Simulation updates and studies TOF issues

A.Kummali, V.Monaco
(University and INFN, Torino)

FIRST analysis meeting, 6/2/2014

1) Changes in the simulation code and reconstruction

2) Minimum energy for TOF TDC hits reviewed

3) Attempt to improve the dependence of the VTX cluster size on the charge in the simulation

4) Studies of VTX/TOF matching probability in the global reconstruction.

5) TOF calibration/reconstruction issues in the central slats

Changes in the simulation code and MC reconstruction (mainly for TOF)

- Fits to determine energy thresholds for TOF TDCs hits repeated (no changes, checking if all the slats are included in the files currently used).

- TOF attenuation factors as determined by fits on data for each slat (by TO-Politecnico) applied in the simulation and in TATactNtuMC. Corresponding maximum detectable kinetic energy for protons calculated as a function of slat number and y (see next slides)

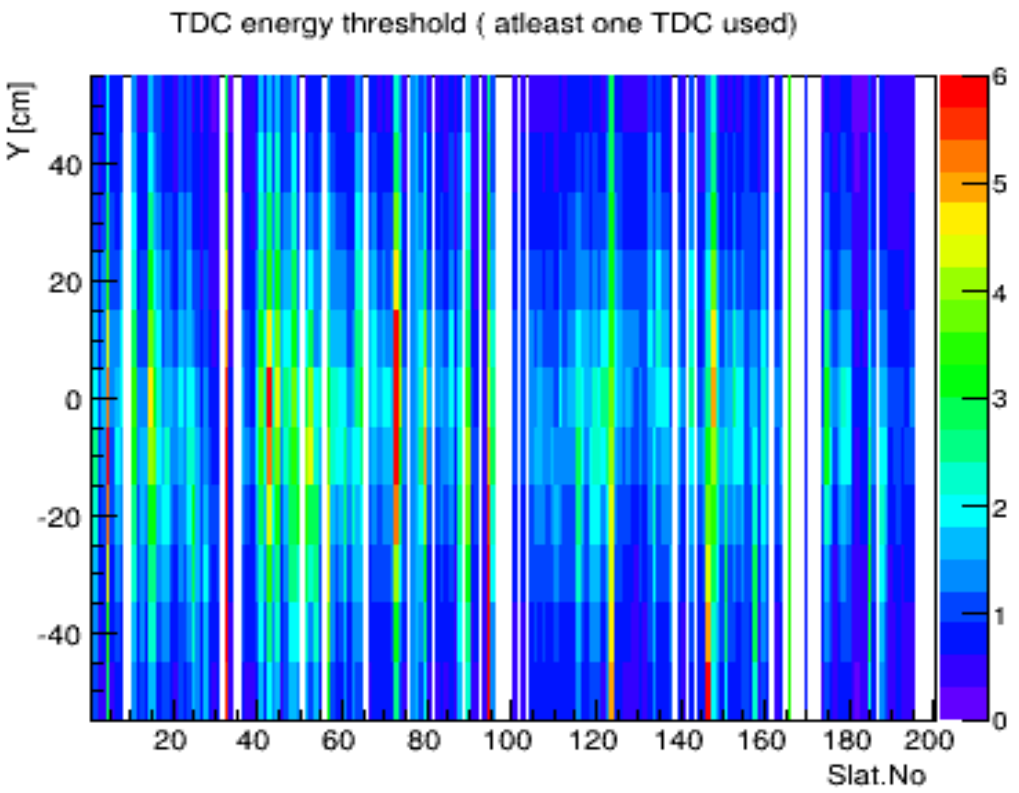
- Some bugs in TATactNtuMC fixed (same TDC energy thresholds were applied for both the TOF planes, error in the y coordinate when single ADC is used in TOF reconstruction).

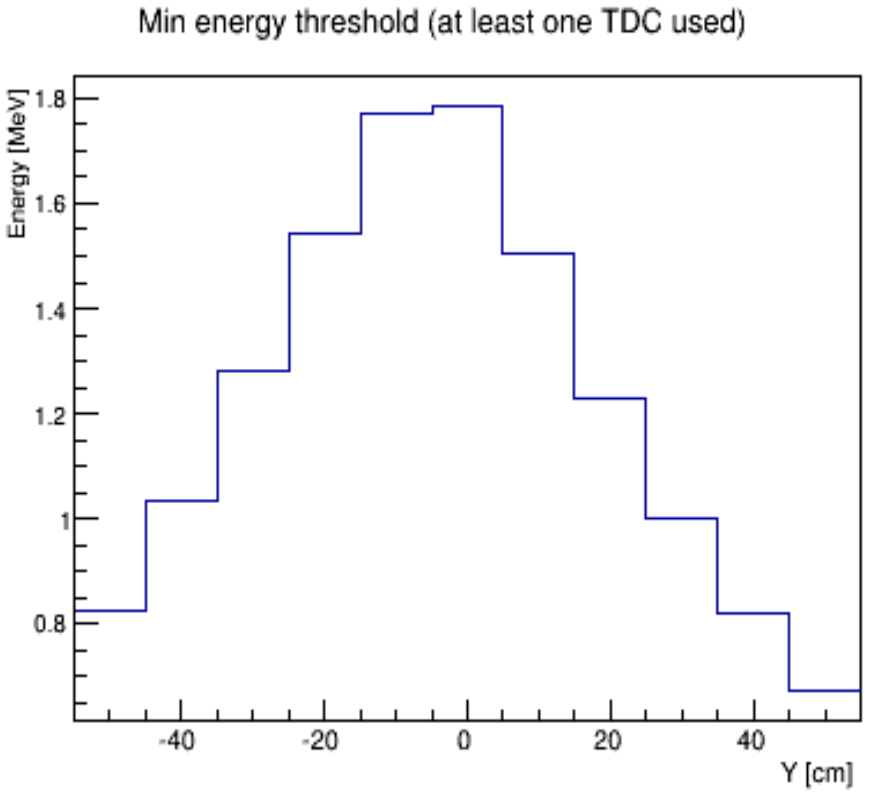
- TATactNtuMC: Correspondence of all the cuts with what is applied in the data (masks for dead ADCs. dead TDCs, etc...)

- Tuning of the VTX cluster size vs particle charge in the simulation (next slides)

Energy threshold for TDC hits

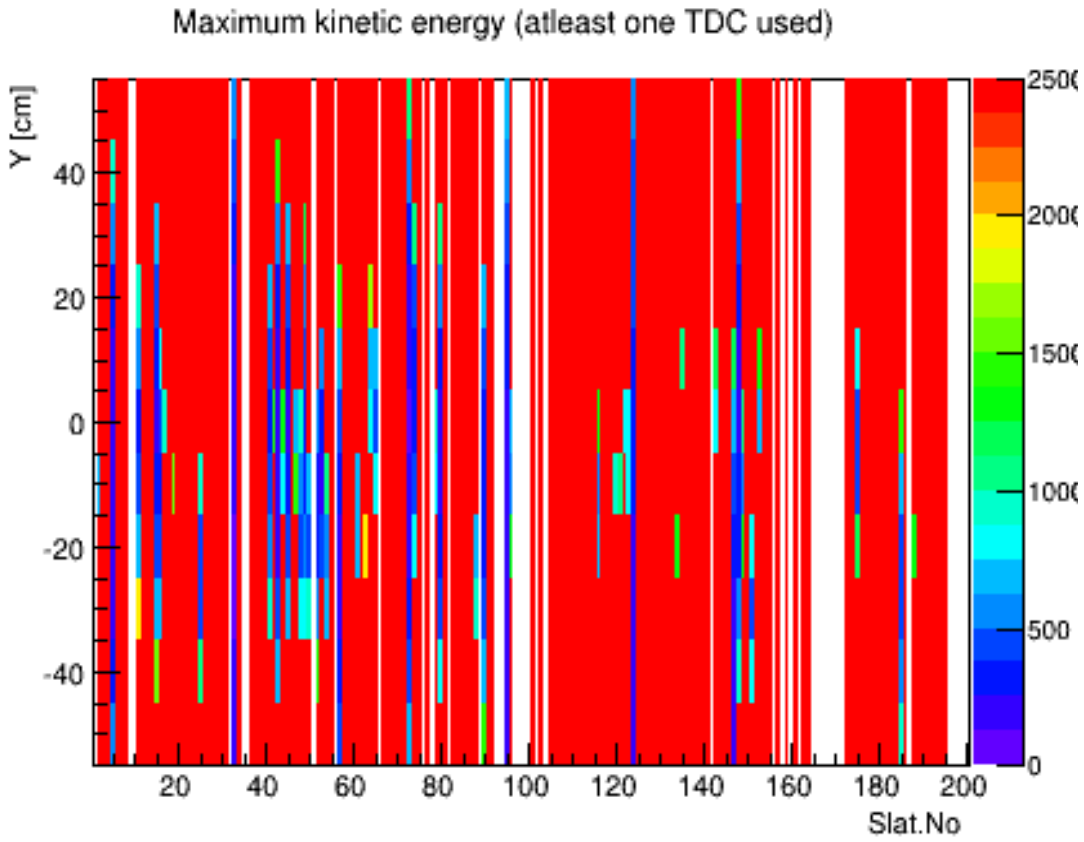
Minimum ADC counts for a TDC hit determined for each TOF top/bottom channel.
ADC count are translated to minimum energy in MeV as a function of slat number and y (taking into account pedestals, calibration factors, Birk corrections, attenuations, etc....) and applied in the simulation.

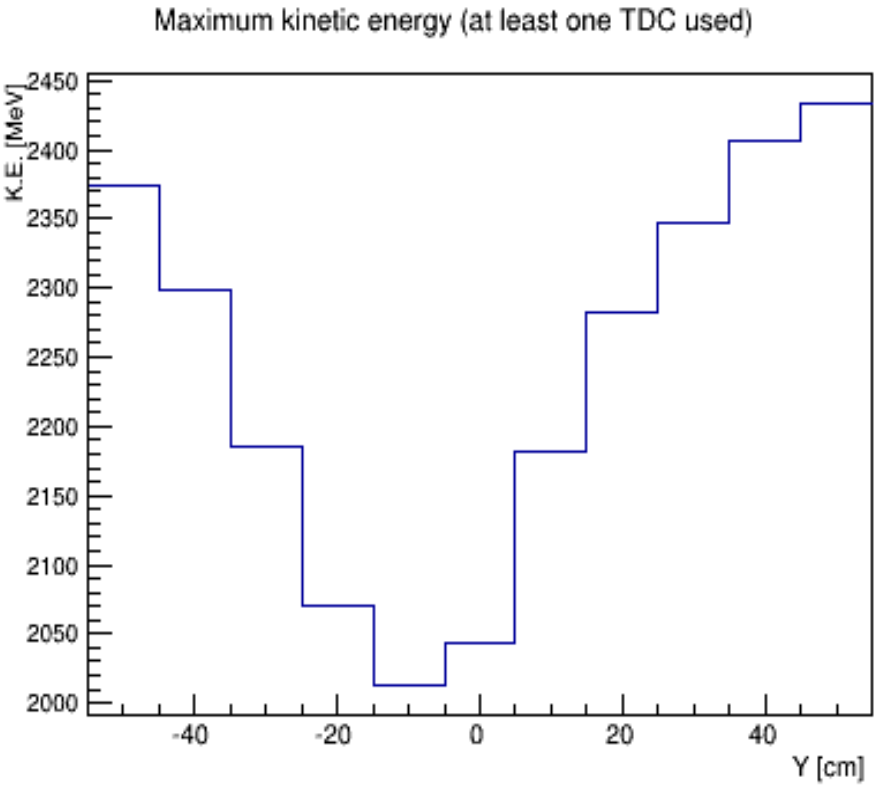




NEW ATTENUATION FACTORS USED !!!
EFFICIENCY FOR PROTONS TO BE CHECKED AGAIN !!!

Maximum detectable kinetic energy for protons (from Bethe-Block)

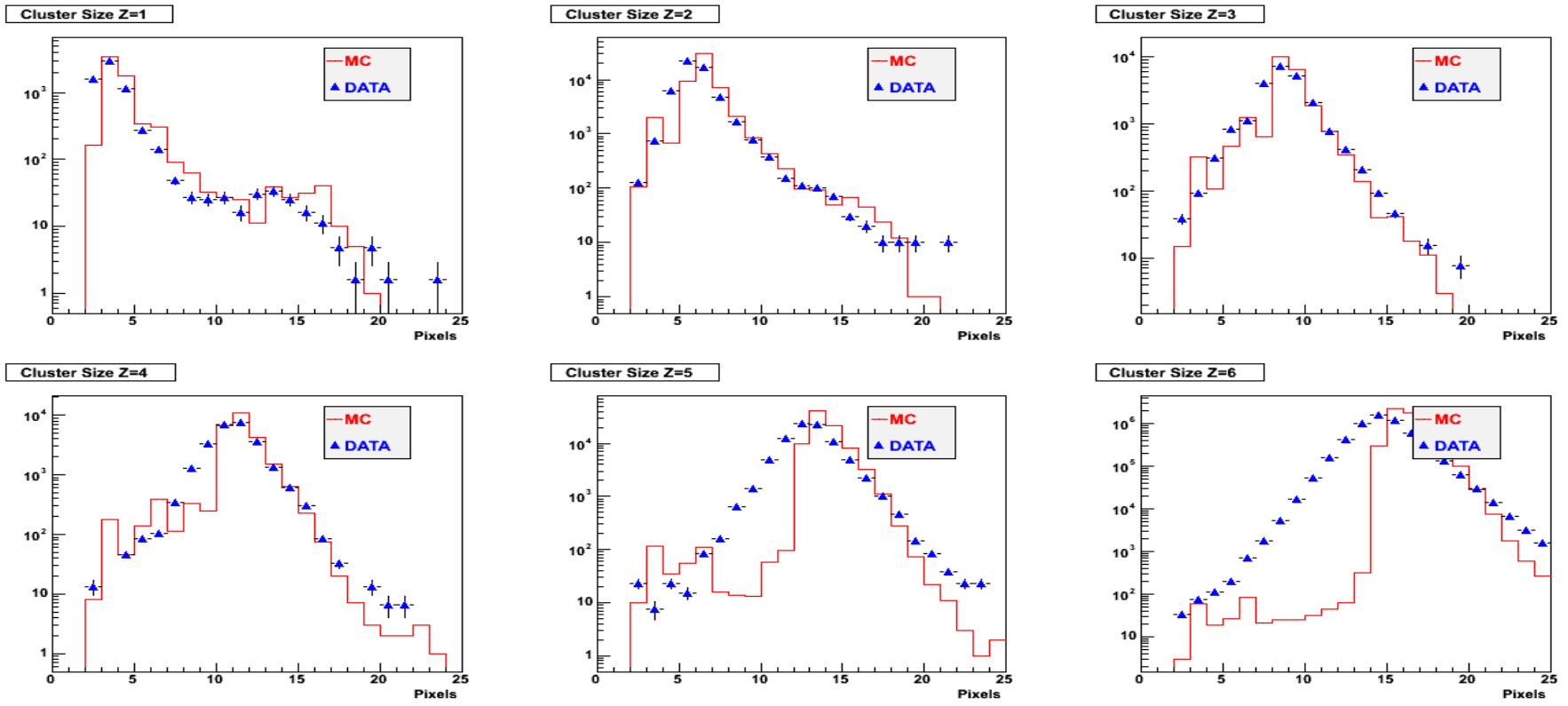




Similar plots produced last year for minimum energy lost in the slat or for maximum kinetic energy were wrong !!!

VTX cluster size

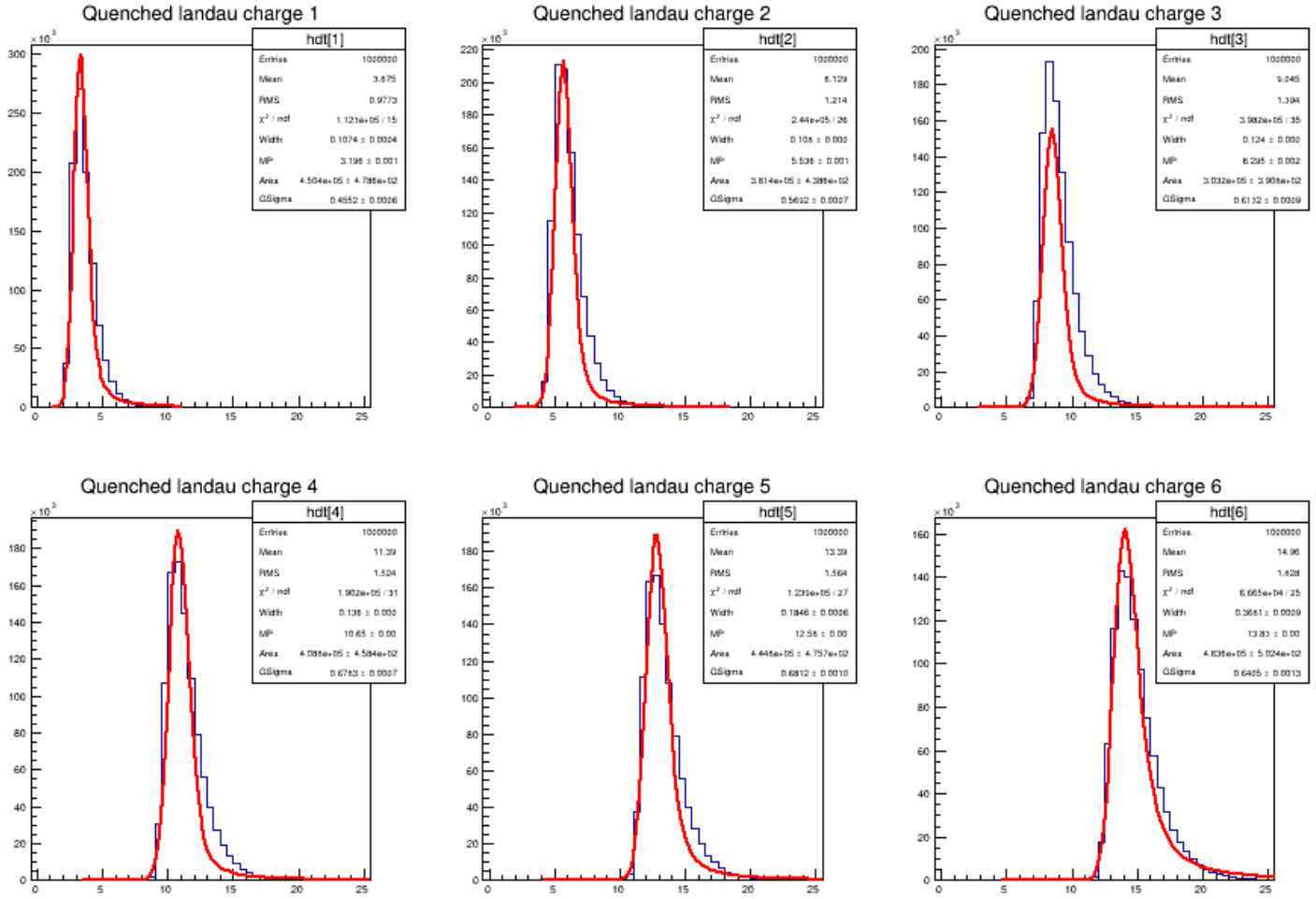
Previous simulation of cluster size distributions used the energy lost in the VTX plane and a parameterization of the number of pixels vs the energy lost.
Not satisfactory agreement for B and C.



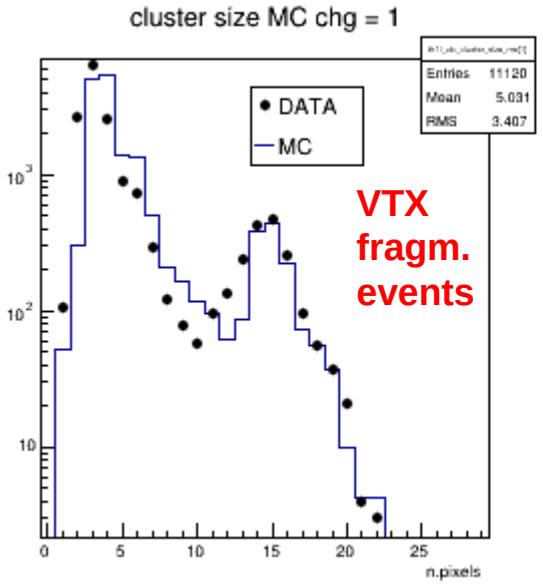
PLOTS FROM MARCO T. (log scale)

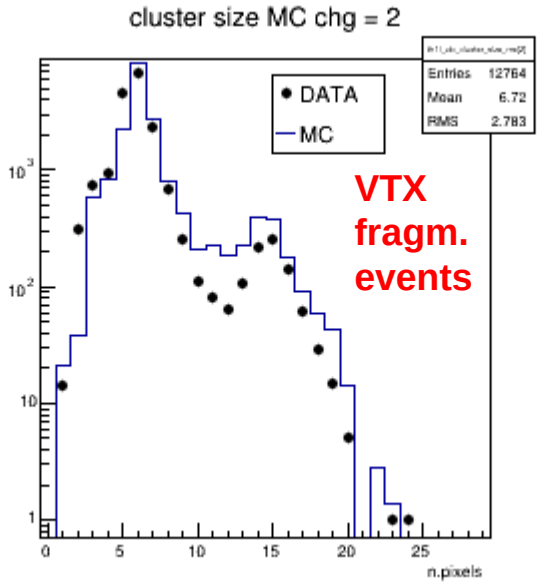
2nd attempt

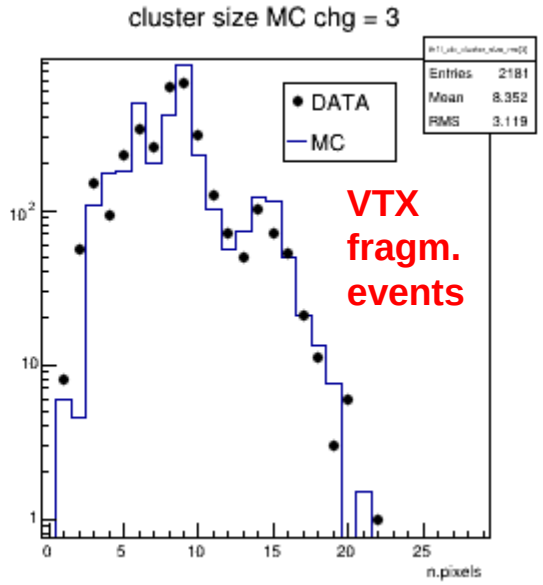
Parameterization of the “quenched” Landau fits provided by Christian Finck with the convolution of a Gaussian and a Landau function. Z from MC track used

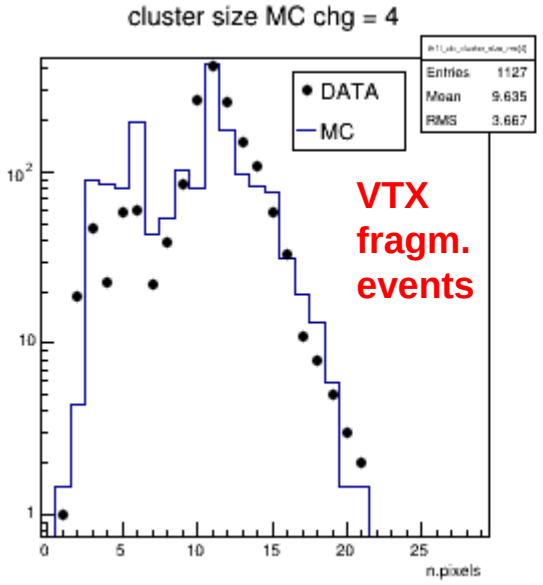


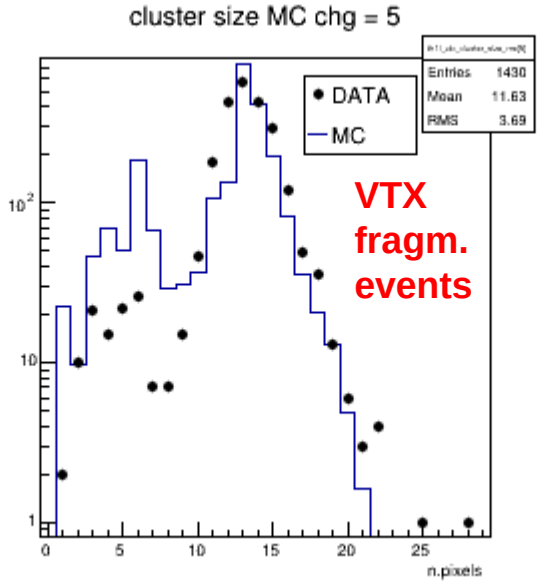
Tails not perfectly reproduced, but I expect better agreement than before fro B and C.

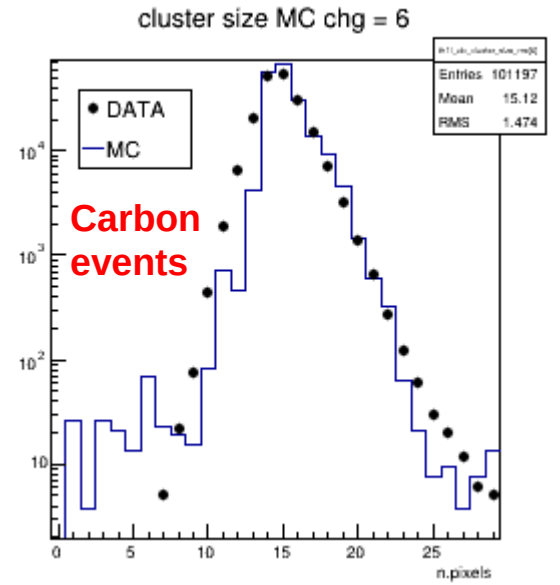










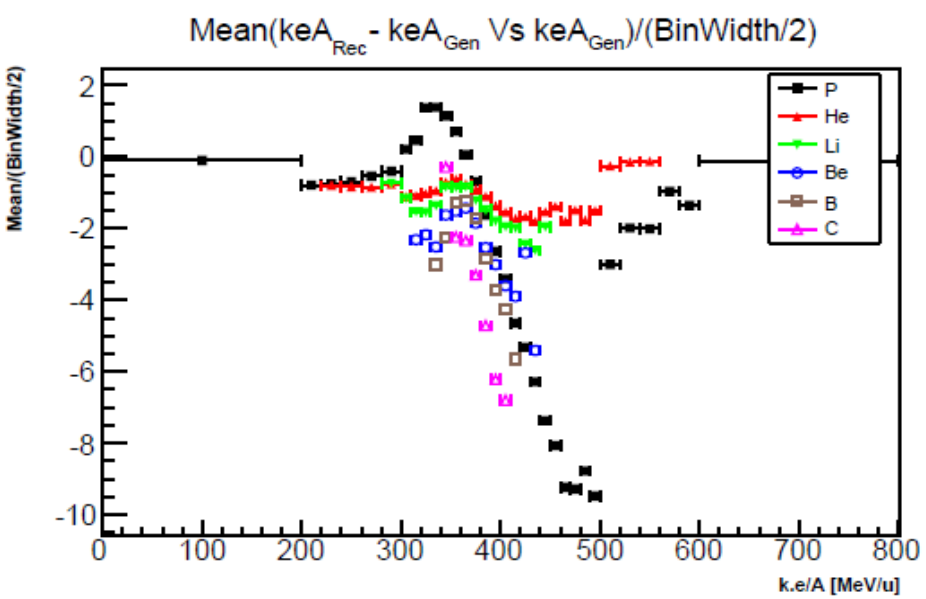


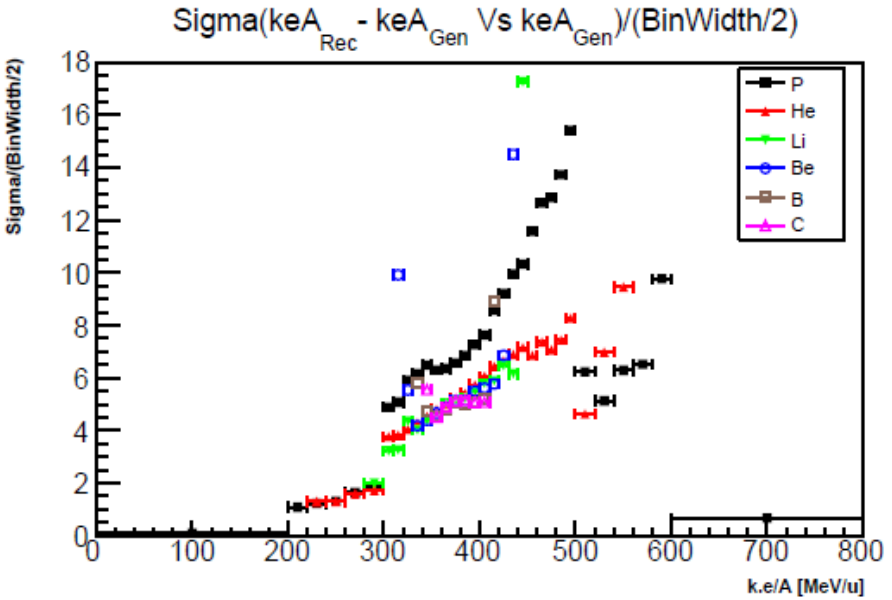
To be checked with more statistics and optimized selection cuts from Marco T.

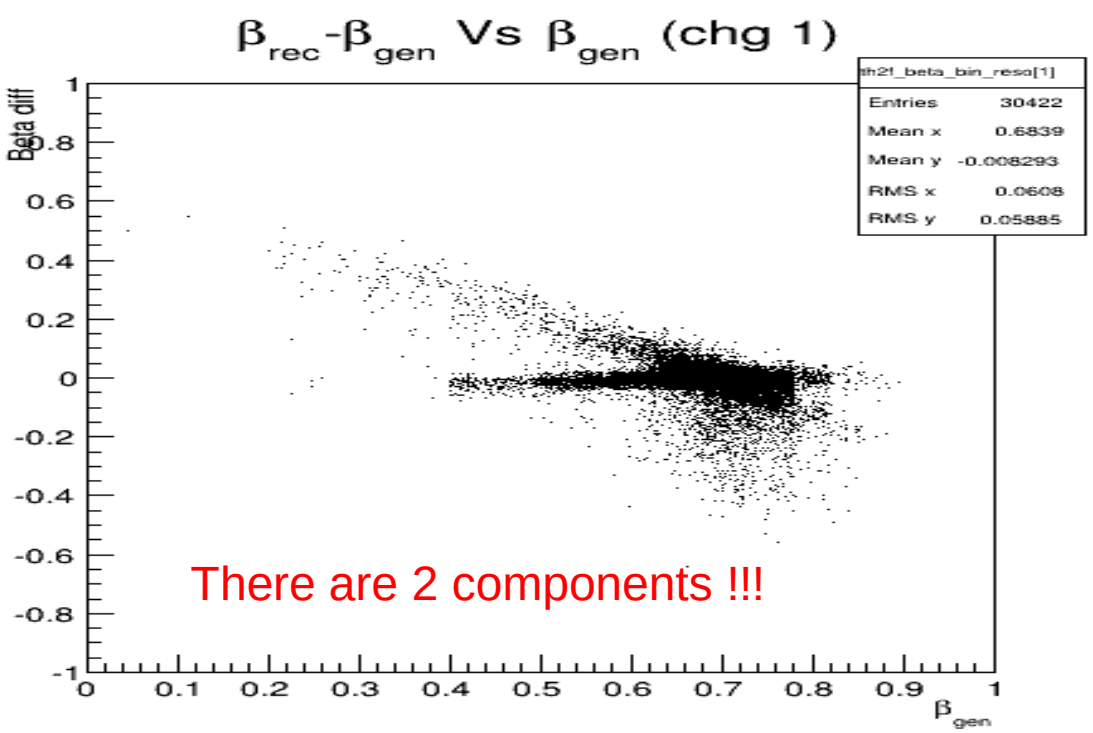
Biases in reconstructed quantities

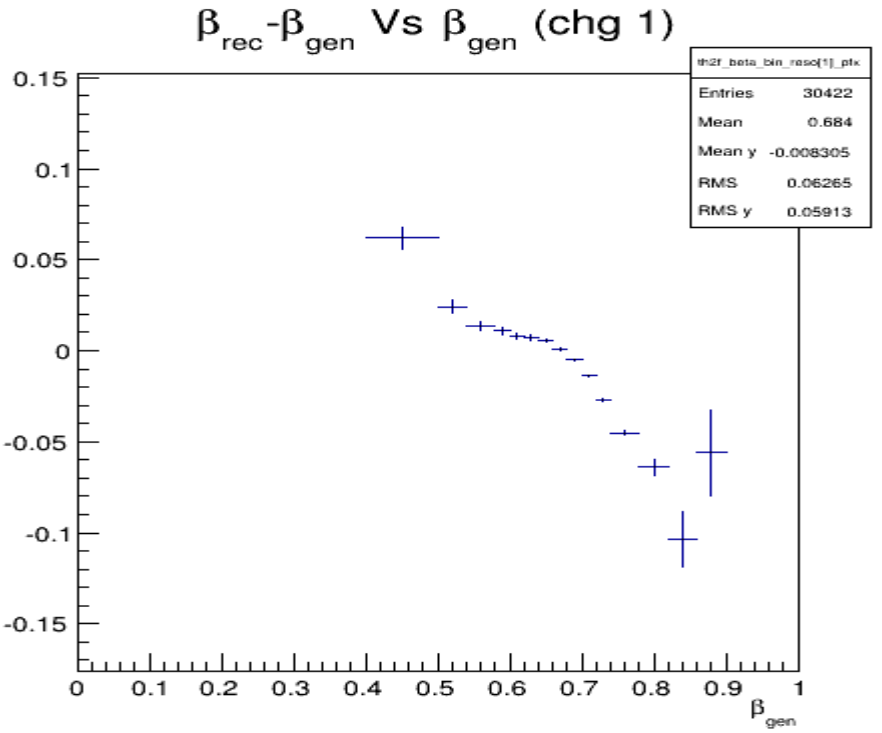
Two main difficulties found in the analysis for the extraction of (differential) cross sections.

- Understanding and handling of charge identification purity/efficiency matrices.
- Strong biases when comparing reconstructed and generated quantities (beta, KE, momentum, mass, etc...) resulting in very low efficiencies and purities (difficult and unstable unfolding procedures).









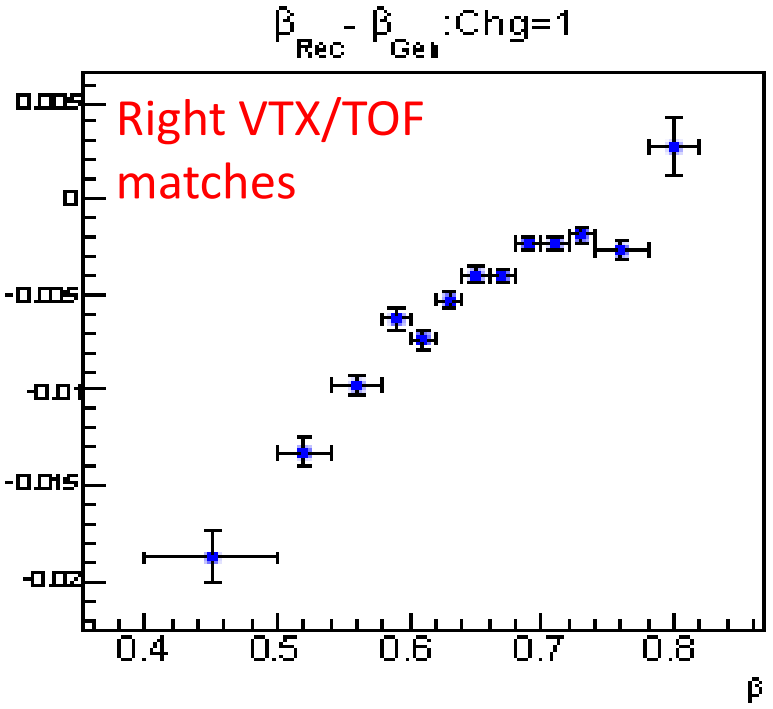
These biases are studied in the Monte-Carlo separately for

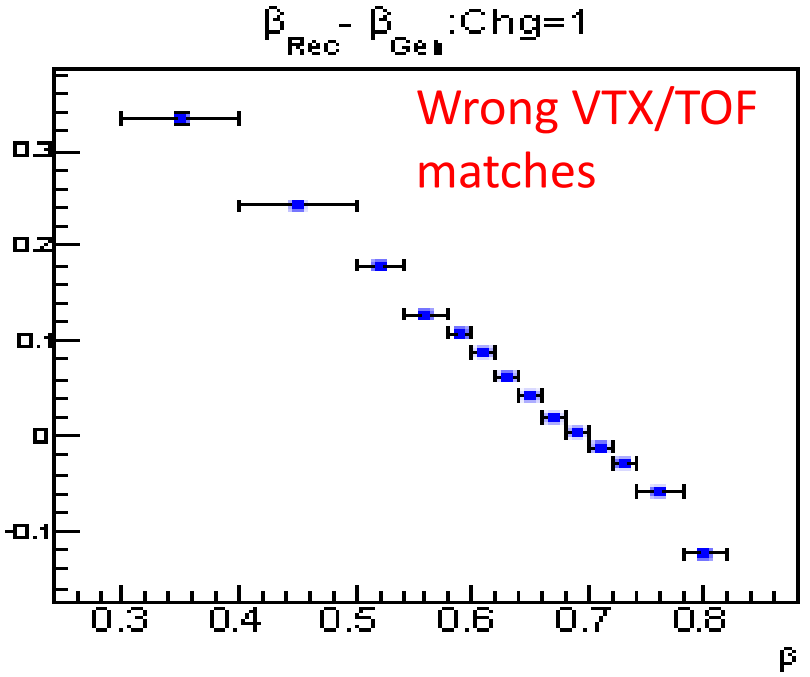
1) MC tracks with the same MCid at the VTX and at the TOF (right matches, no secondary fragmentation)

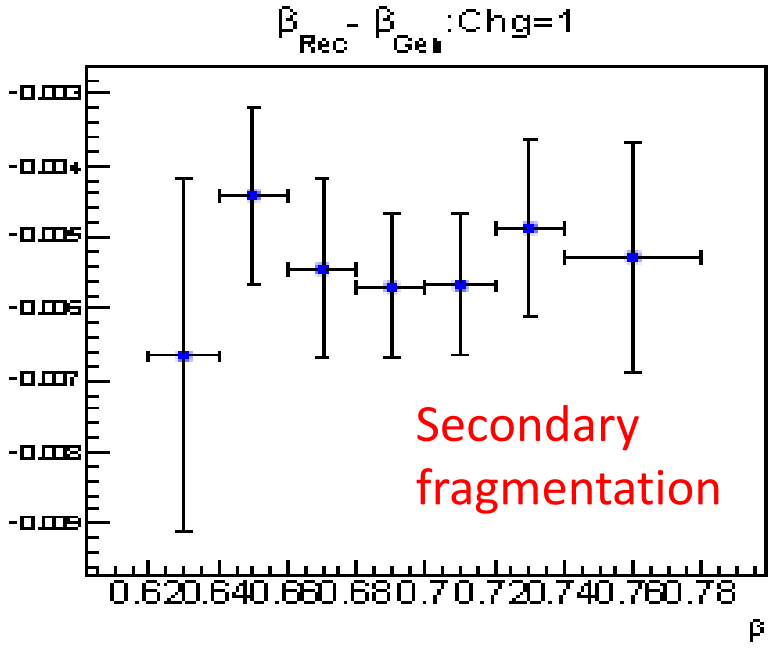
2) MC tracks with secondary fragmentation (navigation in the MC “true” track block from TOF to VTX gives the right VTX/TOF match, but the track ID has changed)

3) wrong TOF/VTX matches based on navigation in the MC track block.

Reconstructed quantities are compared with generated quantities at the target
(MC true charged at the fragmentation point inside the target)

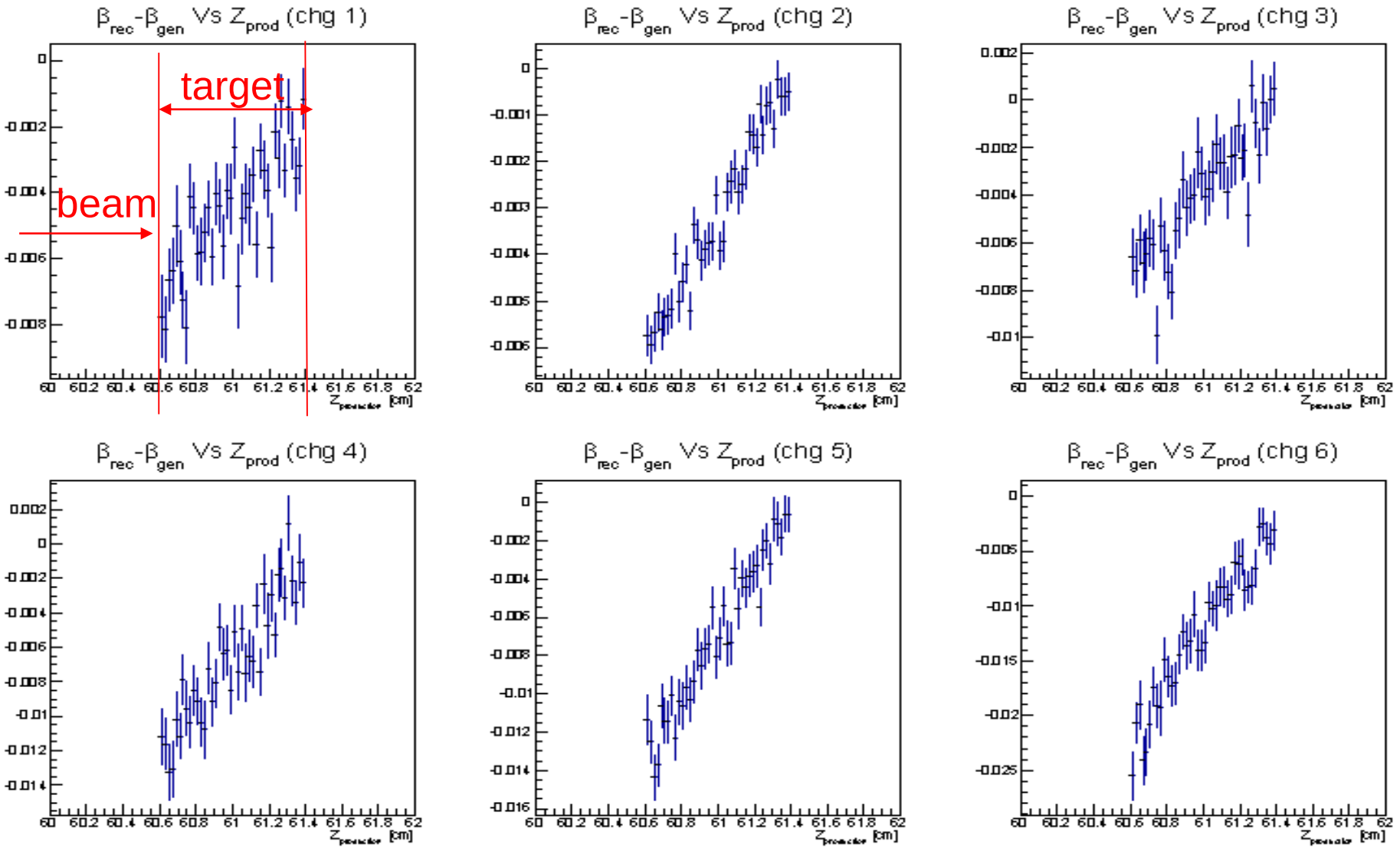




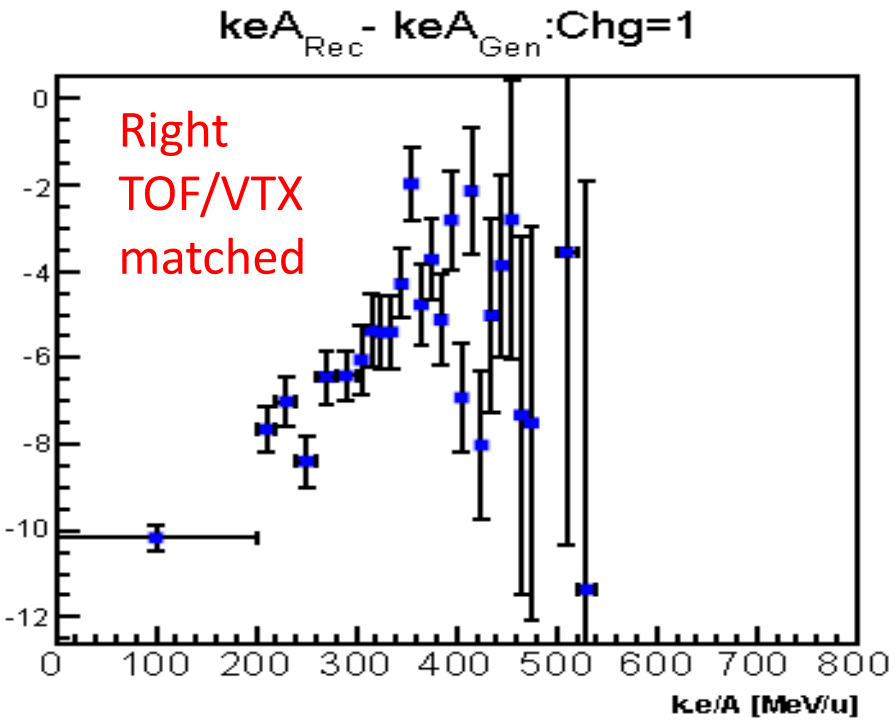


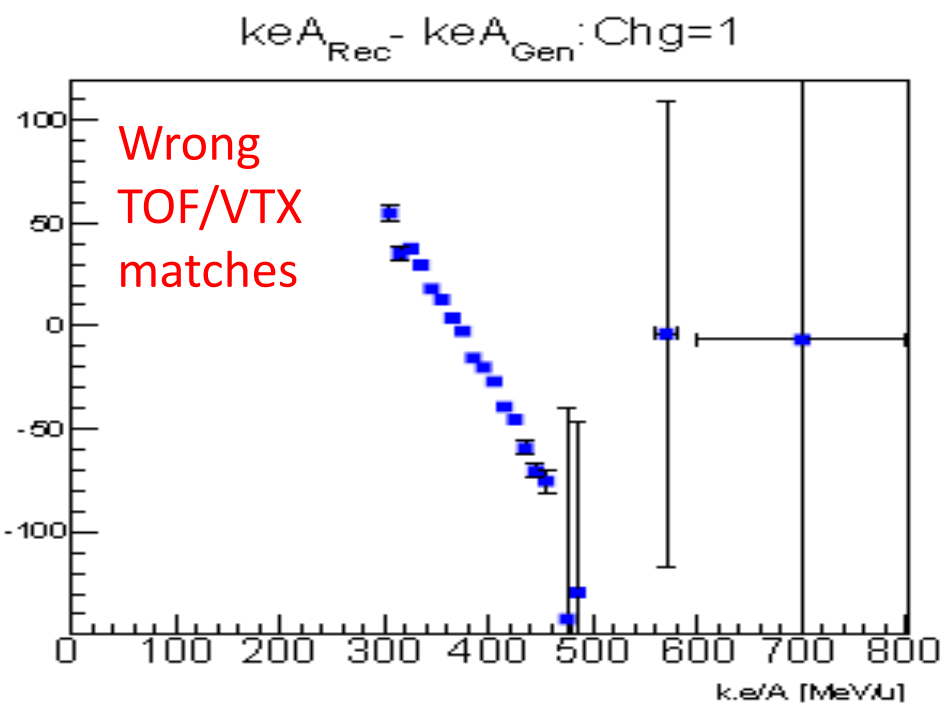
Little offset for also for right matches.

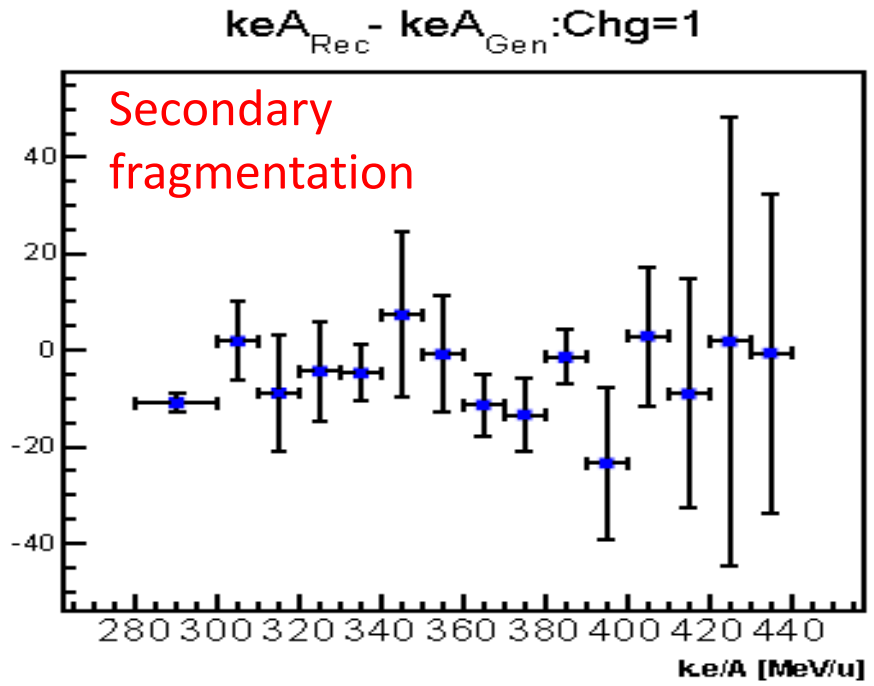
Offsets versus position of the interaction point in the target for right matches



For MC tracks with no secondary fragmentation before the TOF and with a right assignment between VTX track and TOF hit the little offset is related to the energy lost inside the target (the MC generated information is taken at the fragmentation point).







Secondary fragmentation occurs mainly in the TOF itself and it seems to don't affect the reconstruction

Probability of mismatch or secondary fragmentation (old TOF Ytdc used for the TOF/VTX match)

Charge	TOTAL n.tracks (all events)	RIGHT matches (all events)	WRONG matches (all events)	Secondary fragm. (all events)	TOTAL n.tracks (fragm. events)	RIGHT matches (fragm. events)	WRONG matches (fragm. events)	Secondary fragm. (fragm. events)
1	1588	1039 (65,43 %)	480 (30,23 %)	80 (5,04 %)	1441	956 (66,34 %)	421 (29,22 %)	74 (5,14 %)
2	3414	2878 (84,30 %)	428 (12,54 %)	118 (3,45 %)	3103	2651 (85,43 %)	353 (11,38 %)	106 (3,42 %)
3	379	324 (85,49 %)	35 (9,23 %)	20 (5,28 %)	354	306 (86,44 %)	30 (8,47 %)	18 (5,08 %)
4	247	206 (83,40 %)	23 (9,31 %)	19 (7,69 %)	218	185 (84,86 %)	16 (7,34 %)	17 (7,80 %)
5	544	503 (92,46 %)	12 (2,21 %)	29 (5,33 %)	377	351 (93,10 %)	4 (1,06 %)	22 (5,84 %)
6	37573	34907 (92,90 %)	15 (0,04 %)	2651 (7,06 %)	191	168 (87,96 %)	4 (2,09 %)	19 (9,95 %)

Similar values with all the events and with only VTX fragmentation events.

Reduction of fraction of mismatched tracks

The probability of TOF/VTX mismatch can be reduced by

1) improving the resolution in the Y coordinate by using TDC ADCs instead of TDCs

2) by adding the information from the VTX charge in the scoring function used for the VTX/TOF match

3) by excluding from the combinatorial all the tracks not associated to the BM track ?

4) by clustering TOF hits in the same plane ?

Charge	Ytdc total tracks (% wrong mathes)	Yadc total tracks (% wrong matches)	VTXch New sim used (% of wrong matches)	VTXch+ Yadc (% of wrong matches)	VTXch+ Yadc+ BM-match (% of wrong matches)
1	1588 (30,23 %)	2820 (21,02 %)	(18,34 %)	(16,53 %)	(13,47 %)
2	3414 (12,54 %)	3583 (13,02 %)	(12,16 %)	(11,05 %)	(9,15 %)
3	379 (9,23 %)	400 (7,91 %)	(6,13 %)	(5,15 %)	(3,96 %)
4	247 (9,31 %)	256 (8,03 %)	(8,8 %)	(7,86 %)	(6,55 %)
5	544 (2,21 %)	573 (0,68 %)	(1,86 %)	(1,49 %)	(0,29 %)
6	37573 (0,04 %)	39124 (0,02 %)	(0,02 %)	(0,02 %)	(0,08 %)

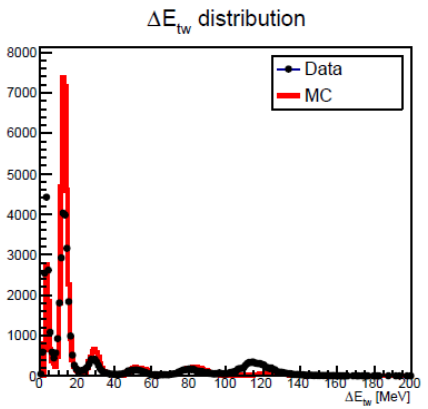
It seems that by using Yadc the fraction of wrong matches is reduced and more tracks are selected.
A selection based on the charge difference between VTX and TOF at least as good as the selection based on Delta(y).
A combination of Y and charge comparison further improve the selection of right combination.
Remaining wrong matches mainly from high multiplicity events.

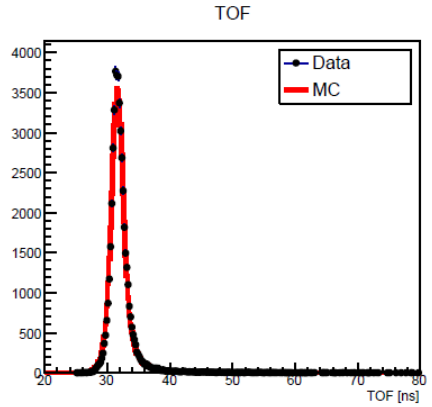
TOF issues

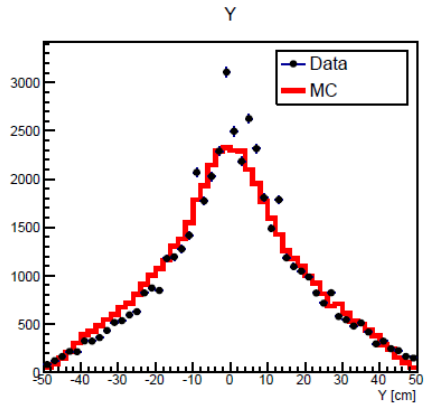
TOF data/MC comparisons (fragmentation events)

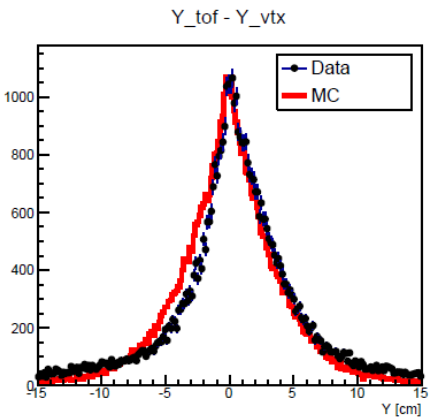
- Data/MC comparison for different TOF quantities was quite good for fragmentation events.

Linear scale

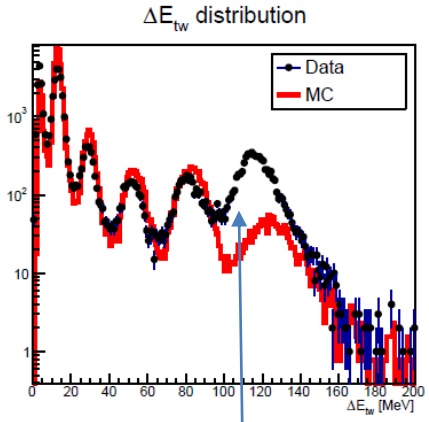


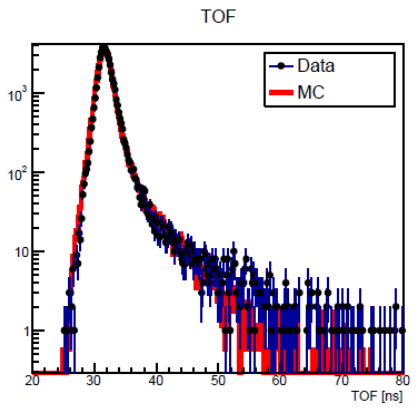


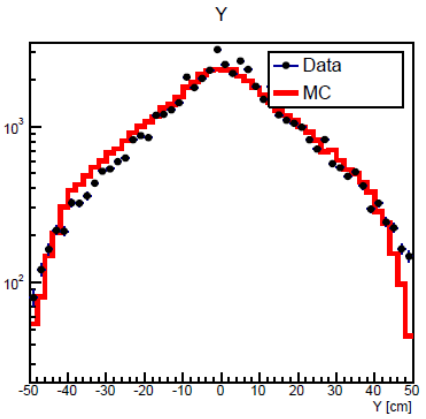




Logaritmic scale



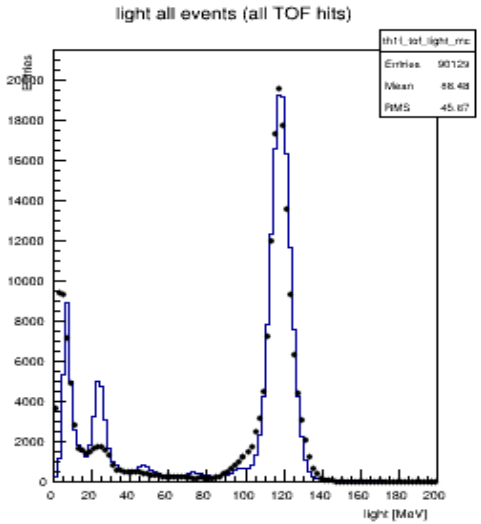


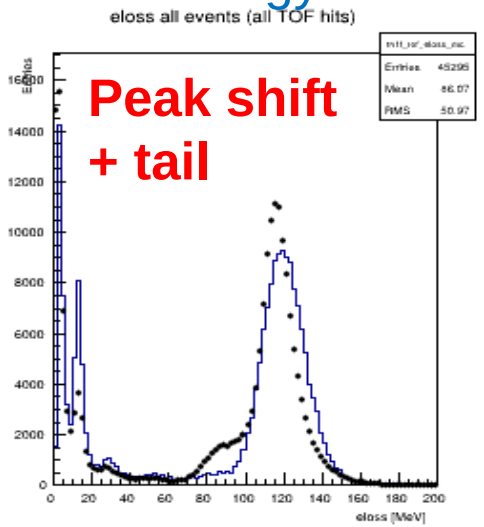


The data peak for Carbon could be to wrong VTX/BM pairing
(the pile-up effect was not simulated when these plots were produced)

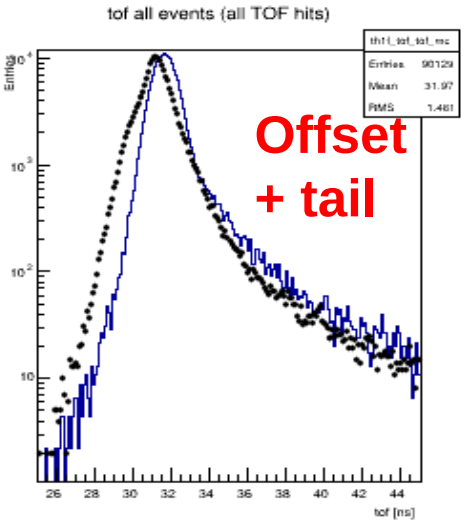
The comparison is not so good when **all the events** are considered

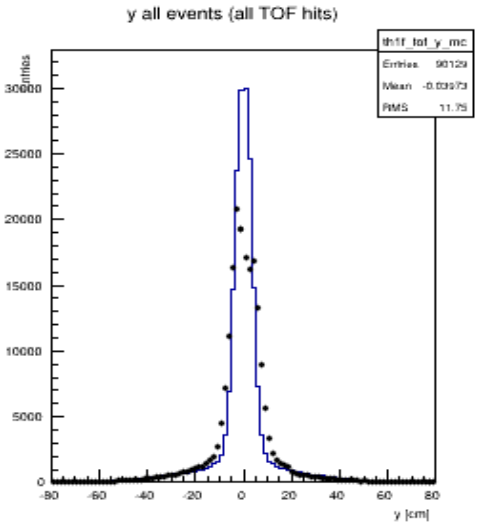
energy

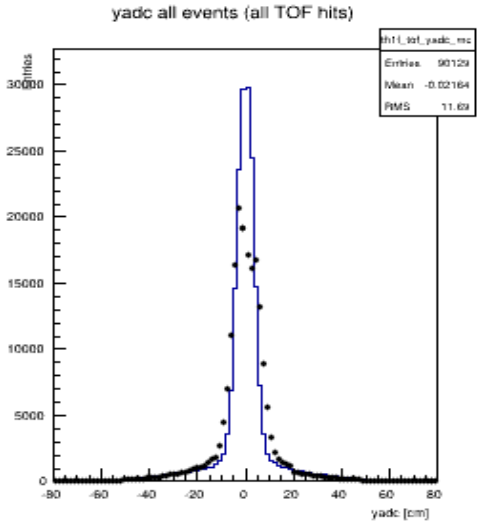


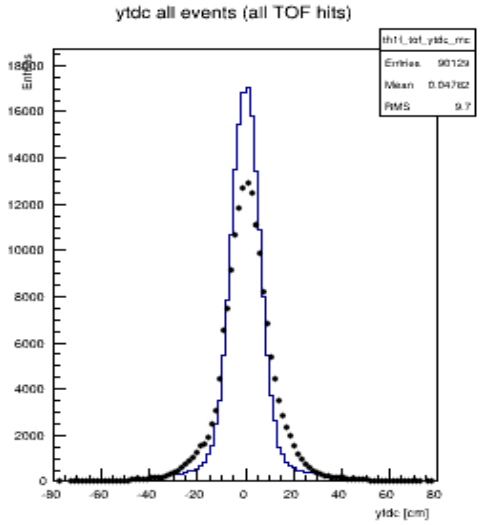


tof

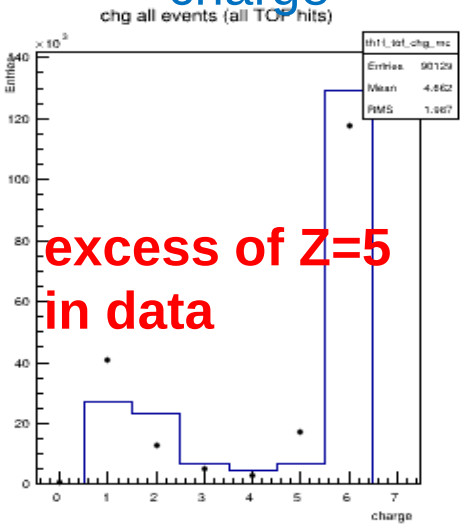








charge



In this sample the contribution of the central slats is strongly enhanced with respect to the previous plots. We think these mismatches are related to problems in these central slats (not worth to optimize the MC before checking the behavior of data in this region)

TOF calibration/reconstruction in the central slats

The central slats around the direction of the original carbon beam are very problematic for several reason

- precence of a hole in the middle of 3 slats in the front plane
- strong fragmentation due to the presence of an intermediate passive module (8 slats) between the front and rear plane.
- these slats (expecially in the front) could have suffered for strong irradiation in the past.

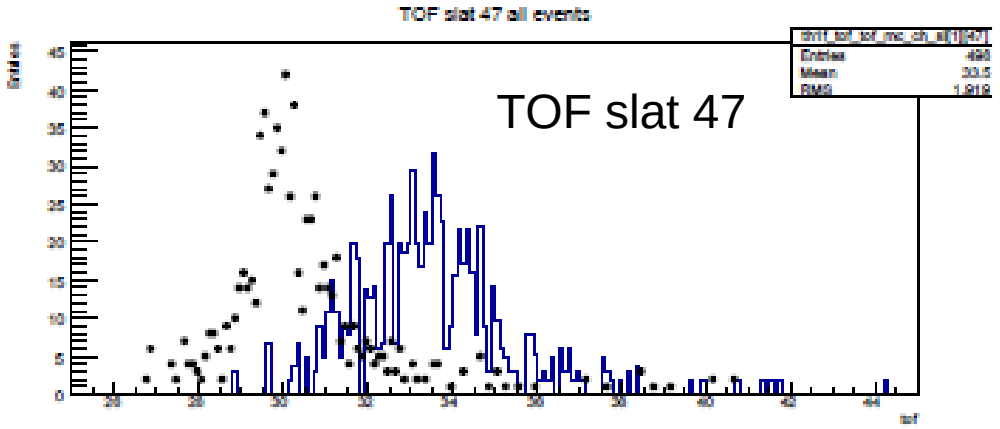
To check the calibration of the central slats, a **sample of carbons** has been selected by requiring

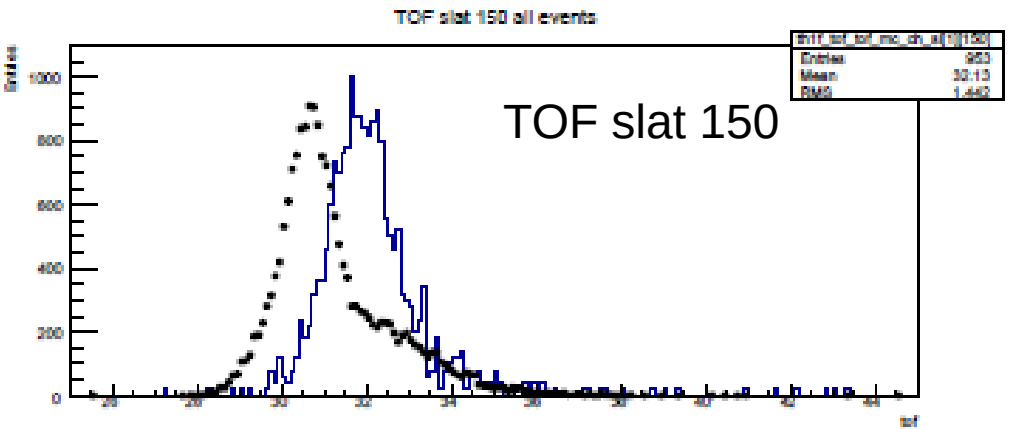
- only 1 VTX and 1 VTX track

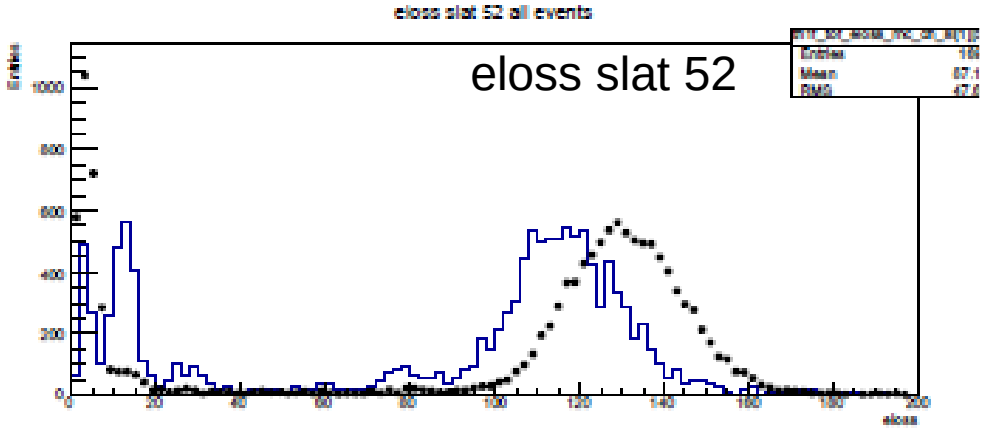
- 1 hit in the F and 1 hit in the R plane OR 1 hit in the F plane

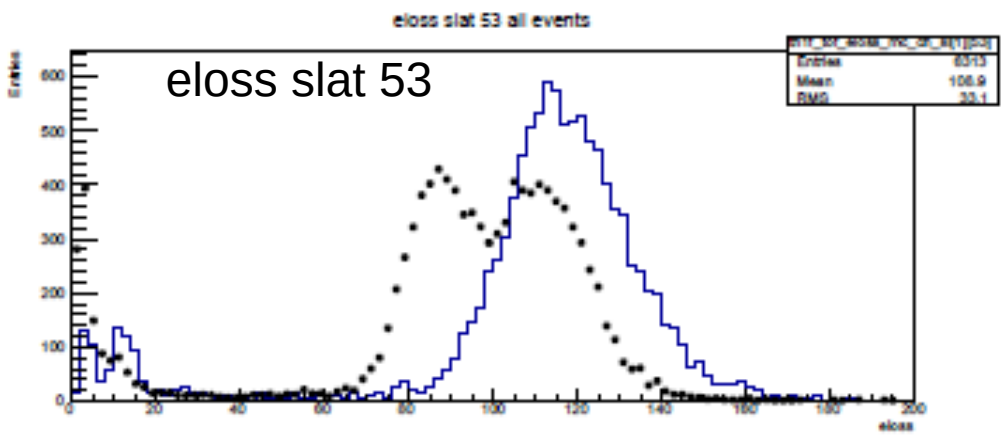
Multiple scattering in the target. The beam is spread in a region of about +- 10 cm around the nominal impact point at the TOF.

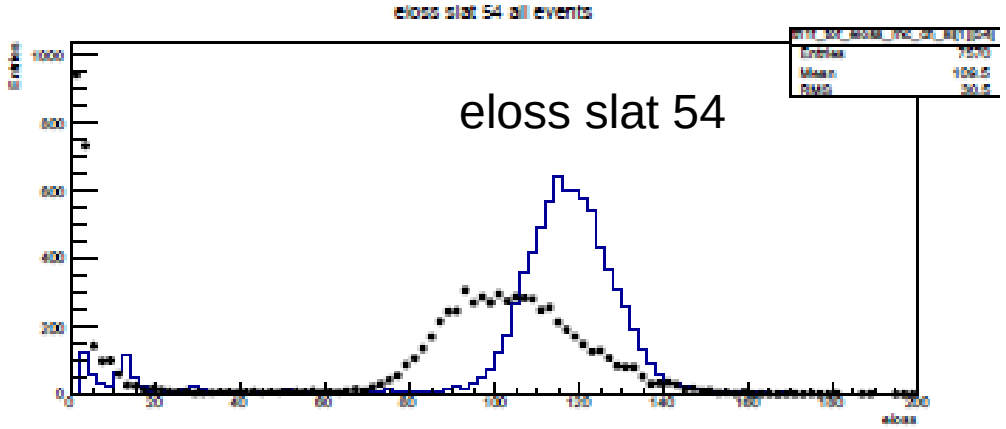
Data/MC comparison for some of the central slats in a sample of Carbon events. Examples of wrong behavior.

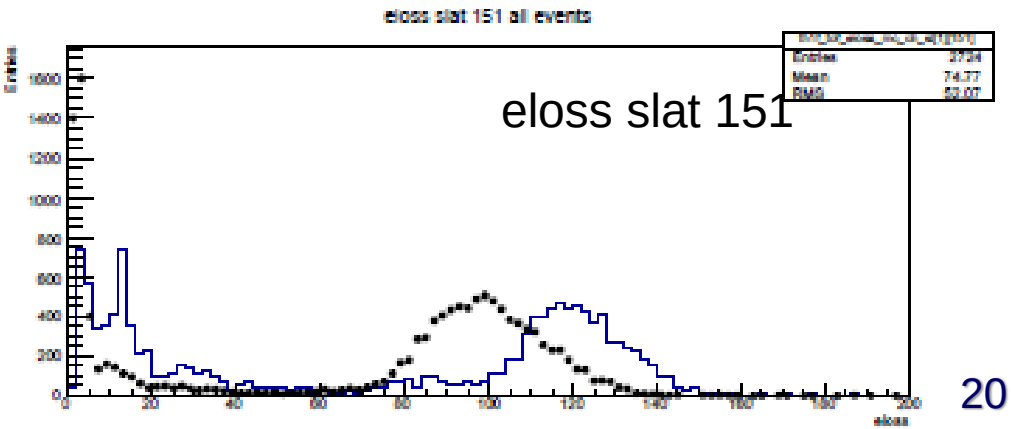




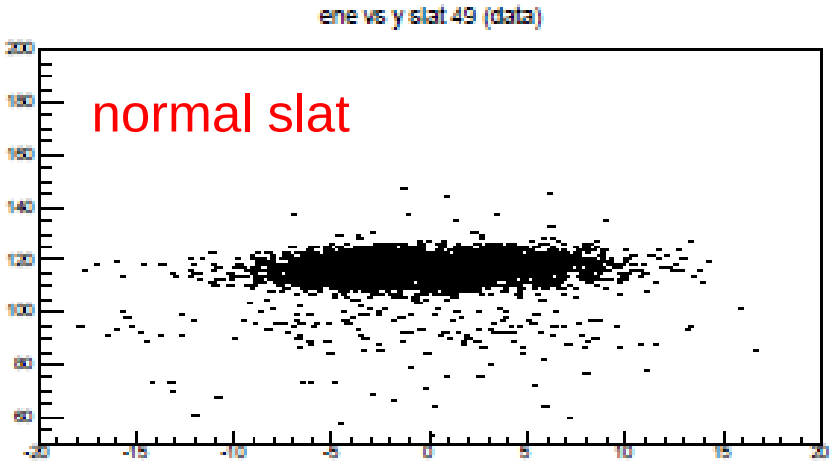


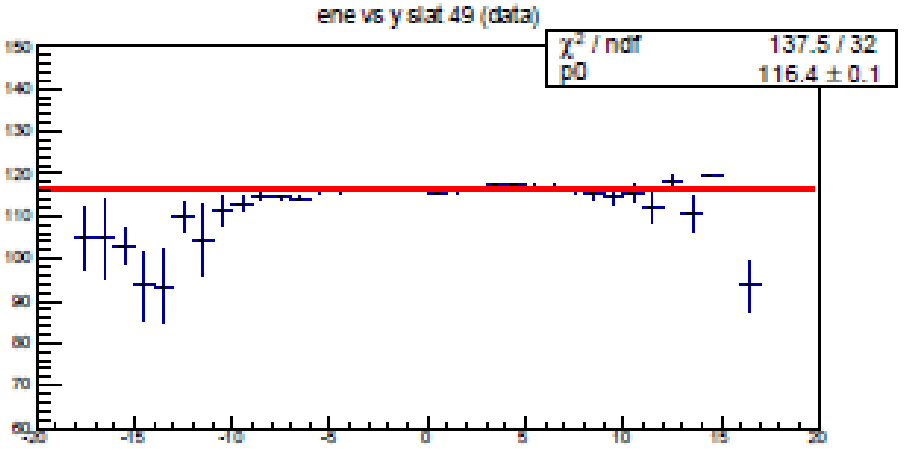


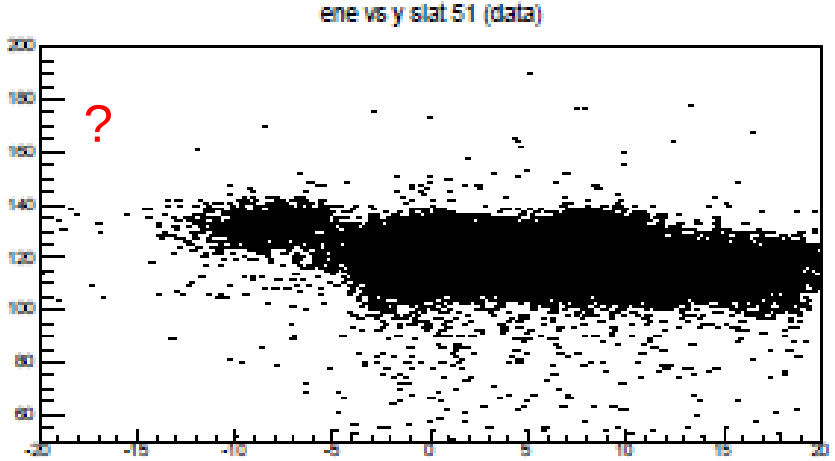


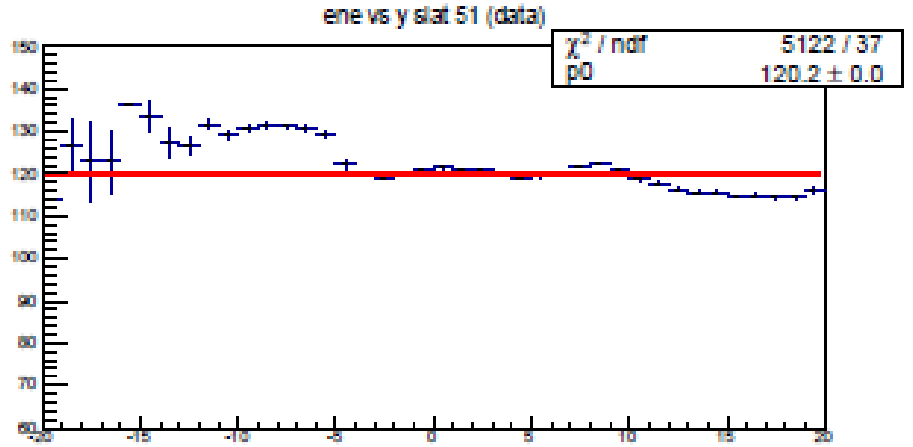


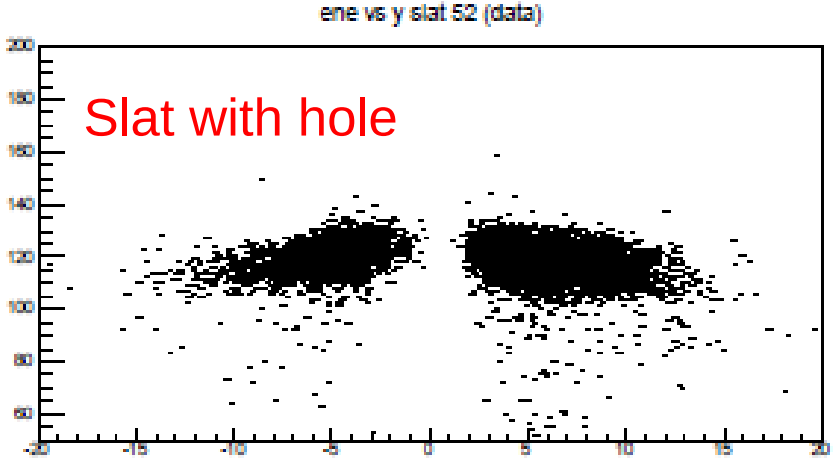
Y dependence of the TOF energy deposition for Carbons (it should be flat)









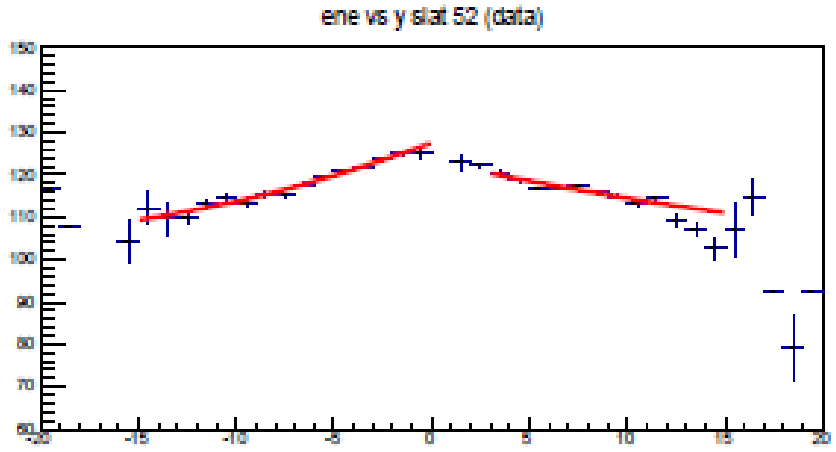


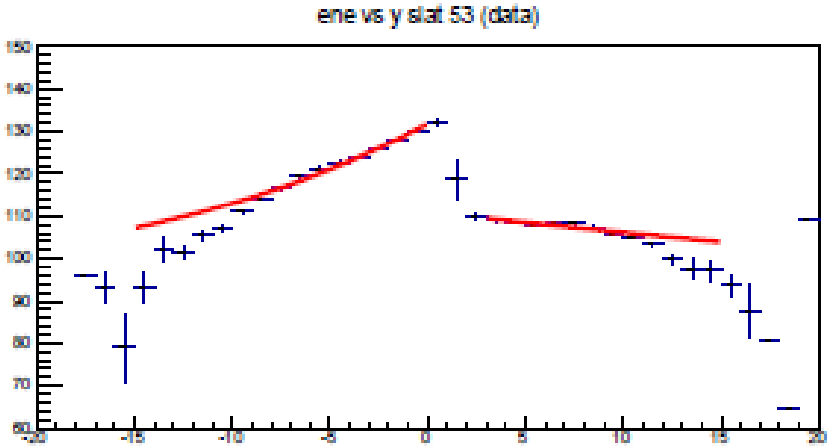
Tried to fit under assumption of reflection in the interfaces scintillator/plexiglas

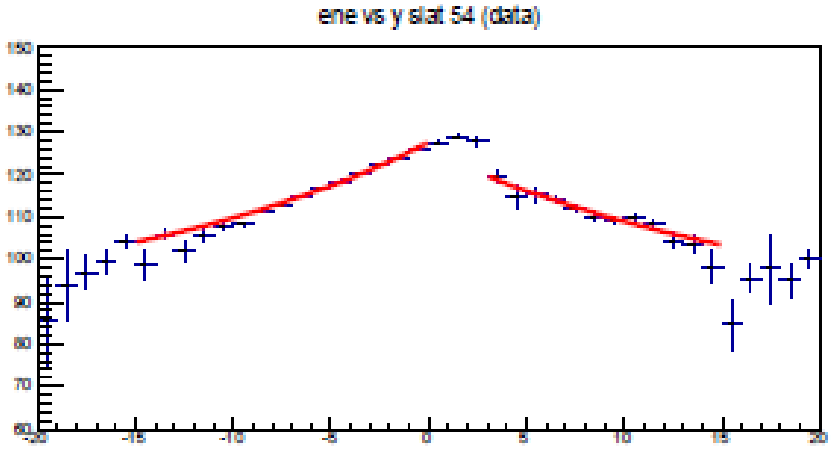
$$E_{B/T} = E_0 \cdot (1+\beta \cdot \exp(\pm 2\lambda_{B/T} y))$$

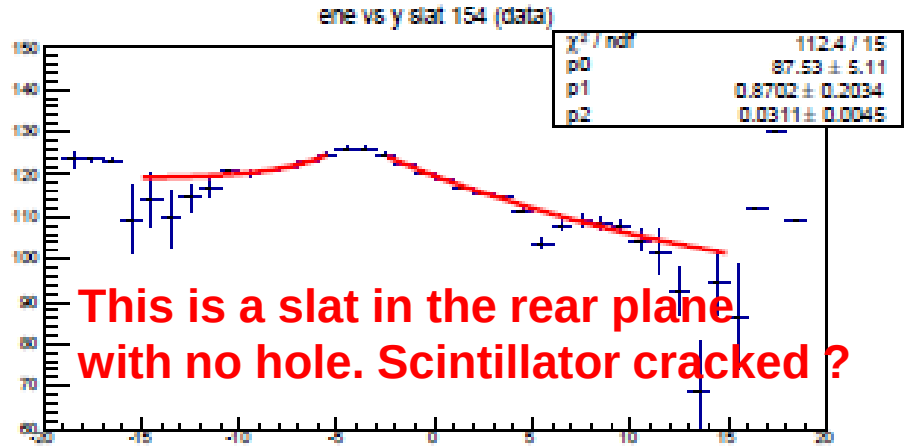
β = fraction of light reflected at y=0

λ = absorbtion coefficient









slat	E_o(top)	β(top)	λ(top)	E_o(bot)	β(bot)	λ(bot)
52	87,0 ± 0,2	1,00 (limit)	0,016 ± 0,001	96 ± 8	0,8 ± 0,3	0,032 ± 0,01
53	78,5 ± 0,1	1,00 (limit)	0,009 ± 0,001	93,24 ± 0,07	1,00 (limit)	0,038 ± 0,001
54	88,8 ± 1,4	1,00 (limit)	0,034 ± 0,005	90,2 ± 0,1	1,00 (limit)	0,037 ± 0,001
151	88,1 ± 0,3	1,00 (limit)	0,039 ± 0,002	75,2 ± 0,8	1,00 (limit)	0,031 ± 0,003
153	87,5 ± 5,1	0,9 ± 0,2	0,031 ± 0,005	119 ± 1	0,7 ± 0,3	0,18 ± 0,06

Not clear if the hypothesis of reflection is true (beta from fit tends to be > 1)

Conclusions

Some of the issues to be fixed from our point of view:

- improve as much as possible the VTX/TOF matching including all the possible informations (VTX charge, exclude tracks not associated to the BM, Yadc, maybe TOF clustering on a single plane, other suggestions ?)
- understand how to handle the irreducible fraction of mismatches in the unfolding procedures for cross-section extraction
- solve the calibration/reconstruction issues in the TOF central slats (mask them in the meantime ?)
- improve the Z identification (maybe by including the VTX chg ?)