PandoraPFA and Calorimeters

Matthias Weber (CERN)

Jet Energy Resolution

Determined using RMS_{90} the total relative energy resolution

$\Sigma E_{PFO} / \Sigma E_{MC}$, where all stable visible MC particles are used in the denominator, ignoring the energies of neutrinos

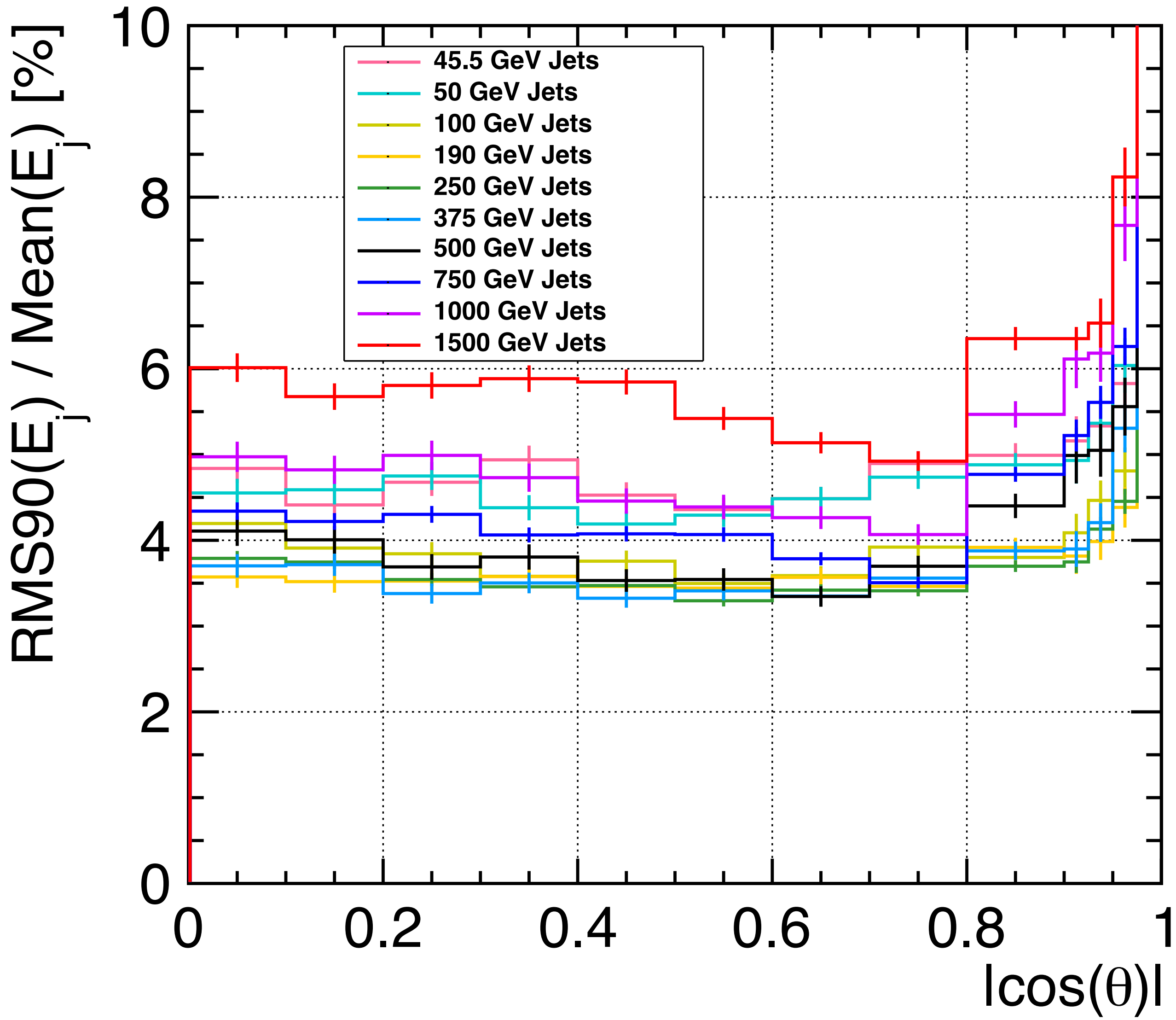
→ Multiply by a factor of $\sqrt{2}$ to get the jet energy resolution values

→compare results of RMS_{90} with total RMS (large non gaussian tails for 1500 and 3000 GeV datasets)

The next slides show a recap of talk in last meeting:

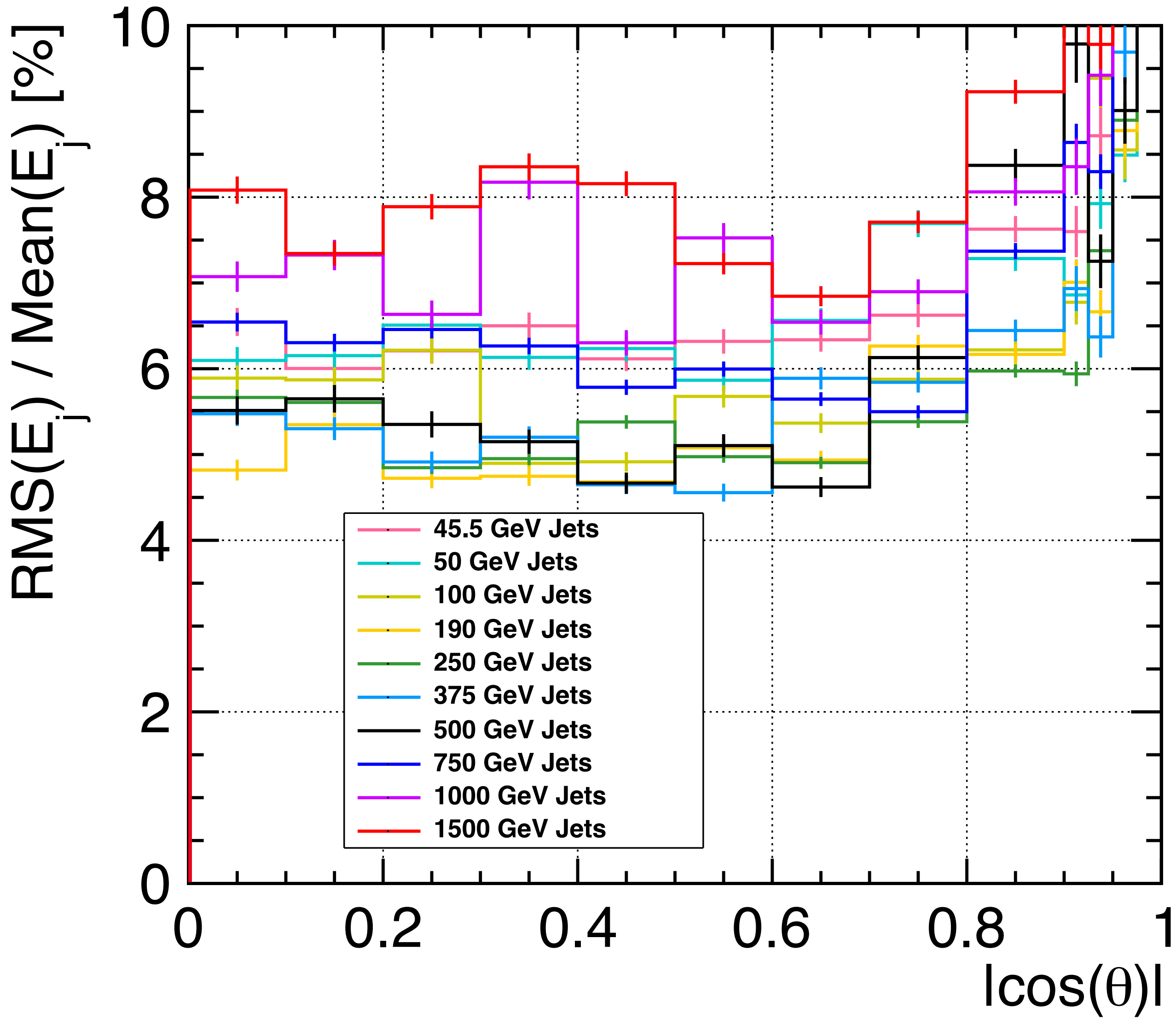
Done with model CLIC_o3_v10

Jet Energy Resolution: RMS_{90}



Plotted vs cos θ of leading quark
→ Fairly flat up to outter endcap, values around 4 % up 500 GeV, 5 % up to 1000 GeV jets, considerably worse at very high jet energies of 1500 GeV (around 6 %)

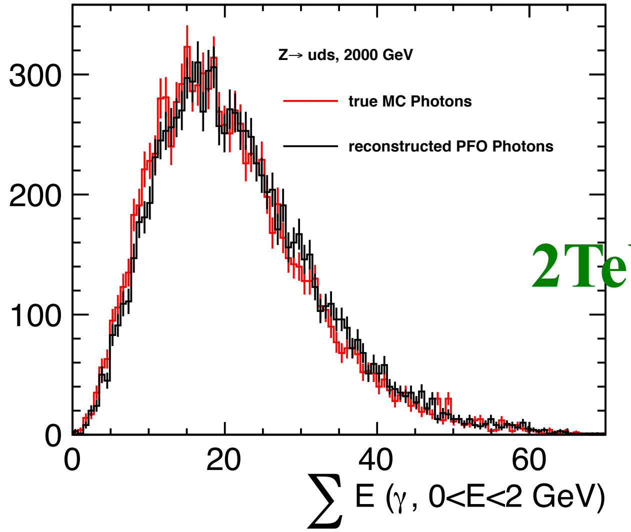
Jet Energy Resolution: RMS



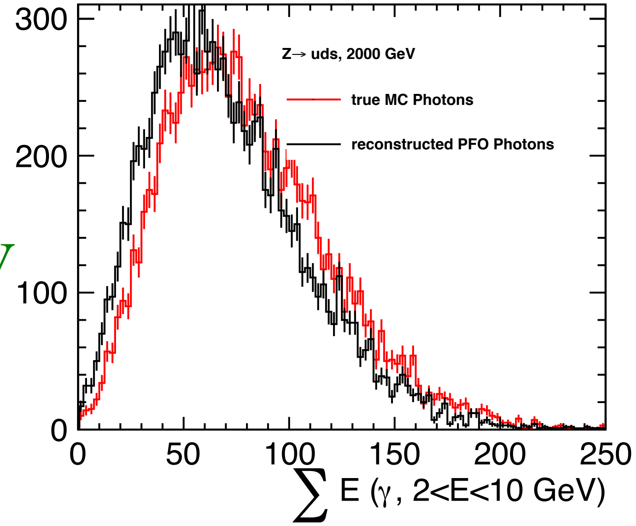
Plotted vs cos θ of leading quark
→ Full RMS values around 5-6 % for almost all samples, around 8 % for 3 TeV dataset (1500 GeV jets)

Energies at 2000 and 3000 GeV: contribution from photons

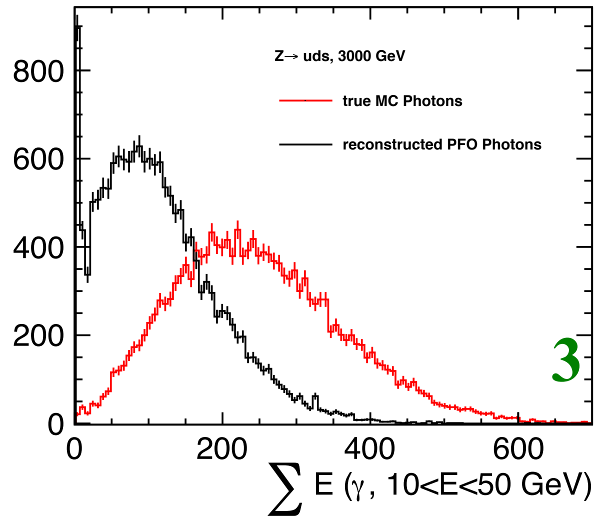
Check what might cause the higher jet energy resolution values for high energetic jets: photon energy distributions



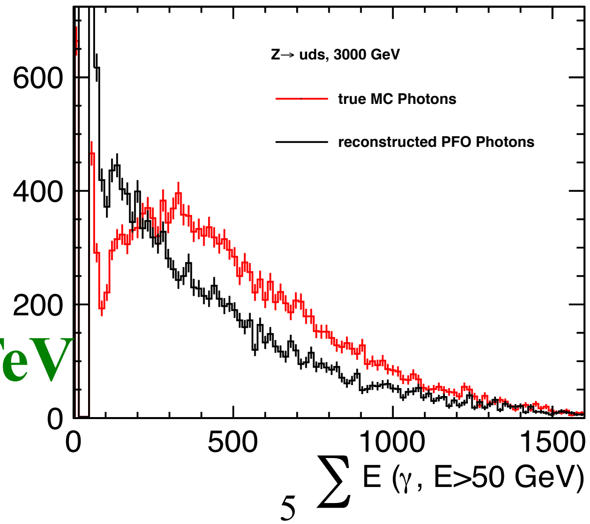
2TeV



For low energetic photons contribution well reconstructed, contribution from photons between 10 and 50 GeV vastly underestimated

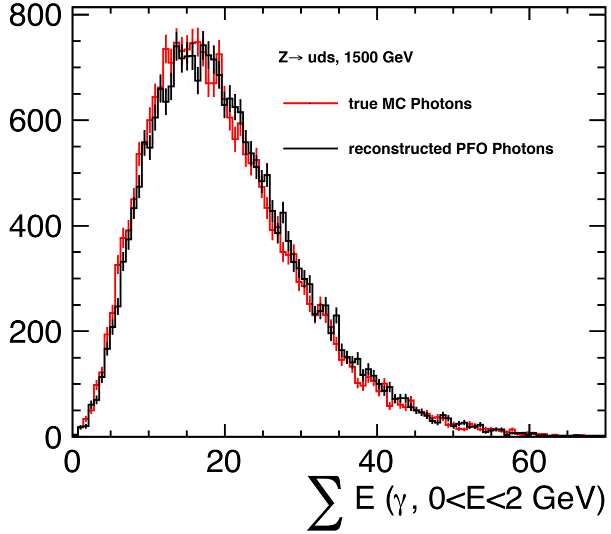


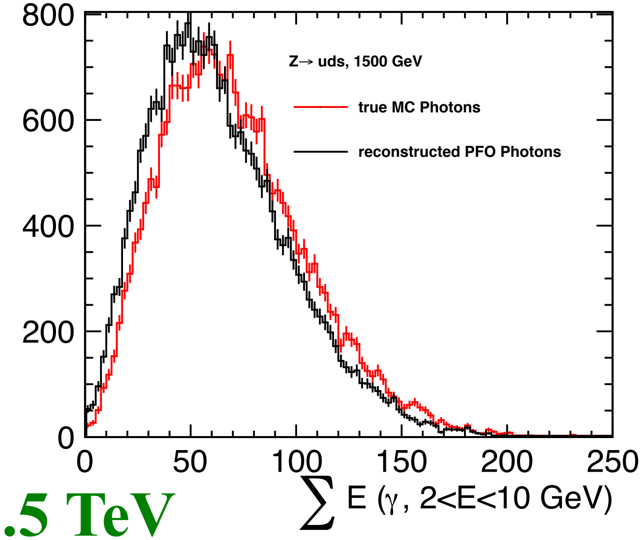
3 TeV



Jet Energy Resolution:: 1500 GeV contribution from photons

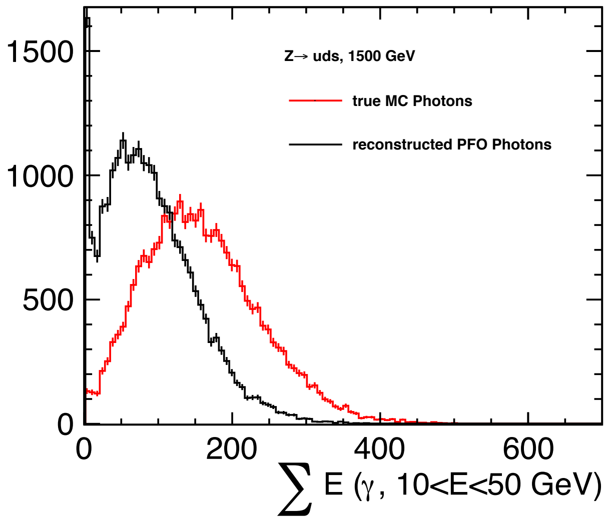
Check what might cause the higher jet energy resolution values for high energetic jets: photon energy distributions

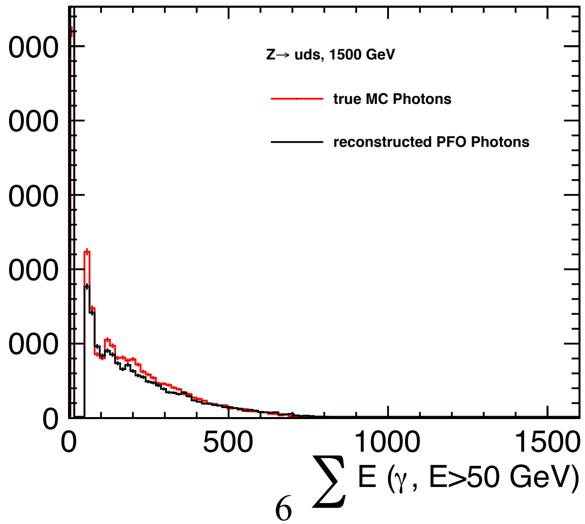




1.5 TeV

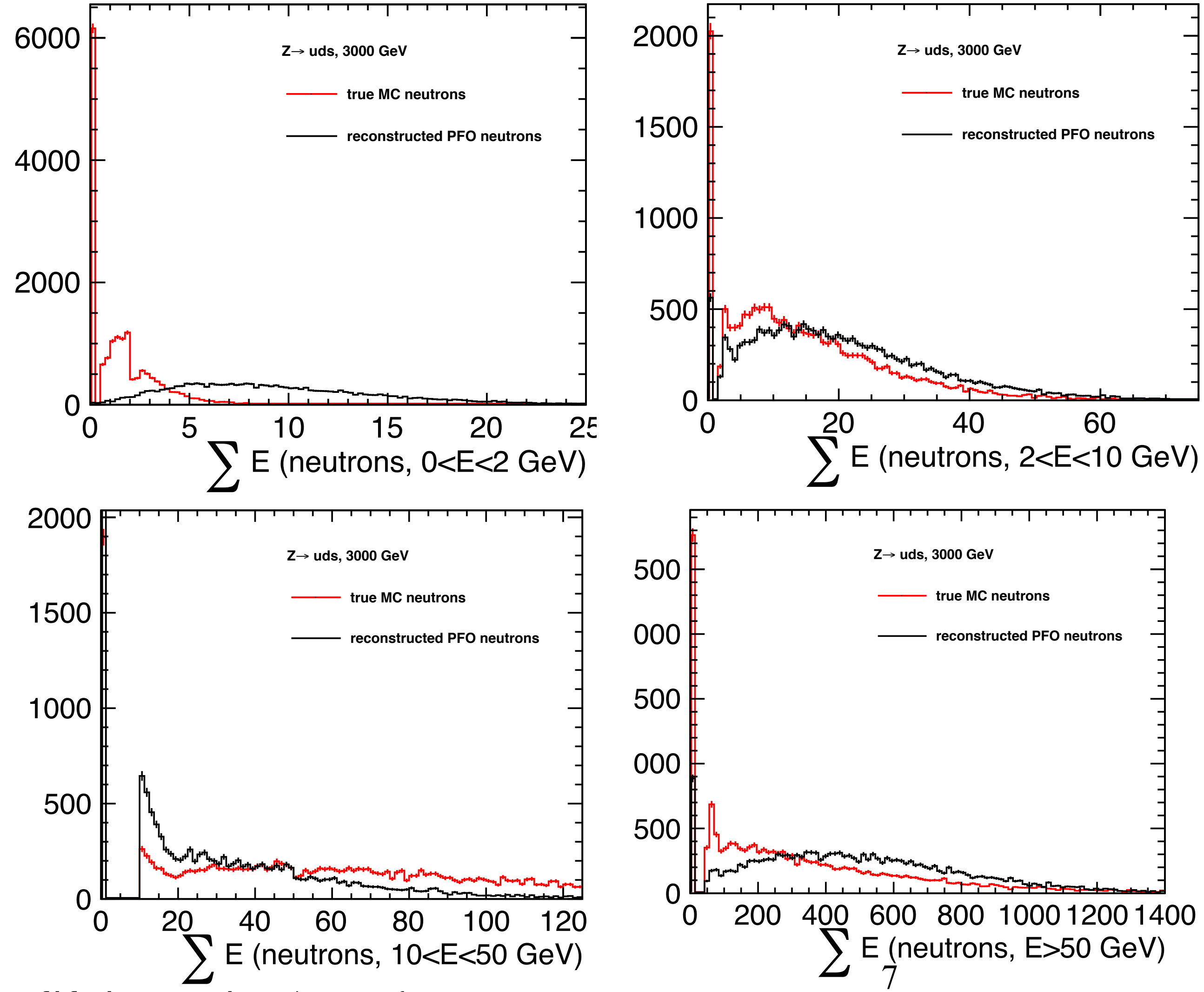
For low energetic photons contribution well reconstructed, contribution from photons between 10 and 50 GeV vastly underestimated





Energies at 1500 GeV: contribution from neutrons

Check what might cause the higher jet energy resolution values for high energetic jets: neutron energy distributions



Contributions reproduced less well (as expected), everywhere overestimated

MC pion energies sum of MC neutrons and MC K^0_L

Jet Energy Resolution: Summary of issues from last time

- Jet Energy resolution (using RMS_{90}) in Z→uds dijet events are for datasets of sqrt(s)<1500 GeV around 4 %, distributions are fairly symmetric

- For datasets at higher energies resolution unsymmetric with tail to lower values → charged component reproduced fairly well, largely a result of underestimated photon contribution, particularly of photons between 10 and 50 GeV

Suggestions and Remarks

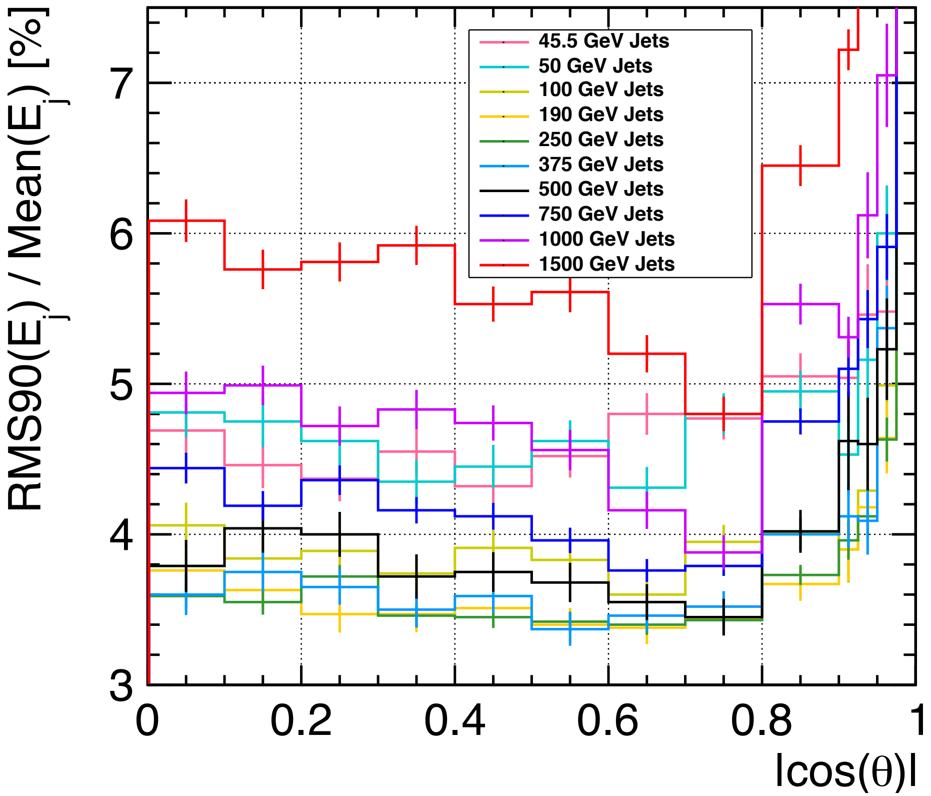
Suggestions and remarks for further checks →presented in the following

- Previous studies: no cut on **MaxHCalHitHadronicEnergy** (MHHHE) can improve energy resolution particularly in HCAL (default cut set to 1 GeV)
- Software compensation can improve reconstruction in high density jets (together without a MHHHE cut →use software compensation weights for ILD for the time being
- Check where deficit in photons might come from
- Run using the PandoraPerfectPhoton configuration file

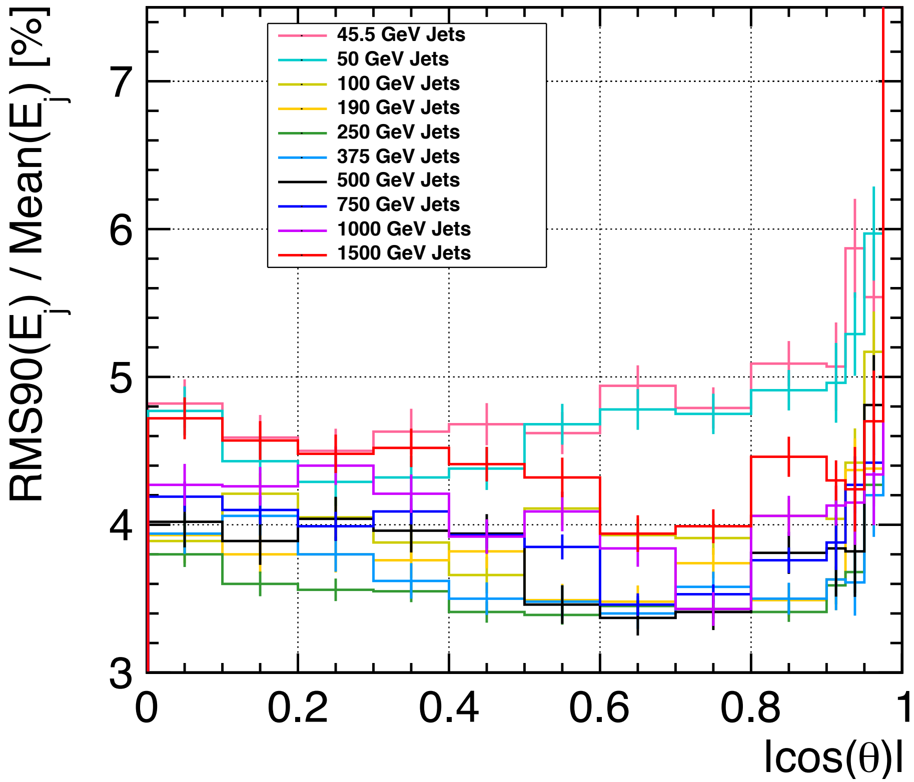
  →should cheat on the pattern recognition

  →allows checking if pattern recognition or energy calibration is driving issue

Jet Energy Resolution for CLIC_o3_v11: default CLIC settings vs MHHE cut removed



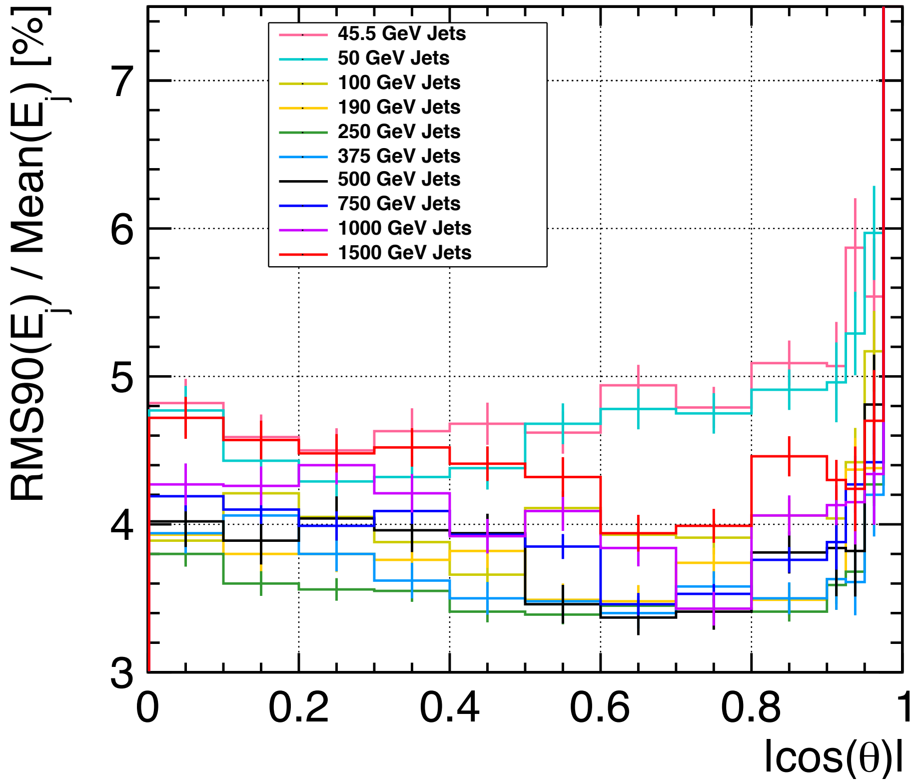
Default CLIC reconstruction parameters

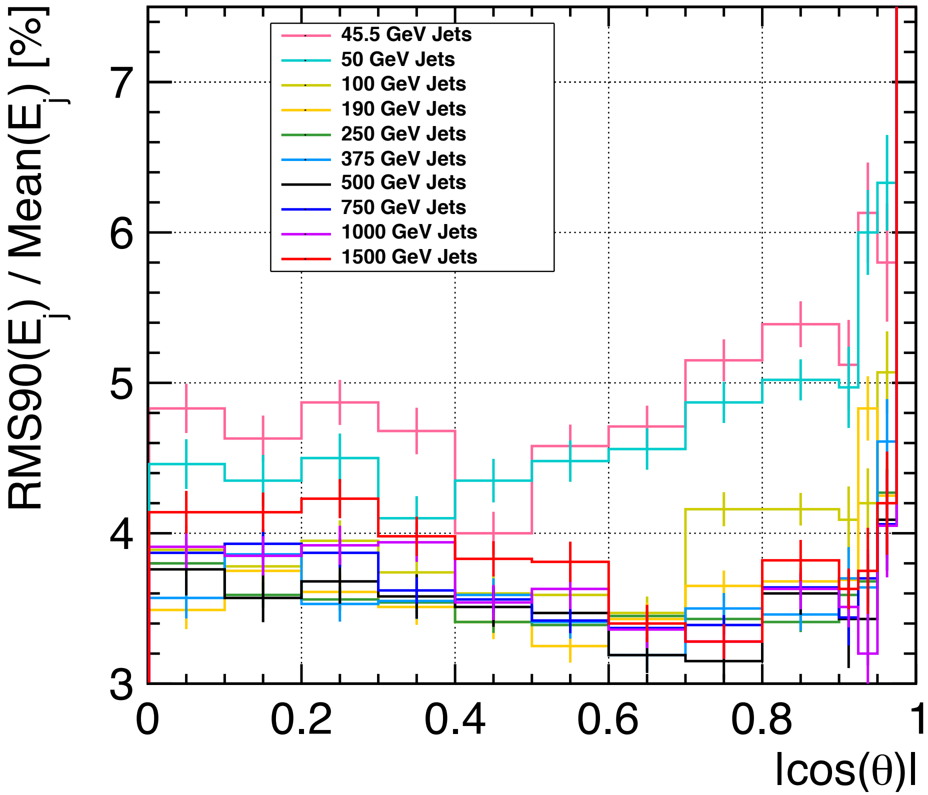


Default CLIC reconstruction parameters, Remove MHHHE cut

Slight improvement for low energy samples, major improvement at high energies (around 1.5 % for 3 TeV samples, 1 % 1500 GeV)

Jet Energy Resolution for CLIC_o3_v11: def and no MHHHE vs software compensation



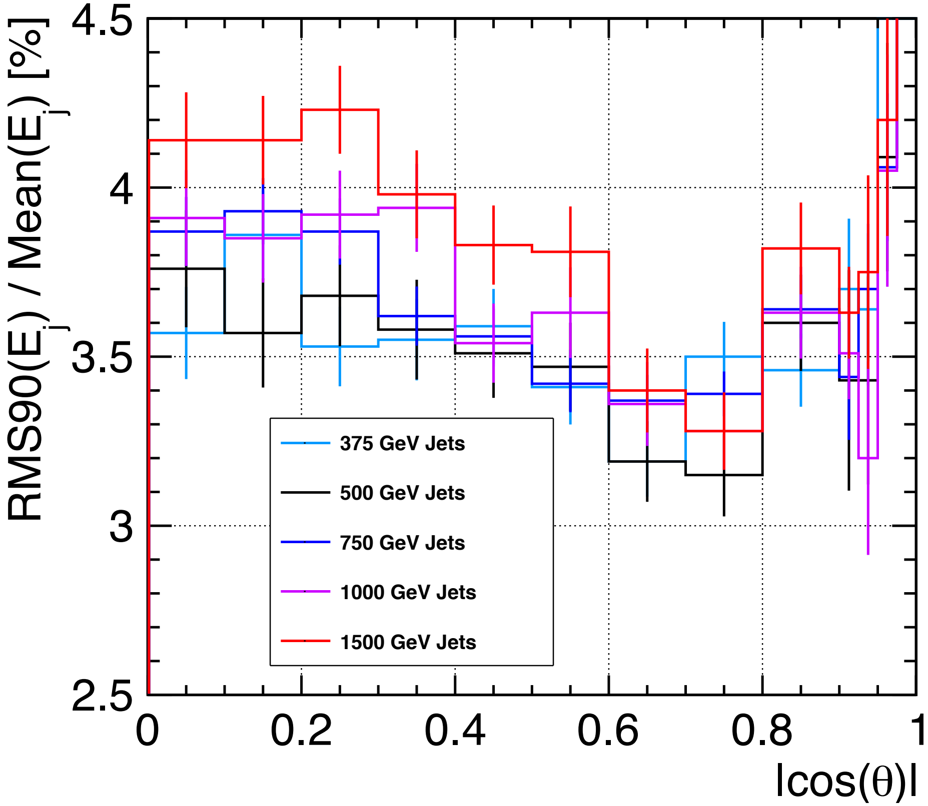


Default CLIC reconstruction parameters, Remove MHHHE cut

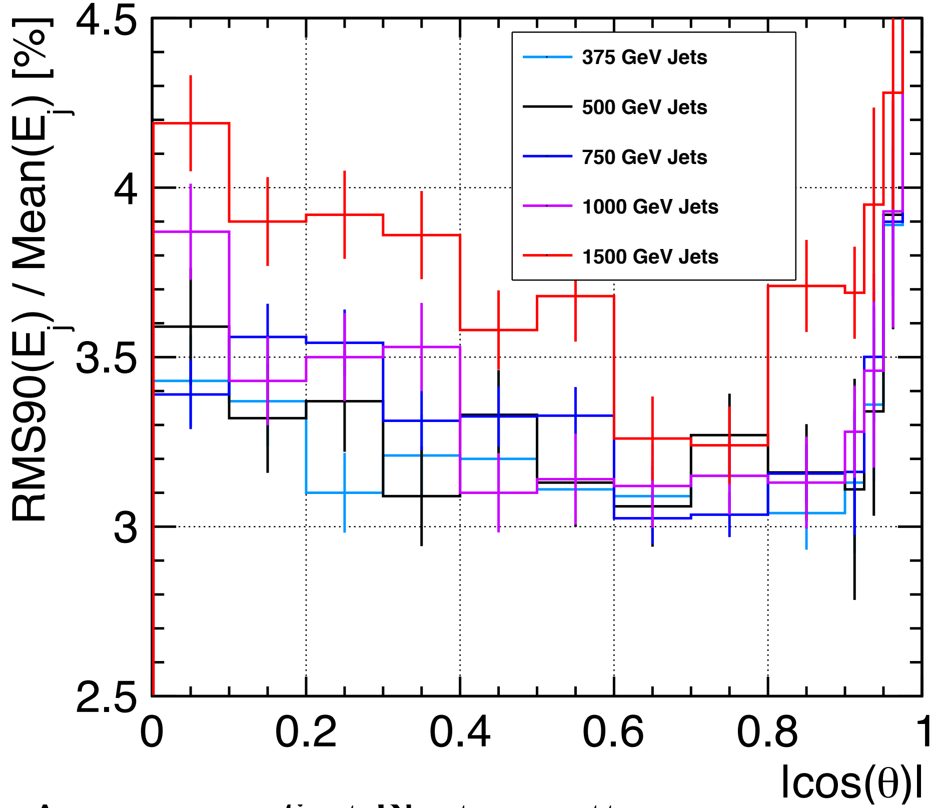
Enable software compensation, configuration has MHHHE cut removed per default

Additional reduced resolution for almost all datasets

Jet Energy Resolution for CLIC_o3_v11: software compensation vs perfect photon



Enable software compensation, configuration has MHHHE cut removed per default

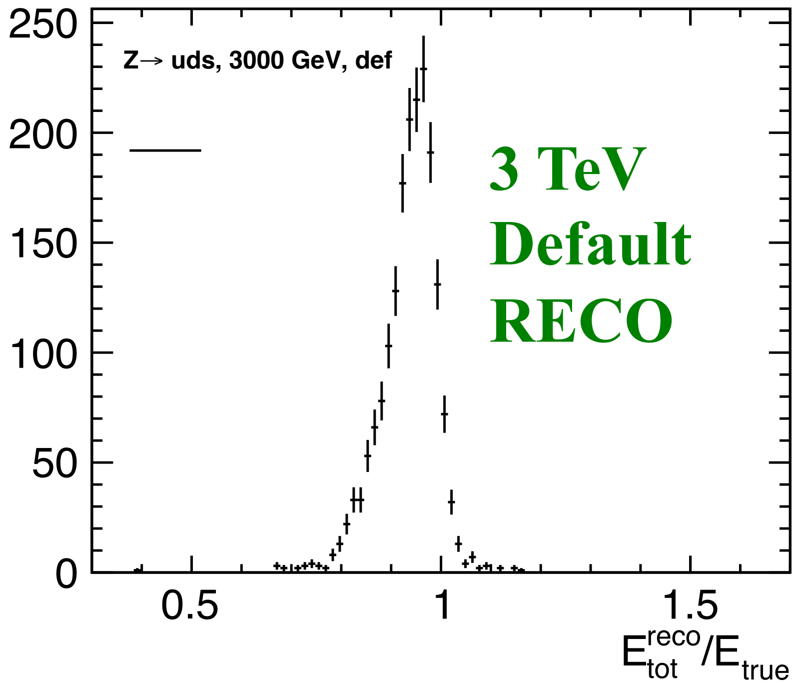


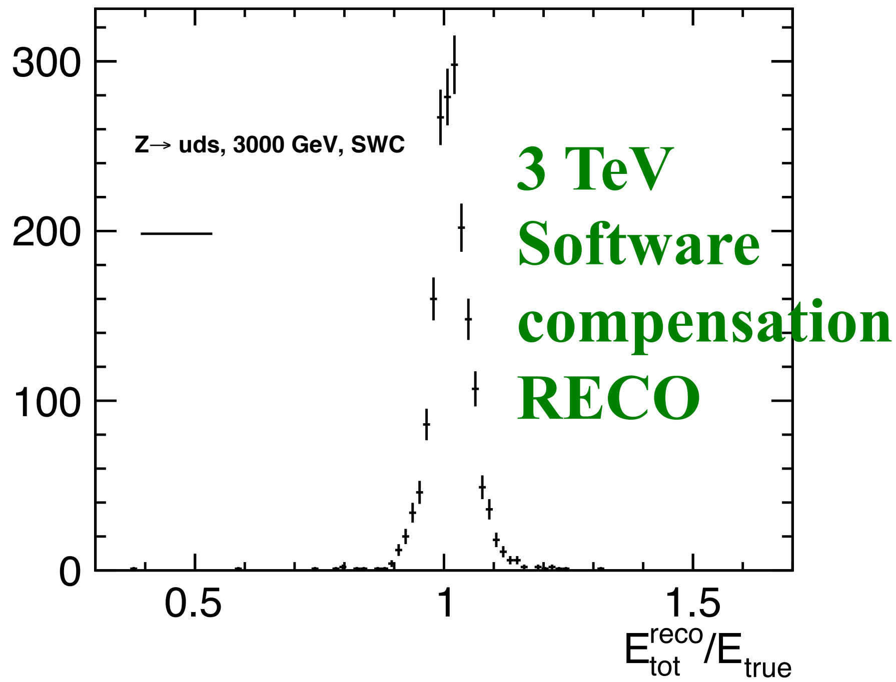
Assume perfect Photon pattern recognition, energy calibration with default settings

Improvements only for high energetic samples, thus effects shown in a reduced overview, around 0.25-0.5 % improvements could be achieved

Total energy reconstruction

Compare the reconstructed energy using the different settings





The default reconstruction has a shifted tail to lower reconstructed values (at 2 and 3 TeV significant, already starting at 1.5 TeV), mean energy 5-7 % lower

This behavior is gone with the software compensation (MHHHE removed), mean of reconstructed energy distribution within 1 % of true energy, symmetric distribution

Photon Identification tuning in PandoraPFA

For each model the photon identification is retuned

→ Use PandoraSettingsPhotonTraining configuration file, result is a likelihood file for photons

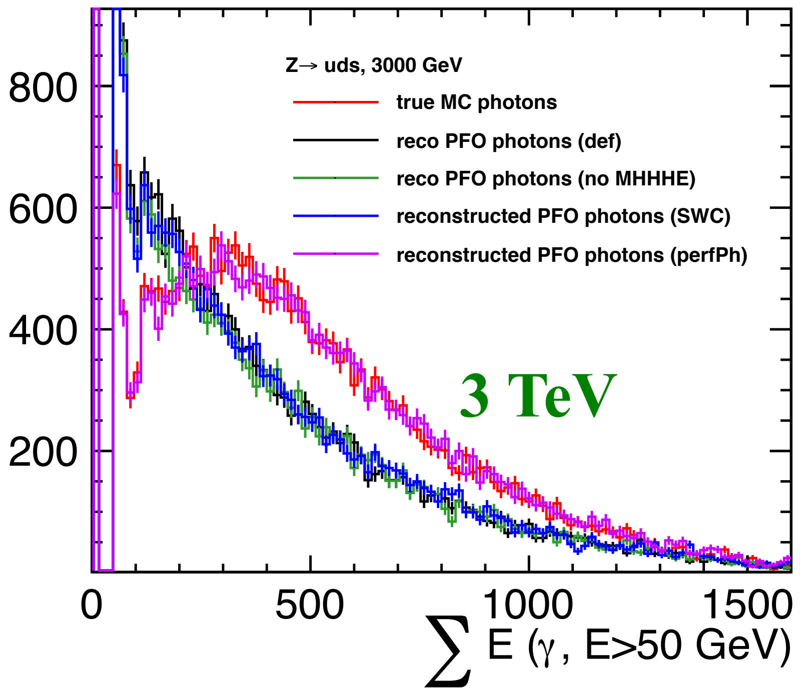
→ Binned in terms of energy (0, 0.2, 0.5, 1, 1.5, 2.0,5,10,20 GeV)

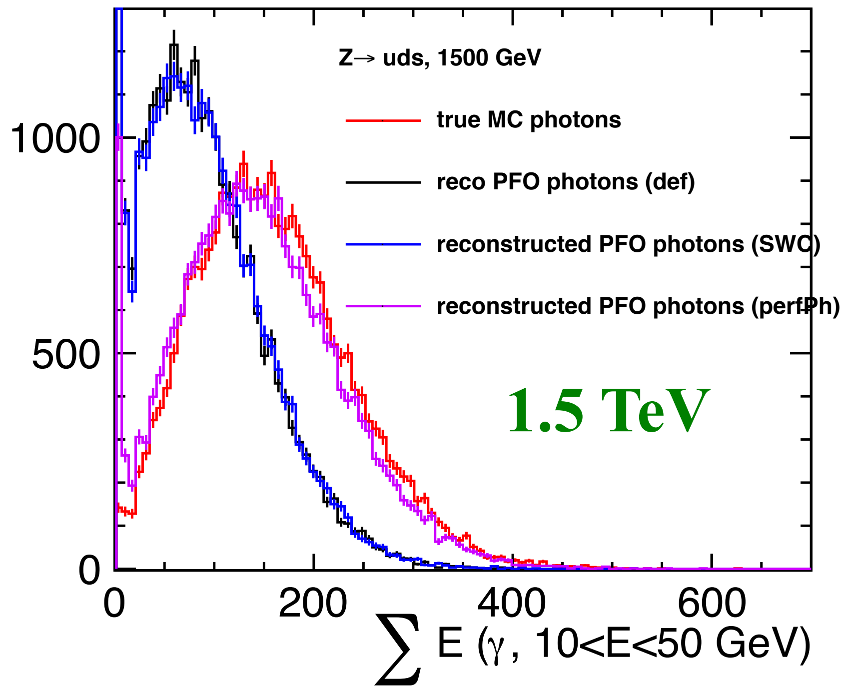
→ After photon likelihood file has been determined rerun calibration

Per default these steps are determined using Z→uds at 500 GeV. Check if running at 1500 GeV leads to any significant change (expectation is no, since highest bin of photons starts in both cases at 20 GeV)

PhotonEnergy component in jets

PandoraPerfectPhoton gives far better result of energy sum of high energetic photons

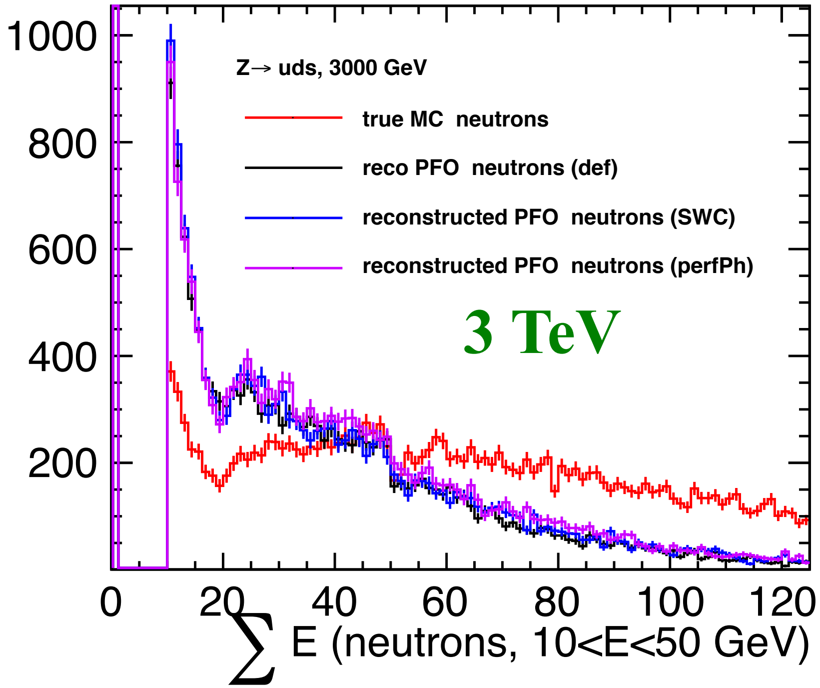


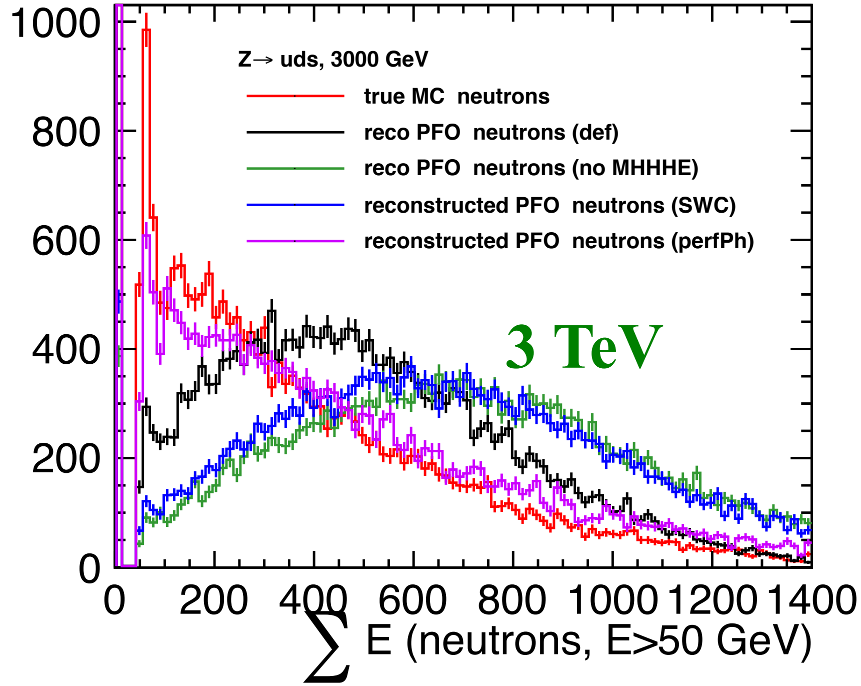


Only (cheated) perfect photon pattern recognition achieves to correctly identify the contribution of high energetic photons to the event energy
All other settings (CLIC default settings, default setting removing MHHHE cut, software compensation) shifted to lower values, but agreeing with each other

PhotonEnergy component in jets where do we lose the energy, where does it go to

Check all energy contributions comparing the perfect photon cheated identification with other reconstruction settings

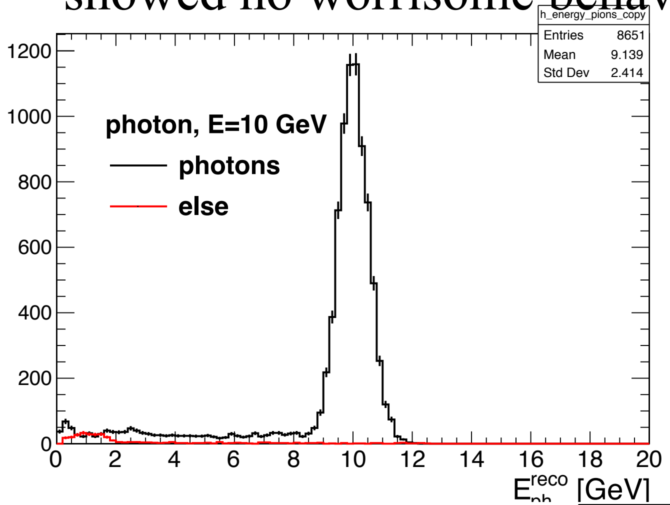


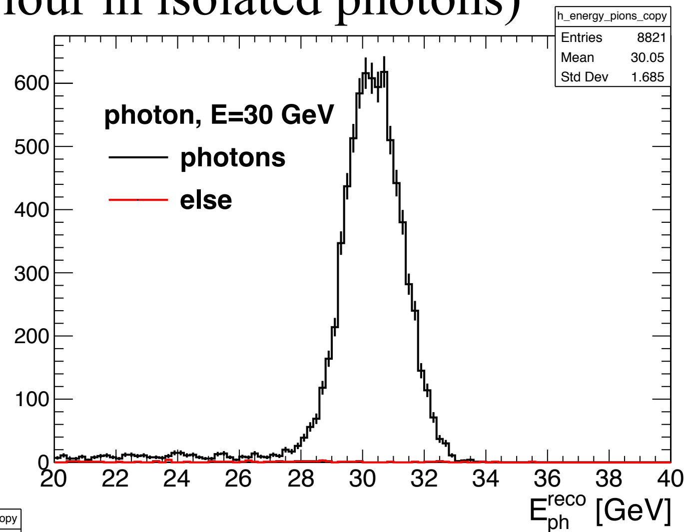


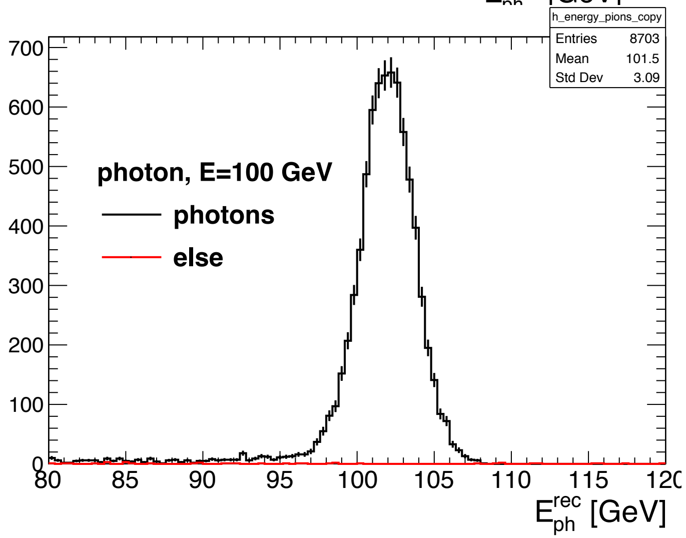
All pion distributions unchanged, same for energy contribution from low and medium energetic neutrons →contribution from high energetic neutrons overestimated by all "real" reconstruction settings, energy from default CLIC settings lower than high MHHHE and SWC settings (this is the energy we loose in the default settings)

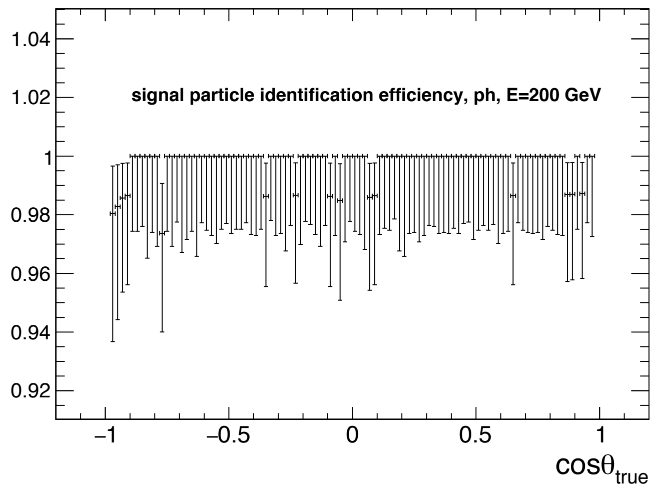
Recap: Behaviour of Isolated Photons

Check if something changed accidently for isolated photons (previous studies showed no worrisome behaviour in isolated photons)









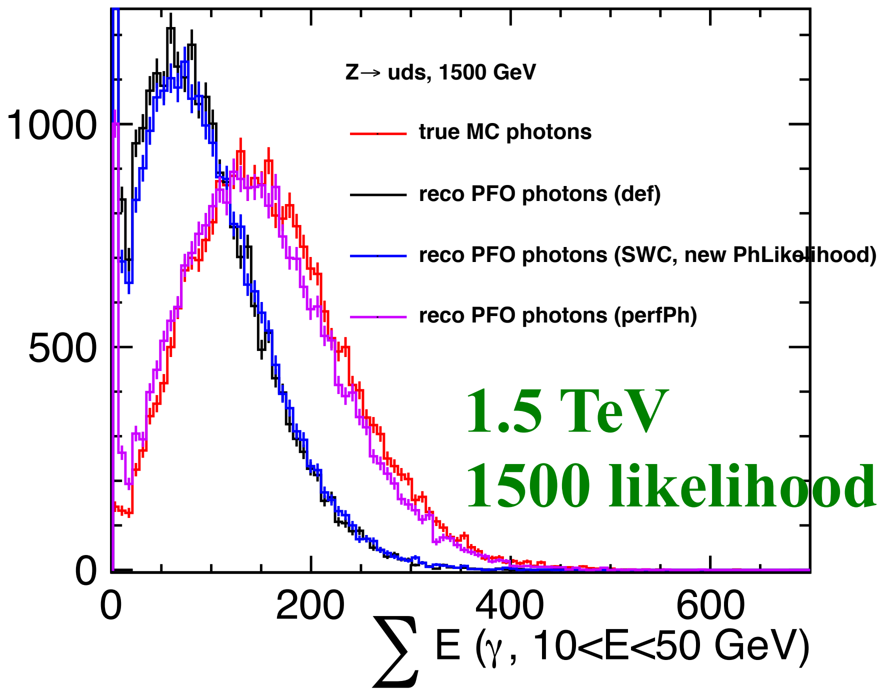
Particle gun samples: 10,30,50,100,200 GeV

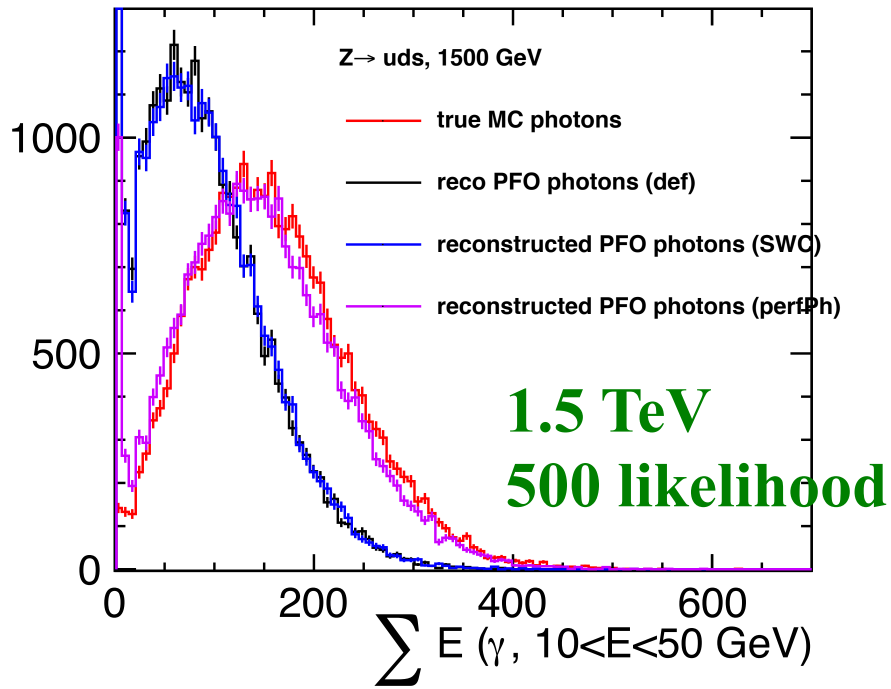
Energy of isolated photons correctly reconstructed

Identification efficiency > 98 %

Hardly any splitting or misidentification into neutrons observed

PhotonEnergy component in jets photonID from 500 GeV and 1500 GeV sample





Distributions are basically identical, nothing seems to be changed
→maybe 20 GeV lower cut not suitable for all higher energetic photons, maybe could test adding another larger bin
→check in more detail at which energy the misidentification into neutrons starts

Summary

Running with software compensation settings improves jet energy resolution at higher centre of mass energies → issue in high energy photon identification in jets, could lead to further improvement

Recover energy response deficit of 5 %, mainly a result of changed reconstruction for high energetic neutron showers

Misidentification of high energetic photons in jets as neutrons, behavior only seen in jets, not for isolated photons.

Plans

Investigate in more detail where the photon misidentification appears:

At what angles, at which energies directly, something to be learned from cluster shapes etc, check if can be solved by addition of more energy bins in photon likelihood determination

Change to conformal tracking

OVERLAY samples start to get available (central production) → repeat everything with overlay

Default software compensation weights used so far, CLIC specific weights

→ On bucket list:

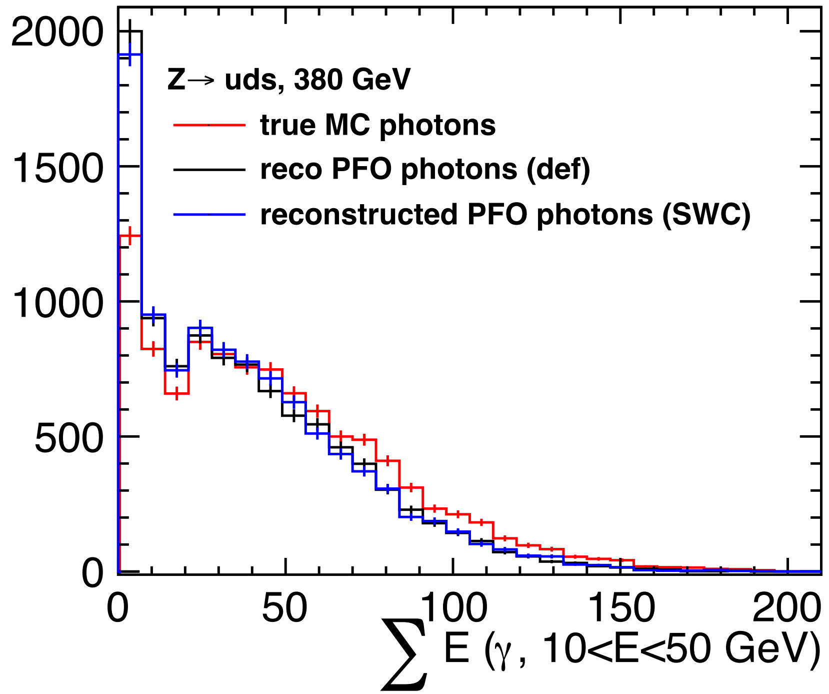
TauFinder performance

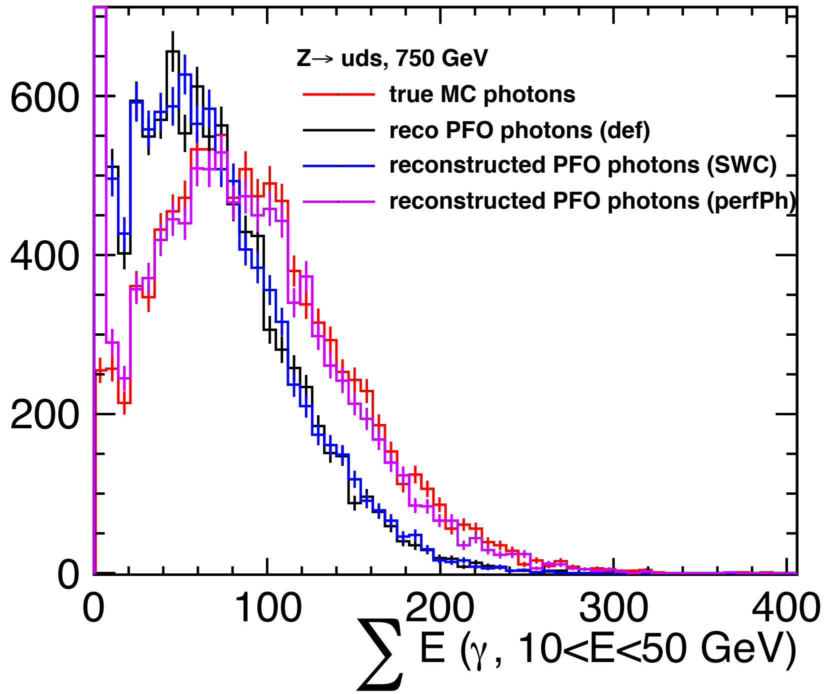
Charged particle identification in ECAL barrel-endcap transition region

Muon identification between polar angles of 88-92°

BACKUP

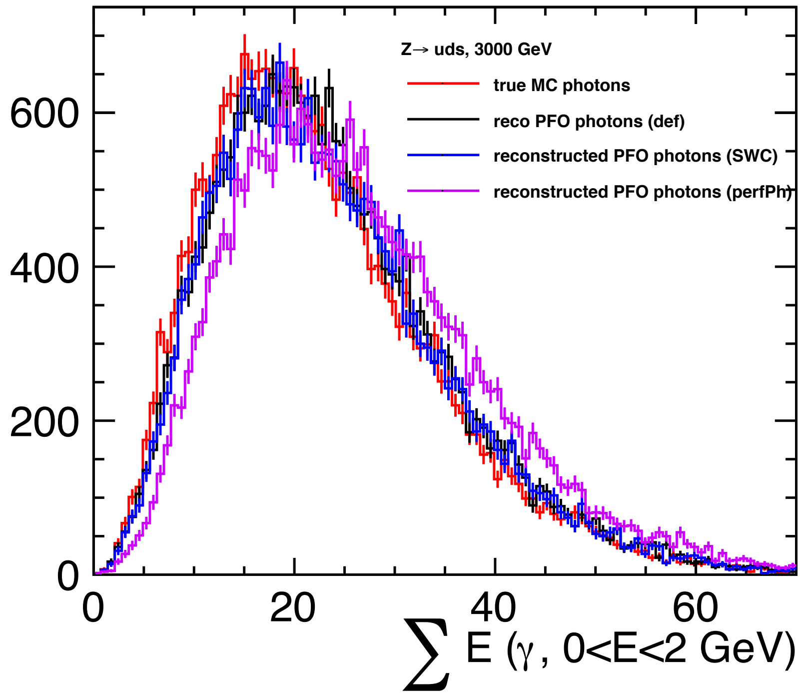
PhotonEnergy component in jets

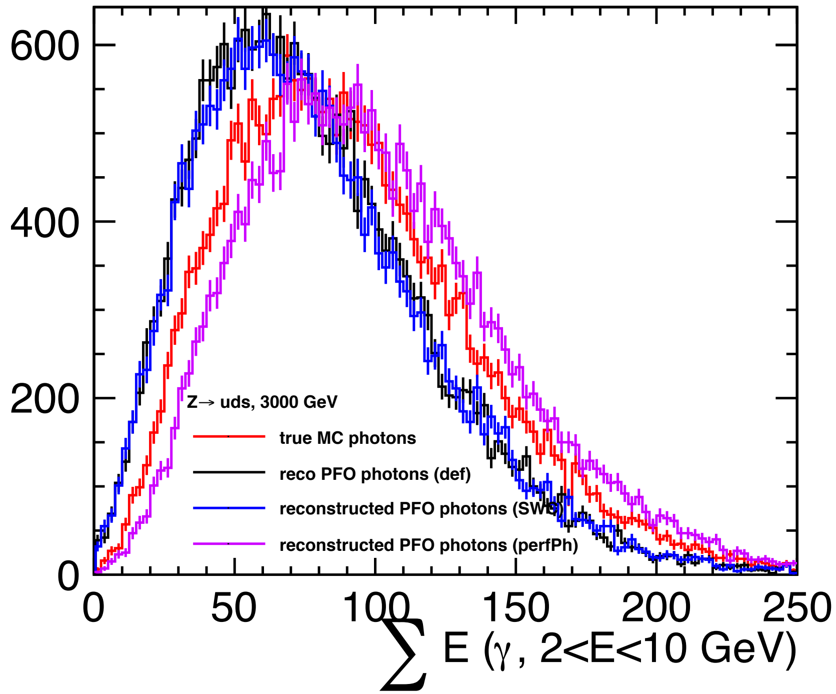




Issue in high energetic photon identification present also at lower centre of mass energies, but less of these present in the jet itself

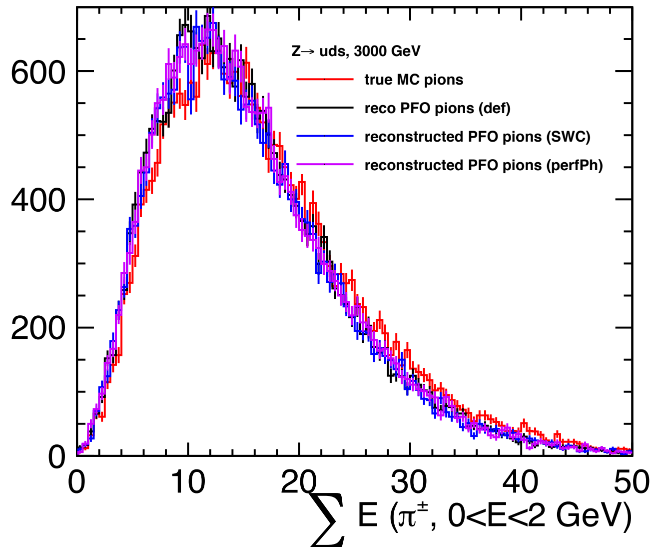
PhotonEnergy component in jets: contribution from low energetic photons

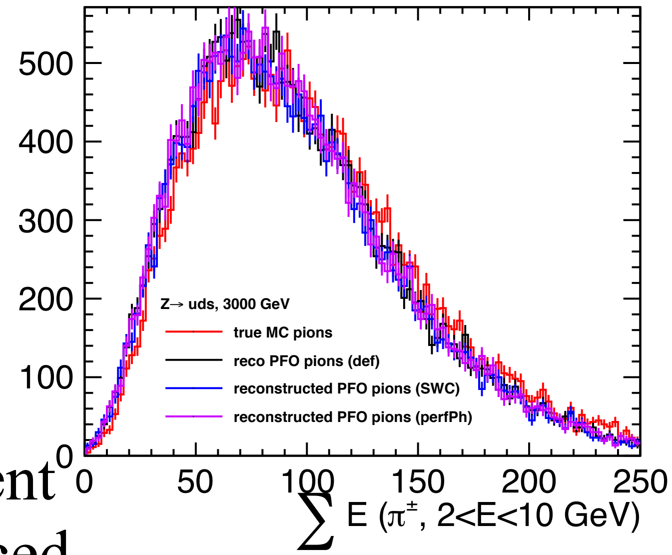




Also low energetic photons not absolutely perfect described in high energetic samples, but shift less pronounced

Pion Energy component in jets





Charged component correctly reproduced