ENERGY SPECTRA OF LIGHT AND HEAVY PRIMARY COSMIC RAYS IN THE ENERGY RANGE FROM 10 TEV TO 100 PEV

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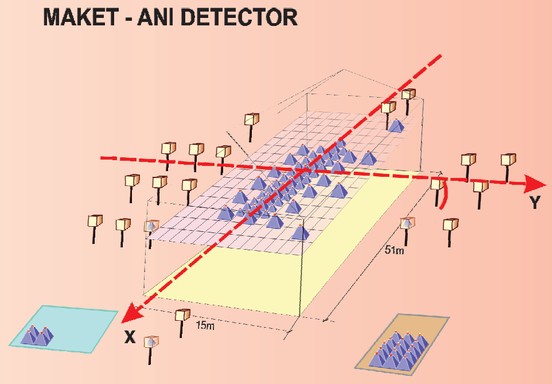
37 ВСЕРОССИЙСКАЯ КОНФЕРЕНЦИЯ ПО КОСМИЧЕСКИМ ЛУЧАМ

MAKET-ANI EAS ARRAY

Mt.Aragats, 3200m, 40.5°N, 44.2°E,
92 plastic scintillators, effectiv area for EAS collection ~1000m^2 for $N_e > 10^5$.

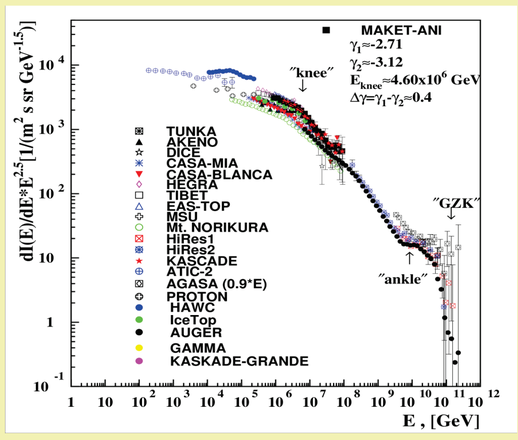
MAKET - ANI DETECTOR

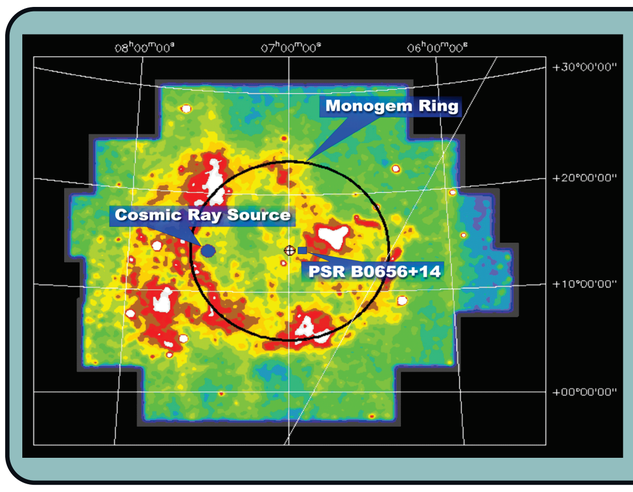


From 1997 to 2004 the MAKET – ANI experiment has taken data with exposition time of ~1.46·10^8 s. The total number of the registered EASs was ~1.2·10^7. A smaller sample of the data (~1.3·10^6) with Ne ≥10^5 and θ ≤46.8° was used for the in-depth analysis of the LDF and size spectra. By 7.2·10^5 near vertical (θ ≤30°) EASs for the first time were obtained the energy spectra of light and heavy nuclei groups in the region of knee.

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 (integrated into 0-30o zenith angle interval due to yield function). 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

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



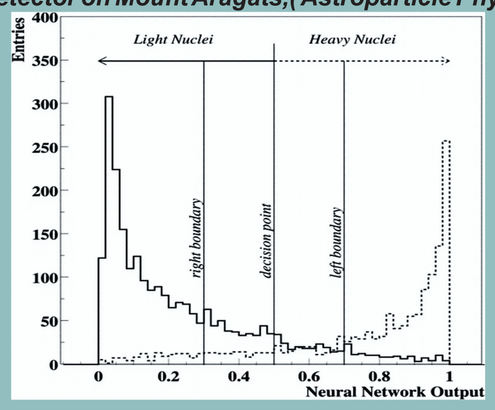


MAKET-ANI first detect the high-energy proton flux from MONOGEM Ring now confirmed by HAWC and LHASSO PEVatron detection .
Initially published 5 enhancement was withdrawn due to a mistake in the detector axes location, however a smaller enhancement of 2.5 remains

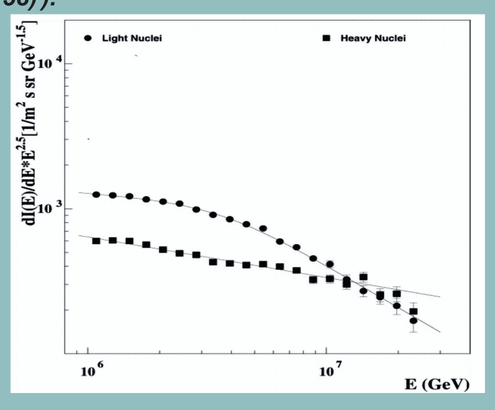
CONCLUSIONS

- *The total number of the registered EASs was ~1.2·10^7, Only 7.2·10^5 near vertical (θ ≤30°) EASs for the first time were obtained the energy spectra of light and heavy nuclei groups in the region of knee.*
- *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.*
- *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. The use of QGSJet-II makes it possible to obtain closer light nucleus (p+He) spectra with EAS, balloon and ACT data.*

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)).

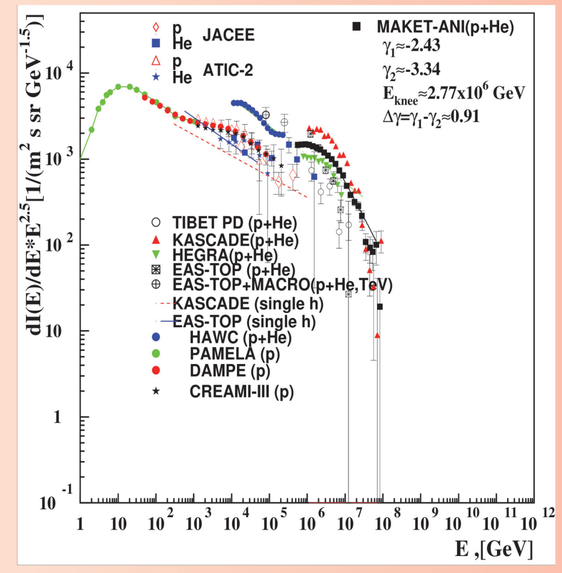


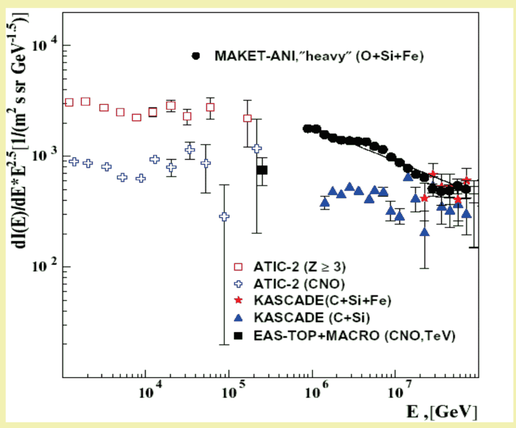
The output of the Neural Network trained to distinguish "light" and "heavy" nuclei (from Chilingarian, Hovsepyan, et al., Light and Heavy Cosmic Ray Mass Group Energy Spectra as Measured by the MAKET-ANI Detector, Astrophysical Journal, 603: L29-L32, 2004).



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).

Primary light component (p+He) measured by the MAKET-ANI detector in comparison to the results from KASCADE, EAS-TOP, HEGRA, EAS-TOP+MACRO, TIBET and primary protons spectra approximations obtained by the single hadrons fluxes EAS-TOP and KASCADE. (All data based on CORSIKA QGSJet01 version). The direct balloon measurements by ATIC-2 and JACEE at 10^2 – 10^5 GeV also presented.
The modern experiments HAWC [80], PAMELA, DAMPE, CREAM also presented.
By S.Ostapchenko (ISVHECRI-2022, India) new QGSJet-II and QGSJet-III models predicted some 10% higher N_e and N_mu. This should impact the energy reconstruction and thereby rescale energy spectra. The MAKET-ANI data on difference beetwen QGSJet01 and QGSJet-II version was corrected.





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 approximations.