Optimization of ECAL for the LUXE experiment

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1. Geometry
2. Energy resolution
3. Positional resolution
4. Reconstruction

At the IP, electron–positron pairs will be produced both in $\gamma_B + n\omega$ and $e^- + n\omega$ processes. A spectrometer system is again employed, using a dipole magnet to separate the electrons and positrons from each other and from photons which continue down the beam line. The calorimeter will allow matching of tracks from the silicon detectors to energy deposits and hence provide extra information in the measurement of the electron and positron energy spectra.

Geometry

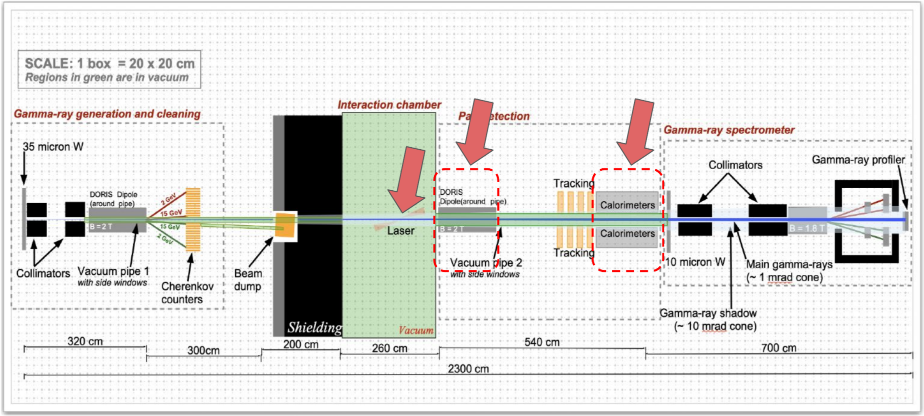


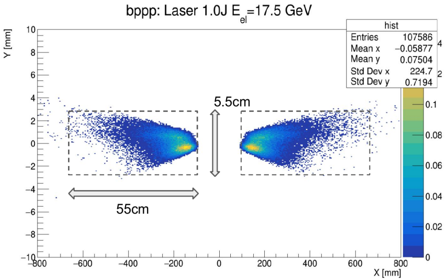
***Figure*3.**[1] Experimental setup of the LUXE experiment

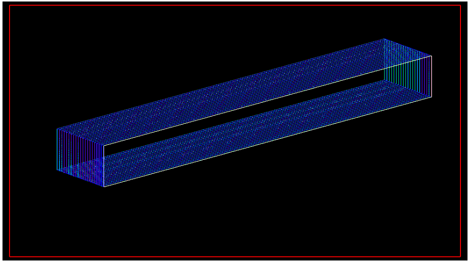
- Magnet: 1.4 T
- Magnet profile: 60cm x 20cm x 150cm
- Nominal length: 1.029 m

- Magnet position: 100cm - 250cm
- ECAL position: 500cm

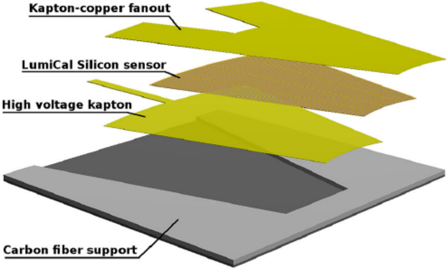
[1] arXiv:1909.00860

Geometry (Geant4 simulation)





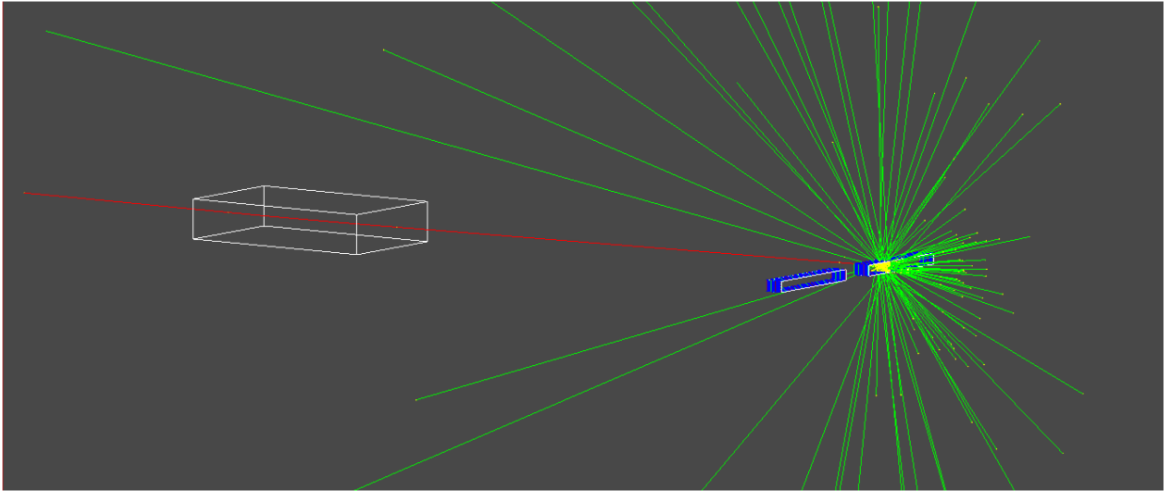
- Layer gap: 0.2mm
- Silicon: 0.32mm
- Carbon: 0.79mm
- Aluminium: 0.02mm
- Tungsten: 3.5mm
- Density: $19.3g/cm^3$
- Fanout (both): 0.15mm (with epoxy)



[a]

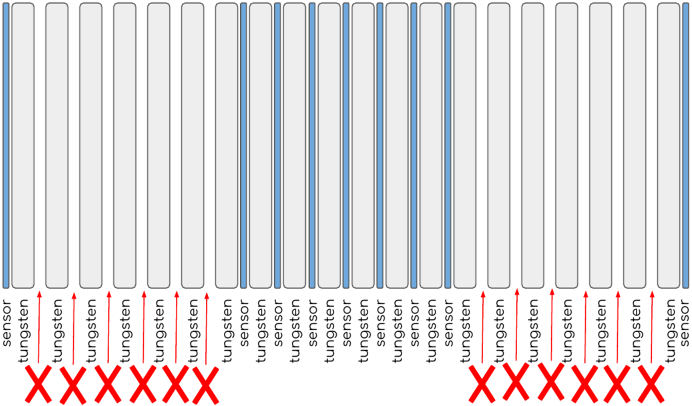
[a] https://doi.org/10.1140/epjc/s10052-019-7077-9

Geometry (Geant4 simulation)



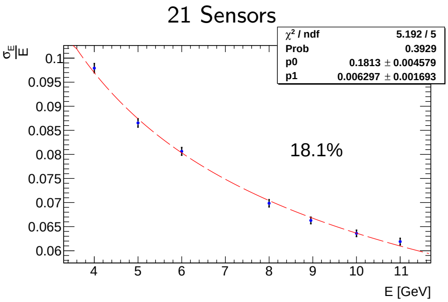
Region covered in ⊥ coordinate x: 100mm .. 650mm
Region covered in ⊥ coordinate y: -27.5mm .. 27.5mm

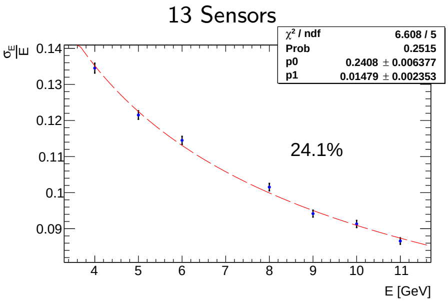
Energy resolution

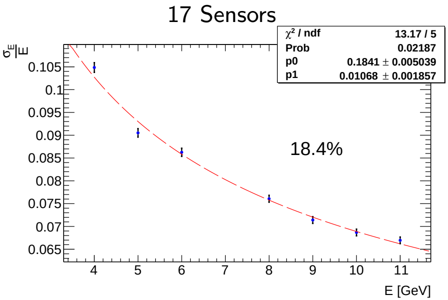


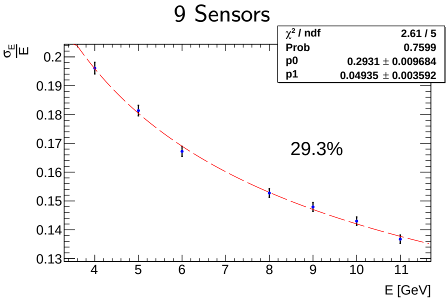
1. Monoenergetic particles are used
2. MC is generated for energies: 4GeV - 11GeV
3. MC runs per energy: 5000
4. Reduce number of sensors starting from external layer
   1. 21 Sensors
   2. 17 Sensors
   3. 13 Sensors
   4. 9 Sensors
5. $\sigma(E)/E = \sqrt{(c_1/\sqrt{E})^2 + c_2/E + c_3}$
   $c_2 = 0$ (no electronic noise)
   c_3 - very small

Energy resolution





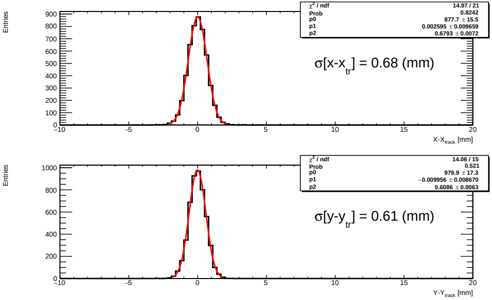




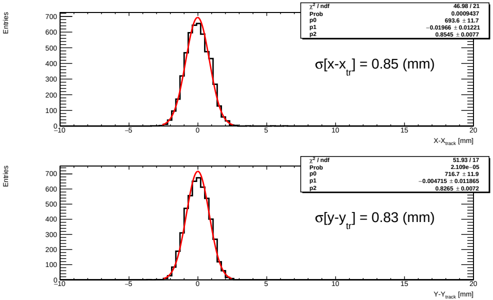
Position resolution

1. Energy: 7GeV
2. MC runs per energy: 5000
3. Pixel size:
    1. 0.5cm x 0.5cm
    2. 0.75cm x 0.75cm
    3. 0.9cm x 0.9cm
4. $X_{cluster} = \sum x_{hit} E_{hit} / E_{cluster}$
5. Gaussian fit for $X_{track} - X_{cluster}$ and $Y_{track} - Y_{cluster}$

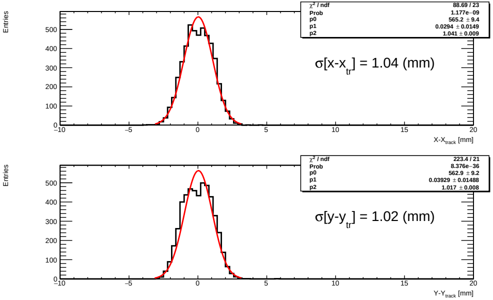
0.5cm x 0.5cm

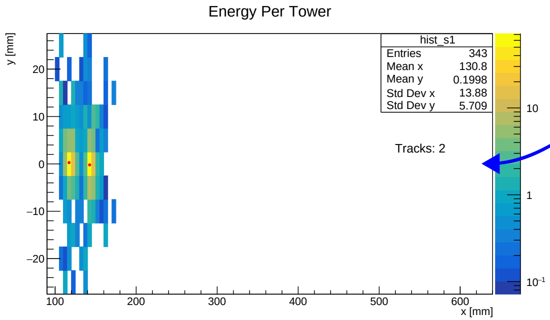


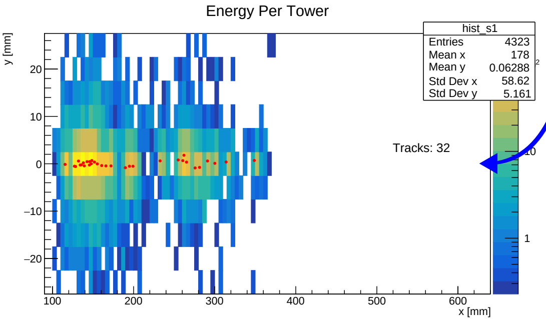
0.75cm x 0.75cm



0.9cm x 0.9cm





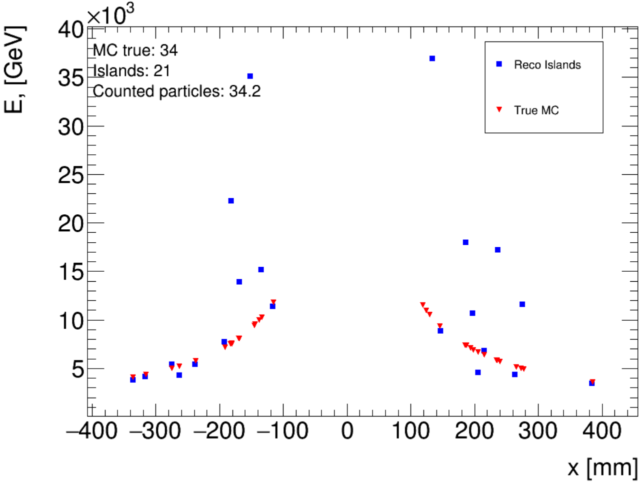


- Cases of $E_{electron} = 17.5\,GeV$
  Laser: 0.2J, 0.35J, 0.5J
  give up to $\sim 4e^+e^-$ per BX
- Cases of $E_{electron} = 17.5\,GeV$
  Laser: 0.7J, 0.85J, 1.0J
- Percent of tracks overlapping with at least one more tracks in this BX within σ_{xy} of the calorimeter:

pixel size	0.7J	0.85J	1.0J
0.5cm x 0.5cm	4.6%	9.3%	13.6%
0.75cm x 0.75cm	7.3%	14.2%	21.2%
0.91cm x 0.91cm	10.1%	19.6%	28.6%

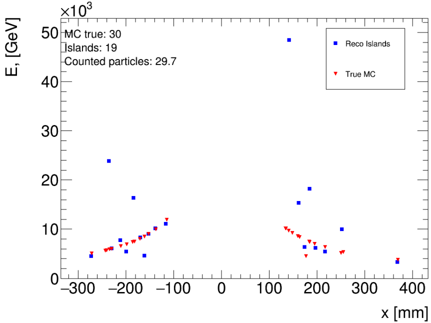
To do:

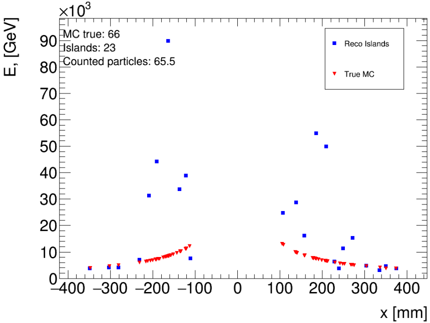
- Which reconstruction approach is better in this situation?

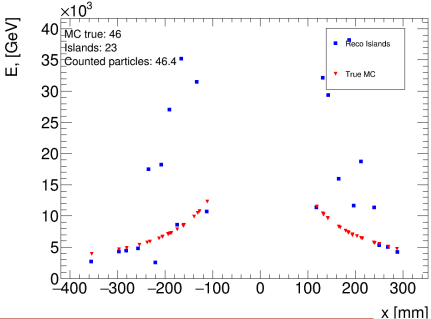


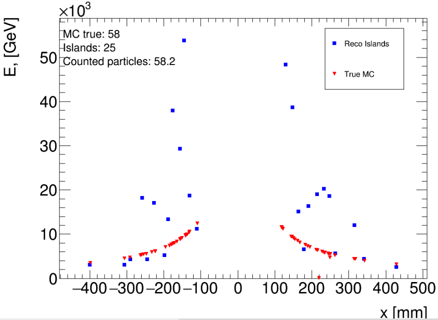
- Reconstructed with the simple closest pad neighbourhood approach
- $X_{cluster} = \sum x_{hit} E_{hit} / E_{cluster}$ + bias correction
- X - position of the cluster corresponds to fixed energy of the track
  $\Rightarrow$ can calculate number of tracks inside cluster $N = \frac{E_{cluster}}{E_{track}(x)}$
- "Counted particles" $= \sum N$

Reconstruction (status) $\gamma_B + n\omega \Rightarrow e^+e^-$









Summing up

Conclusions:

- Basic geometry was implemented
- Energy resolution:

number of sensors	resolution
21	18.1%
17	18.4%
13	24.1%
9	29.3%

- Positional resolution (for 7GeV electrons):

pixel size	σ_x	σ_y
0.5cm x 0.5cm	0.68mm	0.61mm
0.75cm x 0.75cm	0.85mm	0.83mm
0.91cm x 0.91cm	1.04mm	1.02mm

To do:

- Simulation modifications:
  - Background
  - Simulation of dead zones
- Optimize shower reconstruction algorithm
- Disentangle large overlapping showers
- Signal-background separation

... beginning of the long story

Thank you for your attention!