ULTRA-HIGH-ENERGY COSMIC-RAY ORIGIN STUDIES WITH THE TA AND TAx4 SURFACE DETECTOR

ICRR Inter-University Research Results Presentation Meeting
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Grigory I. Rubtsov (INR RAS, Moscow)

Project title: Ultra-high-energy cosmic-ray origin studies with the Telescope Array and TAx4 surface detector

Principal investigator:

Grigory I. Rubtsov, Institute for Nuclear Research of RAS

Project Number: 2024i-F-001
Project started in 2019 FY

Allocated Research Fund

Total (Travel Expenses): 200,000 JPY

Research purpose:

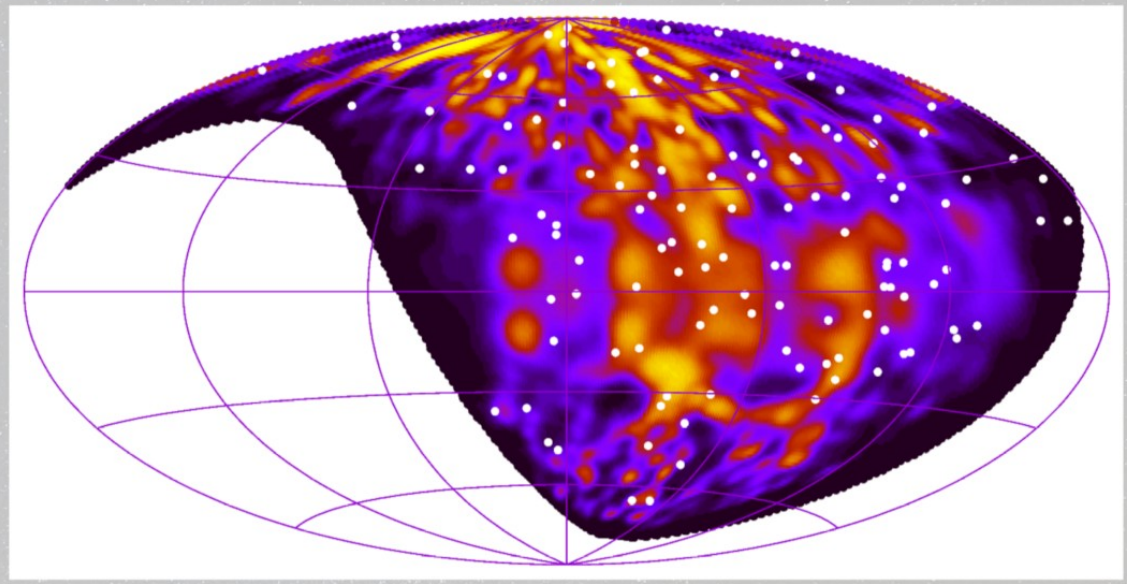
Search for anisotropy and sources, establish chemical composition of the ultra-high-energy cosmic rays

LIST OF PARTICIPANTS

Form 1: Annex (List of participants)

No.	Name	Affiliation	Department (required even if in the University of Tokyo)	Job Title (Leave this column blank for graduate students)
1	Grigory I. Rubtsov	INR RAS	Administration	deputy director
2	Oleg E. Kalashev	INR RAS	Theory department	leading researcher
3	Ivan V. Kharuk	INR RAS	Laboratory for big data analysis	researcher
4	Maxim S. Pshirkov	INR RAS	Department of Experimental physics	leading researcher
5	Sergey V. Troitsky	INR RAS	Theory department	principal researcher
6	Mikhail Yu. Kuznetsov	INR RAS	Laboratory for big data analysis	researcher
7	Igor I. Tkachev	INR RAS	Department of Experimental physics	head of the department
8	Konstantin A. Dolgikh	INR RAS	Laboratory for big data analysis	PhD student
9	Mariia Kudenko	INR RAS	Scientific and educational center	student, laboratory assistant
10	Shoichi Ogio	University of Tokyo	ICRR	Professor
11	Takashi Sako	University of Tokyo	ICRR	Associate professor
12	Hiroyuki Sagawa	University of Tokyo	ICRR	Professor Emeritus

Mass composition inference from arrival directions

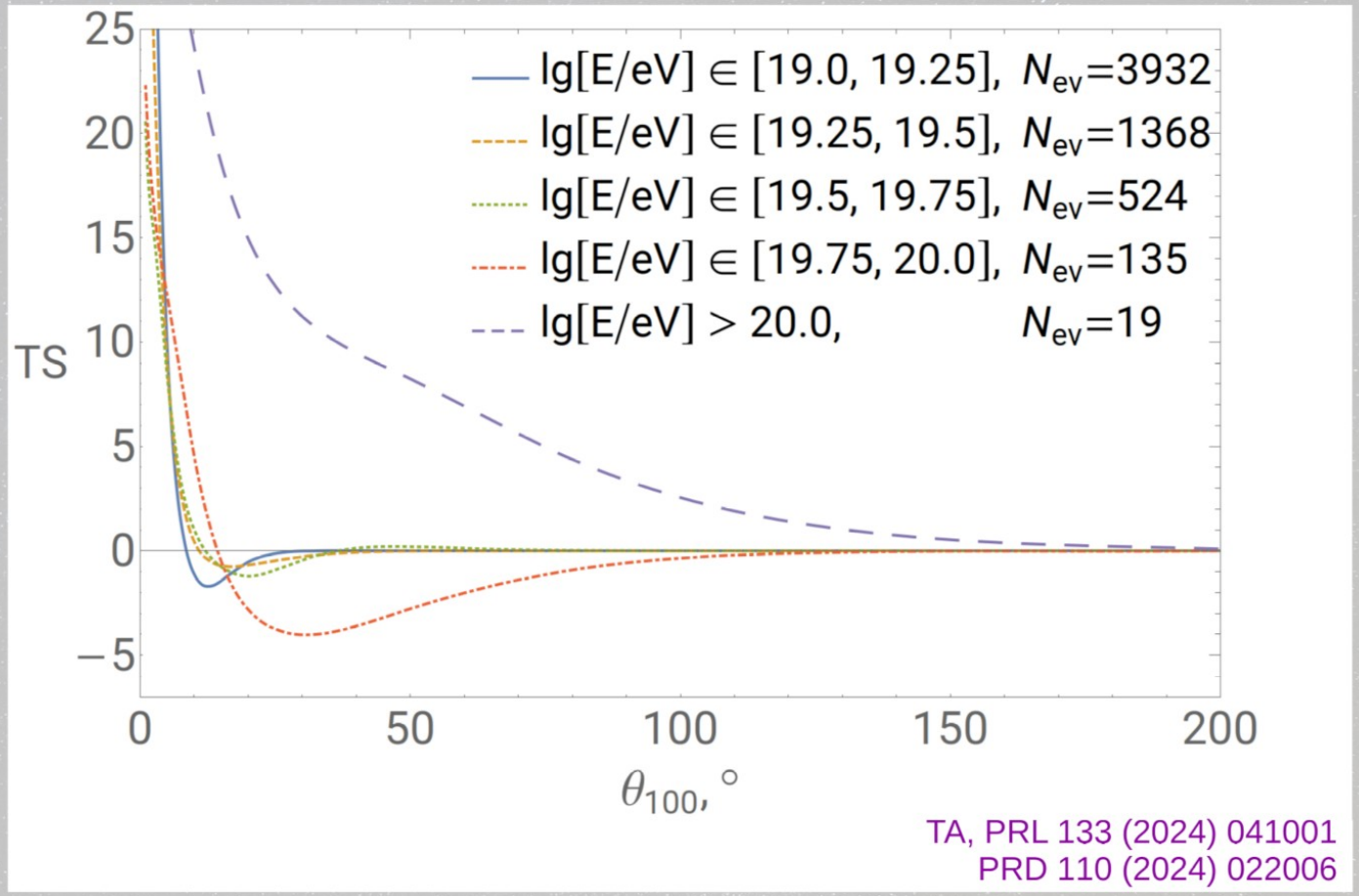


Three-step approach

JCAP 04 (2021) 065

1. **Introduce test statistics: a robust measure** of UHECR set deflection from LSS
2. **Simulate realistic UHECR mock sets** originating from LSS with various injected mass compositions
3. **Apply the test statistics** to both mock sets and data set and infer the mass composition from data

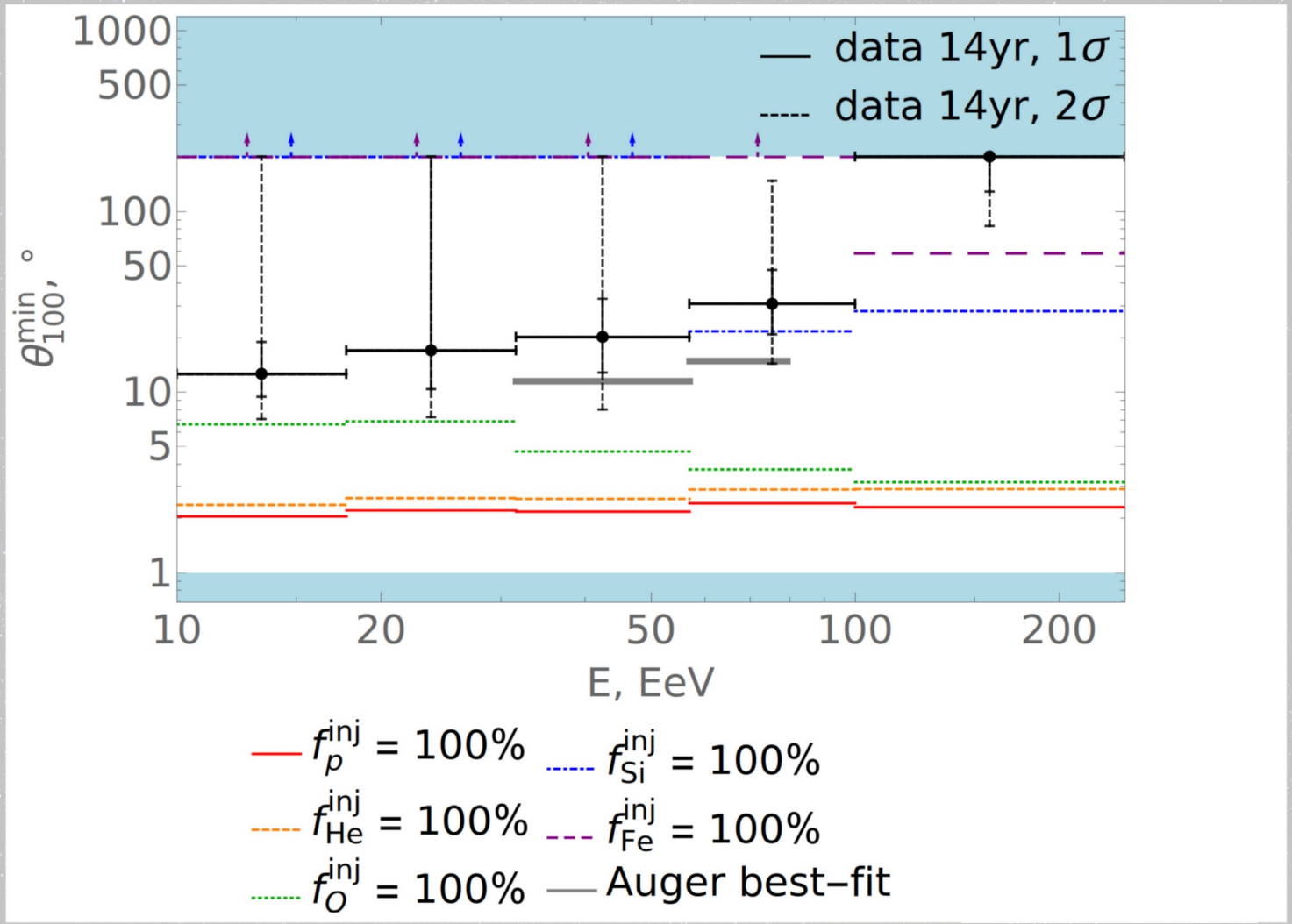
TS for TA SD data



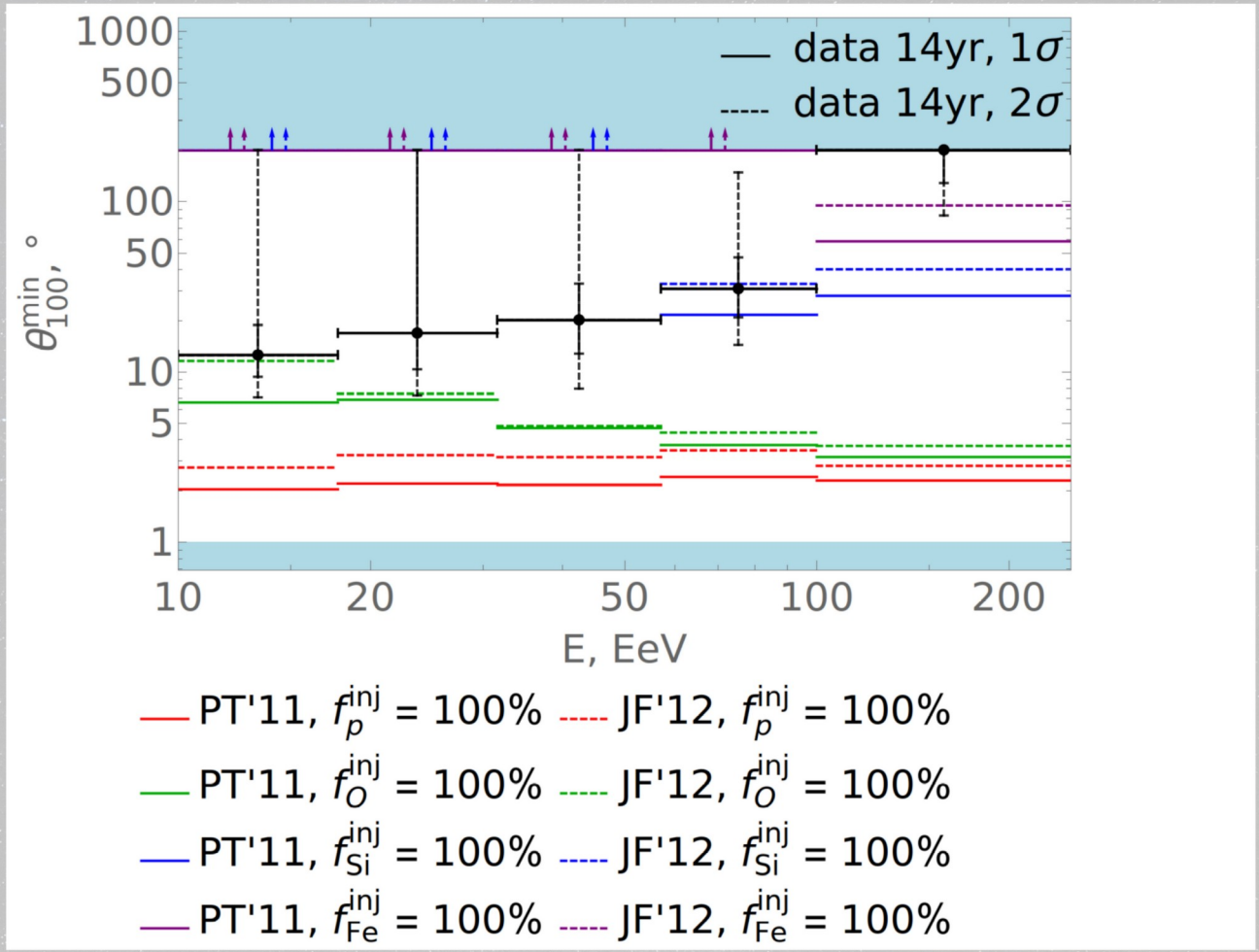
TA, PRL 133 (2024) 041001
PRD 110 (2024) 022006

The events with E > 100 EeV are uncorrelated with the LSS:
indication of a heavy mass composition

TS: injected pure elements vs the data

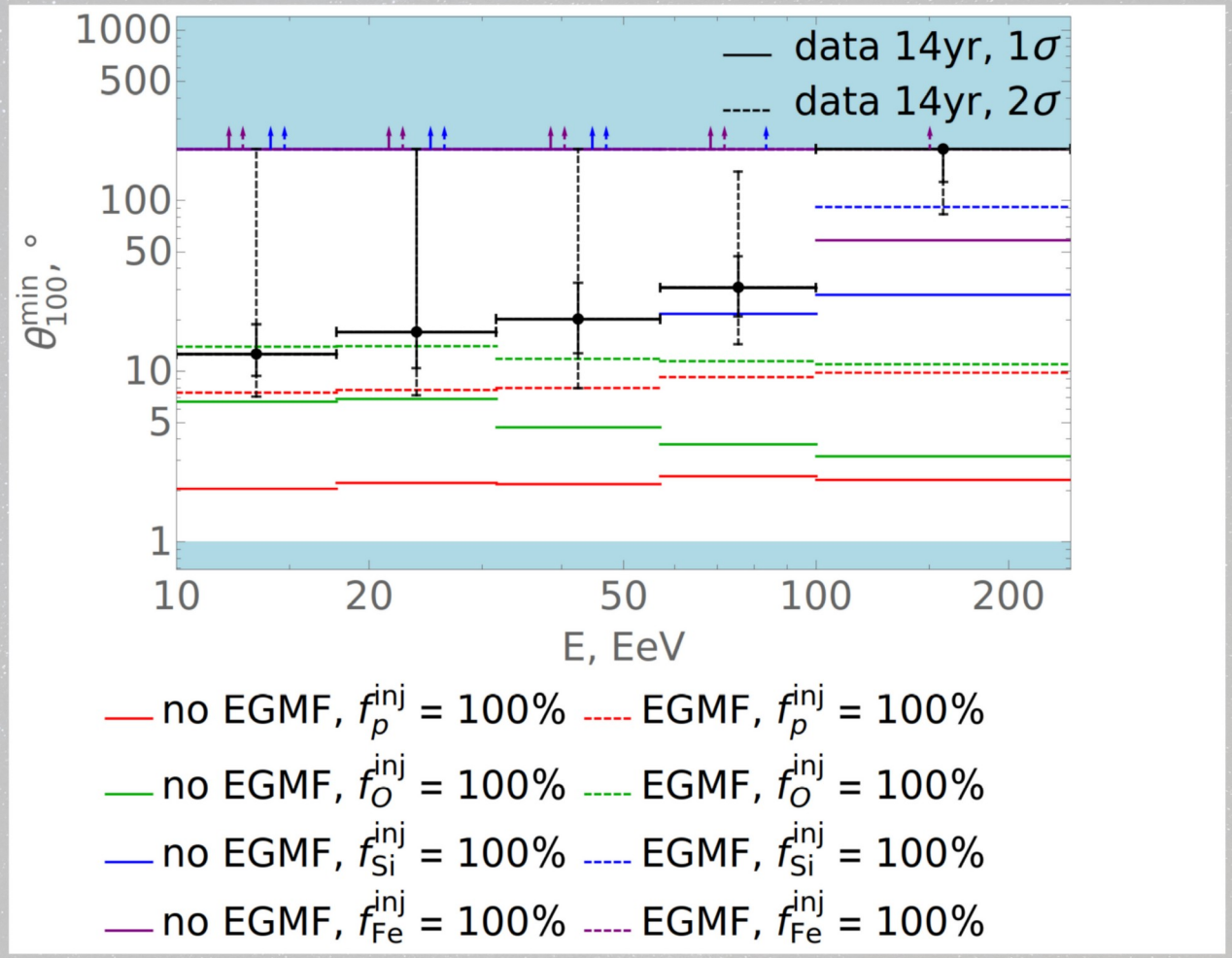


Results and GMF uncertainty



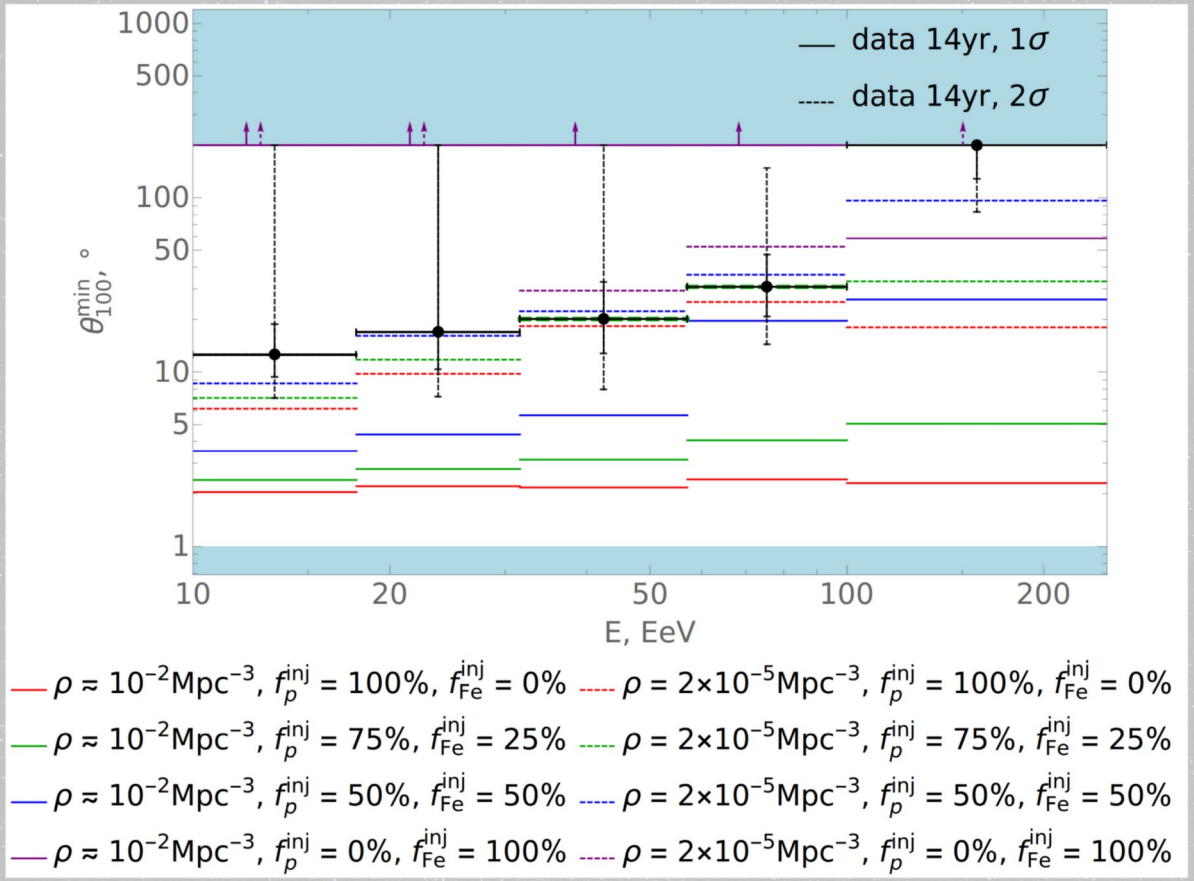
Results at all energies are robust to GMF model change

Results and EGMF uncertainty



Results at E > 100 EeV are robust to a prescence of a strong EGMF

Results and source number density uncertainty



Results at E > 100 EeV are robust to variation in source number density

The injected composition at E > 100 EeV is heavy

CONCLUSIONS

- The cosmic-ray composition at the highest energies (E>100 EeV) is heavy!
- The results are robust to GMF and IGMF models, to the source density.

RECENT PUBLICATIONS

- R.U. Abbasi et al. (Telescope Array Collaboration), Isotropy of Cosmic Rays beyond 1020 eV Favors Their Heavy Mass Composition, Phys.Rev.Lett. 133 (2024) 4, 041001
- R.U. Abbasi et al. (Telescope Array Collaboration), Mass composition of ultrahigh energy cosmic rays from distribution of their arrival directions with the Telescope Array, Phys.Rev.D 110 (2024) 2, 022006.
- G.Rubtsov et al. (Telescope Array collaboration), Search for ultra-high energy photons using the Telescope Array Surface Detector array, PoS UHECR2024 (2024) 024, to appear.

ありがとうございました。