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Performance Studies of the ALLEGRO Electromagnetic Calorimeter

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Introduction

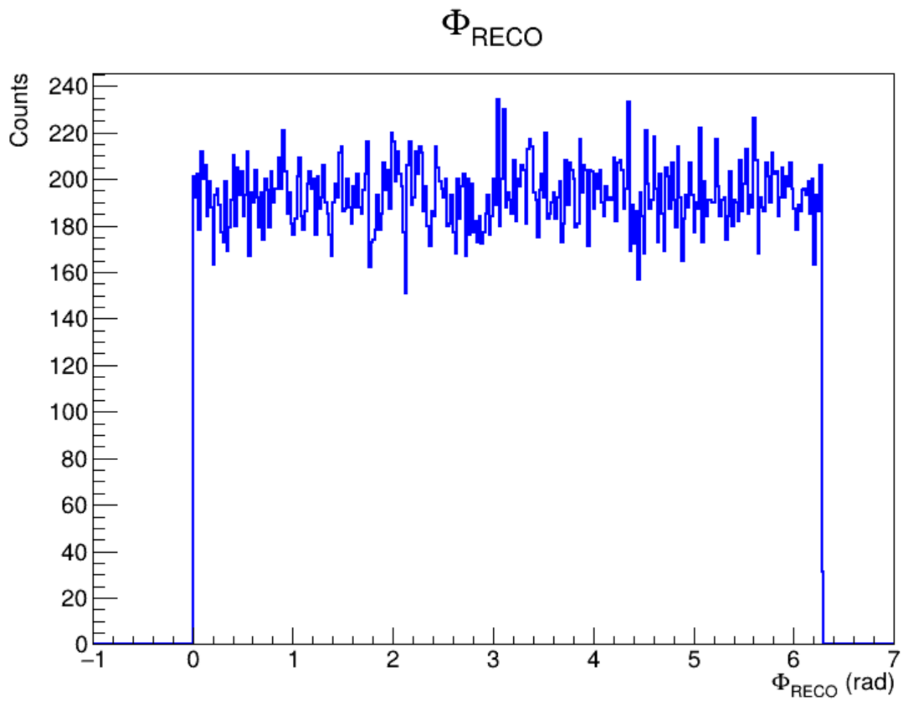
- Software setup
- Clusters Energies distribution
- Resolution
- Moliere Radius
- Summary & Conclusion

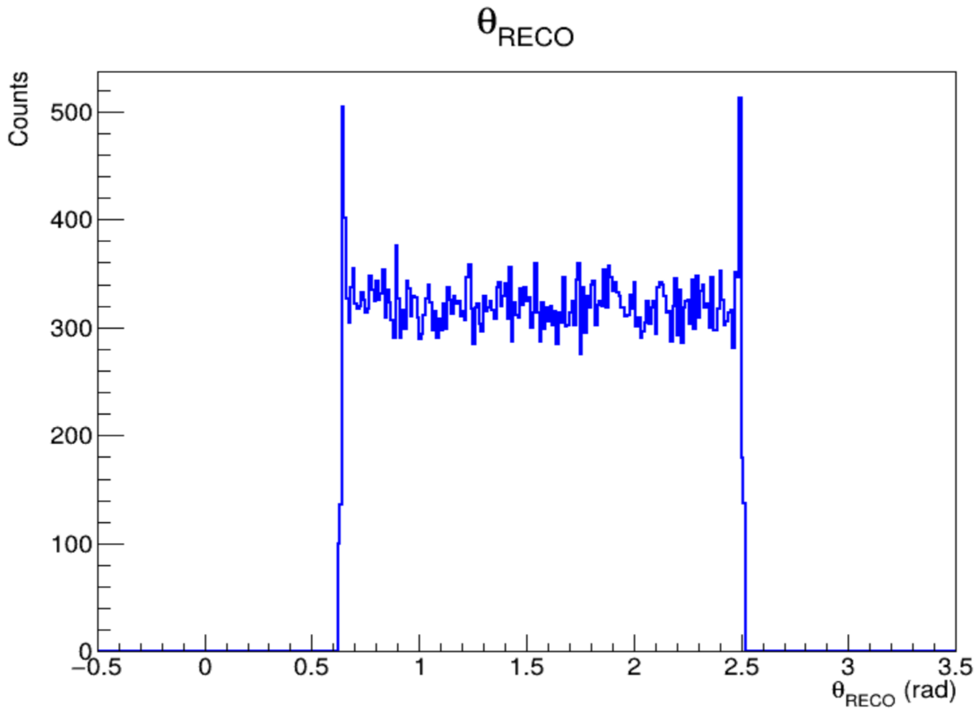
Software Setup

- Electron particle gun with flat distributions in **θ** and **ϕ**
- Focus on the barrel of the electromagnetic calorimeter
- 7 energies : 1, 2, 5, 10, 20, 30, 45.6 GeV
- 4 configurations (Active Medium/ Absorber) : **LAr/Pb, LKr/Pb, LAr/W, LKr/W**
- **100k** events per energy and per configuration
- Simulation and digitization using the Key4HEP software (thanks to Brieuc and Giovanni)
- Calibration via BDT regression (**only for Ar/Pb**)
- For the other configurations, **a constant scale factor was applied** to align the peak at 45.6 GeV

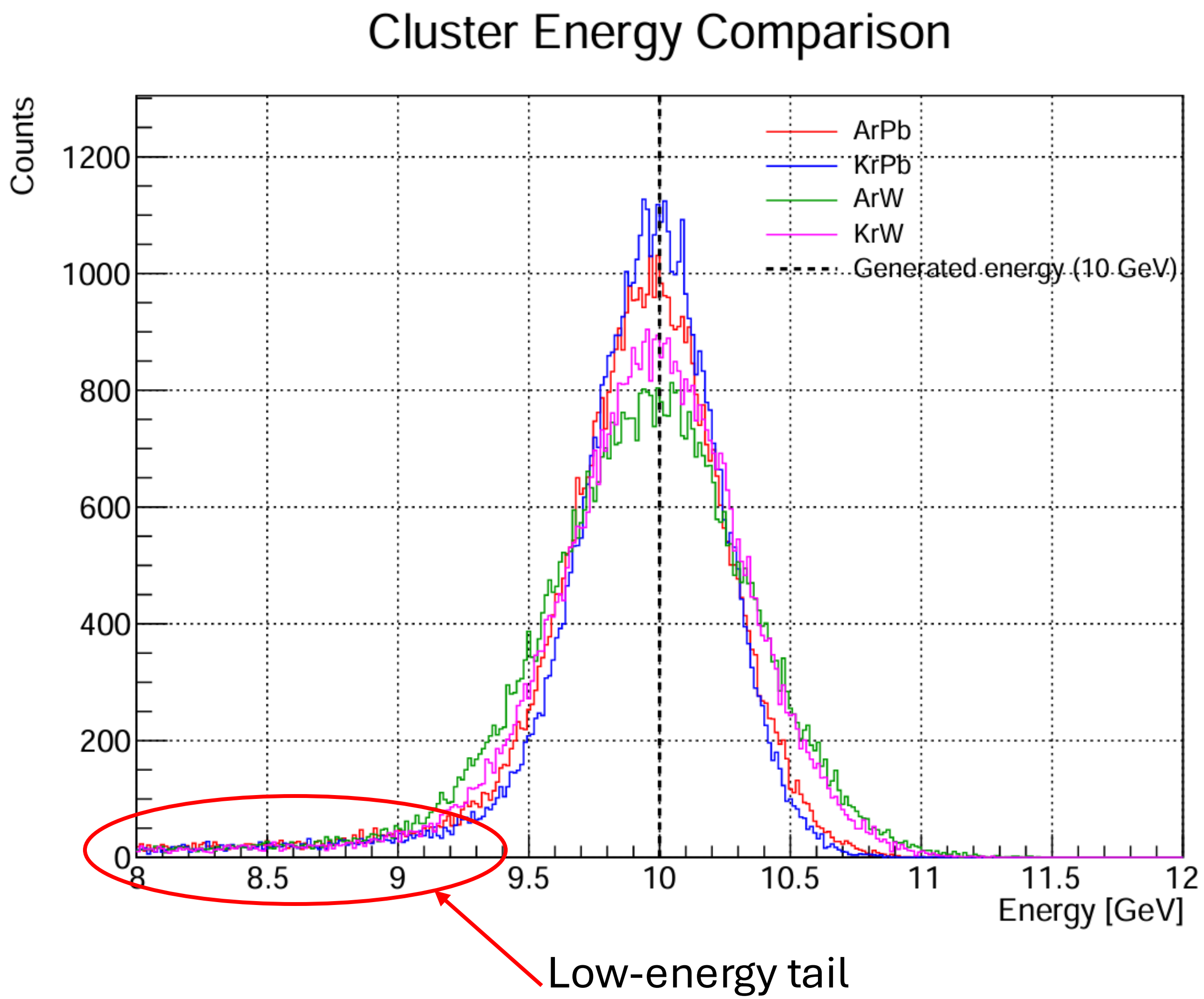
Events selection & reconstruction

- Analysis of clusters only in the barrel
- Cluster reconstruction based on sliding window algorithm
- For energy resolution : **all clusters.**
- For the Moliere radius : **N# particle = 1 AND N# Cluster = 1**.

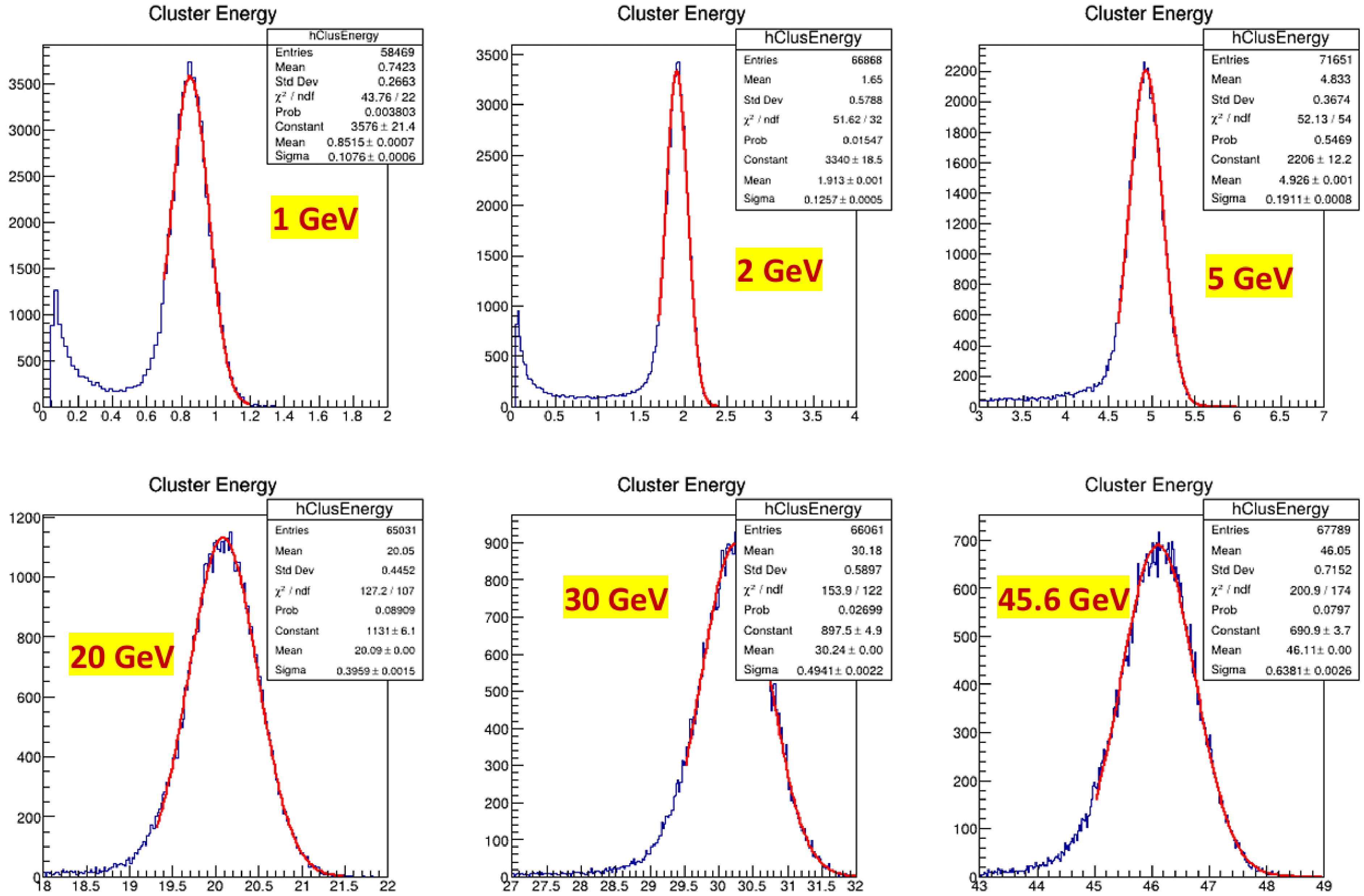




Cluster Energy Distributions



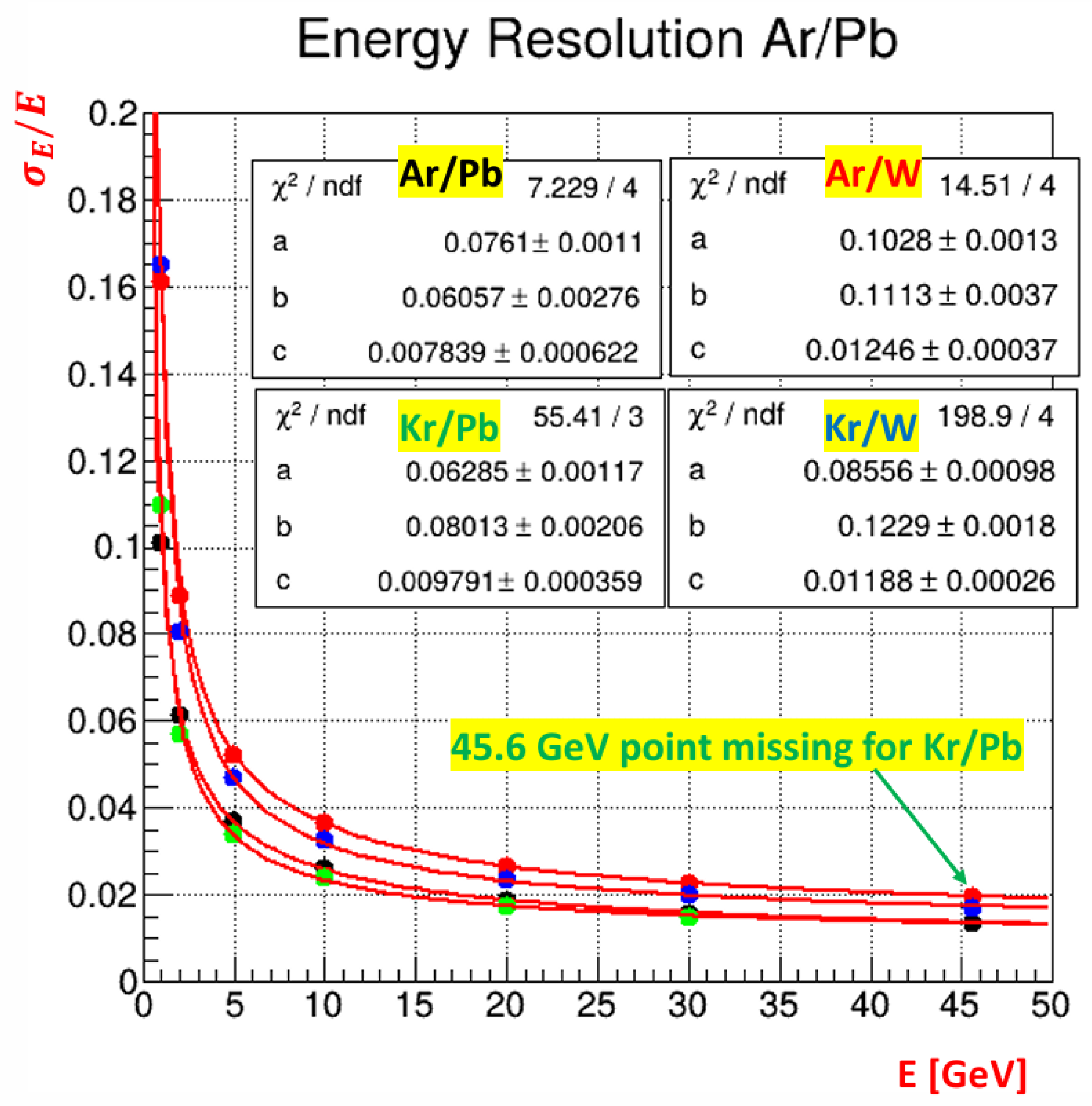
- Only **Ar/Pb** is fully calibrated
- Other setups (Kr/Pb, Ar/W, Kr/W) use **simple scale factors**
- After rescaling, all peaks are aligned
- Low-energy tail present
- Because of this, fit ranges will be optimized by hand to get a good $\boldsymbol{\chi 2}$



Ar/Pb

Visualisation of the gaussian fit of the energy distribution for each energy point

Resolution



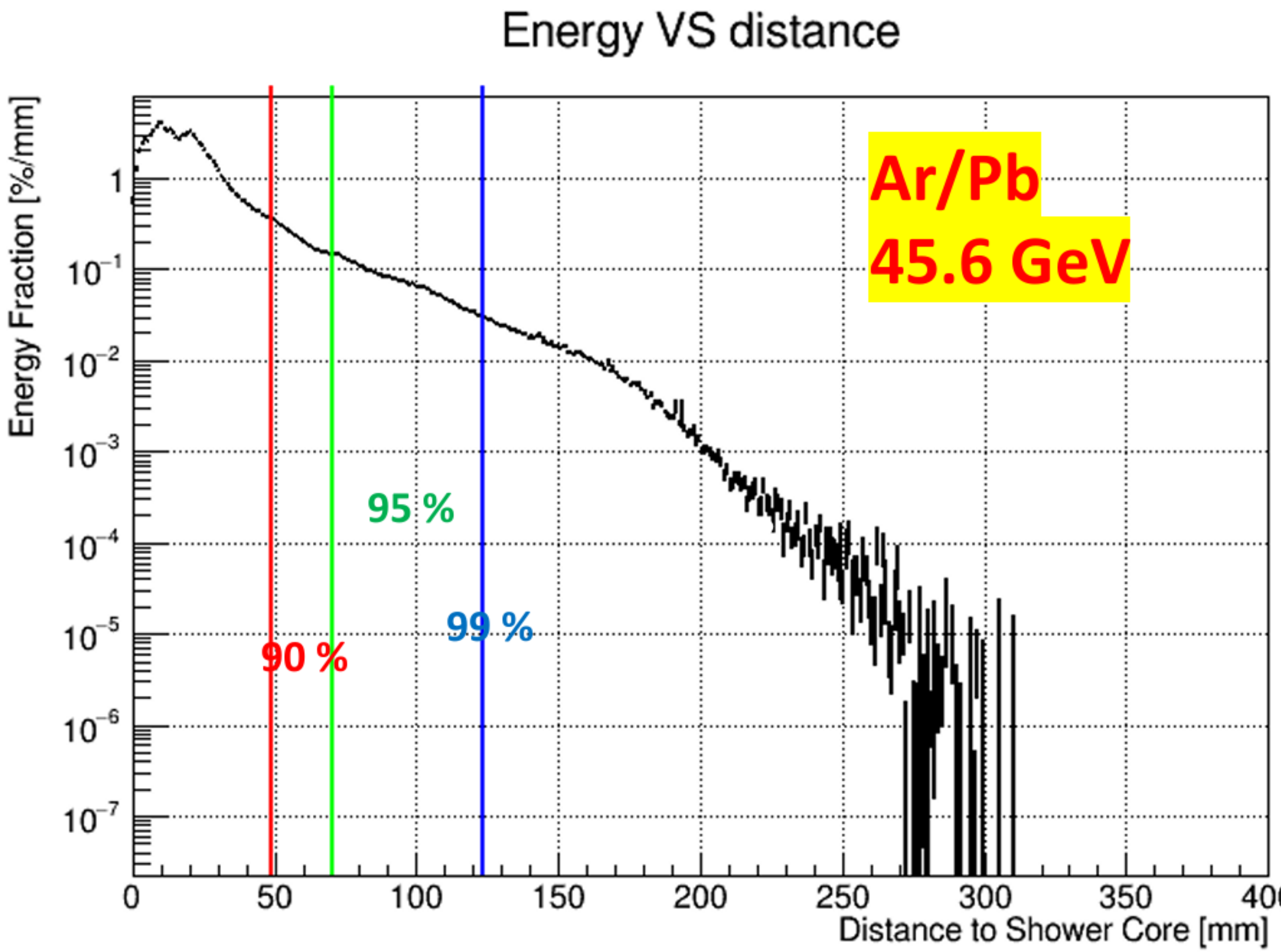
$$\begin{array}{cc} & \begin{array}{ccc} a & b & c \end{array} \\ \begin{array}{c} a \\ b \\ c \end{array} & \begin{pmatrix} 1 & -0.912 & -0.7396 \\ -0.912 & 1 & 0.6243 \\ -0.7396 & 0.6243 & 1 \end{pmatrix} \end{array}$$

- We observe two groups based on the absorbers : **Pb** and **W**
- For both, Kr has the best resolution
- So **Kr/Pb** shows the best resolution across all energies

Moliere radius

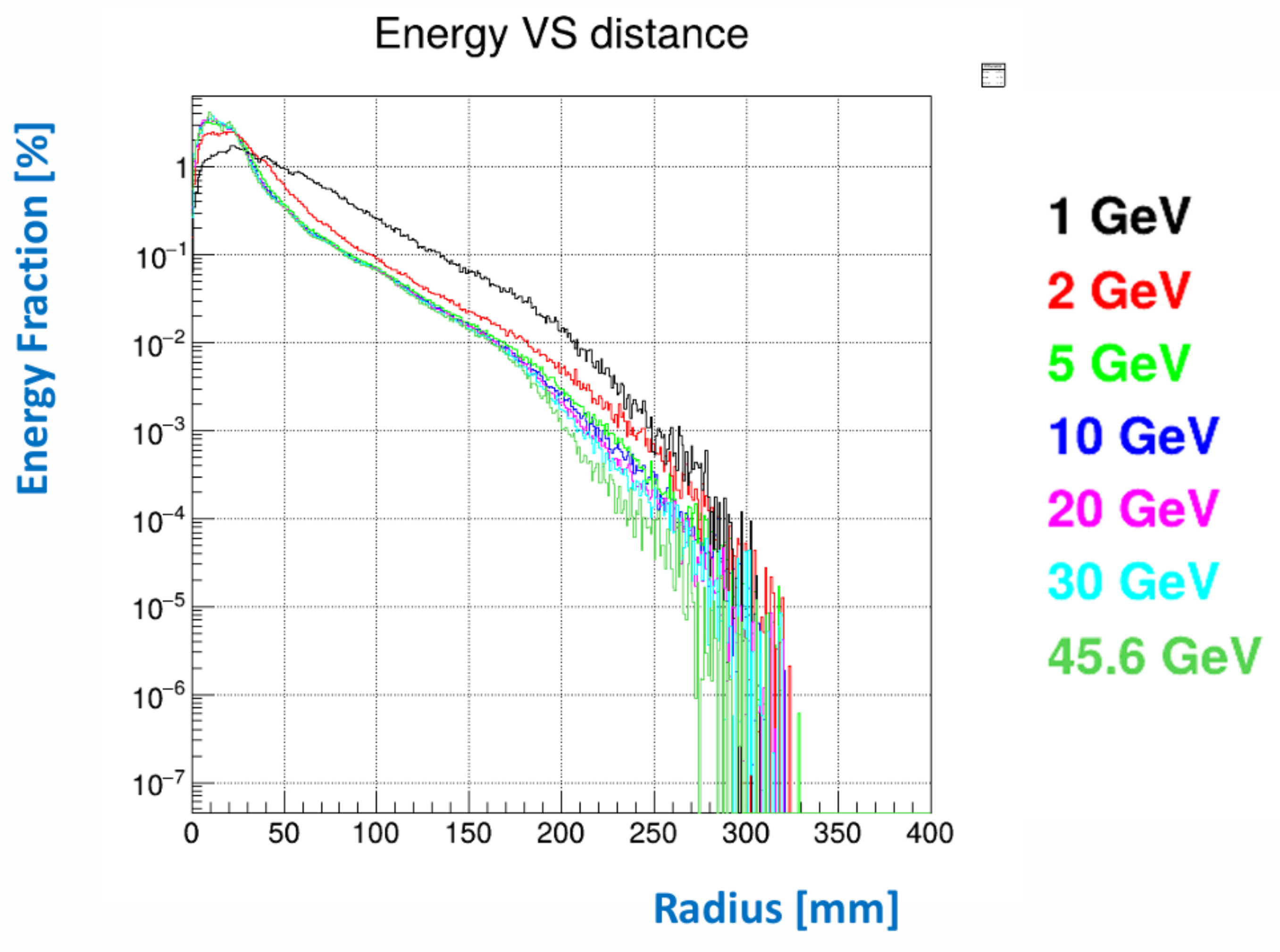
- Moliere Radius quantifies the transverse containment of EM showers.
- Smaller RM → better separation
- Important parameter for jet reconstruction.
- We only considered events with **one particle** and **one cluster** in the barrel
- Moliere Radius is estimated with the **Energy Lateral Profiles** as the radius containing:
  - 90% of the shower energy: RM
  - 95% → 2 × MR
  - 99% → 3.5 × MR

An Example



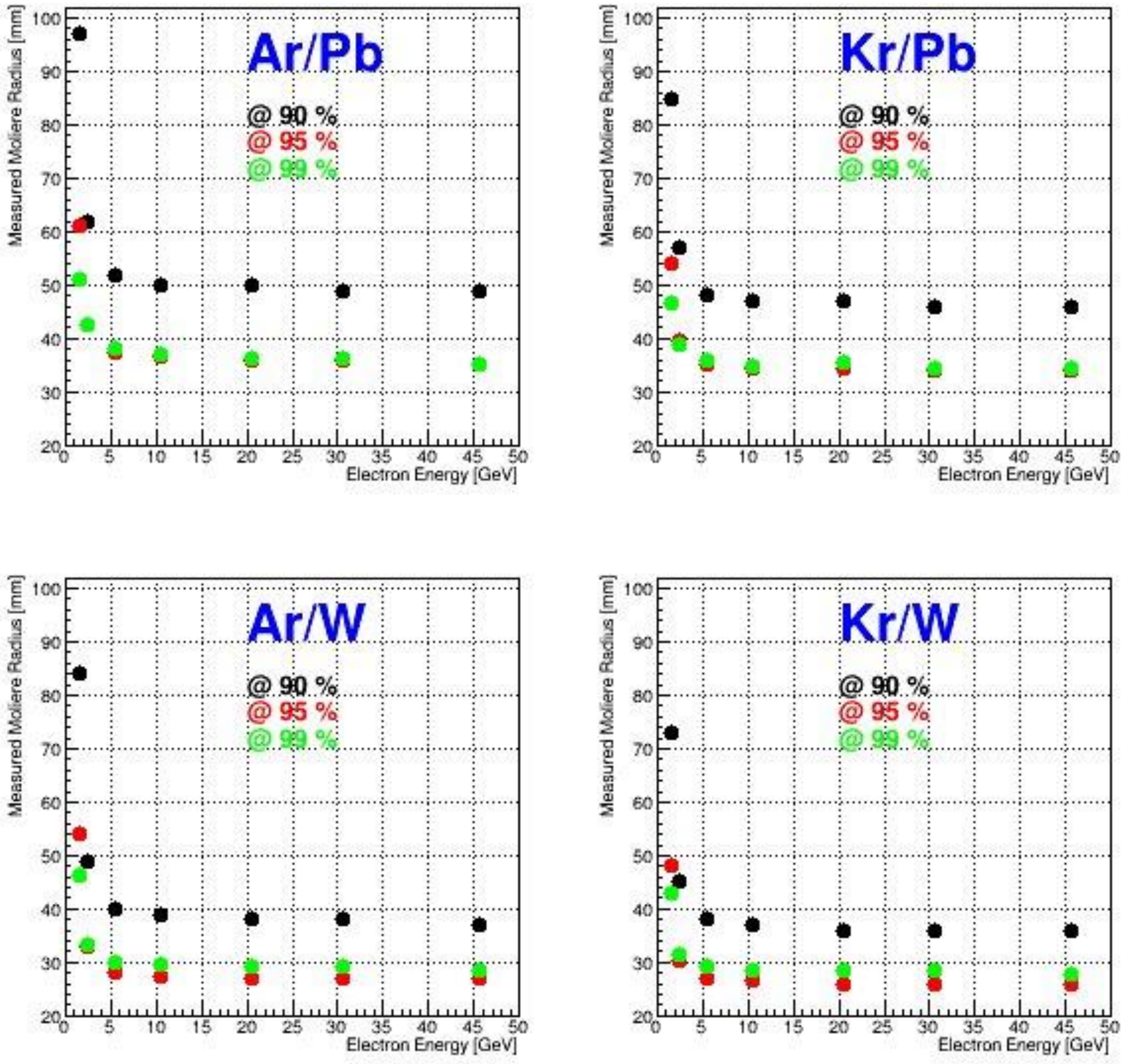
- R90% = 49 mm, so RM = 49 mm
- R95% = 70 mm, so RM = 35 mm
- R99% = 123 mm, so RM = 35.1mm

Longitudinally Integrated Shower Profiles for Ar/Pb



- **1 and 2 GeV** transverse profiles are different from others because of **energy lost before calorimeter**.
- at the shower **core** energy fraction **decreases** because of effect of **finite granularity**

Comparison of Moliere radii for all configurations



- At high energies, the **95%** and **99%** estimators converge towards the same value.
- We use MR obtained from the 99% measure and highest energy.
- **Absorber** material is the **main driver**.
- Thinner showers with Tungsten.

Results obtained with **45.6 GeV**, using the **99%** measure :

Material	Ar/Pb	Ar/W	Kr/Pb	Kr/W
	35.1	28.6	34.3	27.7

Conclusion

- **Resolution** is guided by **Active Material** : better with Krypton.
- **Moliere radius** is guided by **absorber** : better with Tungsten.
- Use thinner Tungsten absorber, to increase sampling fraction. Optimisation needed to keep a low MR
- Need to better understand the simulation to set quality cuts.
- Need to learn how to run calibration.