

Differences between Auger and TA spectra: Systematics or indication of a local astrophysical source?



HELMHOLTZ WEIZMANN
RESEARCH SCHOOL
MULTIMESSENGER ASTRONOMY

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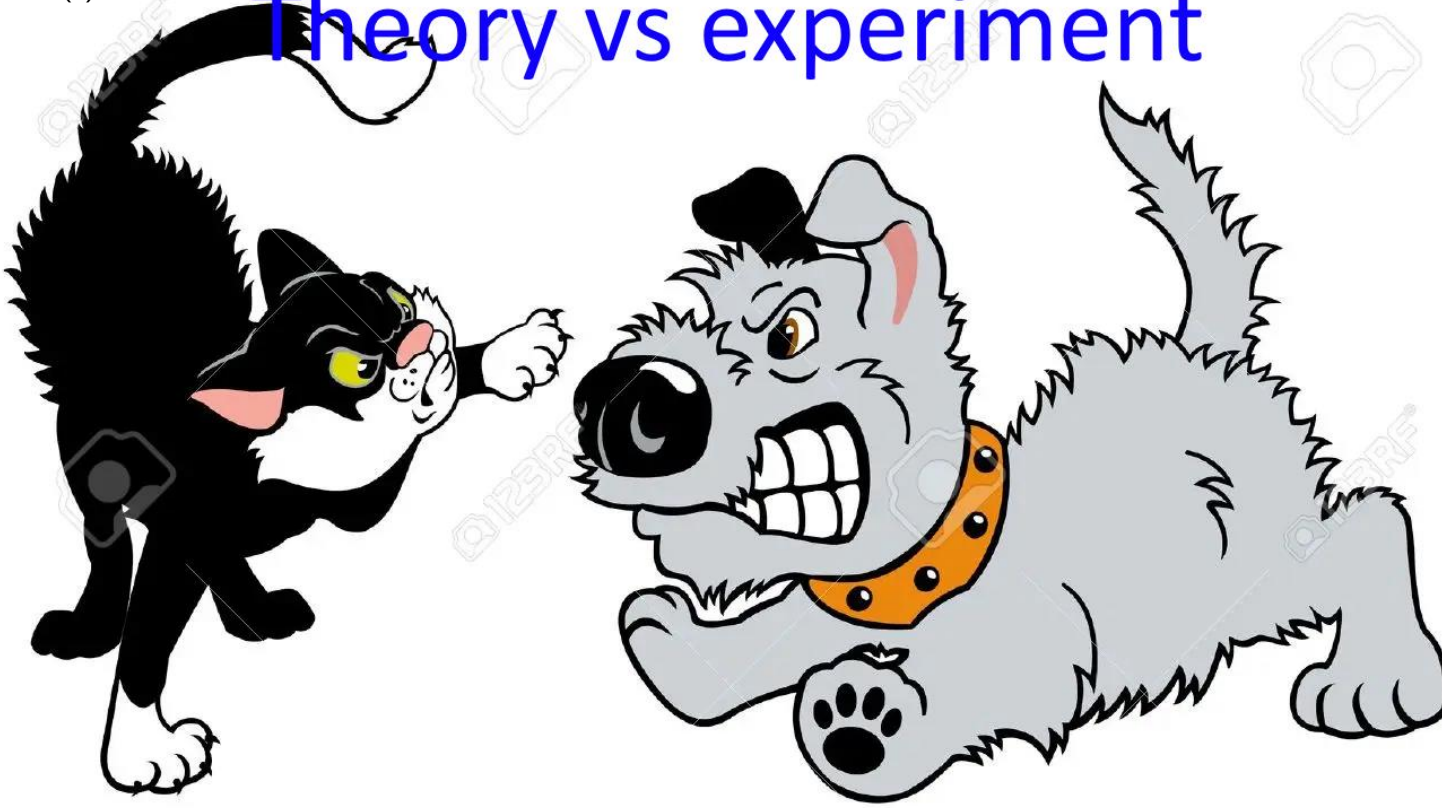
HELMHOLTZ





(2)

Theory vs experiment



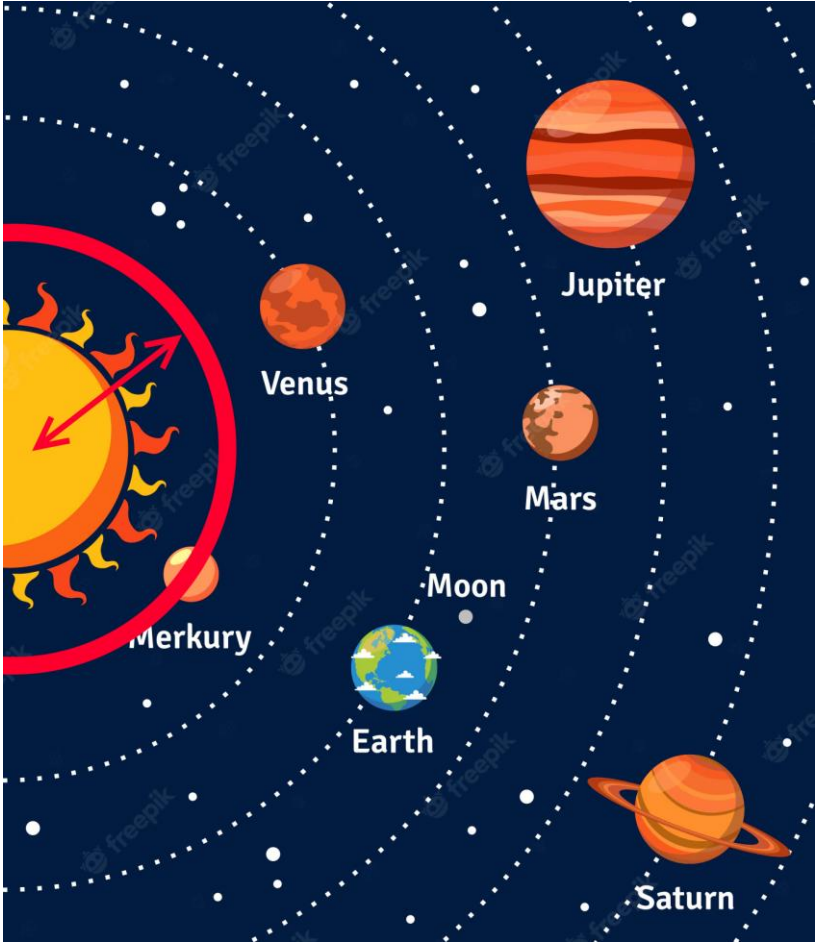
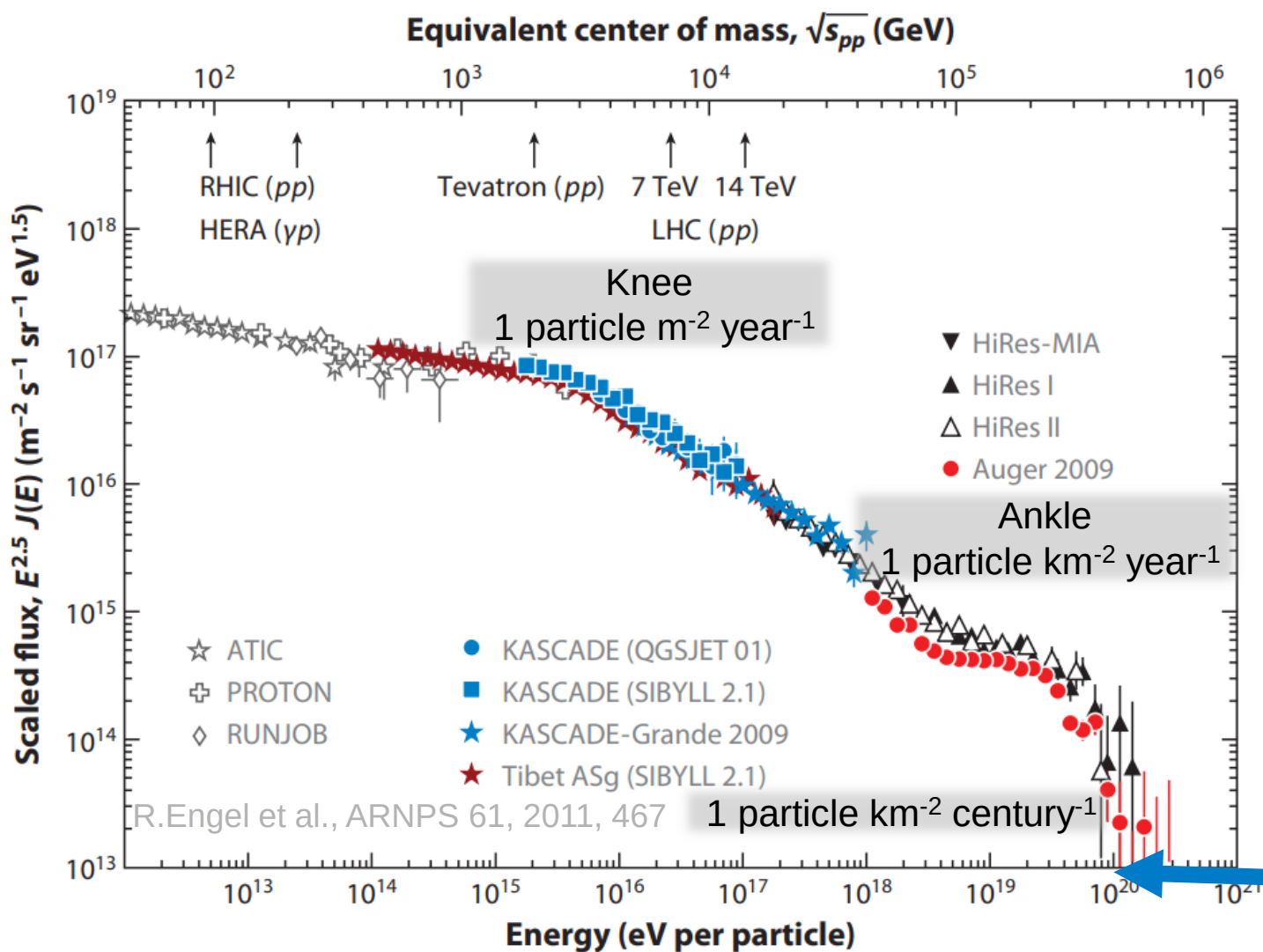
Pierre Auger Observatory

Telescope Array

vs

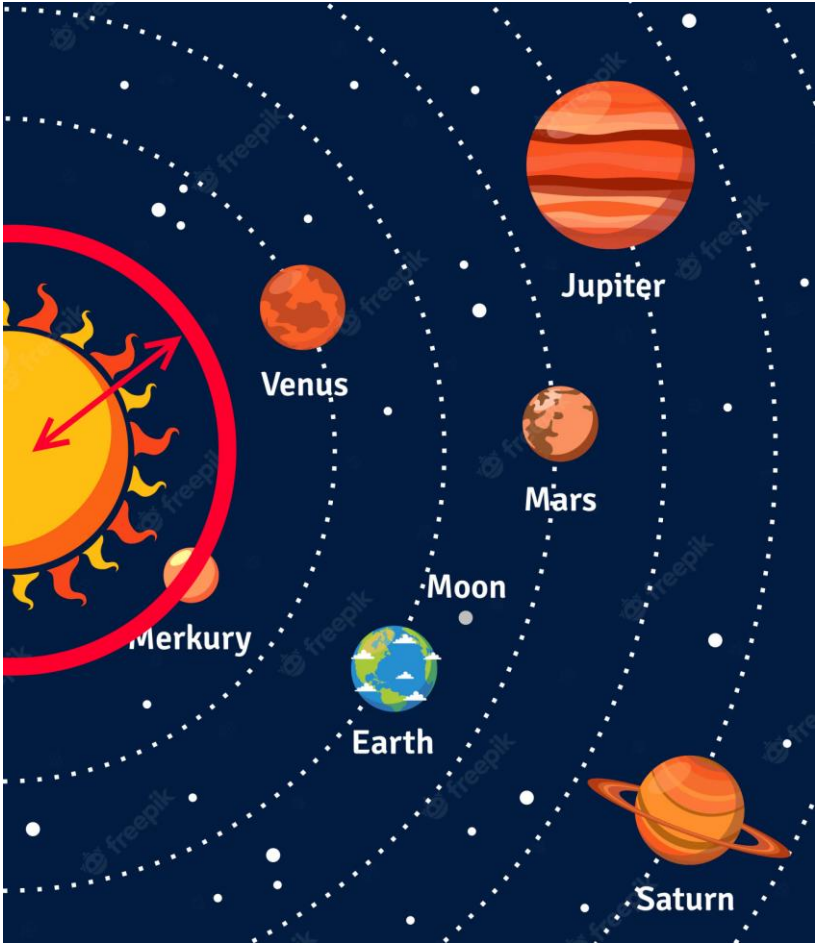
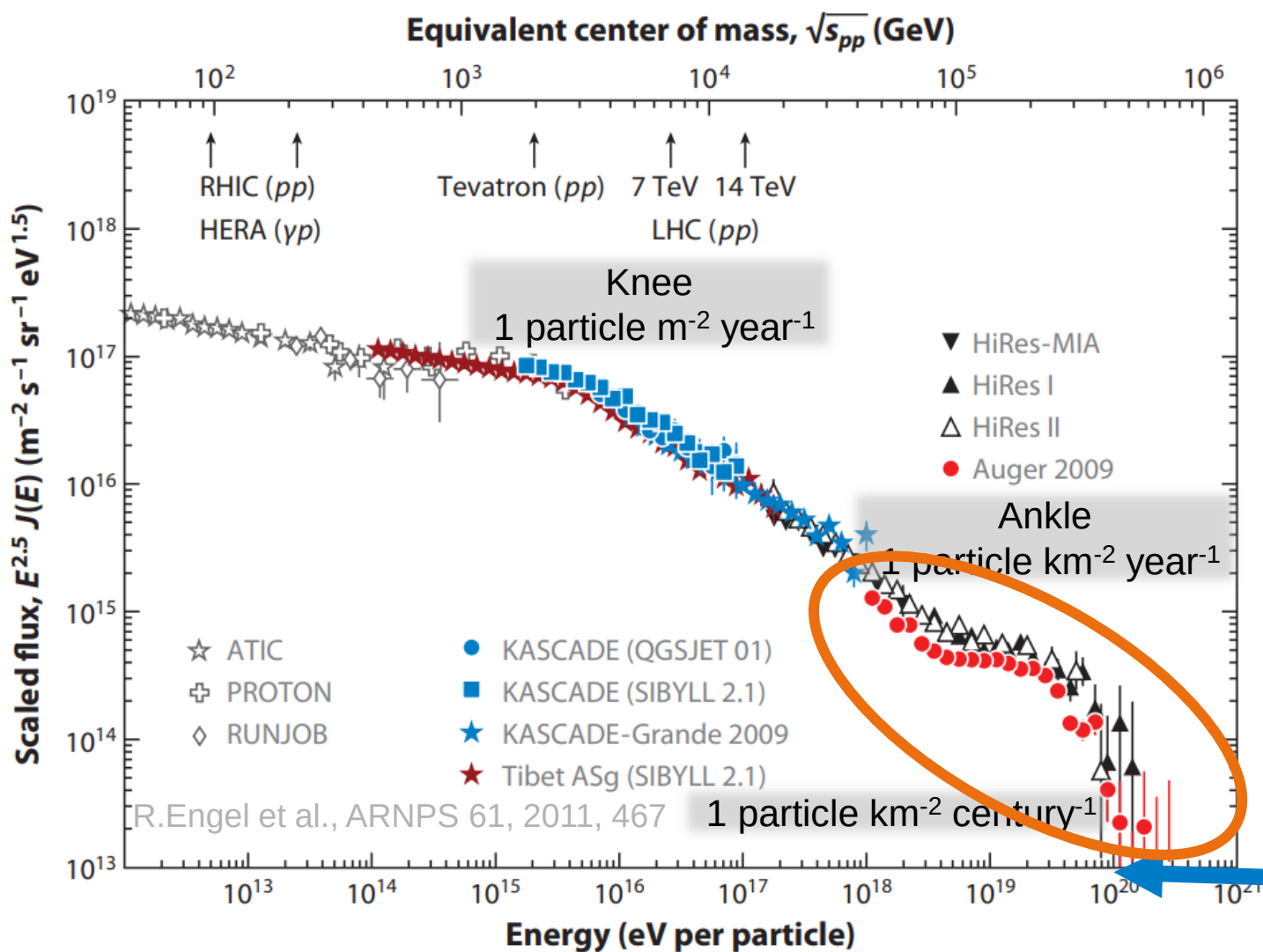


Cosmic Ray Spectra



Need an accelerator of the size of Mercury orbit to reach 10^{20} eV with LHC technology ☹

Cosmic Ray Spectra

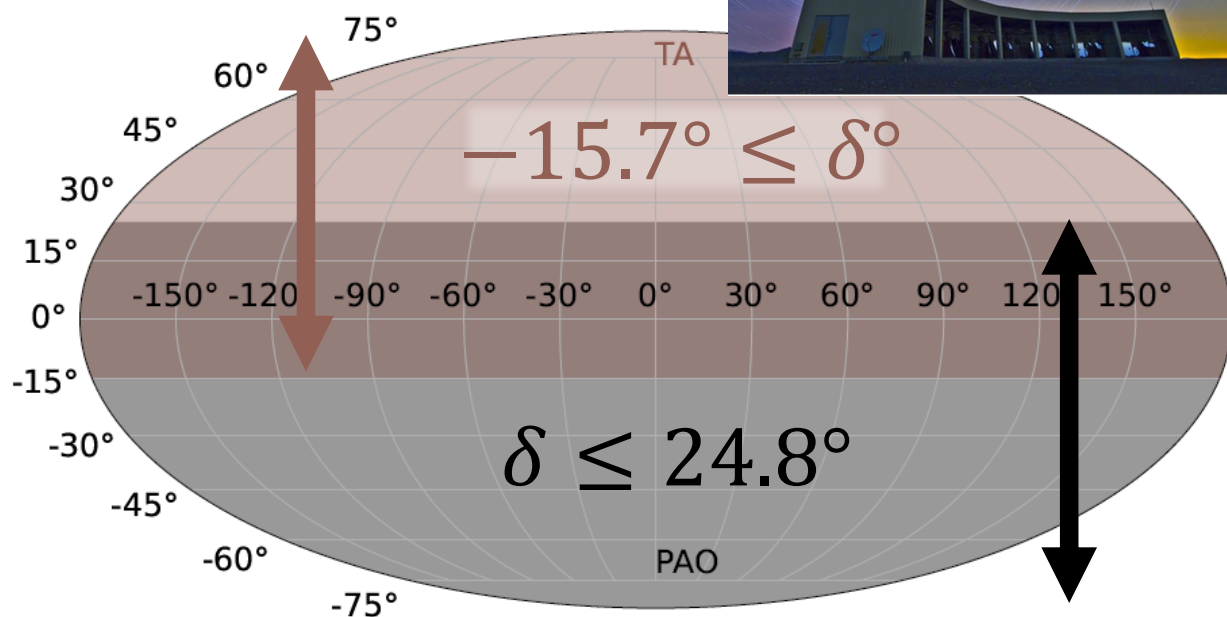


Need an accelerator of the size of Mercury orbit to reach 10^{20} eV with LHC technology ☹

UHECR detectors: TA vs PAO

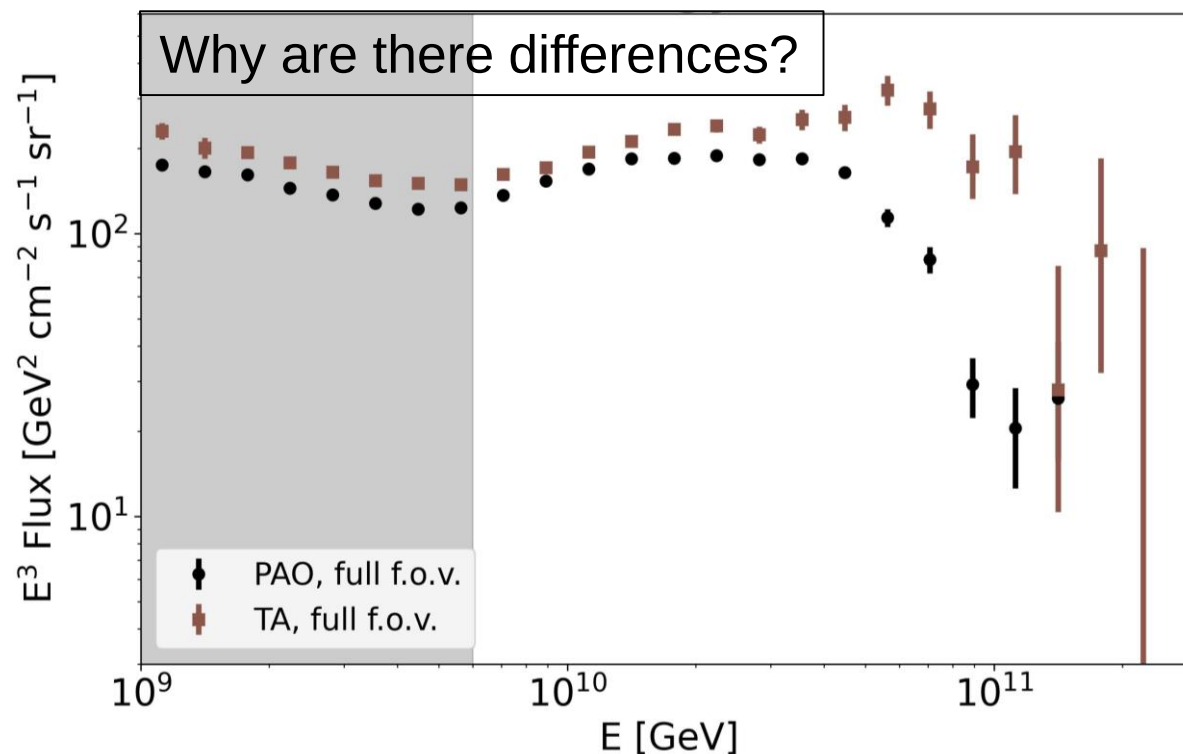
Ultra-High-Energy Cosmic Rays (UHECR)

Telescope Array (TA), USA

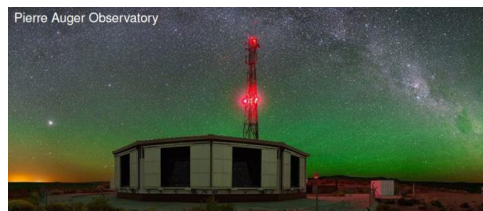


Energy systematic uncertainties:

↖ 14% ↗ 21%



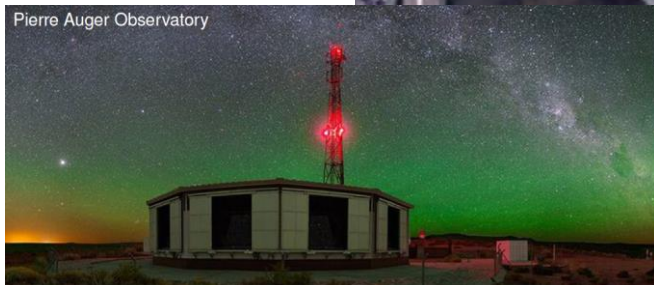
Pierre Auger Observatory (PAO), Argentina



1. Different detectors
2. Different analyses
3. Different fields of view

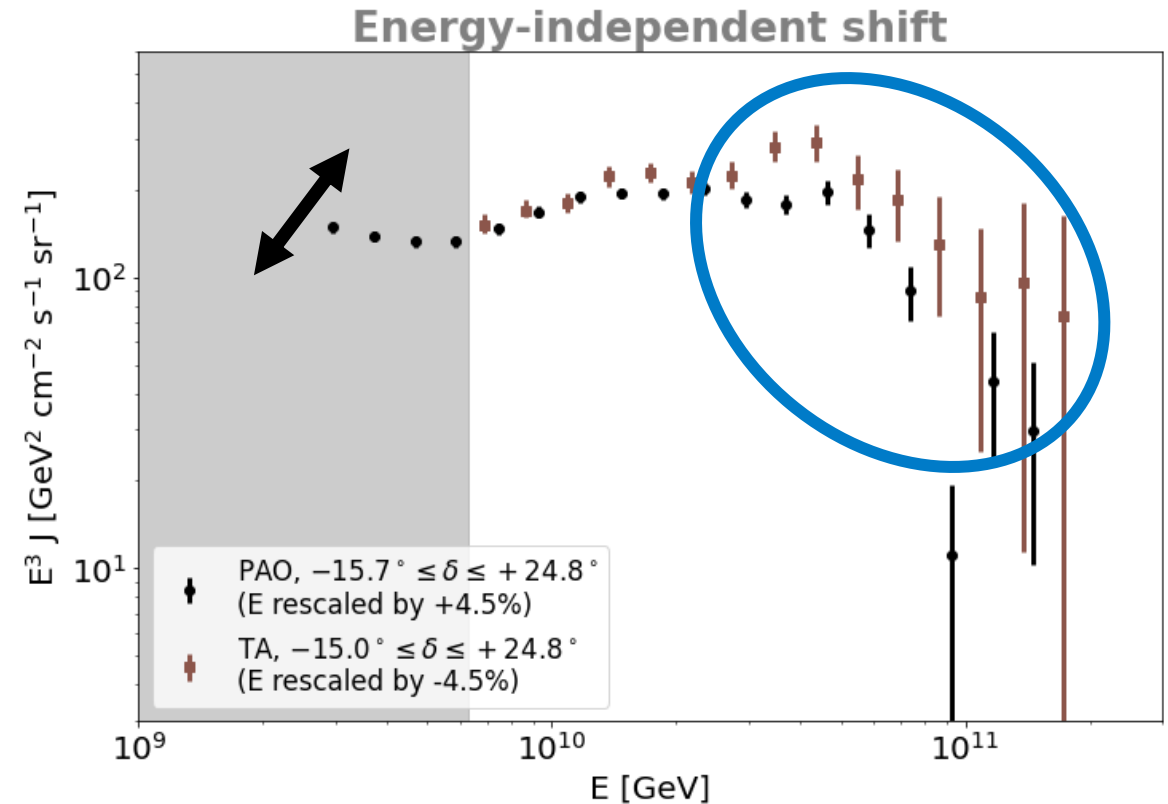
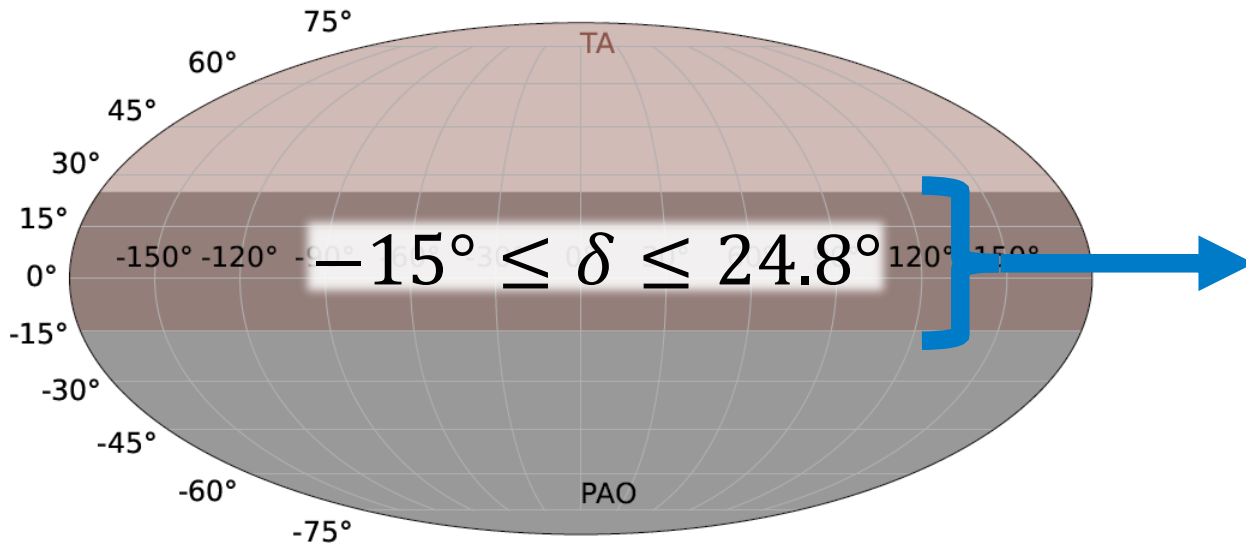
UHECR spectrum

Motivation



Joint group for UHECR spectrum

Simple shift



Energy-independent shift:

$$E_{\text{new}} = (1 \pm 4.5\%)E_{\text{old}}$$

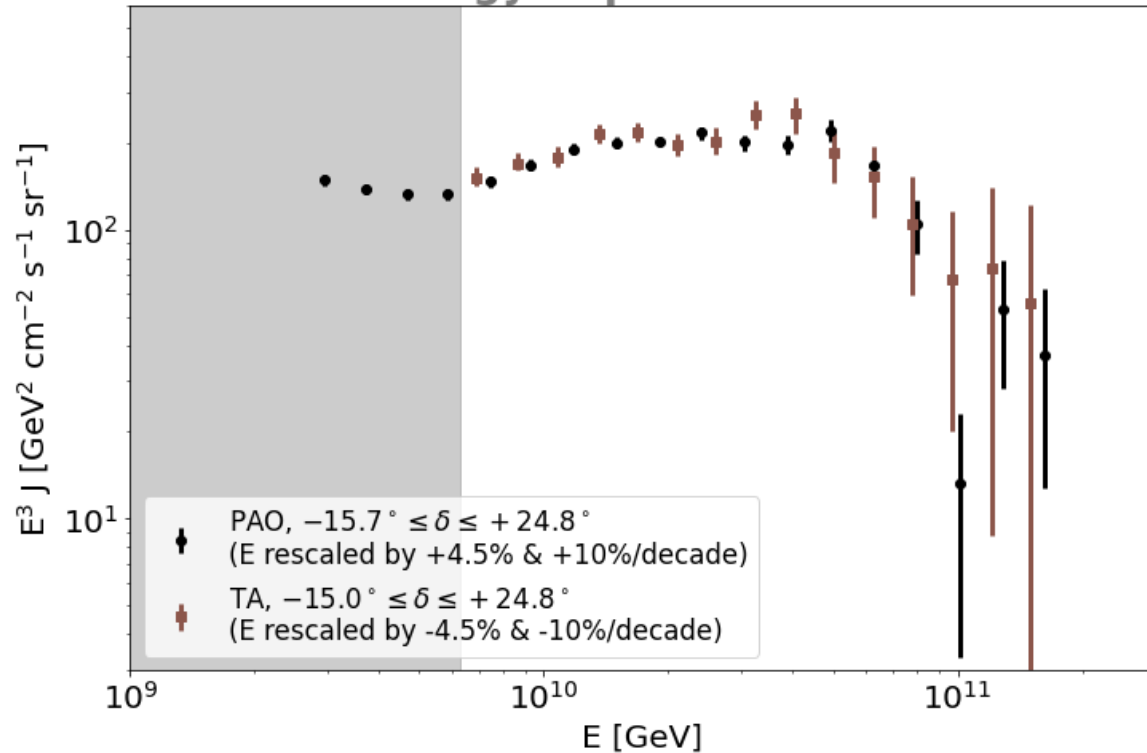
$$E_{\text{new}}^3 \cdot J_{\text{new}} = (1 \pm 4.5\%)^2 E_{\text{old}}^3 \cdot J_{\text{old}}$$

Why are the same numbers used?

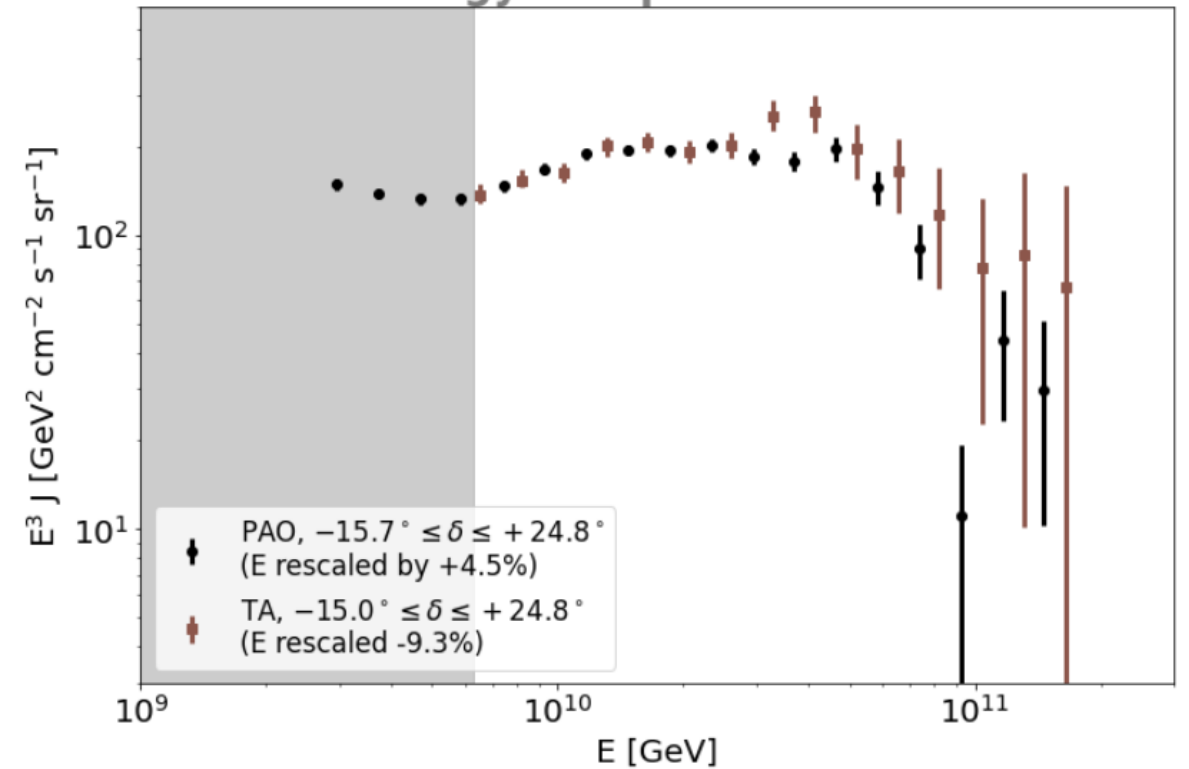
Joint group for UHECR spectrum

Complex shift or simple shift

Energy-dependent shift



Energy-independent shift



$$E_{\text{new}} = \left(1 \pm 4.5\% \pm 10\% \cdot \log_{10} \left(\frac{E_{\text{old}}}{10^{10} \text{ GeV}} \right) \right) E_{\text{old}}$$

$$\text{PAO: } E_{\text{new}} = (1 + 4.5\%) E_{\text{old}}$$

$$\text{TA: } E_{\text{new}} = (1 - 9.3\%) E_{\text{old}}$$

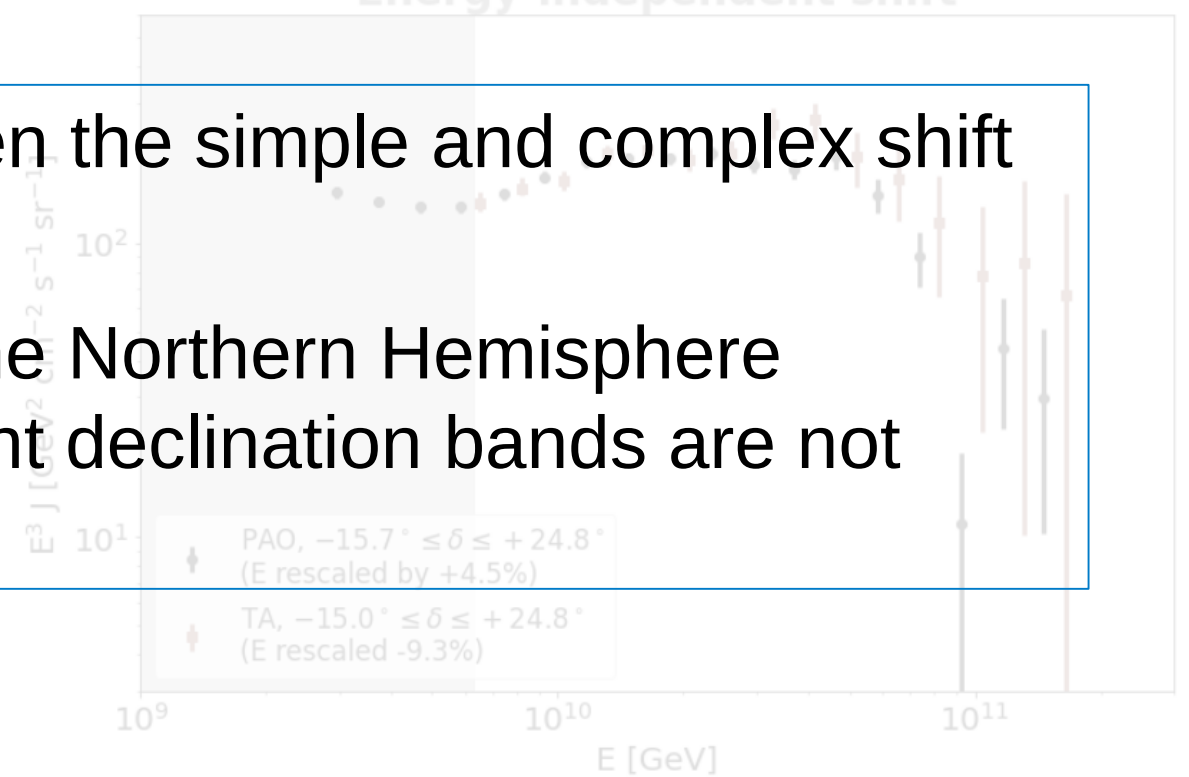
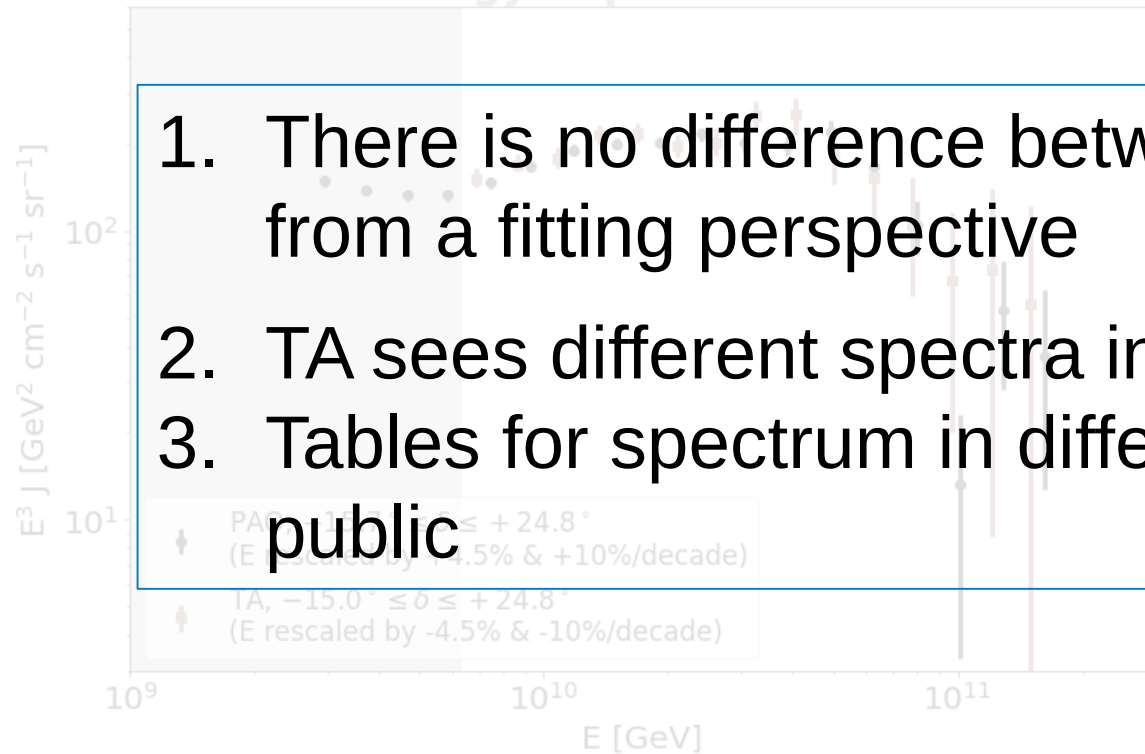
Joint group for UHECR spectrum

Complex shift or different simple shift

Energy-dependent shift

Energy-independent shift

1. There is no difference between the simple and complex shift from a fitting perspective
2. TA sees different spectra in the Northern Hemisphere
3. Tables for spectrum in different declination bands are not public



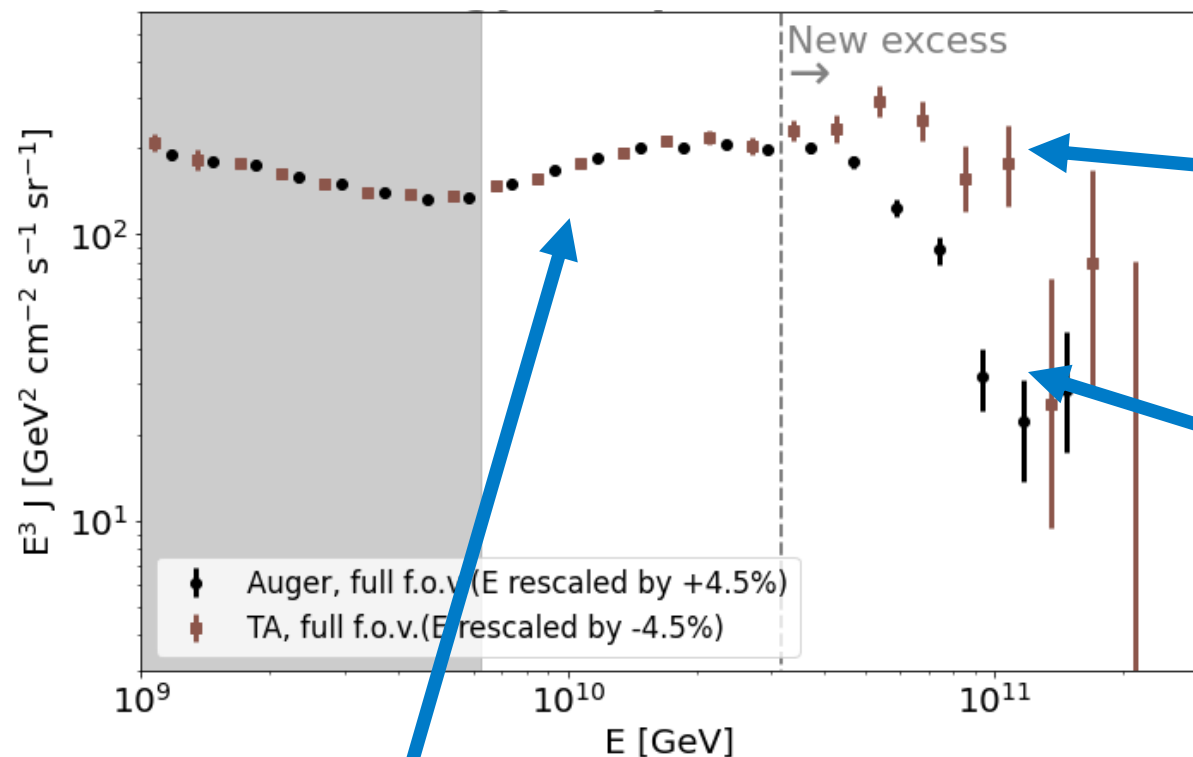
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Our proposal

Pavlo Plotko, Arjen van Vliet, Xavier Rodrigues and Walter Winter
arXiv:2208.12274



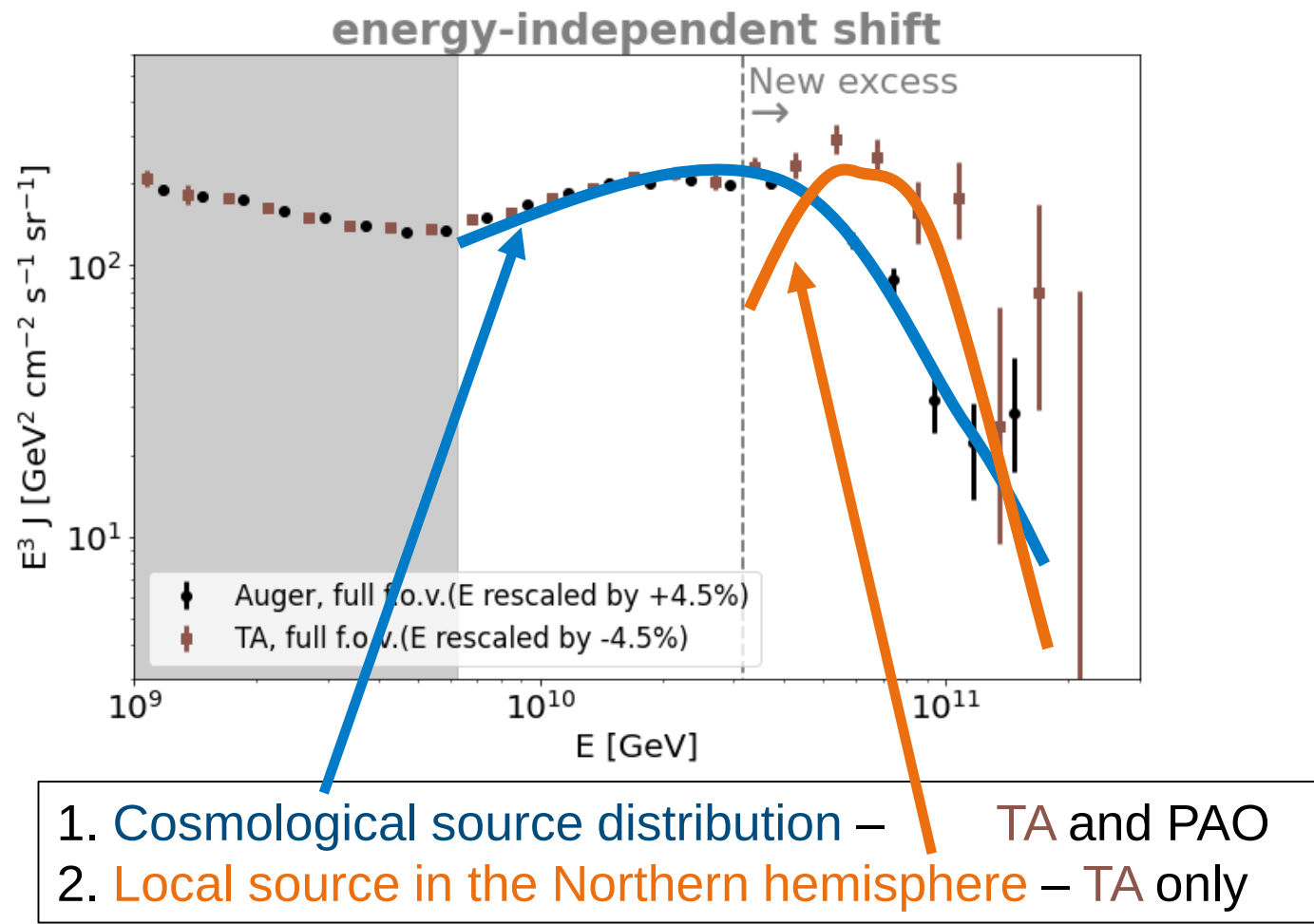
Systematics?

Astrophysical origin?

Can be explained by simple
shift

Our proposal

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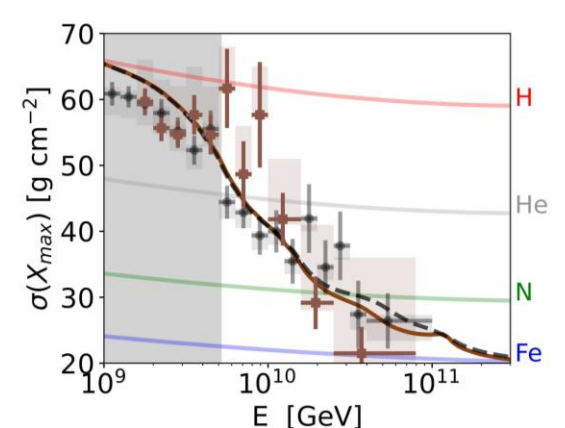
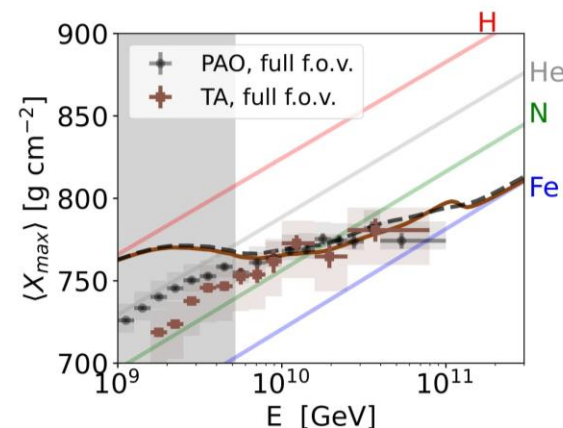
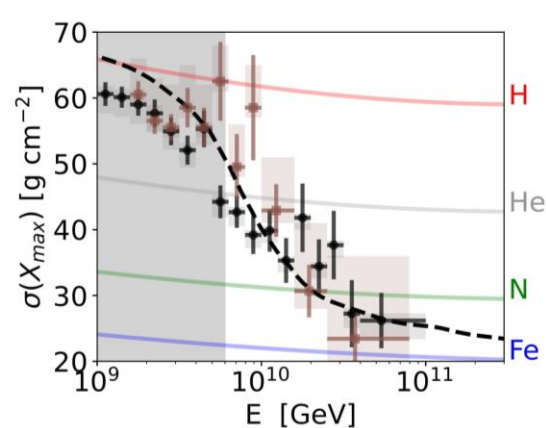
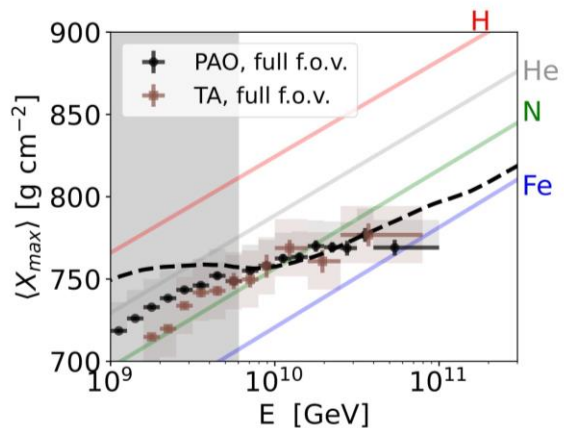
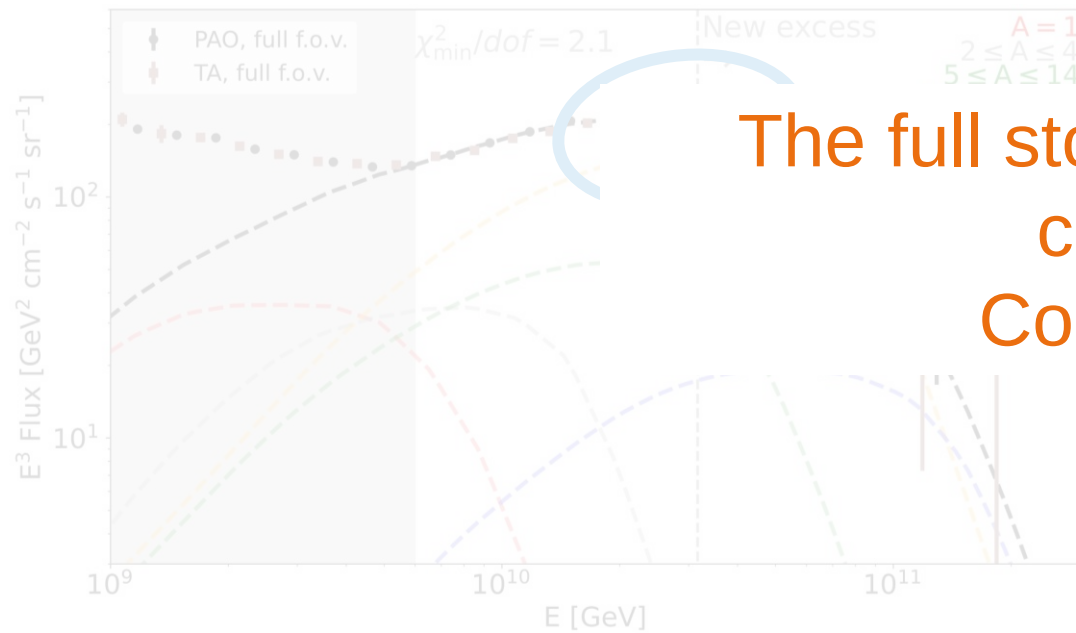


Systematics

vs

Astrophysical origin

The full story is much more complex:
Composition



Take-home messages

Both scenarios could explain the differences
More data are needed (AugerPrime and TAx4)

Systematics:

Physics behind the shifts?

Astrophysical:

Nature of the local source?



Let's be friends 😊

Credits for images

1. “DC VS. MARVEL: WHO HAS THE HIGHER TOMATOMETER?” by Mark Hofmeyer (<https://editorial.rottentomatoes.com/article/dc-vs-marvel-who-has-the-higher-tomatometer/>)
2. “Star Wars vs. Star Trek” by Otis Adams (<https://vocal.media/geeks/star-wars-vs-star-trek>)
3. <https://tech.hindustantimes.com/tech/news/mercury-venus-to-mars-know-how-long-it-takes-all-planets-to-orbit-the-sun-71660207000444.html>
4. “Spider-Man” 2022 by Sony Pictures Releasing
5. <https://thechoiceisyours.whatisthematrix.com> by WARNER BROS
6. <https://www.newsweek.com/dogs-cats-living-together-how-introduce-pets-1607979>

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