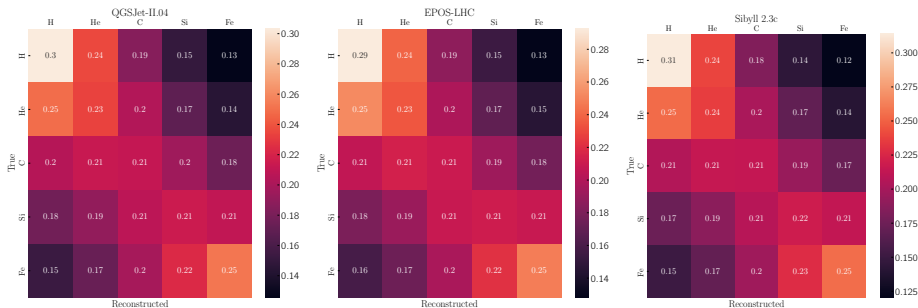


# New insights from old cosmic rays: A novel analysis of archival KASCADE data

D. Kostunin, I. Plokhikh, M. Ahlers, V. Tokareva, V. Lenok, P. Bezyazeekov,  
S. Golovachev, V. Sotnikov, R. Mullyadzhyanov and E. Sotnikova

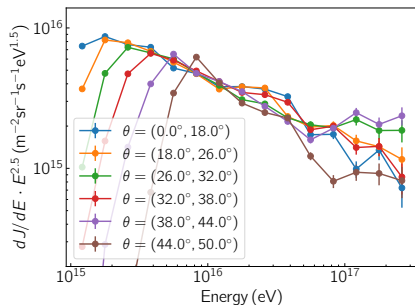
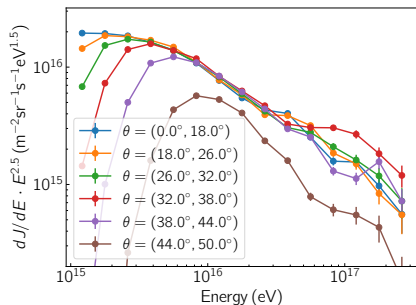
July 8, 2021

# Method



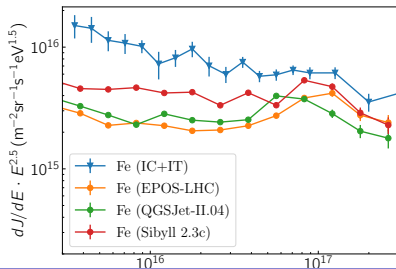
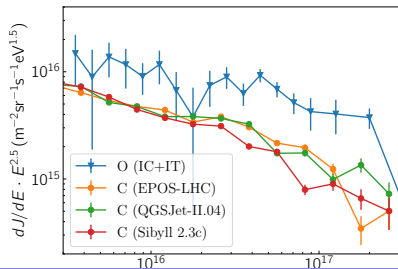
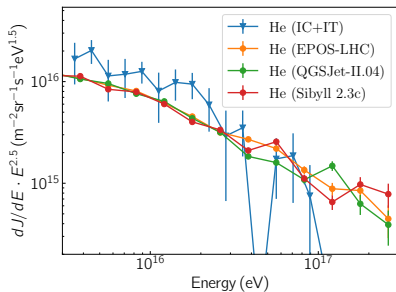
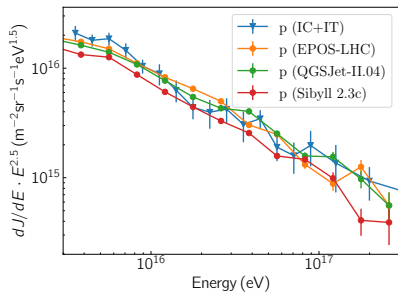
- KASCADE data from KCDC
- Random forest
  - Input: energy  $E$ ; shower core coordinates  $(x, y)$ ; arrival direction  $(\theta, \phi)$ ; muon and electron numbers  $\log_{10} N_\mu$ ,  $\log_{10} N_e$ ; and shower age  $s$
  - Output: primary particle:  $H, He, C, Si, Fe$
- Modern hadronic models: QGSJet-II.04, EPOS-LHC and Sibyll 2.3c

# Testing zenith angle systematics



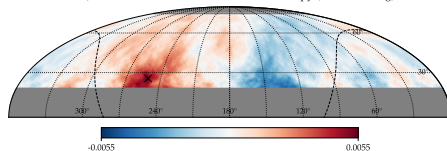
- Zenith bands are selected in order to obtain equal exposure for each curve
- Zenith angle cut might be accurately pushed from  $18^\circ$  to  $\mathcal{O}(30^\circ)$
- Thereby increasing the exposure by a factor  $\simeq 3$

# Mass composition

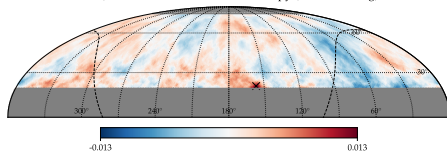


# Anisotropy

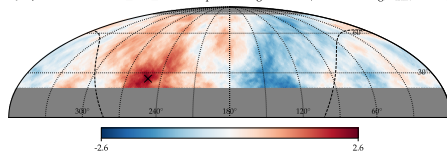
QGSJET-II-04 /  $10^{15.5}\text{V} \leq \mathcal{R} \leq 10^{16.0}\text{V}$  : anisotropy (45° smoothing)



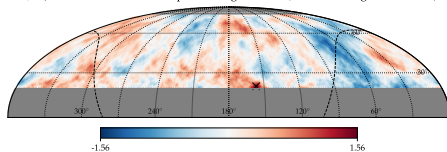
QGSJET-II-04 /  $10^{16.0}\text{V} \leq \mathcal{R}$  : anisotropy (45° smoothing)



QGSJET-II-04 /  $10^{15.5}\text{V} \leq \mathcal{R} \leq 10^{16.0}\text{V}$  : pre-trial significance (45° smoothing,  $\sigma_{\max} = 2.60$ )



QGSJET-II-04 /  $10^{16.0}\text{V} \leq \mathcal{R}$  : pre-trial significance (45° smoothing,  $\sigma_{\max} = 1.56$ )



- Analysys the anisotropy of CR arrival direction in terms of rigidity for the first time
- We do not find strong evidence for large-scale anisotropies and place 90% C.L. UL on the dipole amplitude

# Conclusion

- Novel mass composition analysis based on archival data of the KASCADE
- Reconstruction of large-scale anisotropy of CRs as function of rigidity
- Room for improvement using station responses and KASCADE-Grande data
- Final goal: search for photons
- Software used in outreach and partly published in Jupyter Hub at IAP KIT