# Update on integral and elemental cross sections with GSI2021 data

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**13 December 2022 – XIII FOOT Collaboration Meeting**

# Cross section measurements

400 MeV/u $^{16}$O beam on 5mm Carbon target

With available data total integrated and angle differential cross section are achievable (no kinetic energy)

$$\Delta\sigma(Z) = \int_{E_{\min}}^{E_{\max}} \int_{0}^{\theta_{\max}} \left( \frac{\partial^2 \sigma}{\partial\theta \partial E_{\mathrm{kin}}} \right) \mathrm{d}\theta \mathrm{d}E_{\mathrm{kin}} = \frac{Y(Z)}{N_{\mathrm{prim}} \cdot N_{\mathrm{TG}} \cdot \varepsilon(Z)}$$

$$\frac{\mathrm{d}\sigma}{\mathrm{d}\theta}(Z) = \frac{Y(Z,\theta)}{N_{\mathrm{prim}} \cdot N_{\mathrm{TG}} \cdot \Delta\theta \cdot \varepsilon(Z,\theta)}$$

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Align FOOT detectors and estimate **angular acceptance**

Extract fragment yields from TW

Calculate MC efficiencies for fragments

# Cross section measurements

400 MeV/u $^{16}$O beam on 5mm Carbon target

With available data **total integrated** and angle differential cross section are achievable (no kinetic energy)

$$\Delta\sigma(Z) = \int_{\beta_{\min}}^{\beta_{\max}} \int_{0}^{\theta_{\max}} \left( \frac{\partial^2 \sigma}{\partial\theta \partial\beta} \right) \mathrm{d}\theta \mathrm{d}\beta = \frac{Y(Z)}{N_{\mathrm{prim}} \cdot N_{\mathrm{TG}} \cdot \varepsilon(Z)}$$

Align FOOT detectors and estimate **angular acceptance**

Extract fragment yields from TW

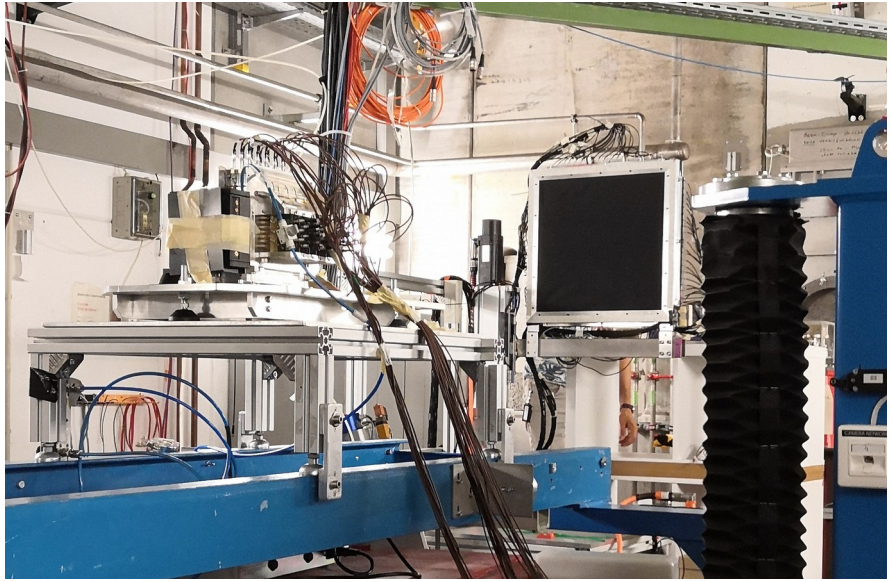
Calculate MC efficiencies for fragments

Evaluate the beta range from data and put in MC for efficiency calculations

# Cross section measurements

400 MeV/u $^{16}$O beam on 5mm Carbon target

| Run | Trigger type | Target | Events |
|---|---|---|---|
| 4305 | MB | C | 162102 |
| 4306 | MB | C | 577096 |
| 4307 | MB | C | 513370 |
| 4308 | Frag + MB | C | 510169 |
| 4309 | Frag + MB | C | 531812 |
| 4310 | Frag + MB | C | 1012099 |
| 4313 | MB | no | 57133 |



# Cross section measurements

400 MeV/u $^{16}O$ beam on 5mm Carbon target

In this analysis VTX is not included, first look at MSD

Fragmentation out of target will be estimated with no target runs

All in SHOE but no track reconstruction here (see Giacomo's presentation)

# MC analysis

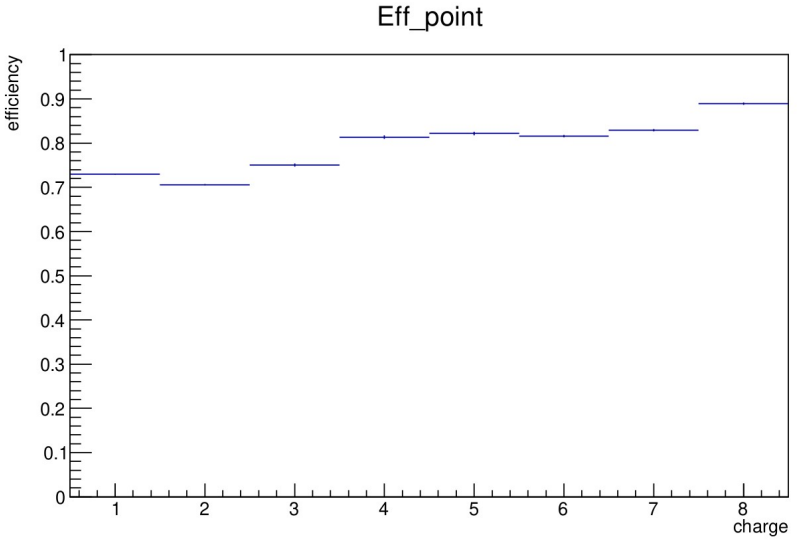
$$\varepsilon(Z) = \frac{N_{\mathrm{TW}}(Z)}{N_{\mathrm{track}}(Z)}$$

asking for a good TW point matched to a fragment produced in TG and kinetic energy between [100,600] MeV/u

asking for a fragment produced in TG within TW acceptance and kinetic energy between [100,600] MeV/u

$$\epsilon_{\varepsilon}(Z) = \sqrt{\varepsilon(Z)\frac{1-\varepsilon(Z)}{N_{\mathrm{track}}(Z)}}$$

before



# MC analysis

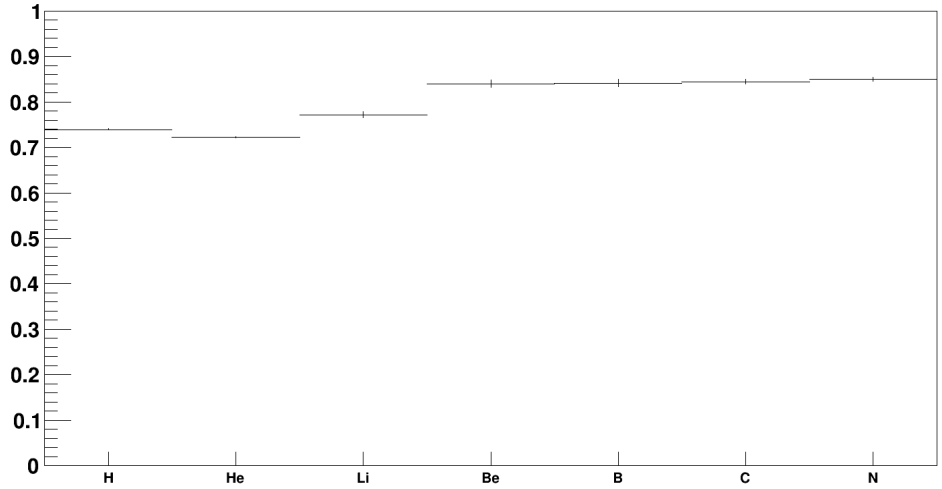
$$\varepsilon(Z) = \frac{N_{\mathrm{TW}}(Z)}{N_{\mathrm{track}}(Z)}$$

asking for a good TW point matched to a fragment produced in TG within TW acceptance with 0.3<β<0.9

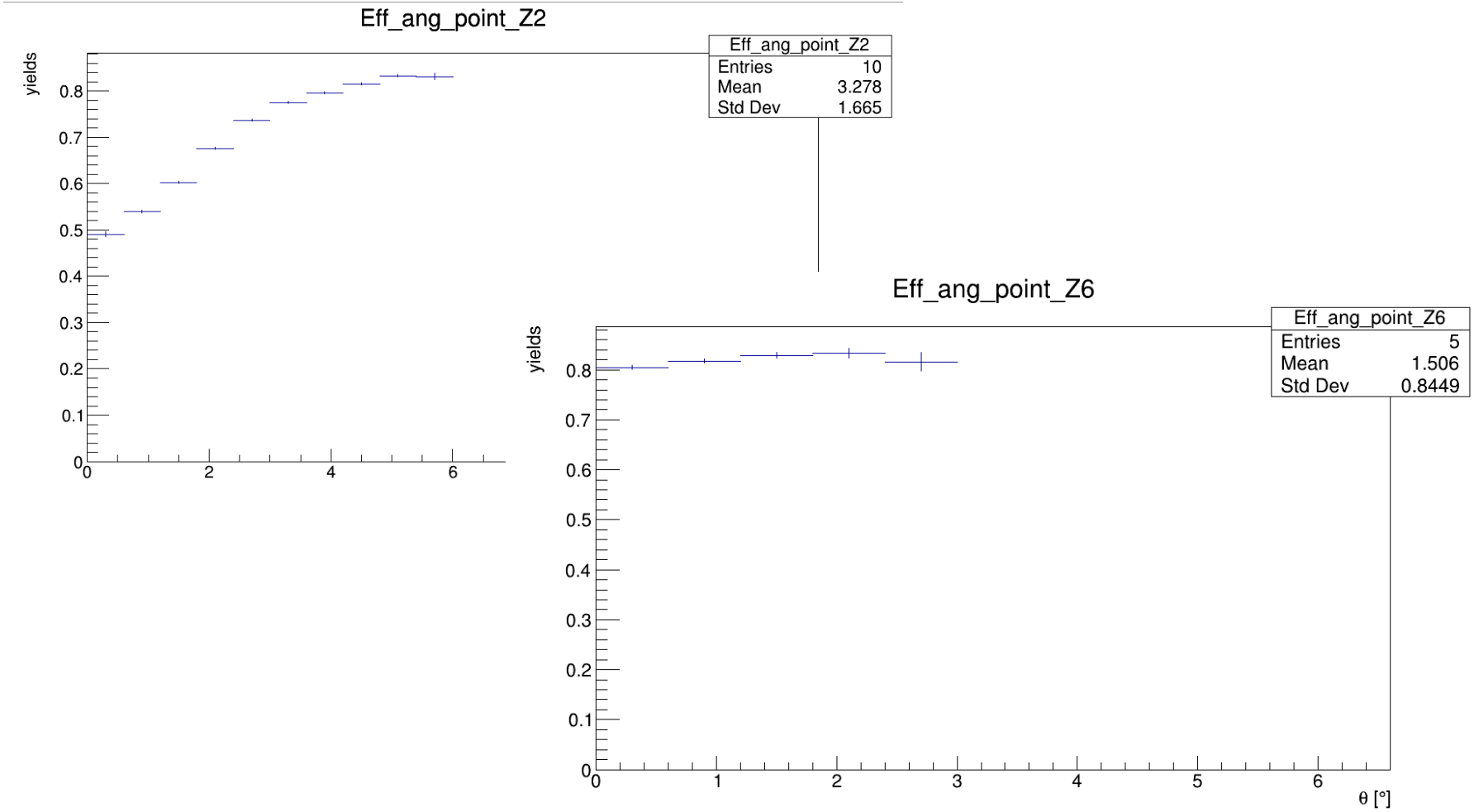
asking for a fragment produced in TG within TW acceptance passing from air to TW bars (using TAMCregion crossing info) with 0.3<β<0.9

$$\epsilon_{\varepsilon}(Z) = \sqrt{\varepsilon(Z)\frac{1-\varepsilon(Z)}{N_{\mathrm{track}}(Z)}}$$

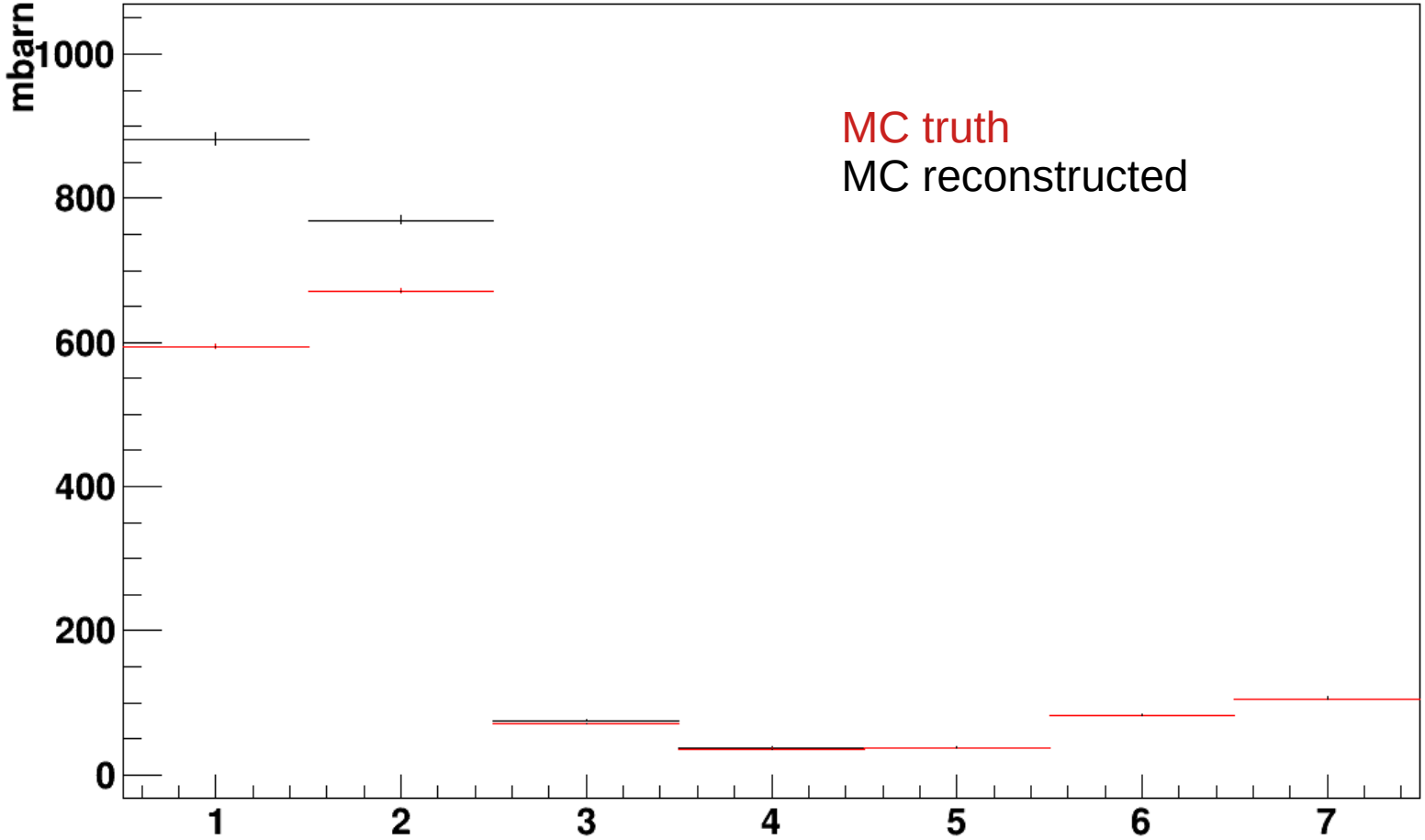
after



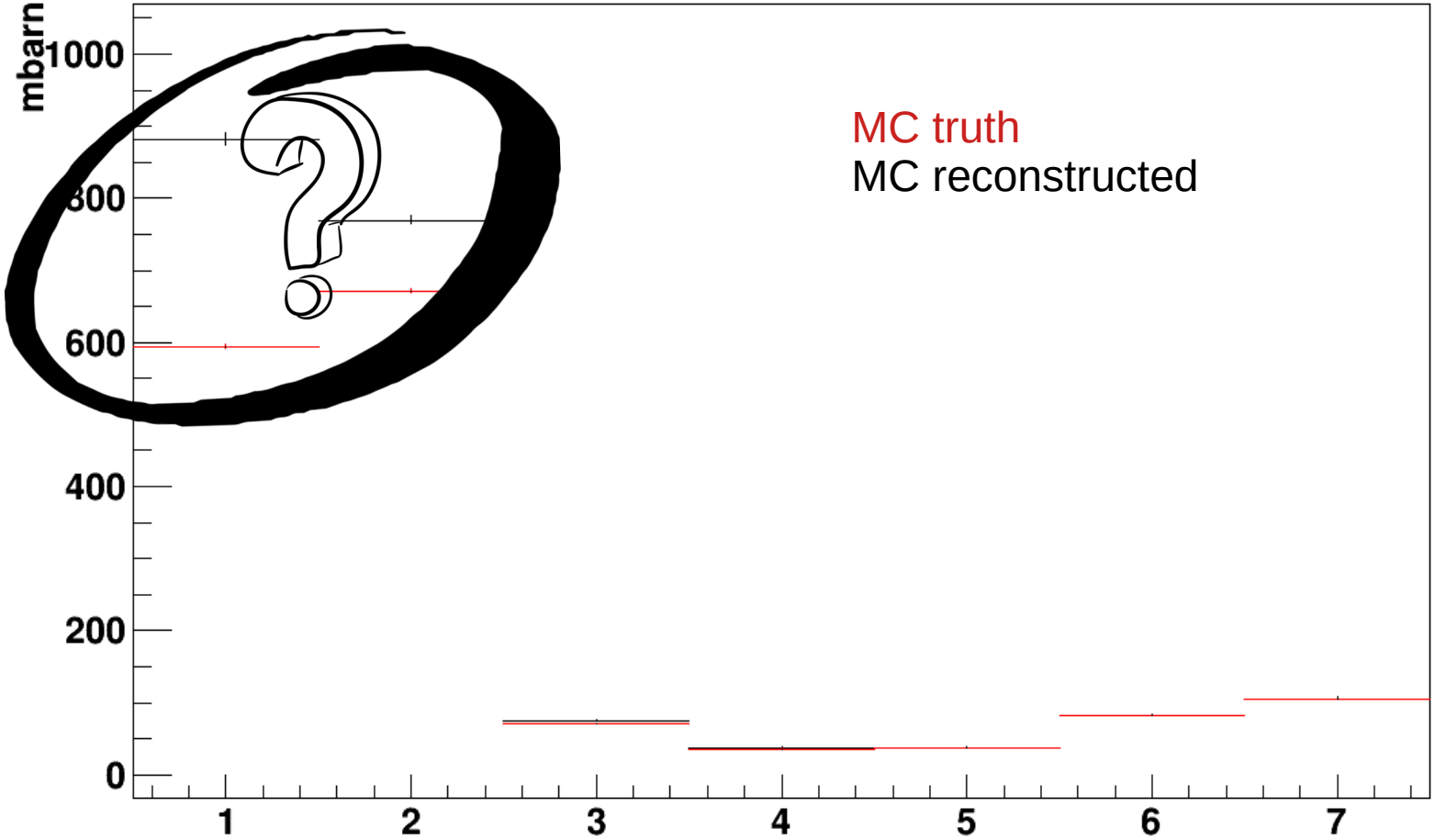
# MC analysis


Eff_ang_point_Z2
yields
Eff_ang_point_Z2
Entries 10
Mean 3.278
Std Dev 1.665
Eff_ang_point_Z6
yields
Eff_ang_point_Z6
Entries 5
Mean 1.506
Std Dev 0.8449
θ [°]

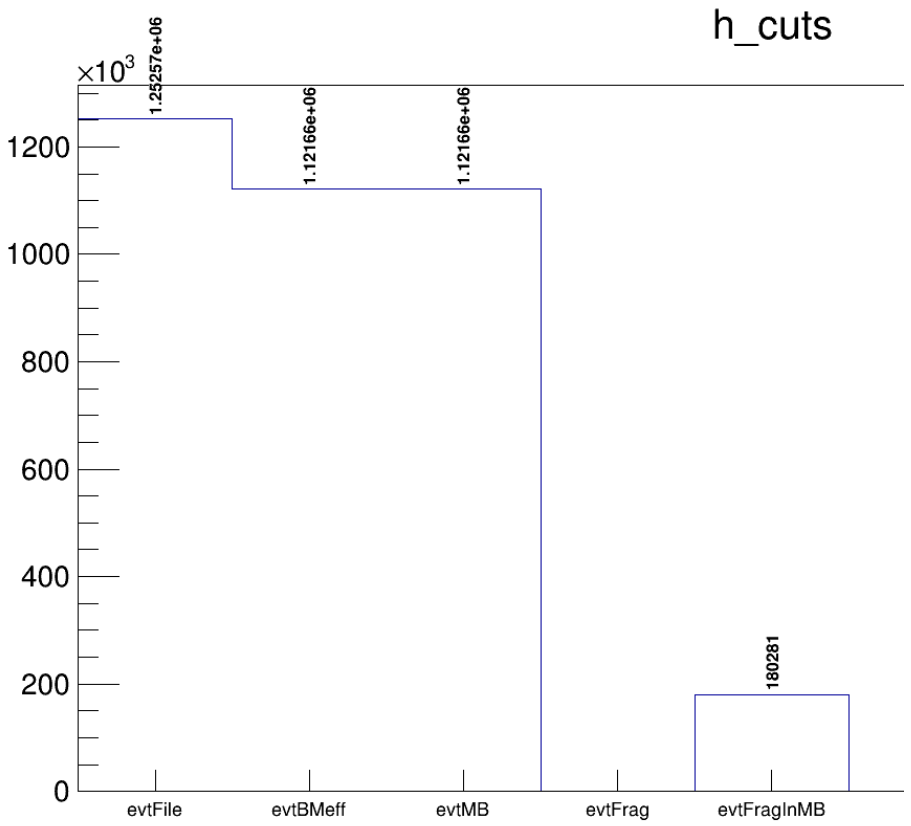
# MC analysis


mbarn
1000
800
600
400
200
0
1
2
3
4
5
6
7
MC truth
MC reconstructed

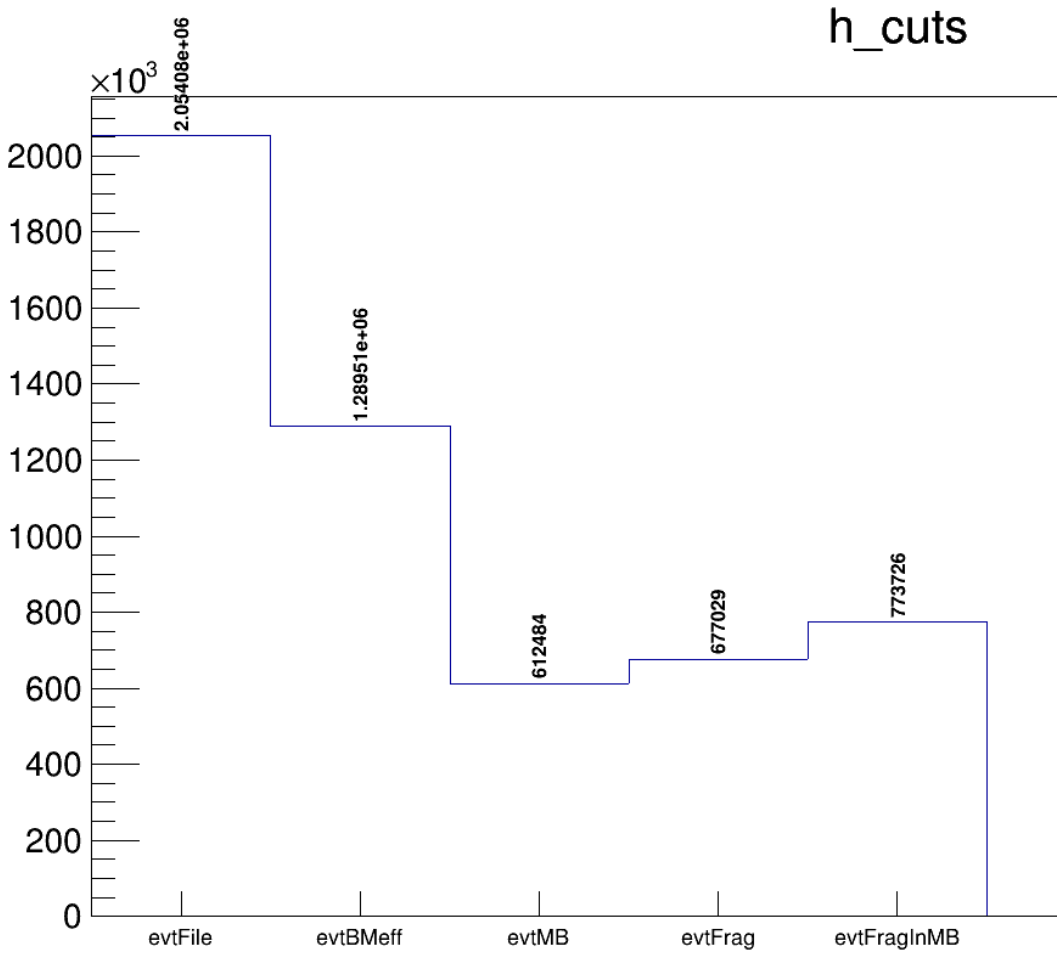
# MC analysis


mbarn
1000
800
600
400
200
0
1
2
3
4
5
6
7
MC truth
MC reconstructed

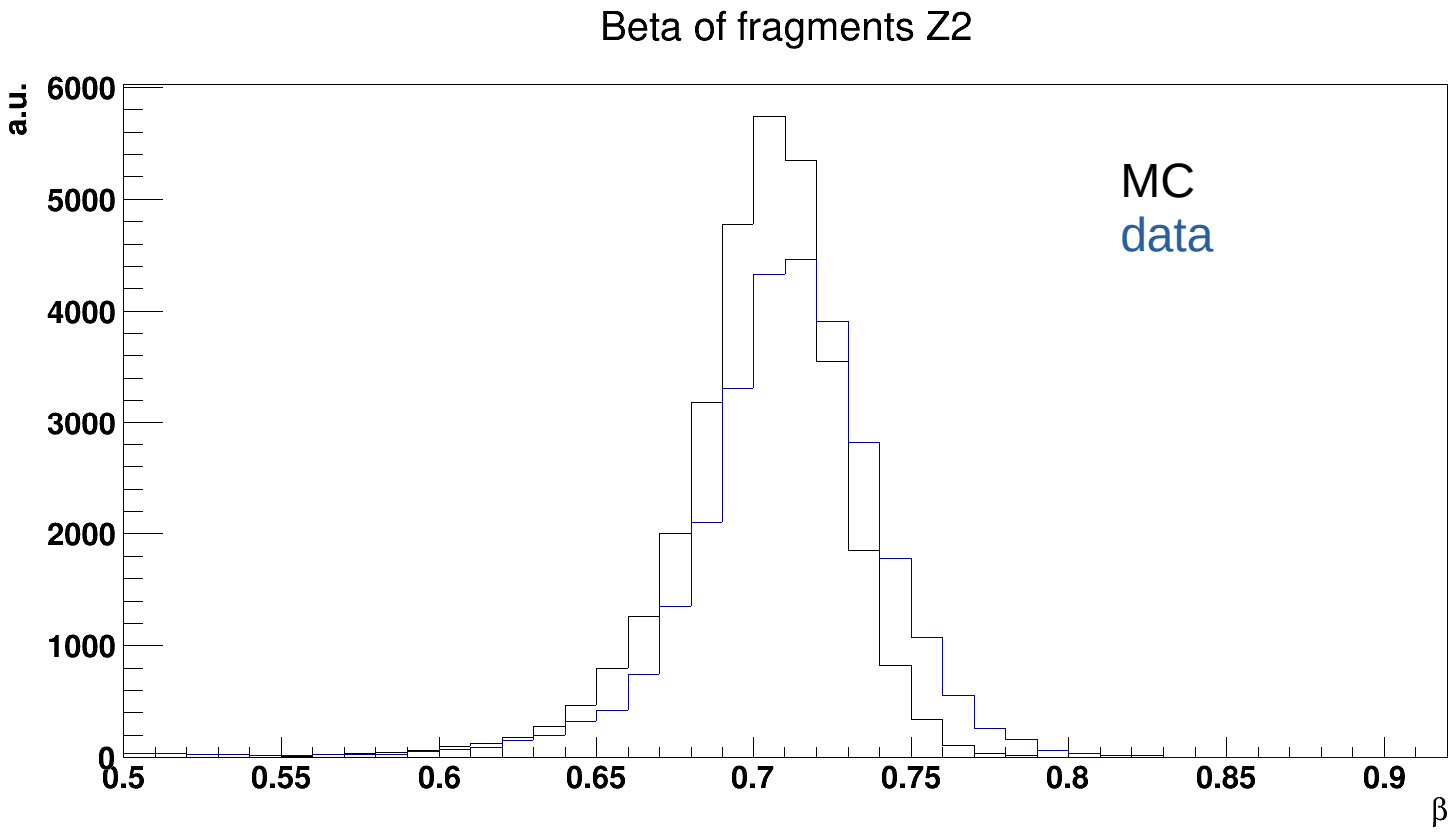
# Cross section measurement MB (4305-6-7)



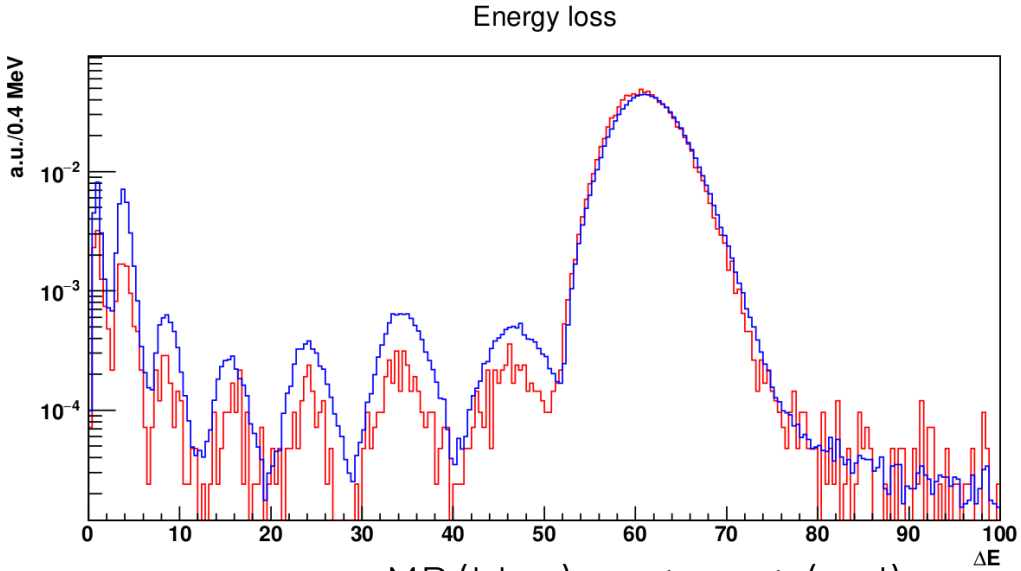
# Cross section measurement FRAG (4308-9-10)



# Beta distribution of fragments (4309)



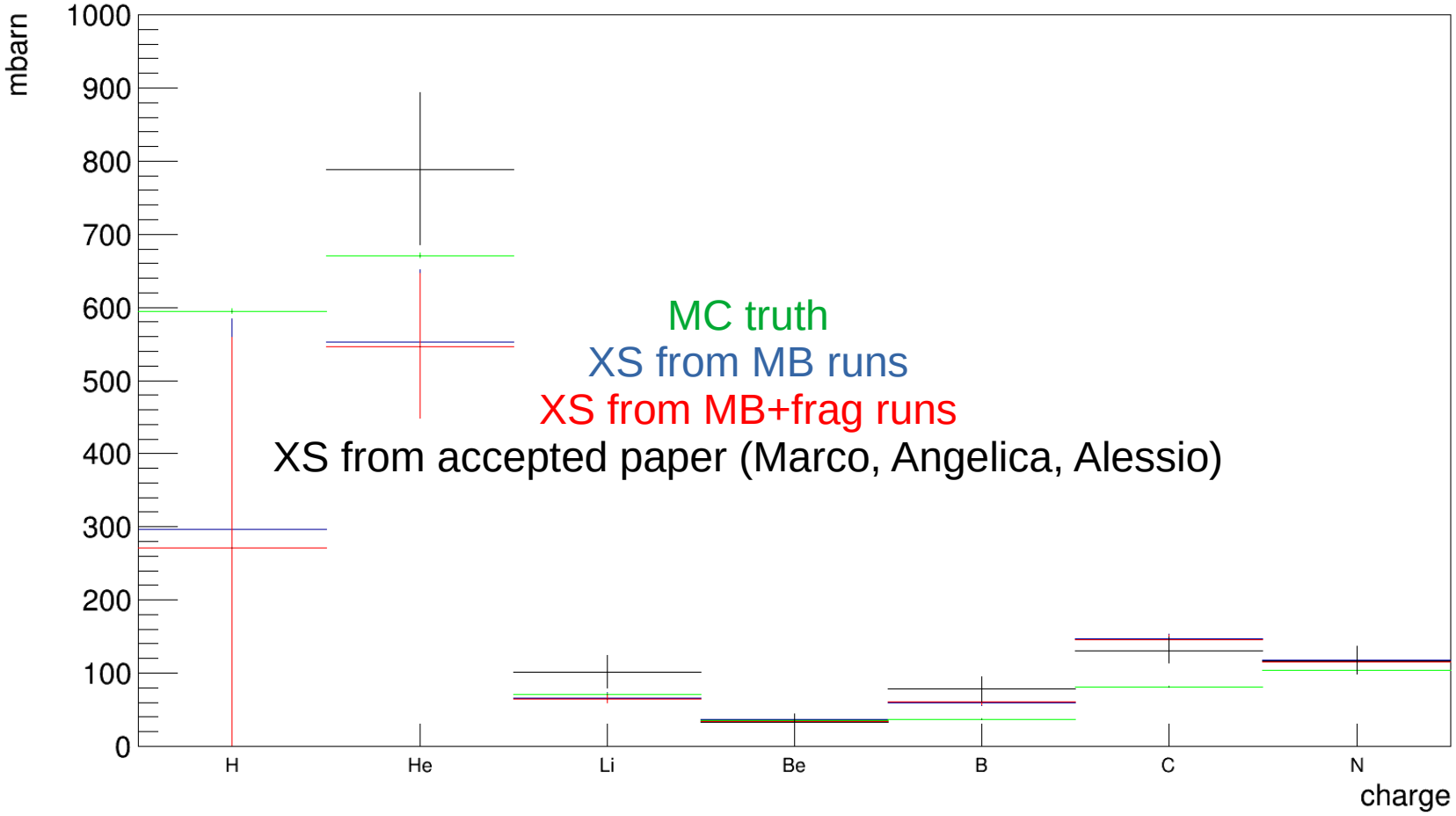
# Background subtraction (4313)



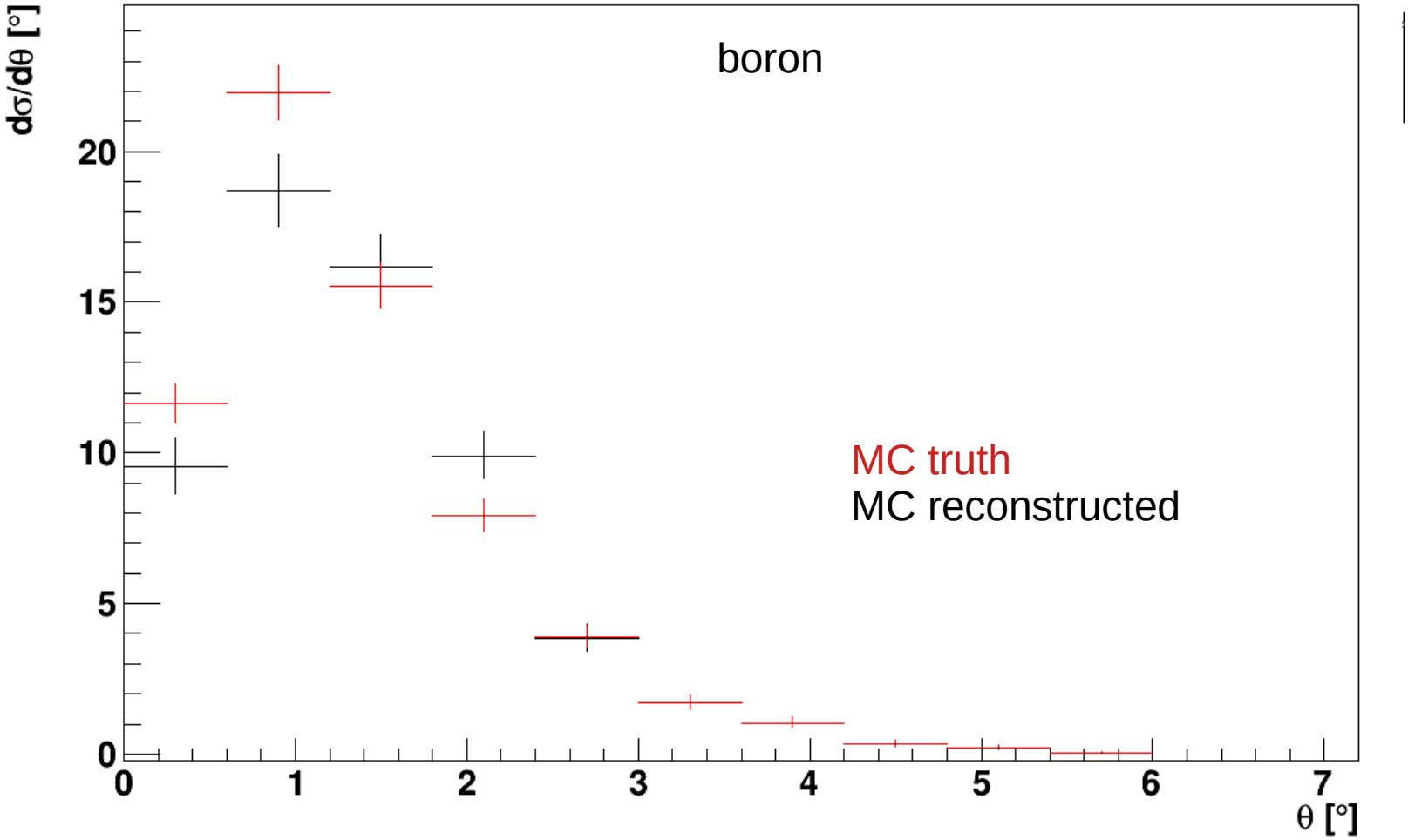

MB (blue), no-target (red)

$$\Delta\sigma(Z) = \frac{1}{N_{\mathrm{TG}} \cdot \varepsilon(Z)} \left( \frac{Y^{\mathrm{sig}}(Z)}{N^{\mathrm{sig}}_{\mathrm{prim}}(Z)} - \frac{Y^{\mathrm{bkg}}(Z)}{N^{\mathrm{bkg}}_{\mathrm{prim}}(Z)} \right)$$

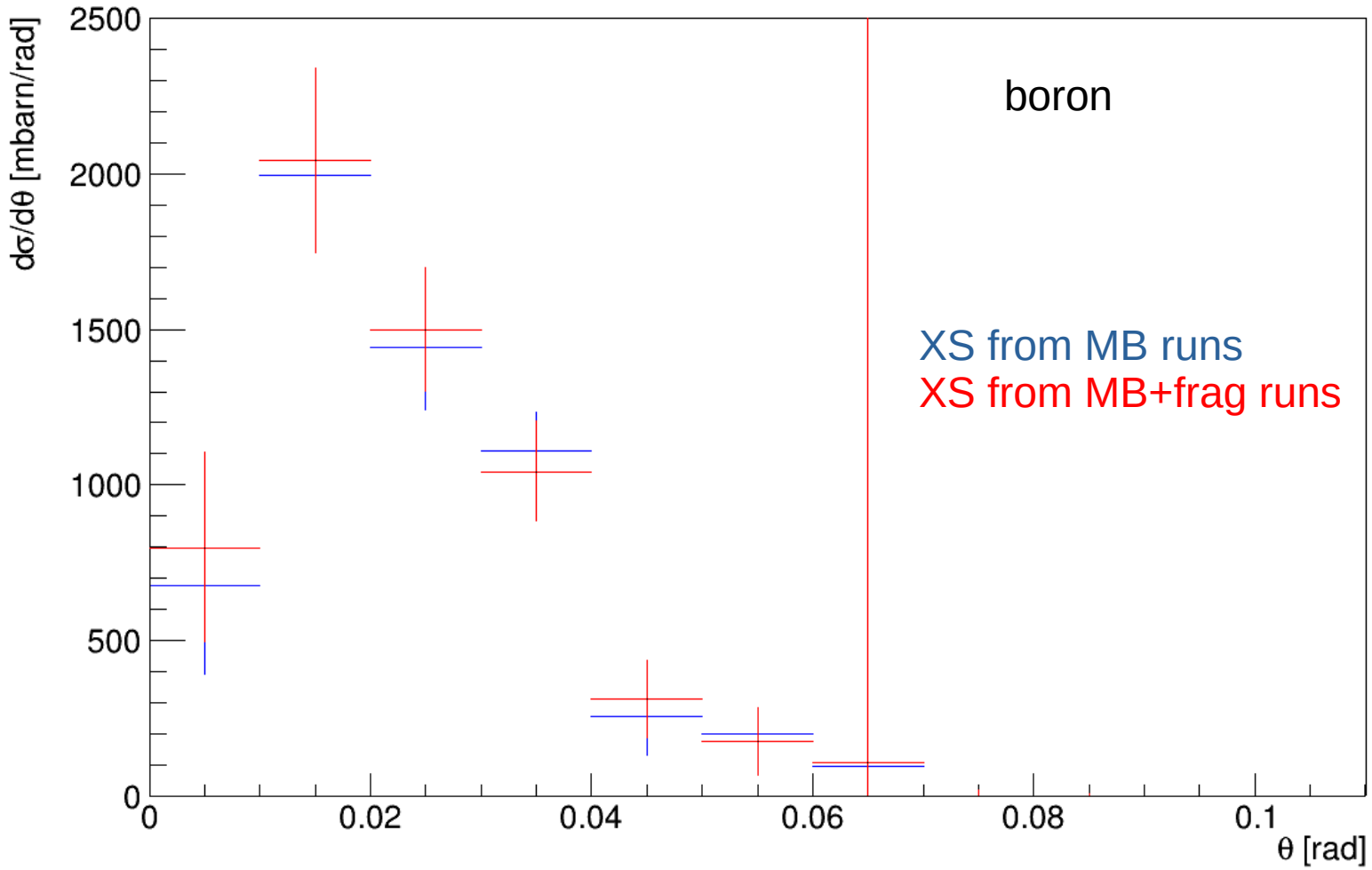
# Results


mbarn
1000
900
800
700
600
500
400
300
200
100
0
H
He
Li
Be
B
C
N
charge
MC truth
XS from MB runs
XS from MB+frag runs
XS from accepted paper (Marco, Angelica, Alessio)

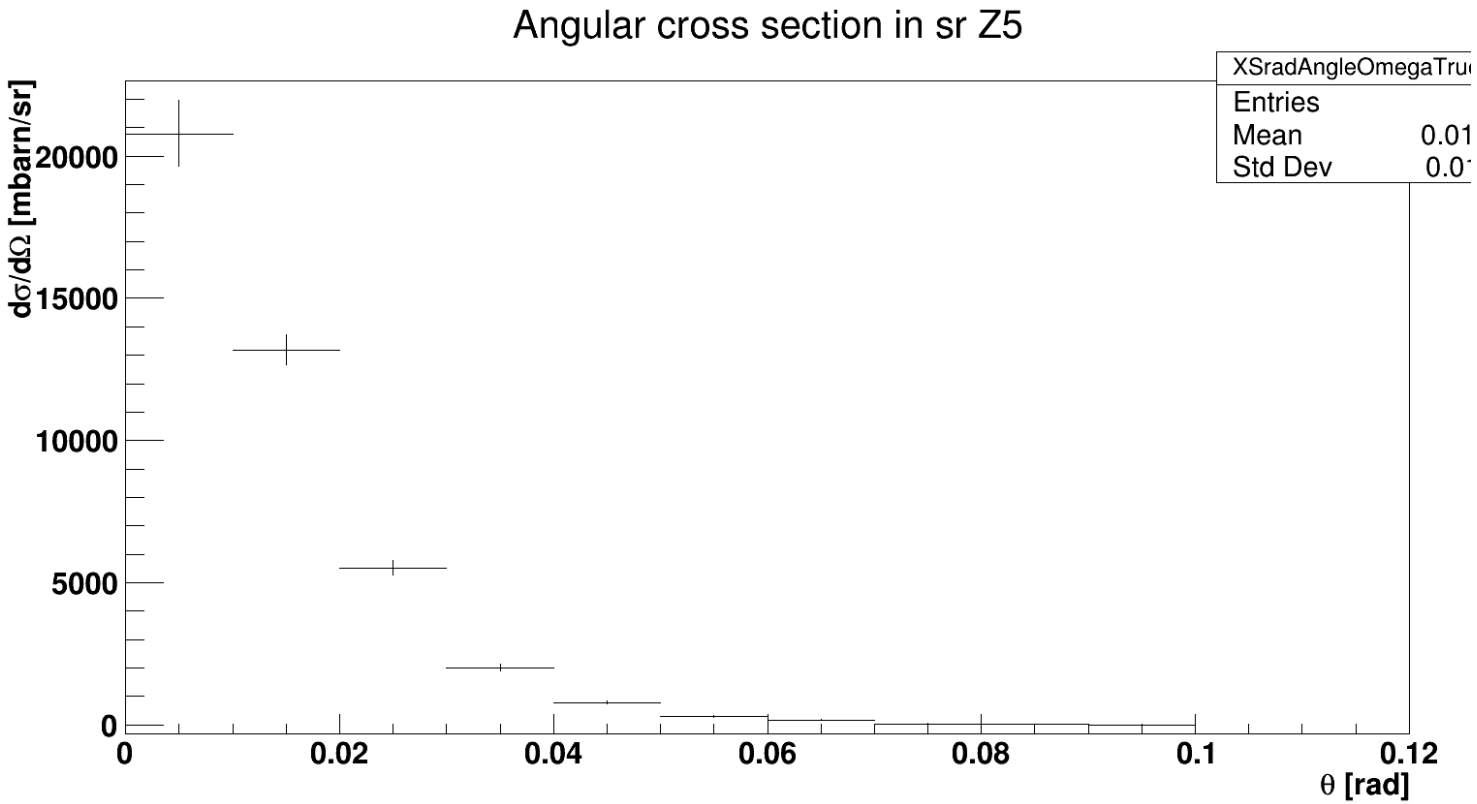
# MC analysis



# Results


boron
XS from MB runs
XS from MB+frag runs
dσ/dθ [mbarn/rad]
θ [rad]
0
500
1000
1500
2000
2500
0.02
0.04
0.06
0.08
0.1

# Results


Angular cross section in sr Z5
XSradAngleOmegaTru
Entries
Mean 0.01
Std Dev 0.0
dσ/dΩ [mbarn/sr]
20000
15000
10000
5000
0
0
0.02
0.04
0.06
0.08
0.1
0.12
θ [rad]

# Conclusions

Minimum bias and fragmentation cross sections again in agreement

Beta cut for MC can be set at [0.3-0.9] according to data

Discrepancy on low-Z fragments in MC under investigation

Up to now systematics are only on the subtraction method, more to be added

After data takings more time can be invested to carry on with analysis

A lot of data to decode in GSI2021 campaign (4 beam-target settings)

Interest in publishing these measurements comparing them with GSI2019 data

# Thanks for listening!