The project we are proposing is included in the activities of the LHAASO experiment. LHAASO is one of the “top five” projects of the strategic plan of IHEP and recently its financing has been approved by the Chinese government.

The experiment will be located in the Sichuan province at 4410 m a.s.l., and will be composed by: 5195 plastic scintillator detectors of 1 m² each, placed on a hexagonal grid (15 m side); 1171 water Cherenkov detectors sampling the EAS muon component, shielded by 2.5 m of ground, 36 m² each, separated by 30 m. These detectors will be used to detect EAS on a 1 km² surface; in its center are located three water pools, where the Cherenkov light emitted by the EAS particles is detected on a 100% active surface of 78000 m² (divided in 3120 5x5 m² cells). The array is completed by 12, 15 m², telescopes that will measure the Cherenkov light emitted in atmosphere during the EAS development.

The scientific objectives of the project are: the search for sources of gamma rays in the 0.3-1000 TeV energy range with unprecedented sensitivity for wide field of view experiments; the study of the cosmic ray spectrum and anisotropies in the $10^{14}-10^{17}$ eV energy range.

The LHAASO collaboration includes many Chinese universities, the Italian group is made by the Torino and Roma Tor Vergata units, who are in charge of the development of the front-end and slow control boards for the silicon photomultipliers (SiPM) that will be used in the wide field of view Cherenkov telescopes. The Italian groups will also be in charge of testing all the SiPM before their installation on the experimental site.

The Italian groups are also involved both in the search for gamma ray sources and in the charged cosmic ray studies. In this second field the Torino unit is studying, using EAS simulations, the resolution of the LHAASO experiment in the event separation according to the mass of the primary particle. This study is of main importance as it will allow the experiment to measure the spectra and arrival direction anisotropy of different primary mass groups. These measurements will help in clarifying the cosmic ray acceleration and propagation at the highest energies reachable by galactic sources.

The LHAASO experiment will begin the data taking at the end of 2018, with one quarter of the detectors, and will be completed by the end of 2020. Therefore in the years before the beginning of the data taking the Torino group activities will be concentrated on the SiPM testing and on the development of the algorithm separating the events according to the mass of the primary particle originating the EAS.

2(a) State-of-the-art and objectives

Cosmic rays of galactic origin reaches energies up to $10^{17}-10^{18}$ eV, the acceleration mechanism allowing to reach such energies is still not known. The latest experimental results indicate that the spectrum of light elements steepens around $10^{15}$ eV (7x$10^{14}$ eV according to ARGO-YBJ results and 4x$10^{15}$ eV according other experiments among which KASCADE). The KASCADE-Grande experiment claimed the detection of a steepening of the heavy primaries spectrum at 8x$10^{16}$ eV. The results about the light spectrum cannot be described in a unique scenario and further measurements are needed.

These results indicate an astrophysical origin for the steepening of the cosmic ray spectrum (the so called “knee”), that is currently explained either as a propagation effect or as the limit of galactic accelerators. To disentangle between these two hypothesis the measurements of the anisotropies in the cosmic ray arrival direction for the light and heavy primaries are needed; the LHAASO experiment, having a 1 km² effective
area and the resolution two separate at least two mass groups on a event by event basis, will reach this result. In this line the Torino unit, collaborating with Chinese institutions, is developing the analysis to define a strategy allowing the separation of two, or more, mass groups.

2(b) Methodology, work plan, team organisation

Before the beginning of the data taking (end 2018) we will run a complete EAS and detector simulation to define and test the algorithm to separate two or more mass groups. The EAS simulation will be performed running the CORSIKA code to generate events on a power law spectrum, and the full detector simulation will be based on the GEANT4 package.

First we will generate events for at least five different primaries (H, He, C, Si, Fe) covering three order of magnitude in energy (on a $E^{-2}$ power law spectrum), then the obtained results will be analysed to define the more appropriate strategy to separate the mass groups.

In parallel the activity of testing the SiPM will continue, the installation of 4 telescope each year is foreseen to maintain the time schedule of the experiment.

The research team is composed by Prof. Andrea Chiavassa, Dr. Piero Vallania, Dr. Silvia Vernetto, Dr. Carlo Vigorito and by post doc and PhD fellows. Prof. Chiavassa is in charge of the analysis about charged cosmic rays, while the rest of the group mainly deals with the search for gamma primaries.

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