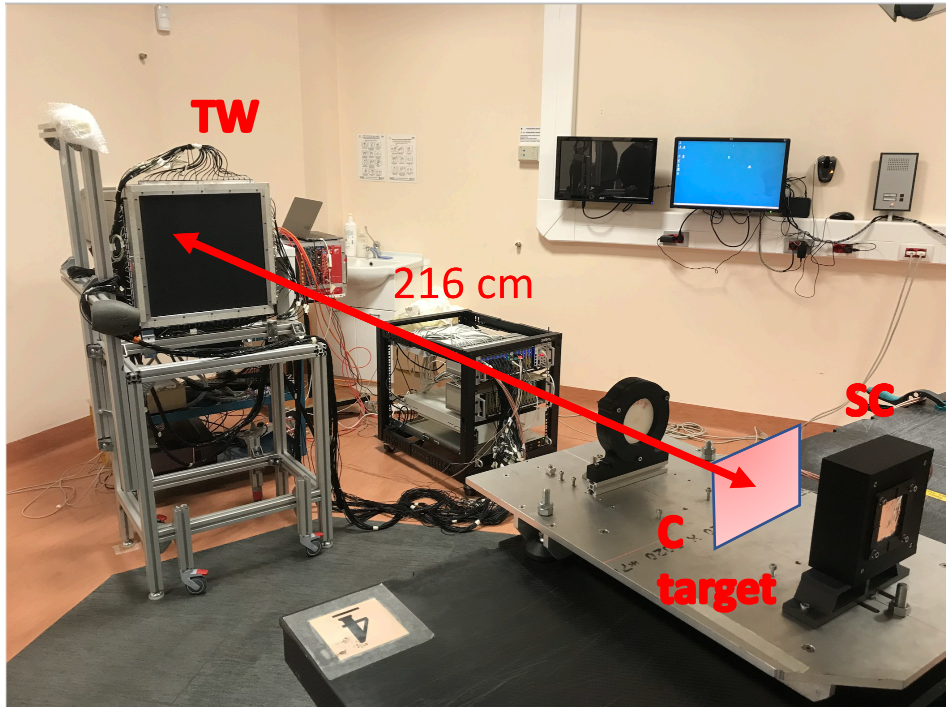
Updates on Alpha Clustering Fragmentation analysis for CNAO2021 data: further MC investigation



We can just identify Z=2 fragments.

Analysis goals:

- Count the number of Z=2 particles produced in target arriving at TW
- How many $^{12}C \rightarrow 3$ Z=2 are we able to identify (they are very probaby 3 α's)?
- Does the multiplicity distribution change with energy?
- Can we analyse the distribution of relative distances of Z=2 fragments and indentify the peak due to $^{12}C \rightarrow {}^{8}Be + \alpha \rightarrow 3\,\alpha$?

G.B. S.M., INFN Milano

A.C.K INFN Pisa

From previous meetings:
Experiment geometry, analysis goals and preliminary selection

- Exp. Data Selection:

For this preliminary analysis we selected a first batch of data from the 3rd night, when 4 different energies were considered (150, 200, 300, 400 MeV/u).
For the moment we limited ourselves only to runs where the majority trigger was used ("Trig. 40")

150: runs 10650-10850 (402k events)
200: runs 10900-11000 (201k events)
300: runs 11100-11231 (264k events)
400: runs 11300-11368 (138k events)

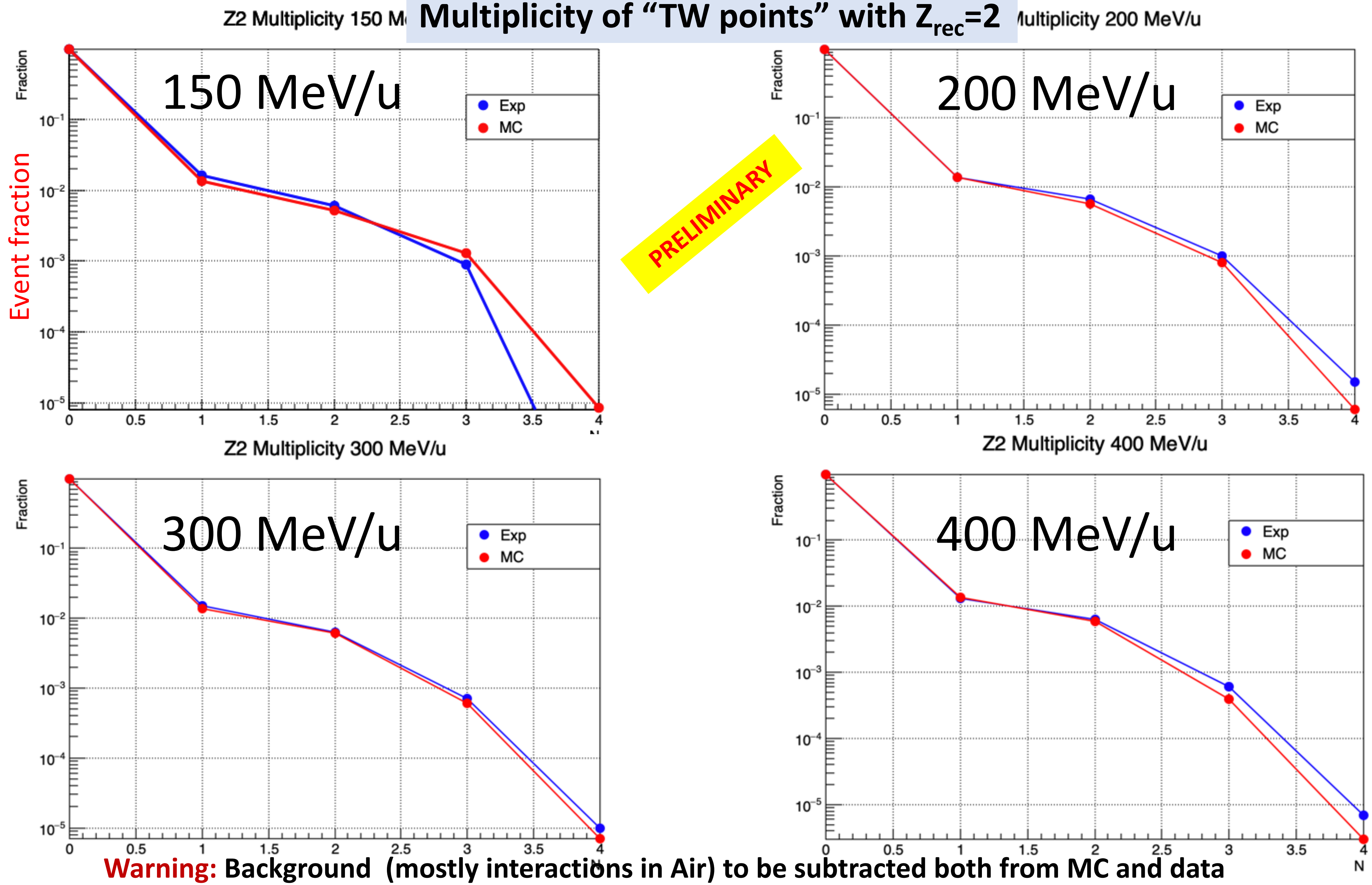
Analysis of multiplicity of exp. data has been performed using both shoe and an independent stand-alone reconstruction (in shoe, exp. data are decoded using DecodeWD)

- MC Data:

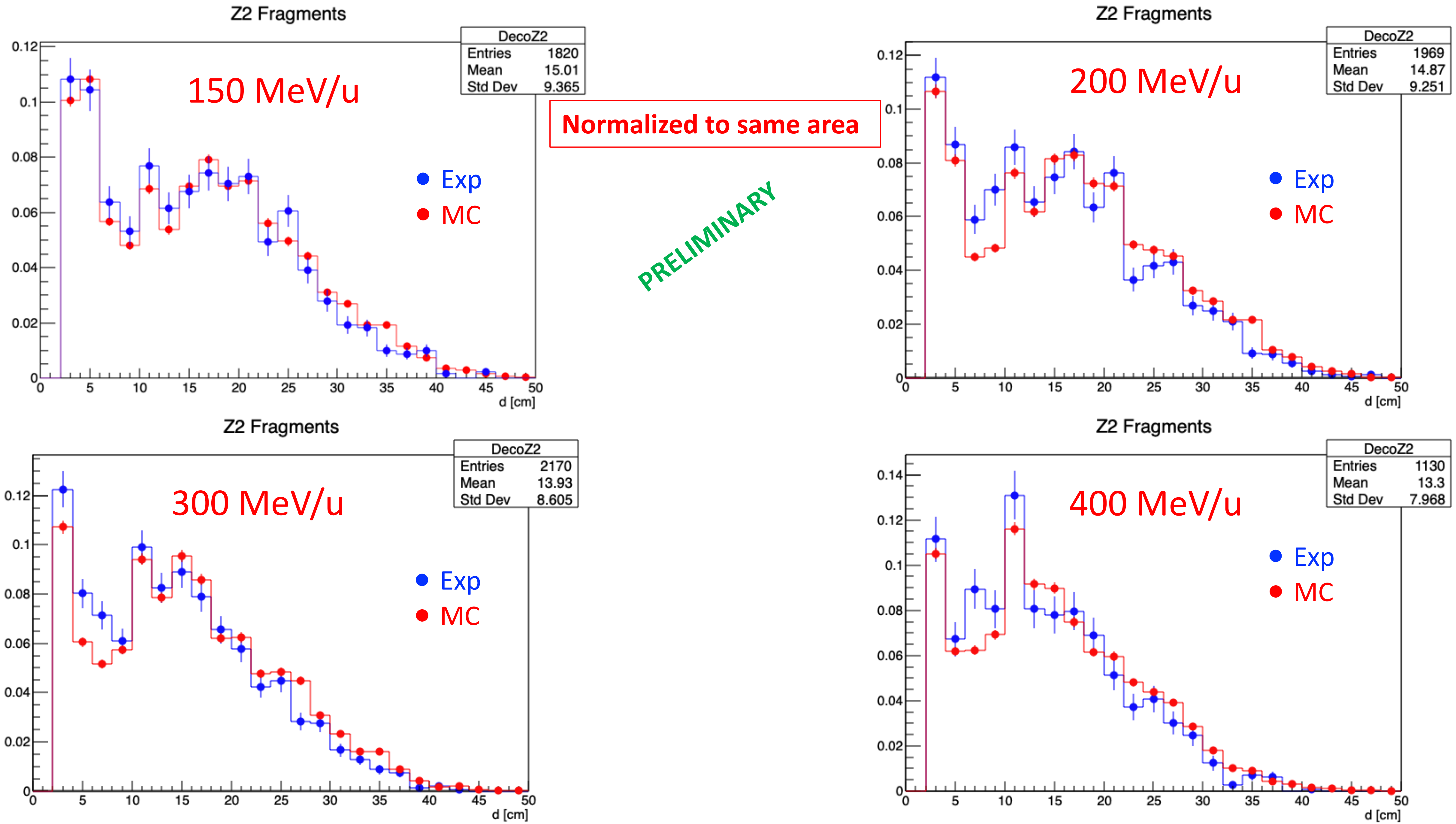
MC data: only shoe reconstruction is available

2.e+6 events for each energy (CNAO2021_MC campaign)

Multiplicity of “TW points” with Z_{rec}=2



Warning: Background (mostly interactions in Air) to be subtracted both from MC and data


Z2 Fragments
DecoZ2
Entries 1820
Mean 15.01
Std Dev 9.365
150 MeV/u
Exp
MC
d [cm]
Normalized to same area
PRELIMINARY
Z2 Fragments
DecoZ2
Entries 1969
Mean 14.87
Std Dev 9.251
200 MeV/u
Exp
MC
d [cm]
Z2 Fragments
DecoZ2
Entries 2170
Mean 13.93
Std Dev 8.605
300 MeV/u
Exp
MC
d [cm]
Z2 Fragments
DecoZ2
Entries 1130
Mean 13.3
Std Dev 7.968
400 MeV/u
Exp
MC
d [cm]

Many question left open. Among them:

1) How many events with N fragments Z=2 detected in TW are really coming from the target?

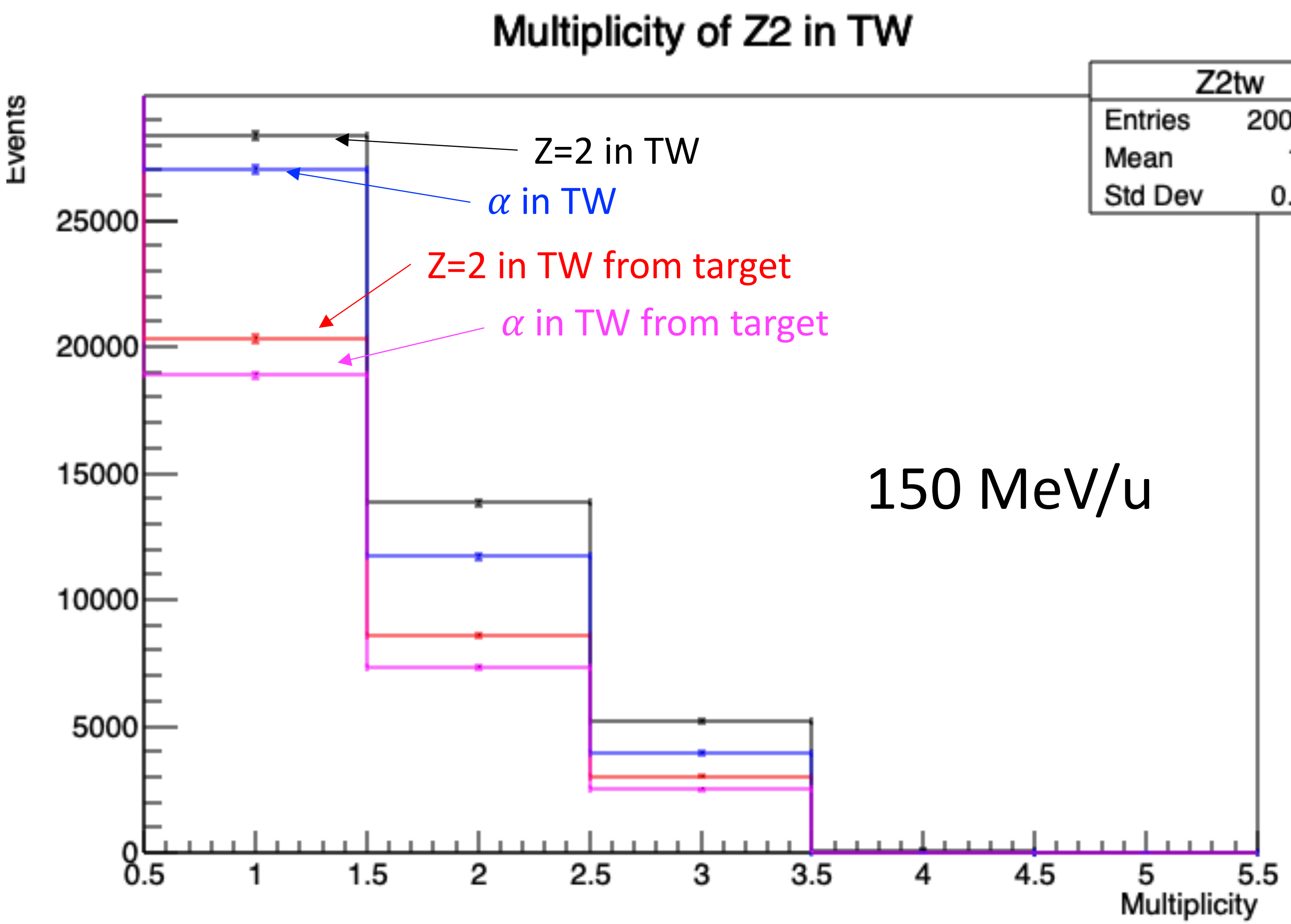
2) In the events of multiplicity N, how many of the Z=2 are actually 4He (and not 3He or 6He)?

3) How many Z=2 fragments arriving at the TofWall are actually detected, considering broken bar readout, multi-hits etc.?

4) How many fragments reconstructed with Z=2 had actually a different Z?

Here we start to give some answers to questions 1, 2 and 3 using MC events

How many Z=2 fragments in TW are really ^{4}He coming from the target?



~94% of background is produced in interactions with air upstream of the TW

(remaining 6% is from SC)

150 MeV/u (2 10^6 primaries)

No. of Z=2 particles exiting the target in the forward direction (all angles and energy): 101086

Of which the no. of ^{4}He is: 77952 ➔77.1% of Z=2

these include also a low energy tail from target fragmentation

No. of Z=2 particles arriving at TW: 72022 ➔71.2% of Z=2 exiting from target

acceptance + loss of low-energy target fragmentation products, but

these ***include also particles generated in air + secondary interactions*** *products*

A cut in energy (E>50 MeV/u) slightly reduces the number (69401)

No. of Z=2 particles arriving at TW actually produced in target: 46576 (46152 for E>50 MeV/u)

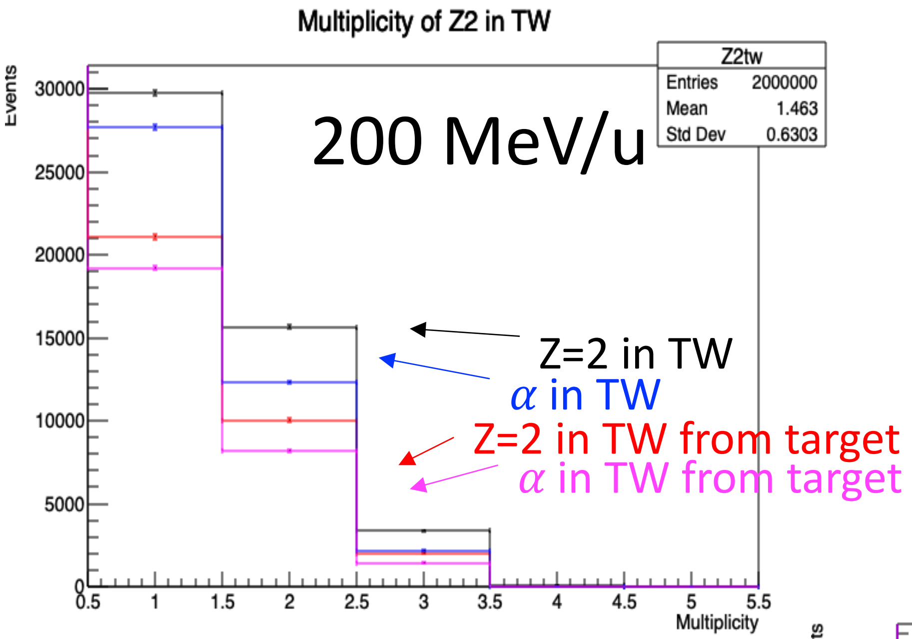
background contribution is huge: 35%

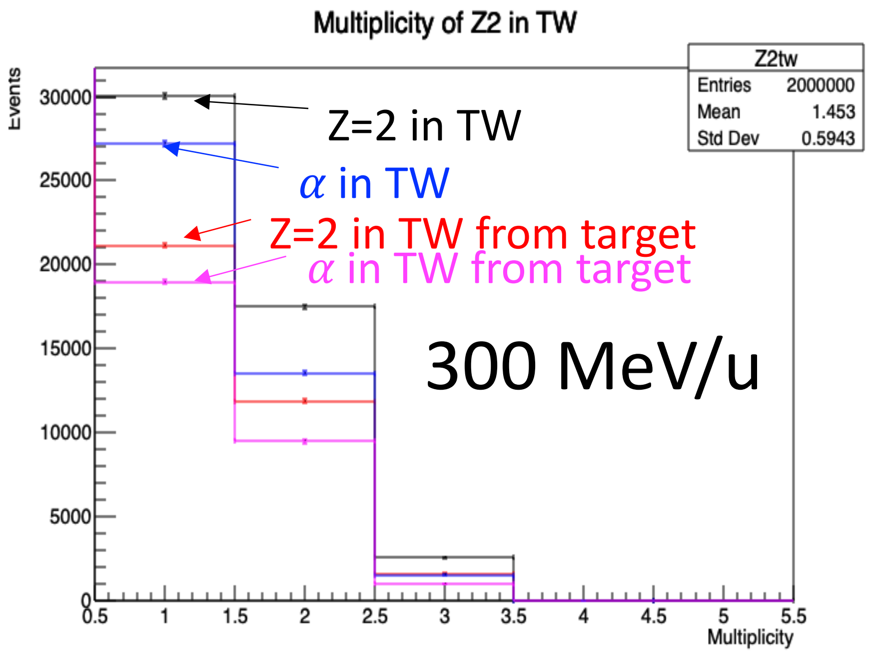
No. of ^{4}He arriving at TW: 62451 (86.7% of Z=2 particles at TW)

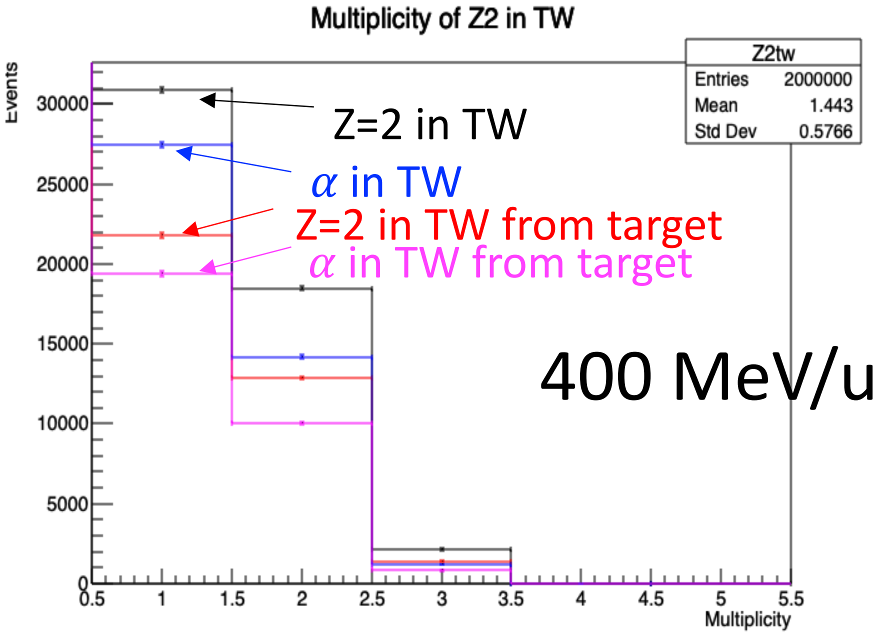
Of which actually produced in target: 41081: **background is 34.2%**

(40835 for E>50 MeV/u)

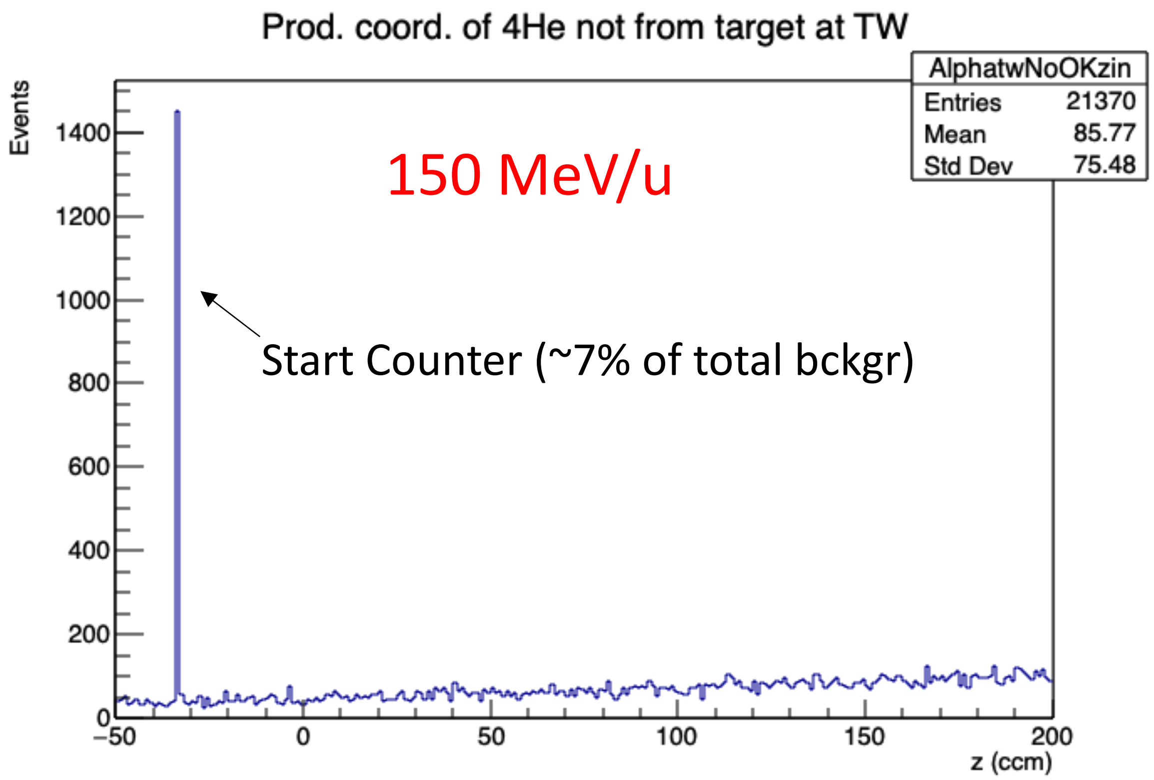
The picture is similar also at the other energies

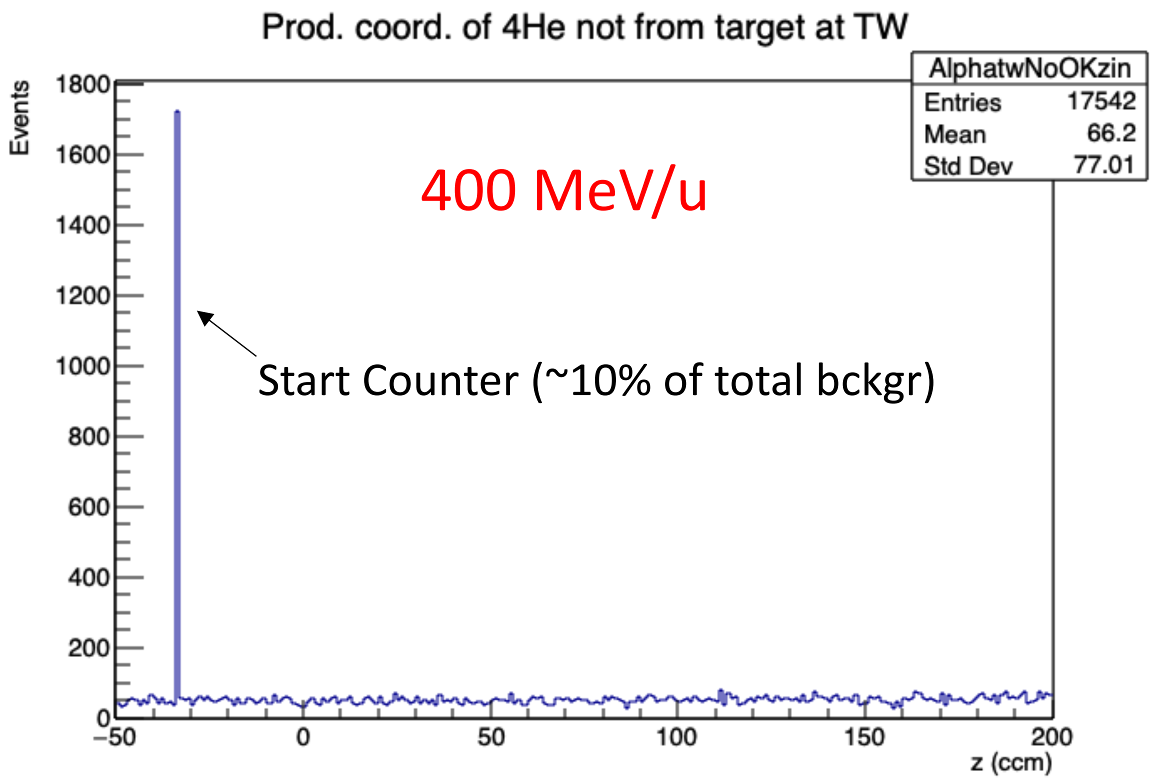






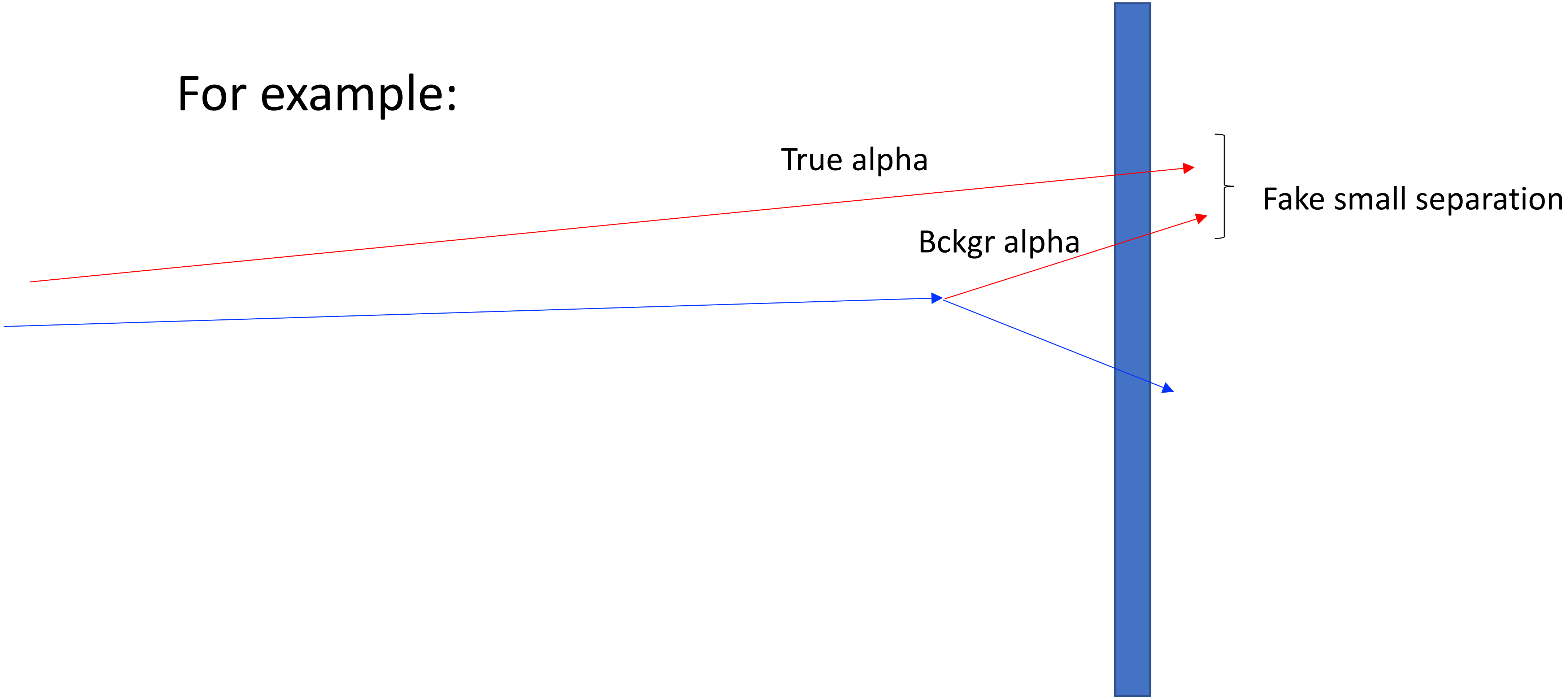
Origin of background



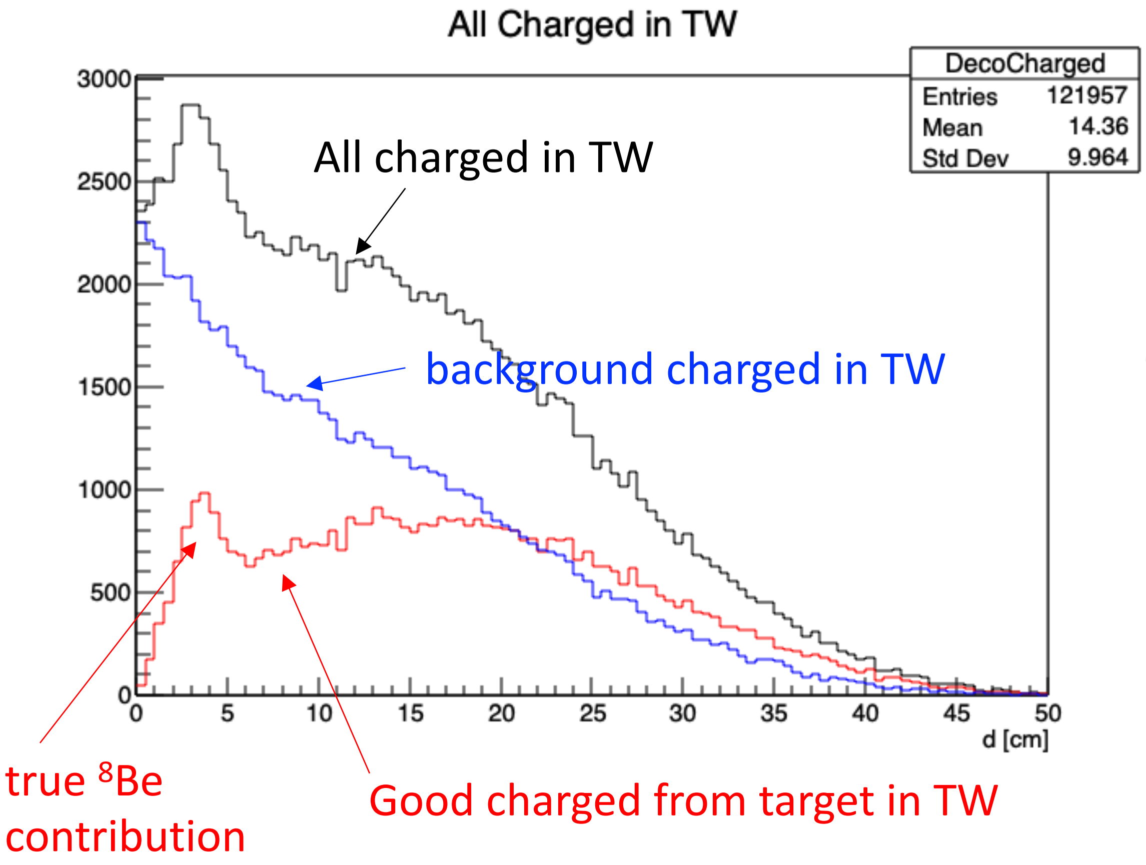


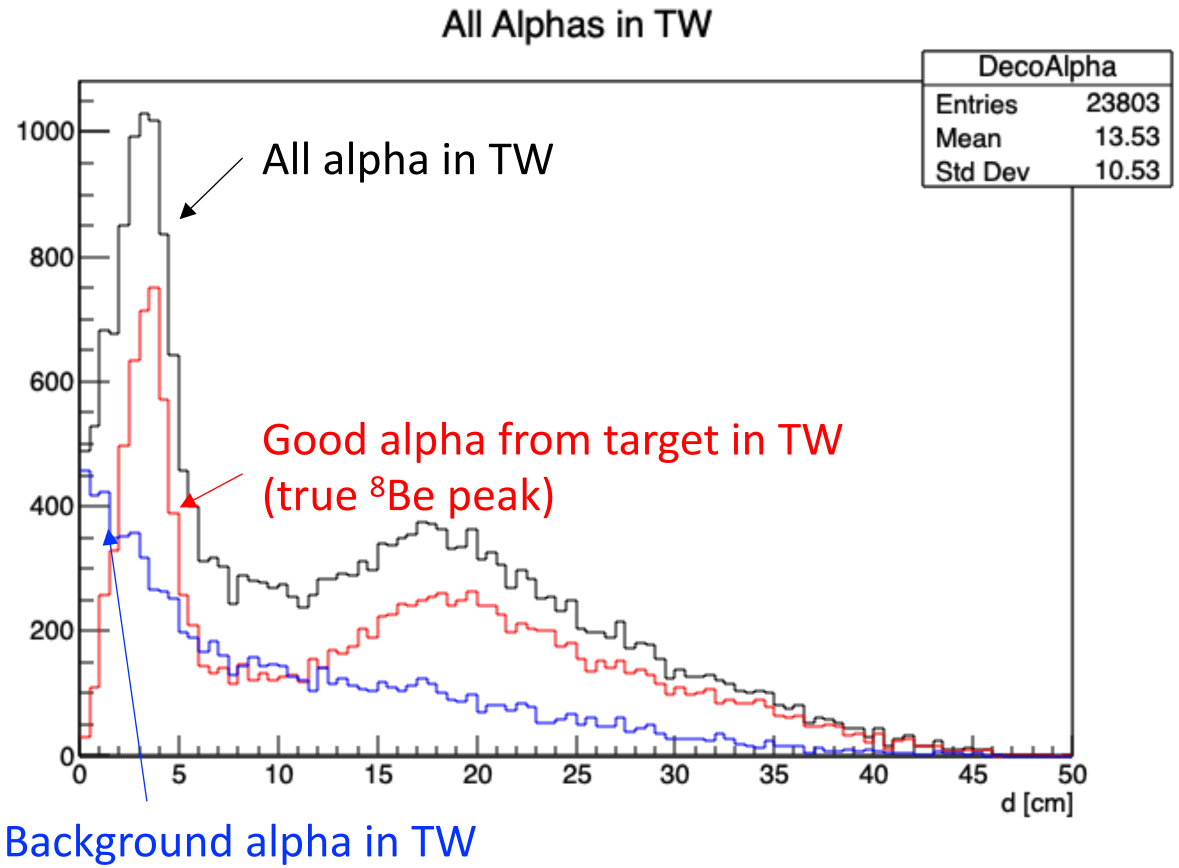
Background destroys also the attempts of measuring track separation

For example:



Example for 150 MeV/u





Background naturally produces an accumulation at short separation values

Trying to clean the event sample

Attempt:

Select events where in the TW there are only 3 charged tracks, each one with Z = 2

150 MeV/u:

- No. of events with just 3 Z=2 particles at TW: 4449

Of these:

the No. of events with 3 real Alpha from target is: 2496 (56%)

the No. of events with 3 real Alpha not from target is: 1126 (25%)

200 MeV/u:

- No. of events with just 3 Z=2 particles at TW: 2827

Of these:

the No. of events with 3 real Alpha from target is: 1426 (50%)

the No. of events with 3 real Alpha not from target is: 1126 (40%)

300 MeV/u:

- No. of events with just 3 Z=2 particles at TW: 2237

Of these:

the No. of events with 3 real Alpha from target is: 1005 (45%)

the No. of events with 3 real Alpha not from target is: 428 (19%)

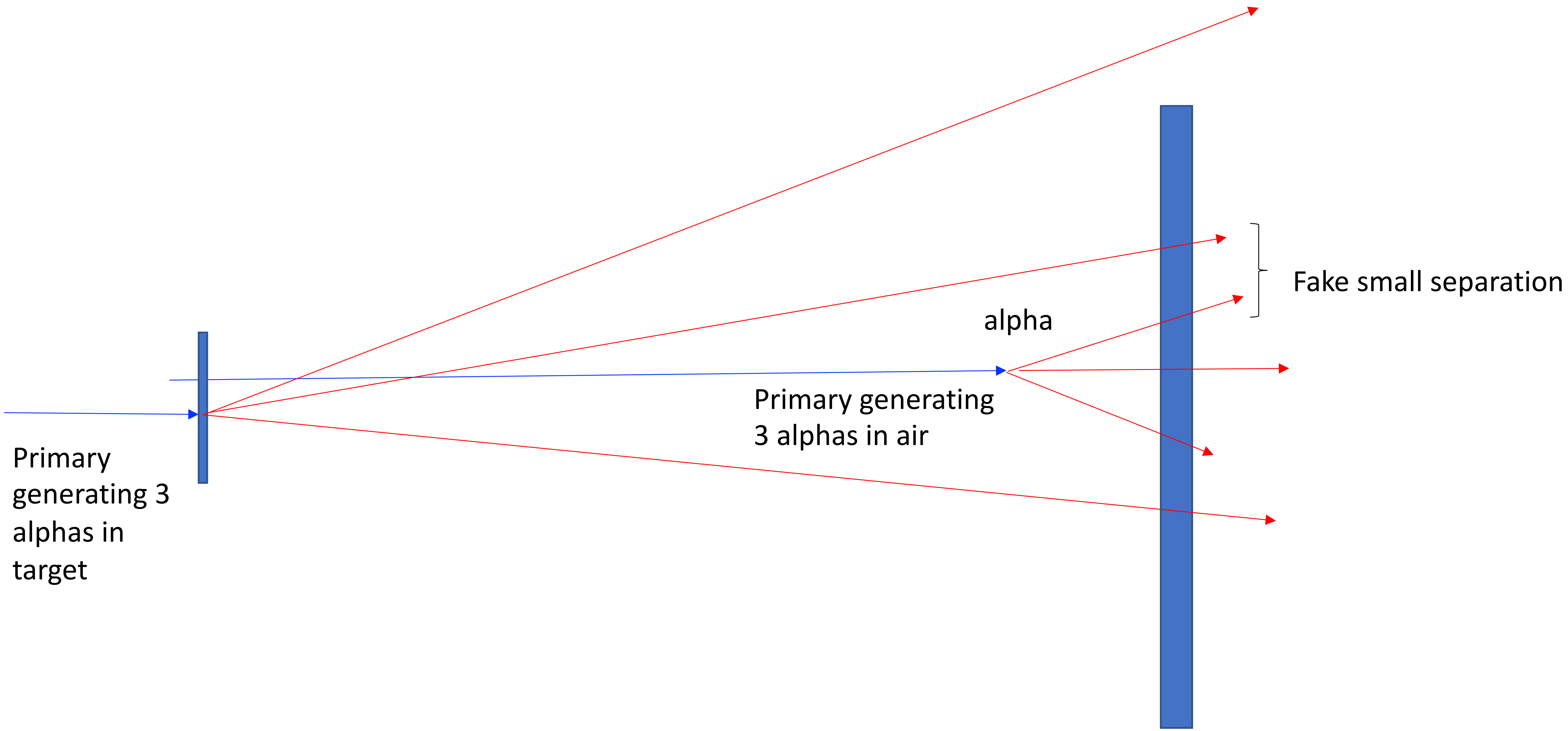
400 MeV/u:

- No. of events with just 3 Z=2 particles at TW: 1891

Of these:

the No. of events with 3 real Alpha from target is: 816 (43%)

the No. of events with 3 real Alpha not from target is: 317 (17%)



0.5 cm of C ~ 0.92 g/cm^2

2 m of air ~ 0.2 g/cm^2 but the closer to TW is the interaction, the higher is the acceptance

Conclusions

- Interactions in air are producing a very high level of background
- Background level is predicted to increase with primary energy
- Unfortunately, in the CNAO2021 campaign, where trackers are missing, it is not possible to reduce background contamination
- All preliminary conclusions cannot be considered reliable in terms of Z=2 clustering analysis, neither in terms of multiplicity or of track separation *(for instance: the observed peak at short separation could be dominated by Z=2 fragment produced close to TW)*

➔ Missing any tracking information, there is no possibility of performing a reliable analysis of CNAO2021 data in terms of Alpha clustering

Just a few positive points

According to MC:

- the alpha fraction in Z=2 sample from target is however high
- an energy cut of 50 MeV/u seems enough to select clean tracks from projectile fragmentation
- Even for 2 m distance from target, the fraction of true fast Z=2 particles which can potentially arrive to TW is still relevant, and of course increases with energy:
  - 150 MeV/u: 51% (57% for ^{4}He)
  - 200 MeV/u: 57% (65% for ^{4}He)
  - 300 MeV/u: 71% (78% for ^{4}He)
  - 400 MeV/u: 79% (84% for ^{4}He)

Conclusions

Quando la sorte t'è contraria e mancato t'è il successo, smettila di far castelli in aria e va a piangere sul...

CNAO2021 data were attractive because of the 4 different energies, but now:

➔ after the completion of TW calibration, CNAO2022 data, having both VTX and MSD trackers, are probably a much better case

➔ One of remaining main issues: **reconstructed vs true Z=2**

Backup Slides

200 MeV/u (2 10^6 primaries)

No. of Z=2 particles exiting the target in the forward direction
(all angles and energy): 89418

Of which the no. of ^{4}He is: 64636 ➔72.3% of Z=2

these include also a low energy tail from target fragmentation

No. of Z=2 particles arriving at TW: 71519 ➔80.0% of Z=2 exiting from target

acceptance + loss of low-energy target fragmentation products, but
these ***include also particles generated in air + secondary interactions*** *products*
A cut in energy (E>50 MeV/u) slightly reduces the number (69712)

No. of Z=2 particles arriving at TW actually produced in target: 47193 (47064 for E>50 MeV/u)

background contribution is huge: 34%

No. of ^{4}He arriving at TW: 59007 (82.0% of Z=2 particles at TW)
Of which actually produced in target: 39915: **background is 32.3%**
(39857 for E>50 MeV/u)

300 MeV/u (2 10^6 primaries)

No. of Z=2 particles exiting the target in the forward direction
(all angles and energy): 73381

Of which the no. of ^{4}He is: 53938 ➔73.5% of Z=2

these include also a low energy tail from target fragmentation

No. of Z=2 particles arriving at TW: 72816 ➔99.2% of Z=2 exiting from target

acceptance + loss of low-energy target fragmentation products, but
these ***include also particles generated in air + secondary interactions*** *products*
A cut in energy (E>50 MeV/u) slightly reduces the number (71714)

No. of Z=2 particles arriving at TW actually produced in target: 49690 (49653 for E>50 MeV/u)

background contribution is huge: 32%

No. of ^{4}He arriving at TW: 58879 (80.9% of Z=2 particles at TW)
Of which actually produced in target: 40934: **background is 30.4%**
(40918 for E>50 MeV/u)

400 MeV/u (2 10^6 primaries)

No. of Z=2 particles exiting the target in the forward direction
(all angles and energy): 68375

Of which the no. of ^{4}He is: 51196 ➔74.9% of Z=2

these include also a low energy tail from target fragmentation

No. of Z=2 particles arriving at TW: 74361 ➔**109% (!!)** of Z=2 exiting from target

acceptance + loss of low-energy target fragmentation products, but
these ***include also particles generated in air + secondary interactions*** *products*
A cut in energy (E>50 MeV/u) slightly reduces the number (73498)

No. of Z=2 particles arriving at TW actually produced in target: 51770 (51775 for E>50 MeV/u)

background contribution is huge: 30%

No. of ^{4}He arriving at TW: 59484 (80% of Z=2 particles at TW)
Of which actually produced in target: 41942: **background is 29.4%**
(41935 for E>50 MeV/u)