PandoraPFA and Calorimeters

Matthias Weber (CERN)

Samples and Software used

Produce single particle gun samples of neutrons and K0L's separately, for each point simulate and reconstruct 70000 events
Use the PandoraSettingsSoftwareCompensationTraining script for reconstruction

Cleaning of clusters in the Pandora training script identical to cleaning for default reconstruction
→Then run **PandoraPFACalibrate_SoftwareCompensation** script in PandoraAnalysis/calibration

Energy points at 2,5,10,20,30,40,50,60,75,90,100,150,200,250,400,500,1000 GeV for neutrons and Kaons, for Kaons additional energy point at 1 GeV

Merge Kaons and neutrons in one sample (relative weight 1:1) and use energy points of 2,5,10,30,75,150,200,400,**1000** for software compensation training

Density binning: 0 2 5 7.5 9.5 13 16 20 23.5 28 33 40 50 75 100, overflow 110

Samples and Software:NEW

Largest neutral hadron energy point/limit of application of software compensation

- Relevance for highest center of mass energy
  - → At 3 TeV largest neutral hadron in PandoraPFA clustering step around 1300 GeV, appears typically at least once in 100 events.
  - → With overlay expect this rate might even increase: add additional single hadron testing point at 1500 GeV to check behavior

Density binning: 0 2 5 7.5 9.5 13 16 20 23.5 28 33 40 50 75 100, overflow 110

- suggestion: reduce number of bins for high density
  - → tested for combined sample of neutrons and Kaons, doesn't reduce memory load, gives slightly worse performance for high energy point

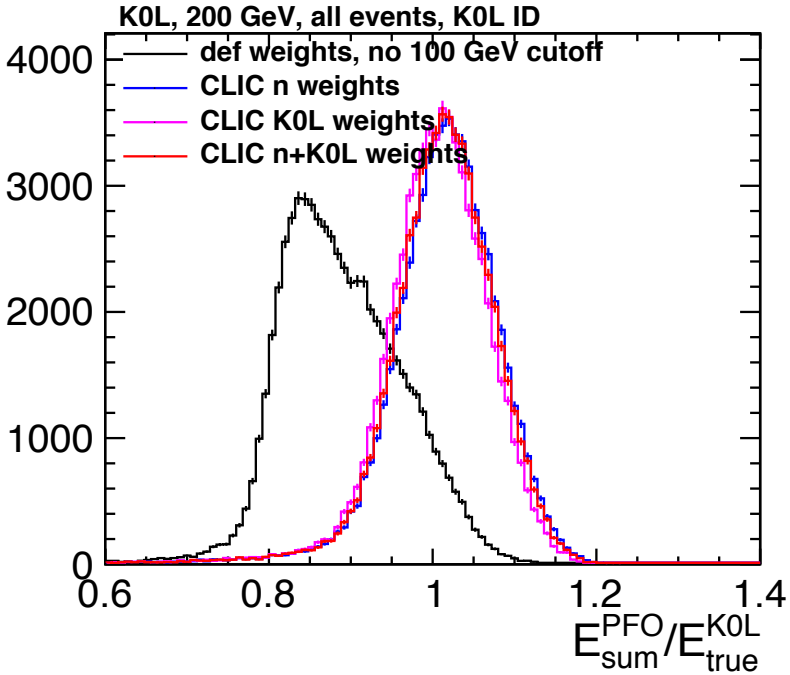
Disable software compensation in PandoraPFA calibration:

- Scripts in ILCSoft suggested calibration with software compensation enabled, consulted with Cambridge group and decided to remove software compensation in calibration step, SWC training after PandoraPFA calibration is fixed

Single Hadron response closures: Kaons at 200 GeV

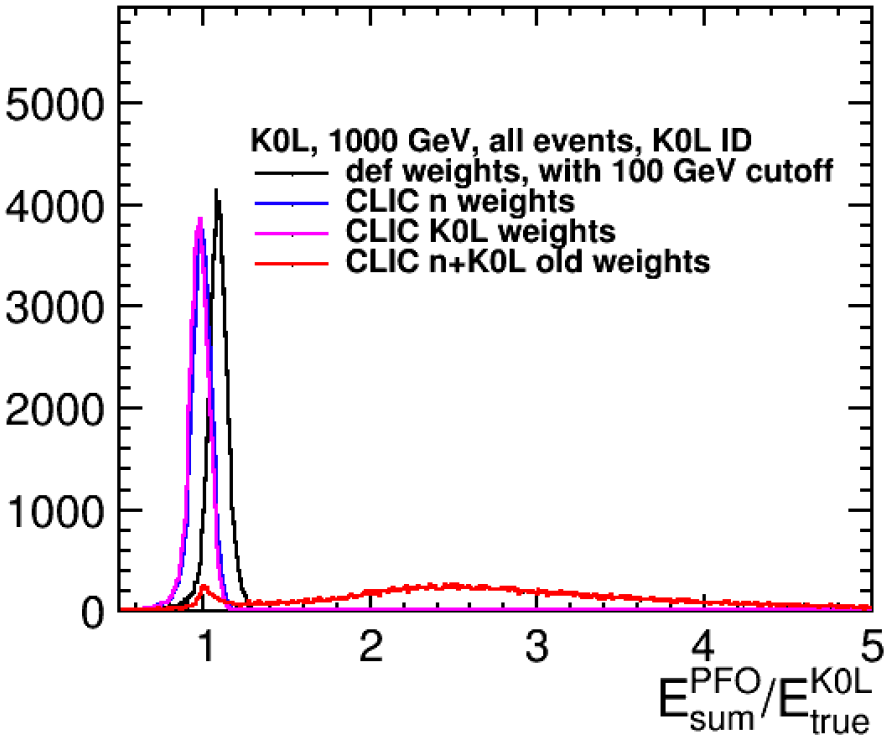
At this point per default the ILD derived weights are not applied anymore (application threshold at 100 GeV) → check performance if we increase this threshold to 1800 GeV

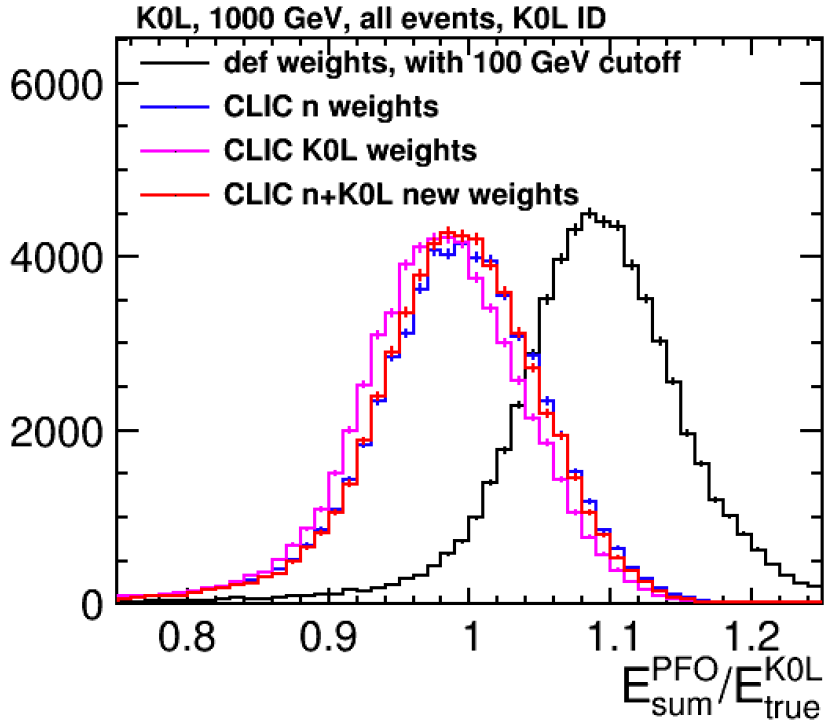
Default (black): no ILD weights applied since hadron energy over threshold E_{max}^{had}=100 GeV



Black: ILD weights applied
Definitely a bad idea
→check behavior of SWC beyond training limit for unwanted effects

Issue at high energies for previous n&K0L combined sample SWC weights



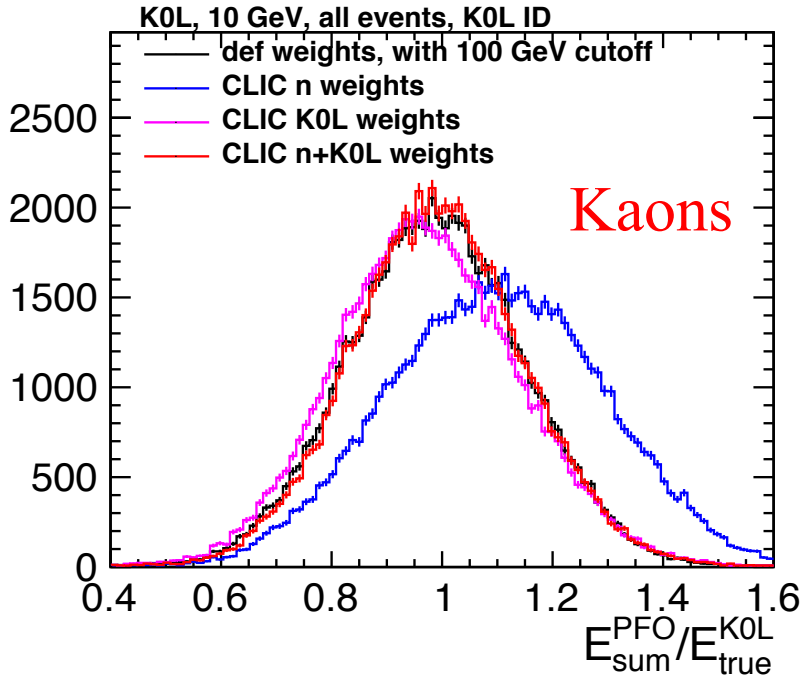


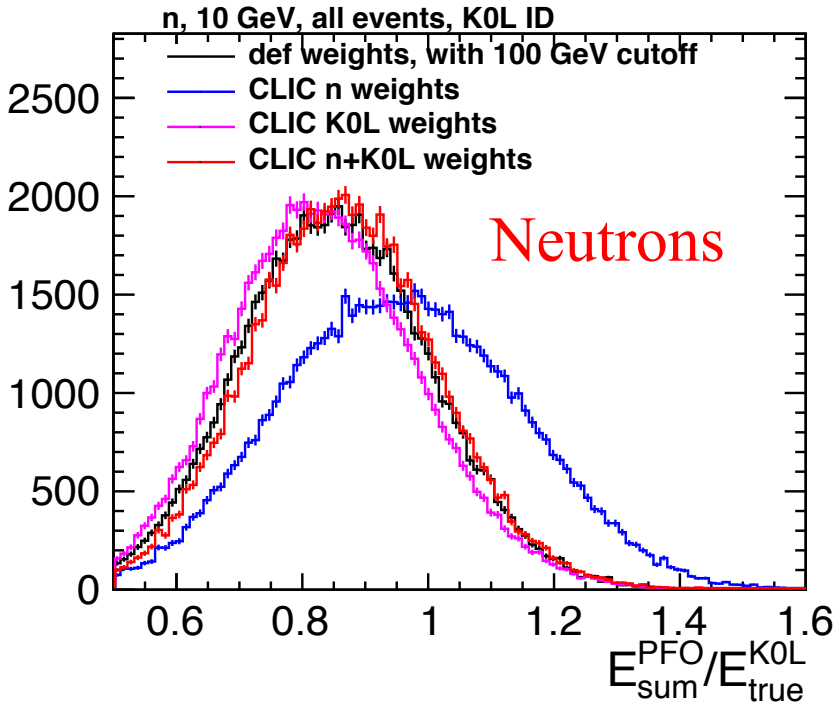
Tuned only up to 400 GeV neutral hadrons, works perfectly fine for 500 GeV hadron dataset, fails catastrophically for 1000 GeV hadrons

Considerable improvement using 1000 GeV sample for tuning
→ For 1500 GeV hadron samples new weights don't lead to unwanted effects either

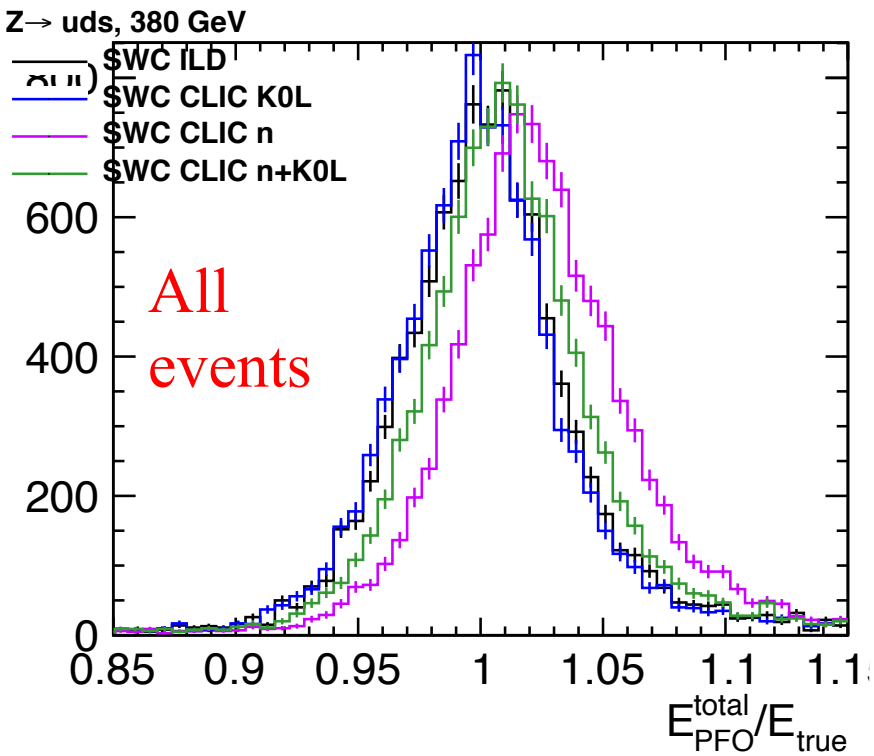
Single Hadron response closures: low energy Kaons and neutrons

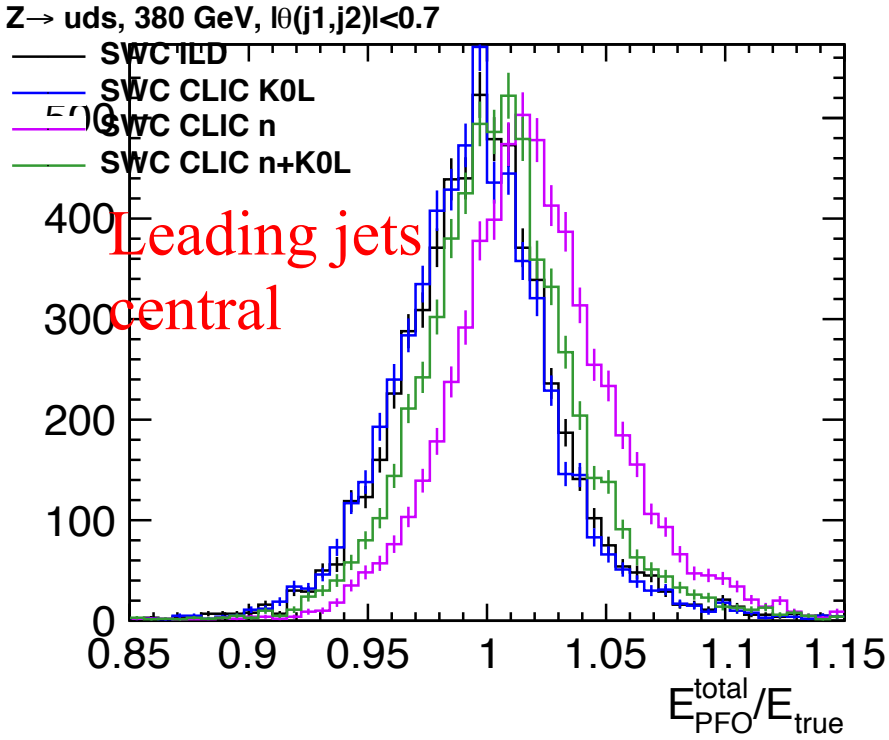
10 GeV Kaons and neutrons:
Kaon sample: mean around 1 except when using neutron weights
Opposite effect for neutron sample: response only close to 1 for software compensation weights from neutrons (response difference between neutrons and Kaons expected)





Jet Energy Resolution
Z to u/d/s sample at 380 GeV

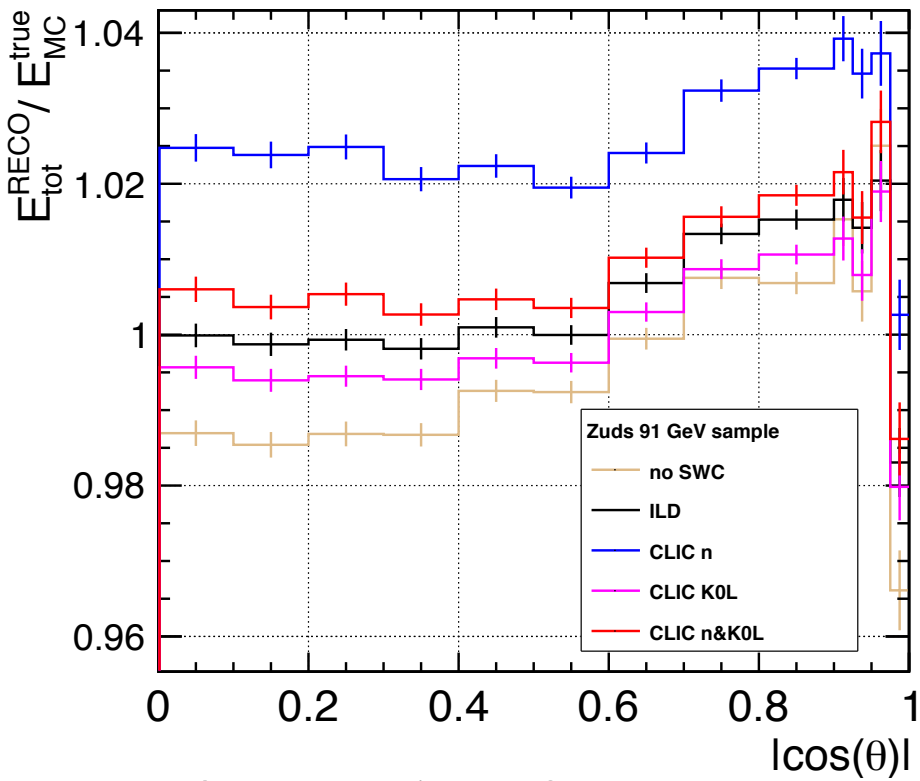




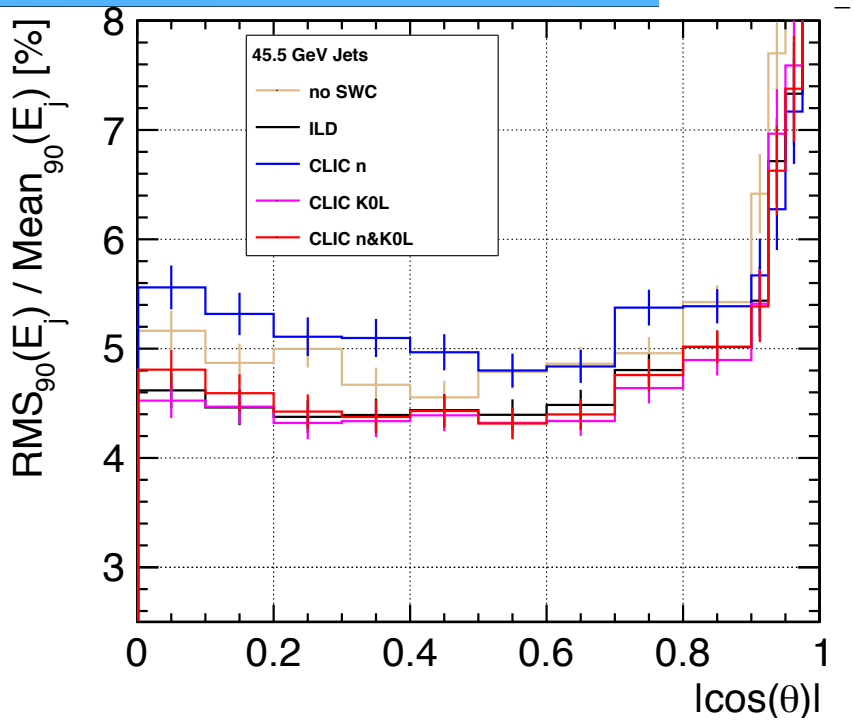
For neutron derived weights response larger than desired

mean/RMS ILD 1.00267/0.0383557
mean/RMS K0L 1.00055/0.0380975
mean/RMS n 1.02361/0.0381131
mean/RMS K0L+n 1.01078/0.0378763

Jet Energy Resolution
Z to u/d/s sample at 91 GeV



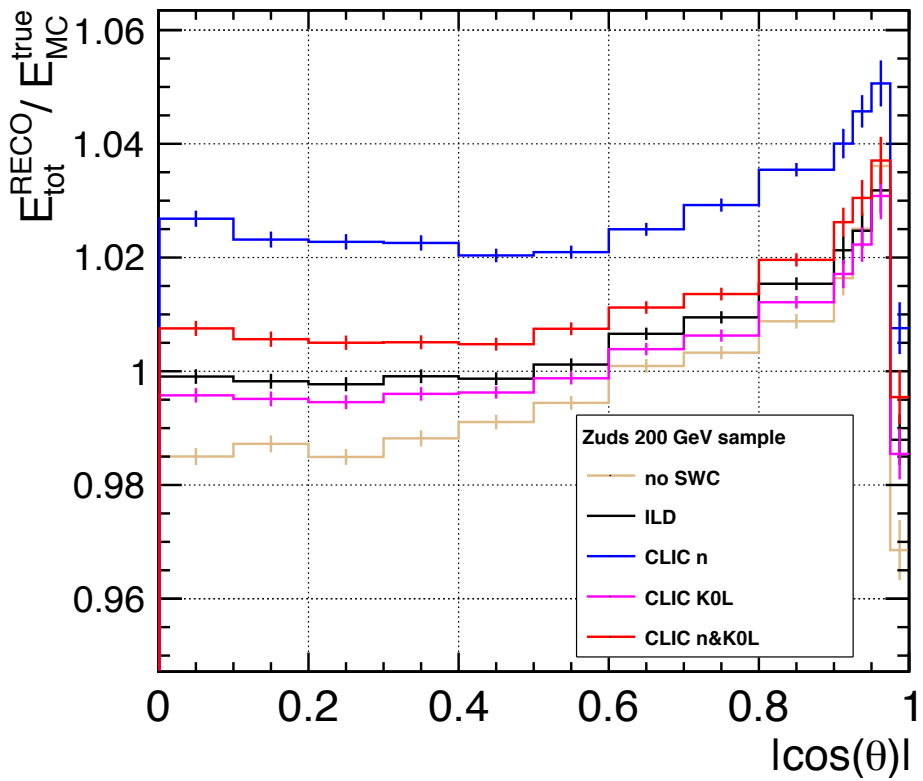
Mean of energy best for K0L case, with neutron derived SWC mean slightly too high



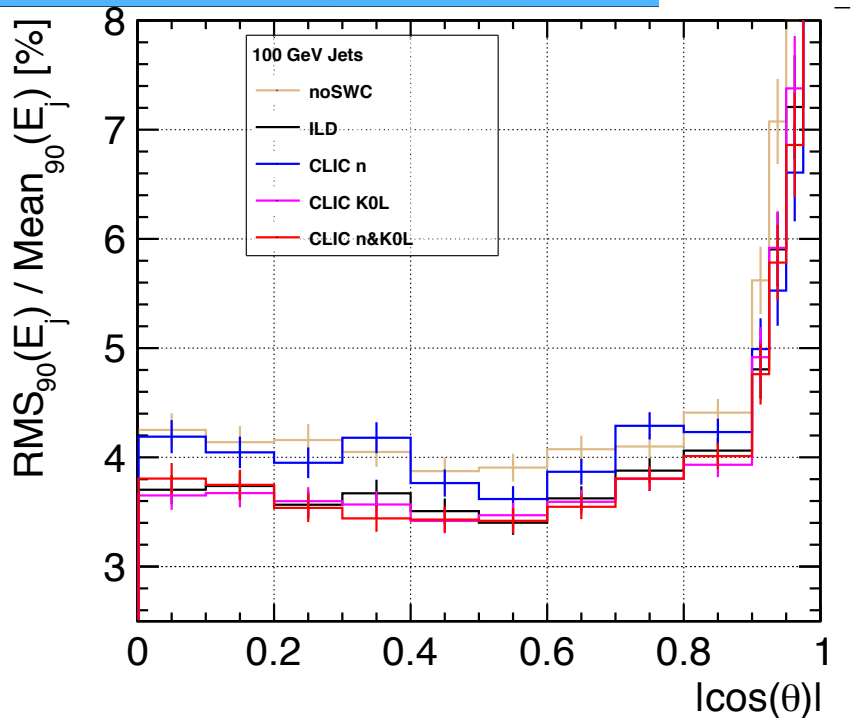
Compatible results with new weights (except for neutron weights), ILD weights trained in this range

→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 200 GeV



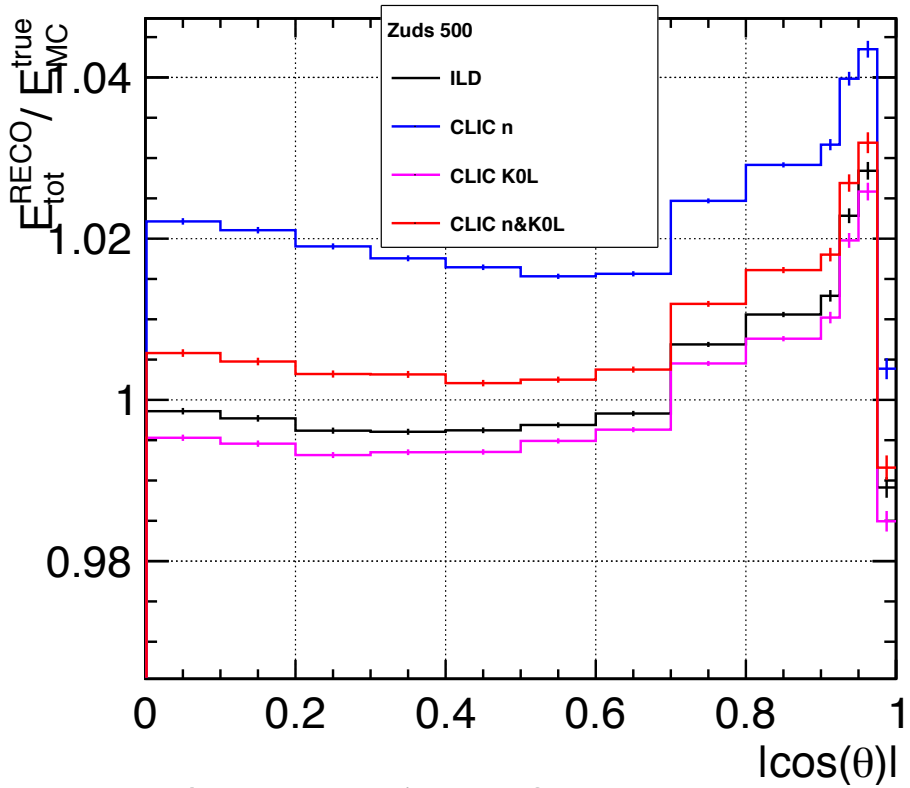
Mean of energy best using ILD weights, no large difference using K0L and combined neutron+K0L weights, with neutron derived SWC mean slightly too high



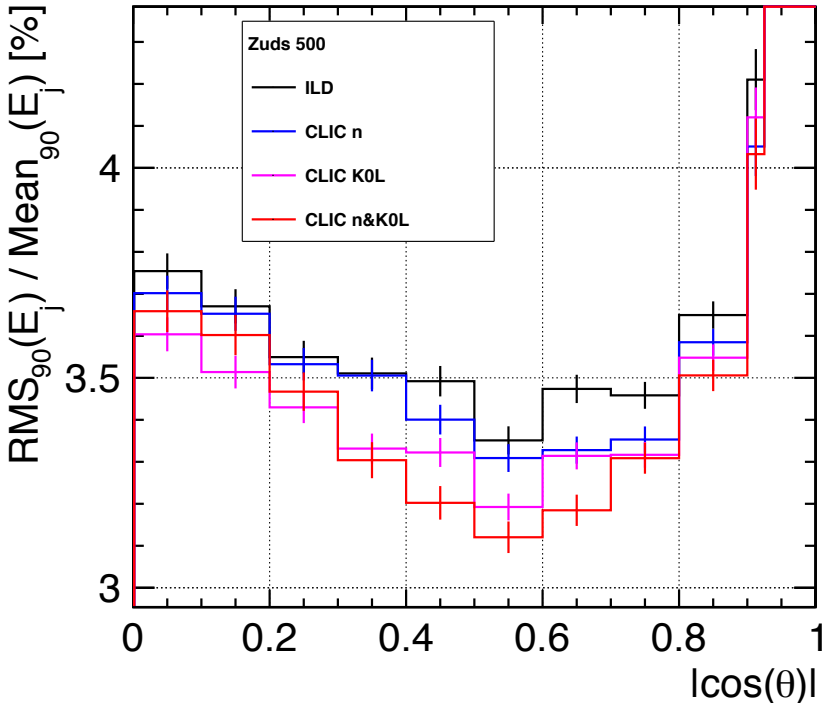
Compatible results with new weights (except for neutron weights), ILD weights trained in this range

→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 500 GeV

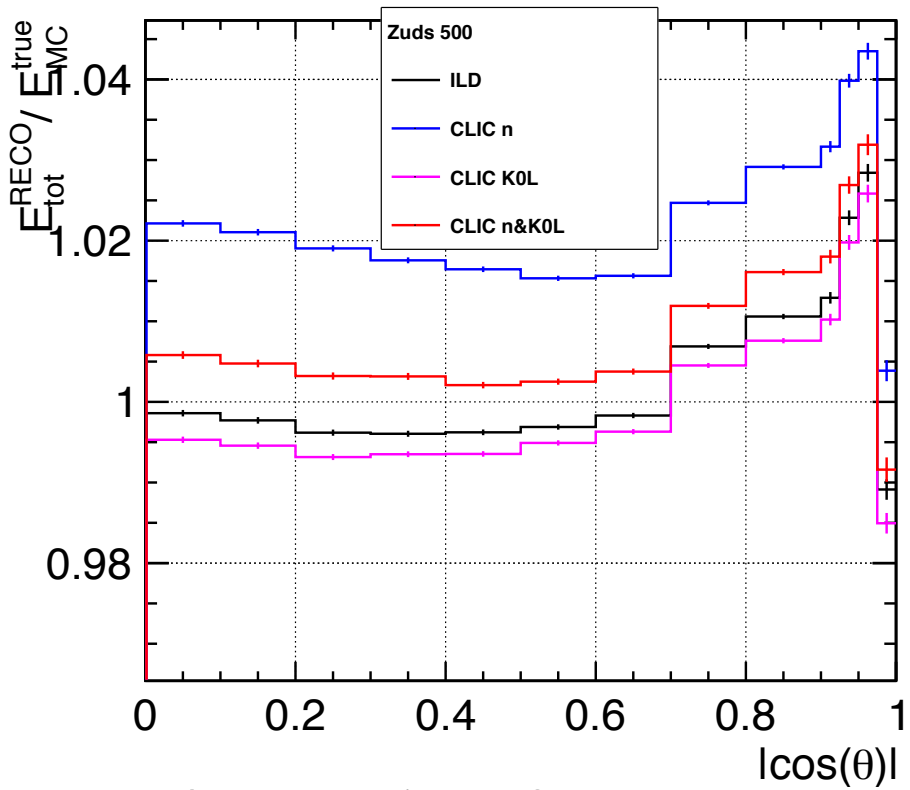


Mean of energy best for K0L case, with neutron derived SWC mean slightly too high

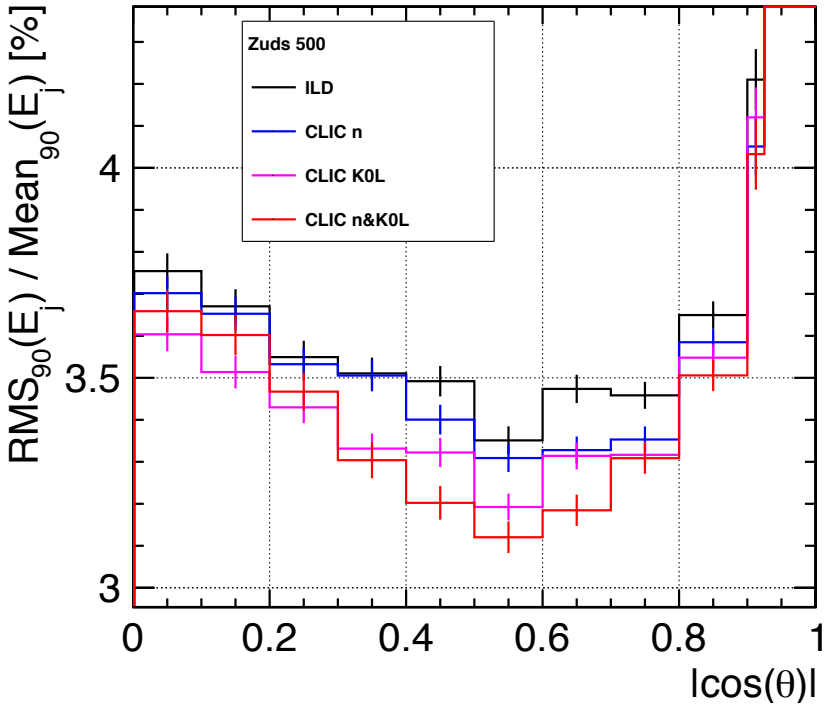


Considerable improvement in jet energy resolution compared to old SWC weights→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 500 GeV

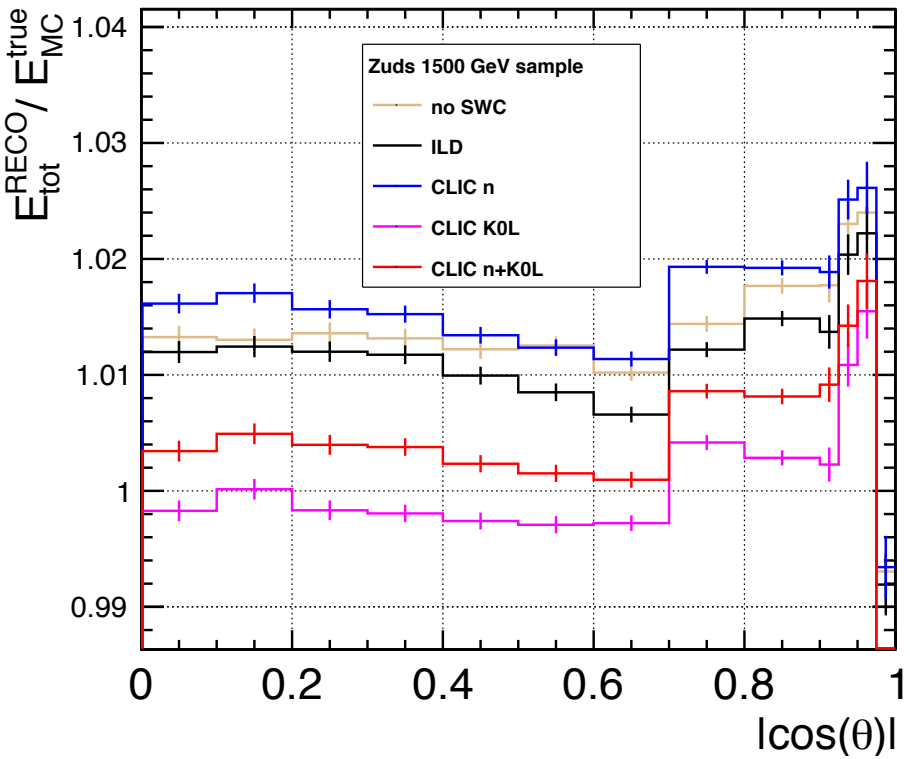


Mean of energy best for K0L case, with neutron derived SWC mean slightly too high

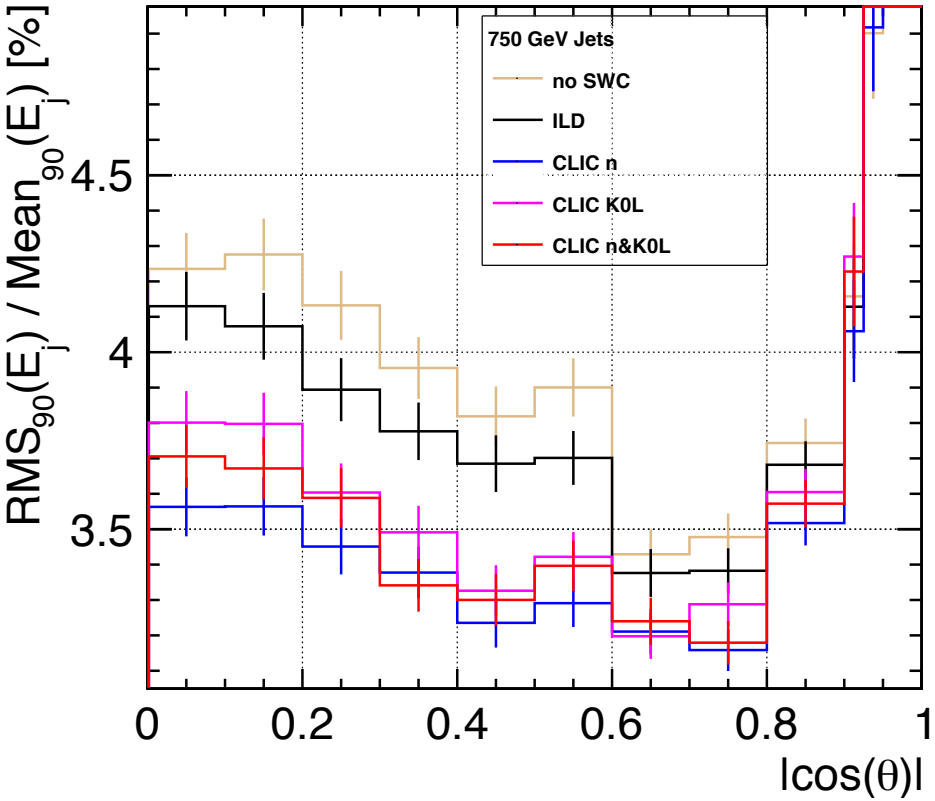


Considerable improvement in jet energy resolution compared to old SWC weights→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 1500 GeV

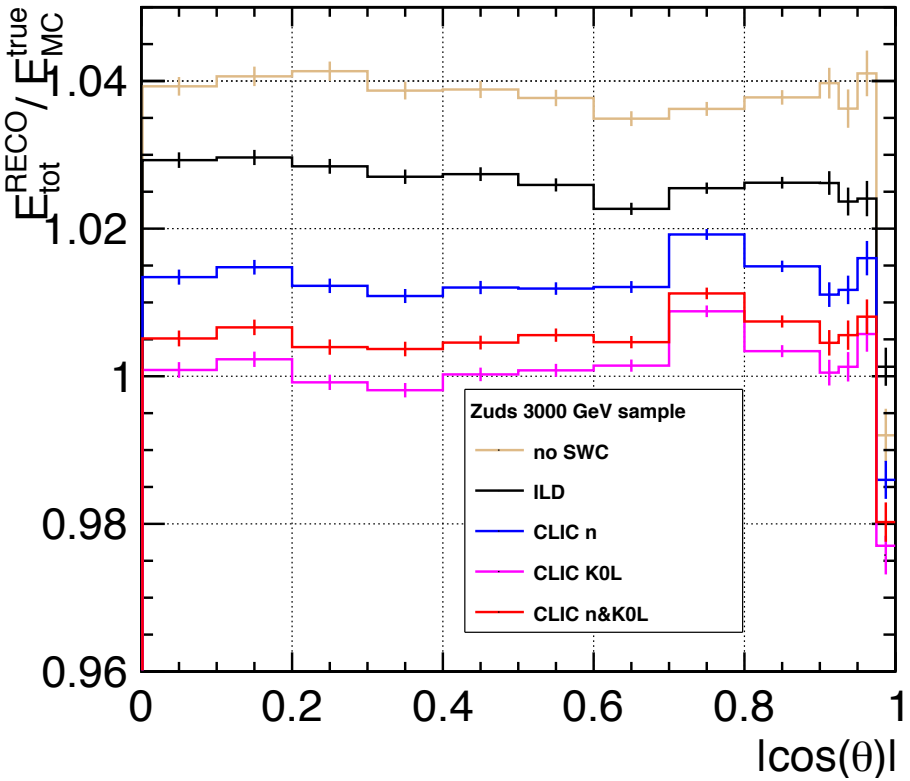


Considerable improvement in jet energy resolution compared to old SWC weights

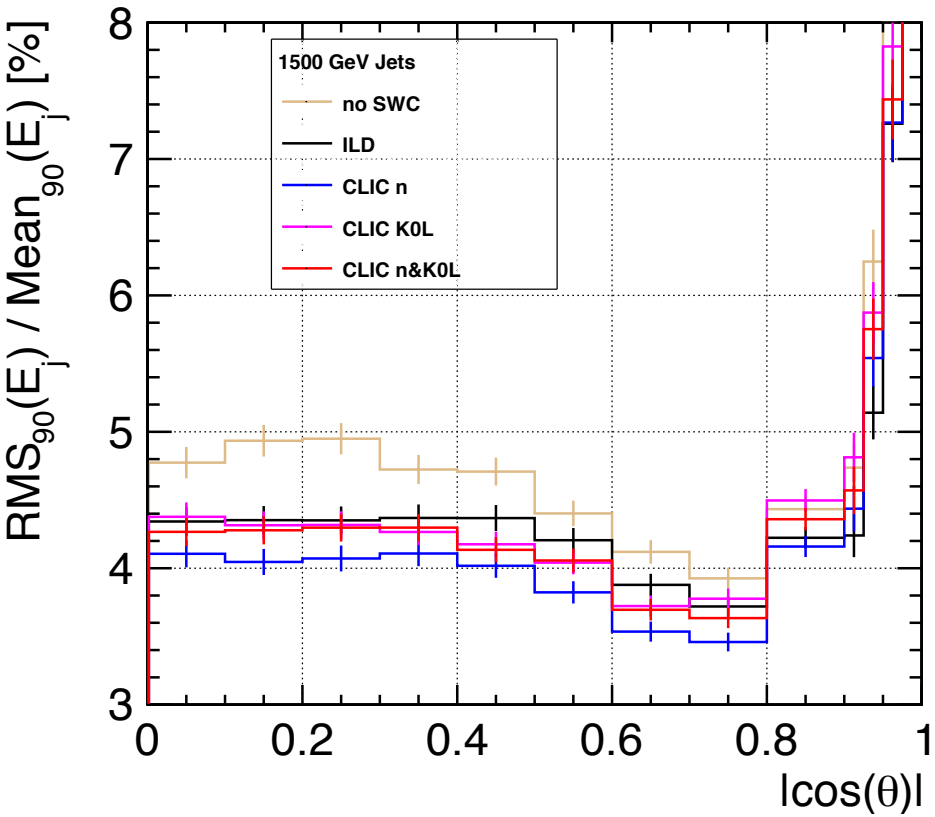


Considerable improvement in jet energy resolution compared to old SWC weights → new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 3000 GeV



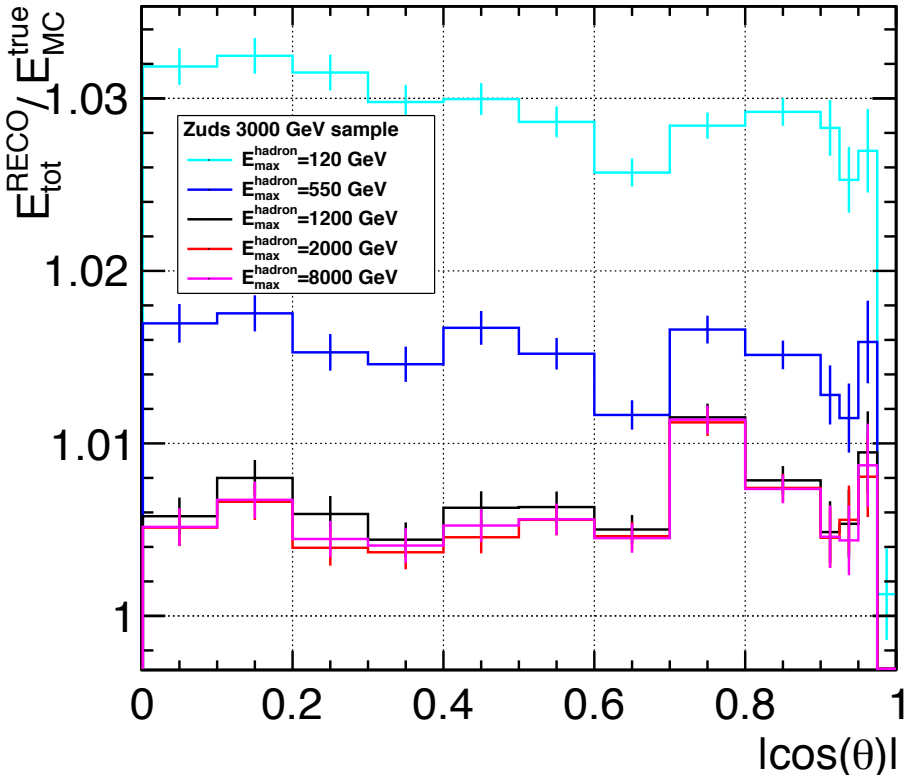
Considerable improvement in jet energy response compared to old SWC weights/ now SWC enabled



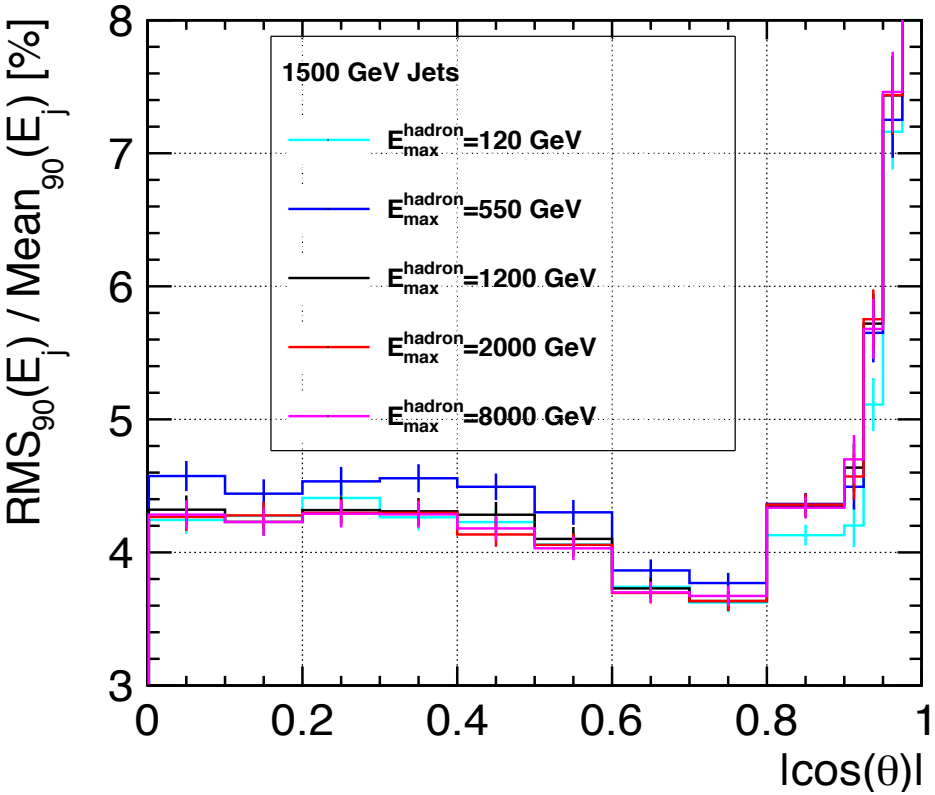
Similar performance using new weights, big improvement with respect to curve Without enabling SWC

→ new weights drom n+K0L have been used

Z to u/d/s sample at 3000 GeV impact of threshold to apply SWC

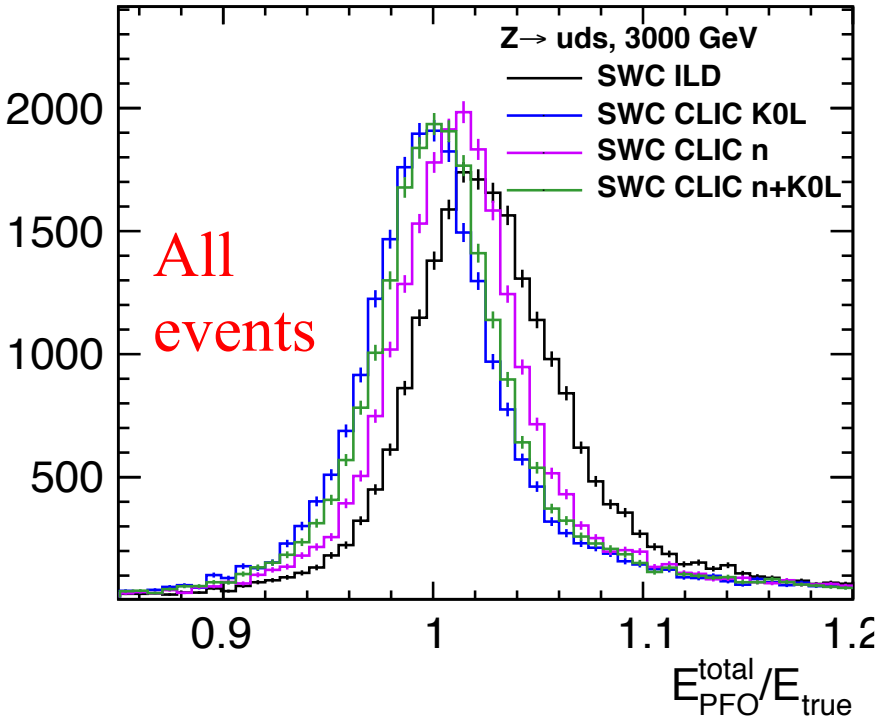


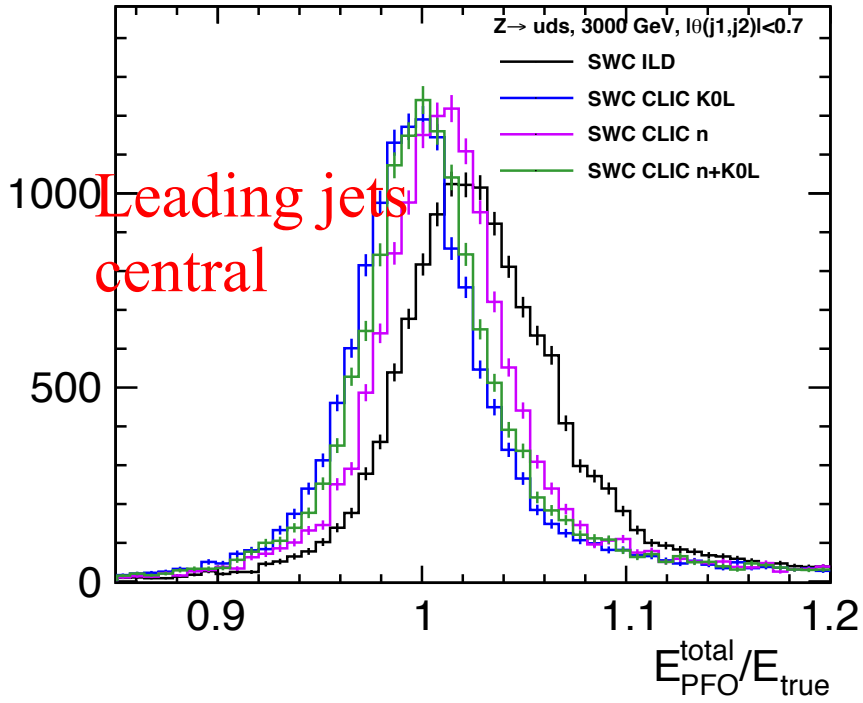
Applying SWC to low energetic hadrons only leads to a shift of the reconstructed energy to larger values, no sizeable impact if cut off is increased beyond 1.2 TeV



No sizeable change of the relative jet energy resolution once threshold is above 1200 GeV

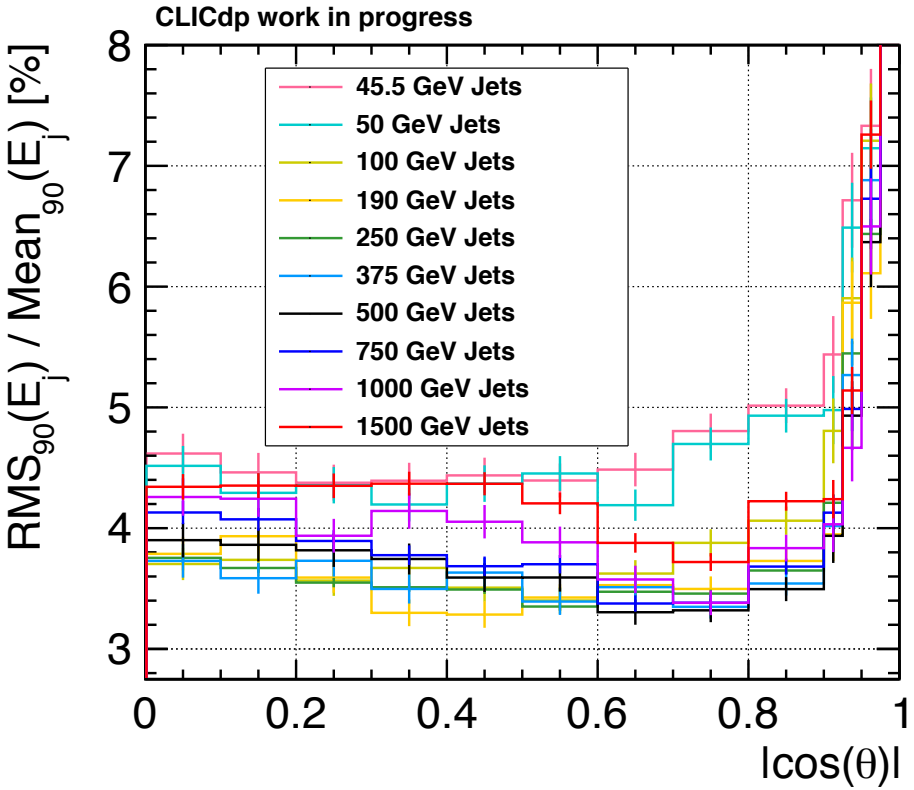
Jet Energy Resolution
Z to u/d/s sample at 3000 GeV



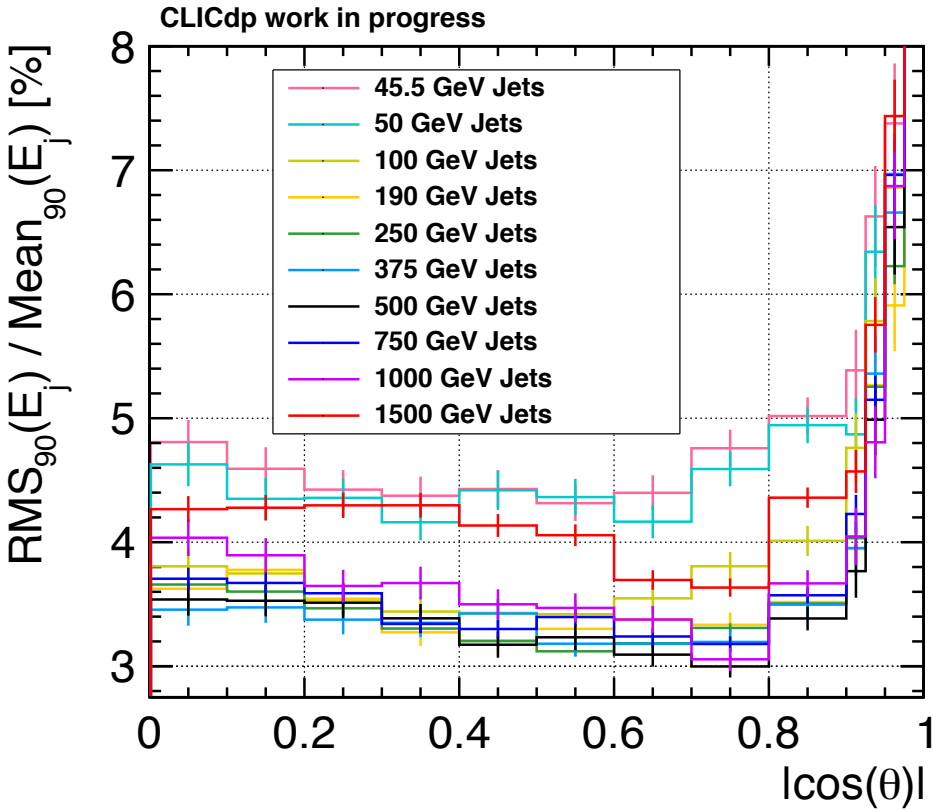


For neutron derived weights response larger than desired
Distribution using ILD weights for hadrons with E < 100 GeV shifted to even larger reponse

Jet Energy Resolution Summary



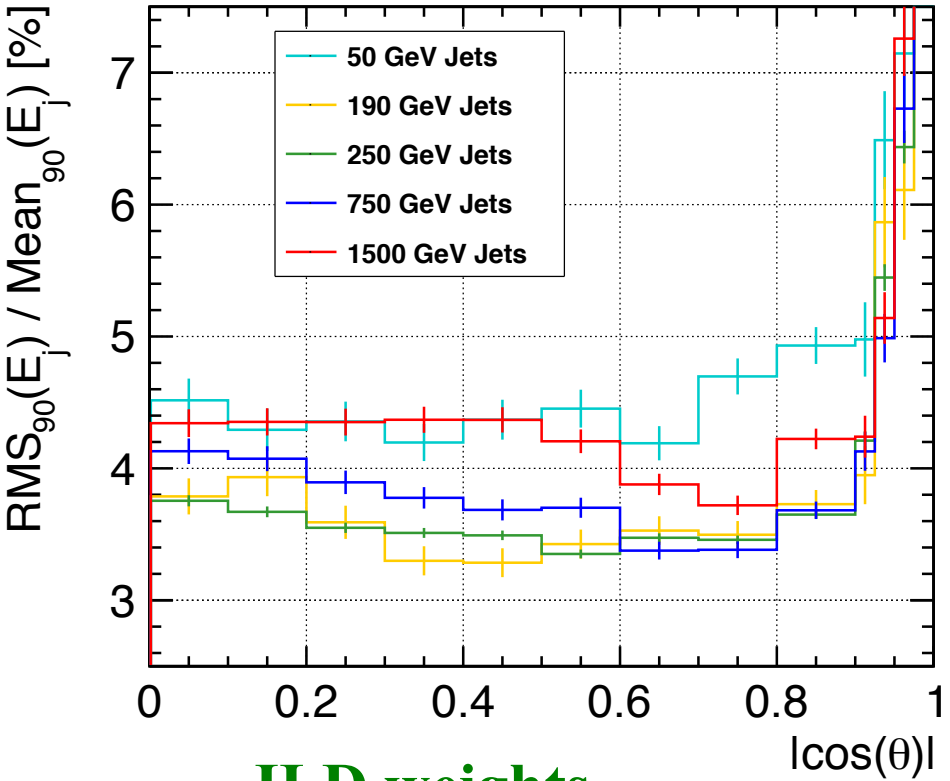
ILD weights



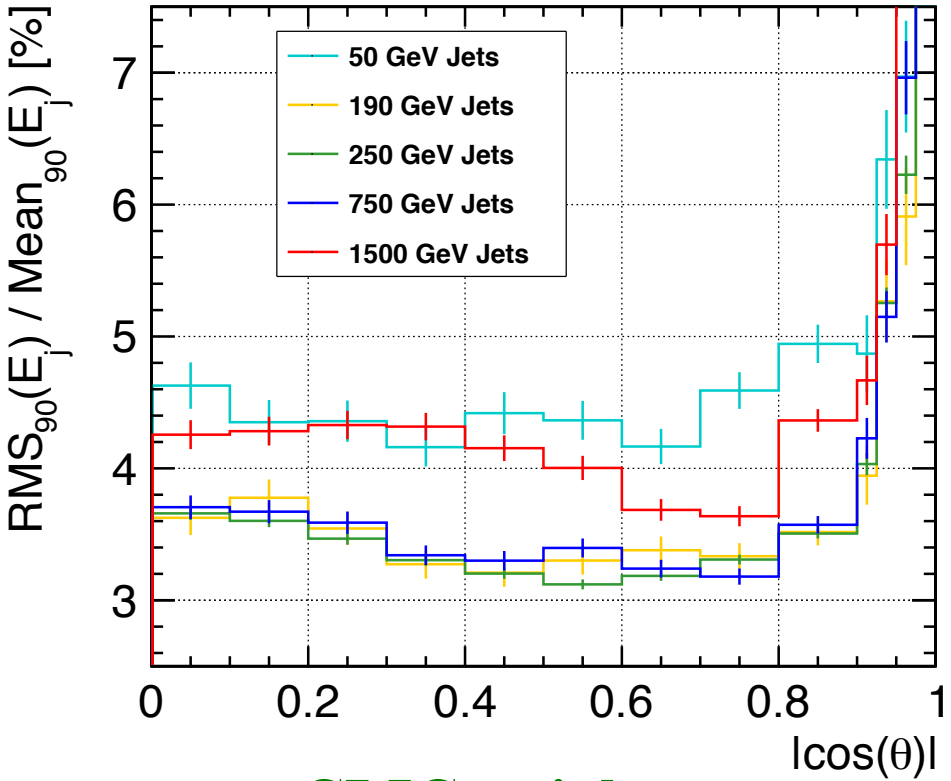
CLIC weights

Improvement in jet energy resolution compared to old SWC weights for almost all jet energies. Up to 190 GeV comparable resolutions, no big improvement for 1500 GeV jets as well

Jet Energy Resolution
Summary Reduced



ILD weights



CLIC weights

Improvement in jet energy resolution compared to old SWC weights for almost all jet energies. Up to 190 GeV comparable resolutions, no big improvement for 1500 GeV jets as well

Summary

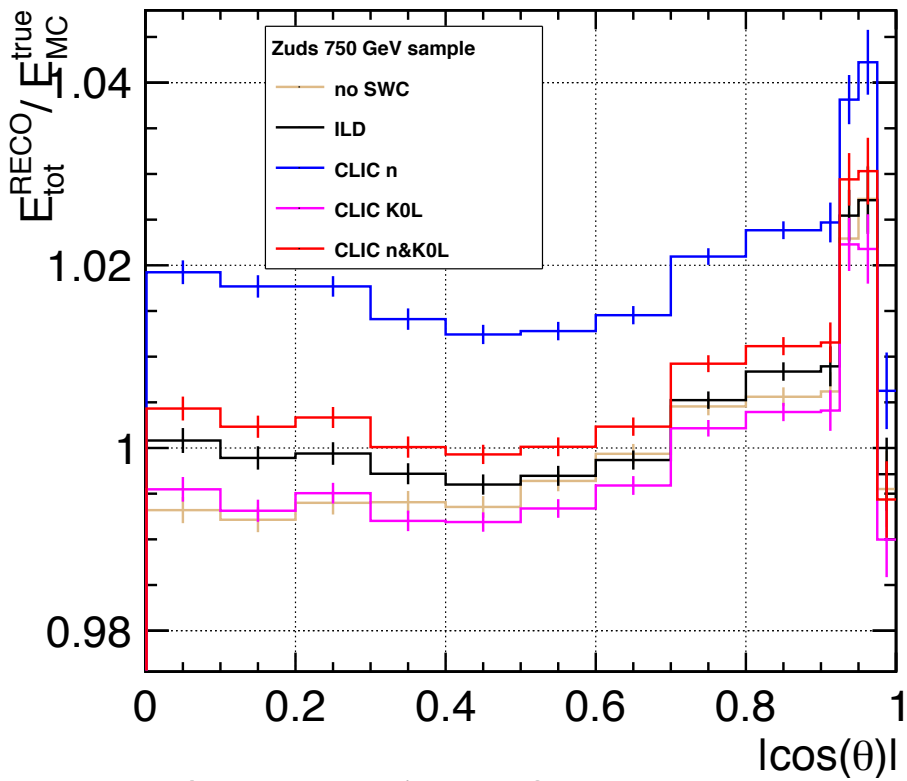
- Software compensation weights derived using neutron, Kaon and a combined neutron+Kaon fully simulated single particle samples, model CLIC_o3_v13

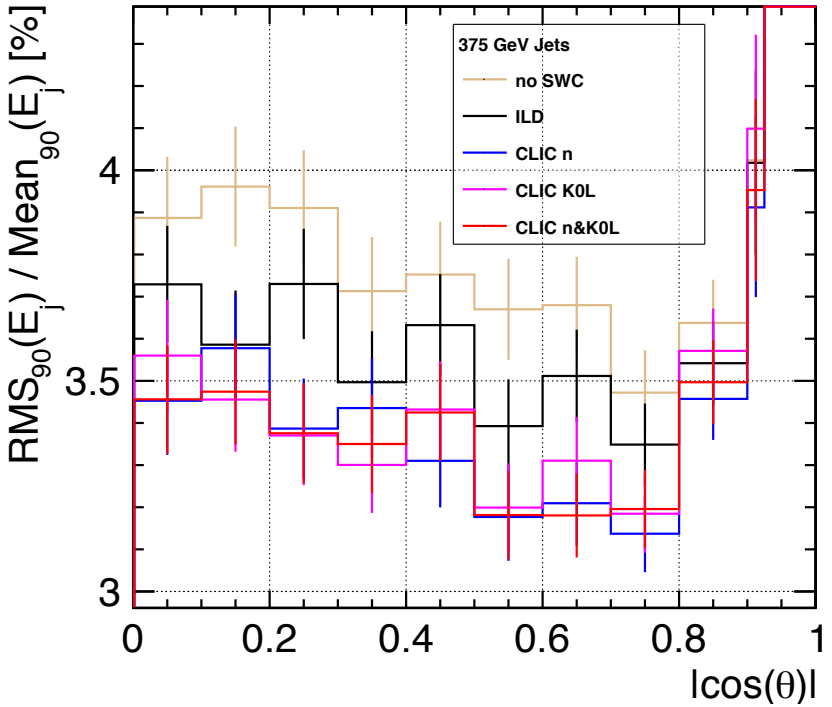
→weights from combined sample show best performance

- CLIC K0L and n+K0L SWC weights and ILD SWC weights show similar performance (response and resolution) for low energetic jets (up to 100 GeV). CLIC n SWC weights are shifted to higher response values and bigger resolution values
  - For high energetic jets CLIC SWC weights perform better (by around 10 %), only for 1.5 TeV jets CLIC and ILD weights perform similarly for resolution, mean of event energy for ILD weights 3 % higher than true energy
  - For 1.5 TeV jets resolutions around 4.5 %, non gaussian tails, for 100-1000 GeV jets resolution values around 3.25-3.75 %

BACKUP

Jet Energy Resolution
Z to u/d/s sample at 750 GeV

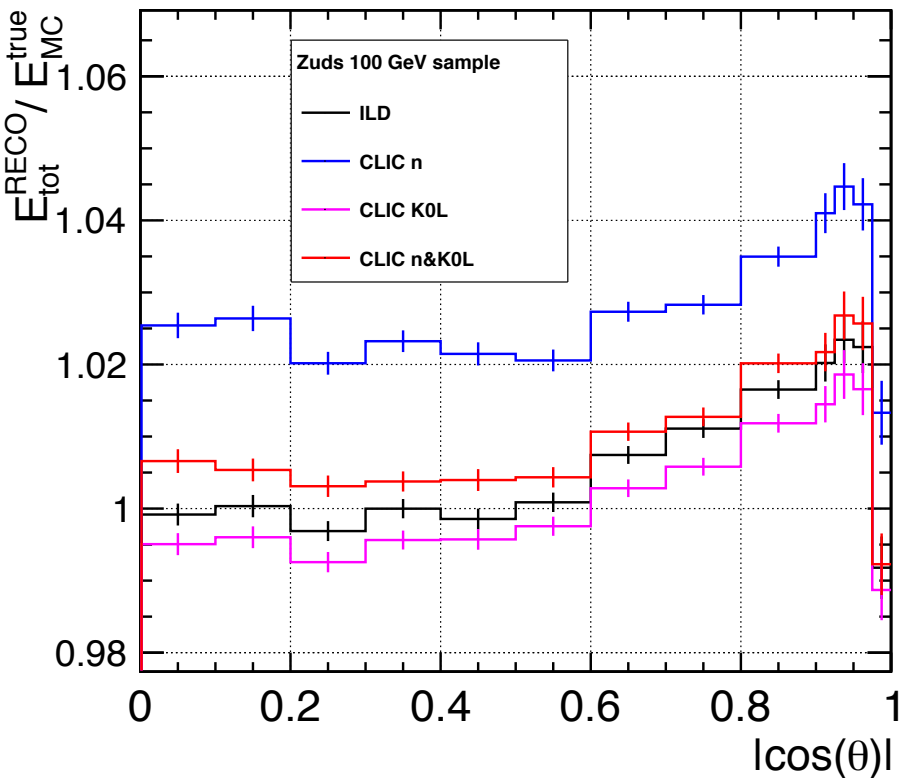




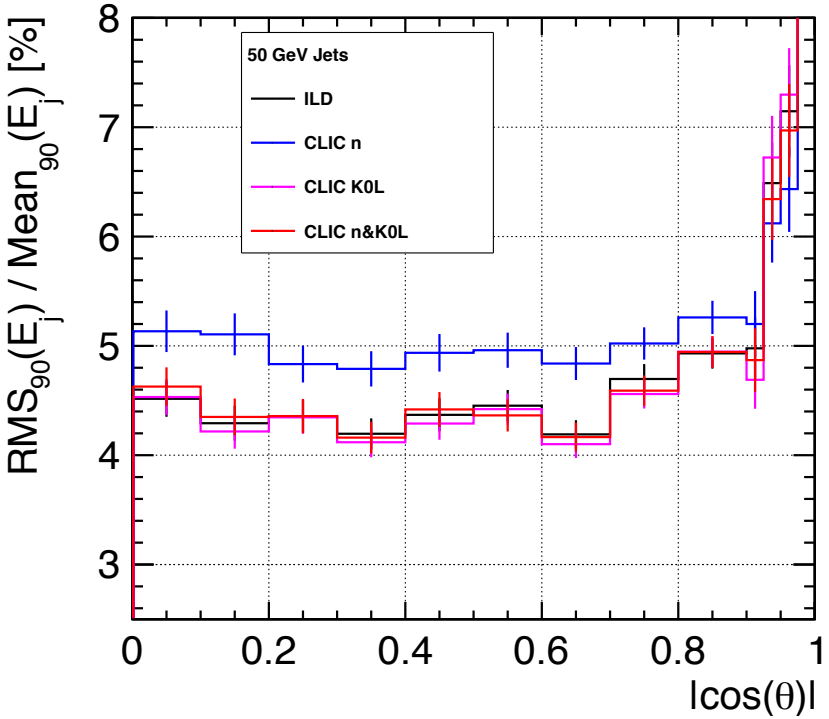
Mean of energy best for K0L case, with neutron derived SWC mean slightly too high

Considerable improvement in jet energy resolution compared to old SWC weights→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 100 GeV



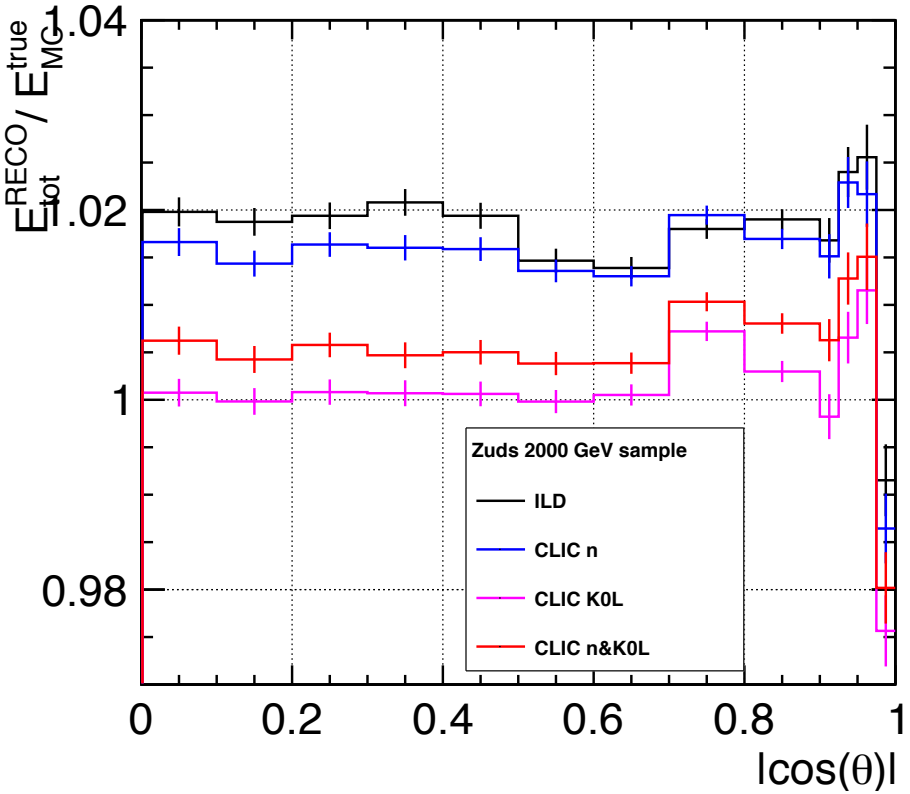
Mean of energy best using ILD weights, no large difference using K0L and combined neutron+K0L weights, with neutron derived SWC mean slightly too high



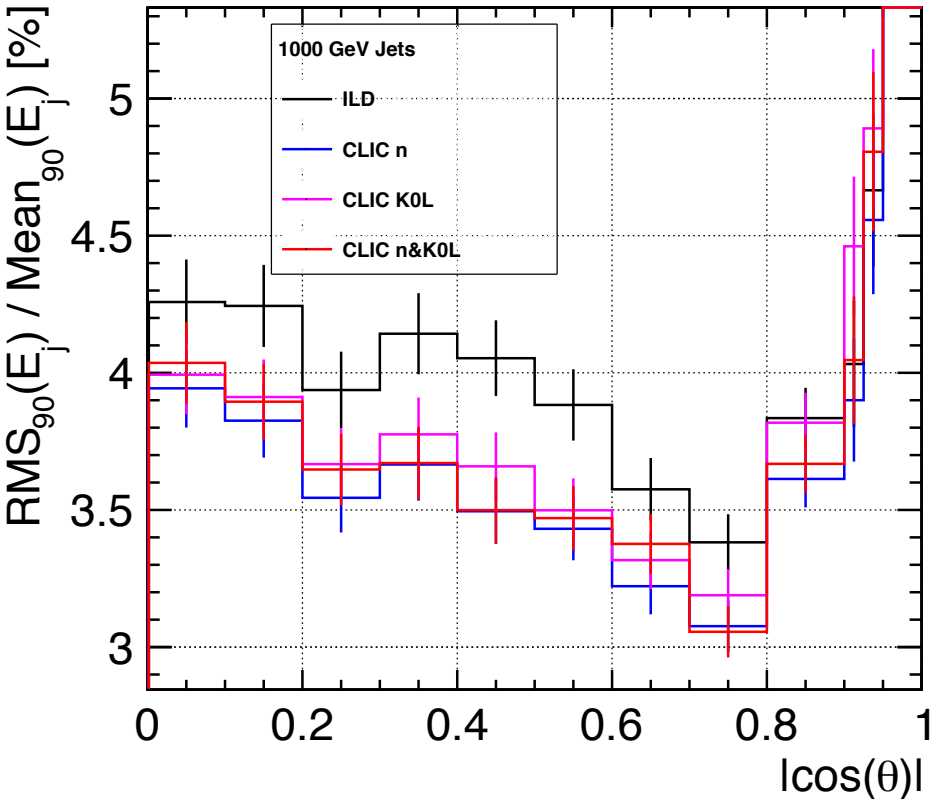
Compatible results with new weights (except for neutron weights), ILD weights trained in this range

→ new weights from n+K0L have been used

Jet Energy Resolution
Z to u/d/s sample at 2000 GeV



Considerable improvement in jet energy resolution compared to old SWC weights (neutron response too high as well)



Considerable improvement in jet energy resolution compared to old SWC weights → new weights from n+K0L have been used

Problem with very high neutral hadrons
K0L at 1500 GeV

No issue observed

Threshold for applying SWC set to E_{hadron}=1800 GeV
→leads to little second peak