The PRISMA-LHAASO project: Status and overview

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Abstract. The status of and main features of the PRISMA-LHAASO project are presented. We discuss here the science project and some preliminary results obtained with the PRISMA prototype.

1. Introduction: The PRISMA-LHAASO project science

There exist (or existed) very few experiments specially designed to solve the 60 years old “knee problem” in cosmic ray. The best of them, namely, KASCADE and Tibet AS gave very precise and interesting but contradictory results and did not solve the problem [1]. It became even less clear. Neither the knee origin nor the cosmic ray energy spectrum and its mass composition are known today. These problems could not be solved in our opinion by a traditional Extensive Air Shower (EAS) method studying electromagnetic and muon components. New approaches [2] based on the new ideas and multi-component EAS analysis will help us to solve this complicated problem.

The idea of a novel type of array for EAS study in 2001 [3] has been developed in 2008 to the PRISMA (PRImary Spectrum Measurement Array) project [4,5]. It is based on a simple idea: hadrons are the main EAS component forming its skeleton and resulting in all its properties at an observational level [6], so the hadron component should also be the main component to be measured in experiments. During its longitudinal developing in the atmosphere the EAS passes through several stages from the first cosmic ray interaction to almost full degradation deep in the atmosphere. Only the hadron content can be used to recognize the stage of EAS development. The development of a novel type of EAS array detector (en-detector) [7], able to record the hadronic component through thermal neutron detection and electronic component as well, can help to solve the problem.

The experiment has to be performed at high altitude where the number of secondary hadrons reaches maximal. The detector looks like an ordinary EAS detector but with a specific thin inorganic scintillator sensitive to thermal neutrons and having low sensitivity to charged particles. A thin layer of scintillator consists of an alloy of natural boron salt with inorganic scintillator ZnS(Ag). The recording efficiency of the compound to thermal neutrons is close to 20%. By spreading these detectors over a large area on the Earth’s surface one can obtain a kind of hadronic calorimeter of practically unlimited area. To make the energy threshold of the array lower it has to be installed at high altitude. We proposed to locate the PRISMA array at 4400 m above sea level in the central part of the LHAASO array.

The PRISMA-LHAASO project is mostly aimed to solve the “knee problem” in the cosmic ray spectrum and to measure any changes of cosmic ray mass composition at energies in the PeV region. The best way to do so could be direct cosmic ray spectrum measurements. Unfortunately, it cannot be performed due to the very low intensity of cosmic rays with energies above 1 PeV. That is why physicists are pressed to use an indirect EAS method. However, as a payment for that, one has to make very complicated and model dependent recalculations from the measurements to primary parameters. Solving the inverse task one should be sure that: i) a solution exists and ii) the measured parameters are connected with real ones by known dependencies. Both points are not known a priori. Solving the direct task one also has to introduce many parameters by hand, concerning the details of the model used, cosmic ray mass composition, existence or presence of the “knee” in the primary spectrum etc. [8].

Traditionally EAS arrays measure the electron component first of all. This is not the best but the simplest and most convenient choice because the electron component is the most numerous. However, the electron component is the secondary EAS component sensitive to EAS longitudinal development, which is formed by the cascading of high-energy hadrons. These two components are in a dynamic equilibrium. However, the equilibrium exists only while hadrons exist. When the cascading hadrons are fully exhausted (note that the number of such hadrons is high only at the maximum of shower development and then exponentially decreases with depth

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The additional geophysical studies on the Earth’s surface could be performed cost free using PRISMA-LHAASO.
detectors. The items need an underground detector location and could use existing underground or basement rooms to decrease the cosmic ray background and to emphasize the radon-neutron source. Otherwise, it will need additional investments.

An example of thermal neutron variations study can be seen in Fig. 2 where a normalized and 60-day smoothed counting rate is shown for both neutrons and for “charged” for about a 3y-period of observation at Yangbajing. Seasonal variations of about 8% amplitude wave anti-correlated with the rainy season is clearly visible in both curves [13]. These data allows us to estimate the neutron background at high altitude. As we have found the neutron background has also a long-term trend, which we connected with the decrease of solar activity in the 24th solar cycle, resulting in an increase of low energy cosmic rays producing neutrons [14].

More results concerning geophysical studies can be found elsewhere [13,15,16].

5. Summary

A novel type of EAS full-scale array (PRISMA-LHAASO) will be made at high altitude in association with the LHAASO project in the next 4 years. Preliminary results obtained with the prototypes and M-C simulations make us sure that en-detectors are very informative and very stable and the future array could give us absolutely new and fascinating results on cosmic rays near and above so-called “knee” in cosmic ray spectrum. We hope that the problem of the “knee” will be solved soon with the PRISMA-LHAASO.

This work was supported in Russia by RFBR (grants 14-02-00996, 16-32-00054 and 16-29-13067_ofi_m), RAS Presidium Program “Fundamental properties of matter and astrophysics”, and in China by NSFC (No. 10975046, No. 11375052).

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