Alma Mater Studiorum - Università di Bologna

Analysis procedure – description

Analysis and Software meeting

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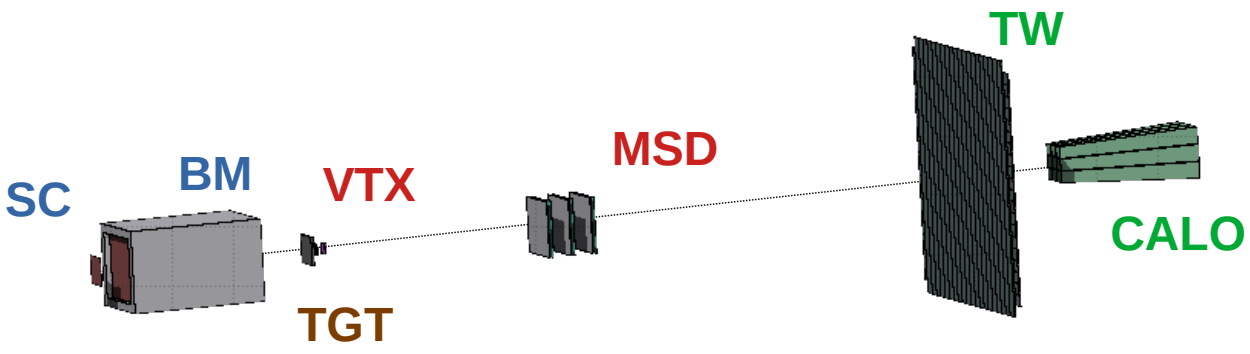
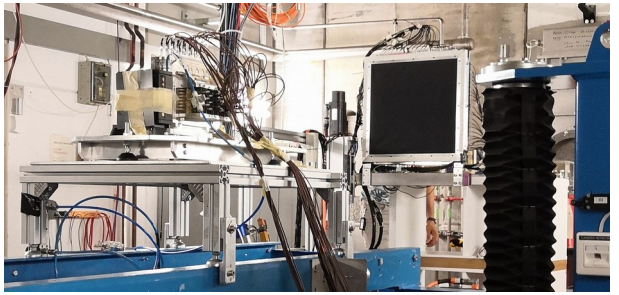
22/2/2023

GSI 2021 Analysis

- Data-taking at GSI (Darmstadt, Germany) in 2021
- **^{16}O 400 MeV/u** on 5 mm **C target**
- Partial setup: no magnet, only one module of calorimeter





MC used Dataset:

- /gpfs_data/local/foot/Simulation/GSI2021_MC/16O_C_400_**2**_shoereg.root
  /gpfs_data/local/foot/Simulation/GSI2021_MC/16O_C_400_**3**_shoereg.root
- 1 million events each

Cross-Section formula

To compute elemental cross section and angular differential cross section:

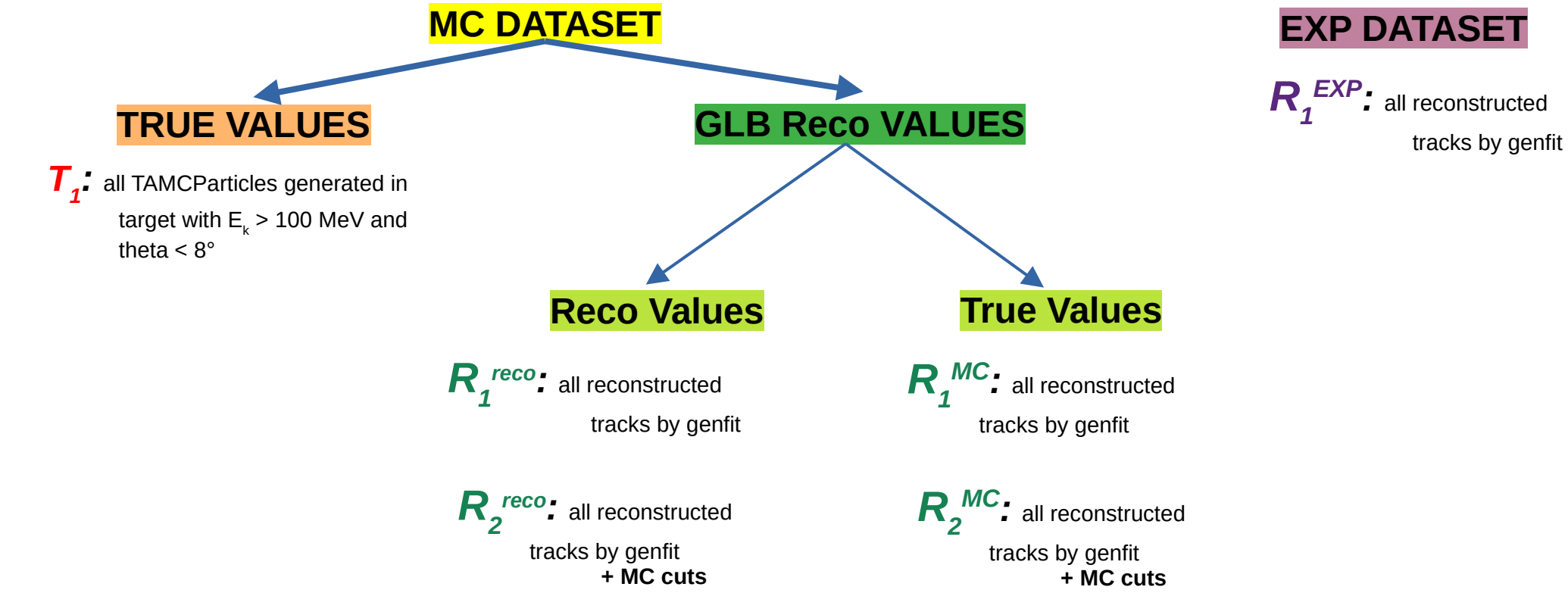
$$\sigma(Z) = \frac{Y(Z) - B(Z)}{N_{beam}\ N_{target}\ \epsilon(Z)}$$

$$\frac{d\sigma}{d\theta}(Z,\theta) = \frac{Y(Z,\theta) - B(Z,\theta)}{N_{beam}\ N_{target}\ \Omega_{\theta}\ \epsilon(Z,\theta)}$$

Y:	fragment counts
Bkg:	background source counts
N_{beam}**:**	n° of primary events
N_{target}**:**	n° of scattering centers per unit area
ε:	efficiency
Ω_{ϑ}**:**	angular phase space

Cross-Section Yields

In the analysis, I am considering the following levels:



T_1: all TAMCParticles generated in target with E_k > 100 MeV and theta < 8°

R_1^{reco}: all reconstructed tracks by genfit

R_2^{reco}: all reconstructed tracks by genfit **+ MC cuts**

R_1^{MC}: all reconstructed tracks by genfit

R_2^{MC}: all reconstructed tracks by genfit **+ MC cuts**

R_1^{EXP}: all reconstructed tracks by genfit

MC CUTS

1) If the TWPoint of the global track has only 1 MC particle matched

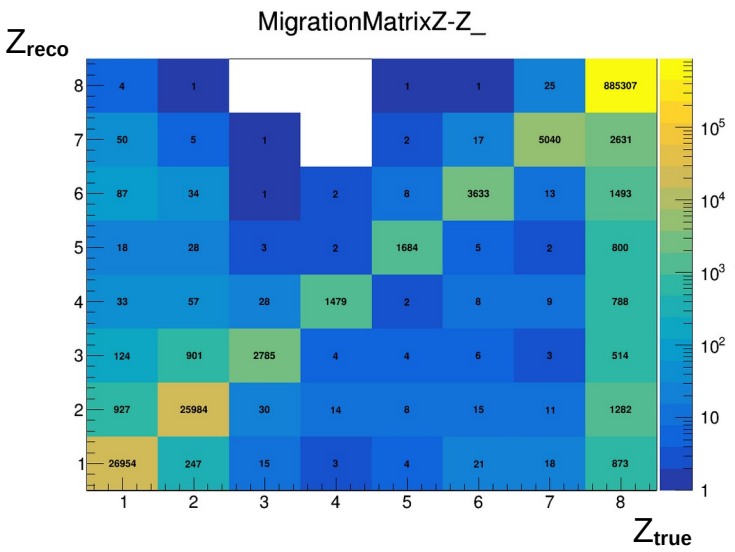
```
if (tmp_poi->GetMcTracksN() == 1)
```

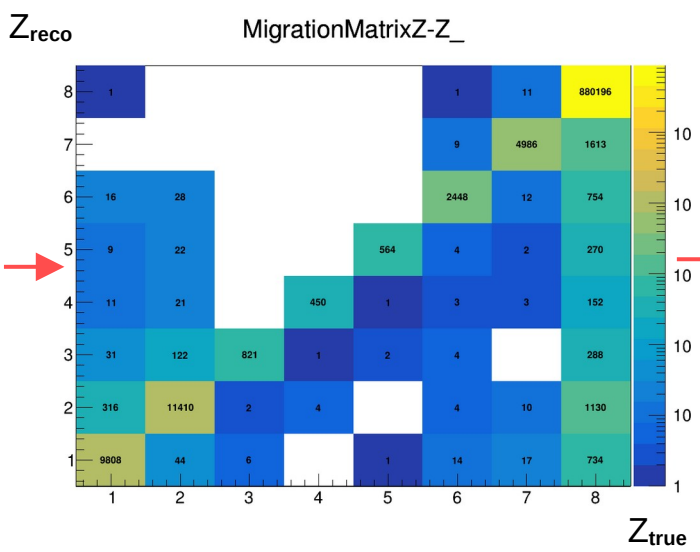
(N.B.: TWZmatch is on)

2) If the TWPoint MC ID is the same of the global track MC ID

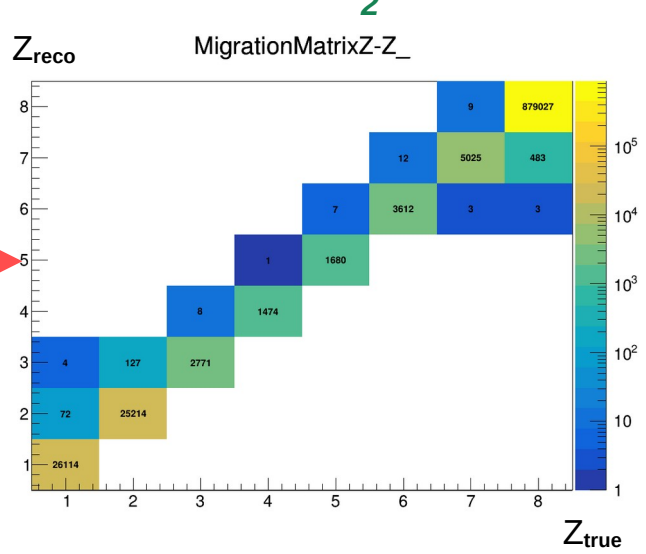
```
if (tmp_poi->GetMcTrackIdx(0) == fGlbTrack->GetMcMainTrackId())
```

R_1



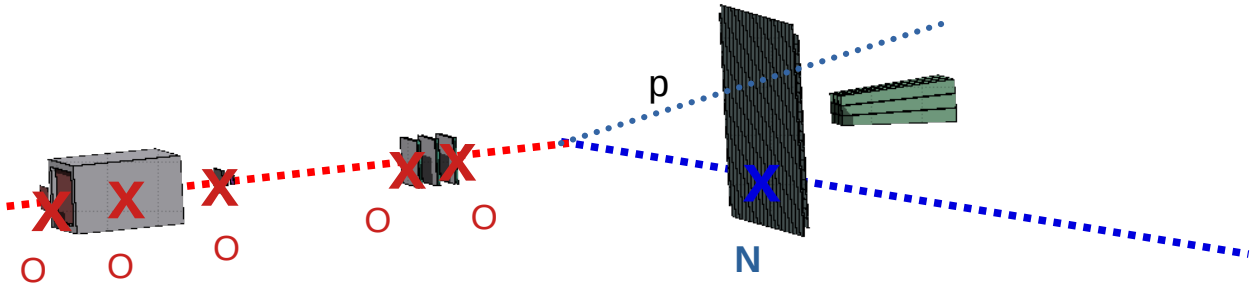


R_2



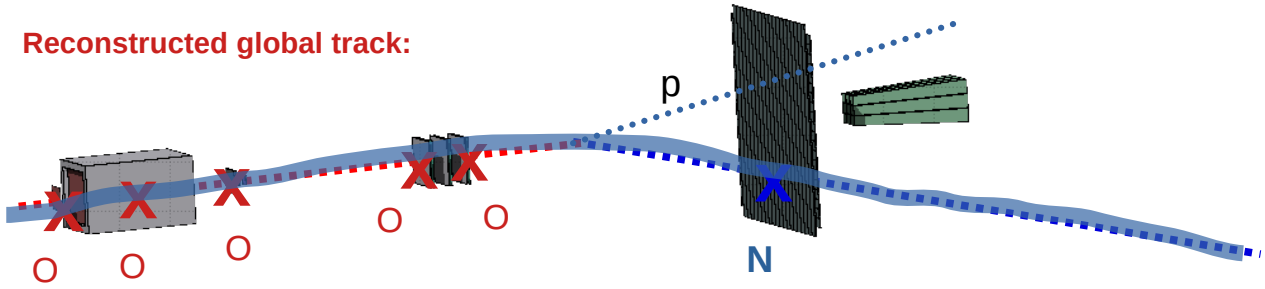
MC ID of the track

- Due to the presence of a lot of secondary fragmentation, some points of a global reconstructed track can belong to other particles:



MC ID of the track

- Due to the presence of a lot of secondary fragmentation, some points of a global reconstructed track can belong to other particles:



McId$_{track}$ is the one of the most probable MC particle (here of the **oxygen**)

McId$_{TWPoint}$ is of the **nitrogen**

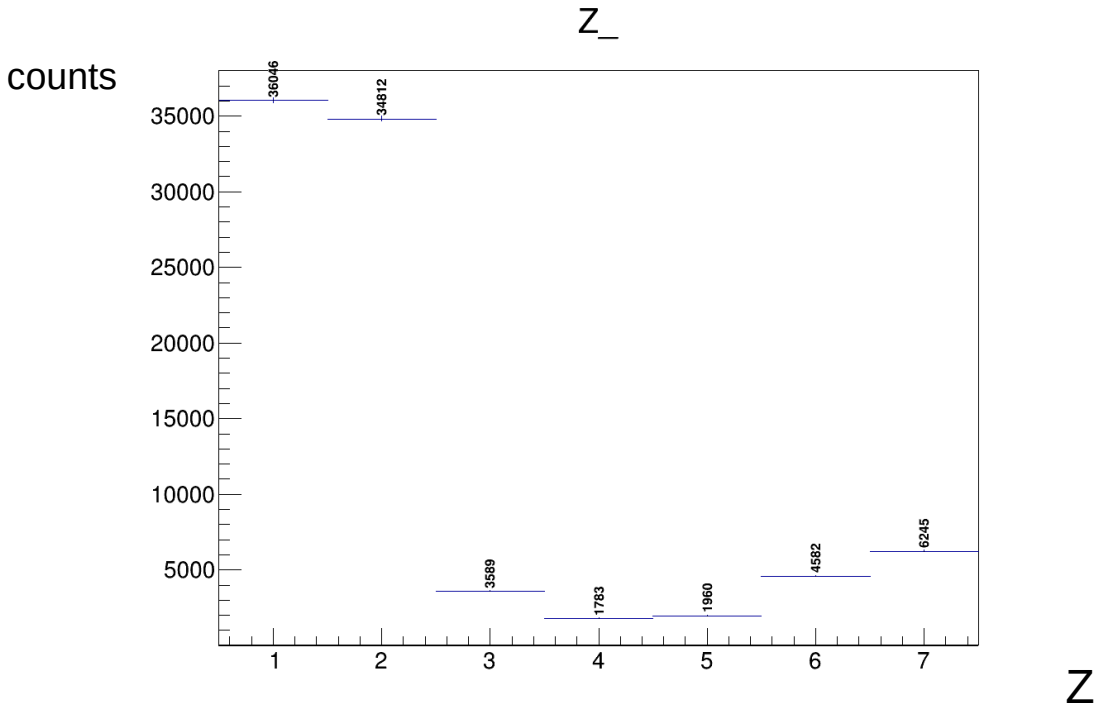
McId$_{track}$ ≠ McId$_{TWPoint}$ → *rejected global track*

Fiducial total cross section

Cross-Section formula by Yields

$$\sigma(Z) = \frac{Y(Z)}{N_{beam}\, N_{target}\, \epsilon(Z)}$$

R_1^{EXP}: all reconstructed tracks by genfit



Cross-Section formula – scale factor

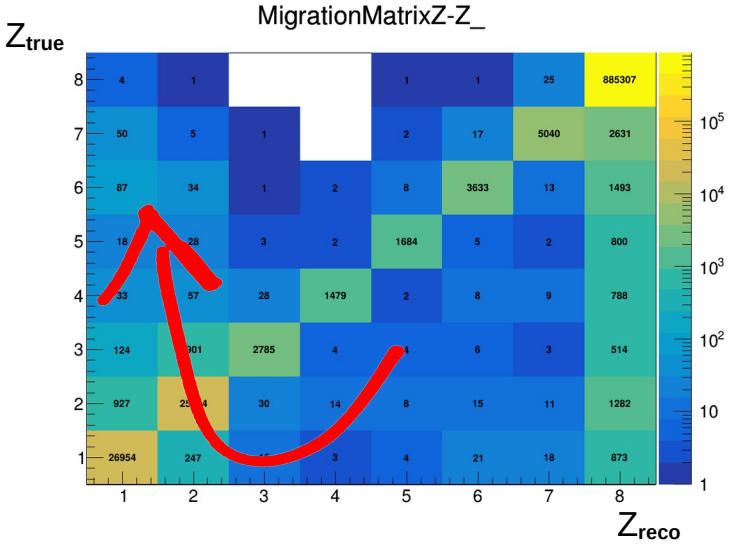
$$\sigma(Z) = \frac{Y(Z)}{N_{beam}\, N_{target}\, \epsilon(Z)}$$

R_1^{MC}: all reconstructed tracks by genfit

R_1^{reco}: all reconstructed tracks by genfit

$$\frac{R_1^{reco}}{R_1^{MC}}$$

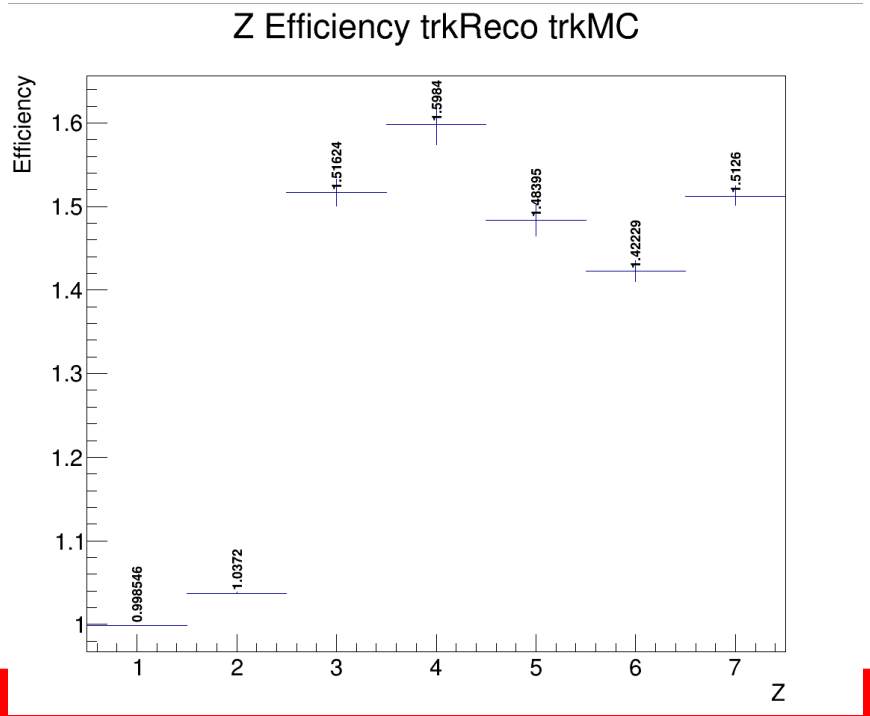
MC - reco scale factor



→ It's a migration from reco to MC level

Cross-Section formula – scale factor

$$\sigma(Z) = \frac{Y(Z)}{N_{beam}\, N_{target}\, \epsilon(Z)}$$



R_1^{MC}: all reconstructed tracks by genfit

R_1^{reco}: all reconstructed tracks by genfit

$$\frac{R_1^{reco}}{R_1^{MC}}$$

MC - reco scale factor

Cross-Section formula – scale factor

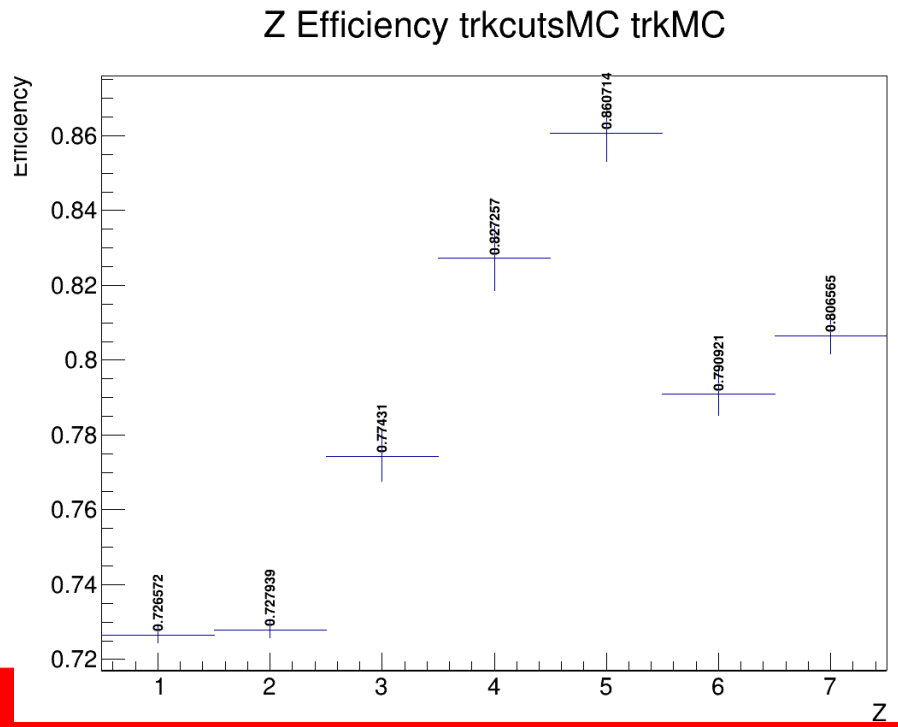
$$\sigma(Z) = \frac{Y(Z)}{N_{beam}\, N_{target}\, \epsilon(Z)}$$

R_1^{MC}: all reconstructed tracks by genfit

R_2^{MC}: all reconstructed tracks by genfit **+ cuts**

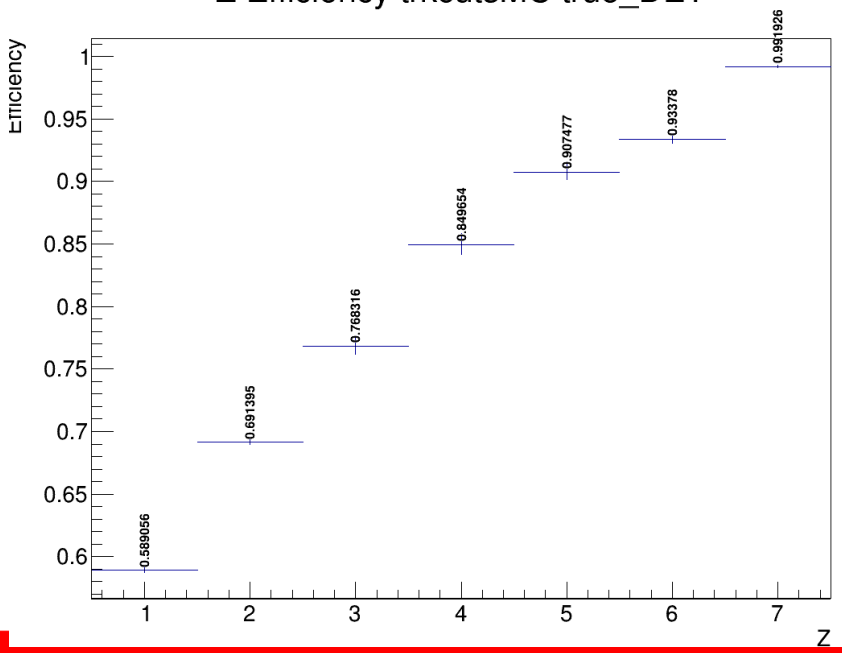
$$\frac{R_2^{MC}}{R_1^{MC}}$$

Global track purity



Cross-Section formula – efficiency

$$\sigma(Z) = \frac{Y(Z)}{N_{beam}\, N_{target}\, \epsilon(Z)}$$



T_1: all TAMCParticles generated in target with E_k > 100 MeV and theta < 8°

R_2^{MC}: all reconstructed tracks by genfit **+ MC cuts**

$$\frac{R_2^{MC}}{T_1}$$

Global track efficiency

- In this term, all efficiencies are considered, from detector to reconstruction ones

Cross-Section formula

$$\sigma(Z) = \frac{Y(Z) - B(Z)}{N_{beam}\ N_{target}\ \epsilon(Z)}$$

$$\sigma(Z) \propto R_1^{exp}\ \frac{R_1^{MC}}{R_1^{reco}}\ \frac{R_2^{MC}}{R_1^{MC}}\ \frac{T_1}{R_2^{MC}}$$

MC-Reco scale factor

Glb track purity

Global track efficiency

R_1^{EXP}: all reconstructed tracks by genfit

R_1^{MC}: all reconstructed tracks by genfit

R_2^{MC}: all reconstructed tracks by genfit **+ cuts**

R_1^{reco}: all reconstructed tracks by genfit

T_1: all TAMCParticles generated in target with E_k > 100 MeV and theta < 8°

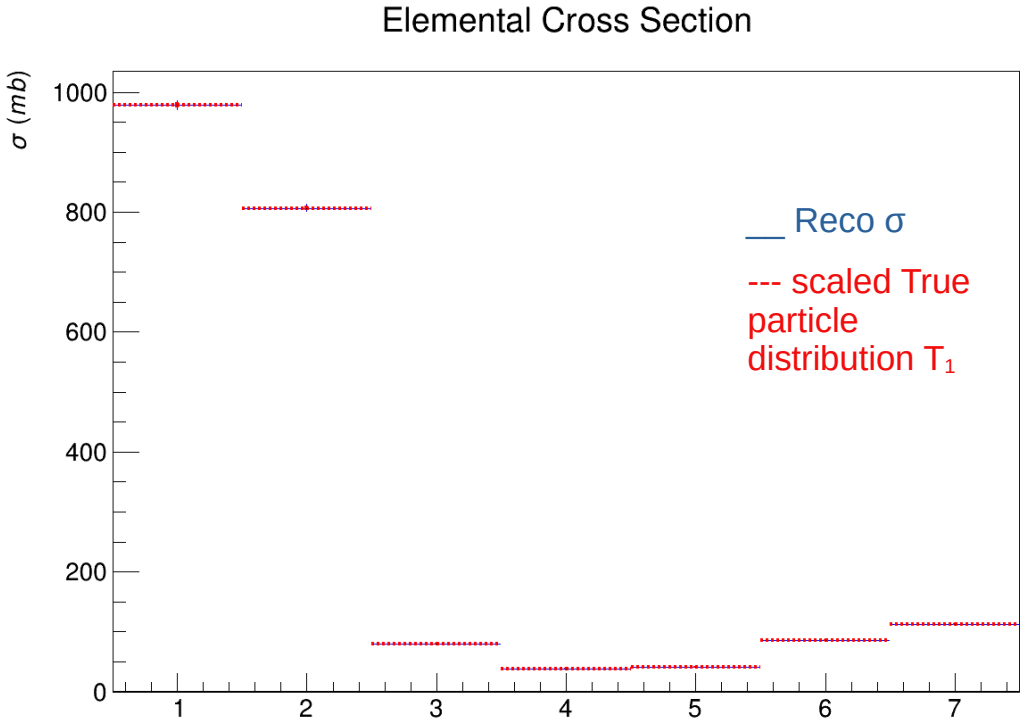
Cross-Section formula – check

In a MC dataset: $R_1^{EXP} = R_1^{reco}$

$$\sigma(Z) \propto \cancel{R_1^{EXP}} \frac{\cancel{R_2^{MC}}}{\cancel{R_1^{MC}}} \frac{T_1}{\cancel{R_2^{MC}}} \frac{\cancel{R_1^{MC}}}{\cancel{R_1^{reco}}} \propto T_1$$

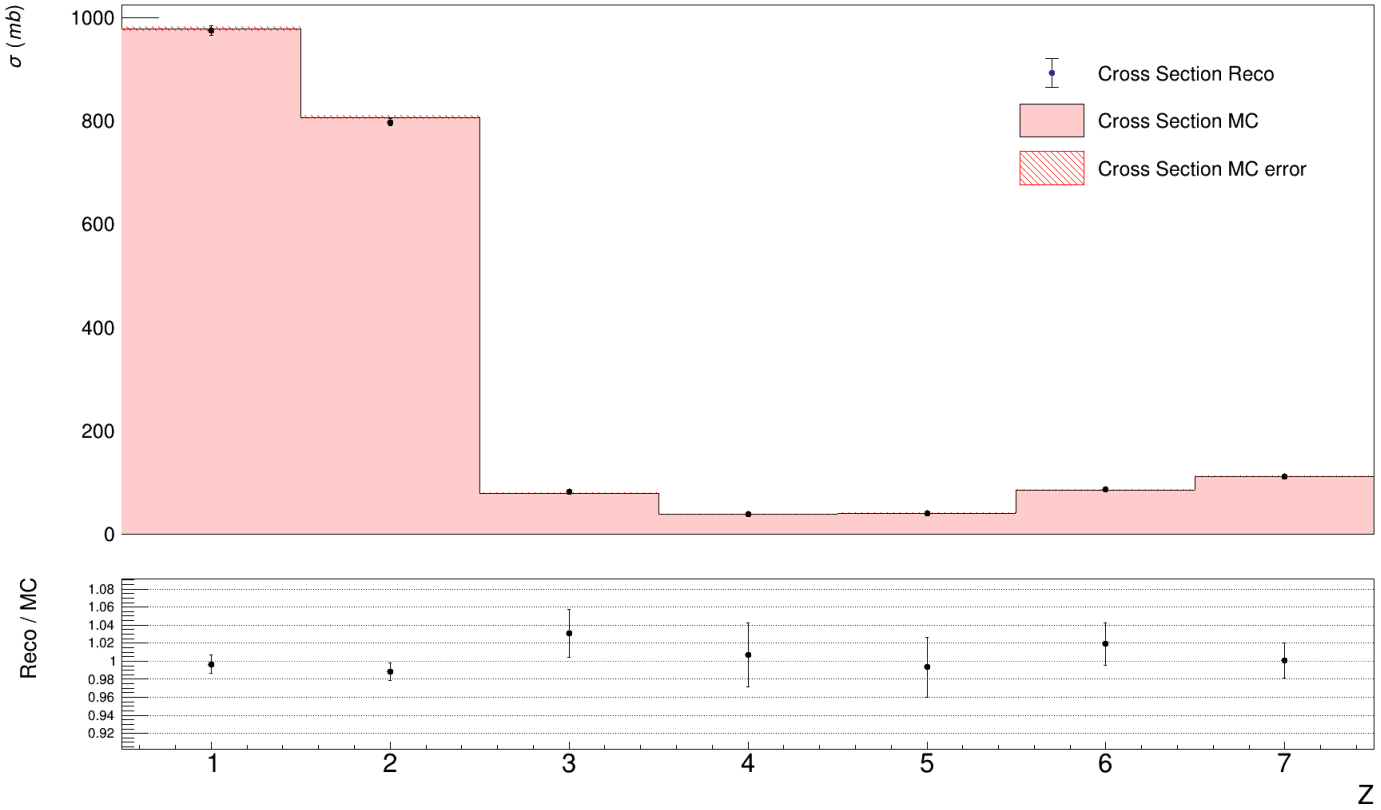
The used “recipe” is justified by the fact it satisfies the MC check

(the two cross sections are from the same dataset)



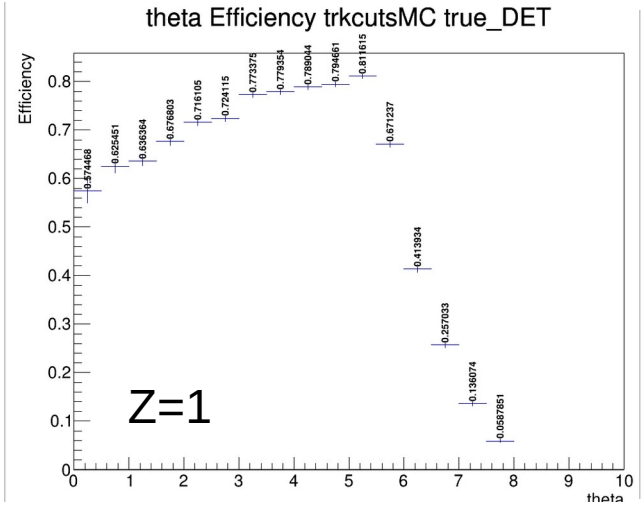
Cross-Section formula – closure test

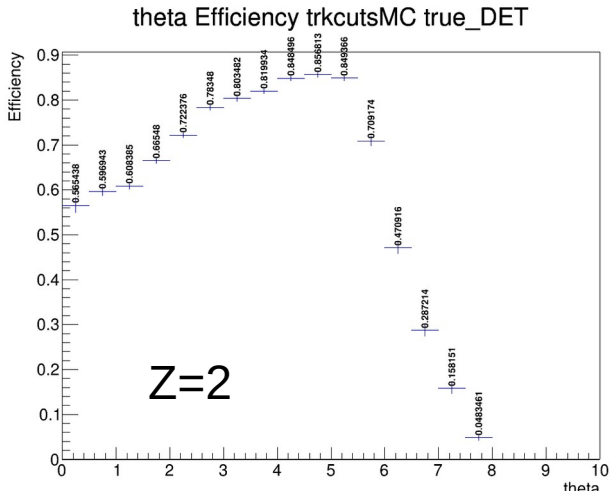
In **blue dots**: dataset for Reconstructed parameters
In **red bars**: independent dataset from same simulation for generated MC parameters

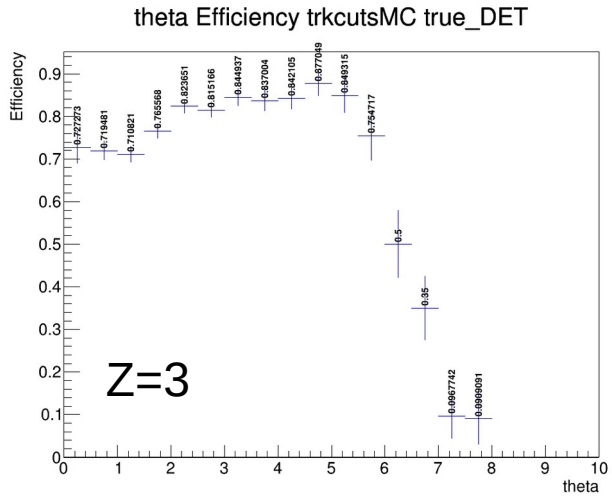


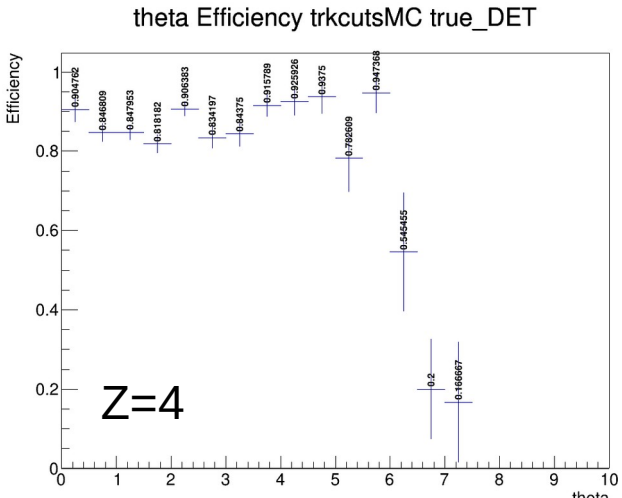
Angular Differential cross section

Cross-Section formula – efficiency





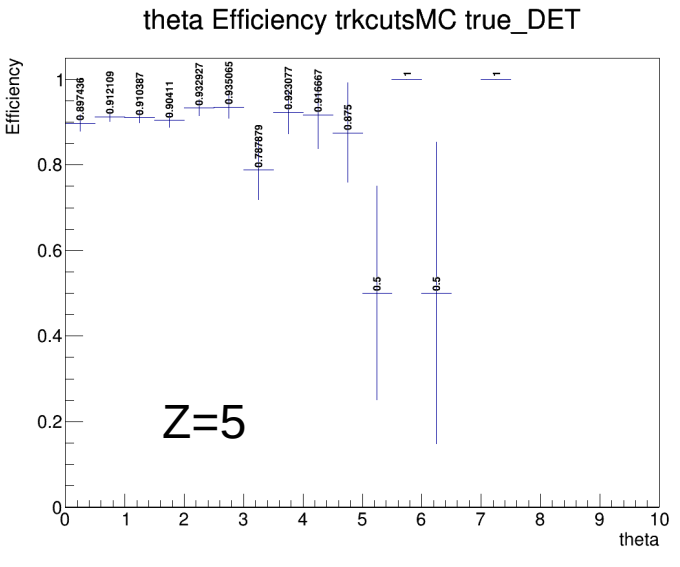


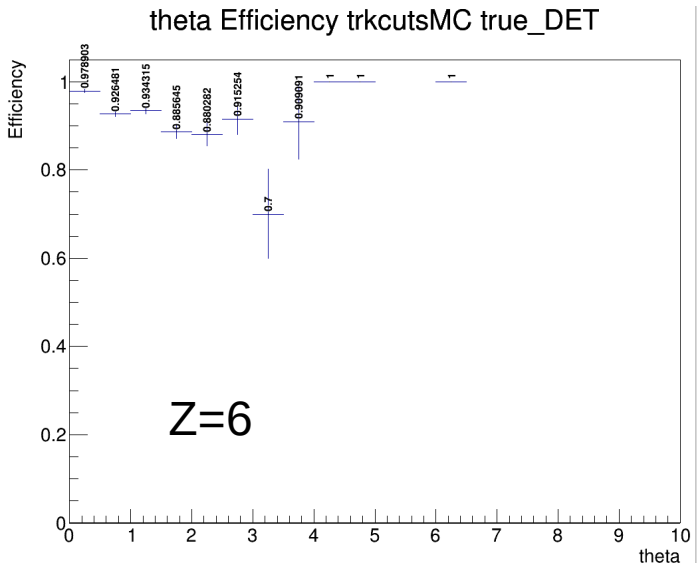


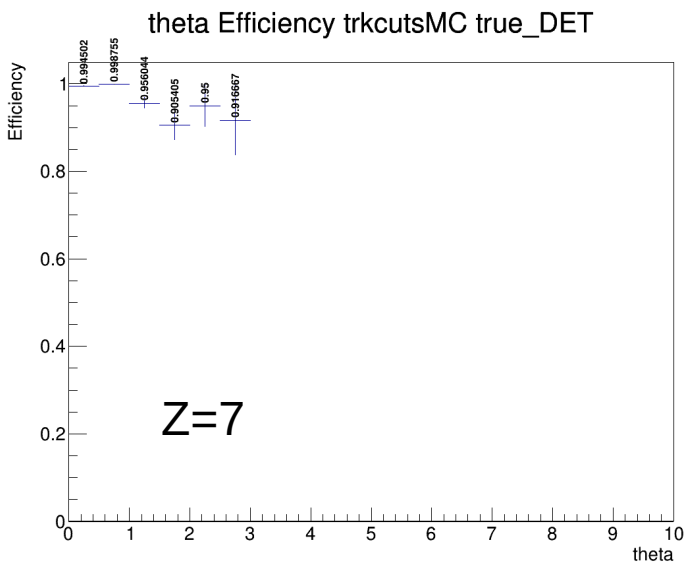
$R_2^{MC} \;/\; T_1$

Cross-Section formula – efficiency

R_2^{MC} / T_1



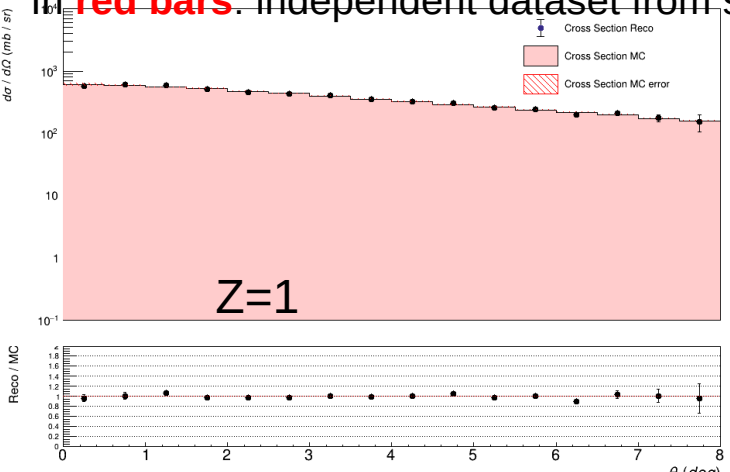


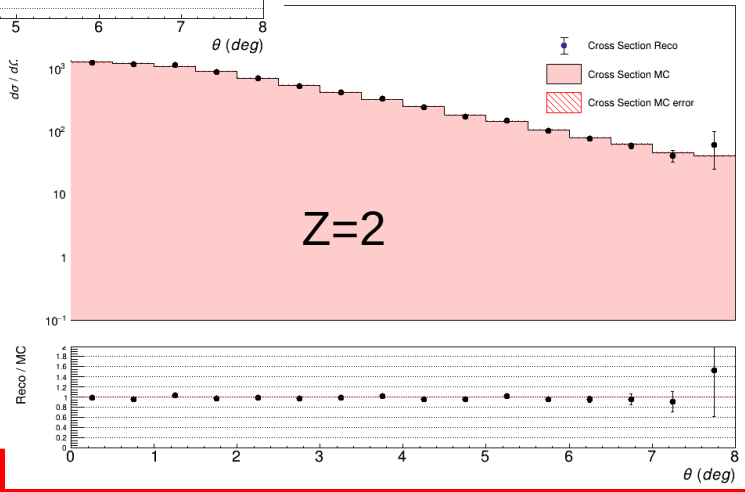


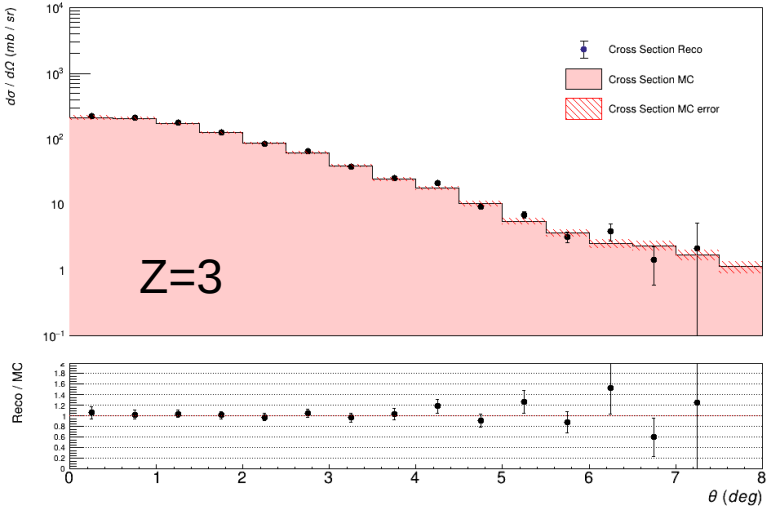
R_2^{MC} / T_1

Cross-Section

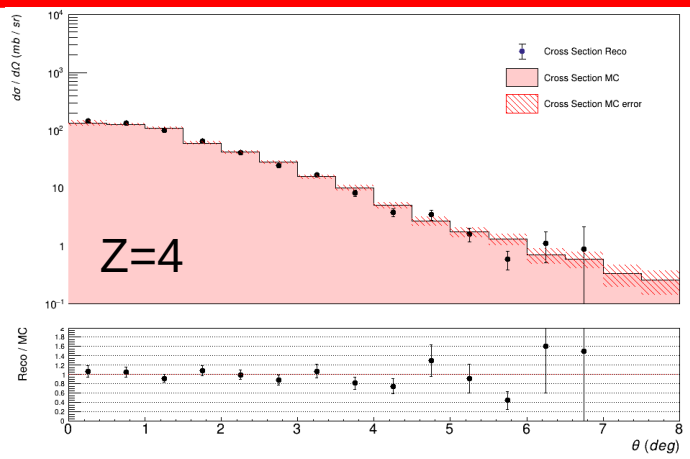
In **blue dots**: dataset for Reconstructed parameters
In **red bars**: independent dataset from same simulation for generated MC parameters

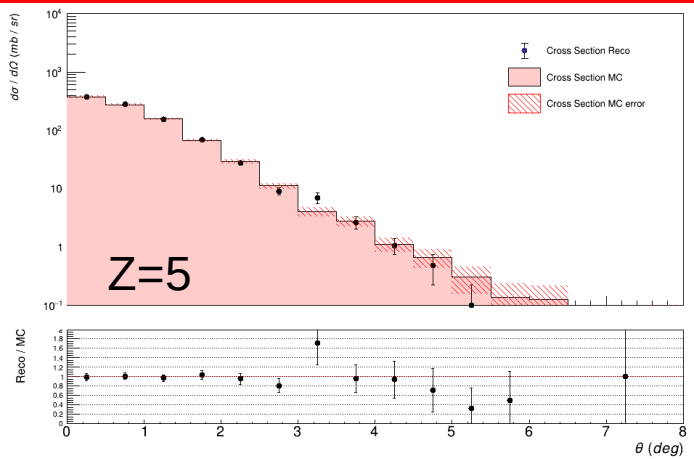


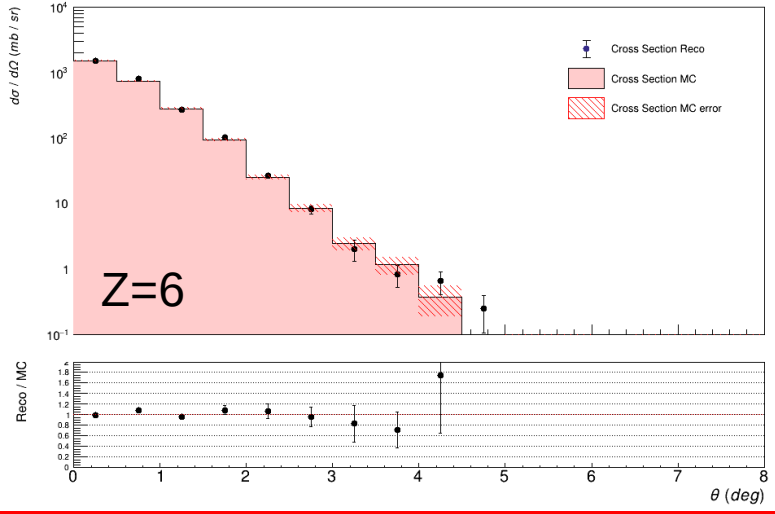


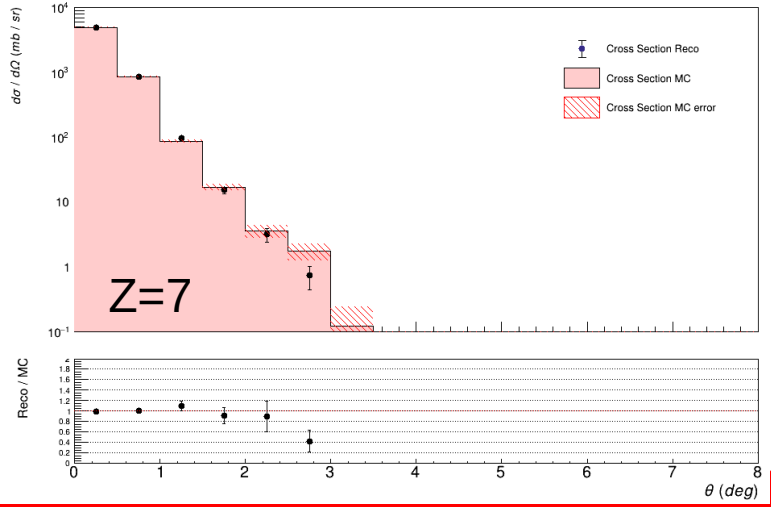


Cross-Section







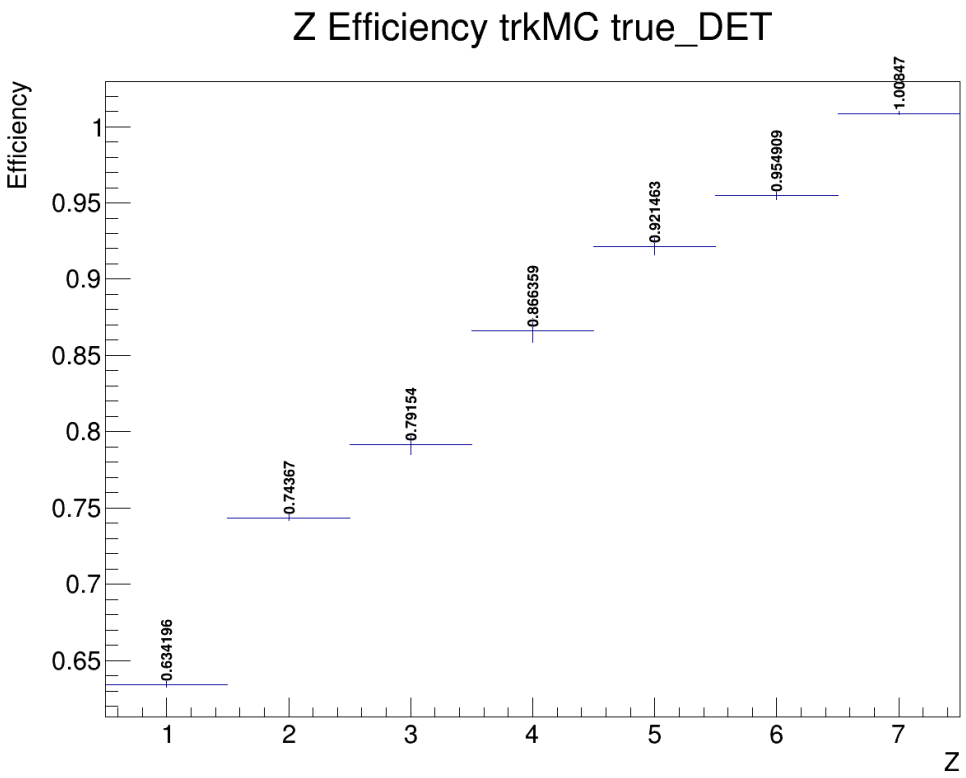


Comments

- Separate efficiencies in its contributions (BM efficiency, global track studies)
- Out of target fragmentation, multi-reconstruction of the same track
- Inspect Z match
- Theta binning is ~ 1°. Binning resolution studies are being implemented in GlbRecoAna
  - Is it needed to introduce theta unfolding?

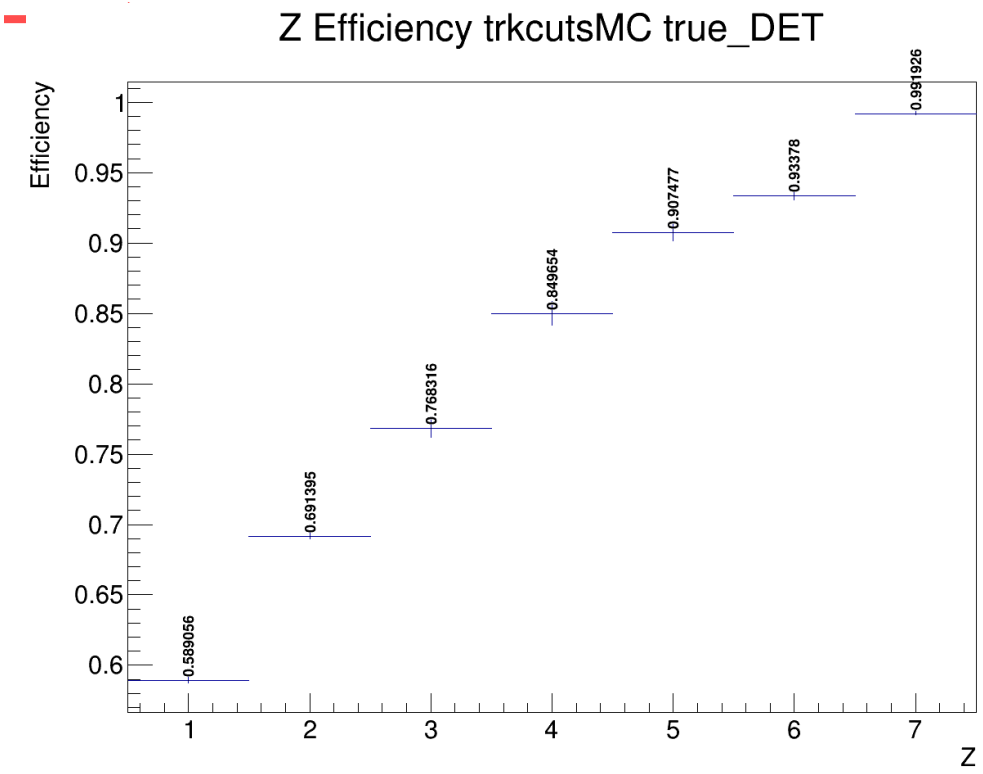
Cross-Section formula – efficiency

R_1^{MC} / T_1



cuts

R_2^{MC} / T_1

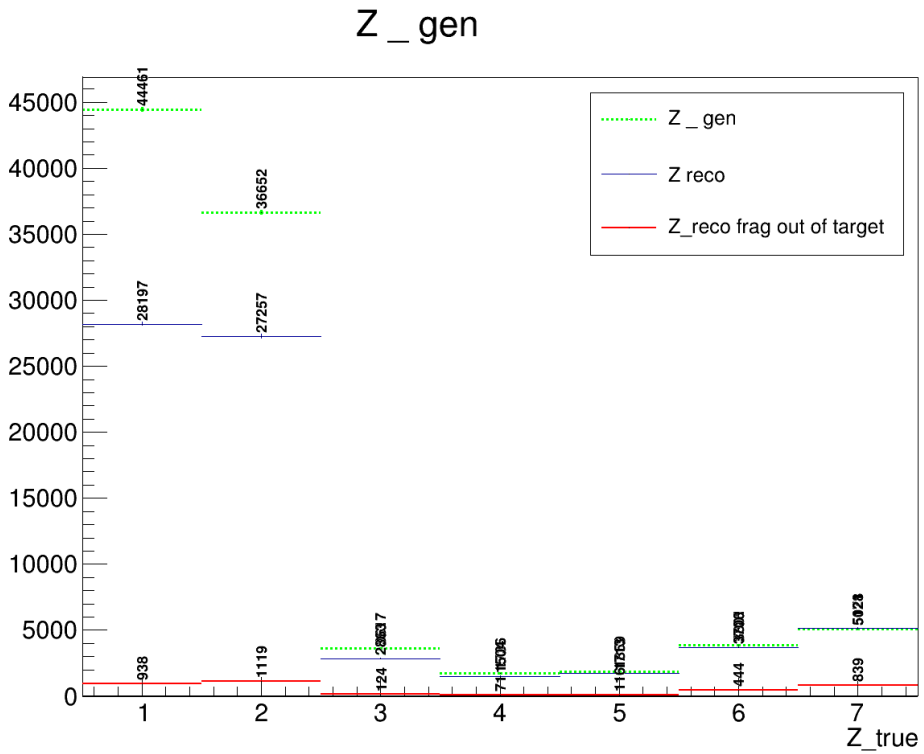


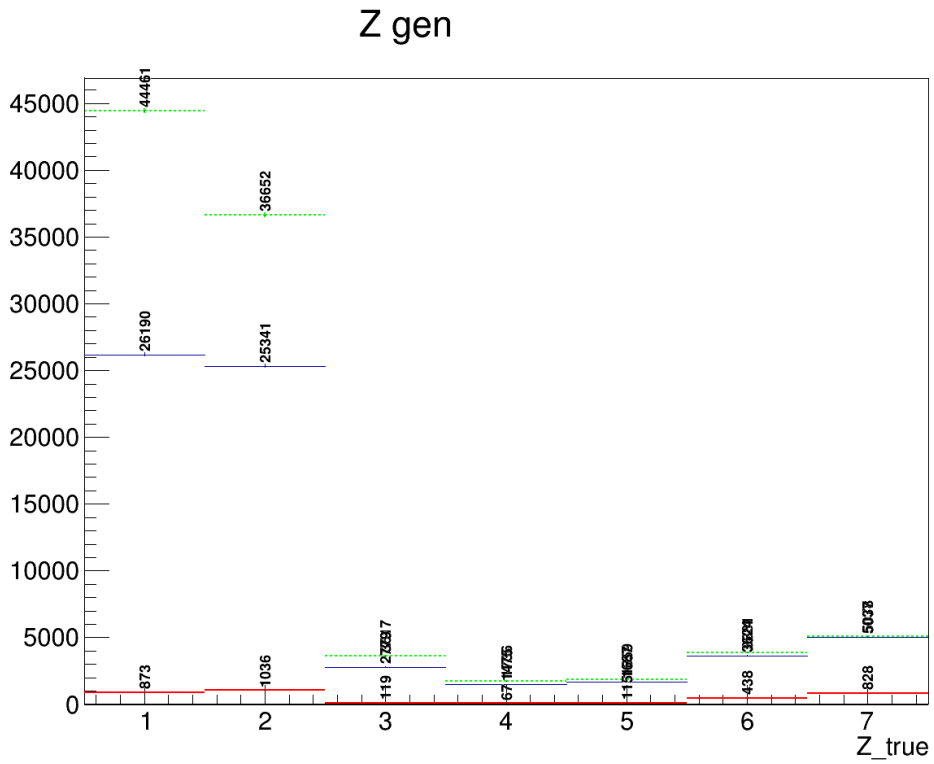
Cross-Section formula – efficiency

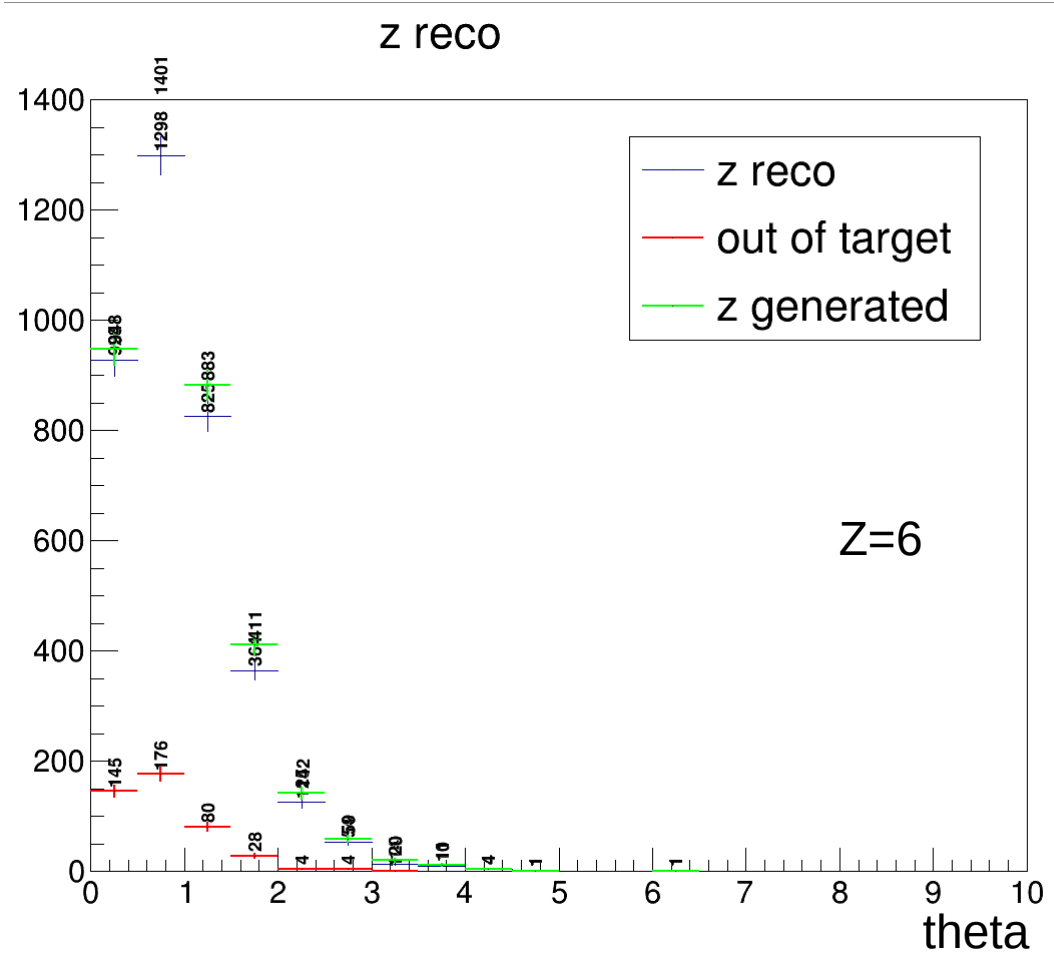
R_1^{MC} / T_1

cuts

R_2^{MC} / T_1






z reco
z reco
out of target
z generated
Z=6
theta
1400
1200
1000
800
600
400
200
0
0
1
2
3
4
5
6
7
8
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10
1401
1298
883
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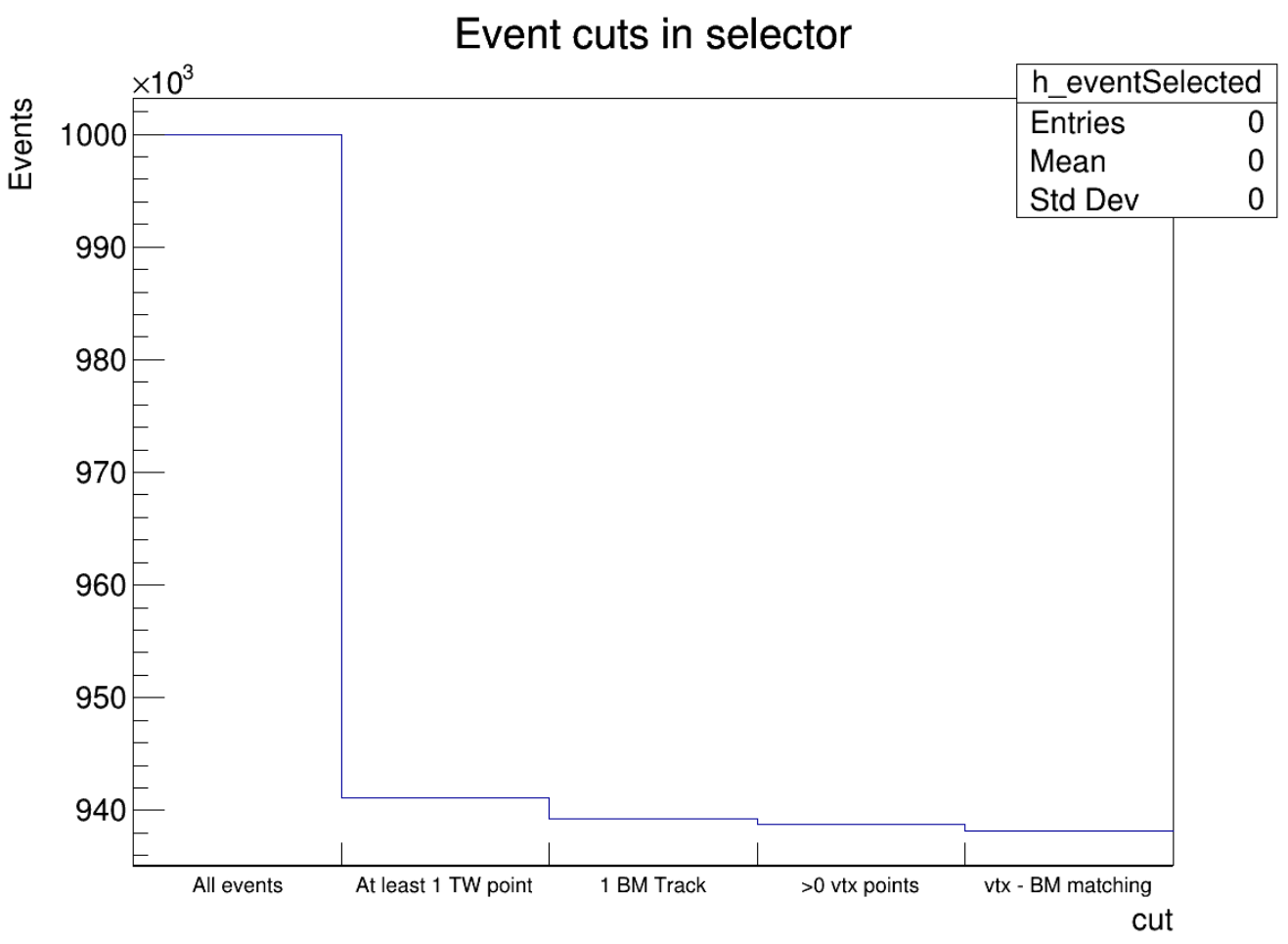
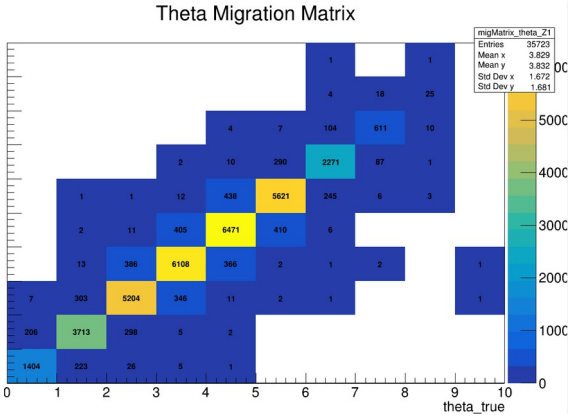
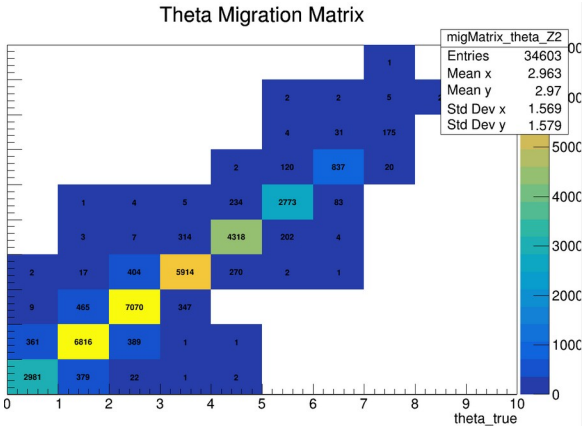
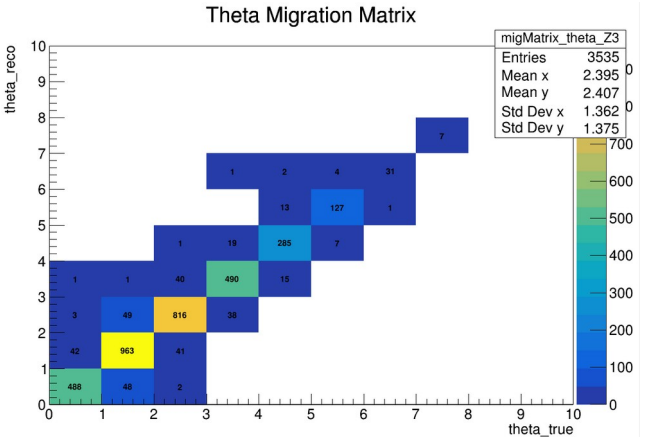
411
364
176
145
80
28
4
4
4
1
1

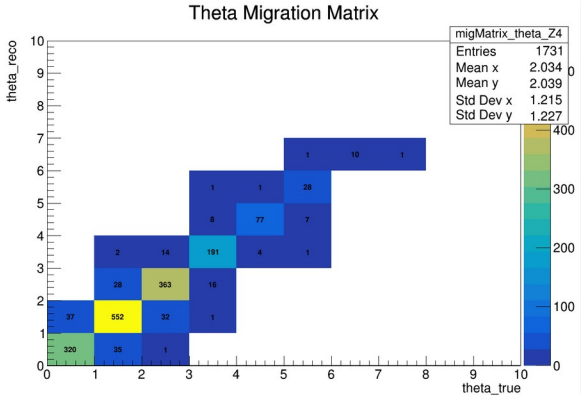

Event cuts in selector
h_eventSelected
Entries 0
Mean 0
Std Dev 0
Events
×10^3
1000
990
980
970
960
950
940
All events
At least 1 TW point
1 BM Track
>0 vtx points
vtx - BM matching
cut

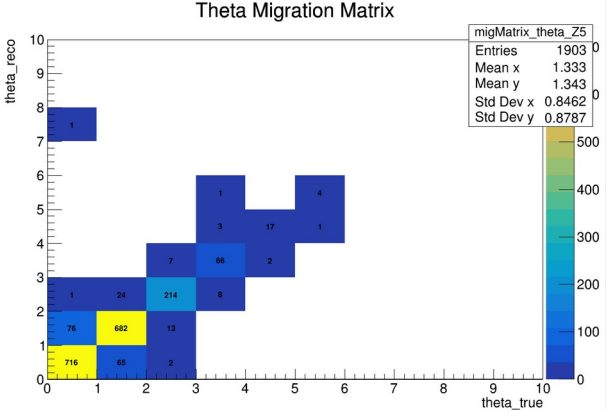
Theta migration matrix

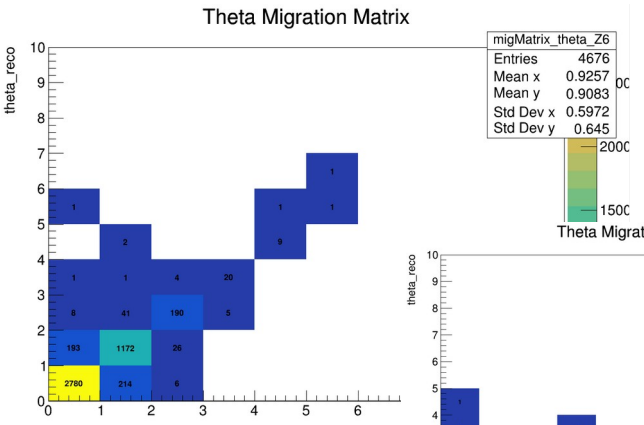


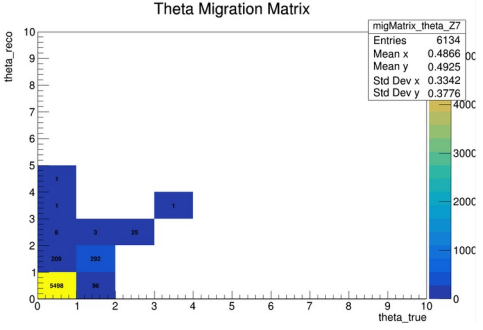




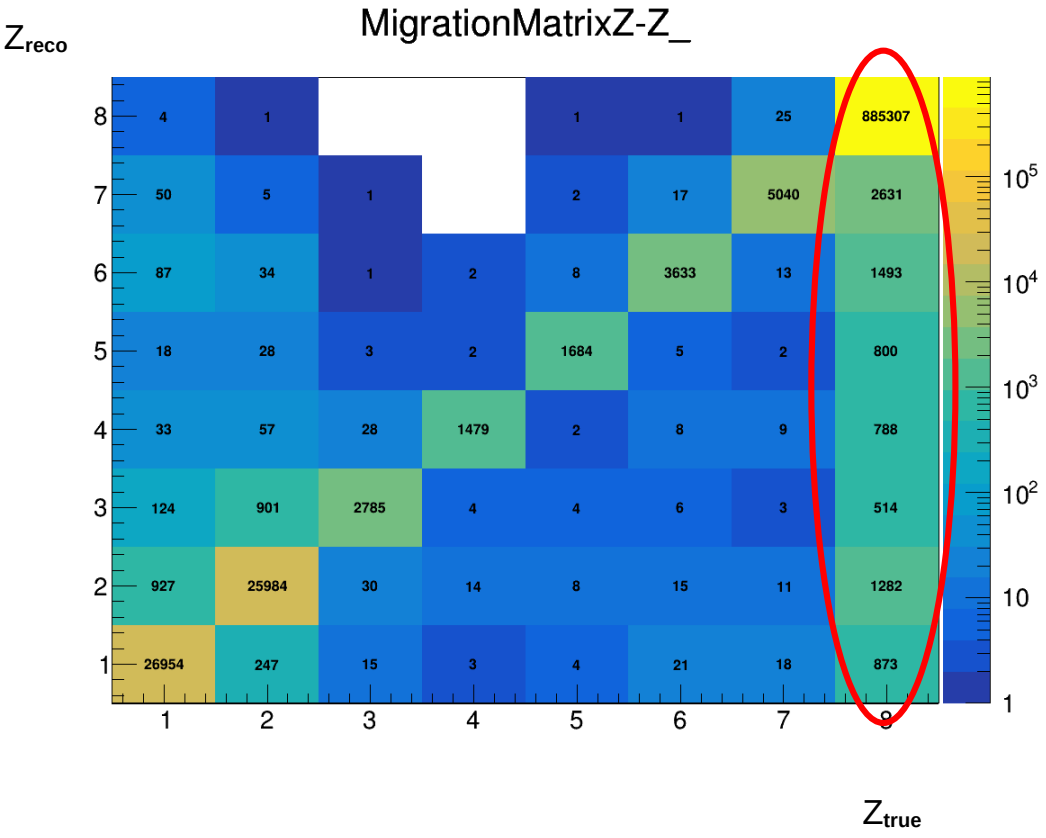






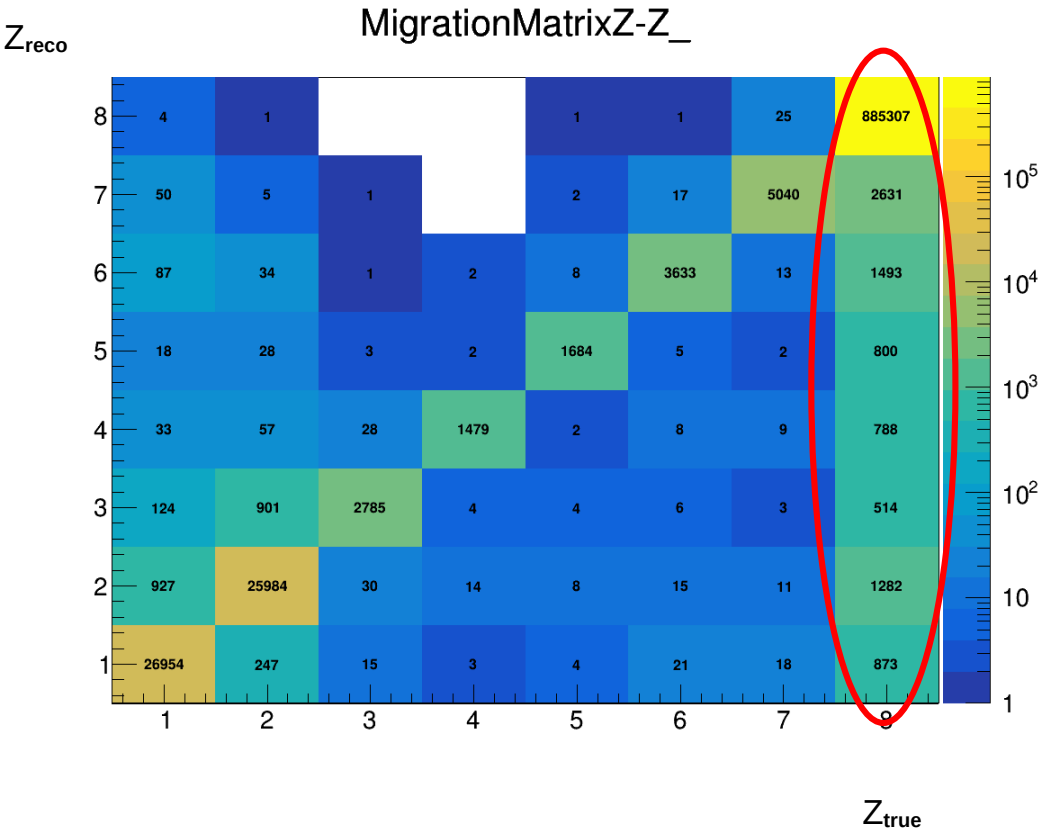


Secondary fragm global tracks



------- Global track reconstruction level
reconstructed tracks: 1
track n° 0
reconstructed charge: 7
TW charge: 7
IdMC of every point of the track:
0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - ***2 6 7 ID_error*** -
TrkIdMC (mode of IdMC)= 0
Fluka code: -2
charge: 8
Region of origin: 2
Mid: -1
Initial Pos: 0.37145 -0.0619677 -104.45

Secondary fragm global tracks



------- Global track reconstruction level
reconstructed tracks: 1
track n° 0
reconstructed charge: 4
TW charge: 4
IdMC of every point of the track:
MC_error : track of particle out of target
0 - 0 - 0 - 0 - 0 - 0 - **0 1 2 3 4 17 20 19** - 1 2 20 - 2 - 1 - 2 -
TrkIdMC (mode of IdMC)= 0
Fluka code: -2
charge: 8
Region of origin: 2
Mid: -1

Out of target global tracks

------- Global track reconstruction level
reconstructed tracks: 1
track n° 0
 reconstructed charge: 6
 TW charge: 6
IdMC of every point of the track:
   MC_error : track of particle out of target
4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 4 - 6 183 217 -
  TrkIdMC (mode of IdMC)= 4
  Fluka code: -2
  charge: 7
  Region of origin: 2
  Mid: 0
  Initial Pos: 0.0313356 0.10144 -54.2098

No TW Point

------- Global track reconstruction level
reconstructed tracks: 1
track n° 0
 reconstructed charge: 1
 TW charge: -1
TW_error: no TW points
IdMC of every point of the track:
   MC_error : track of particle out of target
0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 - 0 -
  TrkIdMC (mode of IdMC)= 0
  Fluka code: -2
  charge: 8
  Region of origin: 2
  Mid: -1
  Initial Pos: 0.225386 0.335826 -104.45

Multiple tracks from same particle

```
//study of reconstructino of more tracks with same ID
if (count(trackID.begin(), trackID.end(), fGlbTrack->GetMcMainTrackId()))
myfile << "track_error: the tamc particle with trackID " << fGlbTrack->GetMcMainTrackId() << " has been already reconstructed" << endl;
else
trackID.push_back(fGlbTrack->GetMcMainTrackId());
```

none