Ununiformality study

Slides from 19 April

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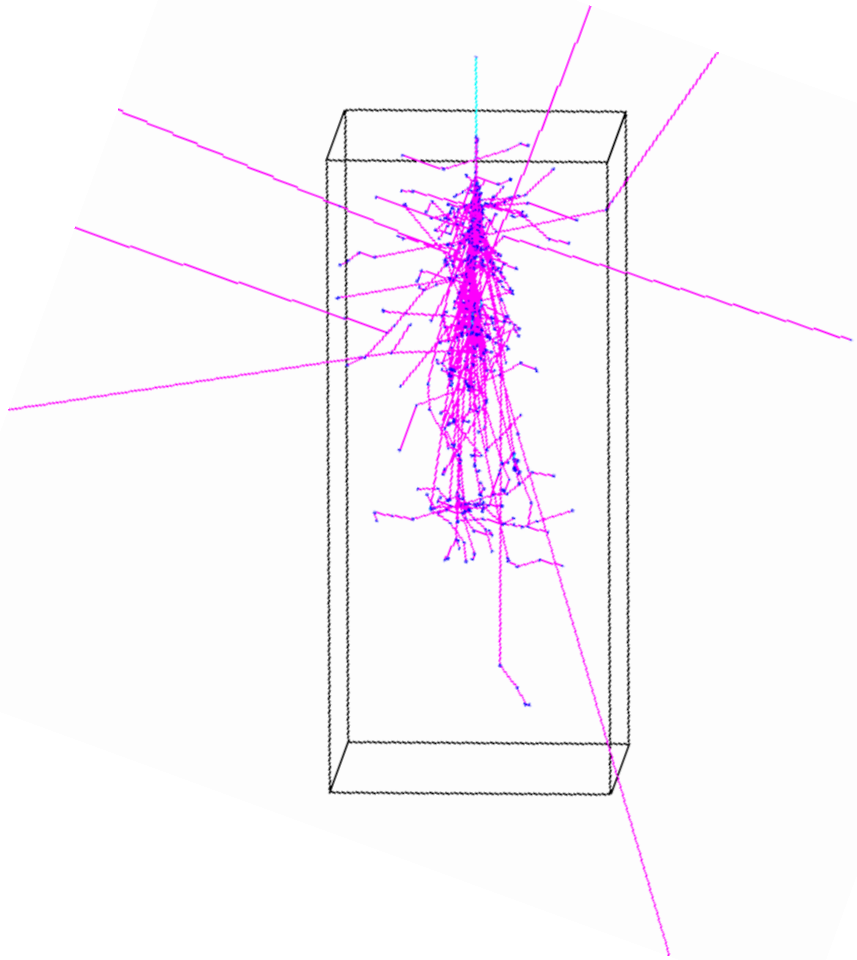
Quick recap

- The simulation gives the energy deposited in a strip for each simulated event.
- Each strip has the dimensions of 1x1x400 mm. There are 168 by 168 such strips in the detector.
- WLS fibres are located each 7 mm and the energy deposited in the strip that contains fibre is not recorded in the simulation output.

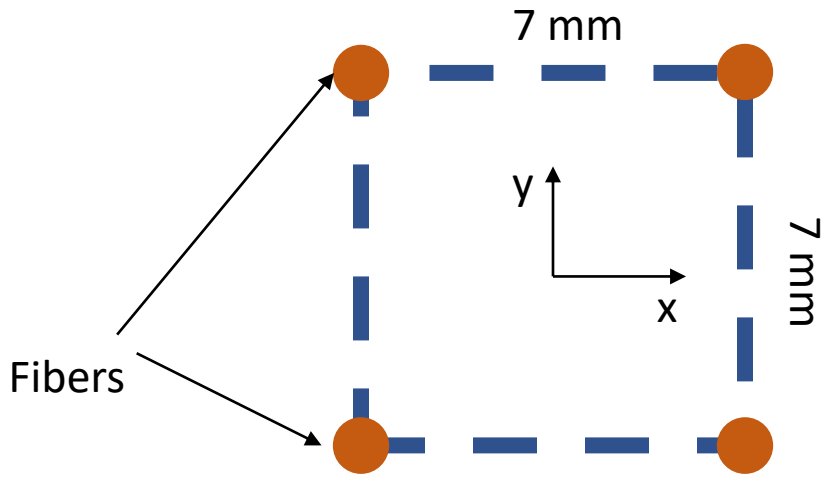


Simulation setup

- The position of the primary hit was quasi-uniformly distributed in the square between fibers.

$$F = 1 - a\cos\left(\frac{2\pi x}{7mm}\right) - \mathrm{b}\cos\left(\frac{2\pi y}{7mm}\right)$$

- The energy deposited in each strip was multiplied by the following weight



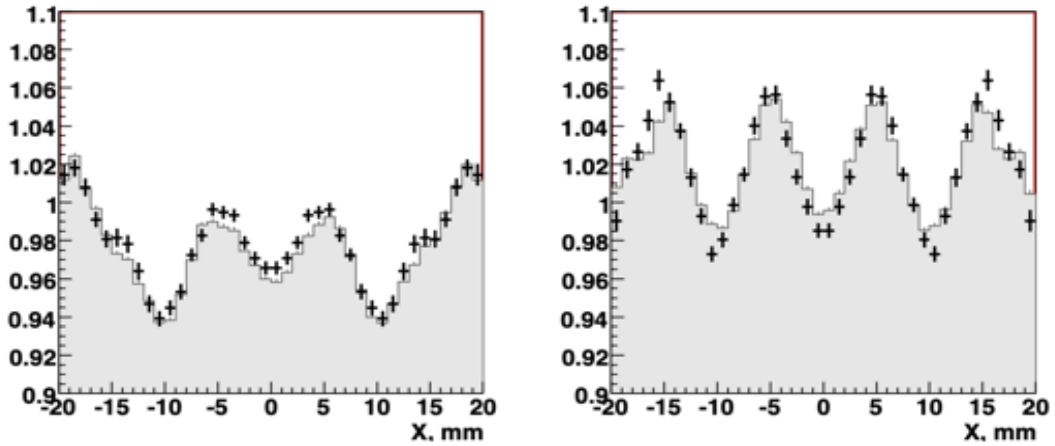
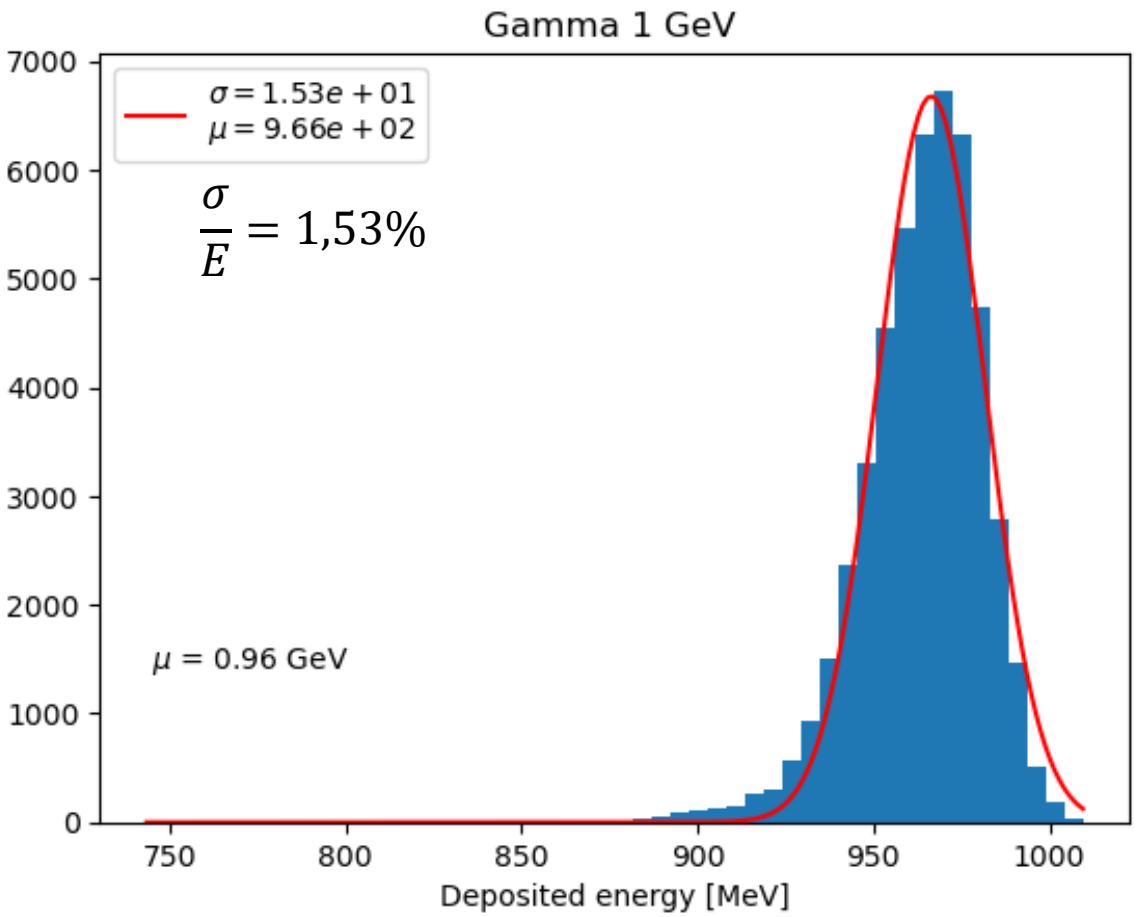


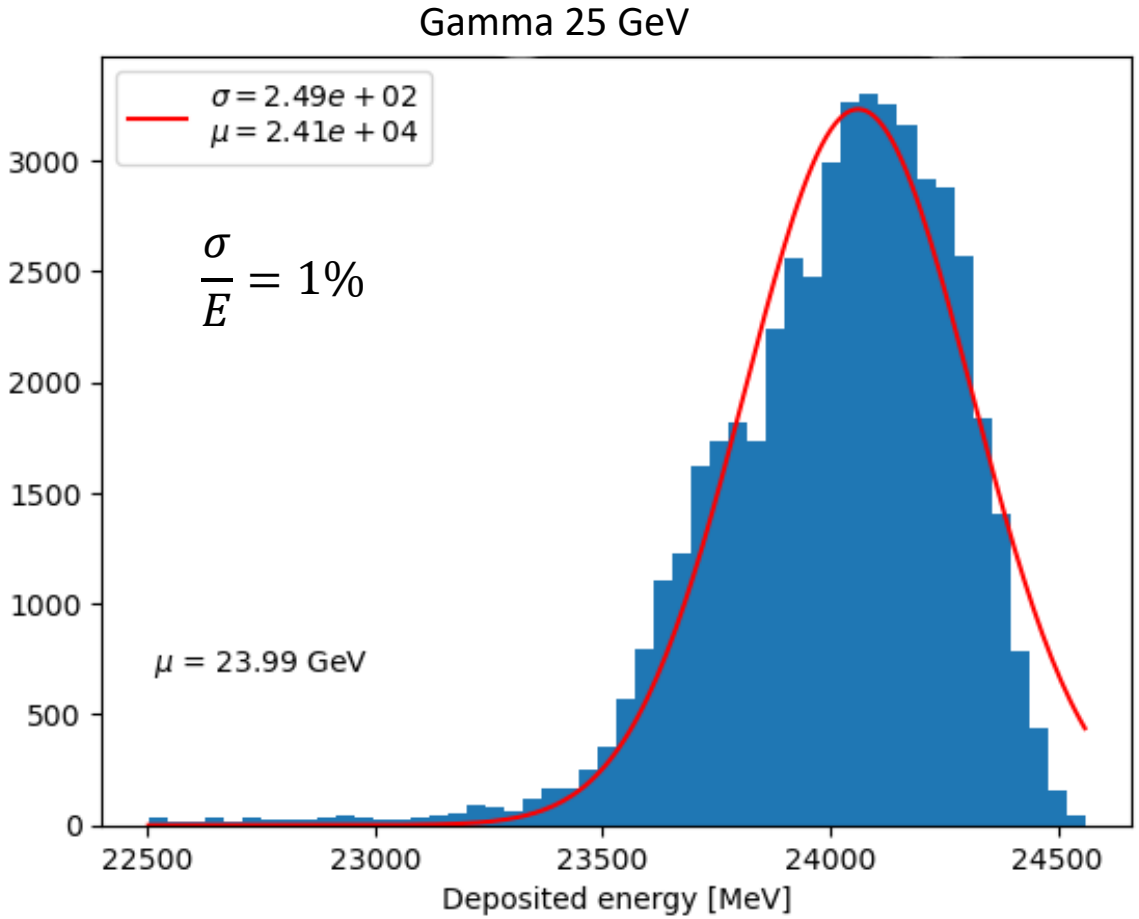
Figure 13 Response uniformity of the inner LHCb module measured with muons (error bars) and simulated (hatched histogram). The scan was made in 1 mm wide bands between two fiber rows (left) and through the fiber positions (right).

Measured energy

- a = b = 7%

Histograms of event by event measured energy





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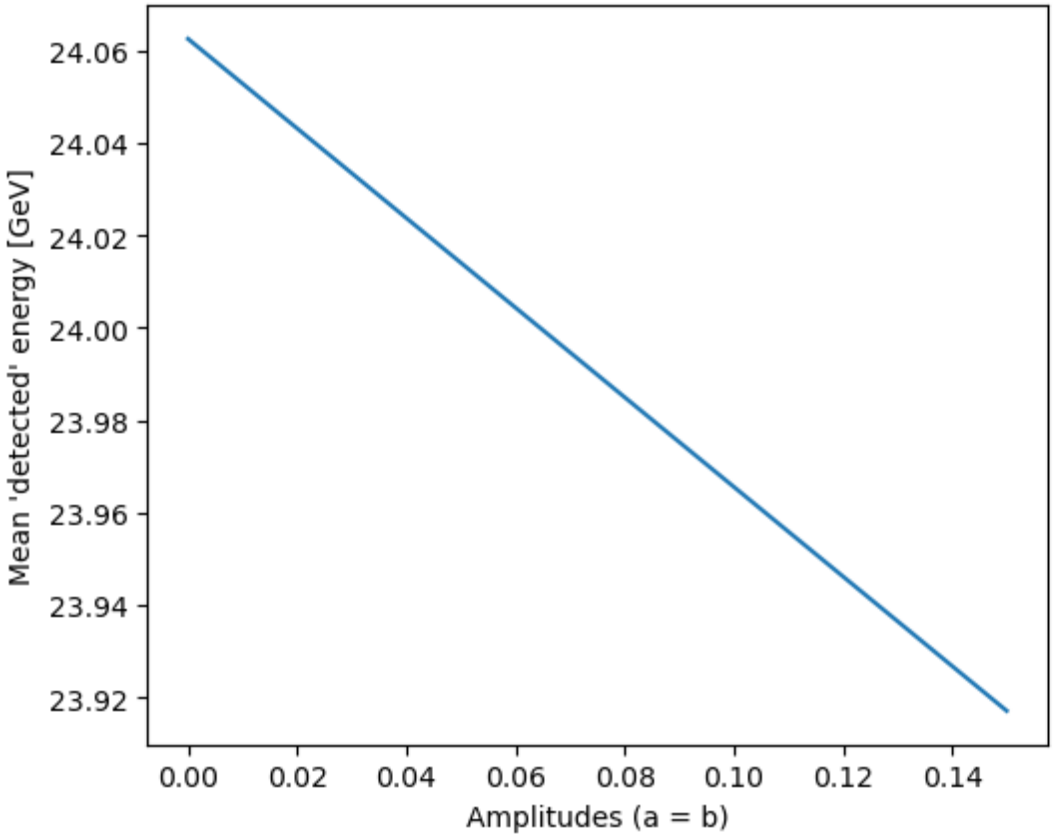
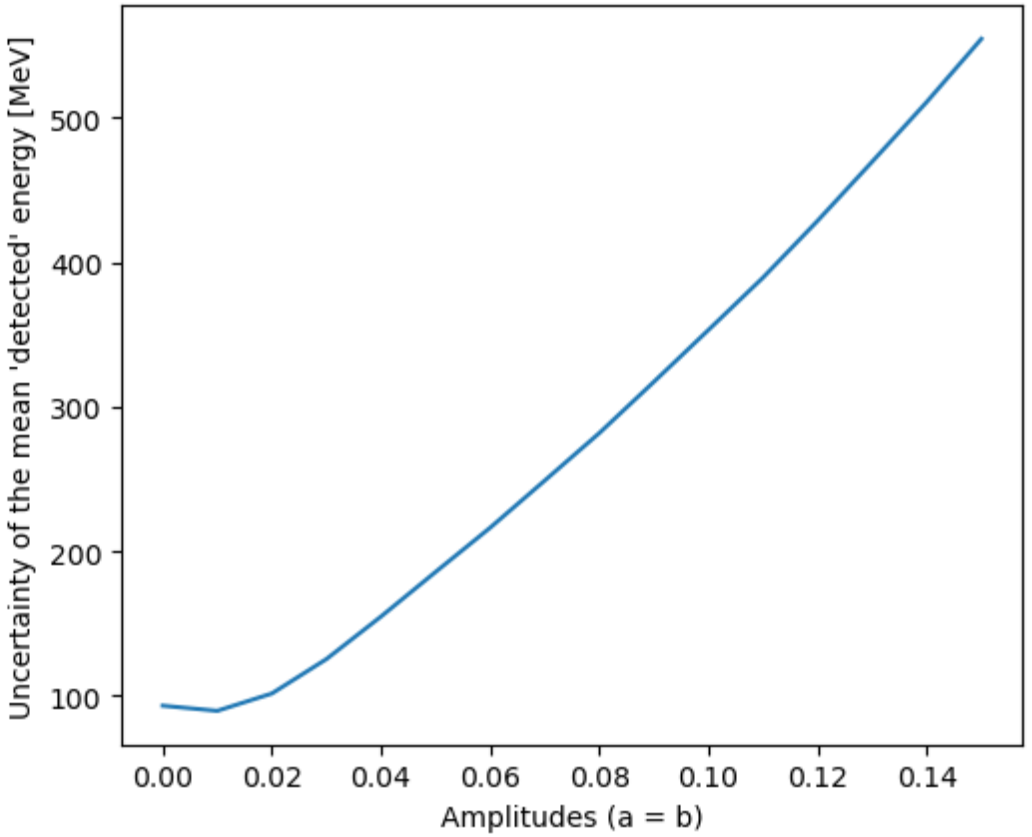
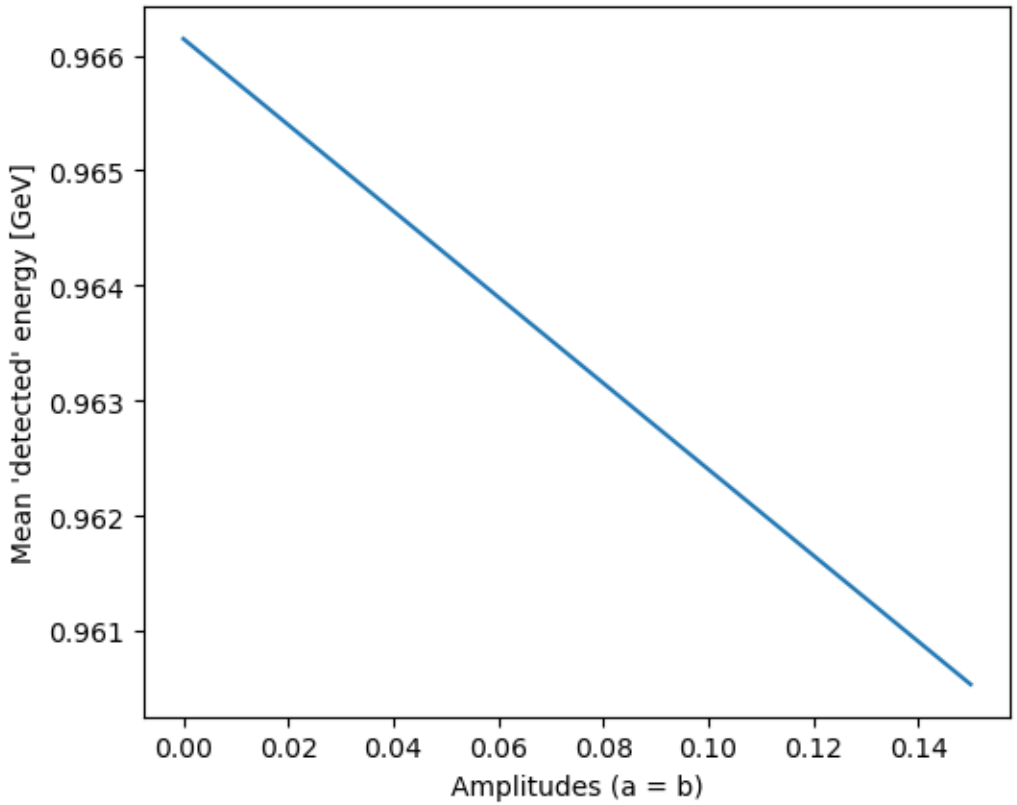
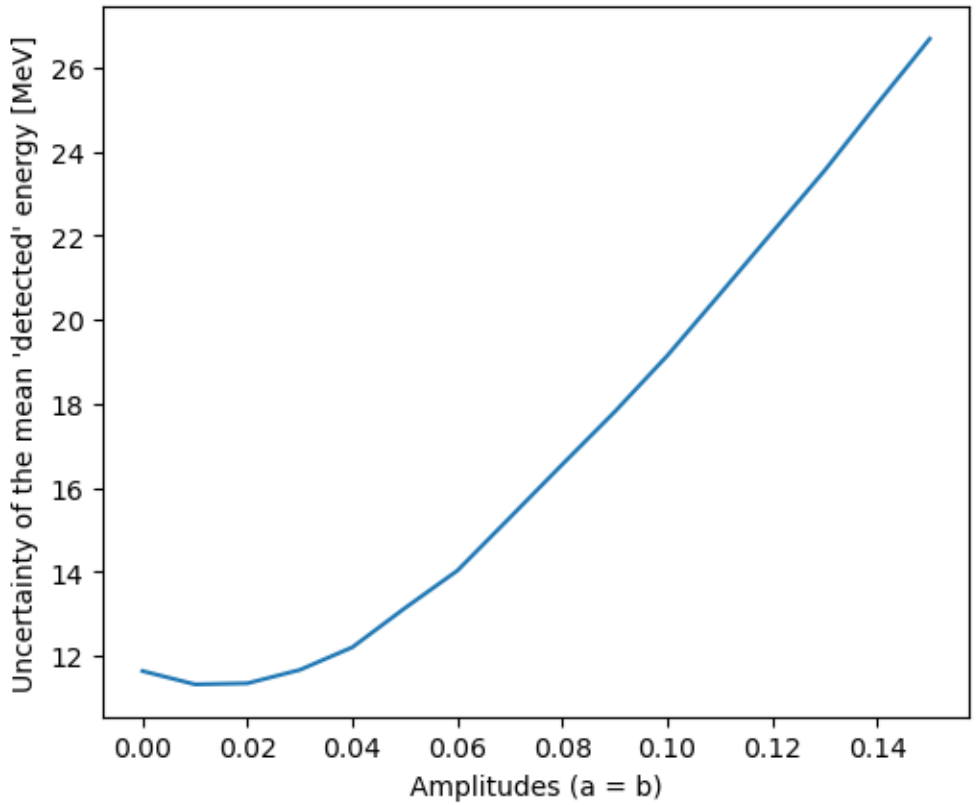
Dependence of the efficiency on the amplitudes 25 GeV





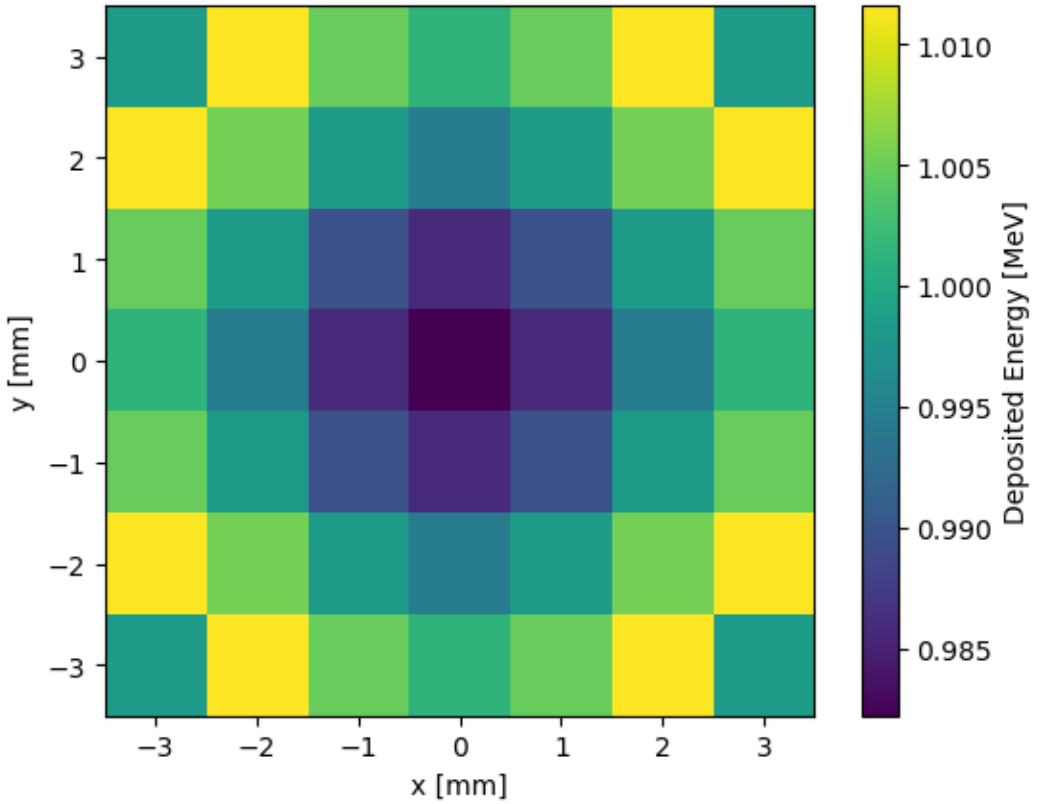
Dependence of the efficiency on the amplitudes 1 GeV



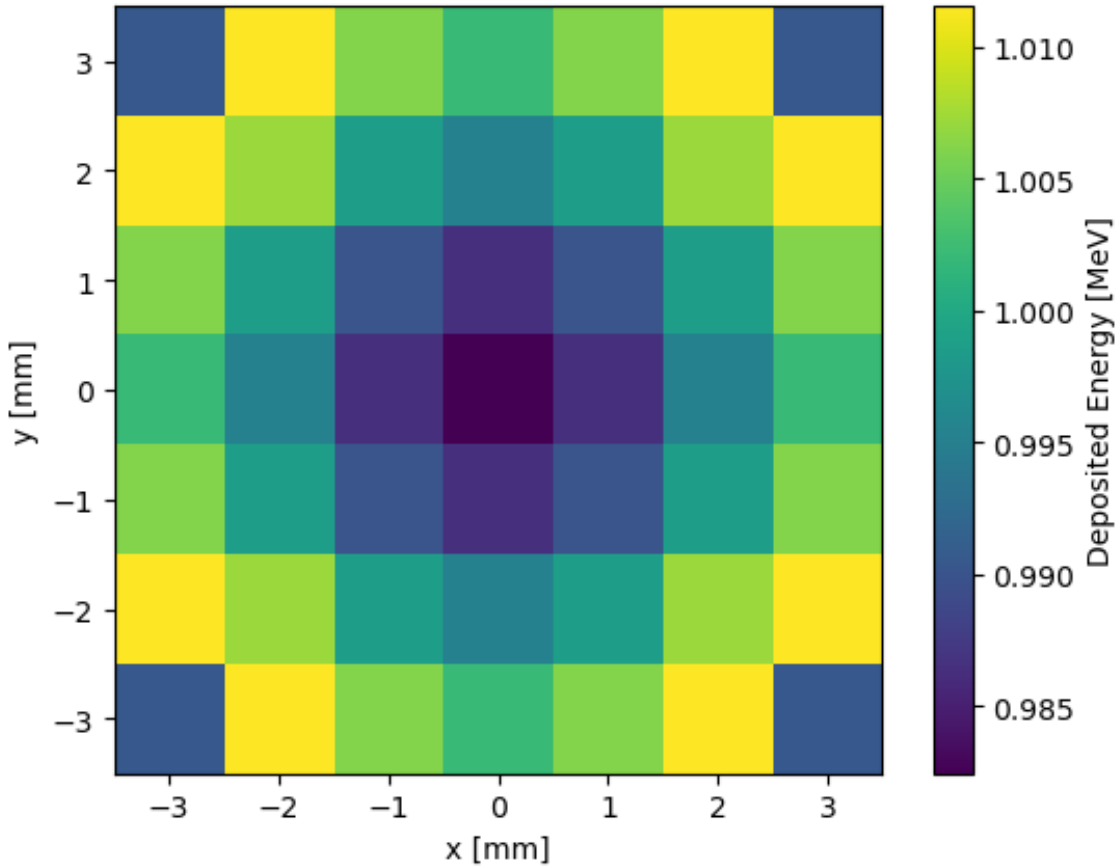


Efficiency maps

1 GeV



25 GeV



Conclusions

- The constant term error on energy measurement grows about linearly with the “non-uniformity”
- The efficiency maps are very similar
- σ/E is worse for 1 GeV gammas compared to 25 GeV

Thank you for your attention

Backup slides

Resolution: constant term simulation. Quick recap

- The energy accuracy of ECAL is usually parametrized as $\sqrt{\left(\frac{x}{\sqrt{E}}\right)^2 + y^2}$. Where y is the "constant term" usually caused by leakage or non uniformity.

- Simulation is held in the box volume with dimensions 168 x 168 * 400 mm.

- Volume is simulated as with one material:
  - 4.53 $\frac{g}{cm^3}$ (partial density) of ZnWO4
  - 1.19 $\frac{g}{cm^3}$ (partial density) of heavy liquid

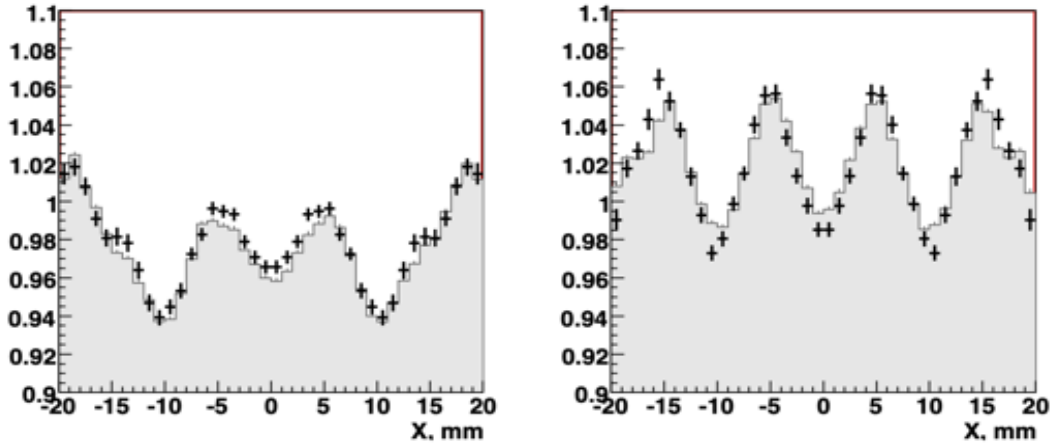
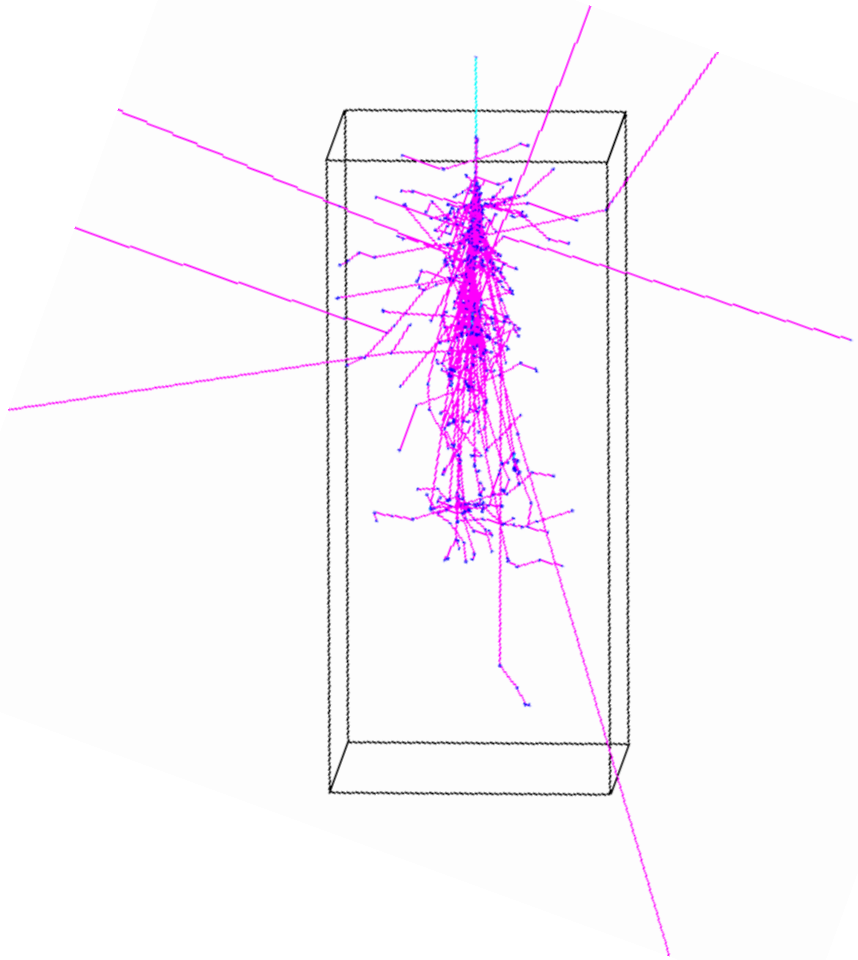


Figure 13 Response uniformity of the inner LHCb module measured with muons (error bars) and simulated (hatched histogram). The scan was made in 1 mm wide bands between two fiber rows (left) and through the fiber positions (right).

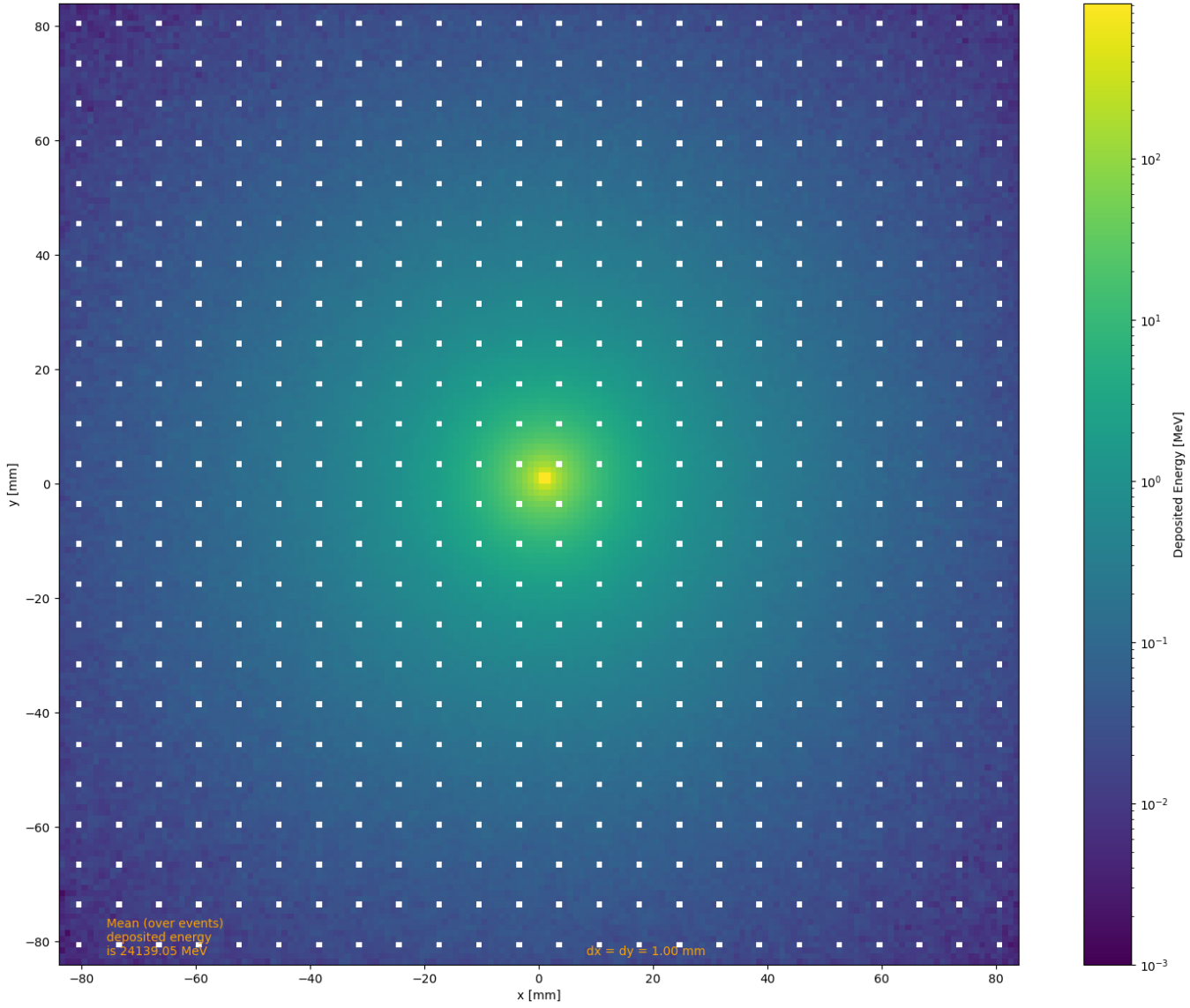
Simulated detector

- Geant4 simulation was made to calculate the energy detection ununiformality.
- The simulated primary gamma (**25 GeV in this presentation**) hit the top face of the detector.
- The fibers were simulated inside the detector. The distance between fibers is 7 mm. Fibers are cylinders of diameter equal to 1.
- The detector was virtually split into strips with dimensions of 1 mm by 1 mm by 400 mm.



Energy deposition in strips

- The plot shows energy mean deposition in strips over 1000 events. The energy deposition of strips containing fibers was omitted (as there is no scintillation in fibers).

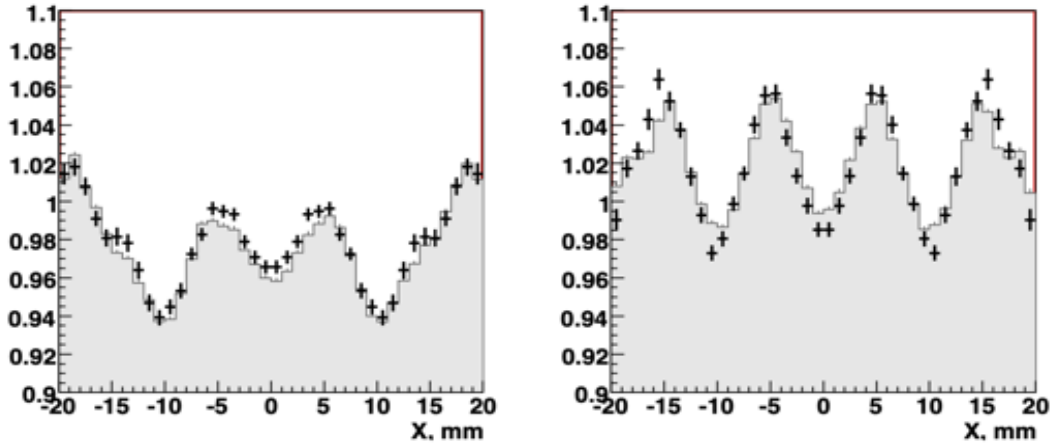


Weights of the strips

- The energy deposited in each strip was multiplied by the weight.
- The weight was estimated from others studied.
- This approach takes into account that light collection efficiency is different for different strips.

$$F=(1 + - a \cos (2\pi (x/7mm)) - b \cos (2\pi(y/7mm)))$$

a = b = 7%



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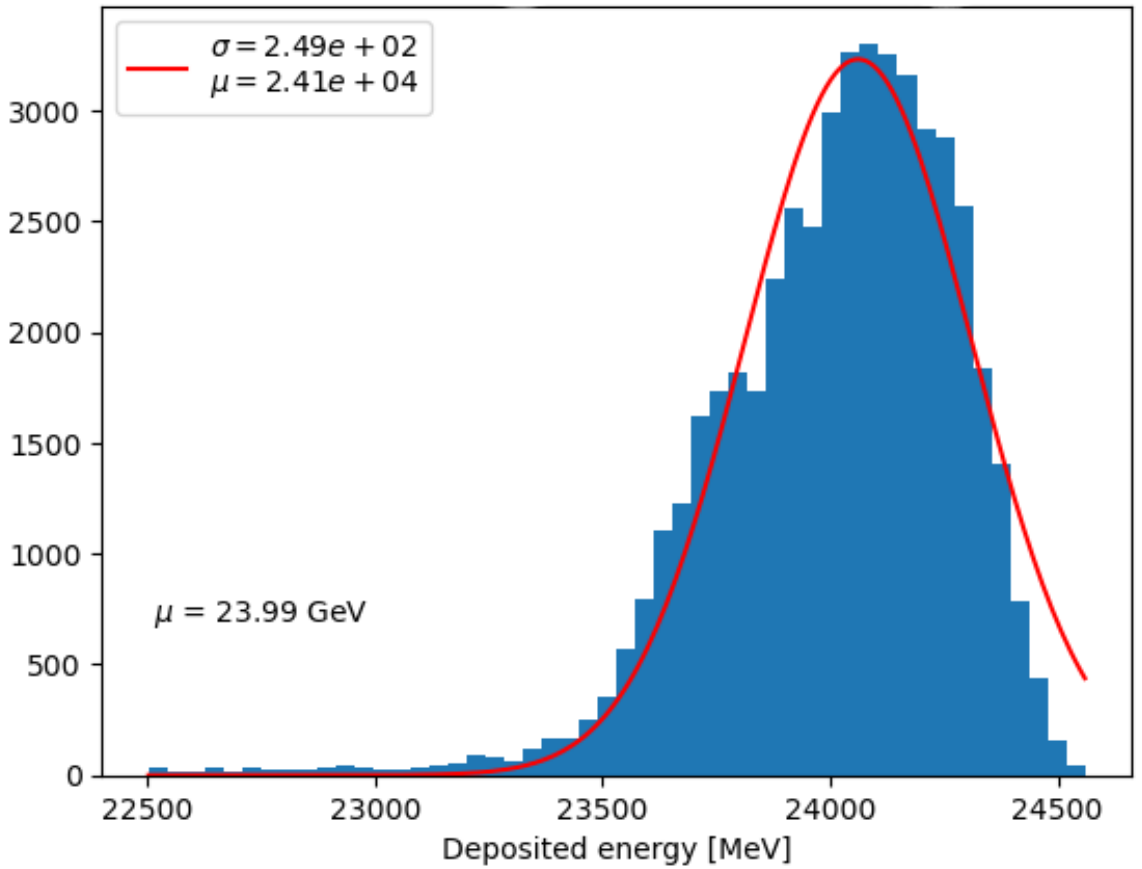
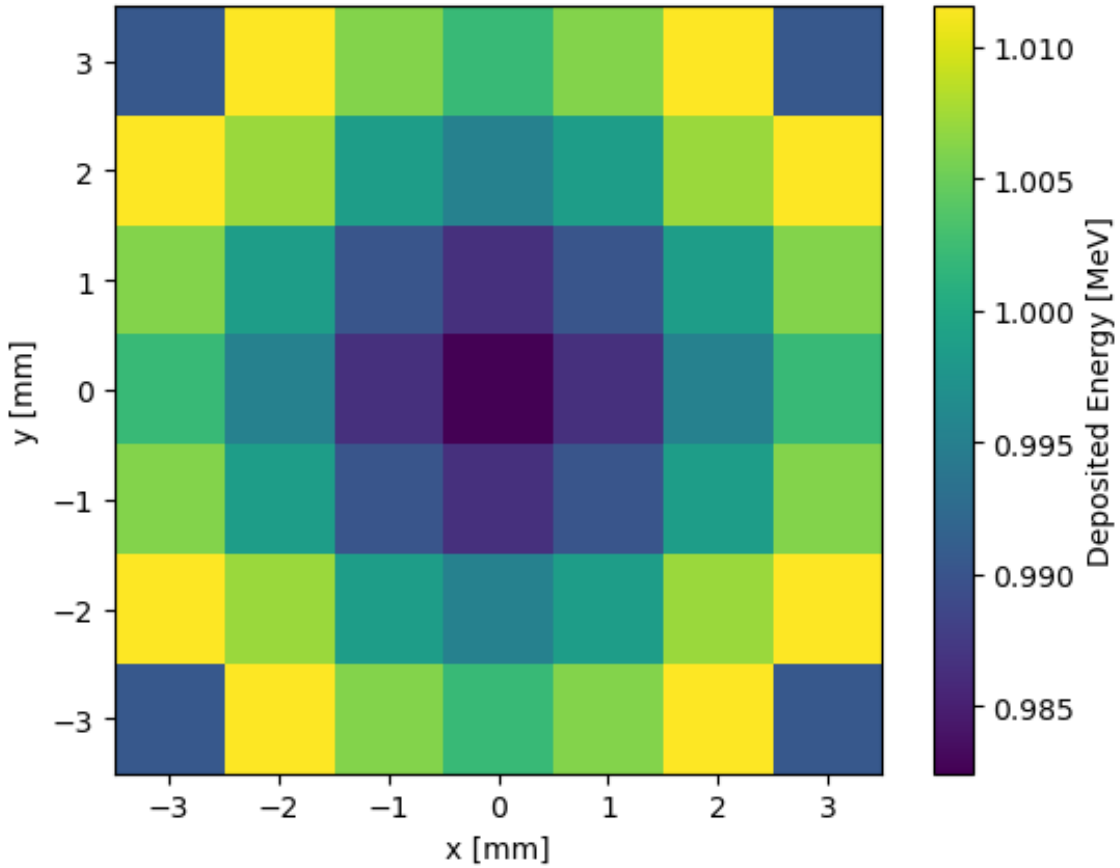
Energy deposition histogram.

- The histogram shows the energy deposited in the calorimeter, after encountering strip weights and excluding energy deposited in fiber strips.
- The particles were shot nearly randomly in the cube with dimensions 7 by 7 mm.



Efficiency map

- Each bin of the histogram represents the mean (over 1000 events) energy that was deposited if the primary hit was in this specific bin.
- The histogram is rescaled in such a way that its mean value is equal to 1.



Geant4 simulation setup

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- Volume is simulated as with one material:
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  - 1.19 $\frac{g}{cm^3}$ (partial density) of heavy liquid
- Projectile particle energy - deposited energy = escaped energy
- escaped energy ≠ The sum of energy of escaped particles