ECL Software Activities

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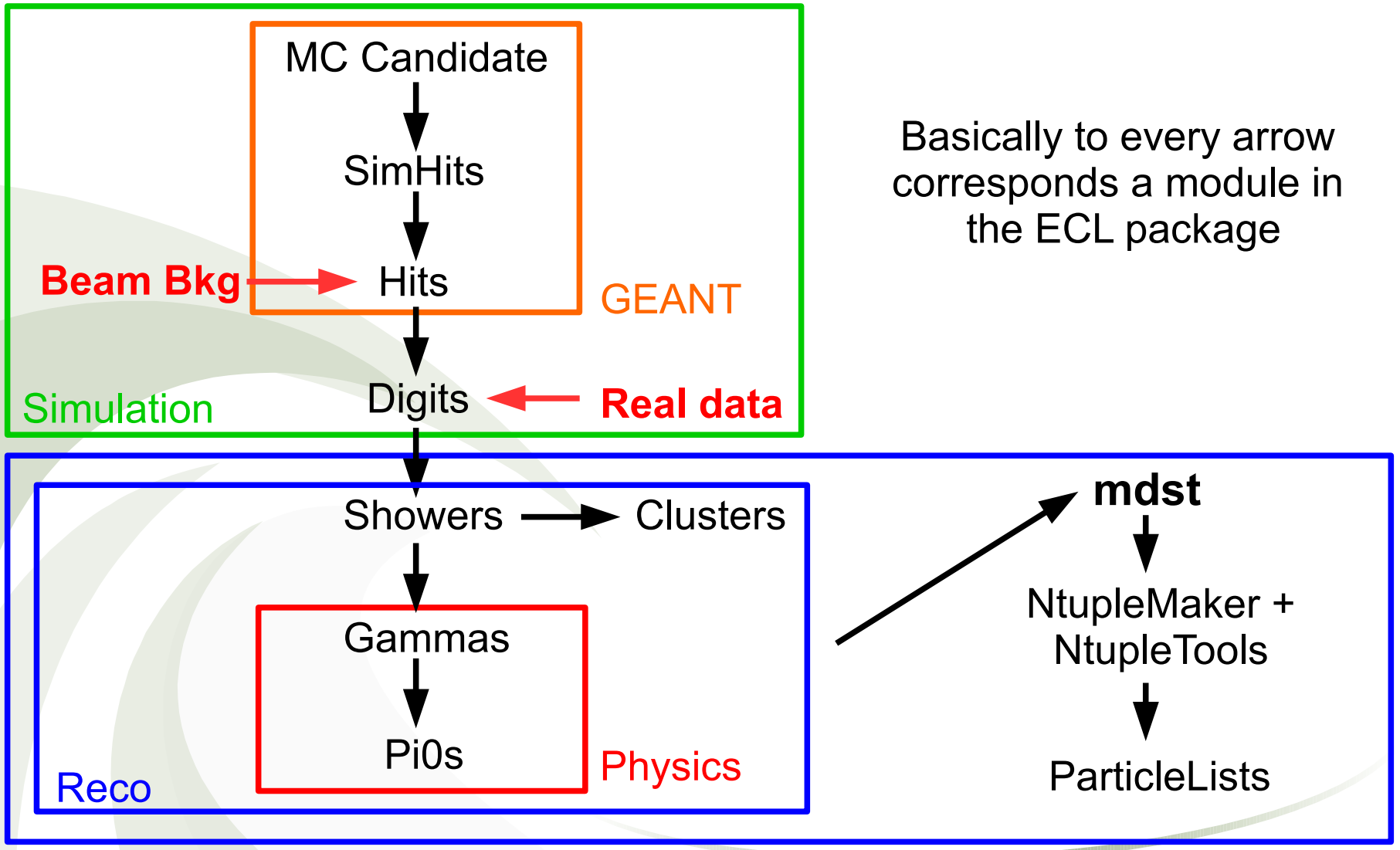
for the italian software group

Italian ECL Meeting, 12th December 2014

Foreword

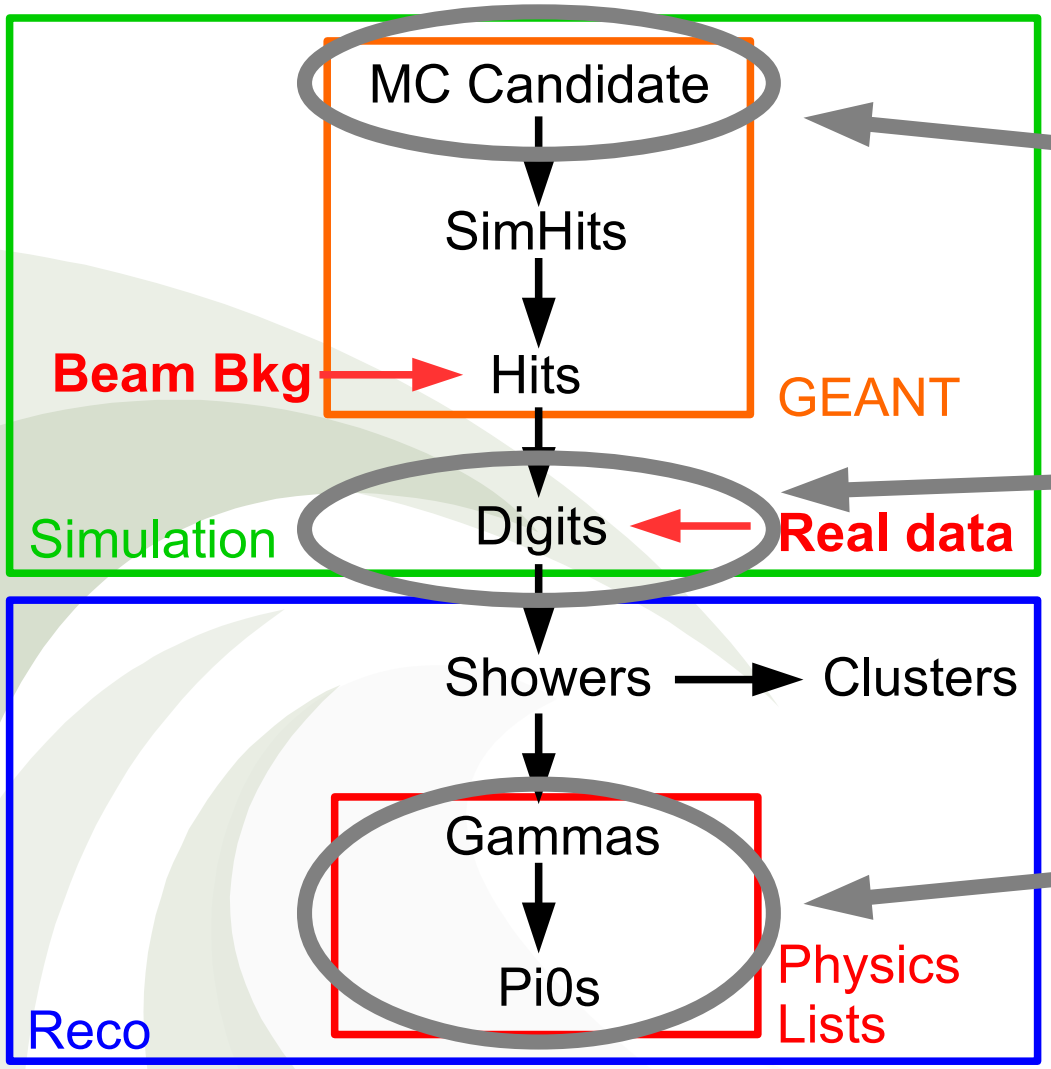
- *Main goal of our involvement in ECL SW activities is to establish if the performance of existing ECL is enough to ensure requested physics accuracy*
- *We started with performance simulations and soon realized that there were (are) many code flaws*
- *We (LNF & PG) got involved in the SW group and are now commited to several tasks*
- *Preliminary performance studies have started recently and continue together with code development*

ECL Software Overview



Basically to every arrow corresponds a module in the ECL package

Code development in LNF-PG



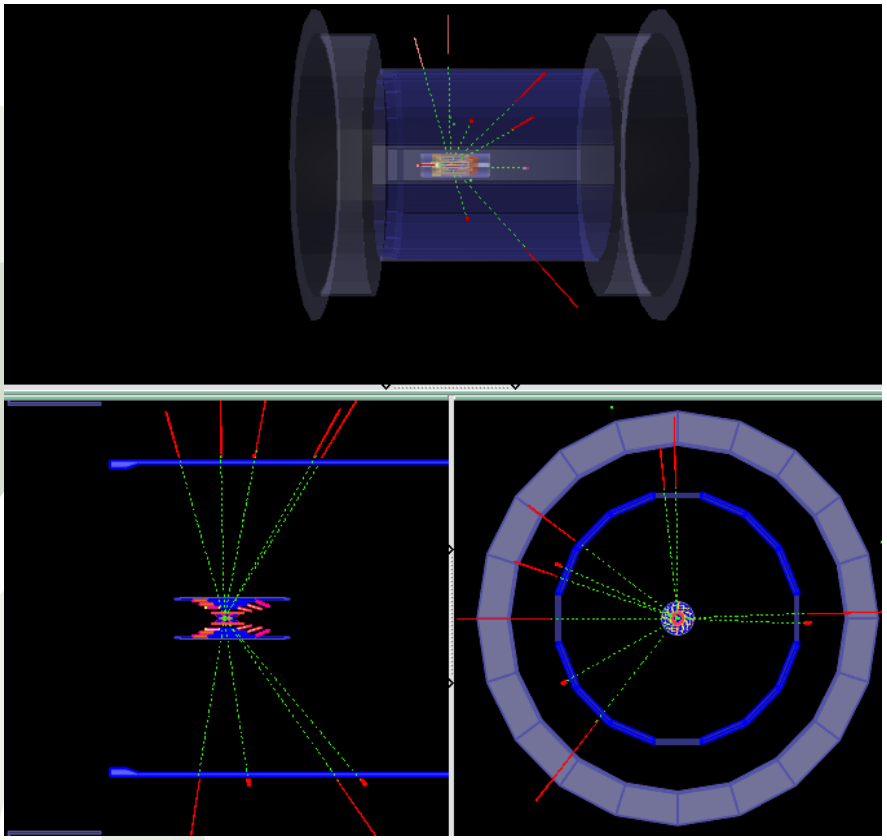
MCMatching has flaws, in particular in the case of multiple association (e.g. more than one candidate contributing to the same cluster)

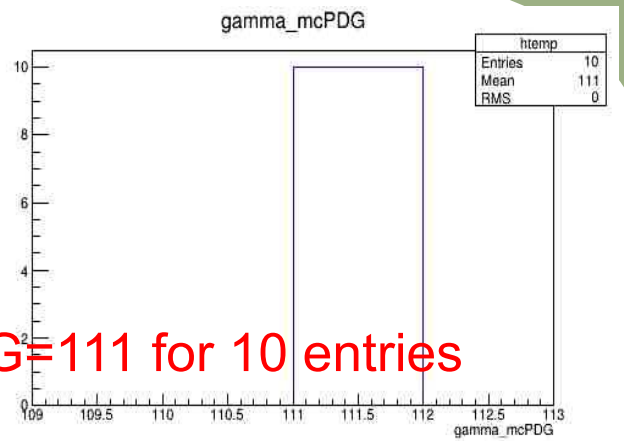
Digitizer has to be generalized to account for different crystal materials and/or read-out electronics

Official ntuple structure is not very well suited for ECL performance studies

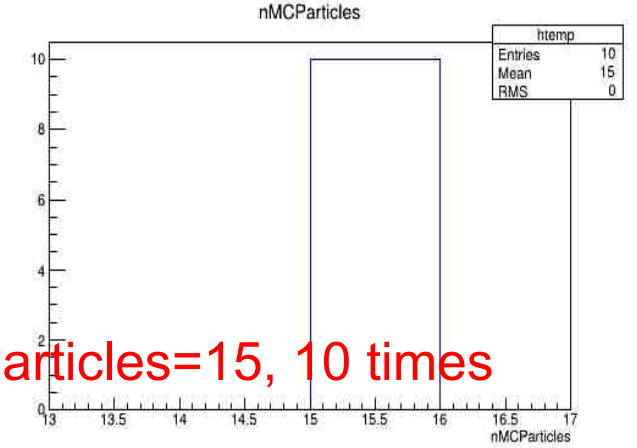
MC Matching

- *MC matching as some flaws*
- *e.g. 5 pi0s, 1 GeV each, 1evt*

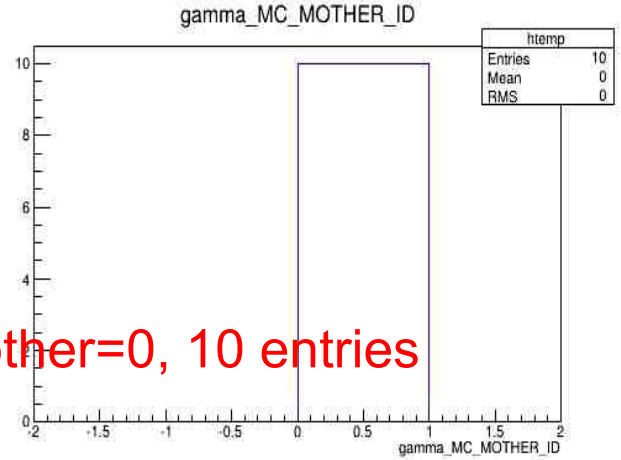




mcPDG=111 for 10 entries



nMCParticles=15, 10 times

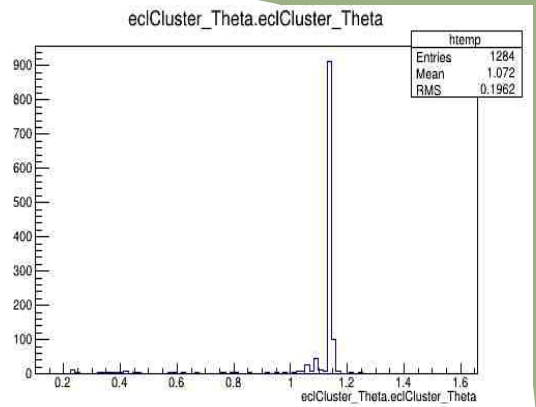


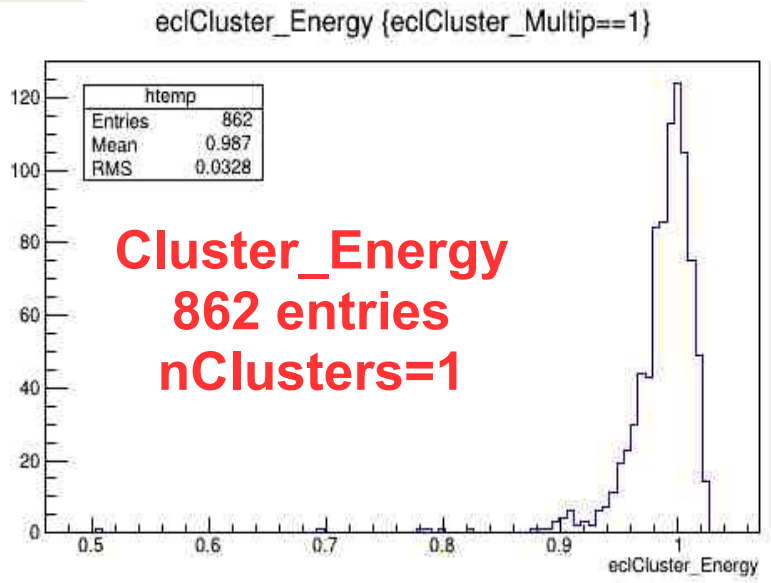
MCMother=0, 10 entries

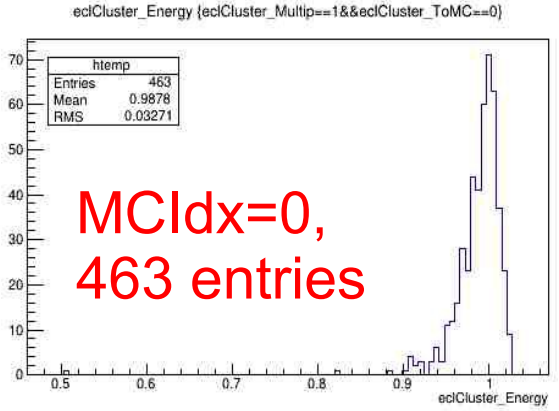
- *Further problems arise once bkg is introduced (see my talk at last B2GM)*

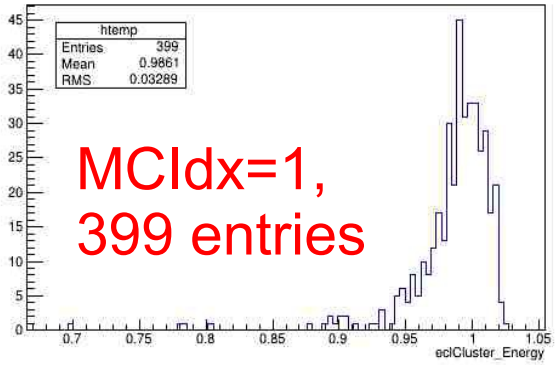
Multiple association

- *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

- *We are currently at work on both single and multiple association*
- *Weights will also be introduced to handle multiple ass. with bkg*

Digitizer

- *The digitizer translates electronics output into time and energy*
- *A 16 point fit is performed to the waveform from the shaper*

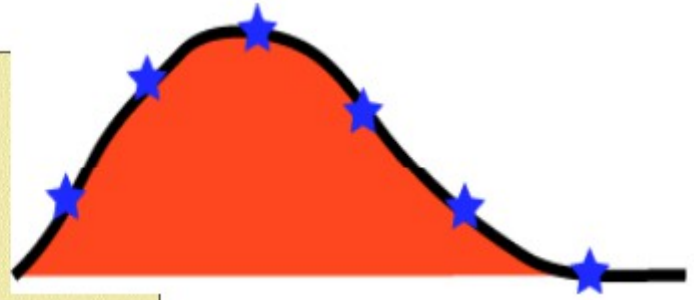
$$\chi^2(A,p,t_0)=\sum_{i,j}(y_i-Af(t_i-t_0)-p)S_{ij}^{-1}(y_j-Af(t_j-t_0)-p)\rightarrow \min$$

A, p, t_0 – fitting parameters : Amplitude, pedestal and time of the signal

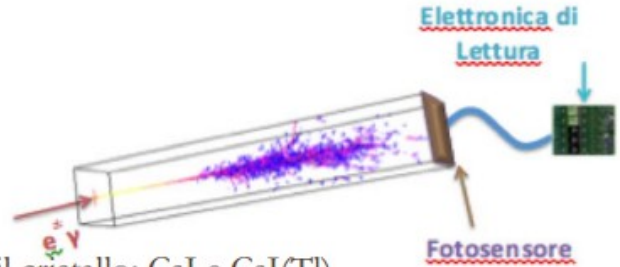
$S_{ij}=\overline{(y_i-\bar{y})(y_j-\bar{y})}$ – covariance matrix,

$f(t)$ – counter response,

y_i – sampled values.



- *From a SW point of view changing crystal/electronics reduces to changing this waveform*



per il cristallo: CsI e CsI(Tl)

per il fotosensore:
pin, apd, fotopentodo

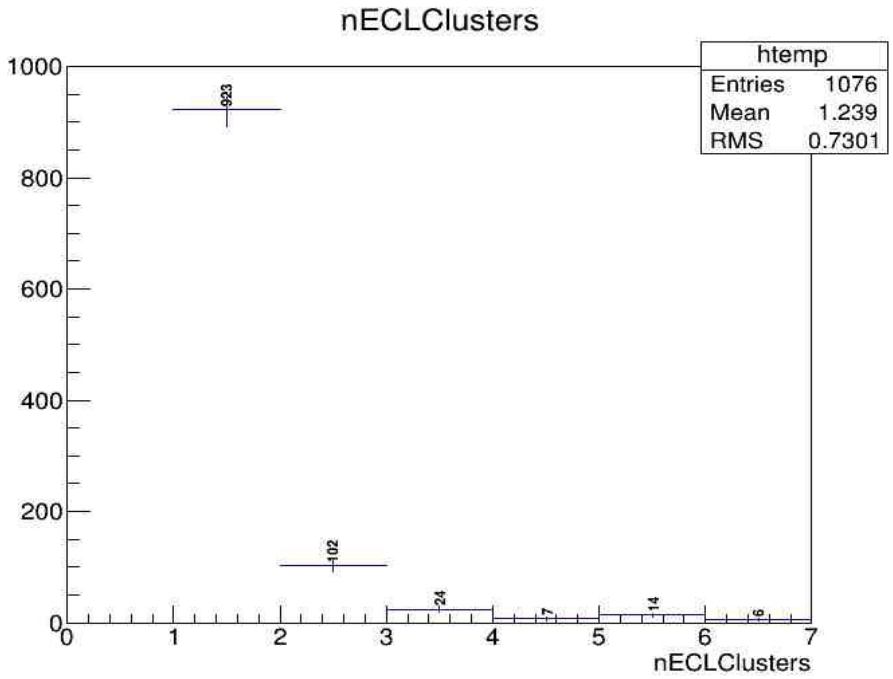
- *The output waveform of the R/O is currently calculated using SPICE*
- *This is a crucial point for upgrade studies and work is ongoing to generalize the code (eclDigitizer module)*

ECLDataAnalysis

- *basf2 ntuple structure (Ntuple maker+ NtupleTools) is not well suited to study ECL performance*
- *Entries are not stored "event-wise" and this leads to some difficulties when analyzing stuff*

1000evts, signle 500 MeV photon per event shot in barrel

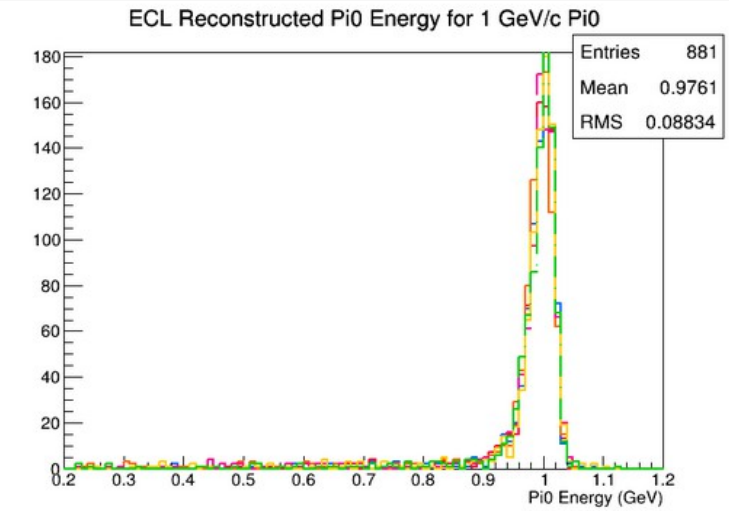
1076 entries, 1 for cluster
923 single cluster events
102*2+24*3+4*7+5*14+6*6 = 410
923 + 410 != 1076... ???



- *After discussion with SW people we wrote our own module*
- *ECLDataAnalysis has now been extensively tested and committed*

ECL Validation

- *A byproduct of our module are new validation scripts*
- *These scripts are run daily to produce plots to be checked by offline shifters to monitor performance of the various subdetectors*
- *For ECL few scripts are presently available and do not match quality requirements*



hPi0s

Warnings: No reference object, No description, No Check, No Contact Person

P-Value: n/a

Chi^2-Test: n/a

Contact: n/a

Description: n/a

Check for: n/a

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

Performance Studies

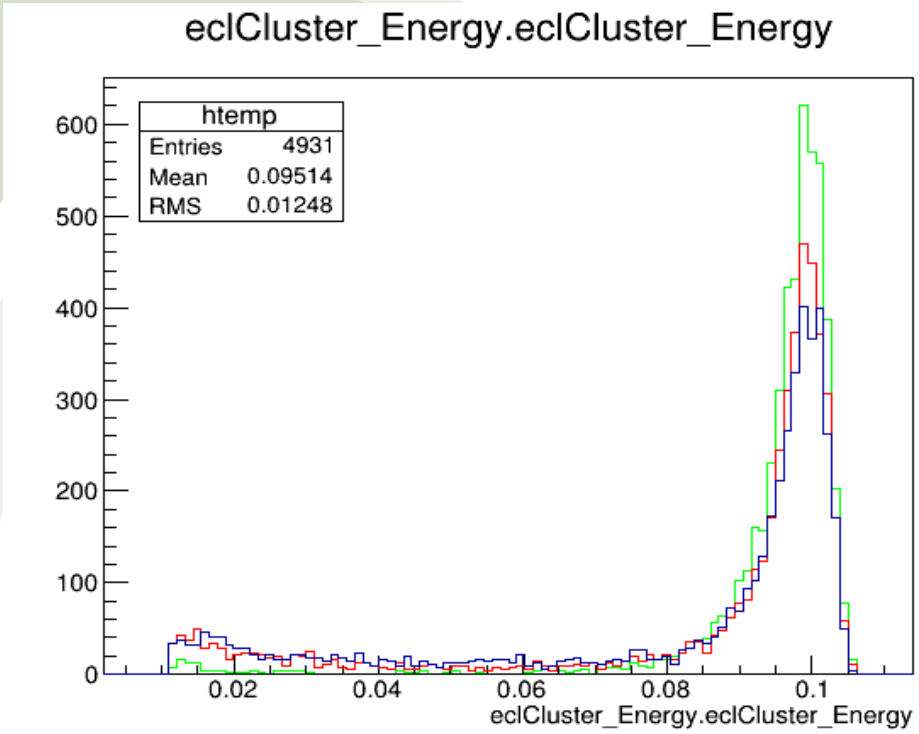
- *The study of the physics case for the upgrade relies mainly on:*
  - *The possibility to simulate degraded conditions as well as different dectector components (ECLDigitizer module)*
  - *A reliable and realistic backgroud simulation*

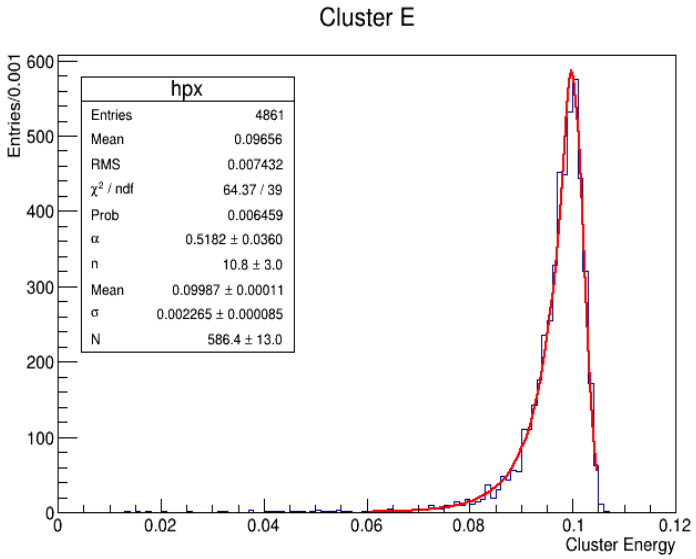
- *Upgrade oriented simulations started after November B2GM for baseline ECL configuration:*
  - *We had to develope our own tools to analyze ECL performance*
  - *Our past simulations have shown serious flaws in bkg simulation*
  - *Thanks to the effort of the SW group a realistic bkg simulation for ECL is now available (since 2 weeks, see Staric's talk at ECL meeting 28th November)*

- *Currently following studies have been performed:*
  - *Intrinsic detector resolution and related effects*
  - *Preliminary resolution in the presence of beam-backgrounds (..ongoing)*

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*

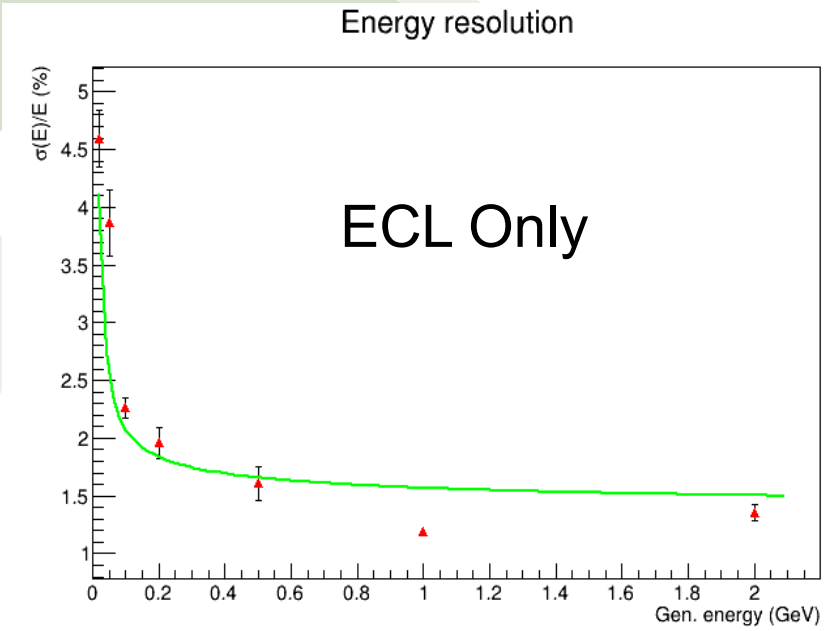


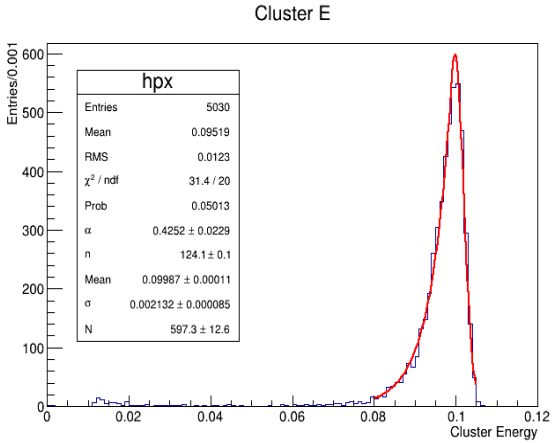


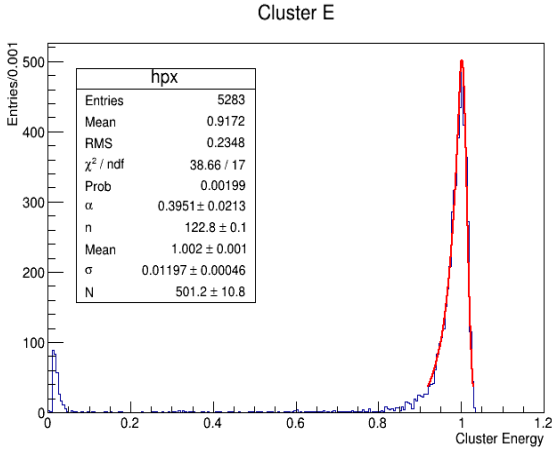
Energy resolution

- *Individual energies fitted with Crystal Ball function*
- *Energy range 20 MeV to 2 GeV, 5000 evts each, 20° < θ < 24°*
- *Resolution function from TDR in green*
- *Agreement far from being perfect..*

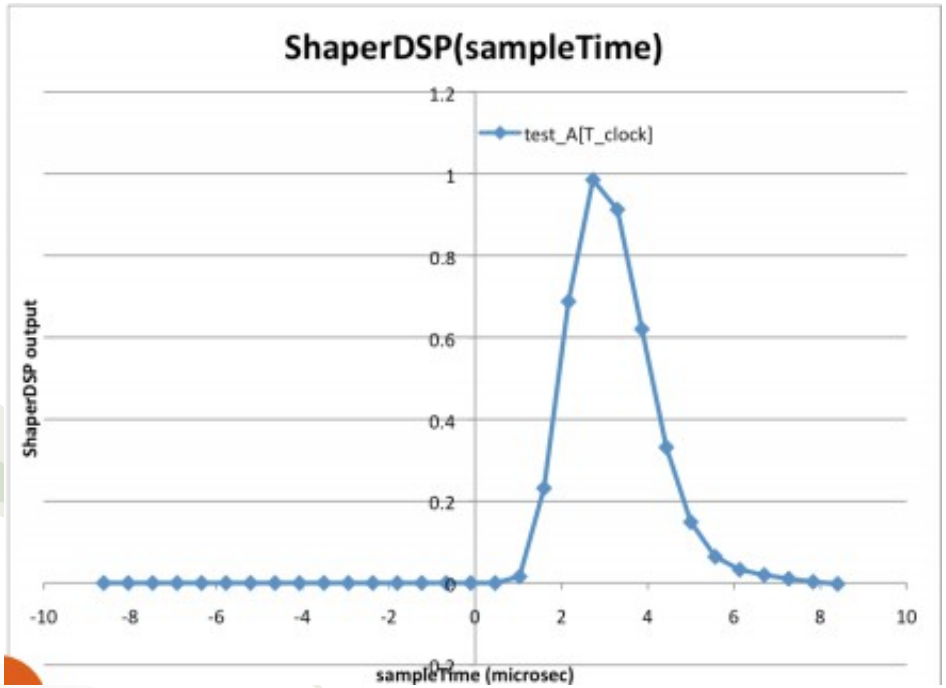
$$\frac{\sigma_E}{E} = \sqrt{\left(\frac{0.066\%}{E}\right)^2 + \left(\frac{0.81\%}{\sqrt[4]{E}}\right)^2 + (1.34\%)^2},$$







ECL Time Window



(from the talk of C. Hearty B2GM June 2013)

ADC clock = 508 MHz / (24 x 12) = 1.764 MHz ==> 567 ns/sample

waveform fit → 15 samples = 8.504 us

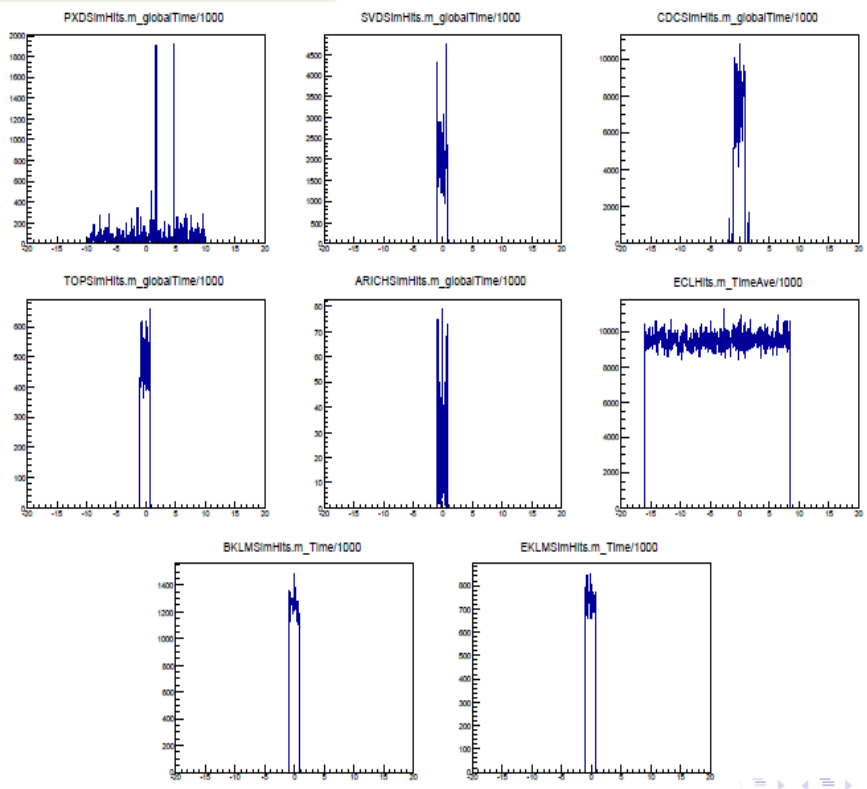
pedestal fit → 16 samples = 9.071 us

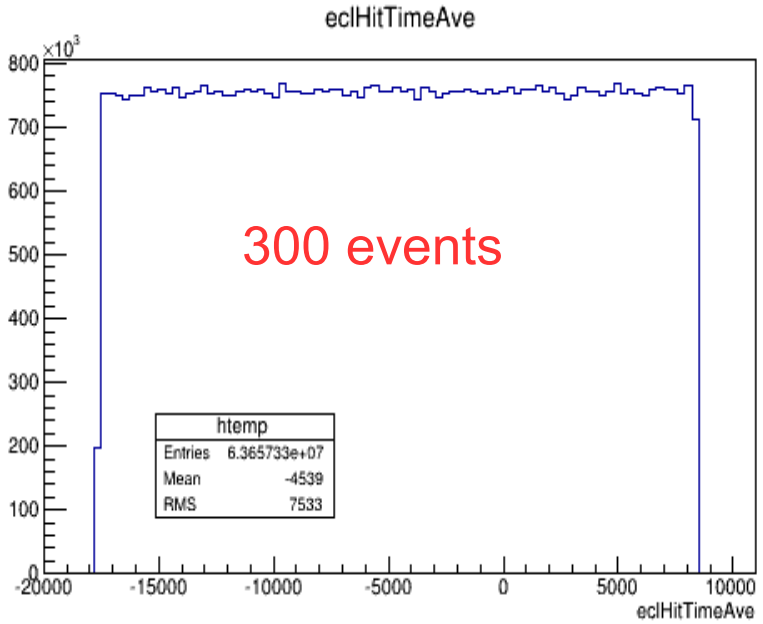
time window before 0 = 17.576 us,

time window after 0 = waveform duration = 8.504 us

Background Status

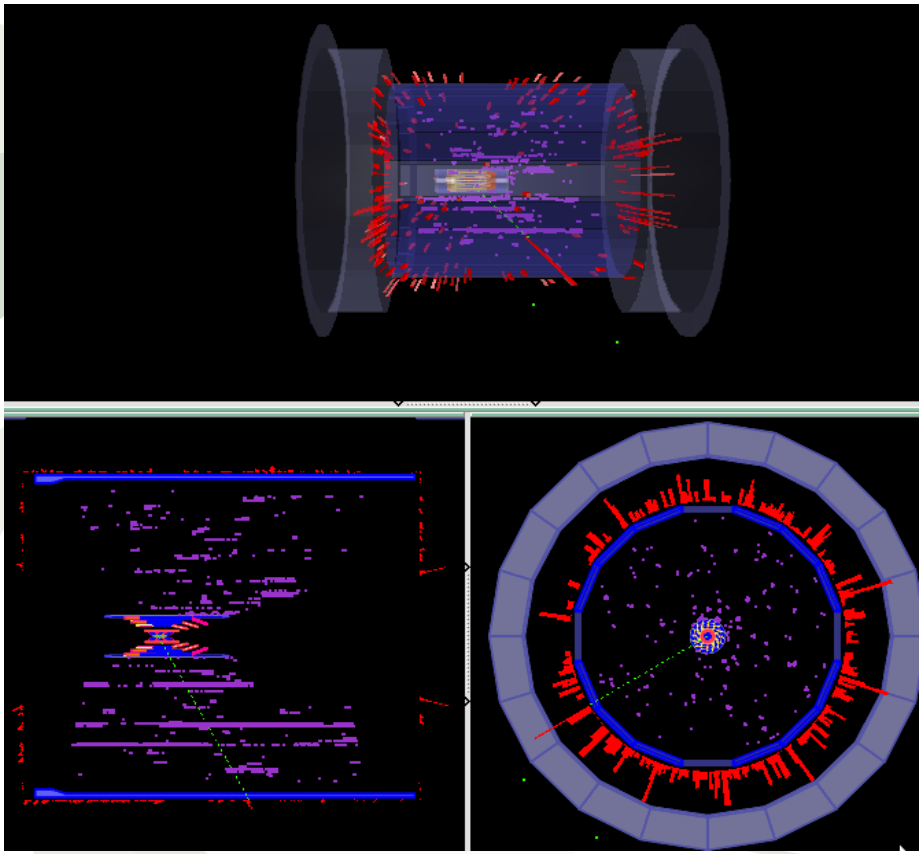
- *Background window has finally been correctly fixed (-17.6, 8.5 us)*
- *New bkg mixer released, allows different windows for different subsystems (Reminder: all detectors use -1, 0.8 us window, except ECL and PXD)*
- *Additional bkg files for ECL and PXD are available for ECL since just about 2 weeks (bkg enters simulation at Hit level)*

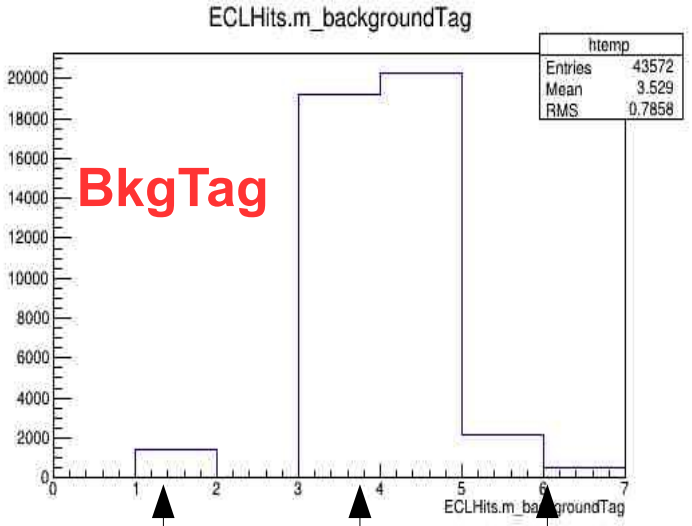




Single photon with bkg

- *Single photon from pGun, E= 100, 500 MeV*
- *3 types of beam bkg: Coulomb, Touschek, RadBhabha ~200 cluster/evt*
- *Clusters are recorded if* $|t - t_0| < 567$ ns





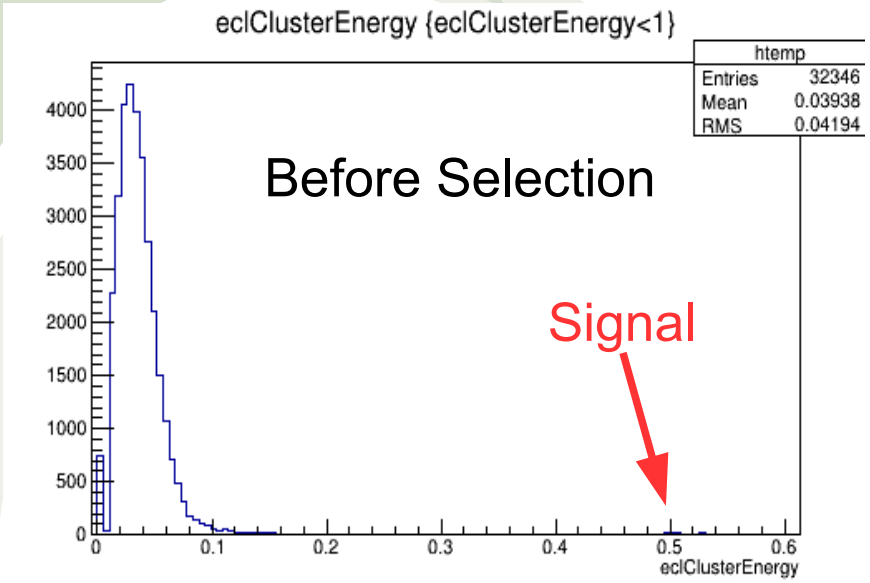
Coulomb LER (left) and HER (right)

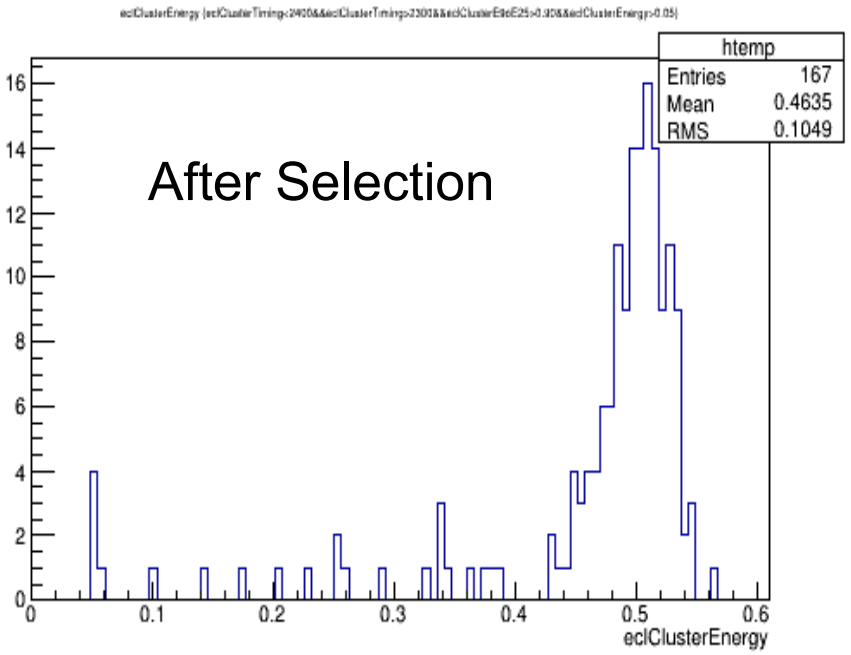
RBB LER (left) and HER (right)

Touschek LER (left) and HER (right)

500 MeV photons with bkg

- *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%*

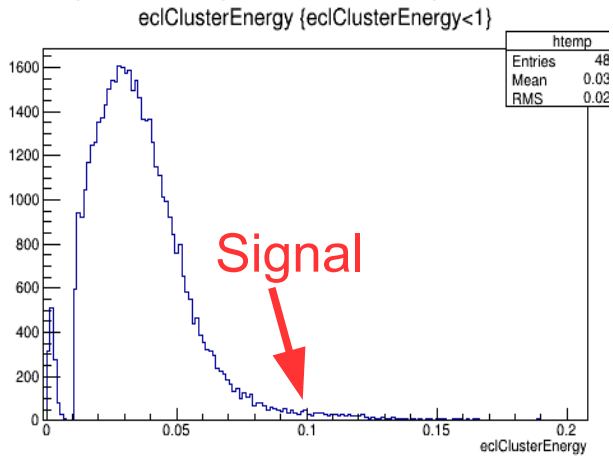


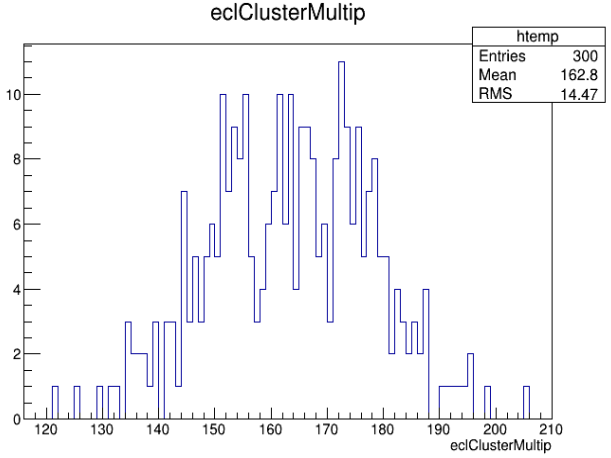


100 MeV photons with bkg

- *300 events, single 0.1 GeV photon in 20° < theta < 24°*
- *Signal is completely enveloped in bkg "tail"*

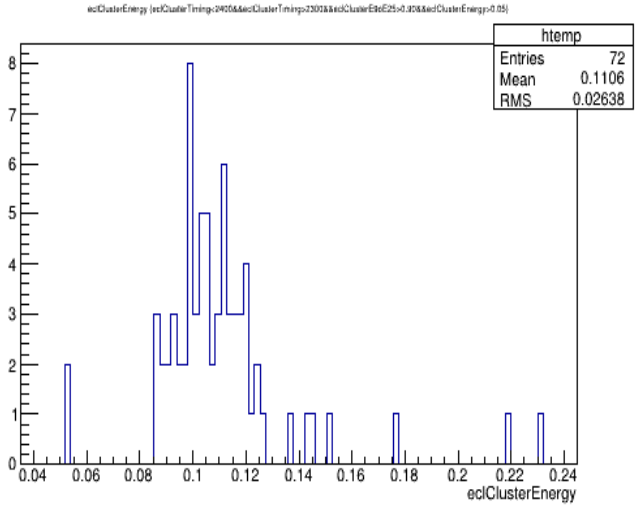
Before selection





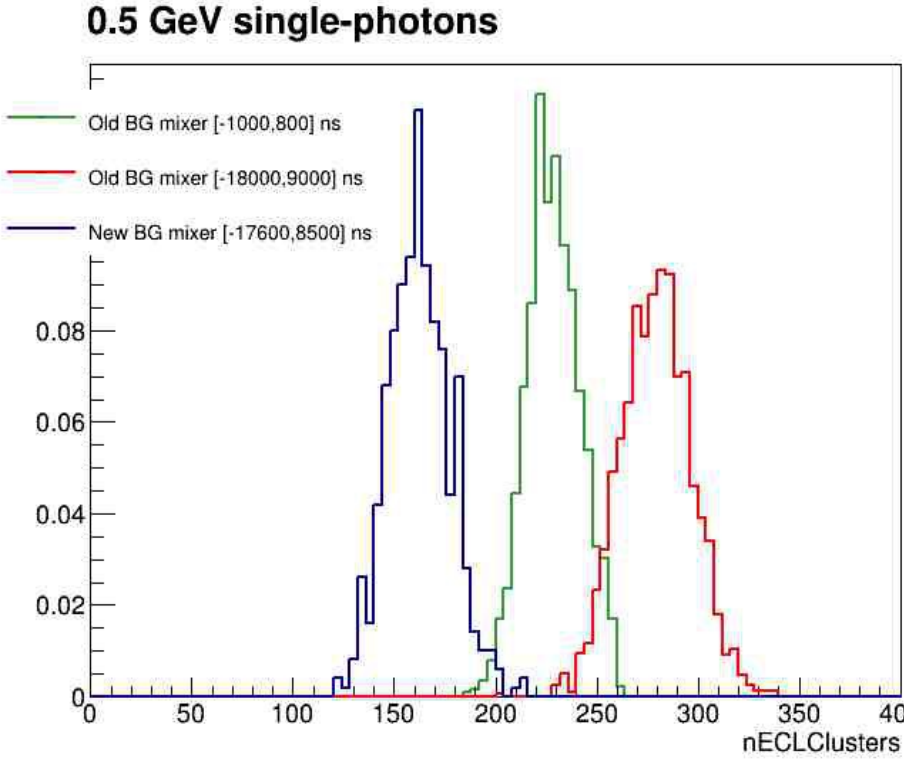
- *With same selection defined previously →eff= 23%, purity= 95.8%*

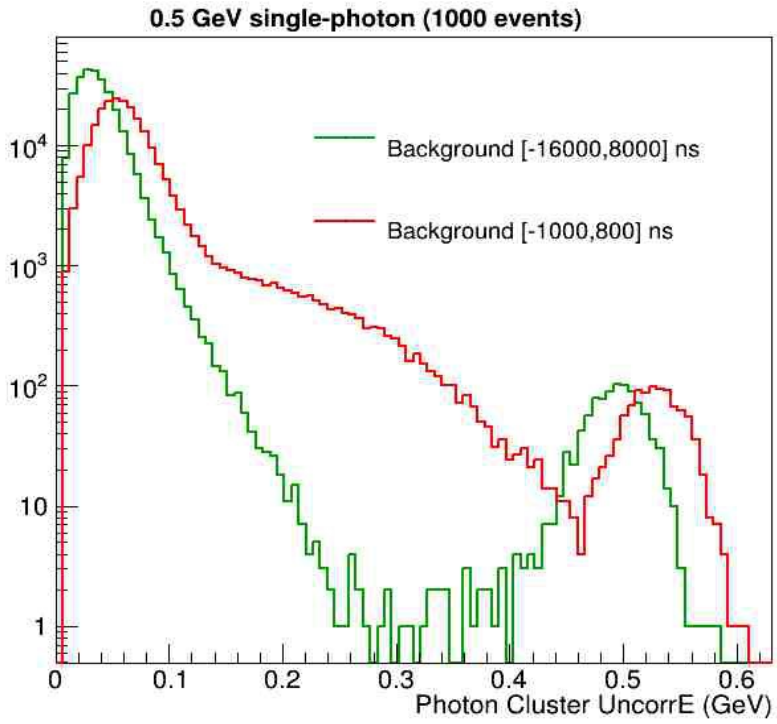
After selection



Background remarks

- *There are some (significant) discrepancies between current and previous releases, the reason is not clear*
- *Still missing a good interplay between ECL and BKG people → we have to address this point*

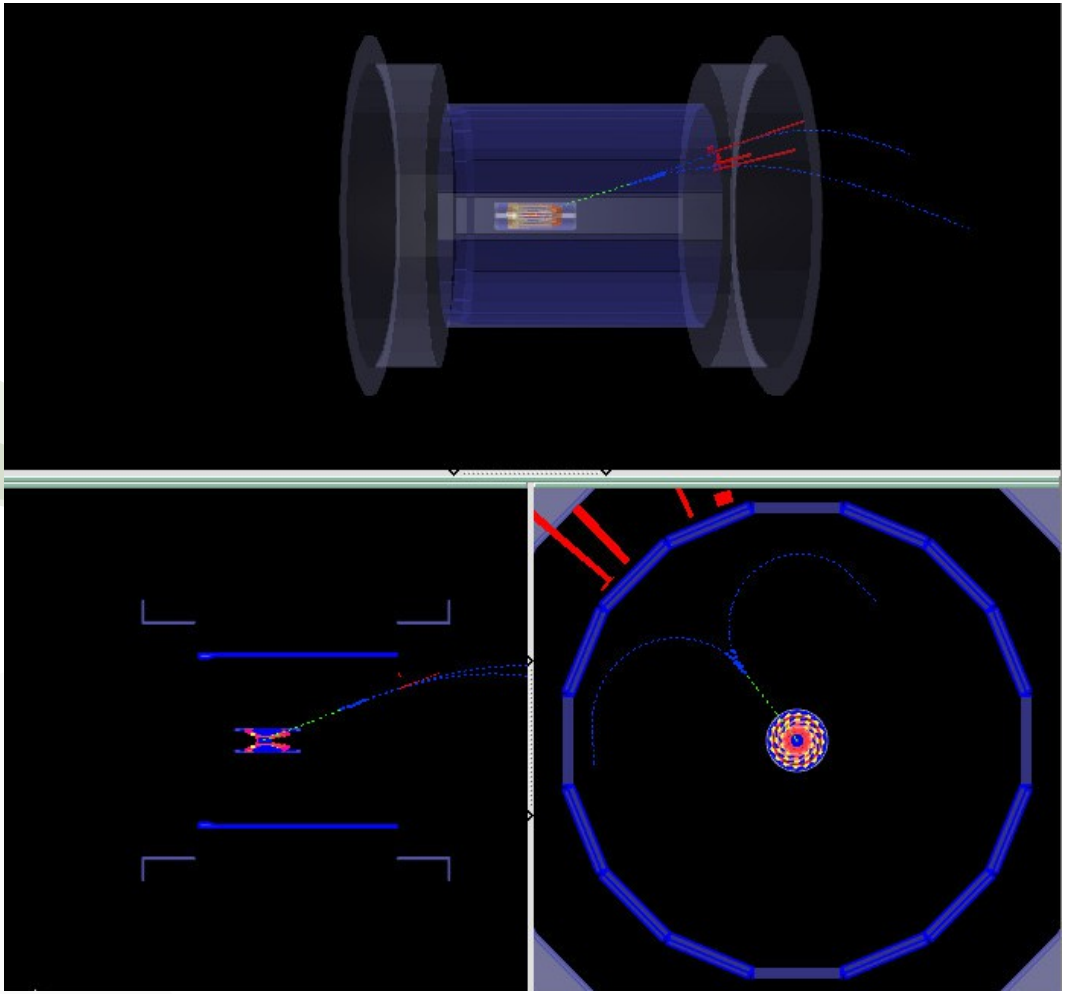




Conclusions

- *We've started to study ECL software with the aim of performing physics studies for the upgrade*
- *We discovered many code flaws*
- *We got deeply involved in code development and the LNF and PG groups are currently responsible of various items:*
  - *MC matching to reconstructed quantities (B. Oberhof)*
  - *Cluster timing and reconstruction (E. De Lucia & E. Manoni)*
  - *Validation SW (E. Manoni + B. Oberhof)*
  - *ECL Analysis tools (E. Manoni + B. Oberhof)*
  - *Performance and background studies (E. De Lucia + B. Oberhof)*
  - *Digitizer development (E. Manoni)*
  - *Etc.. (i.e. anything else that comes along)*
- *Physics simulations is proceeding in parallel to the development of SW and tools*

Thanks!



Pair creation in the CDC

Backups

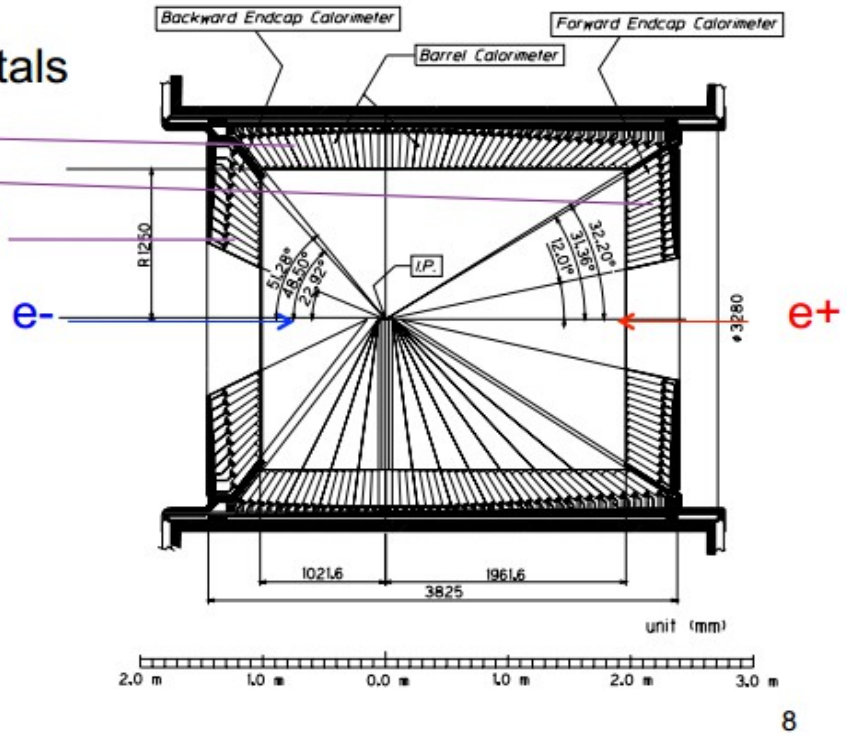
Geometry

Day-1: existent CsI(T_l)

In total, 8736 CsI(T*l*) crystals
(6624 in Barrel,
1152 in Fwd. Endcap
and 960 in Bwd. Endcap)

Covering 12<θ<155° in
Lab. frame.

Inner radius = 1250mm.



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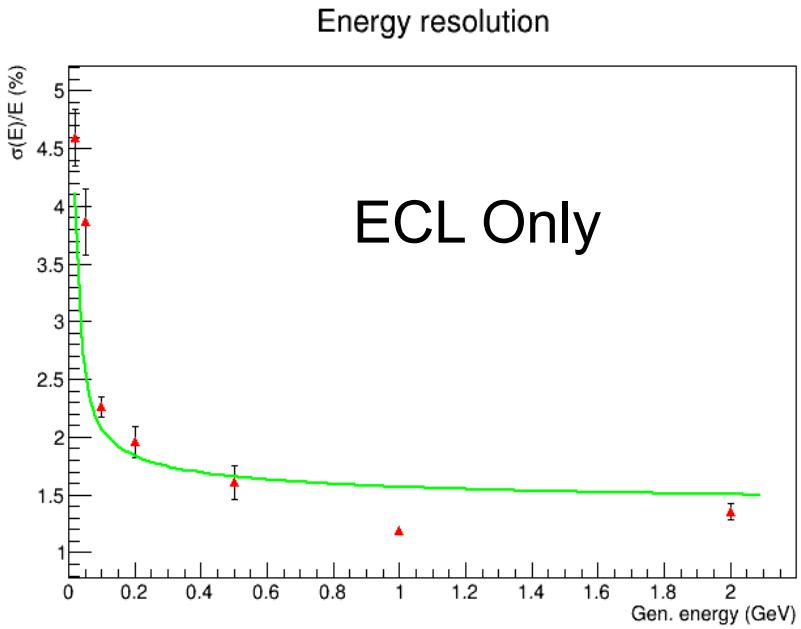
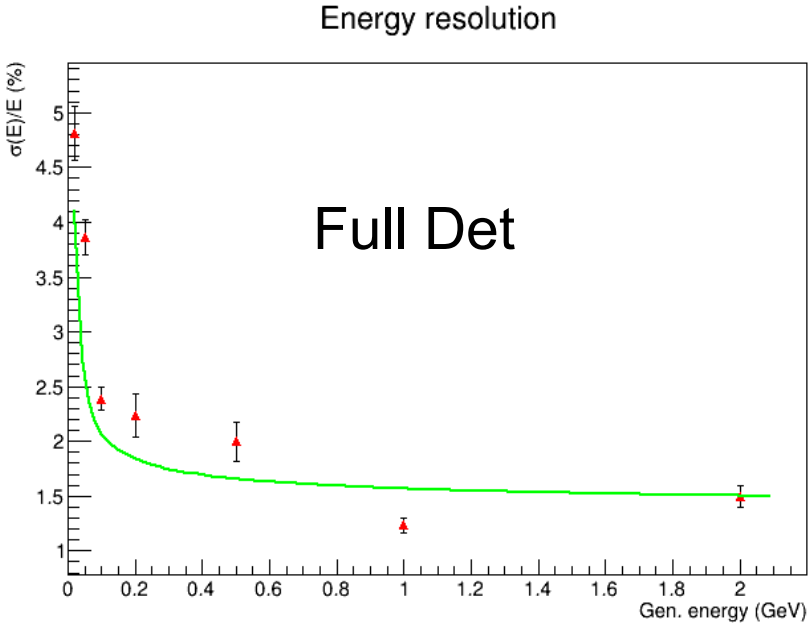
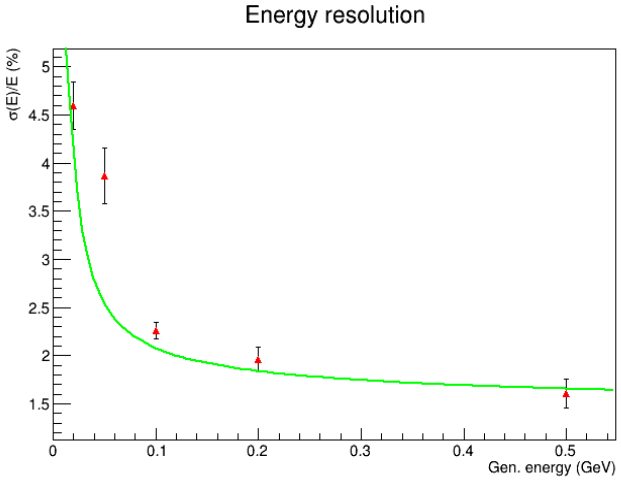
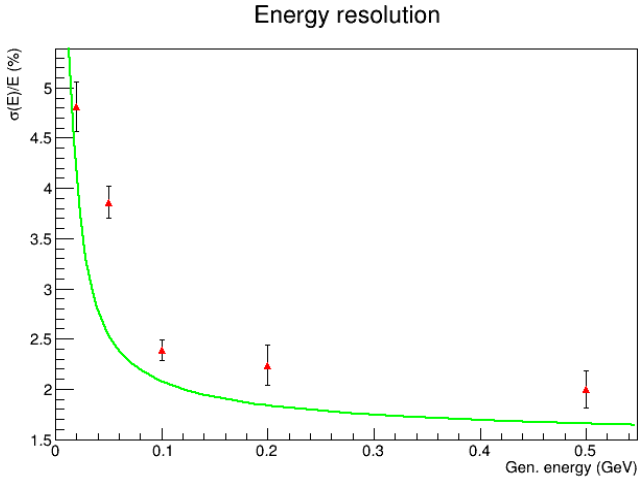
Energy resolution

- *Not really good agreement, seems to depend from ECL alone*



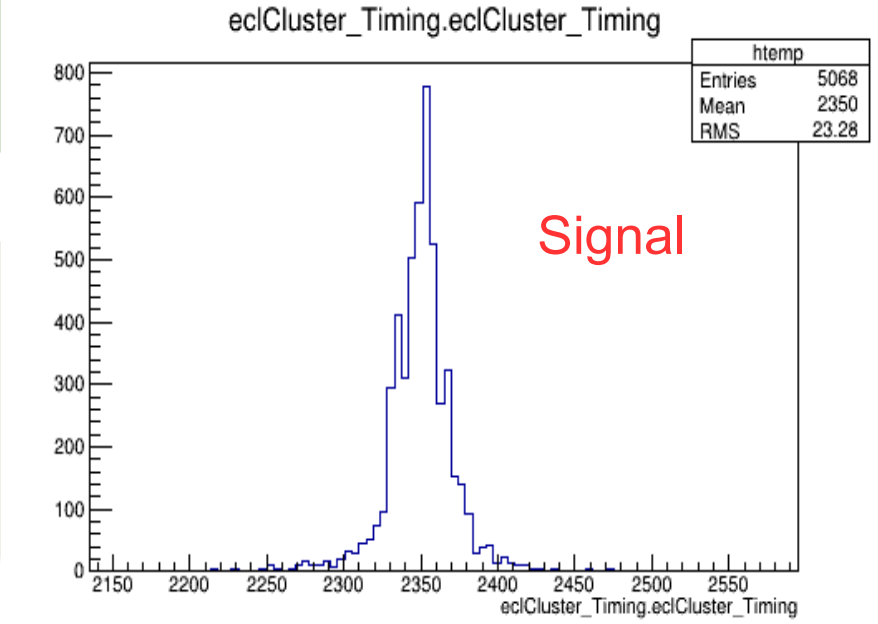


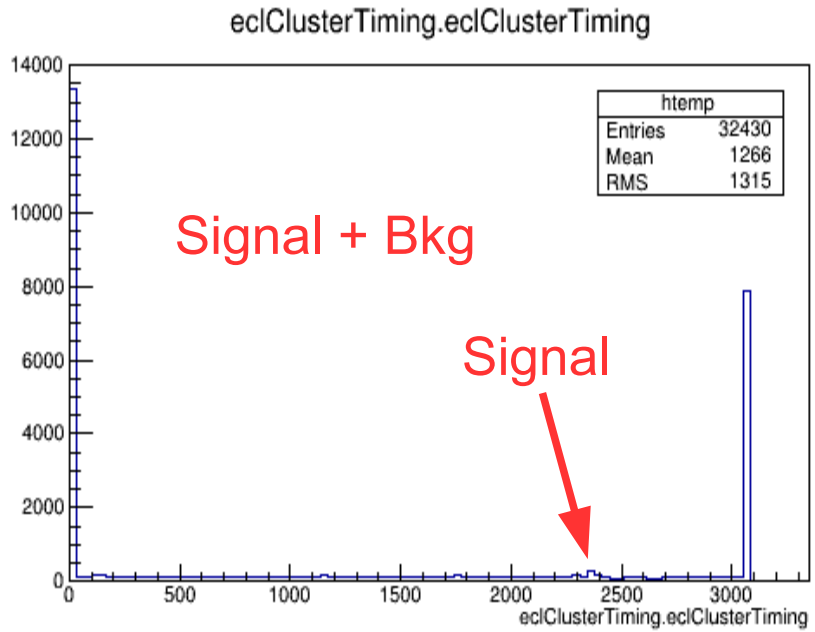




About timing..

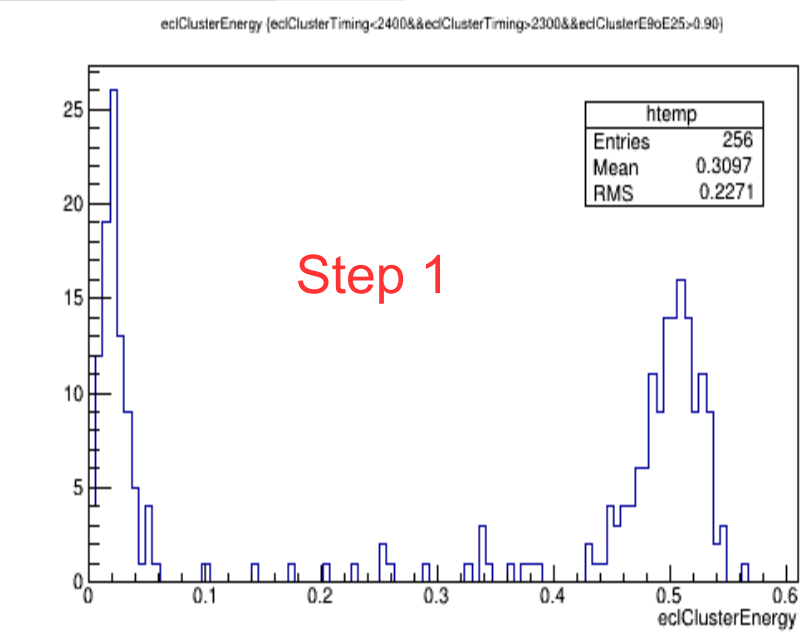
- *ECL digitizer clock rate is 1.76388 Mhz (=567 ns)$^{-1}$*
- *Actual event timing unit for ECL is 567/(96*16) ns*
- *Cluster are accepted if they fall +-567 ns from trigger*
- *This corresponds to 3072 “ECL units” (or steps) (“ECL Unit” = 0.37 ns)*
- *Timing is expected to be good down to 10ns (RMS)*
- *Physics ECL time is peaked at 2350 “steps” (code bias)*
- *I decided to accept only events falling between 2300 and 2400 “steps”*

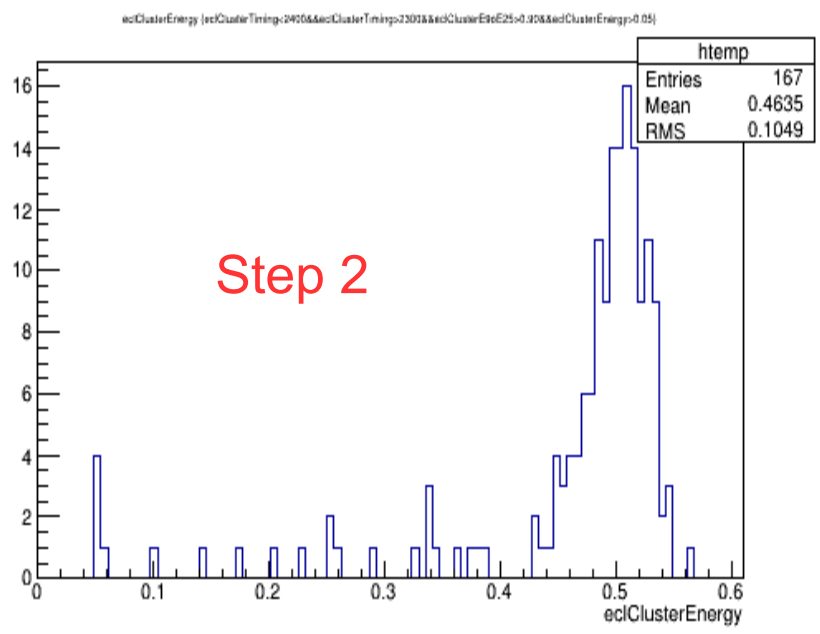




500 MeV photons

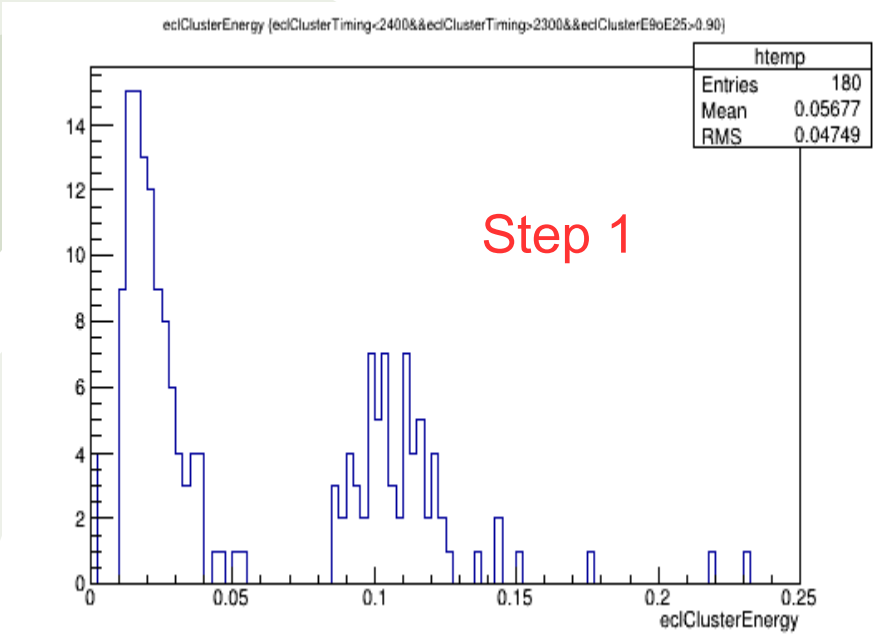
- *First sel step: 2300 < t < 2400 AND E9oE25 > 0.9*
- *Survive: 256 clusters, 162 associated to pGun photons*
- *Second sel step: E > 50 MeV (this was standard value for "good"-photons lis at BaBar)*
- *Survive 167 clusters, 161 signals →eff= 81%, purity= 96.4%*

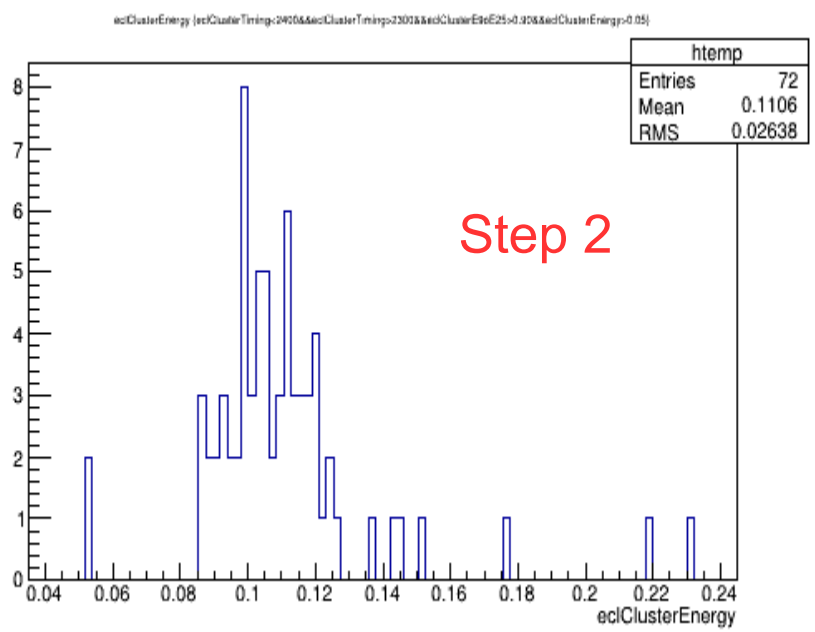




100 MeV photons

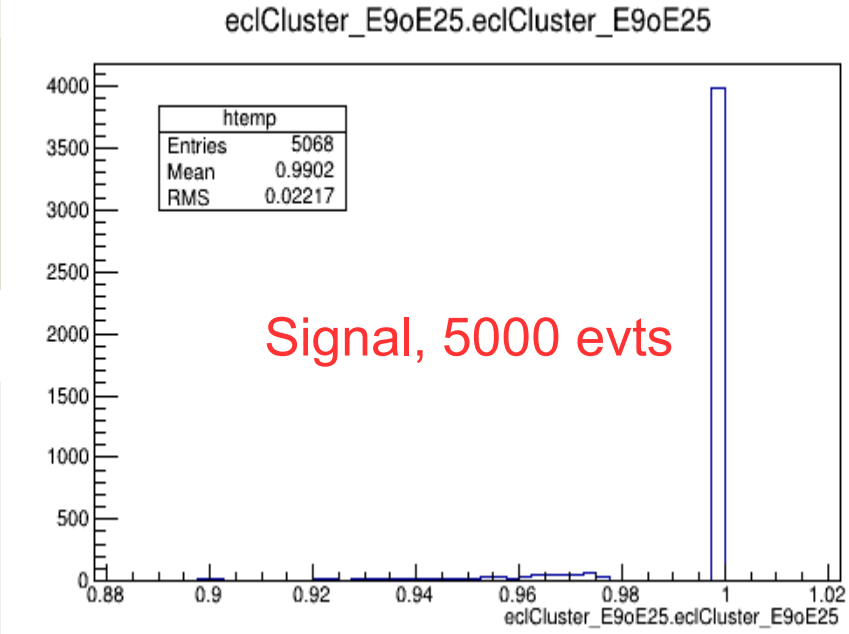
- *First sel step: 2300 < t < 2400 AND E9oE25 > 0.9*
- *Survive: 180clusters, 71 associated to pGun photons*
- *Second sel step: E > 50 MeV*
- *Survive 72 clusters, 69 signals →eff= 23%, purity= 95.8%*

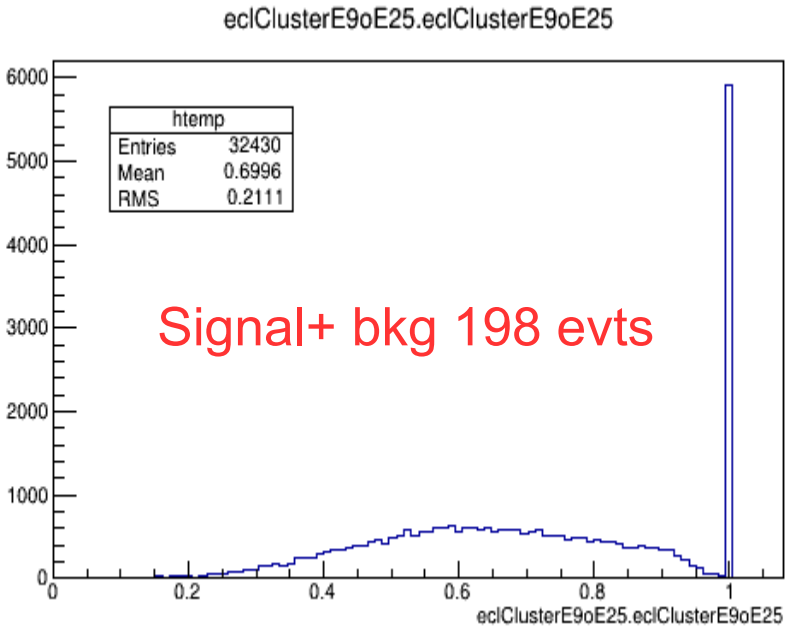




E9oE25

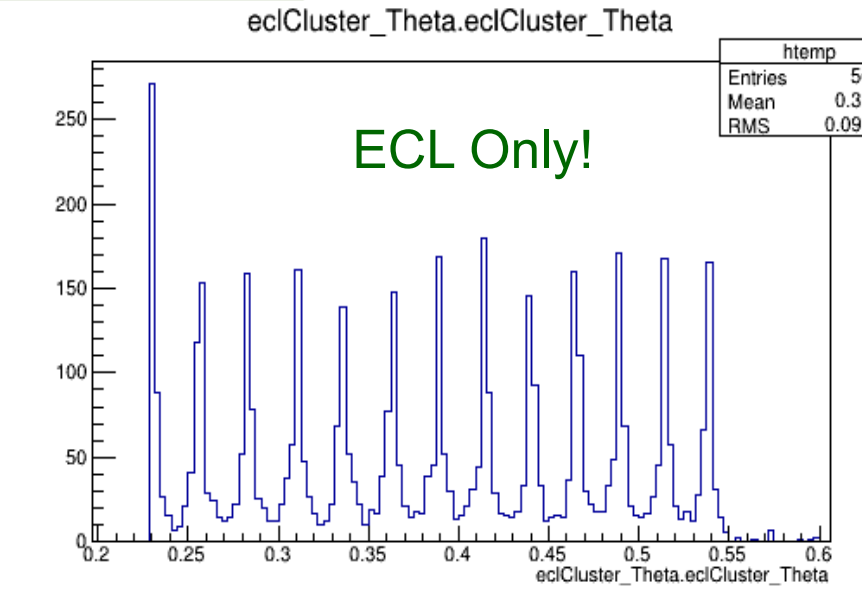
- *E9oE25 describes shower shape*
- *It's close to 1 for "good" photons while tends to be uniform for random (low-energy) beam-background*

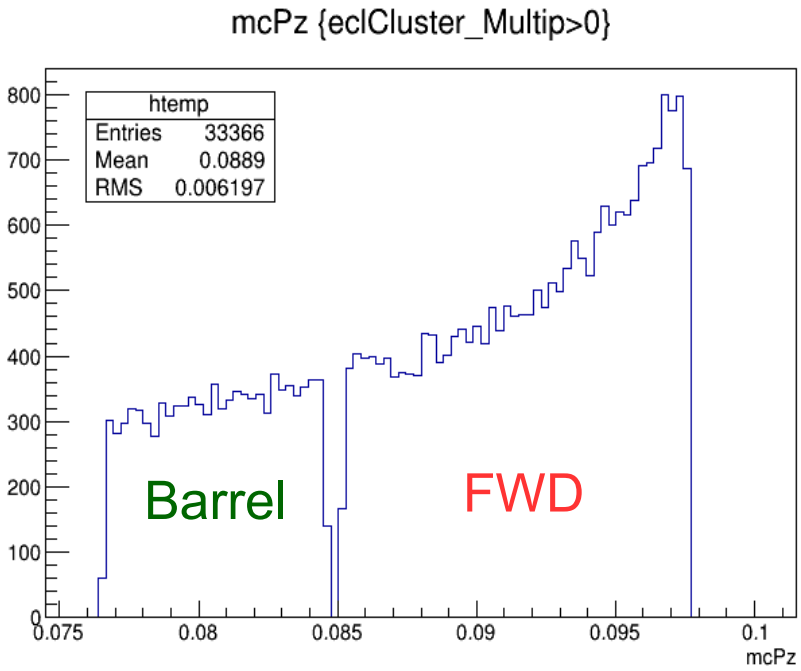




Intrinsic resolution remarks

- *The nominal geometry FWD (12.01° - 31.30°) and actual MC acceptance have observed to be different*
- *High loss of events (i.e. Clusters) close to the inner ring (actual MC acceptance is 12.4° - 31.35°)*
- *Other strange border effects obse*





- *I decided to focus on a smaller ring 20° < theta < 24° FWD (3-4 fwd crystals) for further studies*