Influence of EBL and EGMF on the energy spectrum and mass composition of UHECR

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BERGISCHE UNIVERSITÄT WUPPERTAL

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Großgeräte der physikalischen Grundlagenforschung

1. Introduction
2. Influence of the EBL model
3. Influence of the EGMF model
4. Conclusions

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2 Influence of the EBL model

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4 Conclusions

Introduction

Reconstruct UHECR source properties (spectral index γ, cut-off rigidity R_{cut}, element fraction f_i) by a fit of a simple astrophysical model to the Pierre Auger Observatory data (energy spectrum and chemical composition) assuming different EBL and EGMF models.
Simple model:

- Source positions: Random, following Dolag LSS
- Minimal source distance: $10\,\mathrm{Mpc}$
- Source density: $\rho \approx 7 \cdot 10^{-5}\,\mathrm{Mpc}^{-3}$
- Chemical composition at source: $^{1}\mathrm{H}$, $^{4}\mathrm{He}$, $^{14}\mathrm{N}$, $^{56}\mathrm{Fe}$
- Energy spectrum at source: Broken power-law with rigidity-dependent exponential cut-off:

$$\frac{dN}{dE} = J_0 \sum_i f_i \begin{cases} E^{-\gamma} & \text{for} \quad E/Z_i < R_{\mathrm{cut}} \,, \\ E^{-\gamma} \exp\left(1 - \frac{E}{Z_i R_{\mathrm{cut}}}\right) & \text{for} \quad E/Z_i \geq R_{\mathrm{cut}} \end{cases}$$

Introduction

- EBL models: Domínguez (2011) and Gilmore (2012)
- EGMF models: Dolag (weak) and Benchmark[1] (strong)
- **4D** simulations with CRPropa 3
- Model $X_{\max}$ distribution based on Gumble distributions and EPOS LHC
- Evaluate likelihood for complete $X_{\max}$ distributions
- Markov Chain MC

[1] R. A. Batista et al., J. Cosmol. Astropart. Phys. **2016**, 025 (2016)

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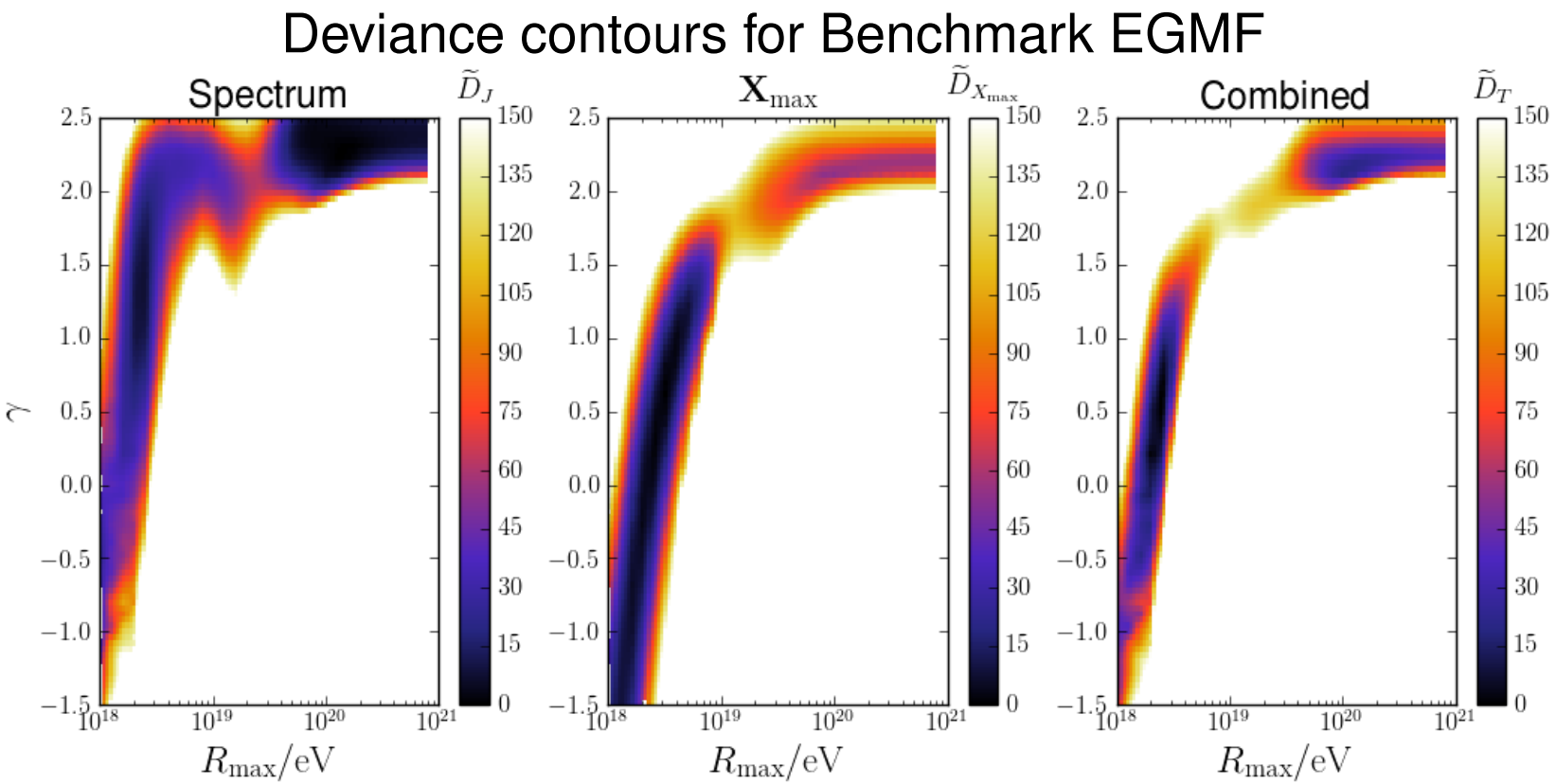
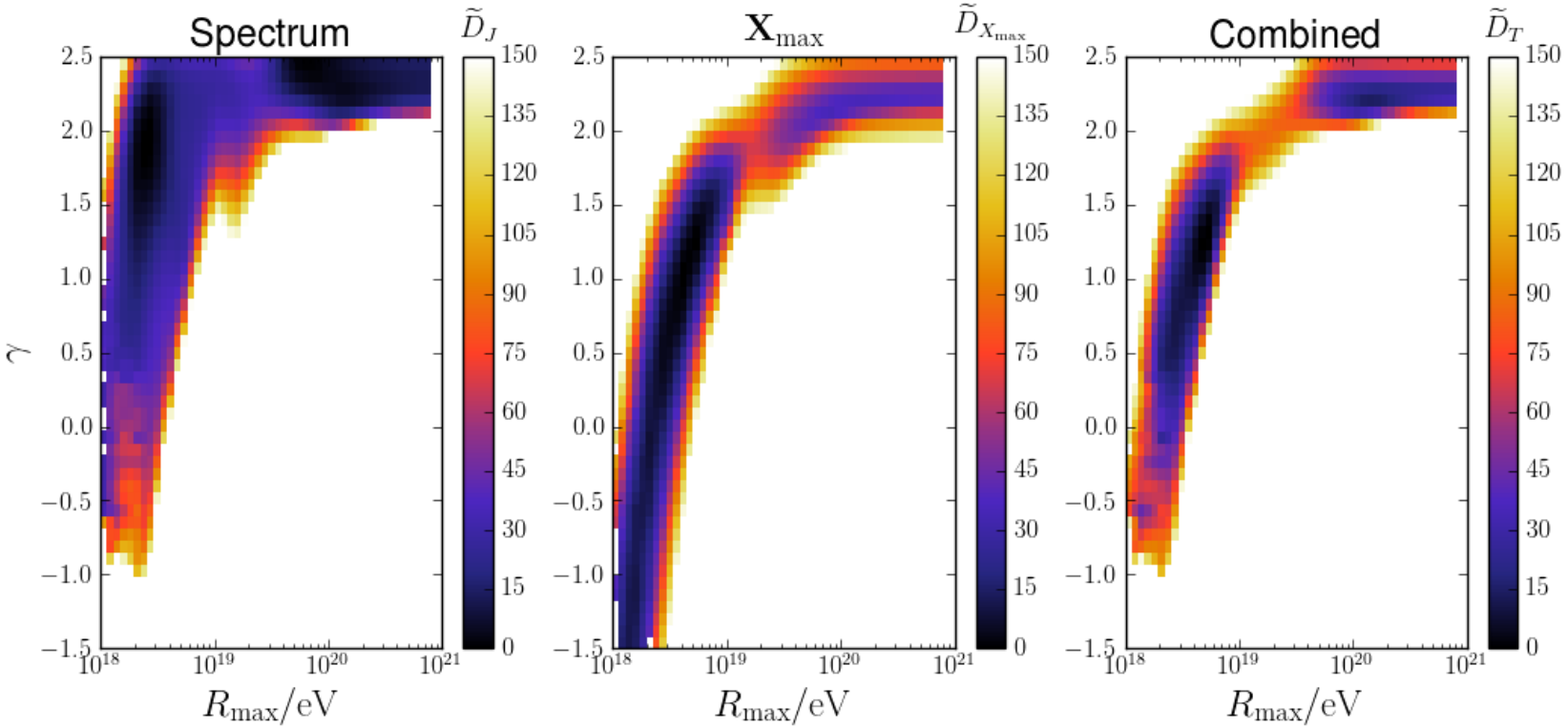
EBL: Domínguez (2011)



EBL: Gilmore (2012)

Deviance contours for Benchmark EGMF



Best-fit parameters (Benchmark EGMF)

Source parameters	Domínguez (2011)	Gilmore (2012)
γ	0.6	1.2
$\log_{10}(R_{\max}/\mathrm{eV})$	18.4	18.7
H	5.1 %	1.3 %
He	2.5 %	1.2 %
N	90.6 %	94.1 %
Fe	1.8 %	3.4 %
D_T/n_T	269.9/128	235.8/128

The higher the interaction rates, the lower the injection cut-off $R_{\max}$ and spectral index γ

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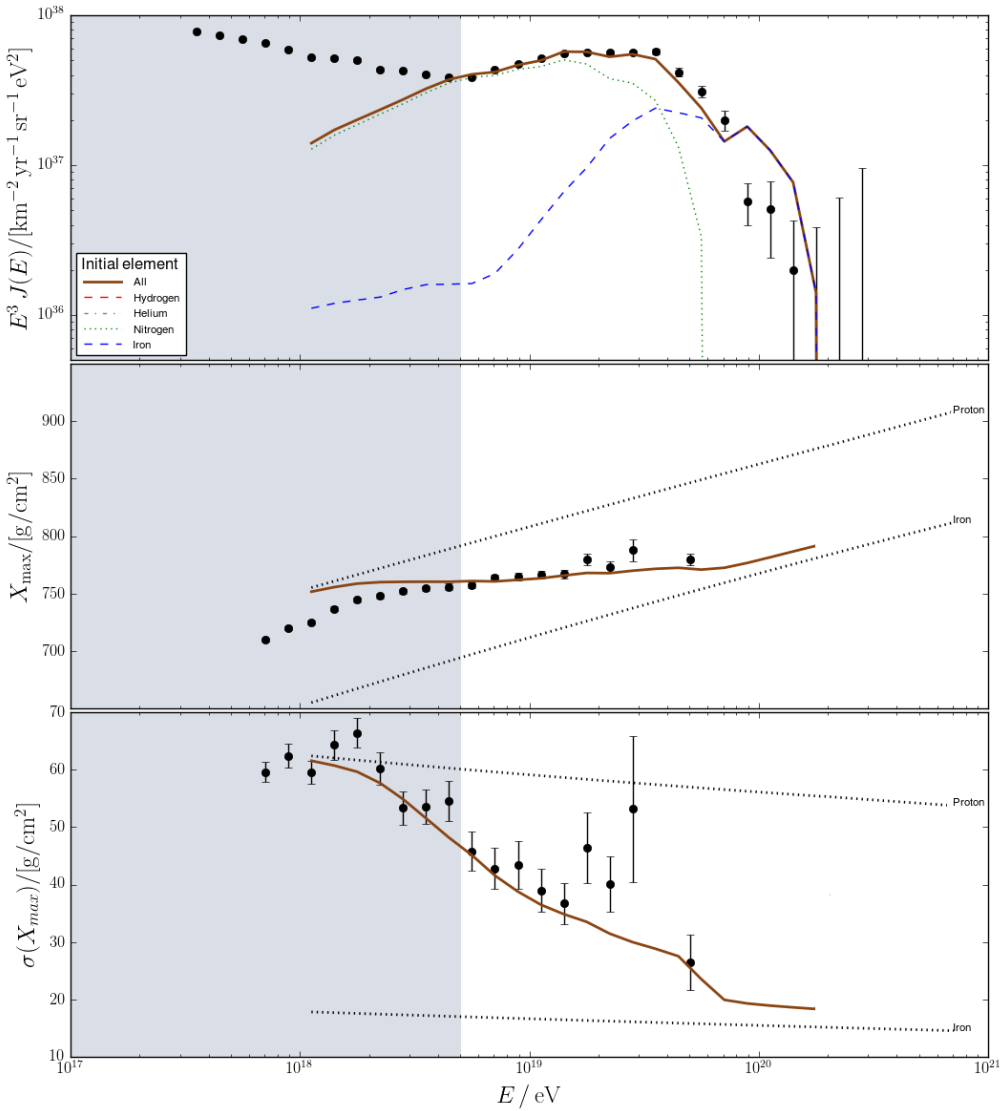

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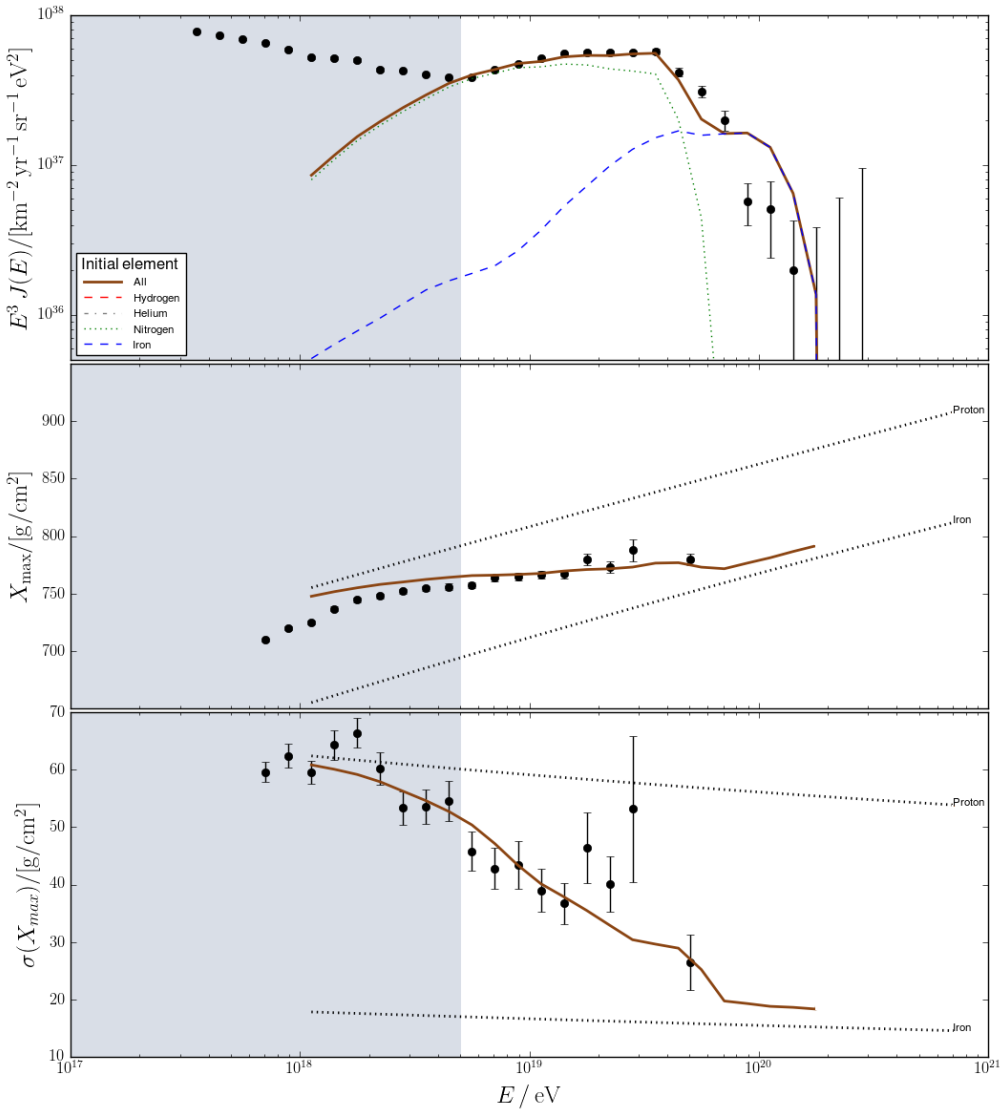

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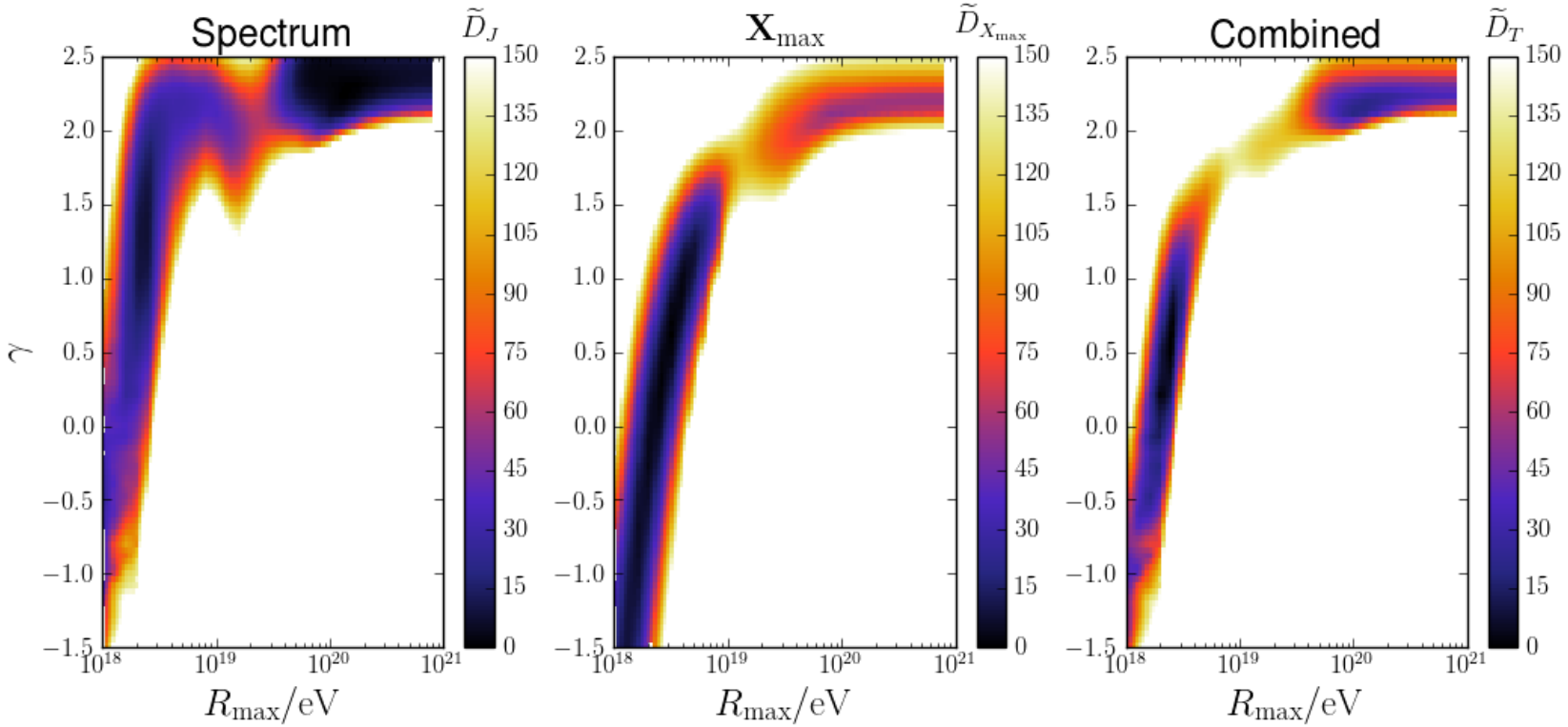
Benchmark EGMF

Deviance contours for Domínguez (2011) EBL



Dolag EGMF

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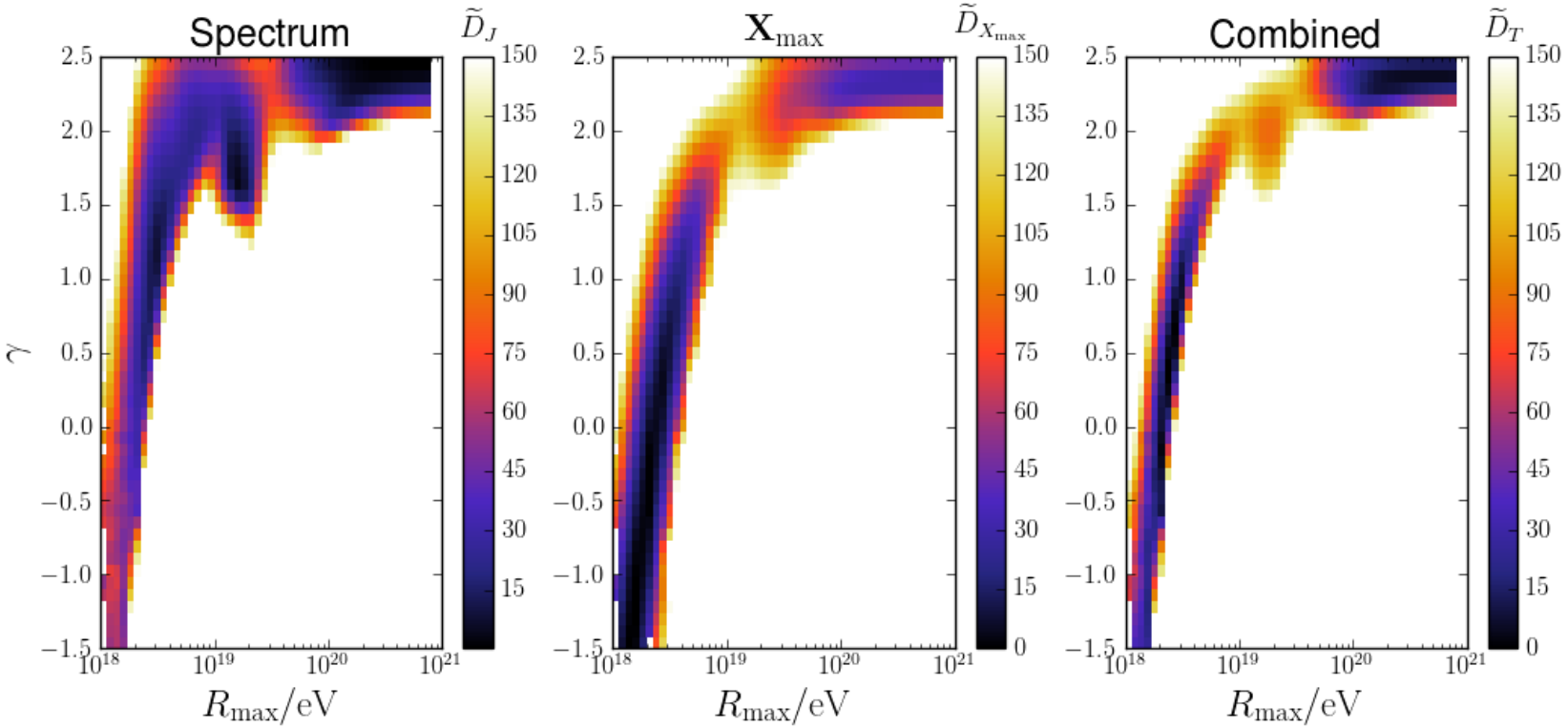

No EGMF

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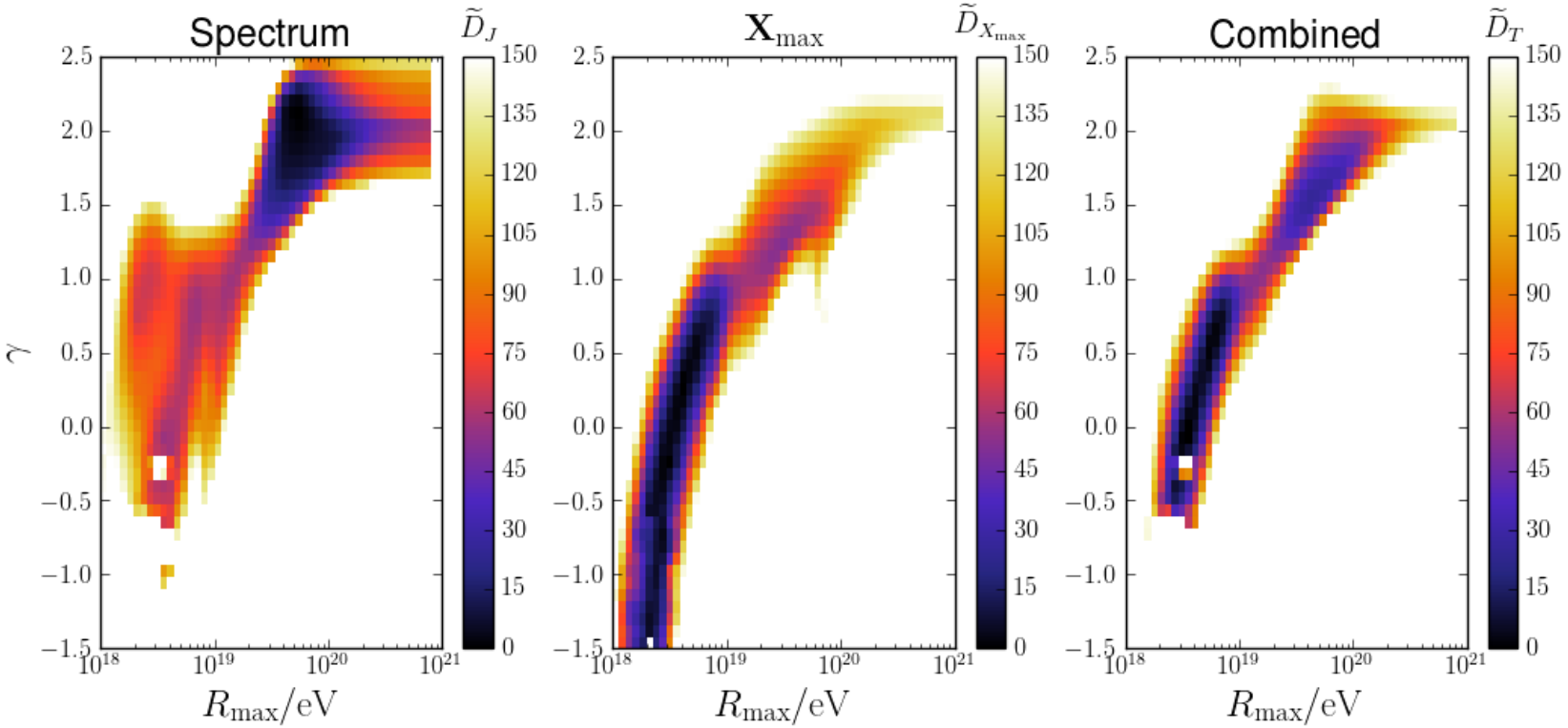
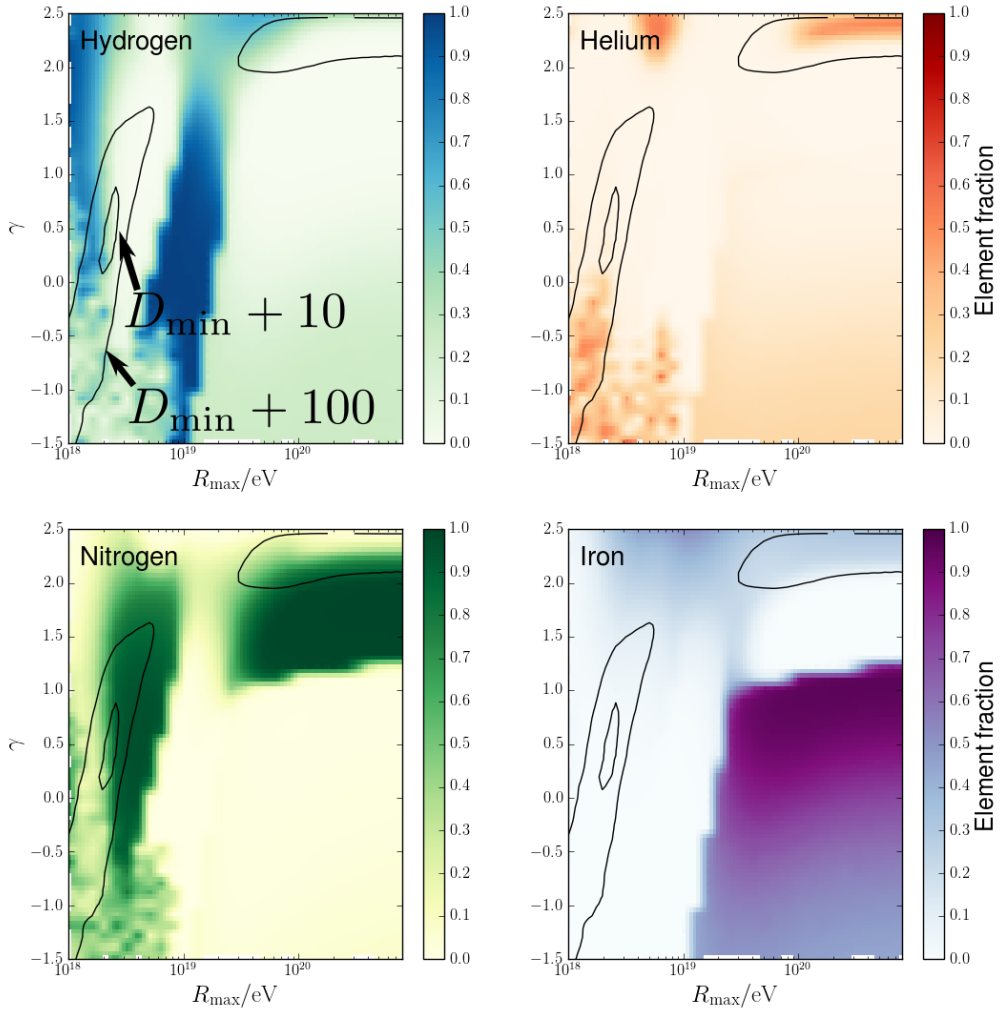


Benchmark EGMF



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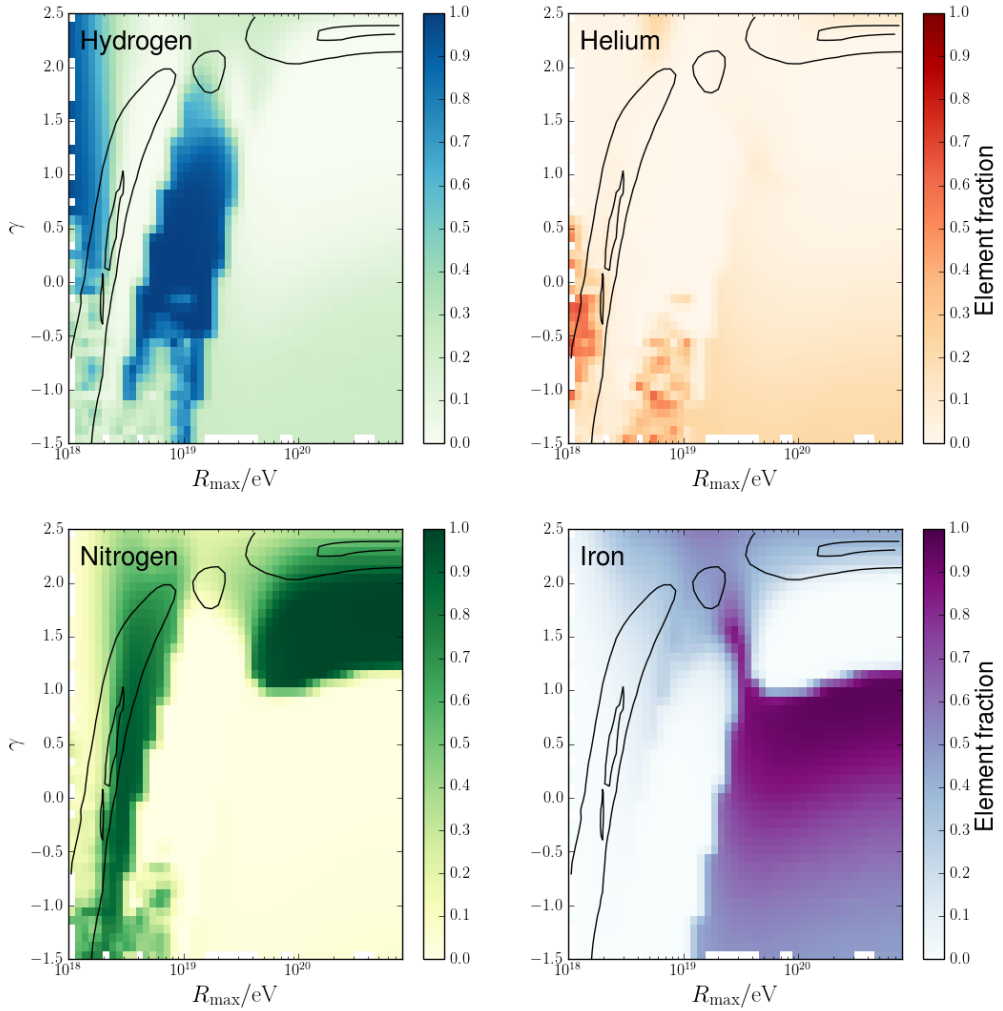
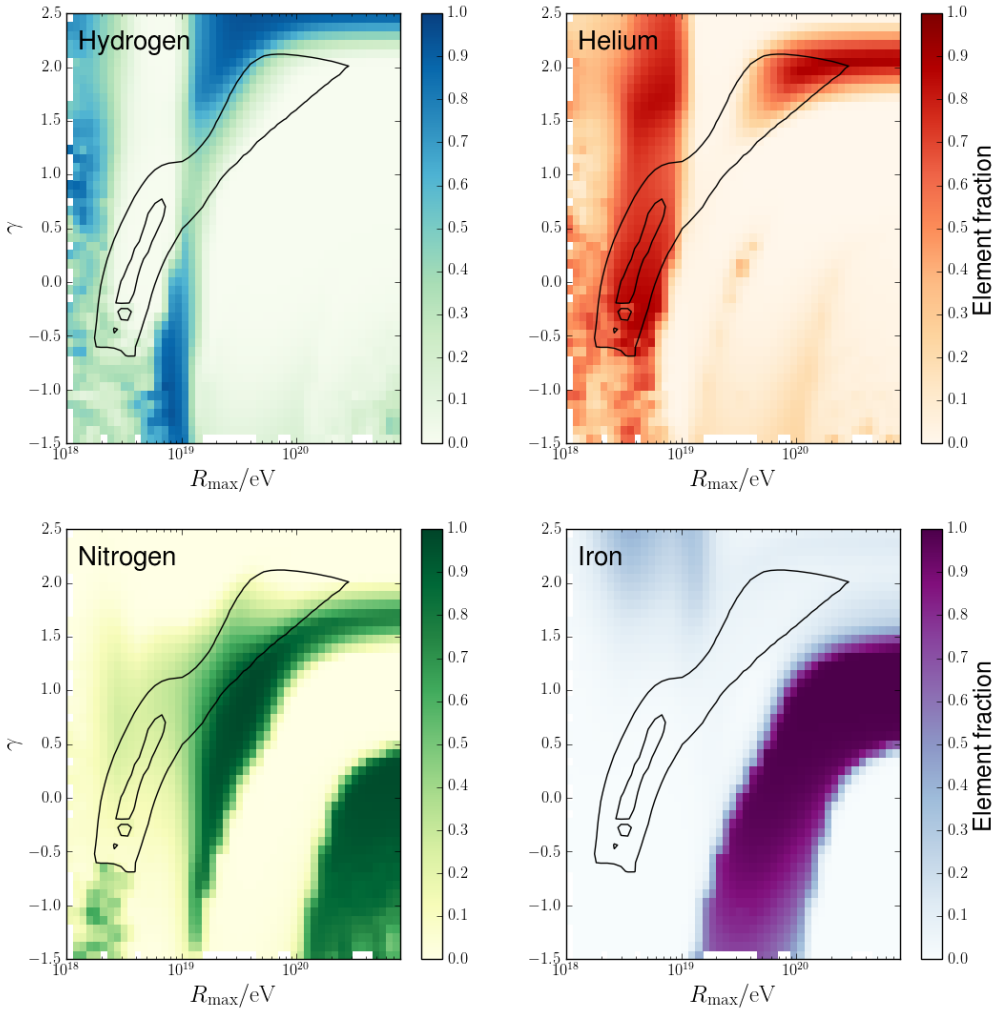

Hydrogen
Helium
Nitrogen
Iron
γ
$R_{\max}/\mathrm{eV}$
Element fraction

No EGMF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Strong influence of the EGMF on $R_{\max}$ and γ

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Strong influence of the EGMF on $R_{\max}$ and γ

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Conclusions

1. UHECR source properties (γ, R_{max}, f_i) were reconstructed by fitting a simple astrophysical model to the Pierre Auger Observatory data (energy spectrum and chem. composition)

2. The values of the best-fit parameters strongly depend on:
   - EBL model
   - EGMF model

3. A nitrogen-rich source composition is favored, if an EGMF is taken into account

4. The higher the interaction rates, the lower the injection cut-off R_{max} and spectral index γ

✍ **Publication including more results in preparation!**