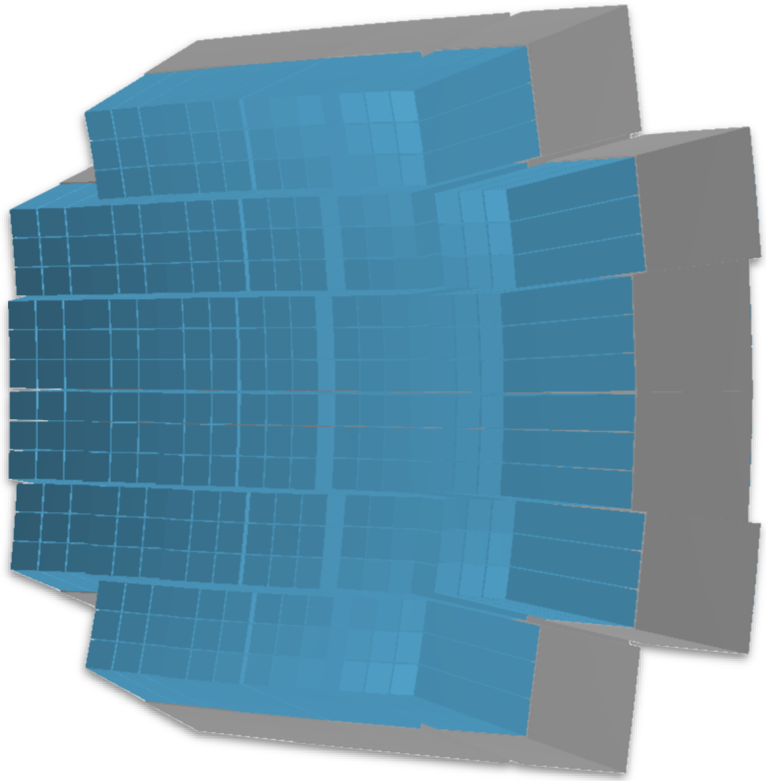
Cluster reconstruction inside the calorimeter with Shoe



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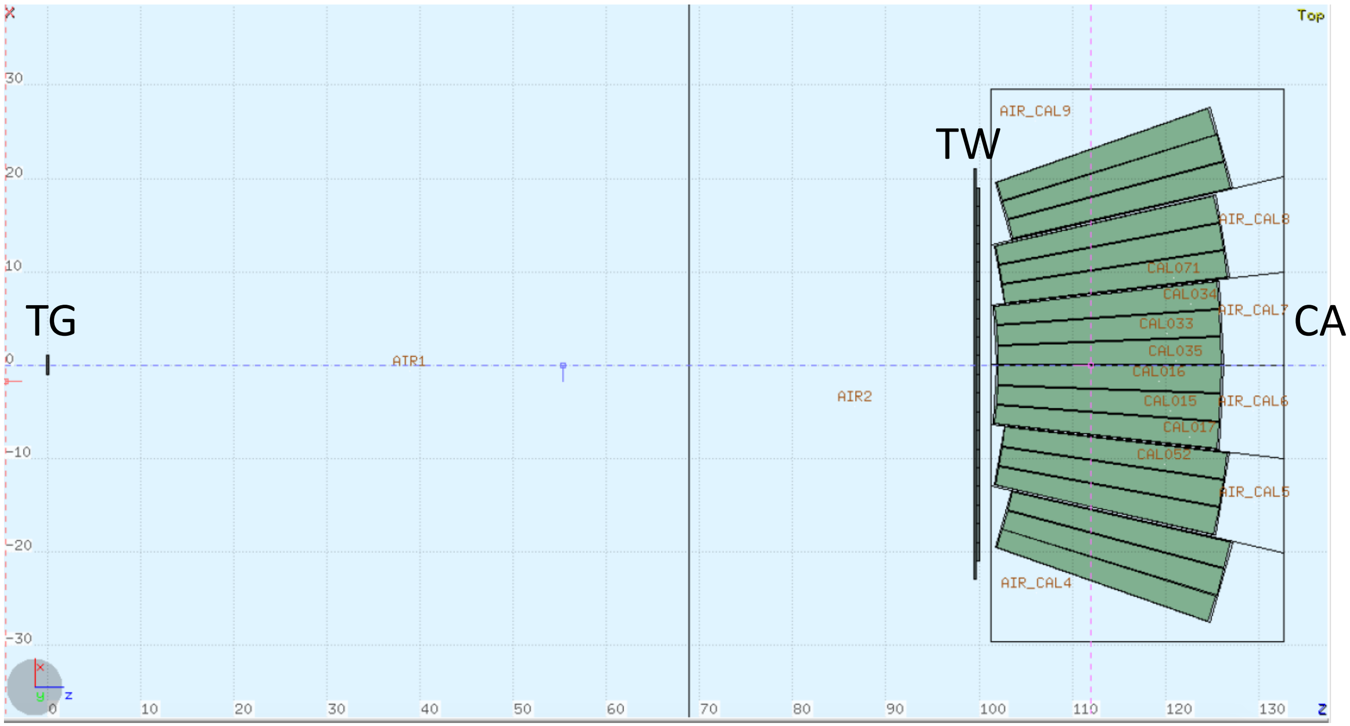
Aim of this study

- ✓ In SHOE there are classes responsible for the events reconstruction in FOOT. In the following I will focus on the stand-alone calorimeter classes
- ✓ For each interaction of a particle inside the calorimeter, fragmentation can occur
- ✓ We are studying how efficiently fragmentation events are reconstructed inside the calorimeter with the SHOE software
- ✓ In particular we have simulated a carbon beam of 200 MeV/A and a simplified geometry including the target (TG), the tof wall (TW) and the calorimeter (CA)



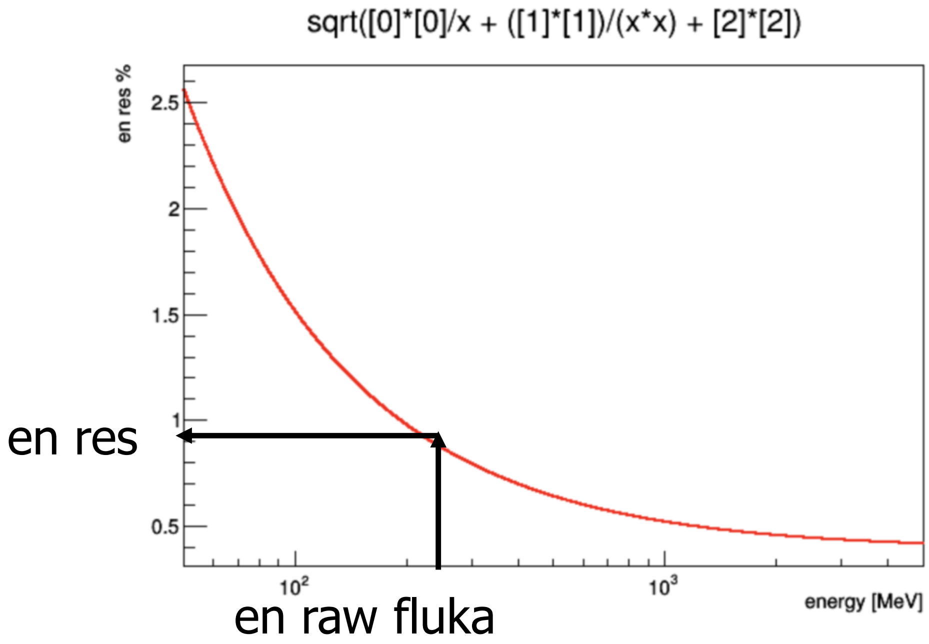
Events reconstruction in SHOE

- For each event of interaction of a C projectile with the target a certain number of fragments is created
- Let's now focus on one fragment reaching the calorimeter

- The fragment releases energy in the calorimeter and there's a class responsible for the analysis of each energy release (TACAactNtuMC)
- The raw energy is provided by FLUKA and digitalize by a specific class (TACAdigitizer)

Events reconstruction in SHOE

- TACAdigitizer takes as input the raw energy provided by FLUKA
- If the raw energy exceeds a certain threshold, a gaussian smearing is applied with a σ given by the calorimeter energy resolution



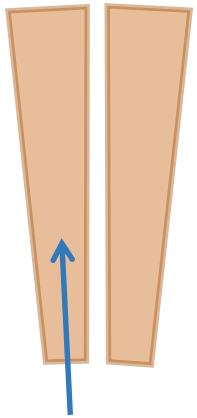
- TACAdigitizer creates also the «hit»
- An hit is an object containing:
  - The ID of the crystal where the particle released its energy
  - The total energy released
  - The information related to all the particles entering in that crystal and releasing energy
  - ....

Events reconstruction in SHOE

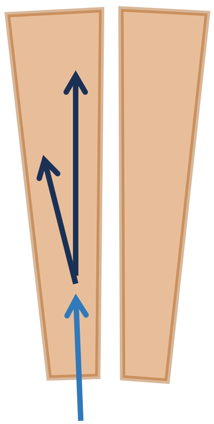
- ✓ For each particle reaching the calorimeter fragmentation can occur (one particle creates n daughters)
- ✓ These daughters are grouped together by the cluster algorithm implemented in SHOE
- ✓ TACAactNtuCluster and TACAntuCluster are the classes responsible for the clusters
- ✓ If more crystals are hit, they are grouped together in a cluster
- ✓ Considering the total number of clusters, how many are reconstructed in a correct way (good cluster)?

Cluster typologies

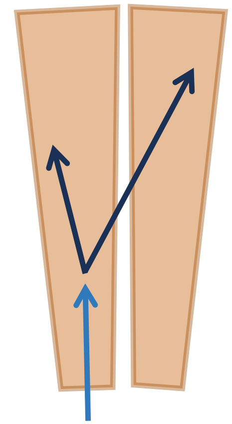
✓ **Good Clusters**:



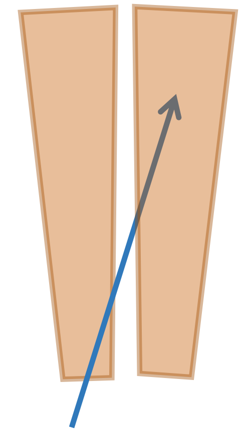
primary fragment hits one BGO



primary fragment + secondary fragments in 1 BGO

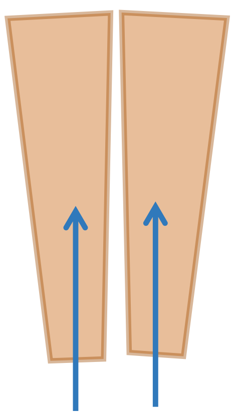


primary fragment + secondary fragments in 2 BGOs

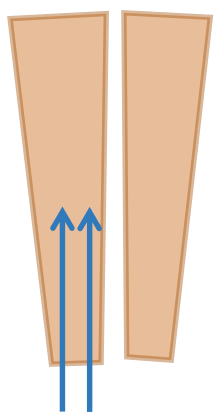


primary fragment hits 2 BGOs

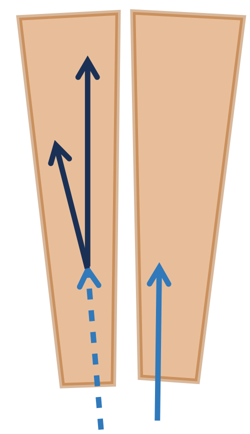
✓ **Bad Clusters**:



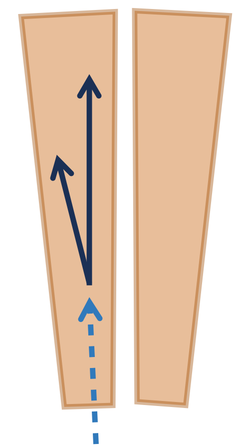
2 primary fragments hit 2 BGOs



2 primary fragments hit 1 BGO



secondary fragments from a primary neutron



secondary fragments from a primary neutron

Efficiency and purity

$$eff = \frac{\#frag\ reconstructed}{\#frag\ arrived}$$

→ Fragments created in the target, directed towards the calorimeter and reconstructed (seen) by the SHOE classes

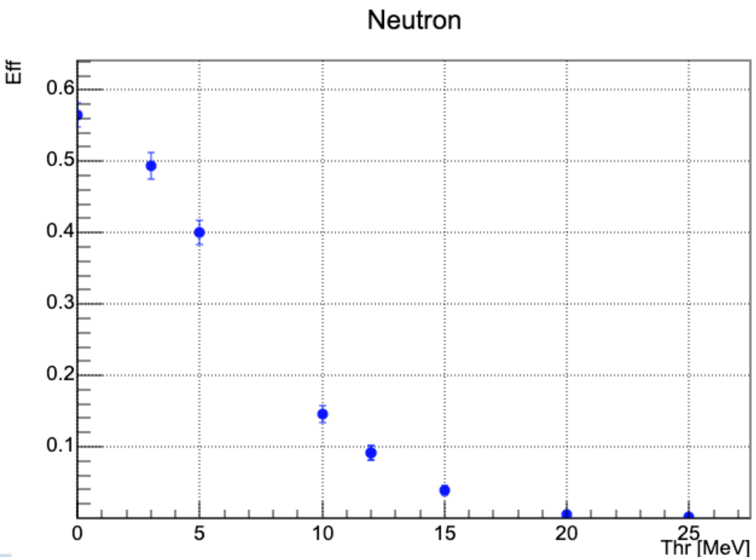
→ Fragments created in the target and directed towards the calorimeter (MC truth)

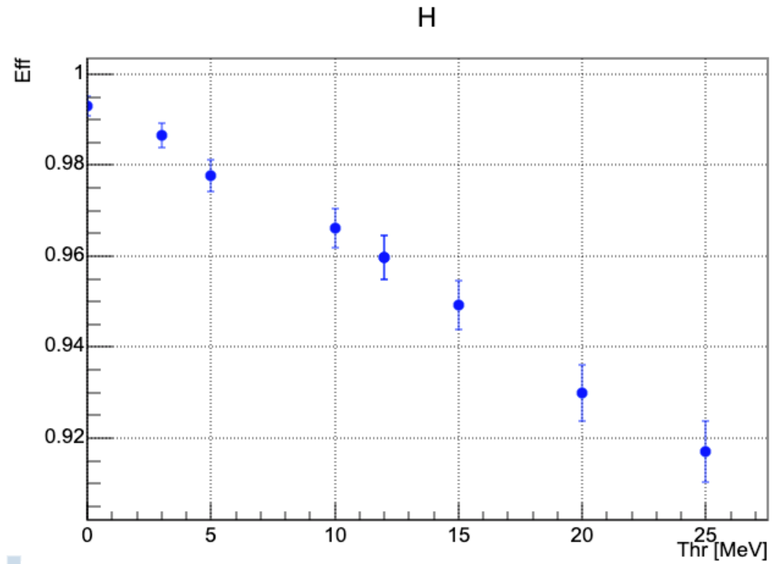
$$pur = \frac{\#good\ clusters}{\#clusters}$$

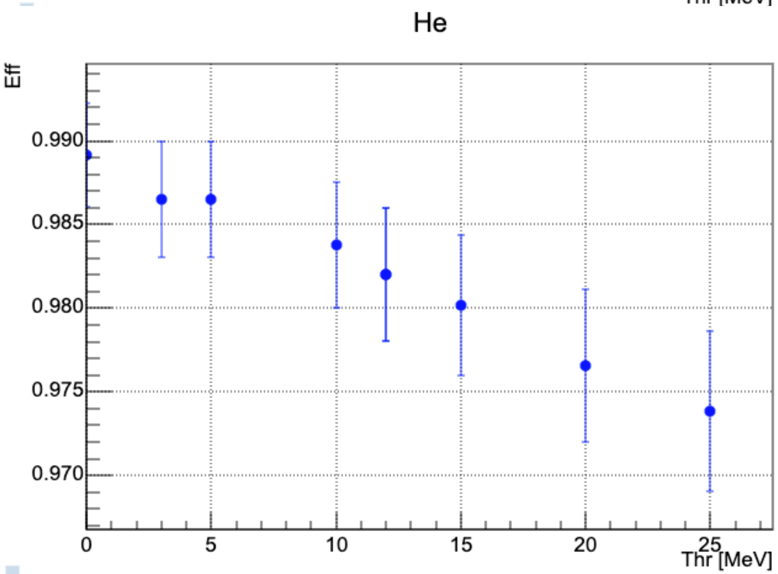
- ✓ The analysis has been performed for different ions ($0<Z<6$) as a function of different values of the energy thresholds (0, 3, 5, 10, 12, 15, 20 and 25 MeV).
- ✓ In particular for Z=1 and Z=2 (where the statistic was higher) we have analysed different kinetic energy intervals of the primary fragments

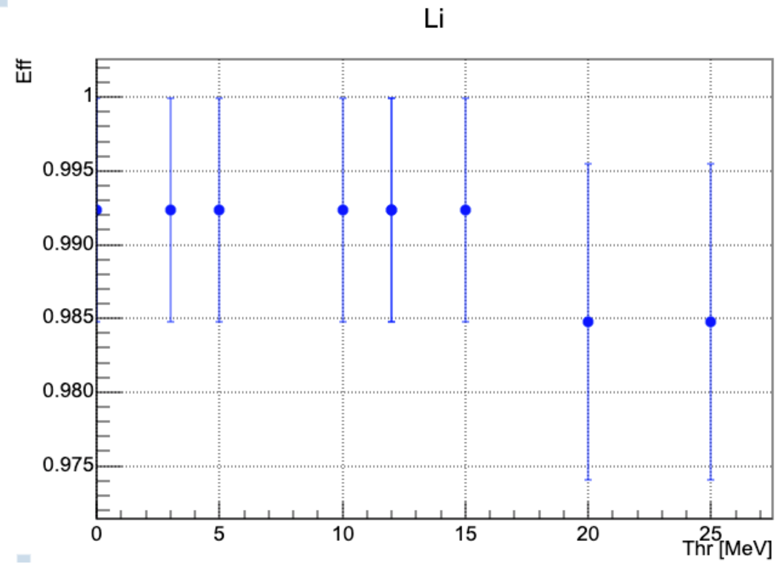
Efficiency

The study shown has been performed taking into account the full kinetic energy interval (0-2.4 GeV) of the primary fragments

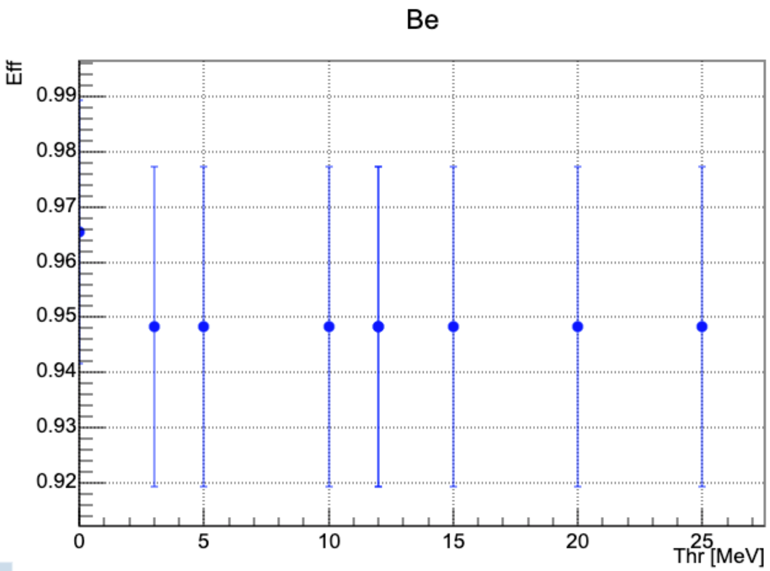


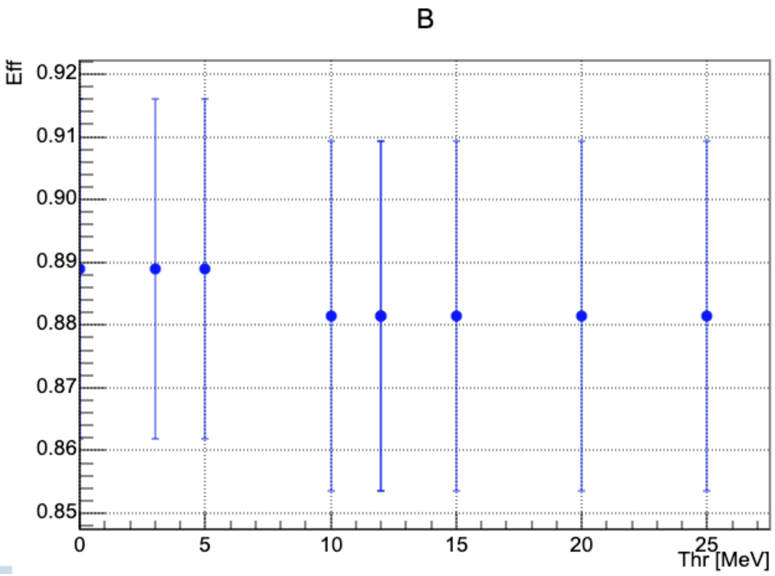


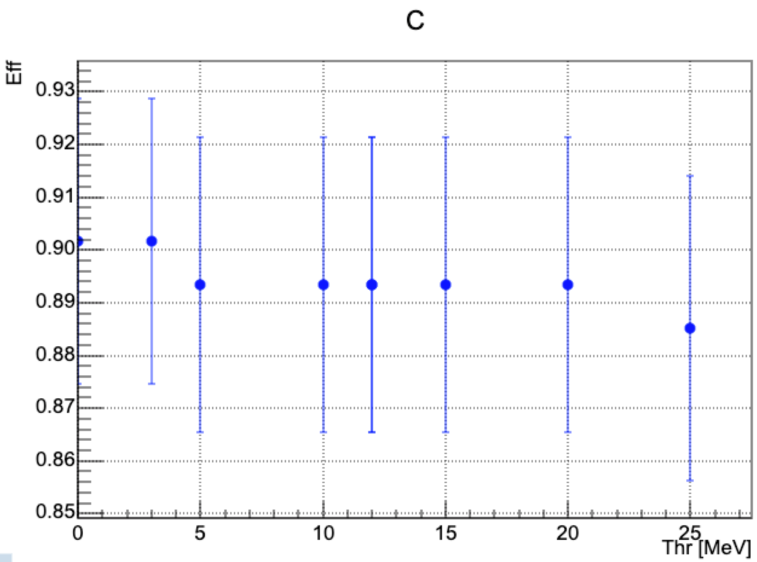




Efficiency

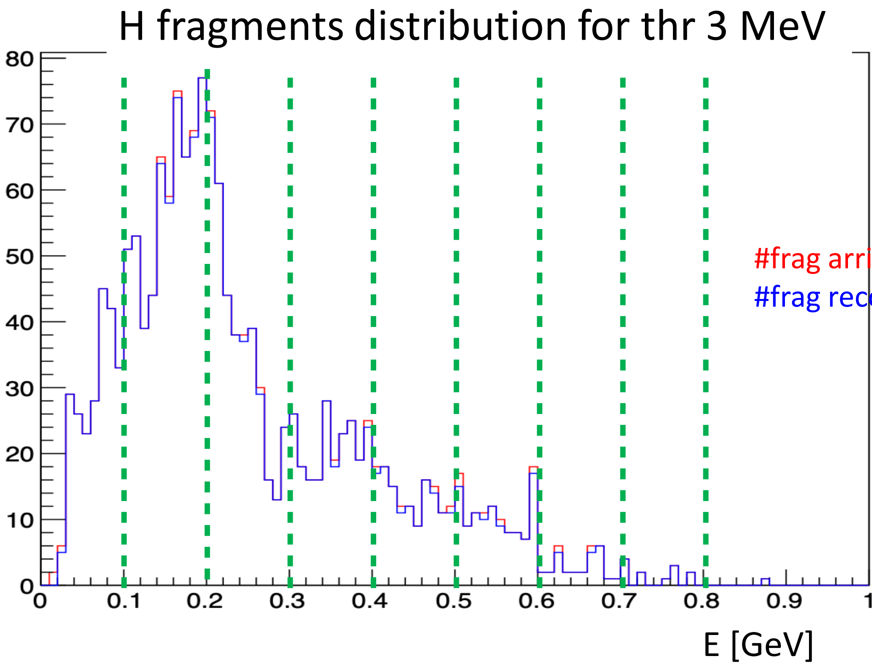




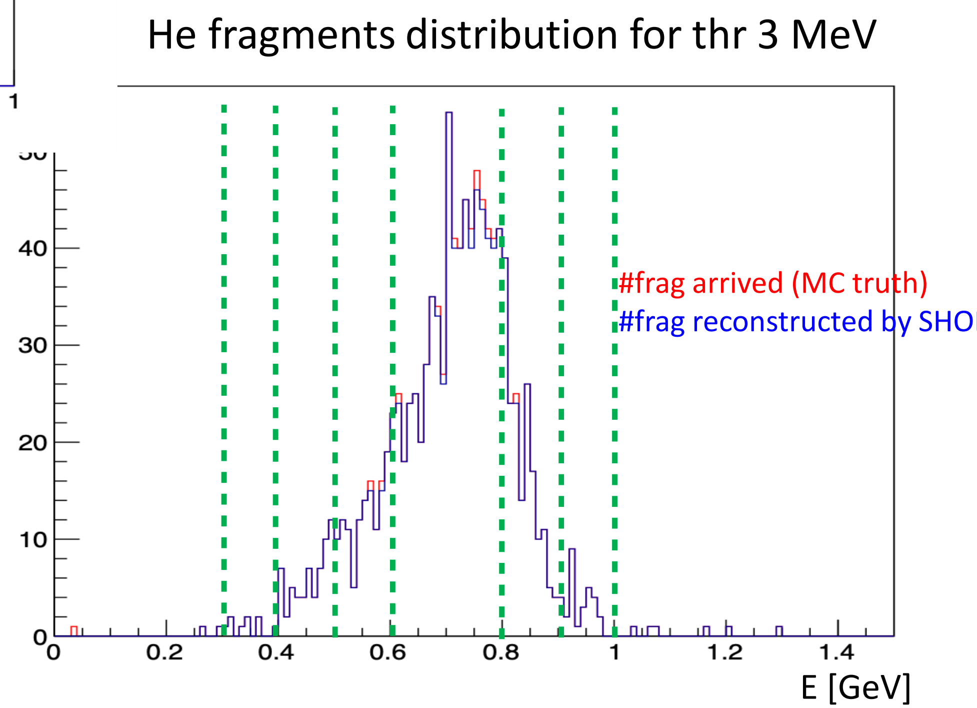


- ✓ The error bars have been computed considering a binomial distribution

Efficiency

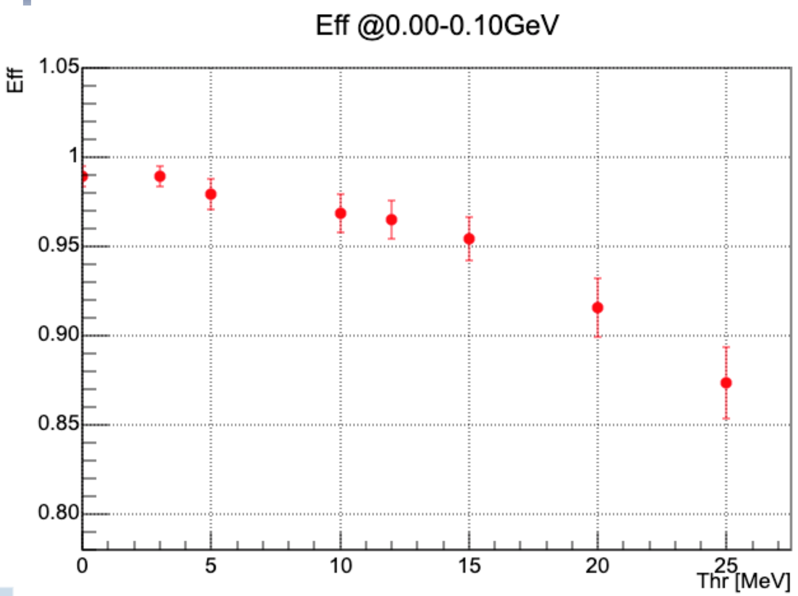


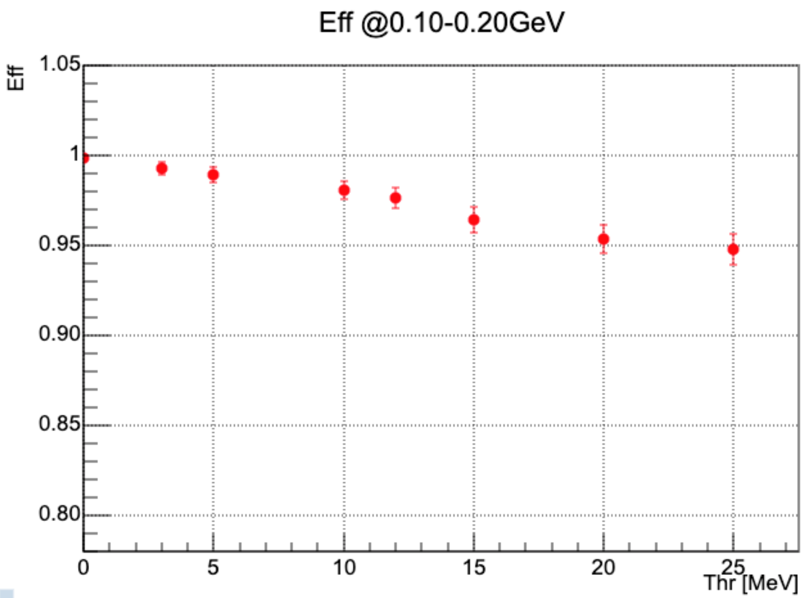
The efficiency has been performed for different kinetic energy intervals for H and He fragments:

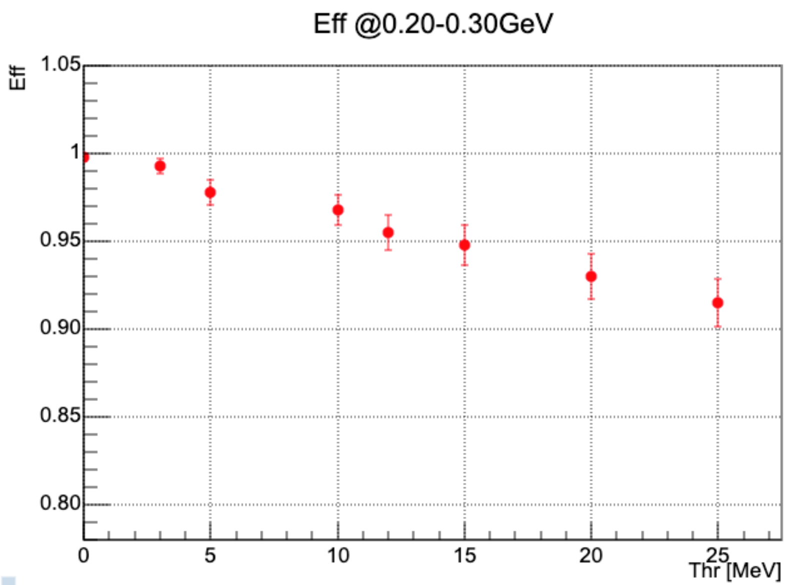


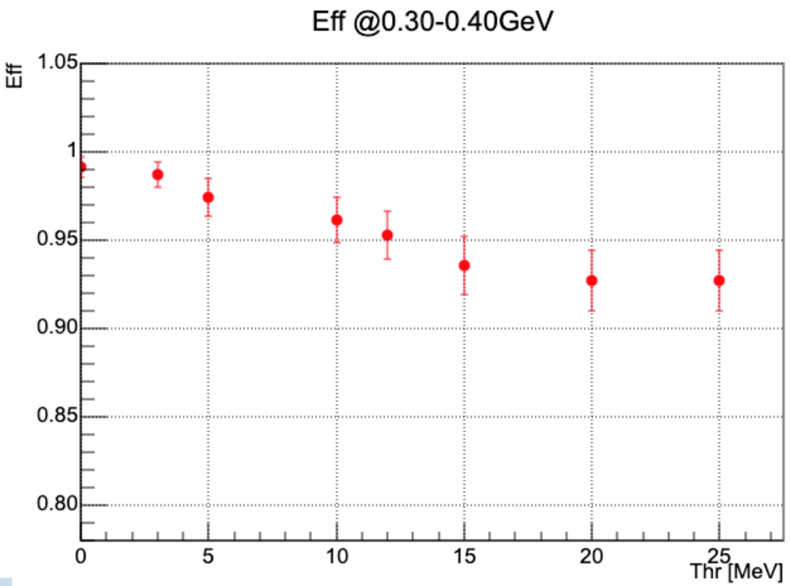
For heavier ions the statistic was insufficient for this analysis

Efficiency for H ions

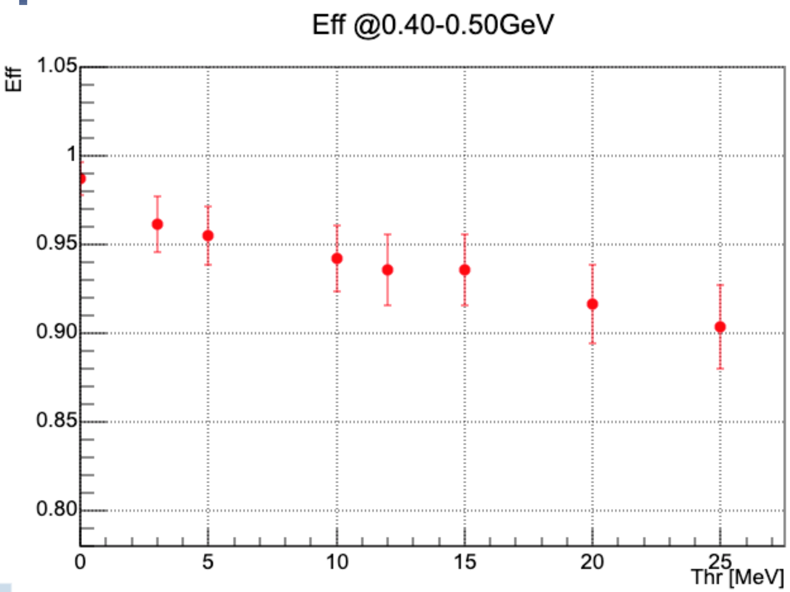


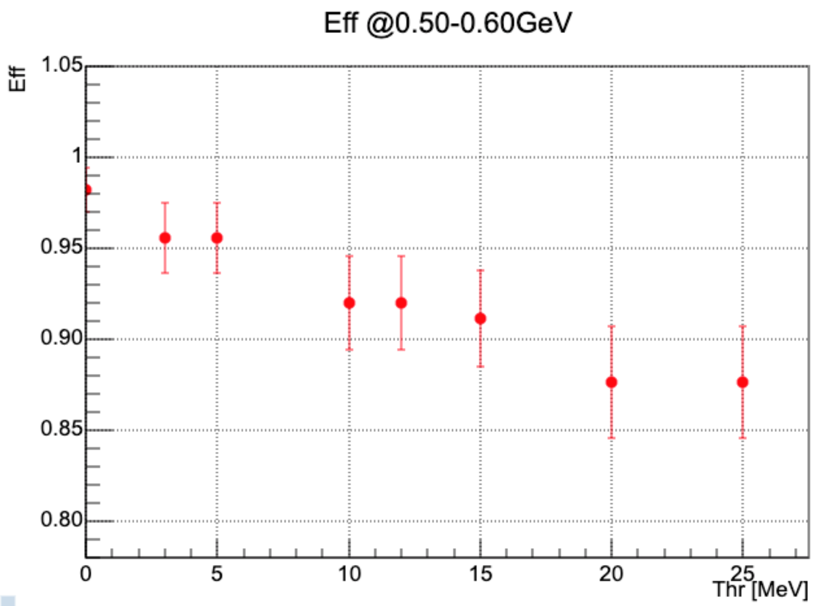


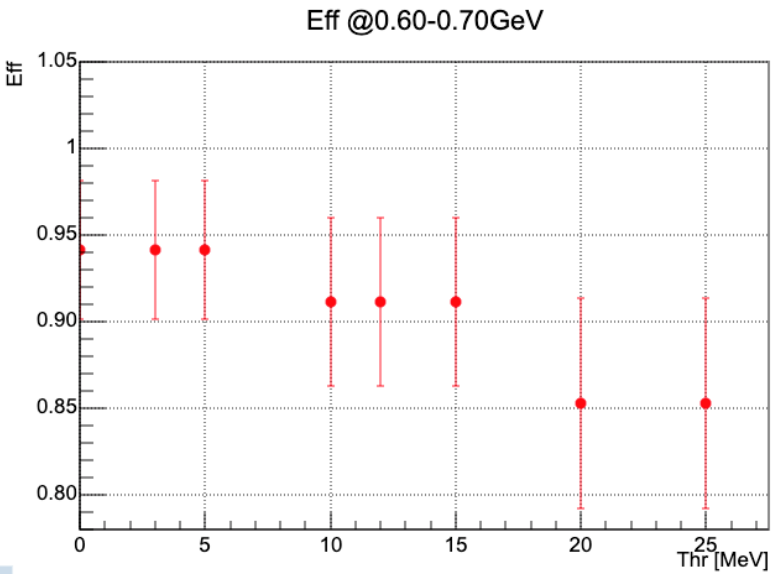


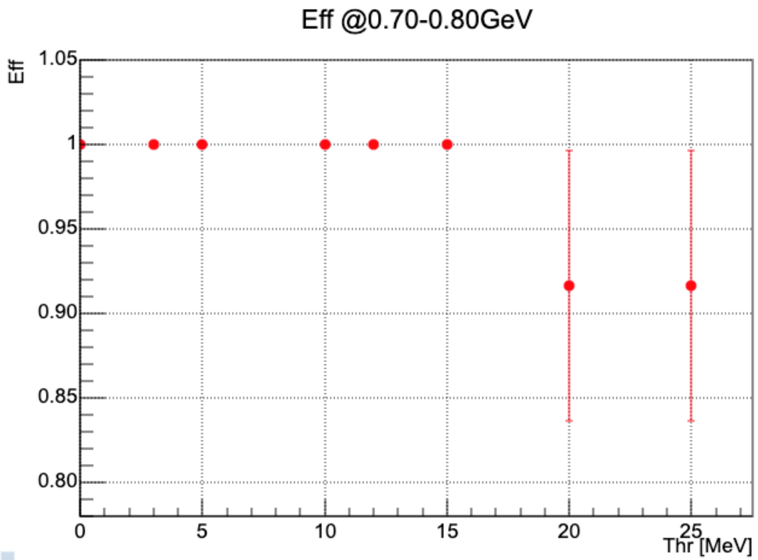


Efficiency for H ions

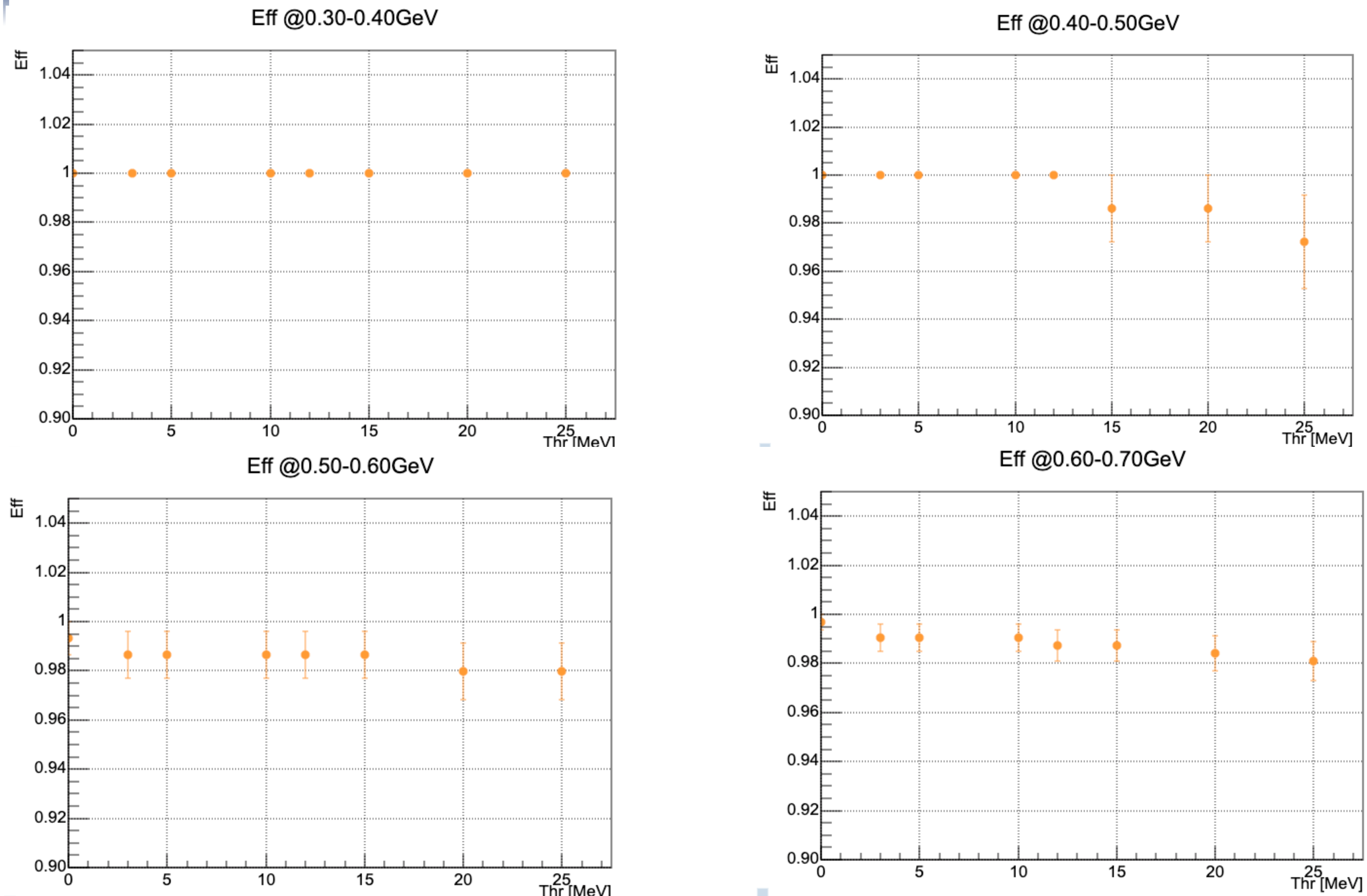




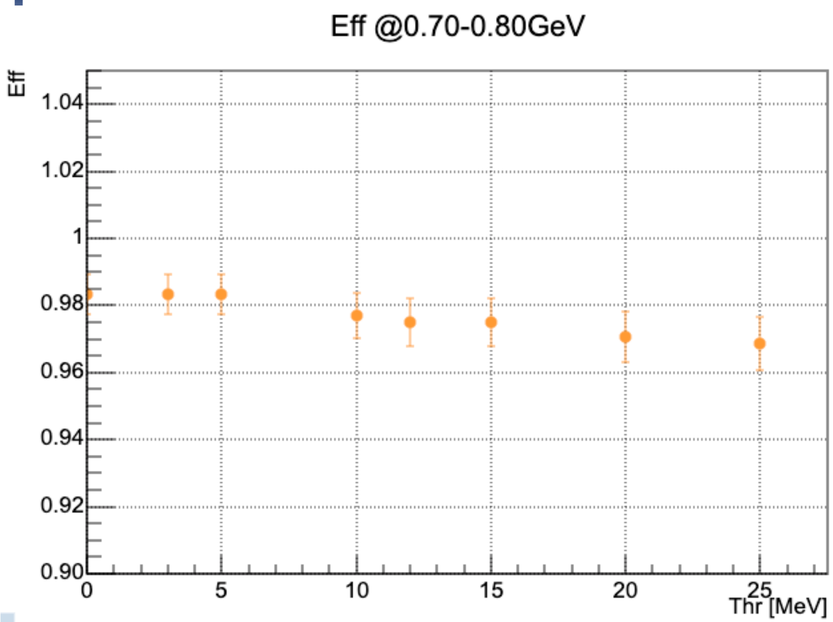


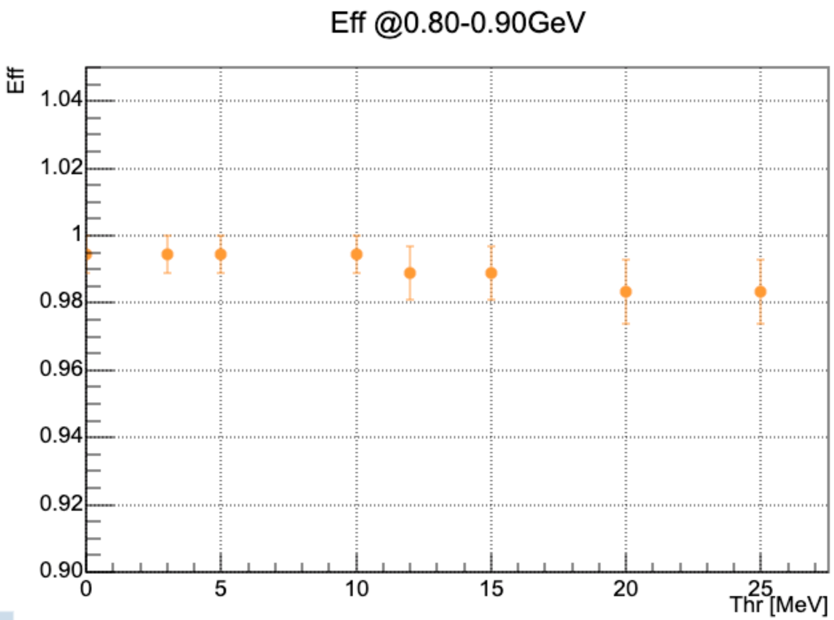


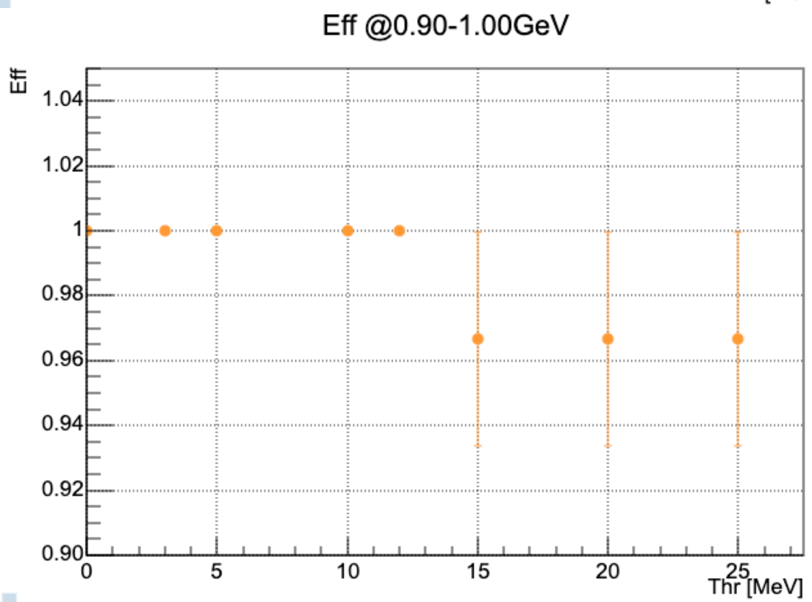
Efficiency for He ions



Efficiency for He ions







Conclusions

- The efficiency has been evaluated for different:
  - Ions: 0<Z<6
  - Values of the energy thresholds: 0, 3, 5, 10, 12, 15, 20 and 25 MeV
  - Kinetic energy intervals (for H and He only)
- With a threshold of 10 MeV the neutrons are reduced a lot and the efficiency for charged particles remain above 90%
- Next steps:
  - Study of the cluster purity
  - Matching with other detectors (mainly TW)