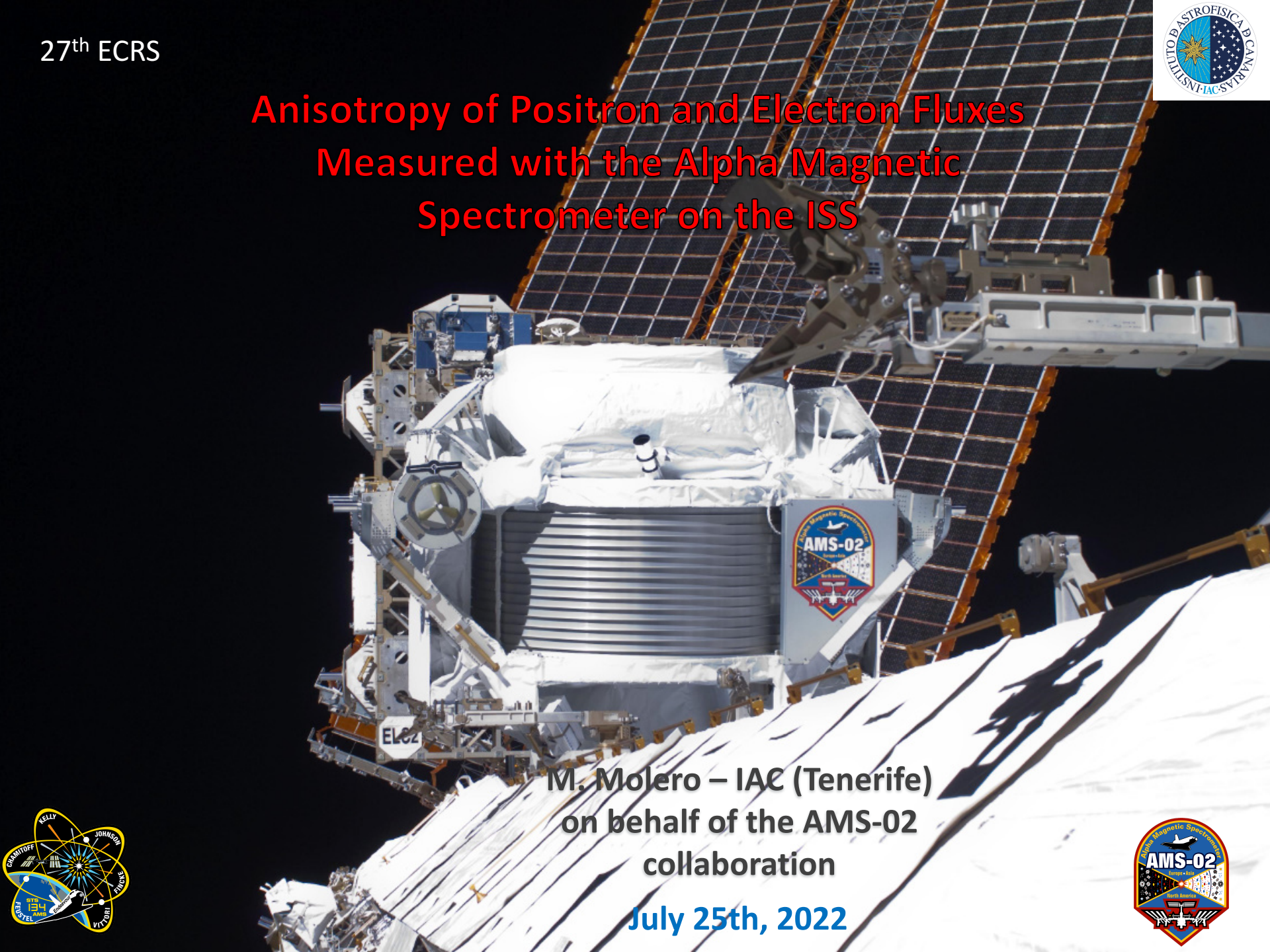
27th ECRS

Anisotropy of Positron and Electron Fluxes Measured with the Alpha Magnetic Spectrometer on the ISS



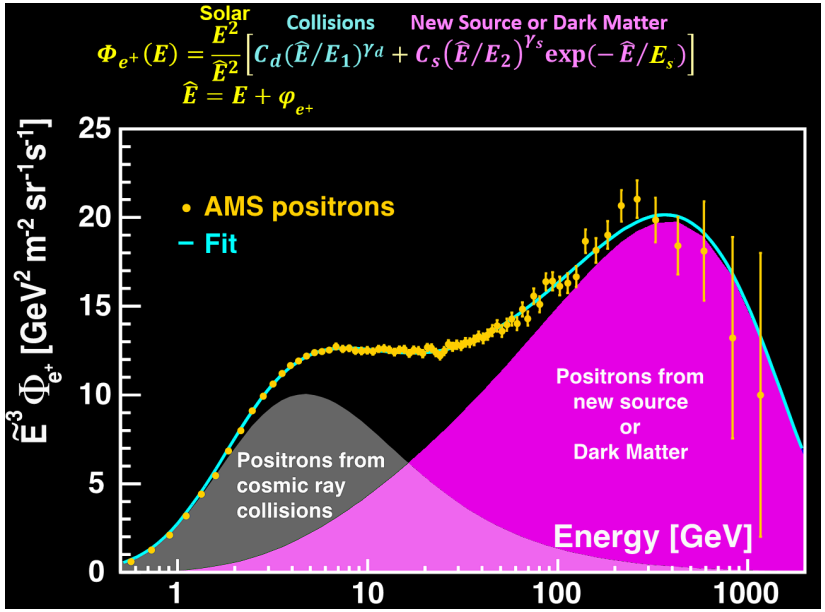
M. Molero – IAC (Tenerife)
on behalf of the AMS-02 collaboration

July 25th, 2022

Motivation: e^+

- The **positron** flux shows an excess at high energies that is not consistent with purely secondary production
- The excess is consistent with the existence of a **source term** of high-energy **positrons** with a characteristic cutoff energy (~880 GeV)

AMS 10 years preliminary data
Refer to the upcoming AMS publication



Typically, the **source term** is classified in two scenarios: **astrophysical sources** and **dark matter**

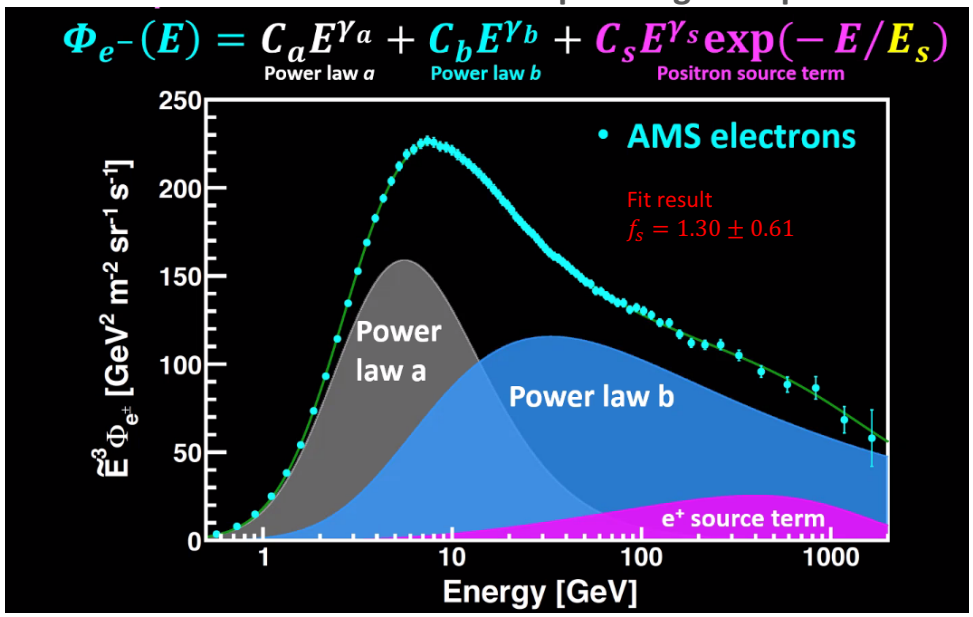
See also: Towards understanding the origin of cosmic-ray positrons by Dimitrii Krasnopevtsev (after this talk)

A local source of CR **positrons** may induce some degree of **anisotropy**

Motivation: e^-

- The **electron** flux shows an excess above ~50 GeV that is not consistent with low energy trends
- The **electron** spectrum can be best described by the sum of 2 power law functions and the contribution of a positron-like source term

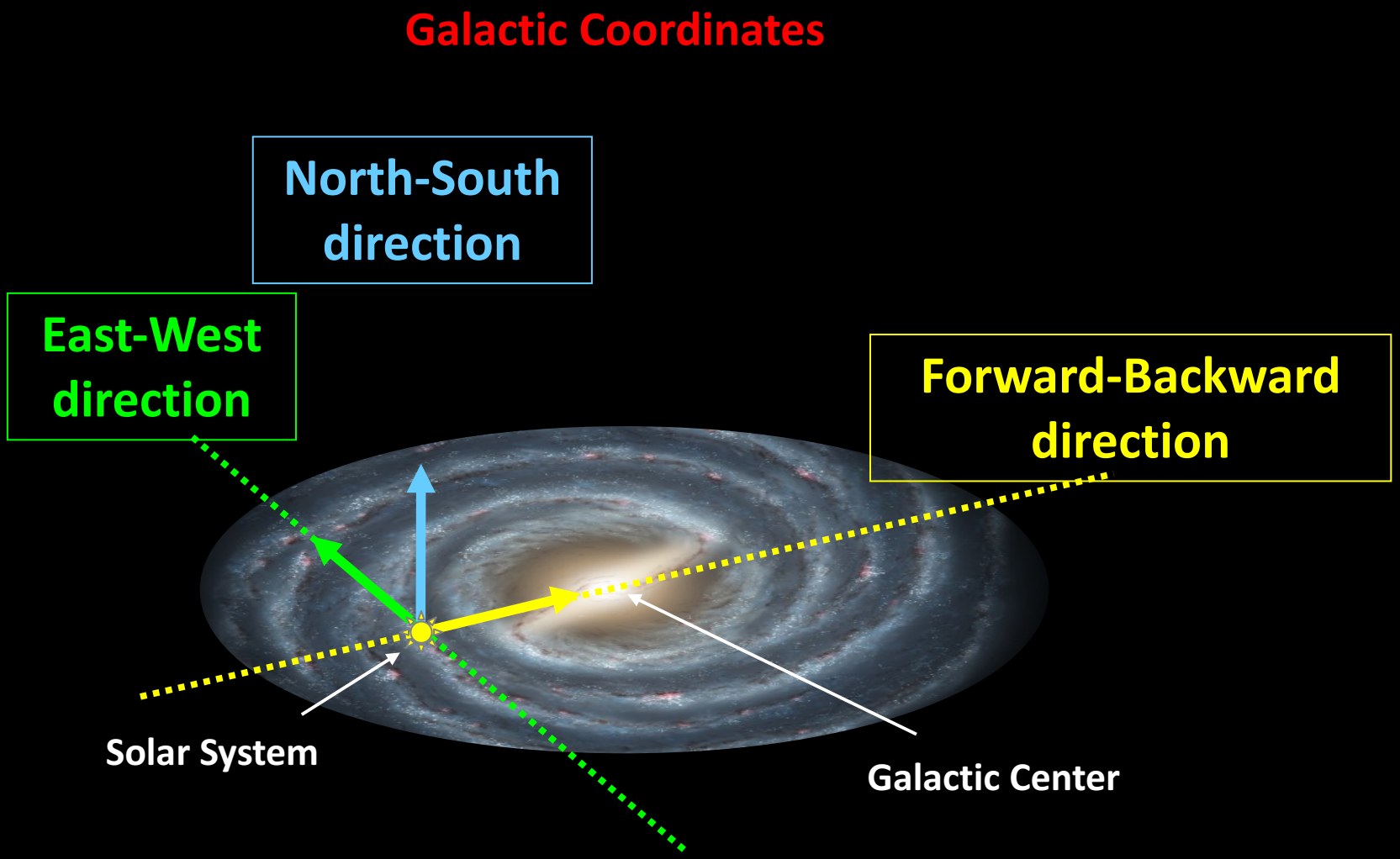
AMS 10 years preliminary data
Refer to the upcoming AMS publication



See also: Towards understanding the origin of cosmic-ray electrons by Maura Graziani (28/07/2022 at 14:15)

A local source of CR **electrons** may induce some degree of **anisotropy**

Coordinate System of Analysis



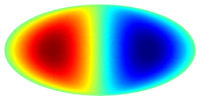
Expansion of the CRs Flux

$$\Phi(\theta,\varphi) = \Phi_0 \left(1 + \sum_{\ell=1} \sum_{m=-\ell}^{m=+\ell} a_{\ell m} Y_{\ell m}(\theta,\varphi)\right)$$

Multipolar Components

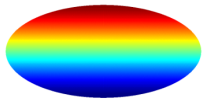
Real basis of spherical harmonics

Dipole Components



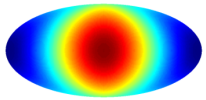
East-West

$$\rho_{\mathrm{EW}} = \sqrt{\frac{3}{4\pi}} a_{1-1}$$



North-South

$$\rho_{\mathrm{NS}} = \sqrt{\frac{3}{4\pi}} a_{1+0}$$



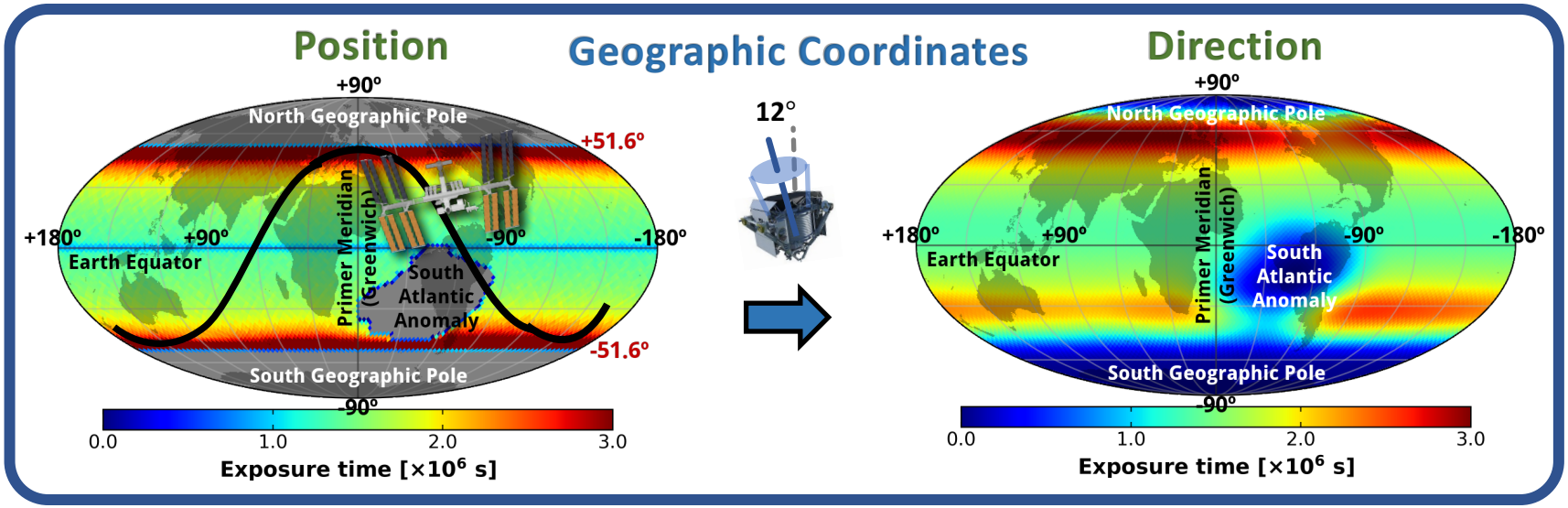
Forward-Backward

$$\rho_{\mathrm{FB}} = \sqrt{\frac{3}{4\pi}} a_{1+1}$$

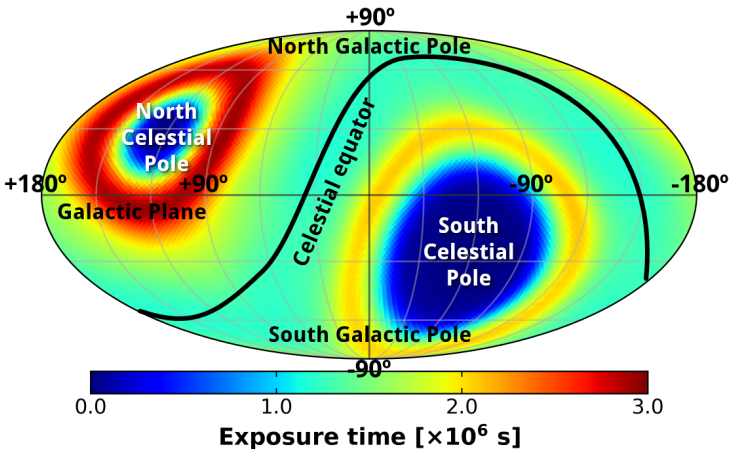
Dipole Amplitude

$$\delta = \frac{\Phi_{\max} - \Phi_{\min}}{\Phi_{\max} + \Phi_{\min}} = \sqrt{\rho_{\mathrm{EW}}^2 + \rho_{\mathrm{NS}}^2 + \rho_{\mathrm{FB}}^2}$$

Exposure of AMS-02



Galactic Coordinates



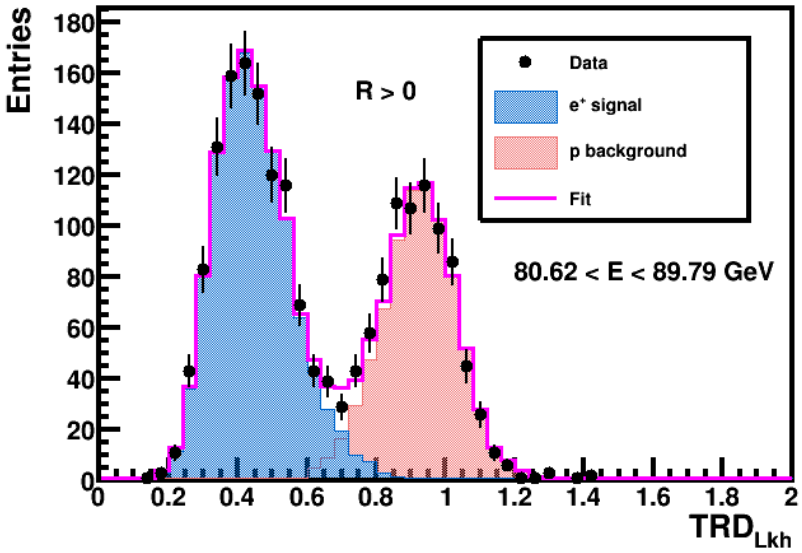
See also:

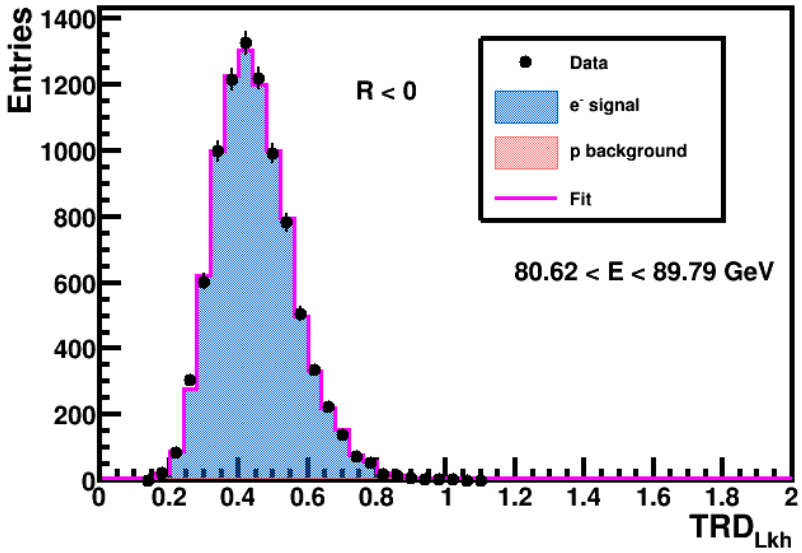
Anisotropy on proton and light primary nuclei with AMS by M. Molero (28/07/2022 at 14:45)

Positron and Electron Anisotropy

- **Positrons and electrons** are separated from protons with a selection based on a cut on the **ECAL estimator** and a **template fit to the TRD response**
- For the anisotropy analysis, selected events are grouped into **5 cumulative energy ranges**:

  E > 16, 25, 40, 65 and 100 GeV





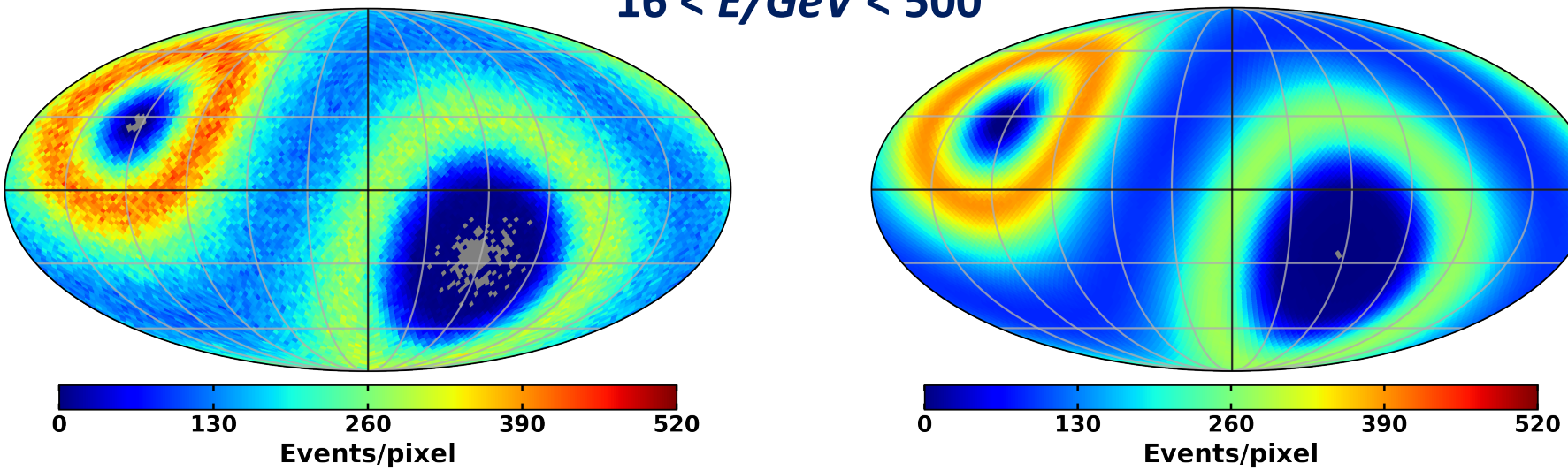
Results are presented for 10 years of data taking with AMS-02

Electron Anisotropy

The arrival directions of **electron** events are compared to the expected map for an **isotropic flux** in galactic coordinates

2.5×10^6 electrons | **Isotropic map**

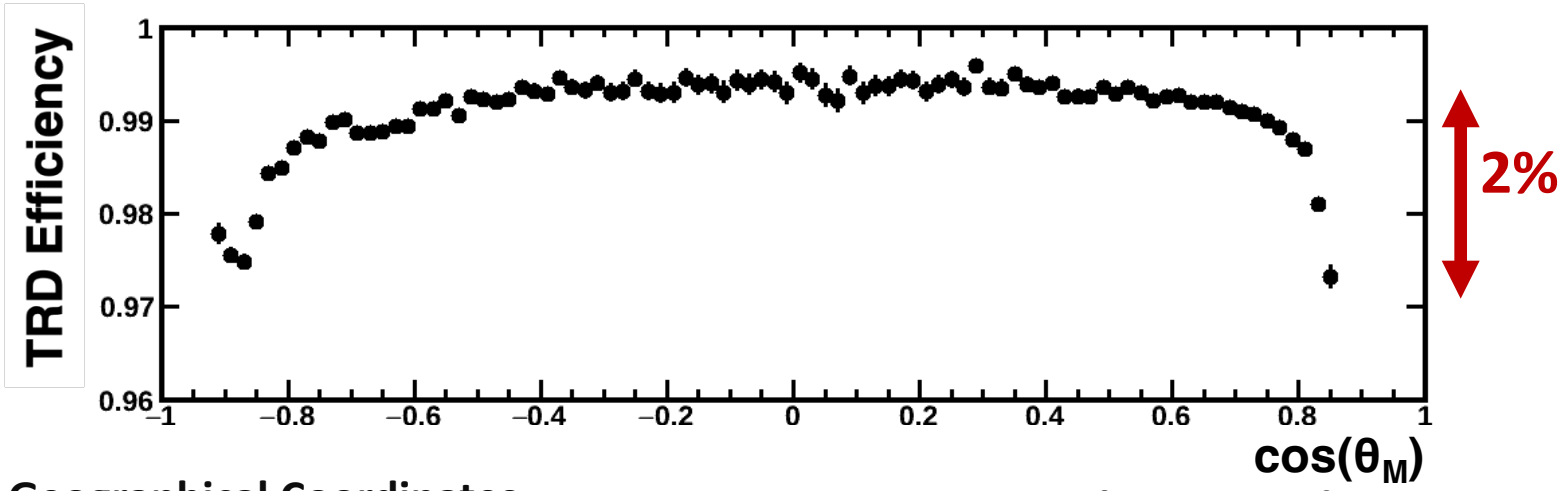
$16 < E/GeV < 500$

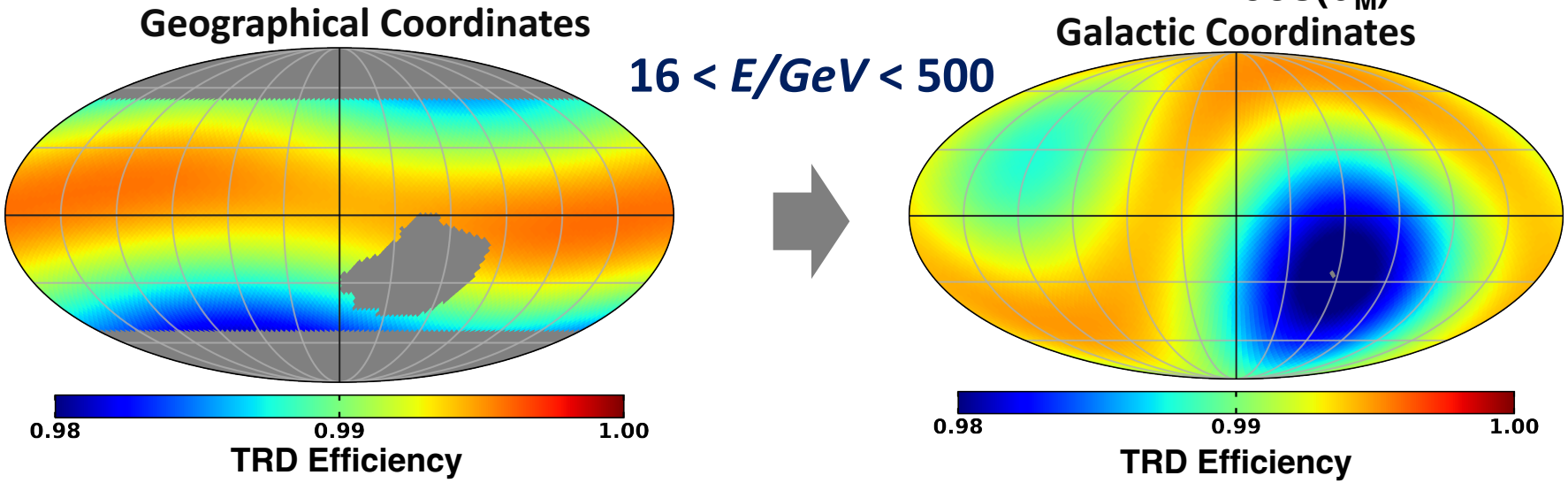


In addition to the sensitivity to **nearby astrophysical sources**, the measurement of **electron anisotropy** provides a test of systematics for the positron analysis

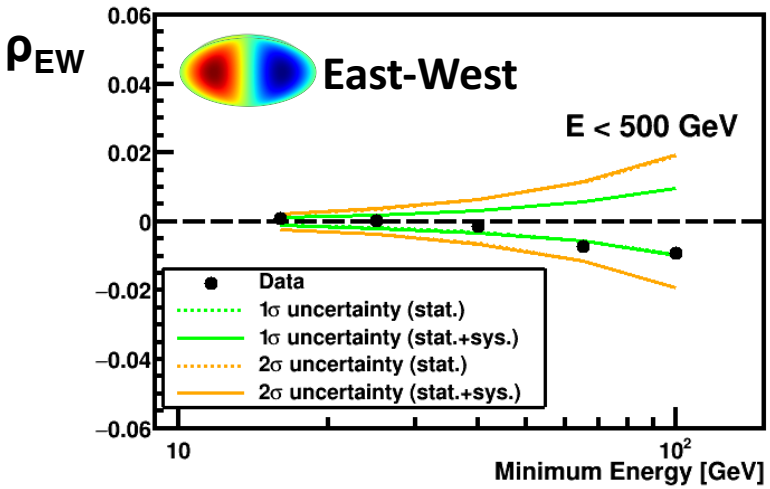
Electron Anisotropy: Detector Efficiencies

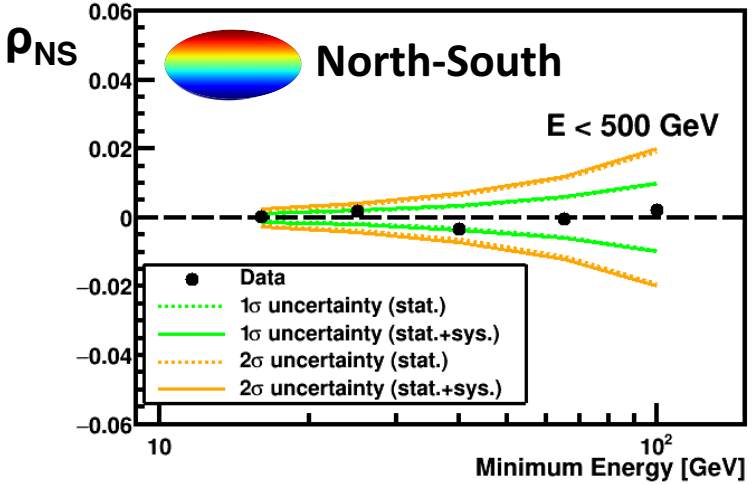
Computation of isotropic map requires detailed understanding of detector efficiencies at different geographical locations

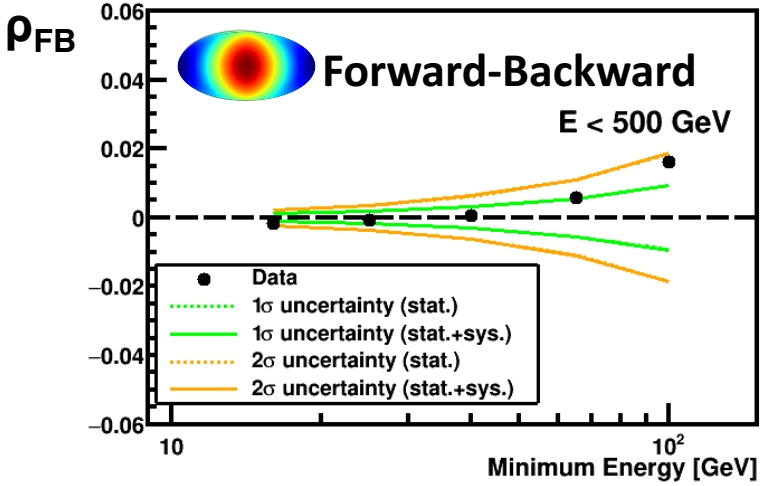




Electron Anisotropy: Dipole Components



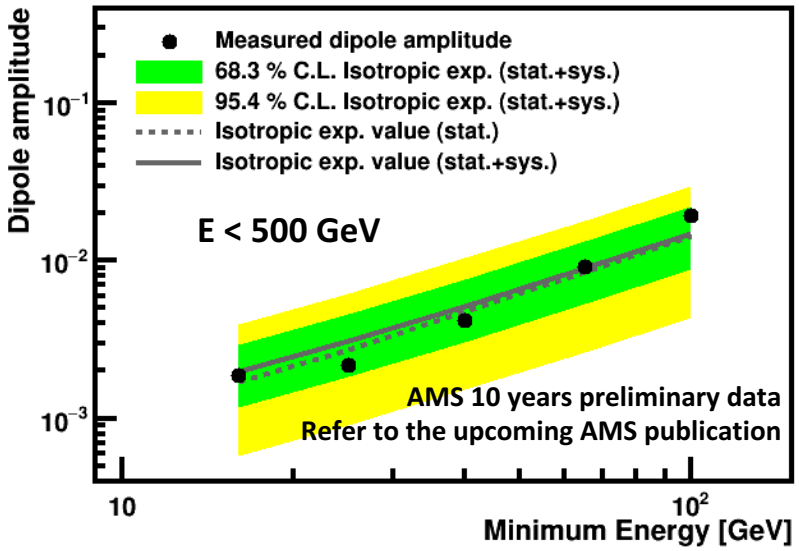


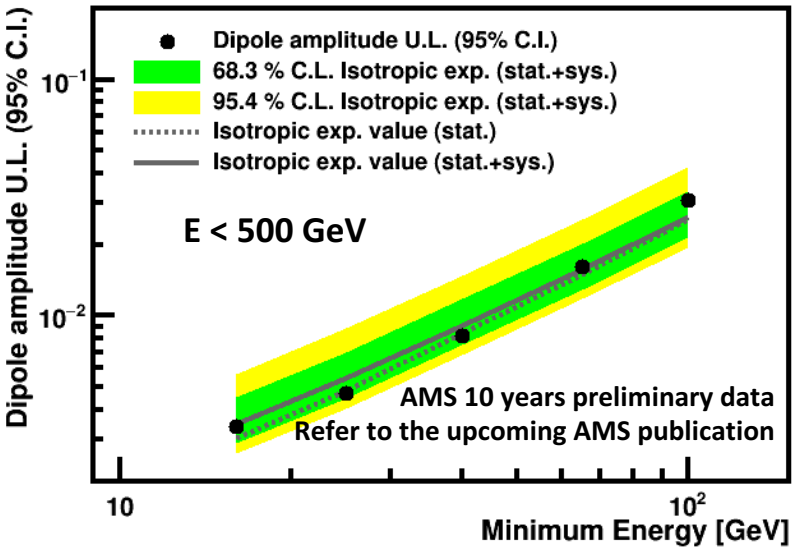


Electron dipole components in galactic coordinates are consistent with **isotropy**

Electron Anisotropy: δ_M and δ_{UL}

Results are **consistent with isotropy** and **upper limits** to the dipole amplitude are established





δ_M = 0.19% for 16 < *E/GeV* < 500

δ_{UL} = 0.34% at the 95% C.I. for 16 < *E/GeV* < 500

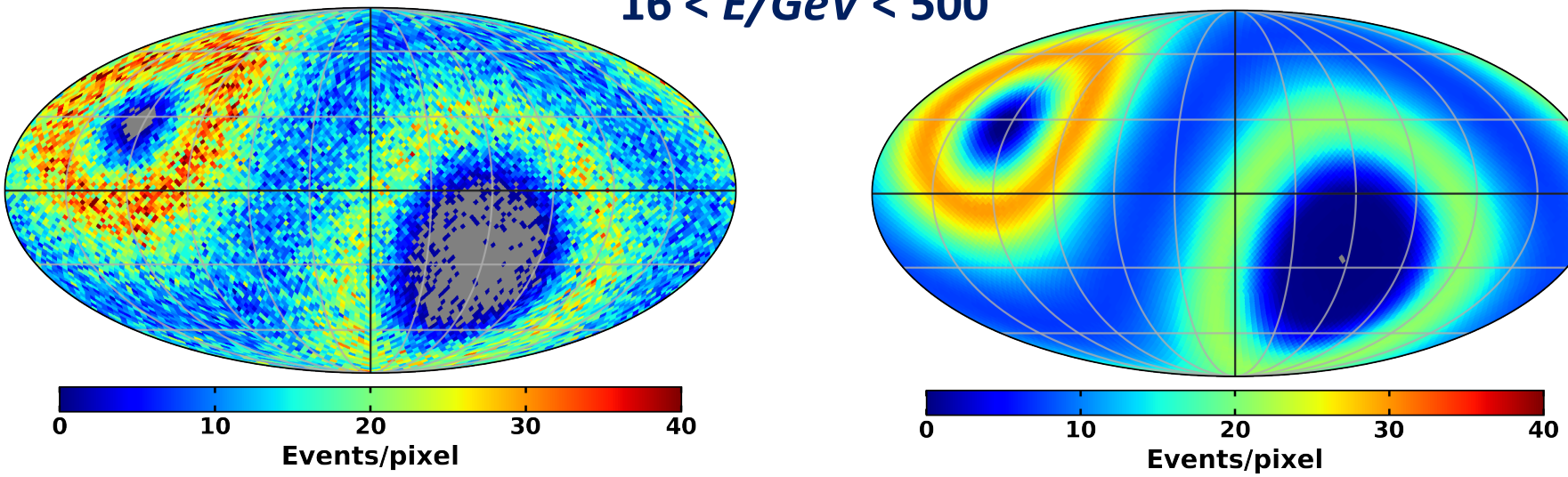
Positron Anisotropy

The arrival directions of positron events are compared to the expected map for an isotropic flux in galactic coordinates

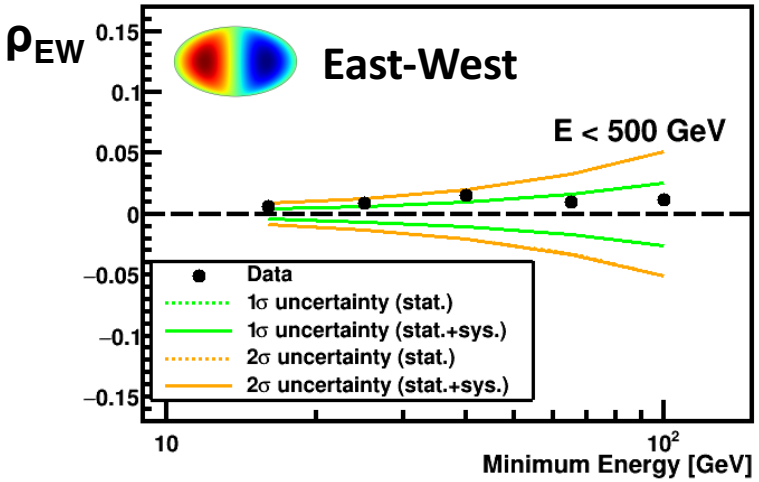
1.9×10^5 positrons

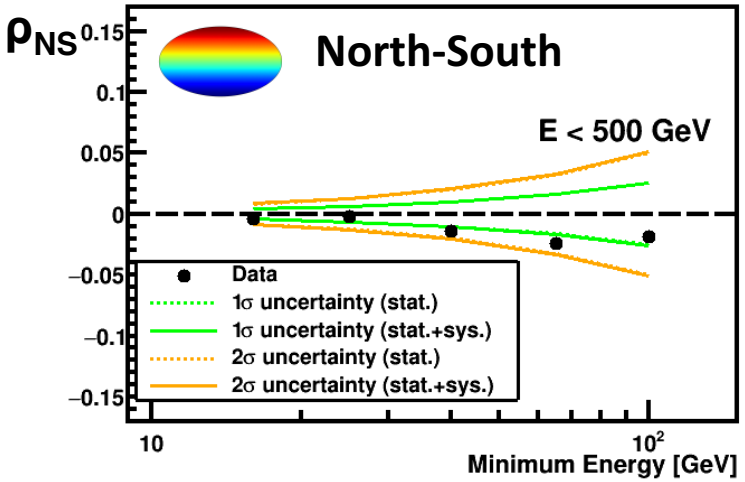
Isotropic map

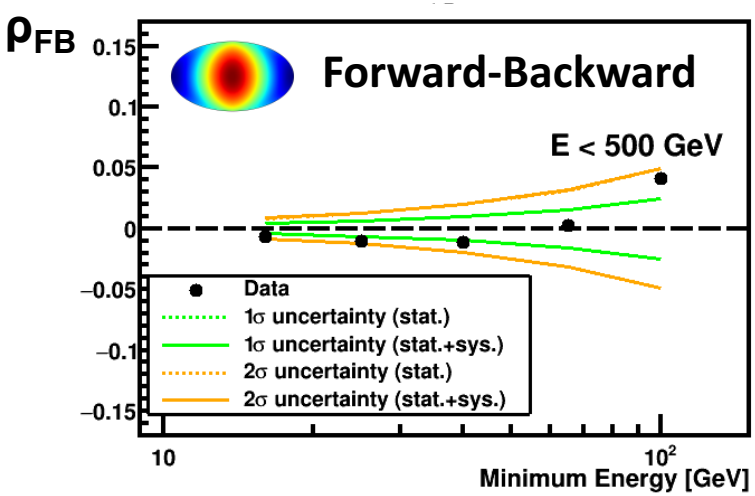
$16 < E/GeV < 500$



Positron Anisotropy: Dipole Components



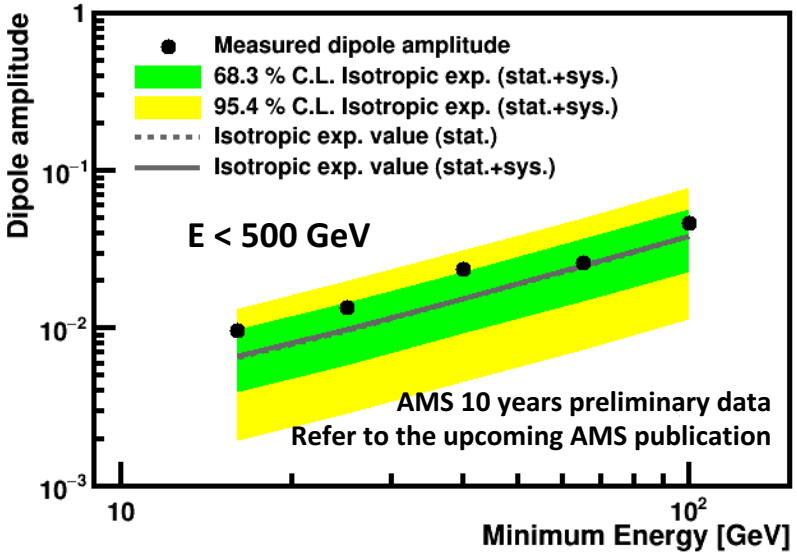


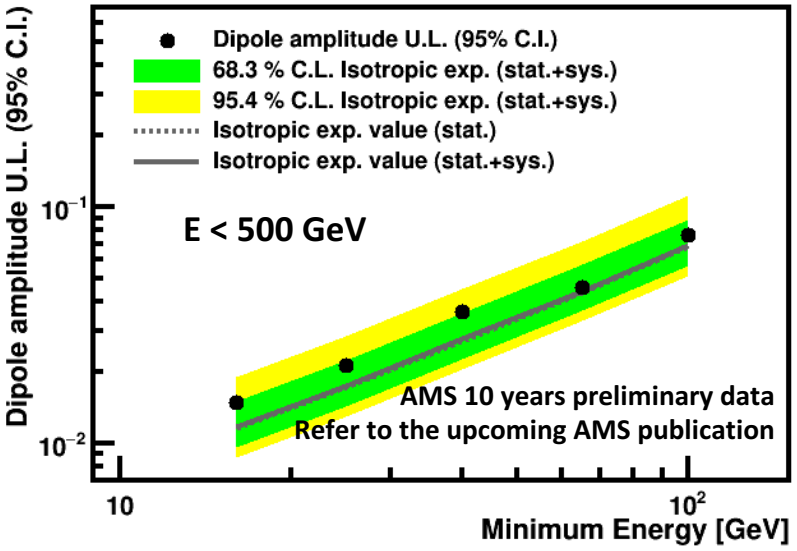


Positron dipole components in galactic coordinates are consistent with **isotropy**

Positron Anisotropy: δ_M and δ_{UL}

Results are **consistent with isotropy** and **upper limits** to the dipole amplitude are established





δ_M = 0.97% for 16 < *E/GeV* < 500

δ_{UL} = 1.50% at the 95% C.I. for 16 < *E/GeV* < 500

Conclusions

- AMS measurements have shown new features in the positron and electron fluxes that challenge the traditional models

- The study of the directionality of the cosmic rays provides additional information to the energy dependence of the fluxes and, in particular, it may help to understand the origin of the observations

- A measurement of the anisotropy in the arrival directions of positrons and electrons in galactic coordinates has been performed

- Positrons and electrons in the energy range of 16-500 GeV are consistent with isotropy and upper limits to the dipole amplitude at the 95% C.I. are obtained:
  - Positrons: δ_{UL} = 1.50 %
  - Electrons: δ_{UL} = 0.34 %

- AMS will continue taking data until the end of the ISS operation, currently 2030. By that time positron statistics will allow us to explore anisotropies below the 1% level predicted by pulsar models