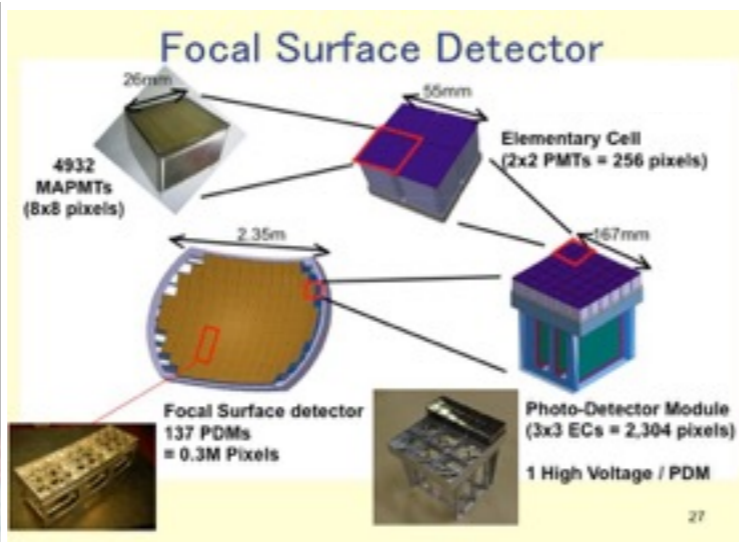




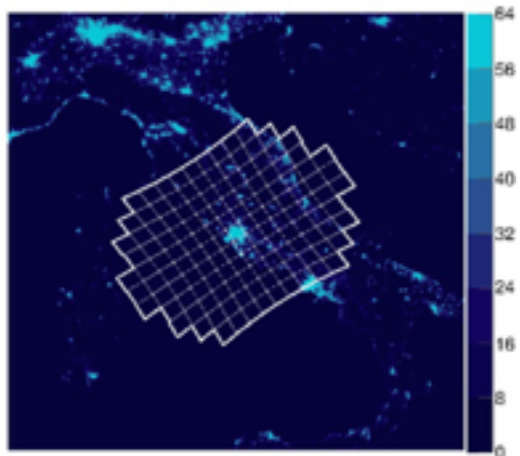
The first level trigger of JEM-EUSO: concept and tests

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Monitored area: $> 1.3 \times 10^5 \text{ km}^2$
 Pixel FoV at ground: $\sim 500 - 600 \text{ m}$
 Time resolution: $\sim 2.5 \mu\text{s}$

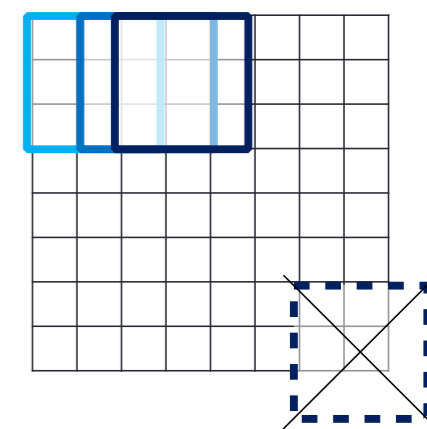
ISS height: 400 km
 ISS speed: $\sim 7.6 \text{ km/s}$
 Orbit duration: $\sim 90 \text{ minutes}$



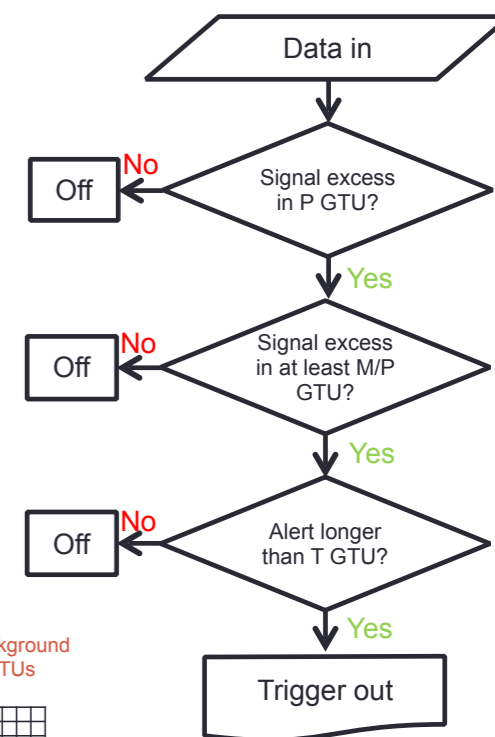
Trigger Concept:

- The trigger logic works at EC level subdividing it in 144 boxes of 3x3 pixels partially overlapping.
- Boxes can not cross MAPMTs
- Pixel counts over a certain threshold (N) are summed for P consecutive Gate Time Units (GTU = 2.5 μs).
- In $M \leq P$ GTUs there should be a pixel in the box with at least N counts.
- If the summation in P GTUs of a box exceeds a pre-fixed threshold (S) a pre-trigger alert is issued.
- N, P and S values are set based on the average background level (night-sky brightness) according to a LUT.
- N, P and S are set every 128 GTUs (250 μs) at EC level by subdividing the EC in 32 blocks of 4x2 pixels and averaging the count-rate in each block every 128 GTU. Parameters are set based on the block with the highest count-rate.
- If a 3x3 box exceeds the S value, a pre-trigger alert is issued.
- If the number of GTUs with a pre-trigger alert in one EC does not exceed a pre-fixed value (i.e. $T = 72$) the trigger is issued. If exceeded, the trigger is not issued because the time duration of the event is not compatible with the EAS duration in the box FoV. With this logic, all anthropogenic lights as well as lightning, meteors, etc.. are eliminated because of their much longer duration (ms or s).

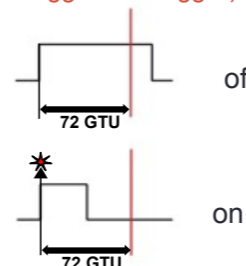
MAPMT and 3x3 pixel boxes



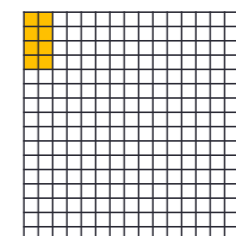
Trigger block diagram



Signal duration (pre-trigger and trigger)



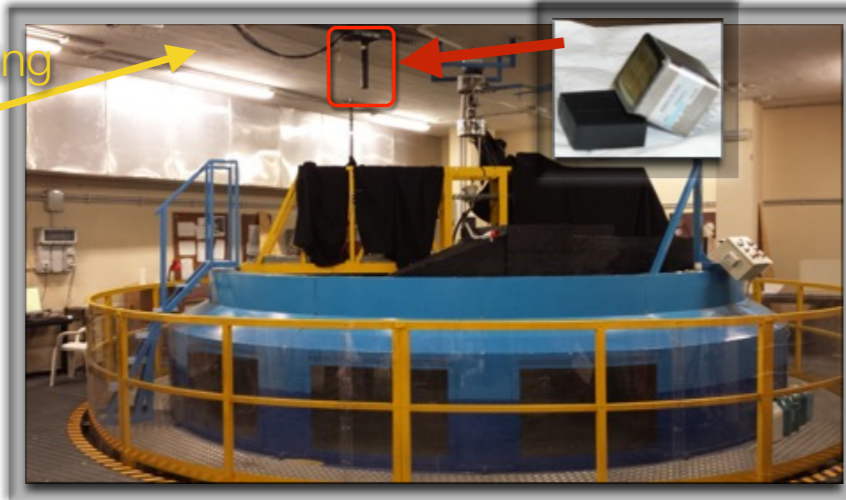
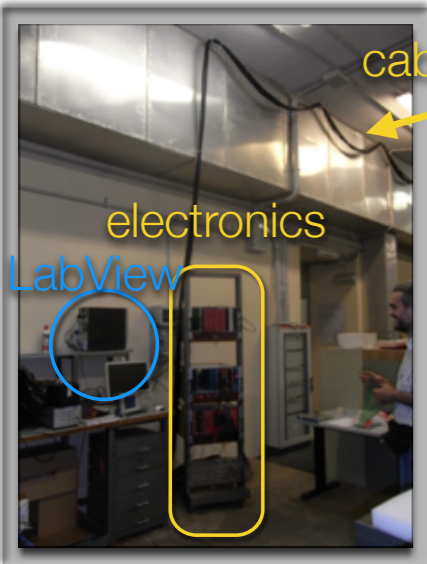
2x4 pixel boxes for background estimation in 128 GTUs



The 1st level trigger should satisfy the following requirements:

- Keep the average trigger rate on false events (i.e. anthropogenic lights, lightnings, meteors, etc...) below 1 Hz per Elementary Cell.
- Adjust the trigger parameters in order to fire on EAS of energy $E_{\text{thr}} < 3 - 5 \times 10^{19} \text{ eV}$ on variable level of light intensity
- It should be implemented on FPGA (Virtex6, XC6VLX240T)
- It should exploit the different time duration of EAS (50 - 150 μs) compared to other atmospheric phenomena (ms or s)

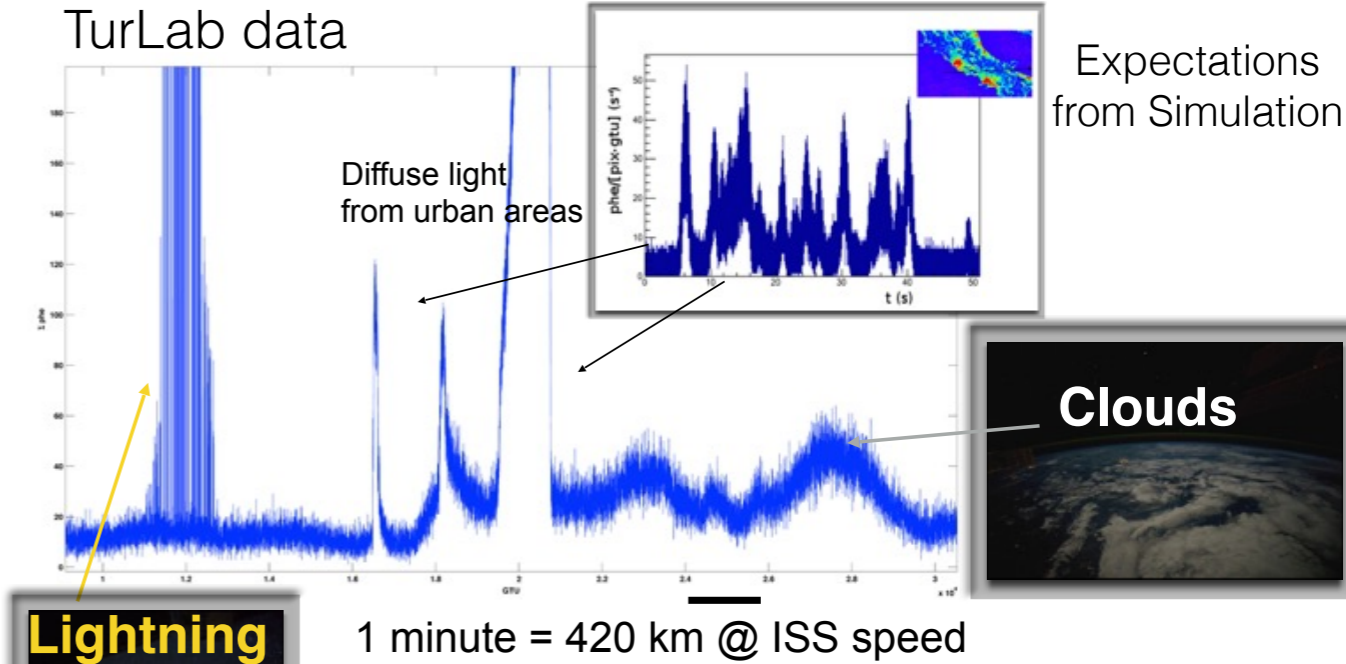
Validation of the Trigger logic at TurLab



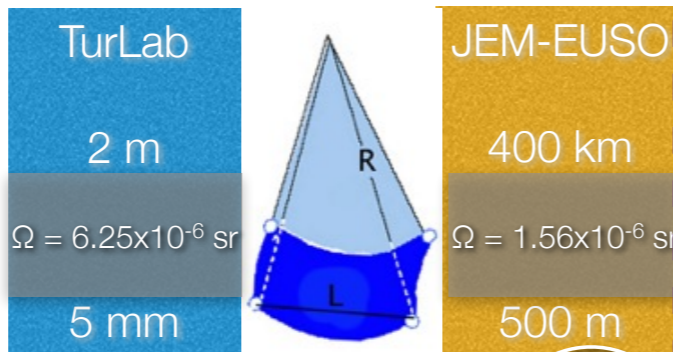
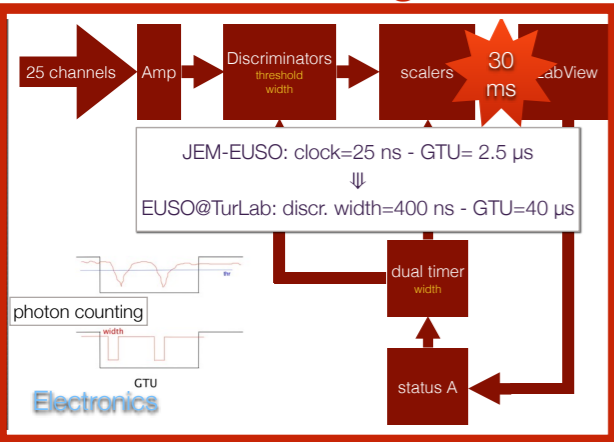
M25 MAPMT

TurLab: <http://www.turlab.ph.unito.it/turlab.php>
 5m \varnothing rotating tank, speed: 12 - 1200 s
 Completely dark environment: -4F
 Rescaling of JEM-EUSO @ TurLab

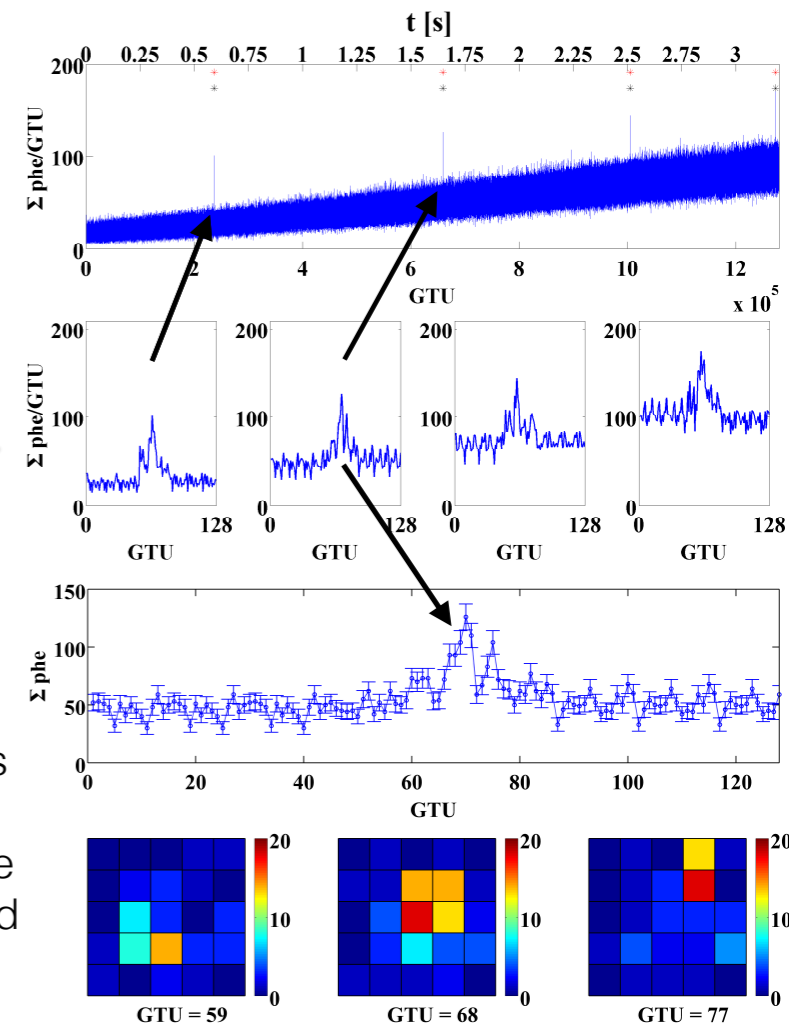
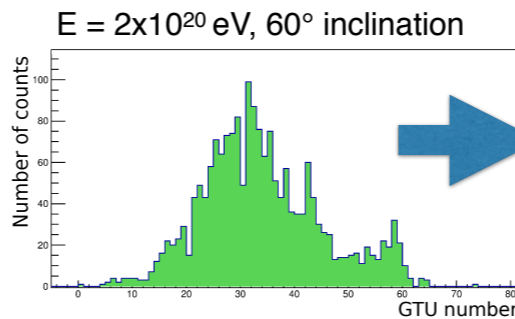
Night-sky background and atmospheric phenomena



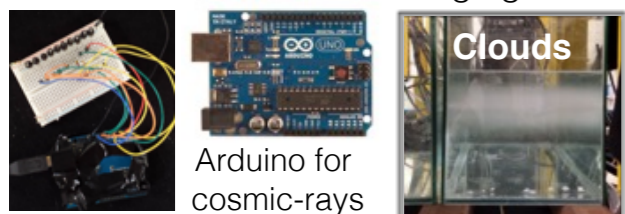
NIM and CAMAC logic



Cosmic ray Events



- Light sources obtained using:**
- fixed or slowly varying diffused light (for background)
 - Arduino-based LED circuits for cosmic rays & Meteors
 - Pulses LEDs for lightning
 - Fixed LED light for cities
 - Different materials for changing albedo



ISS: 7.6 km/s — TurLab: 10⁻¹ m/s
 speed ratio TurLab/ISS: 10⁻⁵
 5 mm/500 m = 10⁻⁵
 1 rot/2 min
 R = 2 m

Triggers occur only in presence of EAS-like events (*) while thresholds are continuously adjusted on the variable background to avoid triggers on false positives