A study of the first harmonic of the large-scale anisotropies with the KASCADE-Grande experiment

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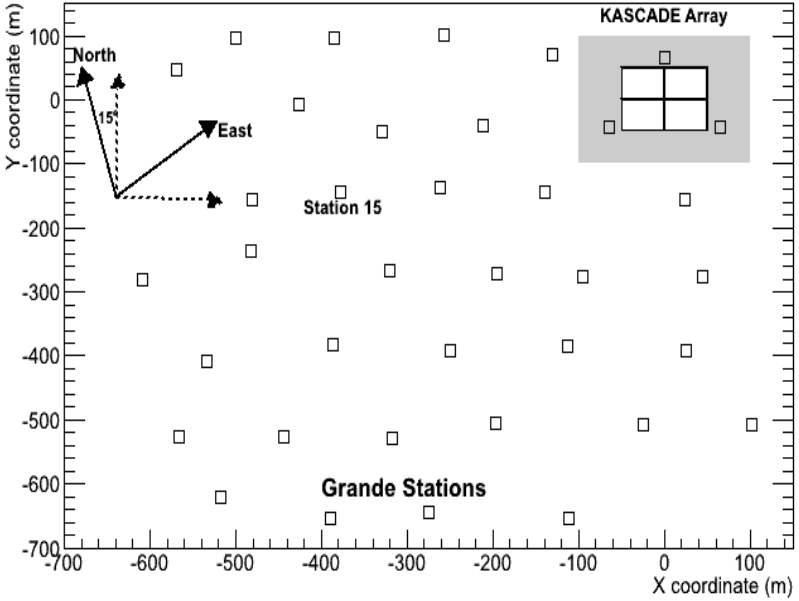
Analysis Method

- To eliminate the spurious anisotropies, due to atmospheric and instrumental effects, we apply the EAST-WEST Method:
  - Differential method: $\frac{dI_{tot}^{true}(t)}{dt} \simeq \frac{I_E^{obs}(t) - I_W^{obs}(t)}{< h >}$
- Instantaneous exposure for the E and W events is the same: i.e. both are equally affected by detector instabilities and weather conditions.
- Harmonic analysis is performed on the differences E-W
- $I_E(\alpha_i)$-$I_W(\alpha_i)$ allows to remove direction independent effects:
  - NO corrections must be applied
  - Reduced sensitivity: higher sentivity required (4 times more events)

The Experiment

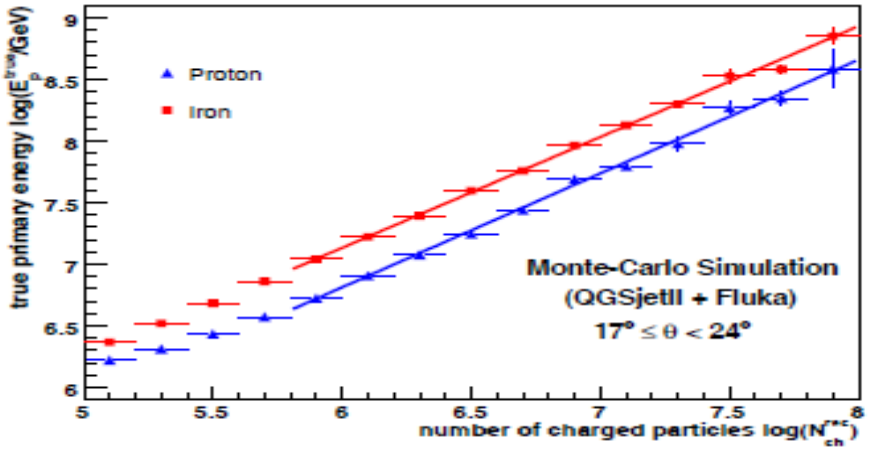
- We use data collected with the Grande array
- μ detectors are not used
- No selection on the core location
- Zenith angle $\theta<40^{o}$
- Log $N_{ch} > 5.2$

- Whole KASCADE-Grande dataset used



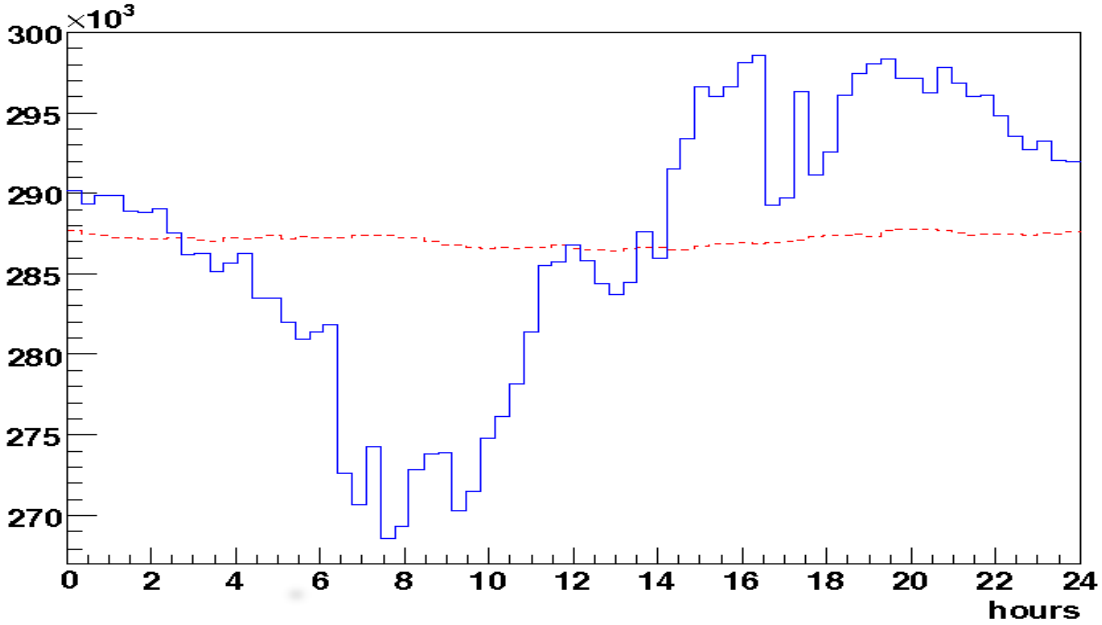
Event Energy Determination

- As reference value of the primary energy we choose the median energy of the event sample
- Energy calibration:
  - E = f (N_{ch})
  - QGSJetII-02
  - H primaries → the estimated median is a lower limit of the true median energy.
  - Log E/GeV = *a* + *b* Log Nch
    - *a* = 1.28±0.08 *b* = 0.92±0.01

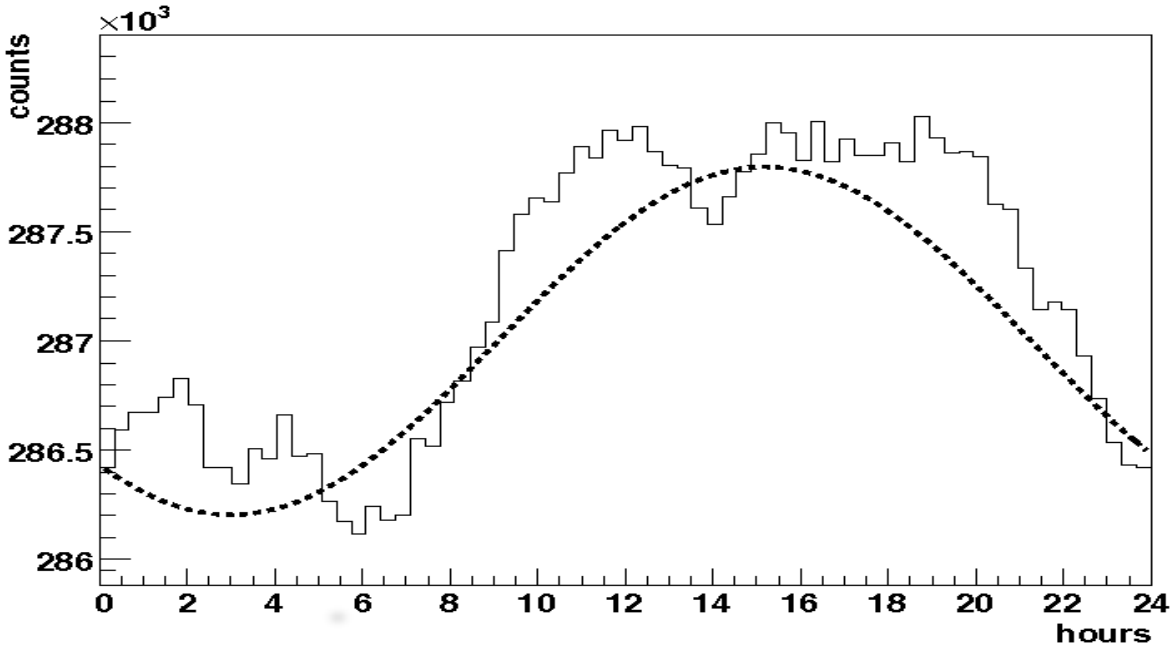


E-W method

- Solar time distribution of the number of counts, in 20 minutes bins



Sidereal time counts distribution

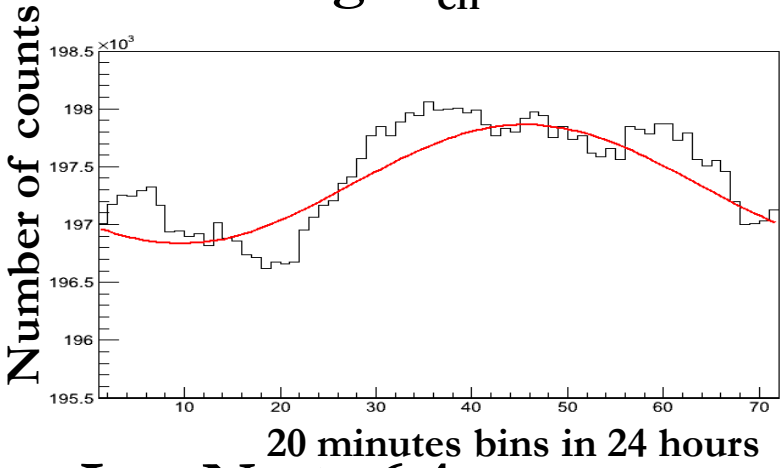


Amplitude and Phase of the first harmonic calculated from the Solar, Sidereal, Anti-Sidereal time counts distributions

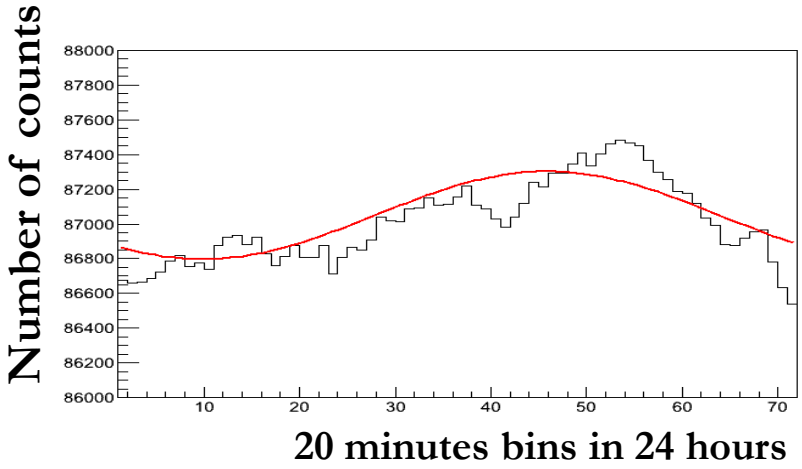
time	$A \times 10^{-2}$	hours	P
sidereal	0.28 ± 0.08	15.1 ± 1.1	0.2%
solar	0.15 ± 0.08	23.9 ± 2.1	17%
anti-sidereal	0.02 ± 0.08	1.8 ± 14.4	96%

- Significance of the Sidereal time amplitude: 3.5σ
- Upper Limit (99% c.l.): $A < 0.47 \times 10^{-2}$
- Reducing the events statistics we cannot expect statistically significant anisotropy detection.
- We study the sidereal time count distribution in intervals of N_{ch} to investigate phase variations with energy
- Error on the phase is smaller if the significance of the amplitude is bigger.
- We obtain error on the phase of the first harmonic of few hours

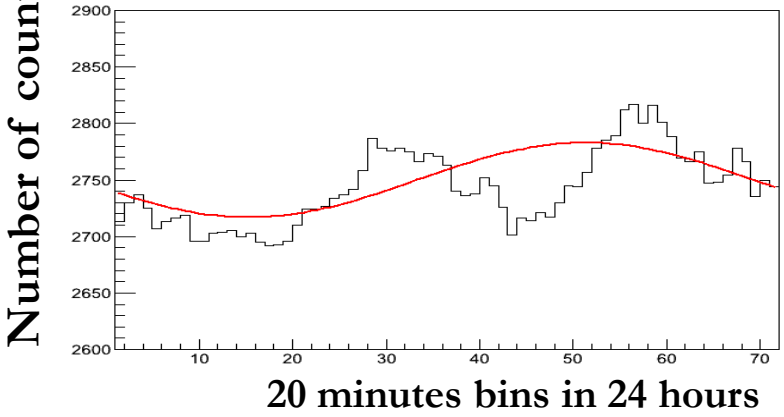
$5.2 < \text{Log } N_{ch} < 5.6$



$5.6 < \text{Log } N_{ch} < 6.4$

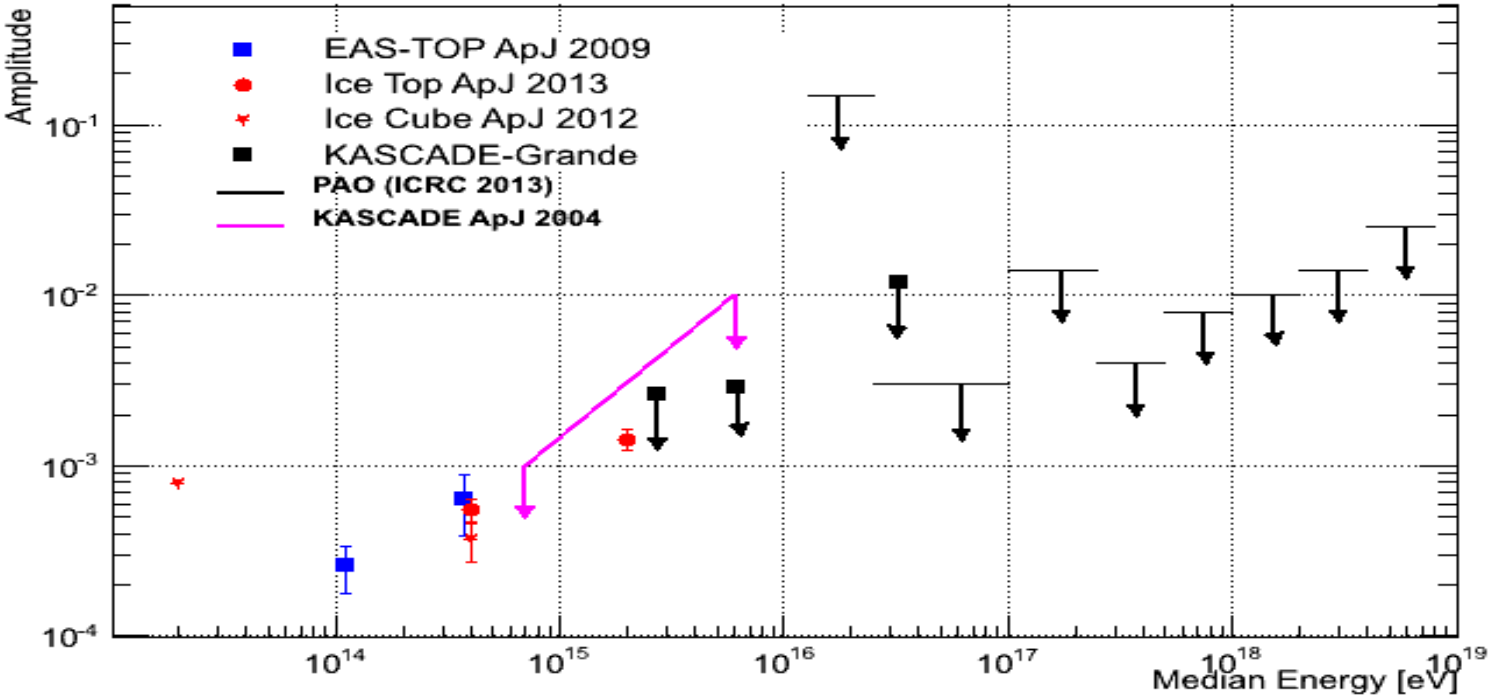


$\text{Log } N_{ch} > 6.4$

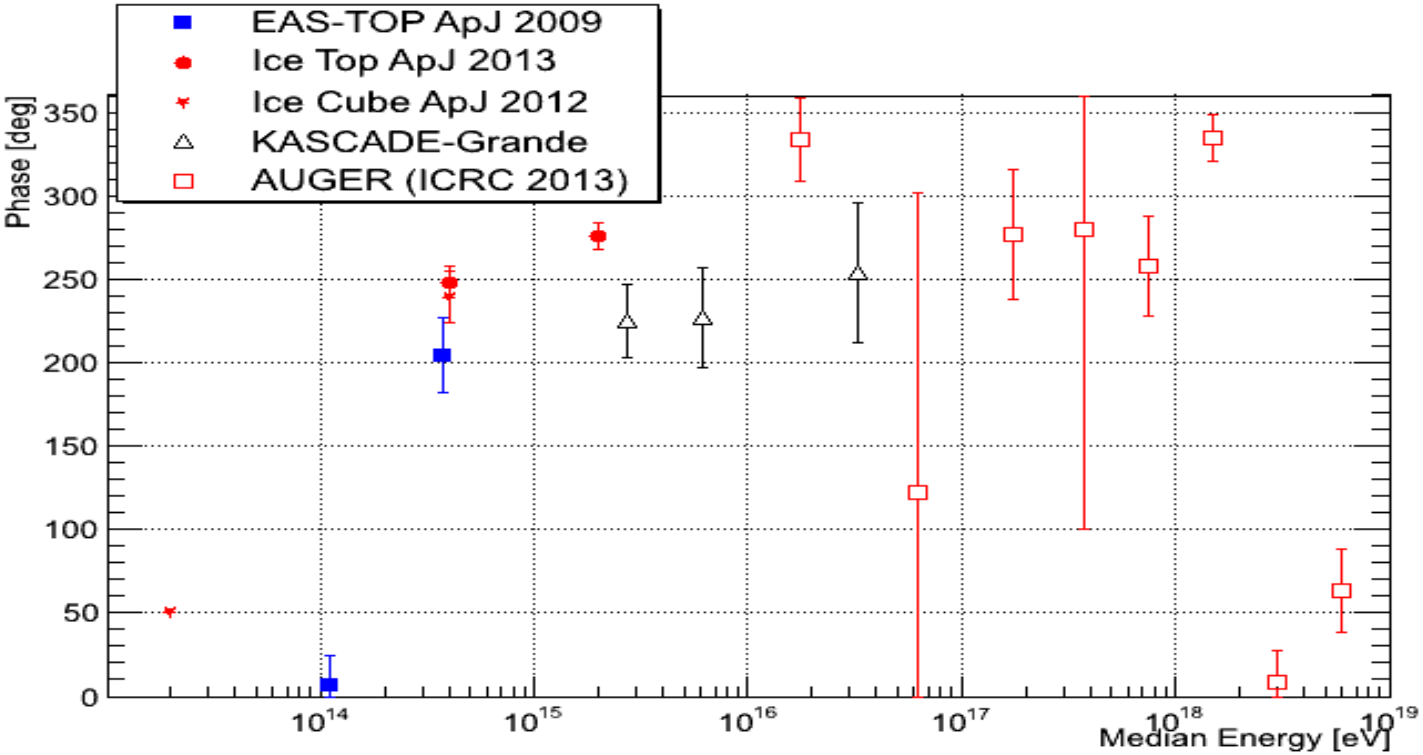


Log N_{ch}	Median Energy (eV)	Ax10^{-2}	Phase
5.2-5.6	2.7x10^{15}	0.26±0.10	225±22
5.6-6.4	6.1x10^{15}	0.29±0.16	227±30
>6.4	3.3x10^{16}	1.2±0.9	254±42

First Harmonic Amplitudes



First Harmonic Phases



Conclusions

- ✓ A search for large scale anisotropy has been performed with the whole KASCADE-Grande data set
- ✓ 99% c.l. Upper Limit $A < 0.47 \times 10^{-2}$
- ✓ A study of the phase evolution with energy has been performed: the obtained phases point the same sky region indicated by the Ice-Top and EAS-TOP experiments at lower and by the PAO at higher energies