Trending CAL performance and mapping crystals

- Trending CAL performance parameters as a function of LAT assembly phase:
  - from Comprehensive Performance Tests
  - from calibration files (calibGenCal)

- Mapping CAL crystals and energy response

- Conclusions
Trending CAL performance parameters from CPT’s 1/10

• What do we trend?
  – Compute pedestals: we trend position and width
  – Check optical response (with muons):
    • a test for changes in the PDA (photo-diode assembly) optical bond quality is made from the ratio of LE or HE diode signals
    • we trend LE+/LE-, LE+/HE+ and LE-/HE-
  – Calibrate electronic gains (with CI):
    • we trend the lowest and highest relative gains (w.r.t. nominal gains)
    • these gains are chosen because any drift from the nominal value would be most greatly amplified
  – Determine front-end integral non-linearity and noise (with CI): we trend non-linearity (RMS deviation from linear fit in %)

• Which phases?
  – 8 first modules: 8T, 16T, 16T_fGASU, 16T_7Feb06
  – 8 last modules: 16T, 16T_fGASU, 16T_7Feb06
    • Except FM117 (data removed by FM116 data…)

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Trending CAL performance parameters from CPT’s 2/10

T00-FM104 TIME EVOLUTION [Reference=grid16] summary (all channels)

PEDESTAL POSITION
- Mean: 0.6945
- RMS: 0.5259
- Underflow: 0
- Overflow: 0

PEDESTAL FWHM
- Mean: 5.924
- RMS: 3.271
- Underflow: 0
- Overflow: 4

DIODE RATIOS
- Mean: 0.05713
- RMS: 0.05807
- Underflow: 0
- Overflow: 0

RELATIVE GAINS
- Mean: 0.005129
- RMS: 0.00417
- Underflow: 0
- Overflow: 0

AVERAGE % NON-LINEARITY
- Mean: 0.000129
- RMS: 0.00011
- Underflow: 0
- Overflow: 0

T01-FM103 TIME EVOLUTION [Reference=grid16] summary (all channels)

PEDESTAL POSITION
- Mean: 0.7633
- RMS: 0.6588
- Underflow: 0
- Overflow: 0

PEDESTAL FWHM
- Mean: 0.5828
- RMS: 0.2906
- Underflow: 0
- Overflow: 0

DIODE RATIOS
- Mean: 5.26
- RMS: 2.486
- Underflow: 0
- Overflow: 1

RELATIVE GAINS
- Mean: 0.005129
- RMS: 0.00417
- Underflow: 0
- Overflow: 0

AVERAGE % NON-LINEARITY
- Mean: 0.000129
- RMS: 0.00011
- Underflow: 0
- Overflow: 0
Trending CAL performance parameters from CPT’s 3/10

T03-FM118 TIME EVOLUTION [Reference=grid16] summary (all channels)

- PEDESTAL POSITION
  - AmplSum0
    - Mean: 0.8000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- PEDESTAL FWHM
  - AmplSum1
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- DIODE RATIOS
  - AmplSum2
    - Mean: 0.5000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- RELATIVE GAINS
  - AmplSum3
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- AVERAGE % NON-LINEARITY
  - AmplSum4
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

T04-FM105 TIME EVOLUTION [Reference=grid16] summary (all channels)

- PEDESTAL POSITION
  - AmplSum0
    - Mean: 0.8000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- PEDESTAL FWHM
  - AmplSum1
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- DIODE RATIOS
  - AmplSum2
    - Mean: 0.5000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- RELATIVE GAINS
  - AmplSum3
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

- AVERAGE % NON-LINEARITY
  - AmplSum4
    - Mean: 0.0000
    - RMS: 0.0000
    - Underflow: 0
    - Overflow: 0
    - RMS
      - 0.5*(MAX-MIN)

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Trending CAL performance parameters from CPT’s 4/10

**T05-FM102 TIME EVOLUTION**

**Summary (all channels)**

- **AmplSum0**: Entries 768, Mean 0.7072, RMS 0.5368, Underflow 0, Overflow 0
- **AmplSum1**: Entries 768, Mean 0.5725, RMS 0.2746, Underflow 0, Overflow 0
- **AmplSum2**: Entries 288, Mean 5.26, RMS 2.705, Underflow 0, Overflow 1
- **AmplSum3**: Entries 1536, Mean 0.05631, RMS 0.05862, Underflow 0, Overflow 0
- **AmplSum4**: Entries 768, Mean 0.004952, RMS 0.004778, Underflow 0, Overflow 0

- **PEDESTAL POSITION**
  - Mean: 0.7072, RMS: 0.5368
  - Mean: 0.5725, RMS: 0.2746
  - Mean: 5.26, RMS: 2.705
  - Mean: 0.05631, RMS: 0.05862
  - Mean: 0.004952, RMS: 0.004778

- **PEDESTAL FWHM**
  - Mean: 2.705, RMS: 1.2
  - Mean: 3.371, RMS: 1.4

- **DIODE RATIOS**
  - Mean: 0.00947, RMS: 0.00692
  - Mean: 0.00947, RMS: 0.00692
  - Mean: 5.732, RMS: 3.371

- **RELATIVE GAINS**
  - Mean: 0.004952, RMS: 0.004778
  - Mean: 0.004952, RMS: 0.004778

- **AVERAGE % NON-LINEARITY**
  - Mean: 0.00947, RMS: 0.00692
  - Mean: 0.00947, RMS: 0.00692

**T06-FM115 TIME EVOLUTION**

**Summary (all channels)**

- **AmplSum1**: Entries 768, Mean 0.5448, RMS 0.2746, Underflow 0, Overflow 0
- **AmplSum2**: Entries 288, Mean 5.732, RMS 3.371, Underflow 0, Overflow 1
- **AmplSum3**: Entries 1536, Mean 0.05704, RMS 0.07335, Underflow 0, Overflow 0
- **AmplSum4**: Entries 768, Mean 0.004112, RMS 0.003629, Underflow 0, Overflow 0

- **PEDESTAL POSITION**
  - Mean: 0.5448, RMS: 0.2746
  - Mean: 5.732, RMS: 3.371

- **PEDESTAL FWHM**
  - Mean: 2.705, RMS: 1.2

- **DIODE RATIOS**
  - Mean: 0.00947, RMS: 0.00692

- **RELATIVE GAINS**
  - Mean: 0.004952, RMS: 0.004778

- **AVERAGE % NON-LINEARITY**
  - Mean: 0.00947, RMS: 0.00692

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Trending CAL performance parameters from CPT’s 5/10

T07-FM116 TIME EVOLUTION [Reference=grid16] summary (all channels)

- PEDESTAL POSITION
  - Entries: 768
  - Mean: 0.6258
  - RMS: 0.3652
  - Underflow: 0
  - Overflow: 0

- PEDESTAL FWHM
  - Entries: 288
  - Mean: 6.074
  - RMS: 3.598
  - Underflow: 0
  - Overflow: 2

- DIODE RATIOS
  - Entries: 1536
  - Mean: 0.0546
  - RMS: 0.0703
  - Underflow: 0
  - Overflow: 0

- RELATIVE GAINS
  - Entries: 768
  - Mean: 0.004638
  - RMS: 0.004419
  - Underflow: 0
  - Overflow: 0

T08-FM107 TIME EVOLUTION [Reference=grid16] summary (all channels)

- PEDESTAL POSITION
  - Entries: 768
  - Mean: 0.6896
  - RMS: 0.5368
  - Underflow: 0
  - Overflow: 0

- PEDESTAL FWHM
  - Entries: 768
  - Mean: 0.5654
  - RMS: 0.281
  - Underflow: 0
  - Overflow: 0

- DIODE RATIOS
  - Entries: 288
  - Mean: 5.523
  - RMS: 3.215
  - Underflow: 0
  - Overflow: 2

- RELATIVE GAINS
  - Entries: 768
  - Mean: 0.004825
  - RMS: 0.004545
  - Underflow: 0
  - Overflow: 0
Trending CAL performance parameters from CPT’s 6/10

**T09-FM106 TIME EVOLUTION** [Reference=grid16] summary (all channels)

- **PEDESTAL POSITION**
  - Entries: 768
  - Mean: 0.7042
  - RMS: 0.5473
  - Underflow: 0
  - Overflow: 0

- **PEDESTAL FWHM**
  - Entries: 288
  - Mean: 5.377
  - RMS: 3.171
  - Underflow: 0
  - Overflow: 2

- **DIODE RATIOS**
  - Entries: 1536
  - Mean: 0.05402
  - RMS: 0.05548
  - Underflow: 0
  - Overflow: 0

- **RELATIVE GAINS**
  - Entries: 768
  - Mean: 0.005075
  - RMS: 0.00447
  - Underflow: 0
  - Overflow: 0

- **AVERAGE % NON-LINEARITY**

**T10-FM111 TIME EVOLUTION** [Reference=test1] summary (all channels)

- **PEDESTAL POSITION**
  - Entries: 768
  - Mean: 0.5615
  - RMS: 0.3989
  - Underflow: 0
  - Overflow: 0

- **PEDESTAL FWHM**
  - Entries: 288
  - Mean: 0.5359
  - RMS: 0.2848
  - Underflow: 0
  - Overflow: 0

- **DIODE RATIOS**
  - Entries: 1536
  - Mean: 0.073
  - RMS: 0.09417
  - Underflow: 0
  - Overflow: 0

- **RELATIVE GAINS**
  - Entries: 768
  - Mean: 0.004166
  - RMS: 0.004032
  - Underflow: 0
  - Overflow: 0

- **AVERAGE % NON-LINEARITY**

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Trending CAL performance parameters from CPT’s 7/10

T11-FM112 TIME EVOLUTION [Reference=grid16] summary (all channels)

T11-FM112

T12-FM110 TIME EVOLUTION [Reference=grid16] summary (all channels)

T12-FM110

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Trending CAL performance parameters from CPT’s 8/10

**G L A S T  L A T  P r o j e c t**

**In s t r u m e n t  A n a l y s i s  W o r k s h o p  6 – 0 6 / 0 2 / 2 7**

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Trending CAL performance parameters from CPT’s 9/10

T15-FM114 TIME EVOLUTION [Reference=grid16] summary (all channels)

**PEDESTAL POSITION**

- Entries: 768
- Mean: 0.6035
- RMS: 0.4063
- Underflow: 0
- Overflow: 0

**PEDESTAL FWHM**

- Entries: 768
- Mean: 0.5354
- RMS: 0.2811
- Underflow: 0
- Overflow: 0

**DIODE RATIOS**

- Entries: 288
- Mean: 6.285
- RMS: 3.762
- Underflow: 0
- Overflow: 3

**RELATIVE GAINS**

- Entries: 1536
- Mean: 0.06483
- RMS: 0.0838
- Underflow: 0
- Overflow: 0

**AVERAGE % NON-LINEARITY**

- Entries: 768
- Mean: 0.004302
- RMS: 0.003969
- Underflow: 0
- Overflow: 0

**T15-FM114**
Trending CAL performance parameters from CPT’s 10/10

T05-FM102

Largest variations seen for LE+/LE- (Cf IA workshop 5)

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• **What do we trend?**
  - Characterize asymmetry functions for small (S) and large (L) diodes: we trend **Right-Left amplitude**
  - Energy calibration: we trend the small and large diode MeV per DAC constant

• **Which phases?** **8T, 16T**
  - Only for the 8 first modules so far…
Trending CAL performance parameters from calibration files 2/5

T00-FM104 TIME EVOLUTION [Reference=16T] summary (all channels)

- Asymmetry-LL R-L
  - Entry: 96
  - Mean: 0.001888
  - RMS: 0.001498
  - Underflow: 0
  - Overflow: 0

- Asymmetry-LS R-L
  - Entry: 96
  - Mean: 0.005351
  - RMS: 0.003982
  - Underflow: 0
  - Overflow: 0

- Asymmetry-SS R-L
  - Entry: 96
  - Mean: 0.004359
  - RMS: 0.003641
  - Underflow: 0
  - Overflow: 0

- Asymmetry-SS R-L
  - Entry: 96
  - Mean: 0.006576
  - RMS: 0.005565
  - Underflow: 0
  - Overflow: 0

- MeV per DAC - LARGE
  - Entry: 96
  - Mean: 0.2205
  - RMS: 0.1368
  - Underflow: 0
  - Overflow: 0

- MeV per DAC - SMALL
  - Entry: 96
  - Mean: 0.643
  - RMS: 0.5778
  - Underflow: 0
  - Overflow: 0

T01-FM103 TIME EVOLUTION [Reference=16T] summary (all channels)

- Asymmetry-LL R-L
  - Entry: 96
  - Mean: 0.001796
  - RMS: 0.001353
  - Underflow: 0
  - Overflow: 0

- Asymmetry-LS R-L
  - Entry: 96
  - Mean: 0.004946
  - RMS: 0.004379
  - Underflow: 0
  - Overflow: 0

- Asymmetry-SS R-L
  - Entry: 96
  - Mean: 0.004154
  - RMS: 0.003615
  - Underflow: 0
  - Overflow: 0

- Asymmetry-SS R-L
  - Entry: 96
  - Mean: 0.006247
  - RMS: 0.005029
  - Underflow: 0
  - Overflow: 0

- MeV per DAC - LARGE
  - Entry: 96
  - Mean: 0.6767
  - RMS: 0.5853
  - Underflow: 0
  - Overflow: 0

- MeV per DAC - SMALL
  - Entry: 96
  - Mean: 0.6767
  - RMS: 0.5853
  - Underflow: 0
  - Overflow: 0

F. Piron & E. Nuss (LPTA)
### Trending CAL performance parameters from calibration files 3/5

#### T04-FM105 TIME EVOLUTION [Reference=16T] summary (all channels)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>RMS</th>
<th>Underflow</th>
<th>Overflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetry-LL R-L</td>
<td>Mean</td>
<td>0.001989</td>
<td>0.001265</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-LS R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-SL R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-SS R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>MeV per DAC - LARGE</td>
<td>Mean</td>
<td>0.004555</td>
<td>0.003445</td>
<td>0</td>
</tr>
<tr>
<td>MeV per DAC - SMALL</td>
<td>Mean</td>
<td>0.006308</td>
<td>0.004893</td>
<td>0</td>
</tr>
</tbody>
</table>

#### T05-FM102 TIME EVOLUTION [Reference=16T] summary (all channels)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Mean</th>
<th>RMS</th>
<th>Underflow</th>
<th>Overflow</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymmetry-LL R-L</td>
<td>Mean</td>
<td>0.001675</td>
<td>0.001265</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-LS R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-SL R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>Asymmetry-SS R-L</td>
<td>Mean</td>
<td>0.000003</td>
<td>0.000003</td>
<td>0</td>
</tr>
<tr>
<td>MeV per DAC - LARGE</td>
<td>Mean</td>
<td>0.3086</td>
<td>0.2218</td>
<td>0</td>
</tr>
<tr>
<td>MeV per DAC - SMALL</td>
<td>Mean</td>
<td>0.6826</td>
<td>0.5088</td>
<td>0</td>
</tr>
</tbody>
</table>
Trending CAL performance parameters from calibration files 4/5

**T08-FM107**
- Asymmetry-LL R-L
- Asymmetry-LS R-L
- Asymmetry-SL R-L
- Asymmetry-SS R-L
- MeV per DAC - LARGE
- MeV per DAC - SMALL

**T09-FM106**
- Asymmetry-LL R-L
- Asymmetry-LS R-L
- Asymmetry-SL R-L
- Asymmetry-SS R-L
- MeV per DAC - LARGE
- MeV per DAC - SMALL

Entries: 96

- Mean: Values for averages
- RMS: Root mean square value
- Underflow: Count of underflows
- Overflow: Count of overflows

RMS: 0.5*(MAX-MIN)
Trending CAL performance parameters from calibration files 5/5

**T12-FM110**

- **Asymmetry-LL R-L**
  - AmplSum0
  - Entires: 96
  - Mean: 0.001956
  - RMS: 0.00175
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-LS R-L**
  - AmplSum1
  - Entires: 96
  - Mean: 0.005087
  - RMS: 0.003953
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-SL R-L**
  - AmplSum2
  - Entires: 96
  - Mean: 0.00546
  - RMS: 0.004696
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-SS R-L**
  - AmplSum3
  - Entires: 96
  - Mean: 0.007516
  - RMS: 0.005519
  - Underflow: 0
  - Overflow: 0

- **MeV per DAC - LARGE**
  - AmplSum4
  - Entires: 96
  - Mean: 0.4329
  - RMS: 0.2367
  - Underflow: 0
  - Overflow: 0

- **MeV per DAC - SMALL**
  - AmplSum5
  - Entires: 96
  - Mean: 0.9084
  - RMS: 0.6831
  - Underflow: 0
  - Overflow: 0

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**T13-FM108**

- **Asymmetry-LL R-L**
  - AmplSum1
  - Entires: 96
  - Mean: 0.002041
  - RMS: 0.001553
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-LS R-L**
  - AmplSum2
  - Entires: 96
  - Mean: 0.005141
  - RMS: 0.00431
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-SL R-L**
  - AmplSum3
  - Entires: 96
  - Mean: 0.005679
  - RMS: 0.004616
  - Underflow: 0
  - Overflow: 0

- **Asymmetry-SS R-L**
  - AmplSum4
  - Entires: 96
  - Mean: 0.006798
  - RMS: 0.005204
  - Underflow: 0
  - Overflow: 0

- **MeV per DAC - LARGE**
  - AmplSum1
  - Entires: 96
  - Mean: 0.002041
  - RMS: 0.001553
  - Underflow: 0
  - Overflow: 0

- **MeV per DAC - SMALL**
  - AmplSum2
  - Entires: 96
  - Mean: 0.005141
  - RMS: 0.00431
  - Underflow: 0
  - Overflow: 0
Mapping CAL crystals using TKR extrapolated tracks 1/5

• Data set (Merit and Svac tuples, calib v1r0):
  – 2T : B2 + B10 + B13 = 20h, EM v3r3p0
  – 6T : B2 + B10 + B13 = 20h, EM v3r3p0
  – 8T : B2 + B10 + B13 = 20h, EM v3r3p1
  – 16T : B2 + B13 + B30 = 21h, EM v3r4p6

• Select events (% is given for 2 towers)
  – TkrNumTracks==1 (~80%)
  – >6 hits above 2 MeV in at least one tower (~25%)

• Use TKR extrapolated tracks (Tkr1XYZDir) to define hits in crystals:
  – Top and bottom faces must be crossed (no edges, no glancing hits)
  – Compute vertical equivalent deposited energy through path-length correction
Mapping CAL crystals using TKR extrapolated tracks 2/5

Divide each crystal in 9 (3mm) * 54 (6mm) bins

Map of number of hits per bin

Map of mean energy per bin
Mapping CAL crystals using TKR extrapolated tracks 4/5

Map of hits per bin

Map of mean energy per bin
Crystal longitudinal energy response profiles (T4L4 logs)

The shape of T4L4C9 energy response profile has changed between 8T and 16T phases, but no variation observed for LE+/LE-ratio and L-R asymmetry amplitude

F. Piron & E. Nuss (LPTA)
Crystal longitudinal energy response profiles (T5L1 logs)

The shape of T5L1C9 energy response profile has changed between 8T and 16T phases, but no variation observed for LE+/LE-ratio and L-R asymmetry amplitude

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Quantifying inhomogeneity amplitude 1/2

- Fit longitudinal energy response profile with a constant: $\chi^2$
  - Actually fit residuals (not the same stat in all slices)
Quantifying inhomogeneity amplitude 2/2

- Fit distribution of residuals with a gaussian function: expect $\mu \sim 0$ and $\sigma \sim 1$
  - Here residuals are computed over the 9*54 bins (no slices)

Residuals from log mean energy for each crystal bin

Calibration pb?
Quantifying inhomogeneity amplitude: results

**Chi2/ndf**
- Entries: 1536
- Mean: 1.355
- RMS: 0.556

**Mean**
- Entries: 1536
- Mean: 0.004582
- RMS: 0.05327

**Sigma**
- Entries: 1536
- Mean: 1.047
- RMS: 0.07016

T4L4C9 and T5L1C9
Annex: distributions of MPV’s 1/2

- For each log, fit a simple Landau function
  - MPV’s slightly different from David’s ones since function shape is a bit different

- For each module, plot distribution of MPVs
  - \(\langle\text{MPV}\rangle = 11.46 \pm 0.02\) MeV
Annex: distributions of MPV’s 2/2

MPV from Landau fit - single tower

T4L4C9 and bad fit

T5L1C9

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Conclusions

- Trending and crystal mapping show that performances are stable
  - Performance trending:
    - definition of some parameters has been improved (e.g. asymmetry amplitude)
    - some variations observed in LE+/LE- ratio
  - Crystal mapping:
    - shows flat or very flat energy maps
    - 2 anomalies found (among 1536 logs…), being investigated
- To do:
  - Add FM117 to CPT trending
  - Add 8 last towers to calibGenCal trending
  - Write a note!