EUSO@TurLab project in view of Mini-EUSO and EUSO-SPB2 missions

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for the JEM-EUSO collaboration

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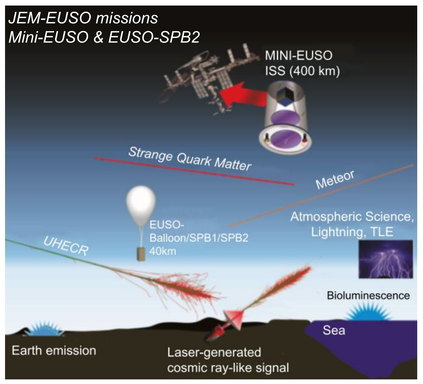
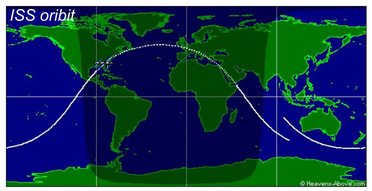
Abstract

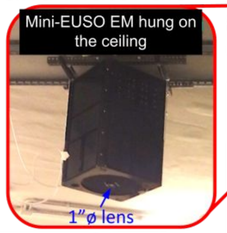
The TurLab facility is a laboratory, equipped with a 5 m diameter and 1 m depth rotating tank, located in the fourth basement level of the Physics Department of the University of Turin. In the past years, we have used the facility to perform experiments related to the observations of Extreme Energy Cosmic Rays (EECRs) from space using the fluorescence technique for JEM- EUSO missions with the main objective to test the response of the trigger logic. In the missions, the diffuse night brightness and artificial and natural light sources can vary significantly in time and space in the Field of View (FoV) of the telescope. Therefore, it is essential to verify the detector performance and test the trigger logic under such an environment. By means of the tank rotation, a various terrestrial surface with the different optical characteristics such as ocean, land, forest, desert and clouds, as well as artificial and natural light sources such as city lights, lightnings and meteors passing by the detector FoV one after the other is reproduced. The fact that the tank located in a very dark place enables the tests under an optically controlled environment. Using the Mini-EUSO data taken since 2019 onboard the ISS, we will report on the comparison between TurLab and ISS measurements in view of future experiments at TurLab. Moreover, in the forthcoming months we will start testing the trigger logic of the EUSO-SPB2 mission. We report also on the plans and status for this purpose.

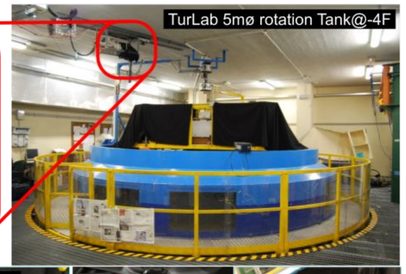
Mini-EUSO & EUSO-SPB2 missions, EUSO@TurLab project

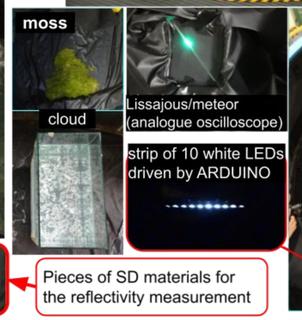




TurLab tank and materials







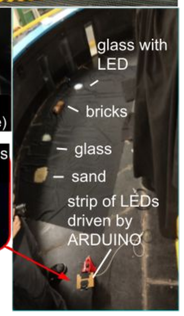


Figure 1: Measurement setup and materials to test at the TurLab tank located at -4th floor of Physics department building of University of Turin. Each materials are passing by in the FoV of the telescope as the tank rotates to simulate the Mini-EUSO observation on the ISS orbit.

Reproduction of Mini-EUSO orbit@TurLab

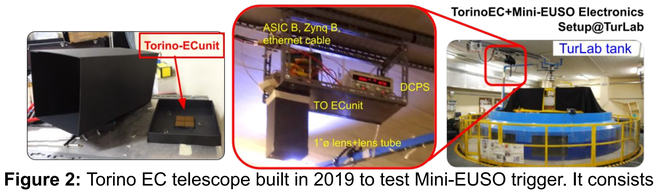


Figure 2: Torino EC telescope built in 2019 to test Mini-EUSO trigger. It consists of one ECunit and front-end and data processing system of Mini-EUSO, external high and low voltage power supplies.

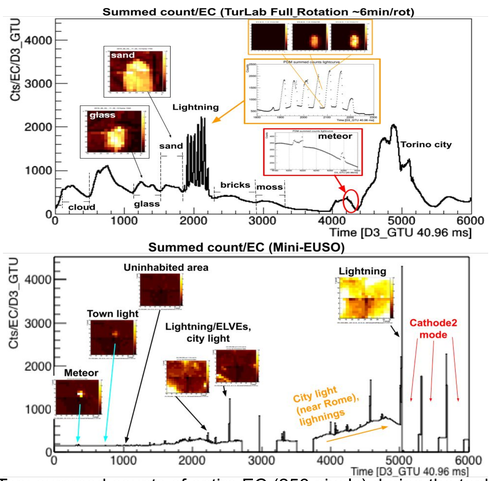


Figure 3: Top: summed counts of entire EC (256 pixels) during the tank rotation at a speed of ~ 6 *min/rot*. TurLab lightning are generated by illuminating ground glass with a white pulse LED. Bottom: an example of Mini-EUSO data in summed counts of entire PDM (2304 pixel) in one night observation in orbit.

Comparison with Mini-EUSO data

Meteor

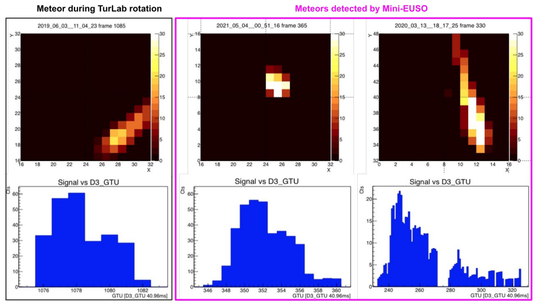


Figure 4: Left: The image of a meteor event reproduced in the TurLab measurement during tank rotation which is passing by through a PMT (top) and its time evolution (bottom) as a function of D3_GTU (40.96ms). Middle and Right: Examples of meteor events detected by Mini-EUSO. Integrated images (top) and time evolution plots (bottom). The blank part in the time evolution plot on the right is due to the gap between 2 PMTs where meteor is passing through.

Flasher Campaign

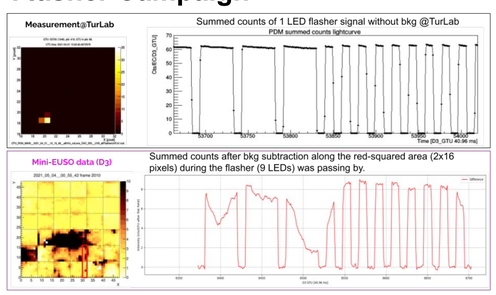


Figure 6: Top: Summed counts of 1 LED flasher measured at TurLab. Bottom: Summed counts of 9 LEDs flasher observed by Mini-EUSO.

City light

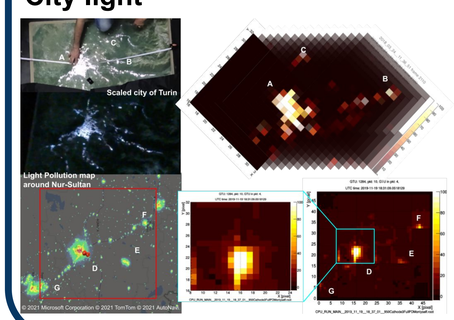
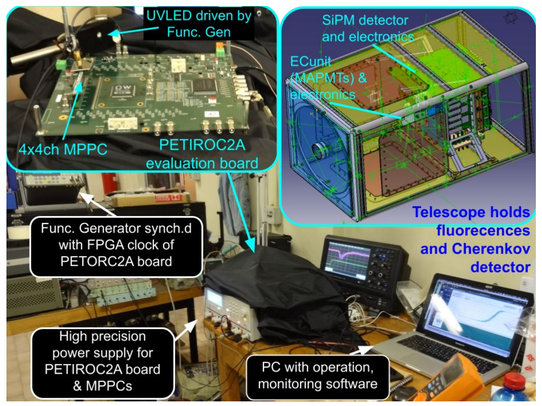


Figure 5: Top: Photos of reproduced night light of scaled city of Turin (left), and the images taken by Mini-EUSO Engineering Model in TurLab measurement, superposed every 10 D3_GTUs across the entire city and its suburbs (right). The tank rotation speed for this run corresponds to three times faster than the one corresponding to Mini-EUSO. Bottom: A light pollution map of Nur-Sultan, one of a cities observed by Mini-EUSO (left), and the image taken by Mini-EUSO. Red square indicates Mini-EUSO FoV, each major cities indicated in the pollution map or the photo of Torino city in TurLab with Alphabet correspond to Mini-EUSO PDM image on the right.

Outlook



igure 7: Preparation for the TurLab measurement for EUSO-SPB2 type detector. Using a 16-ch SiPM device and its dedicated test board (left-top), functional tests are ongoing as shown in the bottom as an example of measurement setup for the test. In parallel, a telescope which can hold both Fluorescence telescope-like system (1 ECunit consisting of 4 MAPMTs and electronics) and Cherenkov telescope-like system (SiPM and its electronics) is designed and going to be built for the TurLab measurement as well as open-sky observation to understand its fundamental performance as well as to test the trigger algorithm.

Conclusion

The EUSO@TurLab project is an ongoing activity with the aim of reproducing the luminous conditions in a laboratory environment that a project of the JEM-EUSO program will see while it's flying in space or on stratospheric balloon platforms. Mini-EUSO type telescope as well as Mini-EUSO Engineering Model are tested in the TurLab facility and the data are compared with the Mini-EUSO data. Further analysis is currently ongoing. The preparation for testing EUSO-SPB2 type of detector is also currently ongoing and we will test it in forthcoming months toward the lunch of EUSO-SPB2 detector.

Acknowledgements

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