FCC Hadron Detector Meeting

Ecal energy deposition and simple clustering

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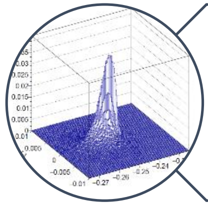
M. Aleksa, A. Dell'Acqua, J. Faltova, C. Helsens,

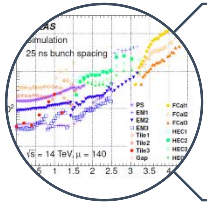
M. Matas, B. Roach, A. Zaborowska

Matas.marek1@gmail.com

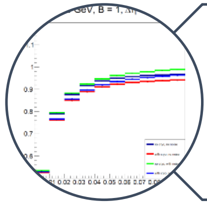
Outline



Electromagnetic shower profile



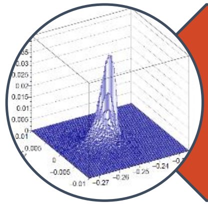
Implementation of noise



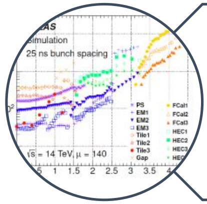
Results

Conclusions

Electromagnetic shower profile



Electromagnetic shower profile



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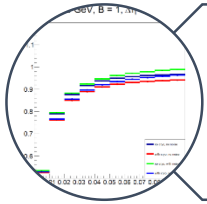

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What we did

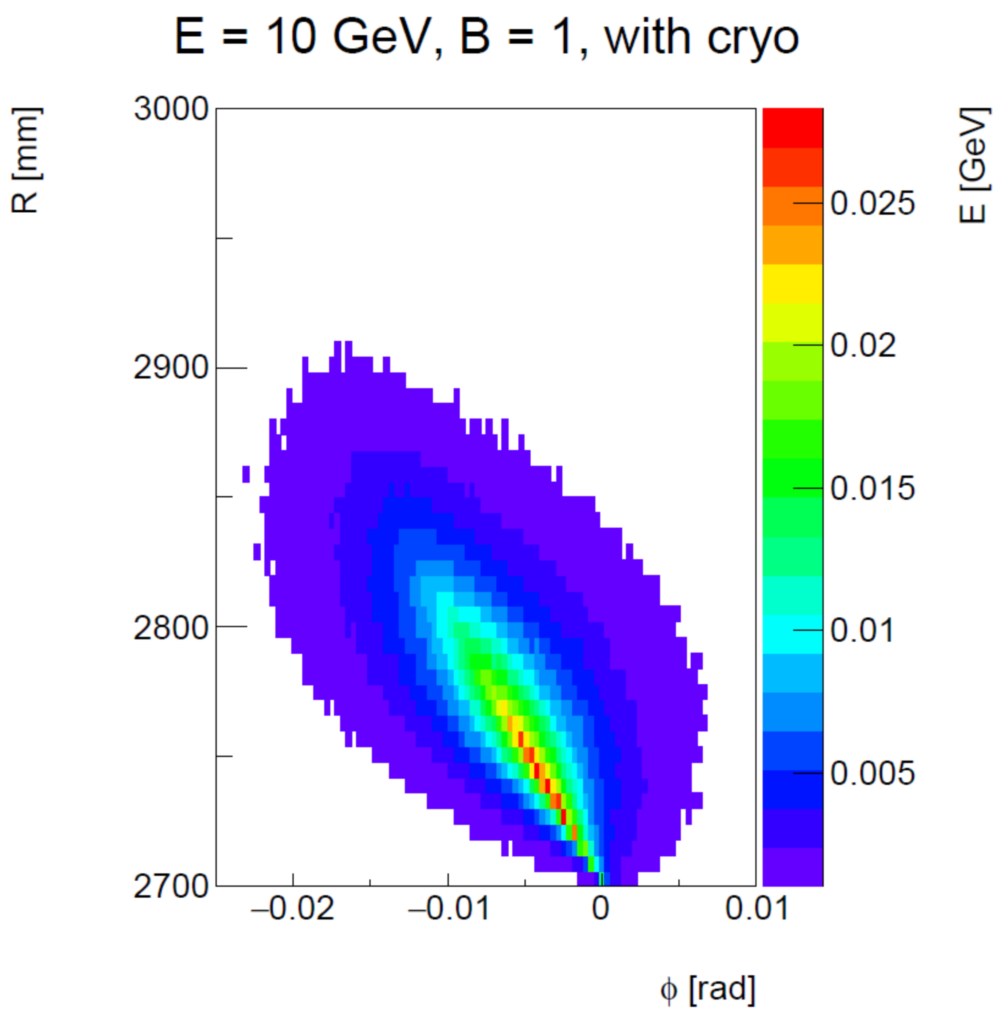
We depicted the **shower evolution** in the Electromagnetic calorimeter and determined the **influence of the magnetic field** on it.

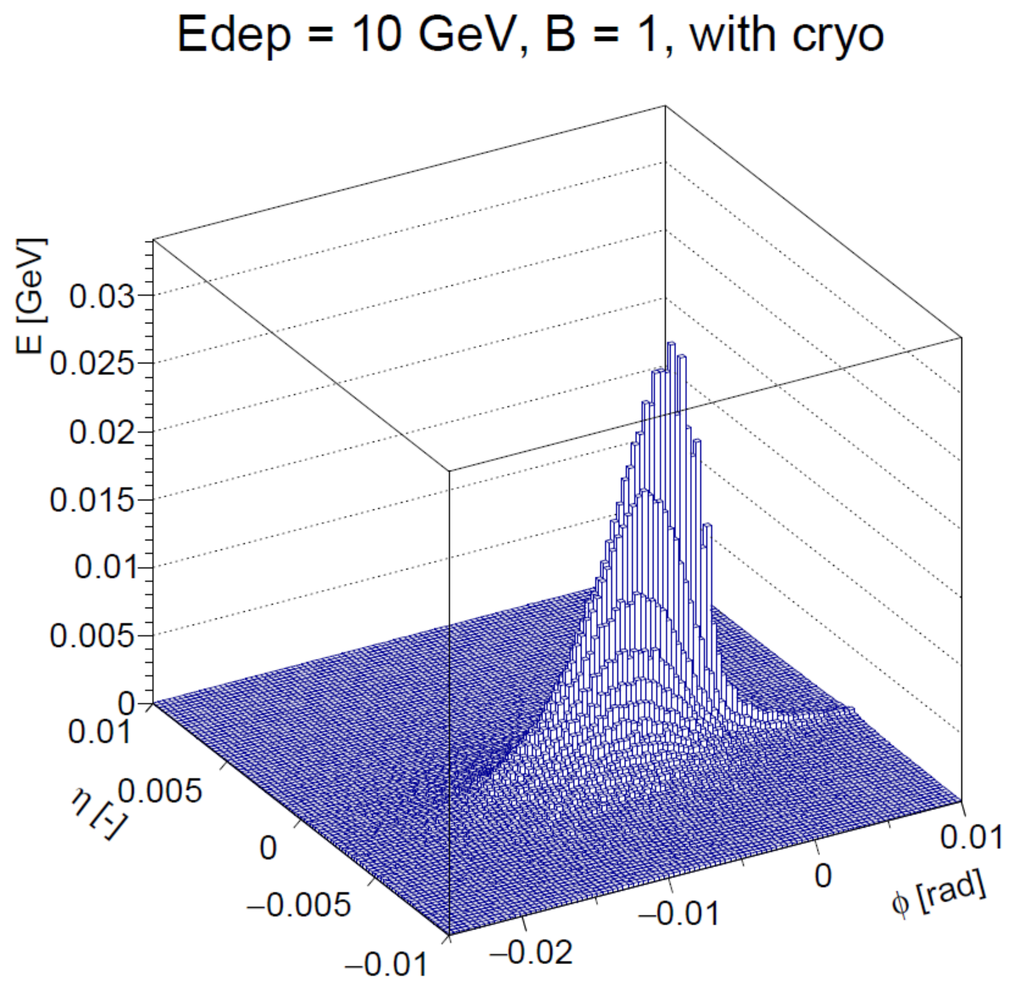
We also **implemented** a simple **clustering algorithm** and **added noise** to the detector cells.

Monte Carlo simulations in the FCC software:

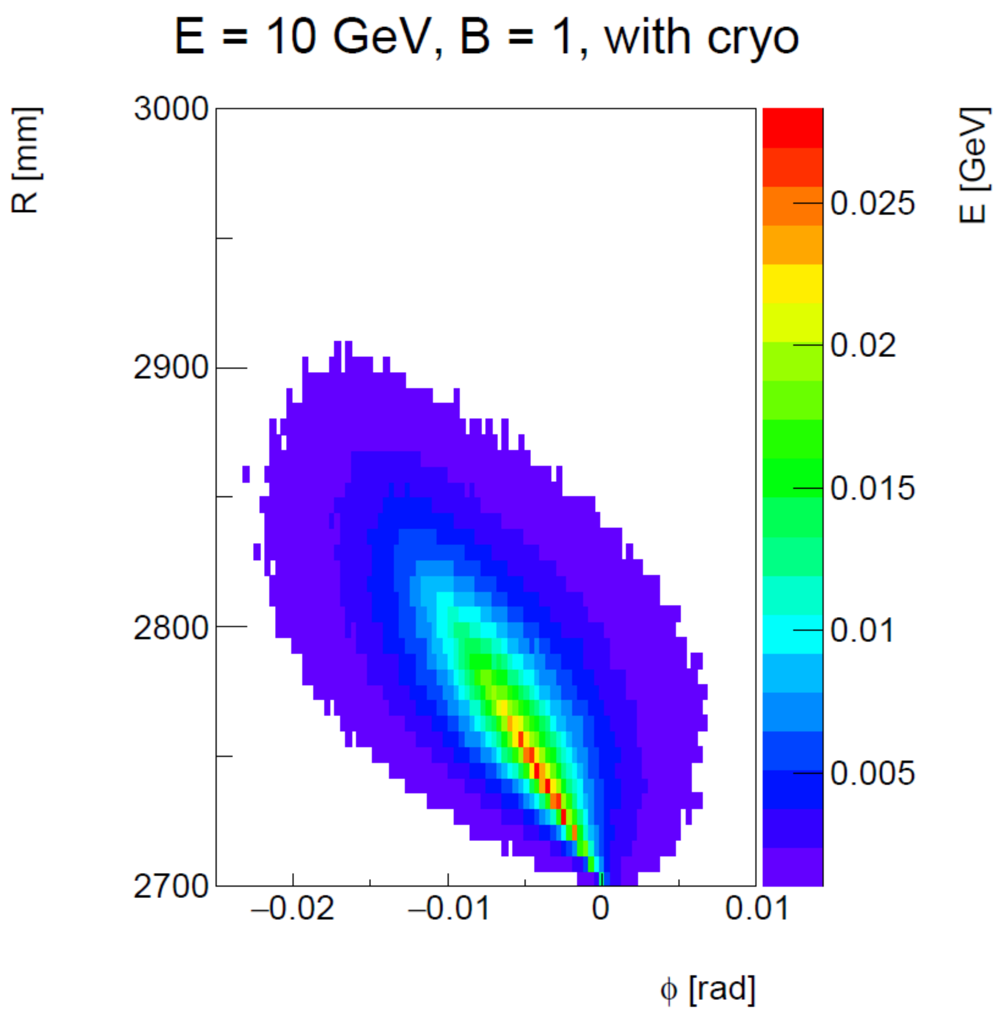
- Single electrons, E = 10, 100 GeV
- $\Phi \in [0,2\pi]$, $\eta = 0$
- B = 0, 6T
- With and without cryostat in front of the calorimeter
- Liquid Argon thickness = 4mm, Lead thickness = 2mm, $R \in$ (2600 mm, 3500 mm)

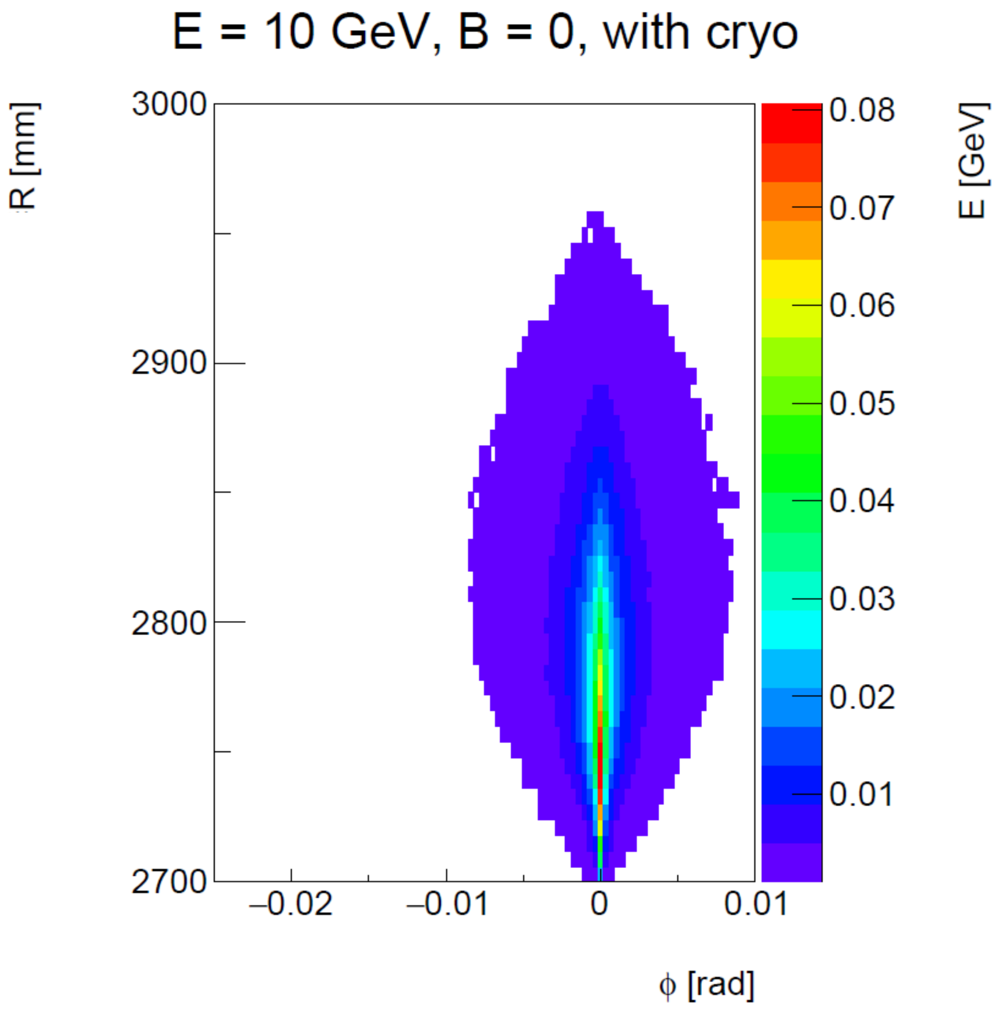
Energy deposition in the calorimeter, 10 GeV electron



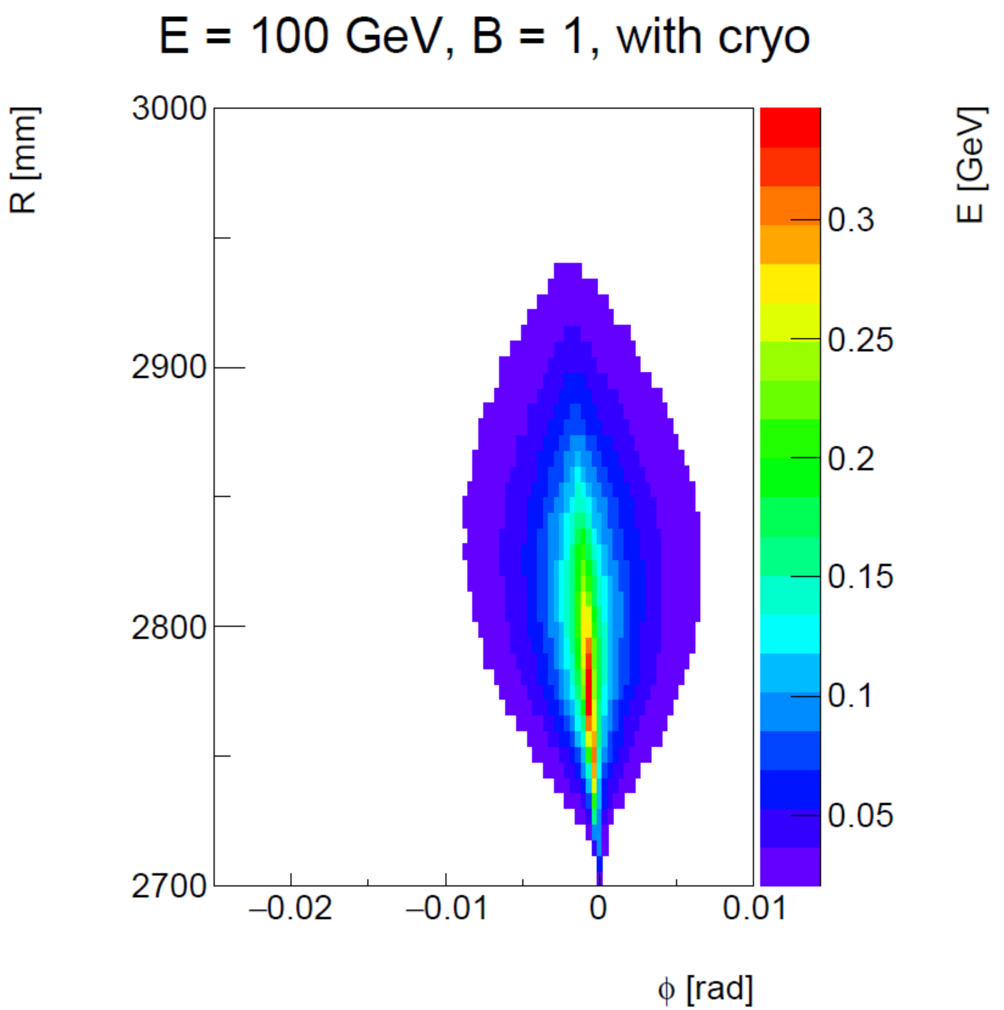


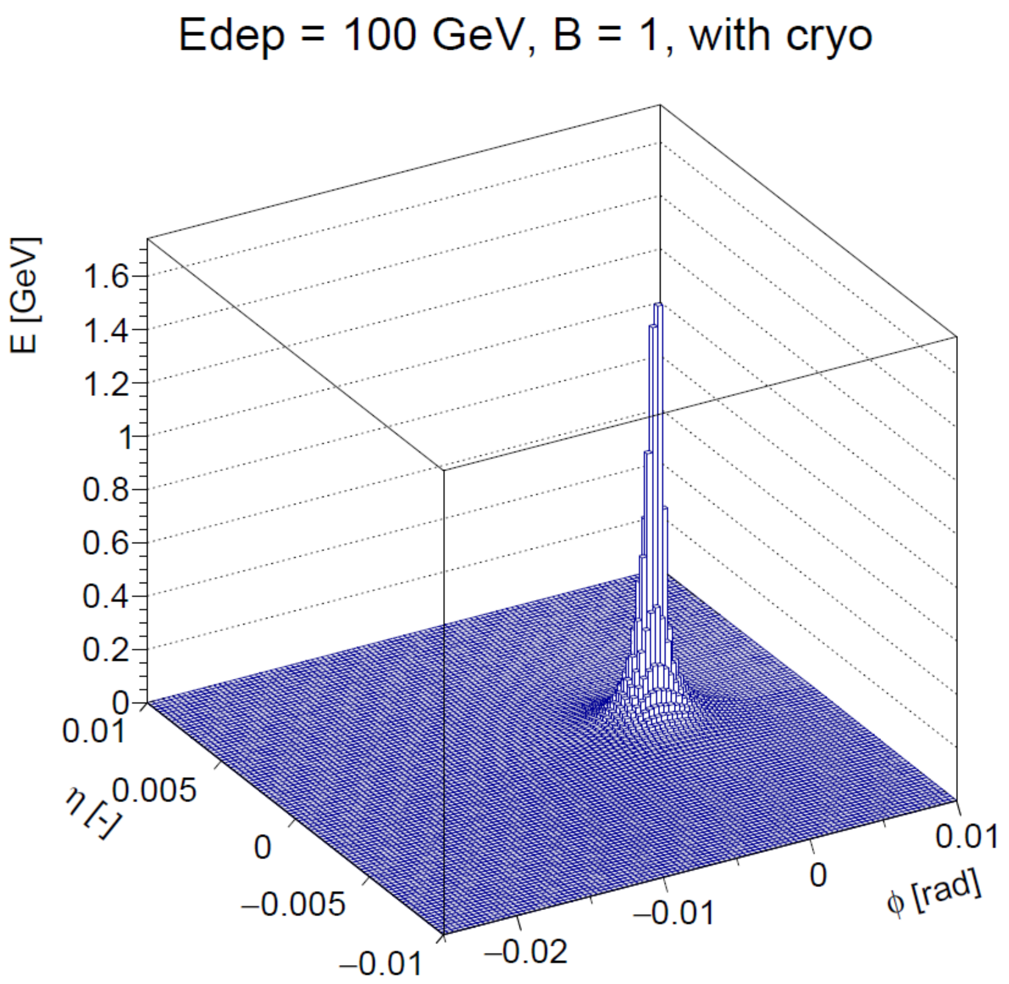
Energy deposition in the calorimeter, 10 GeV electron



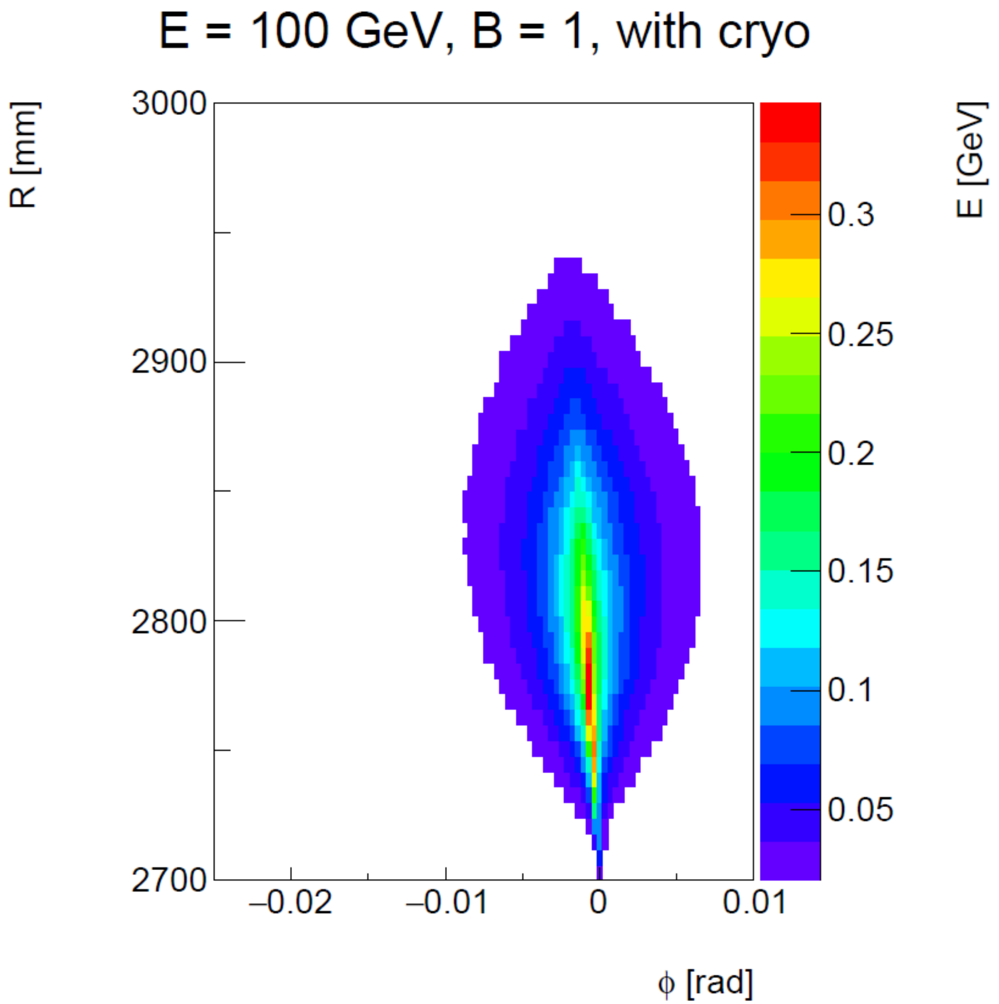


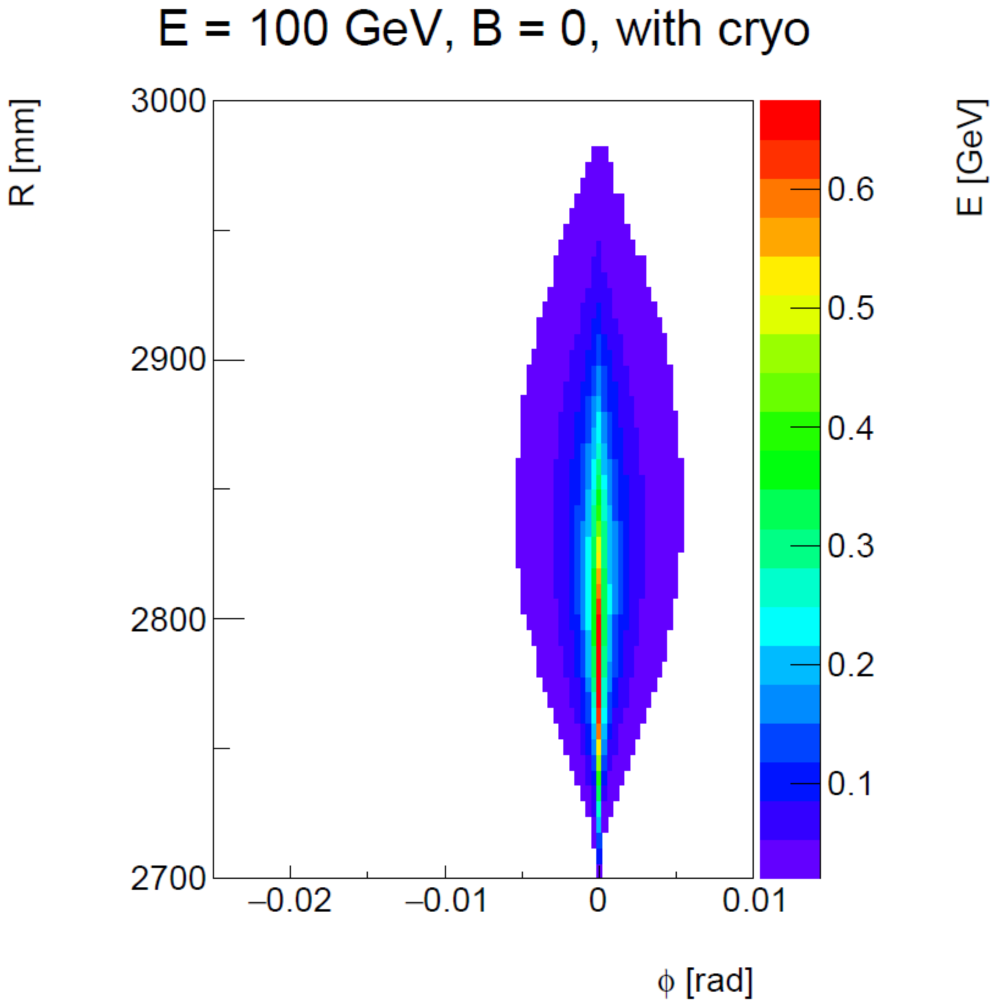
Energy deposition in the calorimeter, 100 GeV electron



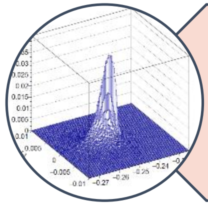


Energy deposition in the calorimeter, 100 GeV electron

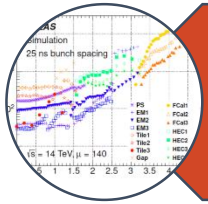




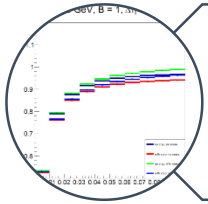
Implementation of clustering and noise



Electromagnetic shower profile



Implementation of noise



Results

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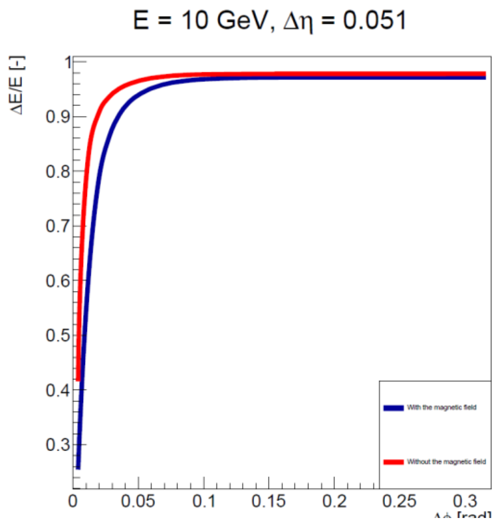
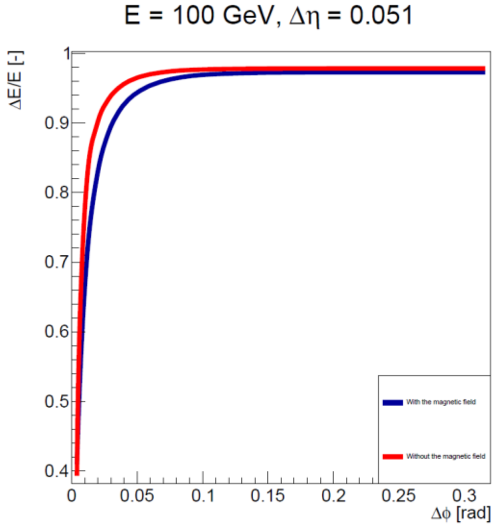
Reminder: Implementation of clustering

Then, we implemented a **simple clustering** algorithm in Φ and η that would help us find a good initial cell size.

- **Impose a large neighborhood** over the bin with maximum energy deposition.
- **Integrate** the deposited energy over the clustering window for **every possible position** in this neighborhood.
- **Store the maximum energy deposit**.
- **Vary the dimensions** of the clustering window in Φ.



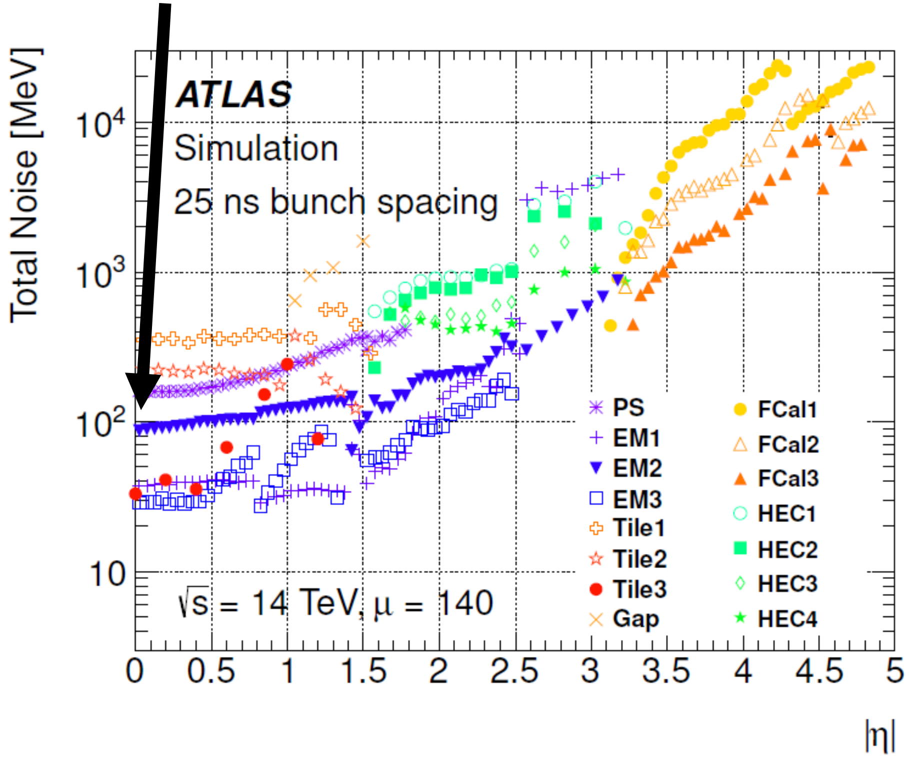


Implementation of noise

Then, we implemented a **uniform Gaussian noise** to the detector cells in Φ and η .

First approximation was obtained from the ATLAS upgrade simulations where σ = 100 MeV (0.025 Φ x 0.025 η).

- For our binning of 0.005 Φ x 0.005 η, σ had to be adjusted to 20 MeV.
- There is no segmentation in R at the moment.
- For the largest cluster size considered (0.1 Φ x 0.05 η), σ = 300 MeV



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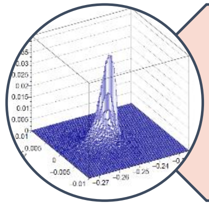
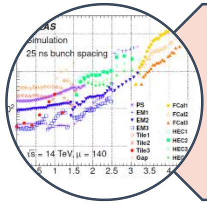
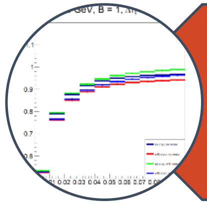


Electromagnetic shower profile



Implementation of noise



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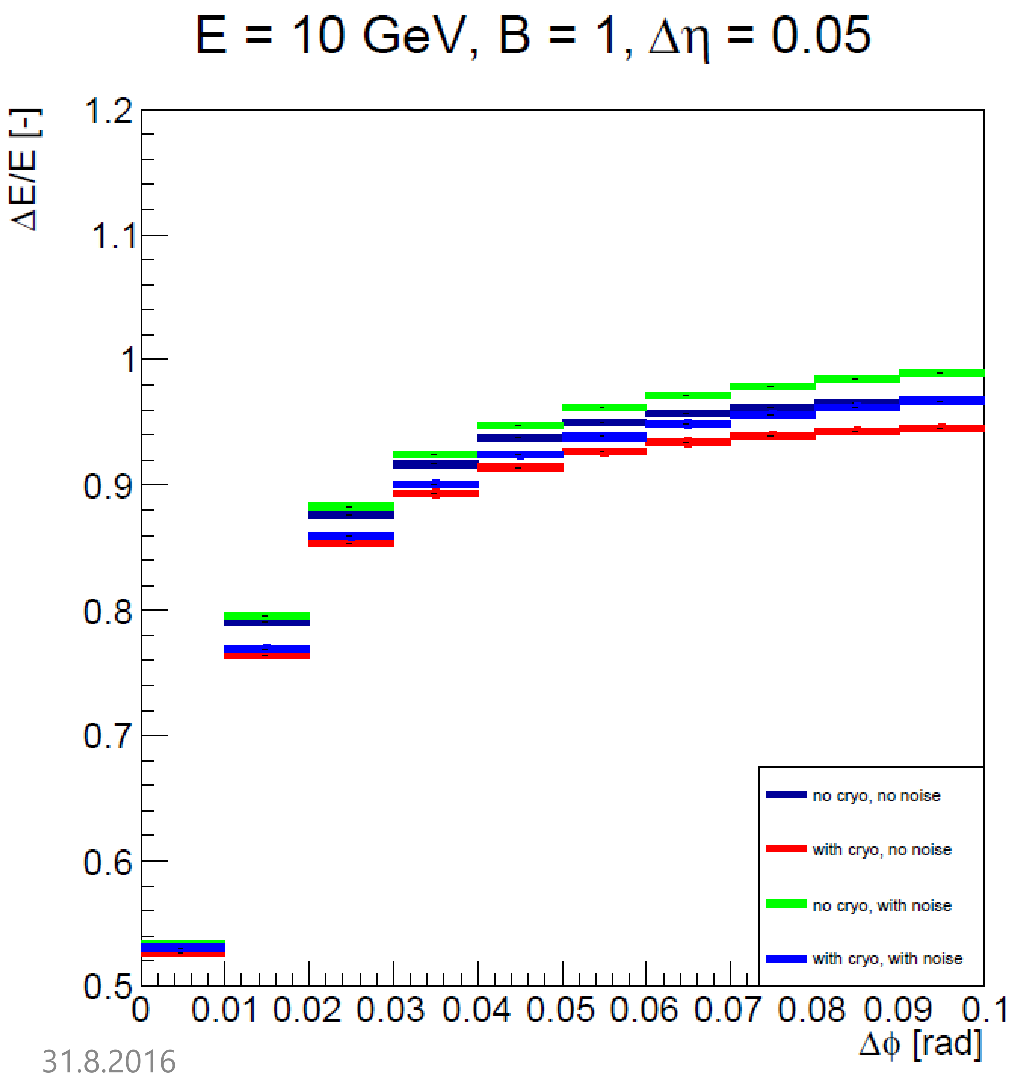
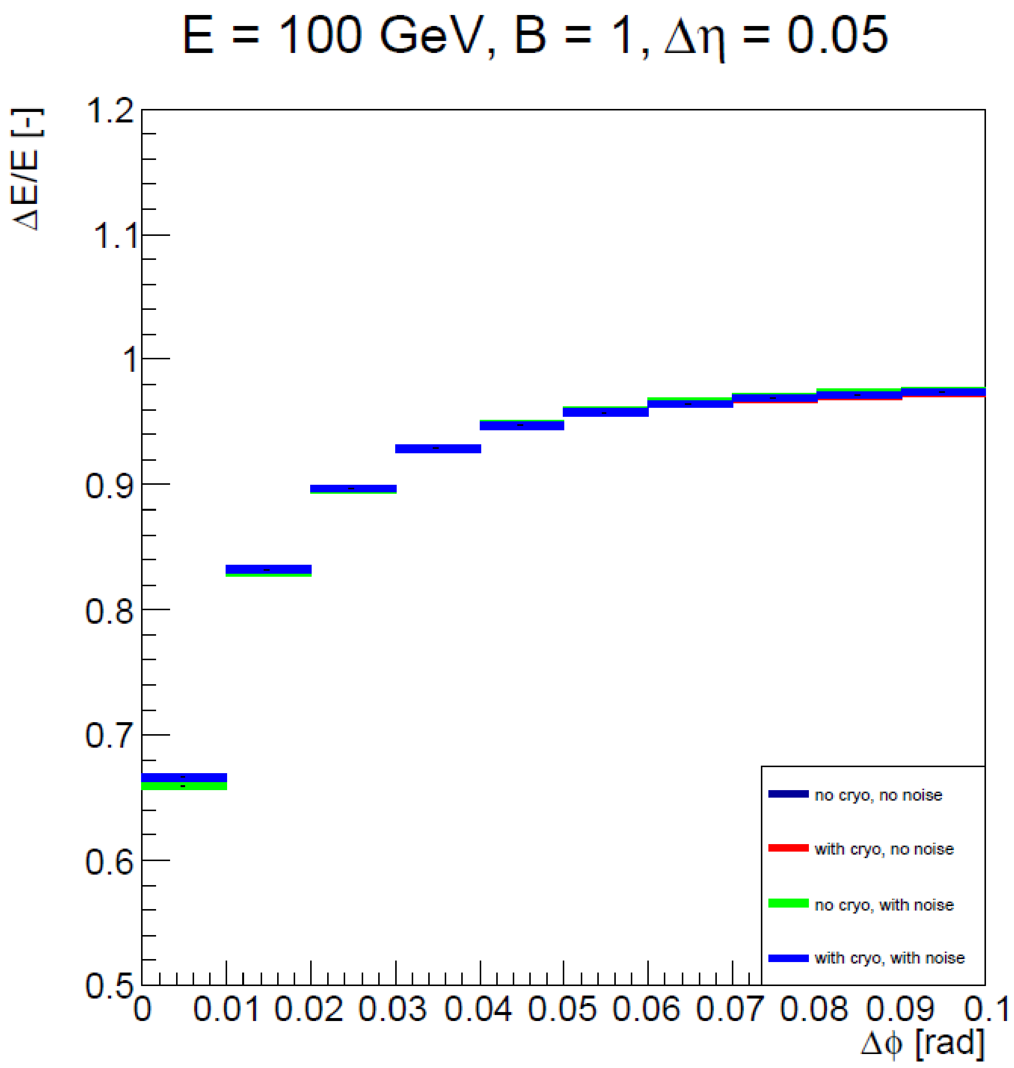

E = 10 GeV, B = 1, Δη = 0.05
ΔE/E [-]
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1
Δϕ [rad]
no cryo, no noise
with cryo, no noise
no cryo, with noise
with cryo, with noise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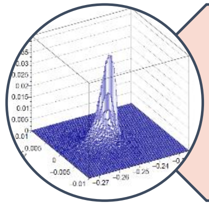
Conclusions



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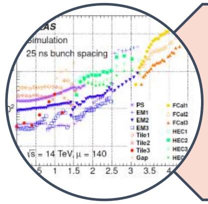

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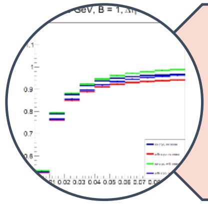

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Geometry of the shower, simple clustering and simulated noise was studied.

- Imposing a magnetic field in the detector **changes** the resulting showers both in their **slope and shape**.
- This effect is smaller for **100 GeV electrons** but still **non-negligible**.
- Addition of the noise increases the energy collected by the simple clustering by **~300 MeV** for the largest clustering window (0.1 Φ x 0.05 η). More sophisticated clustering algorithm is needed.
- Addition of dead material in front of the detector (5 cm cryostat) decreases the deposited energy by **~300 MeV** in the presence of the magnetic field.
- Next: Repeat the simulation with **new dimensions** and **include tracker**.

Thank you for your attention

Ecal thickness vs energy resolution

- Energy resolution: $\frac{\sigma}{E} = \frac{a}{\sqrt{E}} \oplus \frac{b}{E} \oplus c$

a: stochastic term (statistical fluctuations)
b: noise term (electronic noise) – we set it to zero
c: constant term (leakage, uniformity)

- Simplified Ecal simulations with single electrons at different energies (from 20 to 1000 GeV)
  - No B field, no cryostat, no noise
- Difference in the resolution between 30 X_0 and 25 X_0 is very small
  - Current default is 30 X_0 (in ATLAS at η = 0: 22 X_0)
  - Ecal depth of 25 X_0 could be considered

Example: 6 mm LAr + 4 mm Pb

ECAL depth (X_0)	*a*	*c*
25	10.1%	0.53%
27	10.4%	0.36%
30	10.6%	0.20%