Name of research institute or organisation:

Department of Electric & Electronics Engineering,
Giresun University, Turkey
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Title of project:

φ Dependence study of TAUWER Prototype detector and correlation study of cosmic ray rate with solar activity

Project leader and team:

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Project description:

The project aims for the establishment of an improved silicon photomultiplier (SiPM) readout board system to determine the φ dependence of the cosmic ray rate and to correlate the rate with solar weather parameters. The detector prototype shown in Figure 1, will be a part of a large array which will observe the horizontal and upward going exceptional Ultra High Cosmic rays (UHECRs) and fever neutrino triggered air-showers may be caused by the interactions in air or by higher energy tau air-showers originated by ντ skimming the Earth [1]. In order to investigate about the vertical noise, we dump the horizontal component of cosmic rays pointing to the Jungfraujoch and compare these results to the detector pointing to the Concordia place.

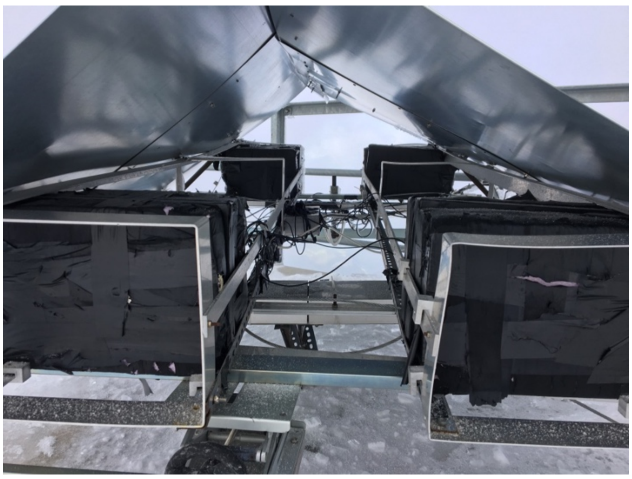
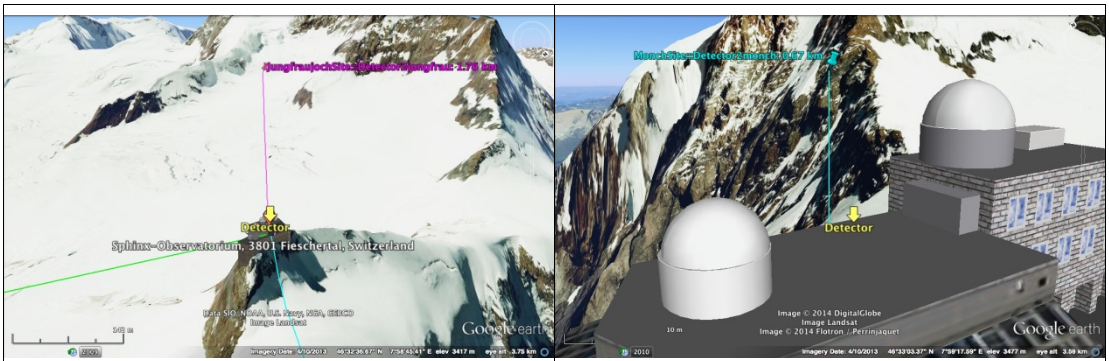


Figure 1. Prototype detector installed at the Sphinx (HFSJG) to test upward/downward particles' separation and environmental effects.

Each detector station, shown in Figure 1, consists of two pairs of scintillator counters (20 x 20 cm^2, 1.4 cm thick) named 'towers', separated by 60 cm. The distance of one pair is 160 cm corresponding to 5.3 ns of time of flight (TOF) of a horizontal track crossing the two scintillating tiles. The detector prototype is using a SiPM produced by SensL and a DRS4 chip as read-out part. In this work we present preliminary results of the prototype detector station.

The first objective is to determine the φ dependence of the cosmic ray rate to evaluate the capability to reject the vertical background. That leads to identifying a good place for observing an air-shower as its maximum developed altitude and directions is studied at high altitude since the air density is so low the noise contribution is also low. For that we change the Φ angle. To detect this influence, the distance between the cosmic ray interaction point and the detection level, the detector prototype, was installed on the terrace of the Sphinx Observatory at Jungfraujoch at 3570 m above the sea level, pointing to the valley 3.3^{o} below the horizon and the distance between cosmic ray is around 1.75 km and to Monch 0.76 km. This setup permits us to measure the vertical cosmic background to verify the capability of the detector to reject them. The setup is depicted in Figure 2 and the data taken in this setup are labelled as phase 1.



(a) (b)

Figure 2. The detector station is located at the Sphinx Observatory. (a) The magenta arrow, pointing to the Jungfrau mountain, is about 1.76 km away from the detector. (b) The turquoise color arrow, pointing to the Monch mountain, is about 0.76 km away from the detector.

Figure 3 shows the registered temperatures inside Tile 1, Tile 2 and the adjusted operating voltages accordingly over all run time for phase 1. The average temperatures on Tile 1 and Tile 2 are about 5.713 ± 3.323 °C, 10.16 ± 5.598 °C, accordingly. The average adjusted operating voltages of SiPMs on Tile 1 and Tile 2 are about 29.65 ± 0.1287 V, 29.8 ± 0.1885 V, accordingly.

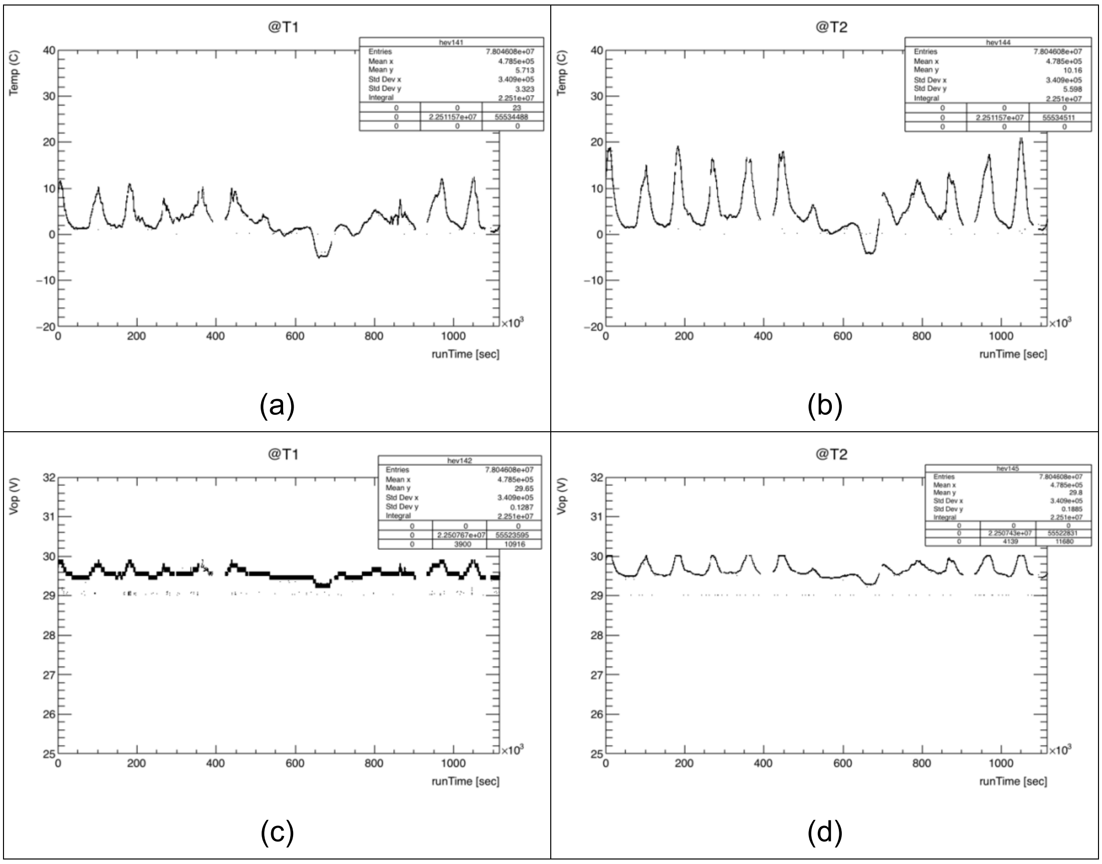


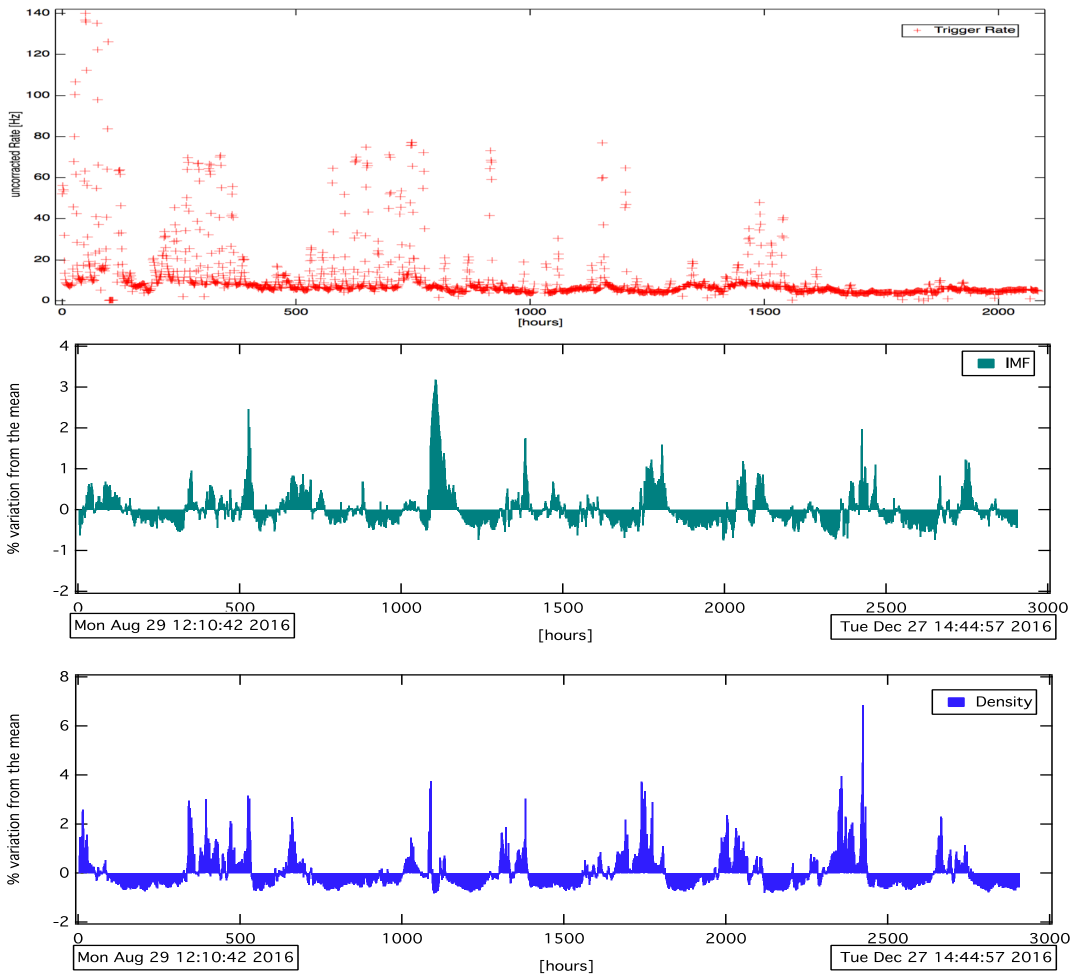
Figure 3. (a) Temperature over all run hours on Tile 1, (b) temperature over all run hours on Tile 2, (c) adjusted operating voltage of SiPM 1 over all run hours on Tile 1, and (d) adjusted operating voltage of SiPM 2 over all run hours on Tile 2.

In December 2016 we have rotated the station through 90º according to the phase 1 setup and started phase 2 pointing to the valley to measure horizontal cosmic ray flux. The comparison between these two measurements gives us the evaluation of vertical background.

Correlation with Space Weather

"Sunspots" are shown as dark spots on the surface of the Sun. Temperatures in the dark points of Sunspots fall about 3700 K (contrast to 5700 K for the surrounding photosphere). They generally last for several days, however very large ones may exist for several weeks. Sunspots are magnetic belts on the Sun with magnetic field strengths thousands of times stronger than the Earth's magnetic field. Sunspots generally move in groups with two sets of spots. One set will have a positive or north magnetic field, while the other set will have a negative or south magnetic field. The field is powerful in the darker sides of the Sunspots. The "F10.7 index" is a measure of the noise level produced by the Sun at a wavelength of 10.7 cm at the Earth's orbit. The radio emission from the Sun at a wavelength of 10.7 centimeters (generally called "the 10 cm flux") has been found to correlate well with the Sunspot number. The Sunspot number is defined from counts of the number of individual Sunspots as well as the number of Sunspot groups and must be reduced to a standard scale, taking into account the differences in equipment and techniques between observatories. The "Kp index" quantifies the disturbances in the Earth's magnetic field from ground level. K perturbation arises from solar particle radiation that is derived from an influx of cosmic rays. There is an anti-correlation between the rate of the cosmic ray and the Kp index. The "solar wind" is the supersonic outflow into interplanetary space of plasma from the Sun's corona, the region of the solar atmosphere beginning about 4000 km above the Sun's visible surface and extending several solar radii into space. The solar wind changes in density, velocity, temperature, and magnetic field properties, with the solar cycle, heliographic latitude, heliocentric distance, and rotational period. It also varies in response to shocks, waves, and turbulence that perturb the interplanetary flow. The "interplanetary magnetic field" (IMF) is a part of the Earth's magnetic field that is carried into interplanetary space by the solar wind. Figure 4 shows the variation of an observed muon flux during a higher solar activity period. On the y-axis is the percentage variation of muon counts, interplanetary magnetic field (IMF), solar proton density, solar plasma speed and plasma pressure and on the x-axis is the number of hours in a day. The higher solar activity time period is indicated by the enhancement of solar parameters, especially the IMF and plasma speed. Moreover, the IMF and plasma speed are two significant parameters that highly impact the variation of galactic cosmic rays with energies below 15 GeV.

Figure 4 shows the uncorrected rate over all run time. The average of the uncorrected rate is about 24.137 ± 0.923 Hz for phase 1. This rate will be used to study the correlation of solar activity.



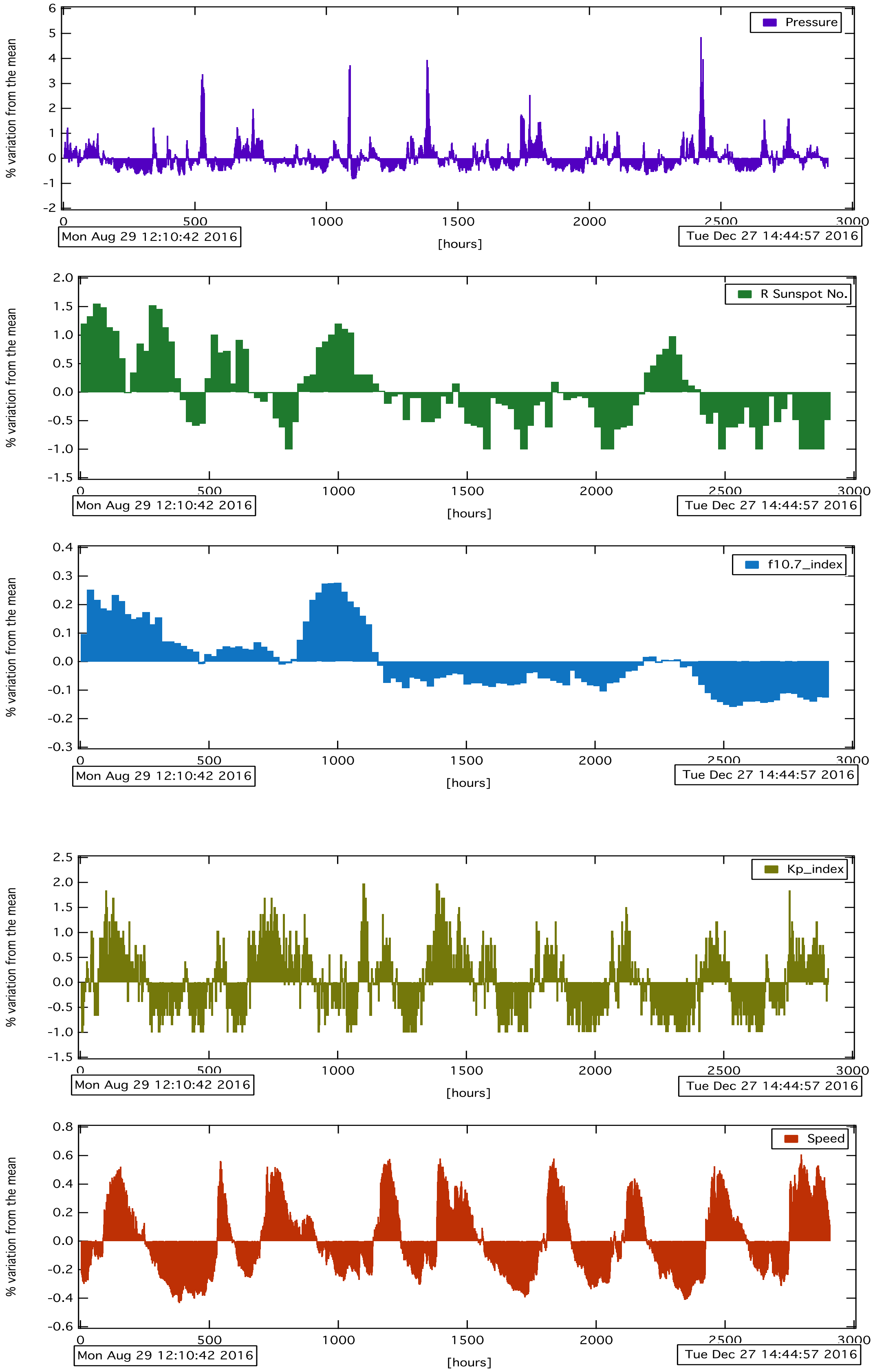


Figure 4. Solar activities observed in June 2016. The percentage variation from the mean pressure uncorrected rate of cosmic rays (green) was measured by the prototype detector working on the Sphinx Observatory terrace. The variation of the mean of solar parameters such as interplanetary magnetic field, solar proton density, solar plasma flow speed, f10.7 index Kp index, sunspot number, and plasma flow pressure, were taken from OMNI solar

weather station [2], the data taking period in terms of hours is corresponding between August 29 to December 27, 2016.

In 2016-2017, we have done extensive tests and the preliminary results were presented at the Turkish Physical Society's "33th International Physics Congress" in September 2017.

References:

[1] A. YILMAZ, H. DENİZLİ and M. IORI, "SiPM Applications on Astroparticle Physics", Accelerator and Detector Physics Workshop @ Istanbul, May 31-Jun 3, 2016.

[2] https://omniweb.gsfc.nasa.gov

Key words:

Cosmic rays, neutrino, silicon photomultiplier, solar activity

Internet data bases:

http://pciori3.roma1.infn.it/

Scientific publications and public outreach 2017:

Conference papers

Yilmaz, A., H. Denizli and M. Iori, Correlation Study Of Cosmic Ray Rate With Solar Activity, Turkish Physical Society's 33rd International Physics Congress (Oral), Bodrum, Turkey, September 6-10, 2017.

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