Status of Local Hadron Calibration Weights

Hadronic Calibration Workshop Sven Menke, MPI München 3. May 2006, MPI München

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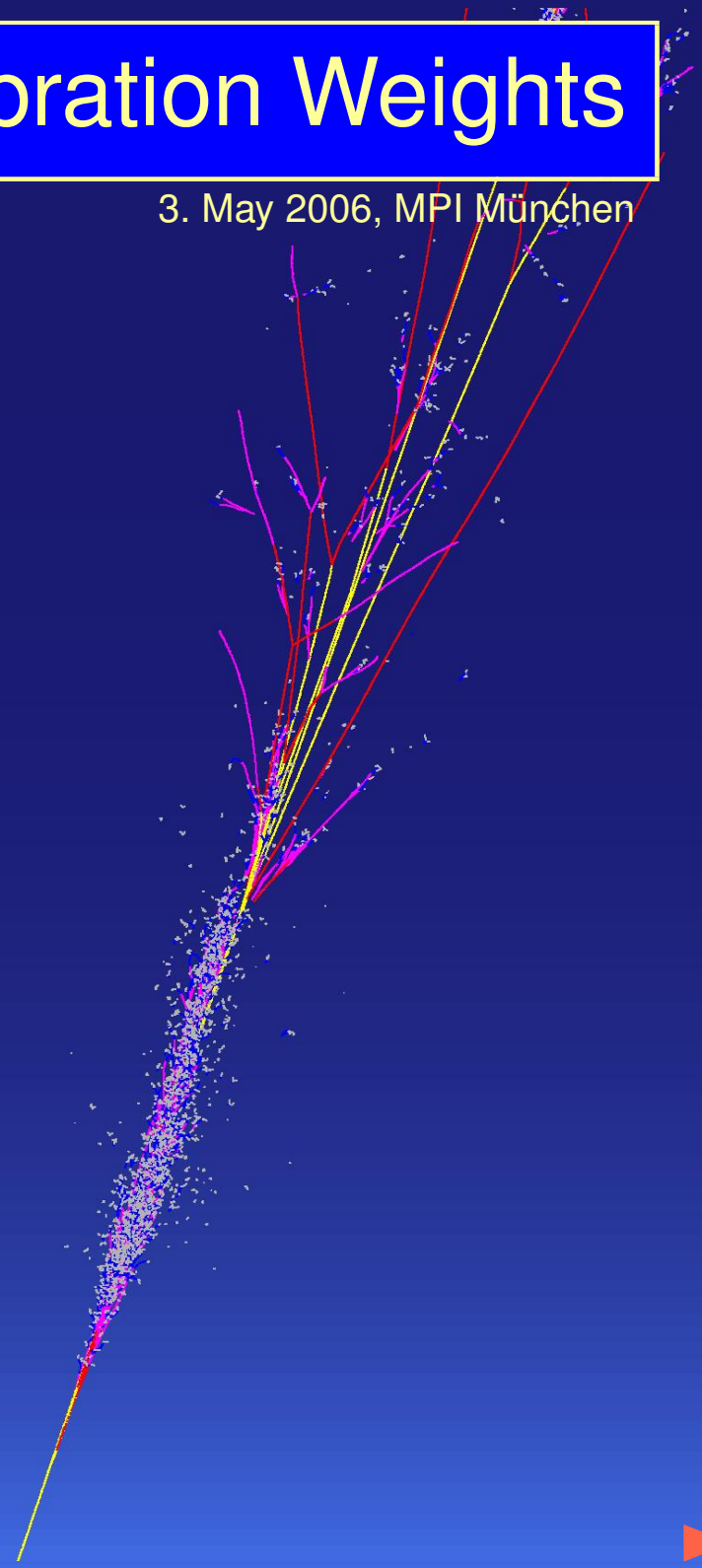
- Conclusions



Introduction

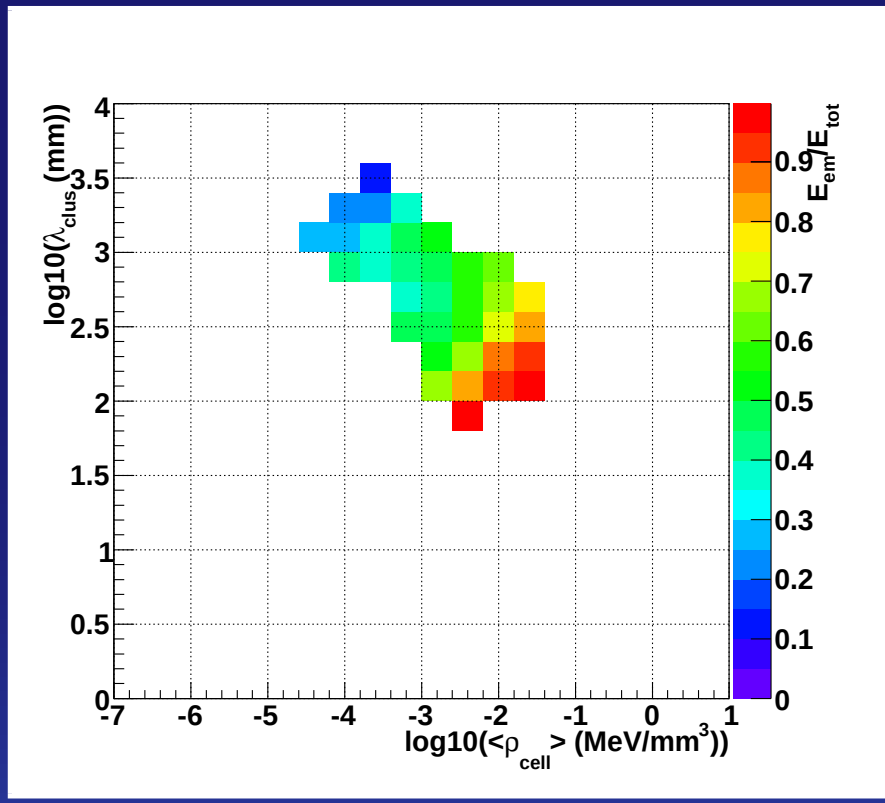
- Local Hadron Calibration in a nutshell
  - start with `4/2/0 CaloTopoCluster` objects with cluster splitting around local maxima and shared border cells
  - classify the clusters as em, hadronic, or unknown based on cluster moments
  - apply `H1`-type cell weights to the cells inside clusters classified as hadronic to correct to the true deposited energy in each cell
  - apply dead material corrections derived from sampling energies and global cluster quantities on the calibrated clusters also as cell weights

Status of Weighting

- Still use half of the postrome single pion files (those with good FCal calibration hits)
- For $1\,\mathrm{GeV}$ and $5\,\mathrm{GeV}$ both sets (π^+ and π^-) are bad – all other energies have at least one good set
- all histograms are made in 25 separate $|\eta|$ regions in steps of $\Delta|\eta| = 0.2$ from $0.0 \leq |\eta| < 0.2$ to $4.8 \leq |\eta| < 5.0$
- 10 bins for the 10 generated energies are used for the final performance control histograms
- cluster classification histograms are made in 5 logarithmic cluster energy intervals ($0\,\mathrm{GeV} < E_0 < 1\,\mathrm{GeV} < E_1 < 4\,\mathrm{GeV} < E_2 < 16\,\mathrm{GeV} < E_3 < 64\,\mathrm{GeV} < E_4$)
- cell weight histograms are made for each calorimeter sampling with 20 bins in $\log_{10}\left(E_{\mathrm{clus}} \times [1\,\mathrm{MeV}^{-1}]\right)$ from $E_{\mathrm{clus}} = 100\,\mathrm{MeV}$ to $1\,\mathrm{TeV}$ times 20 bins in $\log_{10}\left(\rho_{\mathrm{cell}} \times [1\,\mathrm{mm}^3\,\mathrm{MeV}^{-1}]\right)$ from $\rho_{\mathrm{cell}} = 10^{-7}\,\mathrm{MeV\,mm}^{-3}$ to $10\,\mathrm{MeV\,mm}^{-3}$

Status of Weights ► Cluster Classification

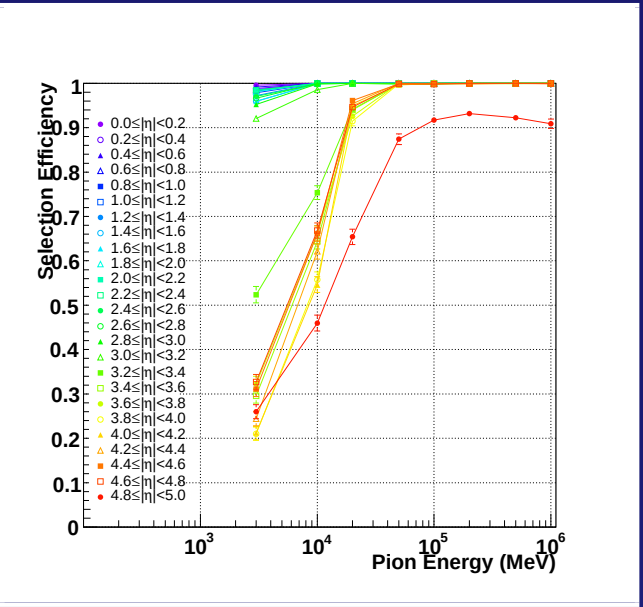
- Cluster Classification is made in 2D
- Spread in each bin tests the validity of the assumption for hadrons
- Currently I favor two moments for the binning:
  - the shower depth λ_{clus} (i.e. the distance of the shower center from the calorimeter front along the shower direction); deep showers tend to be more hadronic in nature
  - the first moment over the cell densities $\langle \rho_{\text{cell}} \rangle$ (i.e. the energy weighted average over the cell densities); high average densities for a given cluster energy indicate e.m. activity
  - the color coded z-axis shows the e.m. fraction of the cluster energy
  - the plot is for the region $2.0 \leq |\eta| < 2.2$ and $4\,\text{GeV} \leq E_{\text{clus}} < 16\,\text{GeV}$

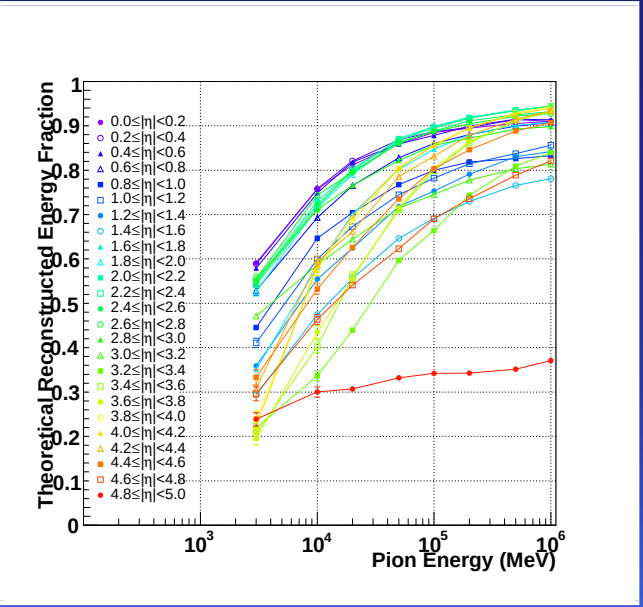


- Hadronic weighting is made for clusters with e.m. fractions not consistent within the spread of the weight with $90\,\%$ and non-zero bin content in the classification histo.

Status of Weights ► Definition

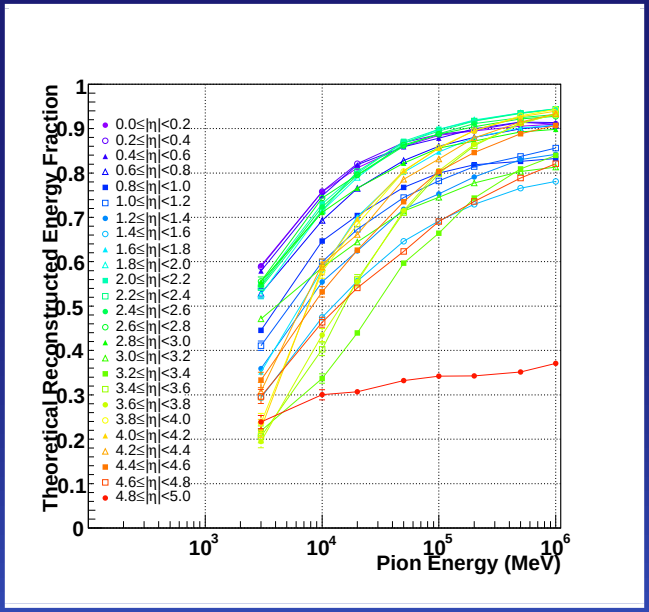
- weights are the average ratio of the sum of all calibration energies for a given cell and the reconstrcuted energy
- cells with negative invisble energy are excluded
- clusters not classified as hadronic are exluded
- The sum of all calibration hits (times the cluster-weight for the cell) of all cells in all clusters in an event is the total deposited energy that can be restored by weighting
- The ratio of the average of this theoretical energy over the momentum of the simulated pion is shown in the lower plot for all 25 $|\eta|$-regions as function of the energy of the simulated pion
- Selection efficiency is defined as having at least one cluster with true energy deposits from the pion
- Efficiency is above 90 % for $|\eta| < 3.2$ for $E > 3\,\mathrm{GeV}$
- Efficiency is above 90 % for $|\eta| > 3.2$ for $E > 20\,\mathrm{GeV}$

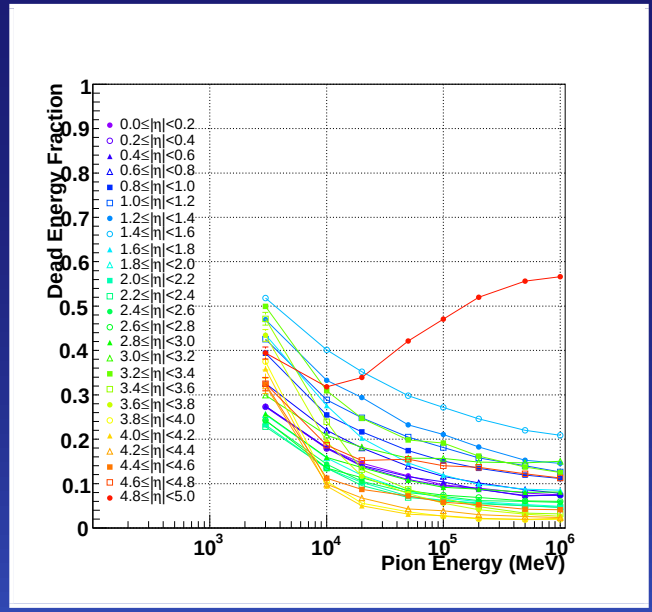


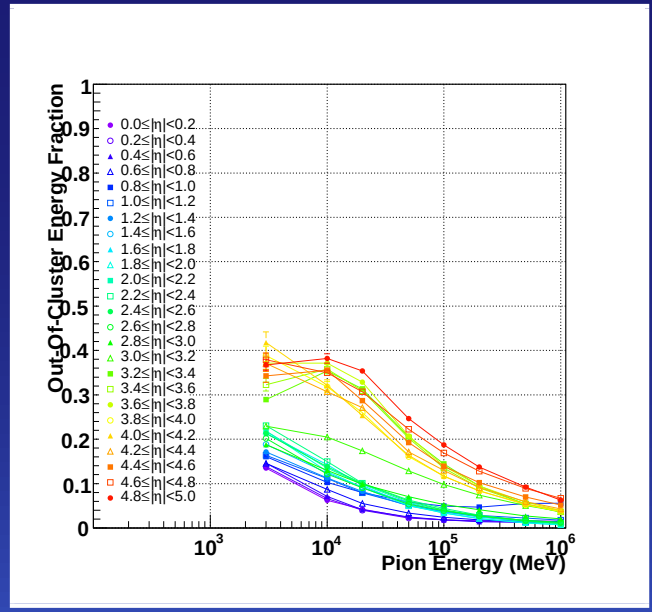


Status of Weights ► Total Energy Deposits

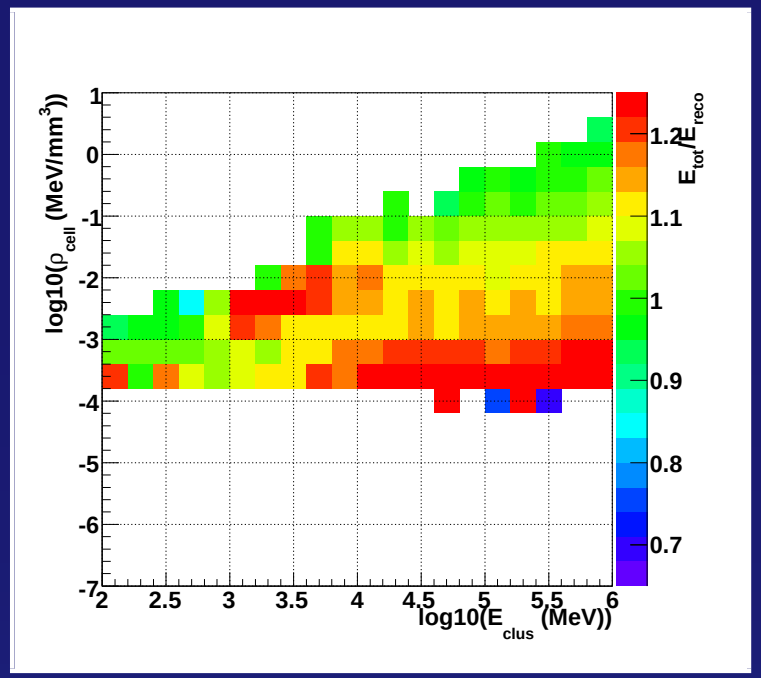
- Only the total sum of all calibration hits inside the clusters can be regained by weighting (left plot, repeated from previous slide)
- The deposits in dead material i.e. outside the calorimeters (middle plot)
- And inside the calorimeters but outside the clusters (right plot) need additional corrections

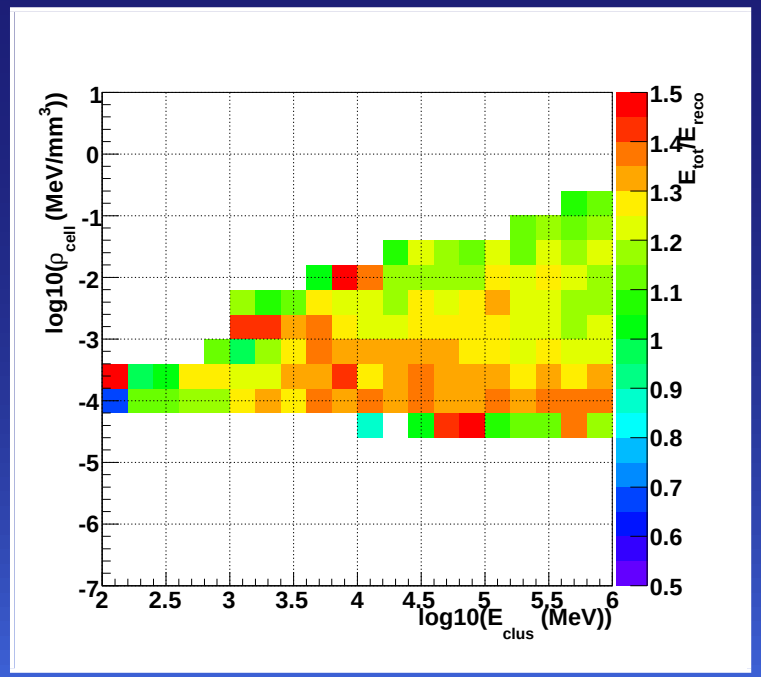






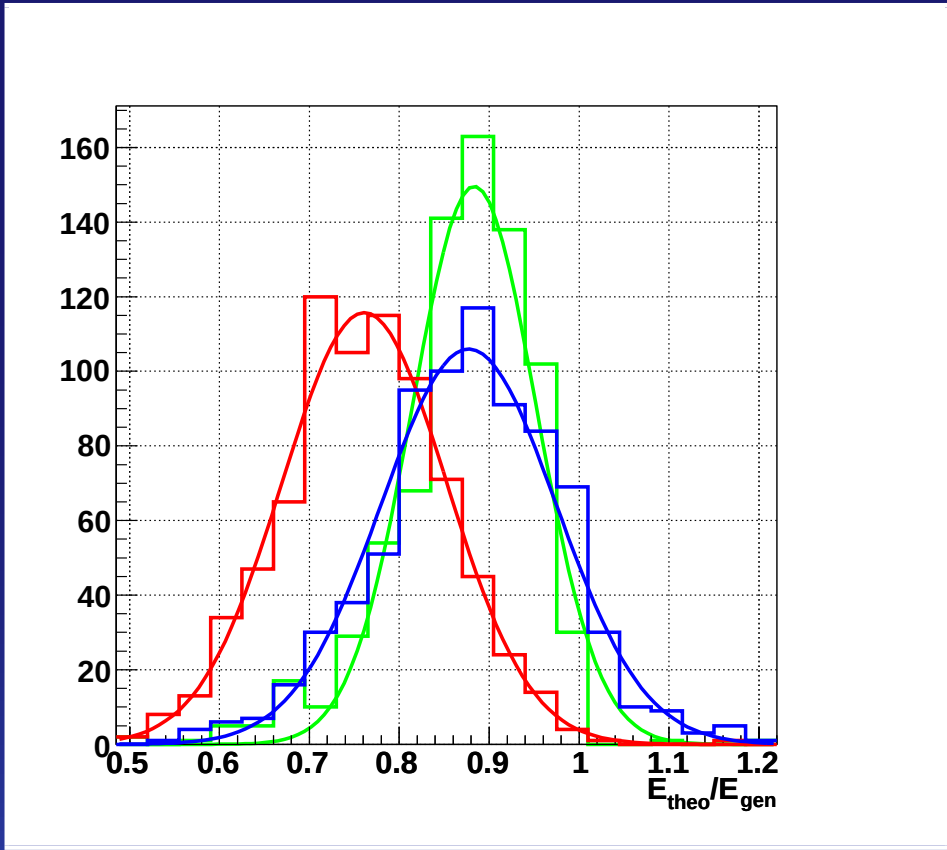
- Cell weights are done in 2D as function of the logarithm of cluster energy E_{clus} and the logarithm of the cell energy density ρ_{cell}
- Only cells with $E_{\text{cell}} > 2\sigma_{\text{noise}}$ are used to define weights – it does not make sense to weight noise
- Only cells with $0.6 < E_{\text{tot}}/E_{\text{cell}} < 3$ are considered for the weights – values outside this range are also dominated by noise
- Cells with negative invisible energy are exlcuded
- Each sampling and $|\eta|$-region gets its own cell weights
- The examples shown are for $2.0 \leq |\eta| < 2.2$
- Upper plot is for EMEC Layer 2
- Lower plot is for HEC Layer 1
- The asymptotic approach of the weights to $w = 1$ with increase in ρ_{cell} is visible
- The differences between layers and subsystems is much larger than the energy dependency





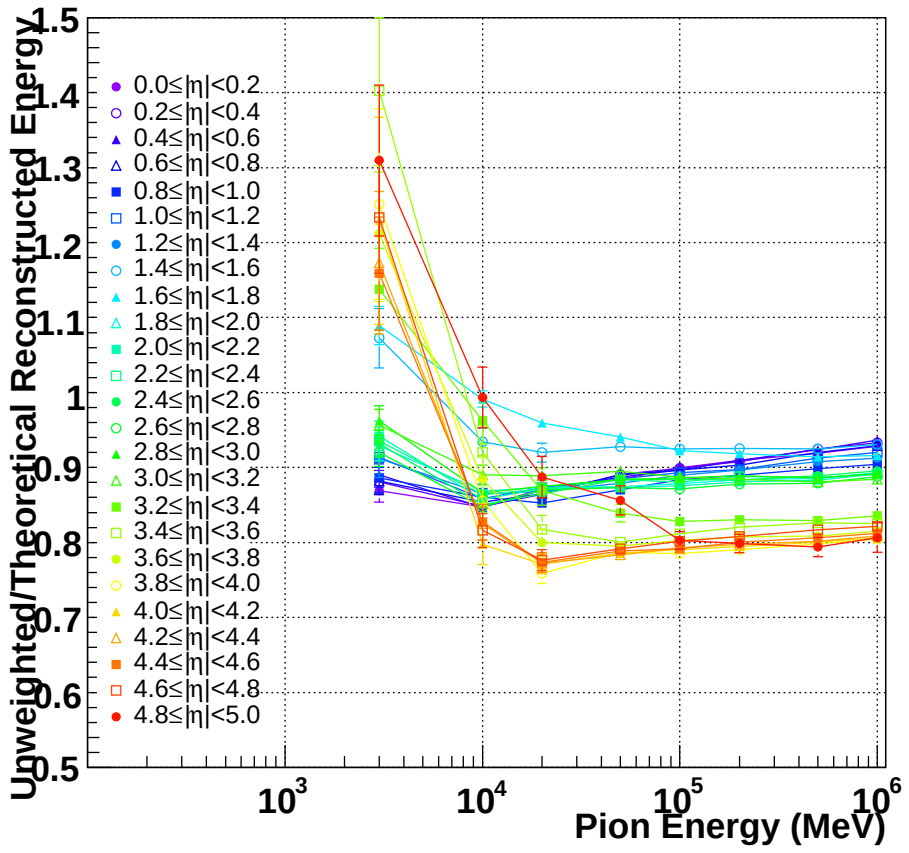
Performance on Single Pions

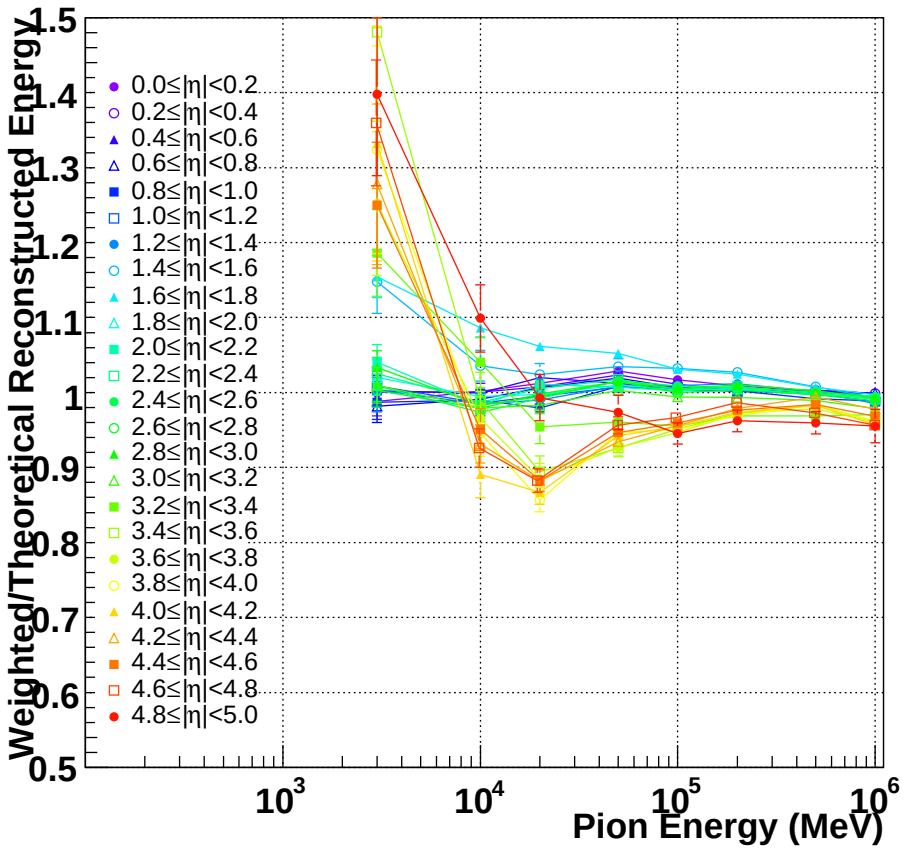
- All cells with $|E_{\text{cell}}| > 2\sigma_{\text{noise}}$ in clusters with $f_{\text{e.m.}} + \Delta f_{\text{e.m.}} < 0.9$ and are weighted
- $|E_{\text{cell}}|$ instead of E_{cell} is used in lookup of the weight, but the sign of E_{cell} is preserved after weighting
- Only weights with at least 10 entries in the weight histogram are used
- Plot shows weighting example for 50 GeV single pions at $2.0 \leq |\eta| < 2.2$ with unweighted (red), expected (green), and weighted (blue) reconstructed energy
- Mean is correct after weighting
- Resolution improves from 12.0 % to 11.1 % (theoretically achievable is 7.8 %)



Performance on Single Pions

- Plots show ratio of reconstructed over expected energy before (left) and after (right) weighting vs. E

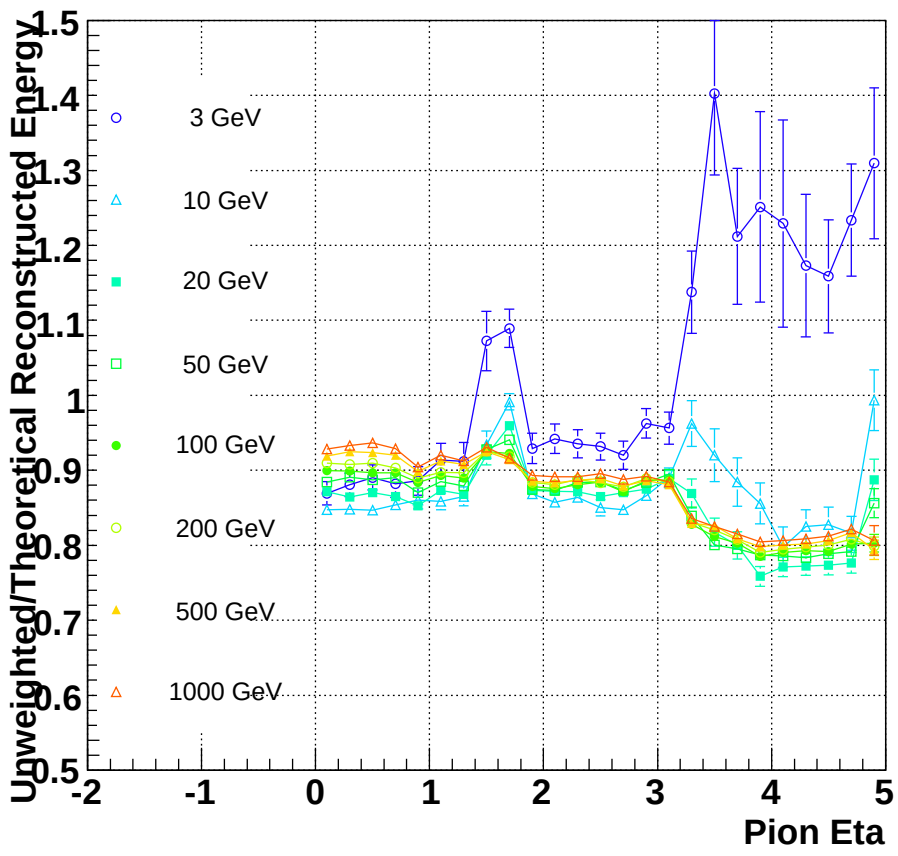


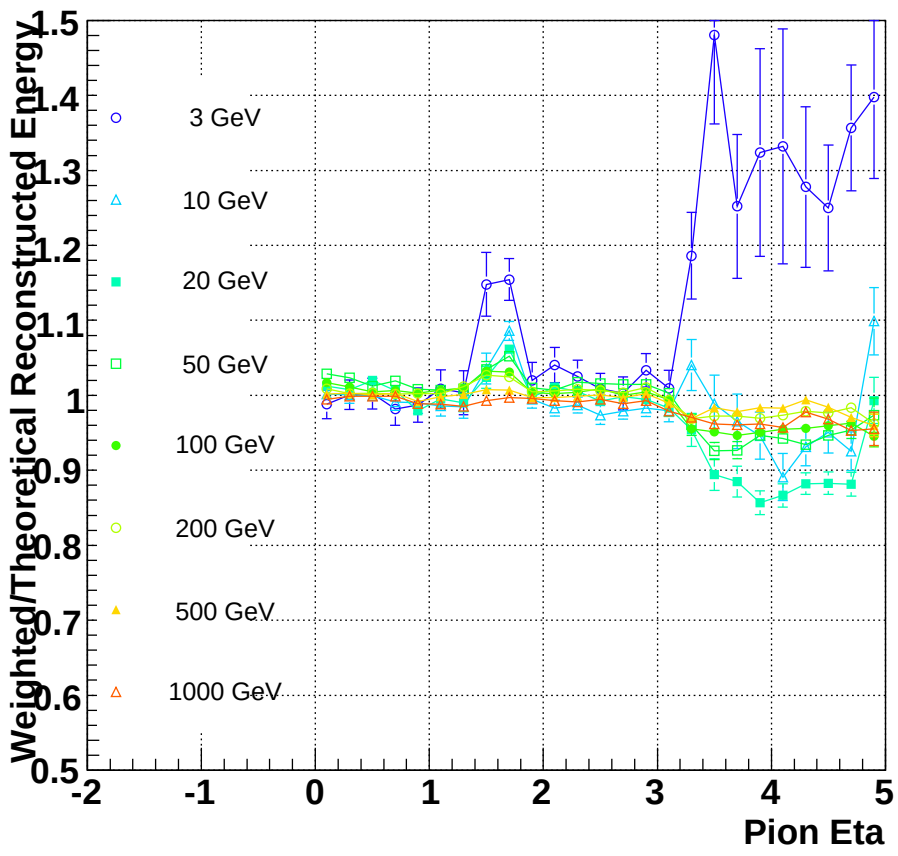


- weighting works for energies above 10 GeV
- FCal might need additional weight for cells with noise

Performance on Single Pions

- Plots show ratio of reconstructed over expected energy before (left) and after (right) weighting vs. $|\eta|$

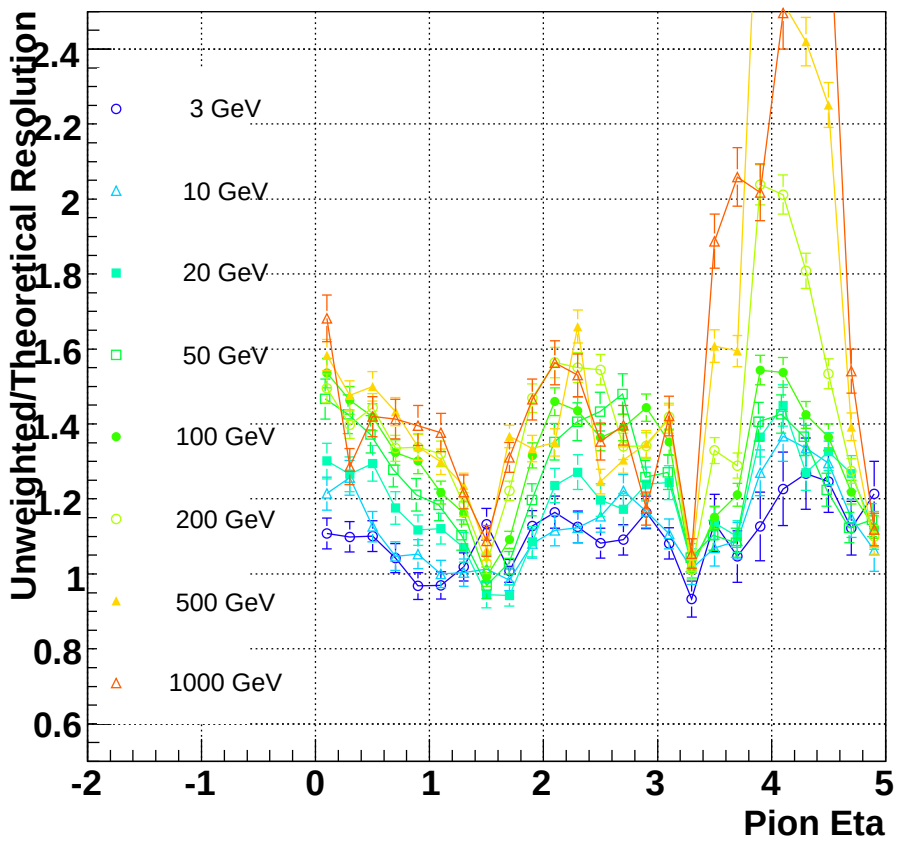


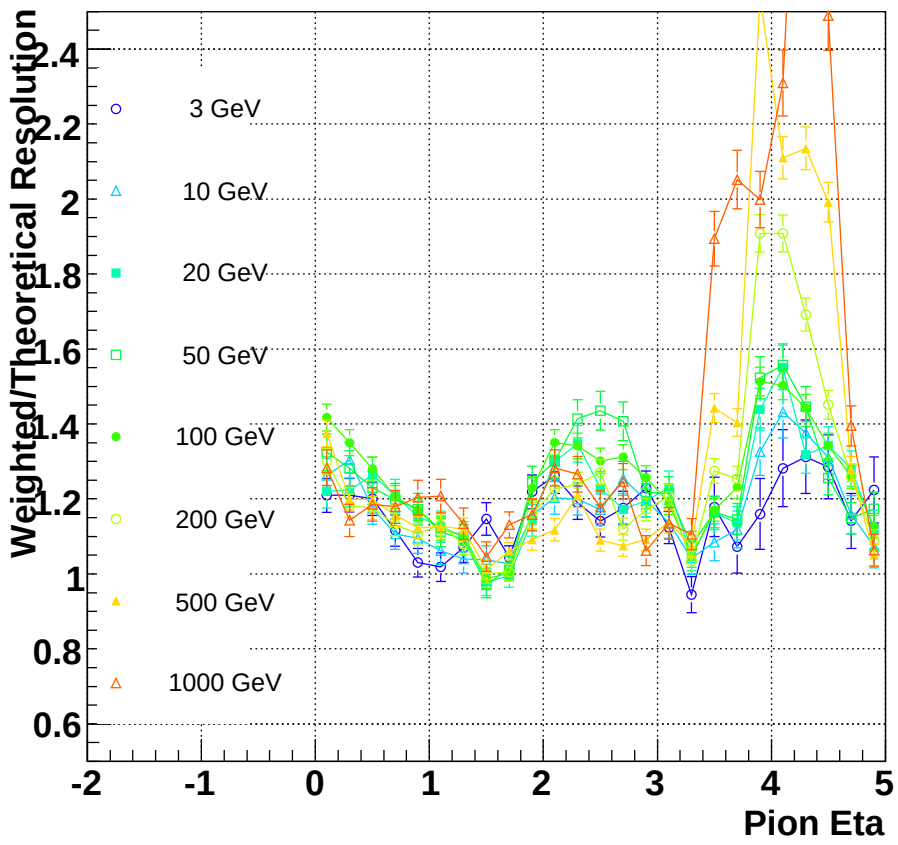


- weighting works for energies above 10 GeV
- FCal might need additional weight for cells with noise

Performance on Single Pions

- Ratio of actual and theoretically achievable resolution before (left) and after (right) weighting vs. $|\eta|$

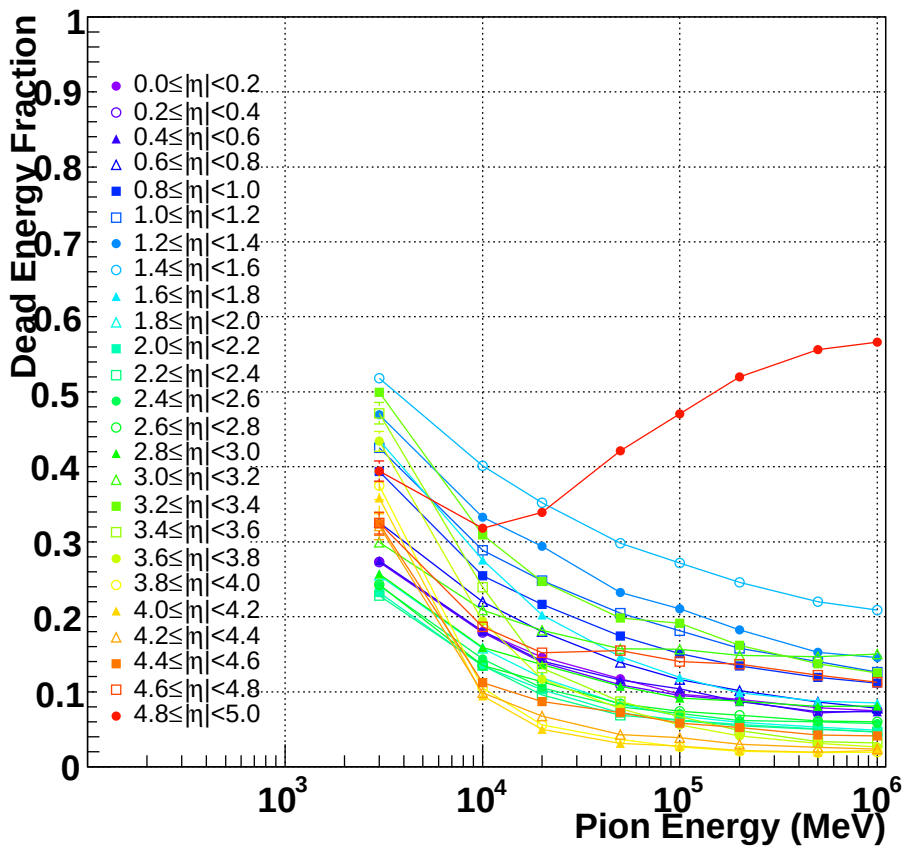


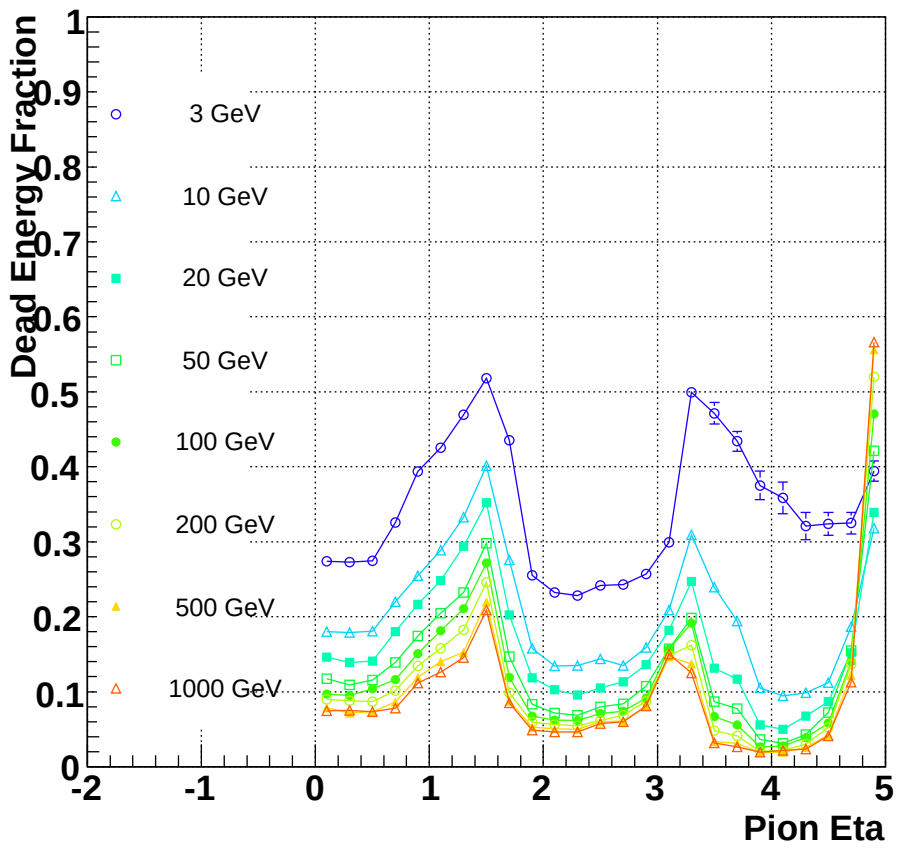


- relative resolution improves above 20 GeV
- dead material corrections will improve both the theoretically achievable resolution and the reconstructed resolution

Performance on Single Pions

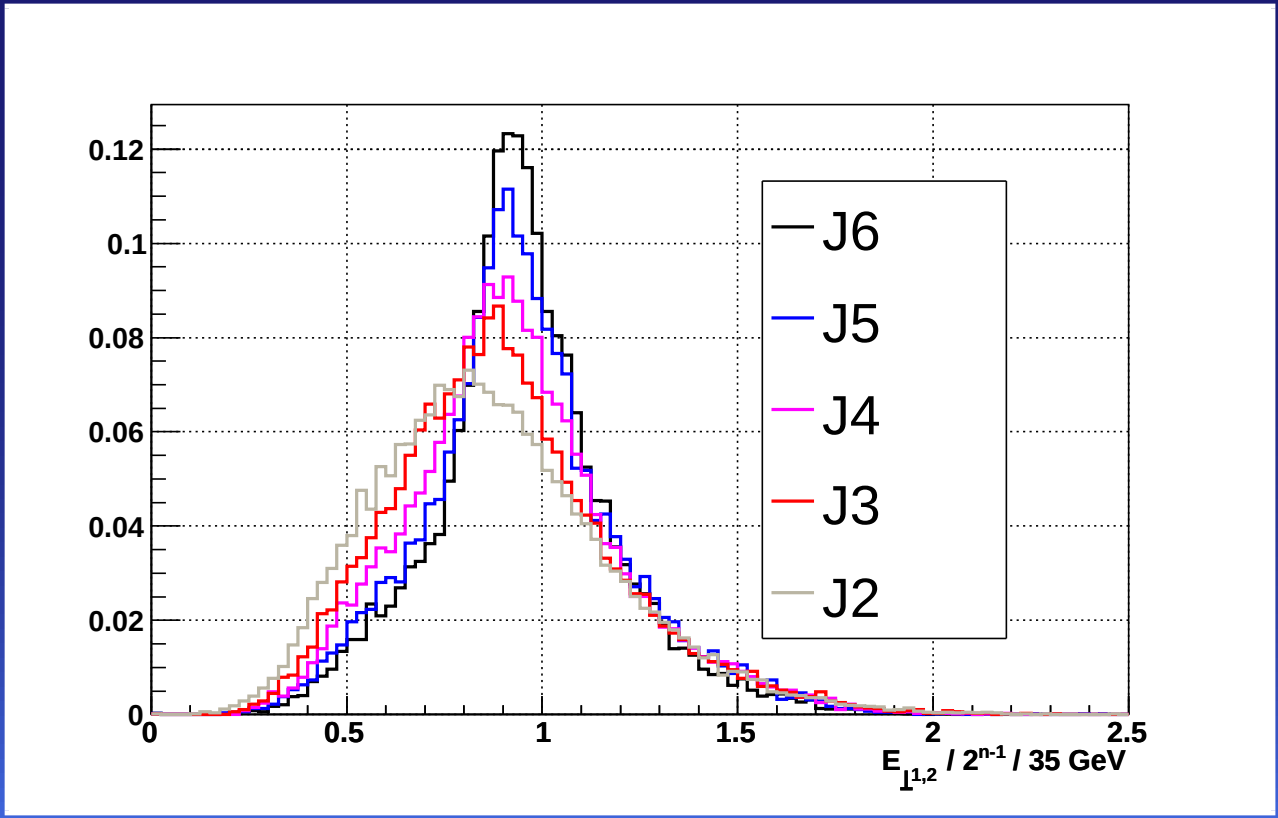
- Expected dead material corrections vs. E (left) and $|\eta|$ (right)





Performance on Dijets

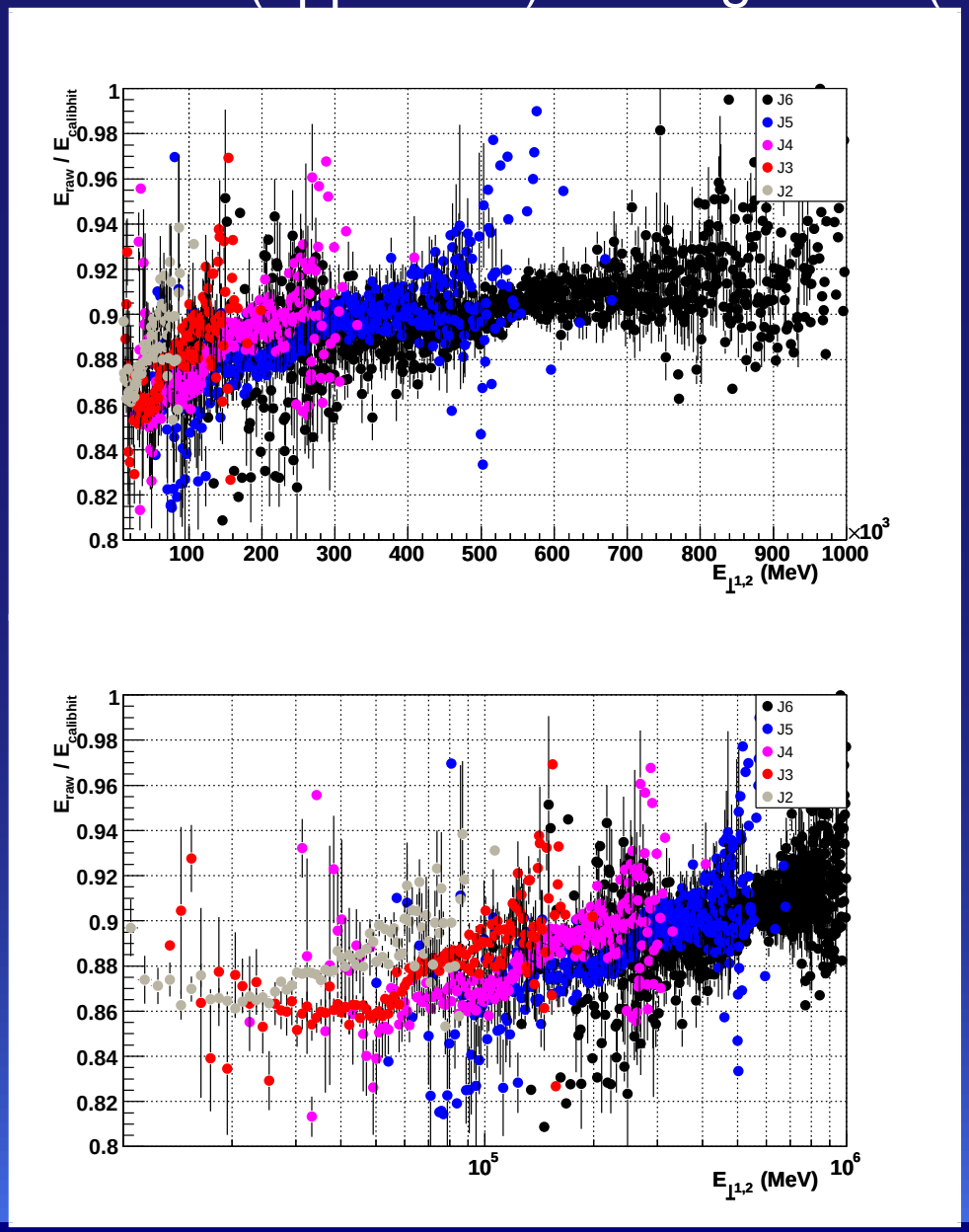
- Use Pavol's postrome dijet samples (J2-J6)
- Use `KtJet` algorithm with the buggy `RParameter` definition
  `RParameter=0.4` $\equiv R = \sqrt{0.4} \equiv \Delta_R^{\text{cone}} \approx 0.7$
- Use only the two leading jets in each sample, wich satisfy roughly $E_{\perp 1,2} \simeq 35\,\text{GeV} \times 2^{n-1}$ for sample Jn
- Plot shows the $E_\perp$ of the two leading jets devided by $35\,\text{GeV} \times 2^{n-1}$ for sample Jn, $n = 2 - 6$

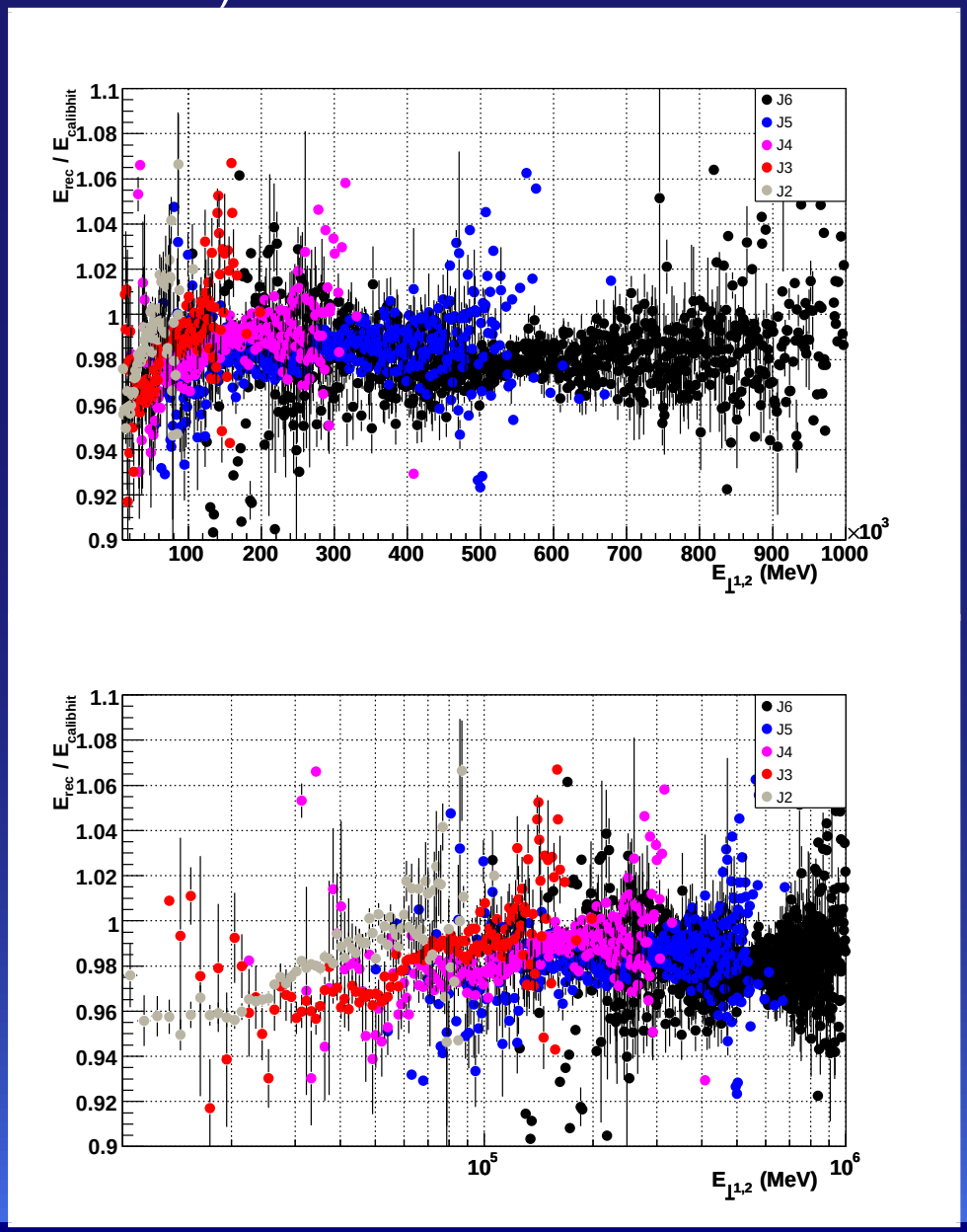


- Truth compared to is either
  - sum of all calibration hits inside topo clusters except gap-scintillators and presamplers
  - or the energy of the truth particle jet made of all stable particles with $|\eta| < 5$ matched in η and ϕ with $\Delta\eta < 0.05$ and $\Delta\phi < 0.05$
- Reconstructed energy is either
  - sum of all reconstructed energies inside topo clusters except gap-scintillators and presamplers for comparison with calibration hits
  - or the total energy of the reconstrted jet for comparison with ruth particle jets

Performance on Dijets ► Comparison to Calibration Hits

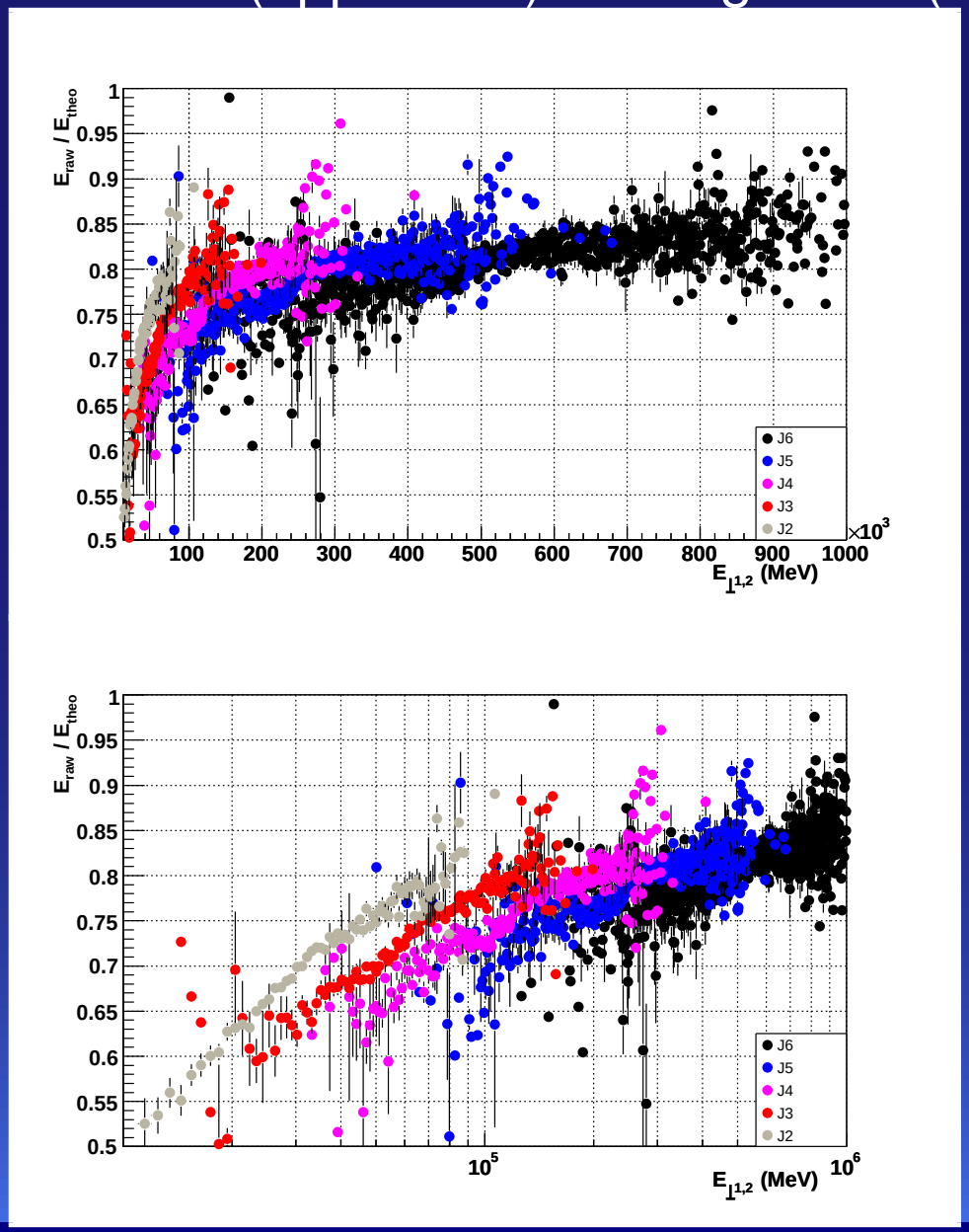
- Plots show ratio of reconstructed over expected energy (calibration hits) before (left) and after (right) weighting vs. $E_\perp$ of the leading 2 jets on linear (upper row) and log scale (lower row)



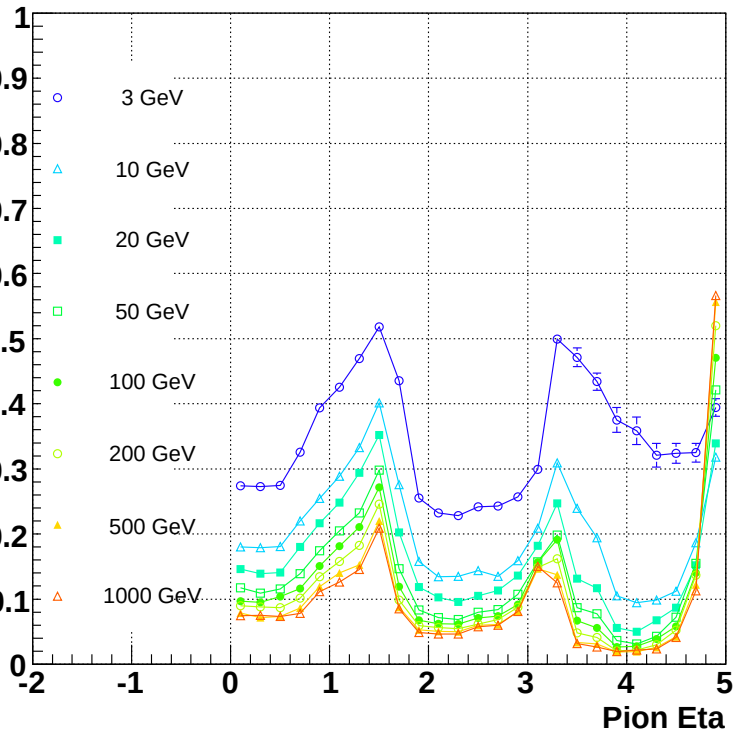


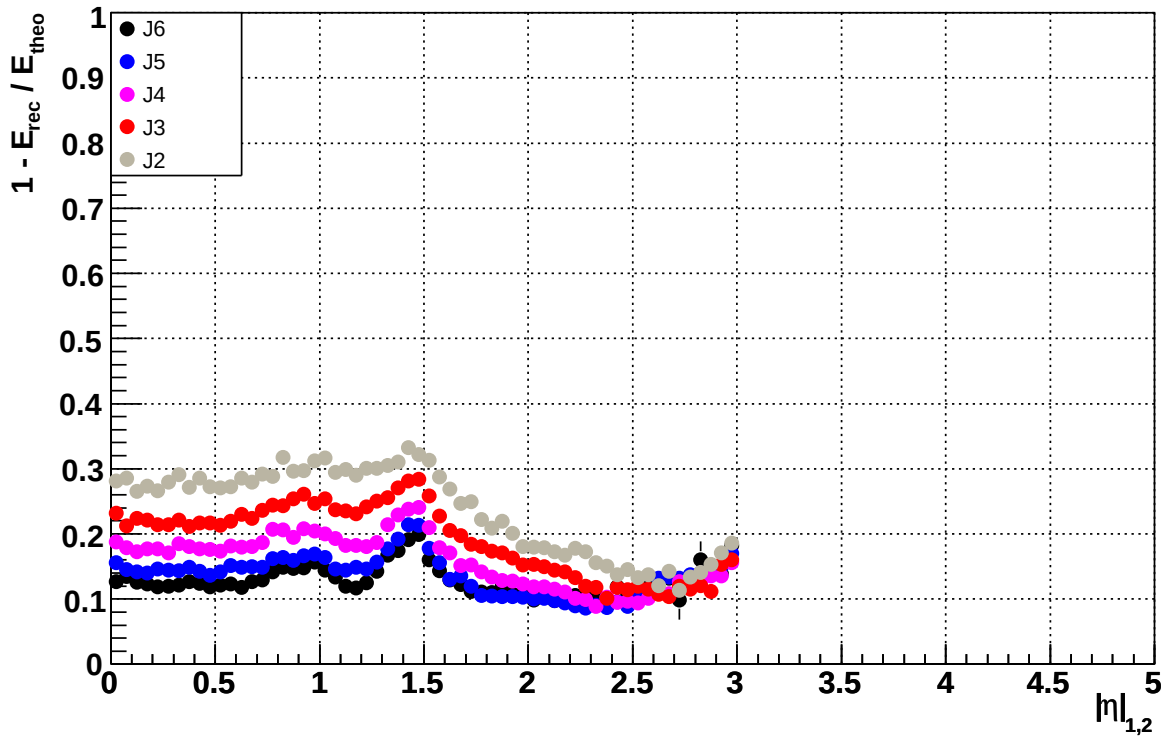
Performance on Dijets ► Comparison to Truth Jets

- Plots show ratio of reconstructed over expected energy (truth jets) before (left) and after (right) weighting vs. $E_\perp$ of the leading 2 jets on linear (upper row) and log scale (lower row)



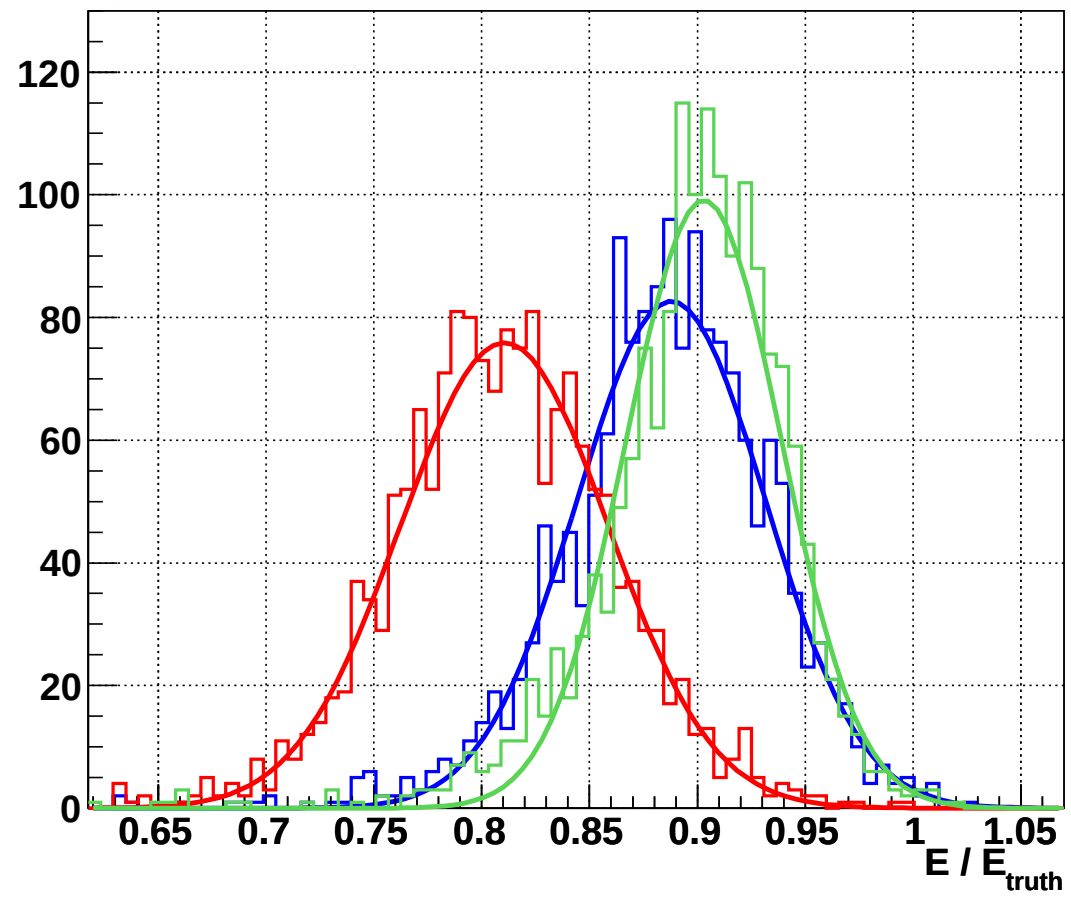
- Plots show remaining correction after weighting for single pions (left) and jets (right) vs. $|\eta|$





Performance on Dijets ► Resolution

- leading 2 jets in J4 sample with truth matching
- select $1.9 < |\eta| < 2.3$
- plot E/E_{truth} for raw (red), weighted (blue) and true calibration hits (green)
- scale is correct to $98\,\%$ after weighting
- resolution improves from $5.9\,\%$ to $4.9\,\%$ (theoretically achievable is $4.0\,\%$)



Conclusions

- Classification
  - explicitly exclude negative invisible energy cells
  - take spread of the em fraction into account
  - not yet updated in athena
- Weights
  - calculate weights only on clusters classified as hadronic
  - explicitly exclude negative invisible energy cells
  - not yet updated in athena
- Performance
  - resolution improves for single pions for both raw and weighted mainly due to the exclusion of negative invisible energies
  - scale and linearity on leading 2 jets in dijet samples o.k. after weighting
  - still need to implement special classification for low energetic clusters with large deposits in active material