

# Phosphorus flux with AMS 10y pass8 data

*Alessio Ubaldi – Perugia  
PhD*

Supervisor: Maura Graziani  
Co-supervisor: Valerio Vagelli



Agenzia Spaziale Italiana

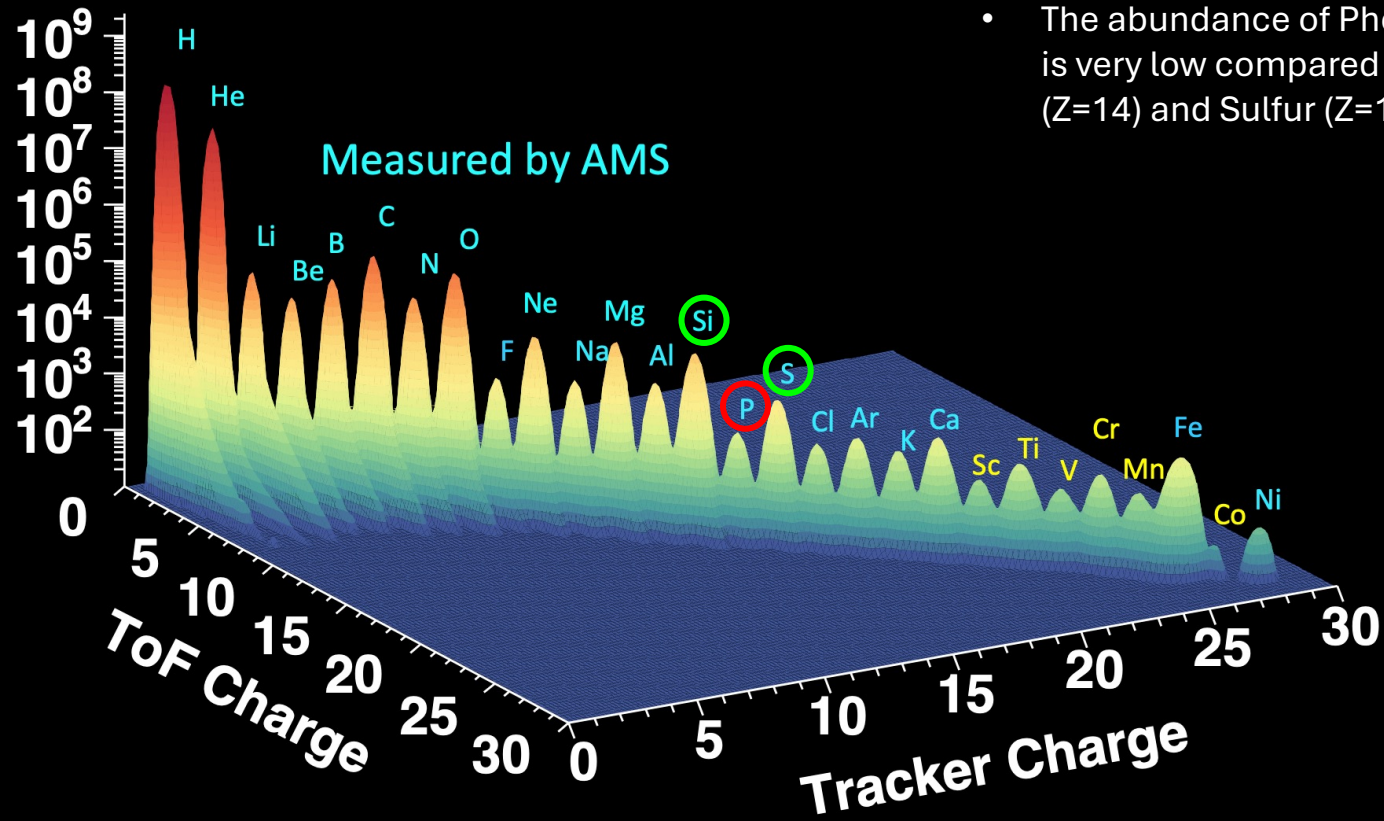


A.D. 1308 —  
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DIPARTIMENTO  
DI FISICA E GEOLOGIA

DIPARTIMENTO DI ECCELLENZA  
MUR 2023/2027

# AMS Study of Cosmic Nuclei



- The abundance of Phosphorus (Z=15) is very low compared to Silicon (Z=14) and Sulfur (Z=16)



# Flux

$$\Phi_P(R_i) = \frac{N_P(R_i)}{\Delta R_i \Delta T(R_i) A(R_i)}$$

- $\Phi_P(R_i)$  is the P flux
- $N_P(R_i)$  are the P counts, after background subtraction and bin-to-bin migration correction
- $\Delta R_i$  is the bin width
- $\Delta T(R_i)$  is the exposure time
- **$A(R_i) = A_{MC}(R_i)(\epsilon_{Data}/\epsilon_{MC})$  is the Mc acceptance multiplied by data-to-Mc corrections interpolated between Silicon (Z=14) and Sulfur (Z=16).**



# Event selection IL1

## Trigger

- Physics trigger

UToF charge «*common*» range [Z-0.625 - 0.0225 \* (Z-9), Z + 1.5 ]

Inner tracker charge «*common*» range [Z-0.5, Z+0.5]

L1 charge «*common*» range [Z - (0.0585 · Z<sup>1.15</sup>+0.35), Z + (0.0334 · Z<sup>1.15</sup>+0.20)]

L1 charge «*common*» range [Z - (0.0585 · Z<sup>1.15</sup>+0.35), Z + (0.0334 · Z<sup>1.15</sup>+0.20)]

## Tof

- $\beta > 0.4$
- UToF charge in «*common*» range

## Inner Tracker + L1

- Hit pattern: L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- N° of inner tracker Y hits > 4
- L1 charge asymmetry  $(Z_x - Z_y)/(Z_x + Z_y) < 0.2$
- Hit on L1 with good status
- Inner tracker and L1 charge in «*common*» ranges
- Track (IL1) in L1 fiducial volume
- $\chi_y^2 < 10$  (both IL1 and INN)
- L1 normalized residuals  $< 10 \chi_{IL1}^2 \cdot ndf_{IL1} - \chi_{INN}^2 \cdot ndf_{INN}$

## RTI default selection

- Livetime fraction > 0.5, zenith < 40, nTrigger/nEvent > 0.98, nError > 0
- nError/nEvent < 0.1, alignment external layer (0,1) < 35 and (1,1) < 45

ChargeRecoType = YJ

FitType = GBL

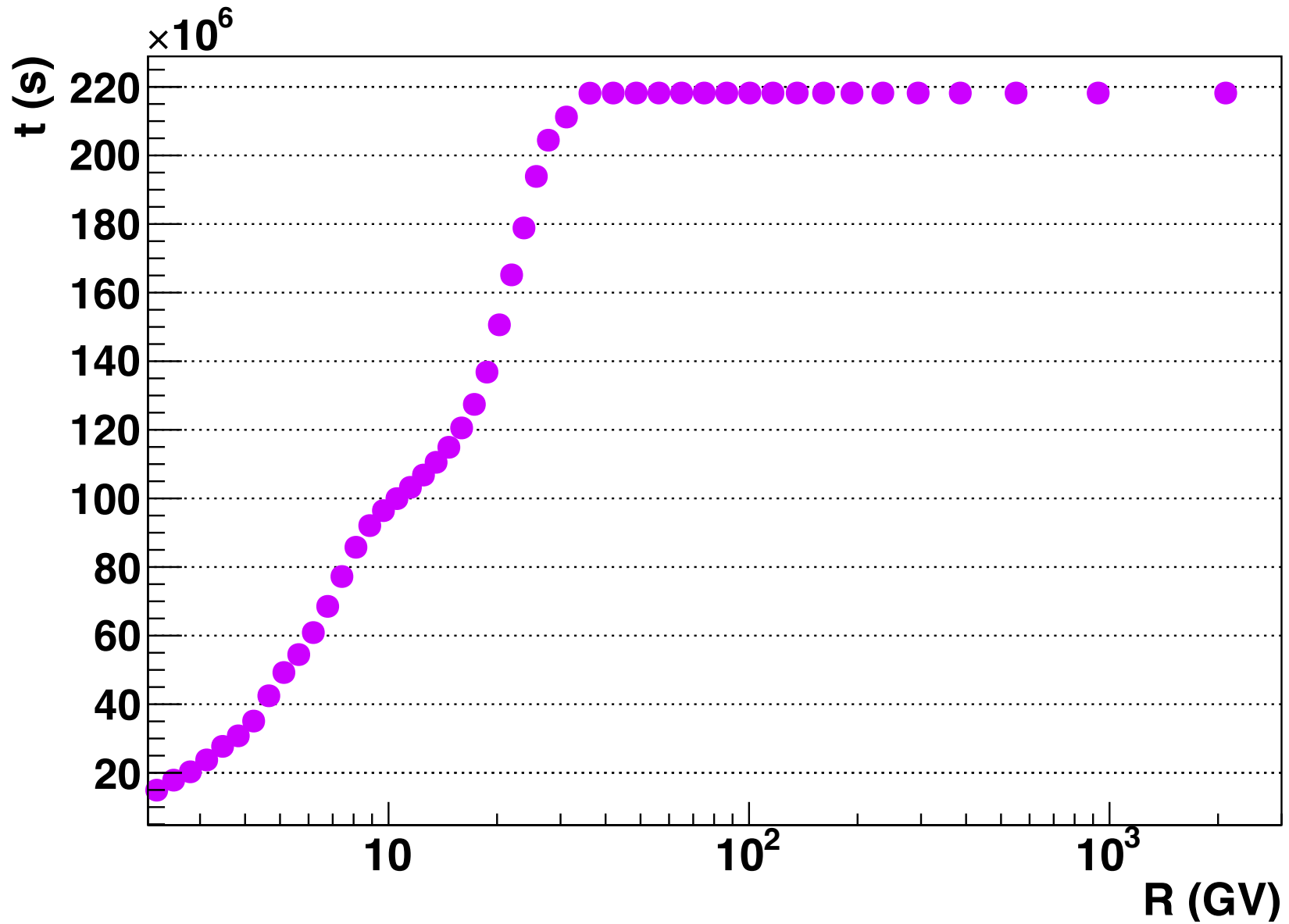
NAIA v.1.0.3

Pass8

Dataset: 19 May 2011– 6 May 2021

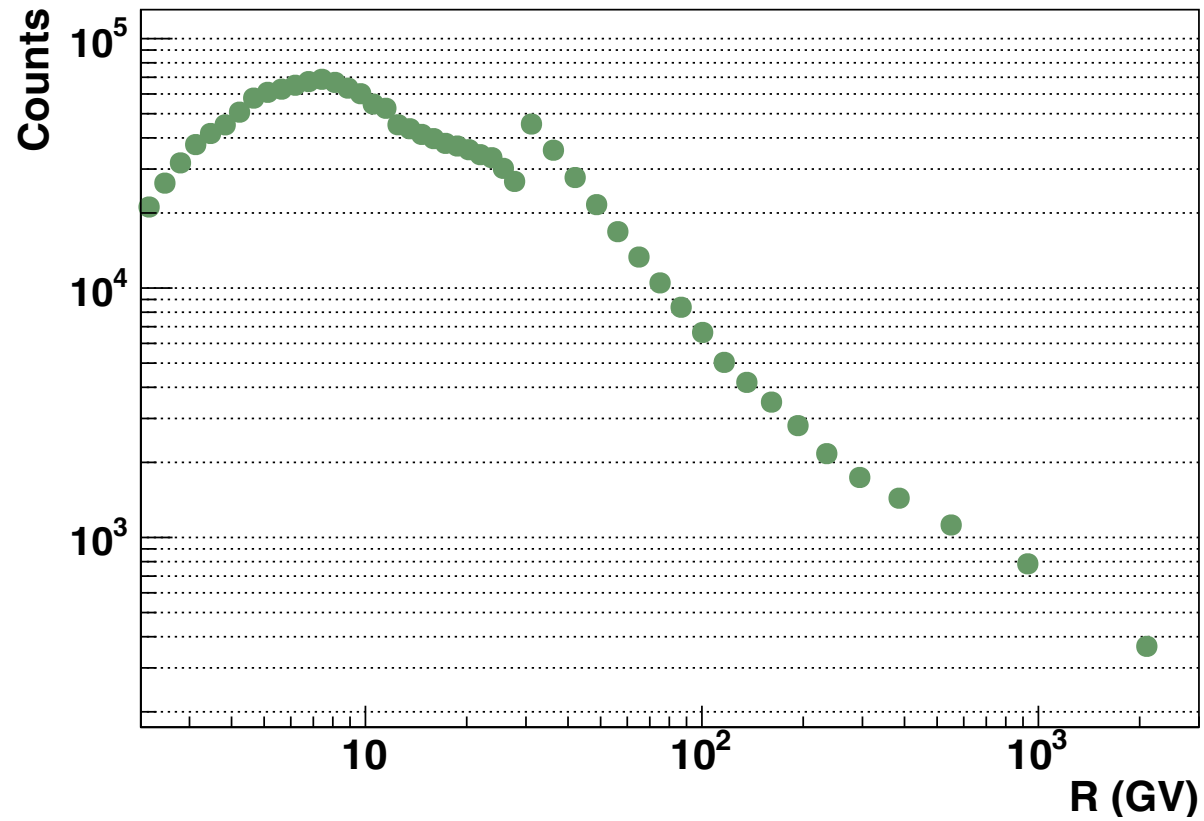


# Exposure time

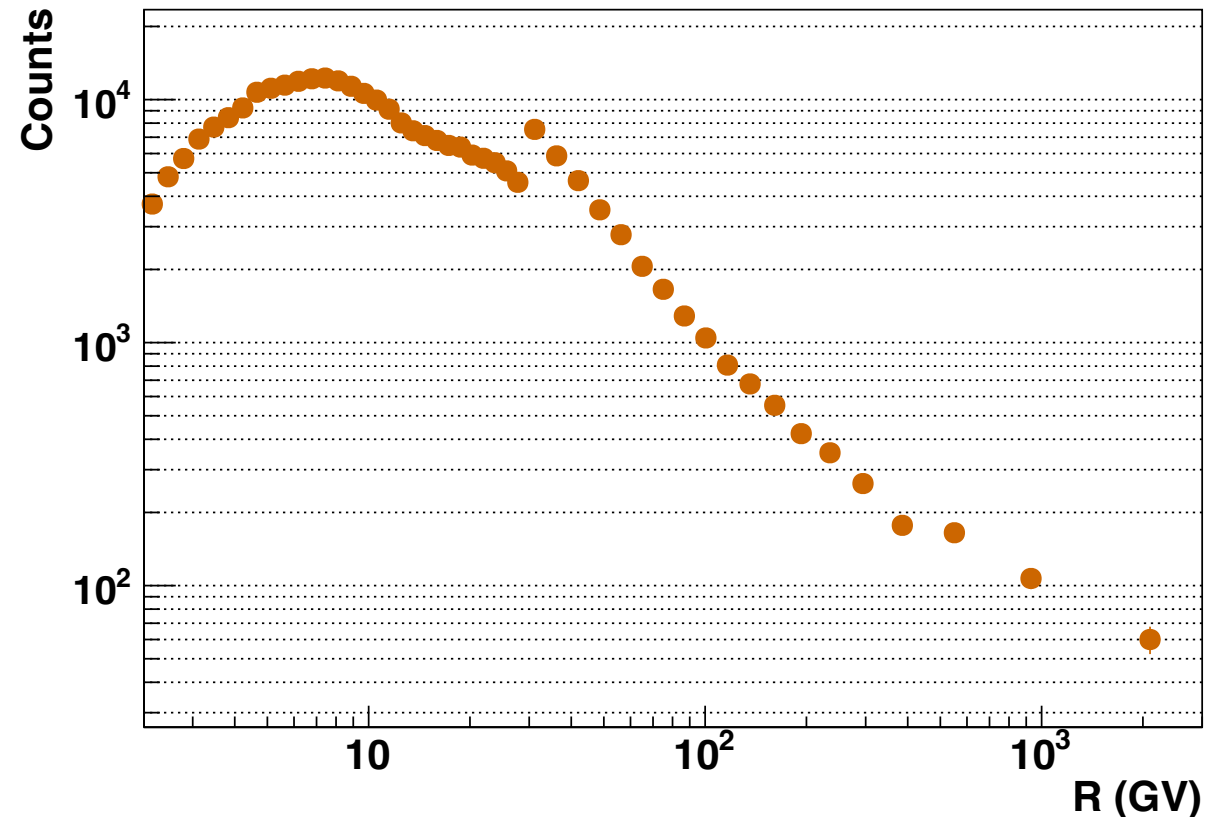


# Counts

Si (Z=14) Counts

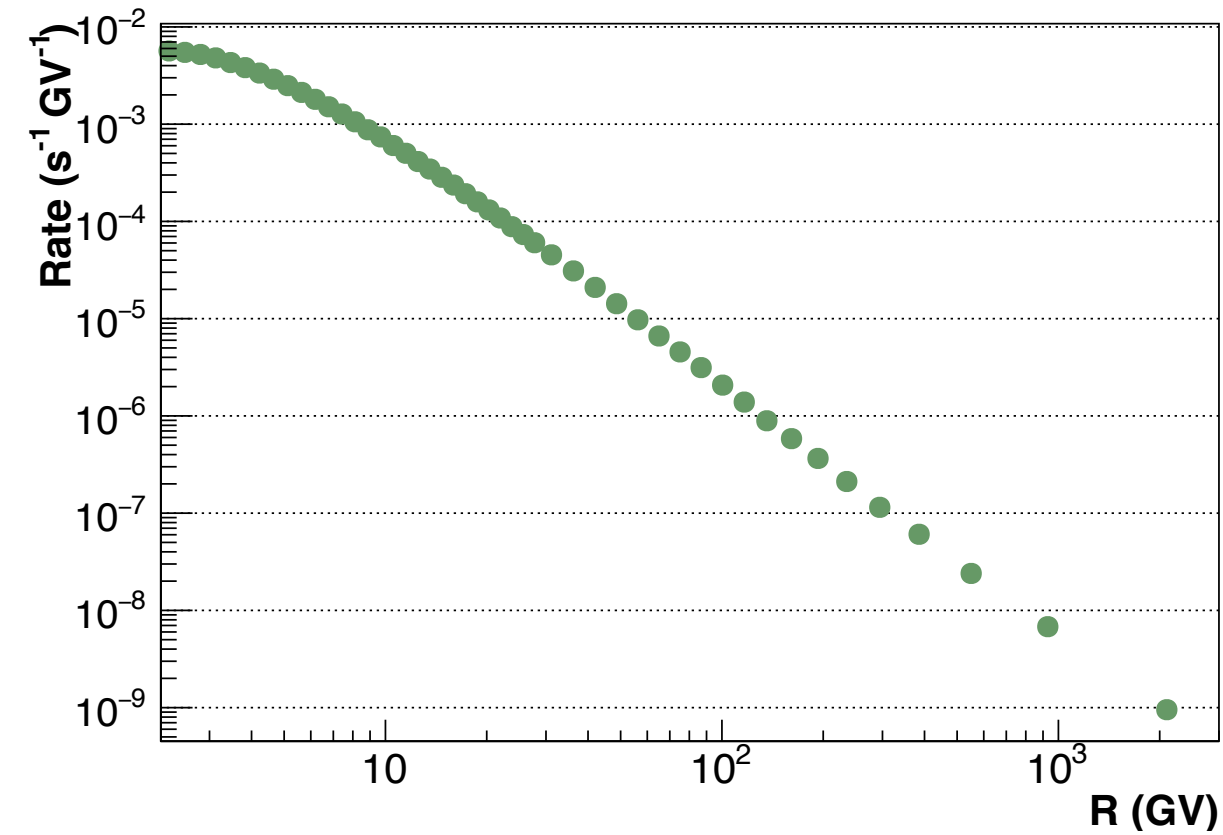


S (Z=16) Counts

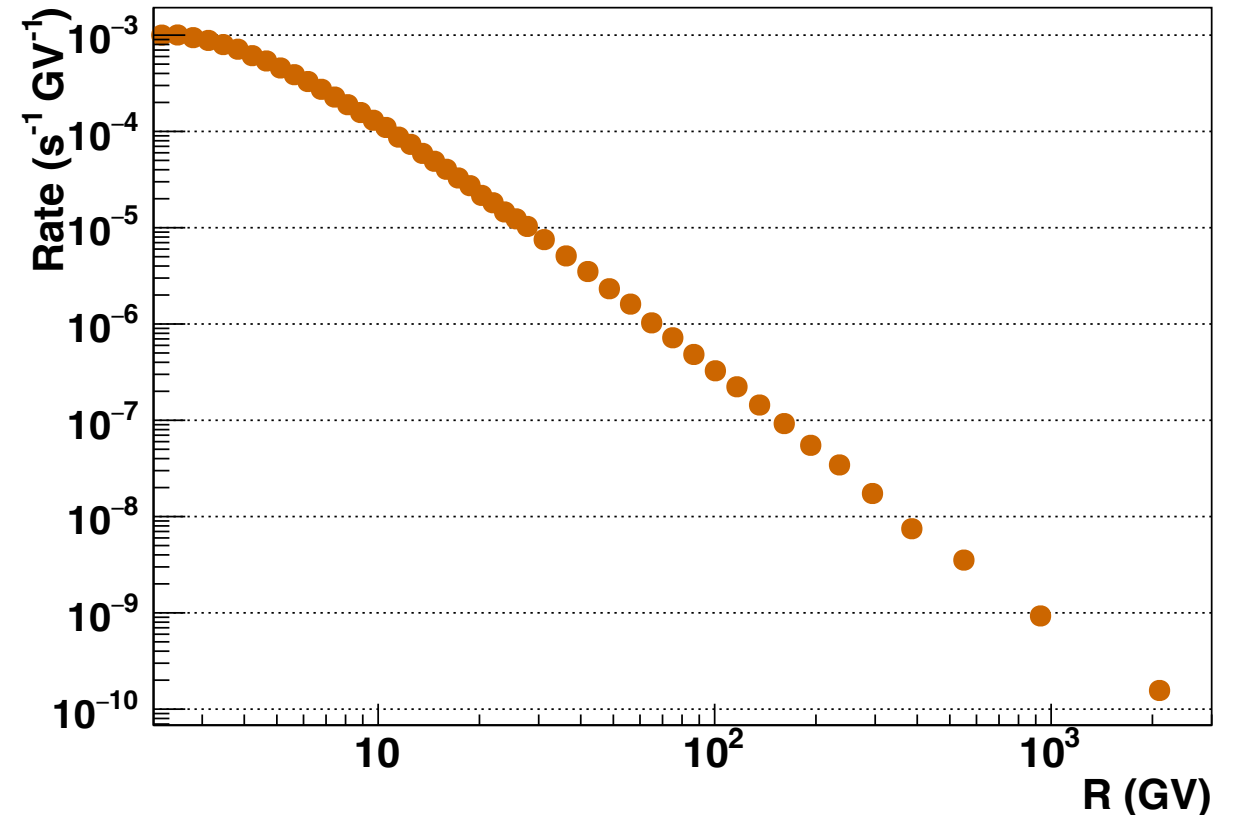


# Rate

Si (Z=14) Rate



S (Z=16) Rate



# L1 efficiency

## Denominator

- Physics trigger
- $\beta > 0.4$
- UToF charge in  $[Z - 0.2, Z + 0.2]$
- Hit pattern: L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- N° of inner tracker Y hits  $> 4$
- Inner tracker charge in  $[Z - 0.2, Z + 0.2]$
- $\chi_y^2 < 10$  (Inn)
- Track (Inn) in L1 and inner fiducial volume

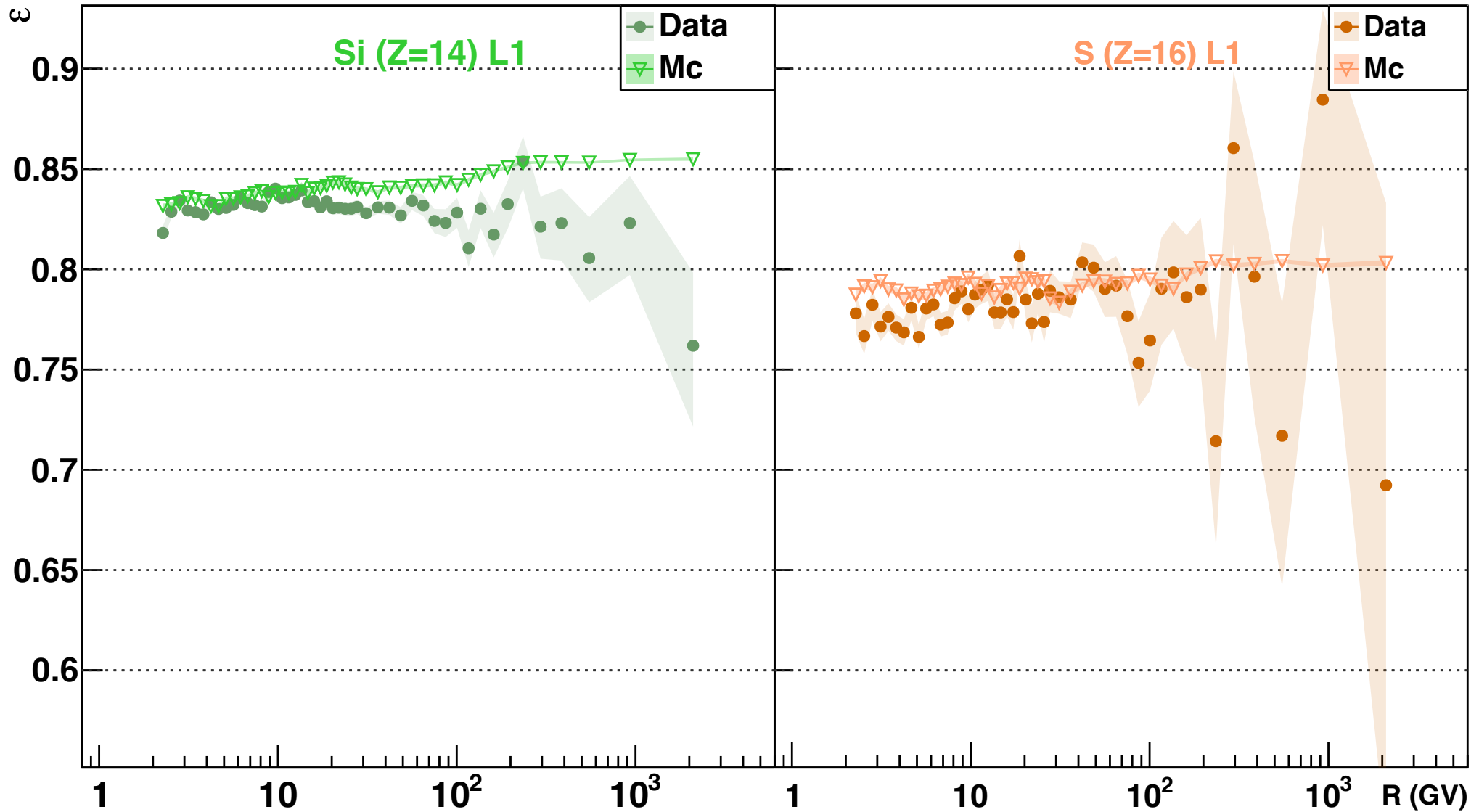
## Numerator

- Denominator
- L1 charge in «common» ranges
- L1 charge asymmetry  $(Z_x - Z_y)/(Z_x + Z_y) < 0.2$
- Hit on L1 with good status
- L1 normalized residuals  $< 10 \quad \chi_{IL1}^2 \cdot \text{ndf}_{IL1} - \chi_{INN}^2 \cdot \text{ndf}_{INN}$
- $\chi_y^2 < 10$  (IL1)
- Track (IL1) in L1 fiducial volume





# L1 efficiency



# Track efficiency

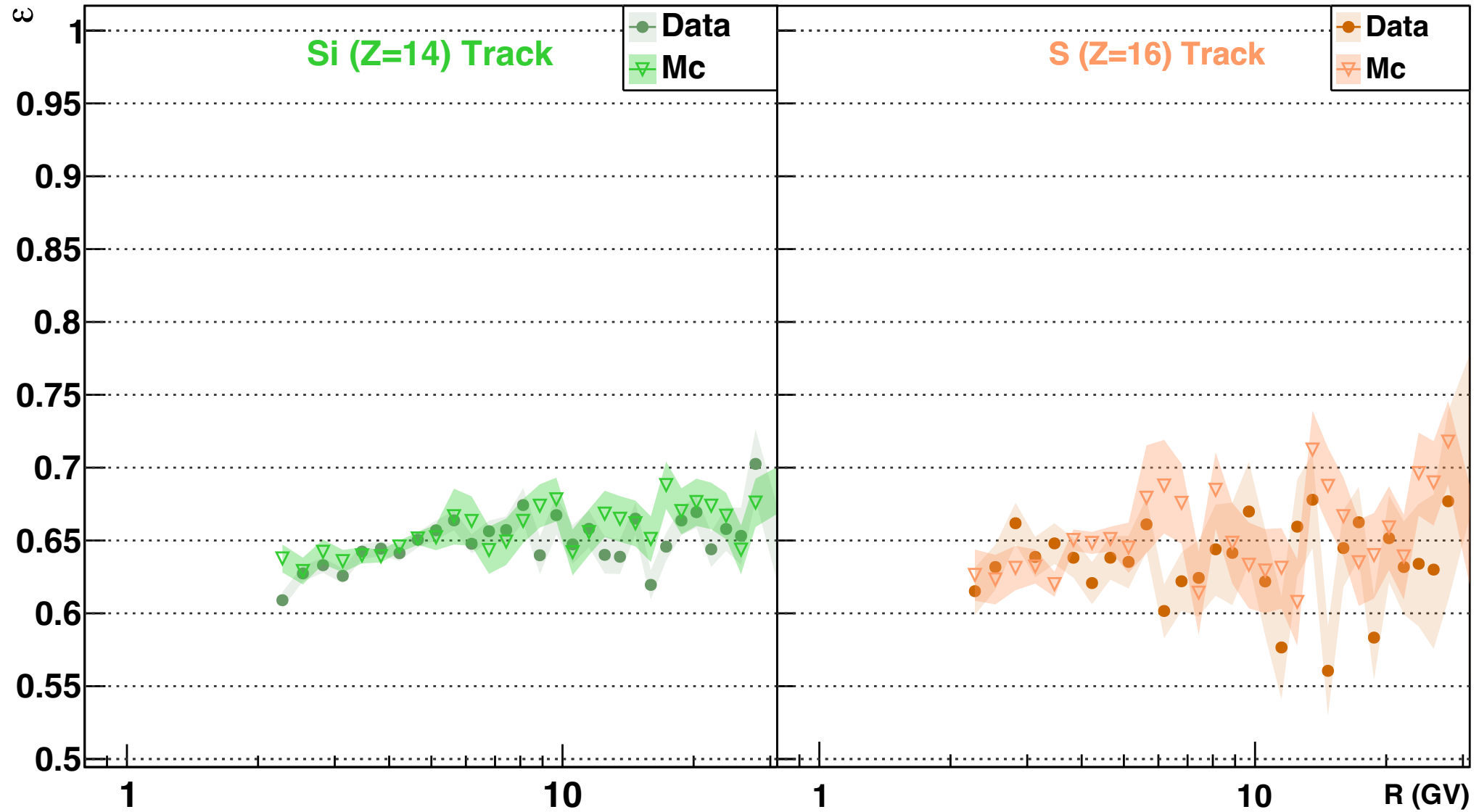
## Denominator

- Physics trigger
- TofSt beta > 0.4
- Unbiased hit on L1;
- Unbiased L1 charge [ $Z - 0.4$ ,  $Z + 0.9$ ]
- Track (TofSt) inside inner tracker
- Track (TofSt) inside L1
- Track (TofSt) in inner tracker fiducial volume
- Track (TofSt) in L1 fiducial volume
- TofSt  $\chi^2$  spatial and temporal < 2
- Upper, lower and total Tof charge [ $Z - 0.3$ ,  $Z + 0.3$ ]

## Numerator

- Denominator
- Hit Pattern: L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- N° of inner tracker Y hits > 4
- Inner tracker charge in «*common*» ranges
- $\chi_{\text{y}}^2 < 10$  (Inn)

# Track efficiency



# Tof efficiency

## Denominator

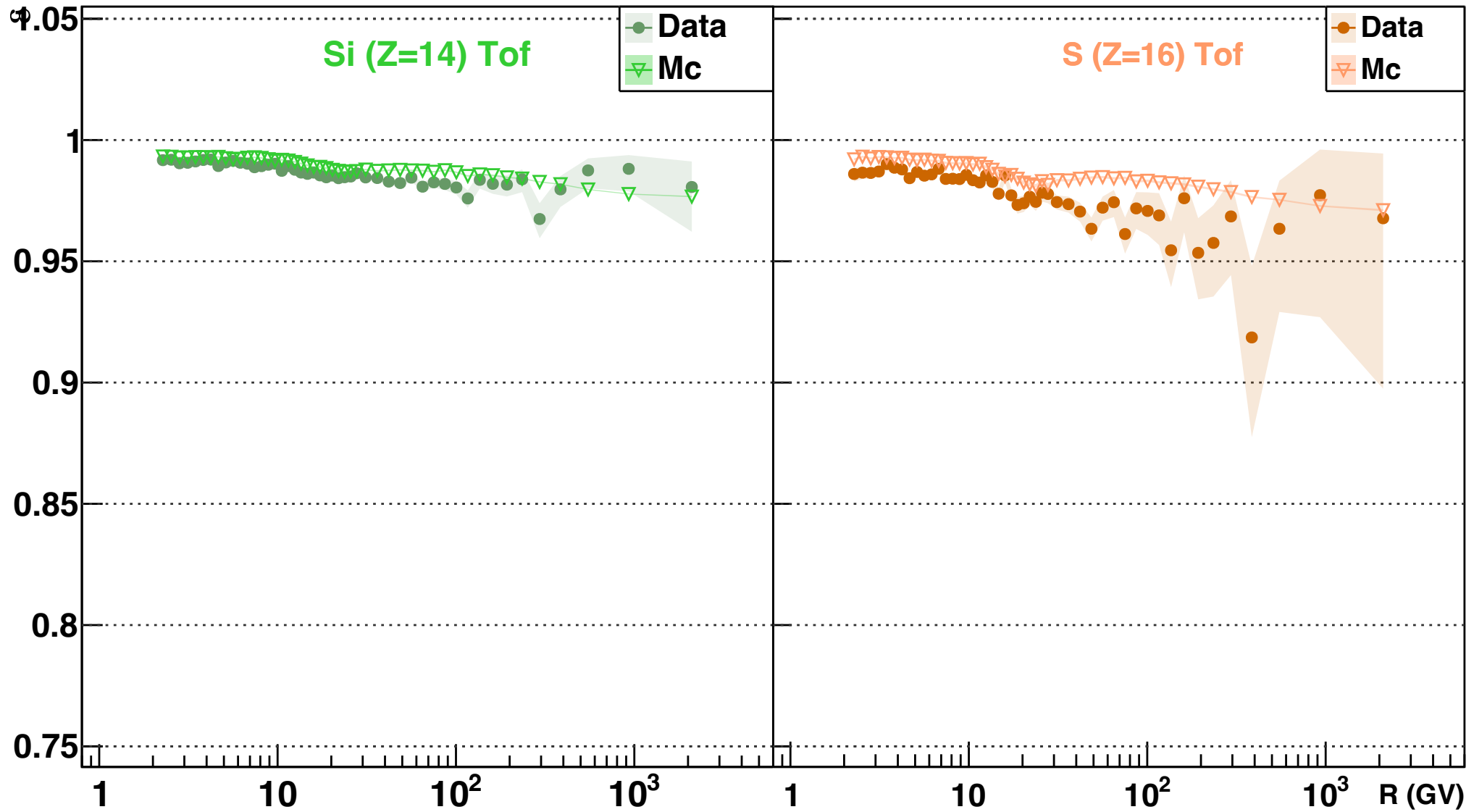
- Physics trigger
- Hit pattern: L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- N° of inner tracker Y hits > 4
- L1 charge asymmetry  $(Z_x - Z_y)/(Z_x + Z_y) < 0.2$
- Hit on L1 with good status
- Inner tracker and L1 charge in «*common*» ranges
- Track (IL1) in L1 fiducial volume
- $\chi_y^2 < 10$  (both IL1 and INN)
- L1 normalized residuals < 10  $\chi_{IL1}^2 \cdot ndf_{IL1} - \chi_{INN}^2 \cdot ndf_{INN}$
- **No second track above 0.2 GV**

## Numerator

- Denominator
- $\beta > 0.4$
- UToF charge in «*common*» range



# Tof efficiency



# Trigger efficiency

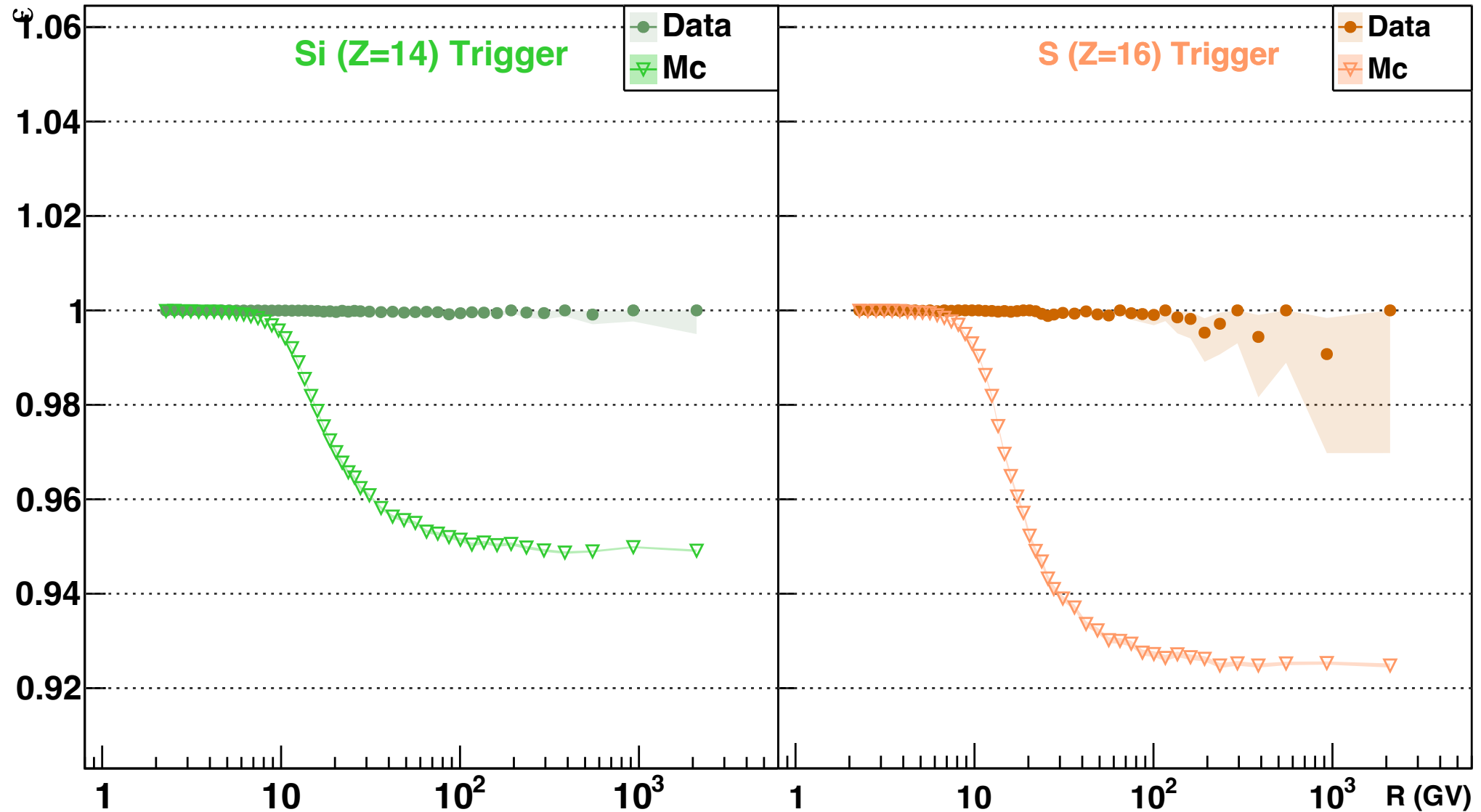
## Denominator

- Physics trigger
- $\beta > 0.4$
- UToF Charge in «*common*» range
- Hit Pattern: L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- N° of Inner tracker Y hits  $> 4$
- L1 charge asymmetry  $(Z_x - Z_y)/(Z_x + Z_y) < 0.2$
- Hit on L1 with good status
- Inner tracker and L1 charge in «*common*» ranges
- Track (IL1) in L1 fiducial volume
- $\chi_y^2 < 10$  (both IL1 and INN)
- L1 normalized residuals  $< 10 \quad \chi_{IL1}^2 \cdot ndf_{IL1} - \chi_{INN}^2 \cdot ndf_{INN}$

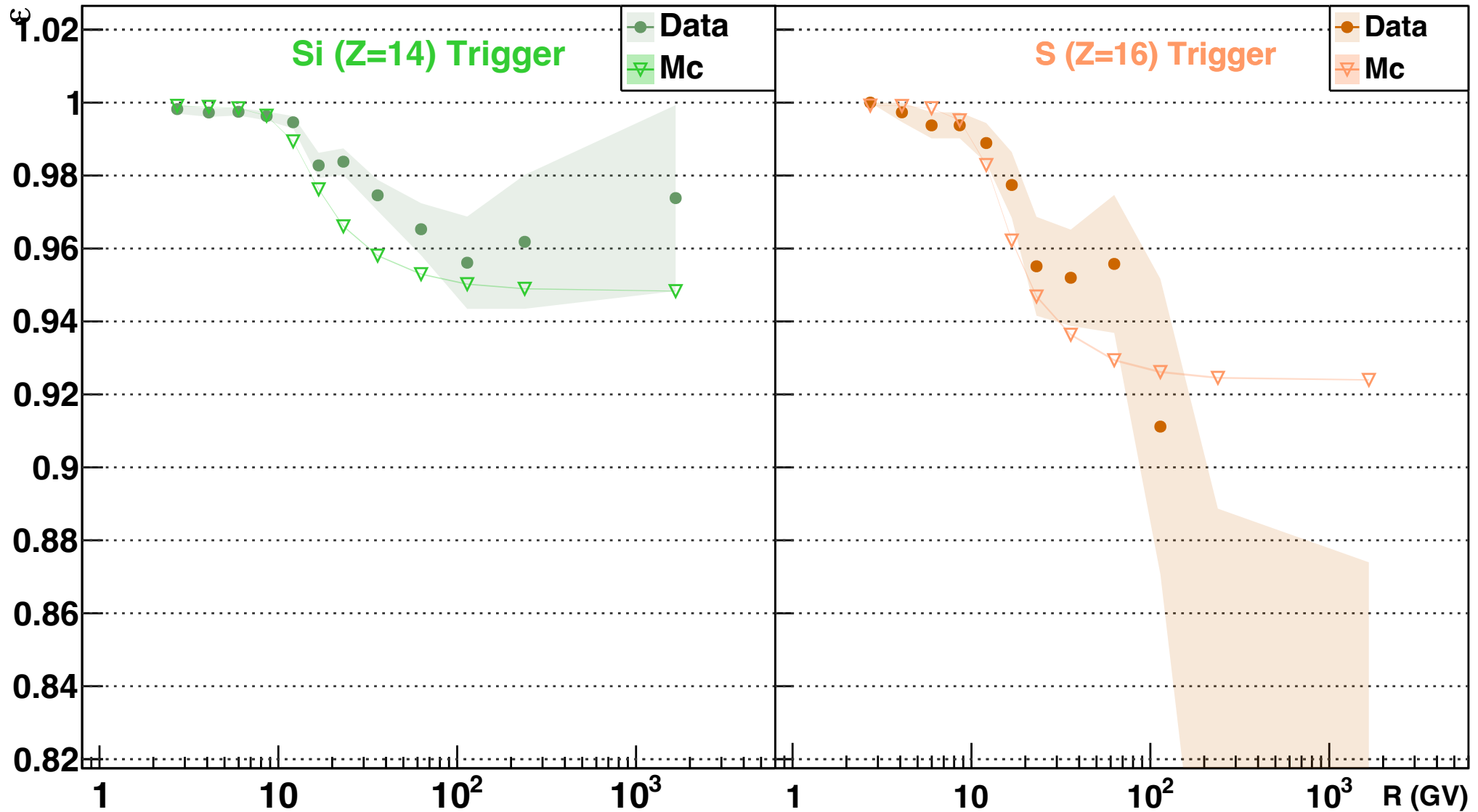
## Numerator

- Denominator
- Physics trigger

# Trigger efficiency

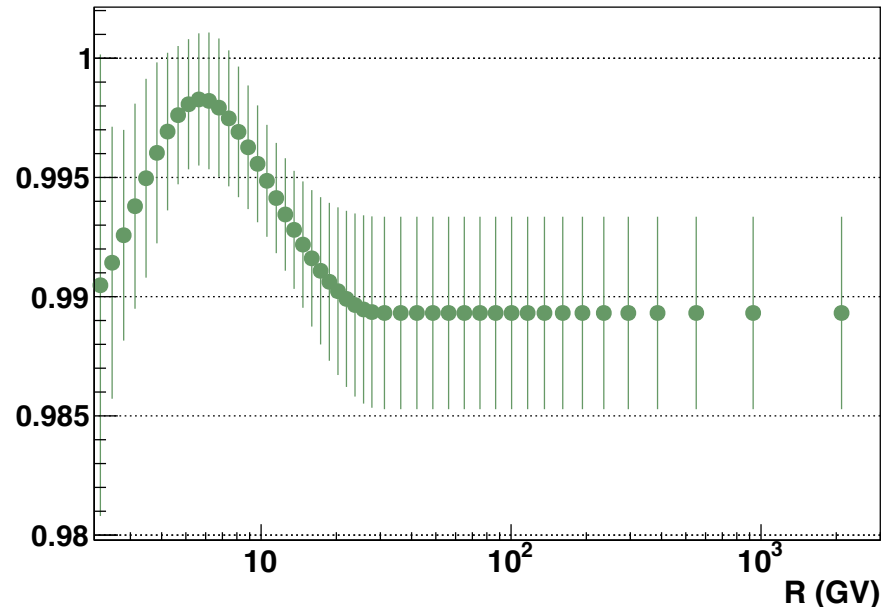


# Trigger efficiency updated

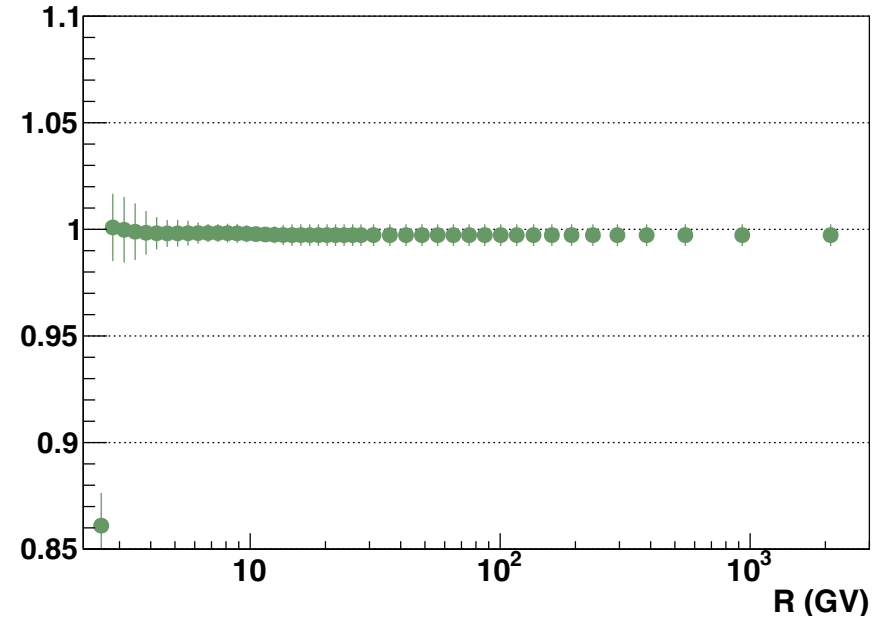




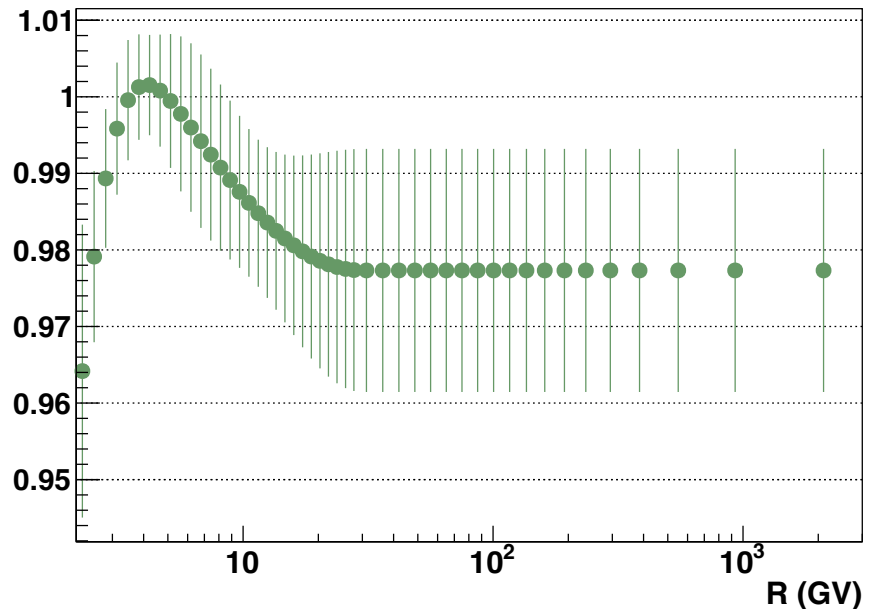
Si (Z=14) L1 spline



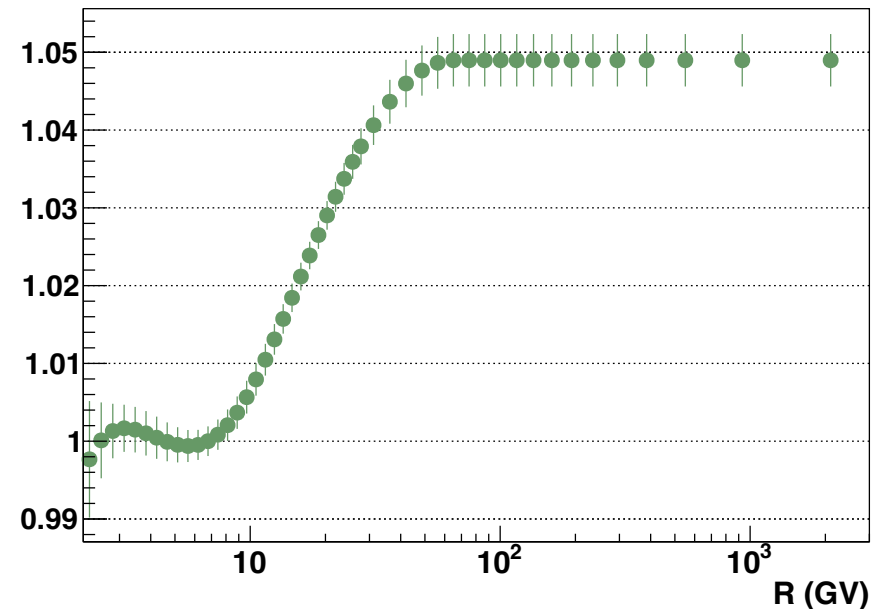
Si (Z=14) Tof spline



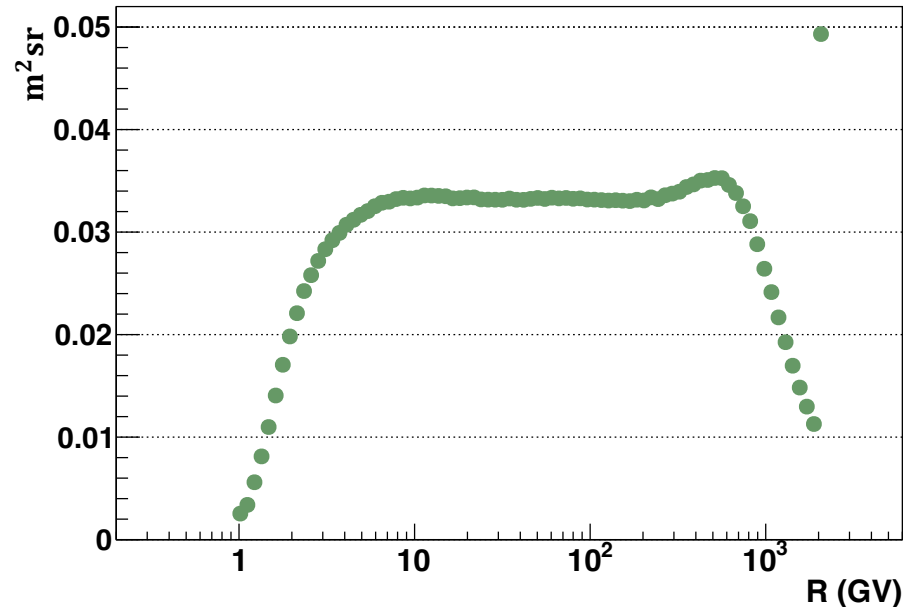
Si (Z=14) Track spline



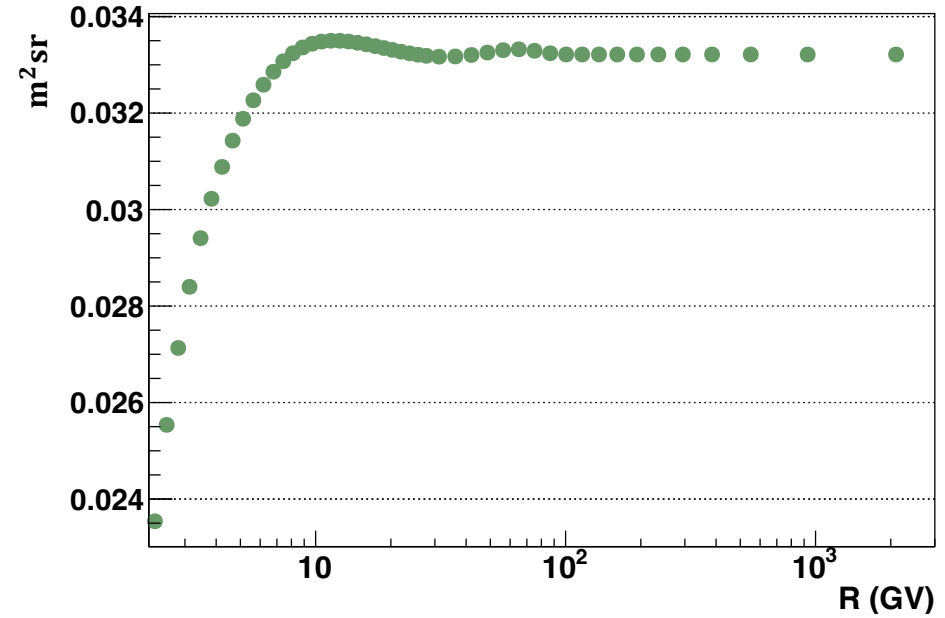
Si (Z=14) Trigger spline



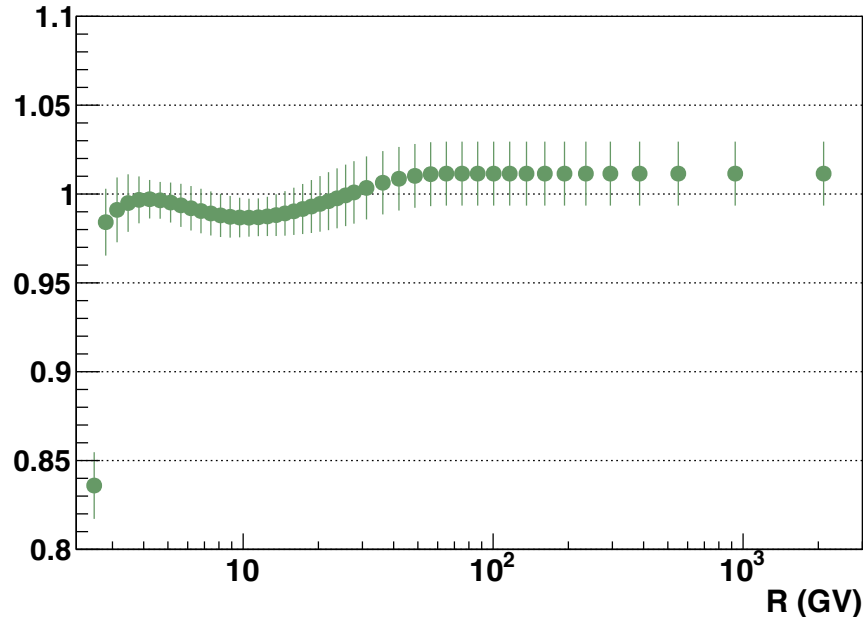
Si (Z=14) Mc acceptance



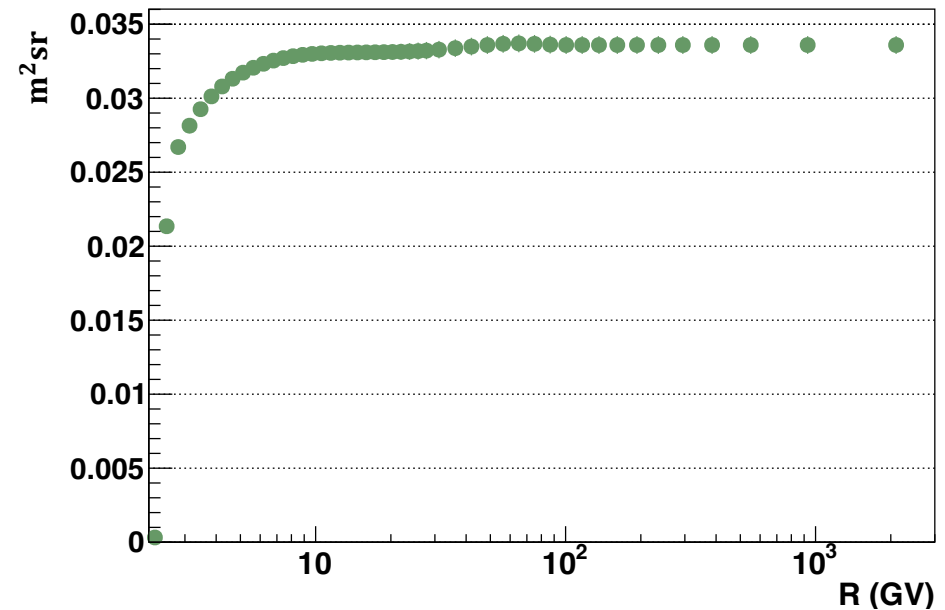
Si (Z=14) Spline mc acceptance



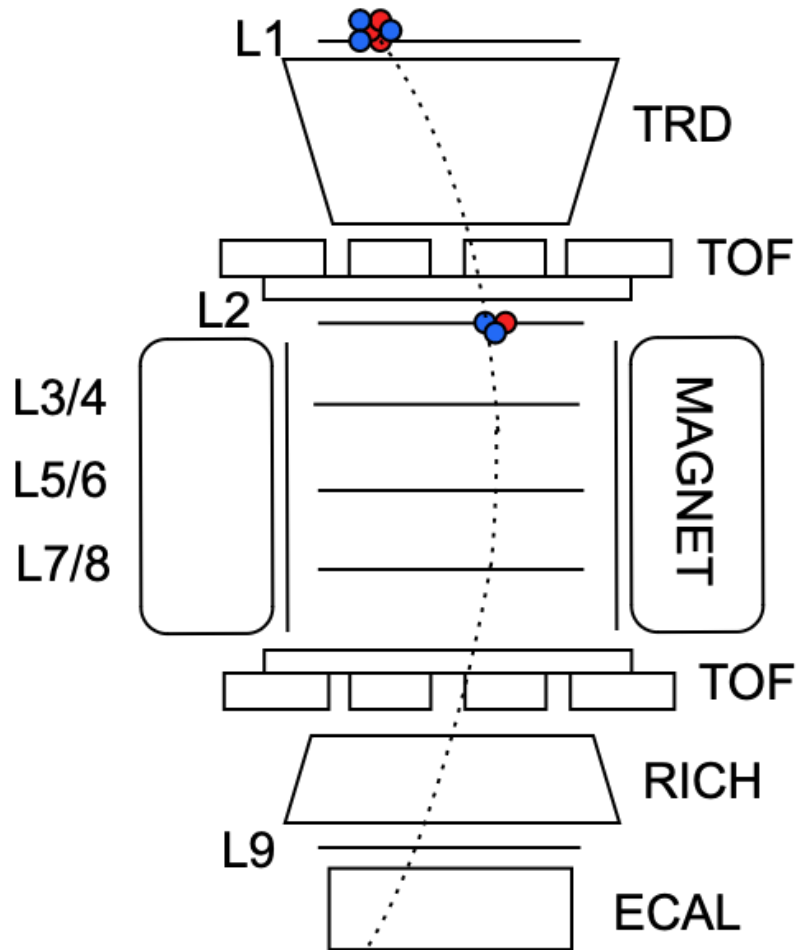
Si (Z=14) Data/Mc Tot



Si (Z=14) Total acceptance



# Contamination below the L1



## Template selections

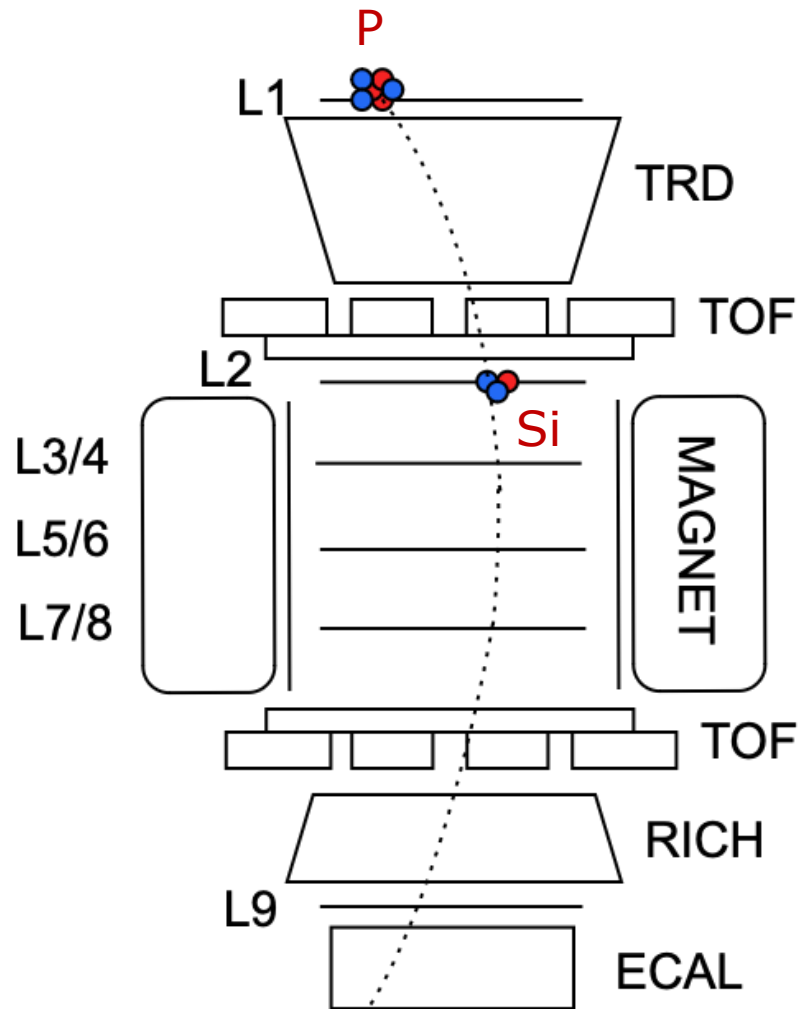
### Layer 1

- Hit pattern side X L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- U&LTof charge  $[Z - 0.5, Z + 0.5]$
- Hit on layer 1
- Inner tracker charge  $[Z - 0.3, Z + 0.3]$
- Inner tracker charge RMS  $< 0.07$

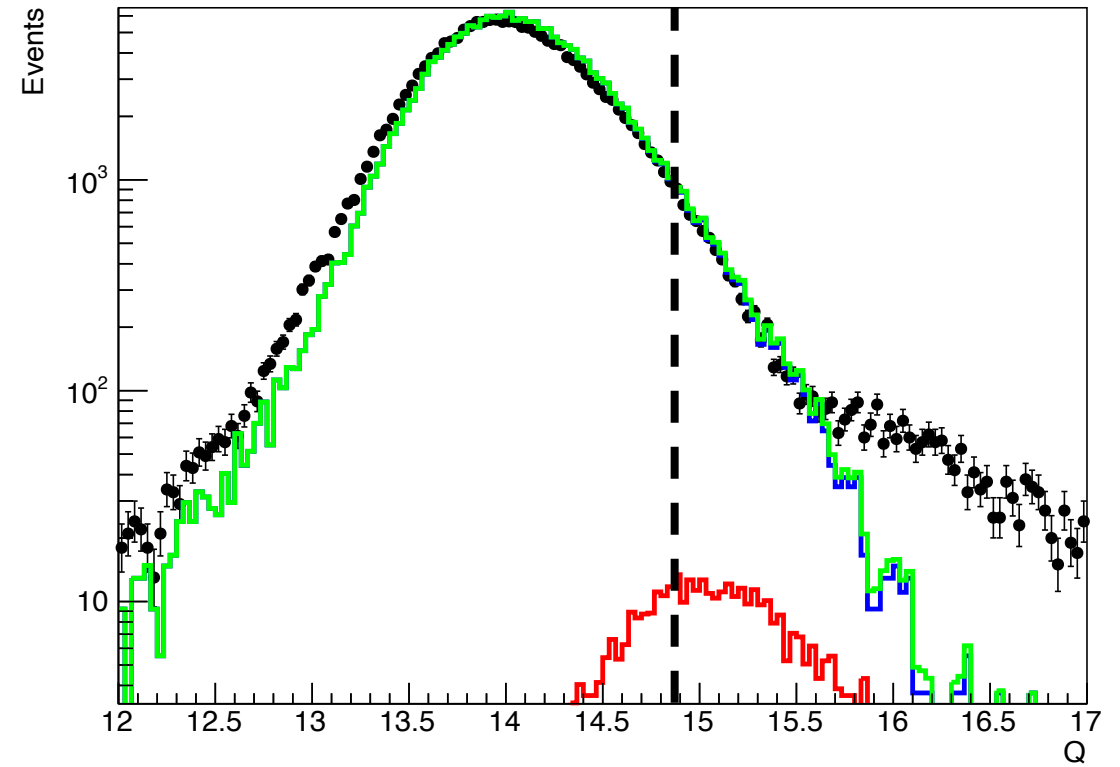
### Layer 2

- Hit pattern side X L2 && (L3 || L4) && (L5 || L6) && (L7 || L8)
- U&LTof charge  $[Z - 0.5, Z + 0.5]$
- Inner tracker charge  $[Z - 0.3, Z + 0.3]$
- Inner tracker charge RMS  $< 0.07$
- L1 charge  $[Z - 0.3, Z + 0.5]$

# Silicon

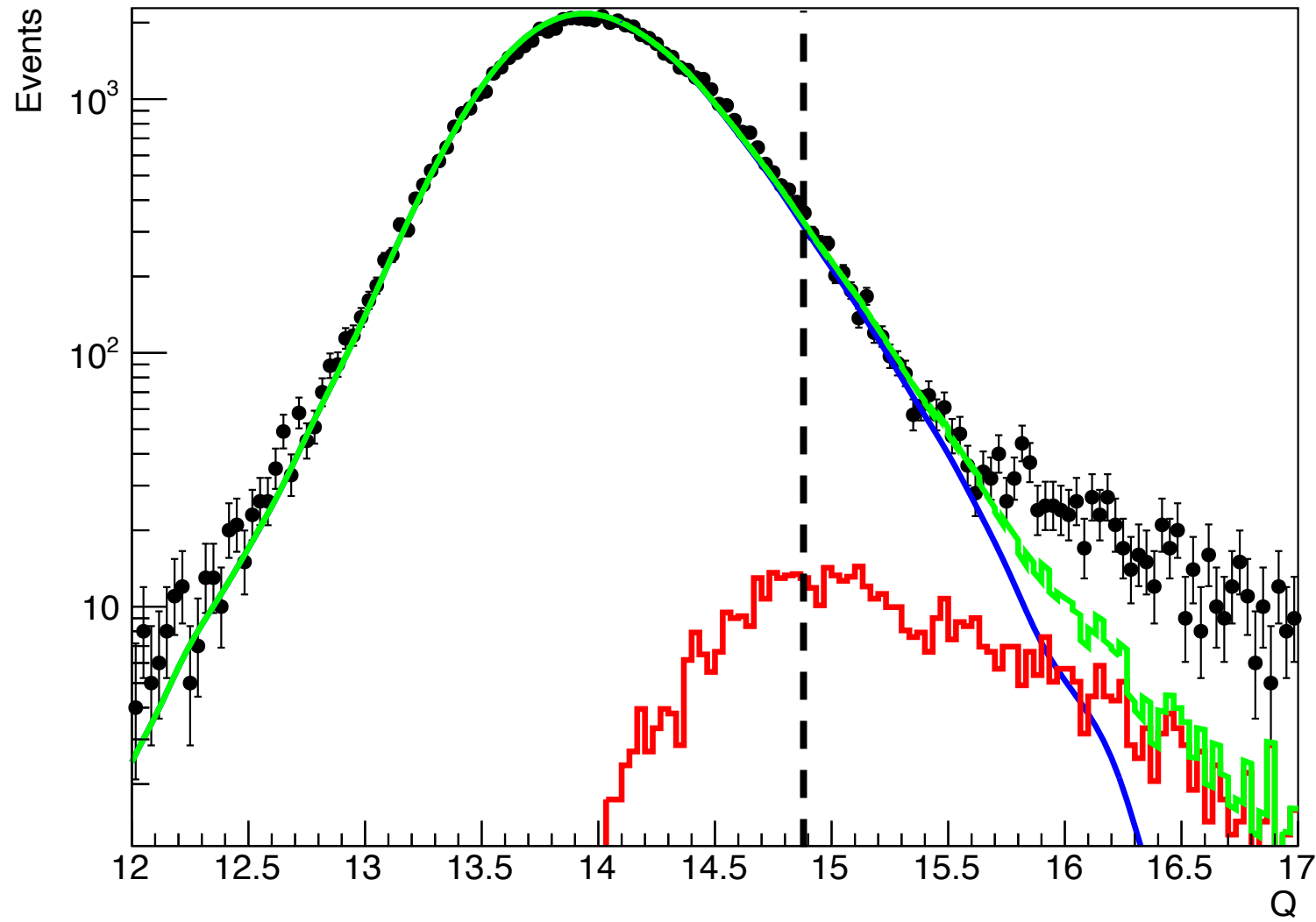


Silicon @  $2.970 < R \text{ (GV)} < 3.640$



- L1 distribution when selecting Si
- L2 Template for Si
- L1 Template for P
- Template fit

Silicon @  $2.400 < R \text{ (GV)} < 2.670$  -  $\chi^2=3.748928$

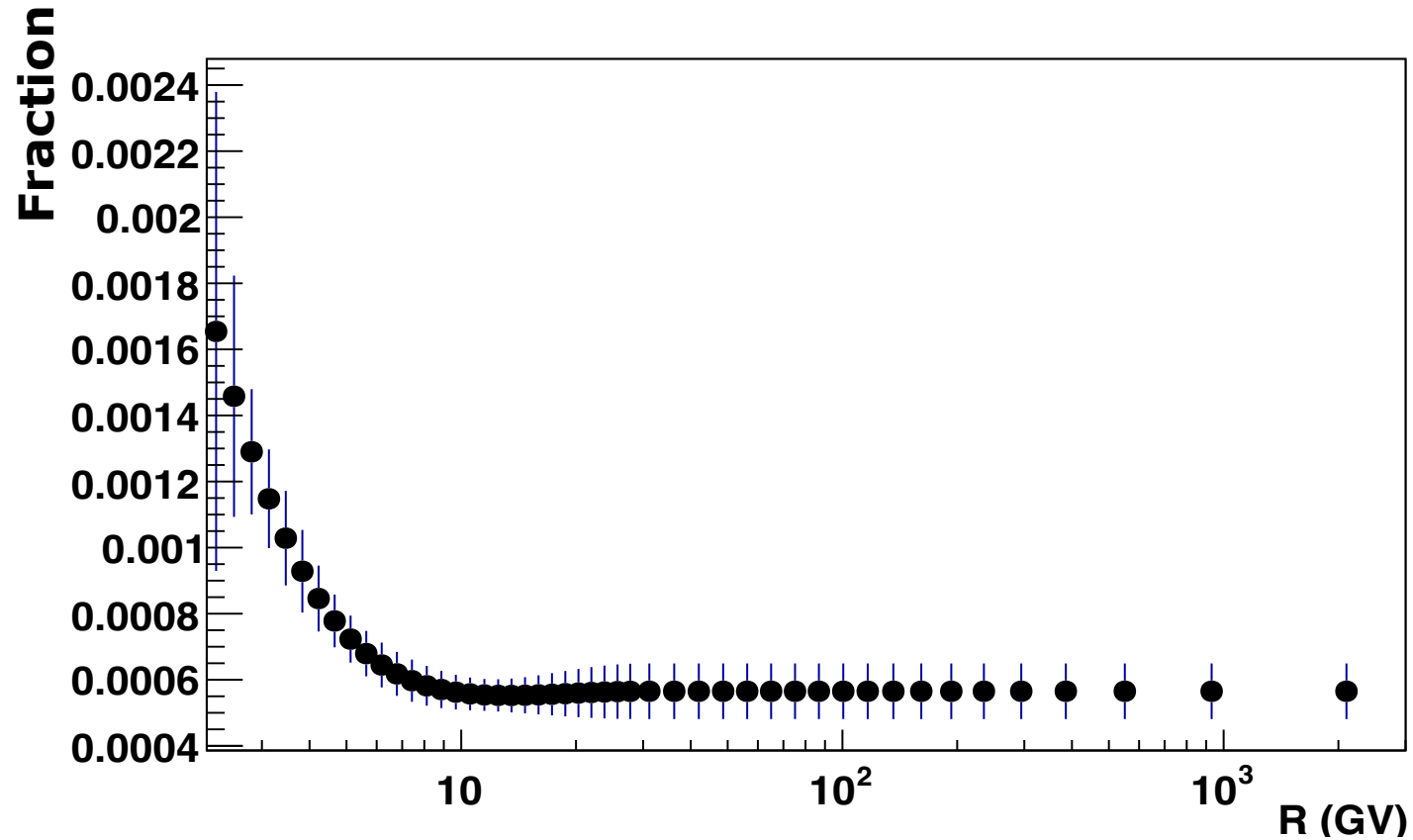


- I'm introducing a shift and a smear parameter to match the differences between the L1 and L2
- I'm currently doing a convolution between the L2 signal distribution and a Gaussian

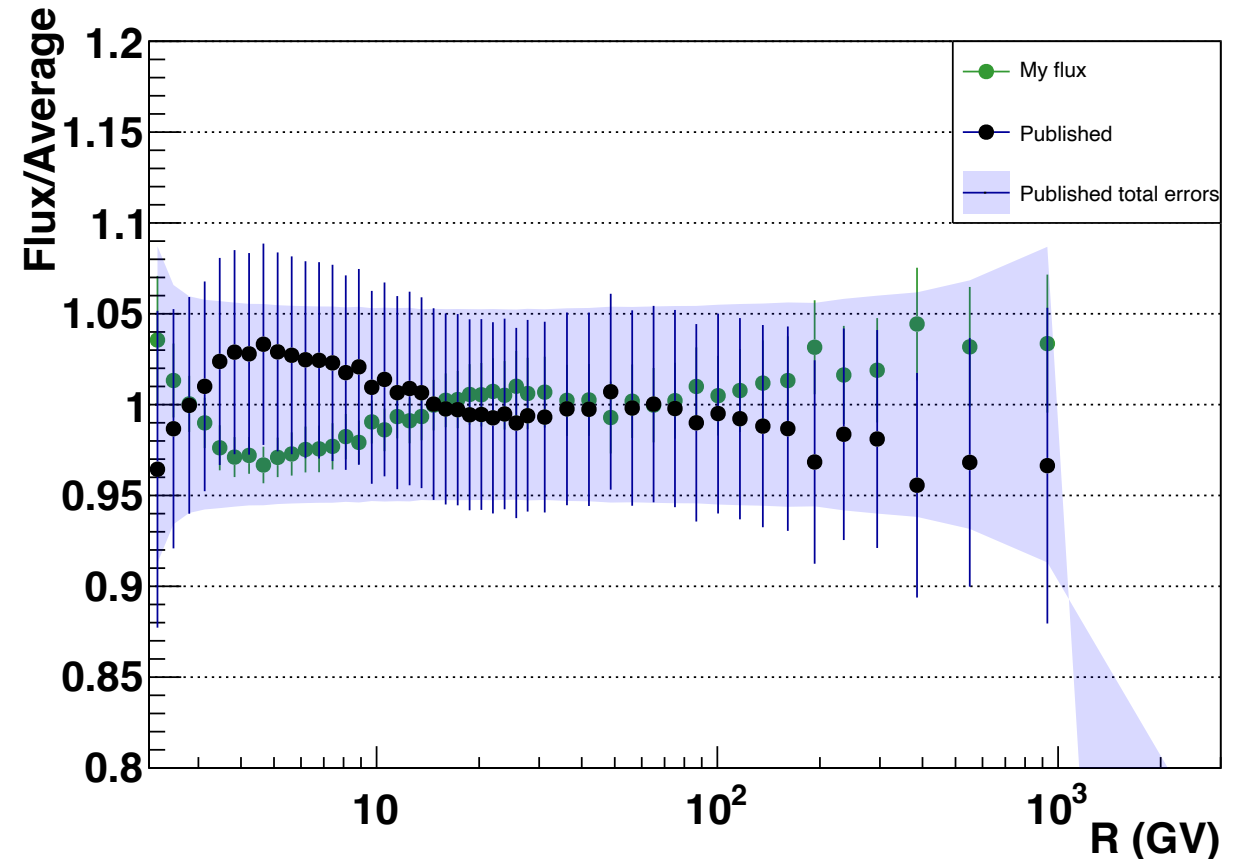
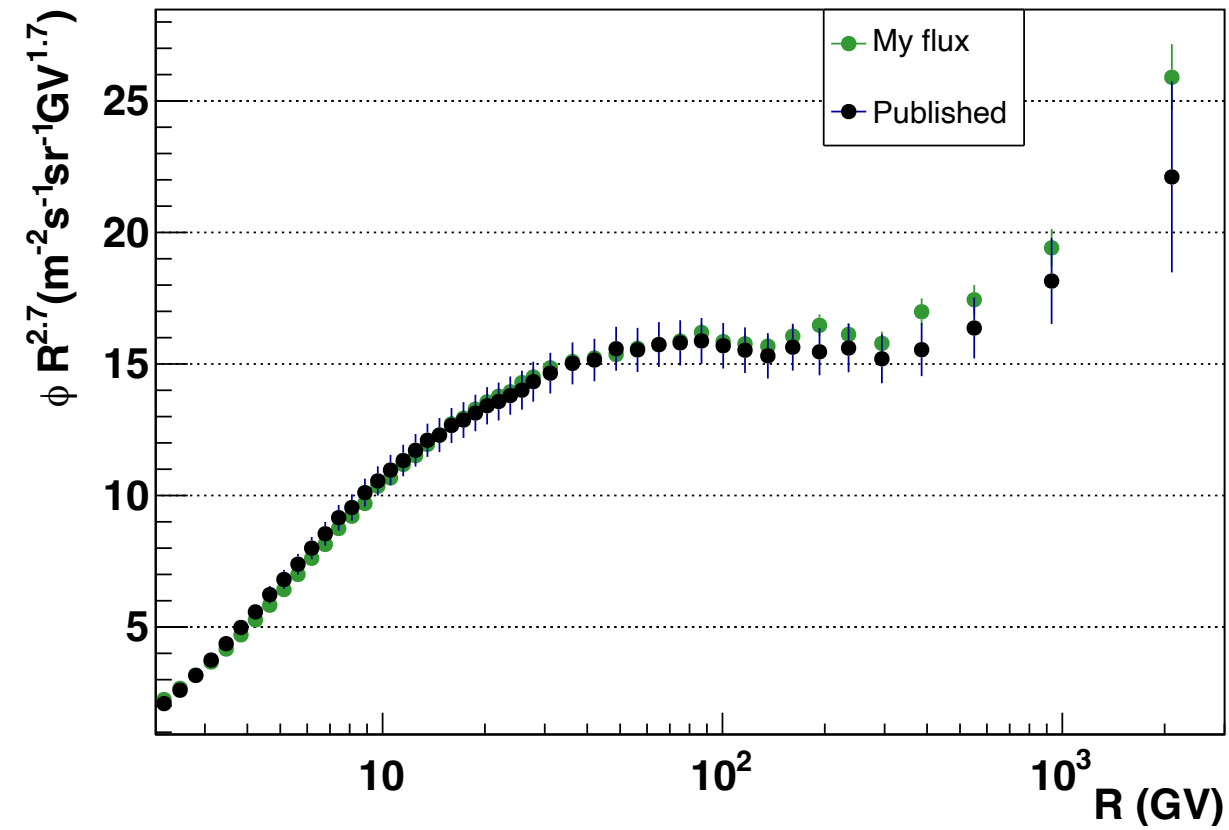
- L1 distribution when selecting Si
- L2 Template for Si
- L1 Template for P
- Template fit

# Silicon contamination

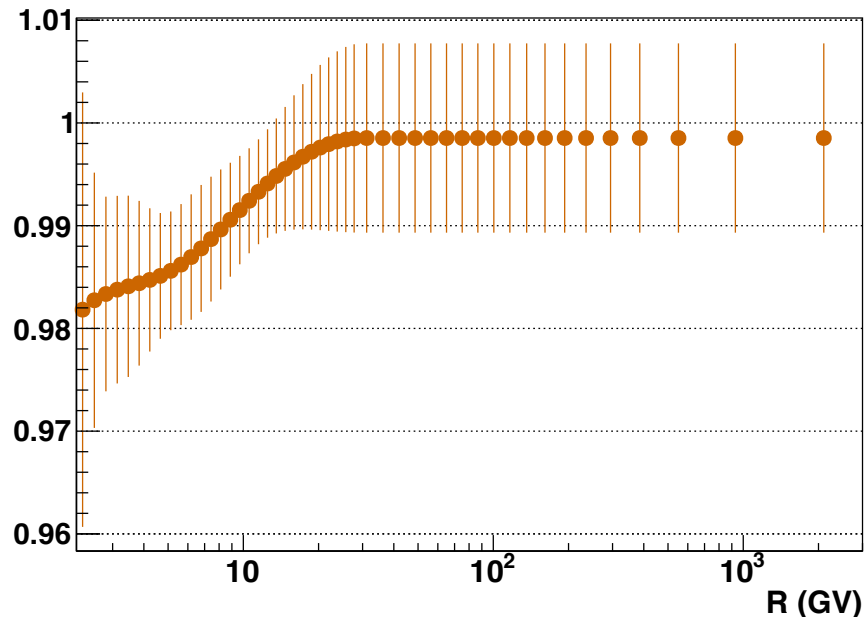
$$f(R) = \frac{n_P(R) \int_0^{Z+0.89} f_P(x, R) dx}{n_P(R) \int_0^{Z+0.89} f_P(x, R) dx + n_{Si}(R) \int_0^{Z+0.89} f_{Si}(x, R) dx}$$



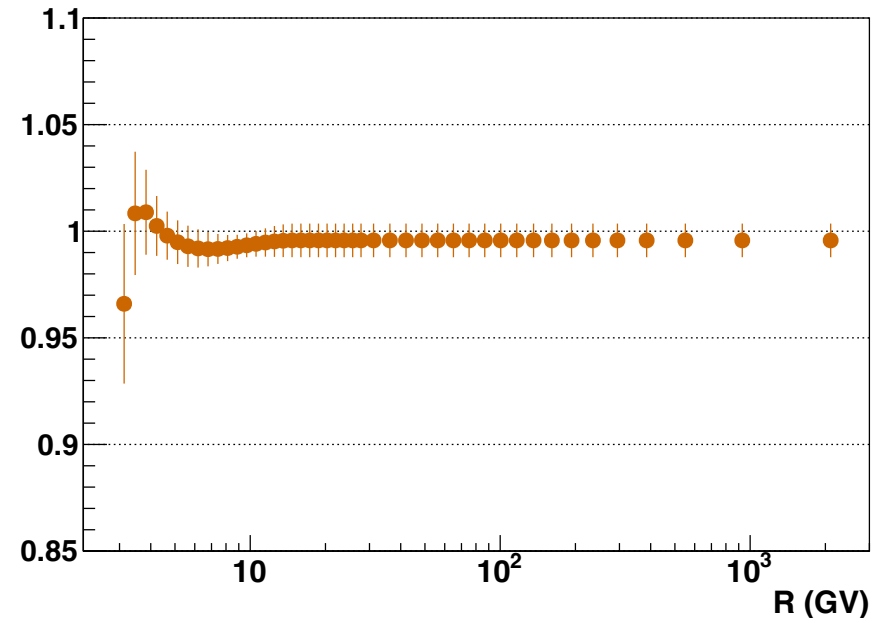
# Folded Silicon flux



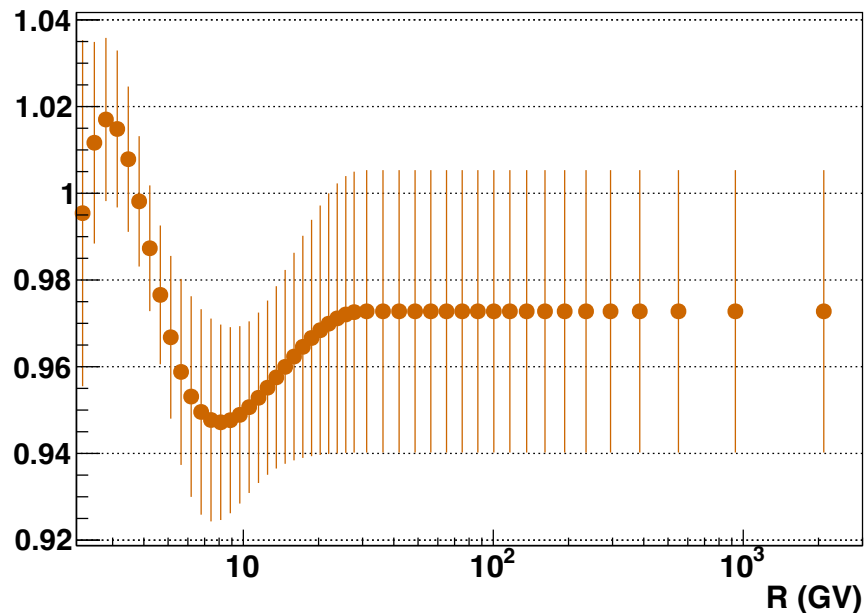
S (Z=16) L1 spline



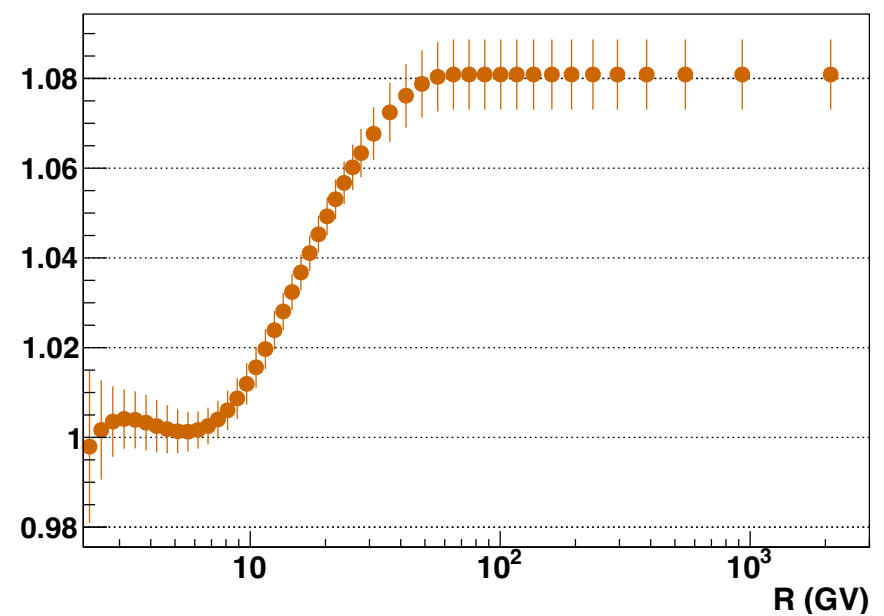
S (Z=16) Tof spline



S (Z=16) Track spline

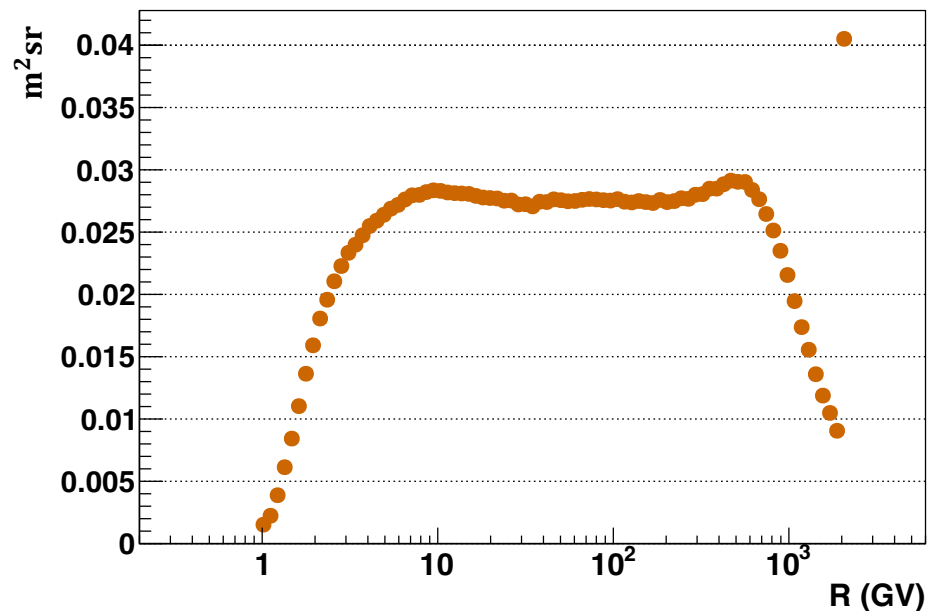


S (Z=16) Trigger spline

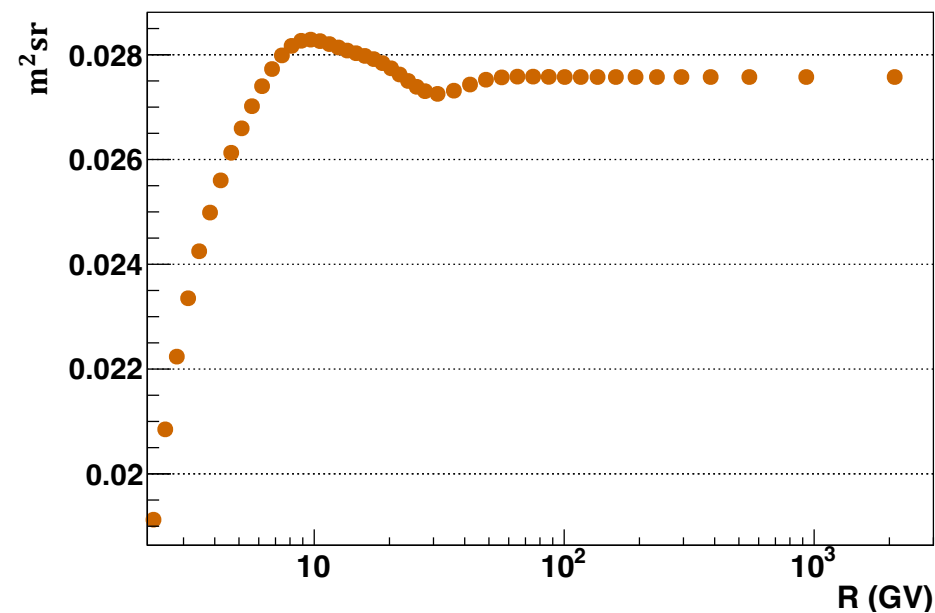




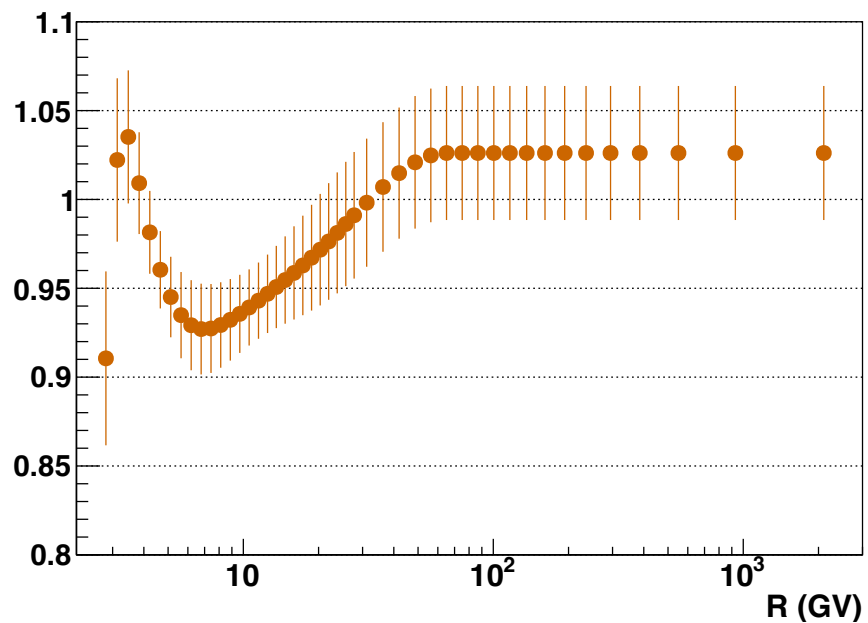
S (Z=16) Mc acceptance



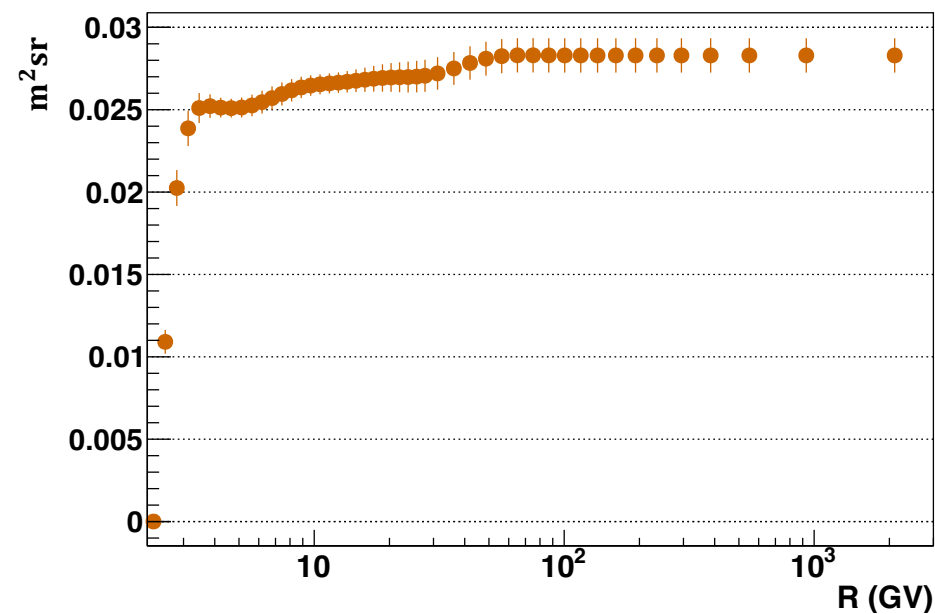
S (Z=16) Spline mc acceptance



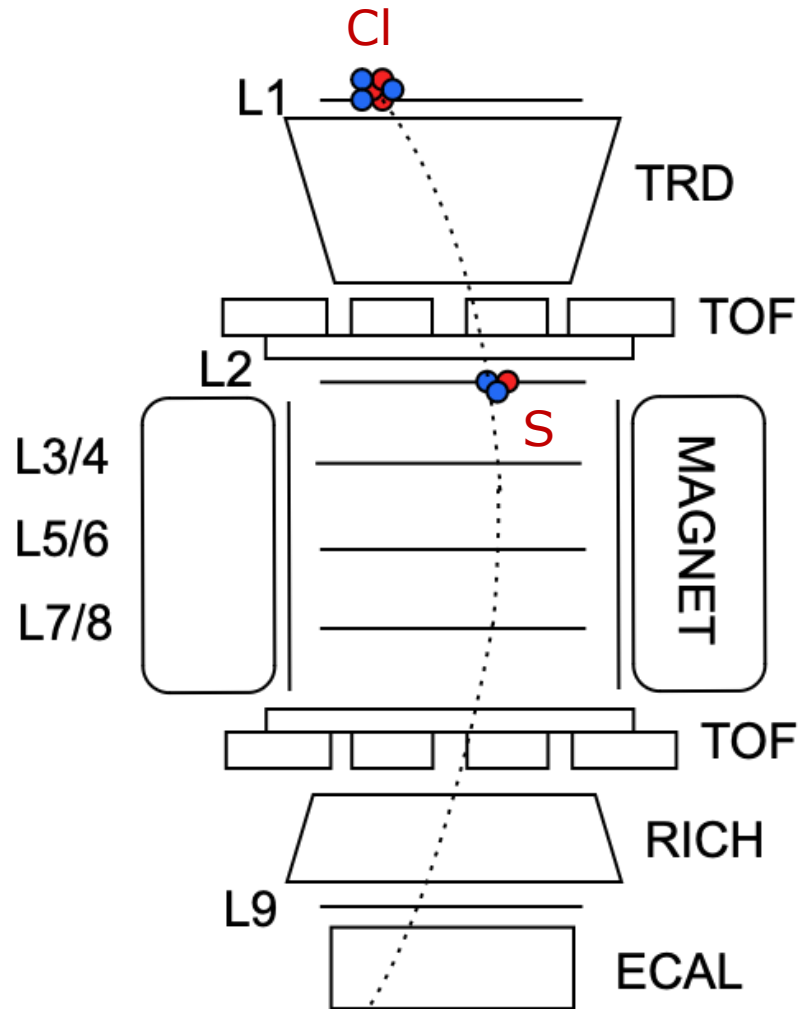
S (Z=16) Data/Mc Tot



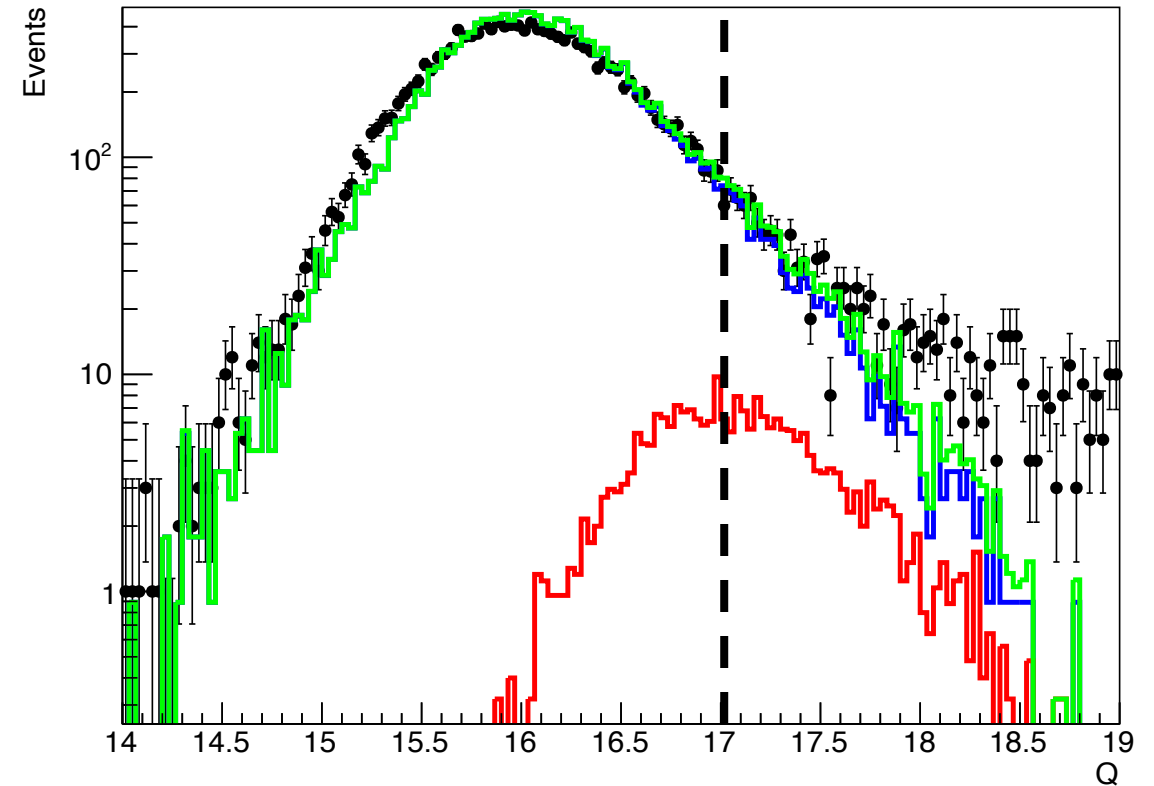
S (Z=16) Total acceptance



# Sulfur

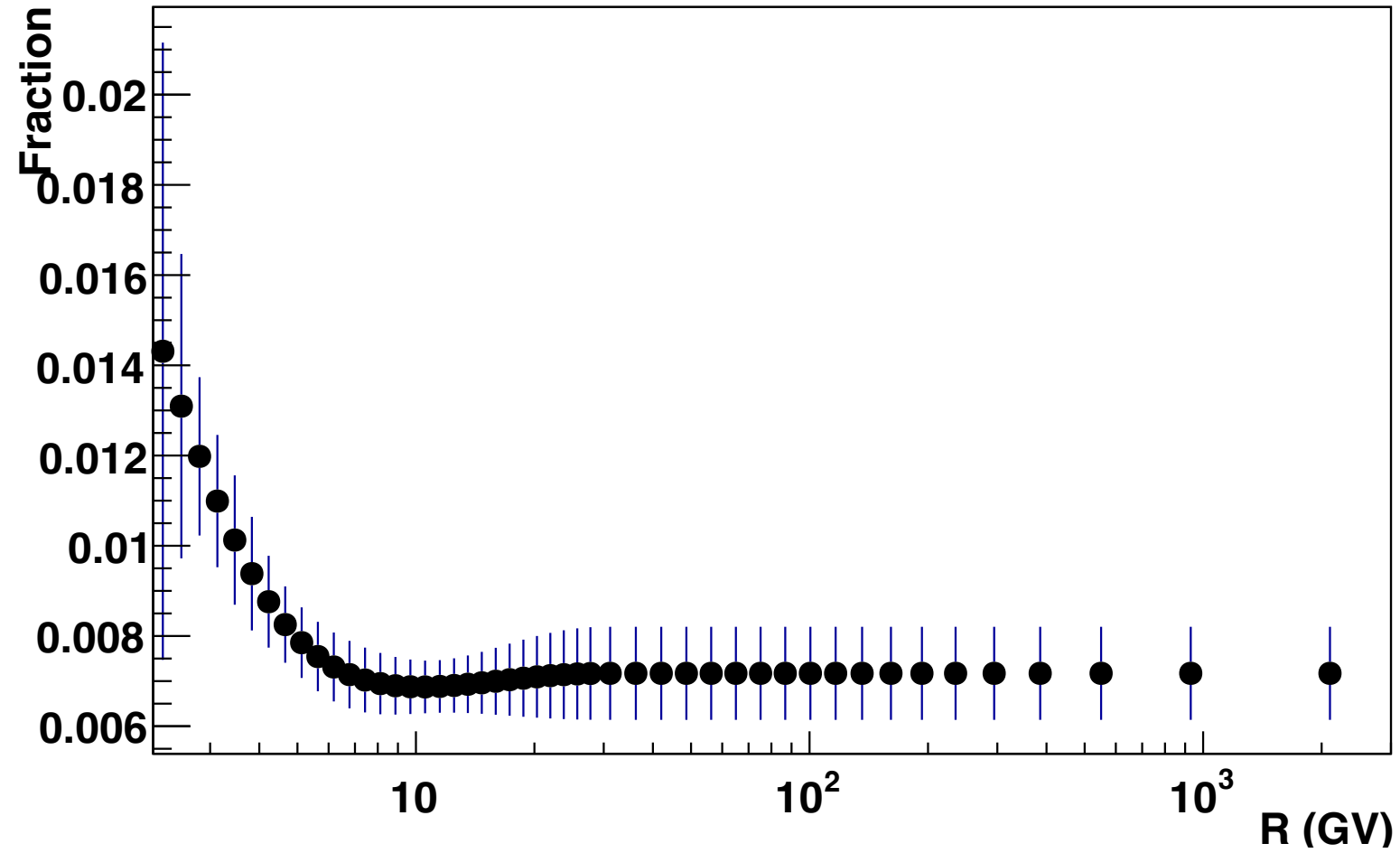


Sulfur @  $2.970 < R \text{ (GV)} < 3.290$

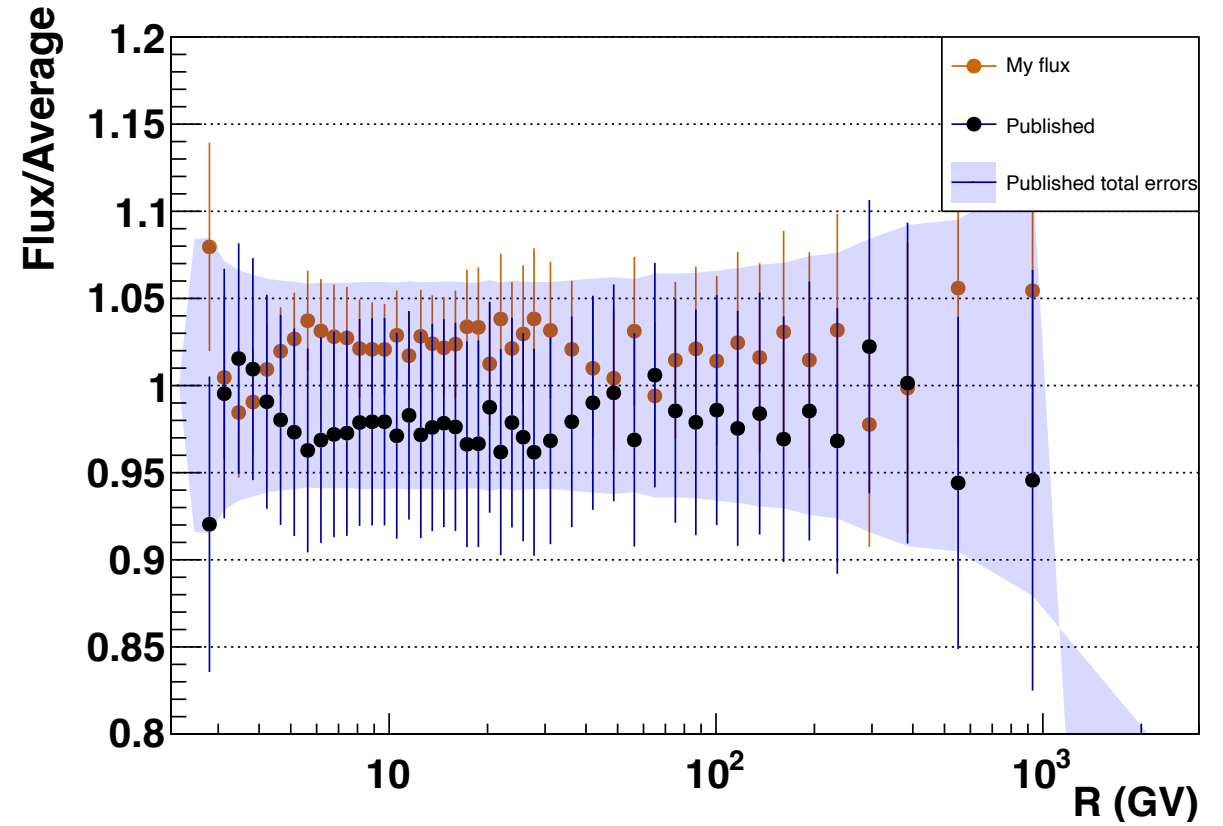
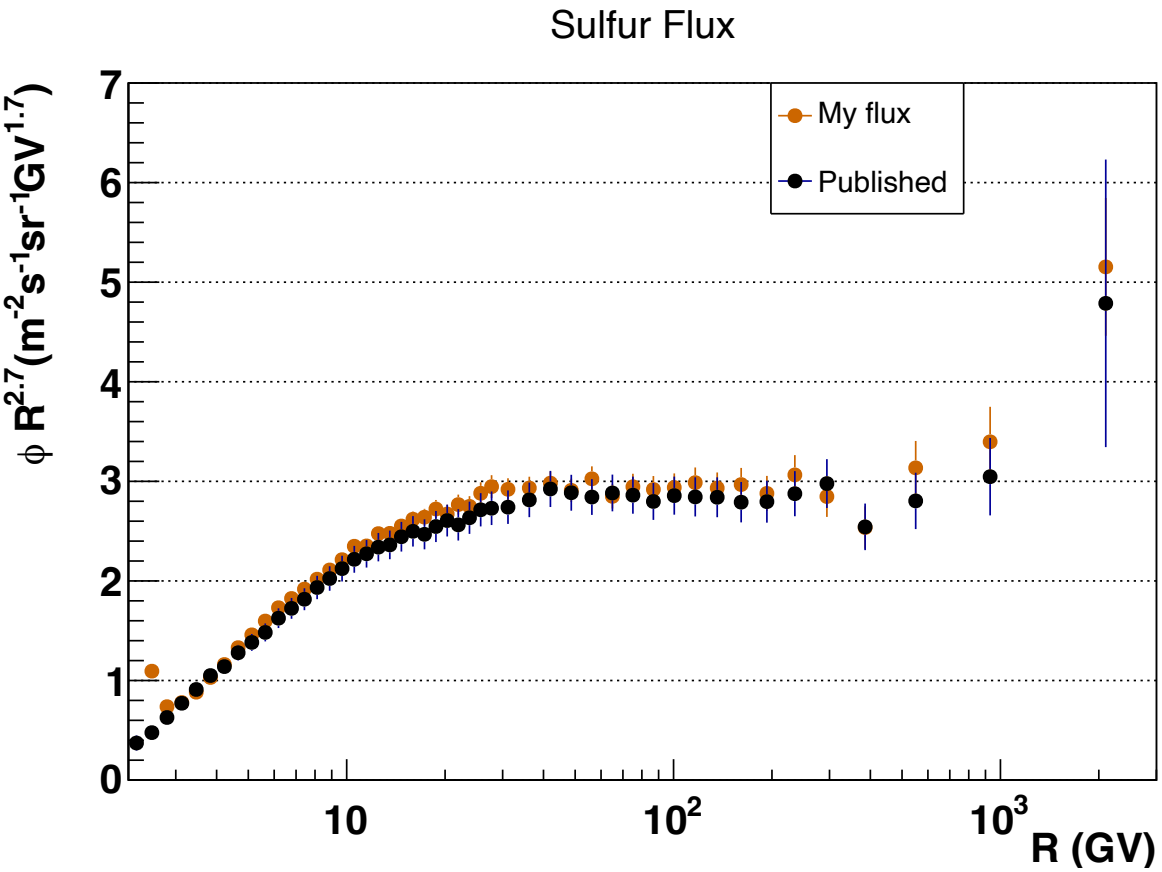


- L1 distribution when selecting S
- L2 Template for S
- L1 Template for Cl
- Template fit

# Sulfur contamination

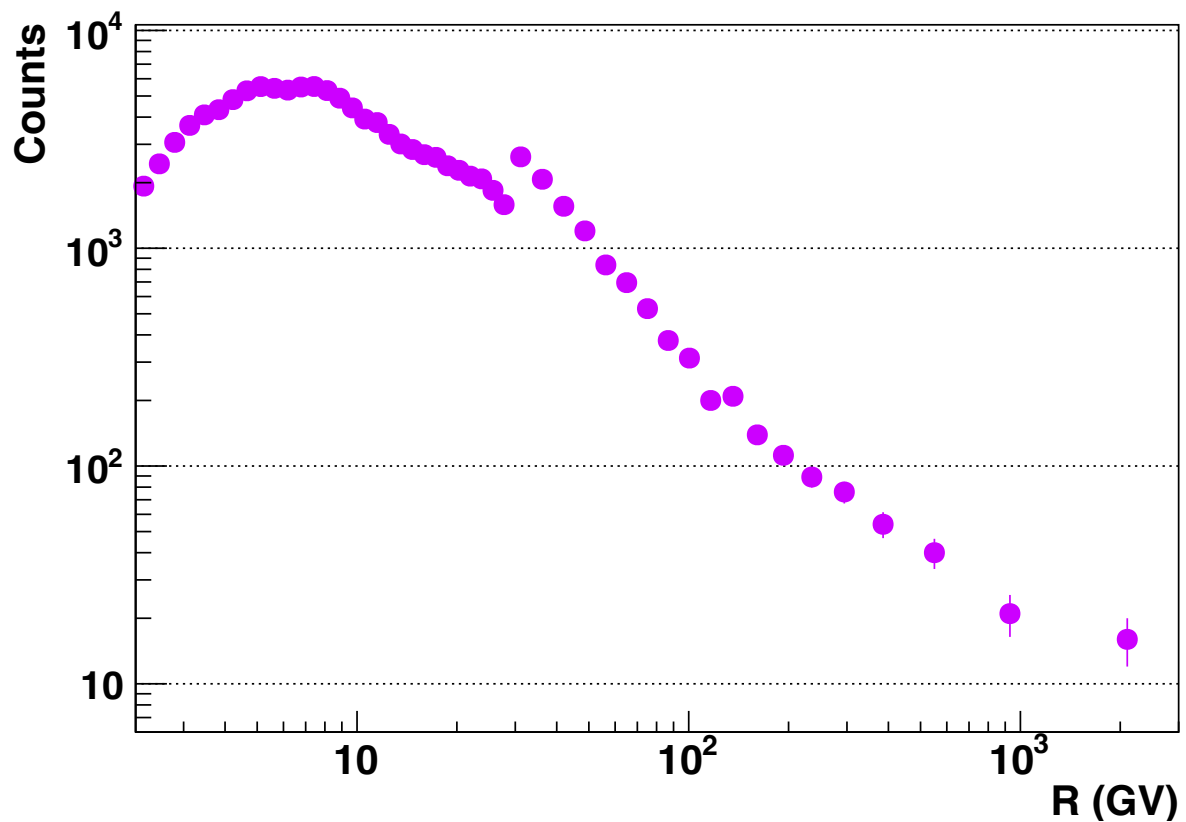


# Folded Sulfur flux

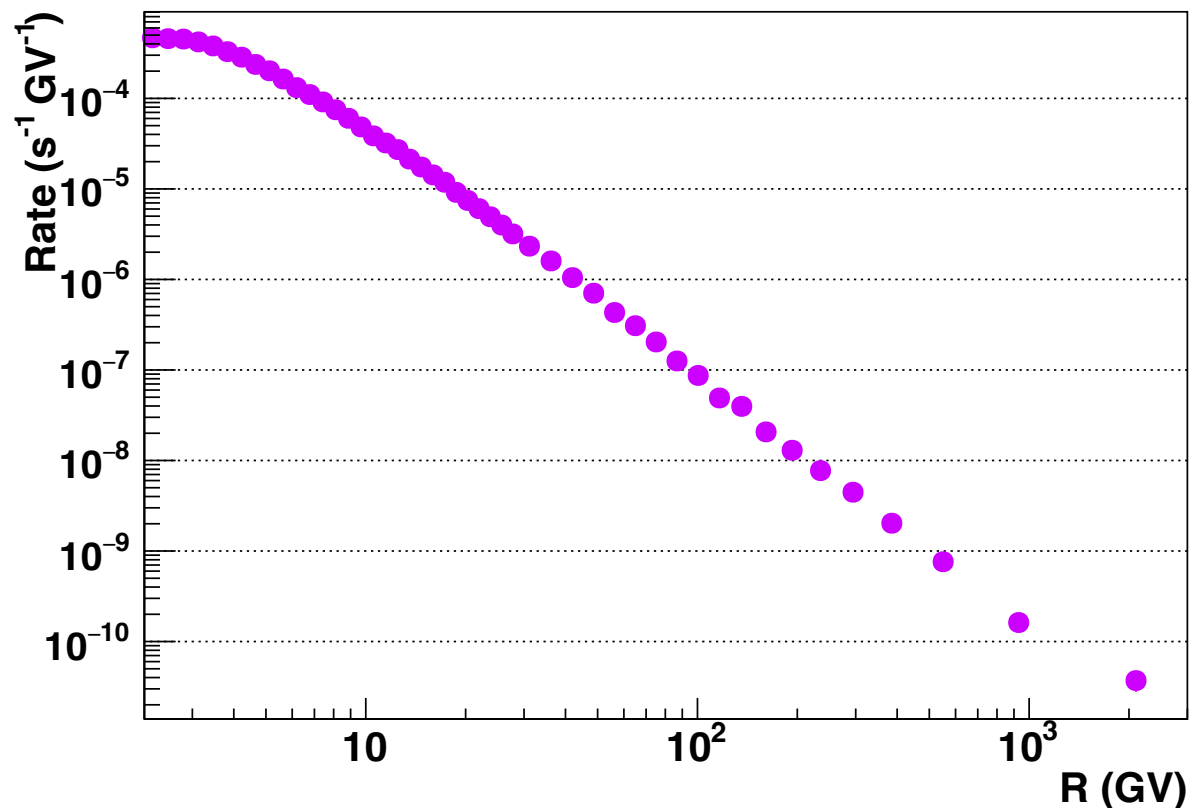


# P counts and rate

P (Z=15) Counts

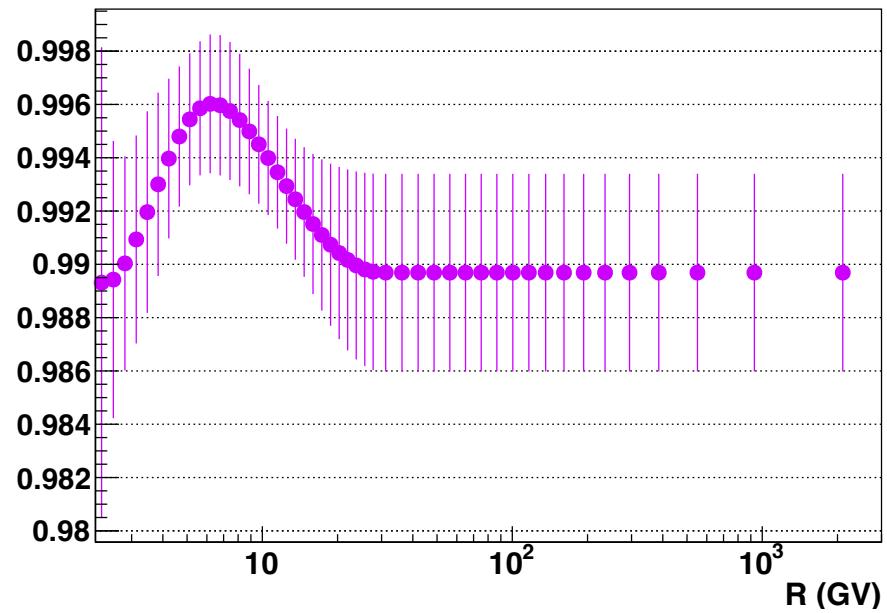


P (Z=15) Rate

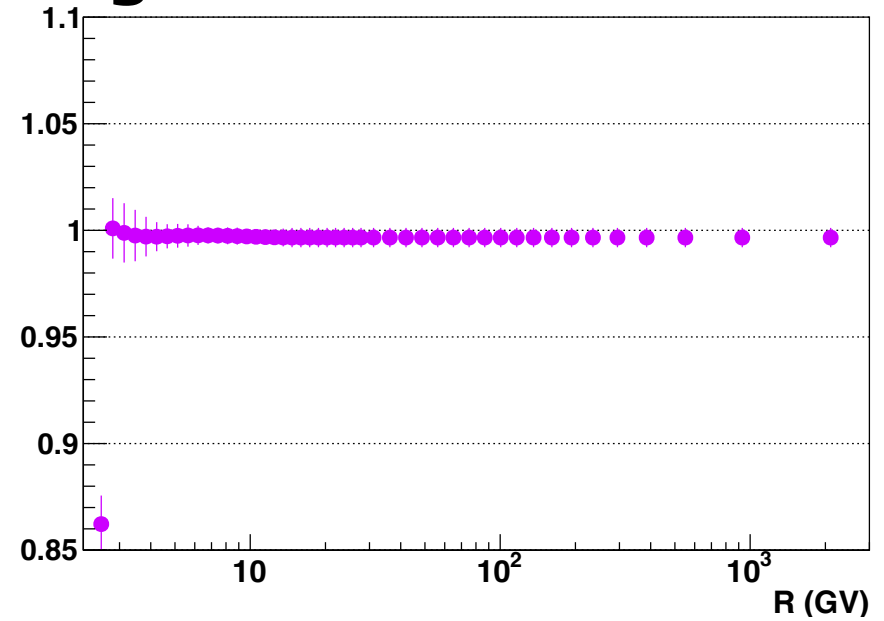


# Weighted averages

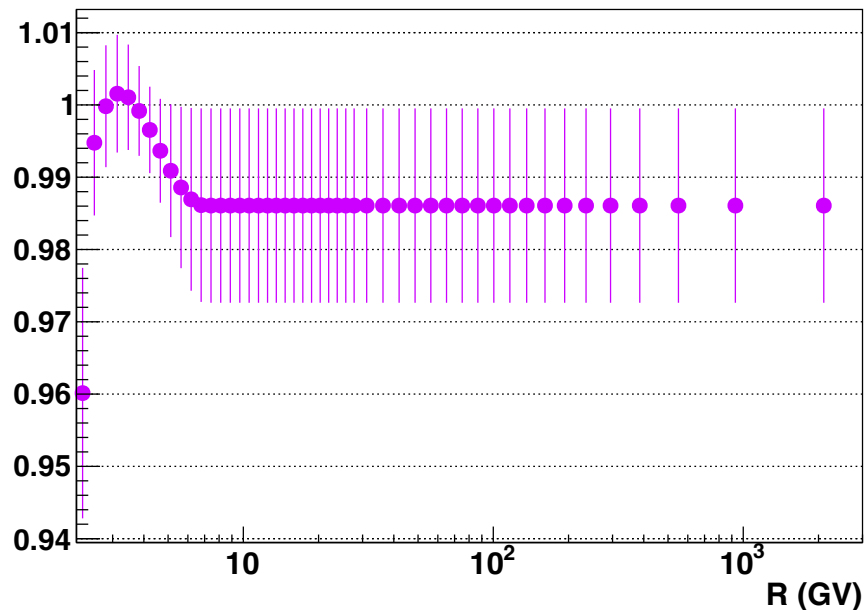
P (Z=15) L1 spline



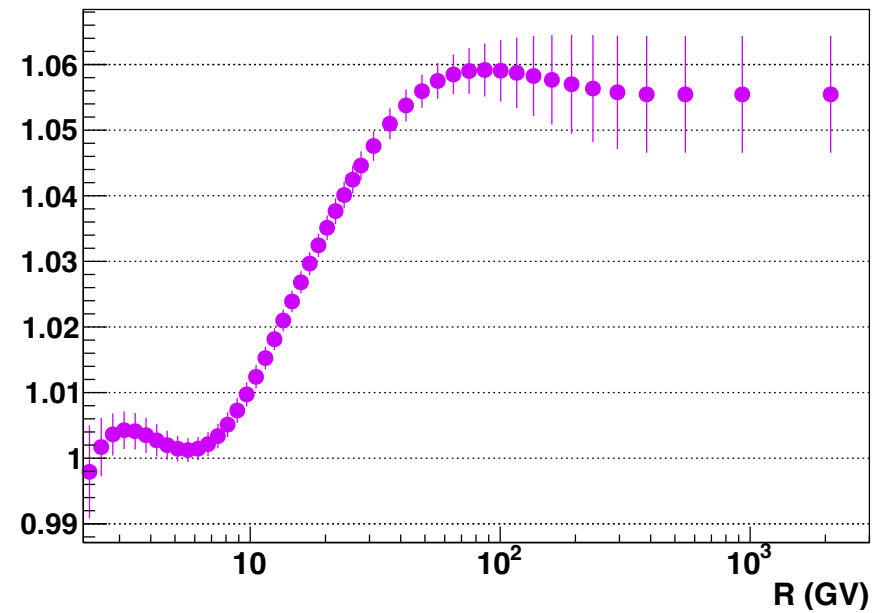
P (Z=15) Tof spline



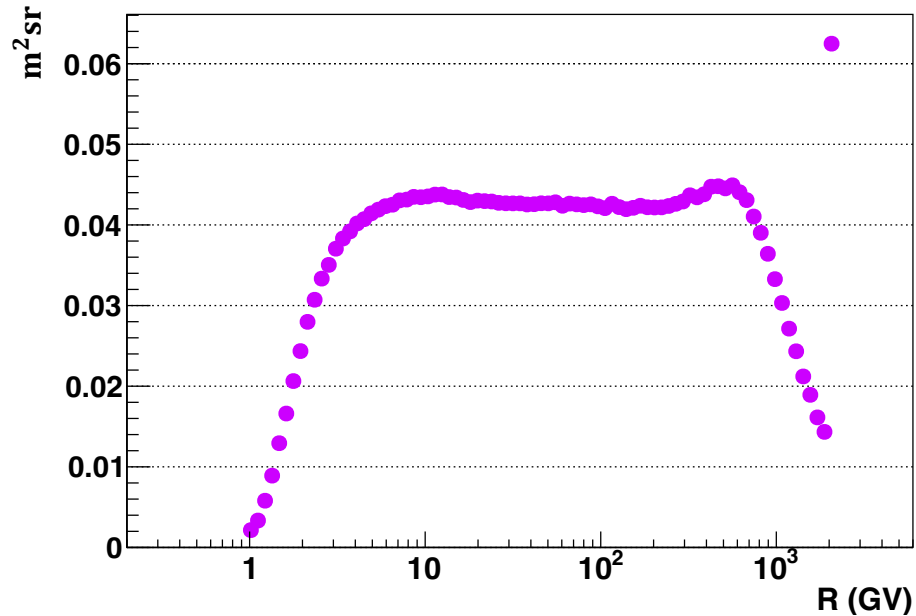
P (Z=15) Track spline



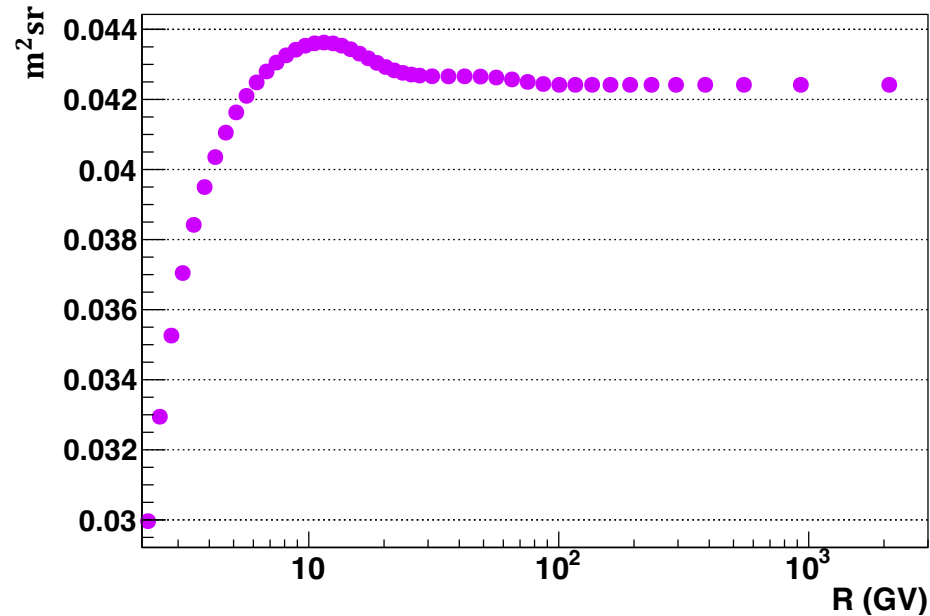
P (Z=15) Trigger spline



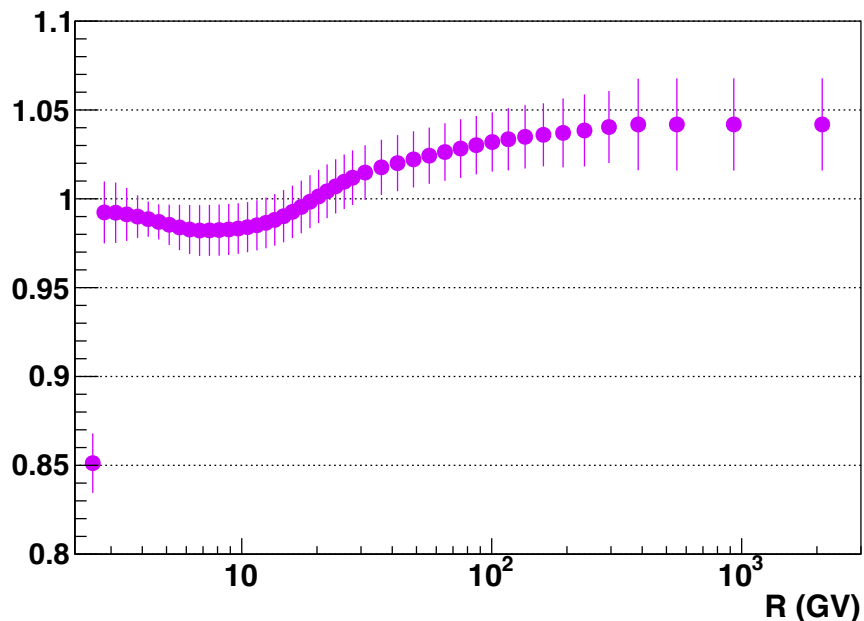
P (Z=15) Mc acceptance



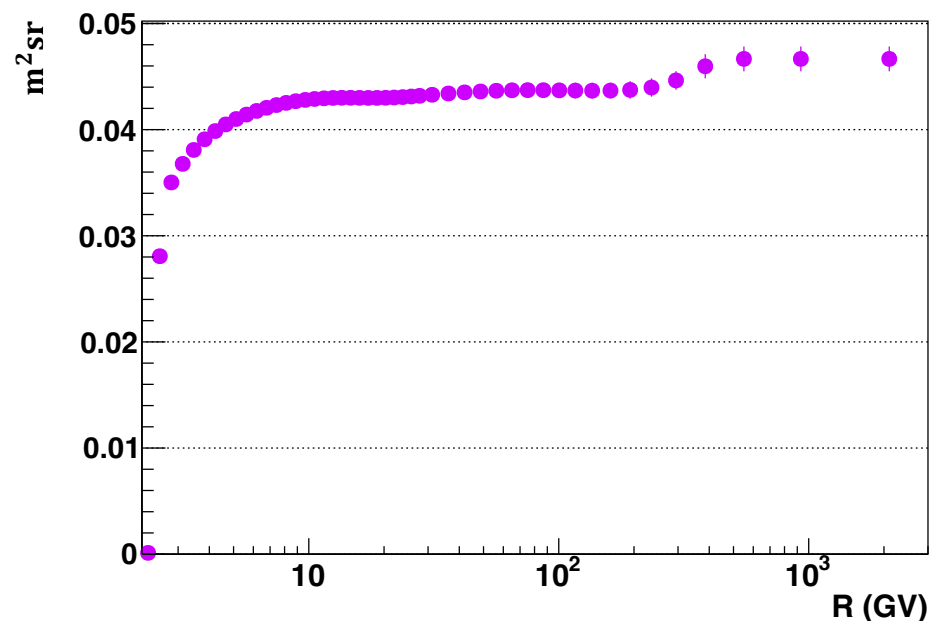
P (Z=15) Spline mc acceptance



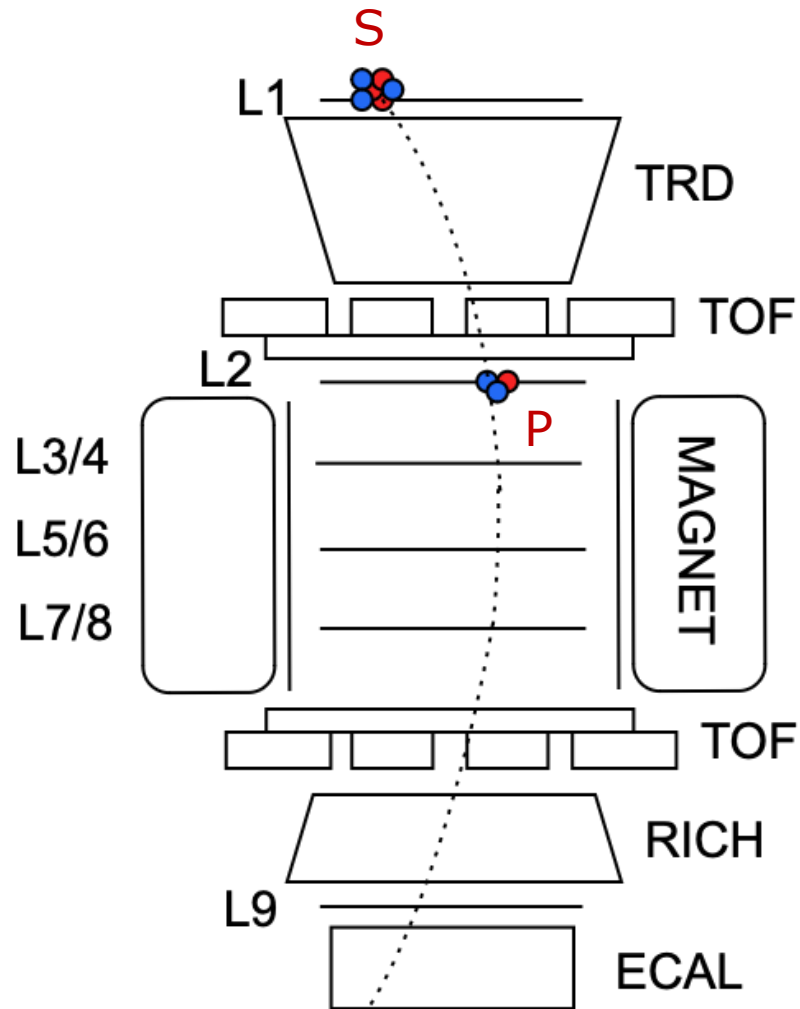
P (Z=15) Total Data/Mc correction



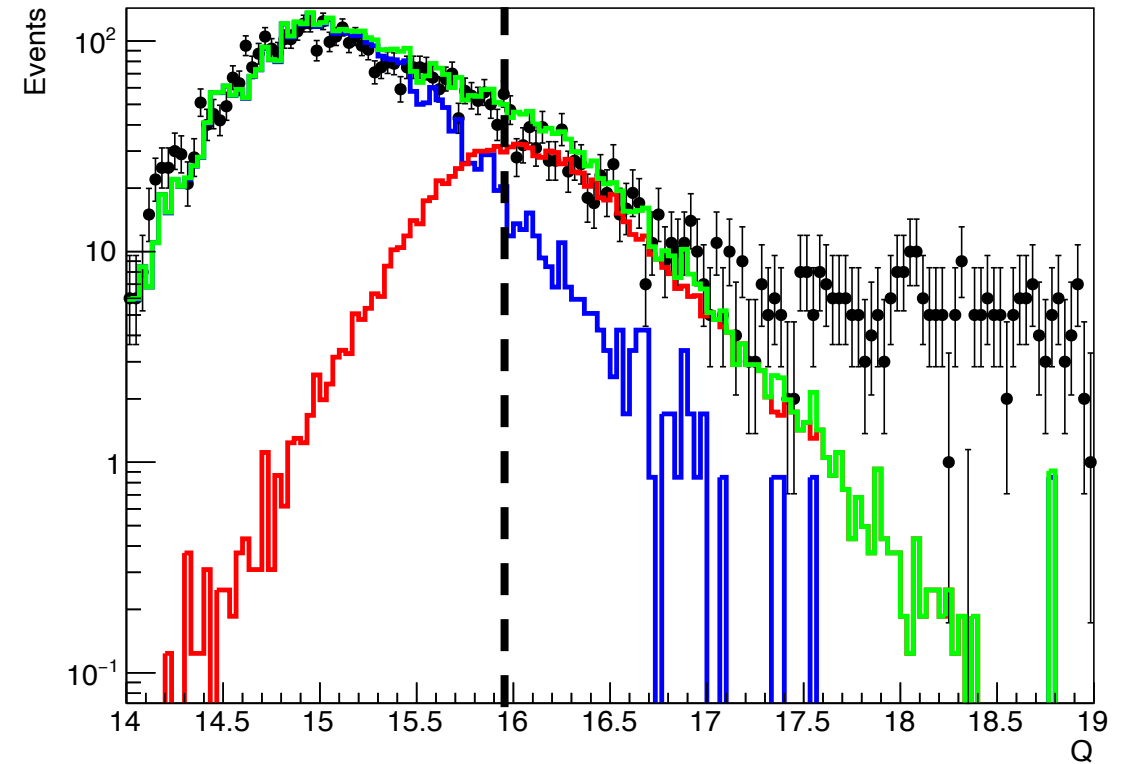
P (Z=15) Total acceptance



# Phosphorus



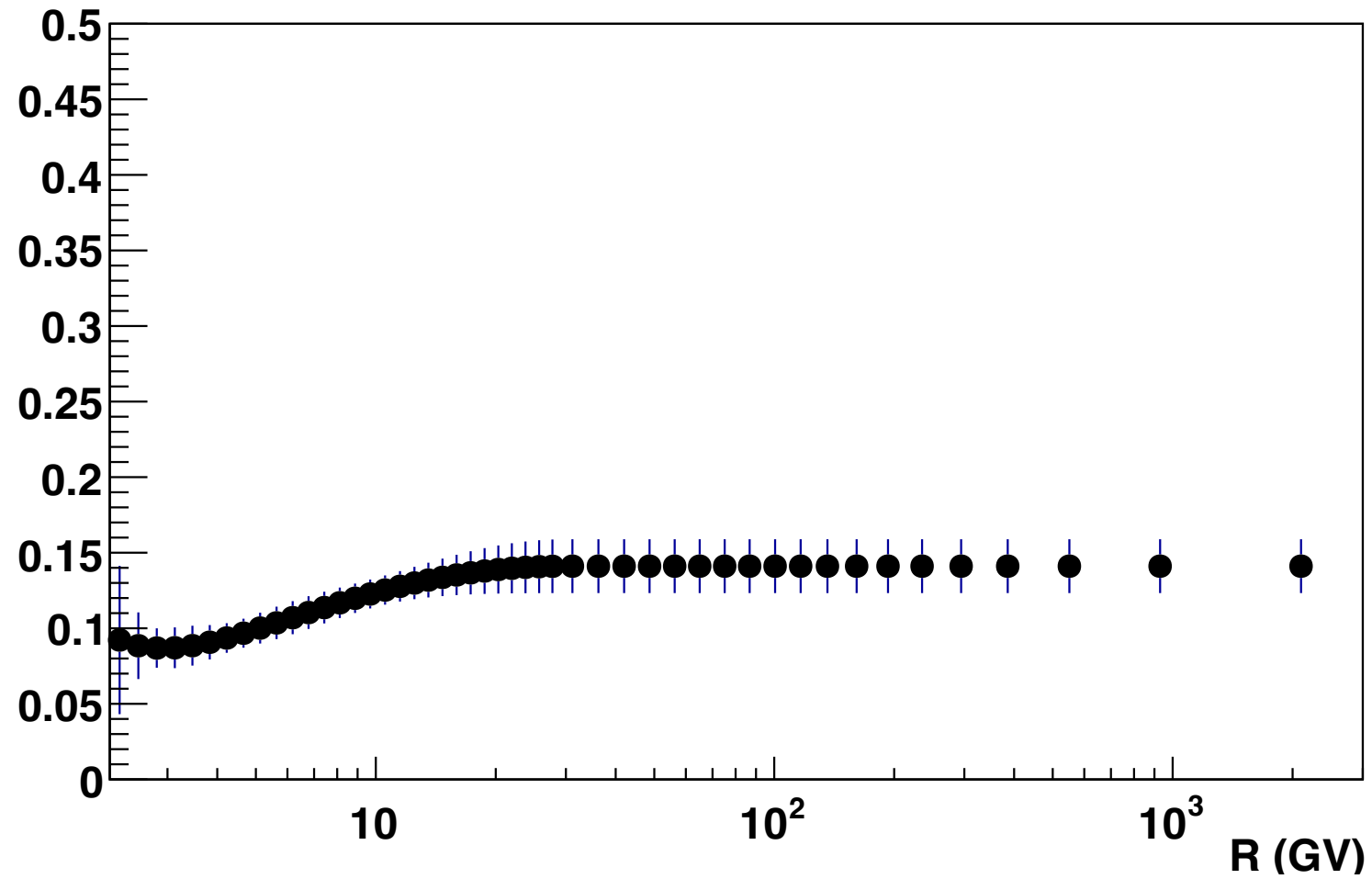
Phosphorus @  $2.970 < R \text{ (GV)} < 3.290$



- L1 distribution when selecting P
- L2 Template for P
- L1 Template for S
- Template fit

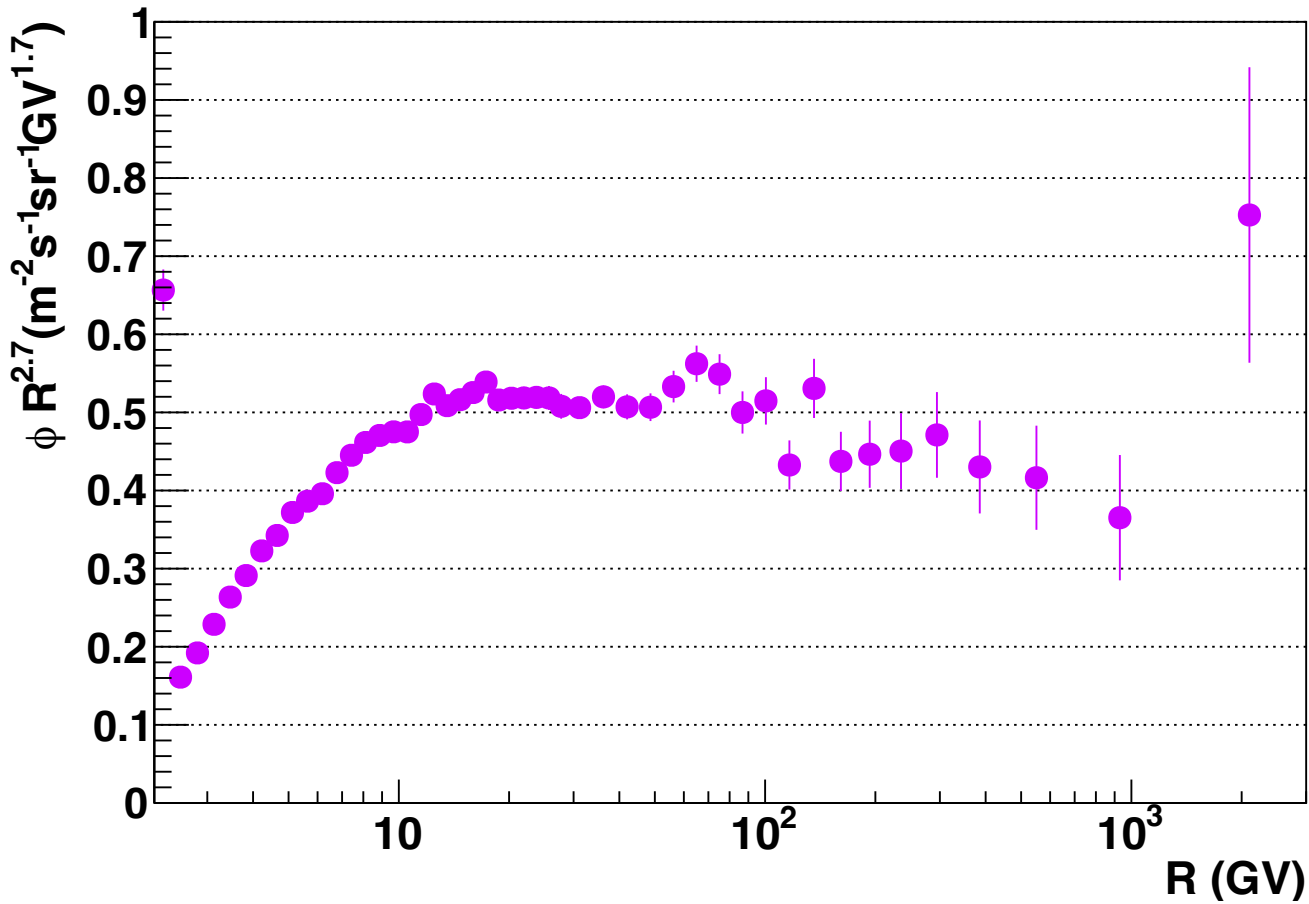


# Phosphorus contamination

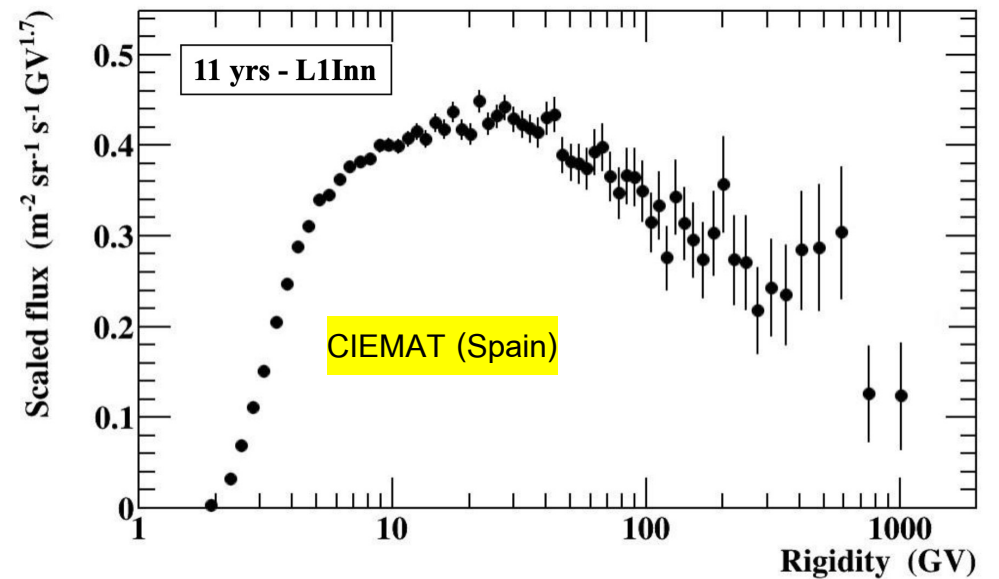
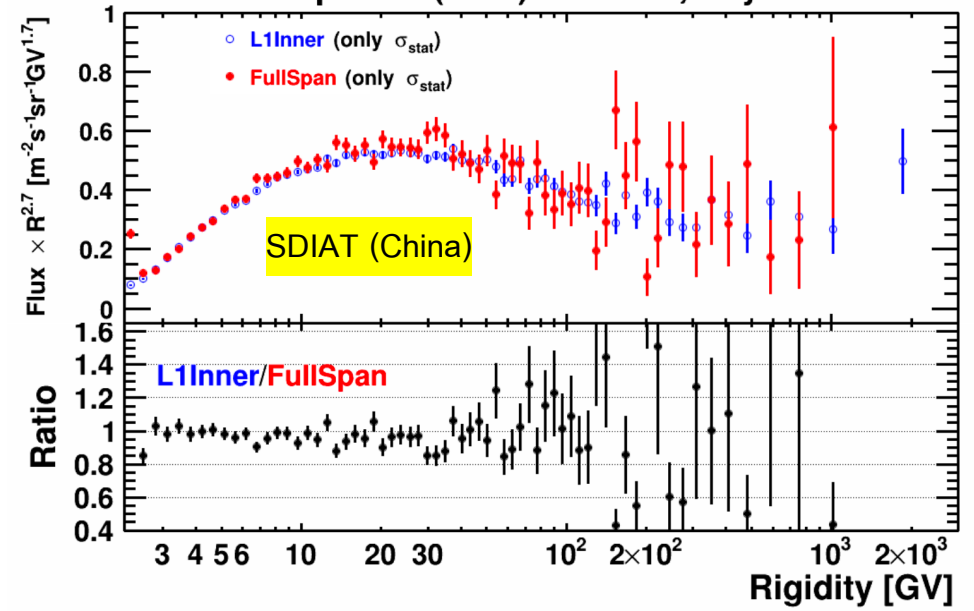


# Phosphorus folded flux

P (Z=15) Flux



Phosphorus (Z=15) Raw Flux, 11 years



# To do

- Unfolding
- Top of the instrument (TOI) correction (fragmentation above the layer 1)

Backup

# Binning

Rigidity bin: **49 bins (published)**

```
const int nRbins_HighZ = 49;  
const double Rbins_HighZ[nRbins_HighZ] = {2.15, 2.40, 2.67, 2.97, 3.29, 3.64,  
4.02, 4.43, 4.88, 5.37, 5.90, 6.47, 7.09, 7.76, 8.48, 9.26, 10.1, 11.0, 12.0, 13.0,  
14.1, 15.3, 16.6, 18.0, 19.5, 21.1, 22.8, 24.7, 26.7, 28.8, 33.5, 38.9, 45.1,  
52.2, 60.3, 69.7, 80.5, 93.0, 108., 125., 147., 175., 211, 259., 330., 441.,  
660., 1200., 3000.};
```

Layer 2 template: **21 bins**

```
= {0.8, 2.40, 2.97, 3.64, 4.43, 5.37, 6.47, 7.76, 9.26, 11.00, 13.0,  
15.3, 18.0, 21.1, 24.7, 28.8, 33.5, 38.9, 45.1, 52.2, 5000};
```

Layer 1 template: **49 bins (published)**