

NAIA/AMS-02 Italy Meeting:
Status of Nuclei Analysis
B, C, N & O

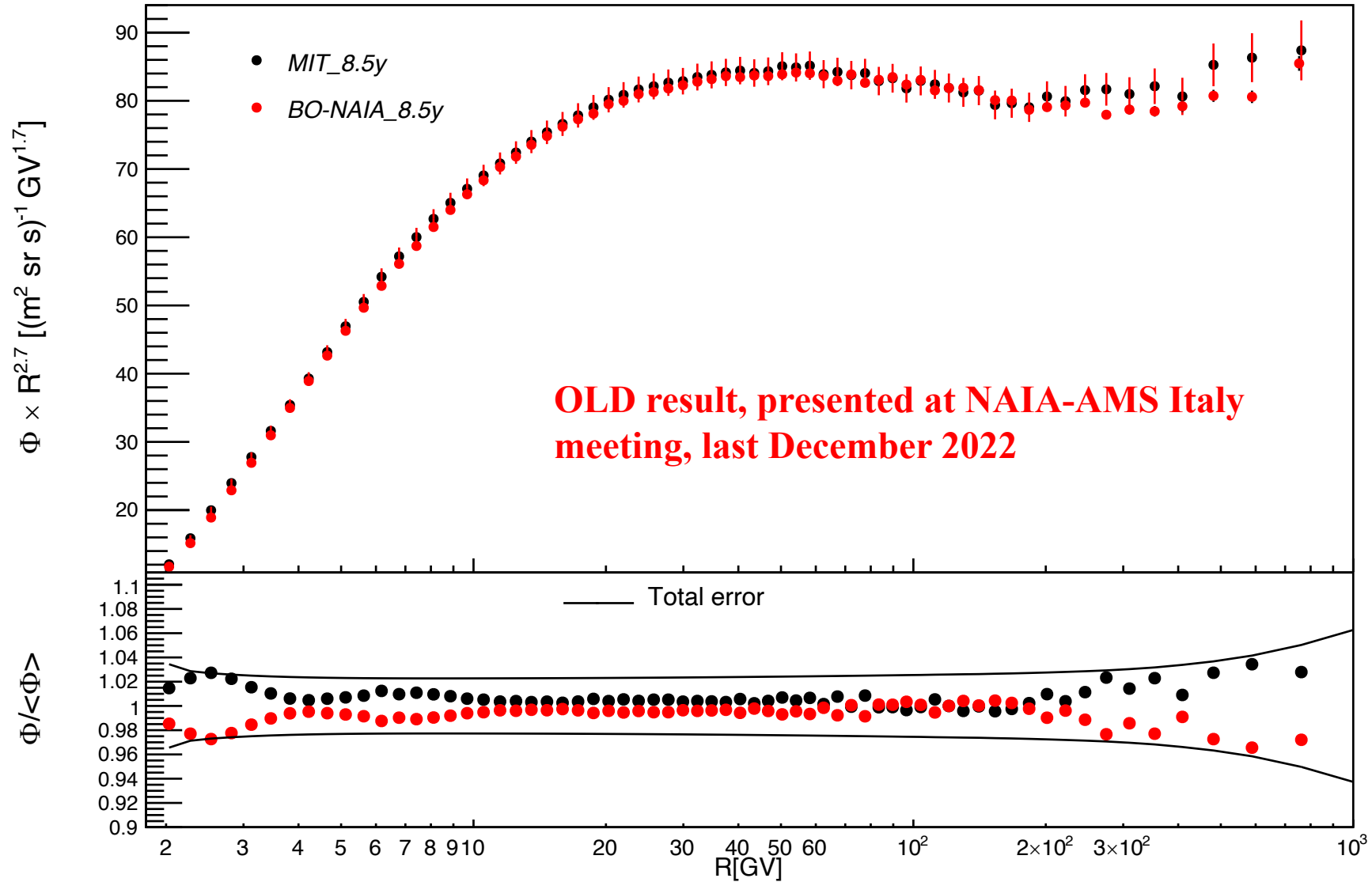
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Alberto Oliva, INFN Sezione di Bologna

Friday 21th of April, 2023

Some useful information

- **NAIA v1.0.0 ntuples**
 - First 10 years of AMS-02 pass8 data, from Bartels 2426 to Bartels 2560.
 - MonteCarlo pass8 B1236 for boron, carbon, nitrogen and oxygen.
 - RTI v7/v8, Valerio is re-processing it (maybe done already?)

Carbon 8.5 years flux : folded acceptance first iteration, no background subtraction



Inner-L1 selection

Orbital Cuts

A good second

Lifetime > 0.05

Zenith Angle < 40

Alignment ($|\text{IMD-PG}_{\text{IL1}}| < 35 \text{ um}$, $|\text{IMD-PG}_{\text{IL9}}| < 45 \text{ um}$)

Not in SAA

$R_{\text{Inner-L1}} > 1.2 \times R_{\text{ctf}}$

Not using the new RTI cuts proposed by Qi Yan

Selection cuts

Physics trigger

β with ≥ 3 hits

$\beta > 0.3$

Inner Tracker Y hits ≥ 5

$L2Y \& (L3Y \& L4Y) \& (L5Y \& L6Y) \& (L7Y \& L8Y)$

Normalize Inner $\chi^2_Y < 10$

L1XY hit on track with good status

Normalized Inner-L1 $\chi^2_Y < 10$

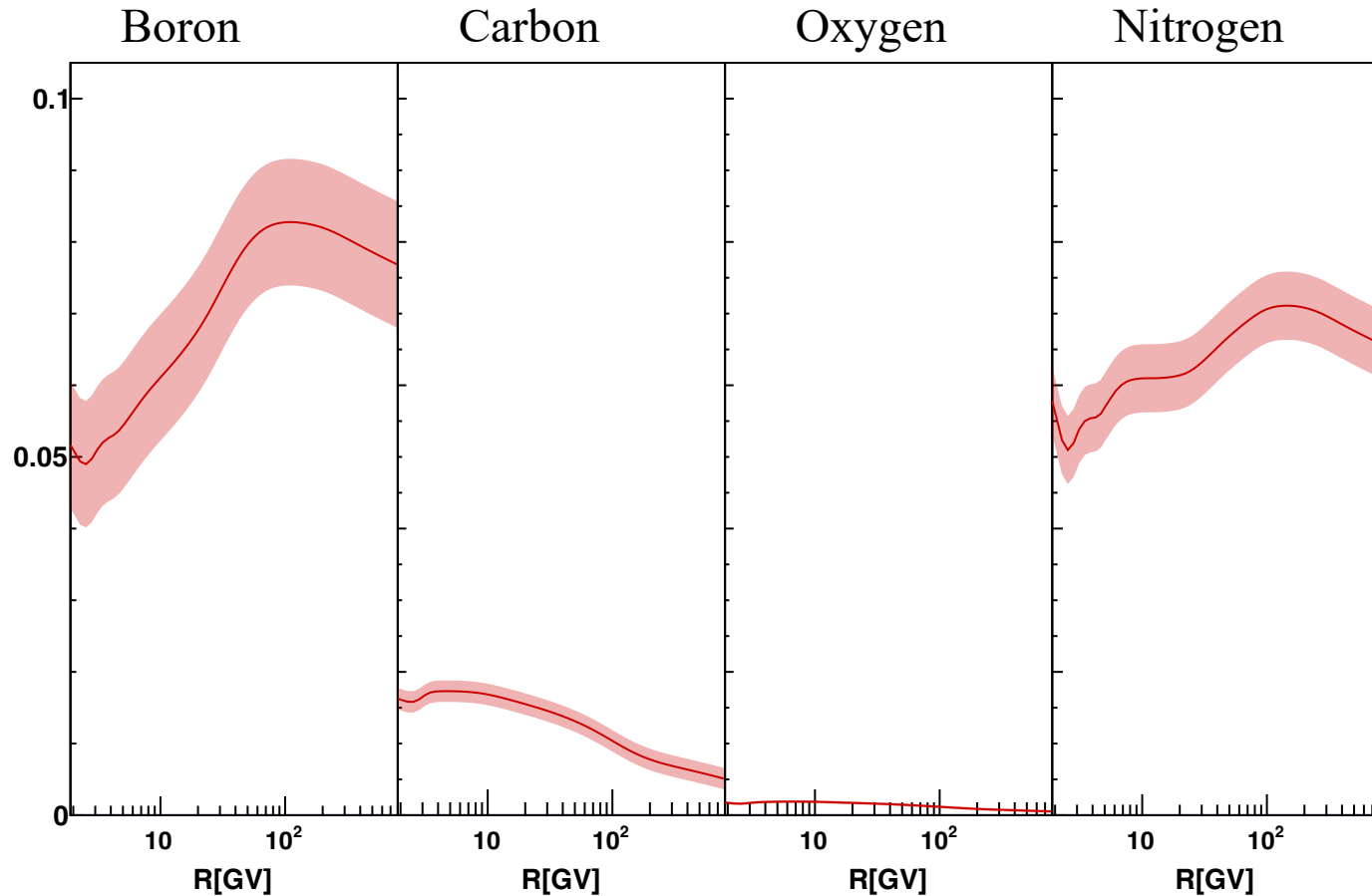
Charge cuts on L1, UTOF, and Inner Tracker:

- $Q_{L1} - Z > -0.16(Z - 3) - 0.46$
- $-0.6 < Q_{\text{UTOF}} - Z < 1.5$
- $|Q_{\text{Inner}} - Z| < 0.45$

Additional L1 charge cut (purity cut):

- $Q_{L1} - Z < 0.65 + 0.03(Z - 5)$

Top-Of-Instrument (TOI) correction



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.

$$C_i = \frac{\sum_{j>i} \Phi_j A_{j \rightarrow i}}{N_i / \Delta T}$$

Measured rate of specie Z_i .

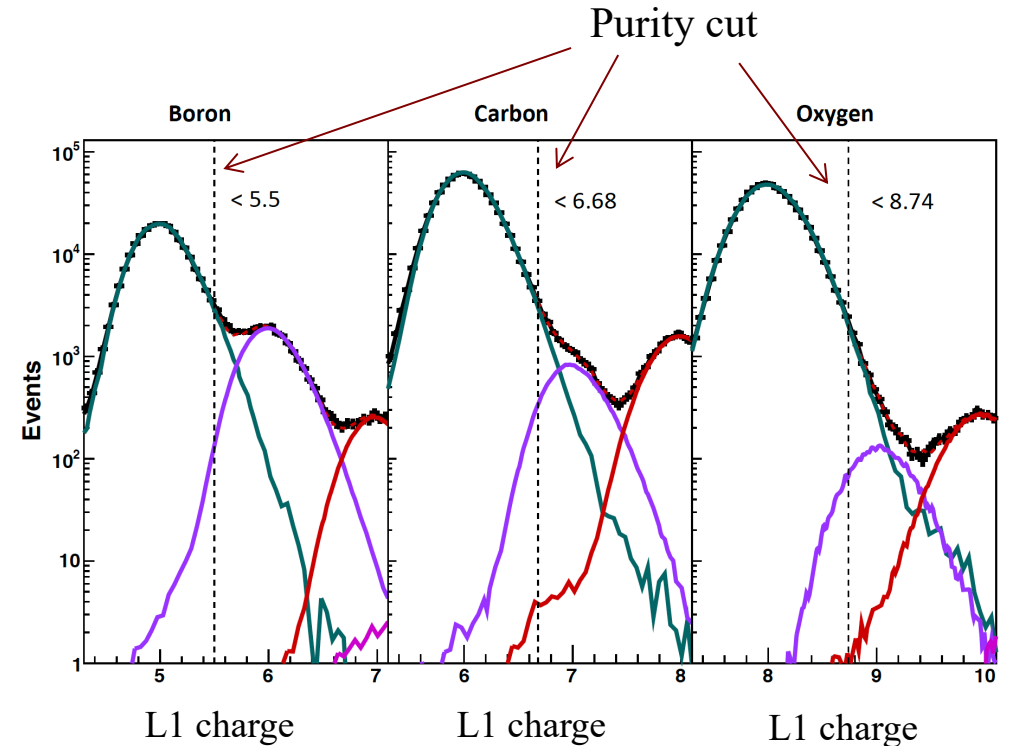
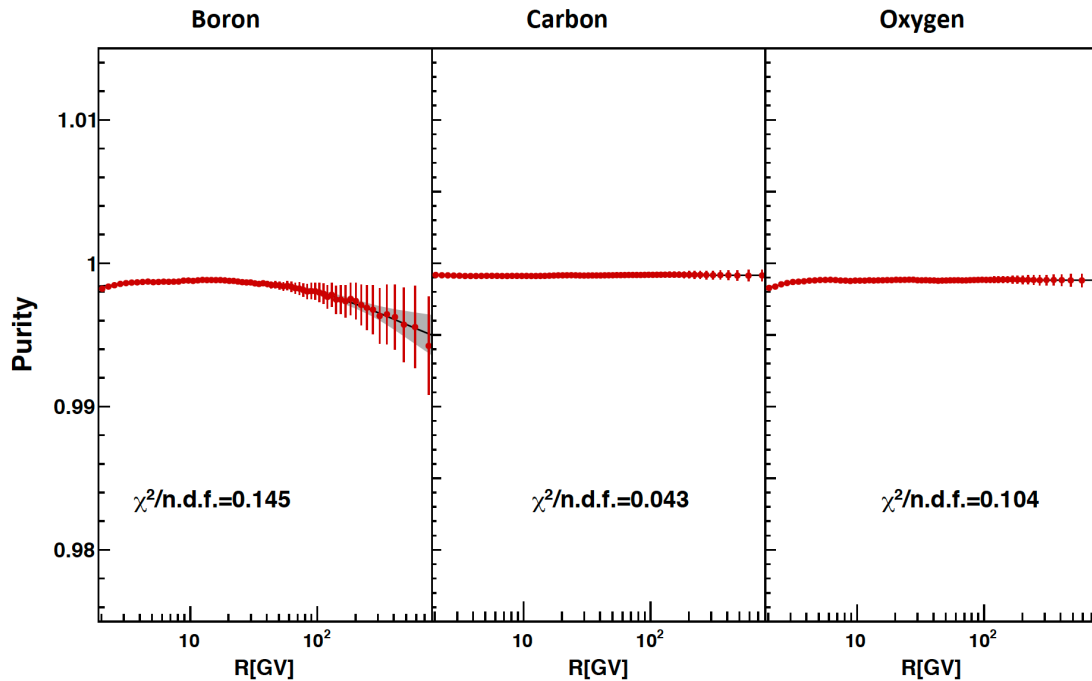
The estimation has been done using Boron, Carbon, Nitrogen, Oxygen and Neon MonteCarlo.

carbon64_20200420V2N_B1215401RAMCKY10COMBUNFOLD**TOI**_totalQYAN.root
oxygen64_20200420V2N_B1220402RAMCKY10COMBUNFOLD_totalQYAN.root

Purity not implemented still

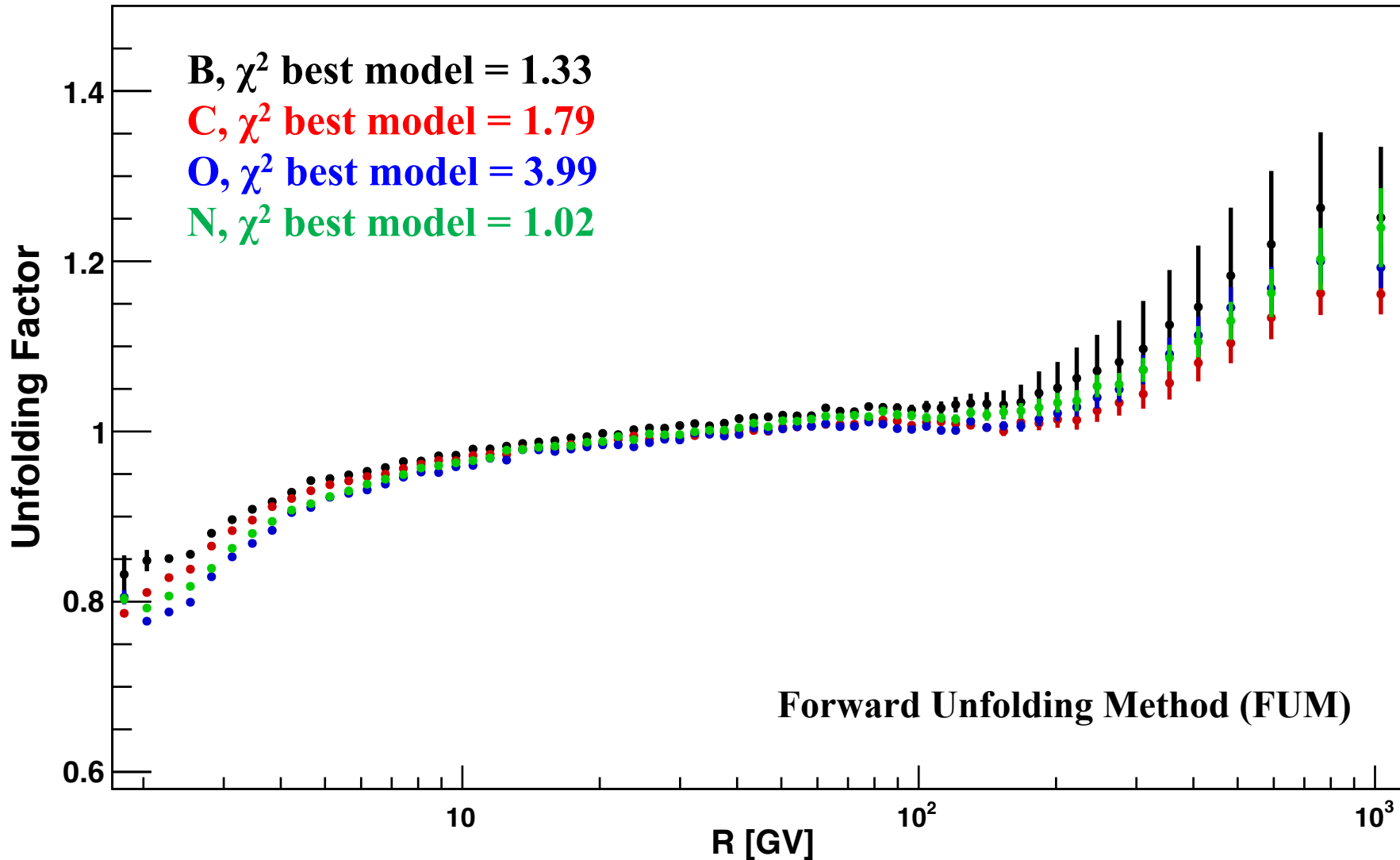
This is purity for 10 years pass7 CIEMAT ntuples

The purity is above 99% for the three nuclei in the entire rigidity range.



From AMS Nitrogen paper: this residual background is < 5% over the entire rigidity range

Forward Unfolding Factor



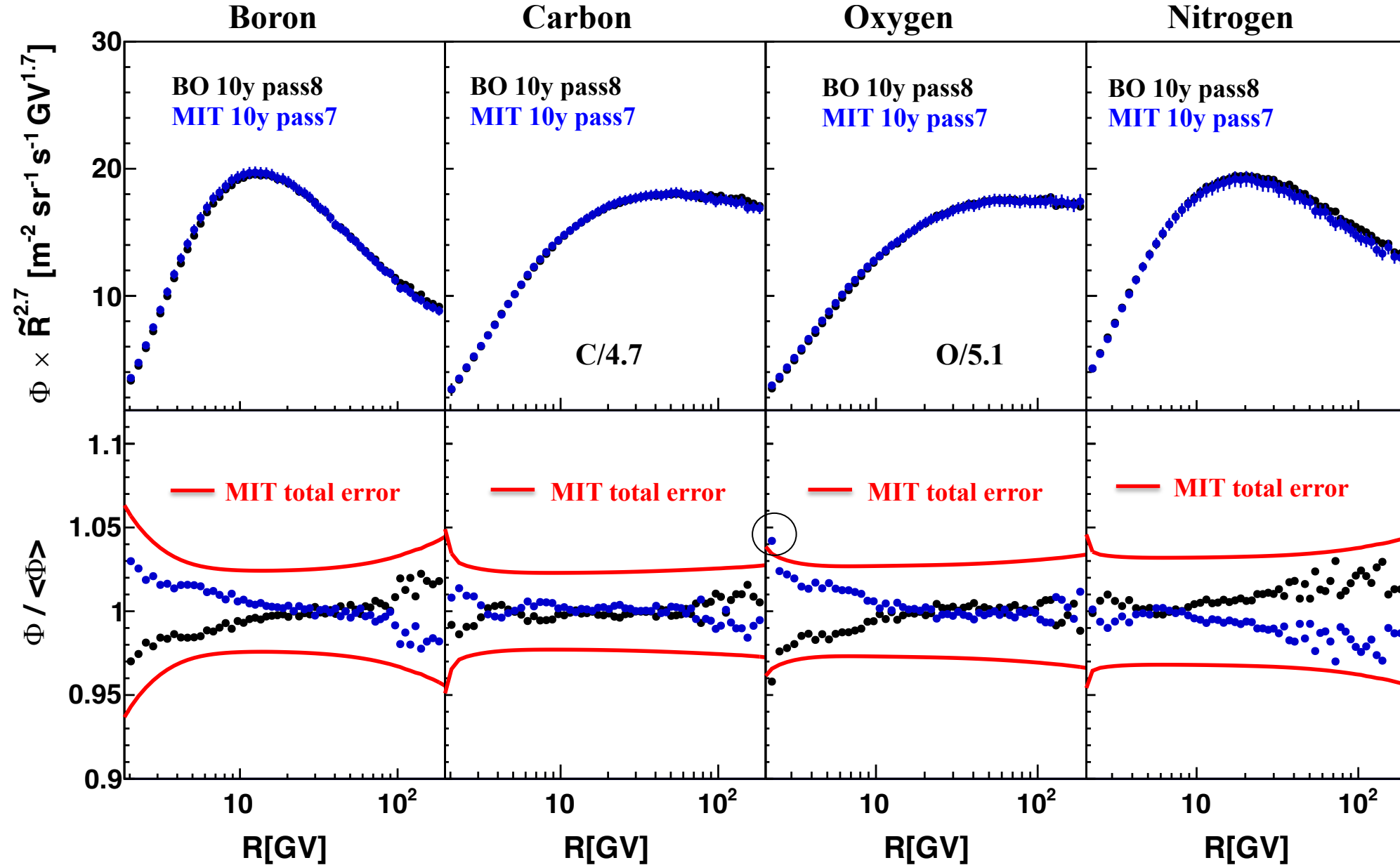
Has been estimated using the Matrix from the MonteCarlo.

The response model used for pass7 is not being use here, since a revision of it is needed:

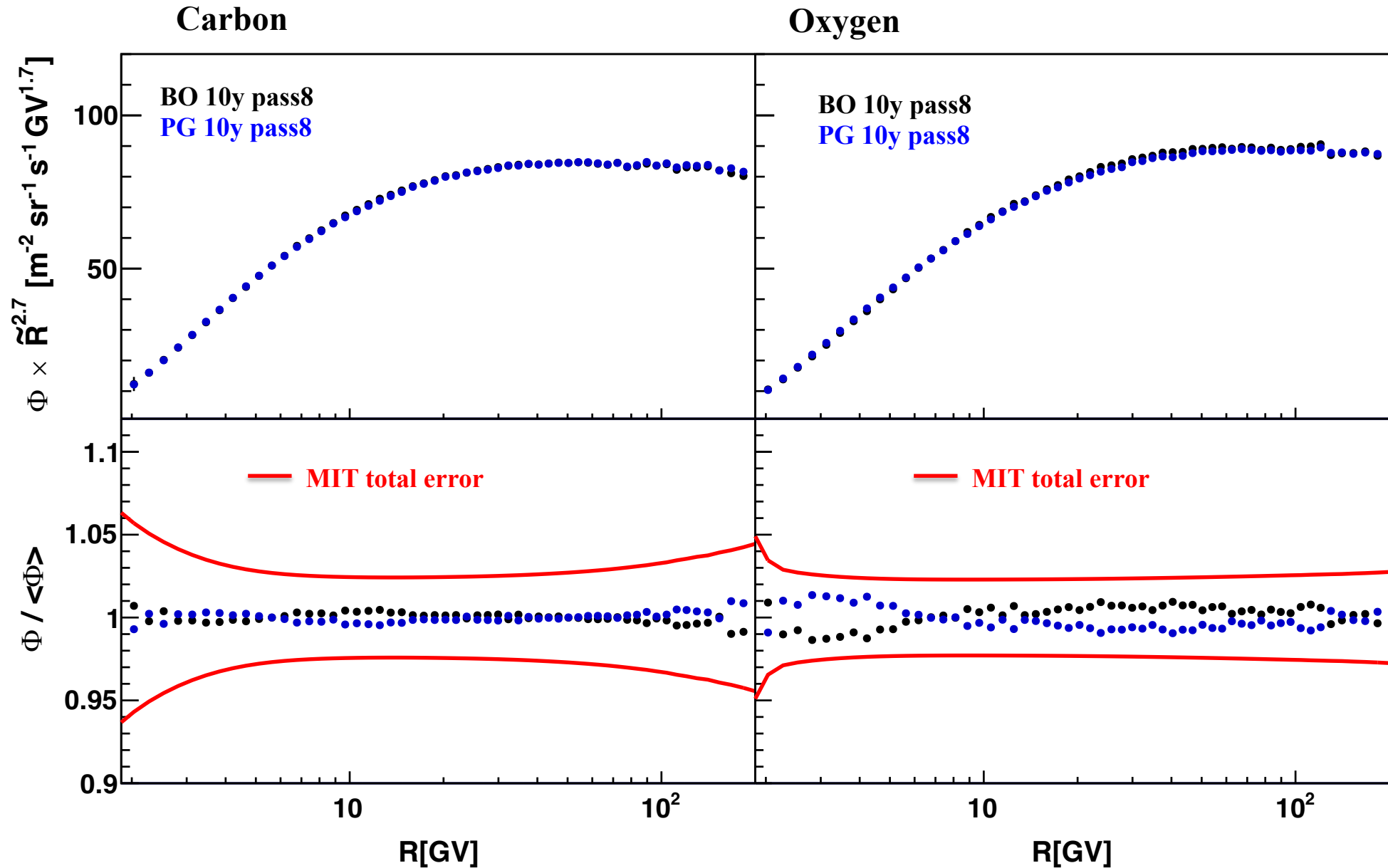
- New reconstruction
- New fitting algorithm

FUM Fluxes vs MIT

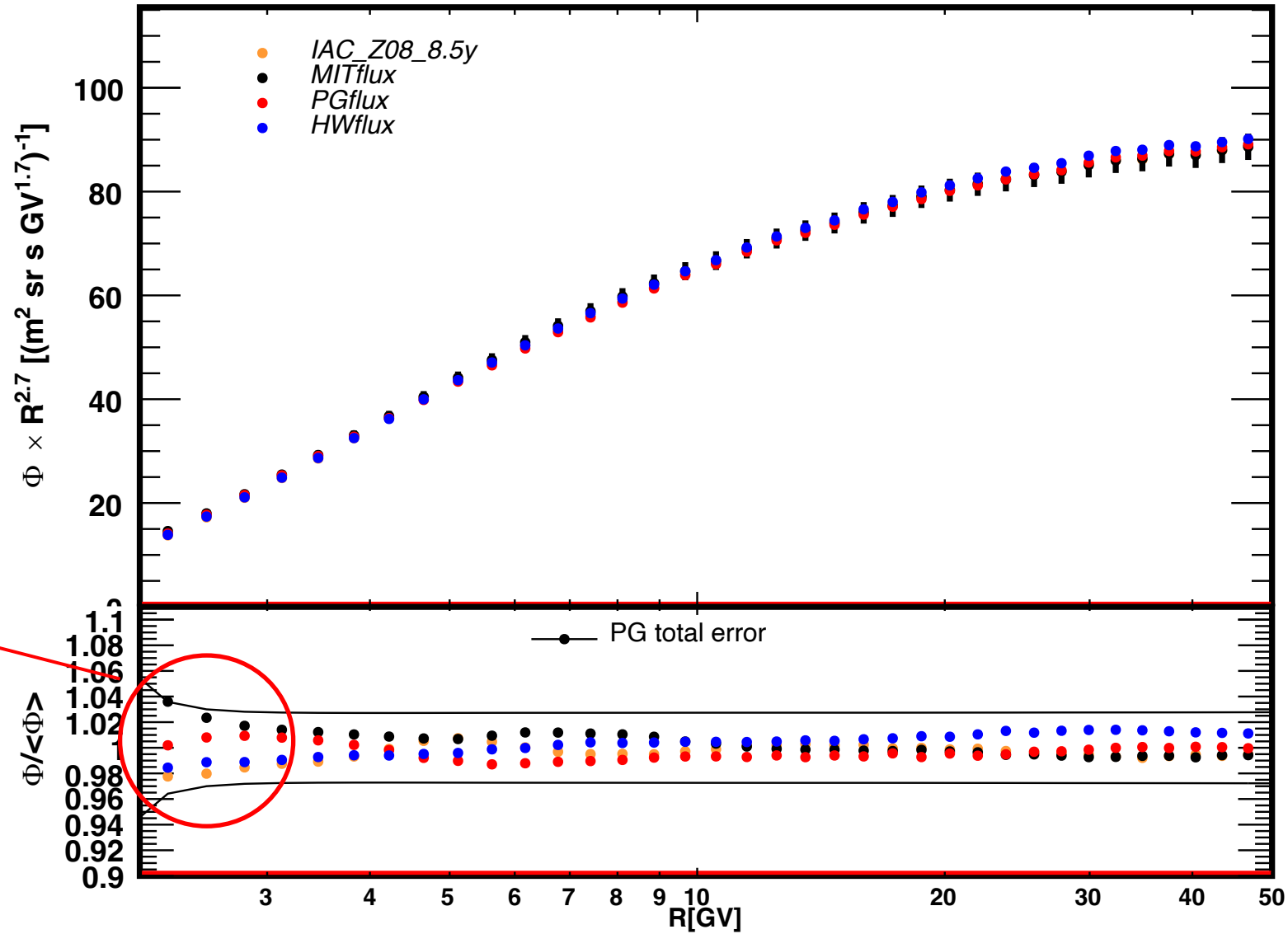
No pass8 public results from Qy still



FUM fluxes vs Perugia



Pass7 8.5 years comparison 06/April/2021



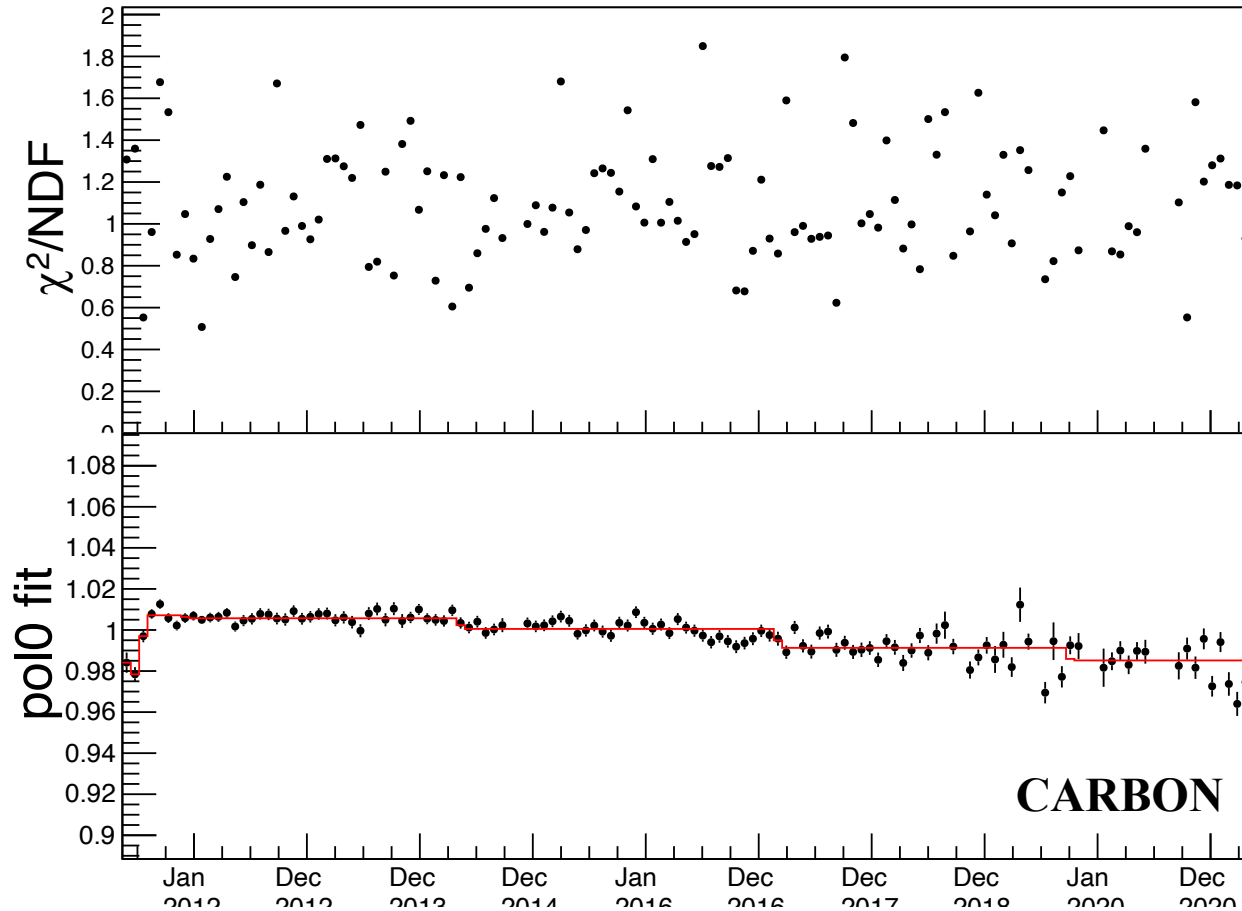
Bartels with <27 days of data taken

BR number	N° of days		BR number	N° of days				
2426	22		2531	12		2549	0	Empty
2459	24		2532	21		2550	0	Empty
2471	19		2533	6		2551	0	Empty
2472	0	TCCS	2535	2	Decision	2552	15	
2473	3	TCCS	2536	19		2553	22	
2504	24		2537	7		2554	21	
2523	16		2538	19		2555	25	
2524	8		2540	12		2558	25	
2526	3	Decision	2541	0	Empty	2559	24	
2527	24		2542	0	Empty	2560	21	
2529	26		2543	7				
2530	11		2548	17				

Tracker data/<data> correction

- Commissioning, 3 first BR
- Thu Dec 1 16:35:34 UTC 2011 dead 6 X-side ladder 3 L2X, 1 L3X, 1L4X, 1L5X
- Thu May 8 15:04:08 UTC 2014 dead 1 L7Y
- Tue Feb 28 17:10:43 UTC 2017 dead 1 L8Y
- Tue Sep 24 06:27:23 UTC 2019 1 L8Y “revived” after power cut
- **Check ELOG for the last 1.5 years (It seems there is no huge jumps)**

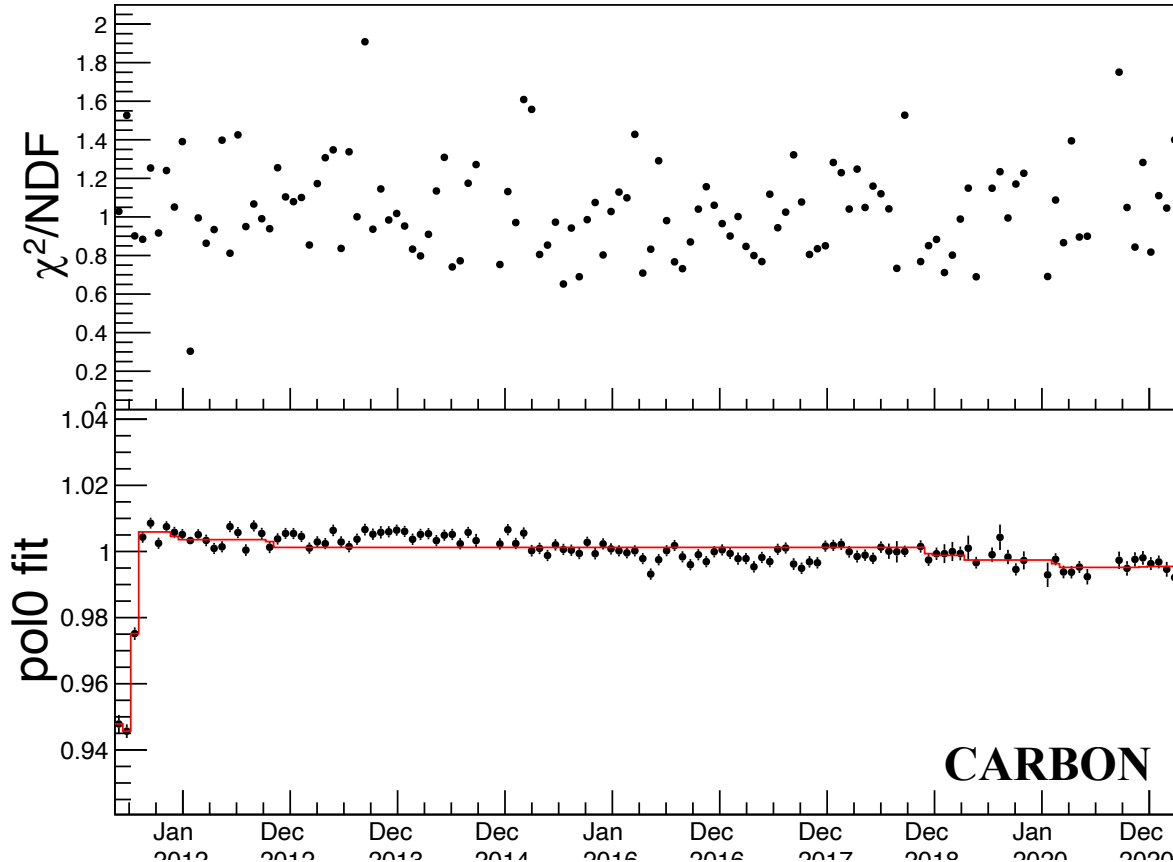
Check Yi Jia dates



PickUp-L1 data/<data> correction

- Commissioning, 3 first BR
- Thu Dec 1 16:35:34 UTC 2011 dead 6 X-side ladder 3 L2X, 1 L3X, 1L4X, 1L5X
- Mon Oct 29 09:38:41 UTC 2012 dead 1 VA L1X
- Mon Dec 3 22:02:01 UTC 2018 suddenly low signal on 1 L1X (-810)
- Mon Apr 29 15:21:19 UTC 2019 came back 1 L1X (-810)
- 12/12/2020 we had power cut with had an AMS shutdown sue to failing power on 4B ***not clear
- 17/02/2020 we had some major reconfiguration, maybe with some power cycling ***not clear

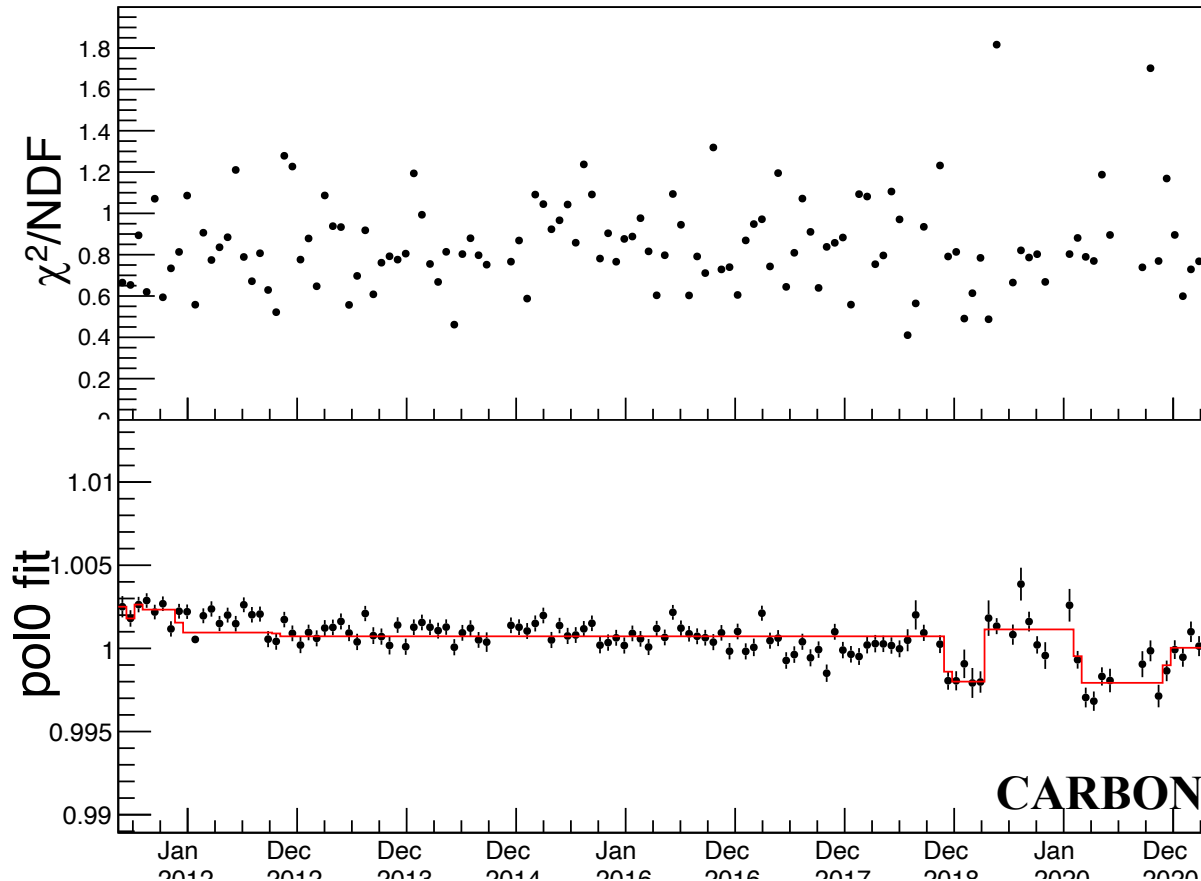
Check Yi Jia dates



Unbiased hit L1 data/<data> correction

- Commissioning, 3 first BR
- Thu Dec 1 16:35:34 UTC 2011 dead 6 X-side ladder 3 L2X, 1 L3X, 1L4X, 1L5X
- Mon Oct 29 09:38:41 UTC 2012 dead 1 VA L1X
- Mon Dec 3 22:02:01 UTC 2018 suddenly low signal on 1 L1X (-810)
- Mon Apr 29 15:21:19 UTC 2019 came back 1 L1X (-810)
- 12/12/2020 we had power cut with had an AMS shutdown sue to failing power on 4B ***not clear
- 17/02/2020 we had some major reconfiguration, maybe with some power cycling ***not clear

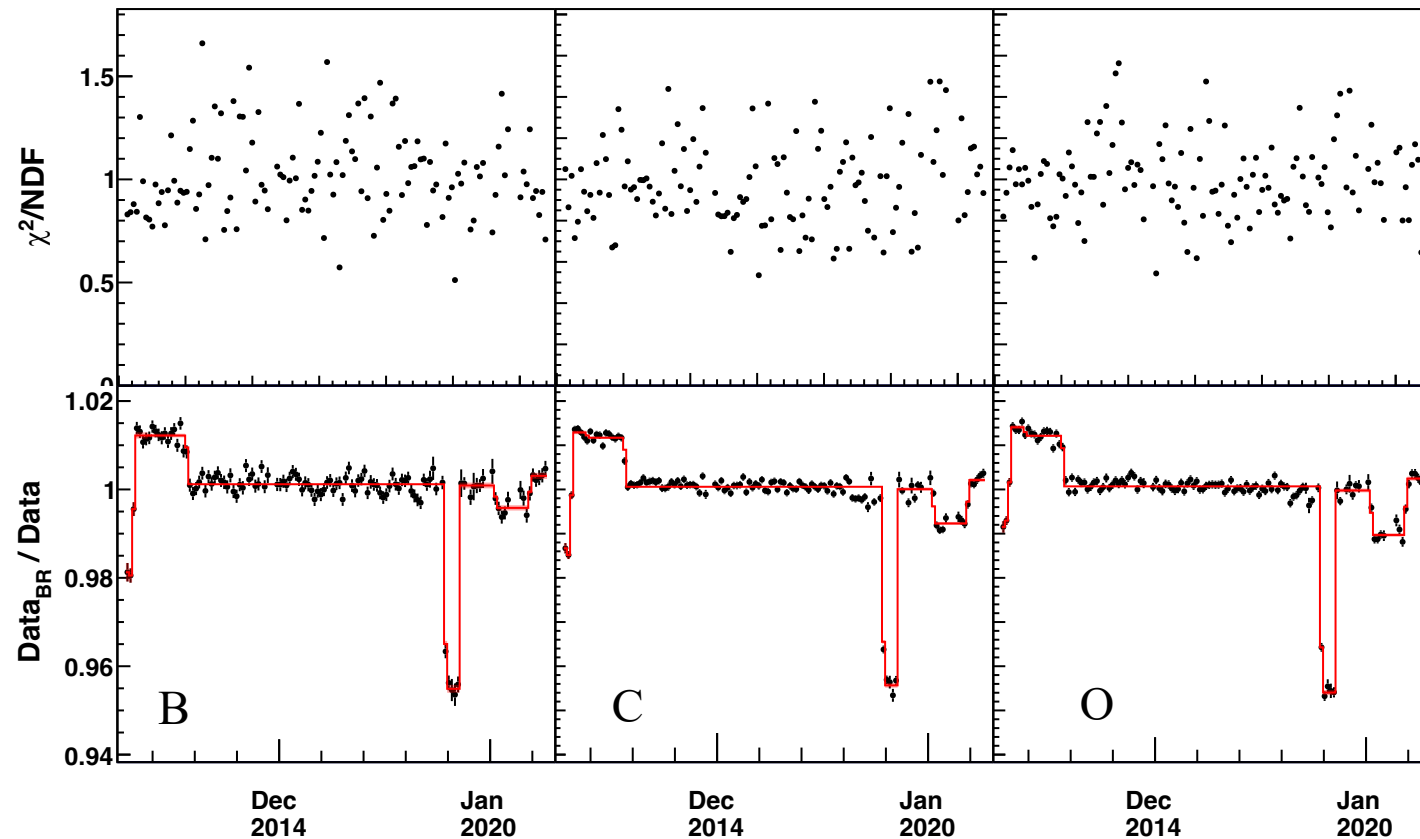
Check Yi Jia dates



Why this improvement here?
Think about it

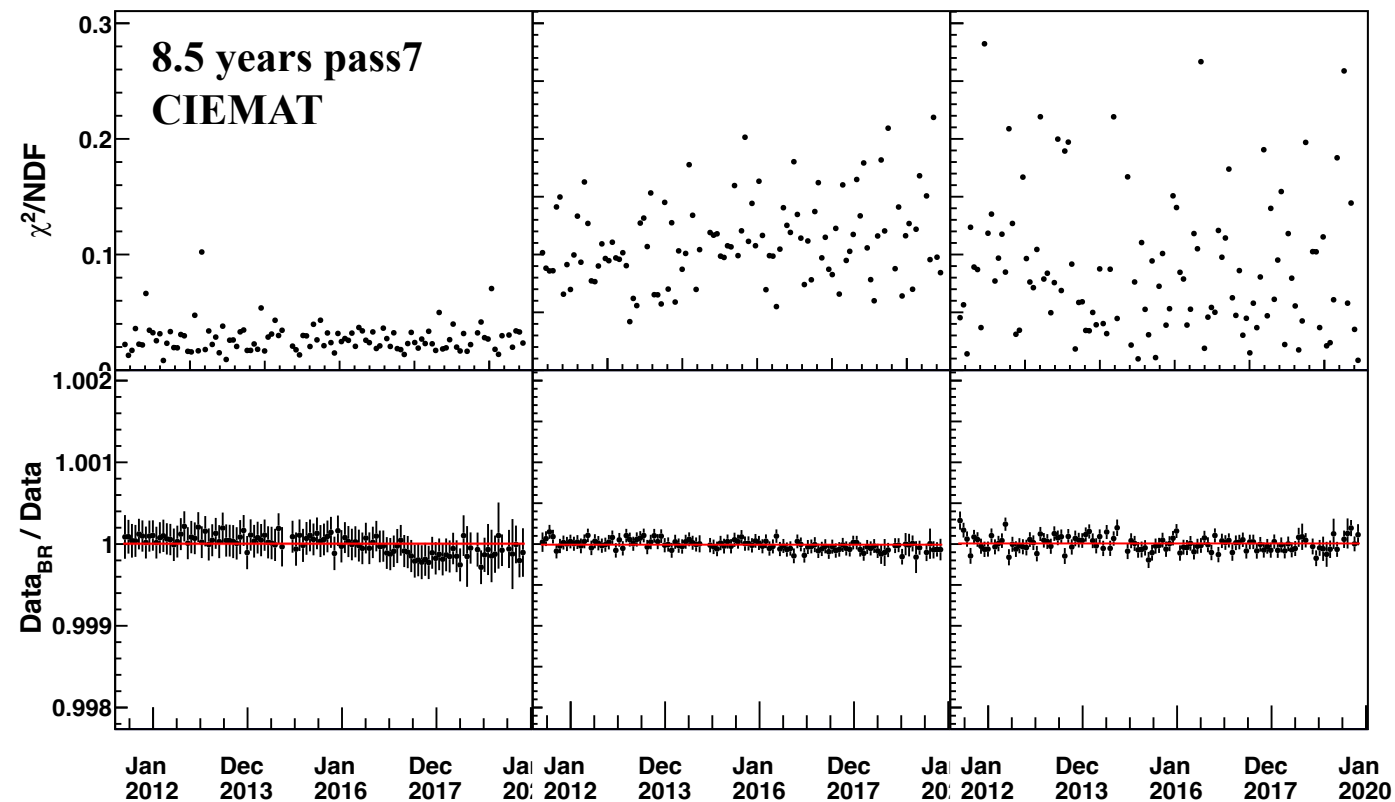
Pass7 Unbiased hit L1 data/<data> correction

- Commissioning, 3 first BR
- Thu Dec 1 16:35:34 UTC 2011 dead 6 X-side ladder 3 L2X, 1 L3X, 1L4X, 1L5X
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Background Subtraction vs Time

MISSING: Purity vs time



Applied: TOI vs time

This should be the flux of that Bartels rotation

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.

$$C_i = \frac{\sum_{j>i} \Phi_j A_{j \rightarrow i}}{N_i / \Delta T}$$

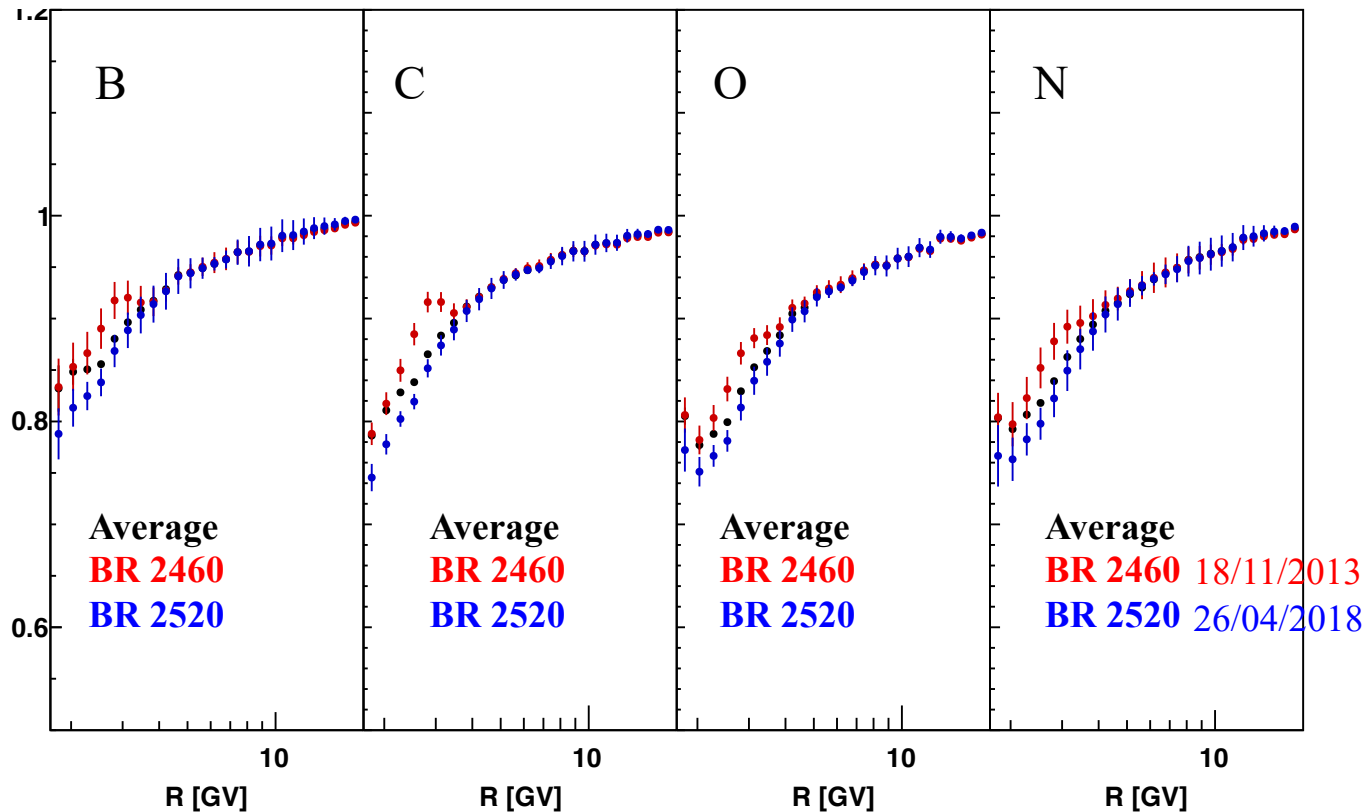
Measured rate of specie Z_i .

The rate is from the specific Bartels rotation

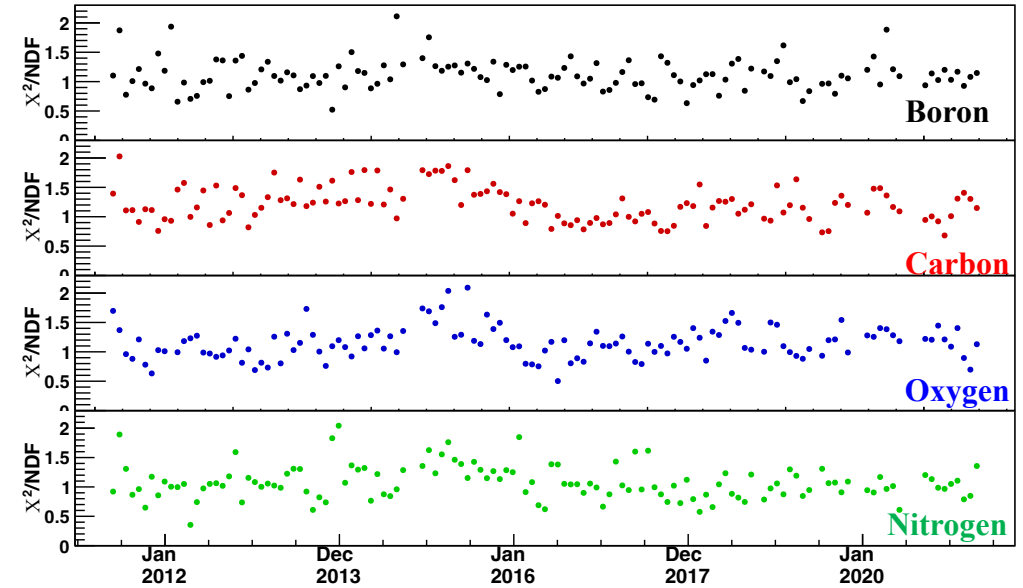
Forward Unfolding vs Time

The flux model for each BR is given by the best-fit flux model obtained from the average flux FUM multiplied by a parametrization of the Φ^{BR}/Φ^{AVG} ratio by a spline allowed to fluctuate only at low rigidities.

This effectively allows to study the solar modulation effects on the unfolding.



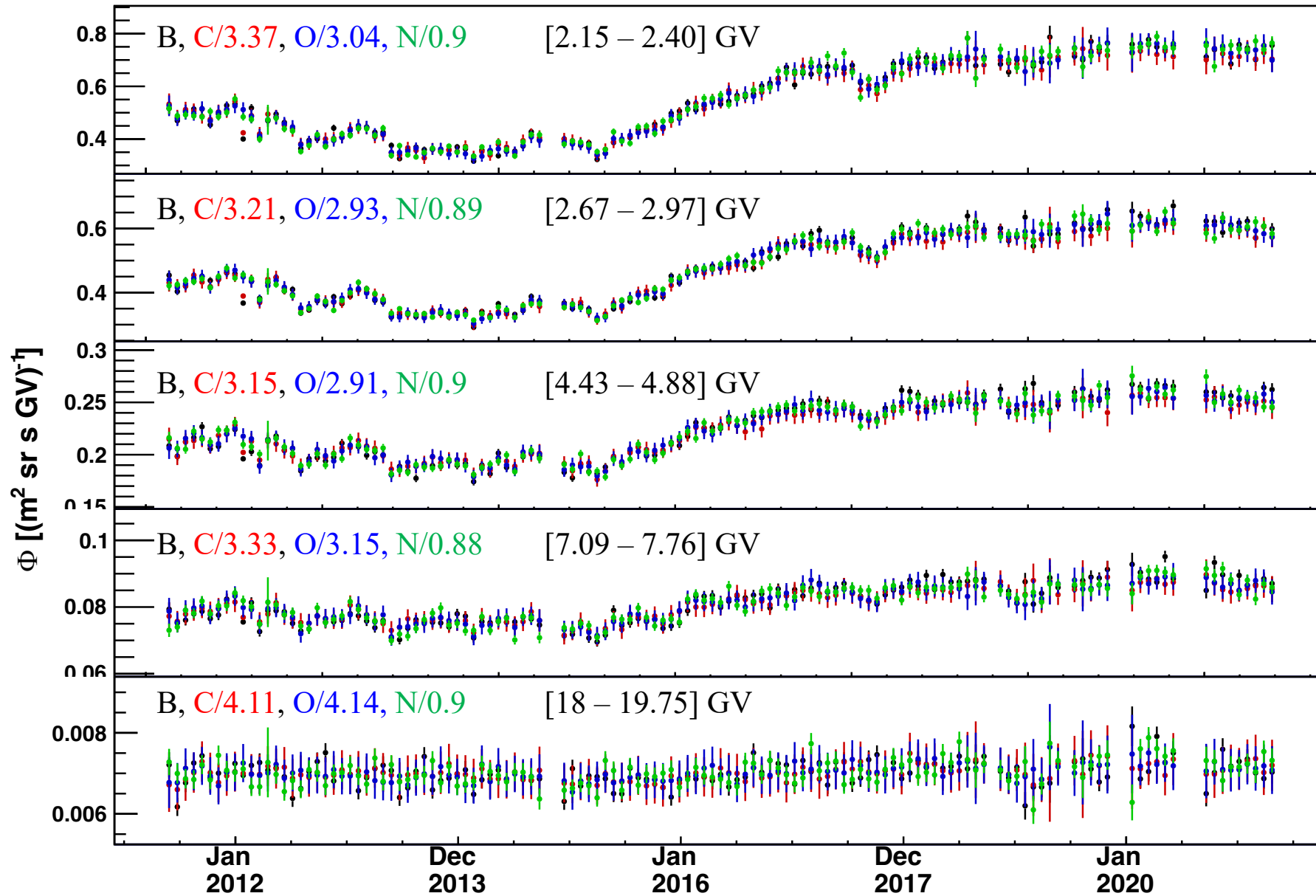
Chisquare of model vs time



Bartels inside **high solar** activity period and **vice-versa**.

Higher solar activity means **lower flux**, which means **higher** unfolding factor **value**, e.g, **less correction**.

Fluxes vs Time



Conclusion

- **Pass 8 NAIA B, C, N & O fluxes has been presented. The agreement with MIT and PG is good, but some work is still to be done: Purity, Oxygen disagreement, etc.**
- **Proposal (if Federico agrees) would be to present at least 10 years of this 4 nuclei in the June general meeting, so we have at least that for the conferences.**
- **We need to have the standard things we had in the past, C/O, B/C+O ratios, the plots with Voyager, etc, at some point. And probably the new favorite plot: **The Hysteresis**.**
- **We need to think about this plots and some interpretations, since those questions will arrive at the moment we present these results to Prof. Ting.**

Back Up Slides

Beta Efficiency Selection

Denominator

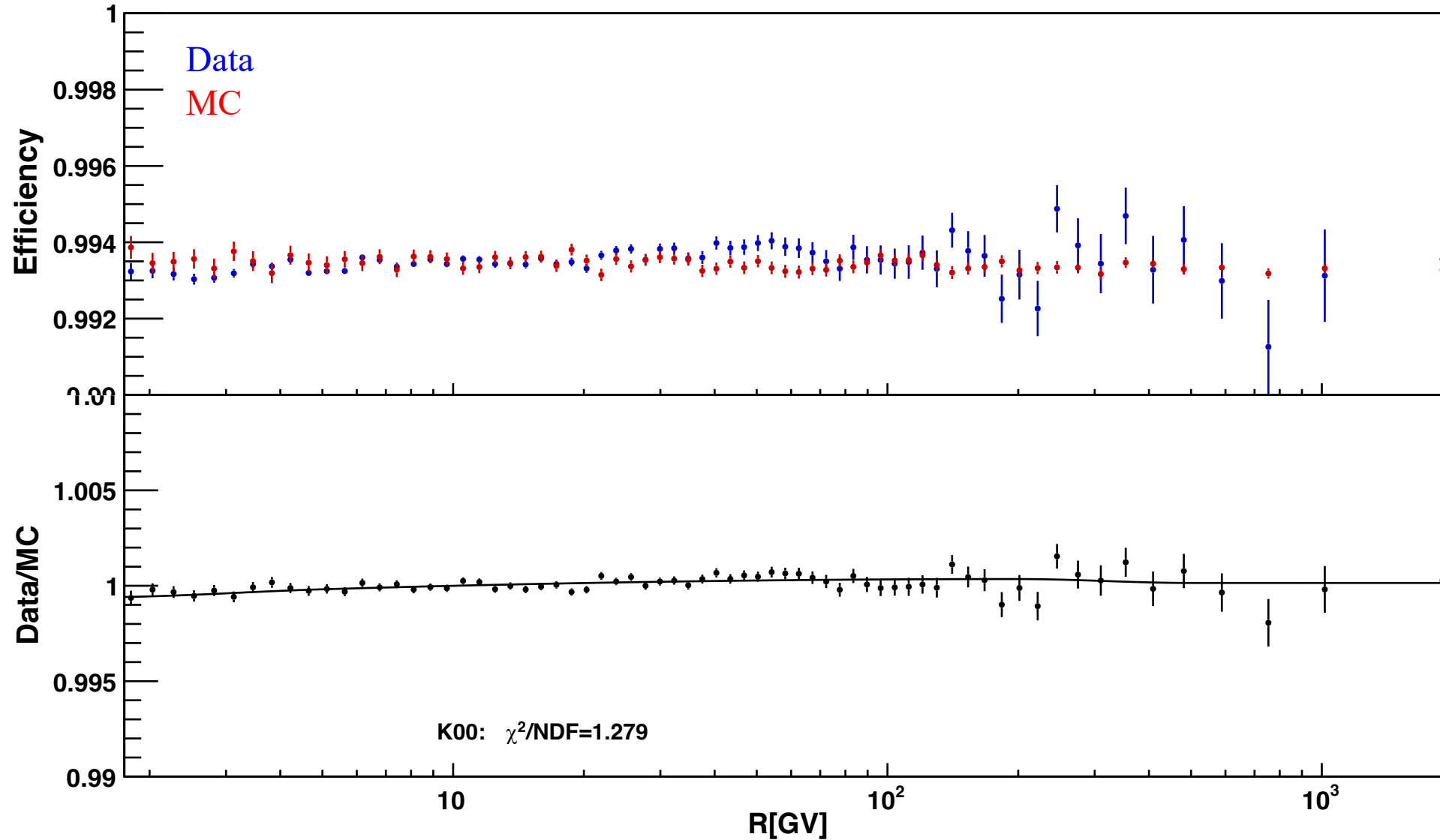
- Standard selection for Inner-L1 with no UTOF and LTOF related cuts.
- Track in fiducial L1+Inner volume.
- Tighter cuts on standalone charges (no beta correction).

Numerator

- Denominator
- β calculated with ≥ 3 hits
- $\beta > 0.3$

UTOF and LTOF charge cuts are done separately

Beta Data/MC Correction



Beta Charge Efficiency Selection

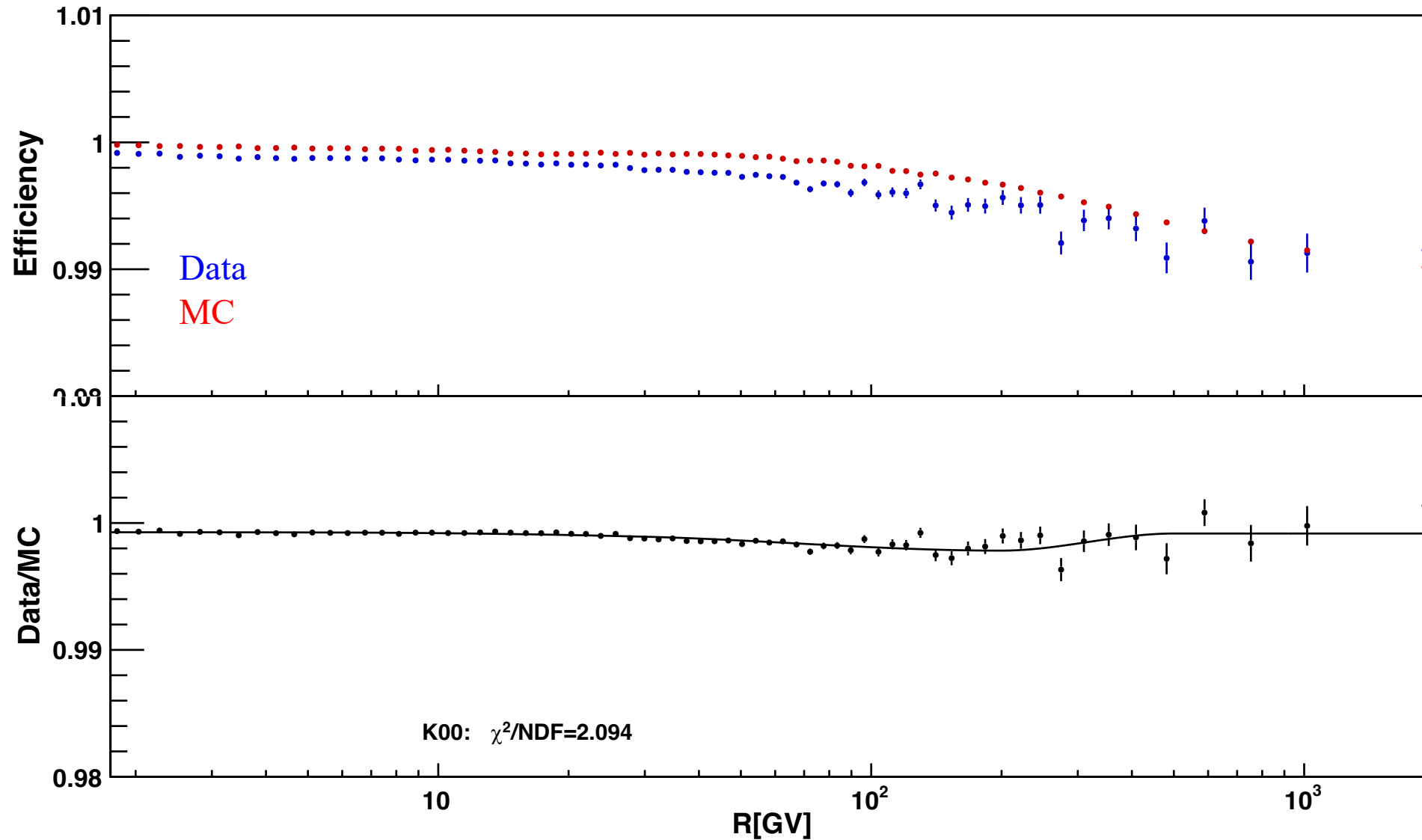
Denominator

- Standard selection for Inner-L1, without cuts on UTOF and LTOF charges.
- $R_{\text{sec}} \leq 0.5 \text{ GV}$ (no high-R positive second track)

Numerator

- Denominator
- UTOF standard charge cut

Beta Charge Data/MC Correction



Tracker Efficiency Selection

Denominator

- Physics trigger
- β calculated with ≥ 3 hits
- $\beta > 0.3$
- $\beta > \beta(1.2 \times R_{\text{ctf}})$
- An unbiased XY hit on L1 with position inside L1 fiducial volume
- TOF in inner Tracker fiducial volume with margin of 4.5 cm
- Unbiased hit on L1 < 9 cm from TOF extrapolation to L1
- Tighter cuts on UTOF, LTOF and UnbiasedL1 charges.

Numerator

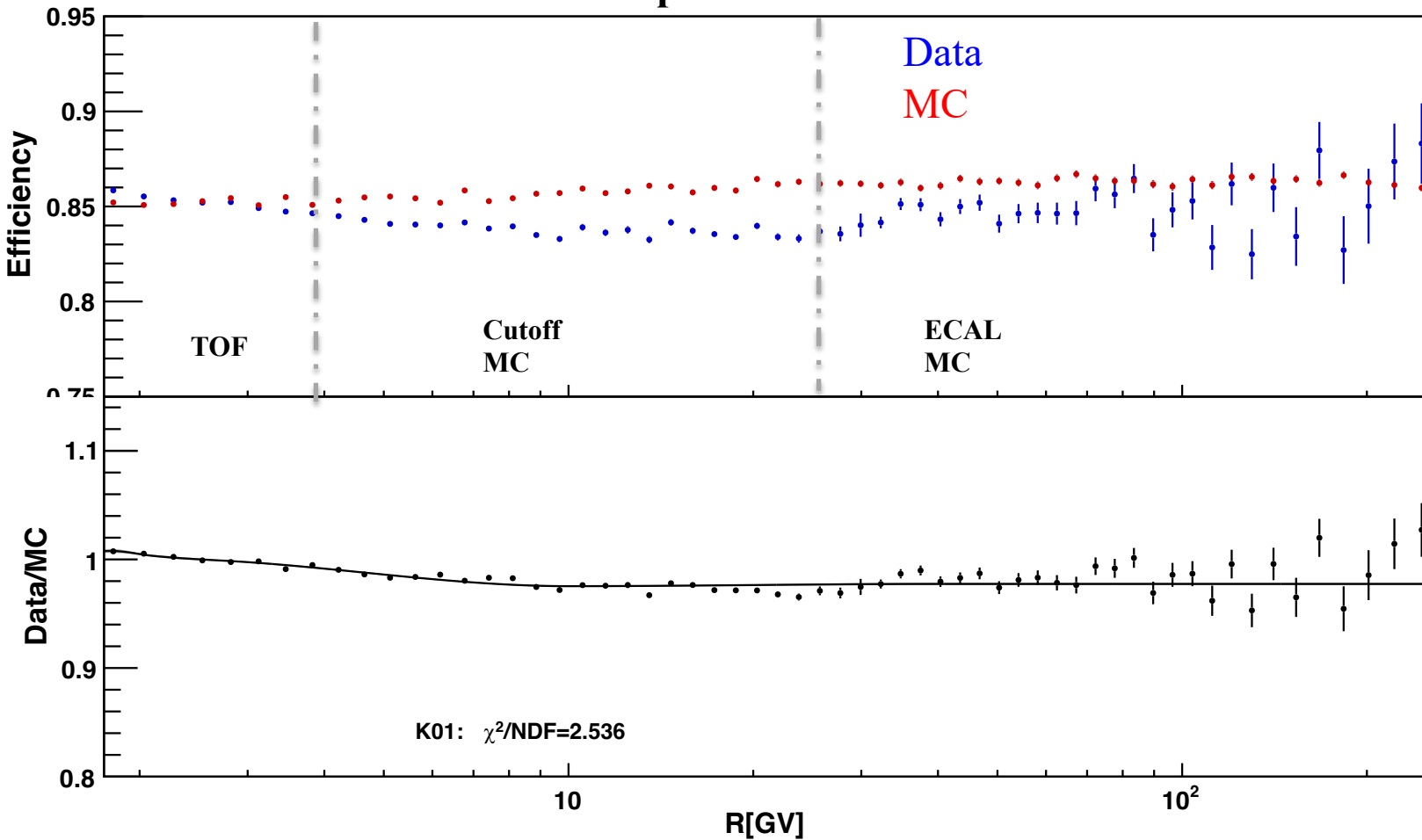
- Denominator
- Inner Tracker Y hits ≥ 5
- L2Y&(L3YIL4Y)&(L5YIL6Y)&(L7YIL8Y)
- Track in fiducial Inner-L1 volume
- Norm. $\chi^2_{\text{Y Inner}} < 10$
- $Q_{\text{Inner}} > Z - 2.5$

Inner Tracker Charge cut is done separately

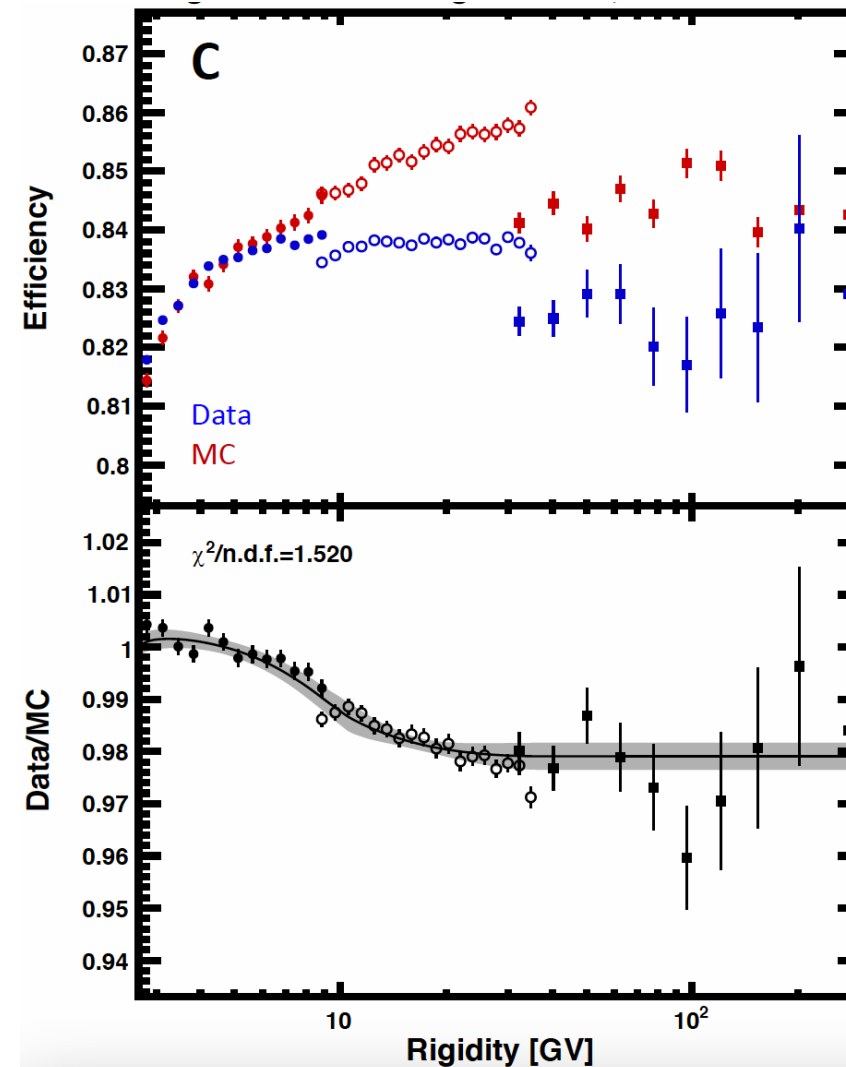
Tracker Data/MC Correction

A clear improvement of track reconstruction at low R can be seen.

Pass8 - New Code - NAIA Ntuples



Pass7 - Old Code - CIEMAT Ntuples



Tracker Charge Efficiency Selection

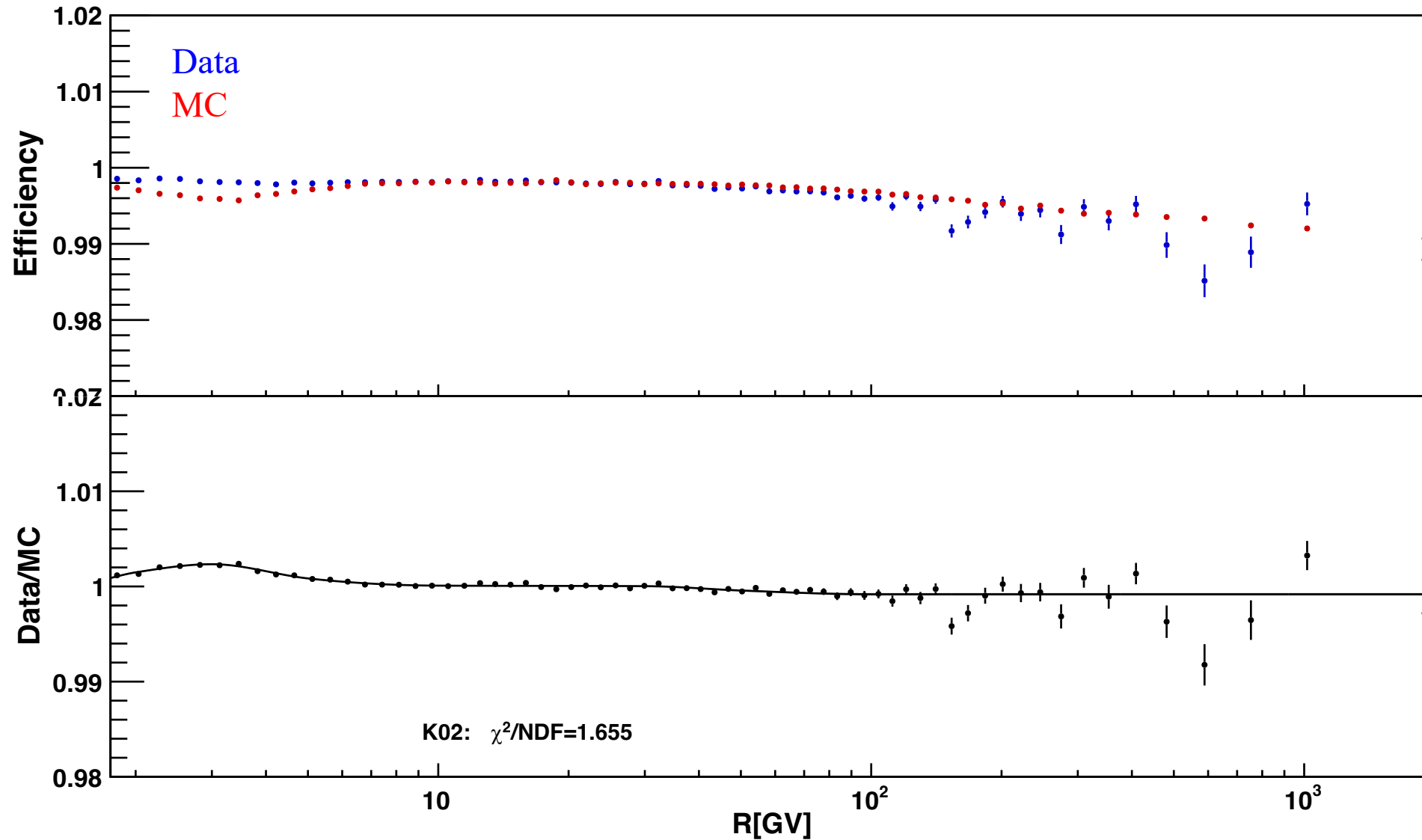
Denominator

- Standard selection without Q_{Inner} cut
- Tighter cuts on UTOF, LTOF and UnbiasedL1 charges.
- $Q_{\text{Inner}} - Z > 2.5$

Numerator

- Denominator
- Q_{Inner} standard charge cut

Inner Tracker Charge Data/MC Correction



L1 Unbiased Hit Efficiency Selection

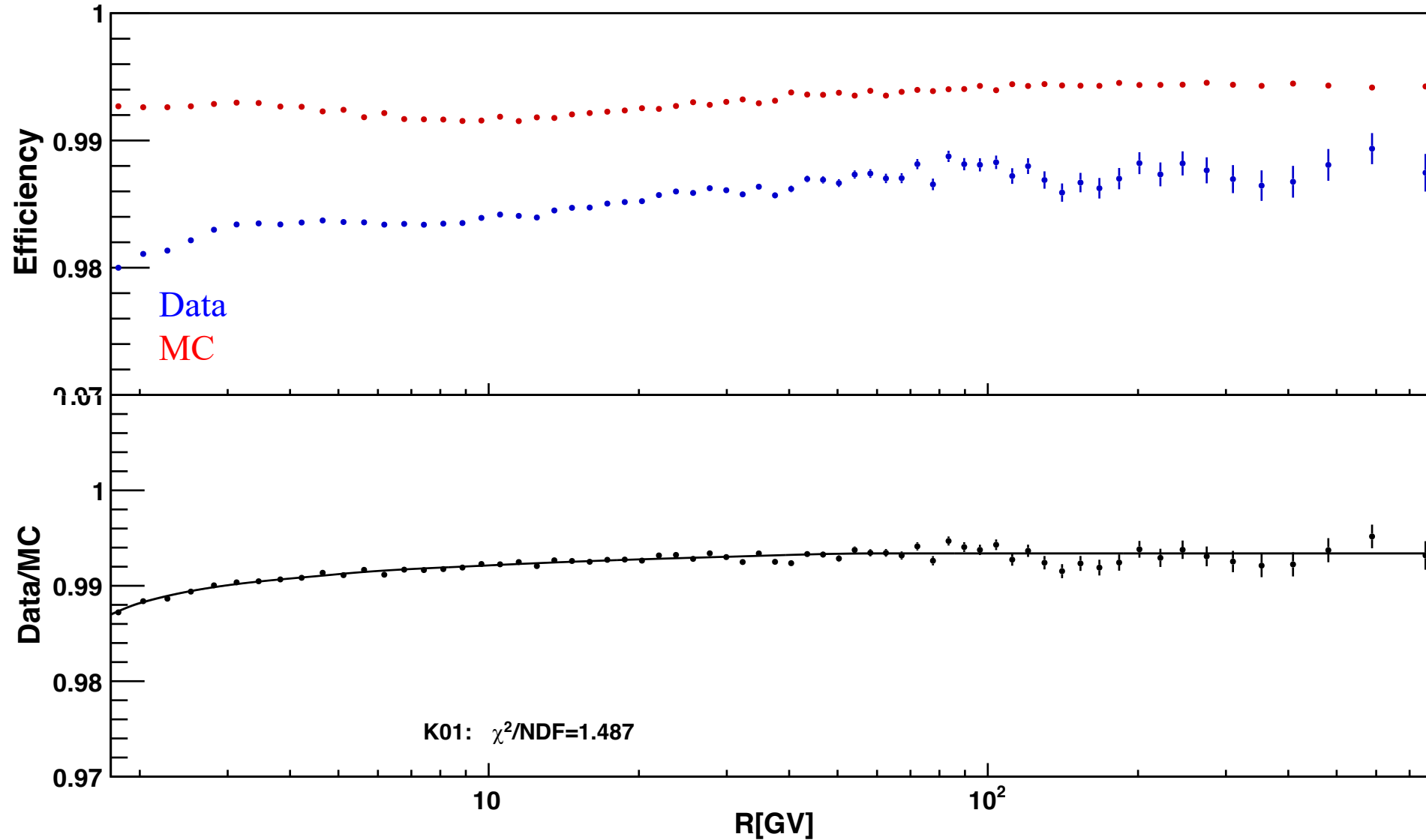
Denominator

- Standard selection excluding L1 related cuts
- Tighter cuts on Q_{UTOF} , Q_{Inner} charges.

Numerator

- Denominator
- Q_{UL1} standard charge cut

L1 Unbiased Hit Data/MC Correction



L1 Hit Association to Track Efficiency Selection

Denominator

- Standard selection excluding L1 related cuts
- $-0.16(Z-3)-0.46 < Q_{UL1}-Z < 0.65+0.03(Z-5)$
- Tighter cuts on UTOF, InnerTrack charges.
- $R_{sec} < 0.5$ GV (no high-R second track)

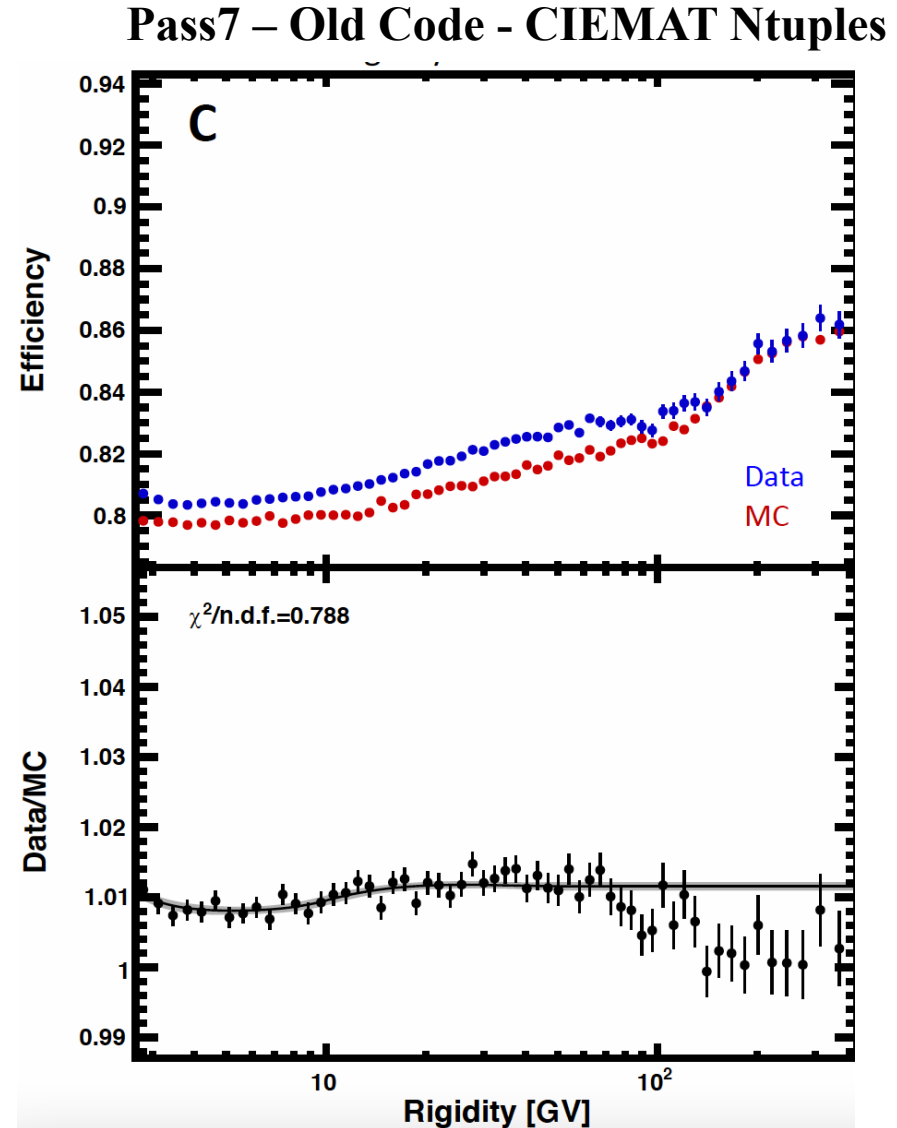
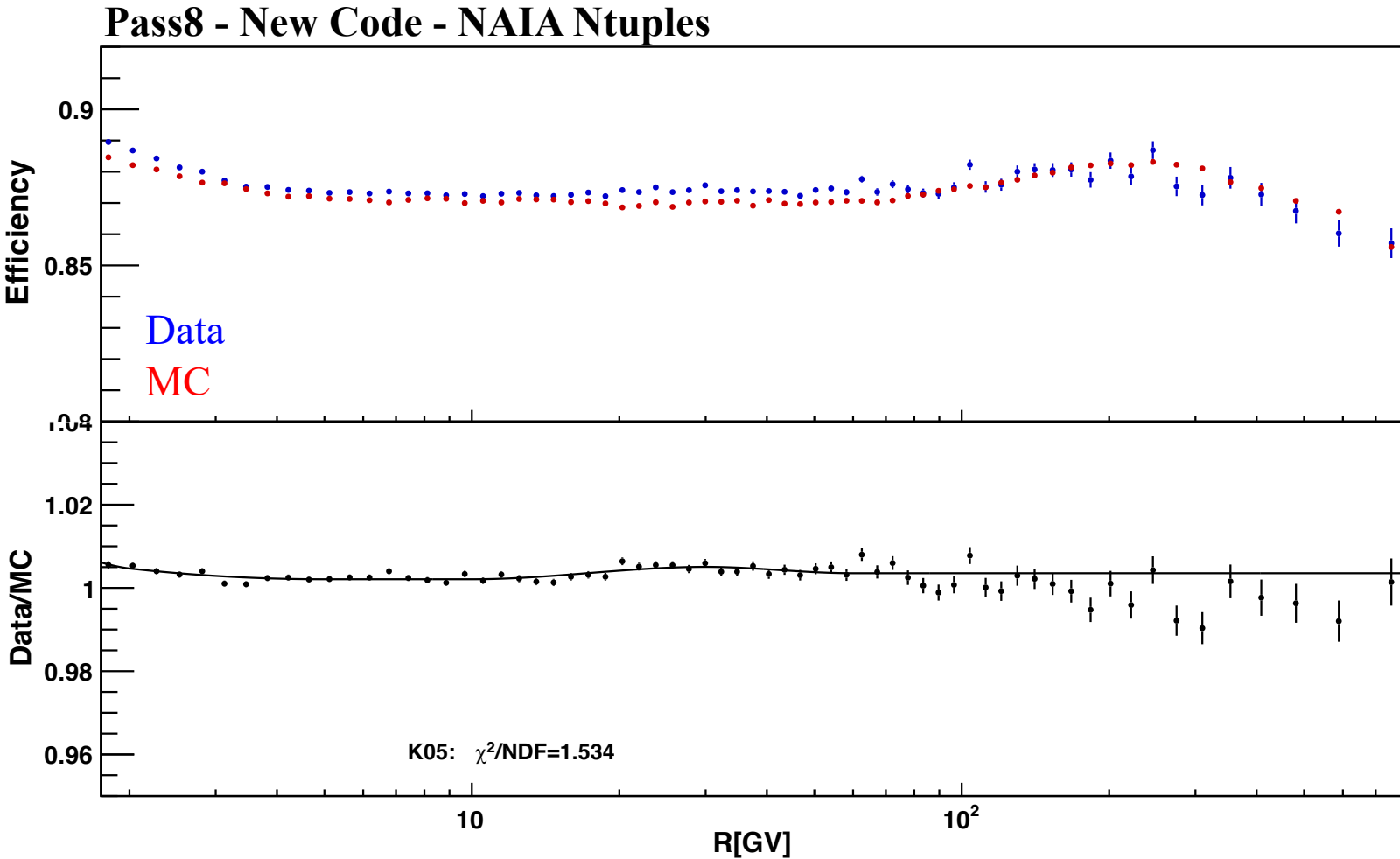
Numerator

- Denominator
- L1XY hit on track with good status
- Normalized L1-Inner $\chi^2_Y < 10$
- Normalized L1 $\chi^2_Y < 10$
- Standard L1 charge cuts

MIT people are studying this efficiency. Maybe it would be better to apply a different cut instead of the normalized χ^2 .

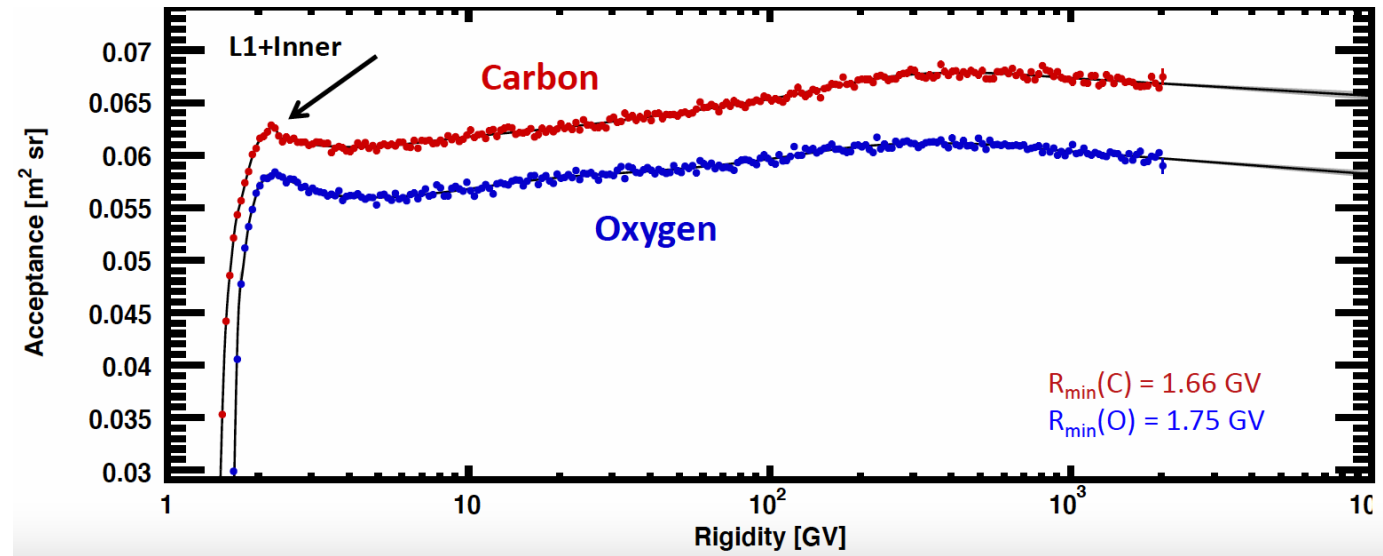
L1 Hit Association to Track Data/MC Correction

From pass7 to pass8 reconstruction, the position matching window for external layer hits have been increased by a factor 5.

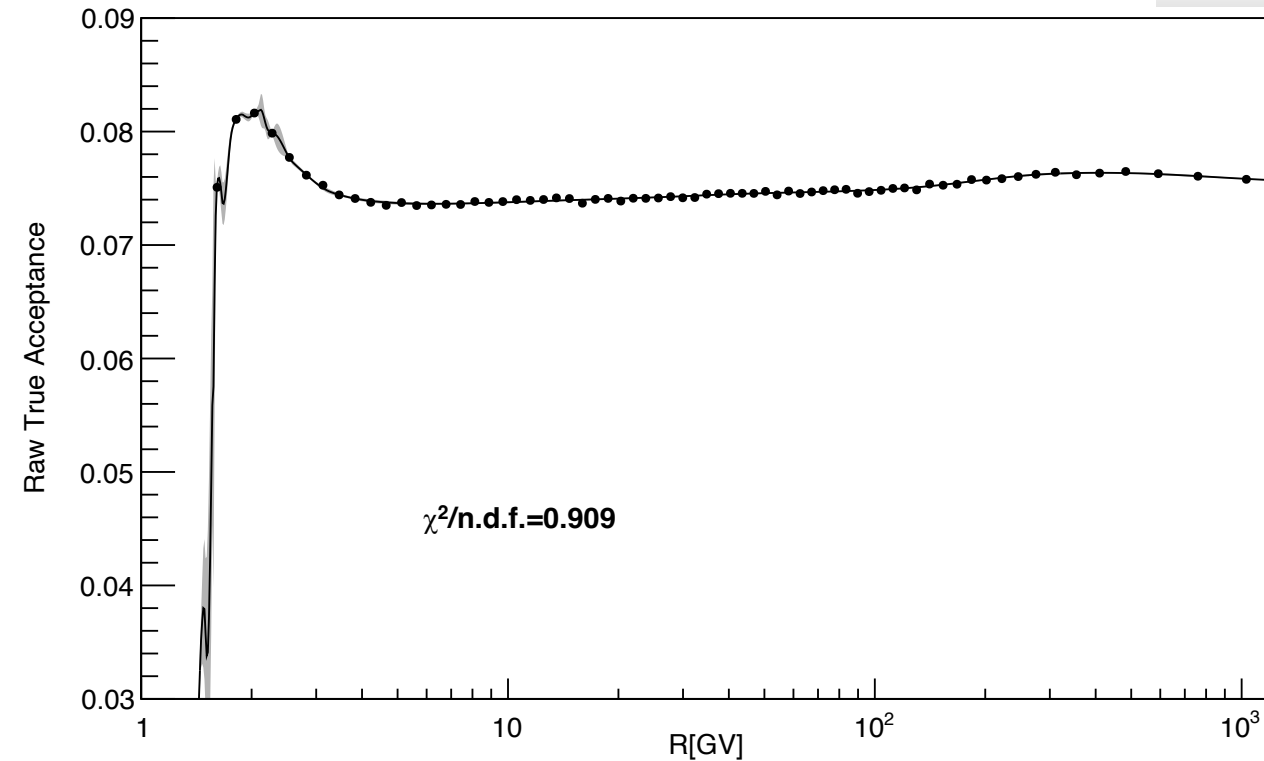


Raw True Acceptance

Pass7 – Old Code - CIEMAT Ntuples



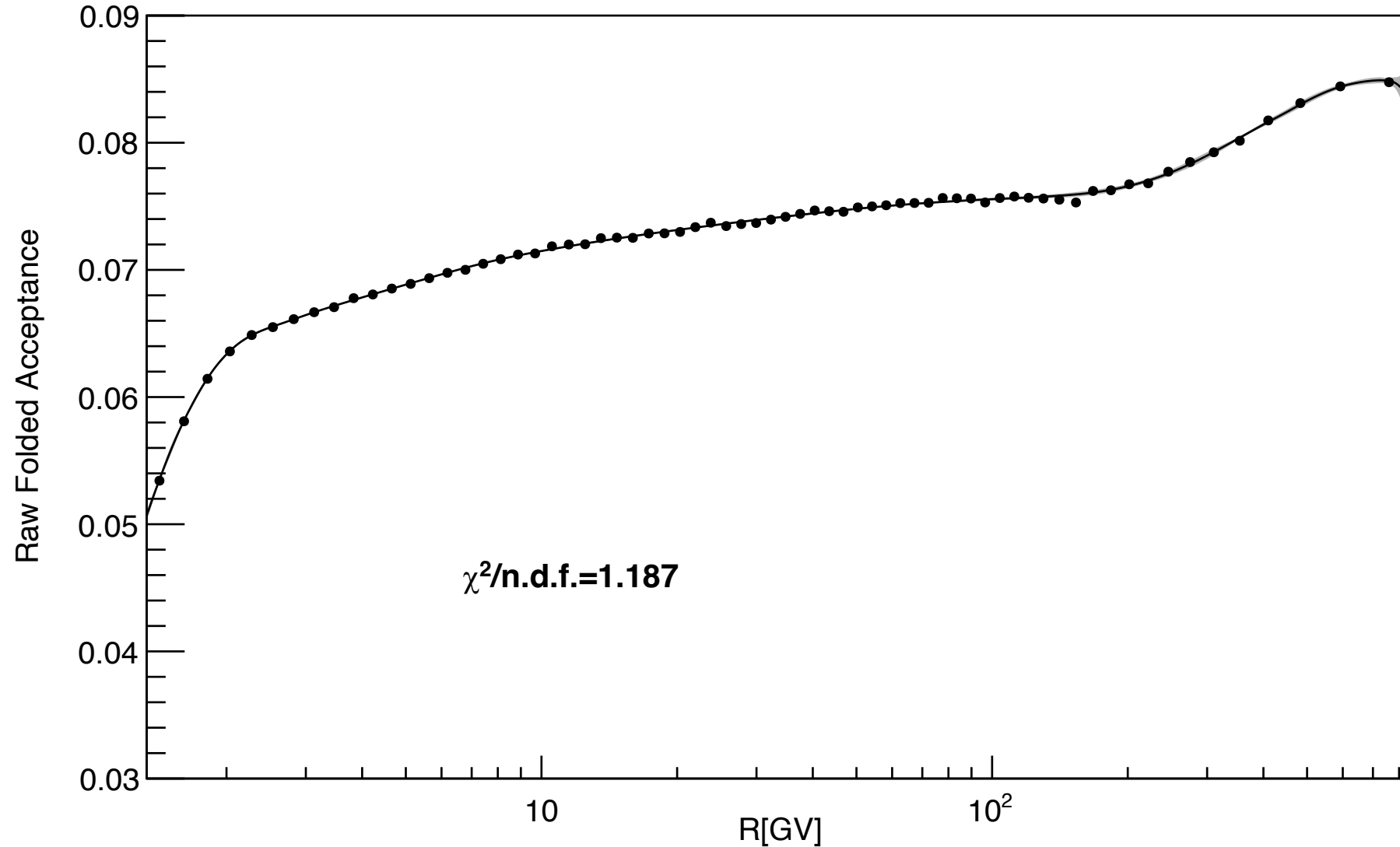
Pass8 - New Code - NAIA Ntuples



Following the reconstruction improvement in pass8, it results in a higher acceptance.

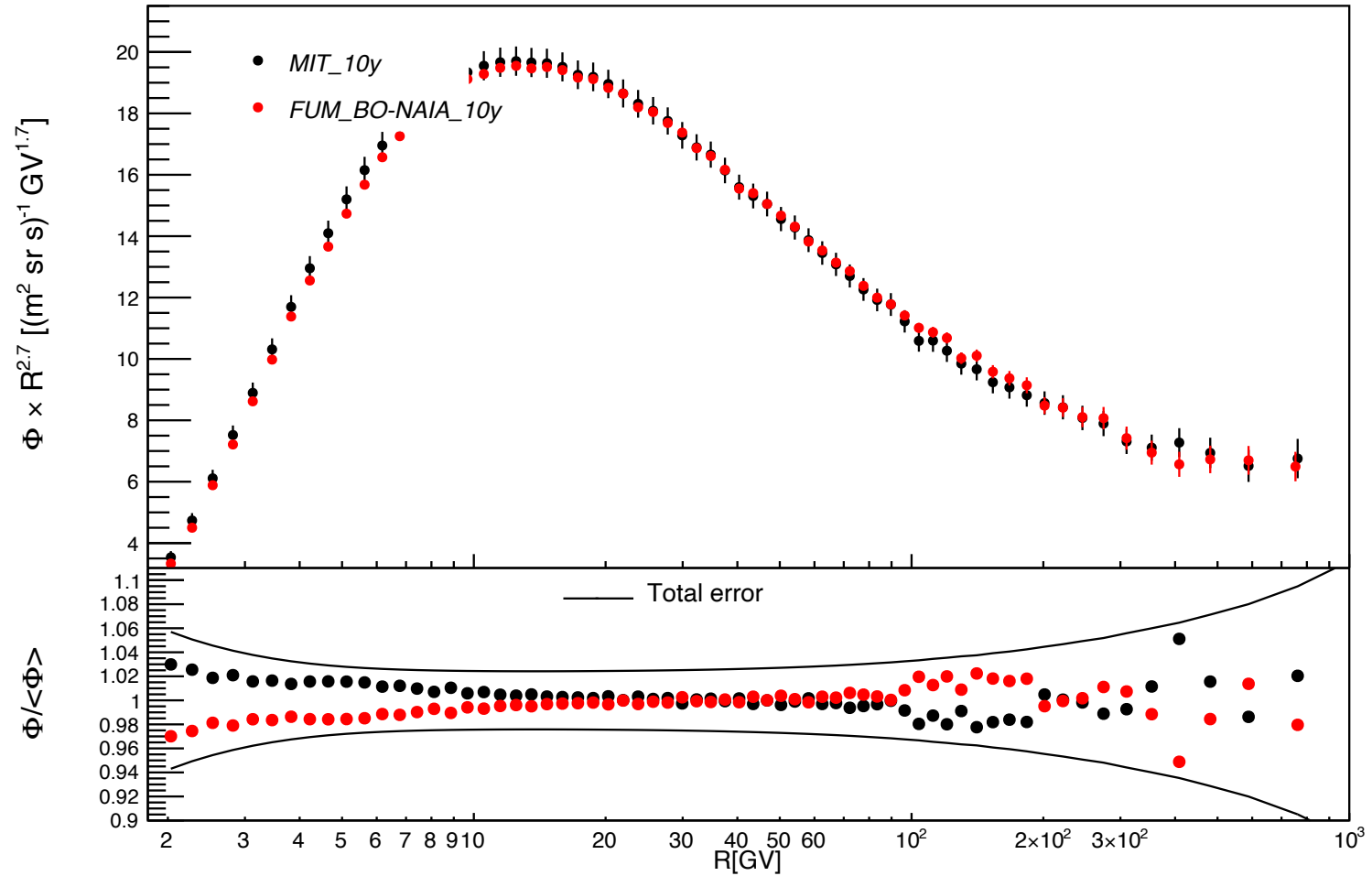
Raw Folded Acceptance

Weighting the MonteCarlo with a combination of MIT 10 years fluxes and Galprop, we can obtain a folded acceptance.



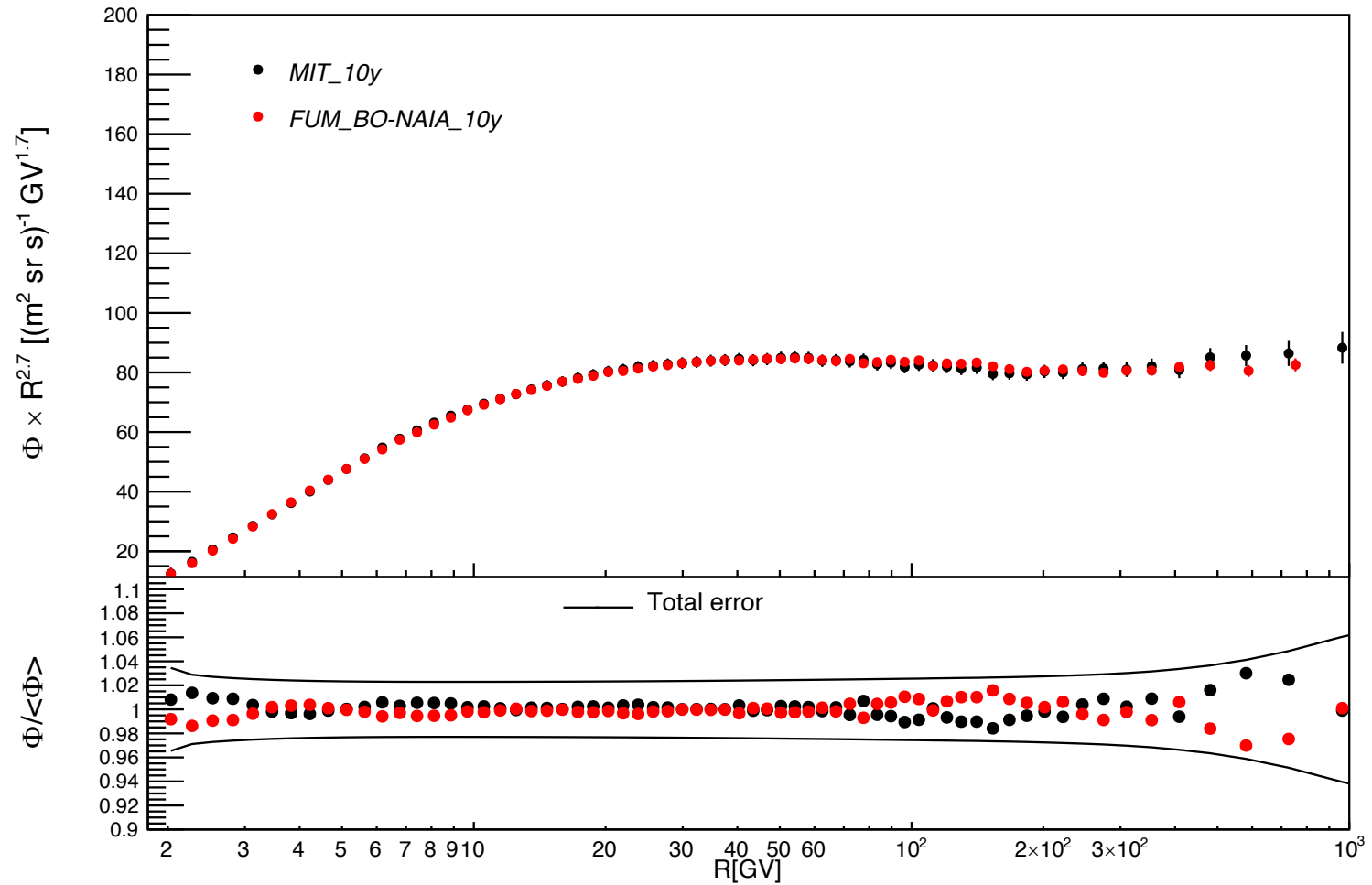
Boron 10 years vs MIT

MIT is pass7 data, no pass8 results are public from Qi Yan



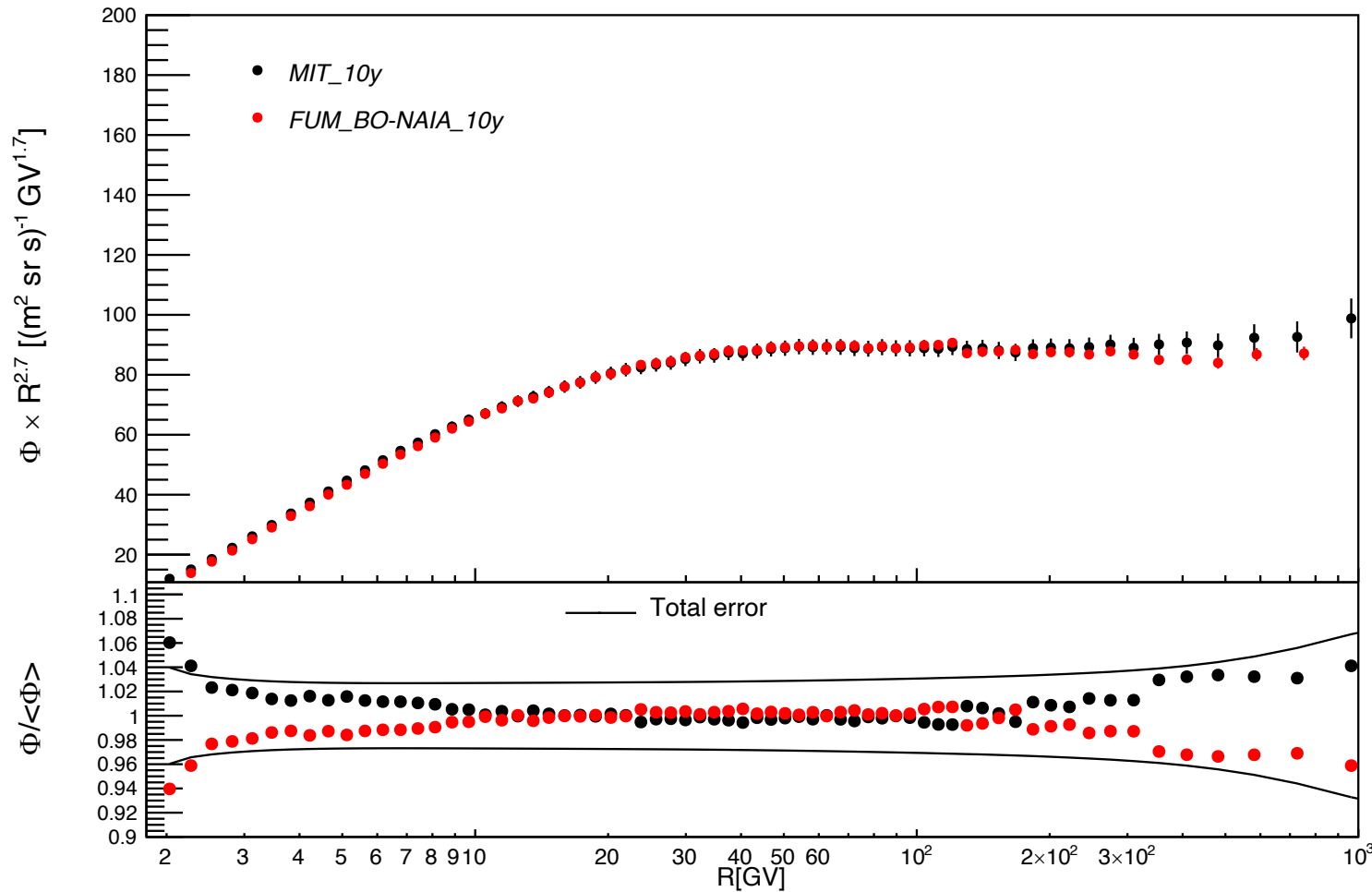
Carbon 10 years vs MIT

MIT is pass7 data, no pass8 results are public from Qi Yan



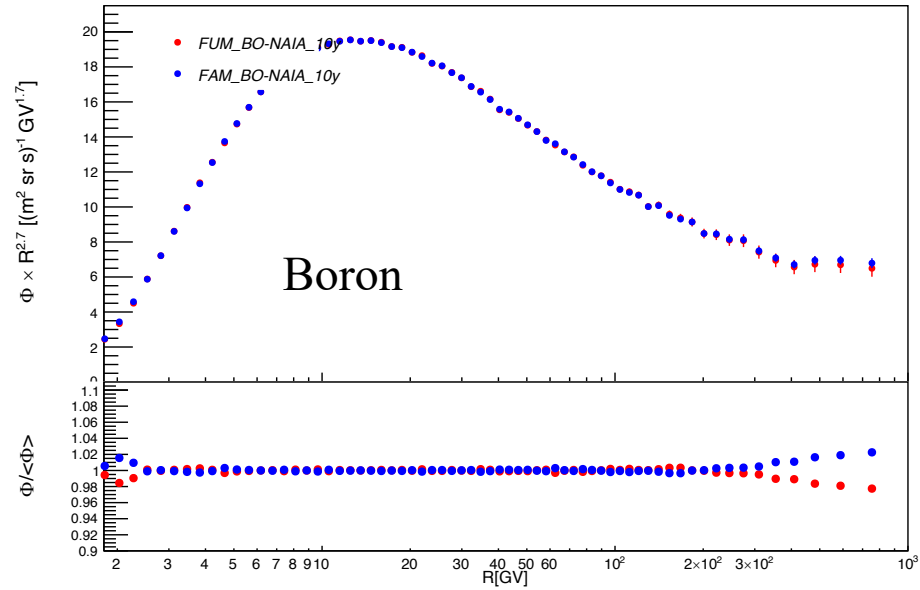
Oxygen 10 years vs MIT

MIT is pass7 data, no pass8 results are public from Qi Yan

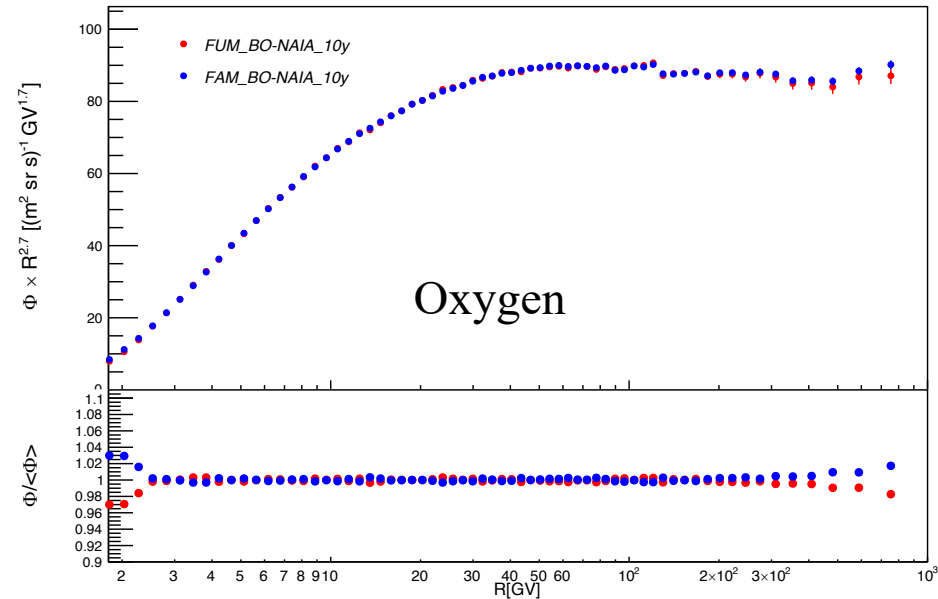
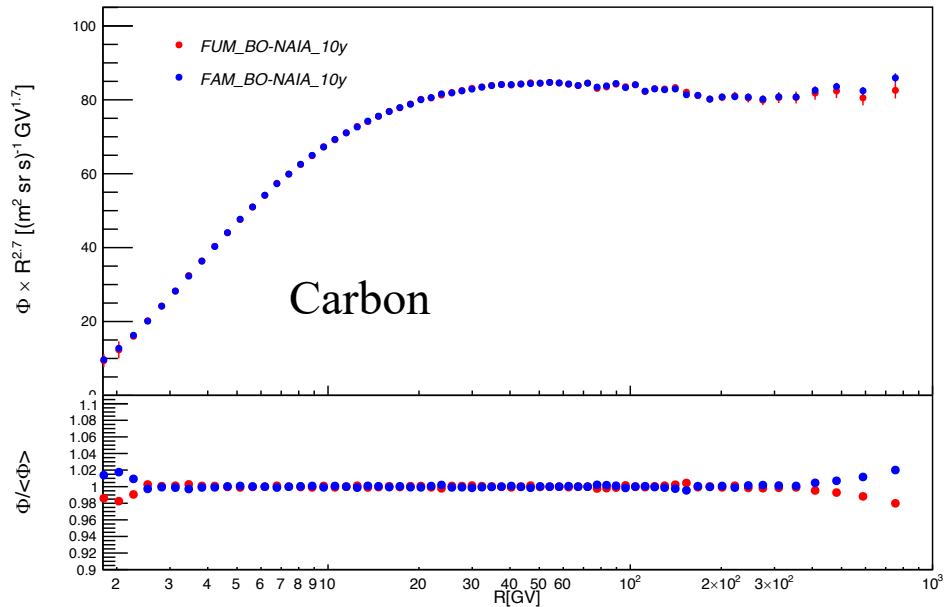


Maybe add here a plot of the old comparison
Since we had this problem before

Forward vs Folded Acceptance methods



Folded acceptance method is just the first iteration
Forward unfolding for Oxygen need some extra tuning

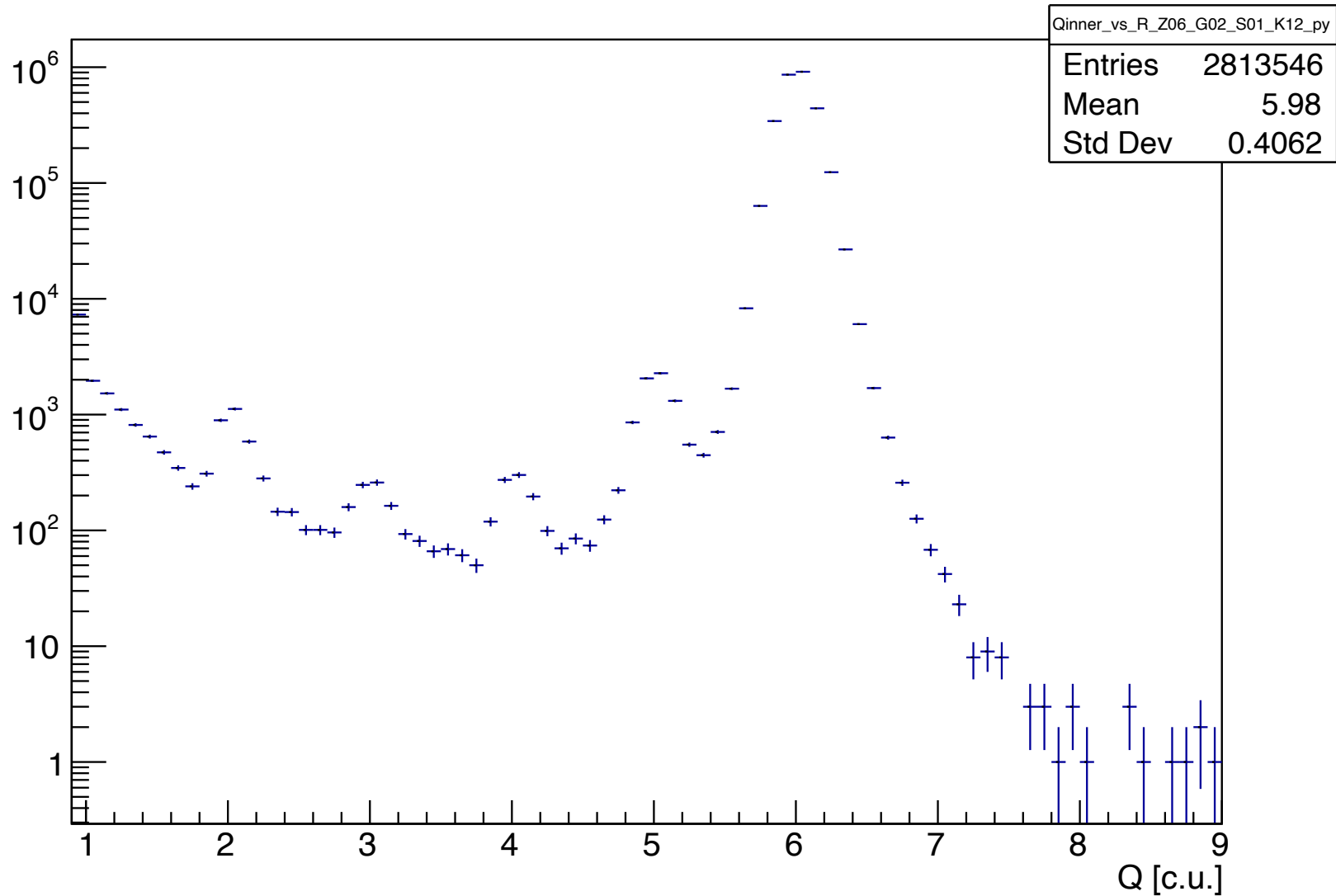


Pass8 updates from Qi Yan presentation

Not only that, the pass8 reconstruction (V6) is using more advanced track finding algorithm than pass7. Here lists a number of other updates:

- a) Better tracker Cluster (Hits) reconstruction:
 - fix missing Clusters (Hits) issue existing in all previous pass: \leq pass7
- b) More powerful inner track candidate builder together with more robust quality estimator
- c) More efficient noisy Hit filter
- d) New missing Hit refinding algorithm
- e) Higher external hit (tracker L1 or L9) picking-up efficiency
- f) Including all latest track fitting algorithms: Choutko (with bugs fixed), Kalman, GBL, ...
 - and all alignments: V5 (Inner/PG, external layers/PG+CIEMAT), V6 (Inner, external layers)
- g) New algorithm of tagging primary track (particle)

Qinner charge distribution



Loose cut on Charge is needed.

Vertical tracks producing gamma rays most probably.

It is a tracker inefficiency, not a tracker charge one, that is why we put it in the tracker numerator.

Trigger Data/MC Correction

Standard selection with trigger as a last cut.

