The EUSO@TurLab Project

M. Bertaina for the JEM-EUSO Coll.
Torino University & INFN

The EUSO@Turlab group:

M. Bertaina, A. Bowaire, G. Cotto, R. Forza, M. Manfrin, R. Mulas, P. Tibaldi
Univ. & INFN Torino

R. Caruso, G. Contino, N. Guardone
Univ. & INFN Catania

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JEM-EUSO is an Astronomical Earth Observatory from Space

- SNR
- GRB
- Pulsar
- Dust and Meteors
- Ultraviolet photons
- Air shower

\[ X, \gamma, \nu, p, n, e \]

- Charged Particles
- UV, X, \gamma, \nu
- Air shower
- Solar wind
- Plasma Discharge
- EHE Neutrinos

The Earth
JEM-EUSO

FoV \hspace{1cm} 1.4 \times 10^5 \text{ km}^2

time resolution (GTU) \hspace{1cm} 2.5 \mu\text{s}

spatial resolution \hspace{1cm} 500 \text{ m}
Focal Surface

320,000 pixels
4.5 m²
PDM

each PDM works independently

2304 pixels

FoV: 27x27 km$^2$
ISS

- 7.5 km/s
- 15.5 orbits per day
- 30-45 min night sight
The Pacific Ocean Through the Cupola

Videos produced by the Crew Earth Observations group at NASA Johnson Space Center

For replication and crediting information, please see our guidelines on our main video page.

European City Lights

Videos produced by the Crew Earth Observations group at NASA Johnson Space Center

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What we see and what JEM-EUSO will see

From satellite and balloon data typical range of night glow background between 300 - 400 nm is:
300 - 1000 ph/(m²·ns·sr)

500 ph/(m²·ns·sr)  $\downarrow$  1.4 phe/pix/GTU

Astroparticle Physics 36 (2013)
JEM-EUSO Coll.
simulating the Earth

Aeolian Islands

reasonable scaling compared to BABY balloon data

O. Catalano et al. NIM A 480 (2002) 547
simulating the Earth crossing central Italy
A laboratory for geo-fluidodynamics studies where rotation is a key parameter:

- Coriolis force
- Rossby Number

Advantage of such a laboratory: Possibility of controlling the boundary conditions

http://www.turlab.ph.unito.it/turlab.php
Experimental approaches @ TurLab

Ink

Qualitative measurements
Fast and simple
fluorescent or standard inks

Particles

Quantitative measurements
Density = 1.03 g/cm³
Diameter: 5-1000 micron
Good reflectivity with ‘spheric’ form
Cheap

Smallest particles (5-10 micron) stay in suspension, in fresh water, for several hours; largest ones (1000 micron) per few minutes.
Planetary Atmospheric & Fluid instabilities

Hexagon at Saturn’s North Pole

instability of Kelvin-Helmholtz in not confined streams

instability in confined streams
Results at a large rotating tank (TurLab)
TurLab

Rotational speed
max: 1 rot. in 12 s
min: 1 rot. in 20 min

dynamic range: 1-100

Ø 5m rotating tank
Current set-up

- 5x5 pixel MAPMT
- electronics
- the tank
Electronics

25 channels → Amp → Discriminators
  threshold
  width
→ scalers
→ LabView

JEM-EUSO: clock=25 ns - GTU= 2.5 μs

↓

EUSO@TurLab: discr. width=400 ns - GTU=40 μs

dual timer
  width

status A

photon counting

Electronics

GTU
resolution

time
1 GTU = 40 μs sampled every 30 ms

space
1 pixel watches a FoV of 5x5 mm²

ISS: 8 km/s — TurLab: 10⁻² m/s
speed ratio TurLab/ISS: 10⁻⁶

5 mm/500 m = 10⁻⁶
Hamamatsu R8900-M25

uniformity 4:1
Possible Configurations
Background is Poissonian on all pixels

4x10^6 GTUs = 100 seconds
2 approaches:

- ‘absolute time’
  \[\rightarrow s\] (for xxx-EUSO’s PDM)
- ‘sampling time’
  \[\rightarrow GTU\] (for offline trigger purpose)

- 300 s \(\rightarrow 2250\text{km}\)
- 10000 GTU \(\rightarrow 200\text{m}\)
1 rotation = 15 minutes

Lightning storm  
Point-like sources

Diffuse light like urban areas

Extended sources like clouds

1 minute = 420 km @ ISS speed
3 rotations = 1 ISS orbit  
(night part = 45 minutes)
different light sources

- light emitting sources
- materials reflecting background light
different backgrounds
same materials can give different response depending on room light conditions
Possible Scenarios
changing tank speed:

abs. time: 0.7 - 70 s
ISS: 5 - 500 km
3600 GTU: abs. time 110 s (ISS 750km)

abs. time: 1.4 - 140 s
ISS: 10-1000 km
Clouds
JEM-EUSO for wave watching?

- The tank can contain water.
- 2 fans produce different conditions of wind.
- We can see waves with the MAPMT.
waves
as wave height increases
we have non-Poissonian luminosity
20-30 GTU: 0.6-0.9 s

meteor

EECR
ARDUINO
An electronics prototyping platform based on open-source hardware and software

- 14 input/output digital pins and 6 analog input pins
- 8-bit Atmel microcontroller @ 16Mhz;
- USB connection
- Ceramic resonator
- Power jack
- Voltage regulators and electronic circuits supporting the microcontroller
A strip of LEDs that are driven by the Arduino with an accuracy of 1µs
First level trigger

320000 pixel counting every 2.5 μs

vs

ISS data transferring 300 kbit/s

rejecting most of light background fluctuations

allowed acquisition rate:

few Hz/PDM
pre-trigger
Conclusions

- At TurLab we can create a wide variety of conditions reproducing the Earth luminosity.
- Measures obtained with a 25 pixel MAPMT were used to test the feasibility of the experimental reproduction of situations that JEM-EUSO will encounter while flying.
- In next step we plan to test at TurLab 1 Elementary Cell of JEM-EUSO.
Wish to do your experiment at TurLab?

http://www.euhit.org

Thank you!