FLE thresholds calibration.

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FLE threshold calibration procedure

- FLE (Fast shaper Low Energy) discriminators are used to form the CAL_LO trigger signal
- To calibrate the FLE discriminator threshold we need to know its output signal
- It is possible by using diagnostic information read out from the front end electronics
  - But this diagnostic information contains only one bit per calorimeter layer (“OR” of output signals from 12 FLE discriminators)
- There are 2 possibilities to solve this problem:
  - Enable FLE discriminator for only one crystal per layer
    • Used in charge injection calibration
  - Enable several crystals per layer, but use the measured signal from slow shaper to figure out which FLE discriminator was fired
    • Used in muon calibration
Trigger configurations

- **We shouldn’t enable the adjacent crystals**
  - To measure thresholds lower than 11 MeV we need muons sharing deposited energy between adjacent crystals
  - Such muons could fire the FLE discriminator of the adjacent crystal, if it is enabled – we’ll mix up the thresholds of 2 crystals

- For muon calibration of FLE thresholds we used 2 configurations (crystals with enabled FLE discriminators are yellow):

  configuration A
  
  “even rows, even columns “

  configuration B
  
  “odd rows, even columns “
Online suite for FLE thresholds calibration

- New FLE calibration suite muTrigNew:
  - One charge injection calibration run with tack delay = 70 (to get diagnostic information)
    - Charge injection DAC settings from 0 to 64 with step=2
      - This corresponds to signal step ~20 ADC units
    - 50 pulses per DAC setting
  - 1 hour muon run with trigger configuration A (100K events)
  - 1 hour muon run with trigger configuration B (100K events)
- This suite should be executed several times with different FLE_DAC setting - to get the calibration curve for each channel
runMuTrigEff – new executable in calibGenCAL package

- **FLE thresholds calibration software** has been moved recently from IDL to calibGenCAL package
- **Algorithm for charge injection**
  - For each DAC setting we find $N_{\text{trig}}$: the number of events with diagnostic bit ON
  - Find the trigger efficiency by dividing $N_{\text{trig}}$ by total number of pulses per DAC settings
  - Plot efficiency versus adc
  - fit the above plot with “step function” $y=1/(1+\exp(b*(x-a)))$, $a$ - threshold, $b$ - threshold width
- Algorithm for muons
  - For each crystal end we select events where
    - all enabled crystals in the same layer have signals below 50 adc units
      » In this case we are sure that the other crystals in this layer can’t produce the trigger bit
    - There is at least one trigger bit ON in some other layer
      » In this case the event is triggered by another layer and we can study the trigger efficiency of this layer
  - For selected events we plot two adc signal distributions:
    - Total number of events per bin (bin width is 20 adc bins)
    - Number of events per bin with trigger bit ON for this layer/side
  - We find trigger efficiency versus adc by dividing the 2nd histogram by the 1st one
  - Fit trigger efficiency versus adc with step function (the same as for charge injection)
Muon spectrum with and without requirement on FLE diagnostic bit

Muon signal spectrum for FM109, layer=4, column=2, side=1

- Blue line: selected events with trigger bit ON
- Red line: all selected events
FLE discriminator efficiency for muons and charge injection

- This plot led us to conclusion that FLE thresholds for muons are bigger than for charge injection by factor ~1.5
- We explained this by difference in the pulse shape between scintillation and charge injection
FLE thresholds calibration versus FLE_DAC

- Initial conclusion was wrong:
  - we have a constant bias of charge injection threshold with respect to muon threshold
  - we do not have a constant ratio between two thresholds
- Slopes of both curves are equal - there is no effect of different pulse shape
Variation of FLE thresholds calibration parameters from channel to channel

- Slopes are equal with 6% rms
- Bias has mean = 92 rms=11 adc units
Conclusion

- The difference in FLE thresholds between muons and charge injection could be described by constant bias, rather than by constant factor

- The explanation of this effect by the difference in pulse shape between muon and charge injection signal does not work
  - Possible explanation of bias: direct crosstalk from charge injection "start" digital signal to fast shaper
    - This signal doesn't change with dac setting - could explain the constant bias
  - Another possibility: DC coupling between some control signal (used for charge injection) and FLE_DAC output

- Muon calibration gives the right answer
  - Charge injection could be used for fast measurement, but it should be first calibrated by muon calibration

- For flight FLE threshold ~100 MeV calibration could be done on orbit using the same procedure.