

# The impact of photonuclear reaction models on propagation of ultrahigh energy cosmic rays

A diagram illustrating the propagation of ultrahigh energy cosmic rays. On the left, a bright, glowing source emits a beam of light. This beam passes through a region with a dashed orange circle and a complex, tangled structure, representing a photonuclear interaction. The beam then passes through a series of four purple spheres, each with a blue glow, representing intermediate stages of particle production or interaction. Finally, the beam reaches the Earth on the right, where it is depicted as a shower of white particles hitting the surface.

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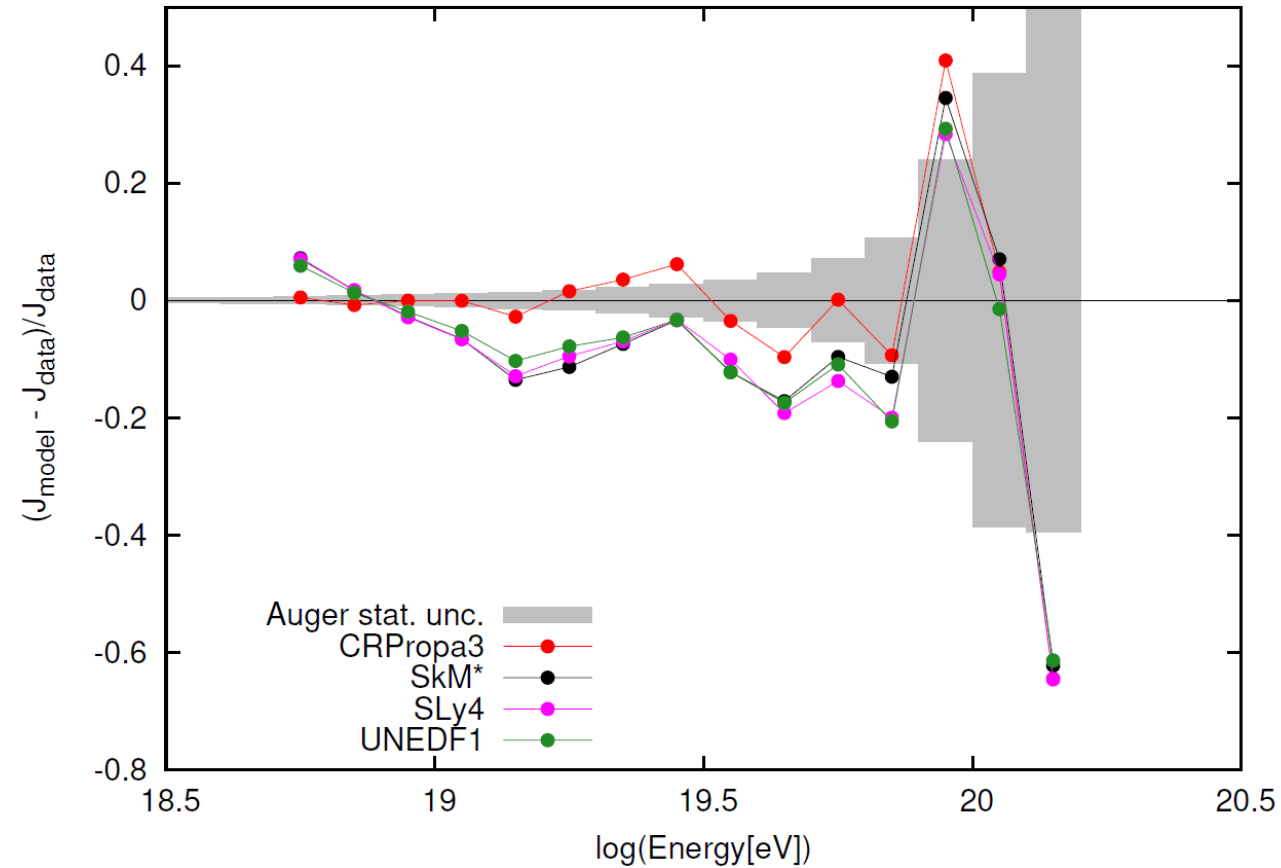
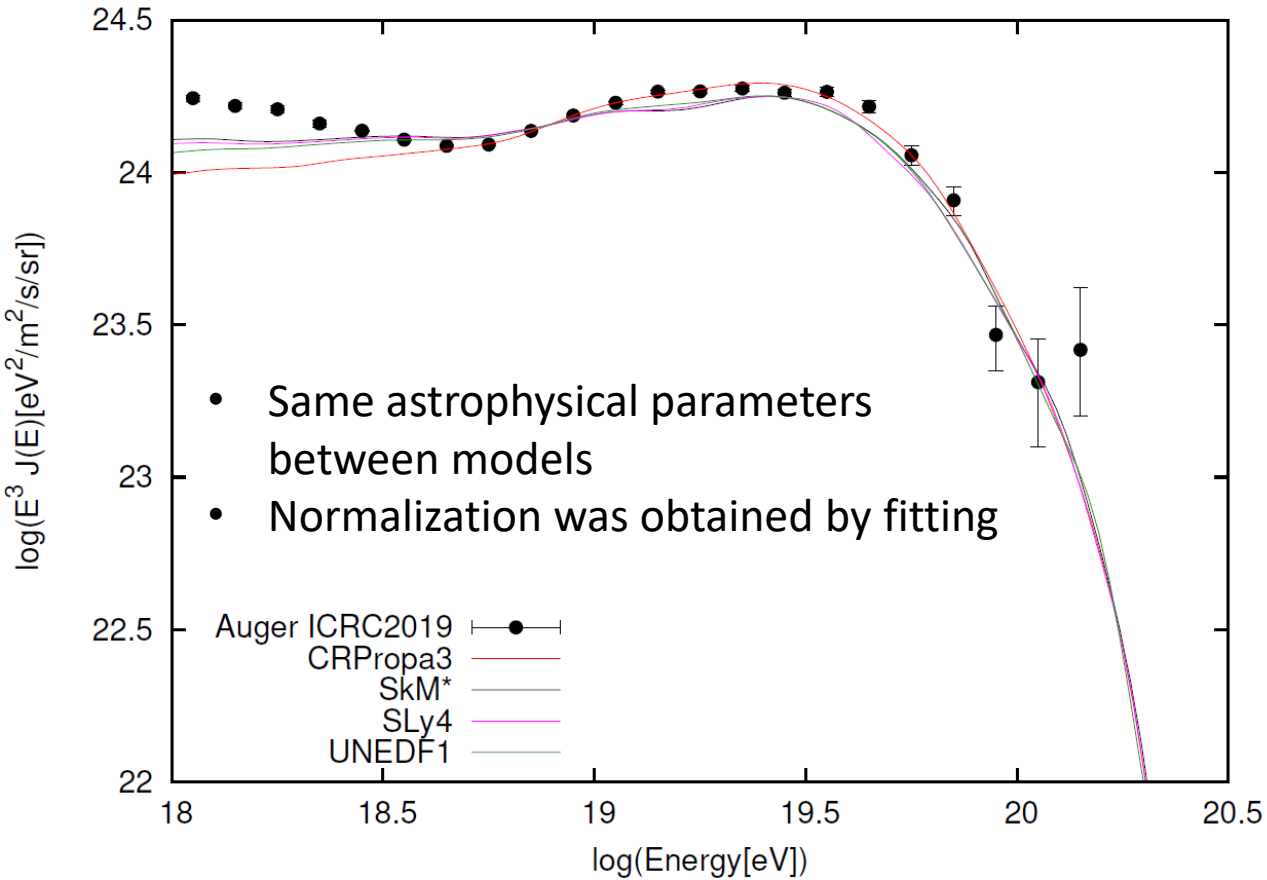
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# Comparison of Photonuclear Reaction Models

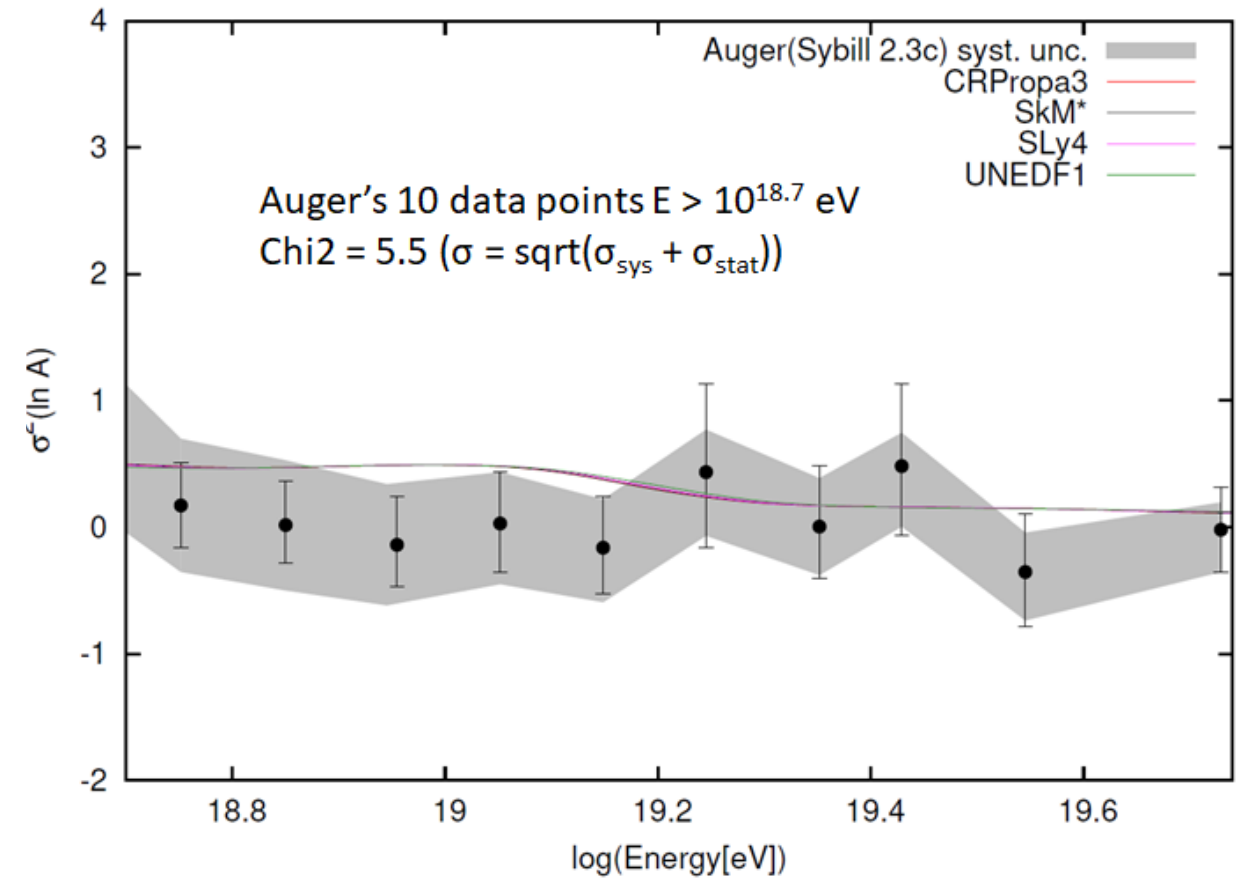
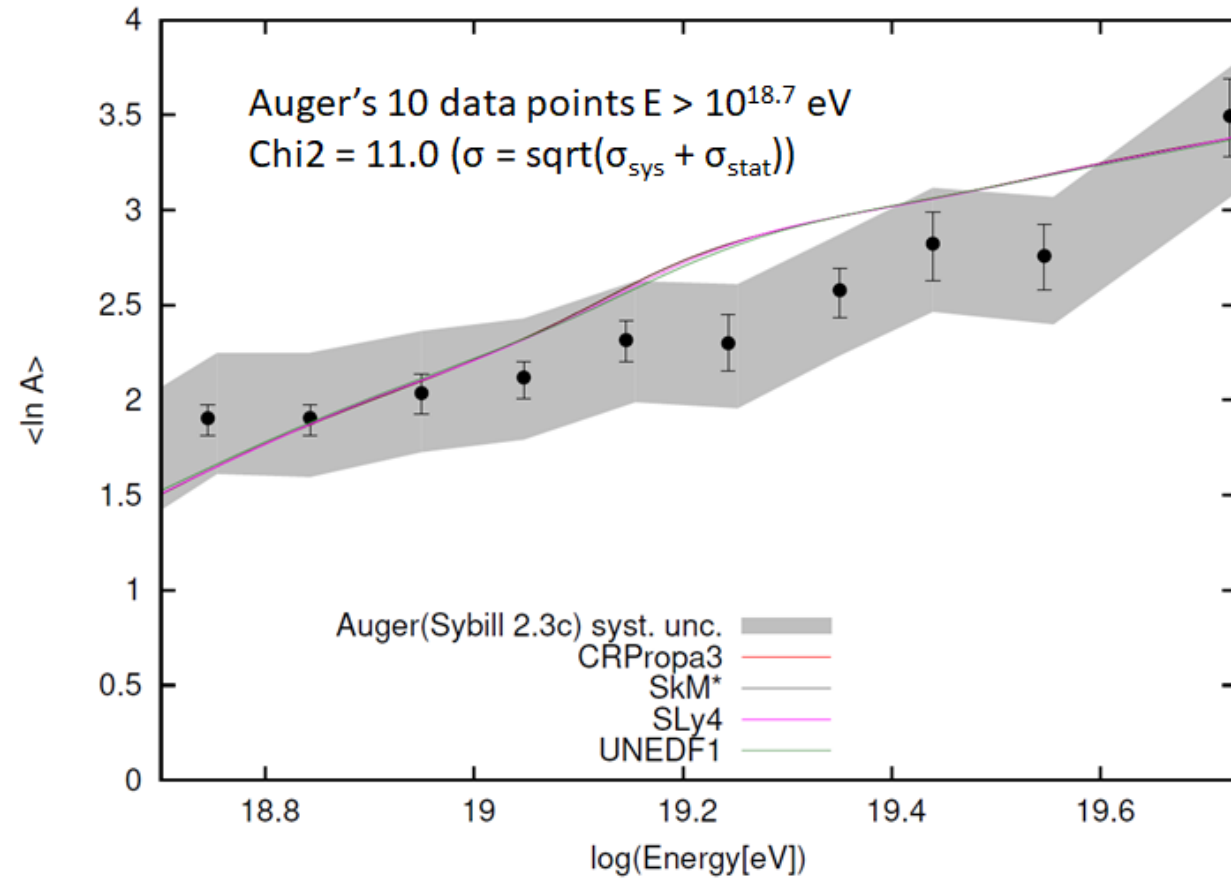
in Simulations of Propagation of Ultrahigh Energy Cosmic Ray Nuclei using CRPropa

- T. Inakura *et al.*, *Phys. Rev. C* **80**, 044301 (2009)  
and T. Inakura *et al.*, *Phys. Rev. C* **84**, 021302(R) (2011).
  - **The random phase approximation (RPA) calculations in Density Functional Theory (DFT)**
  - 3 interaction models
    - **SkM\*** : J. Bartel *et al.*, *Nucl. Phys. A* 386, 79 (1982).
    - **SLy4** : E. Chanbanat, P. Bonche, P. Haensel, J. Mayer, and R. Schaeffer, *Nucl. Phys. A* 627, 710 (1997).
    - **UNEDF1** : M. Kortelainen *et al.*, *Phys. Rev. C* 85, 024304 (2012).
- TALYS [https://tendl.web.psi.ch/tendl\\_2019/talys.html](https://tendl.web.psi.ch/tendl_2019/talys.html)
  - Included in CRPropa
  - Statistical Hauser-Feshbach theory etc.

# Spectrum Fit (Auger ICRC2019)



# $\langle \ln A \rangle$ , $\sigma^2(\ln A)$ (Auger ICRC2019)



# Summary

- We implemented the **random phase approximation (RPA) calculations** in **density functional theory (DFT)** (T. Inakura *et al.* ) in CRPropa and simulated propagation of ultrahigh energy cosmic ray nuclei.
- We found that the difference between the RPA calculations and the default settings of CRPropa in the spectral shape is much larger than the statistical uncertainty of the experimental data when the same astrophysical parameters are assumed. The model predictions of photonuclear reactions will be experimentally tested by the **PANDORA** project in the near future.