Clustering Algorithms for the Forward Calorimeters – Current Status –

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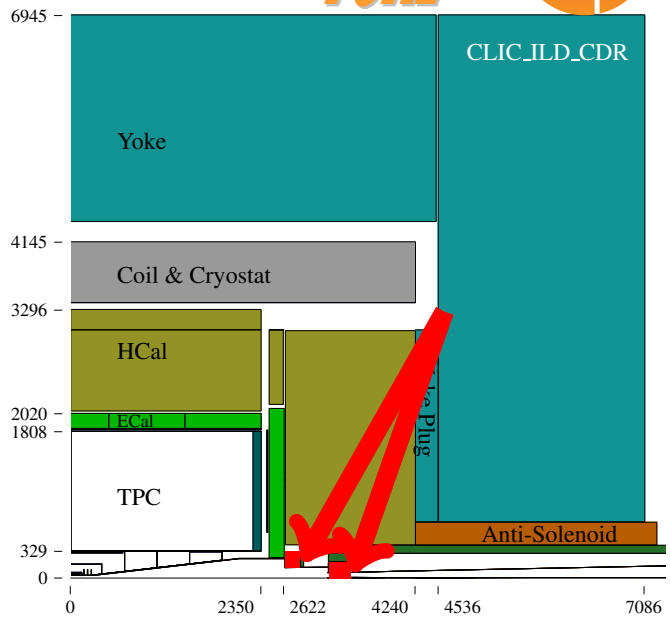
on Behalf of the FCal Collaboration
and the CLIC Detector and Physics Study

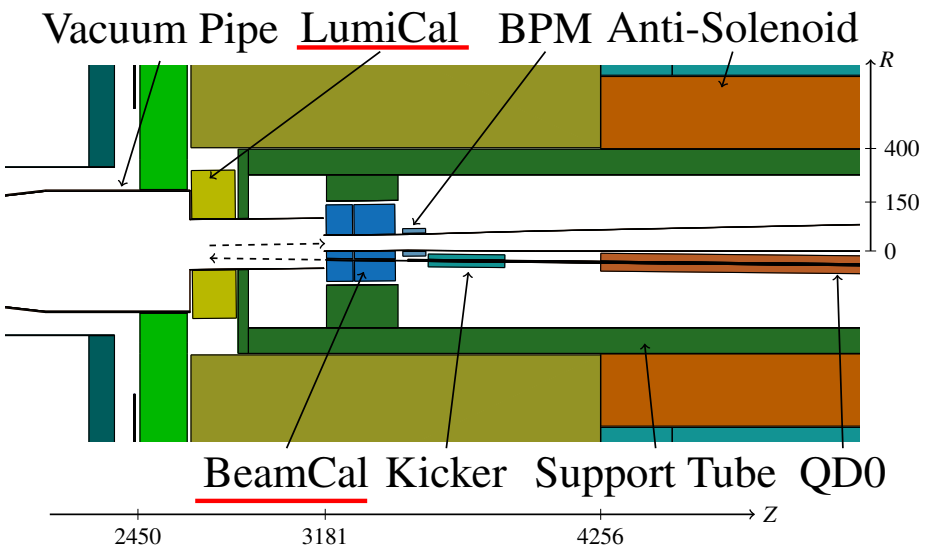
CERN-PH-LCD

Linear Collider Workshop
November 11–15, 2013
Tokyo, Japan

Overview

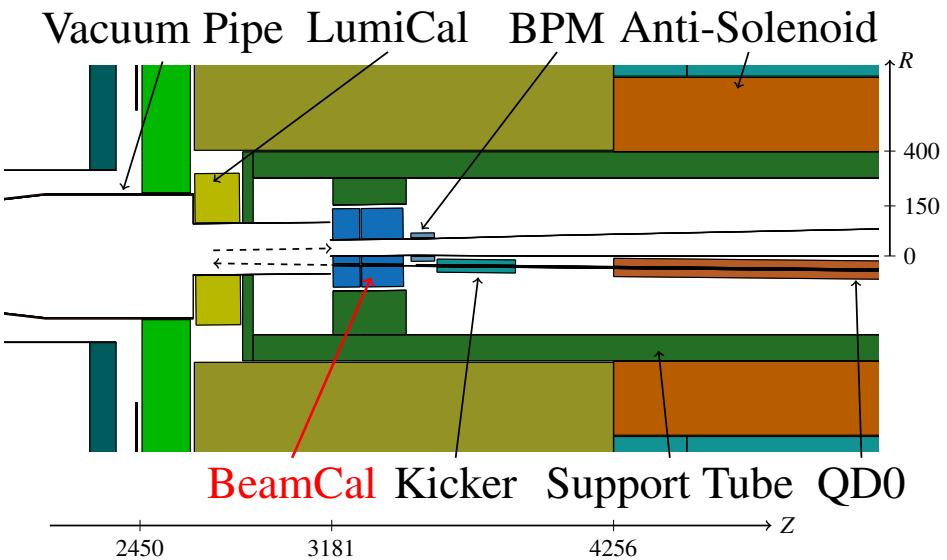
1. BeamCal Clustering
2. LumiCal Clustering
3. Summary and Outlook

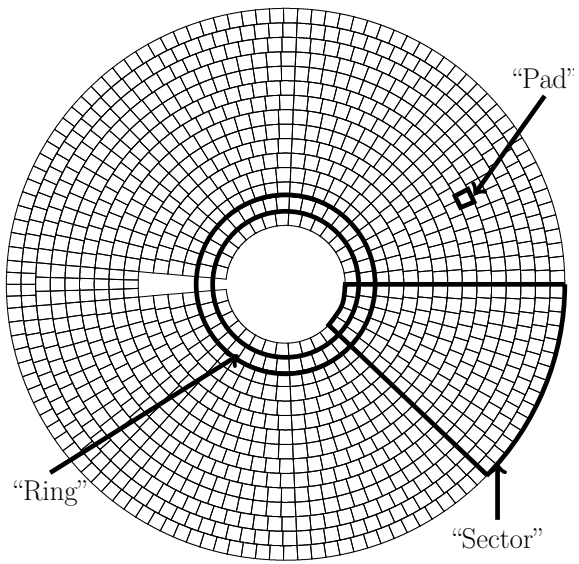




The BeamCal Detector

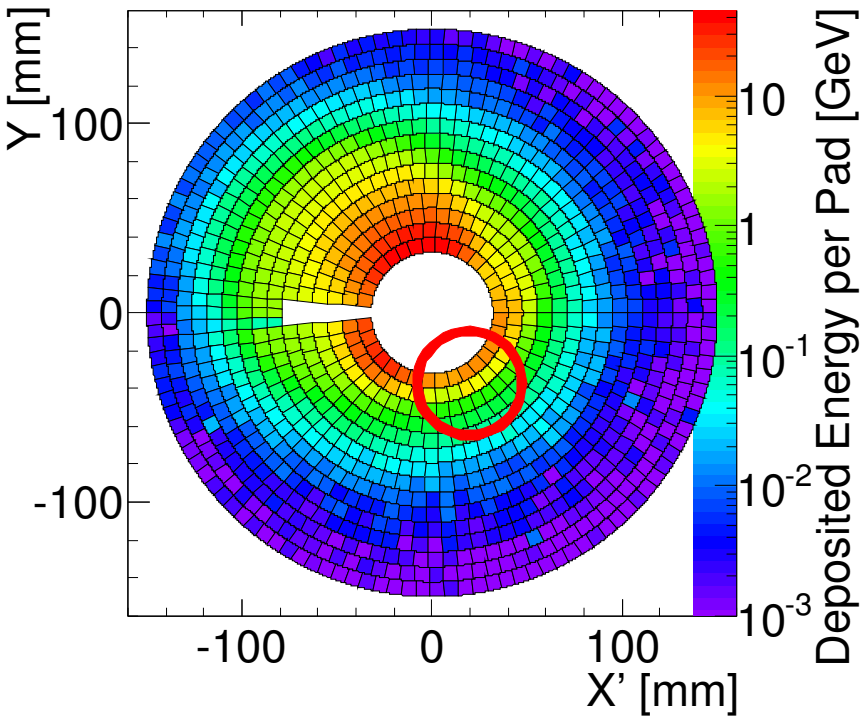
- 10 mrad to 45 mrad (ILC from about 3.5 mrad)
- Absorber for incoherent pairs
- Mask for downstream elements (QD0, BPM)
- Radiation hard sensors required
- Electron tagging for background suppression
- Tungsten sandwich calorimeter, Molière radius of about 1 cm
- Pad size 8×8 mm^2
- ILC opening around outgoing beam pipe larger, different number of pads per sector

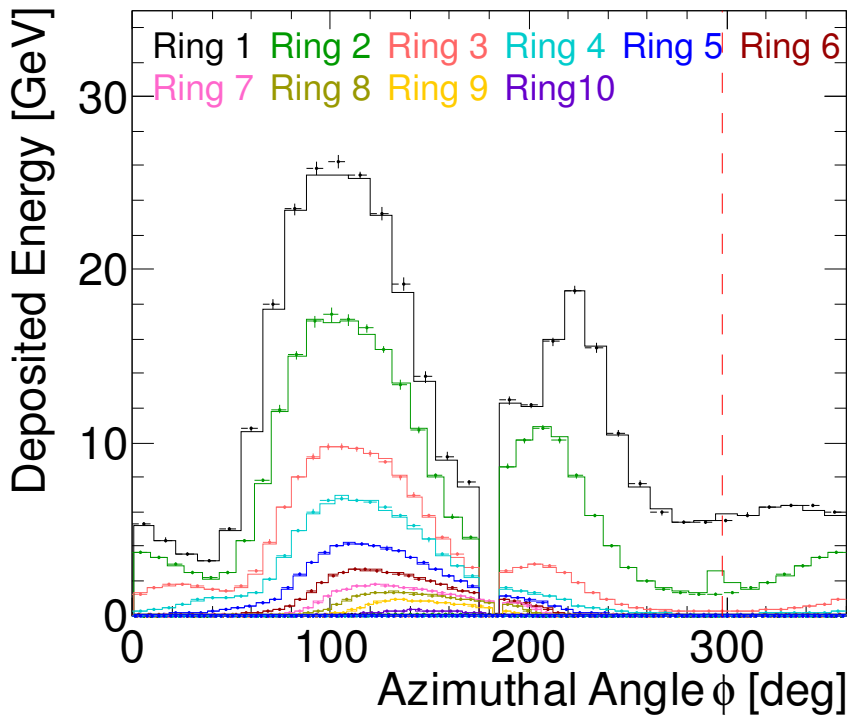




High Energy Electron and Background

- 1.5 TeV electron on top of 40 BX background
- Have to identify cells and cluster with more energy deposited than average background





- Aim for high efficiency and low fake rate, but this can also depend in the analysis

Clustering Algorithm

Idea of the Clustering in the BeamCal

1. Obtain energy deposits in the BeamCal: Background and possibly signal
2. Subtract the average energy deposit from beam-induced backgrounds
3. Find all pads with significant energy deposits
4. Run nearest-neighbour clustering on those pads

Implementation and Recent Development

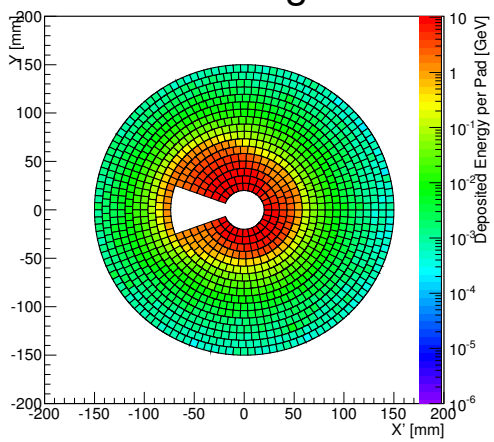
Presented my implementation at ECFA meeting in Hamburg

- Object oriented implementation, hide the details and work on high level objects

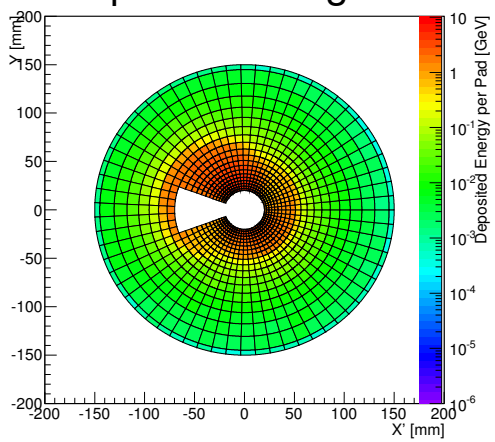
Did some clean-up of the code, small bug-fixes

- Removed hard-coded value used in phi-comparison for neighbouring pads
- Wrapper to run on BeCaS (standalone BeamCal Simulation used for layout optimisation)
- Add LCIO output collection to MARLIN processor
- Moved to ▸ FCal SVN repository
- Nightly checks with Coverity static code analysis availabe at CERN
  - As for the rest of iLCSoft

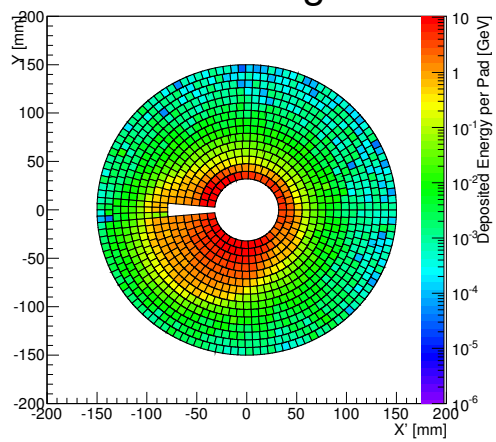
ILC: Uniform segmentation



ILC: Proportional segmentation



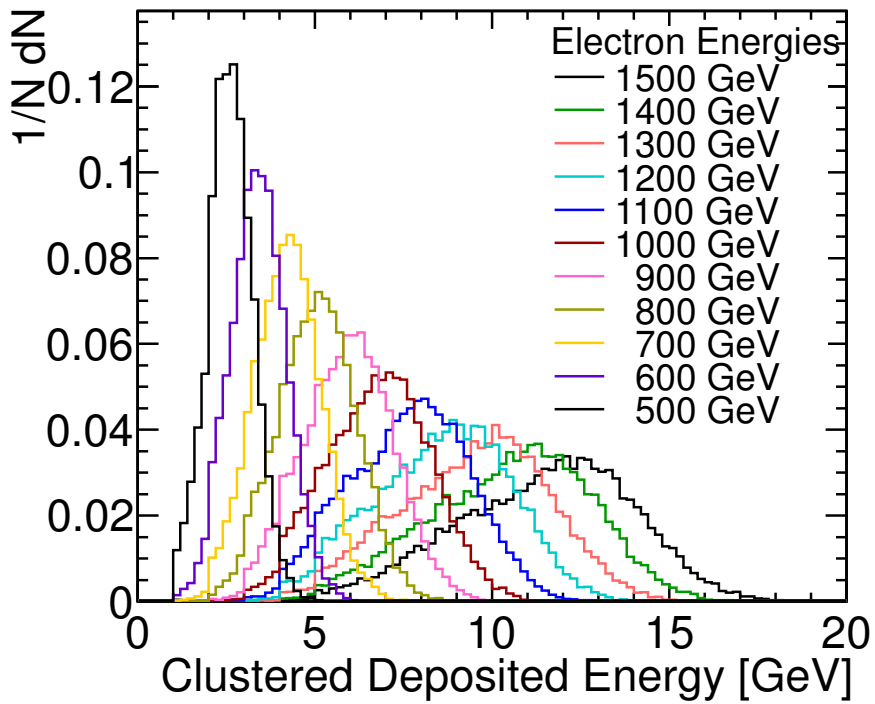
CLIC: Uniform segmentation



Performance

- Clustering takes about 0.04 s per event with 1 BX of background and 0.12 seconds with 40BX of background
  - Backgrounds are overlaid via vector of energy deposits

Reconstructed cluster energies (without calibration) with 40 BX of background in CLIC_ILD_CDR BeamCal

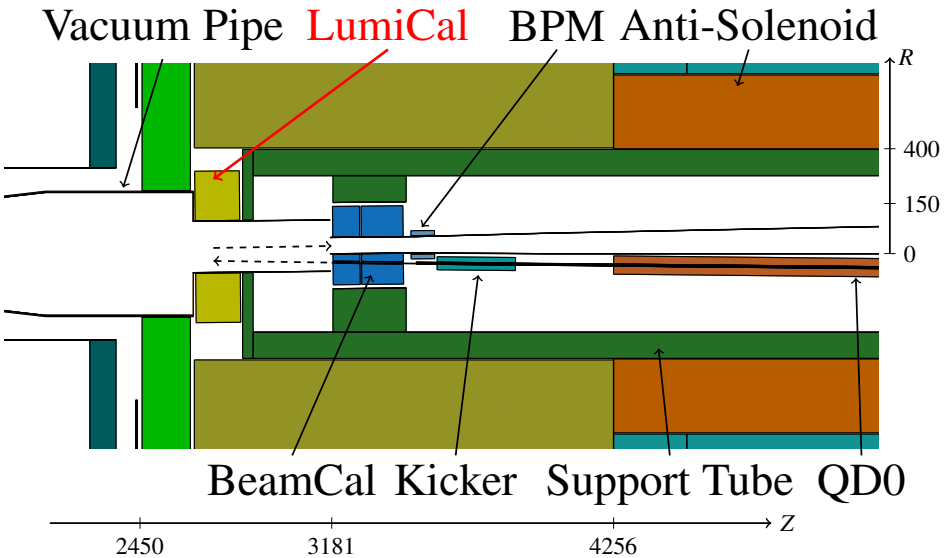


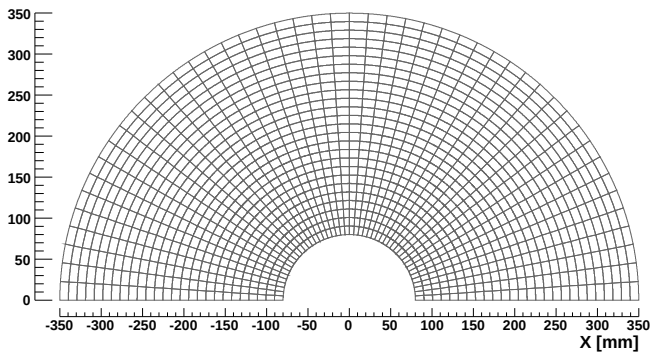
To Do

- Validation (with help from L. Bortko (Desy) for the different ILC layouts)
- Marlin processor with LCIO output
  - Does overlay from large sample of background bunch crossings
  - Needs possibility to also read background average/RMS files (backward compatibility with existing BeamCalClustering in MARLINRECO)
  - Tunable energy calibration
  - Connect hits in the BeamCal to `ReconstructedCluster` object?
    - ⋆ The `SimCalorimeterHits` do not correspond to what is used in the clustering due to the energy subtraction
- Documentation
- Replace MARLINRECO processor in reconstruction chain

LumiCal

- Coverage about 40 mrad to 110 mrad (at CLIC)
- Calorimeter for luminosity measurements via counting of Bhabha events
- Silicon–tungsten sandwich calorimeter, Molière radius of about 1 cm
- Variable pad sizes
- Precise reconstruction of (polar) angle and energy of paramount importance for precise luminosity measurement
- If possible separate electron showers from photon showers

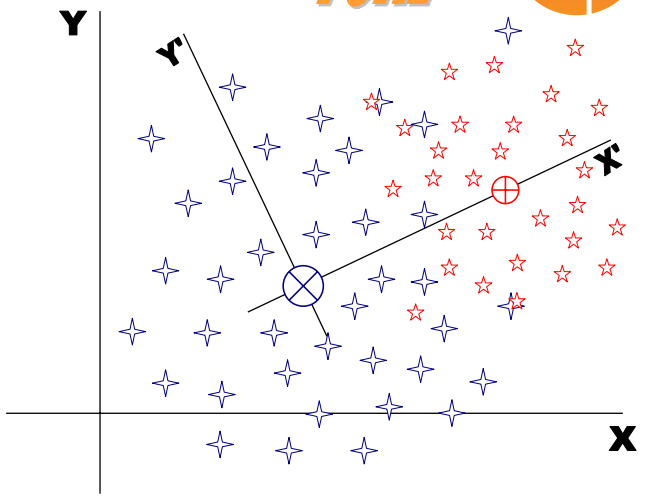


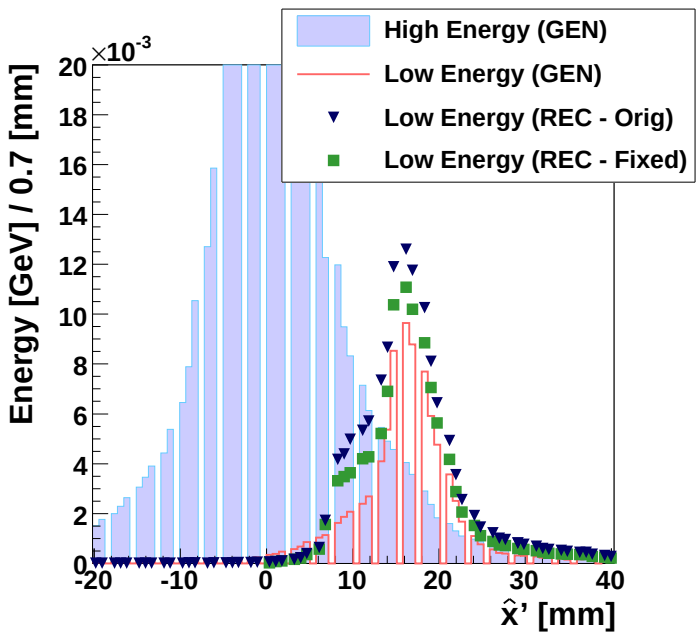


Half-plane of LumiCal with every fourth radial segmentation drawn (I. Sadeh, MSc. Thesis, Tel-Aviv University, 2008)

LumiCal Clustering Algorithm

- Sophisticated clustering algorithm developed and implemented by I. Sadeh ▸ Link
- Nearest-neighbour clustering with shower shape analysis to split nearby showers

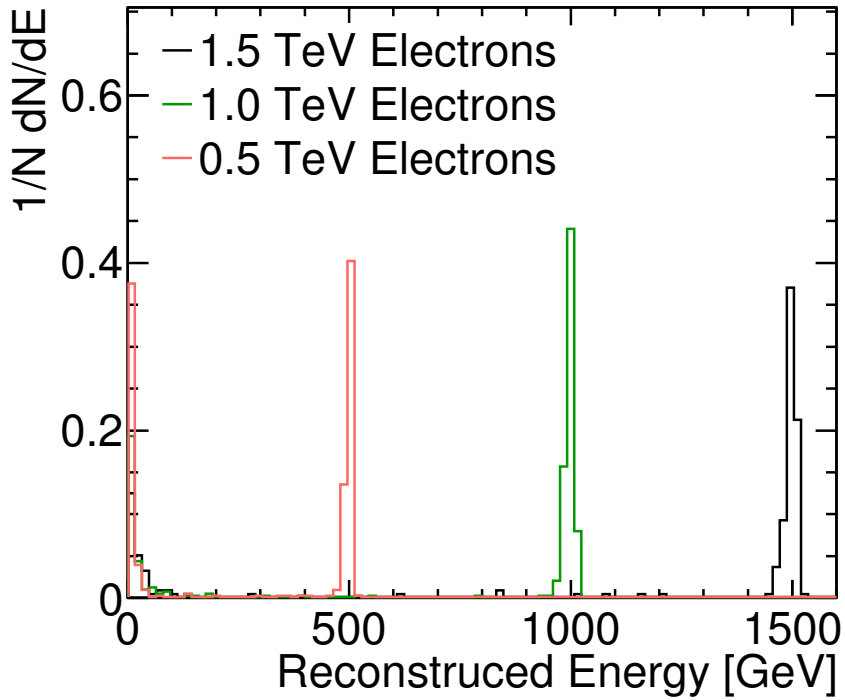




(I. Sadeh, MSc. Thesis, Tel-Aviv University, 2008)

Getting the LumiCal Clustering to Run

- Could not run the algorithm out of the box
- Took some time to understand:
  - Problem caused by different cell ID encoding assumed in the reconstruction and simulation
    - ★ Pick up encoding from collection
  - Fixed faulty logic when computing average of azimuthal angles
- Takes about 0.1 seconds per event (no backgrounds)



Reconstructed energy of cluster from mono-energetic electrons in CLIC_ILD_CDR LumiCal. No cut on acceptance angle, some showers only partially contained

To Do

- Move to FCal SVN (currently on my local git repository)
- Read geometry from, Gear
- LCIO output
- Validate performance (with help from S. Lukic (Belgrade))
- Documentation
- Add to reconstruction chain

Summary and Outlook

- Implementations of forward clustering algorithms for BeamCal and LumiCal will become available in single package soon

Thanks to Iftach for information on his program

Thanks to Lucia for the BeCaS files to test against

Thank you for your attention!