TA anisotropy results and interpretations

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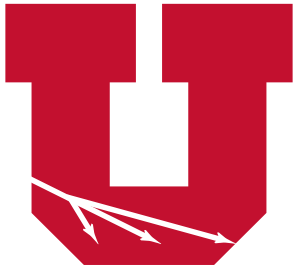
University of Utah

for the TA collaboration

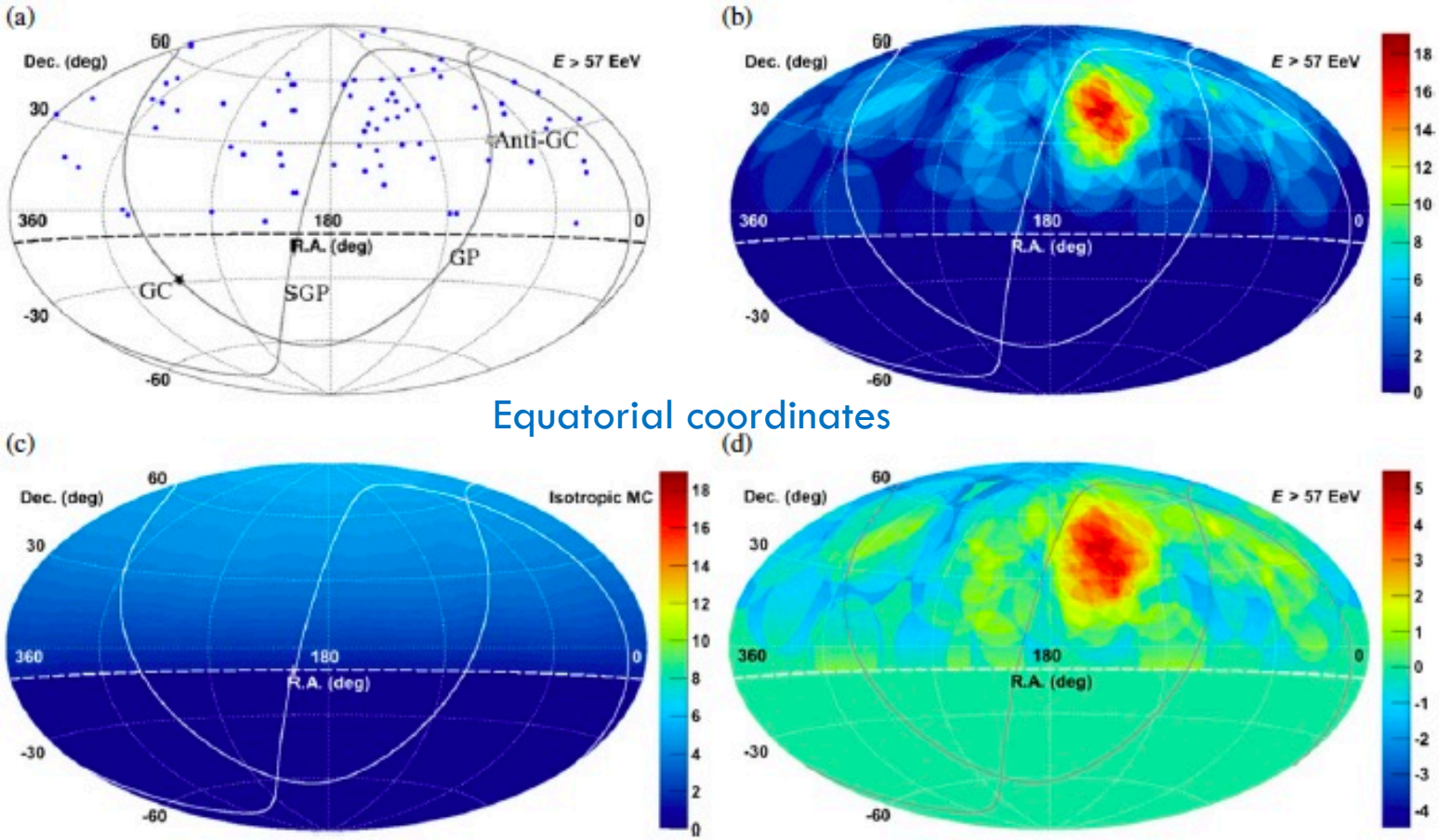


Contents

- Telescope Array experiment
- Update on the hotspot
- Spectral anisotropy at the hotspot
- New excess of events at slightly lower energy
- Expectations for the future decade

Excess of events: Hotspot Abbasi et al., ApJL 790, L21 (2014)

72 events with E > 5.7×10^{19} eV → Li-Ma sig.: 5.1σ, post-trial sig.: 3.4σ

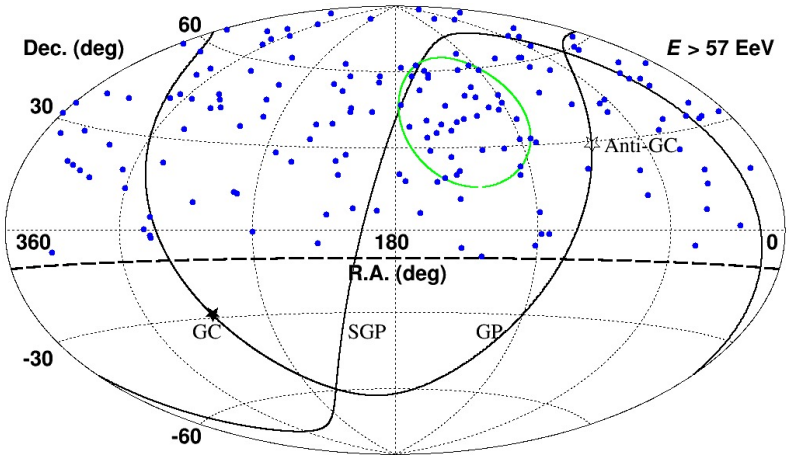


Equatorial coordinates

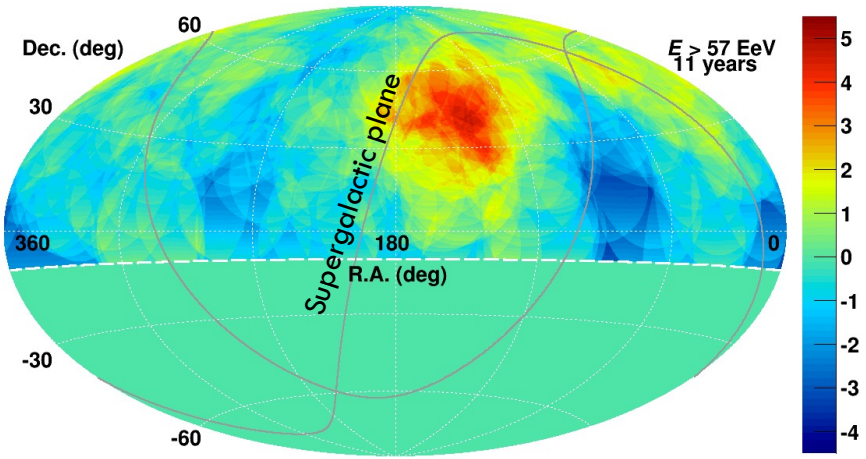
Figure 1. Aitoff projection of the UHECR maps in equatorial coordinates. The solid curves indicate the galactic plane (GP) and supergalactic plane (SGP). Our FoV is defined as the region above the dashed curve at decl. $= -10°$. (a) The points show the directions of the UHECRs $E > 57$ EeV observed by the TA SD array, and the closed and open stars indicate the Galactic center (GC) and the anti-Galactic center (Anti-GC), respectively; (b) color contours show the number of observed cosmic-ray events summed over a 20° radius circle; (c) number of background events from the geometrical exposure summed over a 20° radius circle (the same color scale as (b) is used for comparison); (d) significance map calculated from (b) and (c) using Equation (1).

Update on the hotspot Kawata et al., ICRC 2019

TA events with E > 5.7×10^{19} eV



25° oversampling significance map



Skymaps in the equatorial coordinates

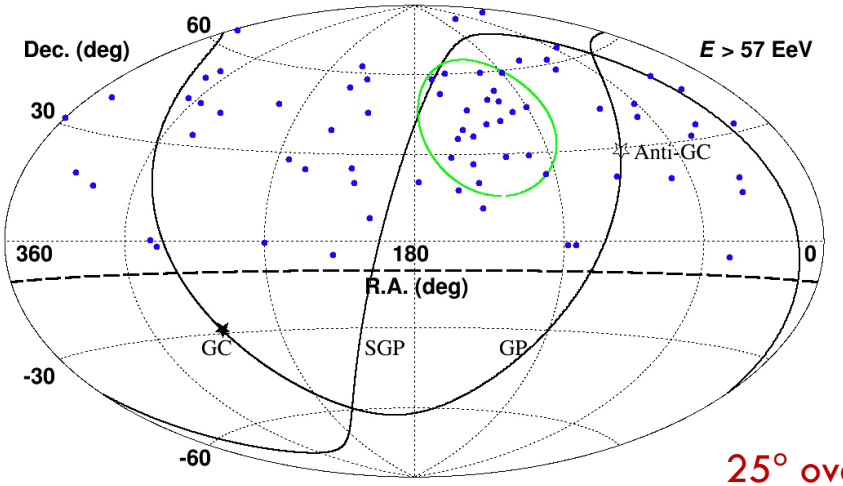
- 168 events with E > 5.7×10^{19} eV (11-year TA SD data)
- Maximum local significance: 5.1σ

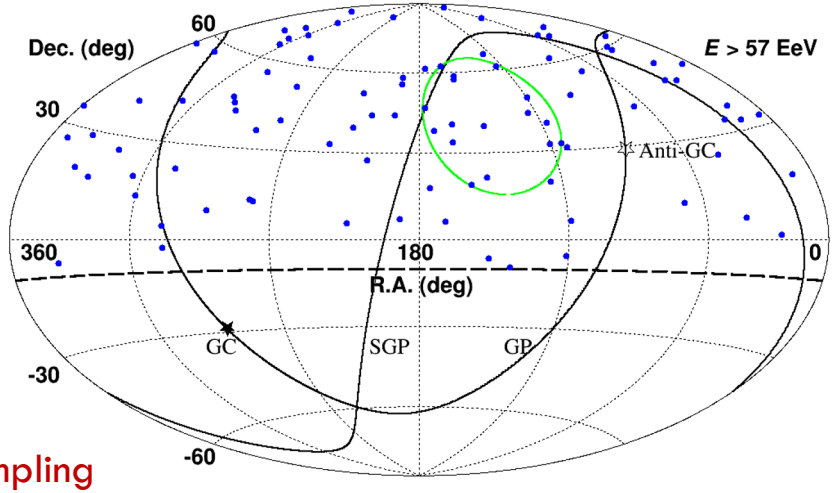
  Observed: 38 events

  Expected from isotropy: 14.2 events } ~170% excess to the isotropy

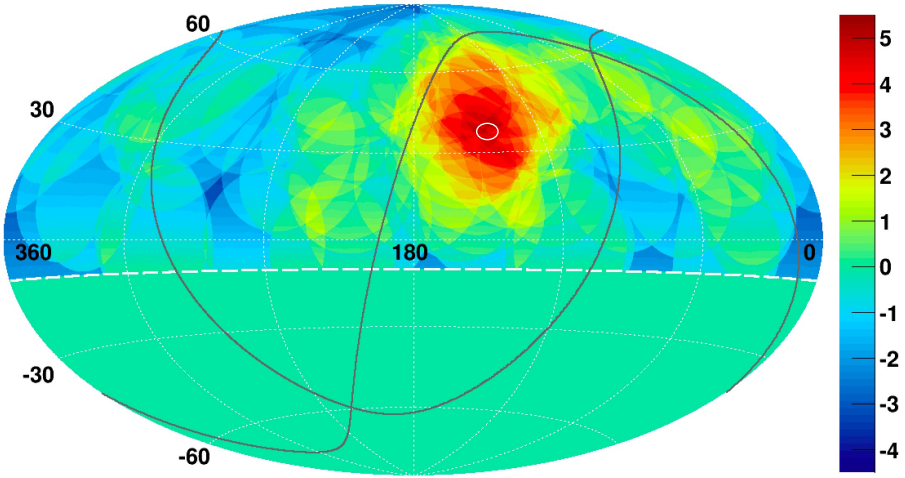
- Post-trial probability: $P(\mathrm{S_{MC}} > 5.1\sigma) = 2.1\times10^{-3}$ → 2.9σ

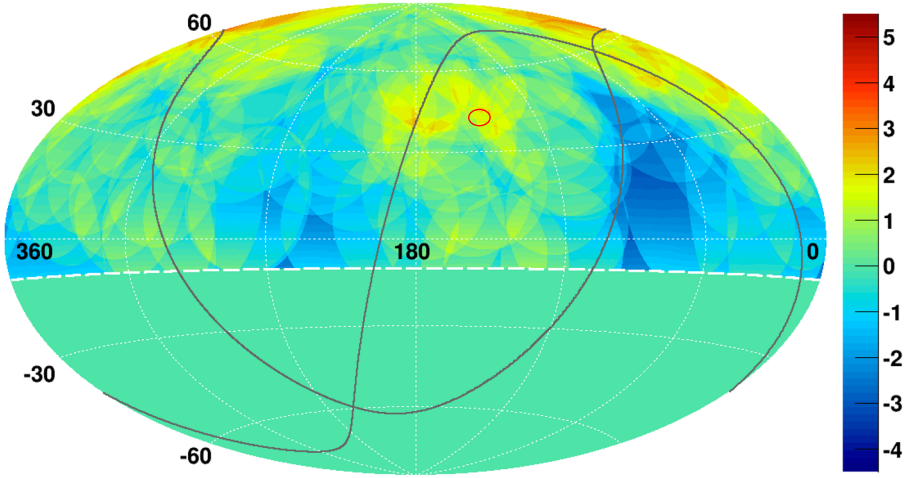
Independent analysis (11-yr hotspot position)





25° oversampling





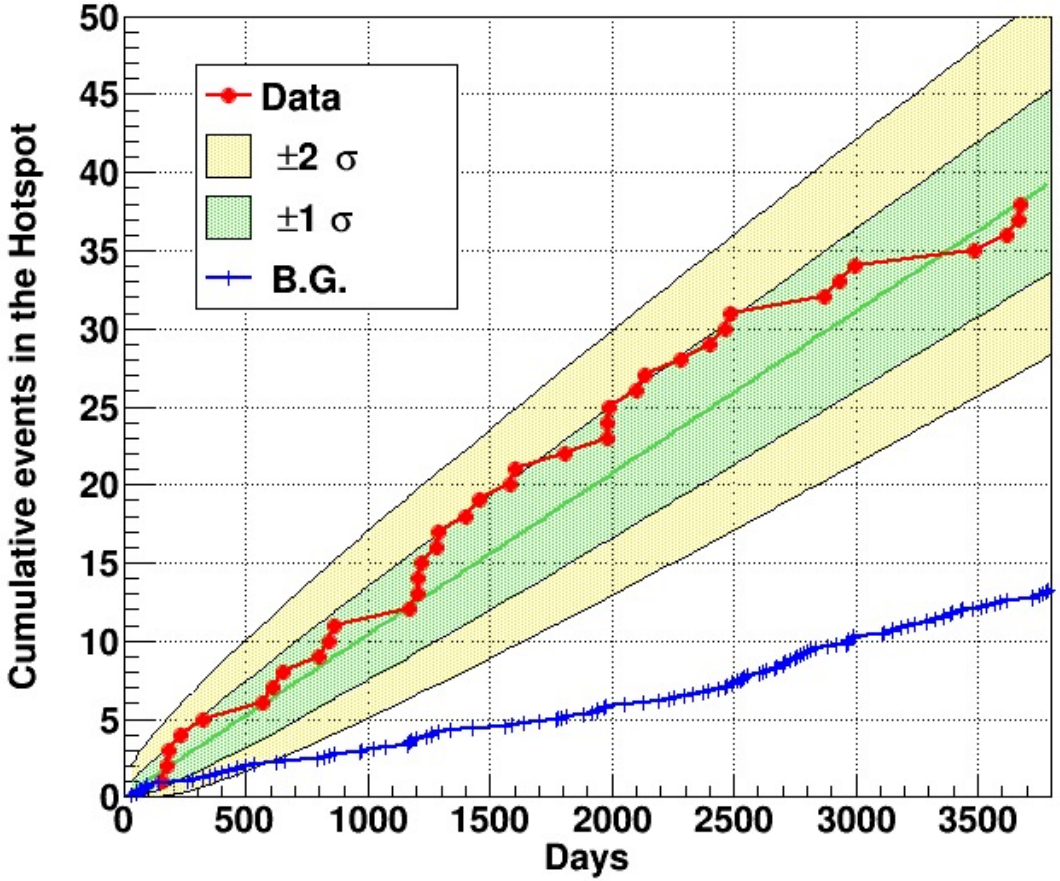
First 5-year: 72 events

S at hotspot center = 5.0σ

Last 6-year: 96 events

S at hotspot center = 2.2σ

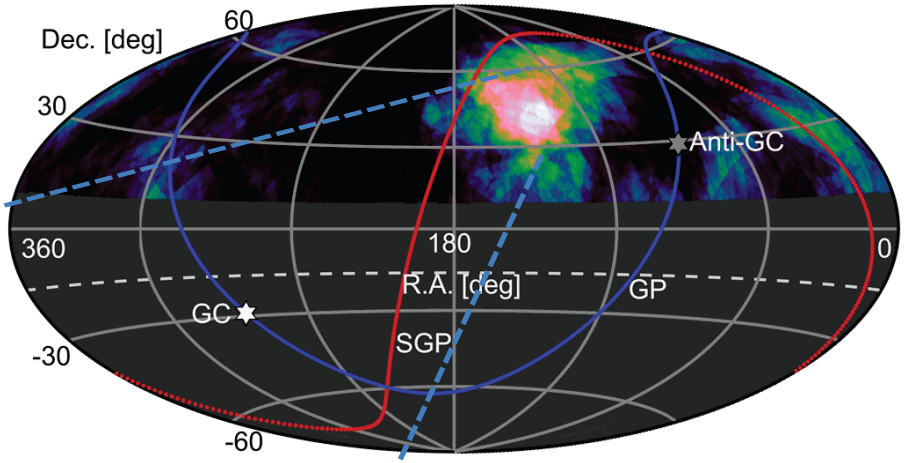
Time variation of the hotspot

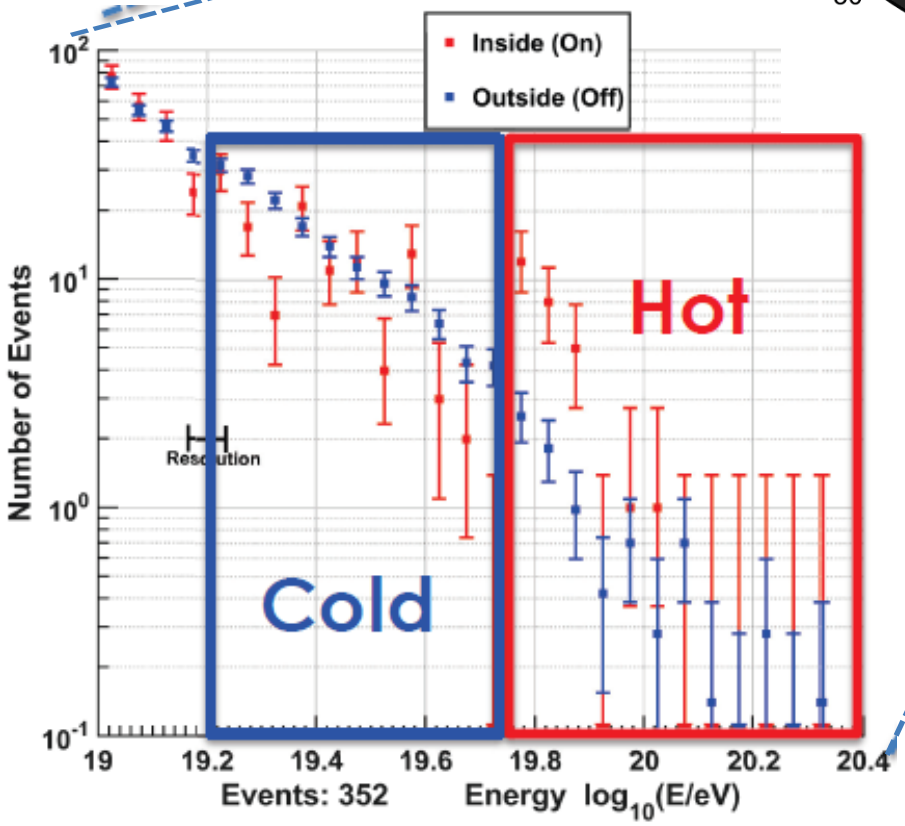


The increase rate of the events inside the hotspot circle is **consistent with the linear increase within ~1σ**

Spectral anisotropy at the hotspot Abbasi et al., ApJ 862, 91 (2014)

Comparison between
the averaged spectrum and
the directional spectrum



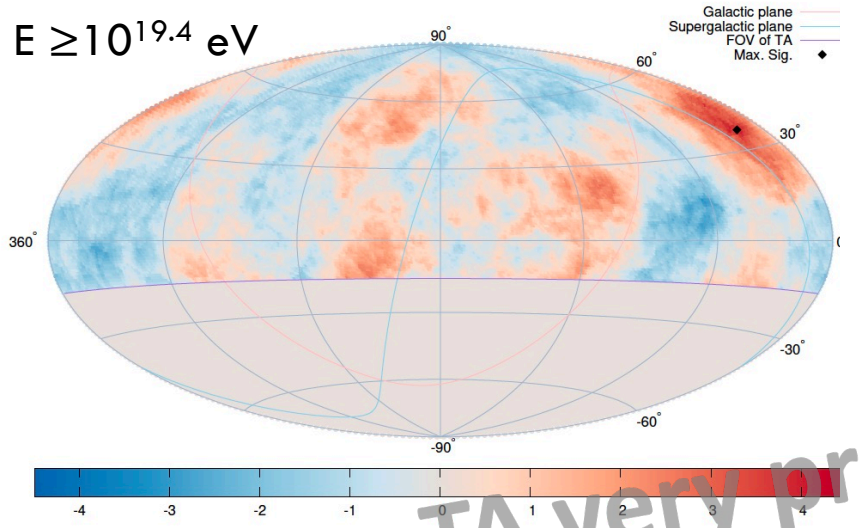


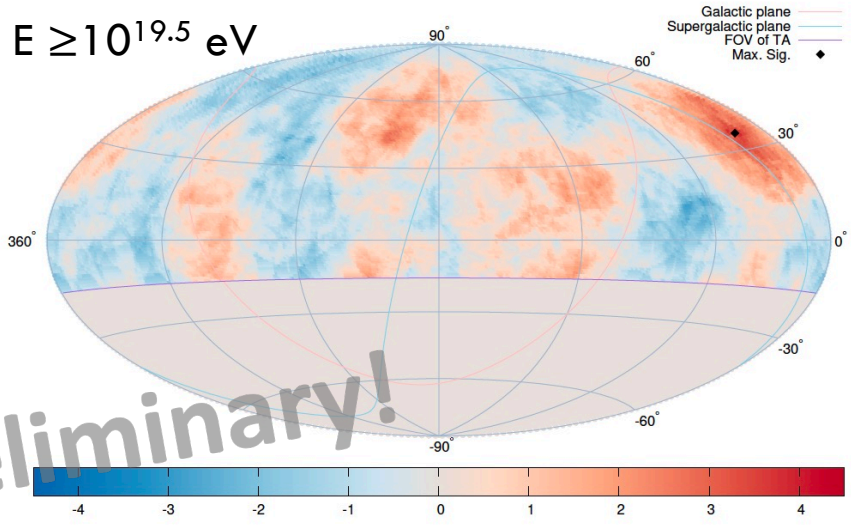
"cold spot" at lower energies,
same place as the hotspot at high

$E \geq 10^{19.2}$ eV

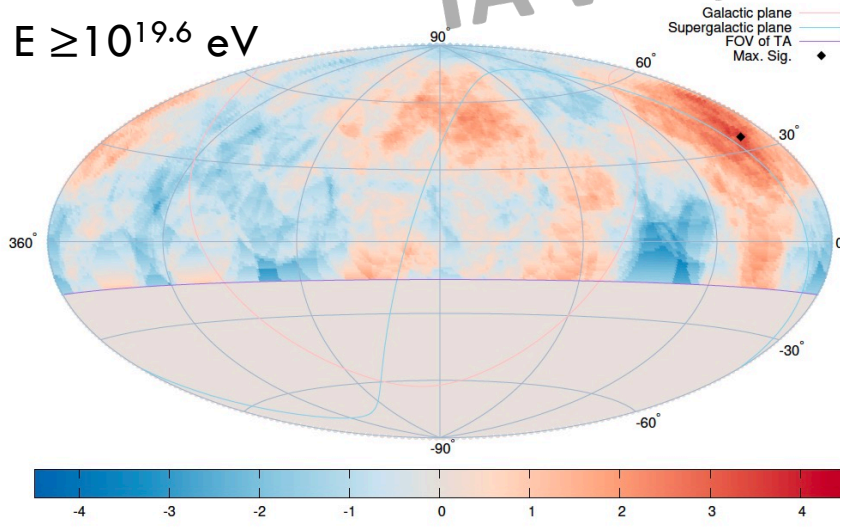
3.7σ post-trial significance

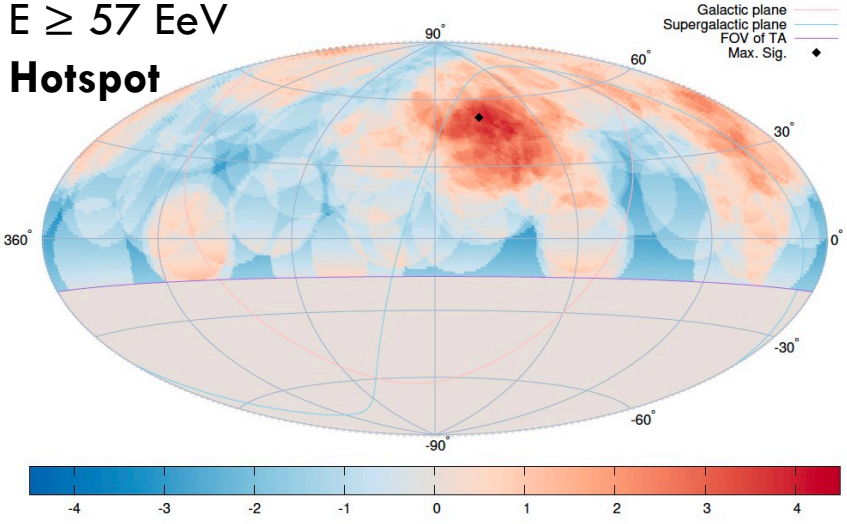
New excess of events at slightly lower energy





TA very preliminary!

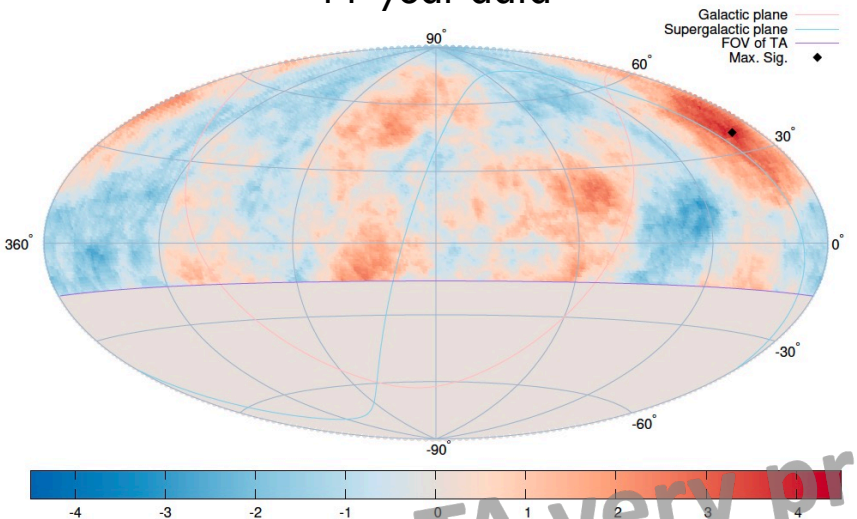




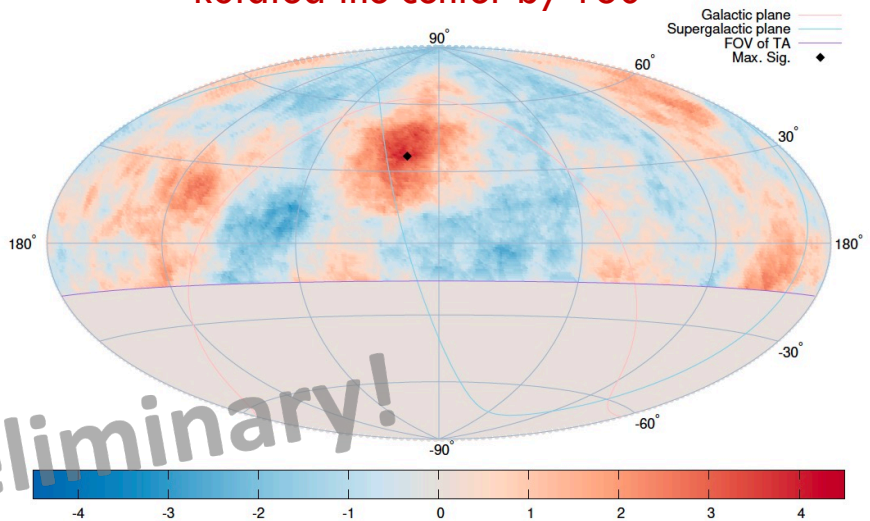
Equatorial coordinates

First 5- and last 6-year data, E ≥$10^{19.4}$ eV

11-year data



Rotated the center by 180°



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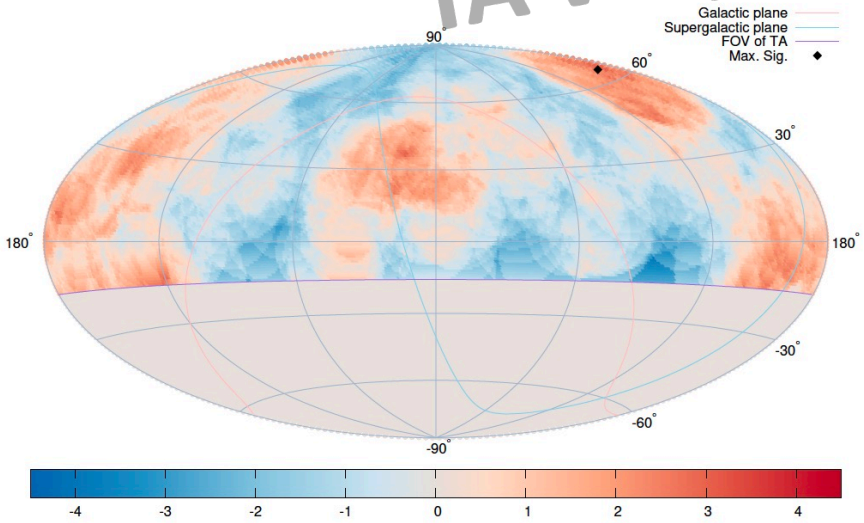
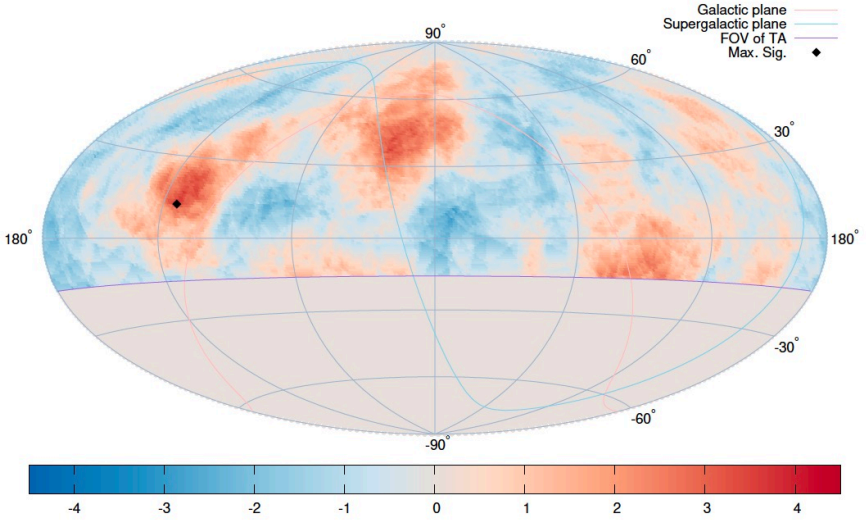


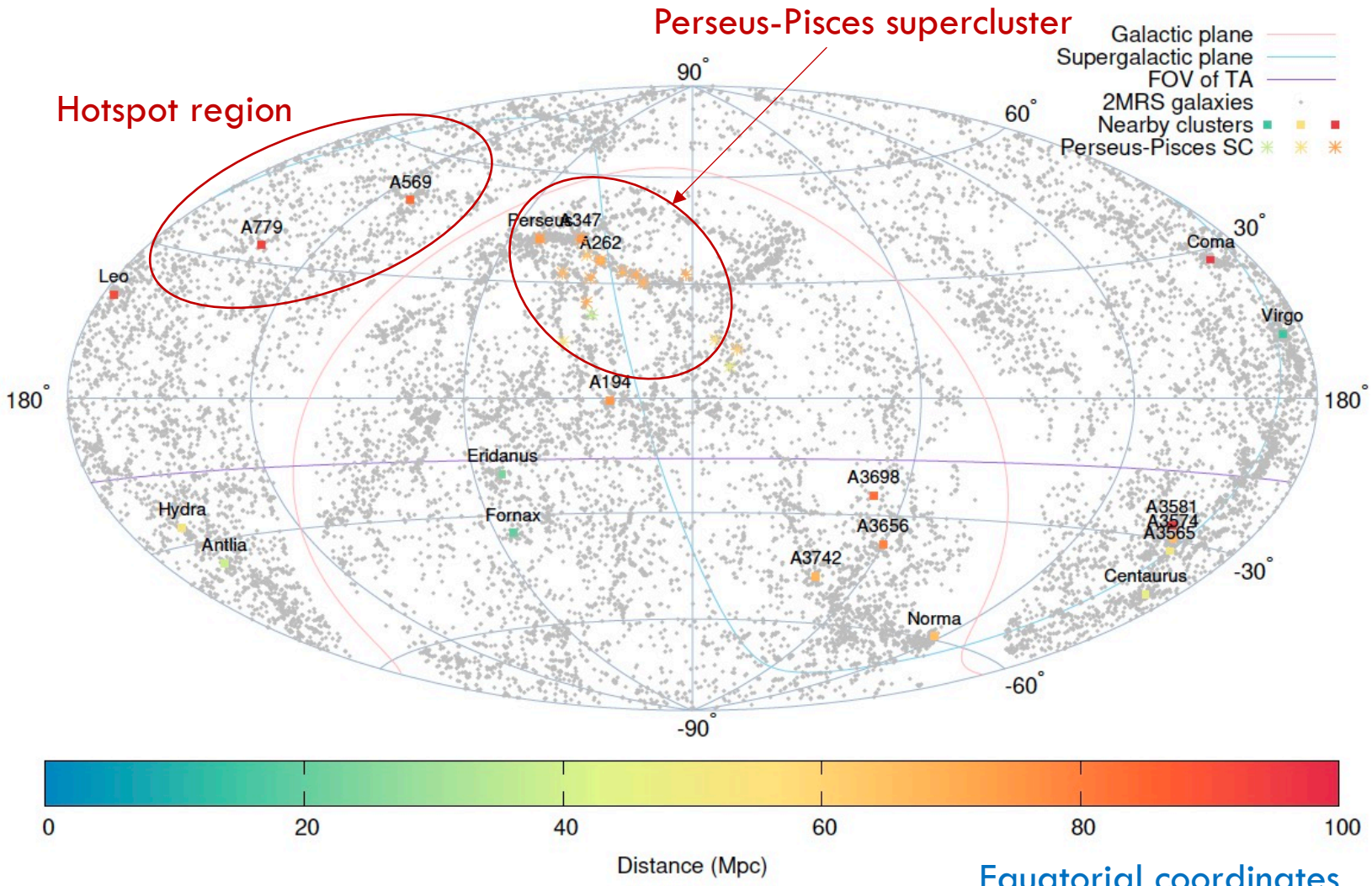
First 5-year data



Last 6-year data

What is behind the new excess?

Sky map with nearby galaxies and clusters of galaxies

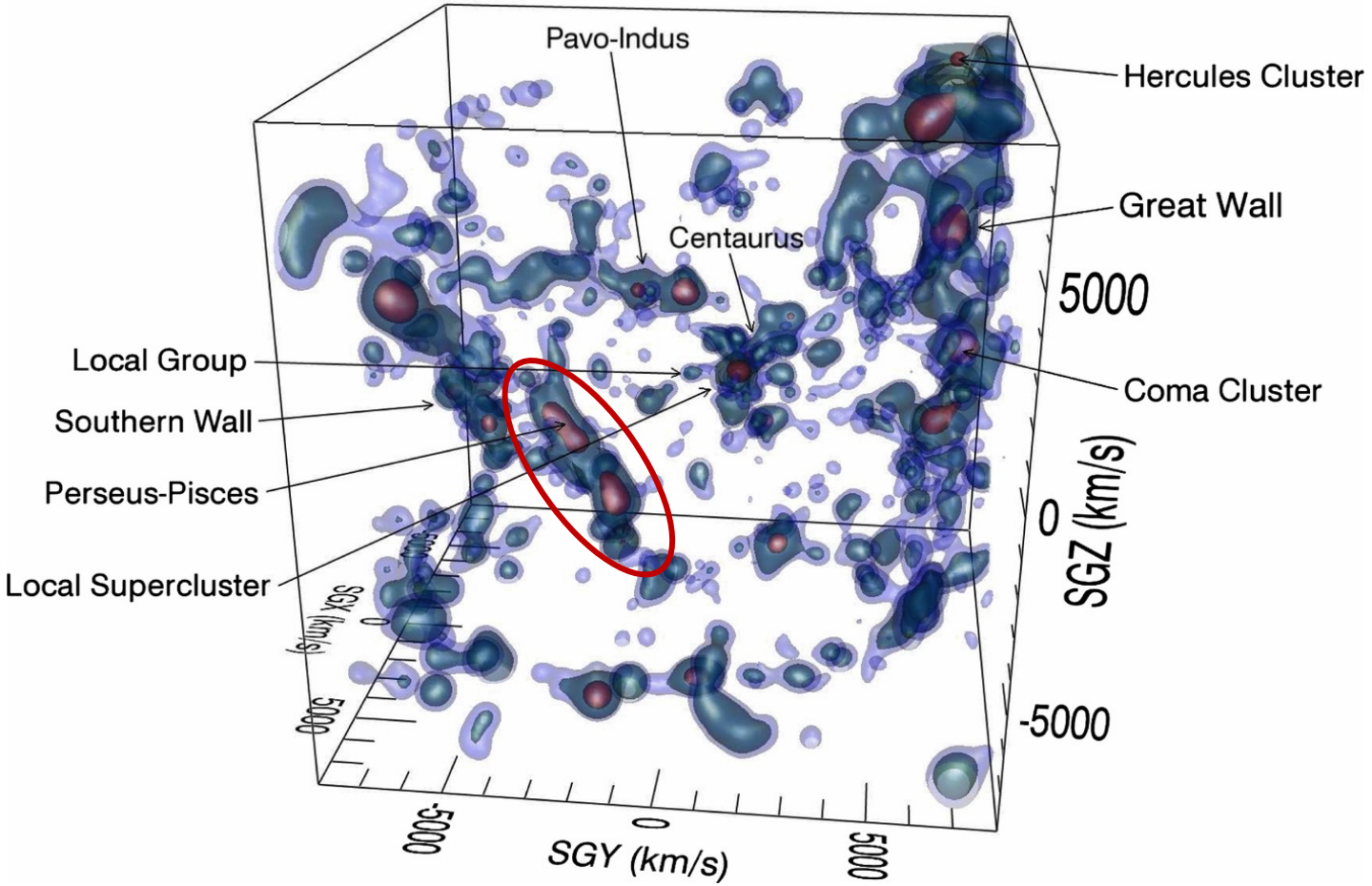


Equatorial coordinates
RA=0 at the center

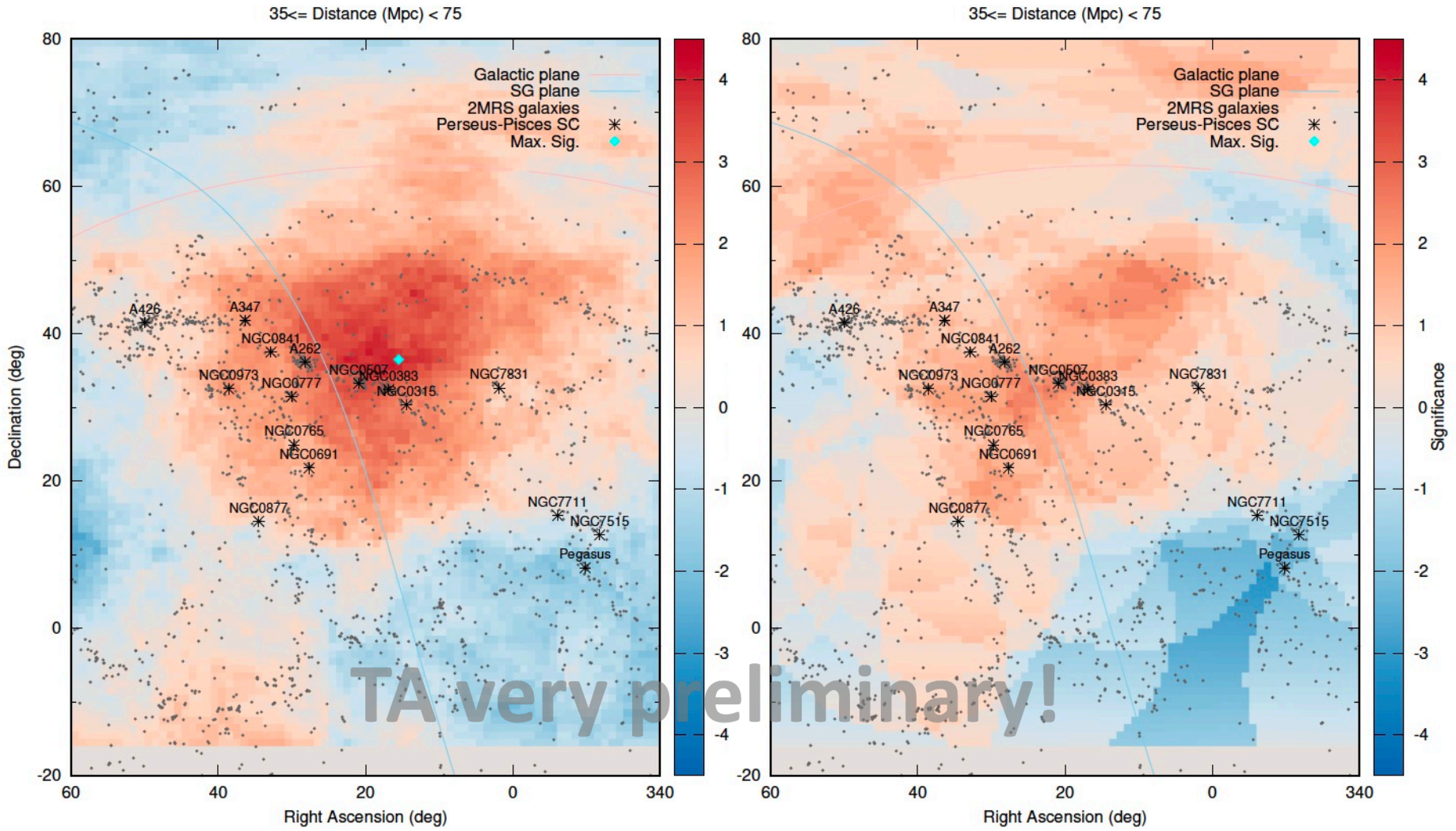
Perseus-Pisces supercluster

Courtois et al., Astronomical Journal 146, 69 (2013)

Density contour maps after making corrections for incompletion



New excess with the Perseus-Pisces supercluster



$E \geq 10^{19.4}$ eV

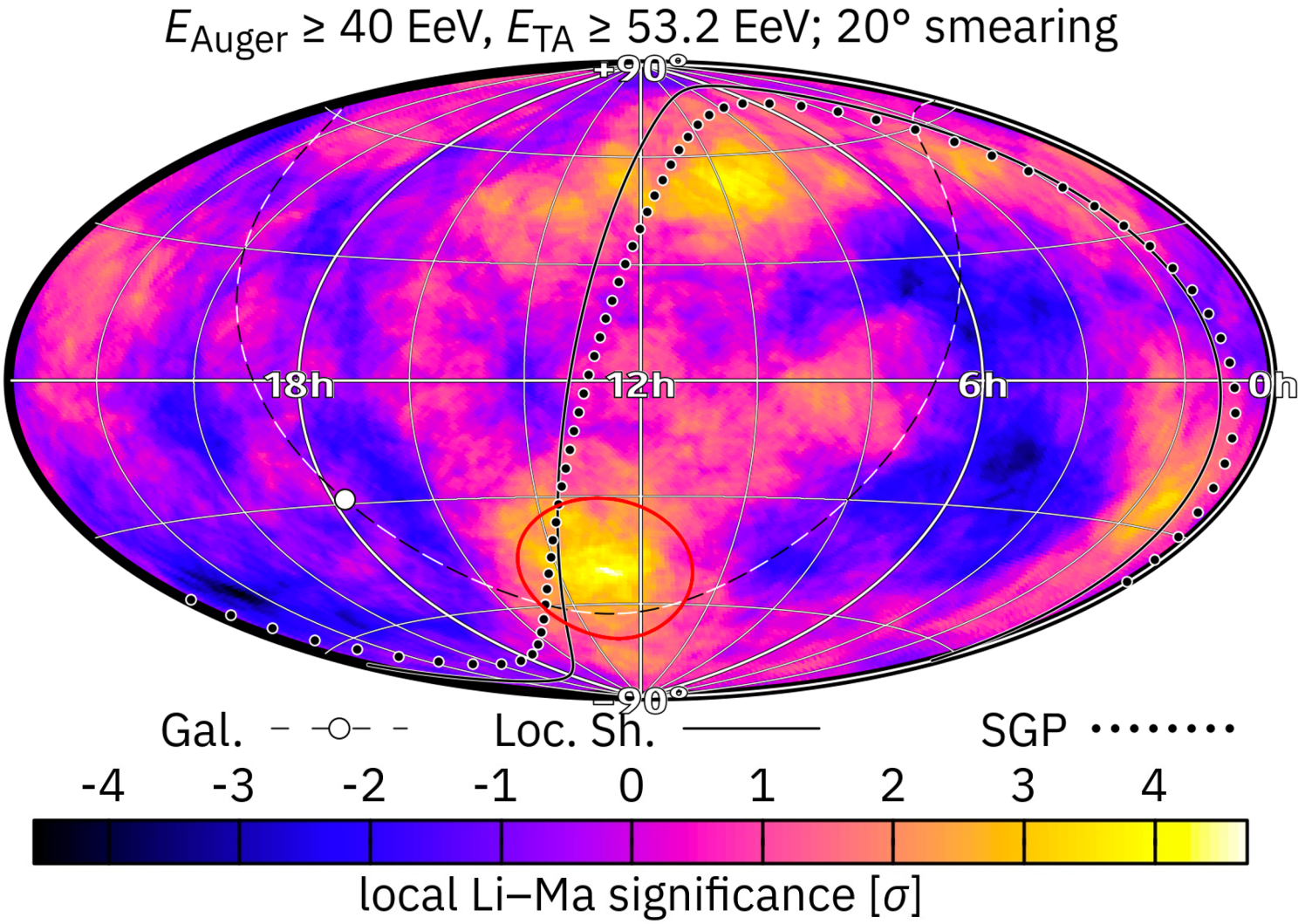
$E \geq 57$ EeV

Summary

- We have persistent hints of intermediate angular scale anisotropies, the hotspot, at the highest energies, $E \geq 5.7 \times 10^{18}$ eV, in the direction of the Ursa Major cluster. ($S_{post} \sim 2.9\sigma$)
- Energy spectrum anisotropy has been found in the arrival directions of events for $E \geq 10^{19.2}$ eV. In the direction of the hotspot, it has a deficit of events with energies $10^{19.2} \leq E < 10^{19.75}$ eV and an excess for $E \geq 10^{19.75}$ eV. ($S_{post} \sim 3.7\sigma$)
- Correlations with supergalactic sheets or filaments may be important.
- We found new excess of events in arrival direction distribution at slightly lower energies, $E \geq 10^{19.4}$eV, in the direction of the Perseus-Pisces supercluster.
- To find out the origin of these anisotropies, it is necessary to measure much more data at the high energy end. → TAx4 in operation + next-generation experiment, like GCOS!

All-sky excess of events: TA-Auger anisotropy working group

di Matteo et al., ICRC 2019



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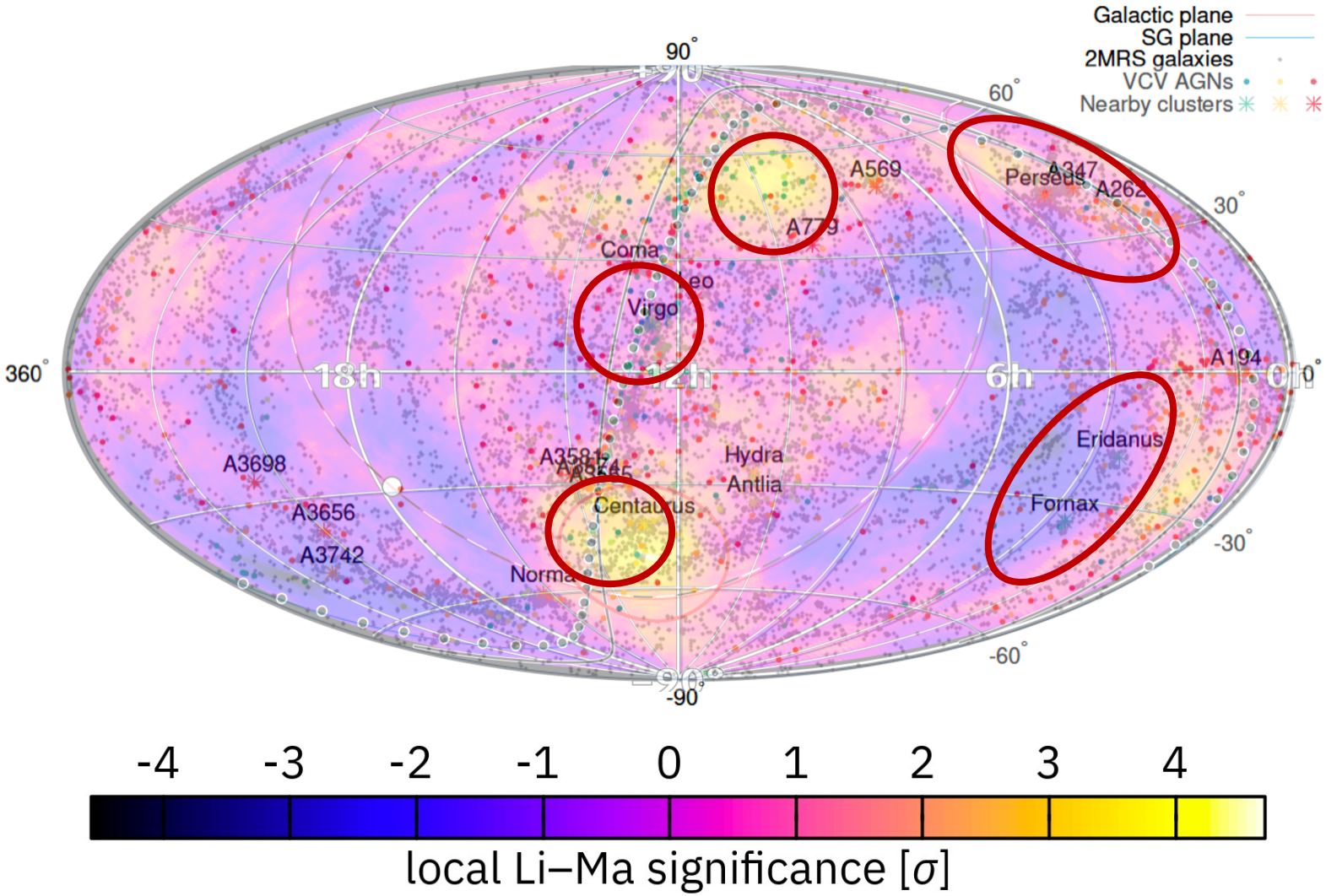
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