Full Detector Simulation with updated 12C_200_2023v2 campaign

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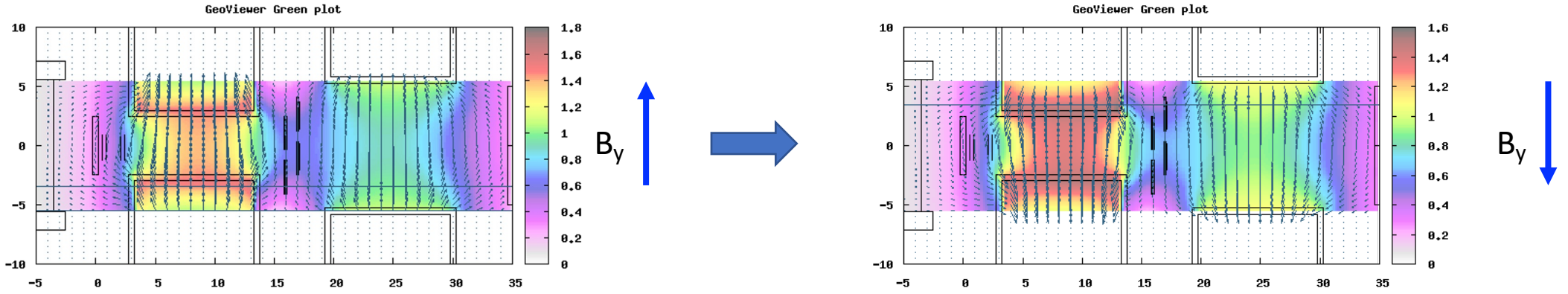
Summary of previous episodes

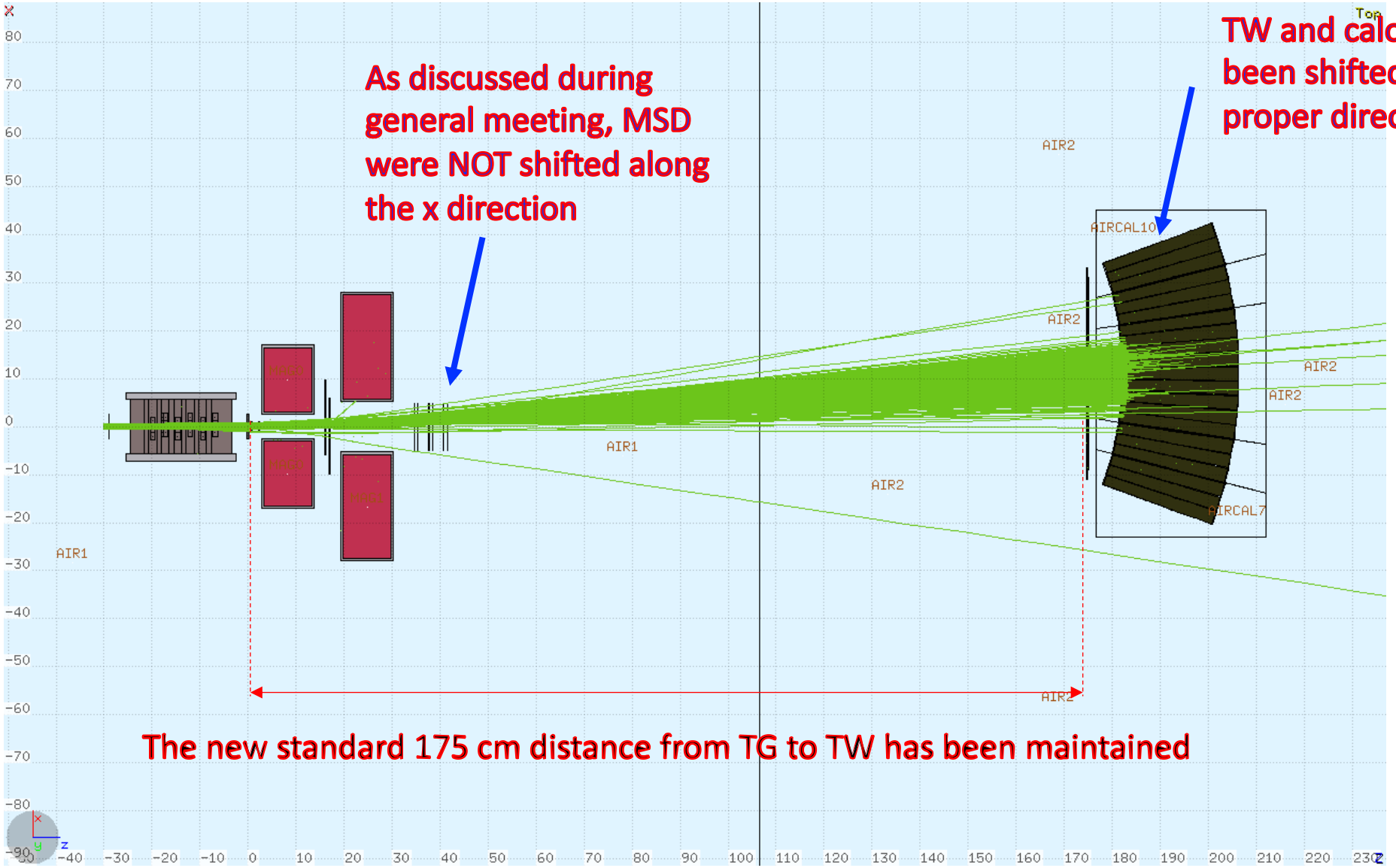
An updated full detector campaign **12C_200_2023** was prepared during spring 2023 using the latest magnet design

After the discussions during June 2023 Collaboration Meeting, we have rotated the direction of magnetic field introducing the modified campaign **12C_200_2023v2**

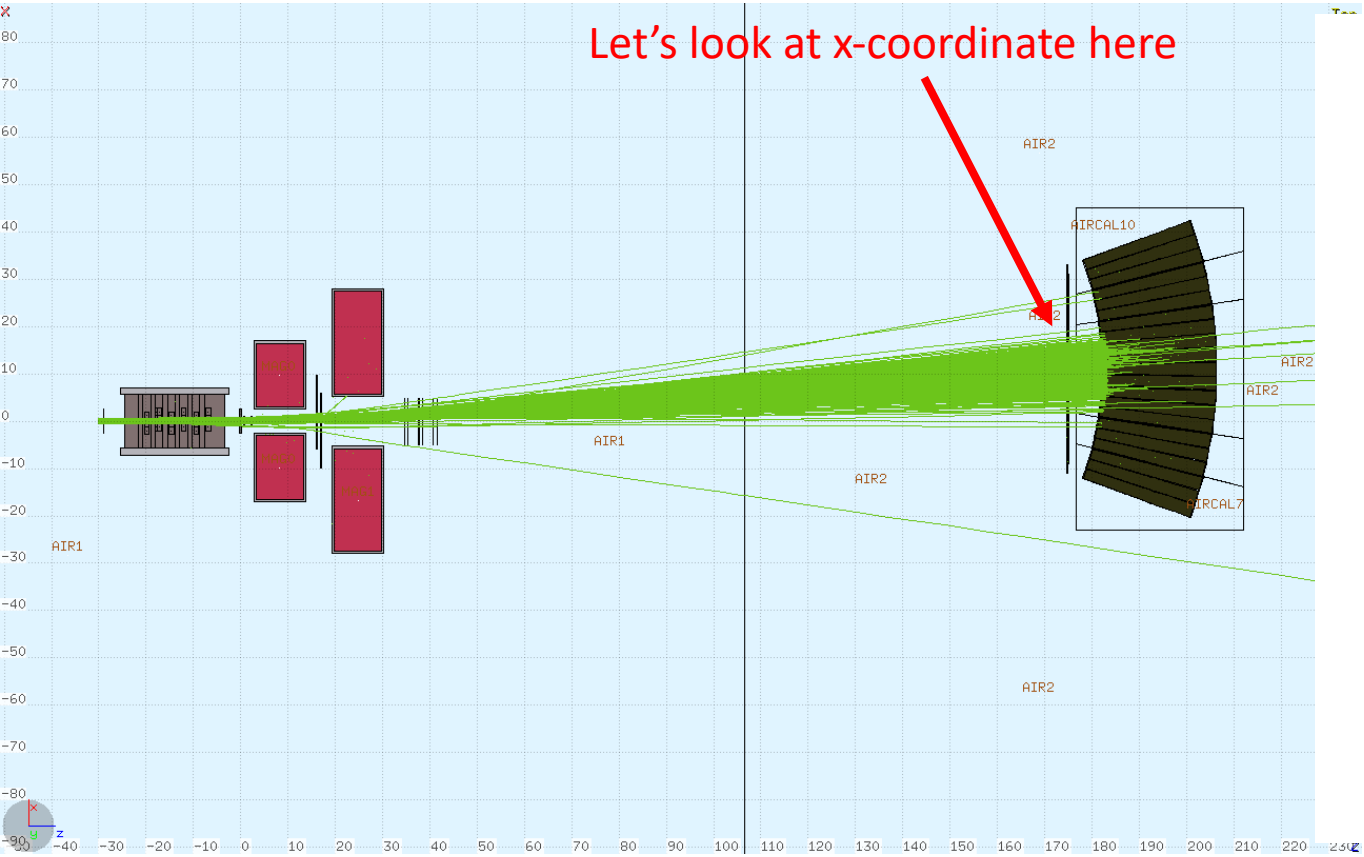


→ shoe/Reconstruction/data/SigmaPhi_FOOT2023rot.table

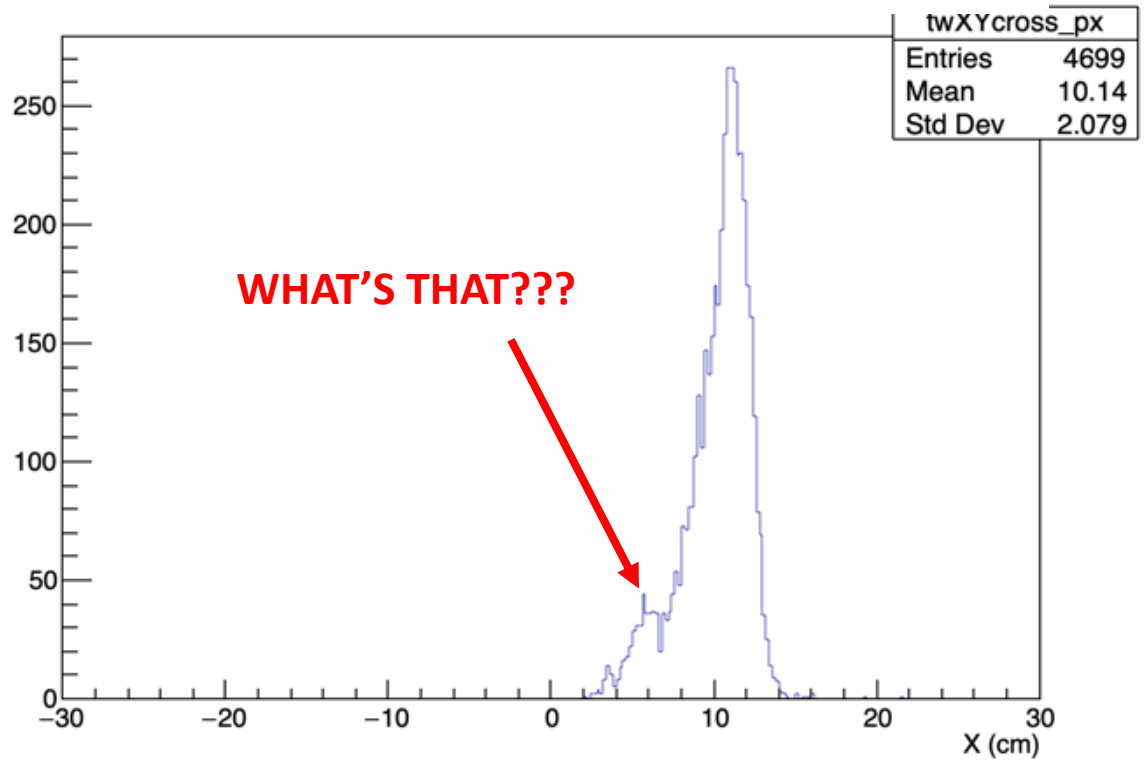
12C_200_2023v2 new design



Detailed analysis of MC tracks in magnetic field



X coordinate of primaries on TW

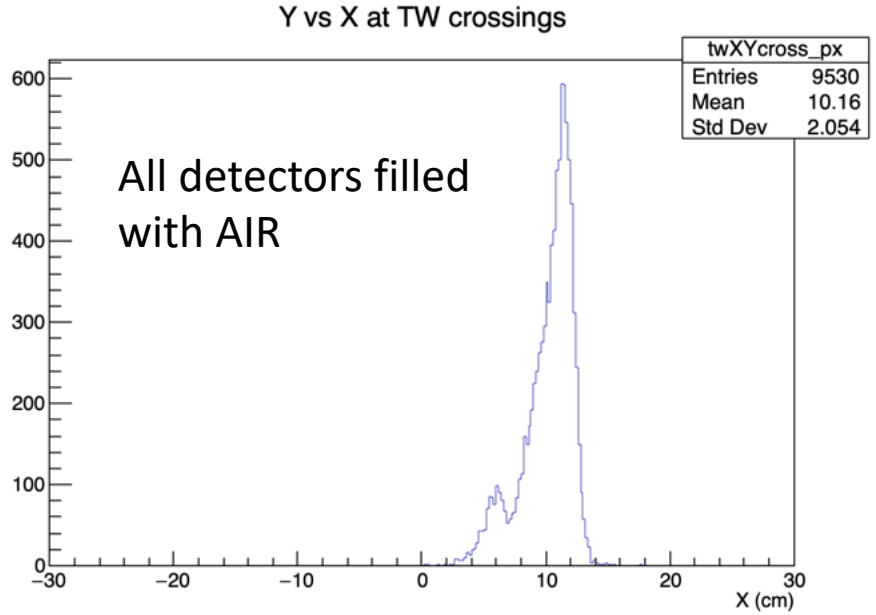


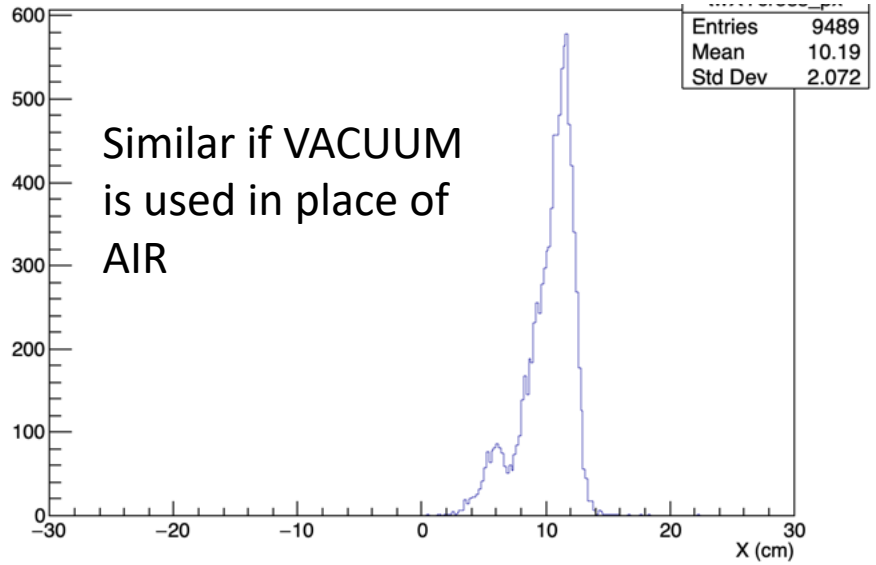
Already detected (see physics meeting of May) but not really understood at that time

Houston, we have a problem…

(Long and painful) attempts to understand

- Effects due to some issues of materials — NO!
- Problems due to ITR or MSD description — NO!
- Flaws in the map of magnetic field — NO!
- Bugs in the map interpolation algorithms — NO!
- …





Solution

We at last realized that *(since the early exploration of FOOT idea in 2016!!!)* we were neglecting some essential recommendations quoted in the section of FLUKA manual concerning the simulation in magnetic field:

- The usual automatic evaluation of step length in the propagation of charged particles does not work properly for tracking in magnetic fields: a minimum STEP SIZE length region by region has to be assigned, smaller than the size of the region themselves. This is particularly important in ITR where the field intensity is high and very thin regions exist (but also in VTX, and MSD!)
- Furthemore: forcing a small maximum STEP SIZE values is fundamental for the code to manage B-fields where significant gradients exist (FOOT is one of the cases!)
- Last but not least: expecially for low density materials (AIR) there are complex interferences between the multiple scattering algorithm and deflection in magnetic field, that can be managed only by forcing small STEP SIZE values

New input directives

```
MGNFIELD       0.1   0.00001      0.1       0.       0.       0.
STEPSIZE     0.001      0.01     AIR1      AIR1
STEPSIZE  0.000001    0.0003     VTXP0     VTXP3
STEPSIZE  0.000001    0.0005     VTXE0     VTXE3
STEPSIZE  0.000001    0.0015     VTXM0     VTXM3
STEPSIZE  0.000001    0.0001     ITRP0    ITRP31
STEPSIZE  0.000001    0.0001    ITRK00   ITRK115
STEPSIZE  0.000001    0.0001    ITRA00   ITRA114
STEPSIZE  0.000001    0.0001    ITRY00   ITRY112
STEPSIZE  0.000001    0.0001    ITRE00    ITRE31
STEPSIZE  0.000001    0.0001     ITRM0    ITRM31
STEPSIZE  0.000001     0.001    ITRF00    ITRF12
STEPSIZE  0.000001     0.007     MSDS0     MSDS5
STEPSIZE  0.000001   0.00005     MSDM0     MSDM5
STEPSIZE  0.000001   0.00005     MSDP0     MSDP5
```

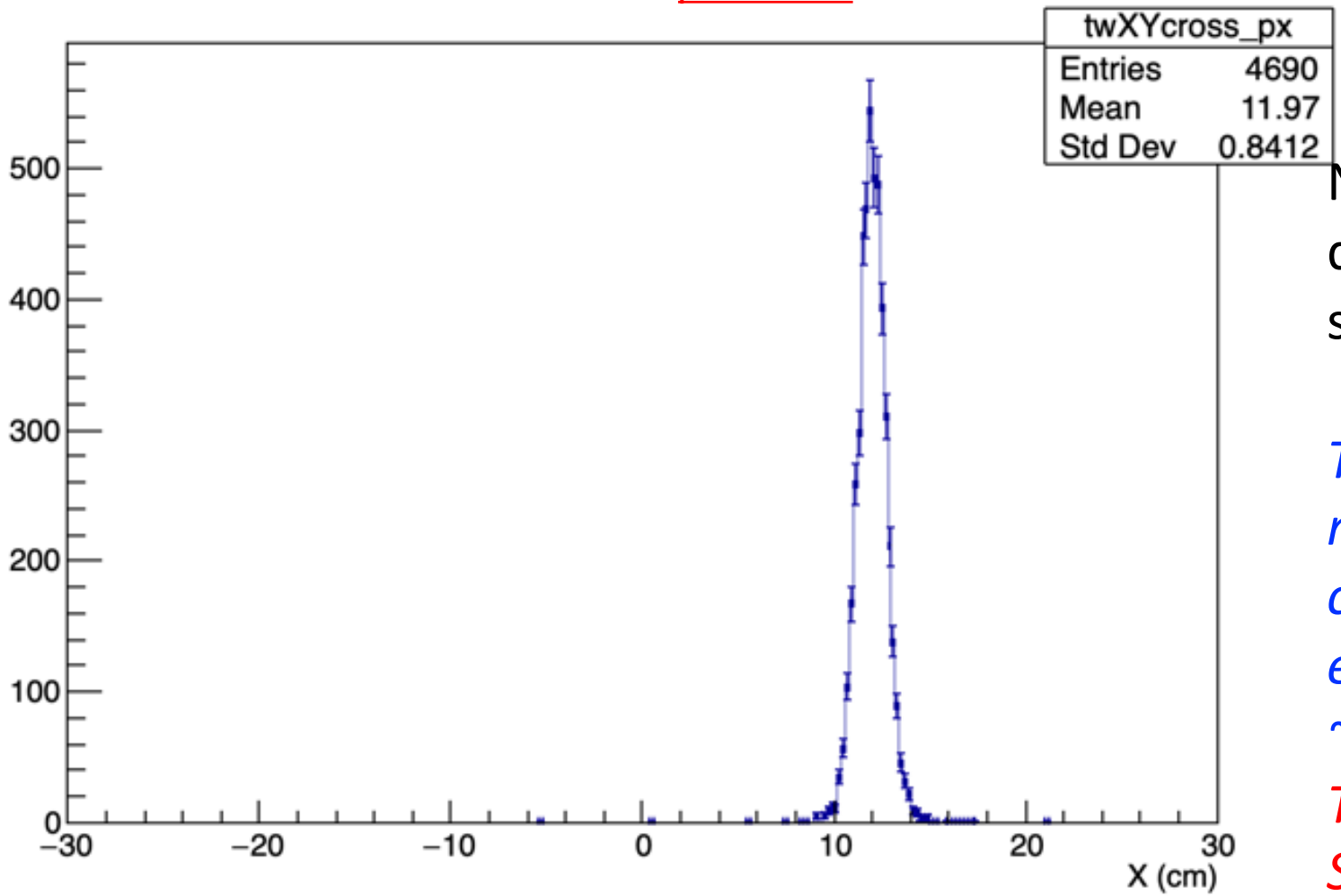
The methods in the different TAXXparGeo.cxx of SHOE (newgeom branch) have been modified so to include new commands in the simulation input produced by makeGeo

Optimization of max step values might still be incomplete…

Warning: limiting the maximum STEPSIZE values naturally increases in a significant way the required CPU time/particle, but it's still under acceptable values

The correct result!

X coordinate of primaries on TW

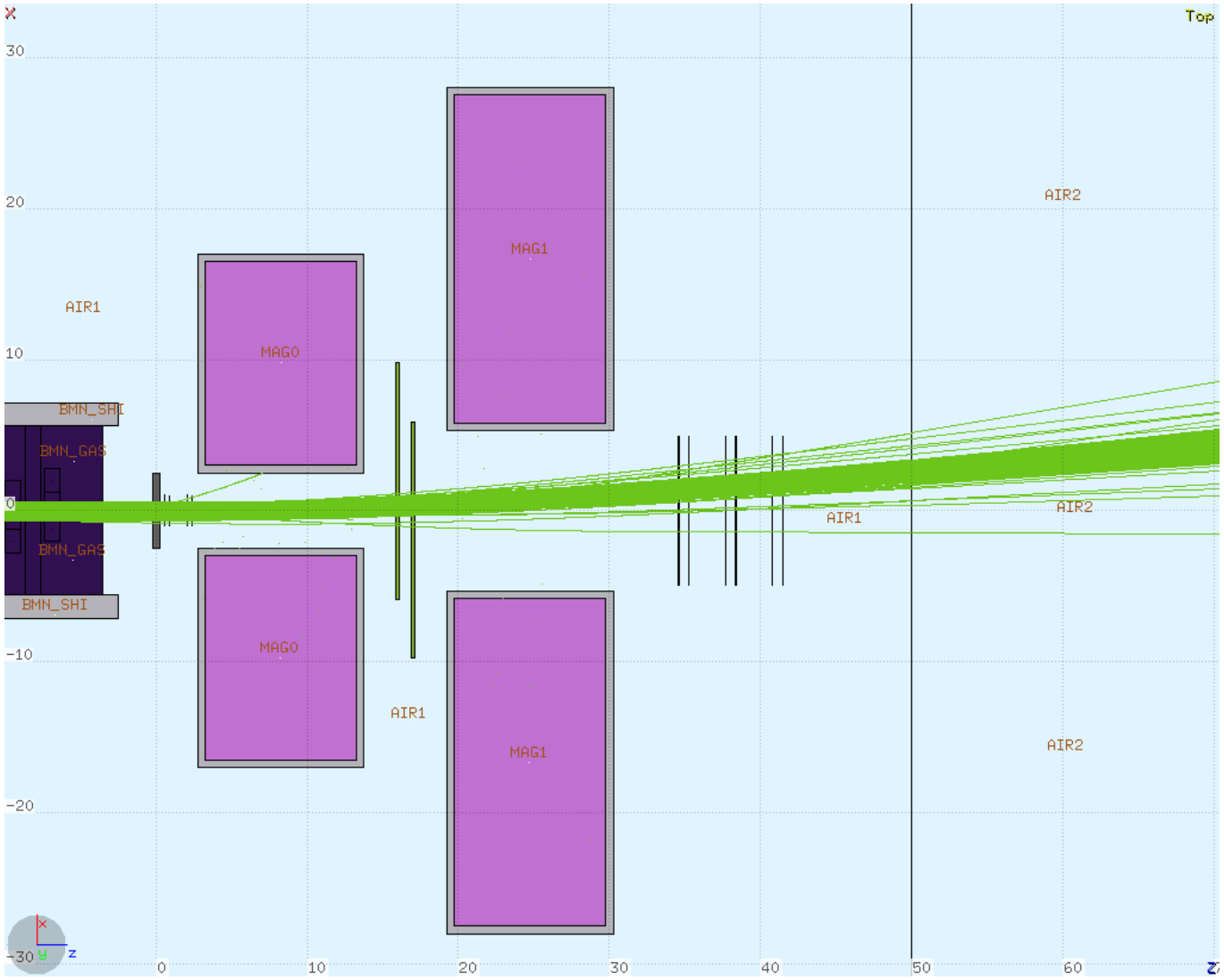


Notice that the width of the distribution is now narrower and symmetric:

This means that, maybe, momentum resolution in mag. field could be better with respect to all evaluations obtained so far (since ~2018):

TO BE RECHECKED WITH THE NEW SIMULATION

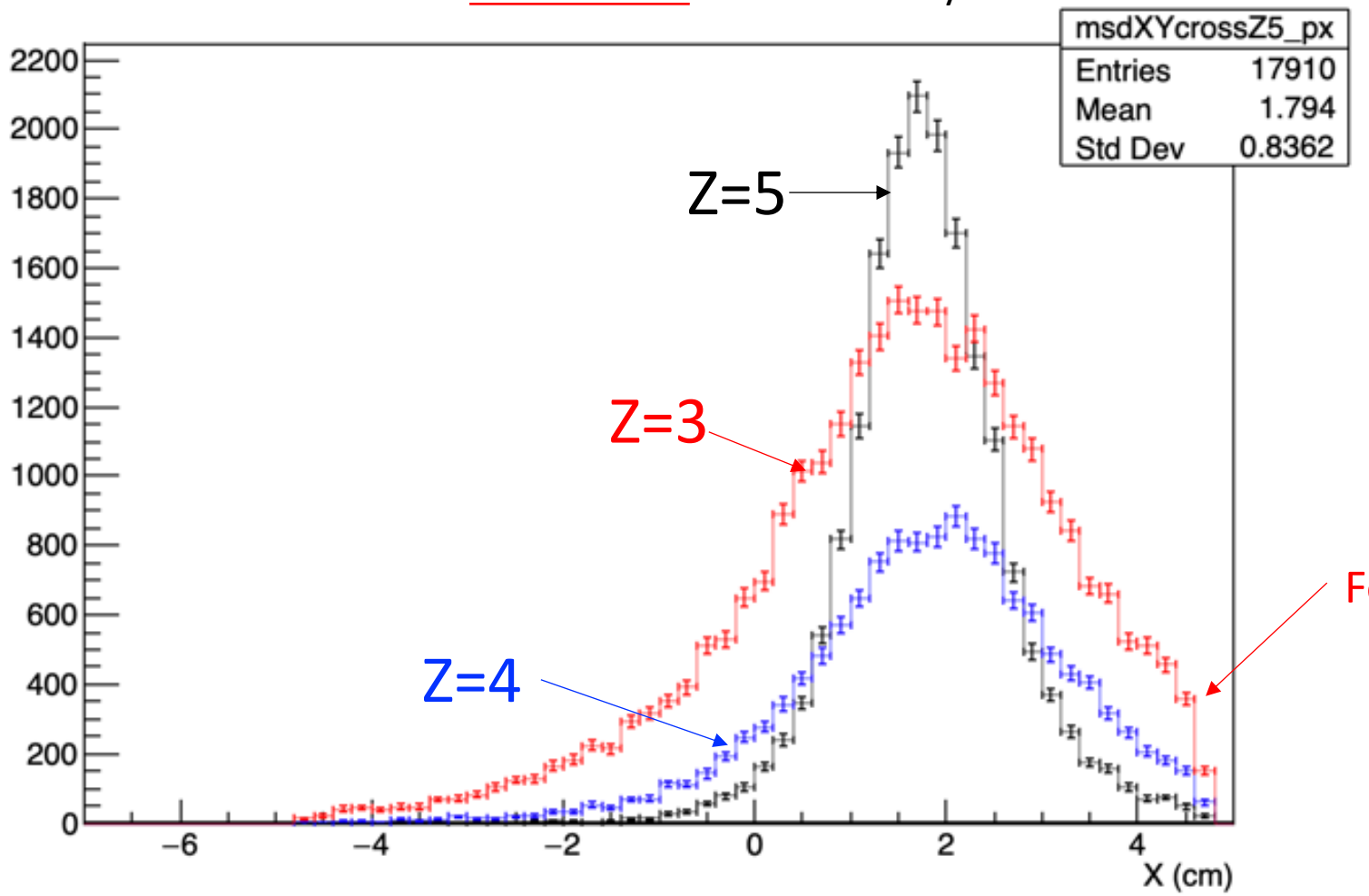
The issue of MSD positioning



Which tracks arriving to TW are we going to miss in the MSD, if they cannot be moved in the transverse direction?

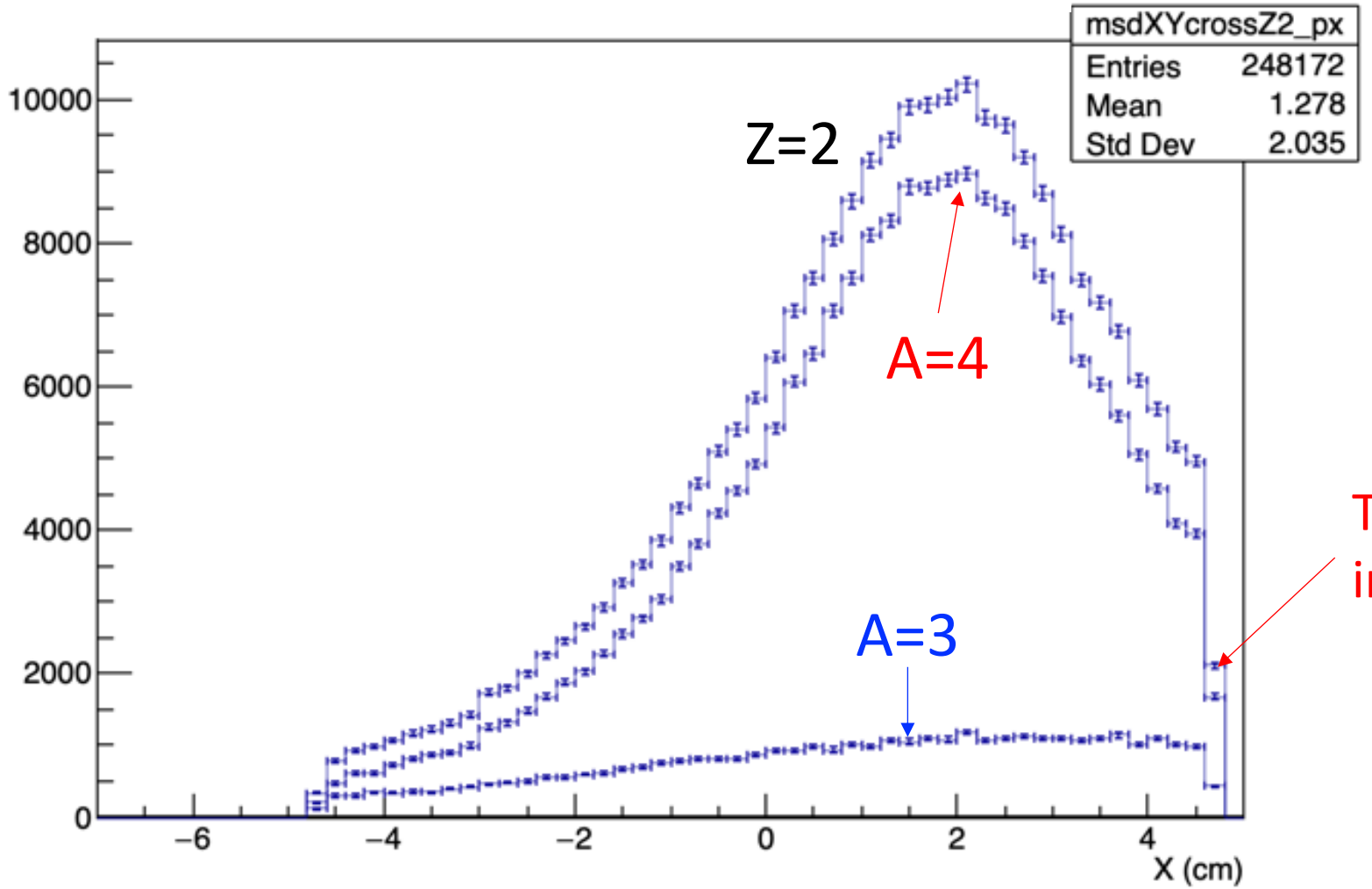
(Here light ions are not shown)

X coordinate of secondaries on last MSD layer



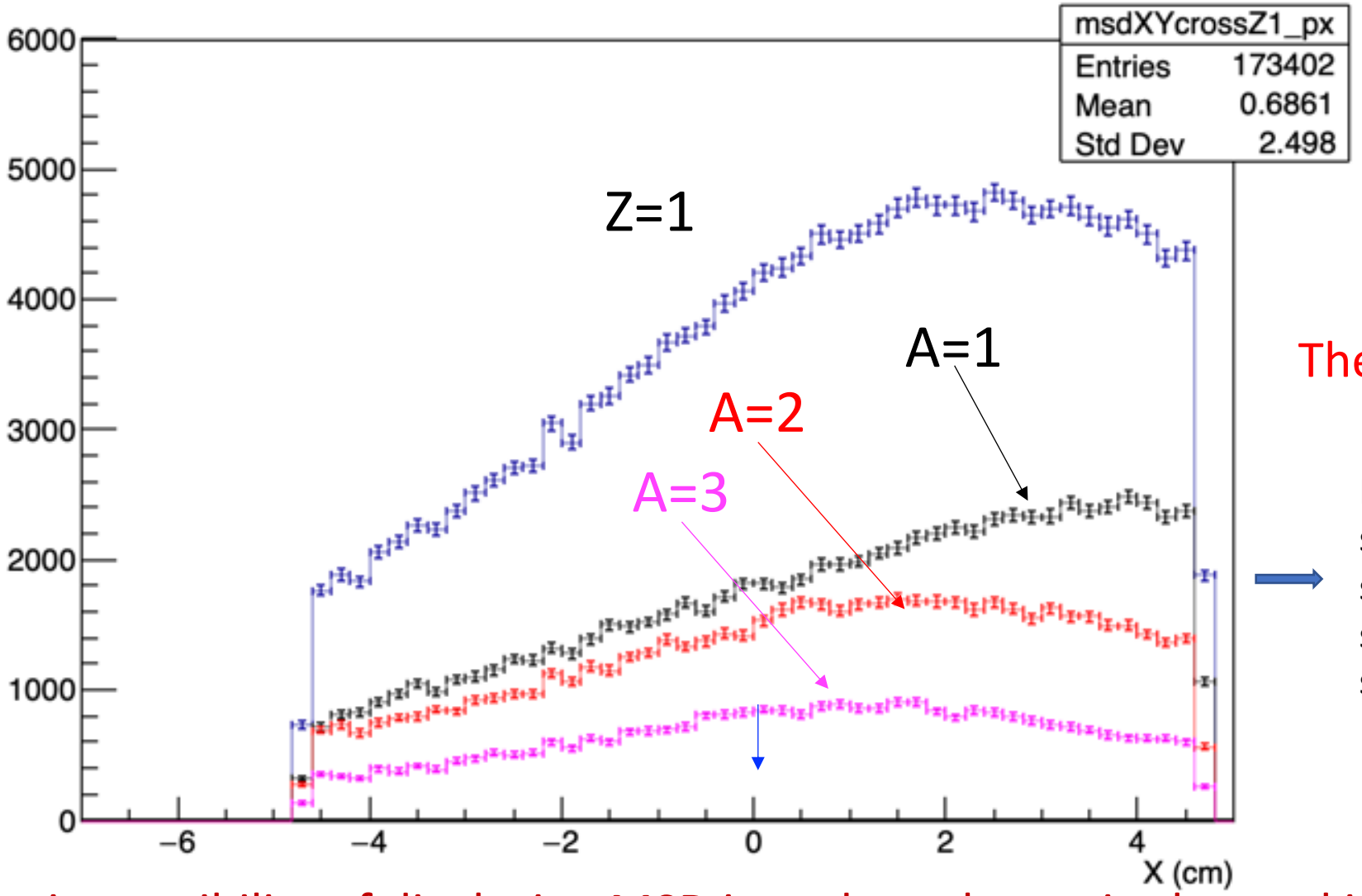
For Z=3 a cut starts to be non negligible

X coordinate of secondaries on last MSD layer



The cut for Z=2 is very important

X coordinate of secondaries on last MSD layer



The cut for Z=1 is ~50%

For Z=1 the Z/A ratio changes significantly and therefore the spectrography properties of our system become evident in the separation of p,d,t

The impossibility of displacing MSD introduces losses in the tracking capability of Z=1,2 (and in small part for Z-3): this has to be considered in particular in the case of ^{4}He primaries!

New Simulation Production

Now available in tier1 in /storage/gpfs_data/foot/shared/SimulatedData/12C_200_2023v2

12C_C_200new_1_shoereg.root 5 10^6 events (untriggered)
12C_C_200new_2_shoereg.root 5 10^6 events (“)

For SHOE processing: -exp 12_200_2023v2 **-run 1**

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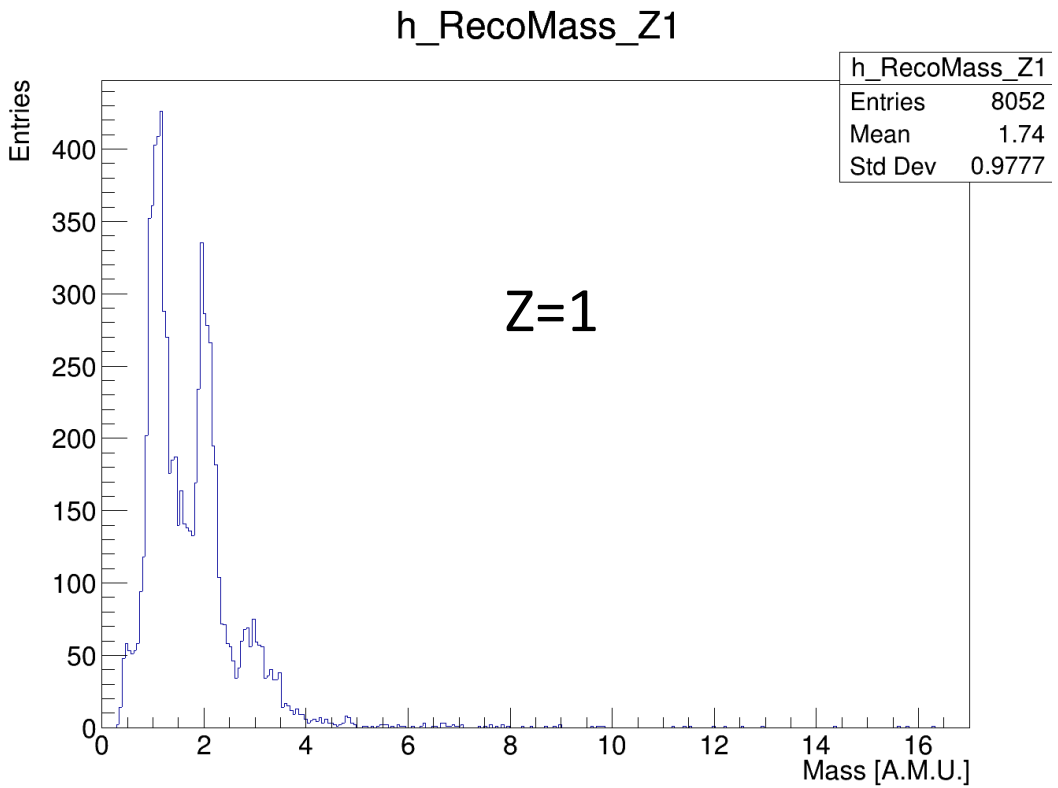
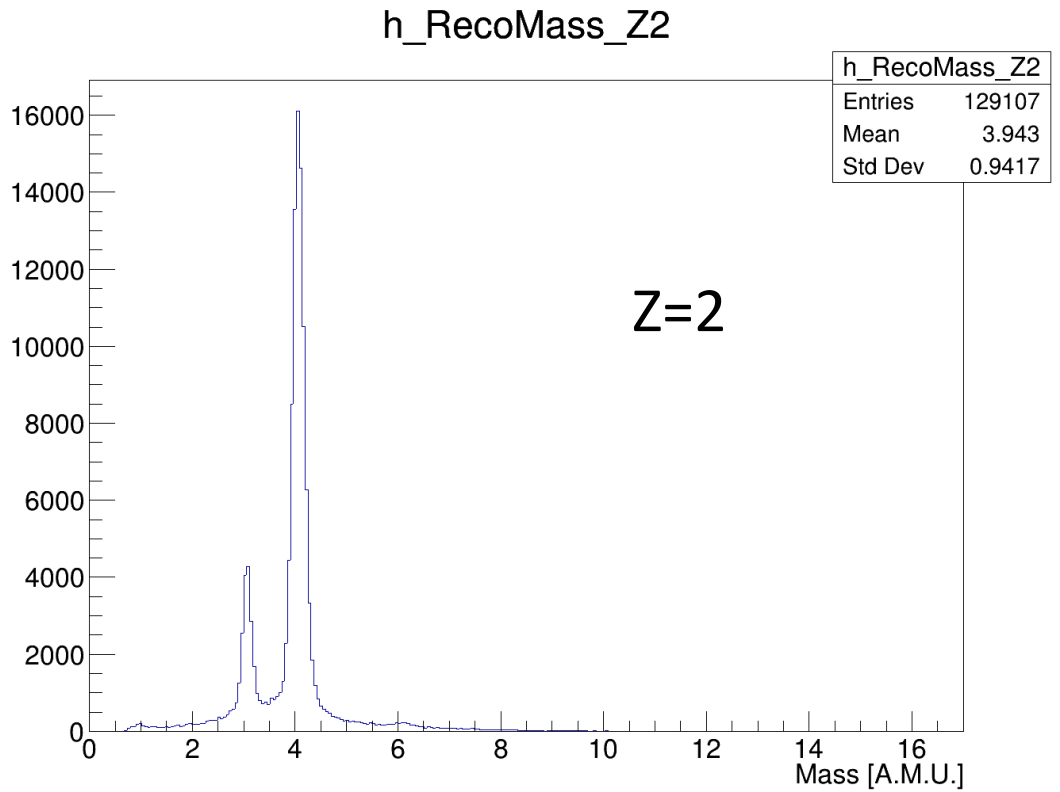
To be done by experts

- The proper TW calibration files for this configuration and distances have to be produced: Z_id cannot work properly at present *(they are just those inherited from old 12C_200 campaigns where the target-TW distance was 100 cm)*

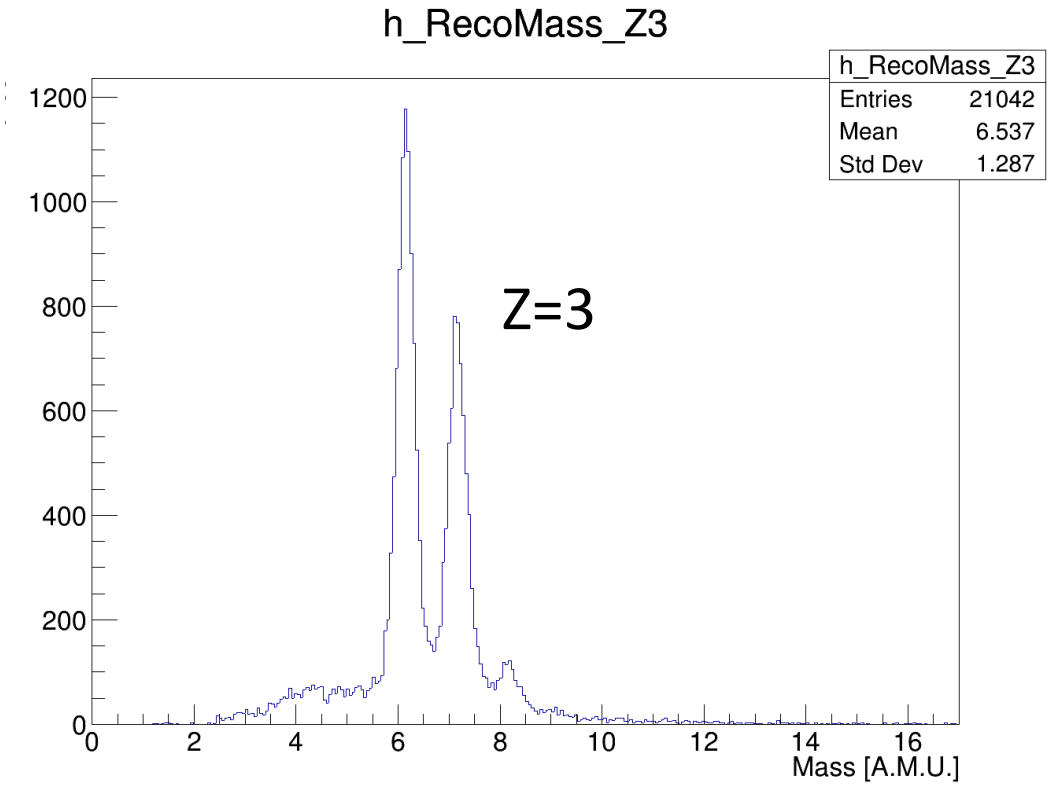
A test of new production by R. Zarrella: mass resolution using ToF and p -1

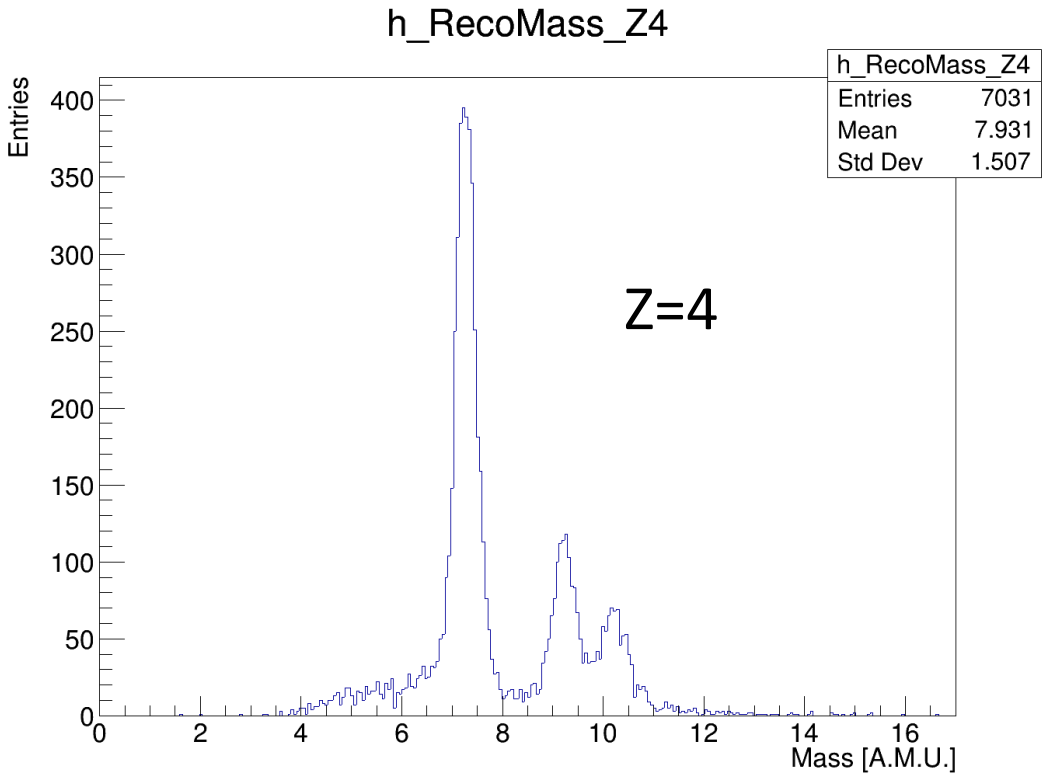




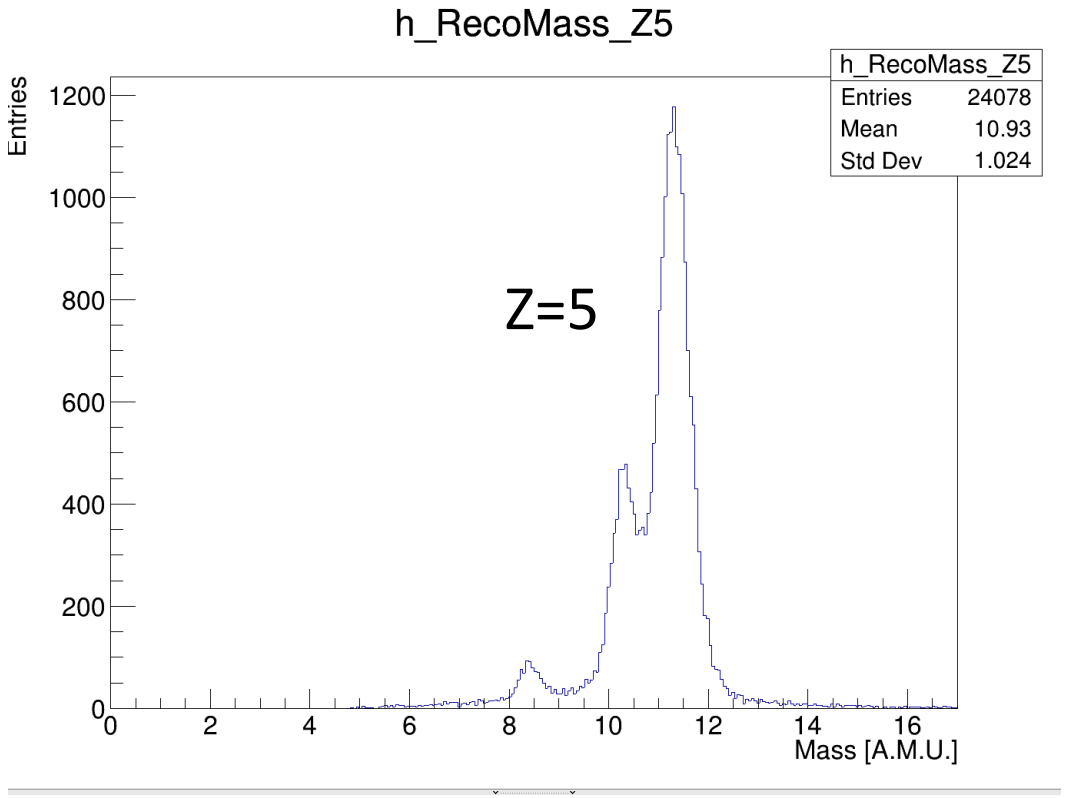
Remember that P *Z_{MC}/Z_{fit} had to be used since Z_id is not yet working

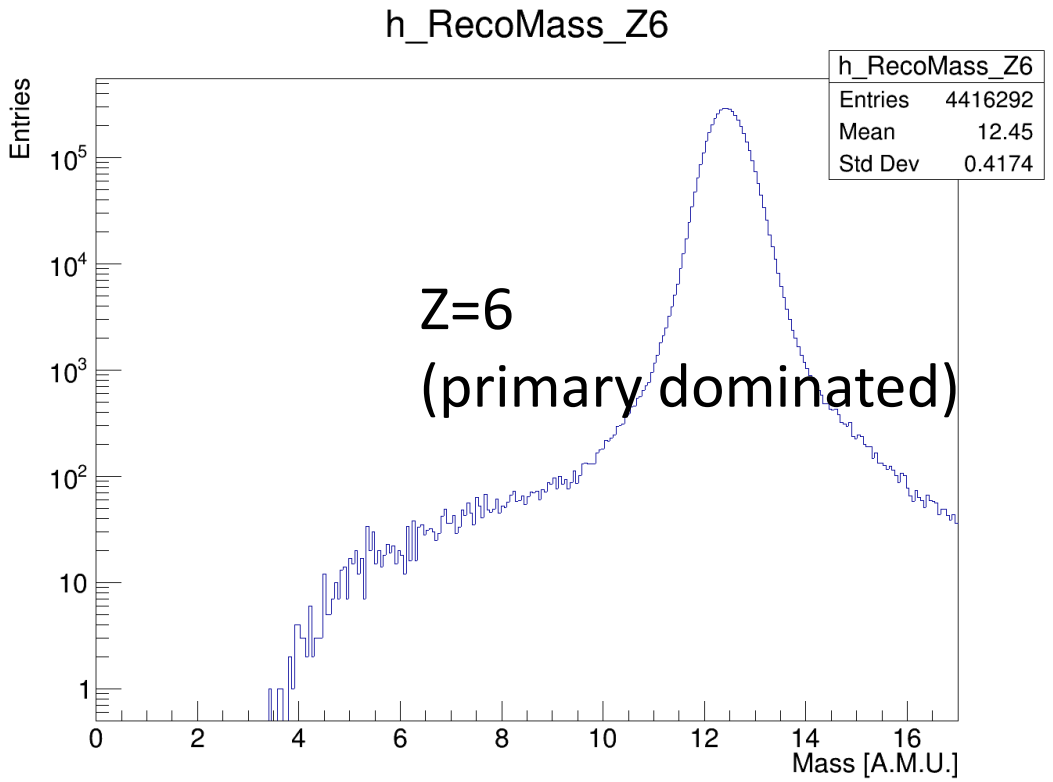
A test of new production by R. Zarrella: mass resolution using using ToF and p -2





A test of new production by R. Zarrella: mass resolution using using ToF and p -2





Conclusions

- The new setup with the desired direction of magnetic field is ready
- This is included the new campaign **12C_200_2023v2**
- A long standing, but so far undetected, issue concerning simulation in magnetic field was found and solved *(sorry, none of us had a real experience with simulation in non uniform magnetic fields)*
- A new production has been prepared (10^7 primary events): FOOTers are strongly invited to use it as soon as possible
- The evaluation of momentum resolution should be redone from scratch: it could be better than previously thought
- The calibration files for Z_id have to be produced
- The question of optimal detector displacement to follow the average curvature should be discussed in more detail, in particular for MSD, where significant losses can be expected for Z=1,2