ECAL reconstruction in 31X/32X

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- Local reconstruction
- Clustering

Local reconstruction

Amplitude and time reconstruction

- Given the recent developments for the time reconstruction (ratio method), a new strategy has been adopted for the amplitude/time reconstruction
  1. amplitude: weights method always performed, unless saturation
  1. if saturation, amplitude with the leading edge method
  2. time reconstruction: ratio method
  3. if signal is out of time, reconstruct amplitude also with the ratio method and store it in the unused bits of the recHit flags
- The thresholds to decide when a signal is out of time and other details may still be improved, and CRAFT can be a useful environment where optimize them

Local reconstruction

Handling of saturated signals

- The simulation has been corrected to reflect the electronics behaviour in case of saturation
  - hysteresis properly emulated: when a sample saturates the 5 subsequent samples are at `gain0` and `MAXADC` value
- The unpacker has been adapted to cope with the new electronics emulation
- The leading edge method and its application have been improved
  - the fifth sample only is used
  - if the fifth sample also saturates:
    - the amplitude value is set to the maximum ADC value (4095) times the ratio between the fifth sample and the sixth (about 0.75)
    - the flag is set to `kSaturated`, i.e. the recovery with the leading edge method was not possible

N.B. the amplitude is then multiplied by the intercalibration coefficients to make a recHit: saturation of the fifth sample does not imply a fix energy value for all crystals (it will be `MAXADC` $\times$ IC coeff.)

Local reconstruction

Killing of dead channels

- Since 31X we have for the first time a detailed DB information about the channel status
  - until then it was just binary (0=good 1=bad)
  - more details here https://twiki.cern.ch/twiki/bin/view/CMS/EcalChannelStatus
- The simulation does not reproduce dead channels
- We have the cfg parameter `killDeadChannels` to switch on the killing of the dead channels, for a realistic simulation of the detector conditions
  - if the dead channel is in an "interesting region" according to the SRP then it will be in the recHit collection with zero energy and flag `kDead`
  - if the dead channel is in a Zero-Suppresed region, it will not be in the recHit collection

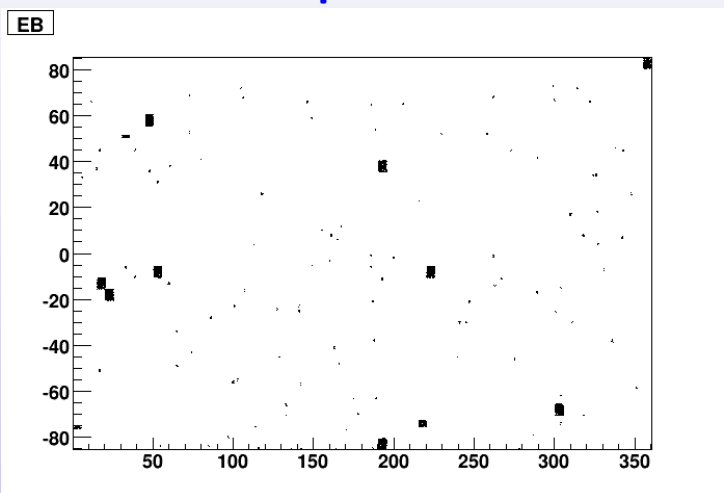
  $\Rightarrow$ when you have a `kDead` channel in the collection it means that some energy has been potentially lost
  - all the above applies also to the recHits of the dead trigger towers

Local reconstruction

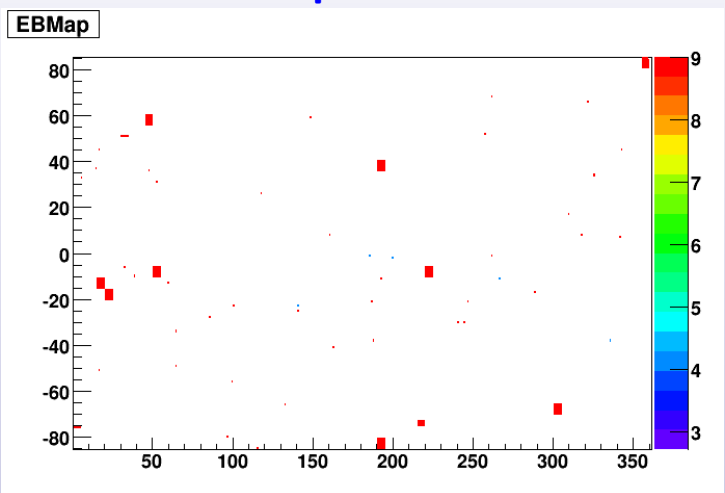
Killing of dead channels

- Example of a map of killed channels

Data Base map of dead channels



Simulated map of dead channels



Local reconstruction

Recovery of dead channels

- Can be switched ON/OFF via configuration file (OFF by default in 3XX)
- Active only for channels with potential energy deposited: it depends on the Selective Readout information
- The recovery of single channels is made with a Neural Network based algorithm
  - another algorithm is being studied, which is shower-shape based and could handle also more complicated topologies of missing channels, as we already have in the detector (e.g. 5×1 dead channels, due to dead VFE)
- The recovery of Trigger Towers is made sharing the Trigger Primitive energy among the channels of the TT
  - the endcap part is present but has not been validated ($\Rightarrow$ always OFF)

Local reconstruction

Flagging system

- An appropriate flagging system has been put in place to track the reconstruction quality

```
// recHit flags
enum Flags {
        kGood,                  // channel ok, the energy and time measurement are reliable
        kPoorReco,              // the energy is available from the UncalibRecHit, but approximate (bad shape, large chi2)
        kOutOfTime,             // the energy is available from the UncalibRecHit (sync reco), but the event is out of time
        kFaultyHardware,        // The energy is available from the UncalibRecHit, channel is faulty at some hardware level (e.g. noisy)
        kPoorCalib,             // the energy is available from the UncalibRecHit, but the calibration of the channel is poor
        kSaturated,             // saturated channel (recovery not tried)
        kLeadingEdgeRecovered,  // saturated channel: energy estimated from the leading edge before saturation
        kNeighboursRecovered,   // saturated/isolated dead: energy estimated from neighbours
        kTowerRecovered,        // channel in TT with no data link, info retrieved from Trigger Primitive
        kDead                   // channel is dead and any recovery fails
};
```

- In case of `kOutOfTime` additional information are available in the recHit, namely the energy reconstructed with the ratioMethod (this can be optimized)

- the full set of status and of corresponding flags is documented here: https://twiki.cern.ch/twiki/bin/view/CMS/ECALDPGFramework
- physics objects should be adapted to handled the recHits flags (using the severity level tool) accordingly

Local reconstruction

Further actions (POG contributions)

- The channel flagging system along with the severity levels need to be extensively tested, as until now it has been tested only on RelVals, and we know data are always different from MC...
- The channel recovery also needs to be extensively tested, especially the impact on physics:
  - with and without recovery
  - electron reconstruction (efficiency, energy resolution, strategies for ECAL-tracker combinations etc.)
  - electron identification (discriminating variables, fakes etc.)
  - jets/MET reconstruction (energy resolutions, fakes etc.)
- The construction of clusters and other physics objects (PF clusters, calo towers for jet/MET) needs to take flags and severity level into account
- PFlow already subscribed to the contribution lists, and so should $e\gamma$ and Jet/MET POGs!

Clustering

Energy corrections

- Updated corrections w.r.t 2XX have been provided for 3XX.
- Now flexible update of parameters via DB if the correction does not change the form of the function
- Current correction schema for standard superclusters (hybrid in EB, multi5x5 with preshower in EE):
  - $f(\eta)$ to describe the shower leakage (not applied for EE)
  - $f(\text{brem})$ to describe the clustering response
  - $f(E_T, \eta)$ to describe the loss due to material
- Uncertainty on the measured energy is also provided (parametrized from MC)

Further actions (POG contributions)

- Association with the pre-shower energy in the EE to be optimized
- Usage of the new energy uncertainty parametrization in the electron objects (tracker-ECAL combination)
  - electron category dependence?
- Interplay between super-cluster corrections for photons and electrons

Clustering

Local containment and crack corrections

- Of the two available studies (Locci[†]/Tourneur[‡]) one[‡] has been implemented it into 3XX but it is not used in the reconstruction chain
- Both studies correct unconverted photons in EB, one[†] is based on TB data, the other[‡] on Monte Carlo studies

[†] see for example http://indico.cern.ch/contributionDisplay.py?contribId=0&confId=40928

[‡] see for example http://indico.cern.ch/contributionDisplay.py?contribId=10&confId=35821

Further actions (POG contributions)

- Converge on a single correction method after a detailed comparison of both
- Study the corrections for EE (basically from scratch!)
- What about electrons? Some preliminary studies[†] suggest that a curved trajectories may end up in an equivalent under/over-tilt of the crystals: to be confirmed and corrected for with an appropriate strategy (particle-level correction instead of super-cluster level?).

Summary

Local reconstruction

- Not mentioned in the talk but worth to do it in the summary: the Preshower is fully operational in the Cosmics Sequences
- Much has been done to achieve a detailed handling of the real detector conditions
- Now is POG-playing time: evaluation of the impact on physics (electrons, jets, MET) of the recovery procedures, recHit flags and severity levels will provide useful feed-back for further developments

Clustering

- Super-cluster energy corrections and energy uncertainties have a well designed strategy, they may be improved especially in the endcaps, where we need to fully understand and exploit the preshower
- Local containment/crack corrections are close to be finalized for unconverted photons in the barrel. Still need to
  - find a strategy to correct electrons
  - find a strategy for the endcaps
  - define the best way to integrate them in the current correction schema

N.B. Keep all the corrections as much factorized as possible

If you want to contribute, there is always room for it!