# TELESCOPE ARRAY ANISOTROPY SUMMARY

***Igor Tkachev** (INR, Moscow)*
***for the TA collaboration***

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# Telescope Array Collaboration


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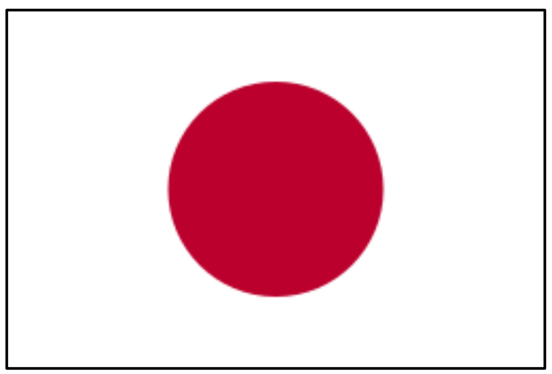
USA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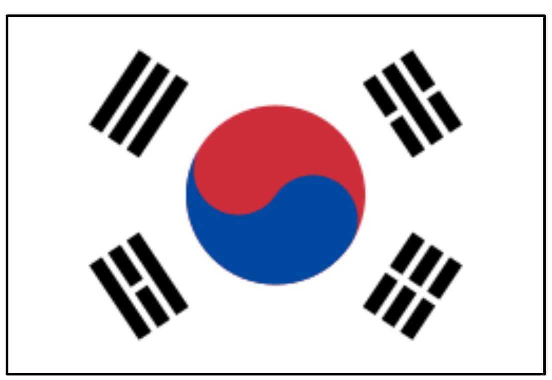
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Russia


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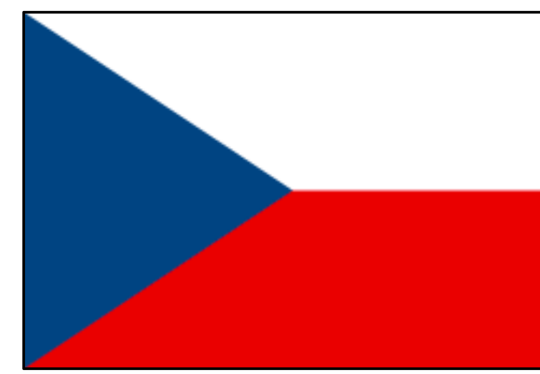
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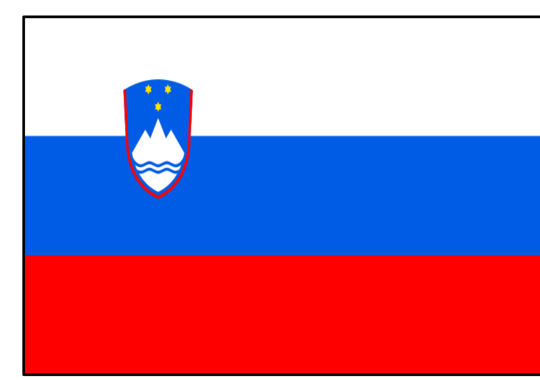

Slovenia

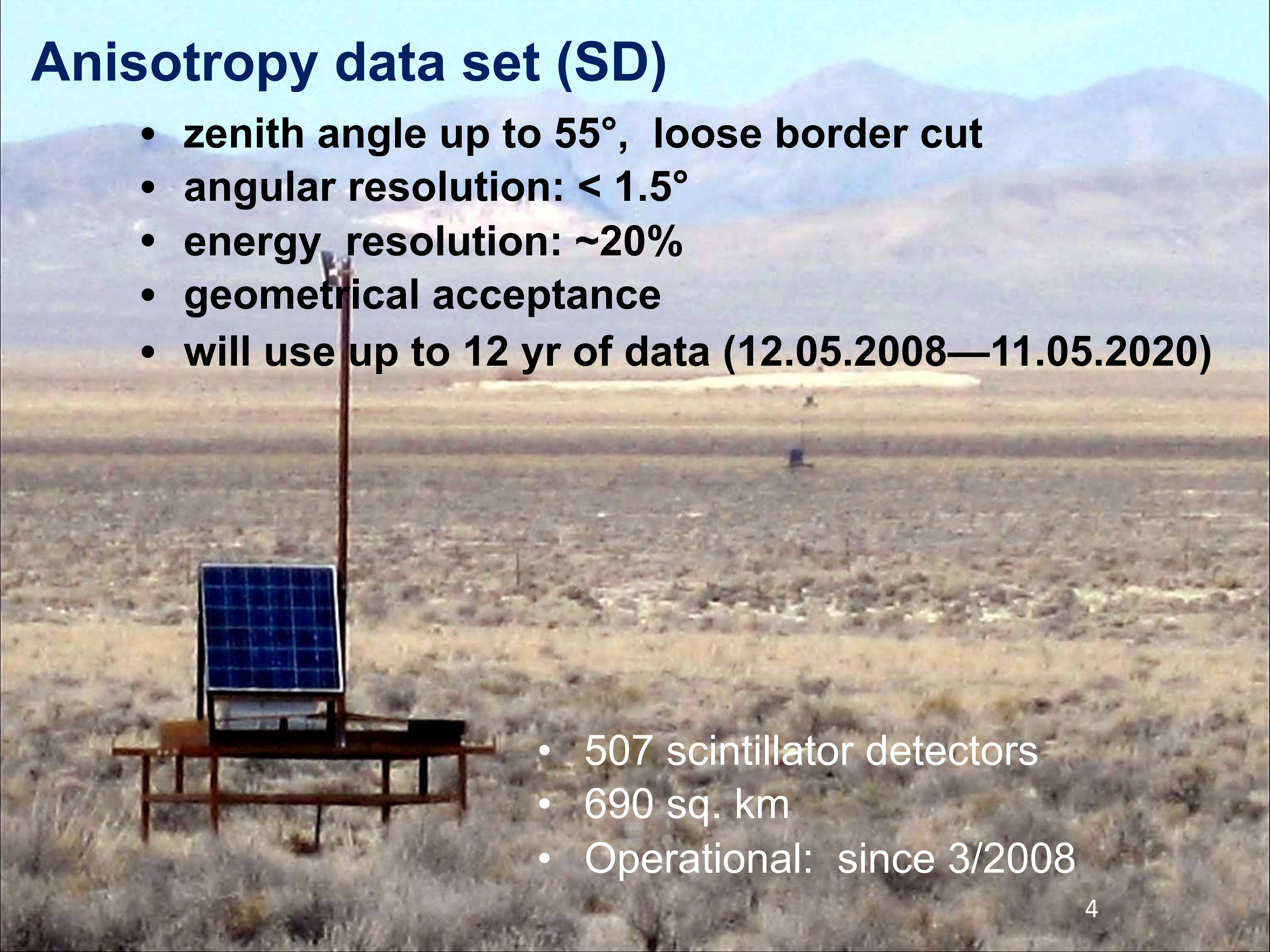
157 members , 36 institutes, 7 countries

# Outline:

1. TA surface detector (SD) data
2. CR clustering
   - Dipole
   - Hot spots
3. Correlations with putative sources
   - Correlation with LSS
4. Spectral and compositional reflections of anisotropy
   - Spectral anisotropies
   - Constraint on CR composition

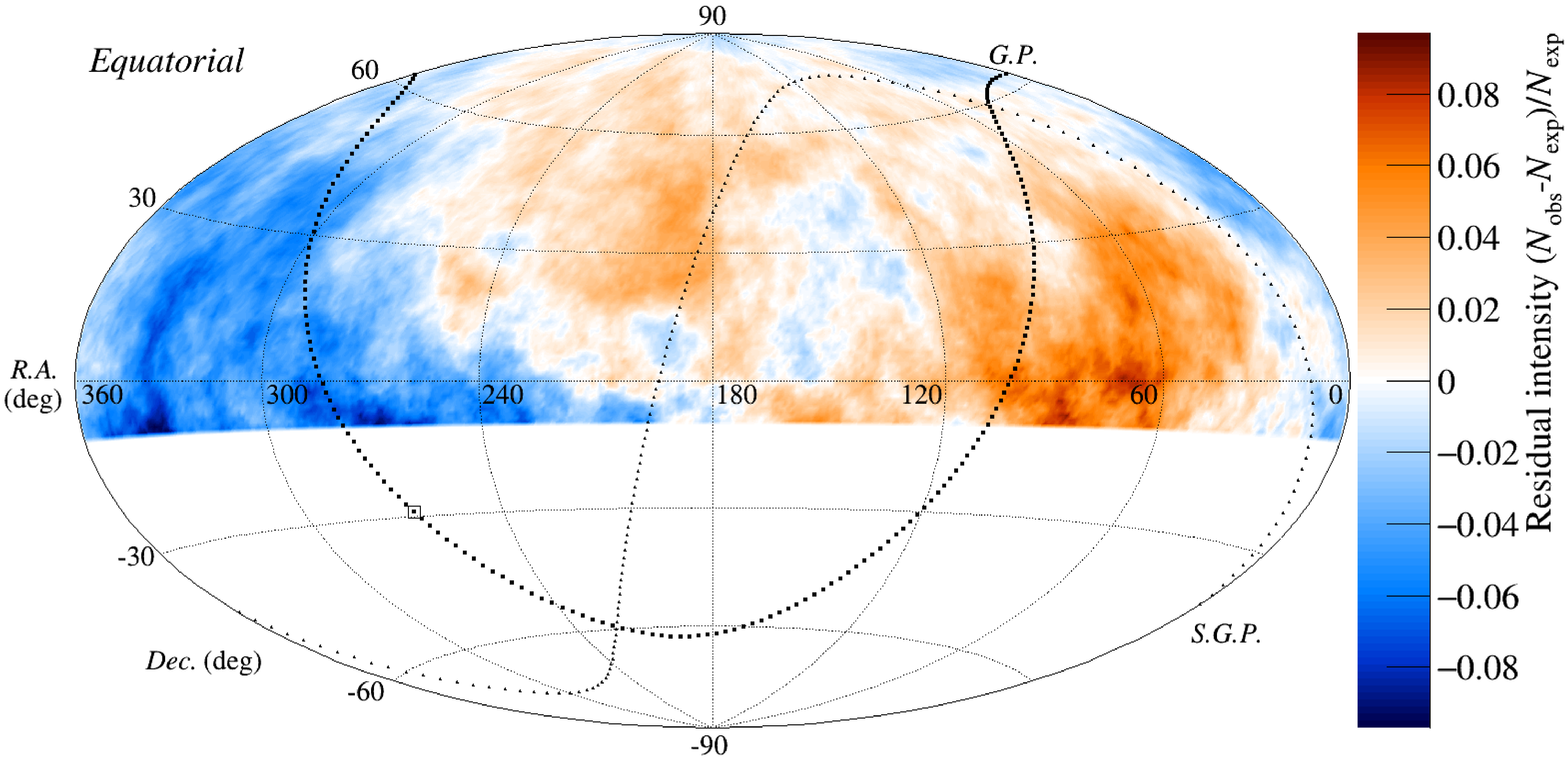
# Anisotropy data set (SD)

- **zenith angle up to 55°,  loose border cut**
- **angular resolution: < 1.5°**
- **energy  resolution: ~20%**
- **geometrical acceptance**
- **will use up to 12 yr of data (12.05.2008—11.05.2020)**



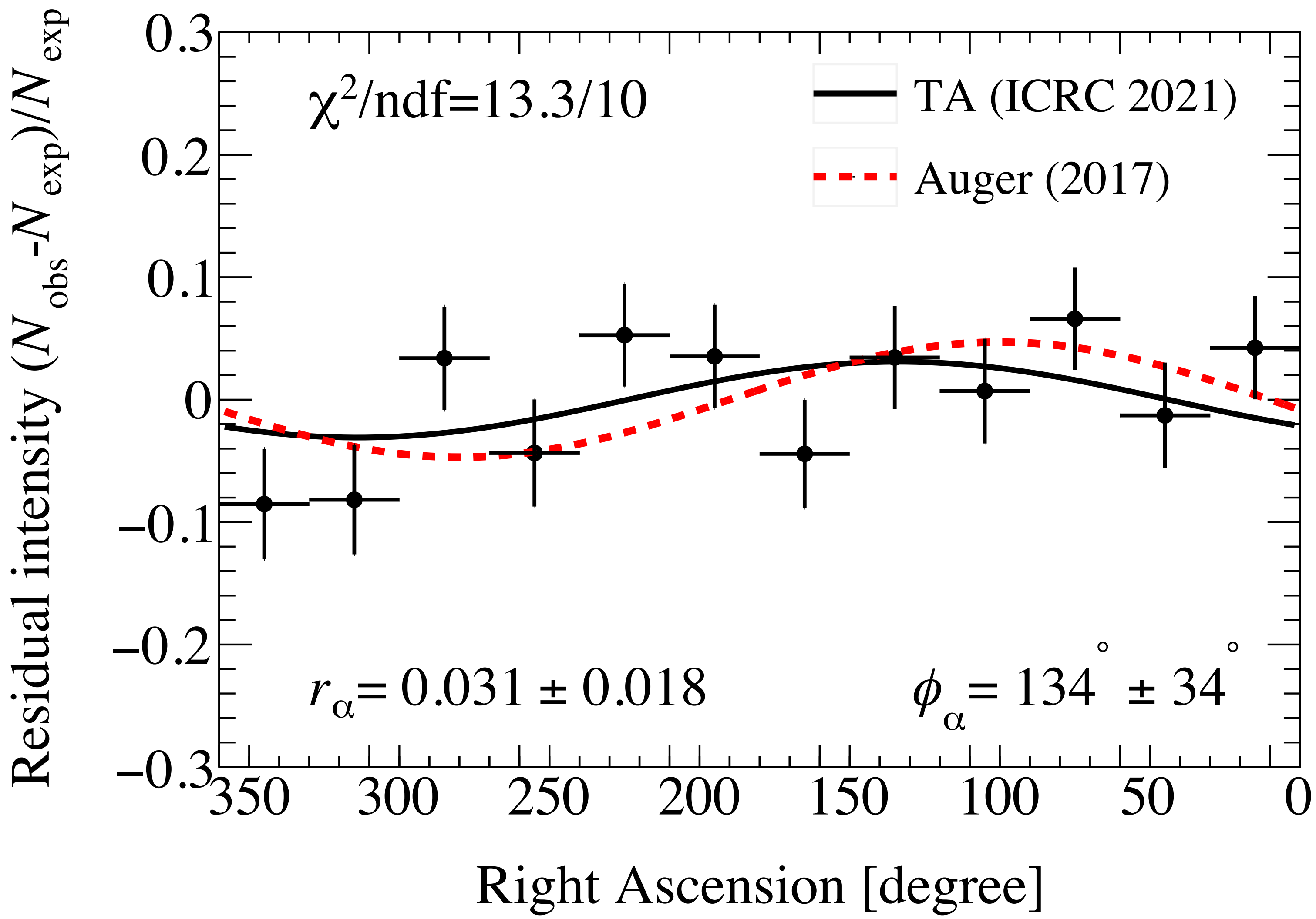
- 507 scintillator detectors
- 690 sq. km
- Operational:  since 3/2008

# CR clustering: Dipole update (12-yr)




Sky map of residual intensity between TA data and an isotropic distribution for E > 8.8 EeV (energy cut corresponds to E > 8 EeV used by Auger).

# CR clustering: Dipole update (12-yr)




Residual intensity as a function of the right ascension fitted to $r_\alpha \cos(x - \phi_\alpha)$.

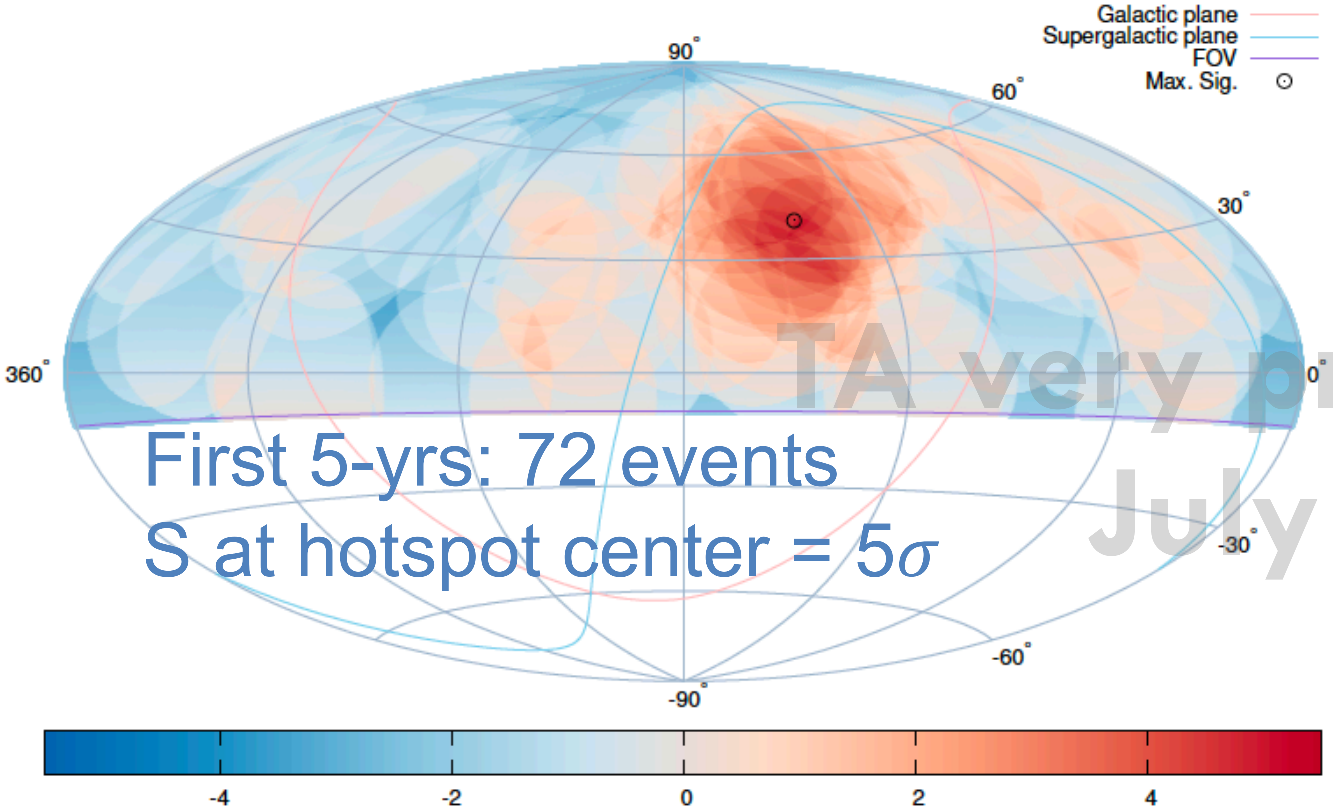
TA 12-yr result : $r_\alpha \simeq 3.1\,\%\,; \quad \phi_\alpha \simeq 134^\circ$

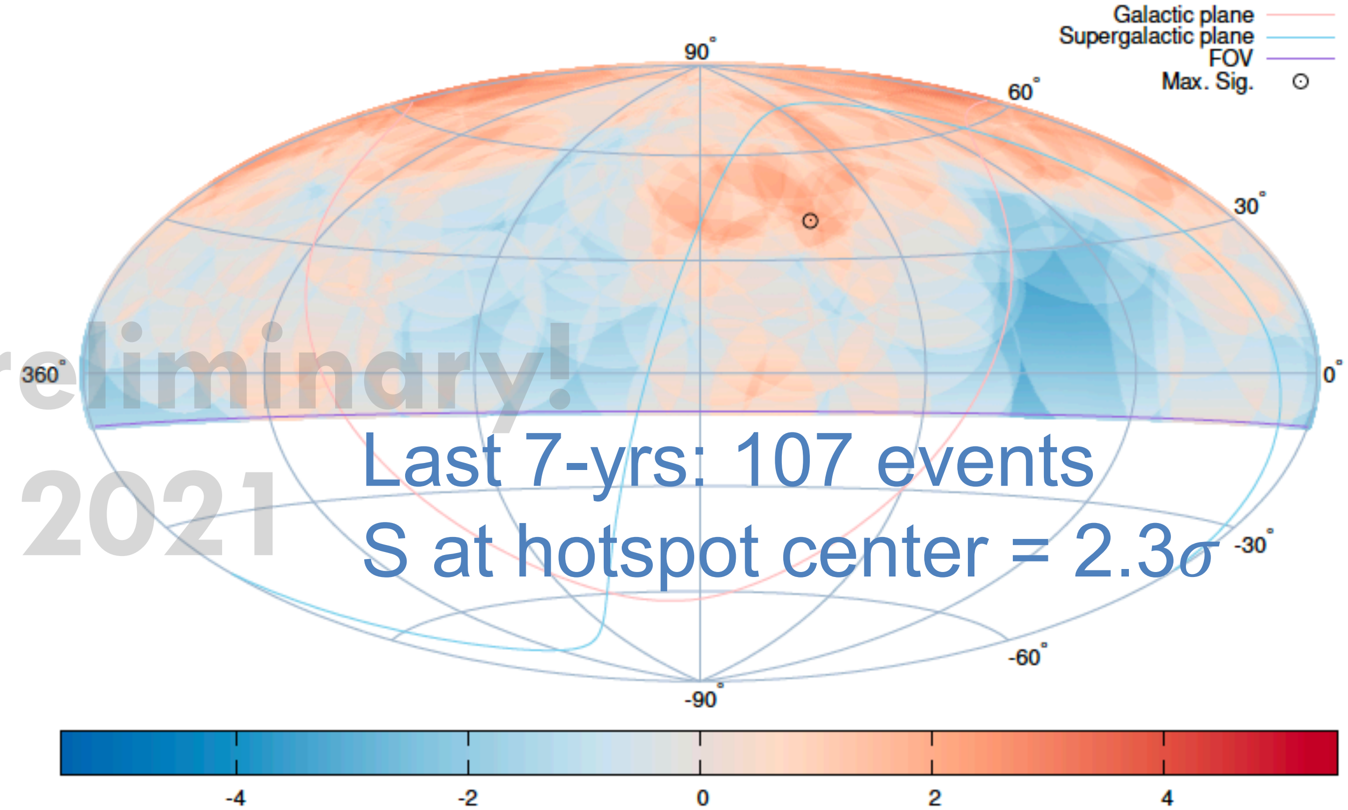
Auger 2017 result : $r_\alpha \simeq 4.7\,\%\,; \quad \phi_\alpha \simeq 100^\circ$

For details see report by T. Fujii at this conference

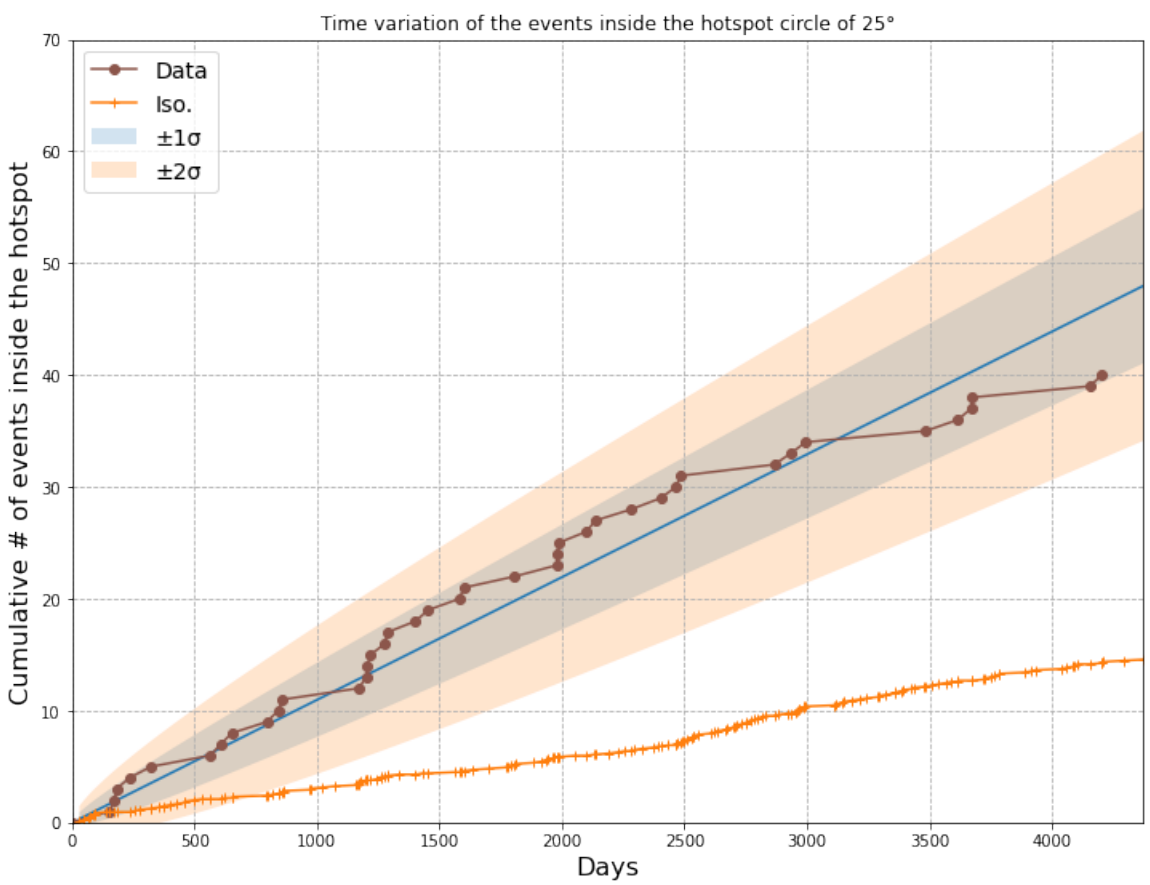
For the TA+Auger WG dipole result see report by P. Tinyakov, this conference

# CR clustering: Hot spot update (12-yr)





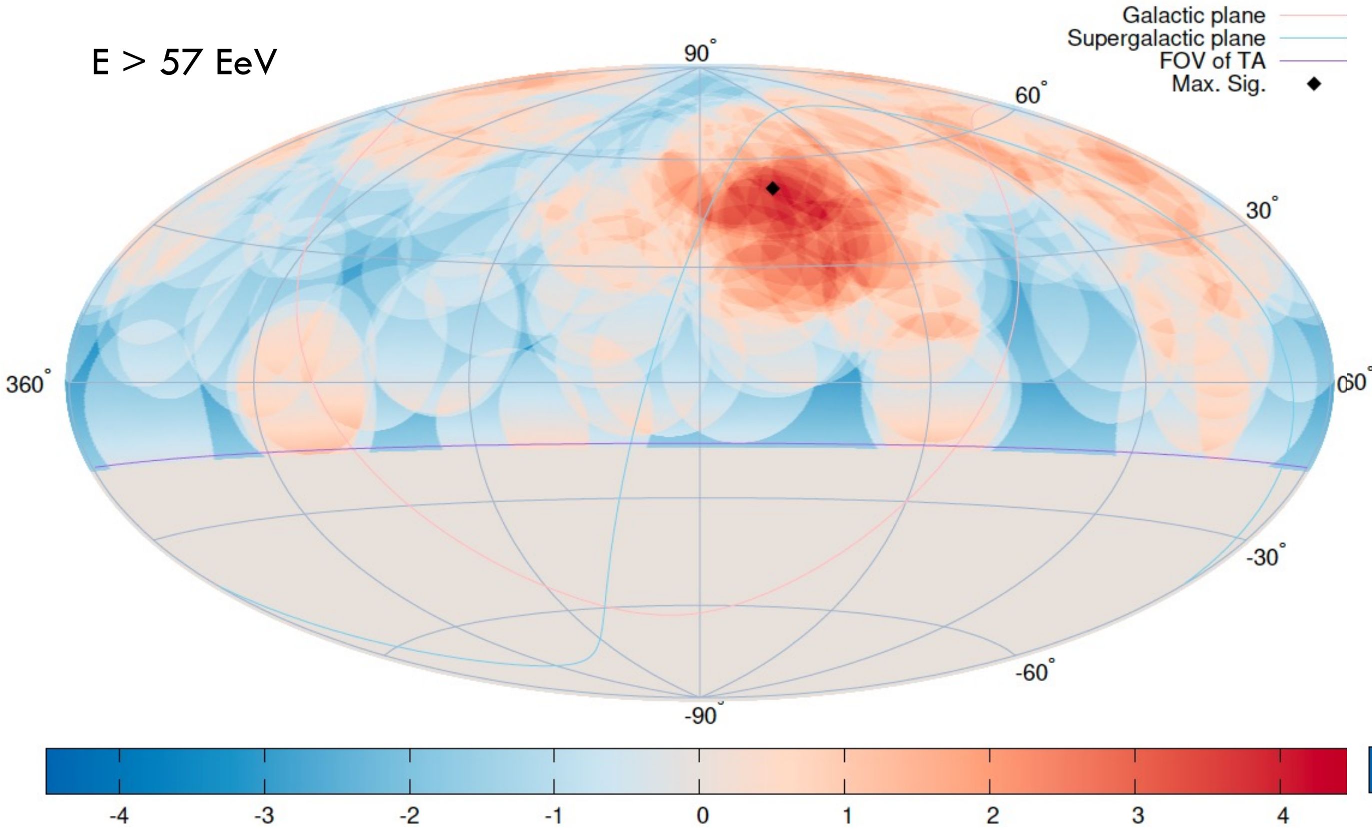

Energy E > 57 EeV

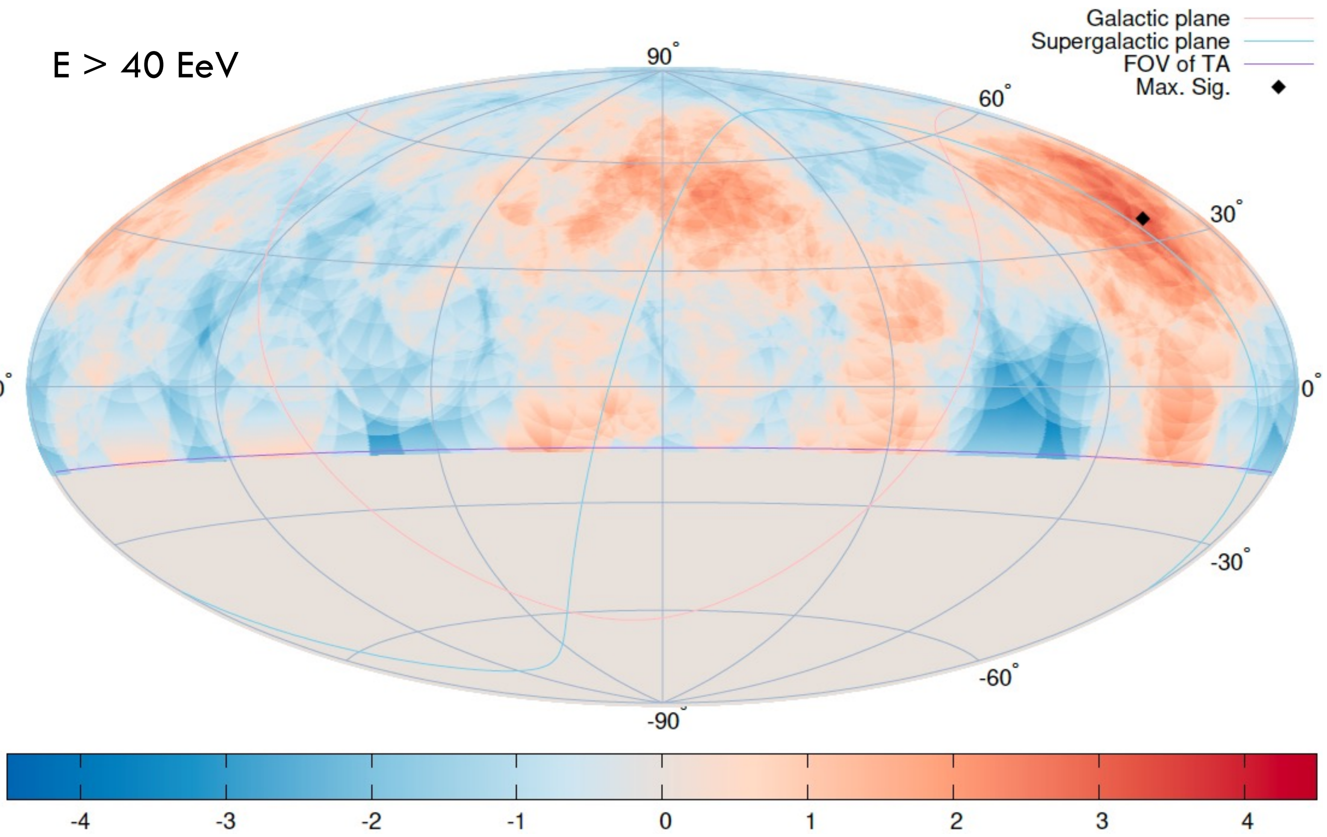
Overall post-trial significance has dropped from 3.4$\sigma$ to 3.2$\sigma$

The growth rate of events inside the hotspot is consistent with the linear one within ~ 1$\sigma$

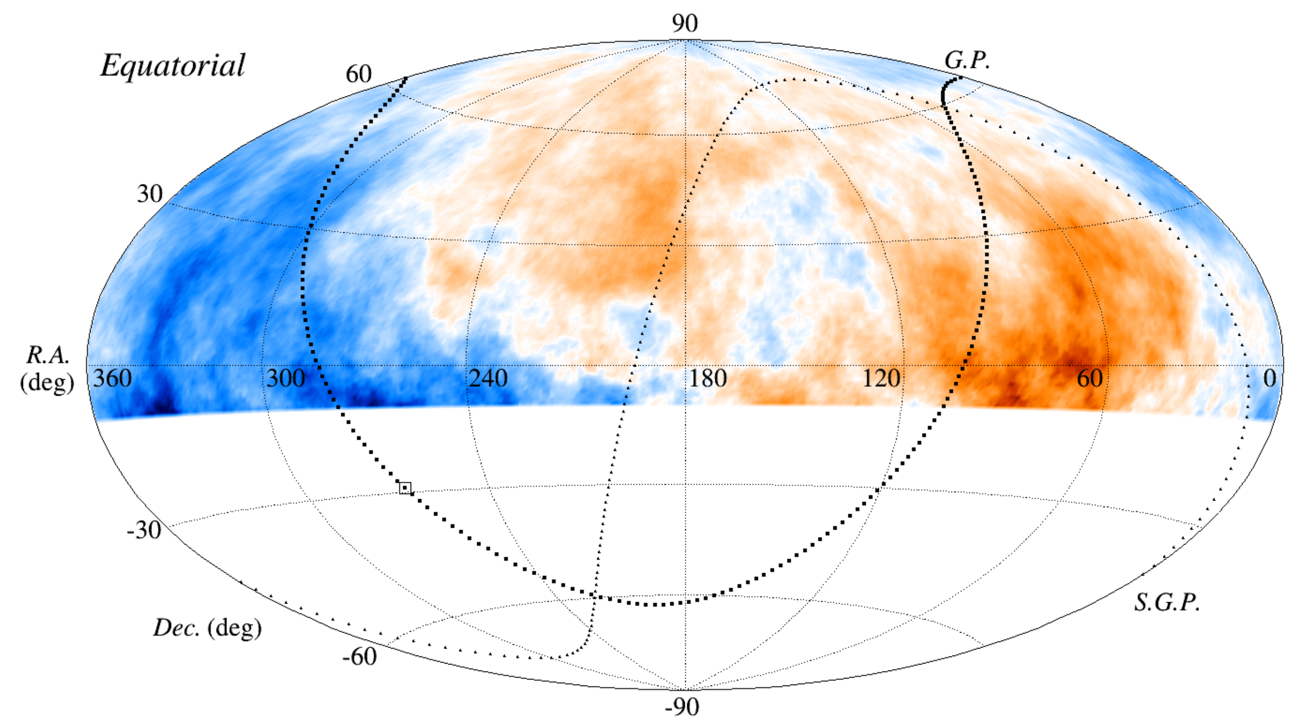
For details see report by J.H. Kim at this conference.

# CR clustering: Medium scales




Sky maps of residual intensities between TA data and an isotropic distribution for E > 57 EeV (upper left) and E > 40 EeV (upper right) and E > 8.8 EeV (bottom)




For energy dependence of the dipole see reports by T. Fujii and P. Tinyakov, this conference

# Sources: Correlation with LSS

Cosmic ray sources follow matter distribution,

but cosmic rays are deflected by magnetic fields.

How to deal with poorly known deflections?

**Recipe:**

- Define smearing angle $\theta_0$ at E = 100 EeV. Let it scale with $E_k$ as Q/E
- Construct expectation for the flux map $\Phi_k$ for a given energy $E_k$
- Normalise a flux map $\Phi_k(\theta_0, \mathbf{n})$ to a unit integral over the sphere
- Apply model GMF deflections
- Define test statistics with observed arrival directions $\mathbf{n}_i$

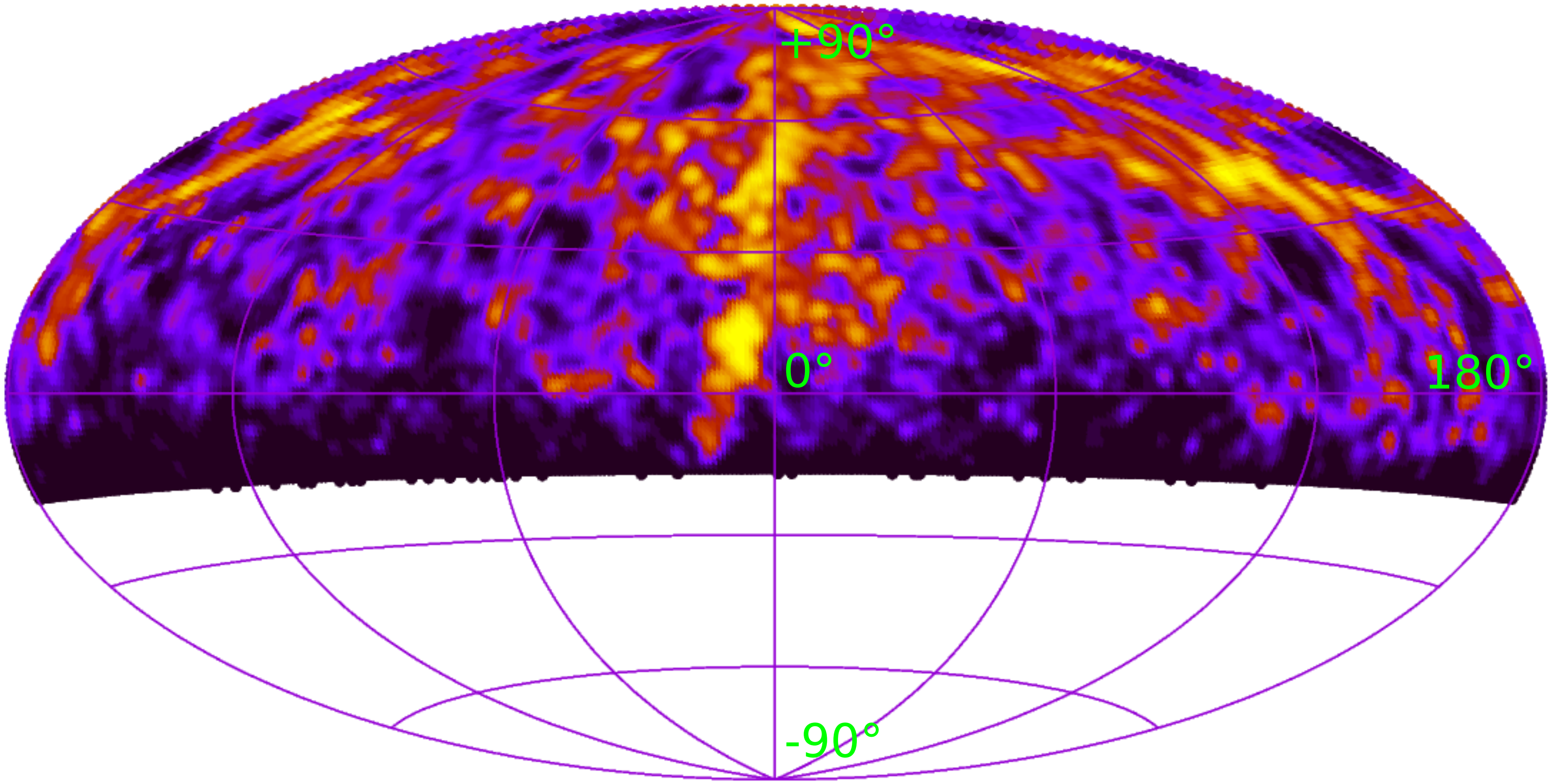
$$TS(\theta_0) = -2 \sum_k \left( \sum_i \ln \frac{\Phi_k(\theta_0, \mathbf{n}_i)}{\Phi_{\text{iso}}(\mathbf{n}_i)} \right)$$

For details see report by M. Kuznetsov at this conference.

For the TA+Auger correlations with LSS and starburst galaxies see WG report by A. di Matteo.

# **Sources:** Correlation with LSS

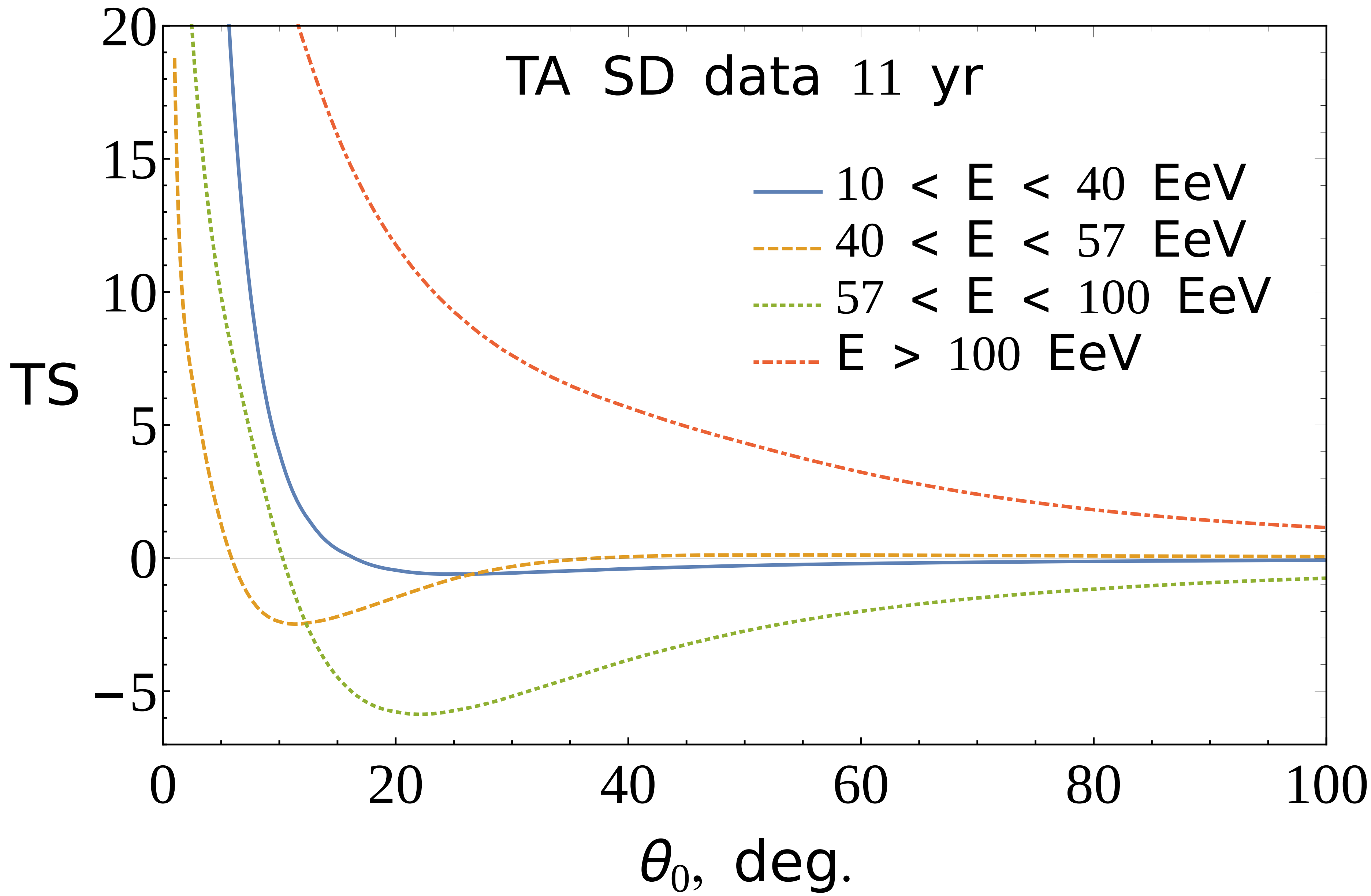
One of the maps




**Sky map $\Phi_k$ of expected flux at $E_k$ = 57 EeV.**

The smearing angle at E = 100 EeV is 1°

# Sources: Correlation with LSS



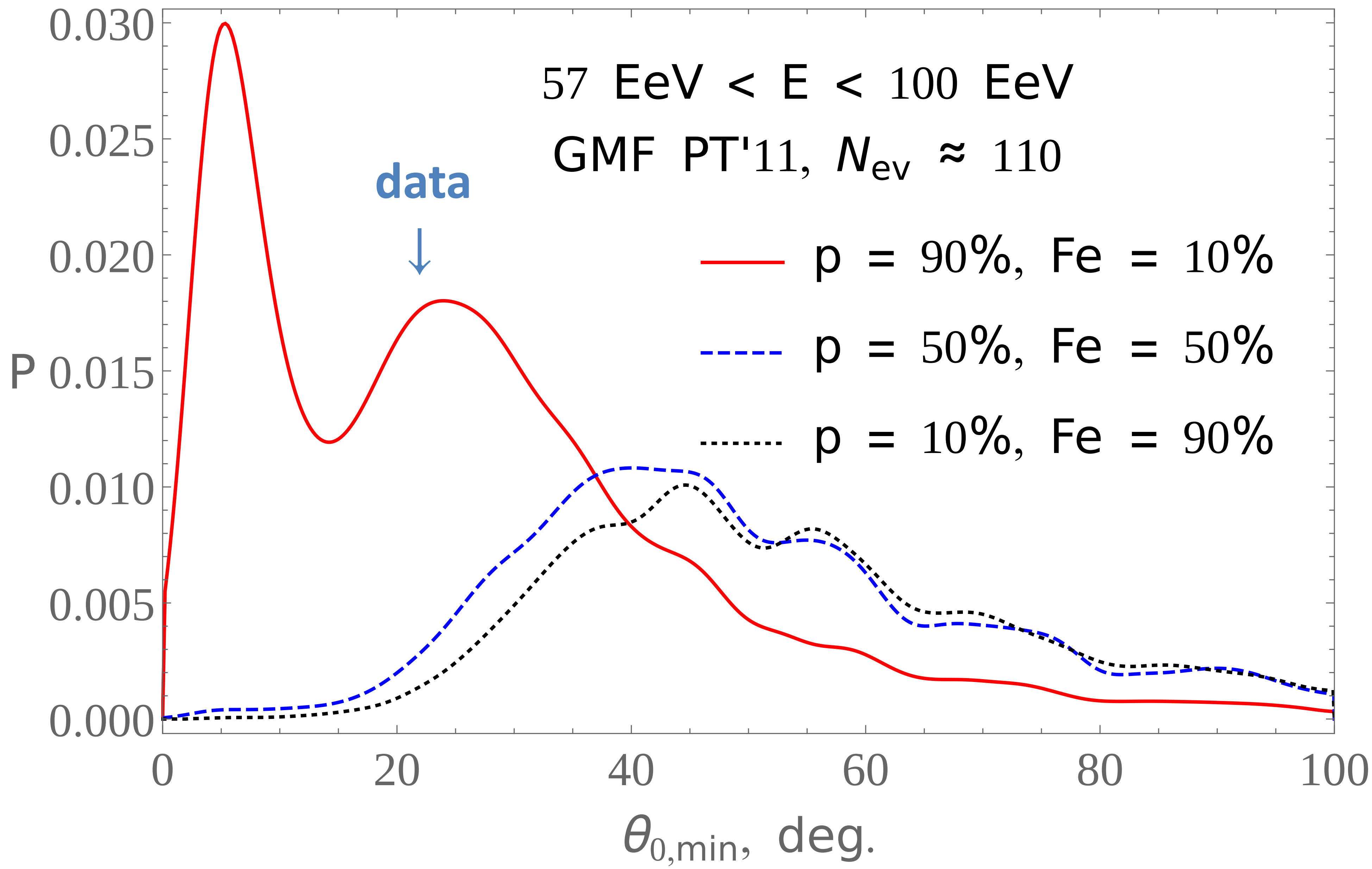

Resulting $TS(\theta_0)$ for the datasets defined in the legend.

Most significant minimum is at ~20° for 57 EeV < E < 100 EeV.

Isotropic distribution is excluded at 2.4$\sigma$ level according to the deepest minimum.

For details see report by M. Kuznetsov at this conference

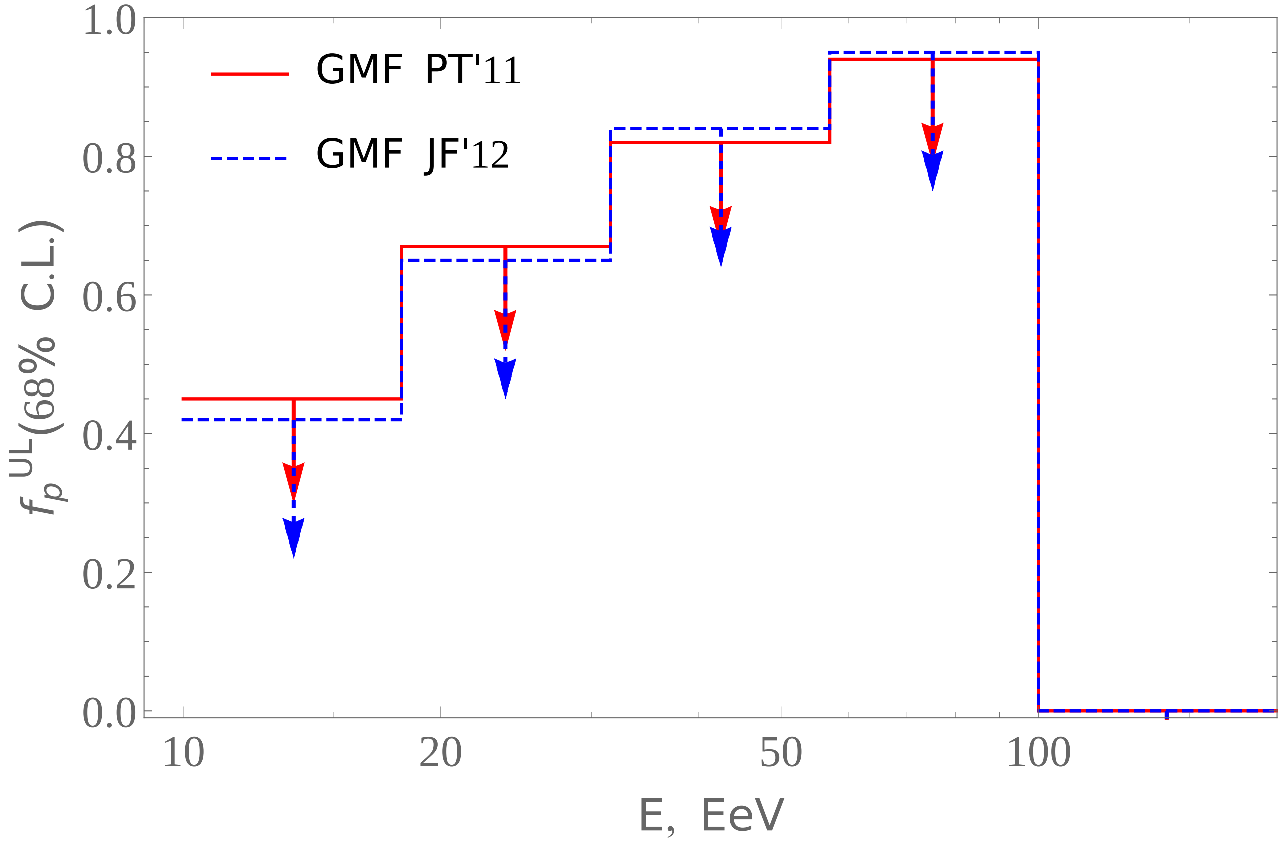
# Correlation with LSS: chemical composition

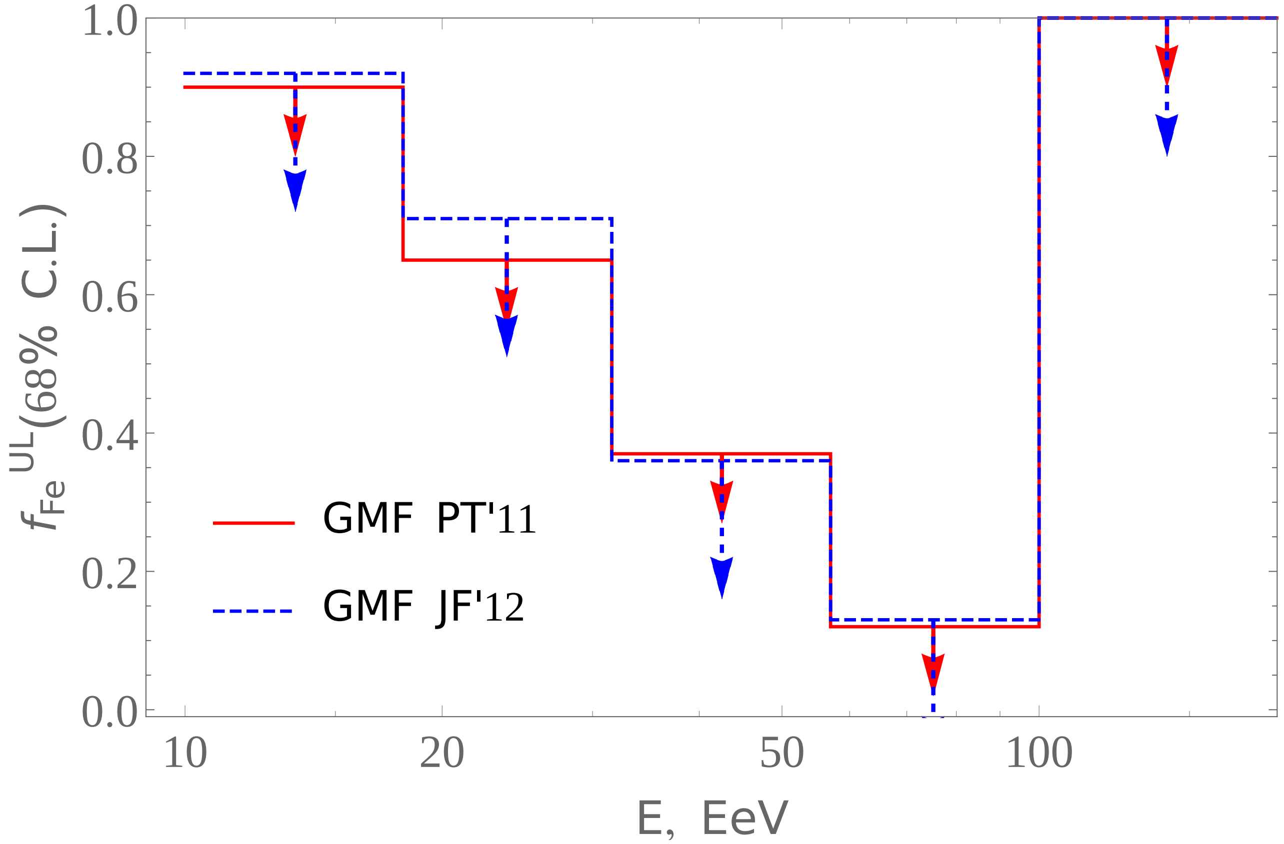



Distributions of TS minima in the p+Fe model.

TA data are compatible with a large fraction of protons.

# Correlation with LSS: chemical composition

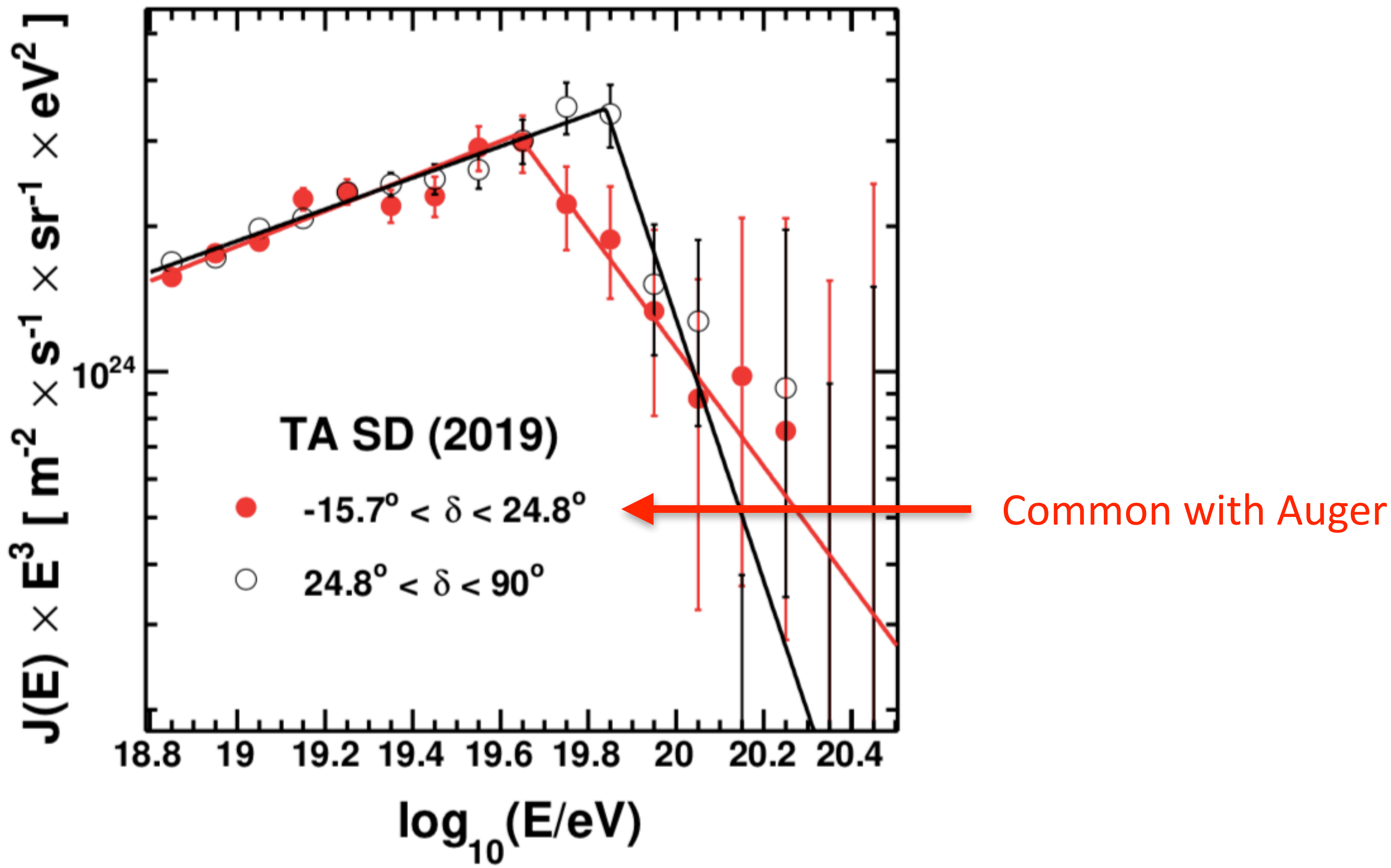



Upper limits on proton and iron fractions at 68% C.L. as functions of energy, derived from correlation with LSS

For details see report by M. Kuznetsov at this conference.

# Spectral anisotropy




TA SD spectra measured in two declination bands

The global significance of the difference is 4.3 standard deviations

For details see report by D. Ivanov at this conference

# Conclusions

- ❑ At largest angular scales and smallest energies indication for the dipole

- ❑ Hints of anisotropy at higher energies
  - ✓ hot spot survives
  - ✓ correlation with large-scale structure
    - ➡ consistent with large fraction of protons
  - ✓ declination dependence of the spectrum