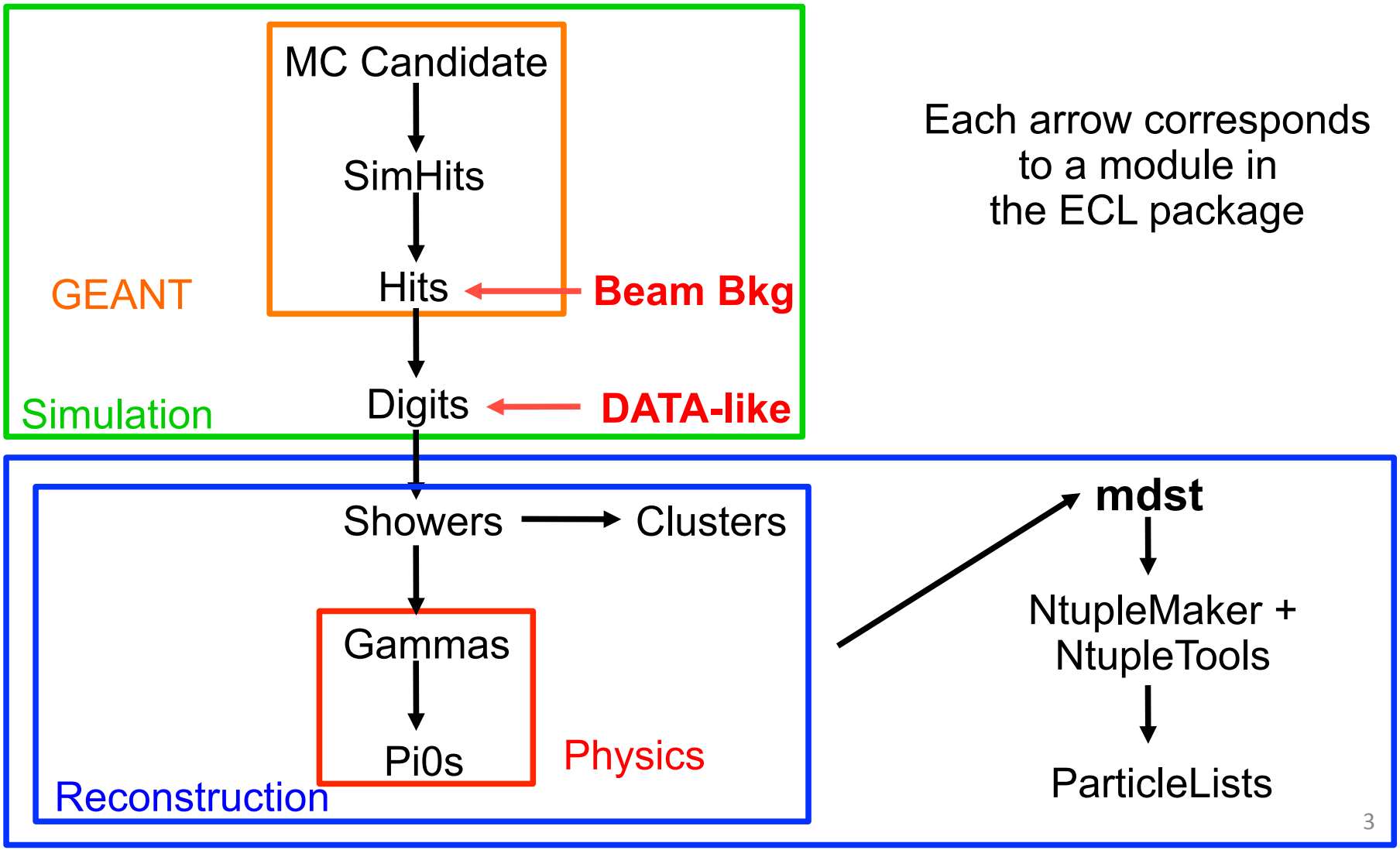
Updates on ECL Software Status

E. De Lucia for the Italian ECL Group

Introduction

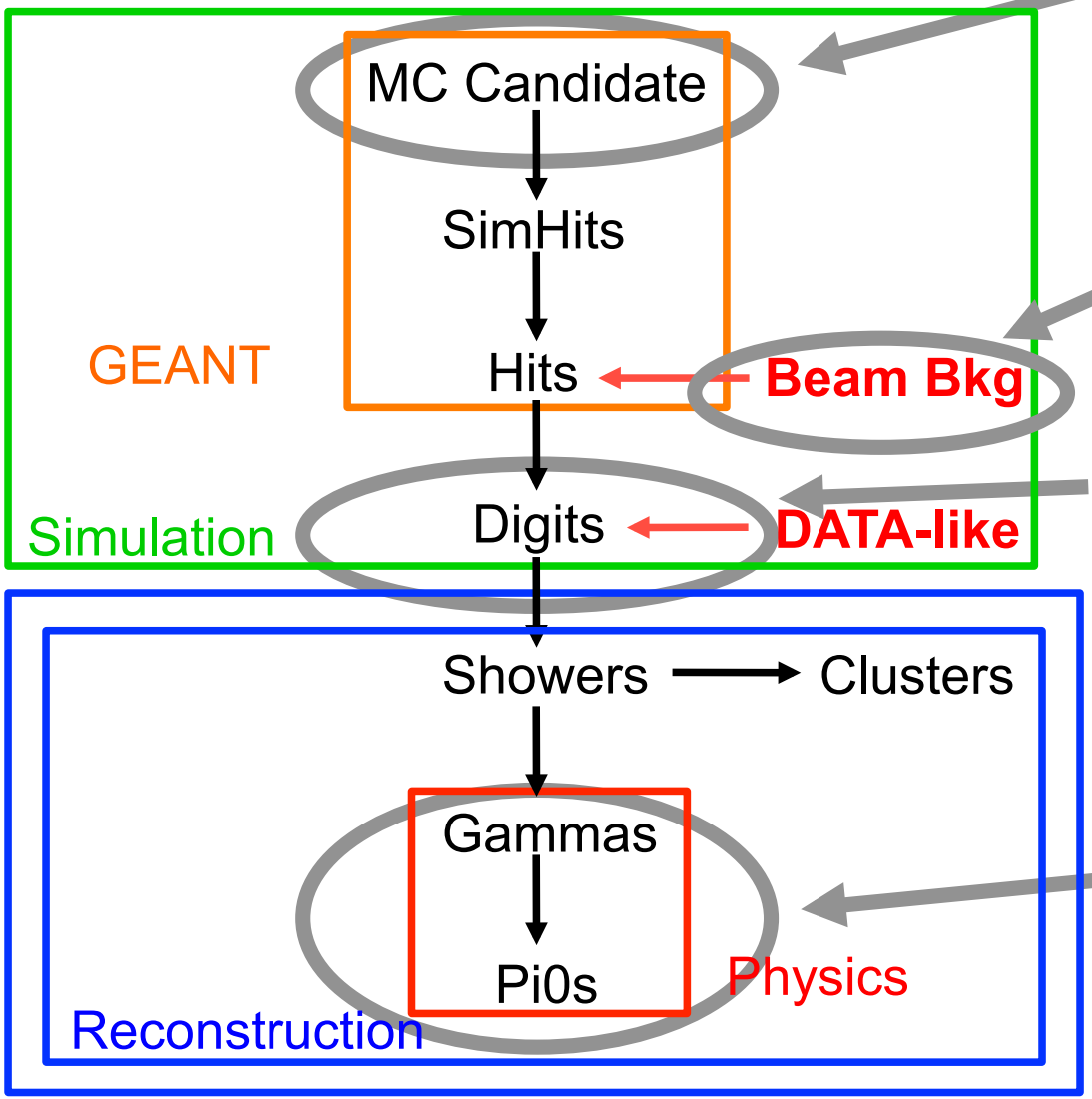
- *Recently several members of the ECL Italian group got involved in ECL SW activities to establish if the performance of existing ECL is enough to ensure requested physics accuracy*
- *The study of the physics case for the upgrade relies mainly on:*
  - *The possibility to simulate degraded conditions as well as different detector components*
  - *A reliable and realistic background simulation*
- *We started with performance simulations and soon realized that there were some code flaws and developed our own tools more suited to analyze ECL performance*
- *Contributed to a more realistic background simulation for ECL and now commited to several tasks*
- *Preliminary performance studies have recently started together with software code development*

ECL Software Overview (I)



Each arrow corresponds to a module in the ECL package

ECL Software Overview (II)



MCMatching, exhibits flaws in particular for multiple association (e.g. more than one candidate contributing to the same cluster)

Beam Background Simulation study its effect on ECL reconstruction & performance

Digitizer has to be generalized to account for different crystal materials and/or read-out electronics

EclDataAnalysis: new ntuple maker. Official ntuple structure not very well suited for ECL performance studies

EclDataAnalysis Module

- basf2 Ntuple maker tools were found not to be ideal for ECL performance study
  - entries not stored event-wise
  - ECL info for tracks not dumped (now fixed by A. Zupanc)
  - (some vars related to MC matching not properly filled, fix in progress)
- Implemented, tested and committed our own Ntuple maker module:

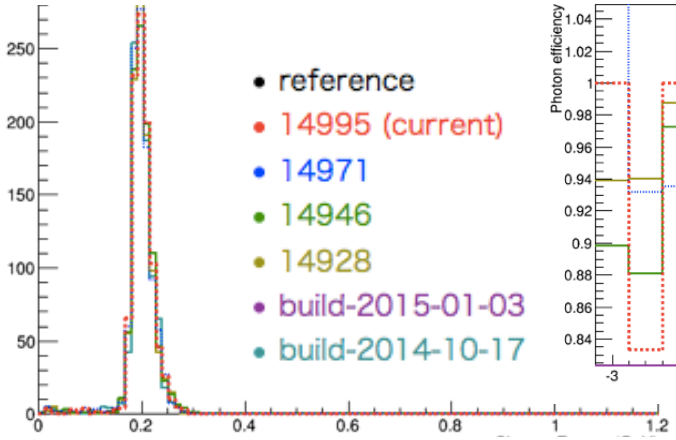
ecl/modules/EclDataAnalysis

  - reads dst data and fills event-wise:
    - ECLSimHit, ECLHit,
    - ECLDigit, ECLShower, ECLCluster,
    - ECLGamma, ECLPi0,
    - MCParticle, TrackFitResult
  - includes info from RelationArray which link, for example,ShowerToGamma, ClusterToShower, Pi0ToGamma (not present in official NtupleTools)
  - saves root file with an ntuple
- N.B. ECLGamma and ECLPi0 modules will soon become obsolete and replaced with Particle Loader and Combiner

ECL Validation Plots using EclDataAnalysis (I)

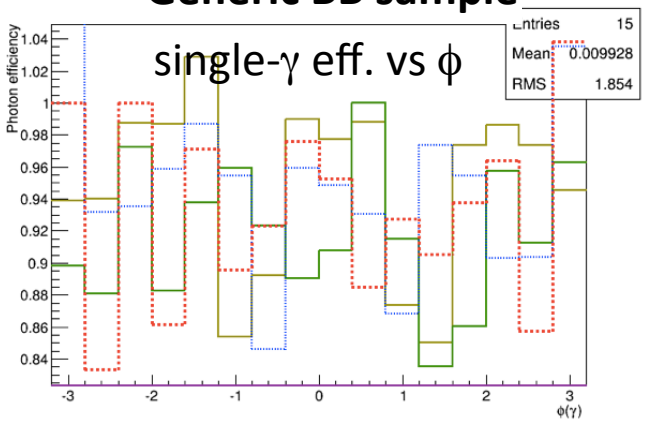
- Validation scripts are run daily producing plots to monitor performance of the various subdetectors to be checked by offline shifters
- For ECL few scripts available and not matching quality requirements

1 GeV single-μ sample

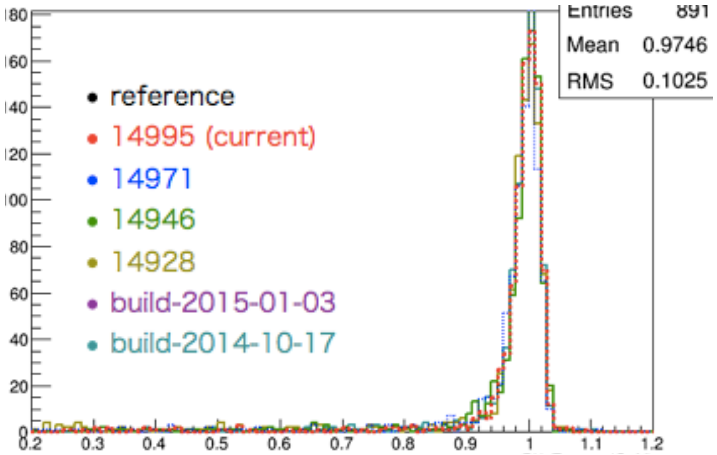


Shower Reconstructed energy (GeV)

Generic BB sample



1 GeV single-π^0 sample

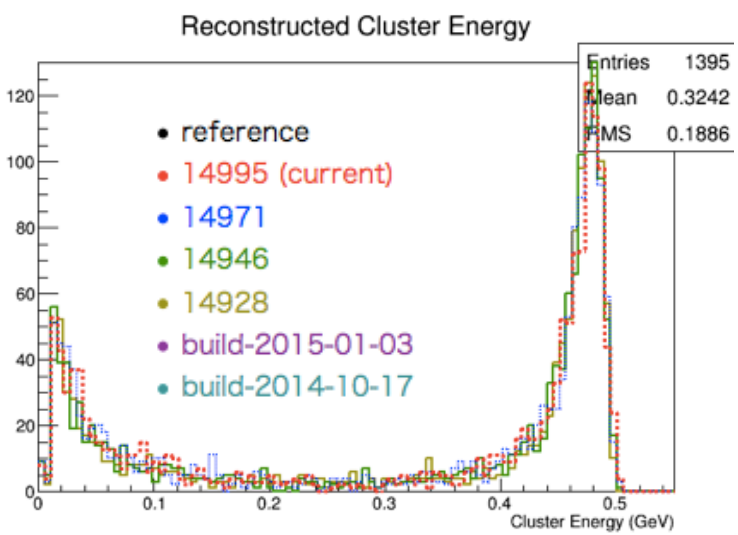


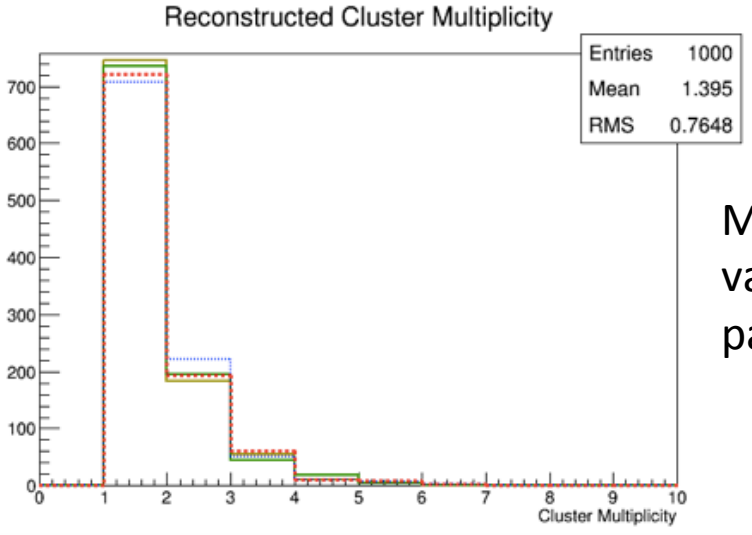
Reconstructed π^0 energy (GeV)

- During last B2GM T. Kuhr requested new scripts to the ECL SW group
- We agreed to be responsible for various sets of plots and first versions have recently been commited and are undergoing tests

ECL Validation Plots using EclDataAnalysis (II)

- Added validation plots for ECLCluster
  - code: ecl/validation/ECLClusterRec.py, ecl/validation/ECLCluster.C
  - generate 500 MeV electrons, thetaParams : [40., 120.], phiParams: [0, 360]





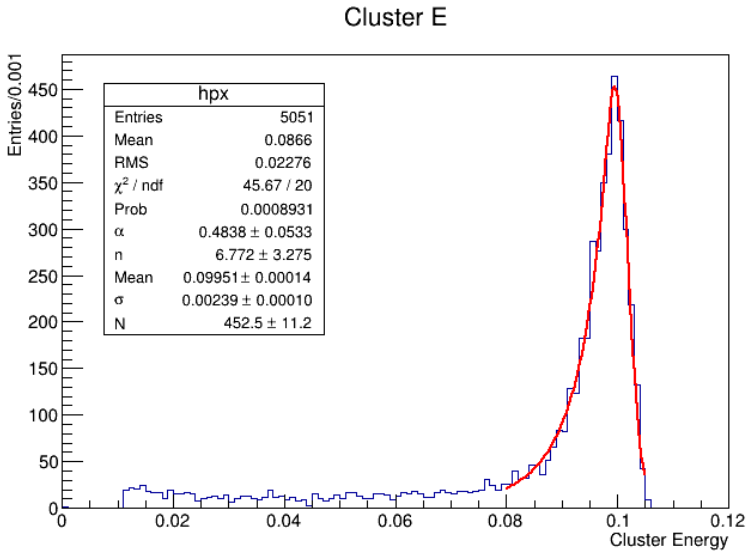
More plots on the validation plot web page

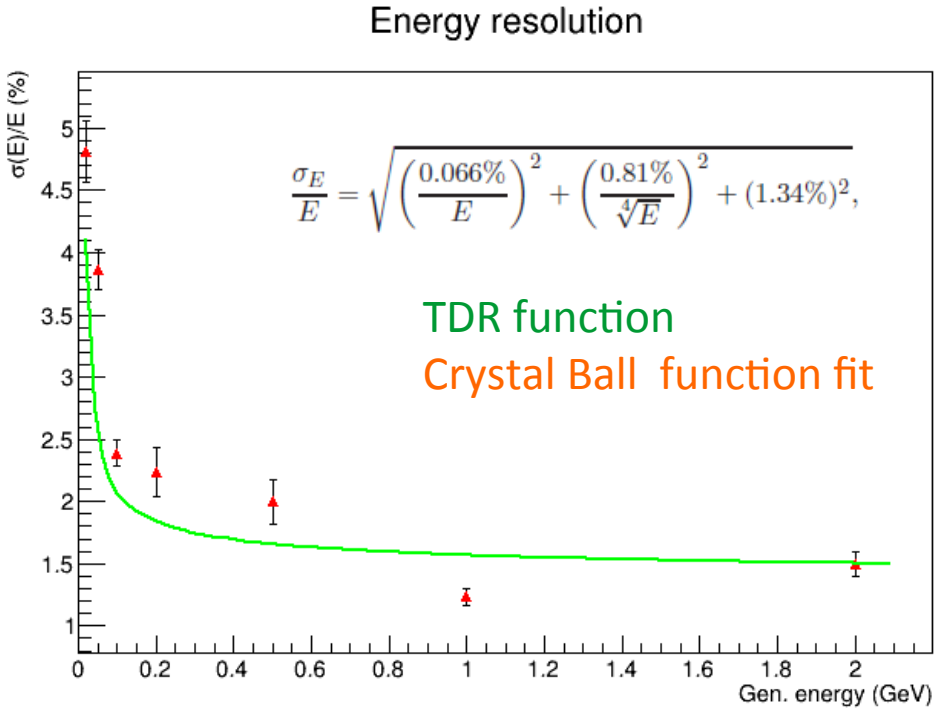
- New validation plots added for charged π and those for π0 coming soon
- Proposed to add following plots:
  - energy resolution estimate by Crystal-Ball or log Gaussian fit (50 MeV, 100 MeV, 1 GeV, 2 GeV)
  - 2D occupancy plot

any other request/suggestion?

ECL Validation Plots: Energy resolution

- *Energy range 20 MeV to 2 GeV, 5000 events each, 20° < θ < 24°*
- *Cluster Energy distribution fit with Crystal Ball function*



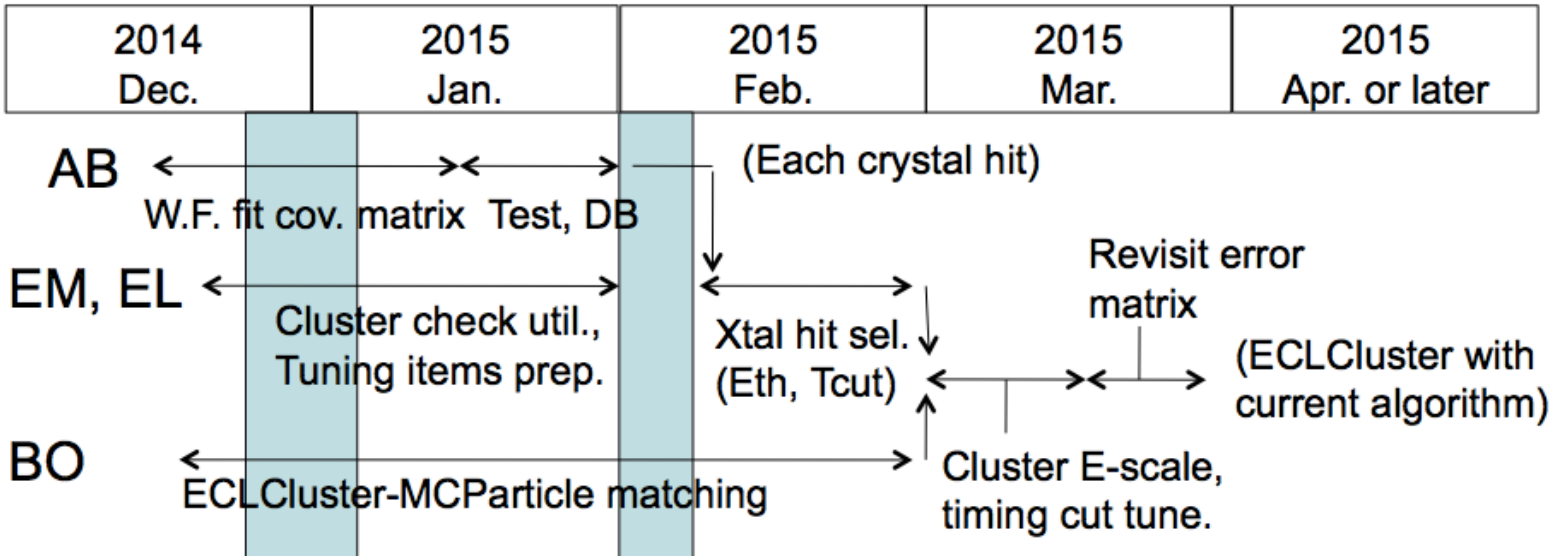


- For validation plot automated scripts the usage of a log Gaussian function has been suggested and its implementation in ongoing

ECL-related Software tasks

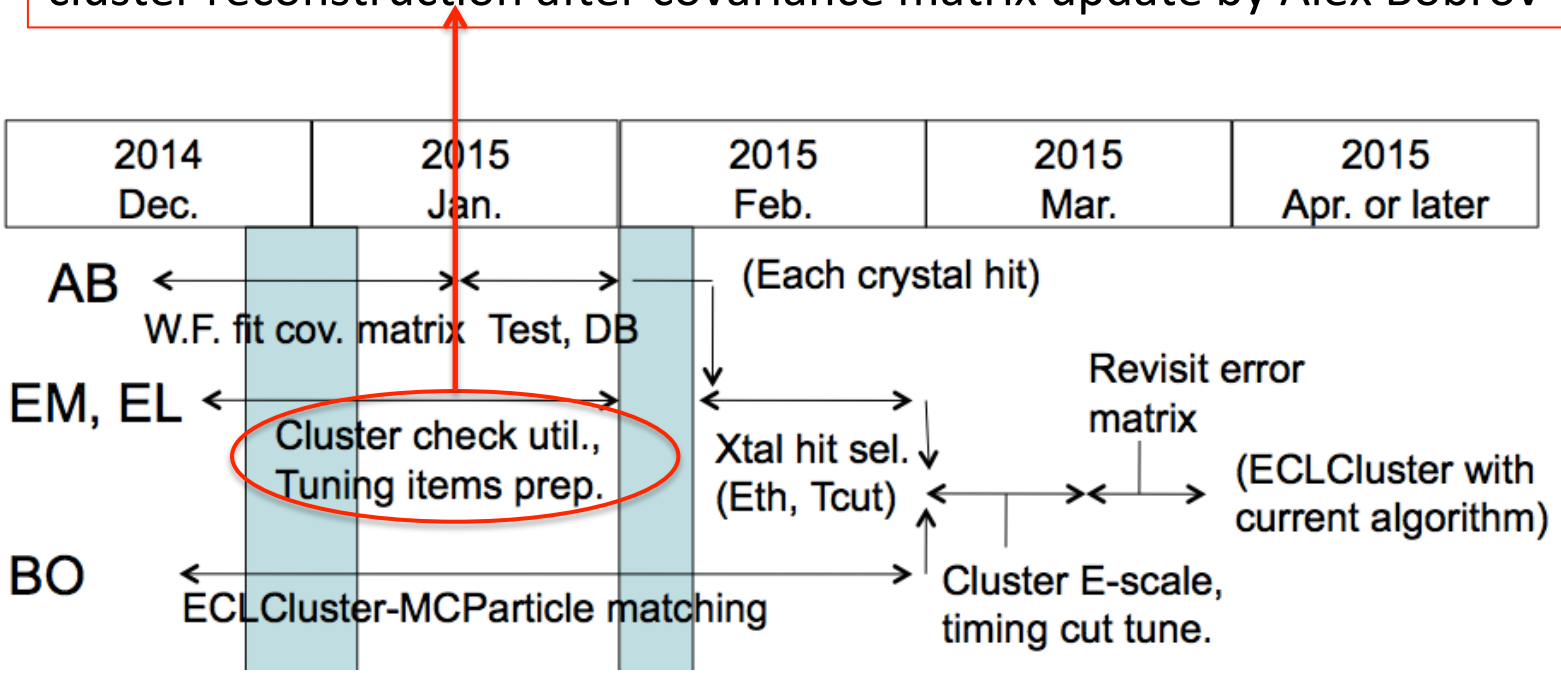
Working ECLCluster to MCParticle truth matching (with beam background mixed in)	Benjamin Oberhof
ECLCluster reconstruction without the bias in energy when beam background is mixed in	Alex Bobrov
Proper treatment of ECLClusters timing and selection to reduce the array size when beam background is mixed in	Elisa Manoni or Erika de Lucia

Short term plan from Miyabayashi-san



ECL-related Software tasks

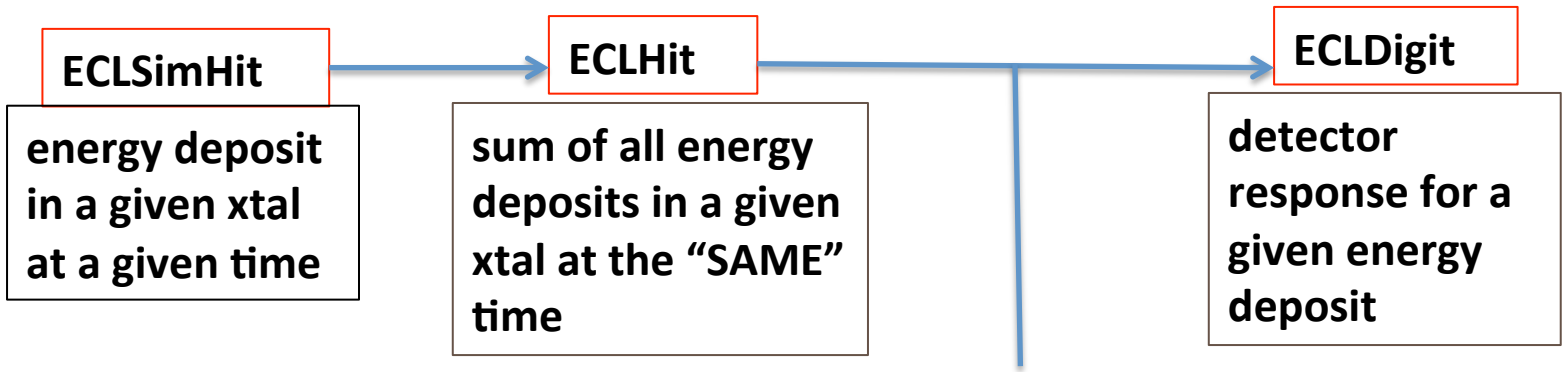
- Cluster check utility – DONE, validation tools
- Tuning items preparation : define variables and set up utility to check cluster reconstruction after covariance matrix update by Alex Bobrov



Tuning items preparation: Covariance matrix in ECL

- The signal digitization (from Hit to Digit = DATA-like information) is implemented in ecl/modules/eclDigitizer/src/ ECLDigitizerModule.cc

- A sketch of the code flow:



  - **from Hit deposit, derive 31 samplings for waveform fit using hit energy, expected signal shape and electronic noise (covariance matrix)**
  - **perform waveform fit through solution of a system of linear equation in which the covariance matrix enters**

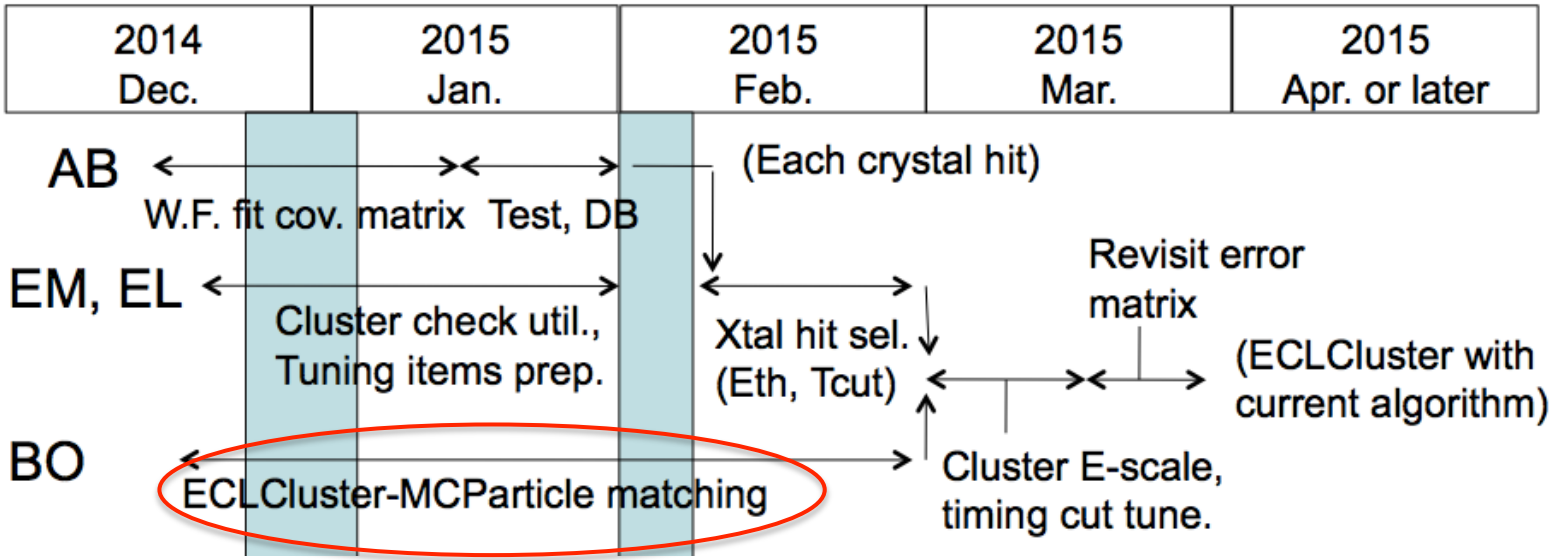
- The covariance matrix will be updated by Alex Bobrov and this update needs to be validated

Tuning items preparation: Covariance matrix validation

The following checks have been proposed for validation

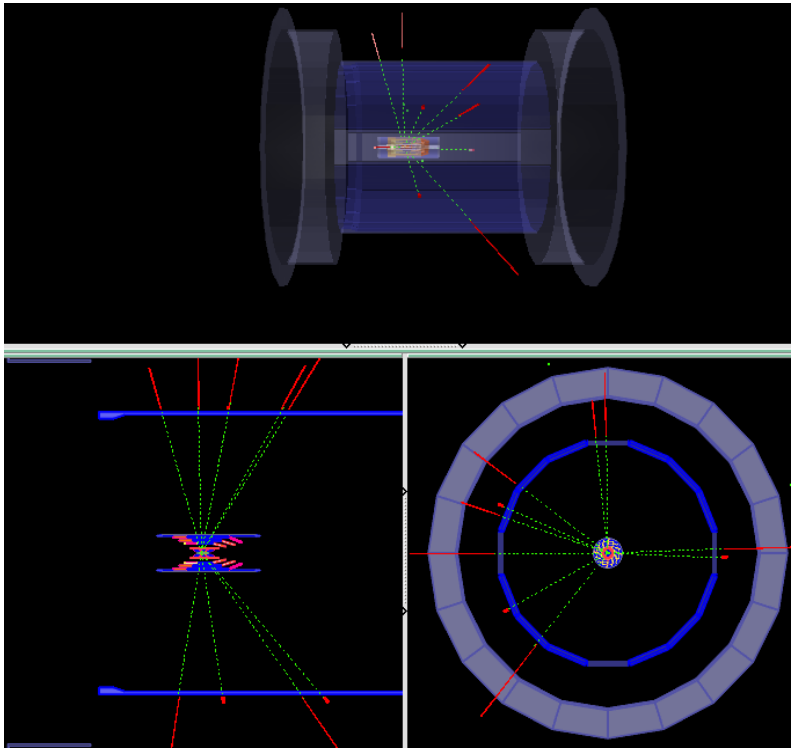
- Compare Hit and Digit quantities
  - Hits: CellId, EnergyDep, TimeAve(,shiftInTime (needed for beam background mixing))
  - Digits: CellId, Amplitude, timeFit (, FitQuality)
- How does the comparison look like using old and new covariance matrix?
- Check energy resolution generating several single-energy photons and evaluating the contribution related to electronic noise. (May be not so sensitive to new covariance matrix implementation)

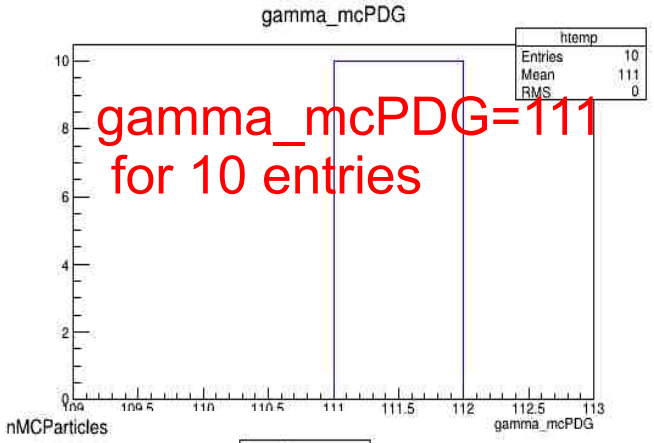
ECL-related Software tasks

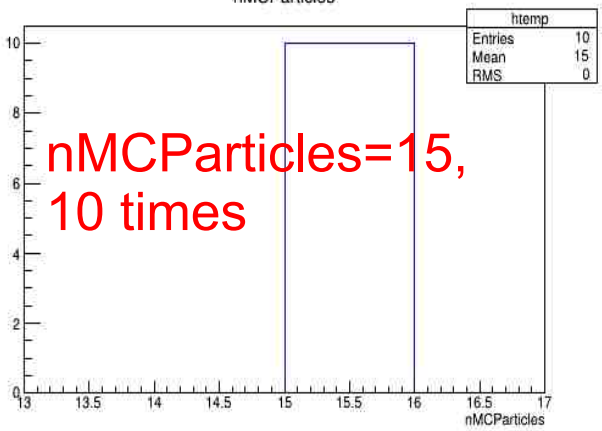


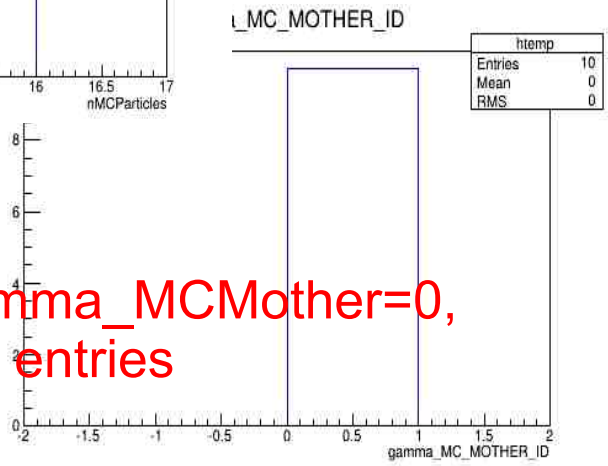
ECLCluster – MCParticle matching(I) *From last B2GM*

- *MC matching has some flaws*
- *e.g. 5 pi0s, 1 GeV each, 1event*





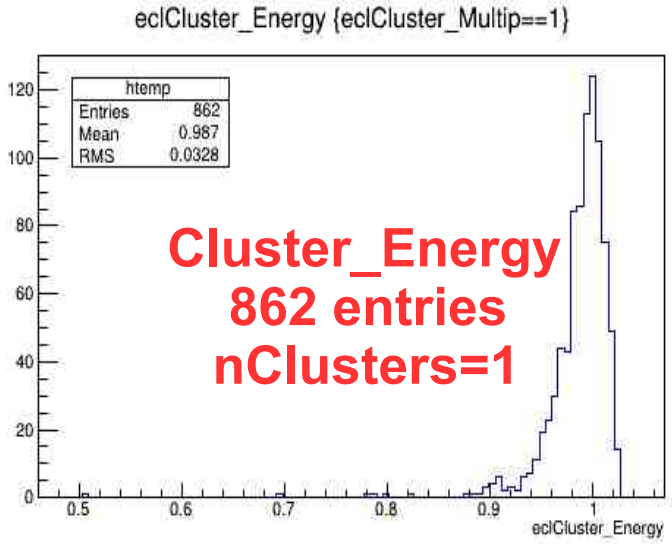




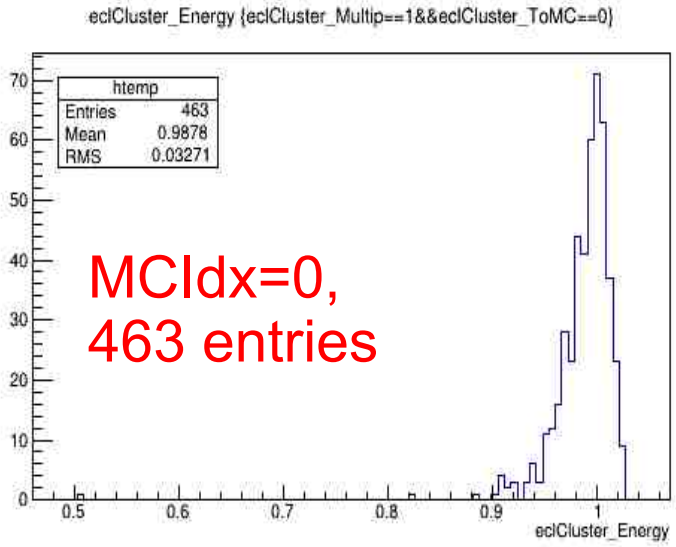
- *Further problems arise once bkg is added*

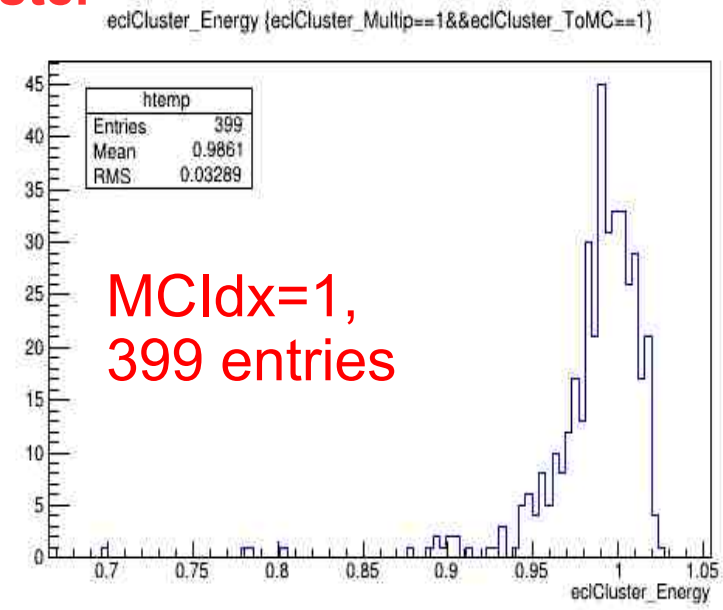
ECLCluster – MCParticle matching(II) *From last B2GM*

- *Two "nearby" photons Δϑ < 1°, Δφ < 1°*
- *500 MeV each, single cluster 1 GeV*
- *Cluster info is not shared between the MC cands*
- *1 cand is associated with all clusterE*



MCCandidate_Idx associated to cluster

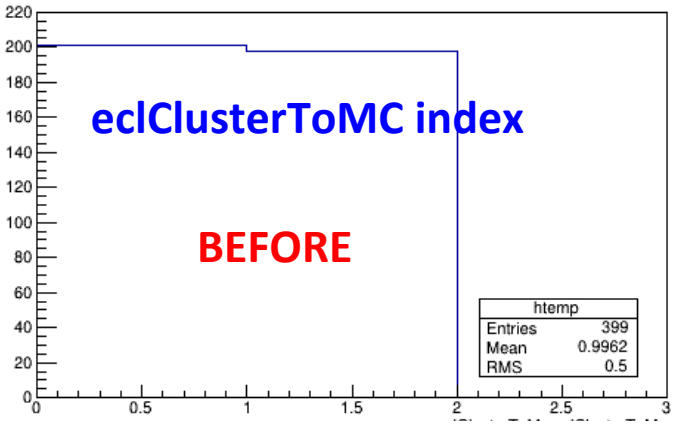


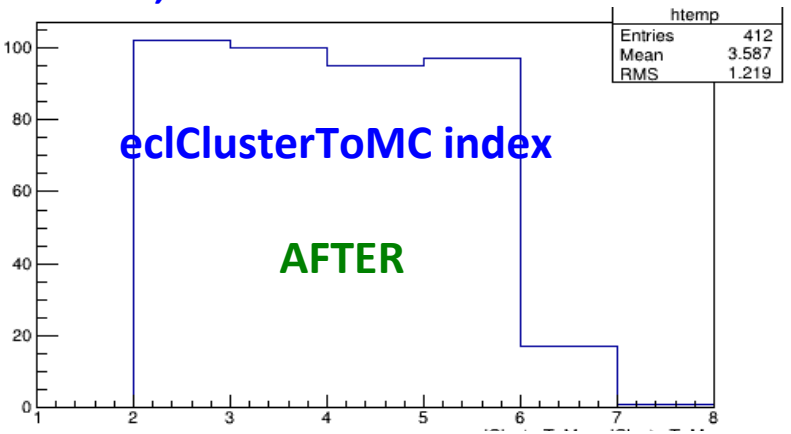


ECLCluster – MCParticle matching (III)

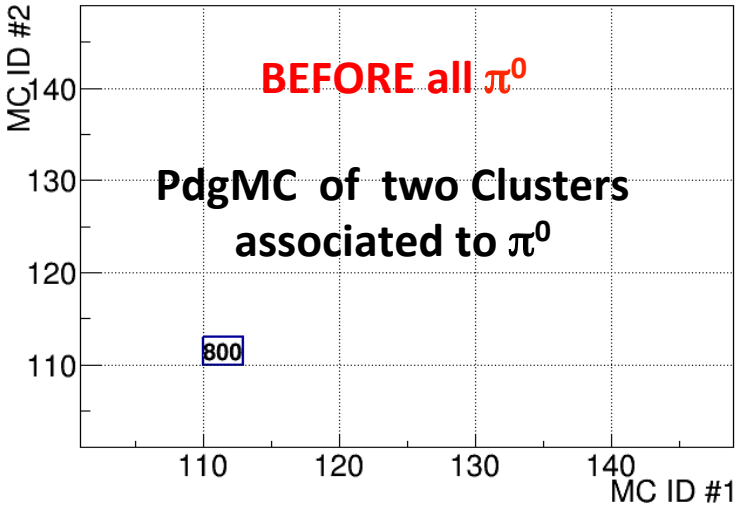
- MC Truth for daughter particles has been fixed in `EclMCMatching` (no bkg)

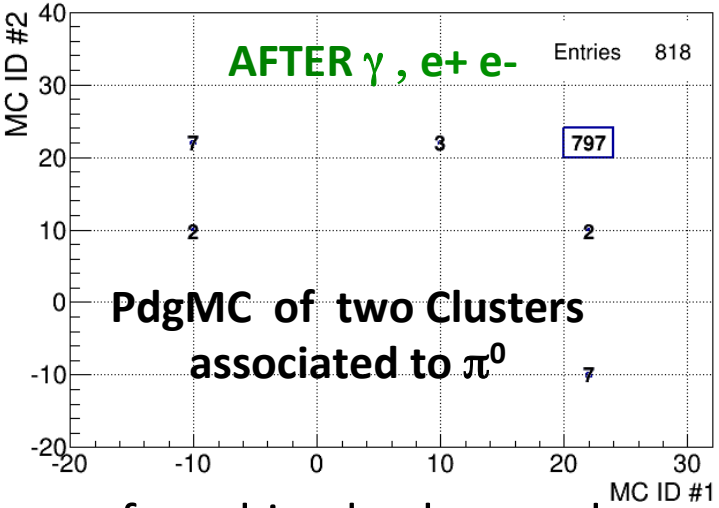
2 π^0/event, E=0.5 GeV, 100 events





π^0/event, E=0.5 GeV, 1000 events

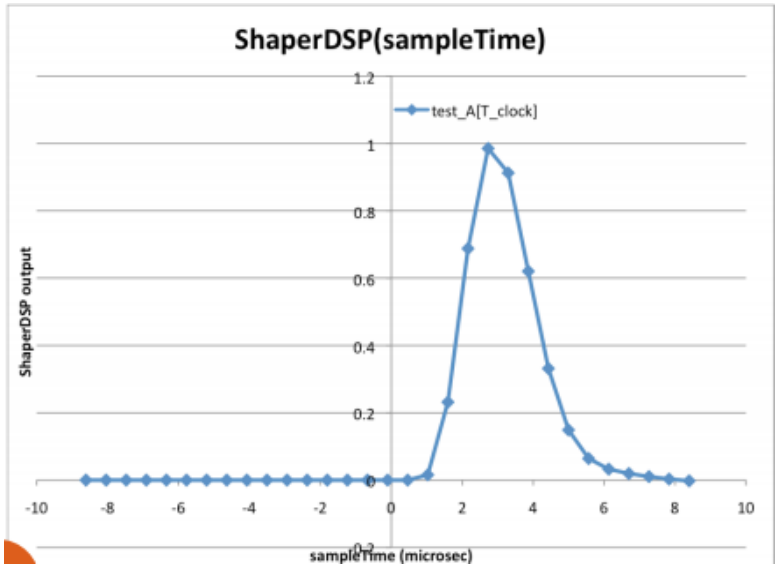


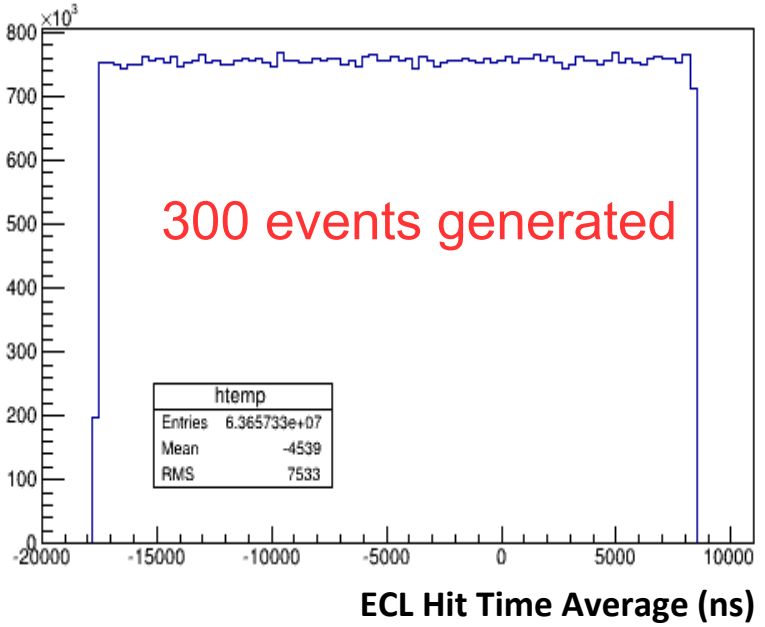


- Now focus on MC association in presence of machine background

Background simulation: Status

- *Background enters simulation at Hit level*
- *New background mixer allows different time windows for sub-systems to be set (Reminder: all detectors use -1, 0.8 us window, except ECL and PXD)*
- *Time window for ECL background mixing now set at proper value (-17.6, 8.5 us)*
- *New background files available from beginning of December*



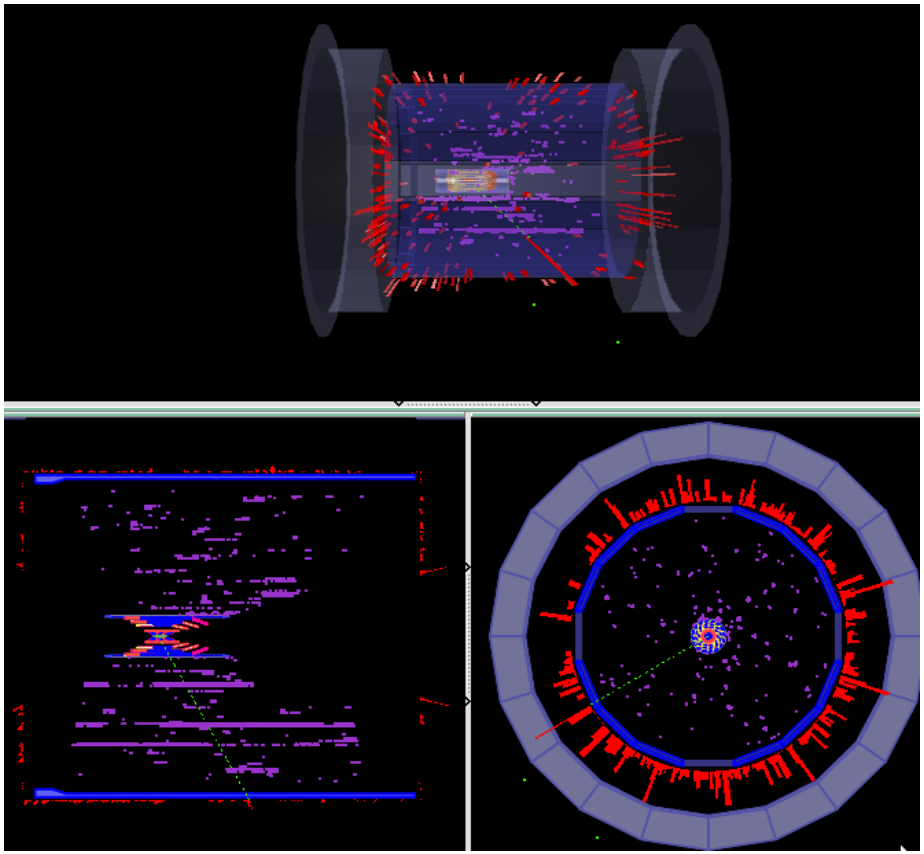


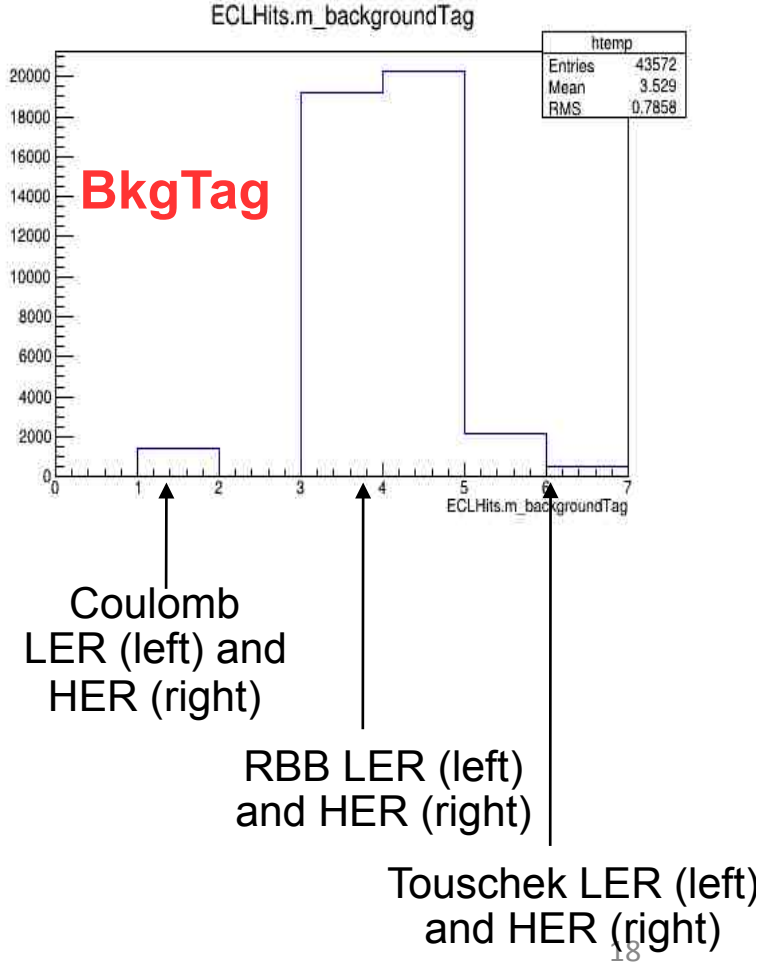
ADC clock = 508 MHz / (24 x 12)
= 1.764 MHz ==> 567 ns/sample
waveform fit → 15 samples = 8.504 us
pedestal fit → 16 samples = 9.071 us

time window before 0 = 17.576 us,
time window after 0 = waveform duration = 8.504 us

Background Simulation: single γ

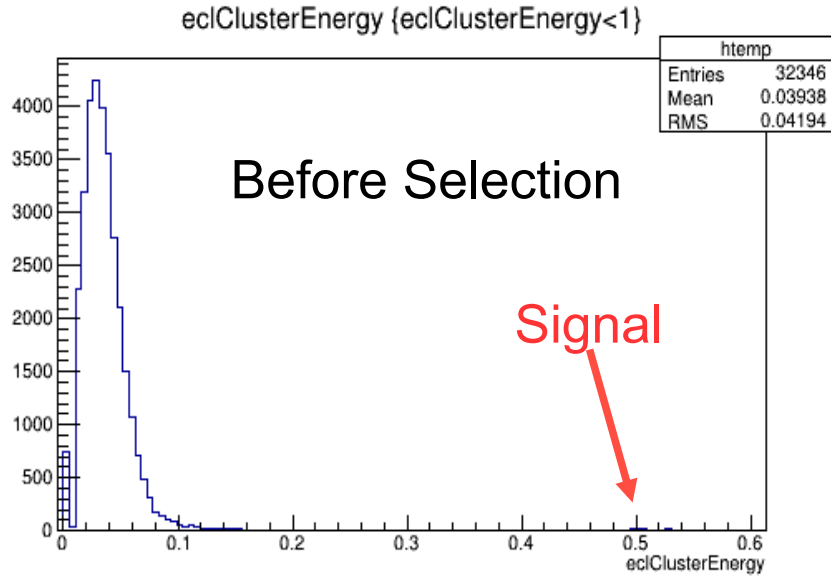
- *Single photon from pGun, E= 100, 500 MeV*
- *3 types of beam bkg: Coulomb, Touschek, RadBhabha ~160 cluster/event*
- *Clusters are recorded if* $|t - t_0| < 567$ ns

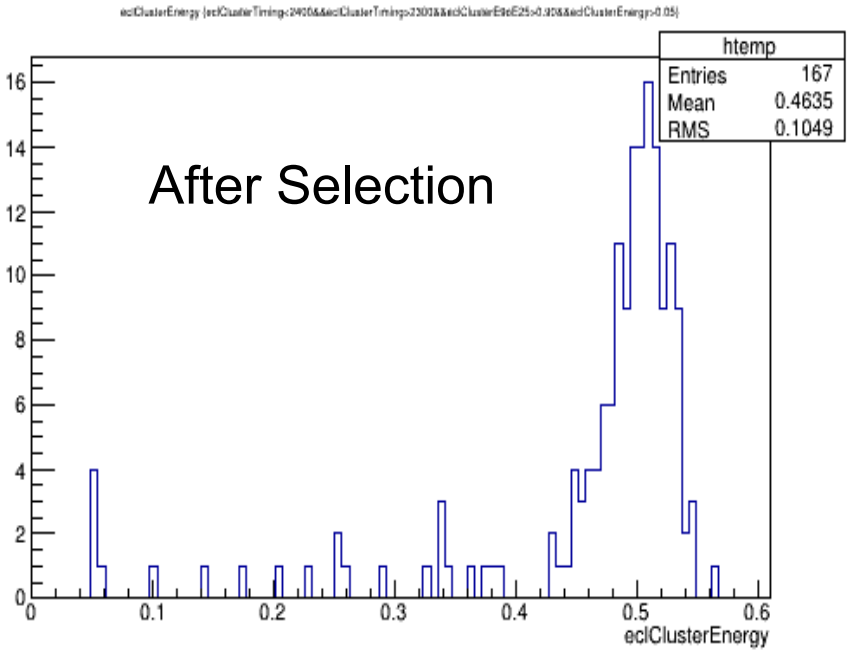




Background simulation: single γ 500 MeV

- *198 events, single 0.5 GeV photon in 20° < theta < 24°*
- *32346 clusters, mostly low-E (but not only!)*
- *Selection: $|t - t_0| < 18.5$ ns (cluster timing RMS for E > 100 MeV at Belle was 10 ns), E9oE25 > 0.9, E_{min} > 50 MeV*
- *Survive 167 clusters of 198, 161 are signals → eff= 81%, purity= 96.4%*

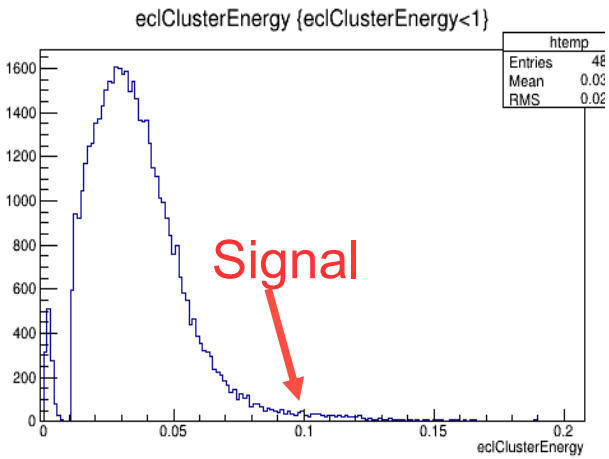


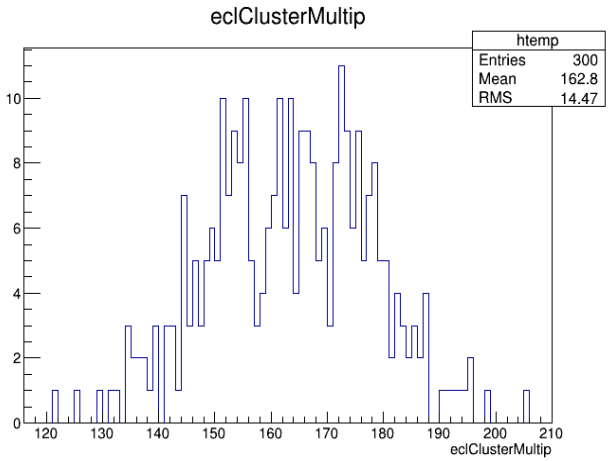


Background simulation:100 MeV γ

- *300 events, single 0.1 GeV photon in 20° < theta < 24°*
- *Signal is overwhelmed by background*

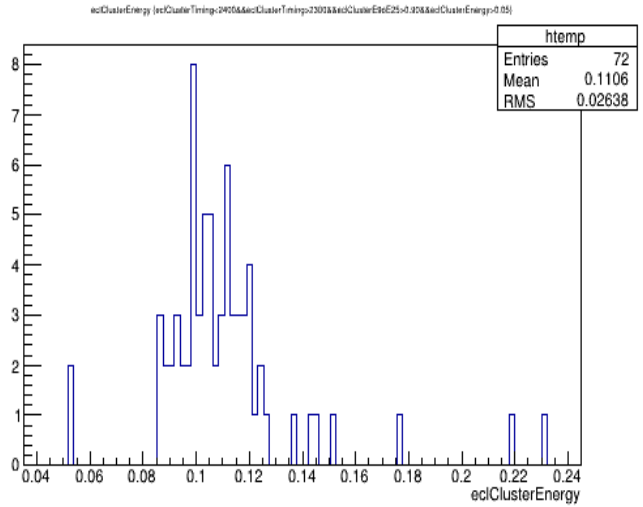
Before selection





- *With same selection defined previouslv →eff= 23%, purity= 95.8%*

After selection



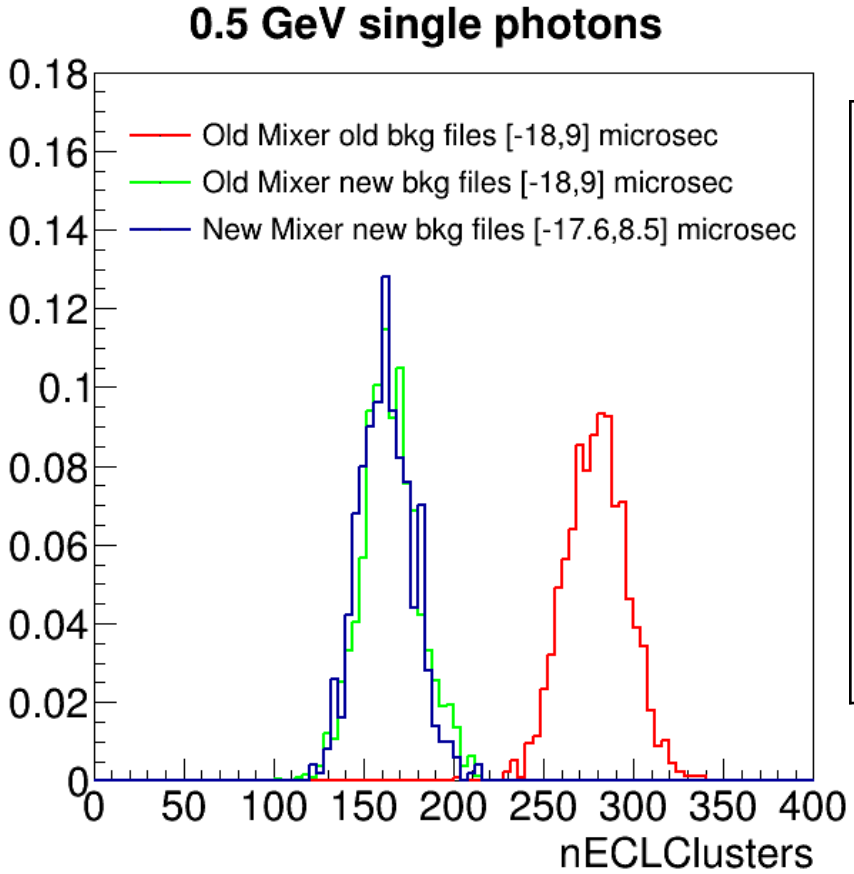
Background simulation: 500 MeV pi0s

- *1000 events, single 0.5 GeV pi0 in 20° < theta < 24°*

ADD plots with comparison between distributions with and without background

Background simulation: some remark

- *Some differences between current and previous release was observed in terms of #ECLClusters, we then ascribed to new background files*



	Bkg Rate Oct '14 (MHz)	Bkg Rate Dec '14 (MHz)
Coulomb HER	1	1
Coulomb LER	70	230
RBB HER	2200	1400
RBB LER	1650	1200
Touschek HER	34	31
Touschek LER	130	90

- A tool to monitor background in ECL may be useful (at central validation level?)

Conclusions

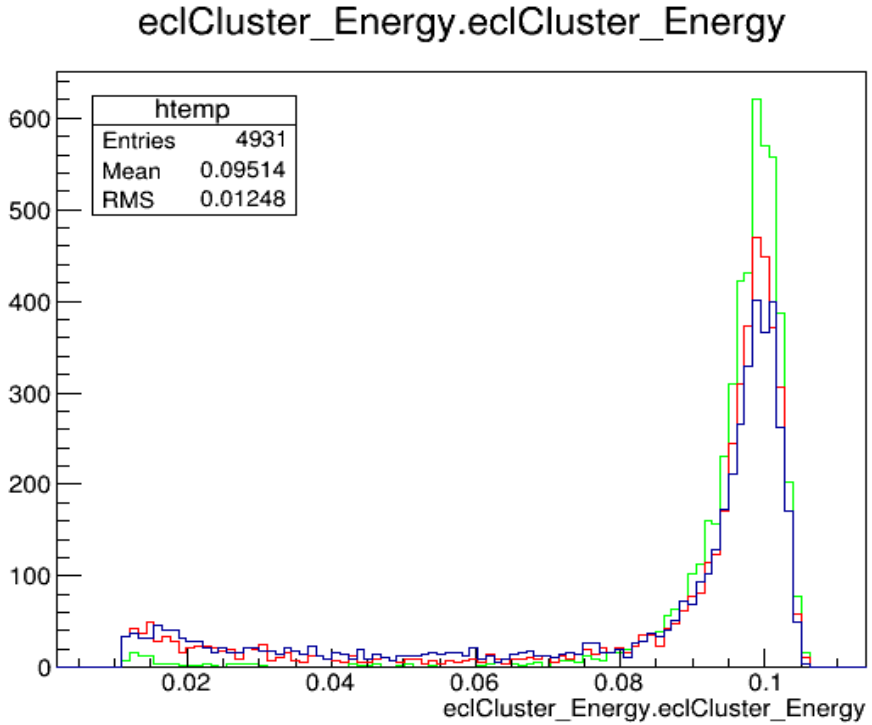
- Detailed validation of ECL reconstruction code ongoing
  - new validation plots for ECLClusters and charged pions committed and coming soon those for neutral pions
  - additional plots to be added and small fixes to be implemented

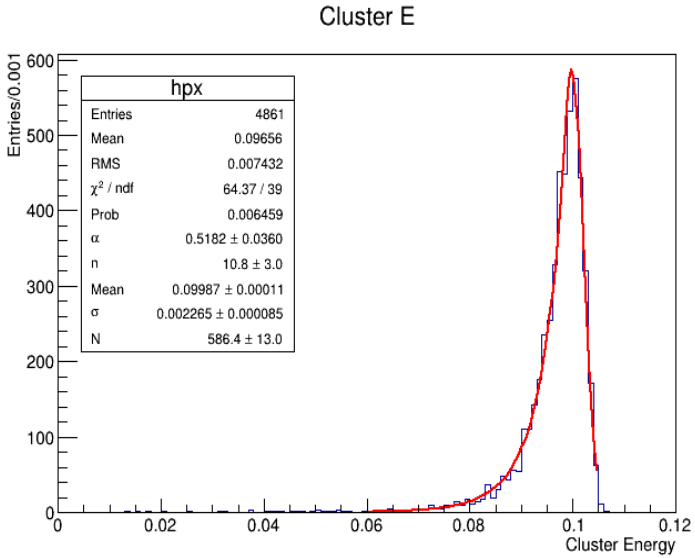
- Commitments for next release started
  - Cluster reconstruction checks done through validation plots
  - Development of tools to validate reconstruction with new covariance matrix ongoing
  - ECLCluster-MCParticle matching fixed without background addition, more tests ongoing, and machine background effect under study
  - Studies on machine background started with single photon and single pi0 samples, to define proper selection finding tradeoff between reconstruction efficiency and background rejection. Useful also to study effect from Clustering procedure optimization.

SPARES

Effect of detector material

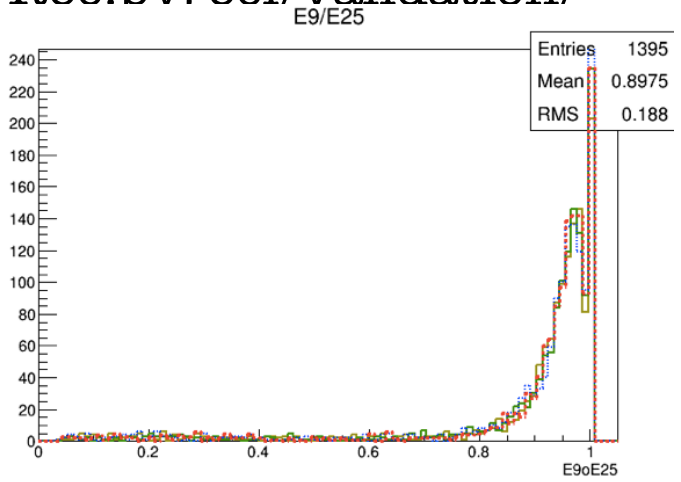
- *Compared 3 different geometries:*
  - *ECL only (green)*
  - *Full detector without ARICH (as discussed at last B2GM) (red)*
  - *Full detector (blue)*
- *5000 events, single 100MeV photons from pGun in FWD endcap (12° - 31°)*
- *No big effect of subdetectors material on resolution, rather on efficiency*

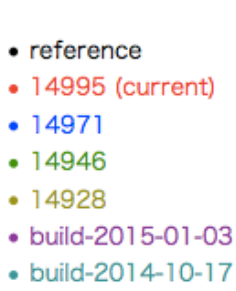


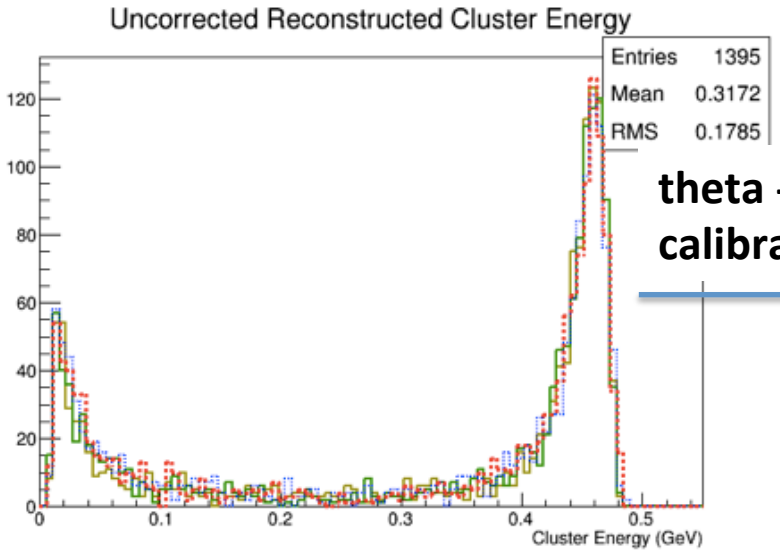


What's new: checks on ECLClusters (I)

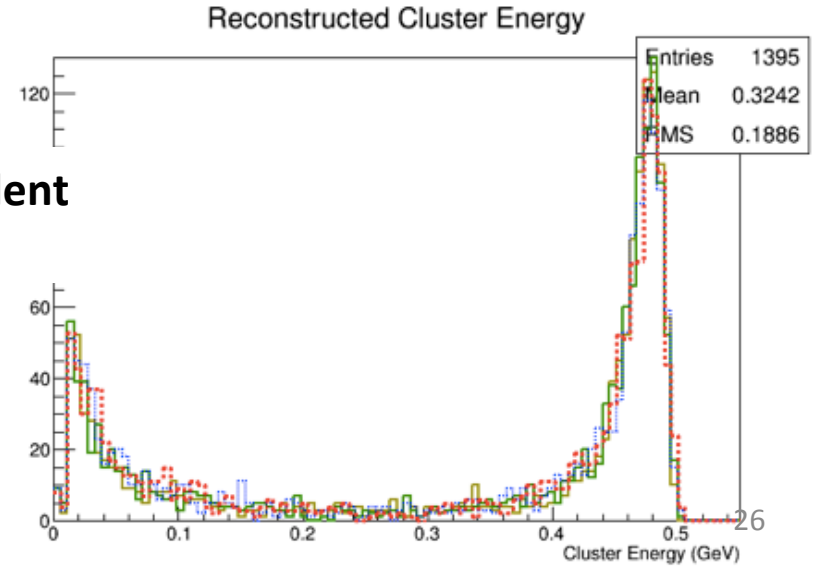
- code: ecl/validation/ECLClusterRec.py, ecl/validation/ECLCluster.C
- generate 500 MeV electrons, thetaParams: [0, 360], phiParams: [0, 360]



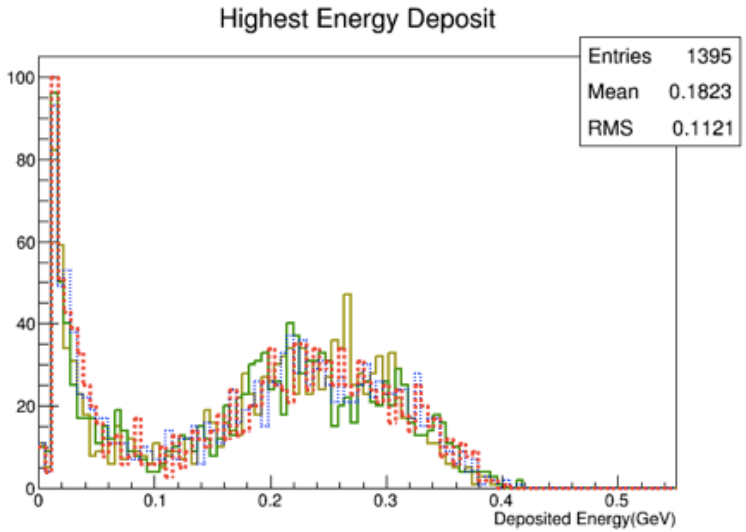


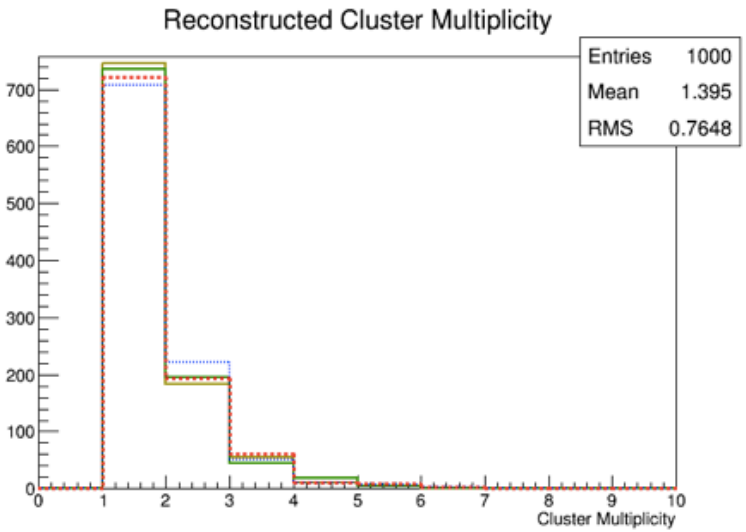


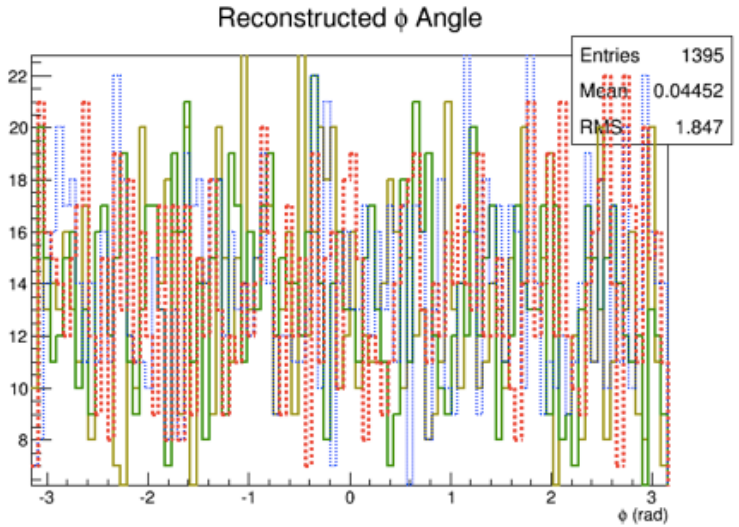
theta - dependent calibration



What's new: checks on ECLClusters (II)



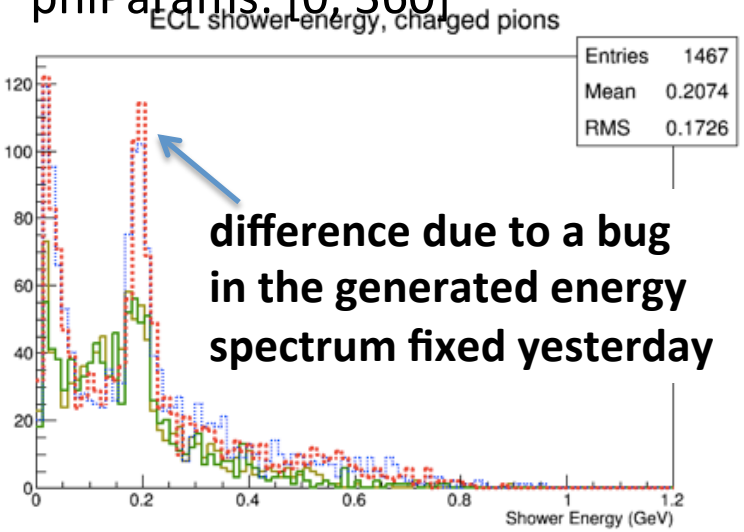


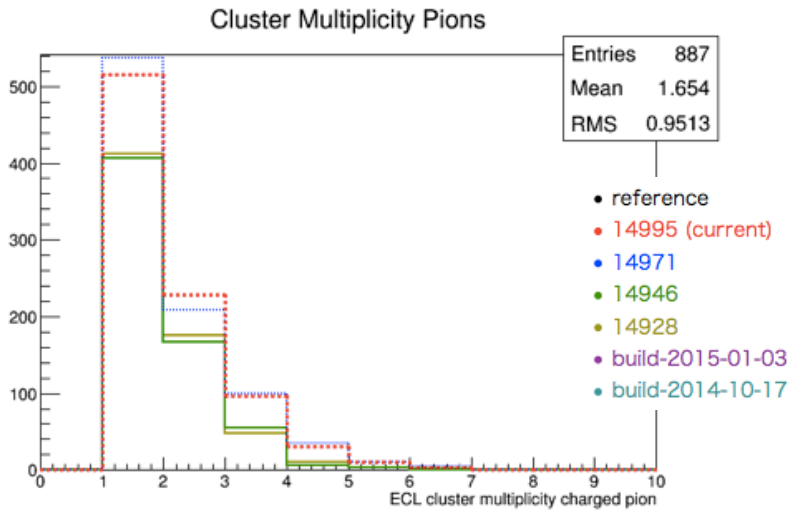


- reference
- 14995 (current)
- 14971
- 14946
- 14928
- build-2015-01-03
- build-2014-10-17

What's new: checks on charged π (I)

- code: ecl/validation/ECLPionRec.py, ecl/validation/ECLPion.C
- generate 1 GeV π^+, thetaParams : [0., 180.], phiParams: [0, 360]

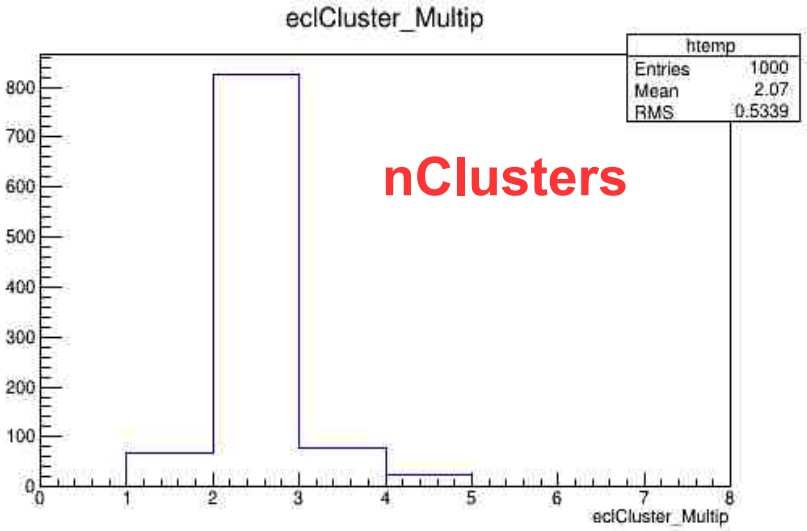


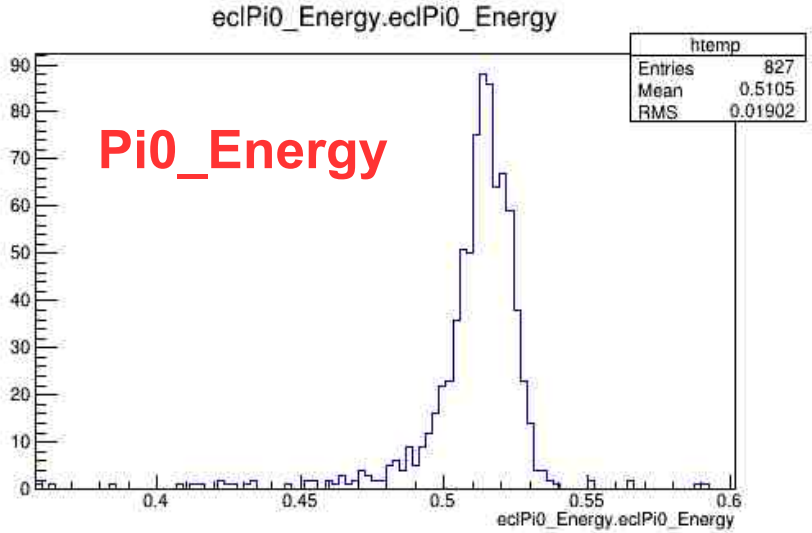


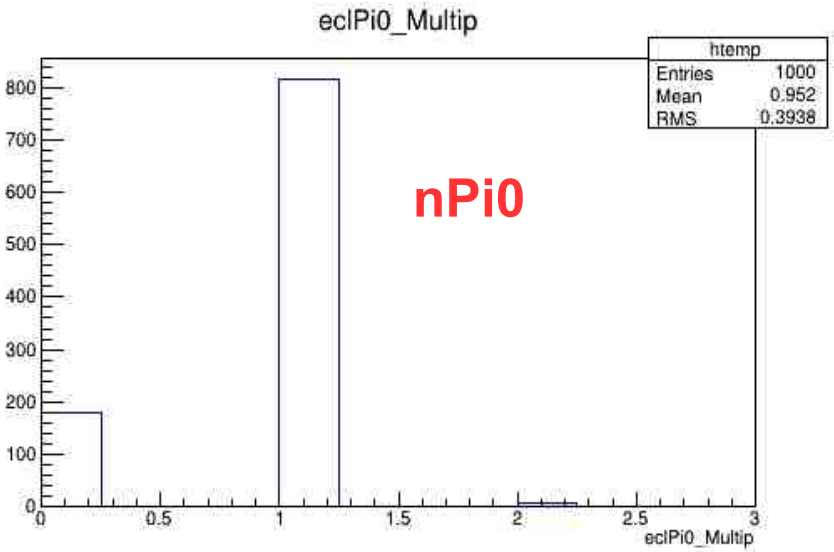
- additional plots will be added (e.g. fake rate)

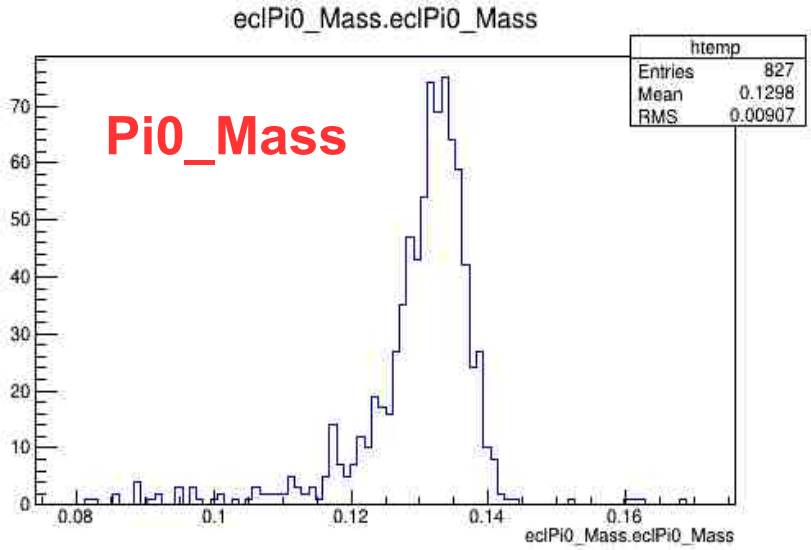
Pi0s

- *Single 500 MeV pi0, 1000 evts*









Reco efficiency about 80%