# Observations of extended very-high-energy halos around Geminga and Monogem with the LHAAS0-KM2A

(LHAASO collaboration)
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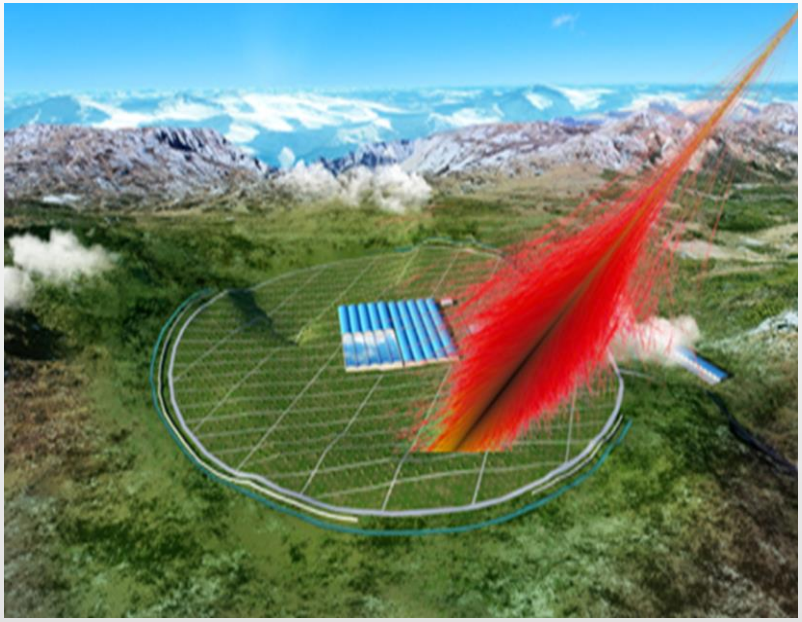
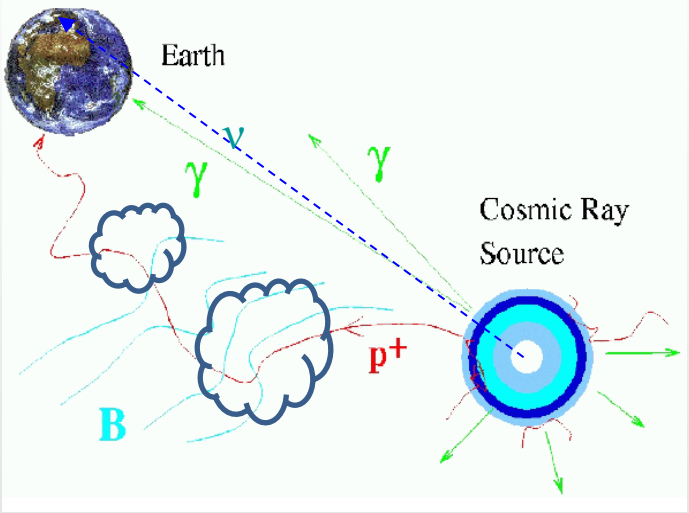
For: ICRC2021

# Content

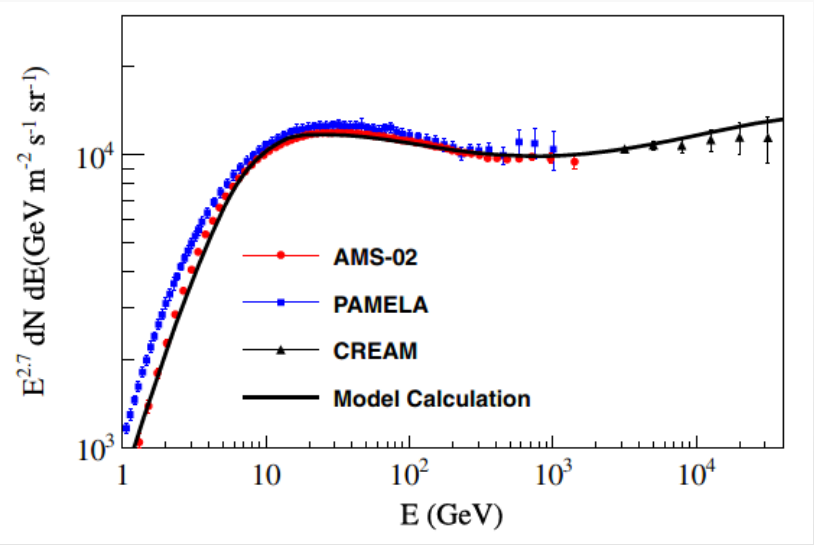
- Cosmicray propagation
- LHAASO-KM2A instruction
- Data instruction
- Morphology analysis method
- Results



# The propagation of CRs:diffusion




The ketch of diffusion

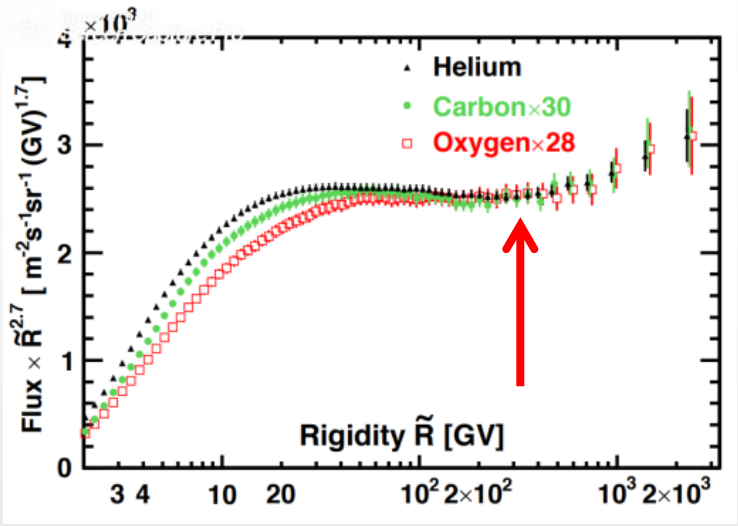


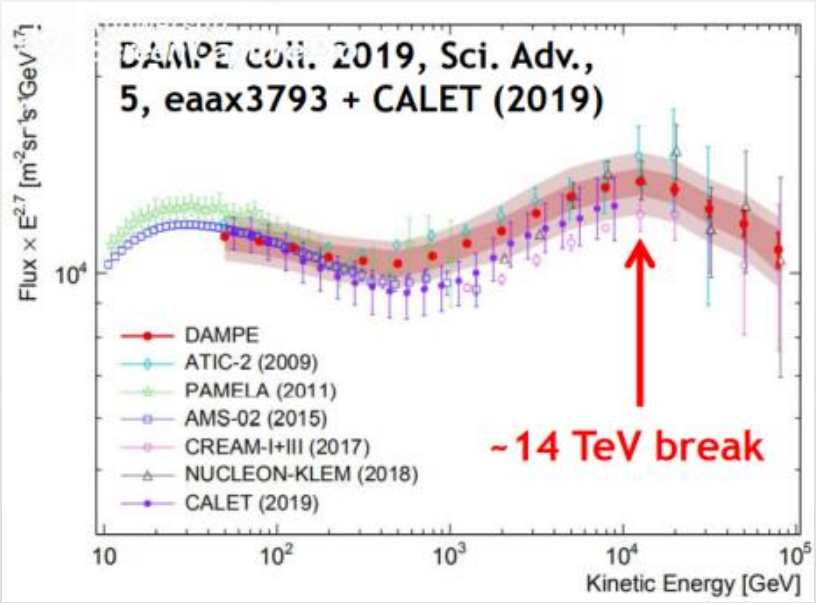

The spectrum of proton

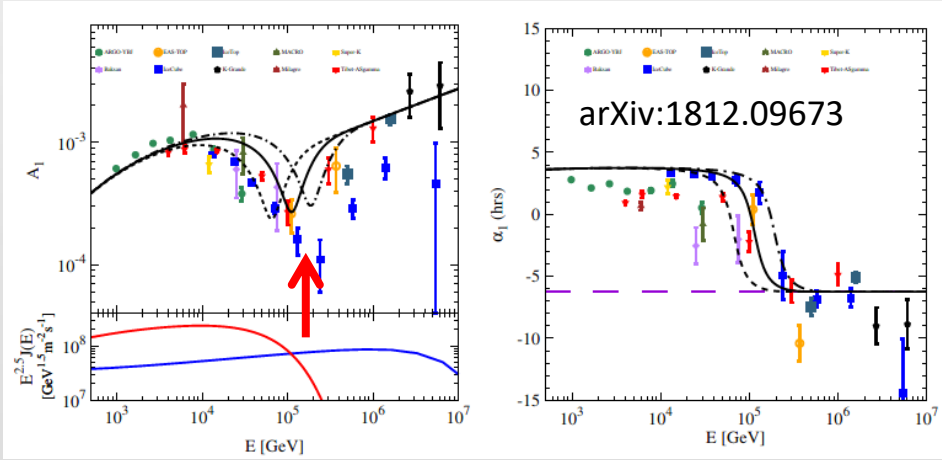
PRD 97, 063008,(2018)

# Spatial dependent diffusion

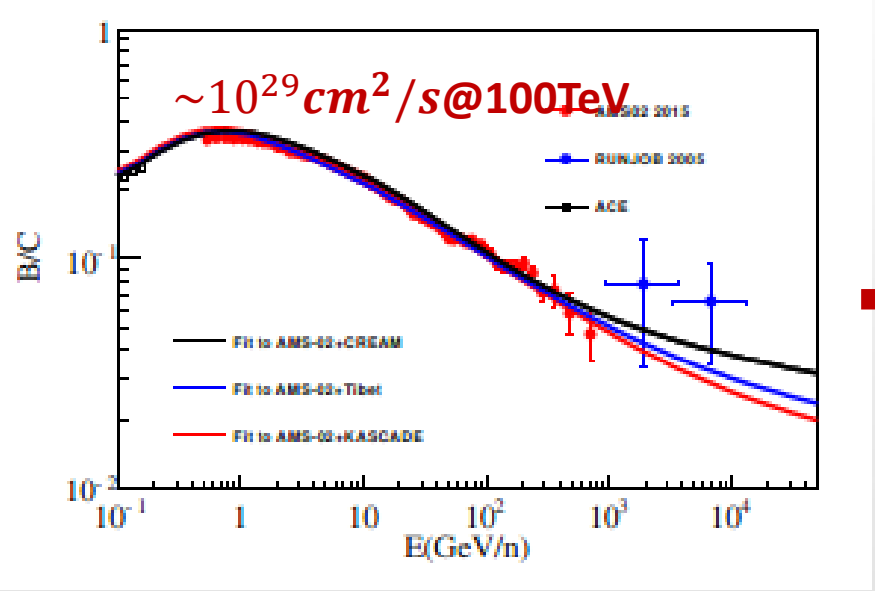
- The harden of nuclei spectra from AMS02
- The spectral cut at 14TeV from DAMPE
- The anisotropy

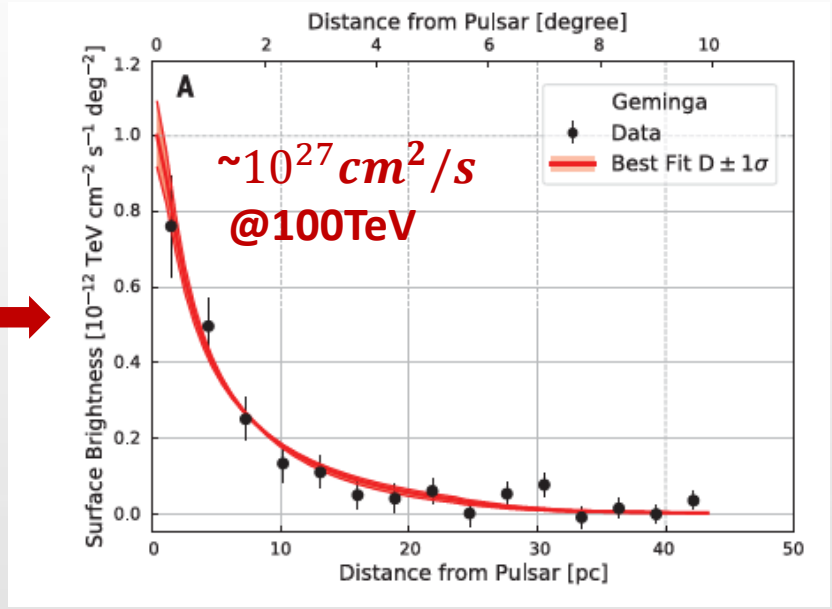


# The low diffusion halos




B/C ratio constrains diffusion coefficient, and extrapolates to higher energy

The measurement of diffusion coefficient

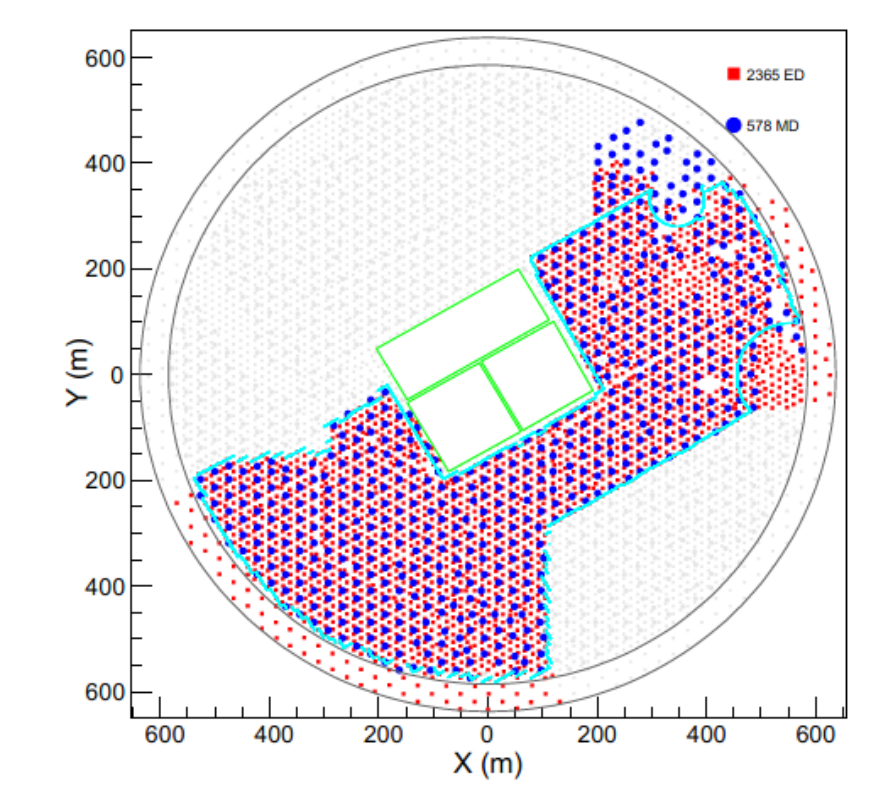
➢ How does diffusion depend on energy?

Interesting

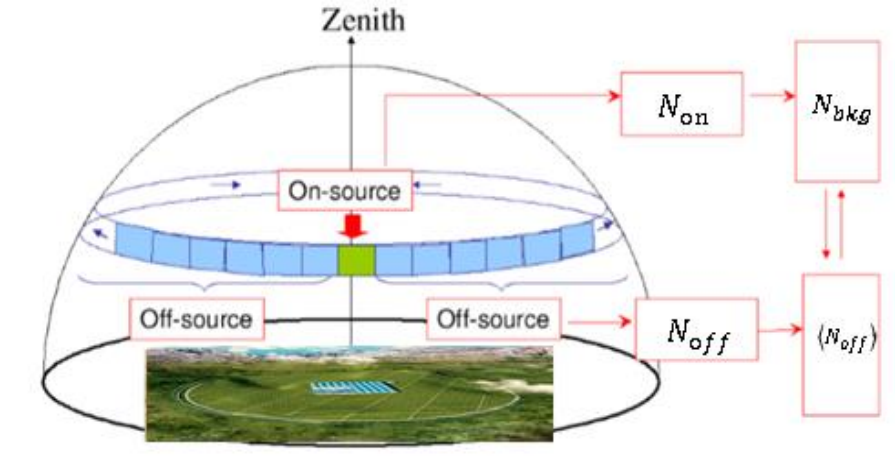
Abeysekara et al., Science 358, 911–914 (2017) 17 November 2017

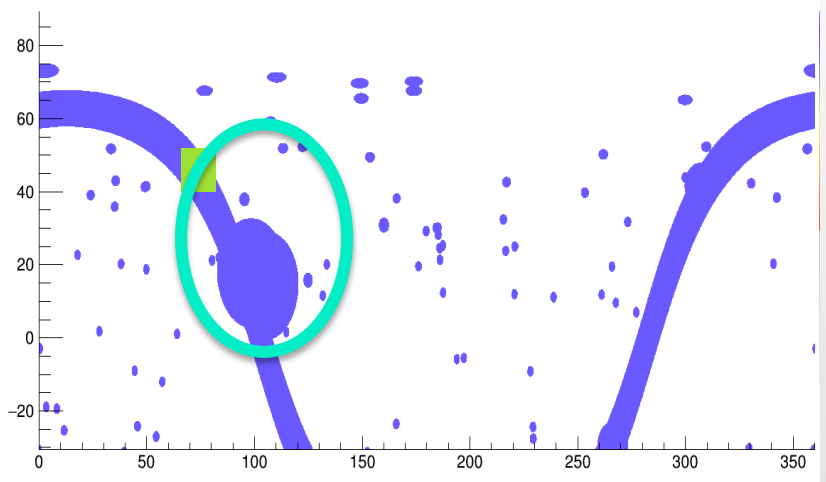
# LHAASO-KM2A

- ½ KM2A:
  - 2356 Electromagnetic particle Detectors (ED)
  - 578 Muon Detectors (MD)
- Data selection:
  - Muon poor events
  - events are on the array
  - Zenith angle is less than 50°



# Background estimation



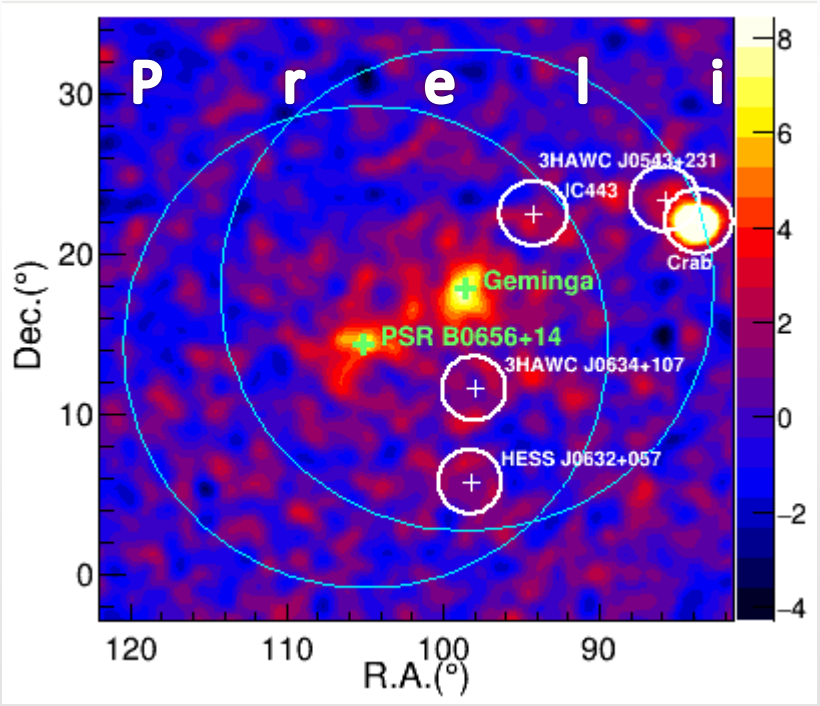




Equi-zenith method

Mask detected TeV-sources (Blue region)

Improve background estimation

# Significance map

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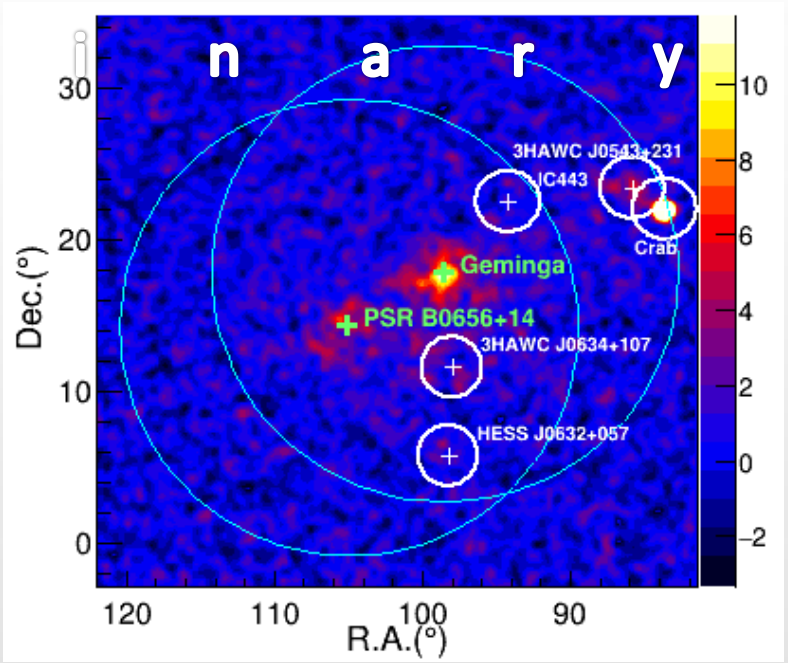



10-25TeV
logE[1-1.4]

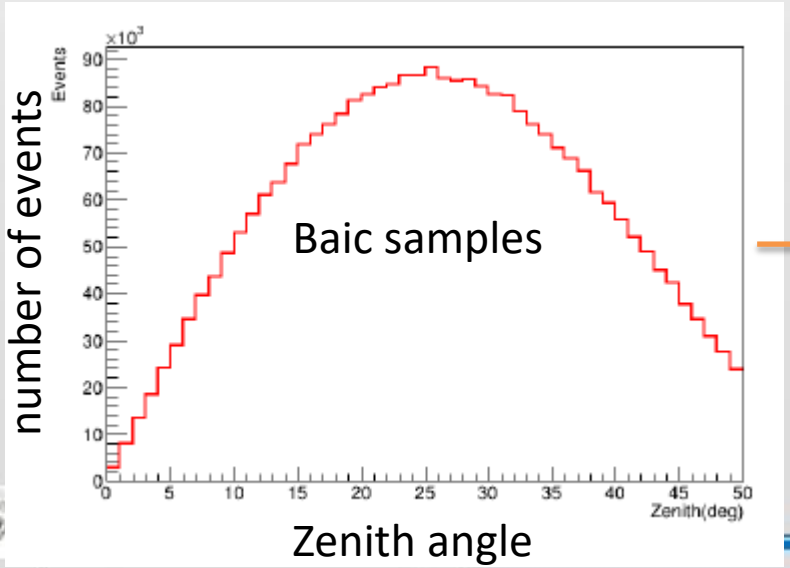
25-63TeV
logE[1.4-1.8]

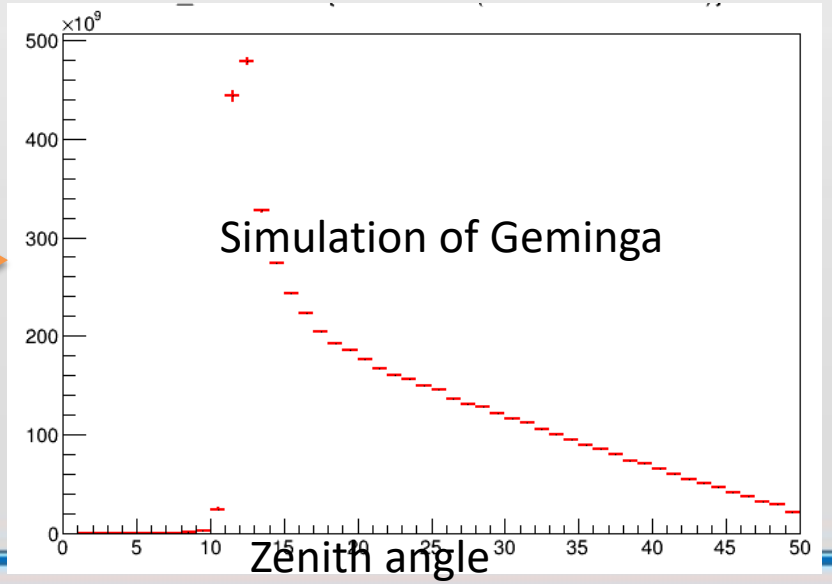
- Mask five white circles with a radius of 2deg, which are known Galactic TeV sources.

# The simulation model

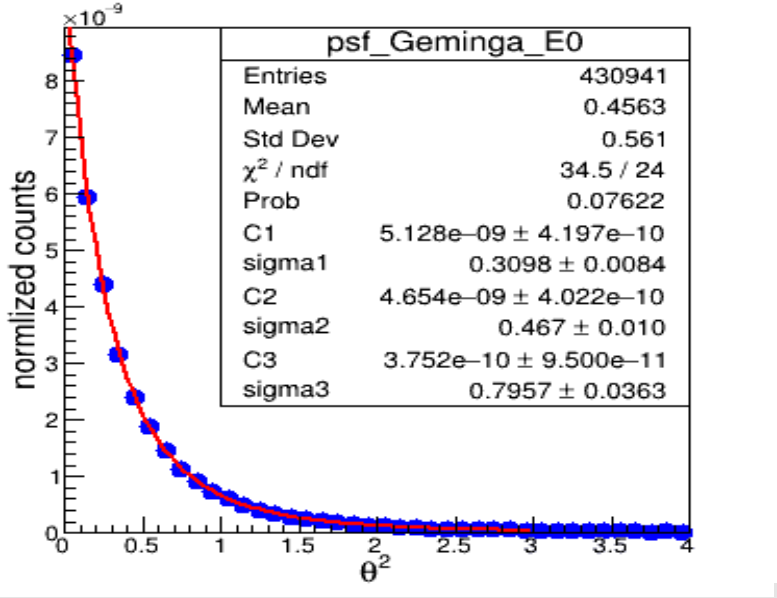
- Soft： Corsika-76400+ G4KM2A
- model: QGSII-gheisha
- Zenith angle： 0-70deg， isotropic injection
- Energy distribution：

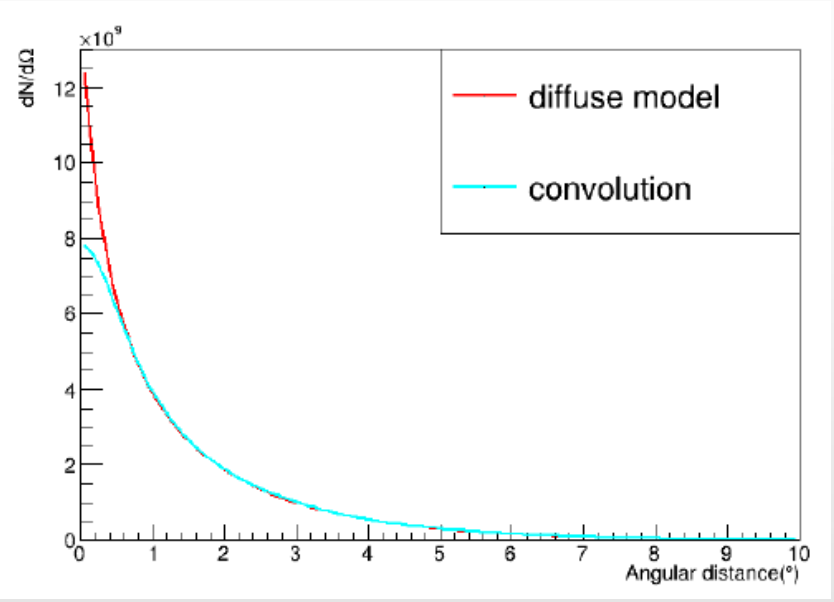
| Energy [eV] | 1.e12-1.e13 | 1.e13-1.e14 | 1.e14-1.e15 | 1.e15-1.e16 |
|---|---|---|---|---|
| Events | 2.e8 | 2.e7 | 2.e6 | 2.e5 |



# PSF convolution




Simulated PSF is a sum of three Gaussian functions.

$$\rho(\theta) = \alpha G1(\theta) + \alpha_2 G2(\vartheta) + \alpha_3 G3(\vartheta)$$

Diffuse model:

$$f(\theta|\theta_d(E)) = \frac{size}{\theta_d(\theta + 0.085\theta_d)} \exp(-1.54(\frac{\theta}{\theta_d})^{1.52}),$$

# Likelihood method

- Spectra:

$$\psi(E) = \psi_0(E/30TeV)^{-\alpha-\beta ln(E/30TeV)} \quad (2)$$

$$D(E_e) = D_0(E_e/130TeV)^{\delta} \quad (3)$$

- Diffusion template:

$$f(\theta|\theta_d(E)) = \frac{size}{\theta_d(\theta + 0.085\theta_d)} \exp(-1.54(\frac{\theta}{\theta_d})^{1.52}), \quad (4)$$

- likelihood：

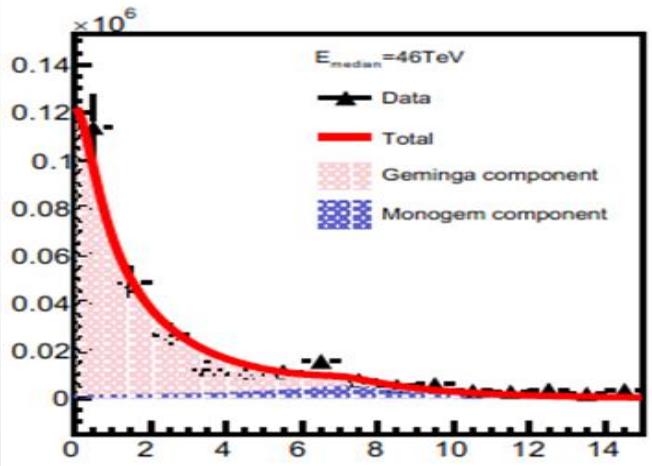
$$ln(\mathcal{L}_{obs}) = ln(\sum_{b=0}^{5}\sum_{p=0}^{n}(\frac{Poisson(N_p, N_{bkgp} + N_{Gp} + N_{Mp})}{Poisson(N_p, N_{bkgp})}) \quad (1)$$

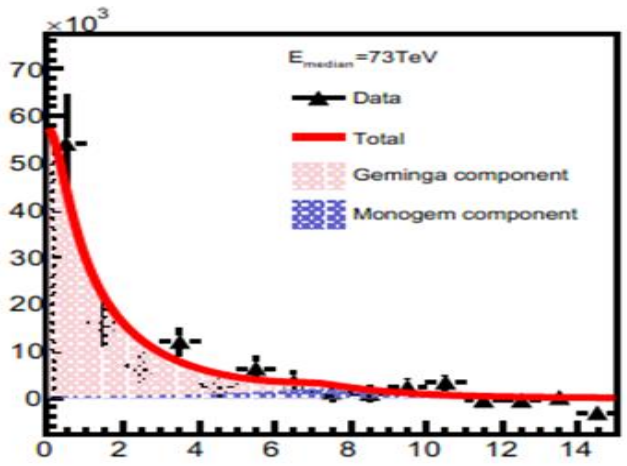
- Assumption:

the diffusion property is the same for both sources

# Morphology results

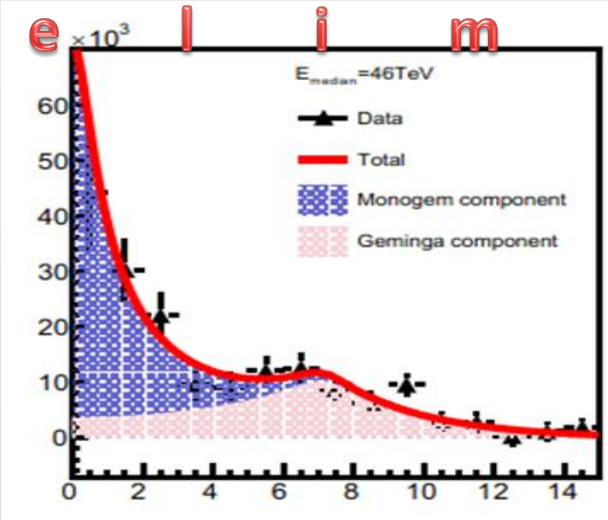
**Geminga:**

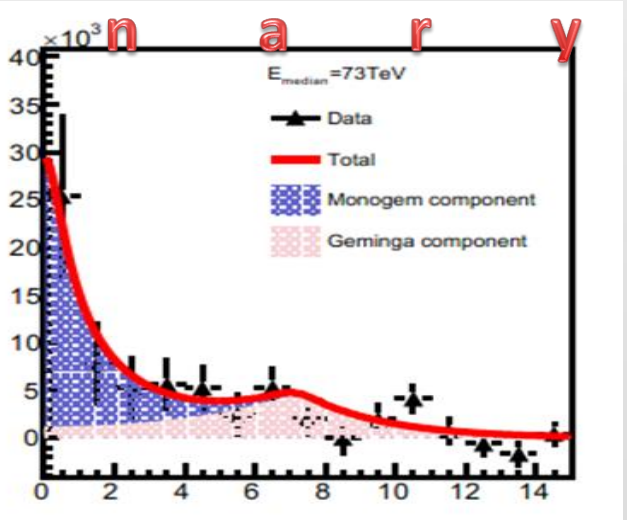



**Monogem:**

Preliminary



# Conclusion

- The morphology of Geminga and Monogem at 46 and 73 TeV
- Next: energy-dependent morphology