MONTE CARLO TOOLS AND STUDIES:

Pile-up in the simulation

Cluster size in the simulation

Bin definition for cross section

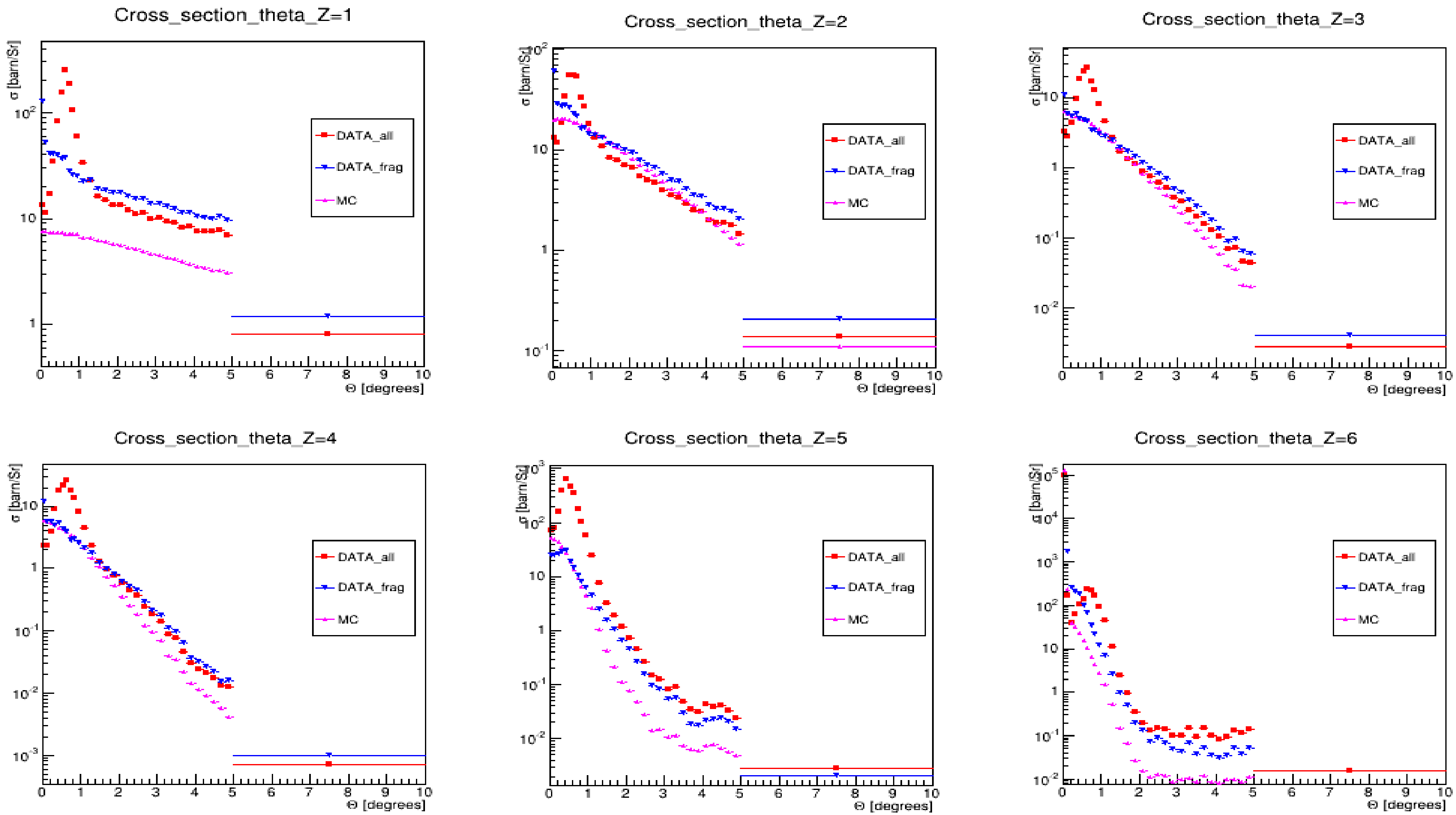
A. Kummali, V. Monaco

Universita' degli Studi di Torino and INFN, Torino

FIRST meeting, Roma, 21 November 2013

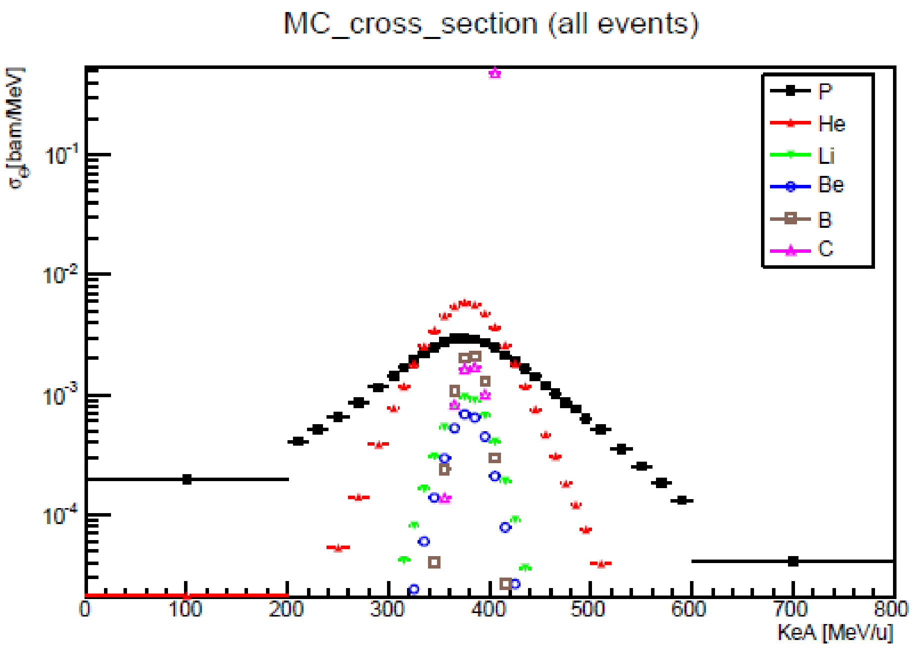
INTRODUCTION

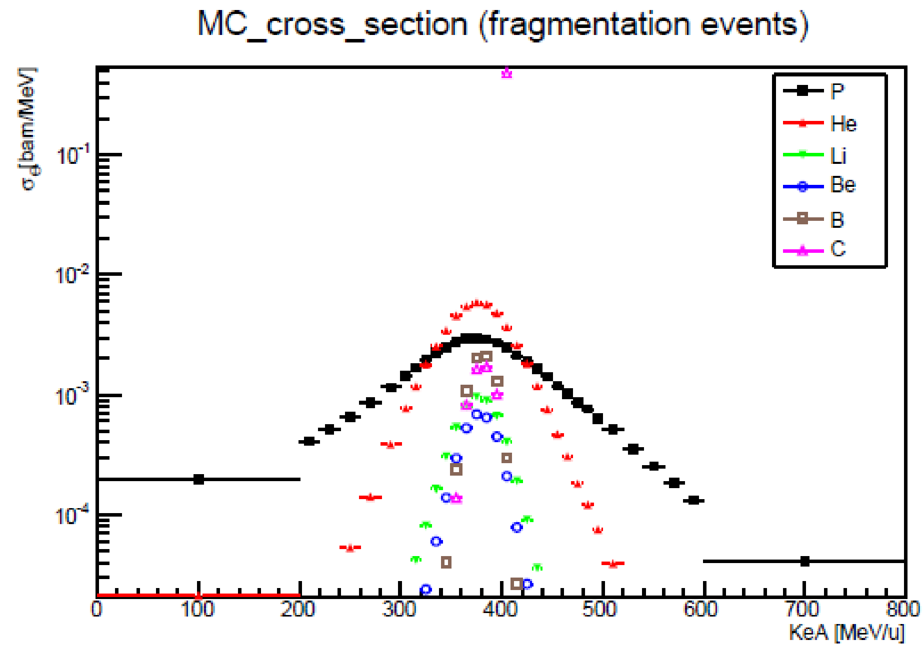
Preliminary cross sections (vs θ or KE/A) evaluated using purities and efficiences from Monte Carlo for each θ/ke bin.

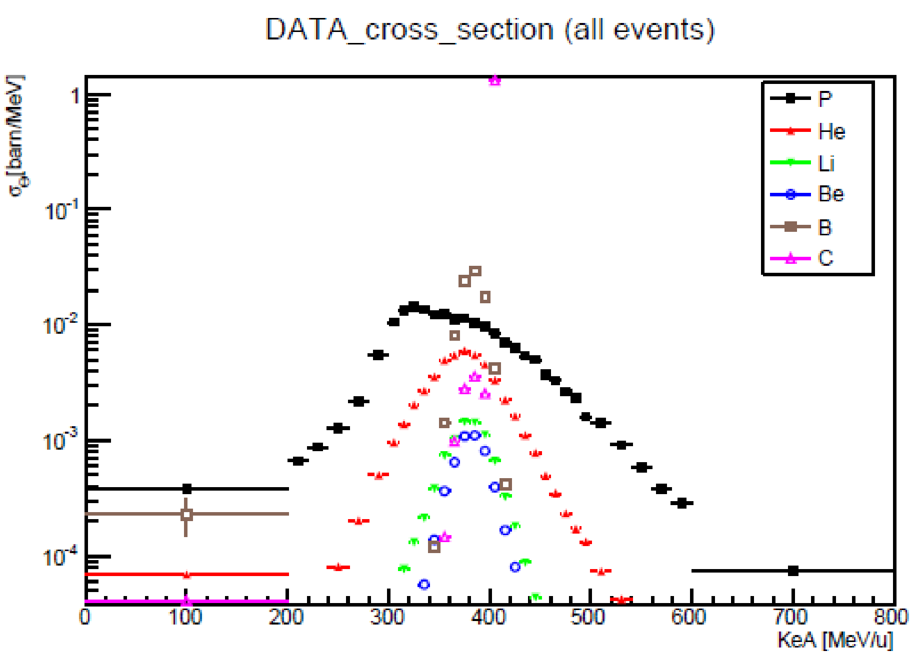


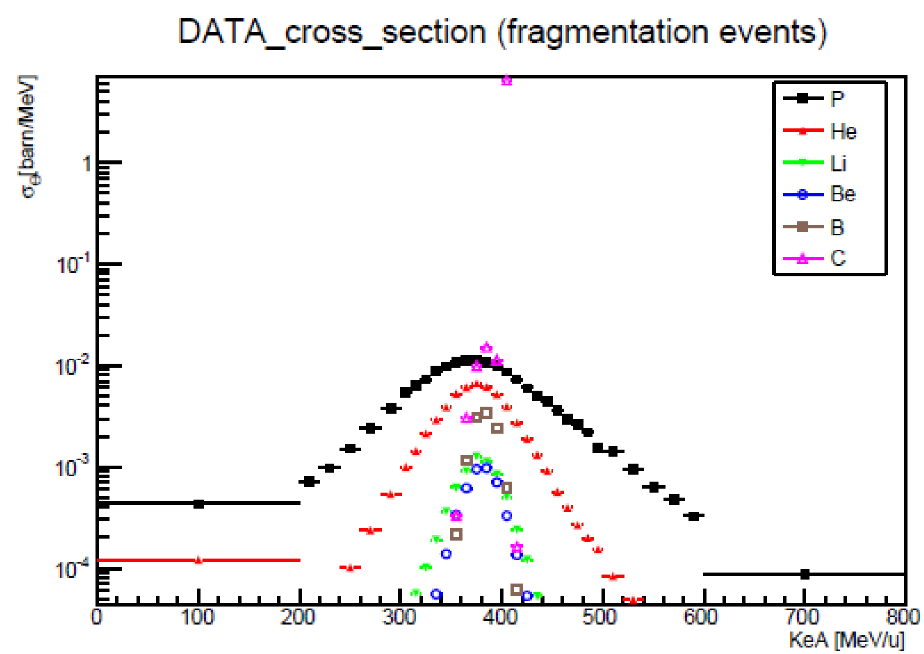
The cross sections obtained with all events or only fragmentation events are different (it means that the MC does not reproduce well some aspect of the experiment),

Differential cross section vs KE/A:

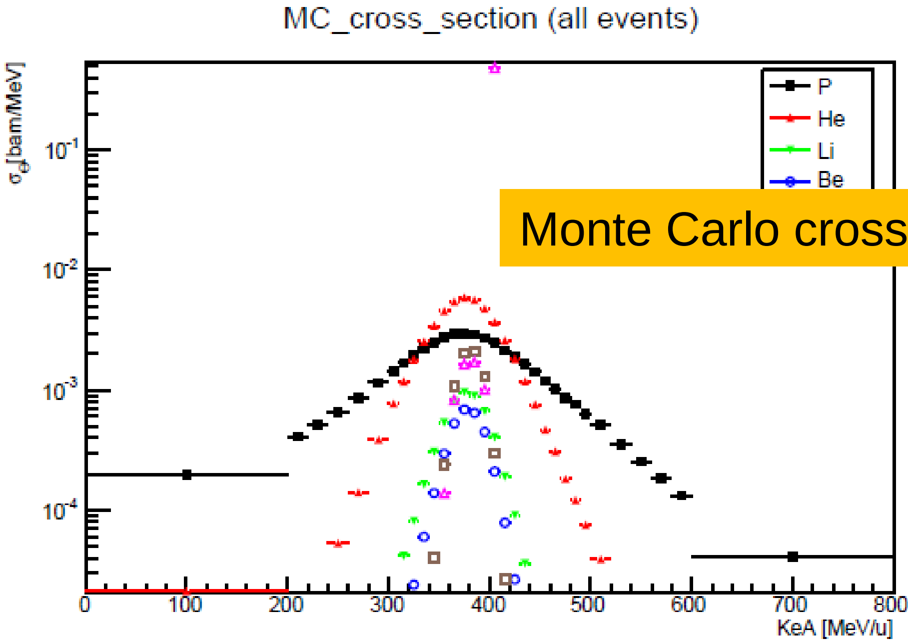


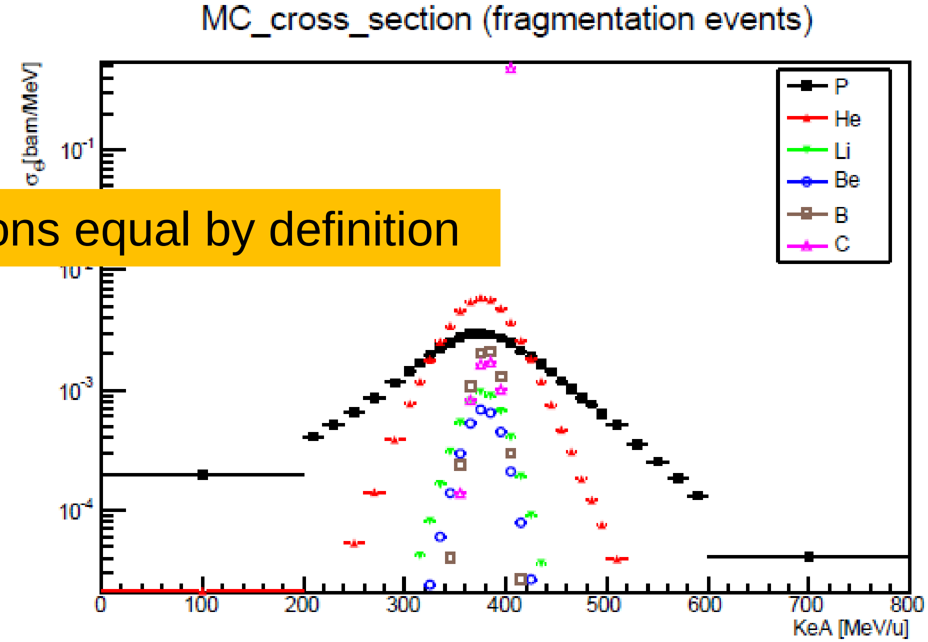




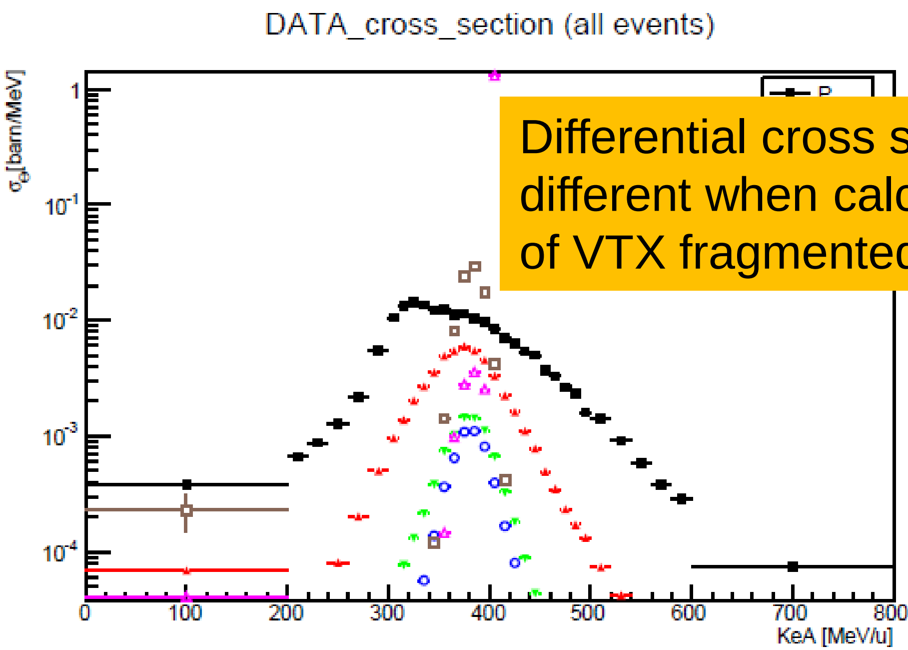


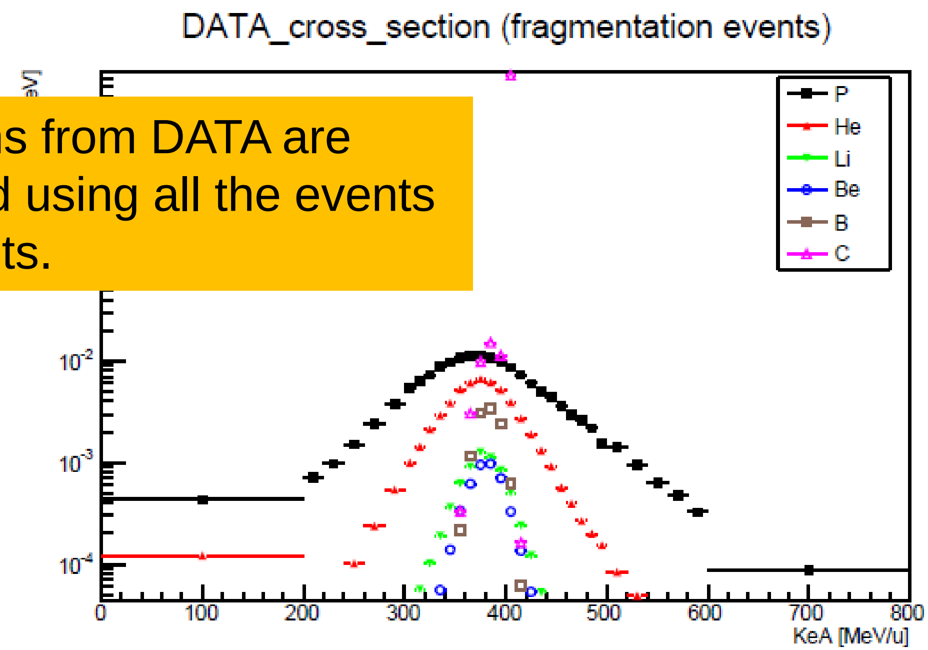
Differential cross section vs KE/A:





Monte Carlo cross sections equal by definition





Differential cross sections from DATA are different when calculated using all the events of VTX fragmented events.

Main observations in the recent past and some missing points in our analysis environment:

- strong fragmentation in the TOF wall (especially in the central slats)
- large contamination from carbons at lower charges
- wrong matches between VTX tracks and TOF hits (from Monte Carlo the probability of error is ~ 15 % without pile-up)
- no attempt in the reconstruction code to use only VTX tracks from the right vertex in case of pile-up in the VTX
- no simulation of pile-up

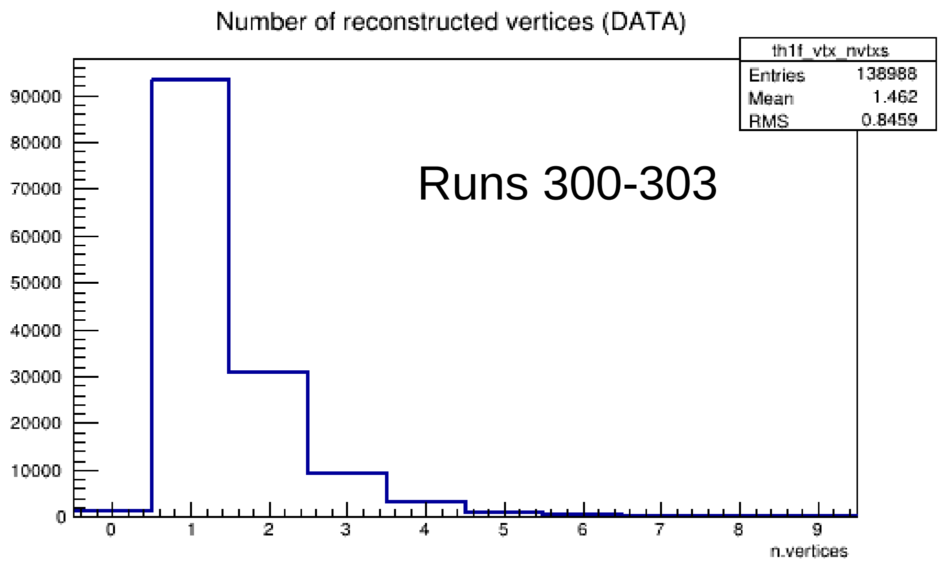
Our opinion is that one of the main differences between data and MC is the pile-up in the Mimosa (not included in the simulation).

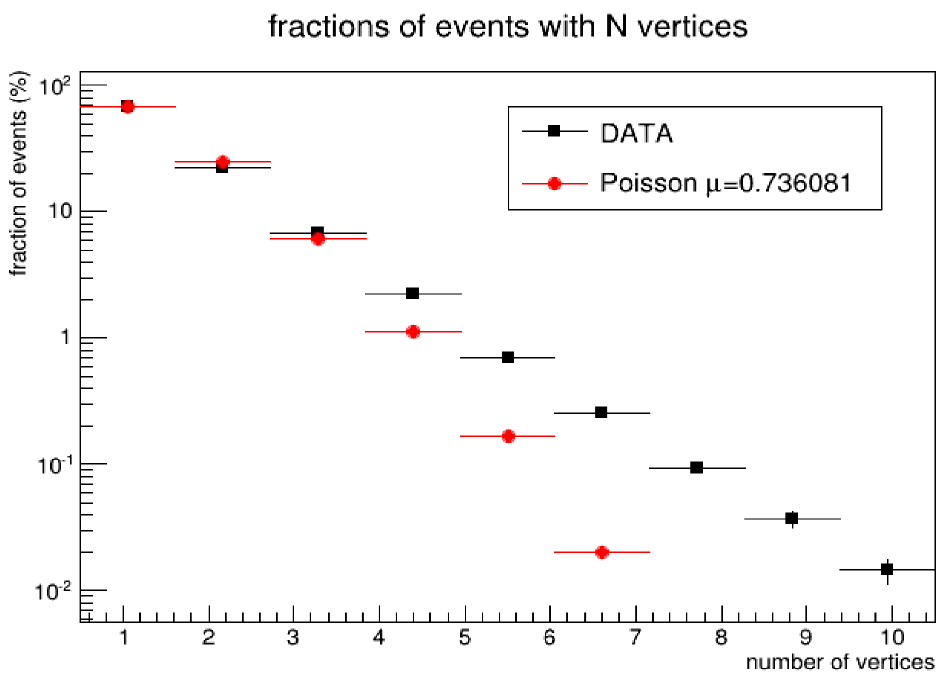
Once the pile-up is properly simulated, we can concentrate on the other important points:

- best VTX/TOF match using the correlation between VTX cluster size and charge.
- take into account in the reconstruction only VTX tracks not associated to pile-up events (BM/VTX match to be checked in the Monte Carlo in the presence of pile-up)
- understand the effects of the requirement of fragmentation from the VTX tracks
- improve the TOF reconstruction, i.e. TOF clustering in a single plane and improvement of efficiency for protons

Some of these studies do not depends directly on the pile-up, but the effects on the reconstruction depend on it.

Pile-up in the Mimosa





According to our reconstructed DATA more than one vertex in **~ 34 %** of the events

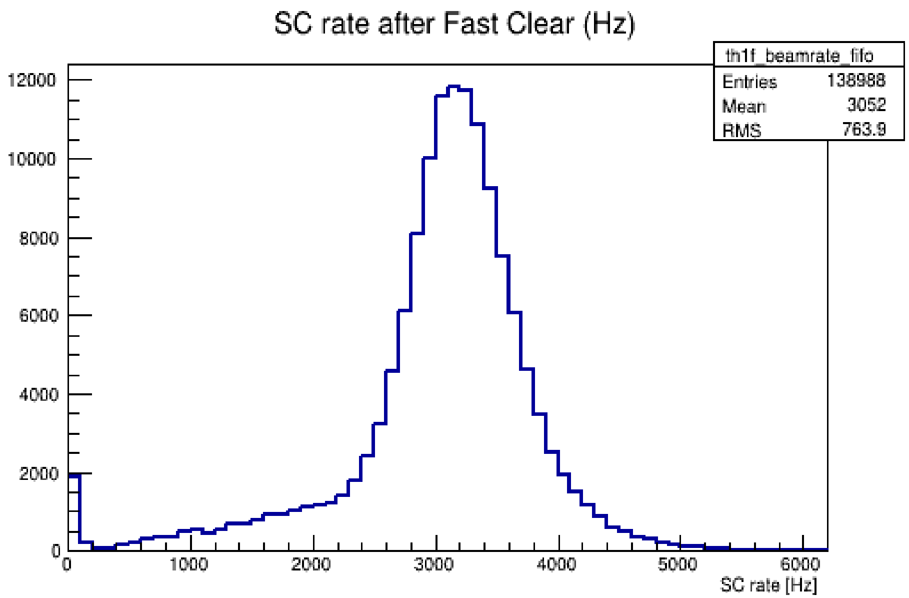
For a beam with uniform time distribution, the probability to have n vertices in a “triggered” event (n>0) is:

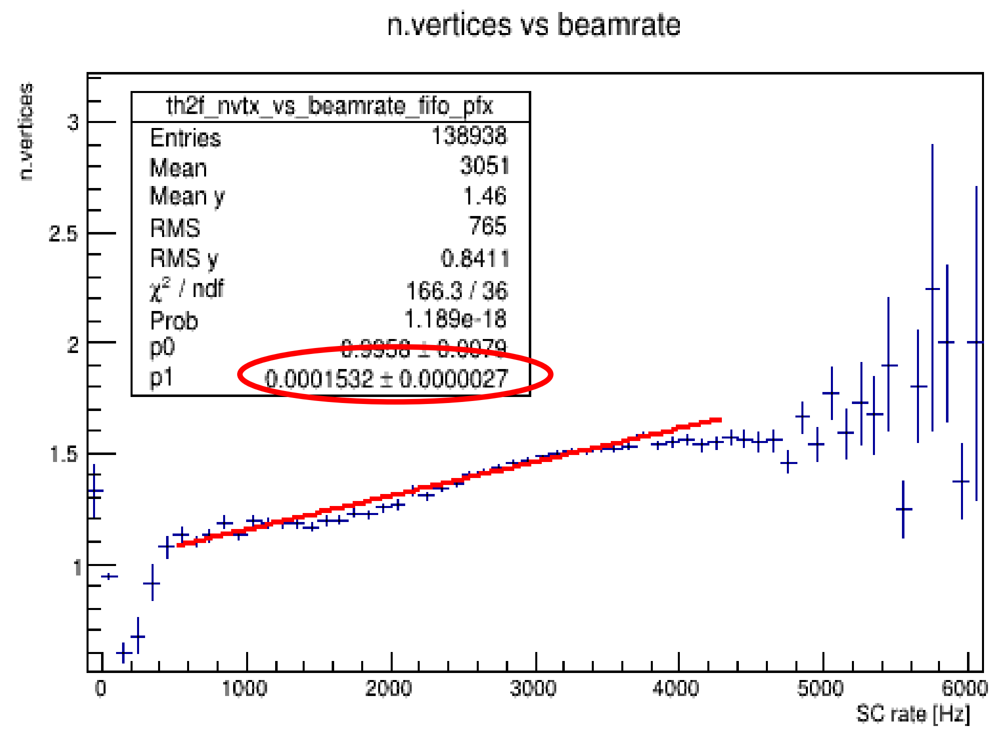
$$P(n|n \geq 1) = \frac{1}{n!} \cdot \frac{\mu^n e^{-\mu}}{1 - e^{-\mu}}$$

The parameter μ is evaluated from P(1) and used to randomly extract the number of vertices in the simulation.

Number of vertices in data above the Poisson prediction for high number of vertices.

Is the number of reconstructed vertices compatible with the long integration time of the Mimosa ?





$$\overline{n_{VTX}(f)} = \frac{\mu(f)}{1 - e^{-\mu(f)}} \rightarrow \mu(f) \qquad \mu(f) = \Delta t_{VTX} \cdot f$$

f = beam rate [Hz]

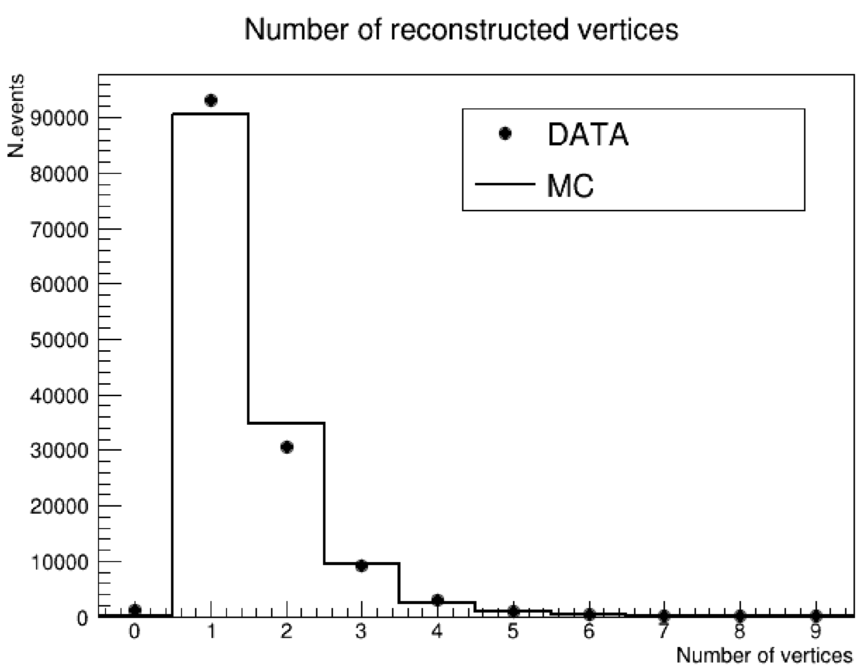
Δt_{VTX} = VTX integration time [s]

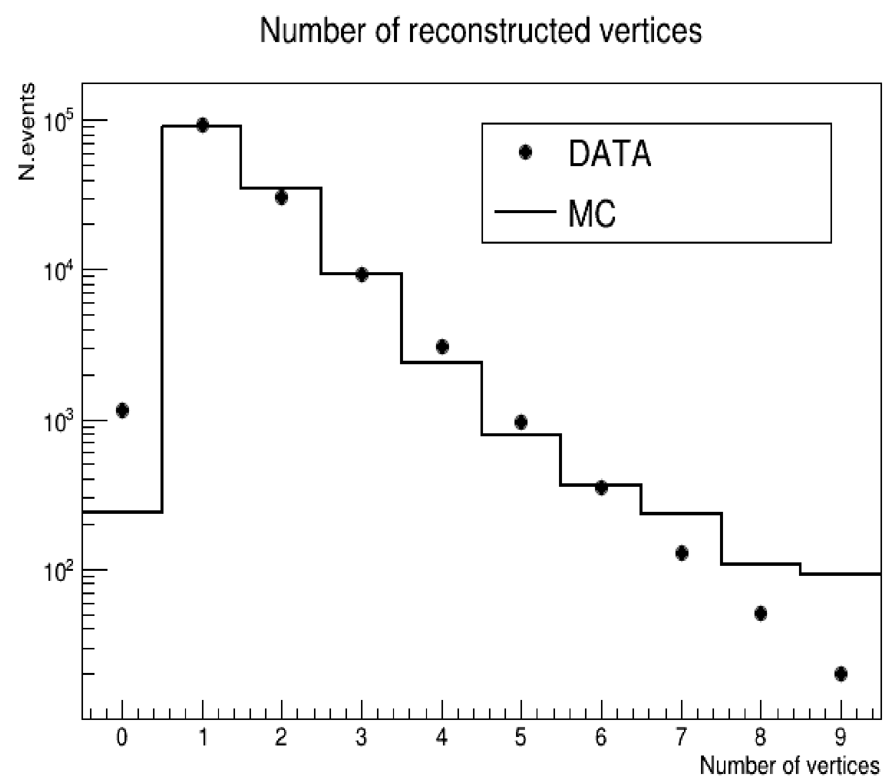
The dependence of the mean number of vertices with the beam rate is compatible with a Mimosa integration time **$\Delta t_{VTX} \approx 150\ \mu s$**.

SIMULATION OF PILE-UP

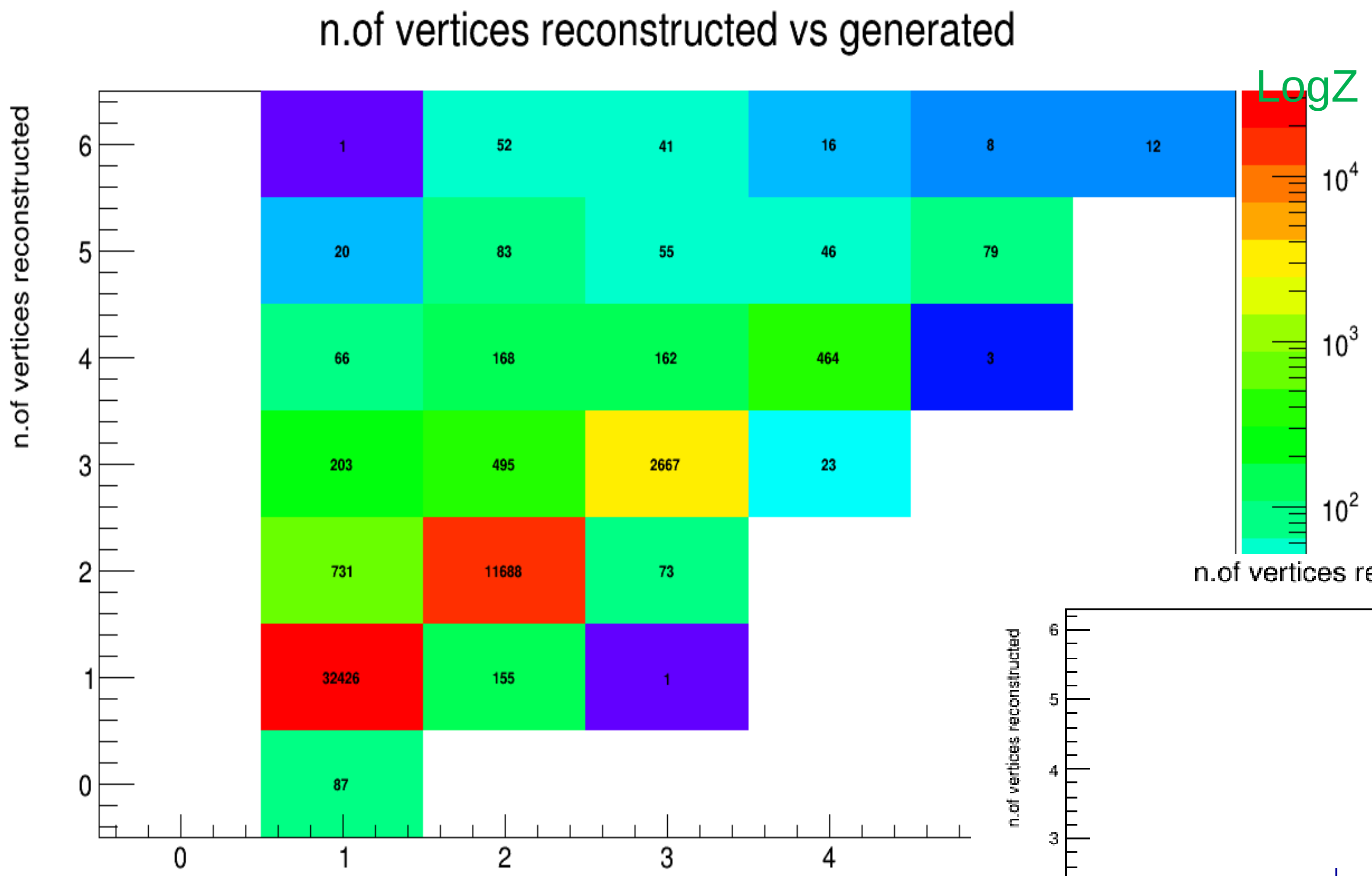
The pile up is simulated by adding VTX hits and MC track blocks from previous events stored in a FIFO.
A flag is used to decide if the stored events are saved in the root file or not.
The track IDs in the MC block for overlapped events are updated to avoid overlaps between different events (the navigation in the MC blocks of different overlapped events are independent).
The overlapped Mimosa hits point to the right track of the corresponding MC block.

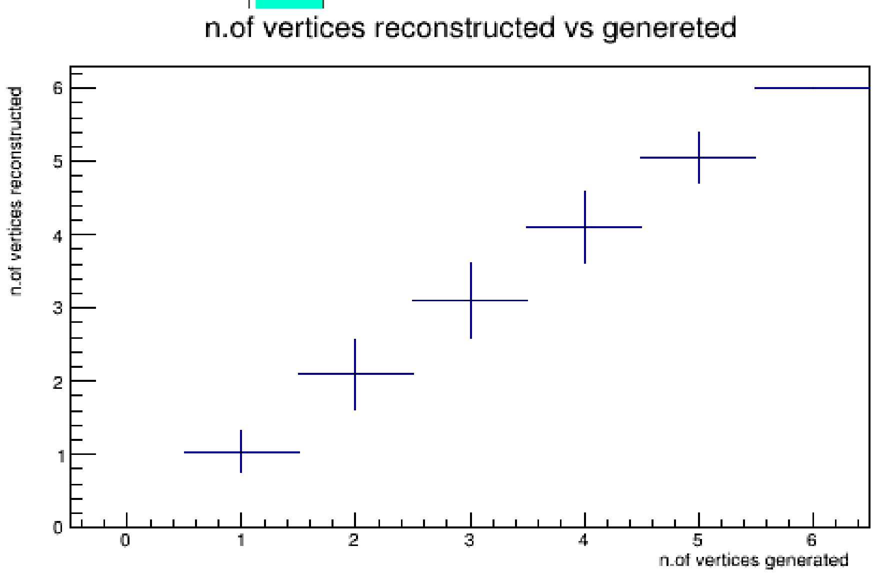
Number of reconstructed vertices data vs MC.





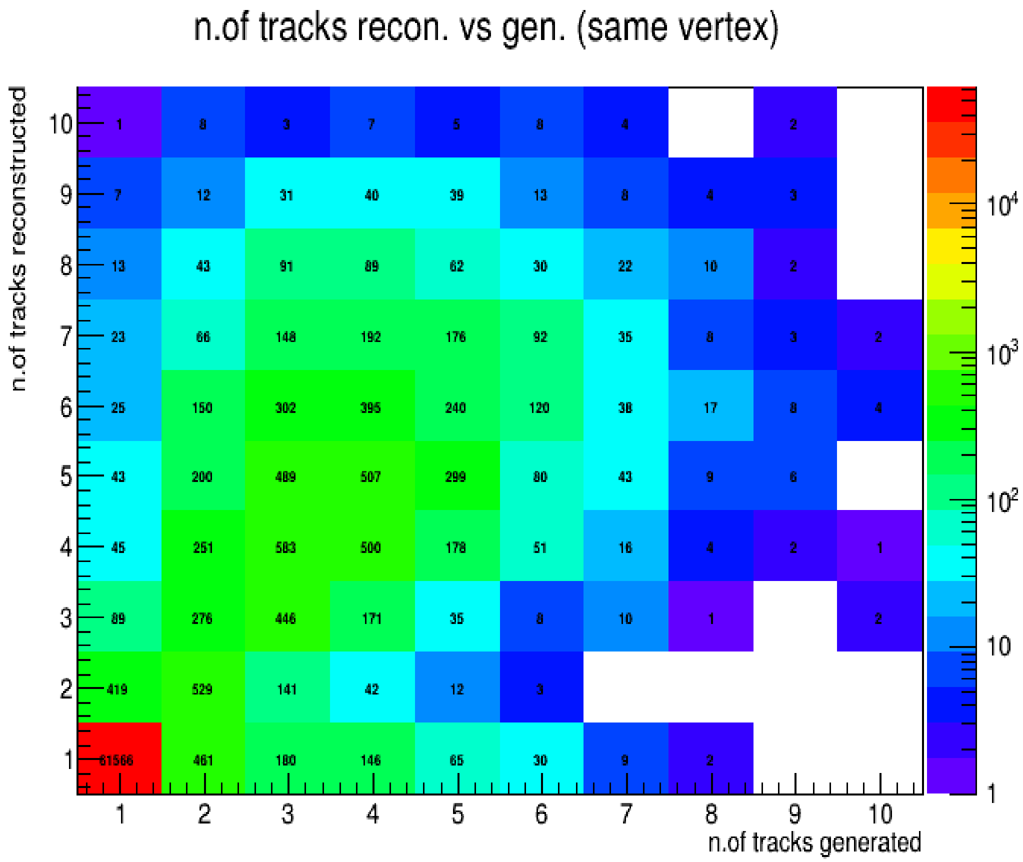
A FIRST LOOK AT THE VTX RECONSTRUCTION
WITH THE SIMULATION IN THE PRESENCE OF PILE-UP

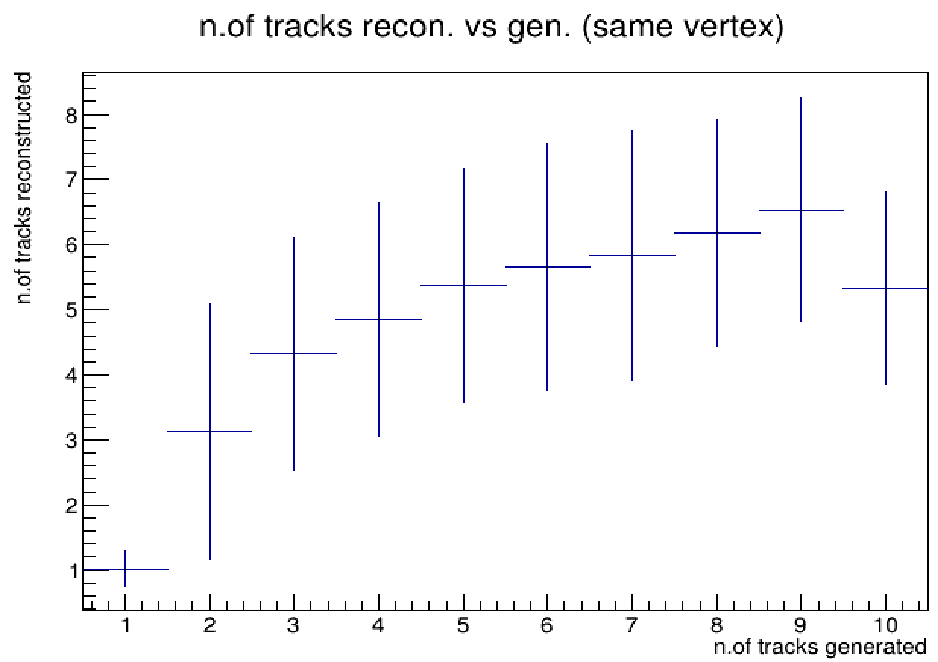




Very good correlation.

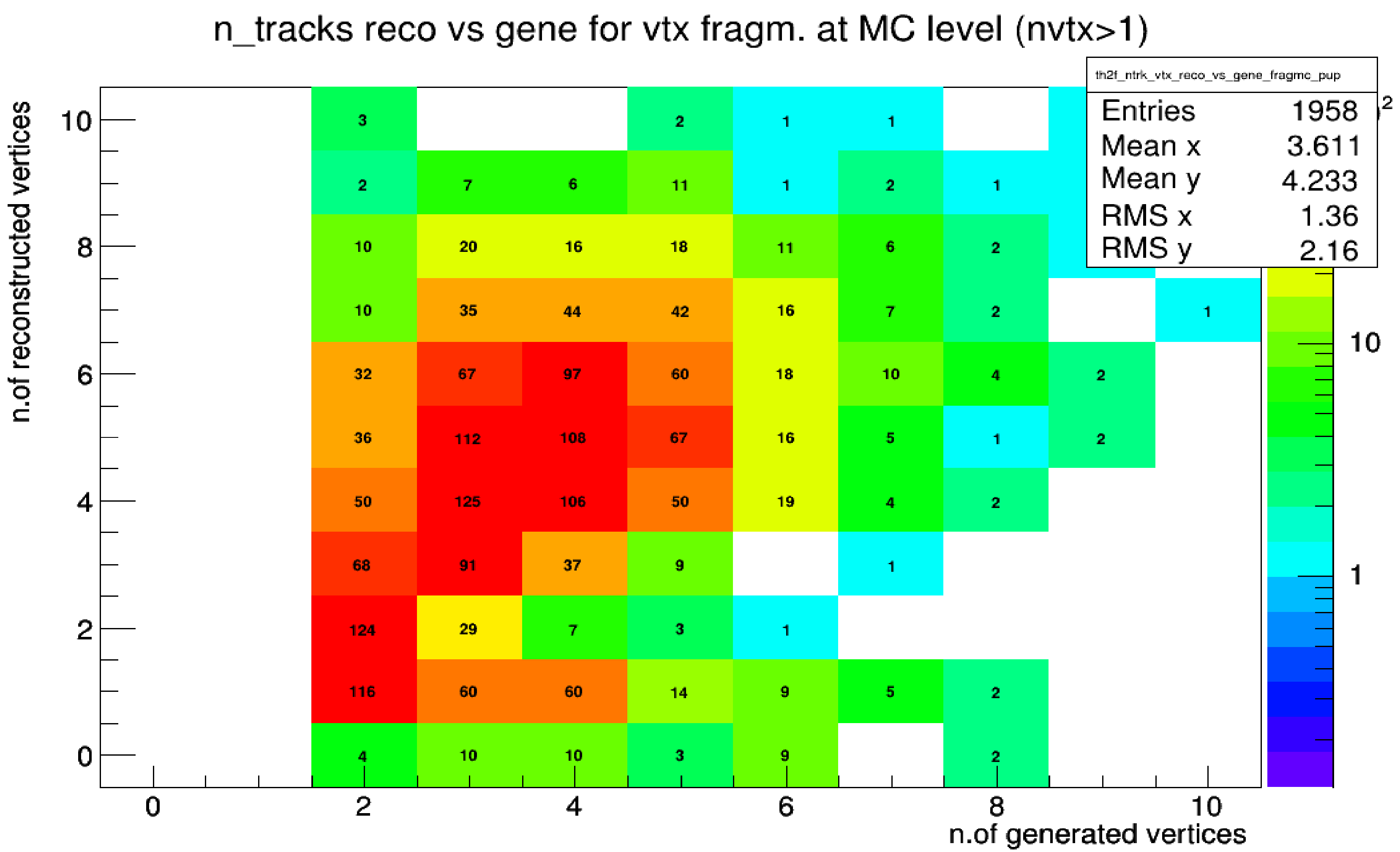
For each vertex the number of reconstructed tracks is correlated with the number of generated tracks for the same vertex (generated tracks = true tracks crossing the VTX)





It seems there is a tendency to reconstruct more tracks than generated in some vertices, less in others (when n.vtx > 1).

N.of reconstructed tracks vs n.of generated tracks from fragmentation vertices (fragmentation vertices defined at MC level).



SELECTION OF FRAGMENTED EVENTS AT THE VTX

Fragmentation events are defined as events where there is
one vertex with >1 track at the MC level

50000 MC events
6013 MC fragmentation events
4986 (**82,9%**) have more than 1 track from the vtx matching the BM.

If only pile-up events are considered:

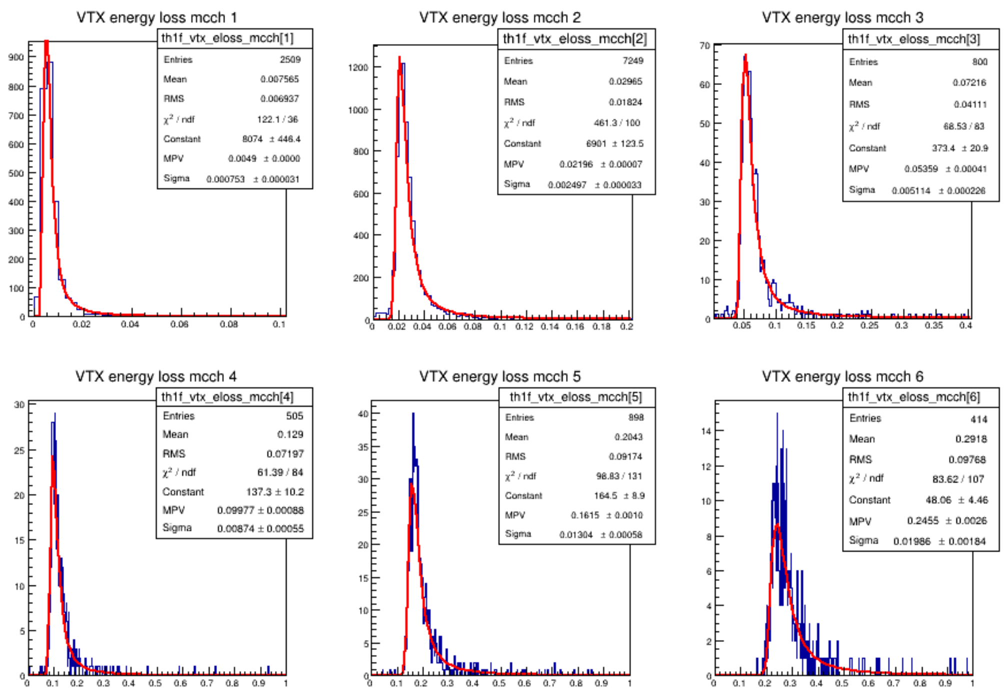
16464 MC events with pile-up
1958 MC fragmentation events with pile-up
1493 (**76,0 %**) have more than 1 track from the vtx matching the BM

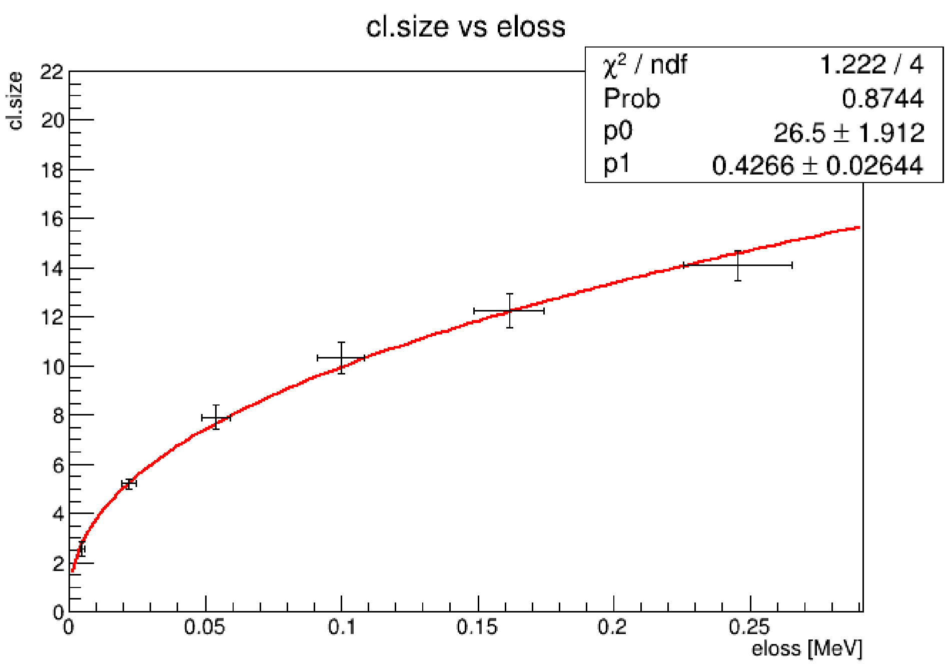
According to the simulation the efficiency to select a fragmentatioon event by requiring >1 track from the vertex associated to the BM track is about 83% (little less in case of pile-up).

VTX CLUSTER SIZE IN THE SIMULATION

The cluster size distributions have been fitted by Christian with a (modified) Landau distribution for each fragment charge.
There is a correlation between the MPV of the cluster size (from DATA) with the MPV of the energy loss distribution from MC.
This correlation is used to simulate the number of pixels belonging to a VTX cluster as a function of the energy loss in the VTX plane.

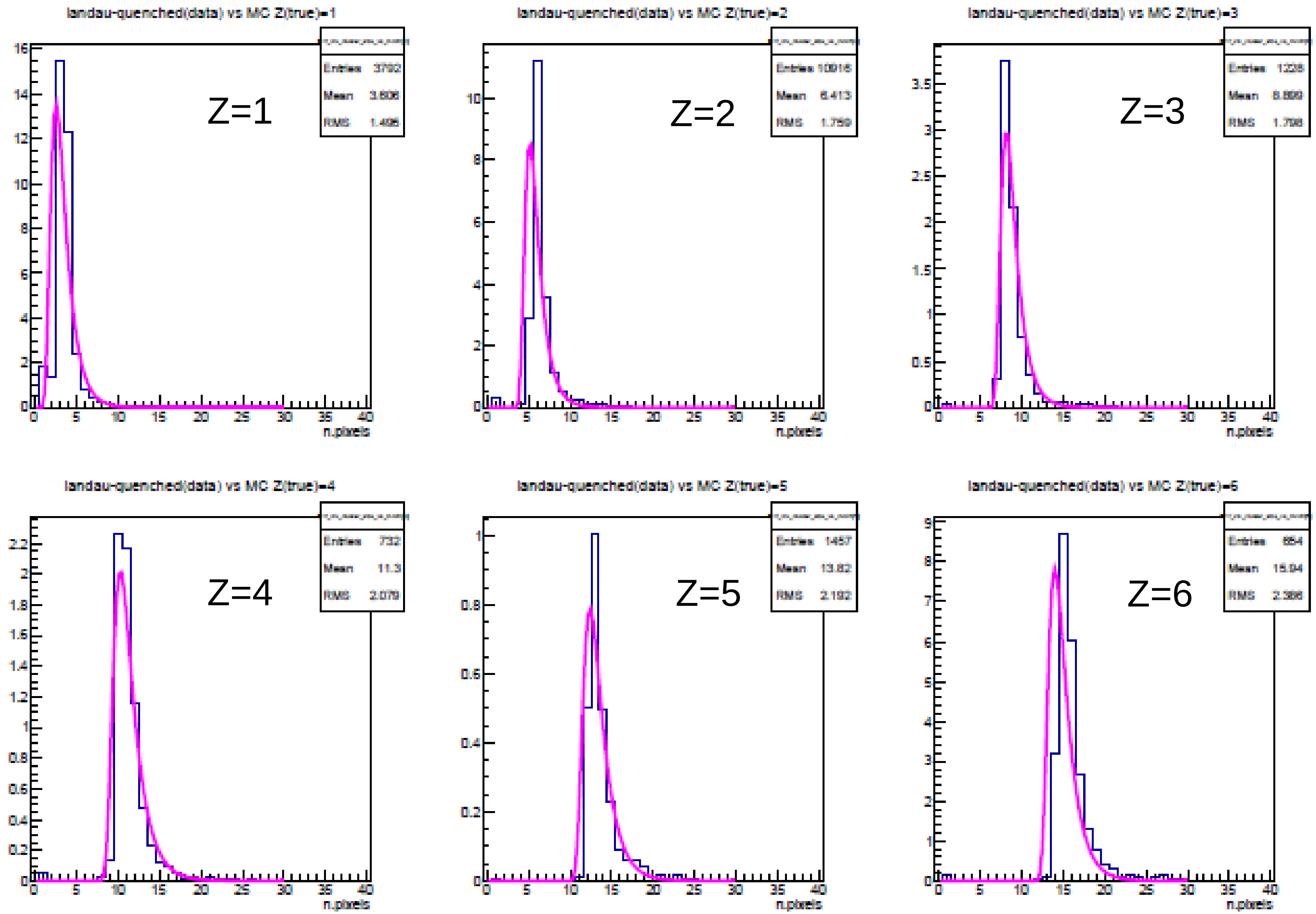
Eloss distribution for each charge





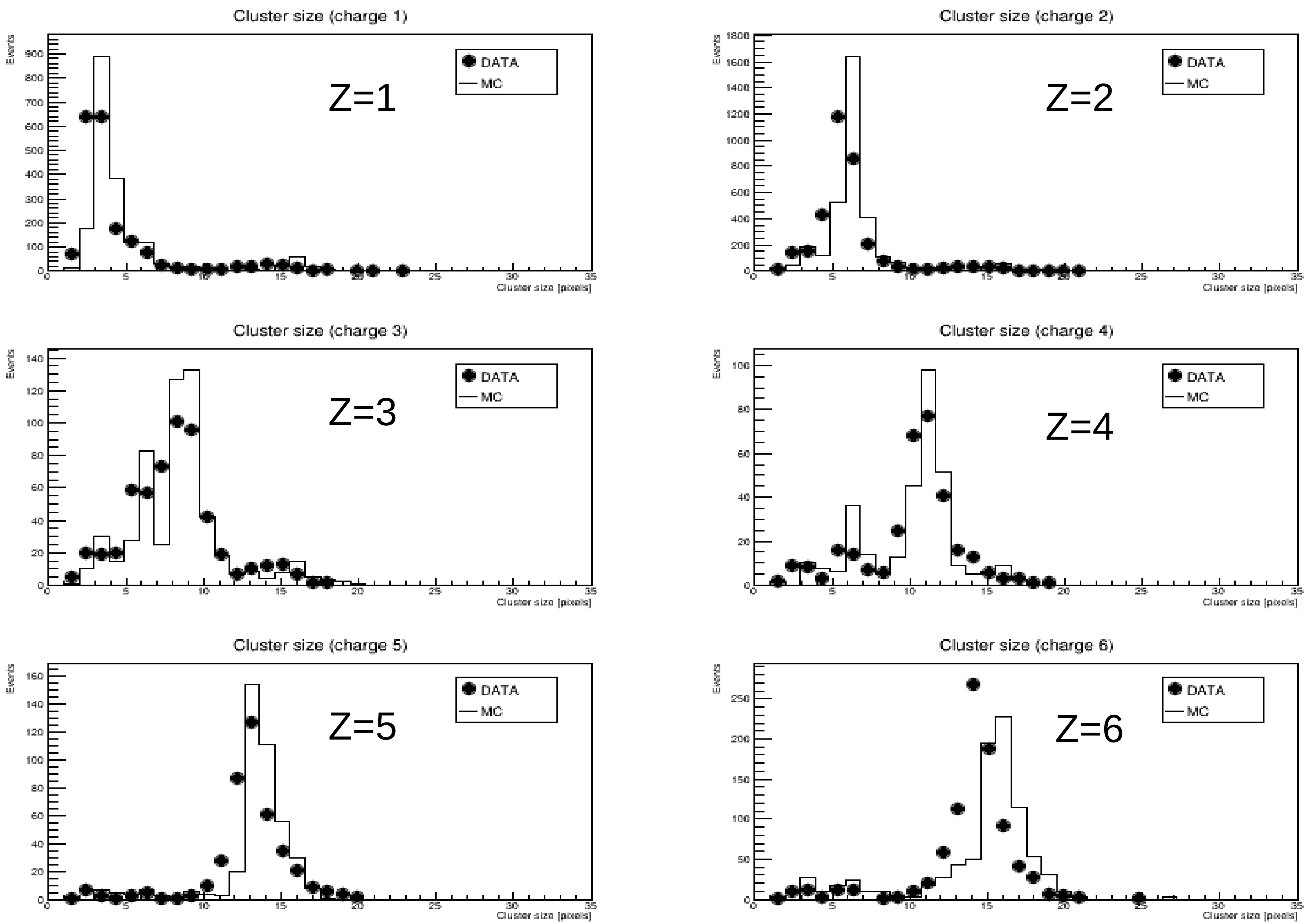
$$cl_{size} = p0 * pow(eloss, p1)$$

Comparison in the cluster size distribution from MC with the (modified) Landau distribution as parameterized by Christian as a function of charge (true MC charge used).



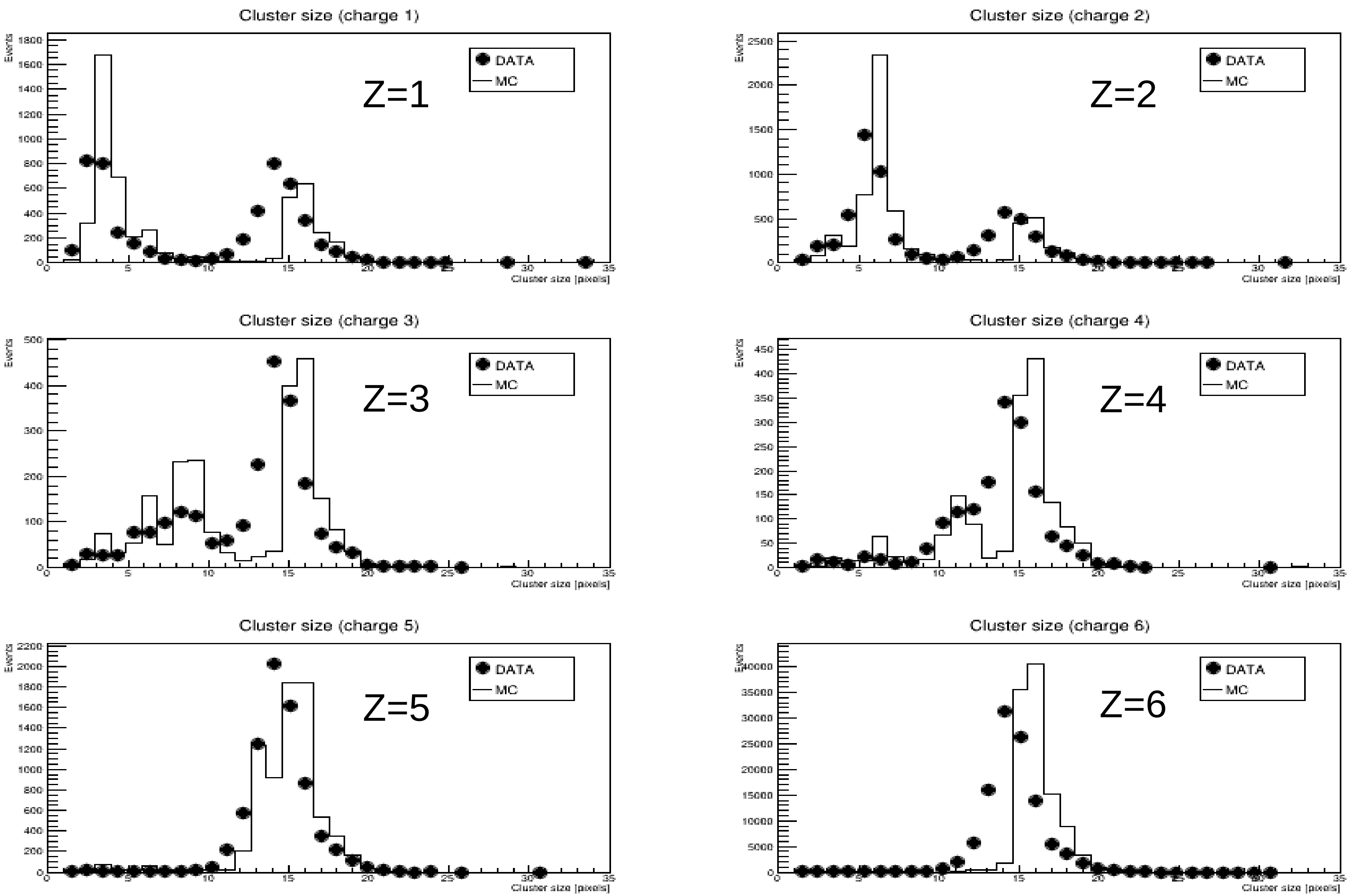
The agreement is worse when reconstructed tracks are considered (wrong VTX/TOF matches, charge reconstructed from TOF, pile up, etc...).

Cluster size distributions (data vs MC) for reconstructed tracks in fragmentation events.



(pile-up included in the simulation)

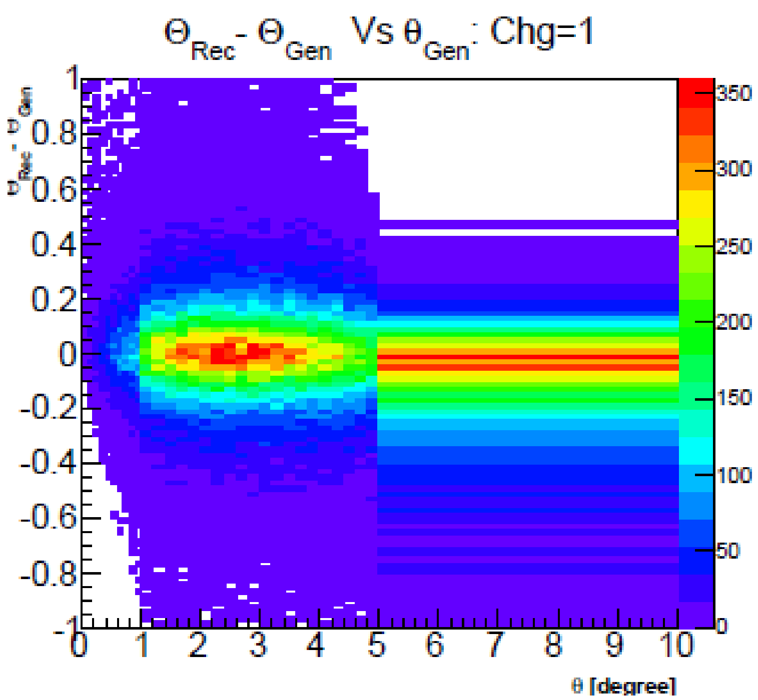
Cluster size distributions (data vs MC) for reconstructed tracks (all events).

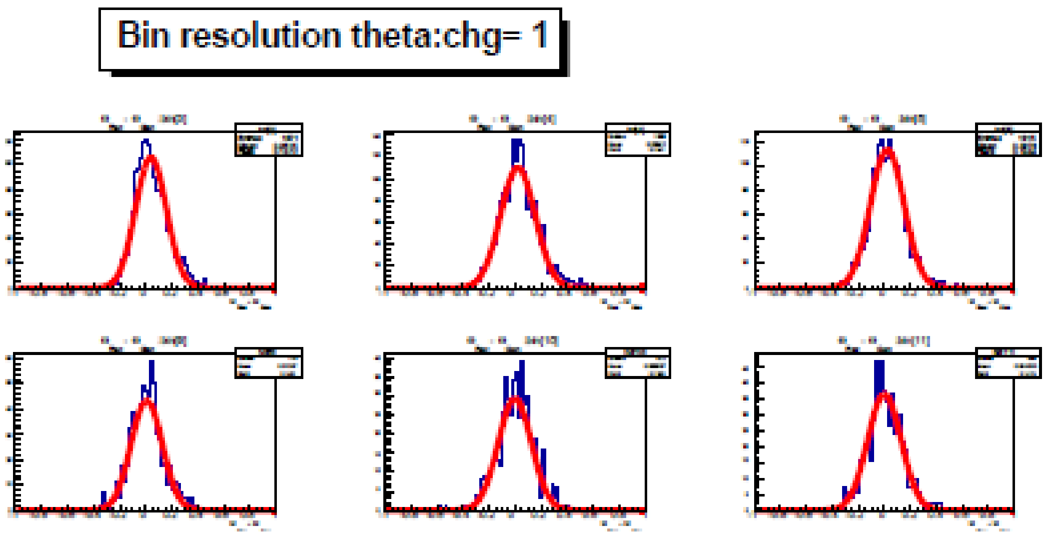


Pile-up included in the simulation.

Bin definition for cross sections

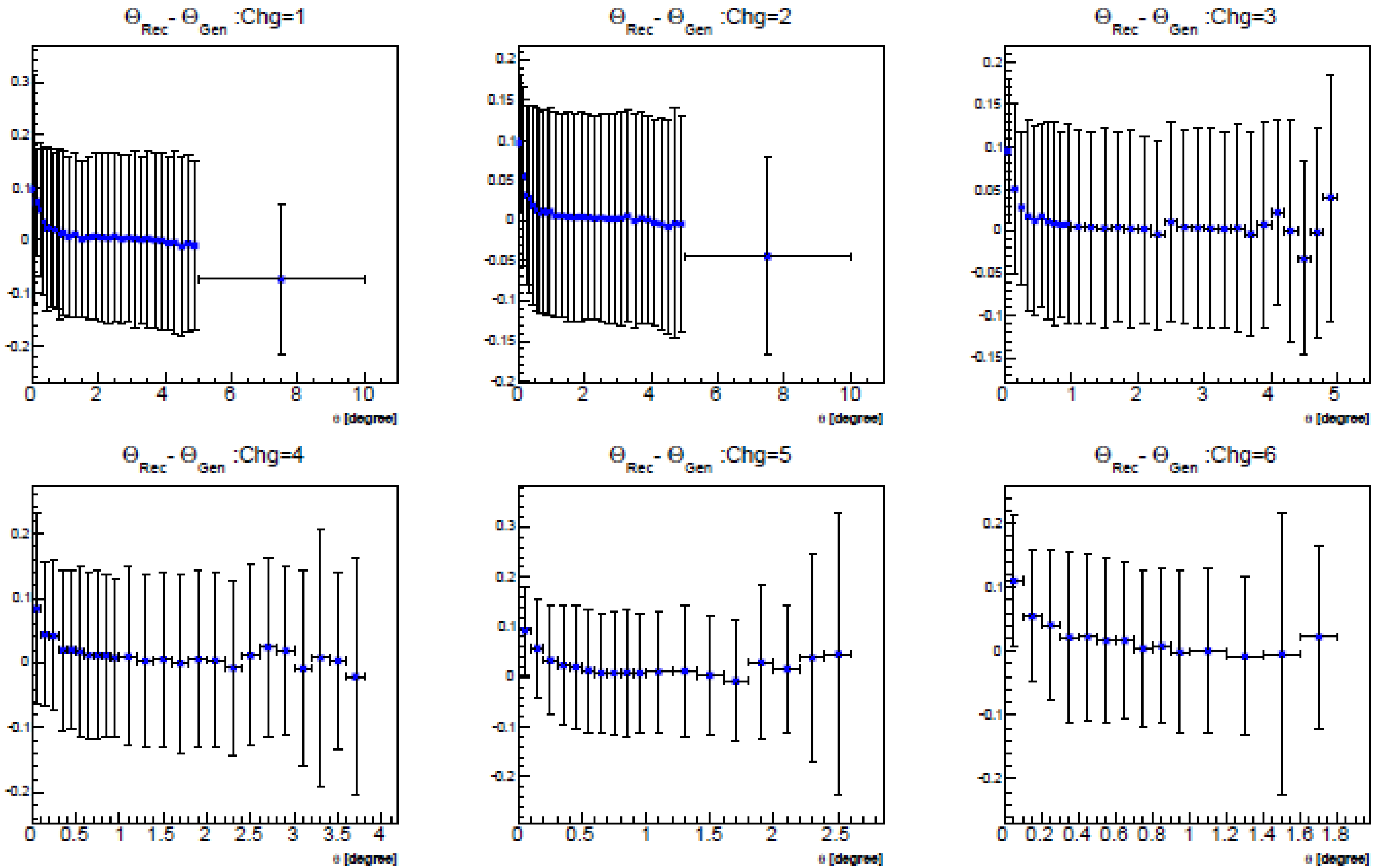
In order to limit the problems in the unfolding, the bin-width definition should minimize the migrations from different bins.
The resolutions and the offsets of reconstructed quantities with respect to the generated kinematic variables are studied for each bin (theta, ke, beta).
A first attempt to change the bin definition in order to minimize the number of tracks in which the kinematic variable is reconstructed in a bin different from the bin of the corresponding generated quantity (and to maximize efficiencies and purities)





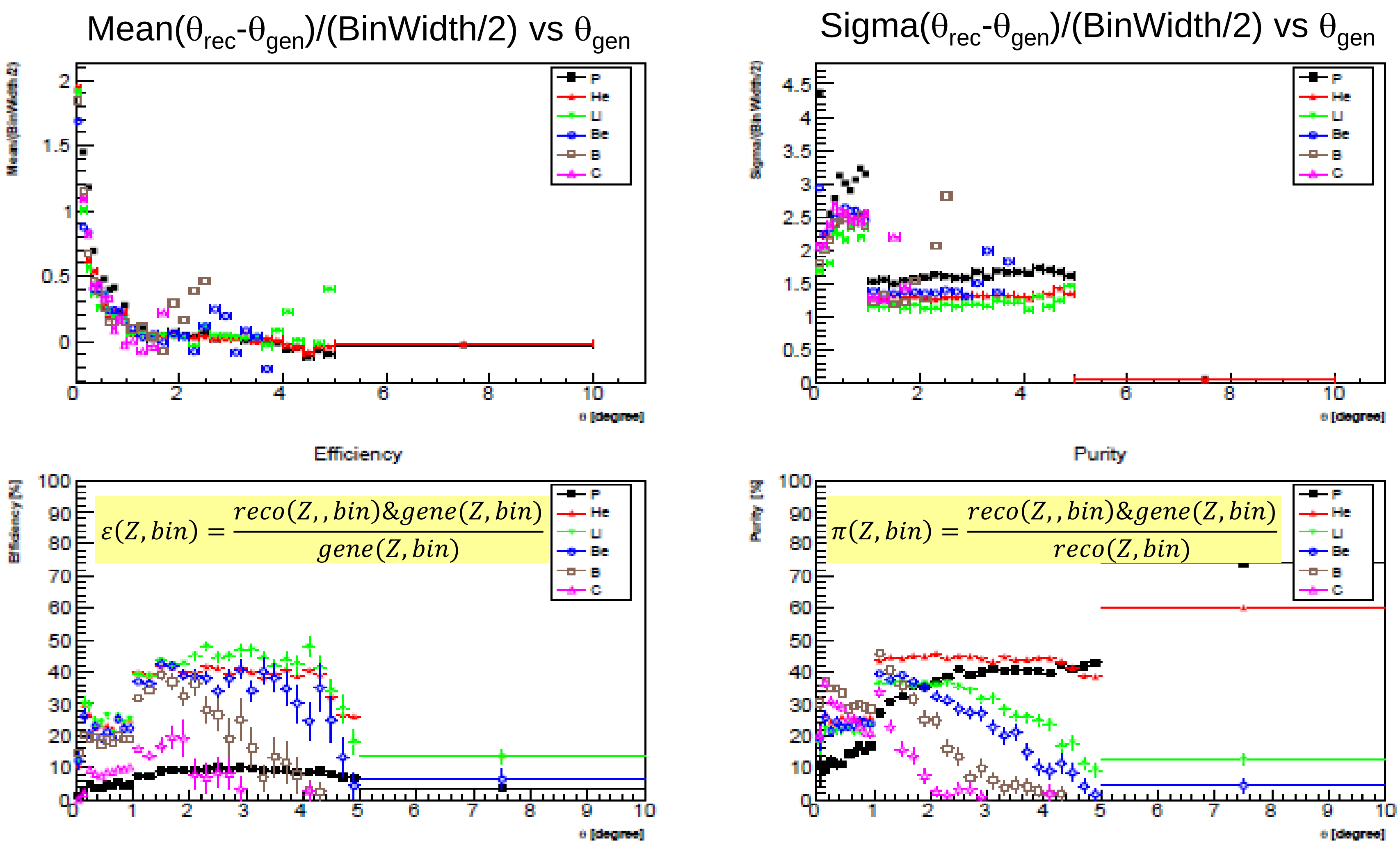
Only fragmented events used
(>1 track from the BM matched vertex).

Mean and sigma values from the gaussian fits of resolutions plot



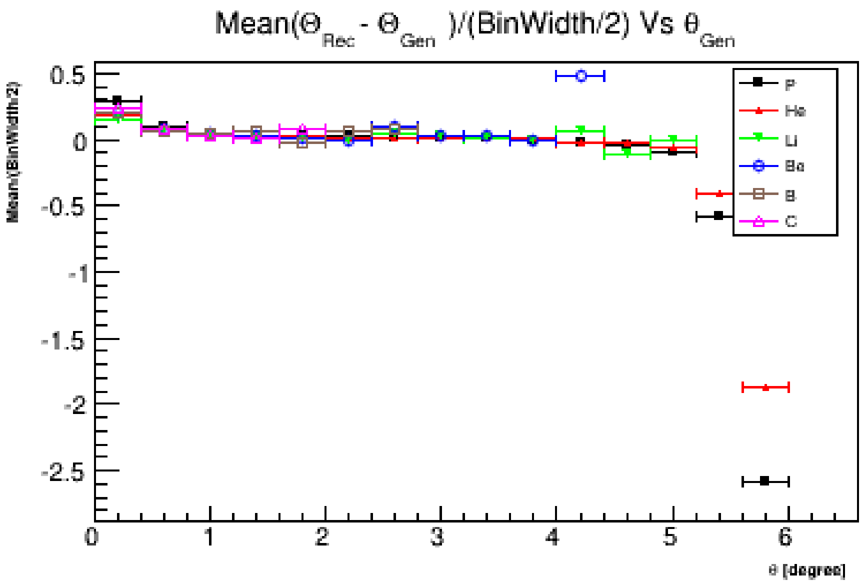
NOTE: we use as generated kinematic variables, the «true» MC values in the fragmentation point inside the target (if any). The theta resolutions include multiple scattering effects inside the target.

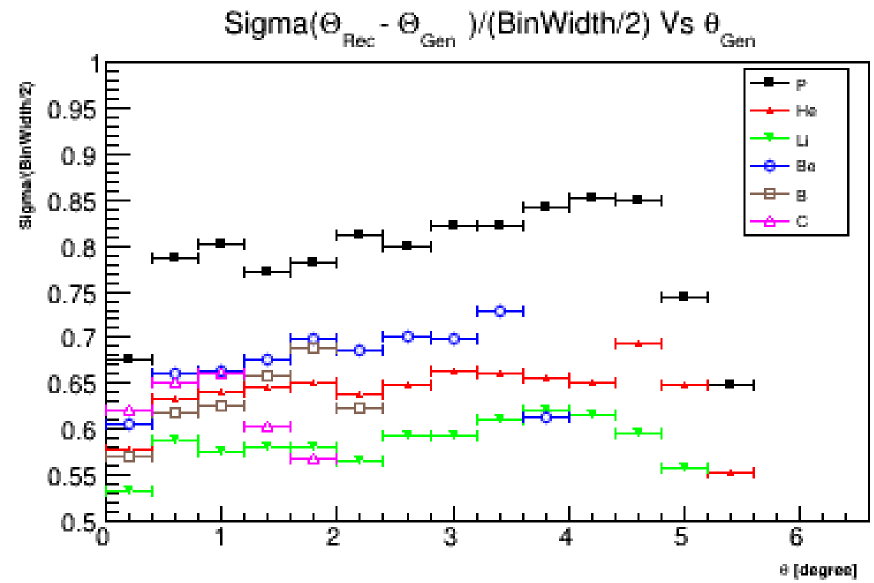
Mean and sigma values divided by the bin width. Efficiencies and purities.

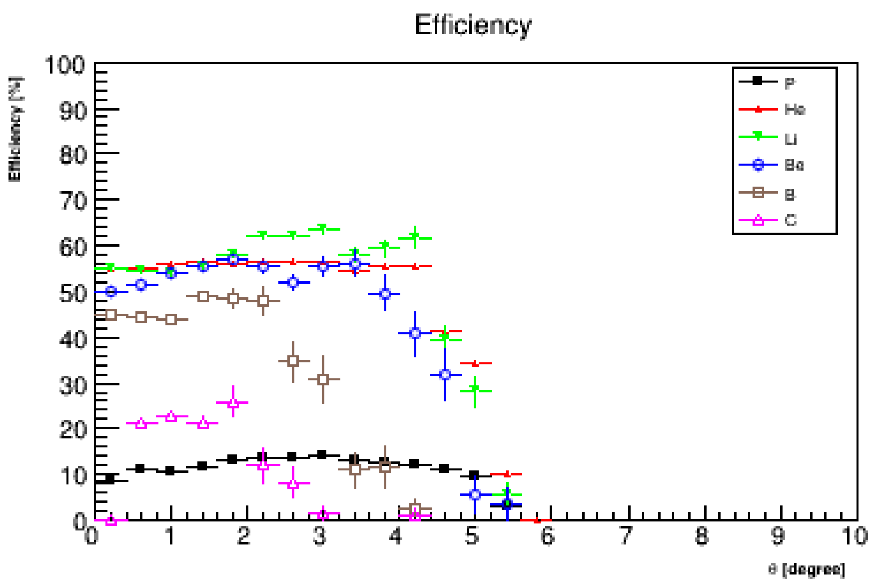


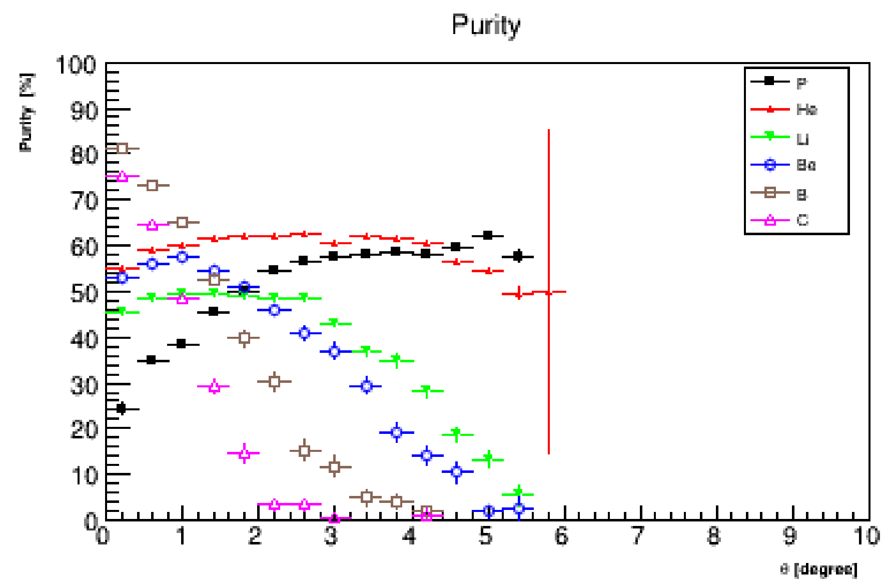
The original bin definition is not optimal for theta< 1 degree (resolutions higher than the bin size, low efficiency and purities).
In addition, this is the region where we suffer from contaminations from carbon to lower charge when the fragmentation cut is released.

Offsets, resolutions (w.r.t. Bin size), efficiencies and purities with wider bins





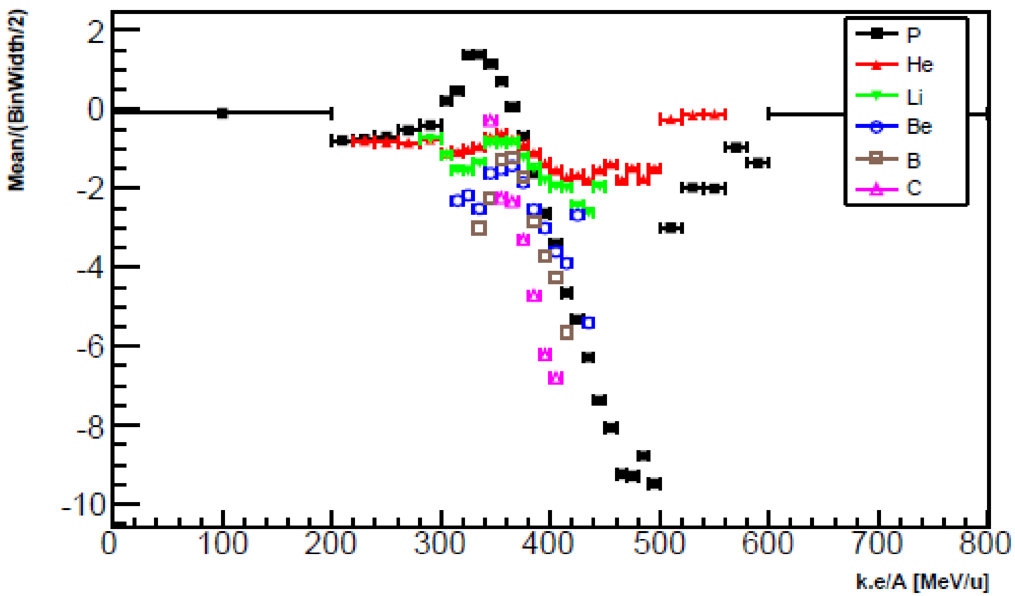




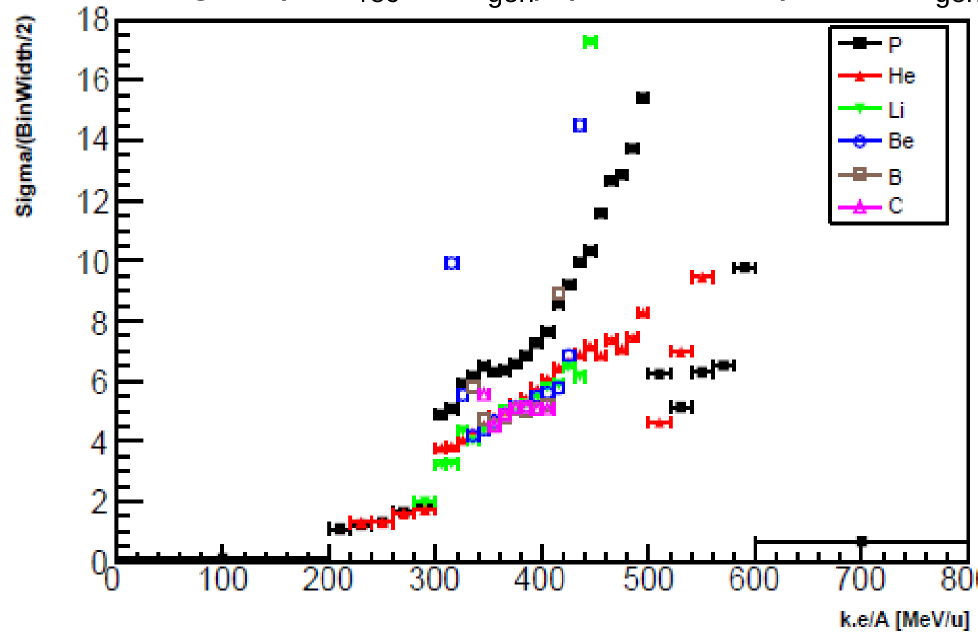
Bins for KineticEnergy/Mass

The KE/A is calculated using the reconstructed momentum and mass.

Mean(keA_{rec}-keA_{gen})/(BinWidth/2) vs keA_{gen}



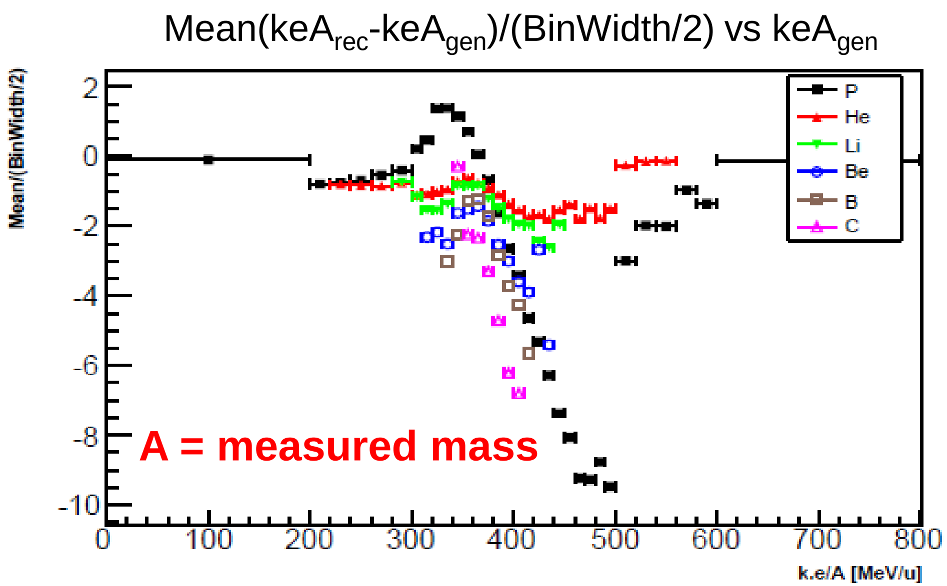
Sigma(keA_{rec}-keA_{gen})/(BinWidth/2) vs keA_{gen}

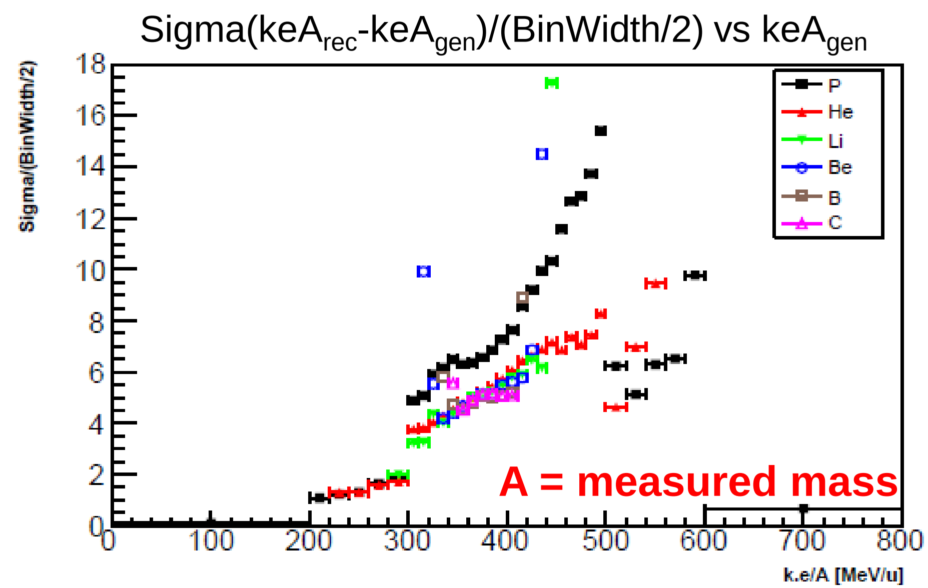


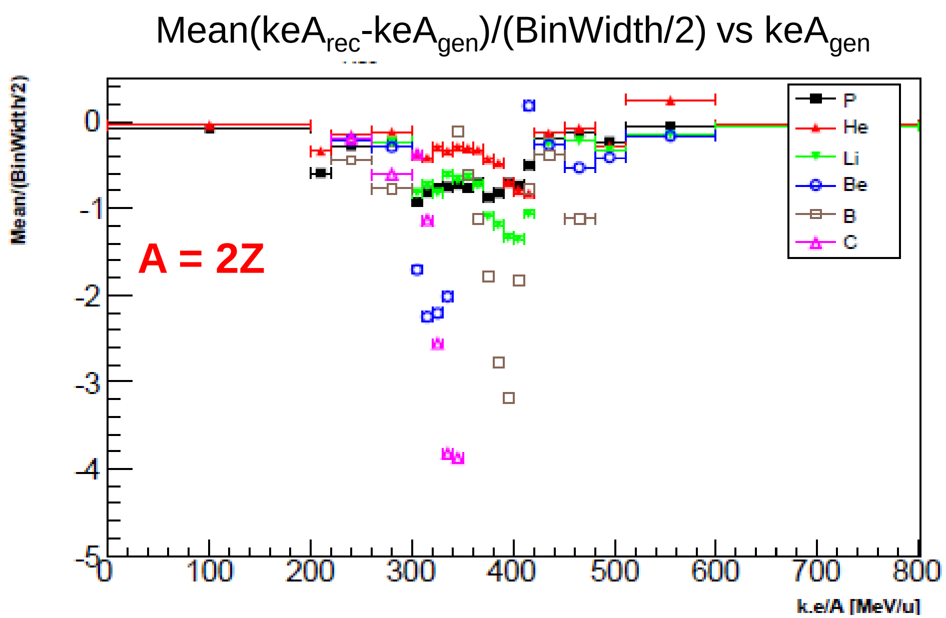
Strong trends and high values for mean and sigma's from resolution fits when compared with the widths of original bin definition).

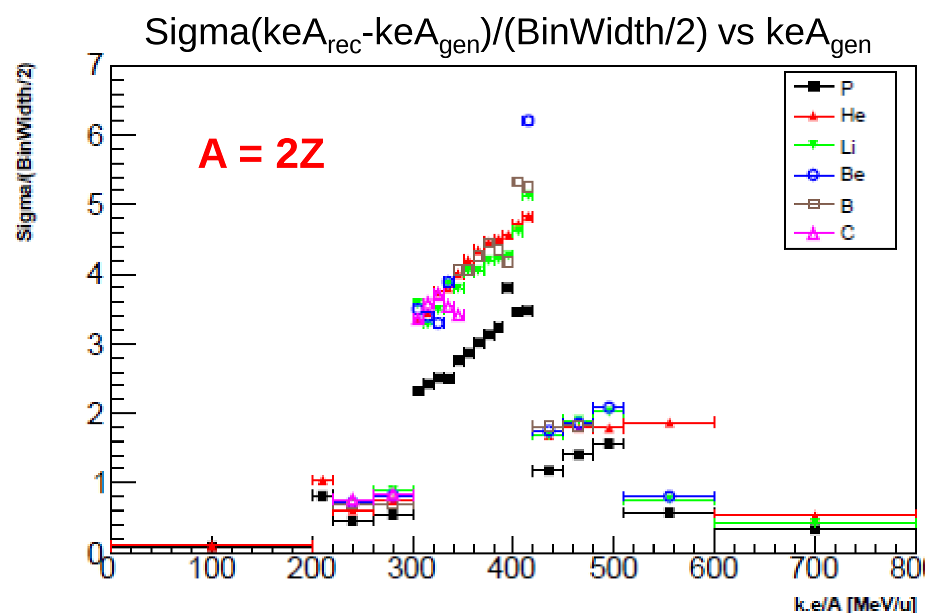
In addition, if we use the measured mass to defined the variable in the differential cross section, is it allowed to fit the same measured mass to find the contribution of different isotopes for each charge ?

In the reconstruction code the momentum is found by assuming that A=2Z (or A=Z for Z=1). What happen if we keep this assumption in the definition of Ke Instead of using the mass measured using the tof ?

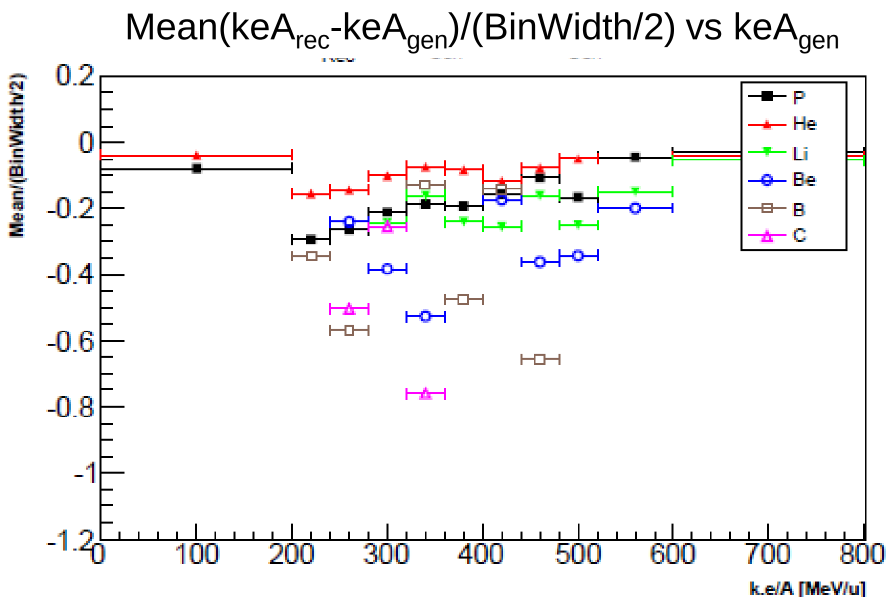


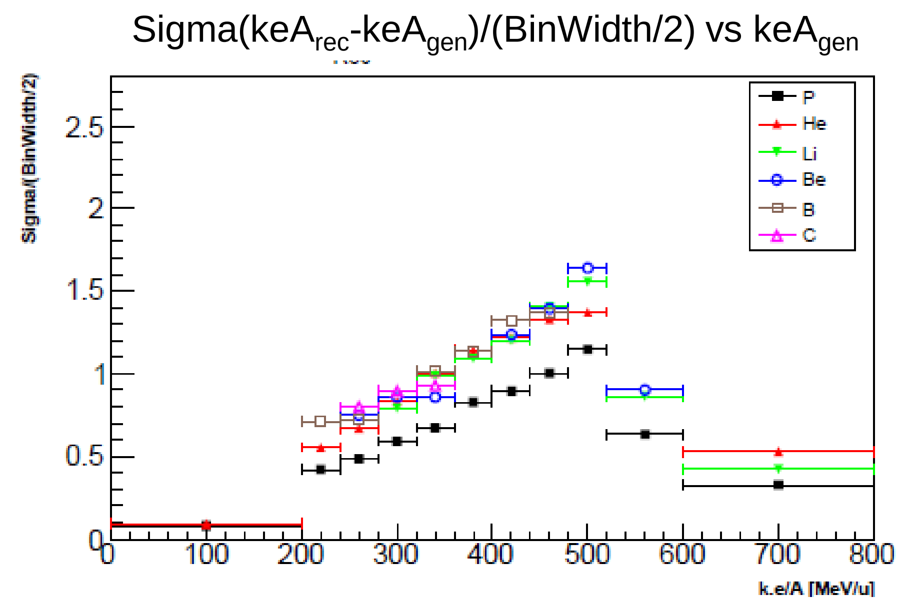


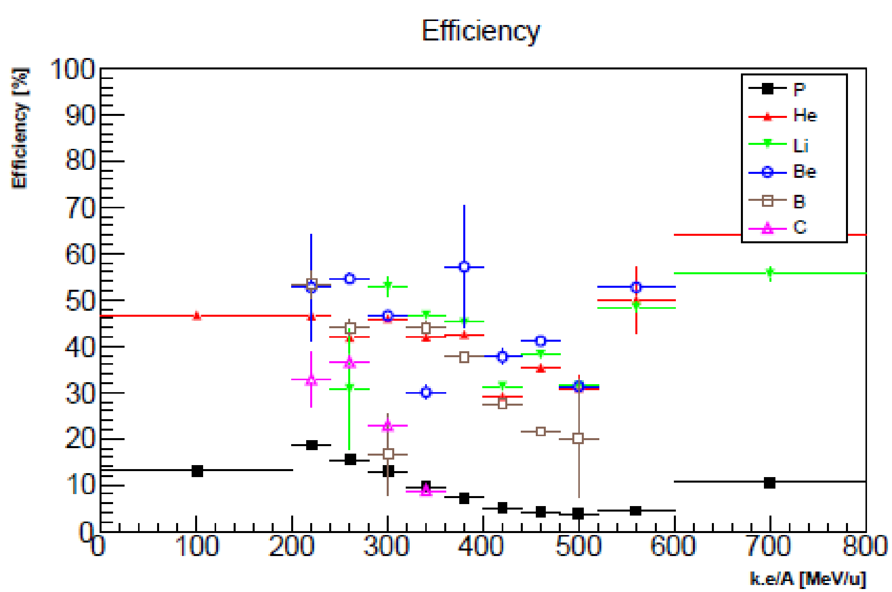


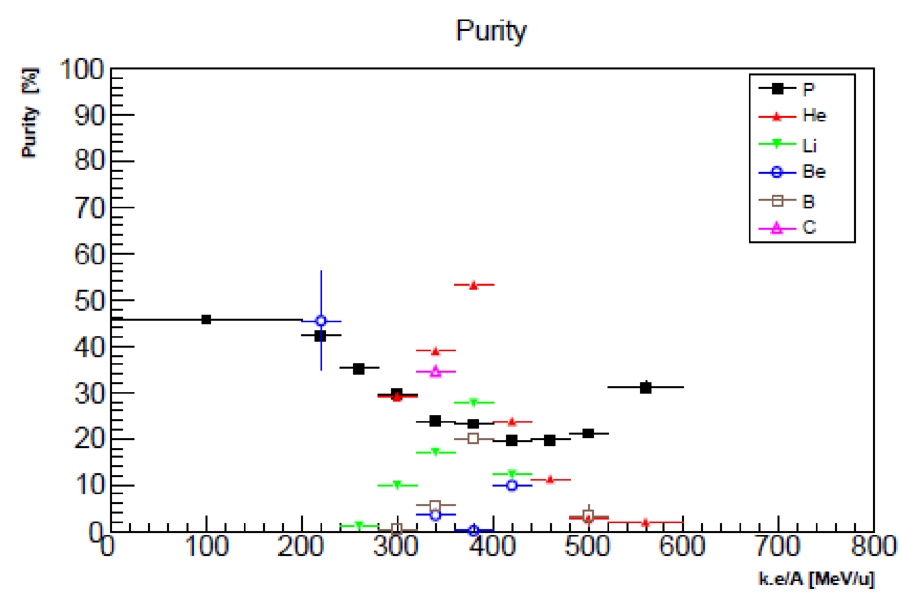


Attempt to optimize the bin size to reduce the bin migrations and maximize the purities and offsets.

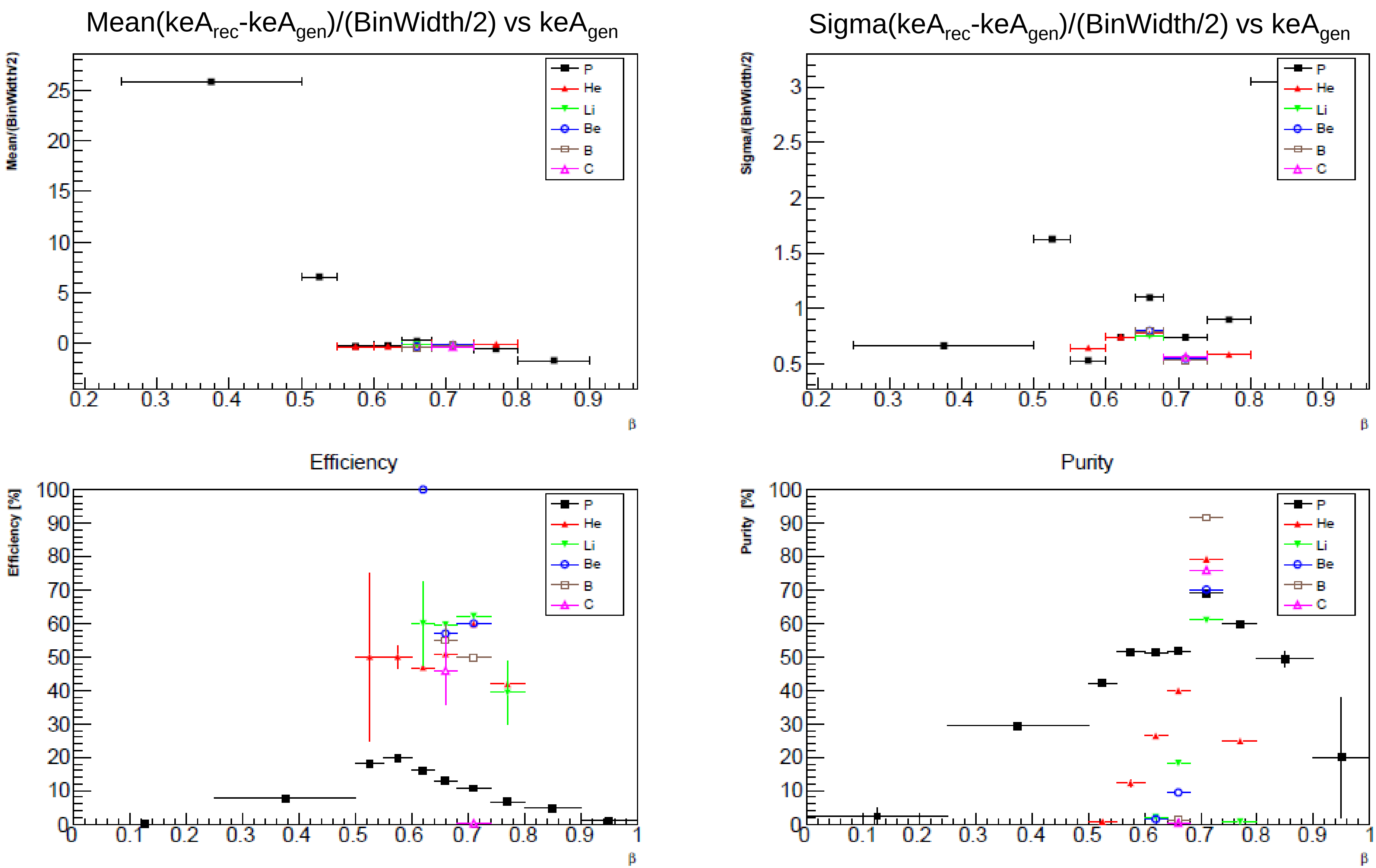








Is it better to define the differential cross section in terms of beta instead of ke ?



DIFFICULT: the measured beta values are limited to a very short kinematic region (due to the acceptance of the apparatus). Very few bins can be defined if the migrations are minimized.