Beam Monitor:

Test Beam results and GSI Operation

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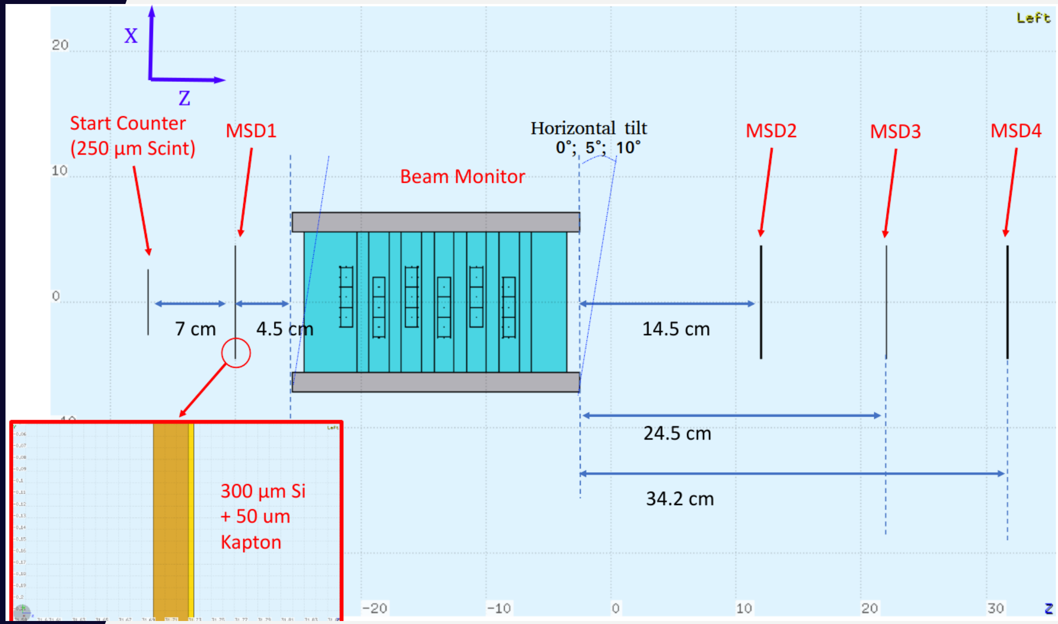
VI FOOT Collaboration Meeting

5th – 7th June, 2019

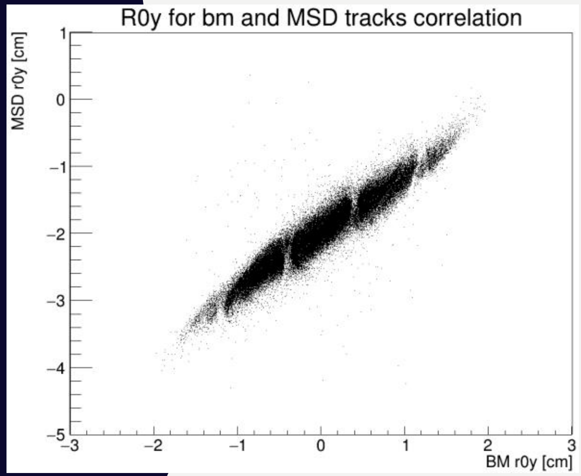
CNAO (Pavia)

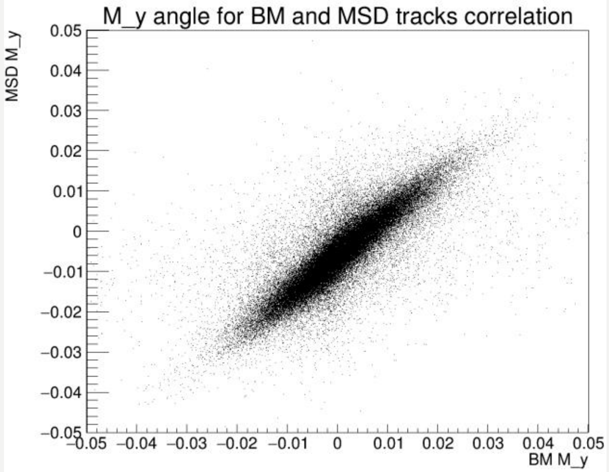
BM space-time rel calibration with MSD

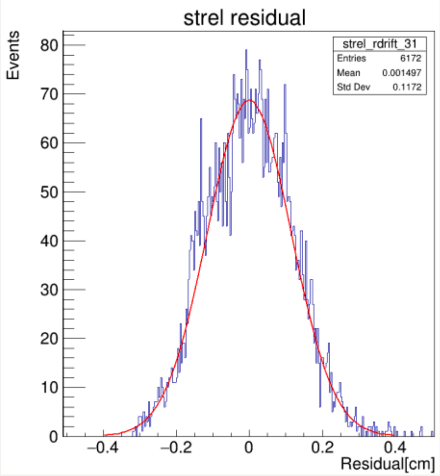


Some difficulties with the hardware of the MSDs

- Several noisy and dead strips
- One dead layer of MSD (up to 4 points on the X coord. and 3 points on Y coord.)
- Alignment issues
- Multiple Coulomb scattering
- **However…Thanks to the work of Perugia's team, we got the MSD tracks and the calibration works!**

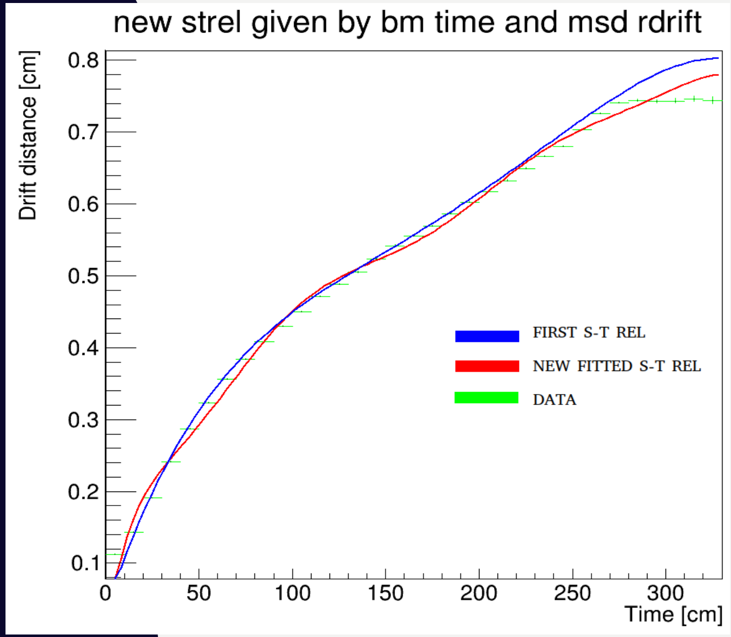


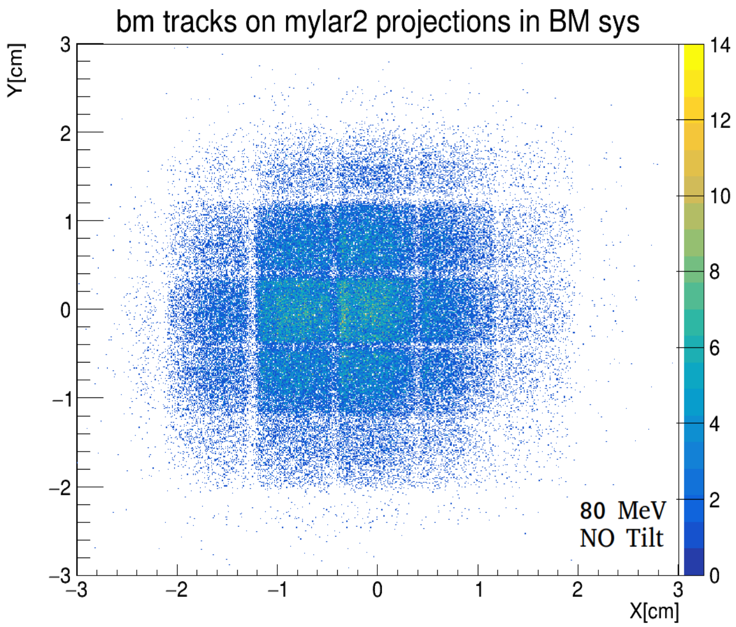


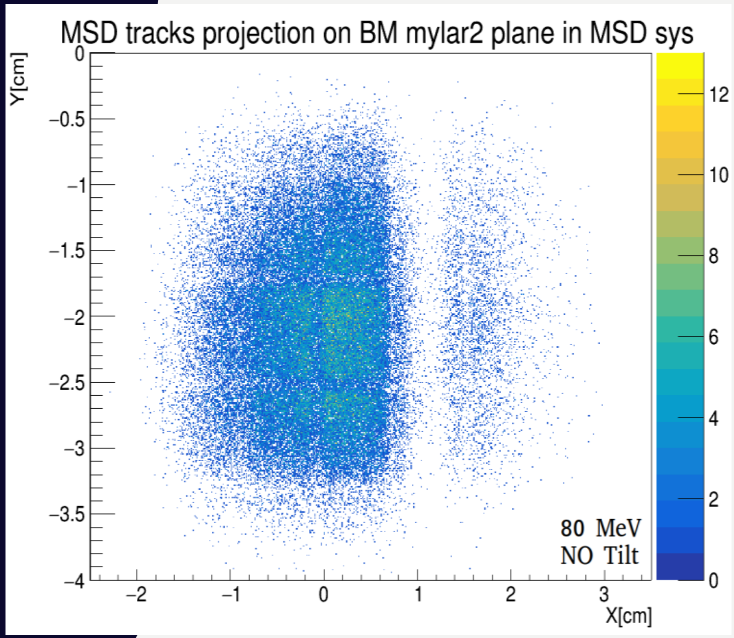


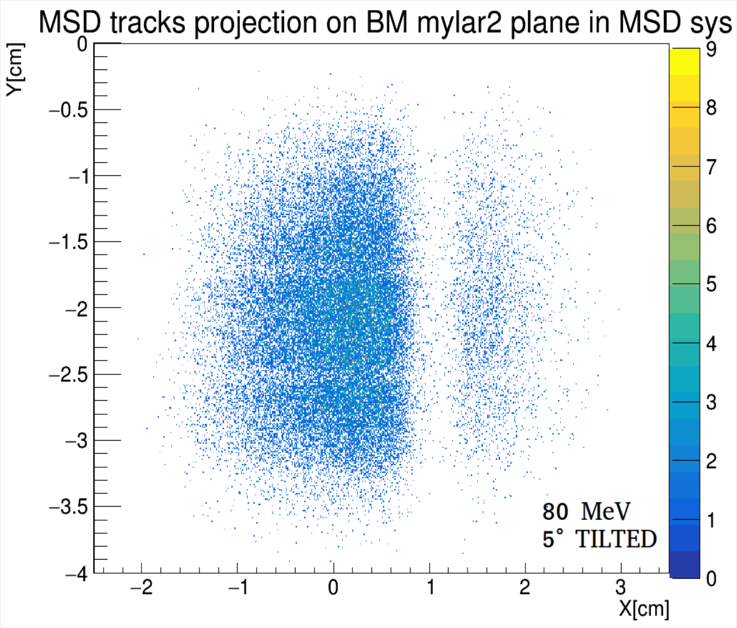
Collected data:
200 kevt.: 80 MeV, 0° tilt
100 kevt.: 228 MeV, 0° tilt
100 kevt.: 80 MeV, 5° tilt
100 kevt.: 228 MeV, 5° tilt
100 kevt: 228 MeV, 10° tilt

BM and MSD track correlation factor ~ 0.94









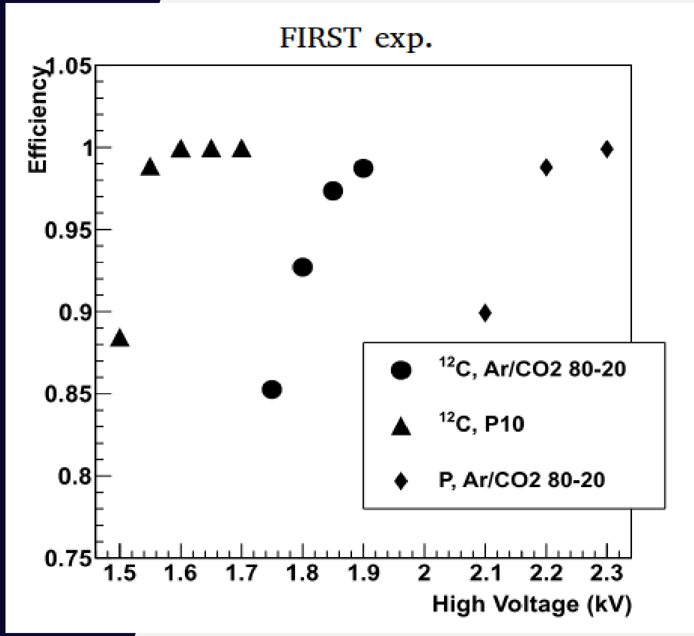
Results

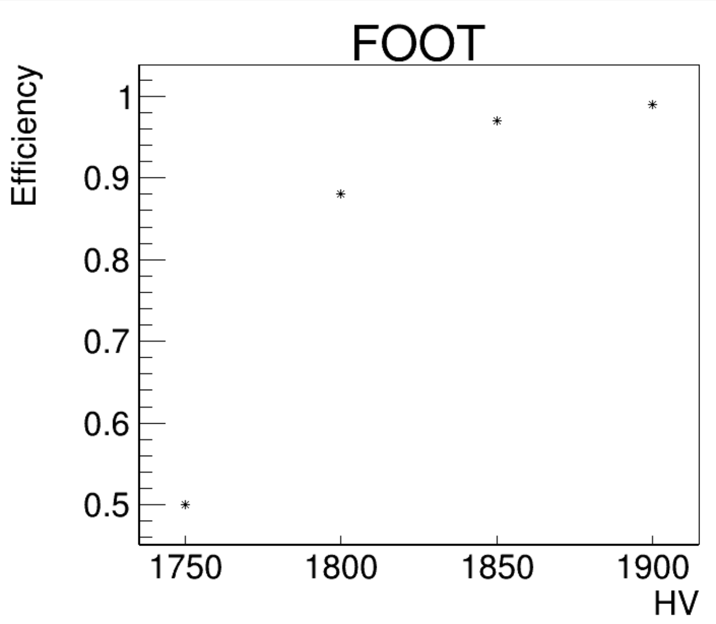
- The fitted space-time rel. are similar to the space-time rel. adopted in FIRST.
- Resolution ~100-200 μm at the center of the cell.
- **The MSD tracks show the BM's wire shadow.**
- When the BM is tilted, the wire shadow disappear on the tilted view.
- Effect given by the Multiple Coulomb scattering and the BM wire displacement.

Next steps

- To improve the BM-MSD alignment
- To evaluate the BM wire displacement

BM @ GSI electronic setup



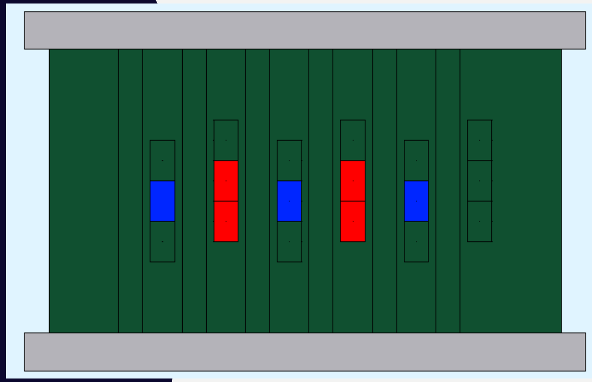


BM data

- 7th April: No target; HV 1850;
Last layer lost the low voltage connection missing the signal from 3 channels.

- 8th April: HV scan; BM tilted vertically ~6mm

- Signal threshold: 20mV

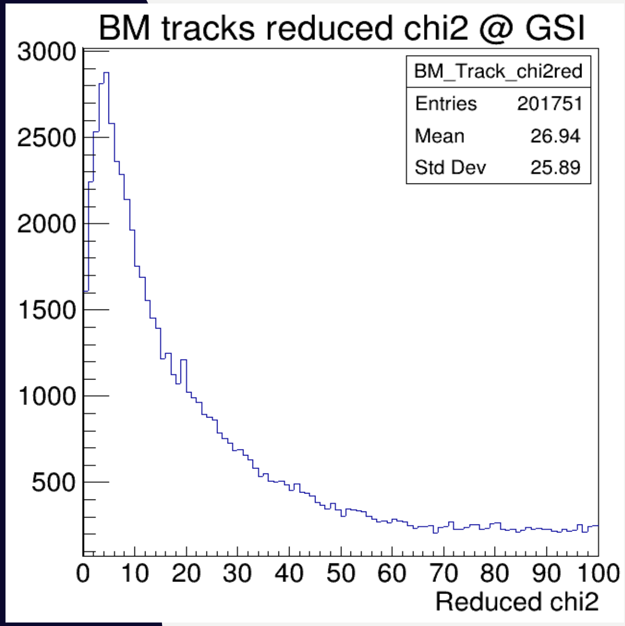


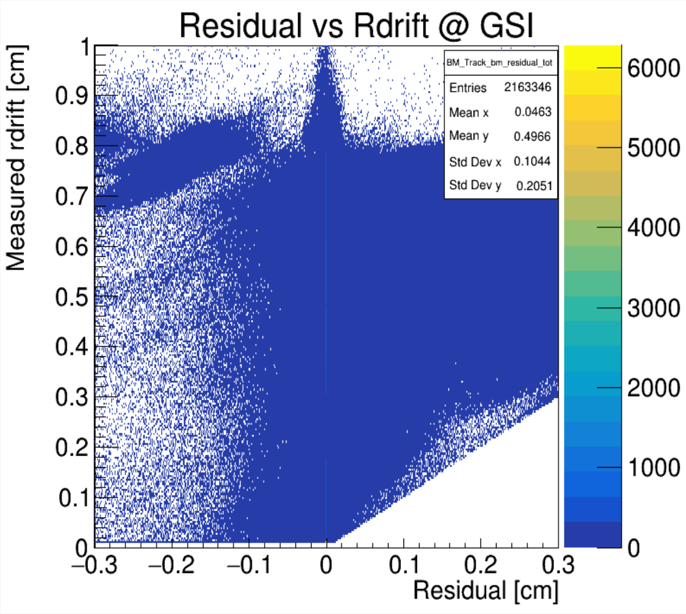
Run	HV	N evts	Eff	N hits
2239	1750	20k	0.50	9.01
2242	1800	200k	0.88	12.17
2240	1850	20k	0.97	15.27
2241	1900	20k	0.99	18.89

Hit efficiency=Probes/Pivots

- Pivot: N events with three consecutive fired wires in even (odd) layers

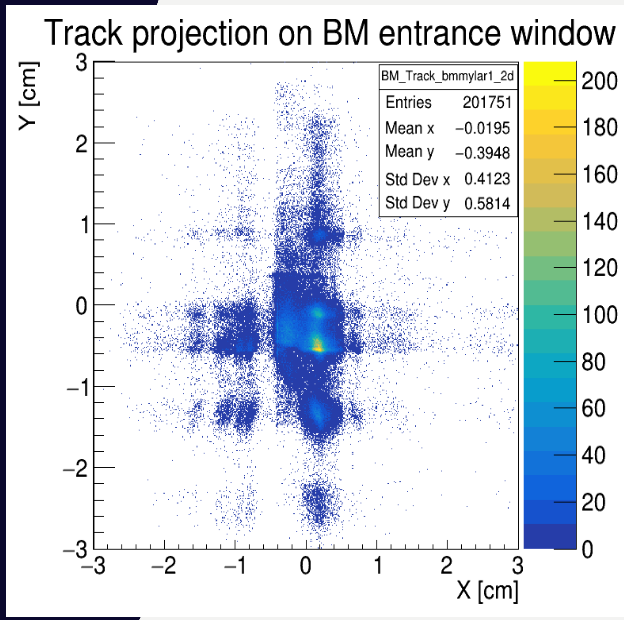
- Probe: N events with 2 hits in the odd (even) layers between the pivots

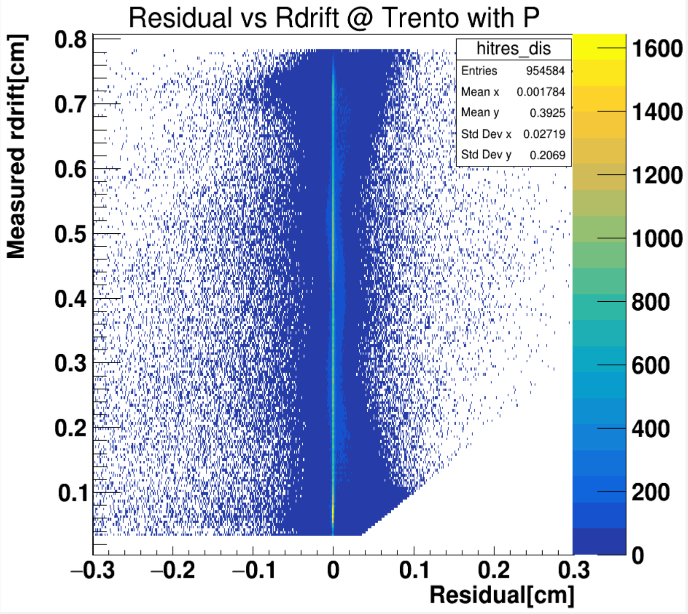




Acquisition

- No problem with the DAQ
- Online monitoring almost perfect
- Remote HV control
- With the GSI mixer, the gas composition was quite stable: CO_2= 21.1 ~ 20.7
- A good HV working point is 1800 -1825





Reconstruction

- Tracking performance is very poor
- **We need better space time relations for Oxygen**
- Options:
  - Calibration with vtx tracks
  - Self calibration algorithm
  - Garfield++
- Possibility to study the Start Counter fragmentation events

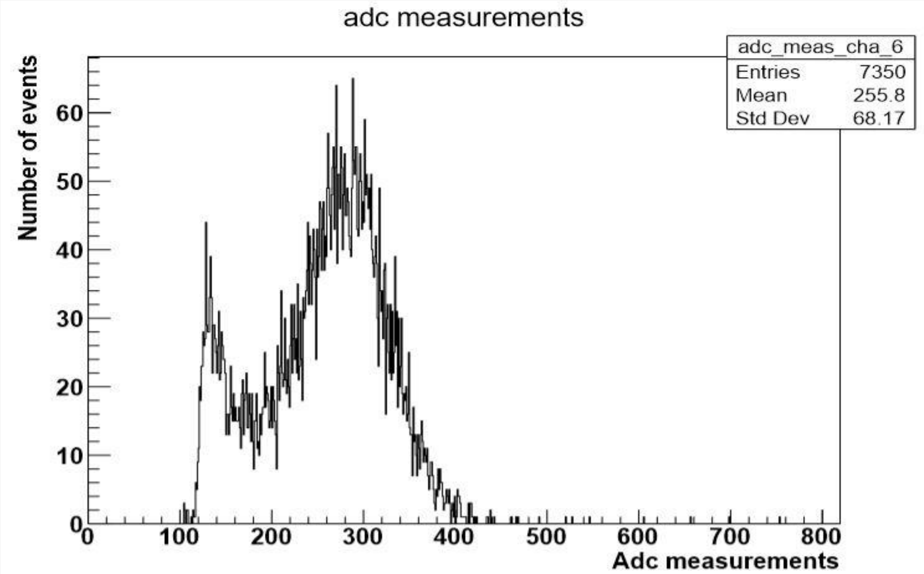
Emulsion runs @ GSI

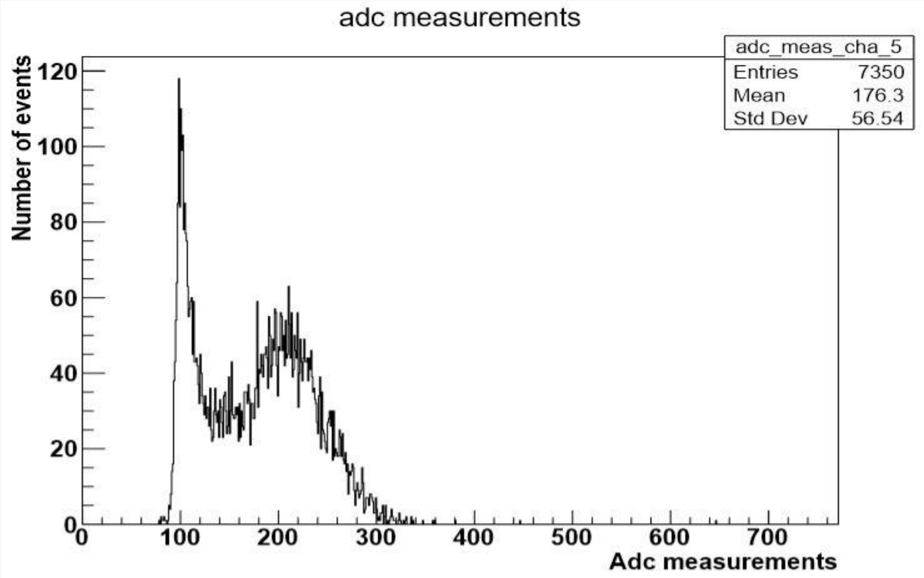
- 5 - 6 April : HV 1850
- Signal threshold: 20mV
- Scanning path : 2.4 cm x 2.4 cm = 5.76 cm^2

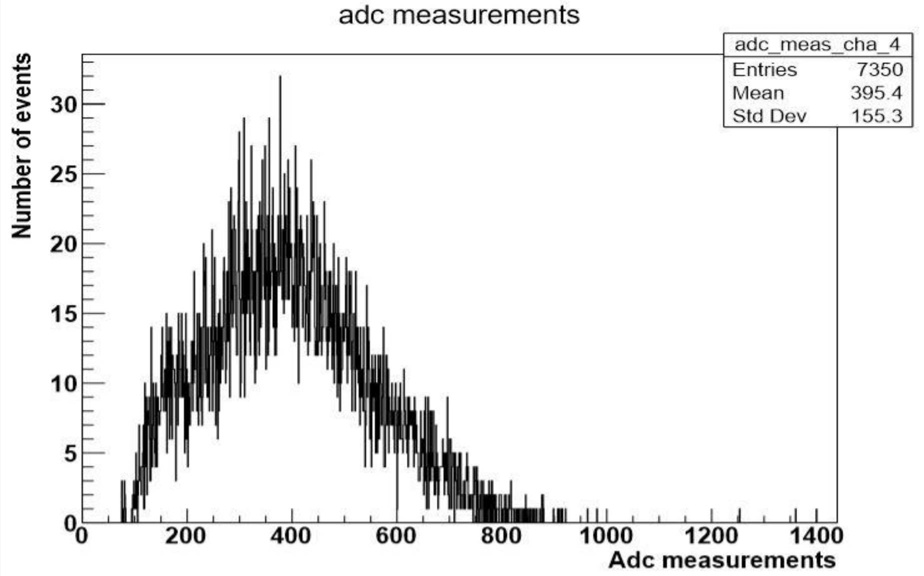
1. Number of ions impinging on the emulsion boxes (from Start Counter data)

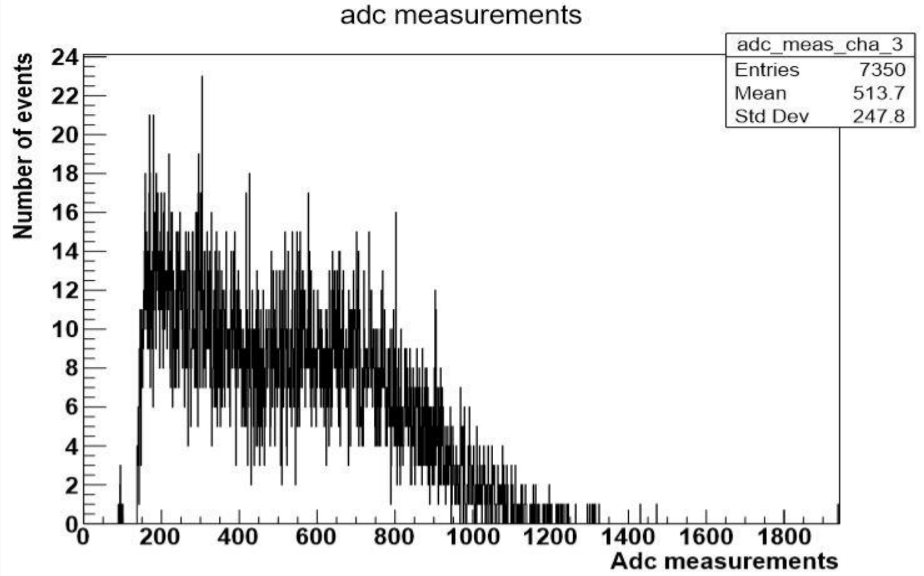
		What we expected	**What we got**
BEAM	TARGET	BEAM INTENSITY	BEAM INTENSITY
^{16}O @ 200 MeV/n	C	**18 $\times 10^3$**	**19.3 $\times 10^3$**
	C_2H_4	**19 $\times 10^3$**	**19.9 $\times 10^3$**
^{16}O @ 400 MeV/n	C	**13.5 $\times 10^3$**	**14.4 $\times 10^3$**
	C_2H_4	**14 $\times 10^3$**	**14.9 $\times 10^3$**

2. Distribution of the four SC channels : there are not double ions



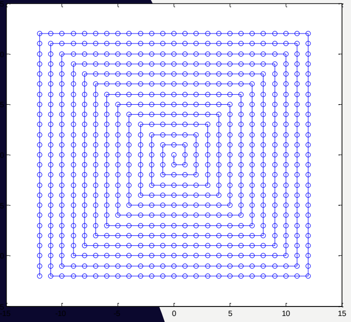


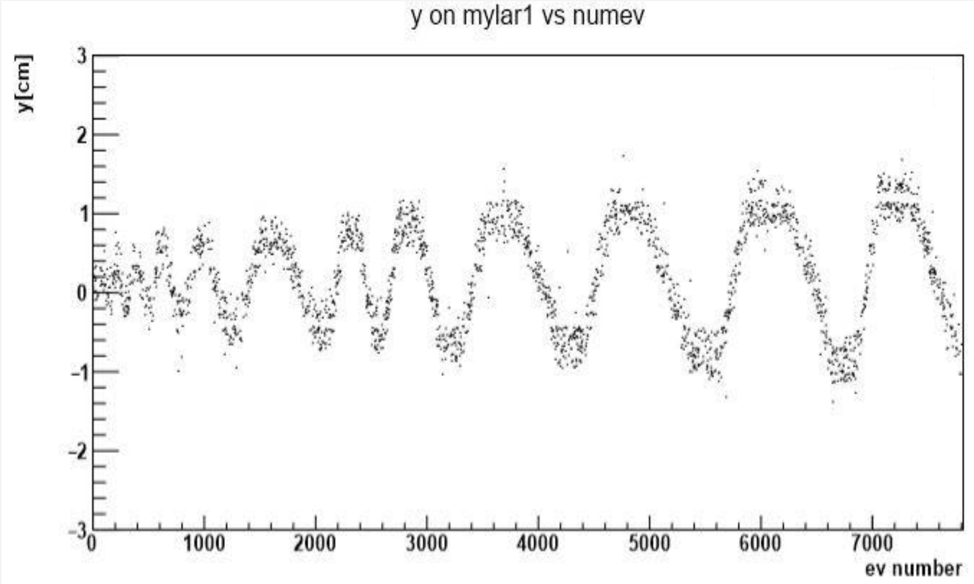


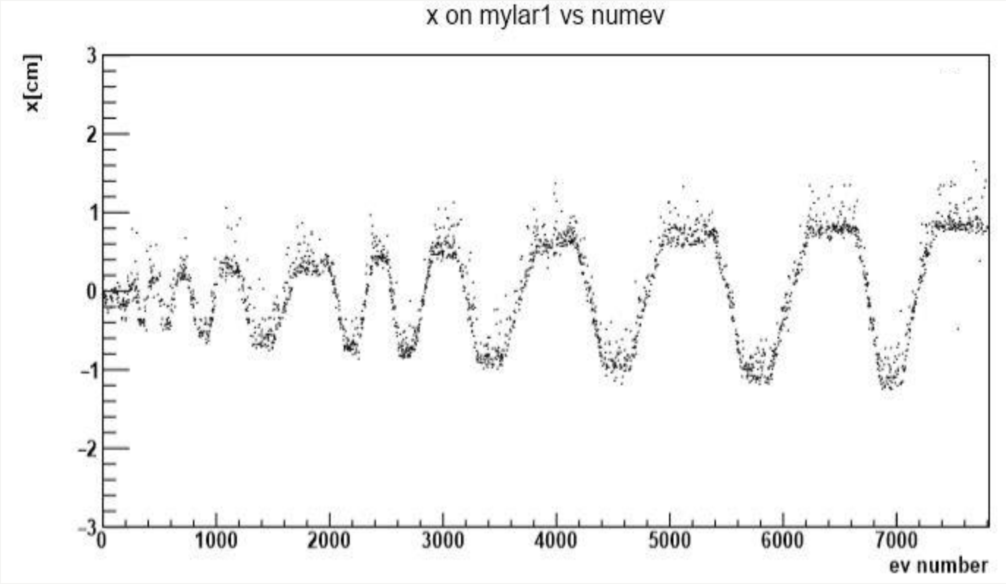


^{16}O @ 400 MeV/n , target: C_2H_4

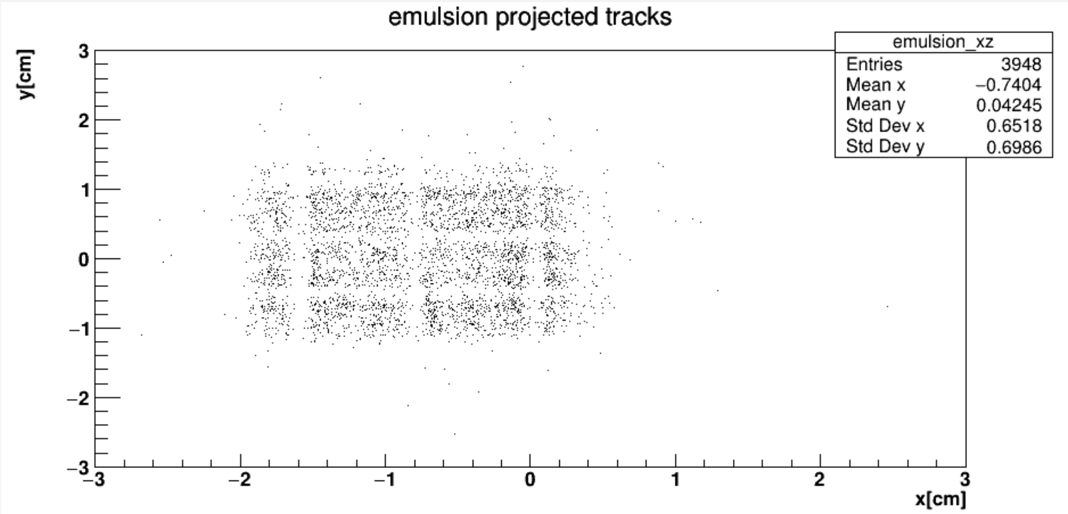
3. Scanning of the emulsion surface: beam position VS number of events





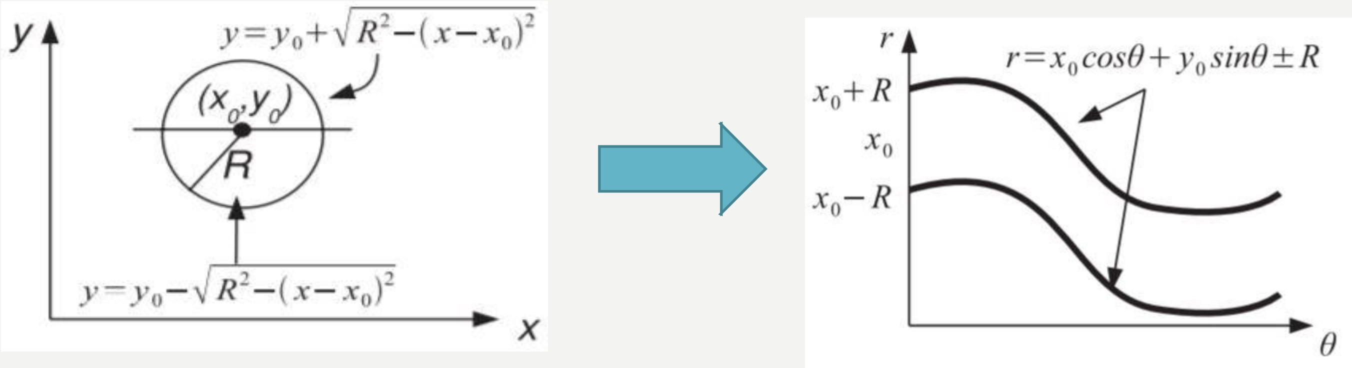


4. Beam profile at the entrance layer of the emulsion box



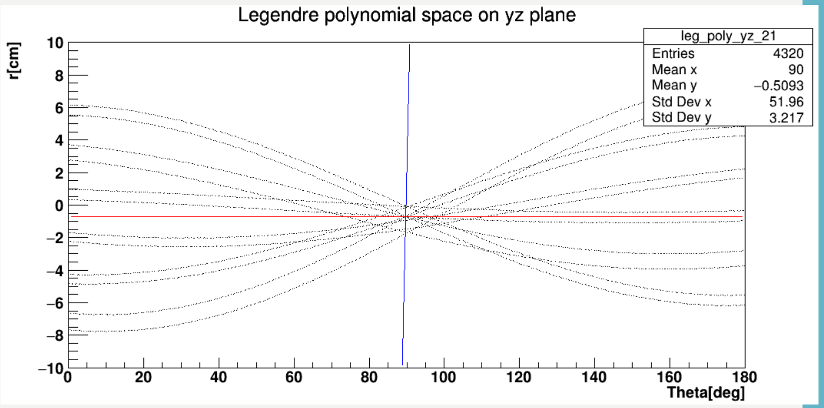
Legendre Transform

Each cell signal is depicted as a circle concentric with the anode wire: the method is based on the transform of each drift circle to the Legendre space (LS).



Each point in the Legendre space represents a tangent line to the circle.

Example from Monte Carlo data
(80 MeV protons)



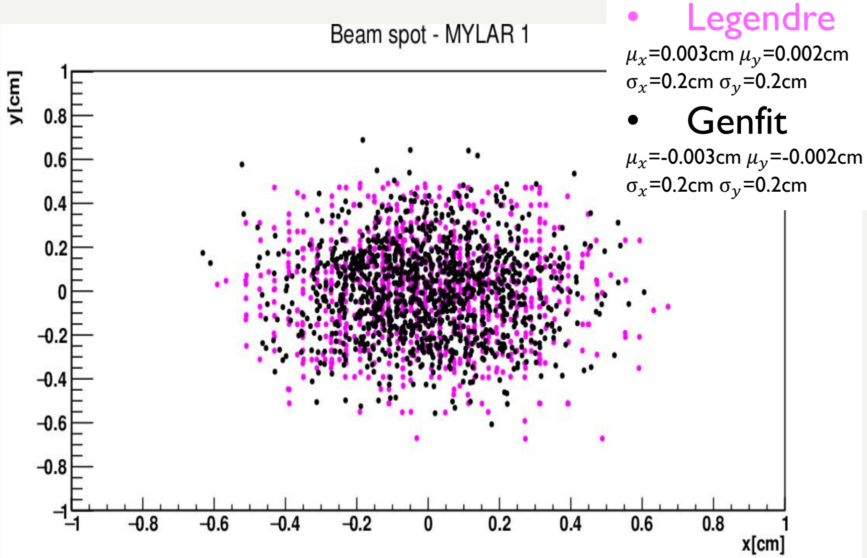
The height of the peaks in the LS represents the number of circles that contribute to the charged particles tracks.

The points with the maximum contribution in the LS represents the common tangent to the circles, i.e. the particle track.

Beam spot reconstruction for single track

Monte Carlo data: 80 MeV proton beam

Reconstructed beam spot

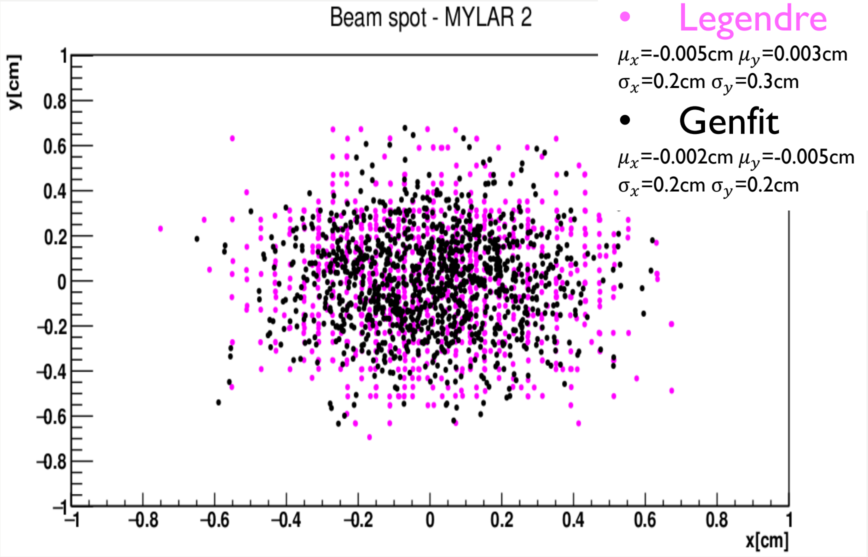


- Legendre

μ_x=0.003cm μ_y=0.002cm
σ_x=0.2cm σ_y=0.2cm

- Genfit

μ_x=-0.003cm μ_y=-0.002cm
σ_x=0.2cm σ_y=0.2cm



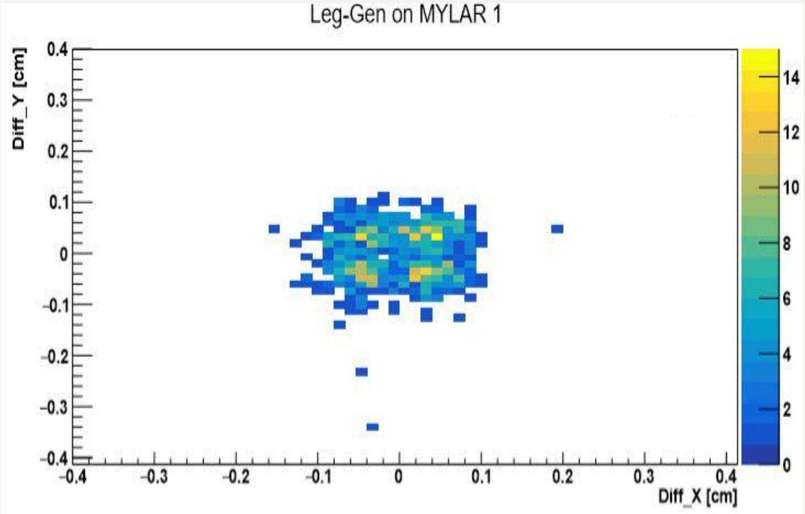
- Legendre

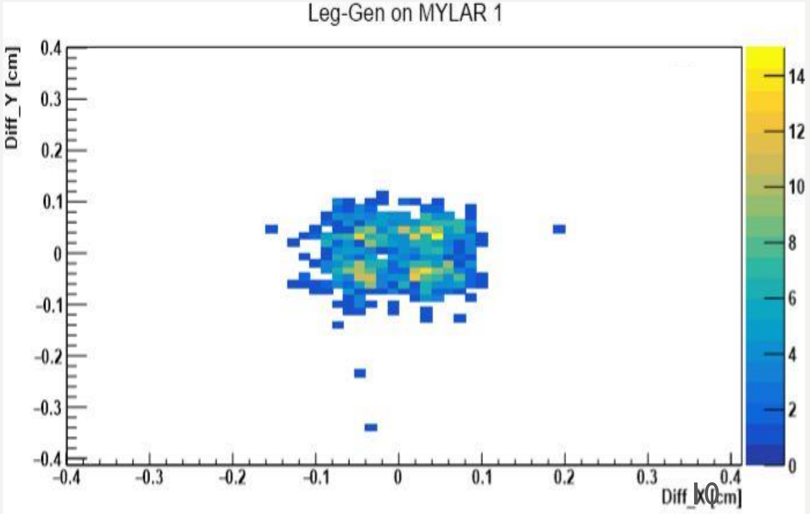
μ_x=-0.005cm μ_y=0.003cm
σ_x=0.2cm σ_y=0.3cm

- Genfit

μ_x=-0.002cm μ_y=-0.005cm
σ_x=0.2cm σ_y=0.2cm

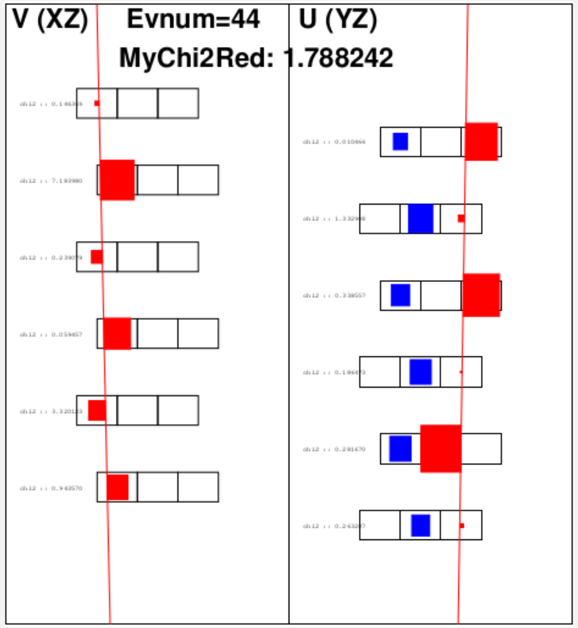
Difference between the Legendre and Genfit methods for each event

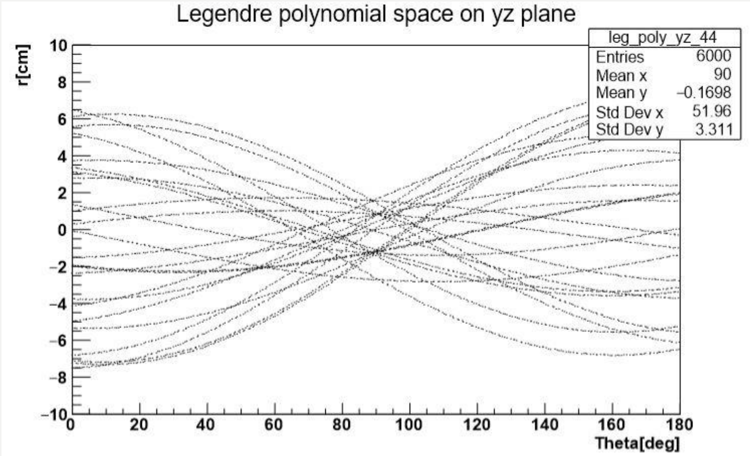




Legendre transform for event rejection

Example from Monte Carlo data (200 MeV/u Oxygen)

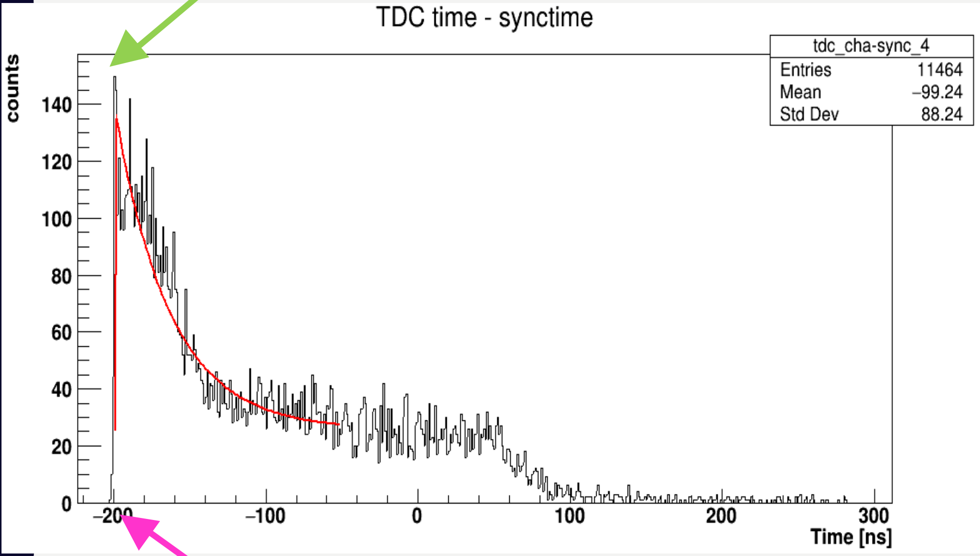




- In principle, the Legendre approach works with multi tracks event (i.e. multiple peaks in Legendre space)
- However, this might not apply to our geometry (few cells, large cells, mainly small angle)
- On-going development of this method on Monte Carlo data
- Is the multi tracking really needed? Cuts based on Chi2 and hit cells might be sufficient to reject the fragmentation events on the SC (to be proven!)

T0 analysis

Peak point



Starting point

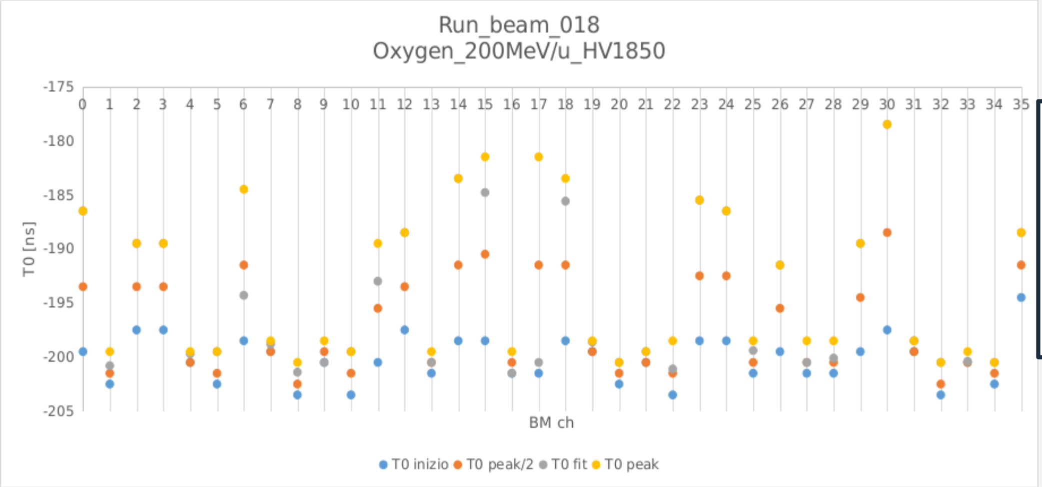
Four different choices:

- T0 **starting point**
- T0 **peak point**
- T0 peak/2 point (= (peak point – starting point)/2)
- T0 **fit**
  - *The calibration of the space-time relations in the KLOE drift chamber* paper
  - The time distribution for a single channel is fitted with the function

$$a + b\,\frac{e^{-d(t-t1)}}{1 + e^{-(t-t0)/c}}$$

  - Fermi-Dirac-like function (t0 = inflection point) + an exponential (rest of the distribution)

Example: 200 MeV/u Oxygen



Standard deviation:

- **T0 starting point** : 2.12 ns
- **T0 peak/2** : 4.38 ns
- **T0 peak** : 7. 09 ns
- T0 fit : 6.73 ns

To do list

- **BM and MSD test:**
  - To improve the alignment procedure and ST calibration
  - To check the space time relation differences for P at 228 MeV and 80 MeV
  - To evaluate the sense wires displacement

- **BM @ GSI**
  - To evaluate the ST relations for Oxygen with a self-calibration method
  - To check the waveforms and study for a better threshold value
  - Config file versioning for the BM
  - To study the Start Counter fragmentation events
  - Calibration with the VTX (?)

- **Software**
  - To separate the TABMactNtuMC in a reader and a decoder for the MC data
  - To complete the reconstruction method based on the Legendre pol

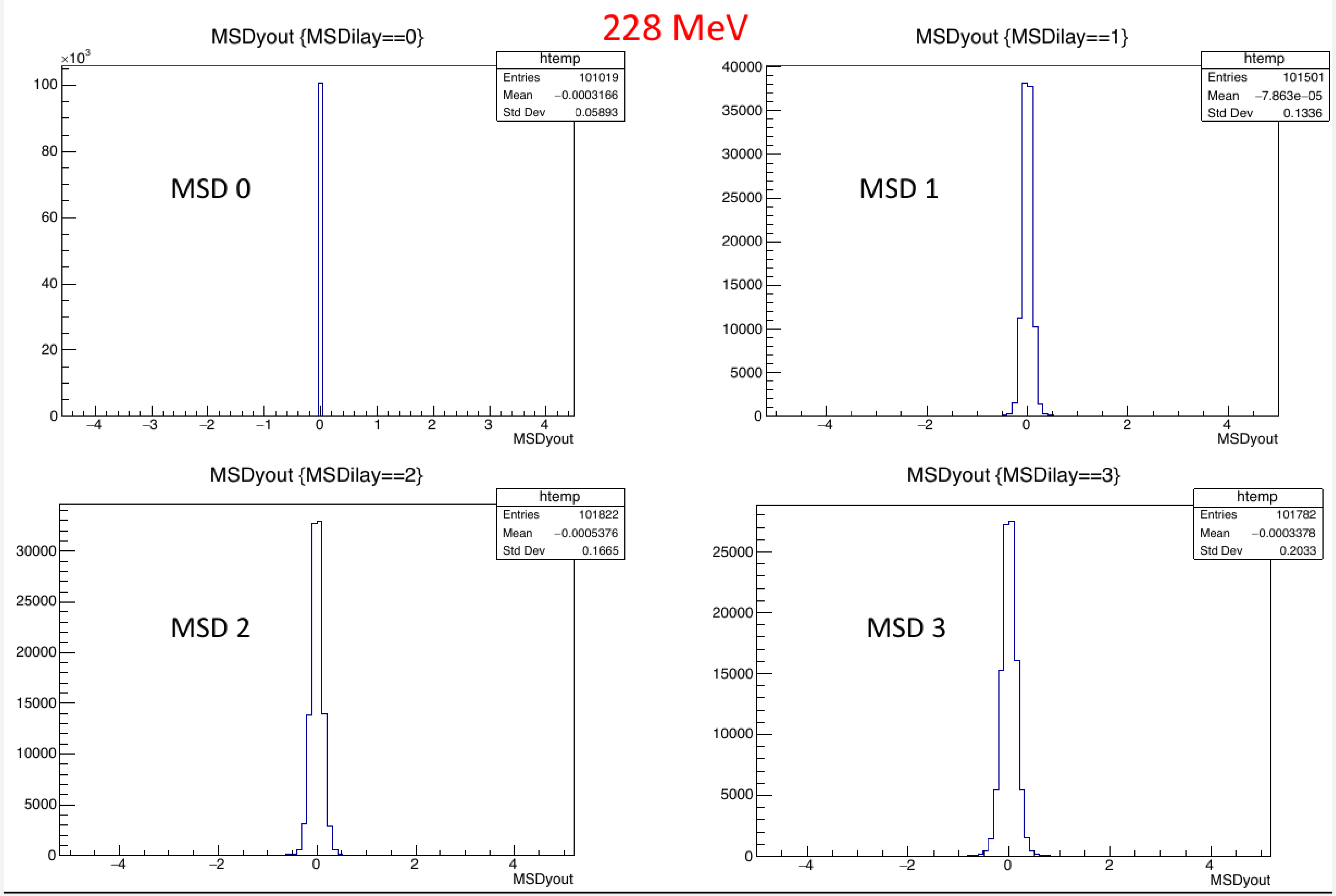
BACK UP

BM software status

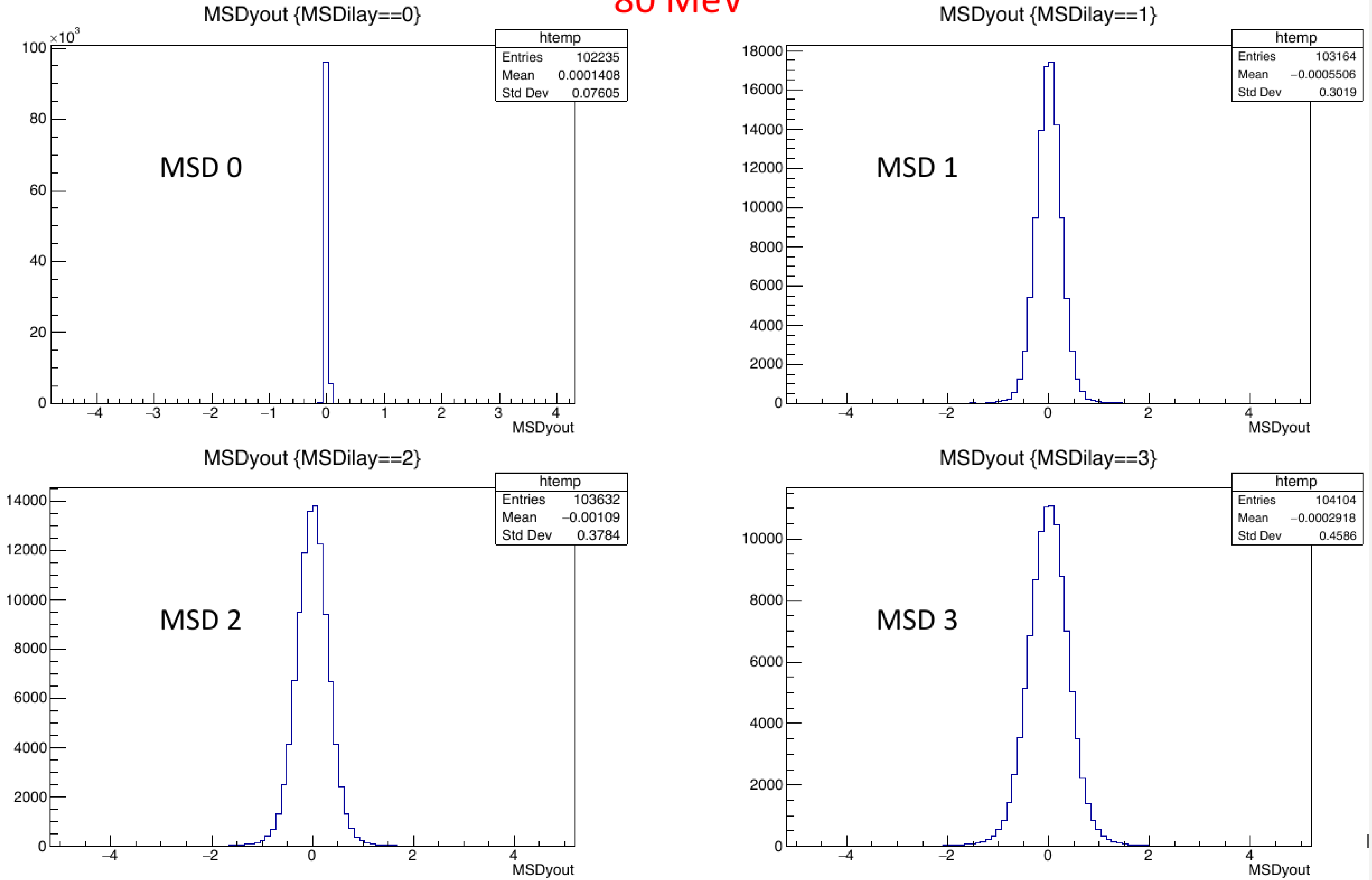
- **Current situation**
- Works with MC, GSI data and previous BM stand alone tests (with ReadBmRawVME.C)
- No multitrack capability, only the least chi2 method is working
- Input/output files:

  ./config/beammonitor.cfg --> general config file
  ./geomaps/TABMdetector.map --> geometry parameters (v)
  ./geomaps/beammonitor_geoch.map --> wire mapping file (v)
  ./config/T0_beammonitor.cfg --> T0 time map file (v)
  ./config/bmreso_vs_r.root --> the resolution parameters
- The beammonitor.cfg file is commented, but long and not user friendly, it will be fixed soon
- Some files need versioning (v)

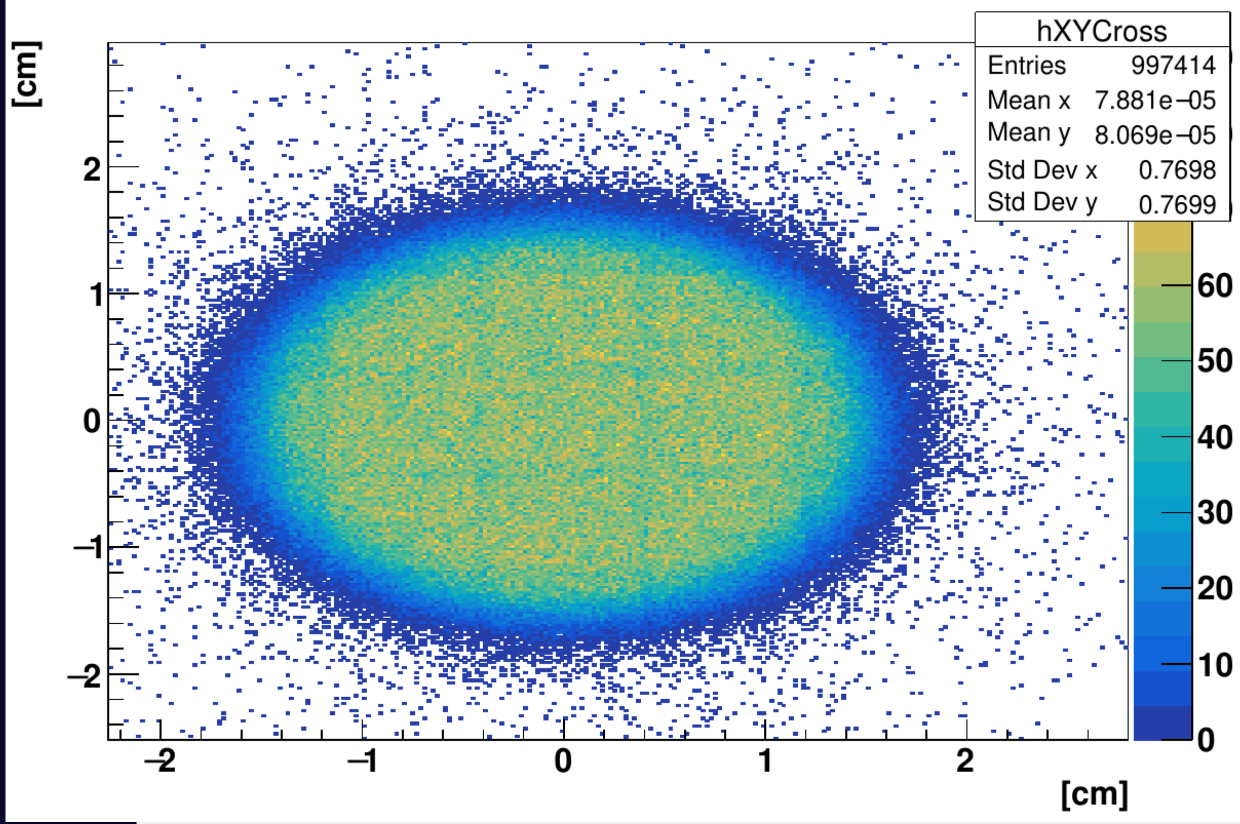
MSD MULTIPLE COULOMB SCATTERING



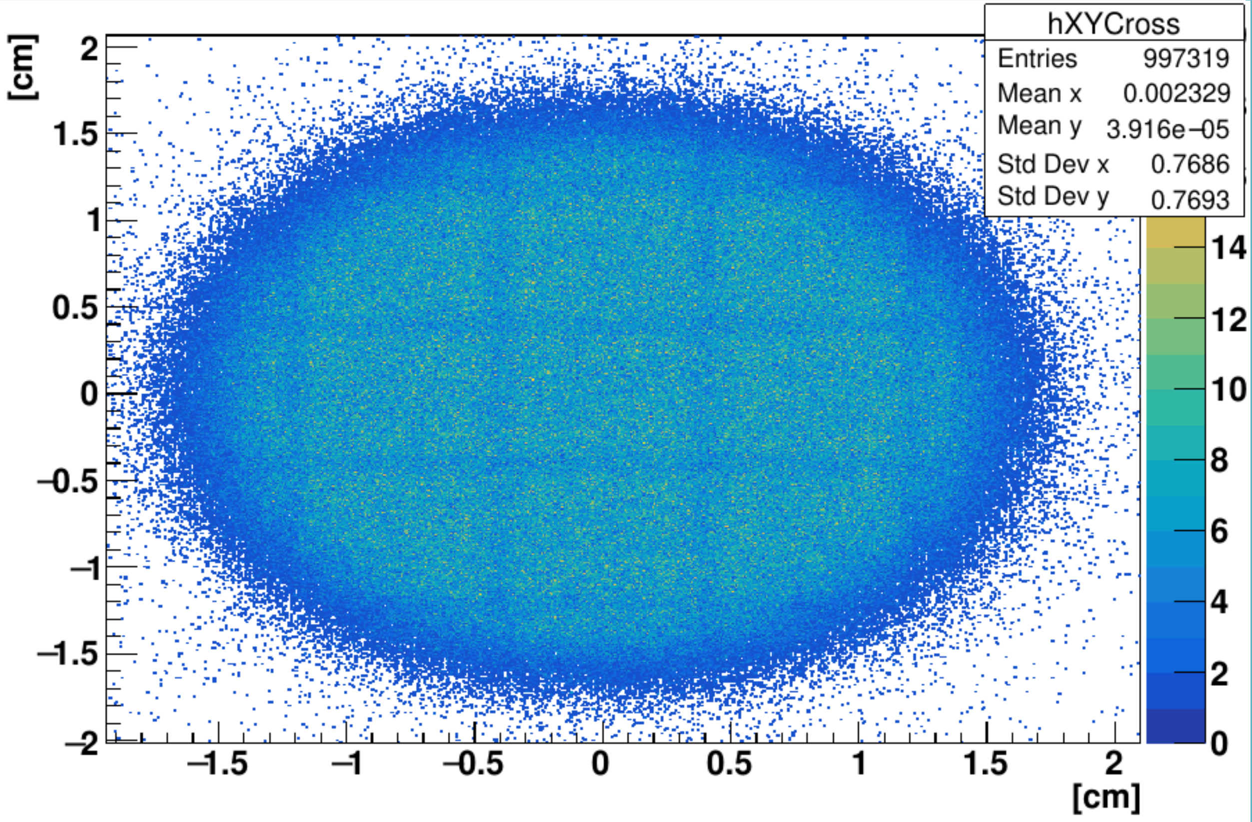
80 MeV


MSDyout {MSDilay==0}
htemp
Entries 102235
Mean 0.0001408
Std Dev 0.07605
MSD 0
MSDyout
MSDyout {MSDilay==1}
htemp
Entries 103164
Mean −0.0005506
Std Dev 0.3019
MSD 1
MSDyout
MSDyout {MSDilay==2}
htemp
Entries 103632
Mean −0.00109
Std Dev 0.3784
MSD 2
MSDyout
MSDyout {MSDilay==3}
htemp
Entries 104104
Mean −0.0002918
Std Dev 0.4586
MSD 3
MSDyout

MC simulation of P @ 80 Mev
Primaries position on BM exit window



Sense wire radius=15 μm
Field wire radius=90 μm



Sense wire radius=30 μm
Field wire radius=180 μm

T0 analysis, peak evaluation