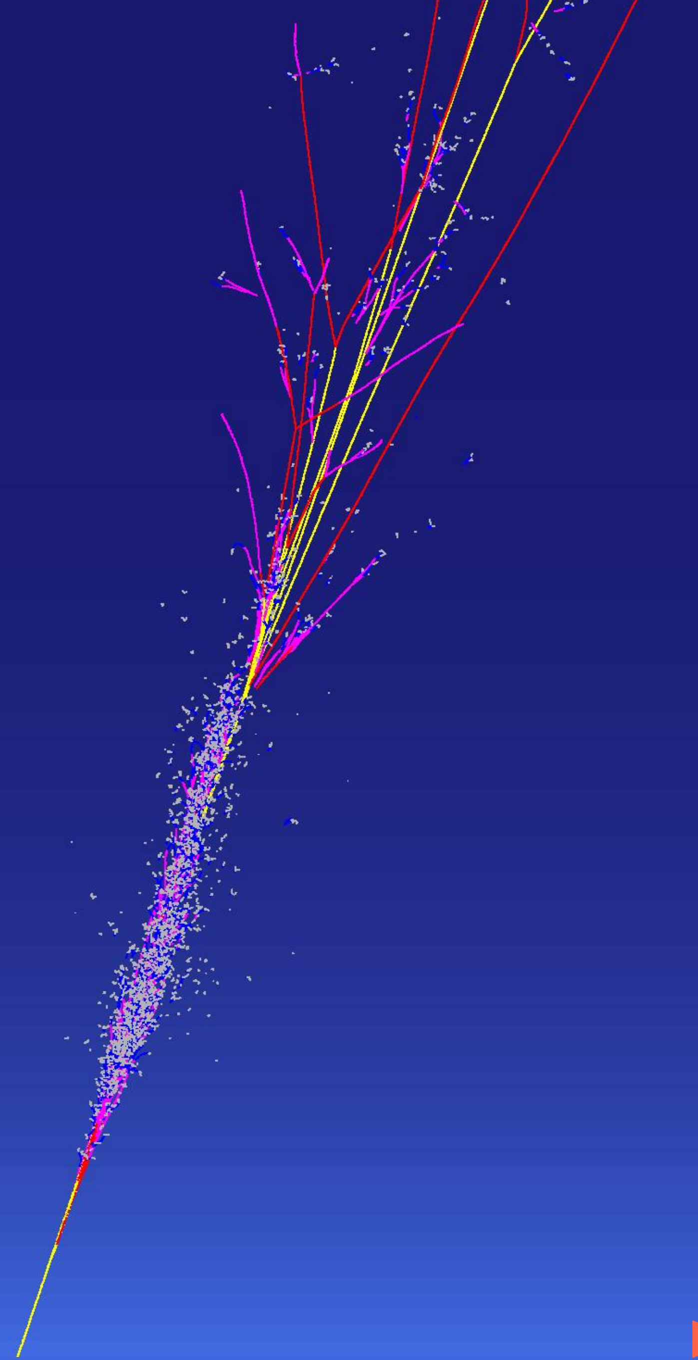
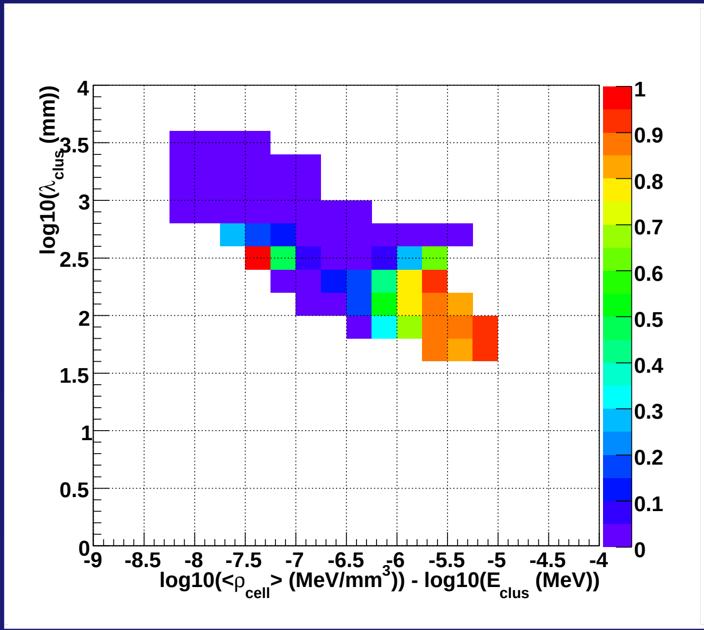
Local Hadron Calibration Session

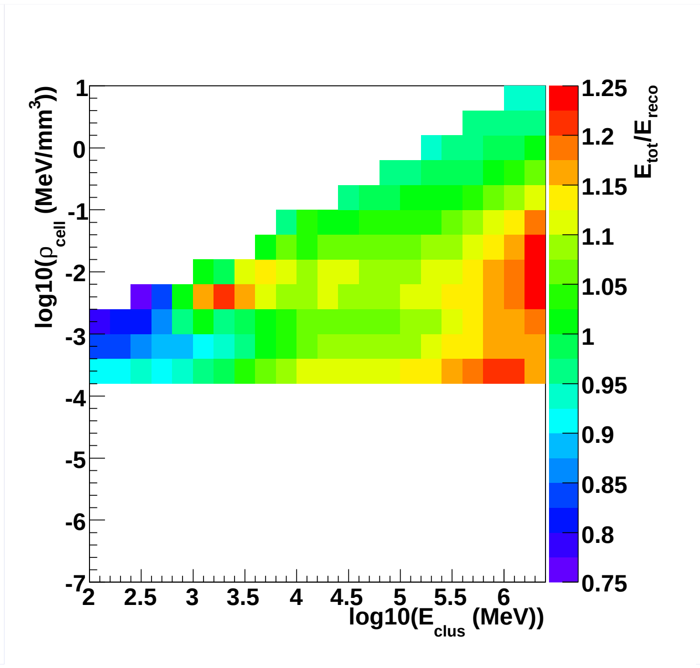
Hadronic Calibration Workshop 09 Sven Menke, MPP München 24. June 2009, Foz do Arelho, Portugal

- Local hadron calibration
  - Classification
  - Cell weighting
  - Out-of-cluster corrections
  - Dead-material corrections
  - Jet-level corrections
- Status of new constants for `QGSP_BERT`
- Algorithm improvements
  - Particle ID for calibration hits
  - Truth particle extrapolation
- Readiness for First Data
  - Pile-up, noise, bad cells



- Classify and calibrate topo clusters to hadron-level
- Classification
  - use shower shape variables (cluster moments) like shower depth and (weighted) energy density of the cell constituents
  - em showers are less deep and have higher average energy density than had showers
  - make a cut on probability ratio to observe a neutral over a charged pion in a given bin derived from single pion simulations (right plot)

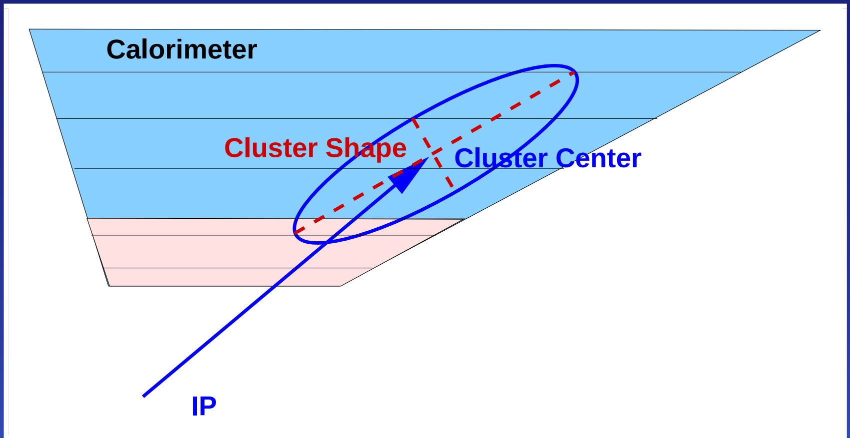




- Calibration
  - cell weights are applied to clusters classified as hadronic
  - derive cell weights from Geant4 true energy (calibration hits) including invisible energy and absorber deposits and reconstructed cell energy for each η region and layer: $w_i = \langle E_{\text{true}} / E_{\text{reco}} \rangle$, $i = \text{bin\#}(E_{\text{cluster}}, E_{\text{cell}} / V_{\text{cell}})$
  - example weights in main sampling of EM calorimeter for $2.0 < |\eta| < 2.2$
- Correct for dead material and out-of-cluster deposits for clusters classified as hadronic and electromagnetic (corrections differ)

► 9 most popular moments are on AOD

- LATERAL normalized second lateral moment
- LONGITUDINAL normalized second longitudinal moment
- SECOND_R the width squared of the cluster
- SECOND_LAMBDA the length squared of the
- CENTER_LAMBDA the cluster center depth in the calorimeter
- CENTER_MAG the distance IP - cluster center
- FIRST_ENG_DENS the first moment of $\rho = E/V$
- ENG_FRAC_MAX the ratio of the hottest cell energy over the cluster energy
- ISOLATION fraction of cells neighbouring the perimeter cells of the cluster which are not included in other clusters

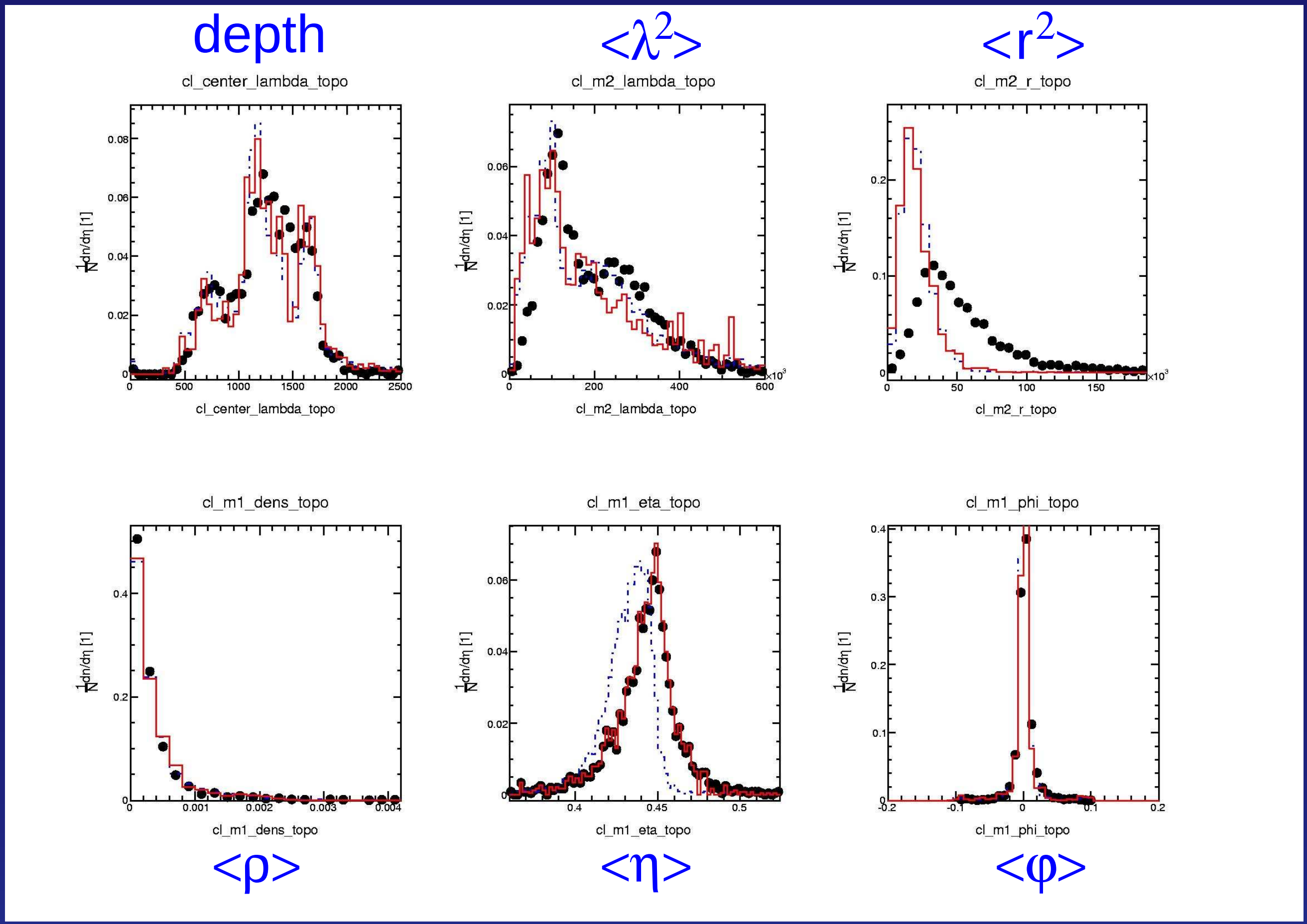


► other important moments available on ESD are

- CENTER_X/Y/Z the position of the cluster
- ENG_FRAC_EM the fraction of cluster energy in EM samplings
- ENG_FRAC_CORE the fraction of cluster energy in the leading cells in every sampling
- DELTA_PHI/THETA/ALPHA angular deviations of the shower axis from IP-cluster-center axis
- ENG_CALIB_* 13 of the 19 new moments of calibration hit energies associated to the cluster (in simulations with calibration hits; these are also on AOD)

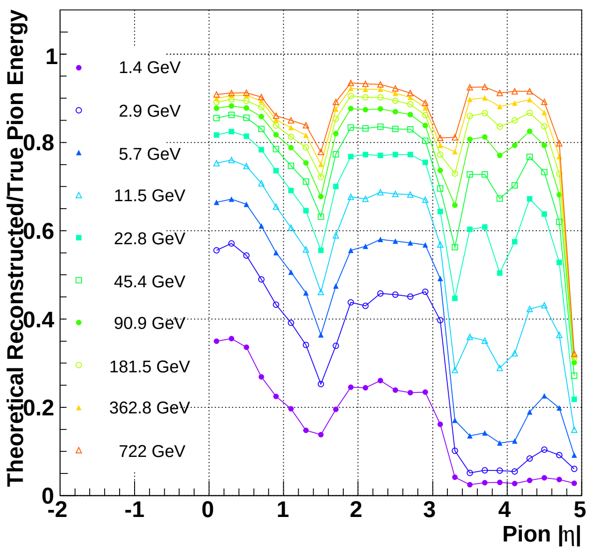
- look at submitted material from Tancredi Carli for 2004 barrel test beam data and 4 G4 physics lists (`QGSP, QGSP_BERT, FTFP, FTFP_BERT`)
- improved radial description but data still wider
- still problem at low pion energies (kink in models)
- look at submitted material from Andrei Kiryunin and Pavol Strizenec for 2004 endcap test beam data and default G4 physics list (`QGSP_BERT`)
- substructure of $\lambda_{\mathrm{CENTER}}$ well described
- largest deviations still in lateral shape
- but improved compared to `QGSP_EMV`

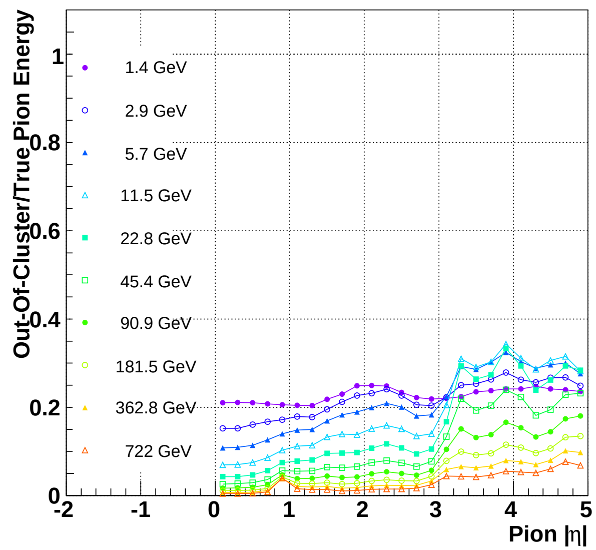
- old comparison from Peter Speckmayer with QGSP_EMV shows much bigger differences in lateral shape

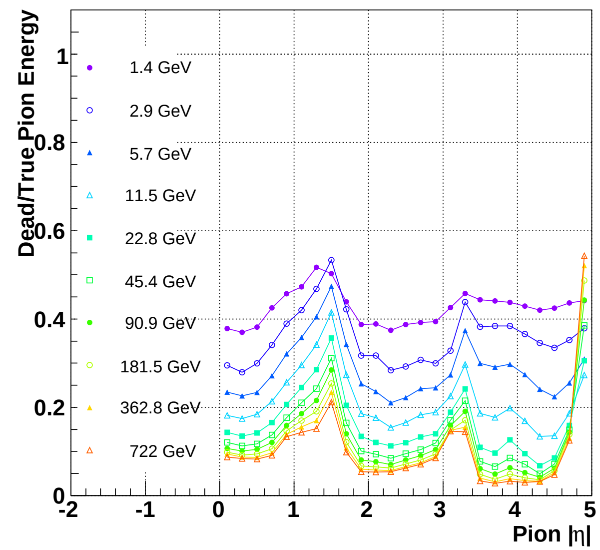


- very important to use only moments which are well described
- validation of default athena algorithms with test beam data is crucial

- **Cell weights**
  - account for the non-compensation of the calorimeters
- **Out-Of-Cluster Corrections**
  - recover lost energy inside the calorimeters due to noise thresholds
- **Dead-Material Corrections**
  - recover lost energy outside the calorimeters







- **Cell Weights**
  - can be defined non-ambiguously from calibration hits and reconstructed cell energy
- **Out-Of-Cluster & Dead-Material corrections**
  - need assignment algorithm of nearby calibration hits to clusters
  - can correct only those cases where a signal cluster is present
    - ► jets need additional corrections for lost low energetic particles

- New athena based weight extraction
  - new athena package CaloLocalHadCalib to
    ► extract classification, cell weights and out-of-cluster corrections from (private) ESDs with calibration hits
    ► Algorithms present are: GetLCClassification, GetLCWeights, GetLCOutOfCluster GetLCDeadMaterialTree
    ► produce one set of histograms (one tree for DM) per athena job; merged later if needed
    ► package is in CVS and in release 14.5.0 (DM since 15.0.0)

- Refinement of hadronic weights with CaloLocalHadCalib and 14.2.21
  - based on $\sim 6 \cdot 10^6$ single pions ($\pi+$,π^-,π^0) produced as mc08.10741[012] on the grid
  - no noise cuts in cell selection
  - use inversion method ($E_{\rm true}/\langle E_{\rm rec}\rangle$instead of $\langle E_{\rm true}/E_{\rm rec}\rangle$)
  - include TileGap1, TileGap2
  - discard weights for $E_{\rm rec} > 0.5 E^{\rm max}_{\rm true}$ to avoid bias; extrapolate beyond

► Refinement of out-of-cluster corrections

- store corrections relative to cluster energy on EM-scale
- correct for out-of-cluster energy assigned to clusters only
  ► with help of recently added `CaloCalibHitClusterMoments`
  `ENG_CALIB_TOT`: total calib hit energy for a cluster
  `ENG_CALIB_OUT_M`: medium ($\Delta\alpha < 0.5$) associated out-of-cluster calibration hits in proportion to `ENG_CALIB_TOT` of all matching clusters
  `ENG_CALIB_OUT_L/T`: same for loose ($\Delta\alpha < 1.0$) and tight ($\Delta\alpha < 0.3$) association – disabled by default
- the new moments are available automatically for each dataset with calibration hits on ESD/AOD/DPD
- similarly for dead-material energy Gena implemented new calibration-hit-based moments
  `ENG_CALIB_DEAD_TOT`: dead material energy assigned to all clusters inside the medium cone (see above) with relative weight $\sqrt{E}\exp(-\Delta R/0.2)$.
- detailed studies are possible with the following additional moments defined by Gena:
  `ENG_CALIB_EMB0/EME0/TILEG3`: calibration hit energy in pre-sampler and tile gap scintillator inside clusters
  `ENG_CALIB_DEAD_EMB0/TILE0/TILEG3/EME0/HEC0/FCAL/LEAKAGE/UNCLASS`: associated dead material energy according to the 8 different regions

- ► Refinement of dead material corrections
  - correct for dead material energy assigned to clusters only
    ► with Gena's assignment of dead material hits to clusters
  - treat presamplers as dead-material
    ► simplifies the separation of out-of-cluster and dead-material corrections
  - effect of bias in dead-material corrections understood:
    binning in noise containing quantity creates bias for cut > 0
    ► use reco vs. truth instead of truth vs. reco for profile
  - make leakage correction explicit instead of implicit
- ► Expected effects
  - better weighting performance due to correct simulation
  - smaller out-of-cluster and dead-material corrections since we correct for assignable stuff only (Discussion at Ringberg)
  - better defined base for jet-level corrections

- look at submitted material from Gennady Pospelov for updated calibration hit moments and single pion performance of current weights and Particle ID studies in jet environment
- look at submitted material from Paola Giovannini for jet-level performance of individual local correction steps

- actual discussion of Jet energy scale deferred to jet-energy-scale session
- look at submitted material from Andreas Jantsch and Serena Psoroulas about jet-moments useful for jet-energy-scale corrections

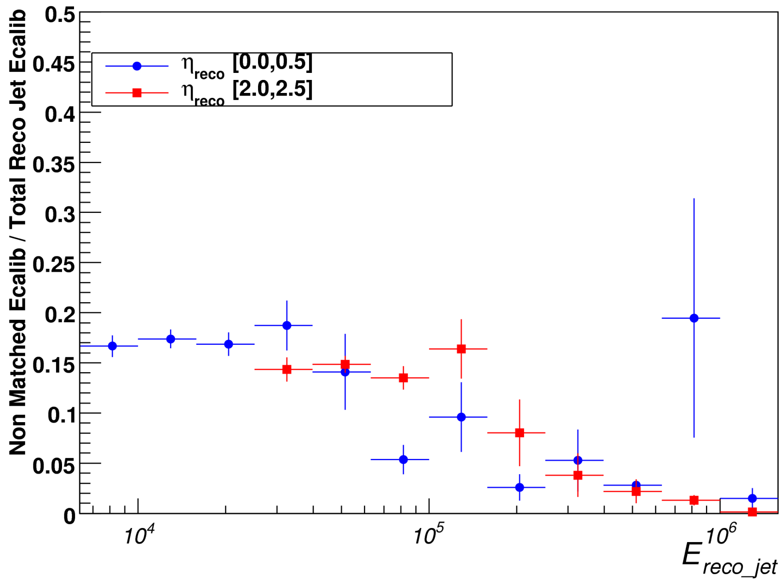
- skip if it will be discussed in Jet-E-scale III session
- On my wishlist since a long time:
  - if we'd know exactly which primary generator particle caused which calibration hit, we'd have no ambiguities in jet-truth-matching!
  - deficits in the jet-truth-matching can be made visible
  - actual true expected energy can be derived for clusters, jets, MET, ...
- Gena modified 10 `athena` packages to keep `ParentID` for every `G4Track` ► provides new method `CaloCalibrationHit::particleID()` returning the barcode of the primary particle causing the hit
- Performance price

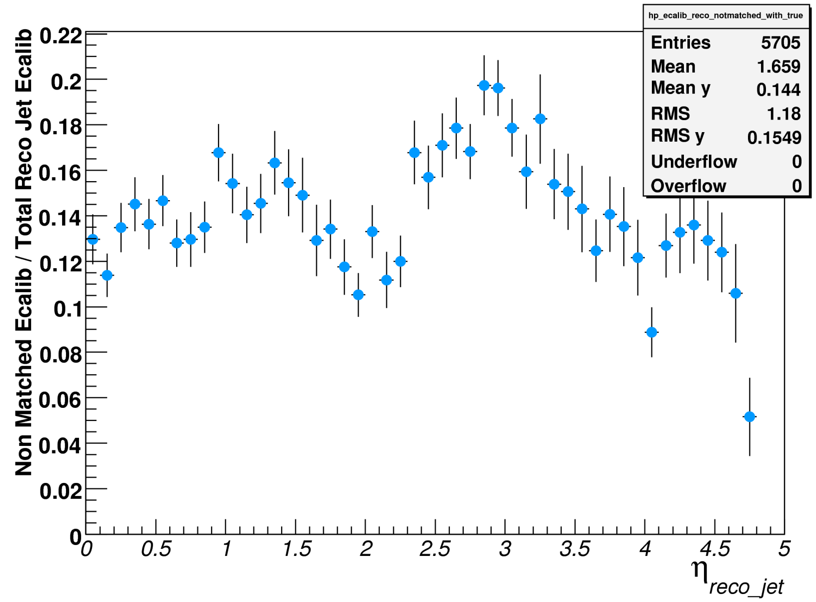
	standard 14.2.21	hits with ParticleID	
average time per event, sec	2139.7 ± 187.6	2320.2 ± 173.1	~ 1.08 ↑
memory per event, Mb	694.1	684.1	~ 1.0
simul size, Mb/event	2.35	5.68	~ 2.4 ↑
av.number of DM hits per event	40770 ± 6277	245500 ± 95160	~ 6.0 ↑
av.number of active+inactive hits	70840 ± 18660	176300 ± 62100	~ 2.5 ↑

J4

► about the same factors for all `JX` samples
► CPU time increases by $\sim 10\%$
► disk size per simulated file increases by $\sim 140\%$ or $3.3\,\mathrm{Mb/ev}$
► disk size per digitized file increases also by $3.3\,\mathrm{Mb/ev}$

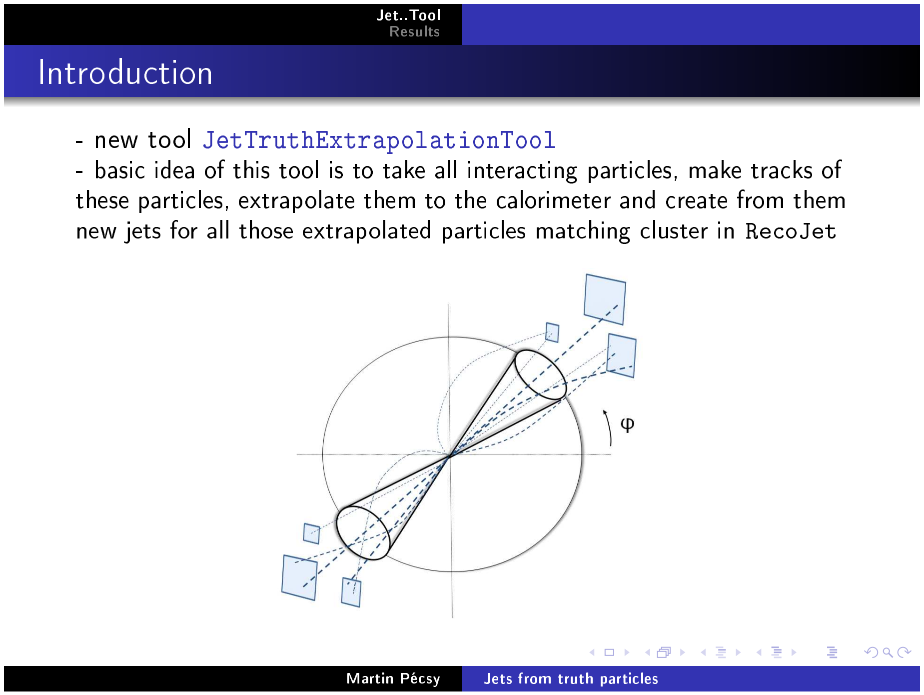
Foreign calibration energy of Cone4LC *reco* matched jet

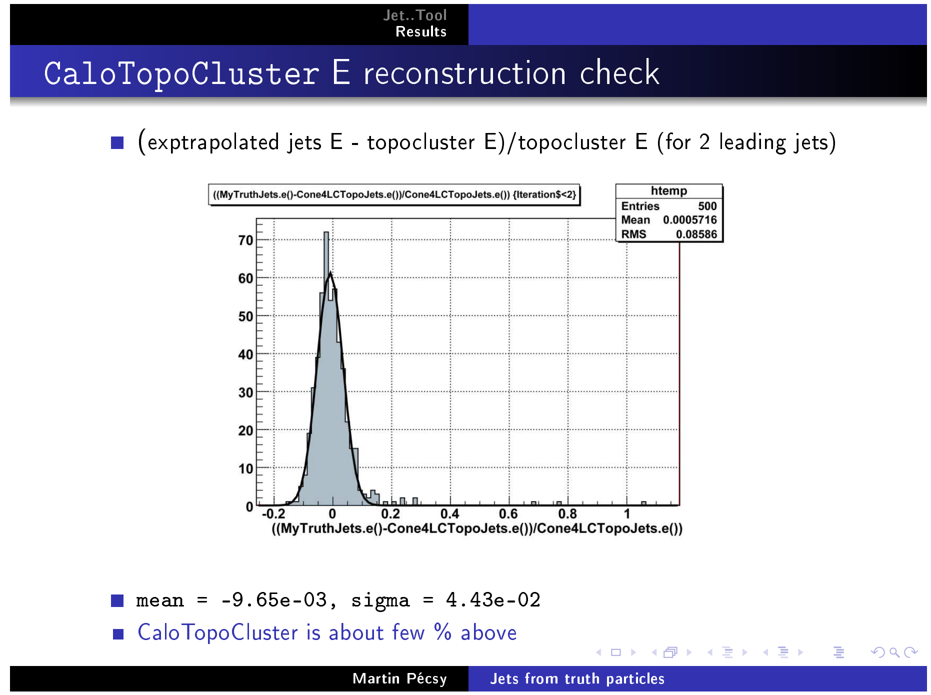




Average ratio of calibration energy inside *reco* jet which doesn't belong to the particles of true matched (ΔR<0.3) jet as a function of energy of reco jet (left), eta of reco jet (right).

Gennady Pospelov, MPI Munich *hadronic calibration meeting, October 8, 2008* *02*





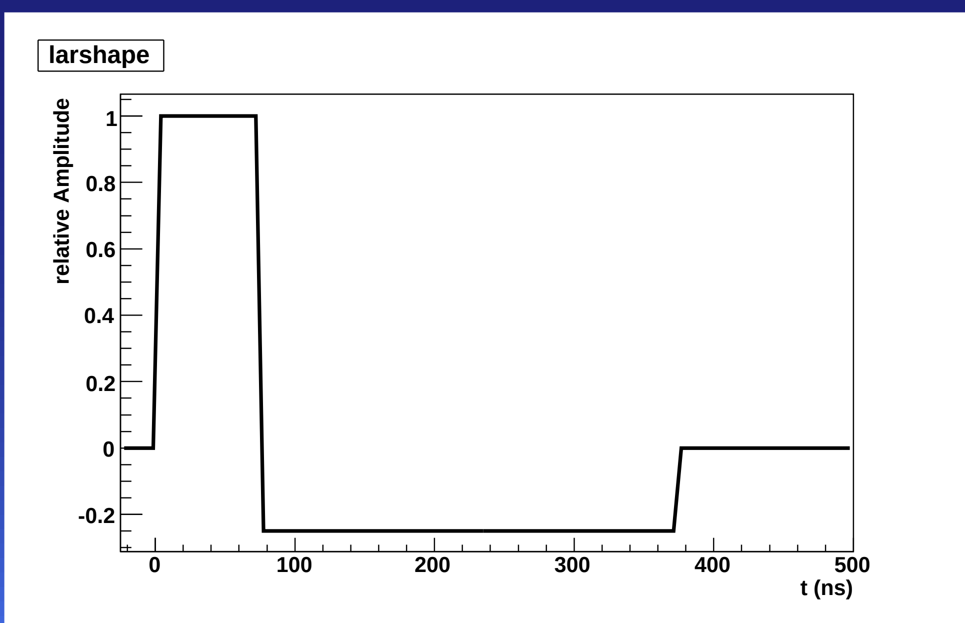
- skip if already discussed in simulation session
- Extrapolation tool can be used when no `ParticleID` is present
- Current status
  - code `JetParticleExtrapolationTool` is in CVS in `JetSimTools-00-01-04`
  - will be used in rel `15.0.0` to have less ambigous truth matching

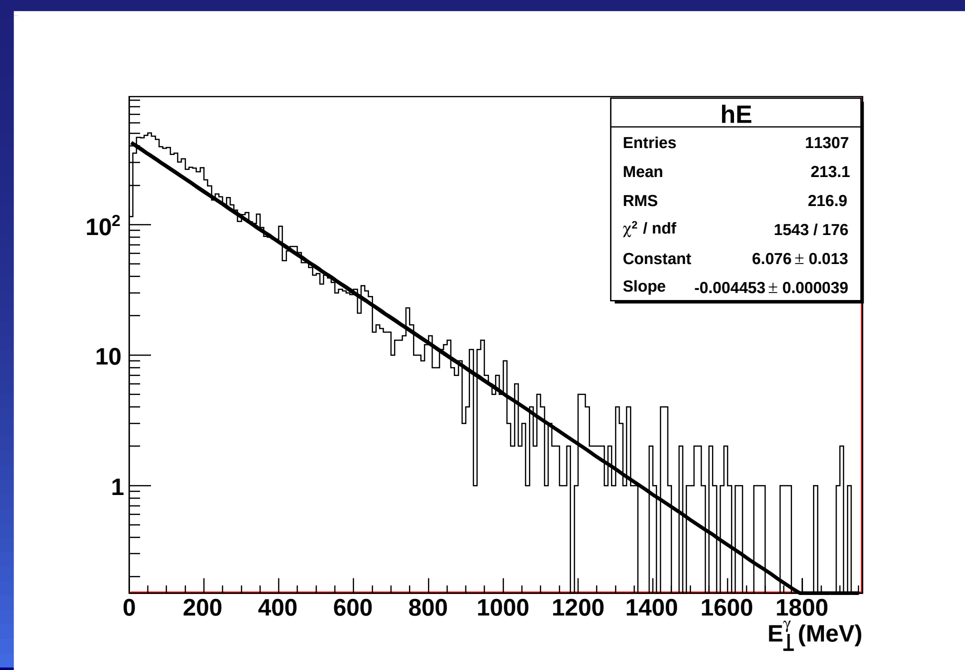
- look at submitted material from Mark Hodgkinson on energy flow technices for correcting cluster energies with the help of tracks

- Electronics noise
  - well described (see comissioniong note on topo clusters `ATL-COM-2009-227` – might have an INT number now ...) for LAr (single Gauss); single Gauss not sufficient for Tile but larger RMS is consistent with larger number of seeds in Tile ► double Gauss will be able to restore elec noise description in Tile
  - code changes in noise tool for double Gauss shape in Tile are already tested (in the release already?)
- PileUp noise
  - see contribution from Christoph Ruwiedel on PileUp energies in LAr cells

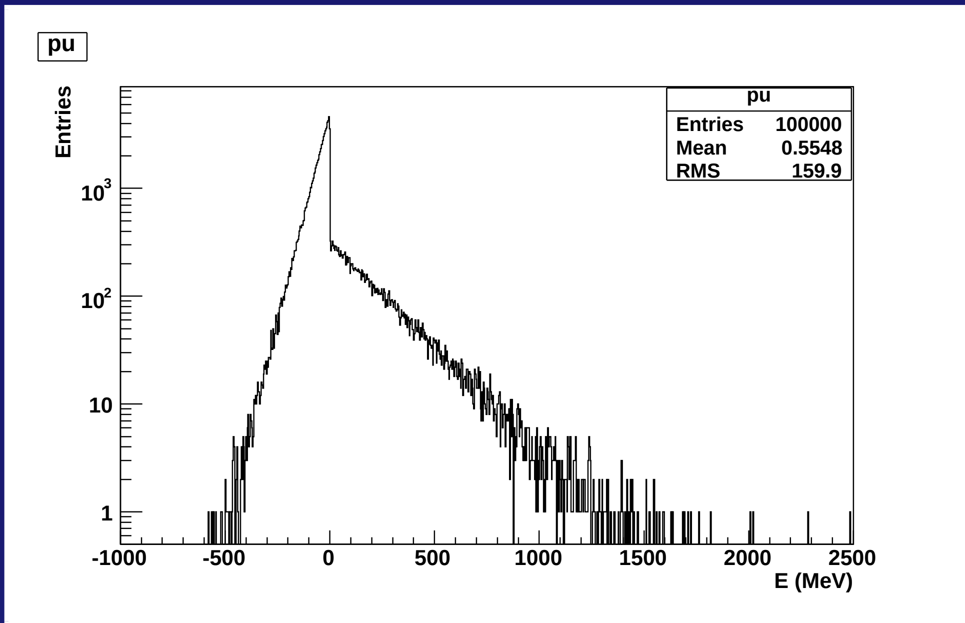
- can we adjust thresholds for topo clustering such that the total energy remains 0 also after the noise cuts?
- simplified LAr shape:
  - total integral over time is zero
  - amplitude for $0 \leq t < t_1$ is 1
  - amplitude for $t_1 \leq t < t_1 + t_2$ is $-t2/t1$
- photon $p_\perp$ spectrum from min-bias simulation (Pythia):
  - exponential distibution
- just one min-bias event over time $t_1 + t_2$ without elec noise:
  - noise thresholds scale with t_1/t_2
  - for positive cut at $n\sigma$ need negative cut at $-t_1/t_2 n\sigma$ in order to keep energy at 0
- add elec noise:
  - weaker scaling until fully symmetric thresholds are restored in the elec-noise only case
- multiple min-bias events over time $-(t_1 + t_2) : (t_1 + t_2)$ with 3 samplings :
  - spectrum gets much more gaussian; tails on positive side remain; mean is still 0
  - noise thresholds still don't scale with t_1/t_2 ► with elec noise same weaker scaling without noise

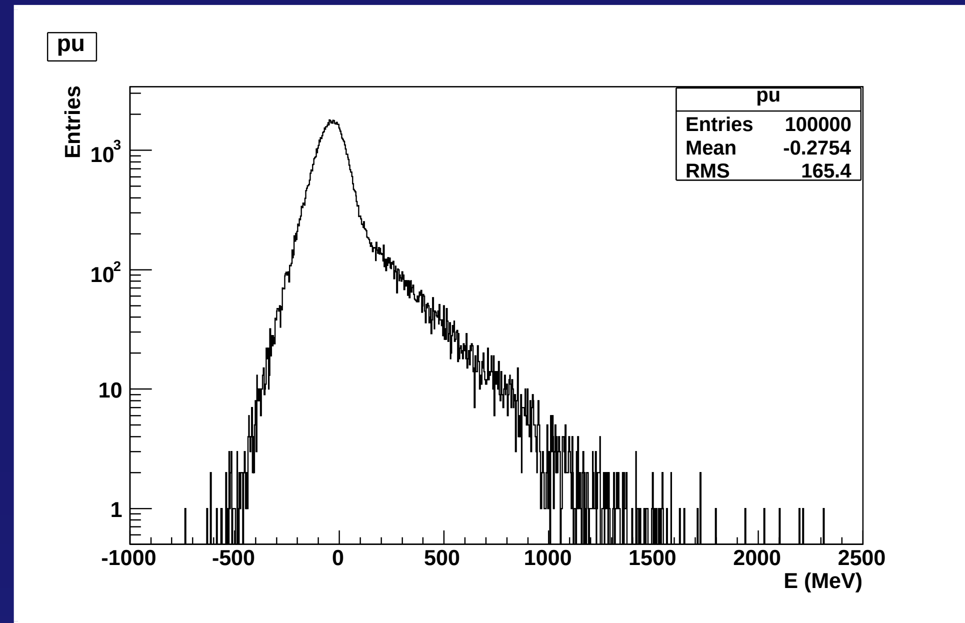
- Example plots
  - $t_1 = 75\,\mathrm{ns}$, $t_2 = 300\,\mathrm{ns}$
  - $dN/dE_\gamma \sim \exp(-E_\gamma/225\,\mathrm{MeV})$
  - elec noise for single min-bias event $30\,\mathrm{MeV}$; reduced threshold scaling from $4/-1$ to $4/-1.18$
  - $\#$ multiple min-bias events/bunch crossing $= 3.33$; reduced thresholds scaling to $4/-2.9$
  - elec noise for multiple min-bias events $300\,\mathrm{MeV}$; same reduced scale

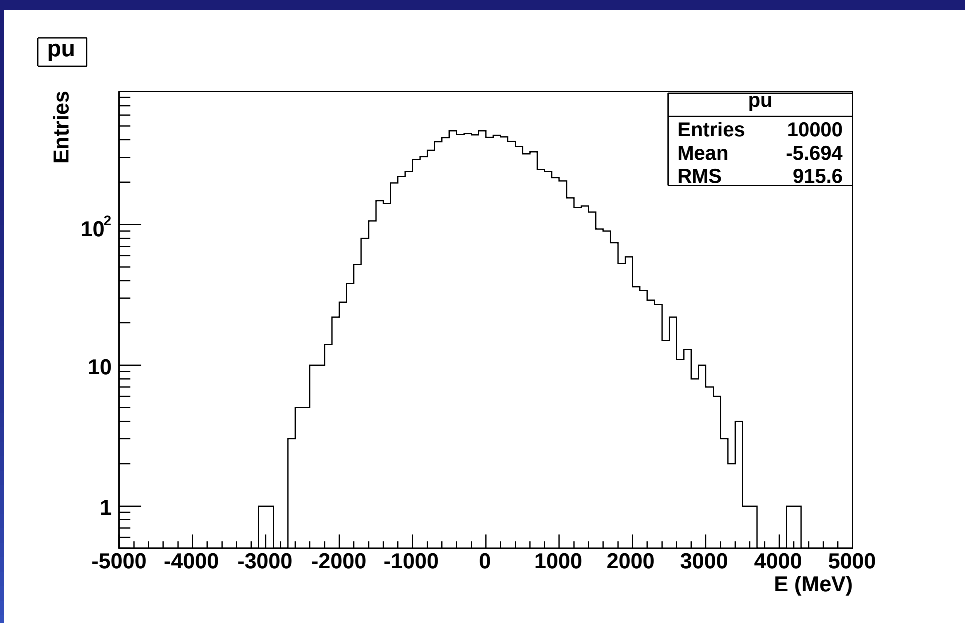


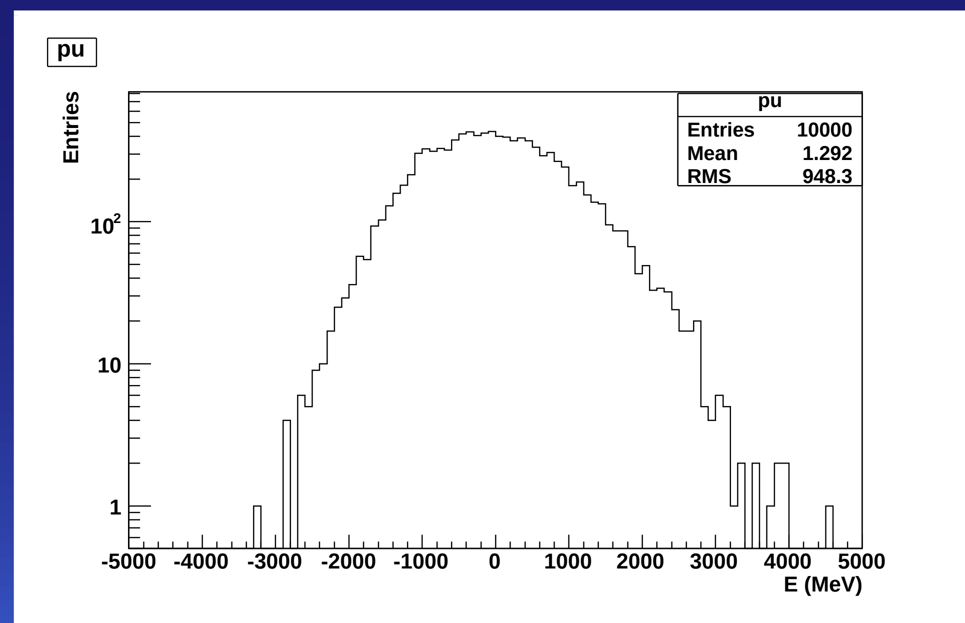


Readiness for First Data ► LAr Shape and PileUp









Conclusions

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