Performance of a standalone simulation and potential improvements of the ECAL trigger primitive algorithms using LHC Run 2 data

CMS Collaboration

Abstract

This note presents the performance of the ECAL trigger primitive algorithms in LHC Run 2, focusing on the reconstruction of signal amplitudes in the ECAL endcaps. Results are presented on the performance of the standalone simulation and on potential improvements in these algorithms that are being considered for LHC Run 3.
TPG optimization for Run III studies

data/MC validation

The ECAL Group

cms-dpg-conveners-ecal@cern.ch

29/10/2019
The ECAL Group

**TPG optimization for Run 3**

- ECAL Trigger Primitive (TP) generation is based on weights applied on the digitized samples.

- These weights need to be **optimized for Run 3:**
  - Increase **granularity** from one per EB/EE to one per strip (5 channels).
  - Take into account the effects of high **out-of-time PU**.

- A **standalone simulation** has been implemented to re-optimize the weights and have enough flexibility to perform further studies.

- The performance of the new sets of weights in terms of **bias and resolution of the TPs** have been assessed re-emulating full-readout runs in 2017 and 2018 and using the standalone MC.
Preamble: Set of weights under consideration

- **Current**: existing weights (one set for the whole EE) - do not account for crystal damage
- **PU0 new avg**: updated average weights (one set for the whole EE) - accounting for crystal damage
- **PU0**: updated weights for each strip (5 crystal regions) - accounting for crystal damage
- **PU50 S2**: updated per-strip weights - optimised for PU=50 and $E_T=2$ GeV signals
- **PU50 S30**: updated per-strip weights - optimised for PU=50 and $E_T=30$ GeV signals

PU optimised weights give the best performance both in data and in the standalone MC.
8b4e 2017

Performance on DATA

Results are shown only for 2017 run with the 8b4e LHC schema because the effects of the out-of-time PU fluctuations on TP generation are more evident with this schema.

Similar performance improvements have been obtained on 2018 run with the 48b7e LHC schema where out-of-time PU contribution is more flat.
data 8b4e - Bias and Spread by $E_T$

**BIAS**

- CMS Preliminary
- $<\text{PU}>=40$
- $2.3<\eta<3.0$
- LHC filling
- schema: 8b4e
- year: 2017

<table>
<thead>
<tr>
<th>Fractional bias</th>
<th>Strip $E_T$ (GeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.4</td>
<td>&gt;8.0</td>
</tr>
<tr>
<td>1.2</td>
<td>8.0</td>
</tr>
<tr>
<td>1.0</td>
<td>6.0</td>
</tr>
<tr>
<td>0.8</td>
<td>4.0</td>
</tr>
<tr>
<td>0.6</td>
<td>2.0</td>
</tr>
<tr>
<td>0.4</td>
<td>1.5</td>
</tr>
<tr>
<td>0.2</td>
<td>1.0</td>
</tr>
<tr>
<td>0.0</td>
<td>0.5</td>
</tr>
</tbody>
</table>

**SPREAD**

- CMS Preliminary
- $<\text{PU}>=40$
- $2.3<\eta<3.0$
- LHC filling
- schema: 8b4e
- year: 2017

<table>
<thead>
<tr>
<th>Fractional spread</th>
<th>Strip $E_T$ (GeV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.2</td>
<td>&gt;8.0</td>
</tr>
<tr>
<td>1.0</td>
<td>8.0</td>
</tr>
<tr>
<td>0.8</td>
<td>6.0</td>
</tr>
<tr>
<td>0.6</td>
<td>4.0</td>
</tr>
<tr>
<td>0.4</td>
<td>2.0</td>
</tr>
<tr>
<td>0.2</td>
<td>1.5</td>
</tr>
<tr>
<td>0.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>
The plots show the amplitude bias and resolution for different sets of amplitude weights versus signal $E_T$ by strip

○ The fractional bias is defined as: $(\text{online/offline} - 1)$

○ The fractional spread is defined as: $\sigma(\text{online/offline} - 1) / (\text{online/offline})$

○ Error on the points: error on the mean of the bias and error on the spread of the bias

• Dataset: Full-Readout ZeroBias data from November 2017 with PU=40 with the 8b4e filling scheme (8 colliding bunch trains separated by 4 empty bunches) for TPs with $|\eta| > 2.3$

• There is a strong $E_T$ dependence to the amplitude bias and resolution. It is more striking for low energy ($< 2 \text{ GeV}$) TPs (by strip)

• There are significant improvements observed when updating from the current weights, especially at the lowest $E_T$ values.

• PU optimised weights perform the best in term of resolution for all energies.
data 8b4e - Bias and Spread by BX

**BIAS**

- Current
- New (avg)
- Per strip (PU=0)
- PU optimized
- PU optimized

**SPREAD**

- Current
- New (avg)
- Per strip (PU=0)
- PU optimized
- PU optimized
The plots show the amplitude bias and resolution for different sets of amplitude weights versus bunch crossing (BX) position in LHC train.

- The fractional bias is defined as: \( \frac{\text{online/offline} - 1}{\text{online/offline}} \)
- The fractional spread is defined as: \( \frac{\sigma(\text{online/offline} - 1)}{\text{online/offline}} \)
- Error on the points: error on the mean of the bias and error on the spread of the bias

- Dataset: Full-Readout ZeroBias data from November 2017 with PU=40 with 8b4e filling scheme (8 colliding bunch trains separated by 4 empty bunches) for TPs with \(|\eta| > 2.3\)
- There is a strong bunch position dependence to the amplitude bias
- There are significant improvements observed when updating from the current weights, especially in terms of flatness in the response along the LHC train
- PU optimised weights perform the best in term of resolution.
8b4e 2017

DATA/standalone MC comparison
STANDALONE MC

DATA

data/MC comparison 8b4e - Bias by BX
The ECAL Group
TPG optimization for Run 3

23-10-19

11

Caption: data/MC comparison 8b4e - Bias by BX

- Fractional TP Amplitude bias versus position in LHC bunch train
  - for 2017 data and simulation, with 8b4e filling scheme (8 colliding bunch trains separated by 4 empty bunches) for TPs with $|\eta| > 2.3$
    - Data: Full-Readout ZeroBias data from November 2017 with PU=40
    - Standalone MC: Simulated signals with same TP $E_T$ spectrum and BX distribution as data, with PU=40
    - Mean TP energy by strip : 1 GeV
- The plots show the amplitude bias for different sets of amplitude weights:
  - The fractional bias is defined as:
    - data: ( online/offline - 1)
    - Standalone MC: ( reconstructed/true -1)
  - There is a strong bunch position dependence to the amplitude bias, seen in both data and simulation with the same trend
  - There are significant improvements observed when updating from the current weights
data/MC comparison 8b4e - Spread by BX

**STANDALONE MC**

- CMS Simulation Preliminary
- (13 TeV)

- \( \langle PU \rangle \geq 40 \)
- \( 2.3 < |\eta| < 3.0 \)
- LHC filling
- schema: 8b4e
- year: 2017

- Current
- New (avg)
- Per strip (PU=0)
- PU optimized

- PU=50, ET=2GeV
- PU optimized

**DATA**

- CMS Preliminary
- (13 TeV)

- \( \langle PU \rangle \geq 40 \)
- \( 2.3 < |\eta| < 3.0 \)
- LHC filling
- schema: 8b4e
- year: 2017

- Current
- New (avg)
- Per strip (PU=0)
- PU optimized

- PU=50, ET=3GeV
Caption: data/MC comparison 8b4e - Spread by BX

- Spread in TP Amplitude spread versus position in LHC bunch train
  - for 2017 data and simulation, with 8b4e filling scheme (8 colliding bunch trains separated by 4 empty bunches) for TPs with $|\eta| > 2.3$
    - Data: Full-Readout ZeroBias data from November 2017 with PU=40
    - Standalone MC: Simulated signals with same TP $E_T$ spectrum and BX distribution as data, with PU=40
    - Mean TP energy by strip : 1 GeV
- The fractional spread is defined as:
  - data: $\sigma(\text{online/offline} - 1) / (\text{online/offline})$
  - Standalone MC: $\sigma(\text{reconstructed/true} -1) / (\text{reconstructed/true})$
  - There is a strong bunch position dependence to the spread, seen in both data and simulation with the same trend.
  - The spread, or resolution of the TPs, improves when the weights are updated
  - PU-optimised weights perform best, removing the bunch crossing dependence, for both data and standalone MC
Conclusions

- Optimized set of weights show a clear **performance improvement on data**
- **Same trend** in the standalone MC and emulator results
- **Same ranking** for different set of weights in the standalone MC and emulator