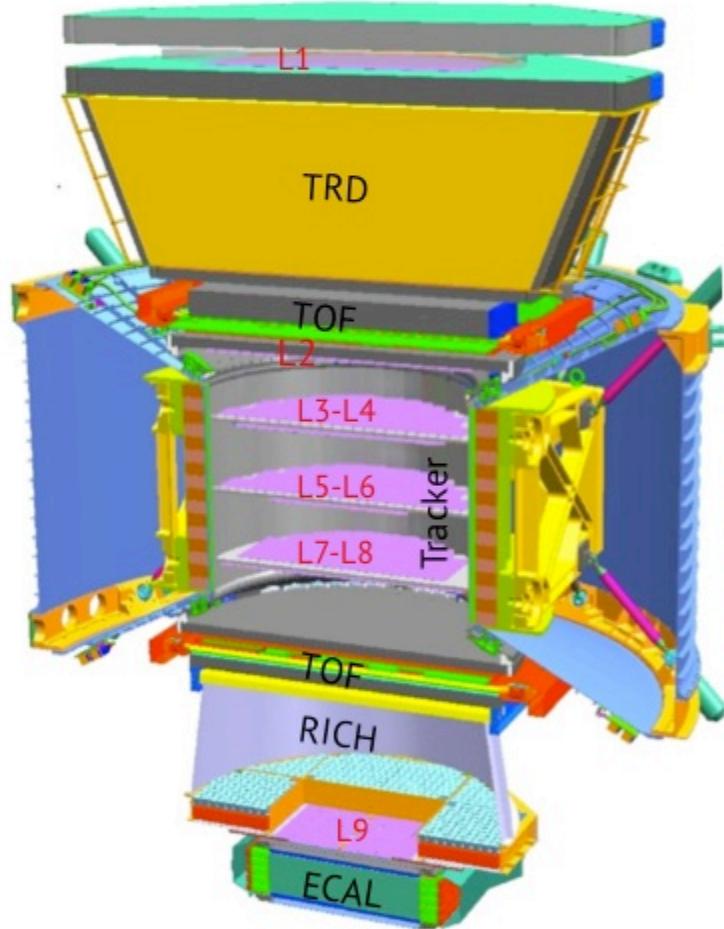




Precision measurement of He flux with AMS

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Academia Sinica

He properties measurement by AMS



Tracker (L1 – L9) + Magnet

Rigidity and Charge Sign

Bending Coordinate Resolution($Z=2$) $\approx 7 \mu\text{m}$

MDR($Z=2$) $\approx 3.2 \text{ TV}$

TOF

Velocity and Direction

$\Delta\beta/\beta^2 \approx 2\%$

TRD, Tracker, RICH ,TOF, ECAL

Charge Magnitude

Along Particle Trajectory

ΔZ ($Z=2$) $\approx 0.08-0.2$

He event selection

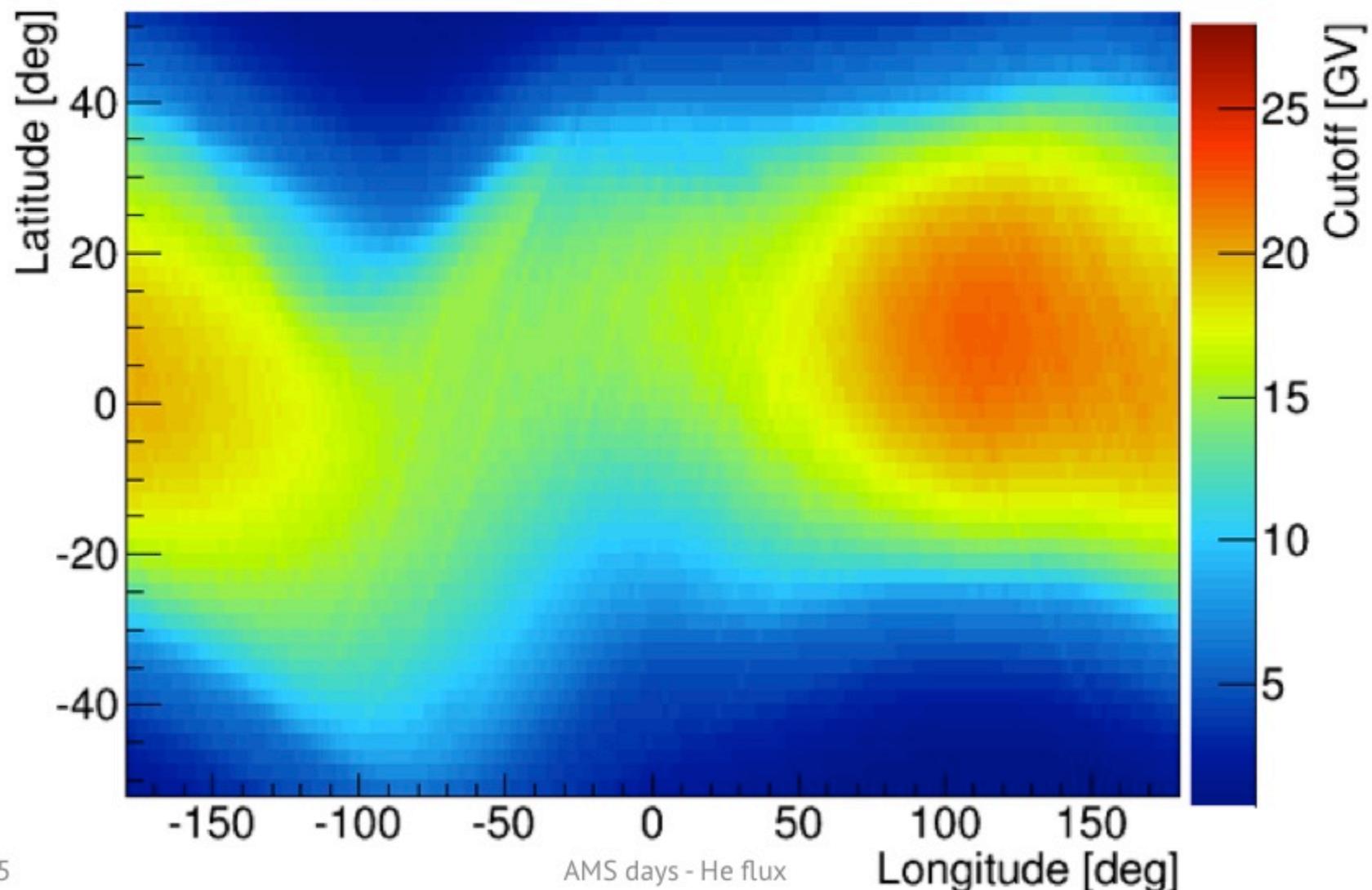
Data sample : May/2011 – Nov/2013 (30 months)

1. Downgoing particle ($\beta > 0.3$)
2. Rigidity (R) above Geomagnetic cutoff :

$$R > 1.2 R_{\text{IGRF-cutoff}}$$

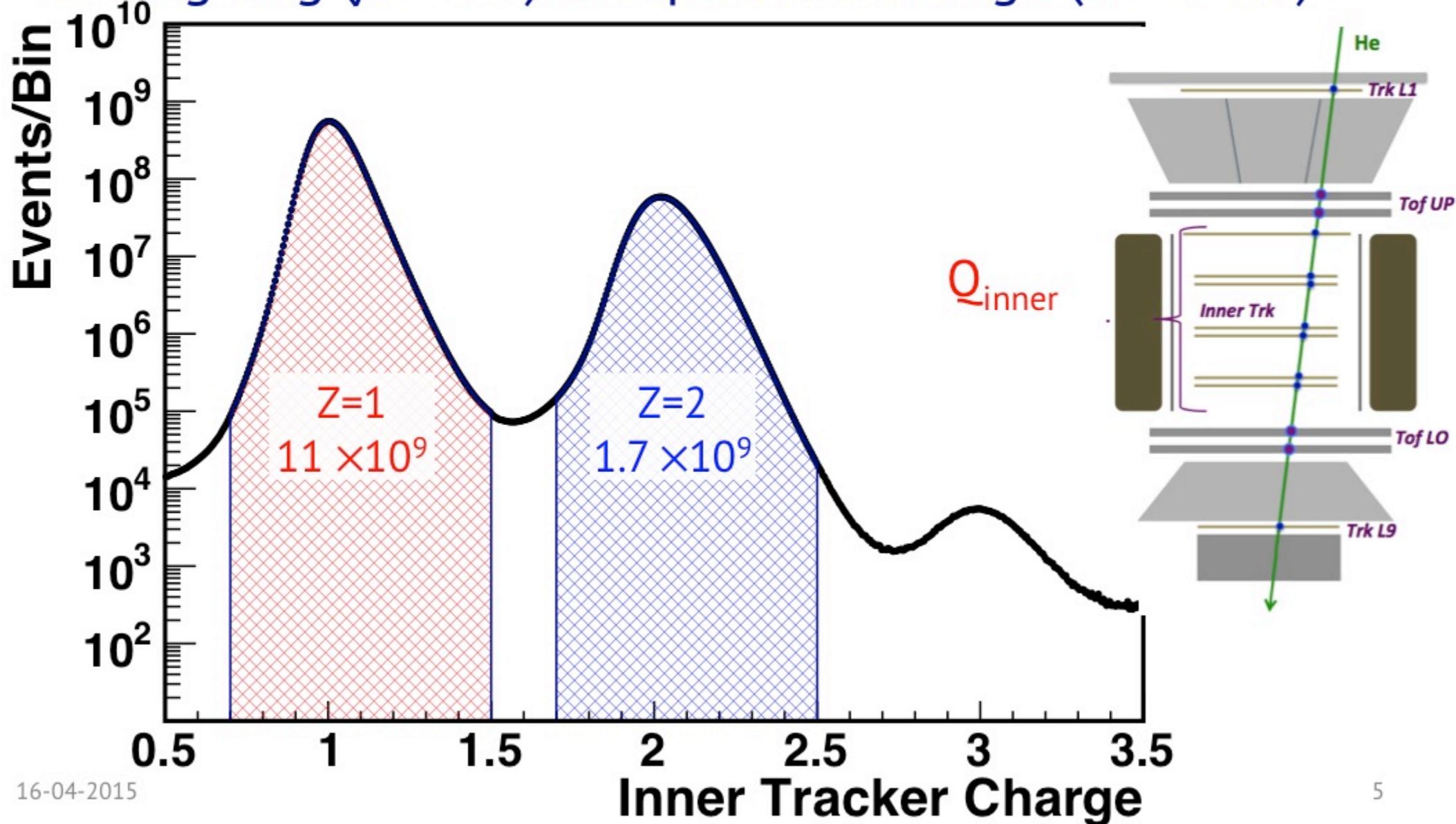
Geomagnetic Cutoff Rigidity

Backtracing particles from the top of AMS out to 50 Earth's radii
using the IGRF geomagnetic model



He selection (1)

Downgoing ($\beta > 0.3$) and positive charge ($R > 1$ GV)



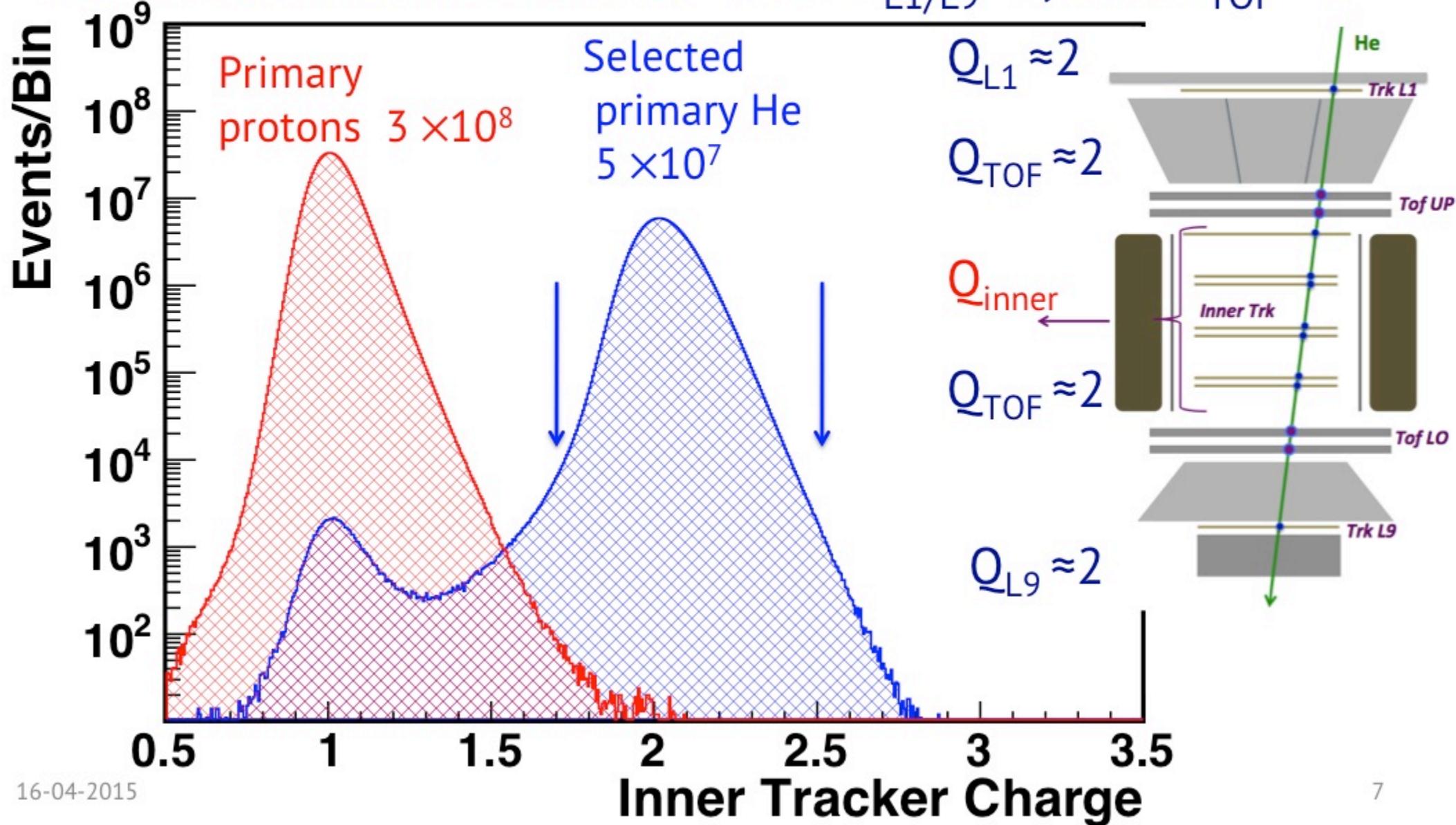
He event selection

Data sample : May/2011 – Nov/2013 (30 months)

1. Downgoing particle ($\beta > 0.3$)
2. Rigidity (R) above Geomagnetic cutoff :
$$R > 1.2 R_{\text{IGRF-cutoff}}$$
3. Track has top (L1) and bottom (L9) layers
to ensure the best resolution ($\text{MDR}_{\text{L19}} \approx 3.2 \text{ TV}$)
4. Charge compatible with $Z=2$ along the trajectory
e.g. Inner Tracker : $1.7 < Q_{\text{inner}} < 2.5$
5. Quality of the track fitting : $\chi^2/\text{d.f.} < 10$

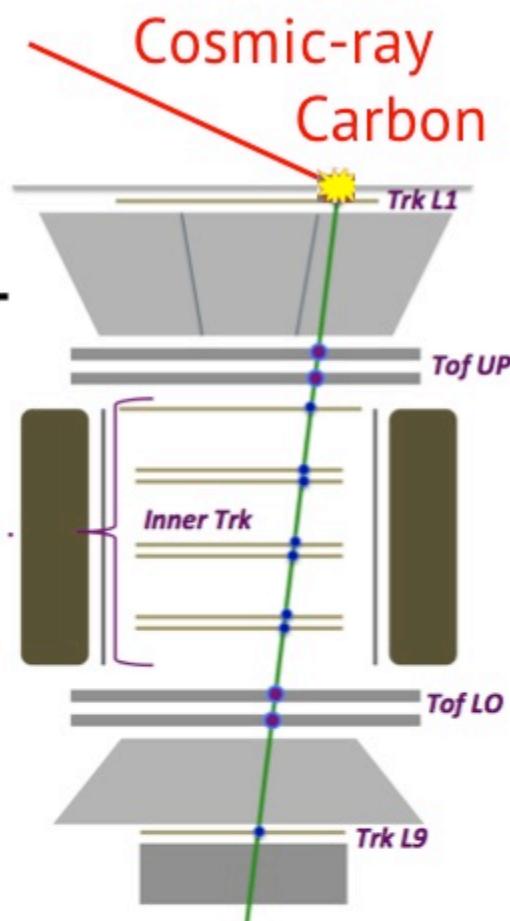
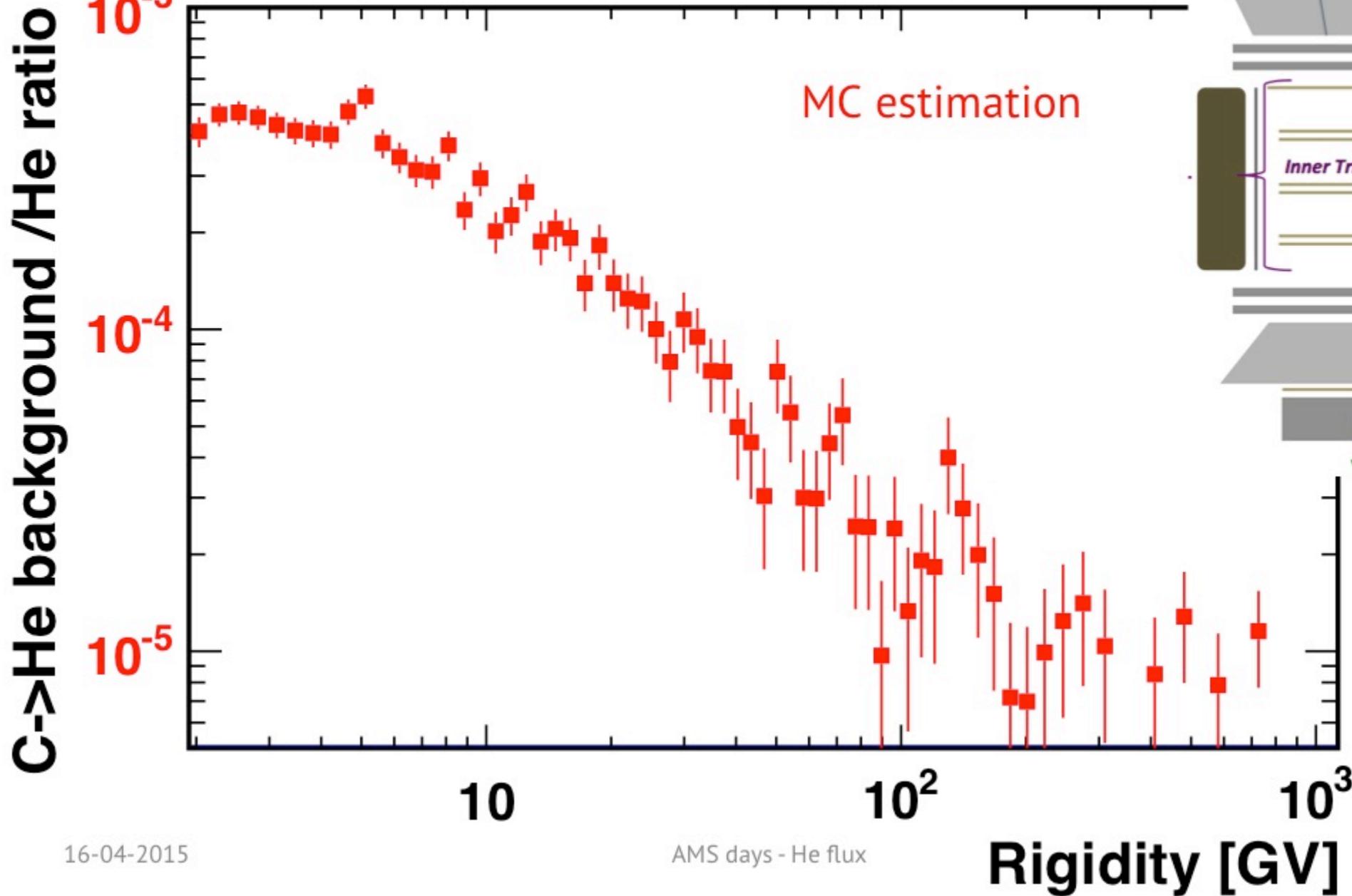
He selection (2)

Track has hits in L1 and L9 with $Z_{L1/L9} \approx 2$, and $Z_{TOF} \approx 2$



Minor backgrounds

Secondary He produced by Carbon interacting above L1



Flux measurement

Assuming flux over geomagnetic cutoff is isotropic

The differential flux is defined as :

$$\Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$

Events Corrected for
Bin to Bin Migration
due to Tracker Rigidity
Resolution

Time
 6.3×10^7 sec

Rigidity
2-3000 GV

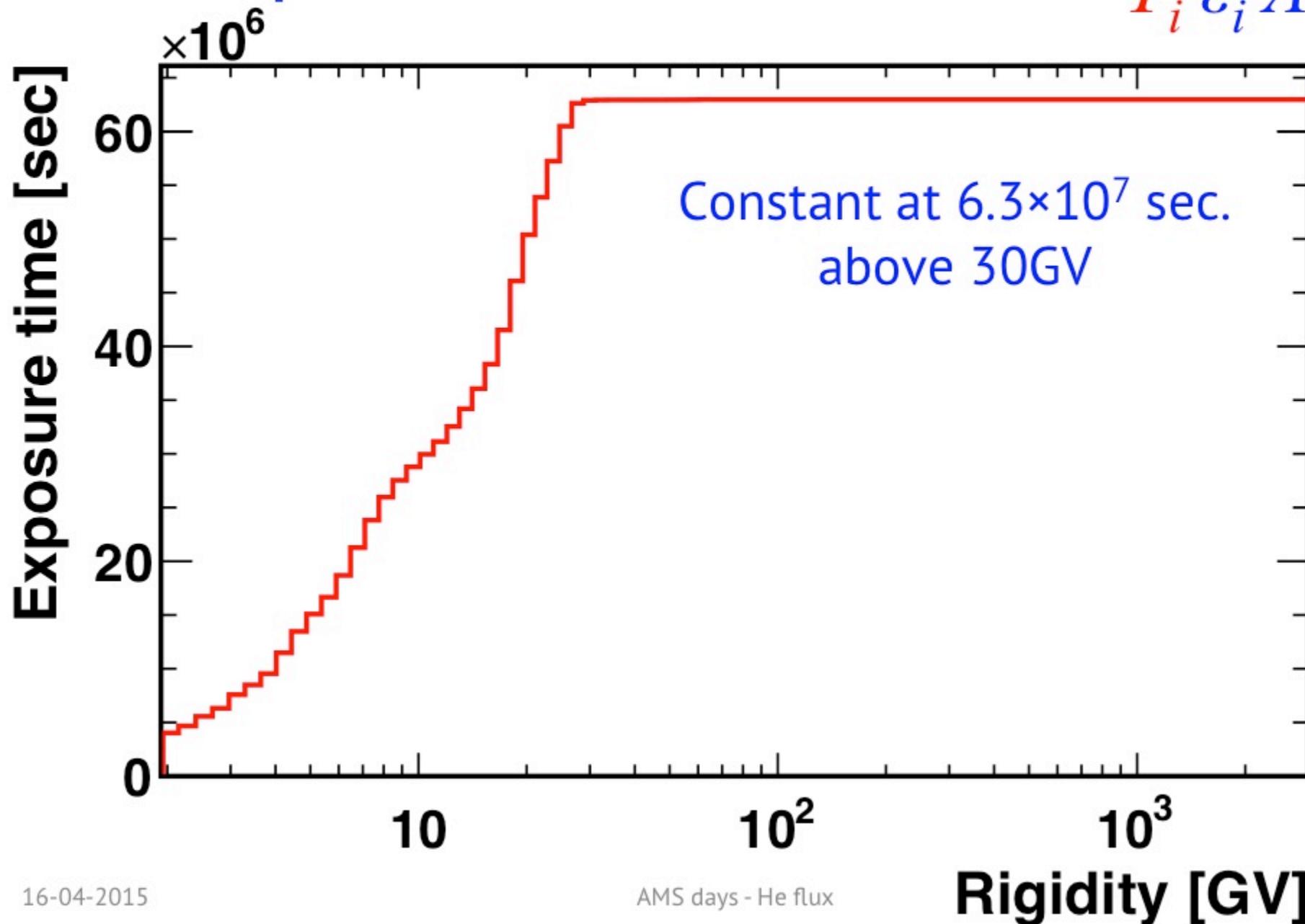
Trigger
Efficiency

Bin width

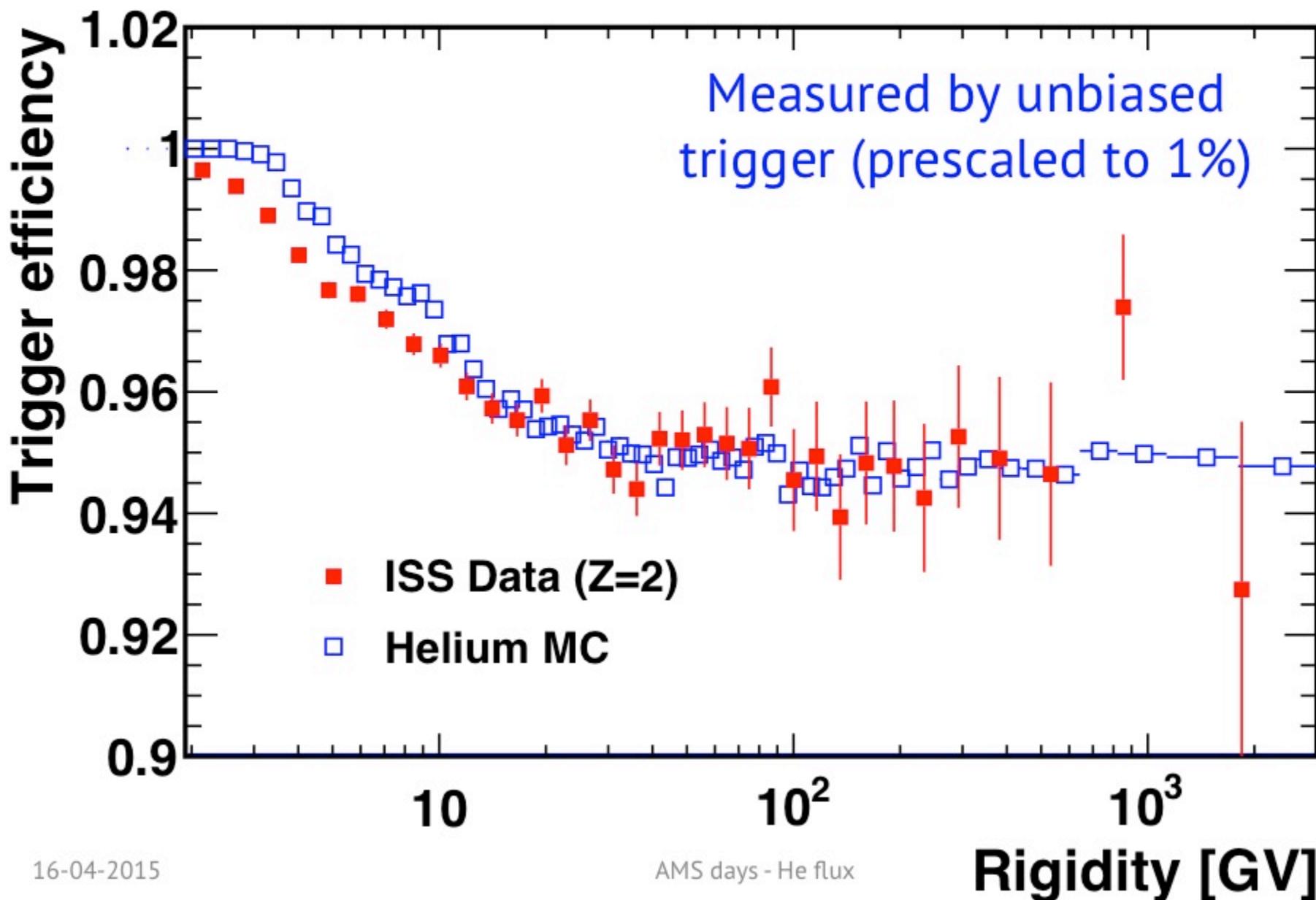
Effective
Acceptance

Exposure time

$$\Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$



$$\text{Trigger efficiency } \Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$



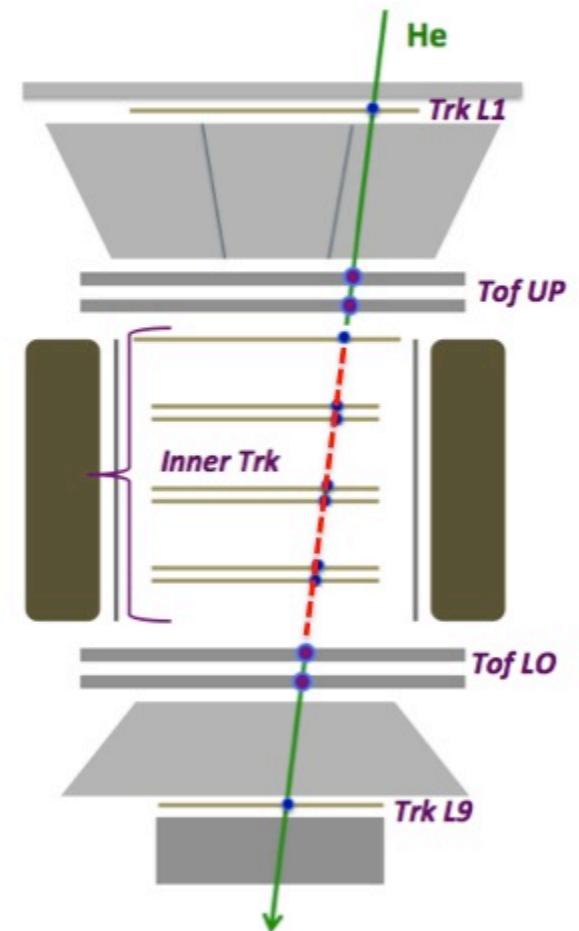
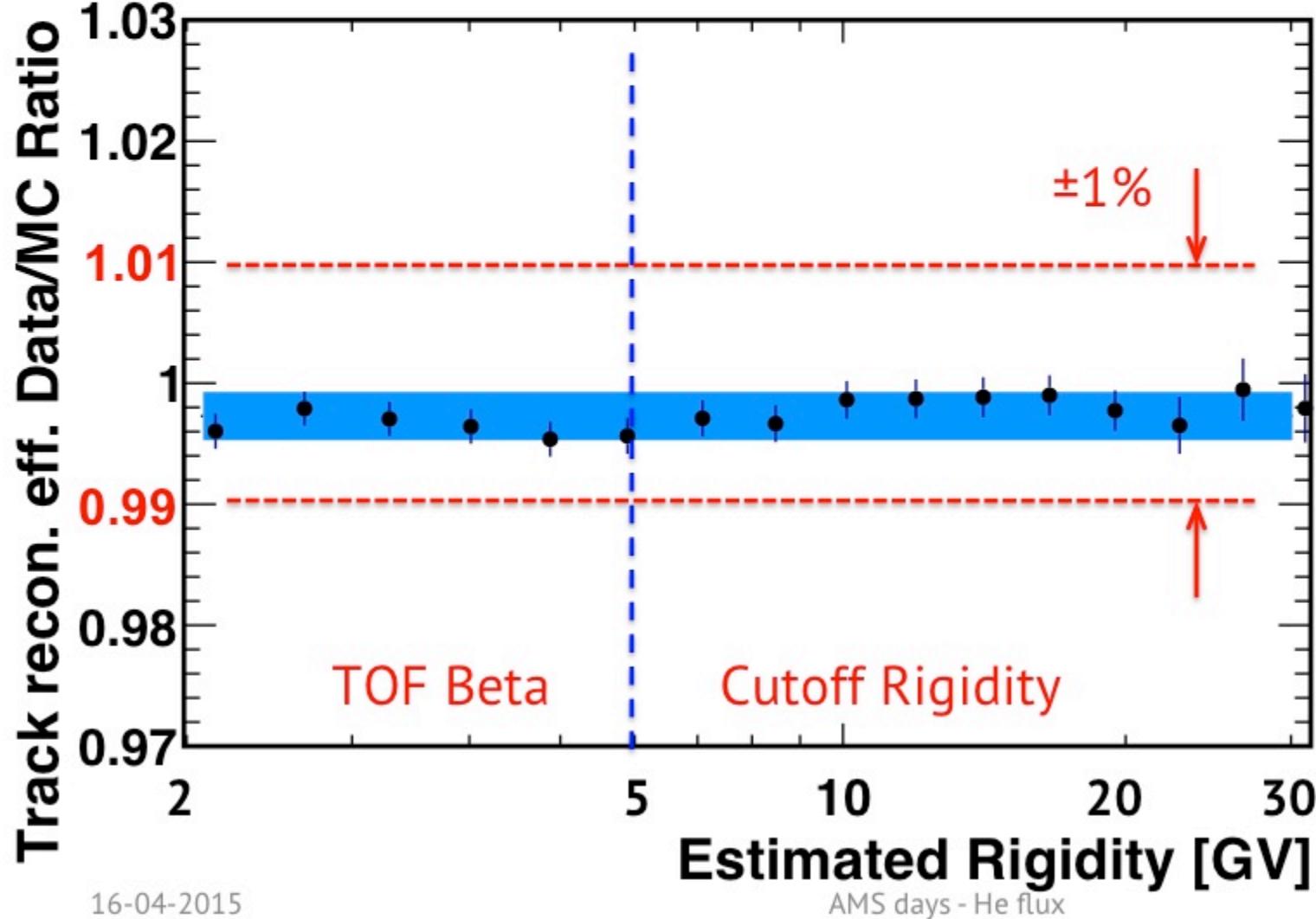
Acceptance – MC validation

$$\Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$

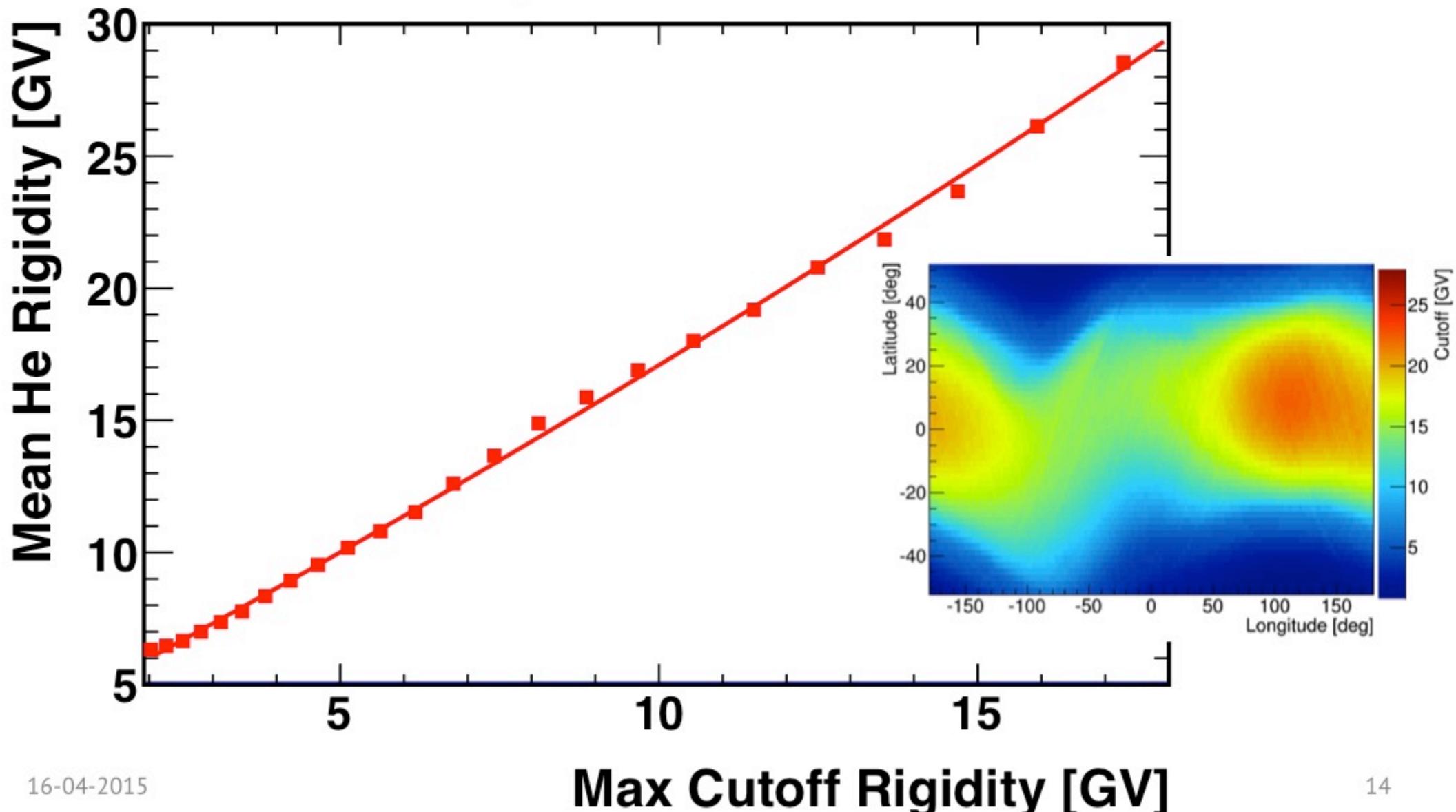
1. Track reconstruction efficiency
 - Validation of the description of the detector performance in MC simulation
2. L1 hit association efficiency
 - Validation of the He elastic scattering
3. Survival probability between L8 and L9
 - Validation of the He inelastic cross section

Data/MC comparison (1)

Comparison of Track reconstruction efficiency

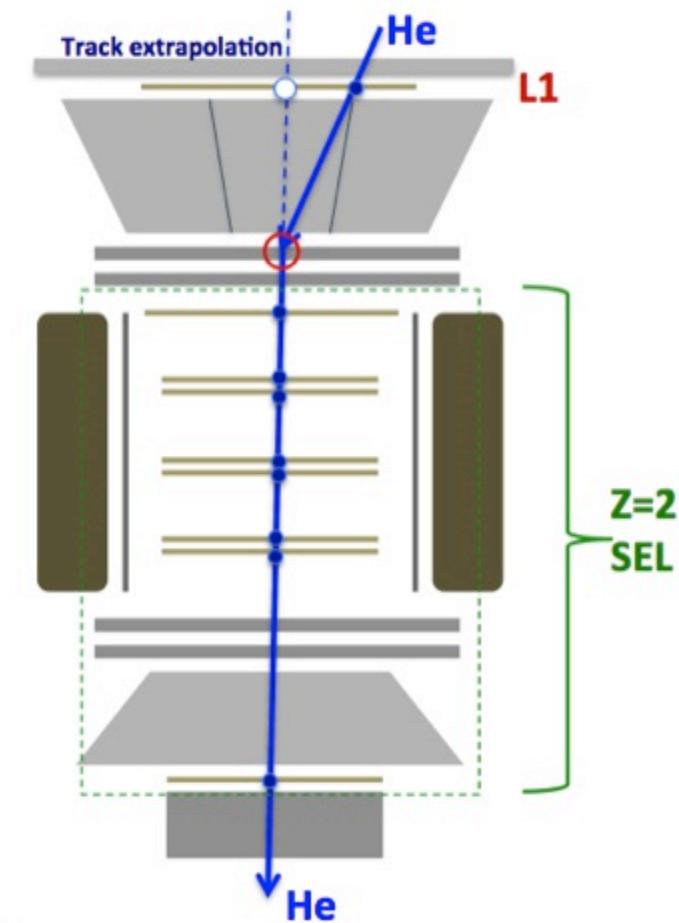
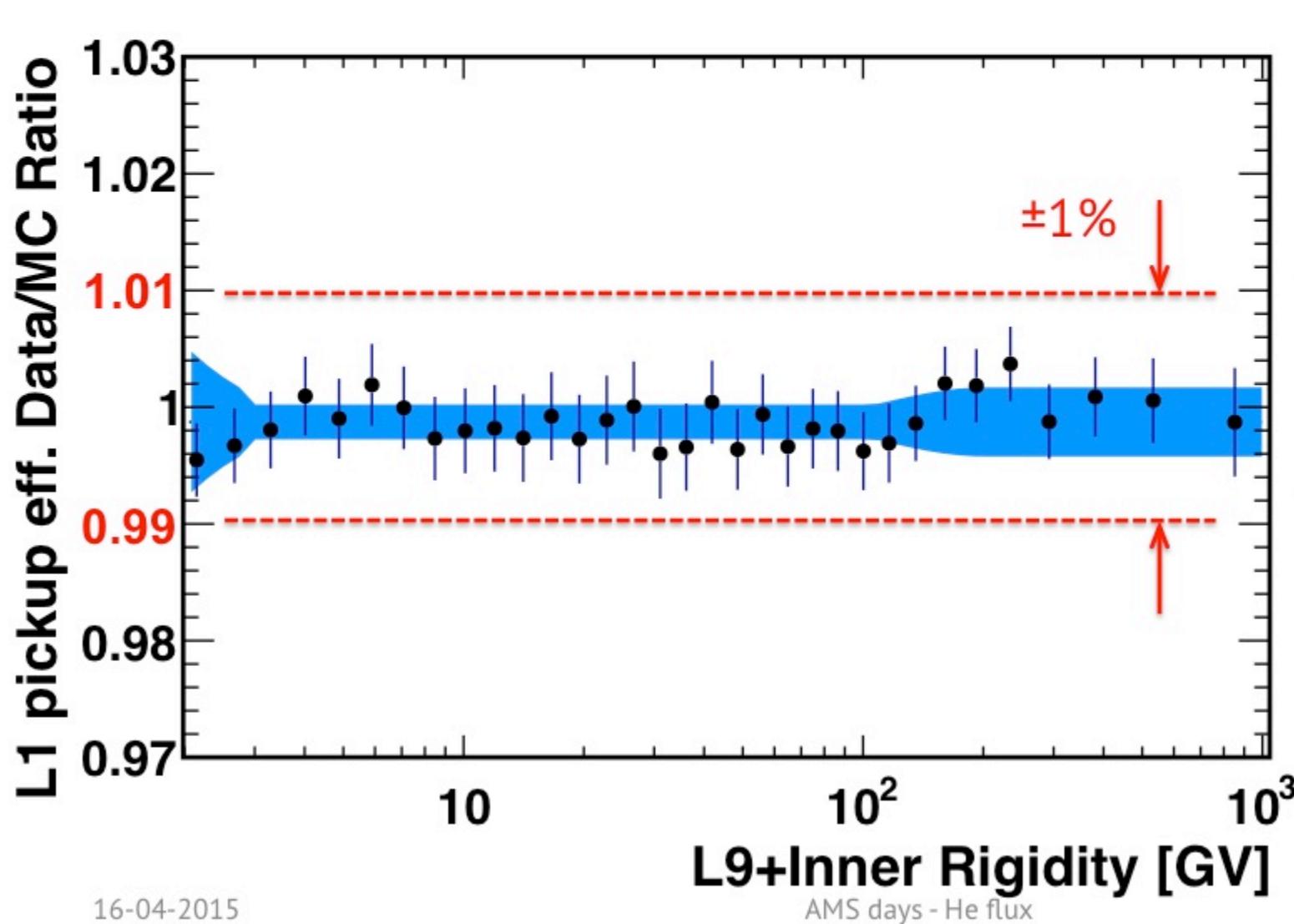


Rigidity estimation from cutoff - independent of Tracker



Data/MC comparison (2)

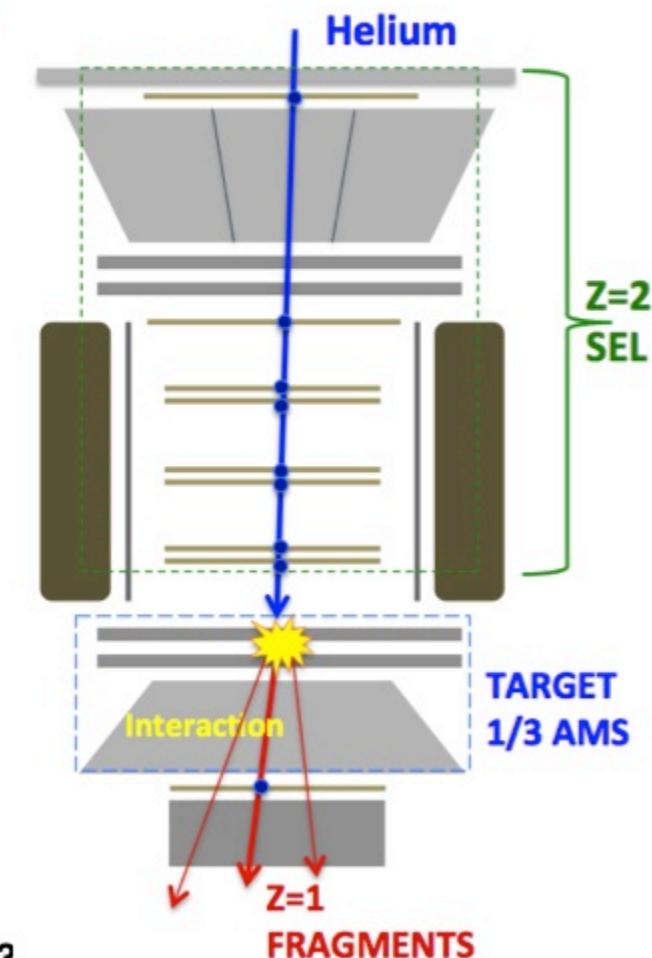
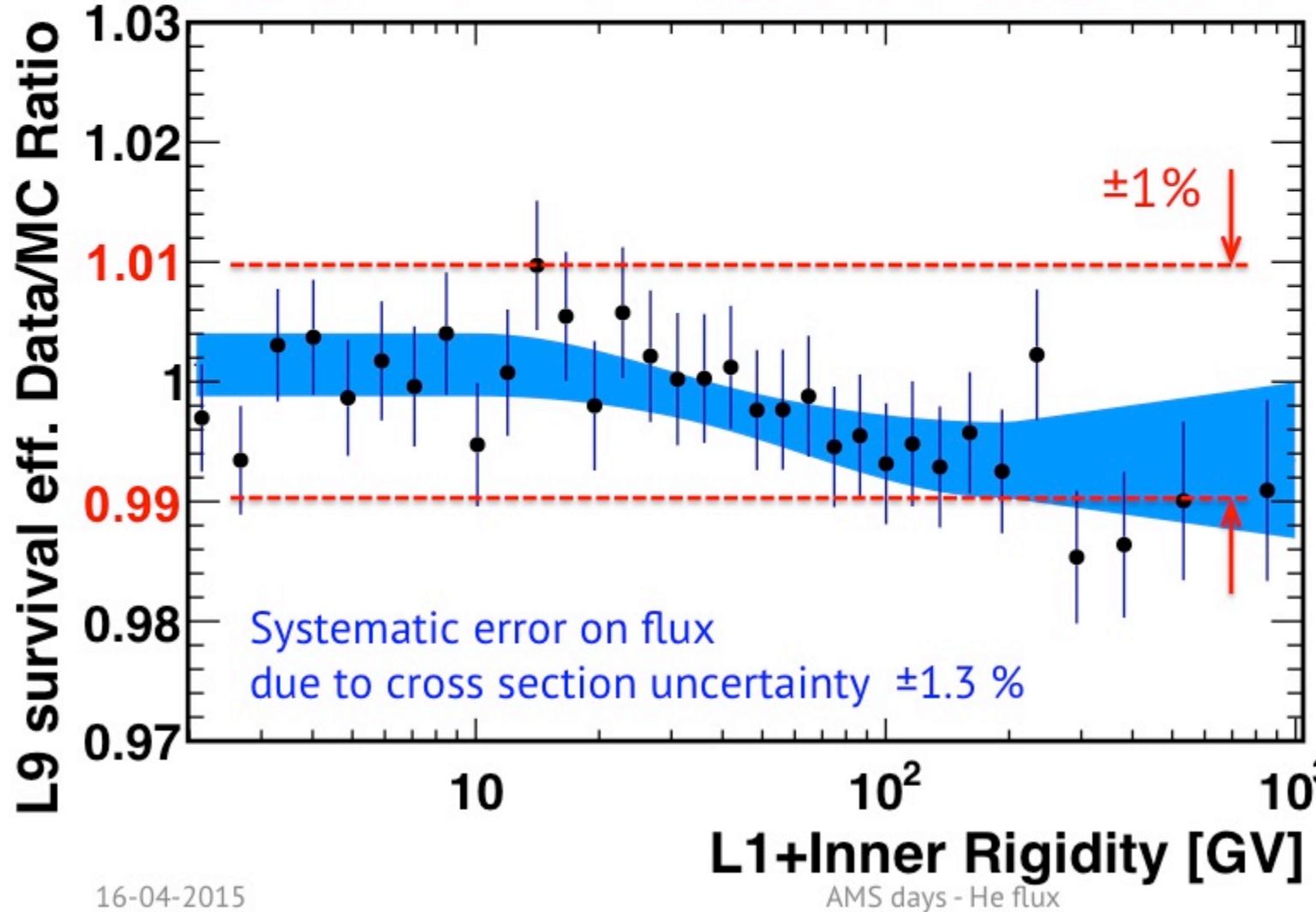
L1 hit association : Validation of elastic scattering



Data/MC comparison (3)

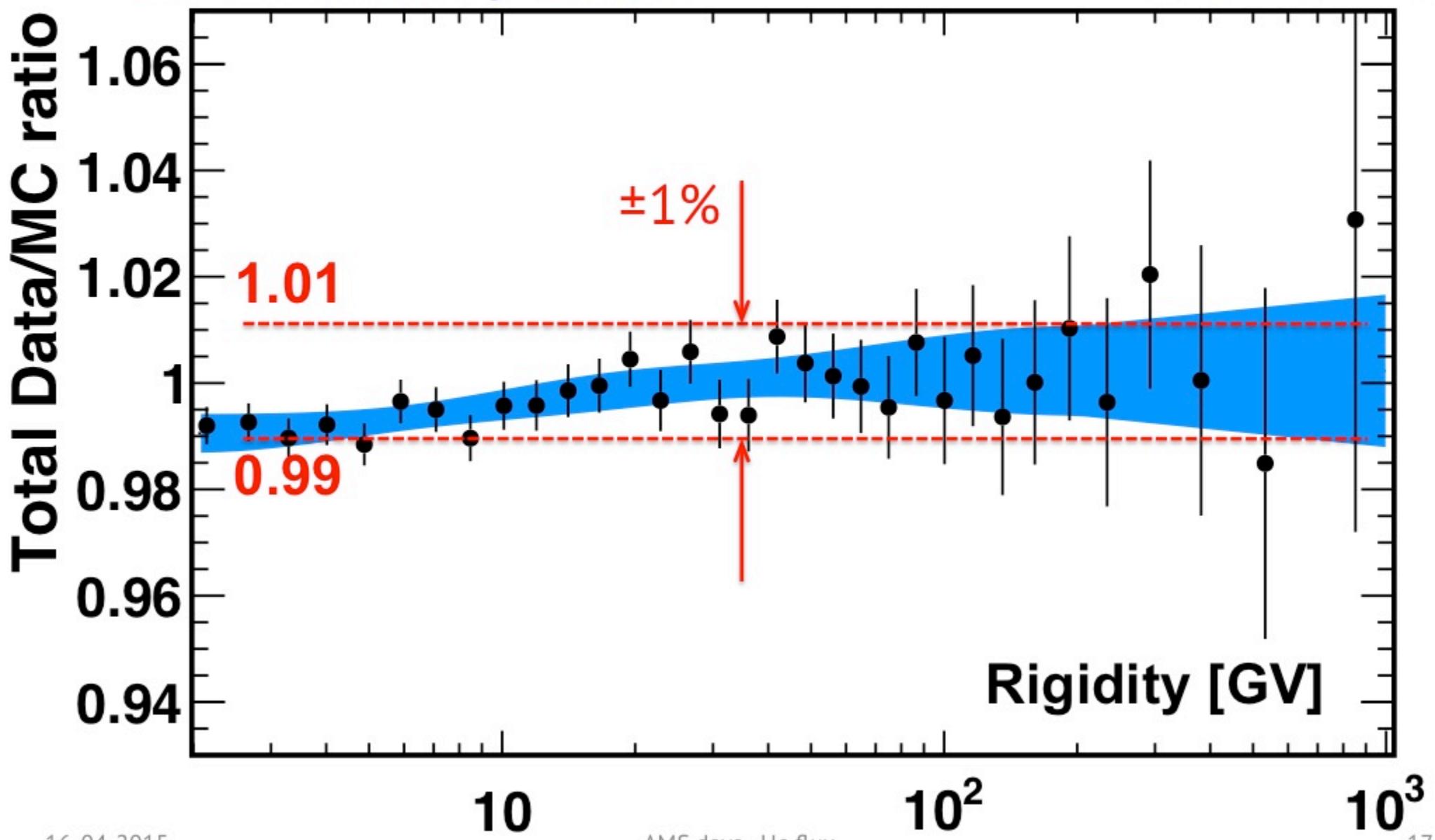
Survival probability between L8 and L9 :

Validation of He inelastic cross section



Total MC correction
to the acceptance

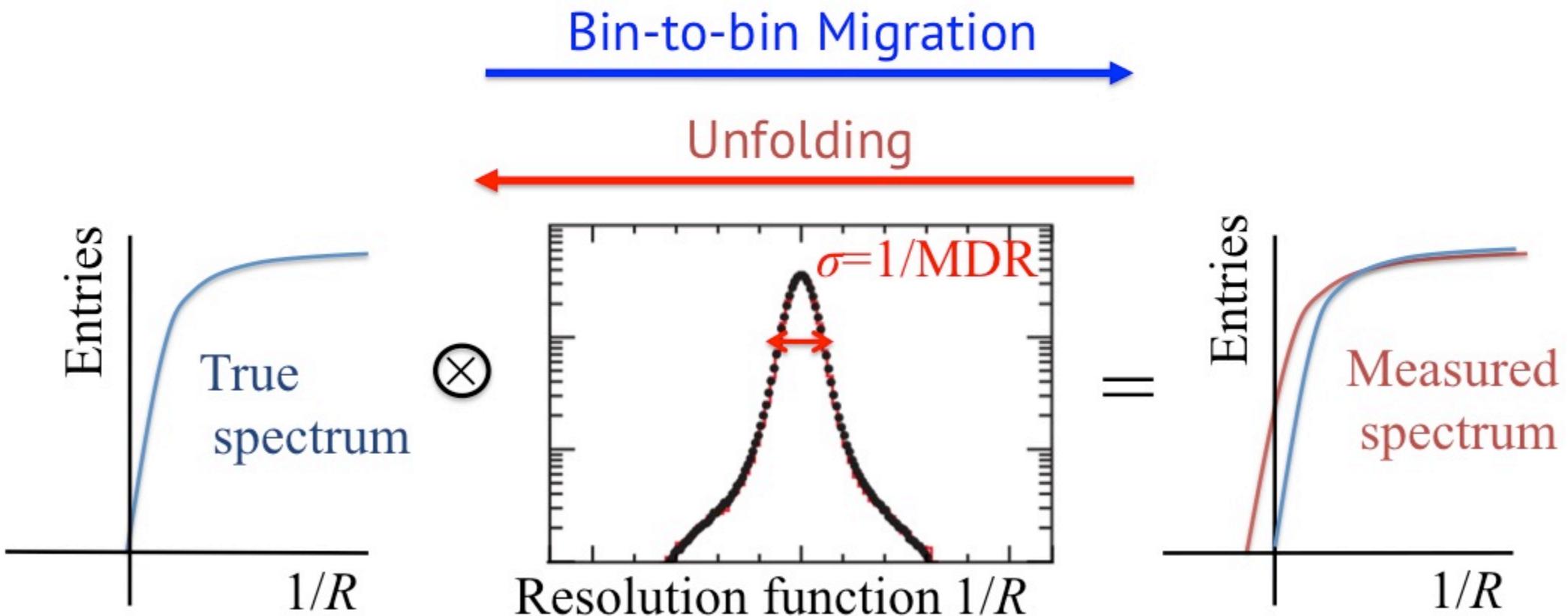
$$\Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$



Unfolding

$$\Phi_i(R_i) = \frac{N_i}{T_i \varepsilon_i A_i \Delta R_i}$$

Correction of bin-to-bin migration
due to the finite resolution function



Tracker resolution, rigidity scale

1. Tracker resolution

MC verification with

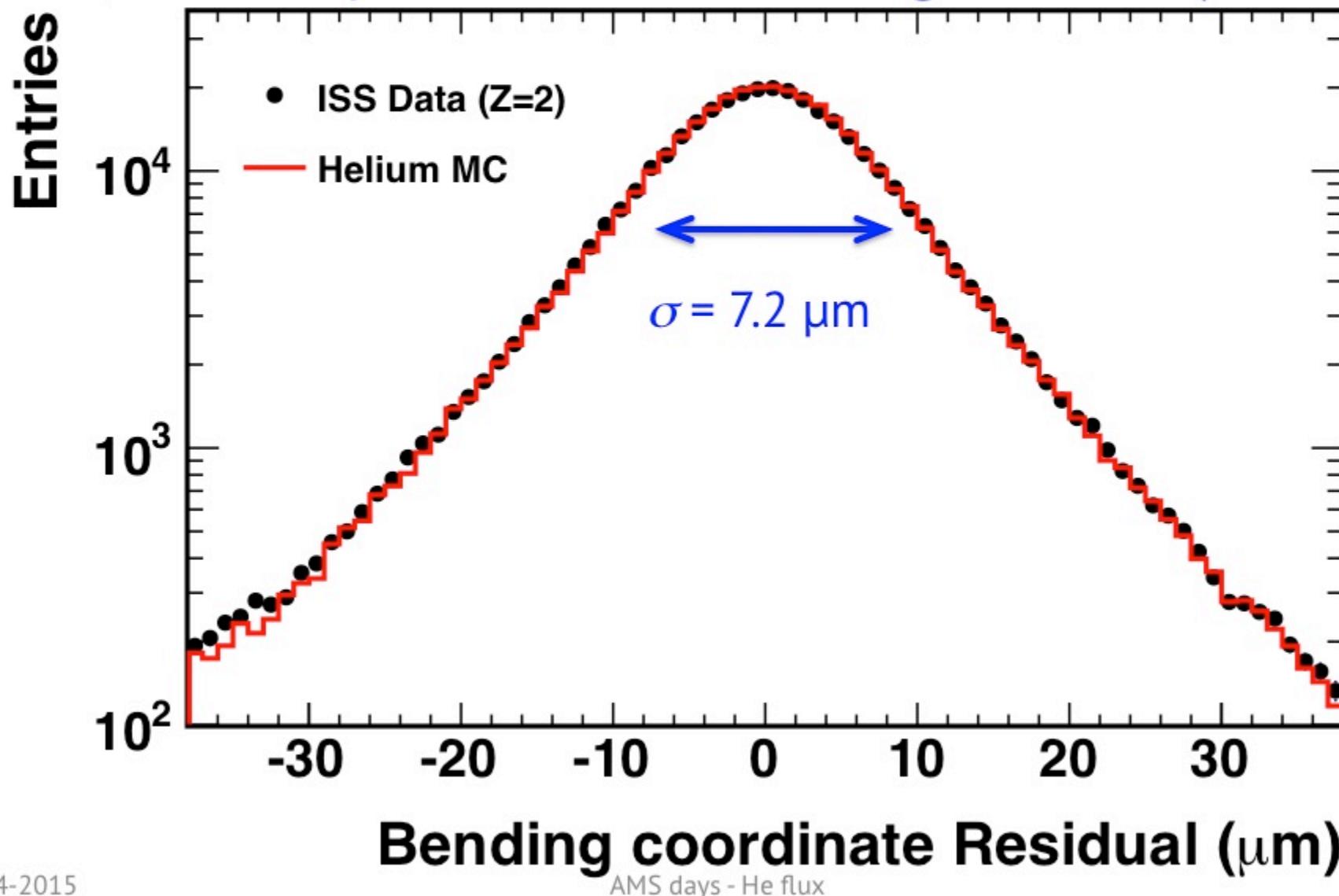
- Coordinate resolution from fitting residual

2. Absolute rigidity scale

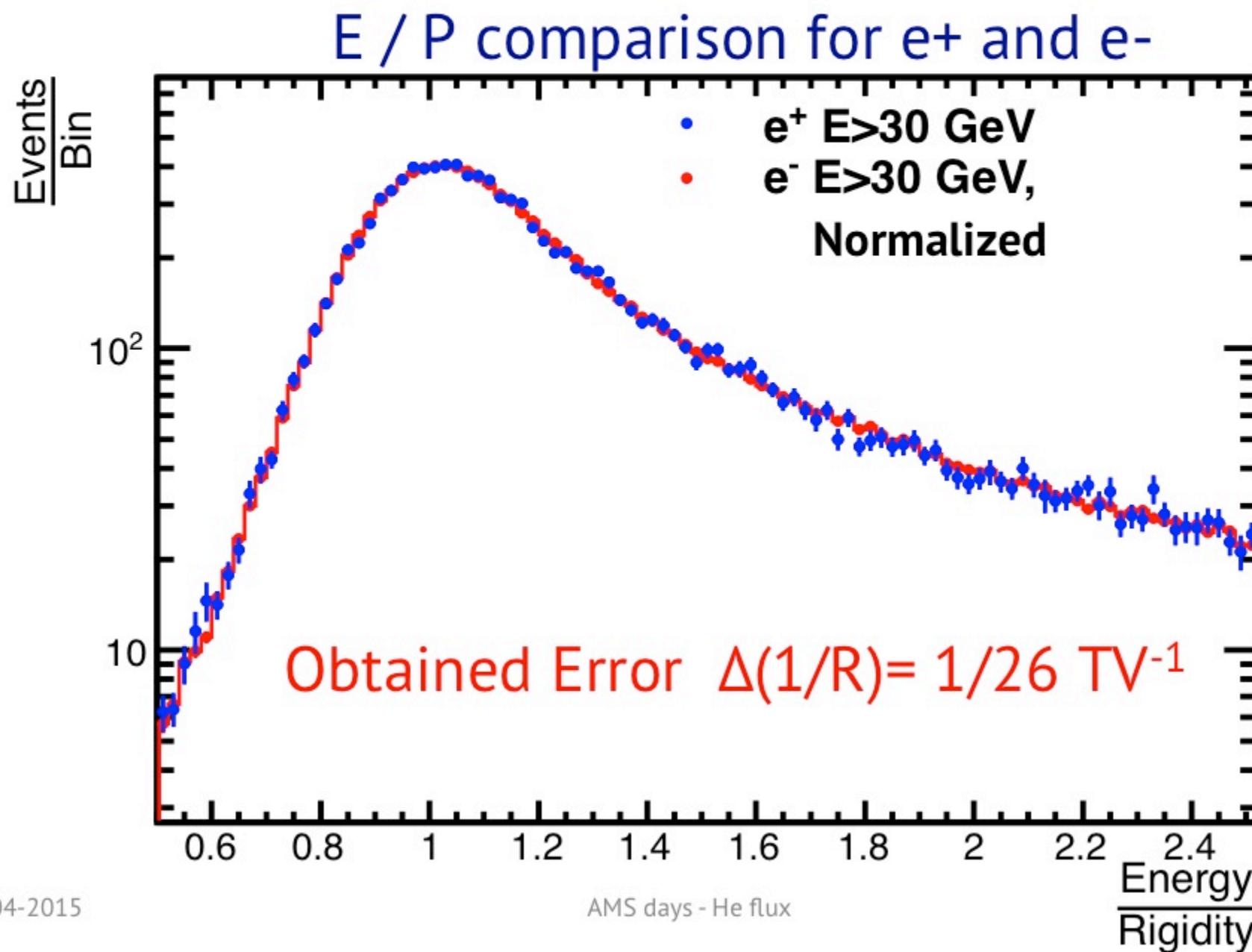
- Comparison of $(\text{Ecal energy}) / (\text{Tracker rigidity})$ between e^+ and e^- sample

Verification of Tracker resolution

Data/MC comparison of track fitting residual ($R > 40$ GV)



Verification of Rigidity scale



Main systematic errors

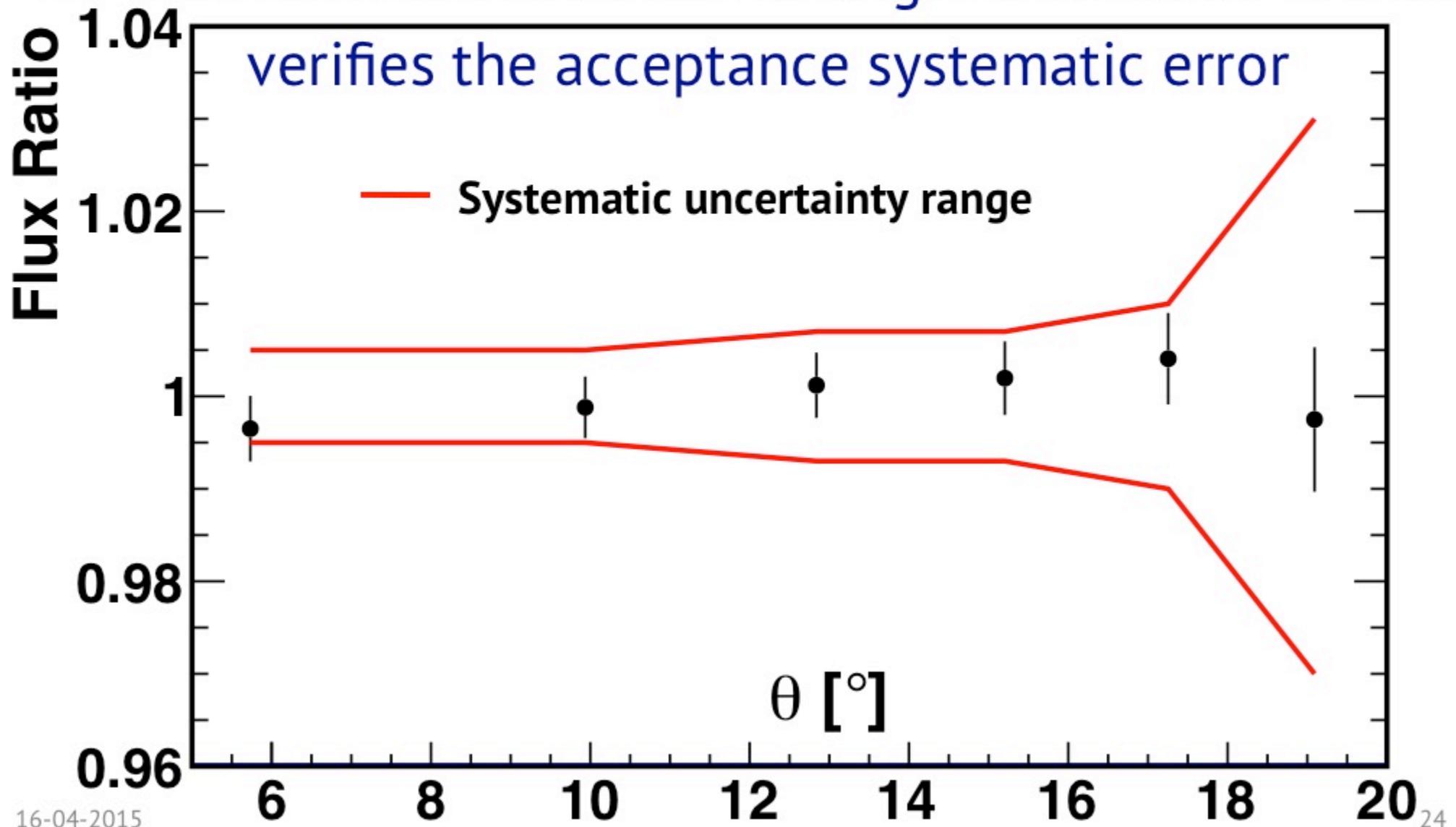
Source	Error at 200 GV (%)
Trigger	0.3
Acceptance	1.5
– Selection	0.8
– Cross section	1.3
Unfolding & Rigidity Resolution	1.0
Rigidity scale	0.7
– Residual Tracker misalignment	0.5
– Magnetic field accuracy	0.5
(Statistics	0.6)

Verifications of systematic errors

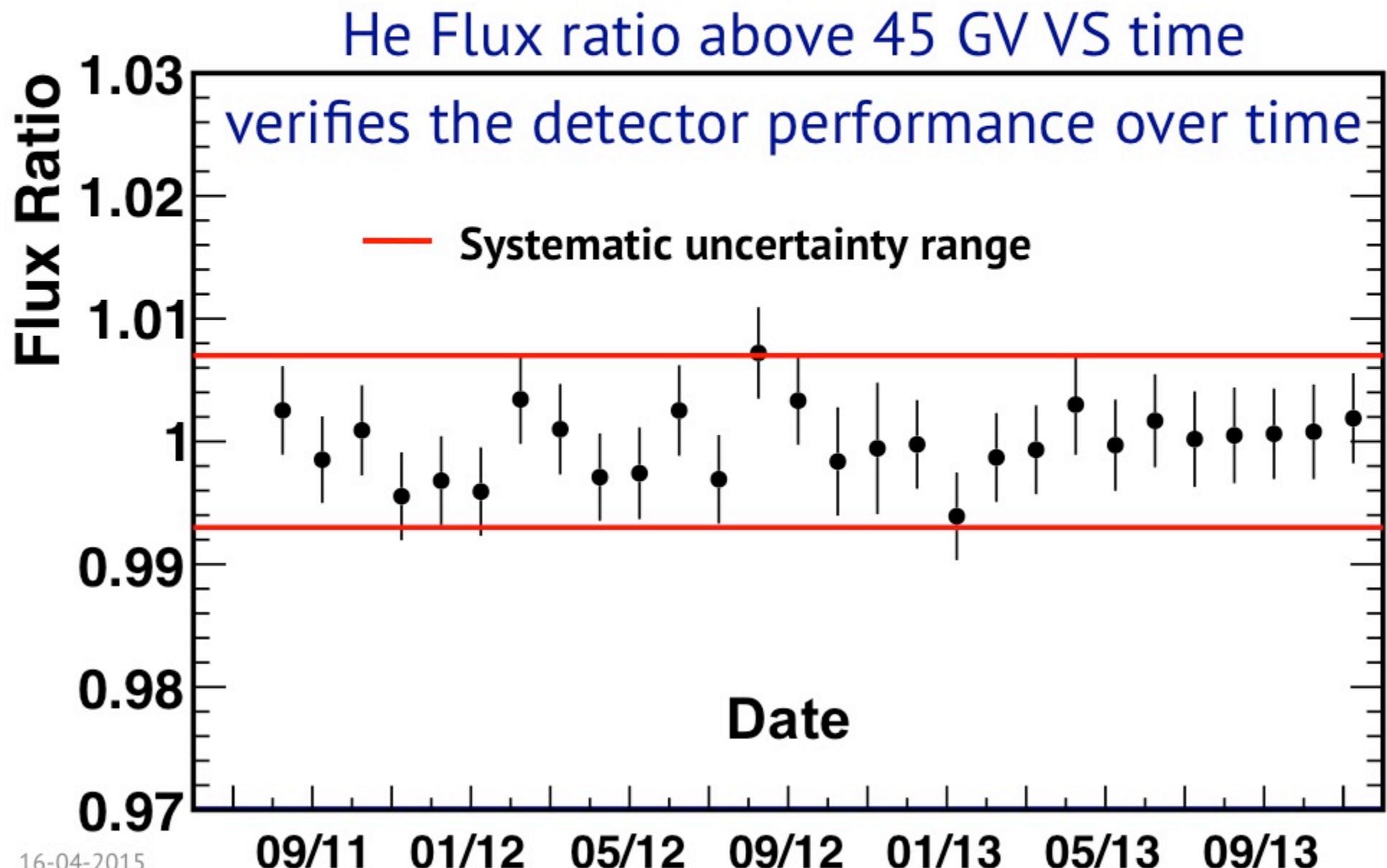
1. Flux ratio above 30 GV versus angle to AMS z-axis
 - Verification of systematic error on acceptance
2. Flux ratio above 45 GV versus time
 - Stability of detector performance over time
3. Flux ratio between Inner and Full Tracker
 - Verification of systematic errors on unfolding and rigidity resolution function

Verifications of Systematic errors (1)

He Flux ratio above 30 GV VS angle θ to the AMS z-axis

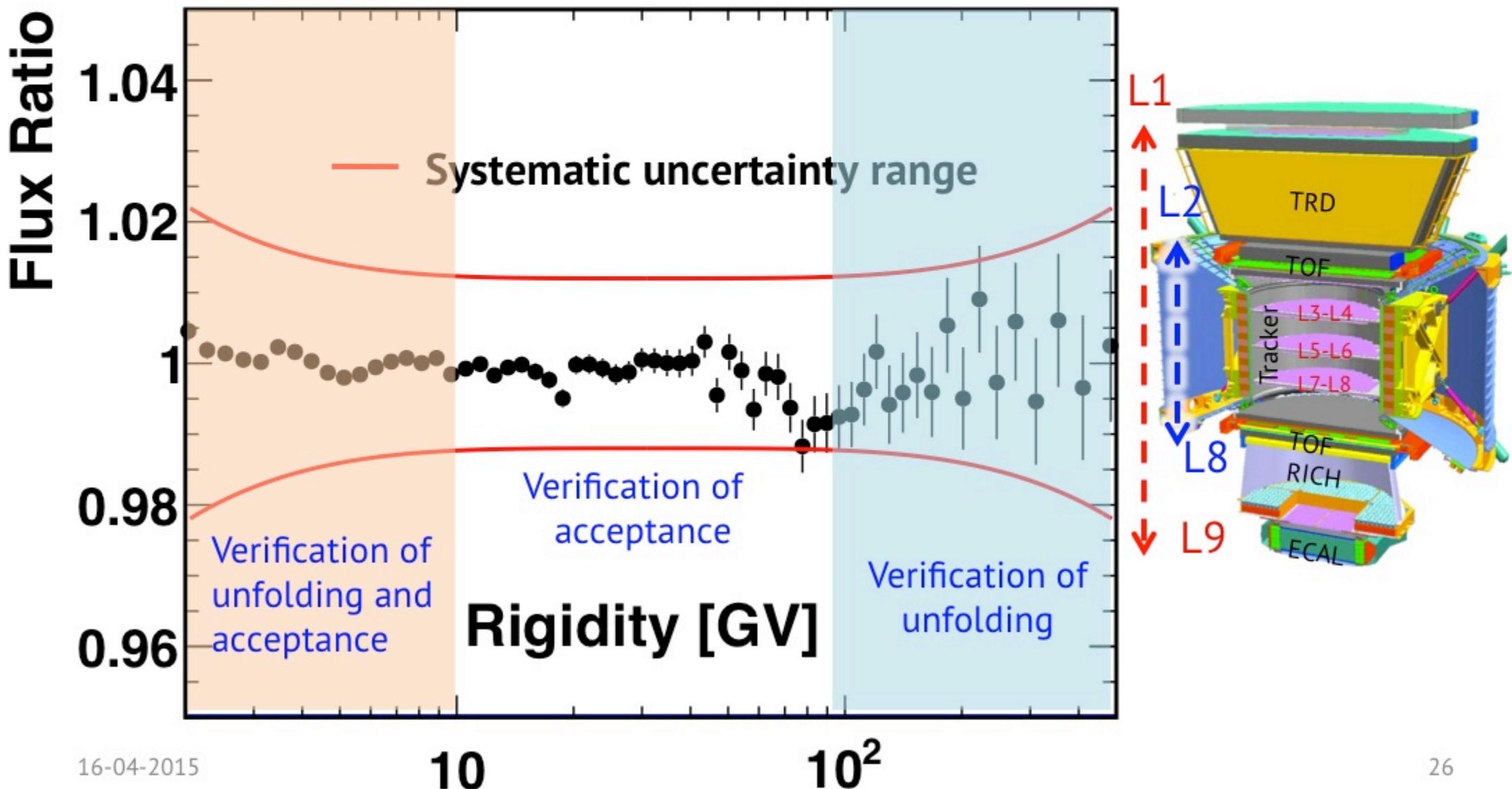


Verifications of Systematic errors (2)

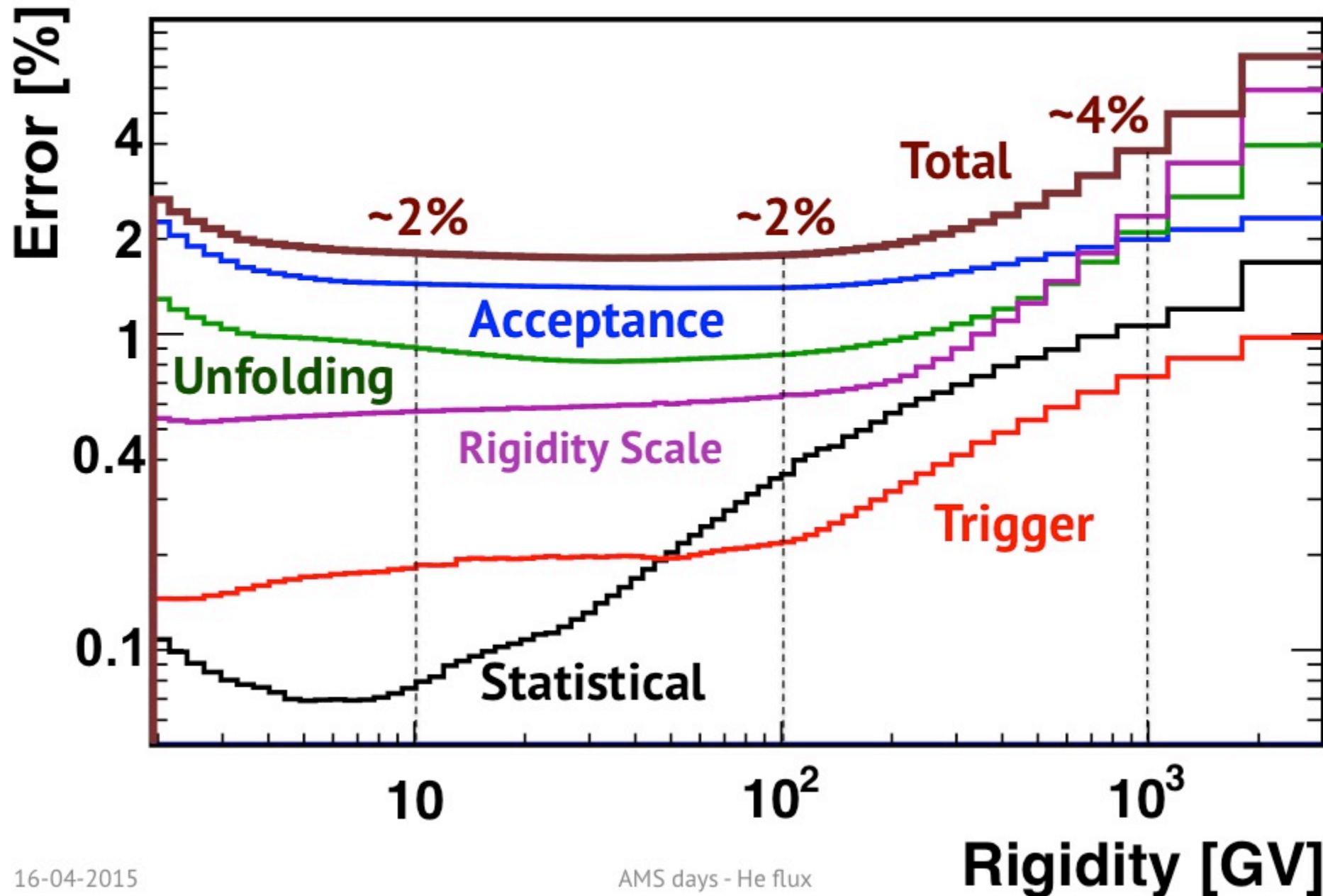


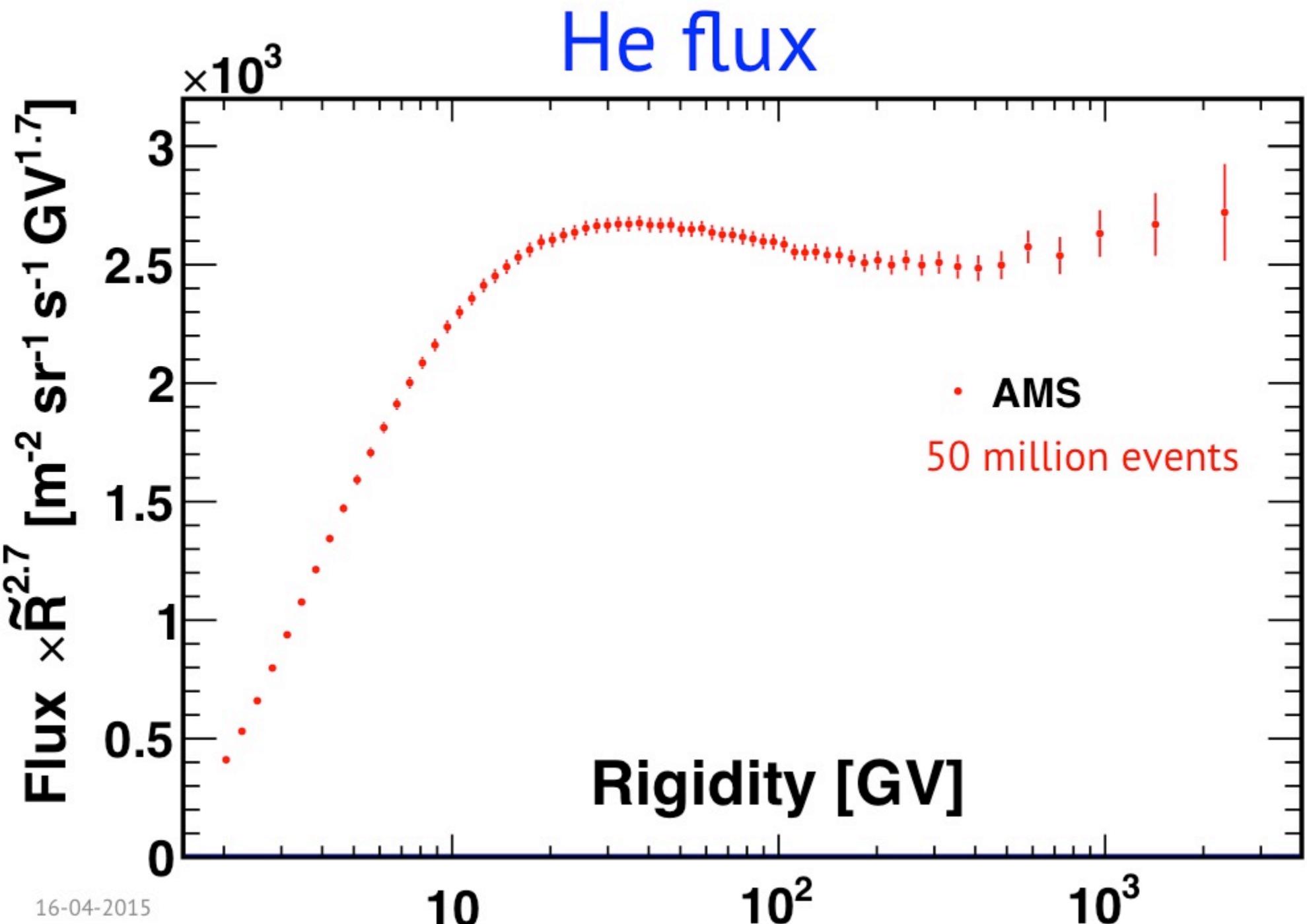
Verifications of Systematic errors (3)

He Flux ratio between Inner and Full Tracker

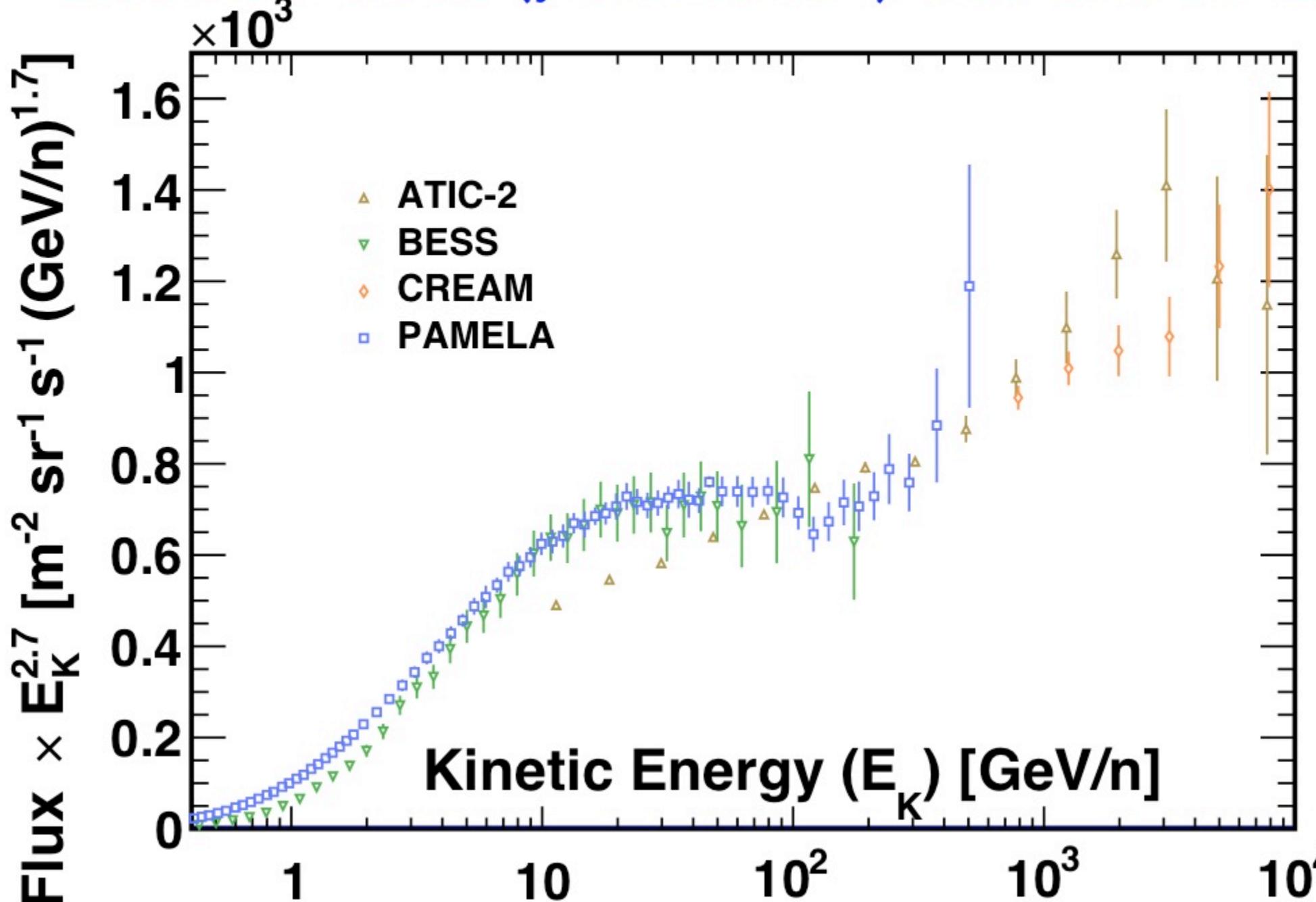


Breakdown of Errors

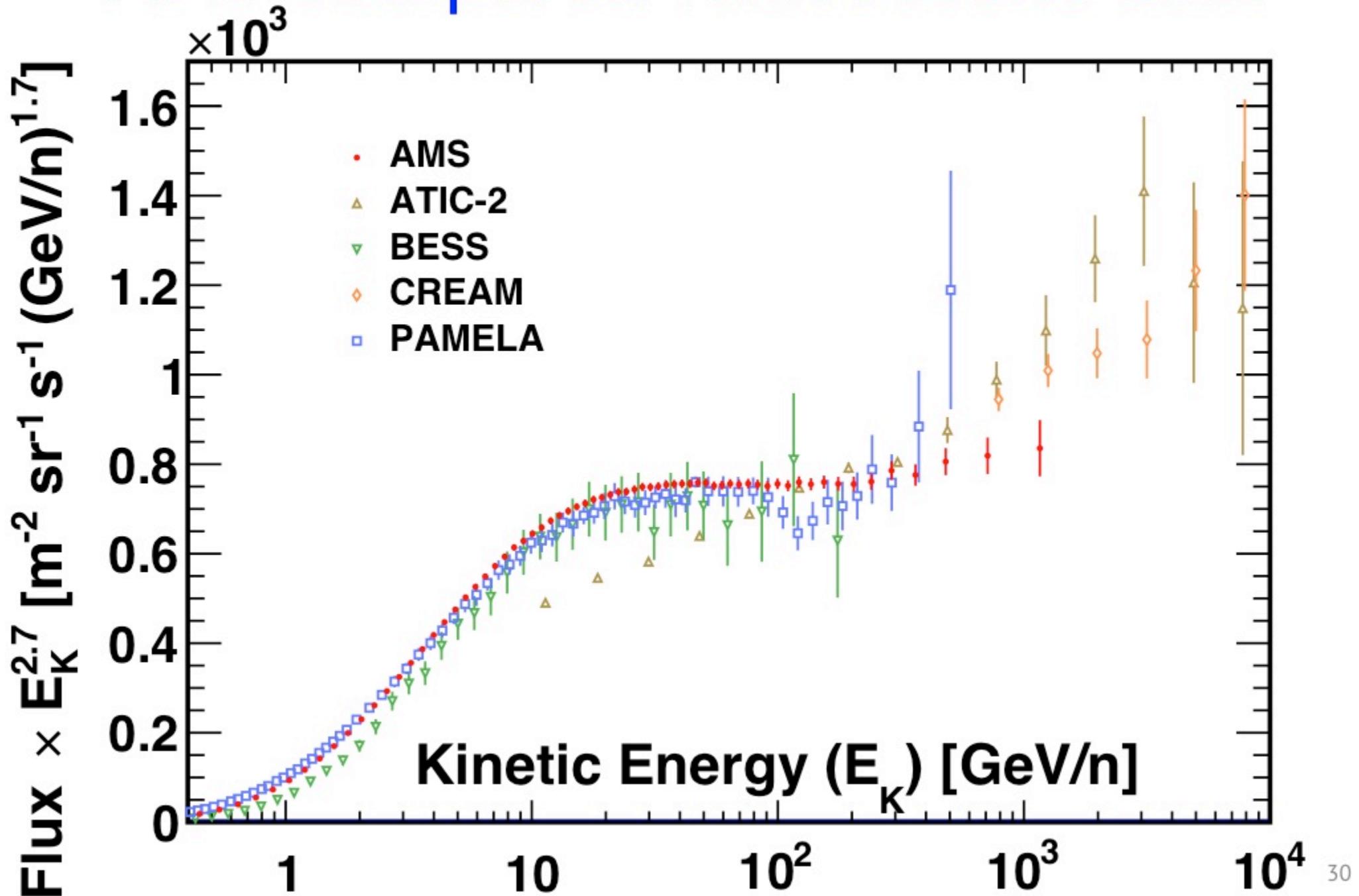




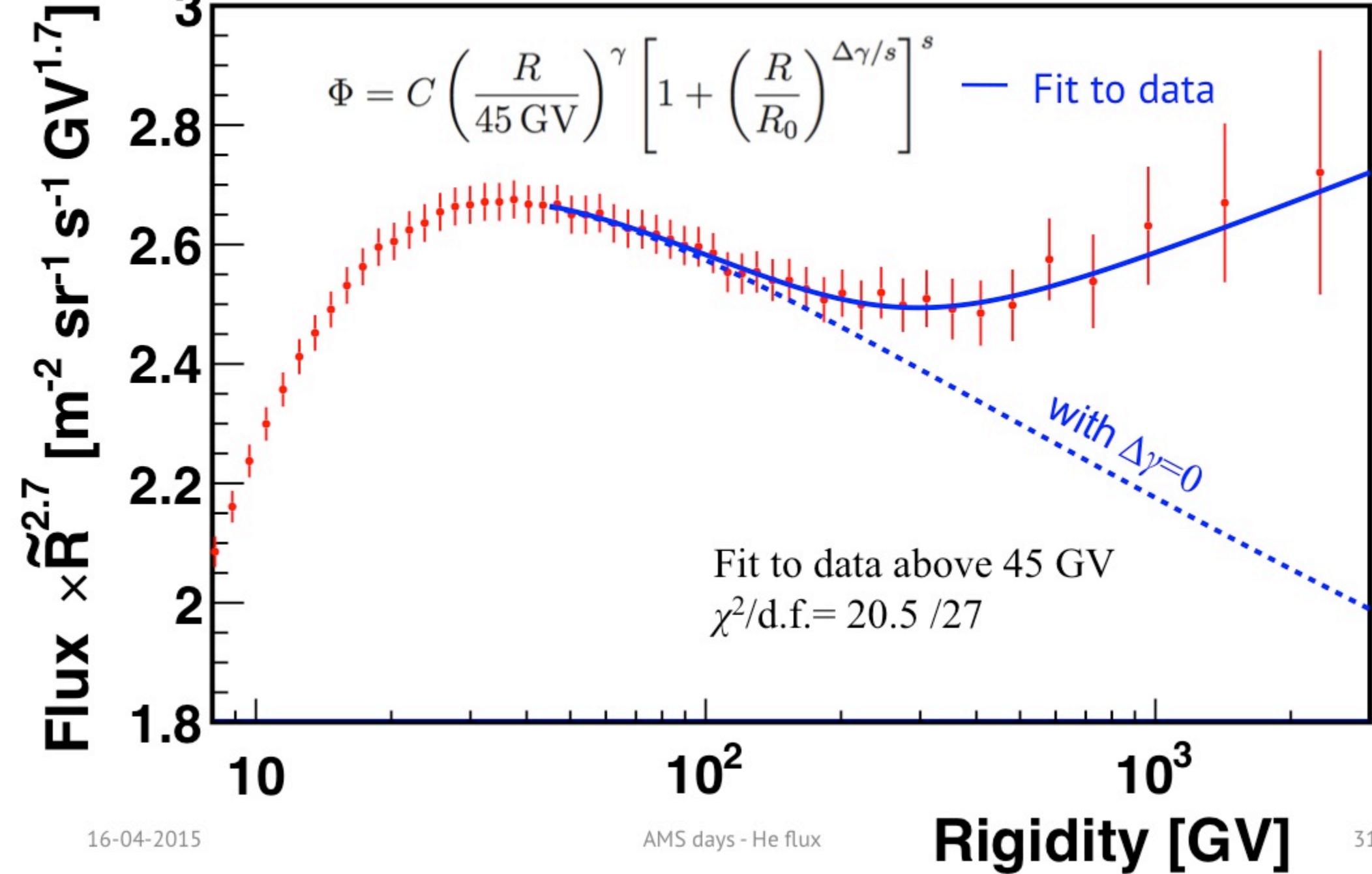
Recent data (year 2000-) before AMS



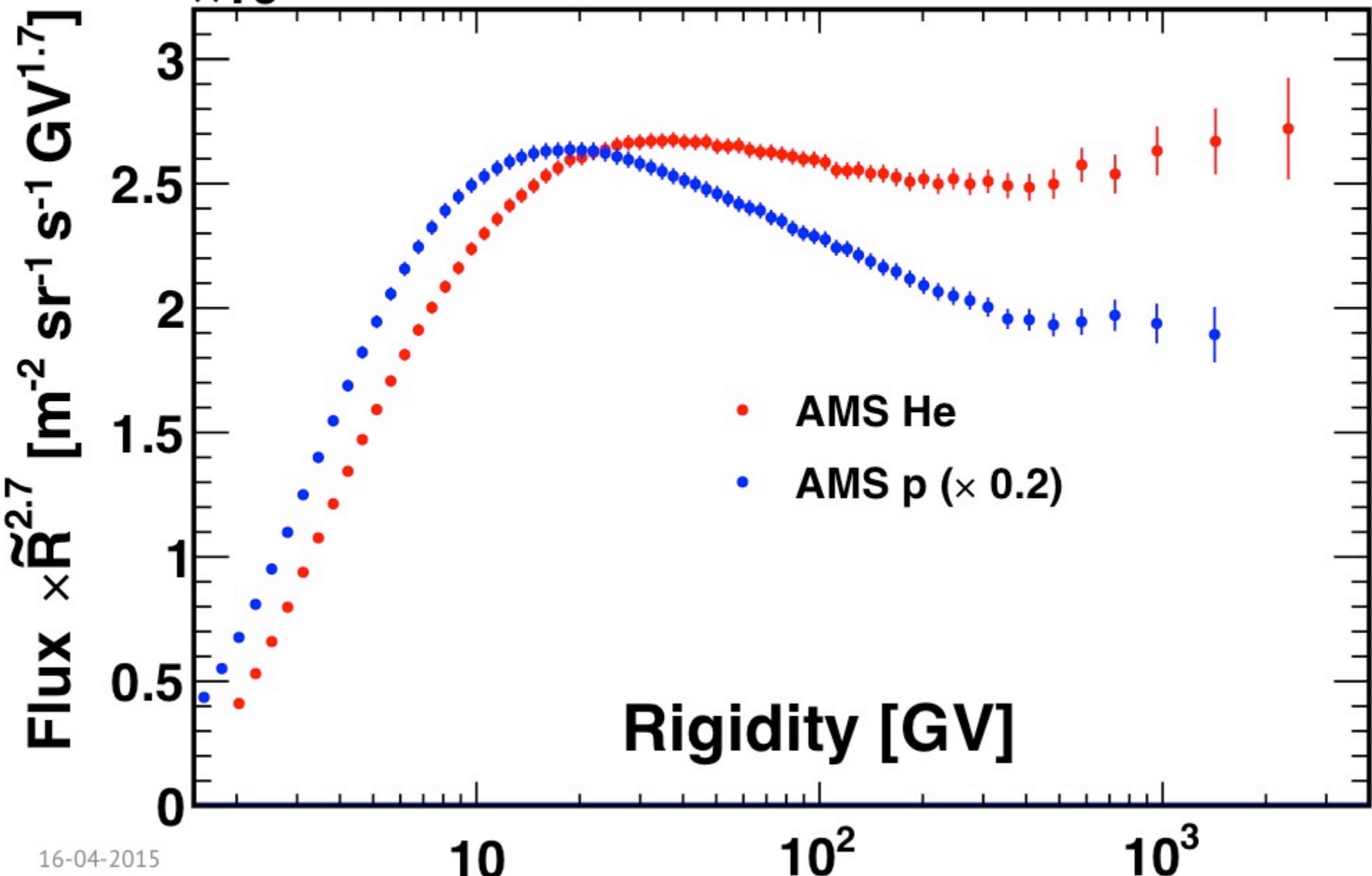
AMS compared with recent data



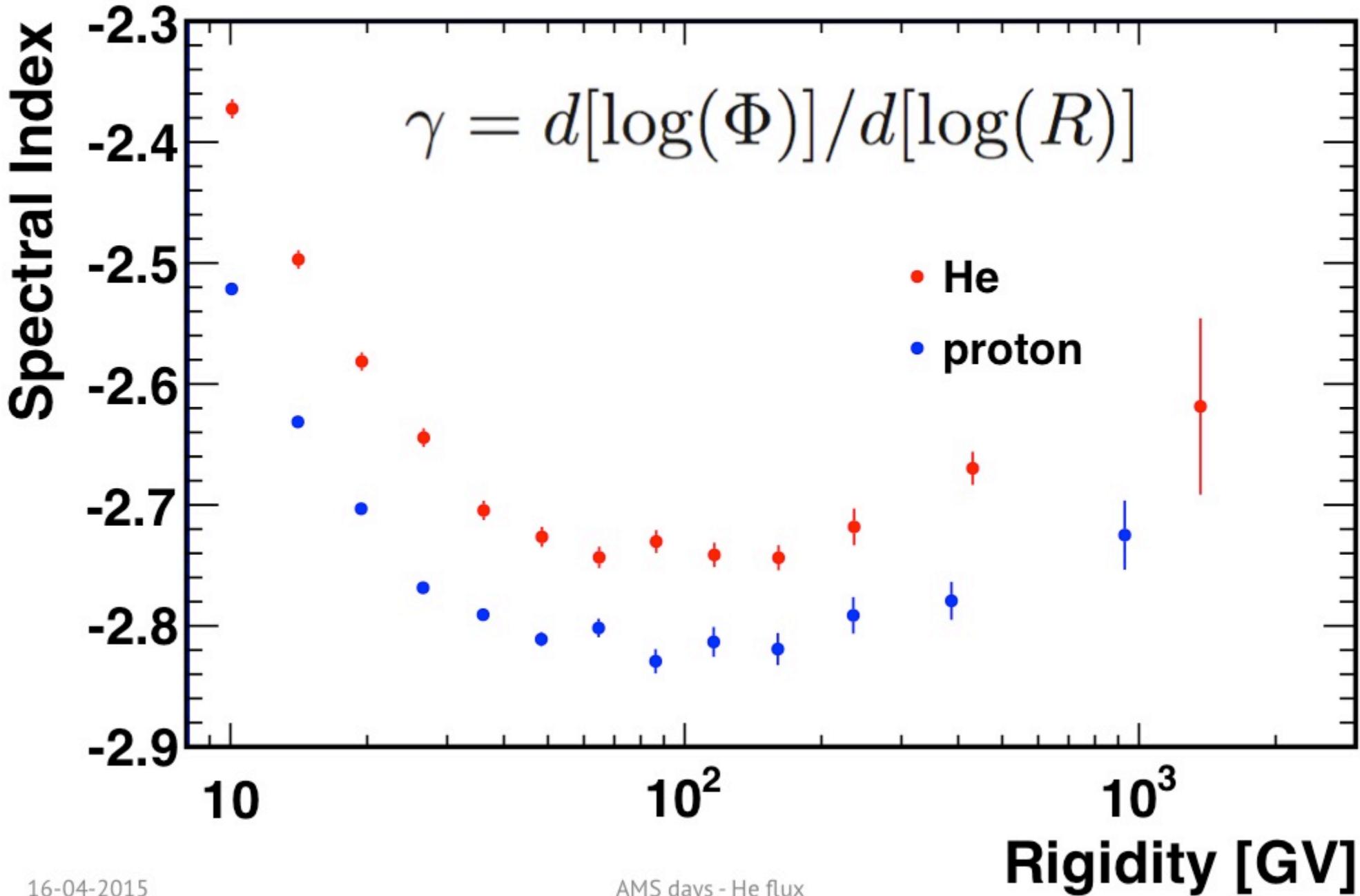
He flux fitting



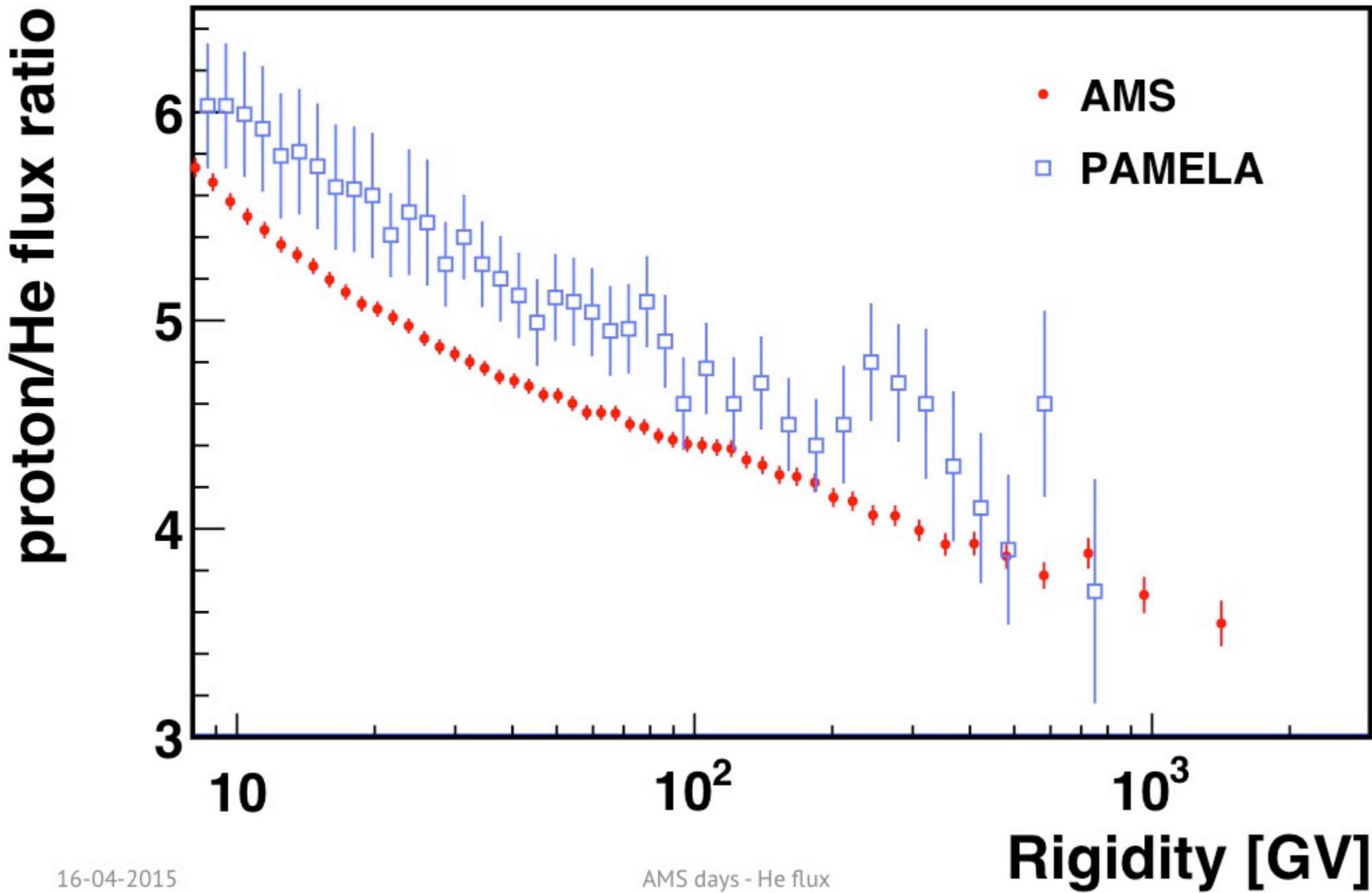
AMS p and He flux



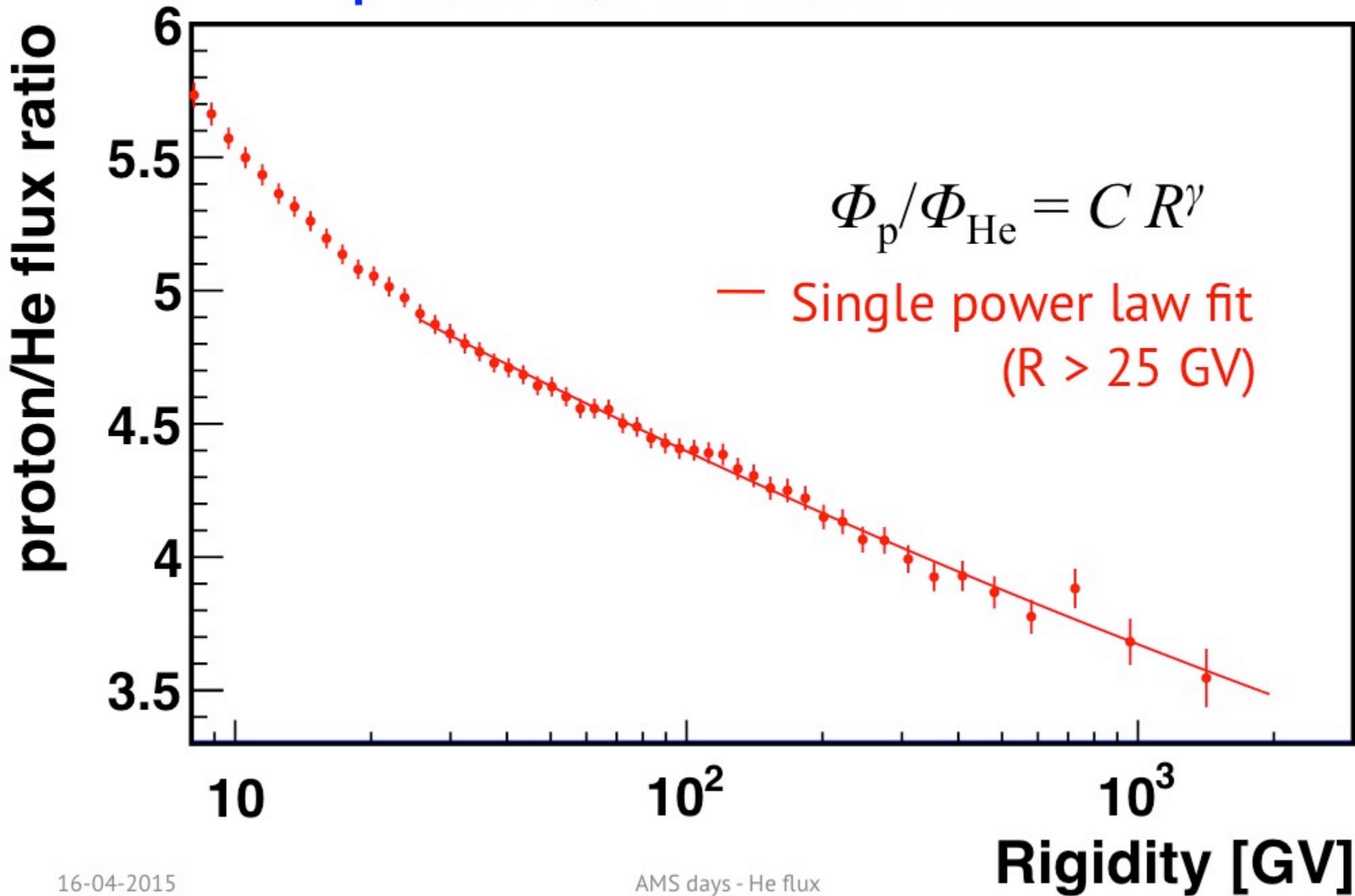
Spectral indices for p and He



proton/He flux ratio



proton/He flux ratio



Conclusion

- Precision measurement of helium flux with AMS is done from 2 GV to 3 TV based on 50 million events
- The detailed variation of the helium flux spectral index is obtained. The index is progressively hardening at high rigidities
- The proton/helium ratio is consistent with a single power law above 25 GV