Latest results from the Telescope Array

P. Tinyakov[1]
for the Telescope Array Collaboration

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Conference in memory of Veniamin Berezinsky
L'Aquila, October 1-3, 2024

Photos by ***N.Nolde,*** *INR, 2010.*

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Nolde, INR, 2010.

Outline

Telescope Array experiment

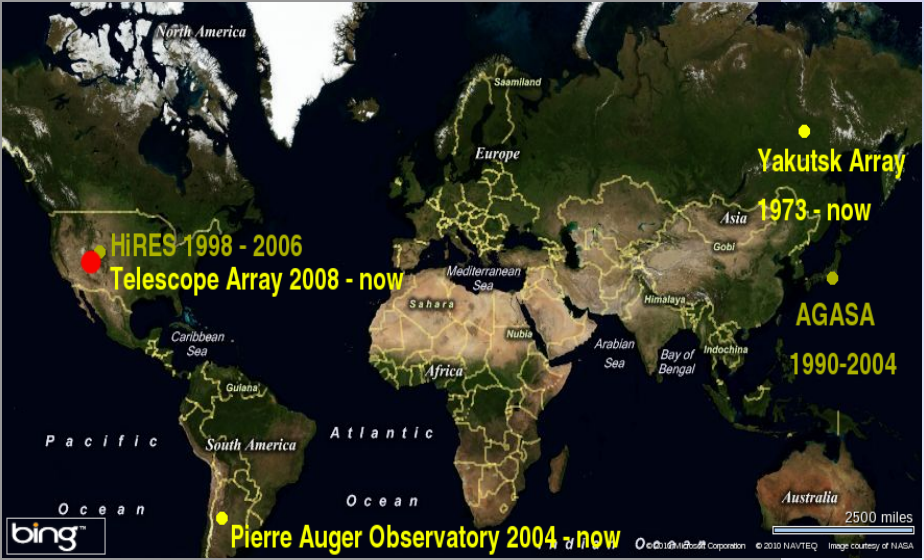
Spectrum

Composition

Anisotropy

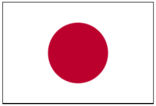
Summary & Outlook

UHECR experiments



Telescope Array Collaboration

USA



Japan

Korea

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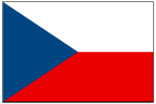
[37] *Department of Physics, Ehime University, Matsuyama, Ehime, Japan*

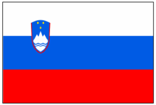
145 members, 32 institutes, 7 countries

Russia

Belgium

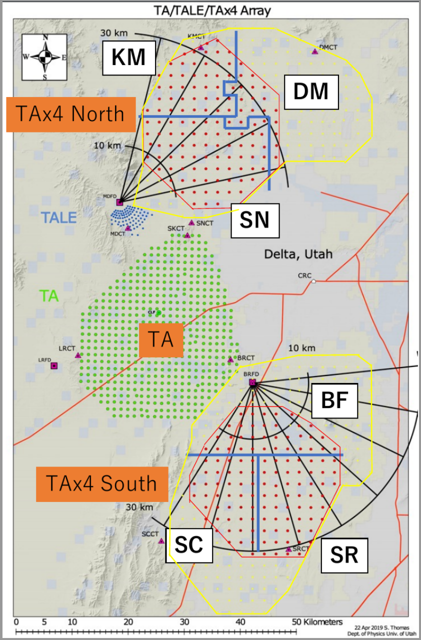


Czech Republic

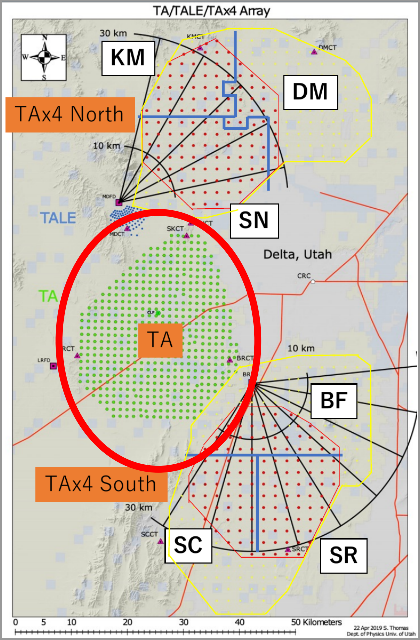


Slovenia

TELESCOPE ARRAY DETECTOR



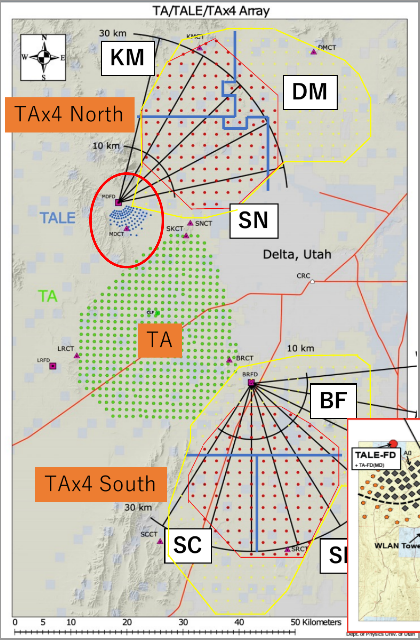
TELESCOPE ARRAY DETECTOR



TA:

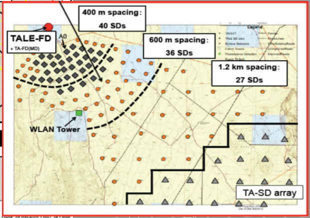
- 507 scintillator detectors covering 680 km^2, 1.2 km spacing
- 38 fluorescence telescopes in 3 towers
- operational since March 2008

TELESCOPE ARRAY DETECTOR

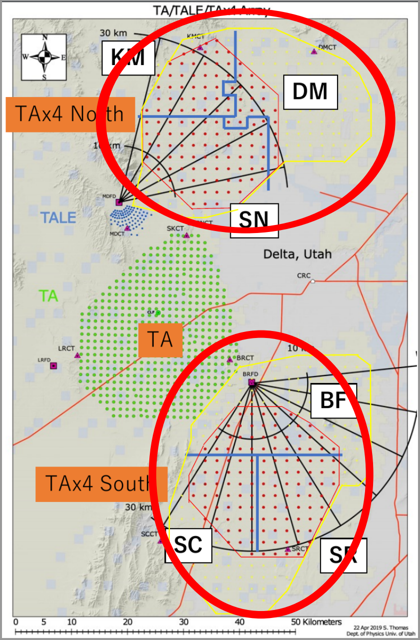


TALE (low energy extension):

- 103 scintillator detectors same as TA, 400 – 600 m spacing, 70 km^2
- 10 fluorescence telescopes looking high, 30° – 59°



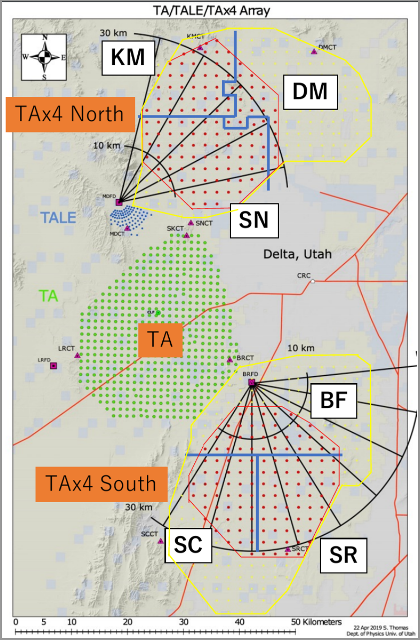
TELESCOPE ARRAY DETECTOR



TAx4:

- SD: 257 scintillator detectors (half of the planned), 2.08 km spacing, $\sim$ 1000 km^2; data taking since Nov 2019
- FD: 2 fluorescence towers, North (data taking since June 2018) and South (data taking since Sept 2020)

TELESCOPE ARRAY DETECTOR



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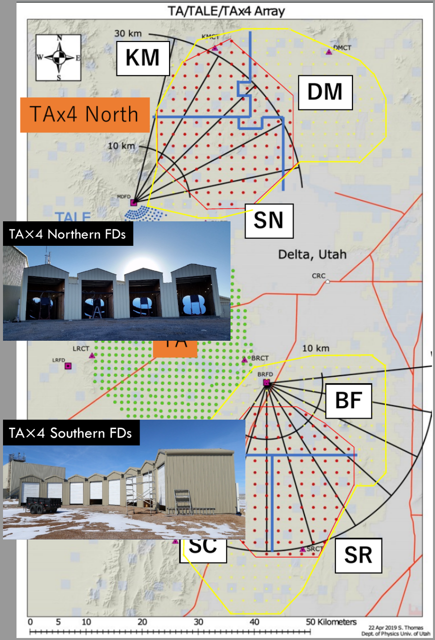

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SPECTRUM

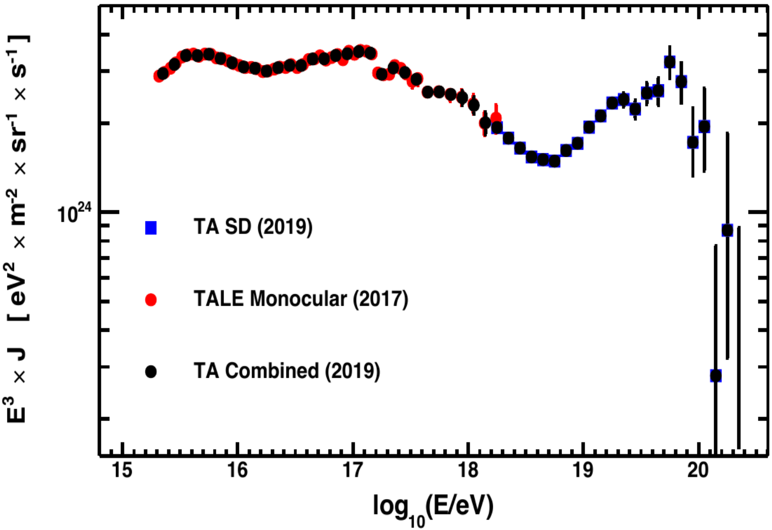
TA spectrum

TA measures spectrum by several techniques:

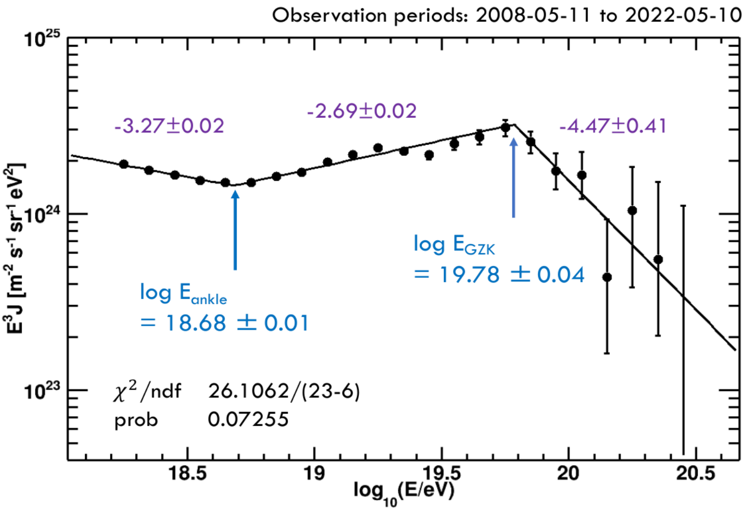
- Fluorescence detector (FD-mono) – at three stations independently + in stereo mode (FD-stereo)
- Surface detector (SD) – largest statistics
- Hybrid (SD+FD) – used for calibration
- Cherenkov light TALE – lowest threshold
- All spectra agree after rescaling of SD energies down by 1.27

⟹ CR spectrum over nearly 5 decades

Combined spectrum from TA + TALE:

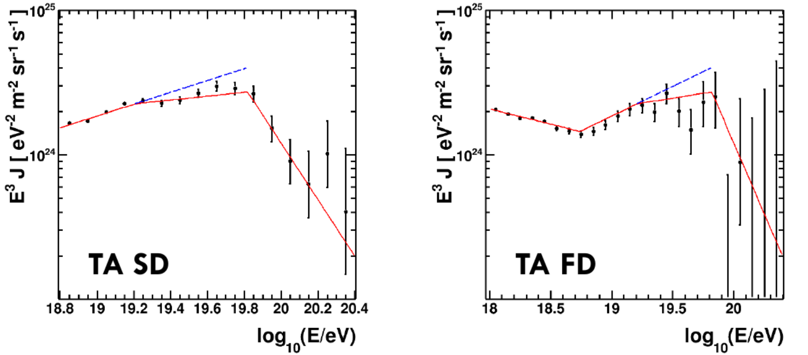


TA spectrum update



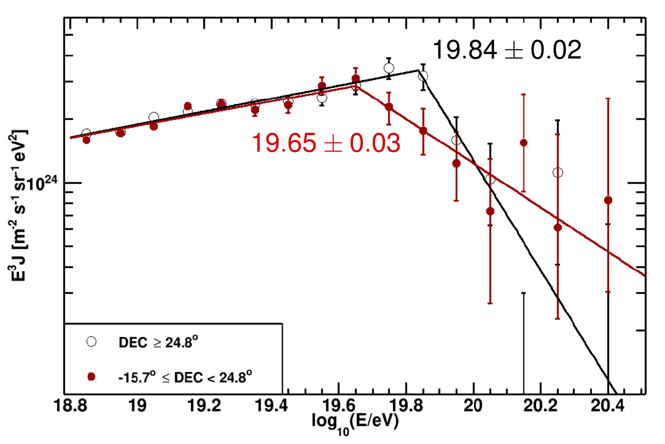
Jihyun Kim @ ICRC2023

“Shoulder” above 10^{19} eV



- first observed by Auger
- position of the shoulder: $10^{19.20\pm0.03}$ eV
- significance 6.5σ
- consistent with Auger at 1.2σ

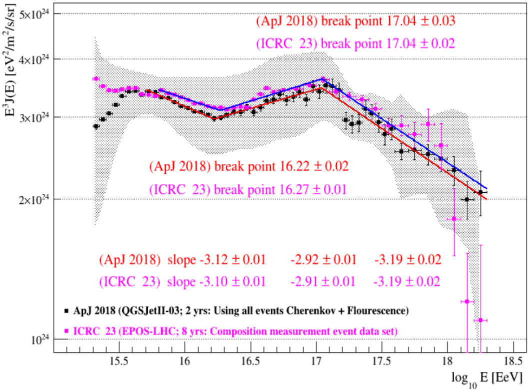
Declination dependence of the spectrum



- global significance of the difference is estimated as 4.4σ
- no instrumental cause was identified
  $\Longrightarrow$ astrophysical origin is likely

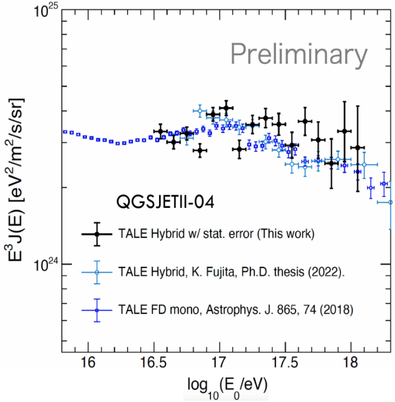
TALE mono & hybrid (ICRC2023)

TALE FD Monocular Data



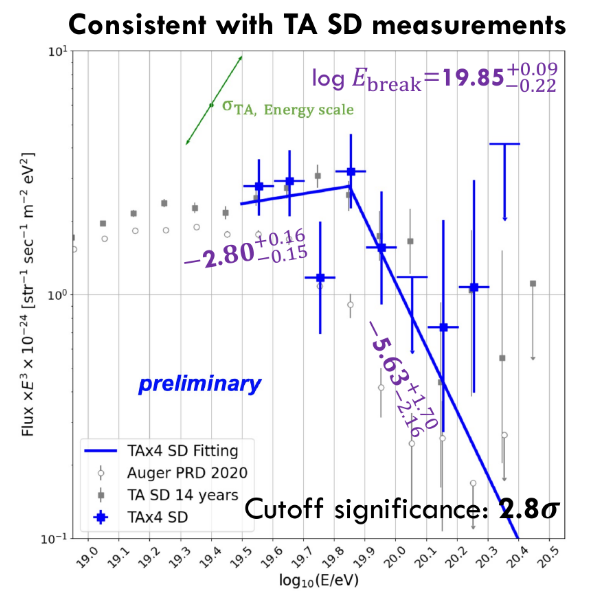
Tareq AbuZayyad, CRI4-04 Jul. 26

TALE Hybrid Data



Hitoshi Oshima, CRI4-02 Jul. 26

TAx4 3 yrs of data



Kozo Fujisue @ ICRC2023

Latest results from the Telescope Array

P. Tinyakov for the Telescope Array Collaboration

Telescope Array experiment

Spectrum

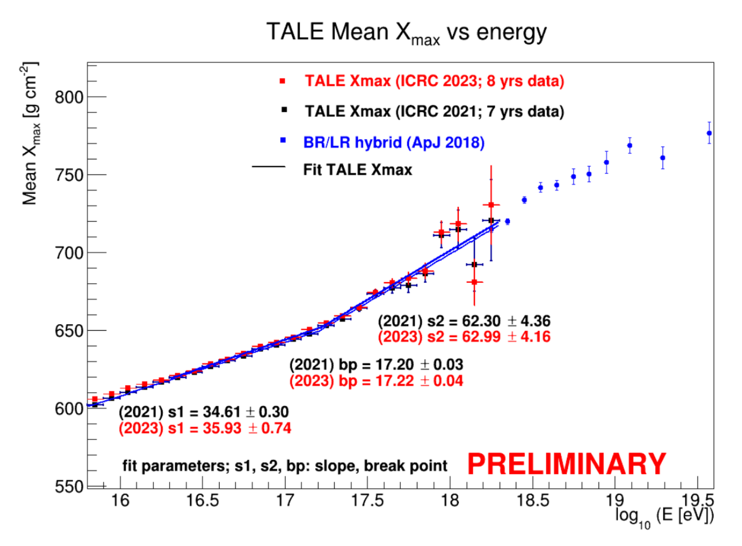
Composition

Anisotropy

Summary & Outlook

COMPOSITION

TALE FD monocular data 2014-2022

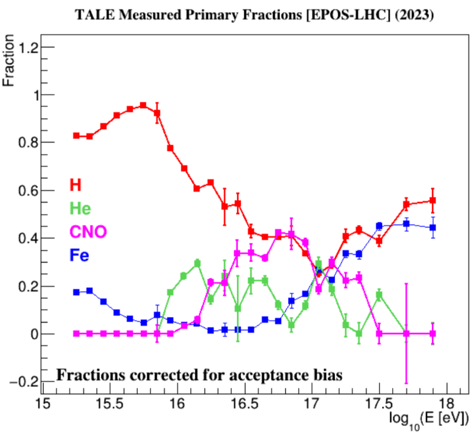


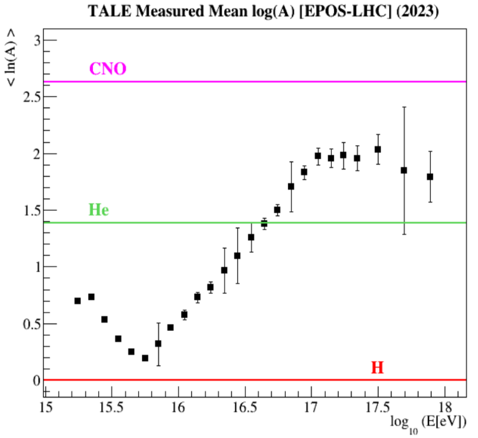
Tareq AbuZayyad @ ICRC2023

Composition in TALE FD monocular data 2014-2022

- energy range $\log(E) = 15.2 - 18$
- bins of 0.1 in $\log(E)$
- in each bin fit the data $X_{\max}$ distribution with the sum of MC distributions for 4 primaries: proton, He, nitrogen (CNO), Fe
- Monte Carlo: EPOS-LHC hadronic model

Composition in TALE FD monocular data 2014-2022



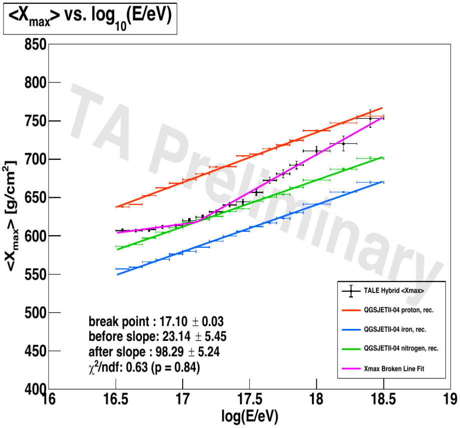


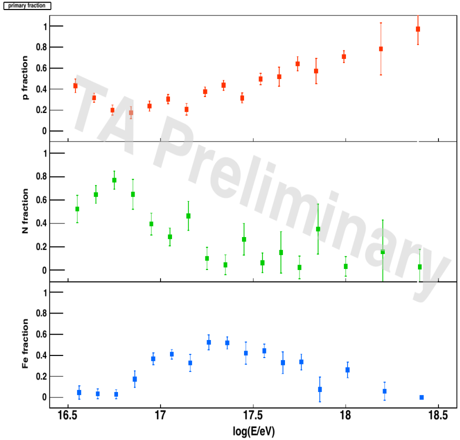
Latest results from the Telescope Array

Tareq AbuZayyad @ ICRC2023

TALE FD hybrid data (Nov.2017 - Mar.2023)

Latest results from the

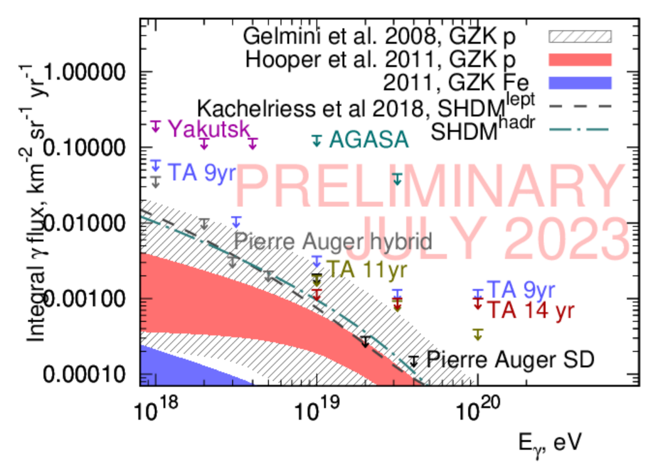




Keitaro Fujita @ ICRC2023

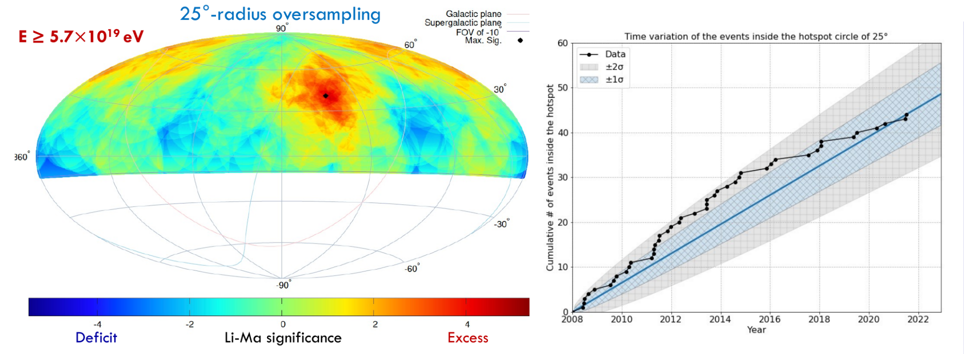
TA updated photon limits

- Neural network is trained on simulated data to distinguish between the proton and photon showers.
- Both reconstructed composition-sensitive parameters and raw signals registered by the SD are used as input



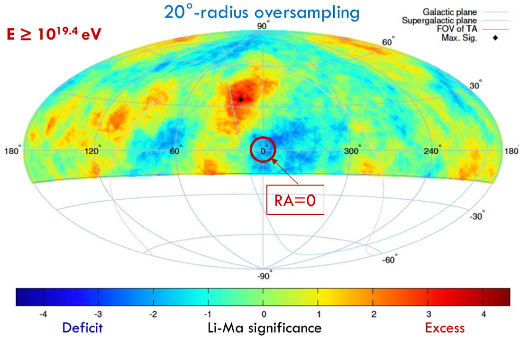
ANISOTROPY

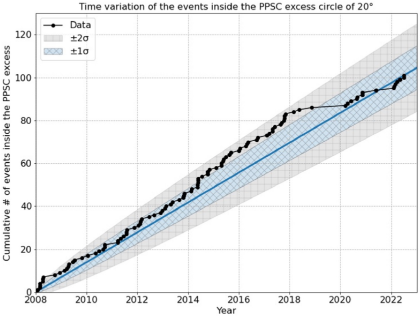
TA hot spot: update 2023



- 216 events (15 yrs of SD data)
- max local significance 4.8σ at $l = 144.0°, \quad b = 40.5°$
- global significance $2.7 \times 10^{-3} = 2.8\sigma$

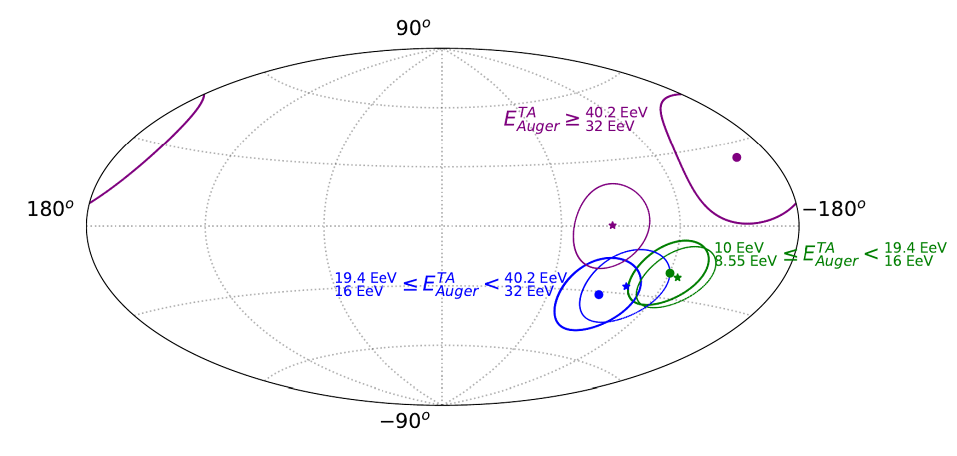
PPSC excess: update 2023





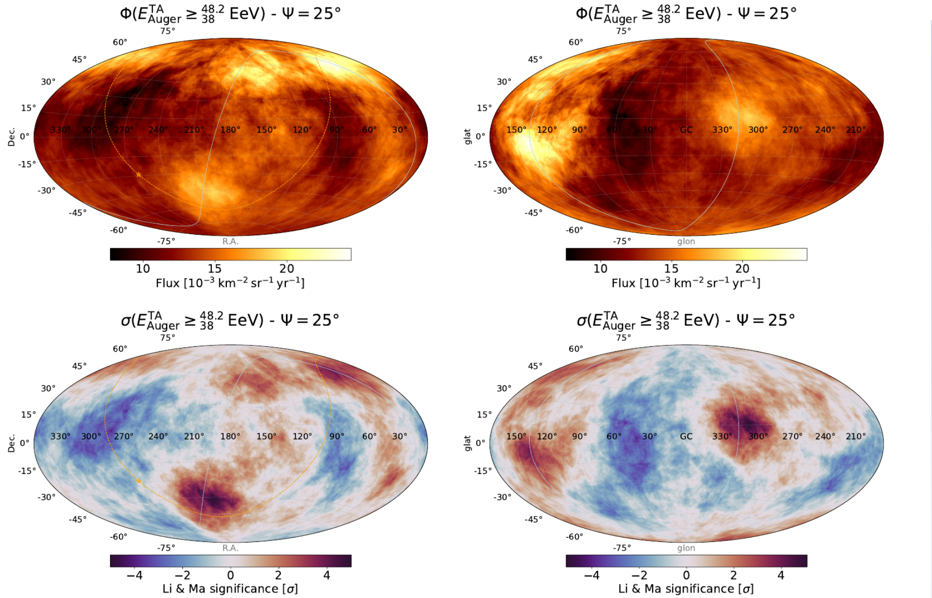
- 1125 events (15 yrs of SD data)
- max local significance 4.0σ at $l = 17.9°$, $b = 35.2°$
- probability to find such an excess on top of PPSC is $\sim 10^{-3} = 3.3\sigma$

Anisotropy WG update 2023



- stars, thin lines — Auger only
- dots, thick lines — Auger + TA (full sky)

Full sky UHECR flux map



Composition from (an)isotropy?

- assume sources follow LSS
- measure typical UHECR deflection θ
- θ is mostly sensitive to composition $\Longrightarrow$ info on composition from deflections

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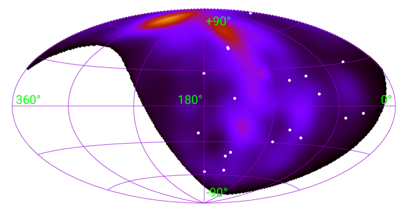

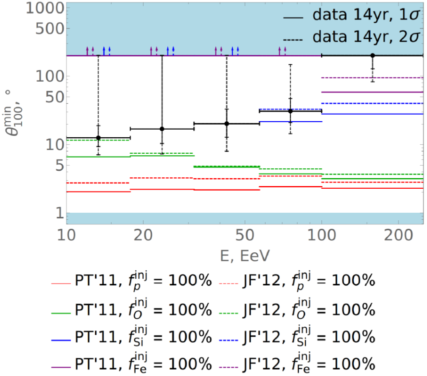

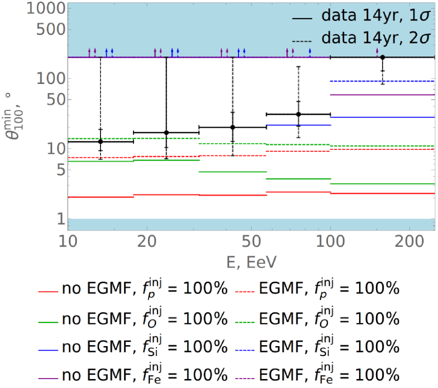

SUMMARY & OUTLOOK

- Consistent measurement of spectrum over 5 decades
- Composition measurement by TALE SD and TALE Hybrid at low energies
- More data is needed at high energies
- TAx4 is up and taking data, but only half of it is completed $\Longrightarrow$ need to construct another half a.s.a.p.!