SiW-ECAL with reduced number of layers

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With helps from Daniel Jeans & John Marshall

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Outlook

- Status @ CALICE meeting March 2012, Shinshu University
- Fixed Mokka problem for 20,26-layers SiW-ECAL
- Study of jet energy resolution using PandoraPFANew
  - Check of calibration using photons, K_L's , muons at 10 GeV
  - For Z → uds events at c.m. energies 91, 200, 360, 500 GeV
- Summary & todo list

Reminder: motivations

- SiW-ECAL is one of the major cost drivers of ILD

$$S_{\mathrm{Si}} \propto \frac{\left[\pi(R_{\mathrm{TPC}}+e)^2 - \pi R_{\mathrm{TPC}}^2\right]}{e_1} \times L_{\mathrm{Barrel}} + \frac{\pi R_{\mathrm{TPC}}^2 \times e}{e_1} = \frac{2\pi R_{\mathrm{TPC}} \times e + \pi e^2}{e_1} \times L_{\mathrm{Barrel}} + \frac{\pi R_{\mathrm{TPC}}^2 \times e}{e_1}$$

S_{si} : total Si surface
R_{TPC}: TPC radius
e_1: layer thickness
e : total thickness of all layers
L_{barrel} : Barrel length

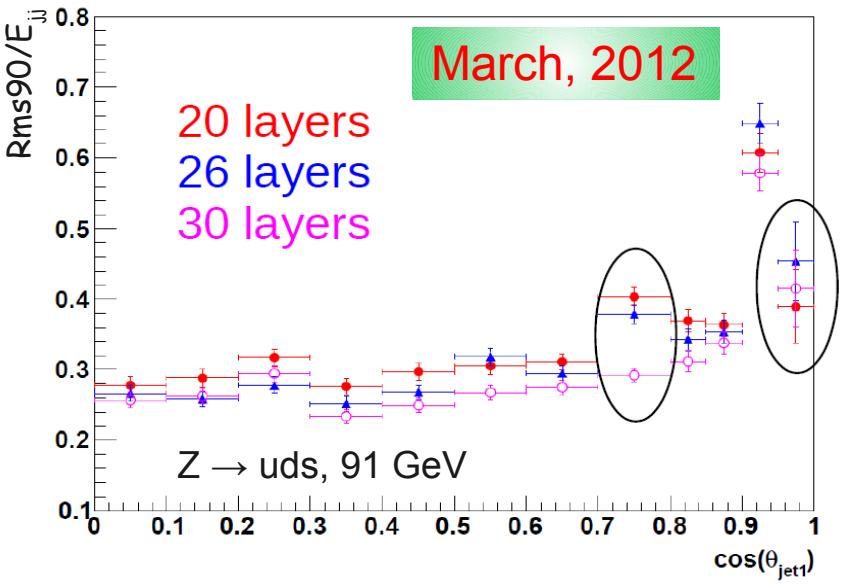
- For its cost-effectiveness, one may reduce
  - TPC radius (studied by M. Thomson @ LoI)
  - or the number of layers

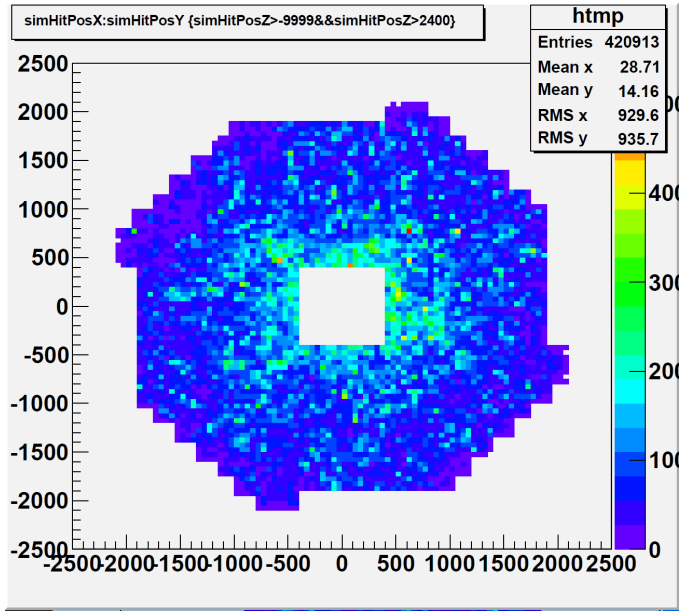
- Two alternative SiW-ECAL models (20 and 26 layers) have been studied for baseline detector ILD_00
- Other configurations are the same for three models (total W thickness, 2 stacks, 1:2 ratio of W thickness, cooling layers, carbon fibre, ...)

ECAL model	W layers	Layer thickness
30 layers	20	2.1 mm
	9	4.2 mm
26 layers	17	2.4 mm
	8	4.8 mm
20 layers	13	3.15 mm
	6	6.3 mm

Reminder: status in March 2012

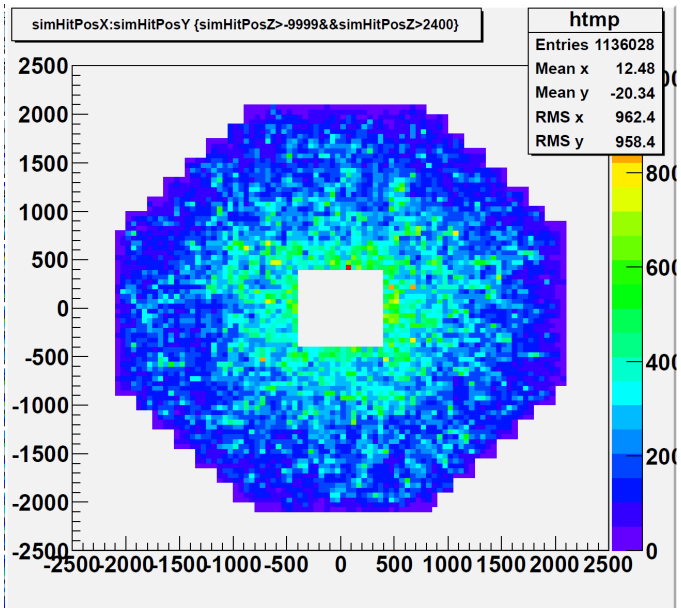
- Problem in barrel/endcap overlap region observed for 20/26 layers (***not*** for 30 layers ECAL model)
- Little feature spotted in Mokka simulation: not enough space when trying to fill an endcap tower → rejected





Hit position Y vs X in Endcap region

Patch by D. Jeans: fill up the gap by special slabs

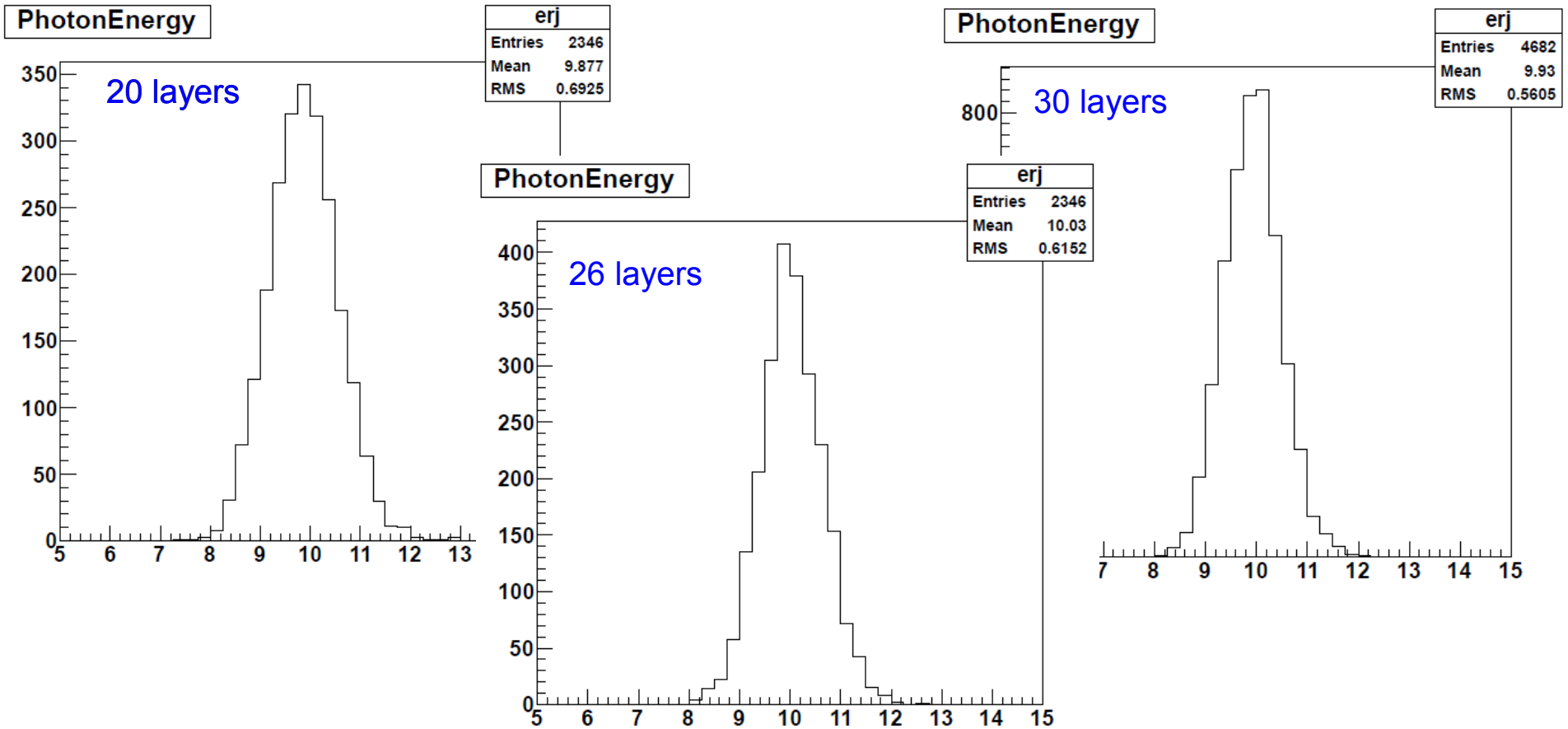


Simulations & softwares in use

- Calibration are checked using
  - 5000 photons at 10 GeV
  - 5000 K_L's at 10 GeV
  - 5000 muons at 10 GeV
    - All events are with $\cos\theta = 0.02$ and random φ values
- Jet energy resolution are estimated for
  - $Z \rightarrow$ uds events at c.m. energies 91, 200, 360, 500 GeV
  - 10k events for each energy
- The simulations are done for all three ECAL models
- PandoraPFANew in ILCSOFT version: v01-13-05.

EM calibration: photons @ 10 GeV

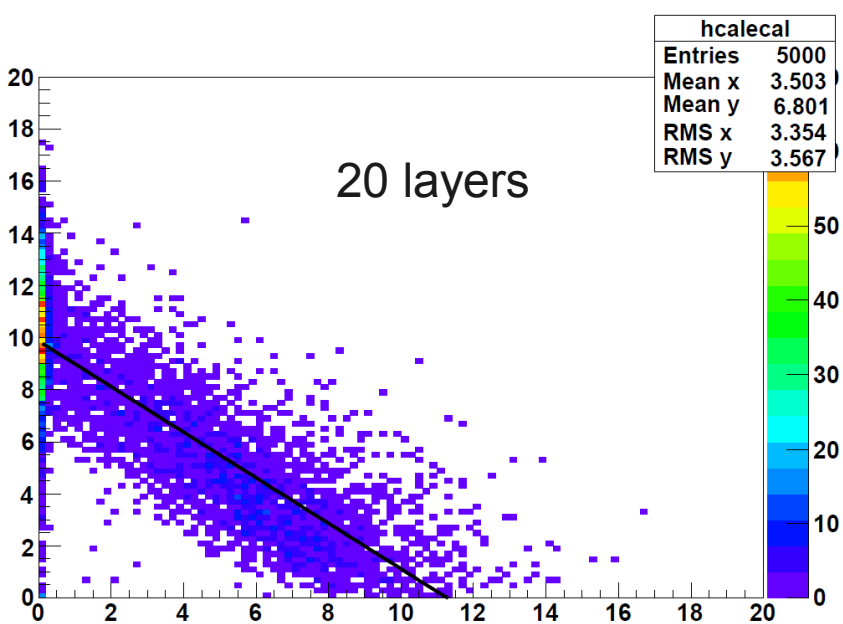
- Due to different ECAL driver compared to official study of Jet energy resolution, the Pandora calibration constants need to be re-estimated

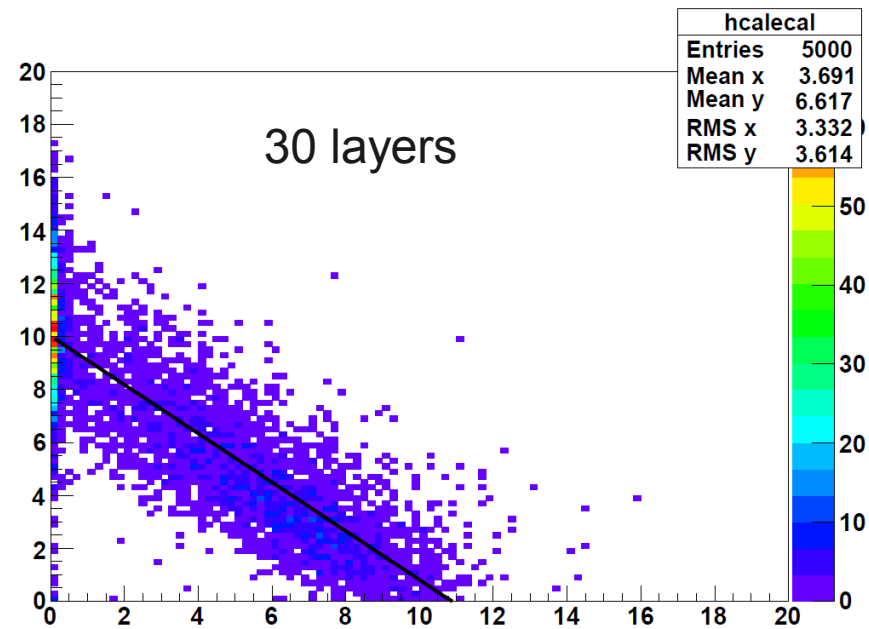


Distribution of reconstructed photon energy after correction.

Check for HCAL calibration: K_L's at 10 GeV

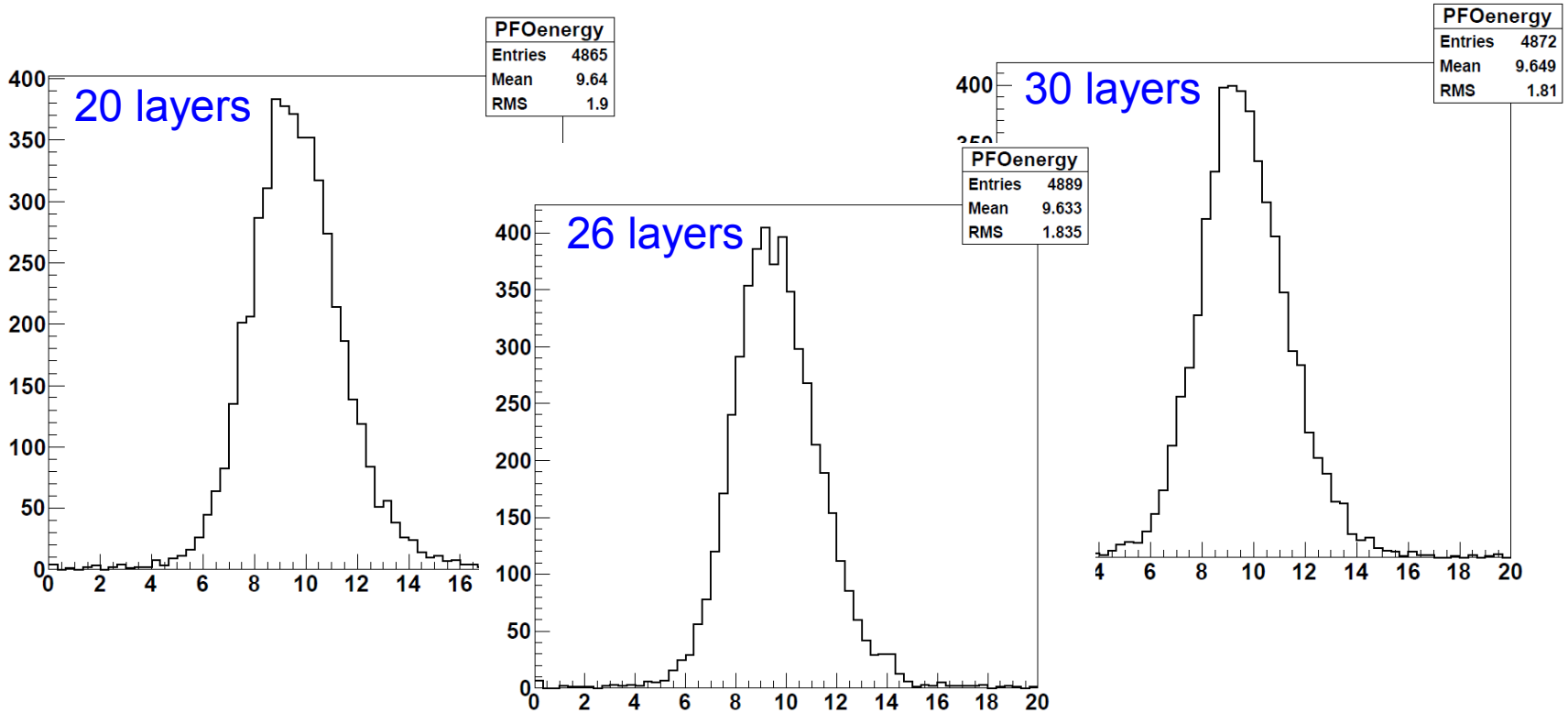
- HCAL calibration is checked using K_L events with energy 10 GeV.
- Part of constants are determined via minuit fit to the correlation between ECAL and HCAL energies (c.f. J. Marshall's talk on PandoraPFA performance, e.g. ILD workshop, May 2012)





HCAL energy vs ECAL energy
Black line shows minuit minimisation function

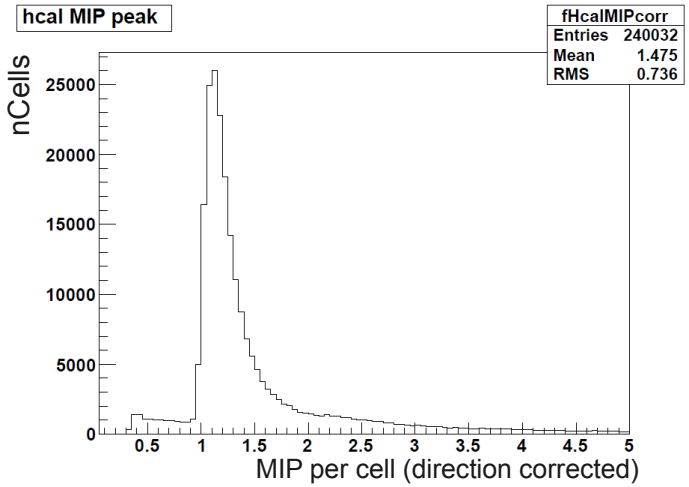
Check for HCAL calibration: K_L at 10 GeV

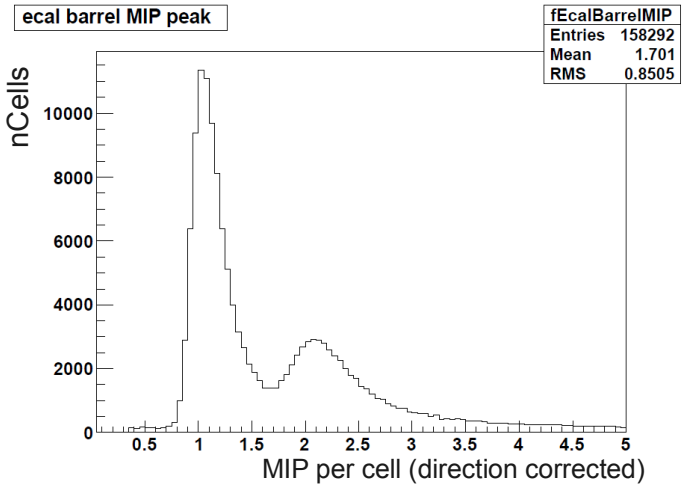


- Energy distributions of reconstructed K_L look reasonable.

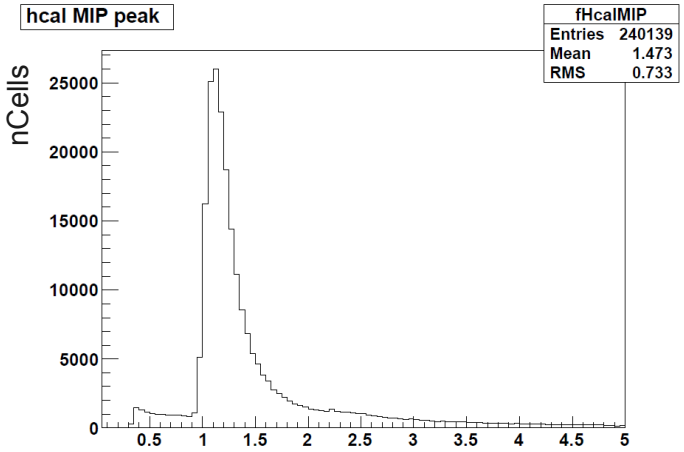
Check MIPS calibration: muon at 10 GeV

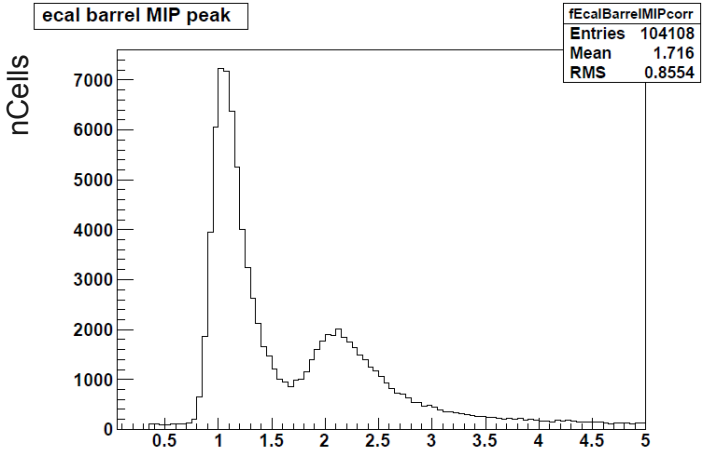
- MIP calibration looks not too bad and similar for 30 and 20 layers.





30 layers

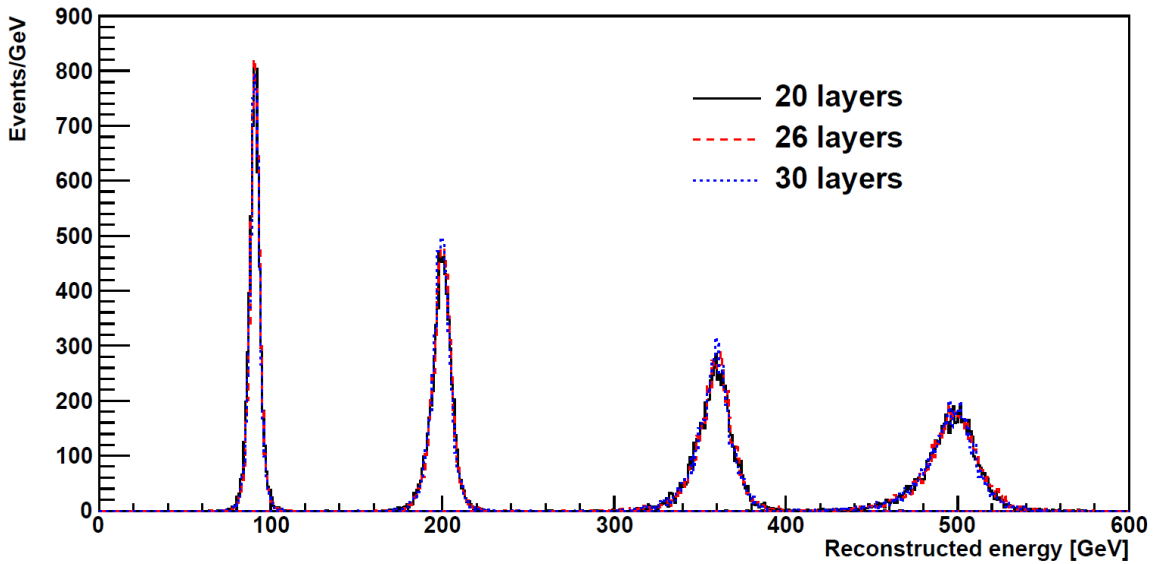




20 layers

Jet energy resolution study for ECAL performance using Z → qqbar events with Z decaying at rest (Z → uds)

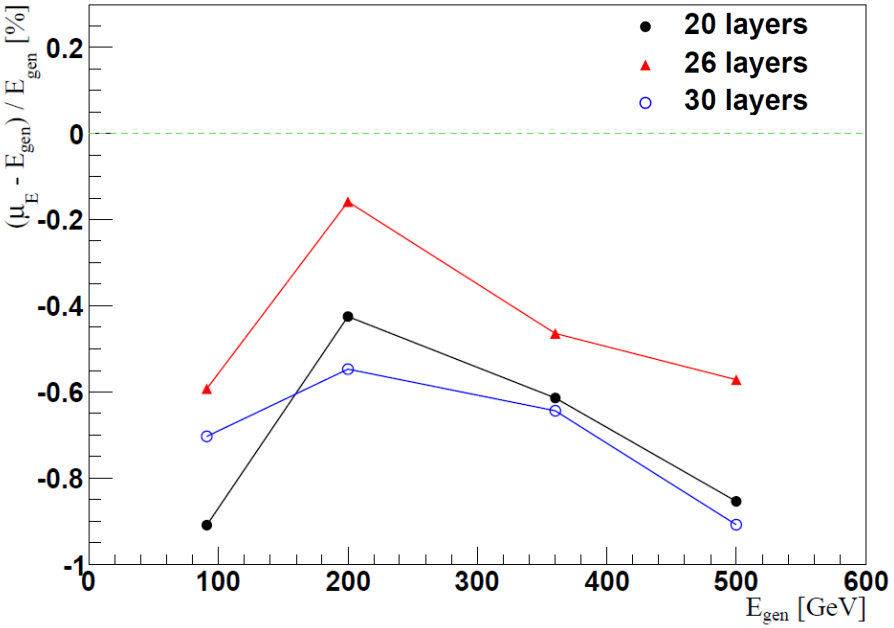
Z → uds events: linearity



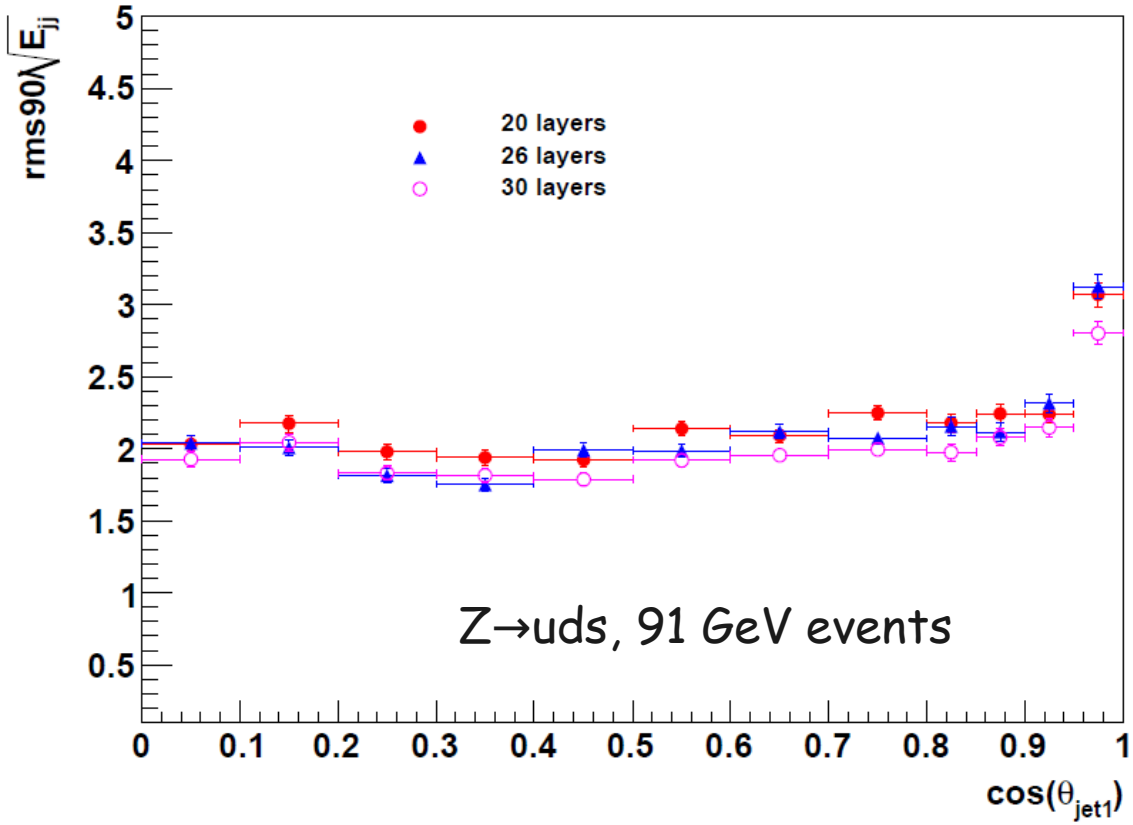
- Distributions of reconstructed total jet energy for 20, 26 and 30 layers and for events at c.m. energies 91, 200, 360, 500 GeV are shown.
- Reasonable mean values obtained.

- Residual value $(\mu_E - E_{gen})/E_{gen}$ shown in% as a function of E_{gen}

  where μ_E is the central value of the distribution and E_{gen} the generated jet energy
- Linearity within 2 – 9 ‰



Jet energy resolution vs cos(θ_jet)

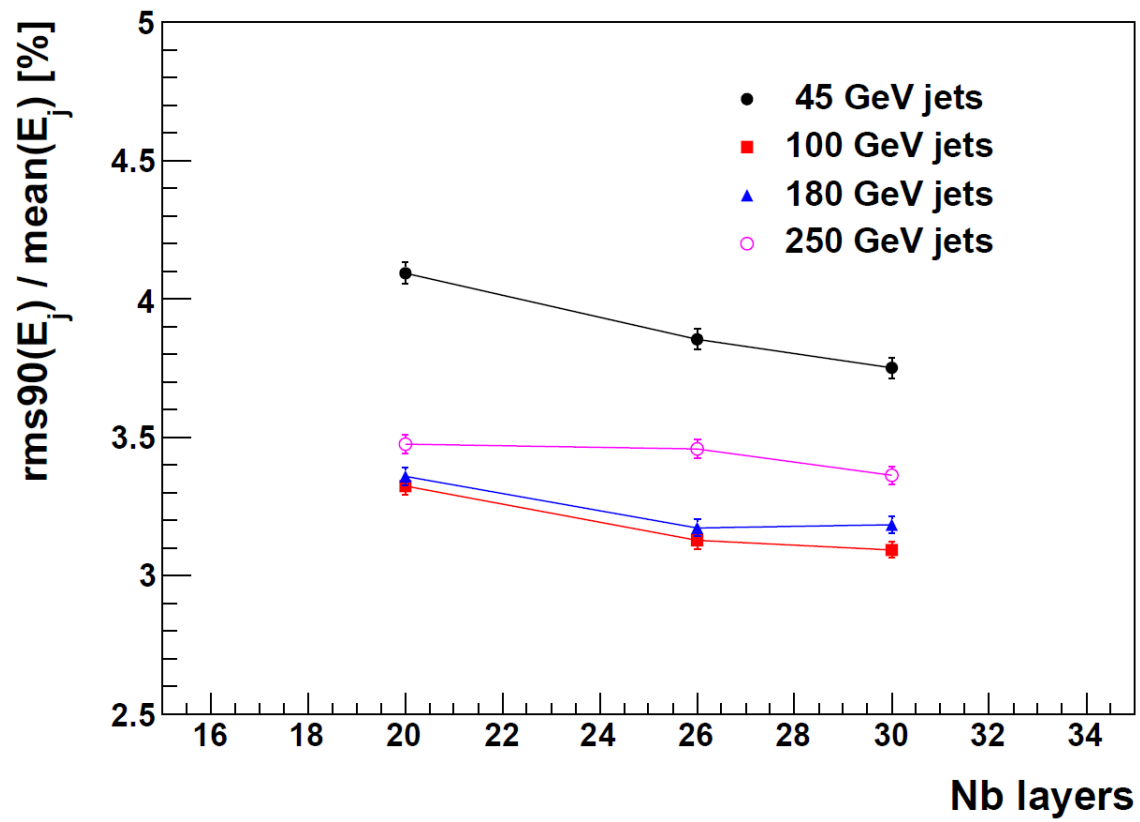


- Jet energy resolution presented in function of cos(θ) of first jet
- Problem at barrel/endcap overlap region fixed
- Example for Z→uds 91 GeV sample

Jet energy resolution

- JER is transformed to single JER and plotted as a function of number of layers for 91, 200, 360, 500 GeV Z → u/d/s.
- JER for 30 layer model consistent with "official" analysis (3.75 vs 3.69 for uds 91 GeV events, J. Marshall), slight difference may due to different ECAL drivers (Mokka) and different calibration constants.

Single JER presented in function of Nb of layers.
A cut |cos(theta_jet)| < 0.7 is applied to avoid the Barrel/Endcap overlap area



10% of degradation is observed going from 30 to 20 layers for 91 GeV sample
3 – 7 % for other energies

Summary

- Results for 30 layers ECAL consistent with official ones (slight difference due to different ECAL drivers)
- Degradation of 10% in single JER observed for 45 GeV jets going from 30 to 20 layers
- From 3% to 7% for other energies

To do:

- Tune Pandora calibration constants for a more precise JER estimation
- Repeat with ILD_o1_v05 (…) in latest ILCSOFT version
- Consider keeping same total Si thickness for 20 and 26 layer models as for 30 layers.