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Abstract

The second generation Extreme Universe Space Observatory on a Super-Pressure Balloon (EUSO-SPB2) mission has been approved by NASA for a long duration flight (up to 100 days), starting from Wanaka, New Zealand, in 2023. EUSO-SPB2 will monitor the night sky of the Southern hemisphere from 33 km altitude to study Ultra-High Energy Cosmic Rays (UHECRs) and astrophysical and cosmogenic neutrinosEUSO-SPB2 features two main independent telescopes, a Cherenkov (CT) and a Fluorescence (FT) Telescope. The hardware implementation and performance of the FT trigger logic are tested taking advantage of the TurLab facility, hosted at the University of Turin.

Keywords: JEM-EUSO, EUSO-SPB2, TurLab, Fluorescence Telescope, Trigger

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1. Introduction

The Extreme Universe Space Observatory on a Super Pressure Balloon 2 (EUSO-SPB2) is a stratospheric balloon mission developed within the JEM-EUSO Program, aimed at the first detection of Ultra-High Energy Cosmic Rays (UHECRs) from above using optical techniques and at the study of astrophysical neutrinos. EUSO-SPB2 will also serve as a prototype for future satellite-based missions, including K-EUSO [1] and the Probe of Extreme Multi-Messenger Astrophysics (POEMMA) [2]. The EUSO-SPB2 payload consists of two telescopes. The first is a Cherenkov Telescope (CT), based on Silicon Photomultipliers (SiPMs), devoted to the study of the background for future below-the-limb very high energy (E>10 PeV) astrophysical neutrino observations. The second is a Fluorescence Telescope (FT) being developed for detection of UHECRs. The FT will consist of a Schmidt telescope and a focal plane based on Multi-anode Photomultipliers (MAPMTs) for a total of 6192 pixels. This ultraviolet camera is read out with an integration time of 1.05 μs by a set of dedicated ASICs. A trigger code running on the 1.05 μs datastream looks for multiple clusters of excess signal within a certain time window. The adaptive thresholds are update every 500 ms and are based on the average count rate observed by each MacroPixel, a MacroPixel being a 2×2 group of non overlapping pixels. Details on the trigger logic are available in [3]. Its hardware implementation and performance both in terms of rejection of noise and ability to detect fast signals is tested taking advantage of the TurLab facility, hosted at the University of Turin, presented in Section 3. This contribution describes the tests and discusses the obtained results.

2. Functional test in the black box

The trigger logic is tested through a scaled down version of the FT, made of a square matrix of 16×16 pixels, with the same exact electronic of the final telescope . The first functional tests were performed in a black box (Fig. 1) where it was possible to detect and trigger on a track-like signal crossing the field of view in a few μs (Fig. 2). The signal was produced by a UV LED focused by a rotating mirror; adjusting the distance and the speed of the mirror it was possible to control the velocity of the signal. This test proved the ability of the trigger logic to detect signals on the μs timescale.

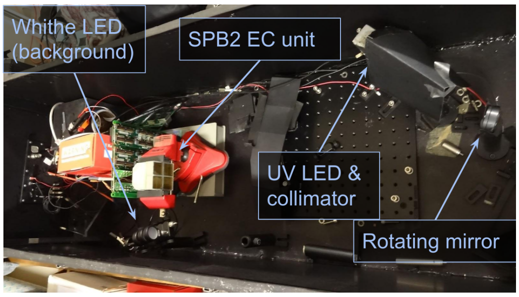

Figure 1: Black box setup.

3. The TurLab facility

TurLab is a laboratory, equipped with a 5 m diameter and 1 m depth rotating tank (Fig. 3). The TurLab tank is located in

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[*] Corresponding author

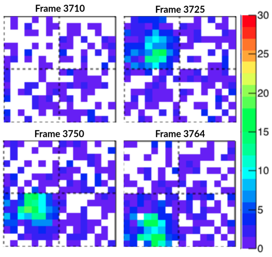

Figure 2: Triggered microsecond timescale track-like signal. The bright spot moves from top to bottom and was detected by the trigger logic.

a very large room, more than 50 m long where the intensity of background light can be adjusted in a controlled way. In the past TurLab has been used to test and validate the data acquisition system of EUSO Balloon, EUSO-SPB1 [4] and Mini-EUSO [5]. The detector has been hung to the ceiling while different passive and active light sources have been placed at the bottom of the tank to test the response of the trigger logic as different sources enter the field of view. In particular, two different light sources flashing at the μs timescale were used, (a single white LED flashing for 100 μs and a stripe of small LEDs switching on in a sequence, to reproduce a track). A set of white LEDs pointed towards the ceiling is used to produce background light (Fig. 4).

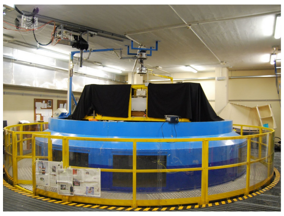

Figure 3: The 5 m diameter rotating TurLab tank with a detector hung above it.

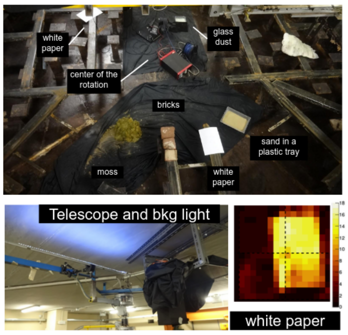

Figure 4: **Top:** Different elements placed inside the tank. **Bottom right:** Detector and background light. **Bottom left:** White paper as it appears in the data.

4. Trigger test at TurLab

The lightcurve of a MAPMT during an entire rotation of the tank (~15 minutes) and the number of triggers are shown in Fig. 5. During these tests the number of triggers were limited to 25 every 5 s. Several parameters like the duration of the rotation and the distance of the detector from the center of the rotation were chosen in such a way that the time it takes for a pixel to completely change its field of view is similar to the expected time necessary during the flight. This allows a fair comparison of the rejection power of the trigger logic. Despite the fact that the intensity of the light changes by more than an order of magnitude, the triggers are concentrated only in specific portions of the rotation, namely when microsecond flashers (LED stripe, white LED) or very bright objects (metallic bar, UV static LED) were in the field of view. The triggers on bright static object do not represent a problem since EUSO-SPB2 is not expected to meet such conditions during its flight. The trigger logic correctly avoid triggering on slowly changing background. Only two spurious triggers (around 130 s and 700 s) were detected in 15 minutes of data taking.

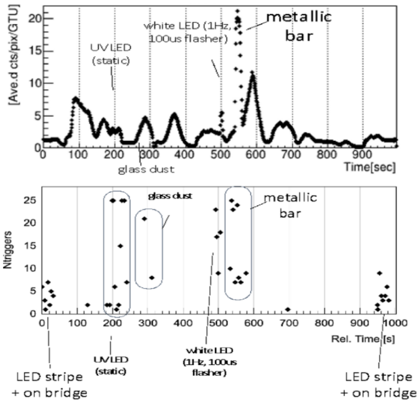

Figure 5: **Top:** Lightcurve of a PMT during a rotation (~15 minutes). **Bottom:** Triggers detected during the rotation.

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