MC Studies of a Tungsten HCAL

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Overview

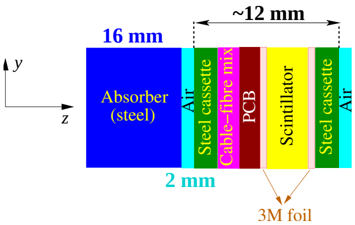
1. Test beam results
2. Particle flow results (ILD)

Introduction

- Idea: look how the hadronic shower develops in a tungsten-scintillator calorimeter (instead of iron)
- Properties:

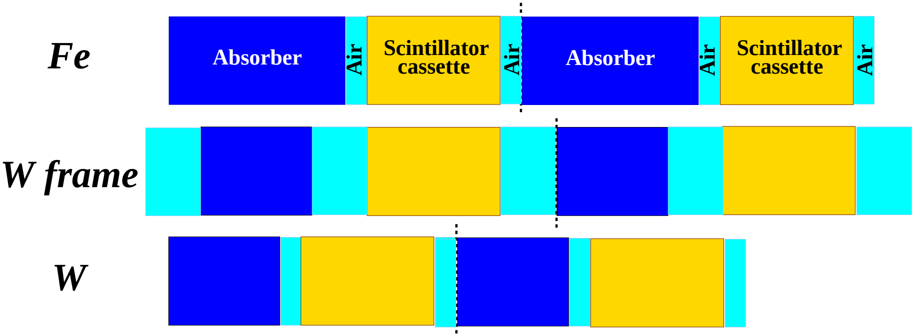
Material	Fe	W
λ_I [cm]	16.77	9.95
X_0 [cm]	1.76	0.35
dE/dx [MeV/cm]	11.4	22.1
R_M [cm]	1.72	0.93

- Method: use Mokka (GEANT4) to generate 18 GeV π^- events in different configurations
- Default HCAL configuration: 38 layers, with **16 mm Fe absorber + 5 mm scintillator**, plus a terminating absorber plate
- In total 5 λ_I's
- Layer structure:



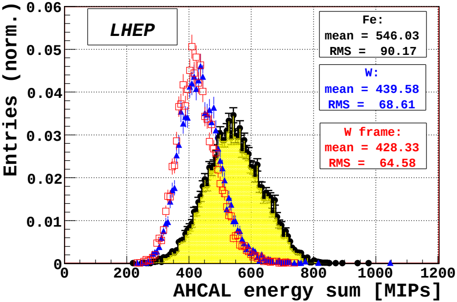
Absorber Configurations

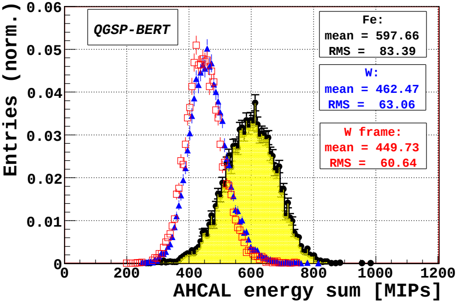
- **W frame**: **10 mm W** absorber plates, 5 mm air
- **W**: 10 mm W, 2 mm air
- Both cases: 5 λ_I's



Results

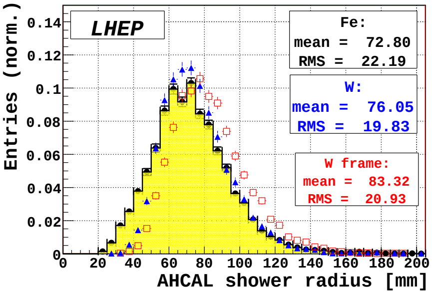
- 18 GeV π^-
- 2 hadronic models: LHEP and QGSP_BERT (more neutrons)
- **Energy sum**:

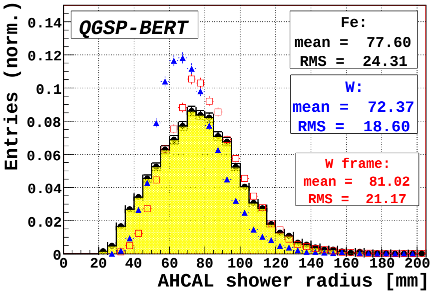




$\Rightarrow\sim$ 25% (30%) more energy deposited in case of Fe for LHEP (QGSP-BERT) than in W (more X_0's in a W-layer)

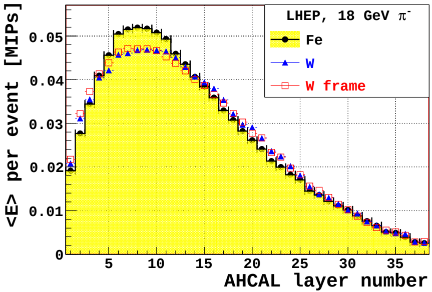
Results: Shower Radius



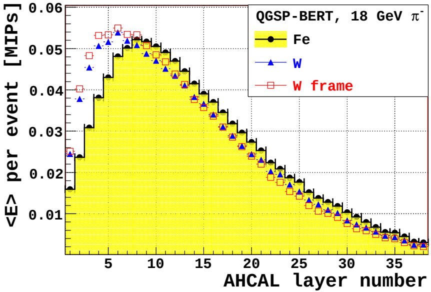


- LHEP vs QGSP-BERT:
  - Fe: larger shower radius due to late neutrons
  - W: smaller radius
- W vs W-frame: larger radius in the latter case

Results: Longitudinal Profiles

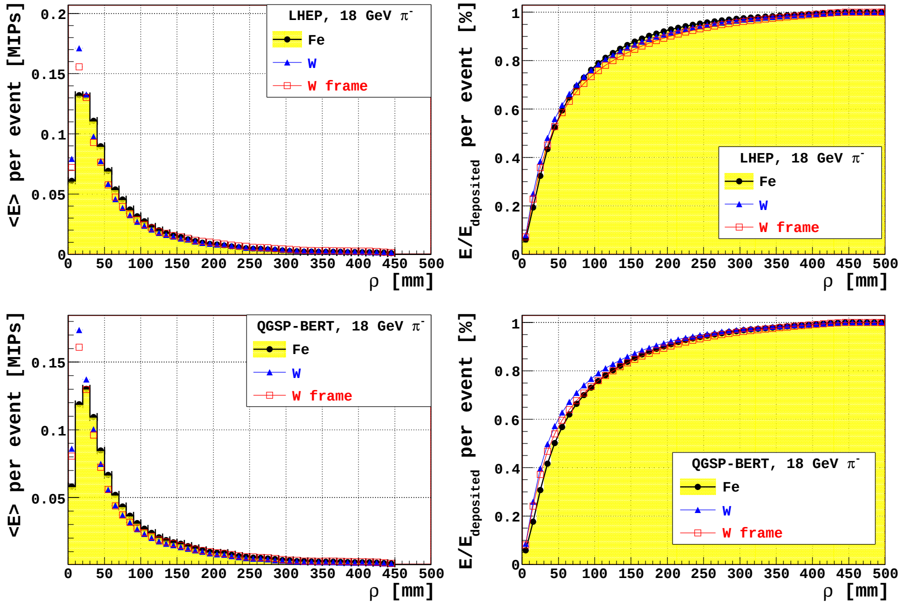


- A little bit faster showering for the W case (higher Z, smaller X_0/λ_I than in Fe)

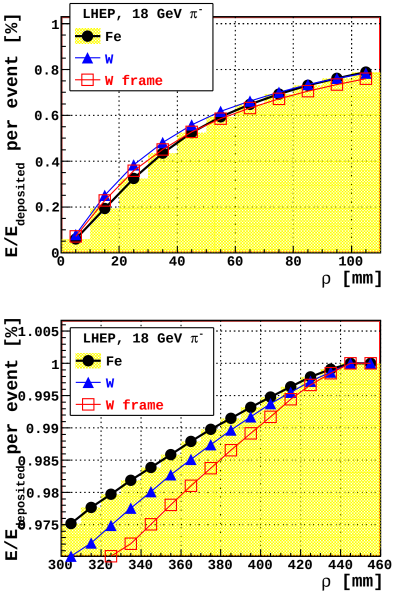


- Stronger effect due to more neutrons

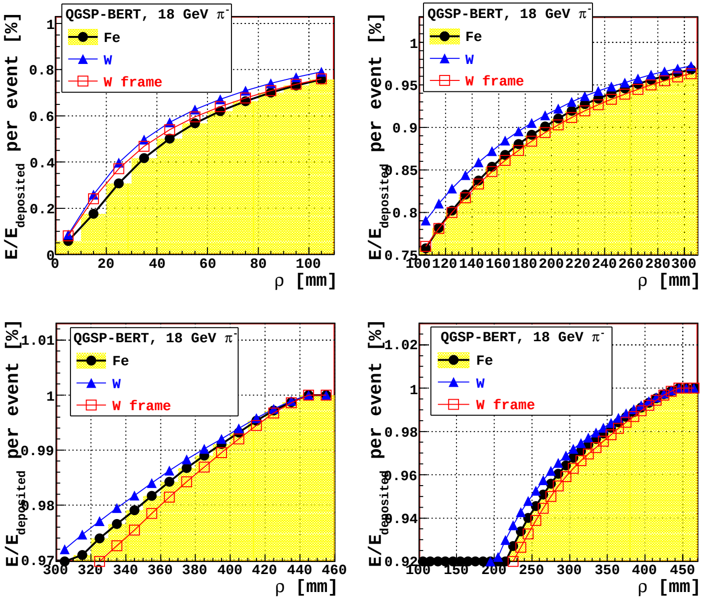
Results: Lateral Containment



Results: Lateral Containment - zoom LHEP



Results: Lateral Containment - zoom QGSP-BERT



Results: Lateral Containment - continued

- Shower radius for 95% radial containment:

	$R_{95\%}$ [cm]	
	LHEP	QGSP-BERT
Fe	24	26.5
W	26	25
W frame	27.5	27

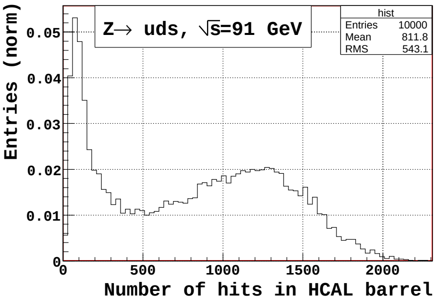
- Fe: neutrons induce larger $R_{95\%}$
- W: smaller $R_{95\%}$

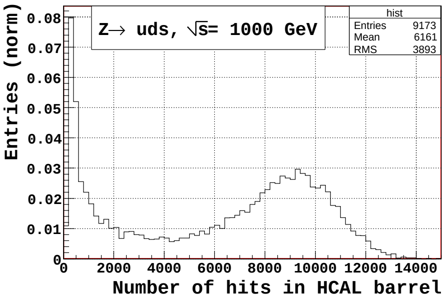
Conclusions

- Hadron shower development in the HCAL with tungsten absorber studied, and compared to the Fe (default) case, with approximately 1 λ_I per layer
- In general, showers in W are more compact, and start earlier than in Fe
- W probably preferable to W-frame case (more compact)

Particle Flow Results: Introduction

- $Z \to uds$ sample, at $\sqrt{s} = 1000$ GeV
- Generated 10000 events for each detector configuration $\Rightarrow$ large production effort (jobs of 10 events need approximately 1 hour...)

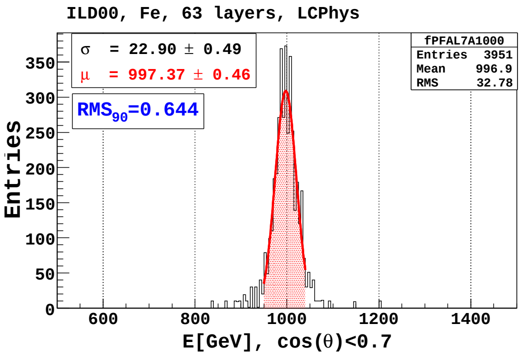




Particle Flow Results

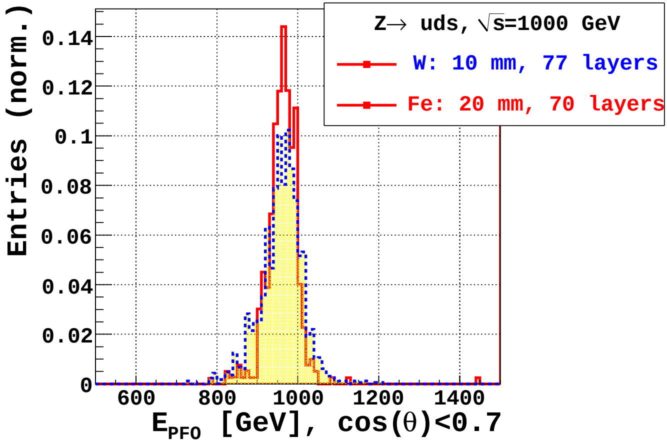
- CLIC group at CERN uses **10 mm W** and the inner coil radius of the CMS
  $\rightarrow$ this allows: **(10 mm W + 5 mm scintillator) $\times$ 77 layers $\approx$ 8.4 λ_I**
  and for comparison:
  (20 mm Fe + 5 mm scintillator) $\times$ 70 layers $\approx$ 8.9 λ_I

- Use these configurations and run Particle Flow Algorithm (Mark Thomson)
- No tuning of the algorithm for high energy
- Example for 8 λ_I HCAL, Fe absorber, $B = 5.0$ Tesla:
  $\sigma_E / E \approx 64\% / \sqrt{E / GeV}$
- Results consistent with the ones from Mark



Particle Flow Results: Energy Resolution

- **Fe**: $\sigma_E / E \approx 81\% / \sqrt{E/GeV}$
- **W**: $\sigma_E / E \approx 121\% / \sqrt{E/GeV}$

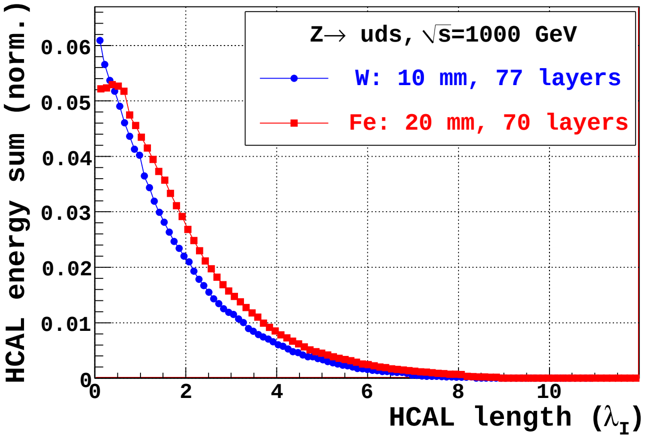


Particle Flow Results: Energy Resolution

- Stupid mistake in the Mokka steering file!
  - WRONG: */Mokka/init/globalModelParameter Hcal radiator thickness* 10
  - RIGHT: */Mokka/init/globalModelParameter Hcal_radiator_thickness* 10
- That means: **20 mm W** instead of 10 mm...
- After one night of resubmitting jobs, half of files ready:
  10 mm W $\times$ **77 layers**: $\sigma_E/E \approx 77\%/\sqrt{E/GeV}$

ILD: Longitudinal Profile

- No HCAL containment selection done



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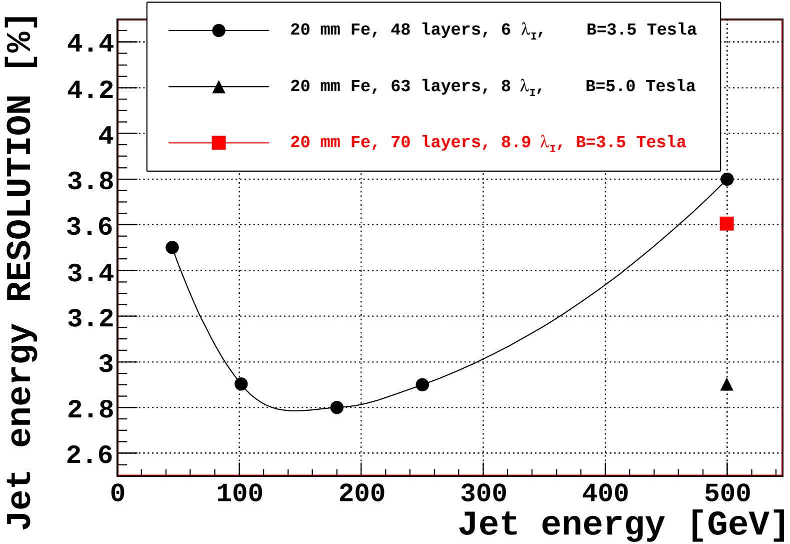

Conclusions

- $Z \rightarrow uds$ at $\sqrt{s} = 1000$ GeV generated for a large AHCAL ($> 8\ \lambda_I$) with W and Fe absorber
- First look into events at this high energy with Particle Flow Algorithm

Overview

- Analysis of sampling effects
- Possible study of composite (W + Fe) structure

Thank you for your attention