



UHECR Signatures and Sources

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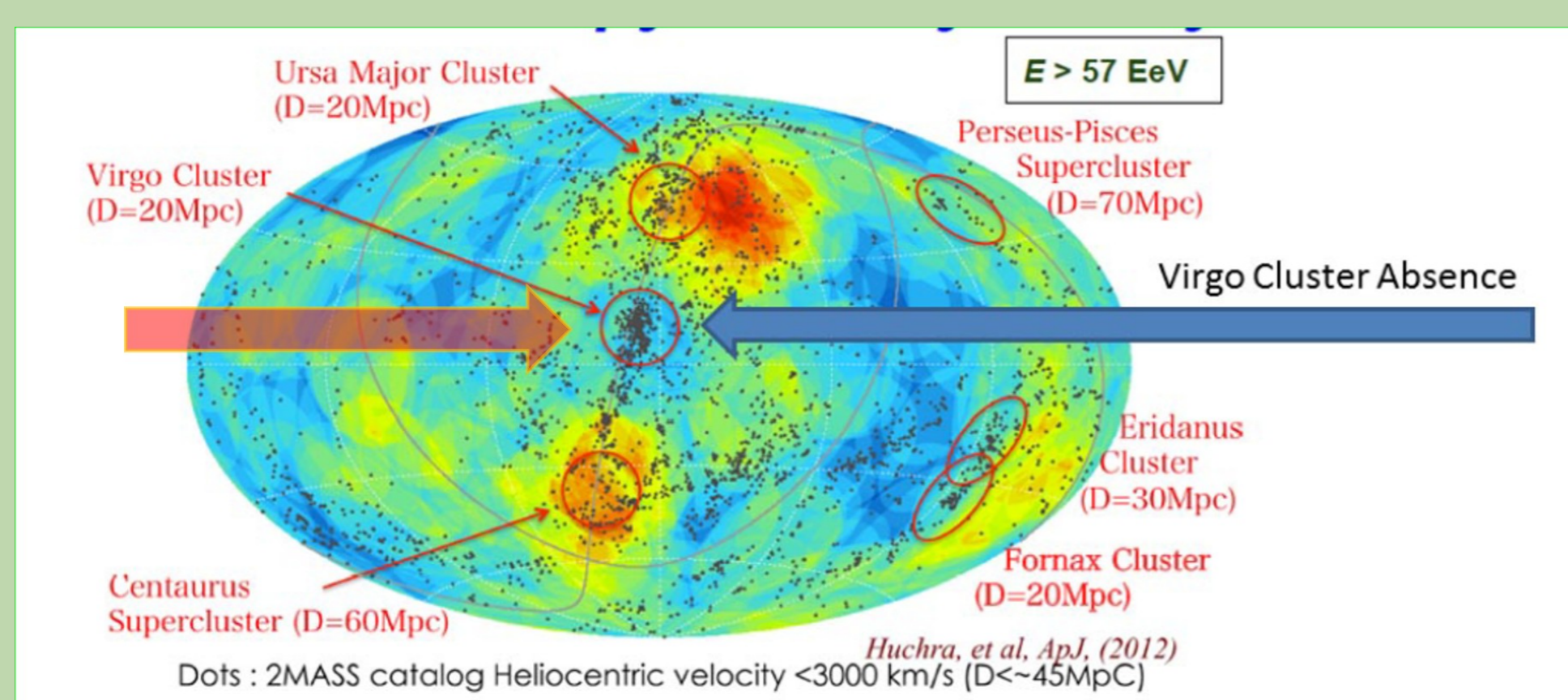
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UHECR: unexpected signatures?

Since 1995, Fly's Eye UHECR records are showing a chain of surprising signatures: the predicted GZK cut off (2-3) was not observed in the highest energy events, nor later in AGASA, the Akeno Giant Air Shower Array (1). Nor was a narrow events clustering (about three degree) observed as expected assuming protons as UHECR source.

Furthermore, a few years later the largest nearby galaxy cluster, Virgo, was strikingly absent from both the earliest large Array in South (AUGER), and in the North (TA). As shown in map below by Huchra (16), two hot spots with a radius of 15 degrees, have arisen.



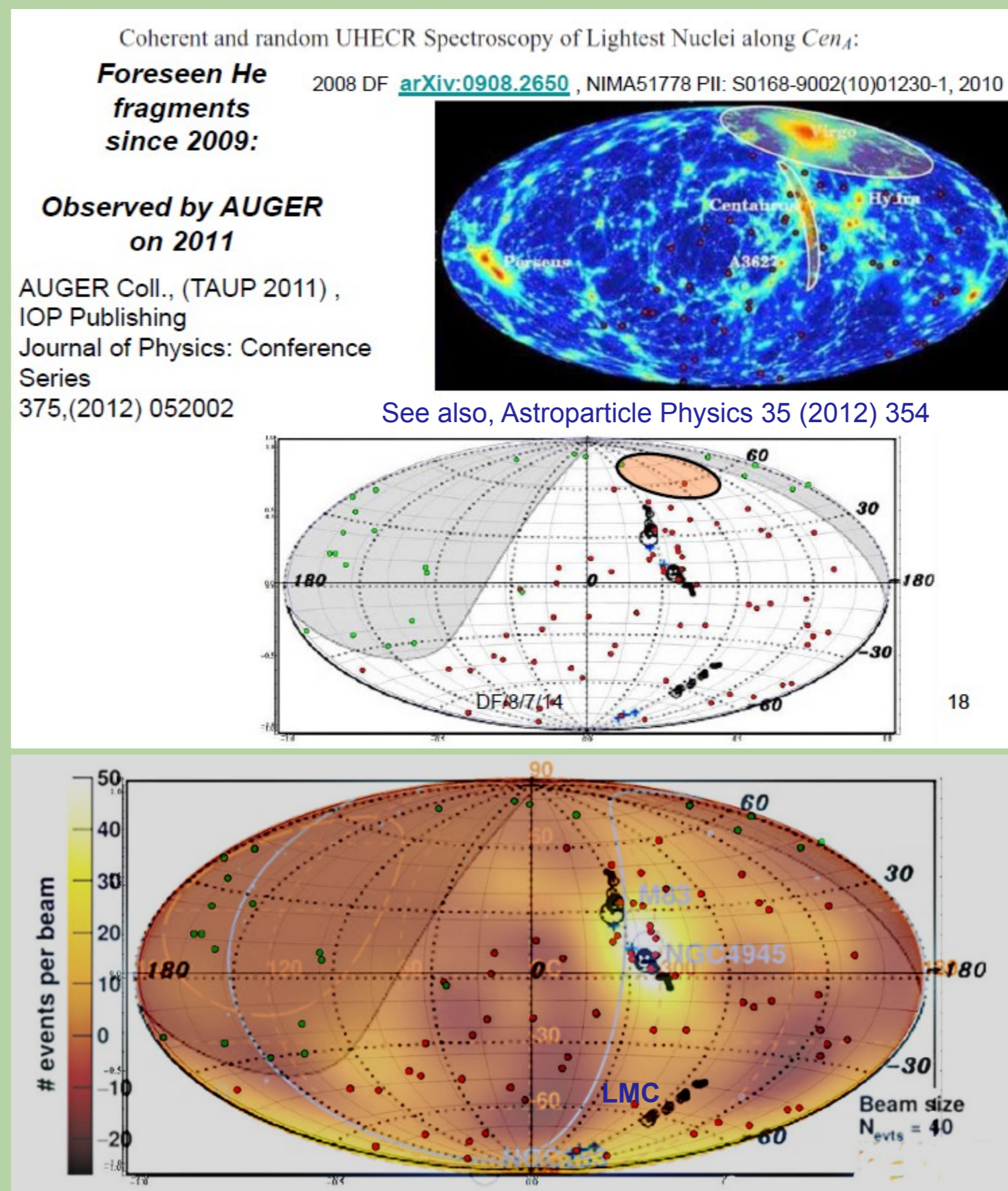
deflection angle. Let us evaluate therefore both the two main contributions:

$$\alpha_{\text{def}}^{\text{He}} \approx 15.5^\circ \left(\frac{Z}{Z_{\text{He}}} \right) \left(\frac{E}{6 \cdot 10^{19} \text{eV}} \right)^{-1} \left(\frac{D}{200 \text{kpc}} \right)^{1/2} \left(\frac{d}{\text{kpc}} \right)^{1/2} \left(\frac{B}{3 \mu\text{G}} \right) \quad (4.1)$$
$$\alpha_{\text{def}}^{\text{Fe}} \approx 3.28^\circ \left(\frac{Z}{Z_{\text{Fe}}} \right) \left(\frac{E}{6 \cdot 10^{19} \text{eV}} \right)^{-1} \left(\frac{D}{40 \text{kpc}} \right)^{1/2} \left(\frac{d}{\text{kpc}} \right)^{1/2} \left(\frac{B}{\mu\text{G}} \right) \quad (4.2)$$

which leads to a total of $\alpha_{\text{def}}^{\text{He}} + \alpha_{\text{def}}^{\text{Fe}} \approx 18.7^\circ$

in good agreement with the observed Hot Spot spread angle size. The delay time is mostly due to the extra galactic magnetic field; thus the time delay between UHECR after its photon direct one, can be evaluated as:

Cen A tens EeV fragments?



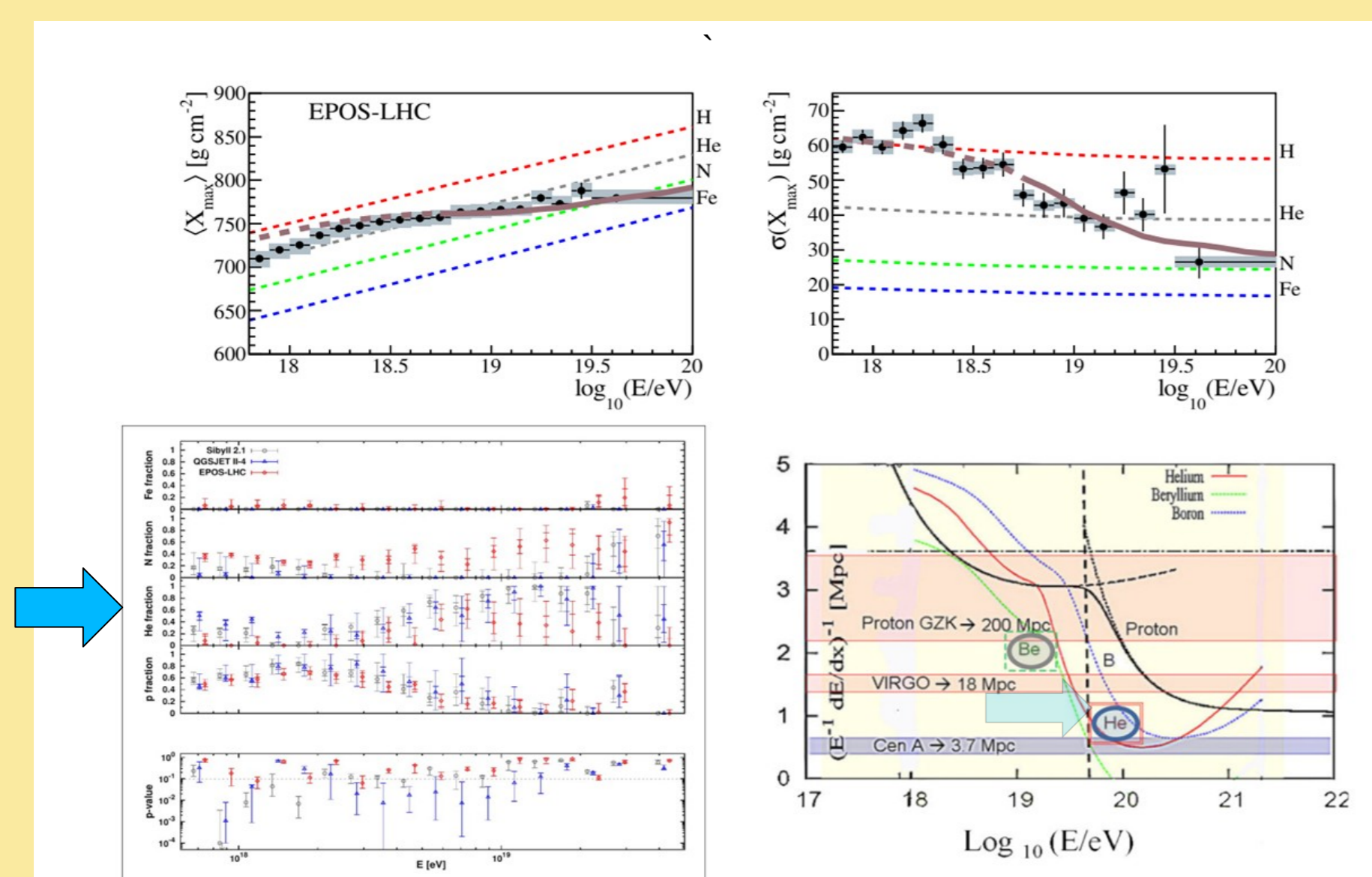
The consequent multiplet bent fragments appear also along the SMC-LMC sky, suggesting also a minor galactic (SMC-LMC) UHECR source contribute.

Virgo ←→ Cen A, M82, NGC 253, AGN

On 2007 the AUGER UHECR event discover (4), made them claim an (apparent) UHECR clustering along Super Galactic Plane; but the amazing Virgo absence, led us, 2007, (5) to a more conservative solving view: Virgo was absent mostly because of the photonuclear distruption of light (He,Be,B...) UHECR nuclei, cut from the 20 Mpc distances. The need of such an (GZK-like earlier cut off) opacity was based not on a proton (or an iron carrier, as most models required) but a dominant lightest nuclei composition. In this view Cen A as well M82, and NGC 253 at nearer distance (a few Mpc) could survive the flight and reach us, spread exactly by a smeared angle for lightest nuclei, an angle size comparable to the observed hot spot above, pointing back toward CenA, M82, and also to a cluster of events near NGC 253 (6).

The 2017 discover of Light Nuclei

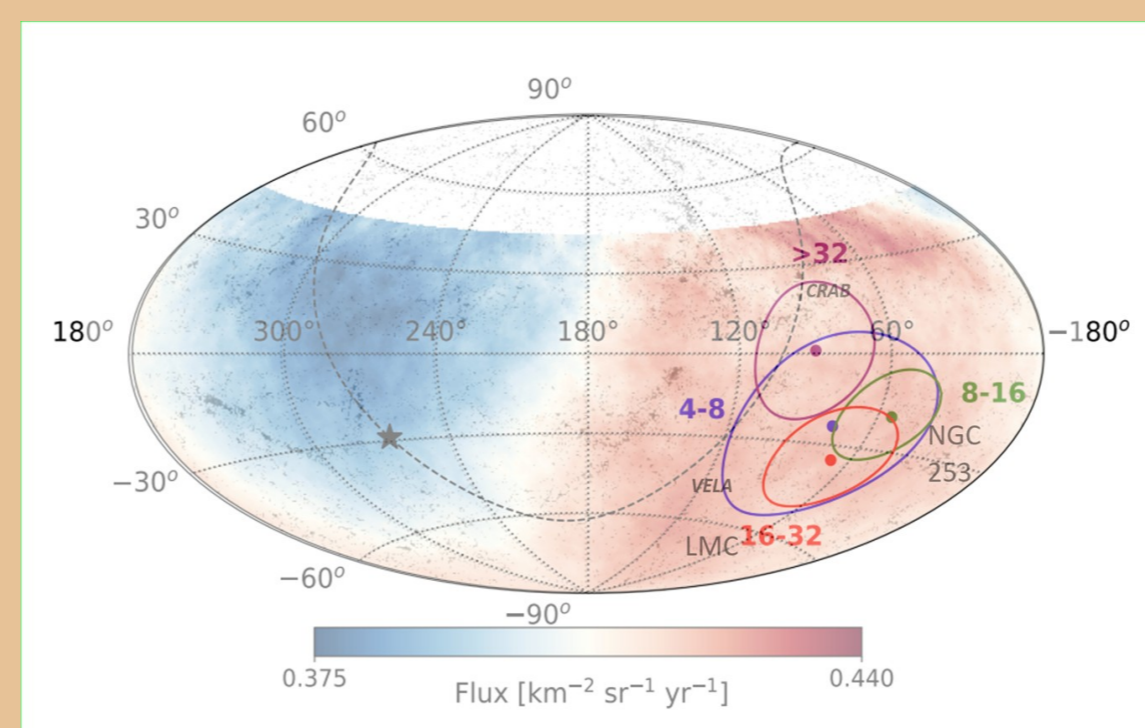
On 2017 the lightest, He,nuclei composition at tens EeV was discovered and widely accepted by most author (5) as it has been summarized in following figures.



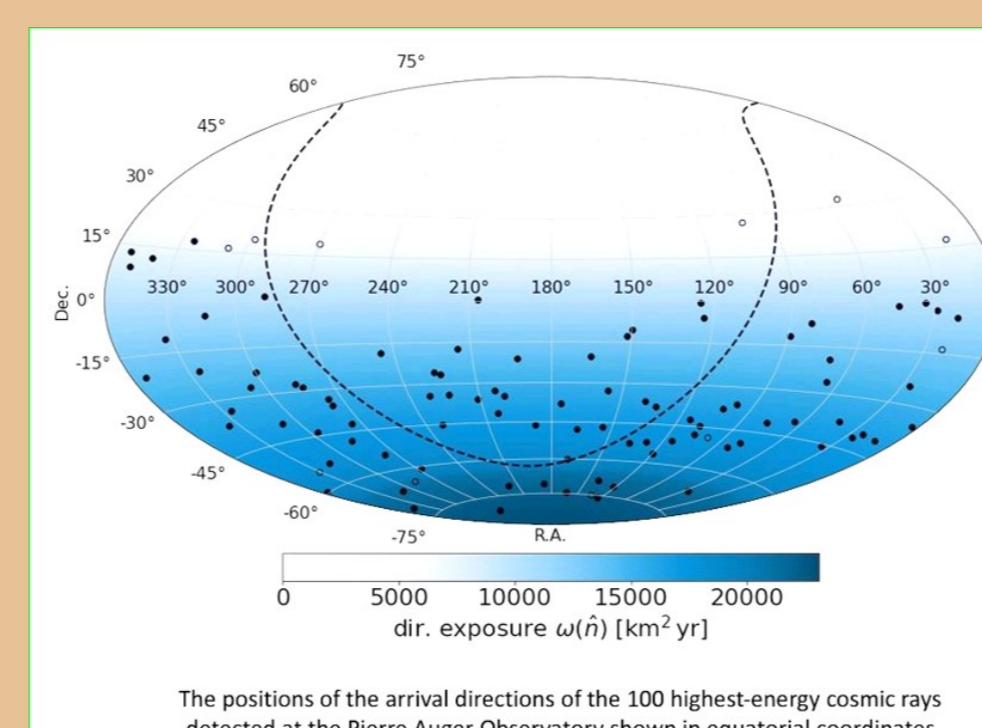
The same He-like bounded distance explains the VIRGO opacity and absence above 30 EeV energy threshold. The same fragility of He-like nuclei in flight from Cen A had been foreseen on 2011 (8-9) to fragment into lighter ones (D..), that had been observed, 2012, along Cen A (10).

GZK cut off, Heavy nuclei at the edge and the Ten EeV anisotropy

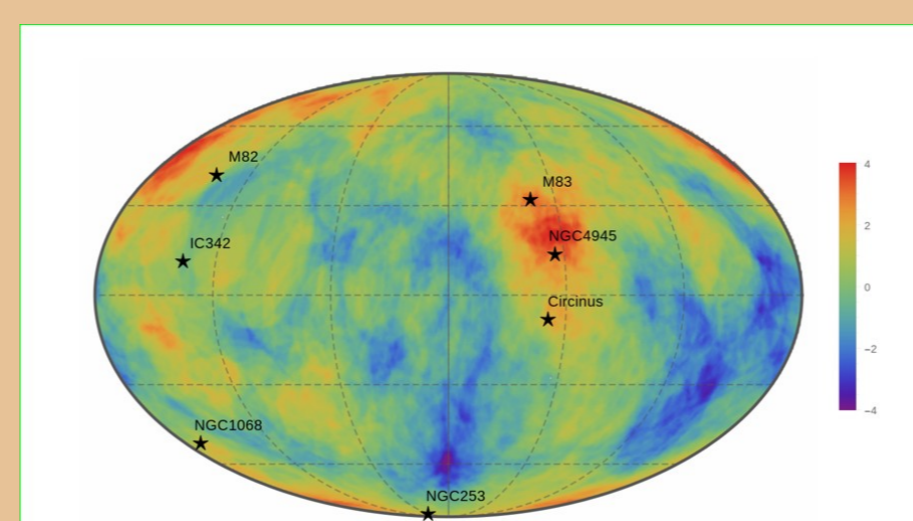
The foreseen GZK cut off seems finally to exist, but also a large (6.5%) unexplained dipole anisotropy occurred. Due to its large value (6.5%) we considered the role of nearby sources, as NGC 253, LMC, SMC, Vela and Crab, that are able to pollute the dipole anisotropy without any contradiction with other cosmological anisotropy.



A minor, but relevant role of the UHECR may hide in the heaviest nuclei: their larger mass, charge and highest energy, as the recent 100 AUGER event above 78 EeV, might be bent in wide angle masking their origination.



In conclusion, the He-Be feeding of the Hot Spot by Cen A, M82 and NGC 253, as well as the minor contribute of LMC, SMC, Crab and Vela and NGC 253 for ten EeV dipole may explain most.



Conclusions

UHECR had a quite long and suffered road map: the expected proton courier and the consequent Virgo rise had been missed. The appearance of very high energetic event uncorrelated to nearby source, as we just mention, may be related to the large charge, mass and energy of Ni-Co-Fe nuclei, whose bending may hide their true source. The Lightest nuclei at 30- 50 EeV, explain the Virgo absence, while being tuned with their observed slant depth and smeared hot spot size. The few EeV AUGER dipole anisotropy might be ruled by NGC 253 and partially by Crab, Vela, LMC-SMC.

The claimed new clustering to far (60 Mpc) Perseus cluster, might be just a mislead nearby polluting galaxy: our own Andromeda and its UHECR signals. More exotic models based on UHE ZeV neutrino scattering on relic dark halo ones (at 0.1 eV or few eV, if sterile ones), leading to Z-boson resonance (11-12) and hadronic UHECR trace, might be also an escape way, if the puzzling UHECR directions toward far AGN (as 3C 454) will persist. Tau airshower from mountains or Earth, by EeV-ZeV, (13-14-15) UHE neutrinos, may soon test this road.

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