Яркий источник космических лучей как решение противоречий между Auger и TA

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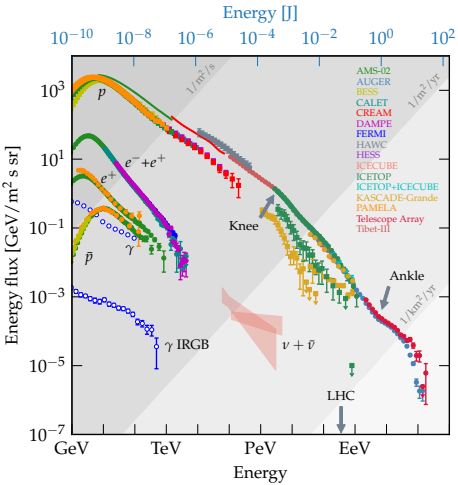
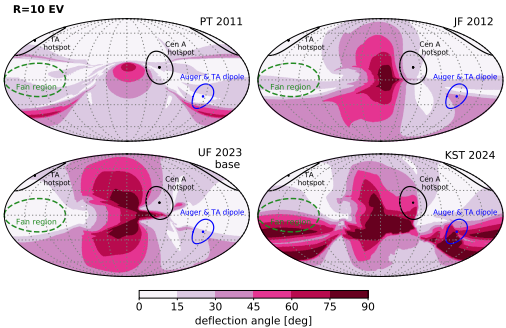
Отклонения

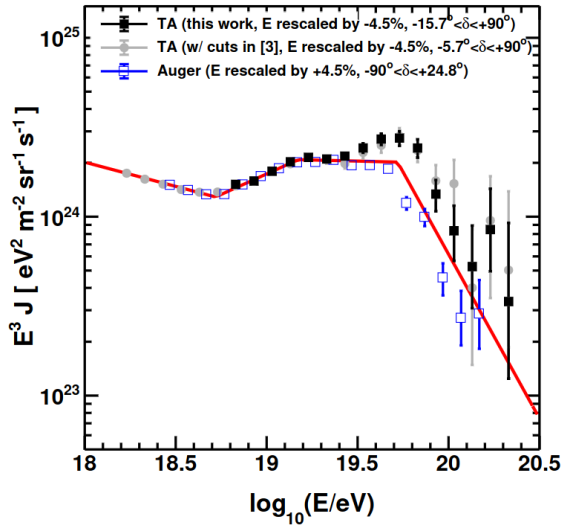


Typical deflection

$$\alpha \approx 48^\circ \cdot \left(\frac{D}{3\,\mathrm{kpc}}\right)\left(\frac{10^{19}\,\mathrm{eV}}{E}\right)\left(\frac{B}{3{\cdot}10^{-6}\,\mathrm{G}}\right)$$



TA-Auger spectrum tension: declination dependence



$> 5\sigma$

systematics
or
evidence for a local source?

The idea of a local source in application to TA-Auger difference is not new, e.g. Globus 2017, Zhang 2024

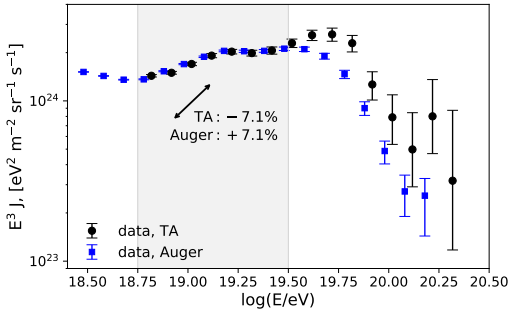
Simultaneous TA-Auger spectrum fitting

Data

- TA spectrum from declination dependence paper
- Auger spectrum from arXiv:2506.11688

Background model

- **Broken power-law** with two break points
- **Has a dipole** as measured by Auger (assuming it was produced by a population of sources following the LSS)



Simultaneous TA-Auger spectrum fitting

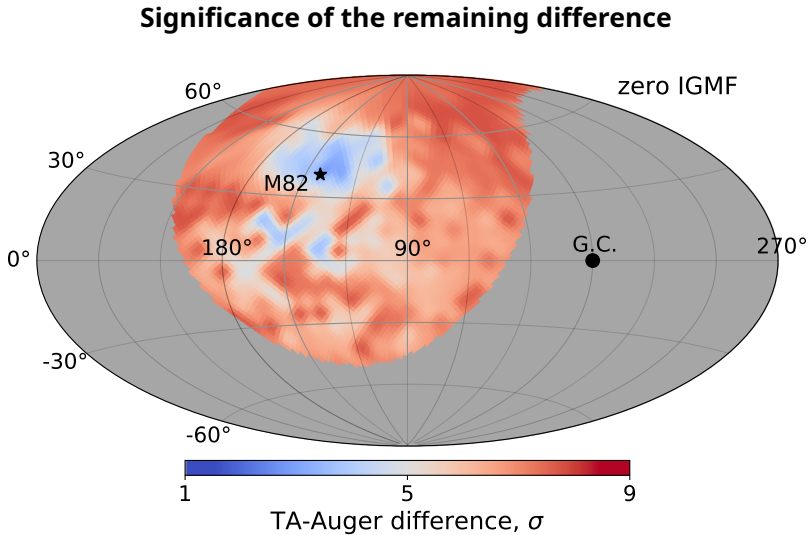
Fit parameters:

- background — 6 parameters
- source spectrum — power-law with cutoff, 3 parameters (slope, cutoff, cutoff steepness)
- source composition — $f_p, f_{He}, f_C, f_{Si}, f_{Fe}$

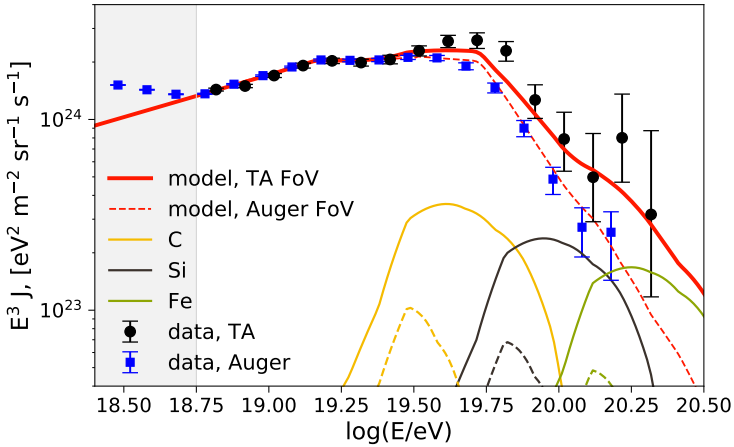
Fit details:

- TA spectrum — χ^2
- Auger spectrum — χ^2
- TA field of view — no hotspots with significance $> 5\sigma$
- Auger field of view — no hotspots with significance $> 2.5\sigma$
- KST24 GMF model

Scan over source positions (l, b)

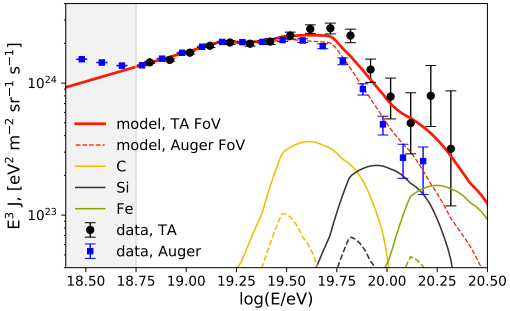


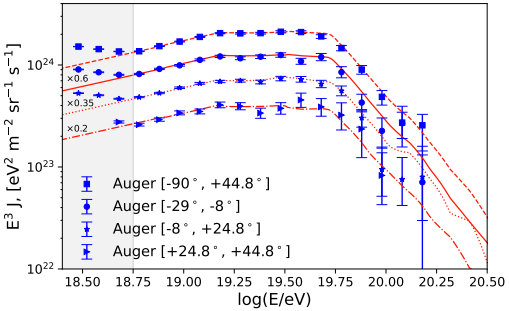
Best-fit TA and Auger spectra (background + source)



Best fit $\chi^2/\mathrm{ndf} = 39.6/19$, corresponds to 2.9σ

Best-fit TA and Auger spectra (background + source)





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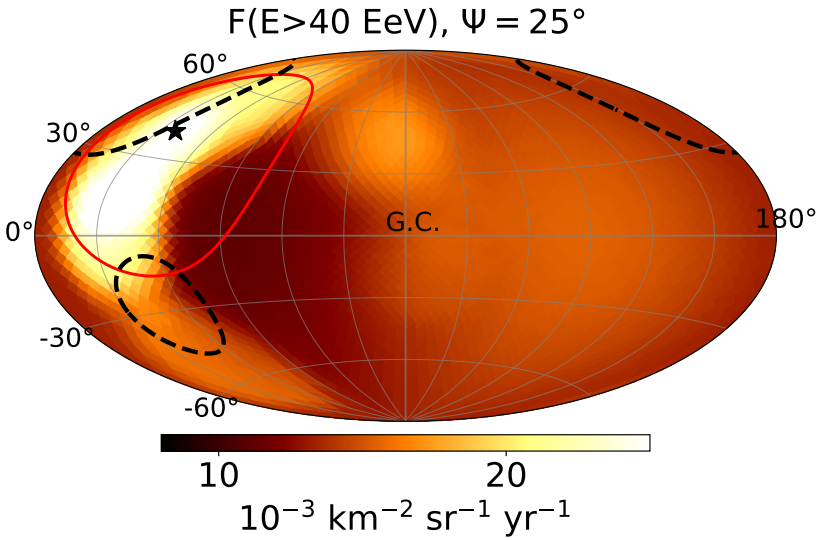
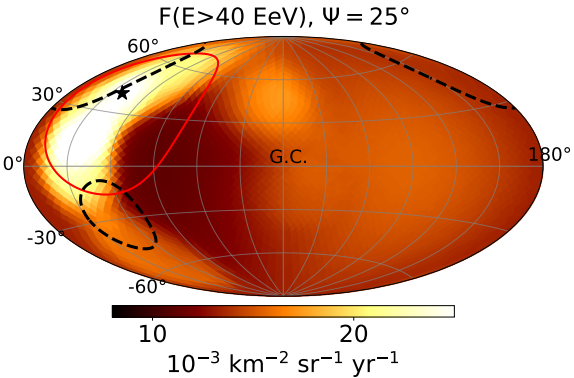
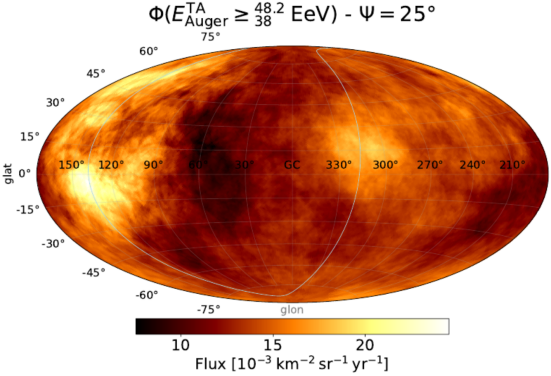
Best-fit UHECR flux map



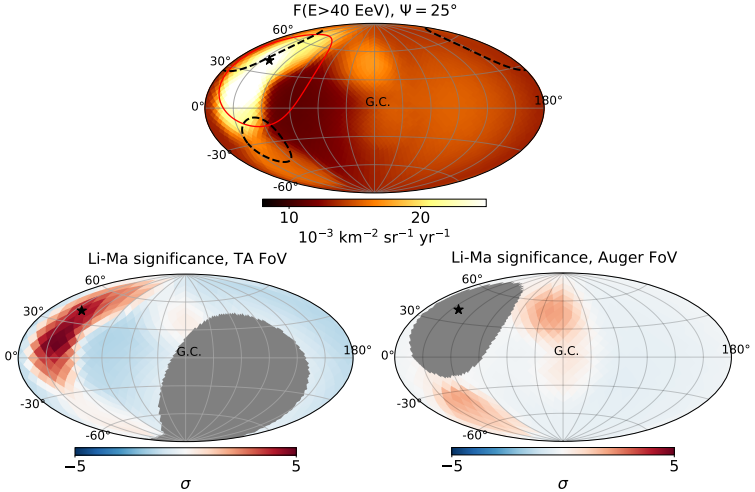
Model vs actual flux maps



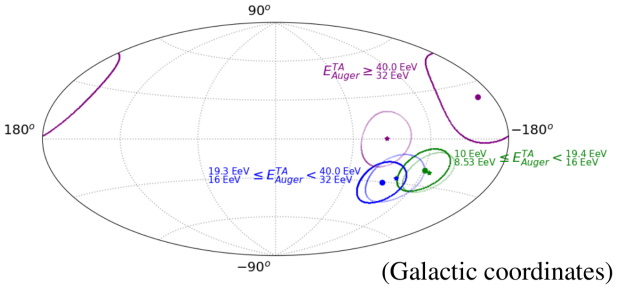


Li-Ma significance maps

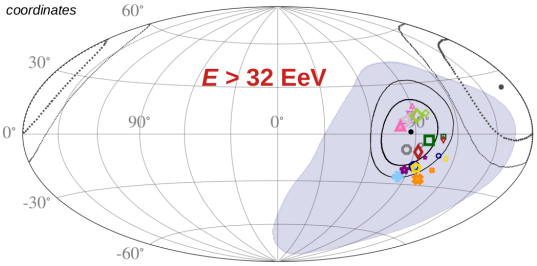
Brighter source would overproduce medium-scale anisotropy



Dipole directions



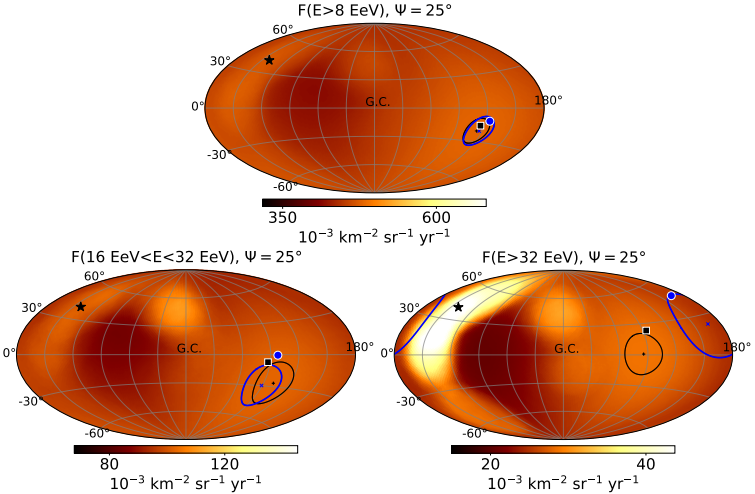
(Galactic coordinates)



Left panel: anisotropy WG. Right panel: T.Bister ICRC 2025

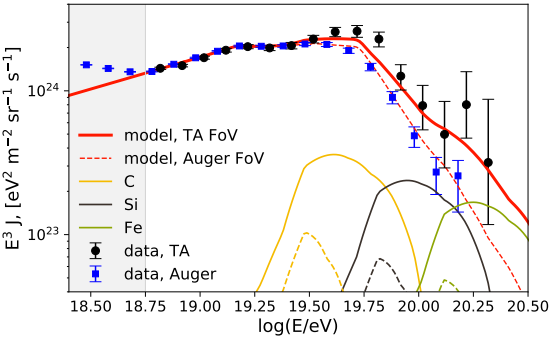
Shift of the dipole direction

The source does not spoil dipole direction at lower energies but shift it to the right direction at $E > 32$ EeV



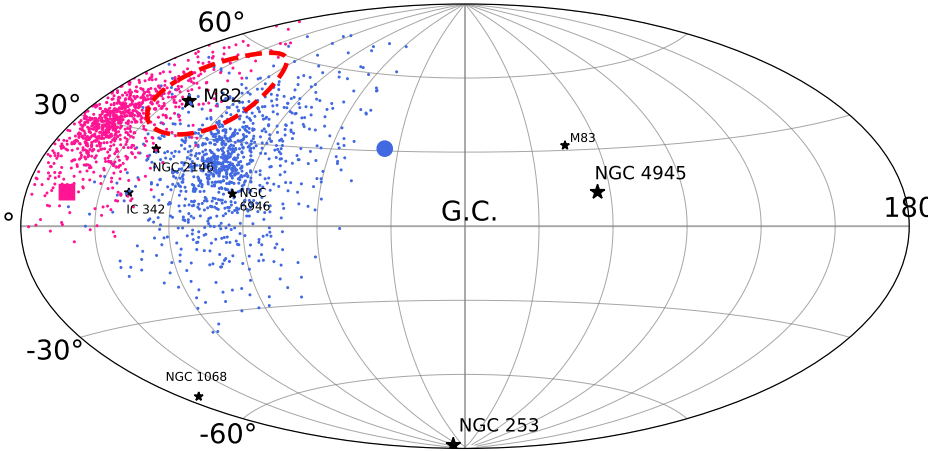
Spectrum of the source

- hard spectrum $\gamma \sim 0$ ($\frac{dN}{dE} \sim R^{\gamma} \exp(-(R/R_{\rm cut})^{\beta})$)
- cutoff at the rigidity of $R_{\rm cut} \sim 10^{18.5}$ eV
- CNO dominated, with Si and Fe at the highest energies



Similar injection spectrum is required to fit the Auger spectrum and composition.

Amaterasu and Oh-my-God particles



Conclusions

- Local source can significantly reduce the TA-Auger spectral tension without overproducing medium scale anisotropy
- Fit is not perfect — probably, unaccounted systematics
- The local source shifts the dipole direction at $E > 32$ EeV to match the combined TA+Auger data
- Source injection parameters and composition are similar to those required by Auger
- The best-fit source region includes the starburst galaxy M82
- Our new GMF model KST24 is **publicly available** (Zenodo, CRPropa)