L1Calo Calibration

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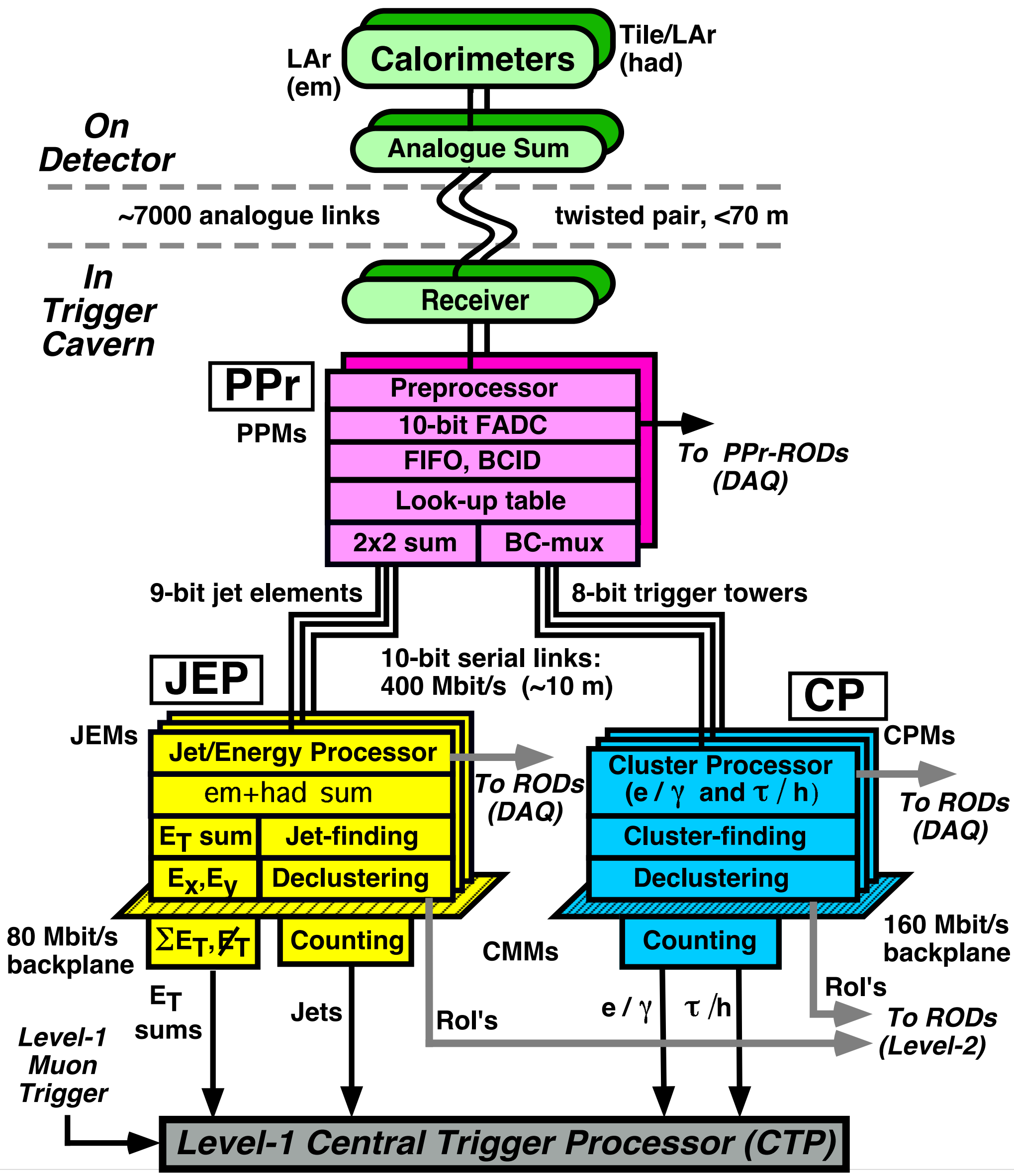
27 February 2013

- Introduction
- Parameters used to configure L1Calo
- Calibration procedures and analysis
- Questions to calorimeter experts

Introduction

Level-1 Calorimeter Trigger Architecture



- L1Calo Calibration uses
  - Receivers
    - Main energy calibration
    - Pulser vs physics corrections
  - Preprocessor
    - Digitisation, synchronisation, BCID, filters, pedestal subtraction, noise cut

L1Calo Configuration Parameters

- For every trigger tower we have:
  - Time of pulse peak (1ns precision, 0-399ns range)
    - NB large range needed to align barrel and endcap signals
      - Actually 400ns is not quite enough to cope with the calibration regime
        - For calibration we have to adjust readout pointers too
        - For the DPS I would recommend longer synchronisation delays
  - Parameters to set the pedestal (slope & offset of DAC)
  - Measured pedestal value
  - Five FIR filter coefficients and overall scale ("drop bits")
    - Different sets for EM barrel/endcap/overlap, HEC, Tile & FCAL1/2/3
      - Also special filters for ~10 Tile towers with very bad min bias switching noise
        - Here we use negative first & last coefficients to subtract large and slowly varying "pedestal"
  - Saturated BCID parameters
    - Thresholds for 1st & 2nd samples and associated Et ranges
  - Lookup table contents (final Et calibration)
    - Parameterised as slope, offset (pedestal) and noise cut

Timing

- Timing Calibration
  - Aim to sample pulse at the peak
  - Physics pulses fitted with gauss/landau or landau/landau
    - Pulse time derived with ~1ns accuracy
    - Stable for ~2 years (apart from systematic clock shifts)

Pedestals

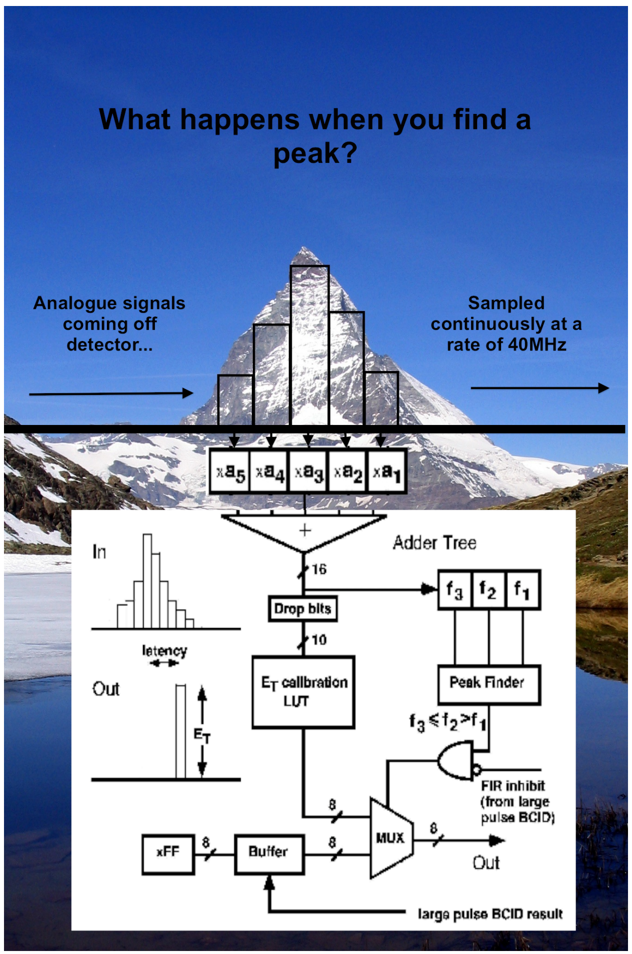
- PPM pedestal slightly sensitive to temperature
  - 0.1 ADC count (25 MeV) change per 0.1 degree
    - Small but adds up over large objects (EtMiss)
    - USA15 cooling water has 0.1 degree variation with 7-8 minute period
- Pedestals also vary with PHOS4 timing
  - Few ADC counts across 25ns
  - Different pedestals needed for calibration vs Physics
- Pedestals also very sensitive to pileup
  - Effect largest at start of bunch train
  - Pedestal shift slightly during each lumi fill
- Measured weekly (or more often)
  - Monitored for each lumi block during a run

Filter and Lookup Tables

- Filter implemented in current PPM ASIC
  - Hard coded algorithm but programmable parameters
    - Five parameters, central three must be positive (or zero)
    - New MCM after LS1 will have programmable algorithm
- Filter output
  - $\sum a_i x_i$ where a_i are 4 bit coefficients, x_i are 10 bit samples
    - Result ~15 bits for real pulse (~14 bits in FCAL)
    - Drop 5 (4) bits to give 10 bit value to lookup table
- Optimise usage of the lookup table
  - Simultaneously try to:
    - Match coefficients to pulse shape
    - Scale coefficients to use the whole 10 LUT input range
      - Otherwise we lose some energy resolution
- Then fill LUT with conversion to GeV
  - LUT slope depends on pulse shape and filter coefficients

Lookup Table (LUT) Slopes

LUT slope calibration in a Nutshell



- When a peak is found- the Look Up Table (LUT) is used to convert the output of FIR filtering intp an energy.
- It is configured by 2 parameters- the LUT slope, and the offset (subtracts the effect of pedestal and implements noise threshold).
- For the purpose of this talk all you need to know is...
- To optimise LUT coverage- fit FIR output (before dropped bits) as a linear function of peak ADC, then:

$$LUT_{slope} = \frac{2^{drop\ bits} \times 1024}{gradient}$$

- When calibrating- use a high luminosity run and calculate LUT slopes on a tower-by-tower basis.

Saturated BCID

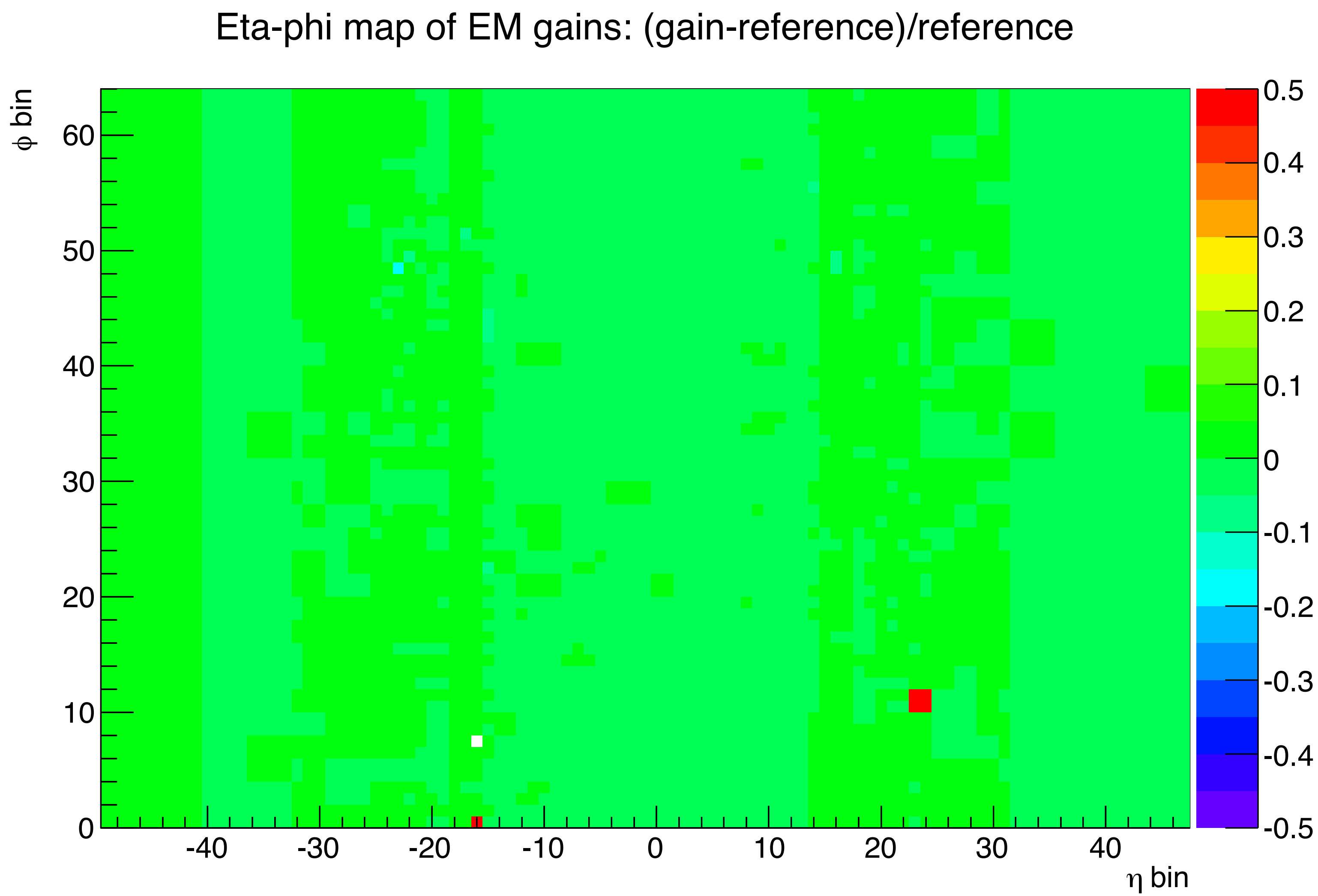
- Filter and LUT used for non-saturated pulses
- Special algorithm for saturated pulses (>255 GeV ADC)
  - Determine correct BCID from slope of rising edge
  - Set thresholds on two ADC samples before saturation
  - Detailed study to set thresholds and check performance
    - Algorithm expected to be OK up to 3.5 TeV
    - Revisit this study for phase 0...?
    - New MCM would allow other algorithms
      - Though still limited by the same saturation level

Energy Calibration

- L1Calo only does electronic calibration
  - Use LAr/Tile charge injection pulser systems
  - Compare L1Calo Et with calibrated Et from full calo readout
  - Assumption is that LAr/Tile calibrate their readout to true Et
- Weekly calibration runs analysed on the CAF
  - Typical pattern
    - Run(s) with receiver gains set to one
      - Derive required calibrated gain
        - Two LAr gain one runs needed for barrel/endcap overlap components
    - Run with receiver gains set to physics gains as cross check
      - NB actually not quite the physics gains due to pulser to physics corrections
  - End results: sets of receiver gains required for correct L1Calo response to calorimeter charge injection pulses
- However we also compare calibration in physics data...

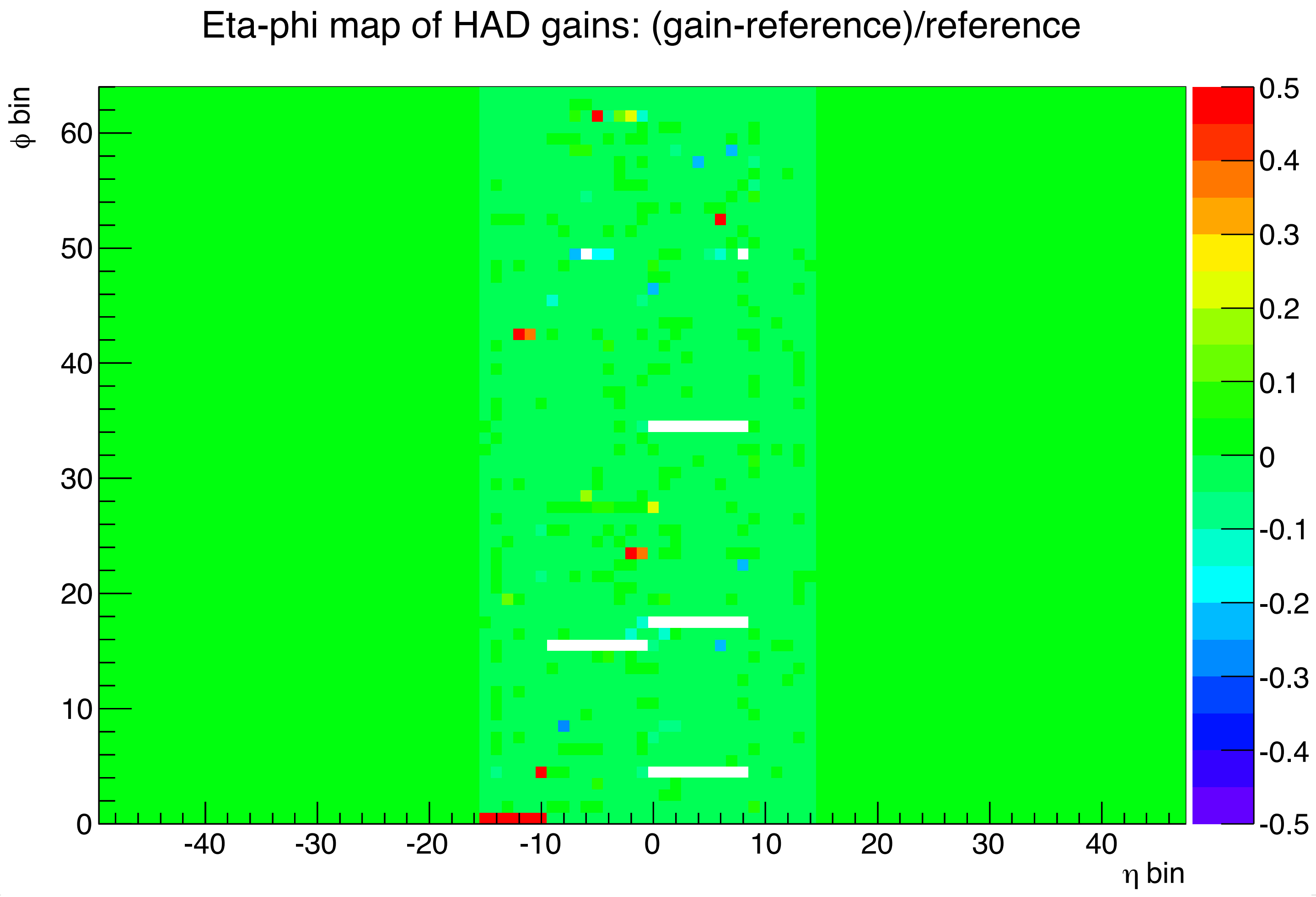
Energy Calibration: Plots (LAr)

- Gain update needed after HV change in EMEC-A (8 Nov)
  - Also some intermittent problems in the C side overlap region



Energy Calibration: Plots (Tile)

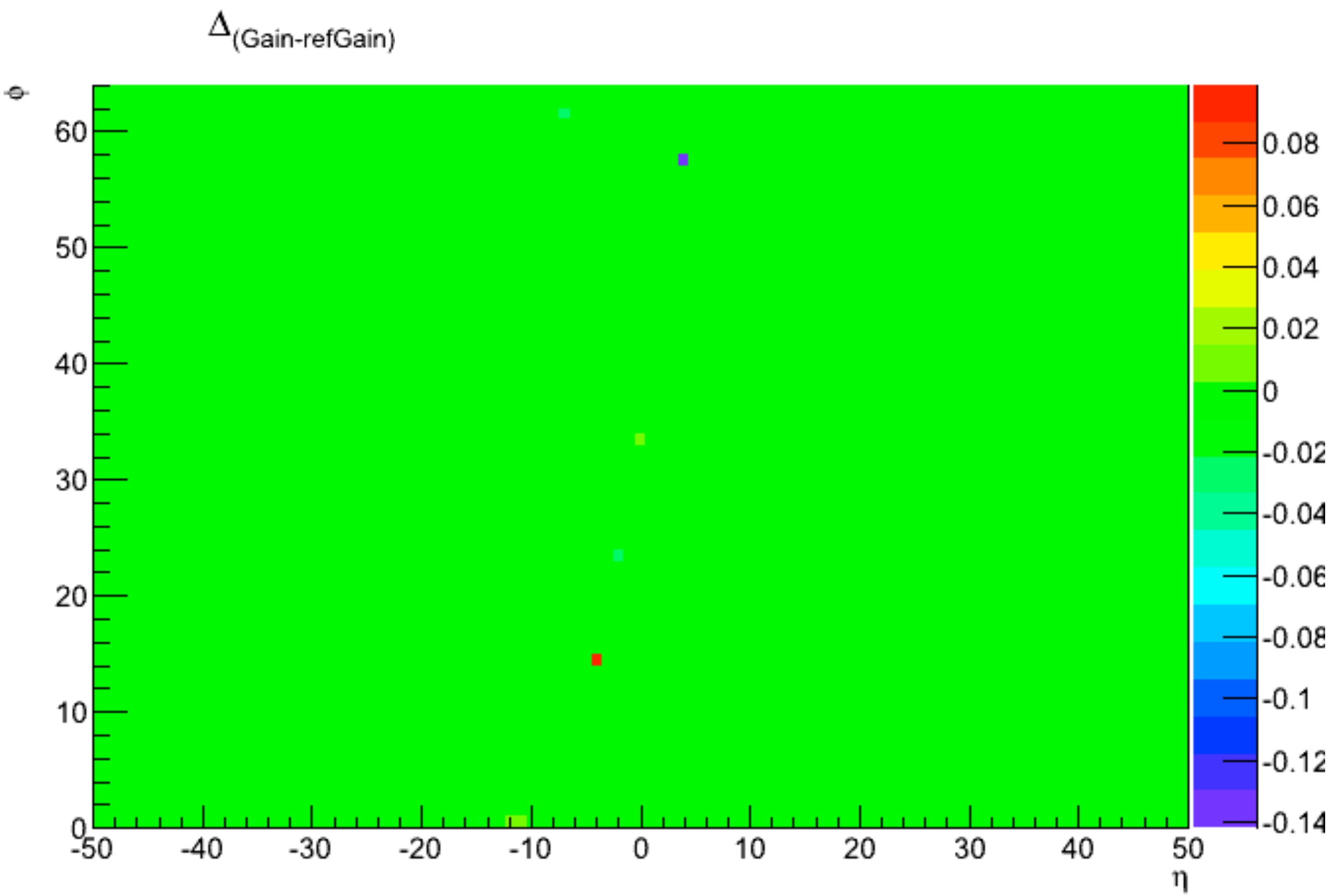
- Typical set of drifted Tile towers (reason not understood)
  - EBC01 in emergency mode but already at maximum gain
  - NB ignore HEC region in this plot (not measured in this calibration)



Energy Calibration: Tile Diff

- Apparent gain changes between two runs 5 mins apart

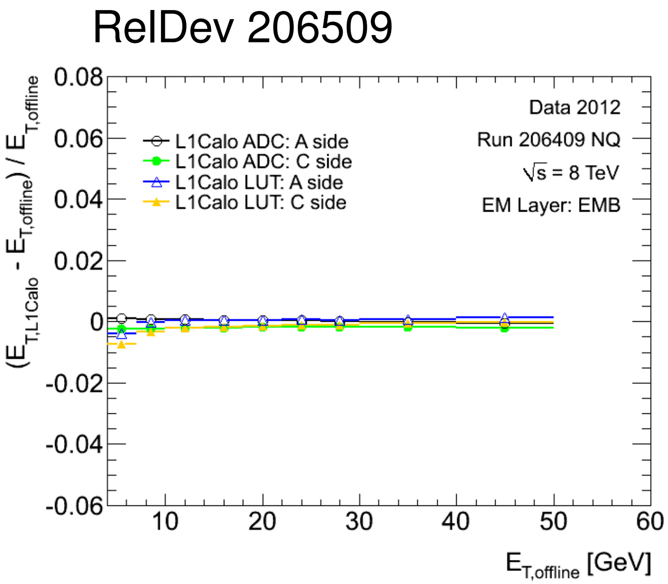
(Gain-ref): *218359 compared with 218364*

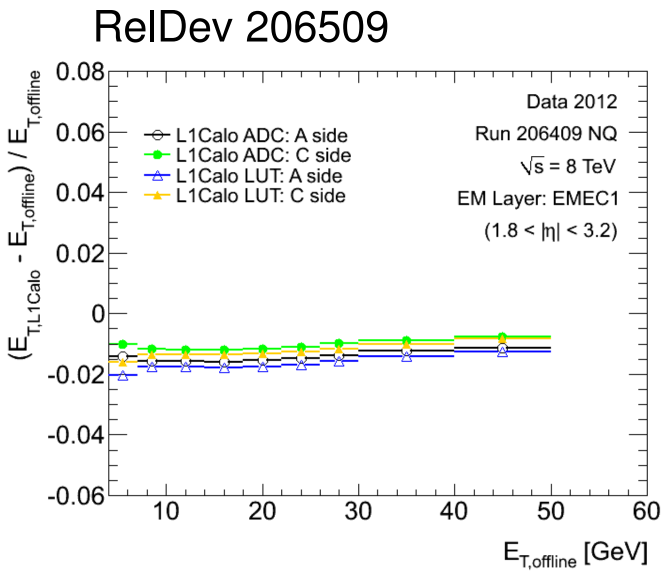


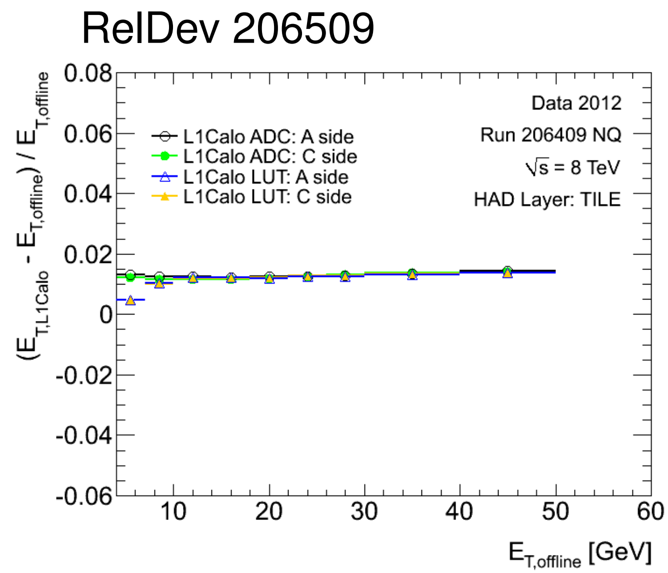
Pulser to Physics Corrections

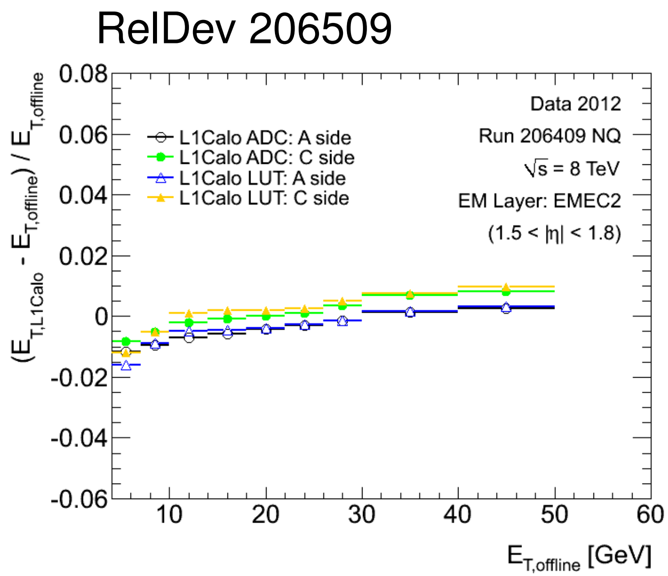
- Energy calibration is done using maximum ADC value
  - Compare peak ADC with calibrated LAr/Tile Et
    - Easier to disentangle other effects from pulse shape, filters, etc
- But pulser and physics pulse shapes are different
  - Additional "pulser to physics" corrections required (~1-2%)
  - Relative calibration of L1Calo and full Calo readout compared
    - Both for peak ADC and for final L1Calo Et (LUT output)
    - Look for linearity (or not) in different calo regions in each case
    - Recently also looked at better treatment for overlap region

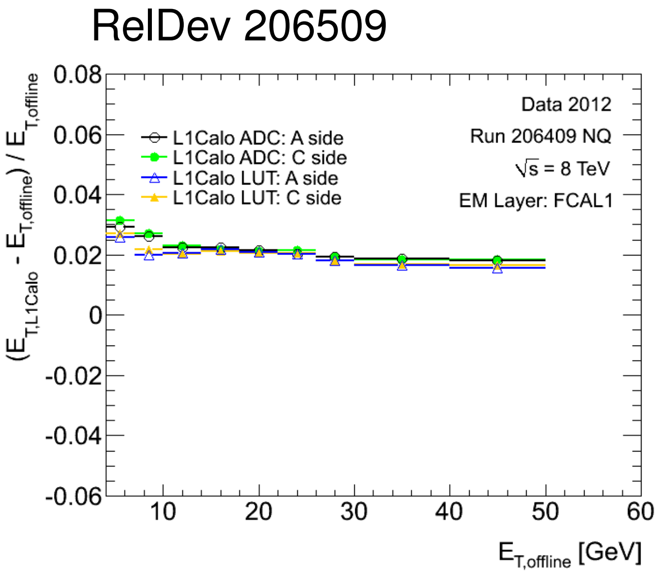
Physics "Gain" (L1Calo/Calo)

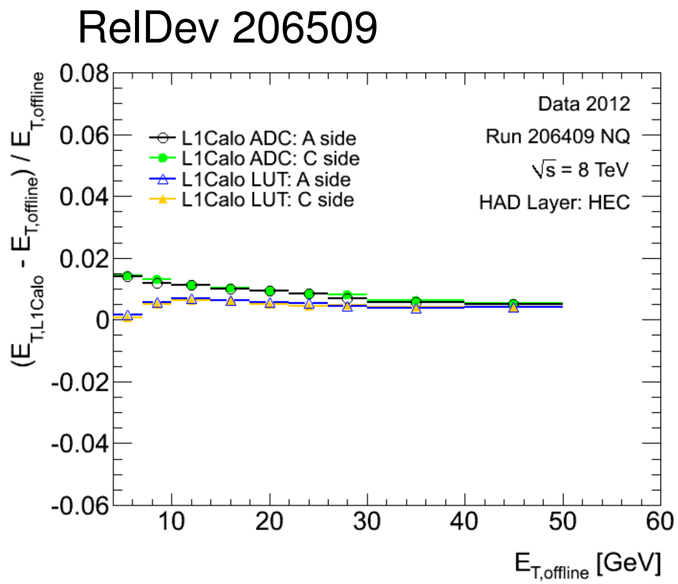






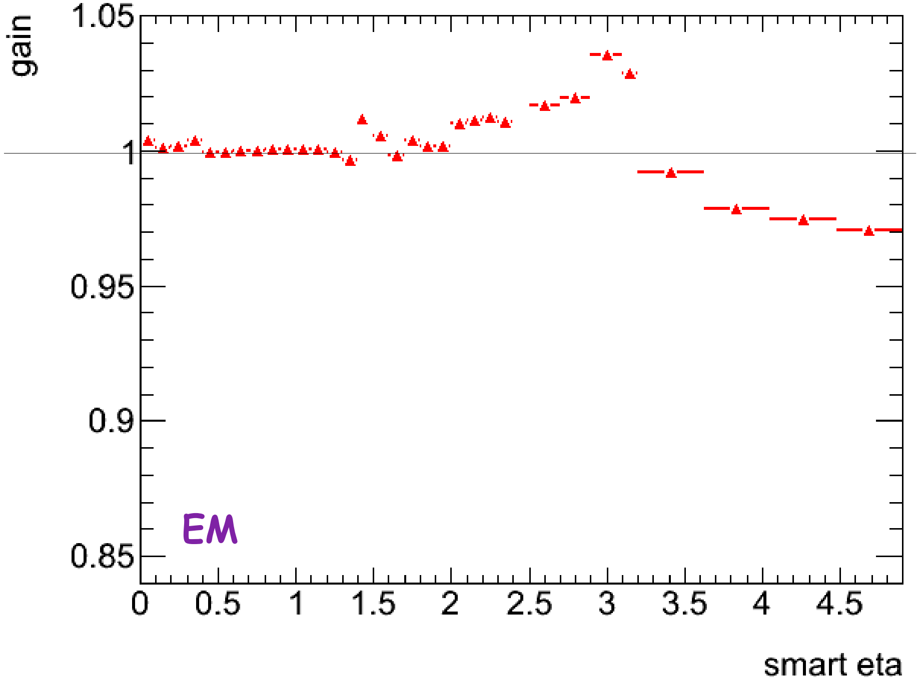




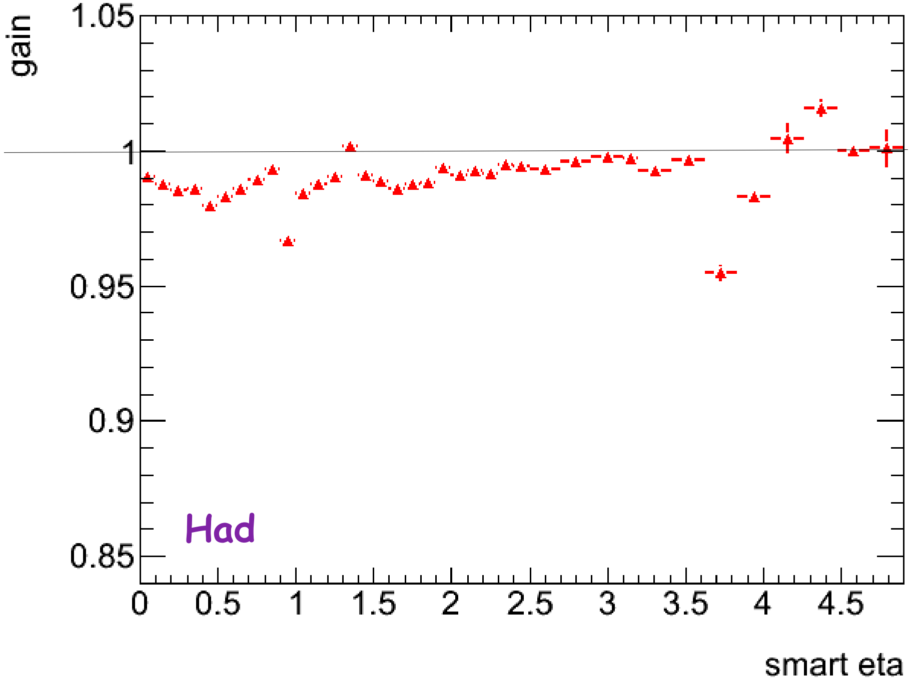


Physics "Gain" (Calo/L1Calo)

Rx gains 206409 EM



Rx gains 206509 Had

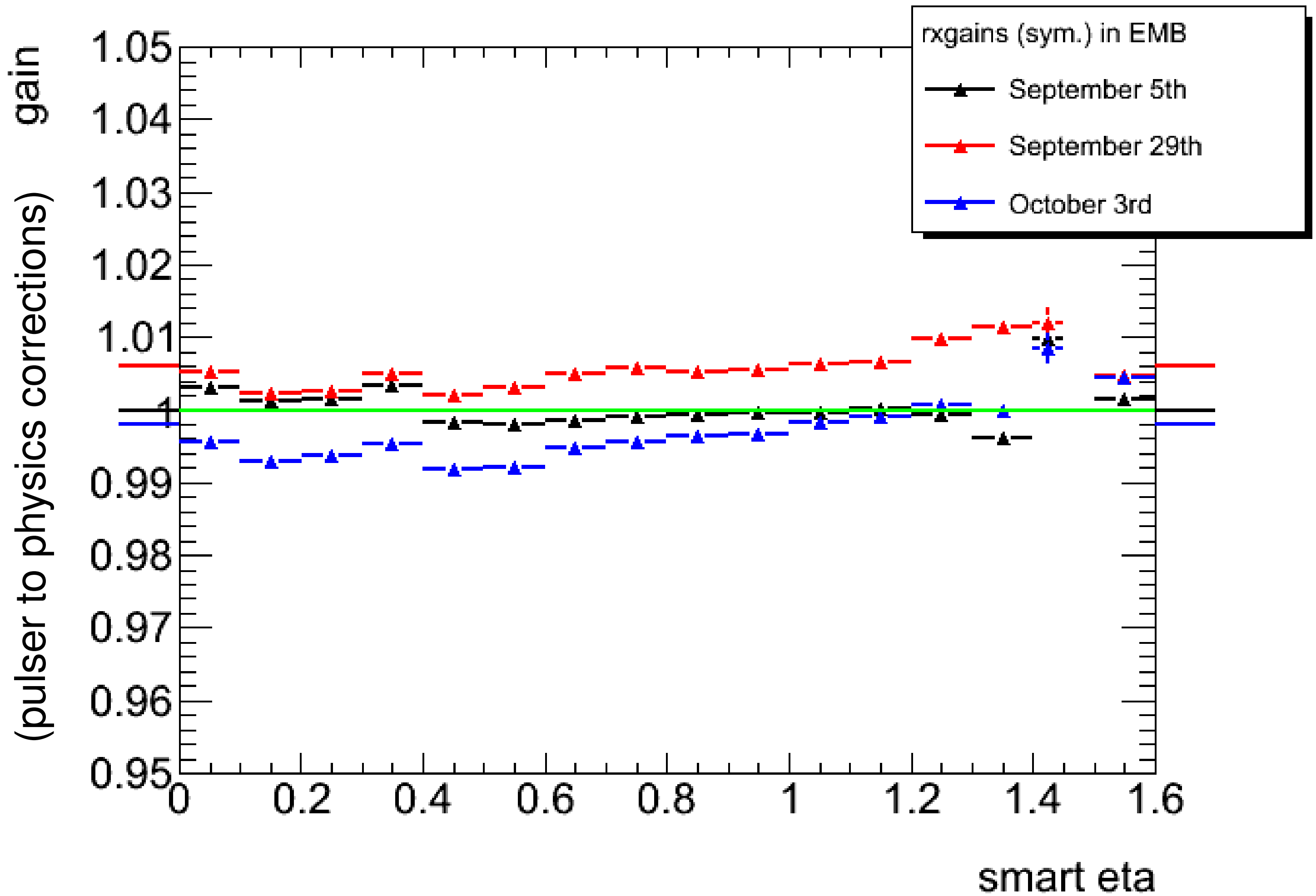


Physics "Gain" (Calo/L1Calo)

Symmetric η–slice gains: EM Layer

Effect of
EM Barrel
PS HV changes

Non-uniform
response vs eta



Symmetrically in η;

Per „receiver" η slice;

Gain = Calo/ADC = Et(Calo)/Et(L1Calo)

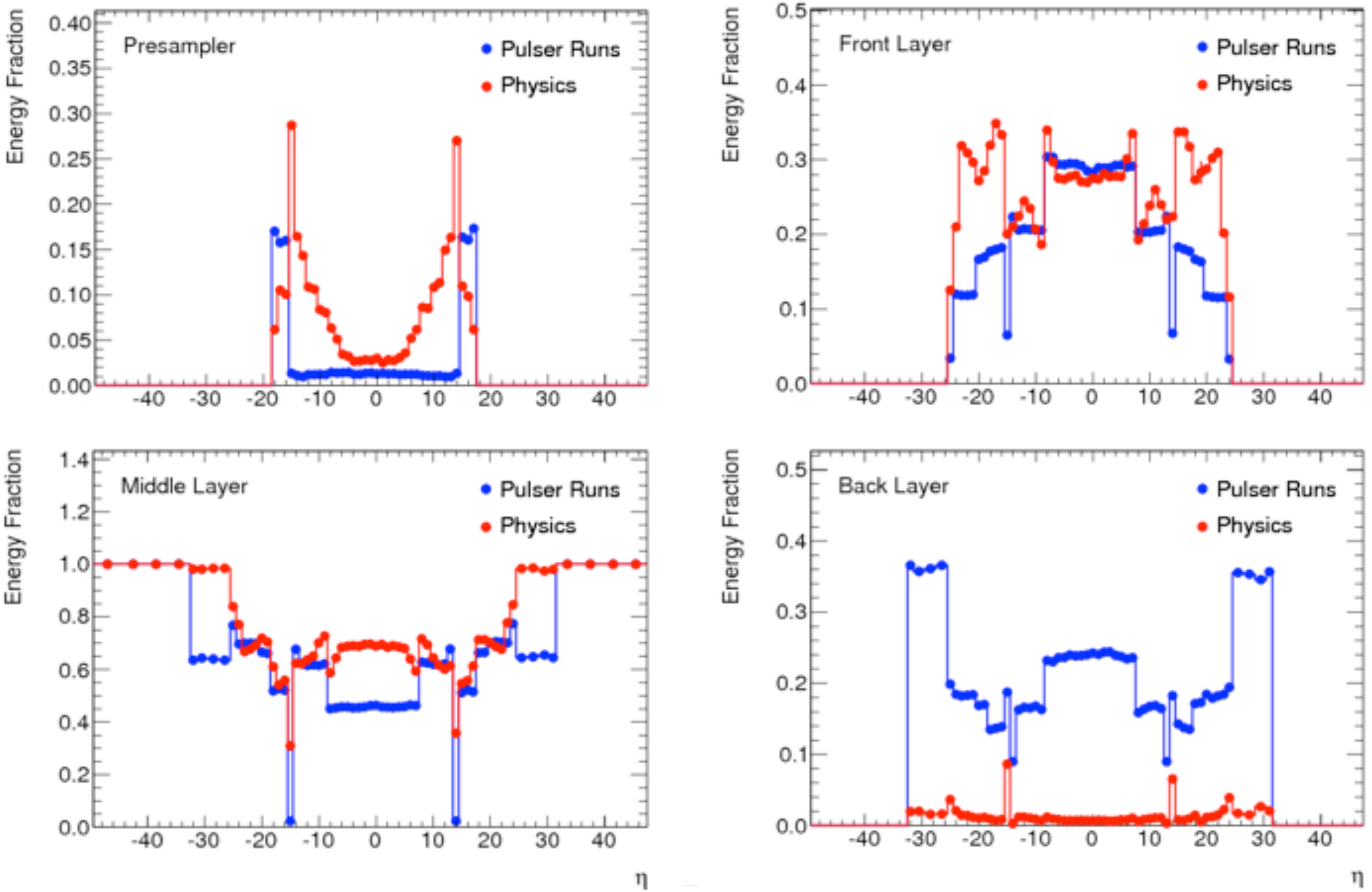
Gain Predictor (LAr only)

- Energy calibration uses calibrated LAr Et
  - This includes any corrections for non-standard HV
  - Also correction for known dead (disabled) cells
- The LAr conditions are not completely stable
  - LAr regularly adjusts HV
    - Typically for small region, occasionally larger scale shifts (eg EMB PS)
  - Occasionally cells are disabled due to noise
    - And sometimes enabled again
- L1Calo response
  - Small changes can wait for next weekly calibration
  - Larger changes we would like to correct quickly
- Gain predictor developed to do this
  - Command line script run by expert when needed

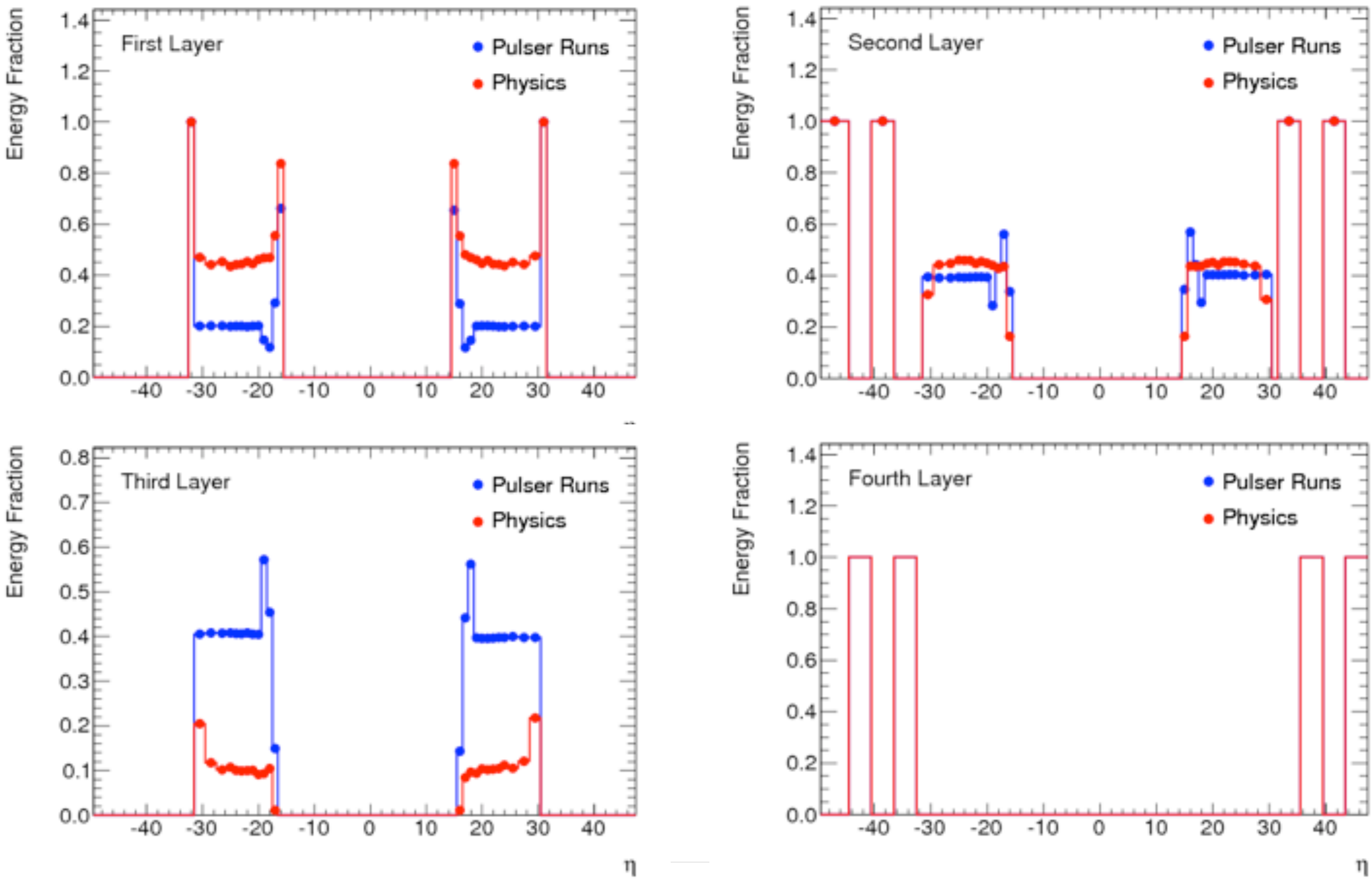
Gain Predictor Methodology

- Compares current status with that at last calibration
  - Or an earlier calibration marked as a reference
- Looks for changes in the HV corrections per layer
  - Uses weights for typical energy deposition per layer
    - For EM HV corrections are either presampler or the rest together
    - In HEC, each layer has separate HV corrections
  - Energy per layer can be very different in physics & pulser
    - Presampler fraction varies with eta in physics but is constant for pulser
    - Back layer of HEC is overrepresented in the pulser compared to physics
      - Real example: large HV correction to HEC 3rd layer (C side phi ~2) resulted in large overcalibration in L1Calo until fixed by the gain predictor technique
    - For HEC this issue will still be there in phase 1
      - Though the EM will be OK as the supercells can be corrected layer by layer
- To do
  - Use this also in standard calibration analysis
  - Extend to handle dead/disabled cells

Gain Predictor: EM Profiles



Gain Predictor: HEC Profiles



Questions to Experts: LAr (1)

- LAr
  - Generally OK and well understood
  - What is expected for rate of HV corrections after LS1?
    - Subjective feeling is that things get worse with lumi
      - Will PS HV have to be dropped again?
    - Will attention to power supplies improve stability?
  - What we should correct via pulser vs other methods?
    - Currently HV corrections and dead cells are automatic in CAF analysis
      - Taken into account when calibrated LAr Et is calculated
    - Experience with gain predictor shows layer weights are wrong
      - Can be significant effect with non-uniform HV corrections
        - Will this get worse in phase 0 and phase 1?
      - Maybe revisit and take HV corrections out of the CAF analysis
        - Could do HV corrections by import gain predictor ideas into CAF analysis procedure
        - Separate set of folders multiplied to get final receiver gain
    - Similar question about dead/disabled cells
      - Currently "Dead Physics" and "Dead Readout" are corrected for

Questions to Experts: LAr (2)

- LAr
  - New MCM will allow for more sophisticated filters
    - We have investigated some ideas...
    - Any suggestions from LAr (or Tile) from current ROD or offline filters?
      - How to deal with increasing pileup etc
      - What is planned for LDPS in phase 1?

Questions to Experts: Tile

- Tile
  - Still some non-understood issues
    - We still see variations between two runs 10 mins apart
  - How to better communicate about individual channel problems?
    - When can we trust very high/low gains from pulser?
  - Overall drifts
    - Cs scans, in between laser scans.
      - Is it correct there is still a 1-2% drift on top?? (In Physics??) [Tile talk in ATLAS week]
      - If so what should L1Calo do?
        - Should we take an overall drift from them
        - Our calibrations get corrected energy
        - What is 3.5% down drift? (a) Physical cause (b) is it included in Cs constants we use?
    - L1Calo: Sten sees 1-2% drifts (Physics). Are these the same?

Questions to Experts: Upgrade

- eFEX and energy reconstruction
  - What type of filters does the DPS plan to use?
    - How is it planned to do calibrations - is anyone thinking about this?
  - Whats the state of simulation of inputs to eFEX?
- EMEC presampler gain wrong (too low by factor ~3)
  - Wrong on TBB? So should be correctable for phase 1?
- EMEC-C "zigzag" region
  - Presume still with us for phase 0
  - But correctable at phase 1?

Summary

- L1Calo calibration generally OK
  - At the level required (~1%)
- But Tile shifts and drifts not all understood
- LAr: work on moving layer weights to CAF analysis?
- New MCM will allow more sophisticated filters

Backup/Notes

Analogue Chain

- LAr
  - Preamp, FEB, shaper+sum, layer sum, tower builder, long cable
- Tile
  - PMT, 3-in-1, adder, long cable, patch panel, short cable
- Common
  - Receiver
    - Shaping, 12 bit variable gain amplifier (VGA), remapping
      - VGA is where the energy calibration is implemented
  - Short cables
    - Some patch panels for final remapping of difficult regions
  - Preprocessor:
    - Analogue input: DAC to set pedestal
    - ADC: strobe at the peak (1ns precision via PHOS4 chip)

Links to Various Talks

- Filter parameters
  - http://indico.cern.ch/getFile.py/access?subContId=2&contribId=0&resId=0&materialId=slides&confId=126262
- LUT Slopes
  - http://indico.cern.ch/getFile.py/access?subContId=0&contribId=0&resId=0&materialId=slides&confId=112869
- Saturated BCID
  - http://indico.cern.ch/getFile.py/access?subContId=2&contribId=4&resId=0&materialId=slides&confId=53510
  - http://indico.cern.ch/getFile.py/access?contribId=1&sessionId=1&resId=0&materialId=slides&confId=66571
  - http://indico.cern.ch/getFile.py/access?contribId=33&sessionId=3&resId=0&materialId=slides&confId=68140