Aladin magnetic field in the FIRST simulation and reconstruction

A.Kummali, V.Monaco
Torino INFN and University

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1) Fluka tracking
2) Geometry and field map
3) Sensitivity on magnetic field uncertainties
4) Tuning of the field scale

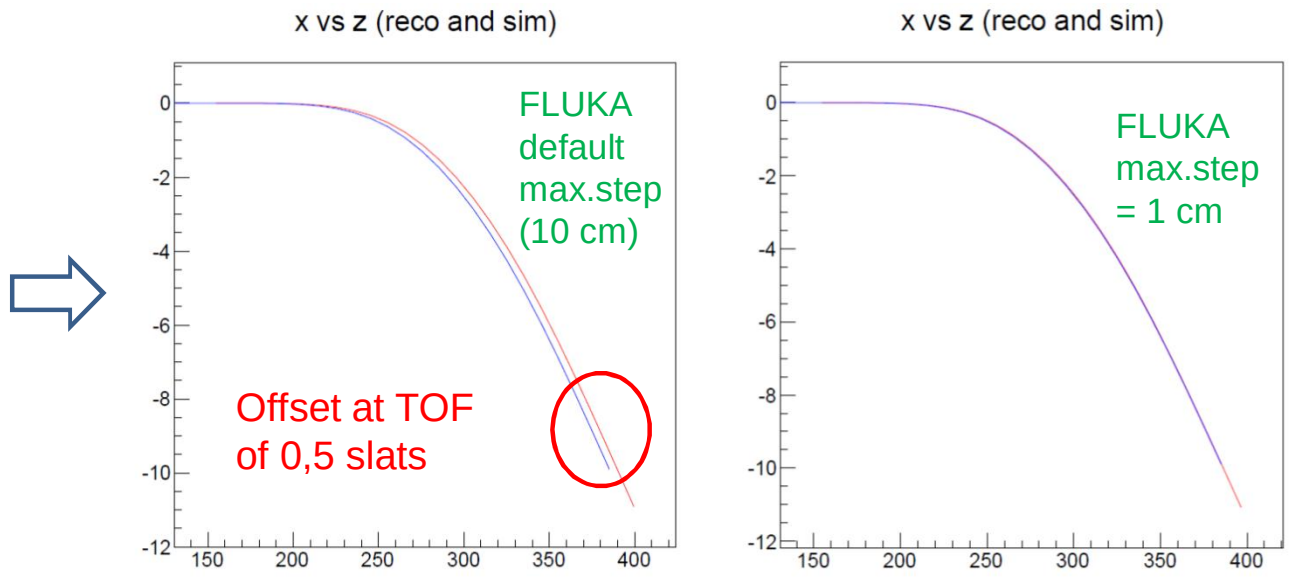
Fluka tracking in the magnetic field

Offsets observed between simulated and reconstructed variables (momentum, mass, k.e., ...) for high charges.

Several possibilities investigated by us, Marco Toppi and others (i.e. TOF geometry and its compatibility with track coordinates at generator level, magnetic field maps in simulation and reconstruction, ...).

The problem was related to a different tracking for a given particle between Fluka and the RungeKutta algorithm implemented in the reconstruction code (fixed by changing the maximum step size in the Fluka tracking, the default was too large to take into account the field inhomogeneitis)

Trajectories of a 400 MeV/u C in the reconstruction (red) and in Fluka (blue)



Mass offsets before and after the fix

Mass MC (simulated-reconstructed) ï fragmentation events

Charge	Sigma [u]	Offset [u]
1	0,0896 ± 0,0009	-0,0155 ± 0,0013
2	0,212 ± 0,002	-0,0545 ± 0,0021
3	0,353 ± 0,009	-0,102 ± 0,010
4	0,415 ± 0,011	-0,143 ± 0,014
5	0,584 ± 0,012	-0,210 ± 0,016
6	0,552 ± 0,018	-0,213 ± 0,032

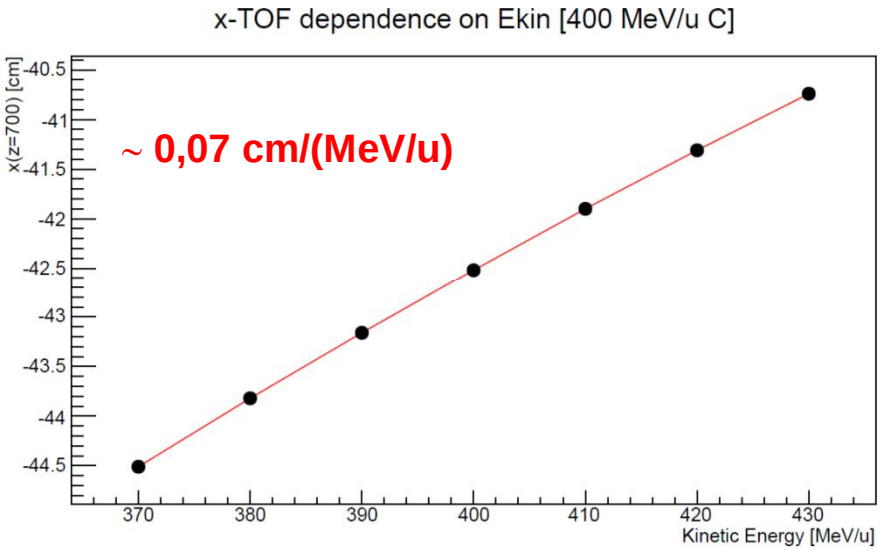
Before the fix

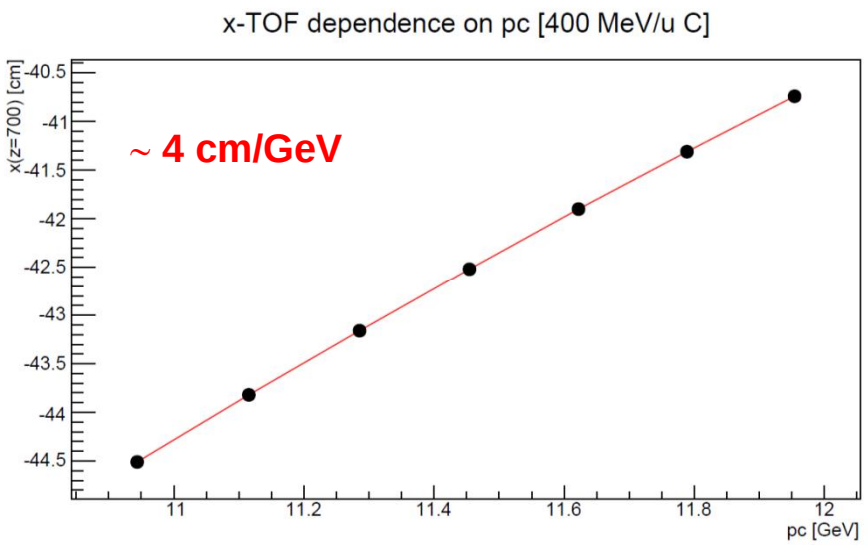
Charge	Sigma [u]	Offset [u]
1	0,072 ± 0,001	-0,005 ± 0,001
2	0,197 ± 0,002	-0,016 ± 0,002
3	0,317 ± 0,009	-0,049 ± 0,012
4	0,396 ± 0,019	-0,023 ± 0,020
5	0,570 ± 0,018	-0,071 ± 0,020
6	0,498 ± 0,032	-0,043 ± 0,030

After the fix

Dependence of the position at the TOF on the KE/ momentum

X-position of simulated tracks at z = 700 cm (no target and no material along the path used in the simulation)
It's an indication of systematic/statistical effects related to uncertainties on the TOF position.

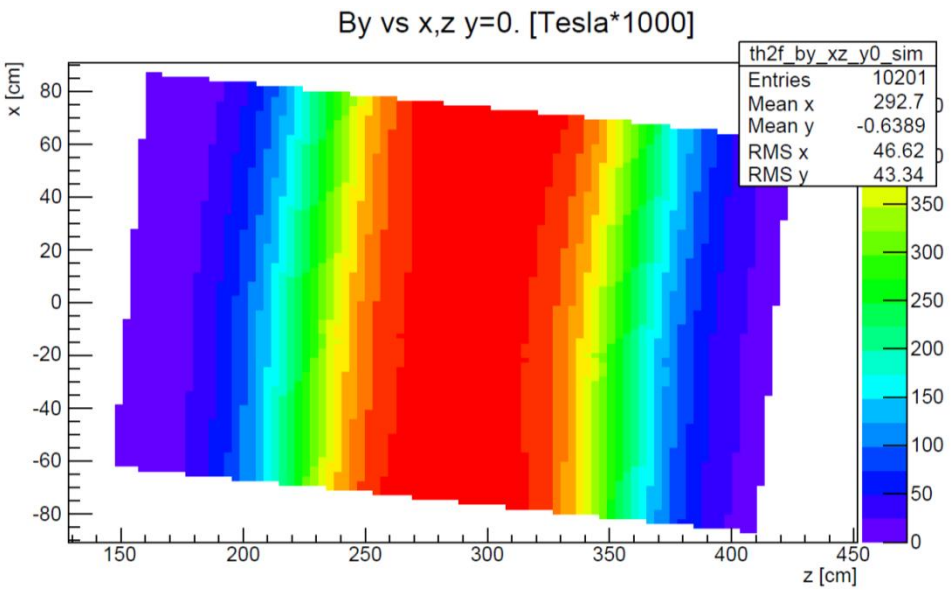


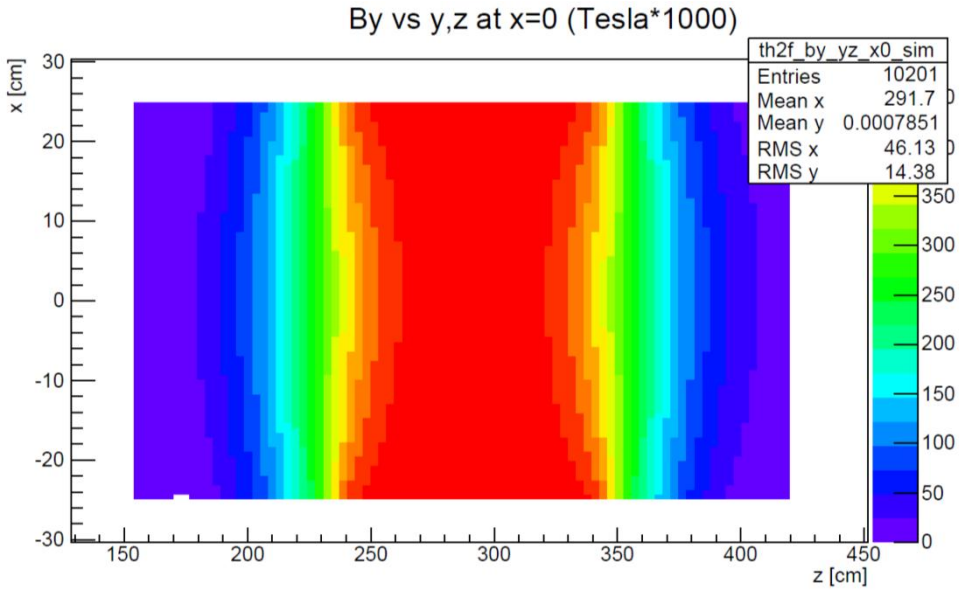


An uncertainty of 1 cm in the TOF position corresponds to a systematic error of ~ 4% in the kinetic energy and of ~ 2 % in the total momentum for 400 MeV/u ^{12}C.

Weaker dependences for low charges with the FIRST kinematics (more bended, less dependence on the TOF position)

Magnetic field map





- Geometry and map inherited by the Spaladin experiment.
- A 3D map (collected at a current of 2500 A) is scaled to the current used in the experiment (see later for estimation of the correction factor).
- Other maps collected at lower currents available but not used in the FIRST software.

Magnetic field geometry

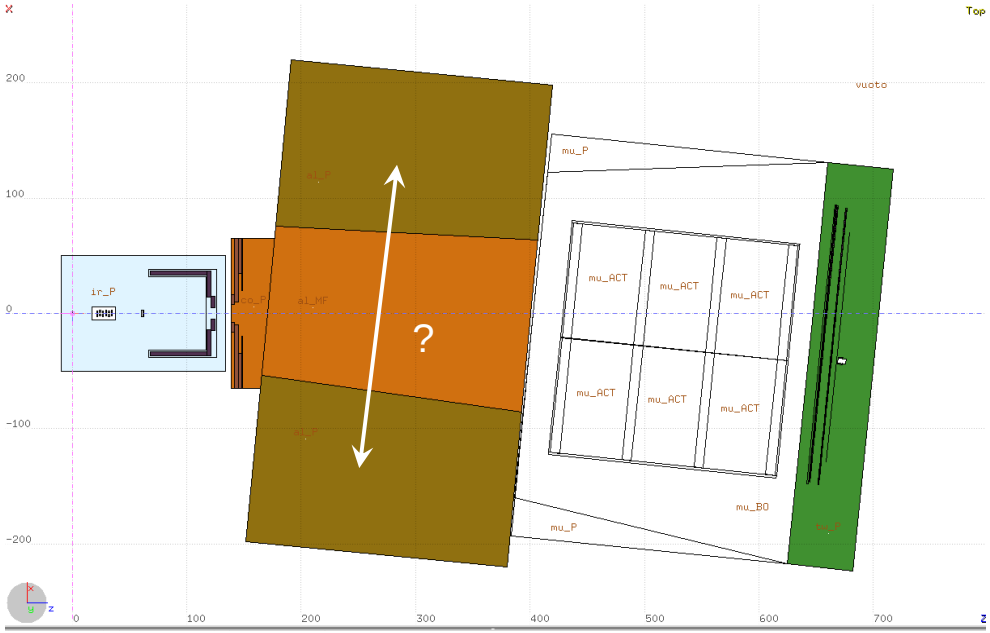
ÅThe external geometry of Aladin with respect to the rest of the experiment is obtained by survey measurements (defining the external limits in the x-z plane).

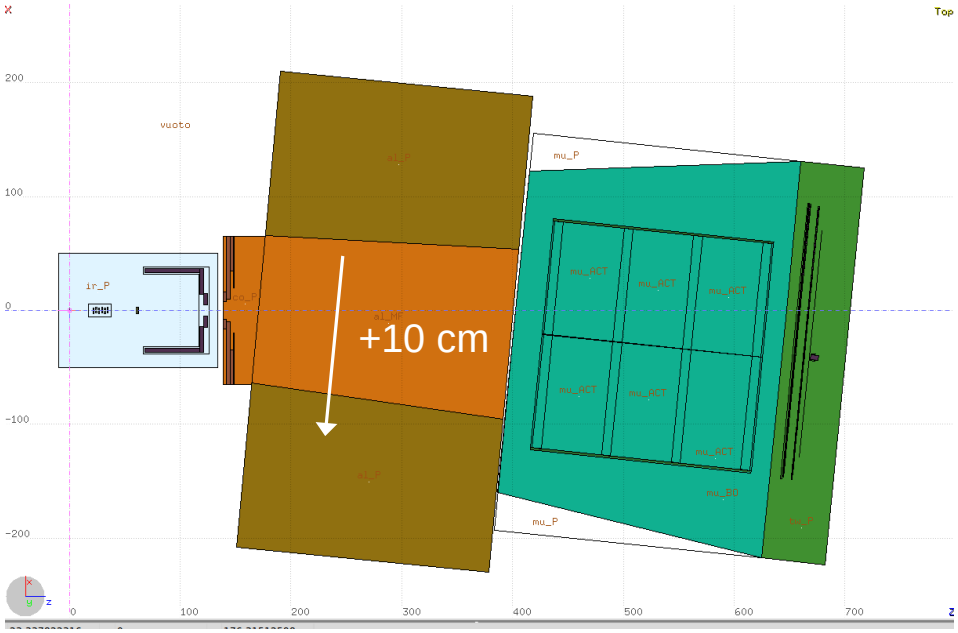
ÅIn FIRST we need the magnetic field inside the trapezoid vacuum chamber. The exact position and dimensions of the vacuum chamber are not know to me.

ÅGeometrical scale factors are applied to the magnetic map to fit the dimensions of the vacuum chamber found in the Spaladin software (can these dimensions be checked ?)

To evaluate the systematics associated to each of these uncertainties, changes in the impact point of a 400 MeV/u on the TOF wall (worse scenario) are studied in the simulation.

Internal position of the vacuum chamber



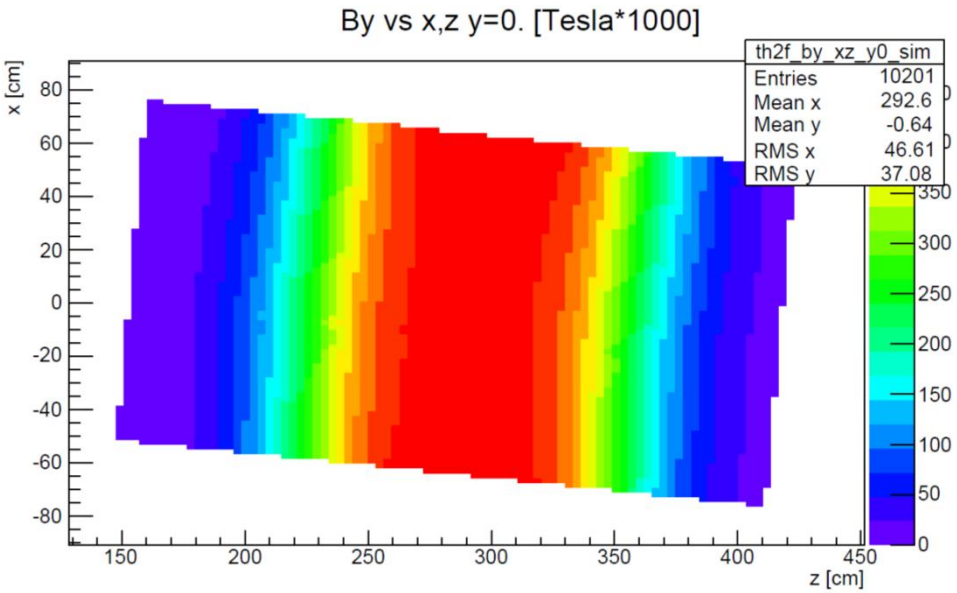


Effect of moving the magnetic field region of **10 cm** along the xôaxis:

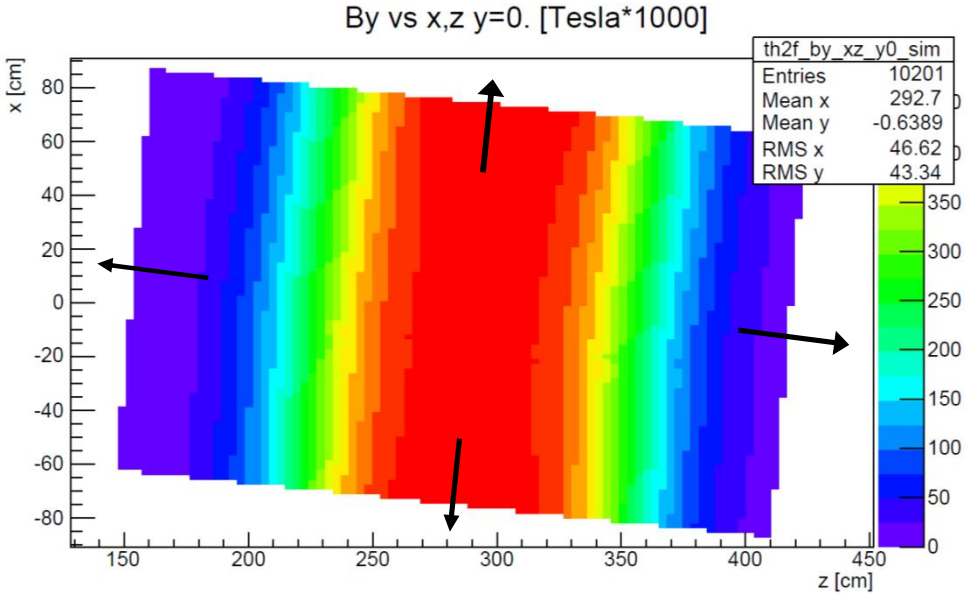
The xôcoordinate at z=700 changes of **Δx_{TOF} = -0,08 cm** (corresponding to **$\Delta(pc) \sim$ 20 MeV**)

NEGLIGIBLE with respect to the uncertainties related to the absolute TOF position !

Geometrical scale factors applied to the map



Original field map.



Enlarged field used in the FIRST simulation and reconstruction code.

Effect on MC trajectory at z=700 cm **Δx(TOF) = +0,03 cm (NEGLIGIBLE)**

Systematic errors due to growing factors applied to the geometry of the magnetic field and to uncertainties in the position along x are very small.

Magnetic field scale

- The magnetic field map (measured at 2500 A) is scaled using a factor related to a user defined effective current.

- The effective current could be different from what has been measured during the experiment (500 A ?), because linear field vs current dependence is assumed.

- **The effective current is determined in the simulation by requiring that the slats hit with and without the magnetic field are the same in Data and Monte Carlo.**

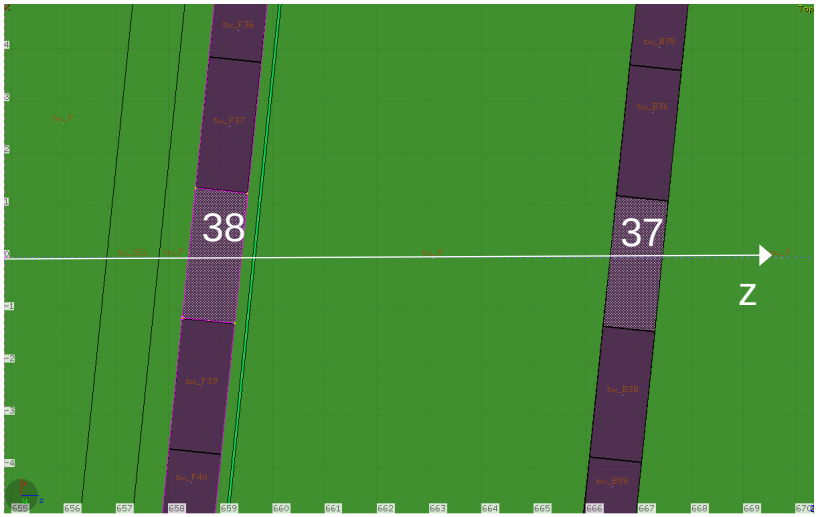
- Same scale factor, geometry and map used in the simulation and in the reconstruction code for both data and MC. Run 310 used for collision data.

- The recent change in the target density (from 2,2 to 4,5 g/cm^3) have an impact on the particle trajectory in the simulation (impact point on the TOF changes of ~ 0,5 slats) **A new tuning of the magnetic field scale factor has been performed using high-density target in the simulation.**

- Any comment or suggestions of alternative methods to determine the field scale are appreciated.

Runs without magnetic field

The reconstruction algorithm assumes the beam direction along the z axis (centered at x=y=0).
The correspondance of this hypotesis with the implemented geometry has to be checked by comparing the TOF slats in events collected or simulated without the magnetic field.



In the geometry implemented in the FIRST software the z-axis crosses the centers of slats

38 (TOF front plane)
137 (TOF rear plane)

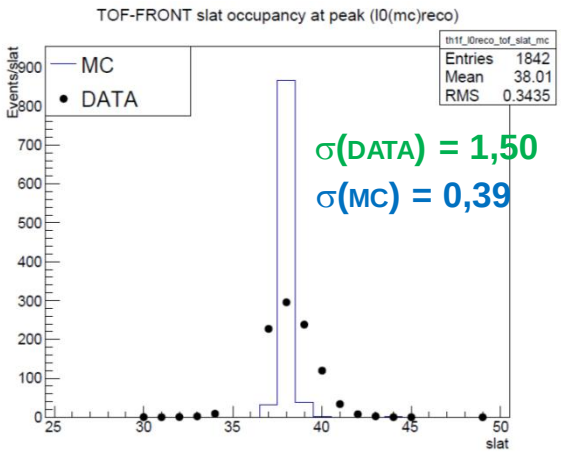
TOF slat positions from data without magnetic field (collected only with target) are compared with Monte Carlo simulation (without target and with target with density 2,2 and 4,5 g/cm3).

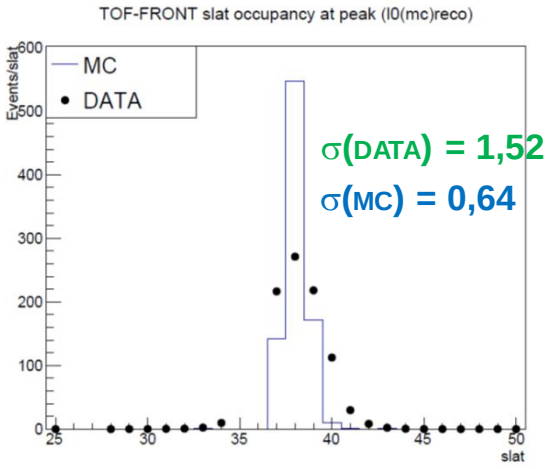
MC NO TARGET

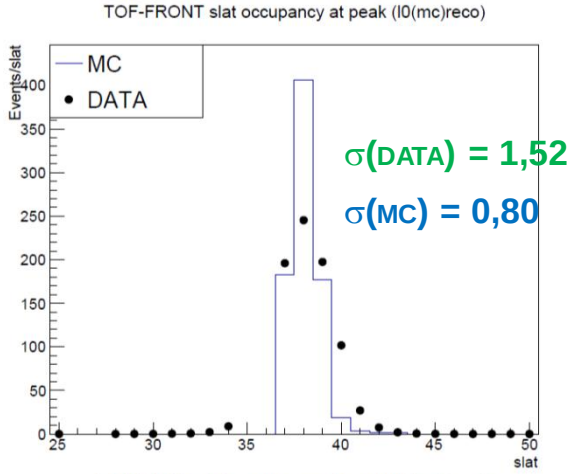
MC TARGET (d_{tgt} = 2,2 g/cm^3)

MC TARGET (d_{tgt} = 4,5 g/cm^3)

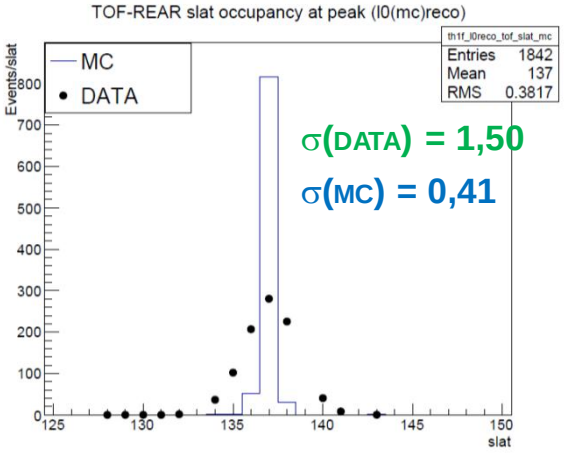
TOF FRONT

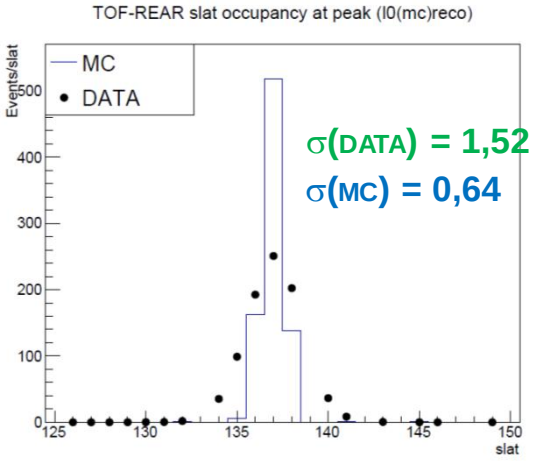


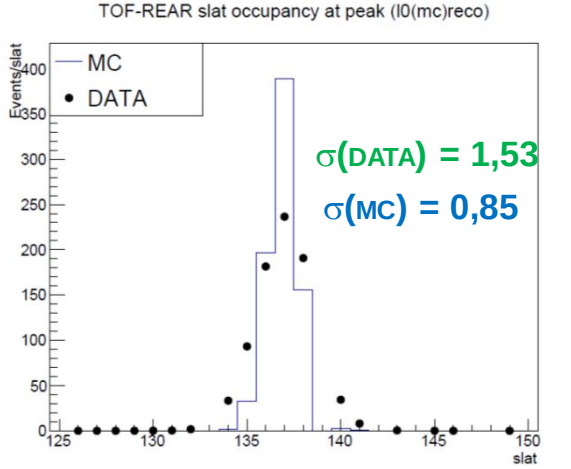




TOF REAR





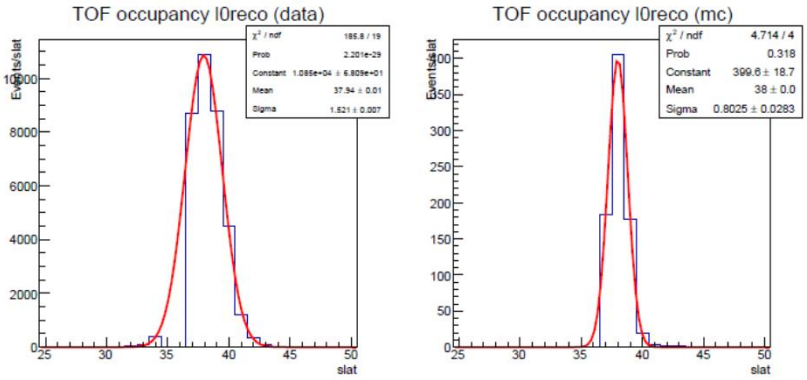


Even with a high density target the TOF slat distributions is broader in data than in the simulation

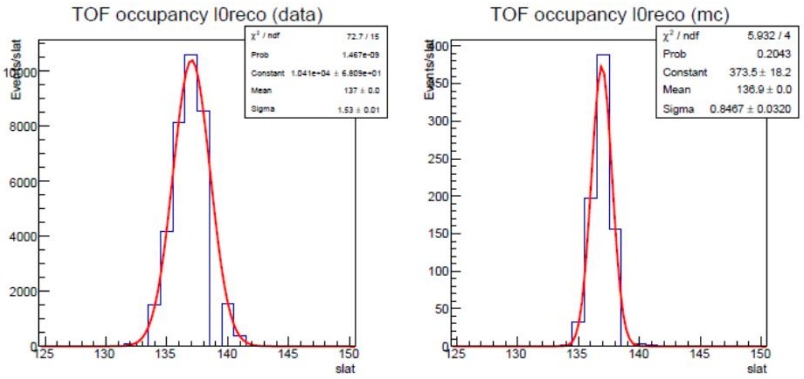
Peak positions without magnetic field

DATA **MC (d(tgt)=4,5 g/cm^3)**

FRONT



REAR



The fit results coulb be affected by some missing slats (masked also in the MC).

	Mean slat FRONT	Mean slat REAR
DATA	**37,96**	**137,05**
MC-no target	**38,01**	**137,00**
MC-target (d=2,2)	**38,04**	**137,00**
MC-target (d=4,5)	**38,00**	**136,90**

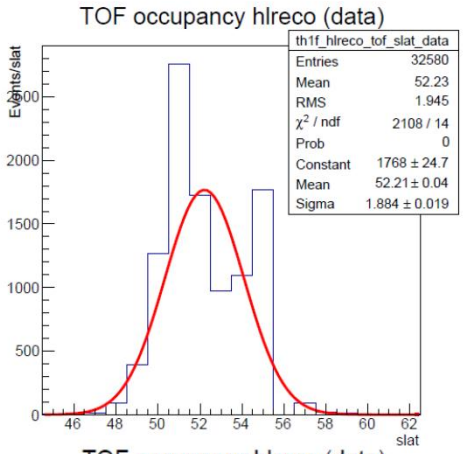
A non deflected beam hits the same slats in data and simulation.

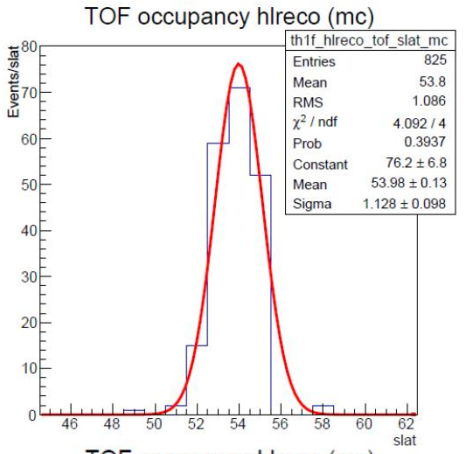
The beam is along the z axis according to our geometry (lucky coincidence ?).

Peak position with magnetic field (target)

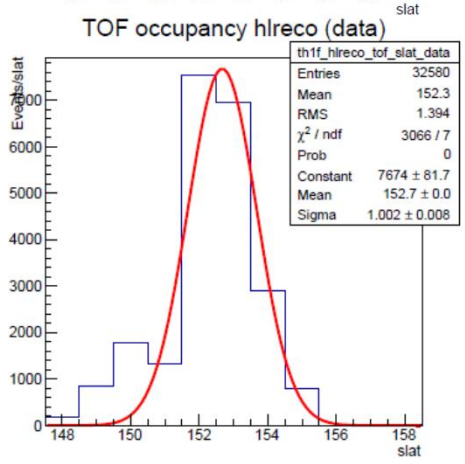
DATA **MC (d(tgt)=4,5 g/cm^3, 710 A)**

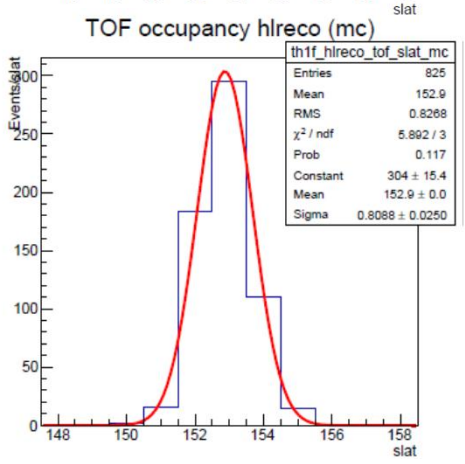
FRONT





REAR



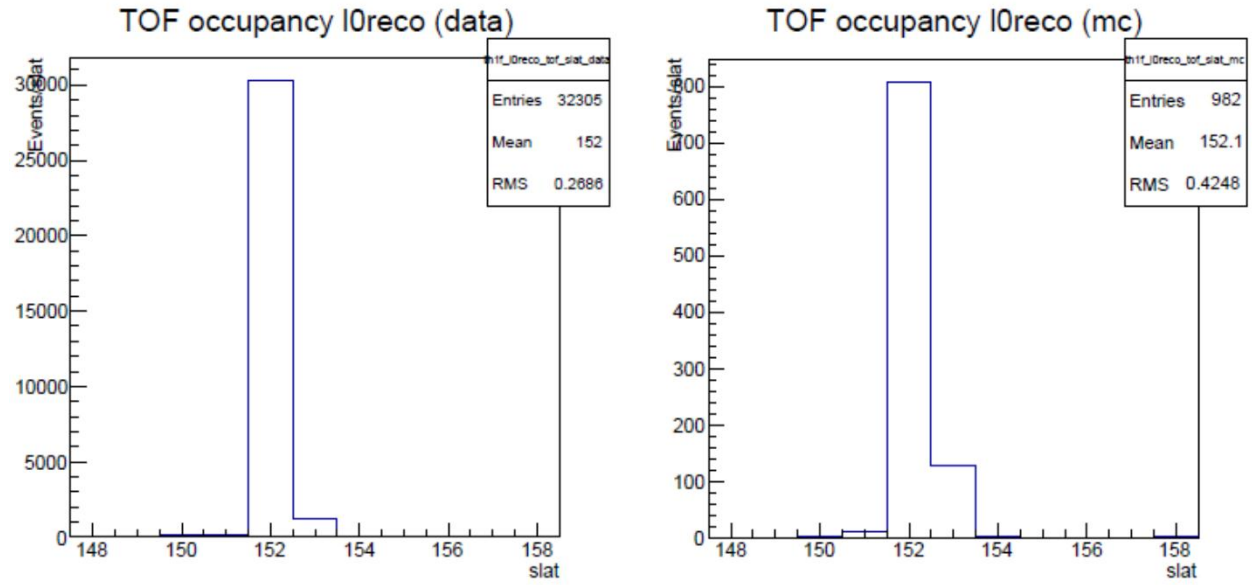


- Distributions could be distorted in the front plane (trajectories distributed around the central hole). Less reliable than the rear slats to determine the peak positions.
- Some little differences between the distributions from l0reco and from tracks selected in hlreco for DATA.
- The fits have been repeated by varying the magnetic field in the simulation (not in the reconstruction)

Peak position with magnetic field (no target)

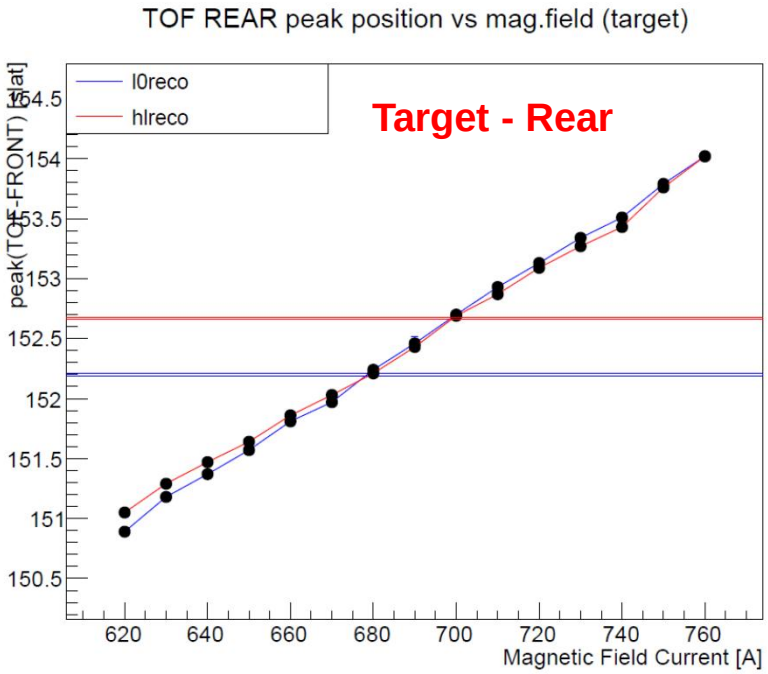
DATA **MC (d(tgt)=4,5 g/cm^3, 710 A)**

REAR

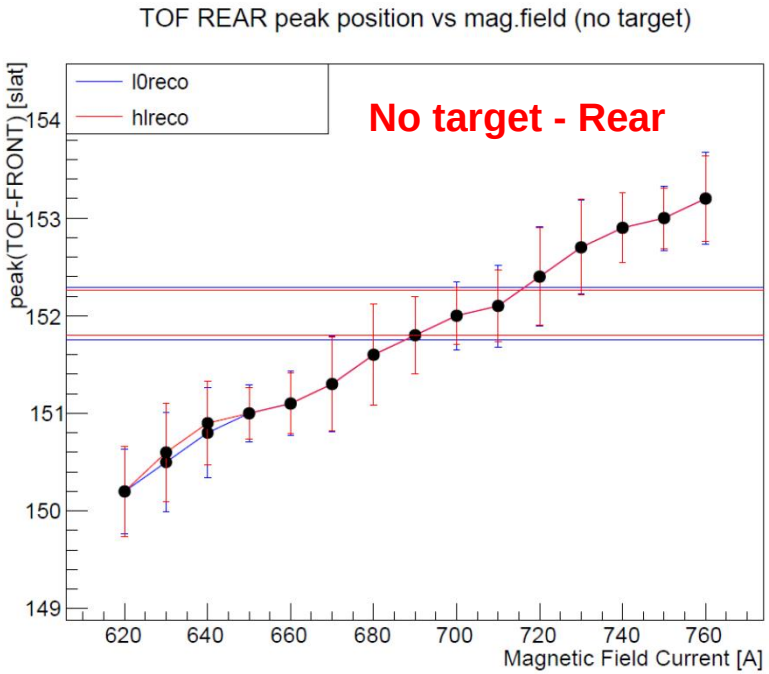


In runs without target very low statistics from Monte Carlo in the front plane
(almost all the carbons go through the hole).
Not enough slats to perform fits (mean and RMS taken as peak position and error for each current).

Tuning of the magnetic field scale



Effective beam current with target
680 A (l0reco) and **700 A** (hlreco).
If the front slats are considered: ~ 660 A.



Effective beam current without target
between **690 A** and **720 A**.
If the front slats are considered: ~ 670 A.

Conclusions

The best value of the effective field current from studies of peak positions in the TOF Rear slats with the high density target in the MC is **between 680 A and 720 A.**

The peak positions in the TOF Front slats are less reliable due to distorsion and low statistics due to the central hole (prediction 660-680 A)

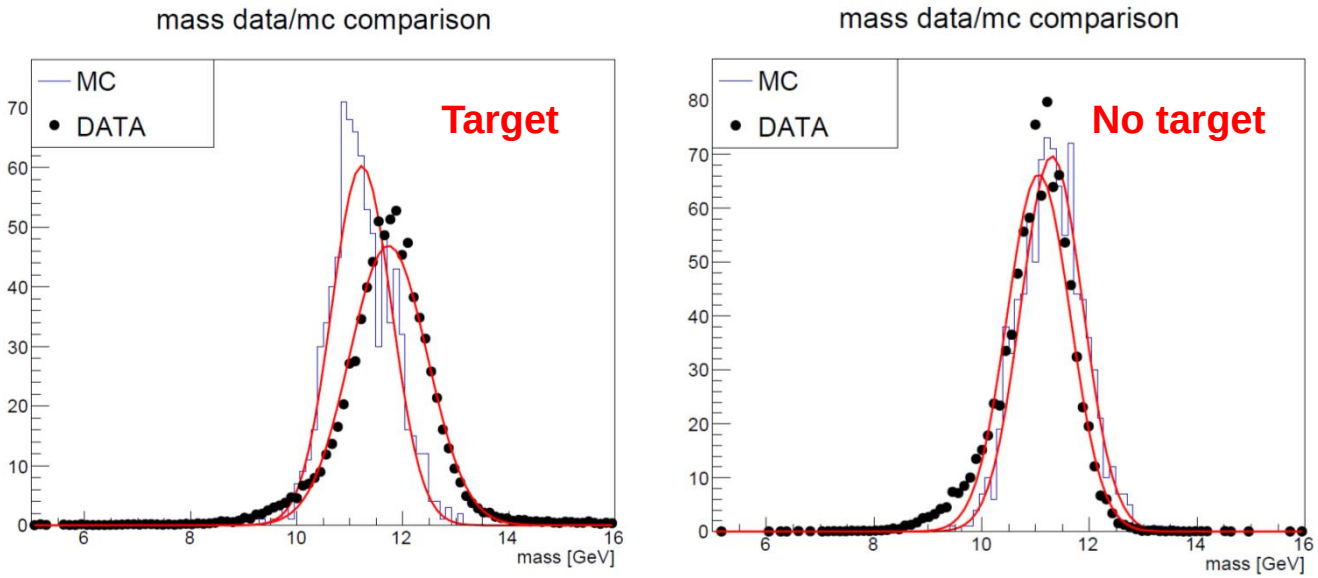
My estimation of the effective current is **(700 ± 20) A** (now we use 710 A).

The uncertainty of **± 20 A** corresponds to a variation in the TOF hit position from the tracking of **± 0,5 slats**.

This uncertainty corresponds to a estimated systematic error in the total momentum for 400 MeV/u carbon of about **± 300 MeV** (~ **2,5 %**).

Systematic error due to field shrinking and position in the direction orthogonal to the beam seem to be negligible.

Carbon mass: DATA/MC comparison (710 A, high density target in the simulation)



The offsets in the mass distributions between data and MC can be related to the TOF value (not only to the magnetic field scale).
Why a so large difference in the events with and without target ?