HCAL Optimization Studies

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Overview

Introduction

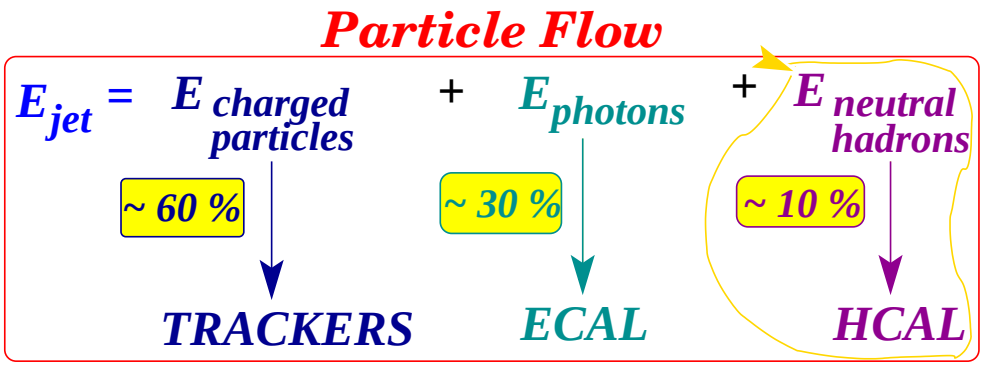
- **Idea**: optimize HCAL properties based on jet energy resolution obtained with **PFA algorithm** (Mark Thomson)
- A lot of studies done with **LDCPrime_02Sc**
  - absorber material - Fe, Pb, Ms
  - scintillator and absorber thickness
  - HCAL depth (Mark Thomson)
  - effect of dead zones...

E_{jet}	Jet Energy Resolution	
	LDC' (LCPhys)	ILD (LHEP)
45.5 GeV	3.9 %	3.7 %
100 GeV	3.2 %	3.1 %
180 GeV	3.4 %	3.3 %
250 GeV	3.8 %	3.5 %

- This talk:
  ILD model: **ILD_00**
  Mokka version: **mokka-v06-07**
  ILC software version: **v01-05**

A very nice 3D view of our favourite detector, in the ILD model, by Paulo Mora

PFA Algorithm



- Disclaimer: presented results are not a direct measurement of HCAL performance

RMS_{90}

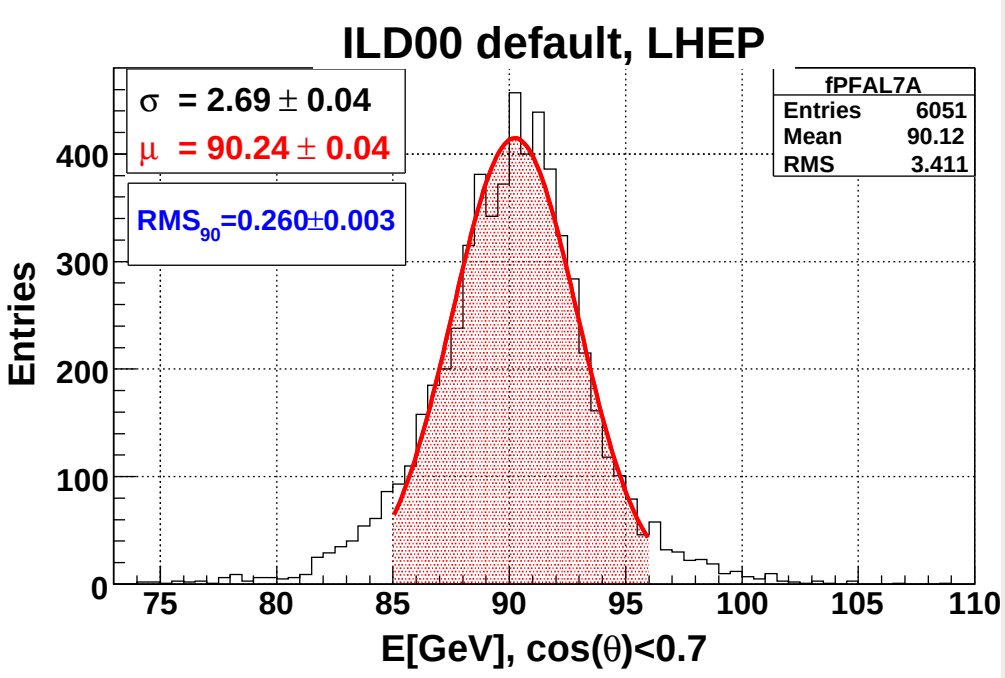
- Jet energy resolution:

$$RMS_{90} = \left(\frac{\sigma_E}{E}\right)_{90\%} \cdot \sqrt{E_{jet}/\mathrm{GeV}}$$

i.e. the smallest region containing 90% of the events

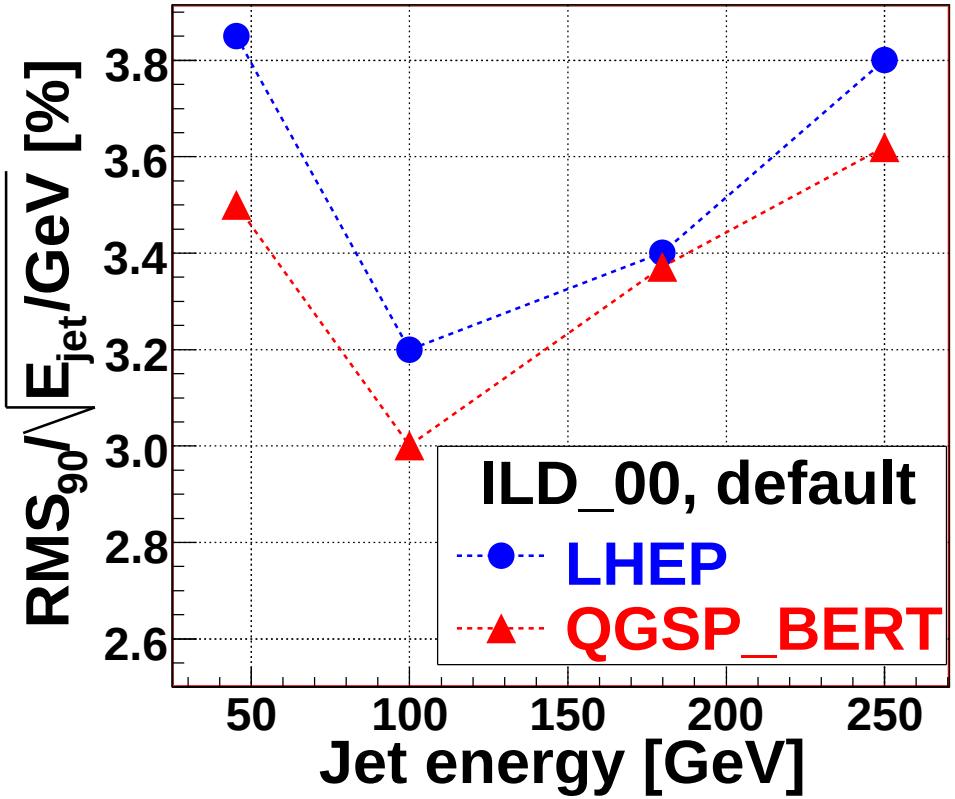
- Example: $Z \to u\bar{u},\ d\bar{d}, s\bar{s}$ at $\sqrt{s} = 91$ GeV, default configuration of ILD_00 model

Example



Physics Lists

- Two 'extreme' Monte Carlo models (i.e. physics lists), as in test beam analysis: LHEP vs QGSP_BERT (high neutron component)

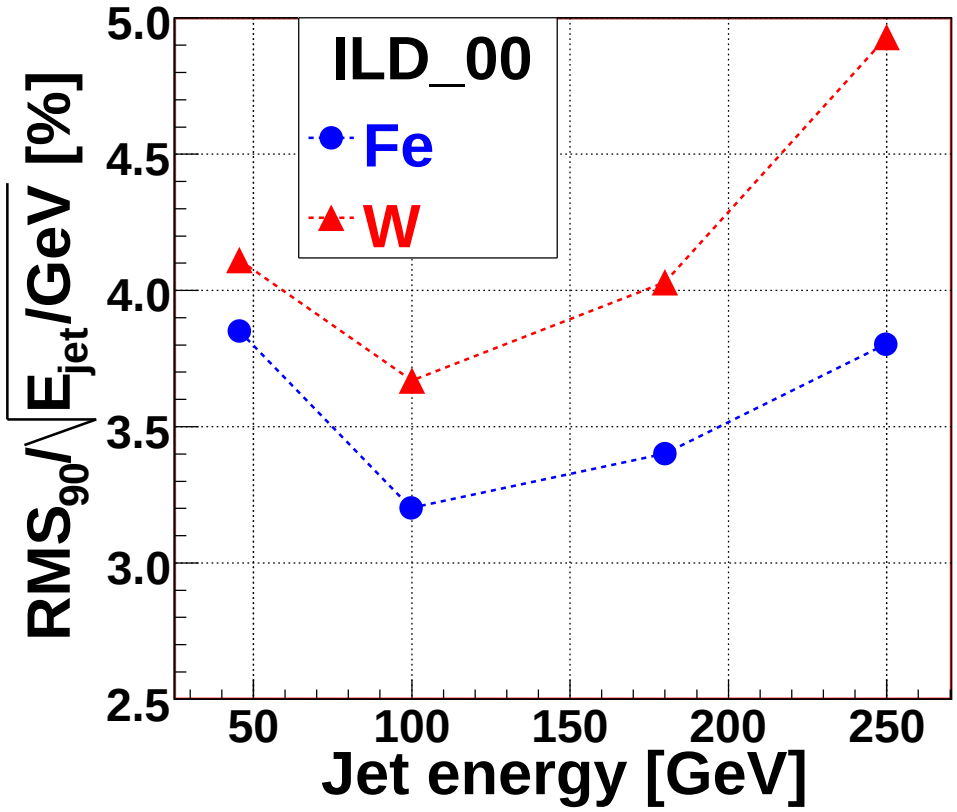


$\Longrightarrow$ Better jet energy resolution for QGSP_BERT (the same was observed in the test beam data)

Absorber Material: Fe vs. W

- Material properties, as used in Mokka simulation

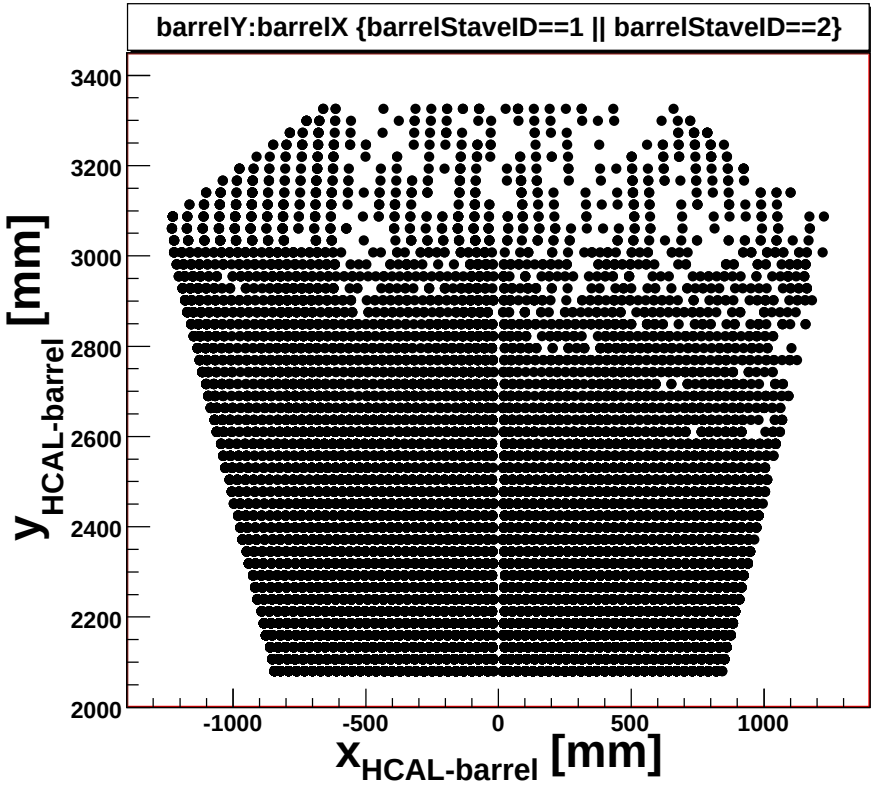
Material	Nuclear interaction length λ [cm]	Density $[\mathrm{g/cm^3}]$	Moliere radius [cm]	Radiation length X_0 [cm]	$\lambda/\mathbf{X_0}$
Fe	16.98	7.87	1.66	1.77	9.59
W	10.31	19.3	0.92	0.35	29.46

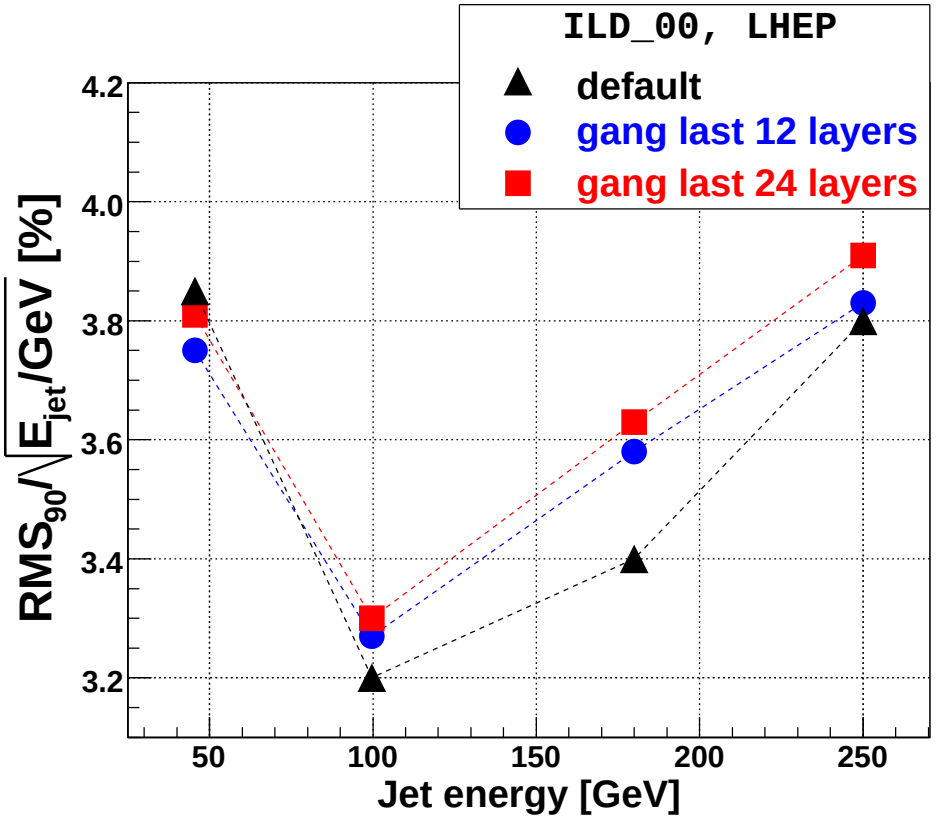


- Point at 250 GeV jets for W still to be confirmed
- Energy resolution worse for W

HCAL Granularity

- *"Gang"* = group $3 \times 3\ \mathrm{cm}^2$ cells in the last 12 (24) layers

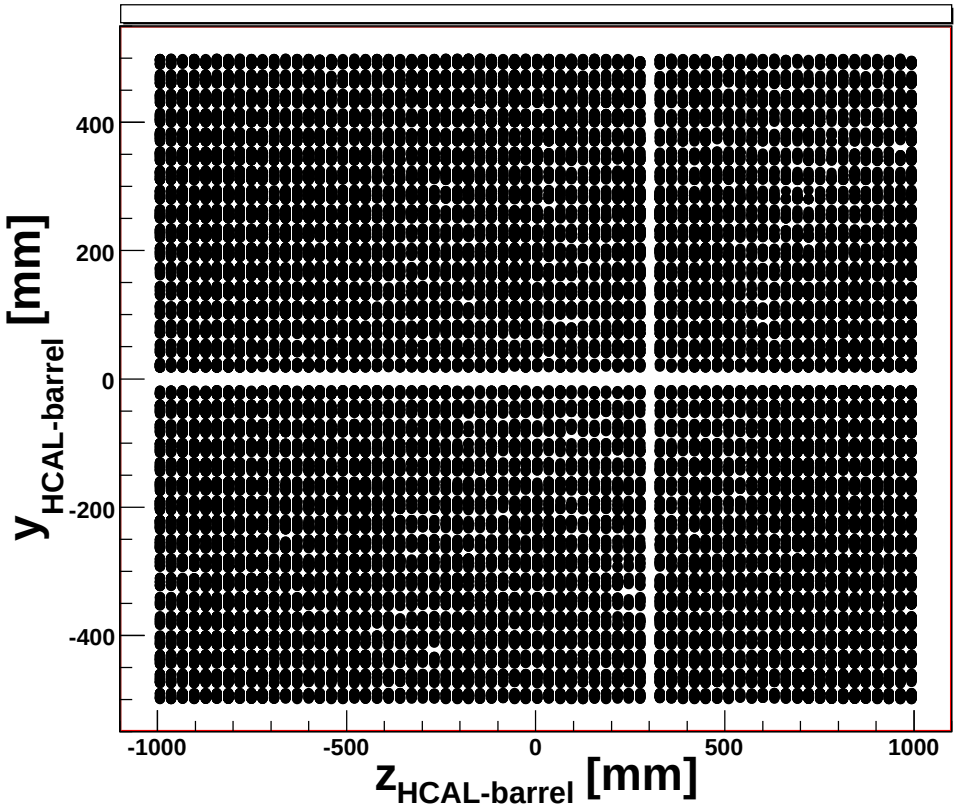


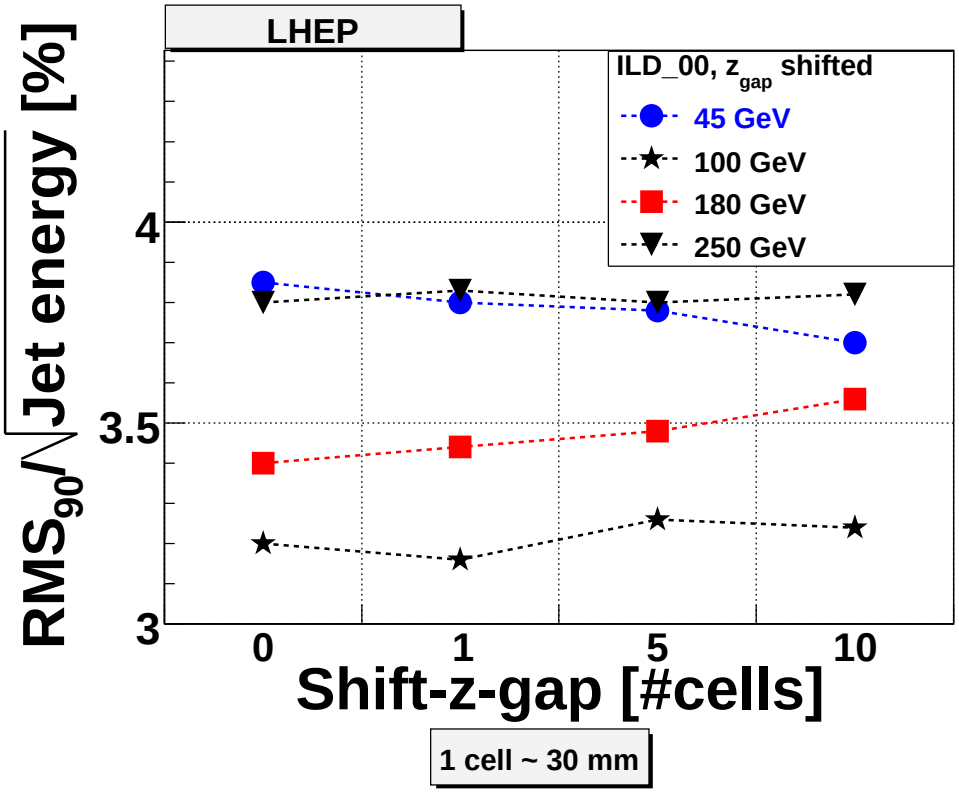


$\Longrightarrow$ Moderate ($\approx$ 0.2%) decrease in jet energy resolution

z Gaps

- **Default**: 2 mm gap at $z = 0$.
- Studies: z gap shifted with 1, 5 and 10 $\times$ *tile_dimension_z* to $+z \Rightarrow$ asymmetric modules





$\Longrightarrow$ The z-gap has no significant impact on jet energy resolution

Conclusions and Overview

Conclusions

- Updates of HCAL optimization studies with the ILD model presented
- Little sensitivity of PFA algorithm to changes of HCAL properties

Overview

- Single particle resolution (more direct way to look at the HCAL)
- Effect of Birks law for QGSP_BERT case
- Time cut (influence of late coming hits)