

中国科学院高能物理研究所  
*Institute of High Energy Physics*  
*Chinese Academy of Sciences*

# Northern sky Galactic Cosmic Ray anisotropy between 10-1000 TeV with the Tibet Air Shower Array

Zhaoyang Feng

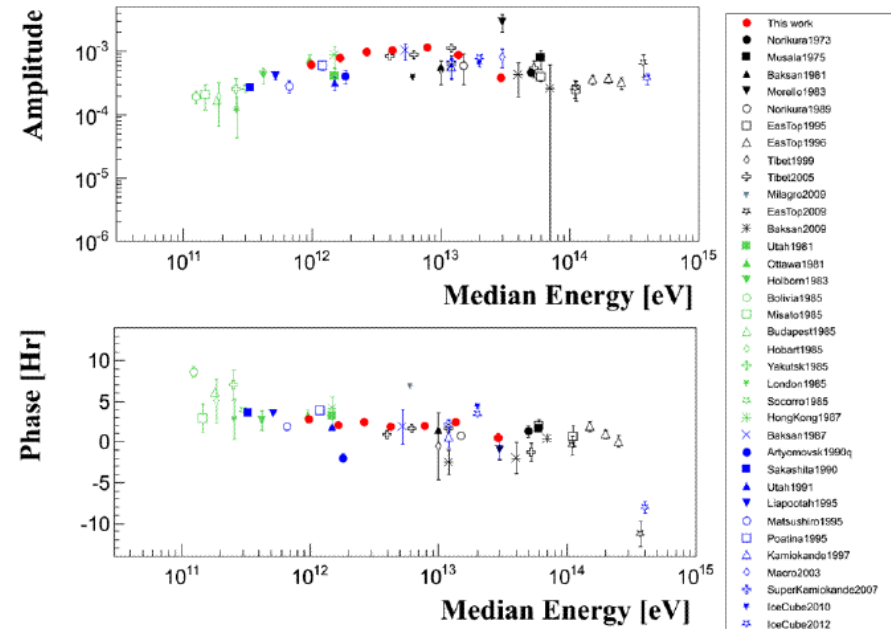
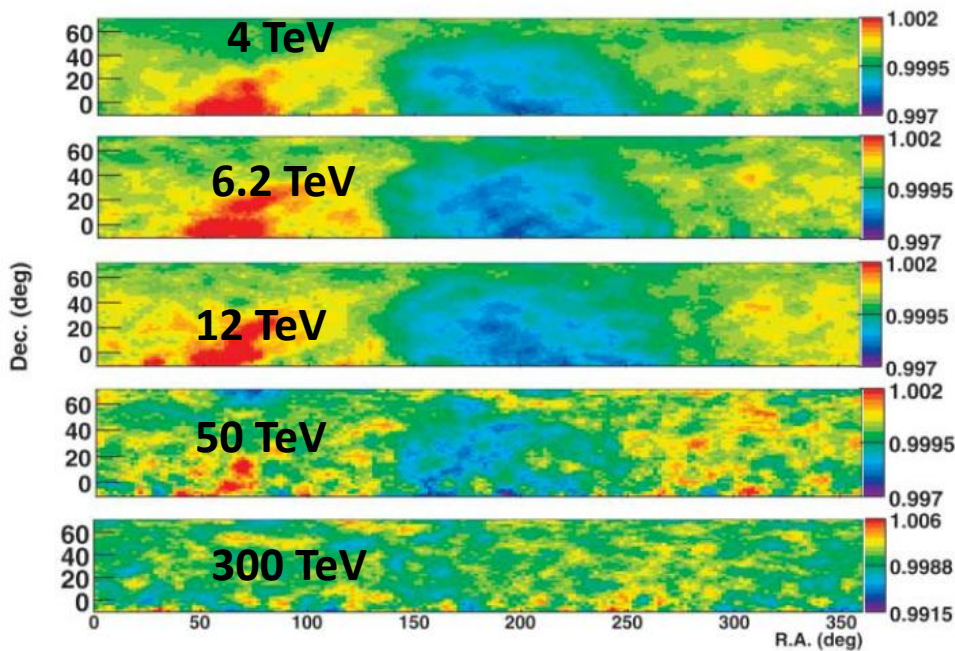
Institute of High Energy Physics, CAS, China

On behalf of the Tibet ASγ Collaboration

**ID0880**, ICRC2015, the Haag

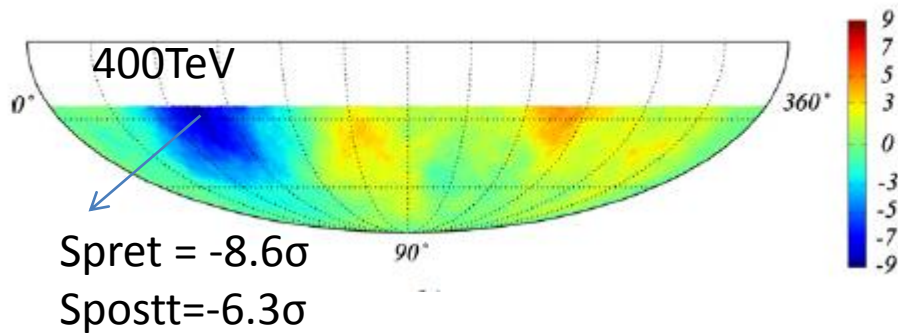
# Large Scale Anisotropy and previous Results

## Tibet AS Array

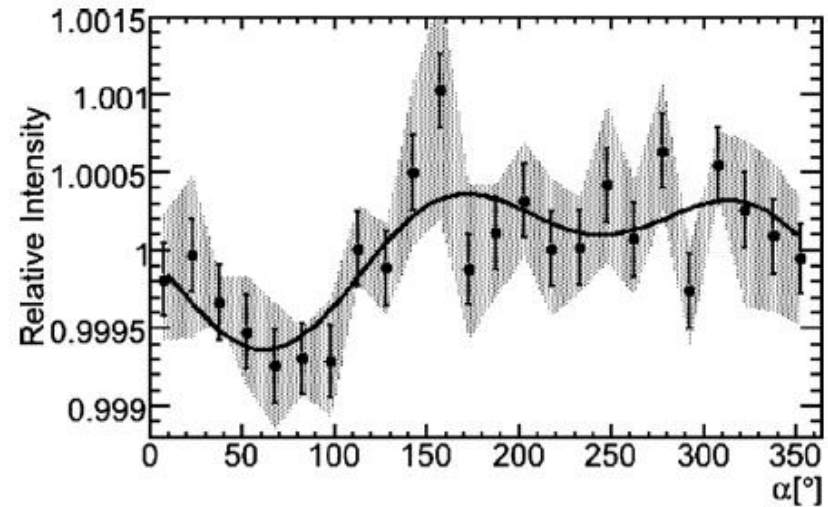


# 400 TeV anisotropy observations in the southern sky

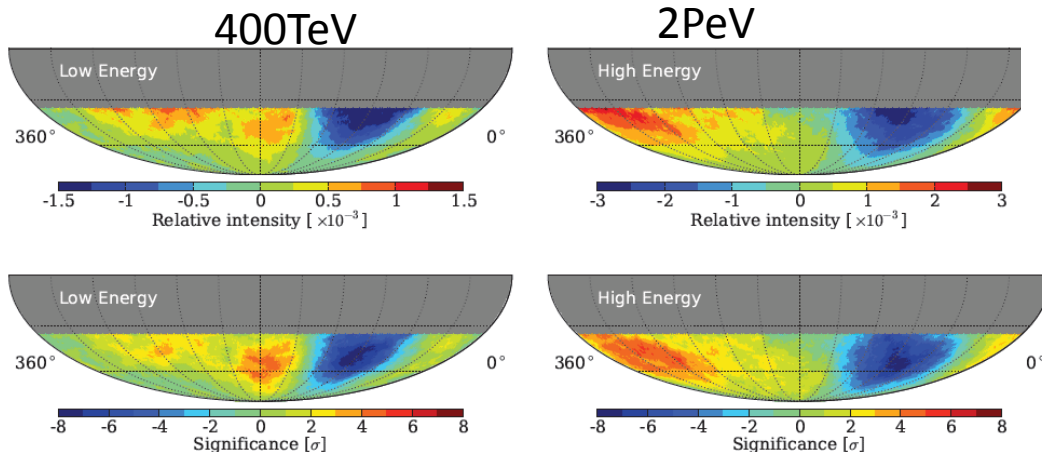
**IceCube:** new anisotropy structure



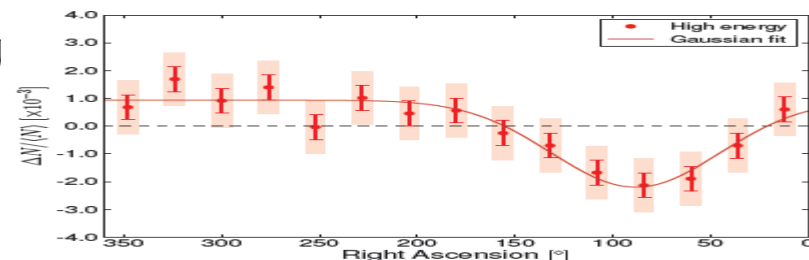
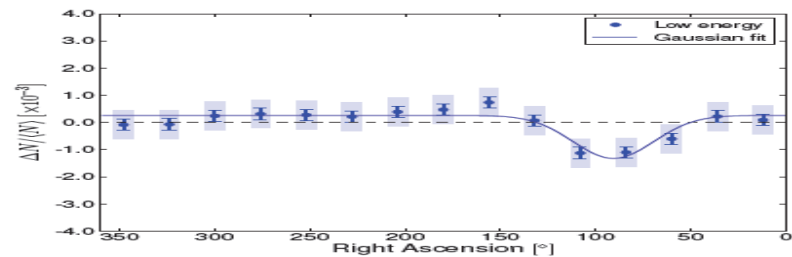
ApJ, 746, 33, 2012



**IceTop:** consist with IceCube results, persists to PeV energies



ApJ, 765, 55, 2013

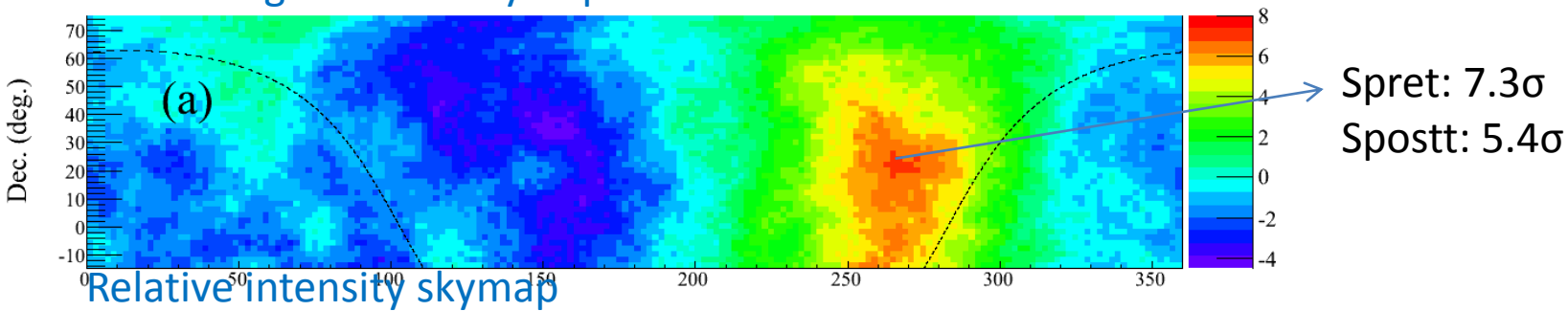


# Large Scale Anisotropy at 300 TeV

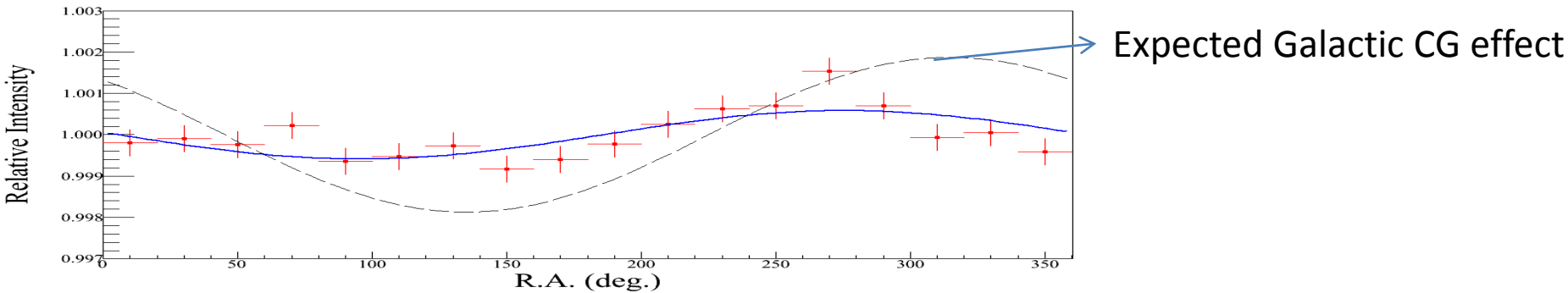
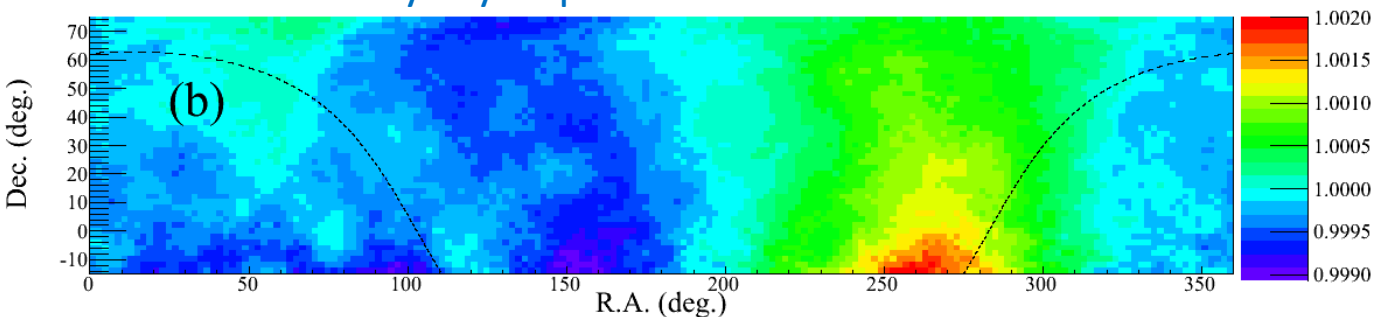
Smooth radius: 29°

Using data with  $\theta < 45^\circ$

Statistic significance skymap



Relative intensity skymap



- The anisotropy structure can't be described in terms of expected Galactic CG effect neither in amplitude nor in phase.



# Tibet AS $\gamma$ Experiment

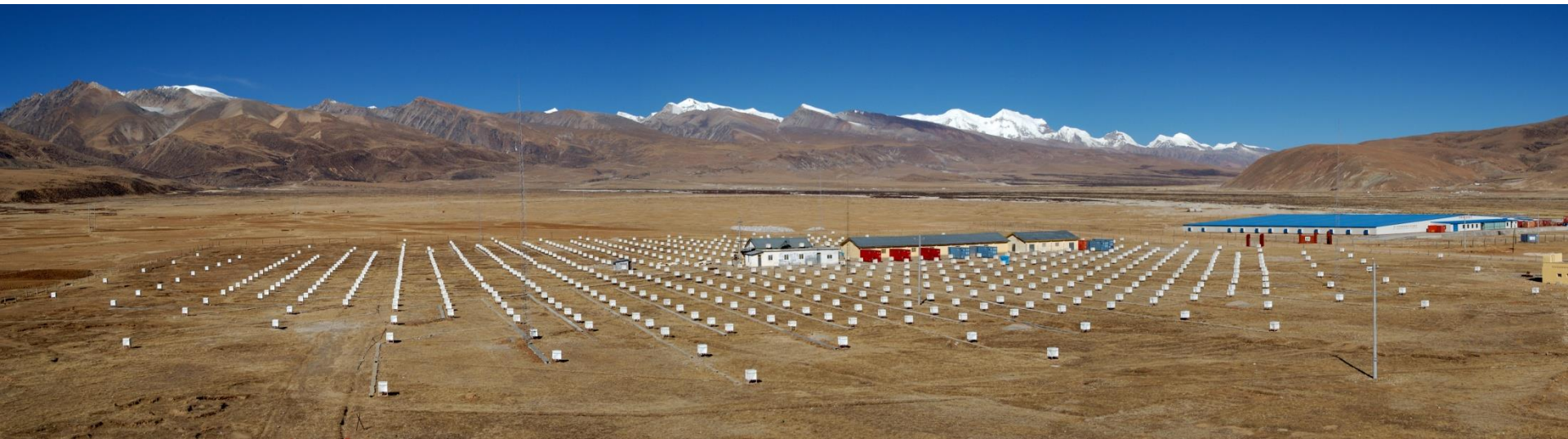
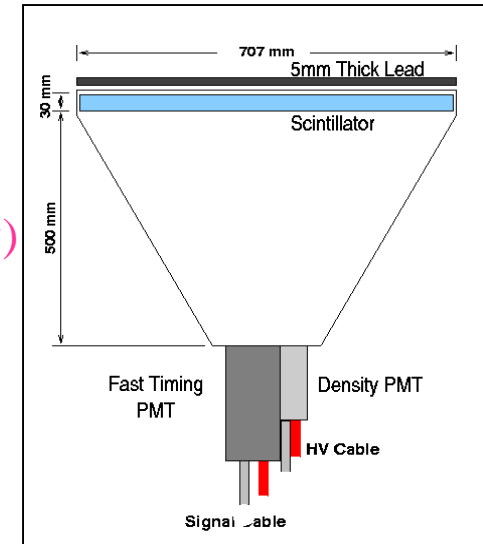
Tibet China (90.522°E, 30.102°N) 4300 m a.s.l., since **1989**

Number of Scinti. Det.  $0.5 \text{ m}^2 \times 789$

Angular Resolution for gamma rays  $\sim 0.2^\circ$  @ 100 TeV( $\gamma$ -ray)  
Energy Resolution for gamma  $\sim 40\%$  @ 100 TeV( $\gamma$ -ray)

F.O.V.  $\sim 2 \text{ sr}$

Effective Area for AS  $\sim 37,000 \text{ m}^2$



# Data sample and new energy estimation

Detector: **TibetII detector configuration**

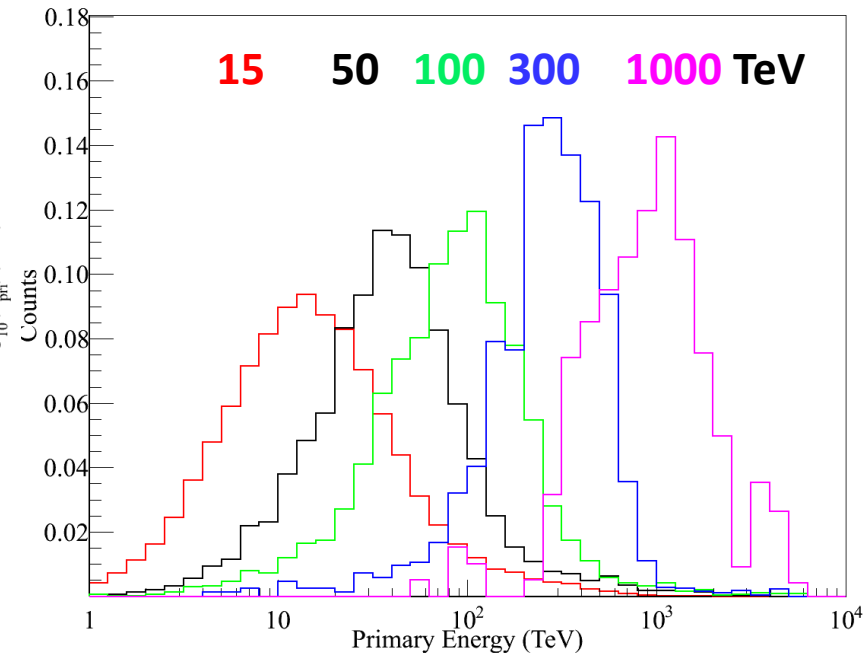
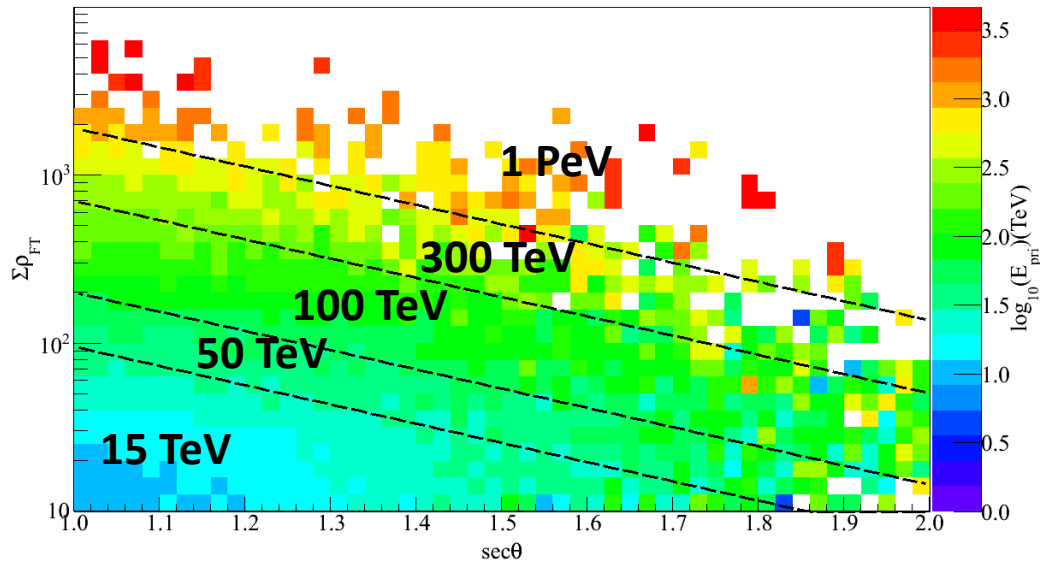
Operation Time: **1995.10-2010.2**

## Cut to select events:

1) The core inside the array.

2) **Zenith angle < 60°**

Energy Band	15TeV	50TeV	100TeV	300TeV	1PeV
# of events	2.33e10	3.97e9	1.96e9	2.71e8	5.72e7

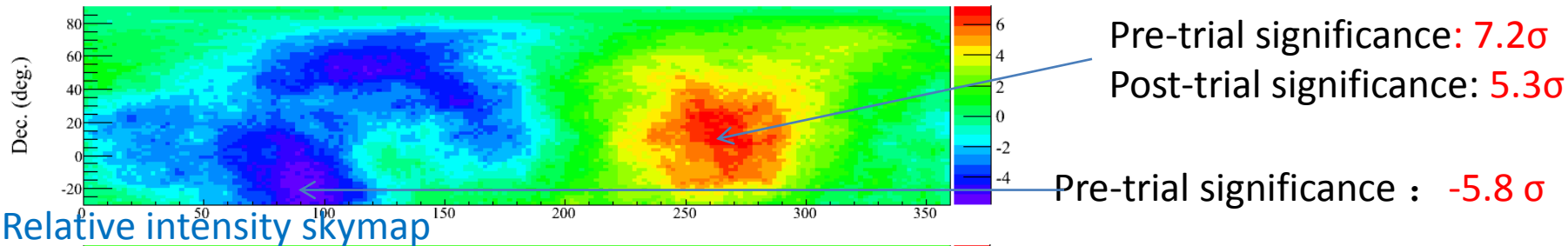


# Result I: 300 TeV anisotropy

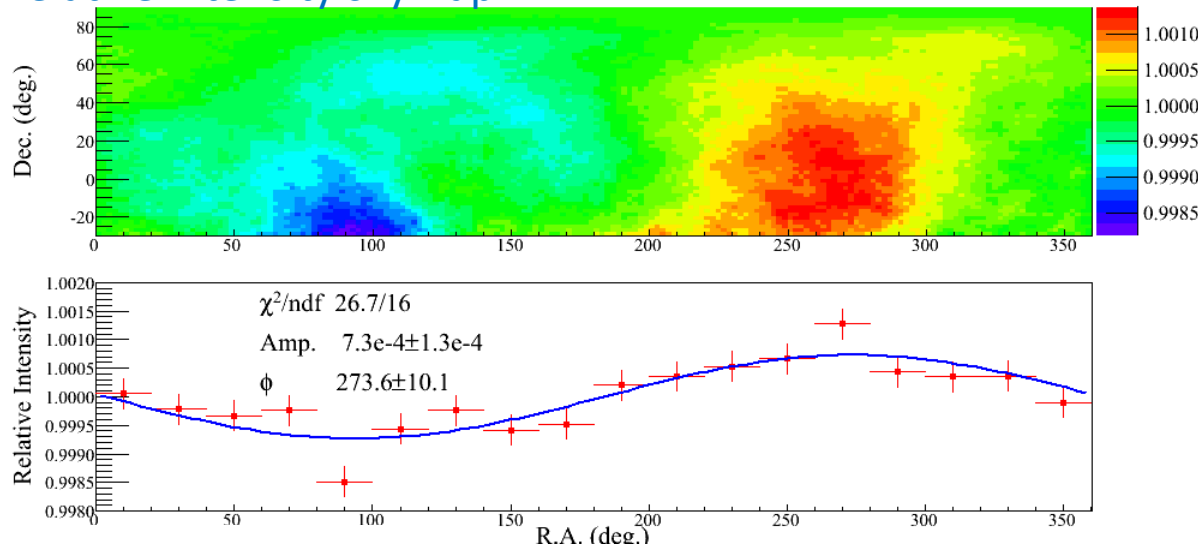
- ◆ Using data with **zenith angle up to 60°**, a **larger data sample** and **FOV** is obtained, comparing to ICRC2013 result.
- ◆ **Expected anisotropy** at solar time, anti-sidereal time and ext-sidereal time **are observed**.
- ◆ **New 300 TeV band** = 300 TeV+1PeV, the event number is  $3.28 \times 10^8$ .

## Statistic significance skymap

Smooth radius: 30°



## Relative intensity skymap

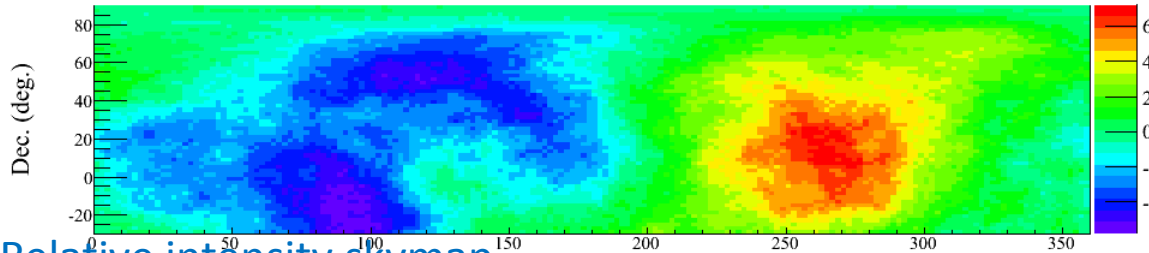


$$R(\alpha) = 1 + A_1 \cos(\alpha - \phi_1)$$

Described by the first harmonic function well.

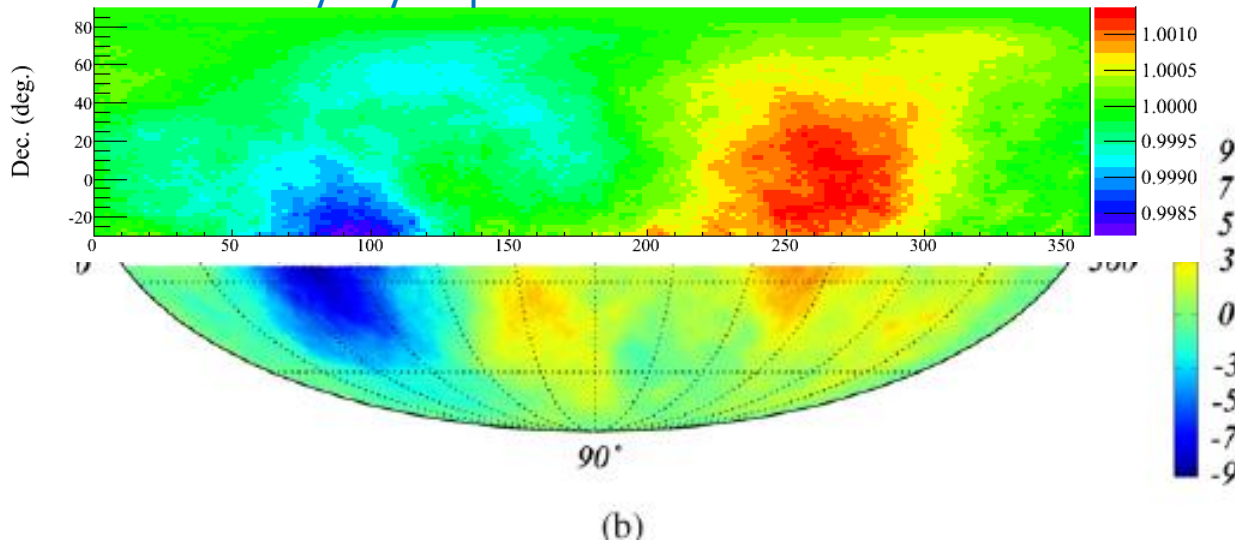
# Global picture of $\sim 300$ TeV anisotropy

## Statistic significance skymap



Tibet AS array in  
Northern sky at 300TeV

## Relative intensity skymap

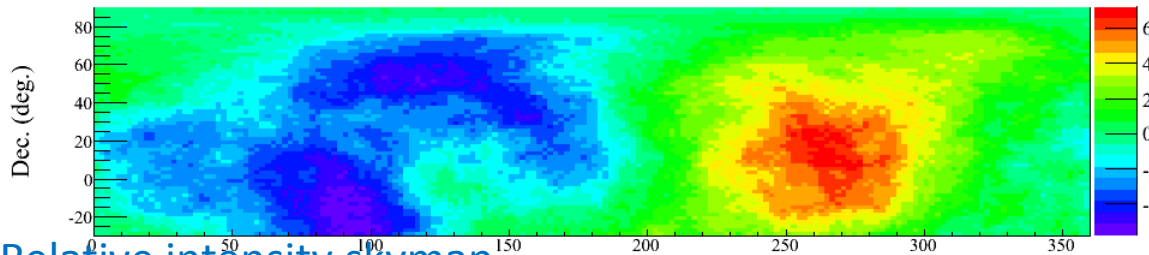


IceCube in Southern  
sky at 400TeV



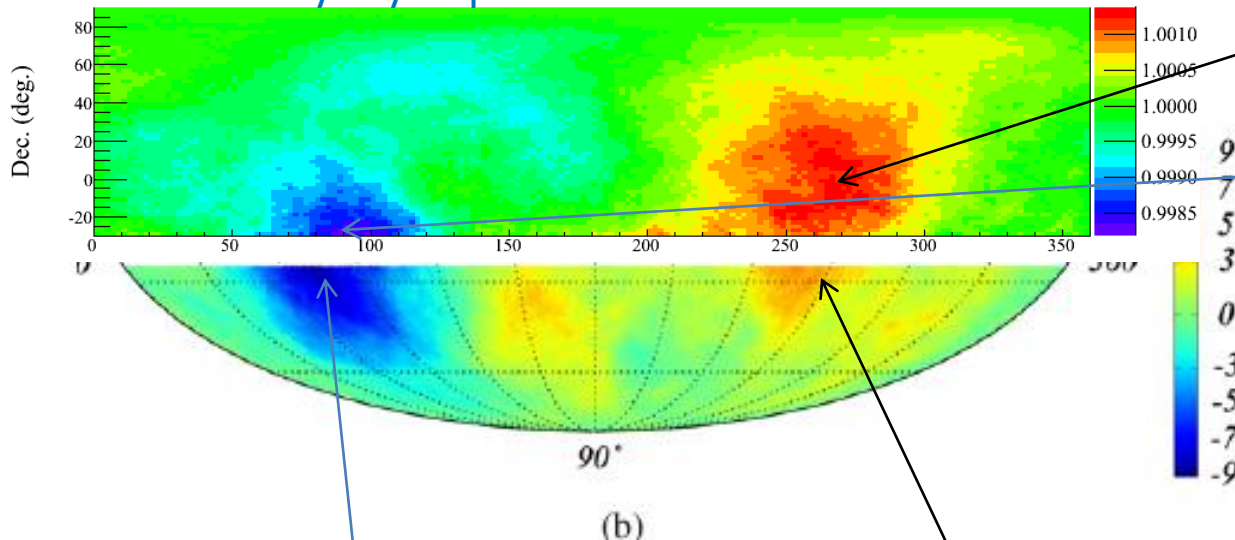
# Global picture of $\sim 300$ TeV anisotropy

## Statistic significance skymap



Tibet AS array in  
Northern sky at 300TeV

## Relative intensity skymap



$(\alpha = 269^\circ, \delta = -13^\circ)$

$(\alpha = 87^\circ, \delta = -29^\circ)$

IceCube in Southern  
sky at 400TeV

$(\alpha = 73.1, \delta = -25.3)$

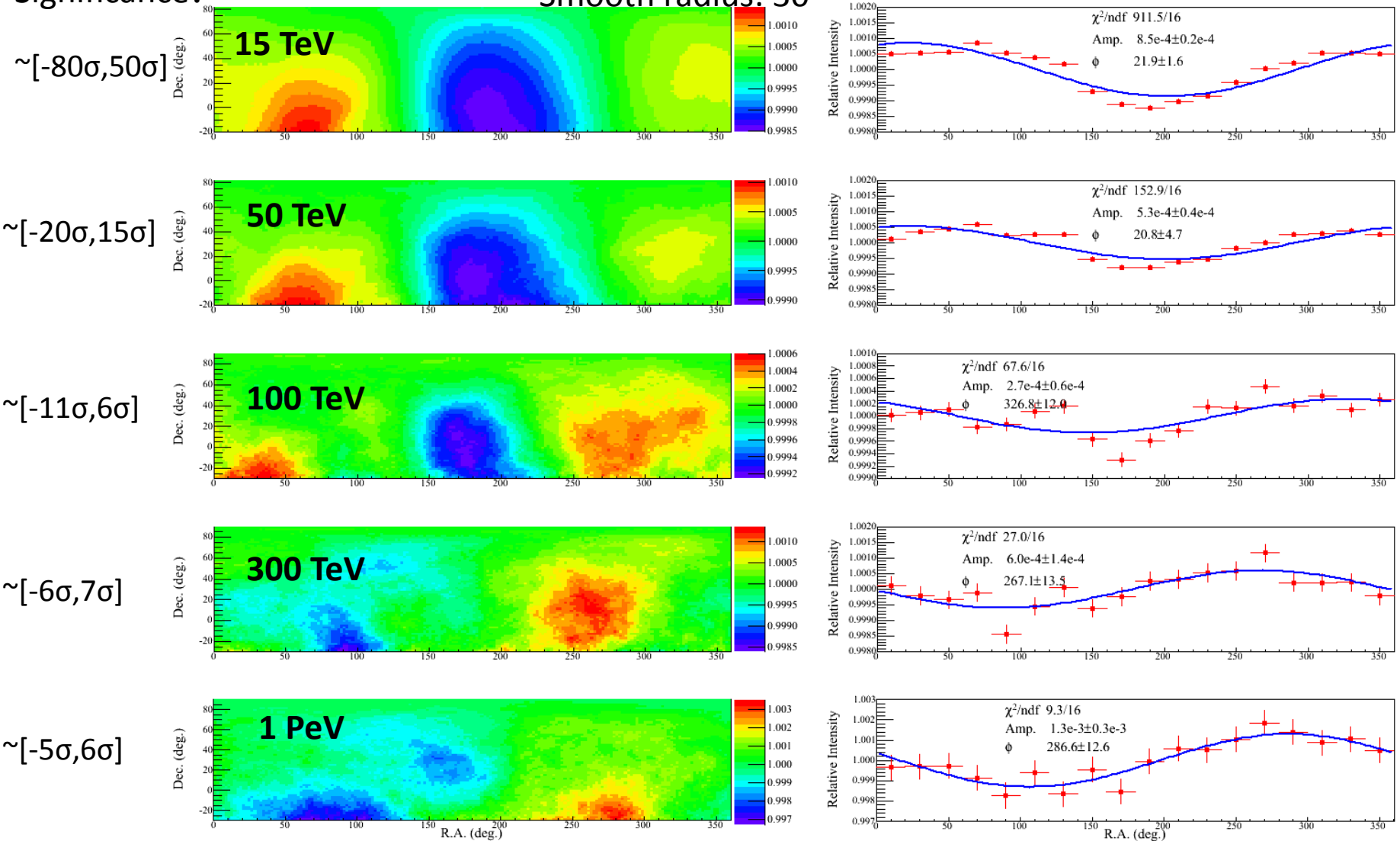
$(\alpha = 256.6, \delta = -25.9)$

# Result II: Transition of CR sidereal anisotropy between 10-1000 TeV

Pre-trial

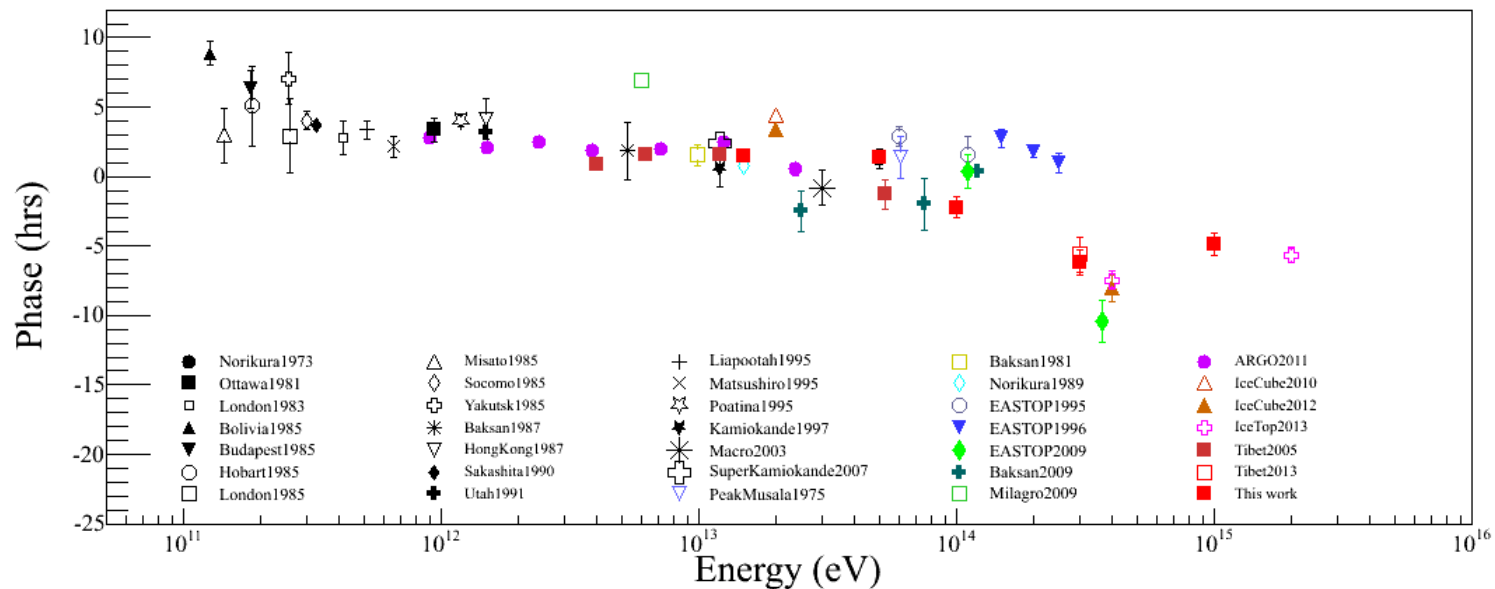
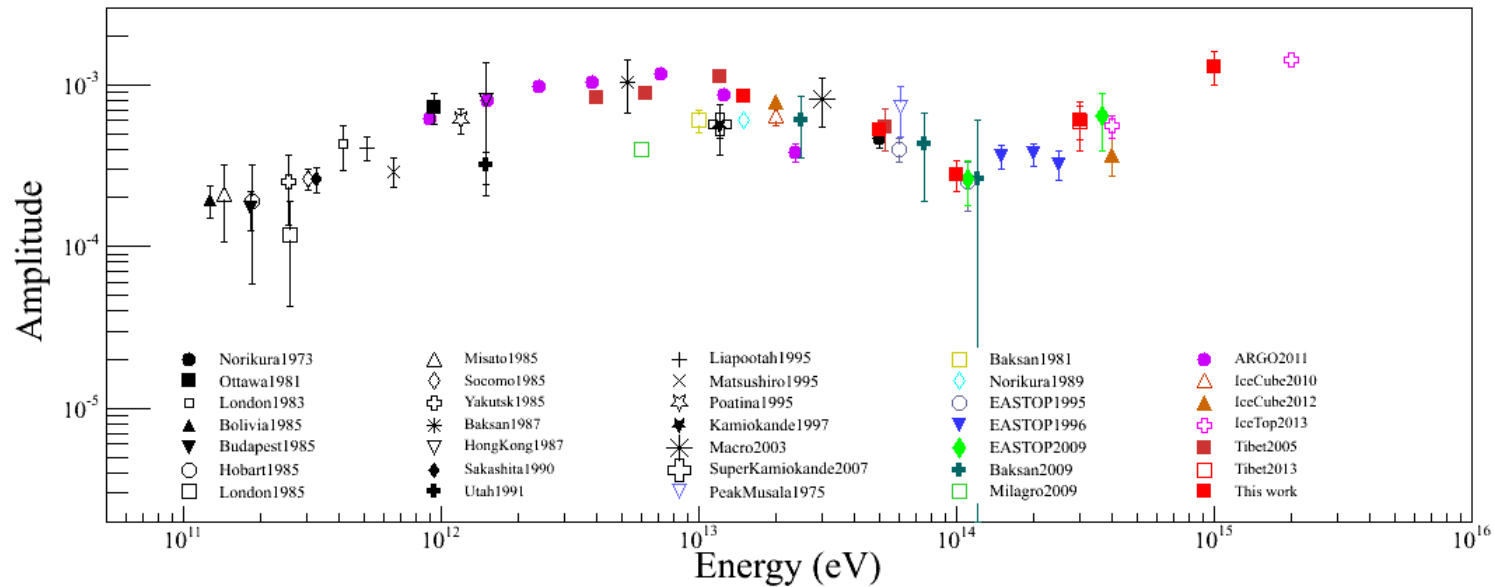
Significance:

Smooth radius:  $30^\circ$



Statistic error only, Systematic error under study

# Result III: Amplitude and phase of the first harmonic fitting as a function of the energy



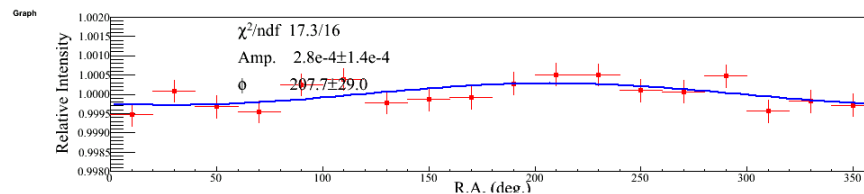
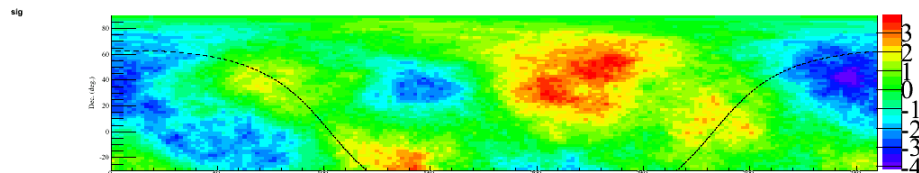
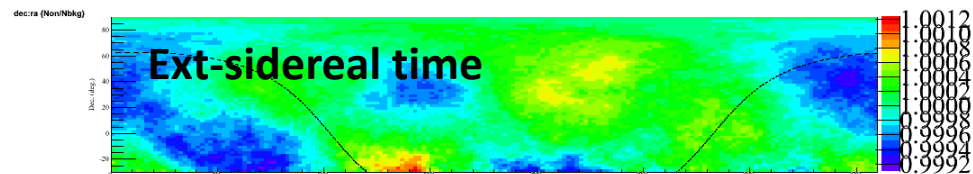
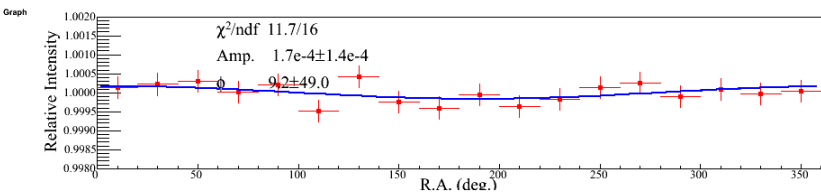
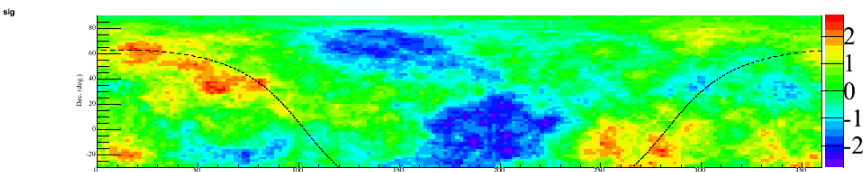
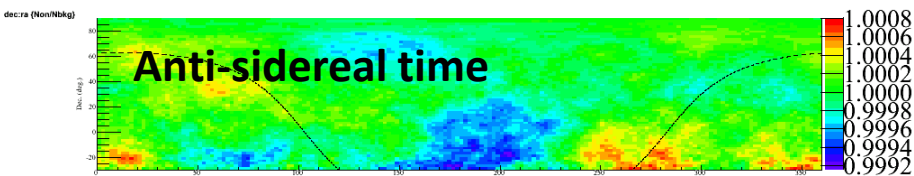
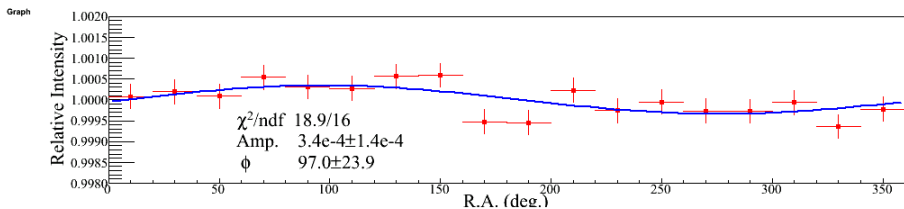
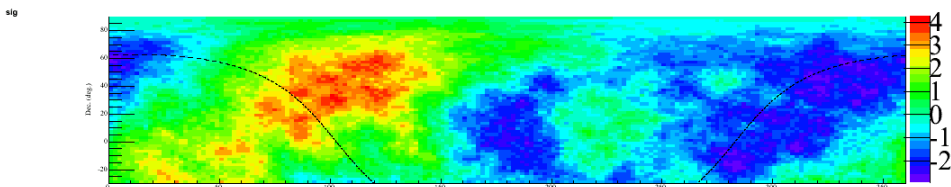
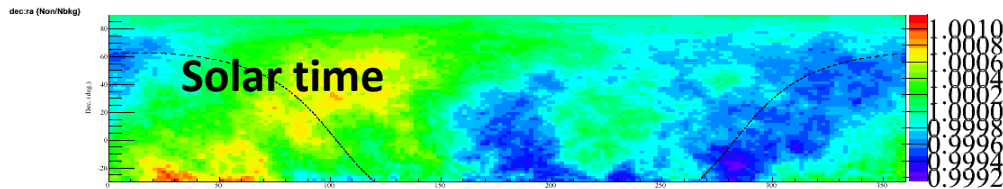
# Summary

With data taken by the Tibet Air Shower Array between 1995.10 and 2010.2

- The two-dimensional intensity map with declination from -30 degree to 90 degree at 300 TeV is **well connected** with IceCube's observation at 400 TeV in 2012.
- **Transition** of the large anisotropy between 10 – 1000 TeV is observed.
- **A new structure** on the energy dependence of the first harmonic amplitude and phase of the large scale anisotropy is revealed **above 100 TeV**.

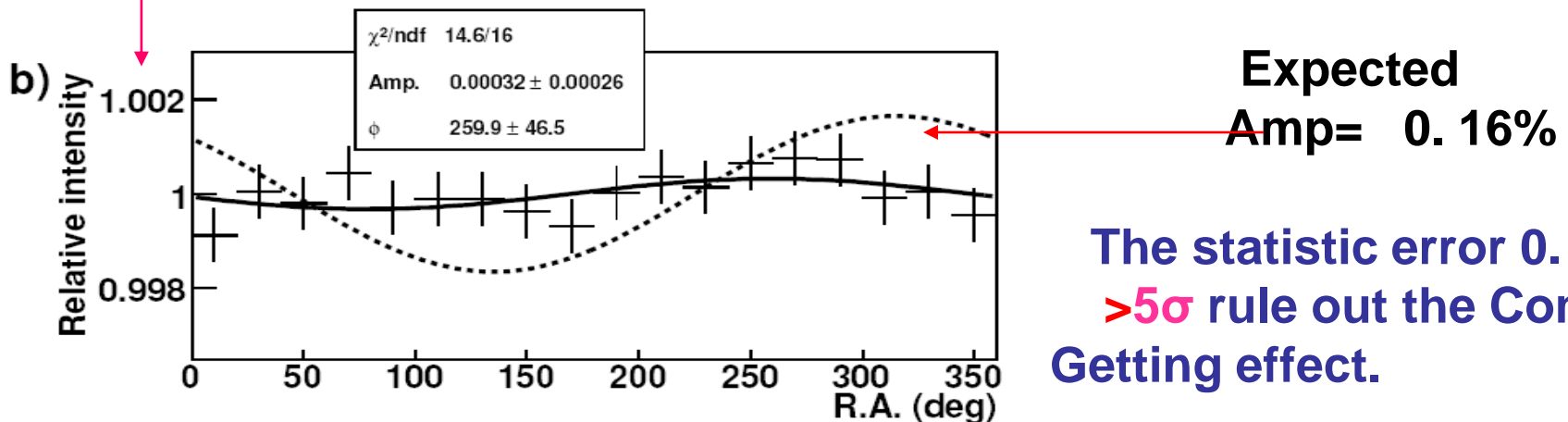
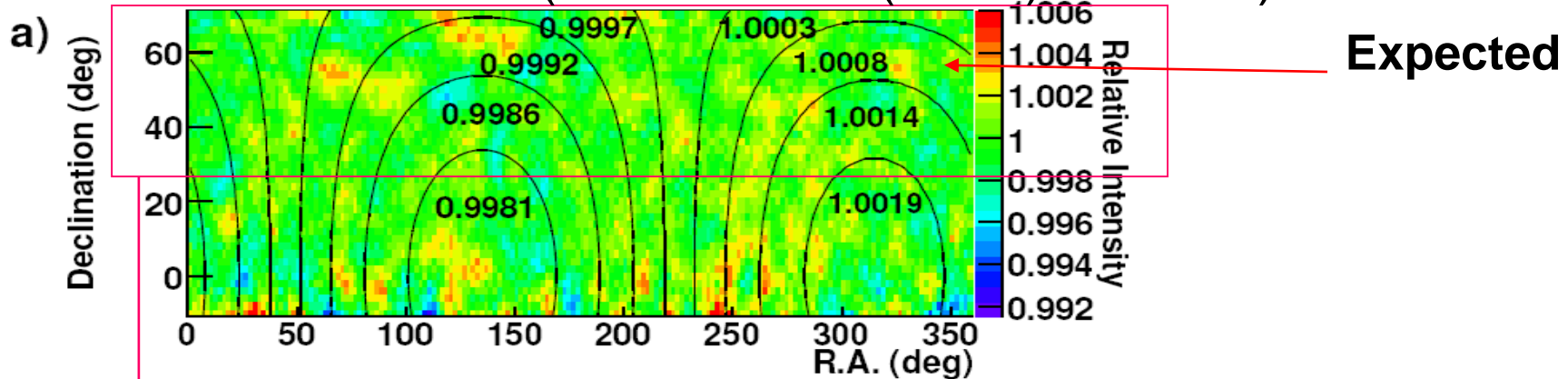
# Backup slides

# Expected anisotropies at 300 TeV

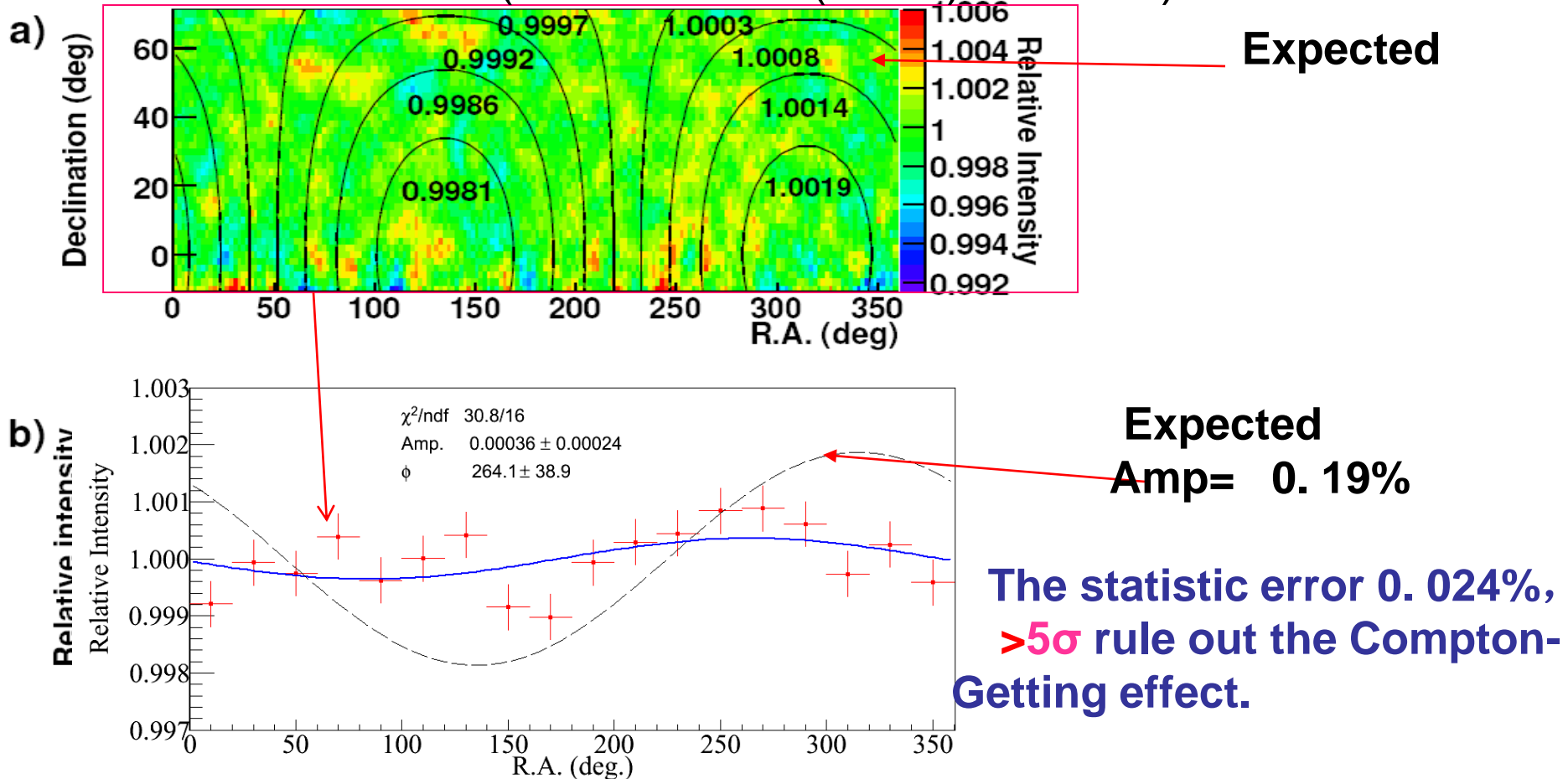




# Celestial Cosmic Ray intensity map for 300 TeV (Science 314(2006)439-443)



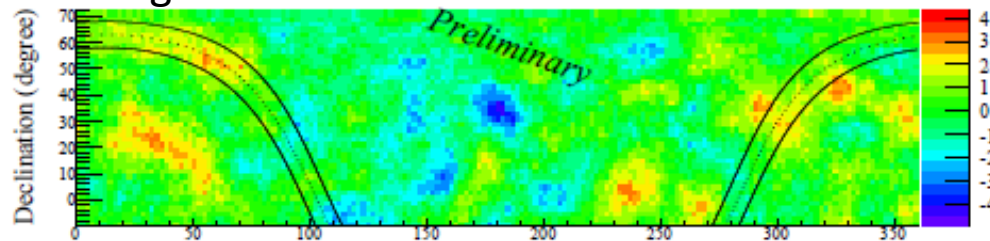
# Celestial Cosmic Ray intensity map for 300 TeV (Science 314(2006)439-443)



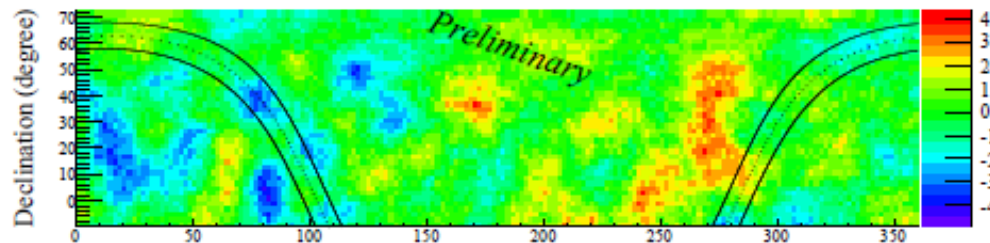
## All Sky Search for Emission of Gamma Ray above 100 TeV Using Tibet Air Shower Array

Zhaoyang Feng\*, Yi Zhang\*, C. Liu\*, C. Fan<sup>†</sup>\*, H. C. Li<sup>‡</sup>\*, B. Wang\*, H. R. Wu\*,  
H. B. Hu\*, H. Lu\*, Y. H. Tan\*  
(On Behalf of The Tibet AS $\gamma$  Collaboration)

Smoothing radius: 10 $^\circ$



Gamma-like sample



Cosmic ray-like sample

We said:

**“Instead, an excess parallel to the Galactic plane is seen. More study is needed to further understand these excesses.”**