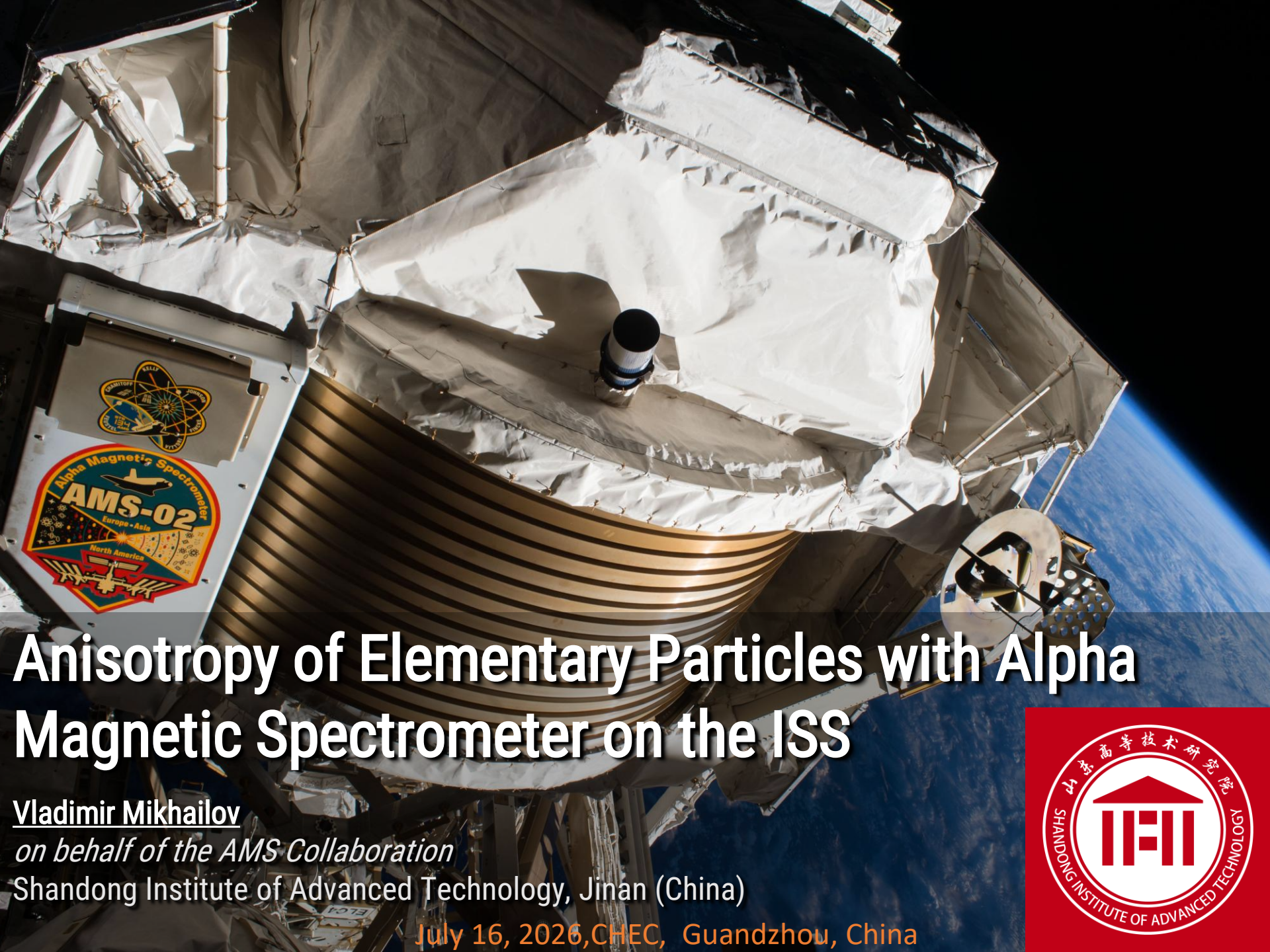




Anisotropy of Elementary Particles with Alpha Magnetic Spectrometer on the ISS

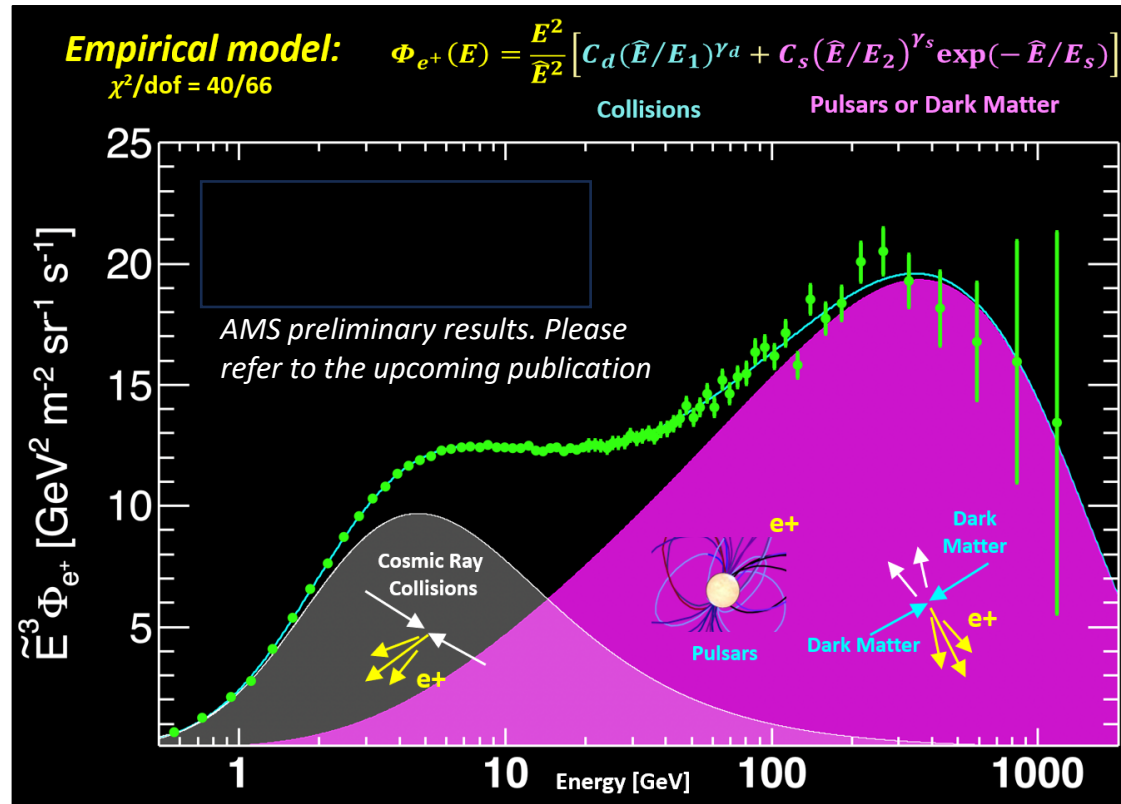
Vladimir Mikhailov
on behalf of the AMS Collaboration
Shandong Institute of Advanced Technology, Jinan (China)

July 16, 2026, CHEC, Guandzhou, China



ORIGIN OF COSMIC RAY POSITRONS

Spectrum of positrons shows a significant excess above secondary component at high energies that is not consistent with their production in cosmic ray collisions



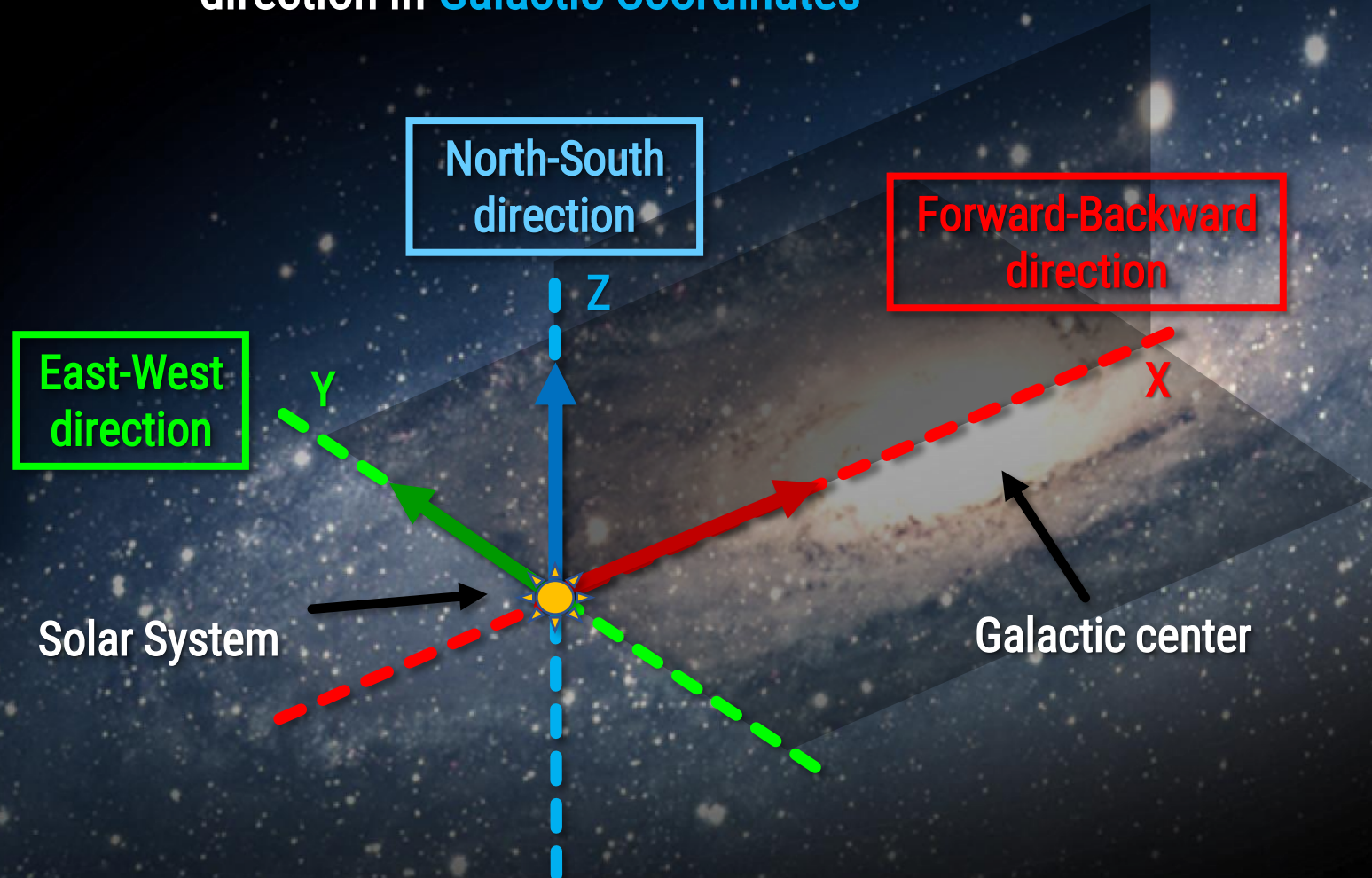
More details presented
by Cheng Zhang

The observation requires the inclusion of **primary sources** whether from a particle physics or an astrophysical origin

Local astrophysical point sources (like pulsars) of cosmic ray positrons may induce some degree of anisotropy on the measured positron flux

ANALYSIS OF THE ANISOTROPY

Measurement of the cosmic ray fluxes as function of the arrival direction in **Galactic Coordinates**

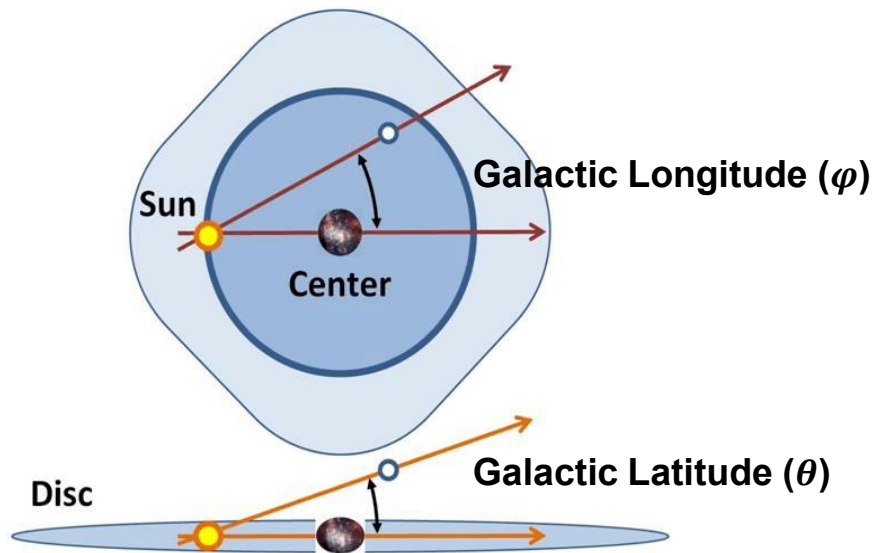


ANALYSIS OF THE ANISOTROPY IN GALACTIC FRAME

The directional dependence of the CR flux Φ in Galactic frame is described in terms of an expansion in spherical harmonics

Dipole anisotropy ($\ell=1$)

$$\Phi(\theta, \varphi) = \Phi_0 (1 + \rho_{EW} \sin \theta \sin \varphi + \rho_{NS} \cos \theta + \rho_{FB} \sin \theta \cos \varphi)$$



Dipole components

	ρ_{EW}	East-West
	ρ_{NS}	North-South
	ρ_{FB}	Forward-Backward

Dipole amplitude

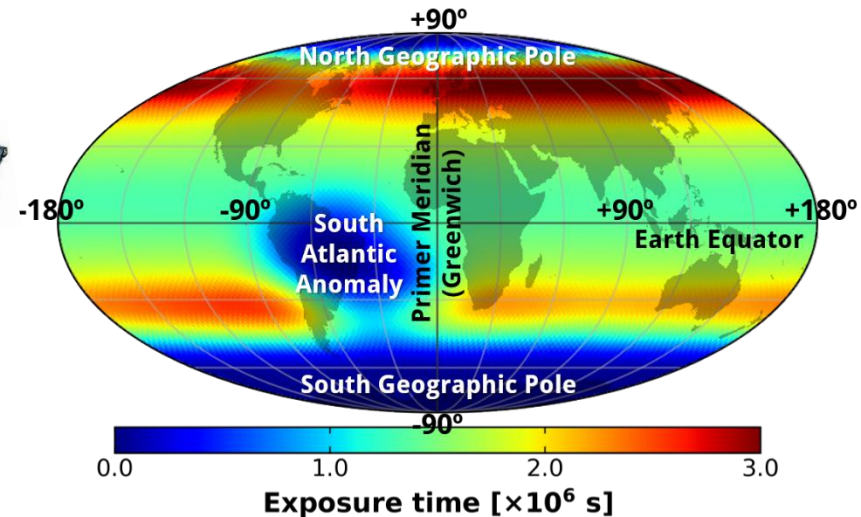
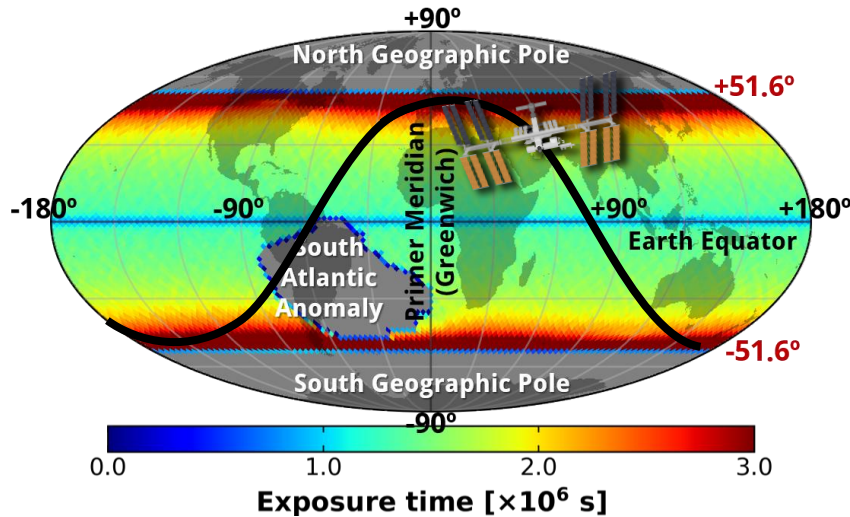
$$\delta = \sqrt{\rho_{EW}^2 + \rho_{NS}^2 + \rho_{FB}^2}$$

AMS SKY COVERAGE

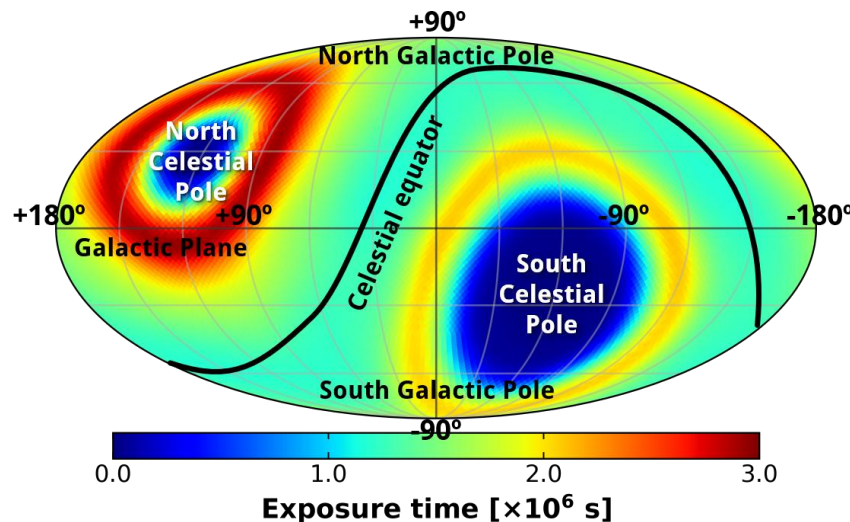
Position

Geographic coordinates

Arrival directions



Galactic coordinates



Total exposure time:
 3.15×10^8 s

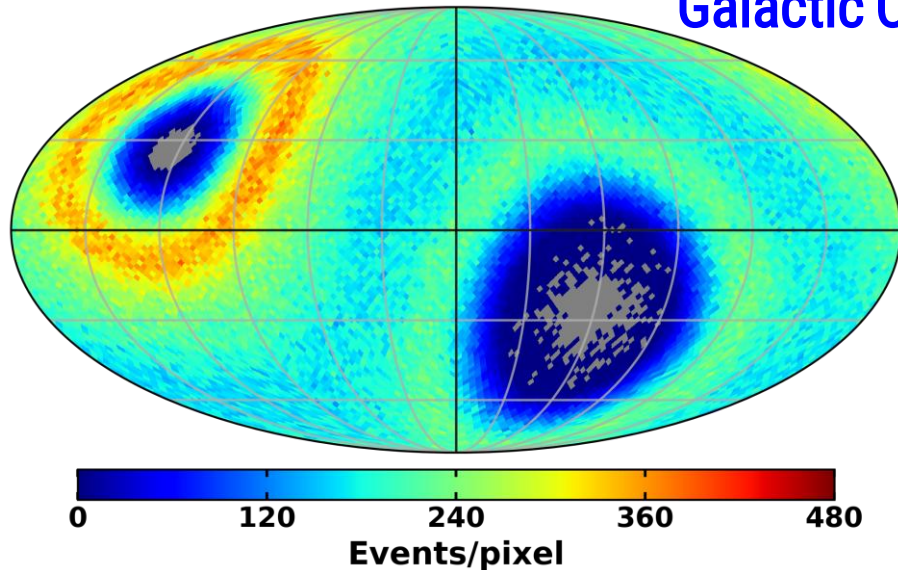
05.2011- 10.2025

DETERMINATION OF THE ABSOLUTE ANISOTROPY

The absolute anisotropy is determined by comparing the observed map of arrival directions from data with the expected map for an isotropic flux in galactic coordinates

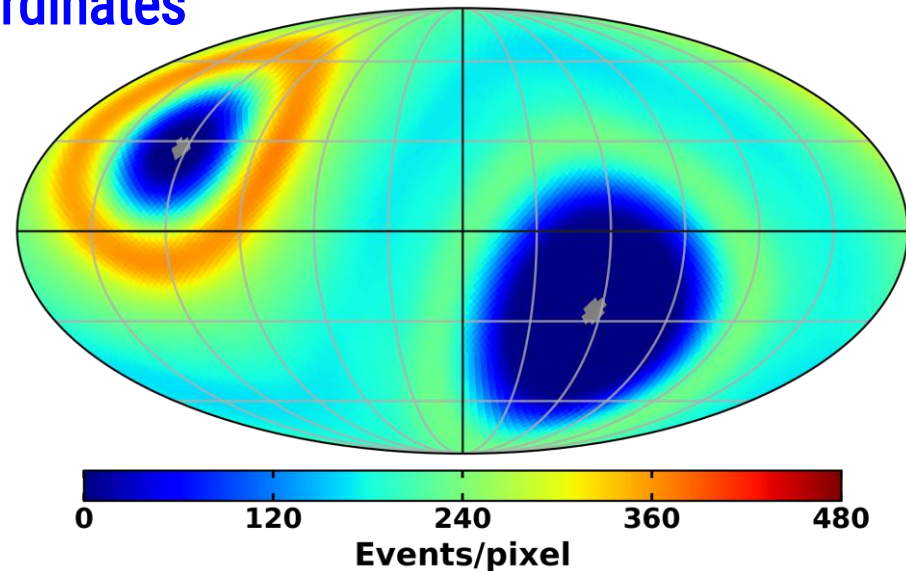
ISS data

Galactic Coordinates



Map of arrival directions of the measured events

Computed Isotropic map



Expected map of isotropic flux includes the exposure time and detector efficiencies

ELECTRON ANISOTROPY

Selected events are grouped into 5 cumulative energy ranges:

$E > 16, 25, 40, 65, \text{ and } 100 \text{ GeV}$

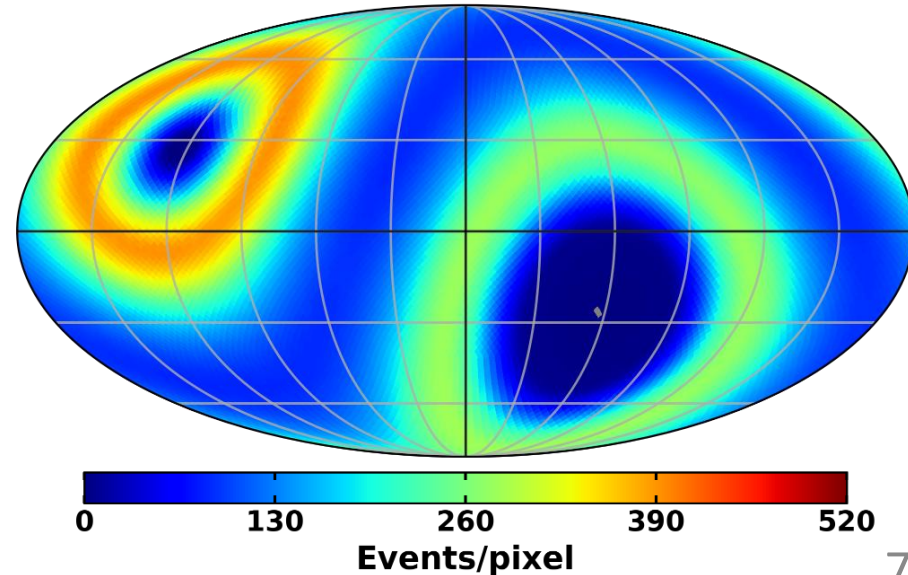
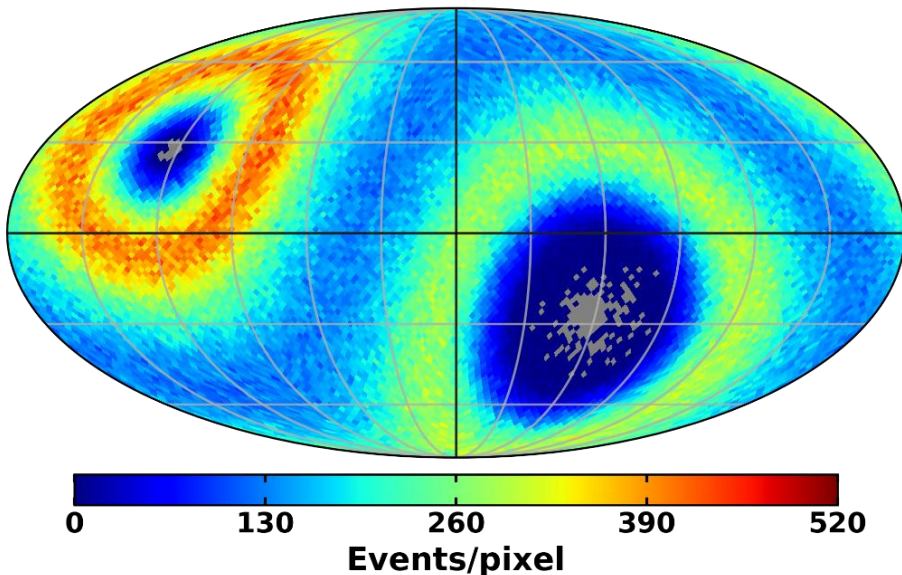
The arrival directions of **electrons** events are compared to the expected map for an **isotropic** flux in **galactic coordinates**

4.4×10^6 electrons

$16 < E / \text{GeV} < 500$
Galactic coordinates

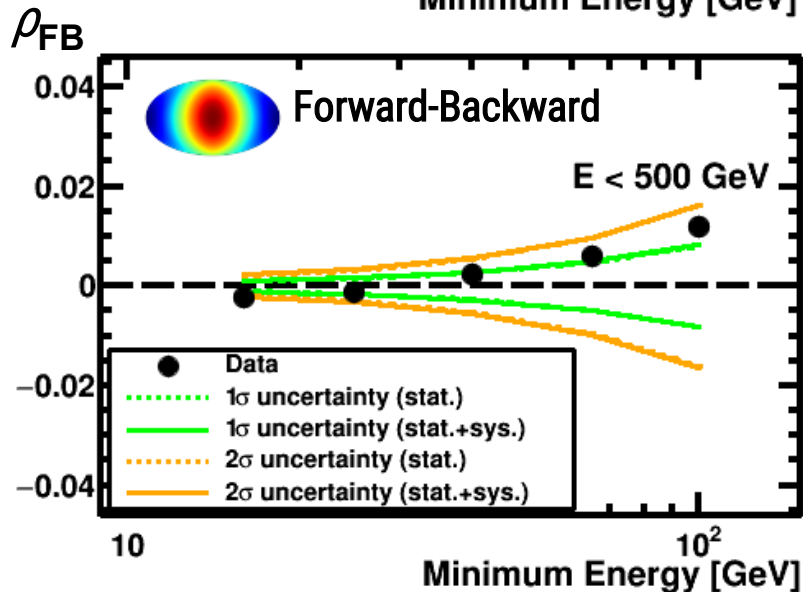
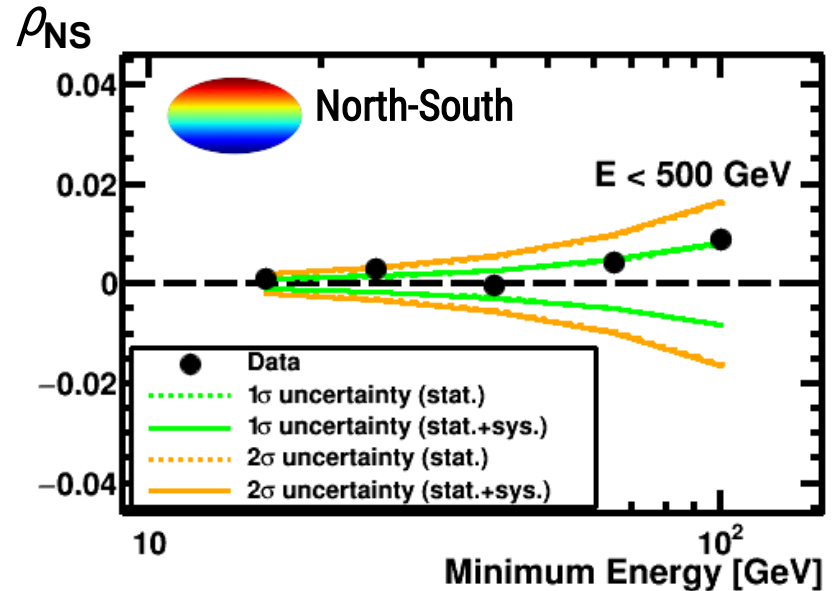
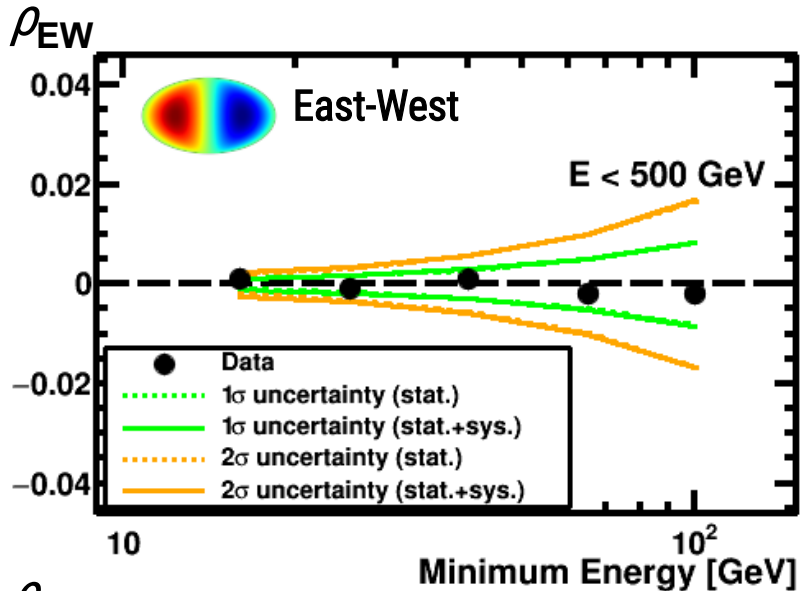
Allows to investigate the origin of power law b in the electron flux

Isotropic map



ELECTRON ANISOTROPY: DIPOLE COMPONENTS

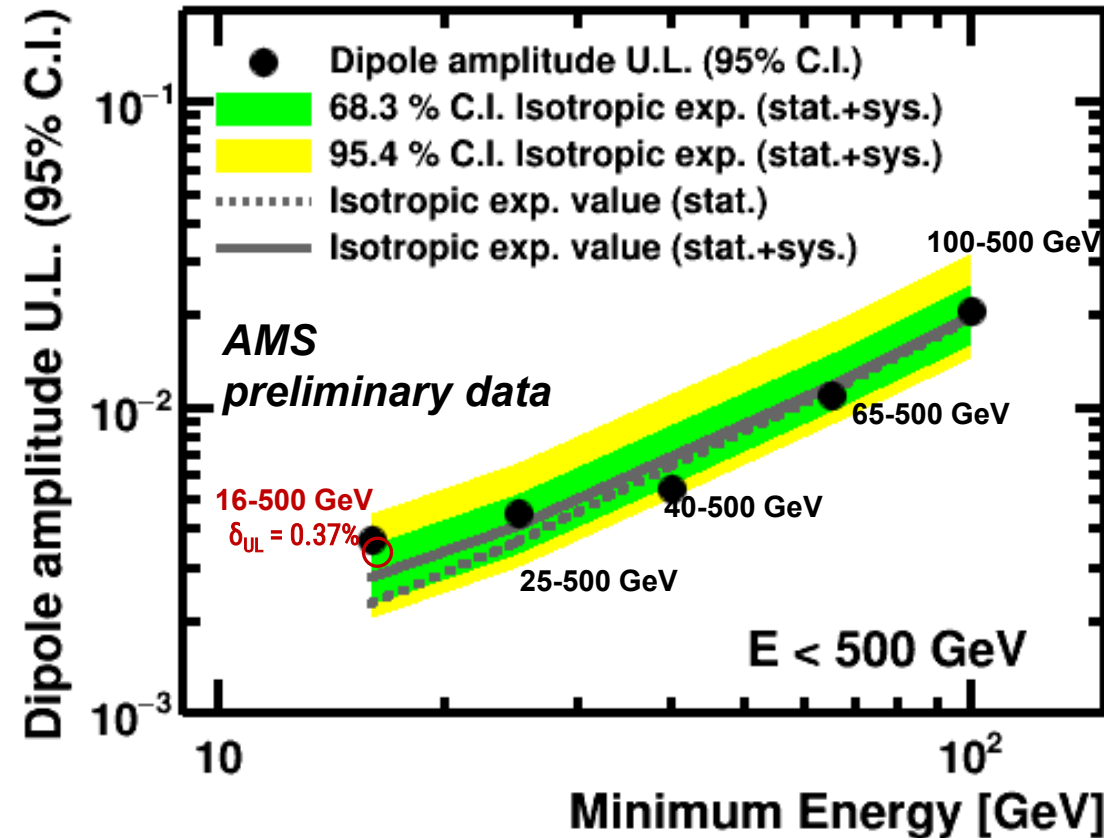
Galactic Coordinates



Systematic and statistical
uncertainties evaluated
Results consistent with isotropy
in all the dipole components and
energy ranges

ELECTRON ANISOTROPY: UPPER LIMITS

Upper limits to the electron dipole anisotropy in galactic coordinates



4.4×10^6 electron events
 $16 < E/\text{GeV} < 500$

$\delta < 0.37\%$ at the 95% C.I.
for $16 < E/\text{GeV} < 500$
0.28% Iso. Exp. (stat.+sys.)

POSITRON ANISOTROPY

Selected events are grouped into 5 cumulative energy ranges:

$E > 16, 25, 40, 65, \text{ and } 100 \text{ GeV}$

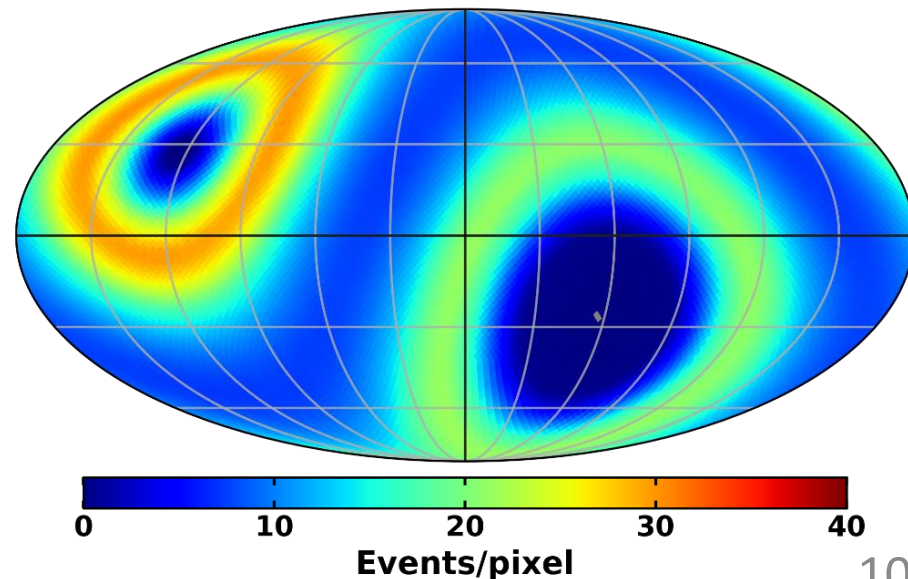
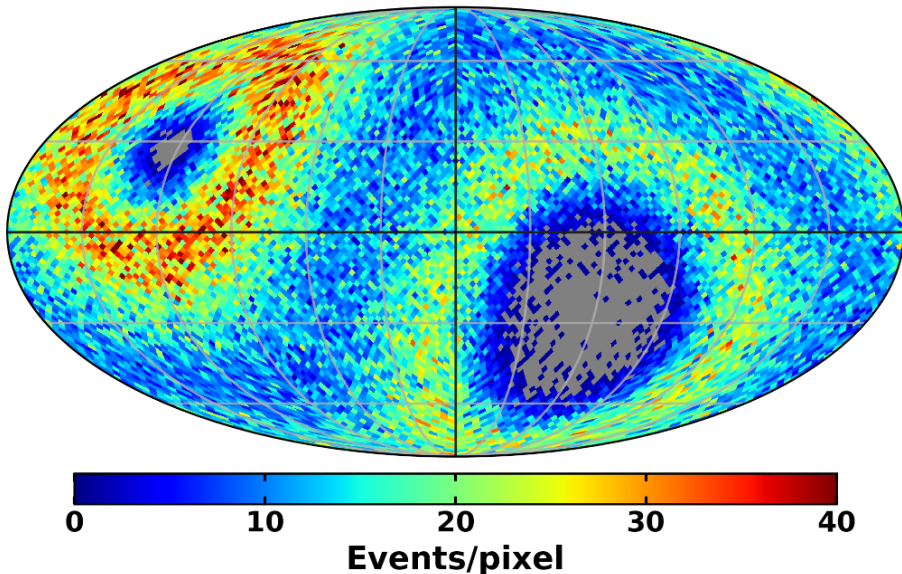
The arrival directions of **positrons** events are compared to the expected map for an **isotropic** flux in **galactic coordinates**

$16 < E / \text{GeV} < 500$
Galactic coordinates

Allows to investigate the origin of the positron source term

3.3×10^5 positrons

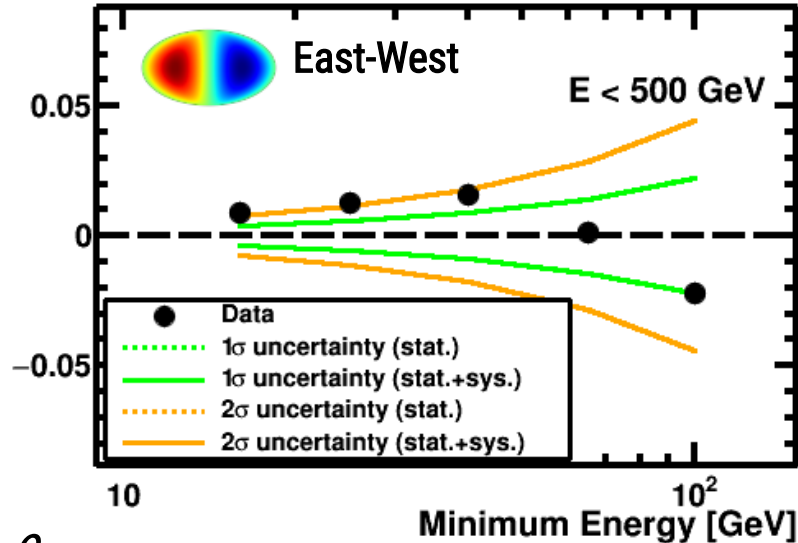
Isotropic map



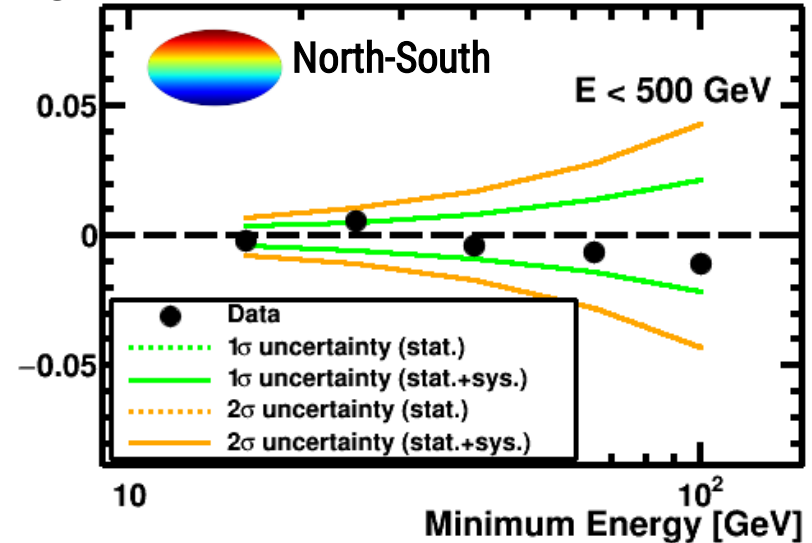
POSITRON ANISOTROPY: DIPOLE COMPONENTS

Galactic Coordinates

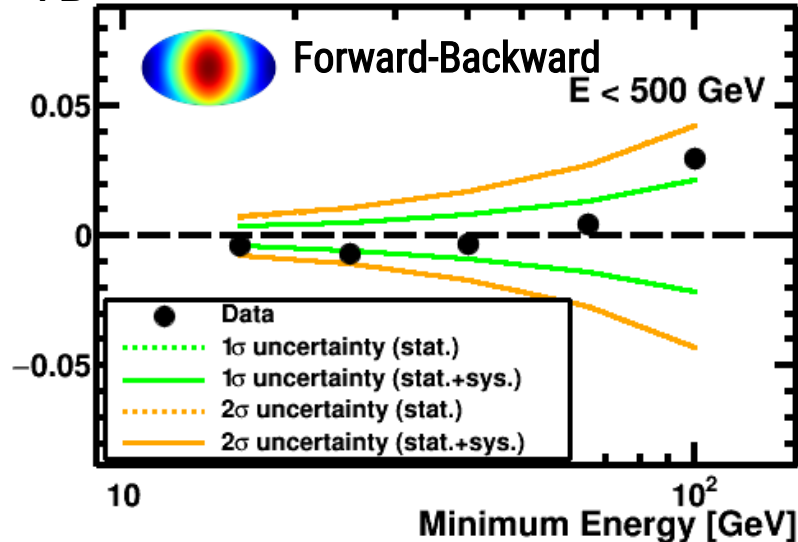
ρ_{EW}



ρ_{NS}



ρ_{FB}

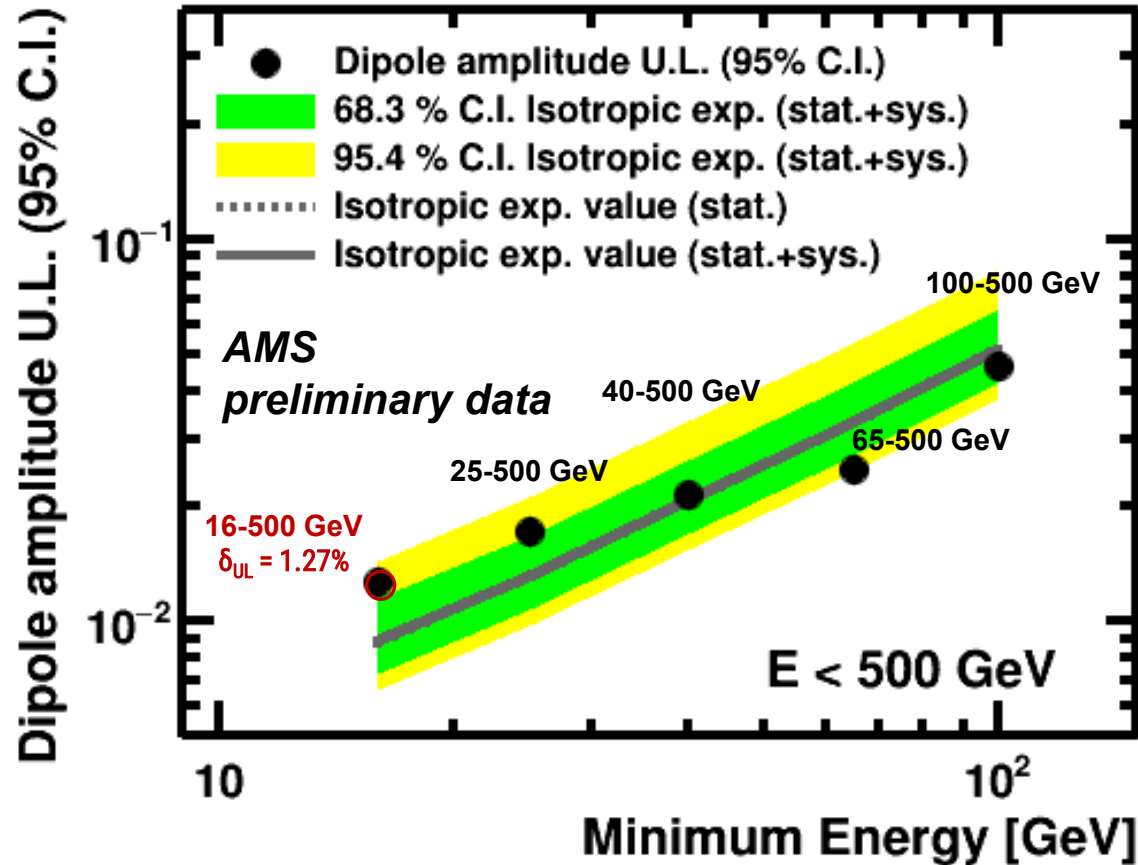


Systematic and statistical uncertainties
evaluated

Results consistent with **isotropy** in all the
dipole components and energy ranges

POSITRON ANISOTROPY: UPPER LIMITS

Upper limits to the positron dipole anisotropy in galactic coordinates



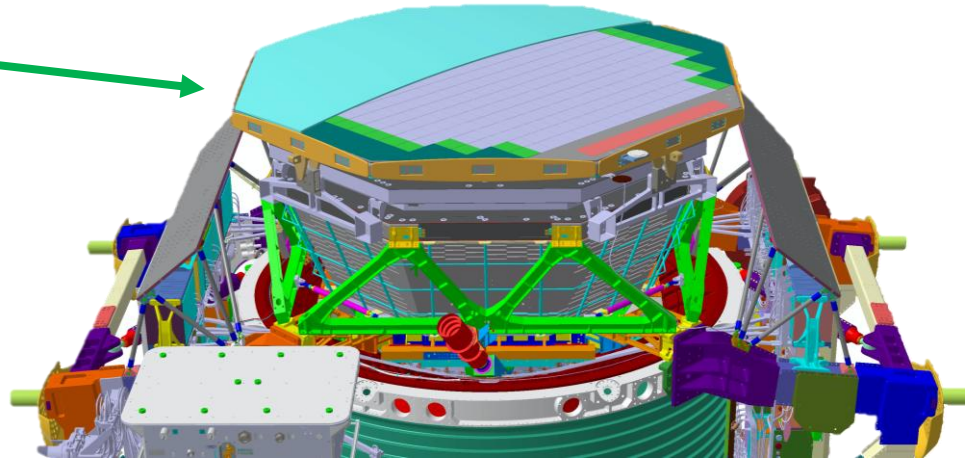
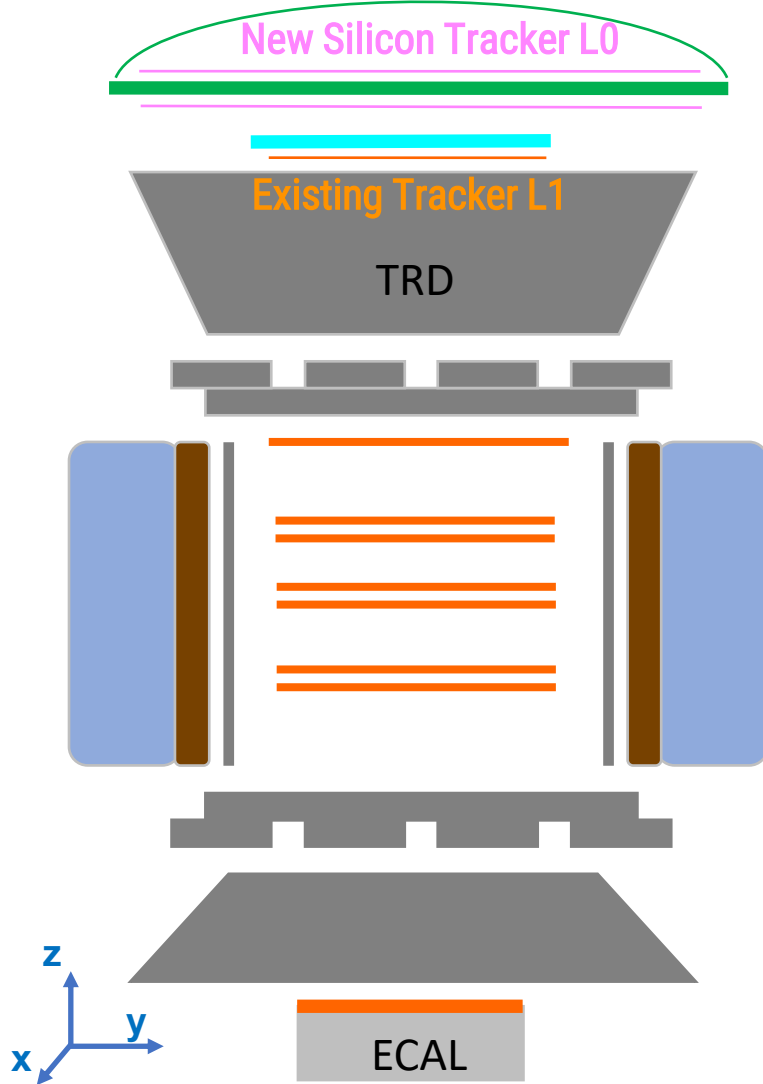
$\delta < 1.27\%$ at the 95% C.I.
for $16 < E / \text{GeV} < 500$

0.89% Iso. Exp. (stat.+sys.)

Analysis dominated by
statistics

*More data will allow to
ascertain the origin of
cosmic ray positrons*

AMS L0 UPGRADE

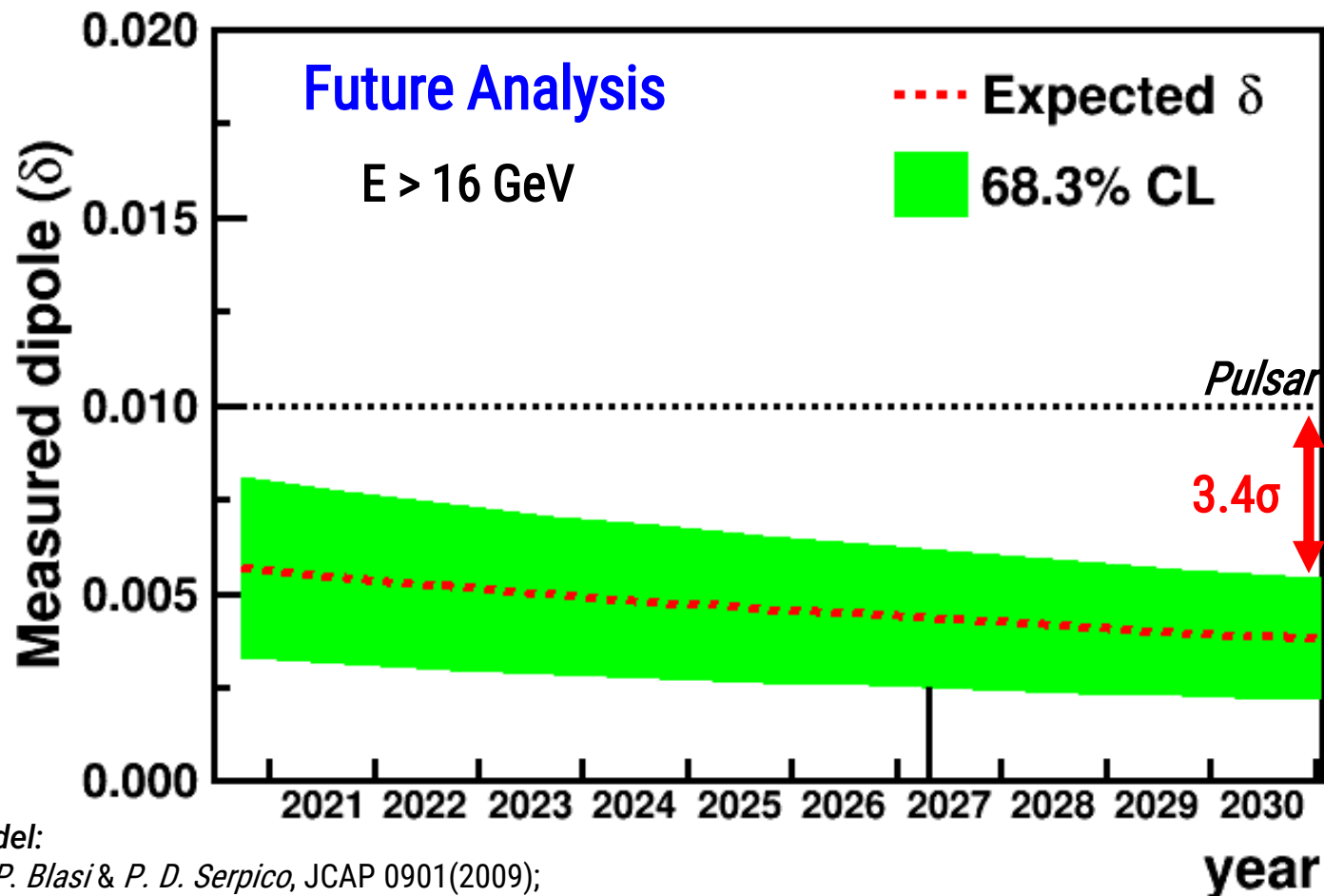


With completion of L0 Upgrade AMS acceptance will be Increased by 300%

Upgrade planned in April 2027

POSITRON ANISOTROPY: PROJECTION UP TO 2030

By 2030, the improved analysis with the L0 upgrade will allow AMS to be sensitive to anisotropies below the 1% level, as predicted by pulsar models that reproduce the positron excess



Pulsar Model:

D. Hooper, P. Blasi & P. D. Serpico, JCAP 0901(2009);

K. Ioka, PTP 123-4 (2010) 743

The measurement of the anisotropy of electrons, positrons and protons provides unique information to understand the origin of the unexpected features observed in their fluxes

AMS sensitivity to 1% level positron dipole anisotropy provides a test of the pulsar origin for the positron excess



THANK YOU FOR ATTENTION!

CONCLUSION

- 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: $\delta_{UL} = 1.27 \%$
 - - Electrons: $\delta_{UL} = 0.37 \%$
- 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

Backup

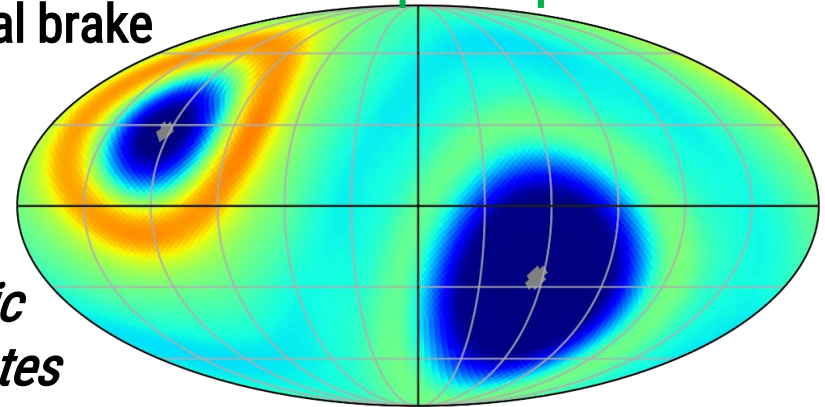
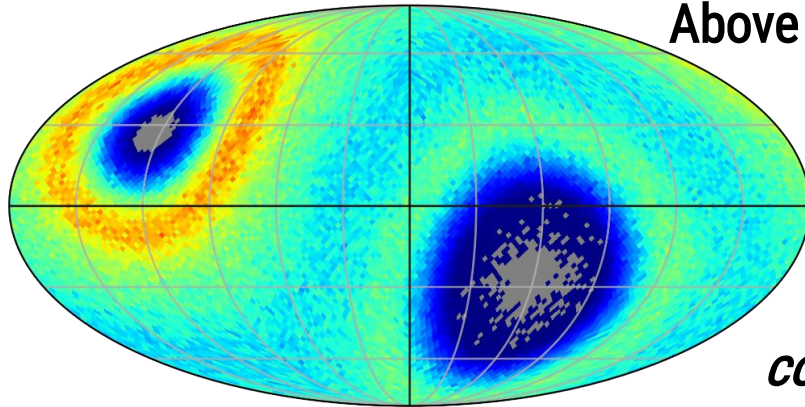
PROTON ANISOTROPY

2.6×10^6 Protons

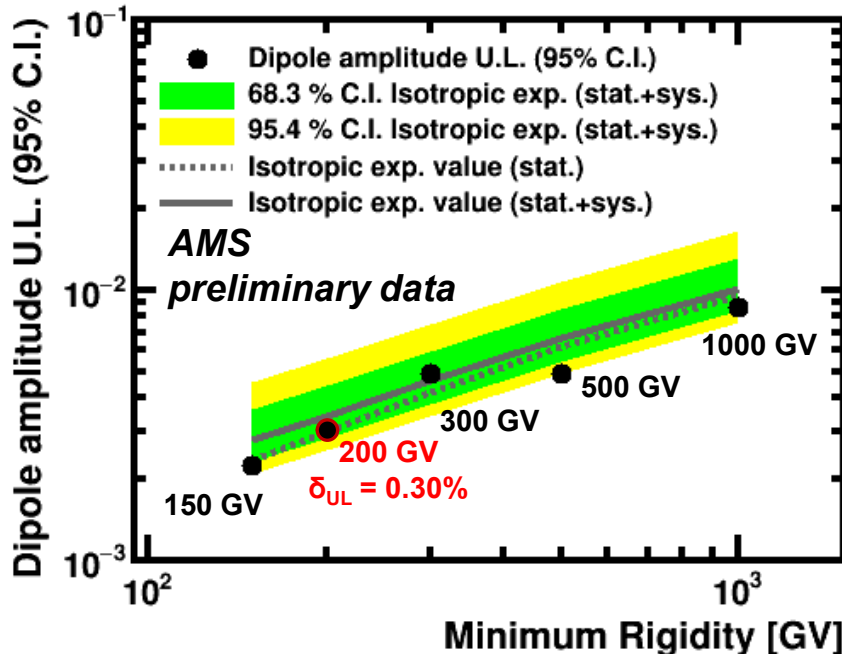
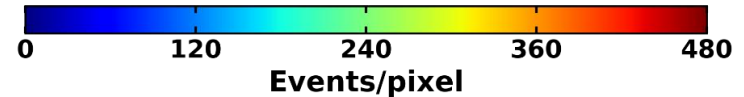
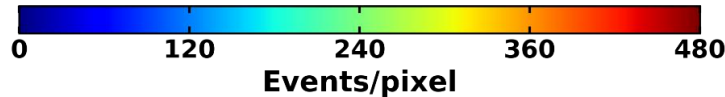
$R > 200$ GV

Above spectral brake

Isotropic map



*Galactic
coordinates*



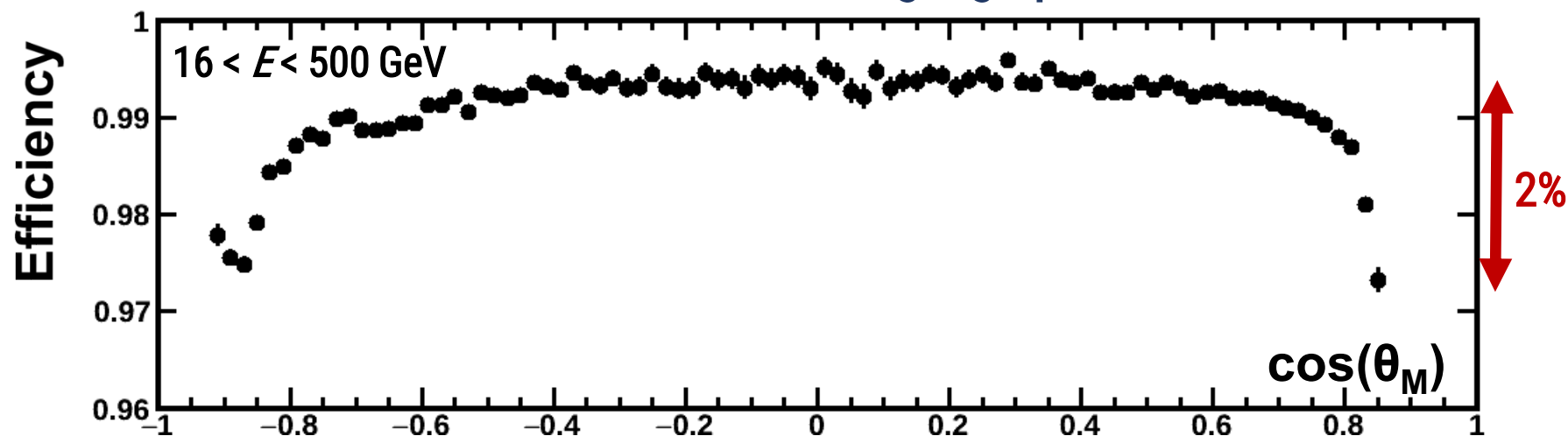
Results are consistent with
isotropy and upper limit to the
dipole amplitude is established

$\delta < 0.30\%$ at the 95% C.I.
for $R > 200$ GV

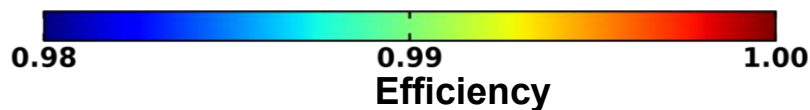
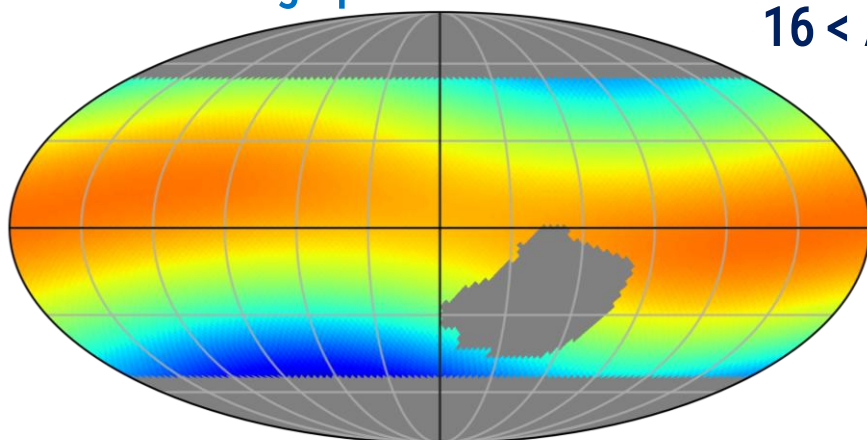
0.34% Iso. Exp. (stat.+sys.)

ABSOLUTE ANISOTROPY: DETECTOR EFFICIENCIES

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



Geographical Coordinates



$16 < E < 500$ GeV

Galactic Coordinates

