INFN BOLOGNA
Istituto Nazionale di Fisica Nucleare
Sezione di Bologna

NAIA v1.1.0:
Some checks for Nuclei Analyses

Alberto Oliva, Erwan Robyn & Alejandro Reina Conde
INFN Sezione di Bologna

Friday 29th of November, 2024

Situation Summary

- **The paper has been published (really?? Yes, really).**
- **This cross-check was triggered after some problems found in the Isotopes Analysis at BO by Erwan.**
- **Anyway, these checks are necessary to be consistent and are needed for the extension of the Light Nuclei vs Time analysis to new Data range.**

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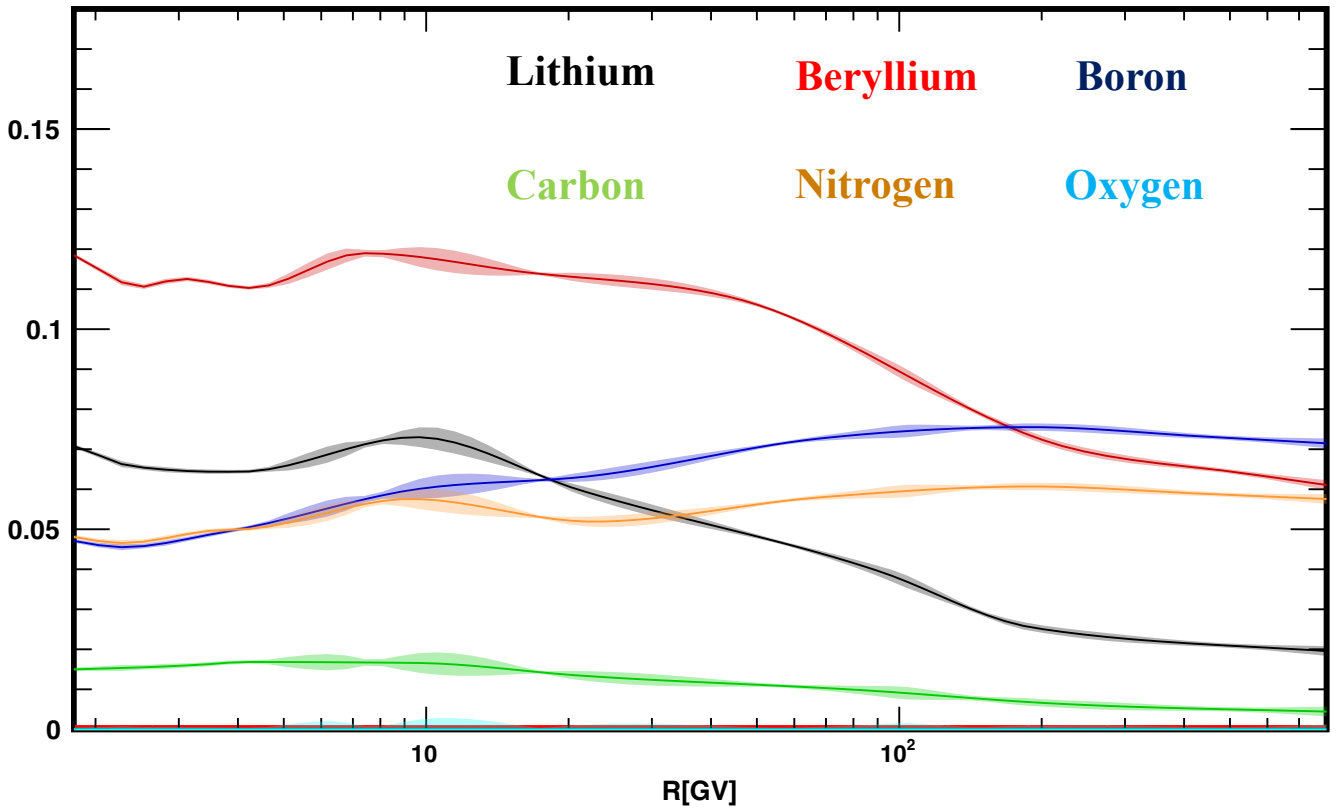
Somehow the Bologna TOI correction method used in NAIA v1.0.0 MC.B1236 is:

- Not working for the NAIA v1.1.0 MC.B1236 (same MC but different NAIA version)
- Working NAIA v1.1.0 MC.B1308 (different MC and NAIA version)

Top-Of-Instrument (TOI) correction (before partial XS)



Fluxes of heavier species (AMS-02 or GALPROP)

"folded" acceptance of particles selected as Z_i that with charge-change interaction to Z_i happening before L1.

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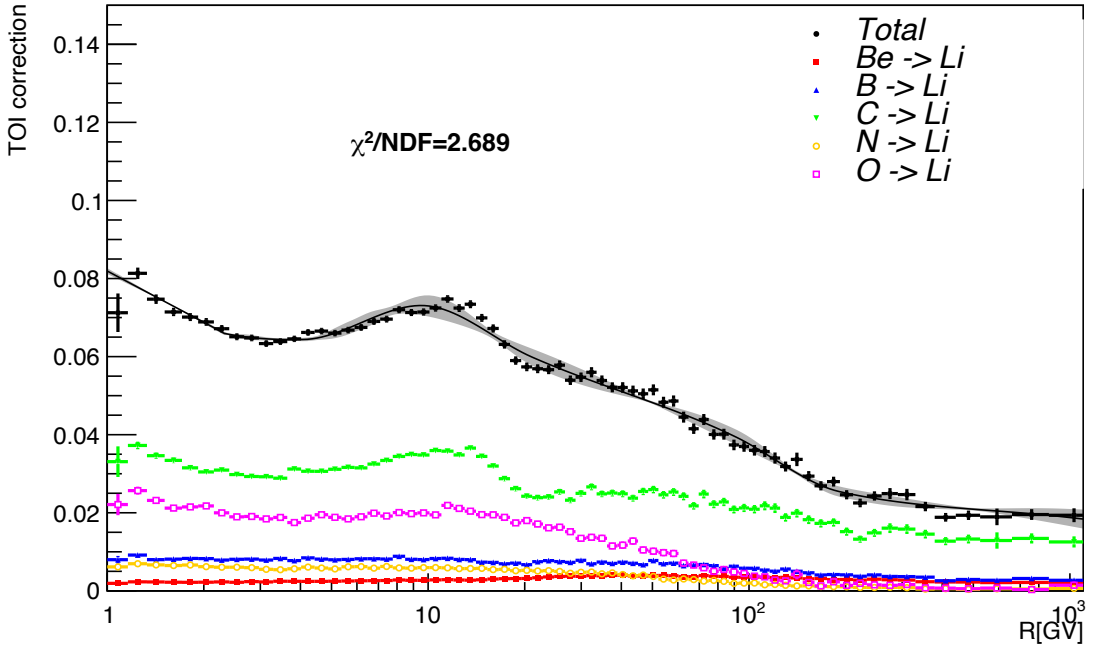
Measured rate of specie Z_i.



The estimation has been done using Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen MonteCarlo.

We need to take into account Partial-XS when doing TOI.

Before it was a normalization factor

```
// yao, 01/12/2020
if      ( (Zfrom==10)&&(Zto== 9) ) { a = 1+0.103; ea = 0; }
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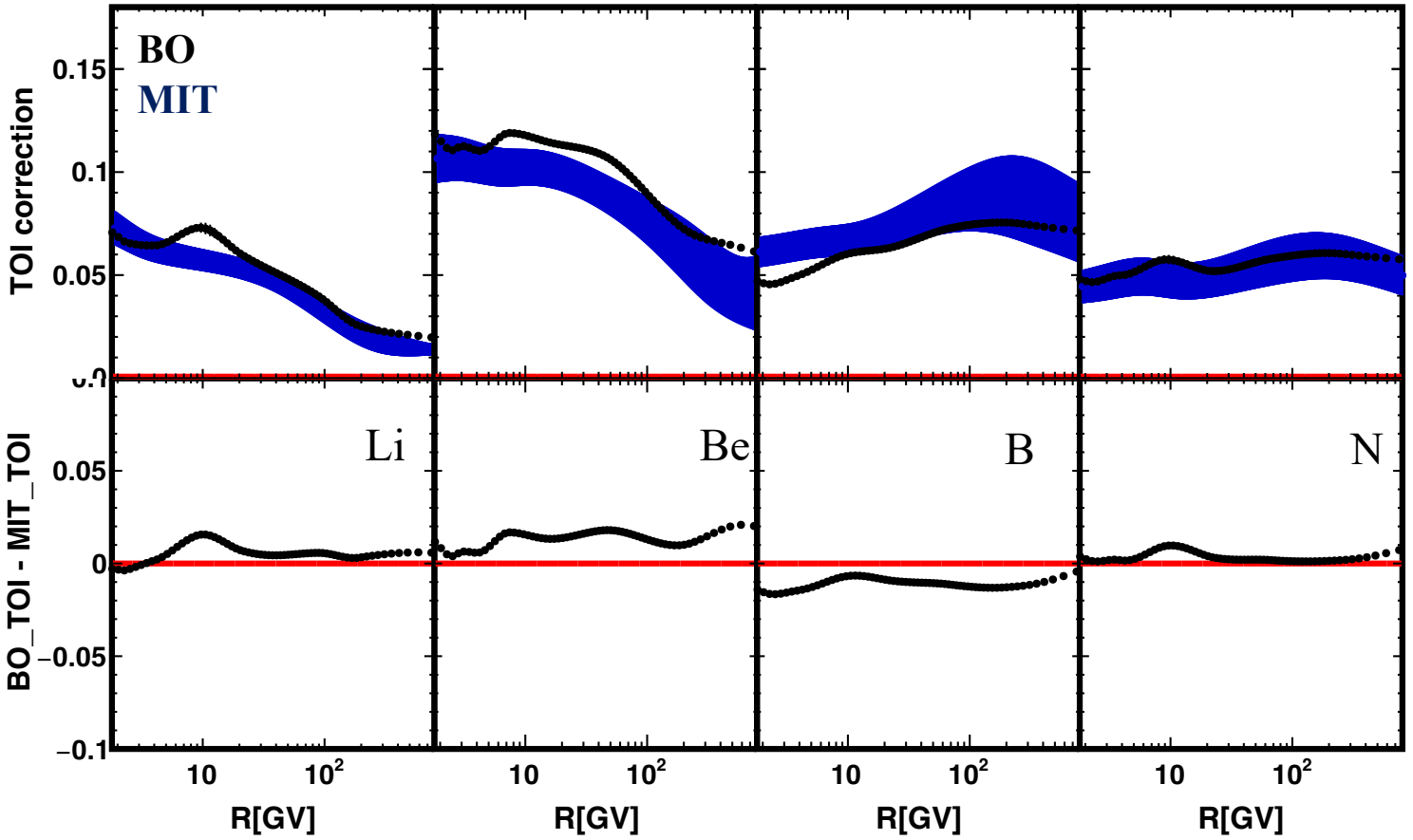
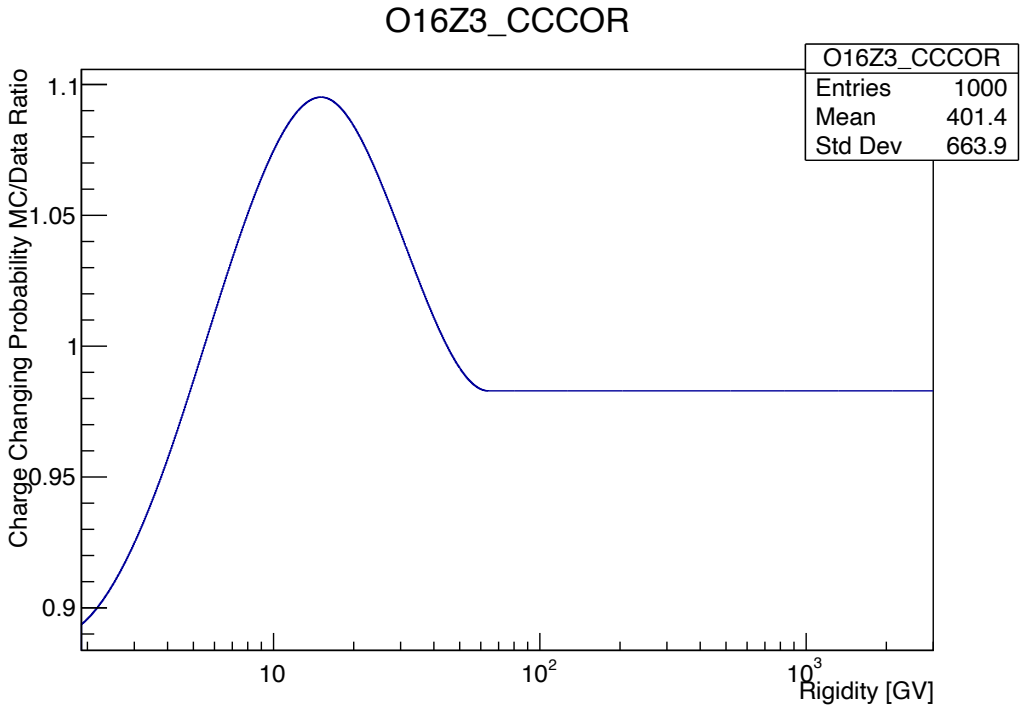


The partial-XS are now dependent on Rigidity, as an example O16 Montecarlo into Lithium



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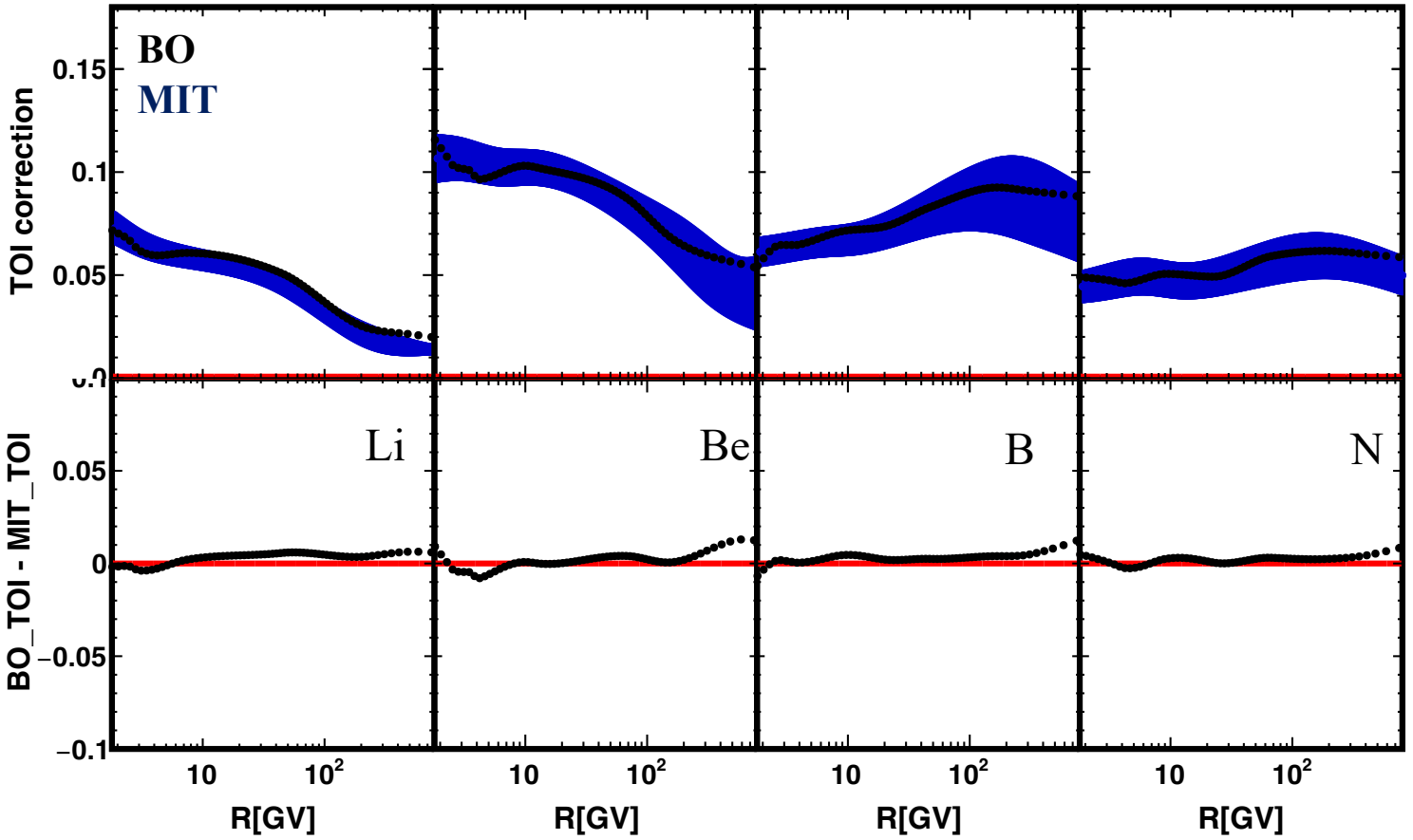

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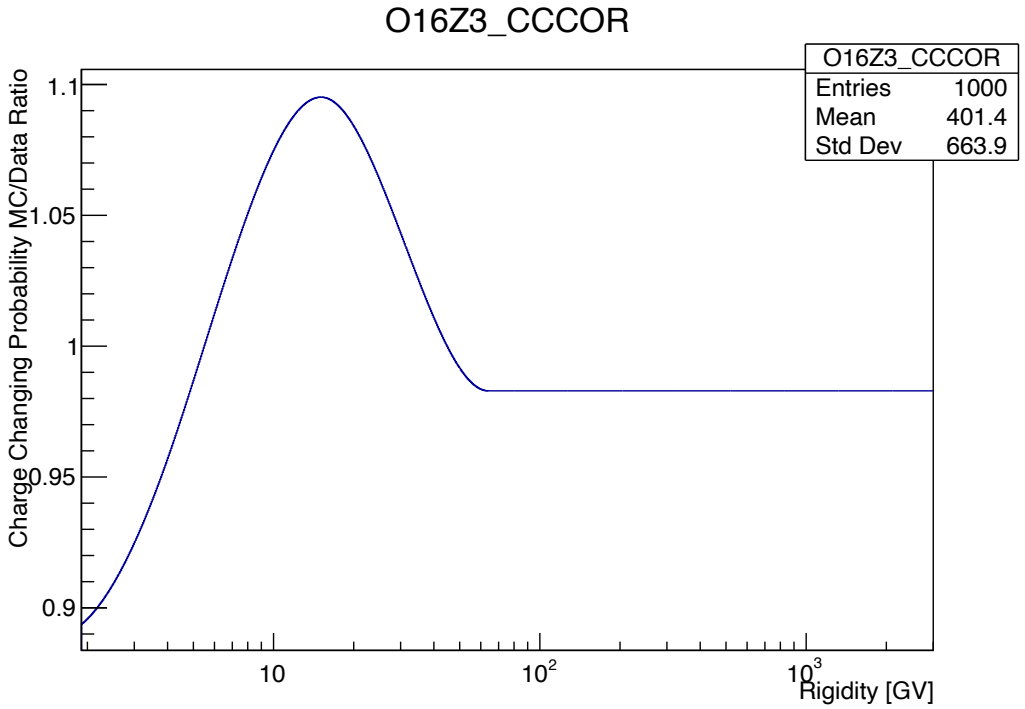
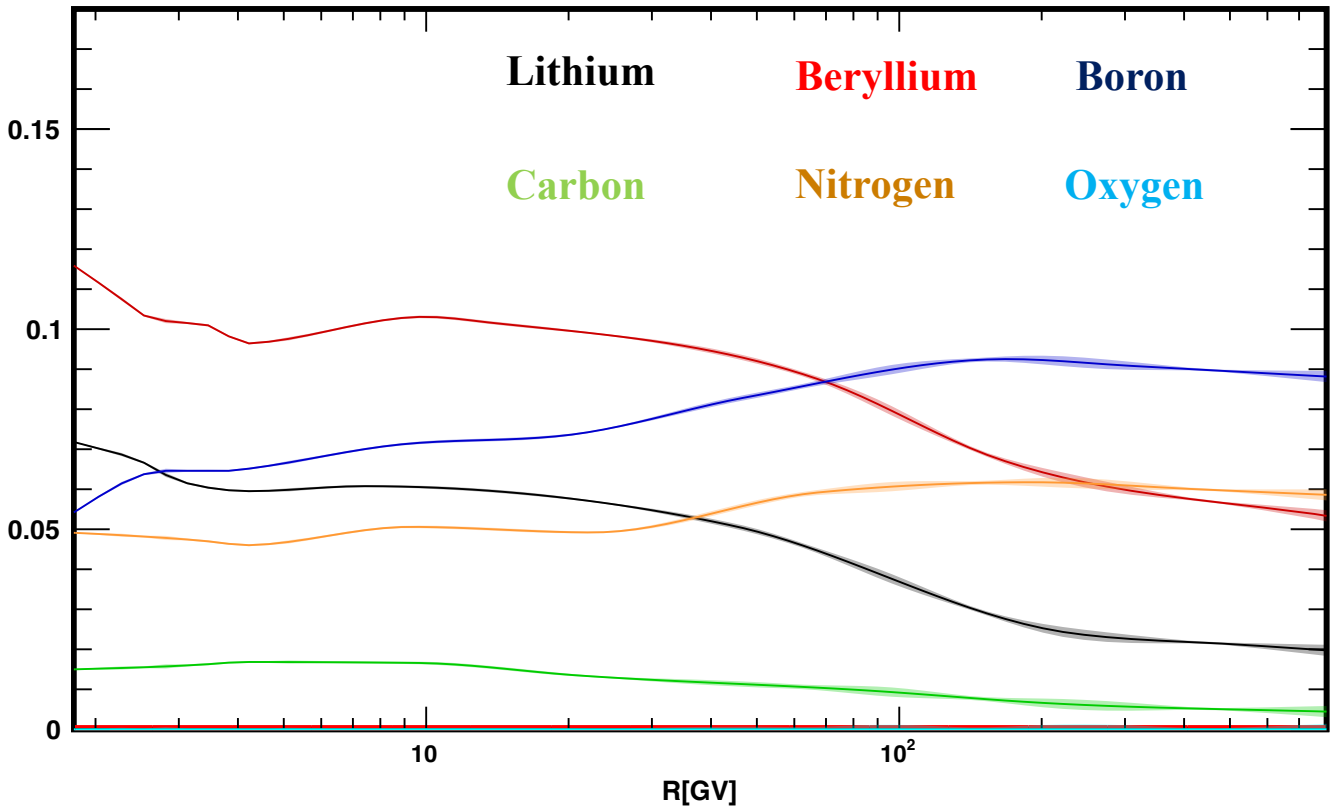


Top-Of-Instrument (TOI) correction (after partial XS)



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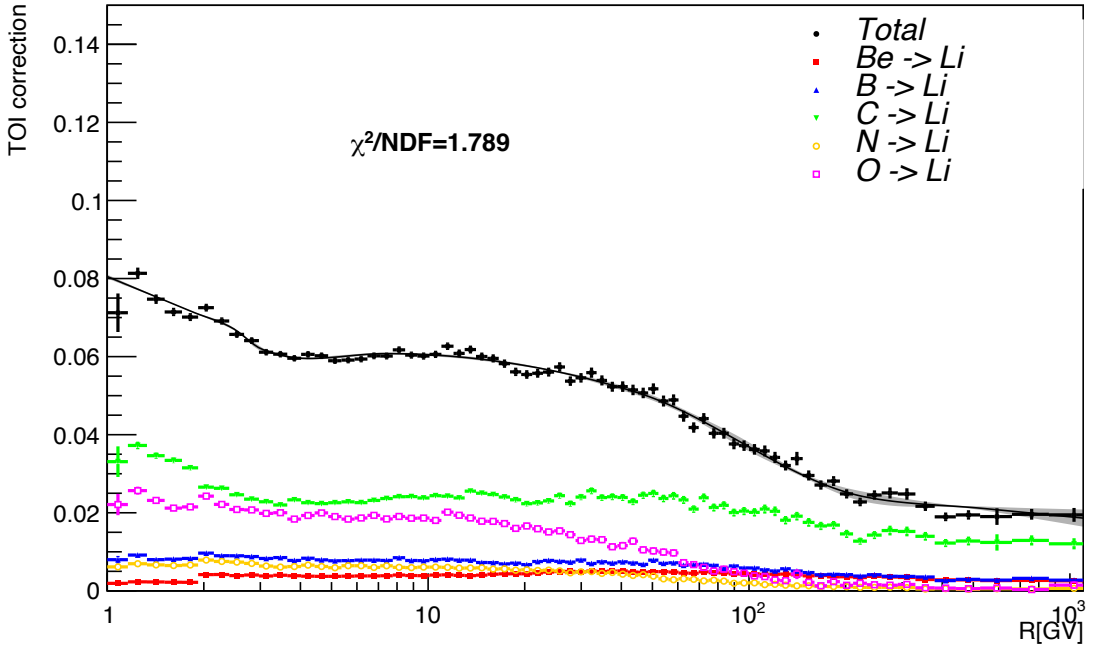
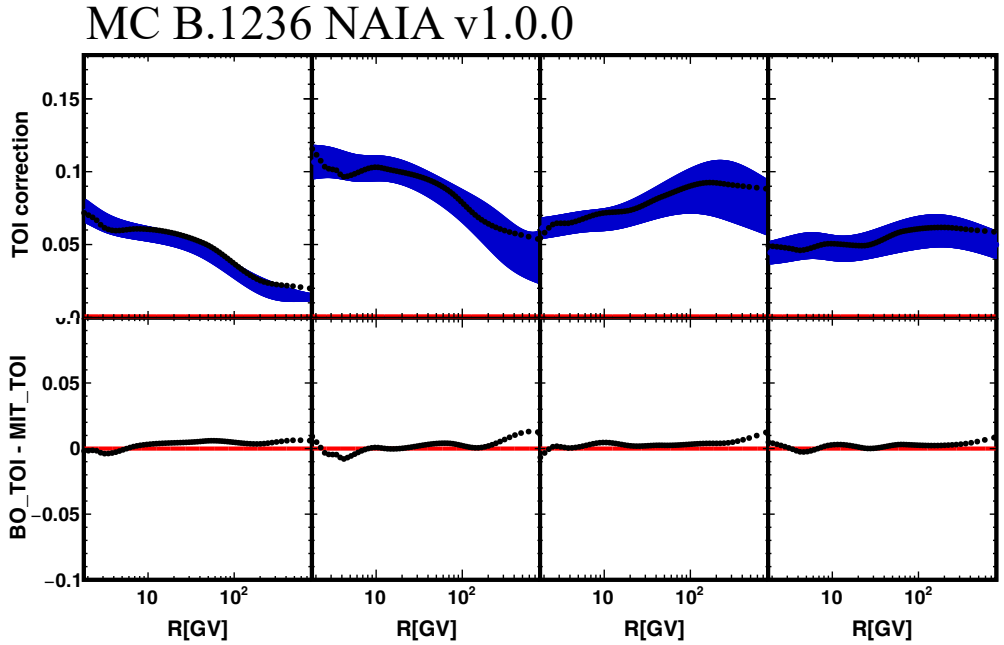


The estimation has been done using Lithium, Beryllium, Boron, Carbon, Nitrogen and Oxygen MonteCarlo.

The differences between TOI w/o partial XS is added as a systematic error.

TOI for the three MC/NAIA combinations



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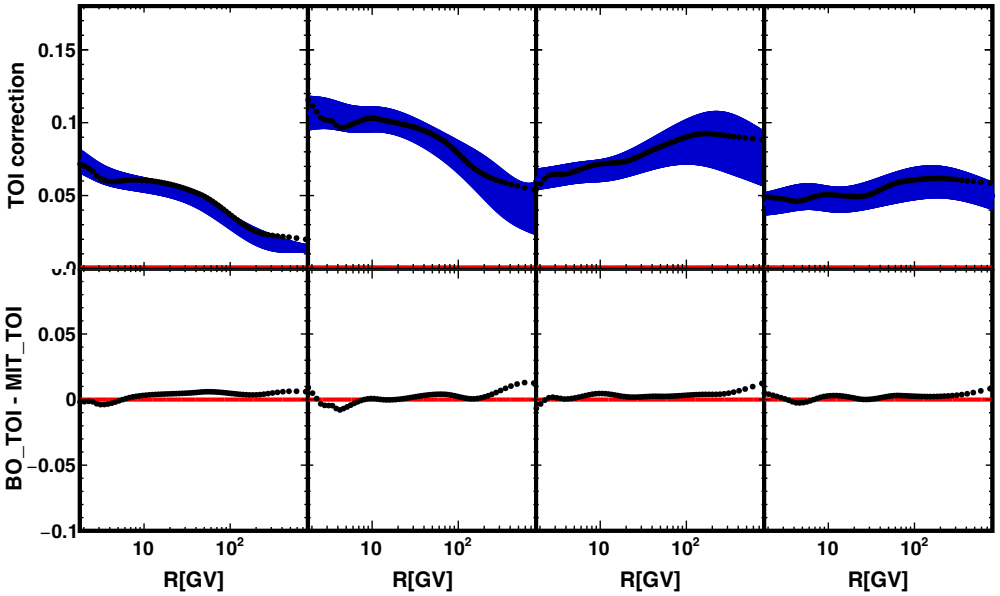
MC B.1236 NAIA v1.0.0



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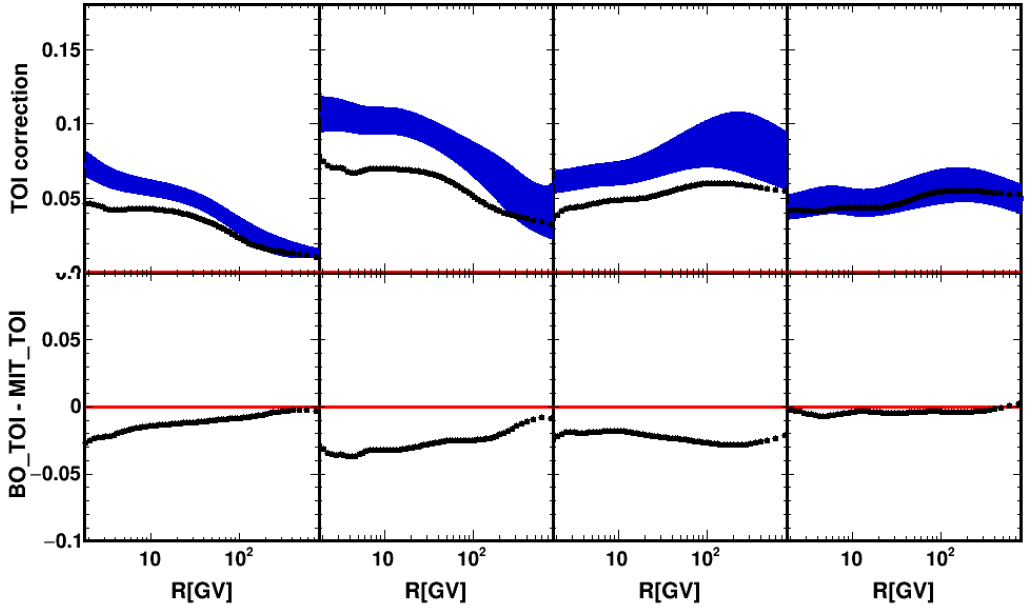

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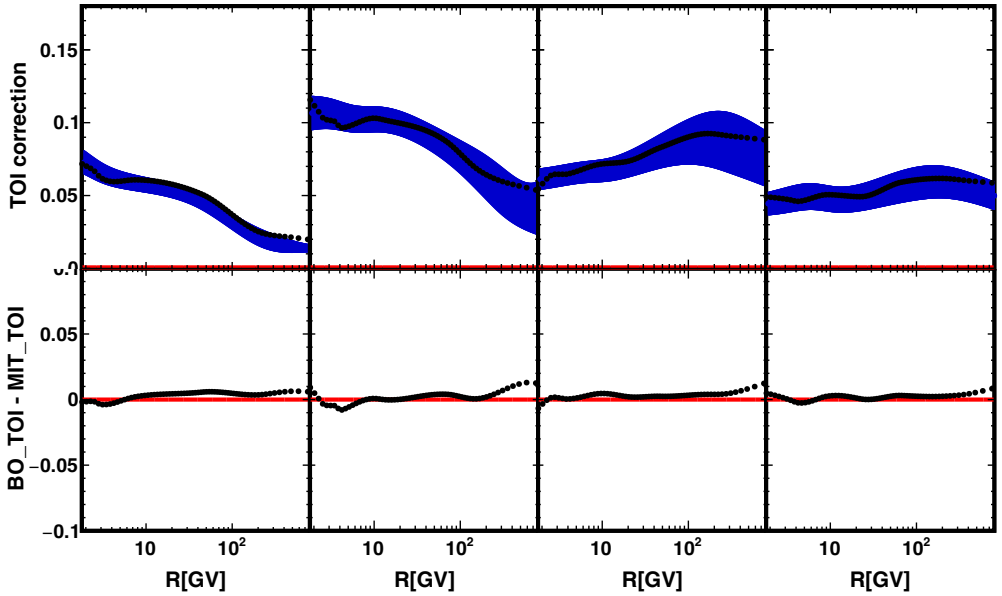

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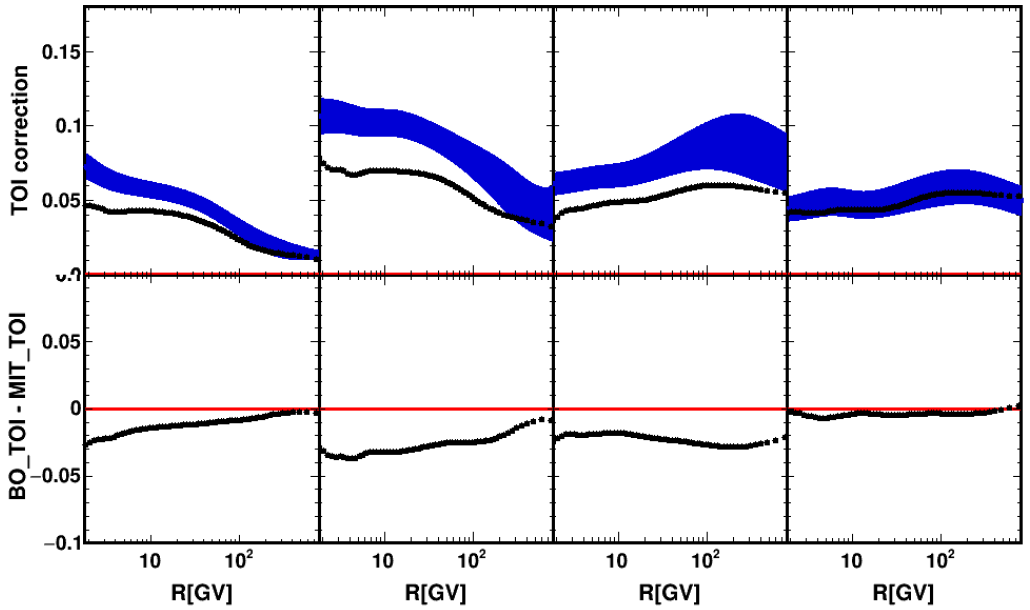
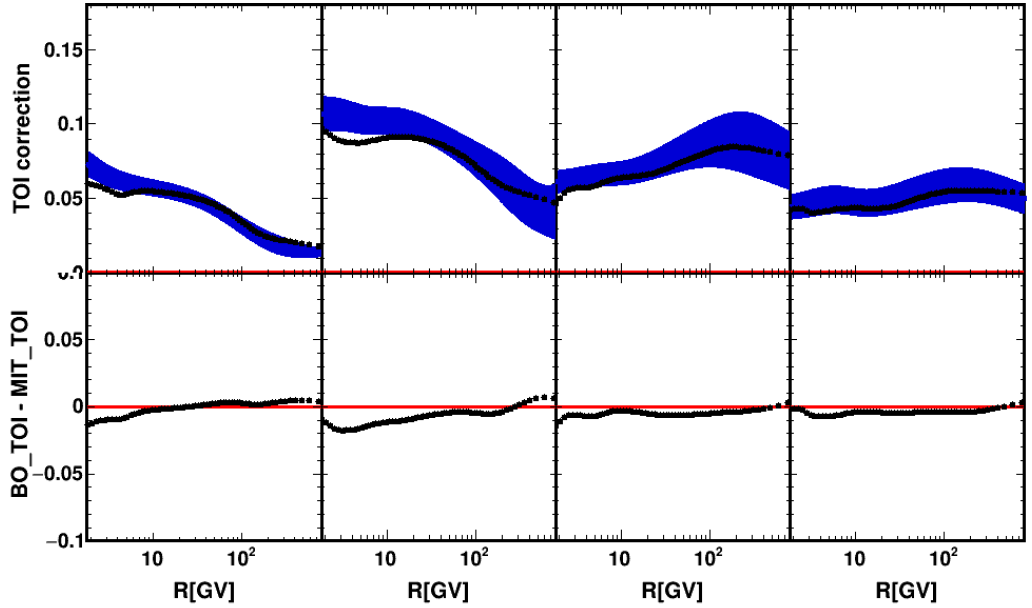


MC B.1308 NAIA v1.1.0



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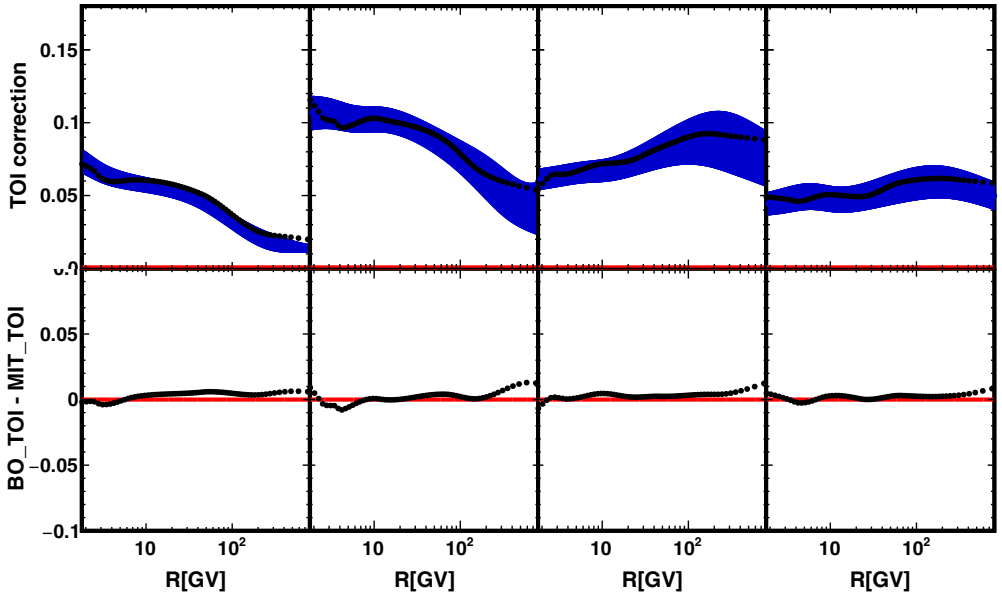

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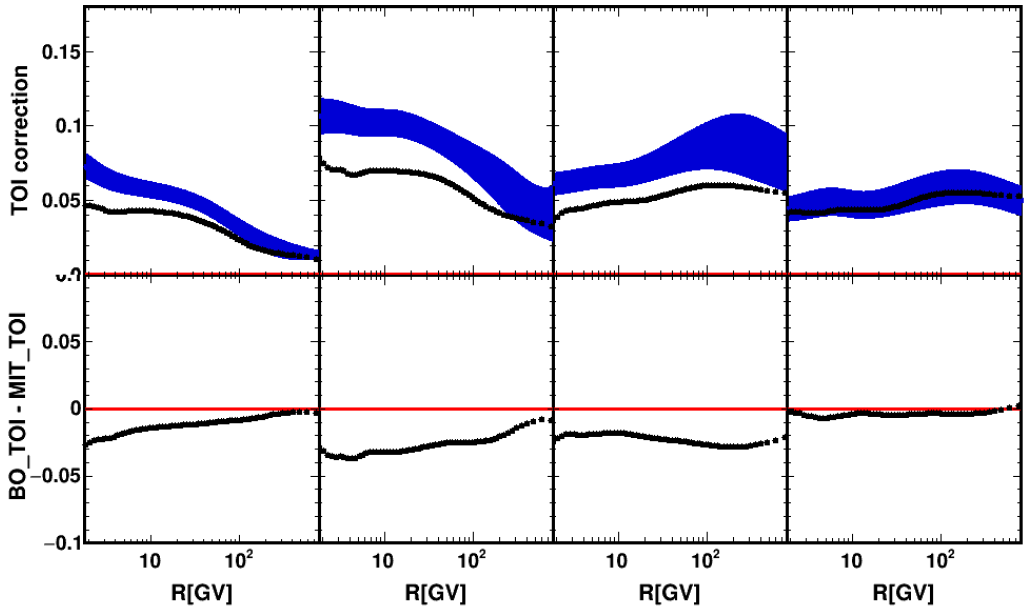

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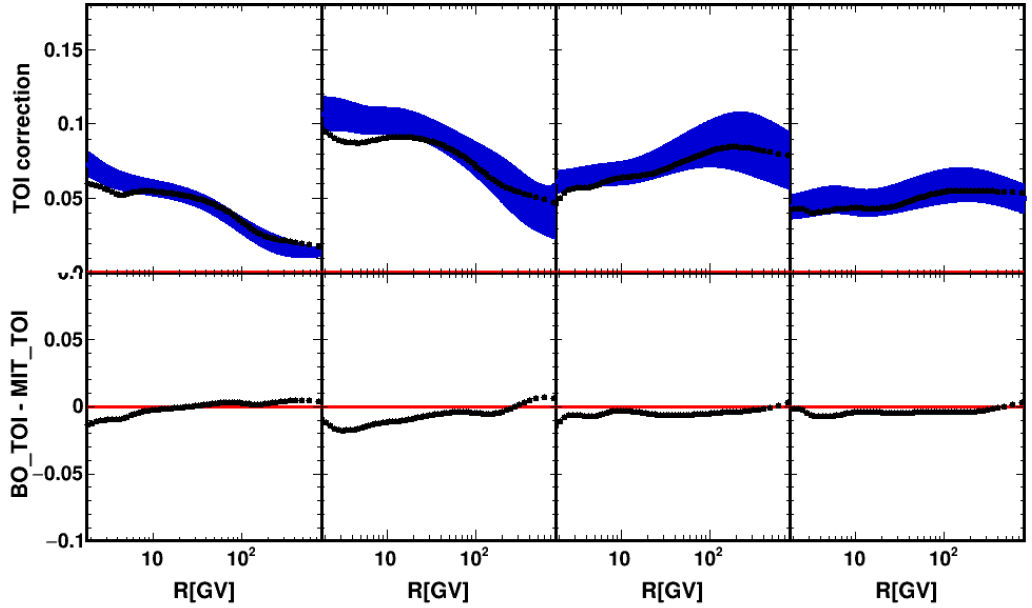

- **Why for the same MC B.1236 TOI is not the same among NAIA versions? (nothing changed in the MC side)**
- **MC B.1308 NAIA v1.1.0 is close enough to consider it fine, still we will see.**

MC B.1236 v1.0.0 vs MC B.1236 v1.1.0

In principle, the TOI of these two should be roughly same:

1. **We did not change anything in the Bologna selection.**

2. **New NAIA implementations could explain some small differences, but not this huge one. (Remember here that MC B.1308 v1.1.0 is giving almost the same TOI)**

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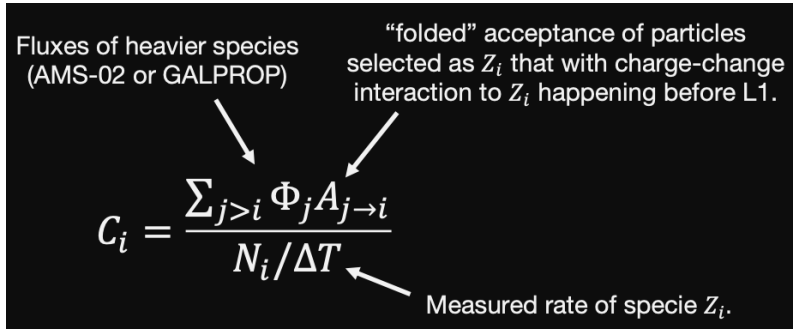

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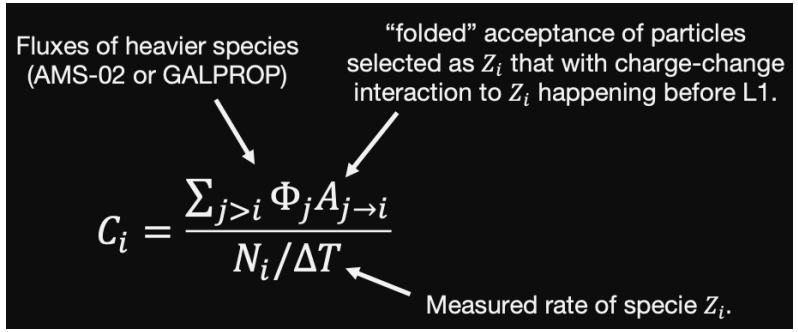

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NAIA runs ^{6}Li	4641	4026	1.1527571
NAIA runs ^{7}Li	5286	5374	0.98362486

Only checked for Li, since Erwan is doing Li isotopes.
Could be checked in general.

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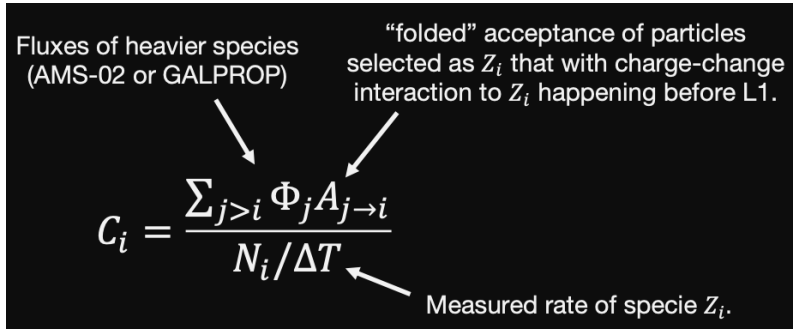

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- **This explain the differences in the TOI (and, for sure, in other ingredients of the analysis that I did not check).**
- **One could argue that the Global Li MC would be safe if the % lost/gained in ^{6}Li is the same as in ^{7}Li.**
- **It is not the case, so the Global = 0.5 ^{6}Li + 0.5 ^{7}Li is not applicable anymore.**
- **In other words, we have a different normalization.**

MC B.1236 v1.0.0 vs MC B.1308 v1.1.0

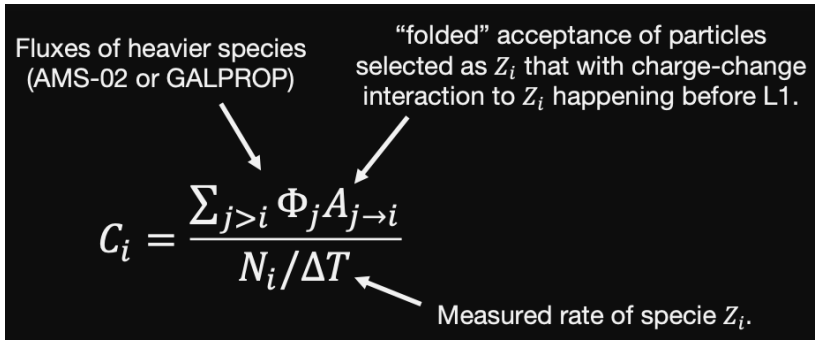
Differences found in the TOI:

1. **New NAIA implementations? Not probable, I think they don't affect what we use in BO to estimate the TOI.**

2. **New MC Beta implementations? Could be, for the TOI you are using the R_{reco} (folded acceptance) which is corrected with Beta.**

In this case is more difficult to track from where the differences are coming.

I tried anyway, but it is still on going.



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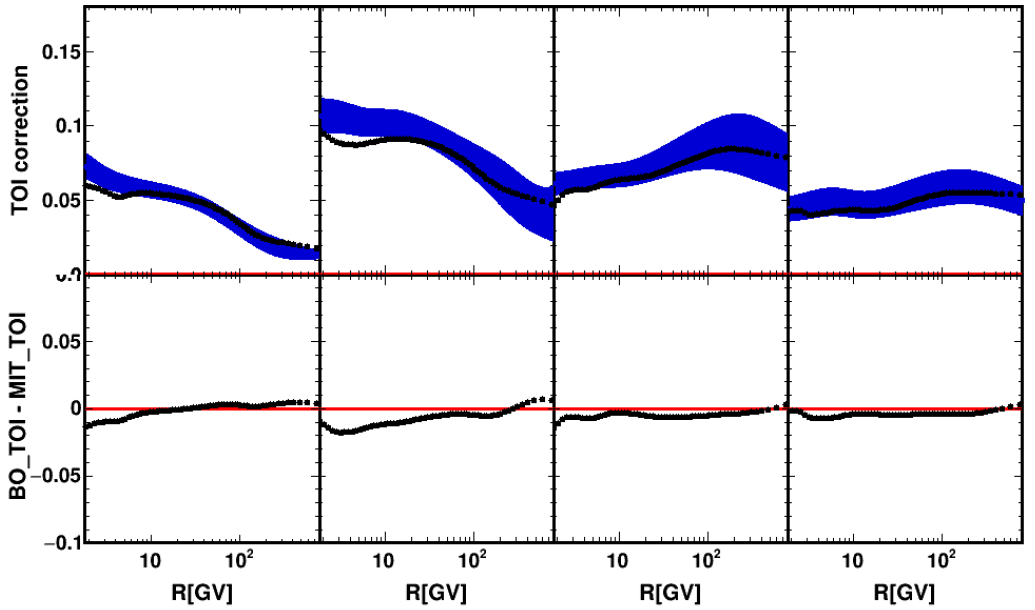

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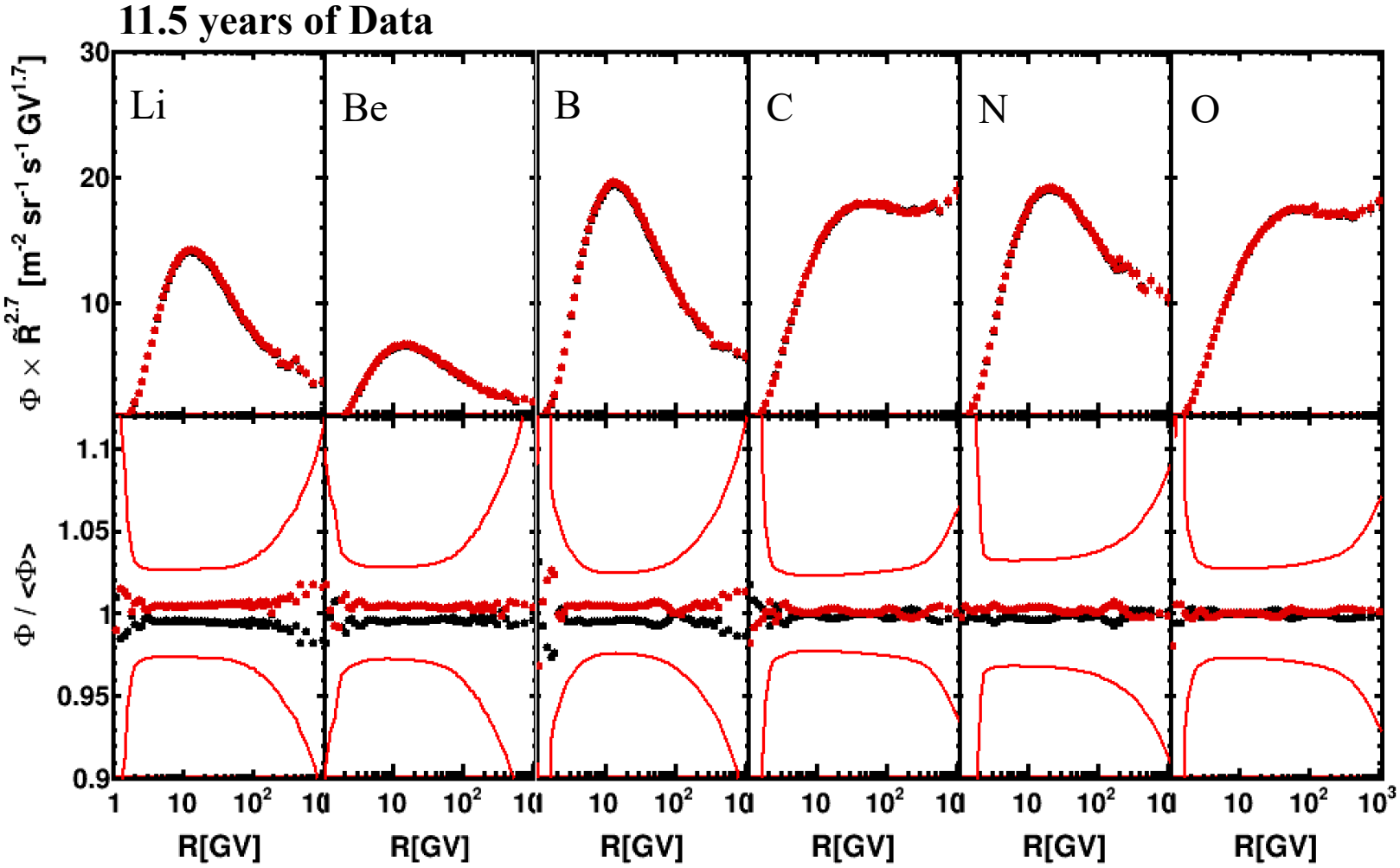

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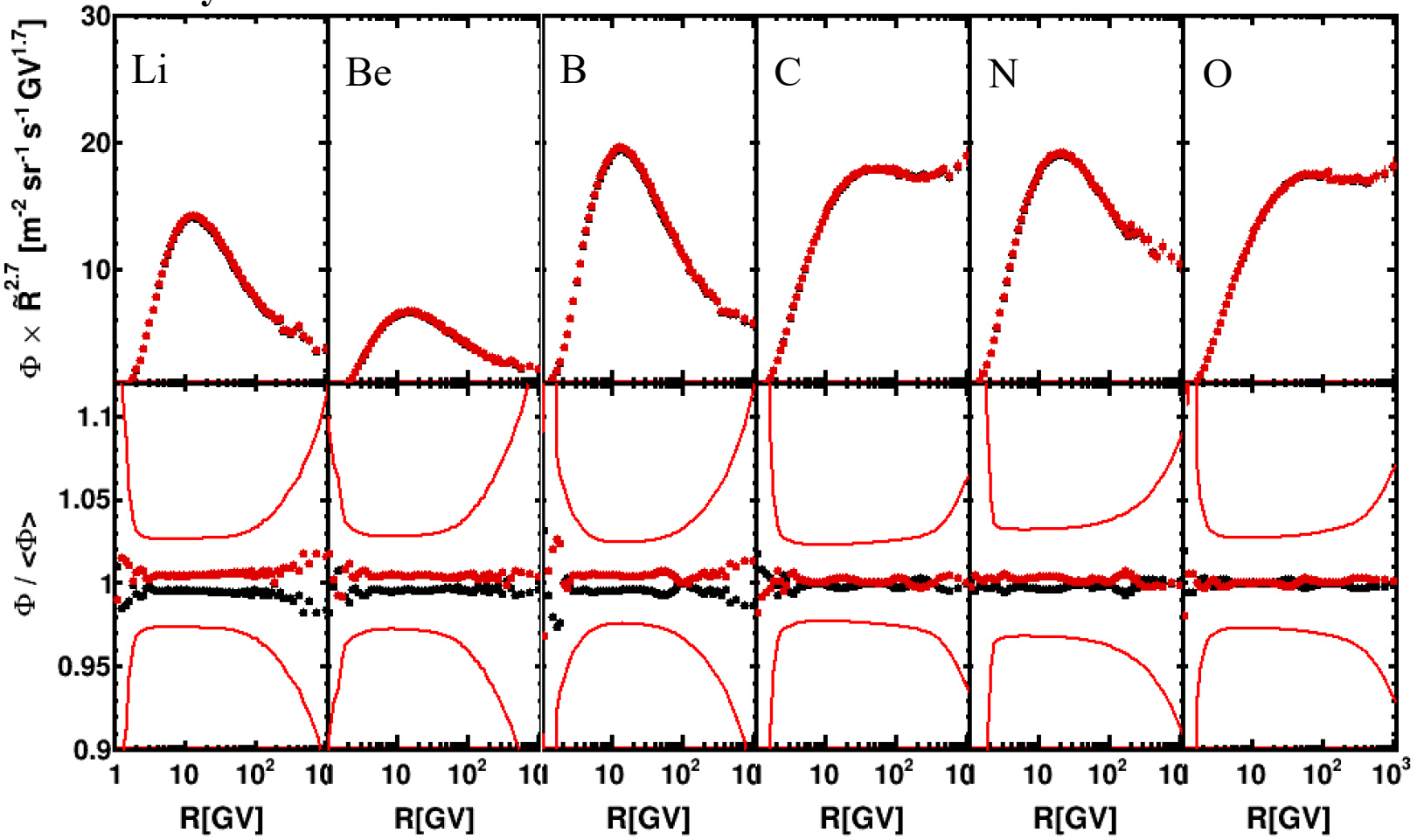
11.5 years of Data



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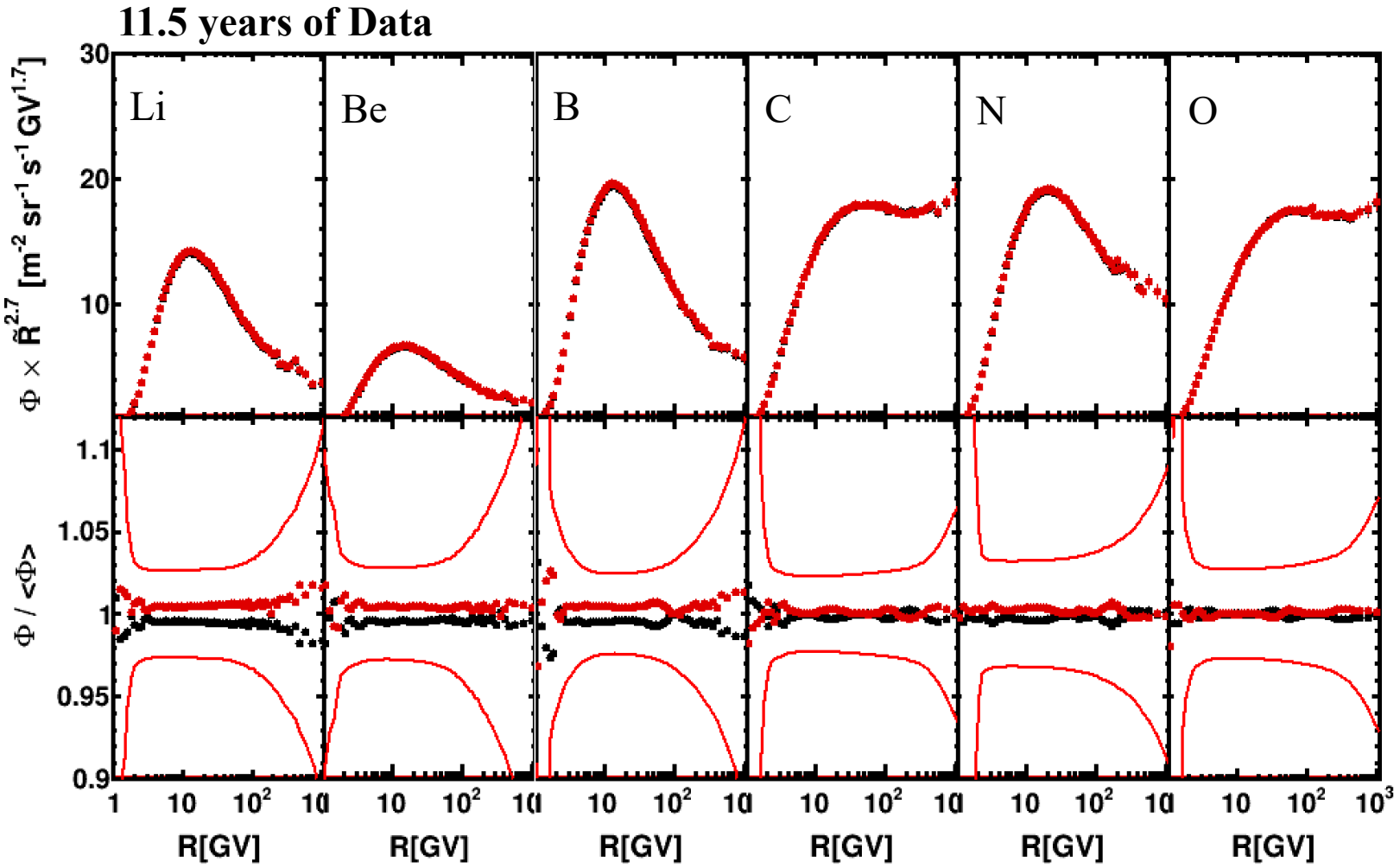

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- **TOI differences could come from the Rate differences.**
- **TOI differences could come from the Partial XS used.****

** Which were calculated by Qi Yan for MC B.1236 and not MC B.1308.

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So we are safe from NAIA production point of view.

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What are the reasons for these differences then?:

- **Changes in the RTI files, you change the CutOff you change the other two.**
- **New implementations in NAIA related with this selection:**

1. We are not using here the TrackPattern implementation solution, but the work around we found in v1.0.0.
2. I don't recall any other data-related changes in NAIA. I have to check the repository.

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Conclusions

- **The MC B.1236 NAIA v1.1.0 is not ready to be used:**
  - I suggest people to use the MC B.1308 NAIA v1.1.0 for all the analyses, or stay in NAIA v1.0.0 if they don't need more than 11.5 years of Data or are not doing Isotopes.
  - Anyhow, would be good to have MC B.1236 NAIA v1.1.0 ready. Because then we are not missing the middle step. Ones could compare NAIA versions using the same MC version, and isolate from where are coming possible differences, NAIA or MC.

    For Valerio: How painful is to re-do MC B.1236 v1.1.0?

- **Further checks will be done to address the differences found for the same ISS B.1236 data version using the different NAIA versions.**
- **After these things have been solved, an extension to the extra one year of data (up to Bartels 2594 now, was 2581 before) would be kind of "easy" to do.**

  For Valerio: Baosong already said there is even more data ready, when are you planning to produce it?.

Conclusions

- **It would be really good if someone in AMS-Italy estimate the Partial XS:**
  - Now is a good opportunity since it seems Yao Chen would be the responsible for this, and maybe not Qi Yan anymore.
  - Knowing that your fluxes were fine, and the differences were coming from the TOI was easier before, since it was a normalization factor. Now, it is not the case. On top of that you have to ask one of the two guys above.

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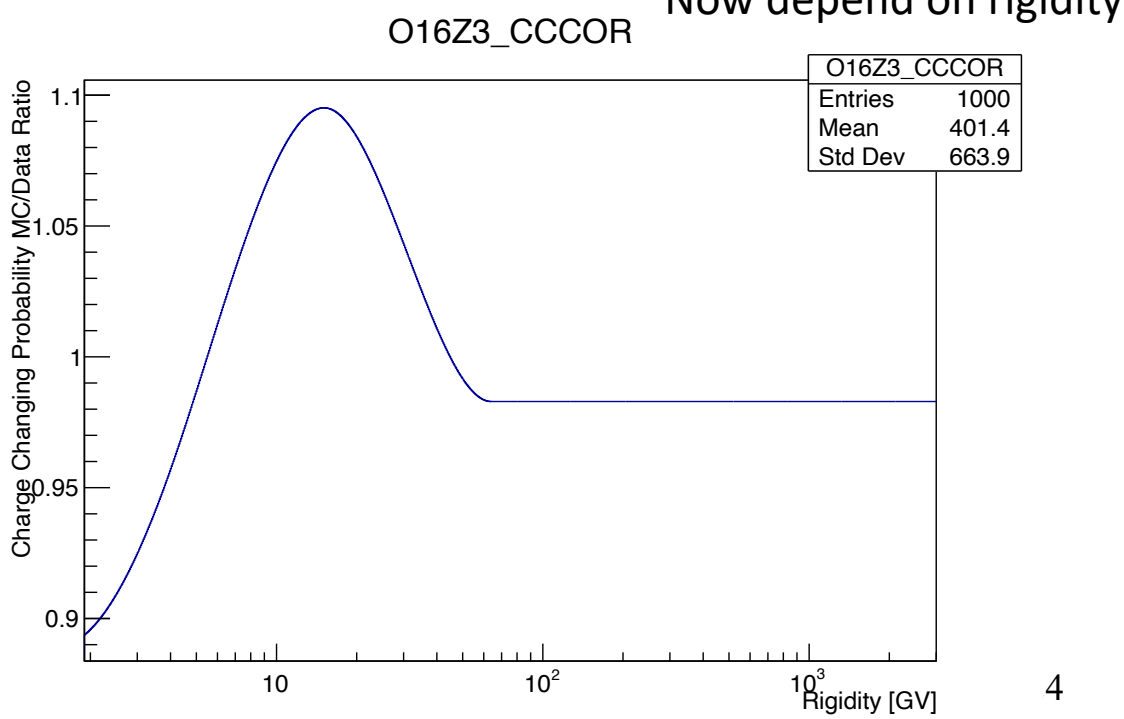
Now depend on rigidity



Back Up

Top-Of-Instrument: Selection

To estimate when the MC particle has interacted and became another one before Layer 1, you need to fulfill two requirements at the same time:

1. Particle was not the primary (generated) particle at Layer 1.

```
auto primary = mcTruthBase->Primary;
generated_charge = primary.Z;
if (NAIA::ContainsKeys(primary.Momentum,NAIA::MCTruth::MCHeight::GenerationPoint))
  generated_rigidity = primary.Momentum[NAIA::MCTruth::MCHeight::GenerationPoint].Mag()/generated_charge;
bool primary_at_l1 = NAIA::ContainsKeys(primary.Momentum,NAIA::MCTruth::MCHeight::L1);
```

2. Particle has a different charge of the primary (generated) particle. For this, we followed the next steps since some variables, as ParticleID (pID, Nskip, etc), were buggy:

```
   //Search the maximum momentum from the list of secondaries
   int sec_size = mcTruthPlus->Secondaries.size();
   double momSec = 0;
   double ZSec = generated_charge; //Should start being equal to ZMC so if there is no secondary ZSec!=generated_charge is false
   for (int ii=0; ii<sec_size; ii++){
     auto sec = mcTruthPlus->Secondaries.at(ii);
     if (sec.Position[0].Z()<159.04) continue; //Interactions above L1
     if ((sec.Z==0)||(sec.Z==-1)) continue; //Removing Z==0 and electrons (should jump gamma-ray and positrons too) (Implement pID
ARC)
     if (sec.Momentum[0].Mag()==0) continue; //Again, many secondaries with Momentum = 0 and Z!=0
     if (sec.Momentum[0].Mag()>momSec){
       momSec = sec.Momentum[0].Mag();
       ZSec = sec.Z;
     }
```

```
charge_change_before_l1 = (!primary_at_l1)&&(ZSec!=generated_charge);
only_charge_change = (primary_at_l1)&&(ZSec!=generated_charge);
only_not_primary = (!primary_at_l1)&&(ZSec==generated_charge);
```

Final condition -> TOI histogram

For other checks -> Two histograms

MC B.1236 v1.0.0 vs MC B.1236 v1.1.0

```
charge_change_before_l1 = (!primary_at_l1)&&(ZSec!=generated_charge);
only_charge_change = (primary_at_l1)&&(ZSec!=generated_charge);
only_not_primary = (!primary_at_l1)&&(ZSec==generated_charge);
```

Final condition -> TOI histogram

For other checks -> Two histograms