Update on ECL Reconstruction from LNF

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Belle2 Italian Meeting
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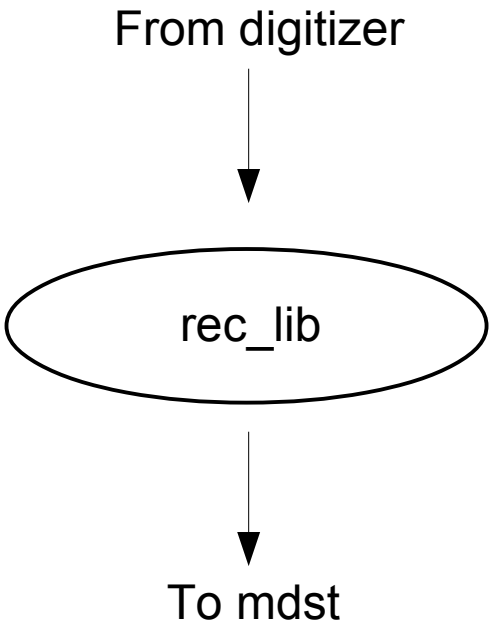
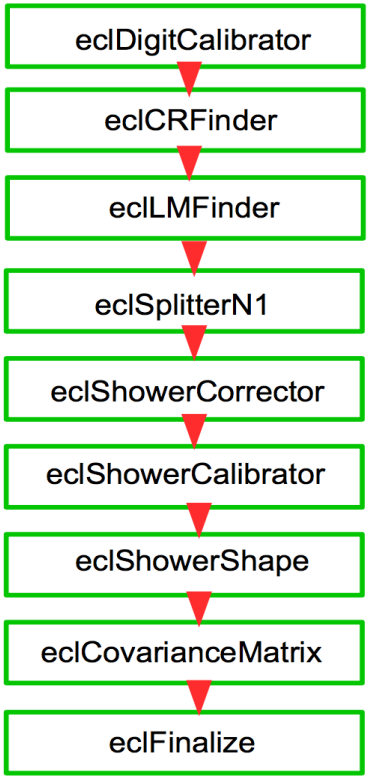
ECL Reconstruction

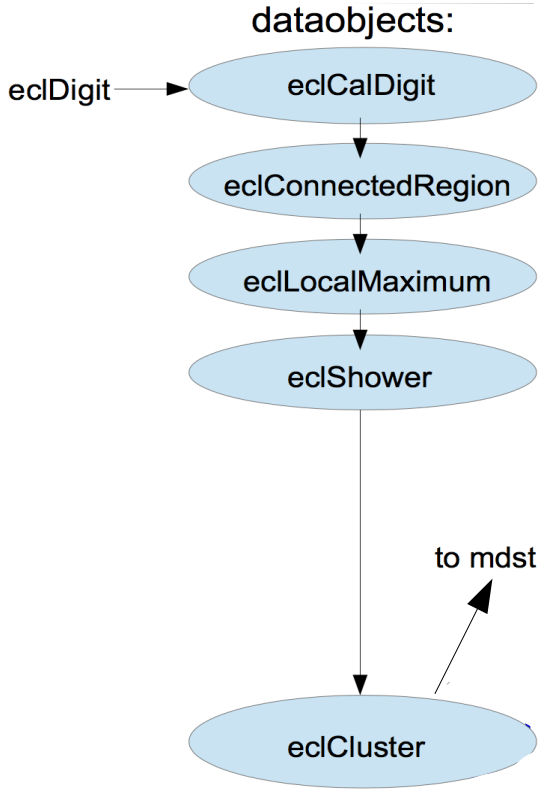
- ECL reconstruction was refactored after release-07

Old ECL reconstruction
≤ release-00-07-02



New ECL reconstruction
≥ release-00-08-00





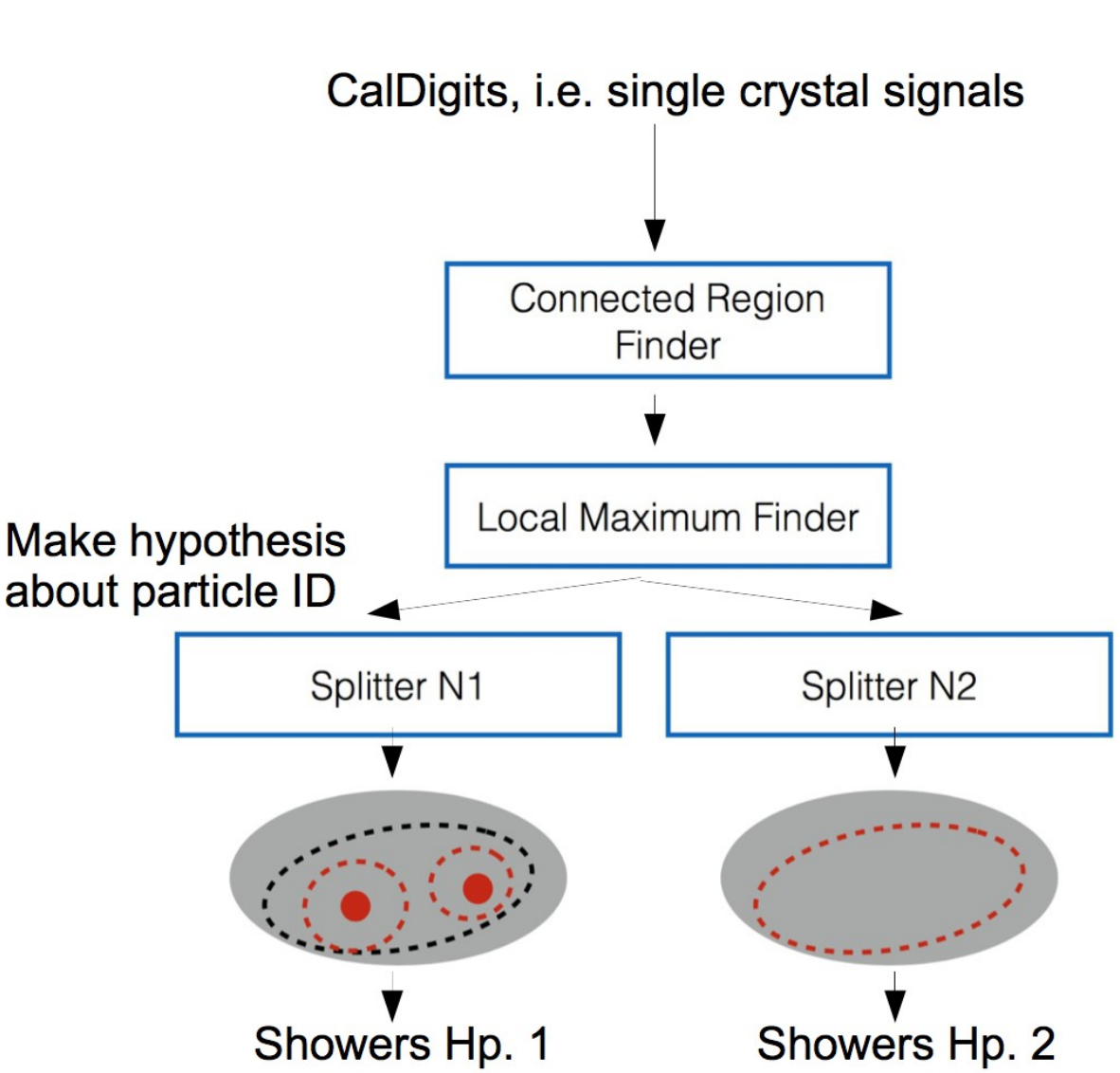
- In order to run with the pure CsI option we had to implement it in the refactored reconstruction chain

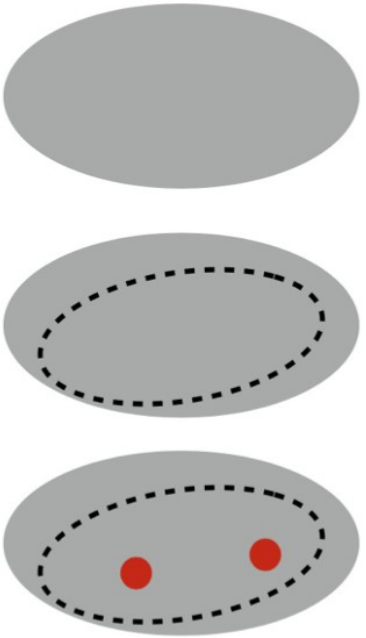
Pure CsI Reconstruction

- The full refactored (i.e. > release-00-07-00) reconstruction chain for pure CsI has been developed and will be in release-00-01-00
- The changes involve many modules and hence requires to update the full ecl package, no changes were made to the digitizer (still Guglielmo's original version)
- An example scripts to run a simulation and dump pure CsI info is provided: ecl/examples/EclPureCsI.py
- No optimization has been done for the clustering algorithm for pure CsI, pure CsI clusters are produced in 2 types (hyp. 5 and 6) in exactly the same way as CsI(Tl)
- Some results about performance shown at last B2GM:

https://kds.kek.jp/indico/event/25459/session/17/contribution/316/material/slides/0.pdf

Connected Regions and Hypotheses





Currently 3 different neutral hp. are foreseen:
1 - n photons
2 - neutral hadron
3 - (merged)pi0

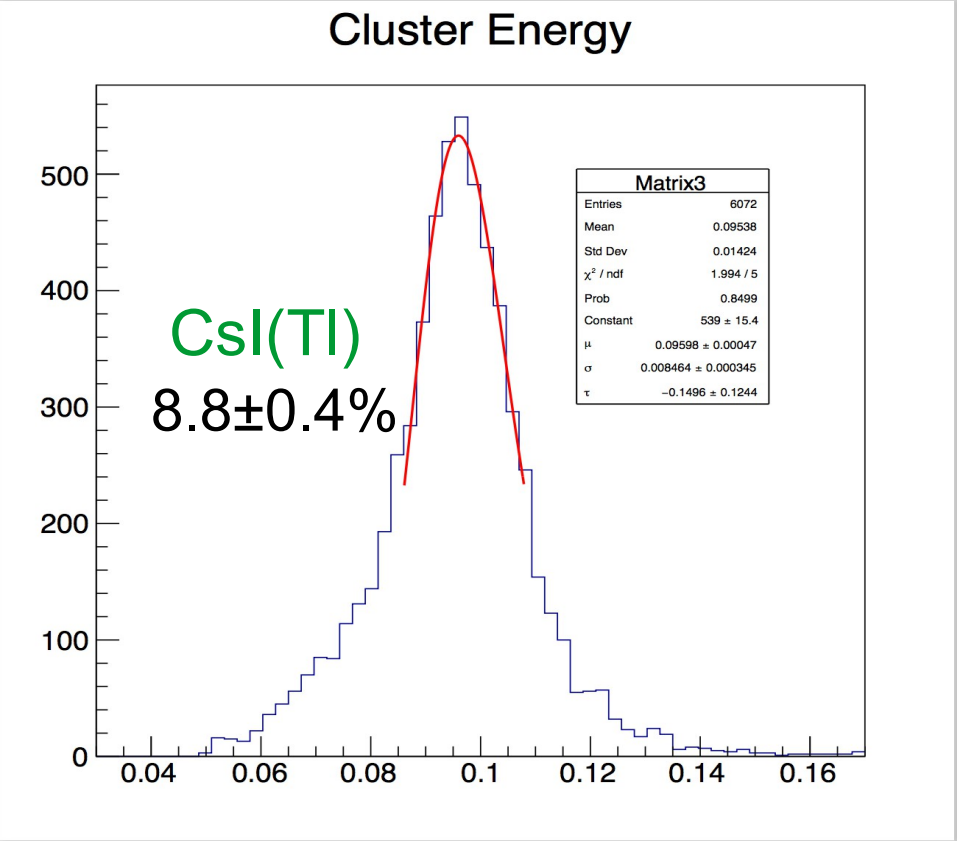
+ 3 chrged hp.:
1 – electron (+n photons)
2 - MIP
3 – charged hadron

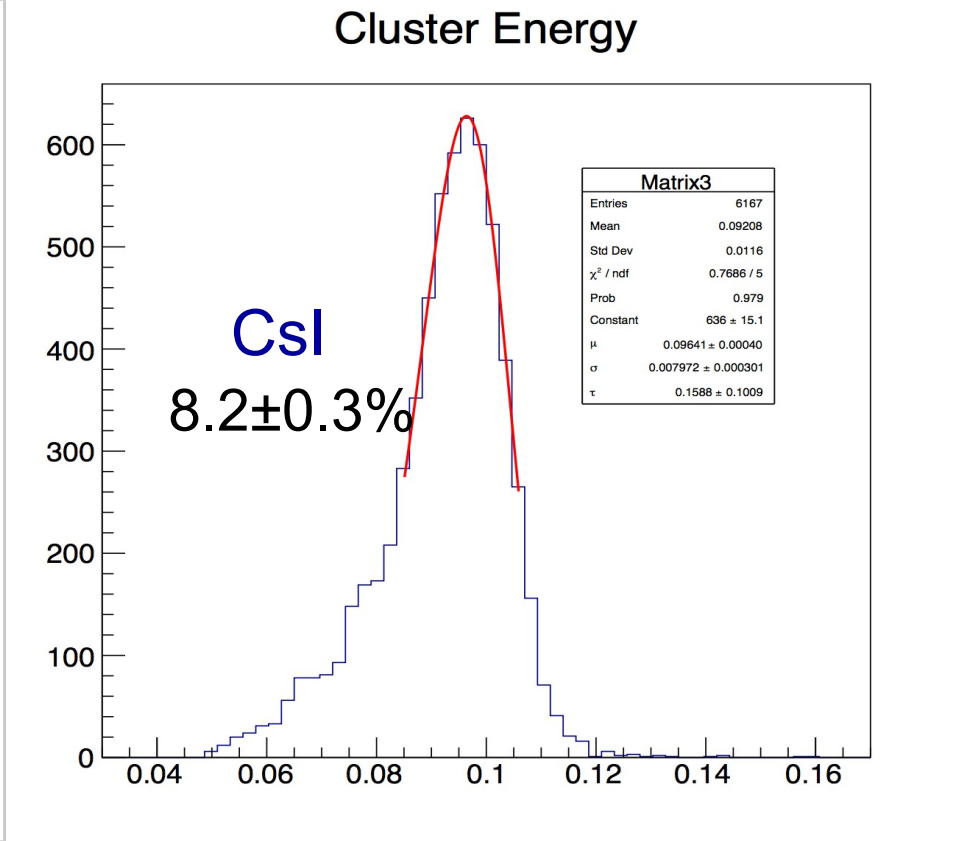
Pure CsI Performance

- Today I will show some results which compare CsI(Tl) and pure CsI performance using different clustering algorithms
- In particular we wanted to understand which could be the optimal clustering algorithm in the case of pure CsI
- The most obvious starting point was to compare the 3 existing algorithms, which in the following I'll call: N1 optimized for CsI(Tl), N2 which returns the whole connected region (release-00-08-00) and the Belle heritage algorithm (release-00-07-02)
- We investigated also different selection criteria with and w/o MC match to understand how the actual performance changes
- Even if the work is not conclusive we found some interesting results which we thought worth to share

CsI(Tl) vs pure CsI MC selection

- Single 100 MeV gamma in FWD with latest bkg files
- Full CsI(Tl) FWD vs full pure CsI FWD (photo-stat=0.4, ENE=1.3)
- Default selection: MC-match + 66% reconstructed energy*
- Novosibirsk fit to the peak

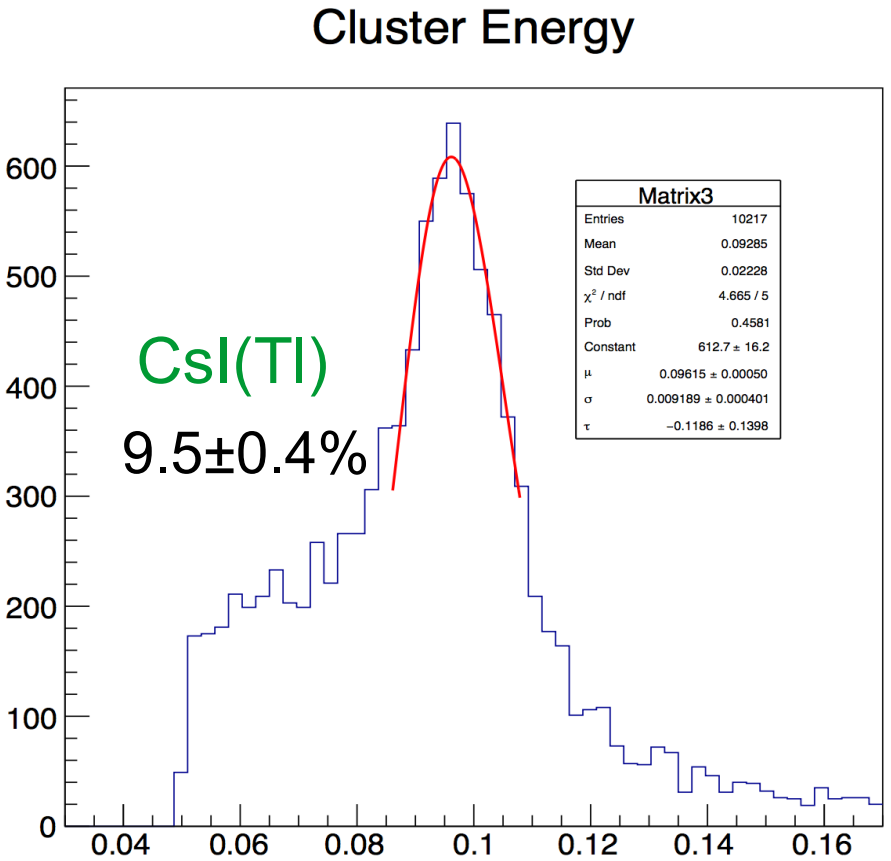


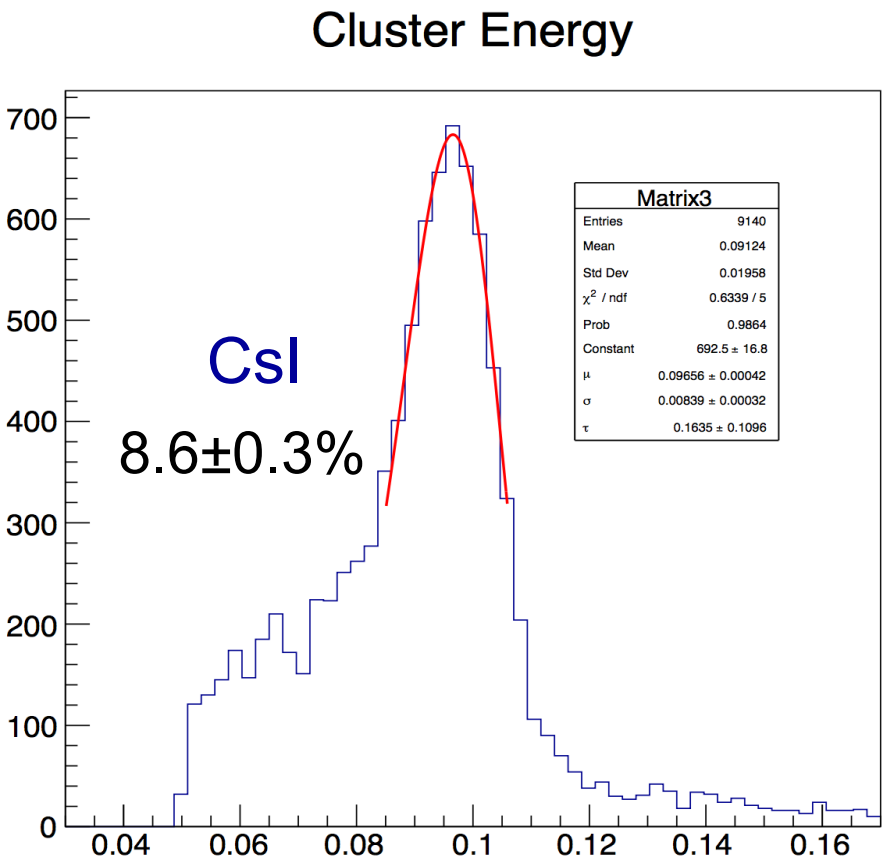


*https://kds.kek.jp/indico/event/22581/session/20/contribution/246/material/slides/0.pdf

No MC selection (1)

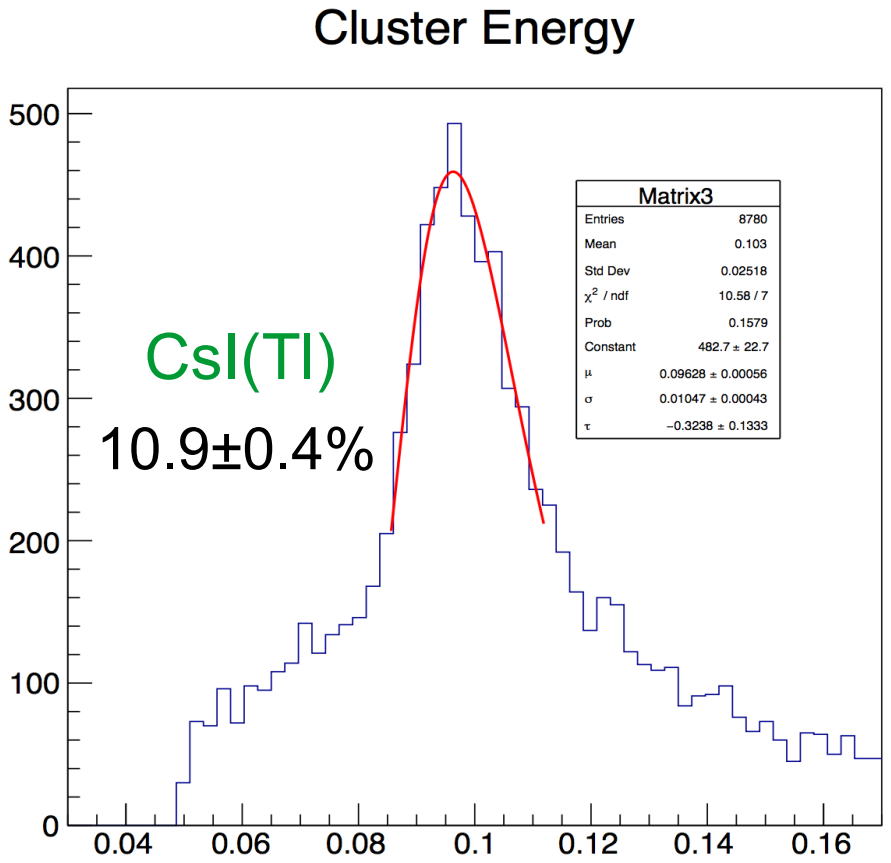
- Selection: > 50 MeV, more than 45 MeV in seed, |t| < 125 ns
- Optimized (i.e. N1) clustering algorithm

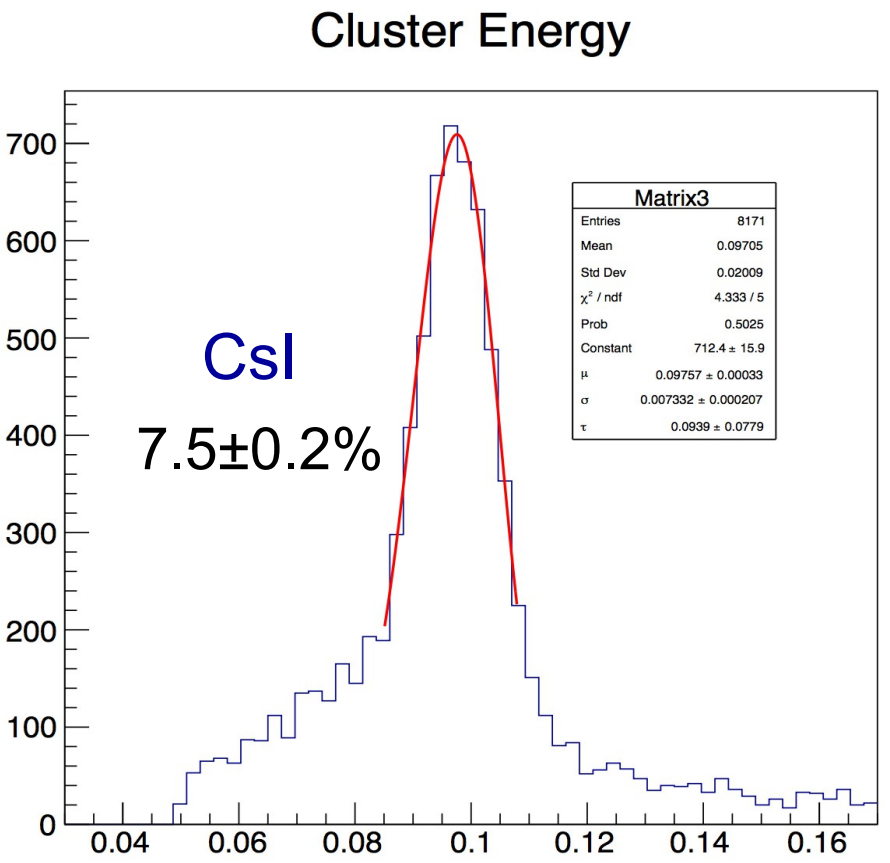




No MC selection (2)

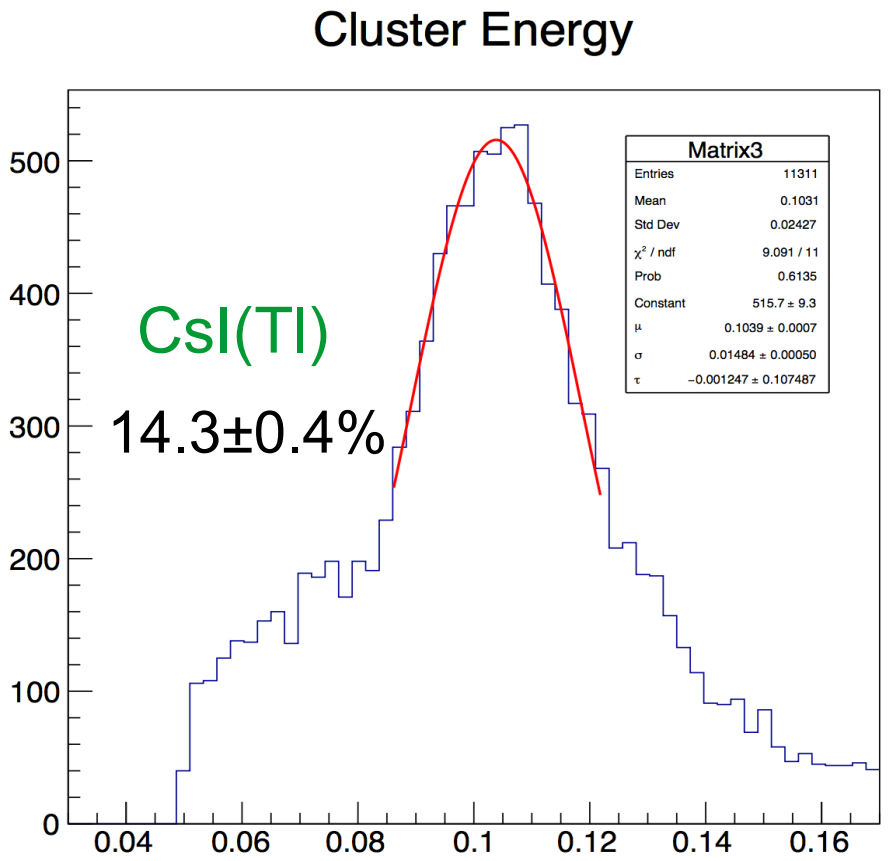
- Selection: > 50 MeV, more than 45 MeV in seed, |t| < 125 ns
- Unoptimized clustering algorithm N2 (i.e. no crystal reduction)
- Pure CsI works better with unoptimized clustering (i.e. more crystals)

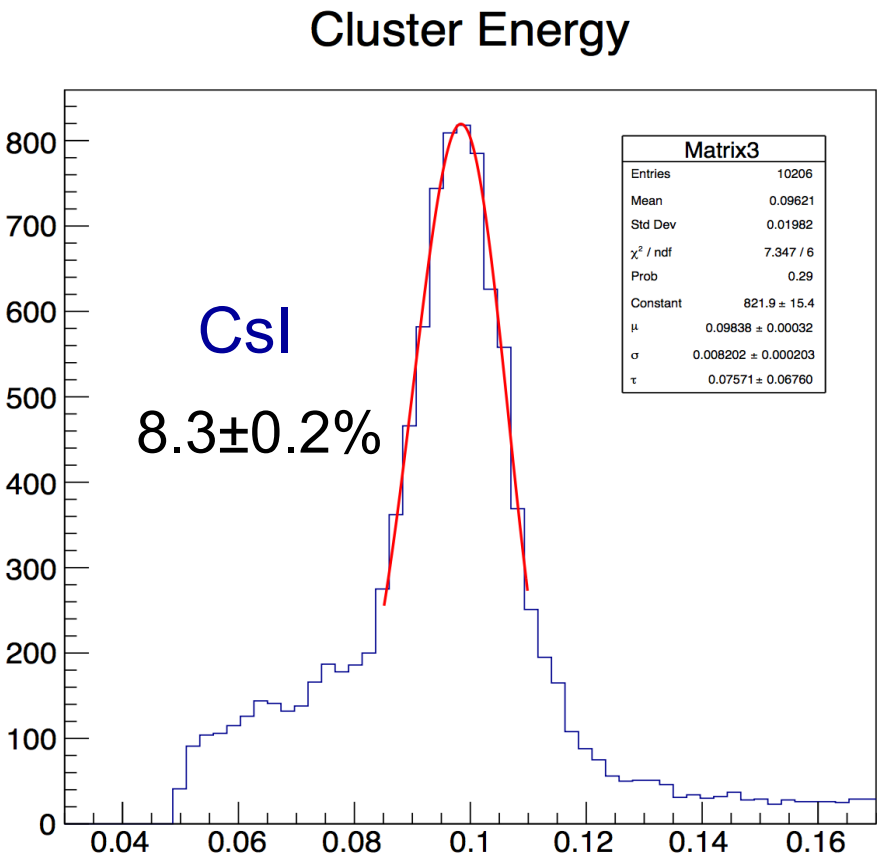




Old Clustering

- Selection: > 50 MeV, more than 45 MeV in seed, |t| < 125 ns
- Release-00-07-02
- While resolution for CsI(Tl) blows up, CsI is rather robust against the choice of clustering algorithm



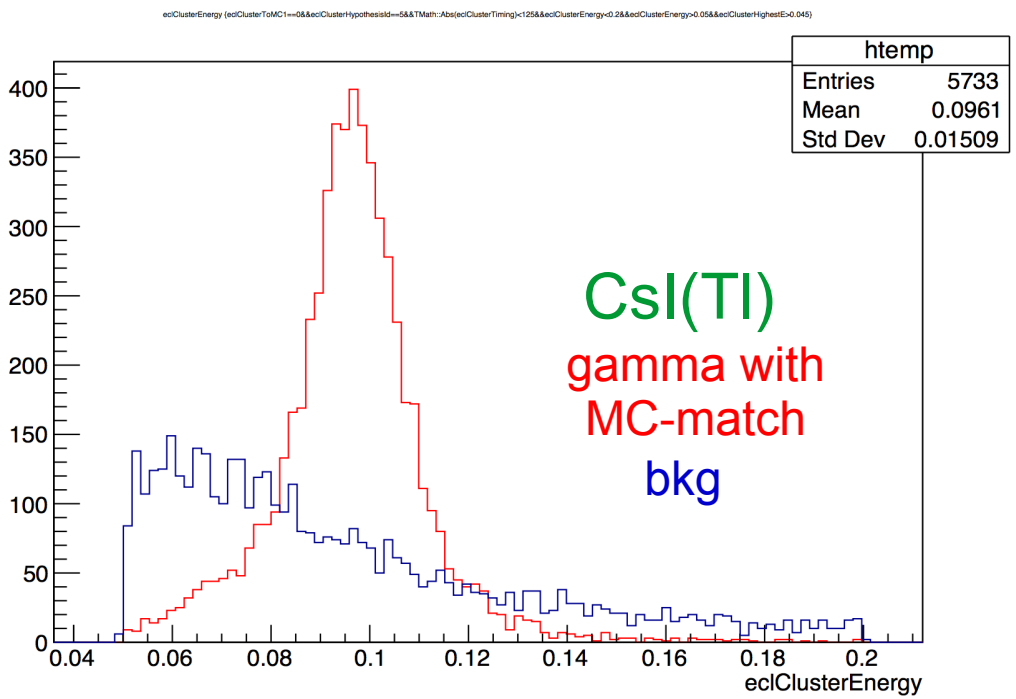


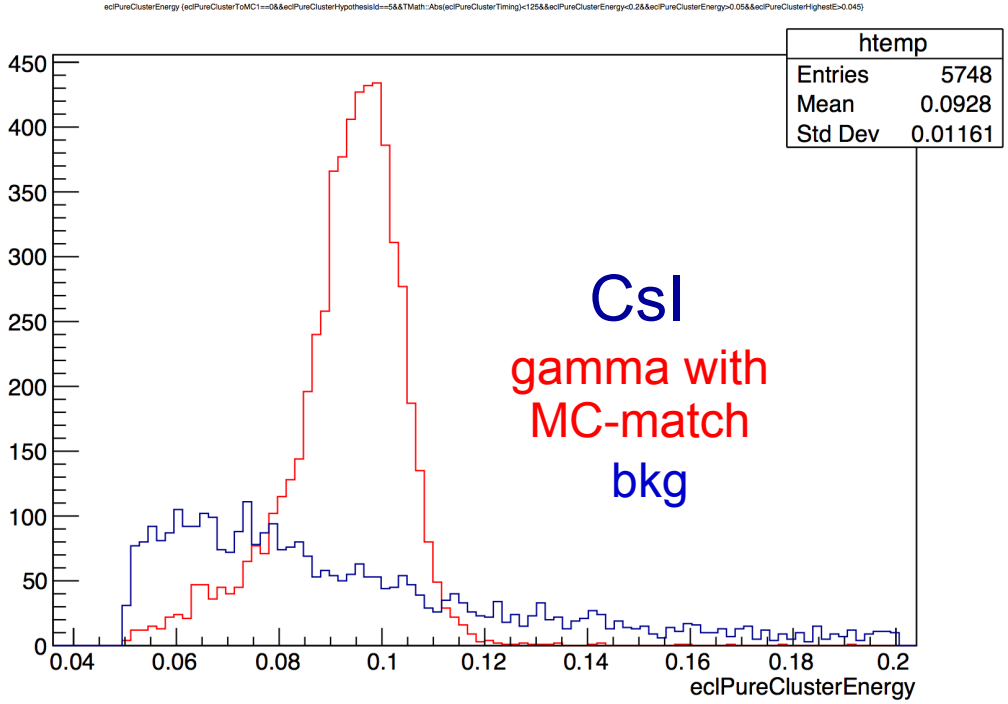
Selection Efficiency @ 100 MeV

- Our selection may seem tight, however if normalize to number of photons which have not interacted before ECL:

  in 10^4 generated events: (MCDecVtxZ<196 cm): ~5700

  → efficiency ~ 100%, S/N ~ 2





Neutral Hadron Clustering

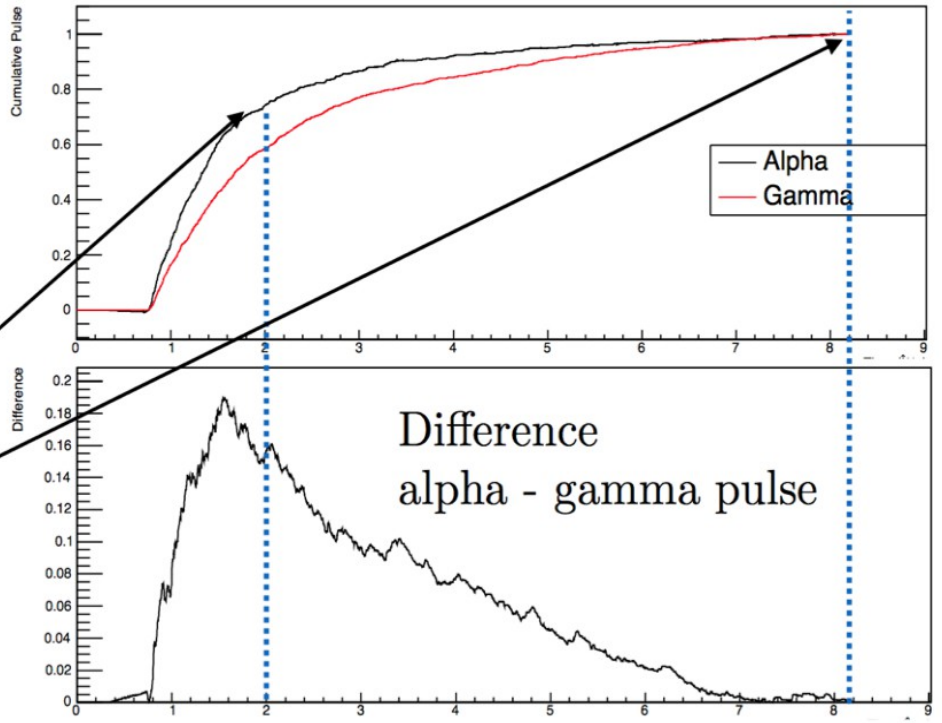
- Differently to what is done for photons for neutral hadrons we associate a single particle to each CR, because:
- Simulations with generic $B\overline{B}$ events have shown that it is unlikely to have contribution from other physics in a CR associated to a deposit by a K_L
- That conversely it is likely that the hadronic processes causes multiple peaks in the CR
- That in this way we have the maximum PID power based on shower shape variables
- In this way we can make best use of some unique single-crystal features of hadronic interactions in the ECL (see next slide)

- On the other hand we do not want the whole CR to be used to extract the hadron direction as this worsens the resolution

PSD

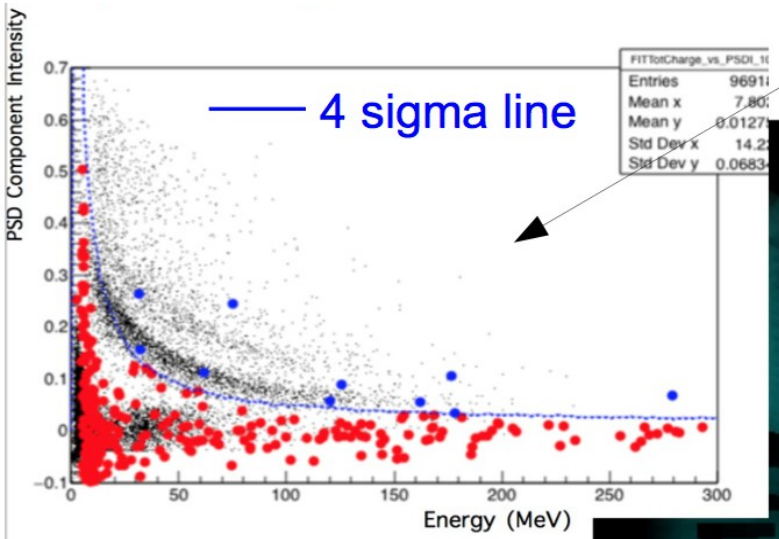
- Basic idea: scintillation response of CsI(Tl) varies with particle type for protons and alphas and electrons
- Use this information to improve particle ID in Belle II
- Known to work at low energies O(10 MeV) and for neutron ID @ 100-700 MeV, what about typical BelleII energies?

$$R_{\mathrm{PSD}} = \frac{Q(1.2\mu s)}{Q(7.4\mu s)}$$



PSD @ Belle2

- First results on ECL cosmic data reading out full waveform and using 3-component fit model look promising
- Issue for Phase-2: hardware does not support 2 and 3-component fits, currently the possibility to use the X^2 of "bad" fits is under study



Black dots is TRIUMF data

Cosmic event with hadron-like topology

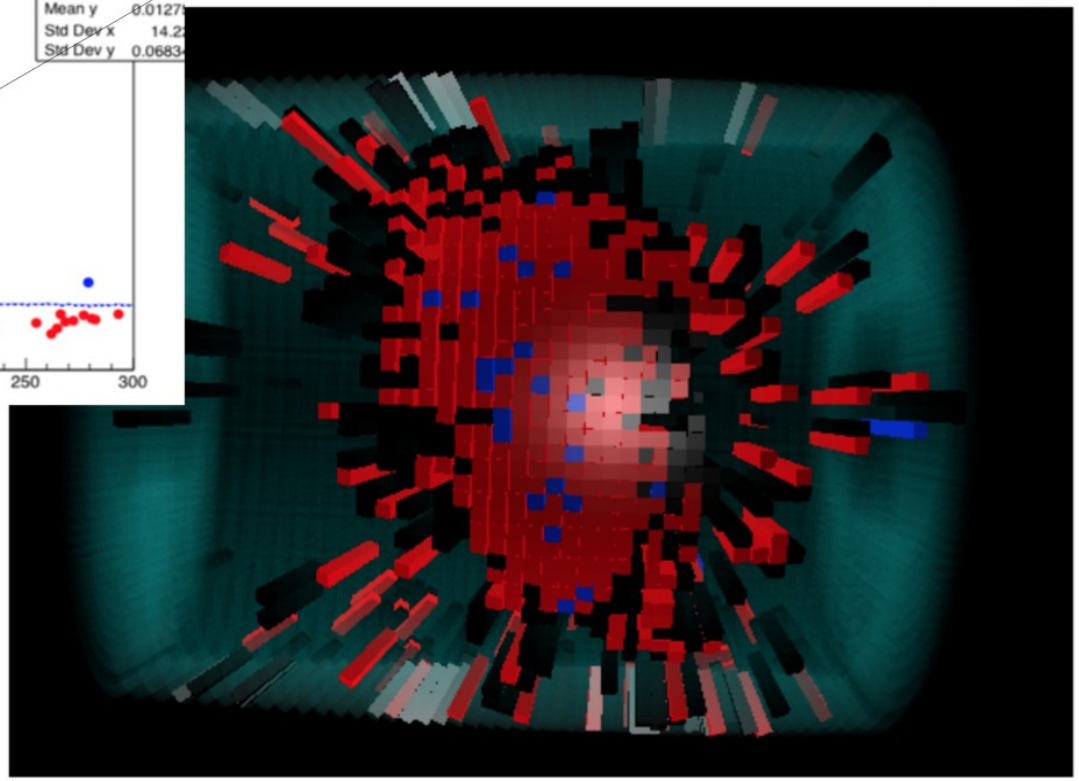
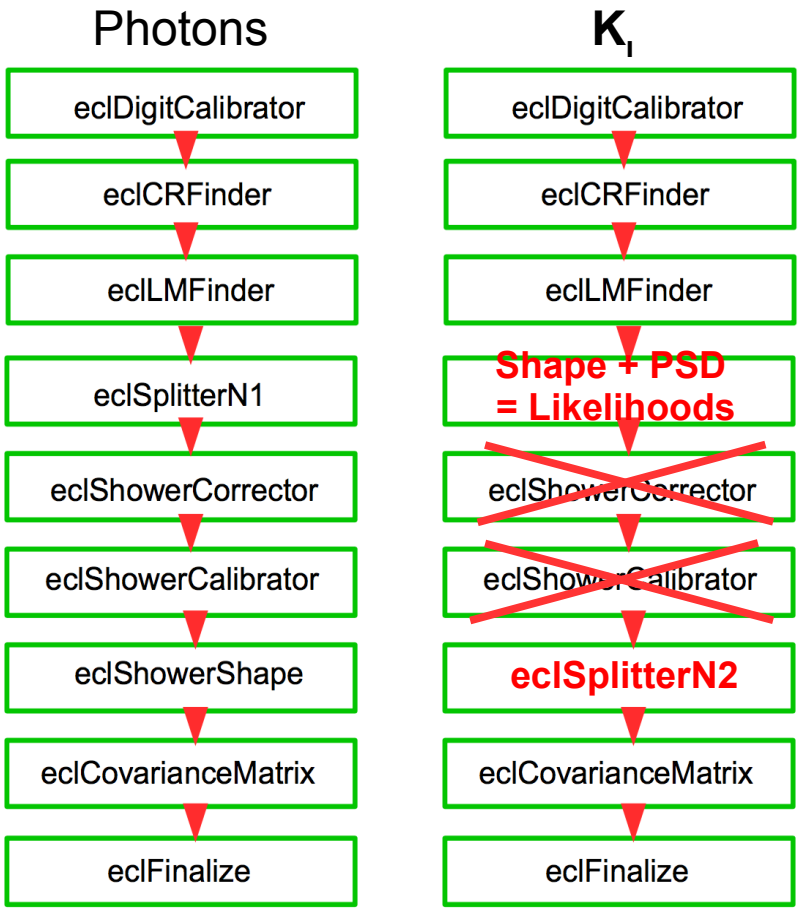


Image Legend:

Red crystals below 4 sigma threshold (electromagnetic)
Blue crystals above 4 sigma threshold (hadronic)
Black crystals have noise (triggered but no pulse)

Neutral Hadron Reconstruction

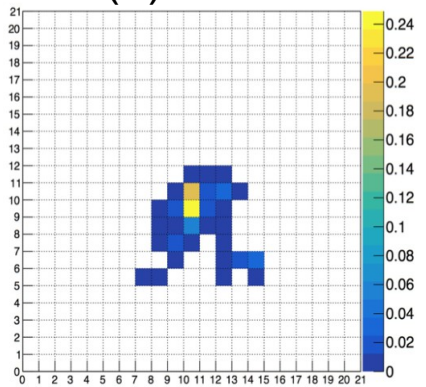
- Based on previous arguments and collaborating with S. Longo (PSD) and J.F. Krohn (MVA for K_L ID) I'm working on the new reconstruction chain for hyp. 6



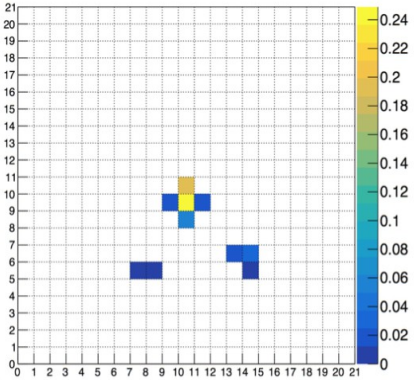
Here we want to calculate shower shape variables and calculate likelihoods using also PSD info

Here we want to optimize the number of crystals in order to get the best $\bar{p}$ resolution

(3) CRs



Final clusters



- Currently almost all ingredients are in place, I'm at work to put everything together

Outlook on Pure CsI

- Our results show that pure CsI is more robust against the choice of clustering algorithm and selection criteria

- Pure CsI performs better with a larger number of crystals (release-09), and, since an object larger than the CR seems unrealistic, for the time being the CR seems to be the best performing “cluster object” for pure CsI

- General comment: the actual value of the resolution depends a lot on selection criteria, fit interval etc.. I think it would be very useful to agree on one (or more) official definition(s) of resolution (selection, fit function, fit interval) to be used by all ECL people

- For the time being no further development of pure CsI is foreseen @LNF

Outlook on other activities

- Ongoing ECL SW activities @LNF:
  - EclSplitterN2: delayed because of other priorities for release-00-01-00, logic already agreed on, based on best resolution on KL direction, needs some final work to be committed
  - Use of PSD (Pulse Shape Discrimination) information in clustering for neutral hadron ID is the next topic on the list
- mDST size issue: we agreed to maintain 2 cluster hypotheses for phase-2
  → testbed for hadron clustering

- Not strictly ECL, but related → K_L0 list, joined effort:
  - ECL reconstruction: PSD (S. Longo), eclSplitterN2 (B.O.)
  - ECL+KLM likelihoods (J.F. Krohn)
  - Analysis: construction new K_L0 particle list and testing (B.O.)

- Lately some fixes to ECL validation because of repeated failures
  → will be taken over by Elisa

Backups