The impact of nuclear physics on the UHECR and neutrino production

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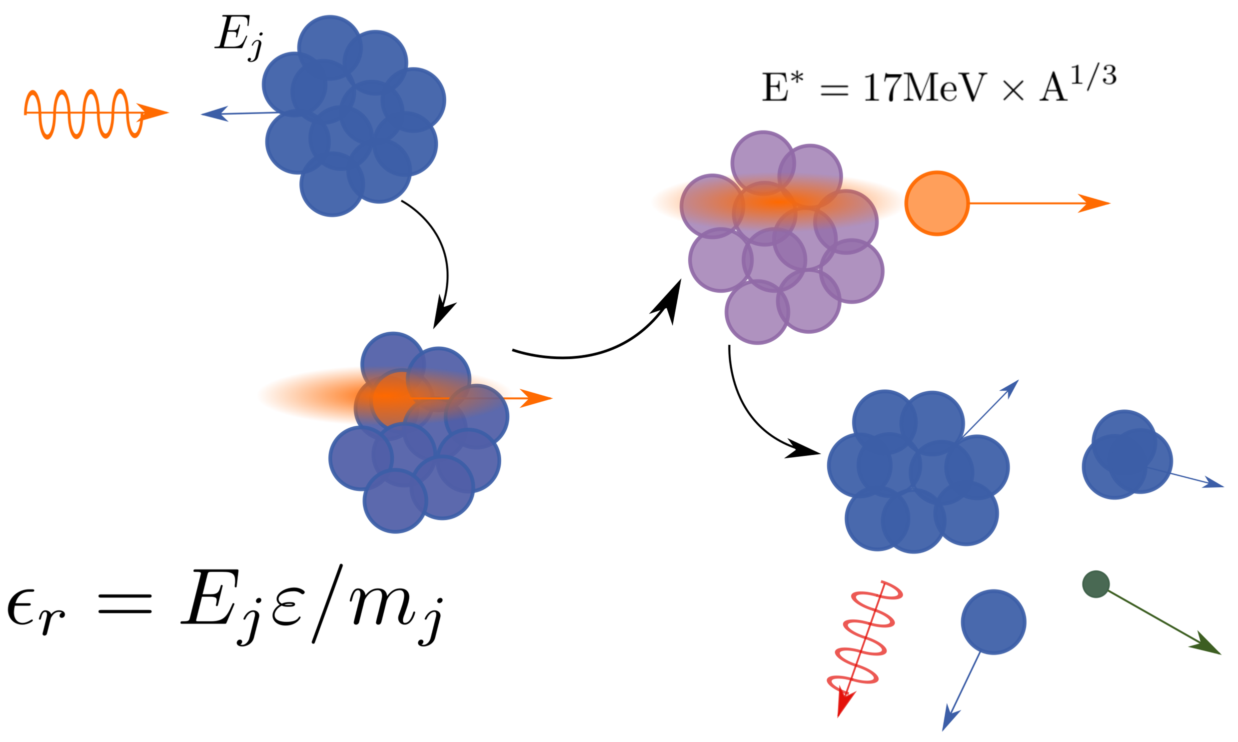
Context

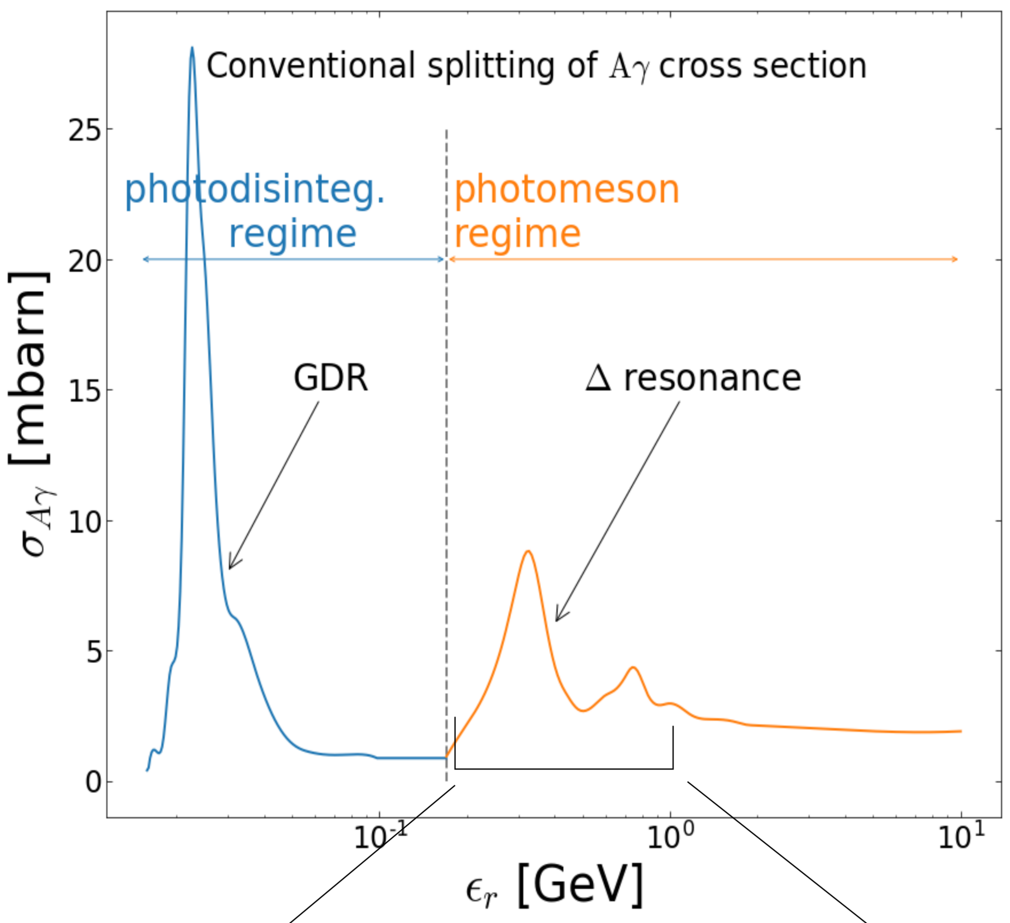
- Strongly accelerated nuclei (E_j above 10^9 GeV)
- Dense photon fields (ε range μeV - keV)
- Nucleus photon interactions (ϵ_r range MeV - GeV)

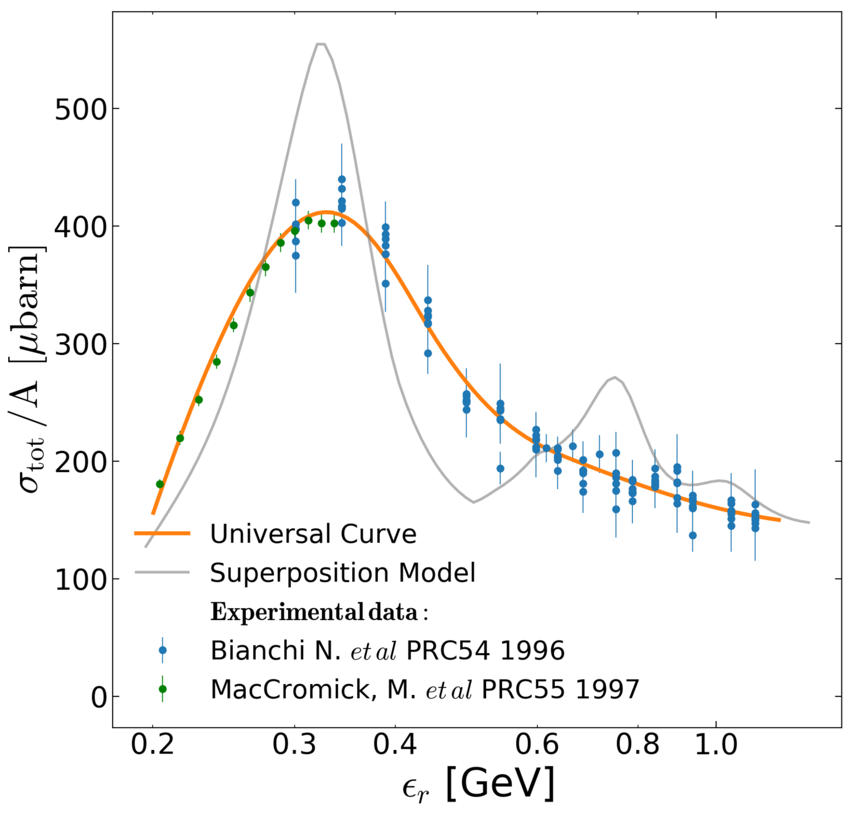
Particle Astrophysics interest:

- Nuclear disintegration (cascades composition)
- Neutrino emission (via pion production)



$$\epsilon_r = E_j \varepsilon / m_j$$

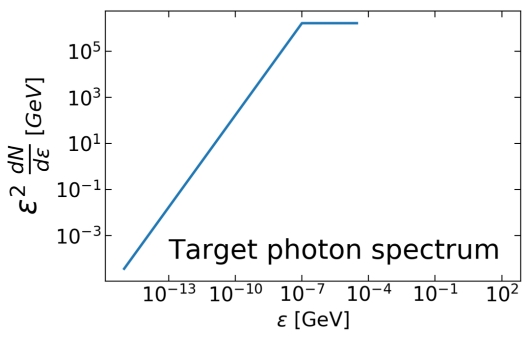




UHECR source

Candidates sources modelling (AGN[2], GRB[3], TDE[4])

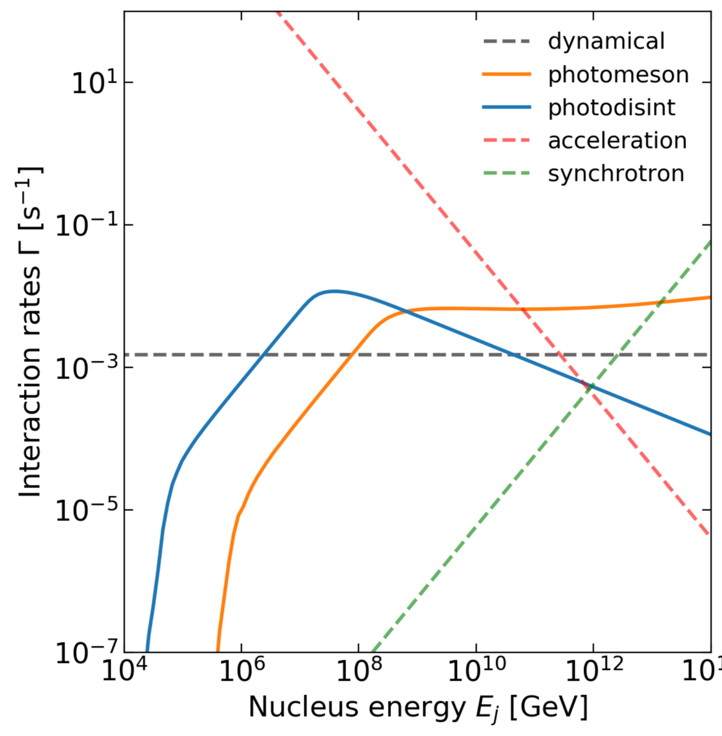
$$\frac{\partial N_j}{\partial t} = \frac{\partial}{\partial E}\left(E \frac{N_j(E)}{t_{loss}}\right) - \frac{N_j(E)}{t_{esc}} + \tilde{Q}_{jk}$$

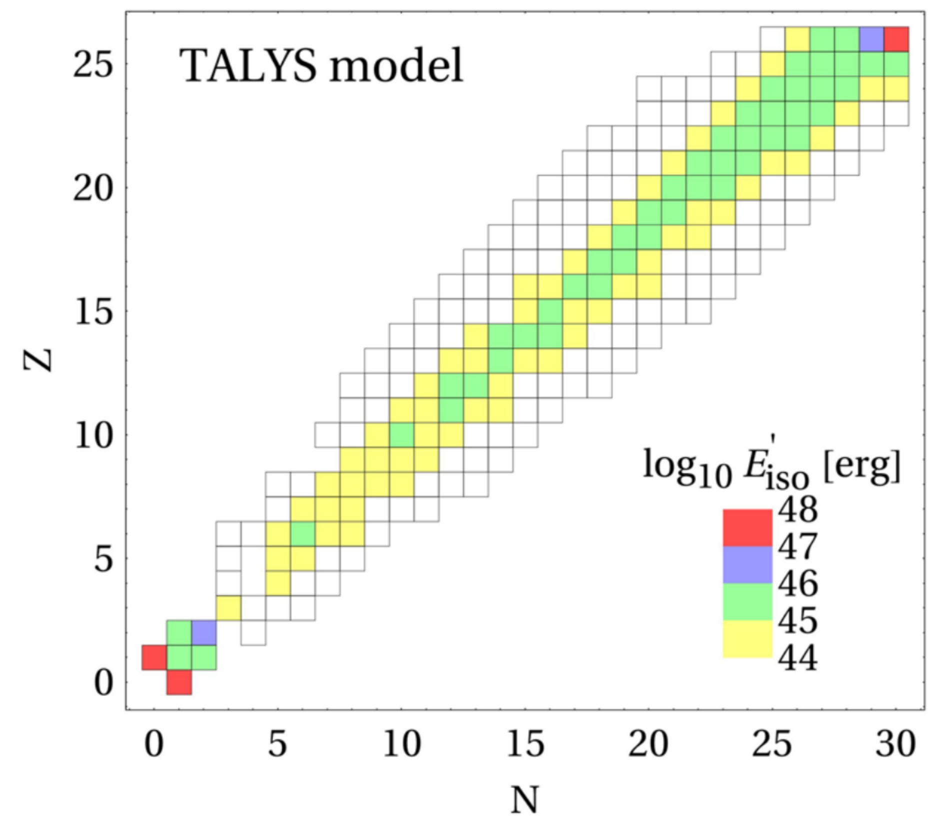


$$\tilde{Q}_{jk} = \int dE_j N_j(E_j) \Gamma_j(E_j) \frac{dn_{j\to k}}{dE_k}(E_j, E_k)$$

$$f_j(y) = \frac{1}{2y^2} \int_0^{2y} d\epsilon_r \epsilon_r \sigma_j(\epsilon_r)$$

$$\Gamma_j(E_j) = \int d\varepsilon n_\gamma(\varepsilon) f_j(E_j \varepsilon / m_j)$$





Photon - Nucleus interaction

- Photodisintegration regime
  - Experimental data insufficient [1]
  - Avaliable models differ [1]
  - Photodisintegration tables from MC codes
- Photomeson regime
  - Mixed Superpositon Model (here **MSM** baseline)
  - Nuclear cross section $\sigma_A = Z\sigma_p + N\sigma_n$
  - Only nucleon and A - 1 interaction products
  - Product multiplicity 1

Residual Decay Model (RDM)

Introduces new products

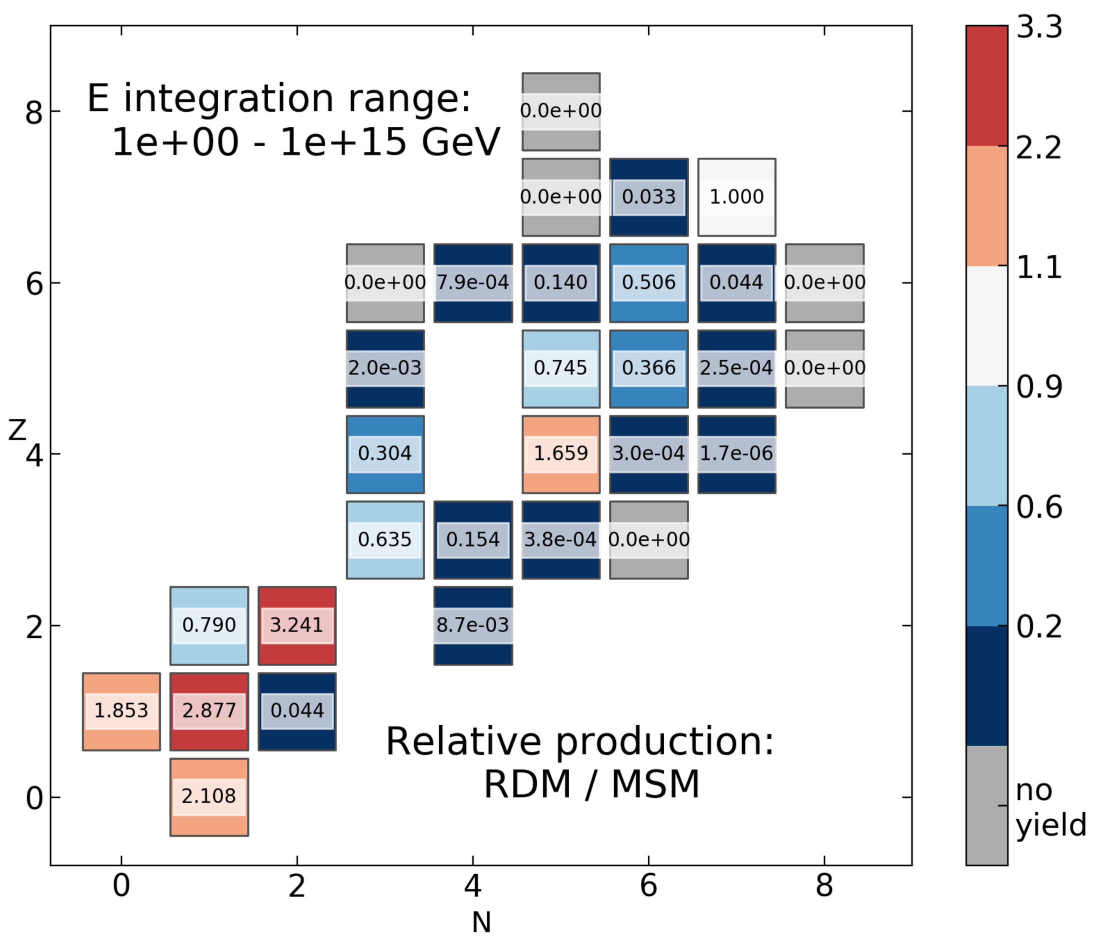
Multiplicities from photodis. model

$$M_X = \left(\frac{\sigma^{incl}_{A\to X}}{\sigma_A}\right)_{E^*_{photodis.}}$$

Residual excitation Ablation - Abrasion

$$E^* = 17\text{MeV} \times A^{1/3}$$

Impact on TDE scenario



IMPROVING PHOTOMESON MODEL

Standard superposition model (MSM) problems:

- Ignores nuclear medium effects
- Mass scaling constant in energy $\sigma_A \propto A$
- Ignores residual decay

Additional elements introduced to improve on MSM model

Outlook

- Assess impact on the production of UHECR in other scenarios, and in the extragalactic propagation.
- Produce baseline models for UHECR propagation (CRPropa, etc.)

References

[1] D. Boncioli *et al.* Scientific Reports Vol. 7, Art. Num. 4882 (2017)
[2] X. Rodrigues et al 2018 ApJ 854 54
[3] D. Biehl *et al.* A&A Vol. 611, Art. Num. A101, 2018
[4] D. Biehl *et al.* arXiv:1711.03555v1

Glauber Mass Scaling (GMS)

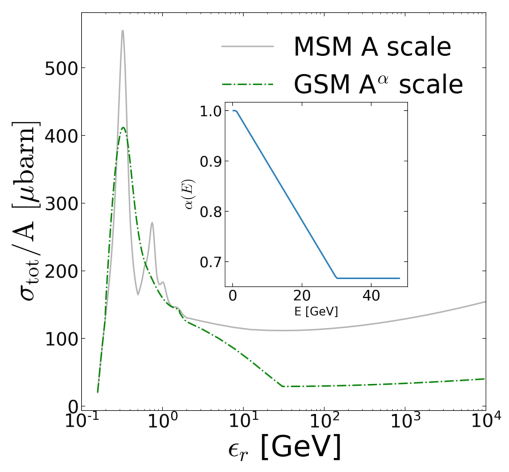
Above 1GeV mass scaling decreases

$A_{eff} = A^{.92}$ is found up to 20 GeV

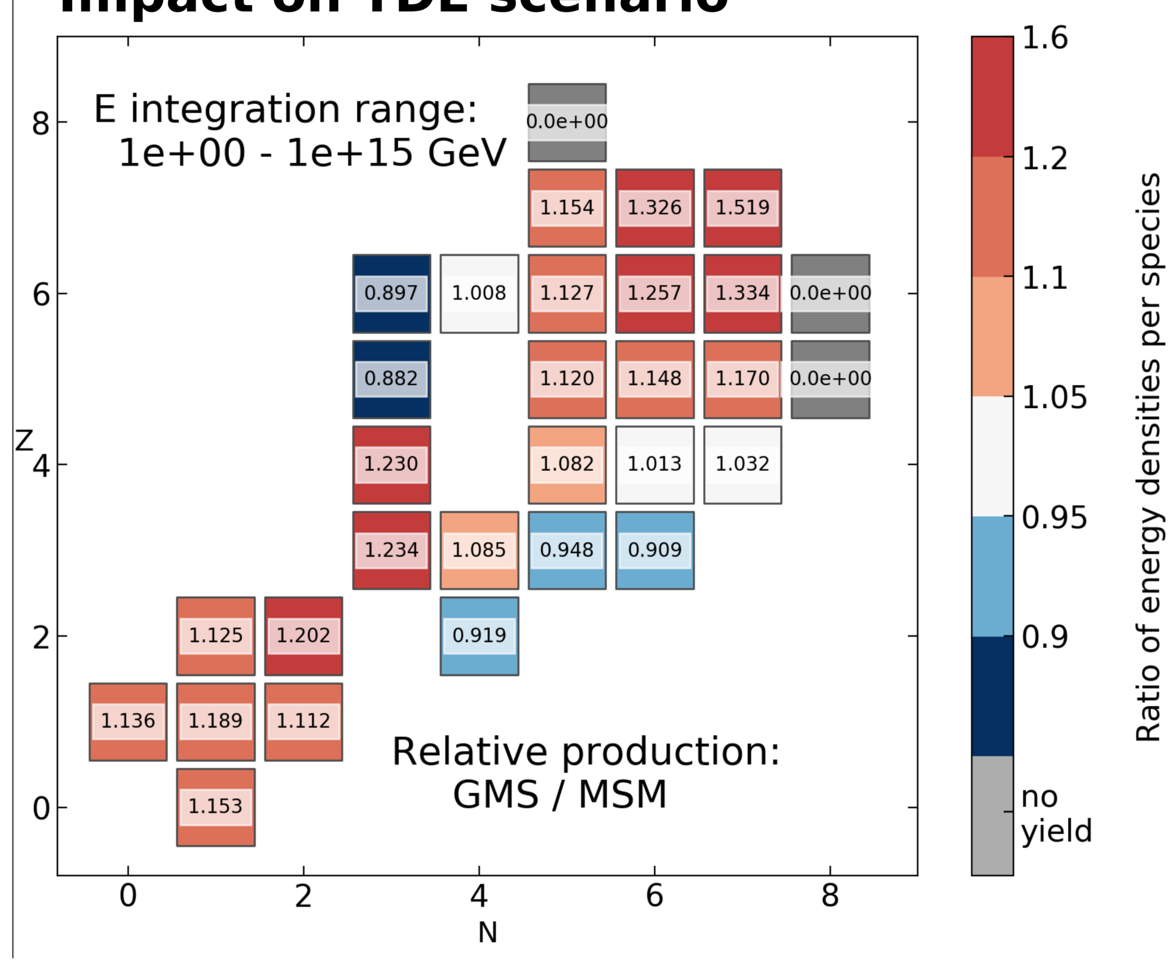
For higher energies theories differ

Glauber Scaling $A_{eff} = A^{2/3}$ has the lowest index and the highest impact on σ_A

In this model Glauber is applied above 30 GeV



Impact on TDE scenario



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