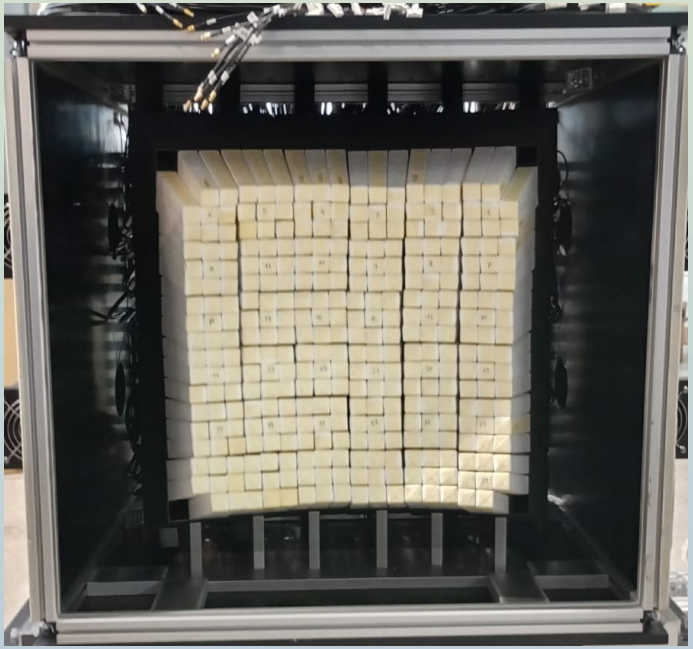
# From CALO calibration towards cross-sections @ CNAO 2024

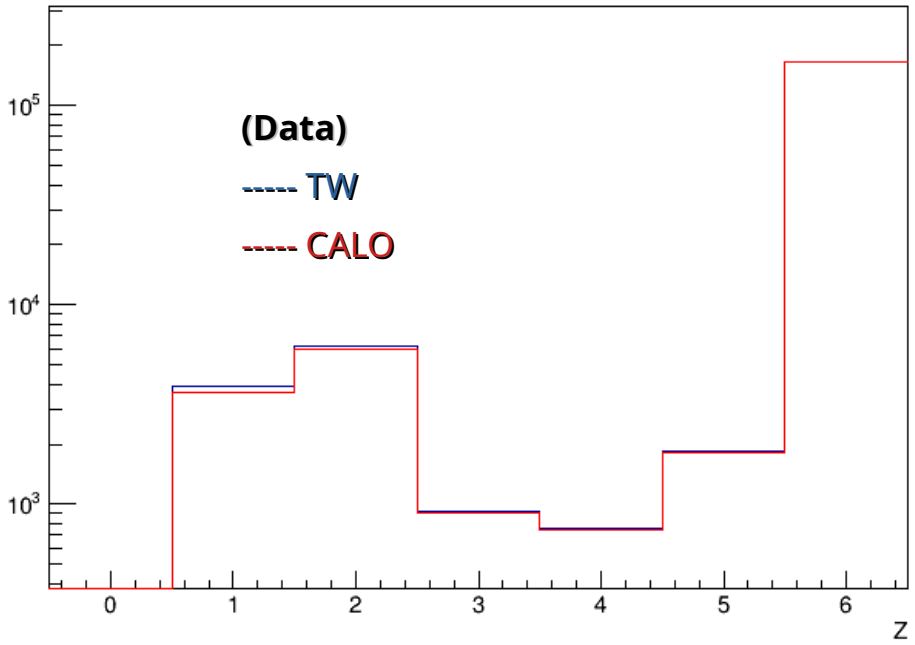
**B. Spadavecchia on behalf of the FOOT Turin group**

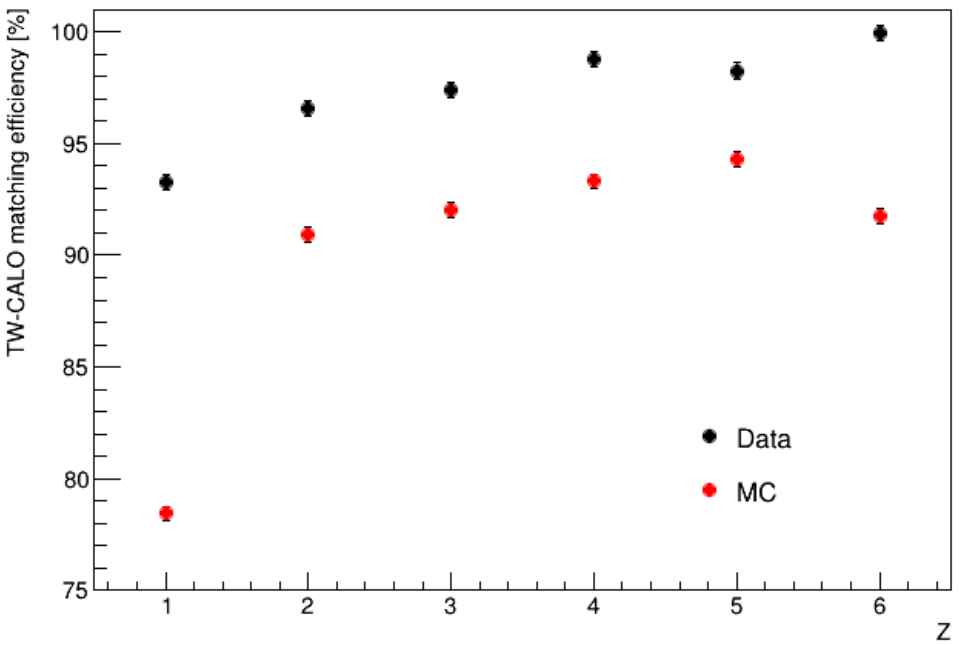


## Summary

- **Studies on clustering and matching efficiency – data vs MC**
- Resolution degrading at higher energies
- Calibration correction for clus size > 1
- Beta vs $E_{kin}$
- Possible clustering improvements

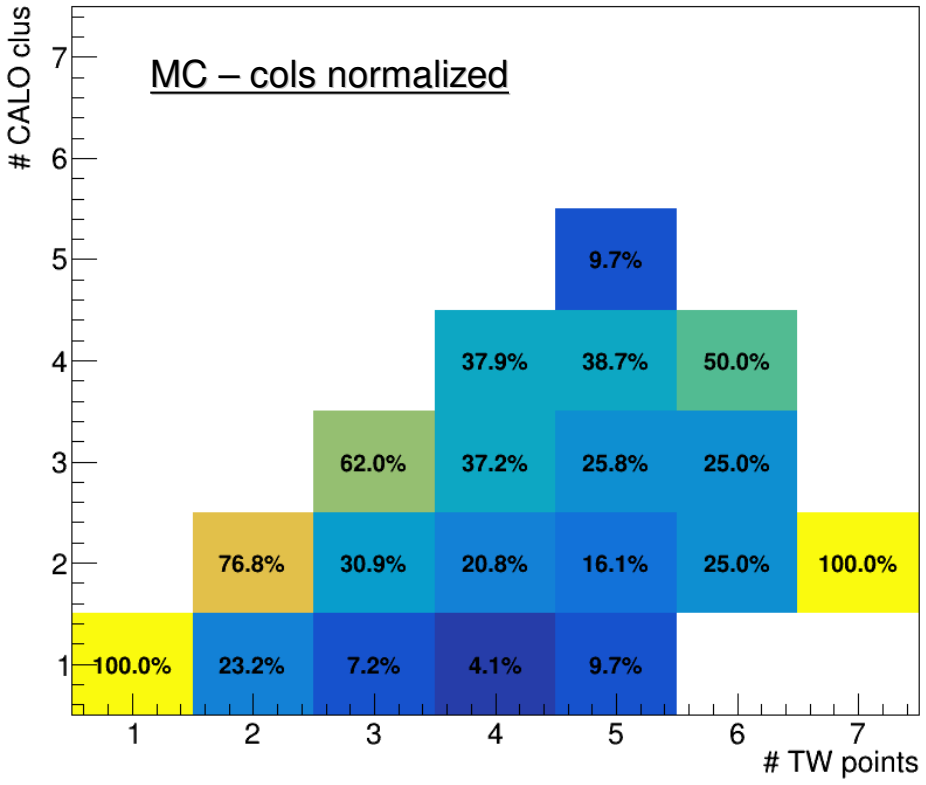
# TW-CALO matching efficiency (data vs MC)

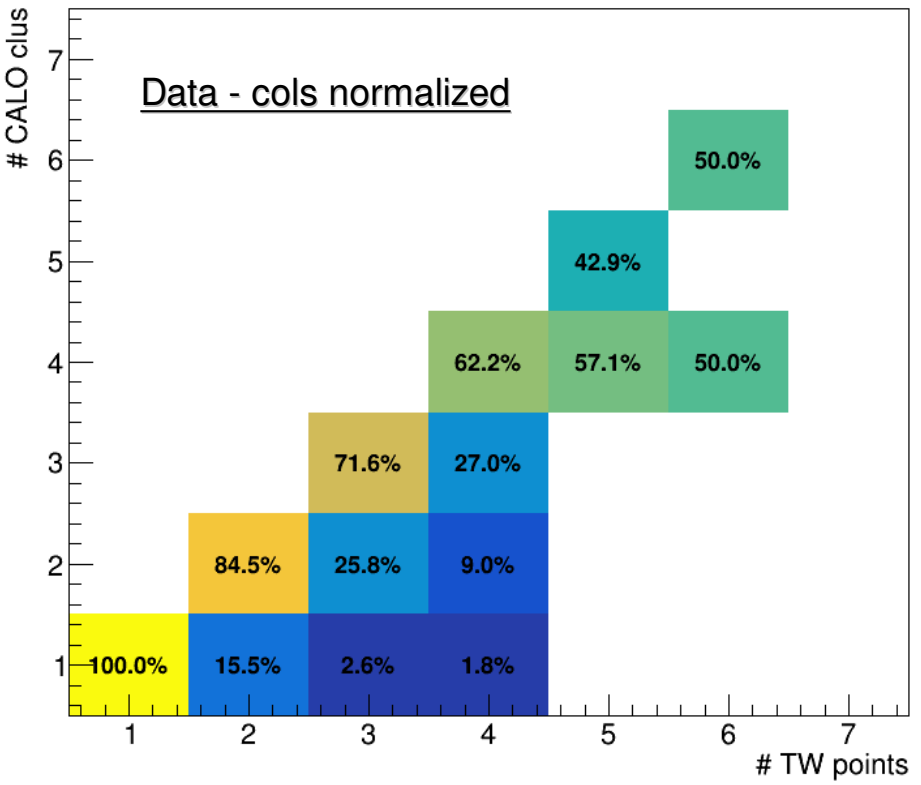



The errors here reported are merely statistical (210k events considered in both data and MC).

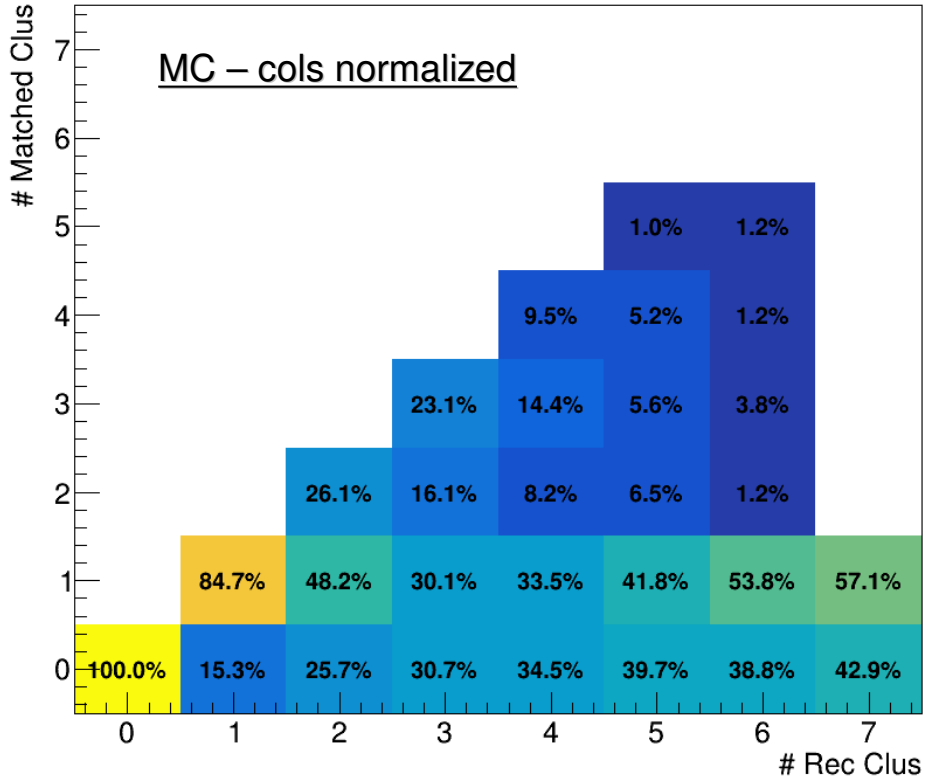
# TW-CALO matching efficiency (data vs MC)

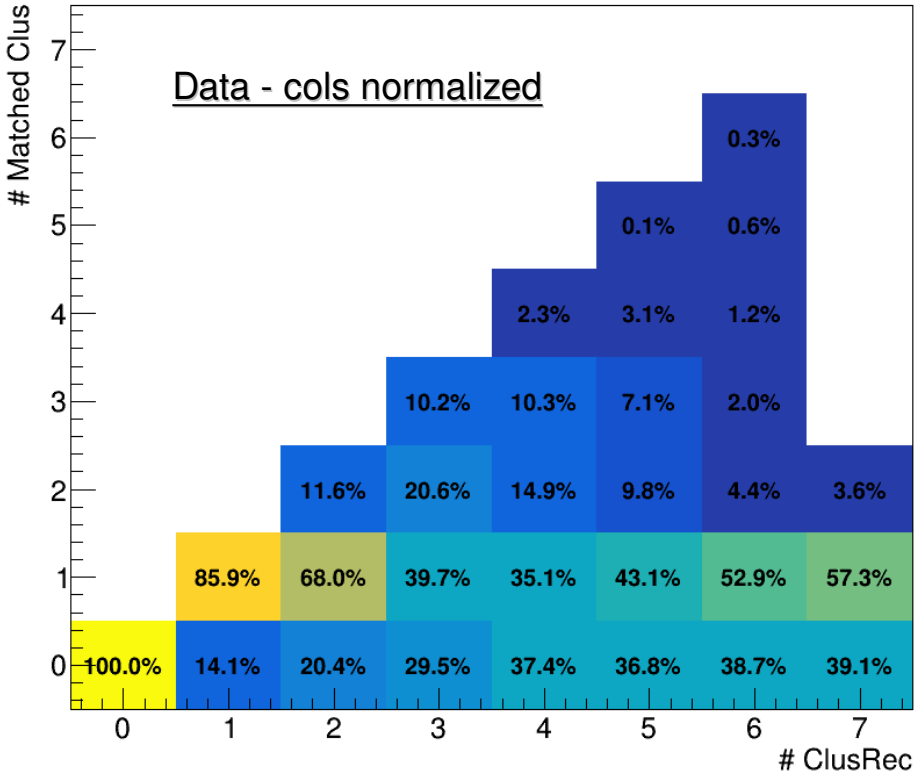



The fraction of successfully matched TW-points decreases when TW-points increase.

# TW-CALO matching efficiency (data vs MC)

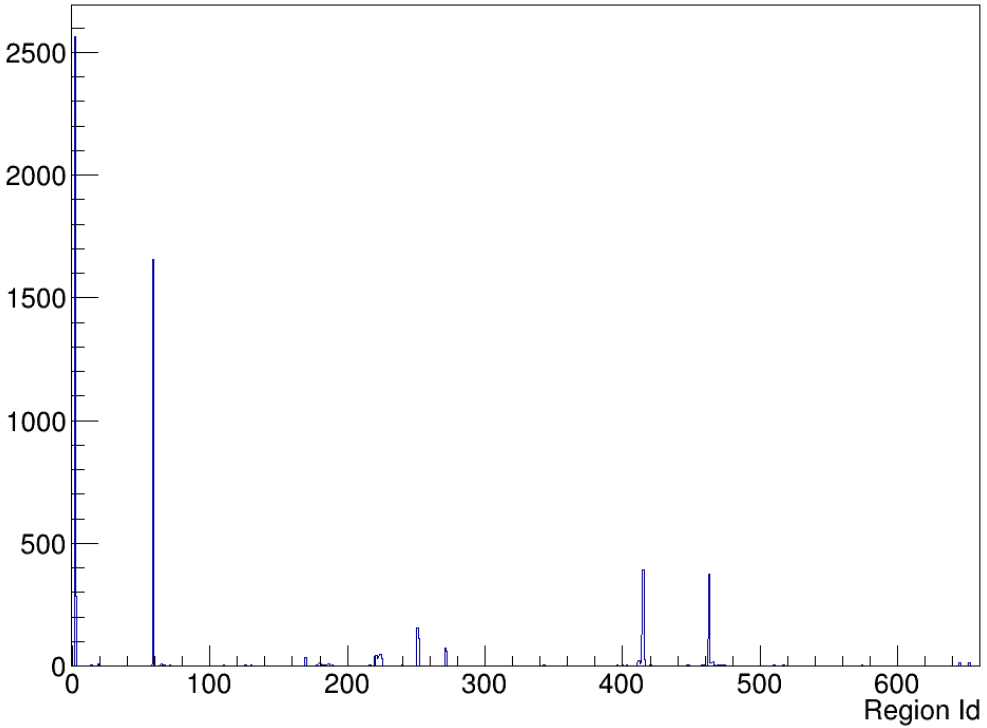



The fraction of successfully matched clusters decreases when clusters increase.

## Cluster – tracks matching (MC analysis)

A track impinging on CALO is called “first-impinging” if it crosses AIR→ AIR_CALO → CALO, in **this** order.




In ≈ 2% of cases, a cluster corresponds to a **non** “first-impinging” track, originated from:

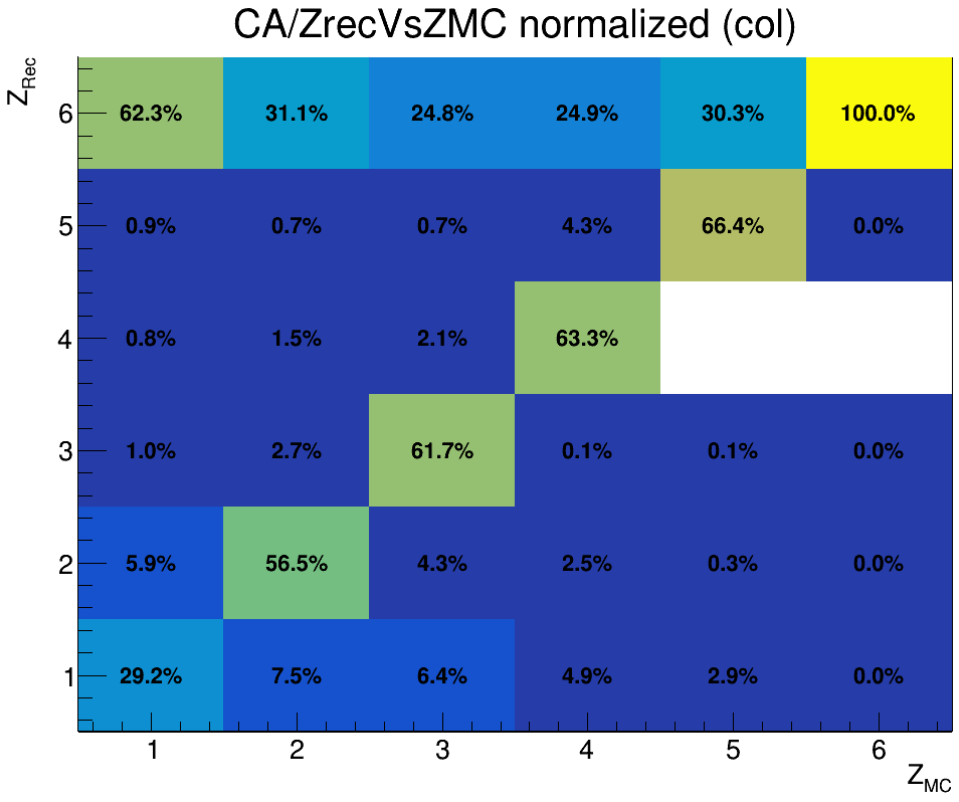
- inside the CALO (i.e. regions 414-415, 462-463)
- primaries (reg. 2)
- target (reg. 59)

→ why are fragments skipping the “first-impinging” check in the last two cases? To be investigated...

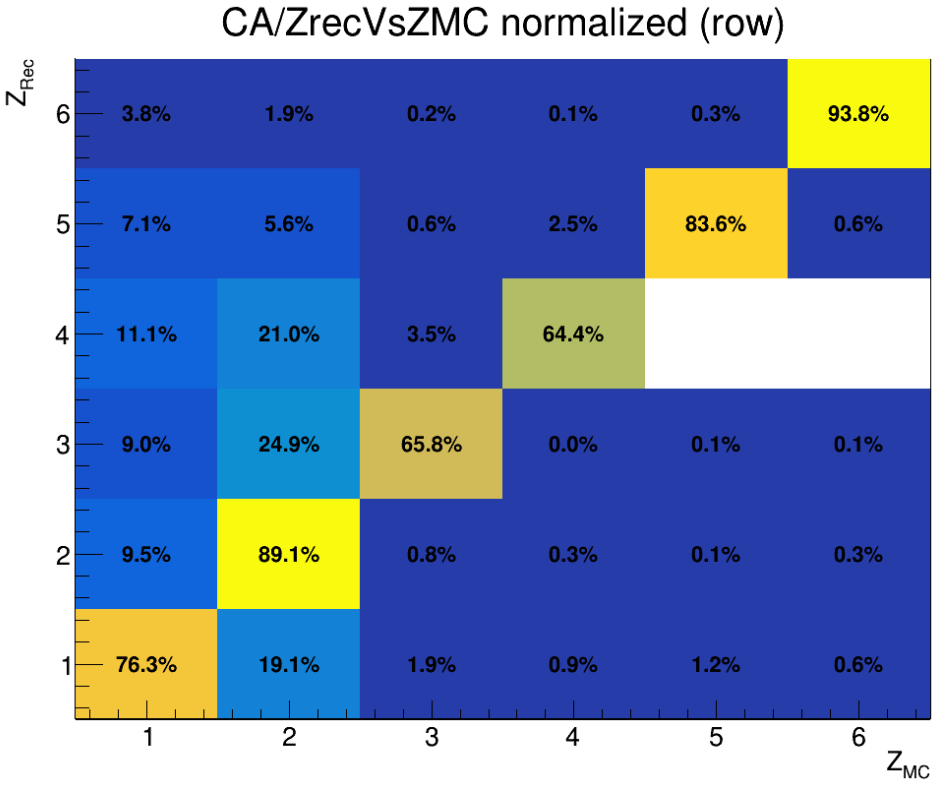
In ≈ 0.05% of cases, a cluster is not matched successfully to any track.

What happens in the remaining ≈ 98% of cases? → next slides

# Intrinsic Z misidentification (MC analysis)

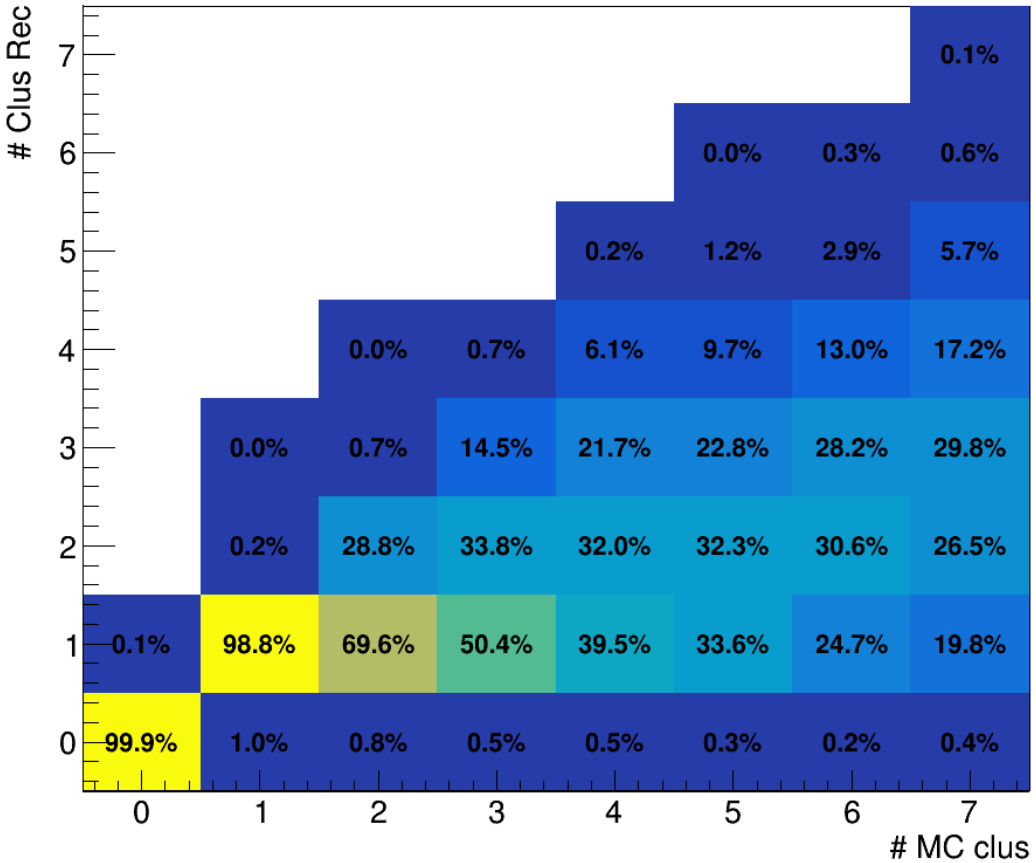



Out of diagonal, $P(Z_{rec} \neq Z_{MC} \mid Z_{MC}) \rightarrow$ statistics loss




On diagonal, $P(Z_{MC} = Z_{rec} \mid Z_{rec}) \rightarrow$ "true positives"

# Pile-up effect on clustering (MC analysis)



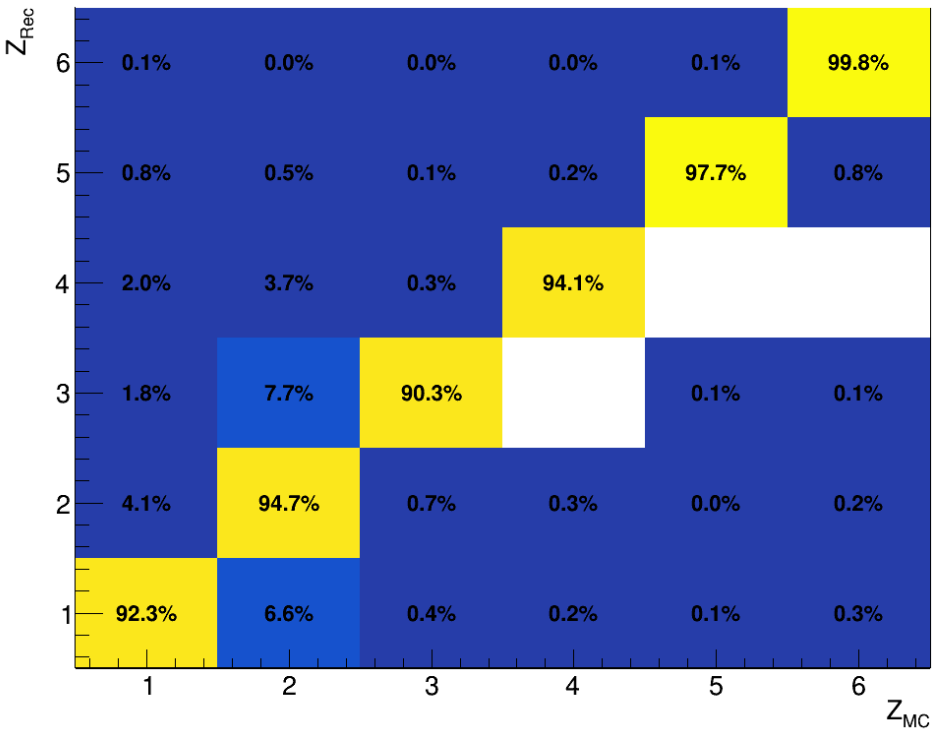

MC clus = first-impinging tracks on the CALO.

The larger the number of MC clusters, the higher the probability they are underestimated.

The cases where ClusRec < ClusMC need further investigation (→ multiple tracks in the same cluster?)

Let's select only the cases when **ClusMC = ClusRec**.

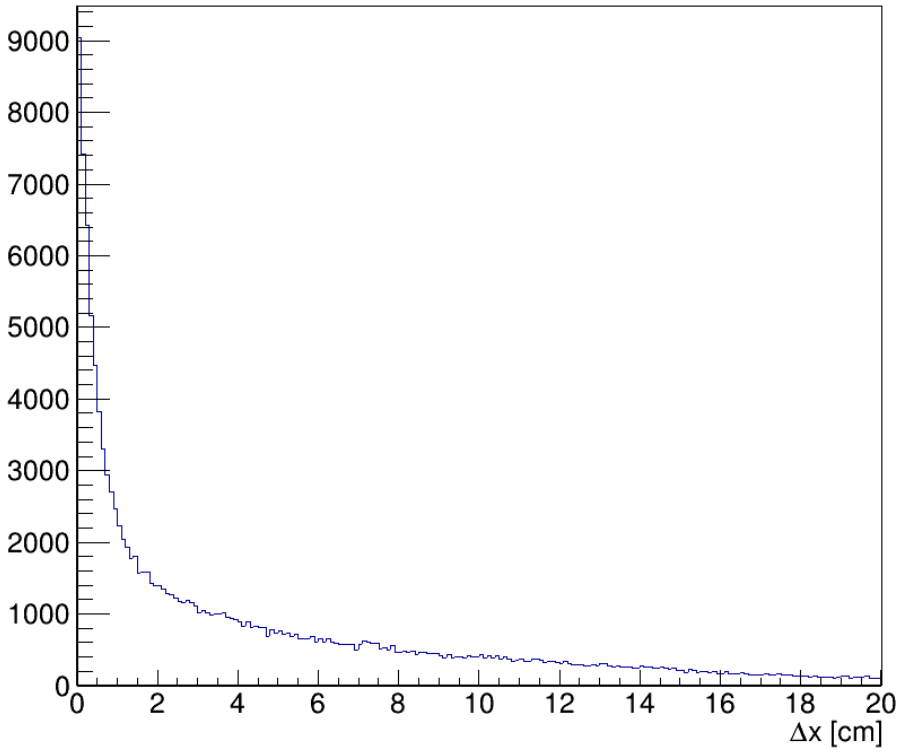
# Intrinsic Z misidentification (MC analysis)

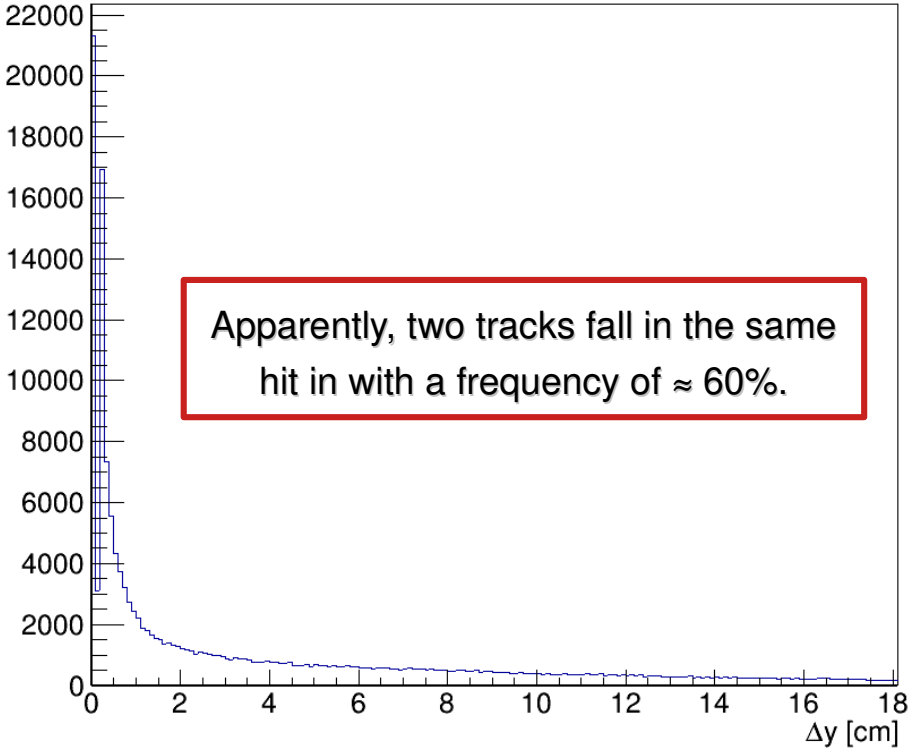




When ClusMC = ClusRec there is a drastical improvement in Z identification.

## Pile-up effect on clustering (MC analysis)

What happens when ClusRec > ClusMC? For each possible pair of “first-impinging” tracks, I tried to plot their mutual distance in order to see how likely it is for them to fall in the same hit (|x| or |y| < 2.1 cm).



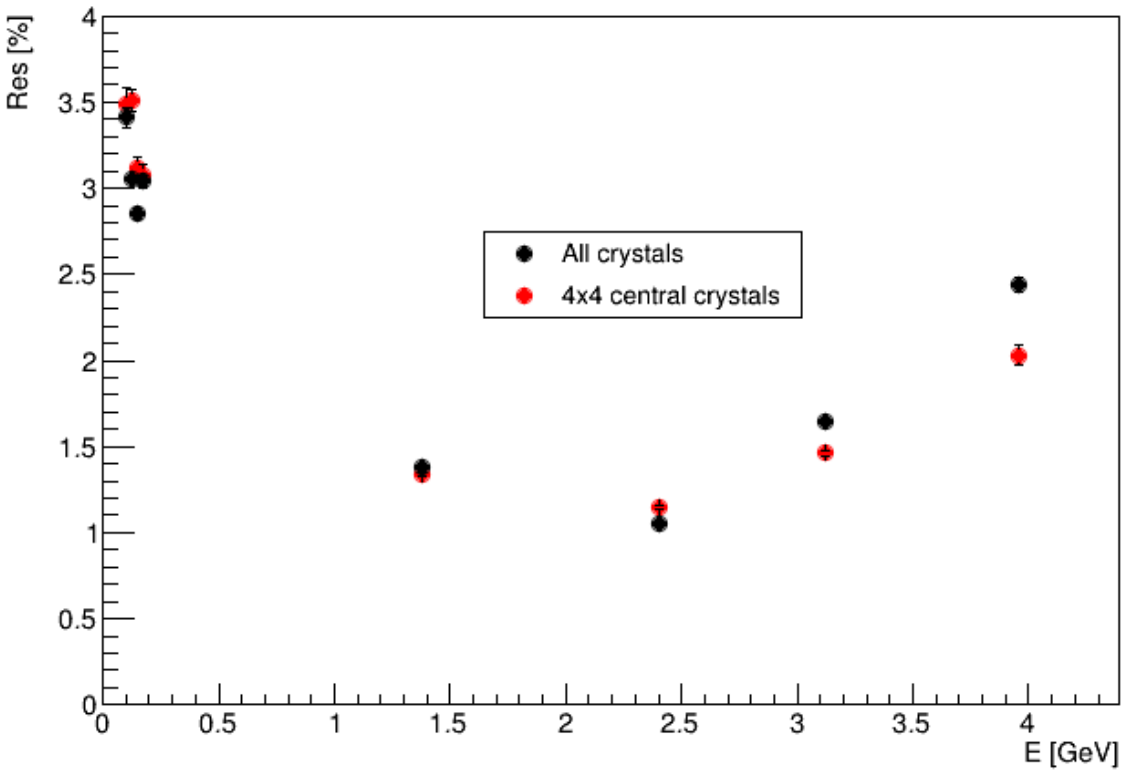




Apparently, two tracks fall in the same hit in with a frequency of ≈ 60%.

## Summary

- Studies on clustering and matching efficiency – data vs MC
- **Resolution degrading at higher energies**
- Calibration correction for clus size > 1
- Beta vs $E_{kin}$
- Possible clustering improvements

# Resolution degrading at higher energies




Integral resolution of the whole calorimeter vs the 16 central crystals

→ small worsening in resolution for outer crystals at higher energies.

## Hypothesis on resolution worsening*

The resolution σ(E)/E, which is standard for calorimeters, assumes linearity in the response.

Since the uncertainty propagation involves the derivative, response no longer linear → derivative is essentially zero in the saturation region → uncertainty diverges → resolution loss.

Assuming that

$$\frac{\sigma(a)}{a} = \frac{1}{\sqrt{a}} \qquad a(E) = \frac{p_0 E^2}{1 + p_1 E + p_2 E^2}.$$

The resolution with respect to energy is

$$\frac{\sigma(E)}{E} = \frac{(1 + p_1 E + p_2 E^2)^{3/2}}{(2 + p_1 E) \cdot \sqrt{p_0} \cdot E}$$

*Credits to G. Traini

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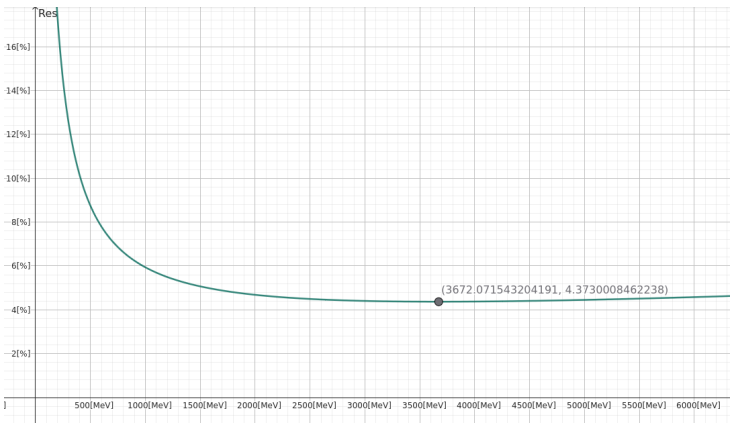
Resolution function has a minimum for a given energy (depending on the three parameters)




strong assumption! There must be some kind of correction factor

→ resolution values are not reliable
→ we can make some considerations on the optimal energy for resolution

*Credits to G. Traini

# Crystal selection

Istituto Nazionale di Fisica Nucleare
SEZIONE DI TORINO

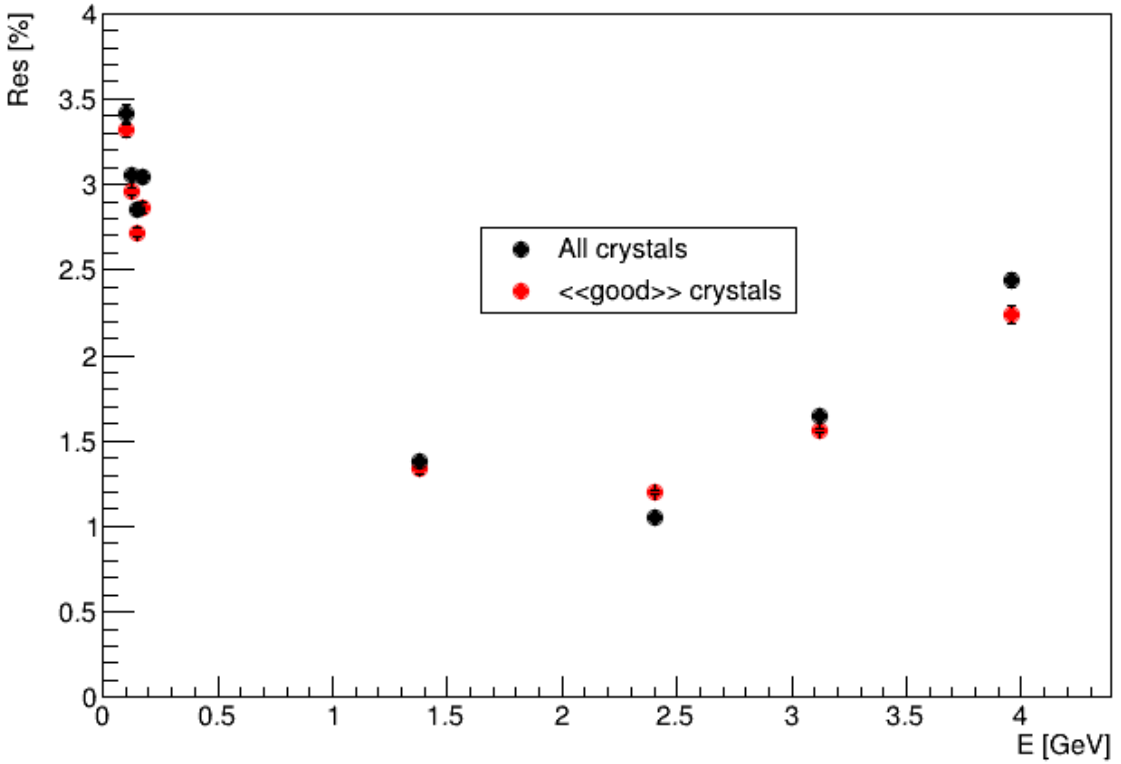
## Carbon – green if $E_{opt}$ > 330 MeV/u

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 9 | 10 | 11 | 18 | 19 | 20 | 27 | 28 | 29 | 36 | 37 | 38 | 45 | 46 | 47 |
| 3 | 4 | 5 | 12 | 13 | 14 | 21 | 22 | 23 | 30 | 31 | 32 | 39 | 40 | 41 | 48 | 49 | 50 |
| 6 | 7 | 8 | 15 | 16 | 17 | 24 | 25 | 26 | 33 | 34 | 35 | 42 | 43 | 44 | 51 | 52 | 53 |
| 54 | 55 | 56 | 63 | 64 | 65 | 72 | 73 | 74 | 81 | 82 | 83 | 90 | 91 | 92 | 99 | 100 | 101 |
| 57 | 58 | 59 | 66 | 67 | 68 | 75 | 76 | 77 | 84 | 85 | 86 | 93 | 94 | 95 | 102 | 103 | 104 |
| 60 | 61 | 62 | 69 | 70 | 71 | 78 | 79 | 80 | 87 | 88 | 89 | 96 | 97 | 98 | 105 | 106 | 107 |
| 108 | 109 | 110 | 117 | 118 | 119 | 126 | 127 | 128 | 135 | 136 | 137 | 144 | 145 | 146 | 153 | 154 | 155 |
| 111 | 112 | 113 | 120 | 121 | 122 | 129 | 130 | 131 | 138 | 139 | 140 | 147 | 148 | 149 | 156 | 157 | 158 |
| 114 | 115 | 116 | 123 | 124 | 125 | 132 | 133 | 134 | 141 | 142 | 143 | 150 | 151 | 152 | 159 | 160 | 161 |
| 162 | 163 | 164 | 171 | 172 | 173 | 180 | 181 | 182 | 189 | 190 | 191 | 198 | 199 | 200 | 207 | 208 | 209 |
| 165 | 166 | 167 | 174 | 175 | 176 | 183 | 184 | 185 | 192 | 193 | 194 | 201 | 202 | 203 | 210 | 211 | 212 |
| 168 | 169 | 170 | 177 | 178 | 179 | 186 | 187 | 188 | 195 | 196 | 197 | 204 | 205 | 206 | 213 | 214 | 215 |
| 216 | 217 | 218 | 225 | 226 | 227 | 234 | 235 | 236 | 243 | 244 | 245 | 252 | 253 | 254 | 261 | 262 | 263 |
| 219 | 220 | 221 | 228 | 229 | 230 | 237 | 238 | 239 | 246 | 247 | 248 | 255 | 256 | 257 | 264 | 265 | 266 |
| 222 | 223 | 224 | 231 | 232 | 233 | 240 | 241 | 242 | 249 | 250 | 251 | 258 | 259 | 260 | 267 | 268 | 269 |
| 270 | 271 | 272 | 279 | 280 | 281 | 288 | 289 | 290 | 297 | 298 | 299 | 306 | 307 | 308 | 315 | 316 | 317 |
| 273 | 274 | 275 | 282 | 283 | 284 | 291 | 292 | 293 | 300 | 301 | 302 | 309 | 310 | 311 | 318 | 319 | 320 |
| 276 | 277 | 278 | 285 | 286 | 287 | 294 | 295 | 296 | 303 | 304 | 305 | 312 | 313 | 314 | 321 | 322 | 323 |

## Protons – green if $E_{opt}$ > 170 MeV

| | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 9 | 10 | 11 | 18 | 19 | 20 | 27 | 28 | 29 | 36 | 37 | 38 | 45 | 46 | 47 |
| 3 | 4 | 5 | 12 | 13 | 14 | 21 | 22 | 23 | 30 | 31 | 32 | 39 | 40 | 41 | 48 | 49 | 50 |
| 6 | 7 | 8 | 15 | 16 | 17 | 24 | 25 | 26 | 33 | 34 | 35 | 42 | 43 | 44 | 51 | 52 | 53 |
| 54 | 55 | 56 | 63 | 64 | 65 | 72 | 73 | 74 | 81 | 82 | 83 | 90 | 91 | 92 | 99 | 100 | 101 |
| 57 | 58 | 59 | 66 | 67 | 68 | 75 | 76 | 77 | 84 | 85 | 86 | 93 | 94 | 95 | 102 | 103 | 104 |
| 60 | 61 | 62 | 69 | 70 | 71 | 78 | 79 | 80 | 87 | 88 | 89 | 96 | 97 | 98 | 105 | 106 | 107 |
| 108 | 109 | 110 | 117 | 118 | 119 | 126 | 127 | 128 | 135 | 136 | 137 | 144 | 145 | 146 | 153 | 154 | 155 |
| 111 | 112 | 113 | 120 | 121 | 122 | 129 | 130 | 131 | 138 | 139 | 140 | 147 | 148 | 149 | 156 | 157 | 158 |
| 114 | 115 | 116 | 123 | 124 | 125 | 132 | 133 | 134 | 141 | 142 | 143 | 150 | 151 | 152 | 159 | 160 | 161 |
| 162 | 163 | 164 | 171 | 172 | 173 | 180 | 181 | 182 | 189 | 190 | 191 | 198 | 199 | 200 | 207 | 208 | 209 |
| 165 | 166 | 167 | 174 | 175 | 176 | 183 | 184 | 185 | 192 | 193 | 194 | 201 | 202 | 203 | 210 | 211 | 212 |
| 168 | 169 | 170 | 177 | 178 | 179 | 186 | 187 | 188 | 195 | 196 | 197 | 204 | 205 | 206 | 213 | 214 | 215 |
| 216 | 217 | 218 | 225 | 226 | 227 | 234 | 235 | 236 | 243 | 244 | 245 | 252 | 253 | 254 | 261 | 262 | 263 |
| 219 | 220 | 221 | 228 | 229 | 230 | 237 | 238 | 239 | 246 | 247 | 248 | 255 | 256 | 257 | 264 | 265 | 266 |
| 222 | 223 | 224 | 231 | 232 | 233 | 240 | 241 | 242 | 249 | 250 | 251 | 258 | 259 | 260 | 267 | 268 | 269 |
| 270 | 271 | 272 | 279 | 280 | 281 | 288 | 289 | 290 | 297 | 298 | 299 | 306 | 307 | 308 | 315 | 316 | 317 |
| 273 | 274 | 275 | 282 | 283 | 284 | 291 | 292 | 293 | 300 | 301 | 302 | 309 | 310 | 311 | 318 | 319 | 320 |
| 276 | 277 | 278 | 285 | 286 | 287 | 294 | 295 | 296 | 303 | 304 | 305 | 312 | 313 | 314 | 321 | 322 | 323 |

# Crystal selection

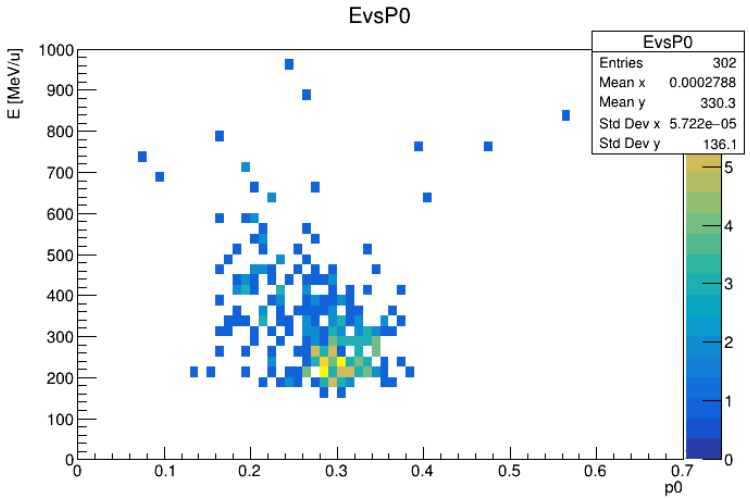


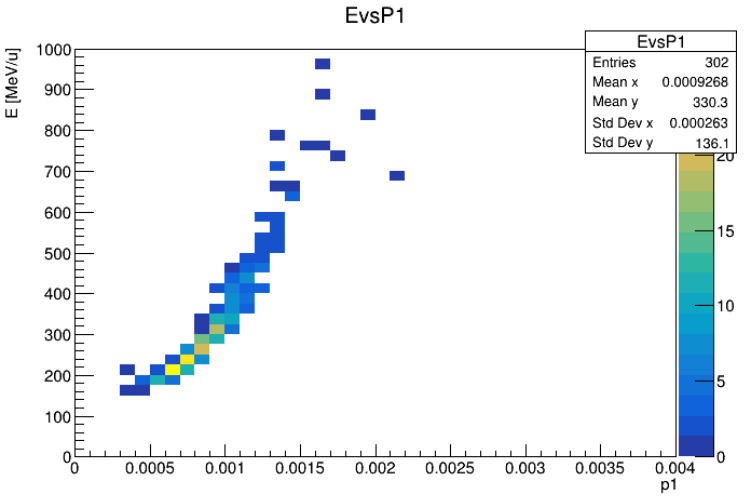

A crystal is “good” if the optimal resolution is for E > 170 MeV (protons) or E > 330 MeV/u (carbon)

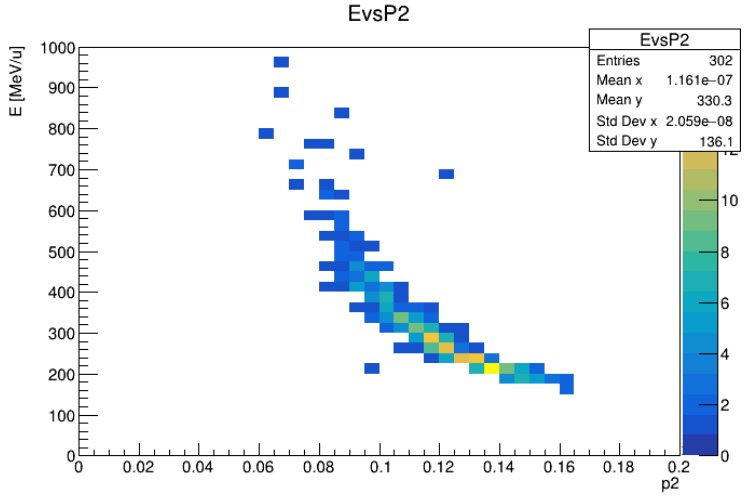
→ small improvement in resolution for “good” crystals at higher energies

→ however, the resolution trend is still the same
→ possible beam sharing contribution.

# Correlation for Carbon



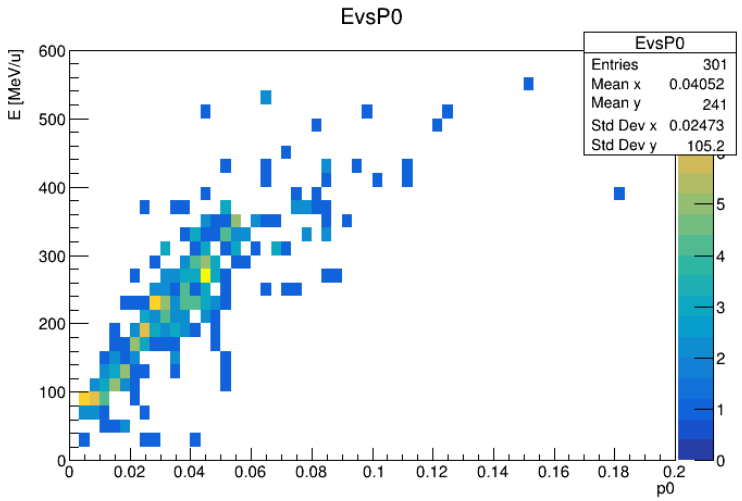



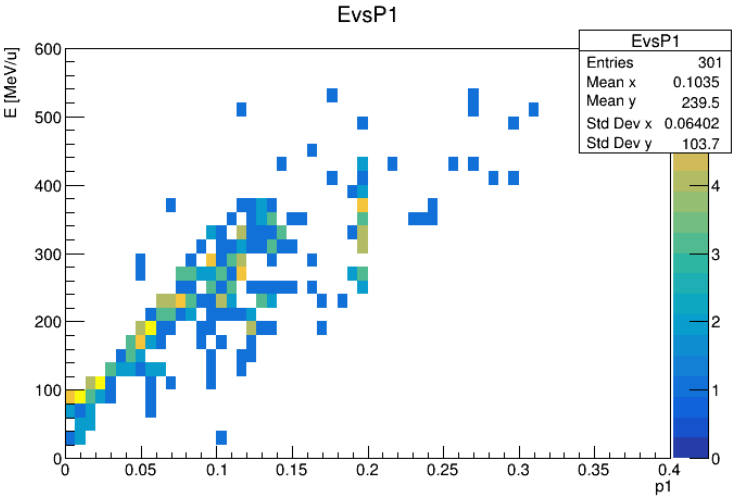



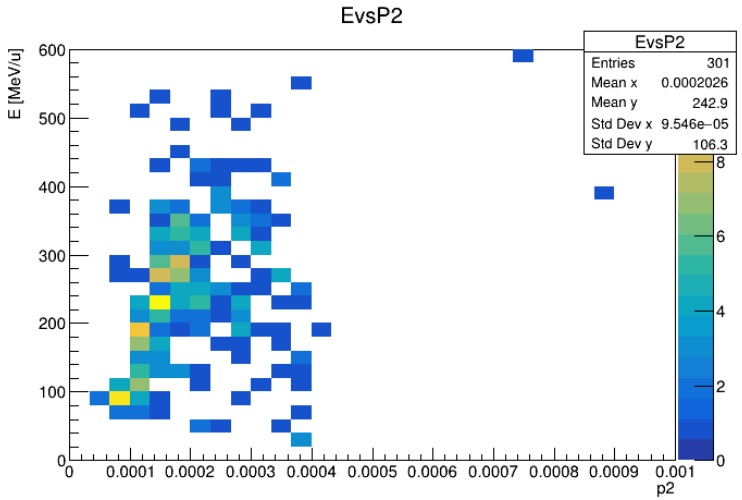

The optimal energy (= optimal resolution) shows a significative correlation with $p_1$ and $p_2$

→ non-linearity terms

# Correlation for Protons



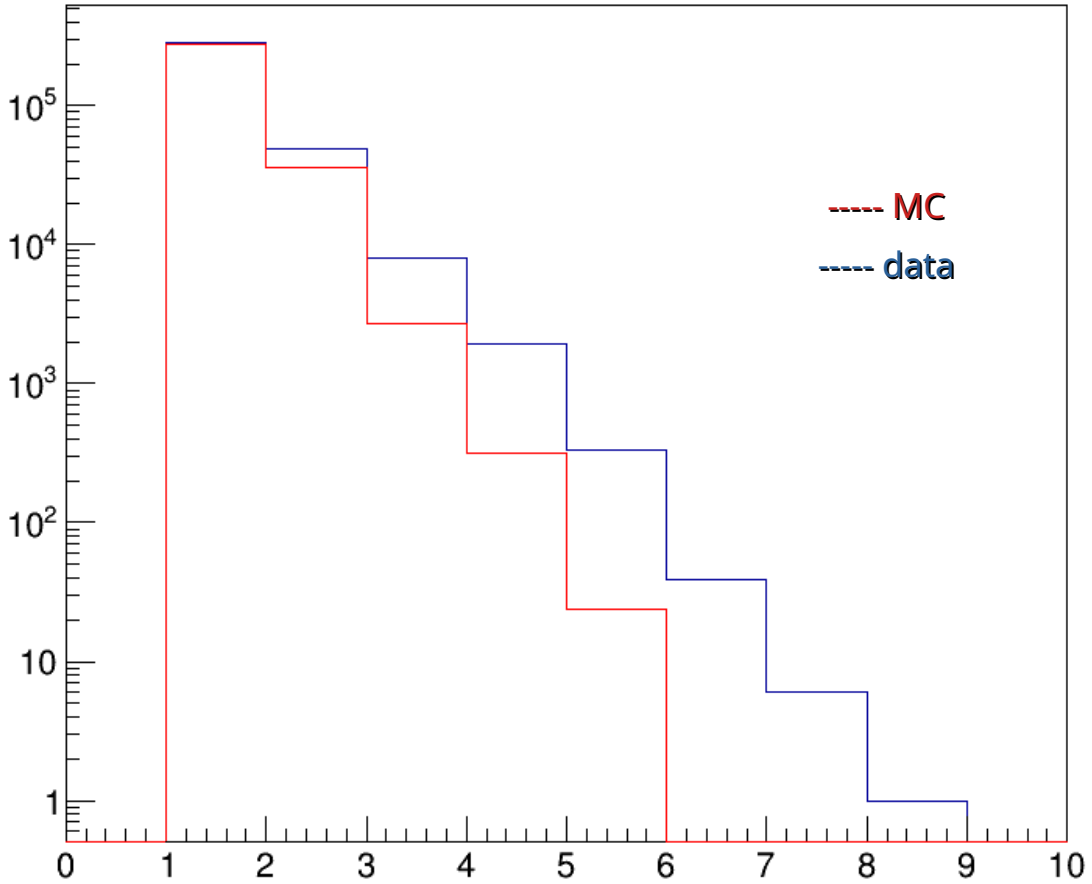




Differently from Carbon, the optimal energy (= optimal resolution) shows a significative correlation with $p_0$ and $p_1$ and no visible correlation with $p_2$.

## Summary

- Studies on clustering and matching efficiency – data vs MC
- Resolution degrading at higher energies
- **Calibration correction for clus size > 1**
- Beta vs $E_{kin}$
- Possible clustering improvements

## Clus size distribution for 400k events: data vs MC

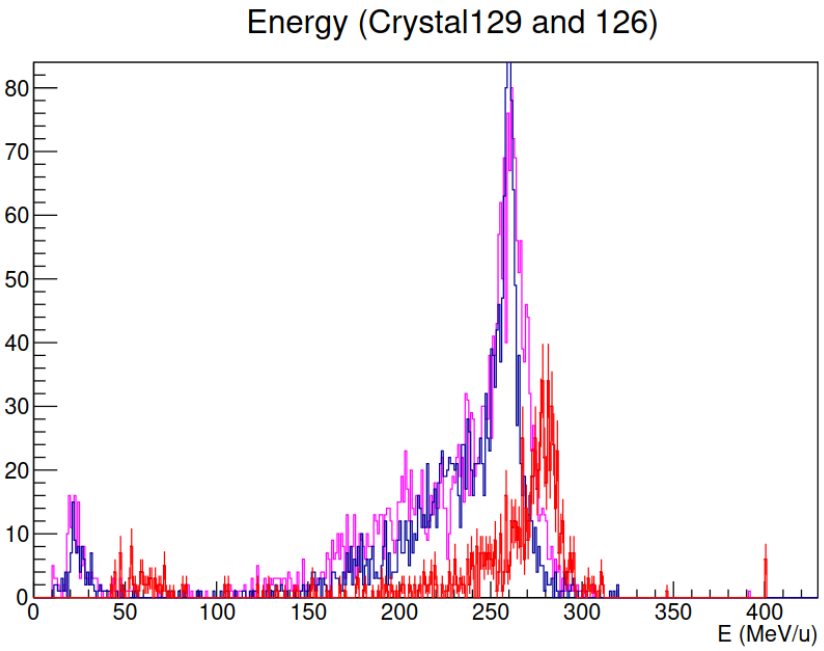



Are there noisy clusters?
Possible, but

warning: log scale on y
→ ≃ 3% clusters have size > 2.

→ Let's evaluate
"clus size = 2" case.

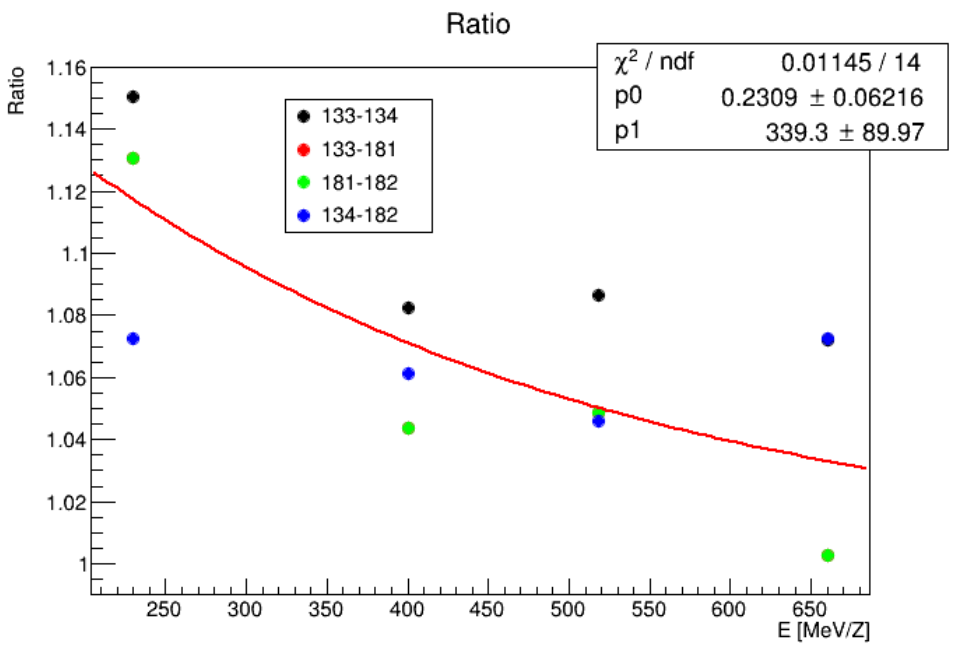
# Corrections for clus size > 1




Observation in calibration runs:
when hits in neighbour crystals occur,

$E_{1+2}^{nhits=2} > E_1^{nhits=1} + E_2^{nhits=1}$

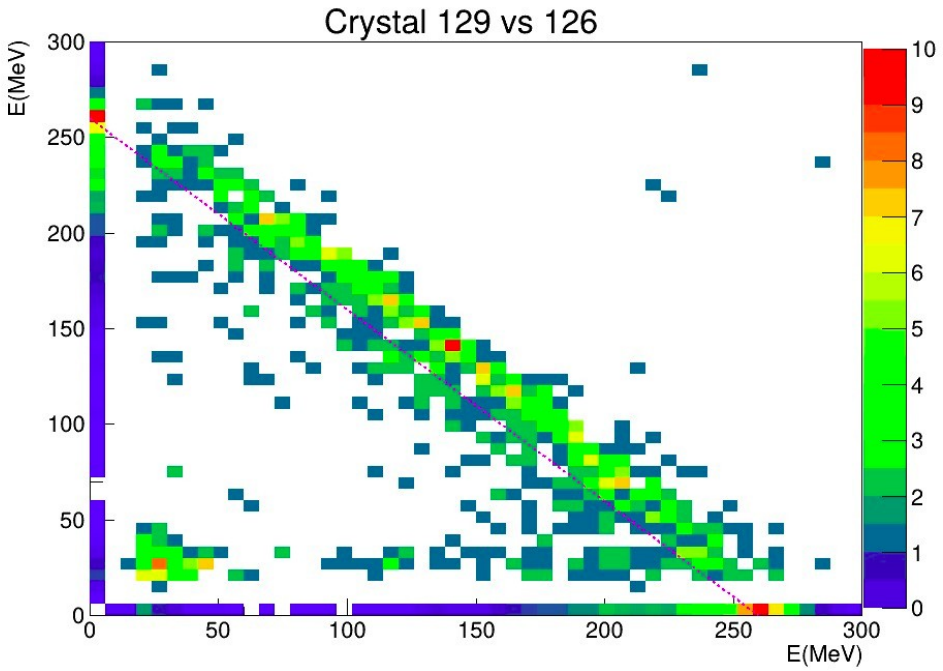
→ define ratio = $E_{1+2}^{nhits=2} / [(E_1^{nhits=1} + E_2^{nhits=1})/2]$




Ratio plot for the 4 crystals in the central spot
C points @ 115, 200, 260, 330 MeV/u

→ fit with $f(x) = 1 + p_0\, e^{-x/p1}$.

## Corrections for clus size > 1

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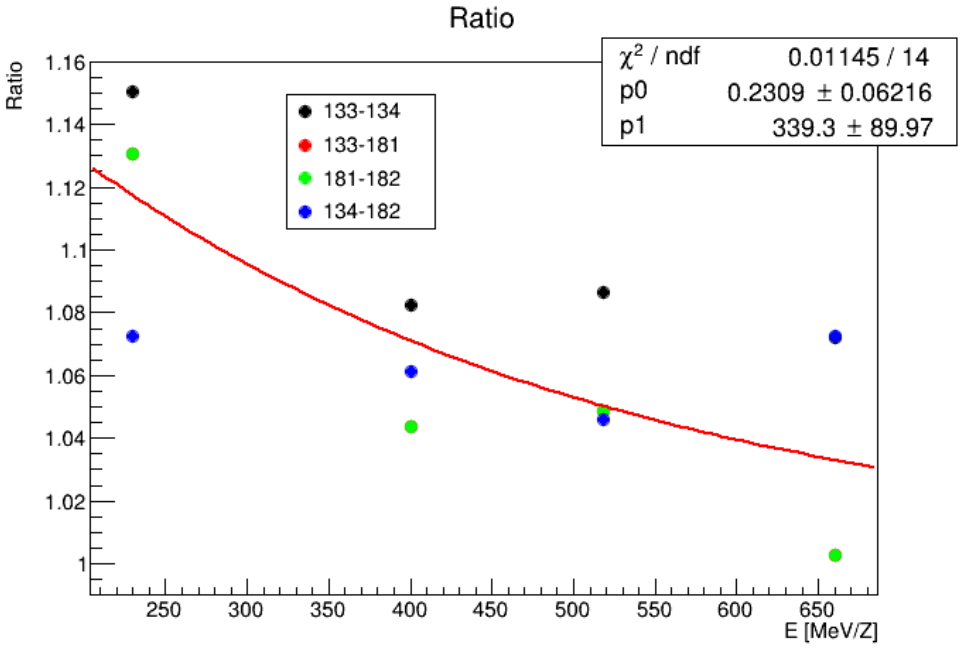


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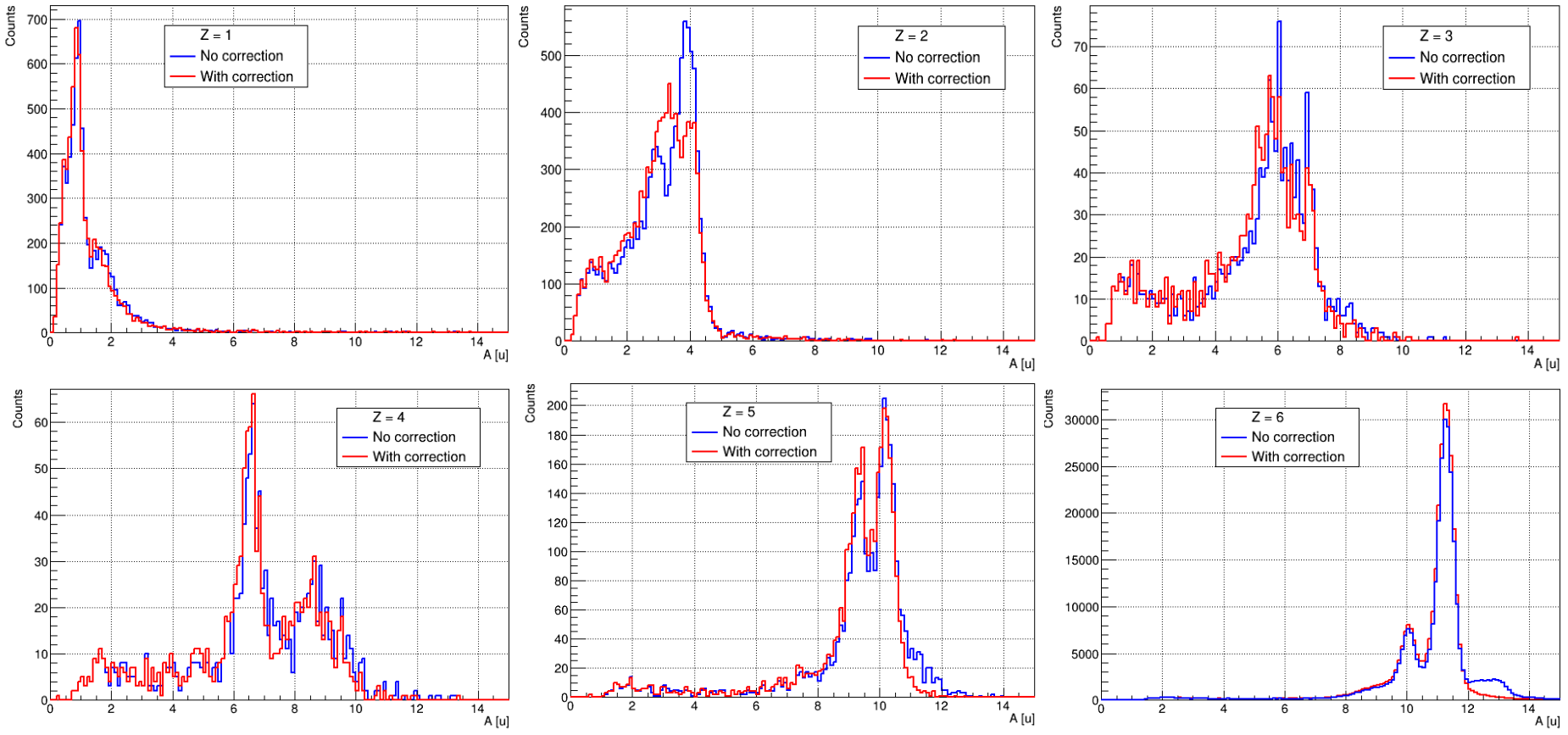
# First attempt for clus size > 1

Carbon function for the 4 central crystals (in MeV/Z) was used on all ion species → definitely not working.



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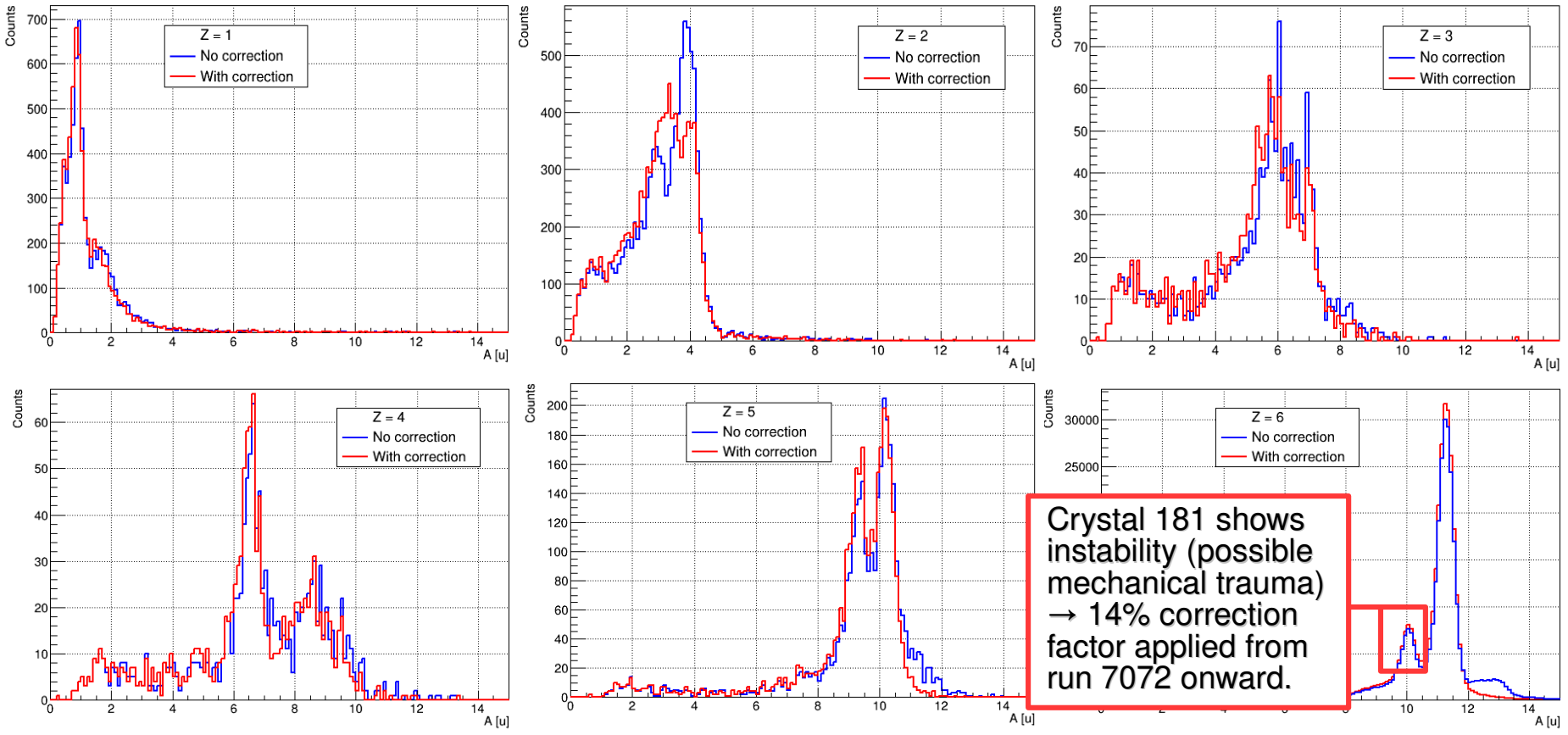
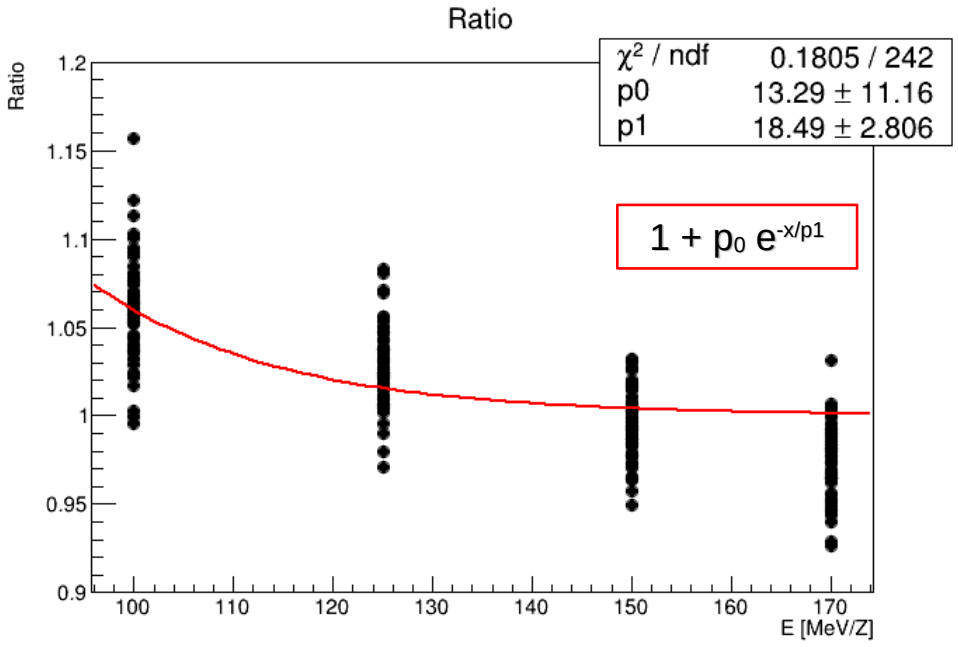
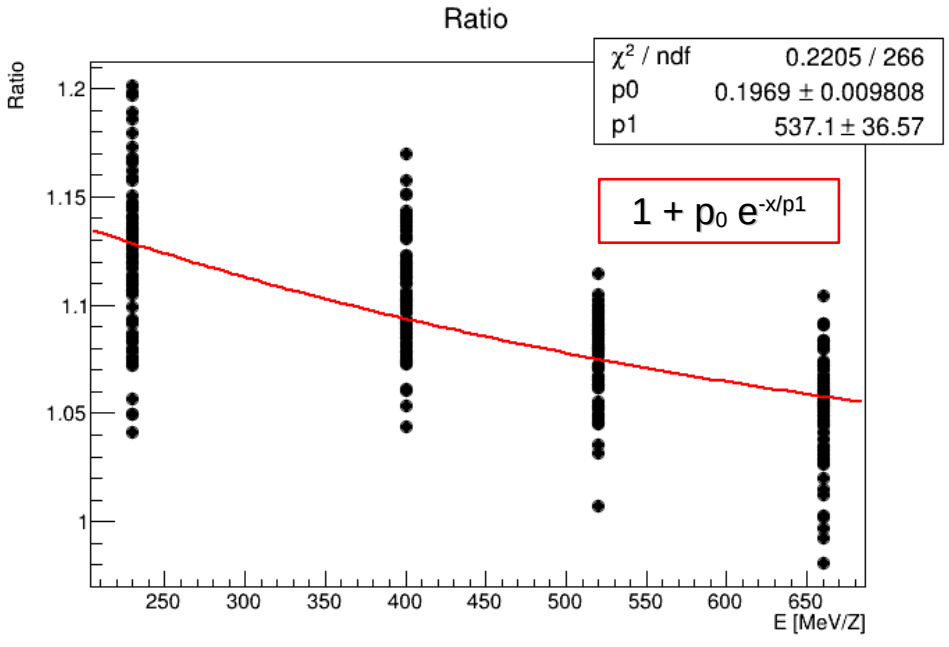



Crystal 181 shows instability (possible mechanical trauma) → 14% correction factor applied from run 7072 onward.

# Corrections for clus size > 1

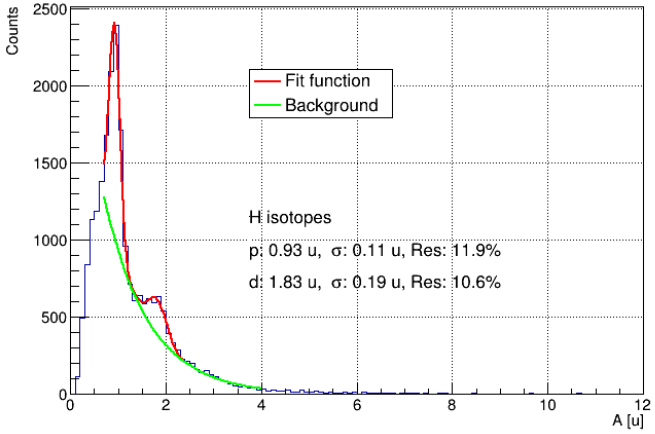


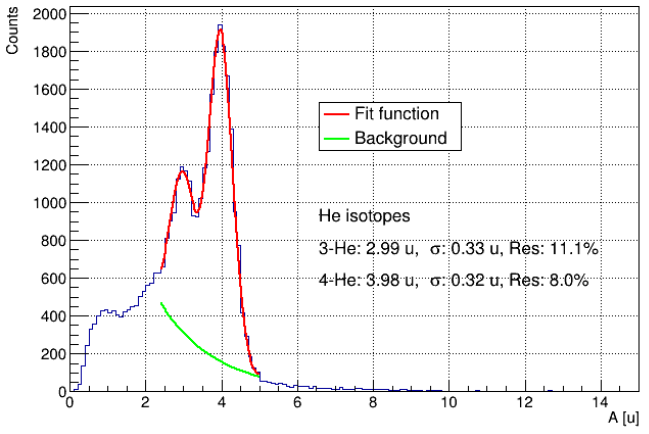

Ratio plot for all the pairs of neighbor crystals
p points @ 100, 125, 150, 170 MeV.

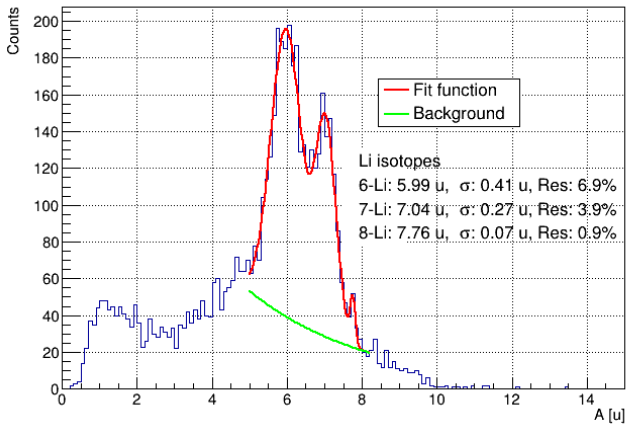


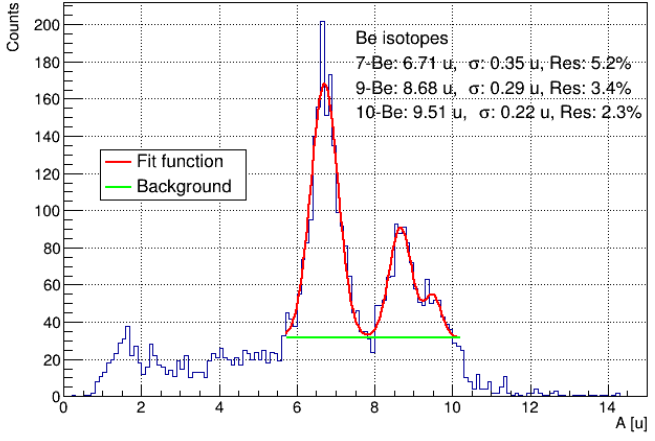

Ratio plot for all the pairs of neighbor crystals
C points @ 115, 200, 260, 330 MeV/u.

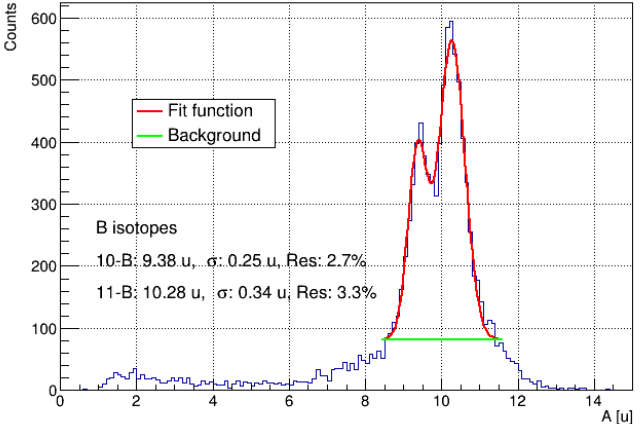
# Fits without correction

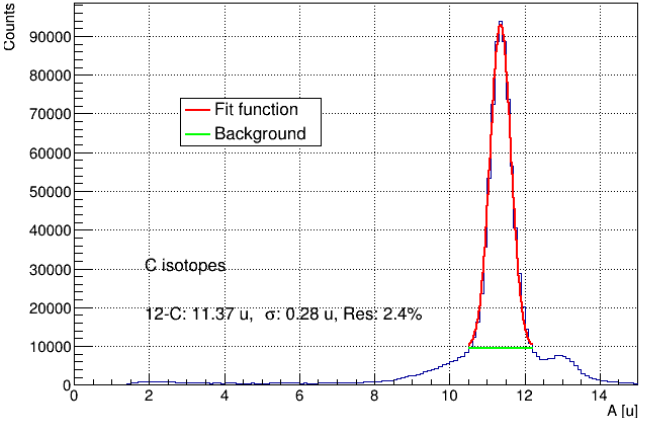


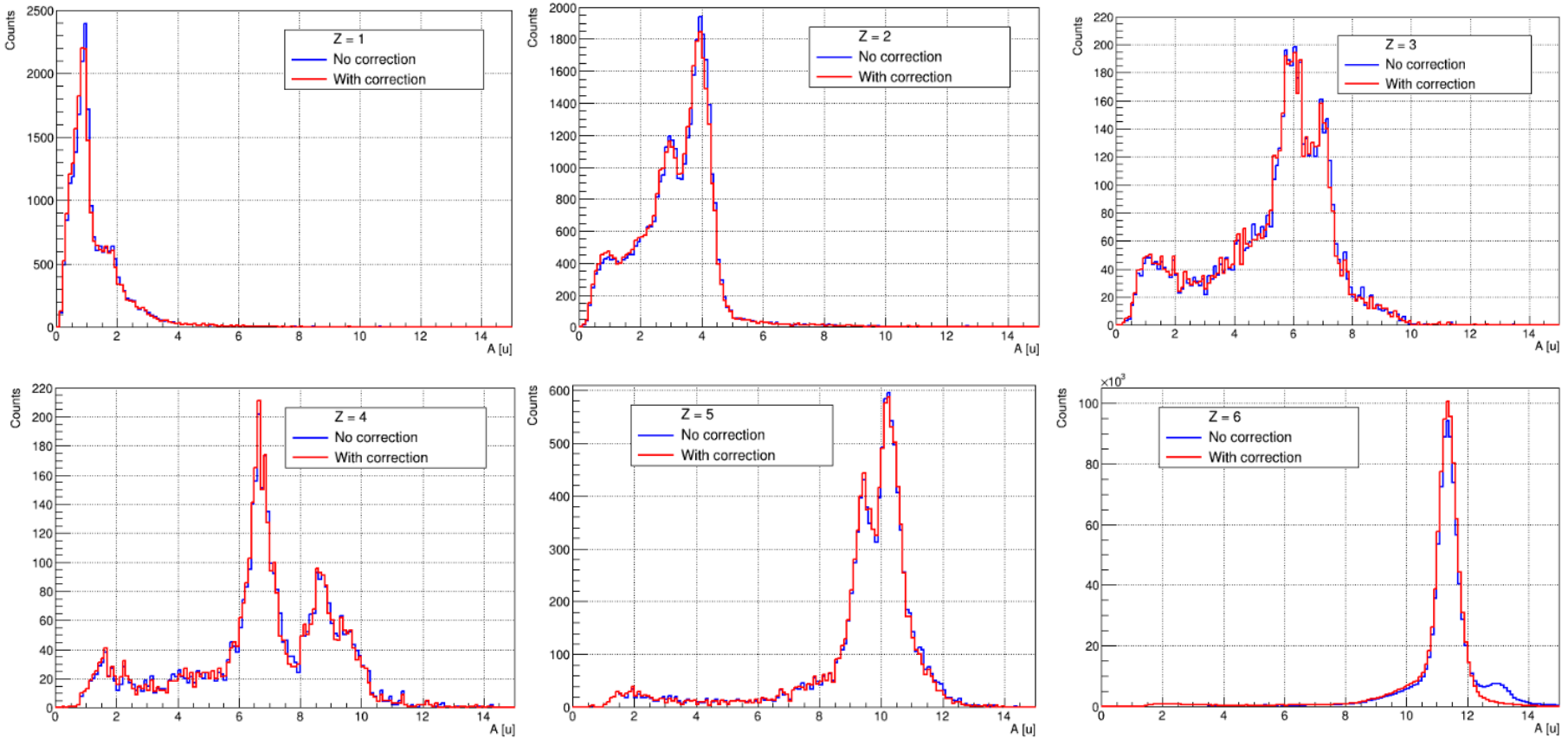



# First correction for clus size > 1

1) linear interpolation between the two function parameters $p_0$ and $p_1$. Clusters with size > 2 **excluded**.



# First correction for clus size > 1 - mass peaks

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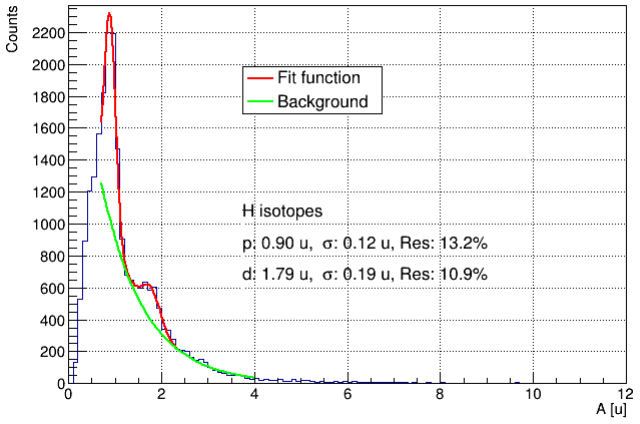
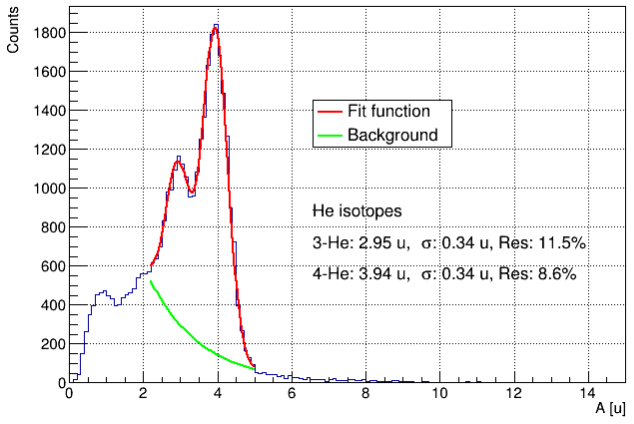
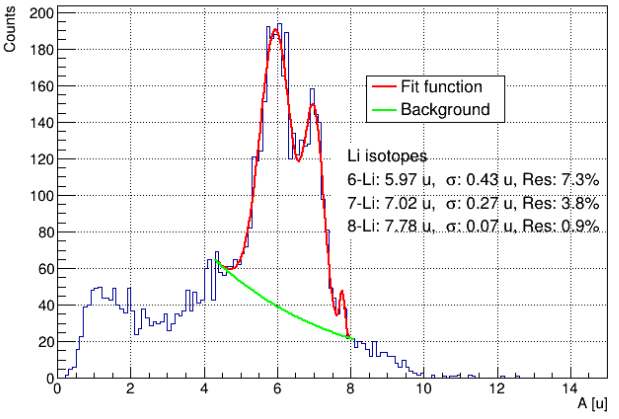
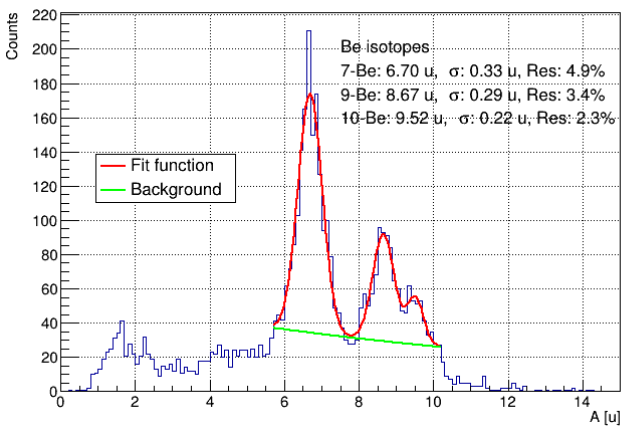
SEZIONE DI TORINO

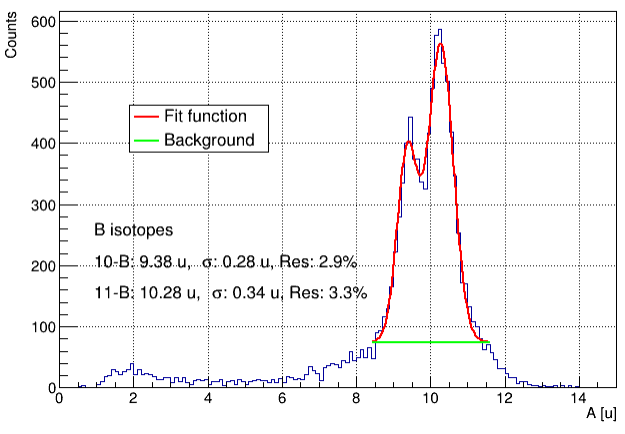
1) linear interpolation between the two function parameters $p_0$ and $p_1$. Clusters with size > 2 **excluded**.

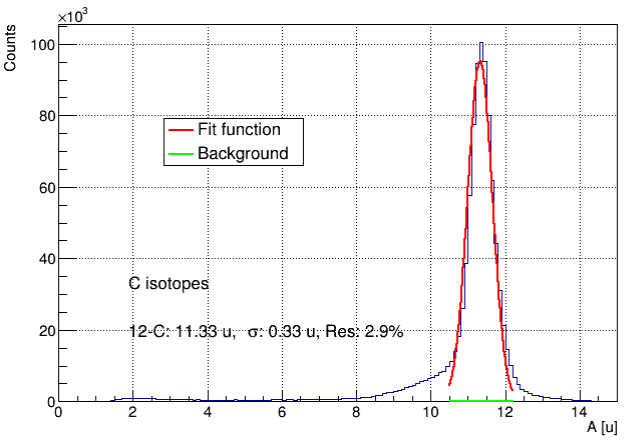


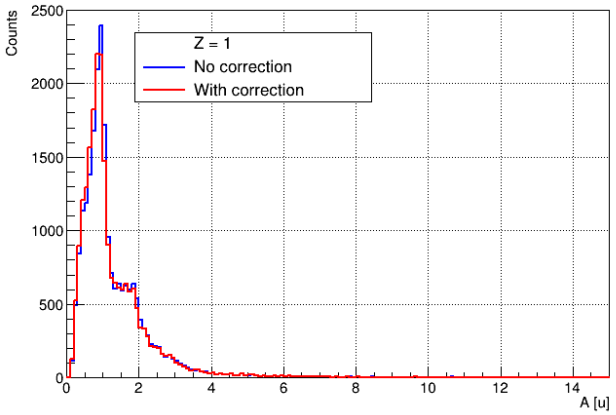



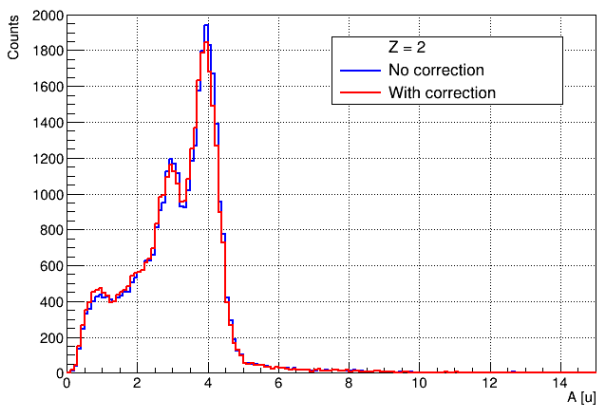



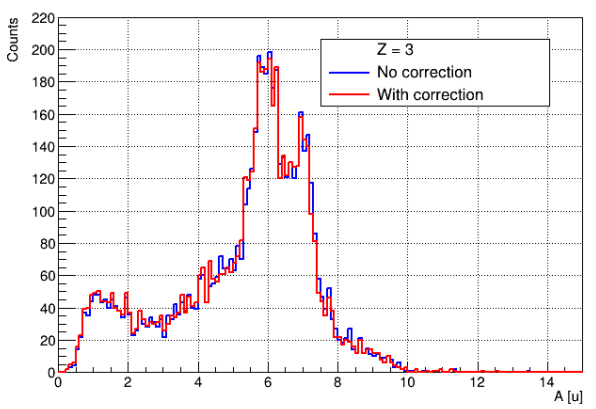



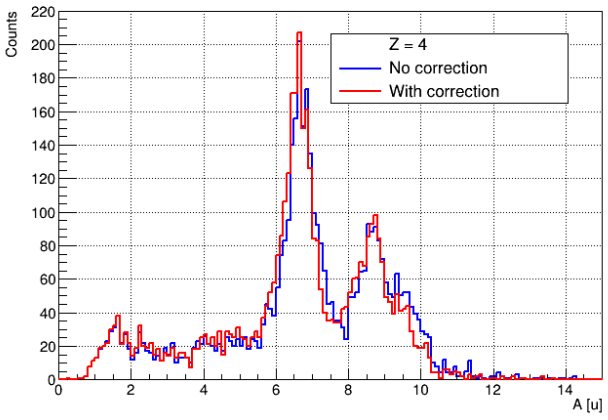
# Second correction for clus size > 1

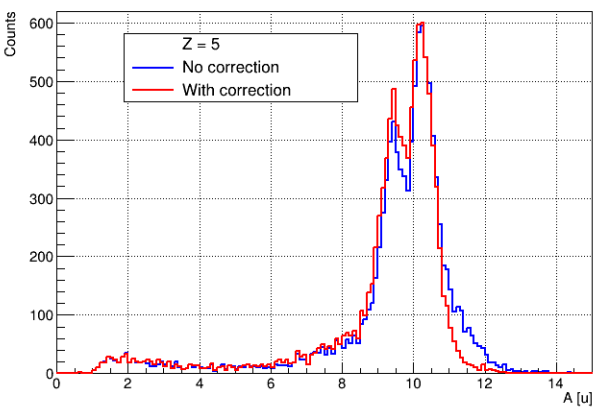
2) proton function for Z < 4, Carbon function for Z > 3. Clusters with size > 2 **excluded**.

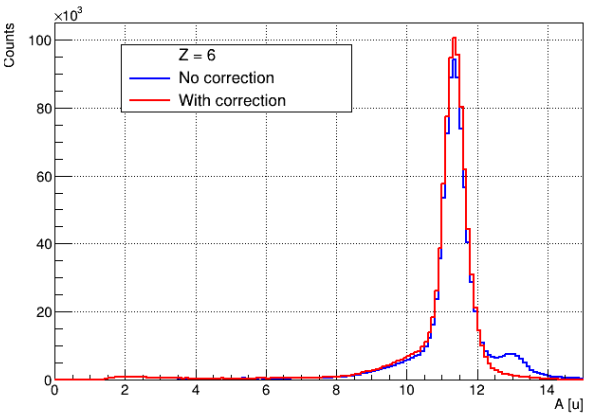


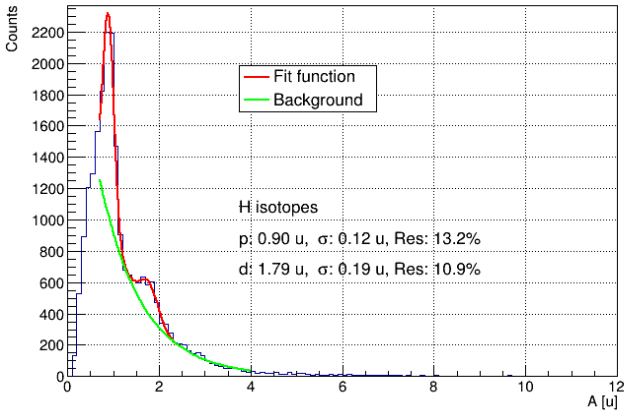



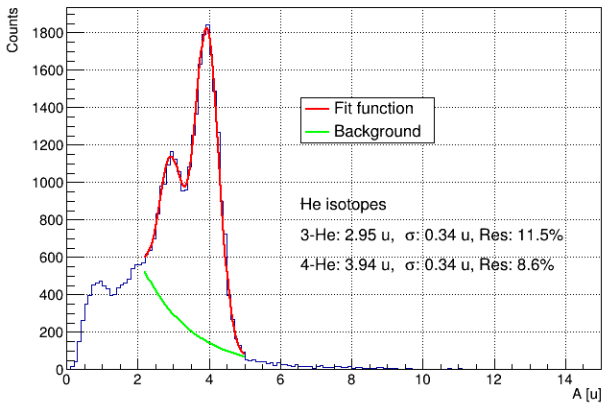



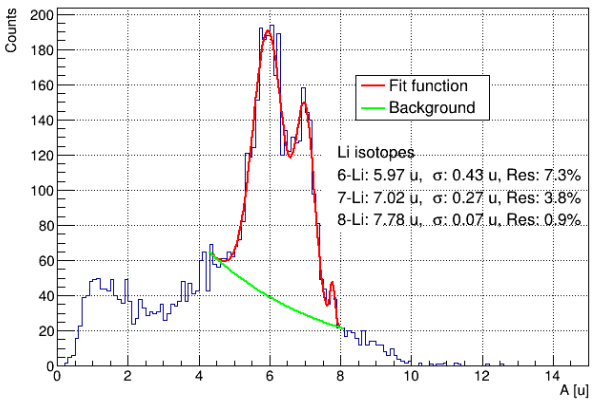



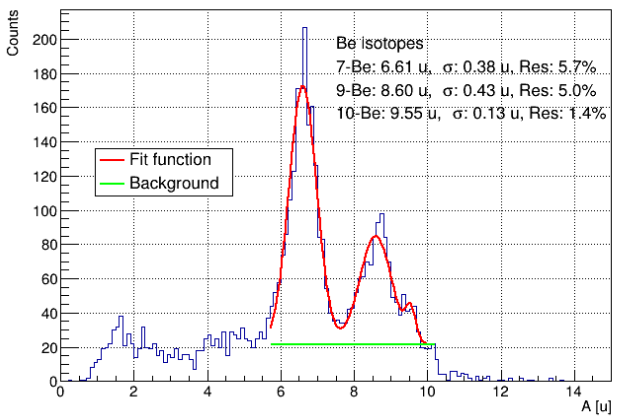
# Second correction for clus size > 1 - mass peaks

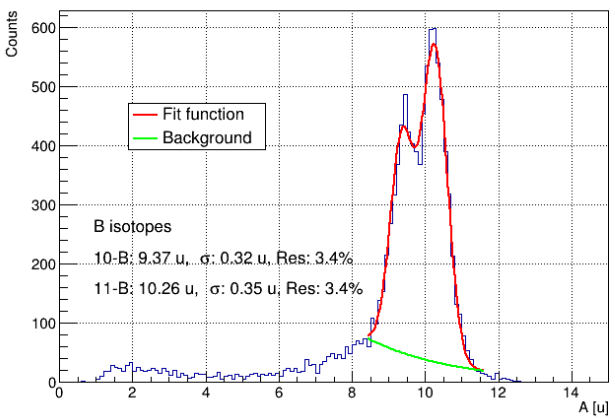
2) proton function for Z < 4, Carbon function for Z > 3. Clusters with size > 2 **excluded**.

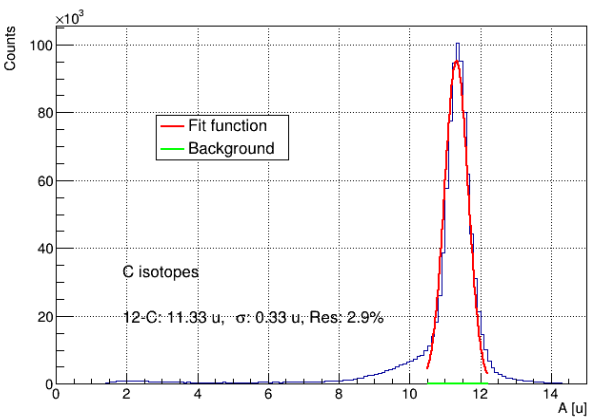


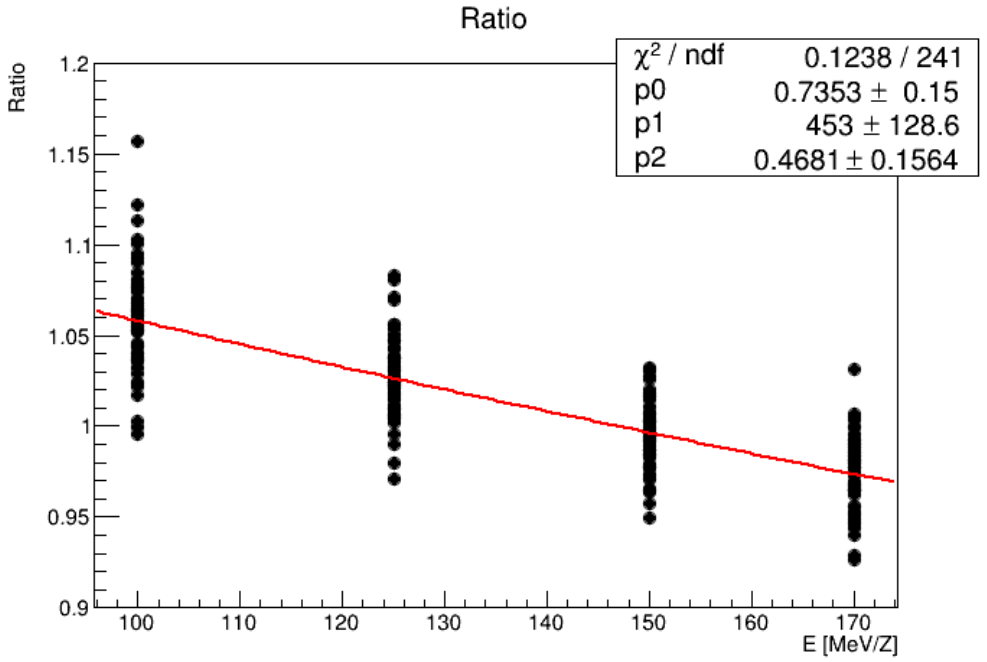



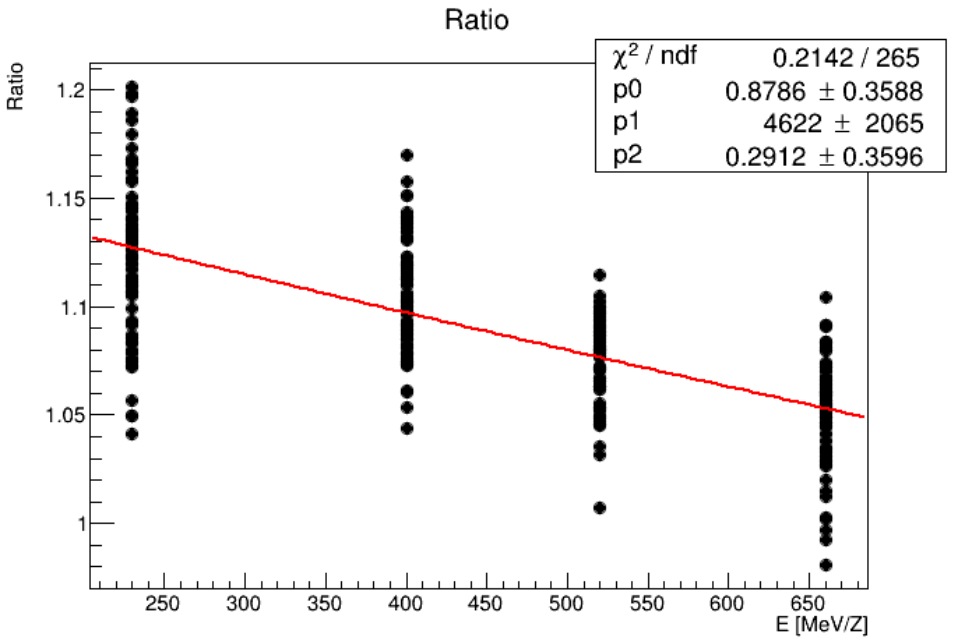



# Third correction for clus size > 1




p points @ 100, 125, 150, 170 MeV.

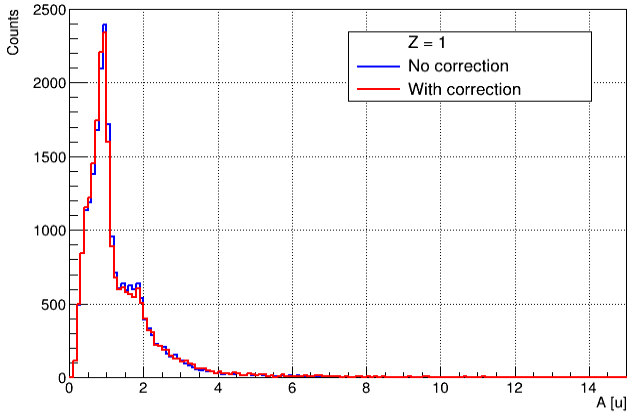


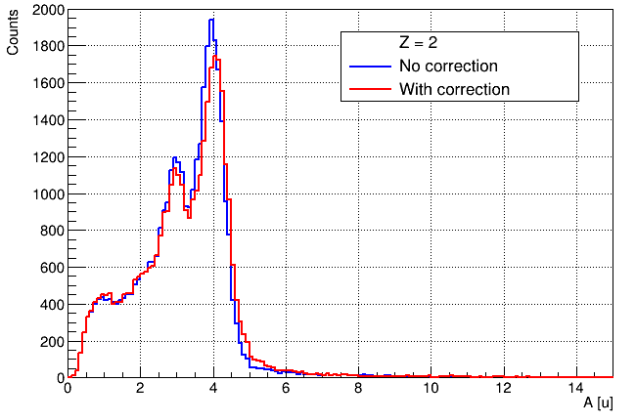

C points @ 115, 200, 260, 330 MeV/u.

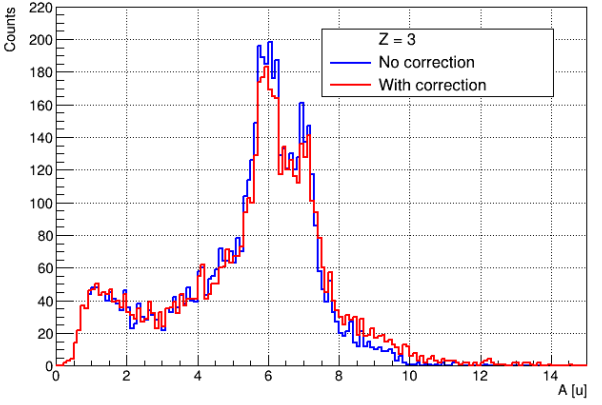
I tried a 3-parameters function, in order not to fix the asymptotic function value at 1.

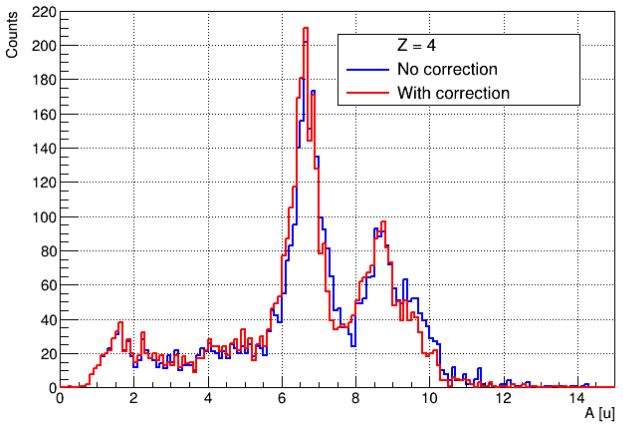
# Third correction for clus size > 1

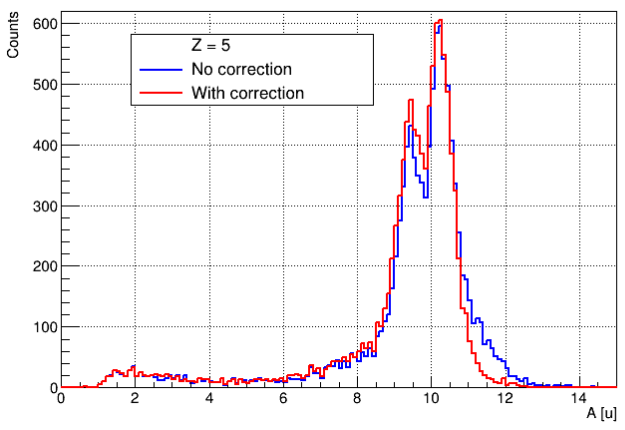
3) 3-parameters proton function for Z < 4, Carbon function for Z > 3. Clusters with size = 2 **excluded**.

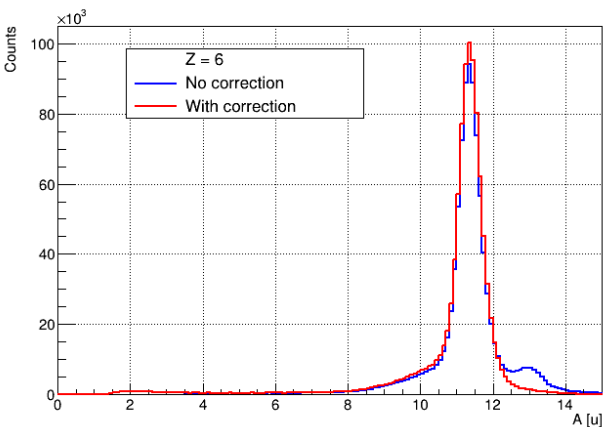


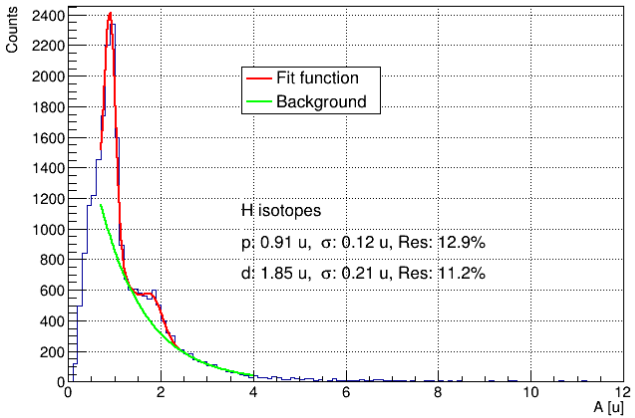



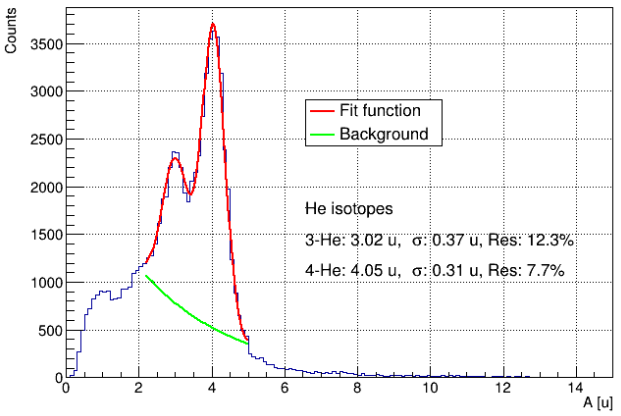



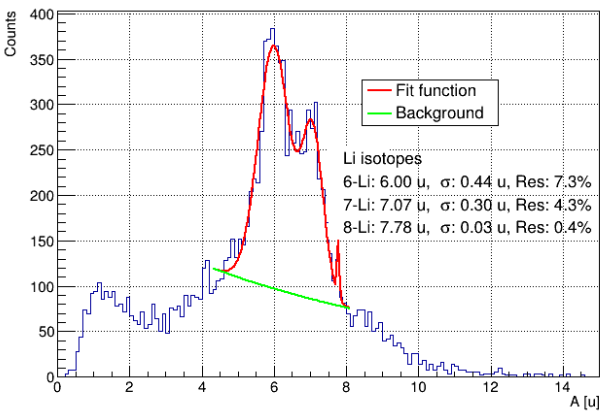



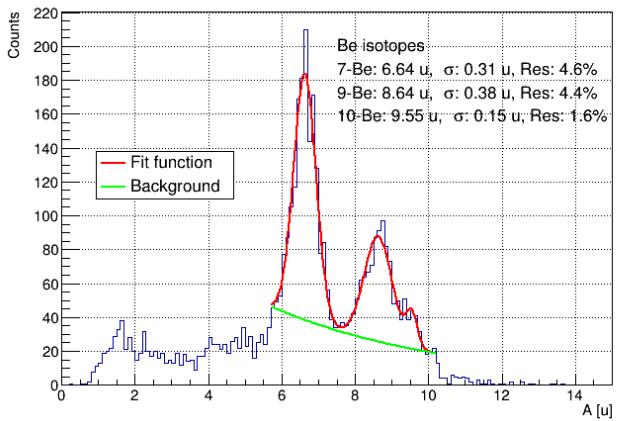
# Third correction for clus size > 1 – mass peaks

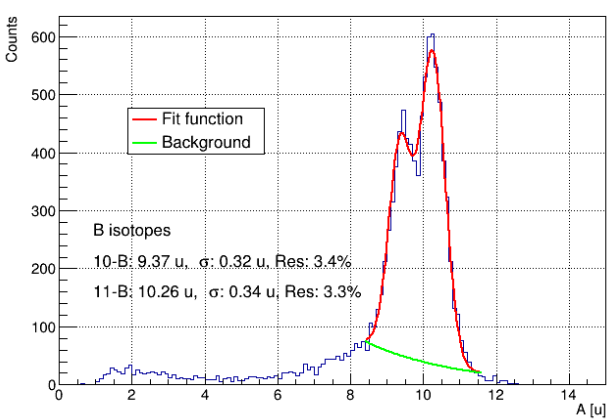
3) 3-parameters proton function for Z < 4, Carbon function for Z > 3. Clusters with size > 2 **excluded**.

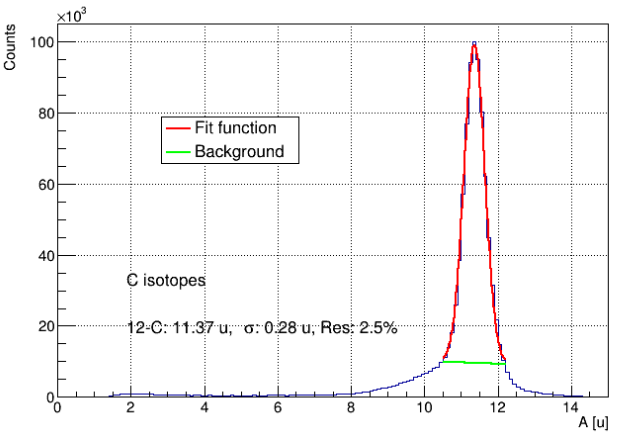


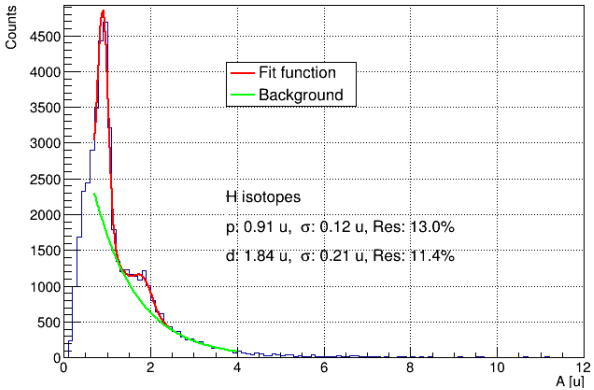



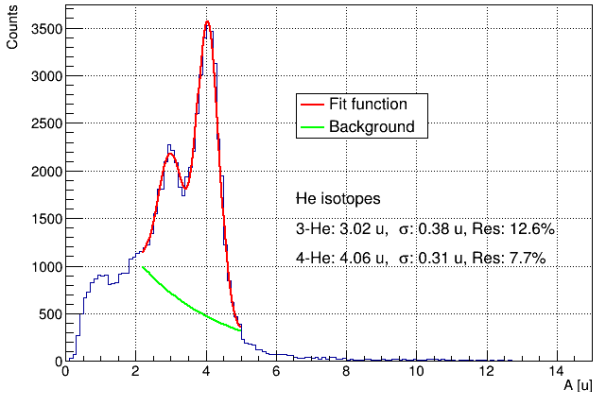



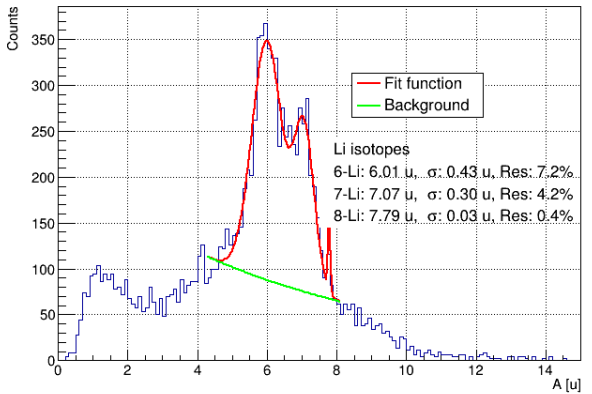



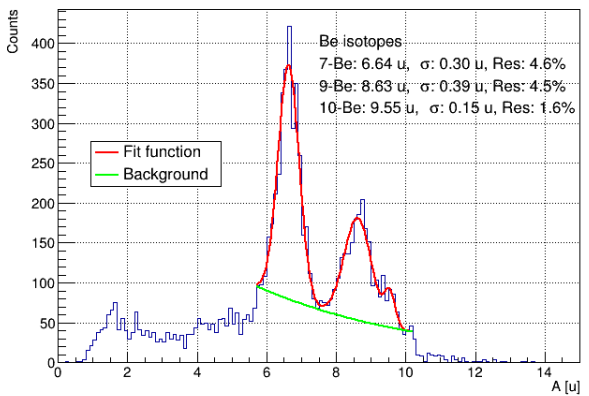
# Fourth correction for clus size > 1 – mass peaks

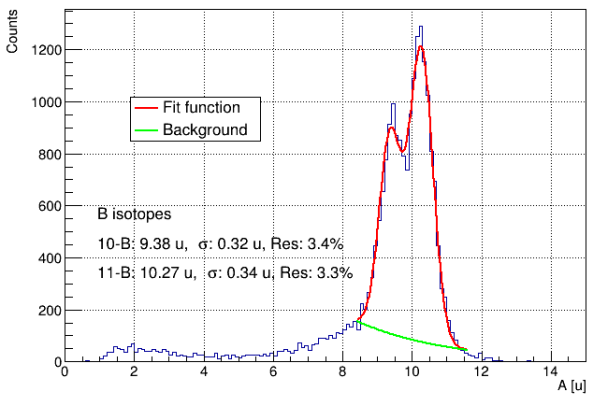
The number of clusters with size > 2 is much larger in data than in MC → assuming that in those cases (about 3%) it's clus size = 2 + some kind of noise, I apply the last correction to **all clusters with size > 1.**

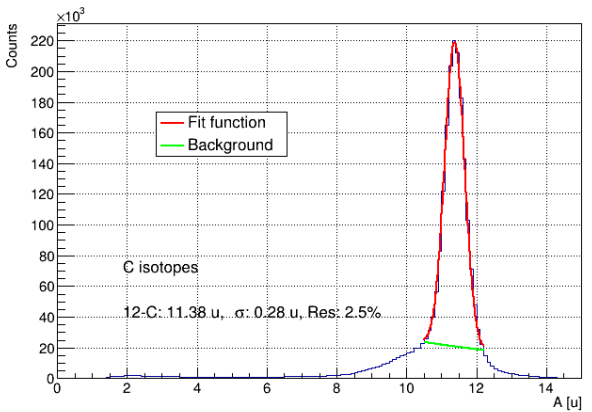


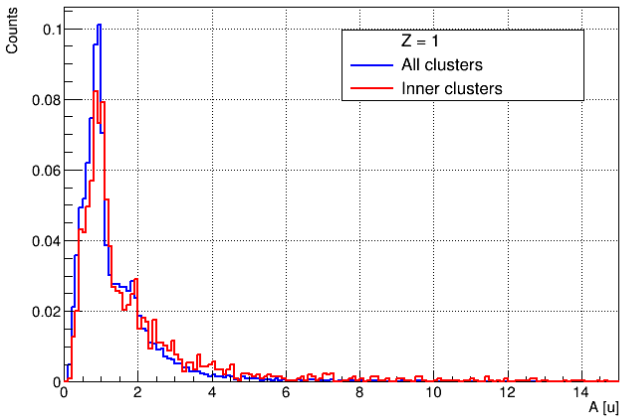



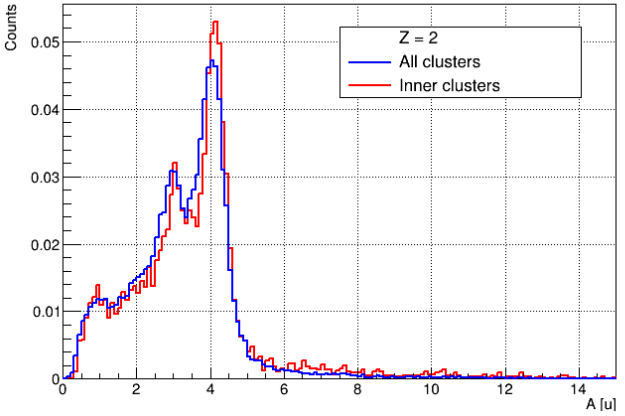



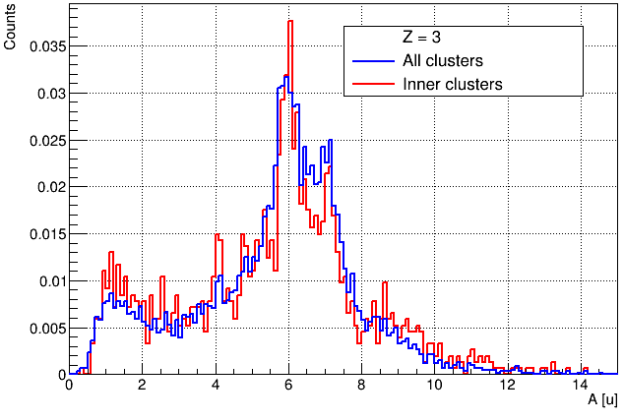



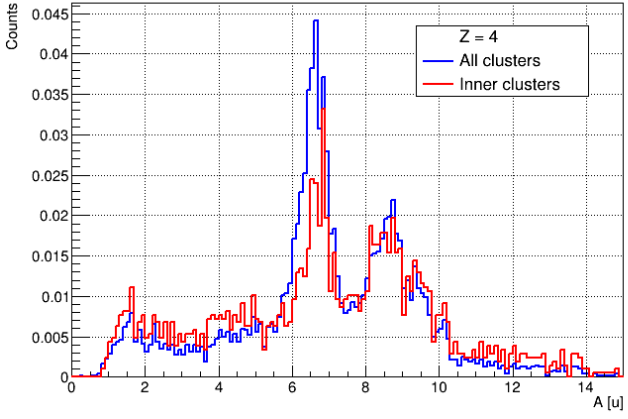
# Inner (|x| and |y| < 5 cm) vs all clusters

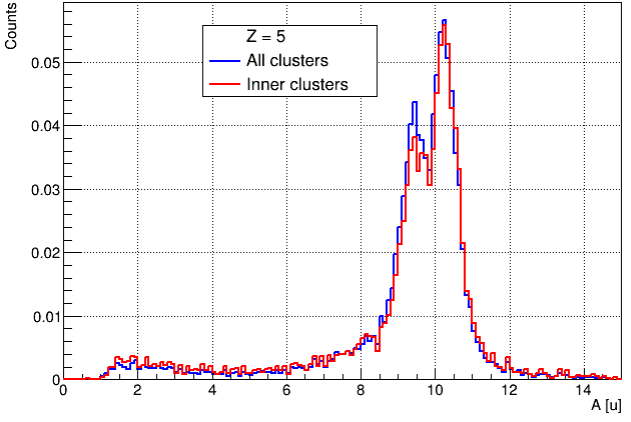
Is the resolution in the inner part of the calorimeter better? All runs + last correction function on clus size > 1.

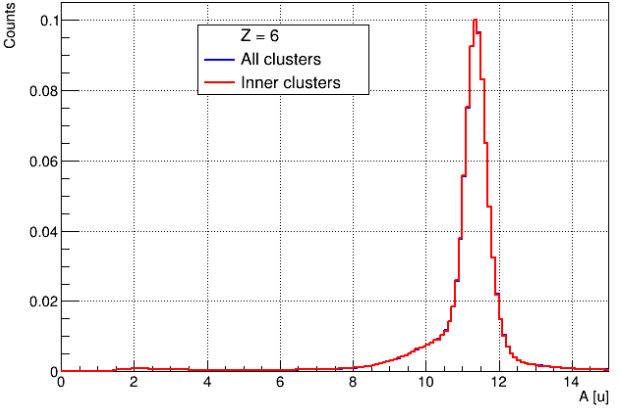


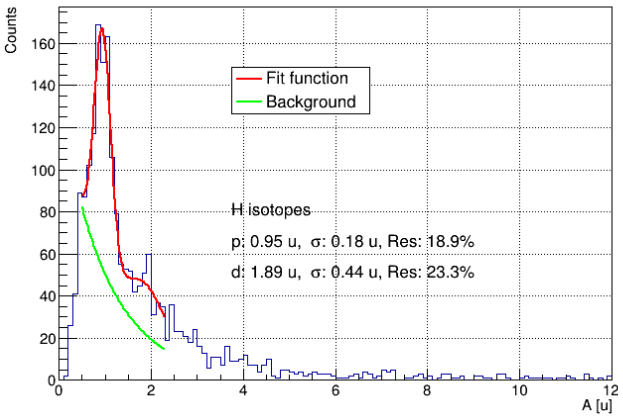



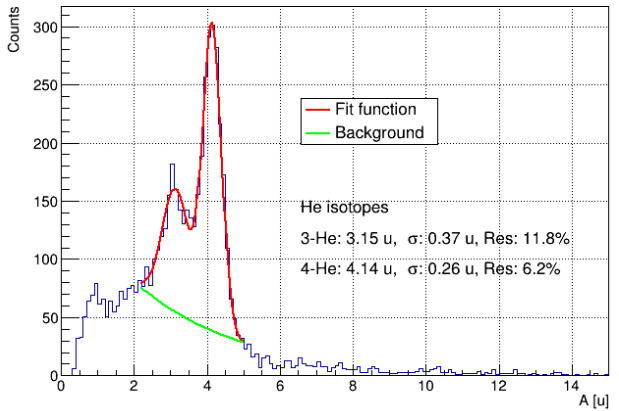



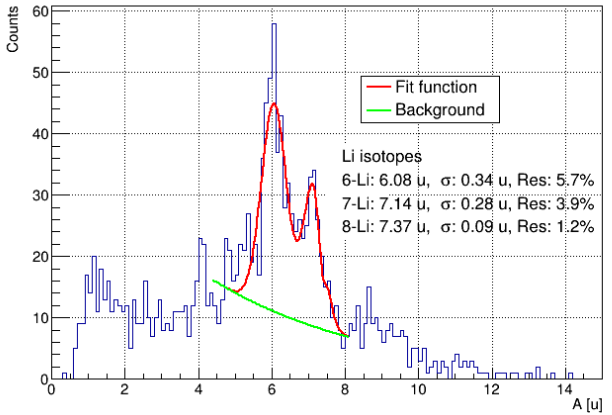



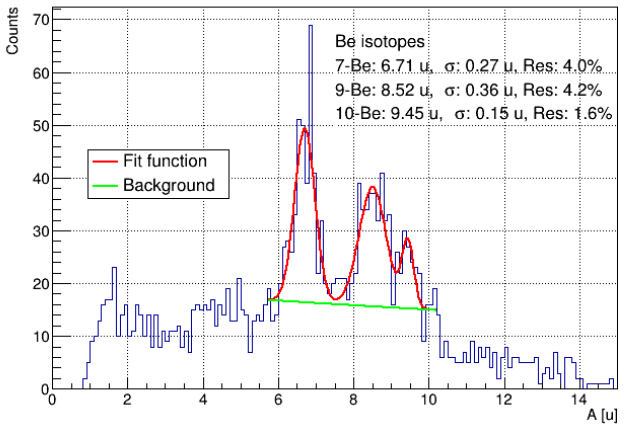
# Inner (|x| and |y| < 5 cm) vs all clusters

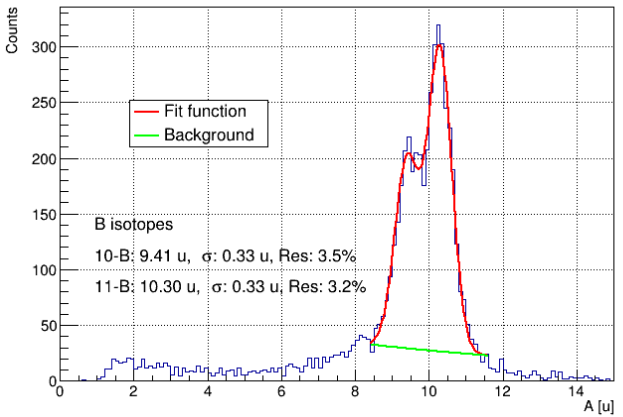
Is the resolution in the inner part of the calorimeter better? For He, Li, Be yes, for H major statistics losses.

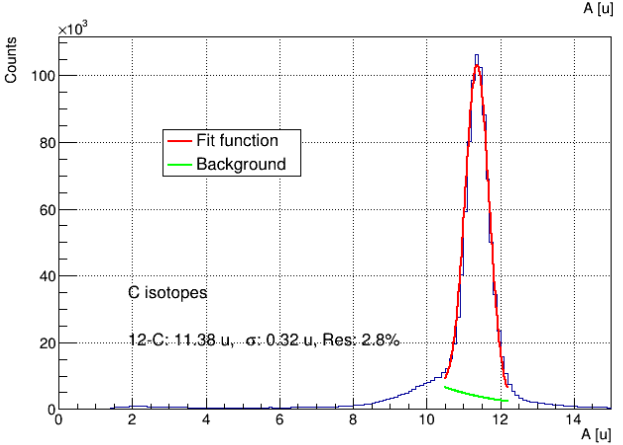


## Summary

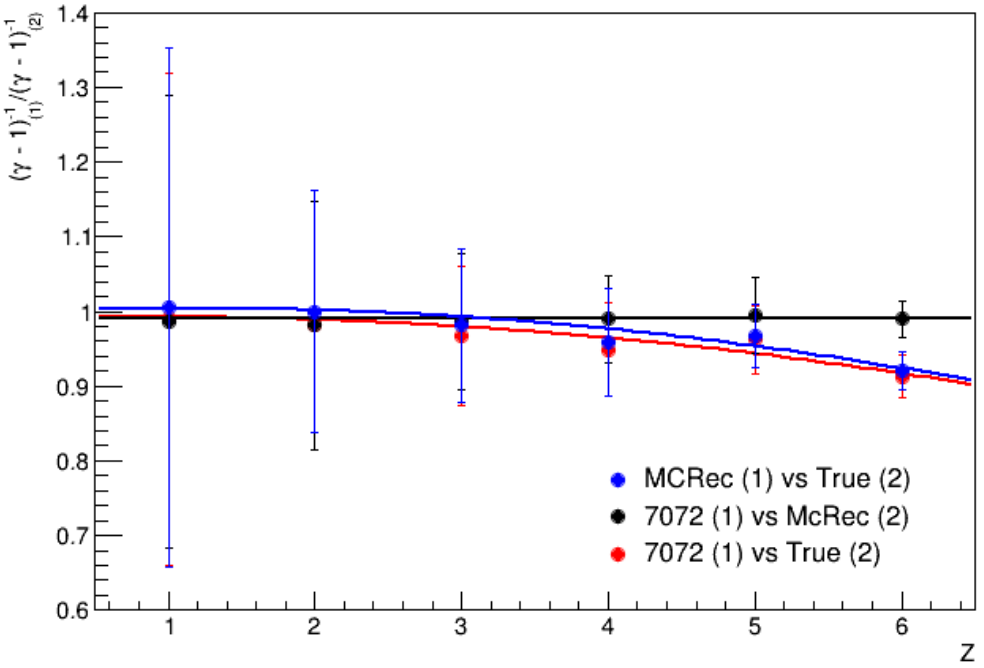
- Studies on clustering and matching efficiency – data vs MC
- Resolution degrading at higher energies
- Calibration correction for clus size > 1
- **Beta vs $E_{kin}$**
- Possible clustering improvements

# β vs $E_{kin}$

β as a function of $E_{kin}$ is given by the following formula, where u = 931.494 MeV/c² and $E_{kin}$ [MeV]:

$$\beta = \sqrt{1 - \left(1 + \frac{E_{kin}}{A_{nom} \cdot u}\right)^{-2}}$$

# β vs $E_{kin}$




→ the parameter $A_{nom}$ was corrected for each ion species.

β as a function of $E_{kin}$ is given by the following formula, where u = 931.494 MeV/c² and $E_{kin}$ [MeV]:

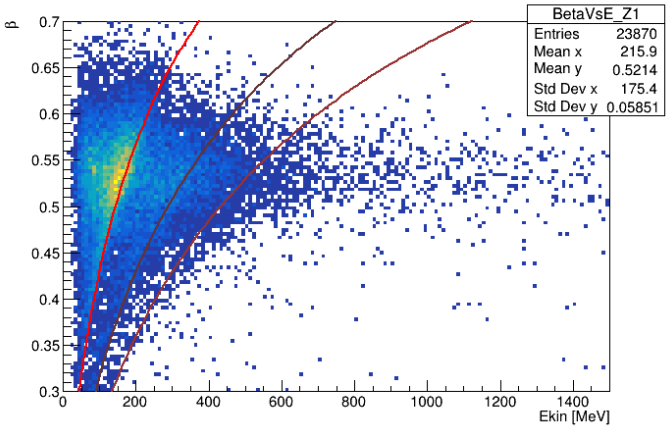
$$\beta = \sqrt{1 - \left(1 + \frac{E_{kin}}{A_{nom} \cdot u}\right)^{-2}}$$

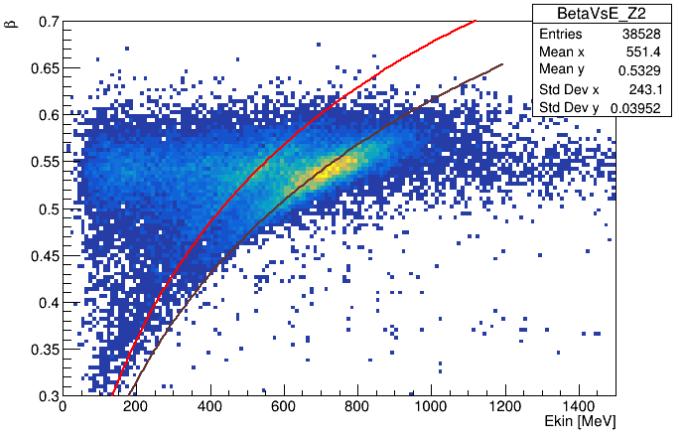
The nominal mass must be corrected according to the known β overestimation from MC simulations

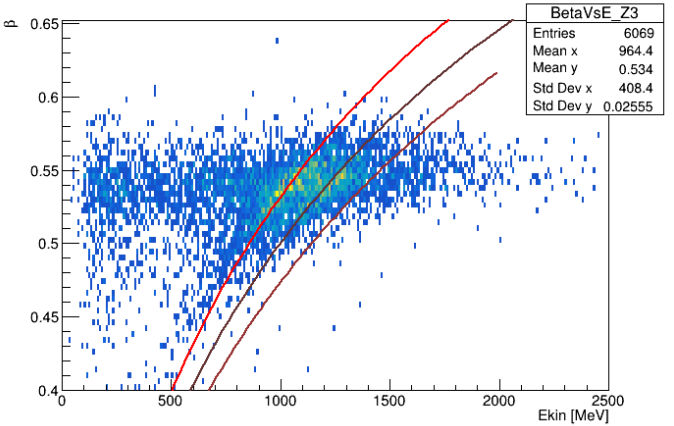
→ $(\gamma-1)^{-1}$ in MC reconstruction is **underestimated** with respect to MC truth

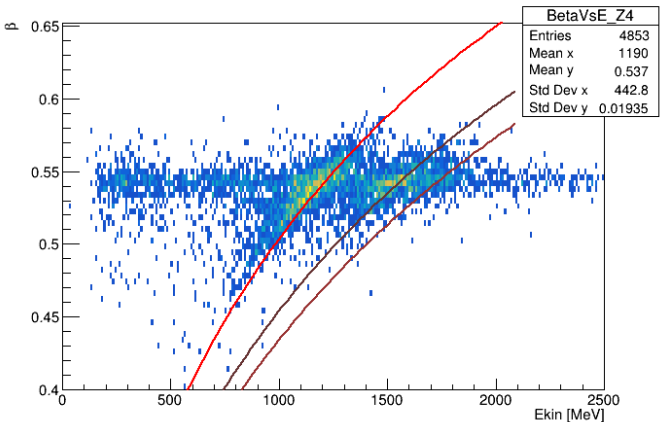
→ from MC simulations, the blue curve was obtained as a function of Z

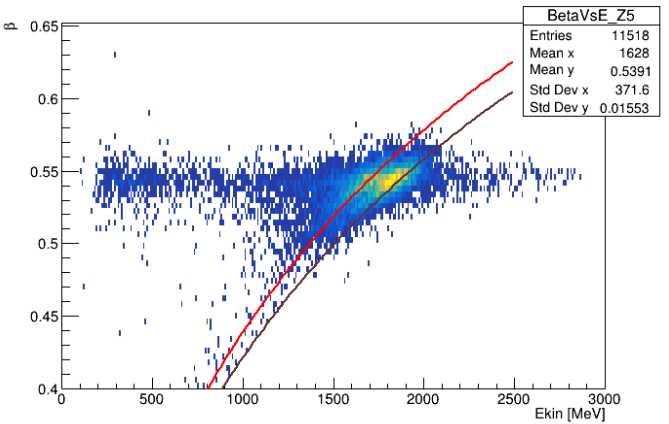
# β vs $E_{kin}$ distributions with $A_{nom}$ correction

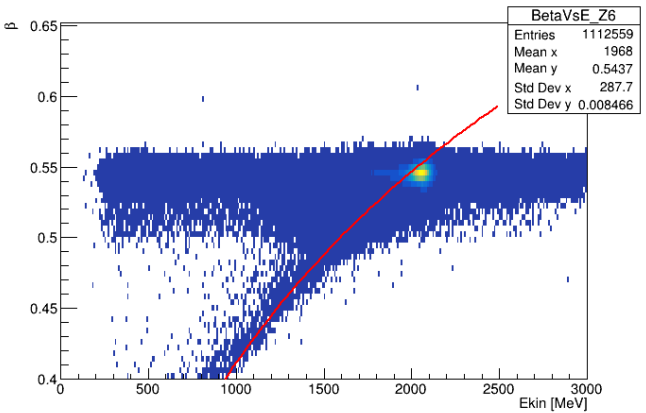


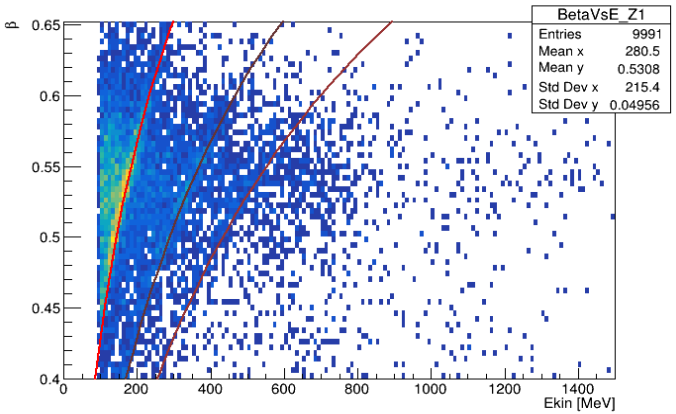



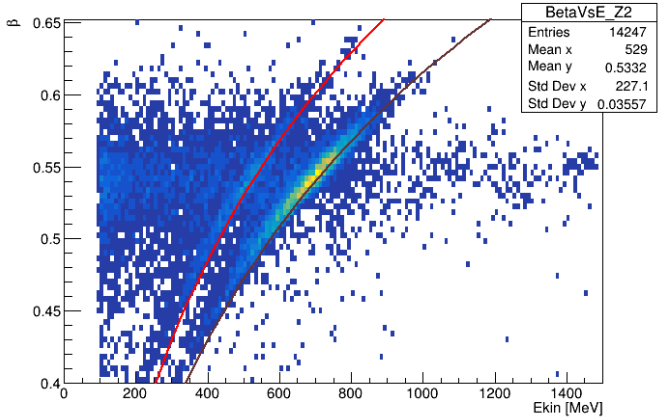



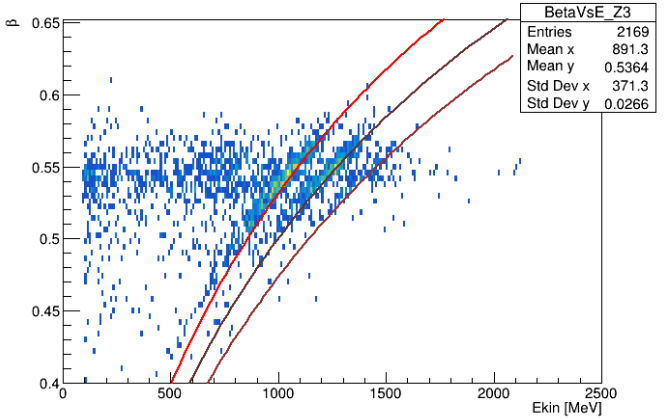



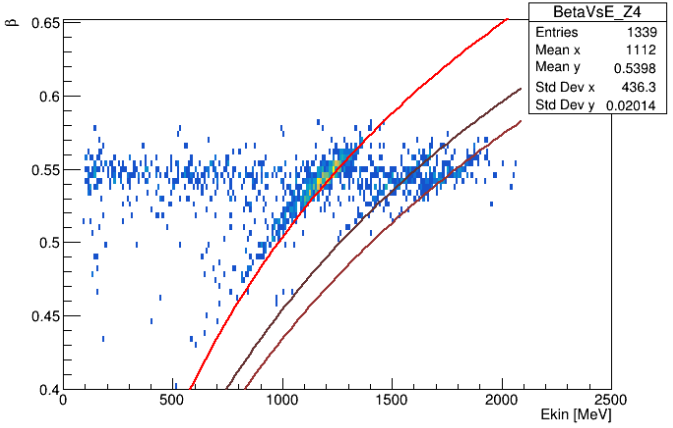



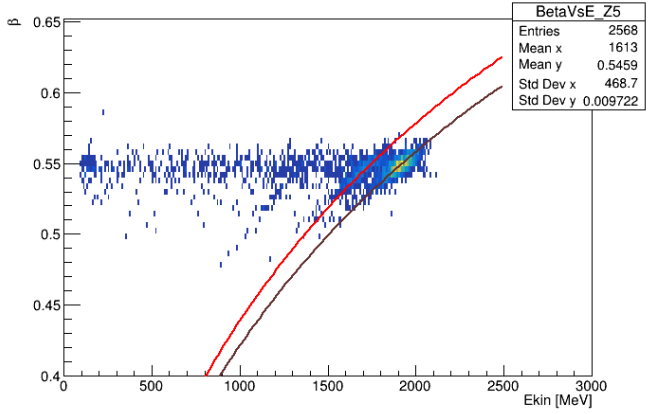
# β vs $E_{kin}$ distributions with $A_{nom}$ correction - MC

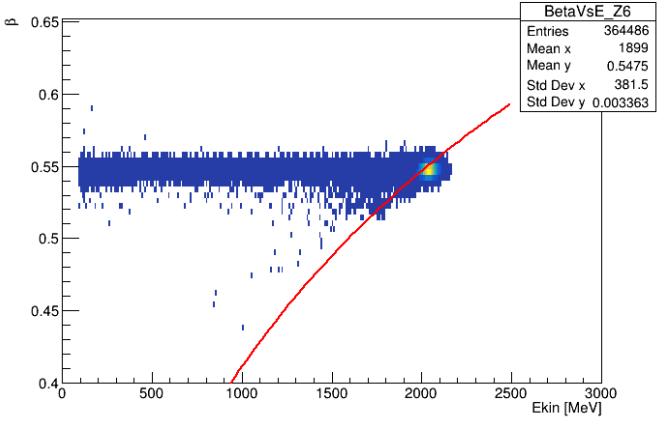


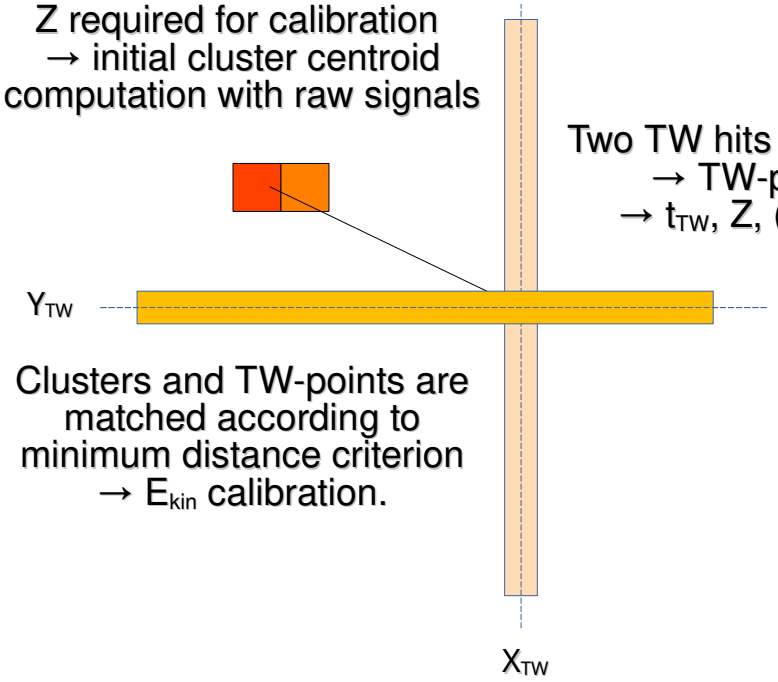



## Summary

- Studies on clustering and matching efficiency – data vs MC
- Resolution degrading at higher energies
- Calibration correction for clus size > 1
- Beta vs $E_{kin}$
- **Possible clustering improvements**

## Main difference between exp and MC clusters

Z required for calibration
→ initial cluster centroid computation with raw signals

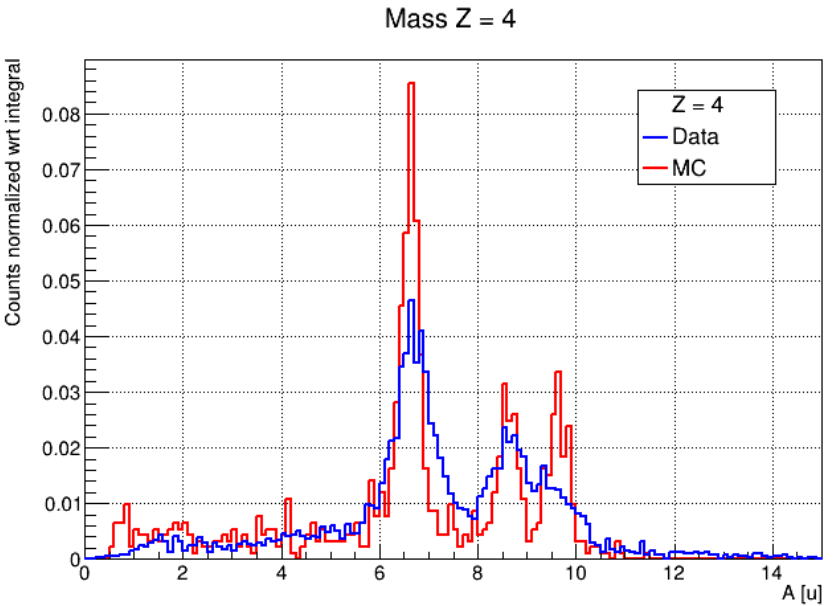



Two TW hits (bars on)
→ TW-point
→ $t_{TW}$, Z, $(X,Y)_{TW}$

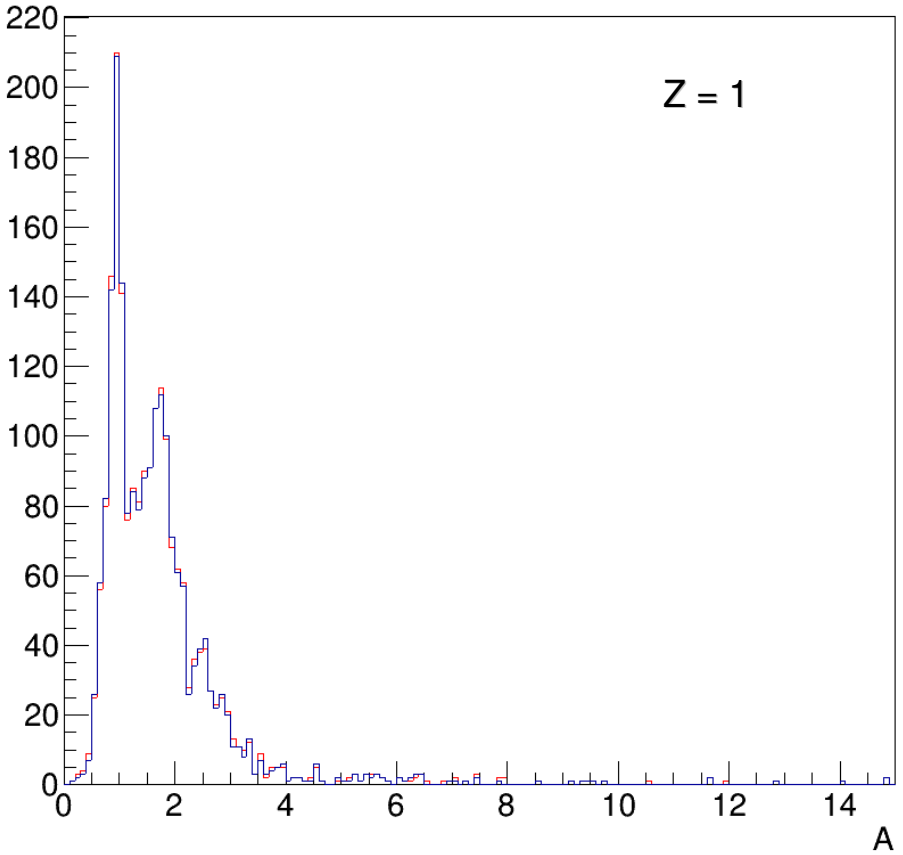
Clusters and TW-points are matched according to minimum distance criterion
→ $E_{kin}$ calibration.

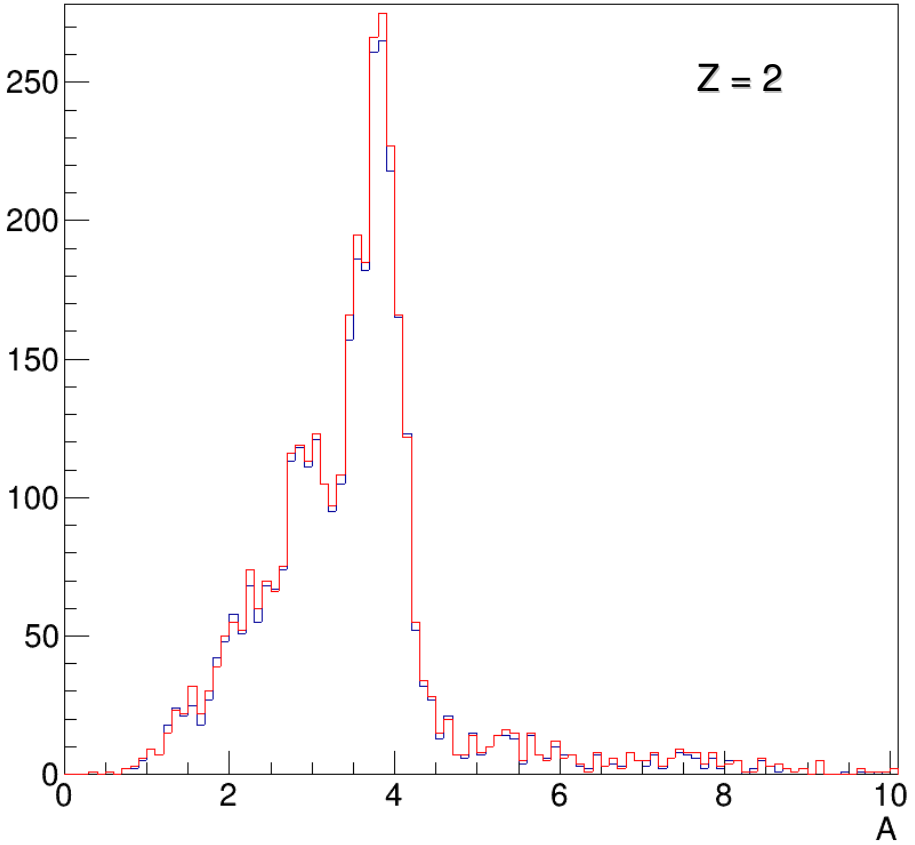
Mass identification performance in MC is still way better (almost optimal) wrt exp data
→ are clusters created differently?

Clusters are created from true $E_{kin}$ values in MC, from (not equalized) ADC values in exp data
→ I tried a second iteration of cluster shaping, position computing and matching after a "first guess" TW-CALO matching.



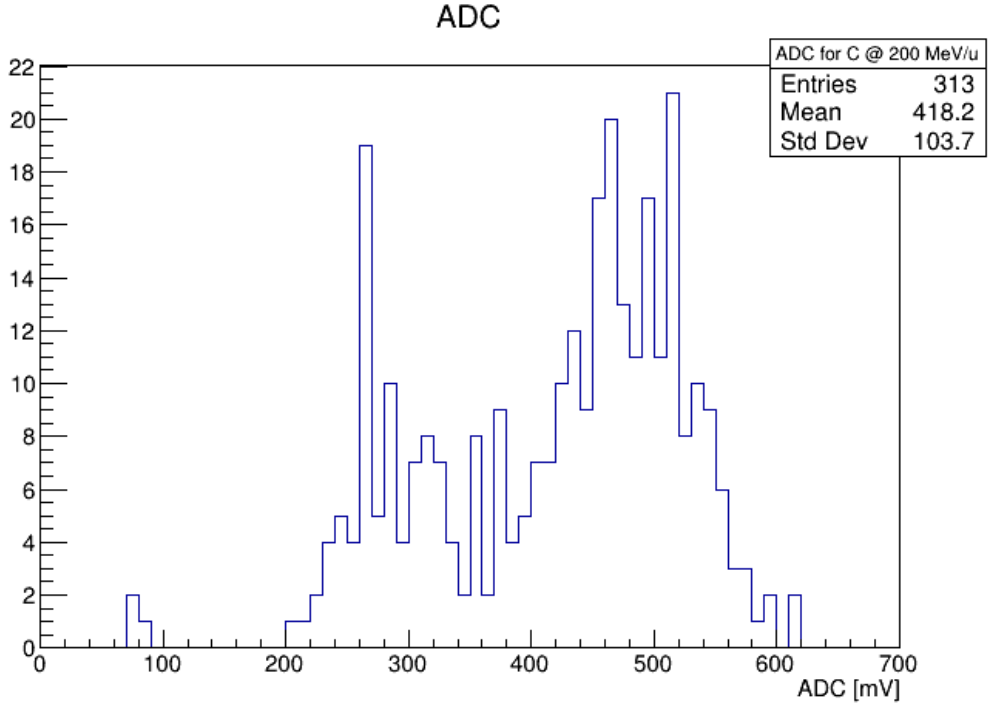
## Before and after 2nd iteration for 400k events (clus size > 1, run 7072)



## ADC equalization

Perhaps, the problem lies in the first clustering algorithm iteration, based on amplitude values (in mV).
Let's see how crystals respond to C @ 200 MeV/u (calibration runs).



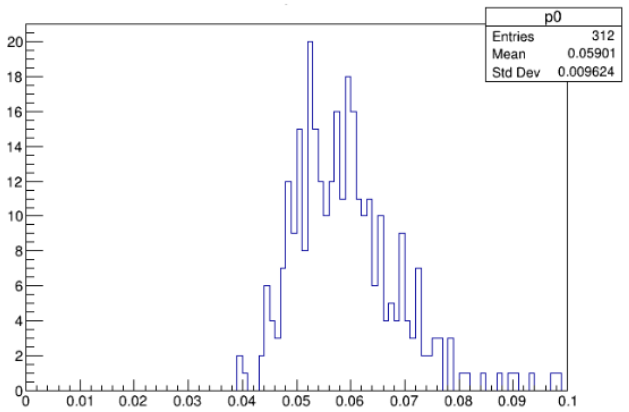

Responses go from 200 to 600 mV, and the central crystals are not the ones with the highest response; in fact, crystal 17 is the one.

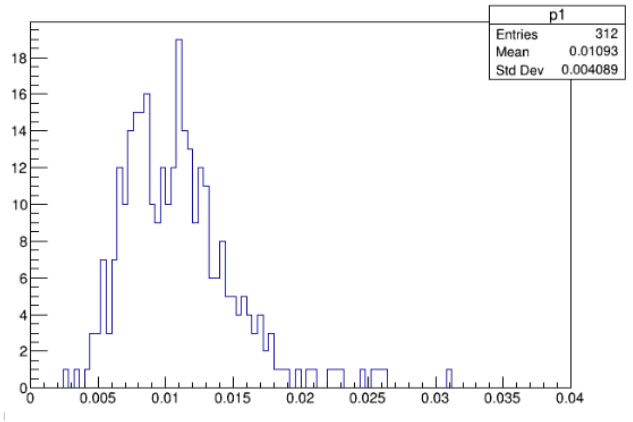
- ch133 → 260.07 mV,
- ch134 → 459.23 mV,
- ch181 → 345.17 mV,
- ch182 → 211.01 mV.

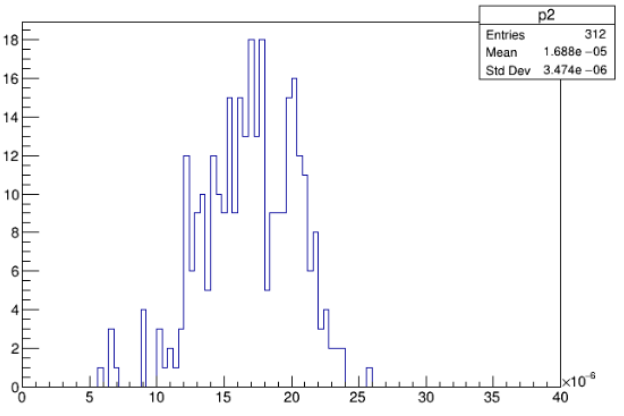
Let's implement a gain factor for all crystals wrt to ch17 and re-run energy calibration.

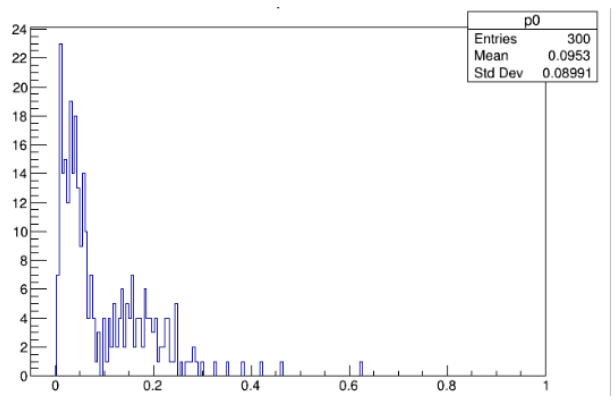
## MBF coefficients after gain correction

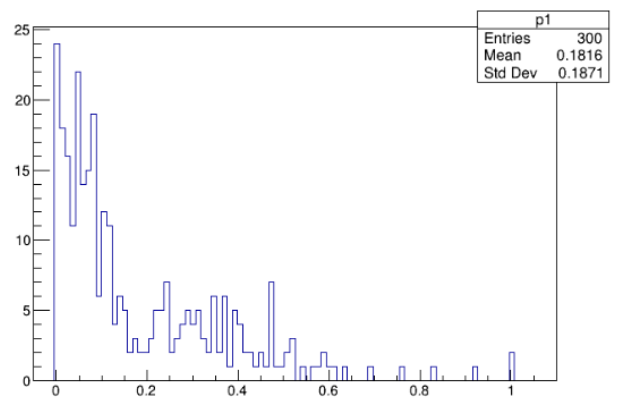
Only request is range limited within (0.,1.) - in principle only $p_0$ should change wrt previous calibration.

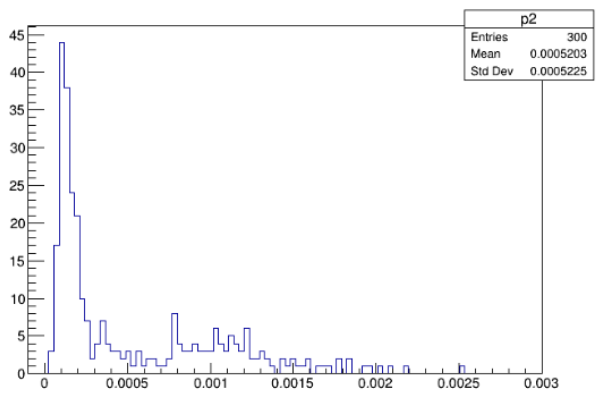


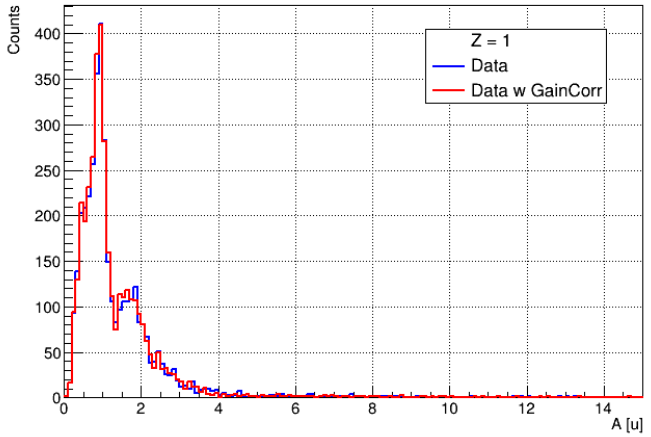



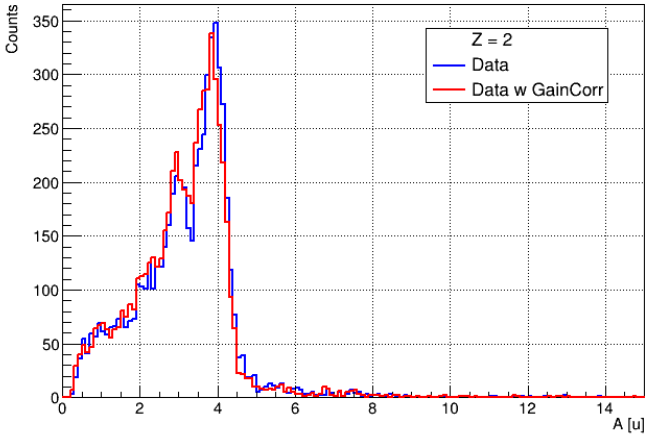



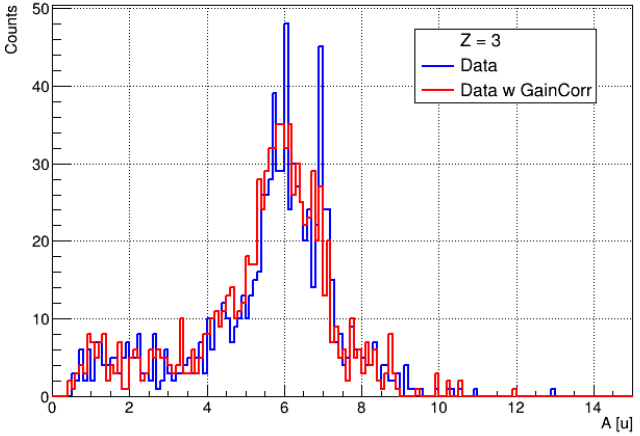



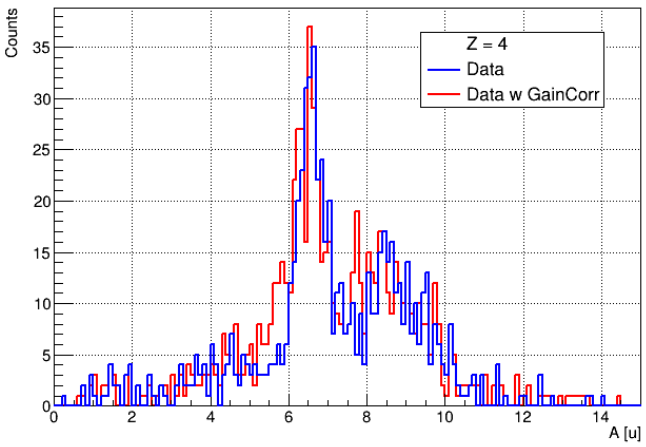



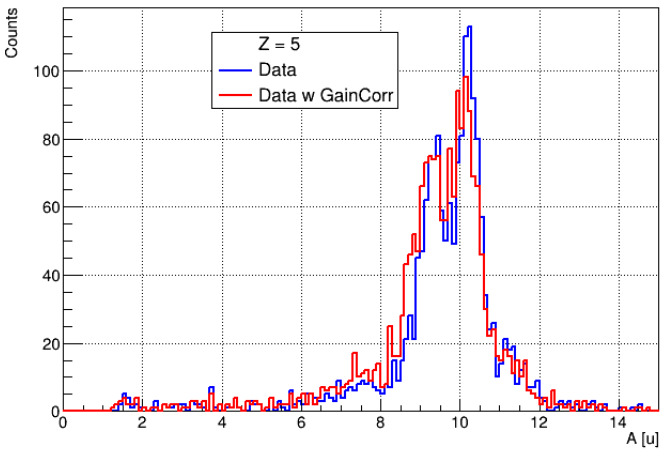
# Mass plot after ADC equalization (230k events) – no cut on crystal 181

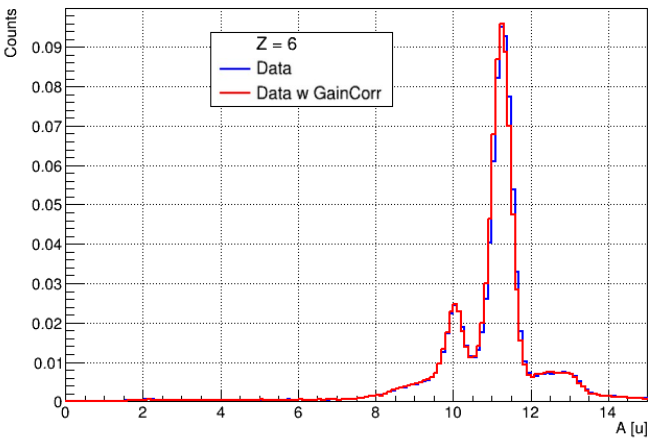


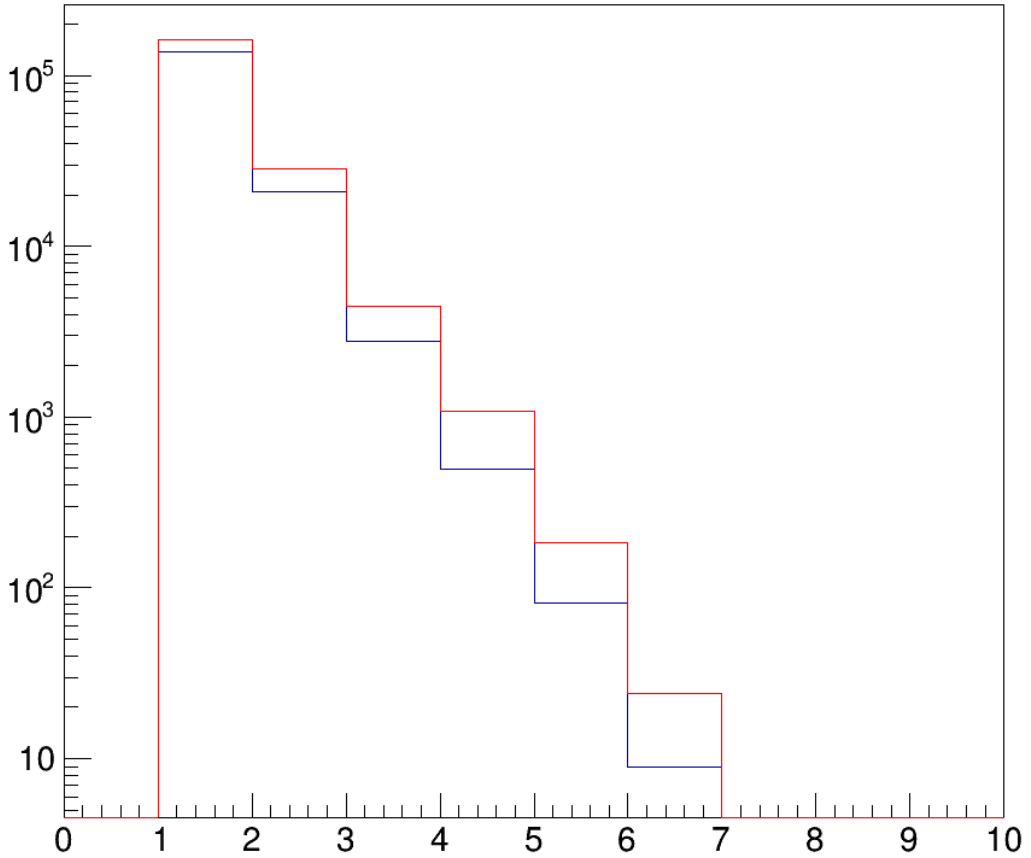



## Cluster size after ADC equalization (230k events)




No improvement in mass distributions coming from the ADC equalization, however the overall number of clusters has increased.

According to PADME, it is possible that different clusters share the same hit(s)?

→ in principle yes, but never observed in 400k events (run 7072).

## Conclusion and possible future analysis

1) There is evidence (MC simulations) that multiple fragments might be overlapping in the same cluster
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3) Three correction methods for clusters with nhits = 2 were tested on mass spectra
→ second background peak in 12-C corrected,
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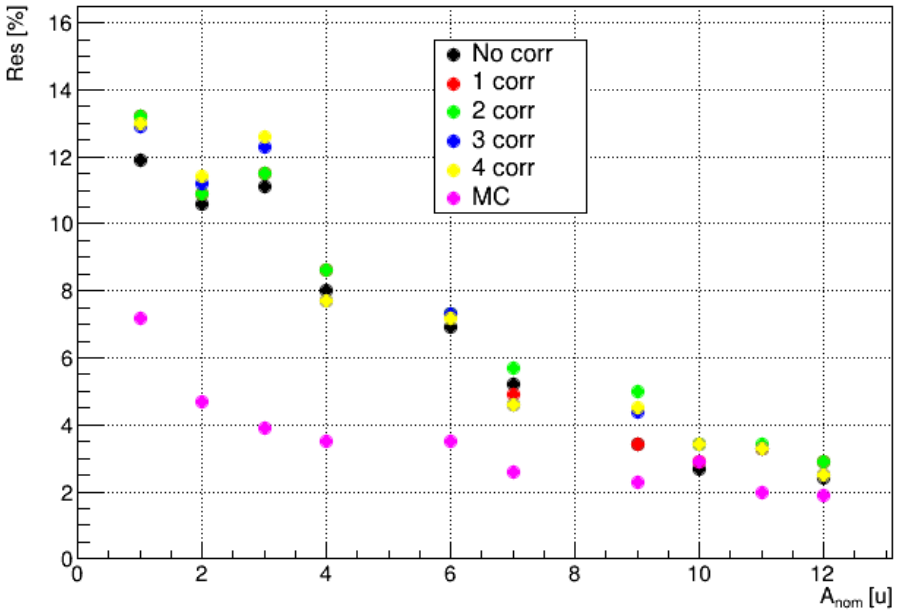

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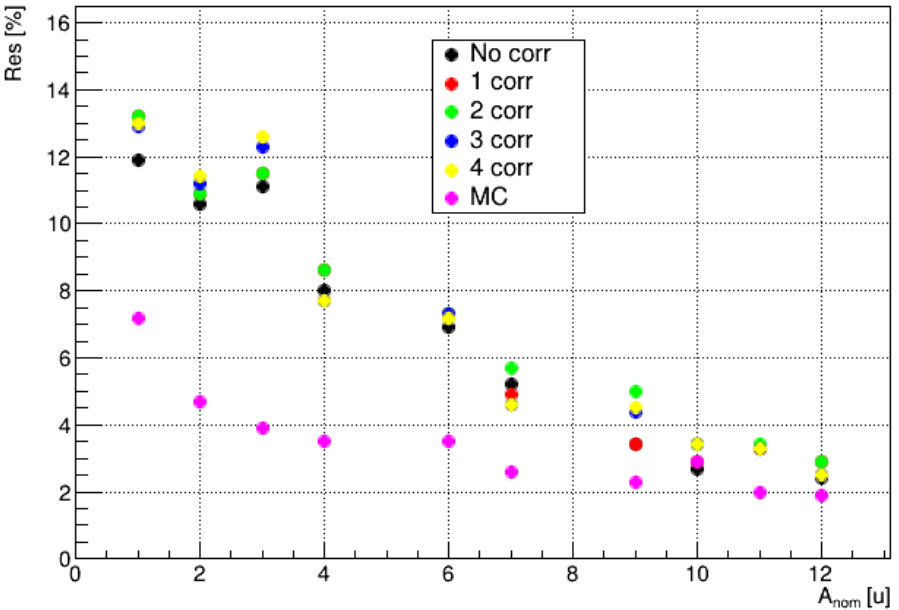
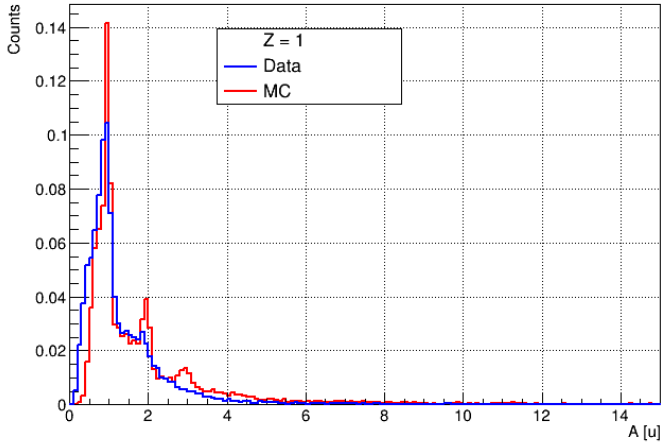
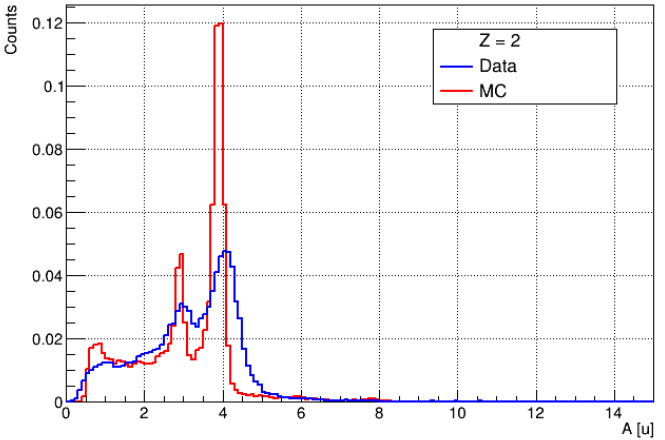
4) Isotope identification is possible via β vs E plots, by incorporating the systematic β overestimation.

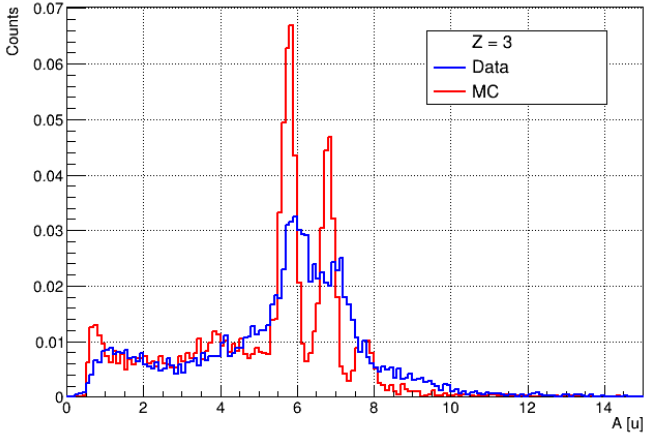


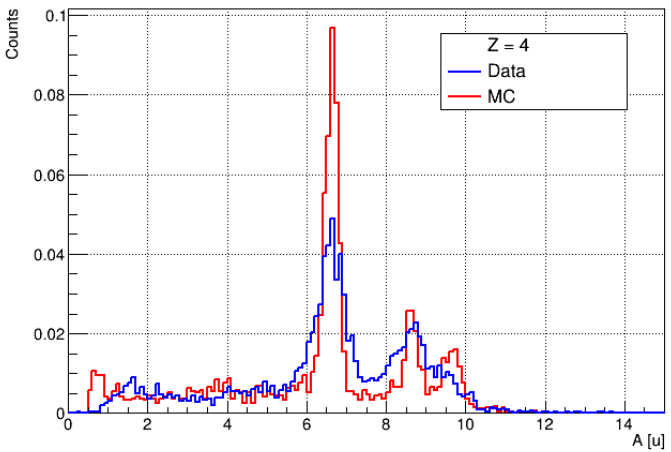

- Closure test via MC simulations: efficiency (on acceptancy + Z identification), out-of-target fragmentation (background modeling improvements) and angular distribution studies are ongoing.
- Look at the β distributions per bin of $E_{kin}$ and for each Z → evaluation of the peak separation and the background impact.

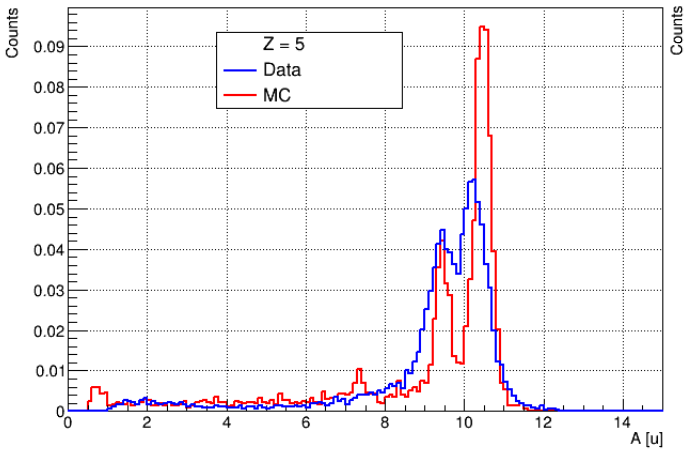
# Normalized mass distributions - data vs MC

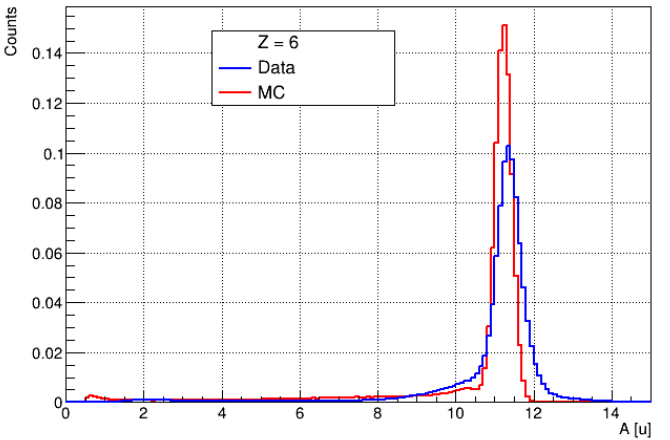


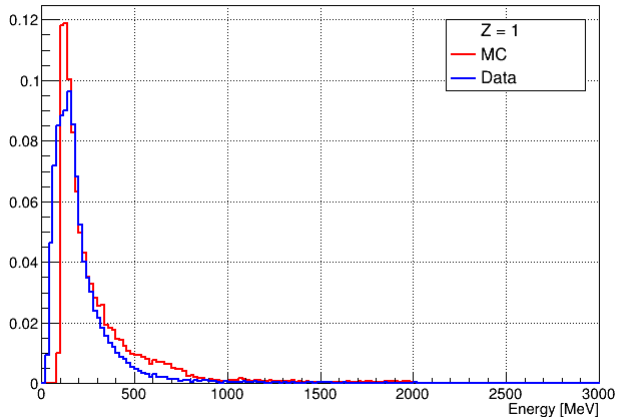



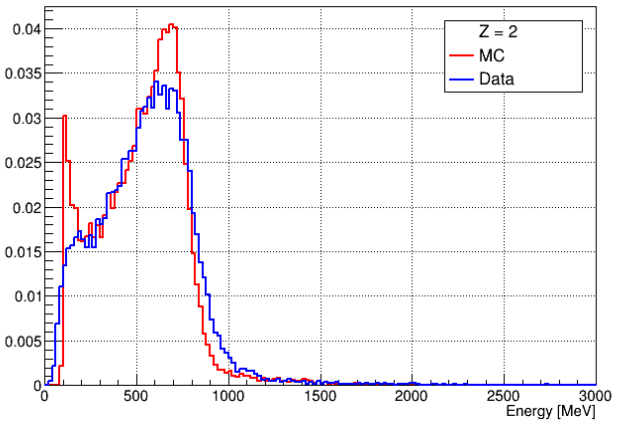



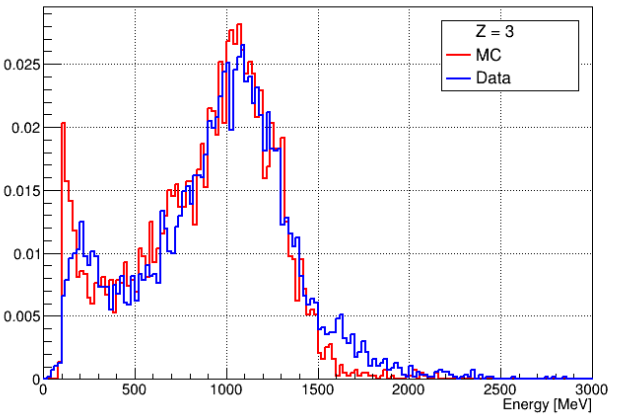



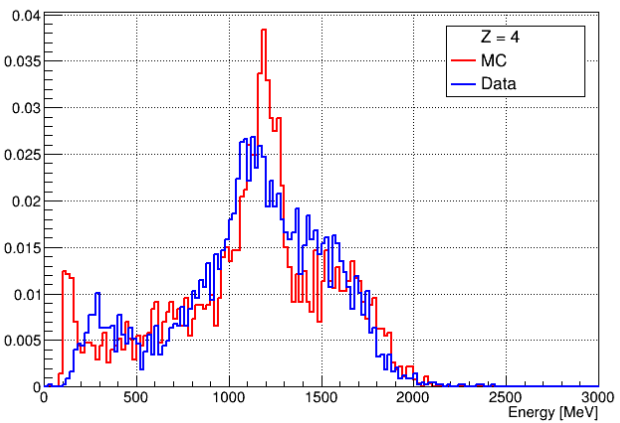



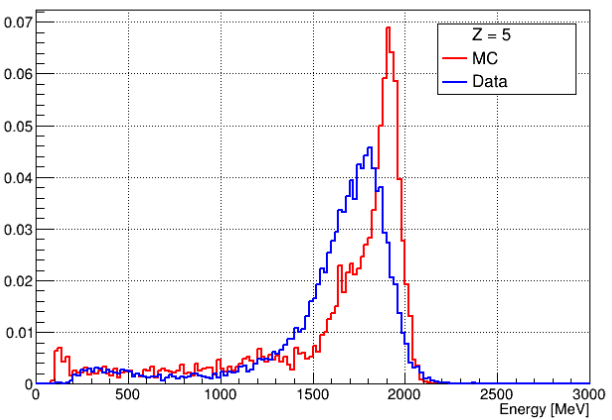
# Normalized $E_{kin}$ distributions - data vs MC

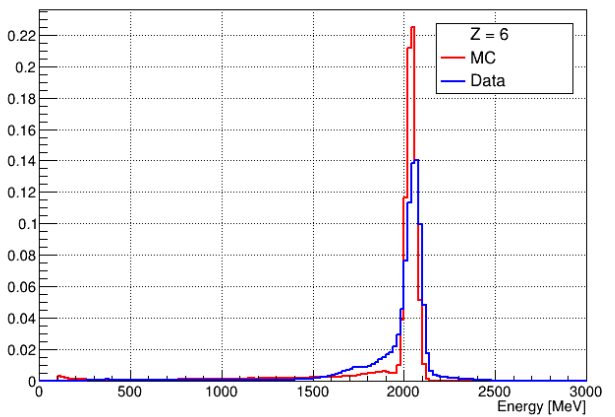


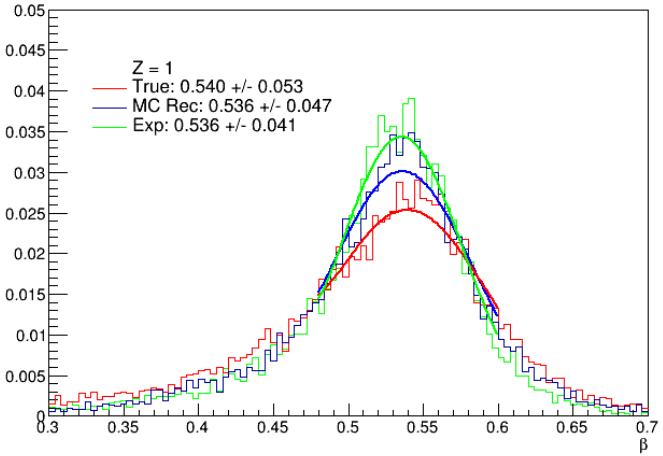



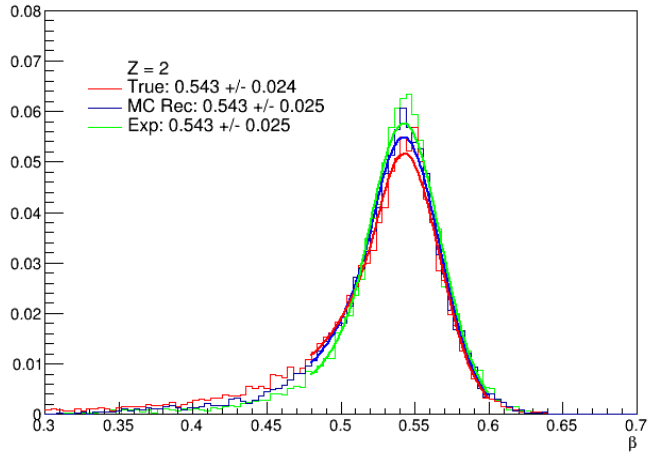



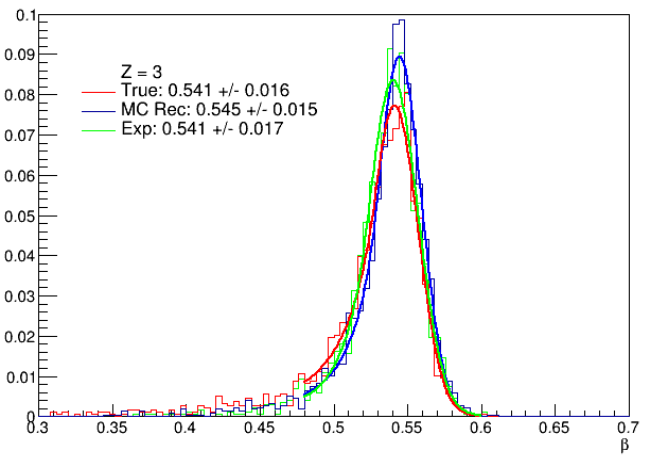



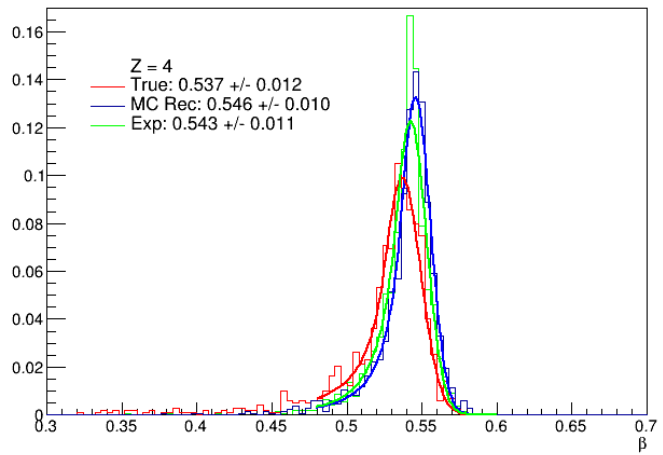



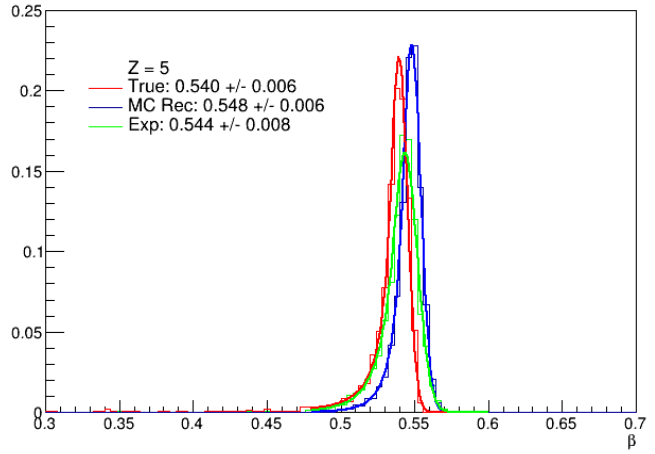
# Normalized β distributions - data vs MC

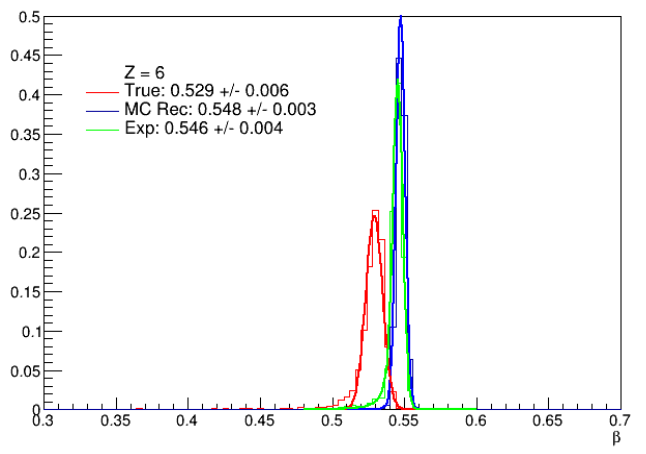


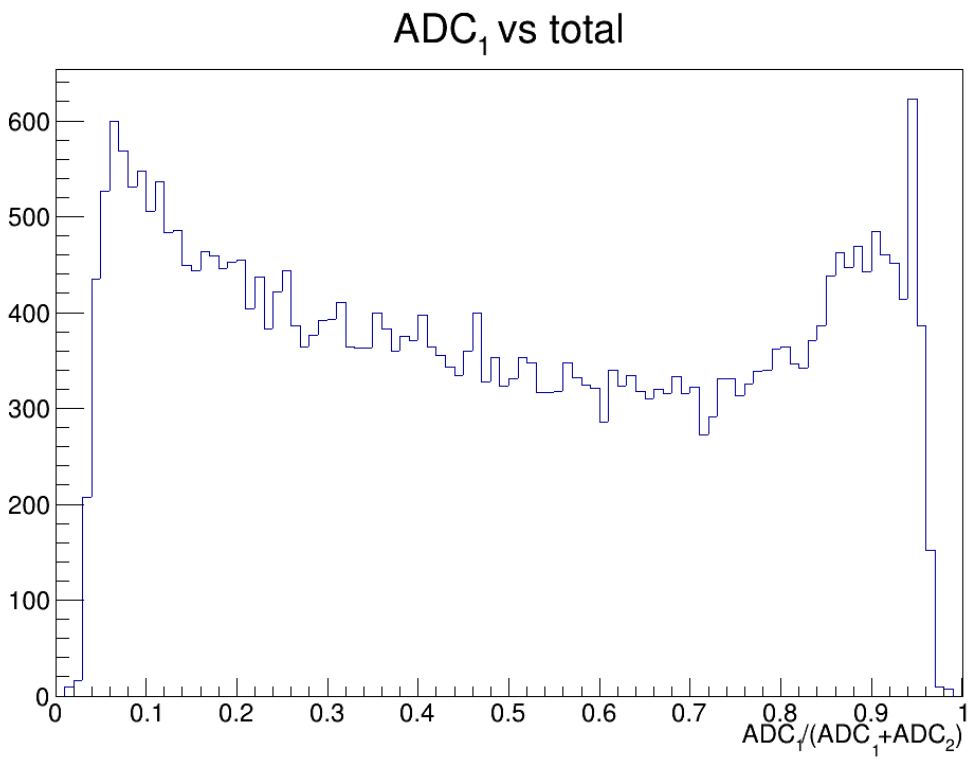



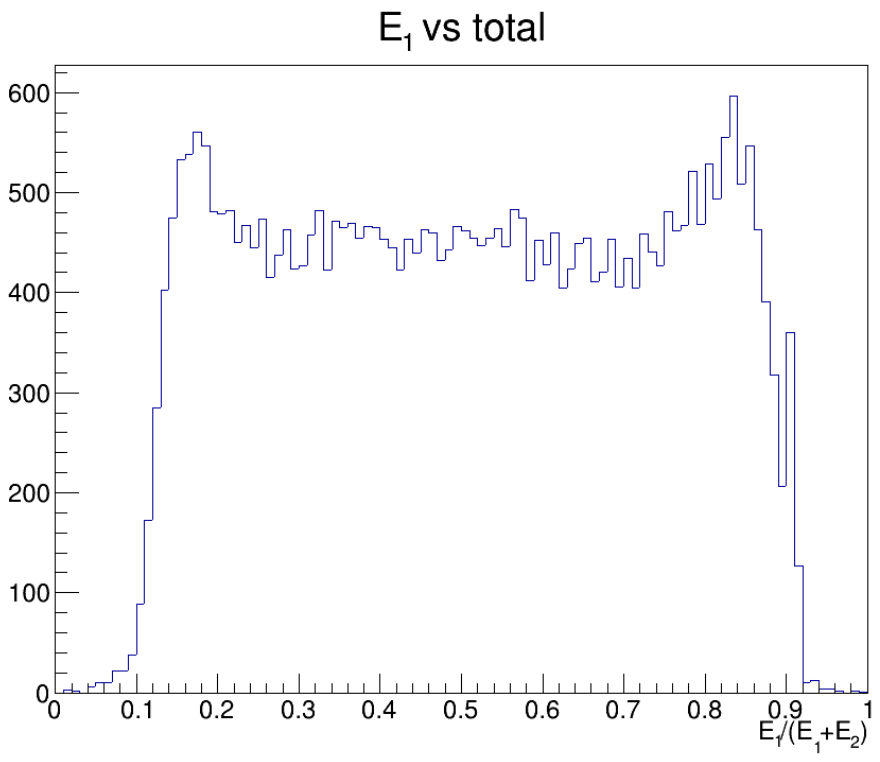



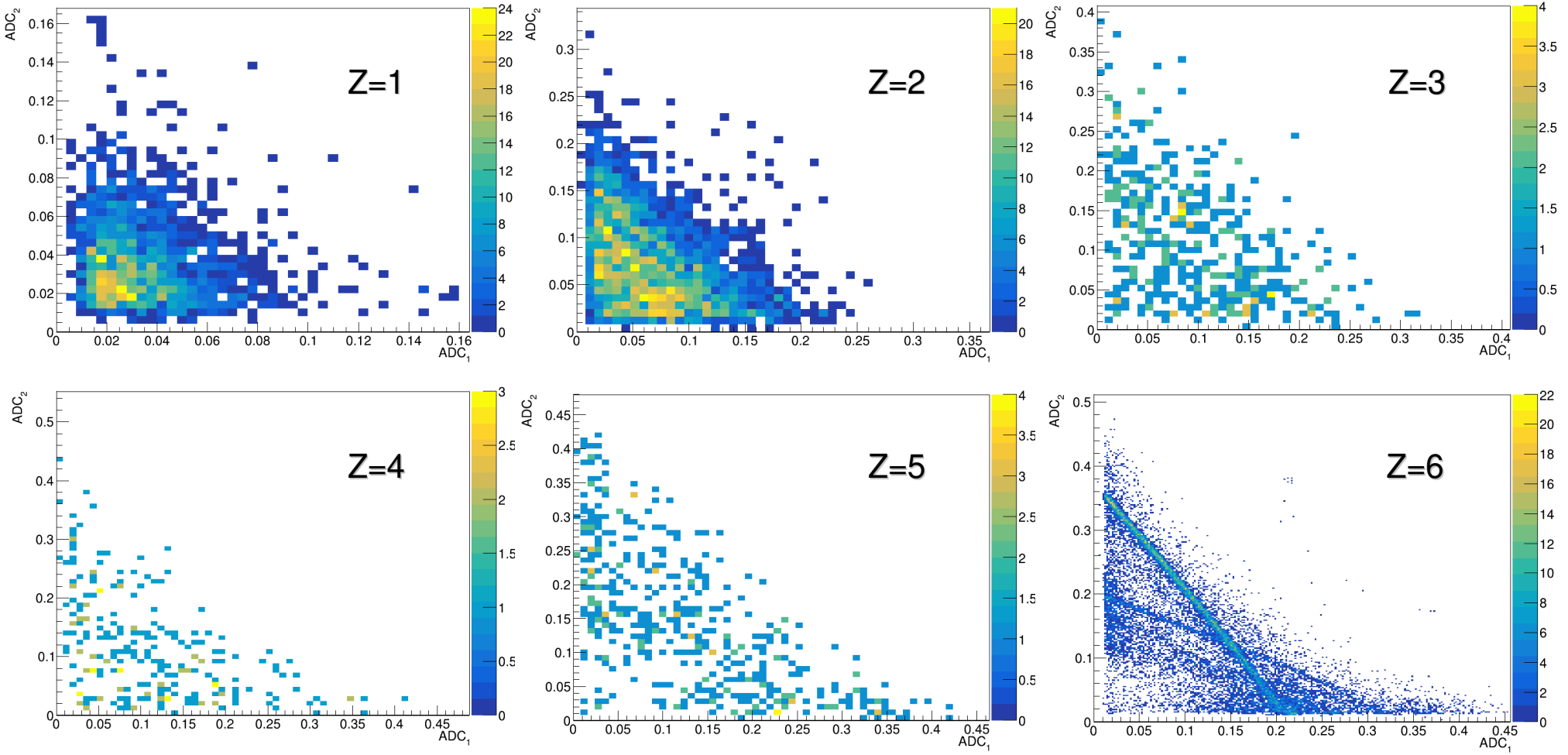



# ADC/E distribution for clus size = 2

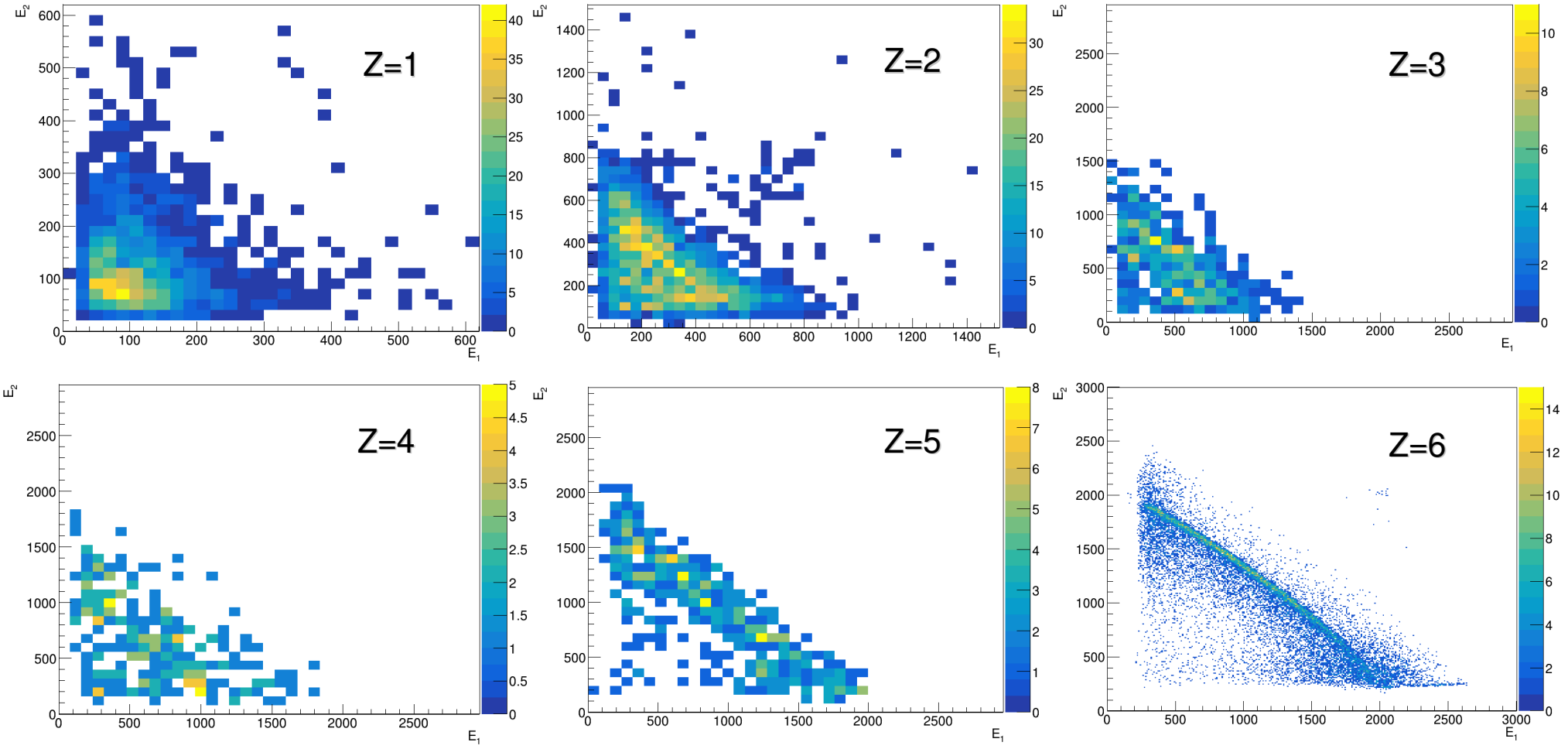


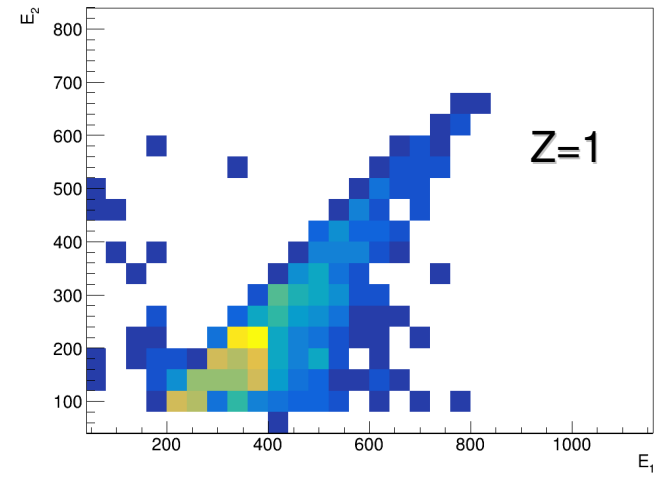
# $ADC_1$ vs $ADC_2$ for clus size = 2

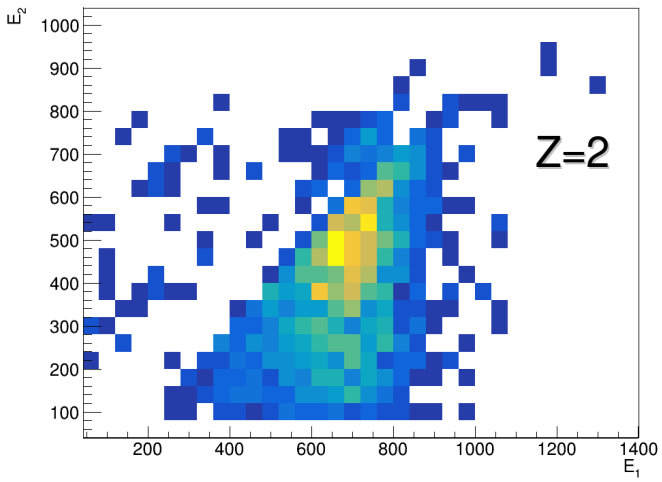


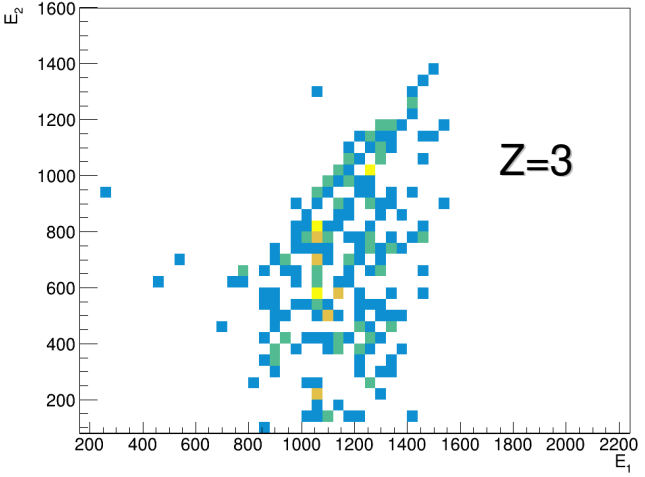
# $E_1$ vs $E_2$ (MeV) for clus size = 2

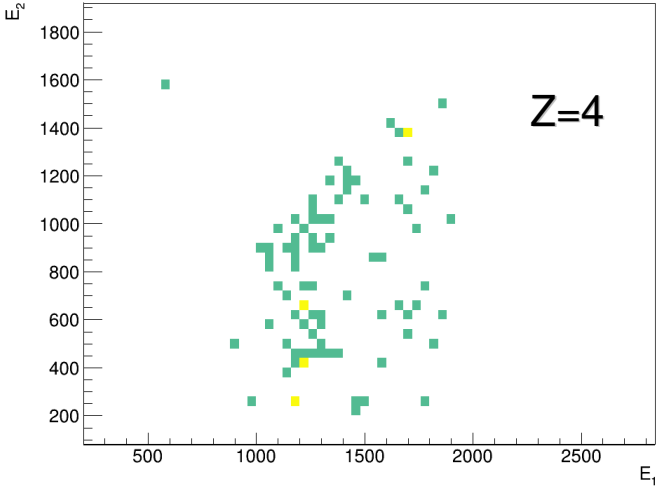


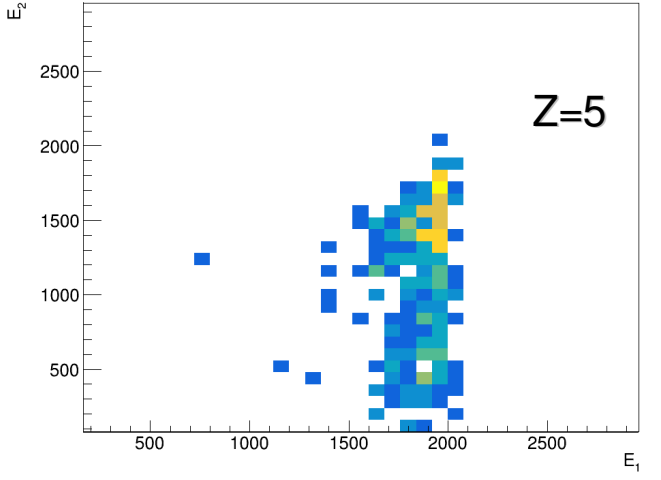
# $E_1$ vs $E_2$ (MeV) for clus size = 2 (MC truth)

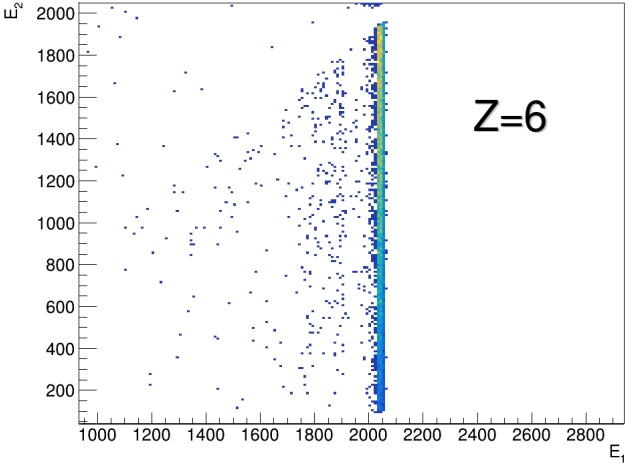


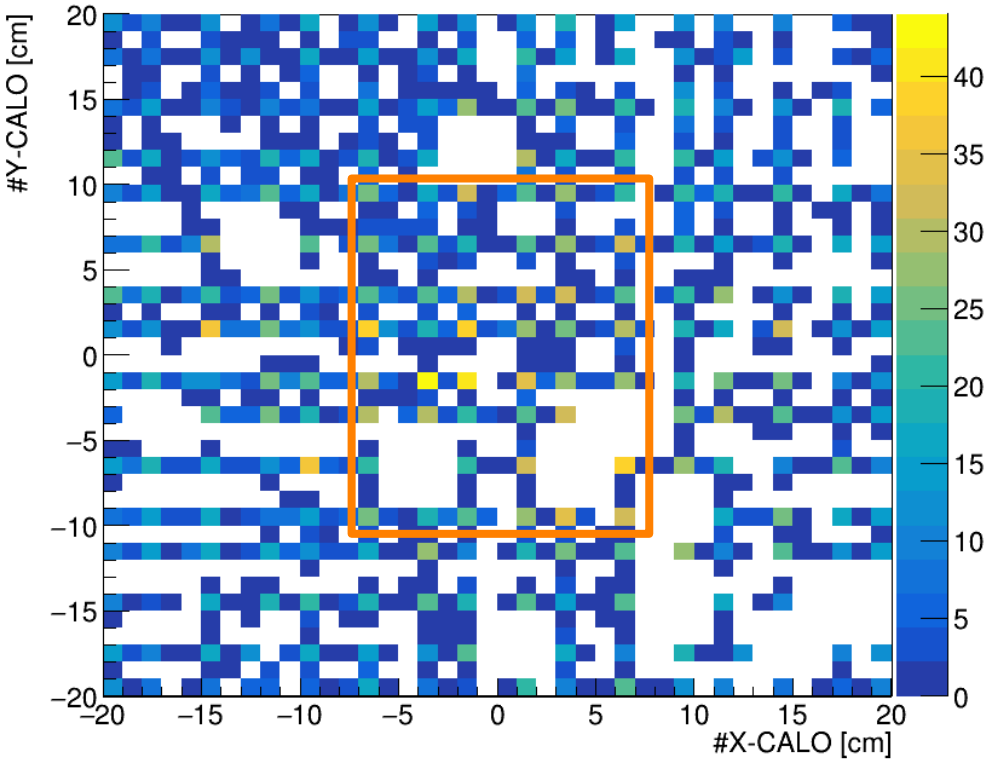



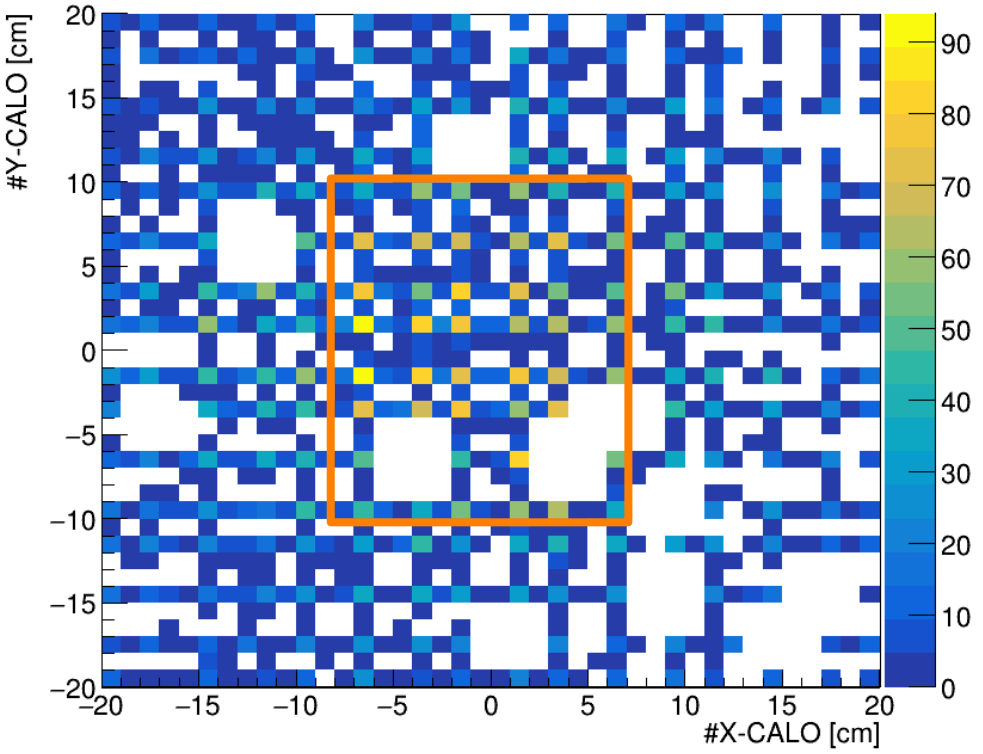



## Cluster distribution (run 7072) Z = 1, 2

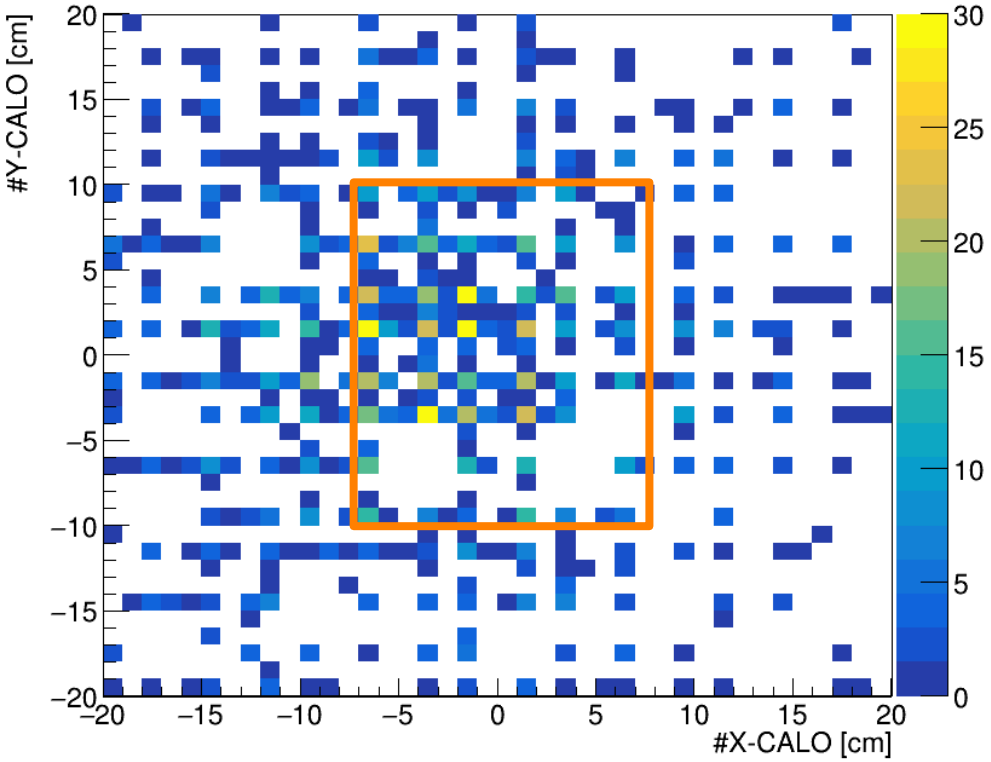
More effects of energy calibration can be investigated by looking at clusters distribution.

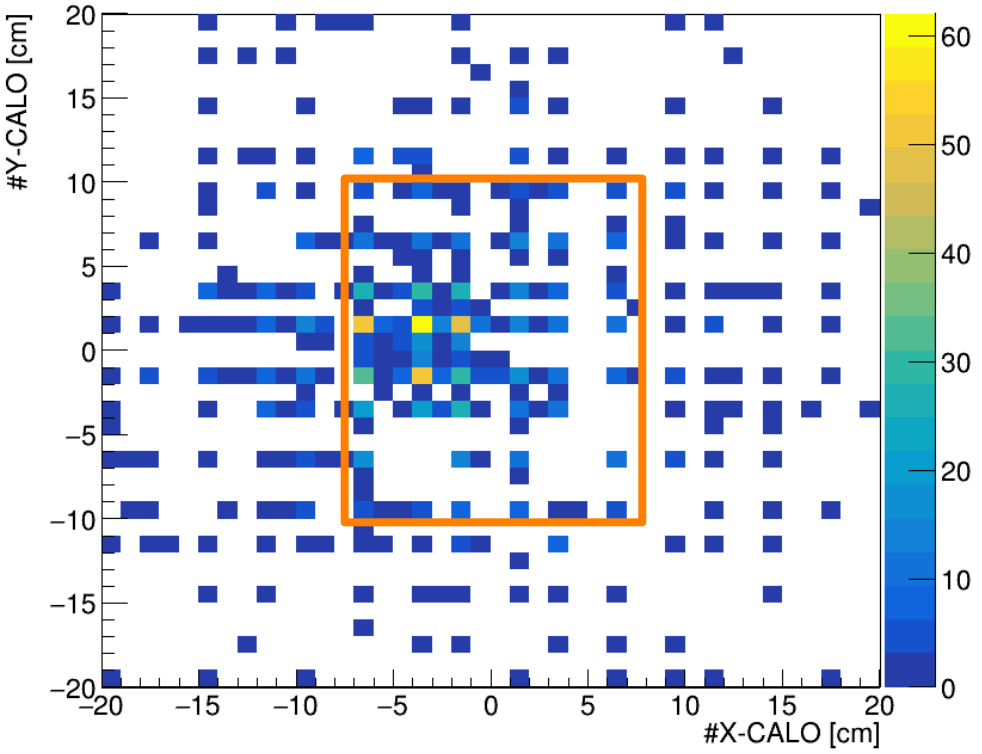


## Cluster distribution (run 7072) Z = 3, 4

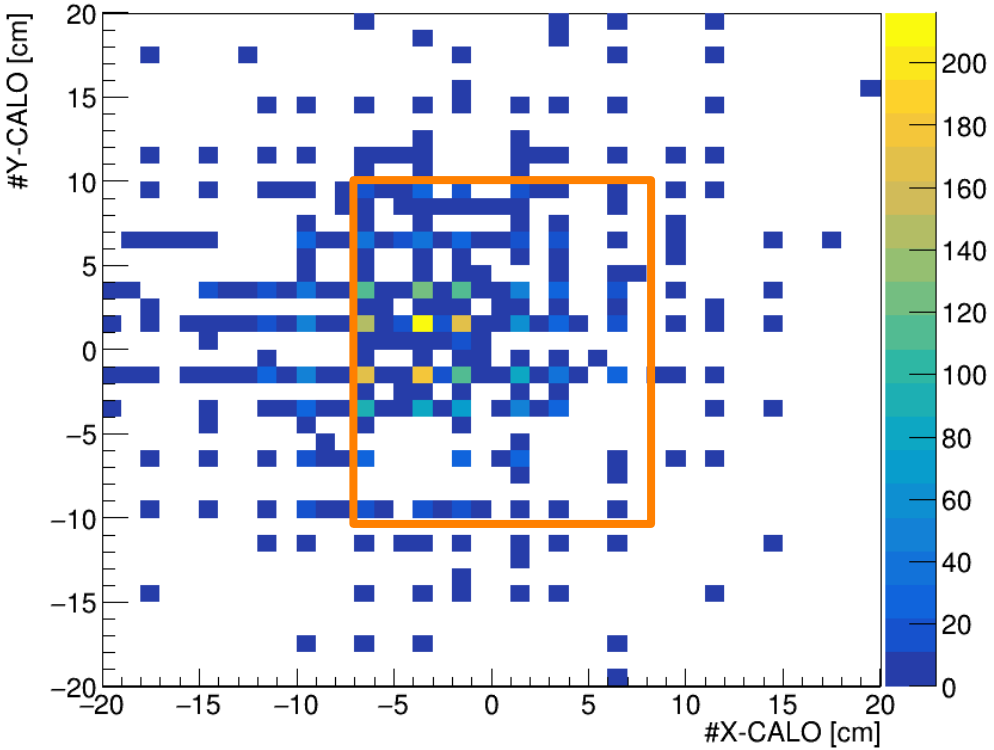
With increasing Z, the fraction of outer clusters (out of the orange box) decreases.

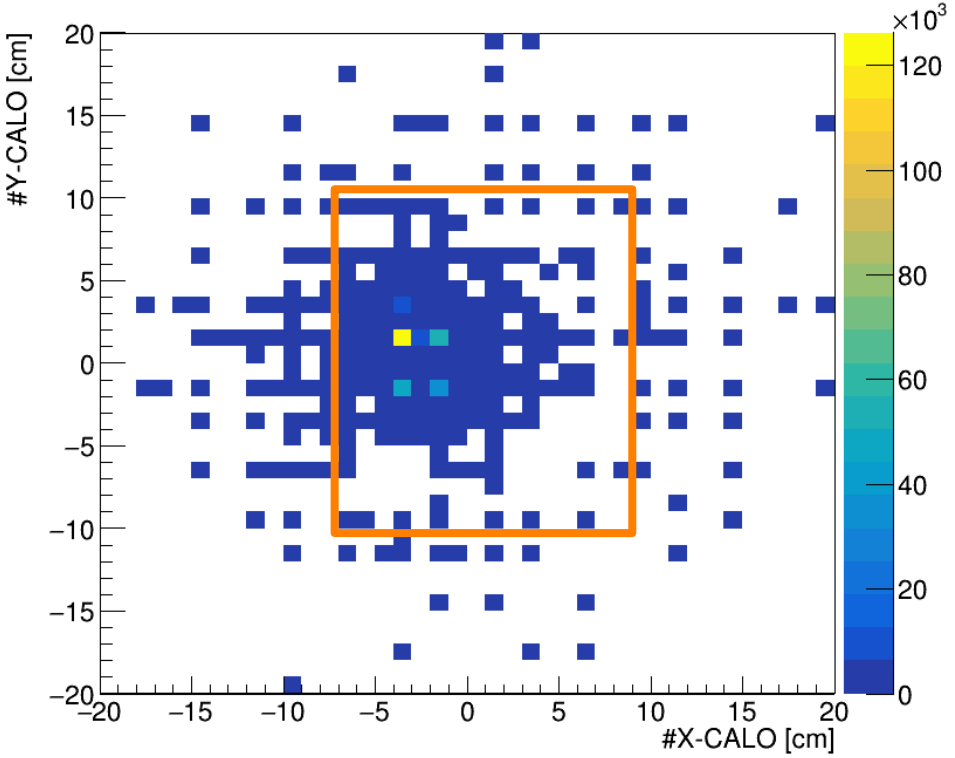


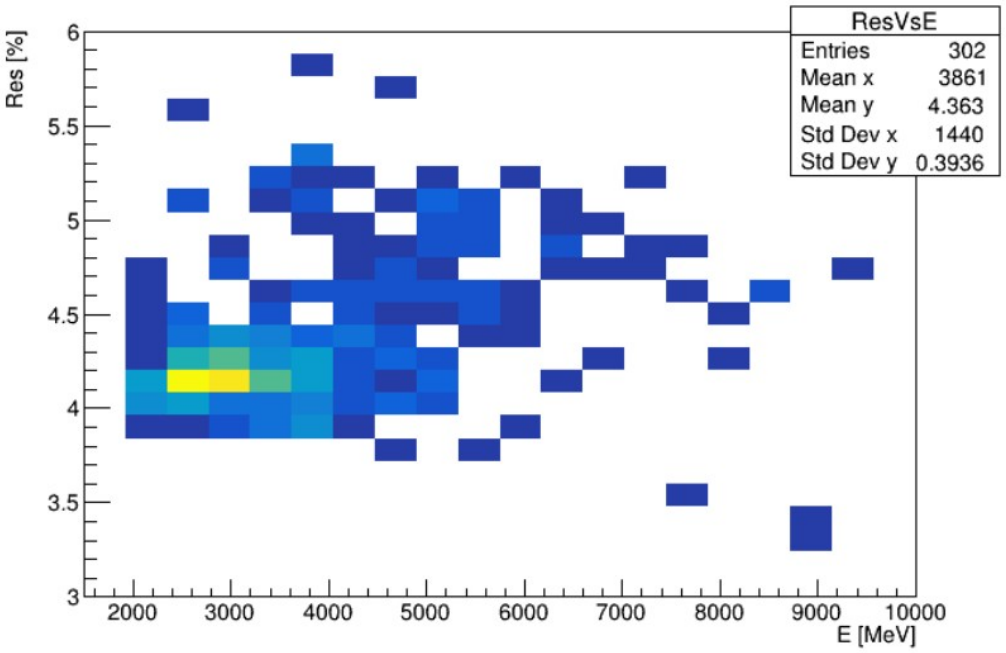
## Cluster distribution (run 7072) Z = 5, 6

With increasing Z, the fraction of outer clusters (out of the orange box) decreases.

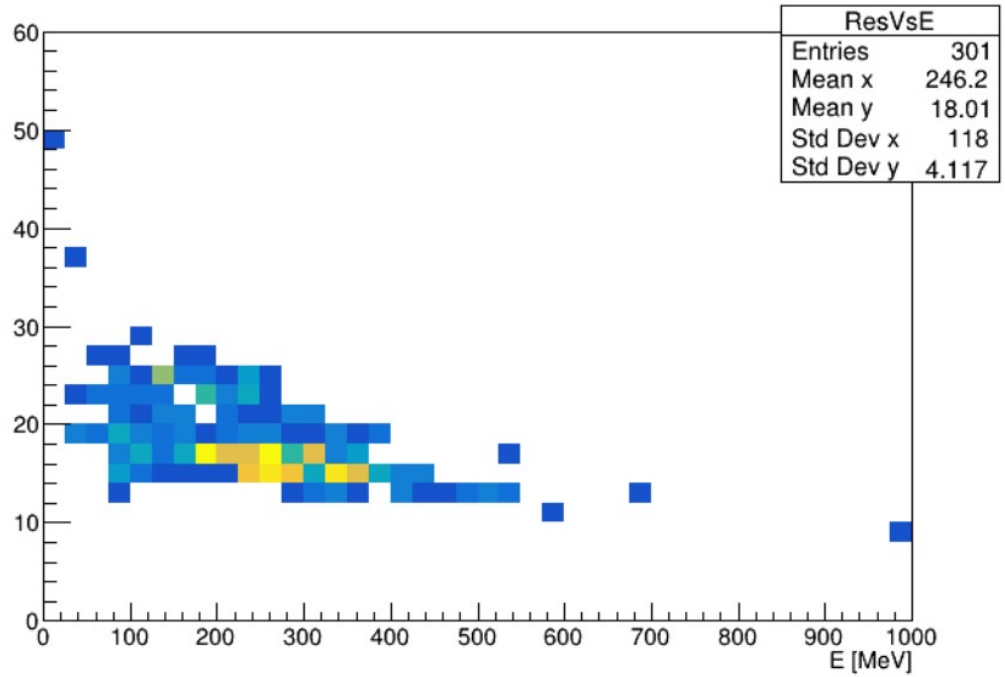


# Resolution vs optimal energy



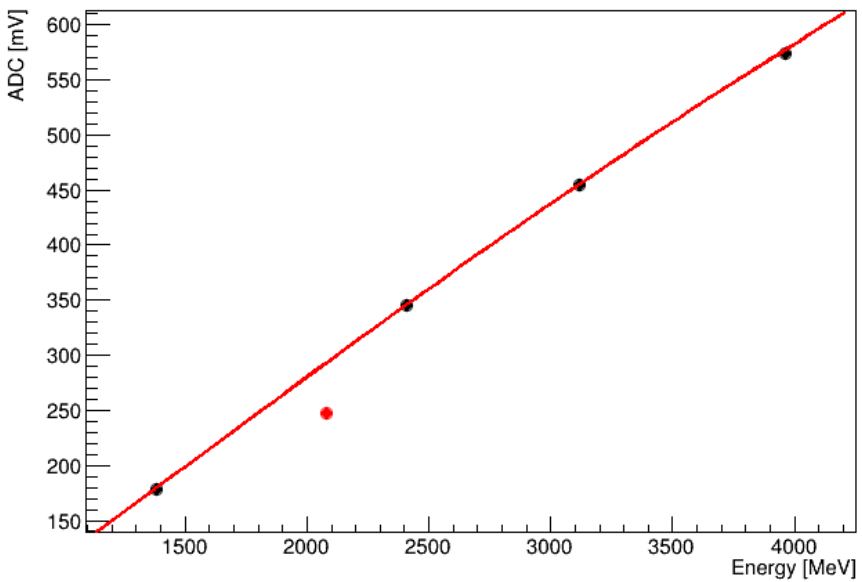

Carbon

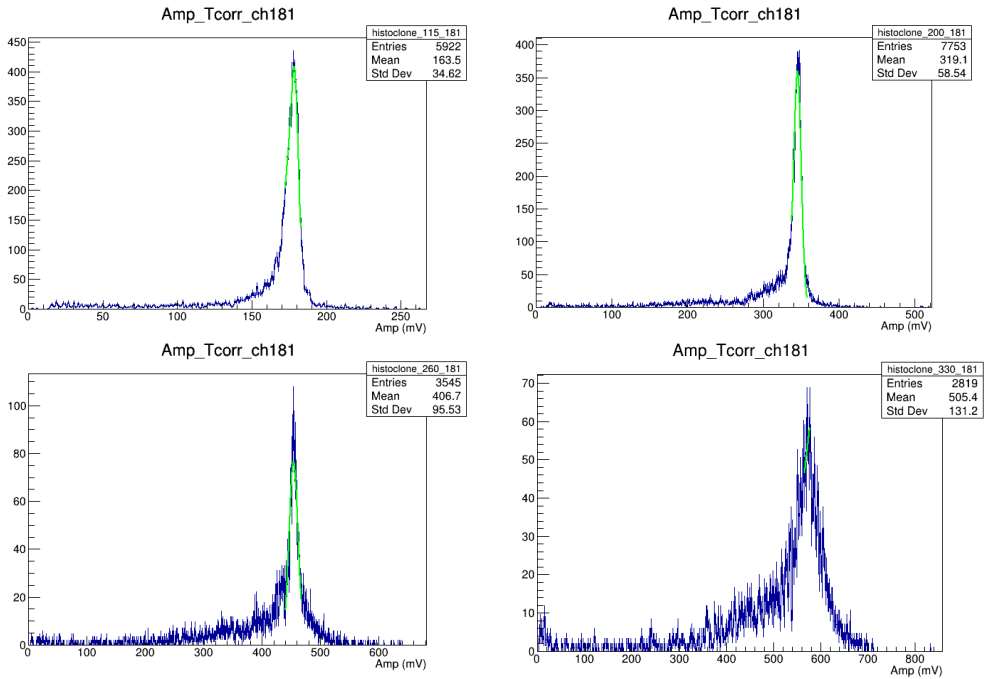



Proton

# The case of crystal 181

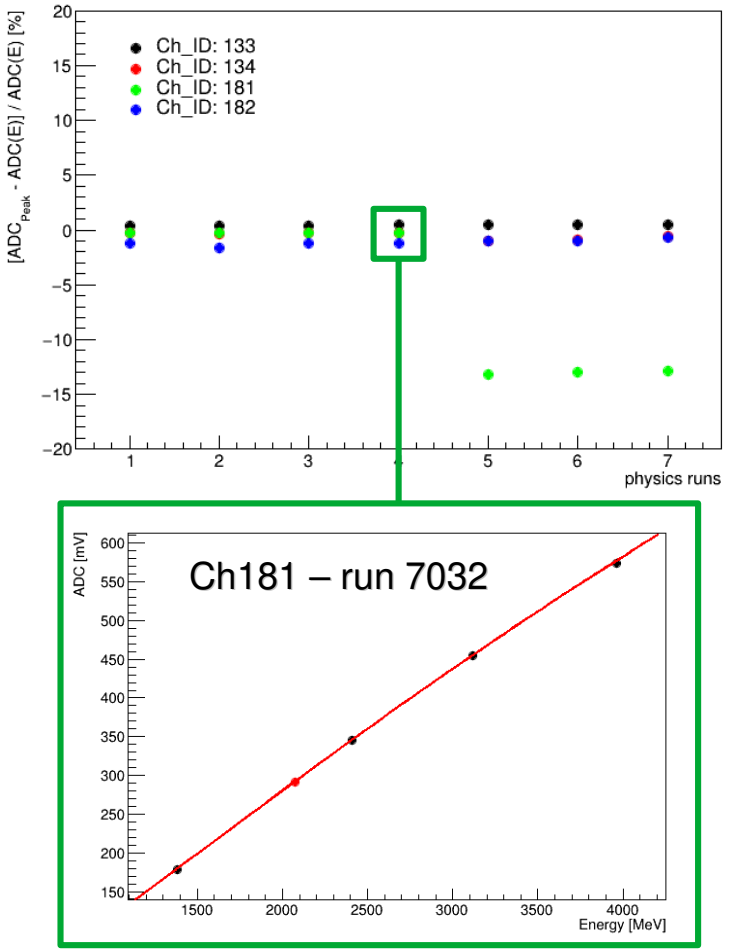
From crystal 181 calibration curve, one would expect a higher ADC response @ 170 MeV/u!



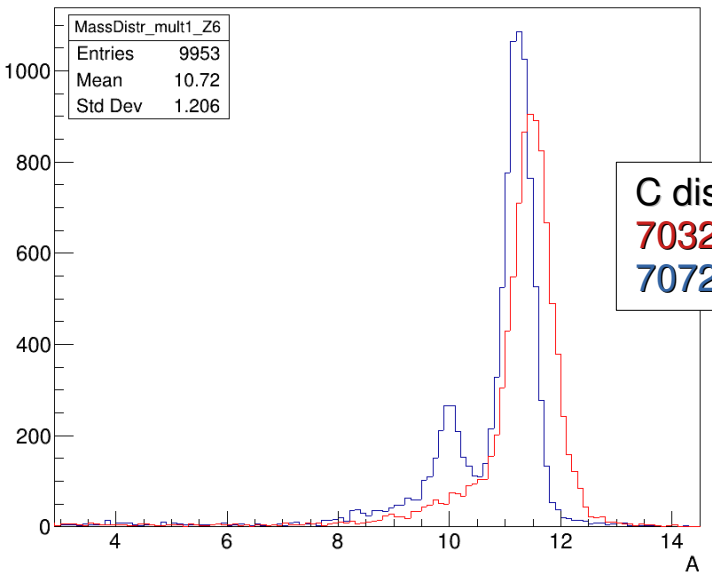

Crystal 181 is also one of the few ones showing good quality C calibration points from 115 to 330 MeV/u.

# The case of crystal 181



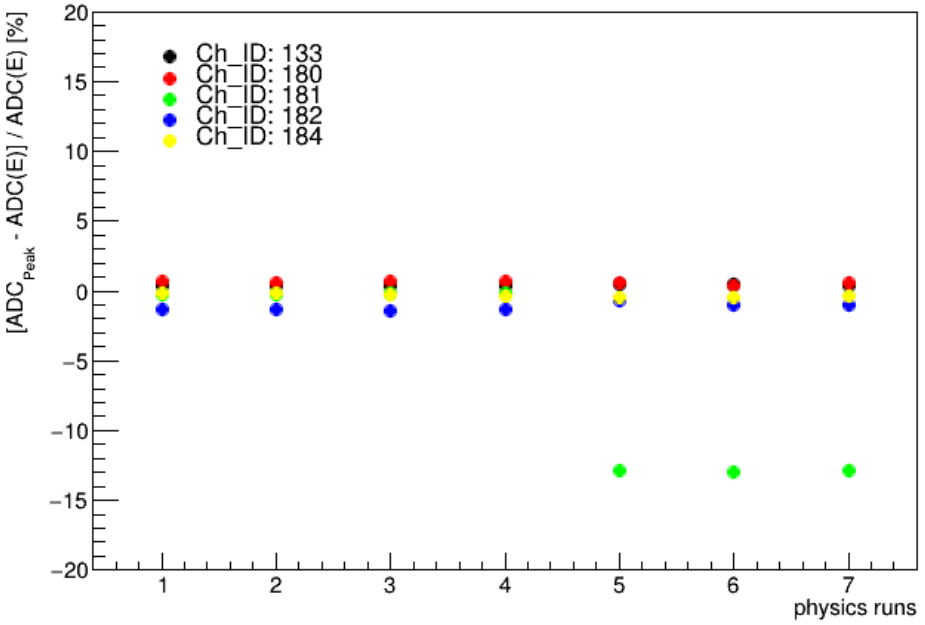

For fragmentation runs 7029, 7030, 7031, 7032 (I night) and 7072, 7076, 7077 (II night) I have:
- computed the average 12C energy;
- evaluated the expected signal amplitude from crystals 133, 134, 181, 182.

Deviation from expected signals is within 2% (or even 1%) in all cases, except for crystal 181 and only starting from run 7072.




C distributions for run 7032 compared with run 7072, with cluster size = 1.

# The case of crystal 181

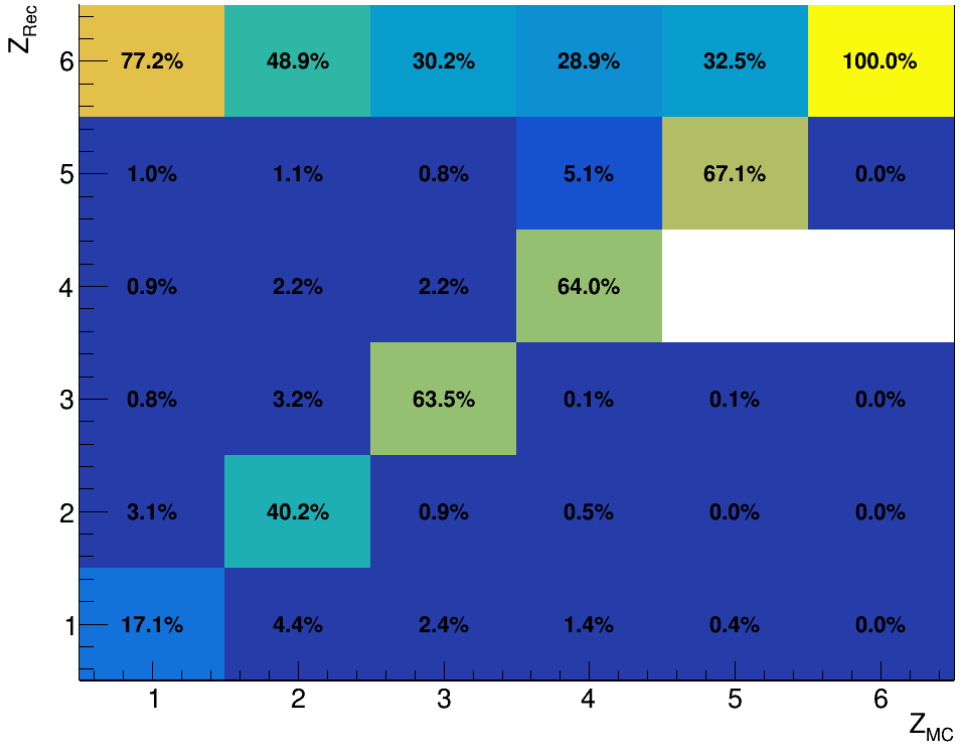



Let's include also crystals 180 and 184, which, together with crystal 133 and 182, are neighbors of crystal 181.
With the exception of 133, these channels share:

- same module (21 in HW numeration);
- same WD board (106) - but different channels;
- same channel for LV and HV supply;

In spite of this, a deviation from the expected ADC response only appears in crystal 181
→ possible mechanical trauma.

# Intrinsic Z misidentification (MC analysis)





I also tried selecting events in which TW points = CALO clusters, but there is no meaningful improvement.