Update on IDEA simulation

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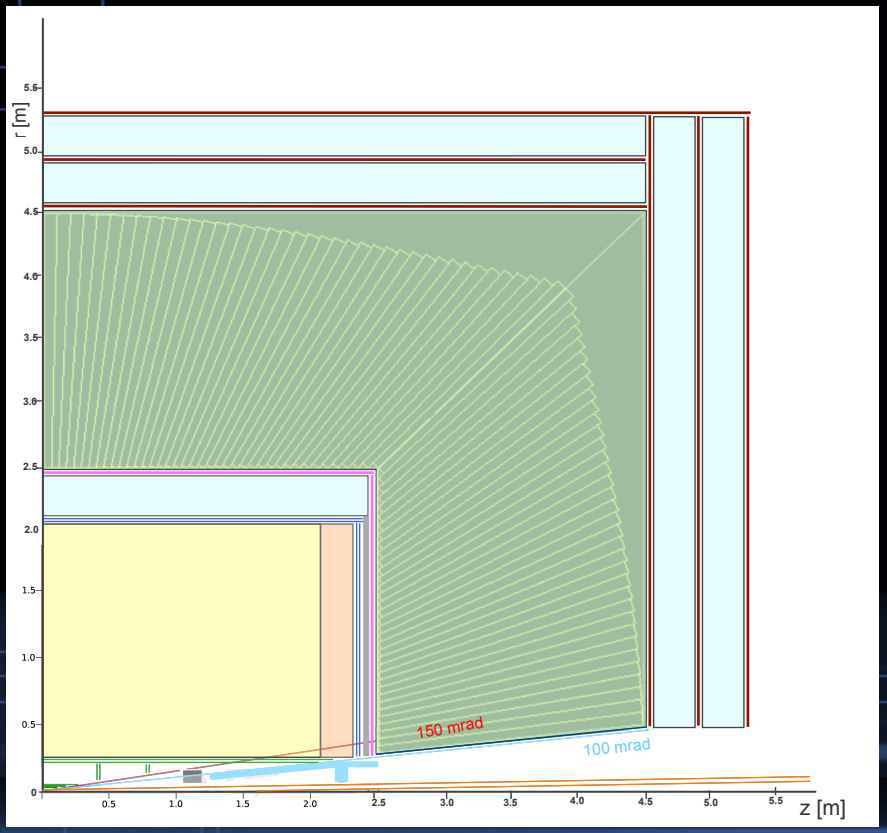
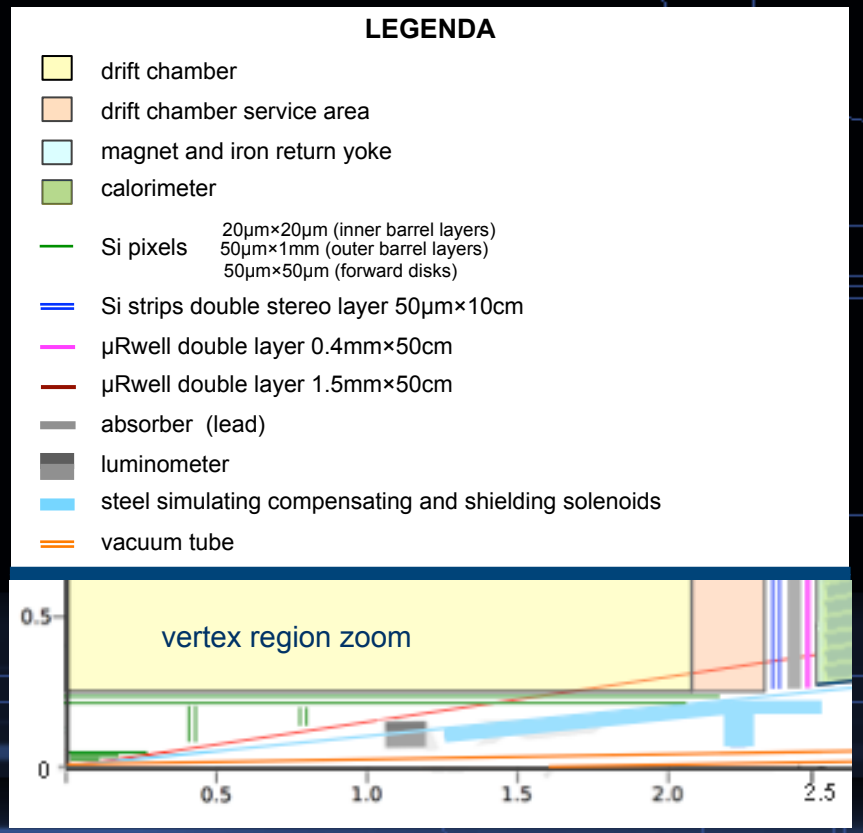
Baseline IDEA layout

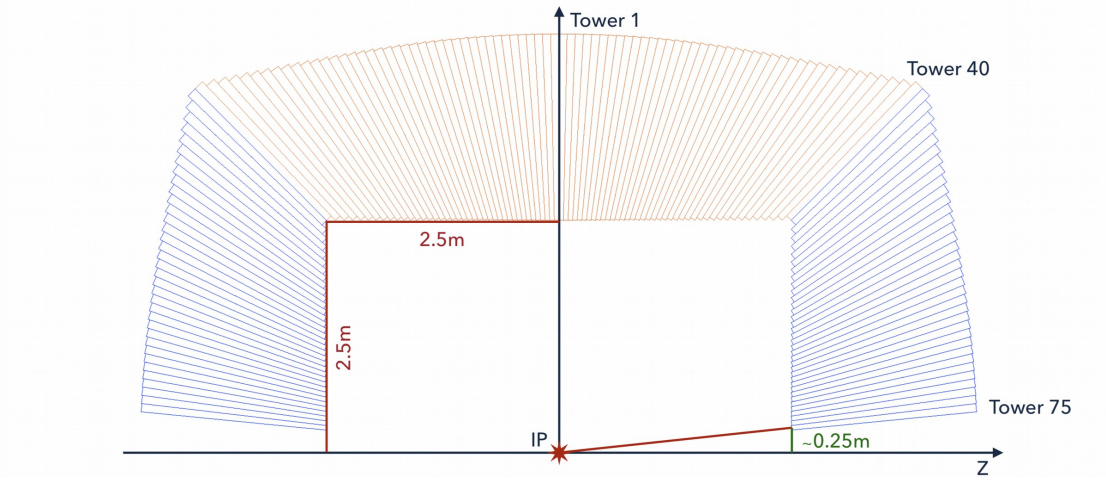




Baseline numbers from 10/2018 to develop FullSim description.
Performance optimization studies with physics benchmarks might/will modify choices.

Pezzotti/Antonello

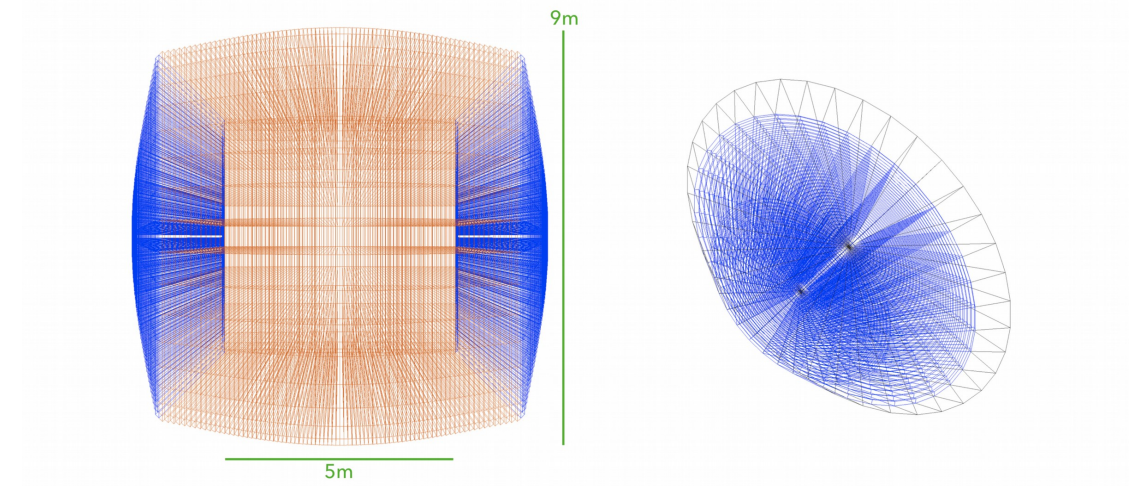
Dual Readout calorimeter FullSim



Cu absorber

1 mm fibres

1.5 mm pitch



75 projective towers
× 36 slices

$\Delta\theta = 1.125°$

$\Delta\varphi = 10°$

~130 M fibres

Lorenzo Pezzotti et al.

Calibration

Loop over each tower:

1) 40 GeV electrons fired at tower centre

2) Estimate energy containment in tower (range: 85% ÷ 95%)

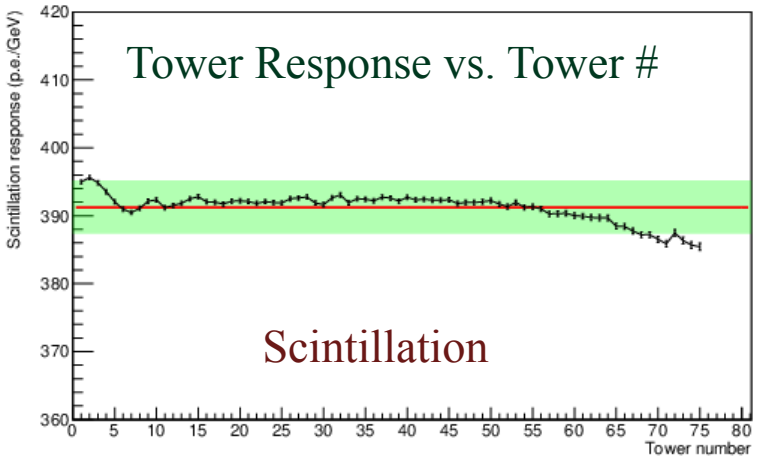
3) Get equalisation constant = S(tower) / E(cont in tower)

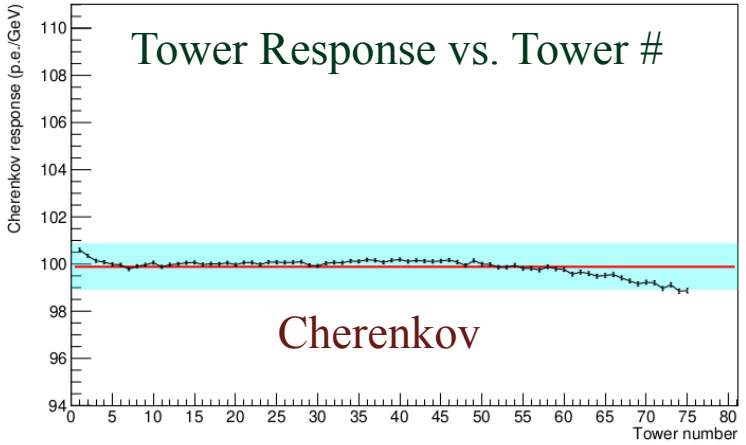
Loop again over each tower:

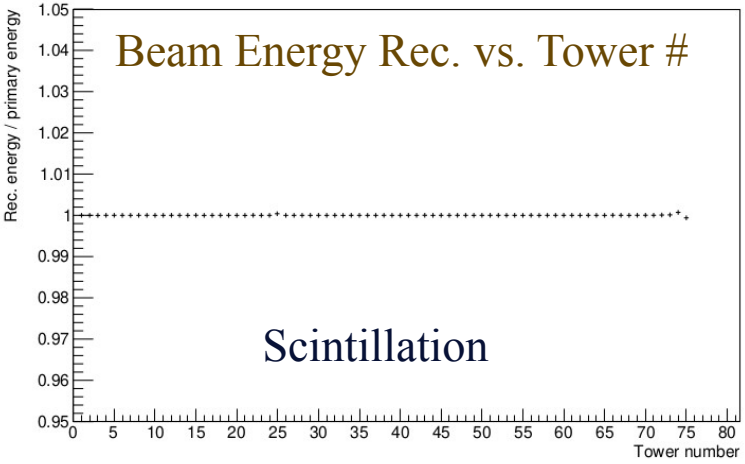
4) Add equalised signals → $S(tot) = \Sigma S_j$

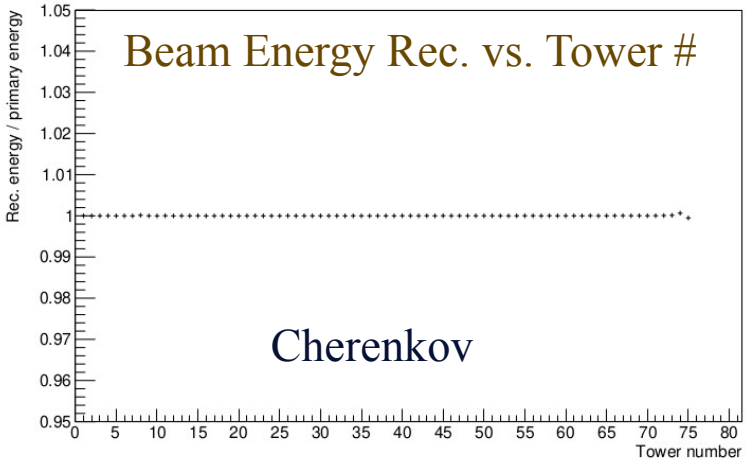
5) Get calibration constant (per tower) = S(tot) / E(cont in calo)

Calibration (40 GeV e^-)

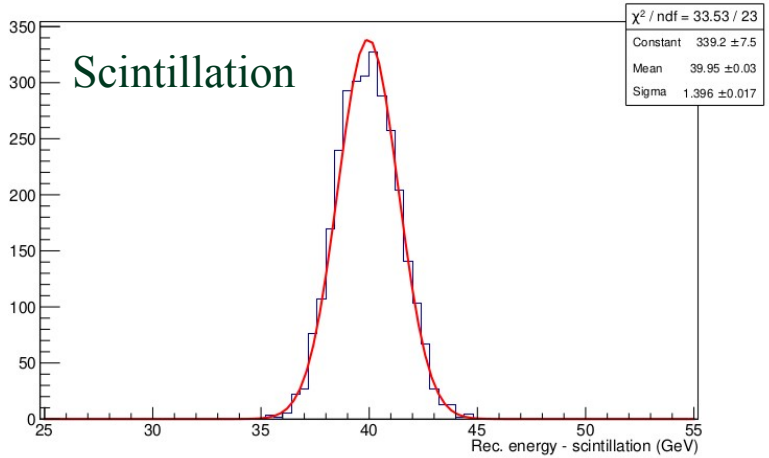


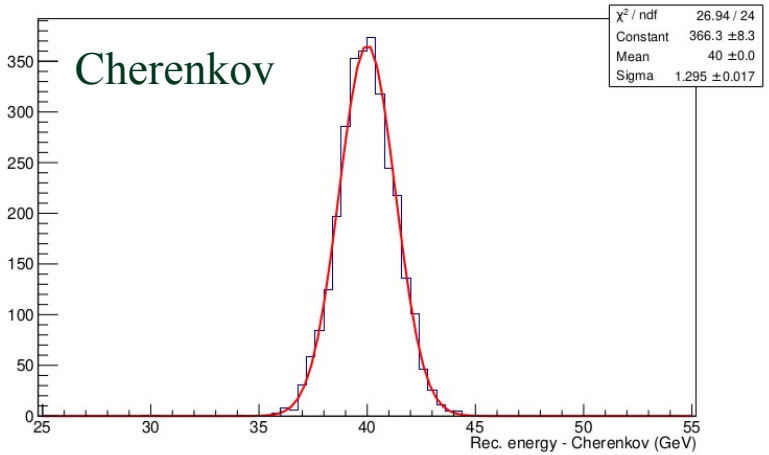


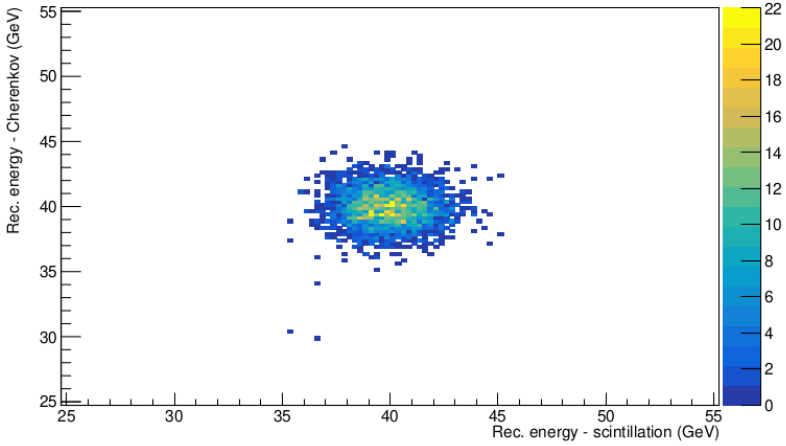




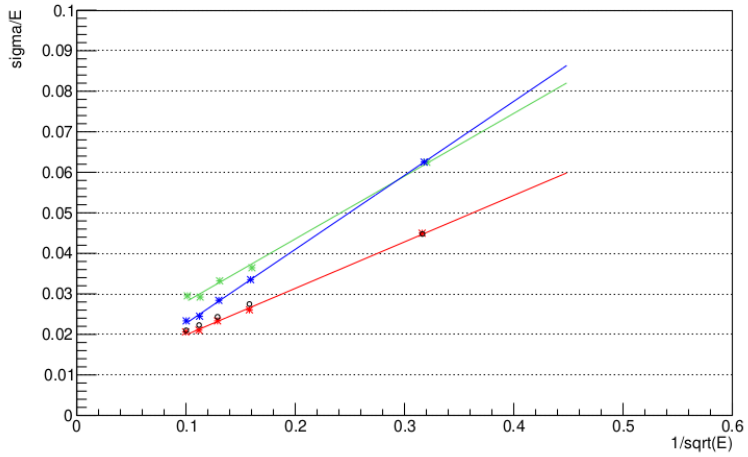
Energy Resolution (40 GeV e^-)







Resolution & Linearity



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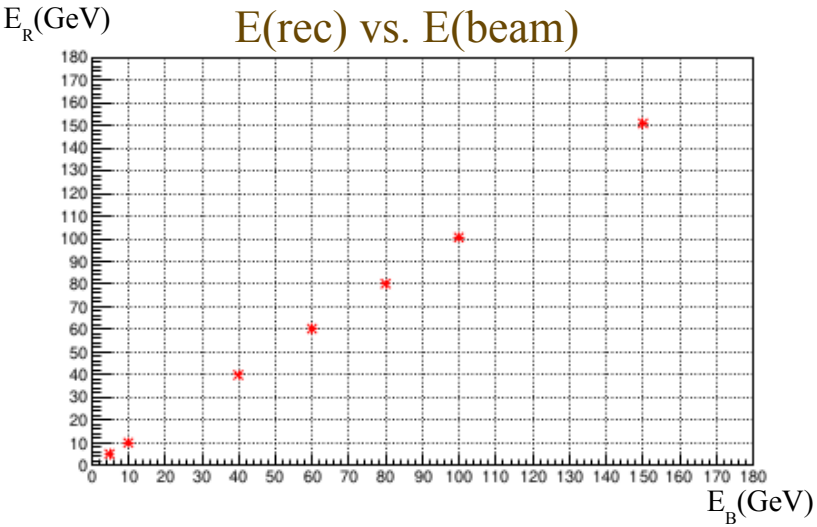
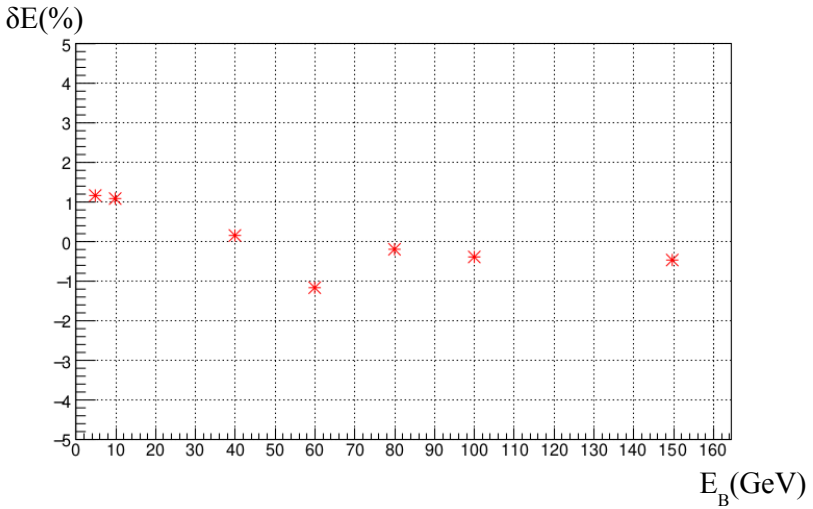
$$\frac{\sigma}{E} = \frac{15.5\%}{\sqrt{E}} + 1.2\%$$

$$\frac{\sigma}{E} = \frac{18.3\%}{\sqrt{E}} + 0.5\%$$

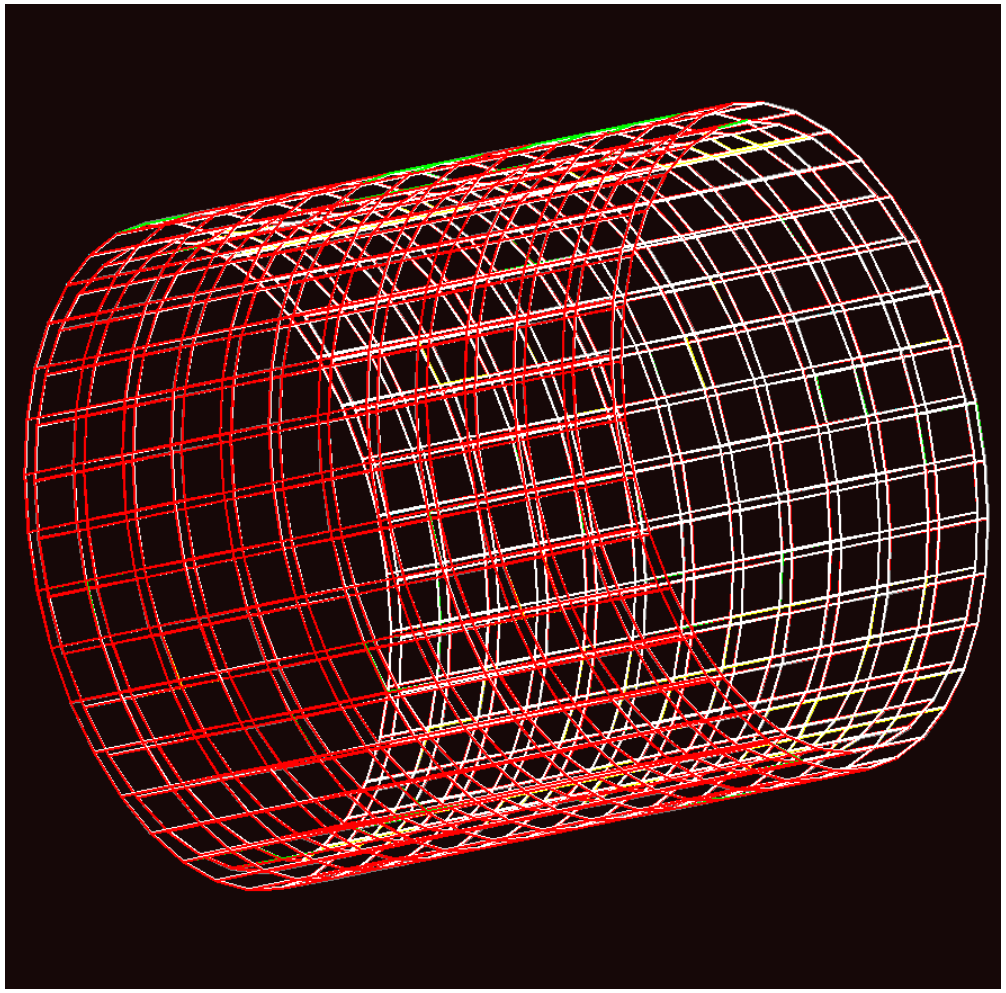
$$\frac{\sigma}{E} = \frac{11.0\%}{\sqrt{E}} + 0.8\%$$

E(rec) vs. E(beam)





Preshower - Full BARREL geometry



Information provided by preshower detector: particle position

↓

To have a bidimensional coordinate for particles:

two μ-RWELL layers

Future μ-RWELL prototypes may provide a bidimensional information per layer

$Z_{preshower}$ = ± 2460 mm = 4920 mm

12 chambers for each sector

↓

1° layer = 34 sectors => 408 chambers

2° layer = 36 sectors => 432 chambers

BARREL

840 chambers

860160 readout channels

Conclusions and plans for preshower

- Implementation of two layers in the preshower barrel in a full geometry of the detector (to have a bidimensional coordinate):

  840 μ-RWELL chambers and 860160 readout channels

- Information about ionization, induction of the signal on strips, charge, …, need a parametrization from other types of simulation: **NOT CONSIDERED**

TO DO!

- Choose the endcap geometry and implement endcap description in Geant4
- Definition of sensitive volumes => X-Y coordinate to be saved at the strip layers
- Attempt to unify the preshower geometry to the DR calorimeter geometry

Fontanesi/Pezzotti

Fast simulation of the IDEA concept

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DELPHES FRAMEWORK • Particle trajectory is followed in the detector.
Input needed: general volumes for acceptances, resolution and response functions from full simulation

- B field
  - Homogeneous magnetic field: 2 T
- Tracker – Drift chamber + vertex

  The response of tracking detectors has been parametrized in the same way for electrons, muons and charged hadrons in terms of efficiency and transverse momentum resolution

$\|\eta\| \geq 3.0$	0.00%
$E \geq 500$ MeV in $\|\eta\| \leq 3.0$	99.7%
$300 \leq E \leq 500$ MeV in $\|\eta\| \leq 3.0$	65%
$E \leq 300$ MeV in $\|\eta\| \leq 3.0$	6%

$$\sigma_{pT} / p_T = \sqrt{[(7.e^{-5} * p_T)^2 + 0.0006^2]}$$

Idea to include in Delphes the full covariance matrix for tracking parameters smearing provided by a specific fast simulation.

- Dual-Readout (DR) calorimeter

  Implementation of a monolithic calorimeter in a dedicated IDEA card:
  - ➢ single segmentation (cell size = 6 cm x 6 cm)
  - ➢ different energy resolution for electromagnetic and hadronic showers

$$\frac{10-13\%}{\sqrt{E}} \qquad \frac{30\%}{\sqrt{E}}$$

New official Delphes release including IDEA card:
https://github.com/delphes/delphes/releases/tag/3.4.2pre18

Validation plots for DR calorimeter

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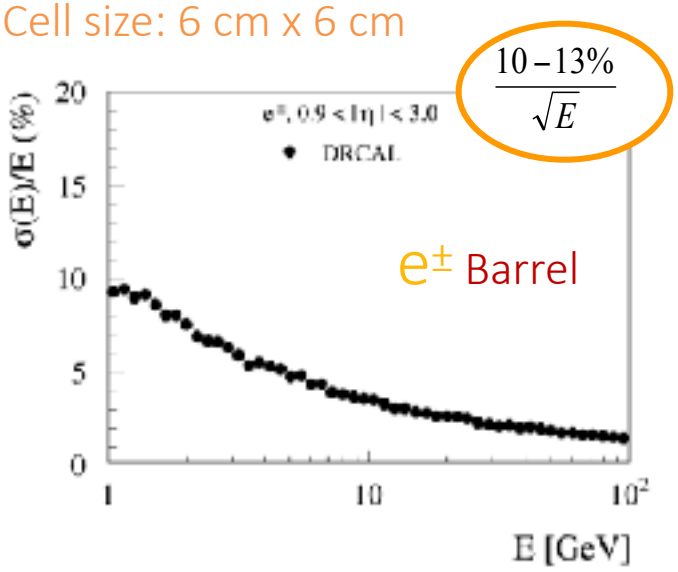
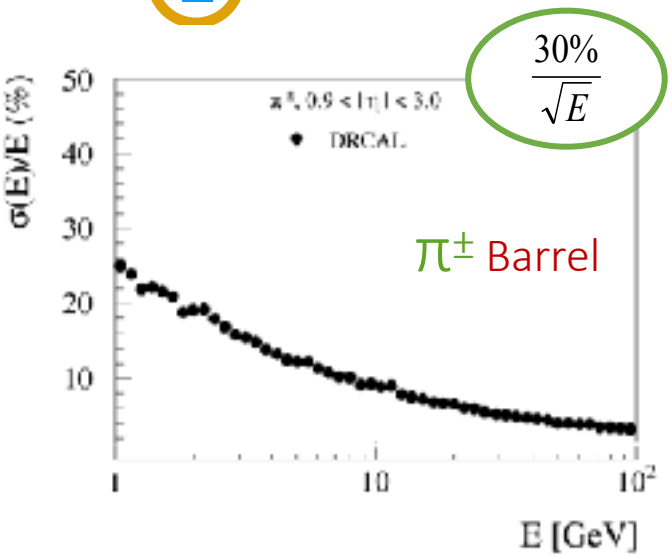
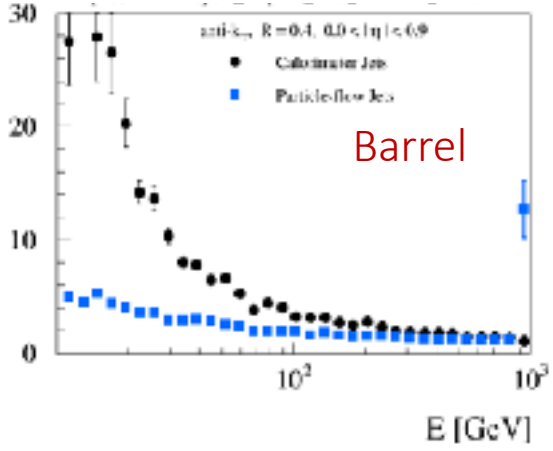
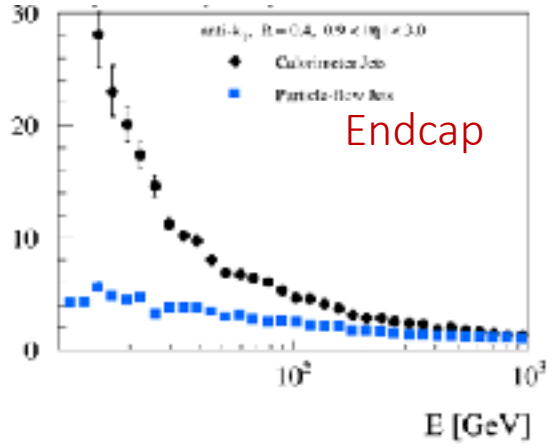
Cell size: 6 cm x 6 cm





Energy resolution for reconstructed objects (both had and em particles) considering two different regions of pseudorapidity (η) with particle gun events (electrons and pions)





Jet Energy resolution using PF reconstruction

Performance study with τ jets

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ZH(ττ+jets): ρ invariant mass

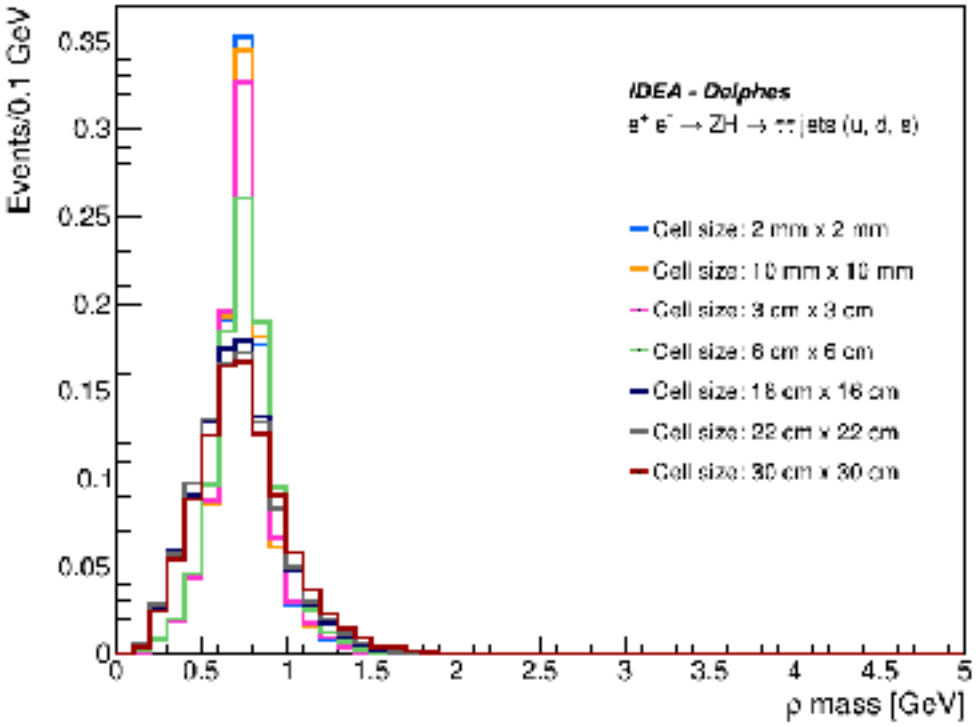
$e^+ e^- \rightarrow Z H \rightarrow$ Jets (u, d s)

$\tau^+\tau^-$

τ decay forced to

$\rho \rightarrow \pi^\pm \pi^0 \nu_\tau$

Combination of both $\pi^\pm + 2\gamma$ and $\pi^\pm + 1\gamma$ categories



Selected event for each category (%)

	$\pi^\pm + 2\gamma$	$\pi^\pm + 1\gamma$	$\pi^\pm + 0\gamma$
2 mm x 2 mm	51%	35%	14%
10 mm x 10 mm	51%	35%	14%
3 cm x 3 cm	51%	35%	14%
6 cm x 6 cm	43%	43%	14%
16 cm x 16 cm	6%	47%	47%
22 cm x 22 cm	2%	32%	66%
30 cm x 30 cm	0.4%	19.3%	80.3%

For the current version of the IDEA card cell size 6 cm x 6 cm chosen:
investigation will continue in parallel with the development of the full simulation

Summary & pland for IDEA simulation and reco

- FullSimulation:
  - significant progress on the **DR calorimeter** simulation with Geant (*Pezzotti, Antonello)*
  - first studies ongoing for calibration/resolution evaluation
  - starting to develop reconstruction
  - NN algorithms being explored to further push performance
  - working to have **Drift Chamber** GEANT simulation also running on lxplus to be combined with Calorimeter (*Tassielli, Fontanesi*)
  - First pass at a **pre-shower** implementation (with μ-rwell) in GEANT (*Fontanesi*)
- Fast Simulation - Delphes
  - new IDEA card added with baseline performance. (*Fontanesi,Pezzotti*)
  - To be validated and updated with FullSim as soon as it becomes available
  - Significant improvements can be provided by the inclusion of the full covariance matrix to provide tracks smearing, the development of new algorithms oriented to e^+e^- physics (adeguate clustering for jets), …(*Bedeschi*)
  - Useful for detector performance optimization studies