Anisotropies of ultra-high energy particles in cosmic magnetic fields

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Abstract

The deflections of ultra-high energy cosmic rays caused by the Galactic and extragalactic magnetic fields limit the information that can be extracted from the arrival directions of particles detected on Earth regarding their potential sources. In this study, we explore the impact of Galactic magnetic deflections on cross-correlation analyses with source catalogs and on local significance, incorporating the coherent field model of JF12 [3] and UF23 [4] with different realizations of the turbulent component following [5].

Simulations with GMF deflections

❏ Starburst galaxies (SBGs) catalog used for simulations with a mixed injected spectrum considering a rigidity cut-off (taken from Ref. [2])

❏ GMF applied to compute the arrival directions of the events on Earth
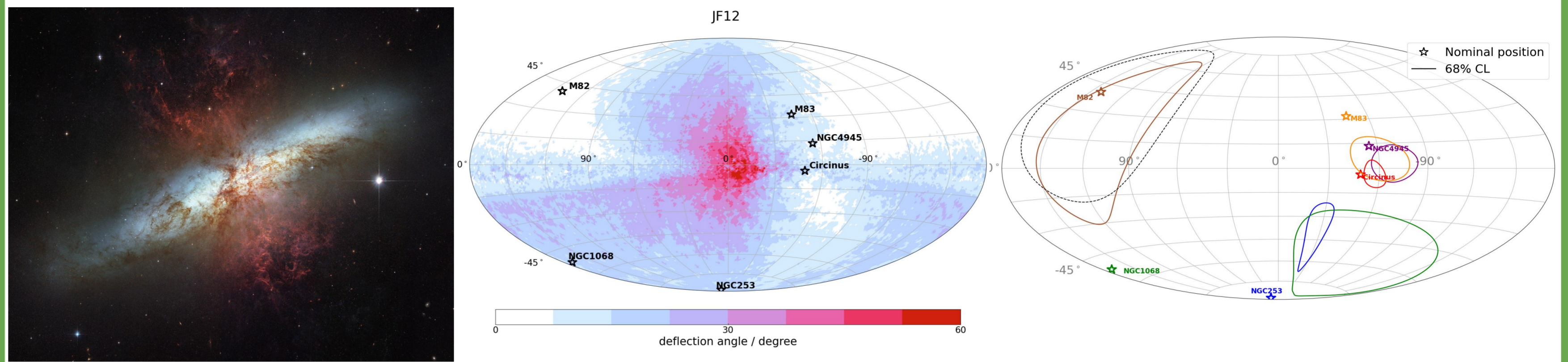
Compatibility of simulated arrival directions with data

❏ Likelihood analysis conducted for different signal fractions together with different realizations of the GMF turbulent component

❏ Calculate acceptance ratio $r = N_{valid}/N_{tot}$ of data sets describing the Auger data in TS, search radius and fitted anisotropy fraction

❏ Good acceptance ratio for different realizations of the GMF ($0.25 < r < 0.45$)

❏ True signal fraction > fitted anisotropy fraction

❏ Reason: heavy elements at high energies are isotropically distributed

❏ **SBG+GMF scenarios are statistically compatible with Auger results** (see also [6])
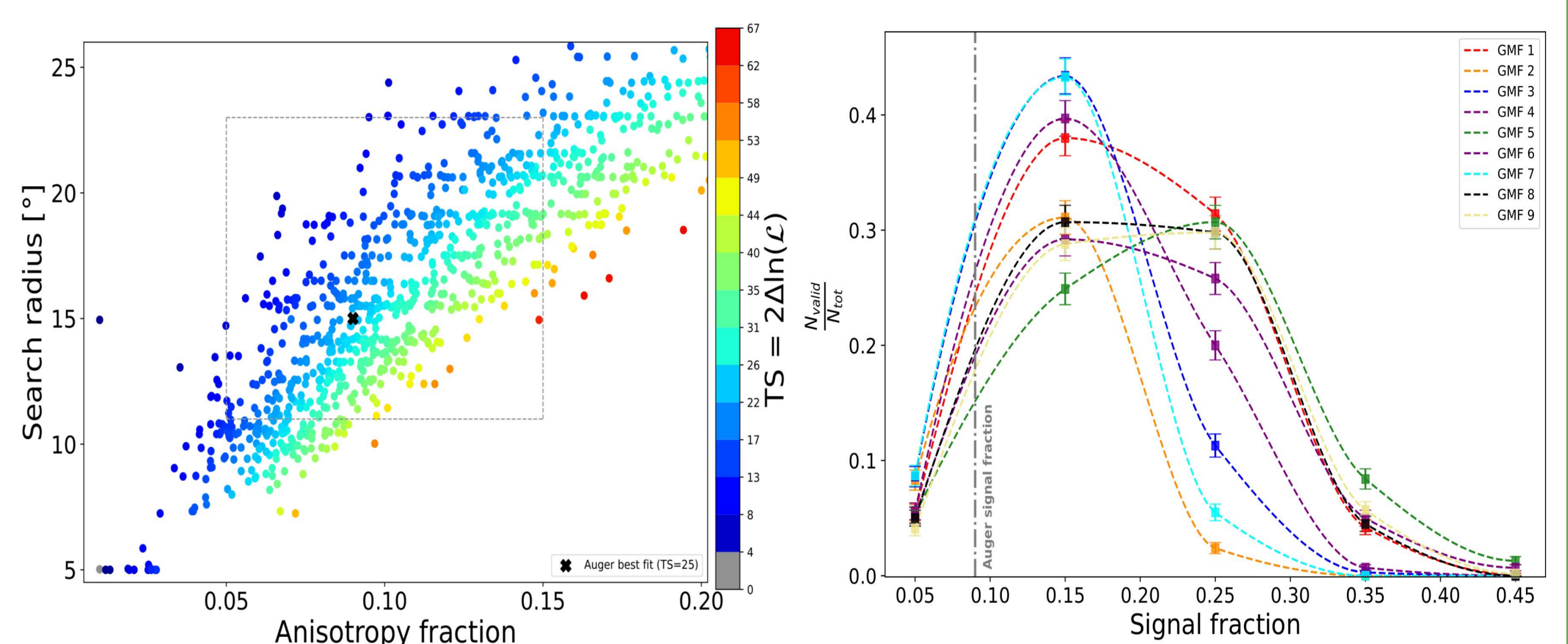
Intermediate scale anisotropy in the UHECR sky

❏ UHECR sky in simulations shows clustering of events not present in data

❏ How to quantify the strength and properties of secondary overdensities

❏ **Is the EGMF necessary?**

Auger dataset

Simulated dataset (twistX)
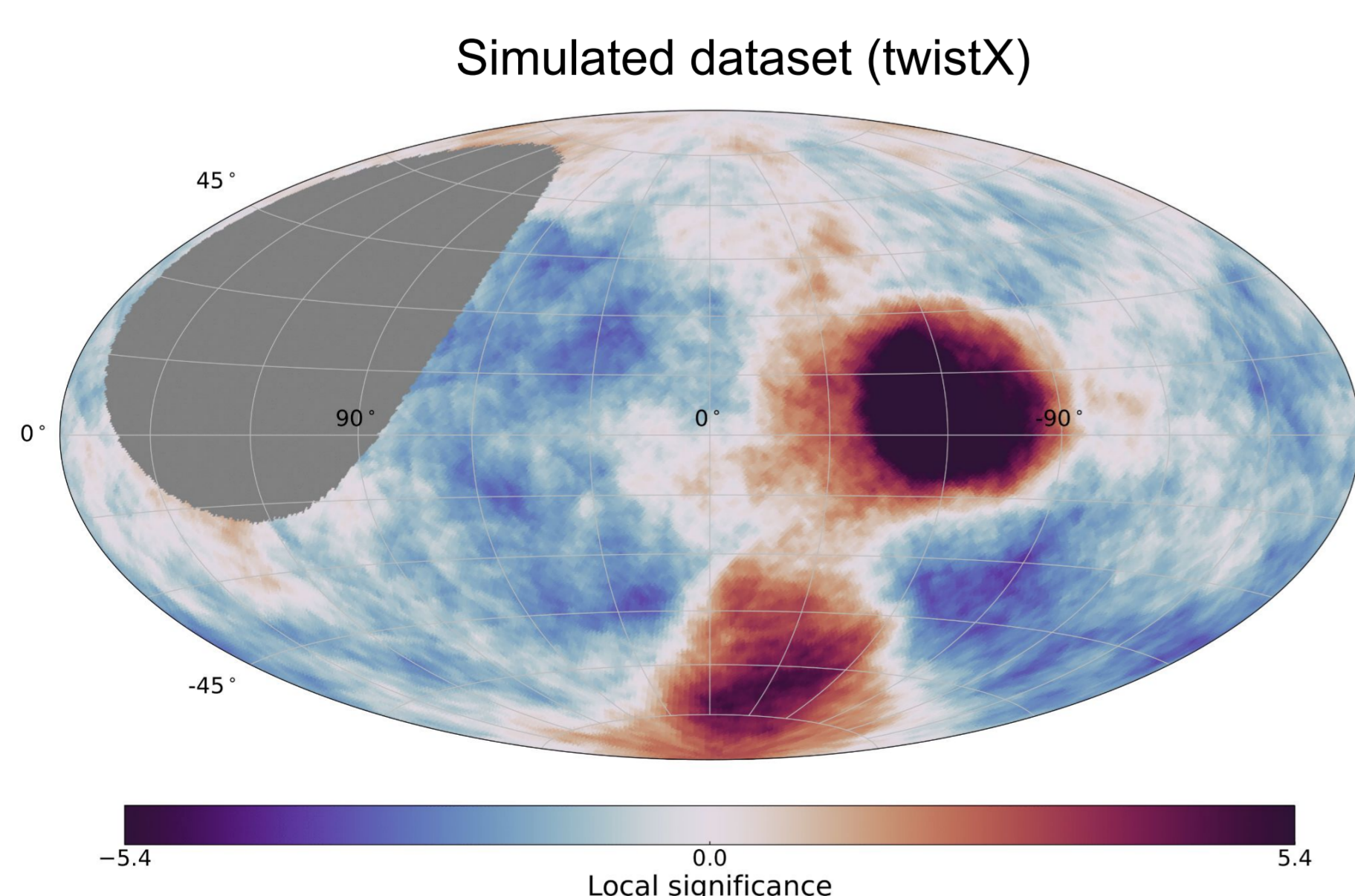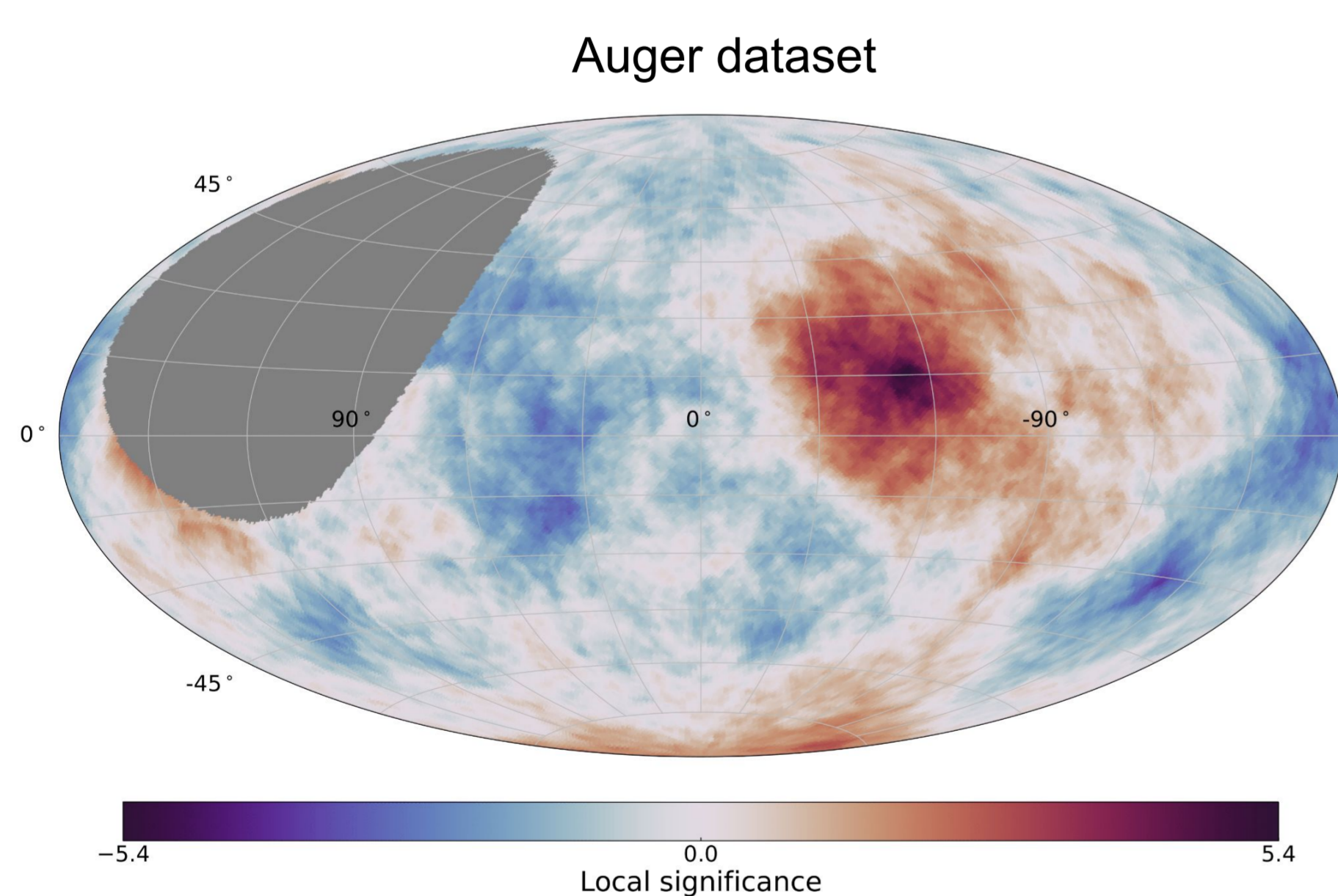
Structures in the arrival directions of UHECRs

❏ EGMF expected to dilute clustering of events in every position of the sky

❏ Different GMF models yield varying interpretations due to differences in both deflection patterns and magnification regions

❏ σ_1^{loc}, σ_2^{loc}: local significance for the first and second overdensity
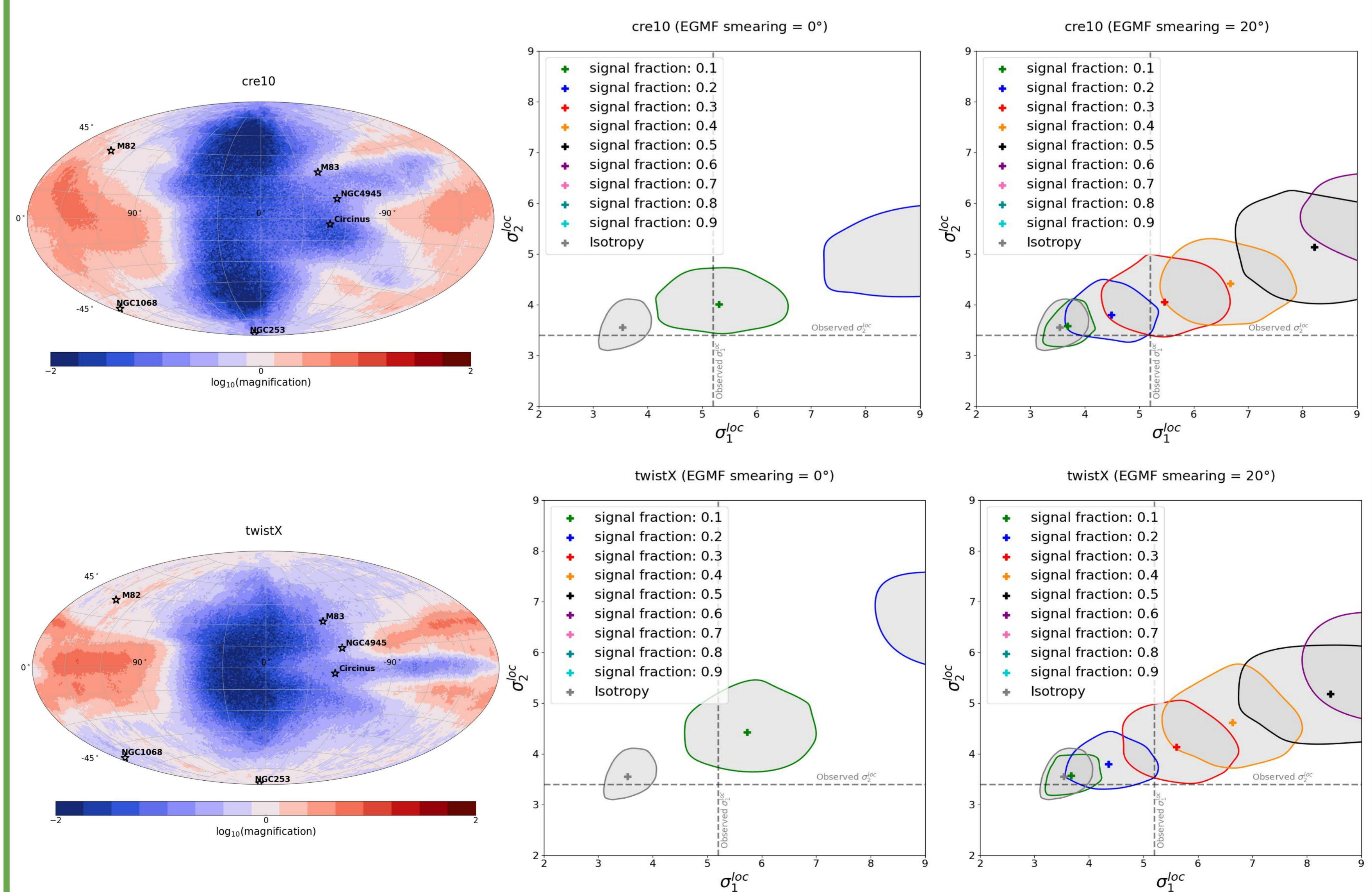
❏ Positive correlation between signal contribution and EGMF smearing component is observed

❏ Next steps and outlook:

  ❏ **Quantifying the strength of the lower limit for the EGMF** (see [6])

  ❏ **Quantifying the strength of the upper limit for the EGMF** (see [7])

References

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