GSI2021 analysis without tracking

Riccardo Ridolfi

12 December 2023 - XV FOOT
Collaboration Meeting

Cross section measurement

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 measurement

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

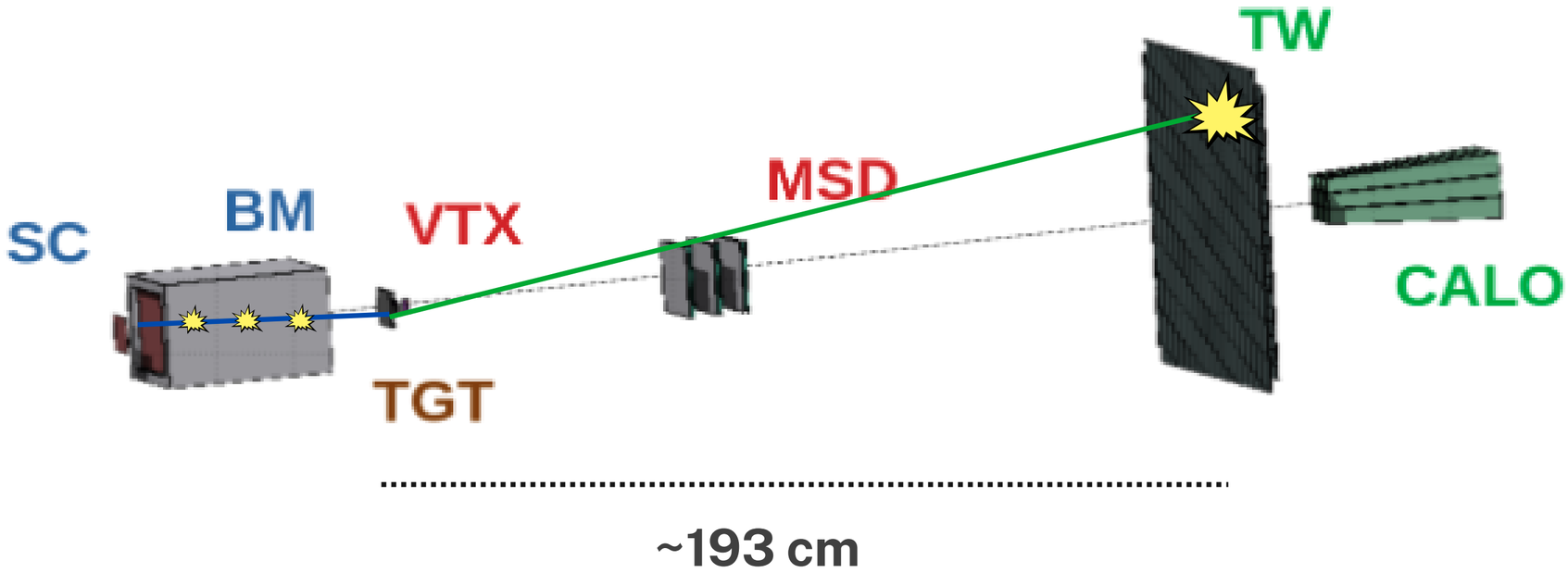
$$\frac{\mathrm{d}\sigma}{\mathrm{d}\theta}(Z) = \frac{Y(Z,\theta)}{N_{\mathrm{prim}} \cdot N_{\mathrm{TG}} \cdot \Delta\theta \cdot \varepsilon(Z,\theta)}$$

Align FOOT detectors and estimate **angular acceptance**

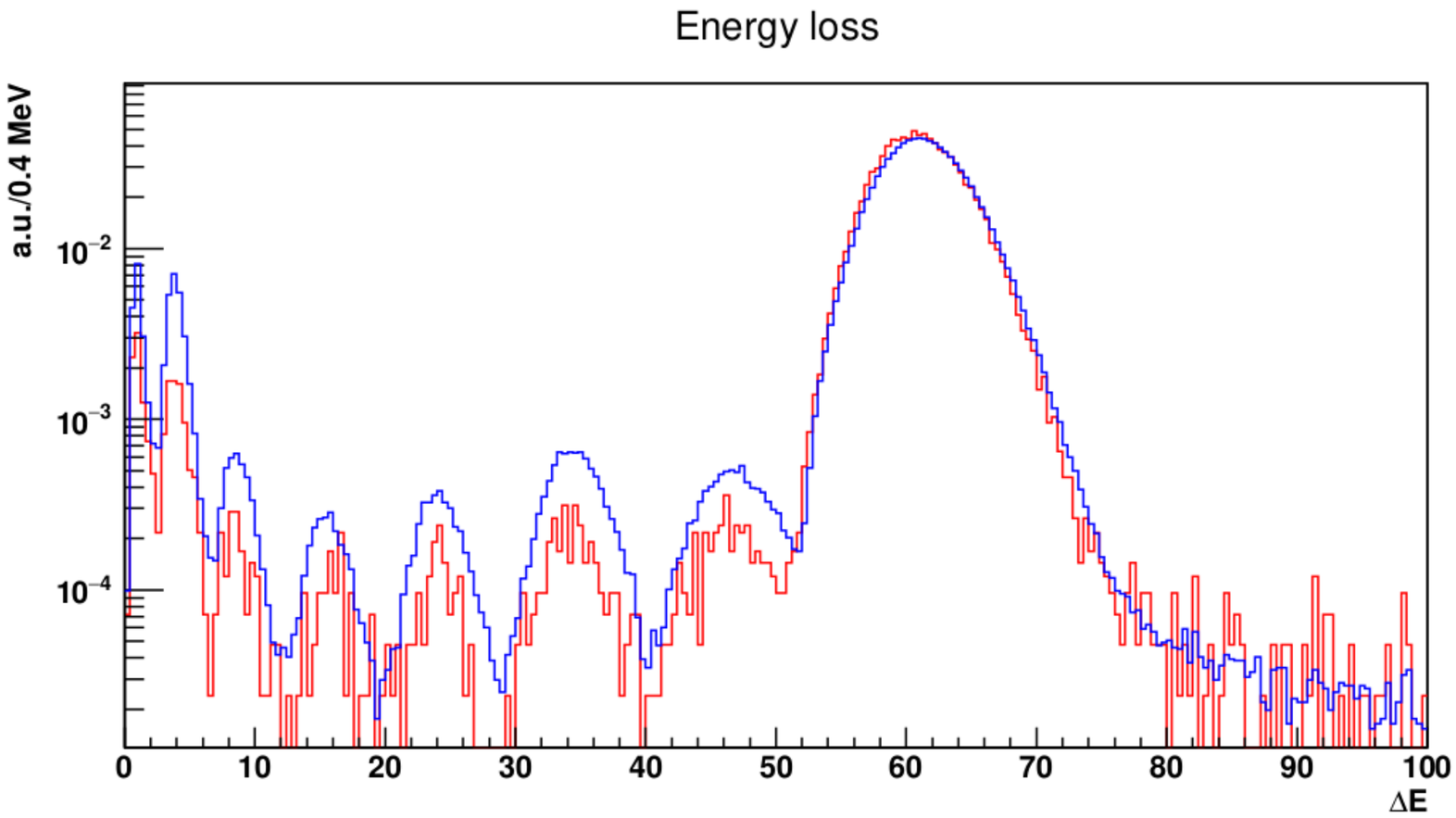
Extract fragment yields from TW

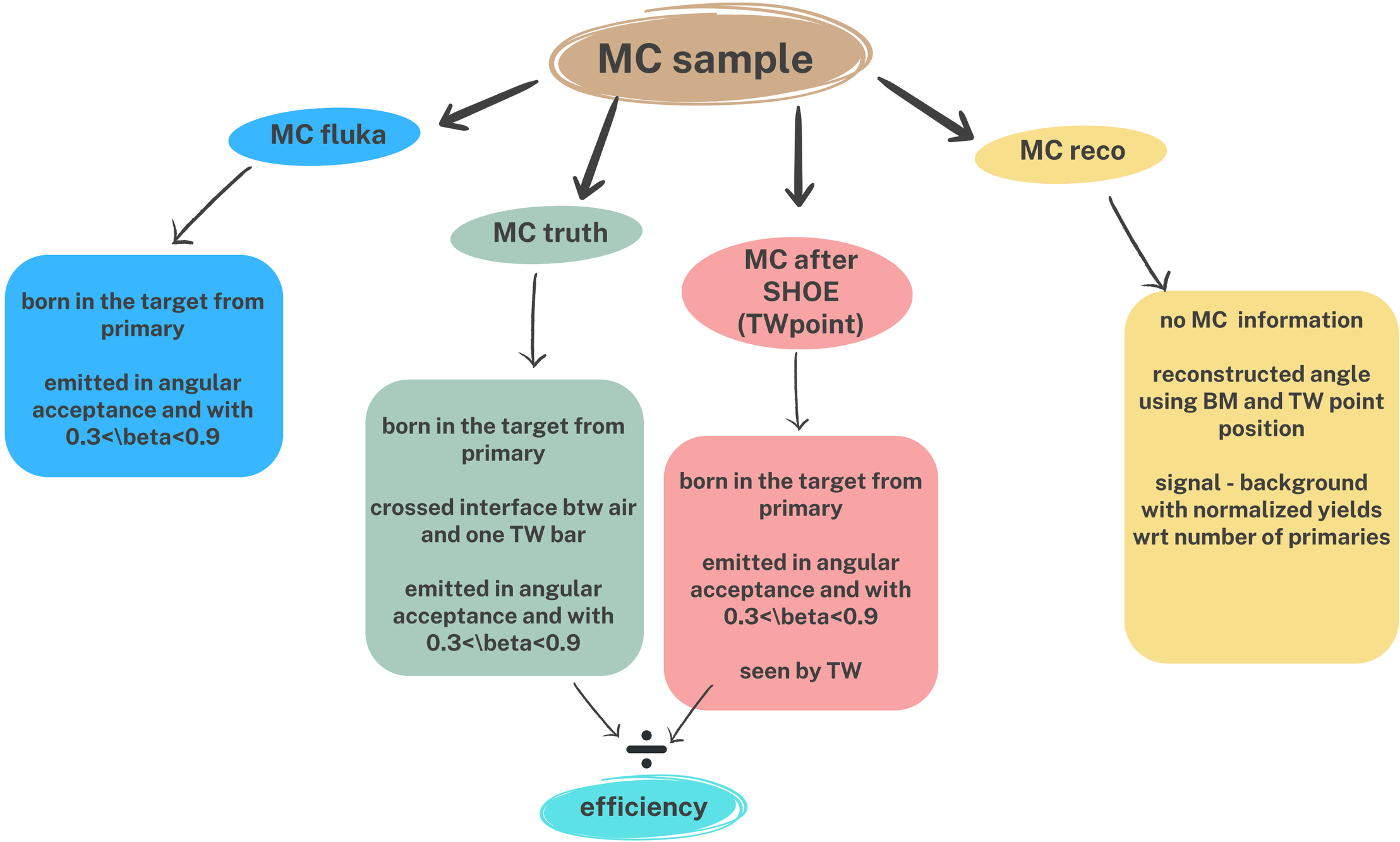
Calculate MC efficiencies for fragments

Angle measurement



Why background subtraction?




MC sample
MC fluka
MC truth
MC after SHOE (TWpoint)
MC reco
born in the target from primary
emitted in angular acceptance and with 0.3<\beta<0.9
born in the target from primary
crossed interface btw air and one TW bar
emitted in angular acceptance and with 0.3<\beta<0.9
born in the target from primary
emitted in angular acceptance and with 0.3<\beta<0.9
seen by TW
no MC information
reconstructed angle using BM and TW point position
signal - background with normalized yields wrt number of primaries
÷
efficiency

What’s new?

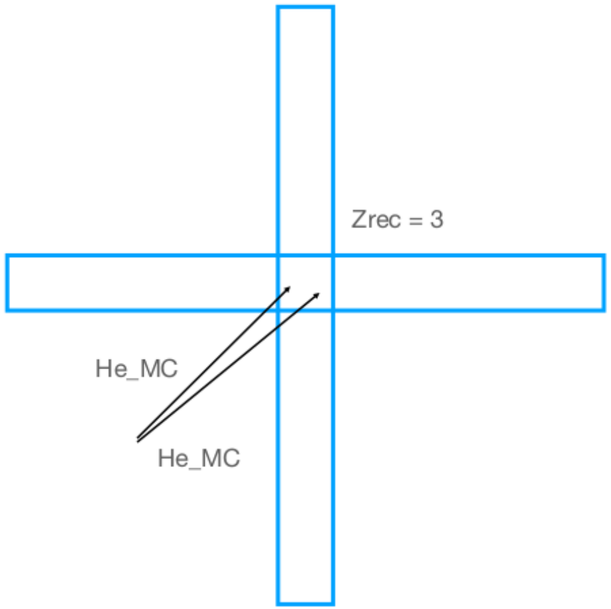
New MC **simulation without target** to ease the process

Some changes triggered by recent discussions and observations, in particular:
-**impact of multiple fragments** in the same TW crossing -> **purity**
-impact of **statistics in background subtraction**

Purity

Marco' s talk
XIV GM

How to manage? (to study CMM, purity and efficiencies)

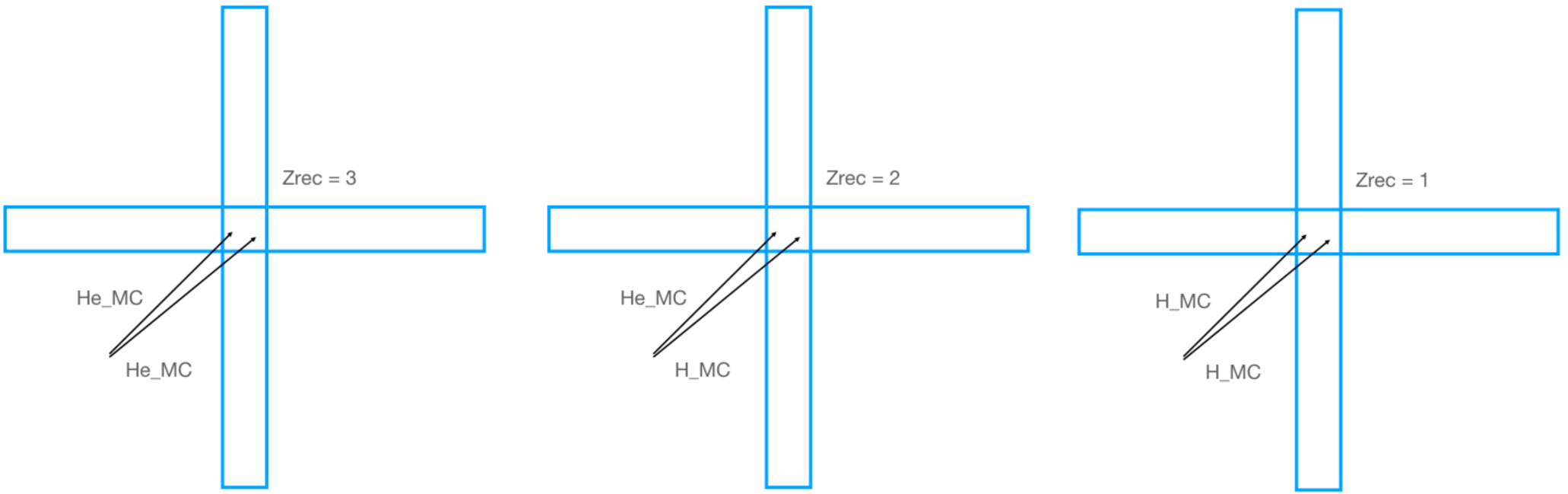


- Needed the matching of the trkId for each track crossing the TW and the one related to the TW points
- In the case of more tracks hitting the same bar check if the vector of trkIds associated to the TWpoints contains at least trkId of the impinging tracks
- If this is the case assign:
  - Good match if Zrec==Zmc
  - Wrong match if Zrec!=Zmc

Purity

Marco' s talk
XIV GM

Events surviving the TW Z match



Wrong match

Good match

Good match

(Reminder: H and He are produced with large beta distributions)

Background subtraction

Marco' s talk
21 June AM

Relative uncertainties in XS (only stat)

$$\sigma(Z) = \frac{1}{N_{\mathrm{TG}} \cdot \varepsilon(Z)} \cdot \left(\frac{Y_S(Z)}{N_S} - \frac{Y_B(Z)}{N_B} \right) = \frac{1}{N_{\mathrm{TG}} \cdot \varepsilon(Z)} \cdot (S(Z) - B(Z))$$

$$\frac{\Delta\sigma}{\sigma} \approx \left(\frac{1}{S-B} \right) \cdot \sqrt{S^2 \cdot \left[\left(\frac{\Delta Y_S}{Y_S} \right)^2 + \left(\frac{\Delta N_S}{N_S} \right)^2 \right] + B^2 \cdot \left[\left(\frac{\Delta Y_B}{Y_B} \right)^2 + \left(\frac{\Delta N_B}{N_B} \right)^2 \right]}$$

Fragmentation physics

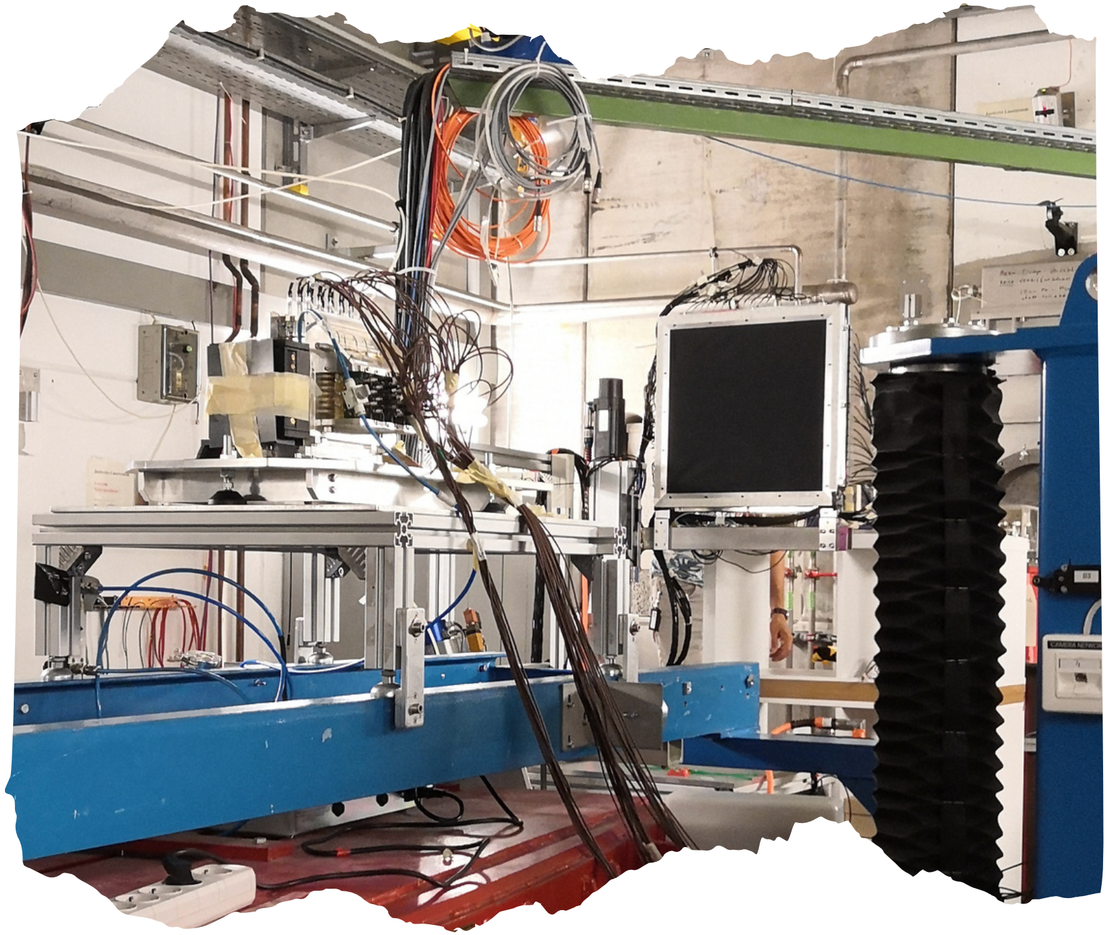
Available Statistics

$$S = \frac{Y_S}{N_S} \qquad B = \frac{Y_B}{N_B}$$

- Y_S fragments yields in TG runs (S->S+B)
- N_S primaries in TG runs (S->S+B)
- Y_B fragments yields in NO TG runs
- N_B primaries in NO TG runs

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



Background subtraction

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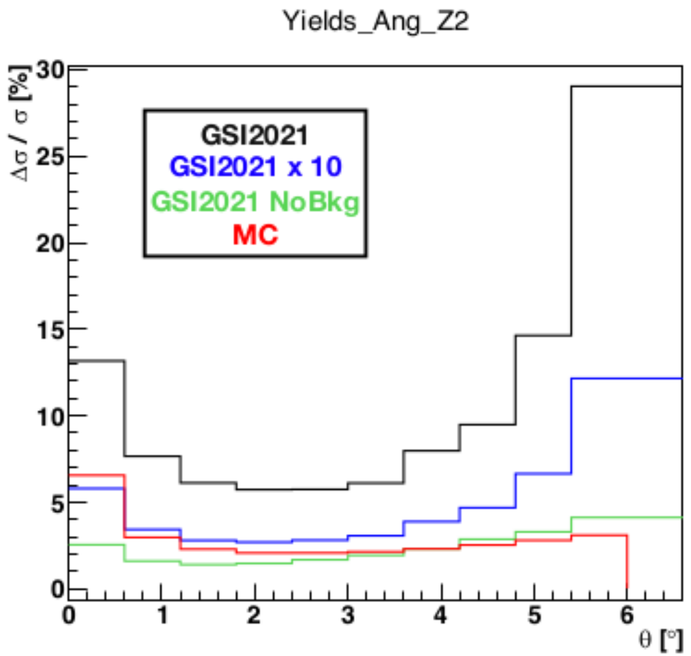
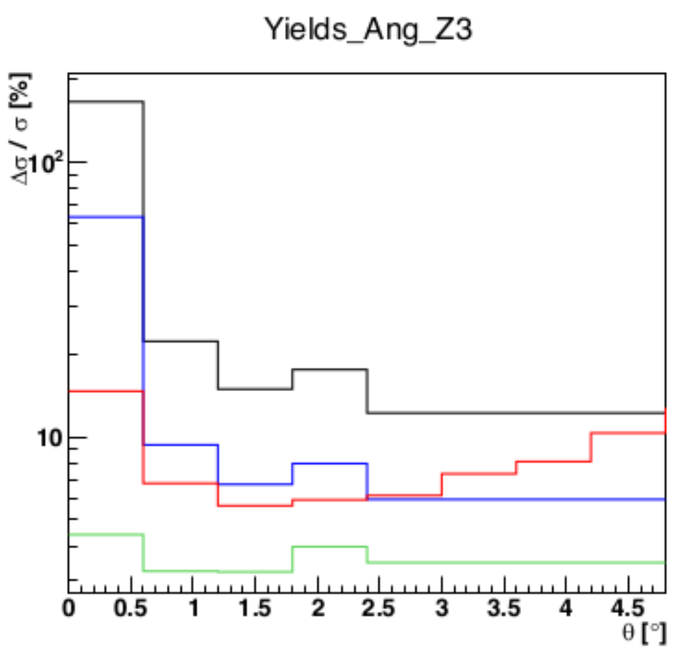
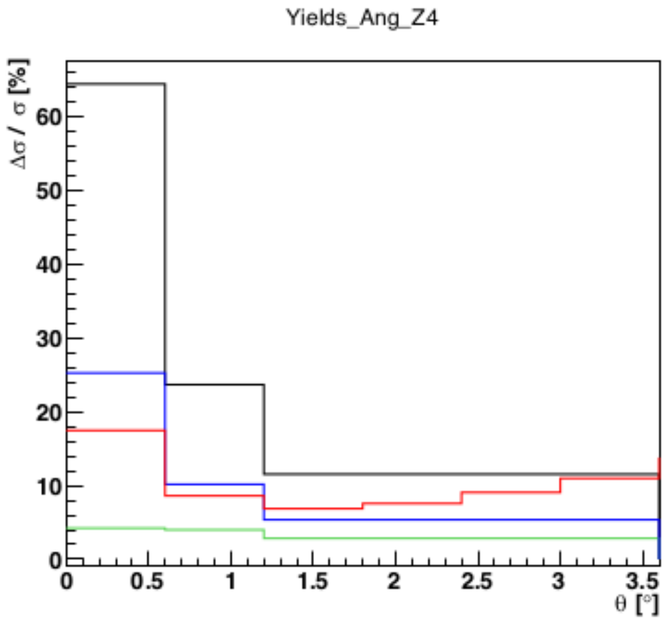






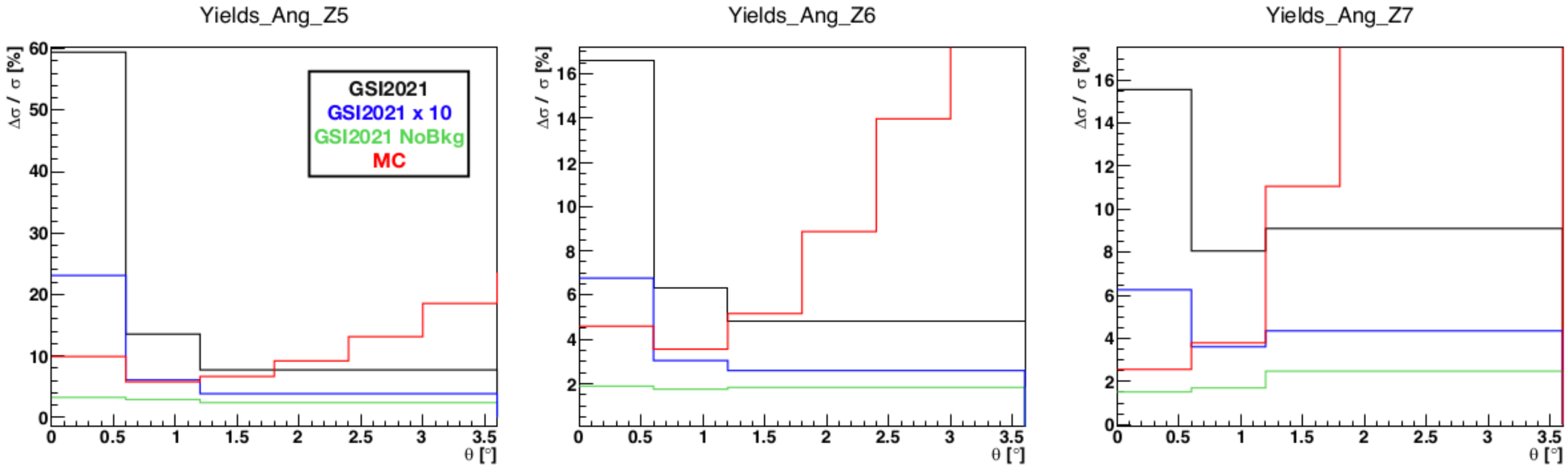
N primaries in MC ~~ 993k

- Y_S fragments yields in TG runs (S->S+B)
- **N_S primaries in TG runs (S->S+B) ~ 1.1M**
- Y_B fragments yields in NO TG runs
- **N_B primaries in NO TG runs ~ 52k**

Background subtraction

Marco' s talk
21 June AM

Relative uncertainties in XS (only stat)



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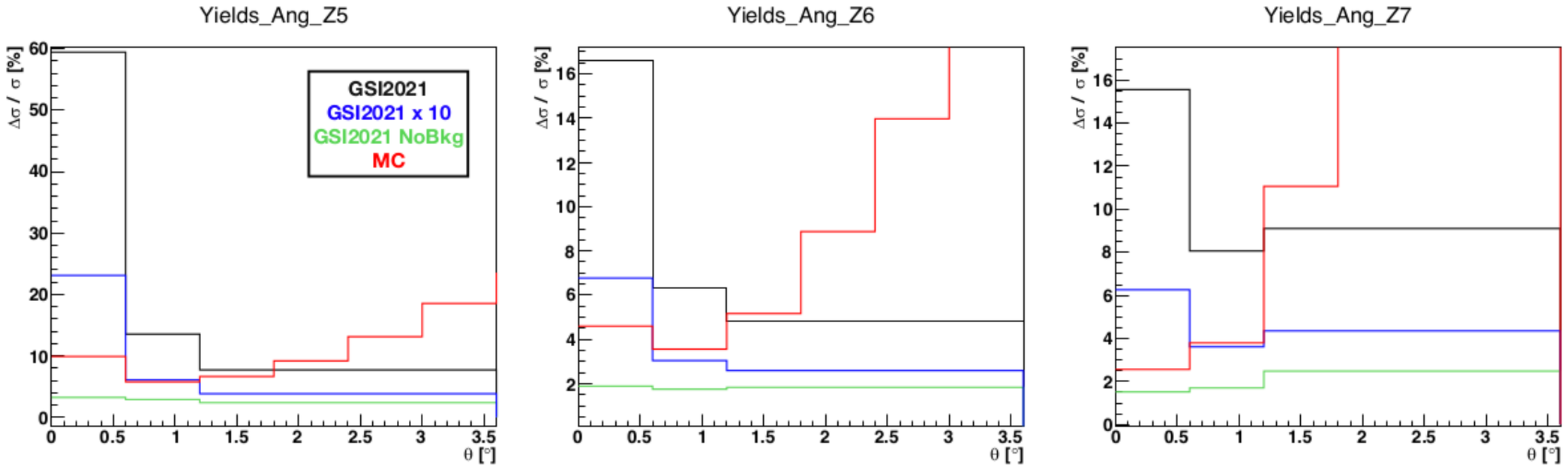
- **N_S primaries in TG runs (S->S+B) ~ 1.1M**
- Y_B fragments yields in NO TG runs
- **N_R primaries in NO TG runs ~ 52k**

Background subtraction

Marco' s talk
21 June AM

Relative uncertainties in XS (only stat)



- Y_S fragments yields in TG runs (S->S+B)
- **N_S primaries in TG runs (S->S+B) ~ 1.1M**
- Y_B fragments yields in NO TG runs
- **N_B primaries in NO TG runs ~ 52k**

N primaries in MC ~ 99.2k

REDUCE NUMBER OF BINS!

New analysis flow

Evaluate **efficiencies** and **purities**

Repeat for with and w/o target samples

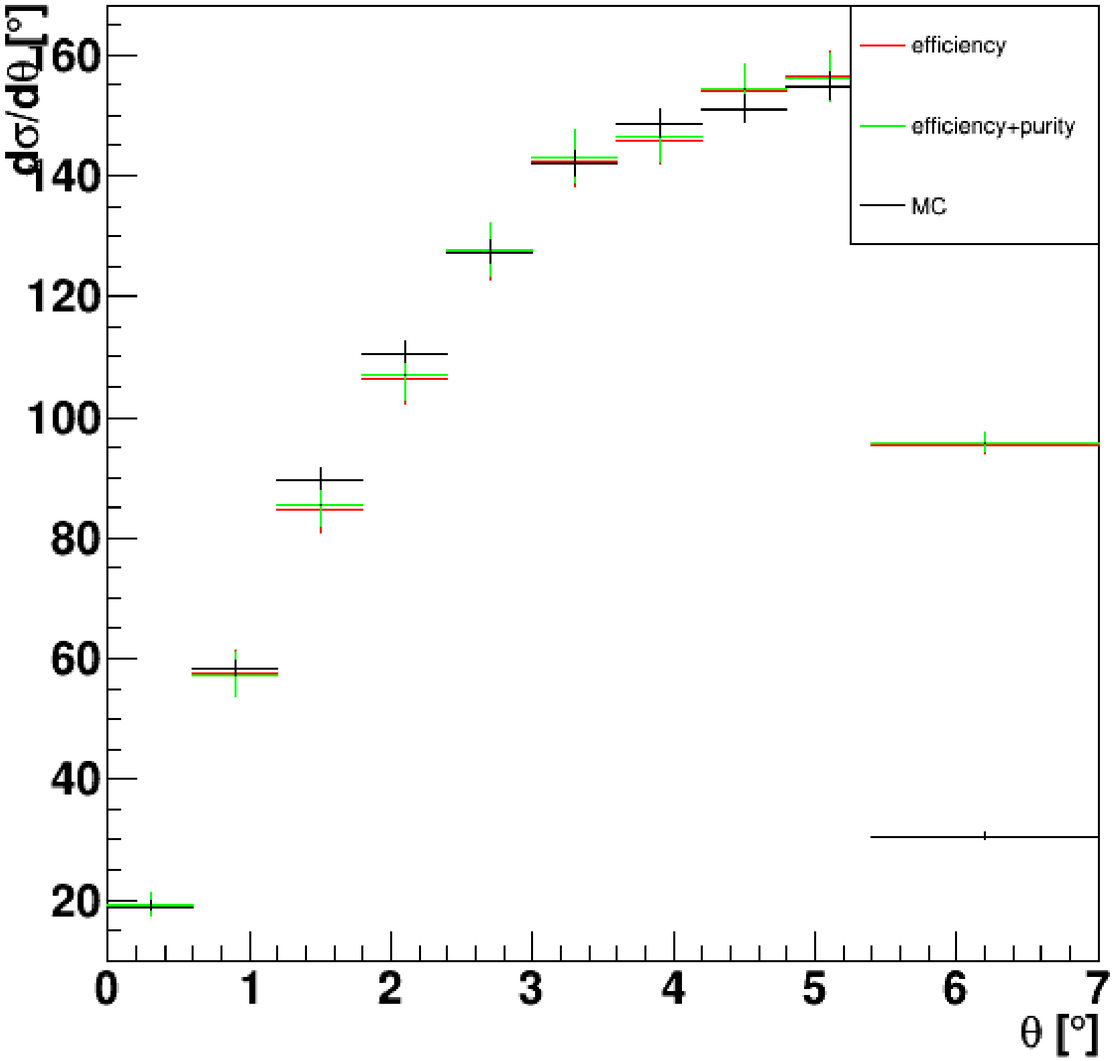
Normalize yields and **subtract** background

Apply efficiency for fragmentation in target

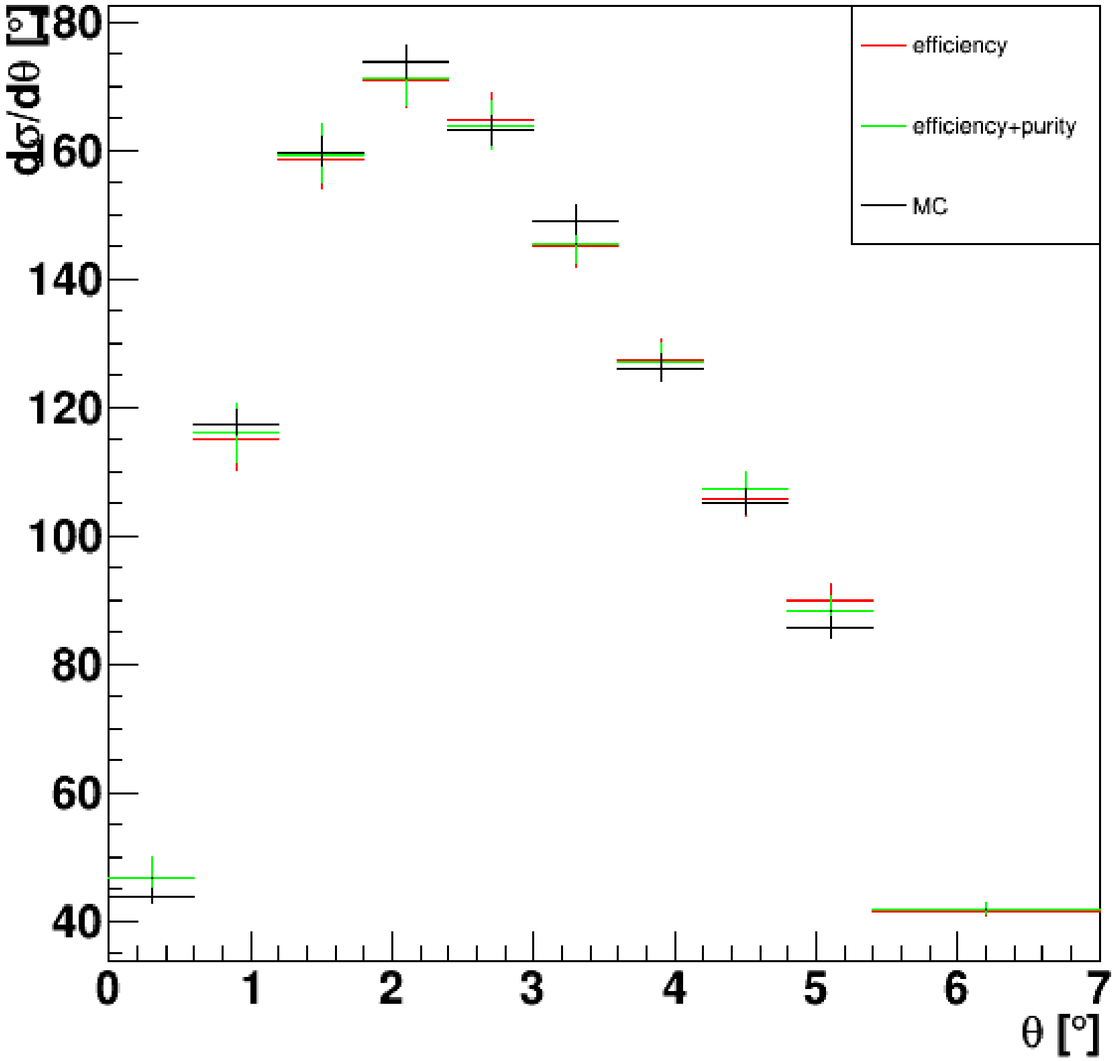
Calculate angular **cross sections**

Compare with MC

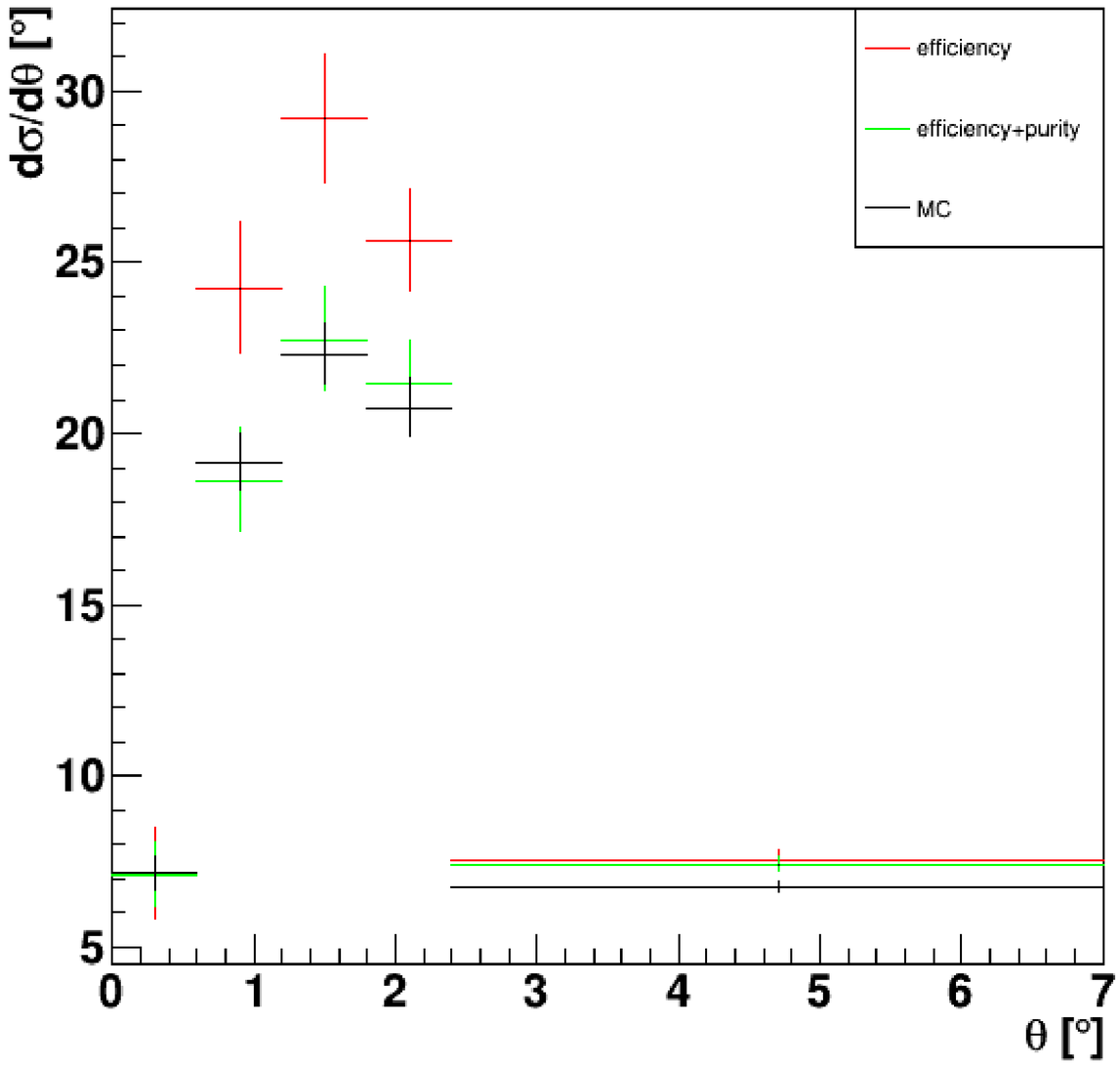
Angular cross section Z1



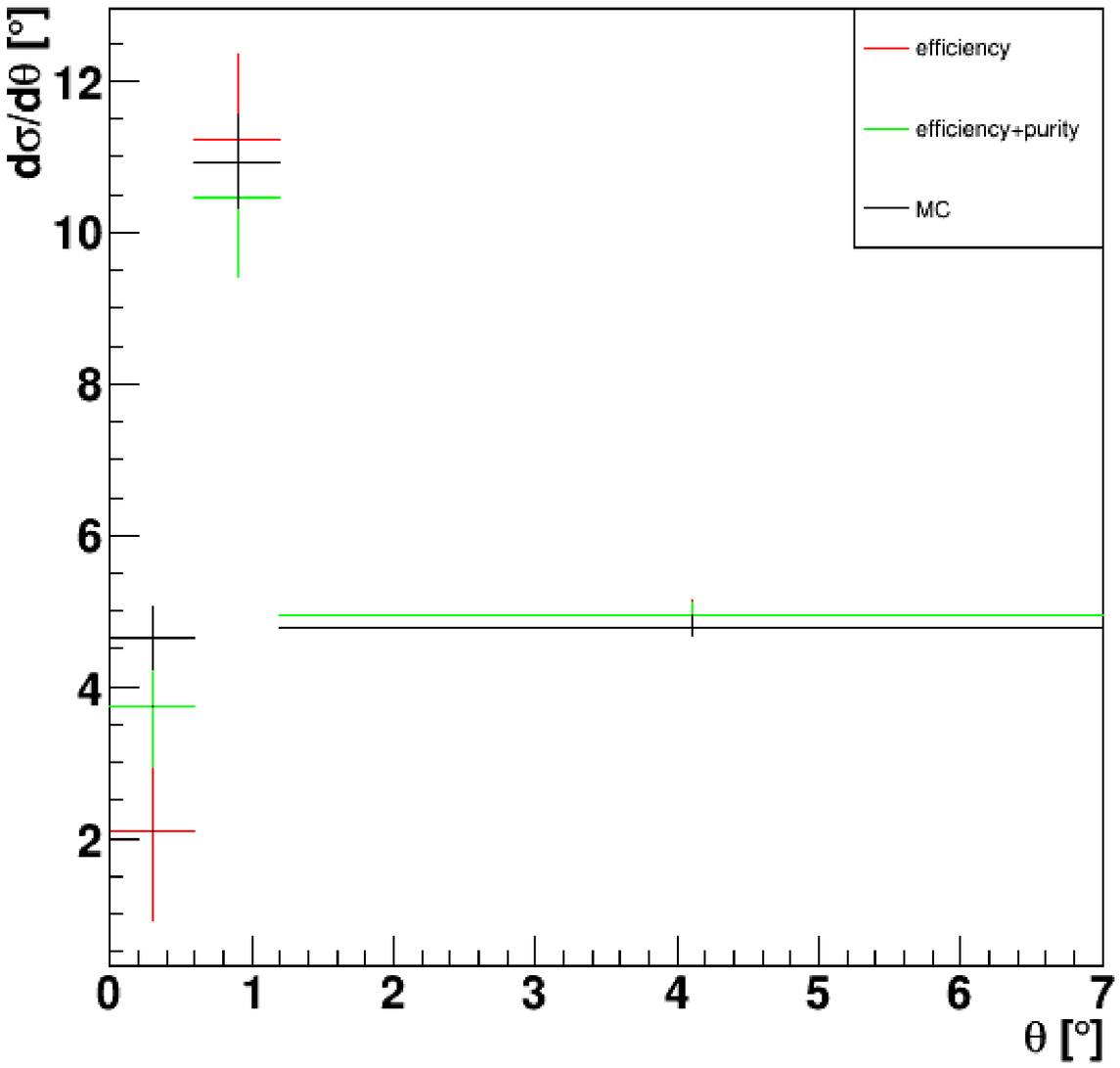
Angular cross section Z2



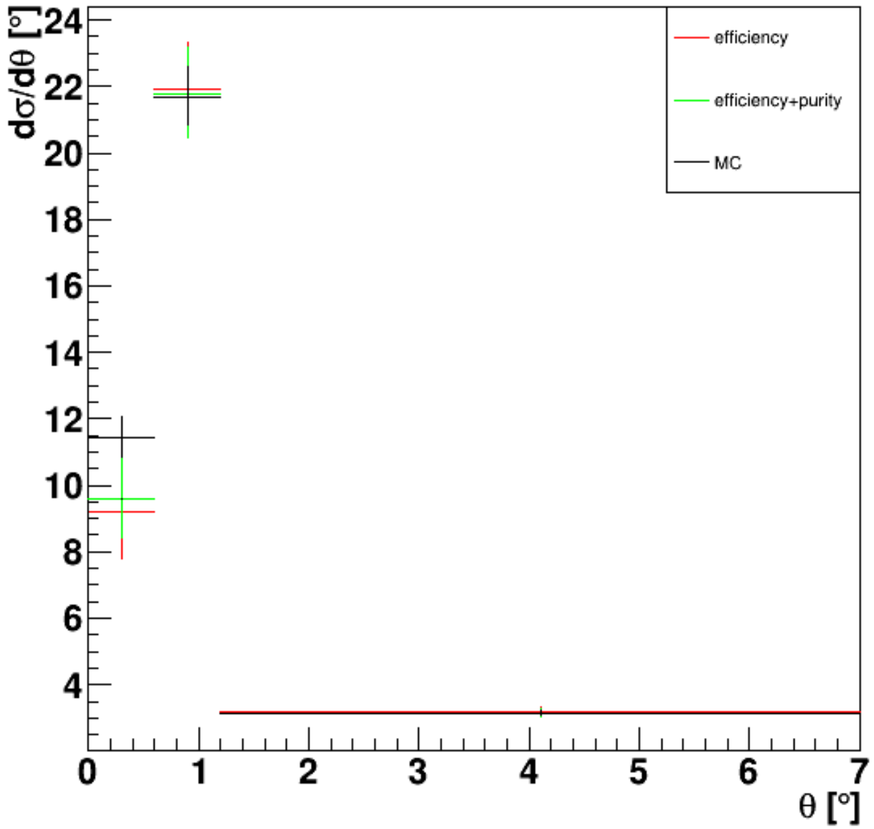
Angular cross section Z3



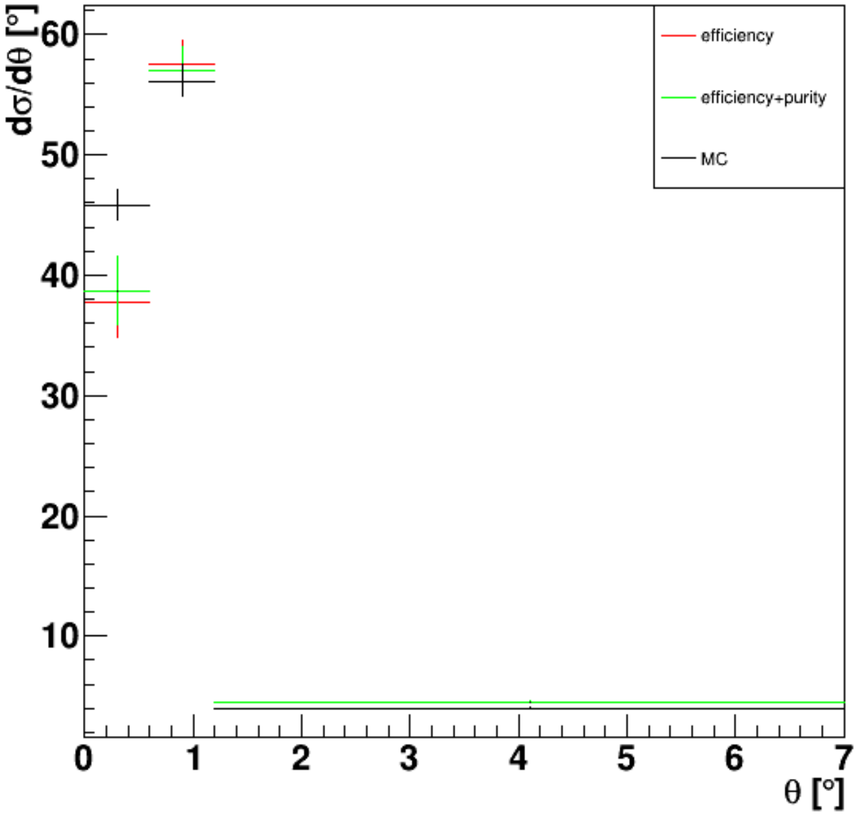
Angular cross section Z4



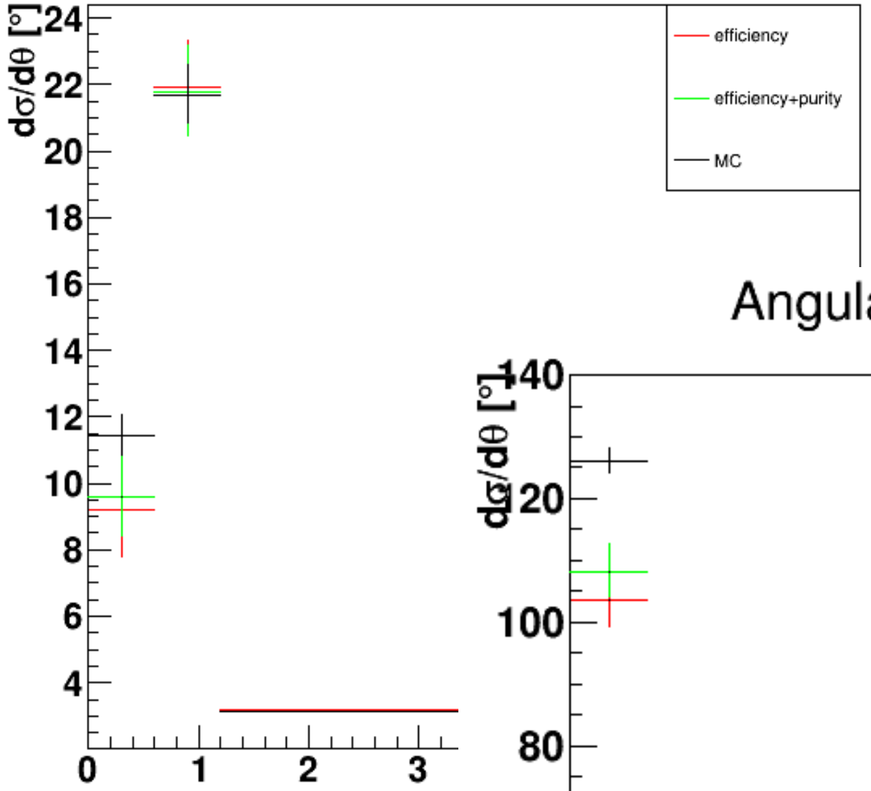
Angular cross section Z5



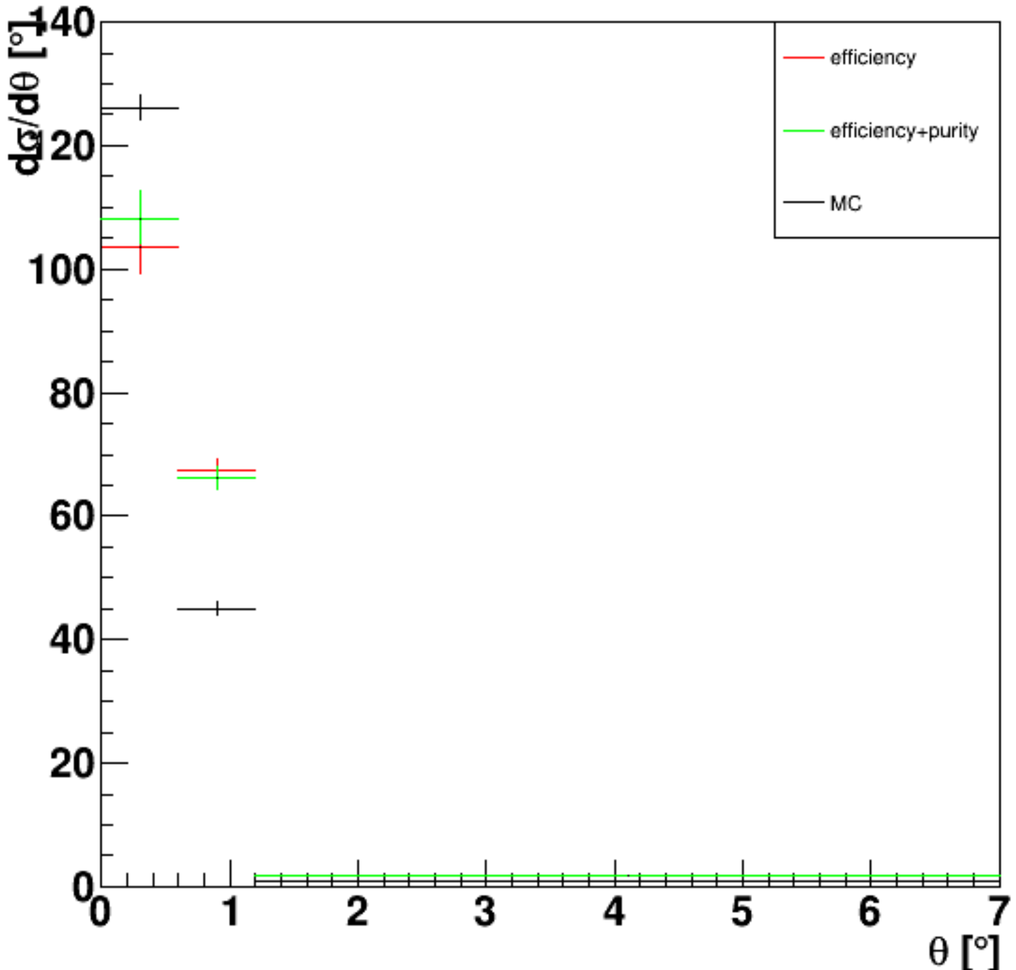
Angular cross section Z6



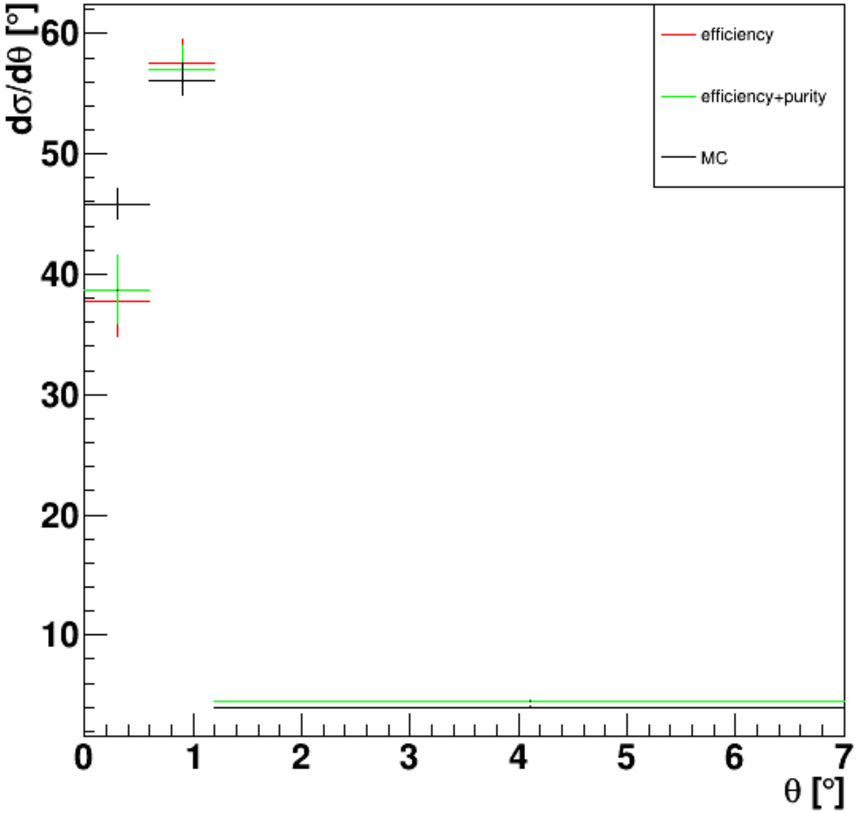
Angular cross section Z5

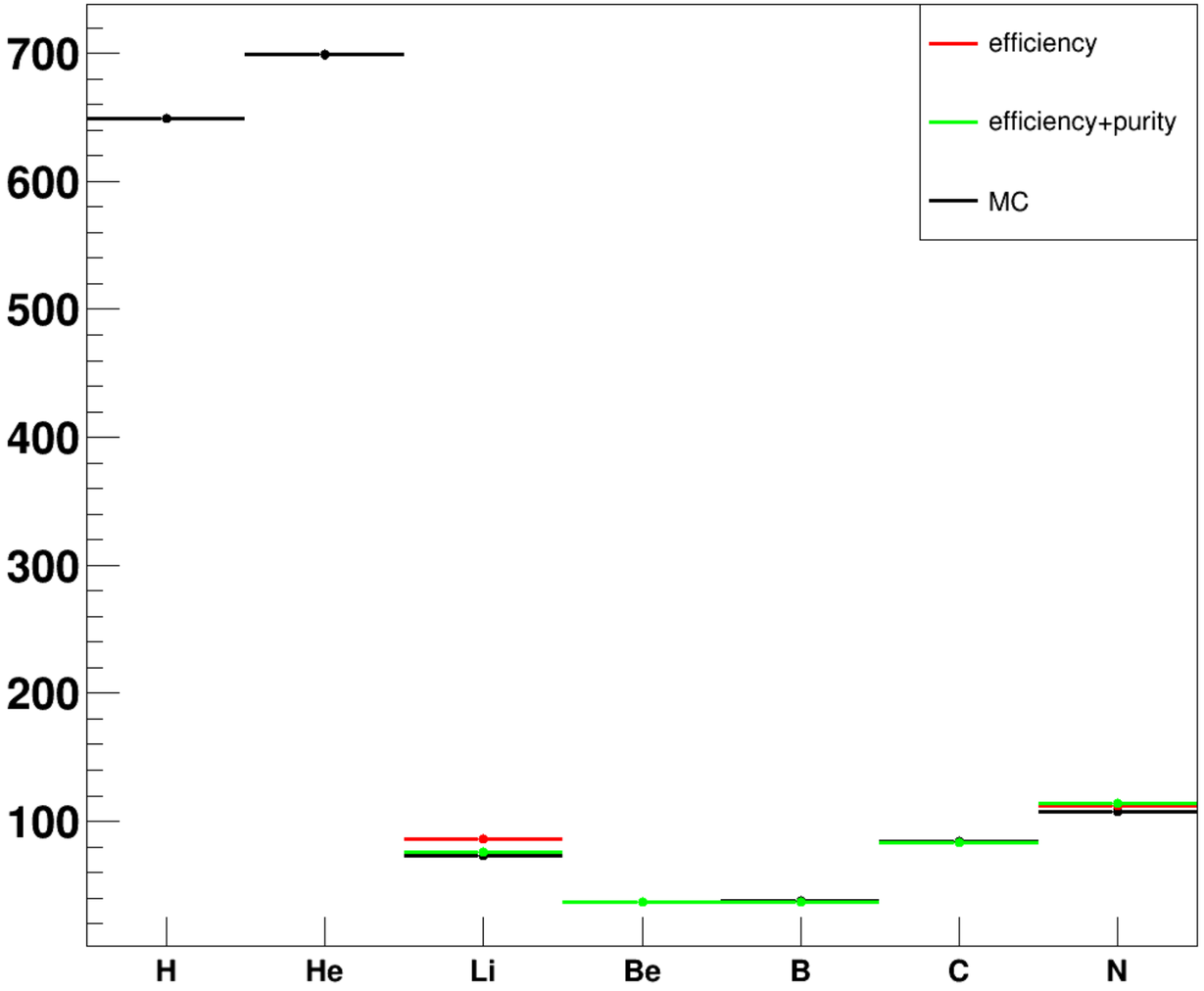


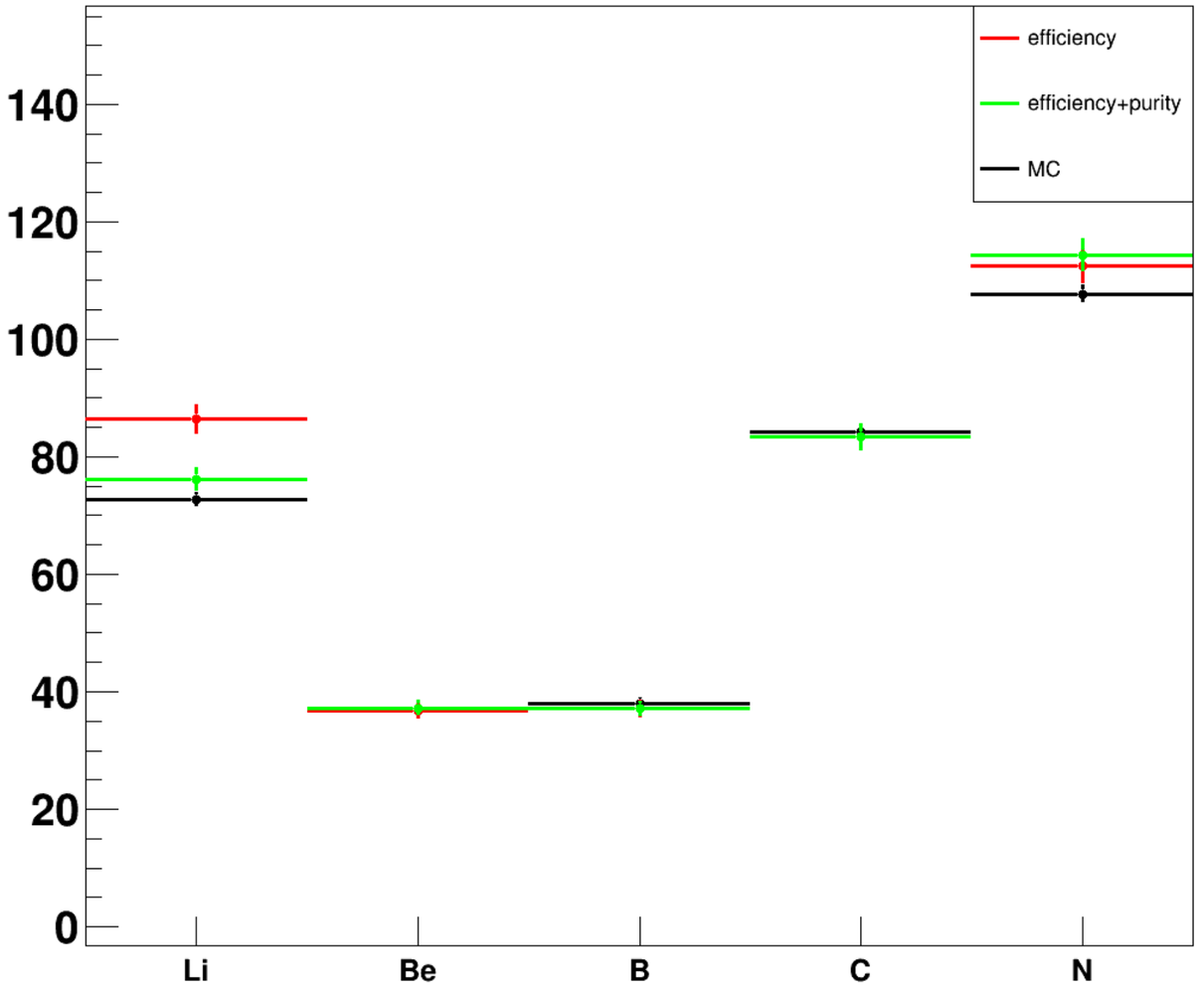
Angular cross section Z7



Angular cross section Z6




700
600
500
400
300
200
100
efficiency
efficiency+purity
MC
H
He
Li
Be
B
C
N


140
120
100
80
60
40
20
0
efficiency
efficiency+purity
MC
Li
Be
B
C
N

Some comments…

Purity correction goes always in the “right” direction

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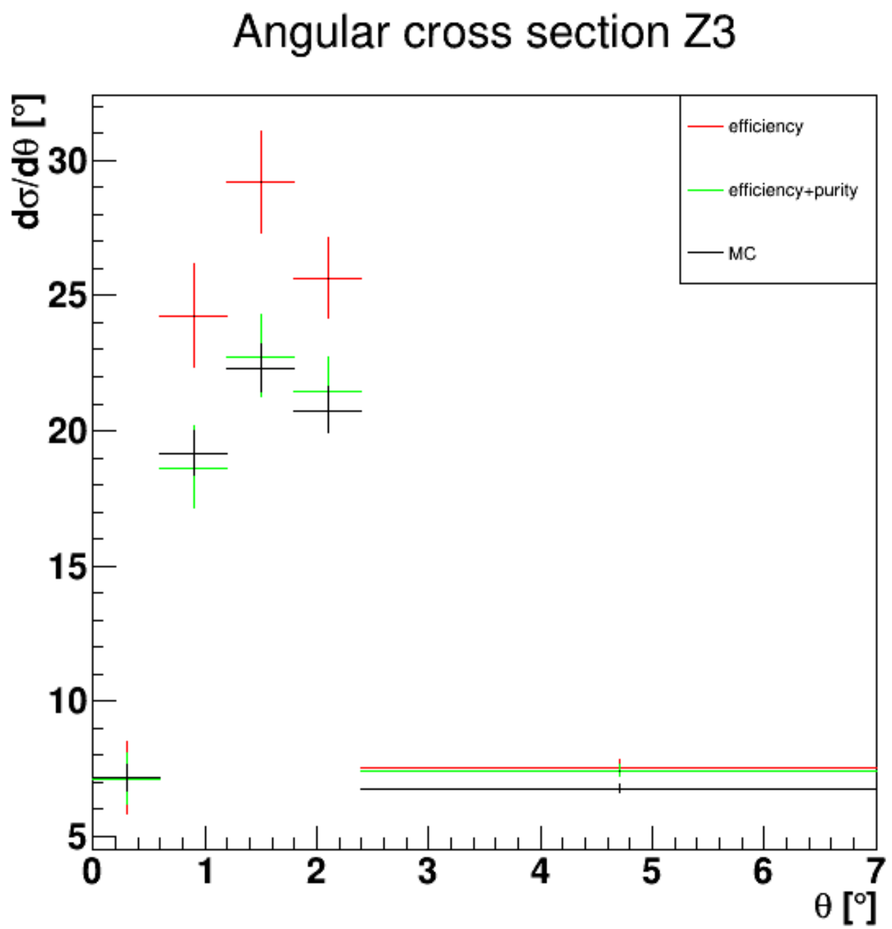
Purity correction goes always in the “right” direction

Huge contribution in Li (and Be) cross section as expected

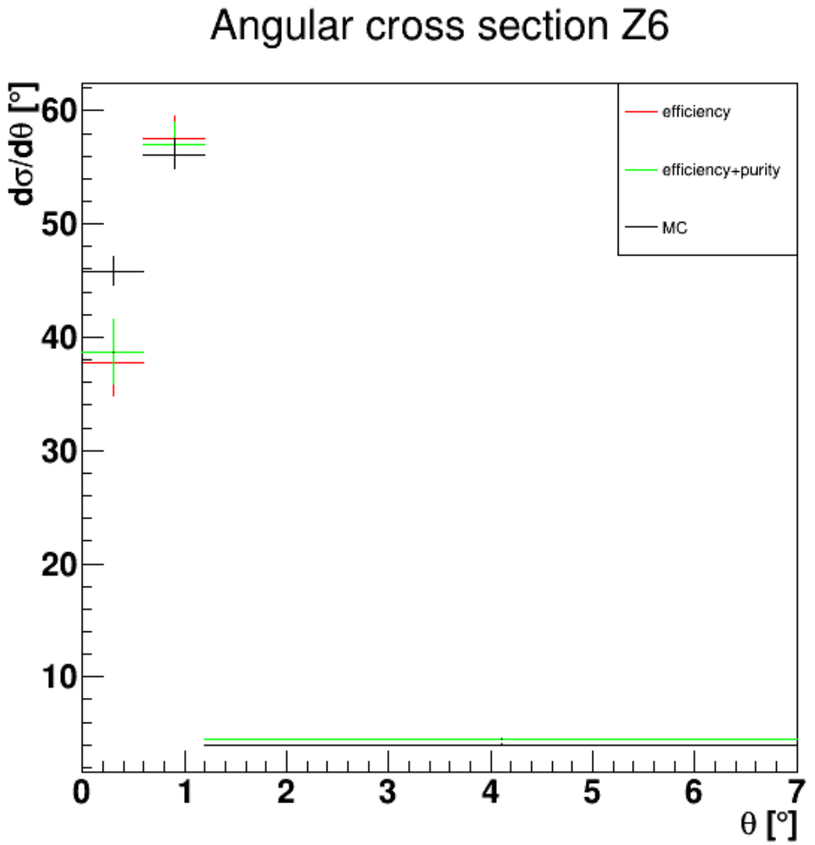


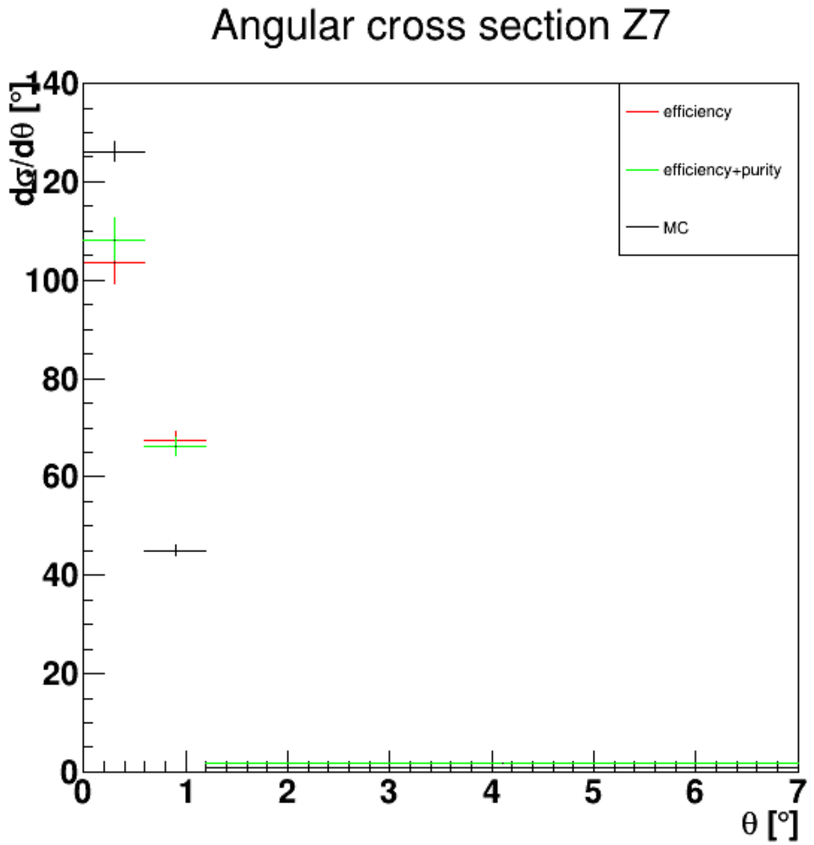
Some comments…

Purity correction goes always in the “right” direction

Huge contribution in Li (and Be) cross section as expected

Difference in C and N to be understood





Some comments...

Purity correction goes always in the “right” direction

Huge contribution in Li (and Be) cross section as expected

Difference in C and N to be understood

Angle unfolding procedure will have an impact

Conclusions

Background subtraction strategy seems to work also for angle differential cross sections

Purity correction implemented(very important for Li and Be)

Good agreement in MC closure test except for first bin of C and N

Angle unfolding machinery ready to be performed

Very few statistics for background reduces final number of bins

Comparison with “with tracking analysis” ongoing (and promising!) (Giacomo’s talk)

Thanks for listening!

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TUnfold, an algorithm for correcting migration effects in high energy physics

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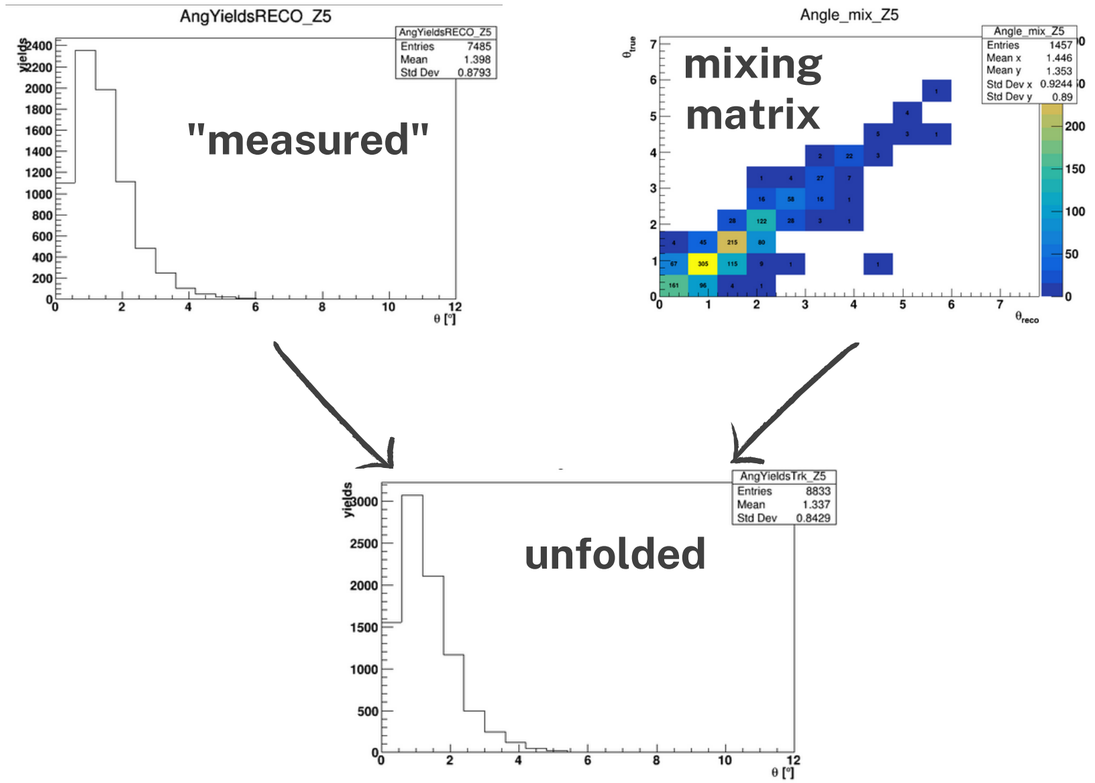
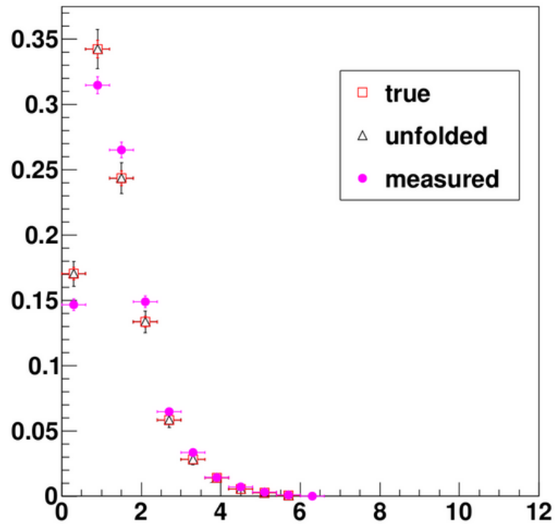
Abstract

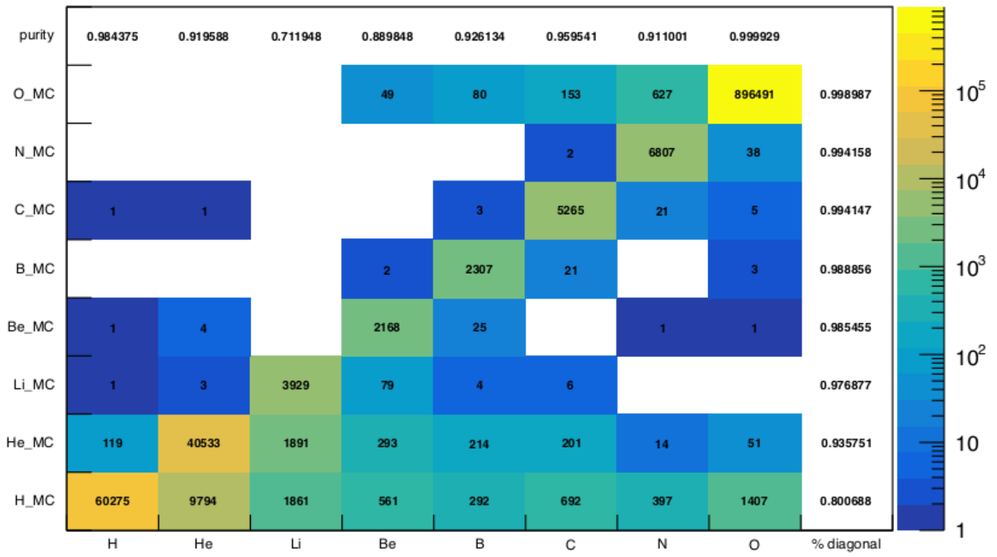
TUnfold is a tool for correcting migration and background effects in high energy physics for multi-dimensional distributions. It is based on a least square fit with Tikhonov regularisation and an optional area constraint. For determining the strength of the regularisation parameter, the L-curve method and scans of global correlation coefficients are implemented. The algorithm supports background subtraction and the propagation of statistical and systematic uncertainties, in particular those originating from limited knowledge of the response matrix. The program is interfaced to the ROOT analysis framework.





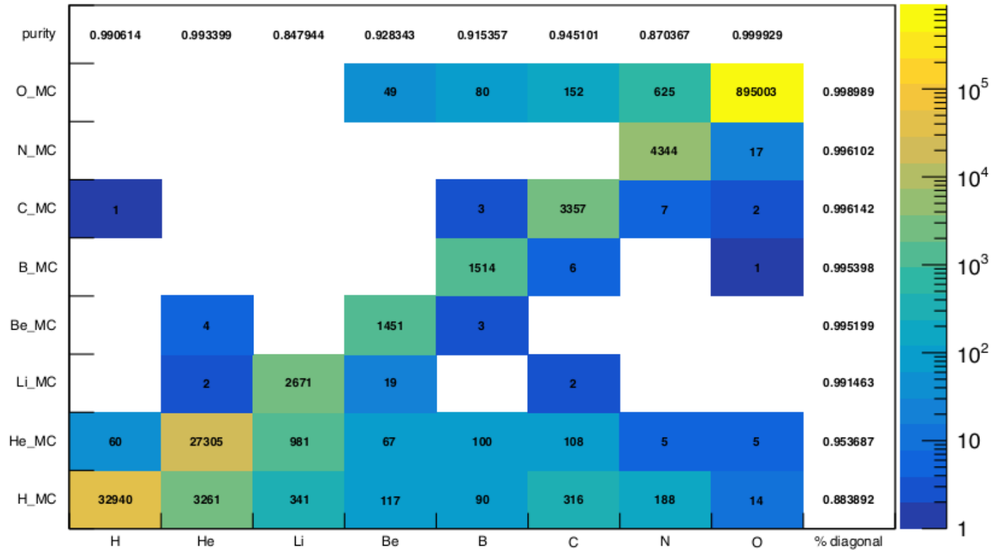
CMM matrix: GSI2021_MC(16O_C_400_1)

CMM_crossing

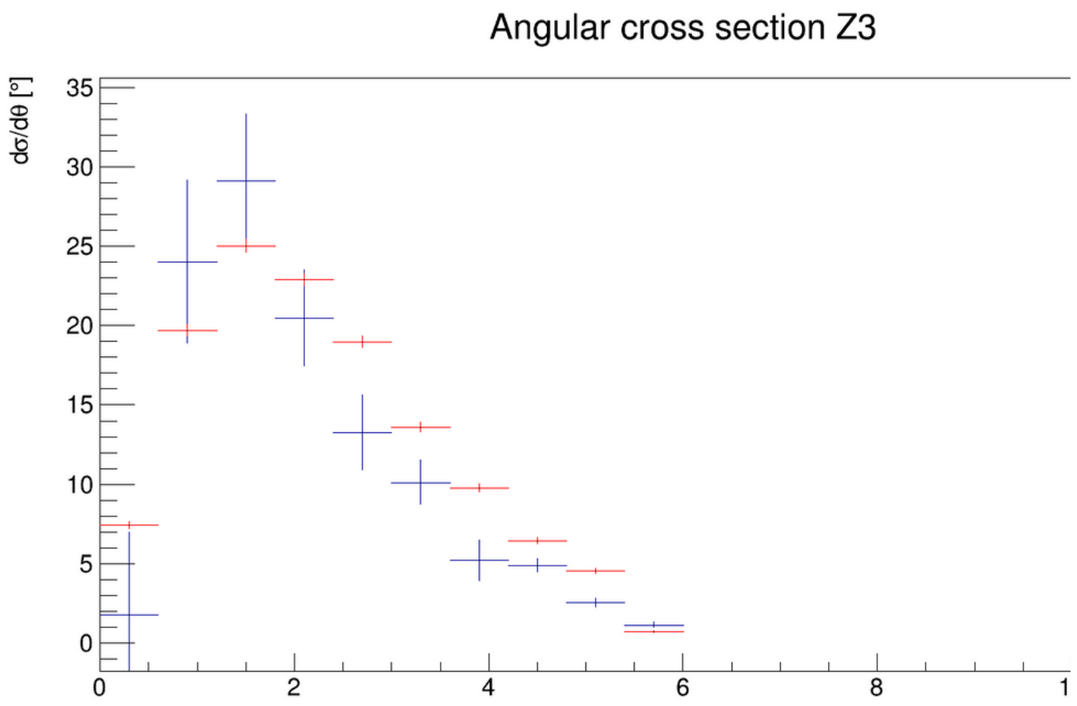


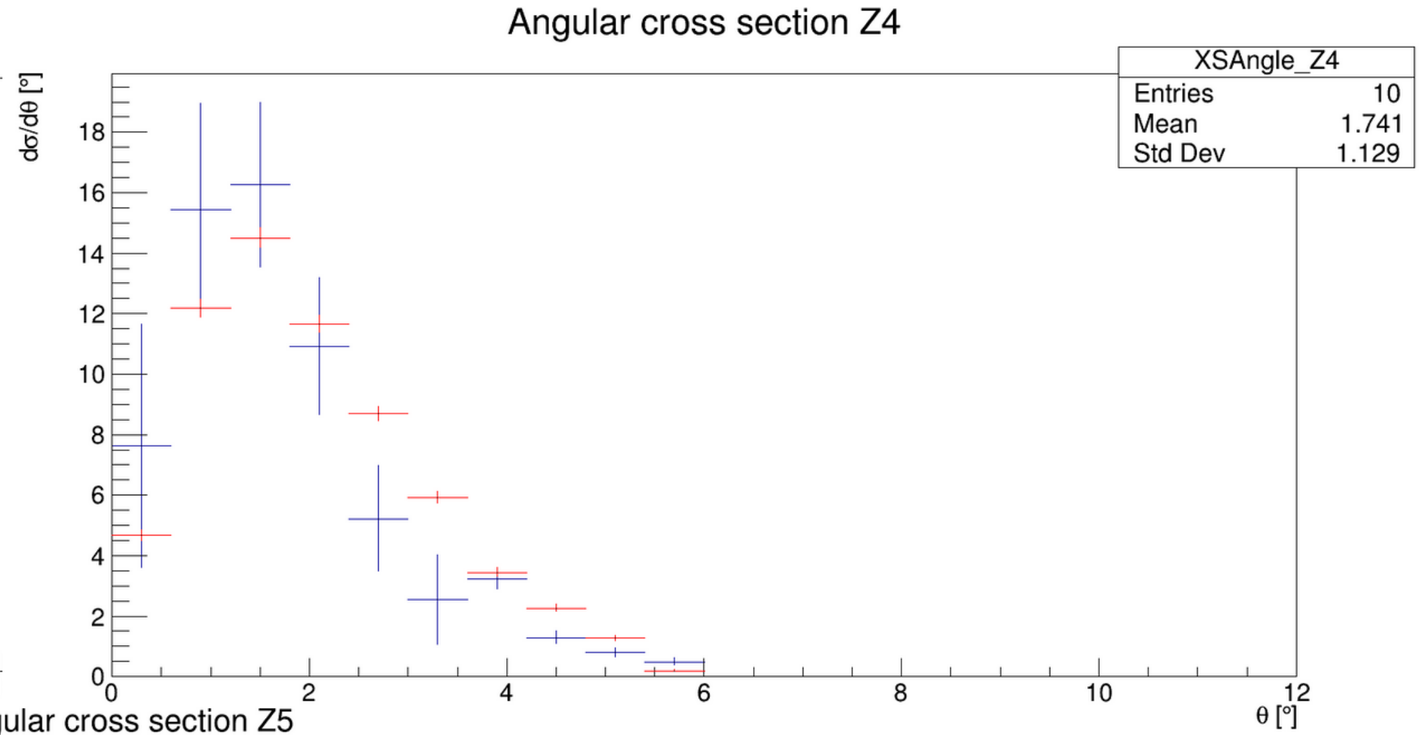
Purity = N(Zrec=Ztrue) / N (Zrec)

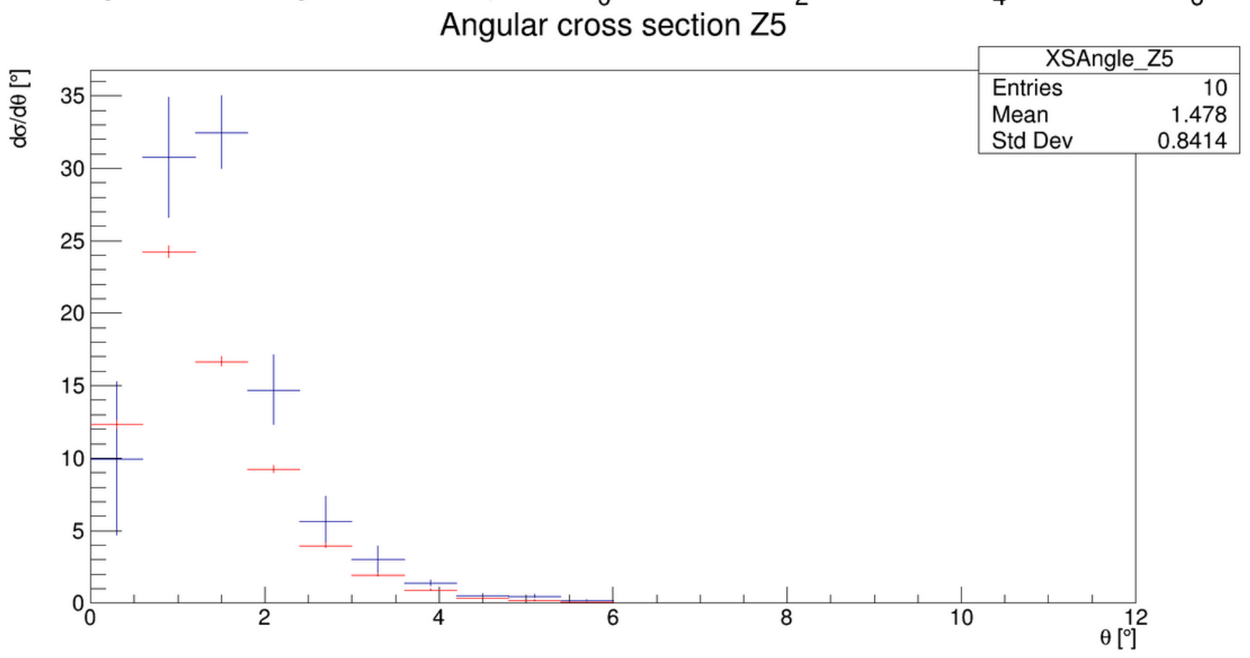
CMM_crossing_inTG



Let's look at the data (preliminary)!







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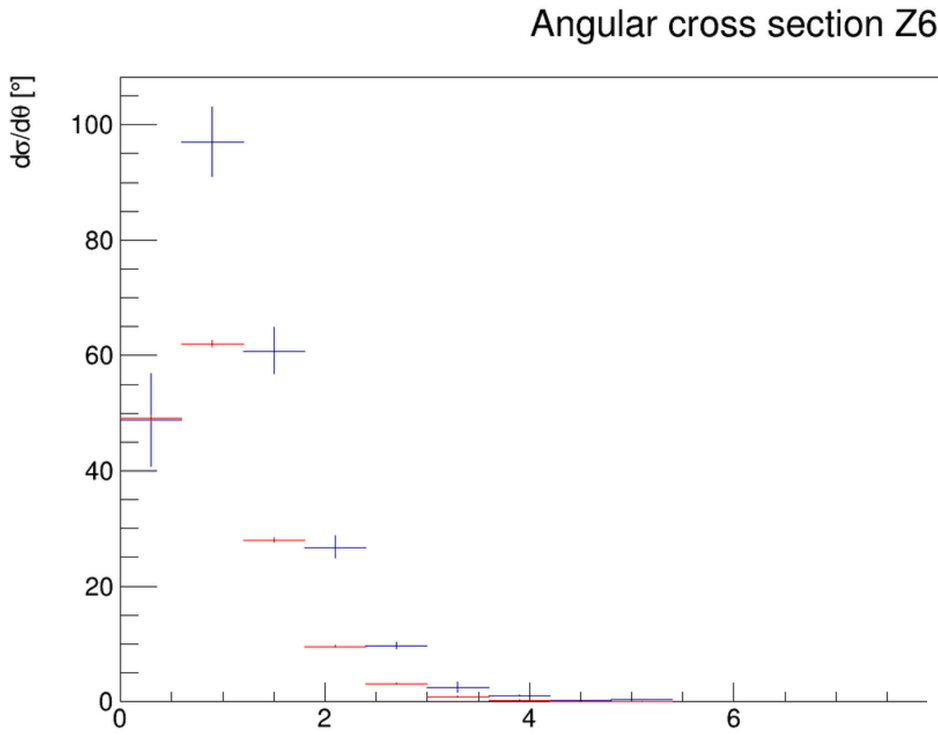

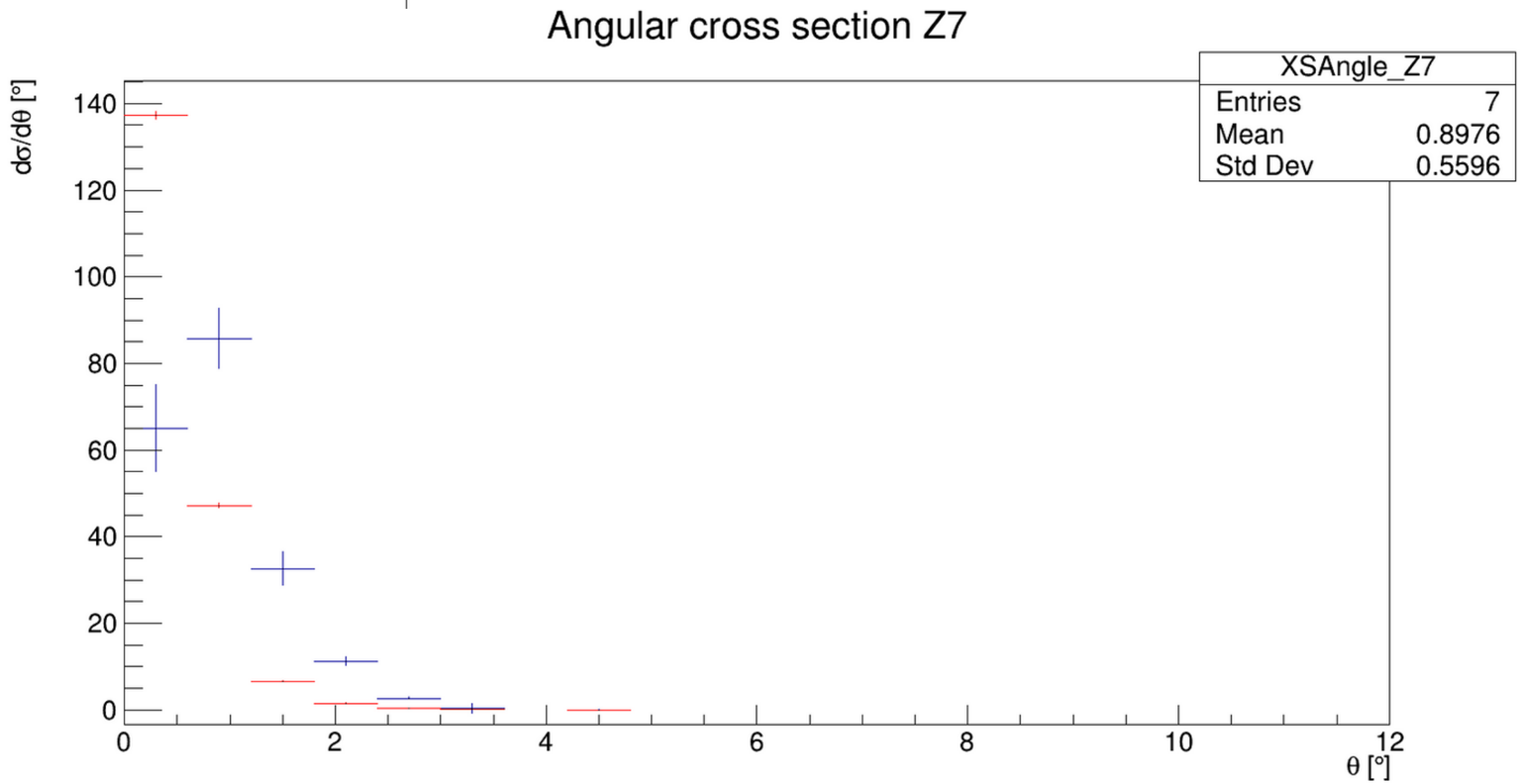

Very few background sample for 400 MeV/u Oxygen...

11	Carbon target	MargaritaMajorit	400	Carbon 5 mm	1,252,568		VTX in data
12	Carbon target &	Fragmentation	400	Carbon 5 mm	2,054,080		VTX in data
20	Alignment	MargaritaMajorit	400	no target	57,133		VTX in data