The universal particle detector at mountain level

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Objectives

Many experiments show the effect of the appearance of the numerous neutrons delayed by hundreds of microseconds after the passage of the main shower disc in the vicinity of the EAS core [1-9]. But there is no agreement about its origin.

One proposed explanation is “the arrival of new type of primary cosmic ray particles…” [3]. The detailed study of the effect has been done at [4]. The authors said that their experiment show evidence either of the qualitative change in the process of nuclear interaction in the “knee” region of the primary spectrum or the appearance of some component in cosmic radiation that has very unusual exotic properties. Another explanation [8, 9] is that the effect caused by neutrons, which are produced inside the neutron monitor by numerous nuclear scatterings and disintegrations. A.D. Erlykin in his review [1] concluded that this phenomenon complements our knowledge of the EAS development and it is certainly worth of further experimental and theoretical analysis.

The proposed universal particle detector at Aragats cosmic ray station will help to get an answer about neutron delay and its origin. The regular neutron monitor combined with EAS scintillating counters allows us to repeat mentioned experiments with the same or better time resolution. The important addition is the fast silicon-scintillator calorimeter. It will detect the neutrons coming directly from EAS, measure their energy from 10 to 1000 GeV and their arrival delay with respect to the main shower front.

This way we can distinguish between direct EAS neutrons and ones generated by other EAS components. By simultaneous registering charged hadrons in the same energy region we can precisely compare neutrons and other hadrons delays. The detector is planned to collect information during a few years continuously. It allows observing various temporal correlations between neutron, charged hadron and EAS arrival on one hand and various processes and events inside the Earth and beyond.

The device structure

The setup structure is shown in Figure 1. The central part of the detector is relatively small but very fast EM/hadron sampling calorimeter (Figure 2). The active elements of the calorimeter are 1m^2 size 1cm thick scintillators (Sc1-Sc10) and 5 layers of silicon pad (large pixel) detectors (Si1-Si5) for precise particle position determination. Silicon layers are also used to separate hadron showers from EM ones and to determine a single particle charge by dE/dx measurements before interaction.

1m^2 scintillators are positioned between lead and iron absorber layers. Absorber layers are about 1X_0 thick on the top of the device. They are used as EM part of the calorimeter. Hadron part of the calorimeter consists of the same scintillators and much thicker layers of the absorber.

The bottom part of the calorimeter also consists of a few thin layers of absorber, scintillating counters and one layer of silicon. It has to be able to pick up and identify charged and neutral particles going in back direction if they exist.

About ten 1m^2 scintillating EAS counters (SC) are positioned around the calorimeter to register accompanying the hadron particles as well as EAS without a hadron.

Neutron detectors (neutron monitor) are also situated nearby to register “neutron thunder” and temporal correlations between neutron, charged hadrons and other EAS particles. It is assumed that every part of the setup will generate its own trigger to observe all possible correlations and temporal distributions. Important task of neutron counter system is to register the neutrons which came from all the sides including coming from the ground neutrons.

Conclusion

This rather small setup is designed as a more or less universal system to learn more about neutron fluxes and to perform precise measurements of correlation between different particles as well as between particle fluxes and various types of Sun, Earth and human activities.

An additional interesting task is to register the muons horizontally going through Aragats mountain. This way muon energy spectra can be measured from 10 to 100 TeV.

The setup is situated at Aragats cosmic ray station (Armenia) at 2000 m above sea level. First stage is expected to start running in 2008.

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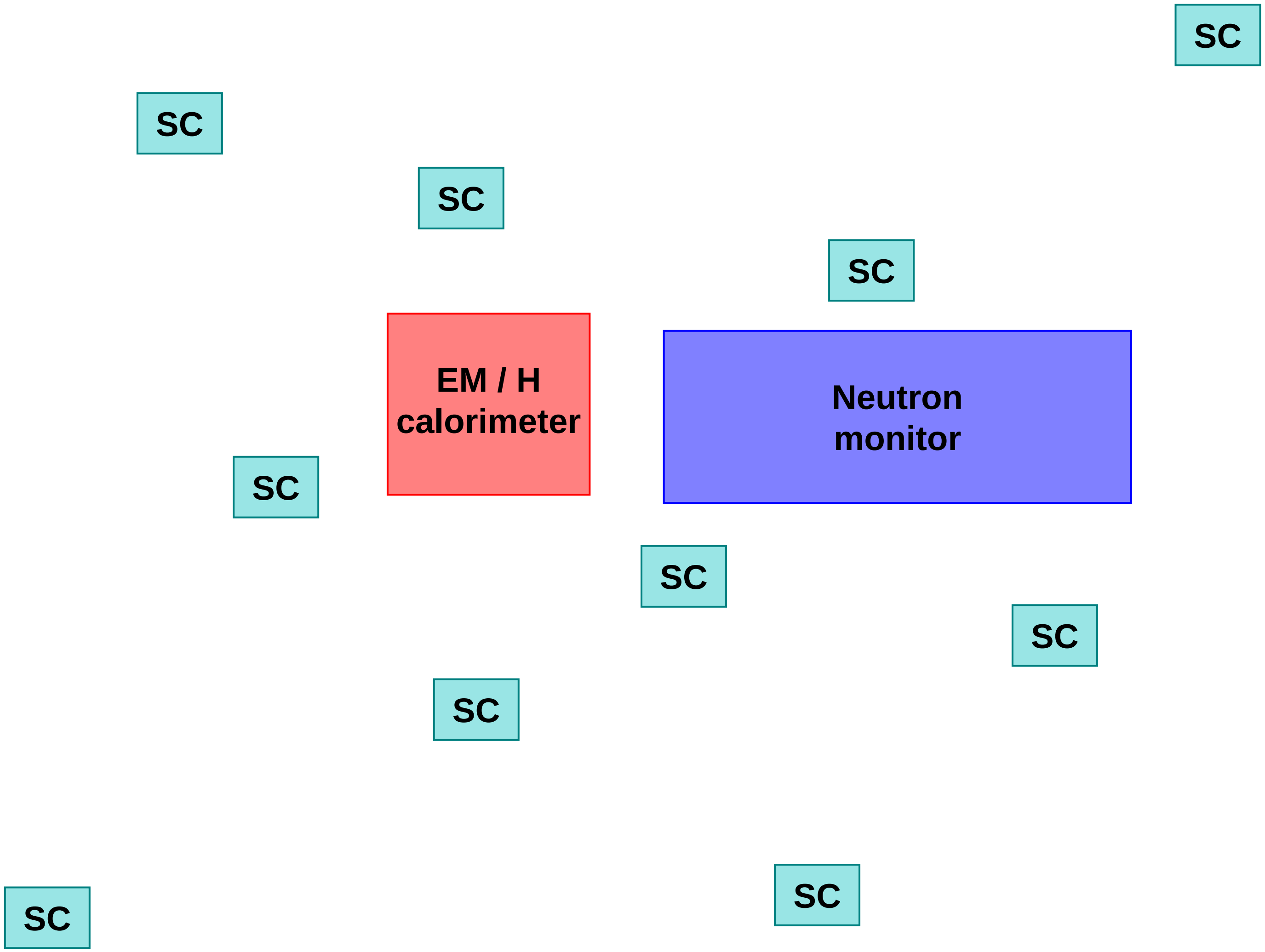

Figure 1. The setup structure.

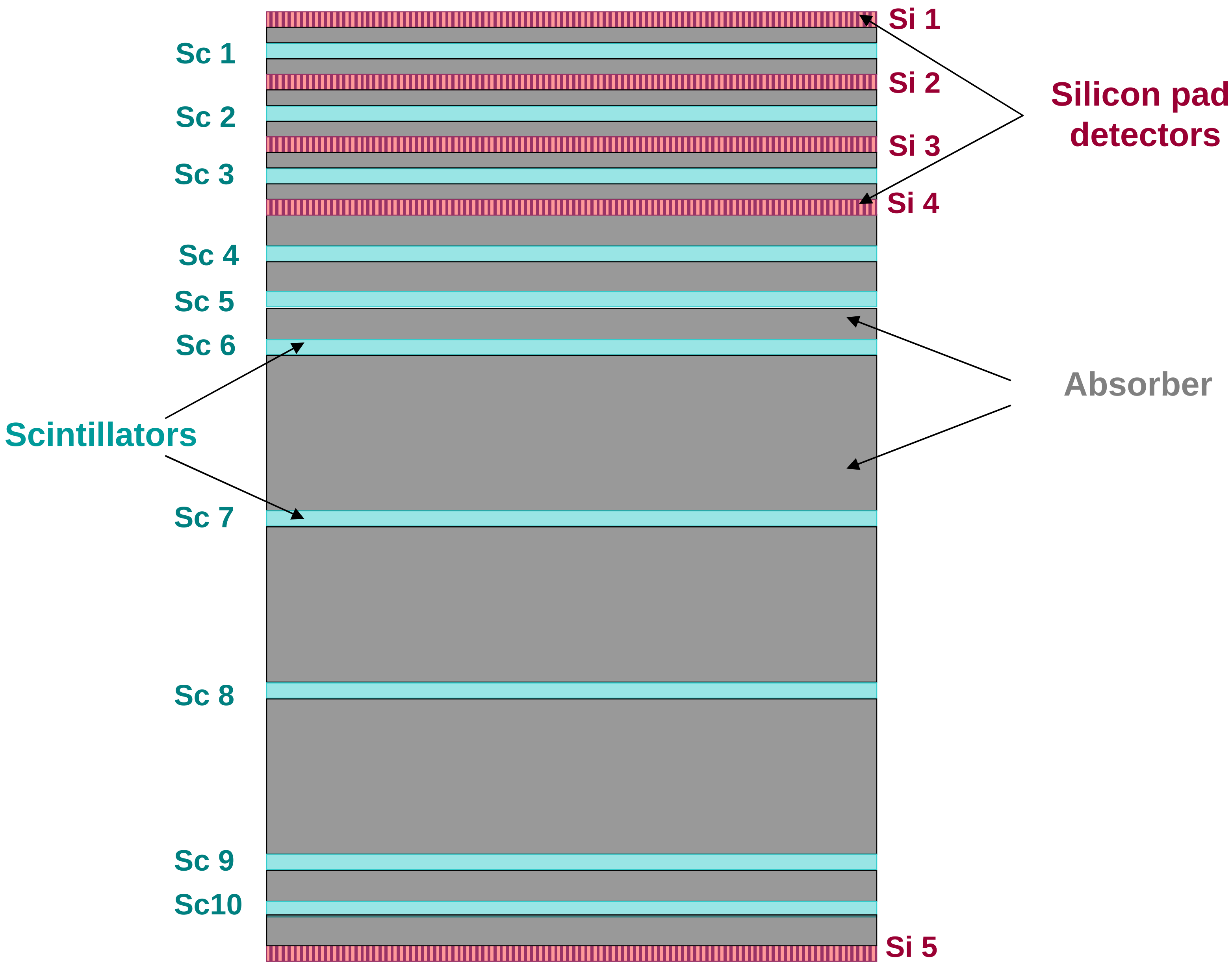

Figure 2. The EM/hadron calorimeter structure.