CRIS 2022

12th Cosmic Ray International Seminar
Naples, Italy, September 12 -16, 2022

How do we explain the UHECR dipole anisotropy?

14 September 2022-Naples

D.Fargion,
P.G.Desanctis Lucentini,
M.khlopov

CRIS2018

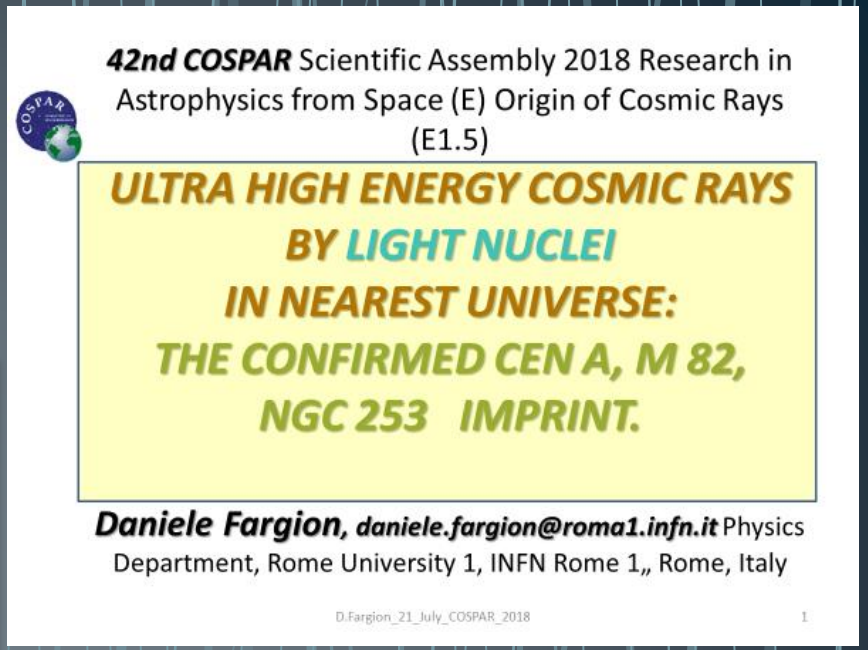
11th Cosmic Ray International Seminar

UHECR : where they come from?

arXiv:submit/2269349 , 21 May 2018, PoS

UHECR : where they come from?

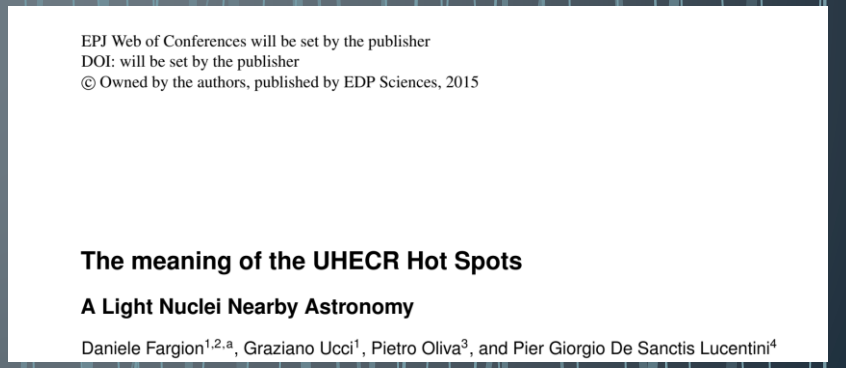
arXiv:submit/2269349 ,
21 May 2018
PoS 2018



42nd COSPAR Scientific Assembly 2018 Research in Astrophysics from Space (E) Origin of Cosmic Rays (E1.5)

ULTRA HIGH ENERGY COSMIC RAYS BY LIGHT NUCLEI IN NEAREST UNIVERSE: THE CONFIRMED CEN A, M 82, NGC 253 IMPRINT.

Daniele Fargion, daniele.fargion@roma1.infn.it Physics Department, Rome University 1, INFN Rome 1„ Rome, Italy



EPJ Web of Conferences will be set by the publisher
DOI: will be set by the publisher

The meaning of the UHECR Hot Spots

A Light Nuclei Nearby Astronomy

Daniele Fargion[1,2,a], Graziano Ucci[1], Pietro Oliva[3], and Pier Giorgio De Sanctis Lucentini[4]

nearby mass anisotropy on 2016 the VIRGO MISSING

Distribuzione della materia (7-21 Mpc)

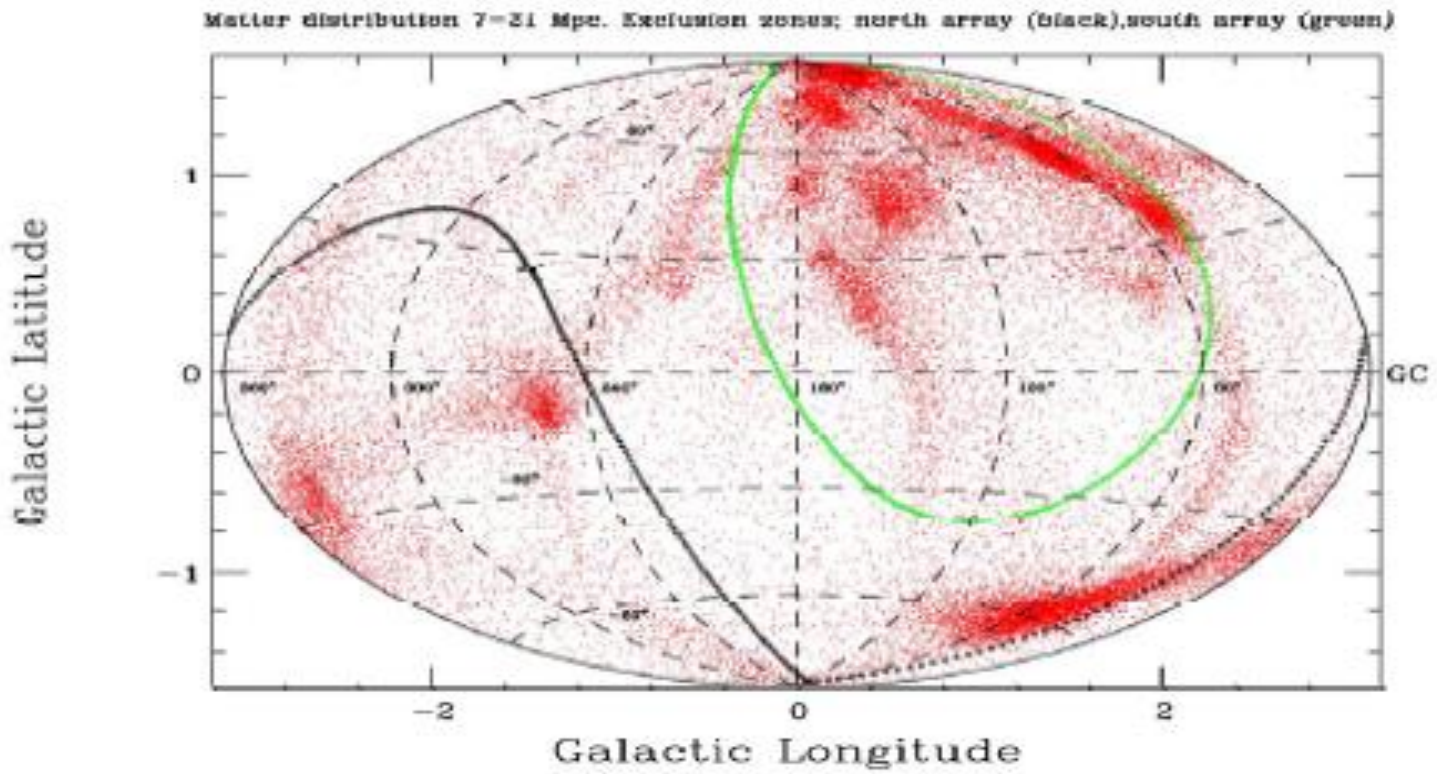
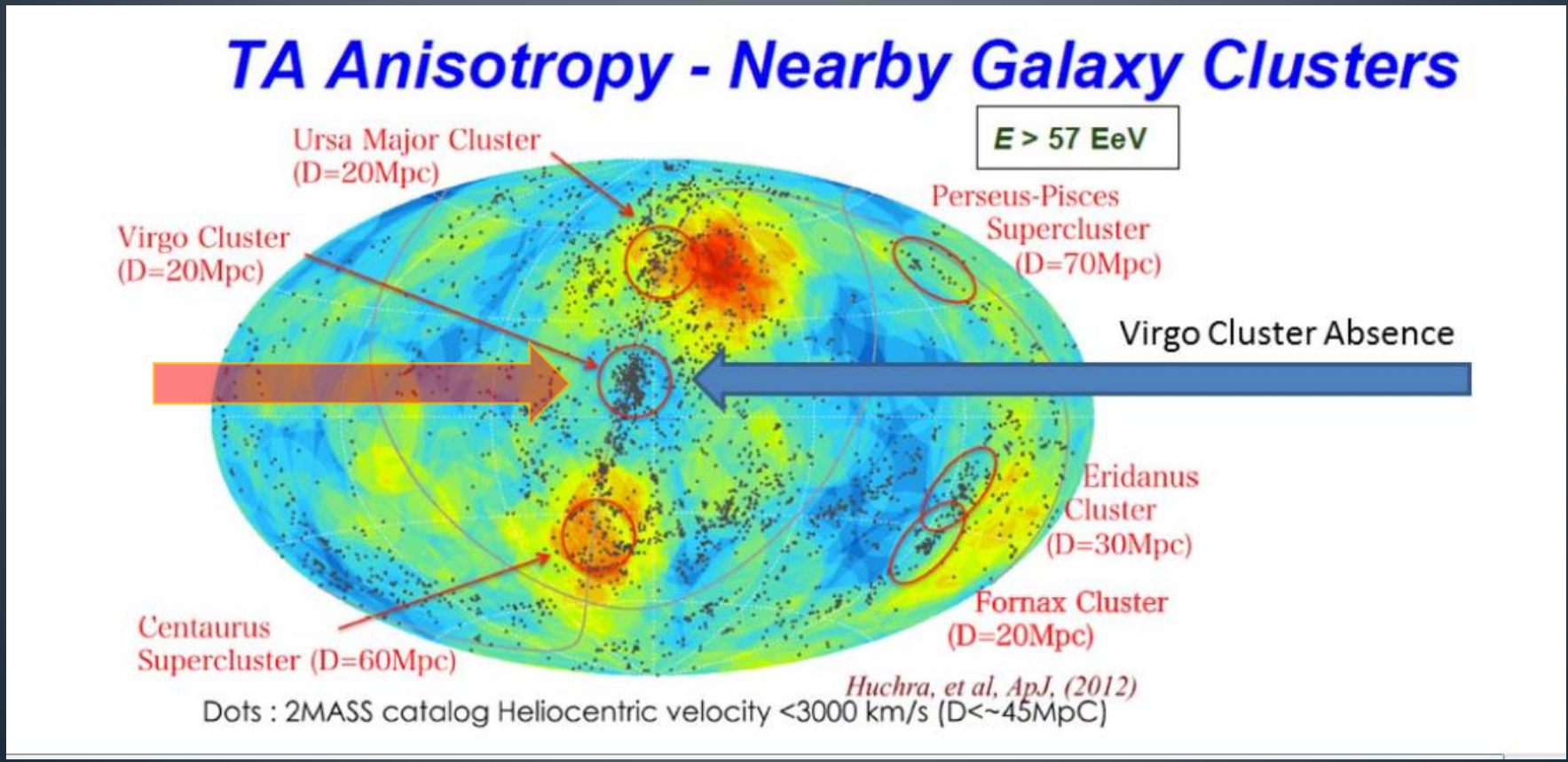


Figure 10: Distribution in galactic coordinates of gravitating matter at distance between 7 and 21 Mpc. The density of dots in the figure is proportional to the column density of the matter in the interval. The exclusion zones are plotted for a zenith angle $\leq$ 60deg. On the left is the exclusion zone for a northern observatory, on the right for a southern observatory. An observatory in the southern hemisphere will not see directly the Virgo cluster. (The data were provided by Andrey Kravtsov, Center

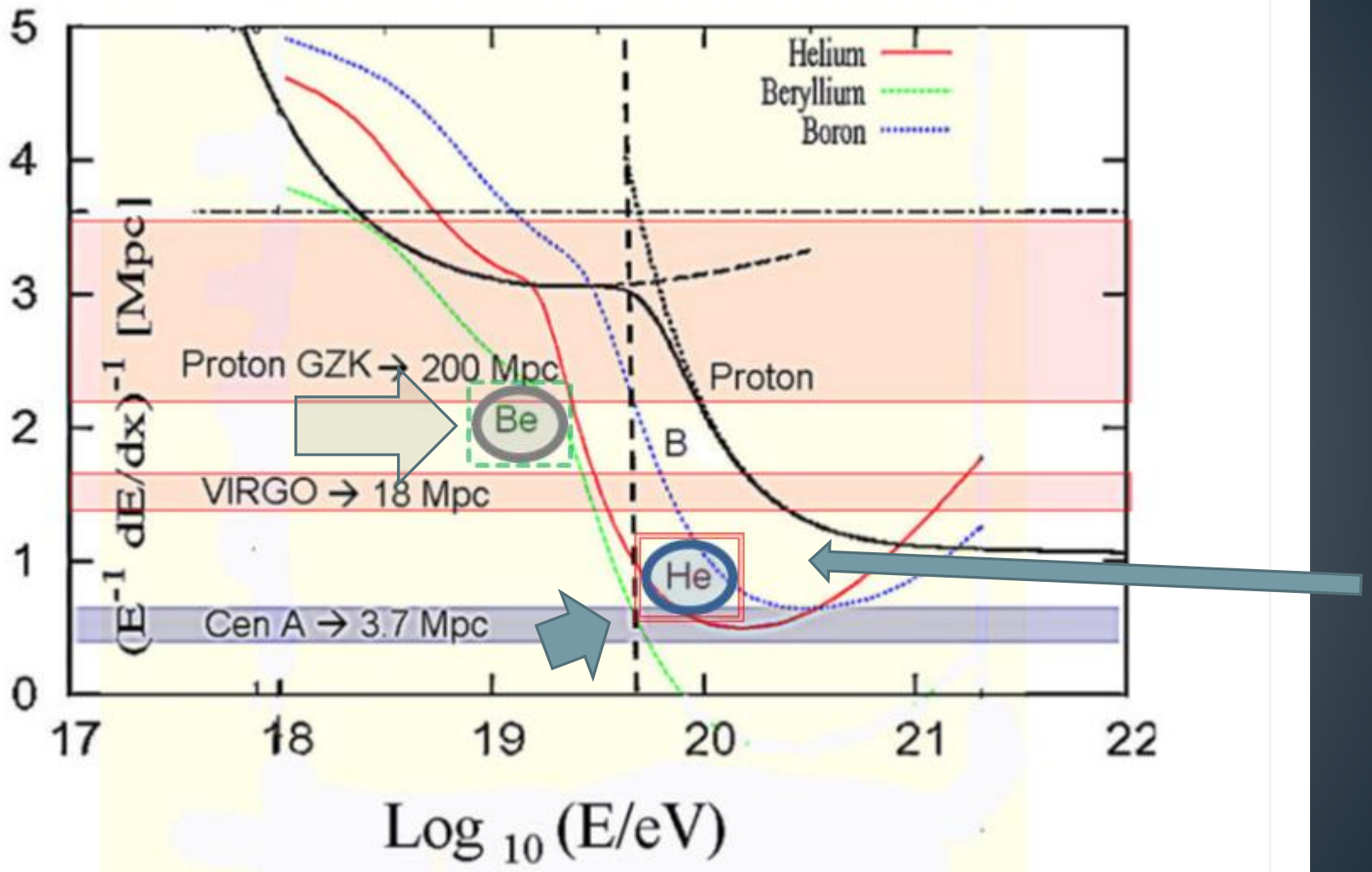
1) The Virgo Absence in a centered map: two Hot Spot



Main NON Message since AUGER 2007

- NO VIRGO CLUSTERING
- ***From Nearest Largest Mass Galaxy Cluster in GZK volume***
- NO NARROW CLUSTERING
- ***(3-6 degrees) as expected for UHECR protons***

Lightest nuclei only for nearby Mpcs source



Lightest Nuclei are opaque and filtered from 20 Mpc

- Virgo may be hidden as observed

Composition, Deflection, Clustering

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

$$\alpha_{\mathrm{He}}^{gal} \simeq 15.5^{\circ}\left(\frac{Z}{Z_{\mathrm{He}}}\right)\left(\frac{E}{6\cdot 10^{19}\,\mathrm{eV}}\right)^{-1}\left(\frac{D}{20\,\mathrm{kpc}}\right)^{1/2}\left(\frac{d_c}{\mathrm{kpc}}\right)^{1/2}\left(\frac{B}{3\,\mu\mathrm{G}}\right) \quad (4.1)$$

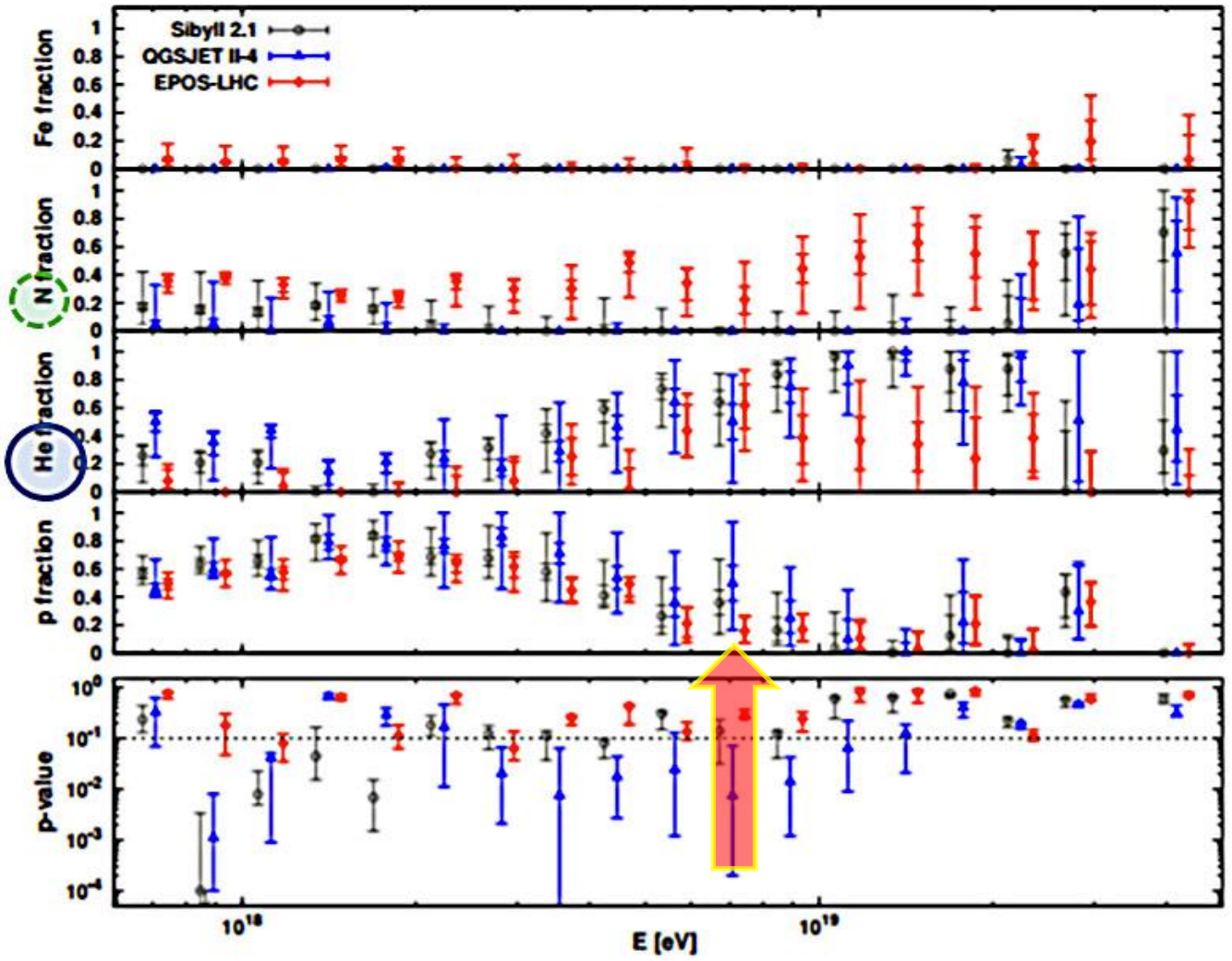
$$\alpha_{\mathrm{He}}^{ex} \simeq 3.28^{\circ}\left(\frac{Z}{Z_{\mathrm{He}}}\right)\left(\frac{E}{6\cdot 10^{19}\,\mathrm{eV}}\right)^{-1}\left(\frac{D}{4\,\mathrm{Mpc}}\right)^{1/2}\left(\frac{d_c}{\mathrm{Mpc}}\right)^{1/2}\left(\frac{B}{\mathrm{nG}}\right) \quad (4.2)$$

which leads to a total of

$$\alpha_{\mathrm{He}}^{ex} + \alpha_{\mathrm{He}}^{gal} \simeq 18.7^{\circ}$$

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:

The recent 2015 Light Nuclei signature probing proton and Fe almost absence above 10 EeV and showeing He –Be dominance at UHECR



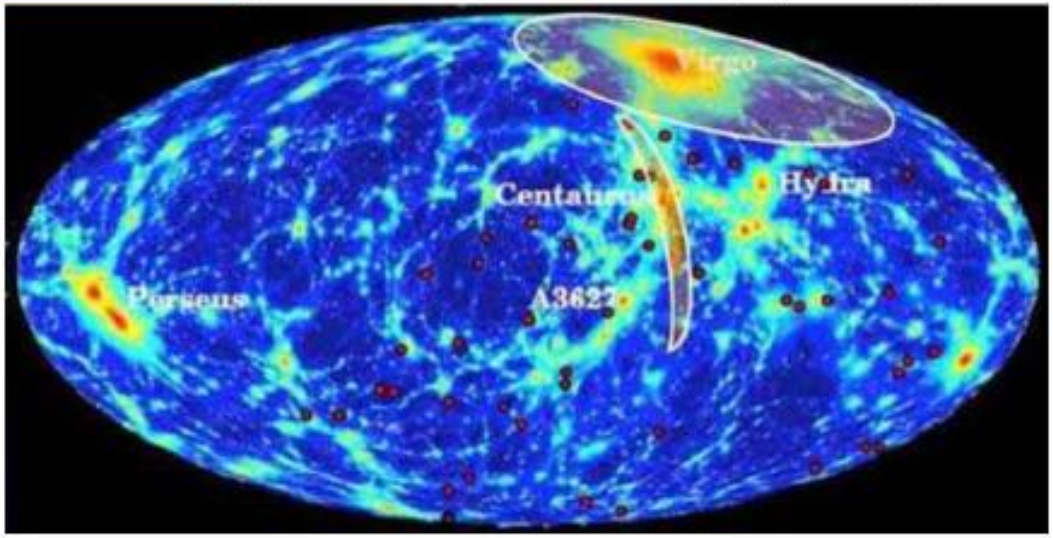
UHECR narrow Anisotropy Summary

- *UHECR have been found mostly made by light and lightest nuclei.*
- *We considered a few localized nearby extragalactic sources for most UHECR clustering as CenA, NG 253, M82.*
- *Foreseen Lower energy, 20 EeV multiplet around Cen A →*

Coherent and random UHECR Spectroscopy of Lightest Nuclei along Cen_A:

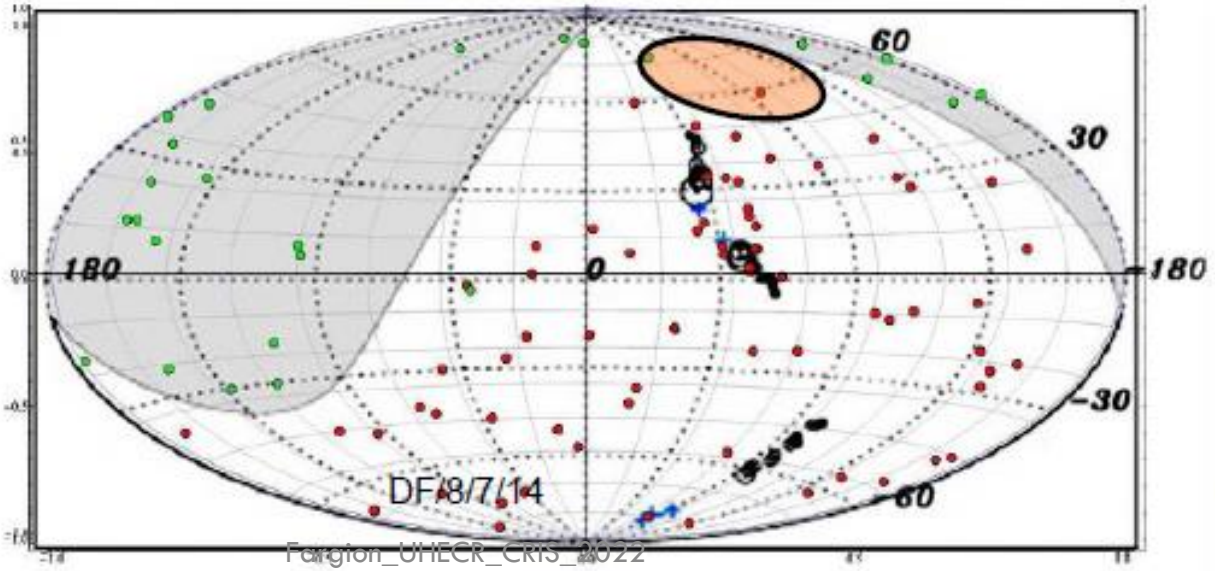
Foreseen He fragments since 2009:

2008 DF arXiv:0908.2650 , NIMA51778 PII: S0168-9002(10)01230-1, 2010



Observed by AUGER on 2011

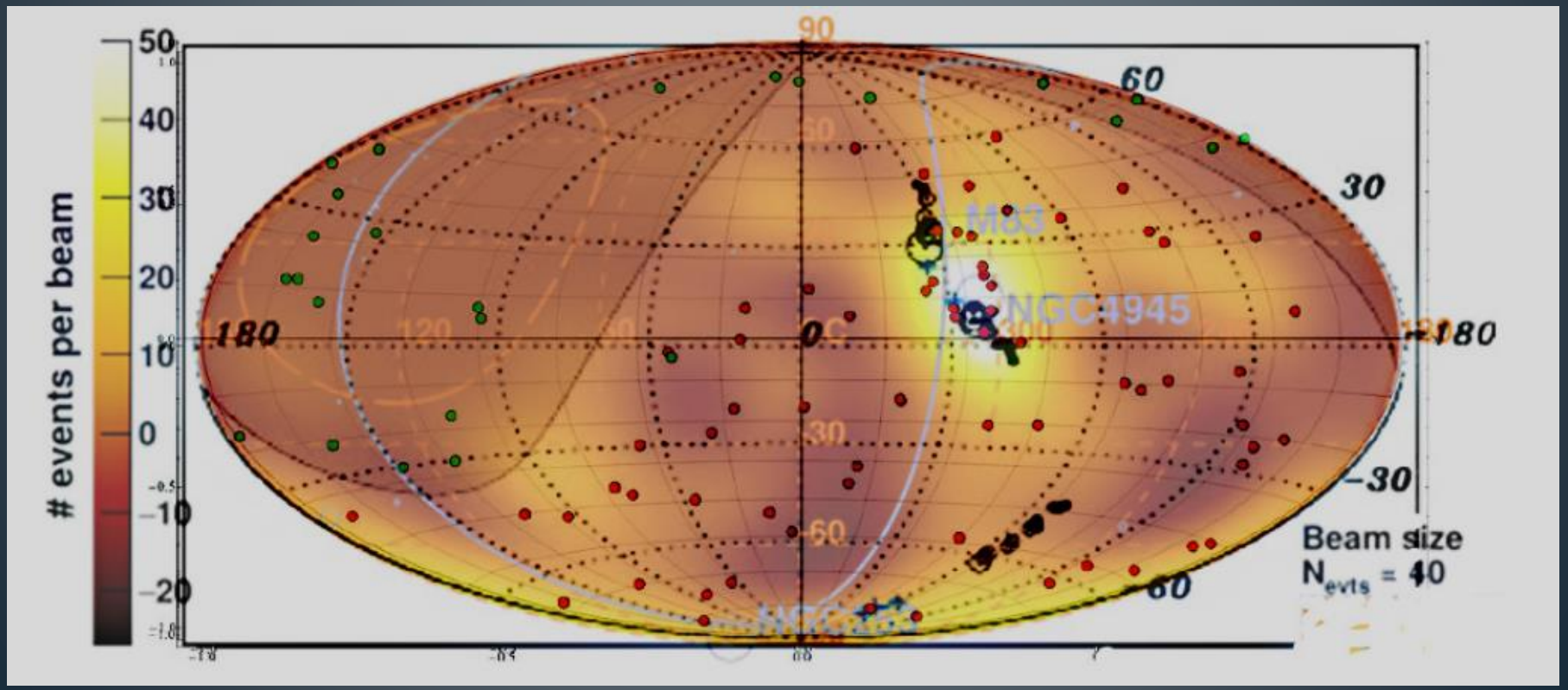
AUGER Coll., (TAUP 2011) , IOP Publishing Journal of Physics: Conference Series 375,(2012) 052002



18

20 EeV Multiplet at Cen A Hot Spot anisotropy foreseen 2009, observed 2011….

Here overlap on 2018 Auger 39 EeV anisotropy



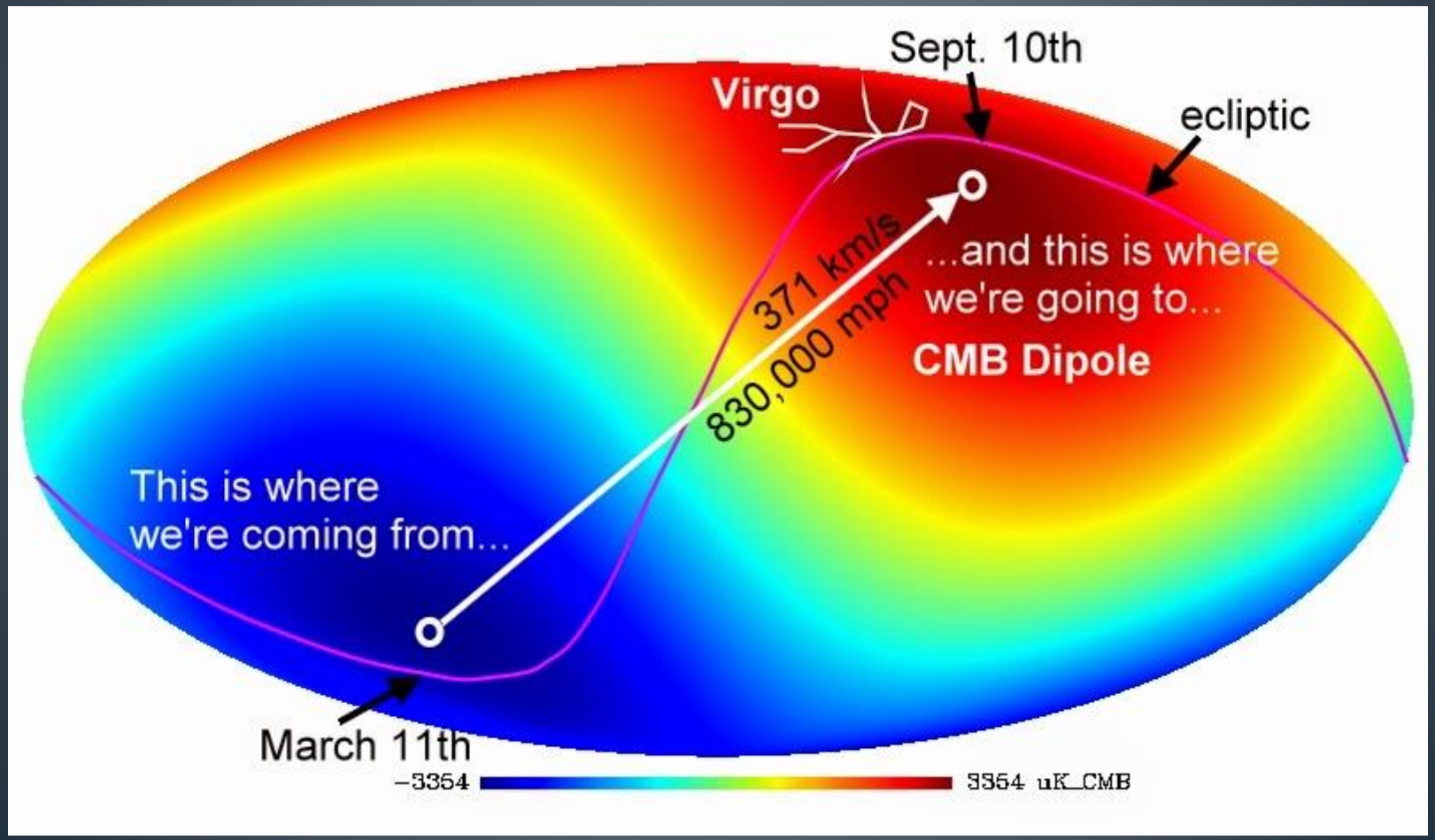
Large scale anisotropy above 4 EeV:

PROCEEDINGS OF SCIENCE

ONLINE ICRC 2021
THE ASTROPARTICLE PHYSICS CONFERENCE
Berlin | Germany
37th International Cosmic Ray Conference
12–23 July 2021

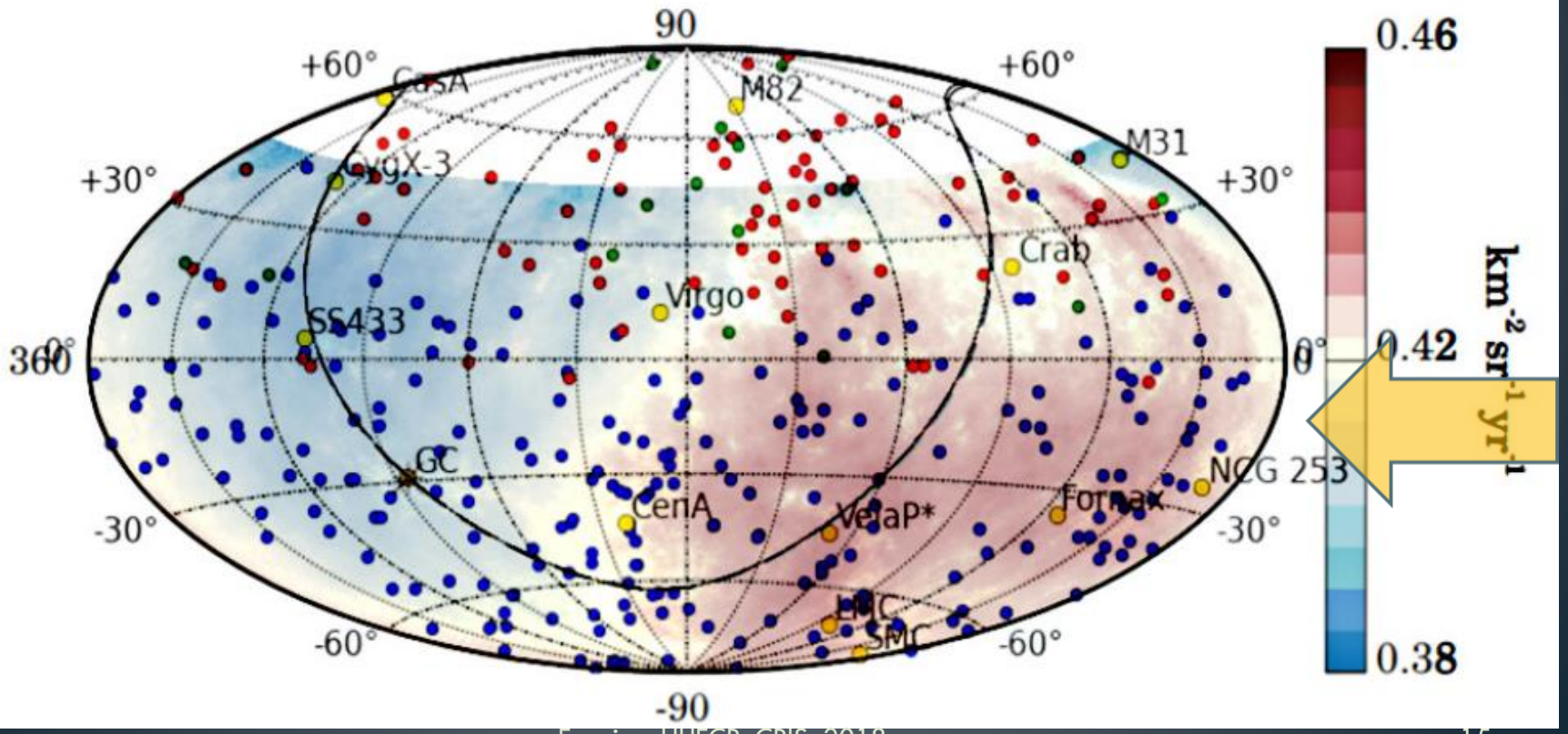
Large-scale and multipolar anisotropies of cosmic rays detected at the Pierre Auger Observatory with energies above 4 EeV

Doppler shift at 600 km/s flight: 0.2% much smaller than AUGER UHECR dipole 6% ➔ 18.000 km/s

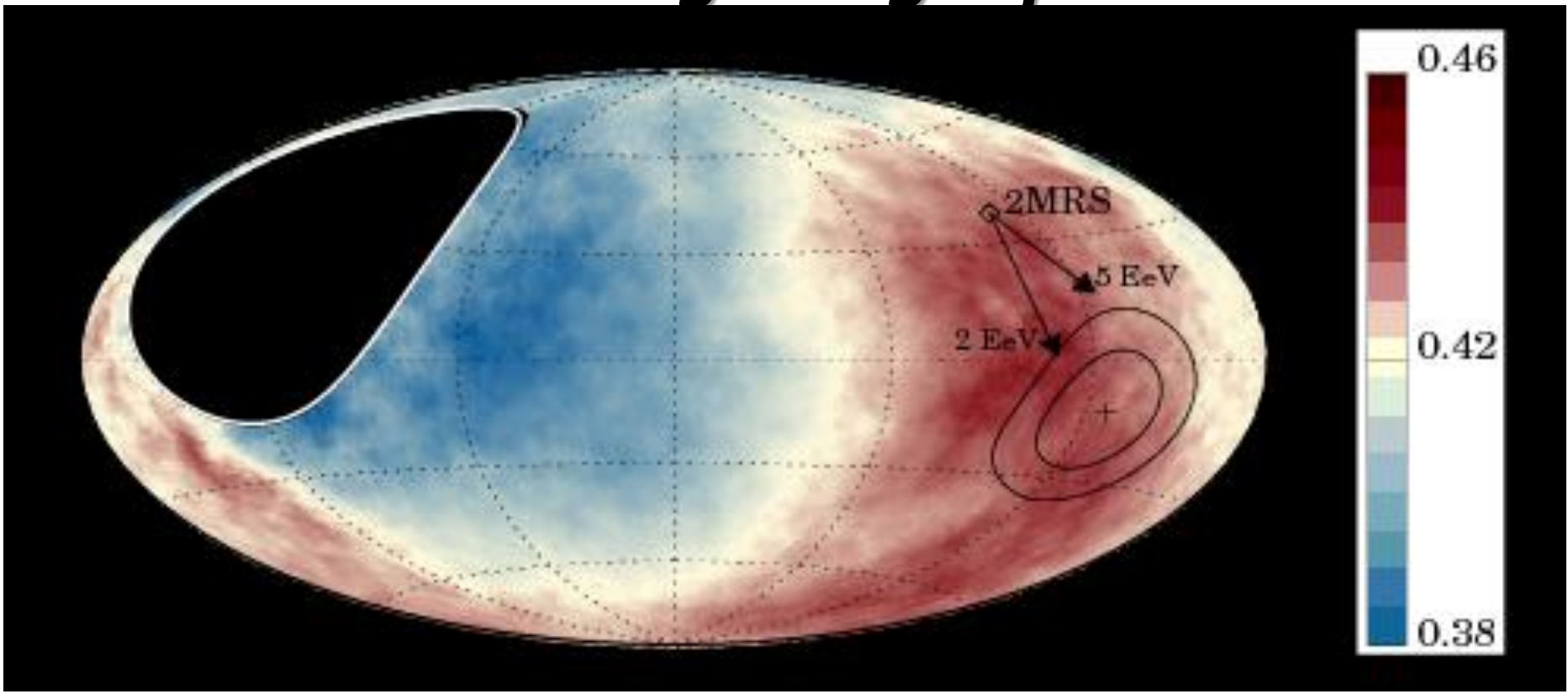


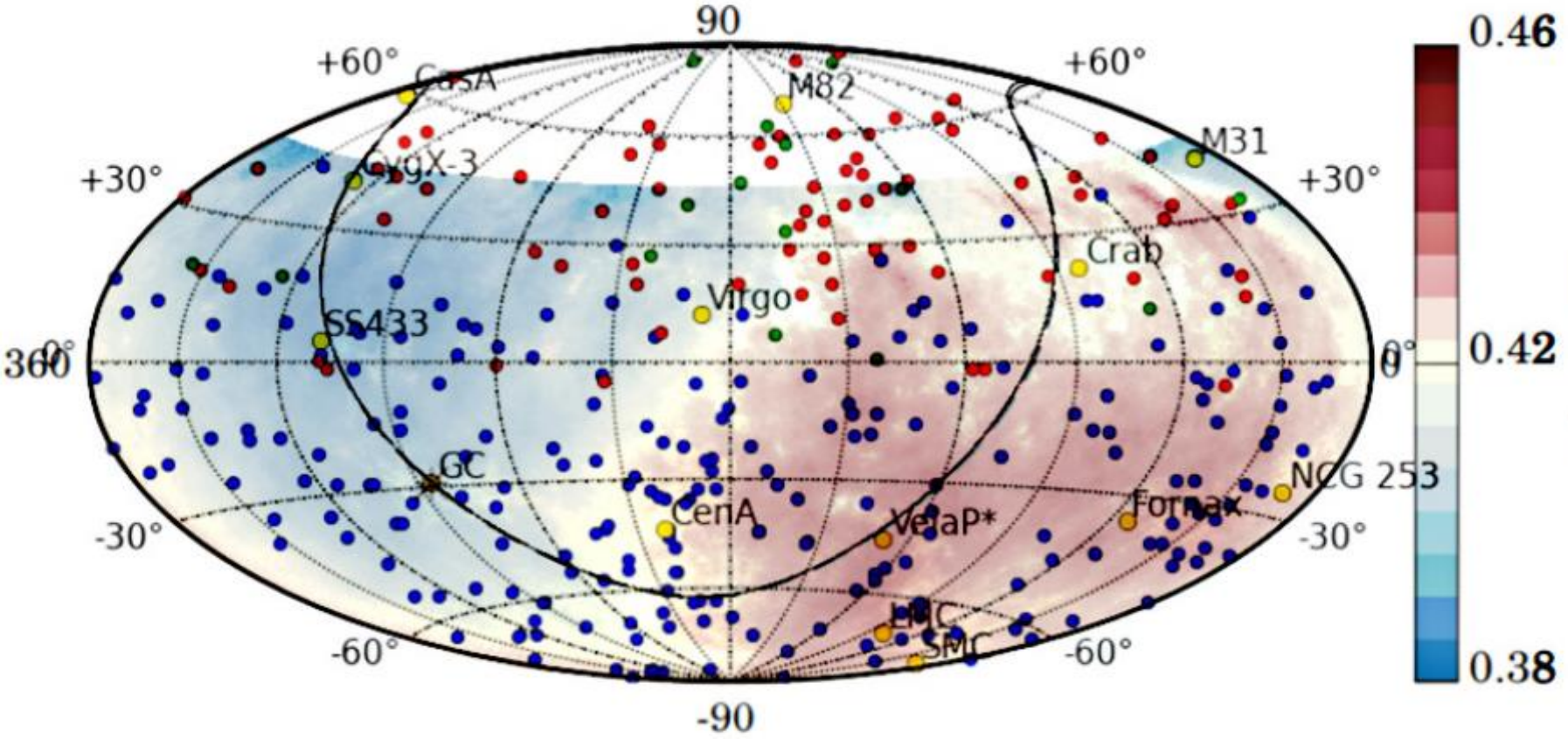
A 5 sigma Dipole 10 EeV UHECR anisotropy: 6 times wider : 90-100 degrees; 6 % value

$$\alpha_{\mathrm{He}}^{DIPOLE} \Rightarrow 93.0^{\circ}\left(\frac{Z}{Z_{\mathrm{He}}}\right)\left(\frac{E}{10^{19}\,\mathrm{eV}}\right)^{-1}\left(\frac{D}{20\,\mathrm{kpc}}\right)^{1/2}\left(\frac{d_c}{\mathrm{kpc}}\right)^{1/2}\left(\frac{B}{3\,\mu\mathrm{G}}\right)$$



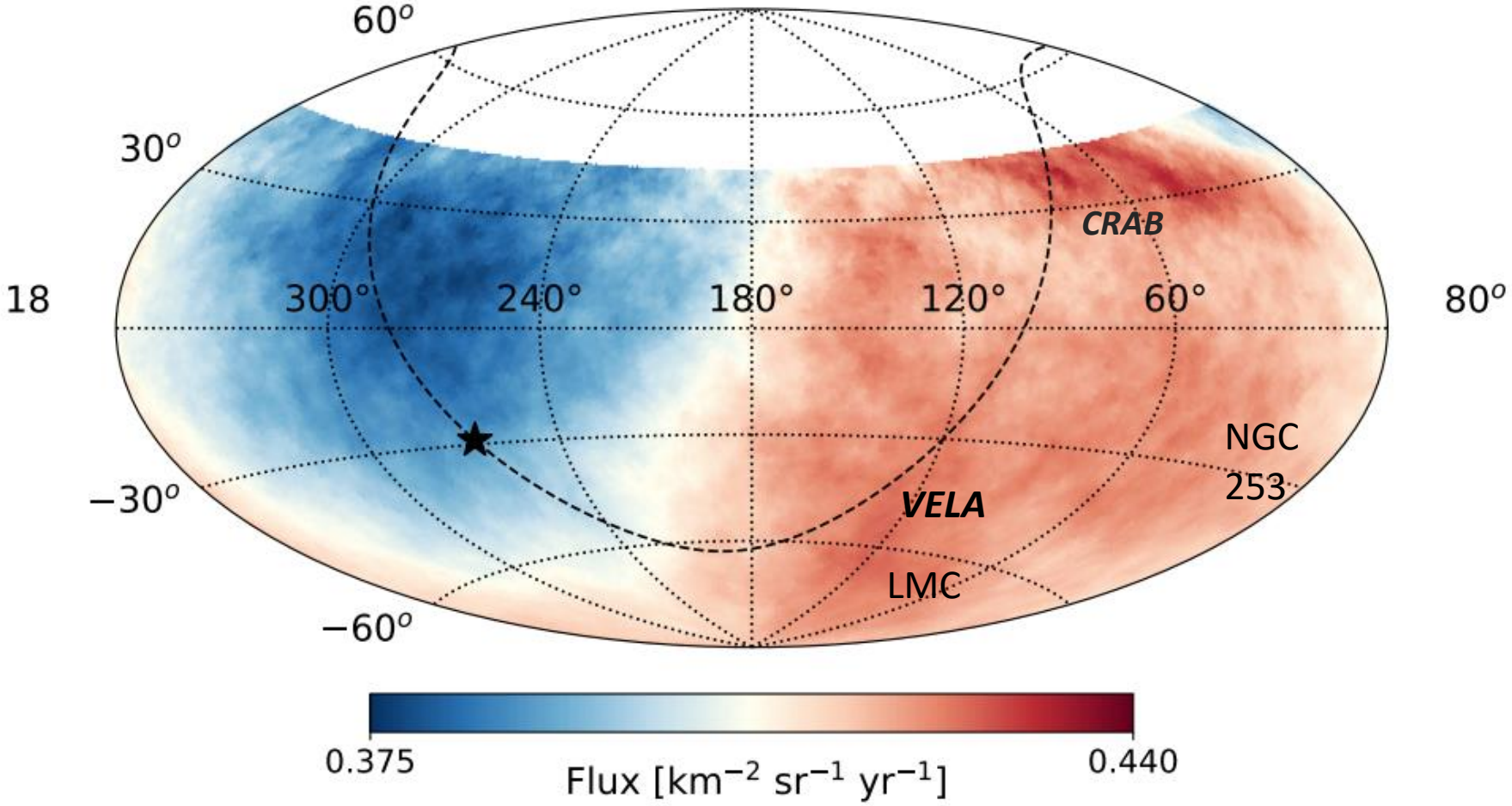
Different direction and SIZE Some missing connection with cosmic big bang dipole



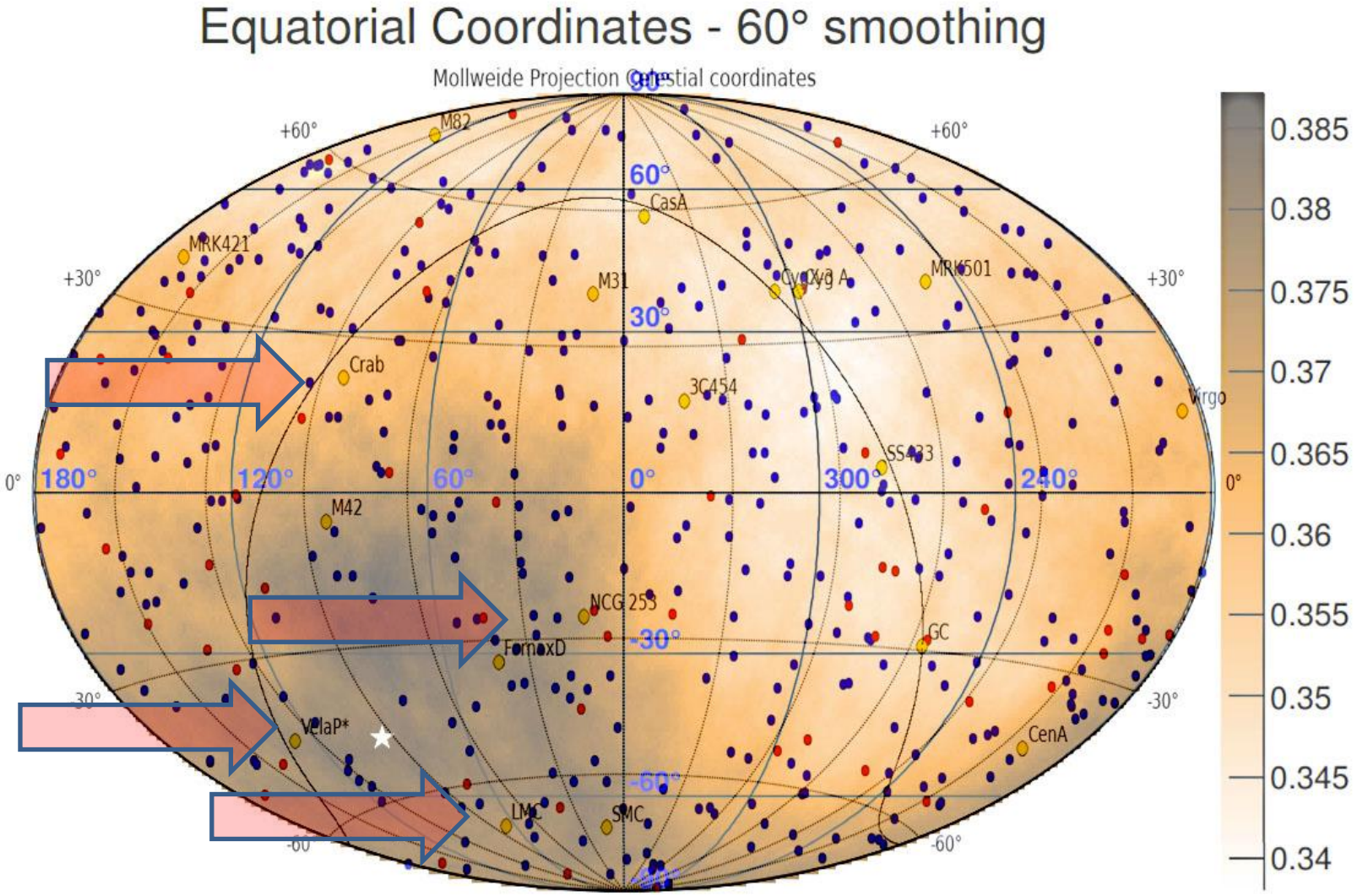

90
+60°
+60°
CenA
M82
M31
+30°
+30°
CygX-3
Crab
Virgo
SS433
0°
360
0°
GC
NGC 253
CenA
VelaP*
Fornax
-30°
-30°
LMC
SMC
-60°
-60°
-90
0.46
0.42
0.38
KM sr yr

Few EeVs UHECR: smeared maps in ***space , energy and time:***

A «fast» variable angle directions → very near sources:



Different map: with galactic sources



Forced Consequences:

Observed a UHECR 6 % anisotropy

It must be a very local, almost Galactic origin:

AS NEAR AS:

LMC, Vela, Crab, NGC 253, FORNAX galaxy among the best candiates

Our Old proposal about tens EeV nearby galaxies clustering→ becoming more real in recent ones

Nearby active galactic nuclei and starburst galaxies as sources of the measured UHECRs anisotropy signal

Cainã de Oliveira and Vitor de Souza

Instituto de Física de São Carlos, Universidade de São Paulo, Av. Trabalhador São-carlense 400, São Carlos, Brasil.

E-mail: caina.oliveira@usp.br, vitor@ifsc.usp.br

Abstract. The Pierre Auger and the Telescope Array observatories have measured independent and statistical significant anisotropy in the arrival direction of ultra-high-energy cosmic rays (UHECR). Three hotspot regions with relative excess of events and a dipole signal have been identified in different regions of the sky and energy ranges. In this paper, we investigate the conditions under which these anisotropy signal could be generated by nearby (<23 Mpc) active galactic nuclei (AGN) and/or starburst galaxies (SBG). We studied a wide range of possibilities including injected nuclei (p, He, N, Si, and Fe), three UHECR luminosity proxies and three extragalactic magnetic field models. The results shows that both local AGN and SBG are needed to describe all the anisotropy signal. The contribution of AGN to hotspots and to the generation of the dipole is dominant in most cases. SBG is required only to explain the hotspot measured by the Telescope Array Observatory.

NEAR SOURCES CONSIDERED

by above authors

Table 1. Properties of the sources considered.

Source	Distance (Mpc)	L_{radio} (10^{38} erg s^{-1})	L_{γ} (10^{40} erg s^{-1})
NGC 253	2.7	1.0	0.8
M82	3.6	1.3	1.7
NGC 4945	4.0	1.0	1.4
M83	4.0	0.4	1.0
IC 342	4.0	0.5	0.4
NGC 6946	5.9	0.7	0.5
NGC 2903	6.6	0.7	0.9
NGC 5055	7.8	0.6	1.1
NGC 3628	8.1	1.0	1.8
NGC 3627	8.1	0.7	2.0
NGC 4631	8.7	1.1	1.0
M51	10.3	1.2	2.9
NGC 891	11	0.9	4.4
NGC 3556	11.4	0.8	2.6
NGC 660	15	0.9	5.8
NGC 2146	16.3	4.1	15.4
NGC 3079	17.4	5.0	5.7
NGC 1068	17.9	17.8	17.7
NGC 1365	22.3	3.1	10.7
Centaurus A	3.8	260	11.2
Virgo A	18.4	760	78.9
Fornax A	20.9	830	27.8

UHECR Anisotropy Summary

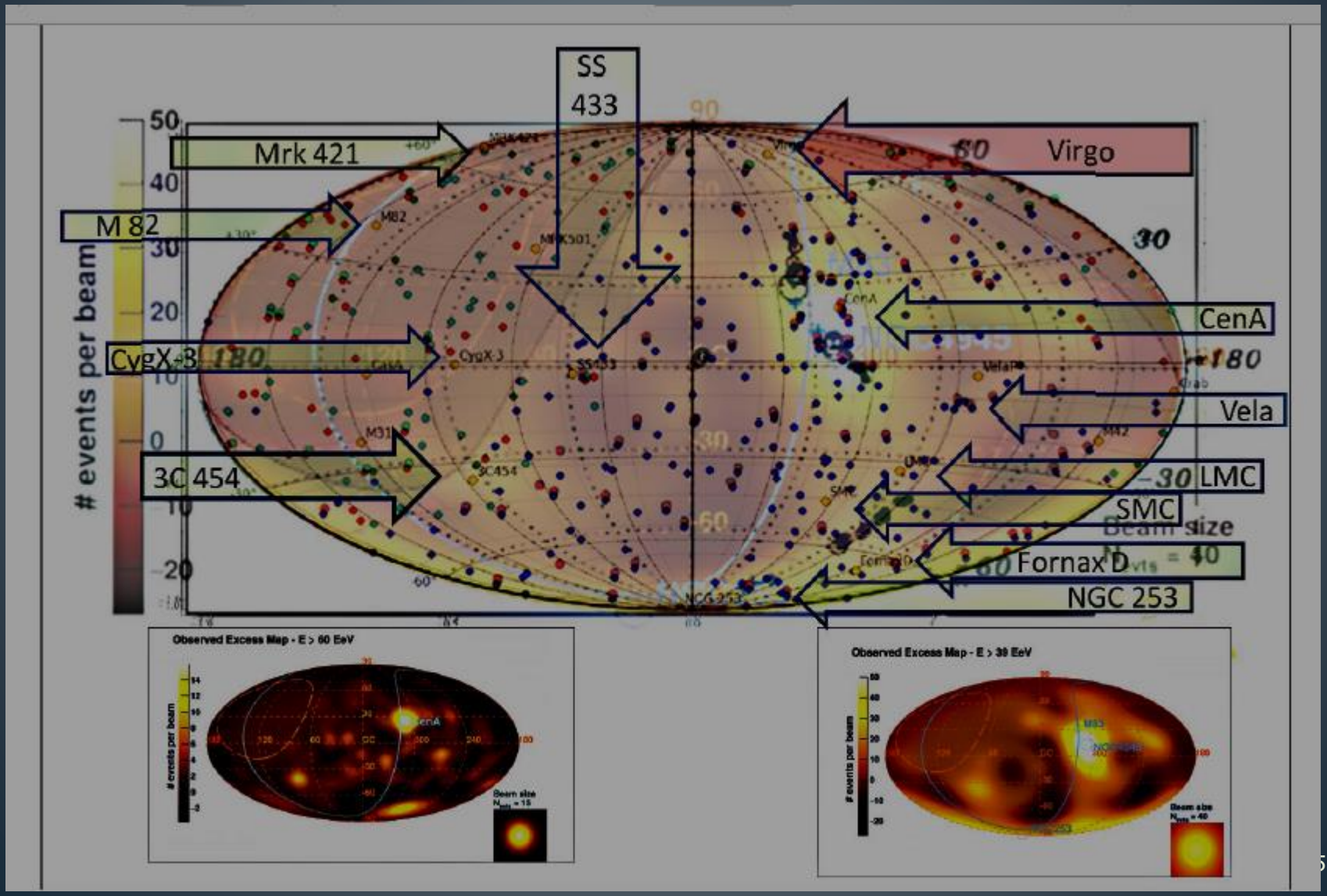
- Results on UHECR (Ultra High Energy Cosmic Ray) composition and their distribution in the sky from ten EeV energy (the dipole anisotropy) up to the highest UHECR energies and their clustering maps:
- UHECR have been found mostly made by light and lightest nuclei in a few Mpc Universe.
- We considered a few sources as
- CenA, NG 253, M82.
- Possible Vela , Crab and LMC at 10 EeV play a role too

In a unique sentence

- After a century of CR and half a century of UHECR we are discovering the **few nearby** AGN sources of UHECR
- Discovering also mainly that

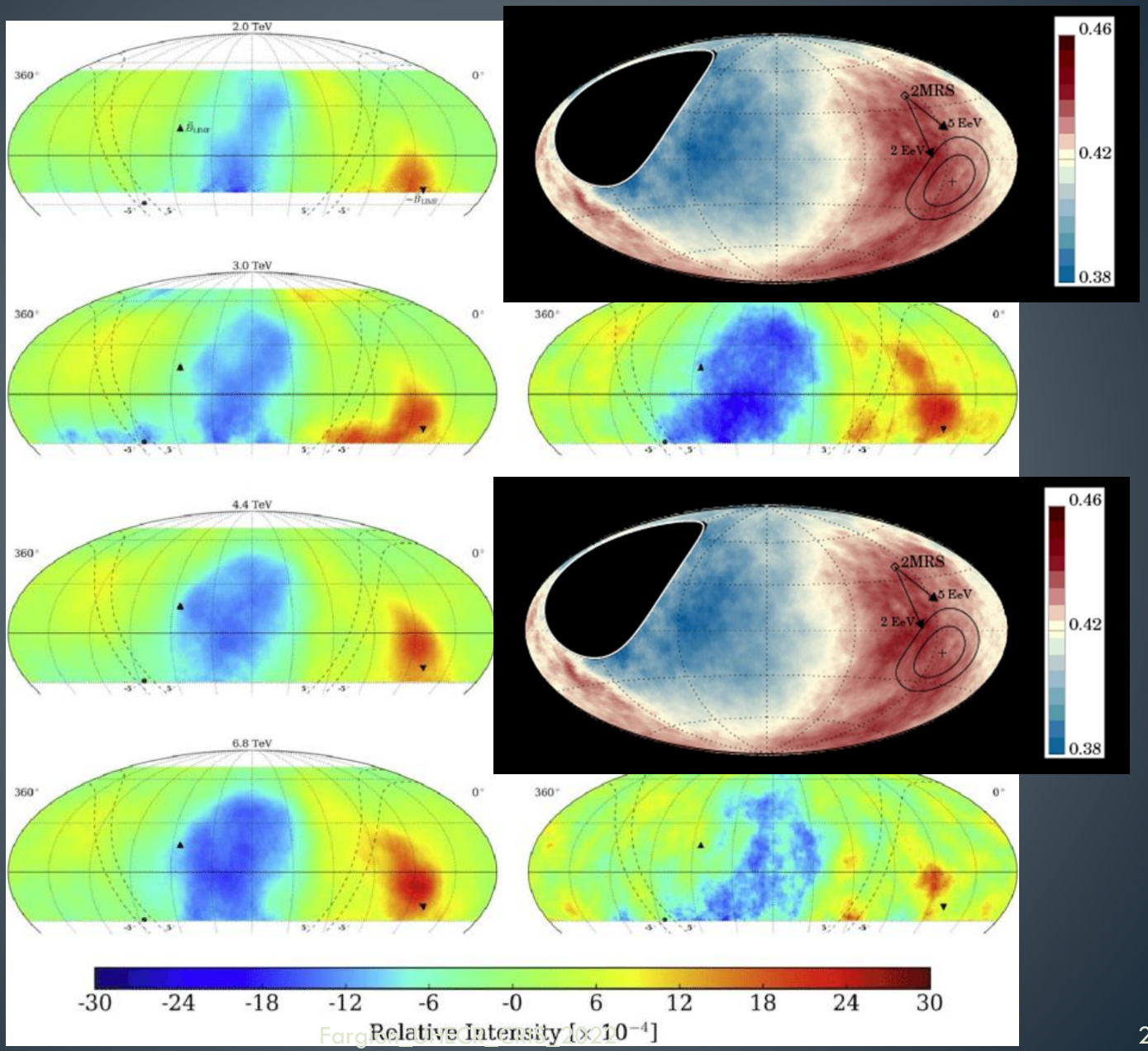
- 1) UHECR are not proton, but He-like
- 2) ***few EeV UHECR are not much cosmic but they might be partially galactic***

Source names and nearer sources: Cen A, M82, NG 253, Vela, LMC, SS433----POS 2018



Thank you for the cosmic attention

TEVS-UHECR connection?



The key question about UHECR Dipole connection with TeVs AYGO HAWC region A

ELSEVIER

Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment

Volume 692, 11 November 2012, Pages 174-179

TeV sky versus AUGER one: Are UHECR also radioactive, heavy galactic nuclei?

Daniele Fargion

Show more

+ Add to Mendeley Share Cite

https://doi.org/10.1016/j.nima.2012.01.069

Get rights and content

Criss May 2018

Where are the Ultra High Energy Cosmic Ray (UHECR) originated?

Arxiv, POS, 21 May 2018

Daniele Fargion[*,a,b] **Pier Giorgio De Sanctis Lucentini** [c] **and Maxim Yu. Khlopov** [d,e,f]

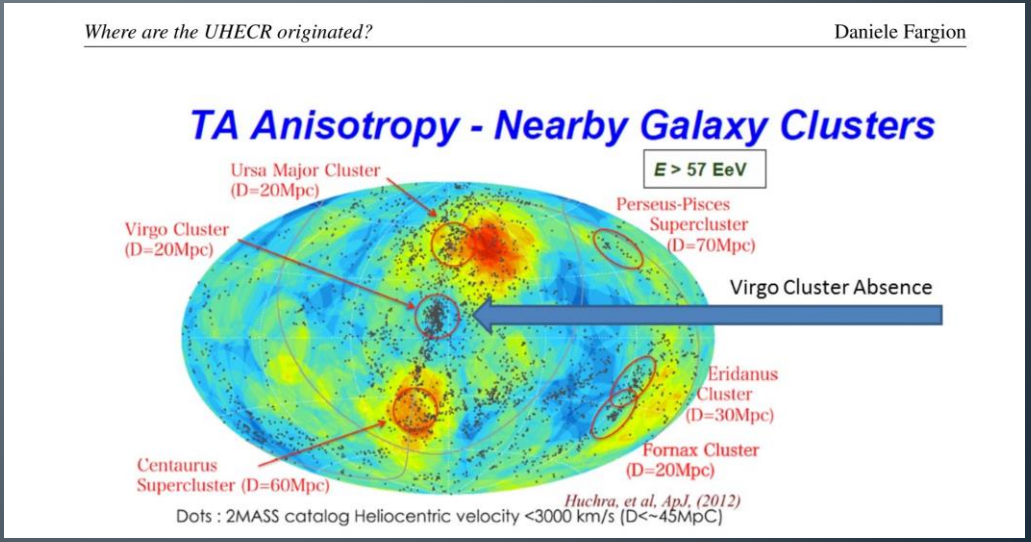
[a] *Physics Department & INFN Rome1, Rome University 1, P.le A. Moro 2, 00185, Rome, Italy*

[b] *MIFP, Via Appia Nuova 31, 00040 Marino (Rome), Italy*

[c] *Physics Department, Gubkin Russian State University (National Research University), 65 Leninsky Prospekt, Moscow, 119991, Russian Federation*

[d] *National Research Nuclear University "MEPHI" (Moscow Engineering Physics Institute), Kashirskoe Sh. 31, Moscow 115409, Russia*

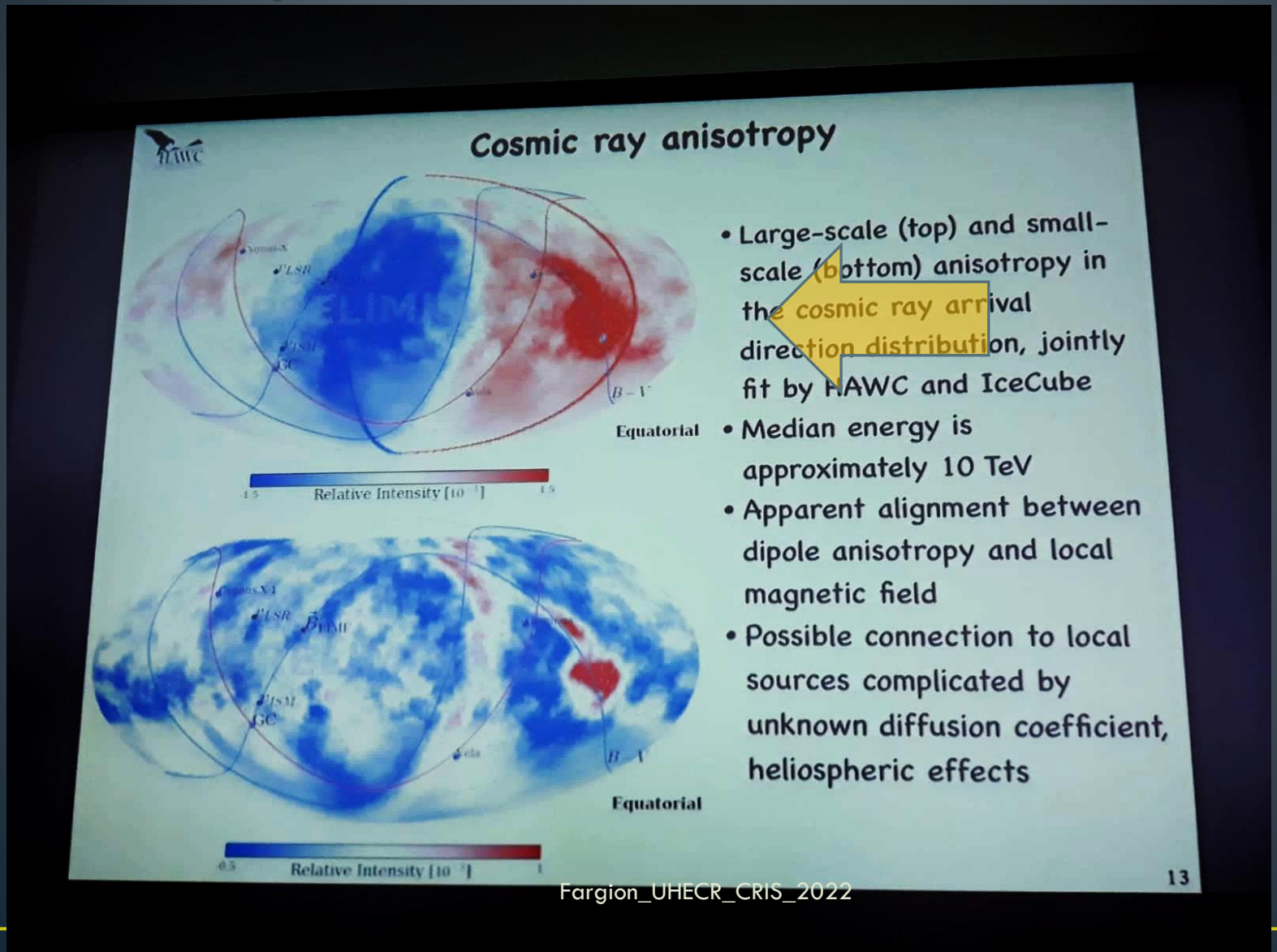
[e] *Centre for Cosmoparticle Physics "Cosmion" 115409 Moscow, Russia*



Hawc talk on Dipole Anisotropy at TeVs

SAME ANISOTROPY as UHECR one but at 0.1 millipercent!

A secondary tail?



Conclusions

- *Lightest Nuclei are main currier of UHECR*
- *Probable overlapping of the Hawc, ARGO,*
- *Dipole at TeVs with 10 EeV UHECR AUGER Dipole*
- *Interpretation:*
- *A Galactic Role by Vela, LMC, Crab and maybe Extragalactic Fornax D, NGC 253*
- *Rare clustering at 3C454 made by Z-Burst events due to UHE ZeV neutrinos scattering on relic (sterile?) eV neutrinos in hot dark halos.?*

Suggestion

UHECR are mostly LIGHTEST NUCLEI by Cen A, M82, NGC 253, but some cases might be NUCLEONS:

TO DISENTANGLE WE NEED A LOCAL UHECR SPECTROSCOPY:

Composition for each group.

- ***Thank You for the kind attention***

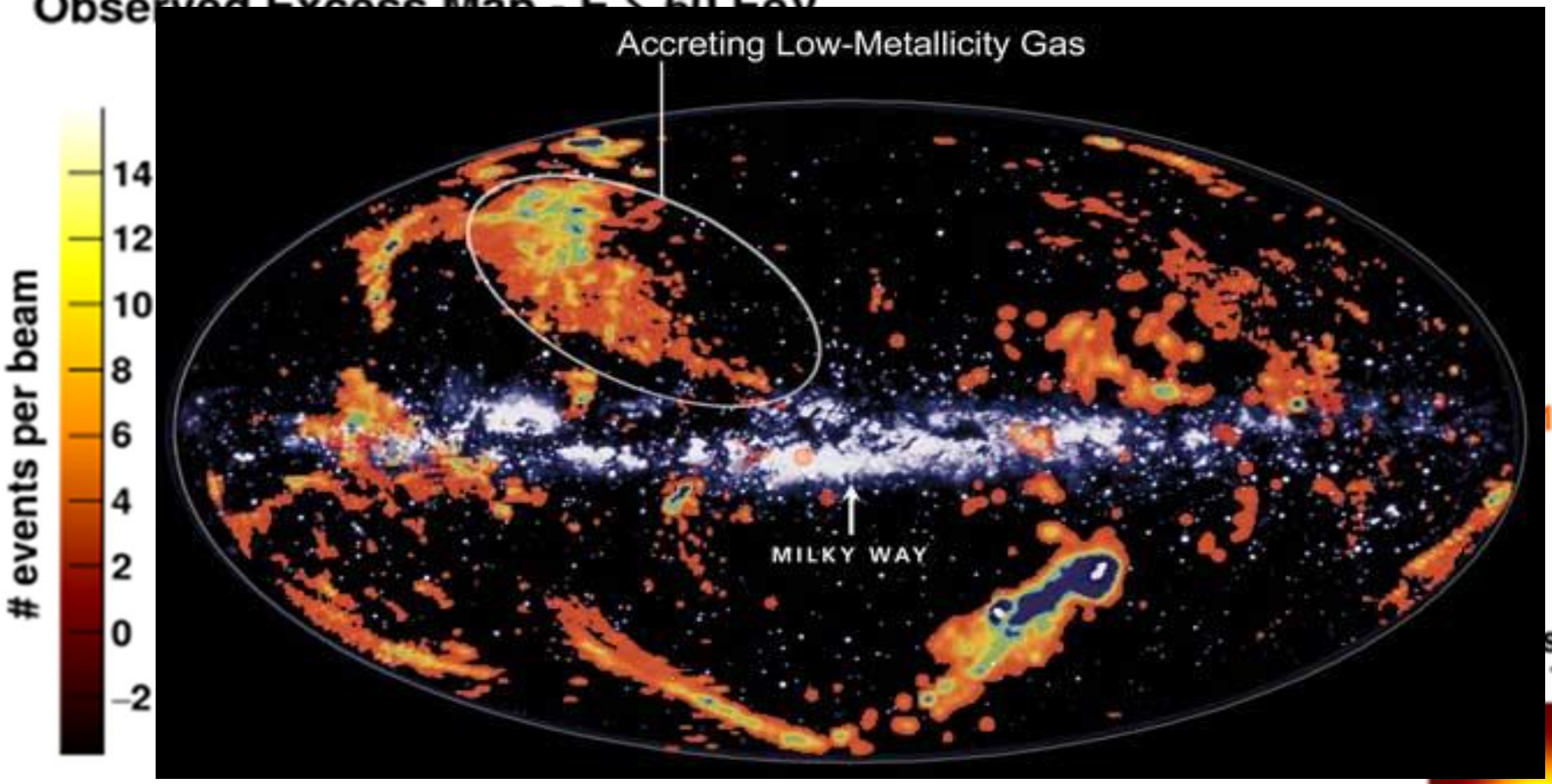
UHECR: Also Galactic? Also Cosmic?

- We comment also on the possible partial role of a few remarkable galactic UHECR sources at 10 EeV energies.
- Finally we revive the eventual role of a relic neutrino eV mass in dark hot halo (hit by ZeV neutrinos) to explain the new UHECR clustering events centered around a very far cosmic AGN sources as 3C 454.

Most Lightest Nuclei..but an apparent clustering to 3c 454 at redshift z=1 !

- Z Burst solution based on ZeV neutrino scattering on relic cosmic ones:
- UHECR by NUCLEONS and not NUCLEI

A much local trace?



Summary

- The recent Ultra High Energy Cosmic Ray (UHECR) dipole anisotropy found by AUGER at EeVs energies, requires an explanation.
  In analogy to the dipole Cosmic Black Body Radiation or other expected cosmic anisotropy one would like to understand the large UHECR dipole at EeV energy by a cosmic (bending, cosmic local clustering, Doppler shift) mechanism.
  However there is not such a tuned process and-or a cosmic source . We suggest a different reading key of present AUGER dipole data.