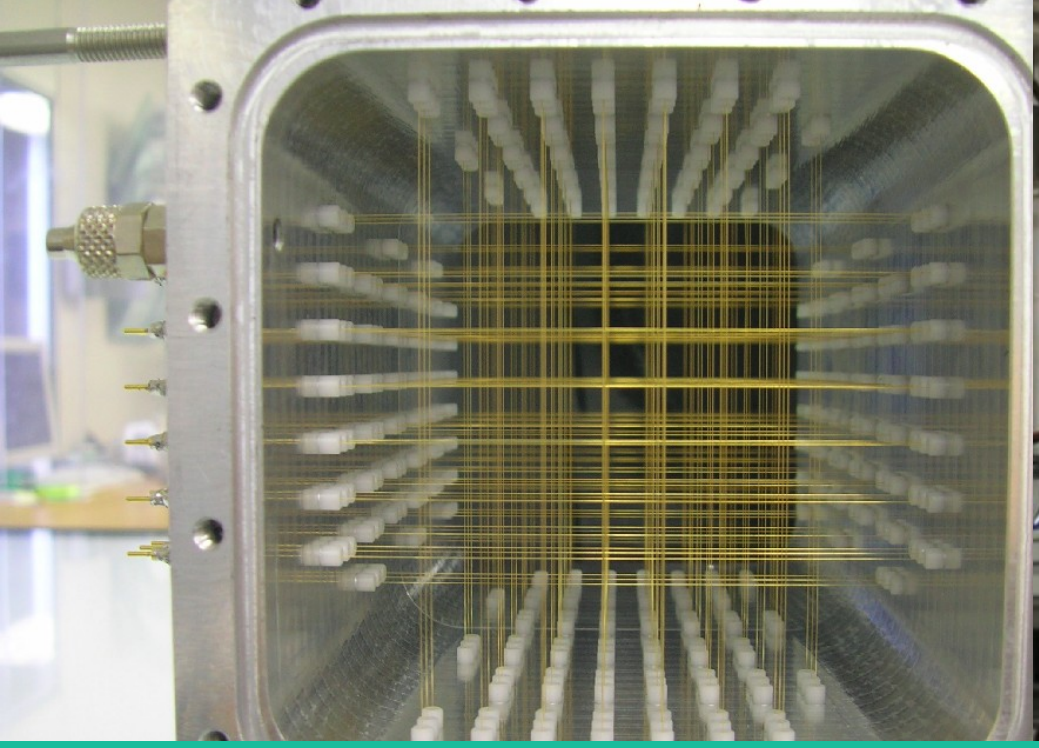
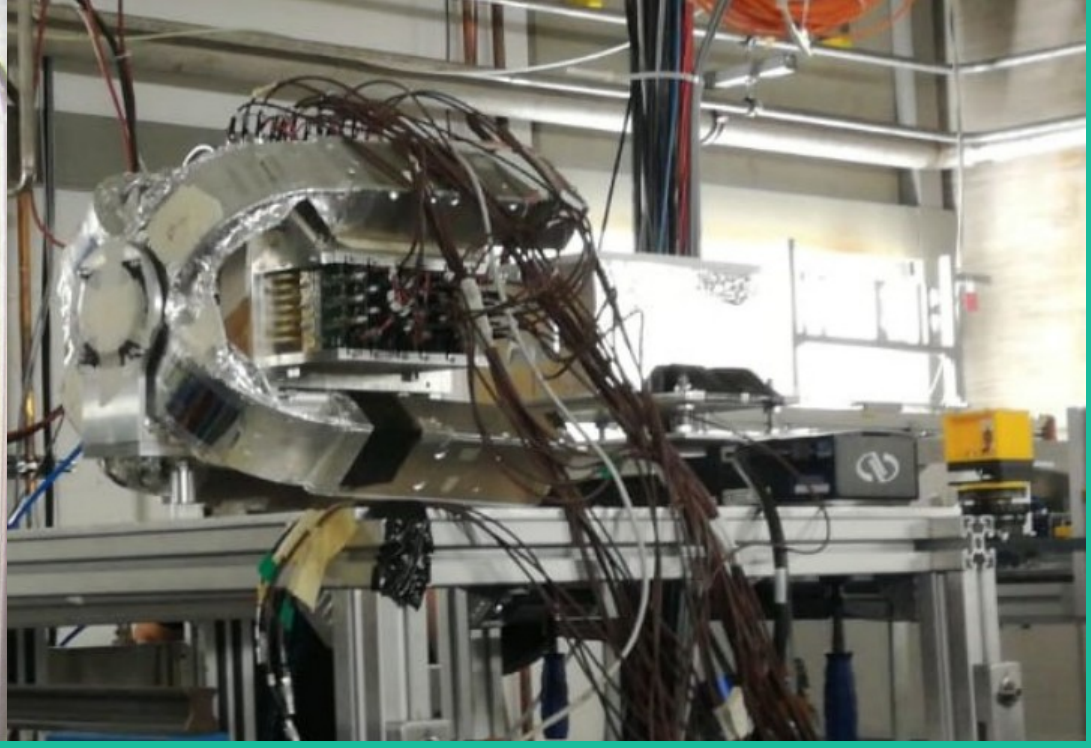




Beam Monitor MC studies

Yunsheng Dong

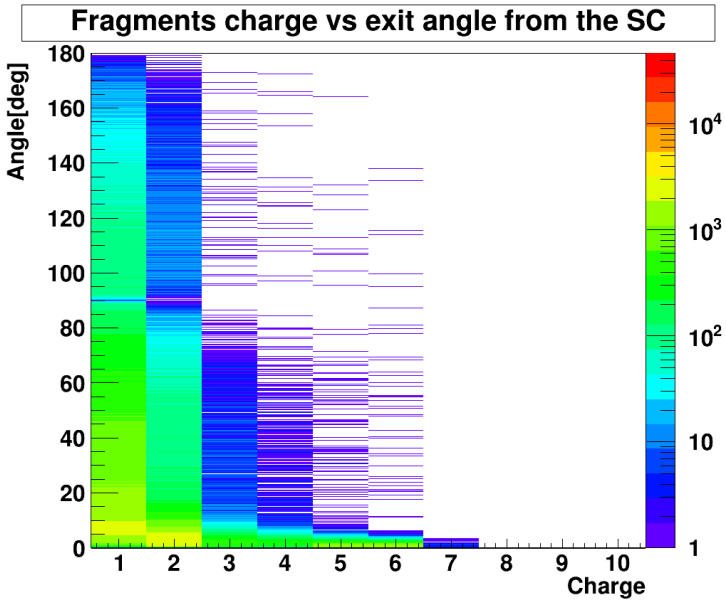
FOOT performance meeting

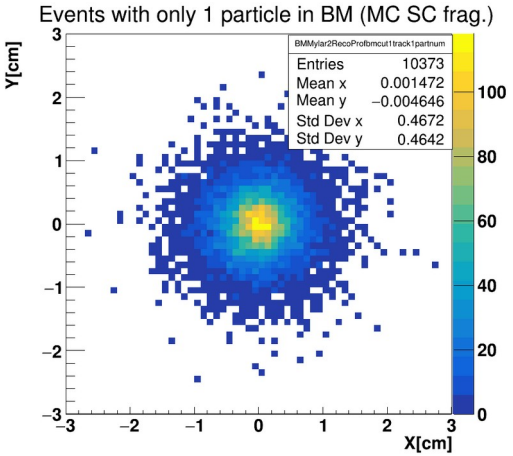
07/10/2020

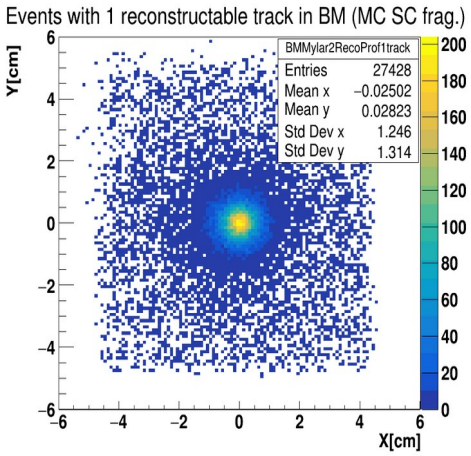
Outline

- **SC and BM fragmentation studies**
- **Inverse kinematic approach studies**
- **Next data taking at CNAO**

Pre-target fragmentation







MC simulation: 12C @ 200 MeV/u on C target

Fragmentation rate:

- Target ~ 1.46%
- Start Counter ~ 0.13%
- Beam Monitor ~ 0.12%

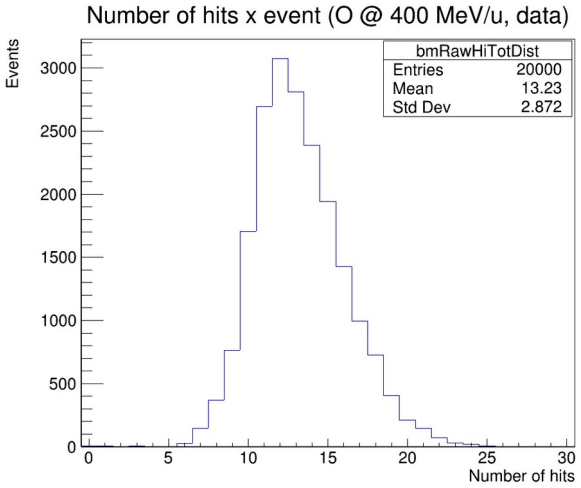
Only SC fragmentation events:

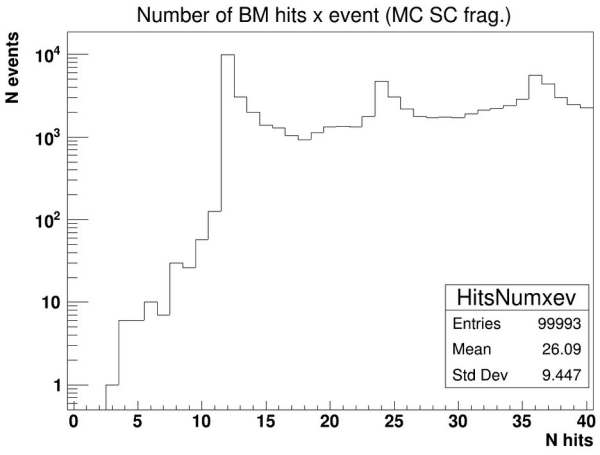
- ~27% 1 reconstructable track + other particle hits
- ~10% only a B or C fragment, no other hits

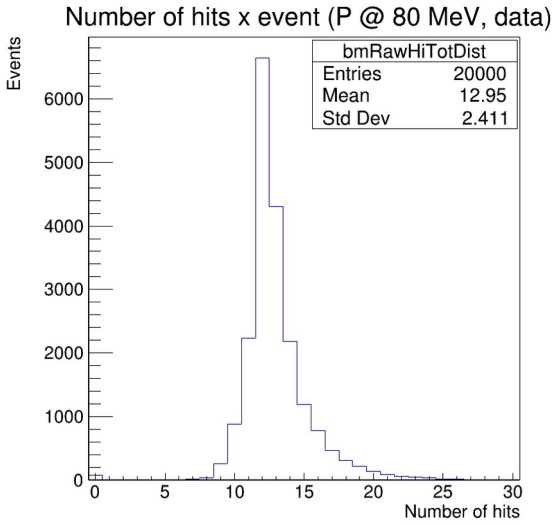
Only BM fragmentation events:

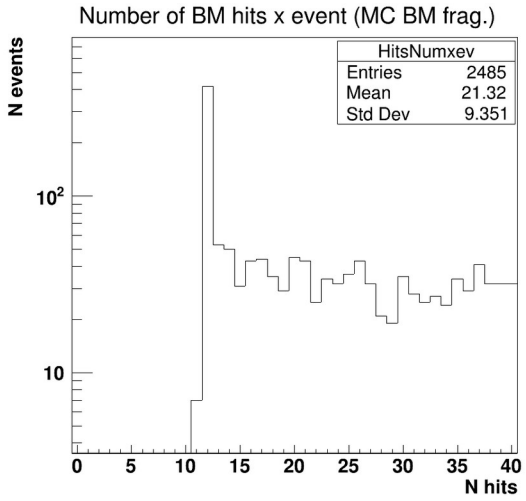
- ~46% 1 reconstructable track + other particle hits
- ~17% only 1 particle track, no other hits

Number of hit selection









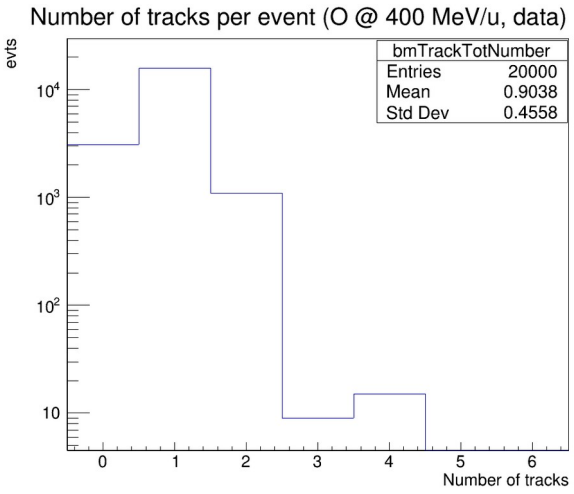
The hit distribution depends on the projectile charge and energy because of delta rays

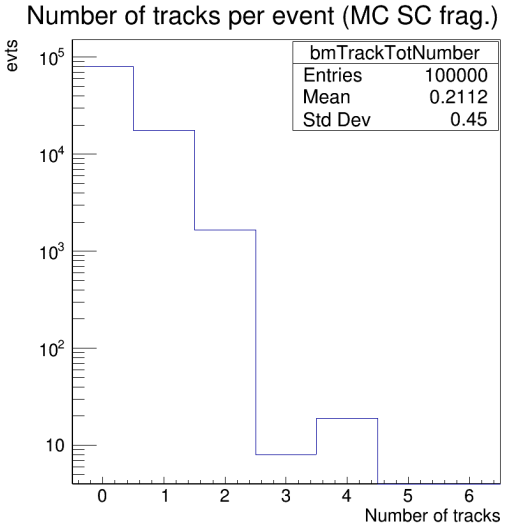
With oxygen @ 400 MeV/u data,
a reasonable cut is $8 \leq N_{hits} \leq 18$

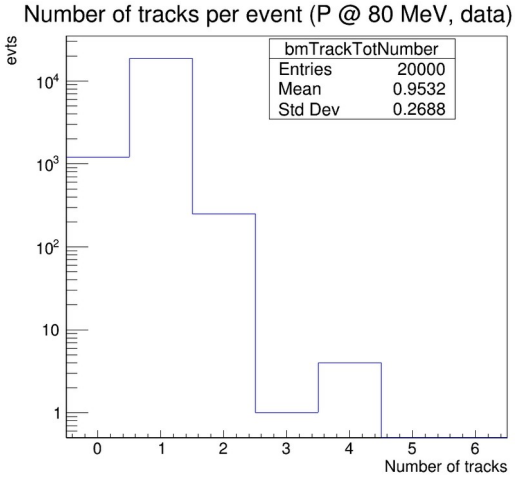
Survival rates:

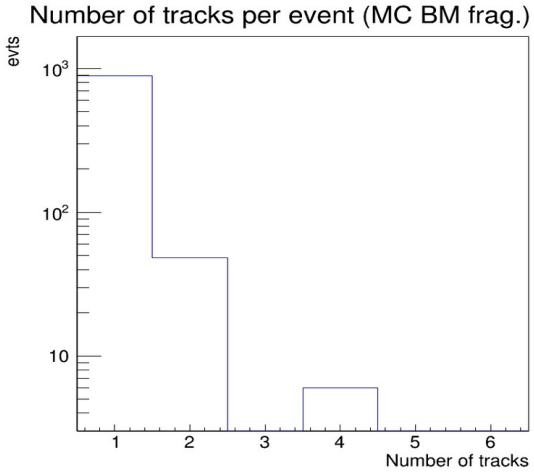
- ~ 96% data with P @ 80 MeV
- ~ 95% data with O @ 400 MeV
- ~ 22% MC with SC fragmentation
- ~ 35% MC with BM fragmentation

Multitrack selection







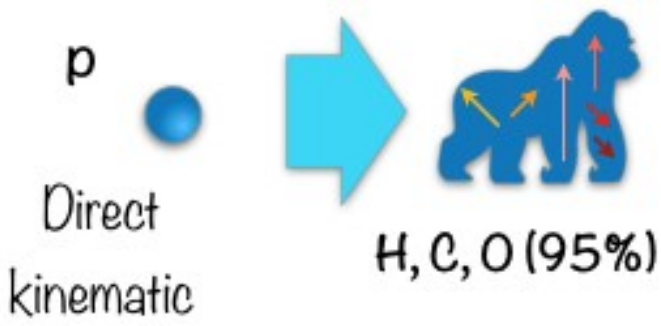


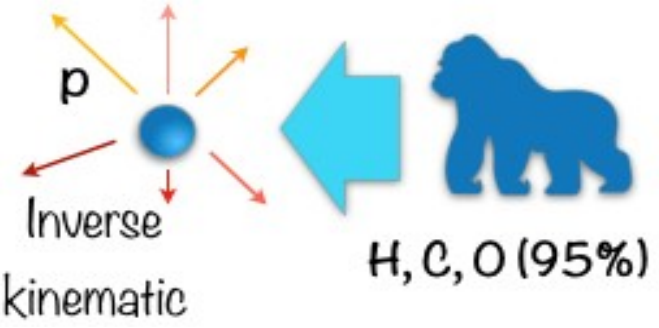
Exploit the BM multi-track reconstruction capability

Select the events with only 1 reconstructed track
(after the number of hit criteria):

- Data with P @ 80 MeV: ~ 93%
- Data with O @ 400 MeV/u: ~ 79%
  (Space-time rel. not optimized)
- MC with SC fragmentation: ~ 18%
- MC with BM fragmentation: ~ 32%

Inverse kinematic approach





- Lorentz transformation to invert the kinematics in the PT target fragmentation data
- The transformation can be written as:

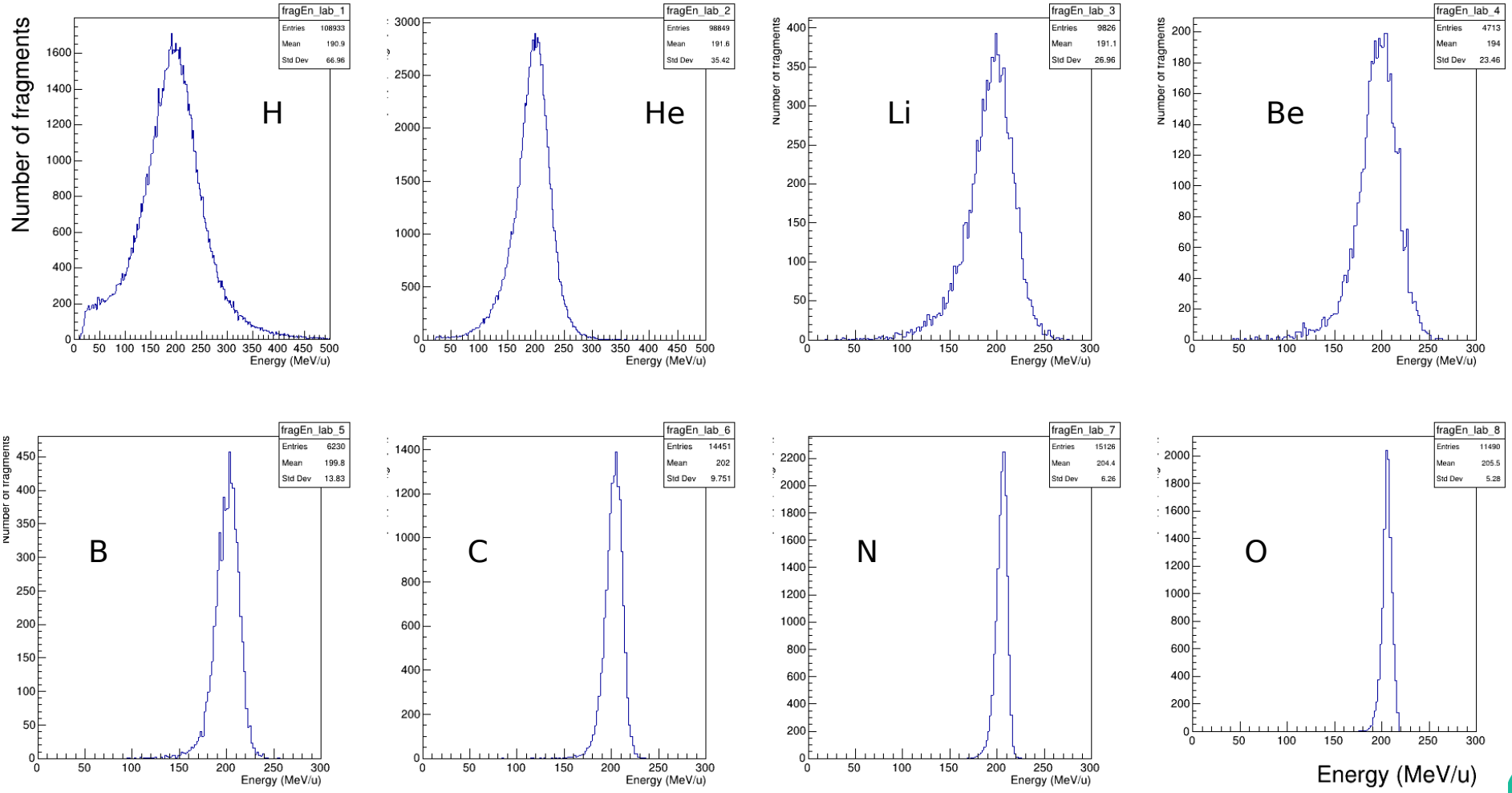
$$\mathbf{A'} = \Lambda\mathbf{A}$$

where **A** is the four momentum of the projectile **measured by the BM** and Λ is:

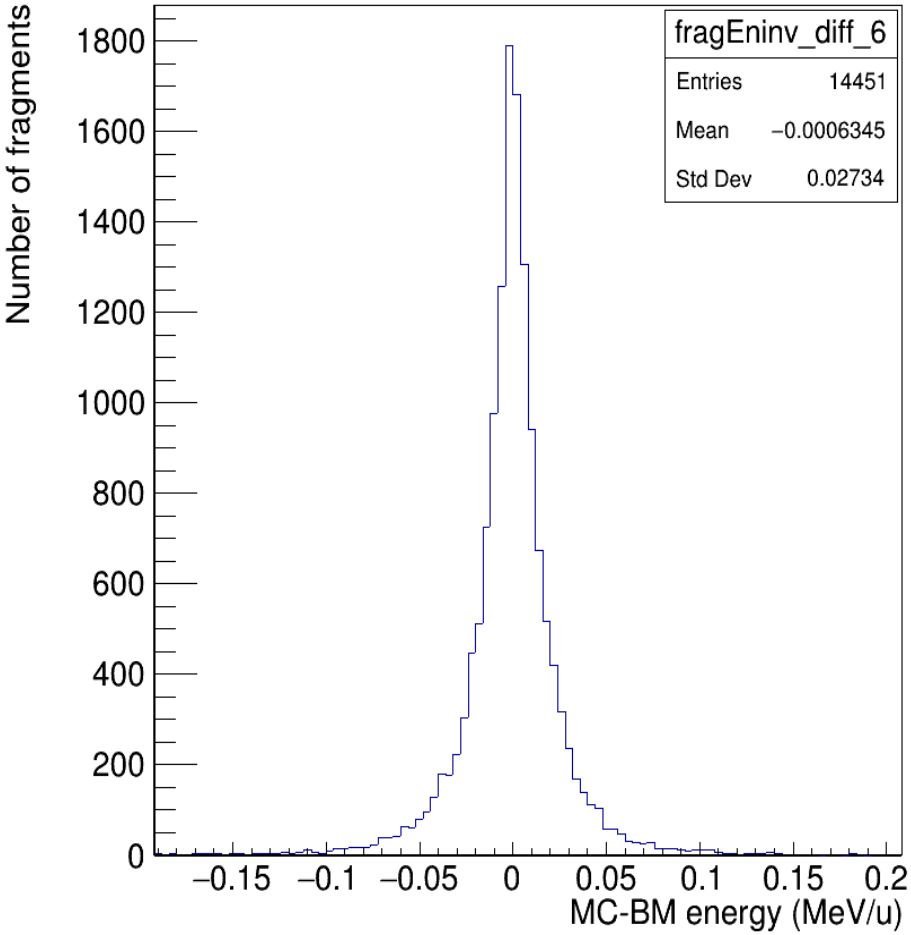
$$\Lambda = \begin{pmatrix} \gamma & -\beta_x\gamma & -\beta_y\gamma & -\beta_z\gamma \\ -\beta_x\gamma & 1+(\gamma-1)\frac{\beta_x^2}{\beta^2} & (\gamma-1)\frac{\beta_x\beta_y}{\beta^2} & (\gamma-1)\frac{\beta_x\beta_z}{\beta^2} \\ -\beta_y\gamma & (\gamma-1)\frac{\beta_y\beta_x}{\beta^2} & 1+(\gamma-1)\frac{\beta_y^2}{\beta^2} & (\gamma-1)\frac{\beta_y\beta_z}{\beta^2} \\ -\beta_z\gamma & (\gamma-1)\frac{\beta_z\beta_x}{\beta^2} & (\gamma-1)\frac{\beta_z\beta_y}{\beta^2} & 1+(\gamma-1)\frac{\beta_z^2}{\beta^2} \end{pmatrix}$$

Energy of fragments in the lab syst.

MC simulation with O @ 200 MeV/u on 2mm of C_2H_4 target
Energy of the fragments that arrive to the Tof-Wall in the lab syst. with MC truth



BM resolution effect

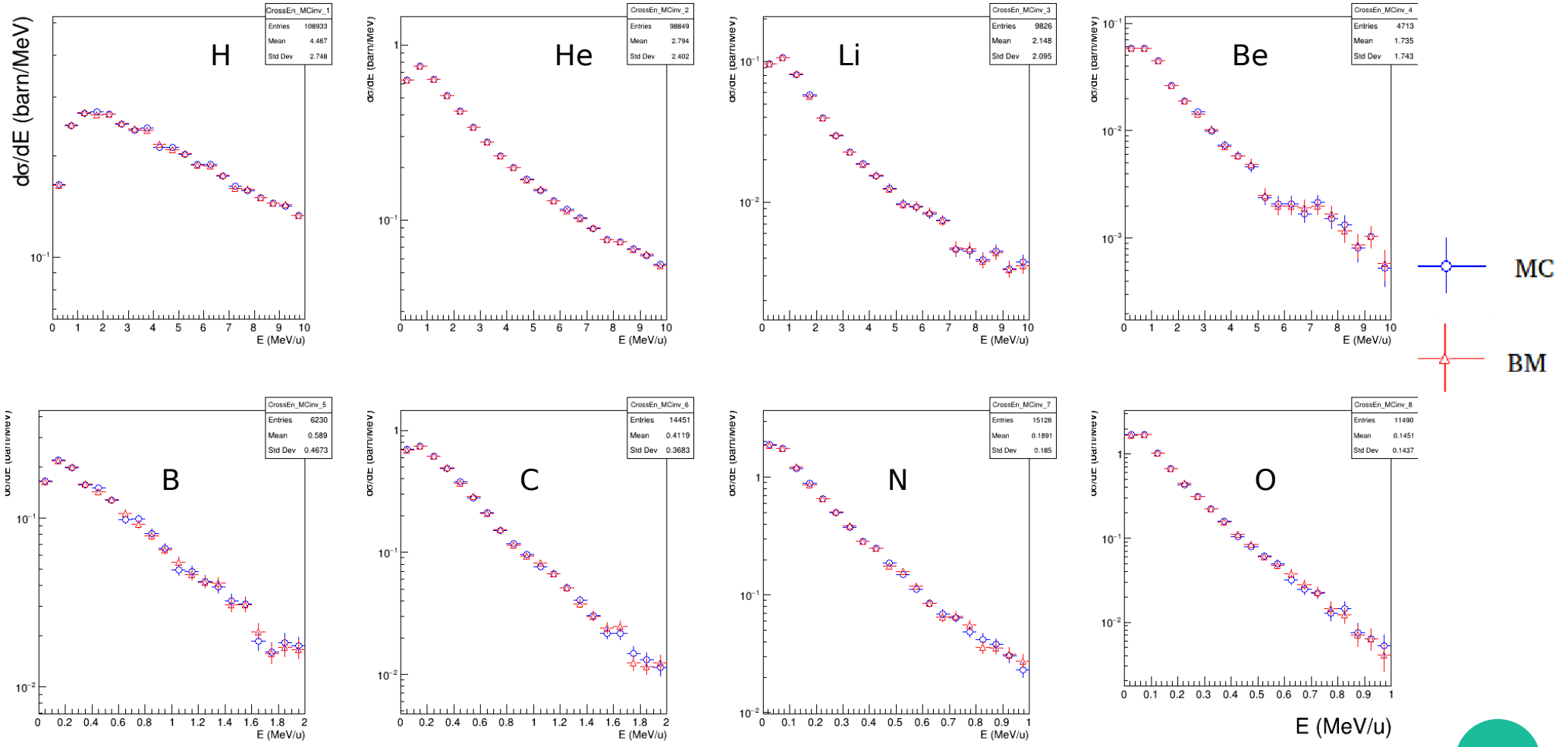


BM resolution effect on the energies of the fragments in the projectile system of reference:

- The BM measured resolution, efficiency and noise are reproduced in the reconstruction software
- Given a FLUKA simulation, the primary track parameters are retrieved by the MC truth and the BM reconstructed track
- The kinematic inversion is performed with the MC truth and the BM track
- For each fragment, the energy in the projectile syst. can be retrieved with the MC truth and BM reconstructed inversion matrix

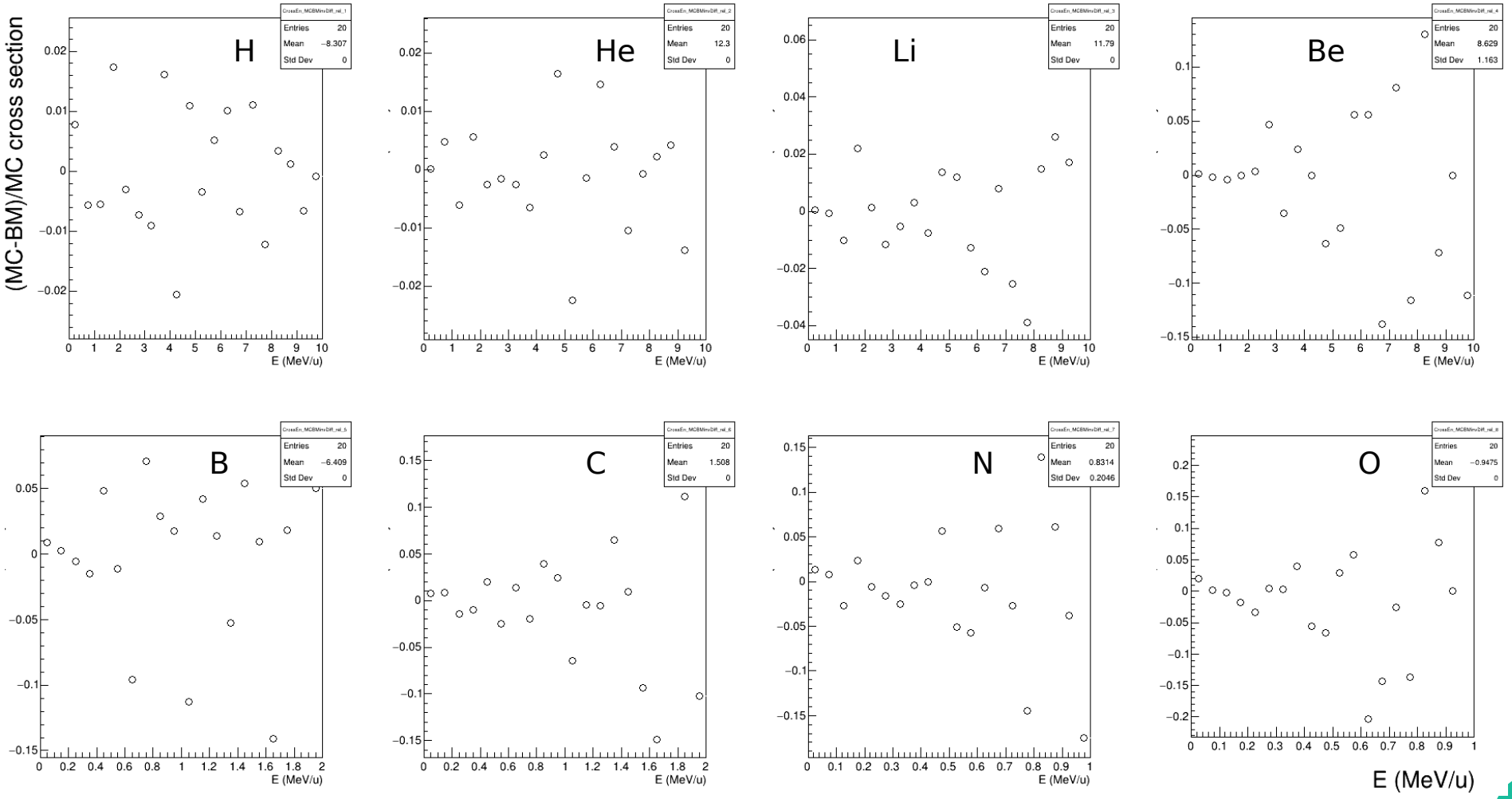
Cross section estimates

dσ/dE in the projectile syst. with the inversion made from the MC projectile parameters and from the track reconstructed by the BM (detectors eff=1, no unfolding, only BM resolution)



Cross section resolutions

Relative cross sections resolution: (MC-BM)/MC
The BM resolution effect on the cross sections is of few %



Next data taking @ CNAO

Next data taking at CNAO in December 2020

Centro Nazionale di Adroterapia Oncologica

People involved (with turn over):

- Milano: Yun, Giuseppe, Silvia
  (Maybe Ilaria and Serena)
- Trento: Sofia, Francesco, Benedetto

BM Requests:

- Without beam: setup and test the channel readout with cosmic rays.
- With beam: if everything works, we do not have real beam time requests.

  we just need a run without the target and with the VTX to try the space-time relations calibration (~200000 evts. at least)

Back up

Cross section estimates in labo syst.

MC simulation with O @ 200 MeV/u on 2mm of C_2H_4 target
dσ/dE in the labo syst. (no unfolding, detector efficiencies etc., only “MC truth”)