

Development of an air shower array using plastic scintillators

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Outline of the talk

- Motivation
- What are air shower arrays?
- Development of air shower array at Darjeeling
- Fabrication of plastic scintillators
- Experimental Set-up
- Results
- Summary and future plan

Motivation

- High energy cosmic rays can only be observed through air showers
- To study cosmic rays at high altitude (Darjeeling)
- To track solar events. Thus, EAS array will be coupled with neutron monitors

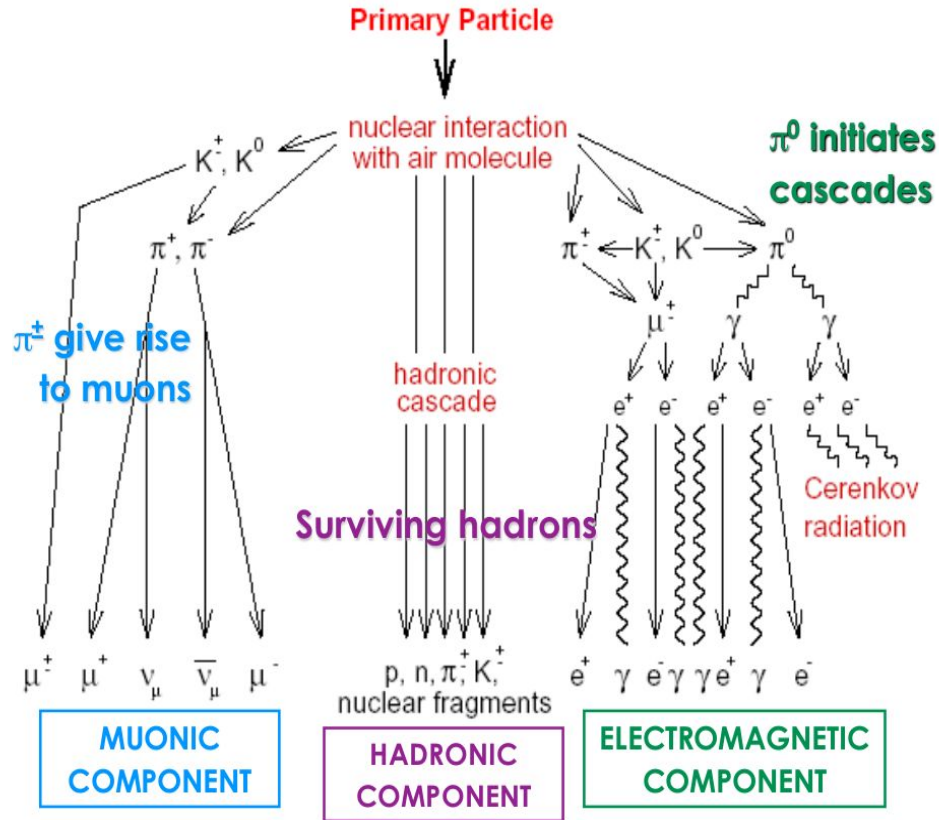
(Between Japan and Ooty, there are no other setups anywhere)

- To measure the local flux of low and medium energy cosmic rays, in correlation with the in-situ atmospheric water and water vapour as well as CCN counts
- To elucidate the aerosol-cosmic rays-cloud connection in the context of regional climate change

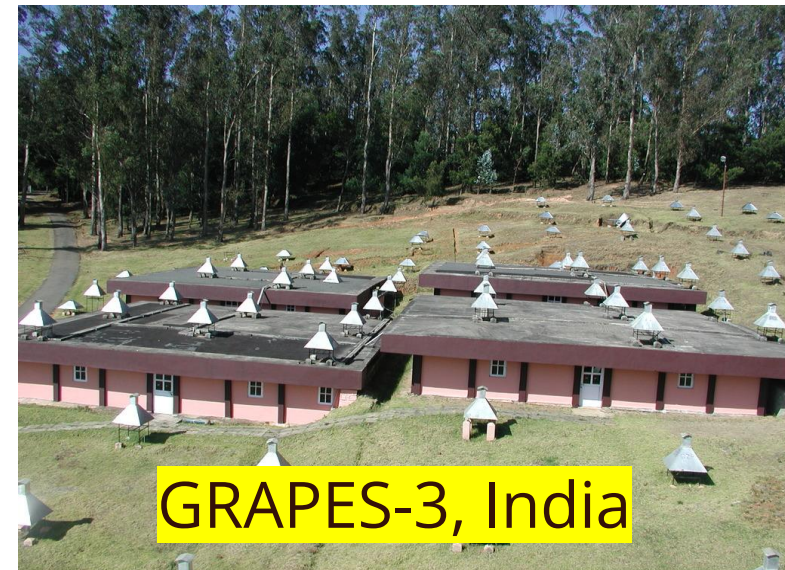
What are air shower arrays?

EXTENSIVE AIR SHOWERS

A high energy primary particle, upon entering the atmosphere, initiates a chain of nuclear interactions



Detectors are spread over large areas on ground to detect the air shower particles



Why Darjeeling ?

- Darjeeling is at same altitude as of Ooty (experimental site for GRAPES-3 air shower array), useful in search of correlated air showers
- Observation at Ooty could be cross-checked by that in Darjeeling
- Strengthen the baseline for any observation in between GRAPES-3 in Southern India and AGASA in Japan

Development of air shower array at Darjeeling

Location : Darjeeling 27°3' N 88°16' E

Altitude : 2200 m

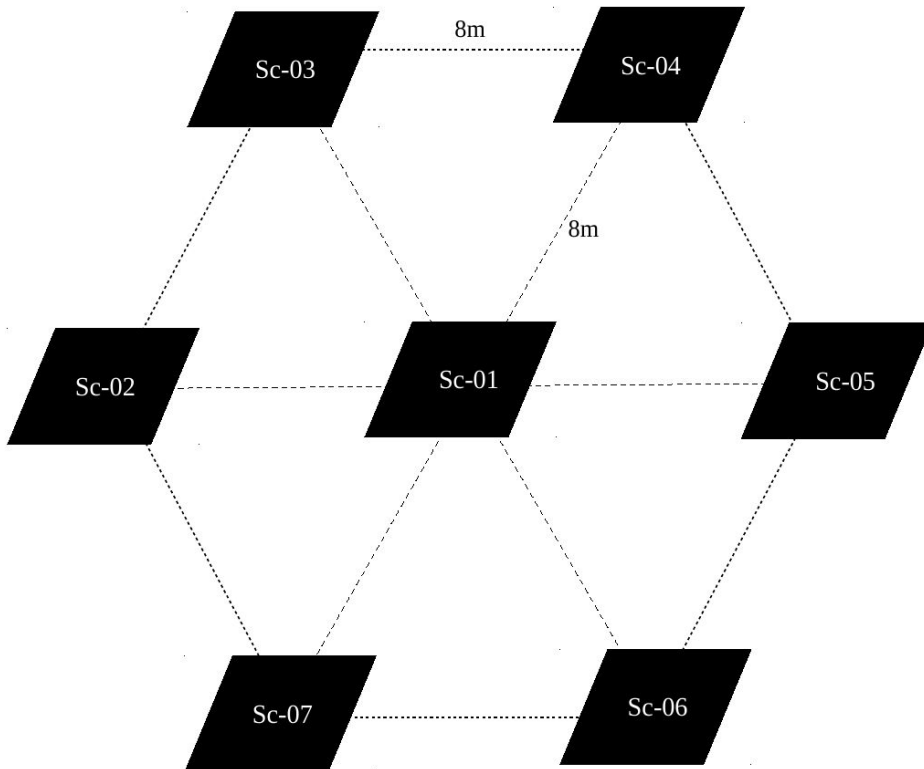
Air shower array shape : hexagonal

Area of coverage : 168m²

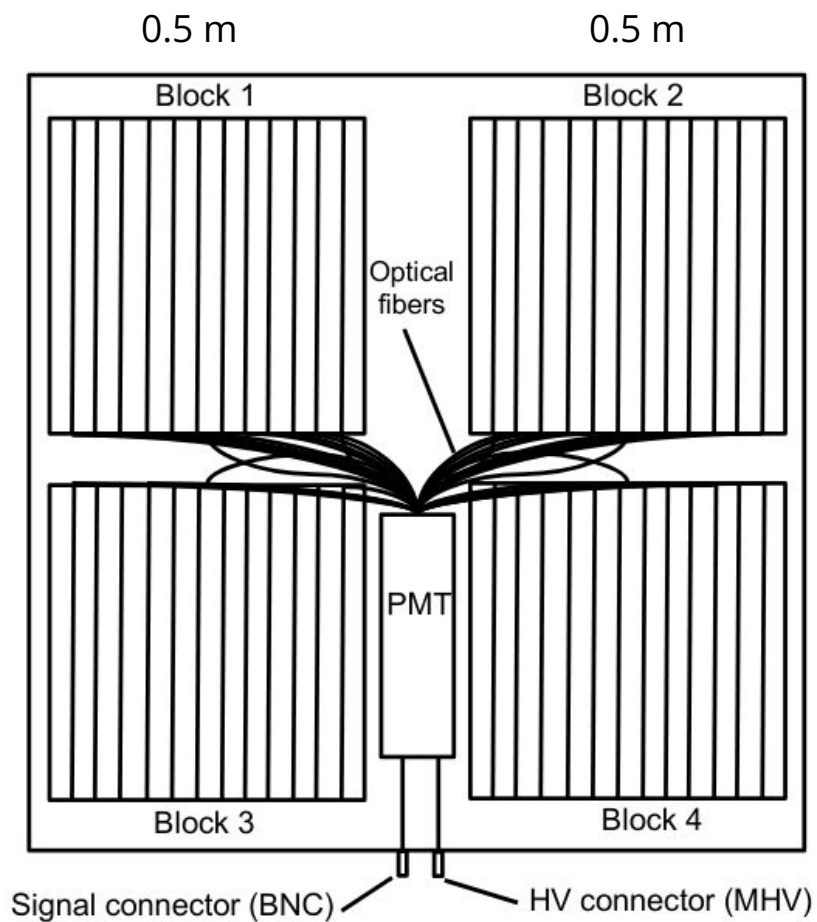
Array elements : 7 plastic scintillators

Dimension : 1 m x 1 m

Thickness : 1 cm



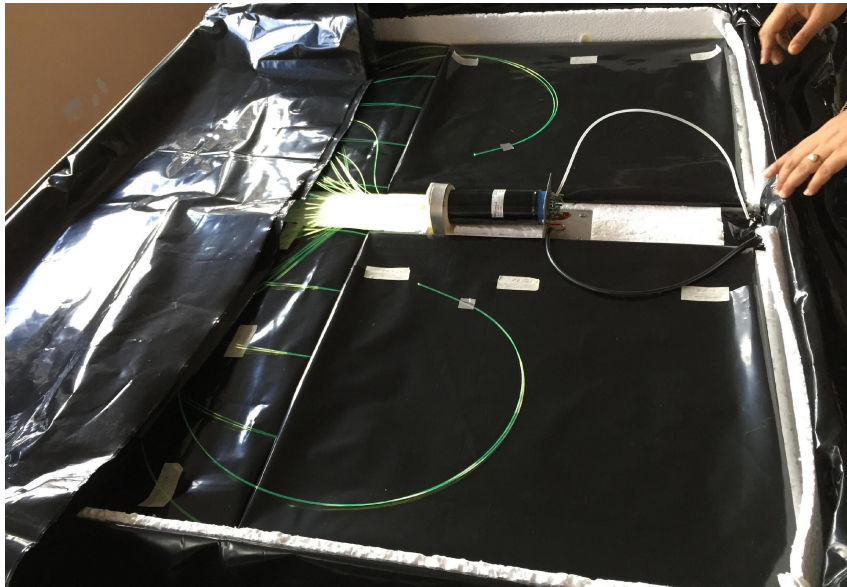
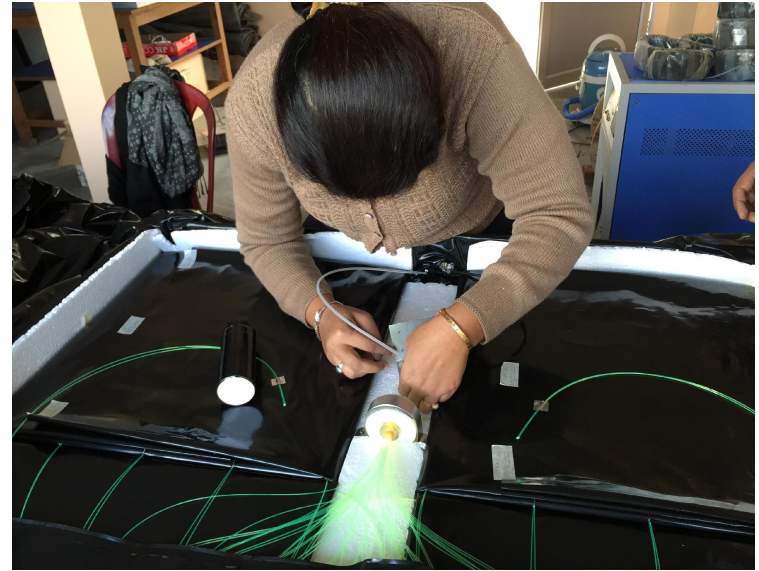
Detector module



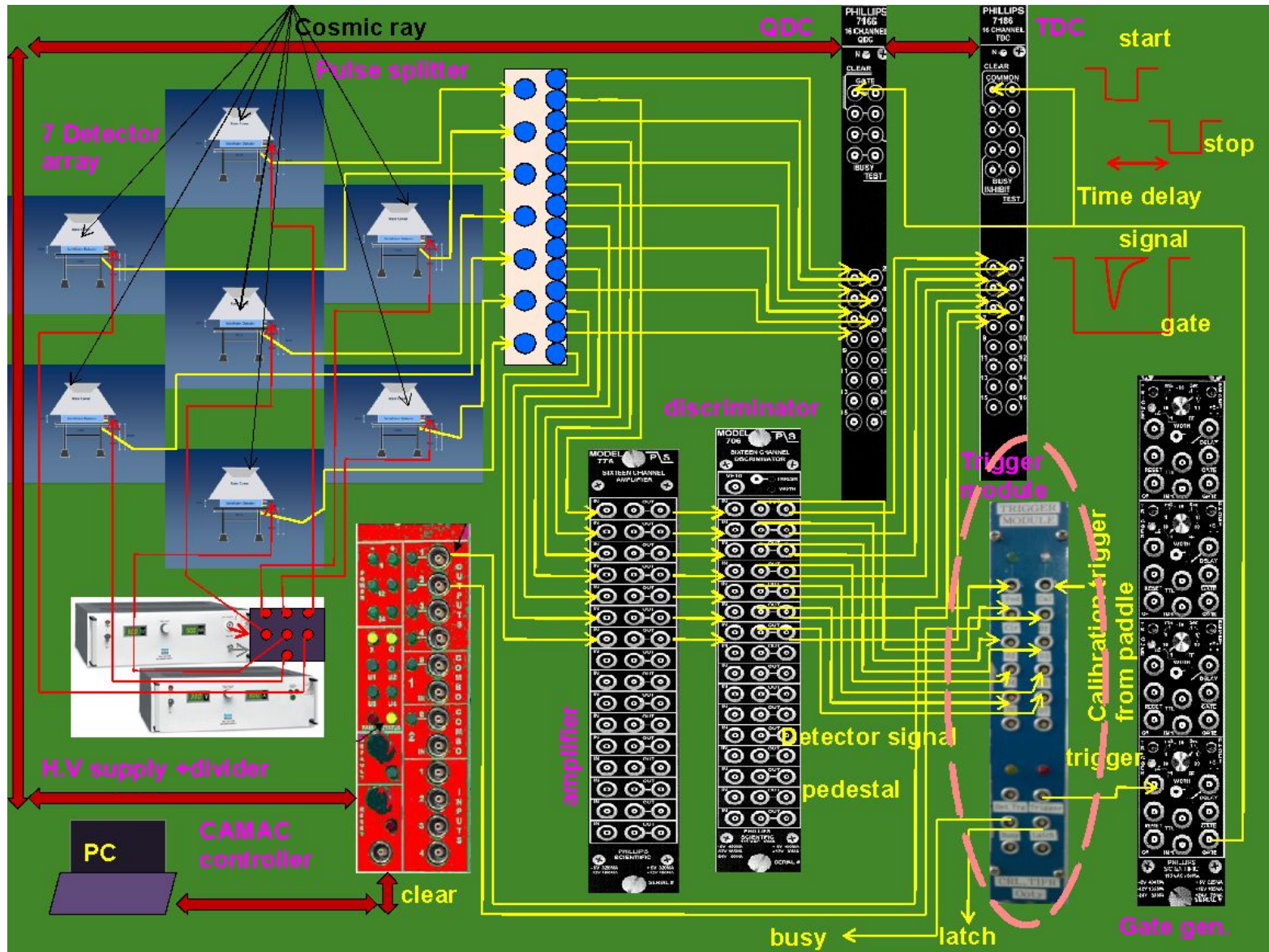
Detector module features

- All four PSD blocks are connected to a single PMT by using circular WLS optical fibers
- 12 parallel grooves were made in a 0.5 m × 0.5 m block to place the WLS fibers
- Total 48 fibers from all 4 blocks were collectively coupled optically to a PMT (ETL9807B) of diameter 5 cm
- No optical contacts among the four PSD Blocks
- The whole system was kept in an aluminum box of 1 mm wall thickness.

Detector assembly



Schematic of the readout system



DAQ and trigger for the array

- The data acquisition for the array is running with NIM
- A shower trigger logic and large shower trigger logic has been implemented
- A standard single width trigger module has been designed and fabricated for this purpose
- The 7-detector array is commissioned in January 2018

Testing of the scintillator detectors



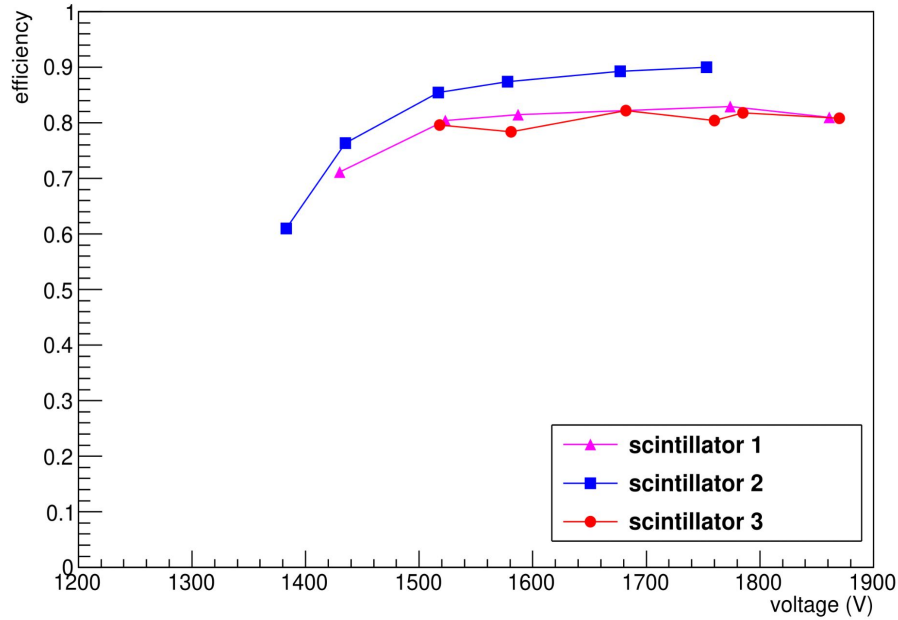
Stack of Scintillator detectors

Detector signal

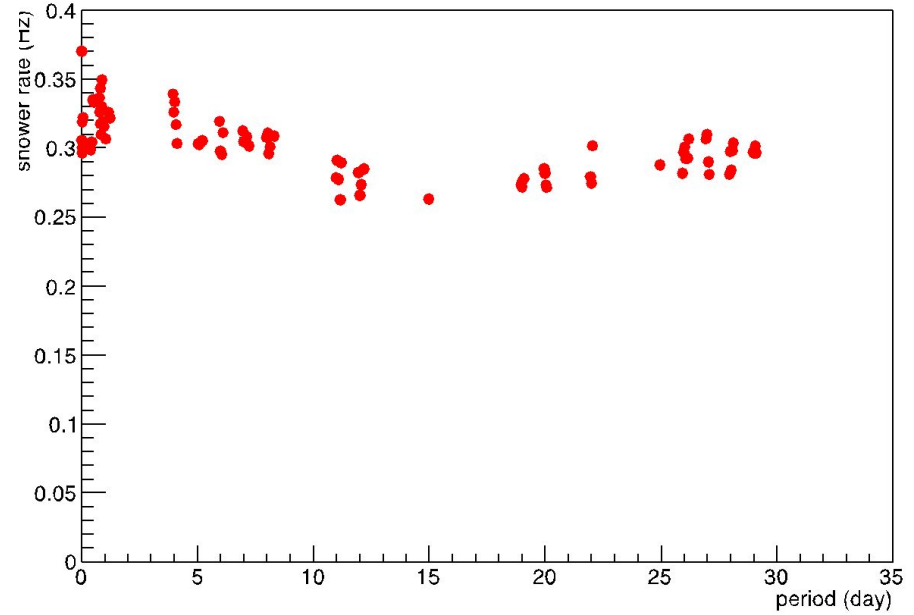


Coincidence signals

Count rates and efficiency of the scintillators



Efficiency as a function of applied voltage



3F rate vs. time during mid November - mid December, 2016

Steps towards the 7-detector array



Fixing of stand



Cabling



Placing of detector



Sealing



Calibration



Cable and electronics

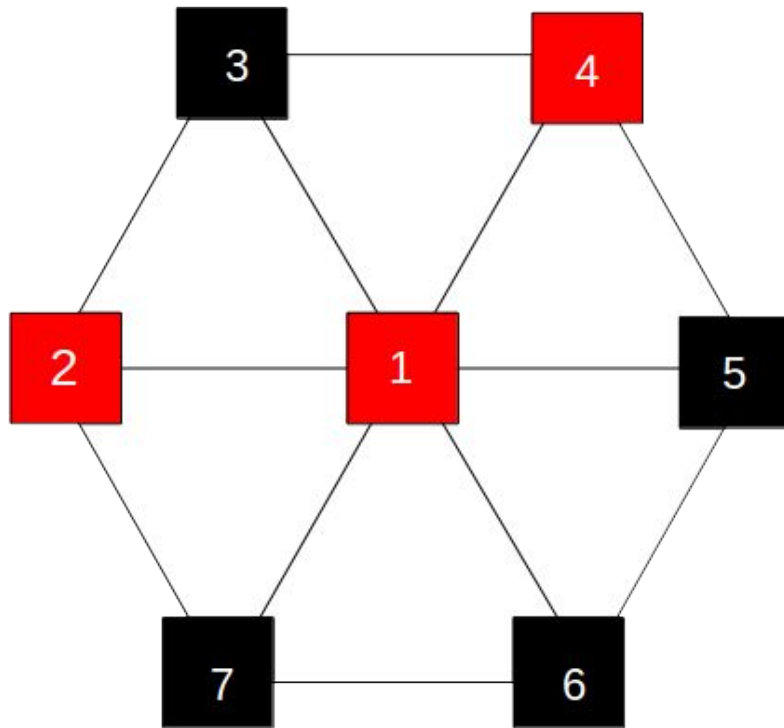
Air shower array at Darjeeling



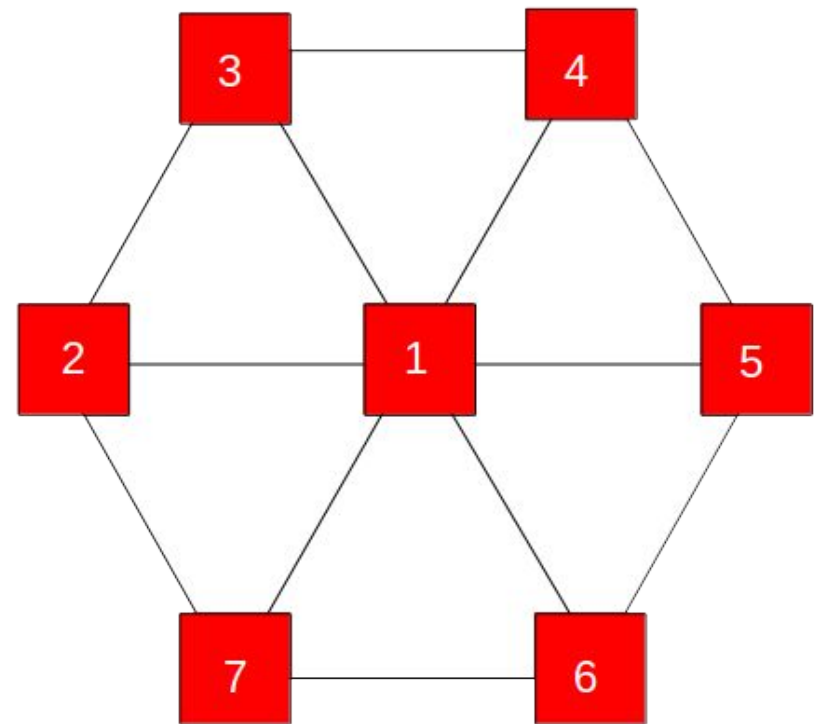
Cosmic ray shower trigger logic

Shower trigger logic \longrightarrow signal from central + any two

Shower trigger logic



7 fold trigger logic

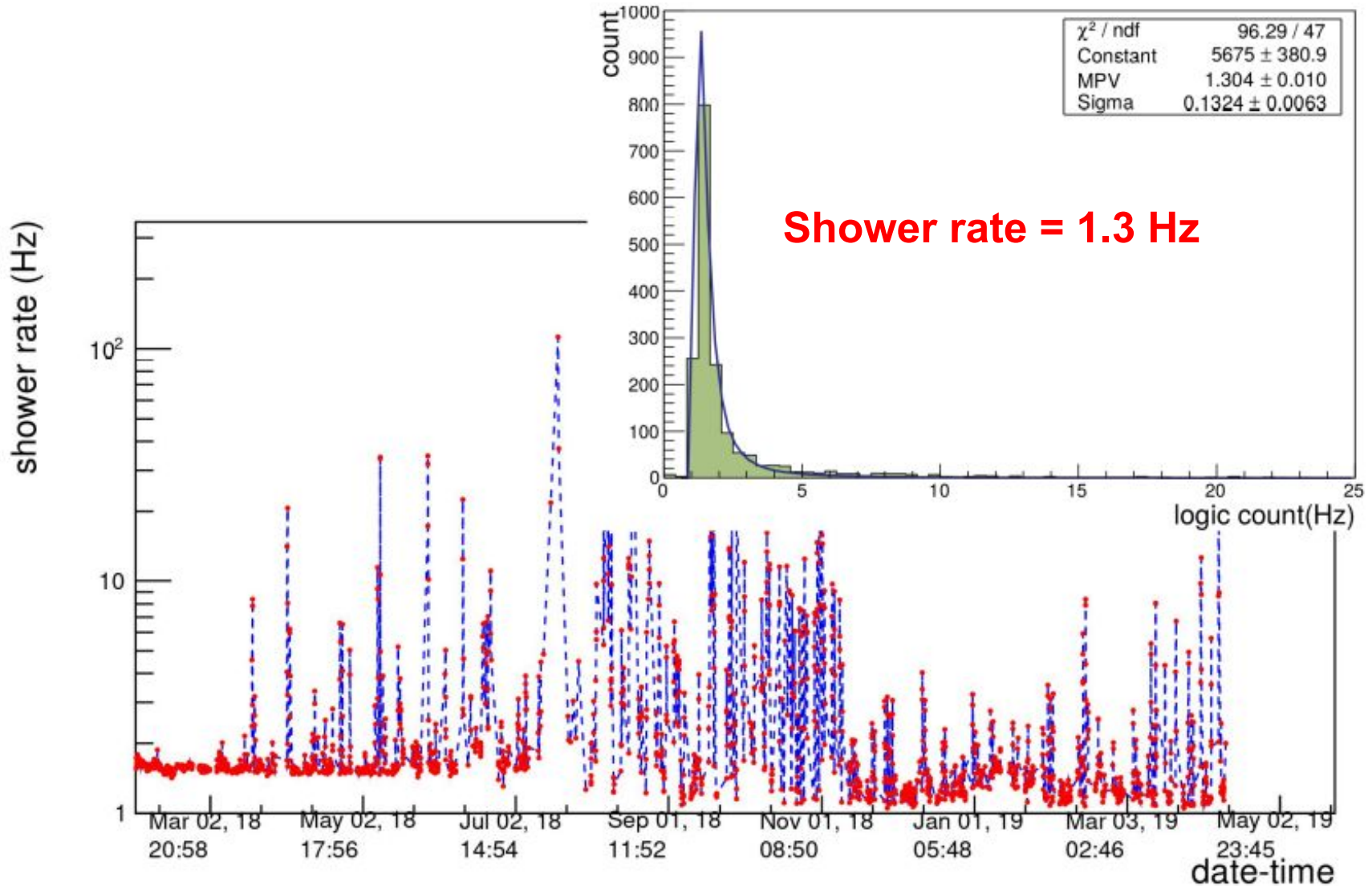


Red means detector produced signal



Black means no signal produced

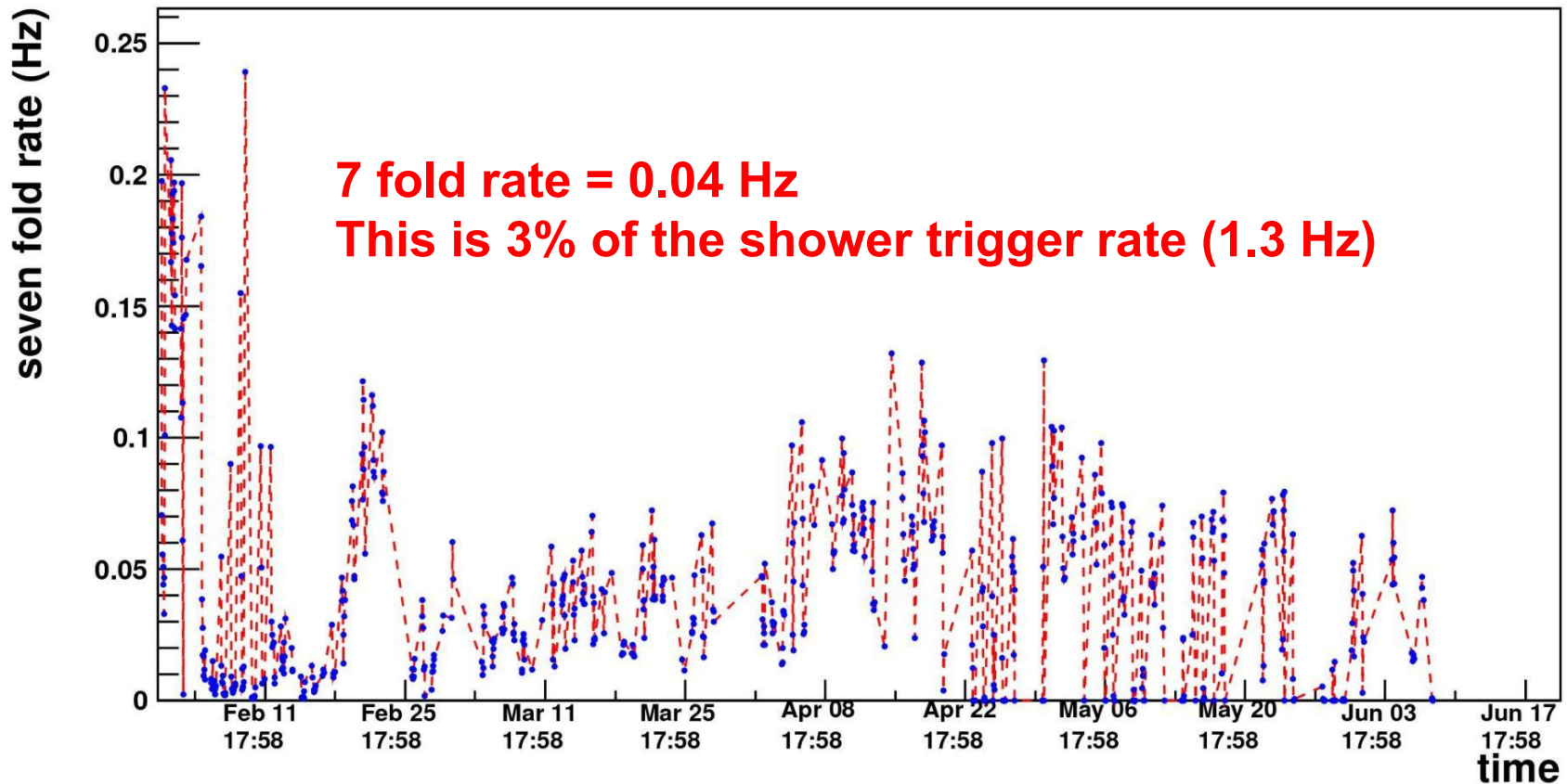
Cosmic ray air shower rate Vs. time



S. Roy et al., Nucl. Instrum. Meth. A, Vol 936 (2019)

S. Roy et al., Springer Proceedings in Physics, Volume 261 (2020)

7-fold rate Vs. time



Summary and outlook

- An air shower array of seven plastic scintillation detectors has been built and commissioned at an altitude of 2200 meters above sea level in the Eastern Himalayas (Darjeeling)
- Continuous measurement of shower rate using this array was carried out since the end of January, 2018 till May 2019
- The average air shower rate is ~ 1.3 Hz with an RMS 0.13 and the 7-fold coincidence rate has been found to be ~ 0.04 Hz with an RMS of 0.02.
- We are now working on integration of the array with a CAMAC based DAQ which will enable recording the data automatically
- This is a pilot project, later this will be extended to an array consisting of 64 such scintillator modules

Acknowledgement

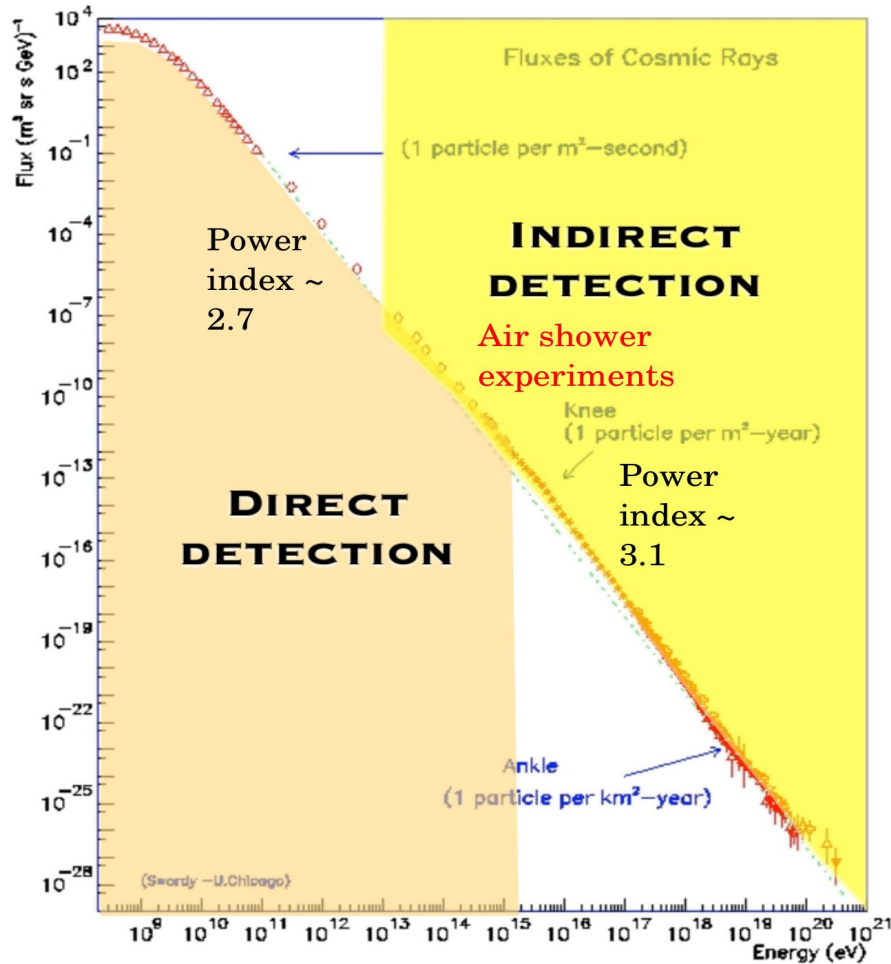
- Mrs. Sumana Singh
- Mr. Deb Kumar Rai, Mrs. Yashodhara Yadav, Mr. Sabyasachi Majee, Mr. Vivek Gurung
- Mrs. Sharmili Rudra
- Cosmic Ray Laboratory, TIFR, Ooty
- IRHPA Phase-II project of DST



Thank you for your kind attention !

BO... INST...

Primary cosmic ray energy spectrum



Correlation of shower trigger and 3 fold signals

