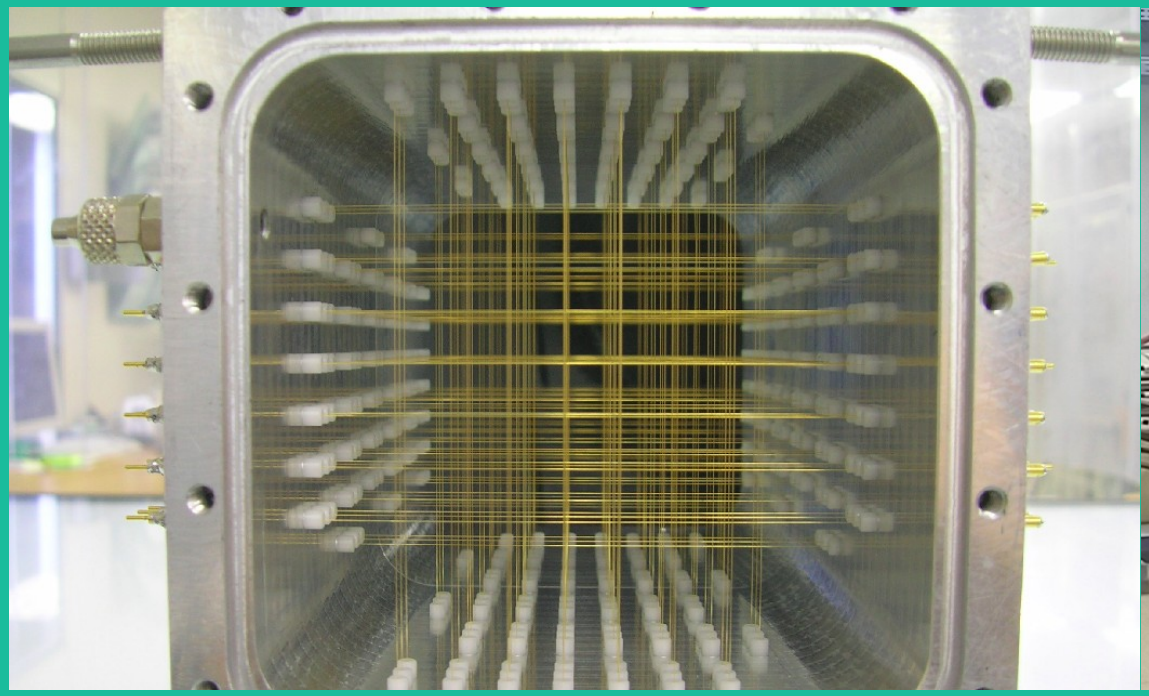
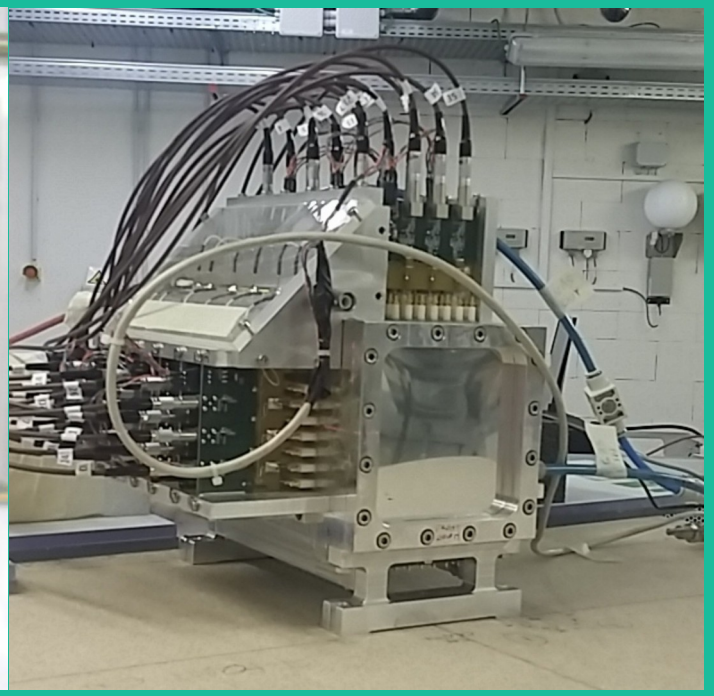




Update on BM detector

Yunsheng Dong

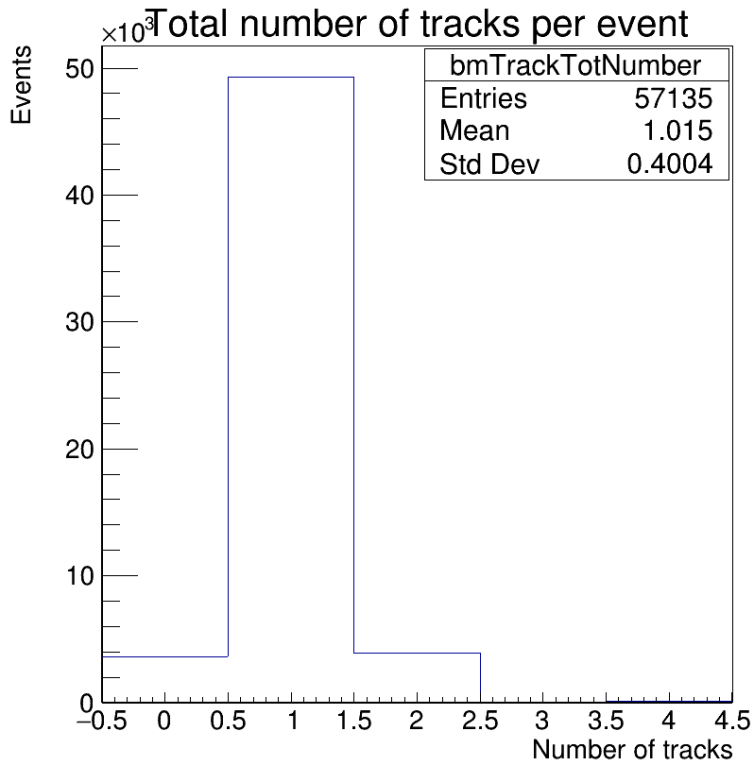
FOOT general meeting

30/05/2022

Outline

- Double track studies
- Space-charge effect studies (thanks to Giuseppe)
- Towards HIT2022

Number of tracks



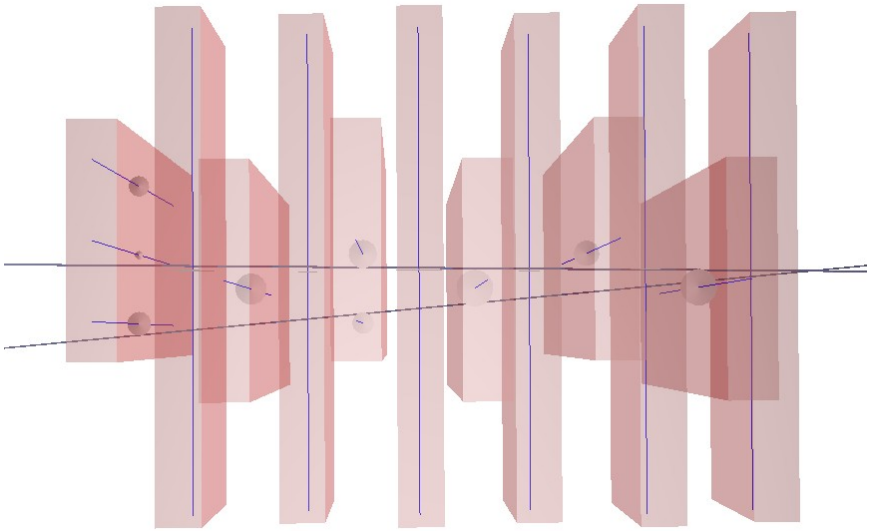
0 trk: 3.6 k ~ 6% (3% MC)
1 trk: 49.3 k ~ 86% (92% MC)
2 trk: 3.9 k ~ 7% (5% MC)
3+trk: 0.2 k ~ 0.4% (0.3% MC)

The track reconstruction is performed on each view independently, then the tracks on the two views are combined.

Anomalous cases:

- 0 track: -50% because the number of hits is insufficient (<3 hit per view)
  -50% because the hits are not aligned
- **2 tracks: there is one track reco on one view and two tracks reco on the other view**
- 4 tracks: there are two tracks on each view combined into four tracks (2 real tracks and 2 ghosts)

Two tracks events



- The BM can reconstruct two tracks in the following cases:

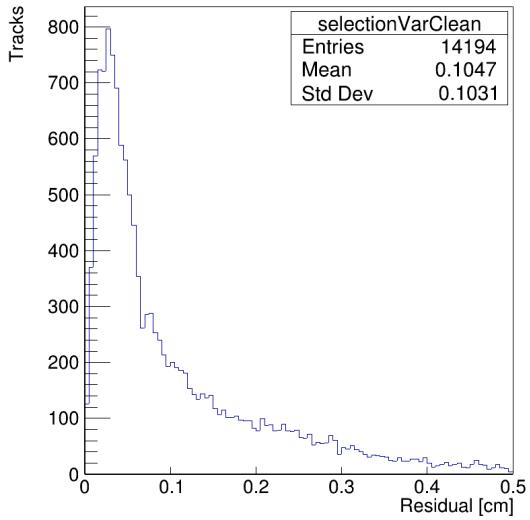
  -There are two real particles inside the BM parallel on one view (0.3% from MC)
  -There is only one real track from one particle, while the second track is given by a random combination of noise, delta rays and cross talk hits (>99% from MC)

- Form MC, the expected rate of pre target fragmentation is of the order of 0.3%.
  This corresponds to the number of events in which the BM reconstructed 4 tracks (~0.25%)

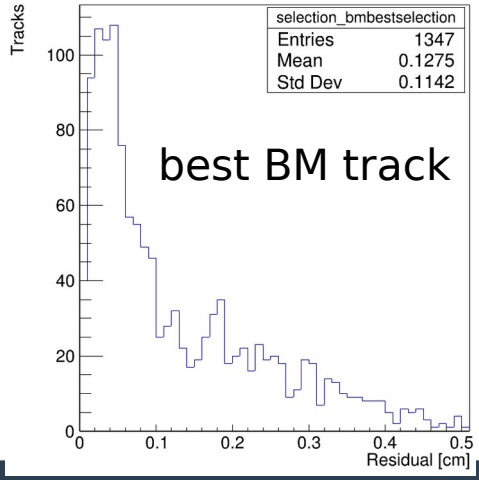
- **Need to find the correct track in the events in which the BM reconstructed two tracks**

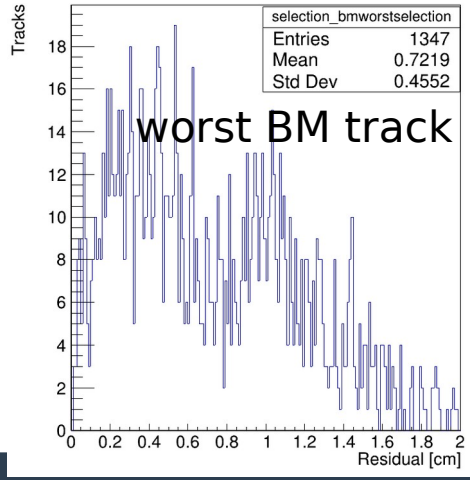
BM-VTX residual

1 BM track 1 VTX vertex:



2 BM tracks 1 VTX vertex:

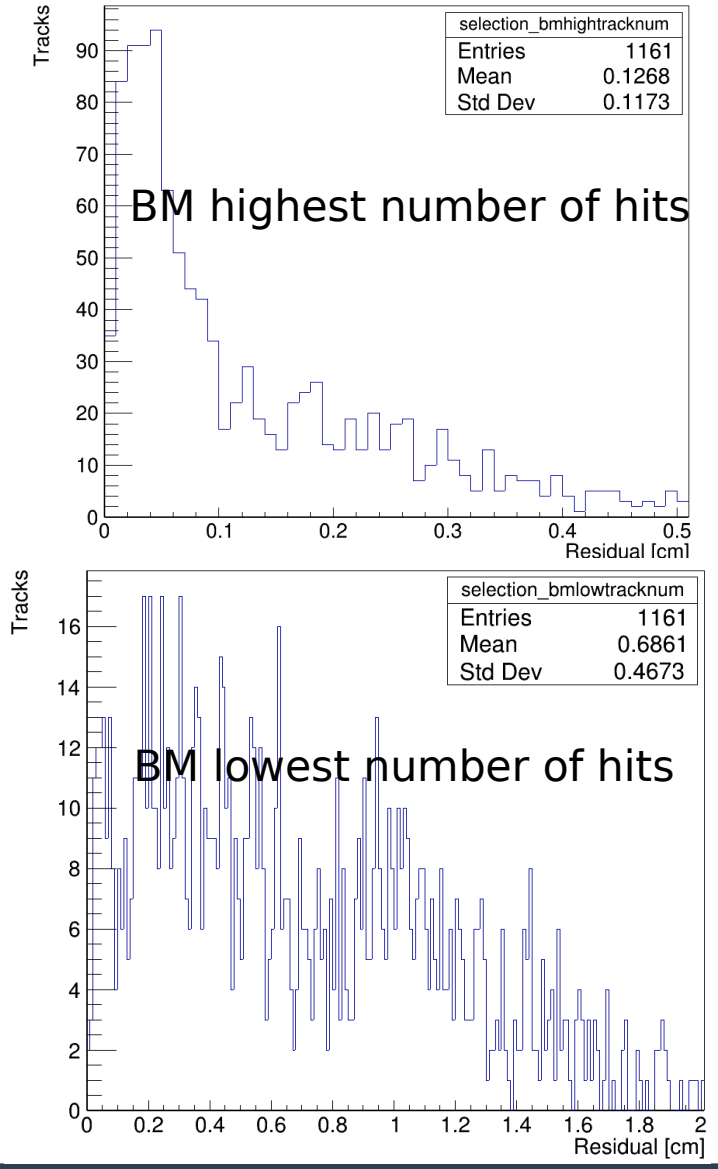




The residual between BM tracks and VTX vertices can be exploited to evaluate the selection criteria

- The residual distribution for the events with 1 VTX vertex and 1 BM reconstructed track has a peak at ~300 μm and a tail up to ~0.5 cm
- Selecting the events in which there is only 1 VTX vertex and 2 BM tracks, the correct BM track can be identified as the track with the minimum residual (best BM track)
- **Therefore one can study different track parameters to identify the correct BM track even without the use of the VTX detector**

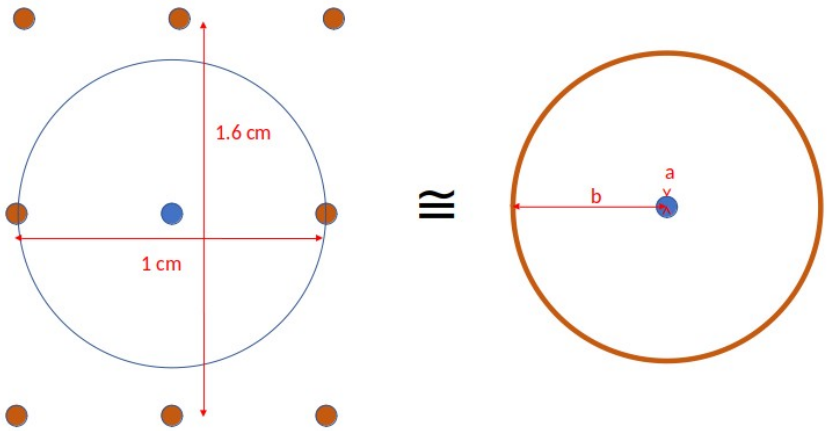
Selection criteria: number of hits

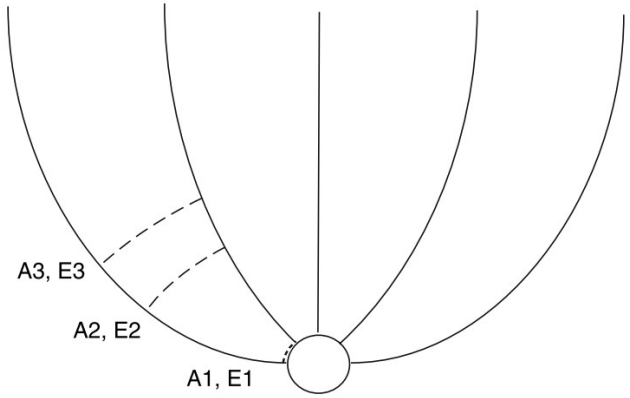


Select the BM track with the highest number of hits

- The BM-VTX residual distribution for the tracks with the highest number of hits shows a peak at ~300 with a tail
- The residual distribution for the tracks with a lower number of hits is completely different
- Checking with the correct BM track identified previously, with this method about 90% (95% in MC) of the BM tracks are correctly identified
- **This selection has been implemented in newgeom and master branch**

Space charge effect intro





- **Space charge effect:** Ions created in avalanches close to the anode take time to travel towards the cathode ($10^{4\text{-}5}$ cm/s). If the incoming particle rate is high, there is a stationary situation with a stationary charge density given by the ion flow that reduces the electric field
- Consider a drift tube with a=sense wire radius; b=cathode distance; V_0=Voltage
- The electric field without space charge is:

$$E(r) = \frac{V_0}{r \log \frac{b}{a}}$$

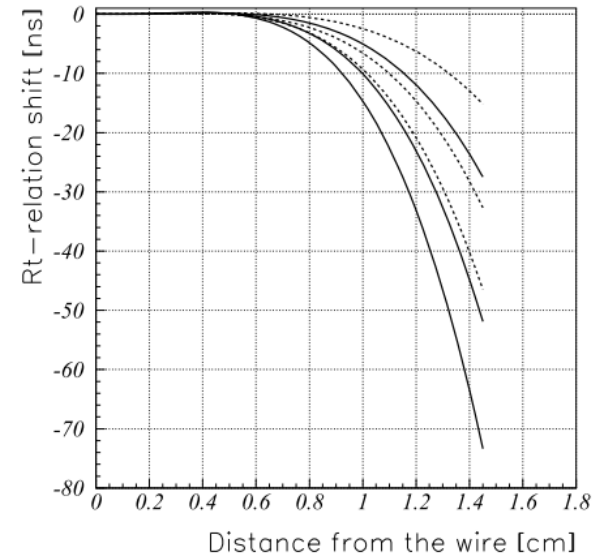
- The effect of the space charge effect is:

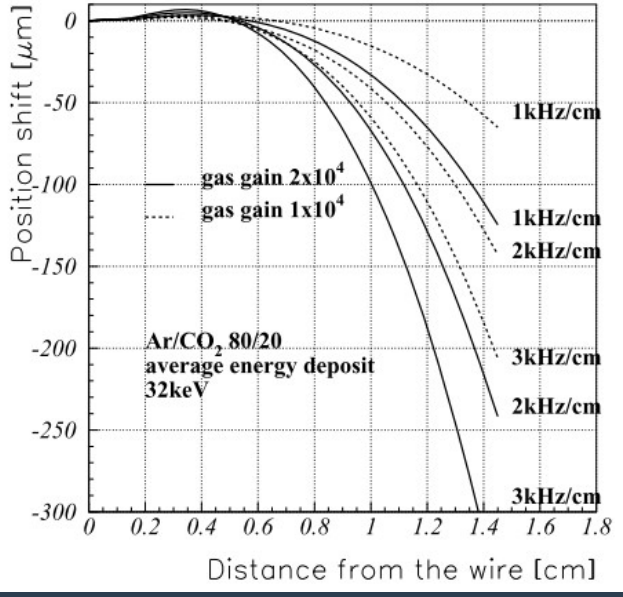
$$E(r) = \frac{1}{r \log \frac{b}{a}} \left(V_0 - \frac{b^2 \rho}{4\epsilon_0} \right) + \frac{\rho}{2\epsilon_0} r$$

$$\rho(r) = \frac{N_c G Q}{2r\pi\mu E(r)}$$

N_c...count rate per unit of length along the tube
Q...average charge deposited per background event
G...gas gain
μ...ion mobility

Space charge effect consequences





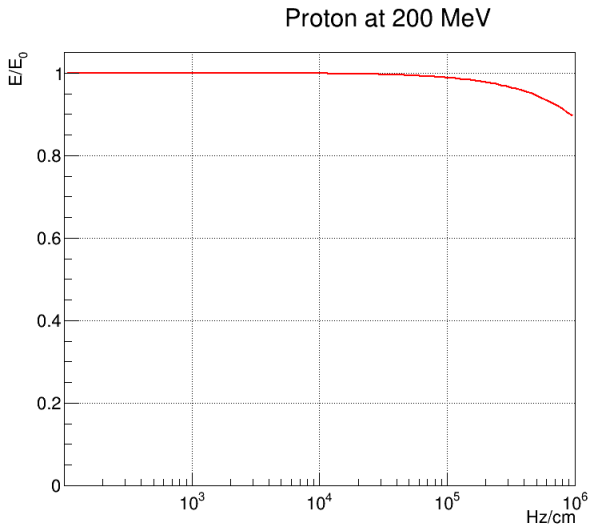
The results of the space charge effect are:

- Reduction of the Electric field close to the sense wire
- Gain reduction
- **Inefficiency of the detector**
- **Space Time relation shift**
- Worsening of the track reconstruction performances
- Plots from ”limits to drift chamber resolution” W.Riegler (1998)

Space charge effects can actually occur in our case: our primaries are not minimum ionizing particles and the amount of charge, after multiplication, can be relevant

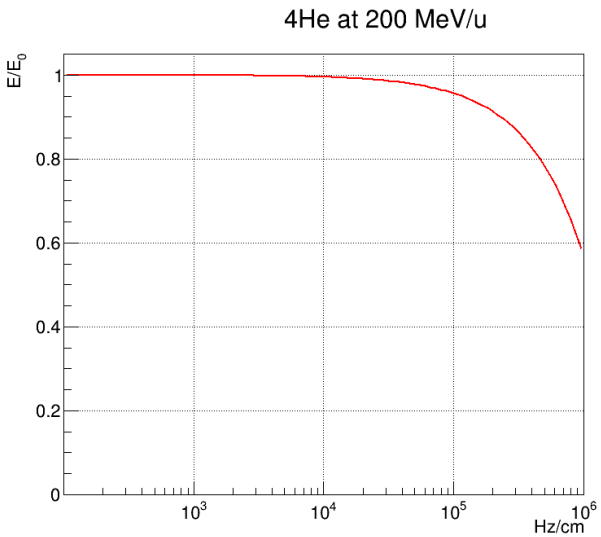
”Mauro Villa might as well be right” cit. G.B.

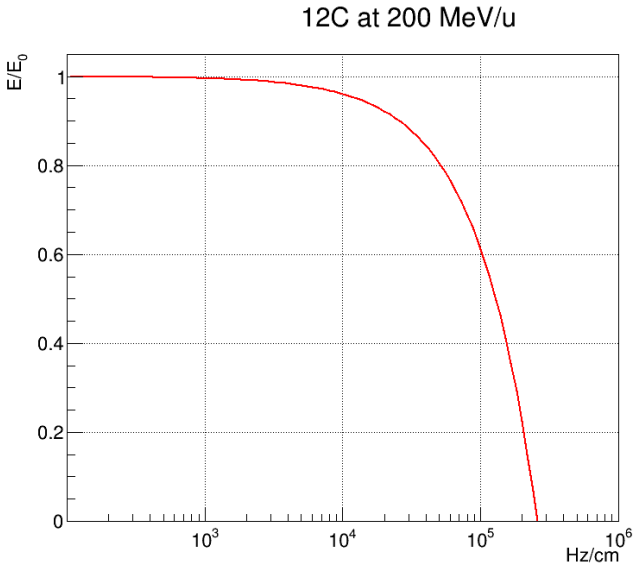
Rough estimate for BM

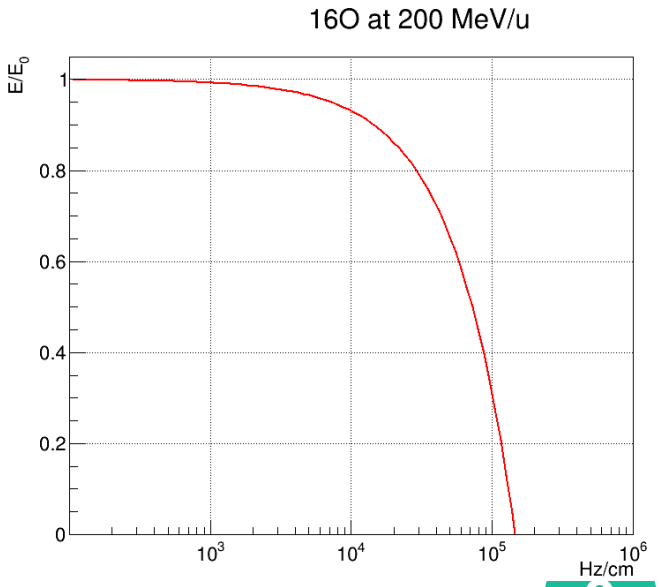


In **first approximation** the BM cell can be considered as a drift tube with:
a=12.5 μm, b=0.5 cm and V=1800 V
The Ar/CO2 80/20% gas parameters can be taken from Garfield++:
Gain=$1.954*10^4$
Ion mobility=1.824 $cm^2/(V*s)$
Particles=97.6 pairs/cm (calculated)

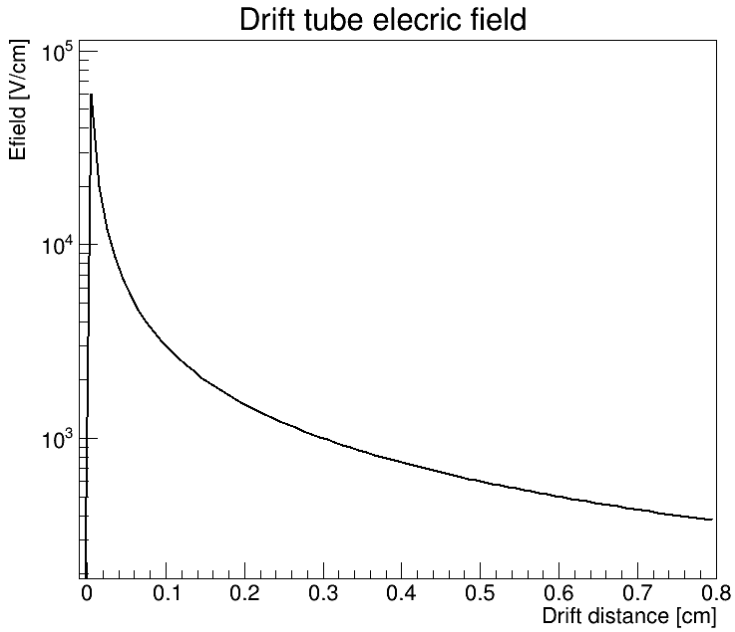
N.B.: The beam rate in the plots is evaluated as Hz/cm

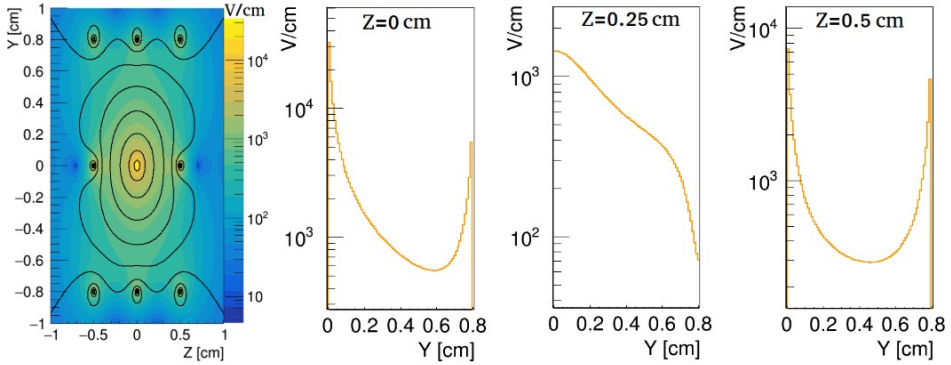






Considerations for BM

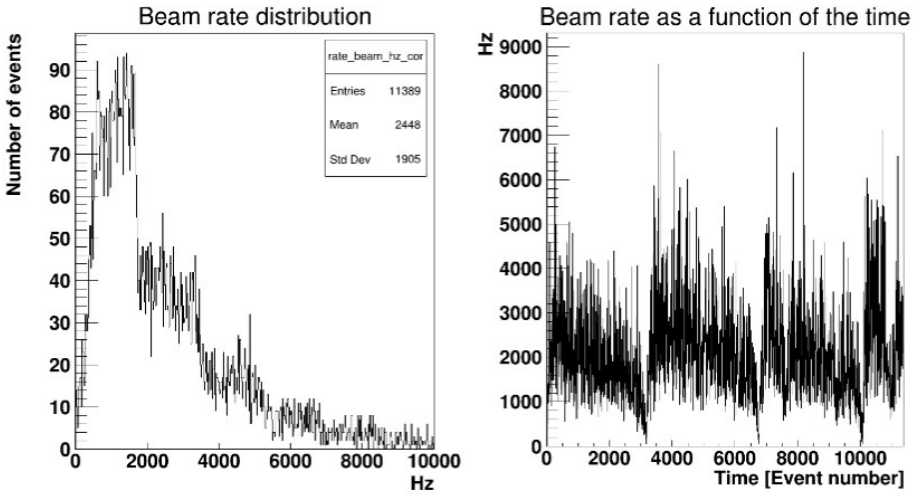




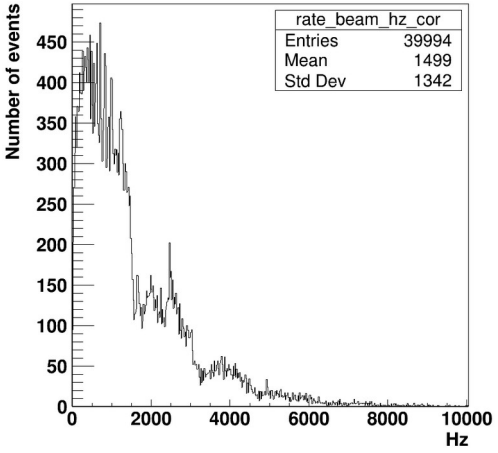
- The space charge effect evaluation of the BM with a drift tube geometry contains different approximations and uncertainties (e.g.: ion mobility, gas gain)
- The BM has already been adopted to measure heavy ions at 200-700 MeV/u with a beam rate of the order of few kHz
- The space charge effect should be negligible at few kHz, as evaluated from the drift tube calculations and from the data collected in the past
- GSI2021 is the first time in which we see this behaviour, but in this occasion **the working point was completely different**:
  -the gas was provided by GSI with a gas distribution system not used in 2019/2020
  -We raised the signal threshold maintaining the HV used in 2019

Previous data takings

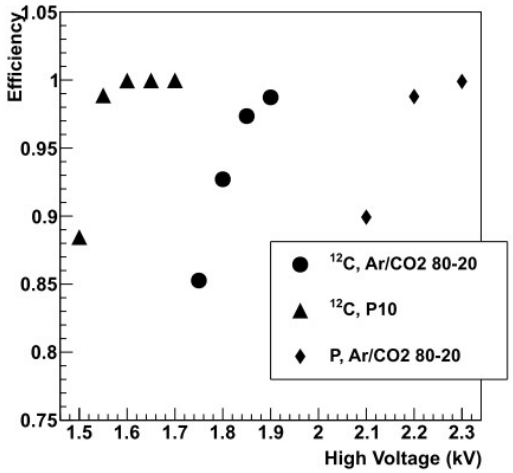
GSI2020 12C @ 700 MeV/u



GSI2019 16O @ 400 MeV/u



Abou 2012

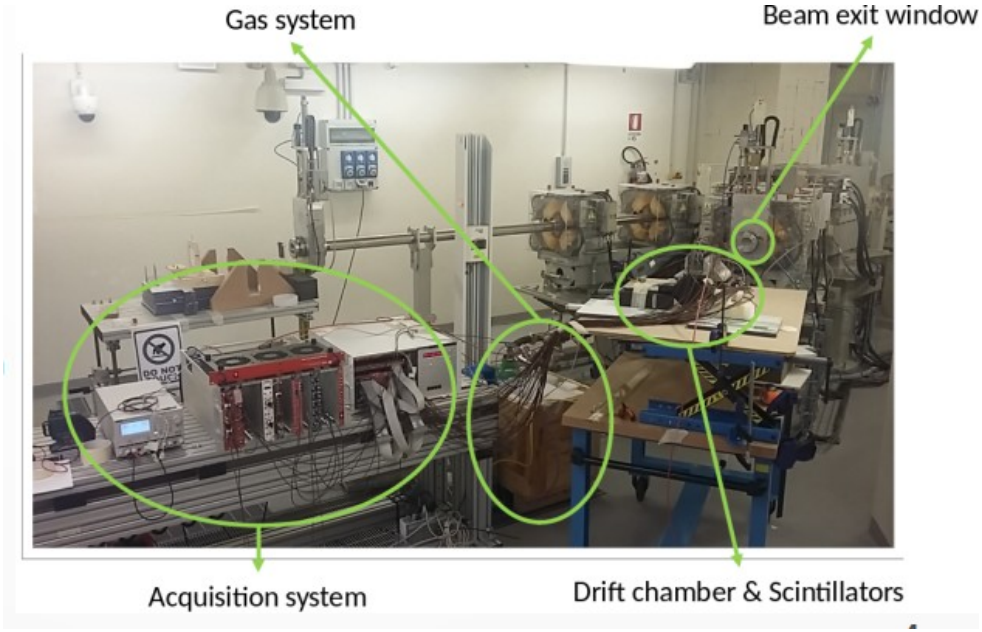


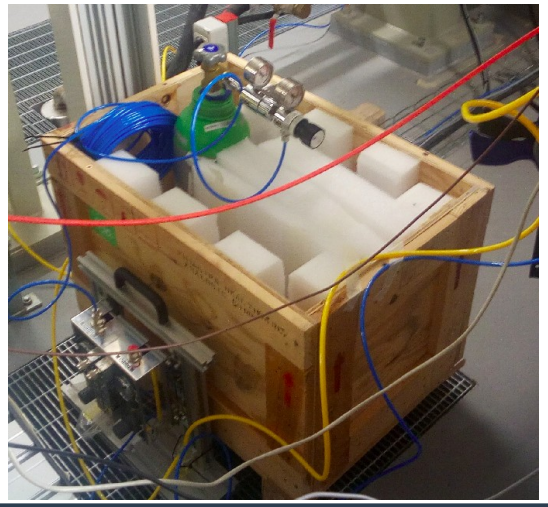
The beam rate was measured in the old BM stand alone runs, where the efficiency reduction due to space charge effect has never been detected.

- GSI2019 with 16O @ 200-400 MeV/u mean beam rate~1.5 kHz, <10 kHz
- GSI2020 with 12C @ 700 MeV/u mean beam rate ~2.4 kHz, <10 kHz
- LNS (FIRST experiment), from Abou et al (2012): 12C @ 80 MeV/u at 1 MHz

Possibility to measure the BM efficiency as a function of the beam rate?… maybe not at HIT, but in CNAO with 12C?

Towards HIT2022





Space charge effect:

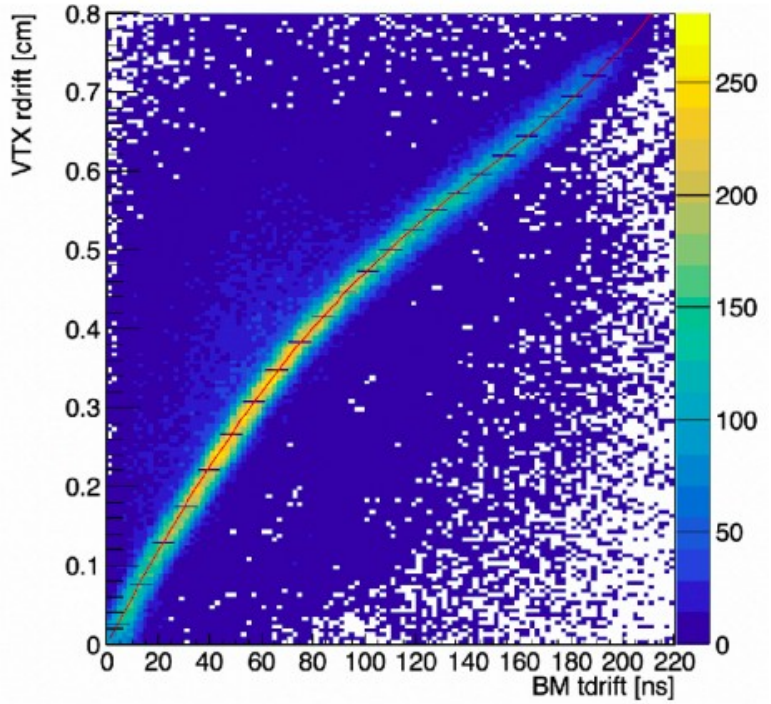
- The BM will operate with He particles, the space charge effect should be negligible at least up to hundreds of kHz
- The DAQ will measure the beam rate and there will be a trigger that vetoes events close in time

Material:

- Electronics in Trento (maybe Bologna can take it?)
- Detector + gas bottle + gas distribution system in Milan (how to transport to HIT?)

Towards HIT2022

Space time calibration in GSI2021 with VTX



Desiderata:

- Since in HIT there is a 4He beam not available at CNAO, the measurement of the BM inefficiency as a function of the beam rate can be postponed at CNAO with 12C
- At HIT, if the VTX and/or MSD are present, a run without target for alignment and space-time relation calibration should be done (100k should be enough)

Personnel:

- Due to different reasons, the Milan team will be decimated in mid-end July
- We'll find a solution to send someone form Milan or to train someone on the BM operations