Observation for large-scale anisotropy of cosmic rays with partial array of LHAASO

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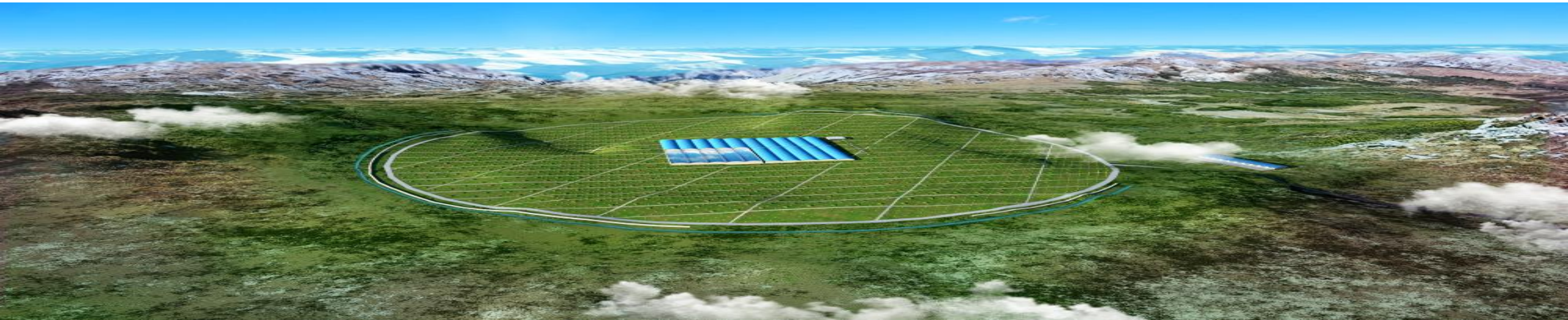
NANJING,2019/04/14



Content

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LHAASO

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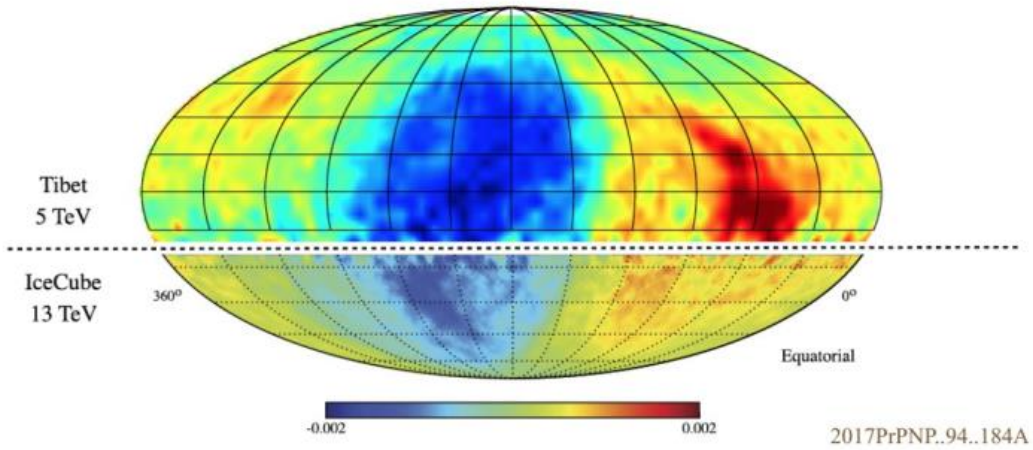
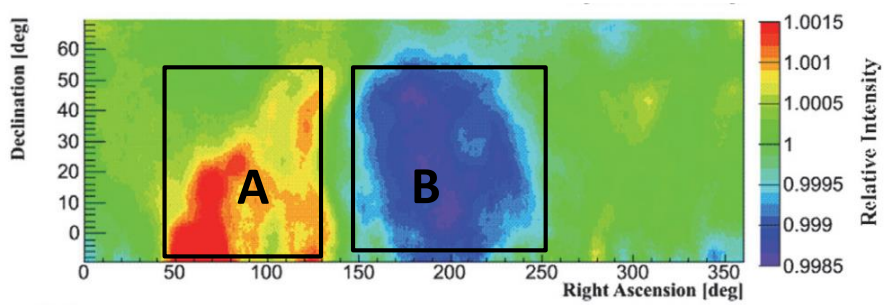
Introduction

Cosmic rays were observed with magnitude of about $10^{-4}\sim10^{-3}$ anisotropy by ground arrays.

Such as Tibet-Asγ, ARGO-YBJ, Milagro, HAWC, Auger ……





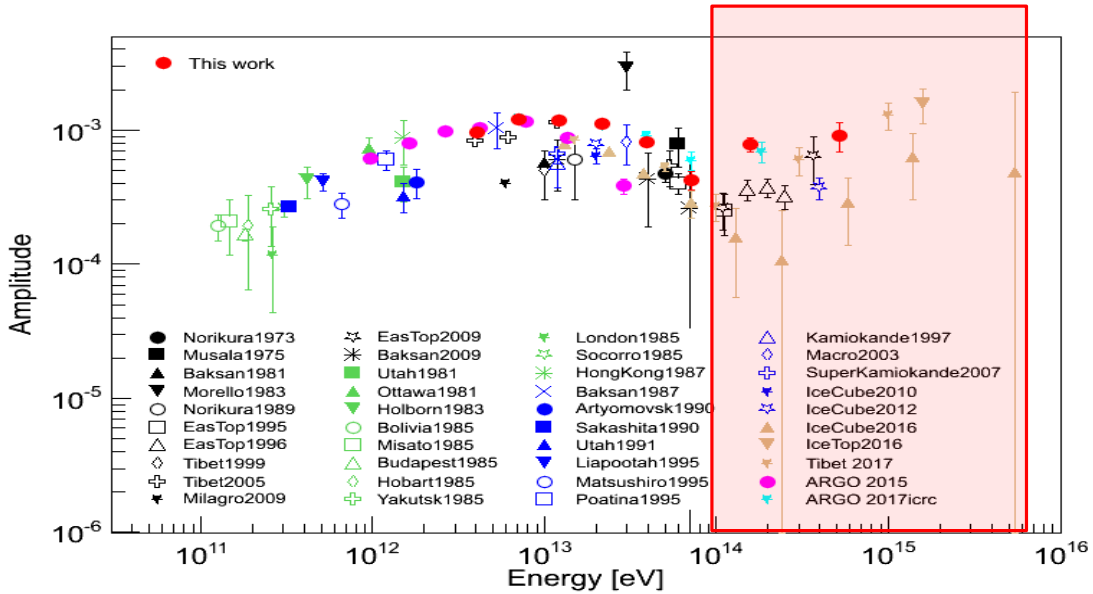
Bartoli et al. 2015

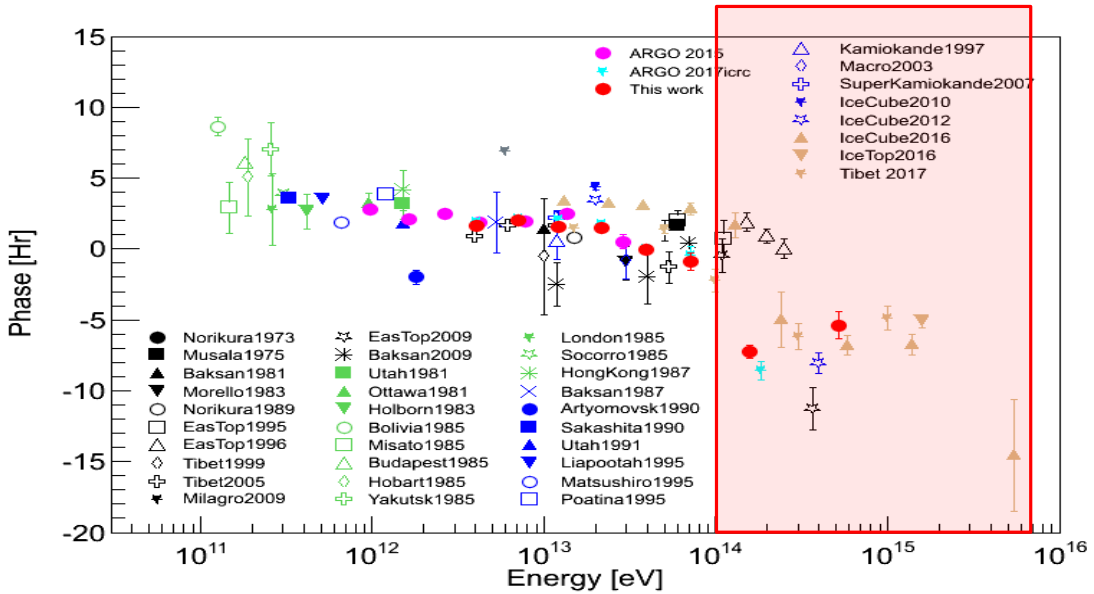
Two typical features:

A: “Tail-in”, excess structure around 50 to 130 R.A.

B: “Loss-cone”, deficient structure around 150 to 250 R.A.

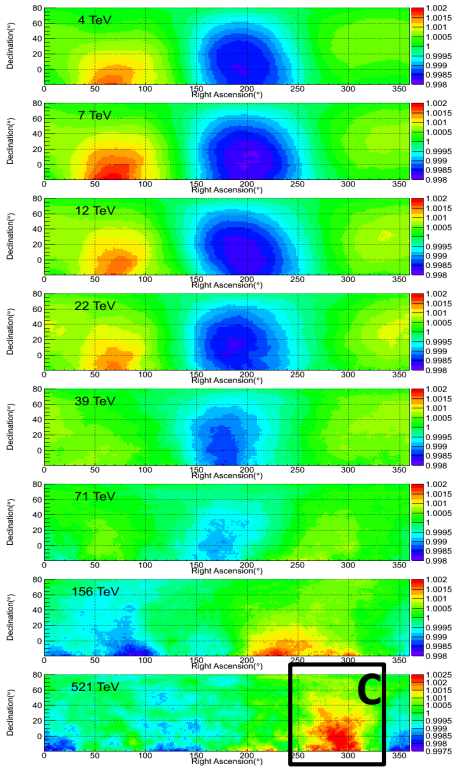
Anisotropy VS Energy





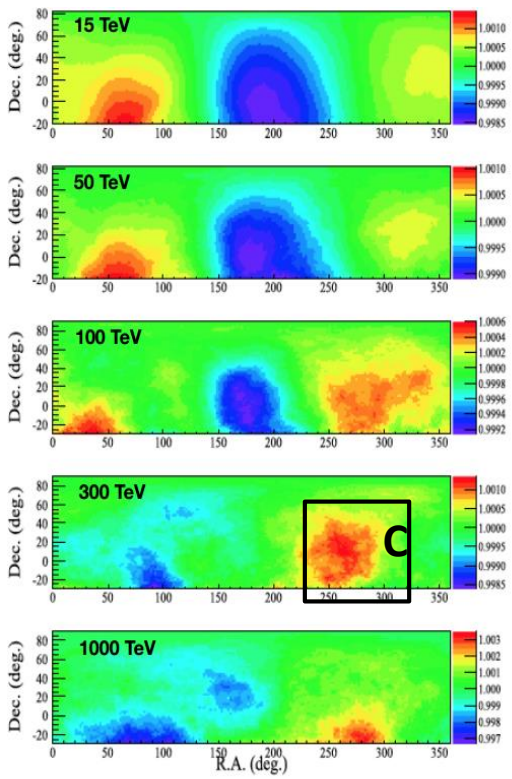
Anisotropy VS Energy

ARGO: 4 TeV to 521 TeV



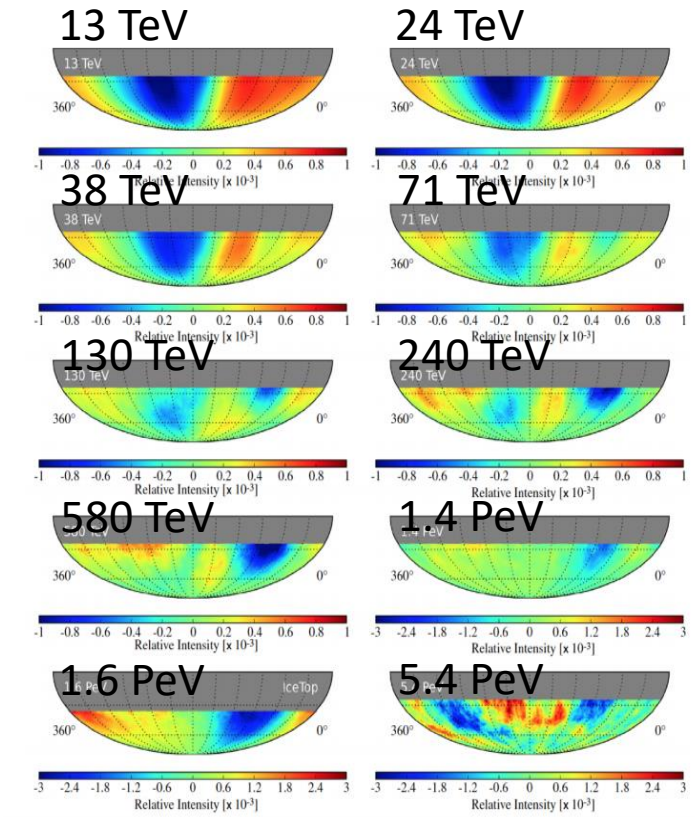
Bartoli et al. 2018

Tibet-ASγ



M. Amenomori et al. 2017

IceCube



Aartsen et al. 2016

C: New "excess" above 100 TeV up to PeV, nearly the Galactic Center direction.

Hint the Galactic origin of CRs

Anisotropy VS Energy

Auger: above 8EeV, with 3*10^4 CRs.

The phase at $\alpha_\delta = 100 \pm 10°$, indicating an extragalactic origin for these ultrahigh-energy particles.

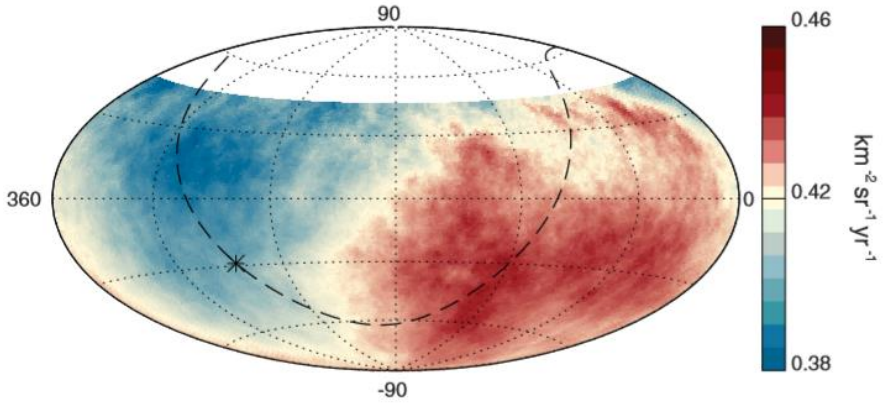


Fig. 2. Map showing the fluxes of particles in equatorial coordinates. Sky map in equatorial coordinates, using a Hammer projection, showing the cosmic-ray flux above 8 EeV smoothed with a 45° top-hat function. The galactic center is marked with an asterisk; the galactic plane is shown by a dashed line.

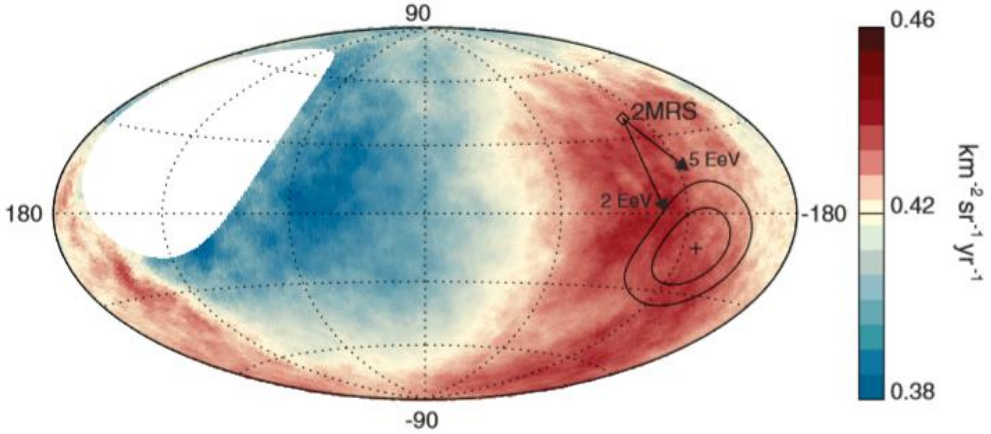
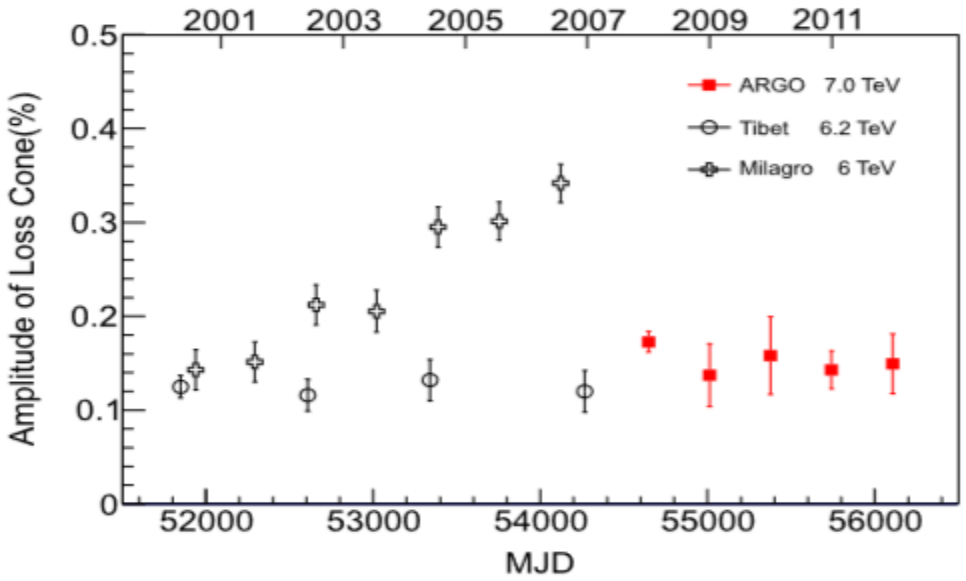


Fig. 3. Map showing the fluxes of particles in galactic coordinates. Sky map in galactic coordinates showing the cosmic-ray flux for $E \geq 8$ EeV smoothed with a 45° top-hat function. The galactic center is at the origin. The cross indicates the measured dipole direction; the contours denote the 68% and 95% confidence level regions. The dipole in the 2MRS galaxy distribution is indicated. Arrows show the deflections expected for a particular model of the galactic magnetic field (*8*) on particles with E/Z = 5 or 2 EeV.

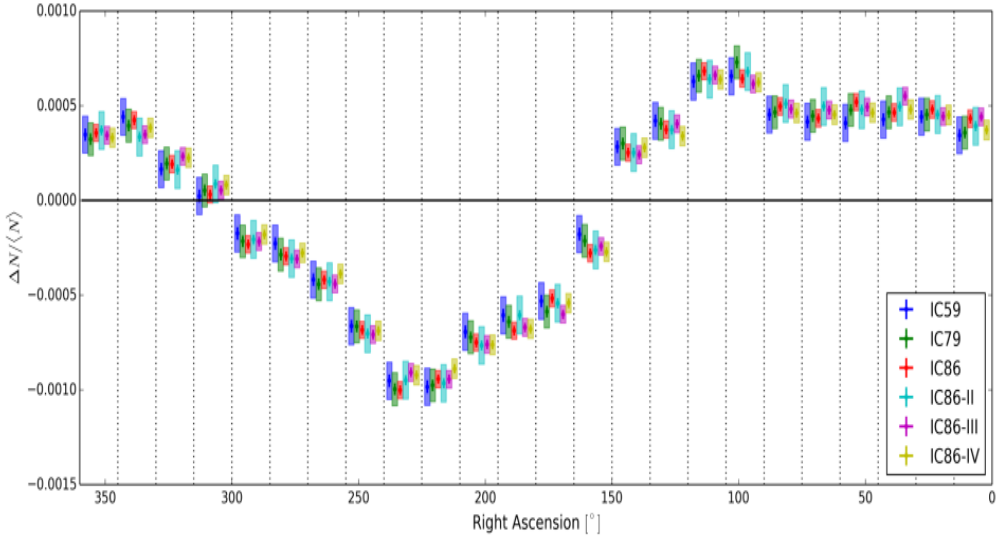
The Pierre Auger Collaboration, Science 357, 1266–1270 (2017)

Long term observation @ TeV

ARGO、Tibet Asγ、Milagro



IceCube



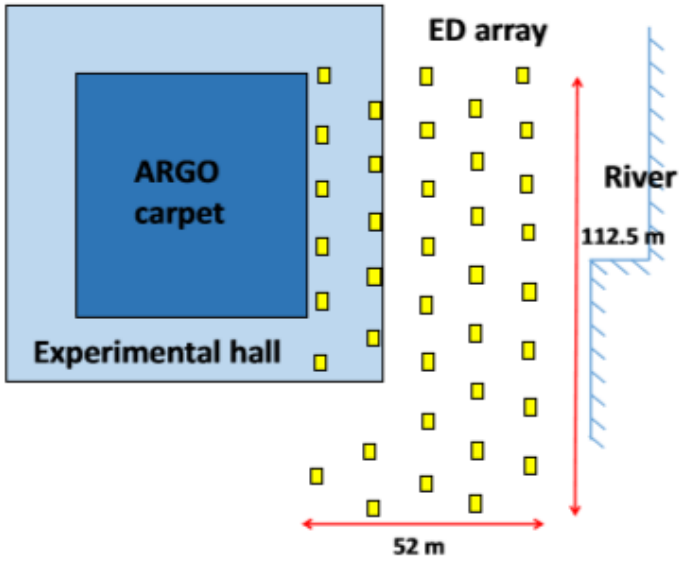
Aartsen et al 2016

LHAASO

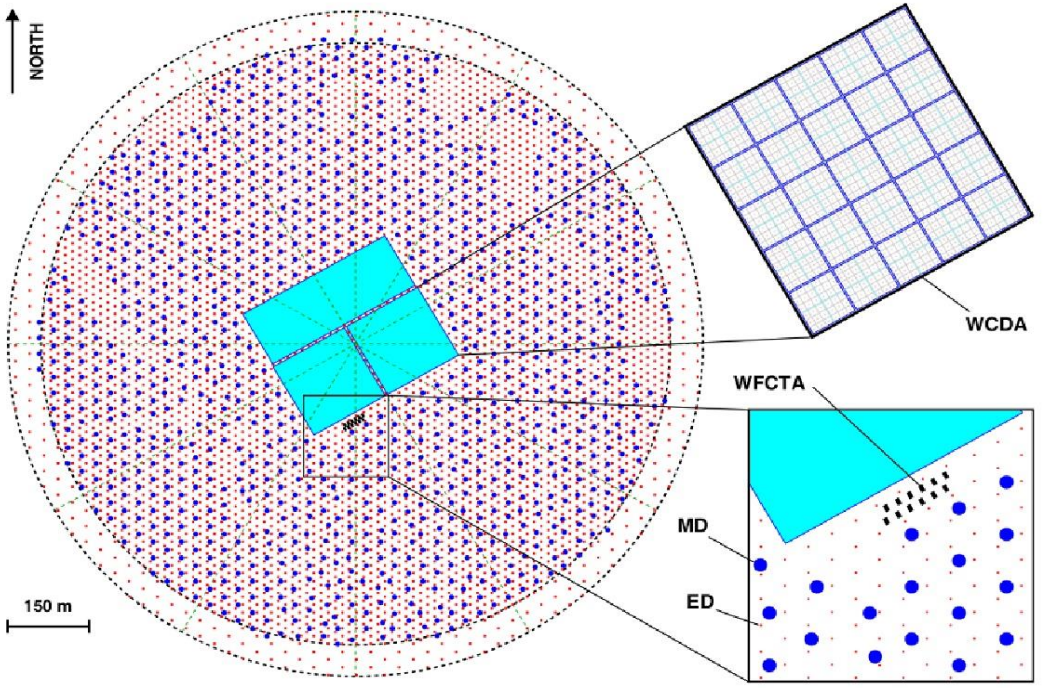
KM2A-prototype array@YangBaJing

KM2A+WCDA+WFCTA@DaoCheng

KM2A prototype array



LHAASO



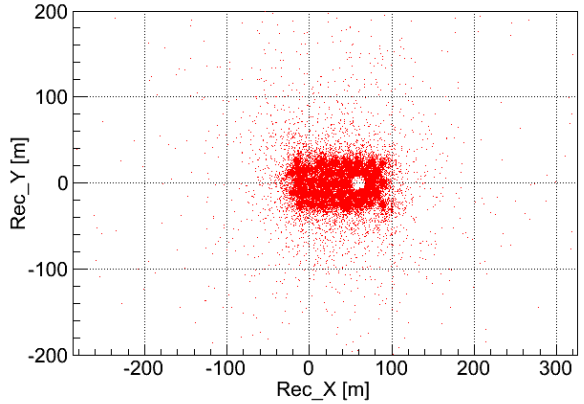
The experiment data

KM2A-protoarray@YangBaJing

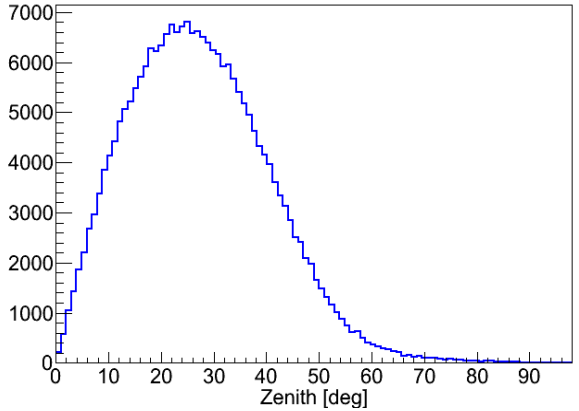
33ED@Daocheng

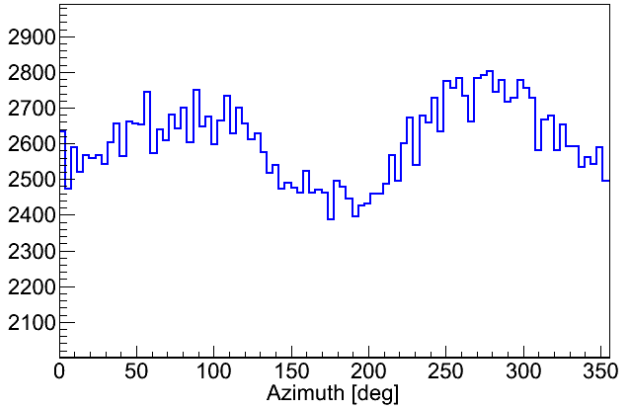
71ED+10MD@ Daocheng

WCDA @ Daocheng



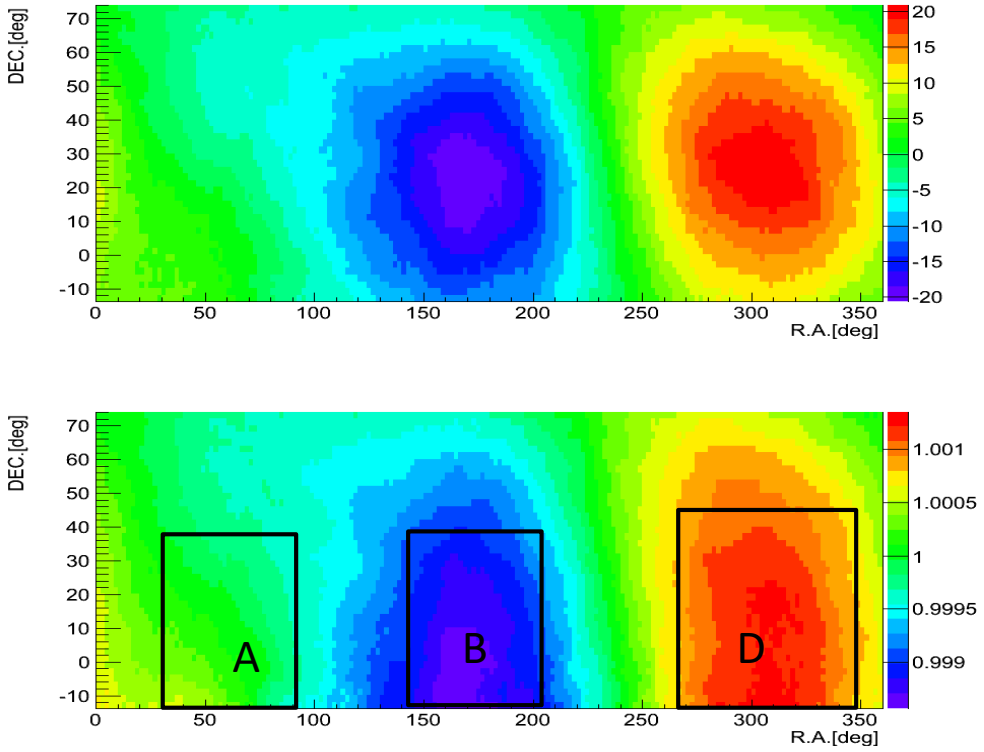
From 2014.10 to 2016.9
nfiltE ≥ 5
Zenith angle < 50°
About 2.08×10^9 events

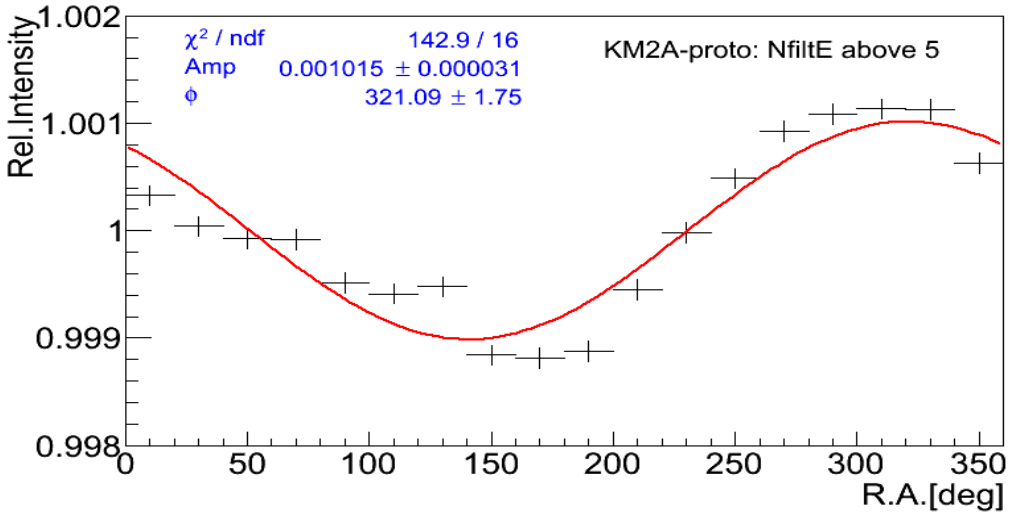




Anisotropy with prototype array

About 29 TeV, with 30 deg smooth





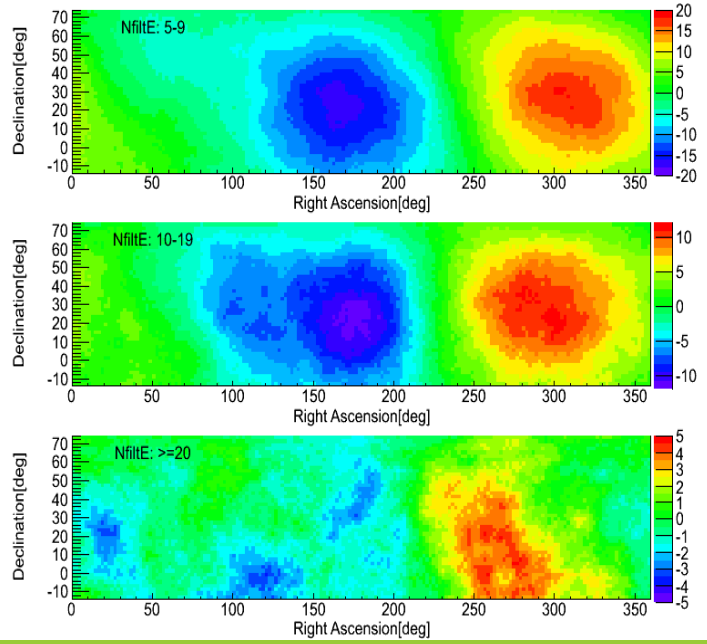
Range A: vanished “Tail-in”
Range B: “Lose-cone”
Range D: Confused “excess”

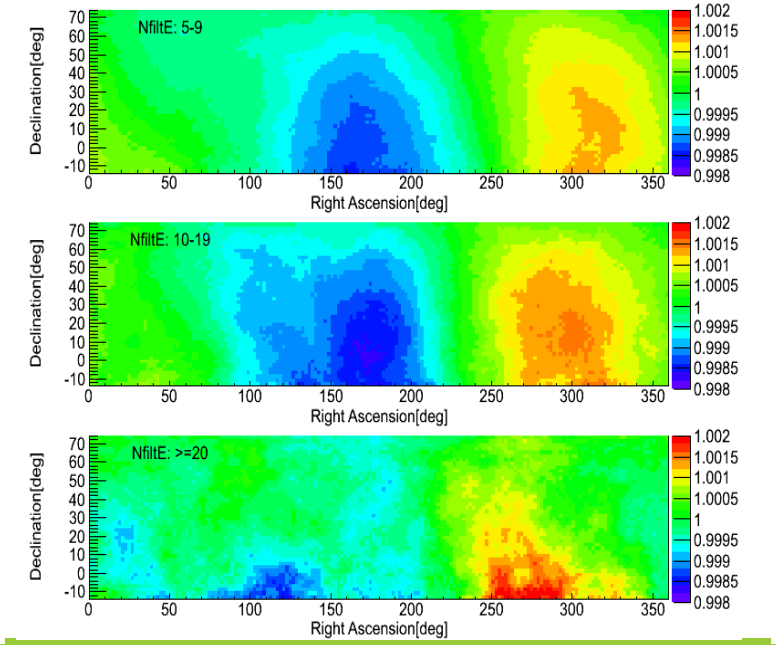
Energy dependence

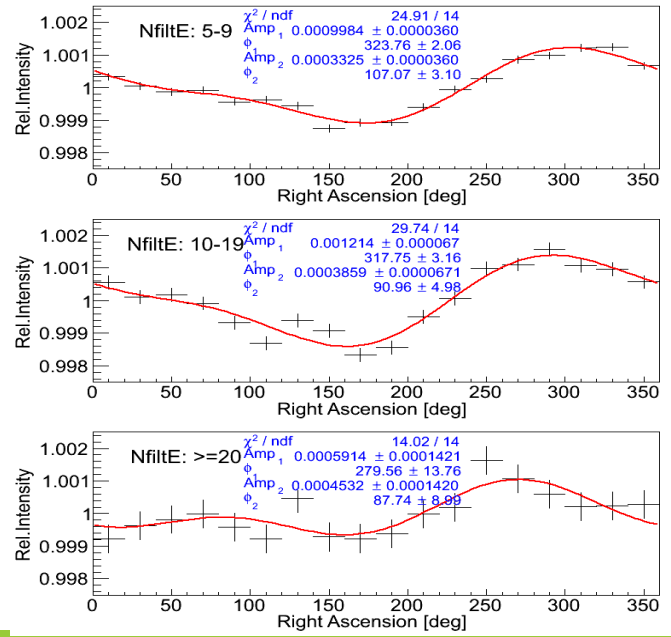
NfitE	Energy (TeV)	events
5-9	18.95	1.54e9
10-19	38.08	4.44e8
>=20	131.51	9.90e7

E(TeV)	18.95	38.08	131.51
Amp	9.98e-04	12.14e-04	5.91e-04
Phase	323.76±2.06	317.75±3.16	279.56±13.76

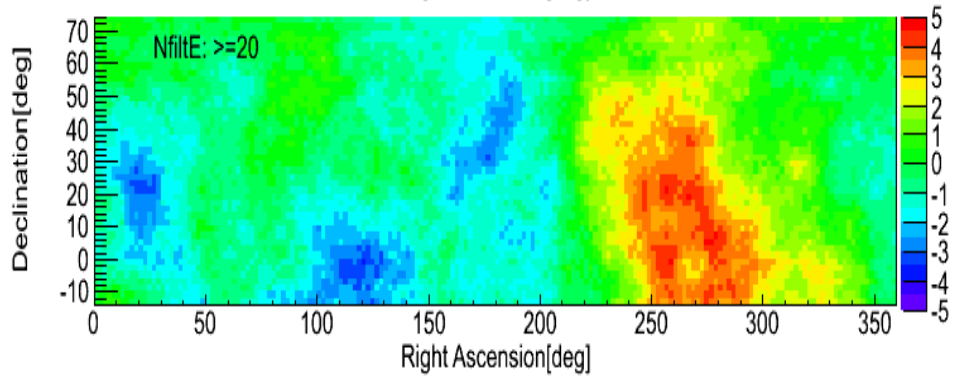
Range D: The phase of the excess has a shift.

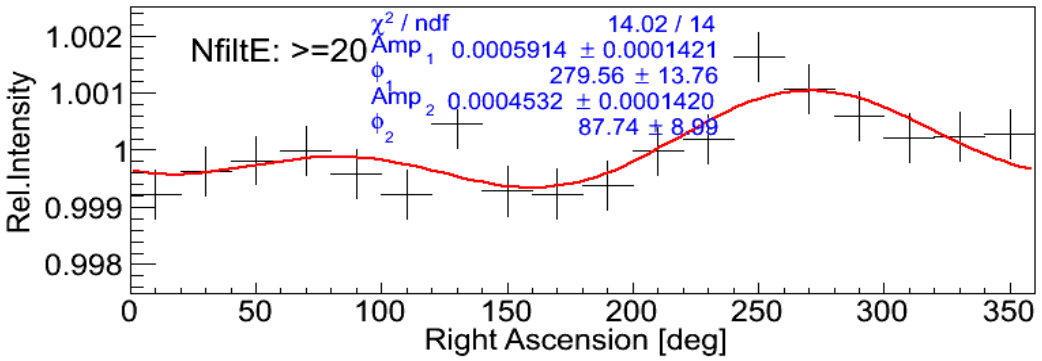


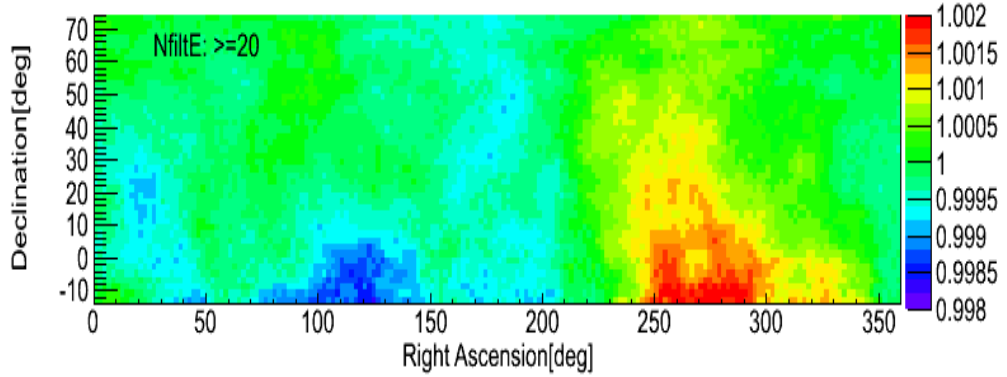




Km2a-proto:130TeV







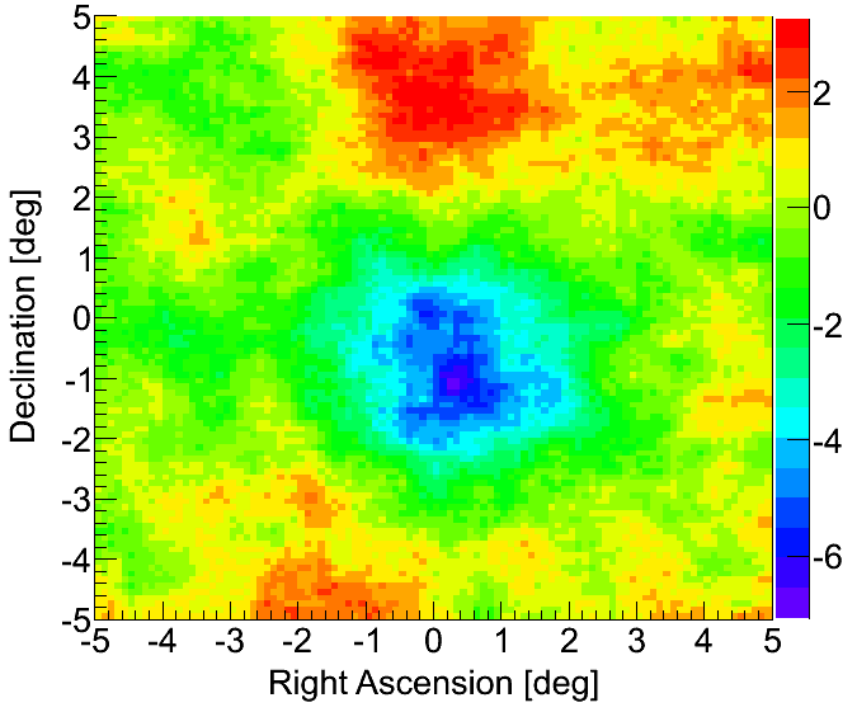
With the phase at **279.56±13.76**, then

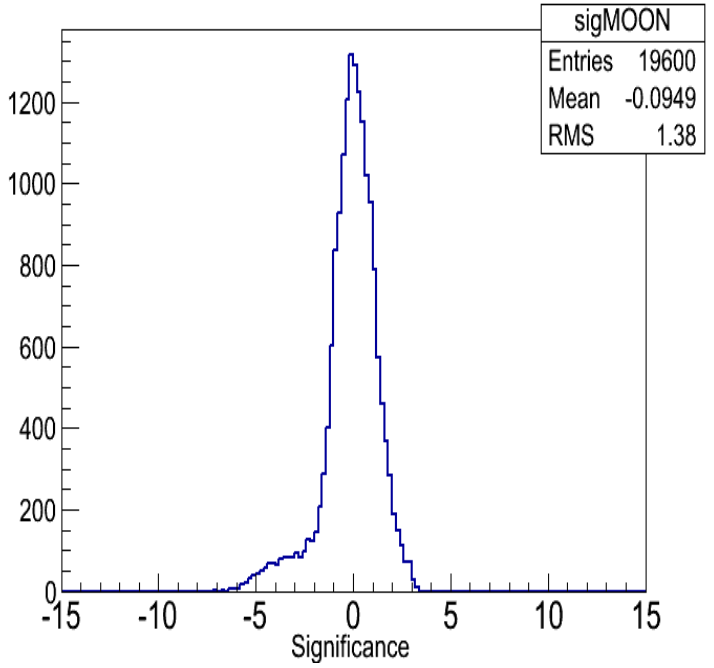
- Range D: Confused “excess” ?
- Range C: The new excess toward Galactic Center ?

Check: Moon shadow

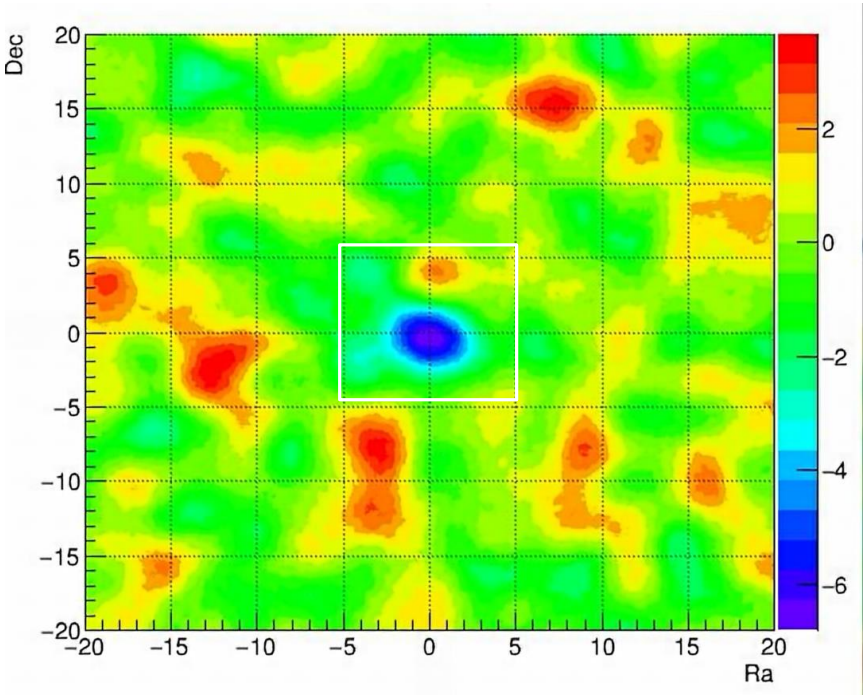
Zen <50， 0.1 degree/bin,1.5 deg smooth,NfiltE>=5

This work

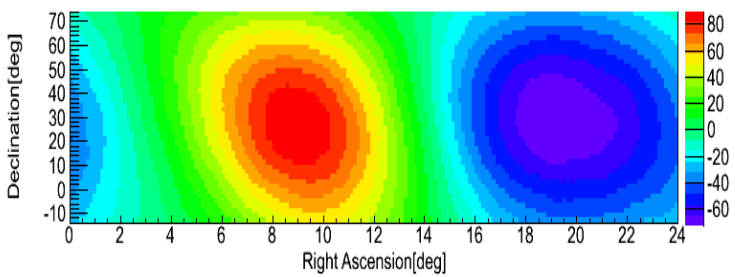


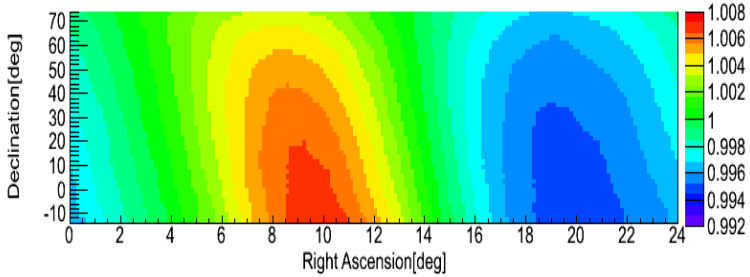


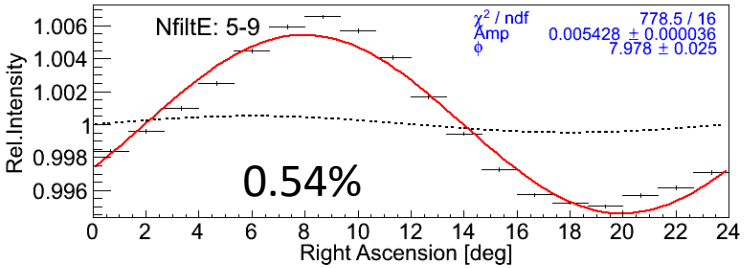
Chensz

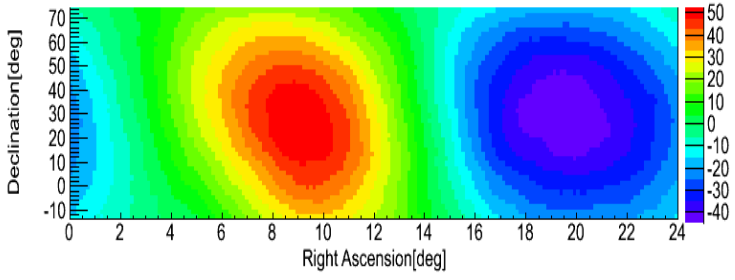


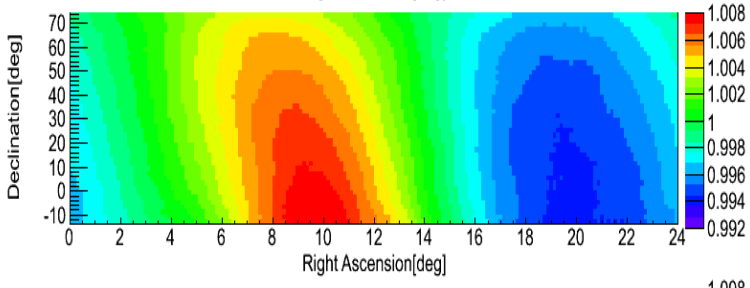
Check: Solar time

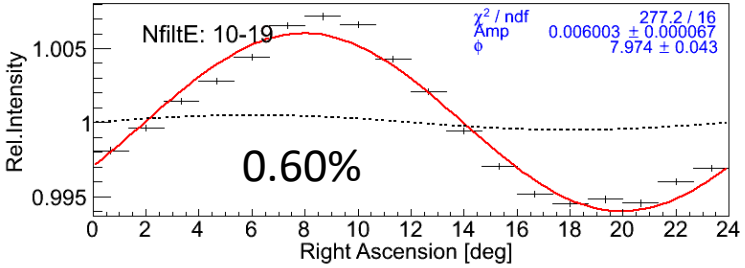


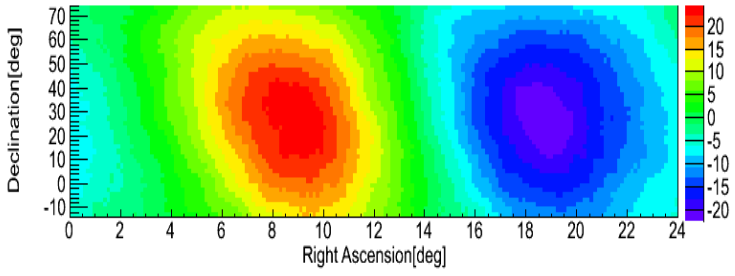


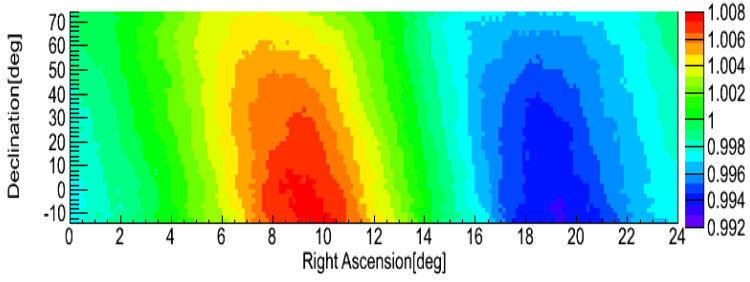


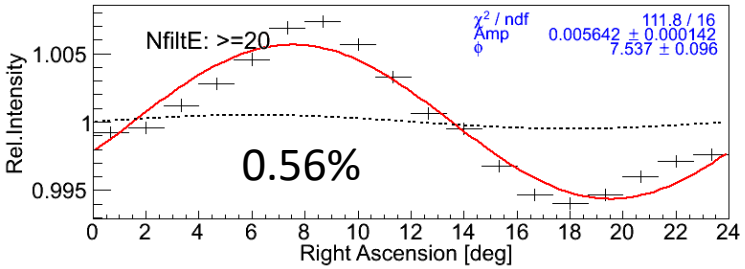






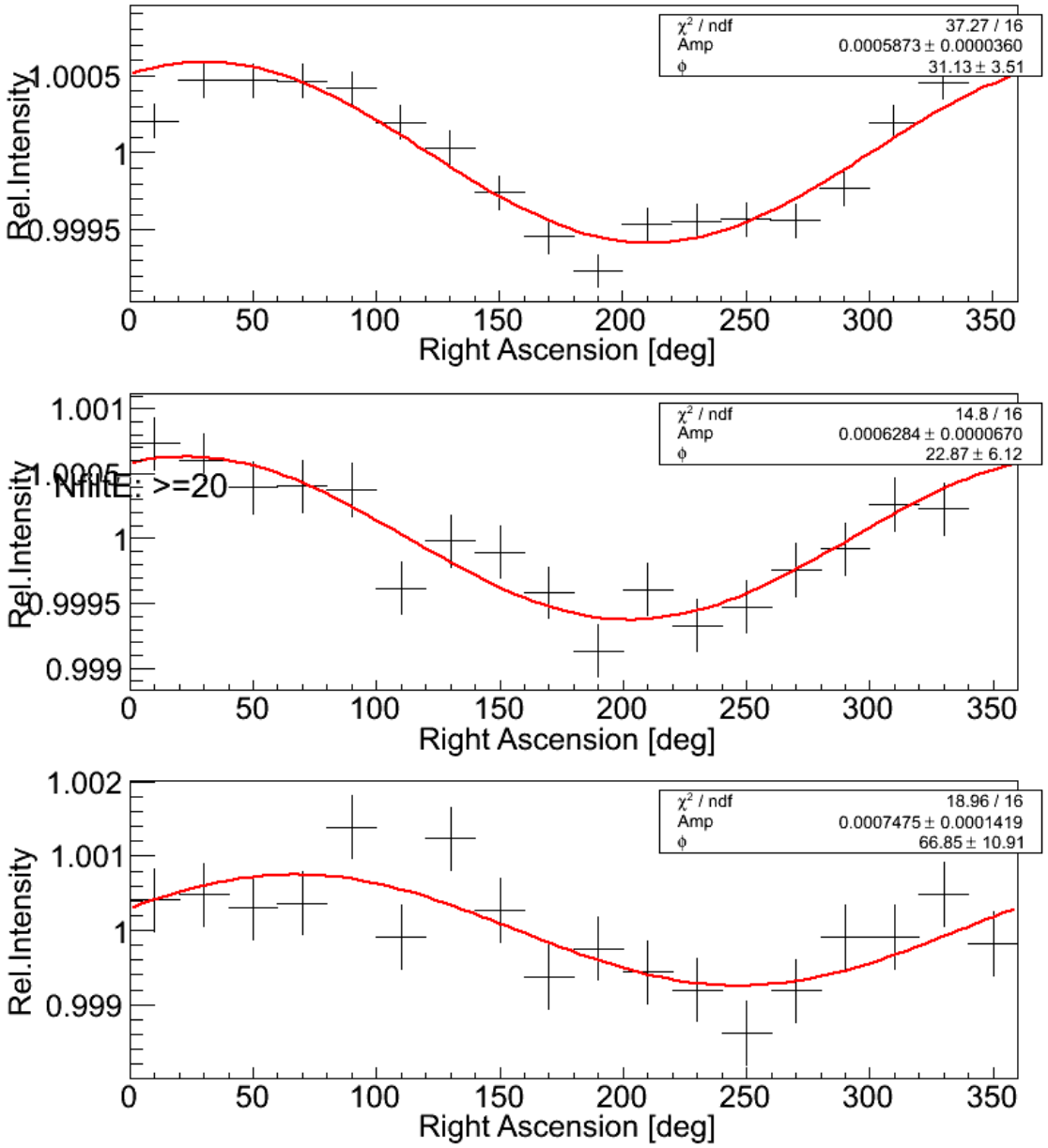






Check: Anti-sidereal

E(TeV)	Amp_sid	Amp_anti	Phi_anti
19	9.98e-04	5.87e-04	31
38	12.14e-04	6.28e-04	23
130	5.91e-04	7.47e-04	67



Conclusion

- The anisotropy with data collected by km2a-prototype array was analyzed.
- A confused excess in range D was observed, and the causes of the feature is still unknown.

Future plan

- More detail work to check the prototype array data.
- Analysis the data collected by portion-array of LHAASO