Ultra-high energy event KM3-230213A as a cosmogenic neutrino

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Outline

1. Introduction & Motivation
2. Simulation pipeline
3. Results & Conclusion

Summary

Cosmogenic neutrino flux in UHECR flux models derived
from Telescope Array experiment is consistent with the KM3NeT
and “global neutrino observatory” measurements at ~2σ level

based on the JETP Lett. 123 (2026) 5, 287-297

KM3-230213A event & Tension

- KM3-230213A event
  - 13 February 2023
  - registered μ (~120 PeV)
  - rec ν energy ~ 220 PeV
- “Global neutrino observatory”
  2.6σ tension

Cosmogenic interpretation

- KM3-230213A possible origin
  - galactic
  - blazar
  - cosmogenic
  - ...

Cosmogenic origin ⟷ **UHECR mass composition**

produced by UHECRs during their
propagation through the intergalactic medium
via p-γ interactions with background photons

Mass composition dilemma

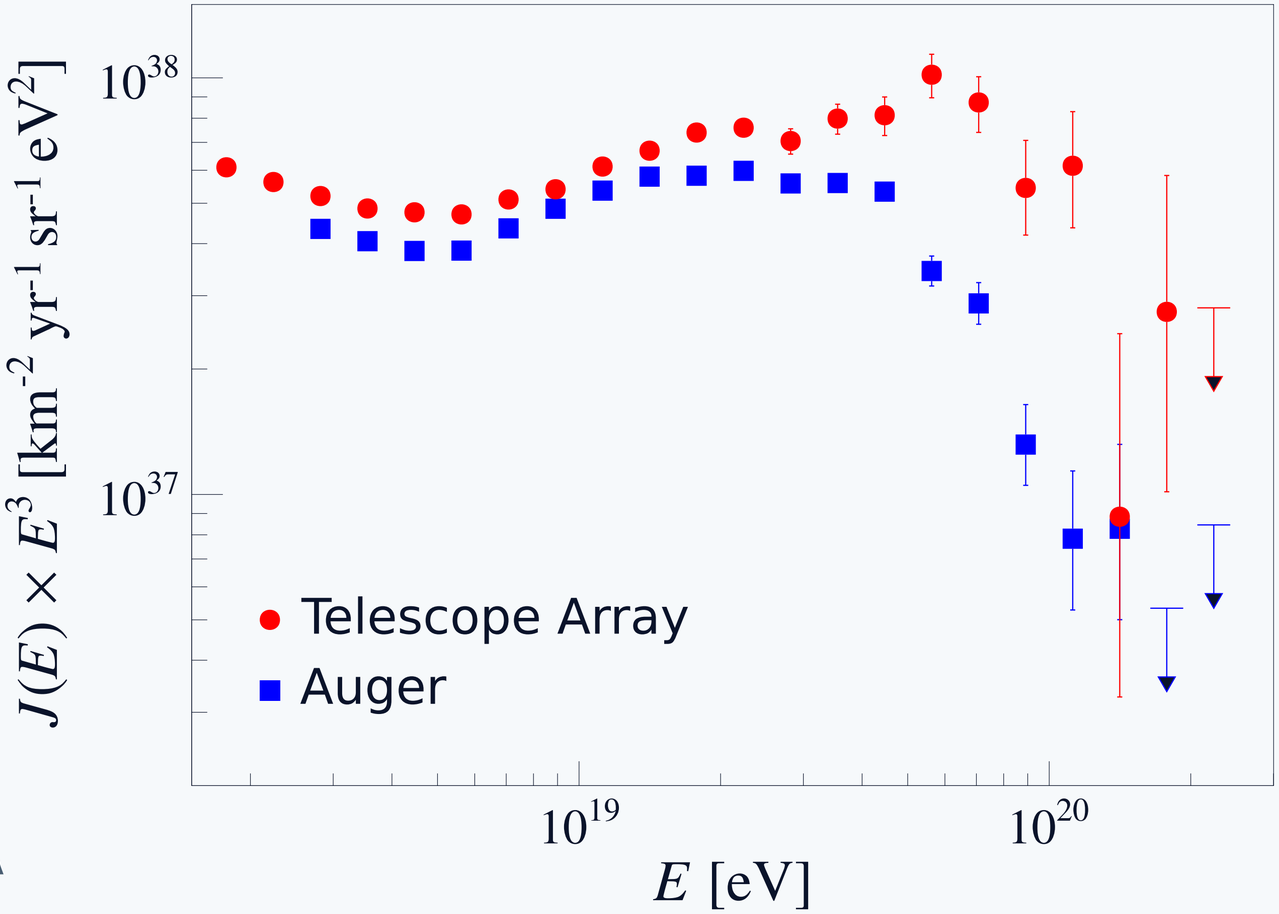
Auger vs Telescope Array

different CR spectrum

different composition

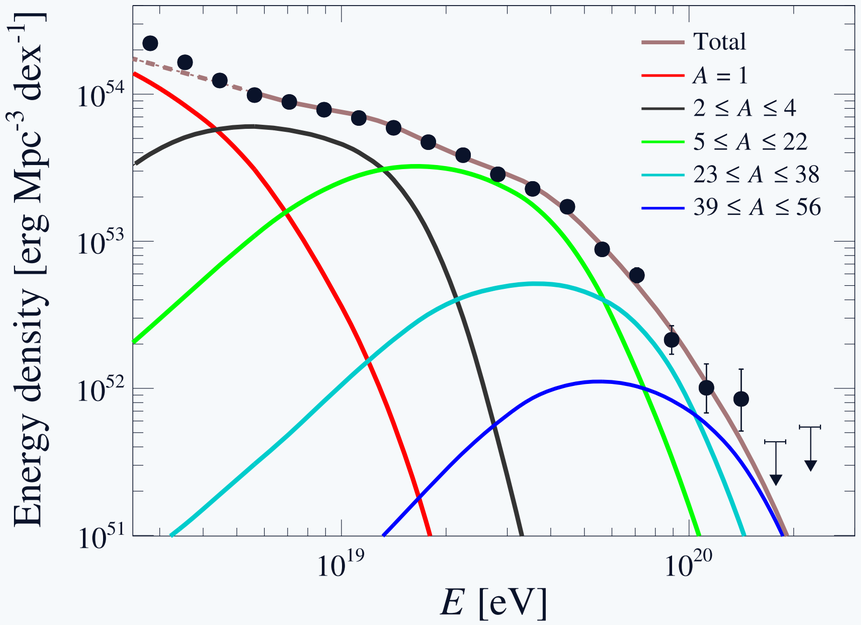
- intermediate nuclei, Auger
- light nuclei, TA

different conclusions about cosmogenic origin of KM3-230213A



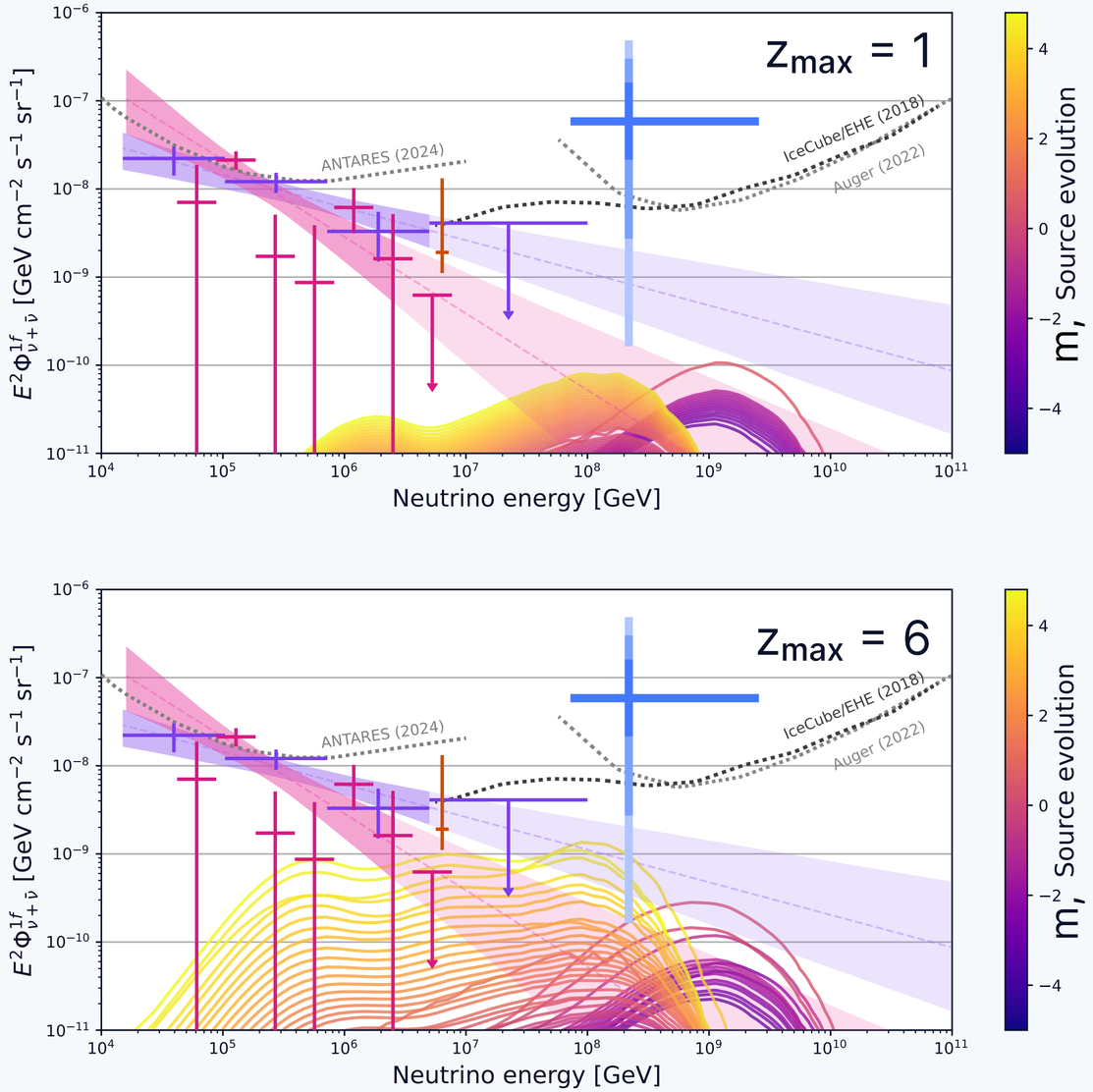
Comparison between the E^3-scaled spectrum (from Phys.Rev.D 102 (2020) 6, 062005)

Auger composition



Energy density obtained with the best fit parameters [1]

need extreme source evolution to achieve the reasonable compatibility



Expected neutrino fluxes as a function of energy for different source evolutions [2]

Source evolution $\mathrm{SE}(x) = (1+z)^m$

[1] Phys.Rev.Lett. 125 (2020) 12, 121106
[2] Astrophys.J.Lett. 984 (2025) 2, L41

TA composition

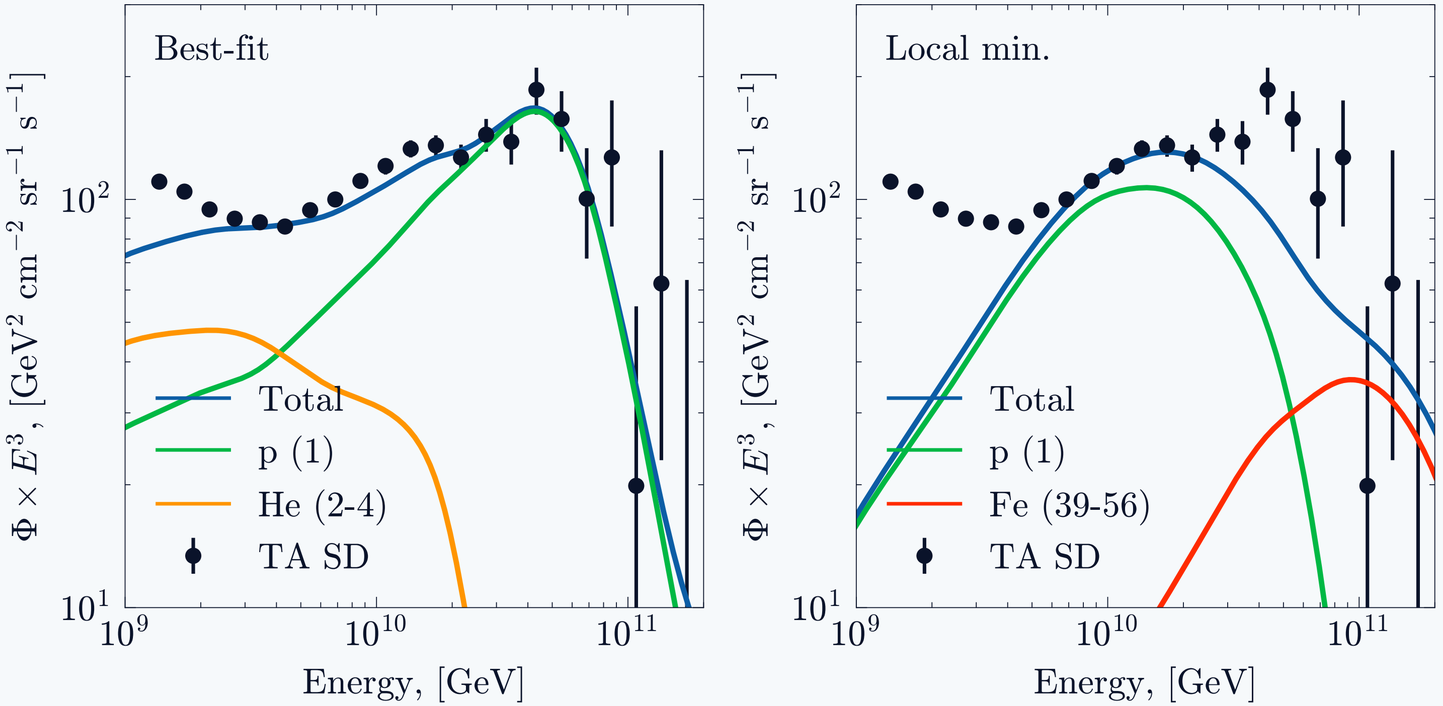
Two fits [1]:

- best
  (injected He 99%, Fe 1%)
- local min
  (injected p 97%, Fe 3%)

Source evolution [2]:

$$\mathrm{SE}(x) = \begin{cases} (1+z)^3 \text{ if } z < 1.5, \\ 2.5^3 \text{ else} \end{cases}$$

z_{max} = 4

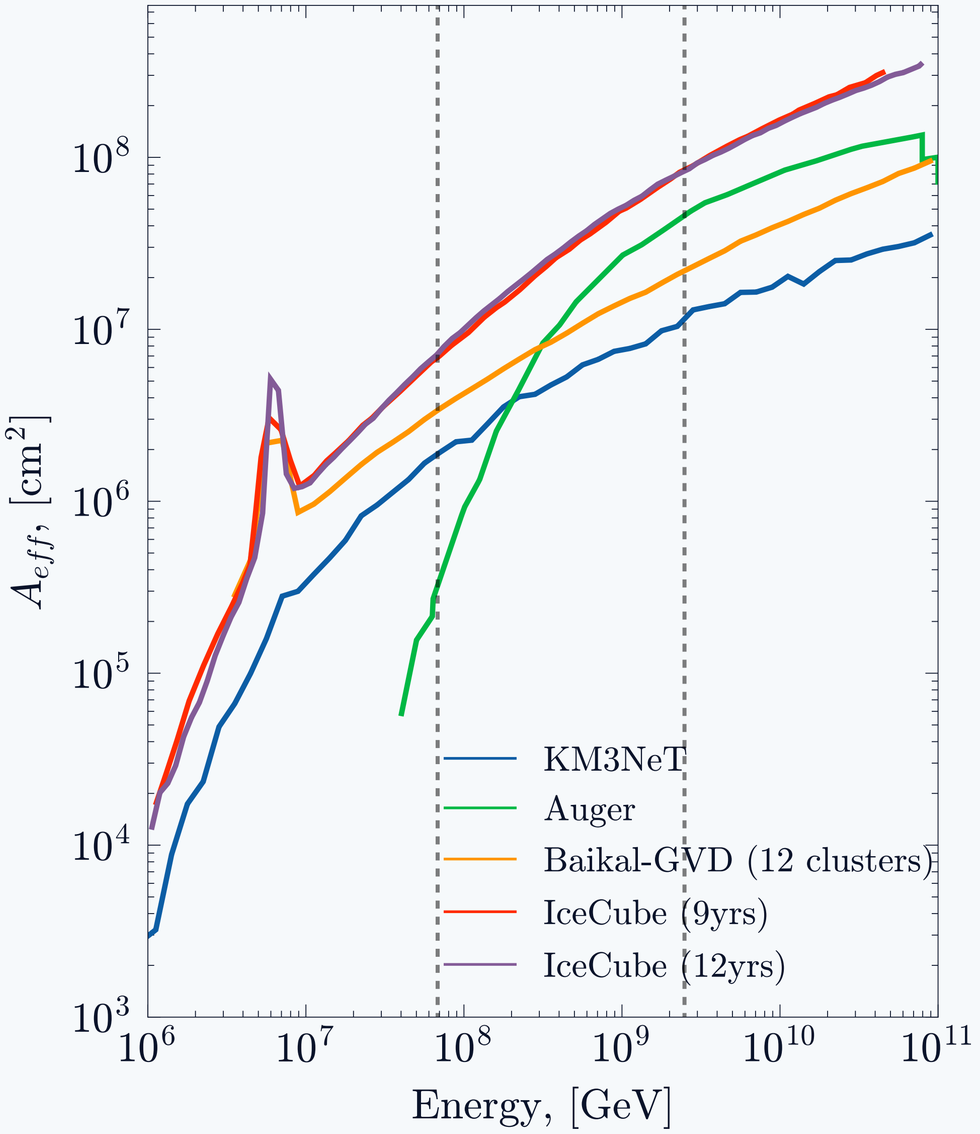


Simulated spectra of UHECR mass components according to the TA flux models (solid lines). Black dots are all-particle UHECR spectrum

[1] PoS ICRC2021 (2021) 338
[2] Phys.Rev.D 100 (2019) 2, 021302

Simulation pipeline

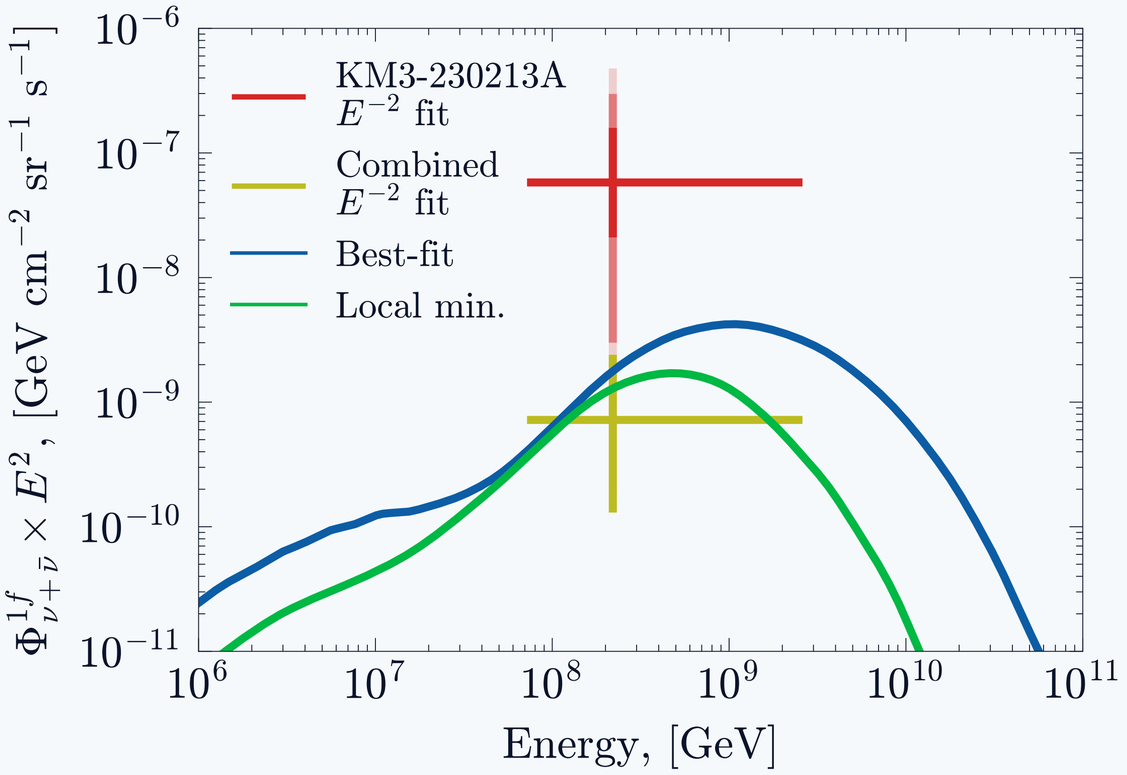
- Initialize the primary CR spectra relying on TA mass composition models
- Propagate injected spectra with CRPropa package
- Convolve the simulated neutrino flux with the exposures of the setups in a KM3-230213A 90% CL energy range
- Compare with data:
  KM3NeT – 1 event;
  Auger, Baikal-GVD, IceCube – 0 events



Effective areas of the experiments
Dotted vertical lines are
KM3-230213A 90% CL energy

Predicted neutrino flux

neutrino fluxes are consistent
with the KM3NeT-only
and “global neutrino observatory”
at ~2σ level



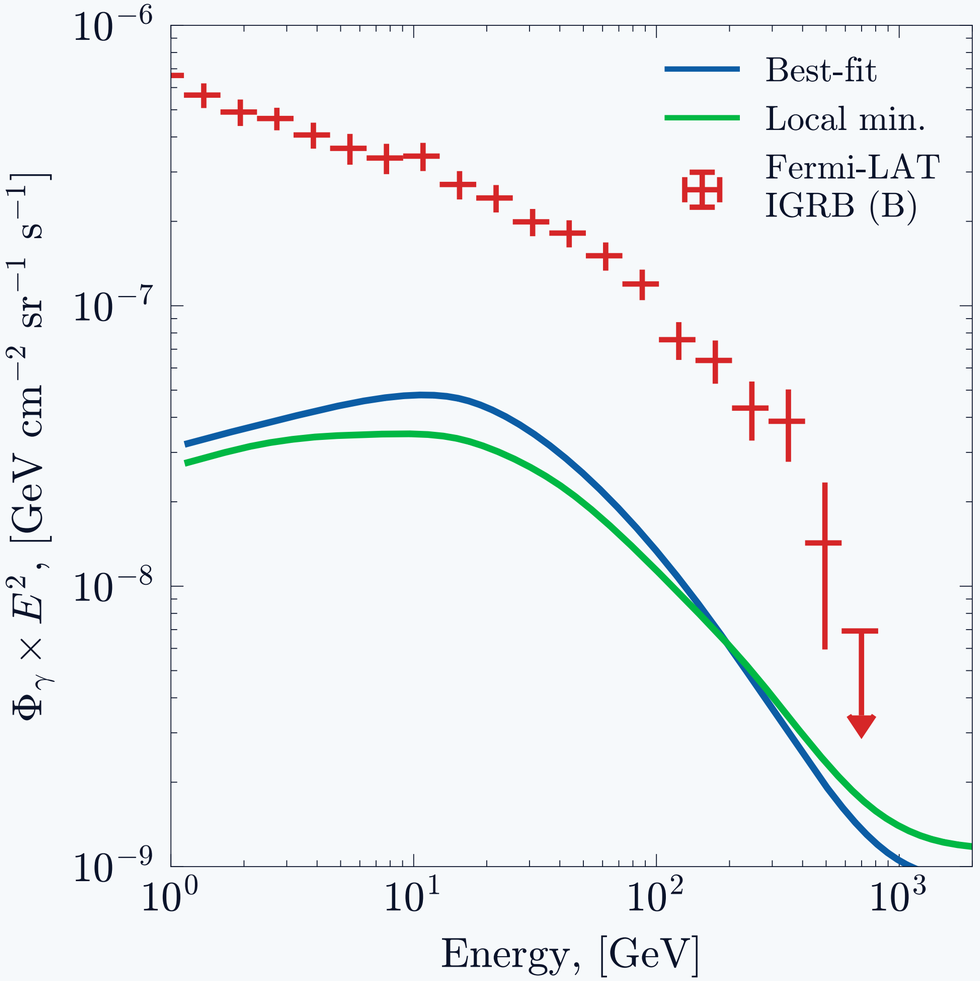
Per-flavour neutrino fluxes. Red and olive crosses denote KM3NeT-only[1] and combined (KM3NeT, Auger, IceCube, Baikal-GVD) E^{-2} fit[2]

[1] Nature 638 (2025) 8050, 376-382
[2] Phys.Rev.D 112 (2025) 8, 083025

Cascade gamma-rays

IGRB constraint is important for proton-dominated UHECR models

Both models do not contradict the Fermi-LAT IGRB measurements [1]

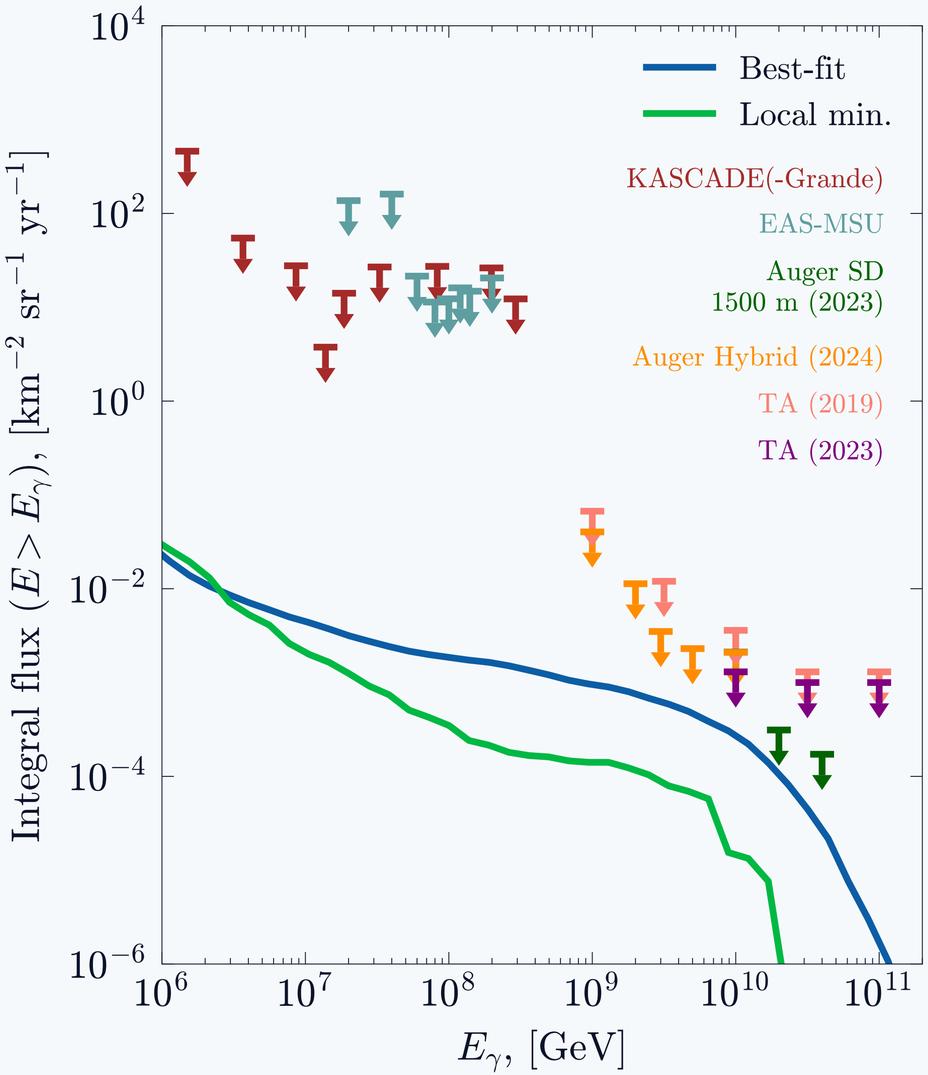


Energy spectrum of cascade photons

[1] Astrophys.J. 799 (2015) 86

UHE gamma-rays

Auger and TA could probe best-fit predictions if their gamma-ray search efficiency improved by ~5x



Upper limits on the integral UHE gamma ray flux

Conclusions

- TA minimal models have a reasonable compatibility (~2σ) with the neutrino data from the experiments without any tuning
  - despite Auger, which leads to the introducing extreme source evolution
- TA minimal models satisfy the gamma ray constraints

Thanks for your attention

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