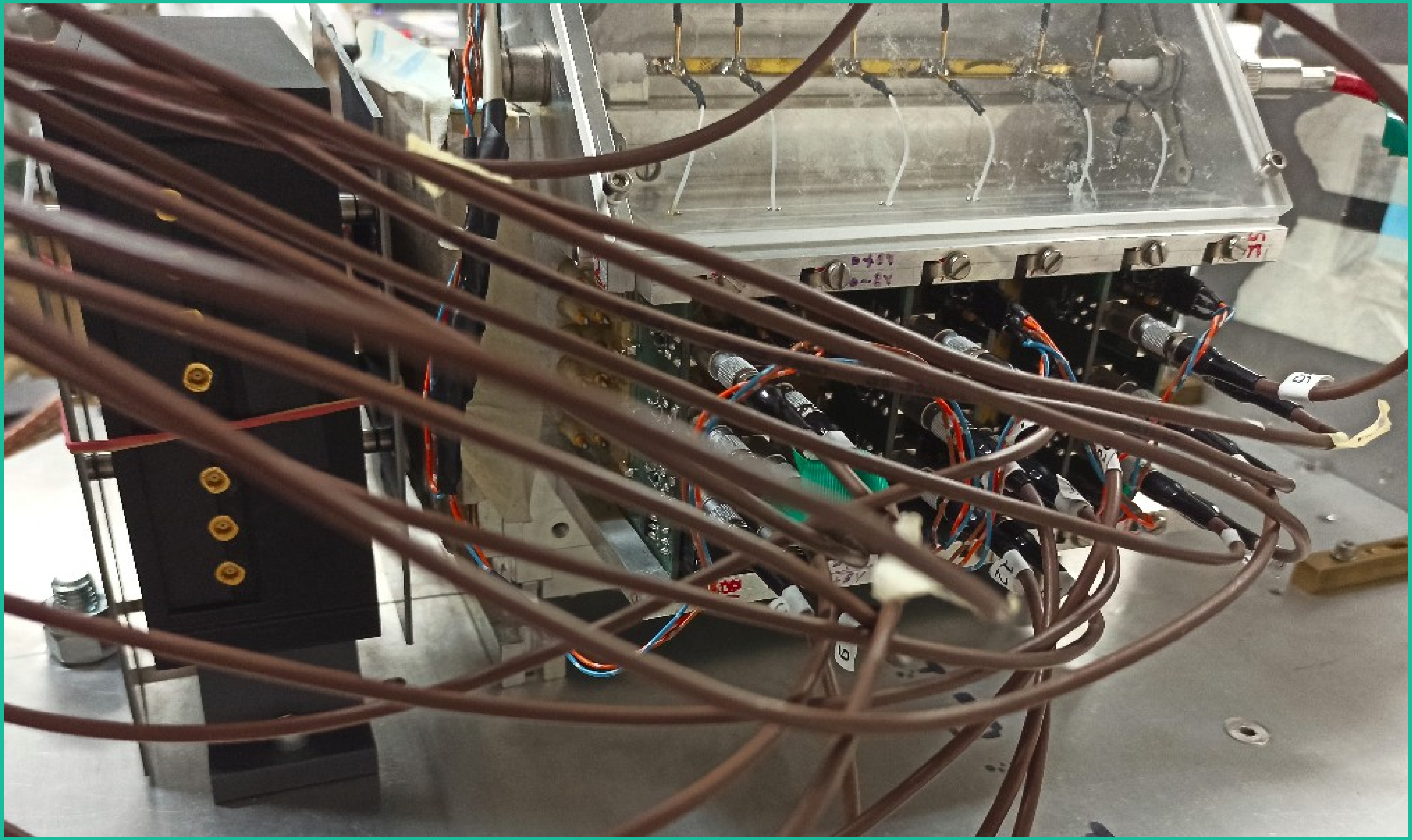


Update on BM @ CNAO2022

Yunsheng Dong

12/12/2022

BM schedule for CNAO2022

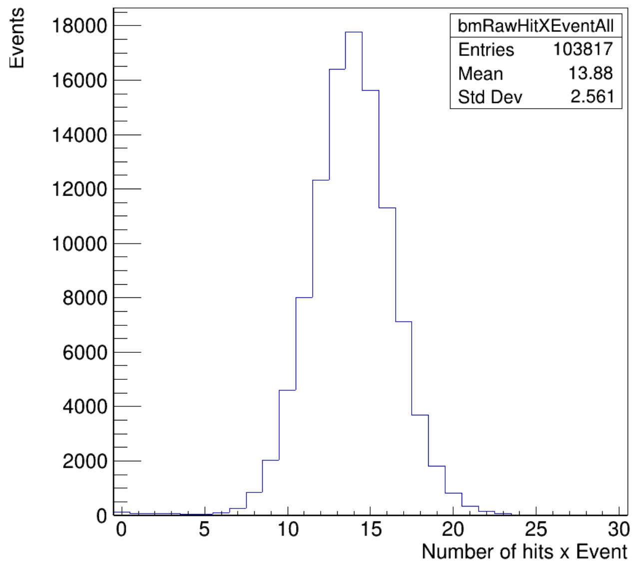
FIRST shift

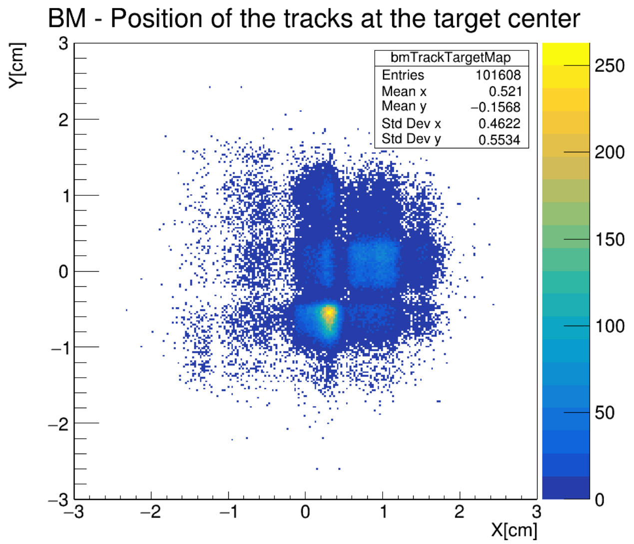
- BM performance assessment as a function of the beam rate
- ^{12}C @ 115 MeV/u
- P @ 226 MeV/u
- MiniDC first test

SECOND shift

- Data taking with BM

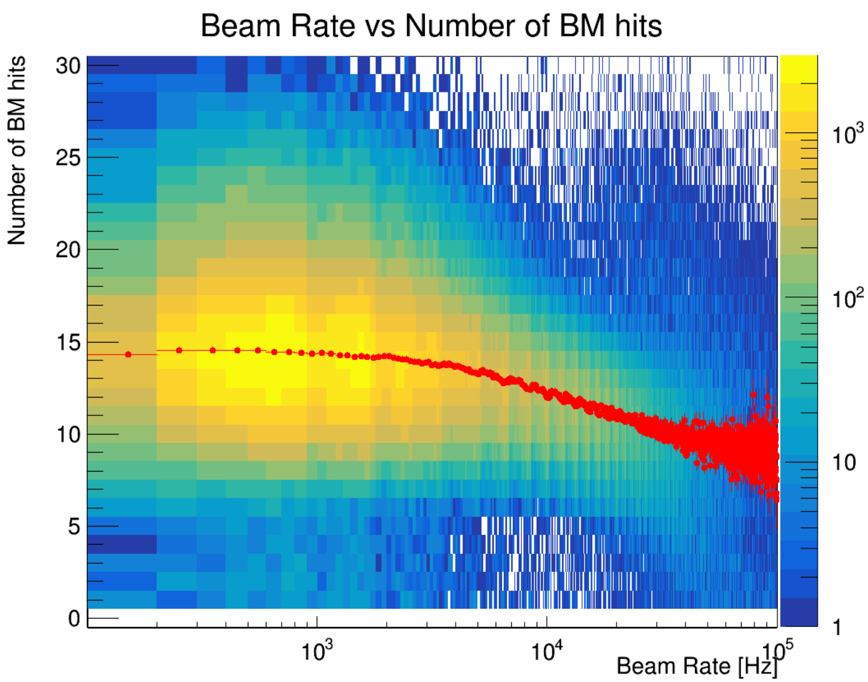
BM working point





- For a given particle energy we performed a scan in HV and signal thresholds in order to find the best working point for the BM
- Best condition for ^{12}C:
  300 MeV/u: HV=1750, Threshold=10 mV
  115 MeV/u: HV=1700, Threshold=10 mV
- For protons @ 226MeV: HV=2075, Th=10mV
- **We need to tune the detector settings and position for each beam particle/energy (few kevents, few minutes)**
- ^{12}C @ 115 MeV/u: “perfect” condition run 5326:
  -Mean BM hits ~ 13-14
  -Raw hit detection efficiency ~ 0.82
  -Mean number of BM tracks per event~0.98

Beam rate vs hits with ^{12}C @ 115MeV/u



For increasing beam rate, also the the current drawn by the sense wires increases. Since each plane of sense wires is connected to HV through a 50 MOhm limiting resistor, the increase of current reduces the effective potential on the wire, and consequently the local electric field. This, for a fixed threshold, produces a decrease in efficiency

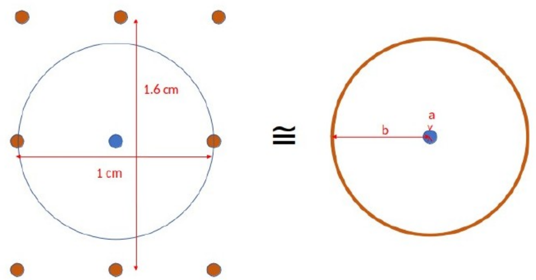
High beam rate → low effective electric field → low signal amplitude (checked with the oscilloscope) → low detector efficiency

- Mean signal amplitude, current and voltage drop:
  -“Perfect“ condition: 30 mV; 0.3 μA → ~1 V
  -50-100 kHz: 20 mV; 2.25 μA → ~10V
  -500 kHz: 7-8 mV; 10μA→ 42V

- **Inefficiency effect starts at about 10 kHz and it becomes critical at 100 kHz**

Beam rate vs efficiency

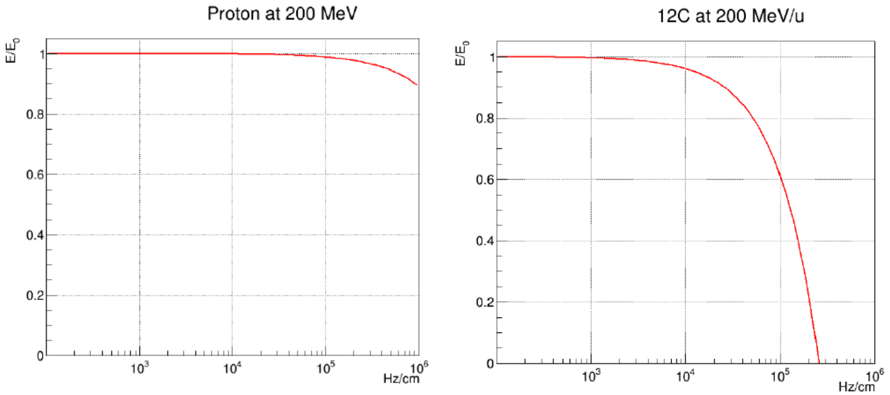
Calculation of space-charge effect



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

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

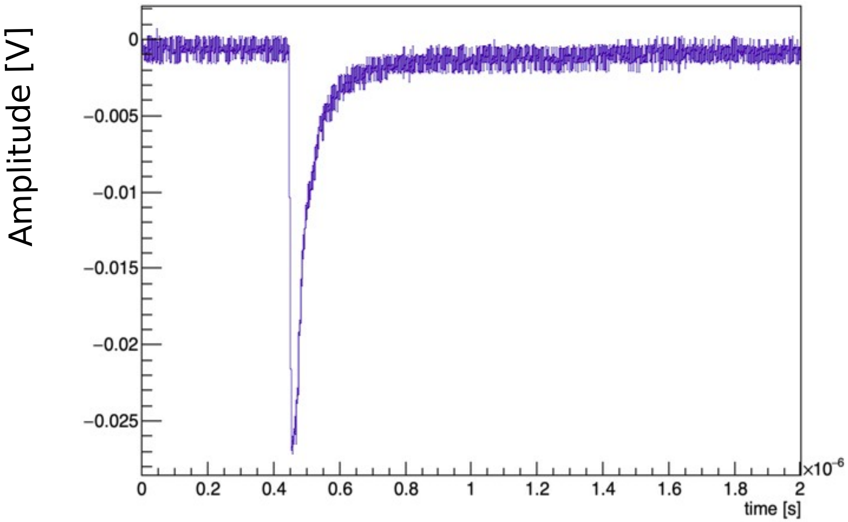
N_c...count rate per unit of length along the tube
Q...average charge deposited per background event
G...gas gain
μ...ion mobility

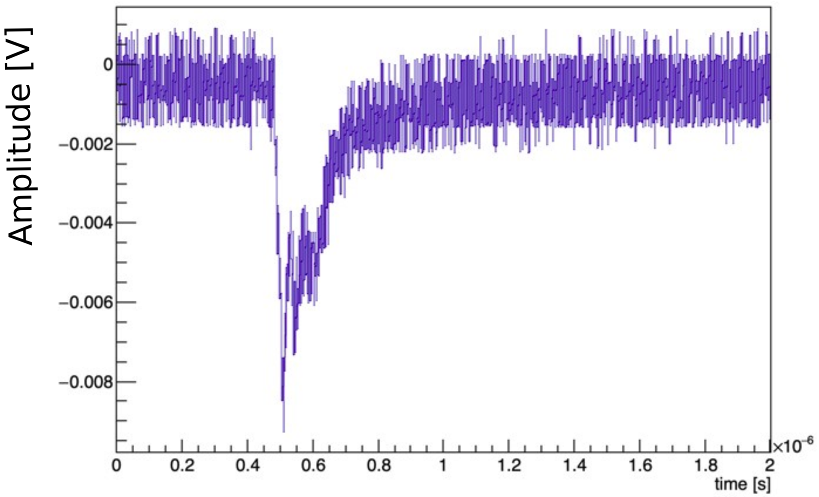


- BM inefficiency is due to the HV limiting resistors and not to a space-charge effect, as we were thinking months ago. Space-charge limitation occurs at much higher rates
- At FOOT rates (few kHz) the BM shouldn't have inefficiency issues (No inefficiency effect @ CNAO2022 second shift)
- At higher rate, the use of low threshold can mitigate the inefficiencies (we tried 5 mV), but there are other effects (e.g.: noise)
- Drop of BM efficiency @ HIT and GSI2021 probably due to a too high setting of the signal thresholds (20 mV) that required an increase of the HV setting.
- No inefficiencies @ GSI2019 (10 mV)
- **Inefficiency with protons @ 226 MeV/u at tens of kHz and critical at hundreds of kHz** (Data not analysed due to decoder issues)

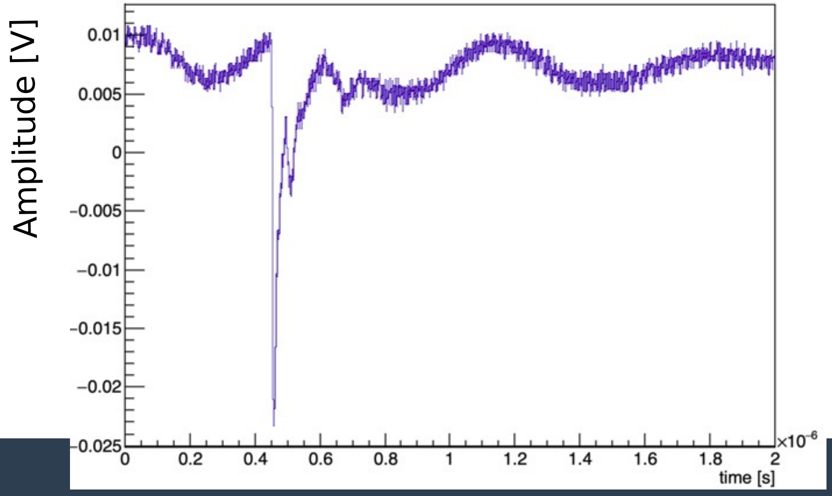
Examples of raw signals

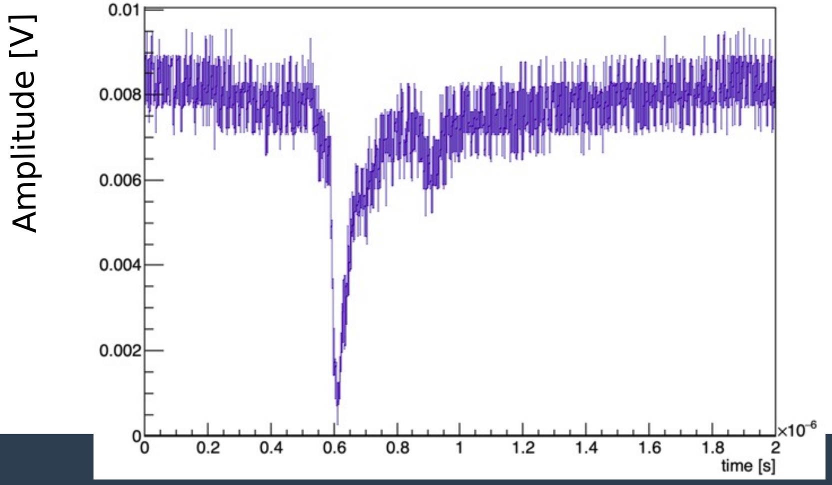
BM signals with 12C @ 115 MeV/u



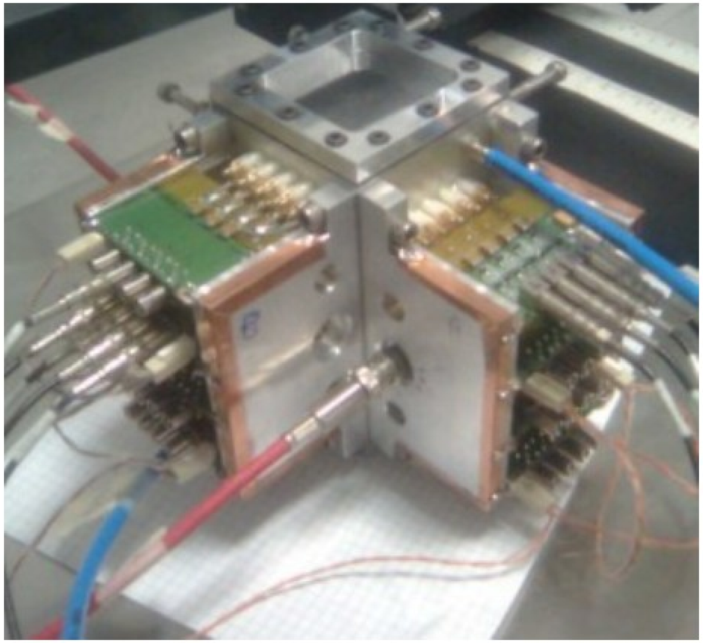


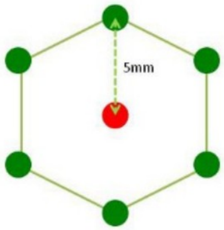
miniDC signals with 12C @ 115 MeV/u

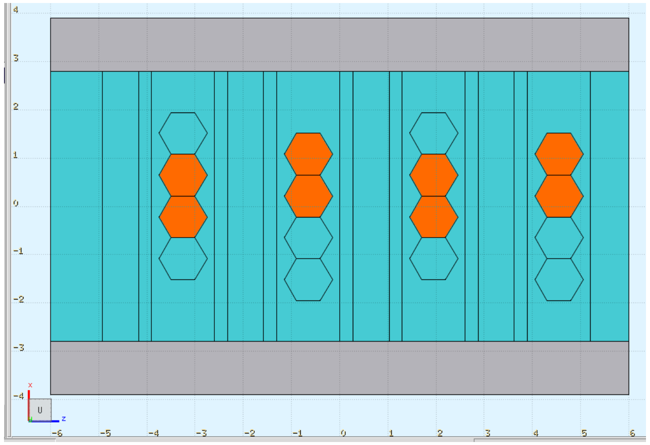




MiniDC



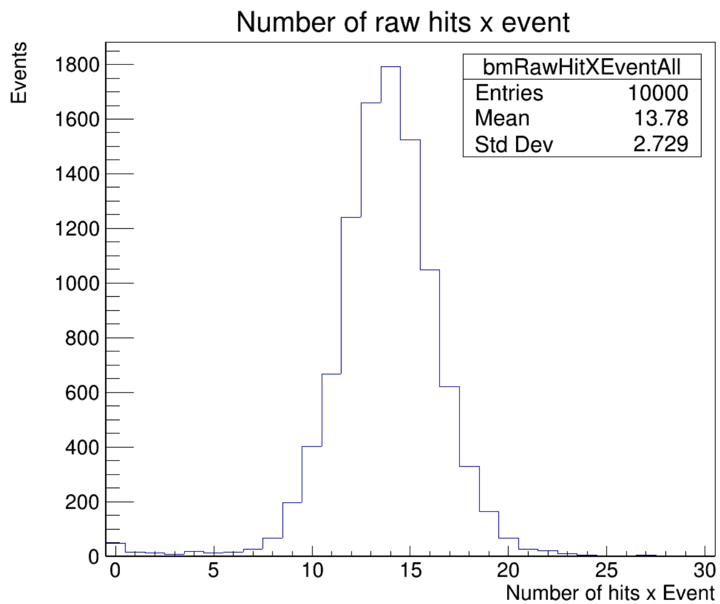


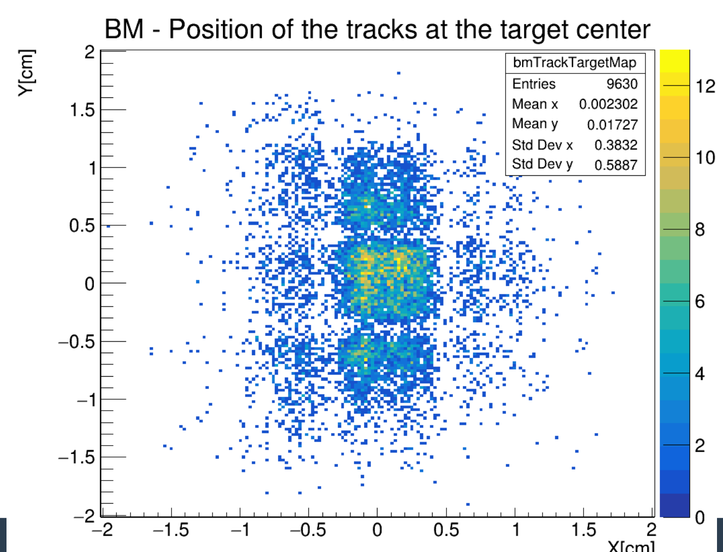


The miniDC is a drift chamber tested by F. Tommasino only with cosmic rays in his master thesis (2009/2010)

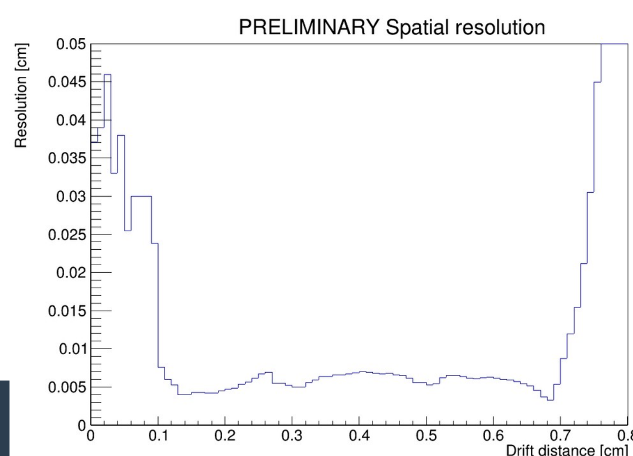
- Is a smaller DC with an active area of $4x4cm^2$
- Each view with 4 planes and 4 cells per plane, with a total of 32 cells
- Hexagonal cell with a maximum distance of 5mm
- With respect to the FOOT BM:
  -Smaller active are, less number of planes and cells
  -Smaller cell size → better E field conformation
- During the data taking, the NIM crate wasn't able to power the additional discriminators.
  We read 8 channels with the BM VME discriminators (red cells in the picture)
- The detector signal checked with the oscilloscope was similar to the BM, signal threshold of 10 mV
- **<u>Preliminary</u> raw hit detection efficiency of about 0.95**

Second shift

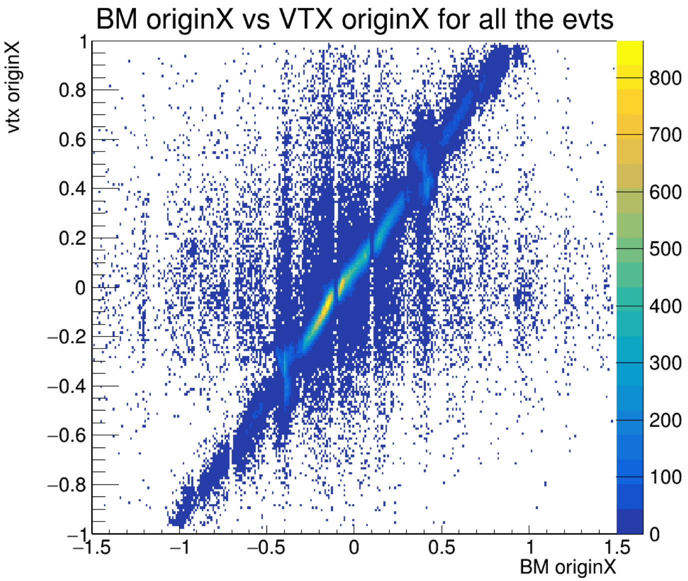


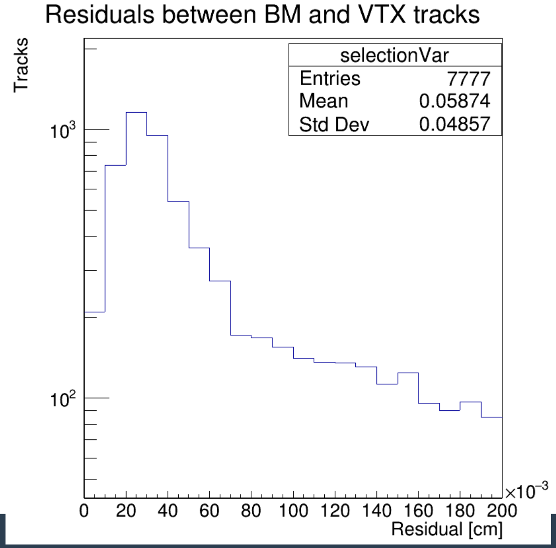


- **The BM pressure has been changed for unknown reasons**
- New working point:
  -Signal threshold at 10 mV
  -High Voltage at 1700 V
- Overall BM performances:
  -Raw hit detection efficiency ~ 0.87
  -**Events with one BM reco track ~ 0.95**
- No inefficiencies detected
- **<u>Preliminary</u> spatial resolution ~ 60 µm in the central part of the cell**



BM vs VTX





- Correlation between BM and VTX tracks both on X and Y view
- **Synchronization maintained also in long runs**
  (eg.: run5469, synchronization maintained till the end 450kevts)
- BM and VTX residuals (difference between the positions of the BM tracks and the VTX vertices) with a peak at about 300 μm
  (with rough estimate of alignment parameters)

Conclusions

- The BM has been successfully tested with ^{12}C and P at different beam rates
- We need to tune the detector settings and position for each beam particle/energy
- The detector efficiency as a function of the beam rate has been measured (at few kHz: raw hit detection efficiency ~ 0.82-0.87; tracking efficiency ~ 0.95-0.98)
- BM start to show inefficiencies with ^{12}C @ 115 MeV/u and P @ 226 MeV/u at about tens of kHz and it becomes relevant at hundreds of kHz
- First test of miniDC showed promising results, preliminary raw hit detection efficiency of about 0.95-0.97
- In the second shift dedicated to the physics:
  -no detector inefficiency has been observed
  -raw hit detection efficiency of about 0.87
  -mean number of tracks per event reconstructed by the BM of about 0.95
  -preliminary spatial resolution of about 60 μm in the central part of the cell
- VTX and BM correlated and synchronization maintained also in long runs

To do list

- Complete the analysis of the BM performances with the respect to the beam rate also with proton data
- Optimize the BM space-time relations and spatial resolution evaluation with the VTX
- Evaluate the miniDC space-time relations and try to characterize the detector (possibility to complete the characterization also in lab with cosmic rays)