Impact of the beam rate at CNAO

Marco Bon - 31/05/2022

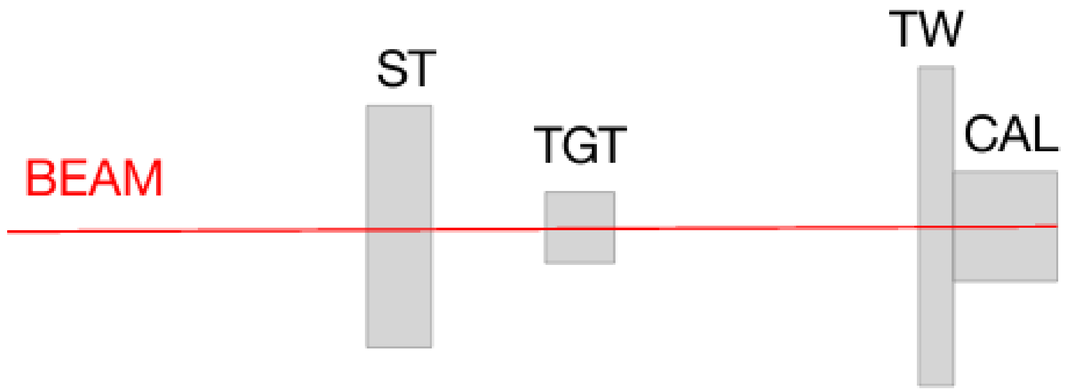
Introduction

- The aim of this presentation is to show the impact of the beam rate on the Z-ID and on the trigger efficiency using data taken from CNAO in November 2021

- Beam: Carbon ions with

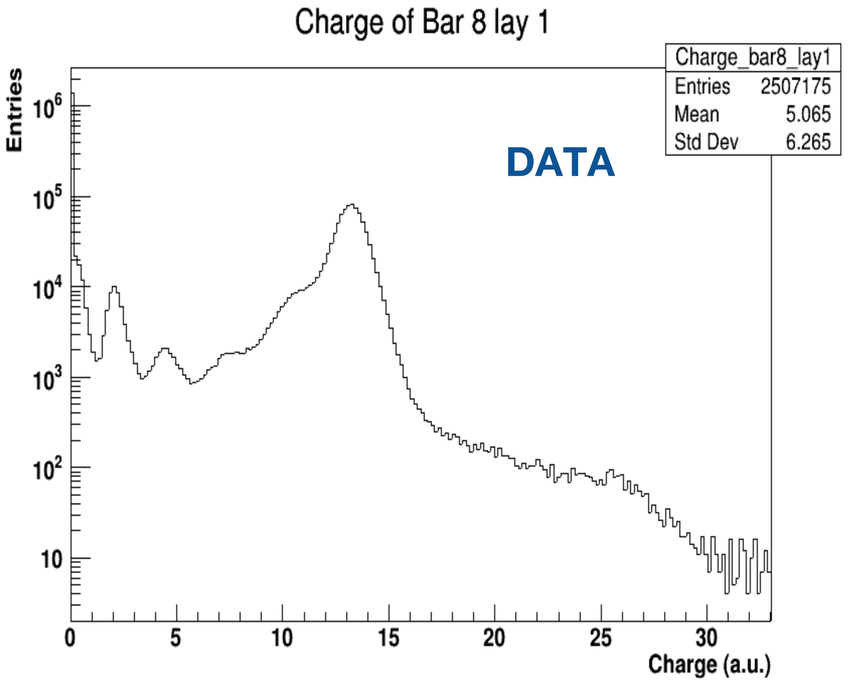
  1) E=200 Mev/N, Target: C, C2H4, Events $\sim 10^7$ (for cross section measurement)

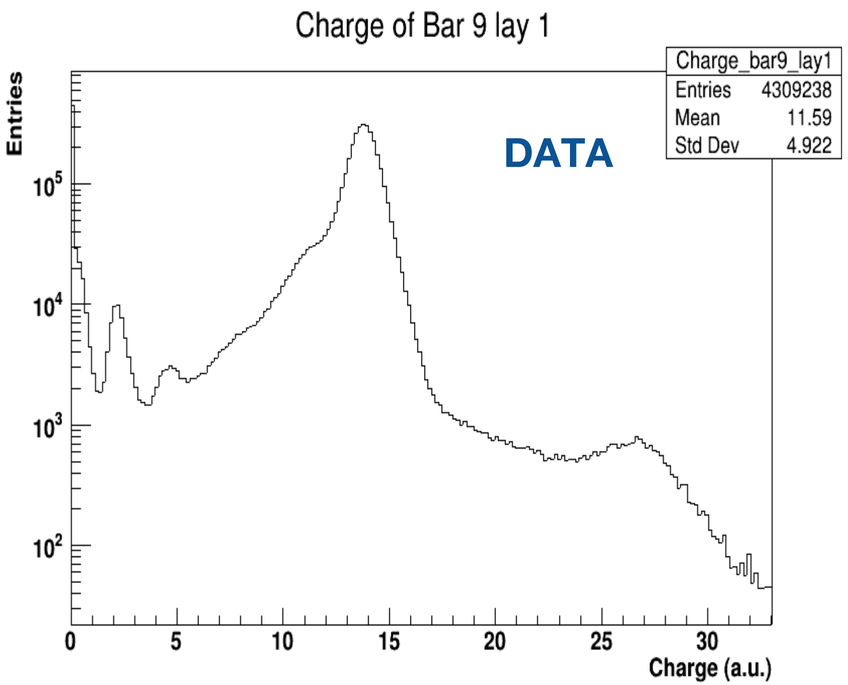
  2) E=(150, 300, 400)MeV/N, Target: C, Events $\sim 10^6$ (for calibration purposes)

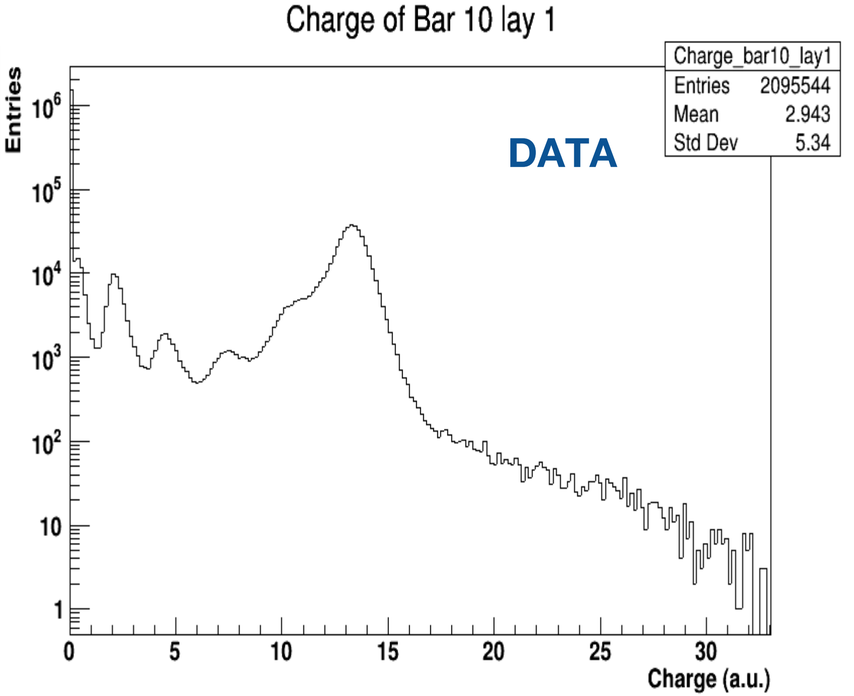


Charge in the central bars

- In the central bars (8-9-10) we don’t see clearly the expected peaks
- 200 MeV/u — All run

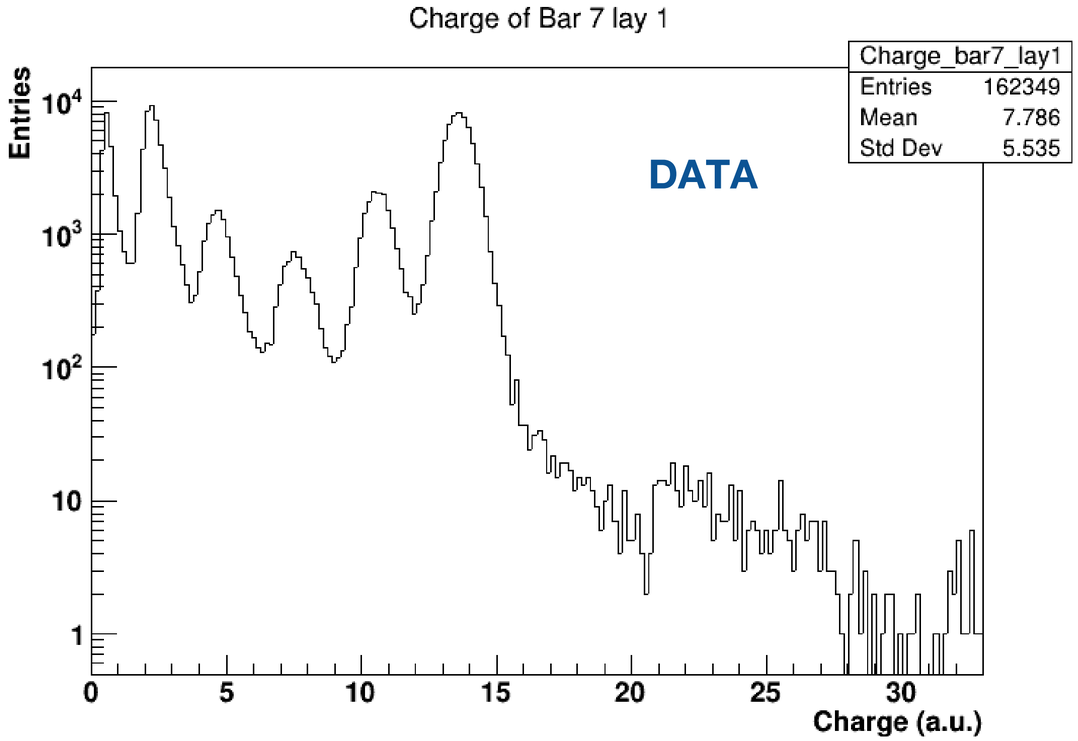


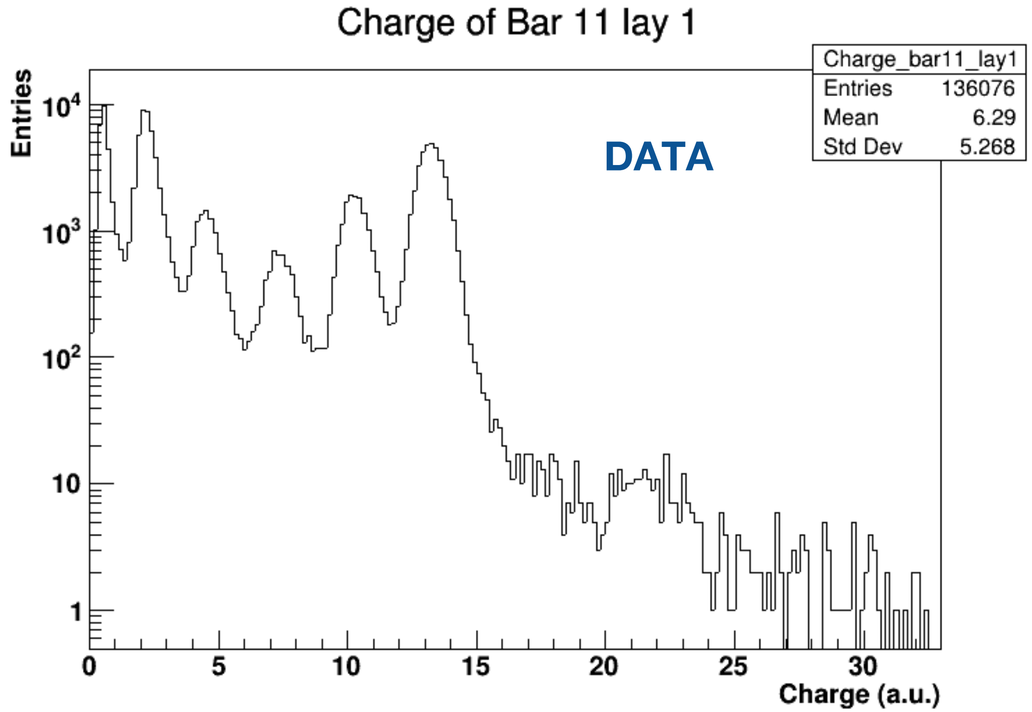




Charge in bars 7-11

- For the “lateral” bars we don’t have the same effect
- 200MeV/N — All runs



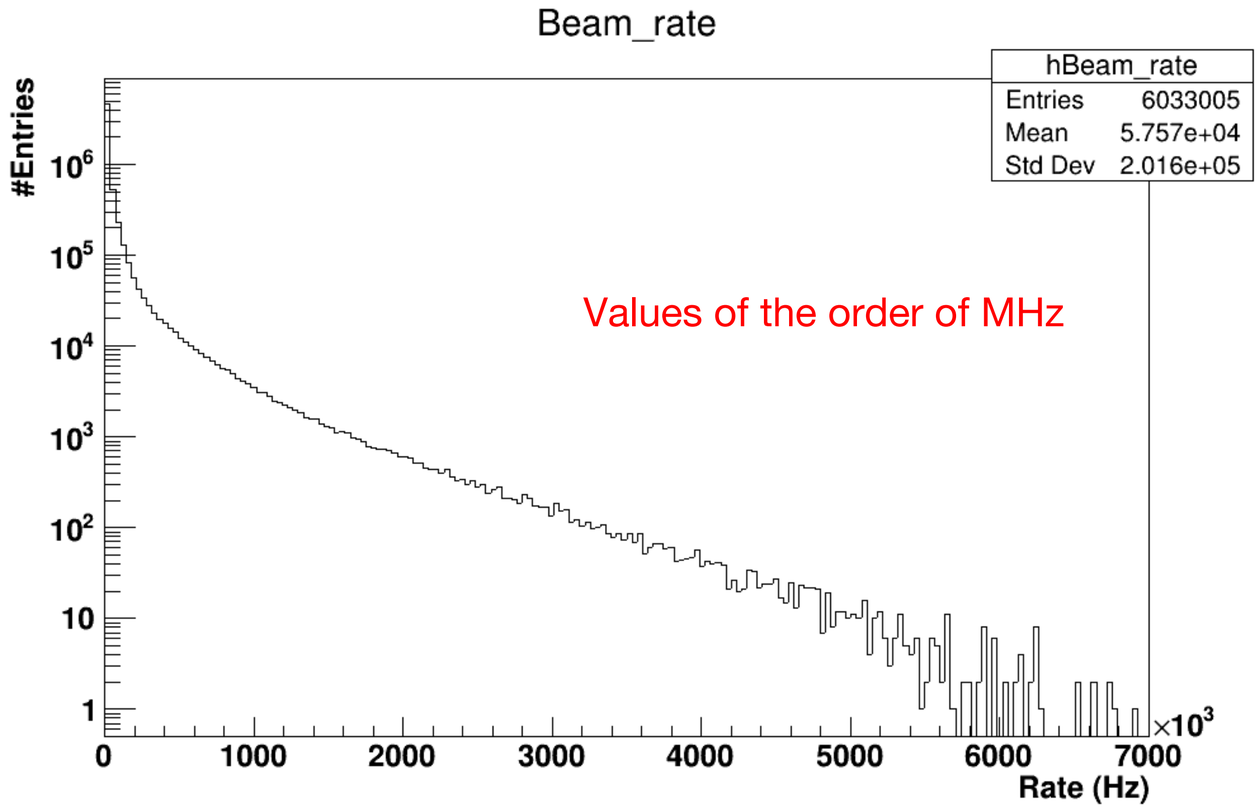


Beam rate

- In order to understand the problem we studied the rate.

$$rate = \frac{TriggersCounter - oldTriggersCounter}{RunTime - oldRunTime}$$

- 200 MeV/u — All run

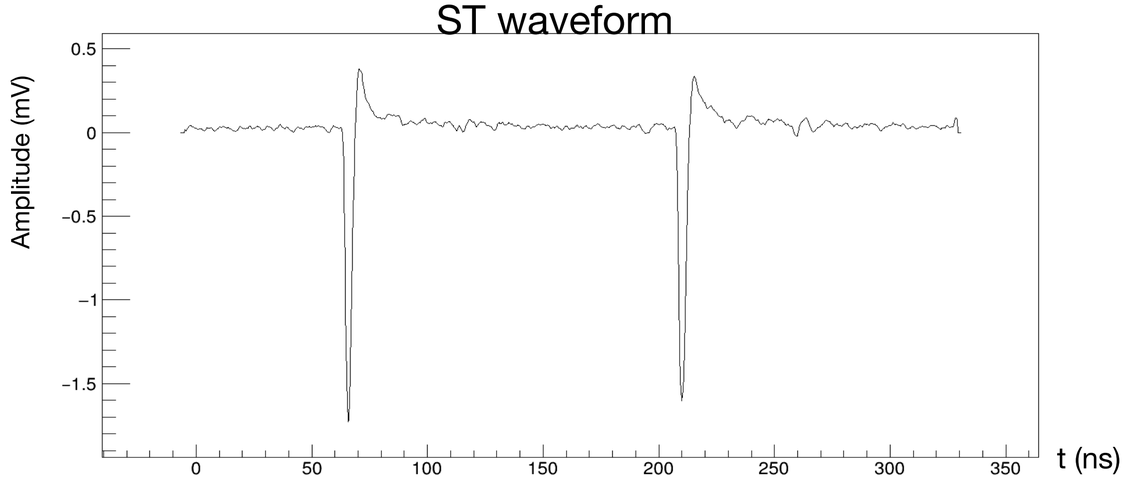


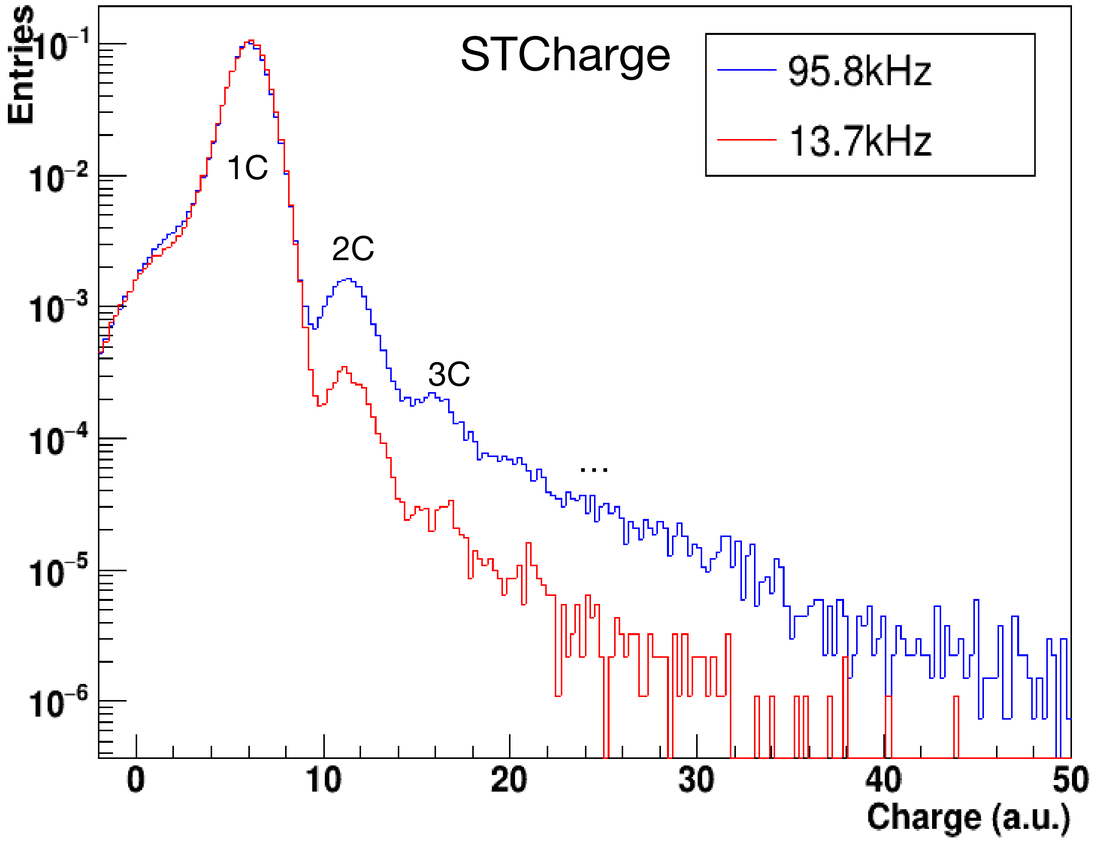
1st NIGHT			
E (MeV/u)	**Runs**	**Trigger**	**Mean beam rate (kHz)**
200	751-865	MB	20.1
200	1000-1093	MB	23.8
200	1100-1446	MB+frag	67.9
2nd NIGHT			
200	2000-2091	MB	18.6
200	2100-2470	MB	18.4
200	2500-2959	MB	13.7
200	3300-3969	MB+frag	95.8
200	4000-4226	MB+frag	65.3
3rd NIGHT			
200	10000-10035	MB+frag	54.9
200	10900-11069	MB	15.9
150	10650-10893	MB	93.2
150	10200-10624	MB+frag	175
300	11100-11231	MB	57.6
300	9660-9859	MB+frag	165
400	11300-11475	MB	21.5
400	9200-9957	MB+frag	52.1

Pile-up estimation

- Because of this high rate we tried to quantify the pile up with the start counter

E (MeV/u)	Runs	Trigger	Mean beam rate (kHz)	Pile-up (%)
1st NIGHT				
200	751-865	MB	20.1	0.49
200	1000-1093	MB	23.8	0.50
200	1100-1446	MB+frag	67.9	1.62
2nd NIGHT				
200	2000-2091	MB	18.6	0.48
200	2100-2470	MB	18.4	0.50
200	2500-2959	MB	**13.7**	**0.42**
200	3300-3969	MB+frag	**95.8**	**2.27**
200	4000-4226	MB+frag	65.3	1.71
3rd NIGHT				
200	10000-10035	MB+frag	54.9	1.71
200	10900-11069	MB	15.9	0.46



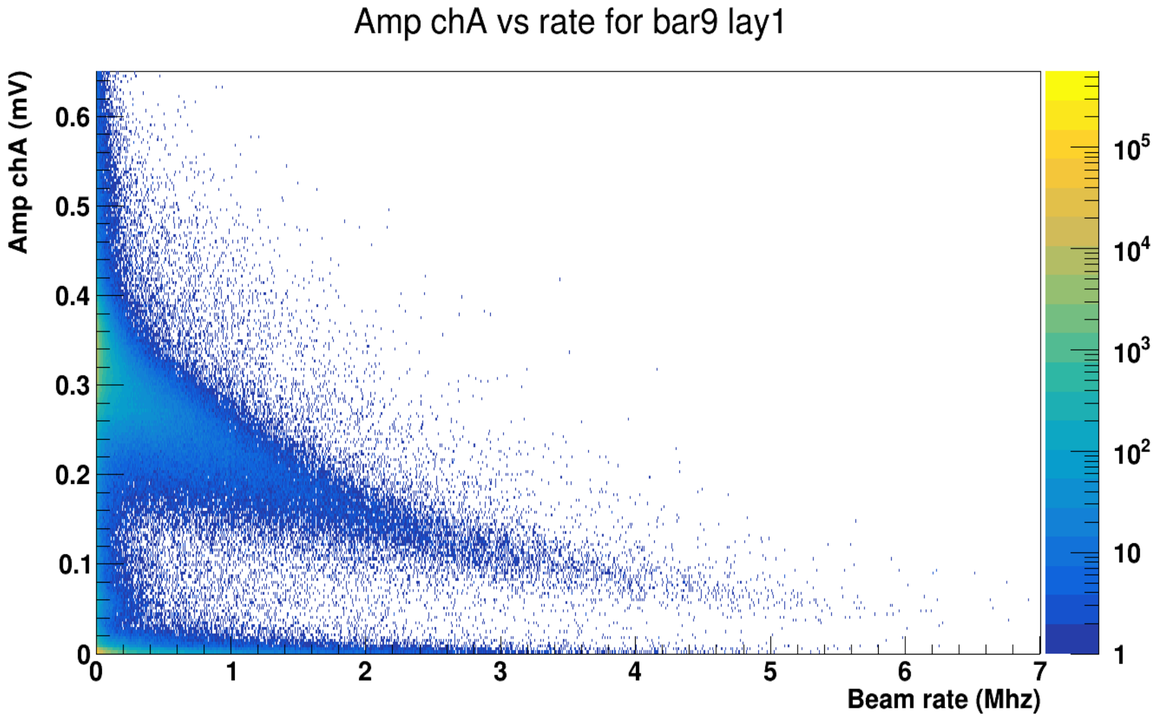


Pile-up estimation

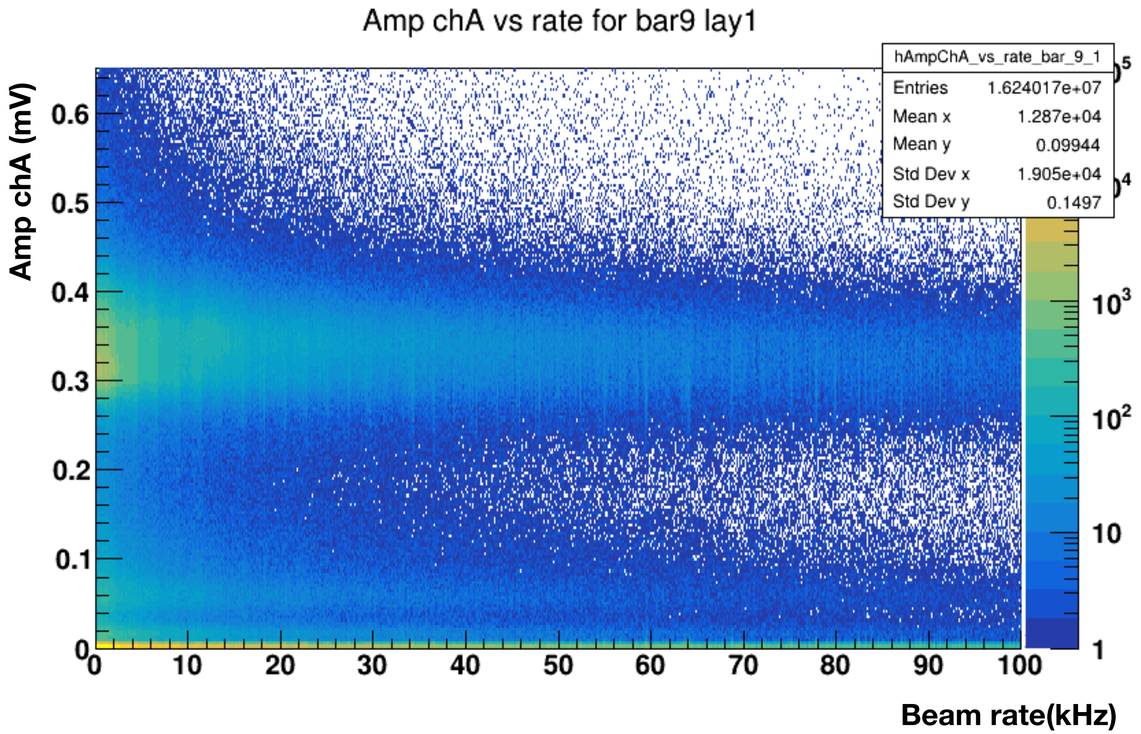
- The fraction of pile up events depends on the beam rate and it varies between 0.4% and 2.5% within all the acquired runs
- The estimated pile-up **is not enough** to justify the absence of peaks in the central bars

TW Amplitude vs rate for the central bars

- At high rates the TW is not able to correctly compute the charge
- 200 MeV/u — All runs

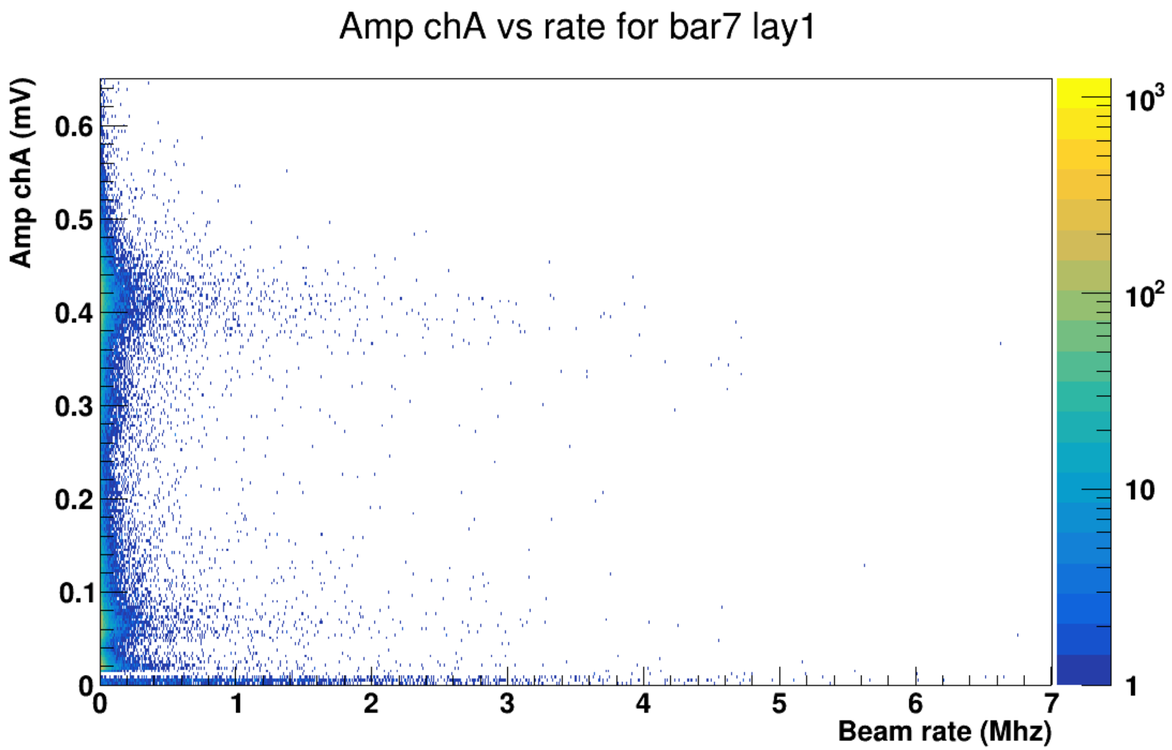


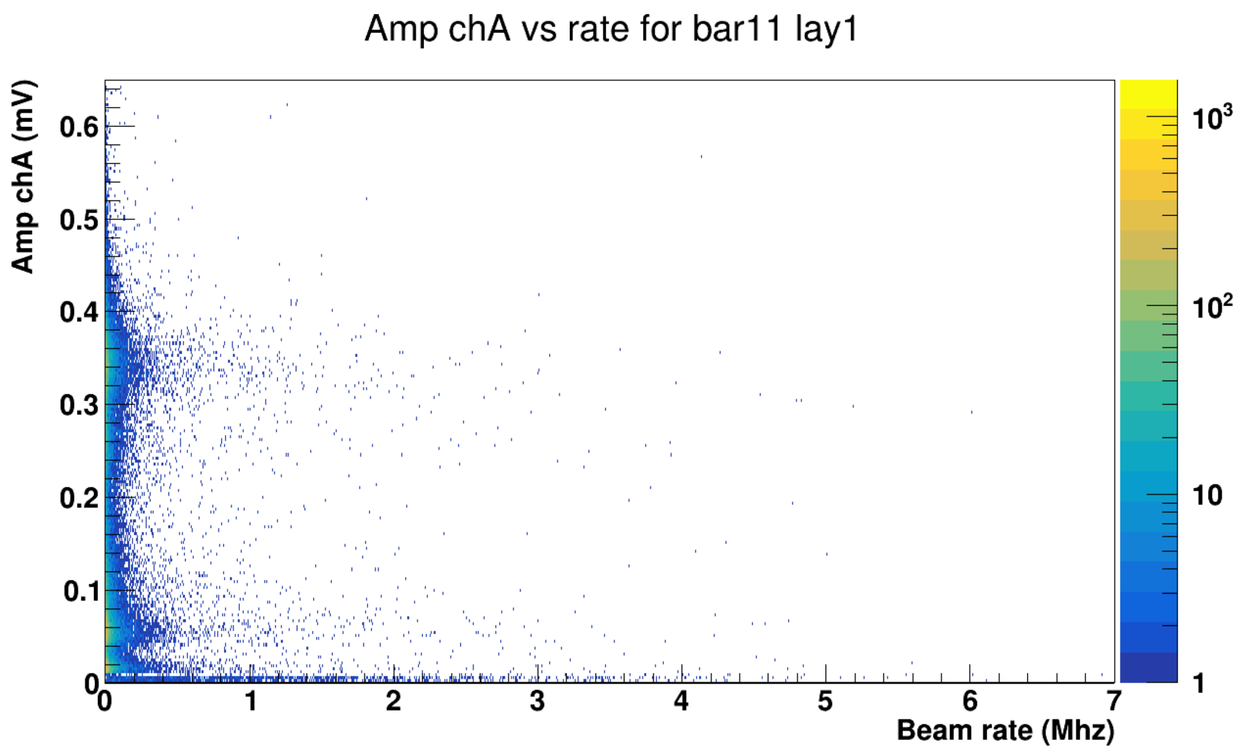
ZOOM



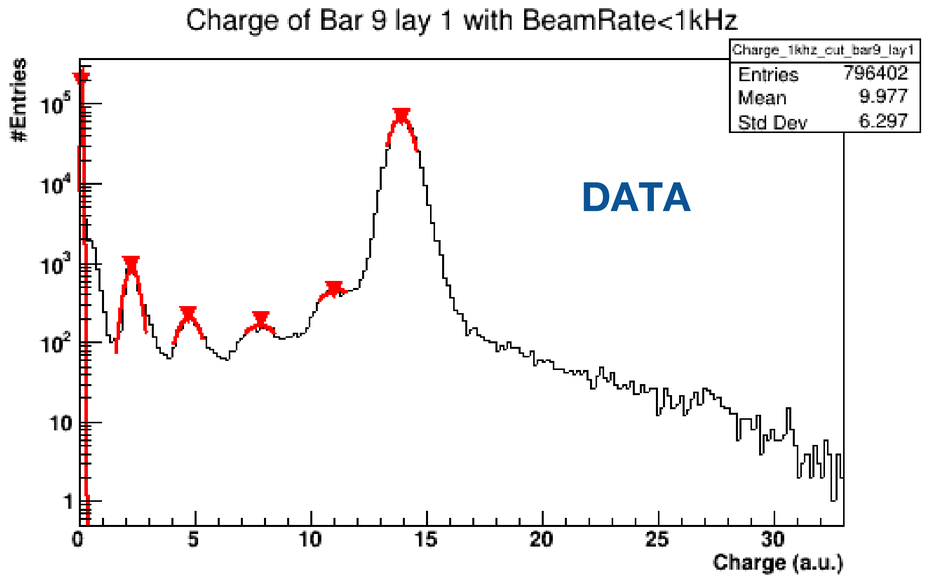
TW Amplitude vs rate for the lateral bars

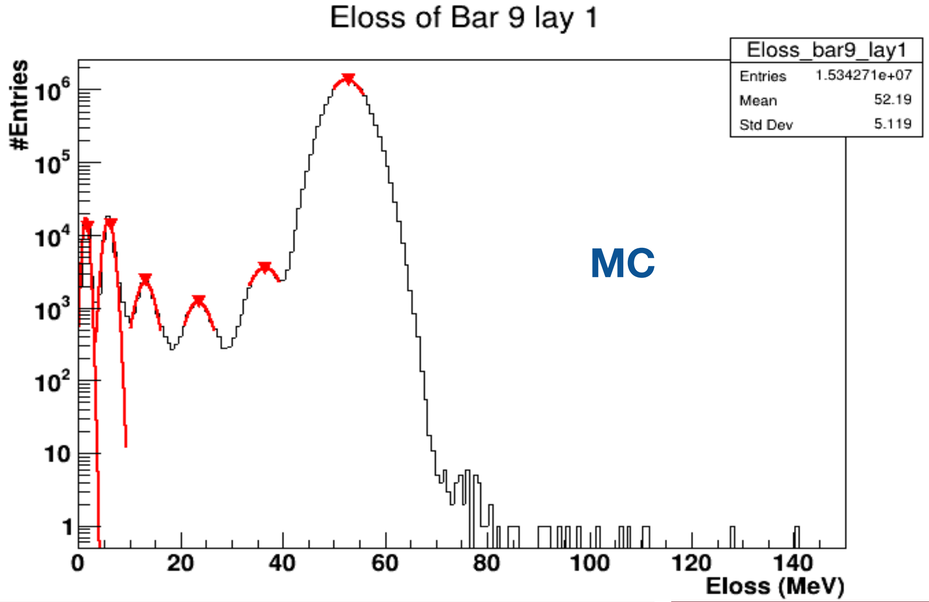
- For the “lateral” bars we don’t have the same effect
- 200 MeV/u — All runs





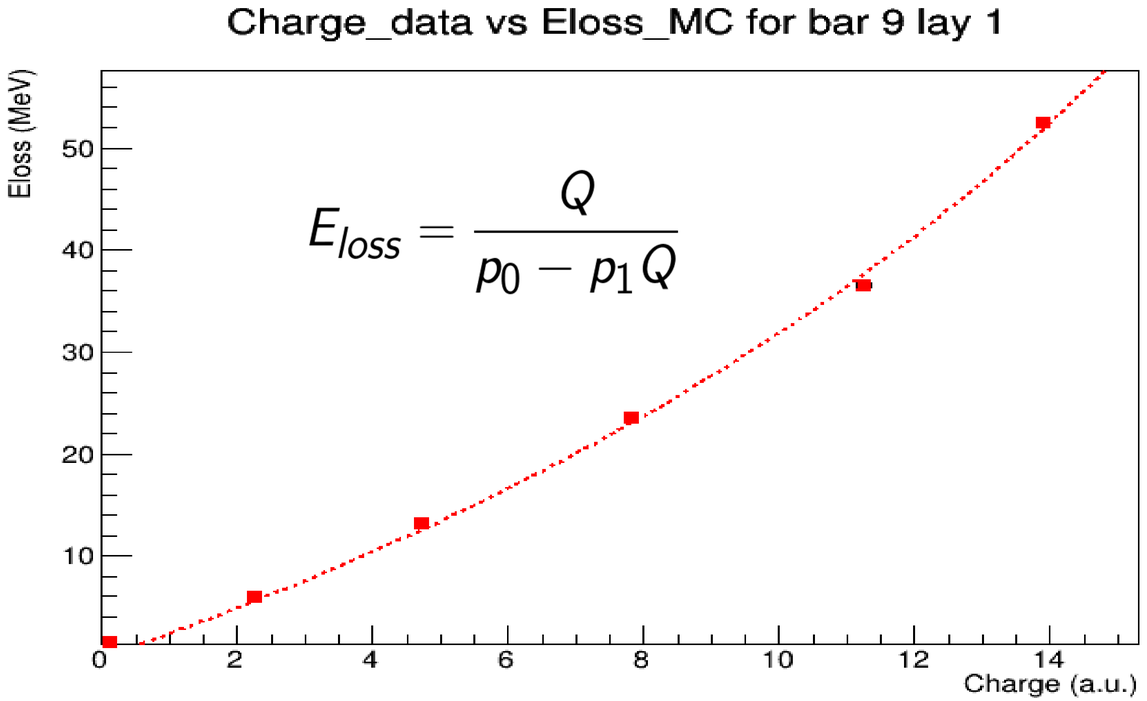
Energy loss calibration





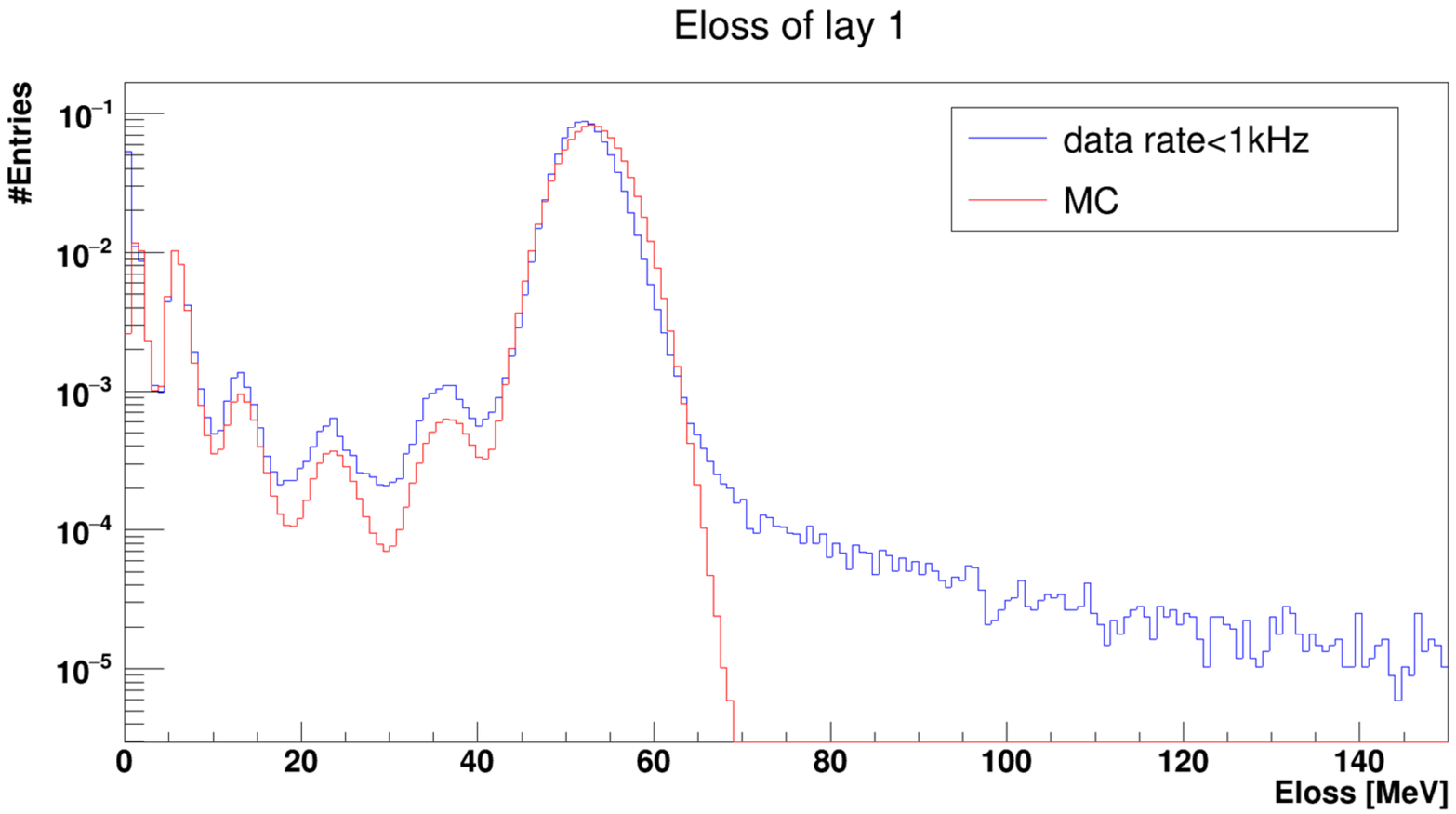
- Calibration used for GSI data does not fit well on CNAO data. In order to calibrate the charge with the Eloss_MC for all bars separately Birks law was used.

- For the central bars, most affected by the high beam rate, to make the peaks more visible, a cut was placed on the charge distributions, imposing that Beam_Rate<1kHz



Energy loss calibration

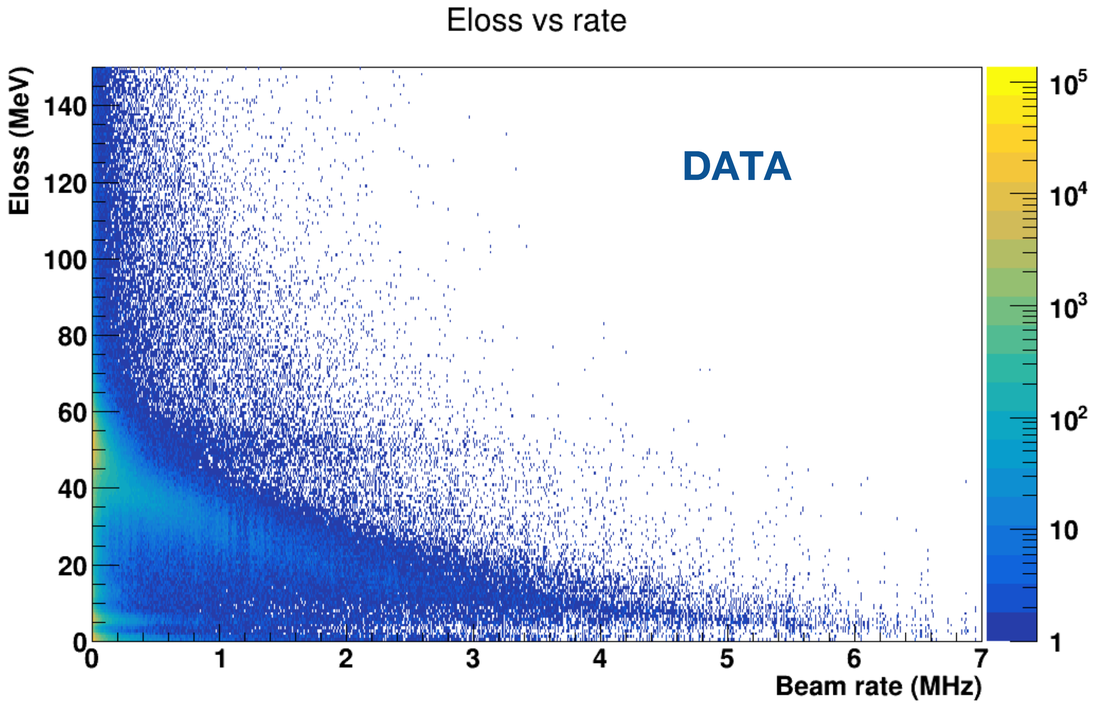
- The calibration works quite well. Here is reported the Eloss of the whole layer 1 after calibration compared with the MC
- 200 MeV/u - All runs



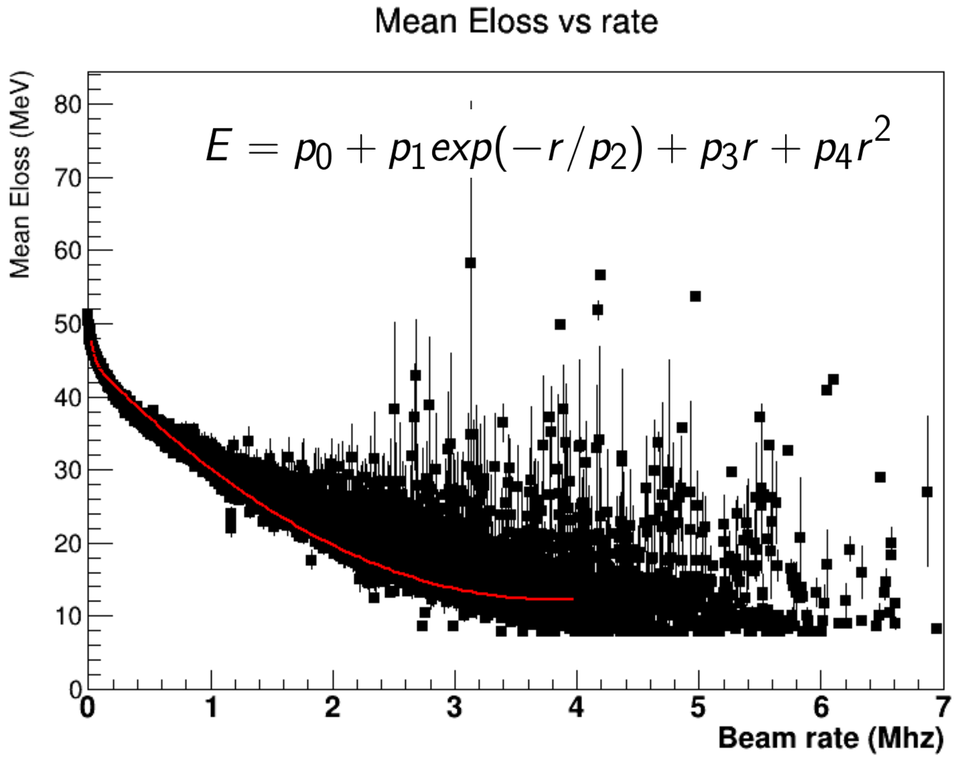
Introducing the rate into MC simulation

- In order to parameterize the Eloss response to the beam rate, we did a smearing of the MC based on experimental data.

- To do this, we studied the average Carbon peak value of the central bars as a function of the beam rate.

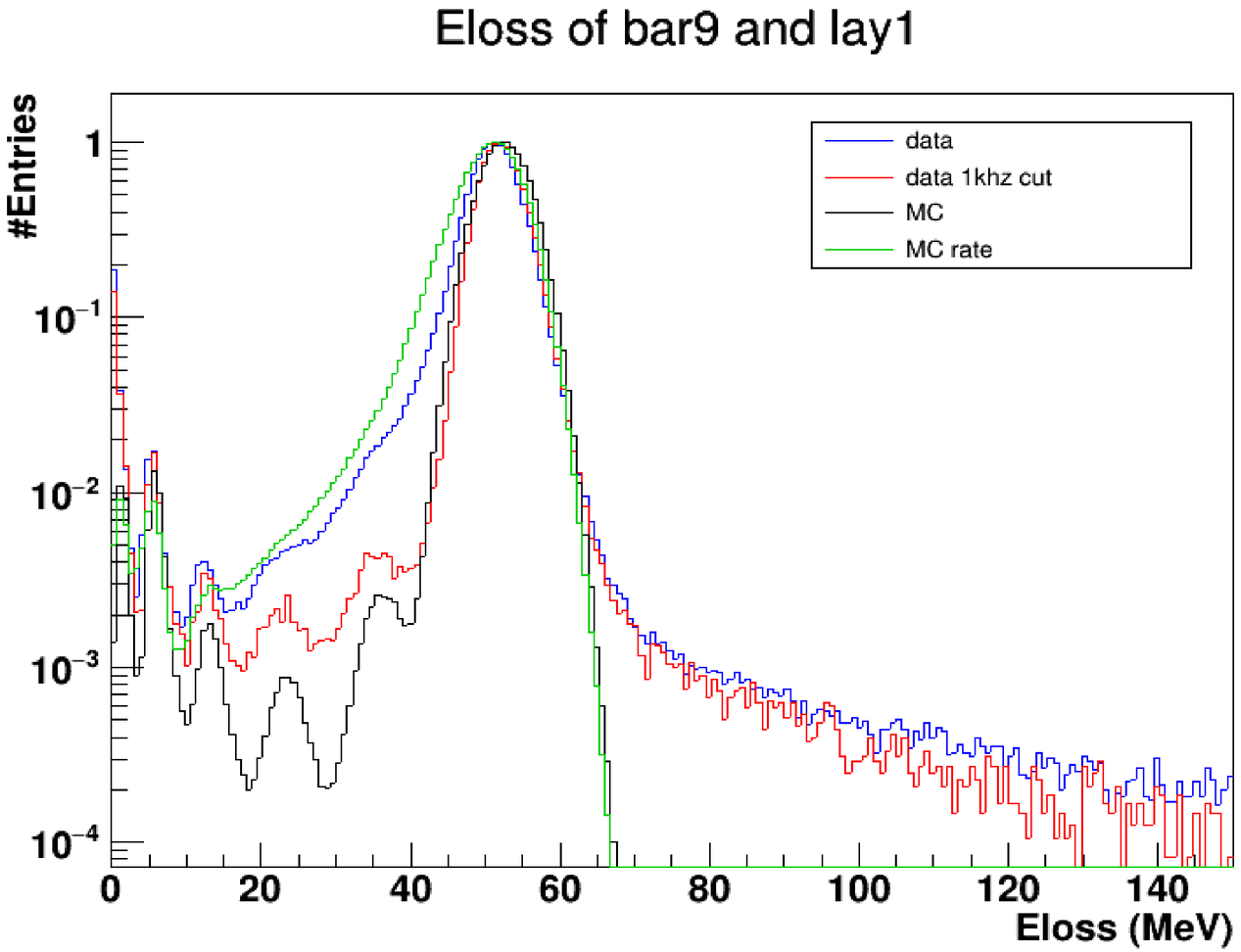


ProfileX( )



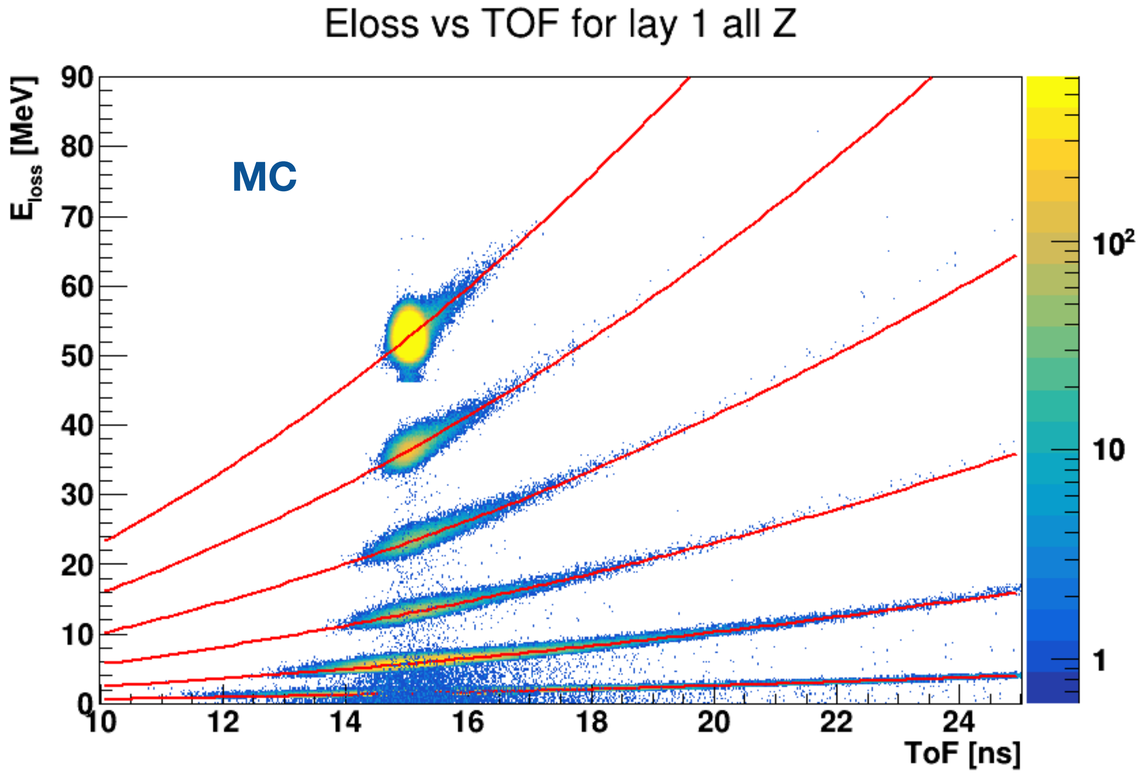
Introducing the rate into MC simulation

- 200 MeV/u — Only MB



Z identification

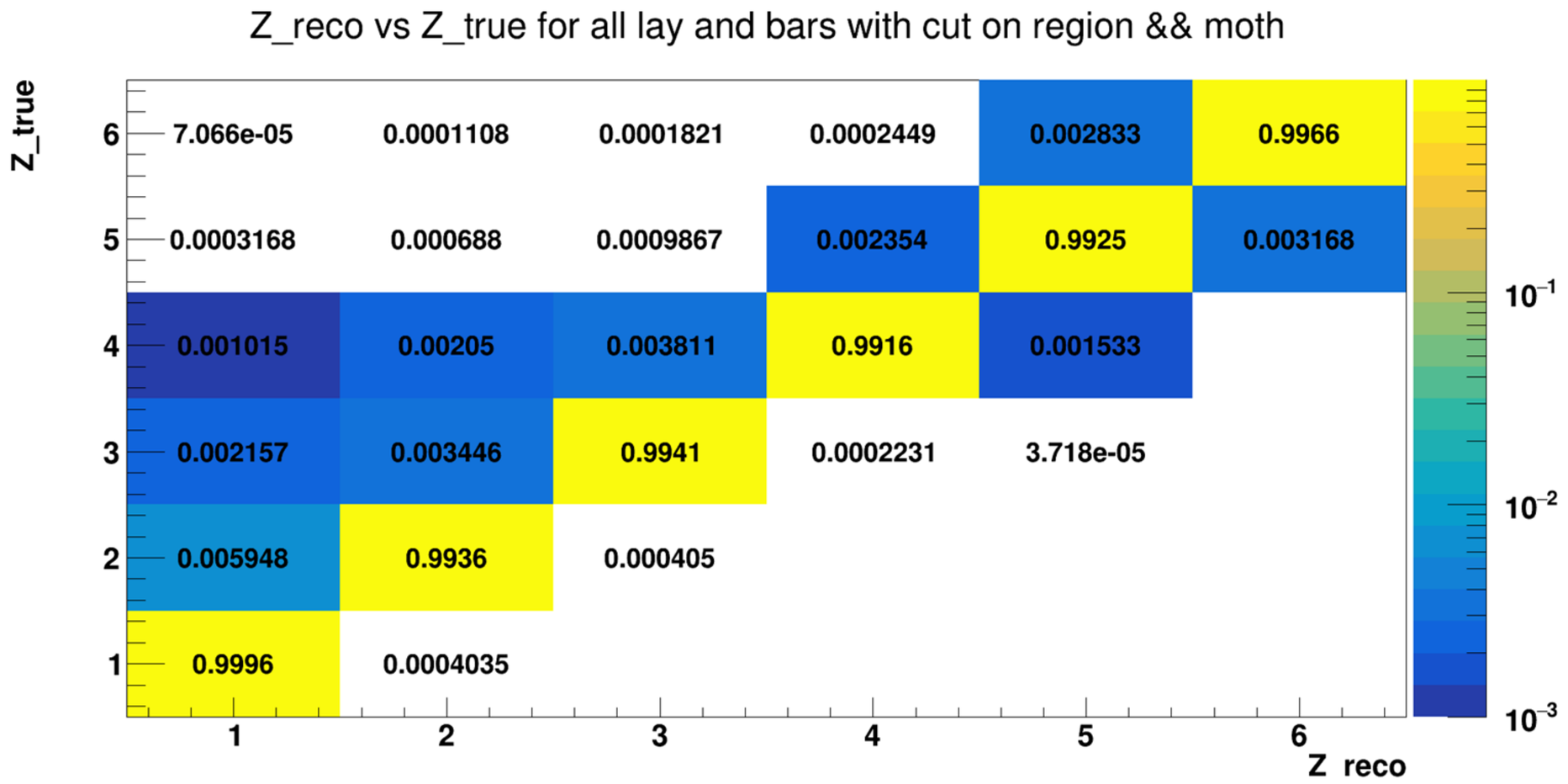
- In order to apply the Z reconstruction algorithm we have to find the Bethe-Bloch parameters
- Only the primary fragments produced in the interaction of the beam with the TG are considered.



$$E_{loss} = p_0 Z^2 \cdot (p_1 ToF^2 - 1)$$

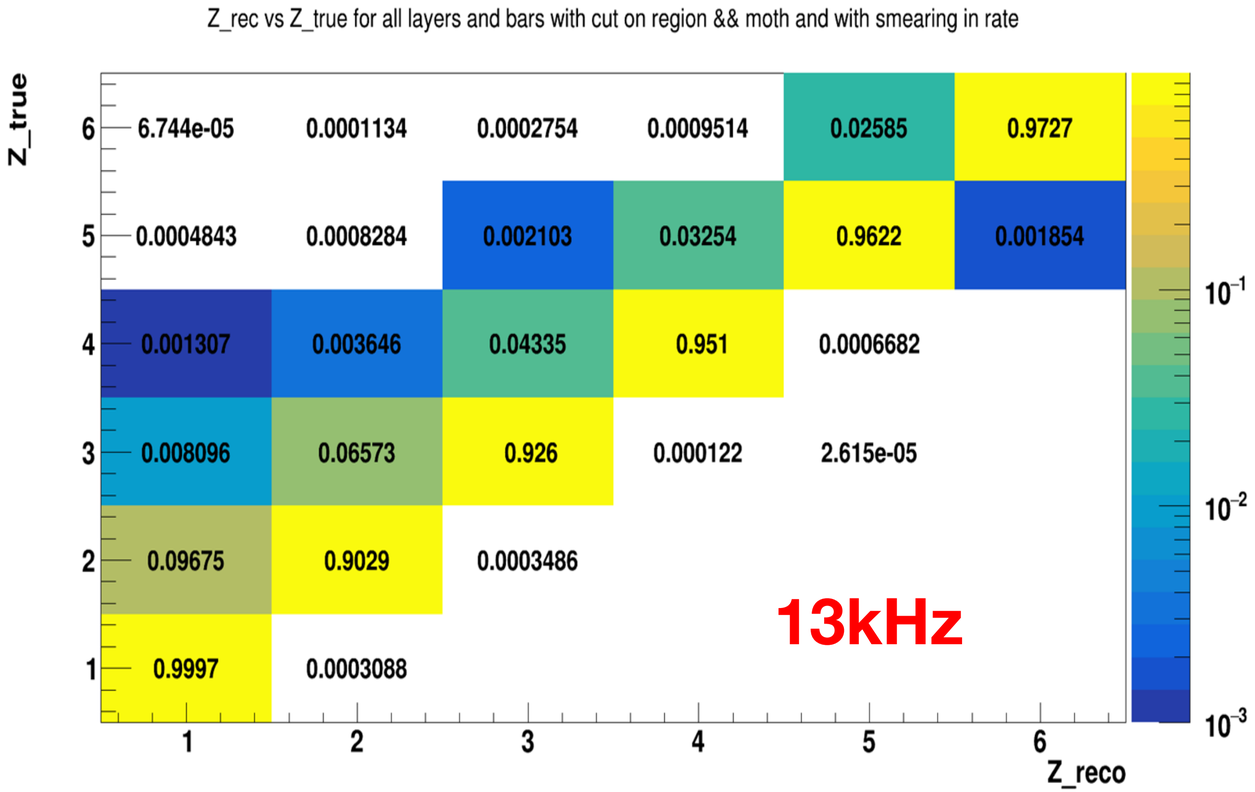
Z identification - no rate

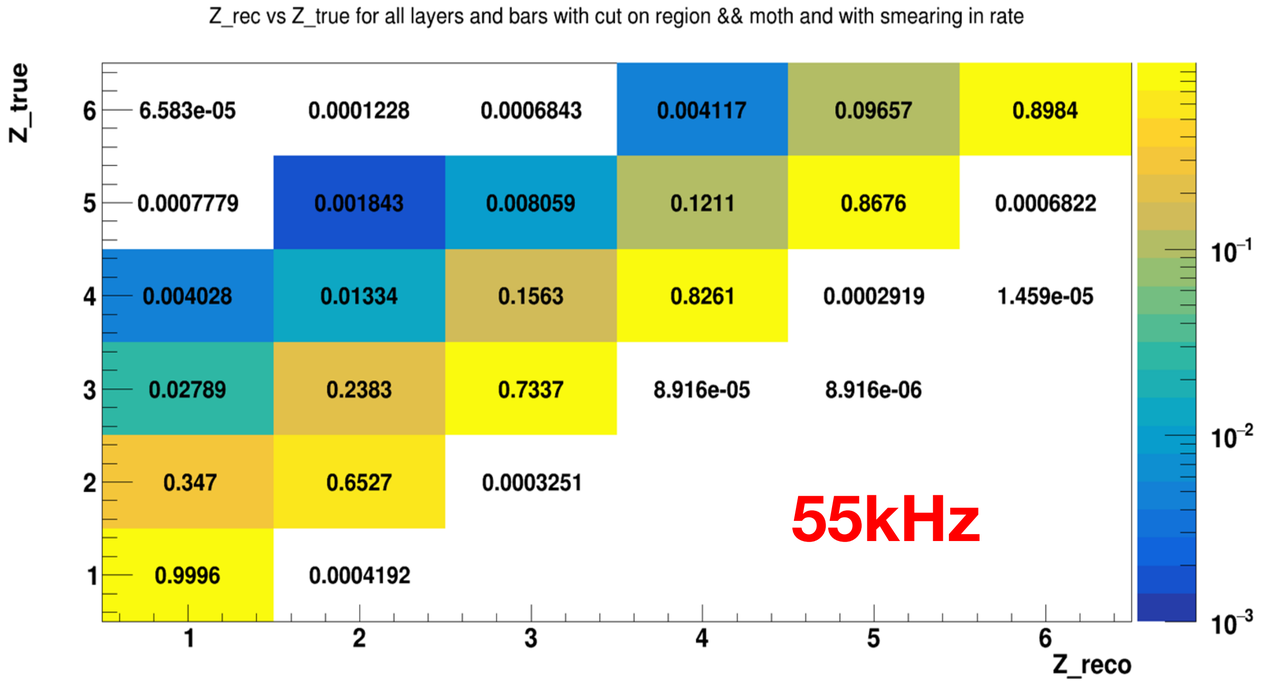
- We studied the performance of Z-ID on the reconstructed hit with only the experimental resolution (NO RATE)

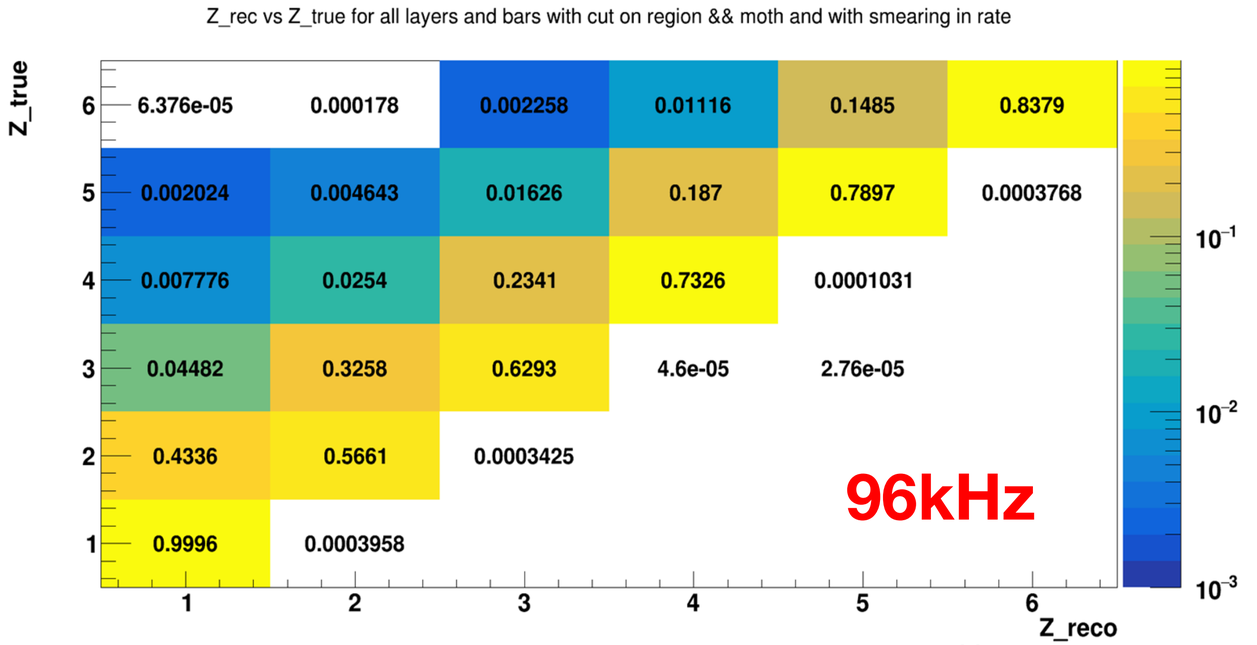


Z identification - rate

- At 13kHz the rate effect on the reconstructed hit is not too evident







Trigger efficiencies

- We also studied the impact of the beam rate on trigger efficiency using the calibrated and reconstructed data

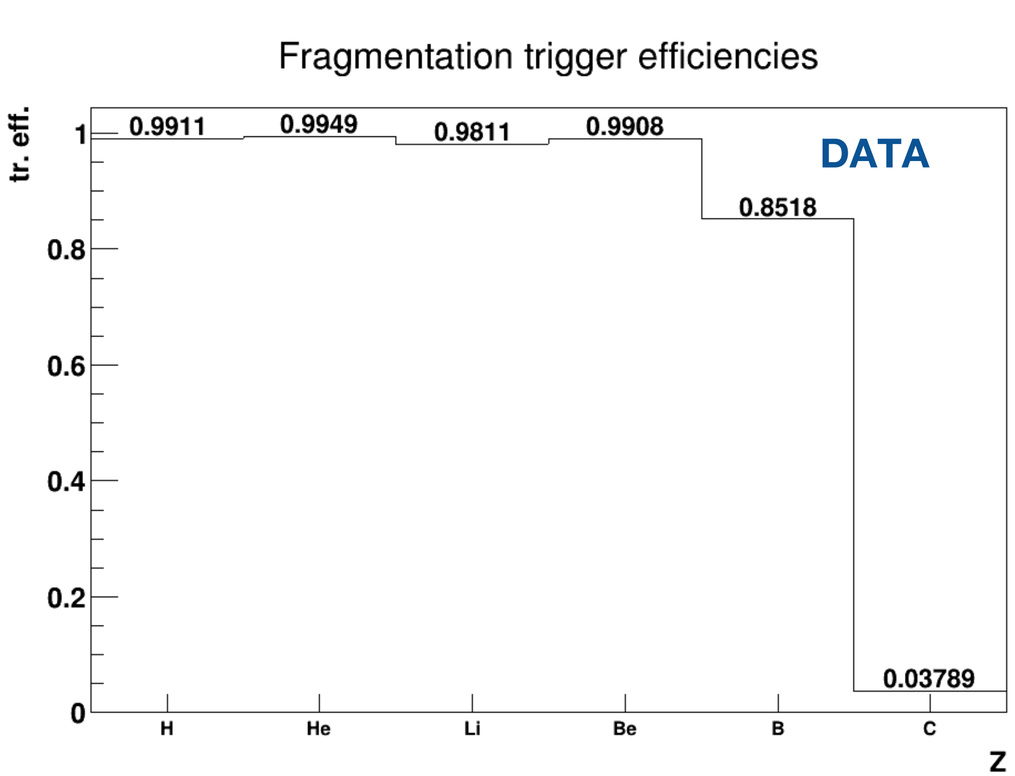
$$\epsilon = \frac{\#points(TriggerID == 40 \;\&\&\; TrStatus[1] == 1))}{\#points(TriggerID == 40))}$$

number of points acquired with the MB trigger that would have fired the fragmentation trigger.

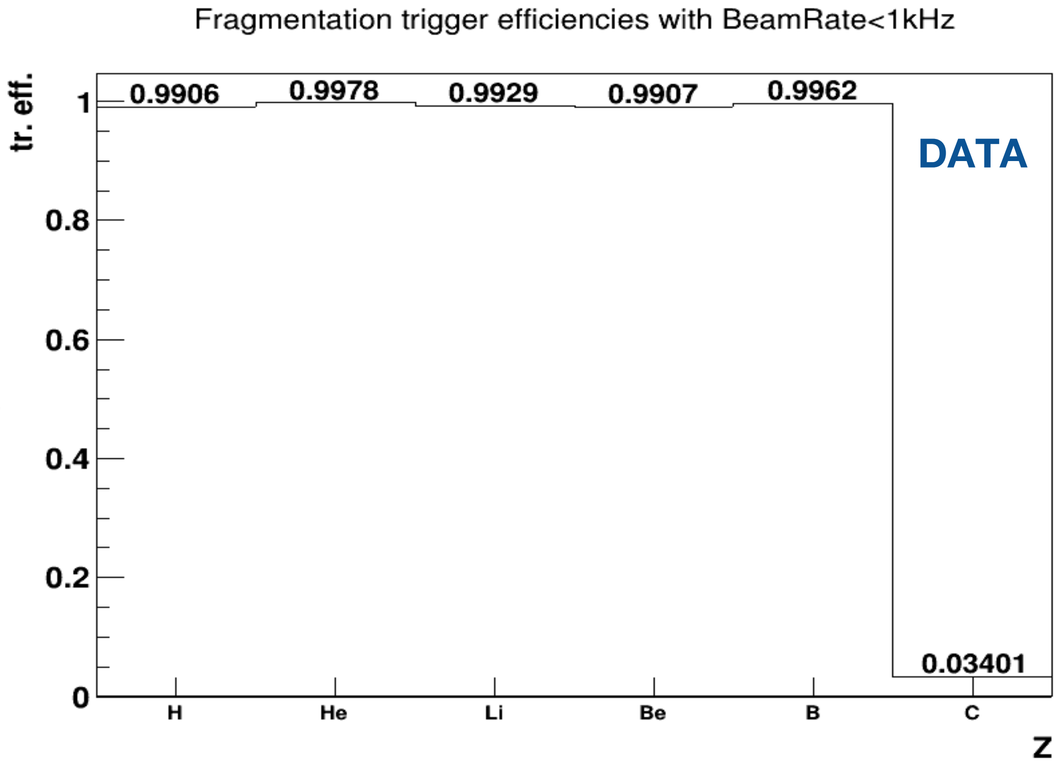
number of points acquired with the MB trigger

Trigger efficiencies -13 kHz

- We focused our attention on the run in which the mean beam rate was 13kHz
- For boron, the results are different from those of Lorenzo Marini's work, but taking the events below 1kHz, even with reconstruction (point), we get the same values.
- 200 MeV/u — run (2500-2959)



1kHz cut



Conclusions

- The fraction of pile up events is small (0.4%-2.5%)

- We introduced in the MC simulation the effect of the beam rate to study

1. the performance of the Z-ID on the reconstructed hit

2. the trigger efficiency

At 13kHz the rate effect is not too evident

At 13kHz for boron fragments the trigger efficiency varies from 0.85 to 0.99 with a cut on the beam rate of 1kHz

We are trying to apply the efficincies to fragmentation data to recover the MB ones.
At the moment there are some discrepances that we are checking…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