HCAL developments for Jets and MET

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Section 1

Introduction

Introduction

- Changes between the Run 1 and Run 2 physics environments are well-documented
- HCAL has implemented hardware upgrades in response
- Software updates must:
  - Account for hardware changes (e.g. recalibration)
  - Respond to physics changes in Run 2 environment

HCAL hardware upgrades during LS1

- HB and HE:
  - Replaced clock, control, monitor modules
  - Removes synchronization problems with isolated sections of HB and HE
- HO
  - Changed hybrid photodiodes to silicon photomultipliers
  - Improves signal to noise for MIPs in HO
- HF
  - Replaced single-anode photomultiplier tubes (PMTs) with thin window multi-anode PMTs
  - Also: installed new cables capable of dual readout
  - Reduces fake signal from PMT window hits

HCAL software responses

HCAL software is responding in many ways,
all of which affect jets and MET

I will discuss three in particular:

1. Calibration
2. Reconstruction
3. Noise filters

Section 2

Calibration

Calibration scope and priorities

- Tuning and development (now - end 2014)
  - Address HCAL shortcomings revealed during Run 1
  - Tune existing Run 1 methods for Run 2 environment
  - Develop new methods when necessary
- Preparing HCAL pre-calibration, (end 2014, 2 months)

  Relying on:
  - Radioactive source calibration: critical for HF startup calibration
  - Cosmics: very effective tool for HO calibration
  - Splashes: useful in 2009 and 2010 for HBHE, not essential in 2015
- Integration of HCAL tools with AlCa (`CMSSW_7_3_X`)
  - If necessary

Calibration outline

Three main areas of focus:

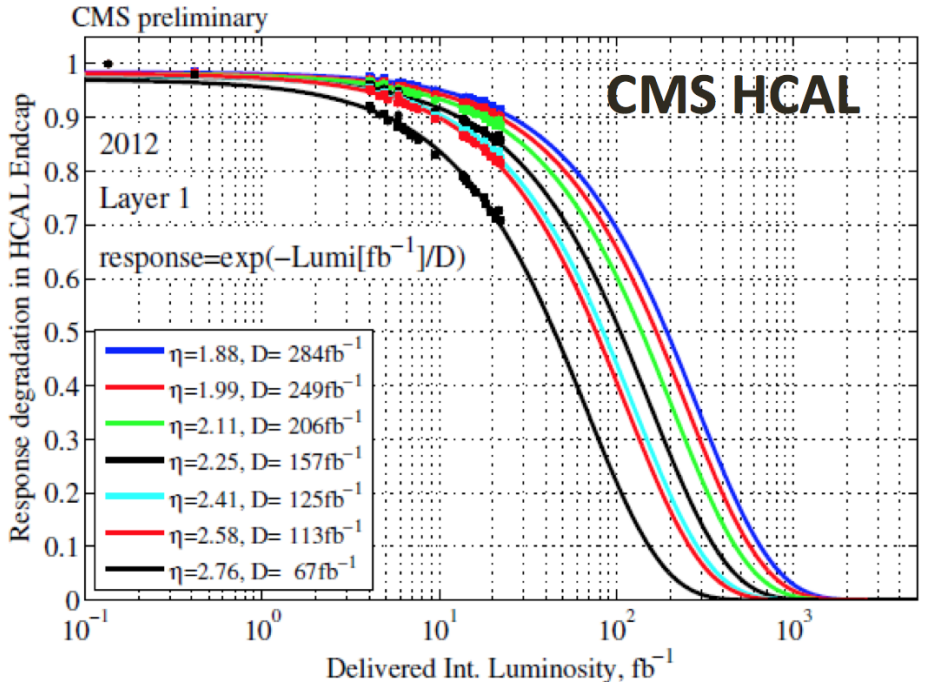
1. Radiation damage correction
2. ϕ symmetry calibration
3. Absolute energy calibration:
   - HB & part of HE: single particle (IsoTracks)
   - HE (& perhaps elsewhere): dijet, γ-jet
   - HF: $Z \rightarrow ee$
   - HO: muons (GeV/MIP sets the scale)

- Conveners: Jordan Damgov and Yurii Maravin

Radiation damage in the HE: what we know today

- In first 20 fb^{-1}, in the high-η region ($|\eta| = 3$)
  - L1 lost 30% orig. signal
  - L7 lost 15% orig. signal
- Even at $|\eta = 2.4|$ the loss was non-negligible
  - L1 lost 15% orig. signal
  - L7 lost 5% orig. signal

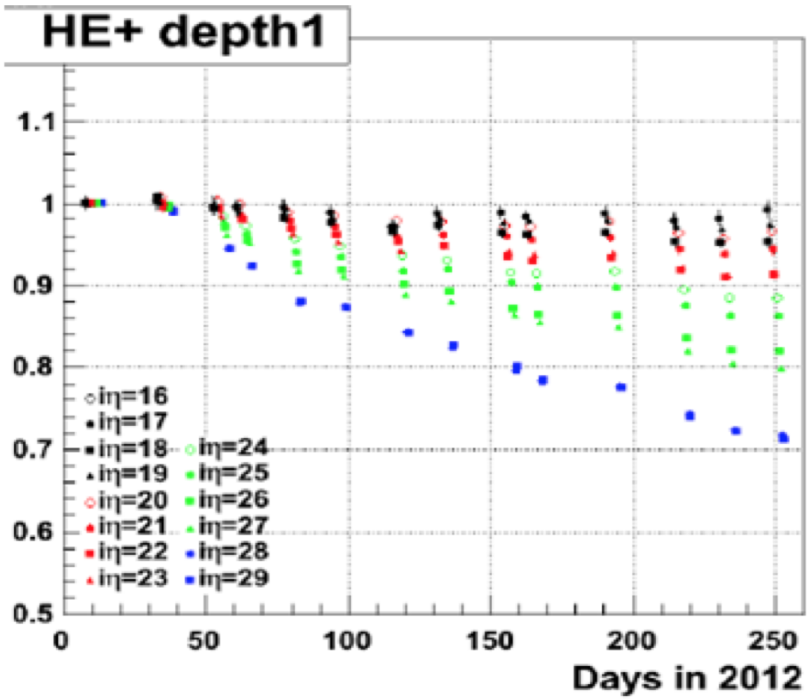
Results for Layer 1 of HE



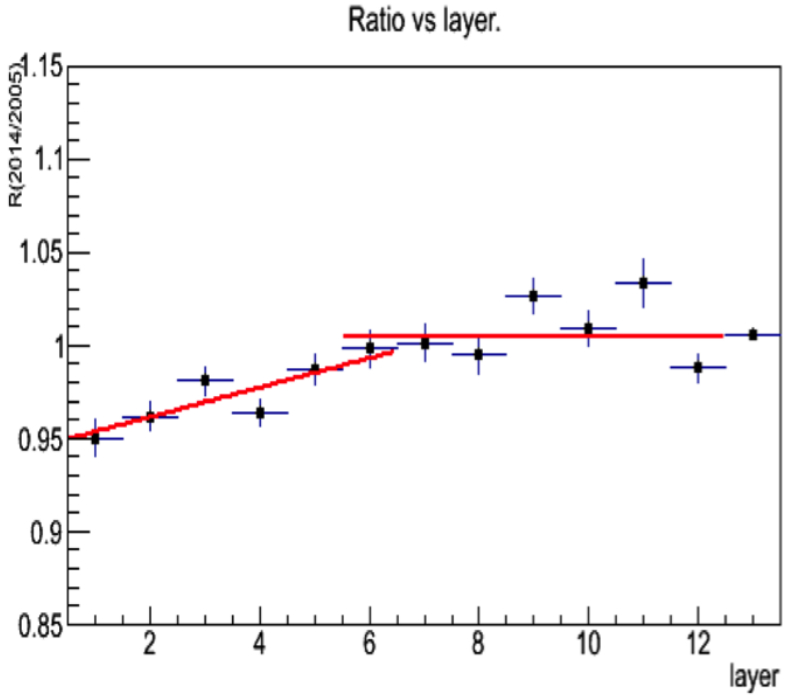
- Raddam work: R. Ciesielski, V. Epshteyn, D. Vishnevskiy

Radiation damage in the HE: how we know it

- In Run 1, radiation damage was monitored with laser measurements
- In 2012, an additional method using pp data with physics triggers was introduced

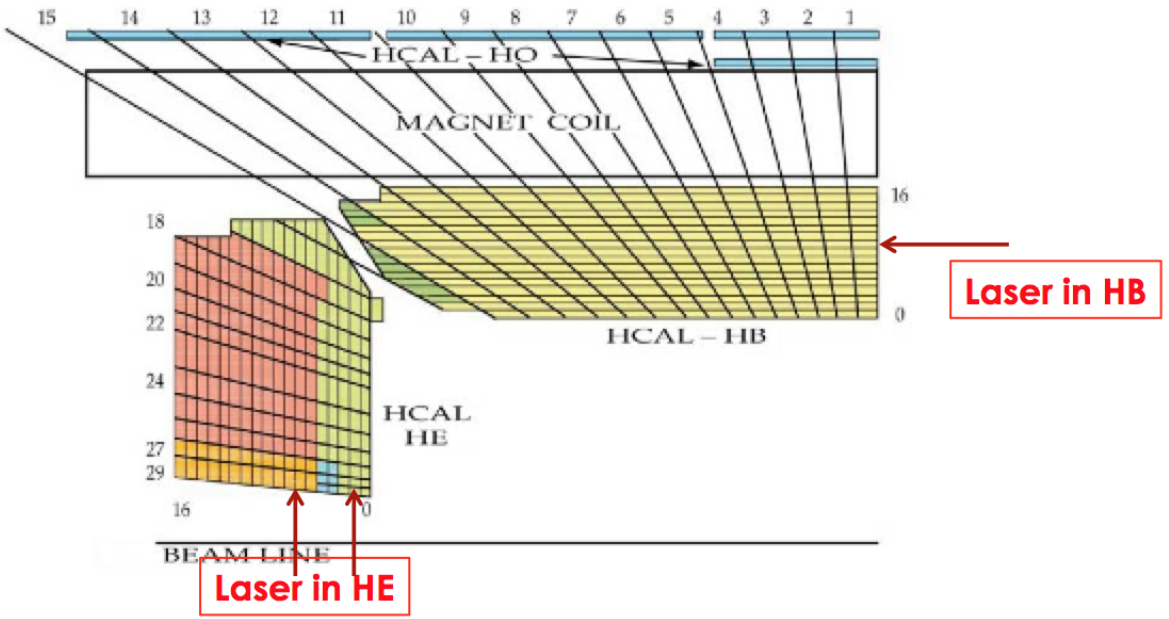


Radiation damage in the HB: what we know today



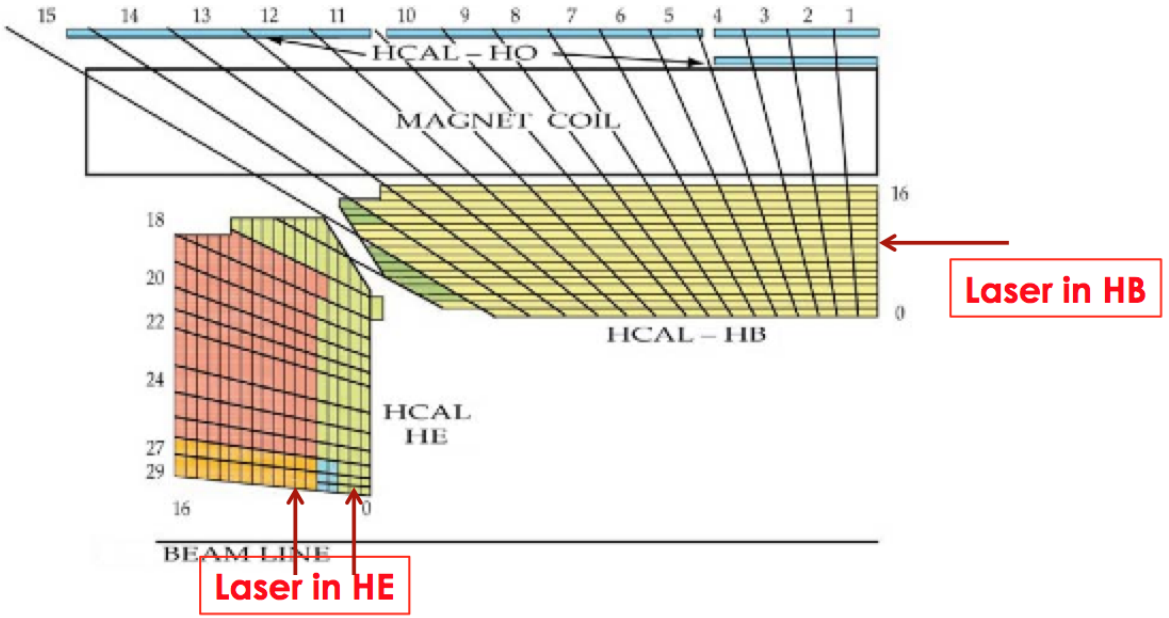
- Ratio of signal from HB Co-60 calibration (2014/2005)
- $2 \times 20^\circ$ wedges on HB-: April, 2014
- Consistent with 5% damage to L1 of HB

Radiation damage in the HB: how we know it



- Laser monitoring can't monitor radiation damage to front layers of HB
- Co-60 calibration (2005, 2014) is the only way to learn about radiation damage to front layers of HB

Radiation damage in the HB: how to deal with it



- More data needed to establish effect beyond stat. fluct.
- Since HB only has 1 depth (unlike HE with 2-3 depths), layer-dependent damage can only be corrected on average, introducing an energy dependence
- Effect can probably be removed by MC corrections.

Radiation damage: what to do about it

- Current plan for HE:
  - Use updated laser measurement algo. and updated laser
  - Use pp data as a less-frequent cross-check
  - First year of Run 2: expect signal loss similar to Run 1
- Current plan for HB:
  - Data suggests layer-dependent radiation damage at 5%
  - More data needed to establish effect beyond stat. fluct.
  - Continue Co-60 sourcing campaign on HB (Friday)
  - 4 additional HB wedges to be sourced
- Correct 2015 data at all levels (L1, HLT, Offline)

ϕ symmetry calibration

- Goal: equalize response in ϕ for η-rings with 2 methods:
- Method of moments
  - Non-zero-suppressed and non-HCAL triggers
  - Worse precision in the HB than iterative method
  - $\sim$ 5 million events yields $\sim$ 2% precision
- Iterative method
  - non-HCAL physics triggers
  - Better precision in the HB than moments method
  - 60 million events yields: 1% HB; 0.2-2.5% HE; 0.3% HF
- Work on both methods is ongoing for Run 2 environment

Absolute HB/HE energy calibration: single particle

- Method for calibration with isolated tracks
- Tracker provides precision momentum measurement
- Require:
  - Good quality tracks reaching ECAL and HCAL
  - Tracks are isolated w.r.t. ECAL energy and other tracks
- Preparing estimates on precision for Run 2 environment
- No IsoTrack trigger coverage in high η HE region

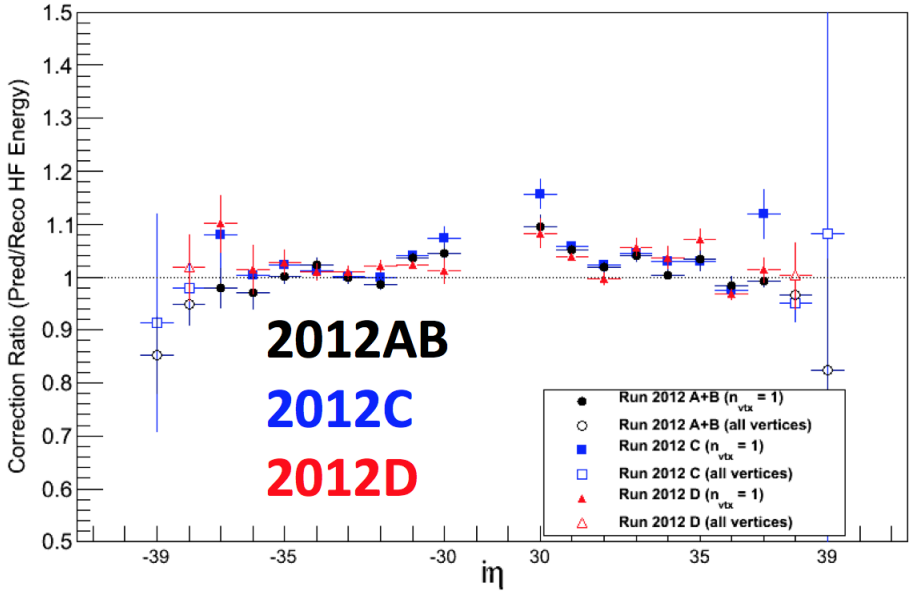
Absolute HE energy scale: dijet balancing

- Method for ring-by-ring calibration with dijet events
- Building on work done by JP Chou (talk, IN2008/046)
- Require:
  - Two PFJets with small $|\Delta\eta|$: i.e. two PFJets in the same part of the jet energy response curve
  - Remove PU using PFJets
    - Need to disambiguate energy corrections
    - Working with PF experts

Absolute HF energy scale: $Z \rightarrow ee$

- 2011 method: DN2011/012
- Require:
  - Precision tag electron in the ECAL with tracking
  - Probe electron in the HF
- For 2015 running:
  - Special trigger needed to collect data at $|\eta| > 4.0$
  - Performance evaluated with CSA14 samples

Results from 2012



Section 3

Reconstruction

Reconstruction scope and priorities

- Primary goal is to develop an algorithm for OOT PU mitigation in 25 ns running (now)
  - A baseline algorithm is ready for `CMSSW_7_2_0`
  - Fine-tuning is ongoing
  - Improvements could go into `CMSSW_7_3_0` (Nov. 10)
- Develop alternative algorithms (until Dec. 2014)
- If we have more than one working algorithm, make a choice for data taking

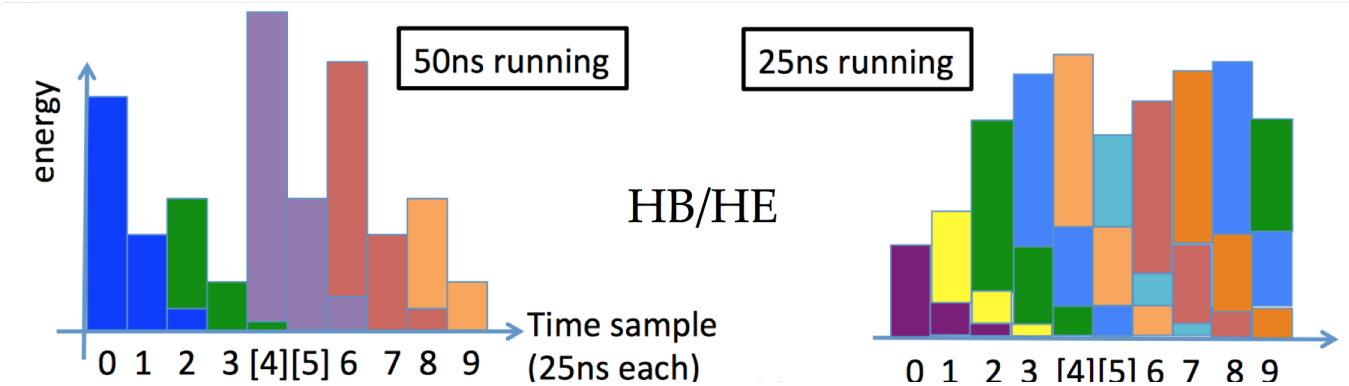
Reconstruction outline

Main areas of focus:

1. Baseline method (complete, improvements ongoing)
2. Alternative method (in development)

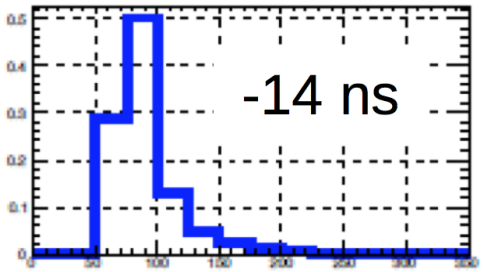
- Convener: Artur Apresyan → Stephanie Brandt

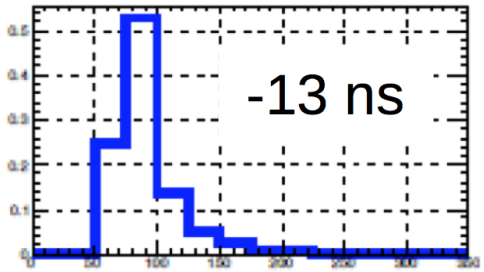
Reconstruction: baseline method

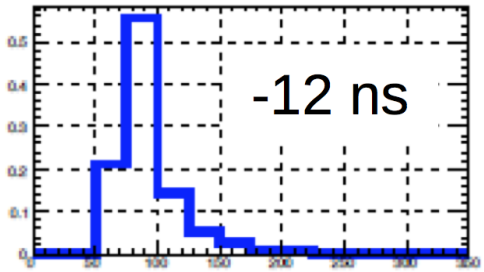


- Algorithm parameterizes pulse shape as function of charge in triggered TS
  - Step 1: Measure shape in data for given $|\eta|$ regions
  - Step 2: Use pulse shape to subtract OOT pulses
- Status:
  - Baseline method validated and ready for `CMSSW_7_2_0`
  - See talk by Artur Apresyan
  - Work is not done! New algorithms are under study!

Reconstruction: alternative method







- Also, new method being investigated by the MIT group
  - Step 1: fit pulse shape for arrival time and total charge
  - Step 2: use fit to estimate the OOT PU contamination in energy when there are two pulses
- Still in development stage, but manpower is present
- Regular status updates in HCAL reconstruction working group

Section 4

Noise filters

Noise filters scope and priorities

- Noise filters that worked in Run 1 need to be updated for the Run 2 environment
- These updates are under development, and the results are encouraging
- Note that these noise filters may change a bit with the reconstruction algorithm

Noise filters outline

Main areas of focus:

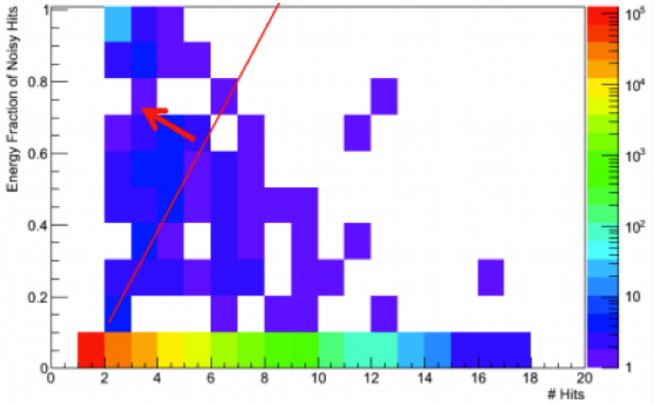
1. R45 upgrade filter
2. Negative energy filter
3. Validation on data and MC & implementation in CMSSW

- Convener: Yi Chen

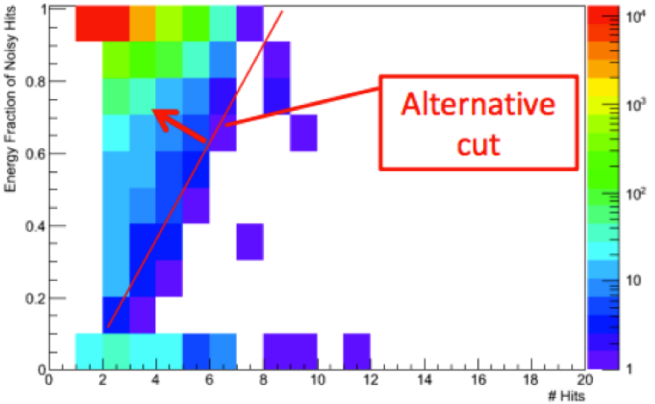
R45 upgrade filter

- $R45 = \frac{TS4-TS5}{TS4+TS5}$ used in 2012 to identify RBX noise
- New method needed for 25 ns
- An RBX with a large fraction of energy coming from "noisy" RecHits is suspect
- Initial results encouraging
- Need more work to finalize version in CMSSW

Healthy RBX



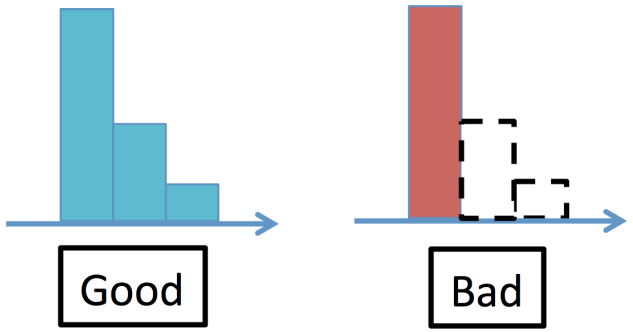
Noisy RBX



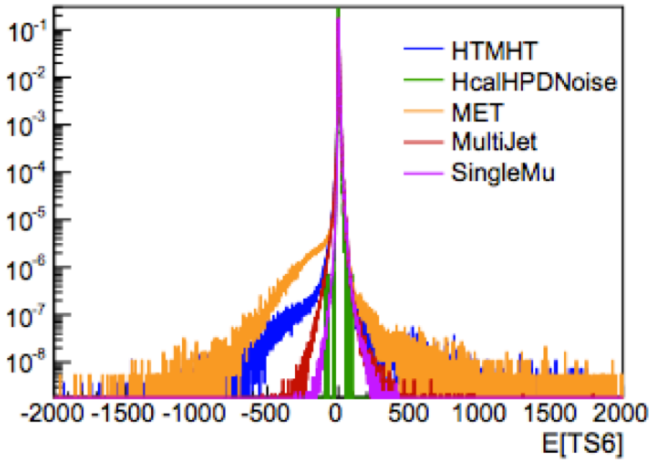
Negative energy filter

- New HCAL reconstruction corrects for expected tail from previous time samples
- For spike-like noise, reconstructed energy from TS6 can be negative
- Initial results encouraging (see plot for data, right)
- Need more work to finalize version in CMSSW

Cartoon of effect



OOT PU-corrected TS6 in data



Section 5

Conclusion

Conclusion

- HCAL is preparing for data taking in 2015
- Lots of new developments are underway:
  - New/updated calibration efforts
  - New/updated noise filtering algorithms
  - New OOT PU mitigation algorithms
- Some improvements are already in place
- Other improvements are coming soon
- Questions are welcome