Energy spectra of light primary cosmic rays in the energy range from 10 TeV to 100 PeV

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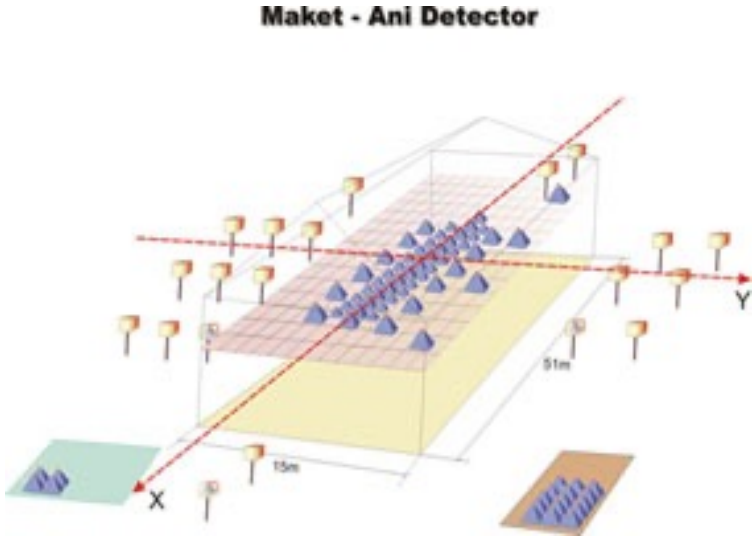
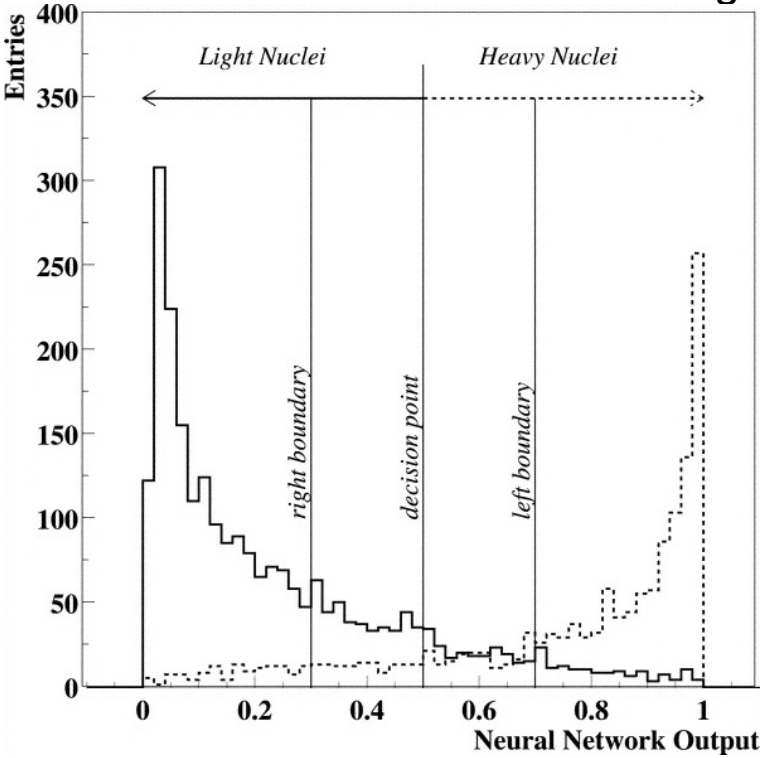
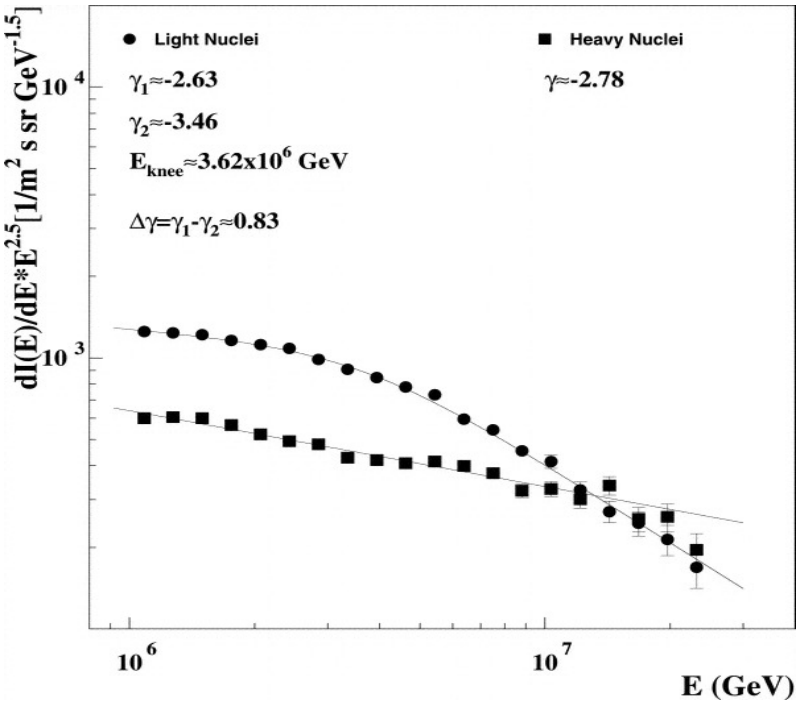


The non-parametric multivariate methodology of data analysis allows event-by-event classification of all EASs and first-time present light and heavy nuclei energy spectra separately. p+He spectrum obtained by MAKET is in good agreement with the spectra from balloon and satellite measurements, within the QGSJet-II model.

With the non-parametric multivariate methodology of data analysis the problem of event-by-event classification of EAS has been solved using Bayesian and neural network techniques (Chilingarian, G.Hosepyan, et al., Study of extensive air showers and primary energy spectra by MAKET-ANI detector on Mount Aragats,(Astroparticle Physics, 28, 58, 2005).



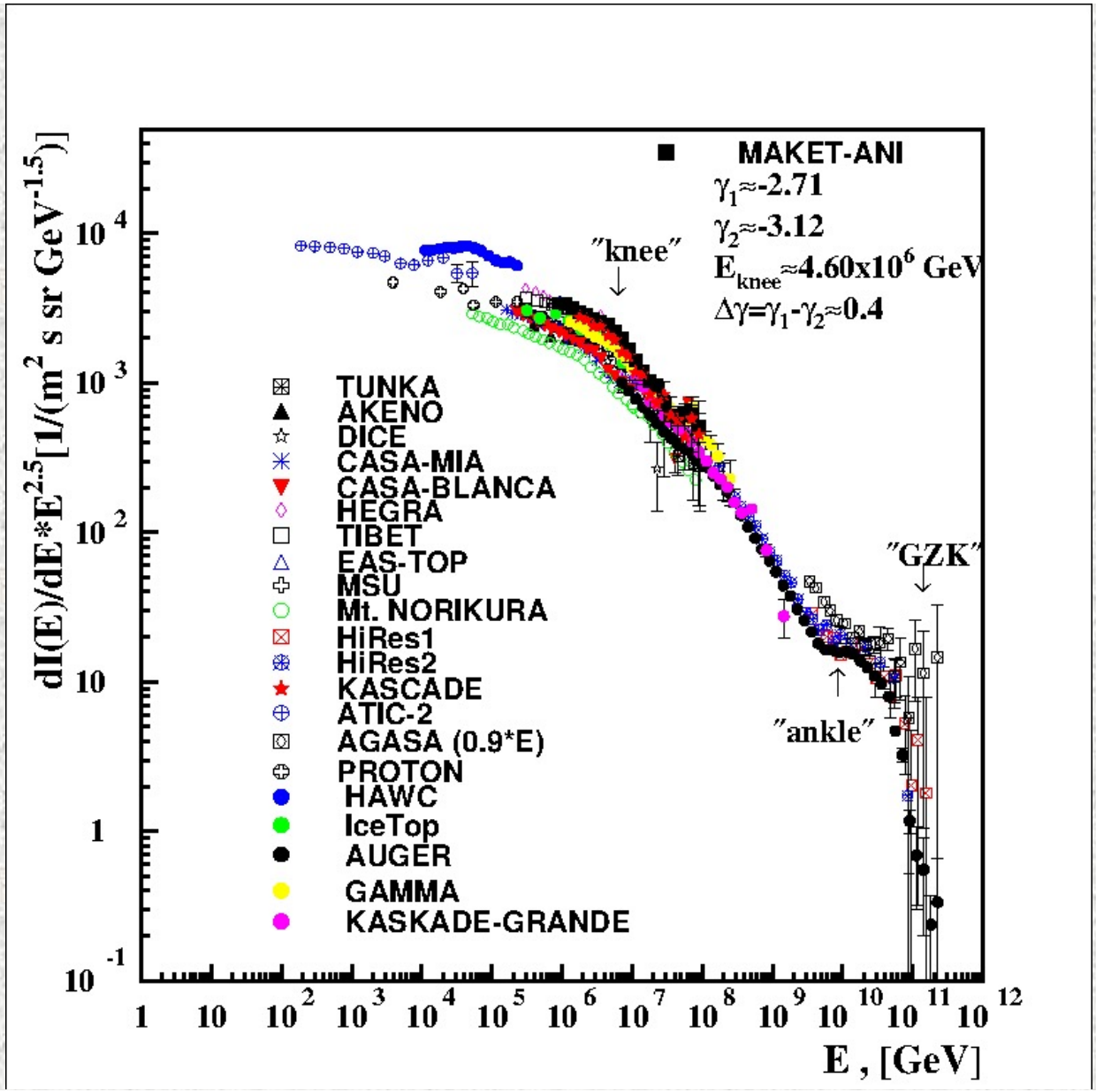
The output of the Neural Network trained
to distinguish “light” and “heavy” nuclei
(from Chilingarian, Hovsepyan, et al., Light and Heavy Cosmic Ray Mass Group Energy Spectra as Measured by the MAKET-ANI Detector, Astrophysical Journal, 603:L29-L32, 2004.)



Energy spectra of light and heavy nuclei obtained by neural classification and energy estimation. The EAS characteristics used are shower size and shape (age parameter).

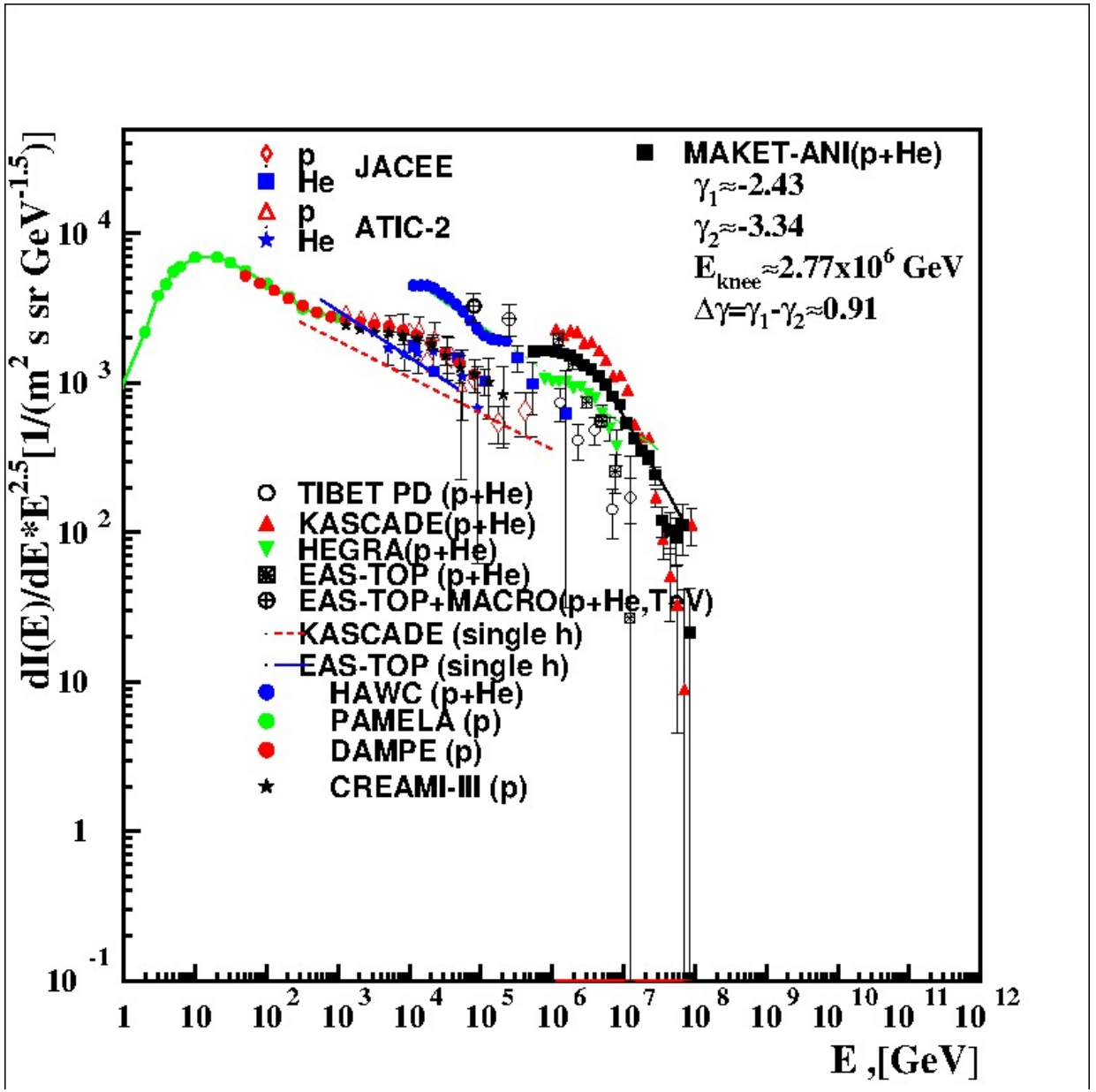
The all-particle spectrum from MAKET-ANI data compared to the world data. The line shows the fit to MAKET-ANI data according to the equation below (integrated into 0-30 zenith angle interval). KASCADE , EAS-TOP, TIBET , HEGRA, AKENO, CASA-MIA, CASA-BLANCA, DICE, Mt. NORIKURA, MSU, TUNKA,HiRes1,2 , ATIC-2, AGASA[, PROTON, HAWC, IceTop, AUGER, KASKADE-GRANDE, GAMMA.

$$\frac{dJ}{dE} = A \cdot \left[1 + \left(\frac{E}{E_{knee}}\right)^{\delta}\right]^{\Delta\gamma/\delta}$$

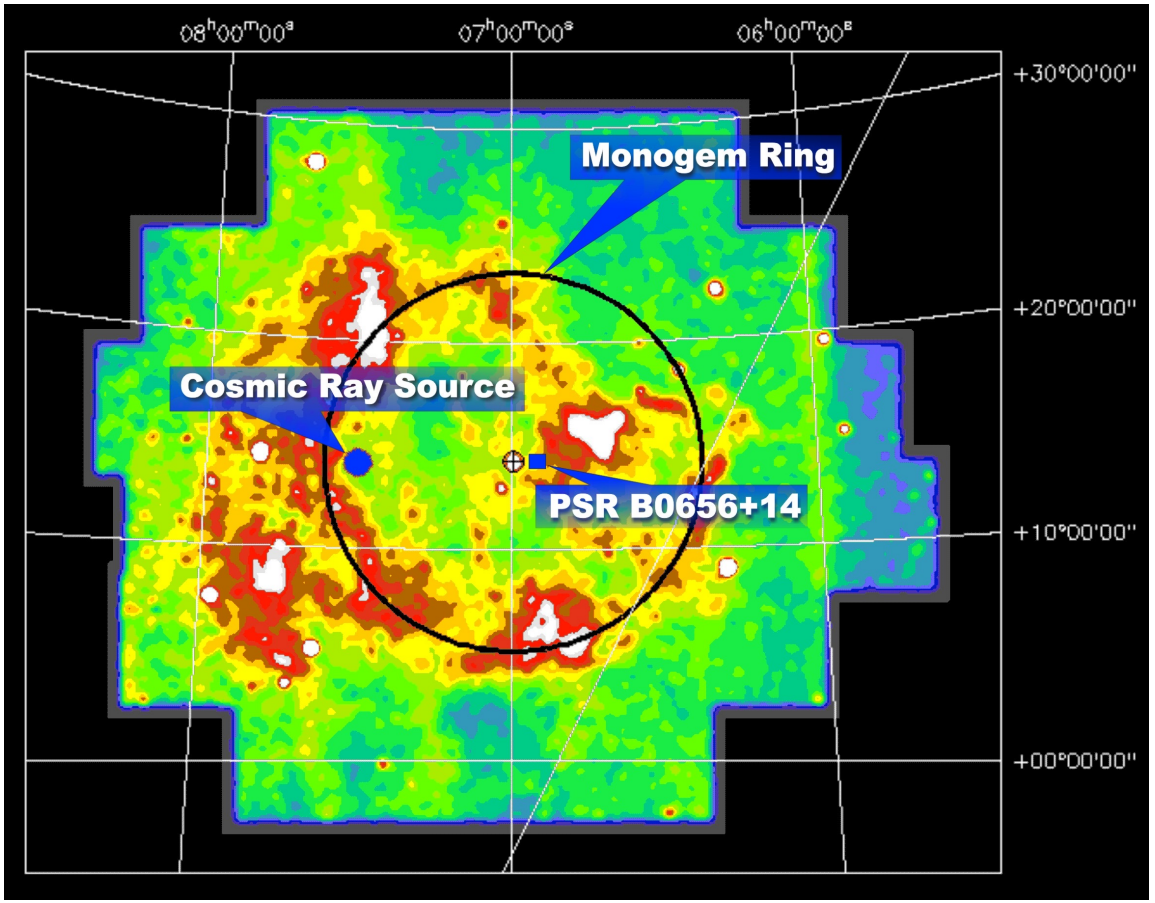


The energy spectrum of the light component (p+He) measured by the MAKET-ANI detector in comparison with the spectra published by KASCADE, EAS-TOP, HEGRA, EAS- TOP+MACRO, and TIBET. The direct balloon measurementsbyATIC-2 andJACEE, HAWC, PAMELA, DAMPE, and CREAM also are presented.

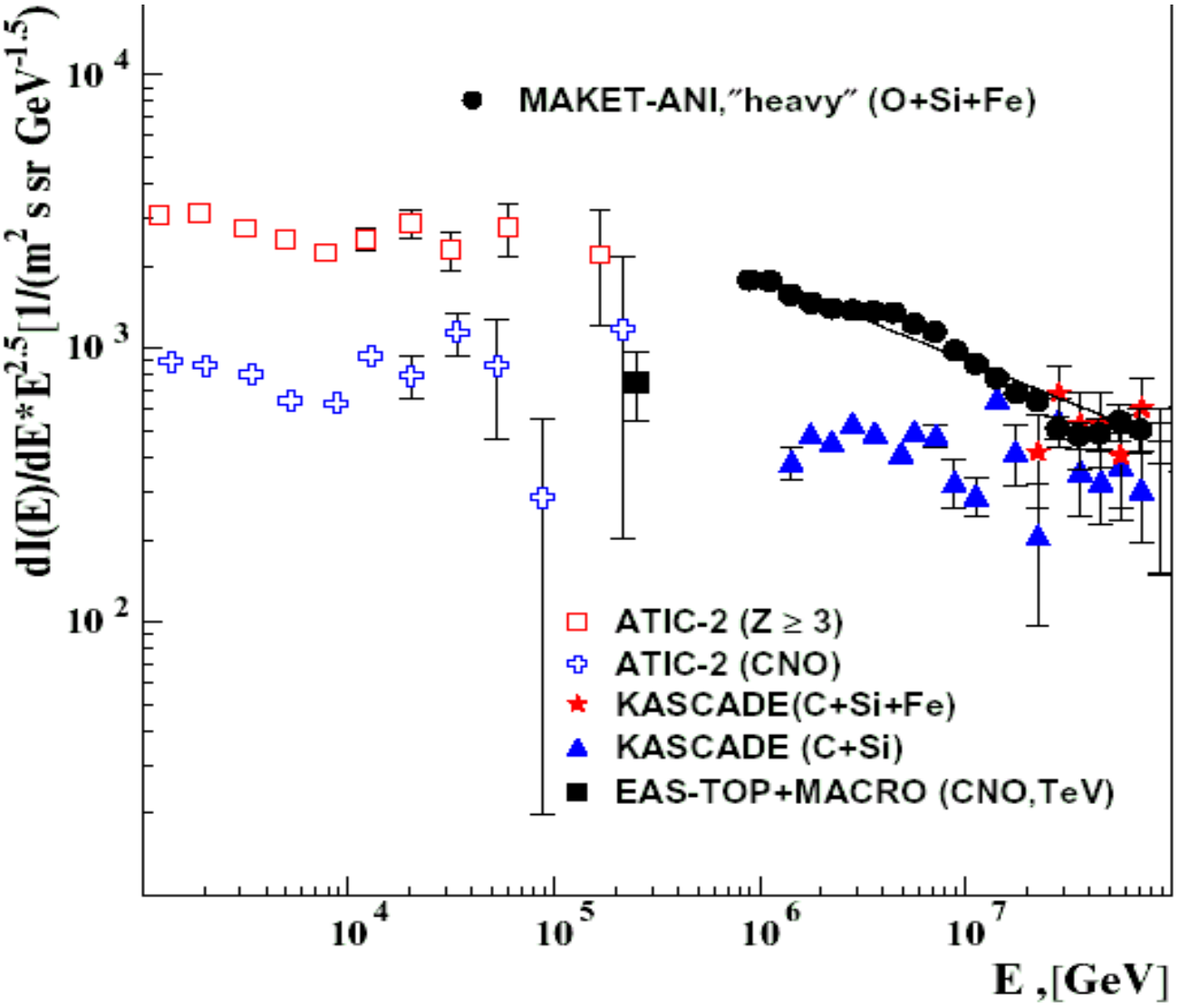
The QGSJet-II and QGSJet-III models (S.Ostapchenko, ISVHECRI-2022, India) predicted 10% higher N_e and N_mu. This should impact the energy reconstruction and thereby rescale down the normalization of our results, bringing them closer to most of the other measurements.



MAKET-ANI first detect the PEV energy proton flux from MONOGEM Ring now confirmed by HAWC and LHASSO. Initially published 5σ enhancement was withdrawn due to a mistake in the detector axes location, however a smaller enhancement of 2.5σ remains



The energy spectrum of the "heavy" nuclei group measured by the MAKET-ANI detector along with spectra from KASCADE , EAS-TOP+MACRO, and ATIC-2 . The solid line is a power function approximation



Conclusions.

- The non-parametric multivariate methodology of data analysis solved the problem of event-by-event classification of EAS using Bayesian and Neural Network techniques
- Spectrum of all particles represented from 10^2 to 10^{12} GeV based on data from 22 experiments are consistent with the nonlinear kinetic theory of CR acceleration in SNR shells.
- p+He spectra obtained from EAS data are in good agreement with the spectra from balloon and satellite measurements according to QGSJet-II model.