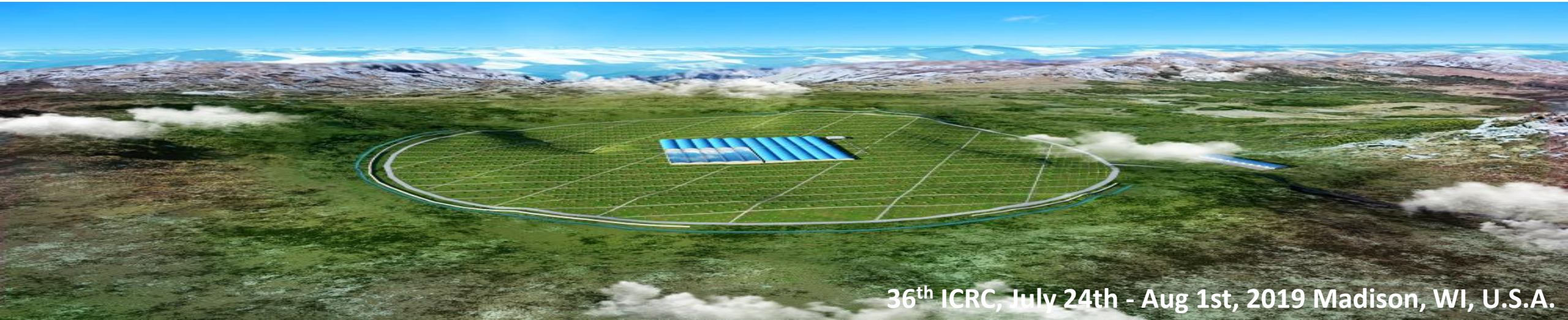




# The Large-scale Anisotropy of Cosmic Rays Observed with the Partial LHAASO-KM2A Array

**Wei Gao**, Shandong University  
for the LHAASO Collaboration



36<sup>th</sup> ICRC, July 24th - Aug 1st, 2019 Madison, WI, U.S.A.

# Content

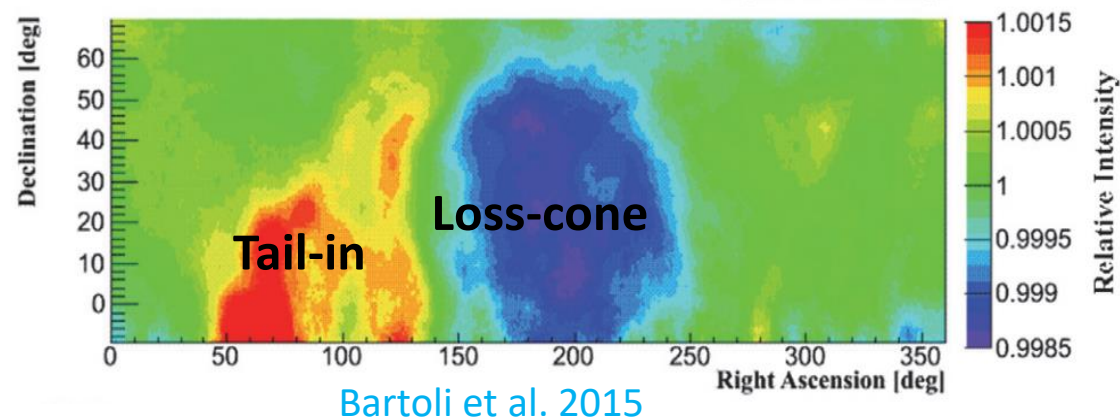
- Introduction
- LHAASO
- Preliminary results
- Summary & Outlook

# Introduction

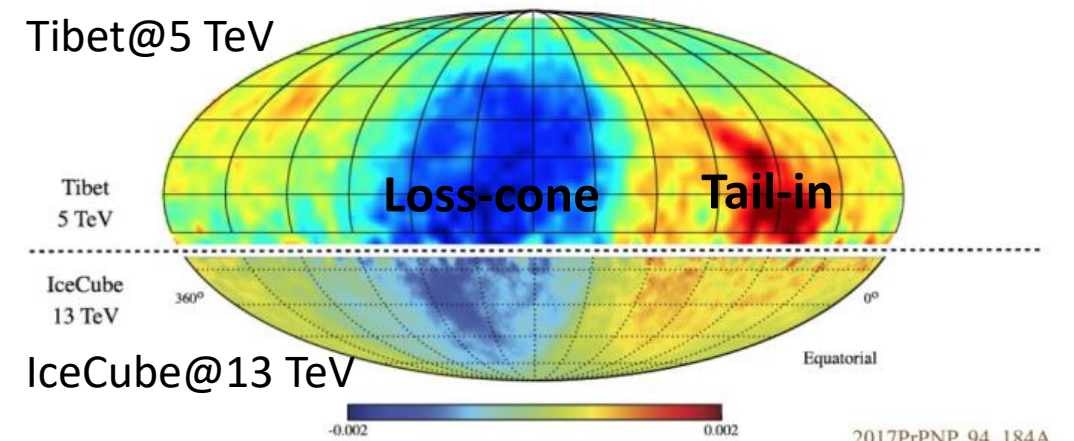
- Cosmic ray anisotropy observation:
  - Northern hemisphere: Tibet-Asy, ARGO-YBJ, Milagro, HAWC, PAO
  - Southern hemisphere: IceCube & IceTop

## Multi-TeV

ARGO-YBJ@1.3 TeV



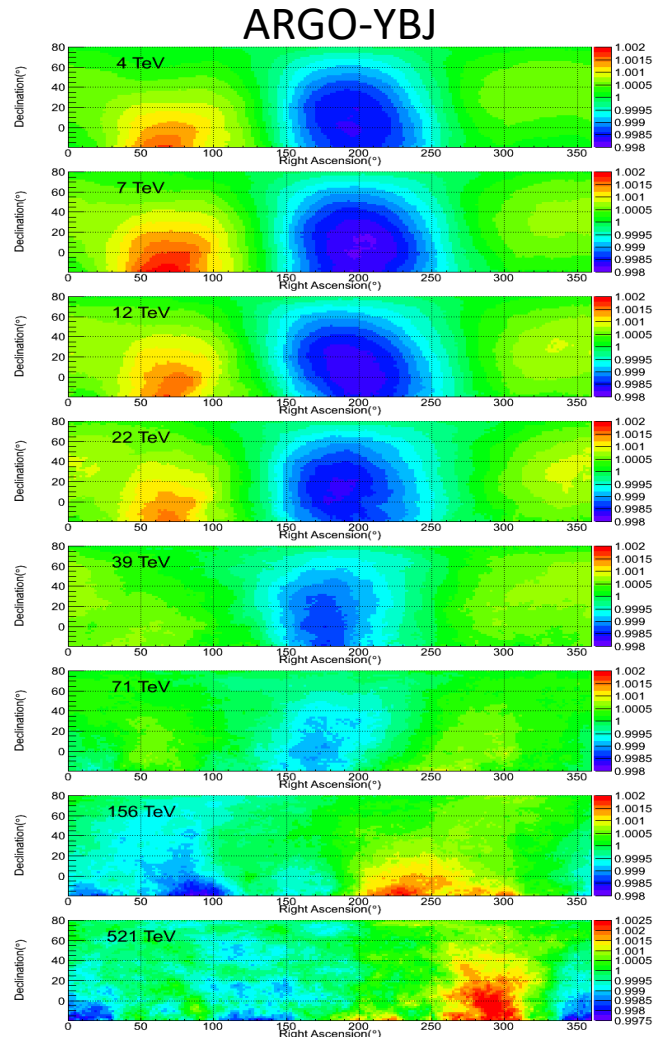
Tibet@5 TeV



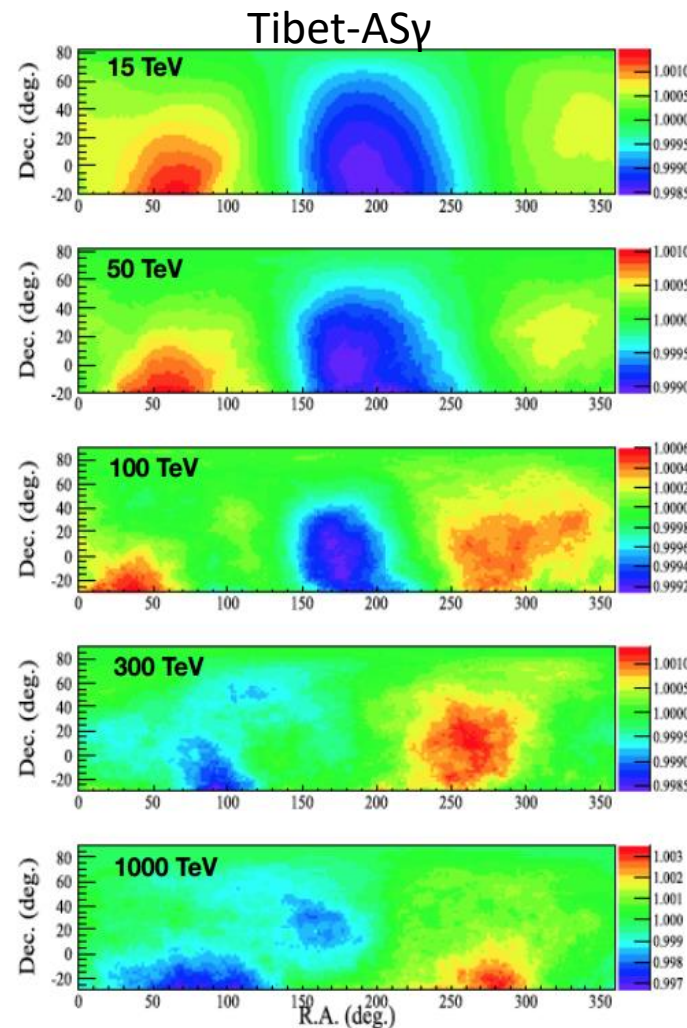
IceCube@13 TeV



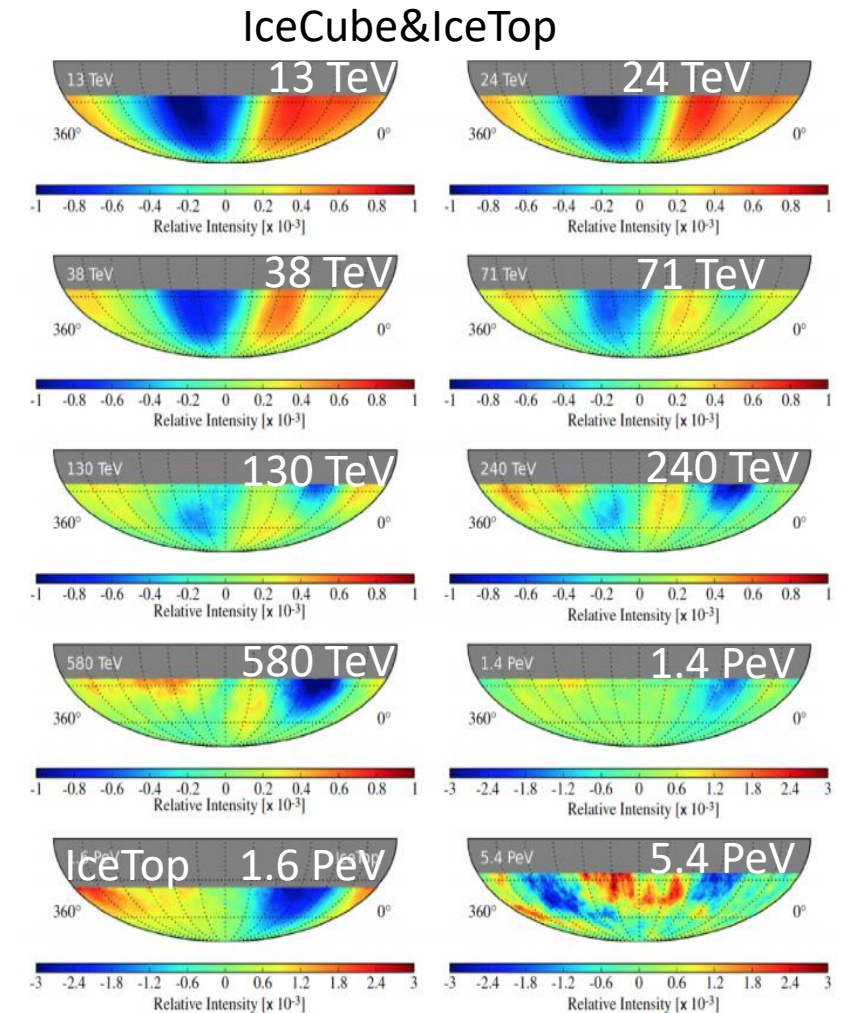
# Anisotropy VS Energy



Bartoli et al. 2018

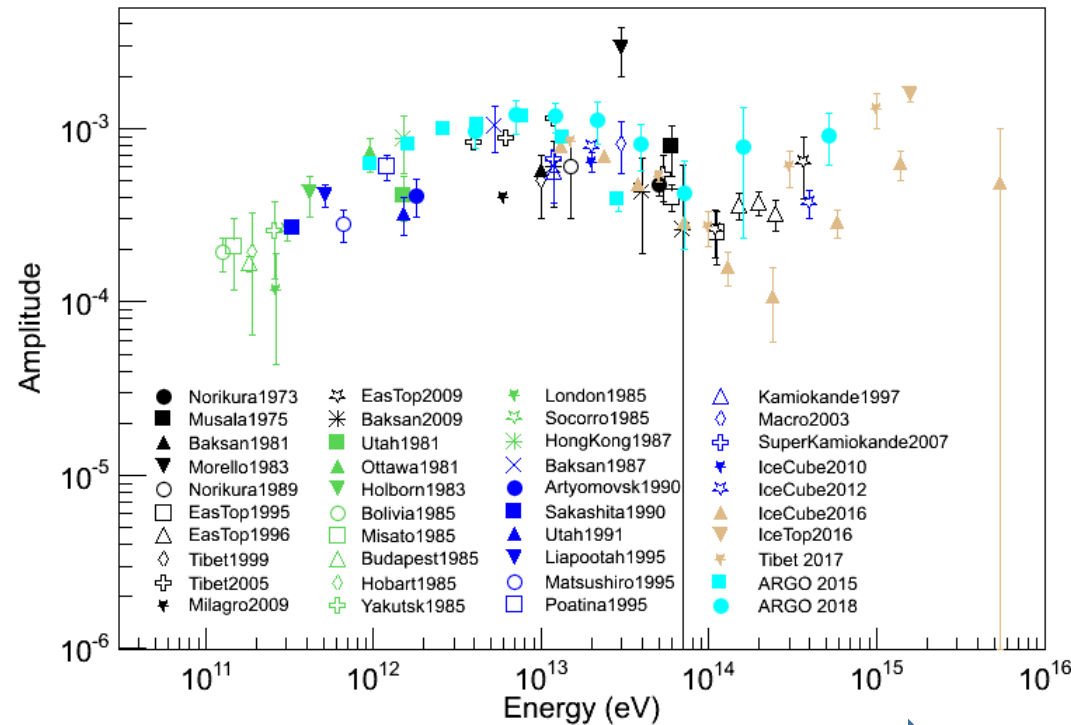


M. Amenomori et al. 2017

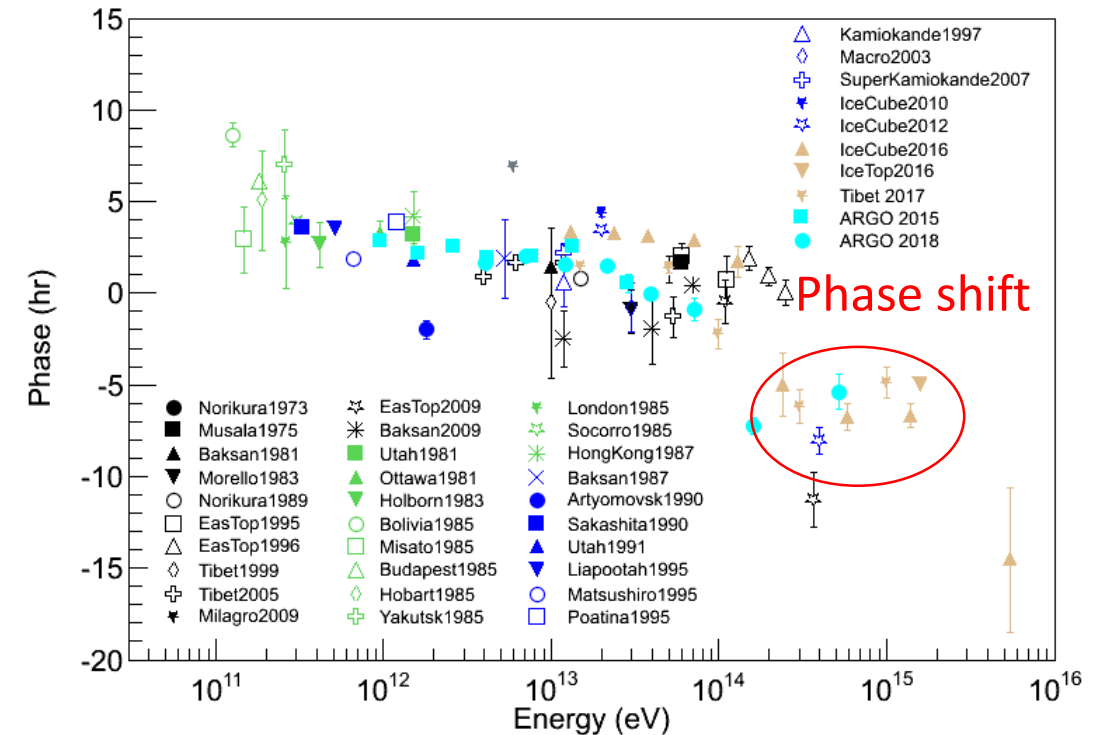


Aartsen et al. 2016

# Anisotropy VS Energy



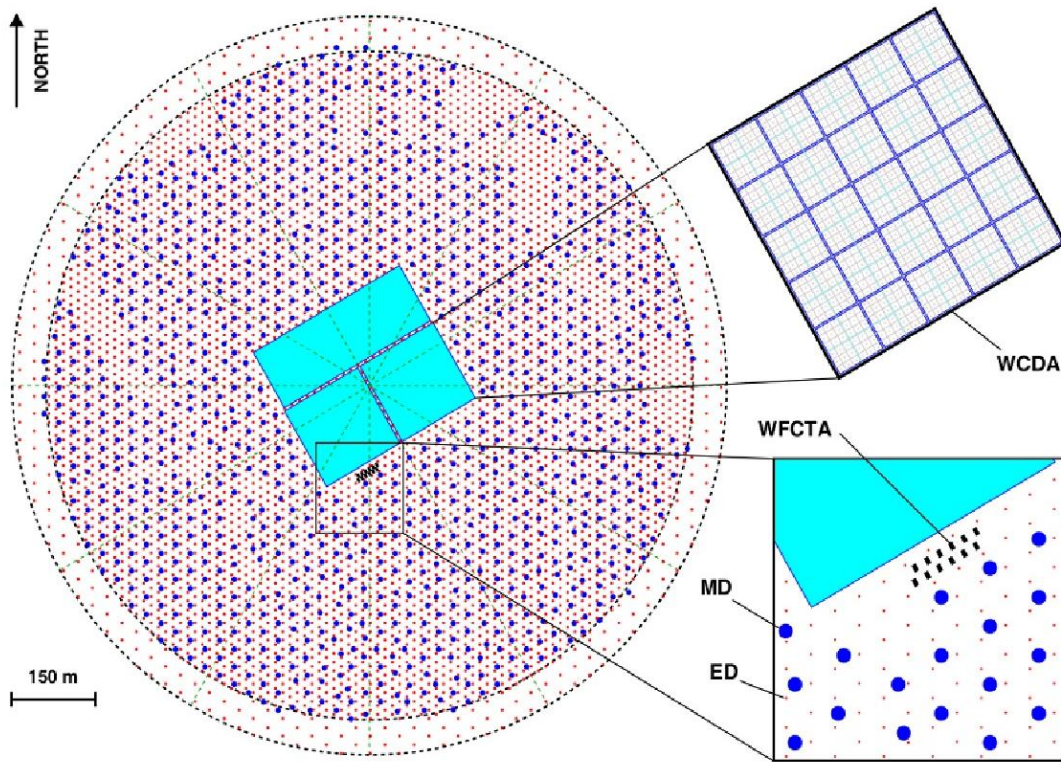
Energy range of LHAASO





# LHAASO (Large High Altitude Air Shower Observatory)

- 4410 m a.s.l. @ Daocheng, Sichuan, China



## Kilometer Array (KM2A):

5195 Electromagnetic particle Detectors (EDs)  
1171 Muon Detectors (MDs)  
1.3 km<sup>2</sup> area

## Water Cherenkov Detector Array (WCDA):

3 water ponds  
3120 detectors  
78,000m<sup>2</sup> area

## Wide Field Cherenkov Telescope Array (WFCTA):

18 wide-field-of-view Cherenkov/fluorescence telescopes

# Detector deployment

- The progress is going smoothly:

--- 2018.02 --- 33 EDs started operation (**this work**)

--- 2019.04 --- 71 EDs and 10 MDs of KM2A, 1<sup>st</sup> water pool of WCDA in operation

--- 2019.07 --- 960 EDs and 230 MDs of KM2A, 2 telescopes of WFCTA, deployed

.....

- **LHAASO detector deployment will be completed by the end of 2020.**

# Data

- Collected by 33 EDs (6600 m<sup>2</sup>)
- Trigger: at least 5 EDs are fired  
Event rate is about 42 Hz

- Dataset for this work:

--- 2018: 02~12

---  $\theta < 50^\circ$

--- No. of hits after noise filter ( $n_{filtE}$ )  $\geq 5$

Total events:  $7.2 \times 10^8$

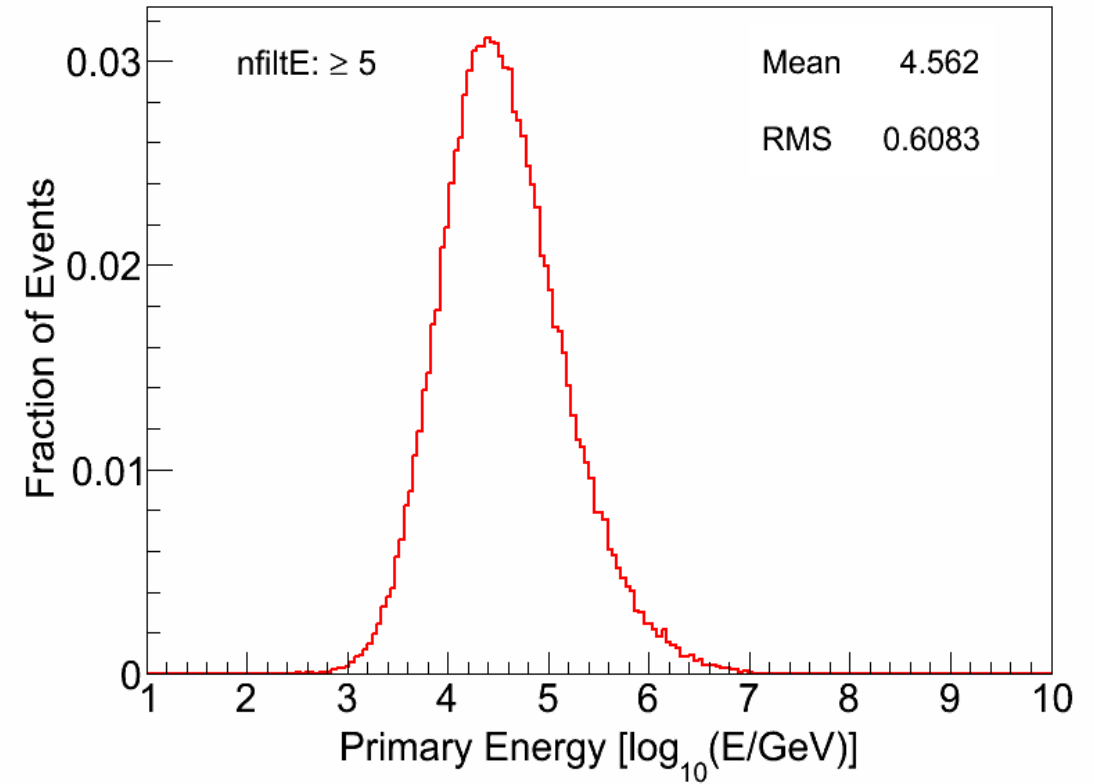




# Simulation

- Corsika7.6400: Fluka & EPOS
- Gassier model 2013
- G4KM2A for 33 EDs

Components	H, He, CNO, MgAlSi, Fe
Zenith angle	$0^{\circ} \sim 70^{\circ}$
Total events	$3.98 \times 10^9$



$$E = 10^{4.562} \text{ GeV} \approx 36.5 \text{ TeV}$$

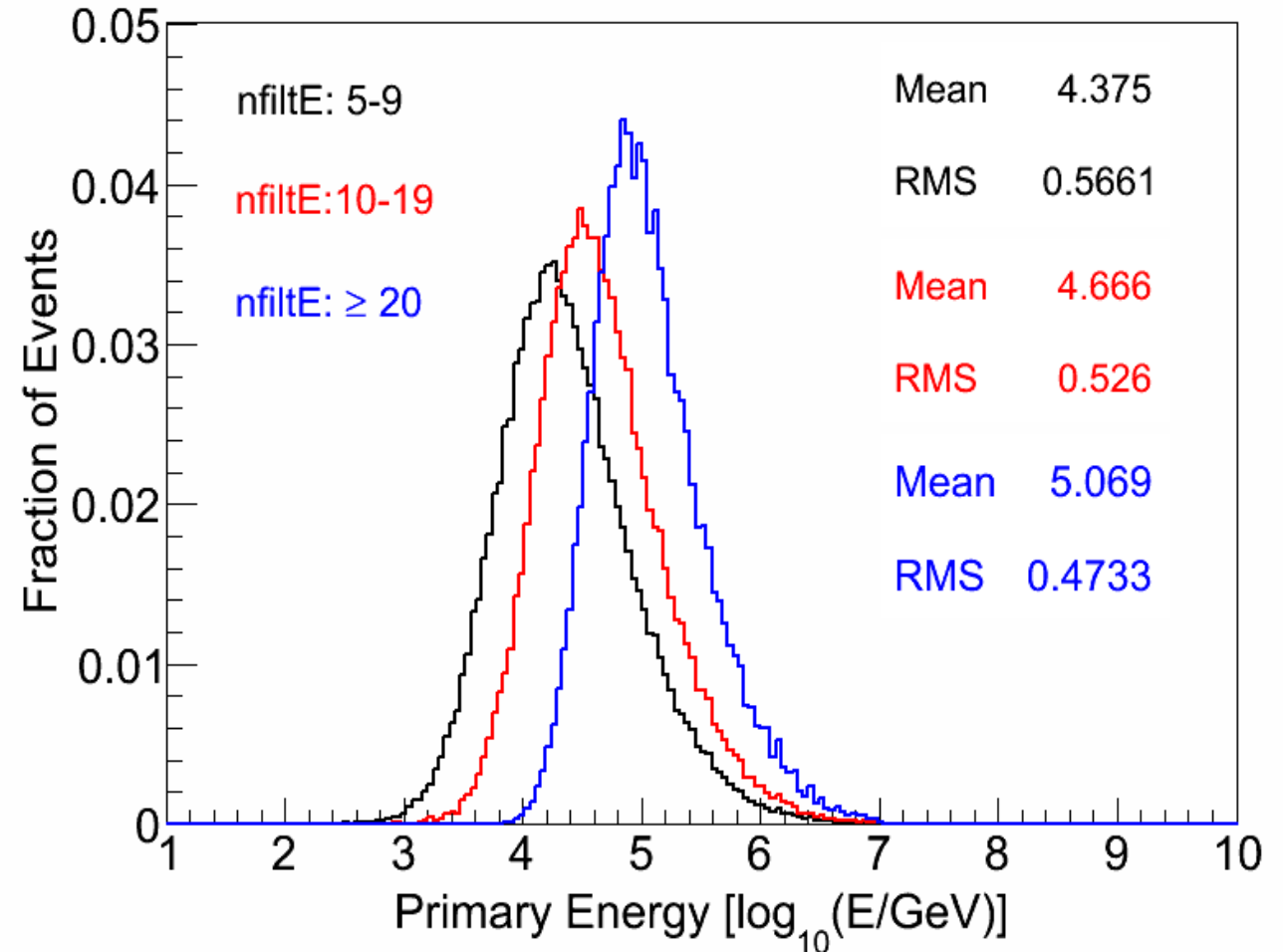
# Energy estimation

- 3 intervals according to  $n_{filtE}$

--- 5-9: about 23.7 TeV

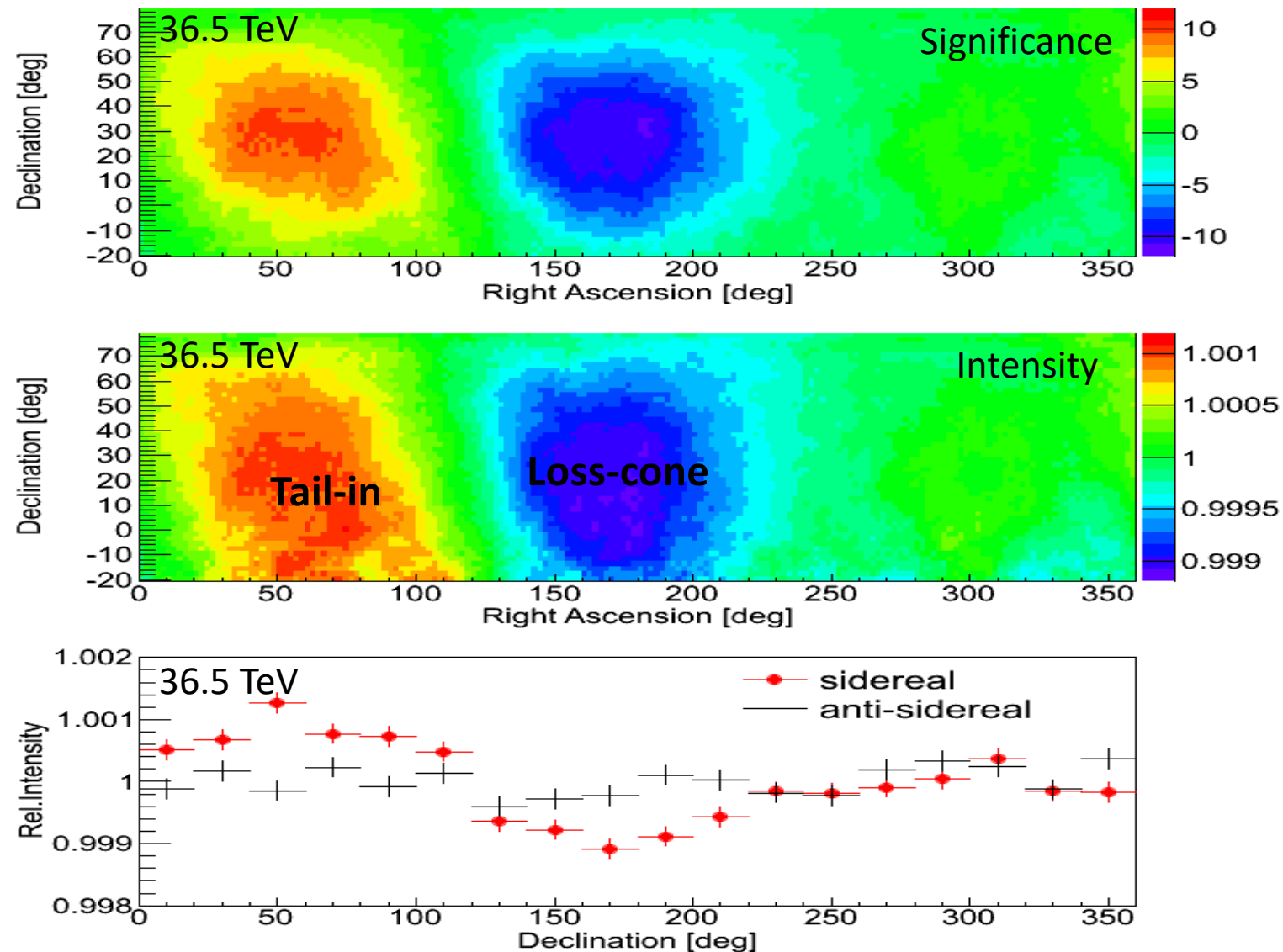
--- 10-19: about 46.3 TeV

---  $\geq 20$  : about 119.2 TeV



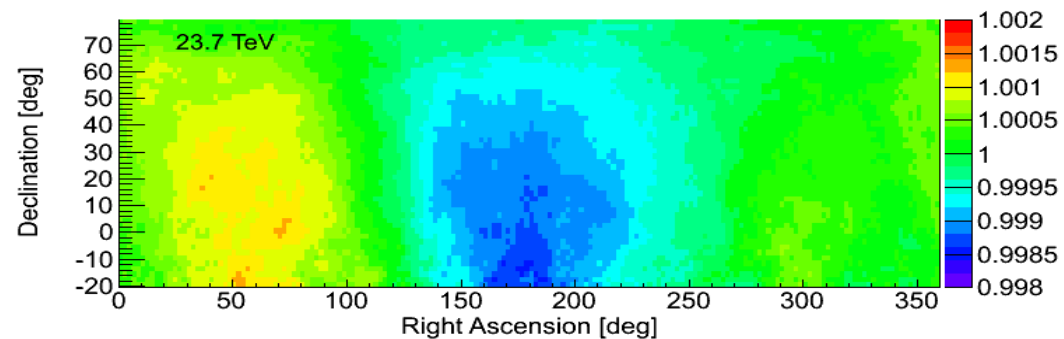
# Preliminary results

- Tail-in:  $10.5 \sigma$
- Loss-cone:  $11.4 \sigma$

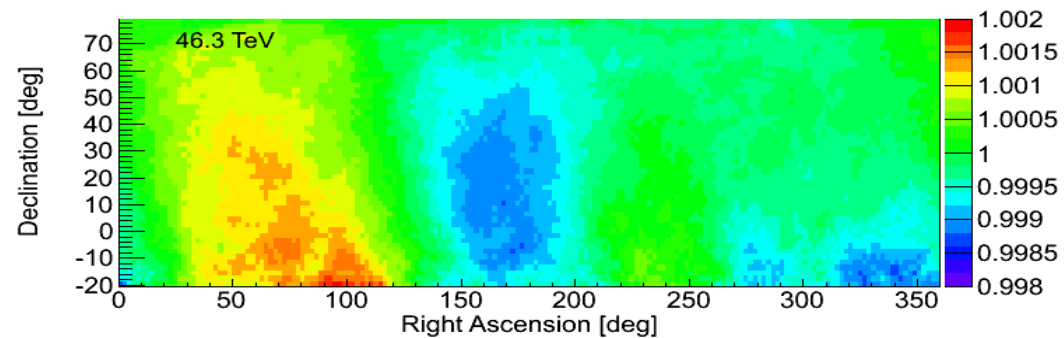




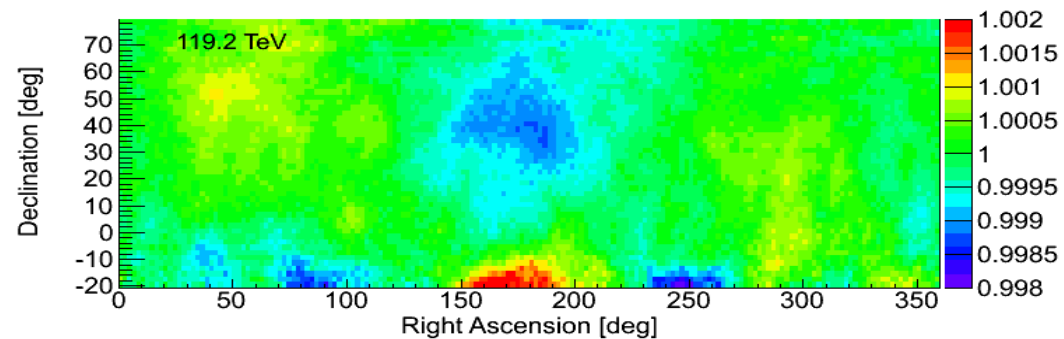
# Anisotropy VS Energy



$$4.01 \times 10^8$$

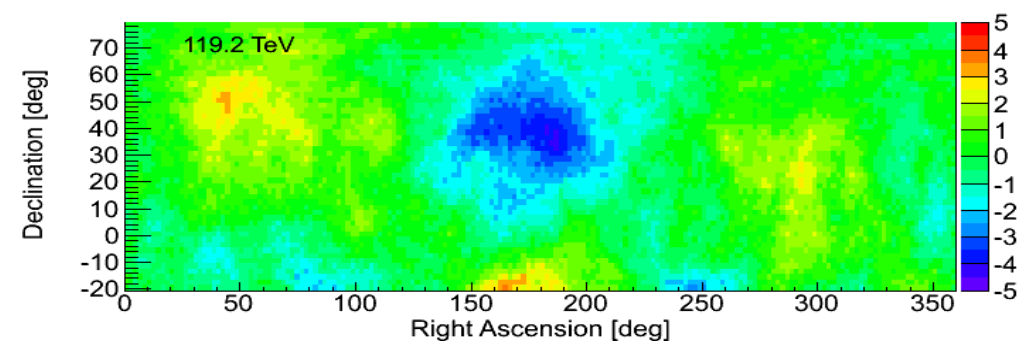
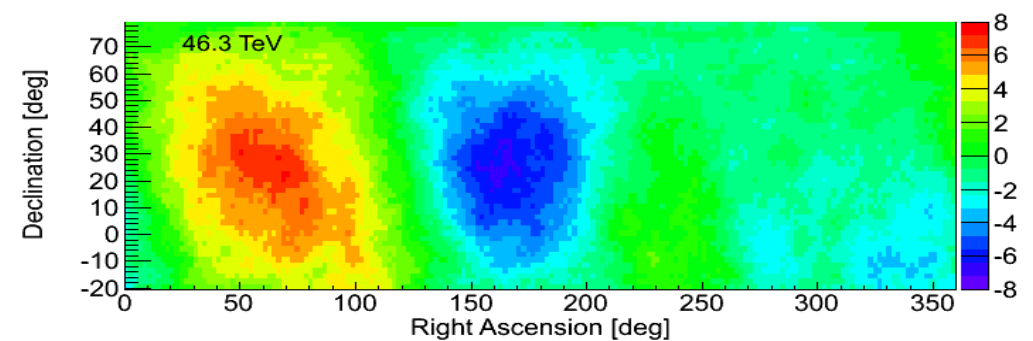
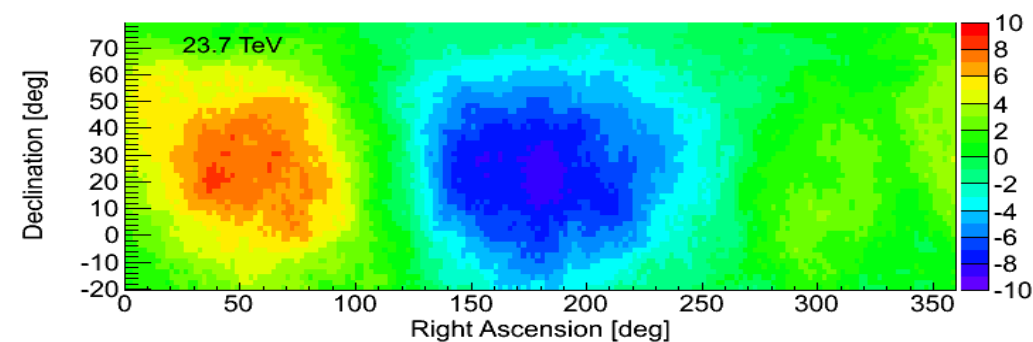


$$2.42 \times 10^8$$



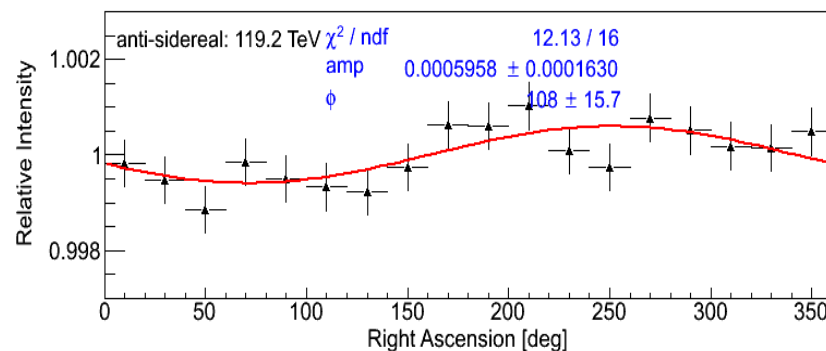
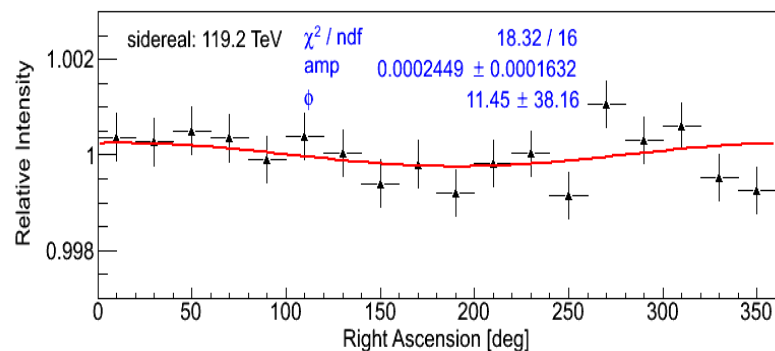
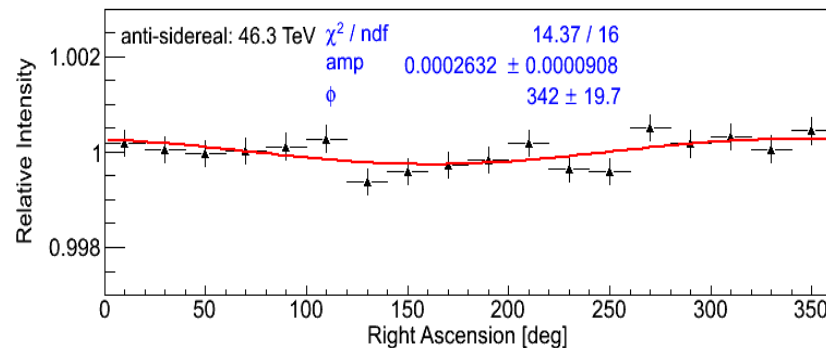
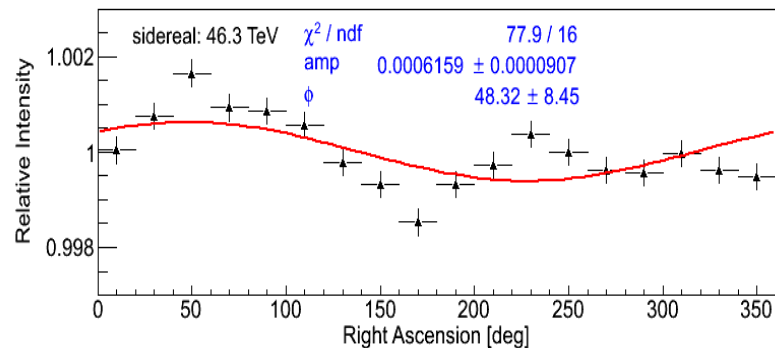
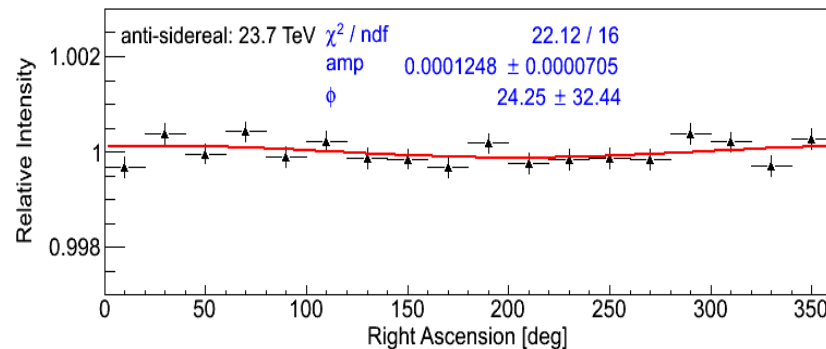
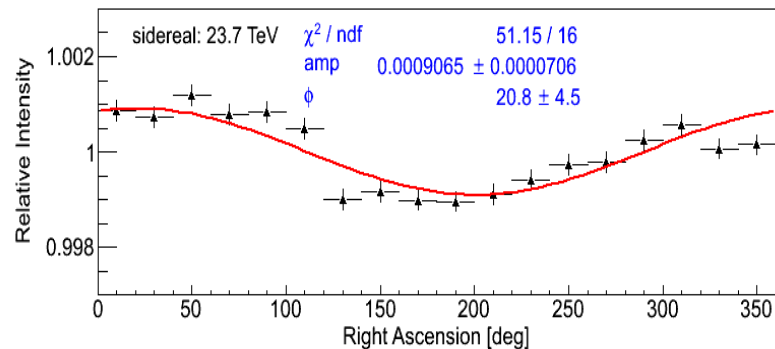
$$7.50 \times 10^7$$

intensity



significance

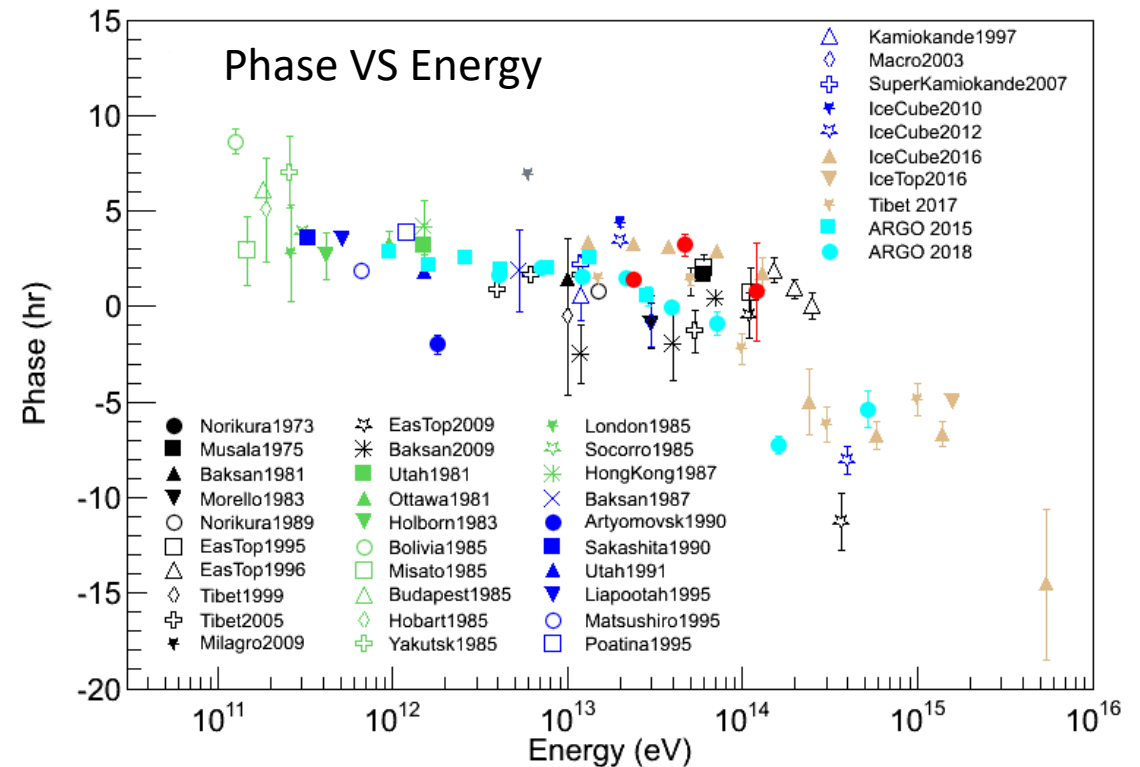
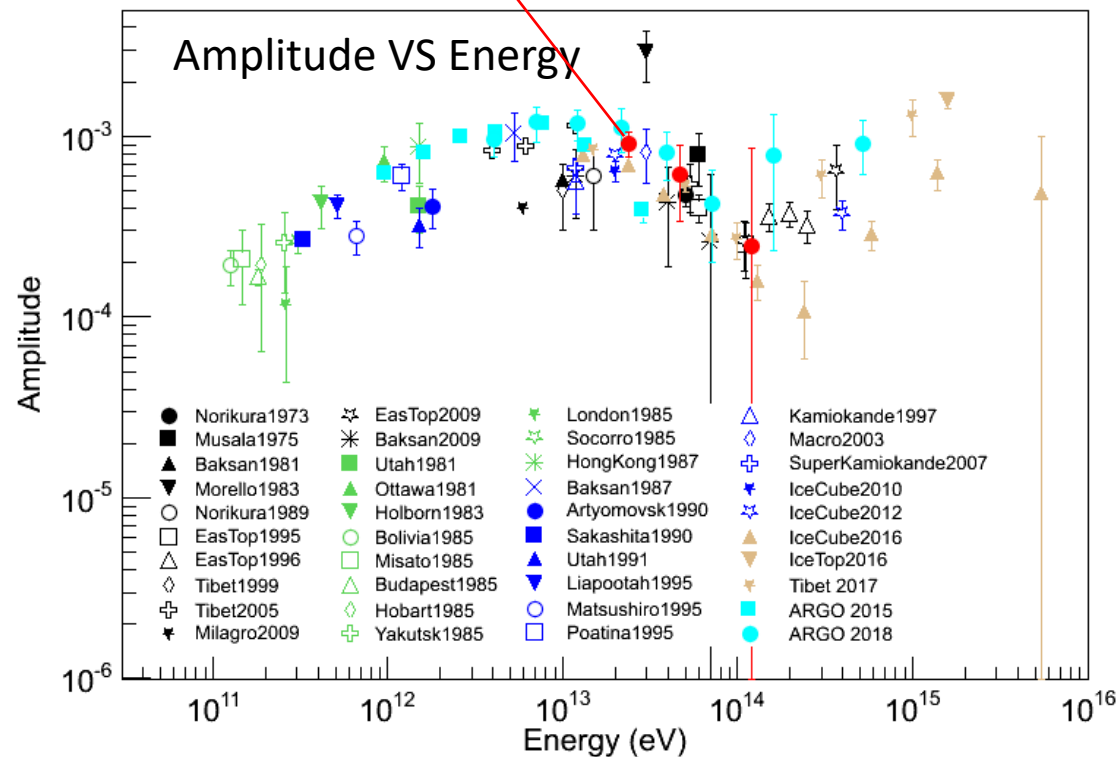
# Anisotropy VS Energy



$E$ (TeV)	$amp \pm \sigma_{stat} \pm \sigma_{sys}$ ( $\times 10^{-4}$ )	$\phi$ ( $^\circ$ )
23	$9.0 \pm 0.7 \pm 1.2$	20.8
46	$6.1 \pm 0.9 \pm 2.6$	48.3
119	$2.4 \pm 1.6 \pm 5.9$	11.4

# Anisotropy VS Energy

This work is generally consistent with others.





# Summary & Outlook

- CR anisotropy is observed by a partial array of LHAASO-KM2A
  - "Tail-in" and "loss-cone" are observed with significances of  $10.5 \sigma$  and  $11.4 \sigma$  respectively.
  - The evolution with energy is consistent with others.
- The construction of LHAASO is going on smoothly and the total array will be in operation at the beginning of 2021.
- More precise studies for anisotropy will be done.

Thanks for your attention!