Determination of the positron anisotropy with AMS

J. Casaus
On behalf of the
AMS-02 Collaboration

CIEMAT (Madrid)

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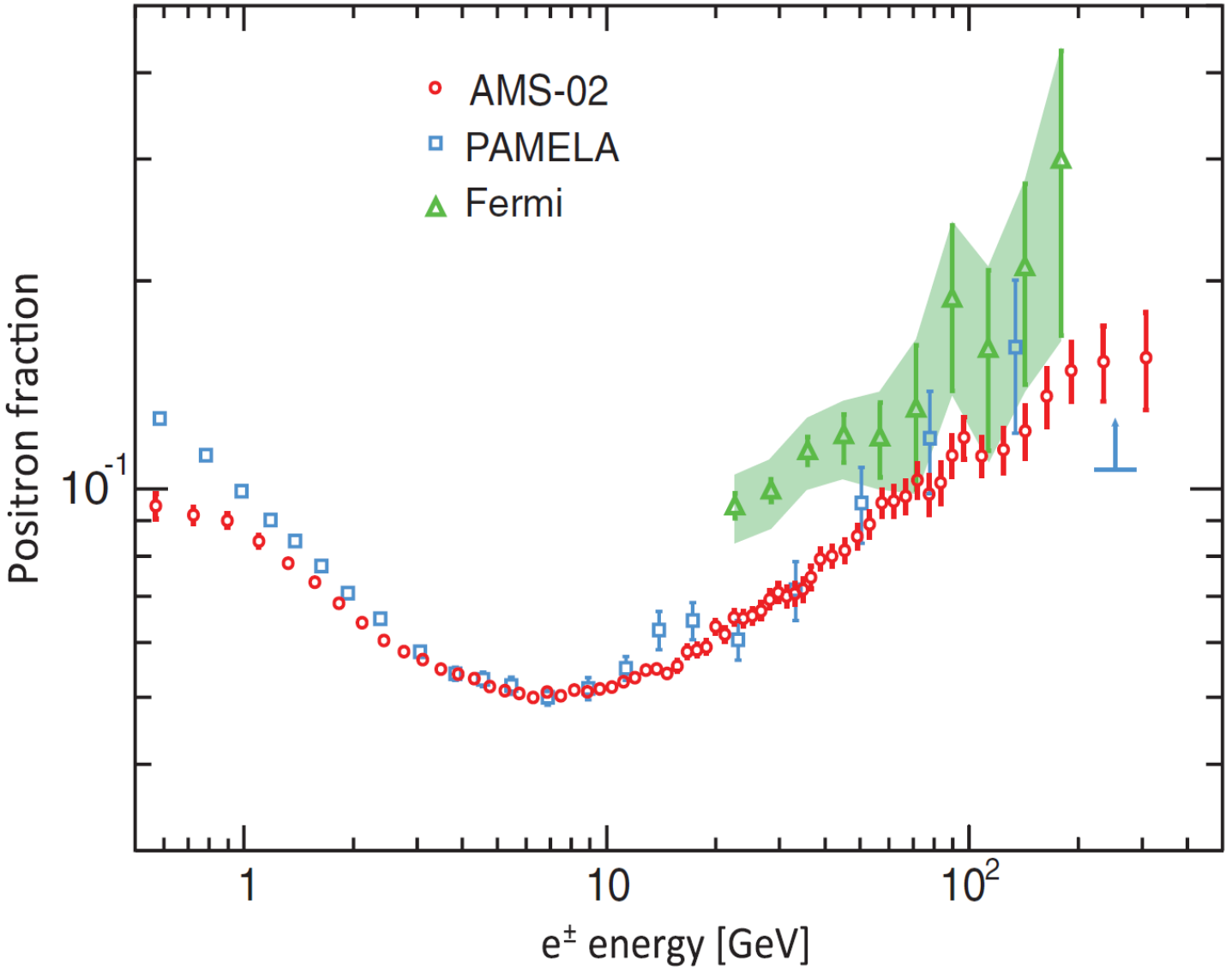
AMS published results on the positron fraction show an increase above 10 GeV

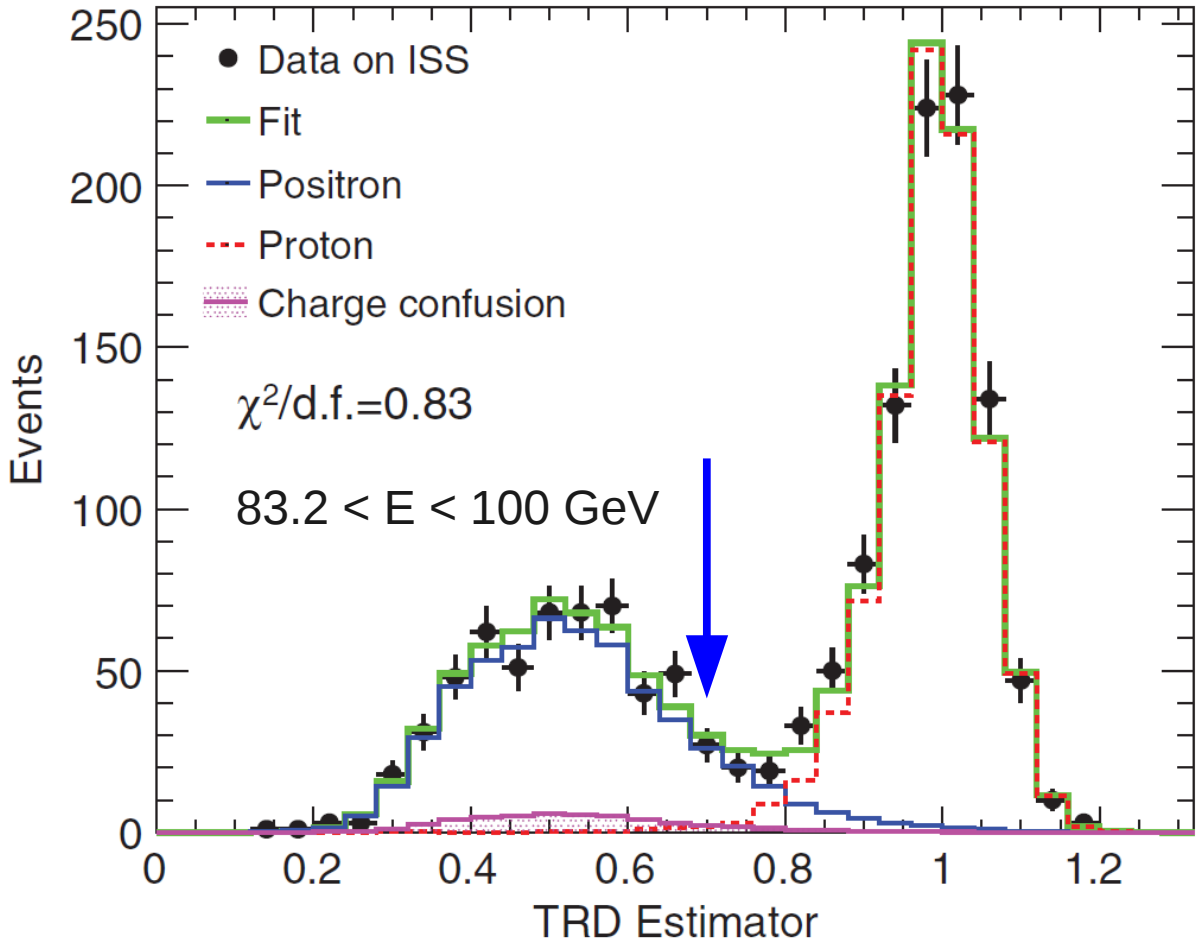


This observation shows the existence of new physical phenomena, whether from a particle physics or an astrophysical origin.

Primary sources of cosmic ray positrons and electrons may induce some degree of anisotropy on the measured positron to electron ratio, that is, the ratio of the positron flux to the electron flux.

A systematic search for anisotropies using the selected sample is performed from 16 to 350 GeV.

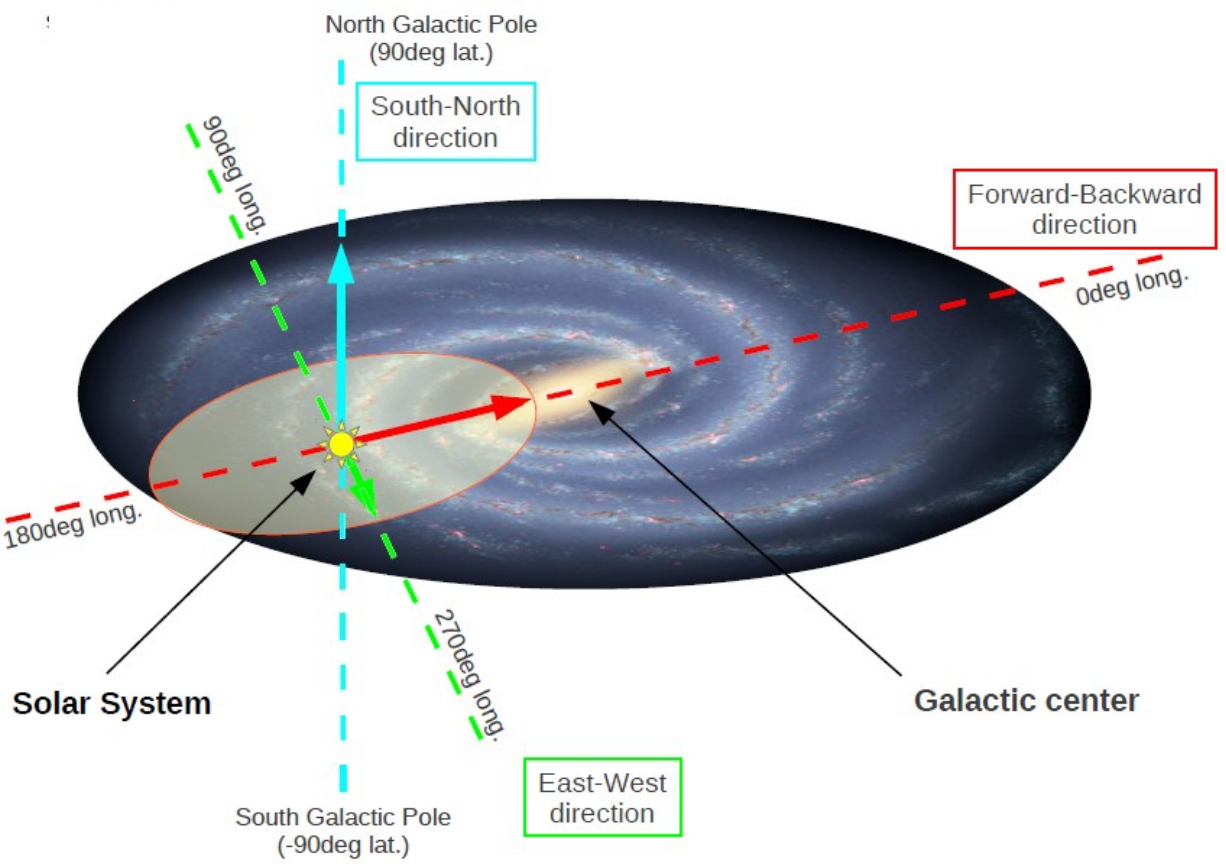
Proton background is reduced to the per mil level with a cut based selection on the TRD and ECAL estimators



35,000 e^+ and 460,000 e^- are selected in the data collected from 19 May 2011 to 10 March 2013

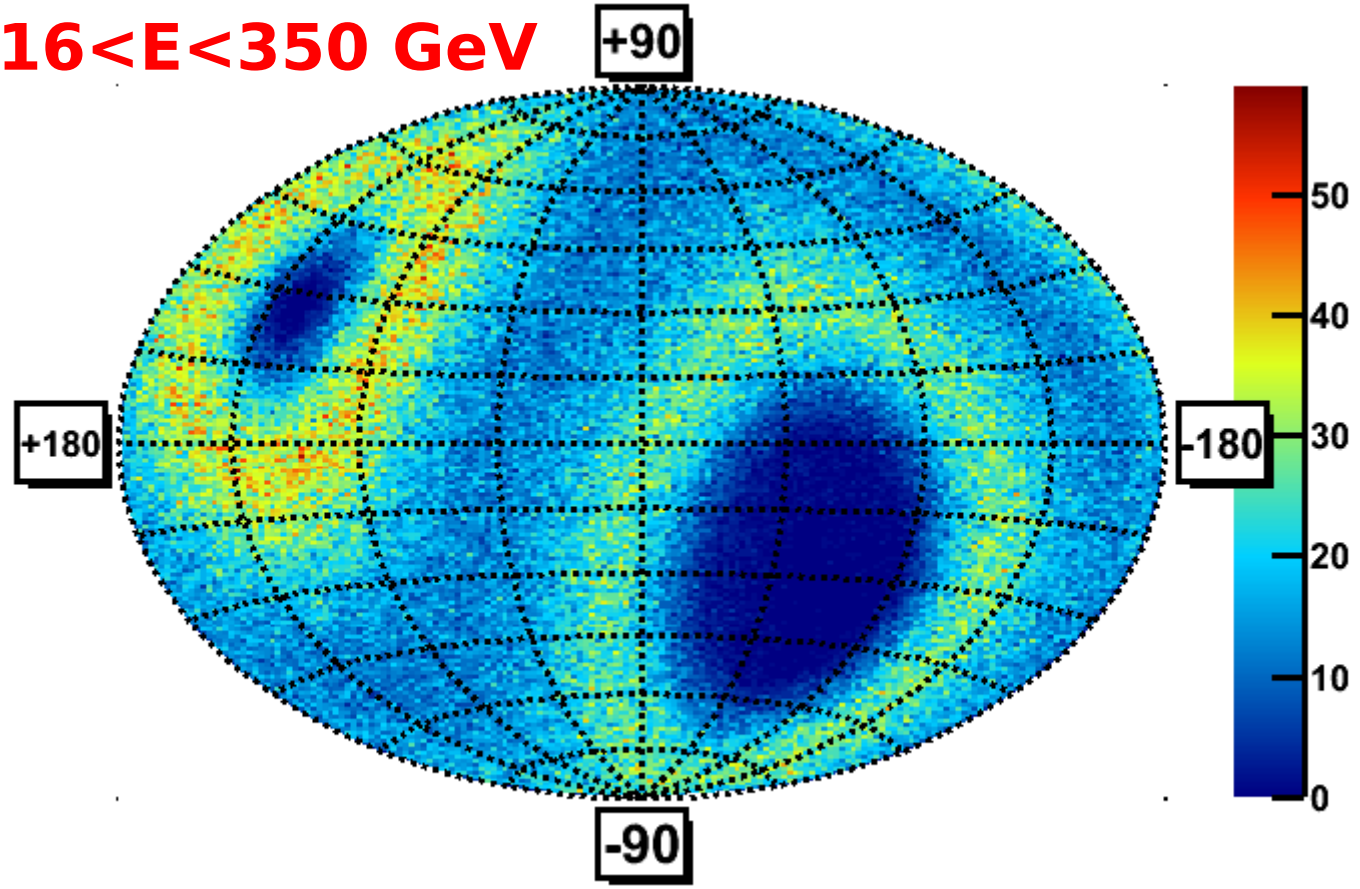
Selected events are grouped into 5 cumulative energy bins: 16-350, 25-350, 40-350, 65-350 and 100-350 GeV.

Their arrival directions are used to build sky maps in galactic coordinates, (*b*,*l*), containing the number of observed positrons and electrons



The maps show the exposure of AMS in Galactic coordinates.

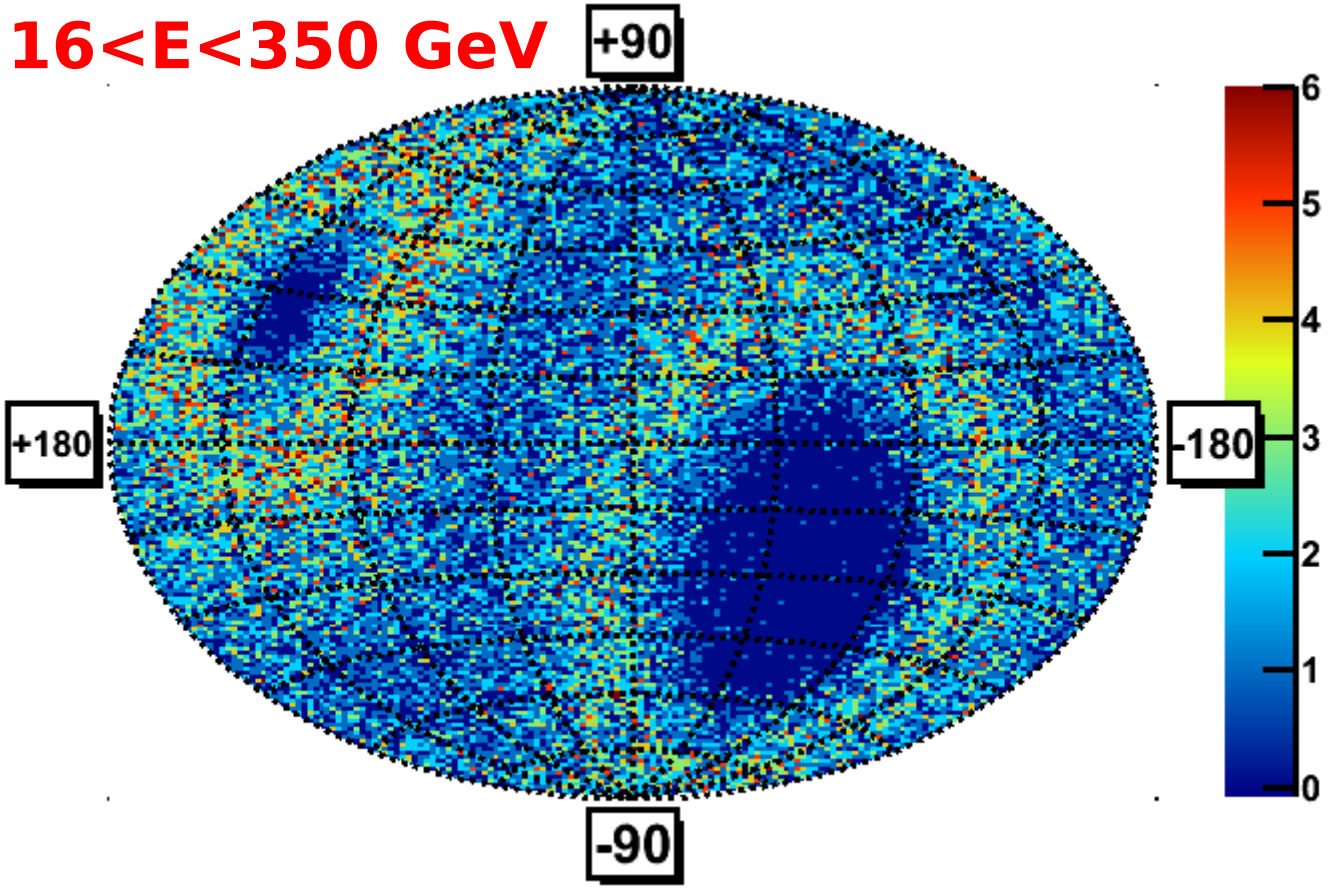
e^- - 16<E<350 GeV



Bins corresponding to directions with low exposure are masked in the subsequent analysis

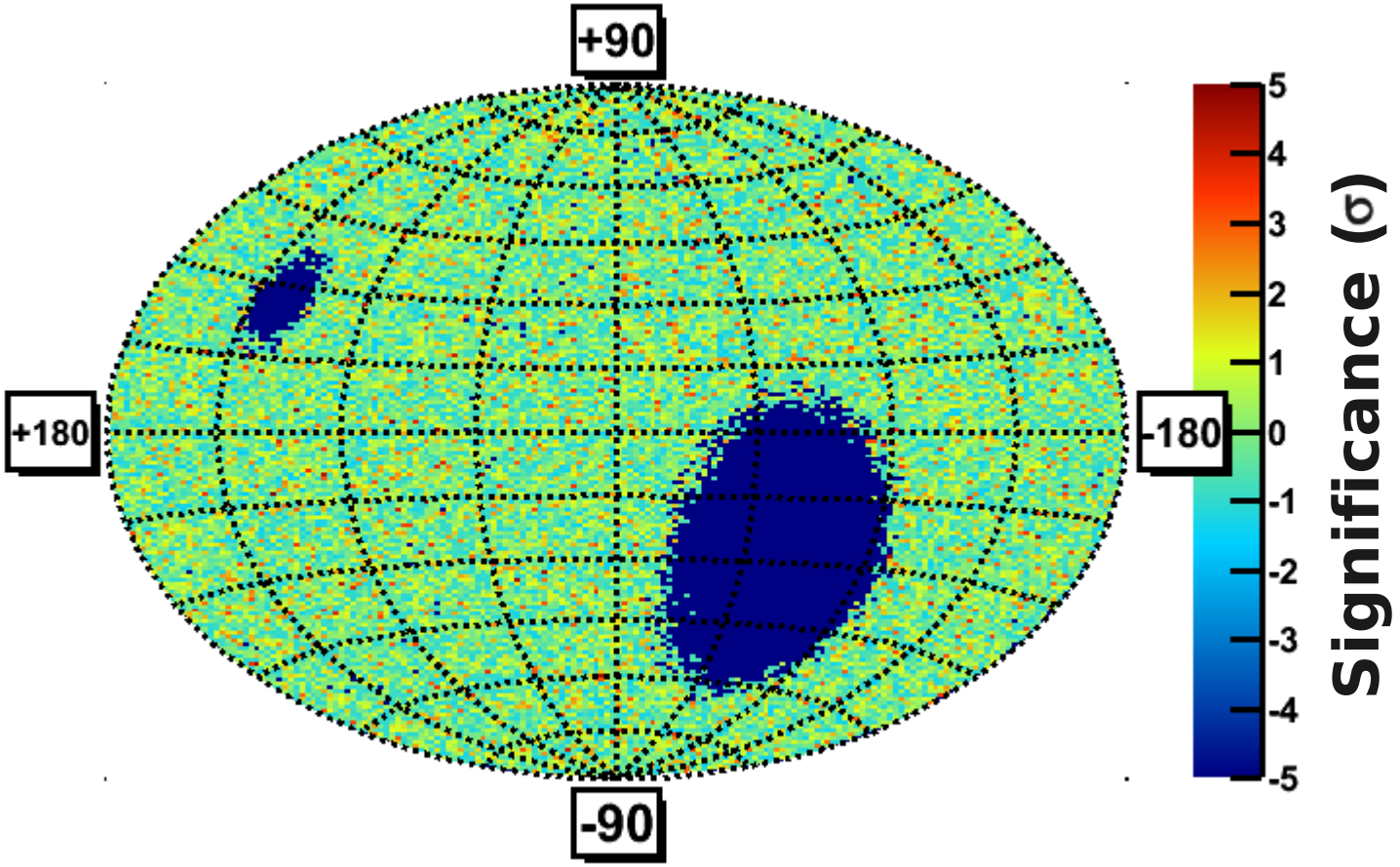
The maps show the exposure of AMS in Galactic coordinates.

e^+ - 16<E<350 GeV



Bins corresponding to directions with low exposure are masked in the subsequent analysis

The relative fluctuations of the positron ratio across the observed sky map show no evident pattern



The relative fluctuations of the positron ratio are described by means of a spherical harmonic expansion

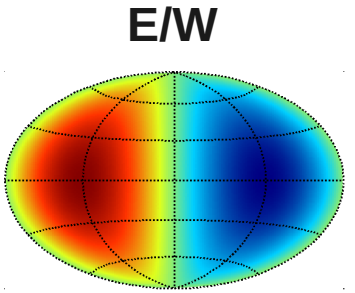
$$\frac{r_e(b,l)}{\langle r_e \rangle} - 1 = \sum_{\ell=0}^{\infty} \sum_{m=-\ell}^{\ell} a_{\ell m} Y_{\ell m}(\pi/2 - b, l)$$

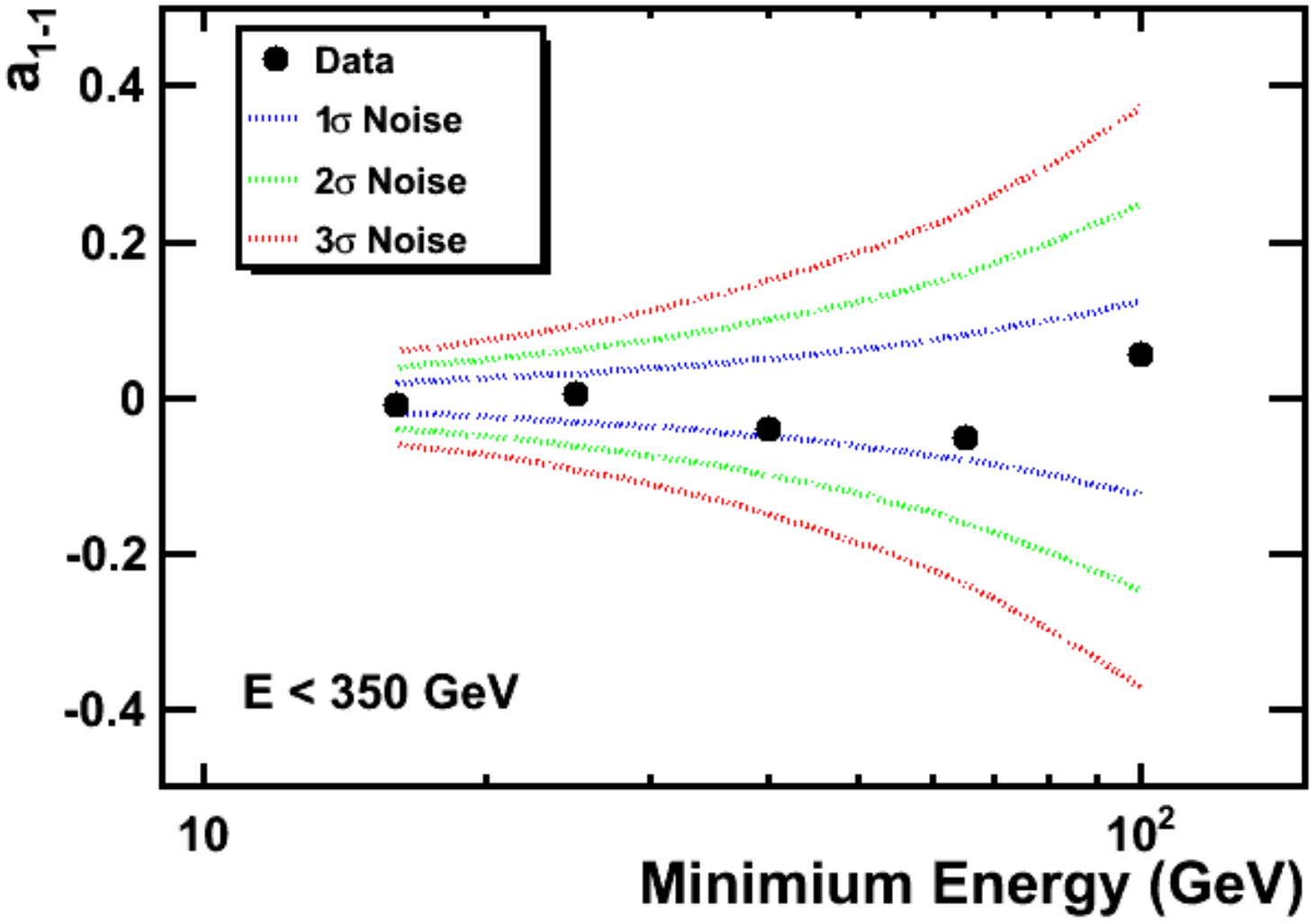
where $r_e(b,l)$ denotes the positron ratio at (b,l), $\langle r_e \rangle$ is the average ratio over the sky map, Y_{lm} are the real spherical harmonic functions, and a_{lm} are their corresponding amplitudes

The amplitudes of spherical harmonic contributions at fixed angular scale, *l*, are fit to data for dipole (*l=1*), quadrupole (*l=2*) and octopole (*l=3*)

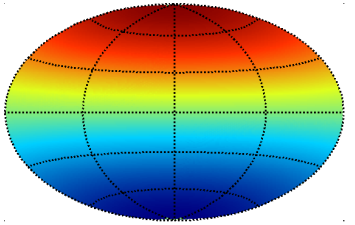
The fit amplitudes, a_{lm}, are found to be consistent with the hypothesis of isotropy at all energies and angular scales

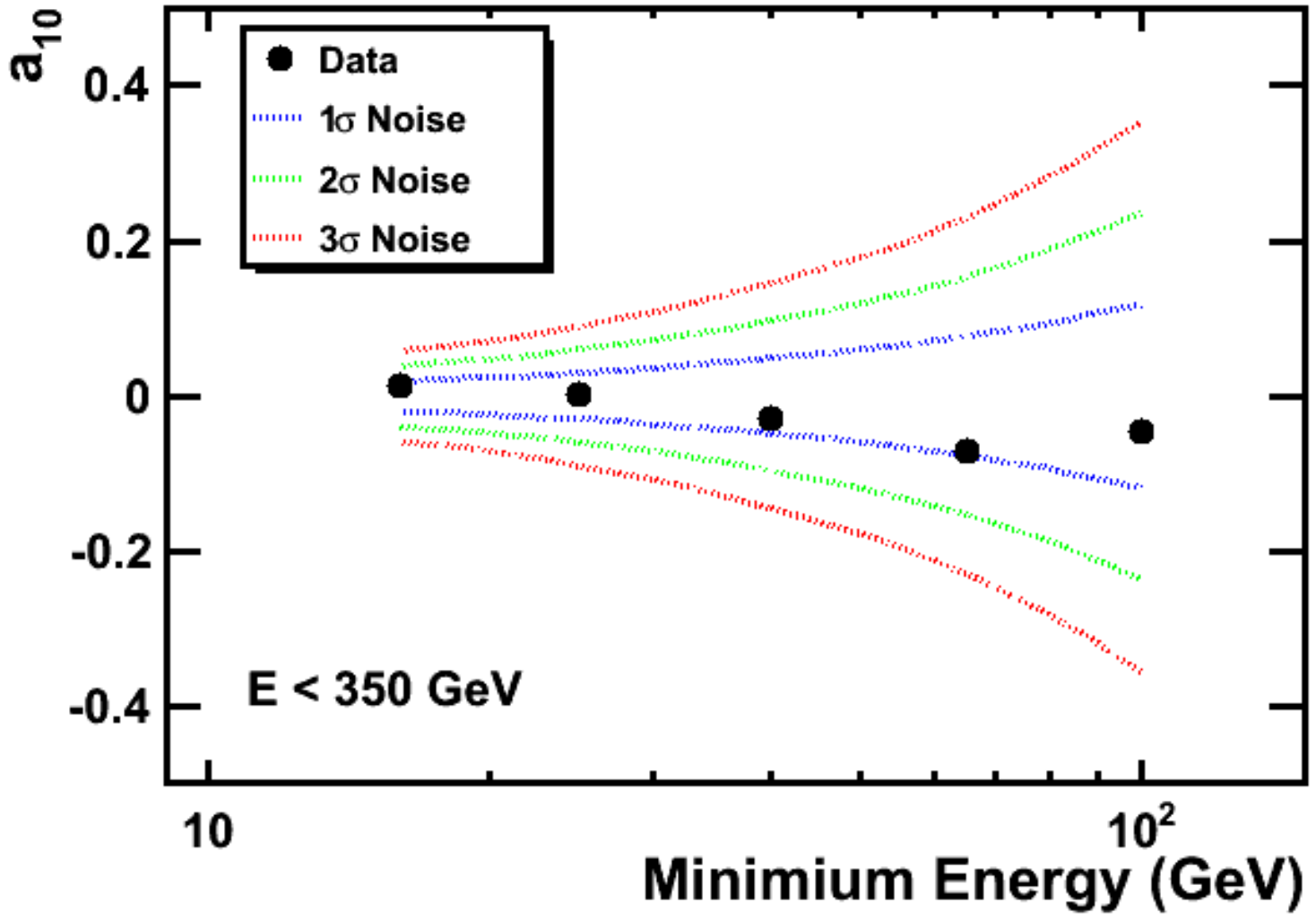
Dipole amplitude $a_{1\text{-}1}$



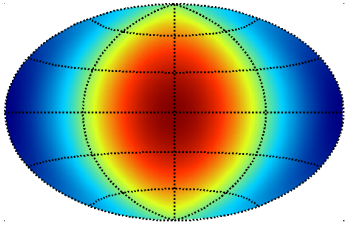


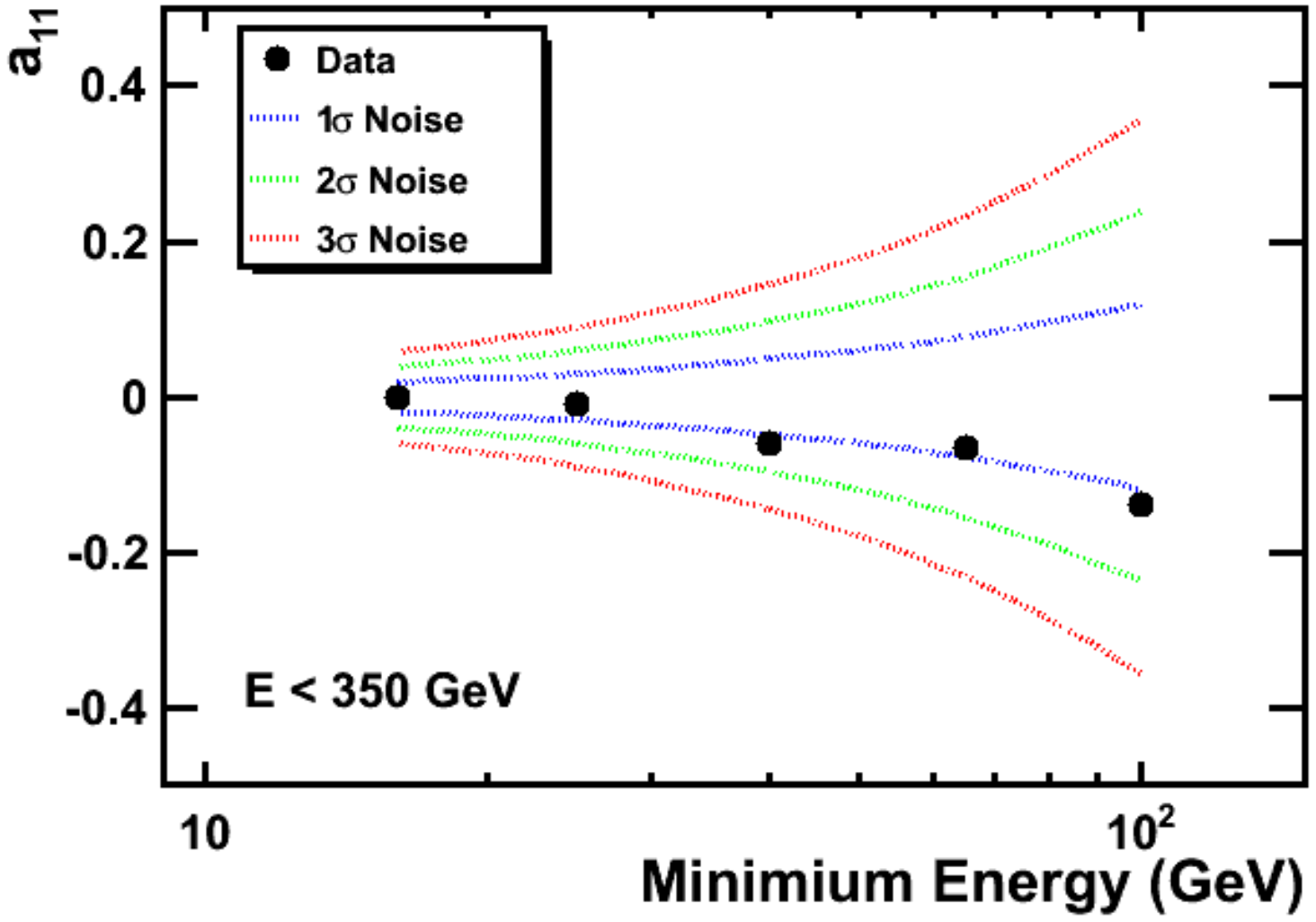
Dipole amplitude a_{10}





Dipole amplitude a_{11}



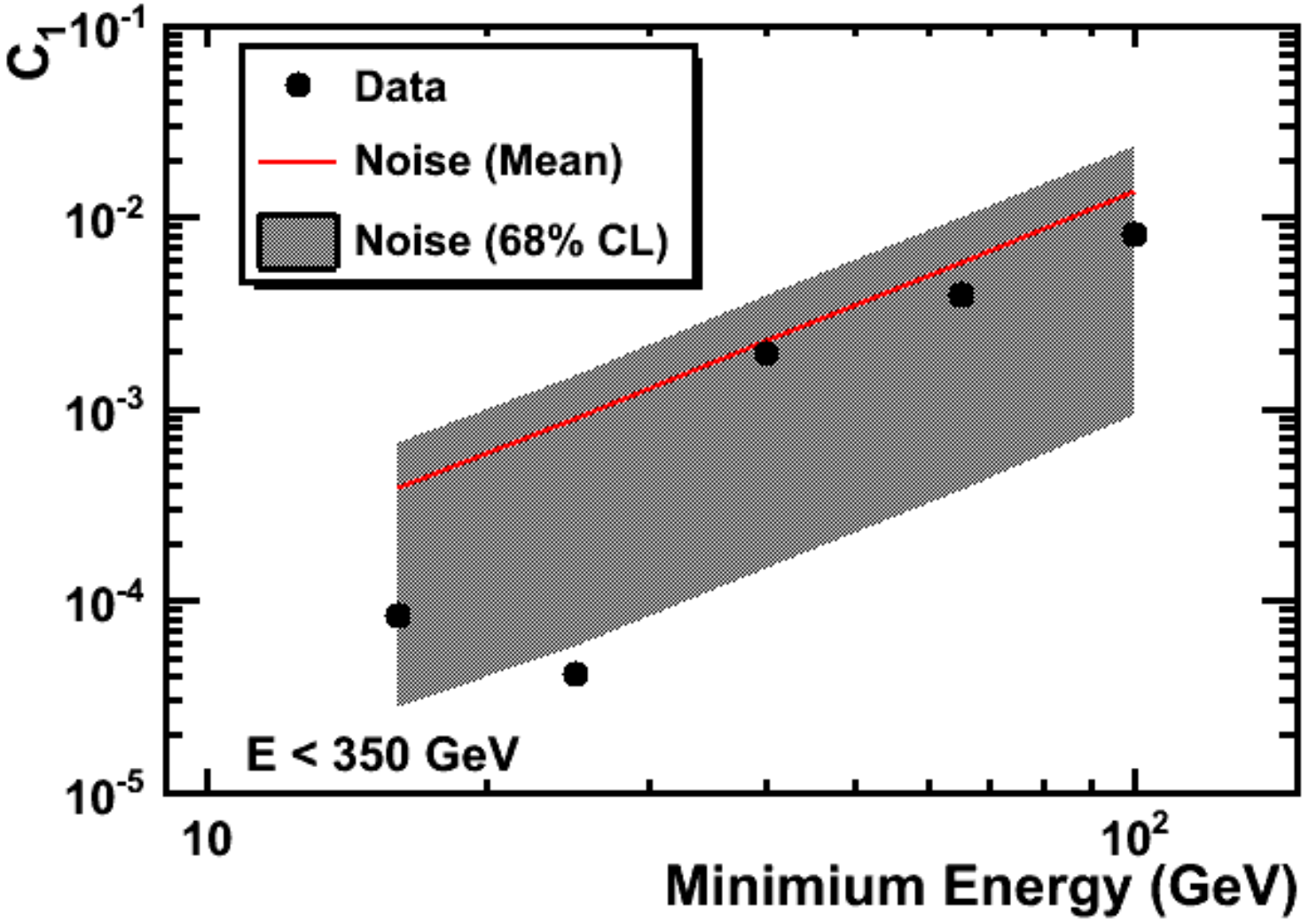


The coefficients of the angular power spectrum of the fluctuations, C_ℓ are defined as

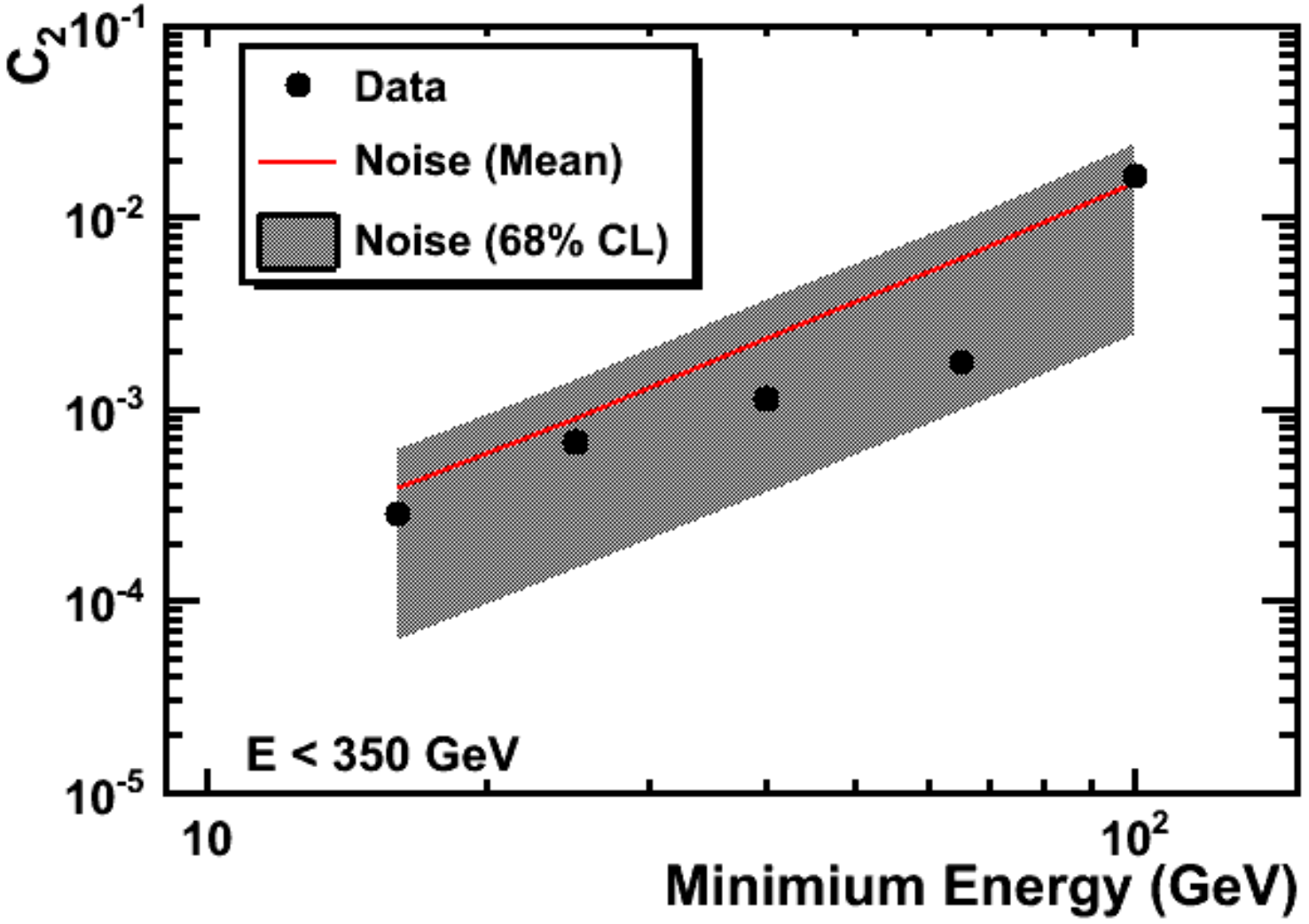
$$C_\ell = \frac{1}{2\ell+1} \sum_{m=-\ell}^{\ell} a_{\ell m}^2$$

The values obtained from the fits to the data are compared to the expectations from isotropy

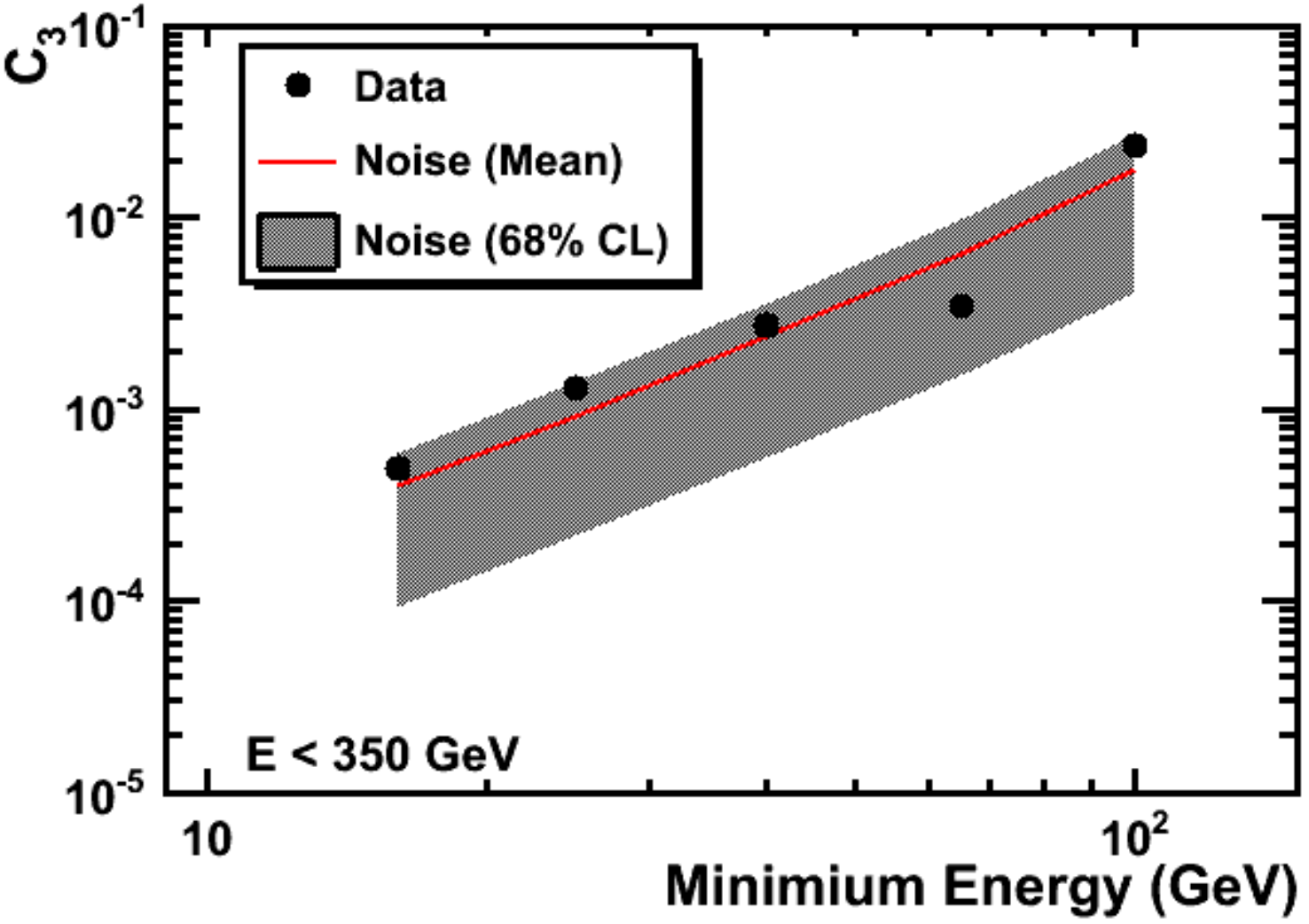
The dipole coefficient C_1



The quadrupole coefficient C_2



The octopole coefficient C_3

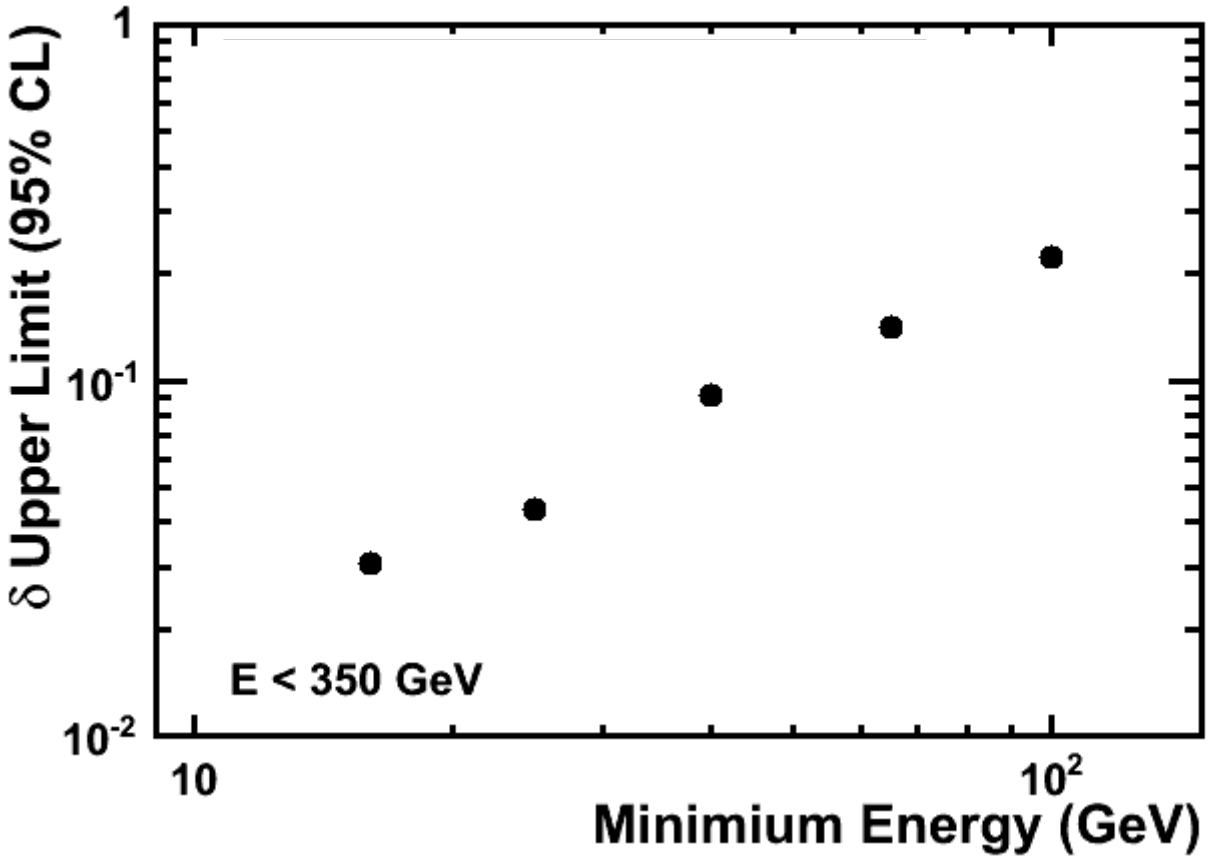


The coefficients of the multipole expansion are found consistent with the expectations from isotropy and upper limits are obtained.

In particular, upper limits on the dipole anisotropy parameter δ

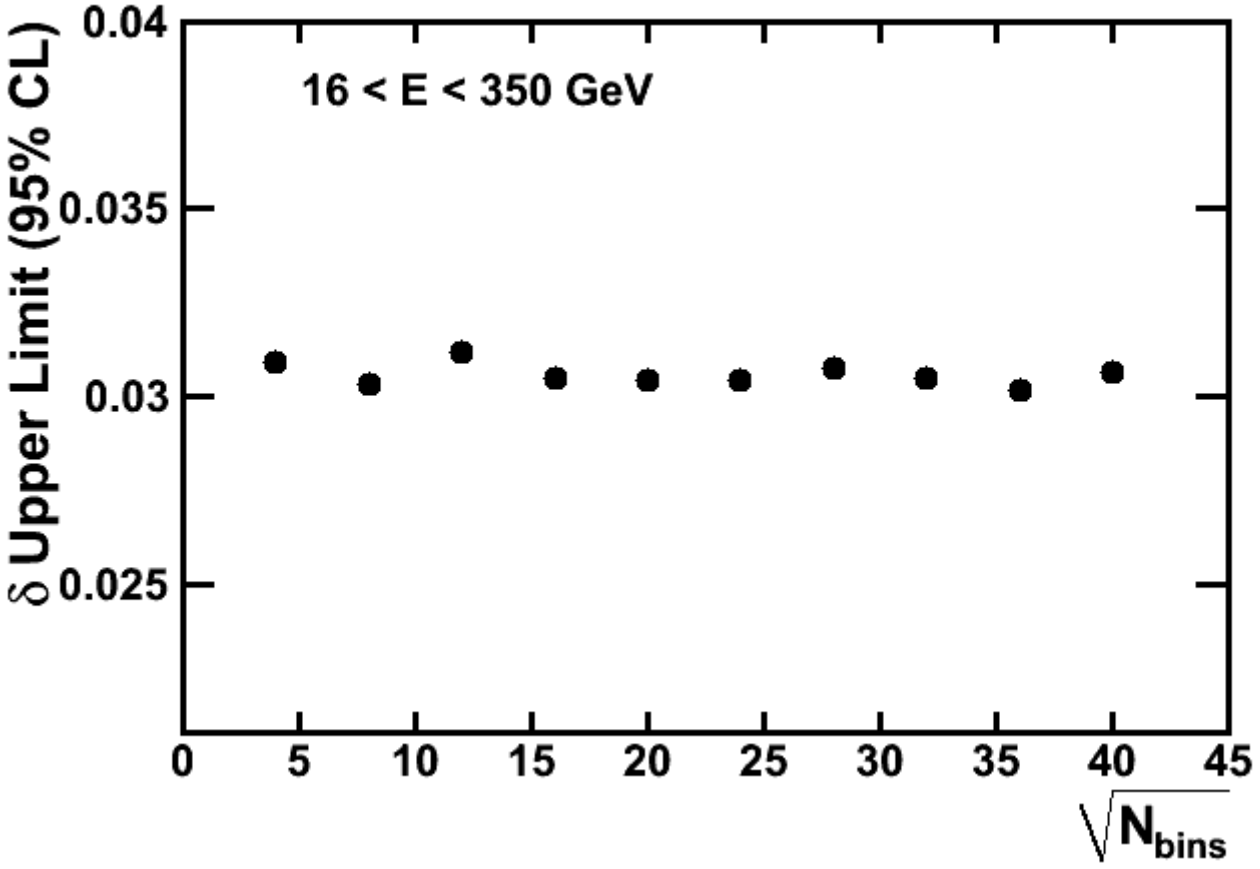
$$\delta = 3\sqrt{\frac{C_1}{4\pi}}$$

AMS upper limits on δ at the 95% CL



δ<0.030 for 16<E<350GeV

Checks including changes on pixelation scheme, on the angular bin size and the number of masked pixels show no indication of significant systematics



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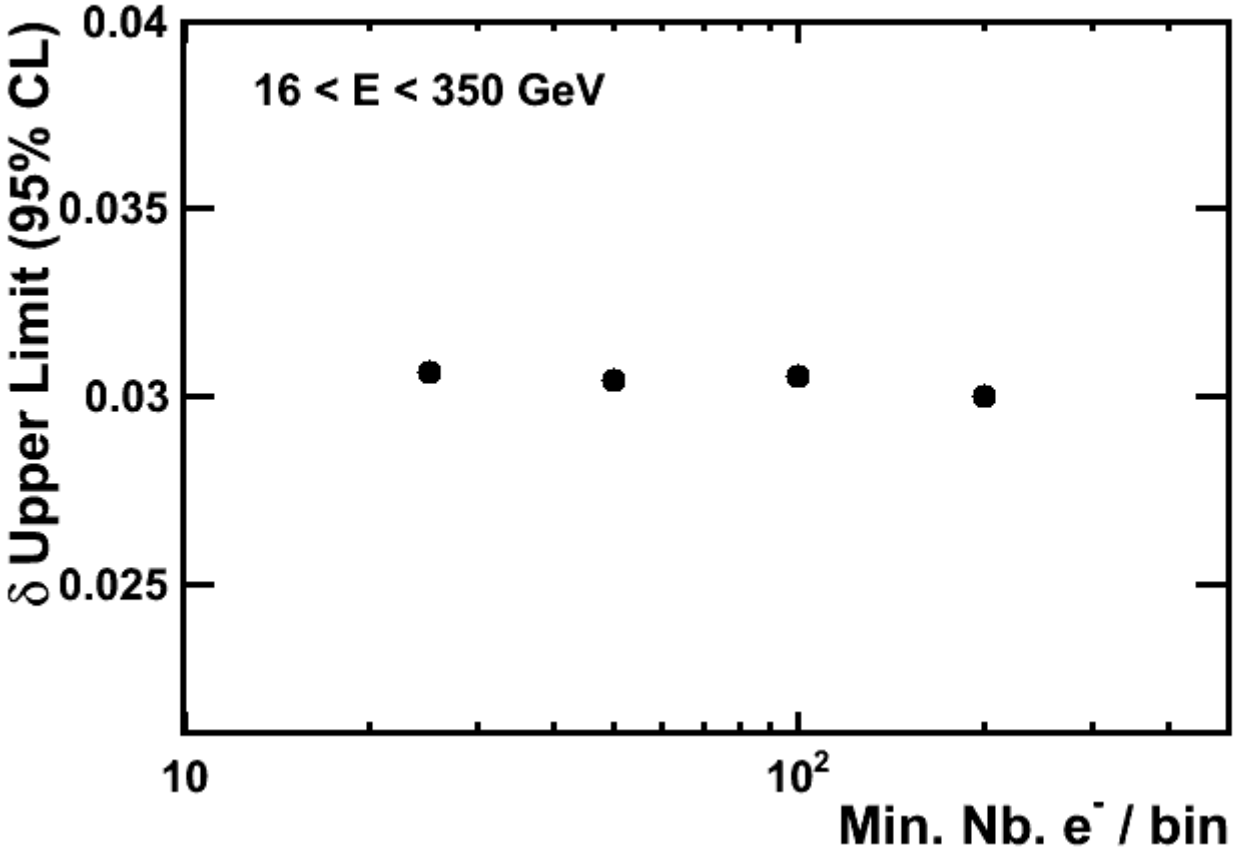
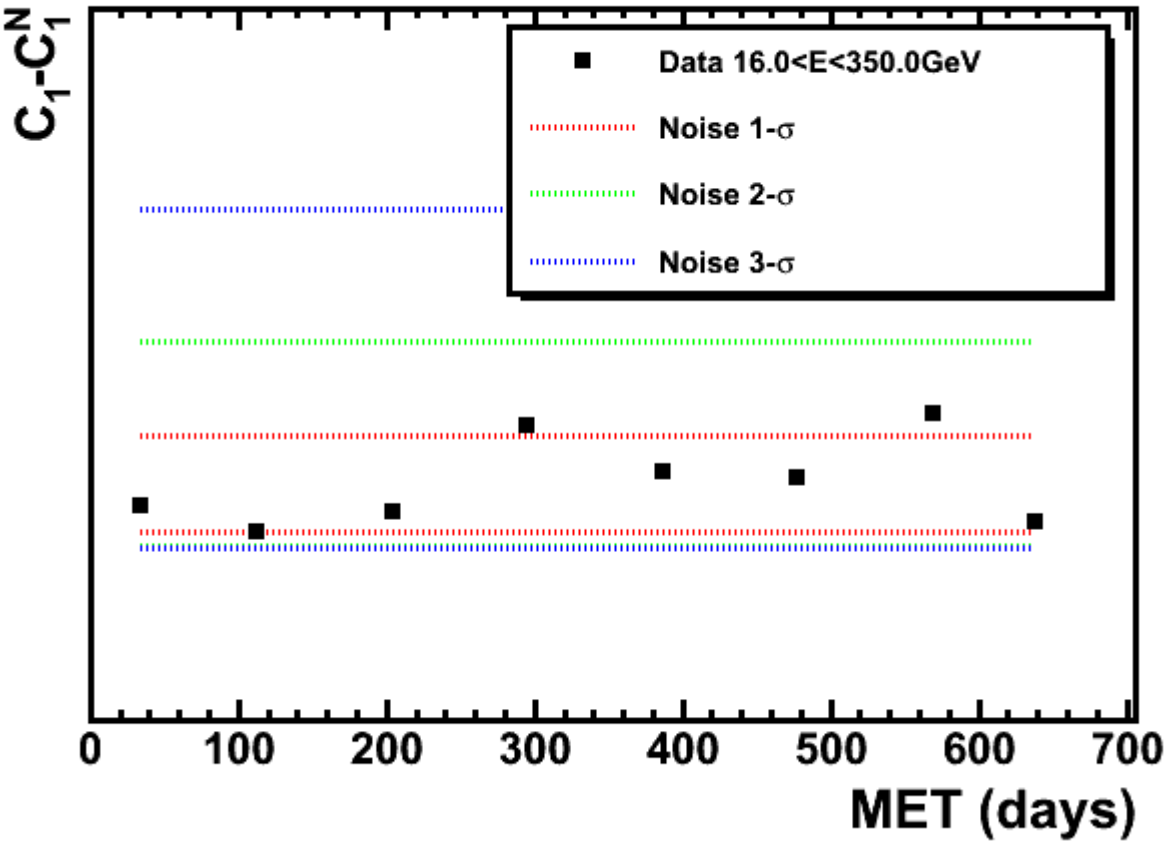


Search for seasonal variations which could reveal a signal of solar origin



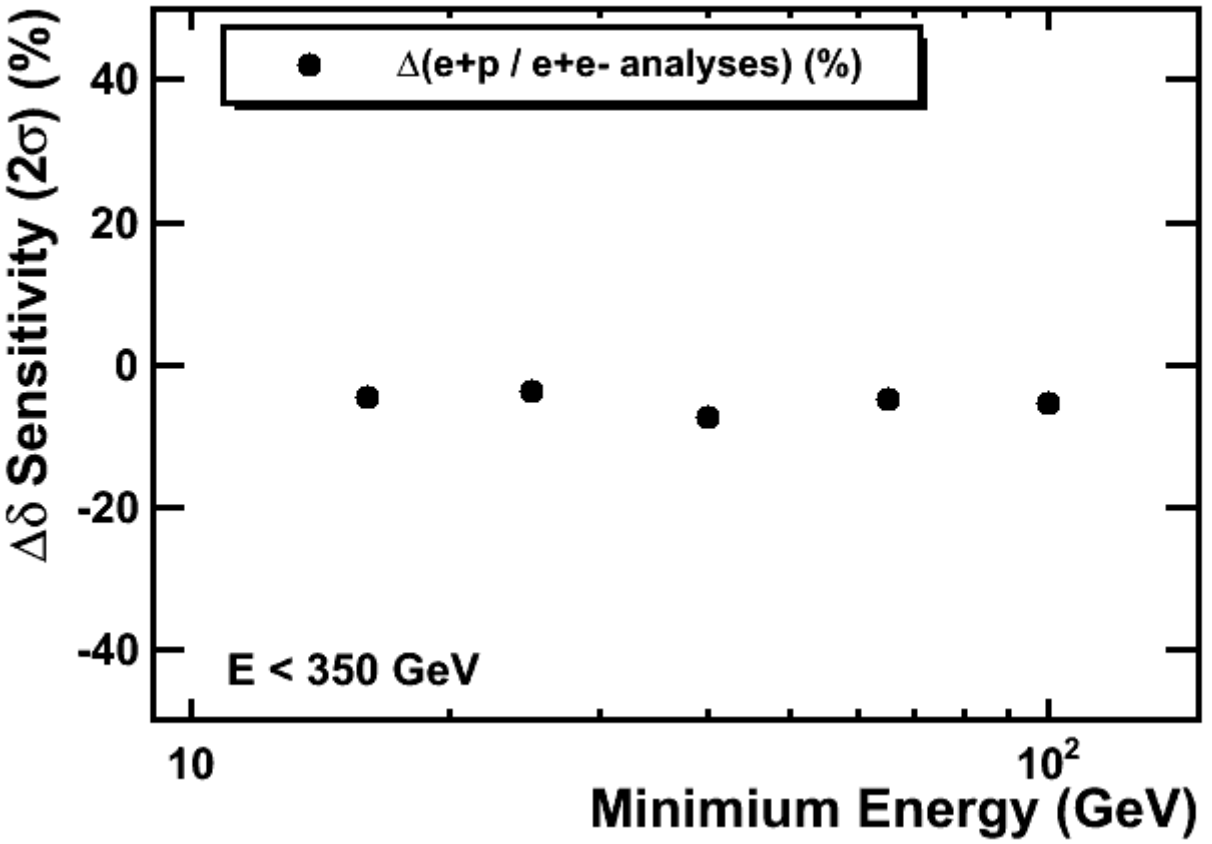
No indication of seasonal variation is found

Anisotropy on e^+/p ratio and limits at the border of the magnetosphere

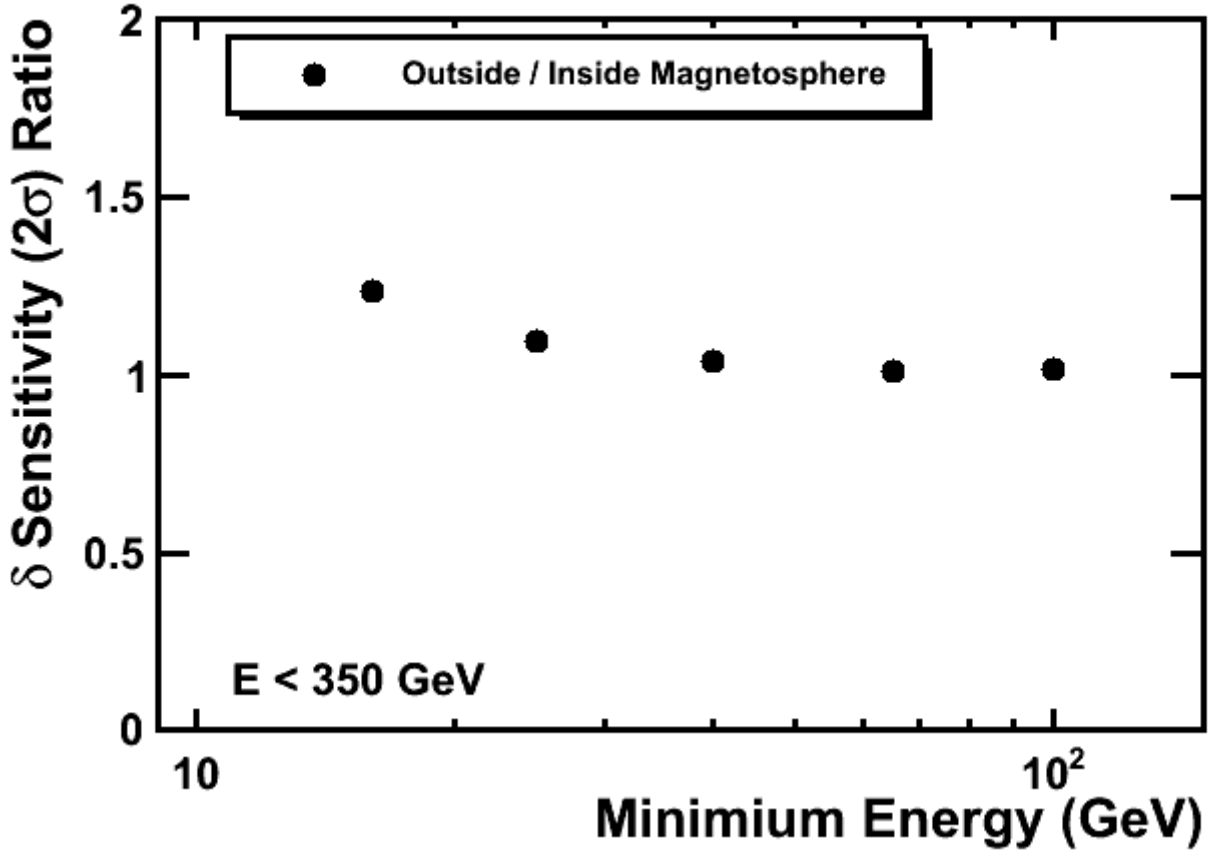
Use the ratio of positrons to protons and repeat the analysis on the asymptotic directions obtained after backtracing their trajectories in the geomagnetic field

The geomagnetic field model includes IGRF-11 for the internal field and Tsyganenko 1996 and 2005 for the external field

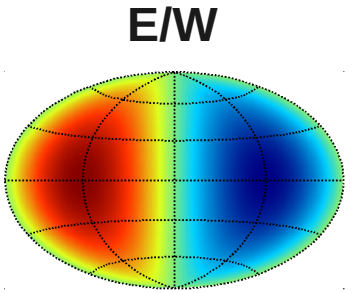
The sensitivity to a dipole anisotropy using the positron to proton ratio is consistent with the one obtained on the positron to electron analysis

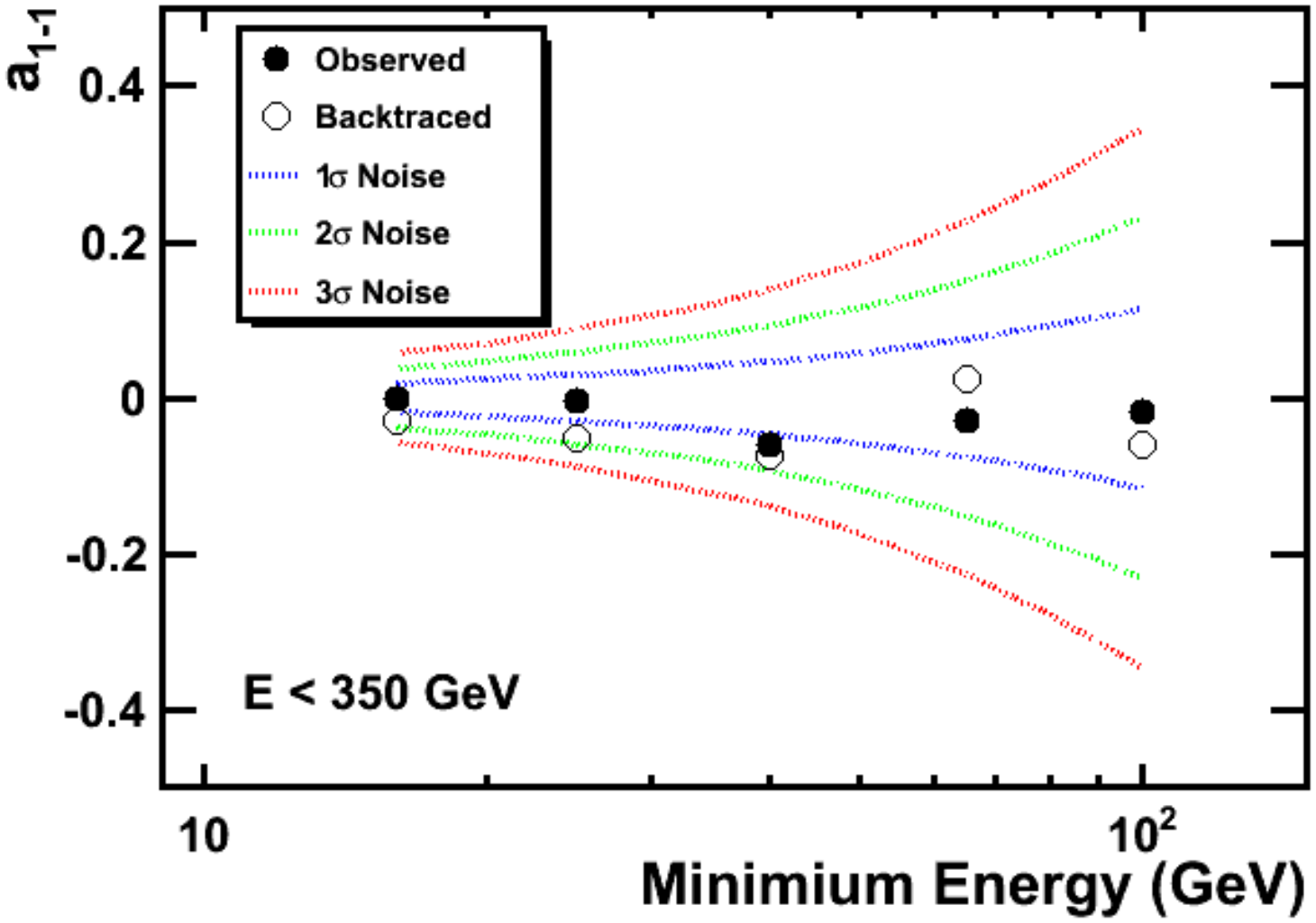


Similar sensitivity to a dipole anisotropy is obtained after backtracing their trajectories in the geomagnetic field to the border of the magnetosphere

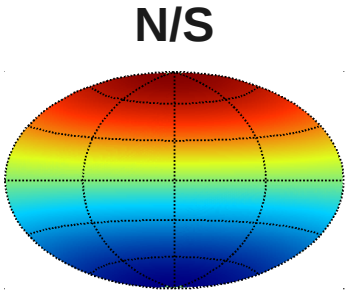


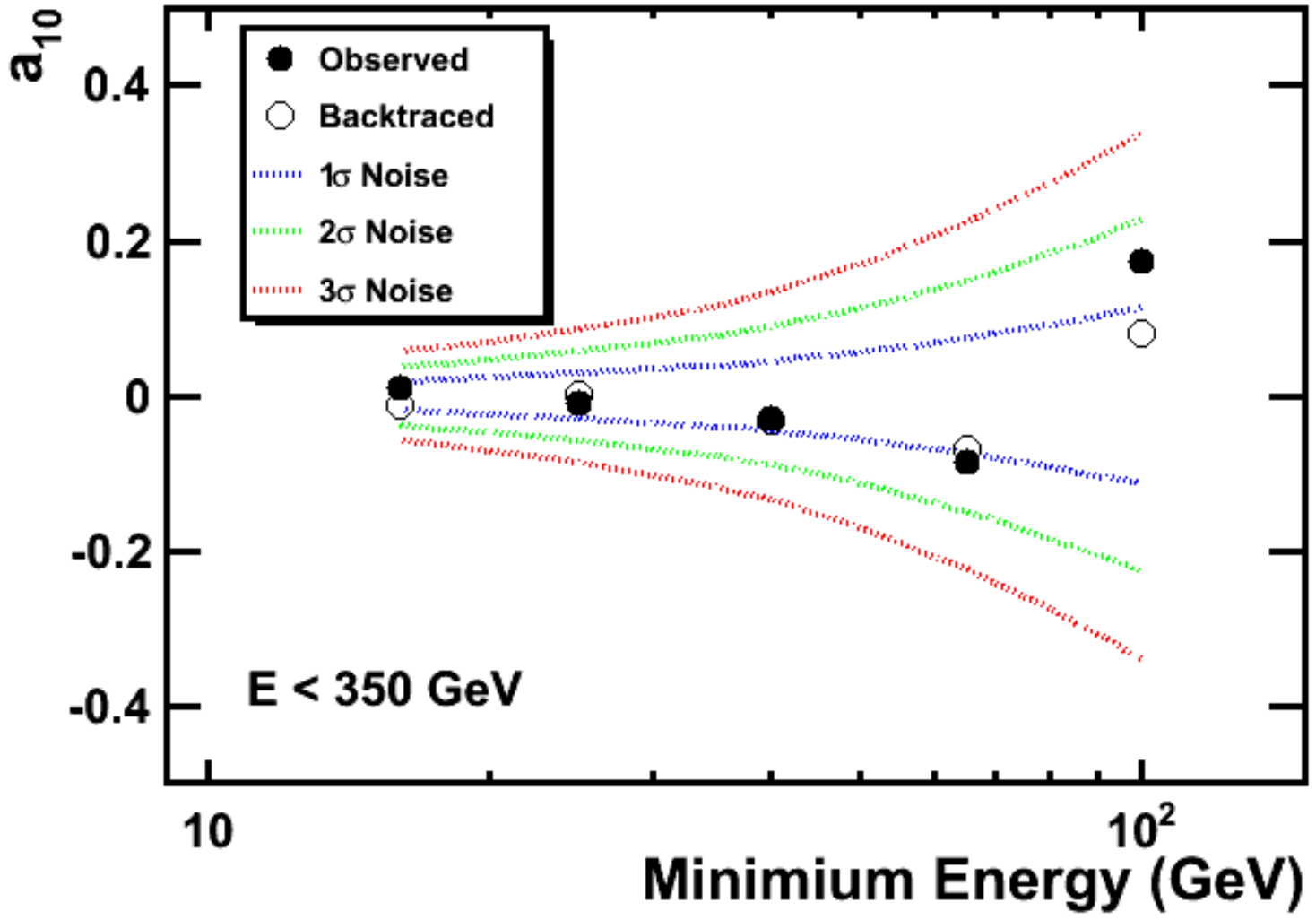
Dipole amplitude a_{1-1}





Dipole amplitude a_{10}





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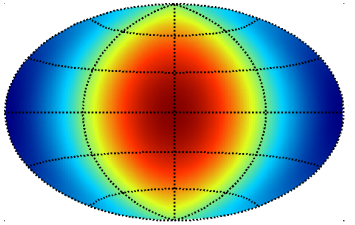

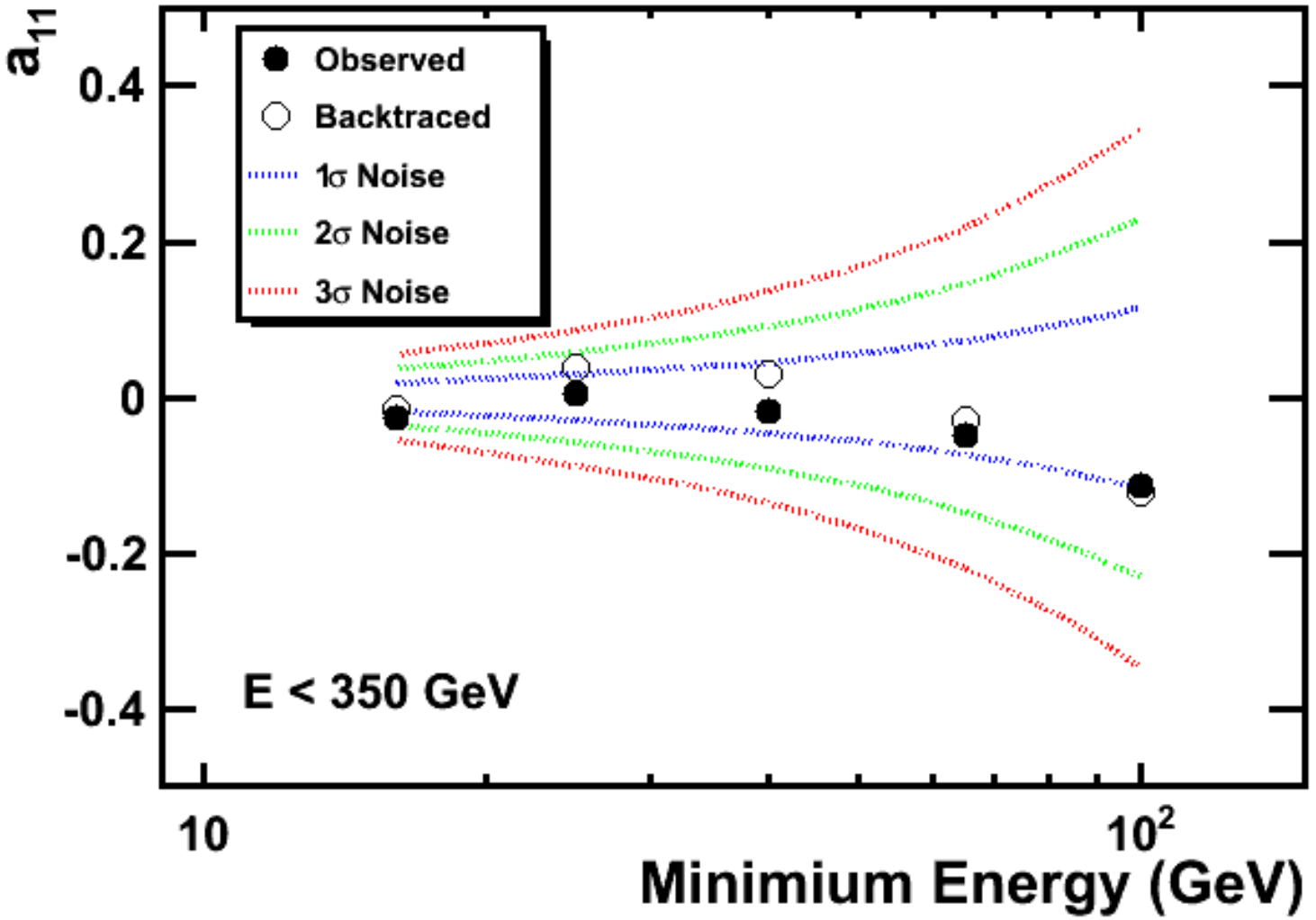

Summary

A systematic search for anisotropies on the cosmic ray positrons is performed from 16 to 350 GeV

No anisotropy is found on the ratio e+/e- at any angular scale and limits are set on the dipole anisotropy parameter,

$$\delta < 0.030 \text{ at } 95\% \text{ CL}$$

No seasonal variations are observed

Summary

Consistent results are obtained on the e^+/p ratio and equivalent limits are computed at the border of the magnetosphere

Anisotropy Discovery Potential

In 10 years, the projected sensitivity of AMS to a dipole anisotropy is 2σ for $\delta=0.010$ and 3σ for $\delta=0.014$