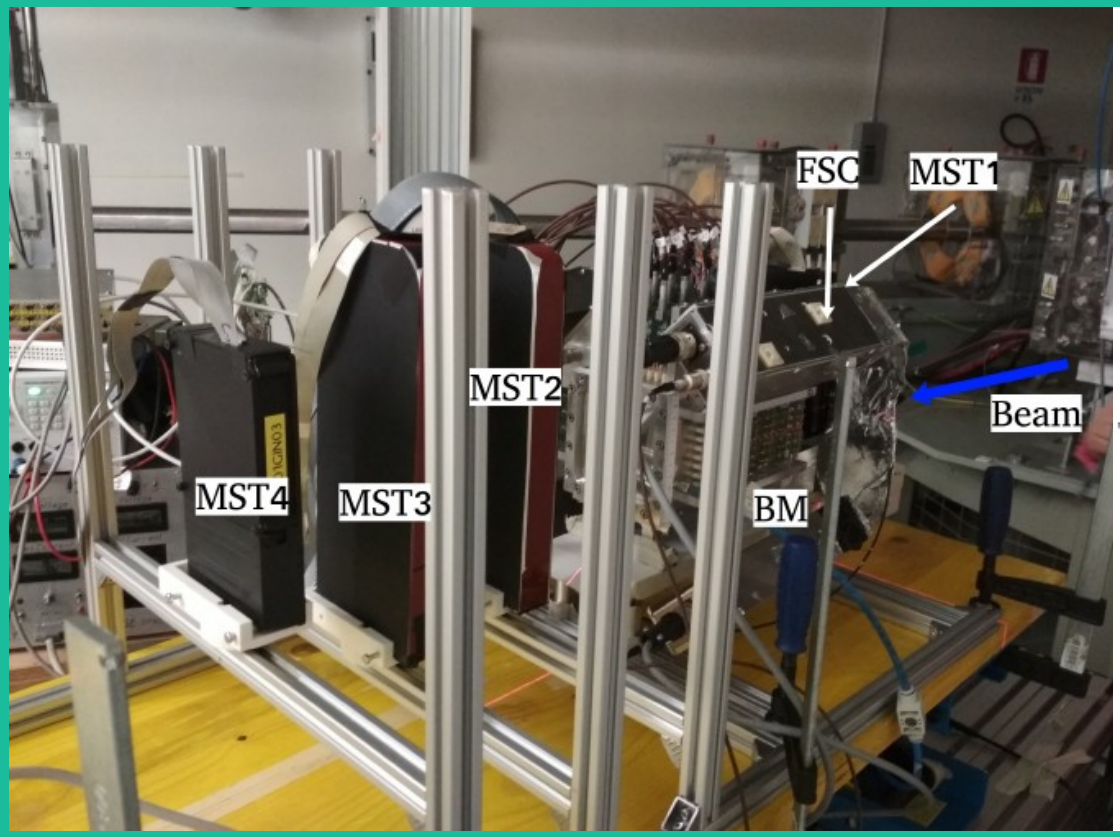
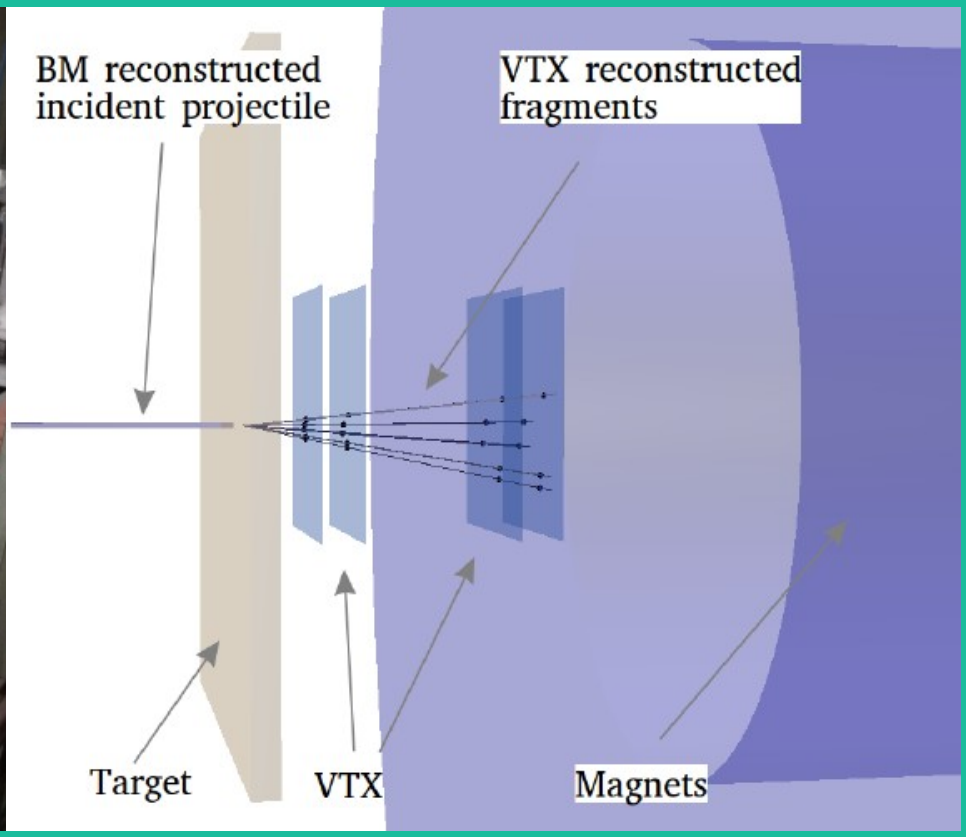




Beam Monitor status

IX FOOT Collaboration general meeting

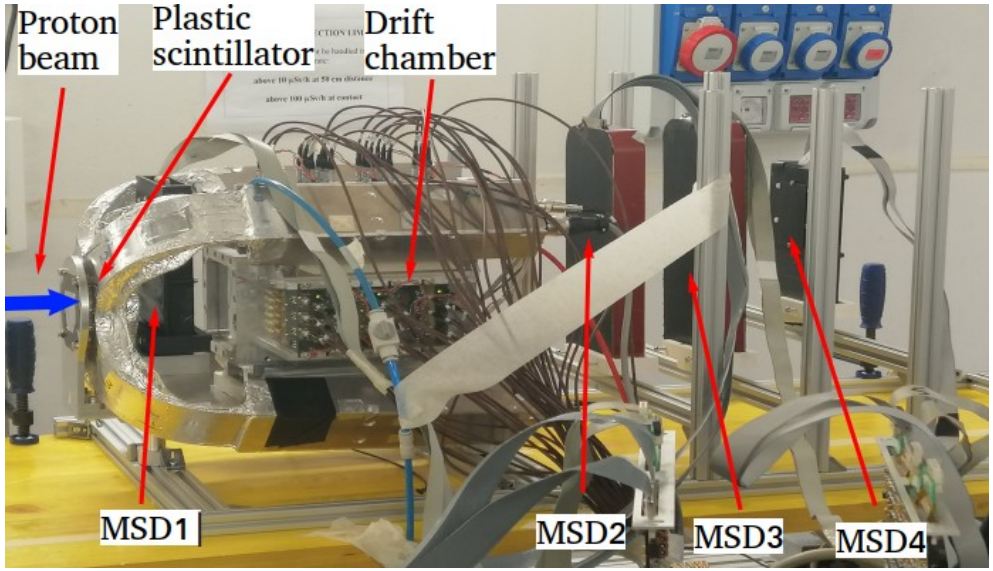
09/12/2020

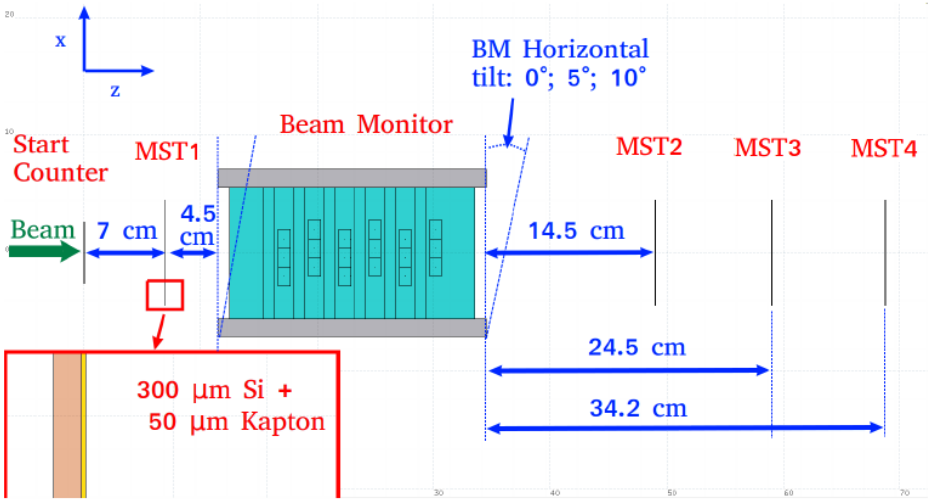
Yunsheng Dong on behalf of the BM team

Outline

- **Beam Monitor performance assessment summary**
- **Impact of the Beam Monitor performances on the inverse kinematic reconstruction**
- **Identification and rejection of the pre-target fragmentation events**

The FOOT Beam Monitor





FOOT Beam Monitor goals:

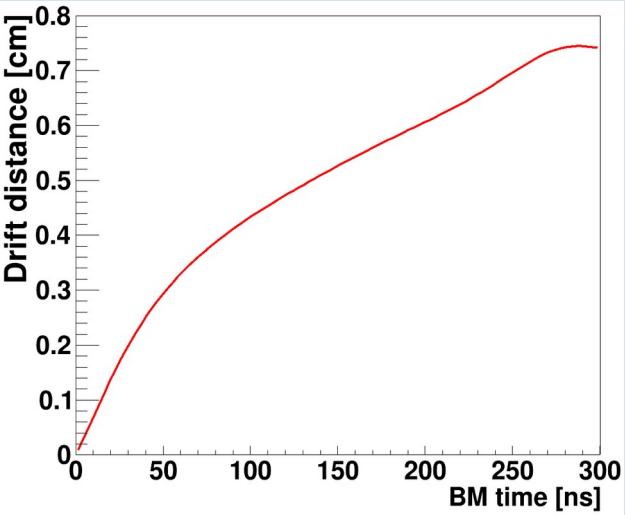
- Measure the beam direction and position
- Identify the pre-target fragmentation events

The drift chamber has been characterized by means of an external tracking detector

- Plastic scintillator for trigger and BM time ref.
- 4 layers of micro-strip silicon detectors (MSD)
- Proton beams at 228 and 80 MeV

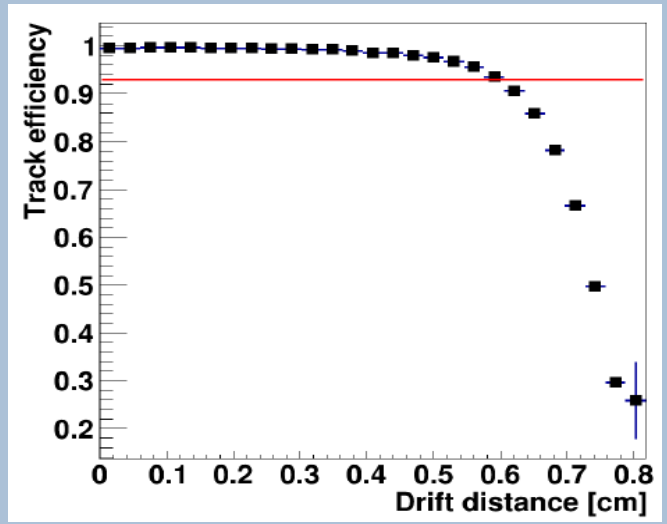
Performance assessment

Reference pubblication: https://doi.org/10.1016/j.nima.2020.164756



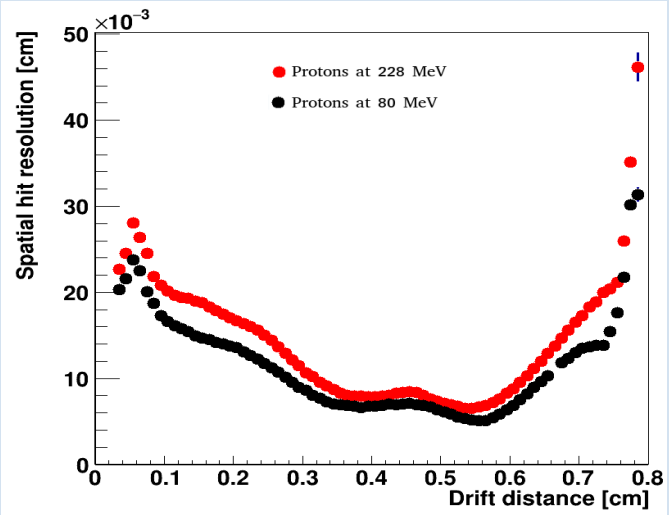
Space-time relation calibration:

- Uses a previous set of space-time relations to reconstruct the drift chamber tracks and align the detectors.
- Combines the drift chamber time measurements with the MSD projected distances.



Efficiency measurement:

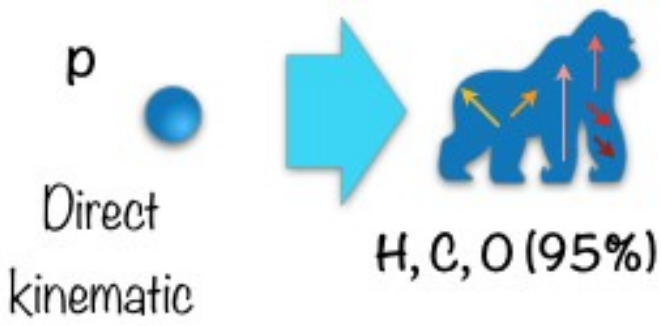
- Propagate the MSD tracks into the drift chamber cells to check the presence of a hit
- **Overall hit detection efficiency: 0.929±0.008**
- **Inefficiency at the cell border due to the electric field drop**

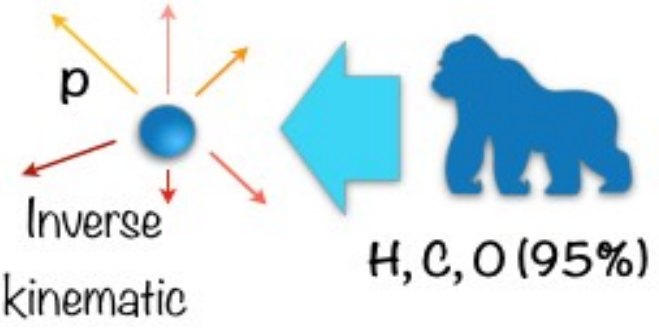


Spatial resolutions obtained with optimized conditions

- Measure the residuals between the drift chamber tracks and hits
- **Spatial resolution in the central part of the cell: 60 − 100 µm**

Inverse kinematic approach





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

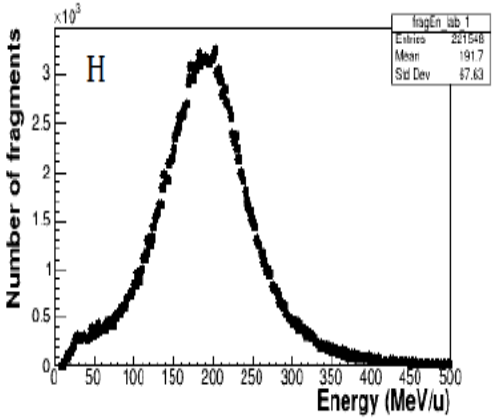
$$\mathbf{A'} = \Lambda\mathbf{A}$$

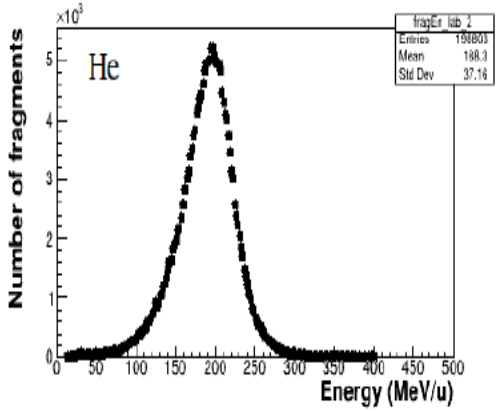
where **A** is the four momentum of the projectile **measured by the BM** and Λ is:

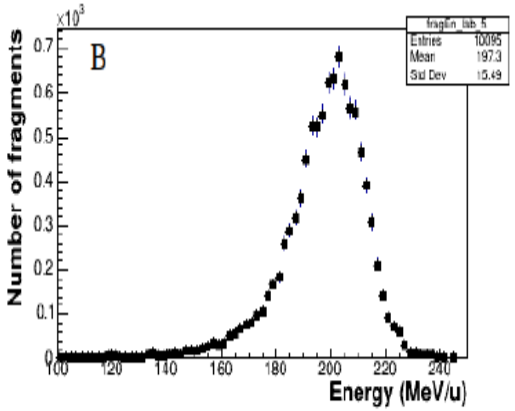
$$\Lambda = \begin{pmatrix} \gamma & -\beta_x\gamma & -\beta_y\gamma & -\beta_z\gamma \\ -\beta_x\gamma & 1+(\gamma-1)\frac{\beta_x^2}{\beta^2} & (\gamma-1)\frac{\beta_x\beta_y}{\beta^2} & (\gamma-1)\frac{\beta_x\beta_z}{\beta^2} \\ -\beta_y\gamma & (\gamma-1)\frac{\beta_y\beta_x}{\beta^2} & 1+(\gamma-1)\frac{\beta_y^2}{\beta^2}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

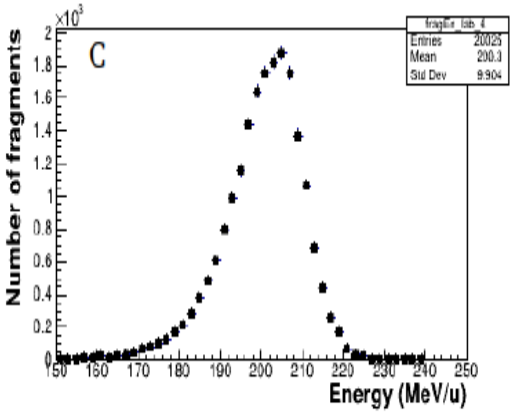
Energy of fragments in the laboratory frame

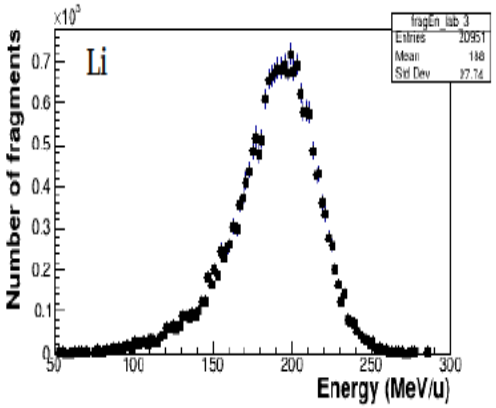
MC simulation with O @ 200 MeV/u on 2mm of C target
Energy of the fragments that arrive to the Tof-Wall in the **laboratory frame** with “MC truth”

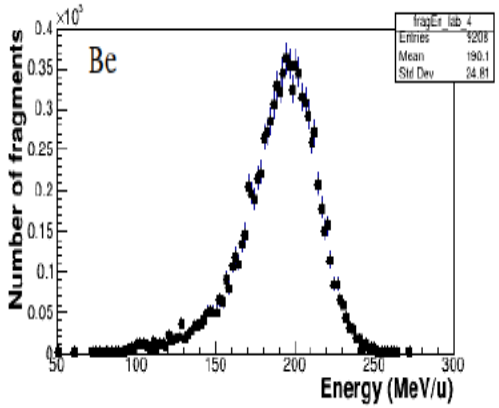


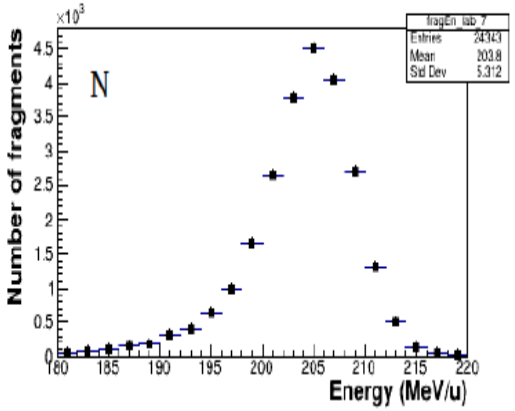


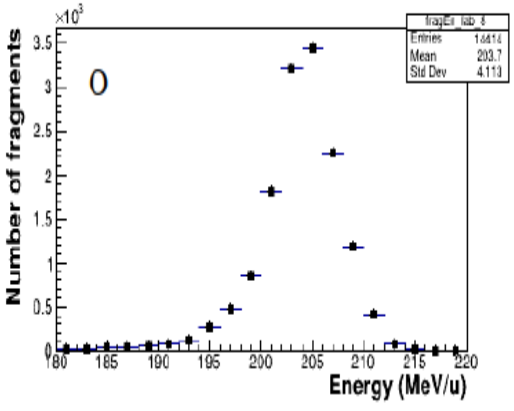






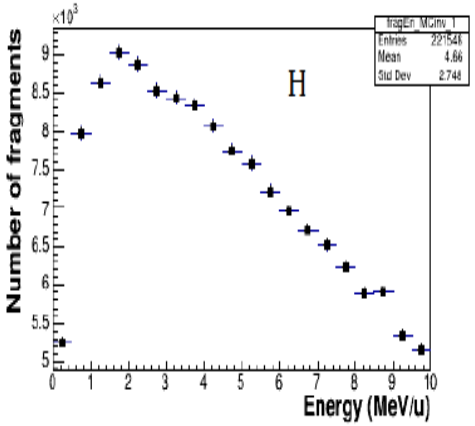


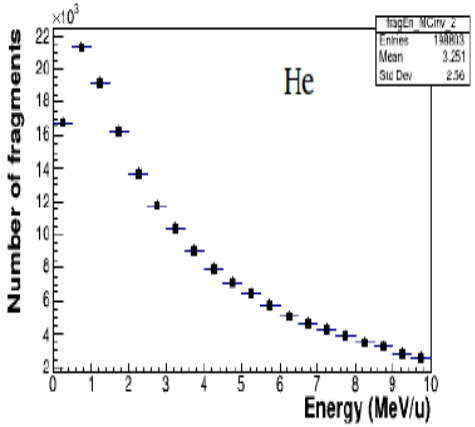


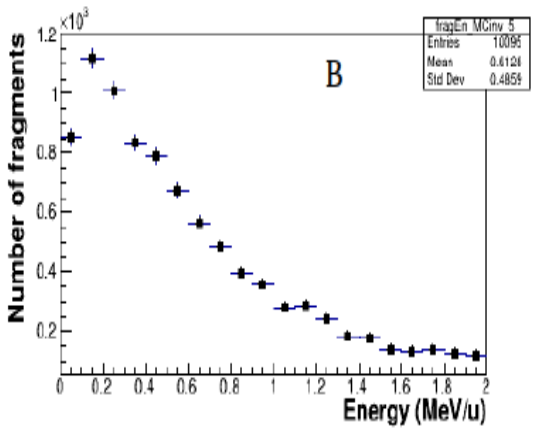


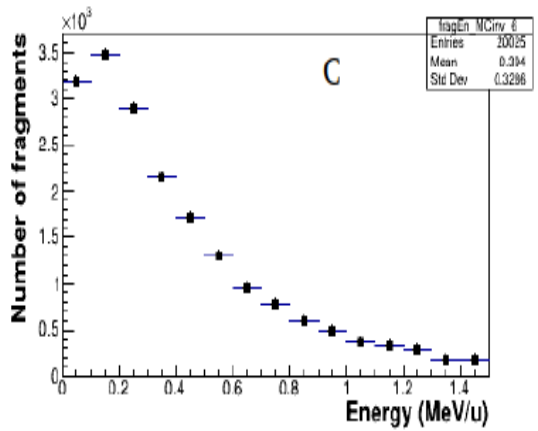
Energy of fragments in the projectile frame

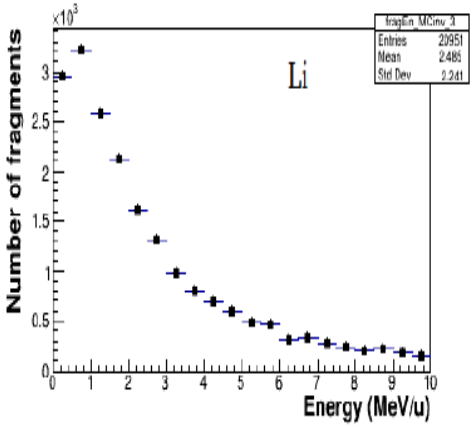
MC simulation with O @ 200 MeV/u on 2mm of C target
Energy of the fragments that arrive to the Tof-Wall in the **projectile frame** with “MC truth”

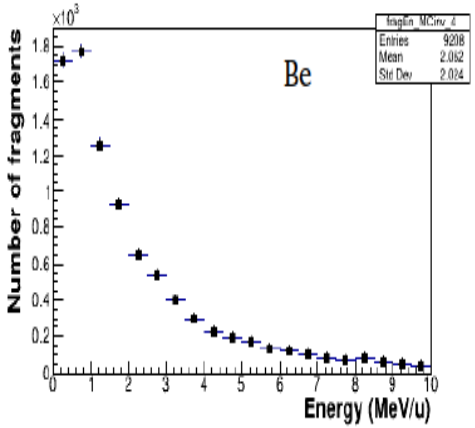


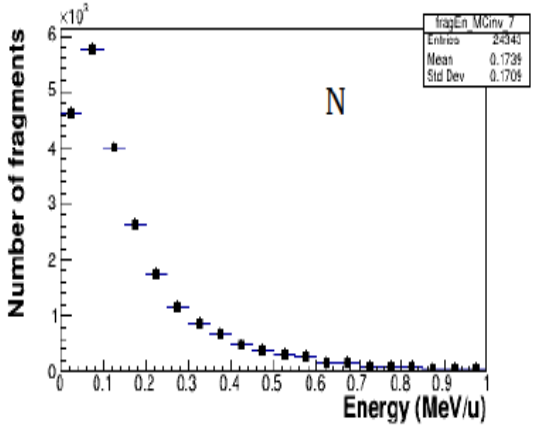


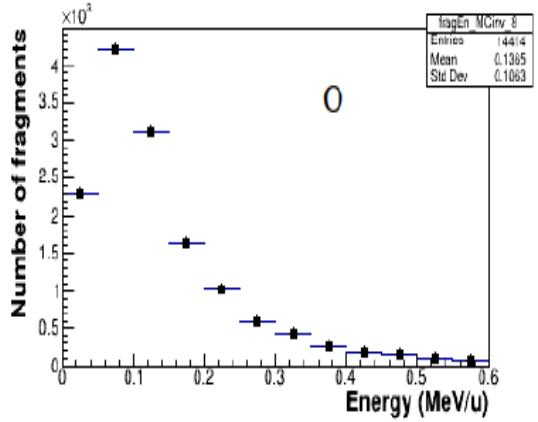




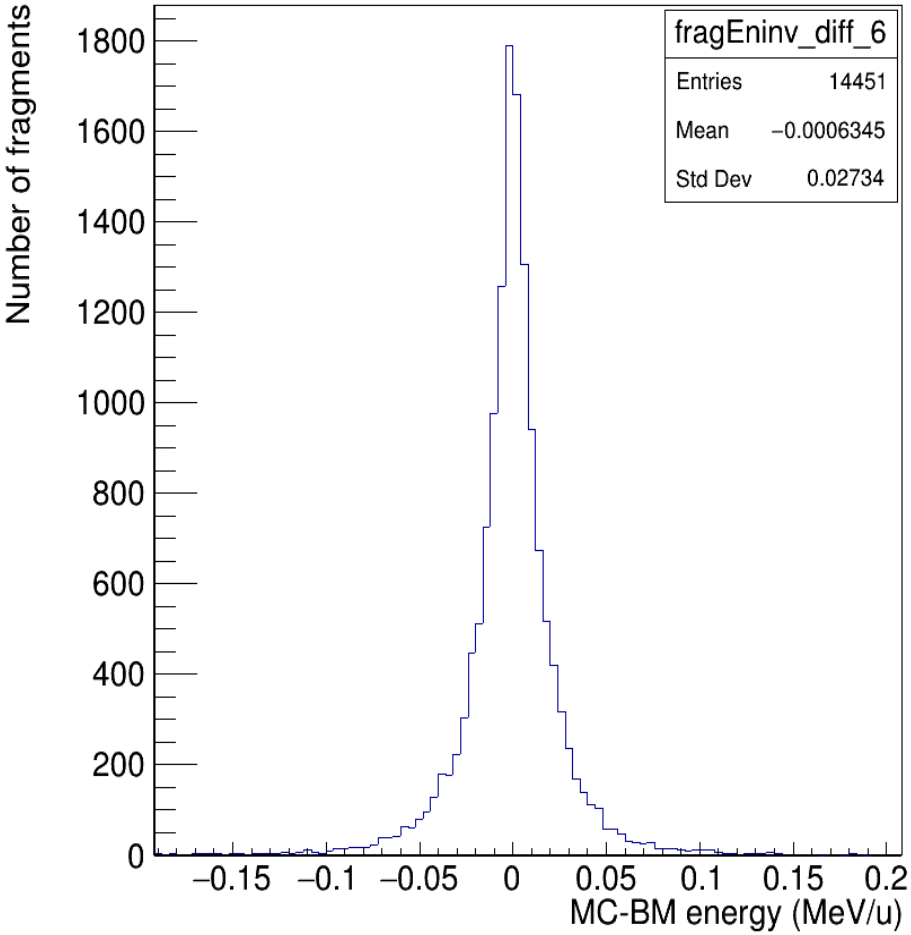








BM resolution effect

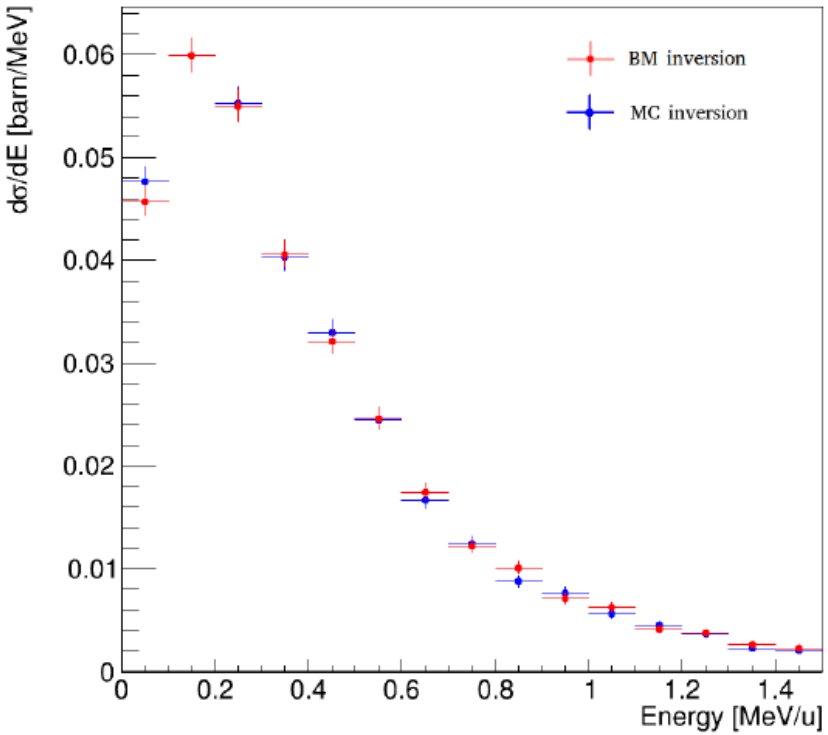


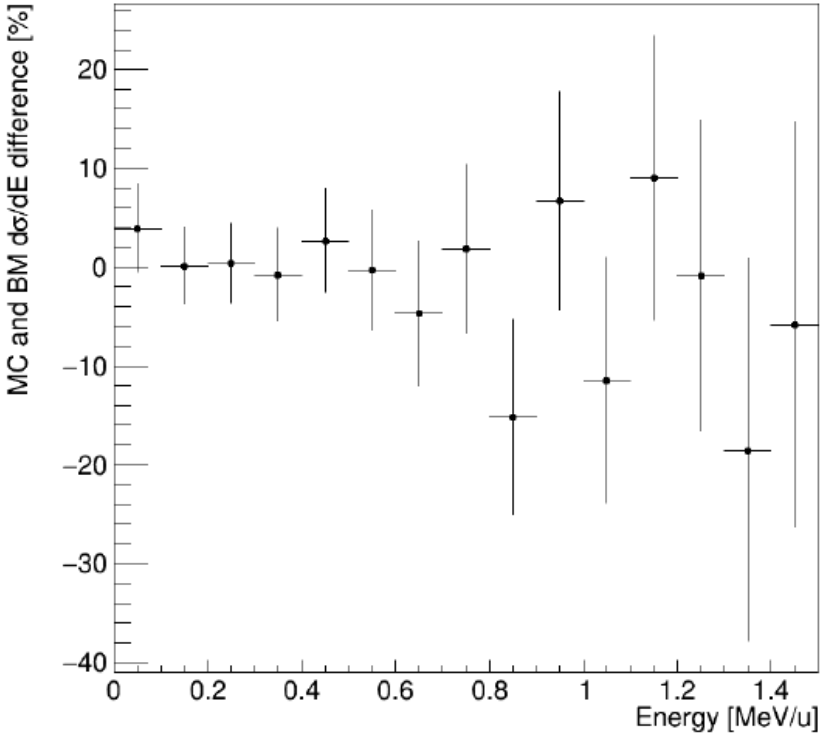
BM resolution effect on the energies of the fragments in the projectile system of reference:

- 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 measurement

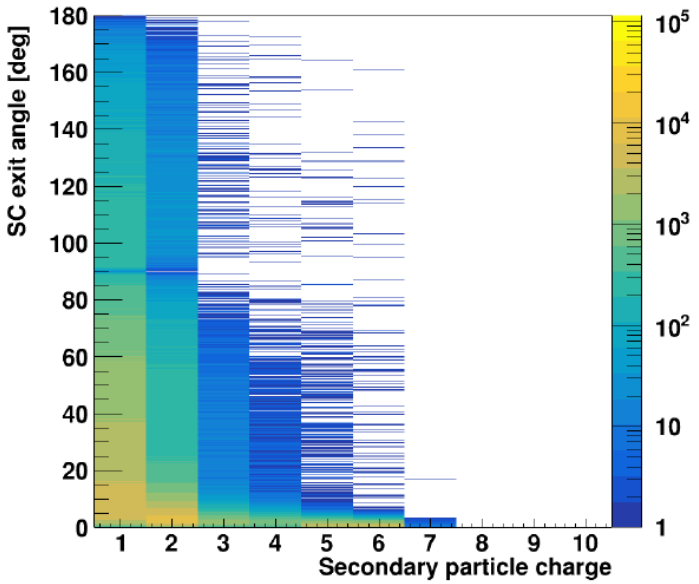
MC simulation with O @ 200 MeV/u on 2mm of C target
Differential cross sections of ^{12}C fragments in the projectile frame





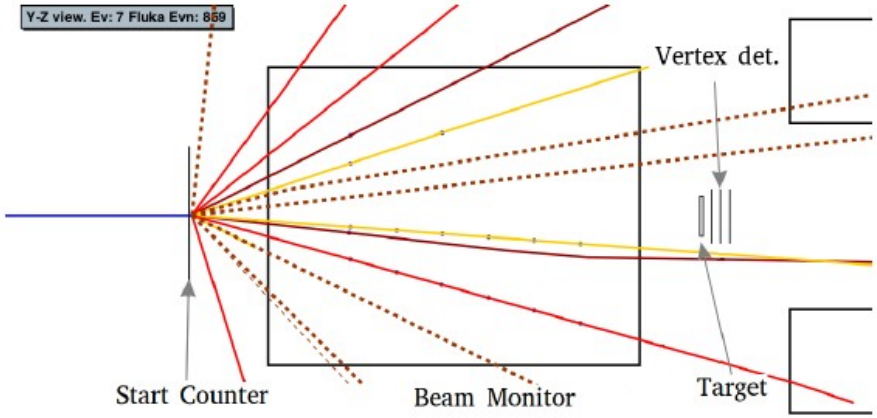
The impact of the Beam Monitor spatial resolution on the cross sections measured with the inverse kinematic approach is of the order of few percent

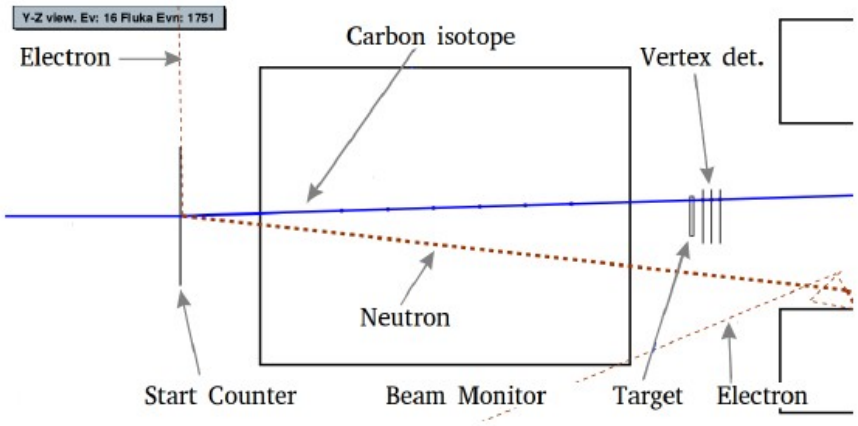
Pre-target fragmentation events



MC simulation: ^{12}C @ 200 MeV/u on a 5 mm thick C target

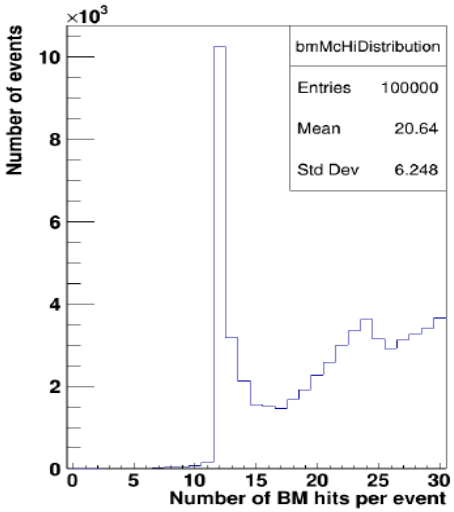
FOOT component	Material	Density (g/cm^3)	Fragmentation rate (10^{-4})
Start Counter	EJ228	1.023	12.37 ± 0.02
BM windows	mylar	1.4	3.01 ± 0.12
BM gas mixture	Ar/CO_2	0.0017	8.9 ± 0.2
BM wires	Al and W	2.7 (Al); 19.3 (W)	0.55 ± 0.05
BM overall			12.4 ± 0.2
Air gaps	atmospheric air	0.00129	3.45 ± 0.13
Target	C	1.83	364 ± 1



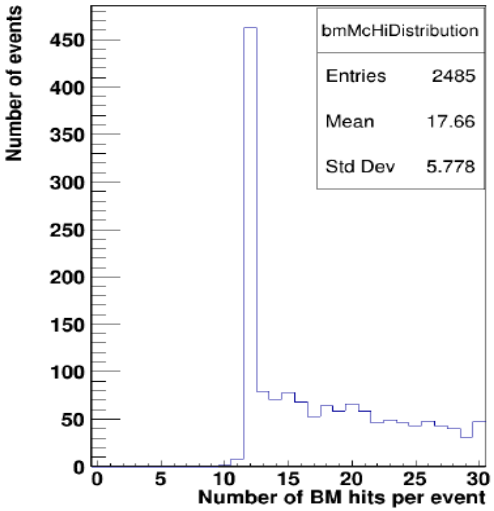


Number of BM hits

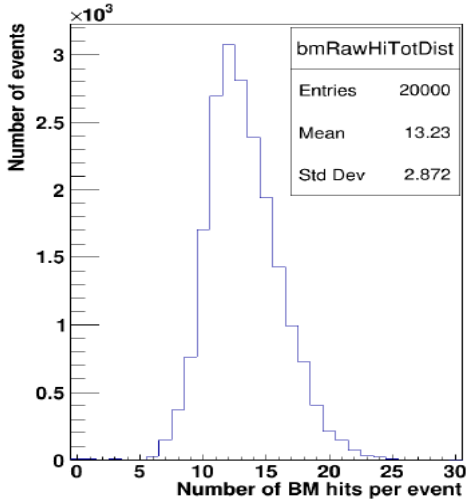
SC frag. evts. (MC)



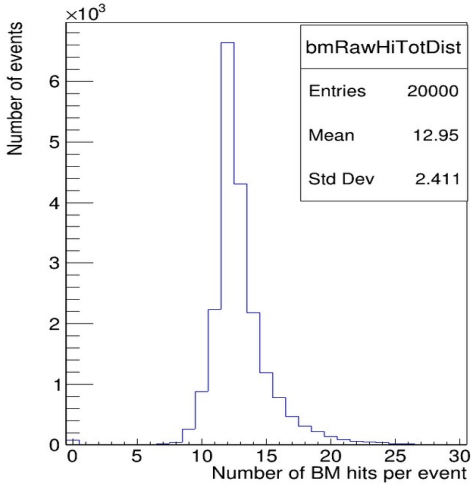
BM frag. evts. (MC)



O @ 400 MeV/u (GSI data)



P @ 80 MeV (Trento data)



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

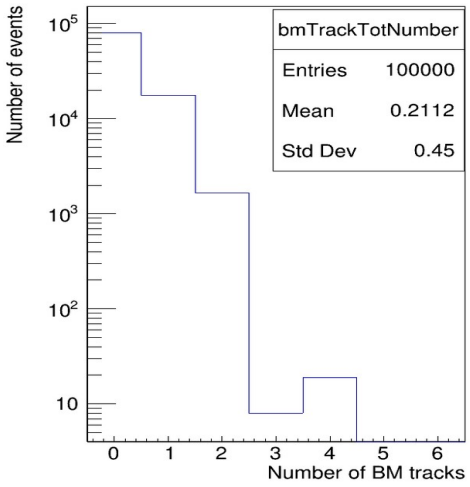
With oxygen @ 400 MeV/u data,
a reasonable cut is $8 \leq N_{hits} \leq 18$

Survival rates:

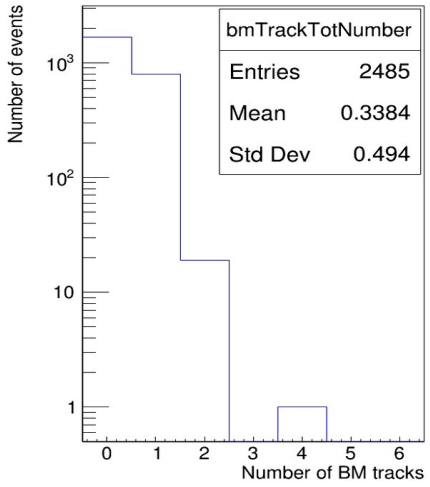
- 0.963 ± 0.007 data with P @ 80 MeV
- 0.945 ± 0.007 data with O @ 400 MeV
- 0.2204 ± 0.0015 MC with SC fragmentation
- 0.356 ± 0.012 MC with BM fragmentation

Number of BM tracks

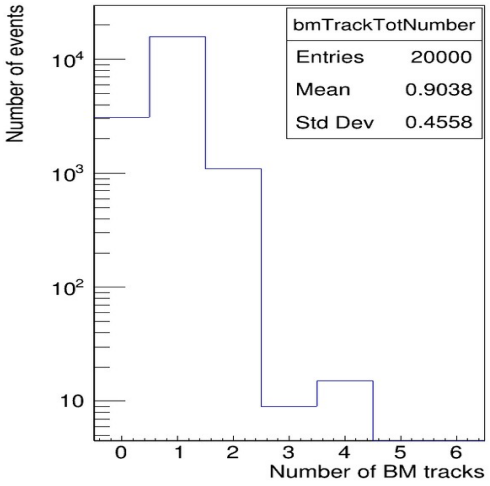
SC frag. evts. (MC)



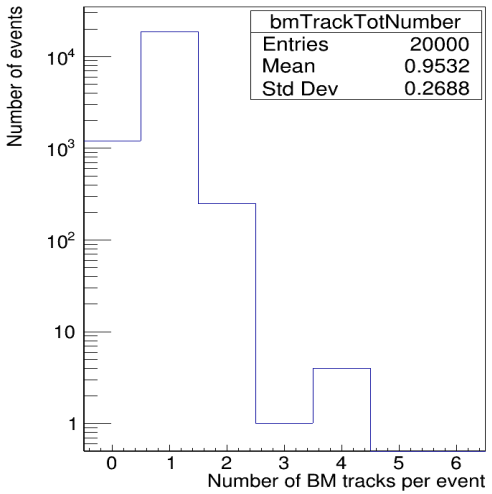
BM frag. evts. (MC)



O @ 400 MeV/u (GSI data)



P @ 80 MeV (Trento data)



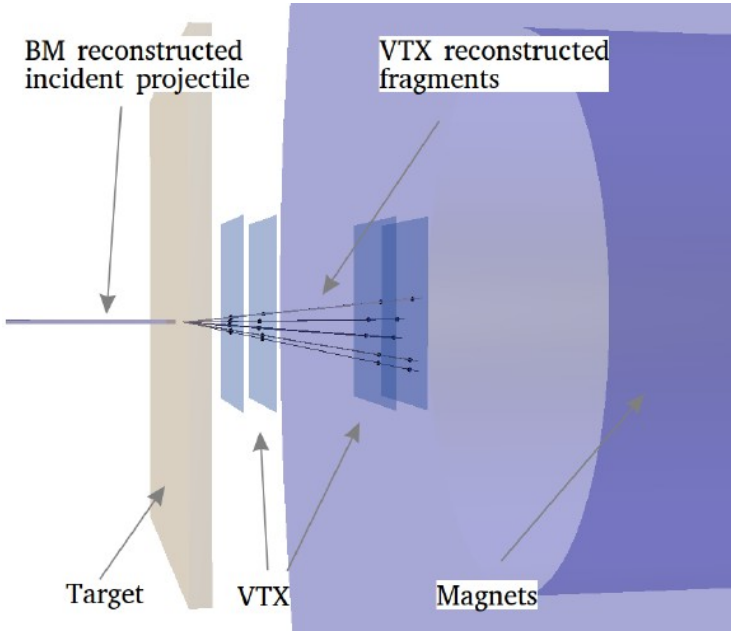
Exploit the BM multi-track reconstruction capability

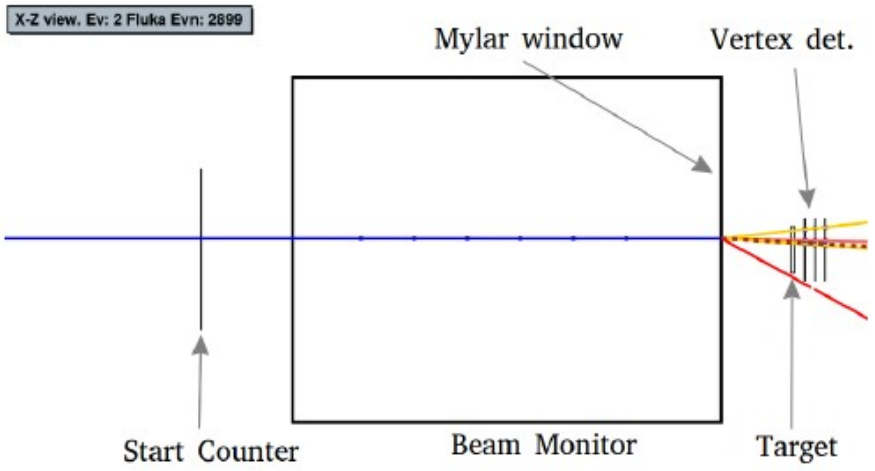
Select the events with only 1 BM reconstructed track

Survival rates:

- 0.927 ± 0.007 data with P @ 80 MeV
- 0.790 ± 0.006 data with O @ 400 MeV/u
- 0.1771 ± 0.0013 MC with SC fragmentation
- 0.322 ± 0.011 MC with BM fragmentation

BM and VTX tracks matching





The VTX detector is useful to reject the events with a fragmentation in the BM

Reject the events in which the VTX has one or more unmatched track

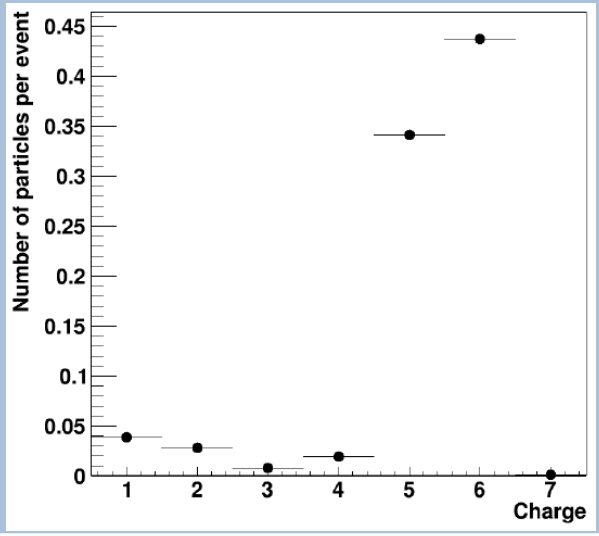
Survival rates:

- 0.1548 ± 0.0012 MC with SC fragmentation
- 0.124 ± 0.007 MC with BM fragmentation

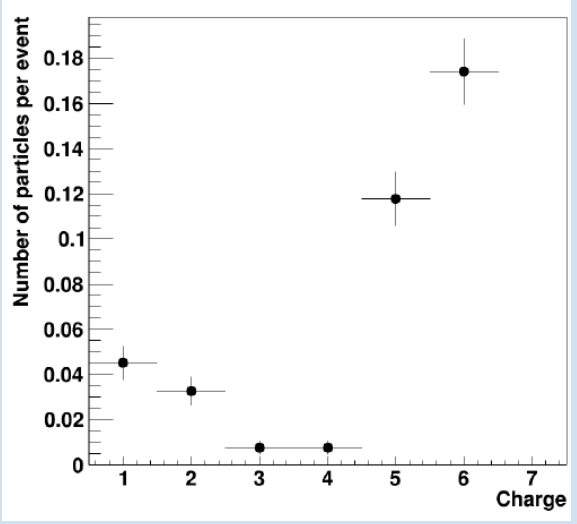
Pre-target fragmentation summary

Dataset	$8 \leq N_{\text{hits}} \leq 18$	$8 \leq N_{\text{hits}} \leq 18$ + one BM track	$8 \leq N_{\text{hits}} \leq 18$ + one BM-VTX track
80 MeV Protons (experimental data)	0.963 ± 0.007	0.927 ± 0.007	no data
400 MeV/u Oxygen ions (experimental data)	0.945 ± 0.007	0.790 ± 0.006	no data
SC fragmentation (MC simulation)	0.2204 ± 0.0015	0.1771 ± 0.0013	0.1548 ± 0.0012
BM fragmentation (MC simulation)	0.356 ± 0.012	0.322 ± 0.011	0.124 ± 0.007

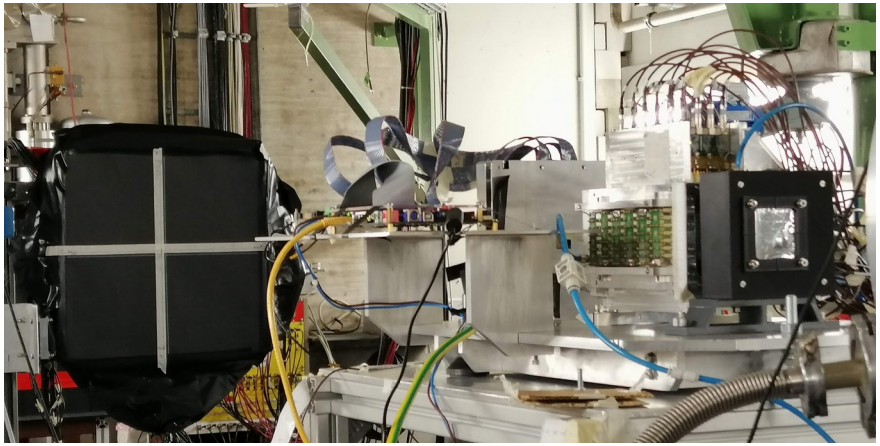
SC fragmentation surviving events



BM fragmentation Surviving events



Next data taking @ CNAO and GSI



To do list:

- Check the detector conditions
- Develop/update few SHOE macros

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: run without the target and with the VTX to check the BM-VTX correlation and try the space-time relations calibration
  (~200000 evts. at least)