GSI2021 Analysis Updates

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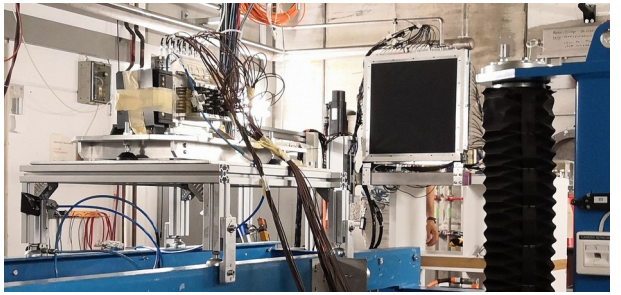
FOOT Physics Meeting

07/02/2024

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



- **VT, MSD, TW** considered
- Analysis based on **Global tracking**
- **MC considerations**

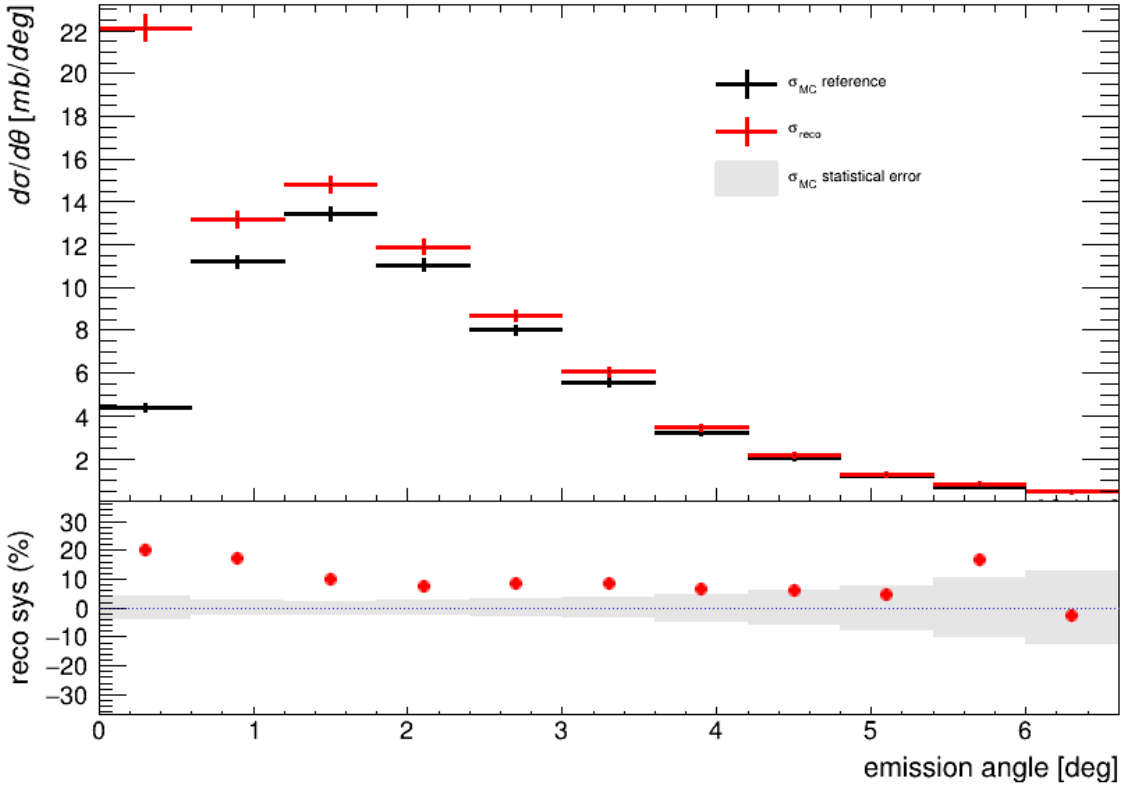
Recap

- **Beryllium (Z=4) differential cross section** as example

PREVIOUSLY ON...

https://agenda.infn.it/event/37748/contributions/217797/

Z=4 Angular Differential Cross section



- Cross sections computed using the formula:

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

- Systematical impact studied with the **reco ratio**:

$$reco\ sys = \frac{\sigma_{reco} - \sigma_{MC}}{\sigma_{MC}}$$

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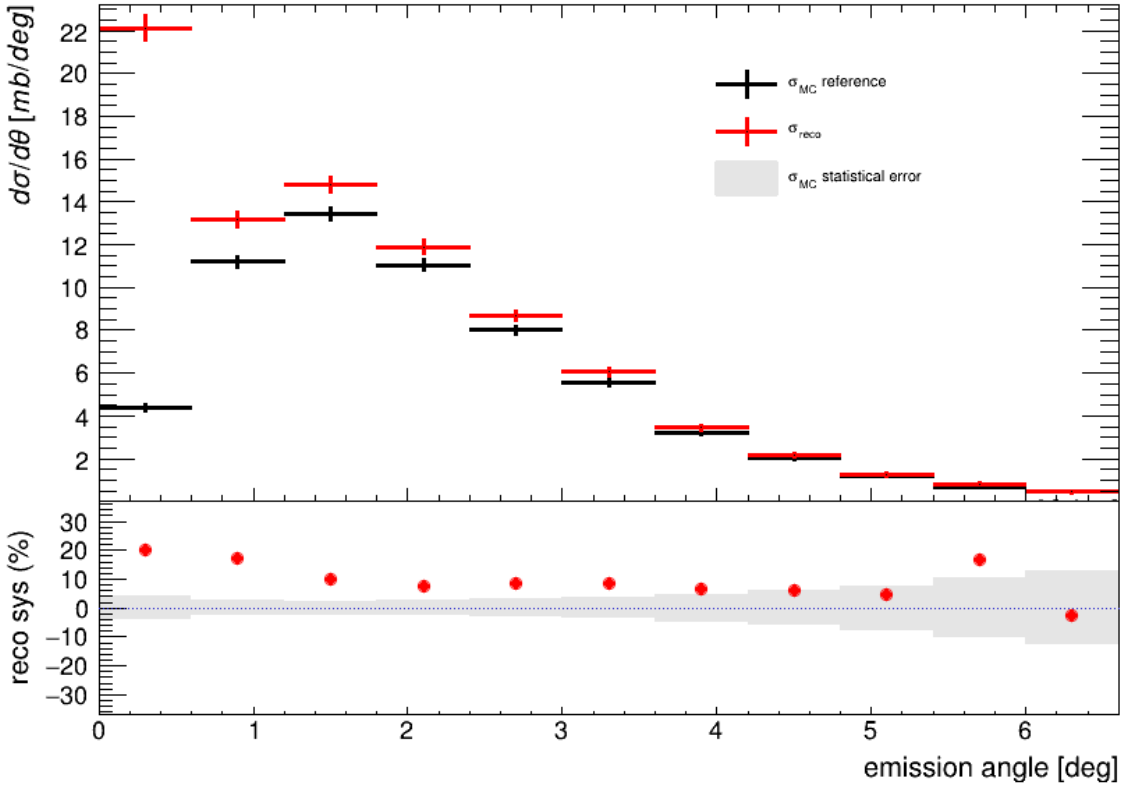

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- Analysis cuts:
  - $\chi^2 / n_{dof} < 2$
  - **res** < 0.001 cm
  - $n_{global\ tracks} > 1$
  - **TW point** in one track (at most)
  - $n_{global\ tracks}$ == **TW point**

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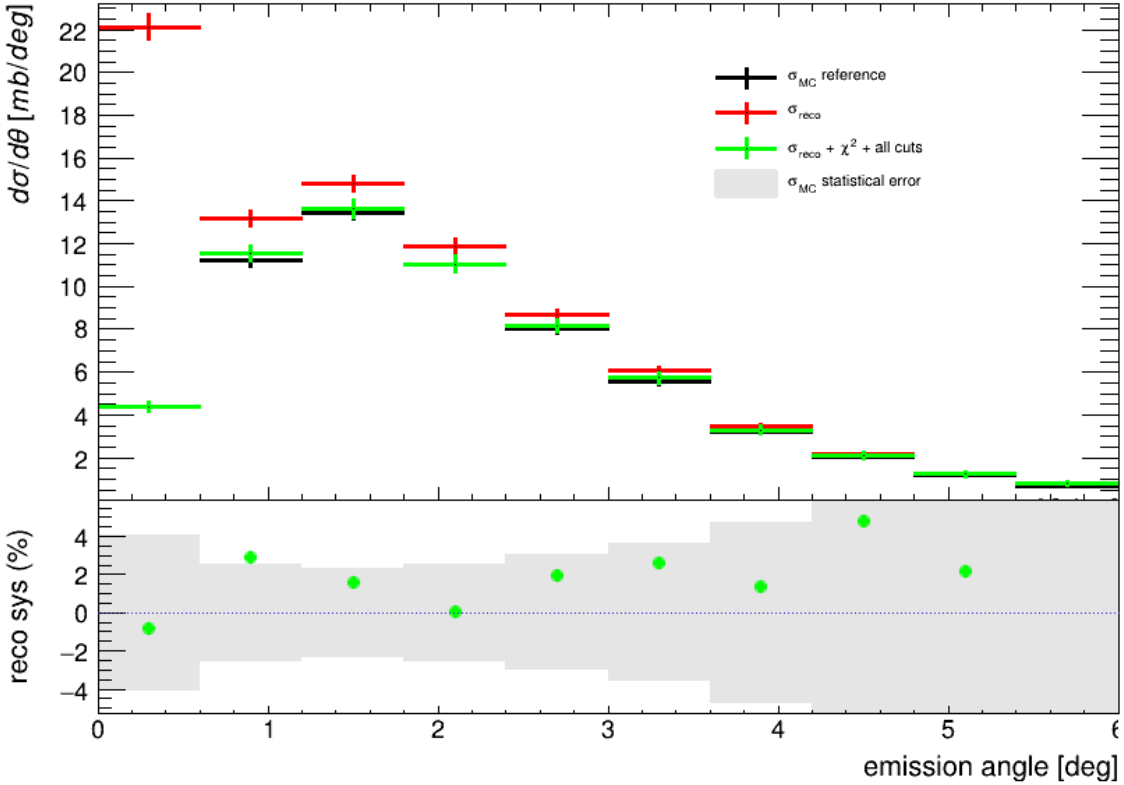

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- **a discrepancy of ~ 4 %** is achieved in a **MC closure test**

N° primary events

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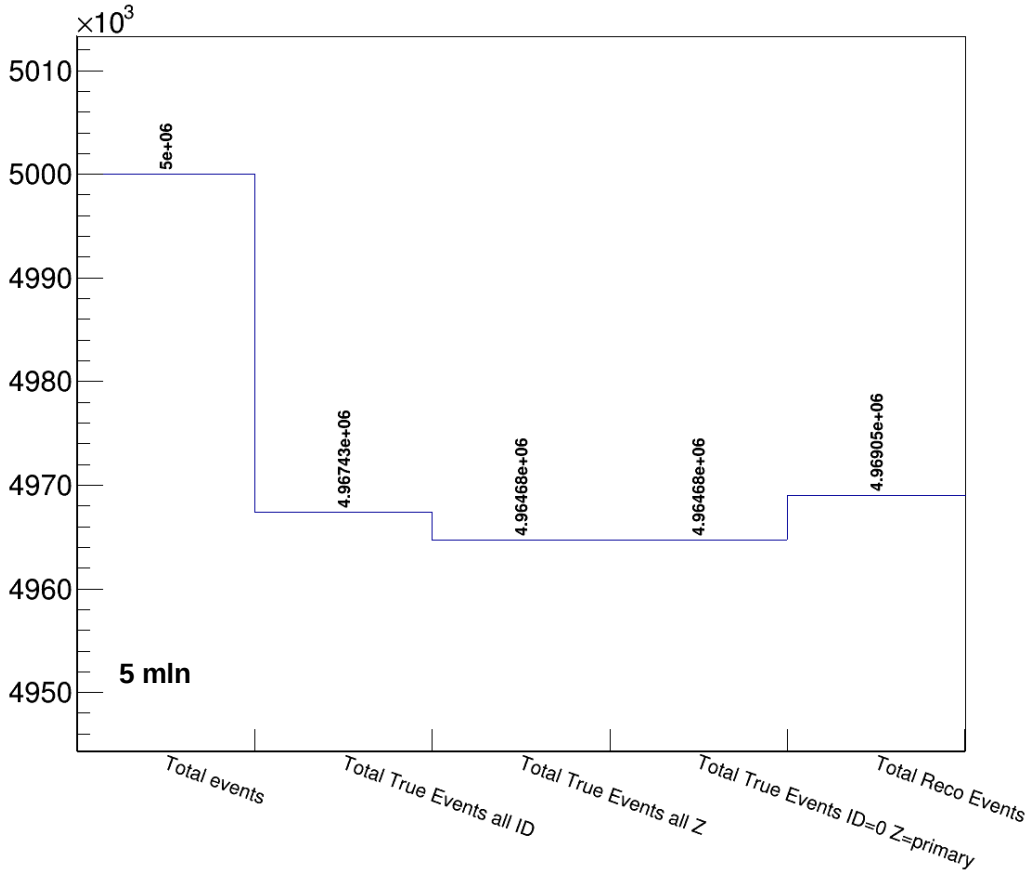

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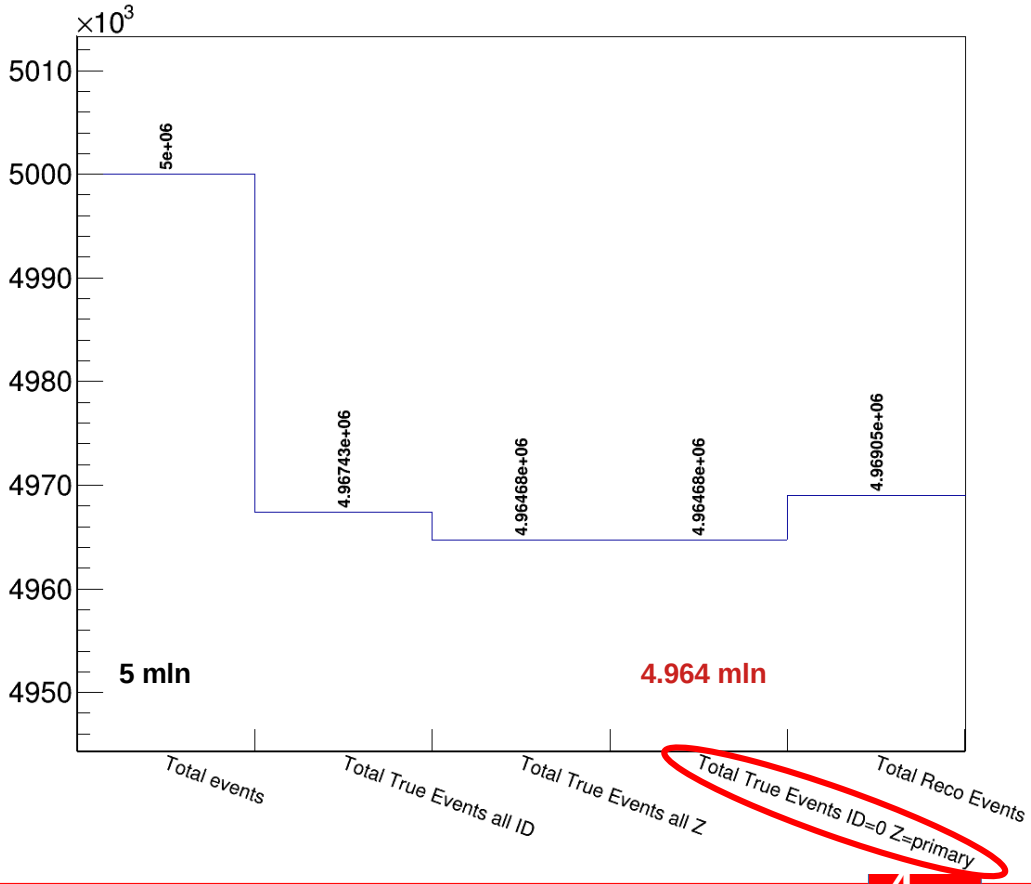
- It should be a primary (Z=8; **ID =0**)



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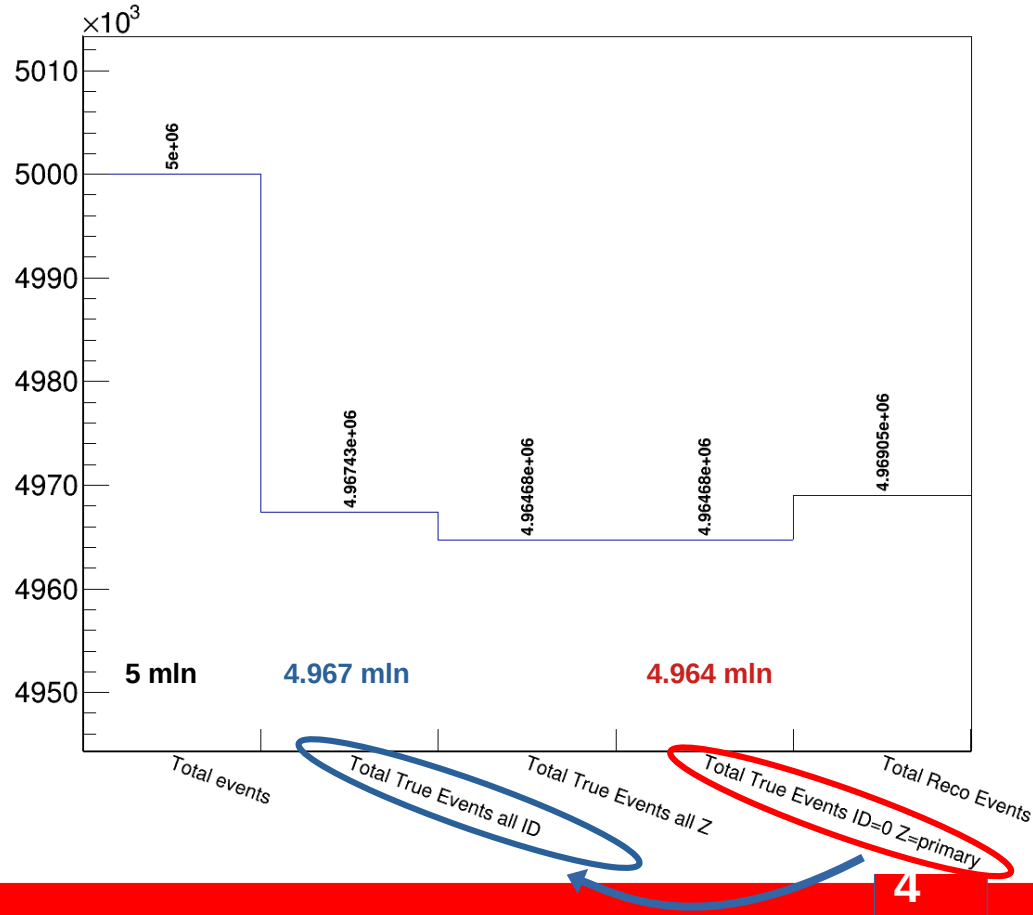
- There are ^{16}O whose ID is not 0 → γ emission, de-excitation..
- They cannot be discern (up to now) in the experiment, so they are considered as good
- **Increase of ~ 0.6 ‰**



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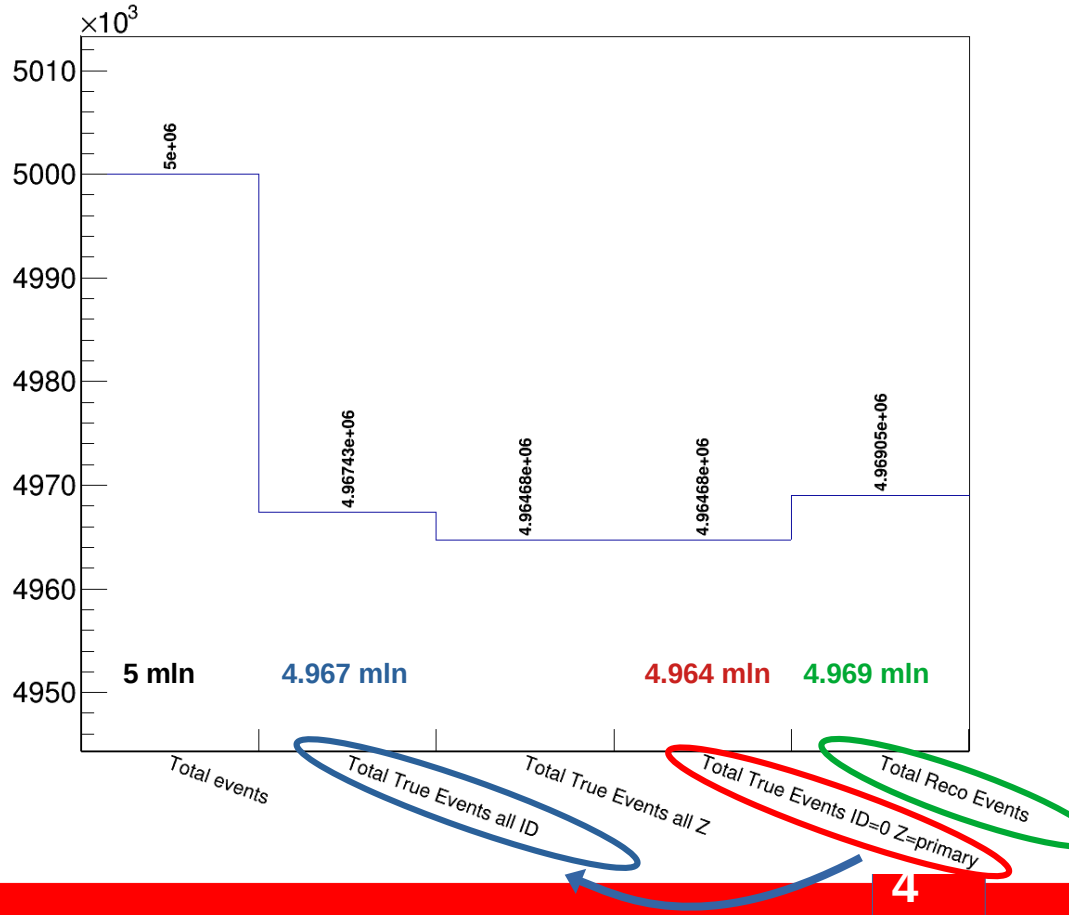
- **Reco events ~ 0.4 ‰ more** than True Events



N° primary events

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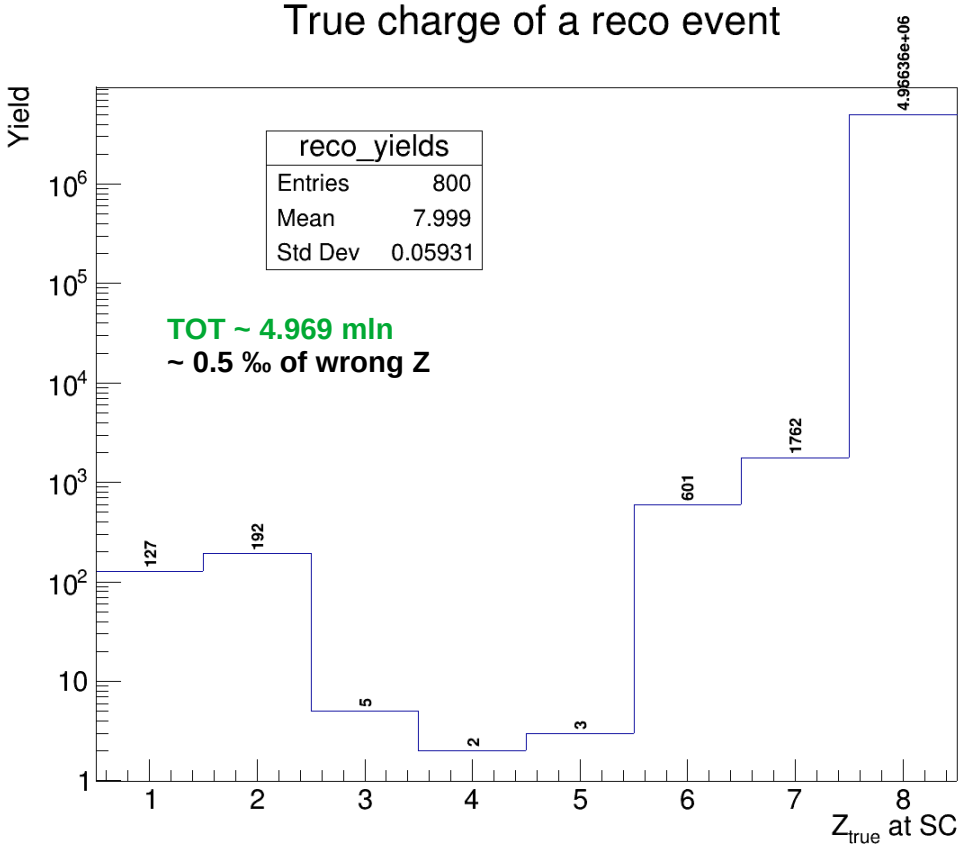
Reco Events

- energy release higher than .005 GeV (energy release of Primary) in SC
- 1 BM track
- vertex of the interaction is inside the target

Is **~ 0.5 ‰ of Reco Events relevant for the XS systematics?**



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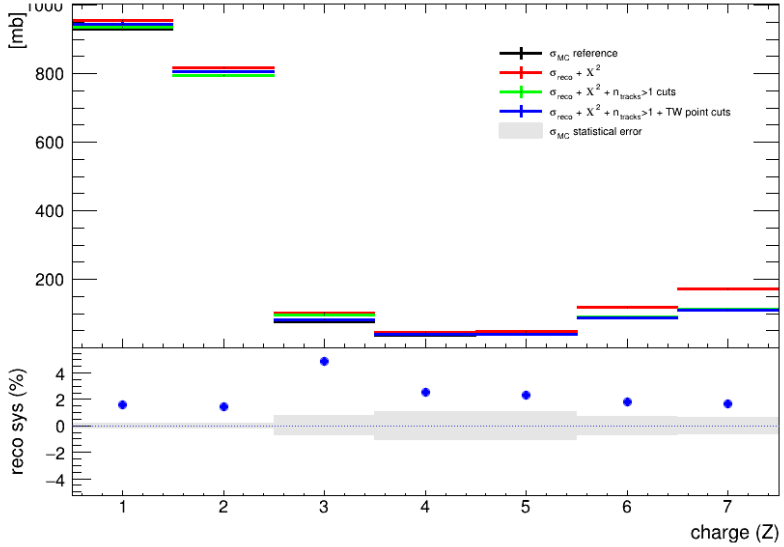

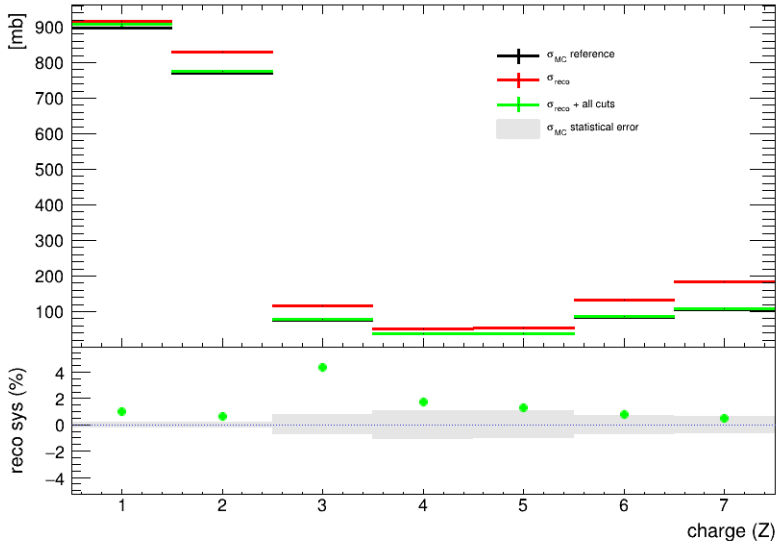

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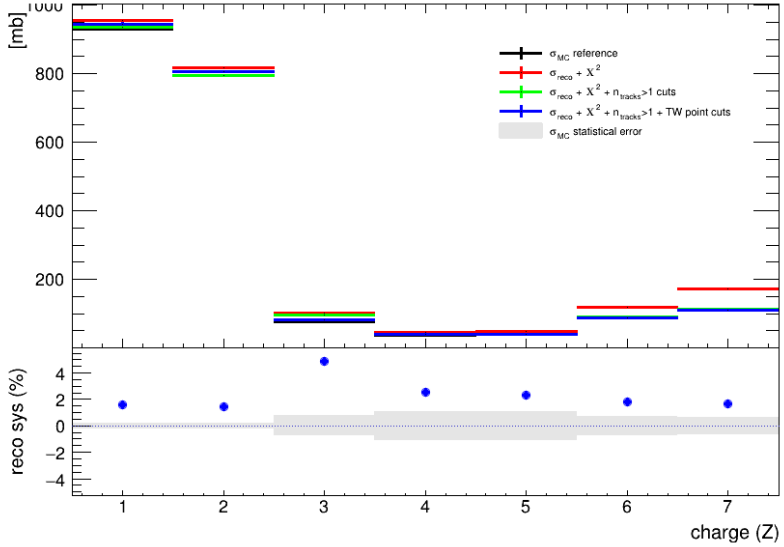

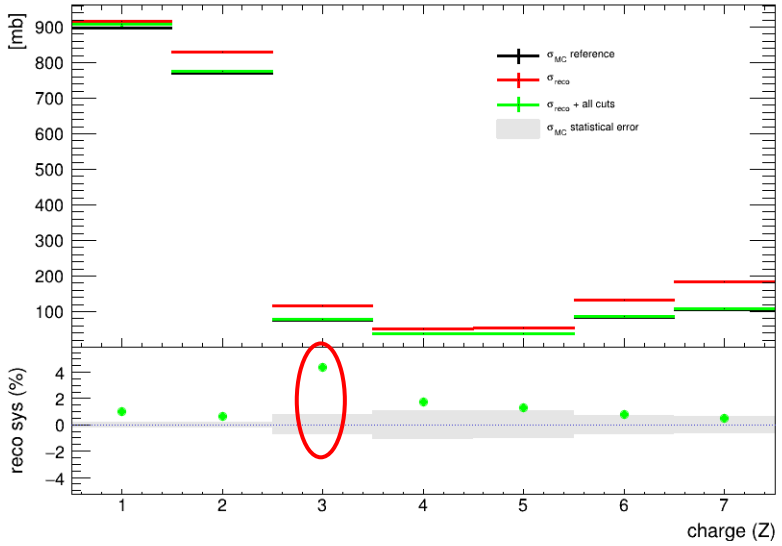

→ little improvement in the systematics after fixing N_{beam}
→ highest discrepancy still for **Li**

He PileUp

PREVIOUSLY ON...

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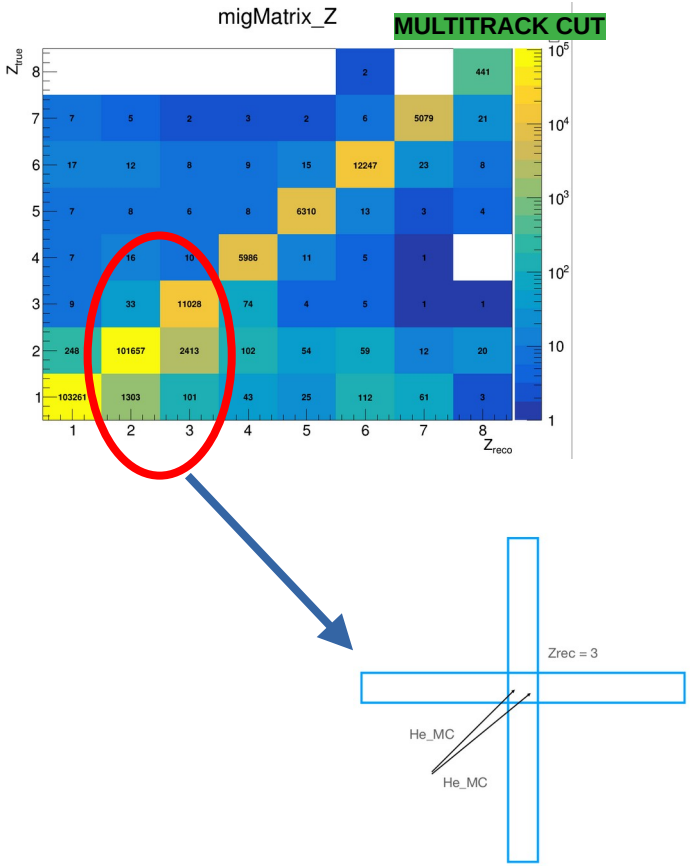

It is possible that more than one fragment pass through the same TW cross, misreconstructing the charge**.**

→ **High impact for misreconstructed Z_{true} = 2 charges into Z_{reco} = 3.**

An event like this can be reconstructed as **two tracks with the same TWPoint by Global Tracking**

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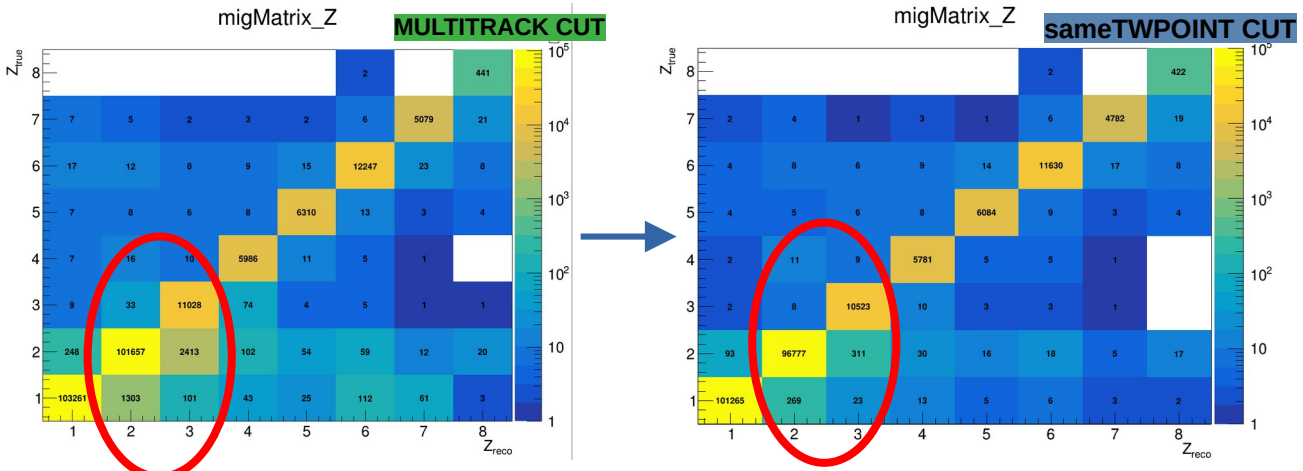

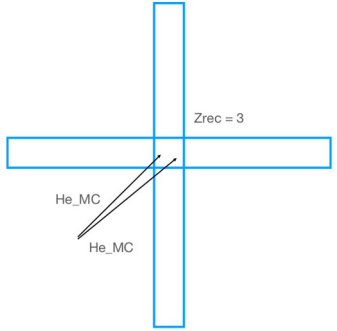

As expected:

- the reconstructed events out of diagonal for Z=2 and Z=3 are considerably reduces (and not only)
- Improvement of diagonalization of CMM
- limited loss of statistics

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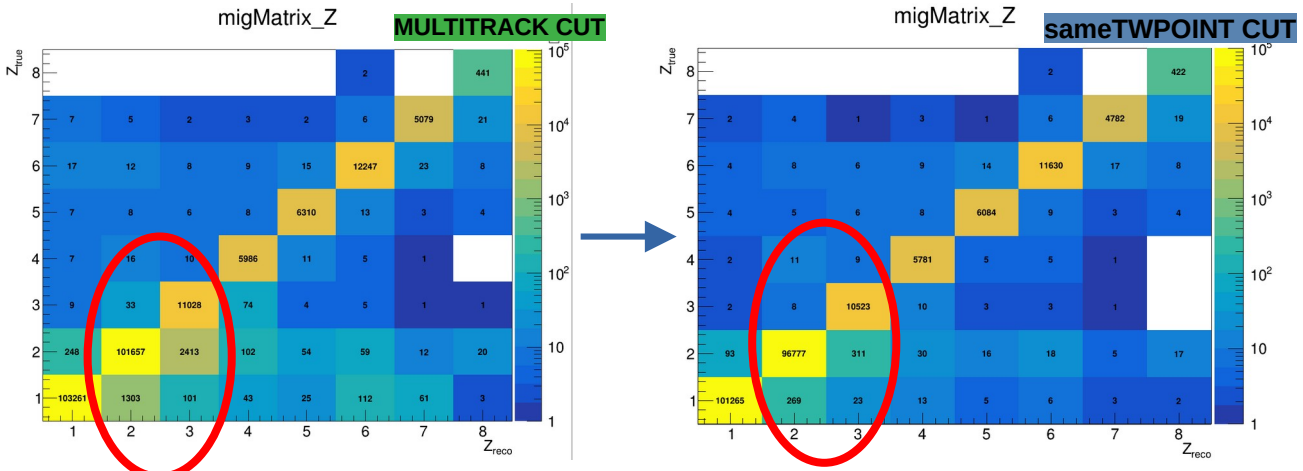

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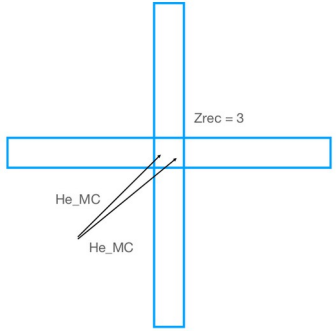
Still bad Z_{reco} = 3 out of diagonal



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- Let’s inspect those tracks with a bad reconstruction of He fragments
- I retrieve all the MC ID of the particles belonging to each point of the track:

```
TrackMCIds:: [[5, 6], [5, 6], [5], [5], [5, 6], [5], [5, 6], [5], [5, 6], [5], [5, 6]]
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MSD points

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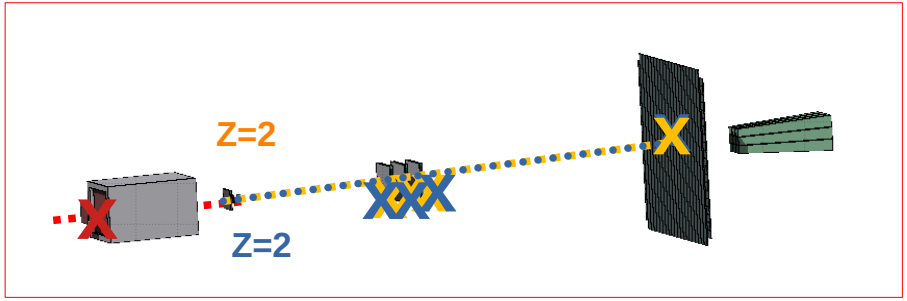

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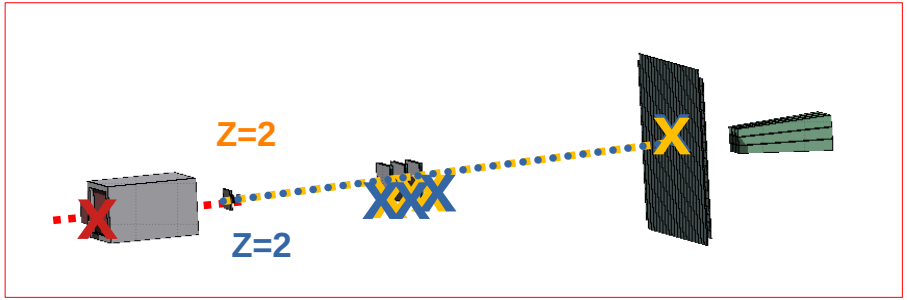

- The global tracking reconstructs only a track (as the merge of two different particles)
  the **TW cut** (same twpoint in different tracks) **is not working** in these cases!

for alpha clustering at the previous GM:
https://agenda.infn.it/event/37748/contributions/217798/attachments/114168/163750/Presentazione%20GM%20Alice.pdf

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  - where points have **MC IDs of two He**

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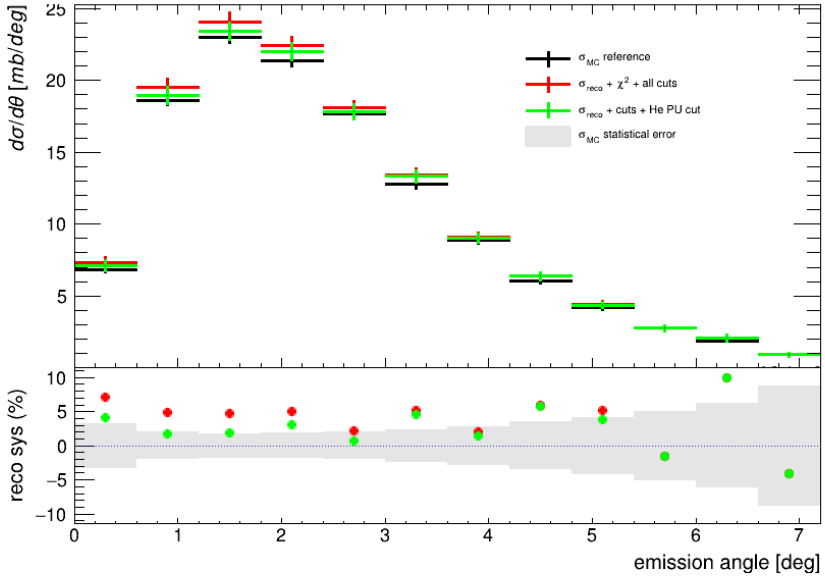

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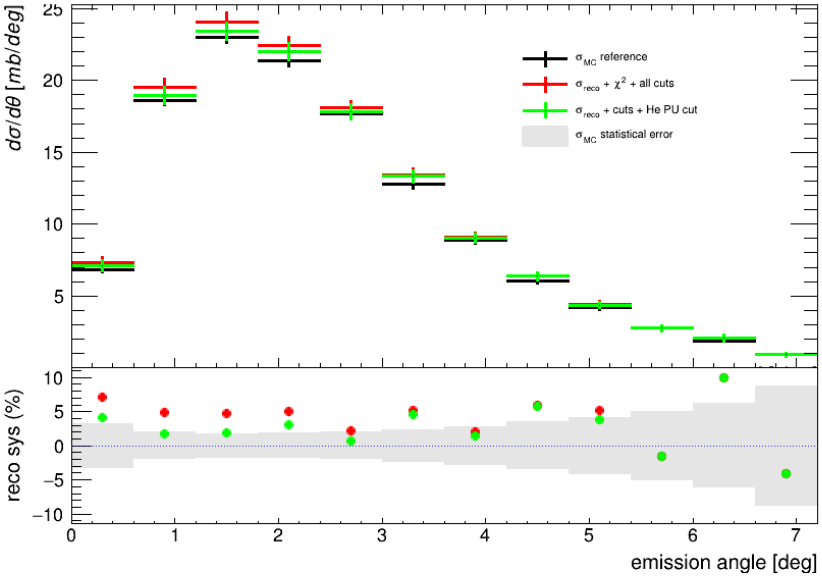
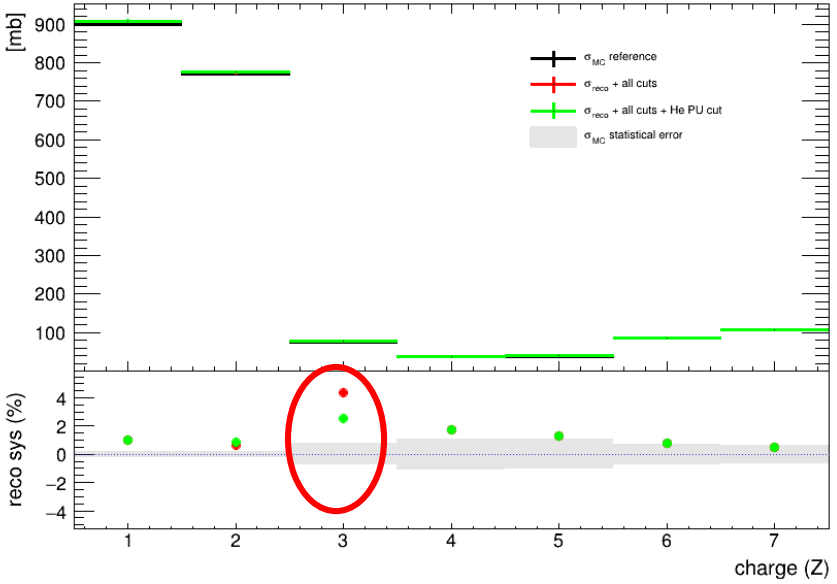


elemental cross section



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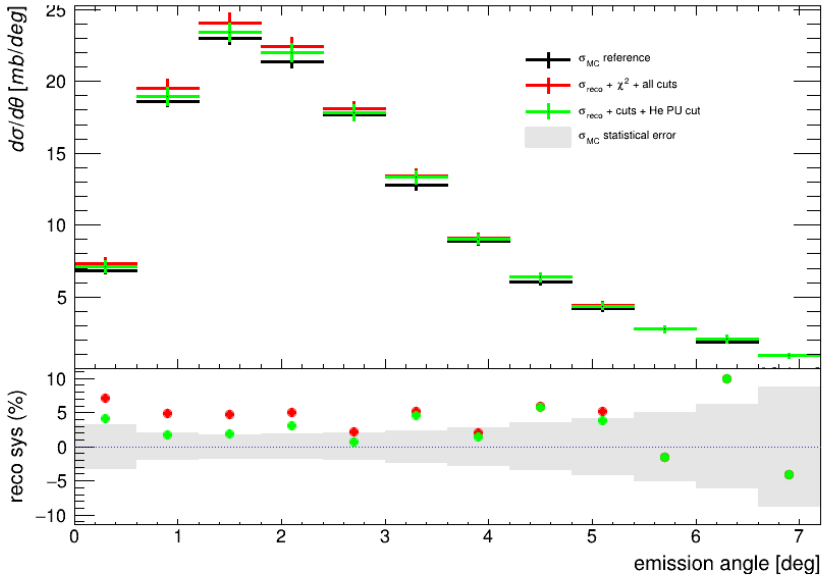

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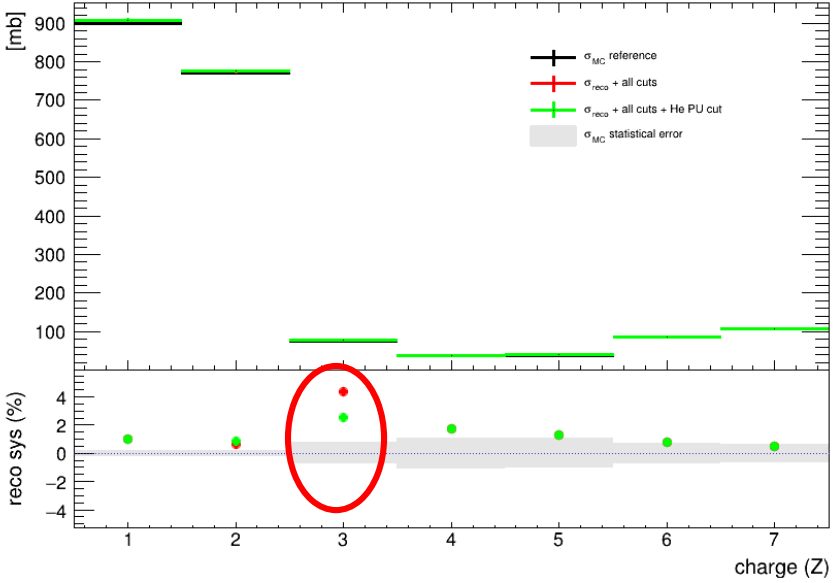

- Improvements in Z=3 differential cross section **up to ~ 2%** → the impact of these events is not negligible
- How to implement a **cut via reconstruction** to consider this?

He PileUp

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  - **improvement for ^{3}Li (not only) higher than for the Pile Up term**

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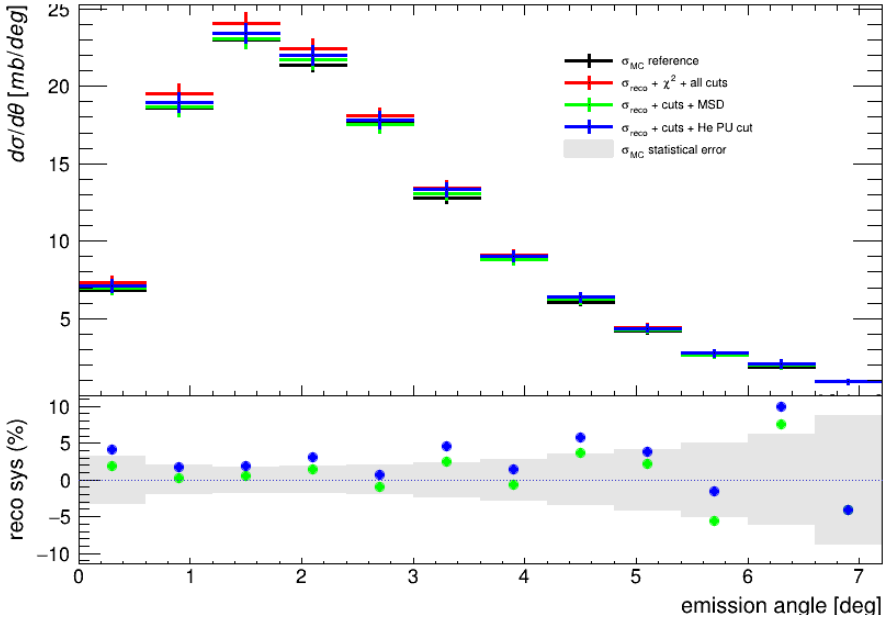

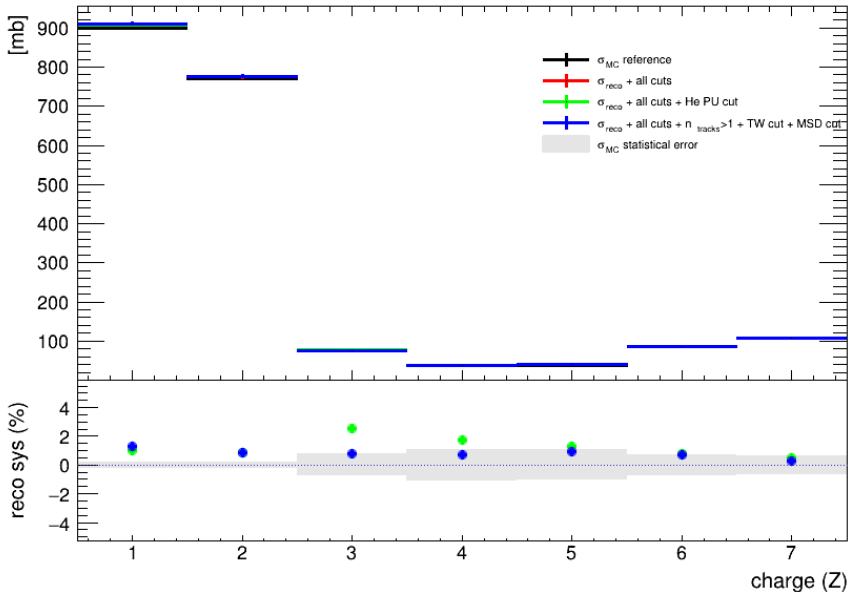

Conclusions

- Applying **Quality Cut**, **Multitrack Cut** and **same TWpoint Cut** **a discrepancy of ~ 5 %** is achieved in a **MC closure test** for angular differential cross section and elemental cross section reconstruction vs the true cross section.
- Such discrepancy can be accounted as a **systematic error** in our reconstructed cross section

- Fixing the choice of **primary events** refines the systematic

- **He fragmentation** is under the intrinsic limits of FOOT up to now.
  Improvements could be introduced working with **MSD** (charge reconstruction) after studies about its energetic resolution .

Conclusions

PREVIOUSLY ON...

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How to further improve our reconstructed XS and reduce systematics?

- Main criticalities to be faced for cross section measurements using Global Tracking:
  - **Fragmentation out of target** → investigate more feature of secondary fragments tracks
  - **TW instrinsic limits** → **MSD charge reconstruction** could be of help (to be checked with MC truth before implementing reconstruction)
  - → $E_{kinetic}$ measured by **calorimeter** should be very different for fragments in the same TW cross!
- check how using the **Z information from other detecto**r (VTX and MSD) improve track quality and so background rejection
- Check if **angular unfolding** is needed

What's next?

- Let's move to **real data** of GSI2021 campaign
- study thresholds and detector efficiencies in **data** for MSD and VTX and tune MC accordingly
- studying the MC reconstructed cross section as a function of **beta** bins
- Let's move to MC dataset with **full setup**
  (in preparation for CNAO2023...)

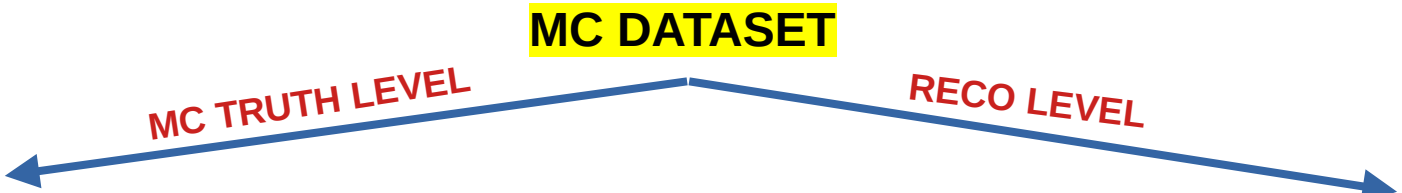
Conclusions

Thanks for the attention!

Back-up slides

Analysis strategy

In the analysis, I am considering the following levels:



N_Reference (MC)

all TAMCParticles
- primary beams
- primary fragments generated in the TG
- which cross the beginning of TW

(all the particle inside the geometrical acceptance of the setup without secondary fragmentation beneath the detectors + check about gamma decay)

I take the **MC_ID** of the track
(most frequent id)

N_Good Reco

(Tracks with MC_ID which satisfies MC GENERATION requirements)

N_RECO

All reconstructed tracks by GENFIT + cuts

Analysis strategy

To compute angular differential cross section:

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

where:

Y:	fragment counts	**N_RECO**
N_{beam}**:**	n° of primary events	
N_{target}**:**	n° of scattering centers per unit area	
ε:	efficiency	**N_Good Reco** / **N_Reference (MC)**
Ω_ϑ**:**	angular phase space	