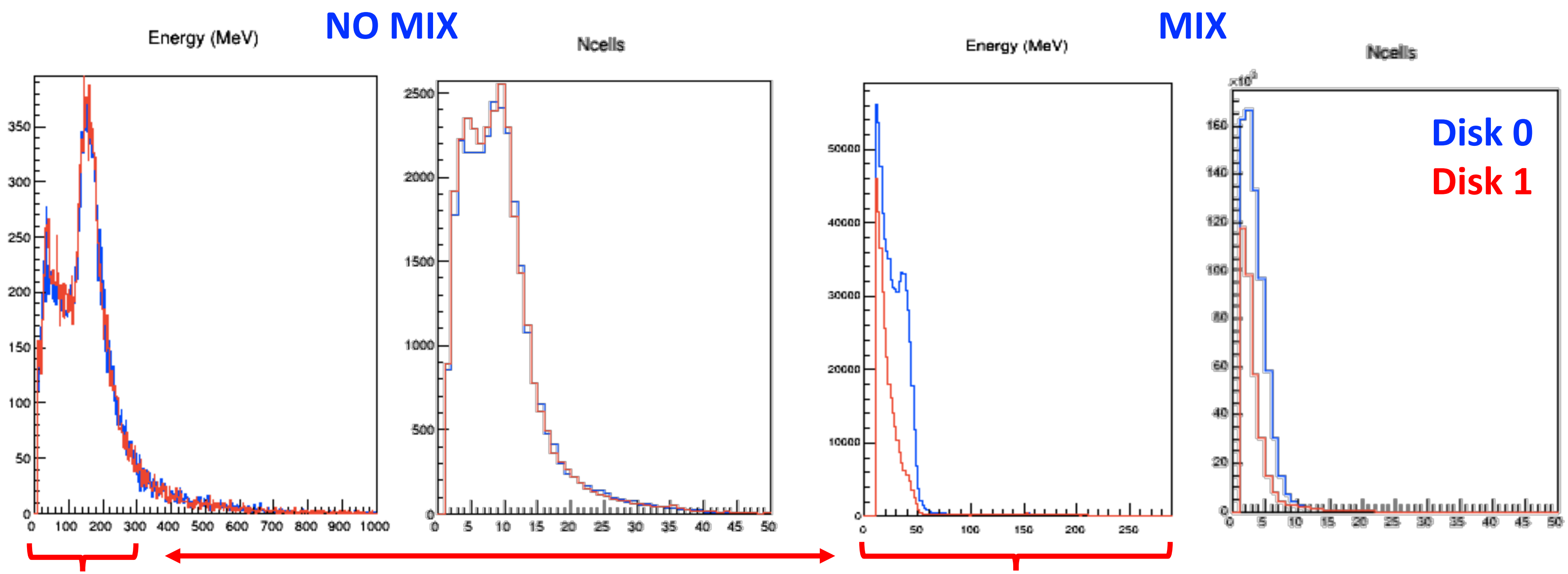
Baseline (mV)



RMS (mV)

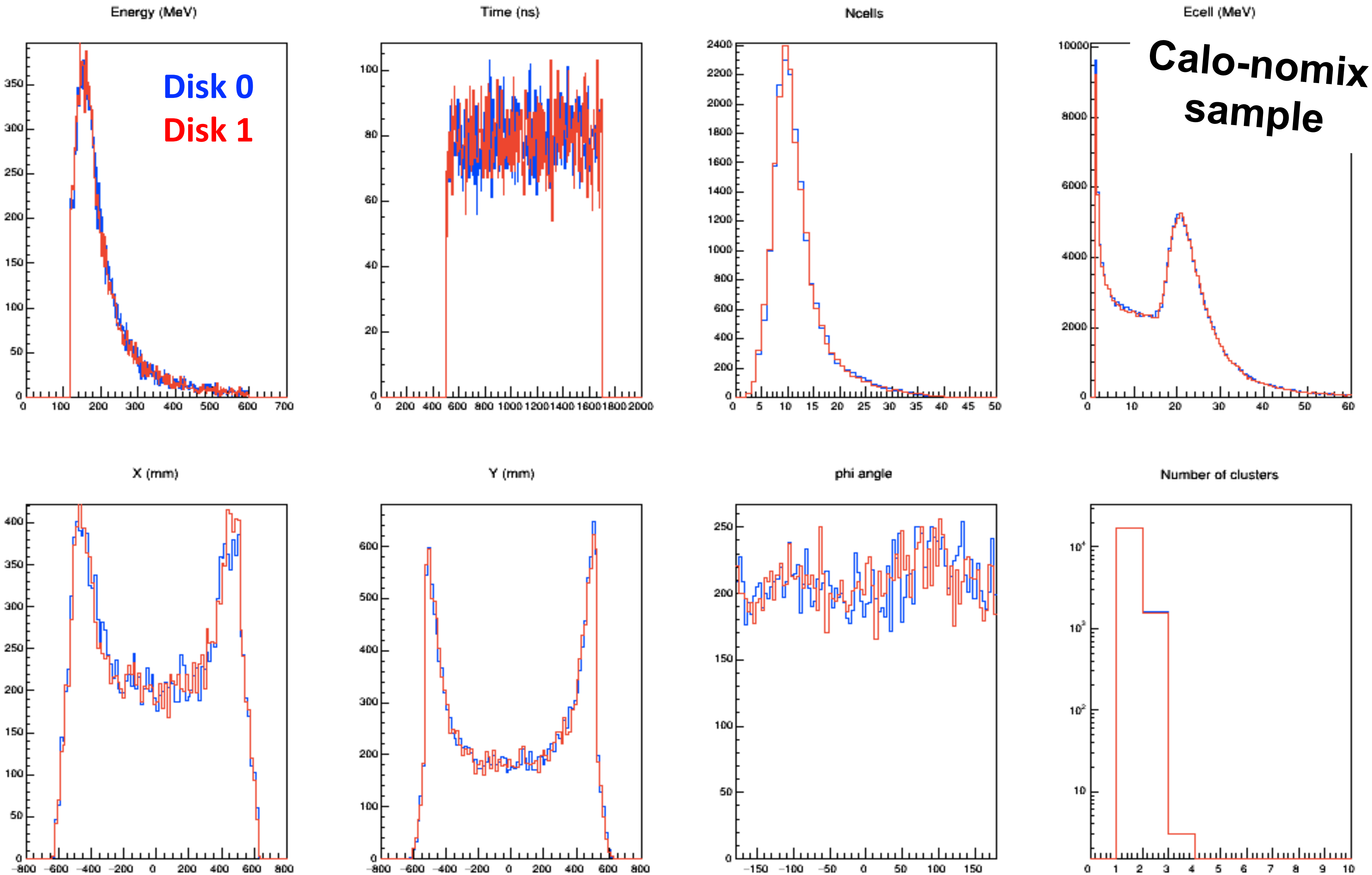
caloCosmics: event selection

Calorimeter cosmics selection studied on 50 kevts of cosmic ray events, both w/ and w/o mix:

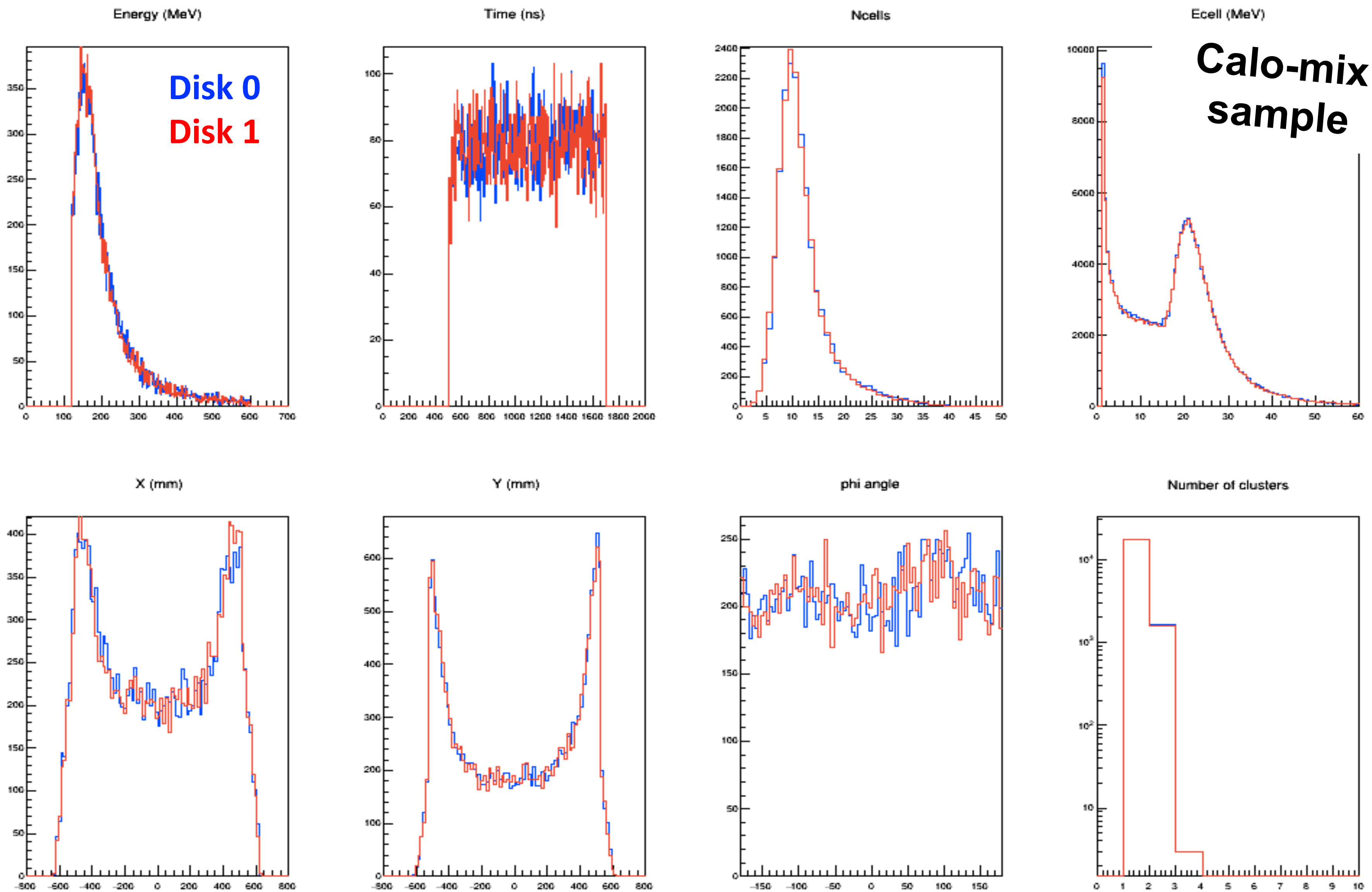


The requirement **120<Eclu<600 MeV** is sufficient to select a clean CR sample for monitoring purposes, to be downscaled to a proper fraction

caloCosmics: summary histos

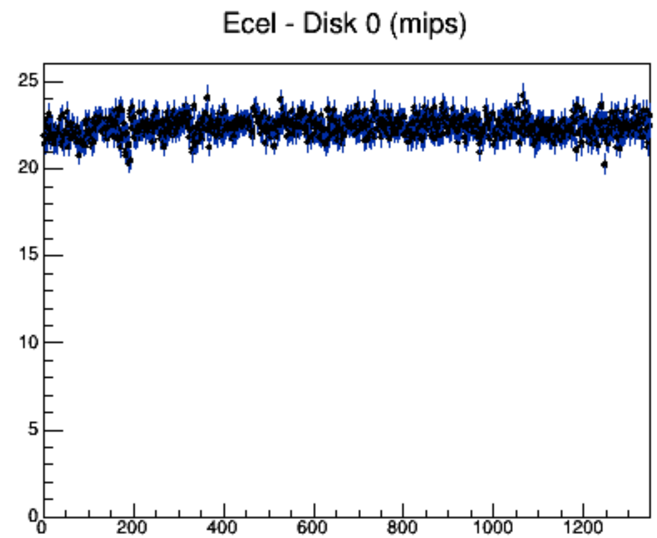


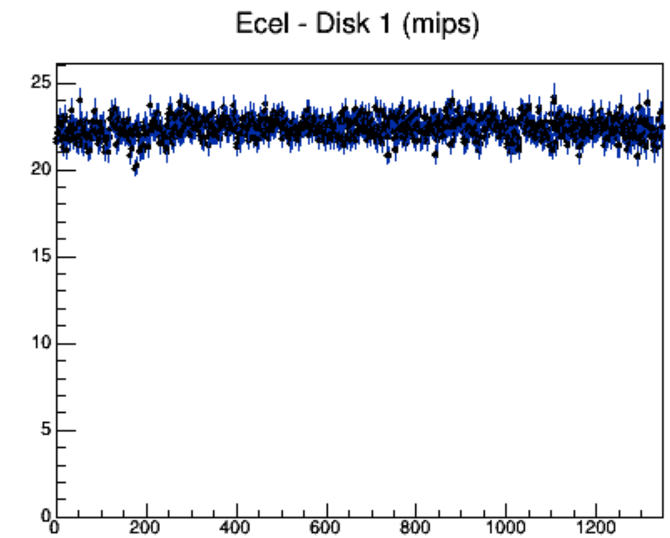
caloCosmics: summary histos



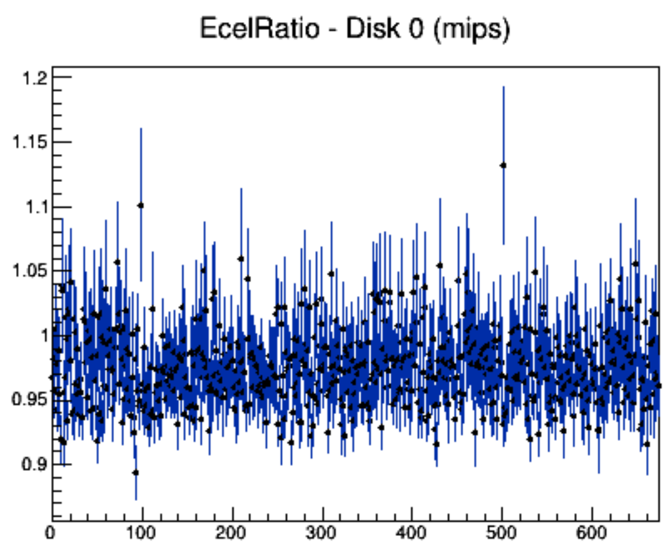
caloCosmics: cell energy

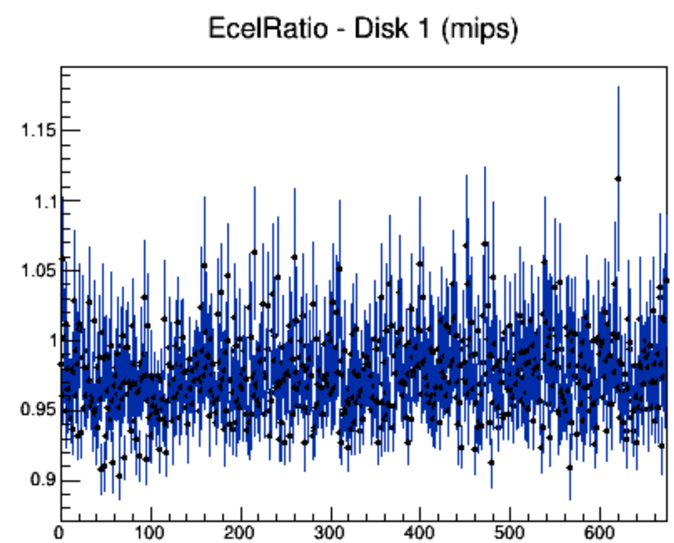
Single readout channels





SiPM0/SiPM1

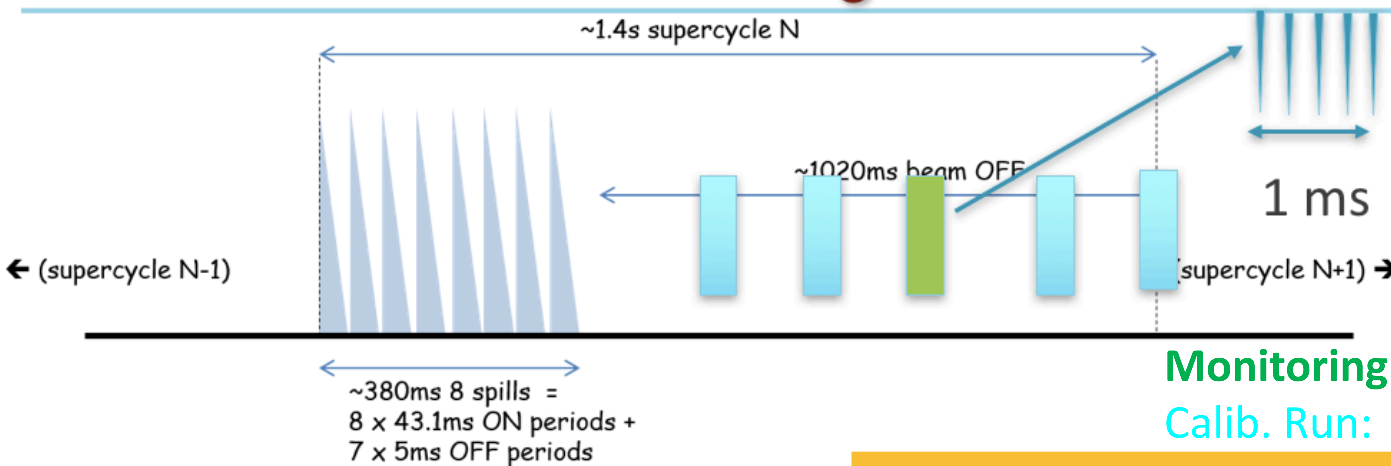




caloLaser

Calorimeter LASER running

Mu2e-doc-33776



Monitoring: beam ON, off-spill, 4 Hz

Calib. Run: beam OFF (~weekly)

- Blue blocks, 5-10 bursts for **Calibration Run**
- Green block, 1 burst for **Monitoring run**
- 1 burst = 5 laser pulses

- **Event-MODE proposed :**
  1. Event Window Type = INJECTION
  2. Beam Time = OFF-Spill
  3. ROC-action : zero-suppression enabled
  4. Fire LASER and read Laser in the same 100 usec window. (+20 usec delay)

For running, the CFO will execute the run-plan programmed generating a CFO HB at proper times in order to:

- Request 5 event windows fired/spill in the normal run. Minimum distance
- Request 25-50 event windows fired/sec in the calibration run

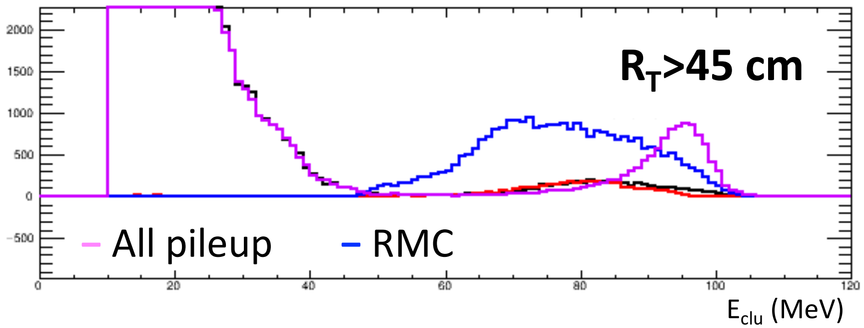
The TTL signal will be generated by a modified HB with Event Mode =INJECTION

- In this way during normal **Monitoring Running** we will have around 5/1.4 sec = 4 Hz laser pulses
- Precision of each pulse in charge is better than 3%
- Precision per 1' running i.e. 240 events << 1% in charge
- 500 ps resolution for timing ➔ T0 better than 50 ps

Higher DQM level: RMCMON

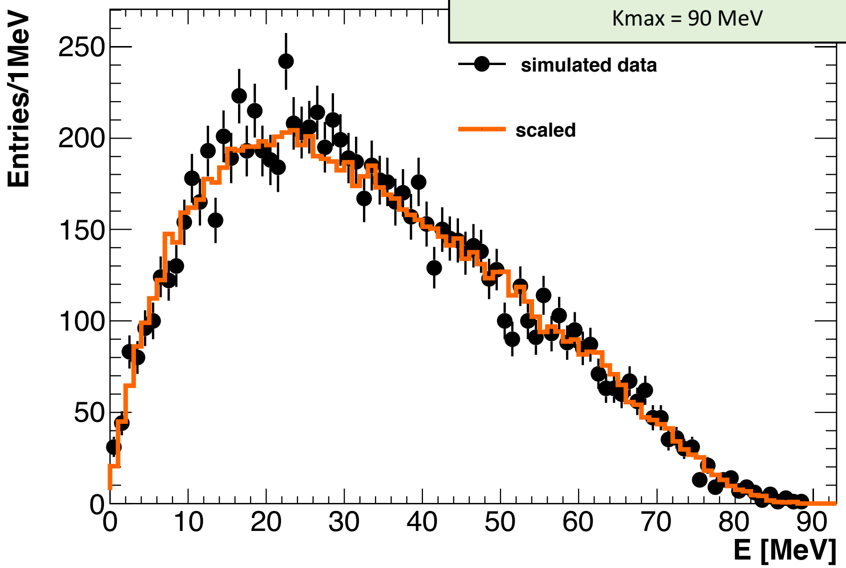
Mu2e-doc-23953

MDC 2018 - flatmugamma
+ pile-up clusters



No pileup events for E_{clu}>57 MeV

Expected RMC spectrum
Kmax = 90 MeV



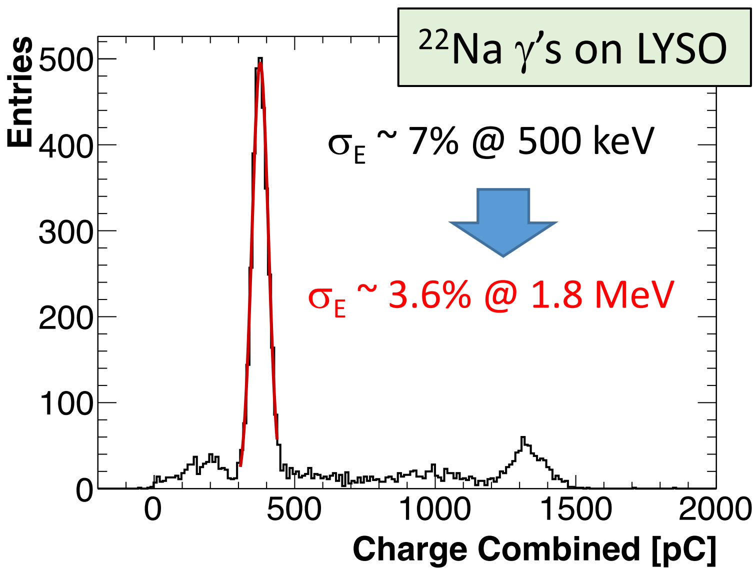
- ✘ It is a monitoring based on calorimeter cluster reconstruction at higher radius
- ✘ Rate of RMC photons in calorimeter with E_{clu}>57 MeV, R_T>45 cm is of ~ 6 E-3 /pulse
- ✘ Even assuming a factor 200 for trigger reduction, the rate of photons readout in pileup with any standard trigger will be high enough (15 events/spill) to determine spectrum and calorimeter end-point with precision each few hours

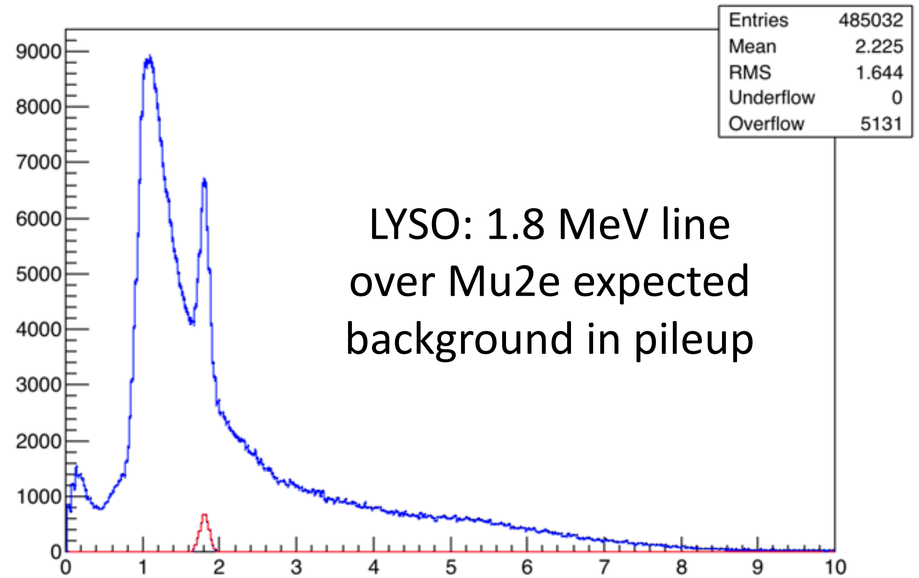
- **ONLINE:** monitoring of very high quality cluster spectrum (different R_T, time cuts)
- **OFFLINE:** ➪ same cluster spectra as in the online DQM
  ➪ Radiative Muon Capture rate, to be monitored vs time

Higher DQM level: HPCMON

Mu2e-doc-31324

- ✘ Basic idea: **monitor Muon Capture** by adding 2 (4) HPCr (High Precision Crystal), either LYSO or LaBr, inside the Mu2e calorimeter and read them out with Mu2e SIPMs
- ✘ Dimension limited to $34\times34\times200$ mm^2 ➪ LYSO/LaBr size: $30\times30\times130/75$ mm^3
- ✘ LYSO crystals will be used in the first phase
  - ➪ It requires to read out as fast stream these 2 (4) crystals for each pulse
  - ➪ HPCr rate very high ~ 0.02/pulse (to be better confirmed by acceptance study)





- **ONLINE:** very fast DQM monitoring of muon capture through HPCr spectra
- **OFFLINE:** ➪ same HPCr spectra as in the online DQM
  ➪ Muon Capture rate (monitor rate vs time, compare with STM measurement)

Conclusions

- ✗ Calorimeter DQM strategy well defined
- ✗ First version of raw data DQM (caloSpy) running on the online machines:
  - histogram definition/organization well advanced
  - histograms produced on disk and displayed through Visualizer
  - work in progress to implement it inside otsdaq
- ✗ Strategy to evaluate SiPM baseline during data taking outlined
- ✗ Second DQM level tools (caloCosmics/caloLaser) in progress
- ✗ Further higher level calorimeter DQM with beam-on events
- ✗ Goal: **caloSpy/caloCosmics/caloLaser ready for calo testing with Module 0**