Cristina Morone (Roma2)

Mario Sitta (Torino)

Michela Marafini (Roma1)

CALORIMETER

Detector performances

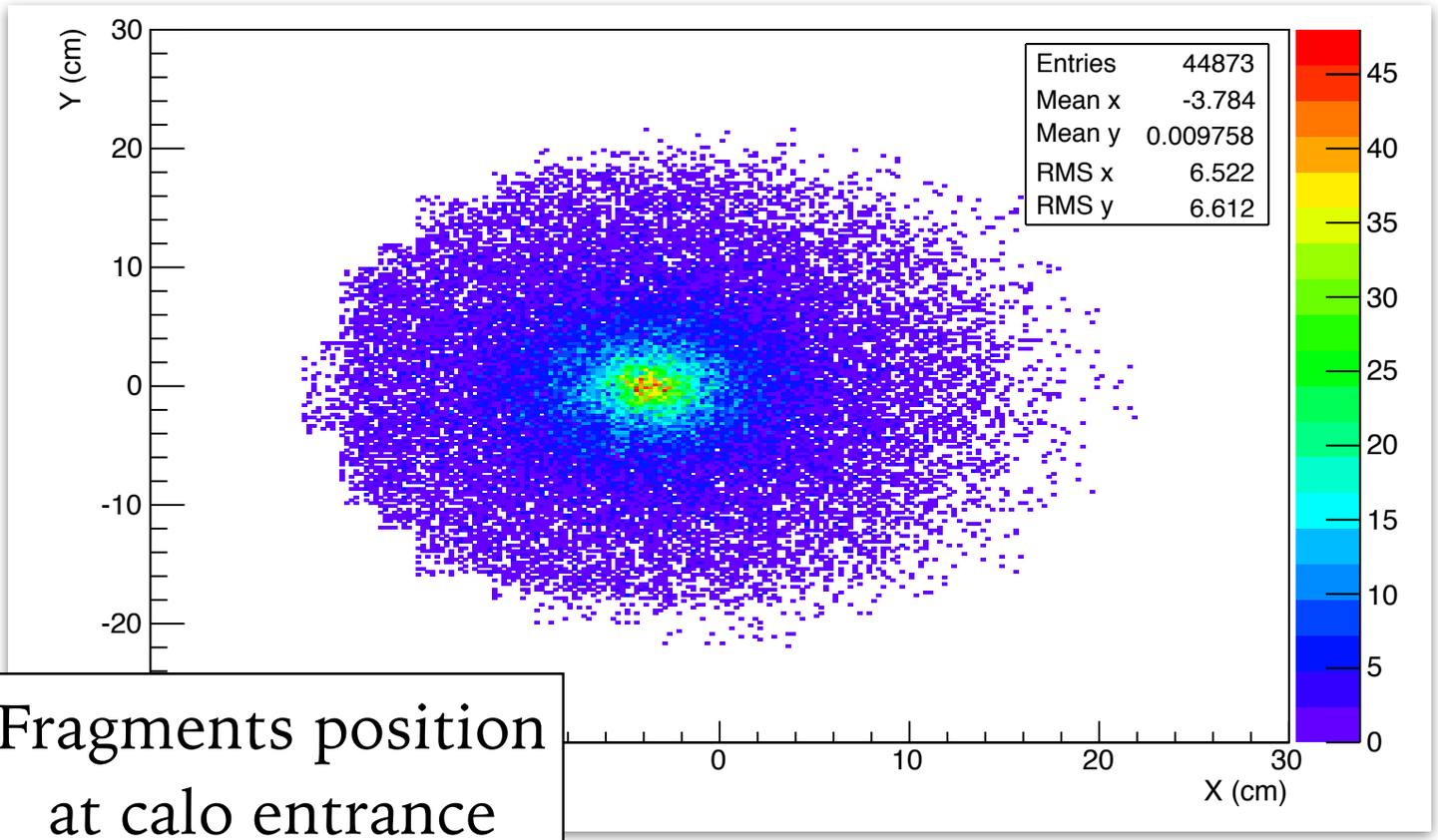
SUMMARY OF THE PERFORMED STUDY

- General simulation, full calorimeter in the foot setup
  - fragments
  - number of involved crystals
  - topology of the events
  - fragment timing
    - Single crystal simulation, BGO length study
      - study on the energy lost (with charged particles/neutrons)
      - different fragments

GENERAL SIMULATION: BASELINE SETUP 7 CM

A fragment species study has been performed for single fragment events in order to characterise the topology of the expected events

- Deposit energy in the calorimeter for different fragments.
- Fragments population => Give info to the single crystal study



Fragments position at calo entrance

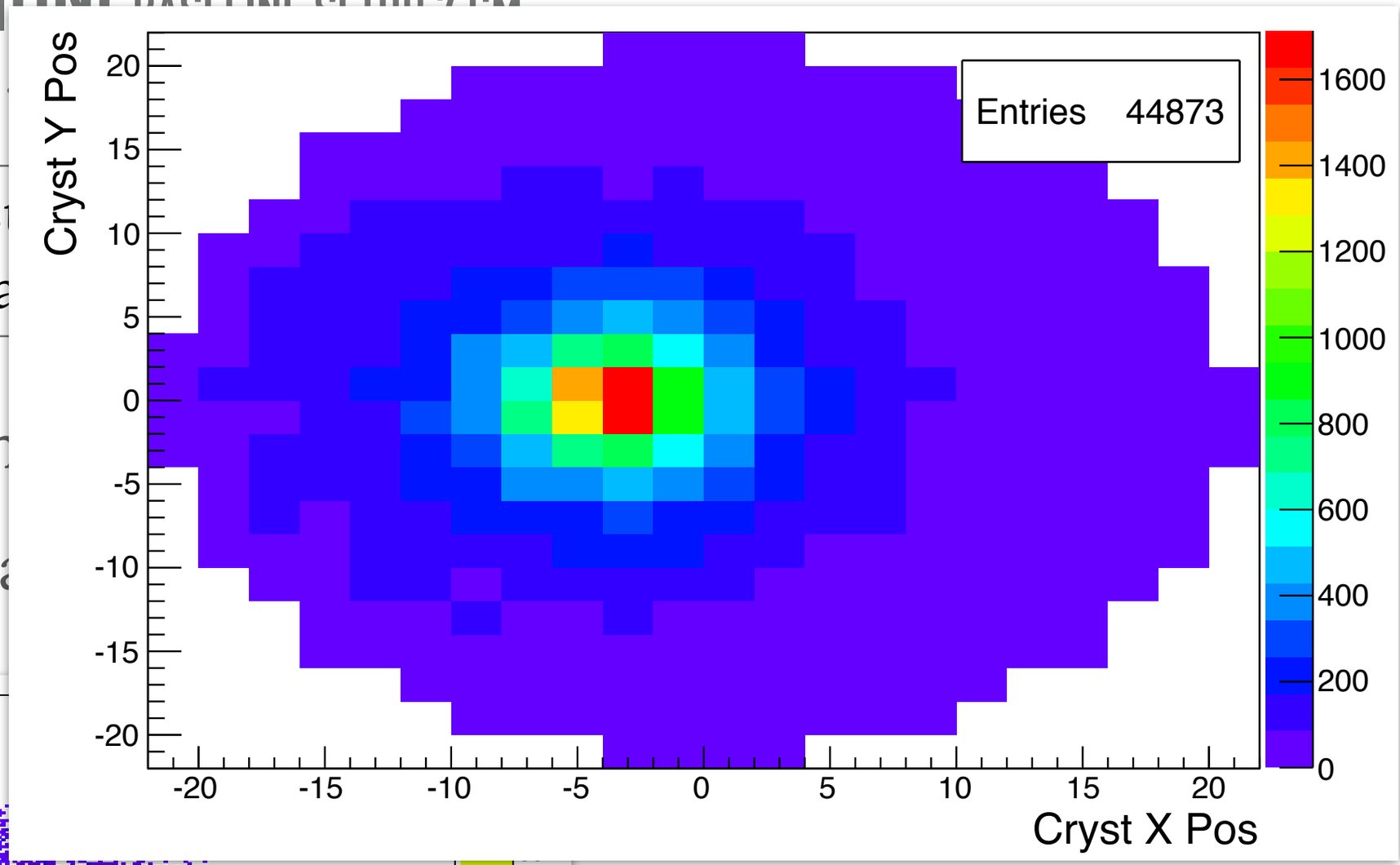
- Event distribution
- Crystals occupancies

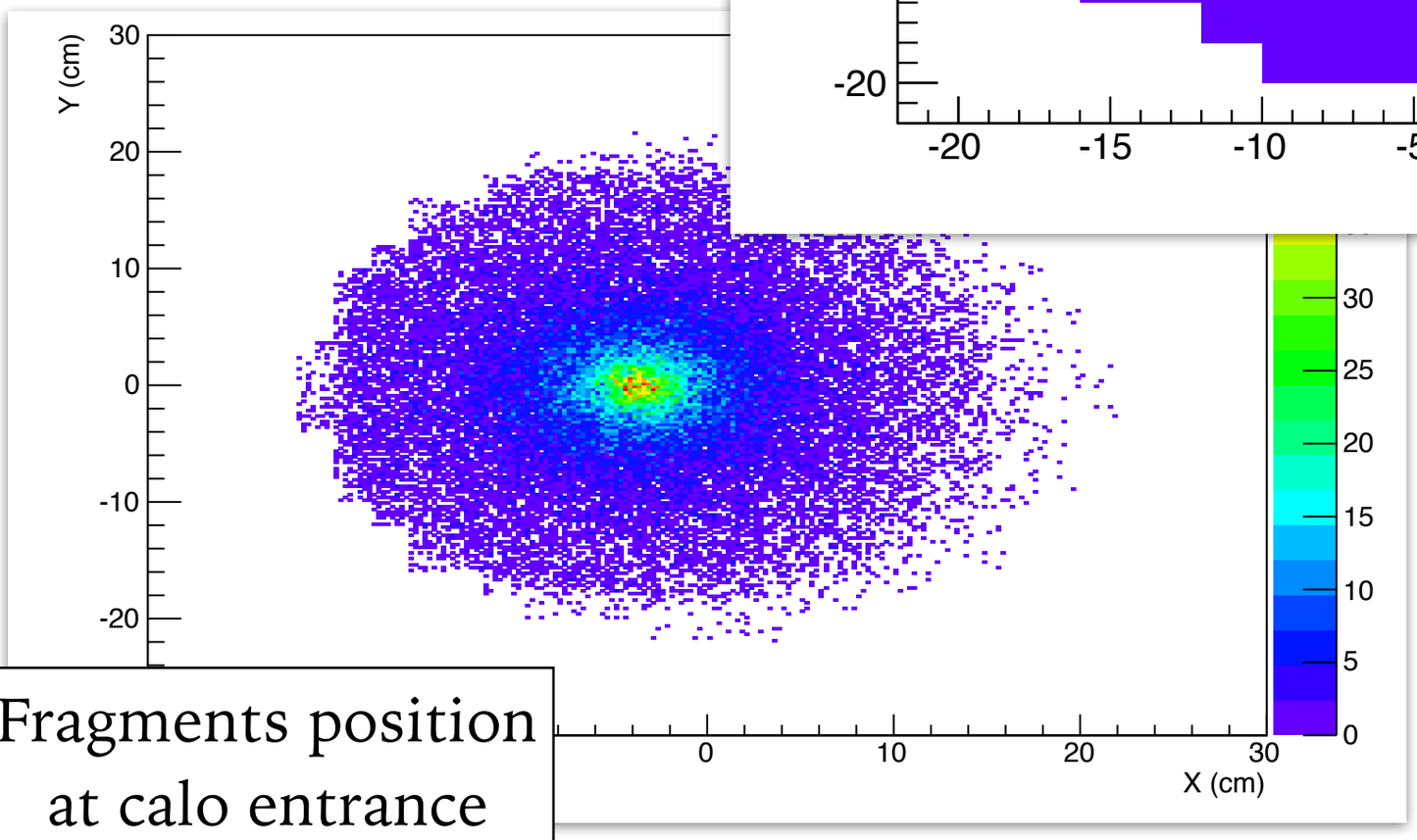
Not centred in zero, as expected, because of the magnetic field

GENERAL SIMULATION. BASELINE SETUP 7 CM

A fragment species s
order to cha

- Deposit energy in
- Fragments popula





Fragments position at calo entrance

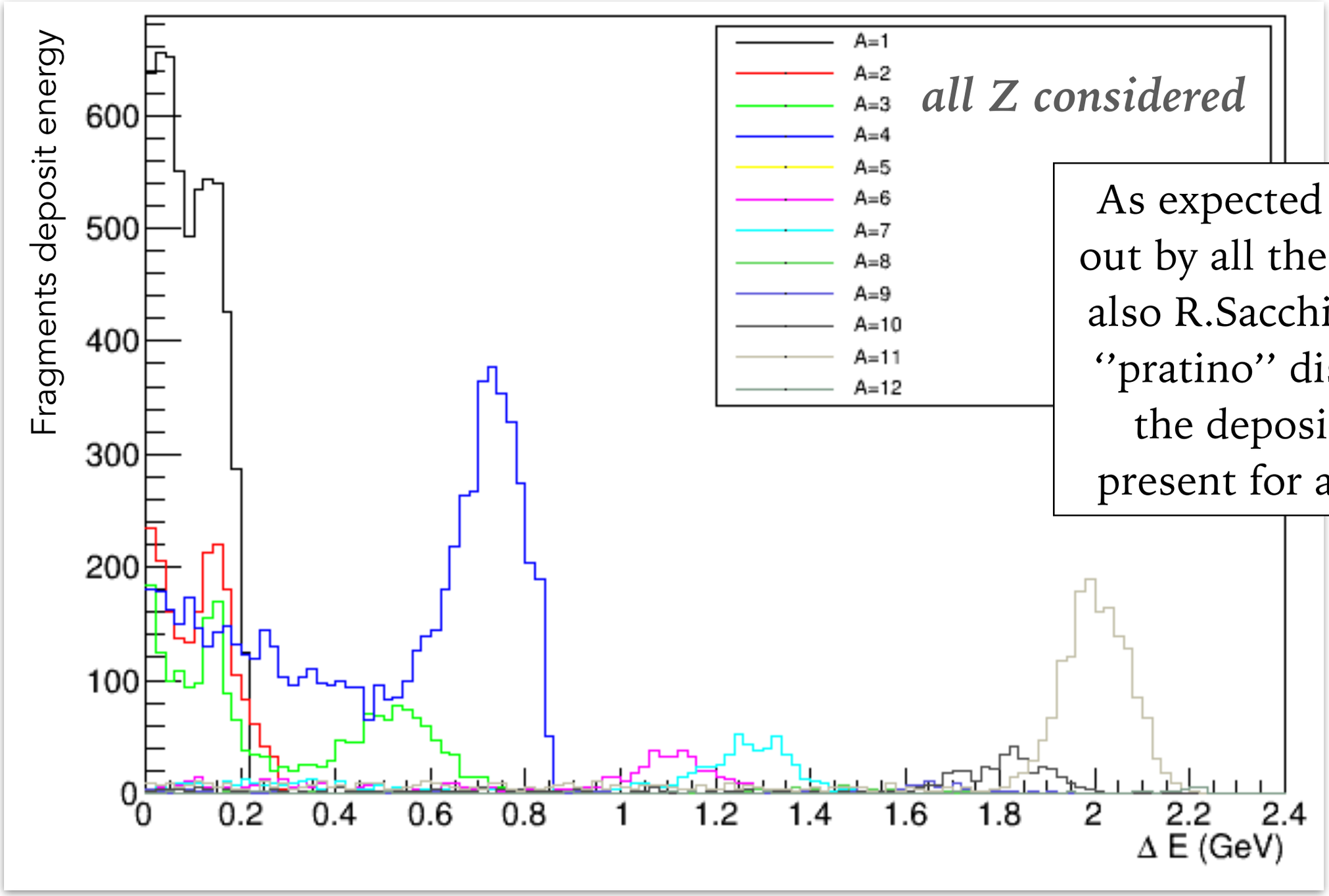
- Crystals occupancies

Not centred in zero, as expected, because of the magnetic field

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

- Deposit energy in the calorimeter for different fragments

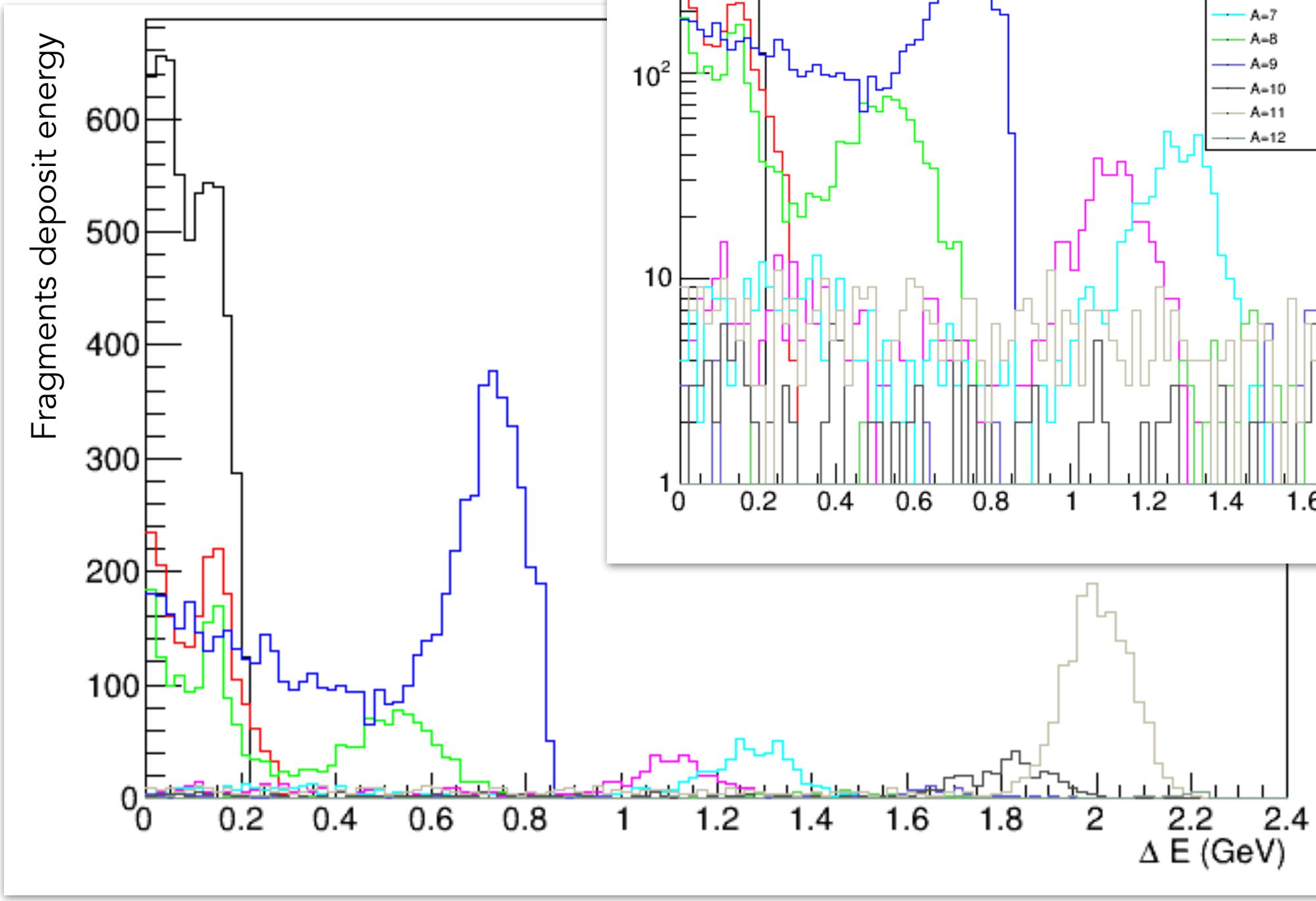


As expected and pointed out by all the analysis (see also R.Sacchi) the peak + ''pratino'' distribution of the deposit energy is present for all fragments

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

- Deposit energy in th



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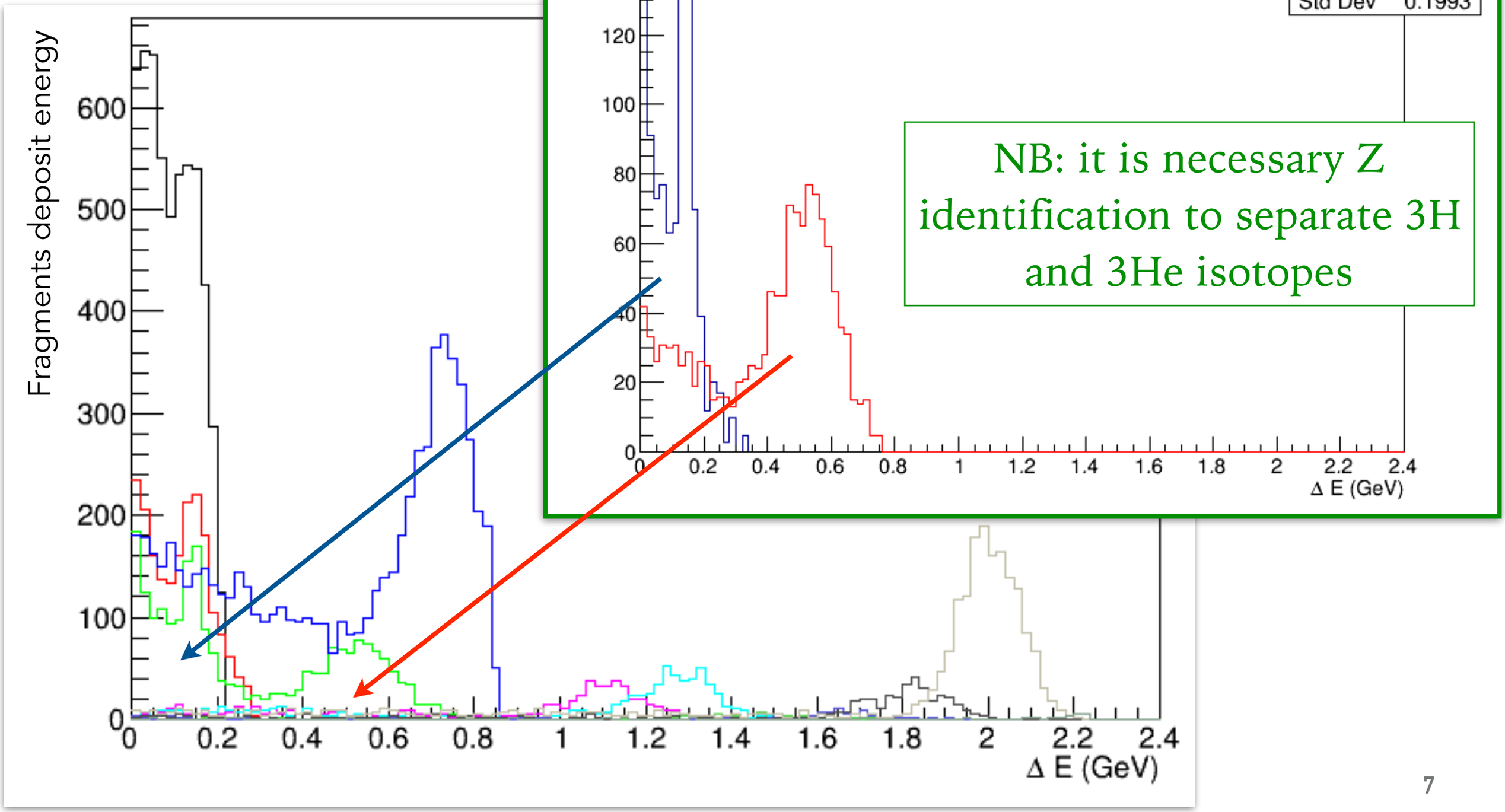

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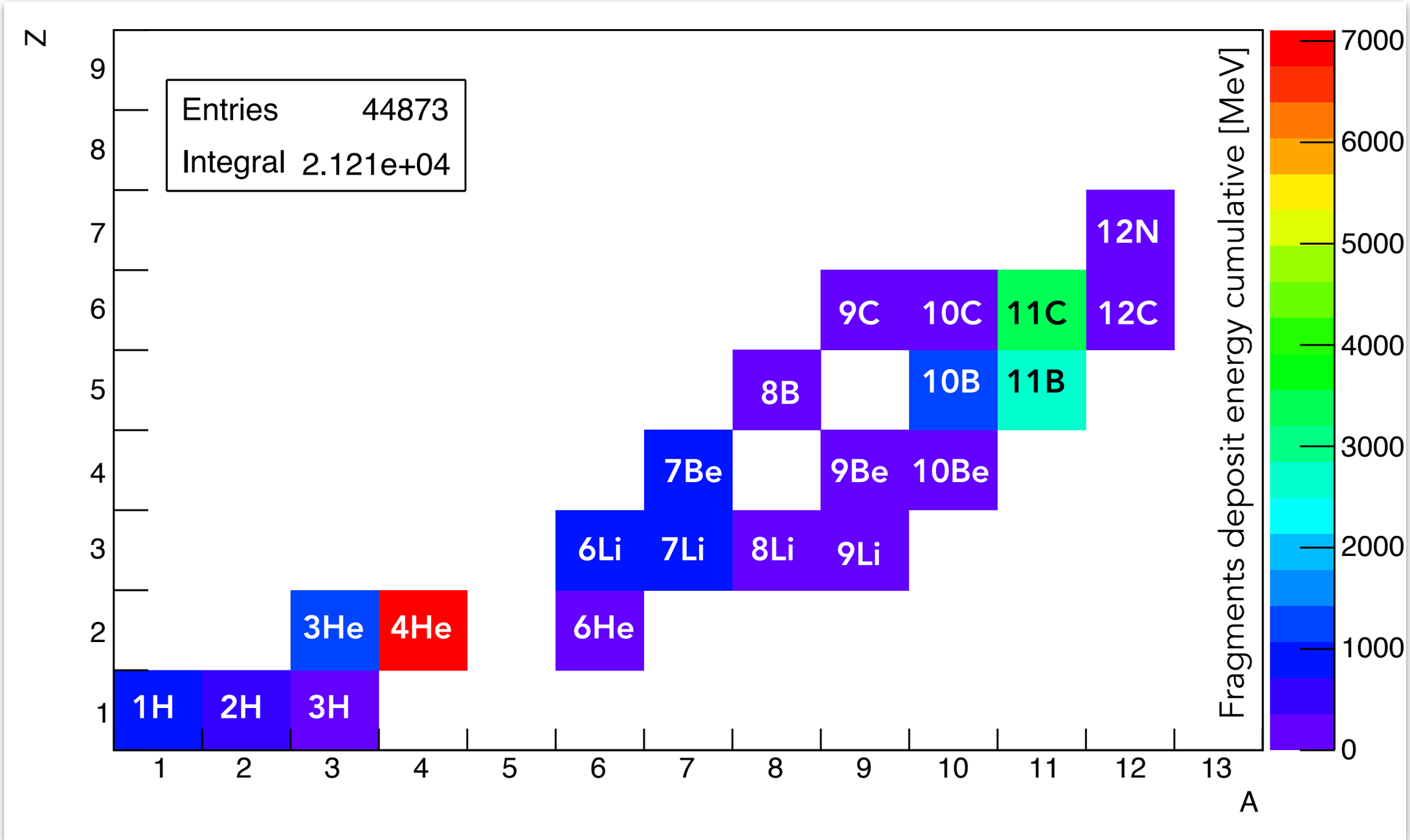
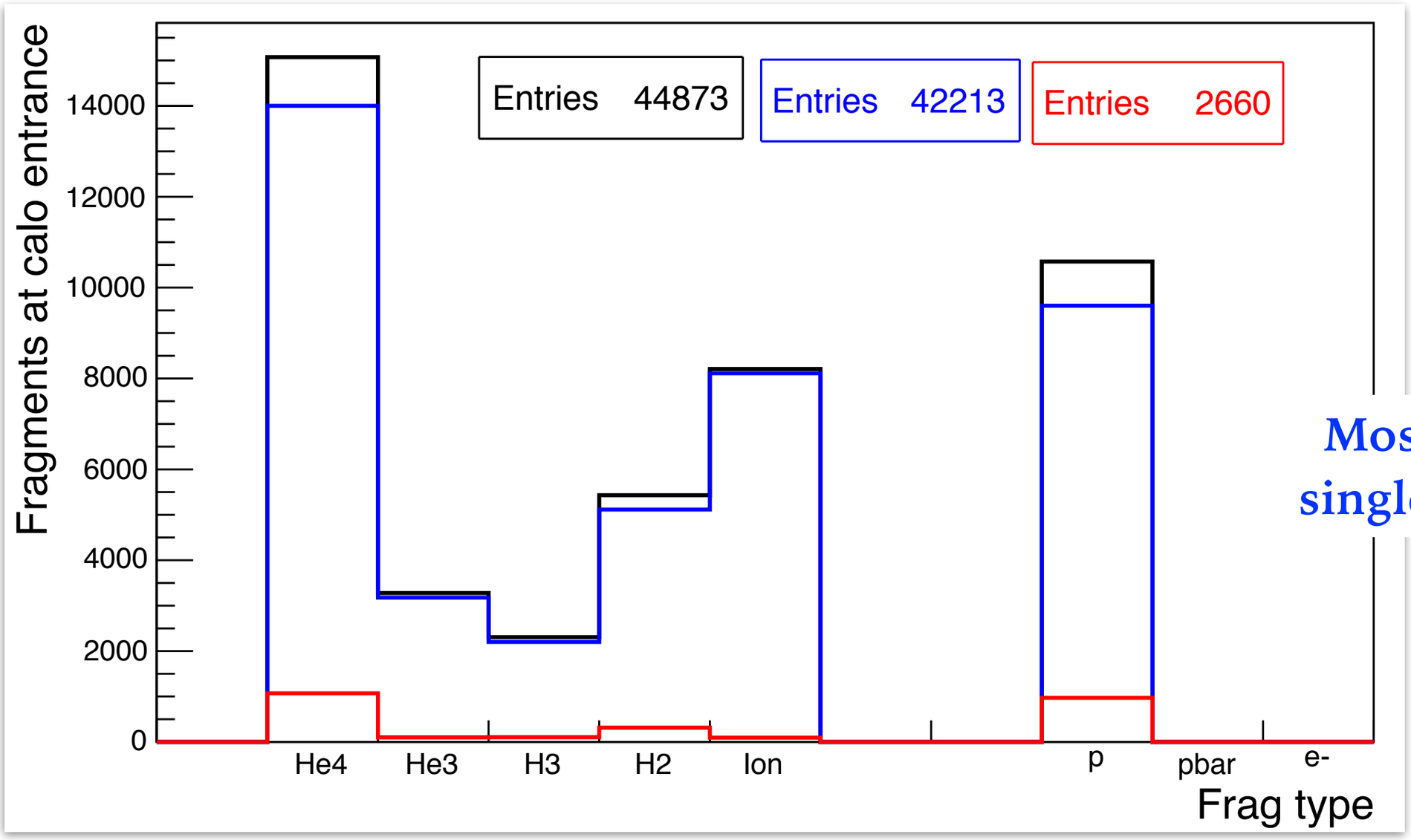


GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

- Fragments population

The most abundant produced light fragments in this setup is He4



Most of the time are single fragment events

multi frag ~6%

GENERAL SIMULATION: BASELINE SETUP 7 CM

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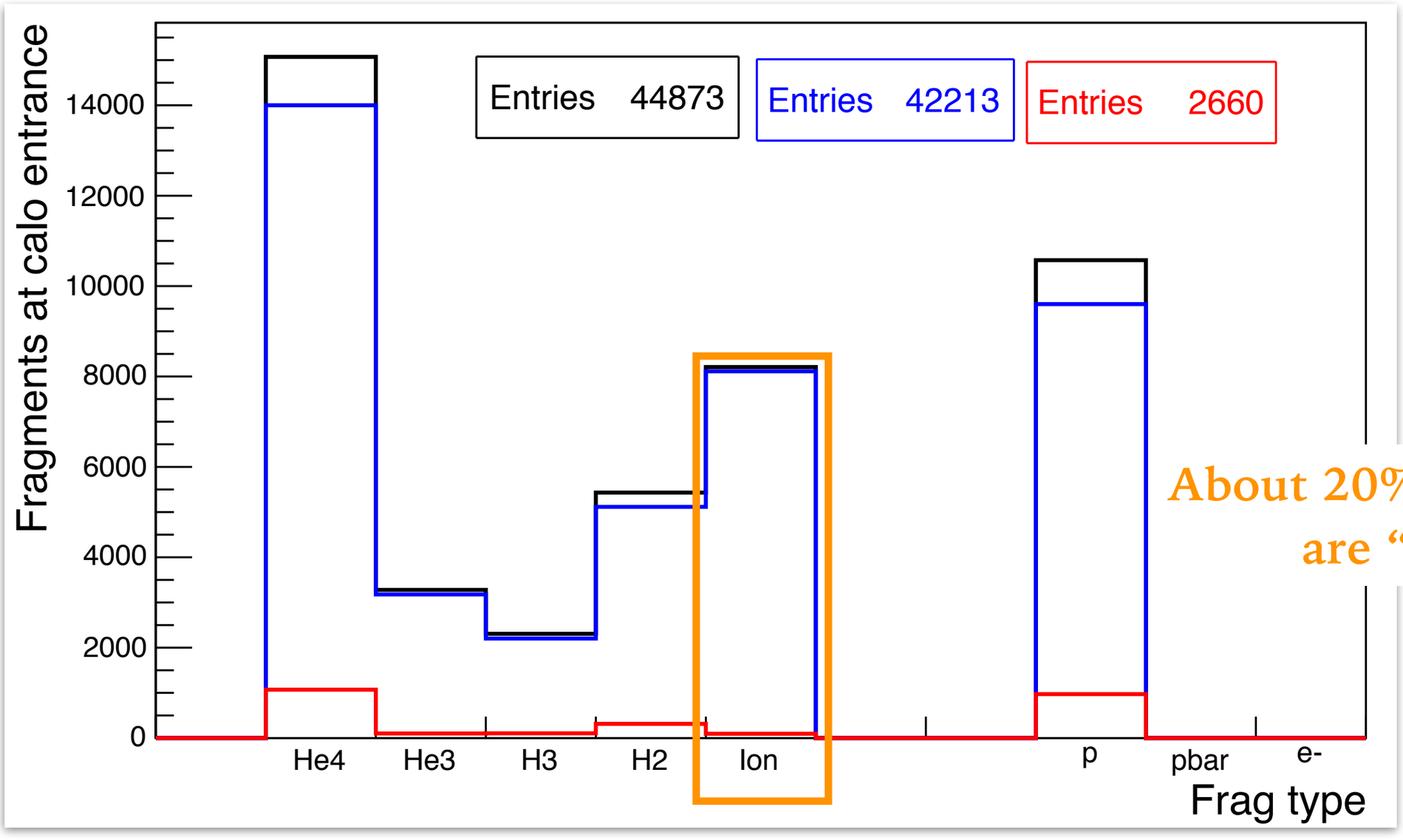


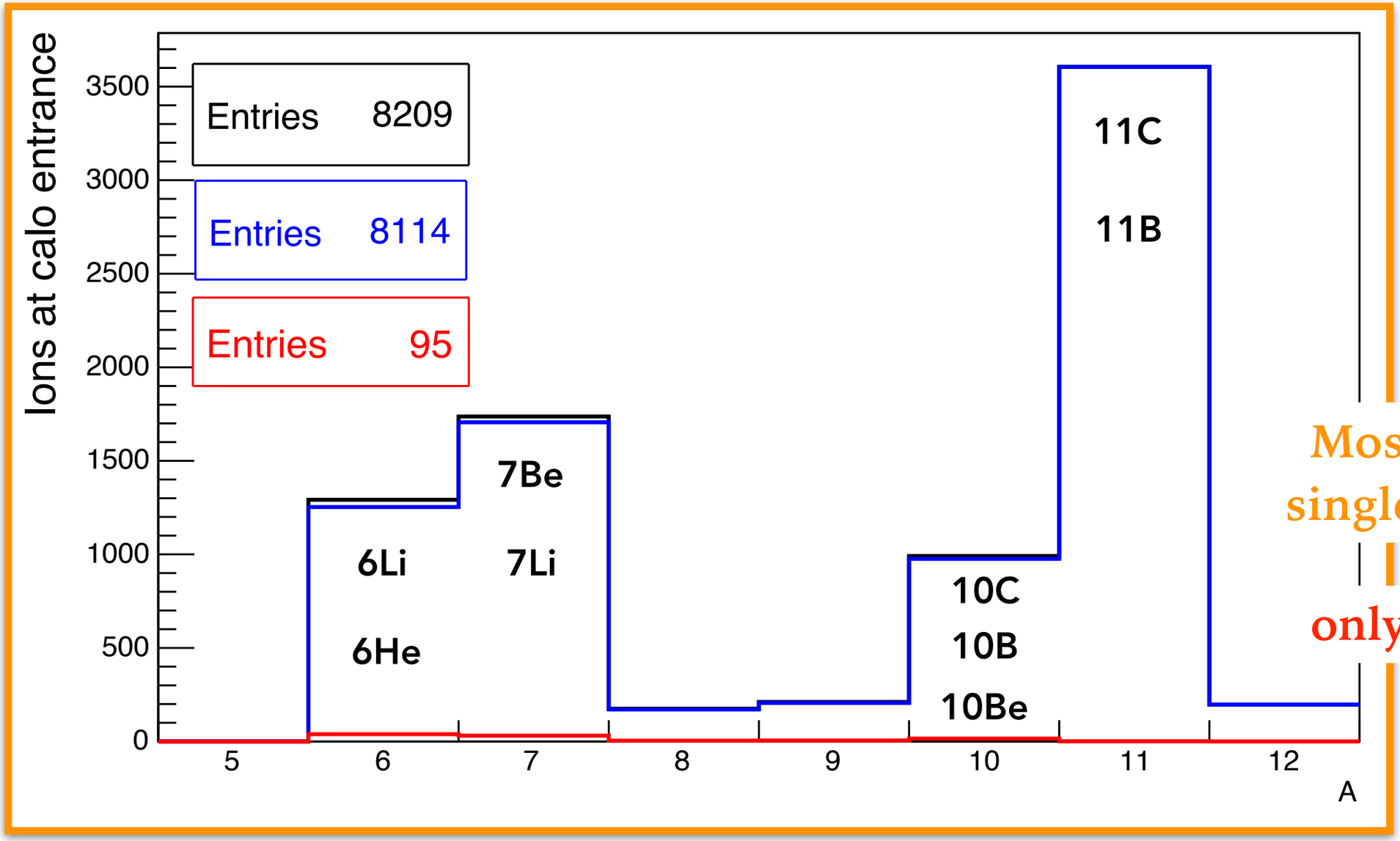
About 20% of the fragments are “heavy” ions

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

➤ Fragments population

The most abundant produced ''heavy'' fragments are ''singles'' and B11/C11



- Total
- Single Frag.
- Multi Frag.

Most of the time are single fragment events

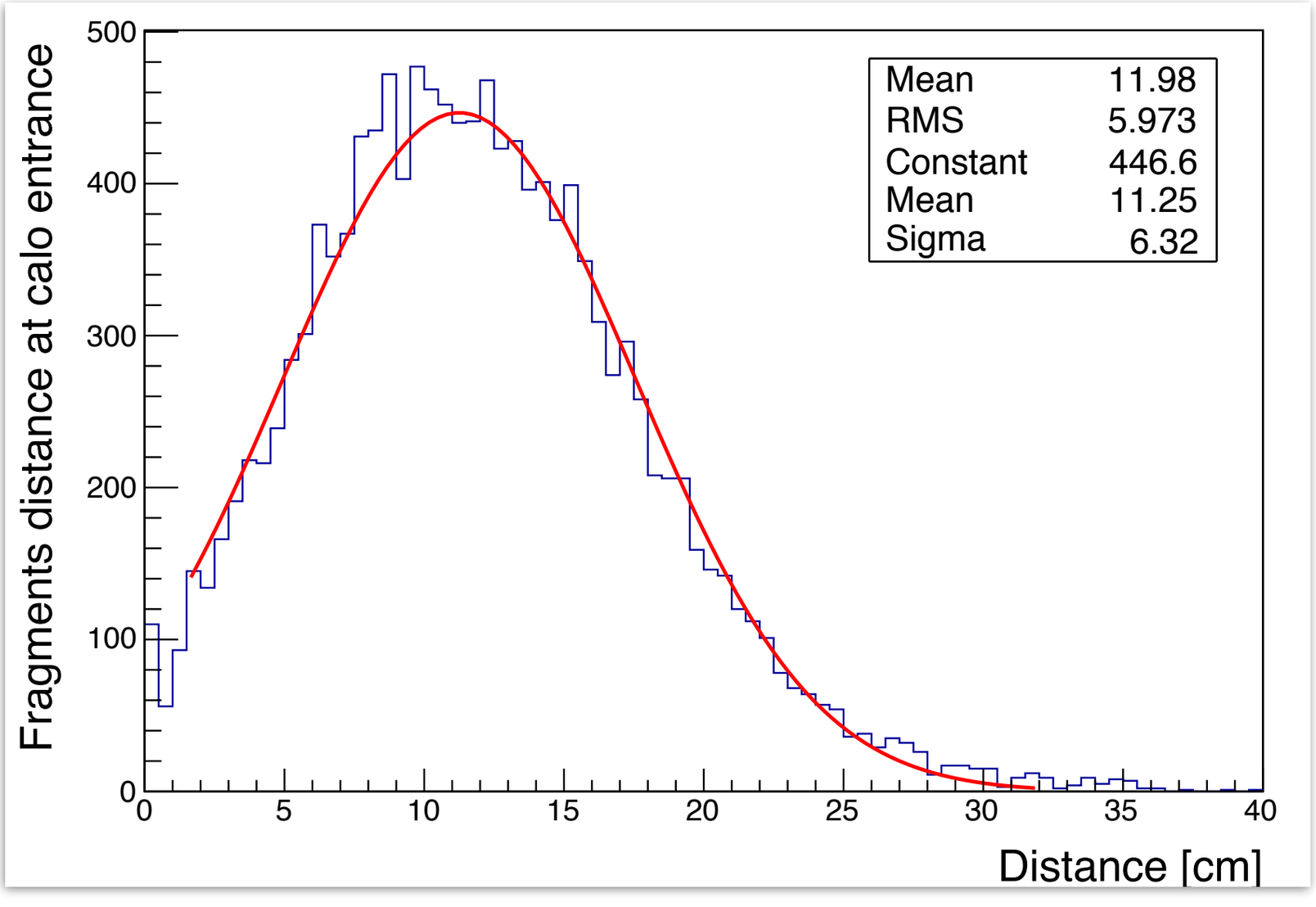
only ~1% multi frag

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

- Involved crystals for multiple fragments events

The probability of multiple-fragments is crucial for a the proper reconstruction of the energy deposit and to define the segmentation needed in the calorimeter.



The size of a single BGO crystal of is 2 cm, therefore we can assume that only **a very small fraction** of events will present multiple-fragments impinging **on two adjacent crystals.**

The information is taken only at calo entrance => we have to study the dynamic of the events along the fragment path

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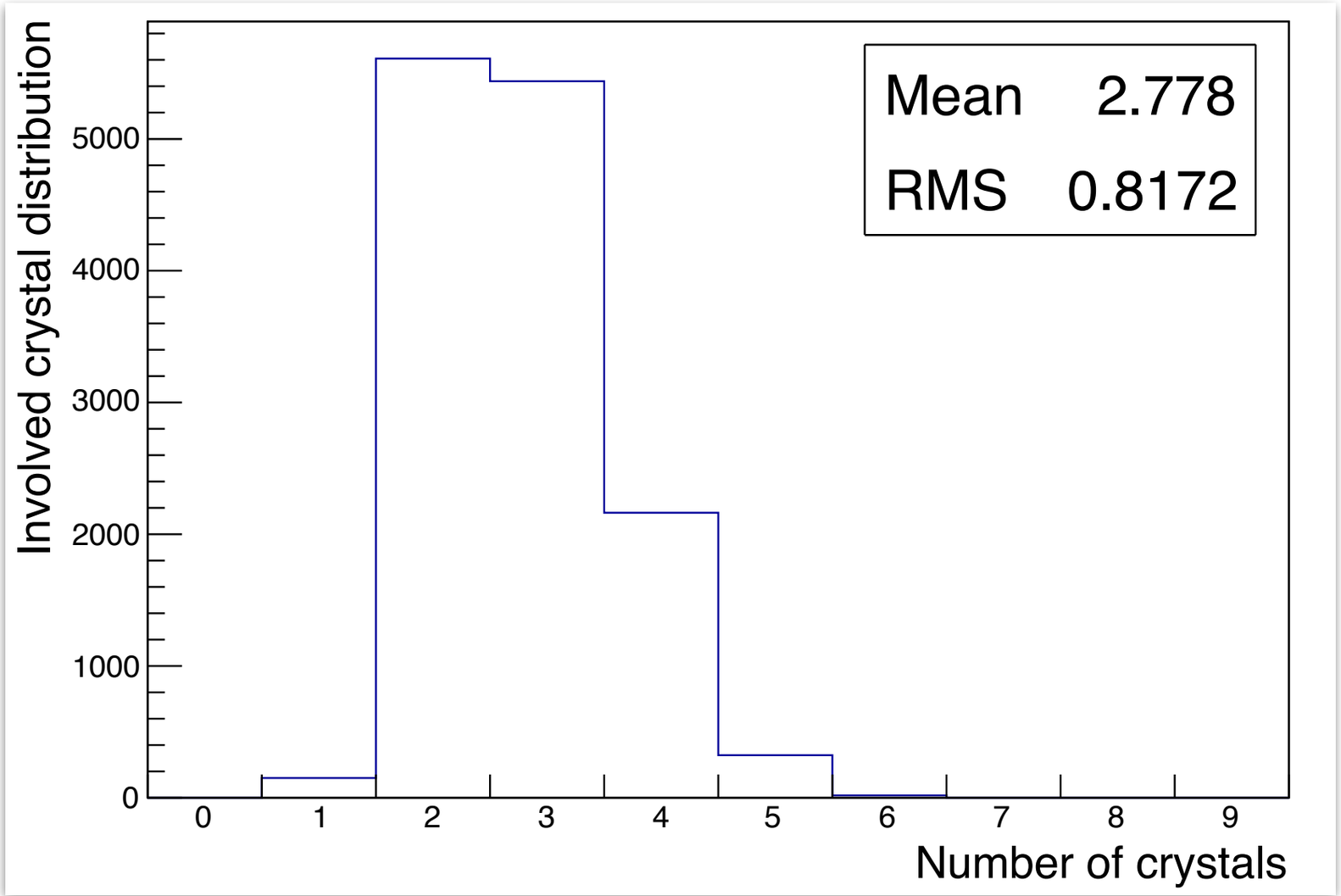


As double check, we notice that only a very small fraction of events occurs in a single crystal, while **most of the events** with multiple fragments **implies** at least **two crystals.**

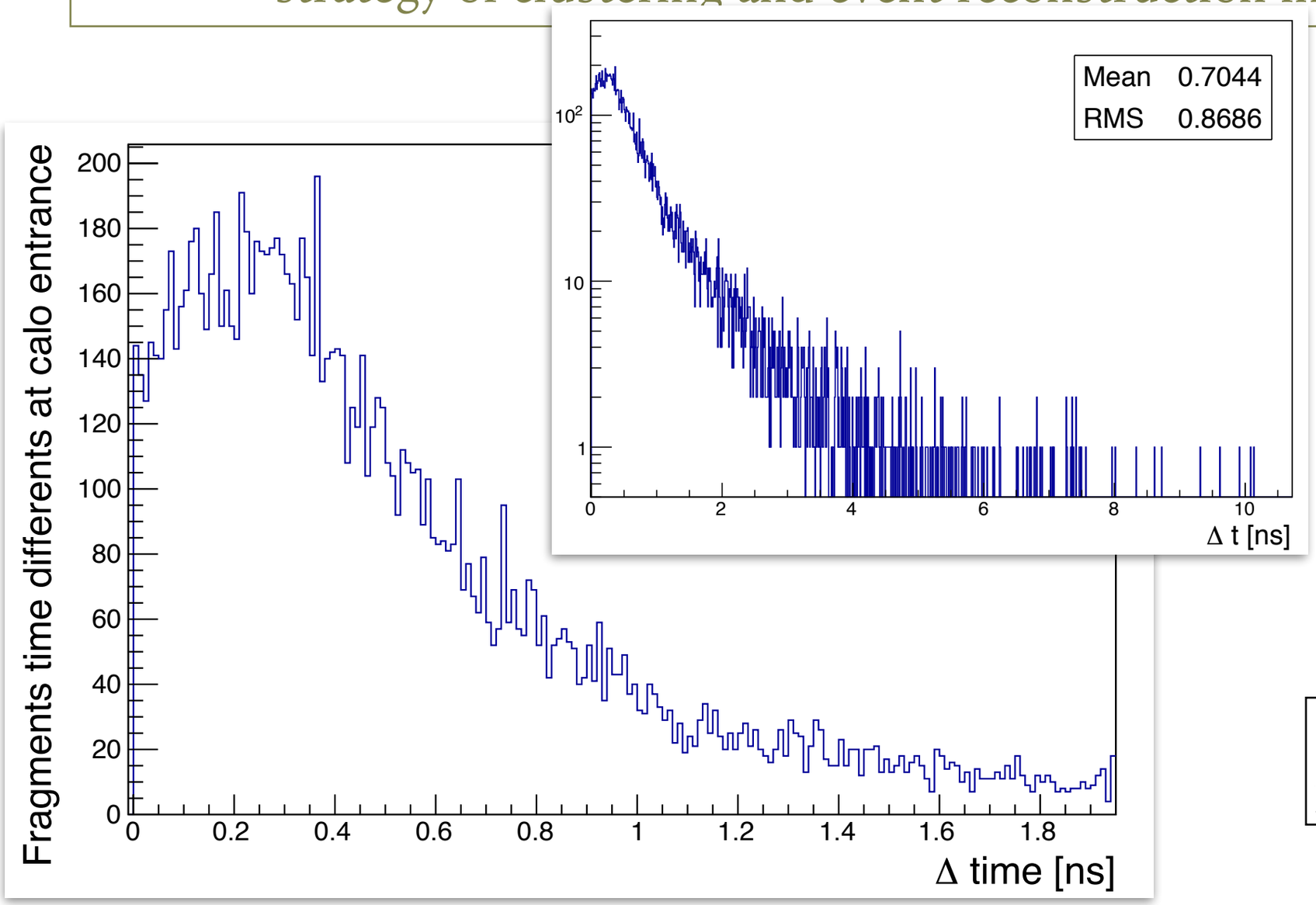
The information is taken only at calo entrance => we have to study the dynamic of the events along the fragment path

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

- Timing of the events for multiple fragments events

The time distribution of multiple-fragments is important in order o define a strategy of clustering and event reconstruction in the calorimeter.



Most of the events occurs in few ns.. if the timing of the events is an stringent requirement the time-resolution of the calorimeter becomes a stringent parameter.

BGO=> Phoswich with 1 cm plastic scintillator (60-150 ps)

GENERAL SIMULATION: BASELINE SETUP 7 CM

Obtained with ^{12}C beam (200 MeV/u) on C_2H_4 target

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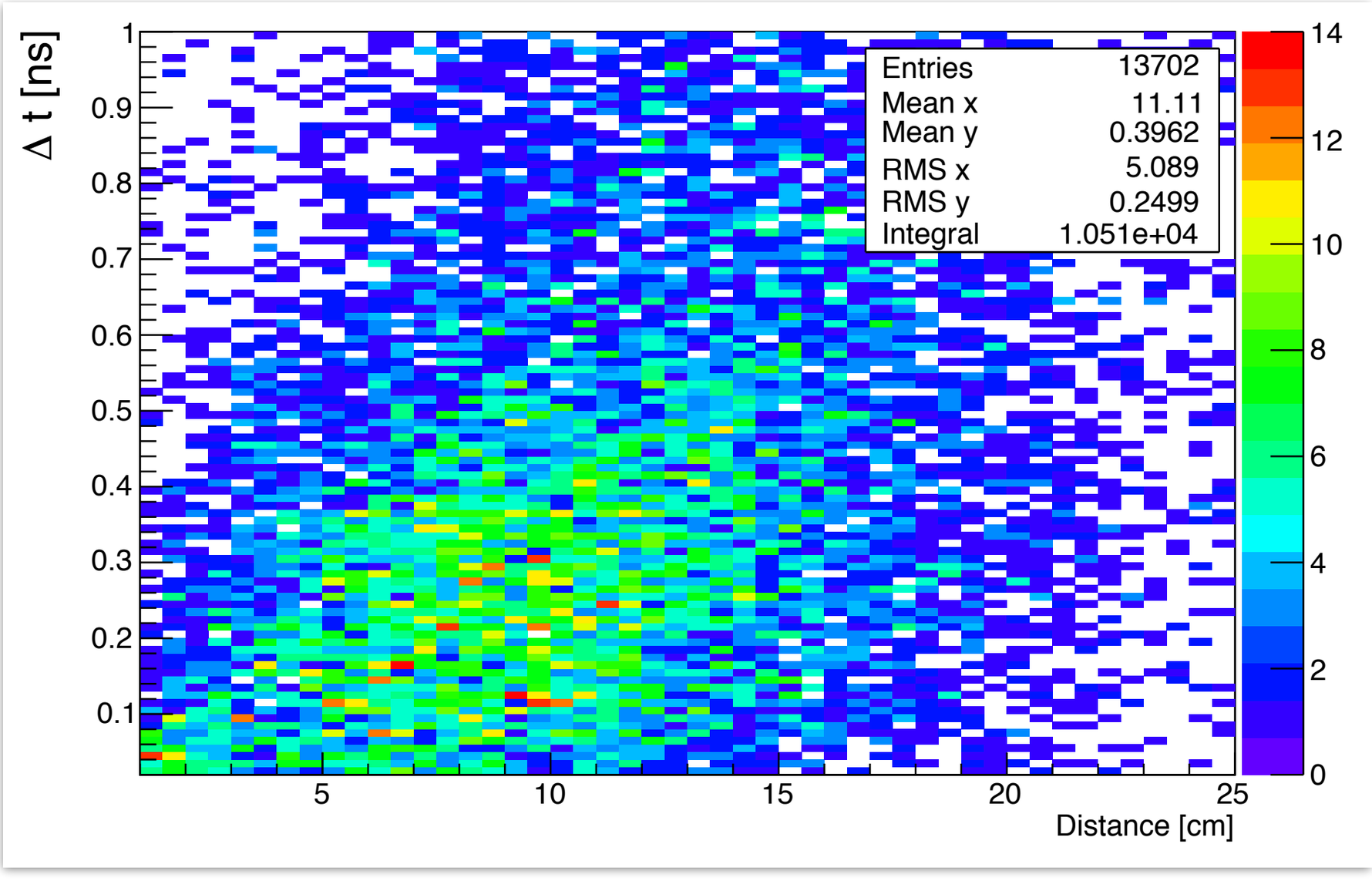


SINGLE CRYSTAL: BGO LENGTH STUDY

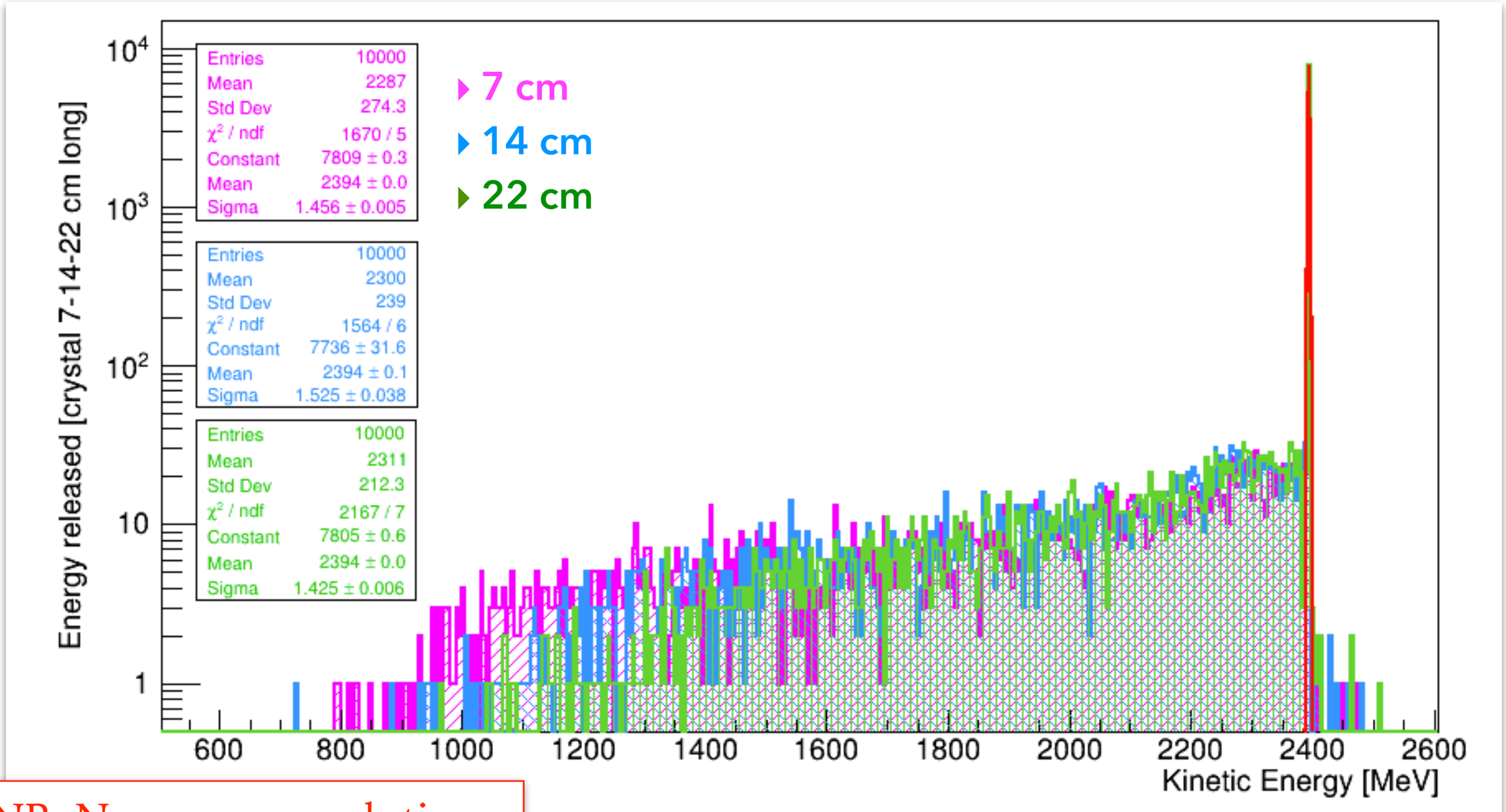
To study how the calorimeter length impacts on the energy containment of the fragments a dedicated simulations has been performed using a single BGO scintillating crystal: mono-block cylinder of 22 cm of diameter.

- Deposit energy in three different lengths of BGO (7, 14 and 22 cm);
- Different ion fragments were shot in the center of the crystal block: Helium, Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen;
- Several energies in a range of [100-350] MeV has been studied;

SINGLE CRYSTAL: BGO LENGTH STUDY

C12@200 MeV/u

- Deposit energy in three different lengths of BGO (7, 14 and 22 cm);

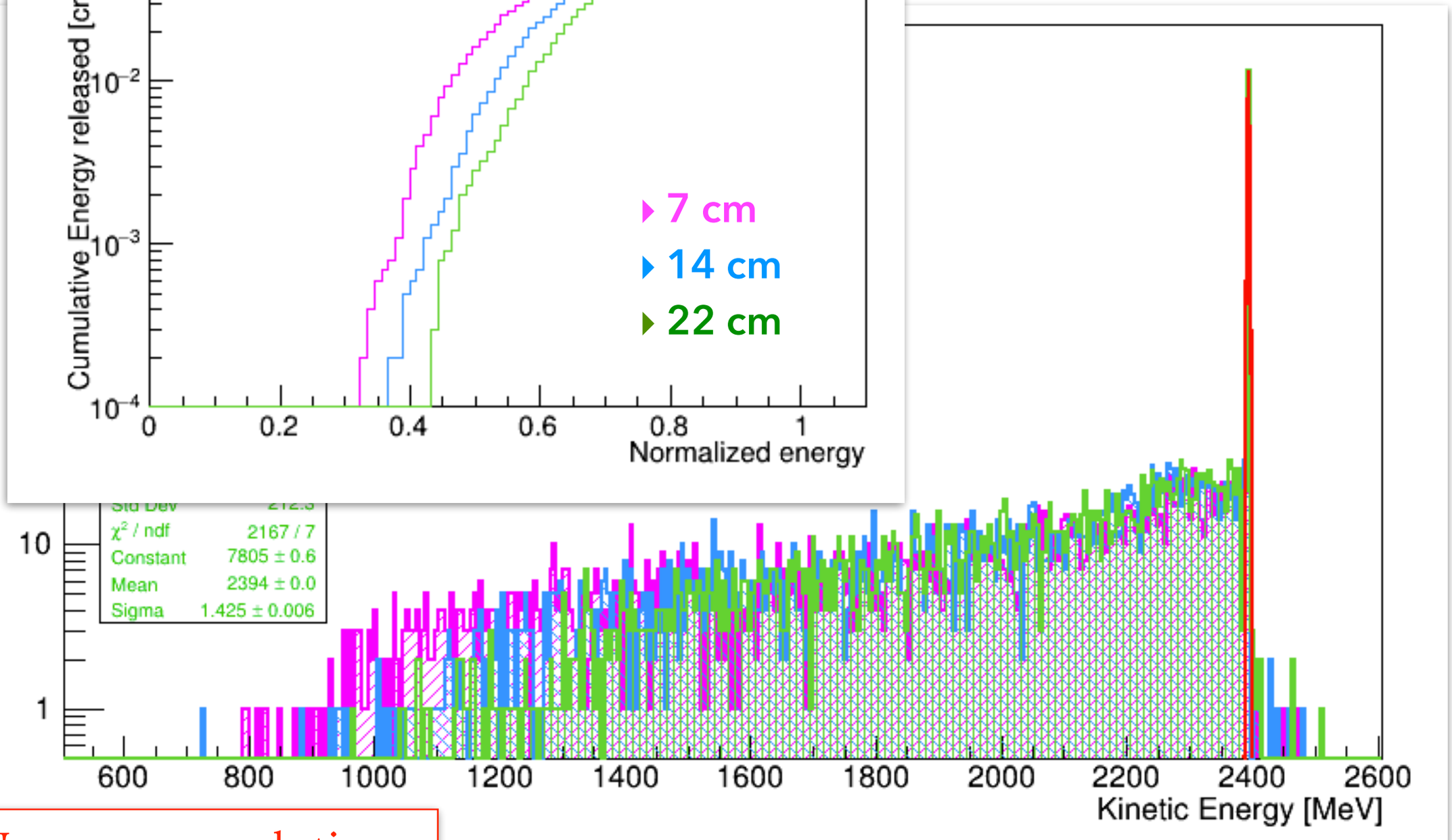


NB: No energy resolution

SING

C12@200 MeV/u

➤ De BGO (7, 14 and 22 cm);

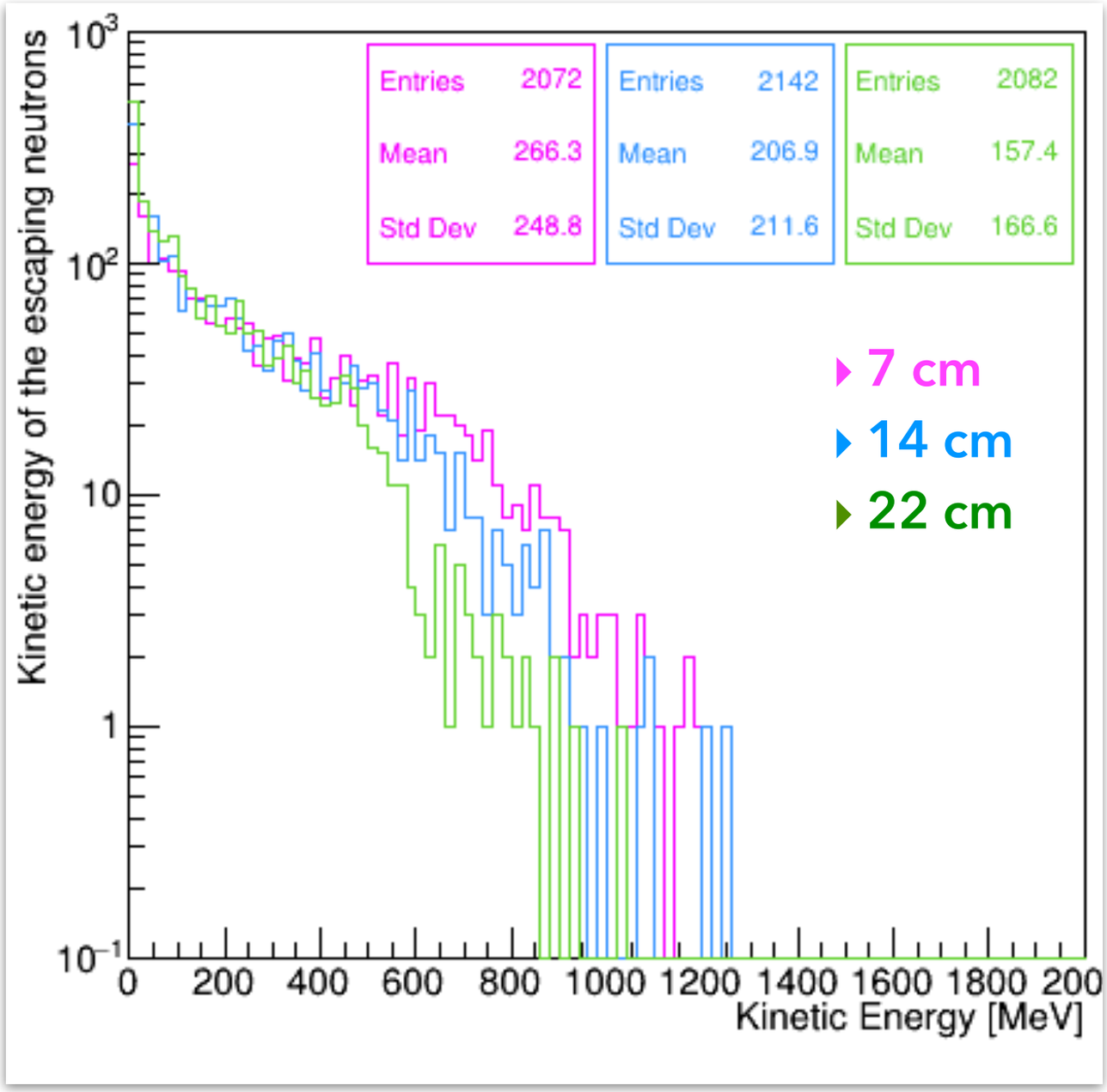


NB: No energy resolution

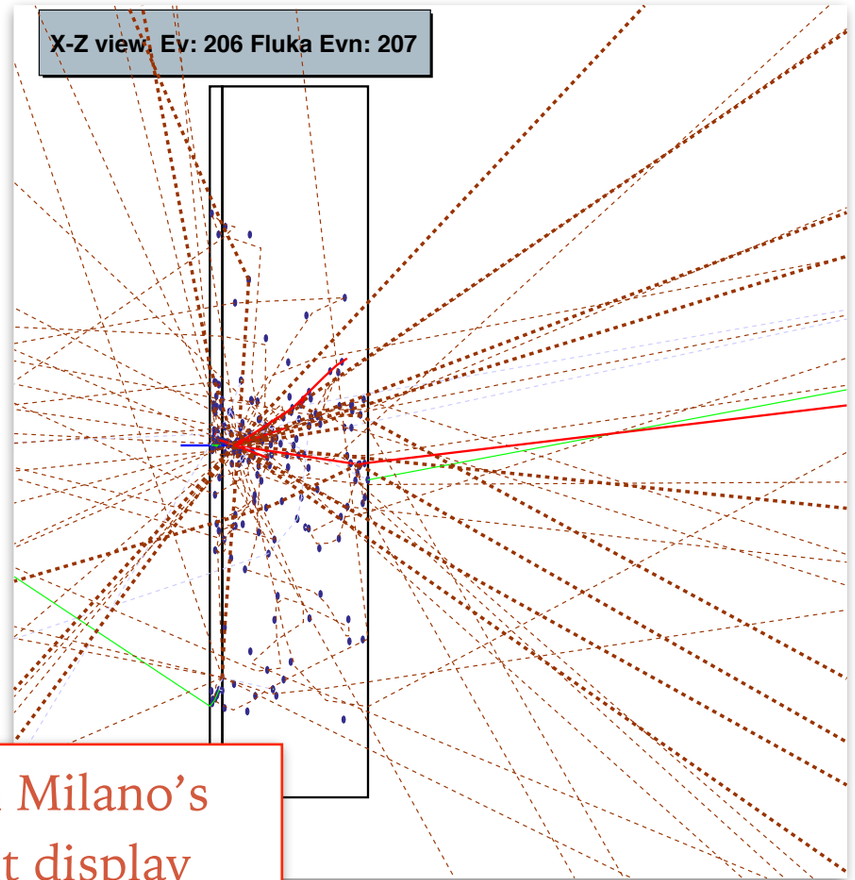
SINGLE CRYSTAL: BGO LENGTH STUDY

C12@200 MeV/u

- The lost of energy is due to the **escape of neutral and charged particles** (and the invisible energy due to nuclear binding energy loss);



The most of the energy is lost with the escaping neutrons, however the crystal size is not the dominant effects: the neutrons, once produced, are very difficult to stop!!



From Milano's event display

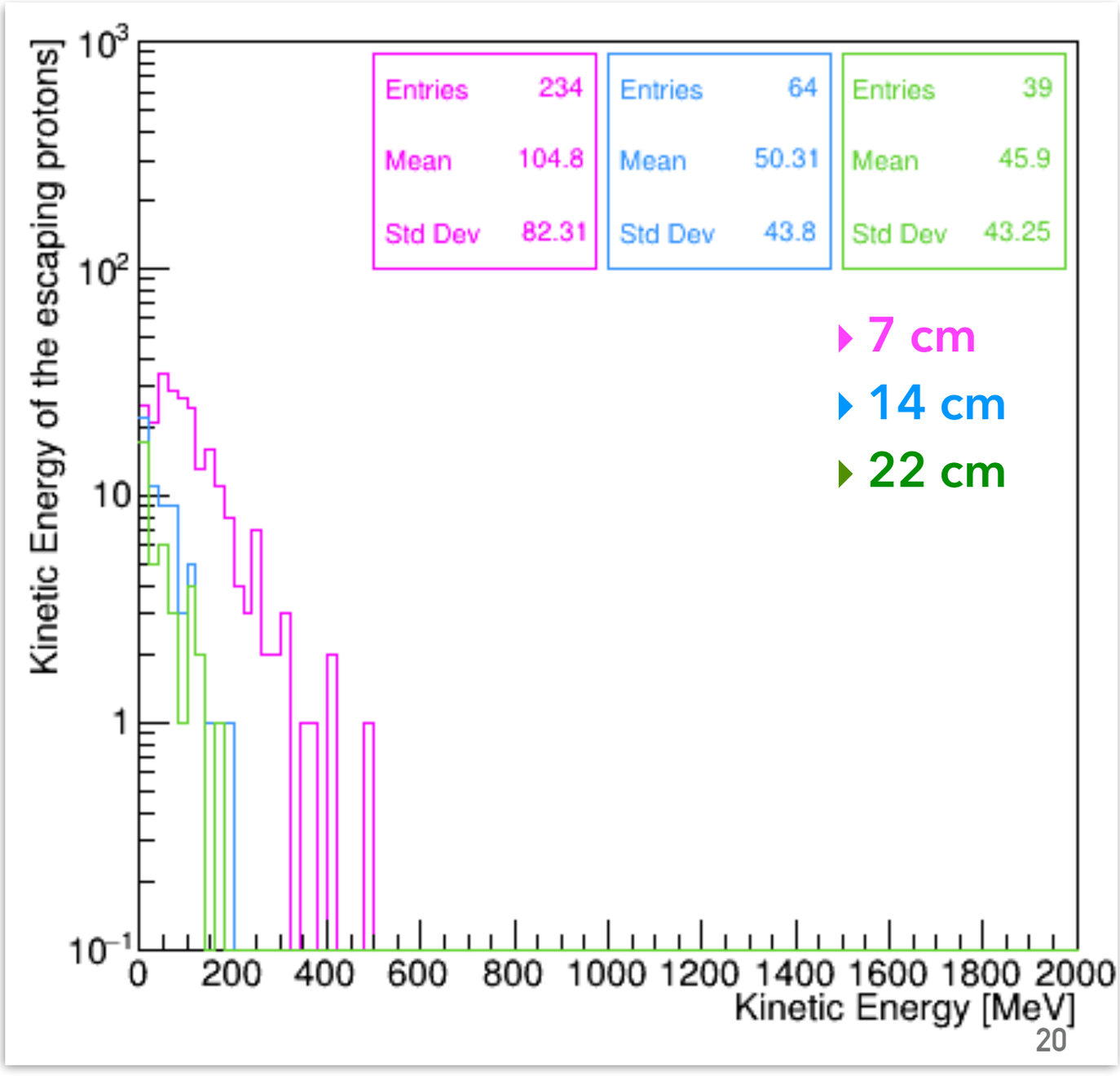
SINGLE CRYSTAL: BGO LENGTH STUDY

C12@200 MeV/u

➤ The lost of energy is due to the **escape of neutral and charged particles** (and the invisible energy due to nuclear binding energy loss);

On the other hand, proton (and more in general charged secondary particles) contribution is marginal but is dramatically reduced increasing the length of the crystal from 7 to 14 cm(or more).

Lets make the calorimeter at least 14 cm long!!



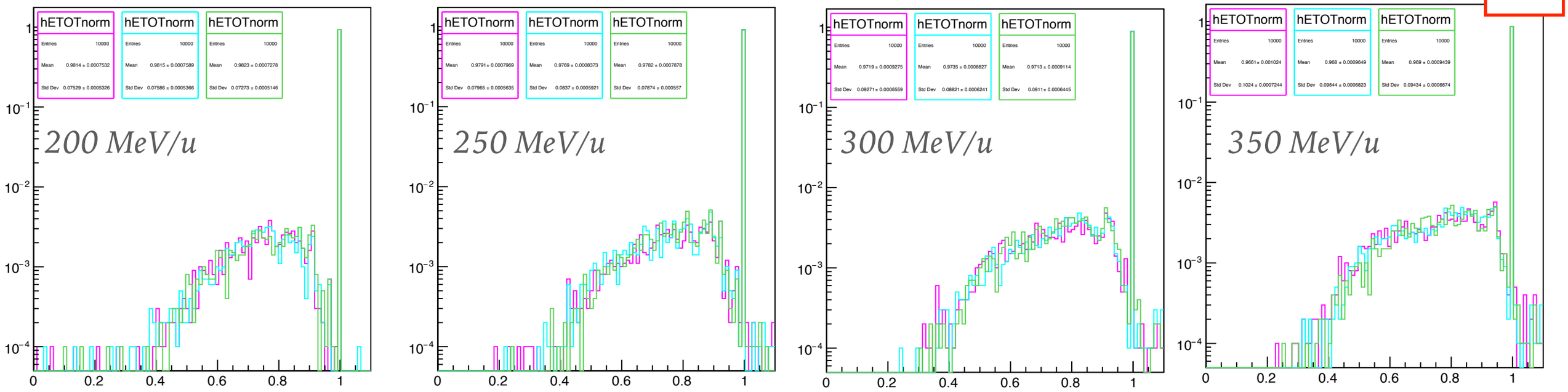
SINGLE CRYSTAL: BGO LENGTH STUDY

- 7 cm
- 14 cm
- 22 cm

NB: No energy resolution

➤ Different ion fragments were shot in the center of the crystal block: Helium, Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen;

He4



The same study for the energy loss in the charged and neutral components of secondary fragments has been performed for different elements and for 4 different energies: 200, 250, 300, 350 MeV/u.

NB: Only elements from “periodic table” from Z=2 up to Z=8.. no isotopes!

SINGLE CRYSTAL: BGO LENGTH STUDY

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- 14 cm
- 22 cm

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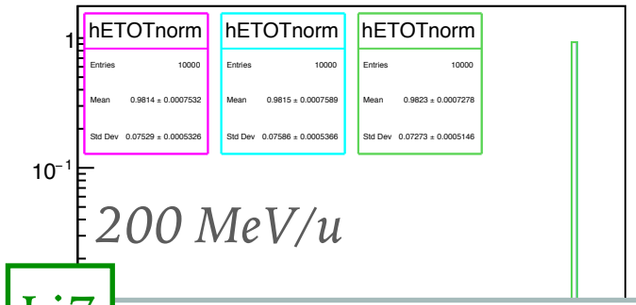
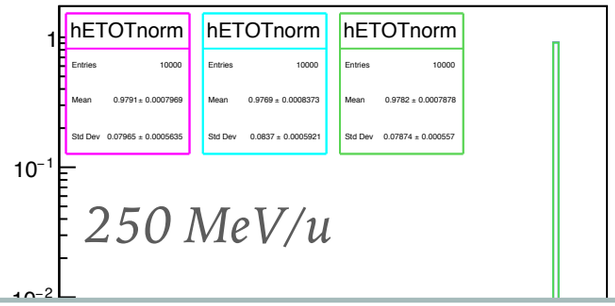
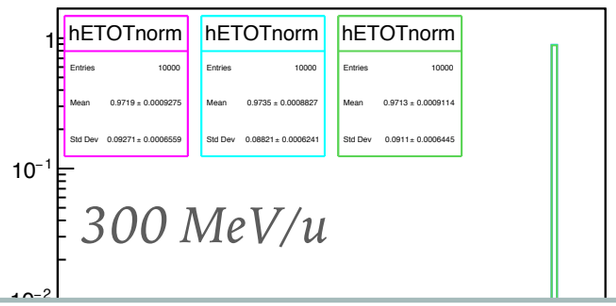
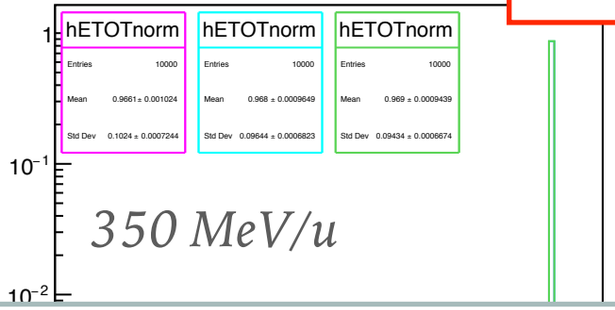
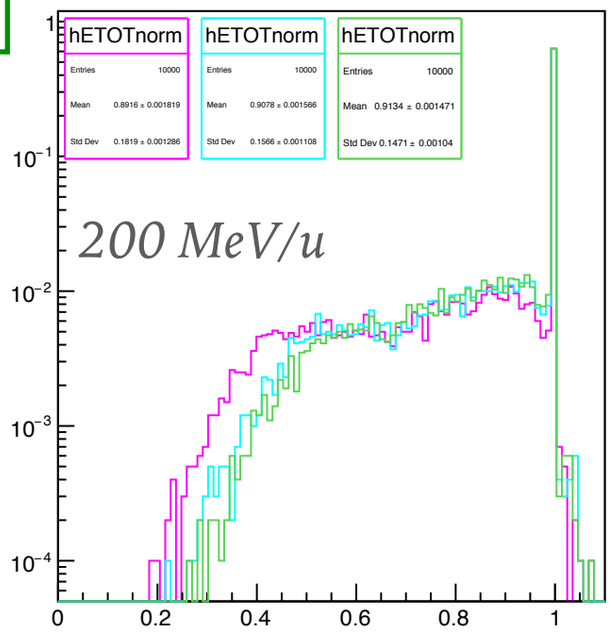


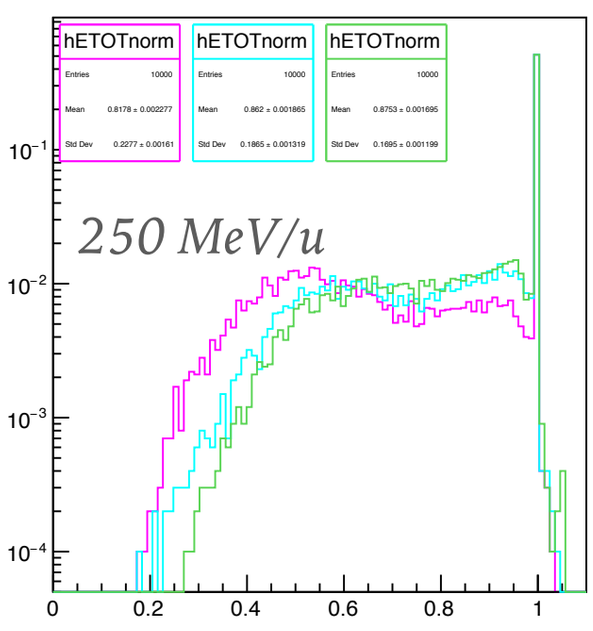


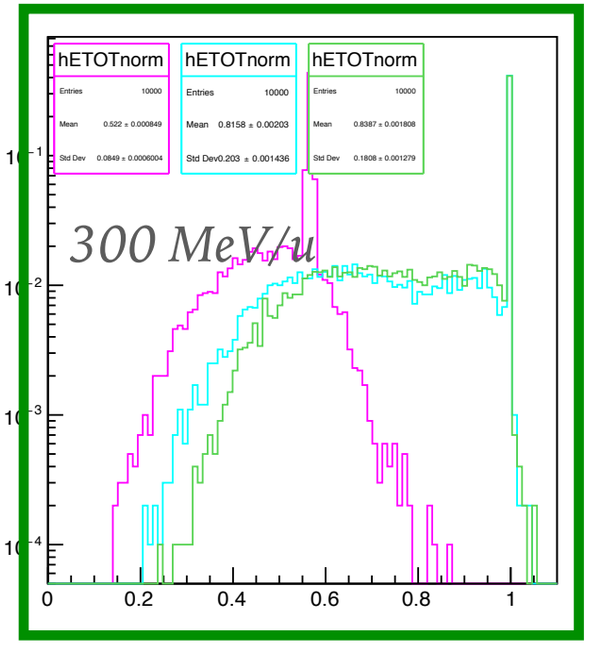


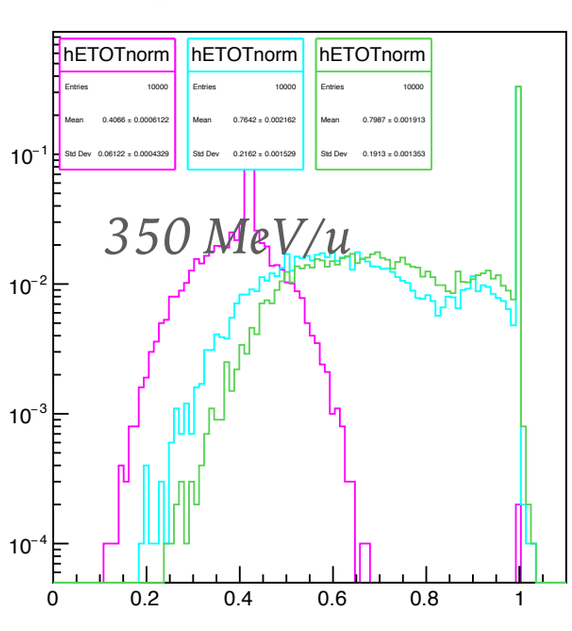


Li7









SINGLE CRYSTAL: BGO LENGTH STUDY

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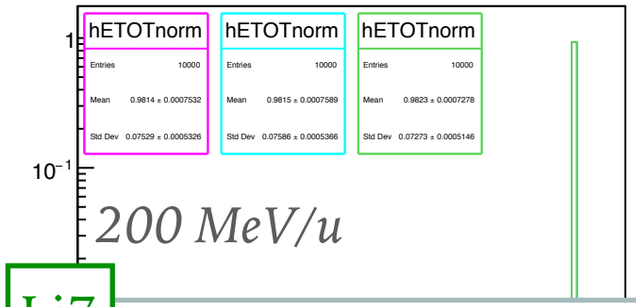

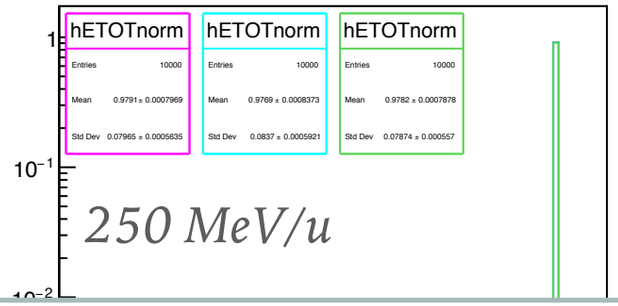

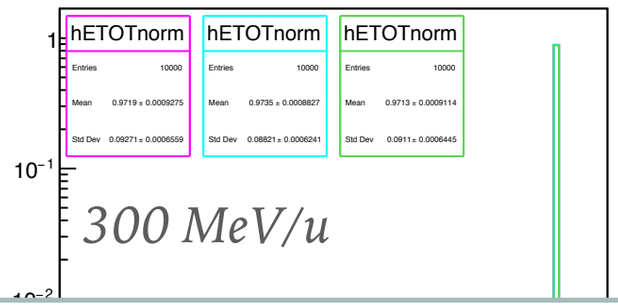

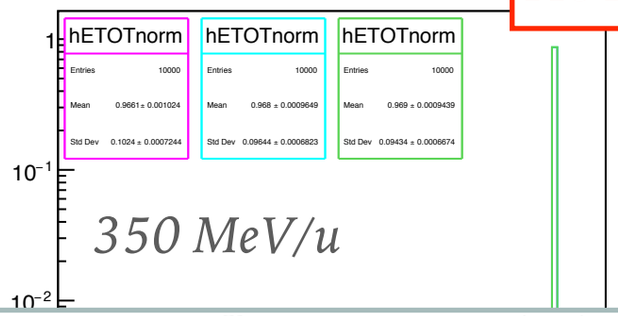

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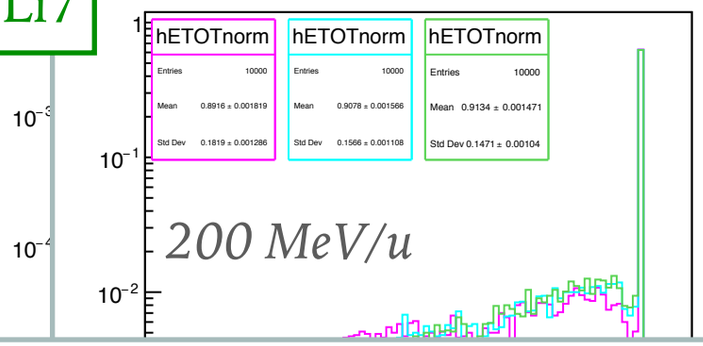
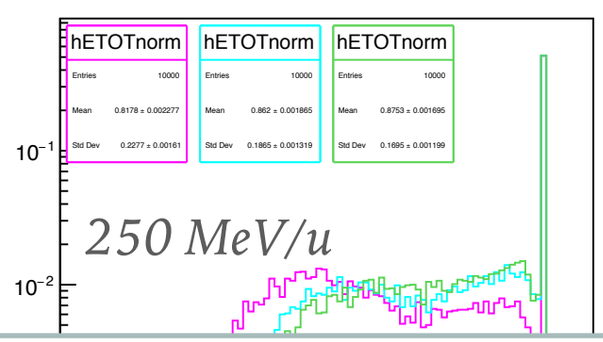
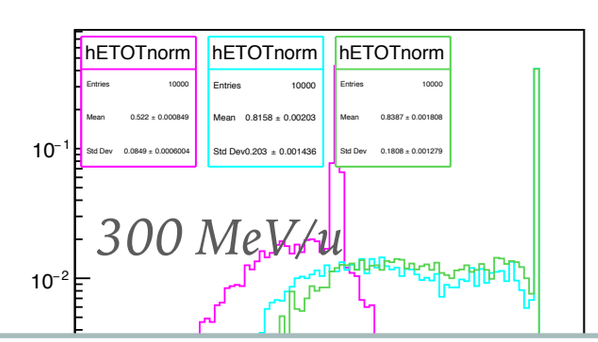
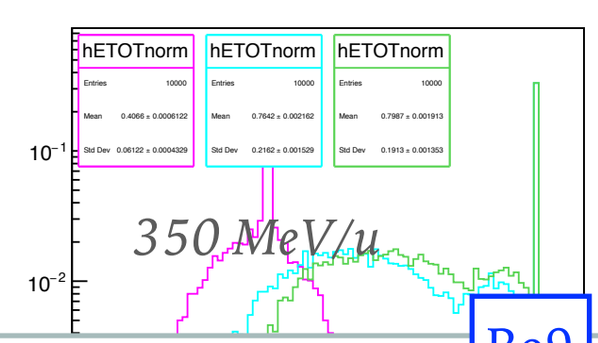
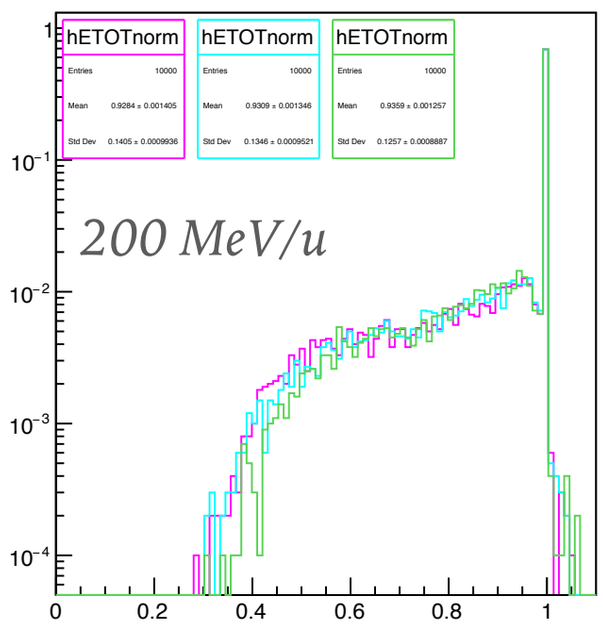


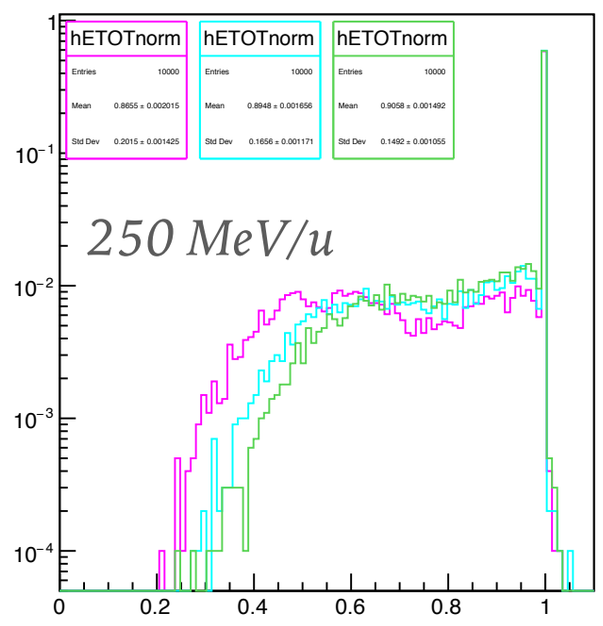


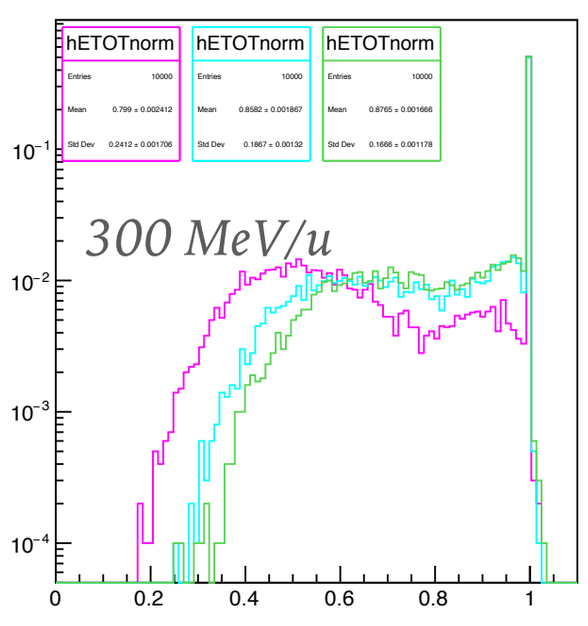


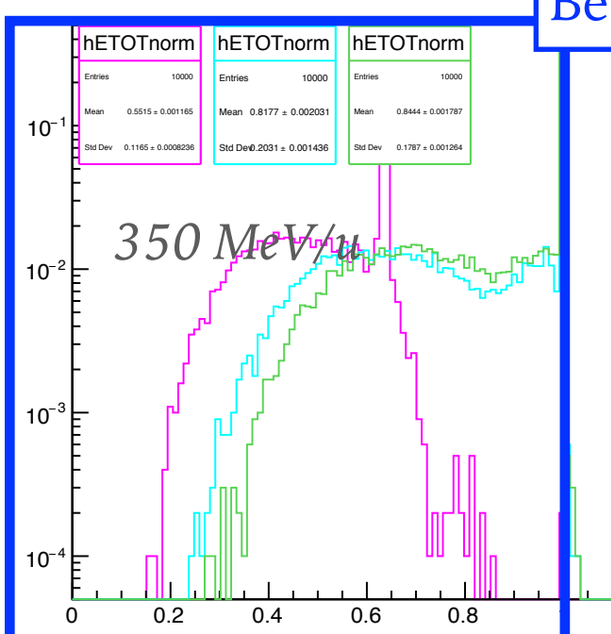


Be9









SINGLE CRYSTAL: BGO LENGTH STUDY

- 7 cm
- 14 cm
- 22 cm

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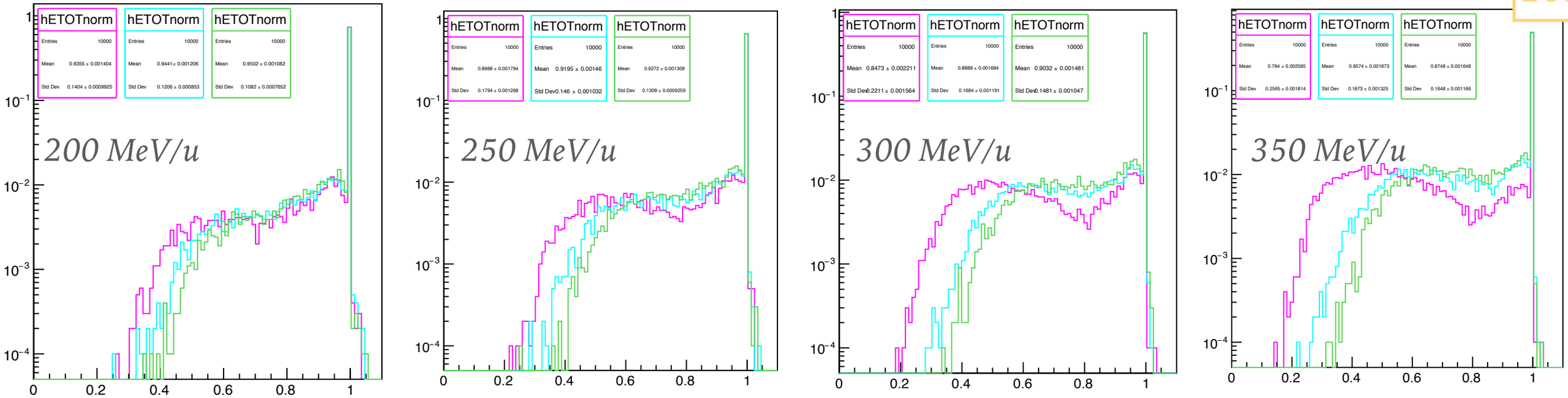
Bo11



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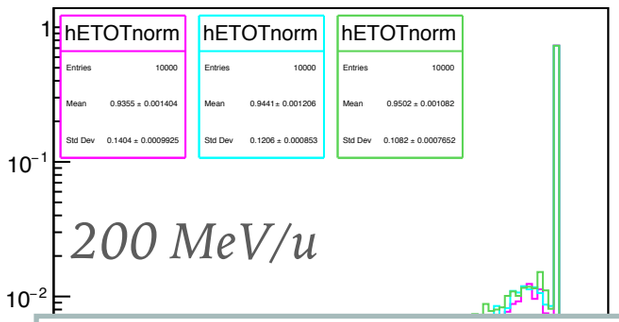
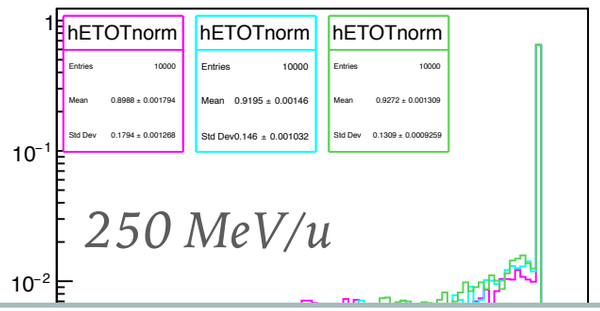
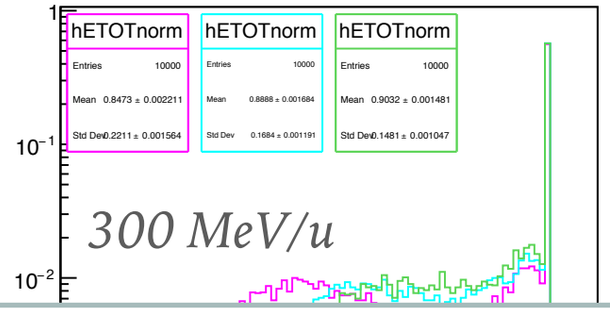
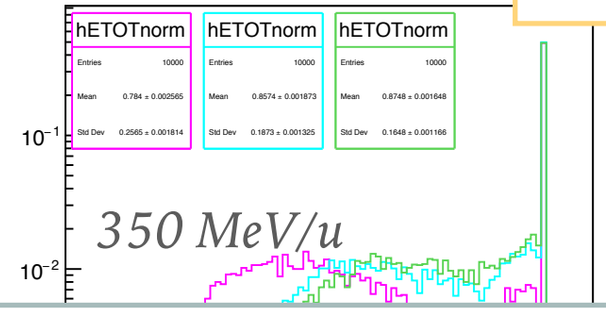
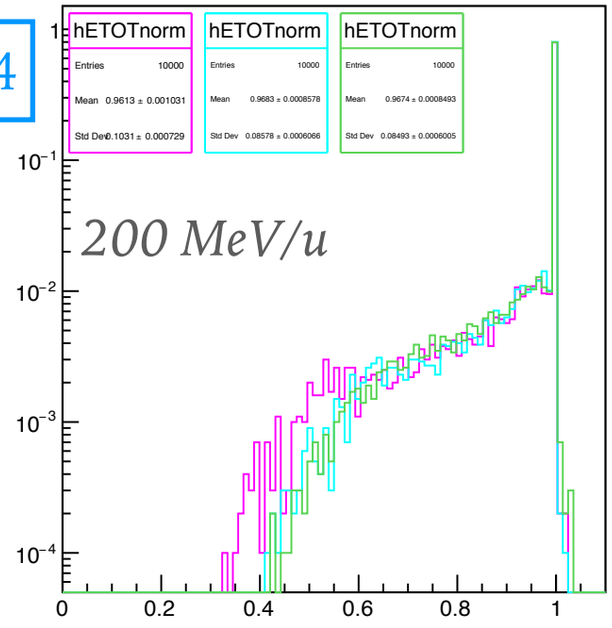


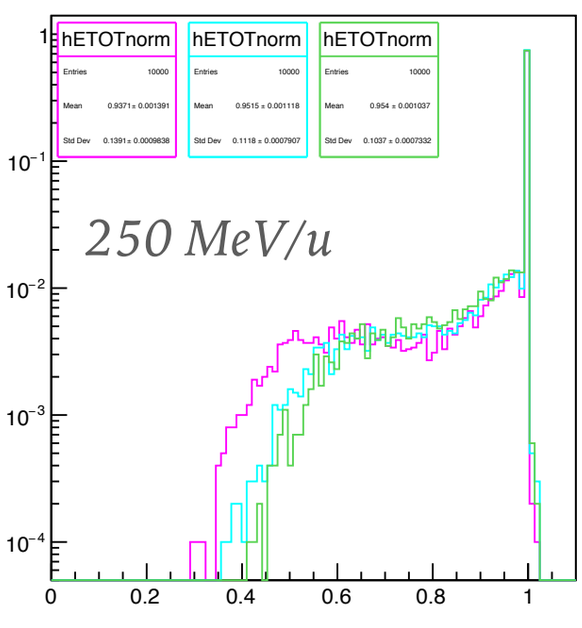


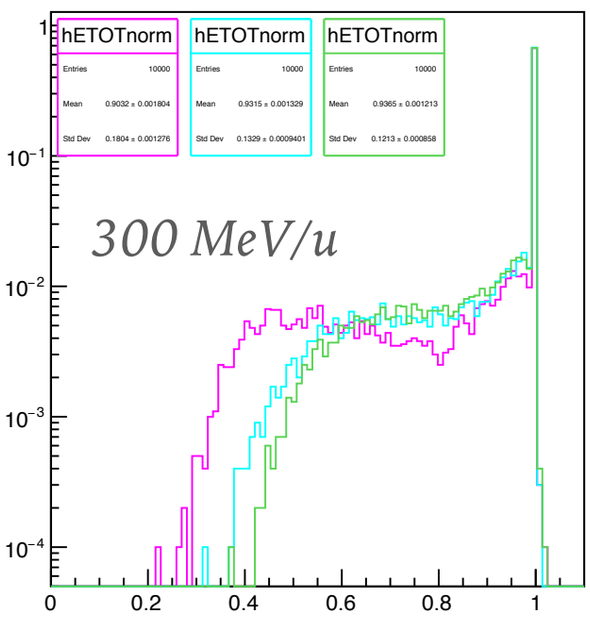


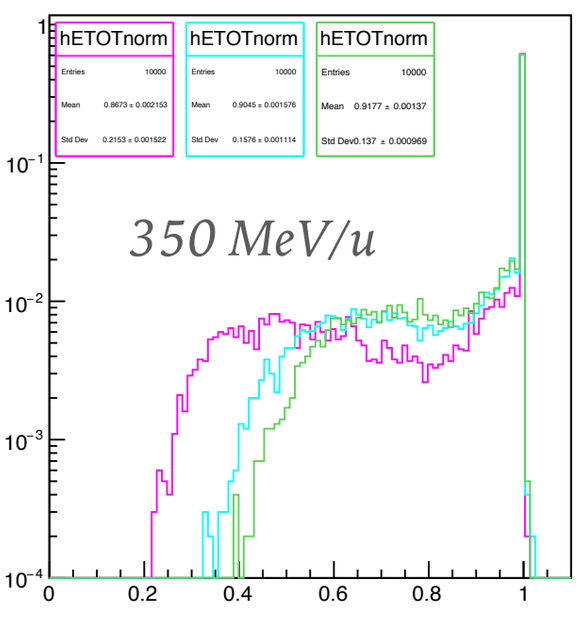


N14









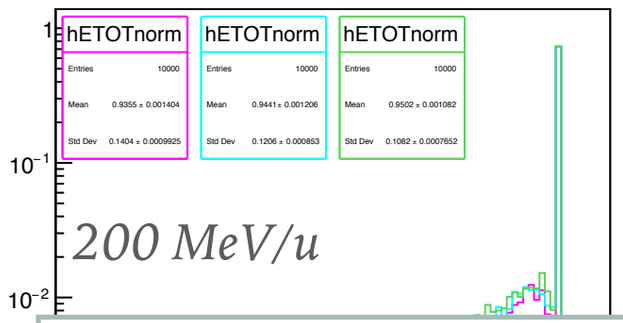
SINGLE CRYSTAL: BGO LENGTH STUDY

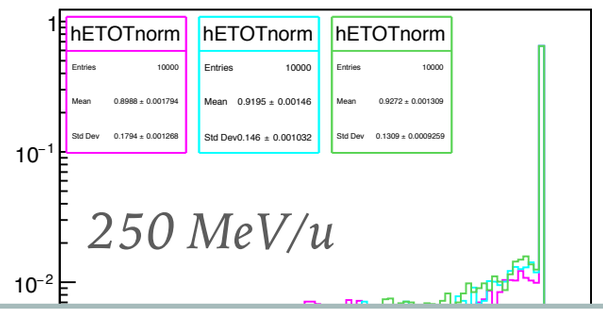
- 7 cm
- 14 cm
- 22 cm

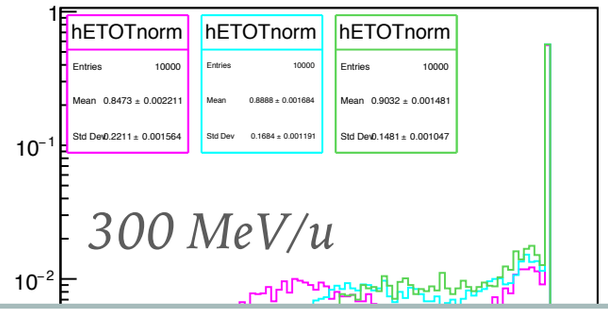
NB: No energy resolution, no isotopes

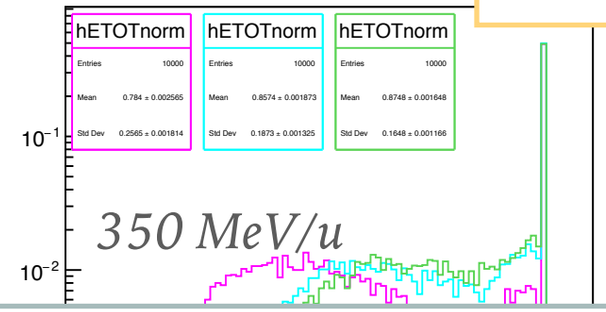
➤ Different ion fragments were shot in the center of the crystal block: Helium, Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen;

Bo11









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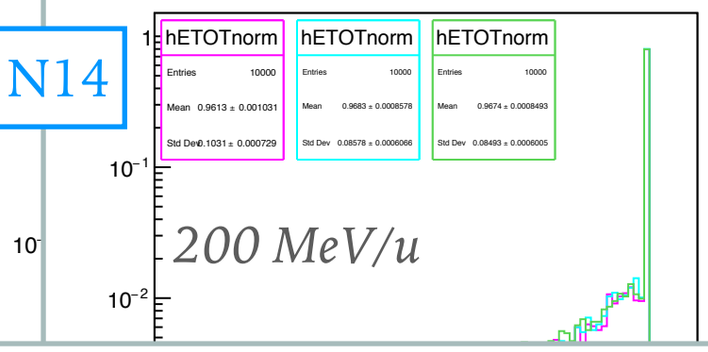
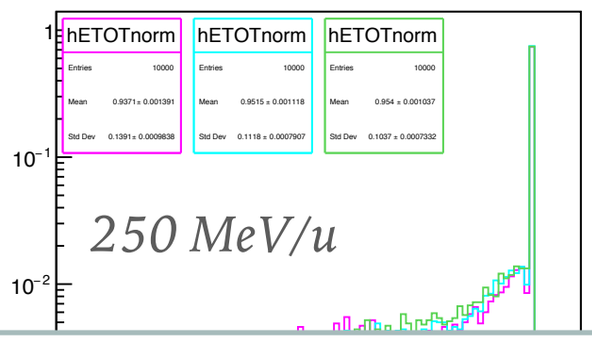
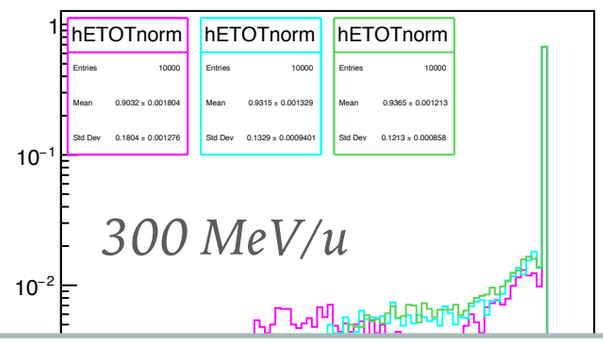
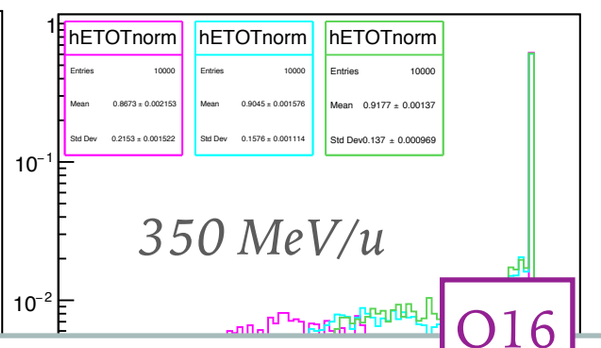
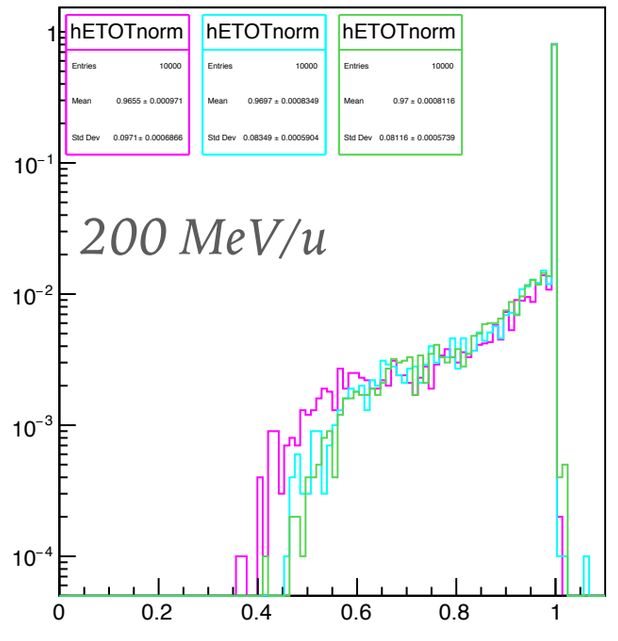


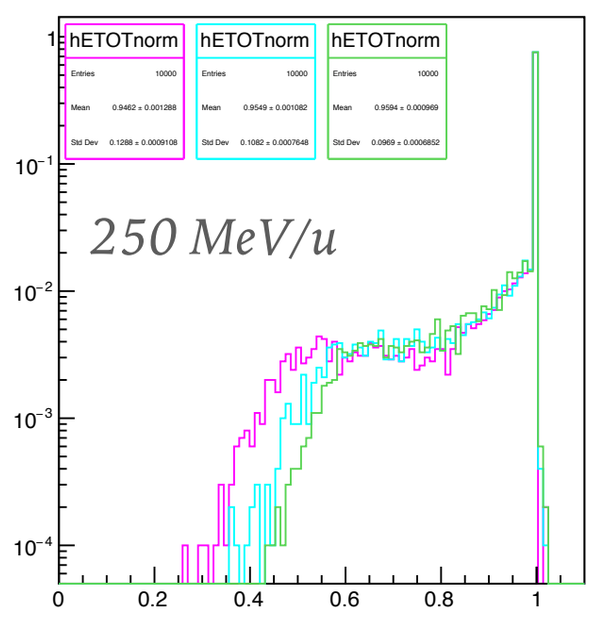


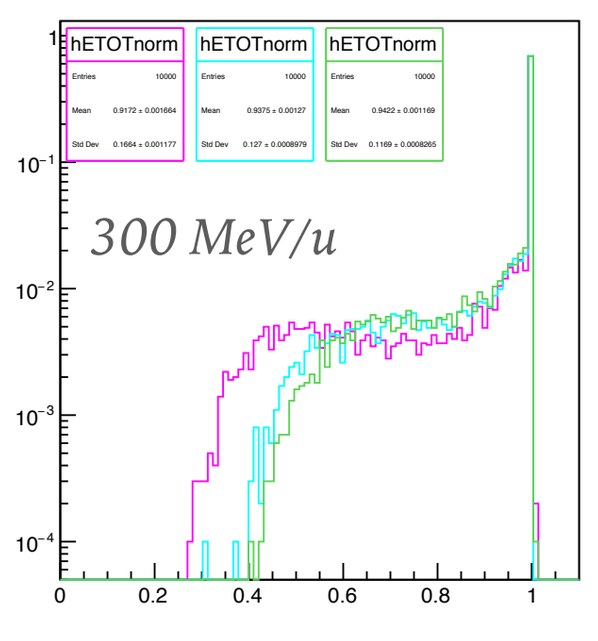


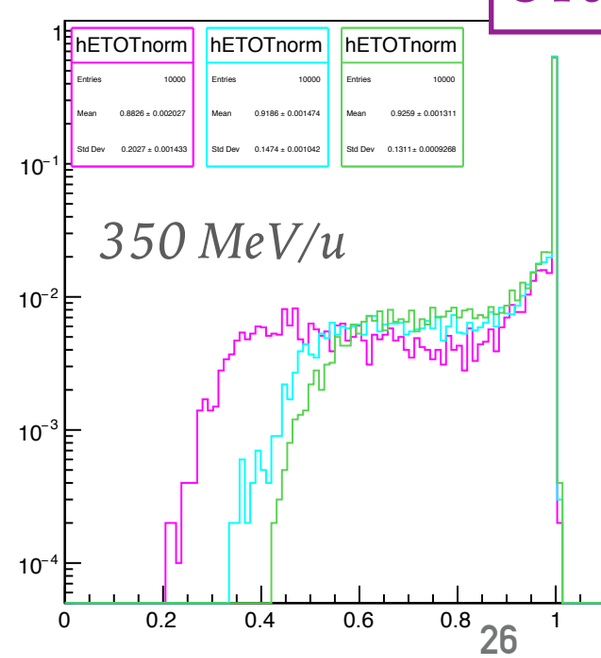


O16









SINGLE CRYSTAL: BGO LENGTH STUDY

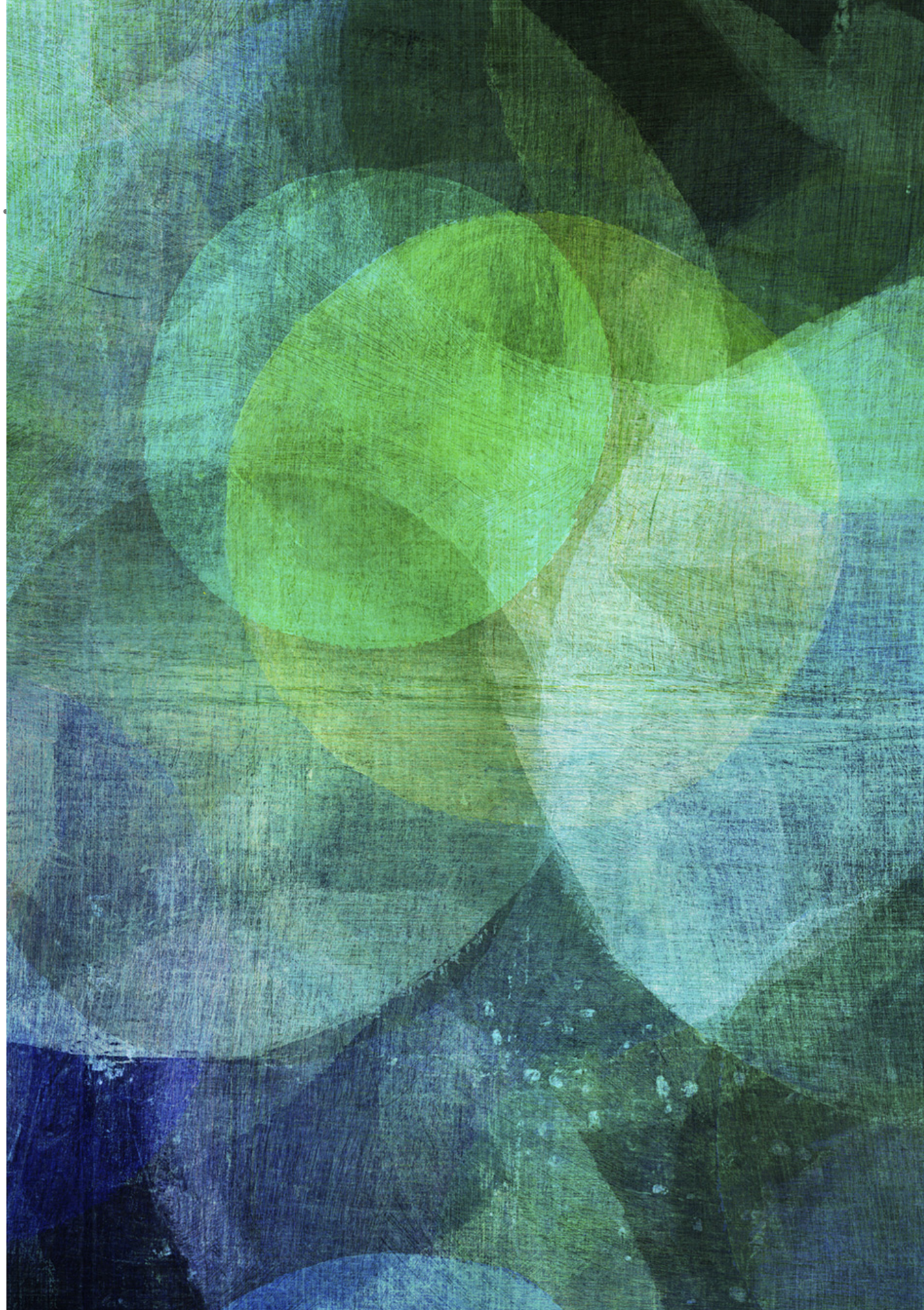
- Different ion fragments were shot in the center of the crystal block: Helium, Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen;

*It is cleat that the longer setup, with **at least 14 cm of BGO is preferable**, not only for energy loss reduction, but also for fragment total containment: the BP of Lithium and Beryllium for example is longer than 7 cm at 300 MeV/u.*

CONCLUSION:

- May be we can start assuming that our calorimeter is going to be longer than 7 cm and implement this assumption in the full simulation.
- Efficiency, **energy and time resolutions** should be now included in our **preliminary** analysis in order to evaluate the detector performances.

BACKUP SLIDES



BACKUPSLIDES

- Wigmans.. =>calorimeters per Heigh Energy Physics

	Lead	*Iron*
Ionization by pions	19%	21%
Ionization by protons	37%	53%
Total ionization	56%	74%
Nuclear binding energy loss	32%	16%
Target recoil	2%	5%
Total invisible energy	34%	21%
Kinetic energy evaporation neutrons	10%	5%
Number of charged pions	0.77	1.4
Number of protons	3.5	8
Number of cascade neutrons	5.4	5
Number of evaporation neutrons	31.5	5
Total number of neutrons	36.9	10
Neutrons/protons	10.5/1	1.3/1