The EUSO@TurLab Project

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Torino University & INFN

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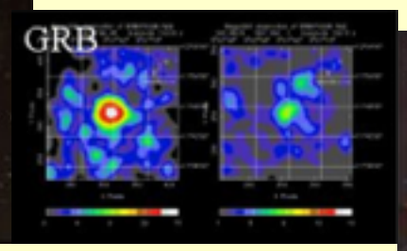
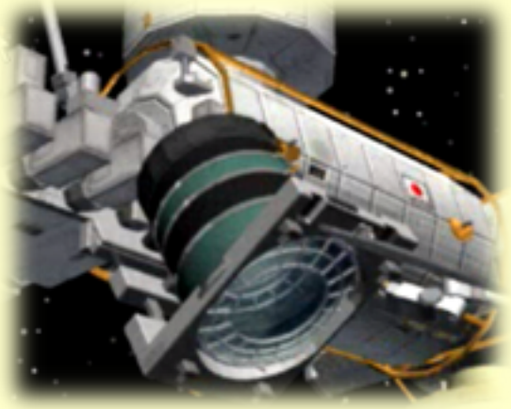
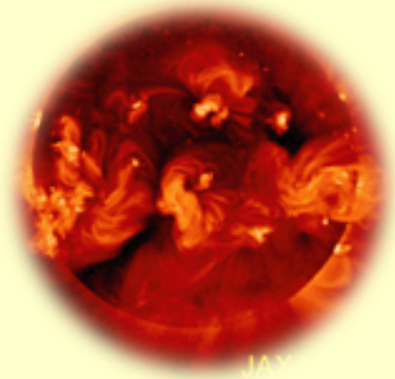
Univ. & INFN Catania

ATMOHEAD2014, Padova, 19-21 May 2014

JEM-EUSO is an Astronomical Earth Observatory from Space







EECR s

Dust and Meteors

Charged Particles

Ultraviolet photons

UV, X, γ, ν
p, n, e

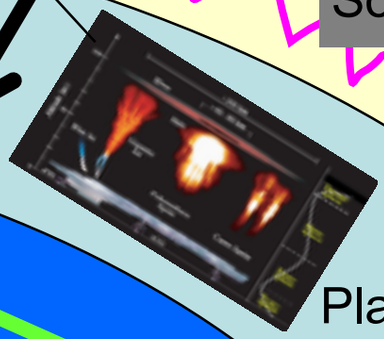
$X, \gamma, \upsilon, p, e$

Air shower

Air shower

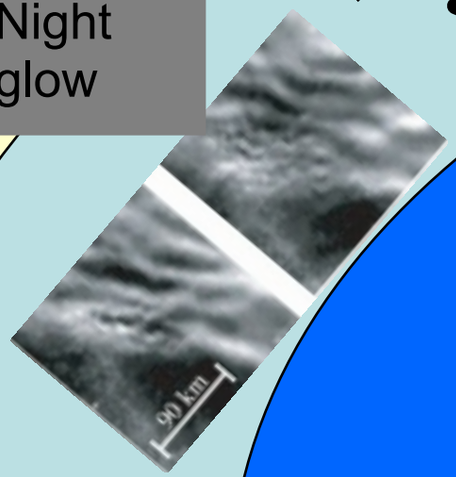
Atmosphere

Solar wind



Plasma Discahrge

Night glow



The Earth

EHE Neutrinos

esa space for europe

JAXA Japan Aerospace Exploration Agency

NASA

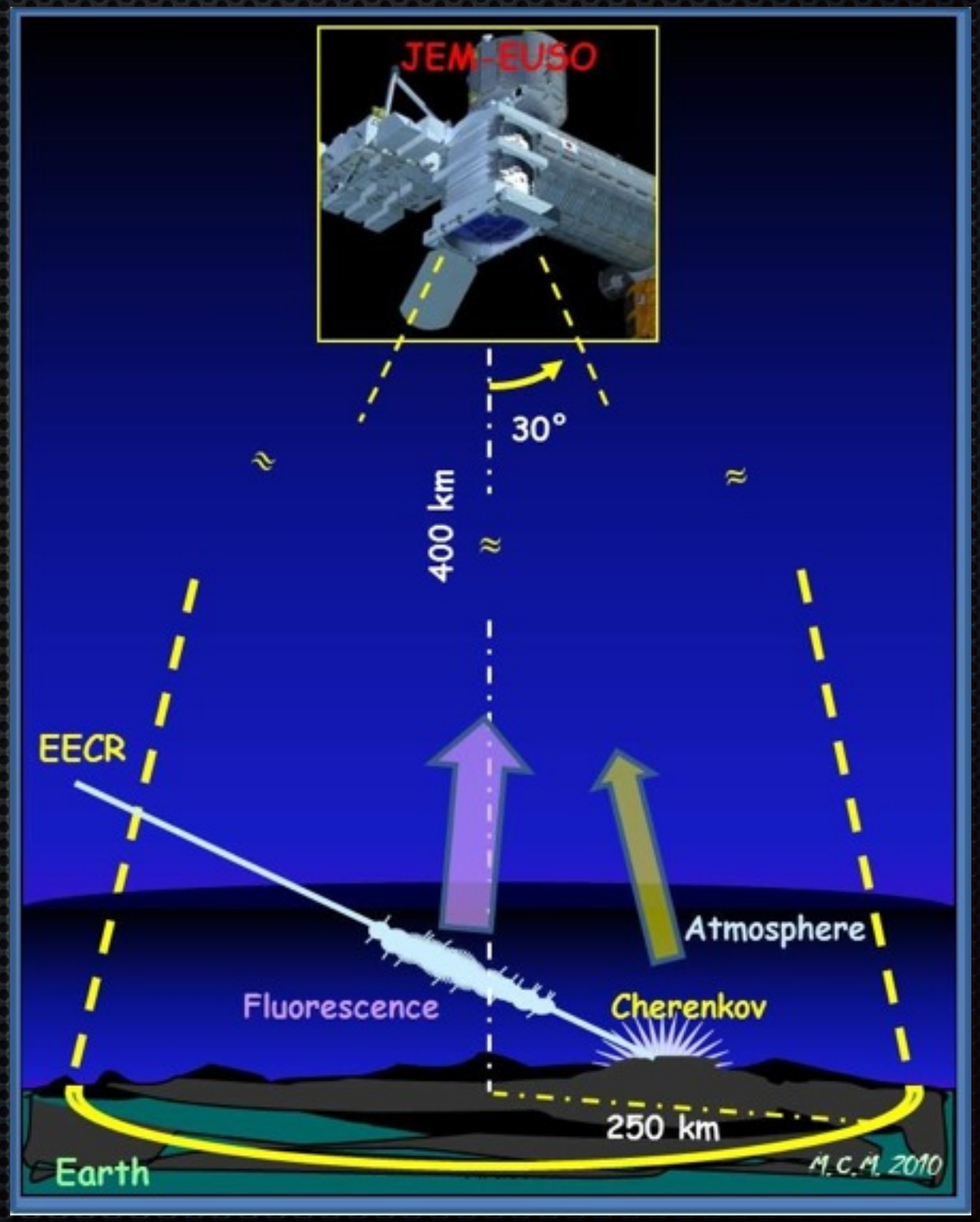
РОСКОСМОС

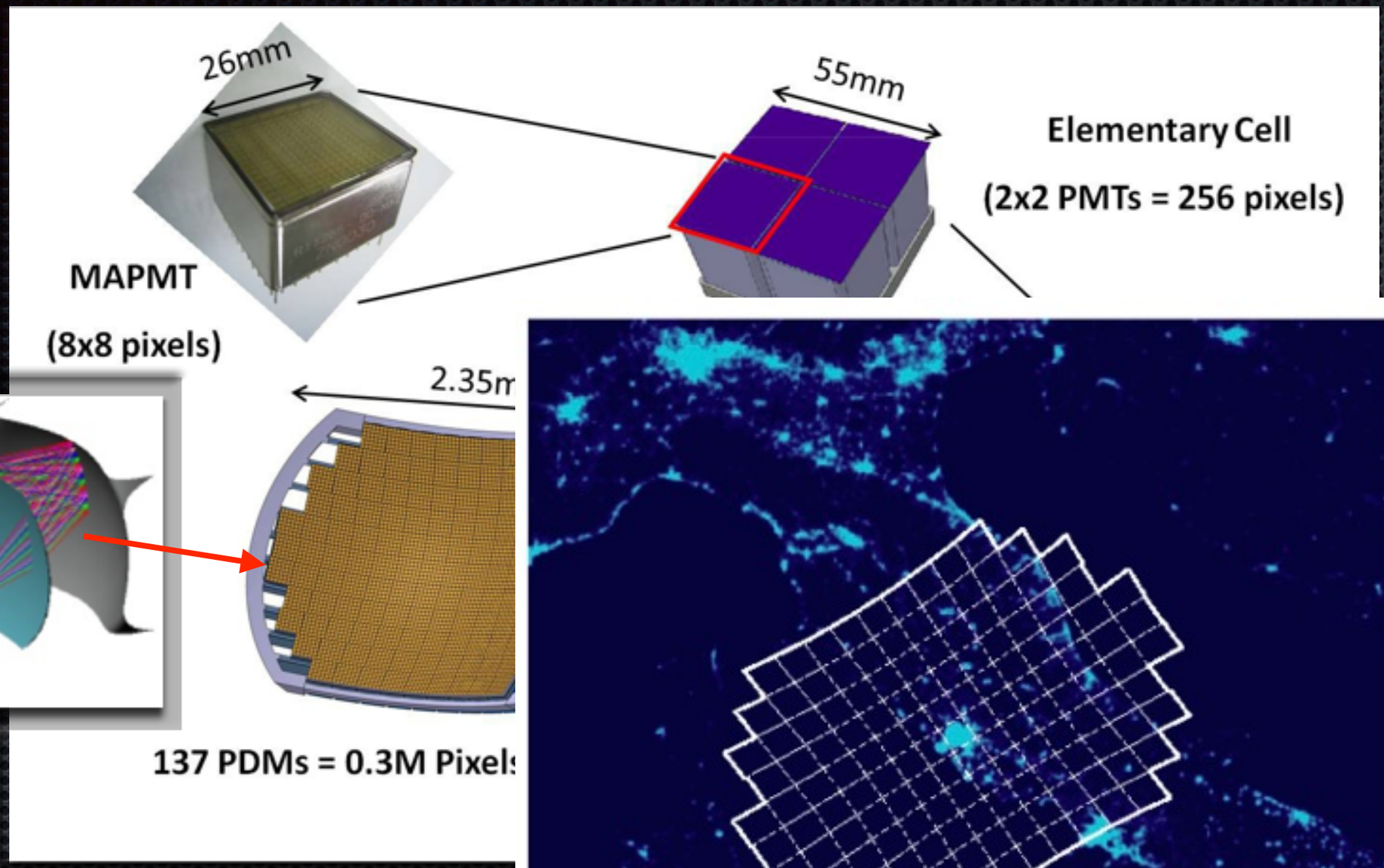
JEM-EUSO

FoV $1.4 \text{ x } 10^5 \text{ km}^2$

time resolution (GTU) $2.5\ \mu\text{s}$

spatial resolution 500 m



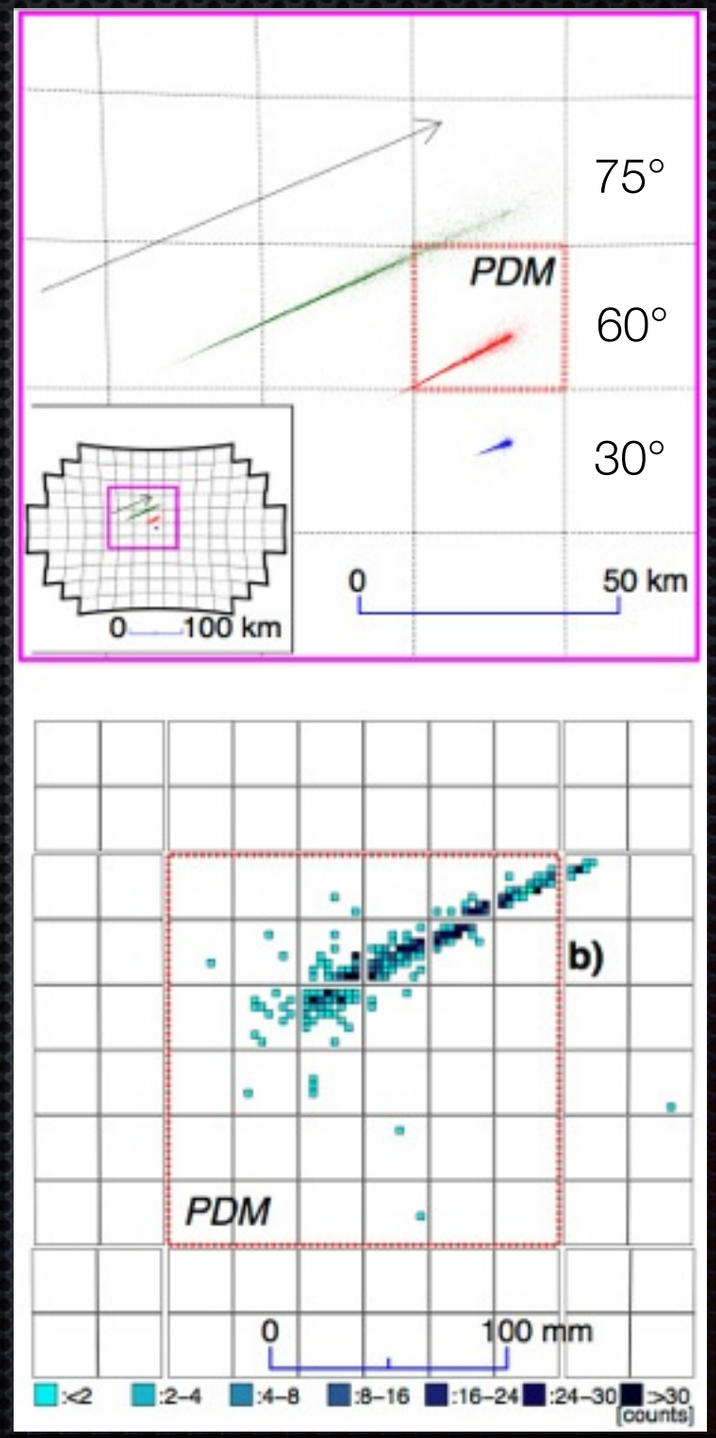


Focal Surfa

320 000 pixels

4.5 m^2

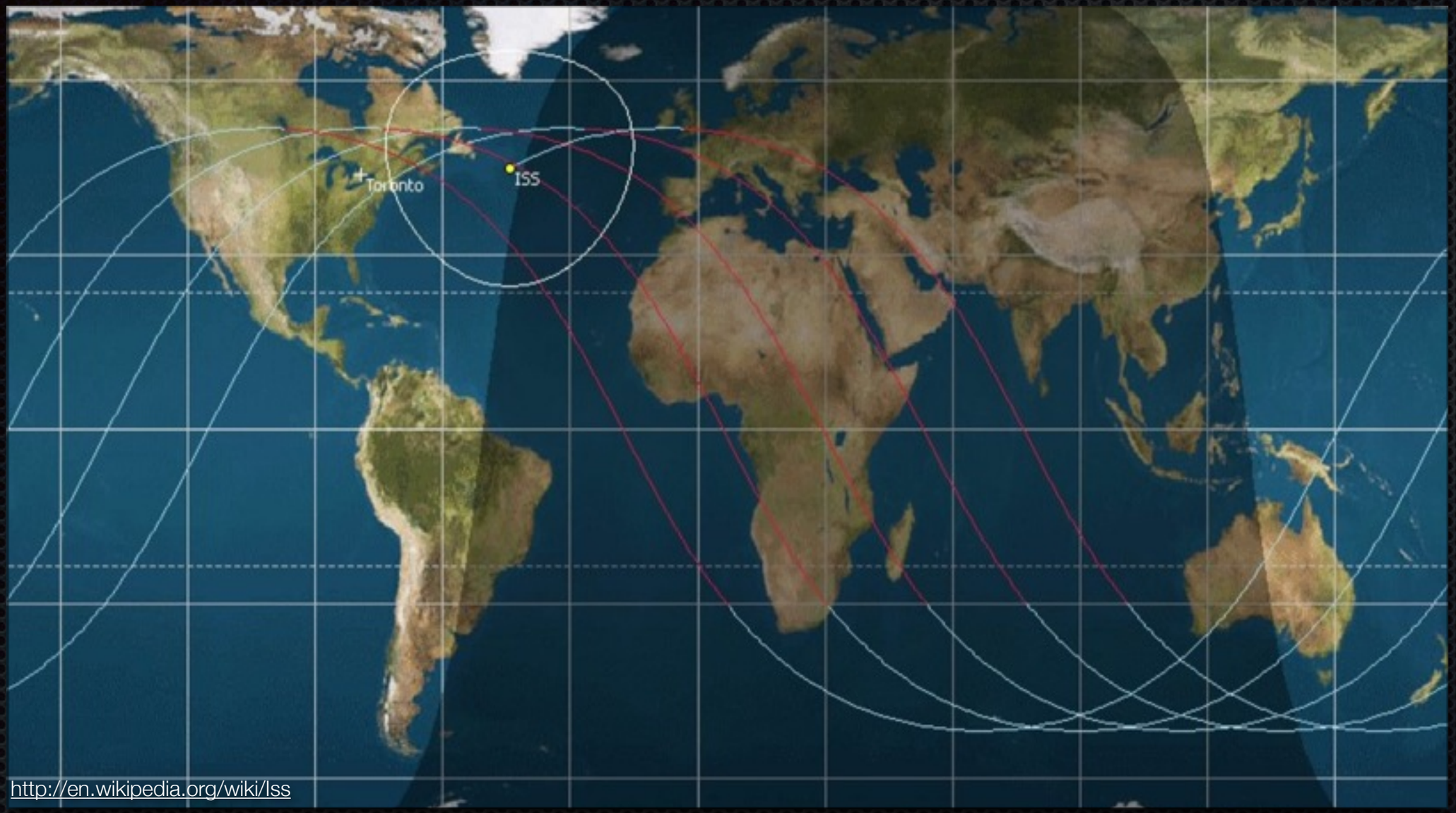
PDM



each PDM works independently

2304 pixels

FoV: 27x27 km^2



http://en.wikipedia.org/wiki/Iss

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

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

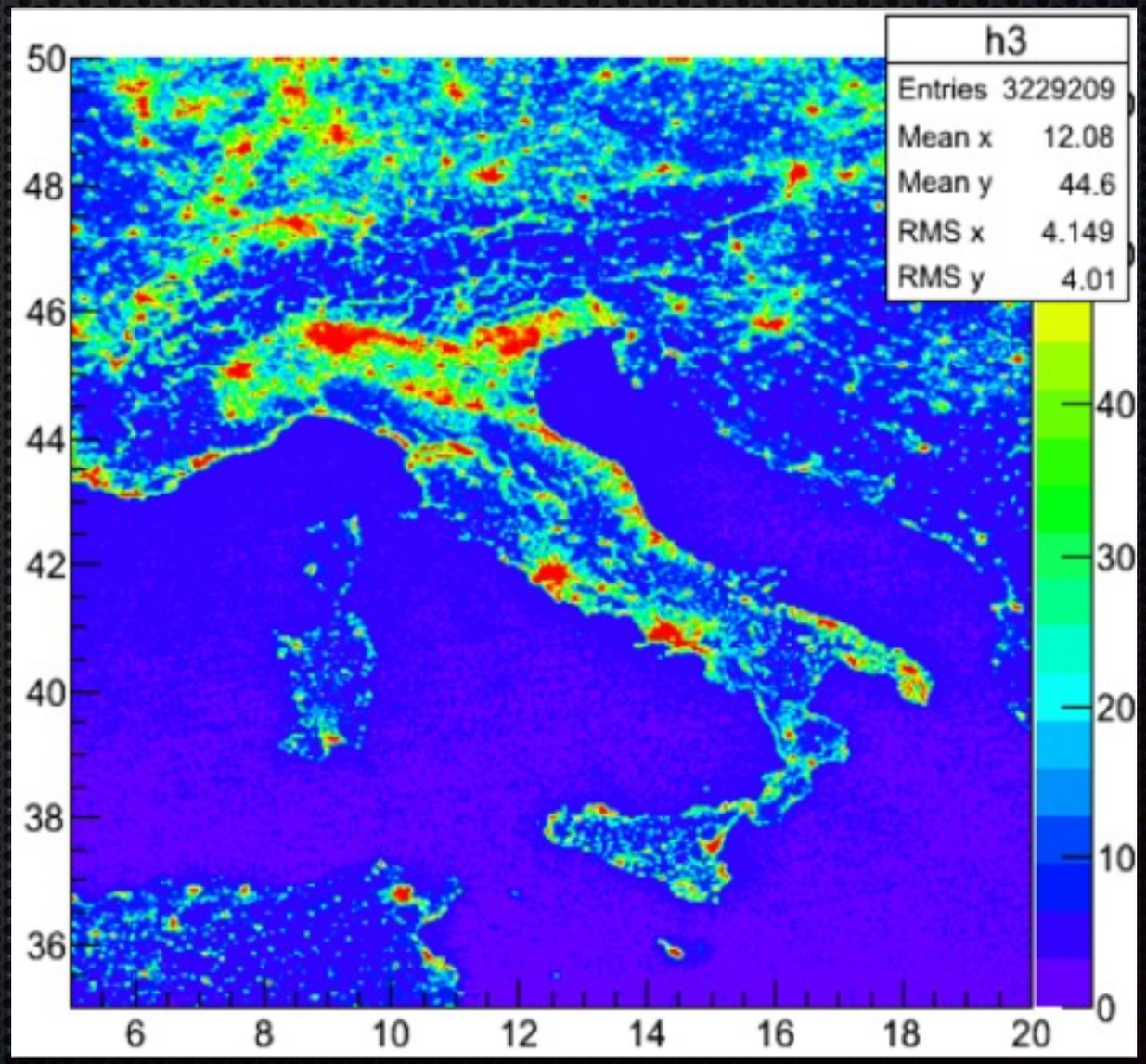
What we see and what JEM-EUSO will see

From satellite and balloon data typical range of night glow background between 300 - 400 nm is:
300 - 1000 ph/(m^2·ns·sr)

500 ph/(m^2·ns·sr) sky

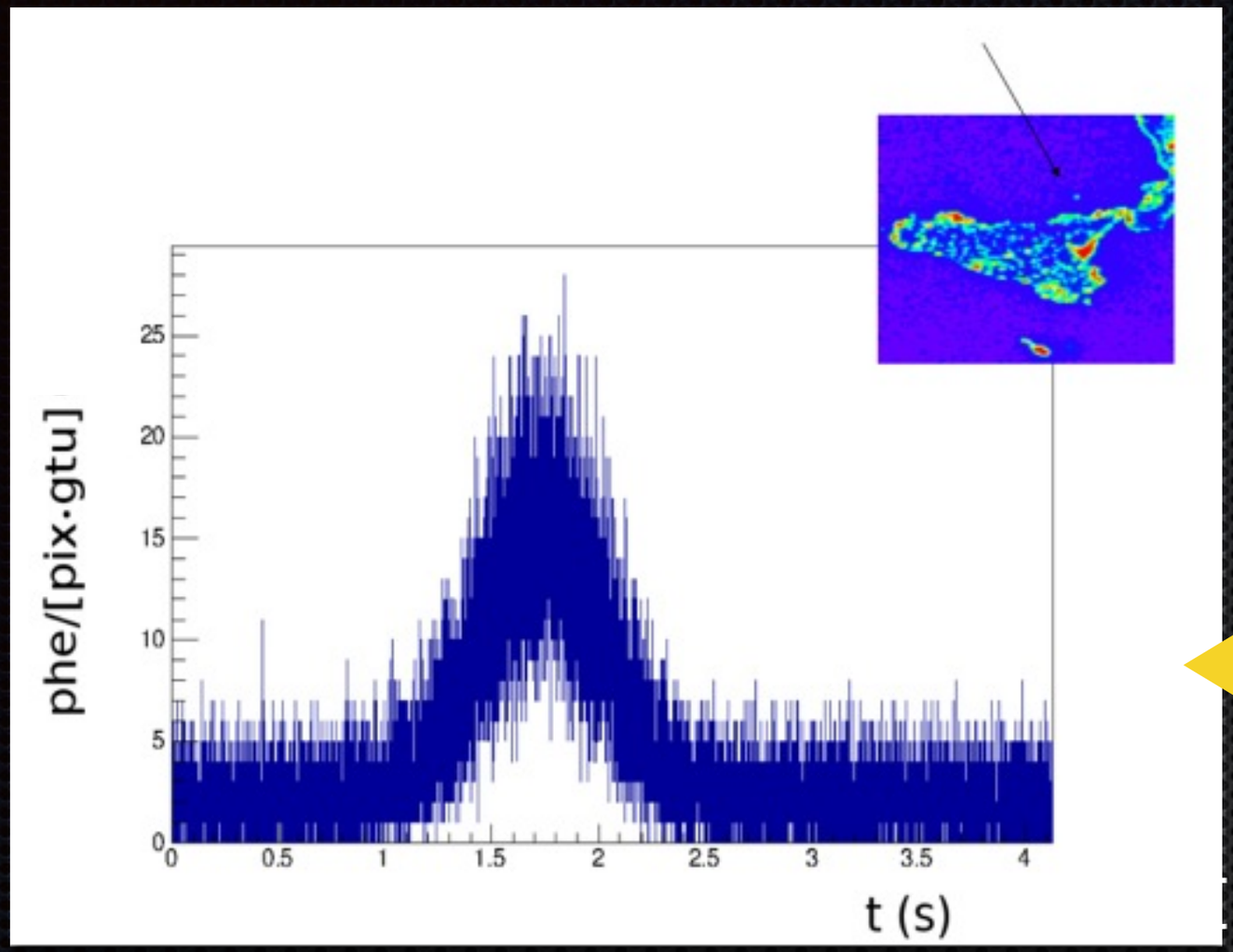
⇓

1.4 phe/pix/GTU JEM-EUSO



DMSP(Defense Meteorological Satellites Program)

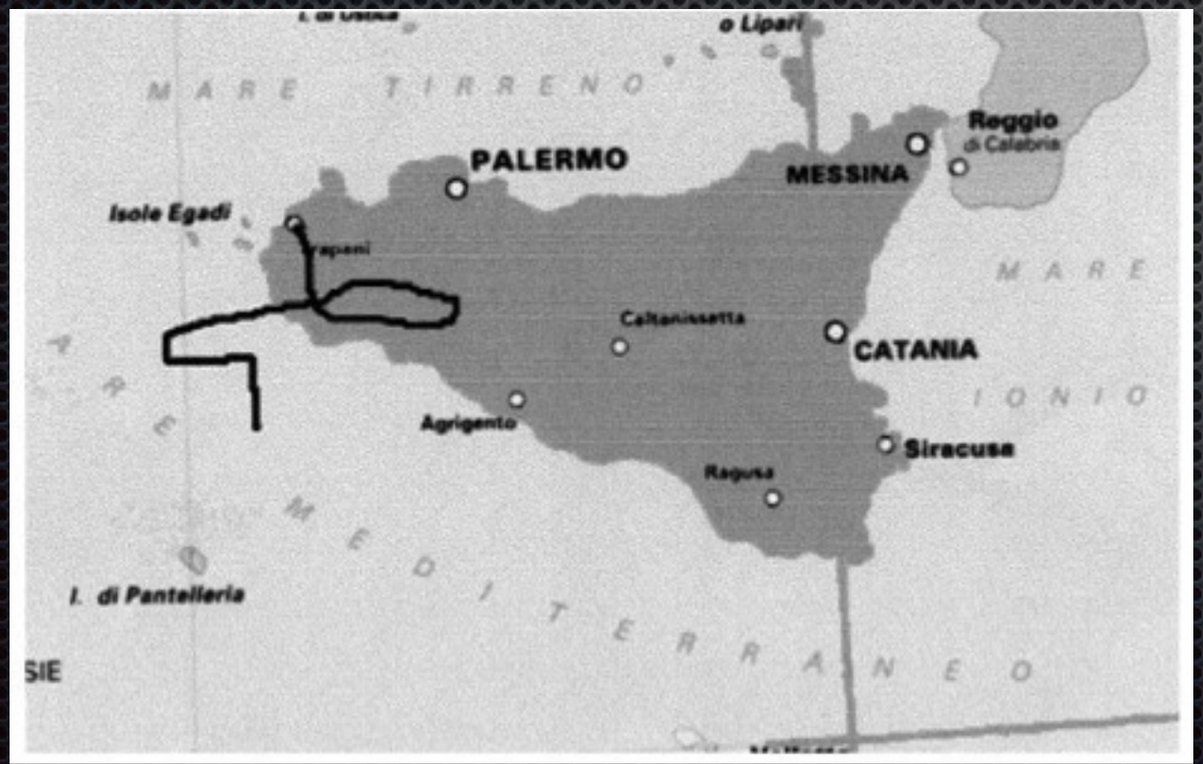
Astroparticle Physics 36 (2013)
JEM-EUSO Coll.



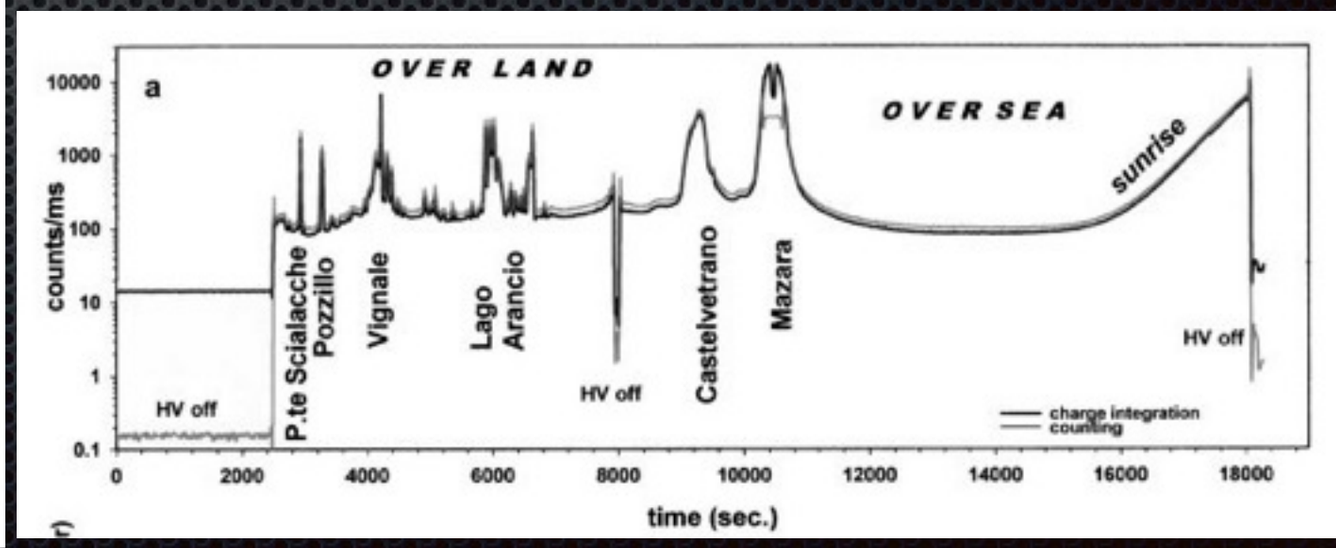
simulating the Earth

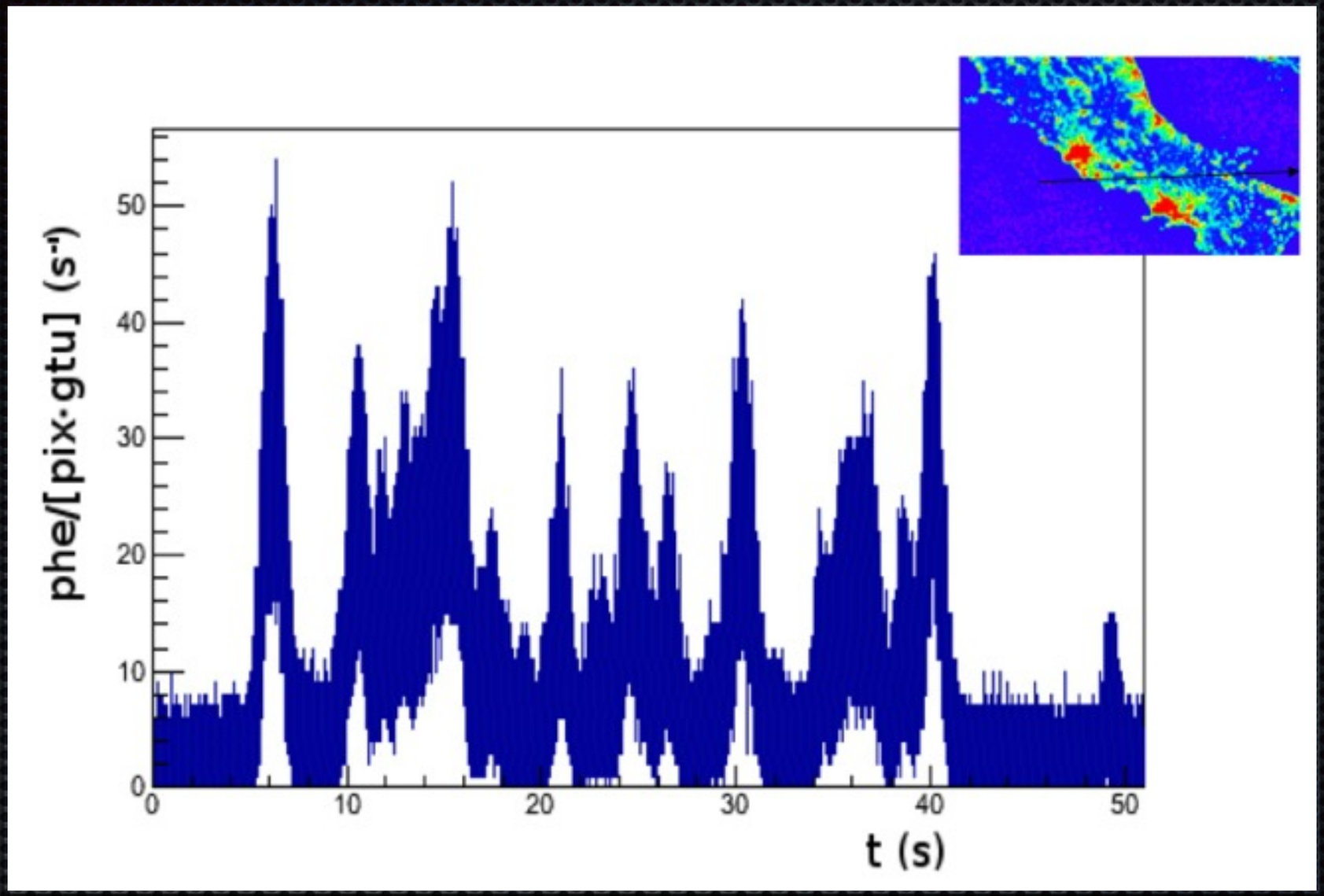
Aeolian Islands

reasonable scaling compared to BABY balloon data



O. Catalano et al. NIM A 480 (2002) 547





simulating the Earth

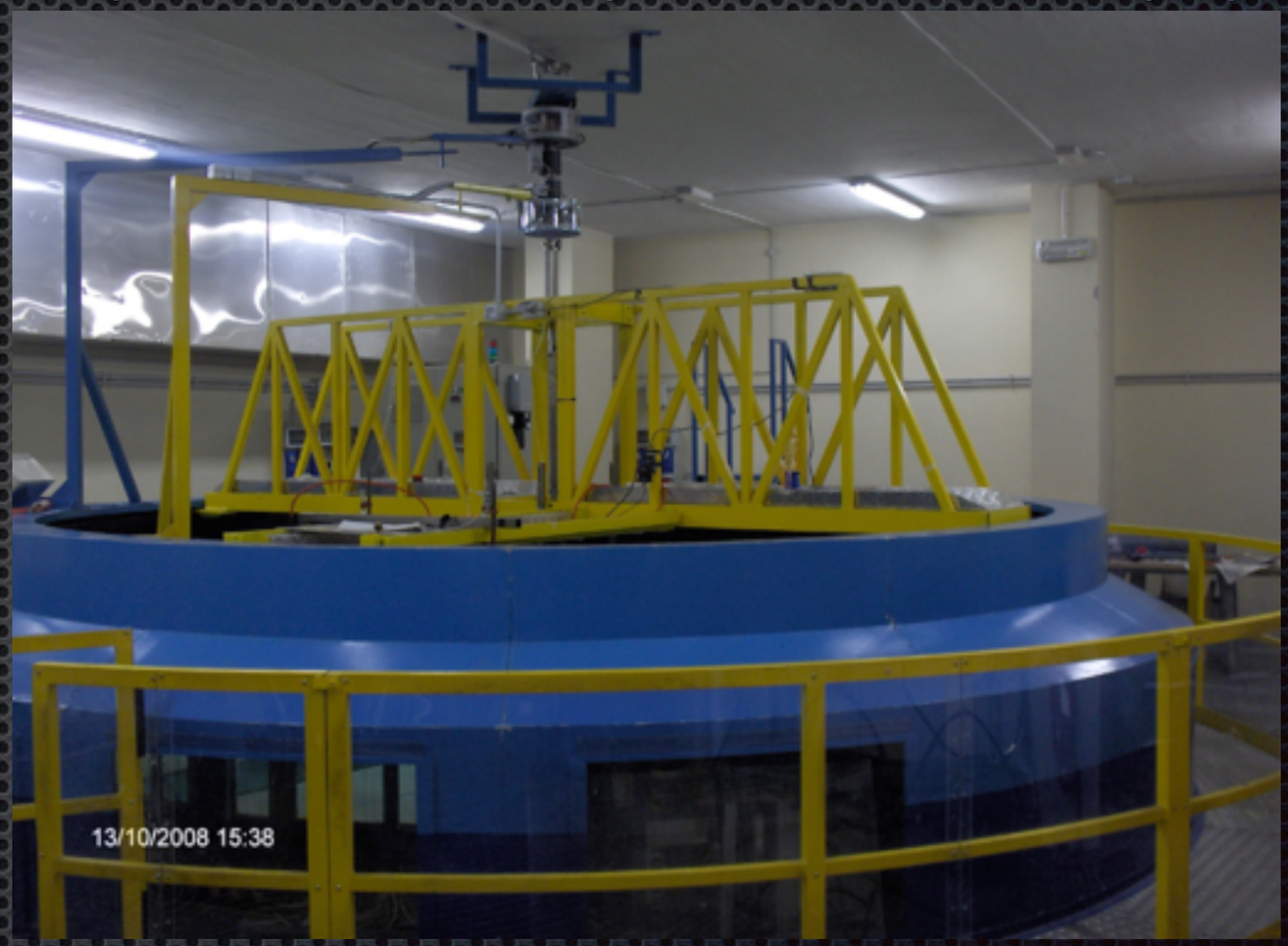
crossing central Italy

The TurLab @ Physics Department - Torino University

A laboratory for geo-fluido-dynamics studies where rotation is a key parameter:

- Coriolis force
- Rossby Number

http://www.turlab.ph.unito.it/turlab.php



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

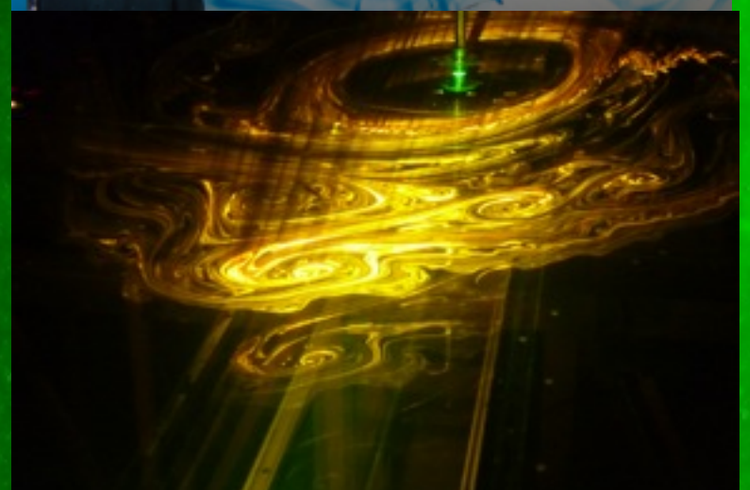
Experimental approaches @ TurLab

Ink

Qualitative measurements

Fast and simple

fluorescent or standard inks



Particles

Quantitative measurements

Density =1.03 g/cm^3

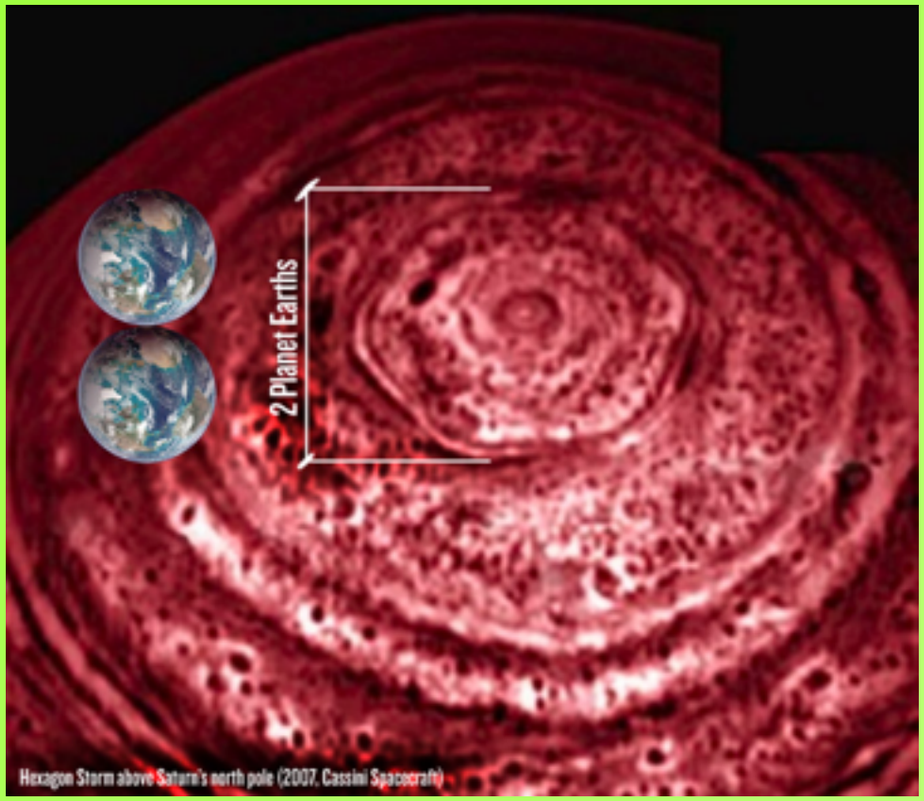
Diameter: 5-1000 micron

Good reflectivity with ‘spheric’ form

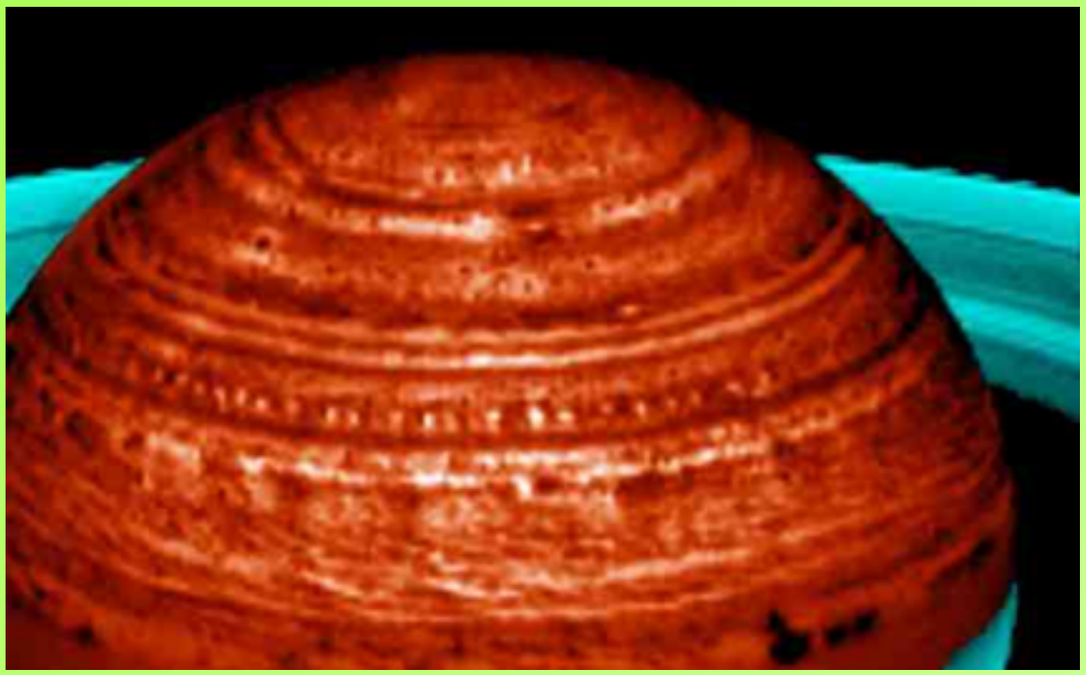
Cheap

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



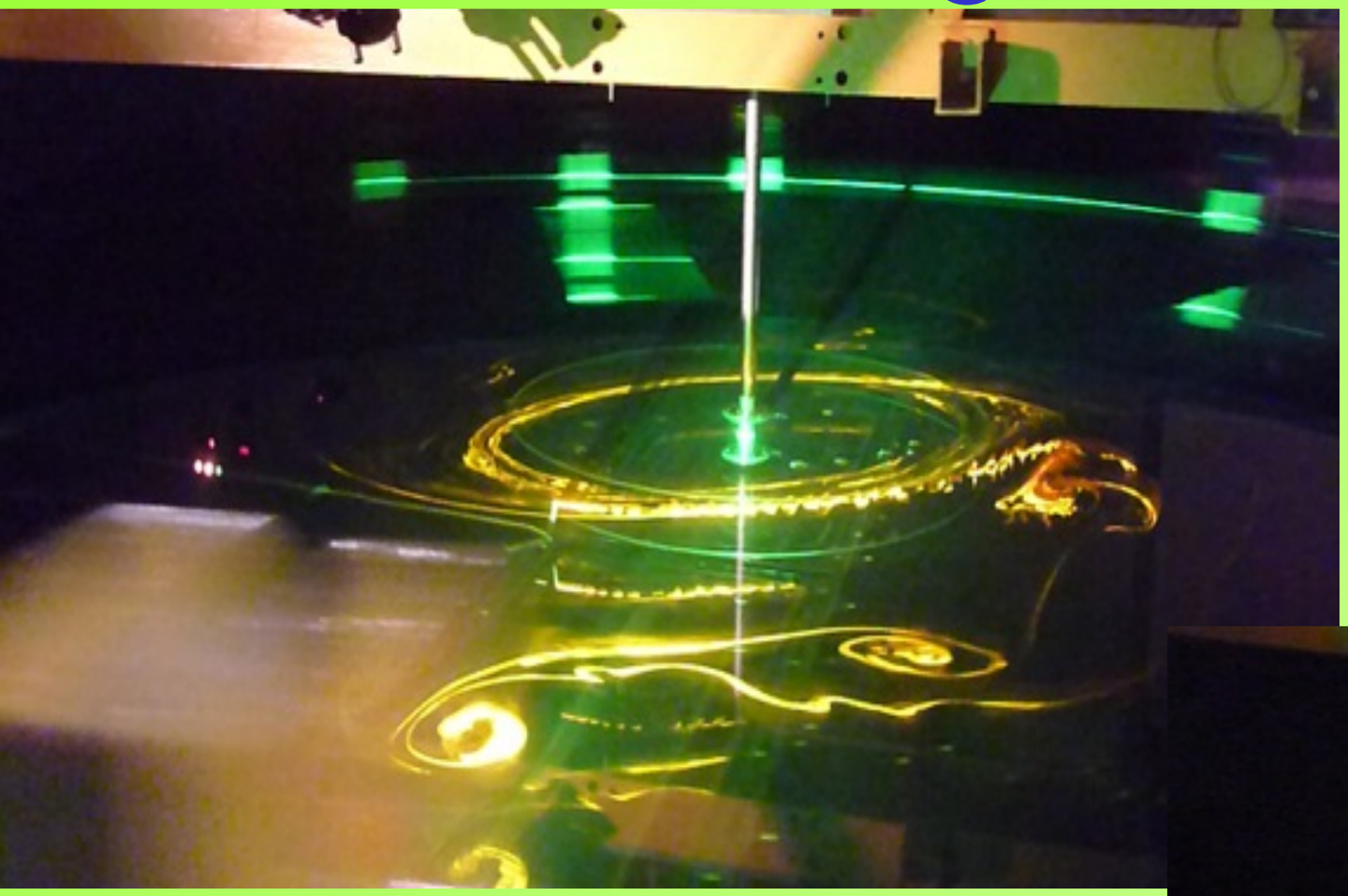
Hexagon at Saturn's North Pole

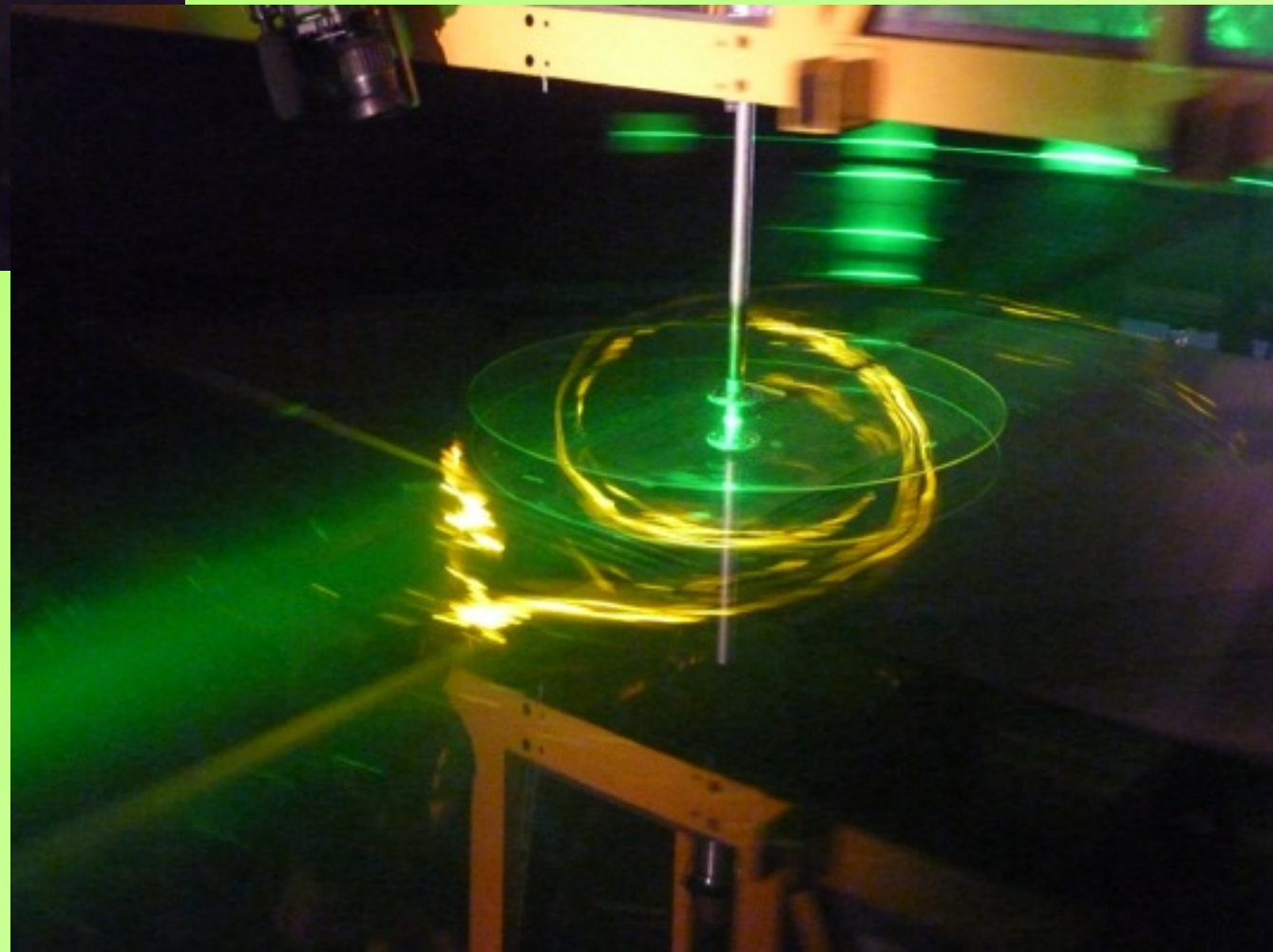


instability of Kelvin-Helmholtz
in not confined streams

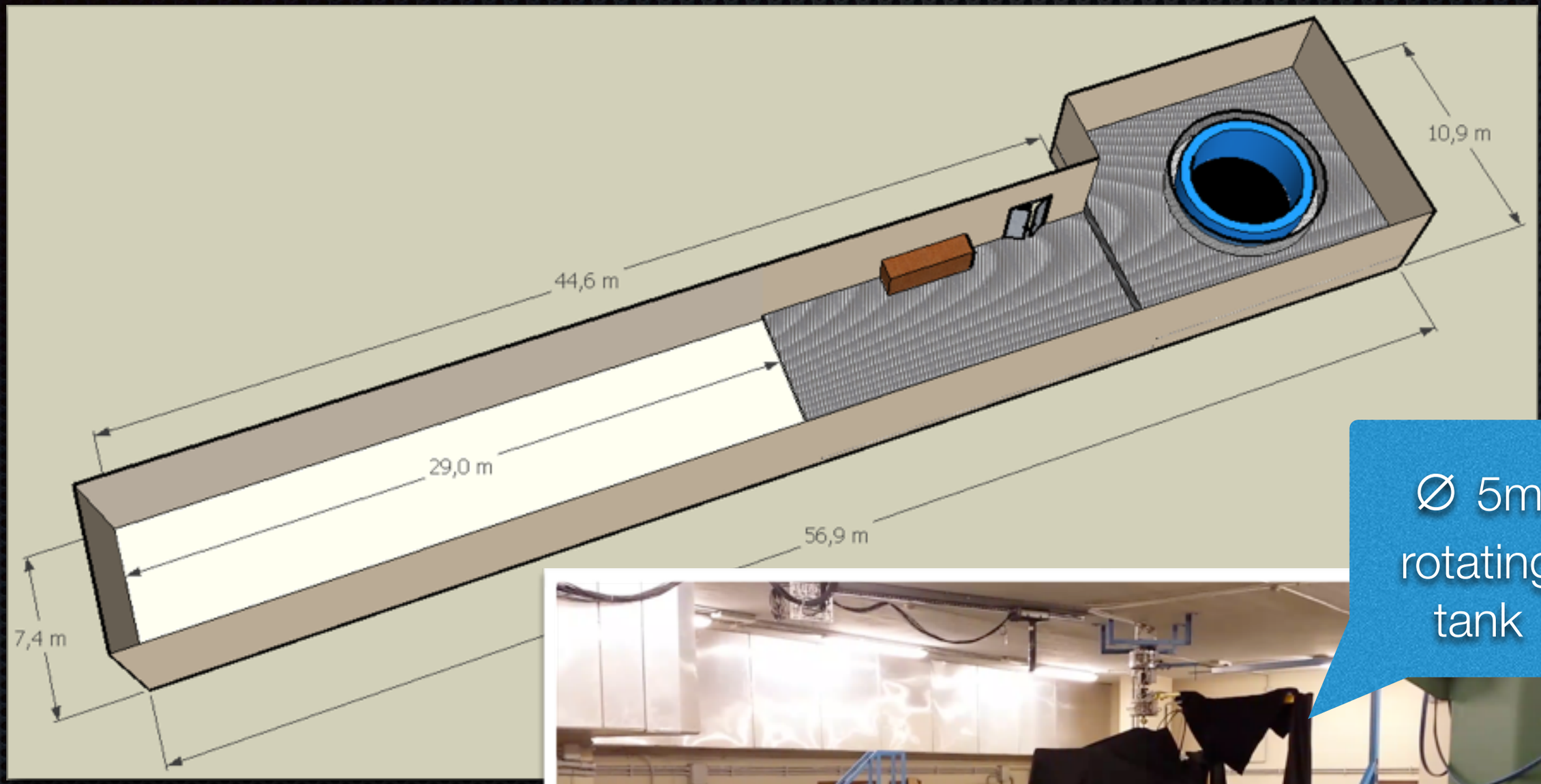
instability in confined streams

Results at a large rotating tank (TurLab)

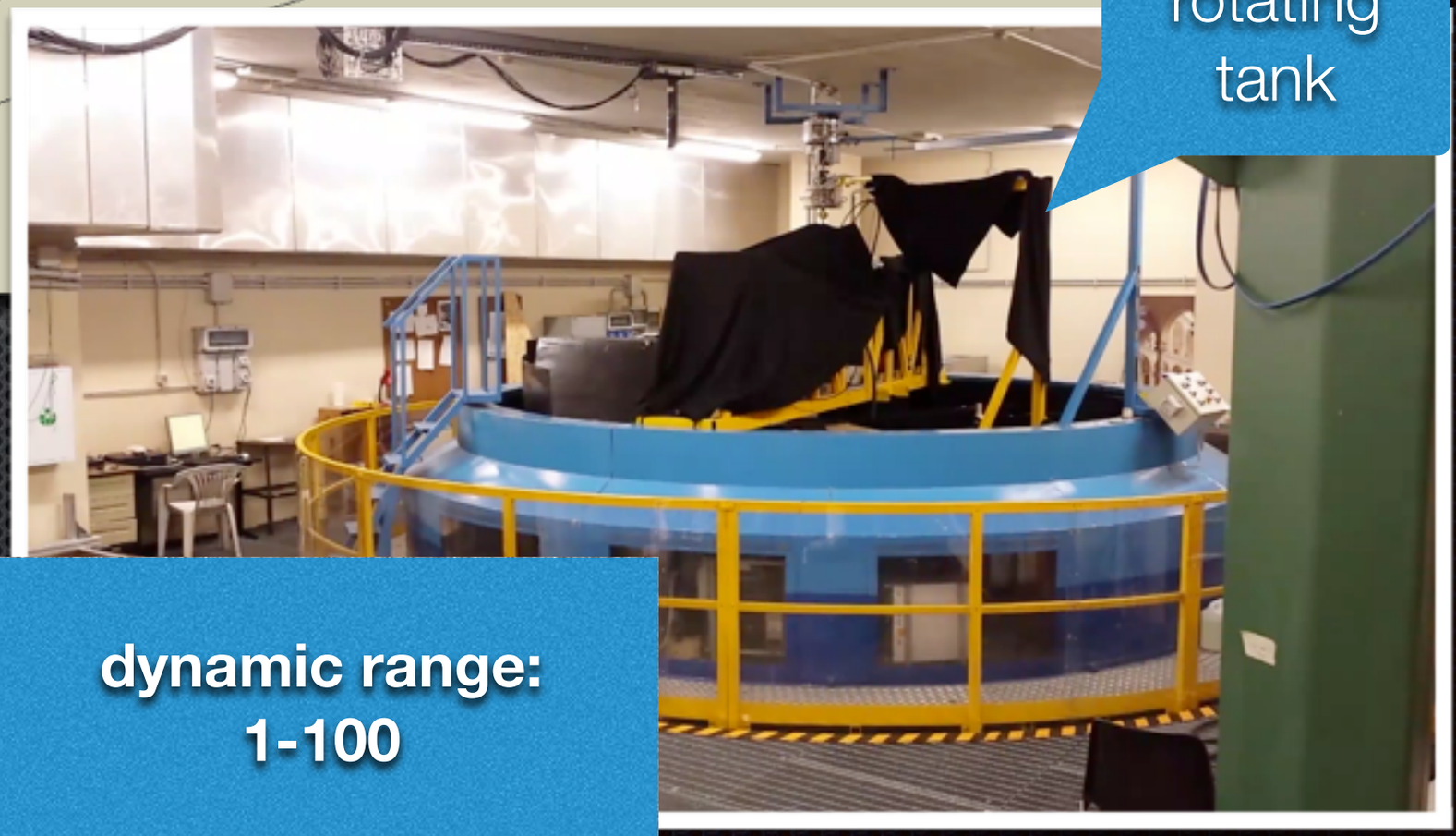




EUSO @ TurLab



Ø 5m rotating tank



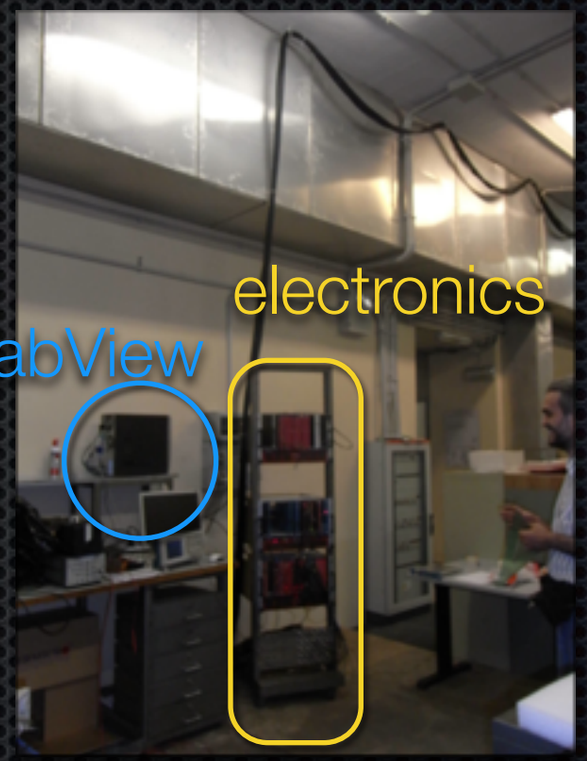
dynamic range: 1-100

TurLab

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

Current set-up

- 5x5 pixel MAPMT
- electronics
- the tank



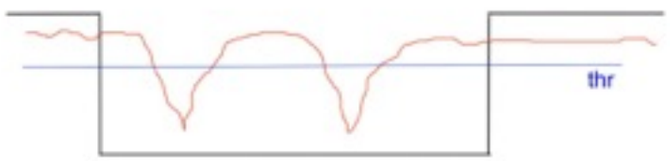
25 channels → Amp → Discriminators (threshold, width) → scalers → LabView

30 ms

JEM-EUSO: clock=25 ns - GTU= 2.5 μs

⇓

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



photon counting

dual timer (width)

status A

Electronics

resolution

time
1 GTU = 40 µs sampled every 30 ms

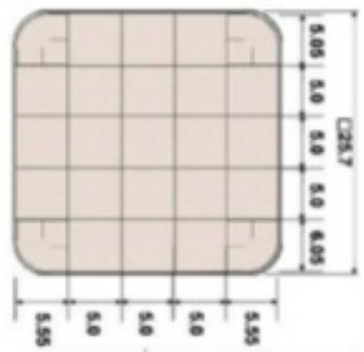
space
1 pixel watches a
FoV of 5x5 mm^2

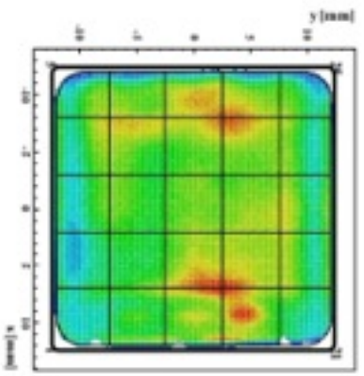
1 rot/20 min
R = 2 m

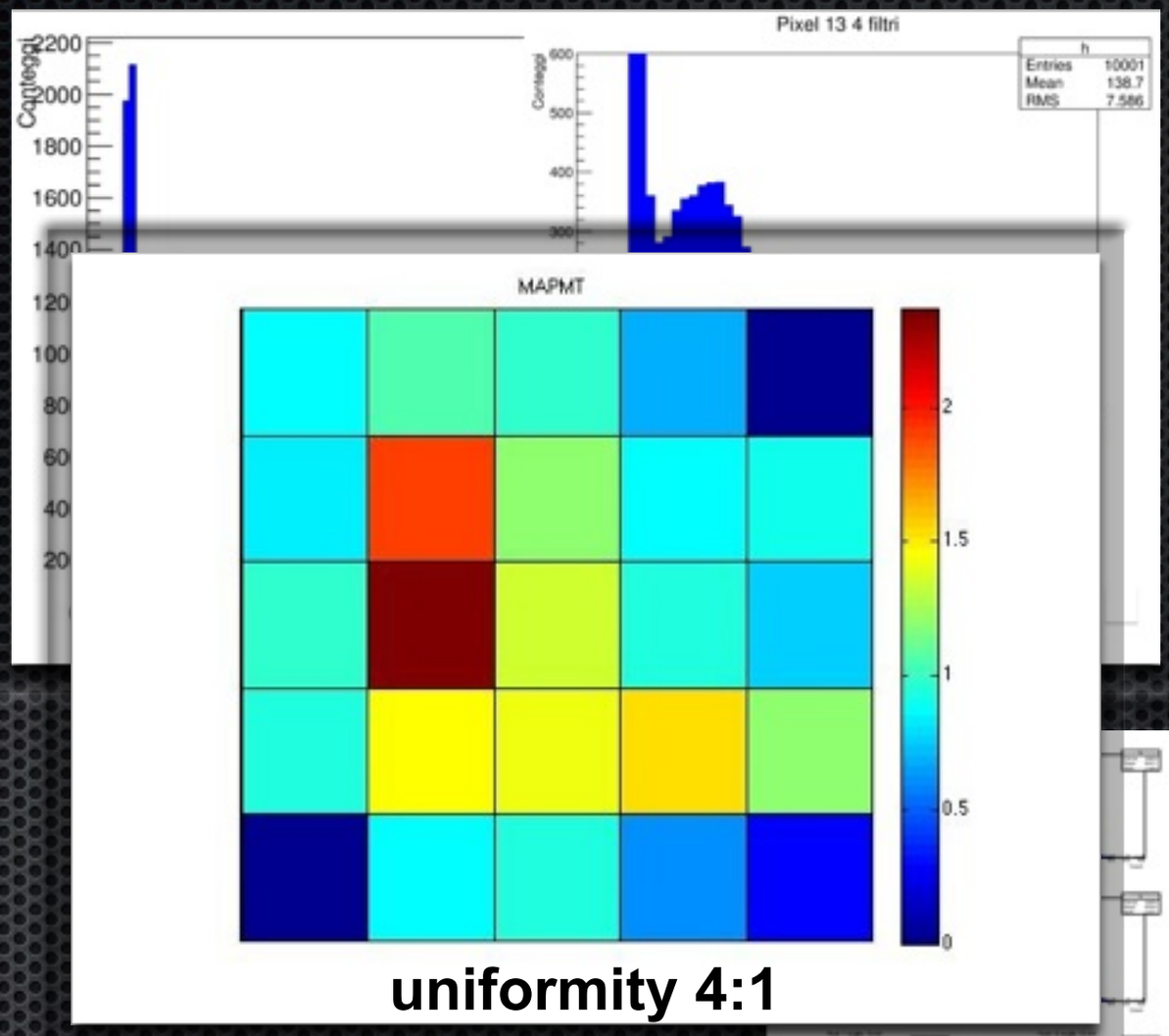
ISS: 8 km/s — TurLab: 10^{-2} m/s
speed ratio TurLab/ISS: 10^{-6}

5 mm/500 m = 10^{-6}

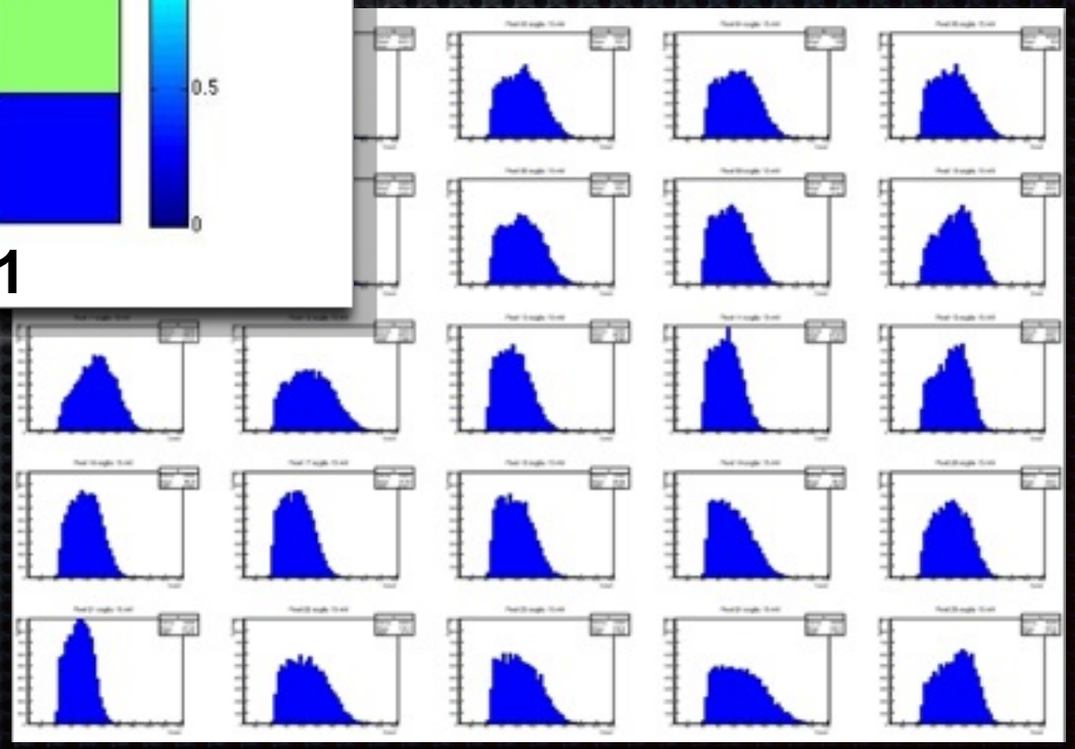
Hamamatsu R8900-M25





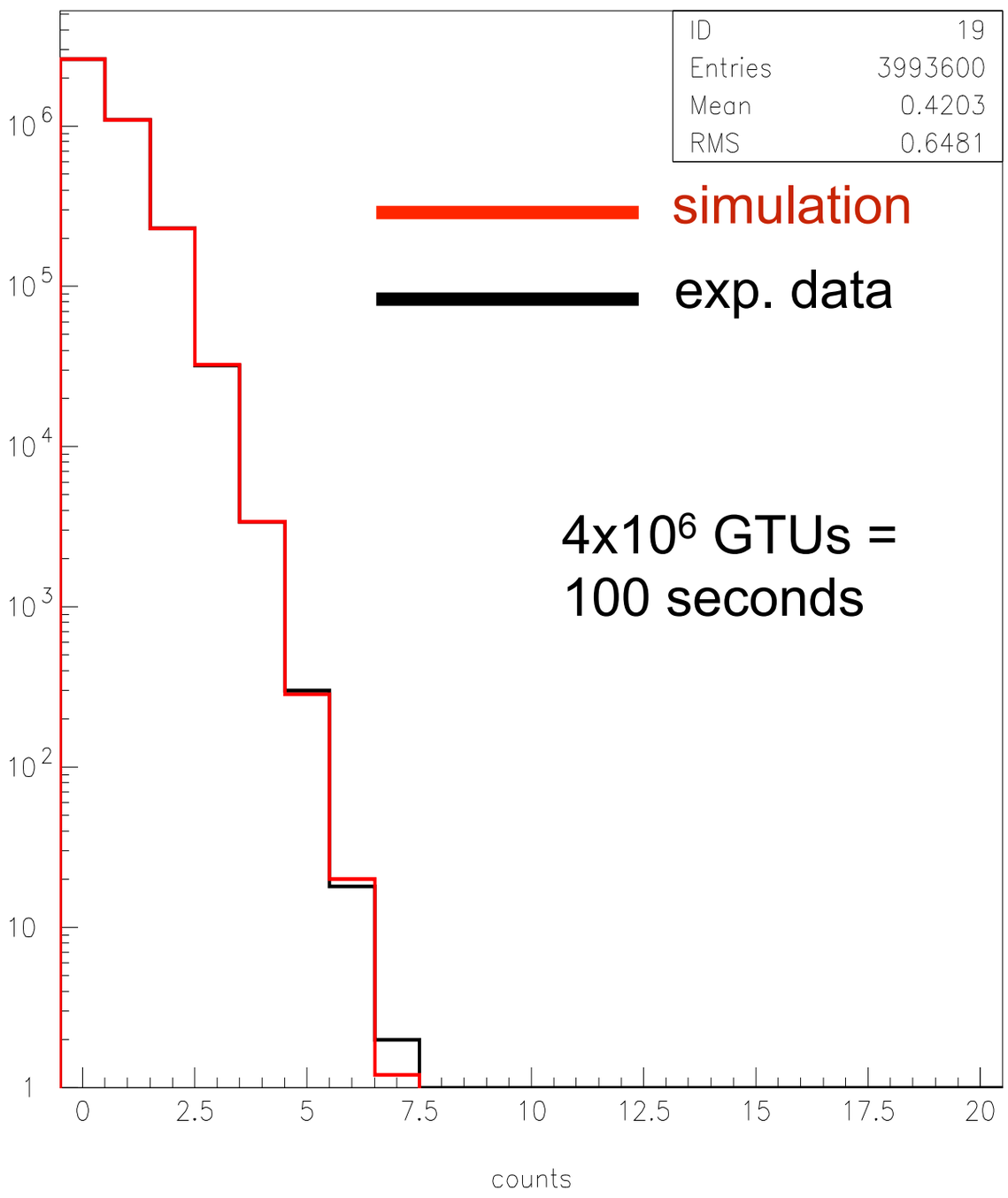


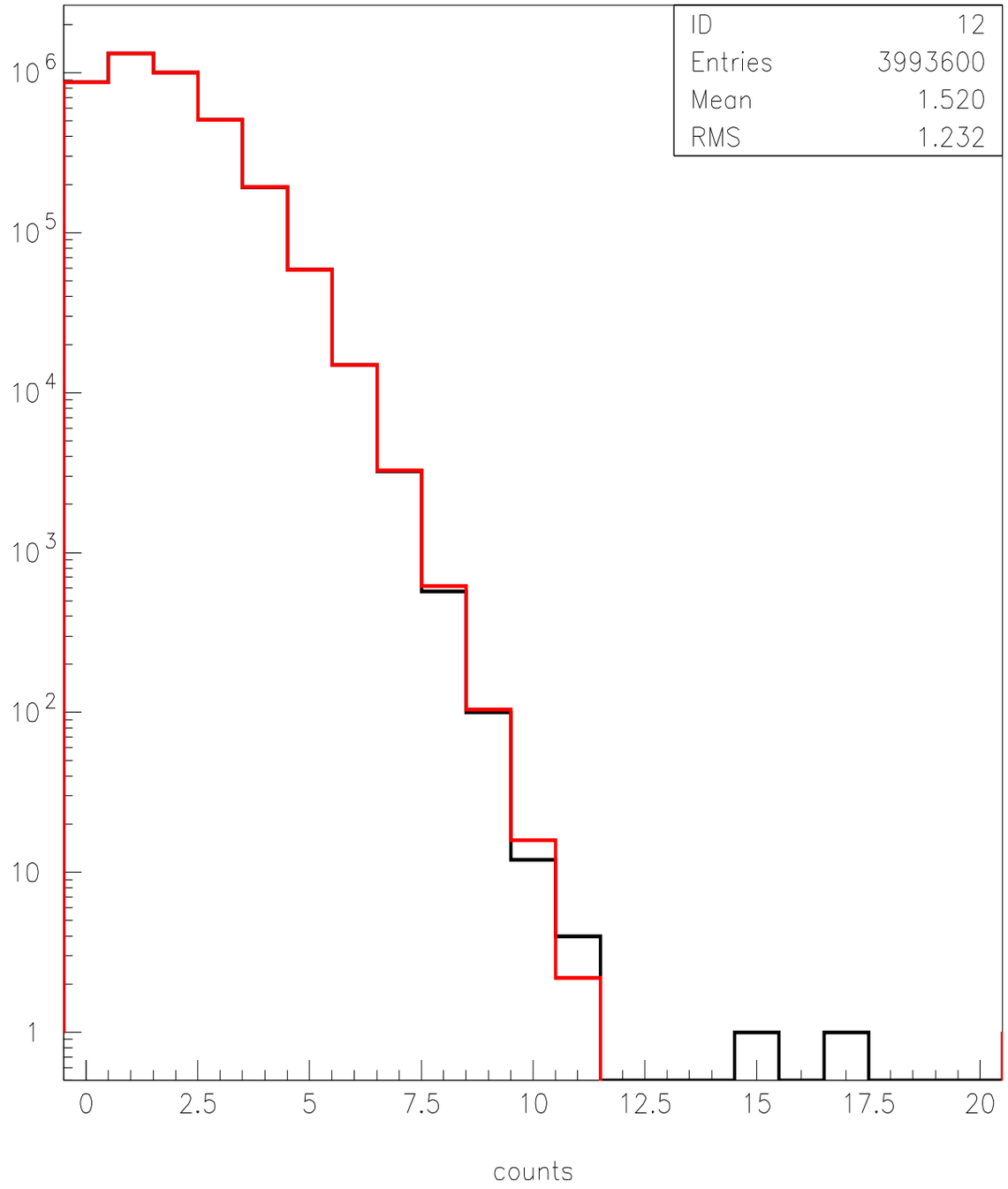
uniformity 4:1



Possible Configurations

Background is Poissonian on all pixels



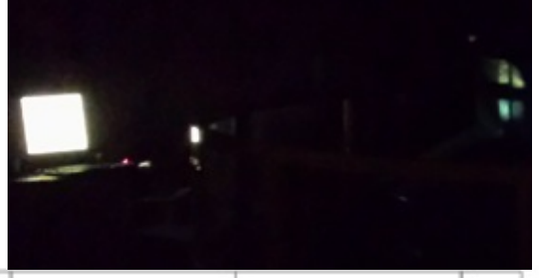


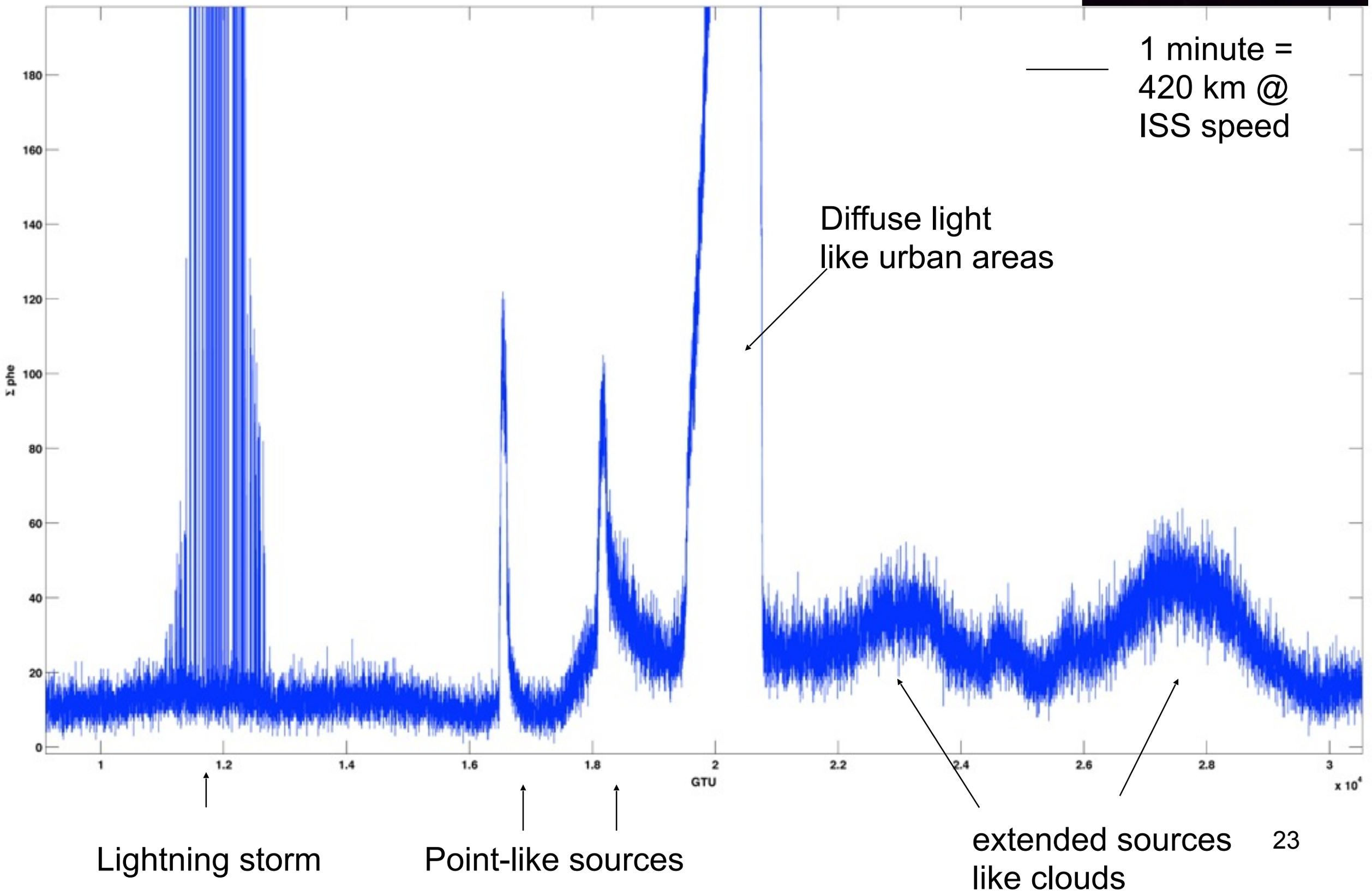
2 approaches:

- ‘absolute time’
  - ↳ s (for xxx-EUSO’s PDM)
- ‘sampling time’
  - ↳GTU (for offline trigger purpose)

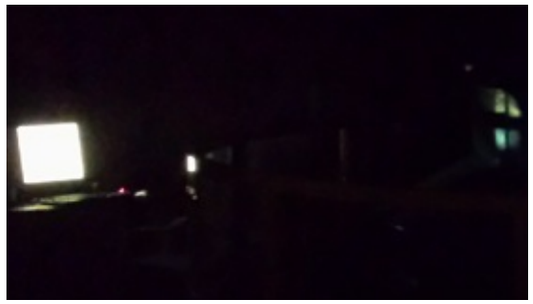
- 300 s (==>2250km)
- 10000 GTU (==>200m)

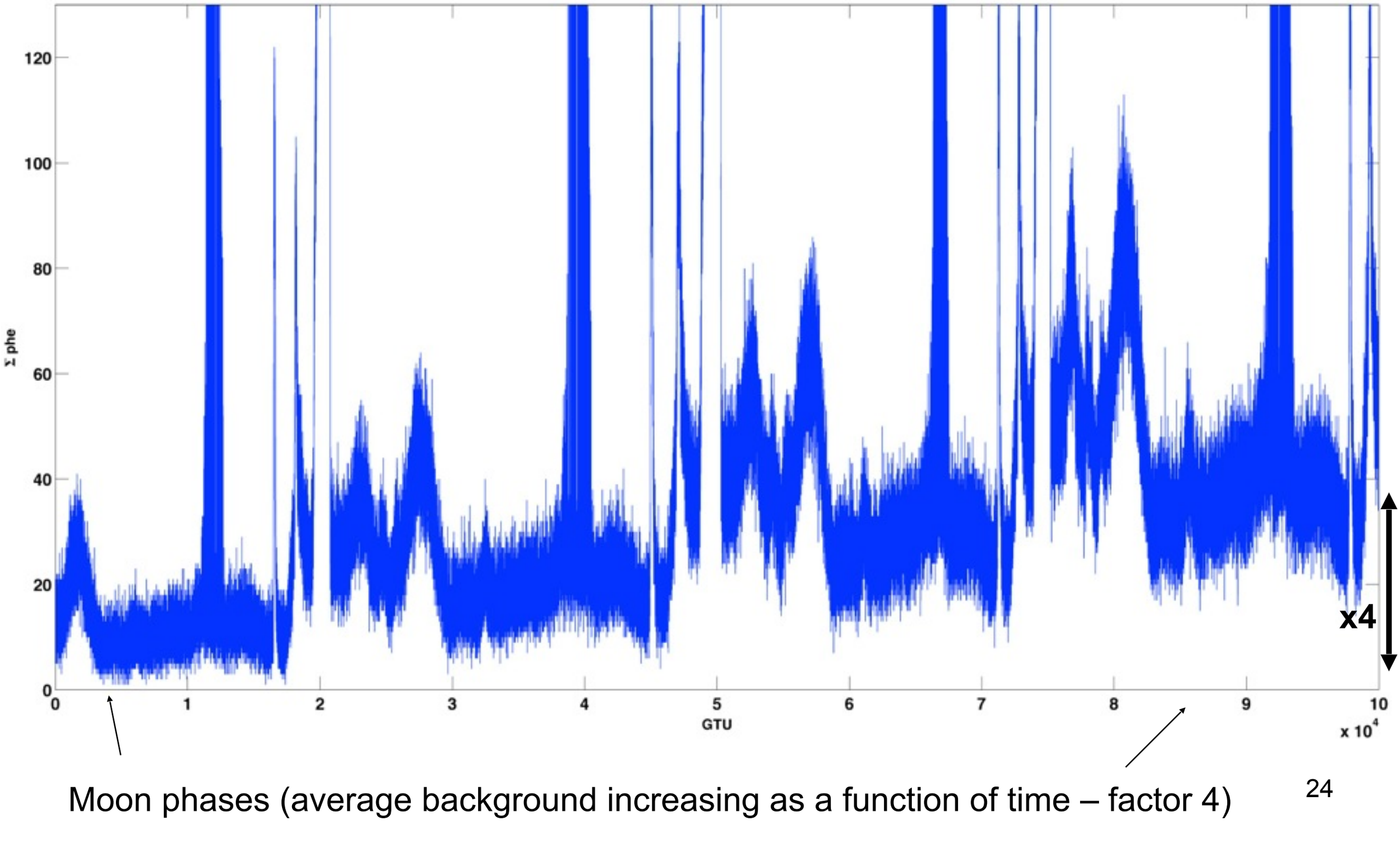
1 rotation = 15 minutes



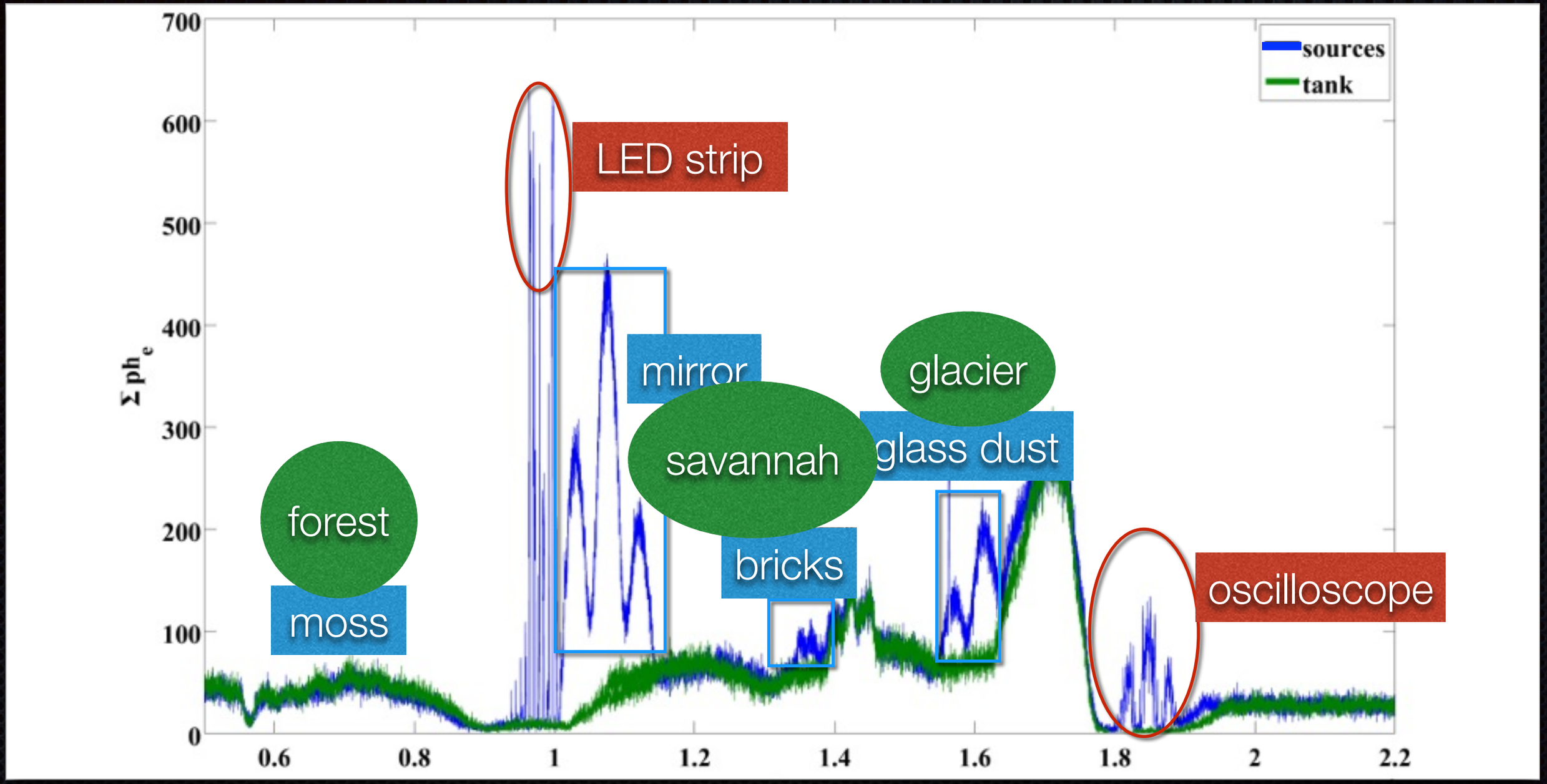


3 rotations = 1 ISS orbit
(night part = 45 minutes)



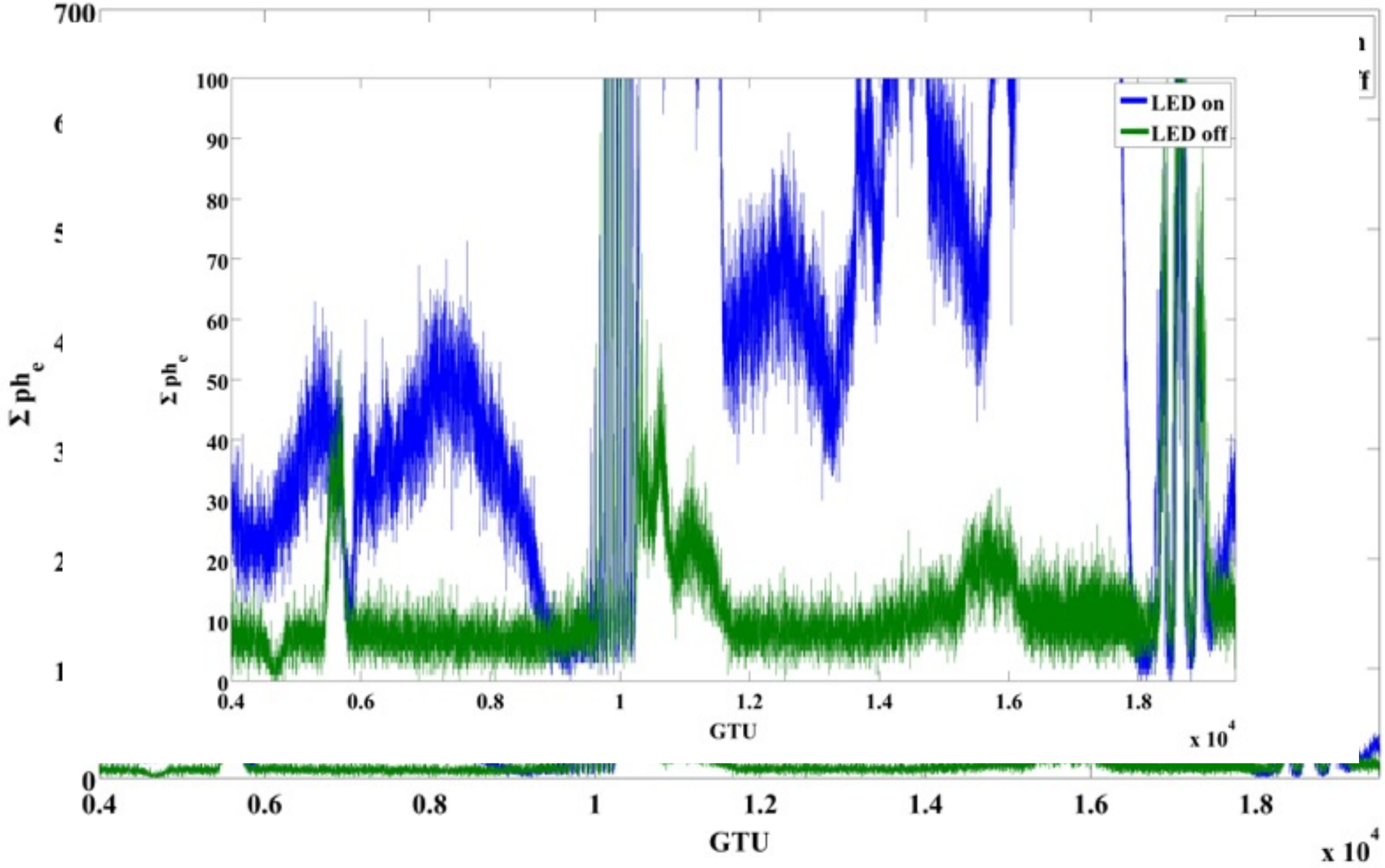


Moon phases (average background increasing as a function of time – factor 4)



different light sources

- light emitting sources
- materials reflecting background light



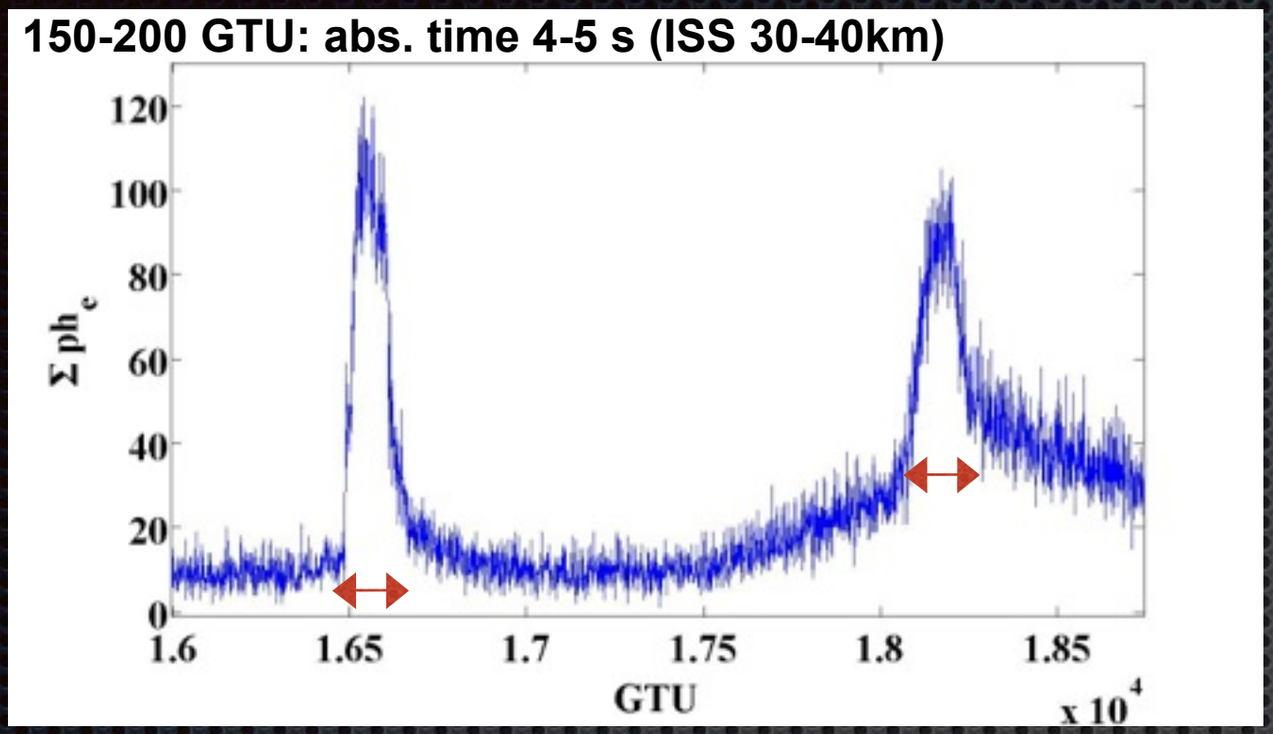
different backgrounds

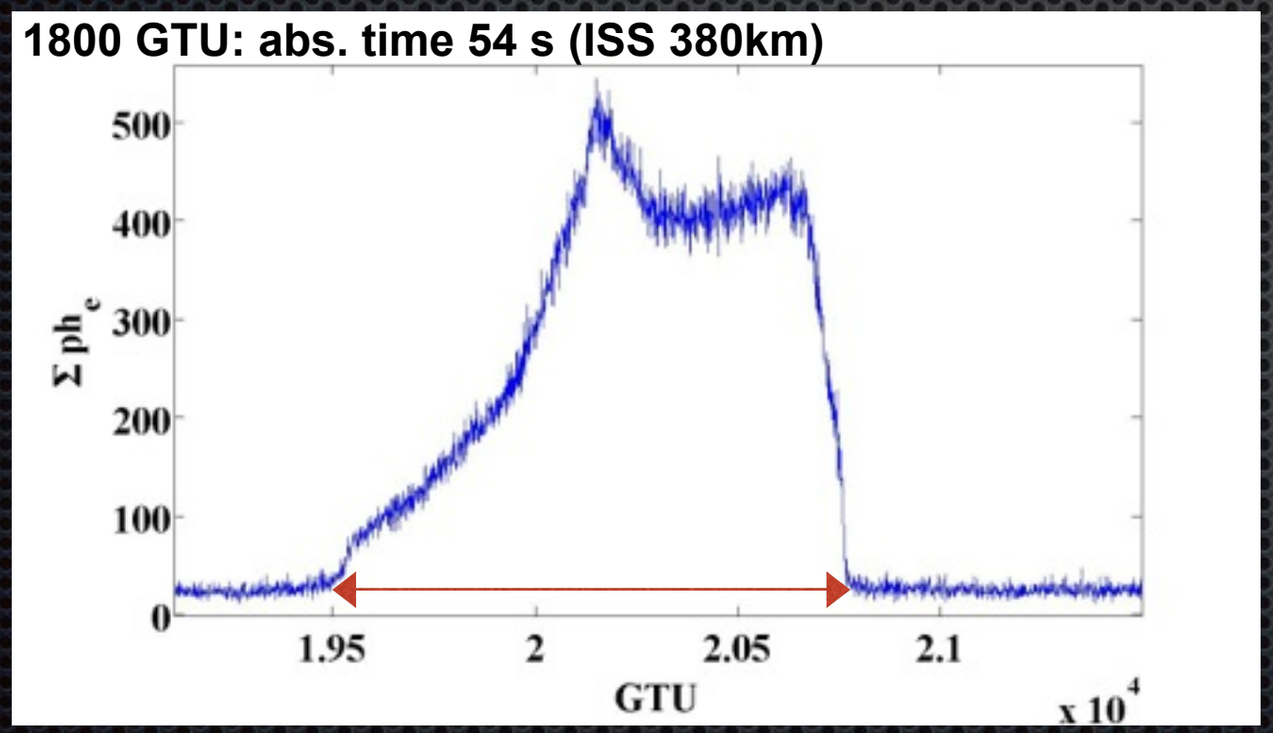
same materials can give different response depending on room light conditions

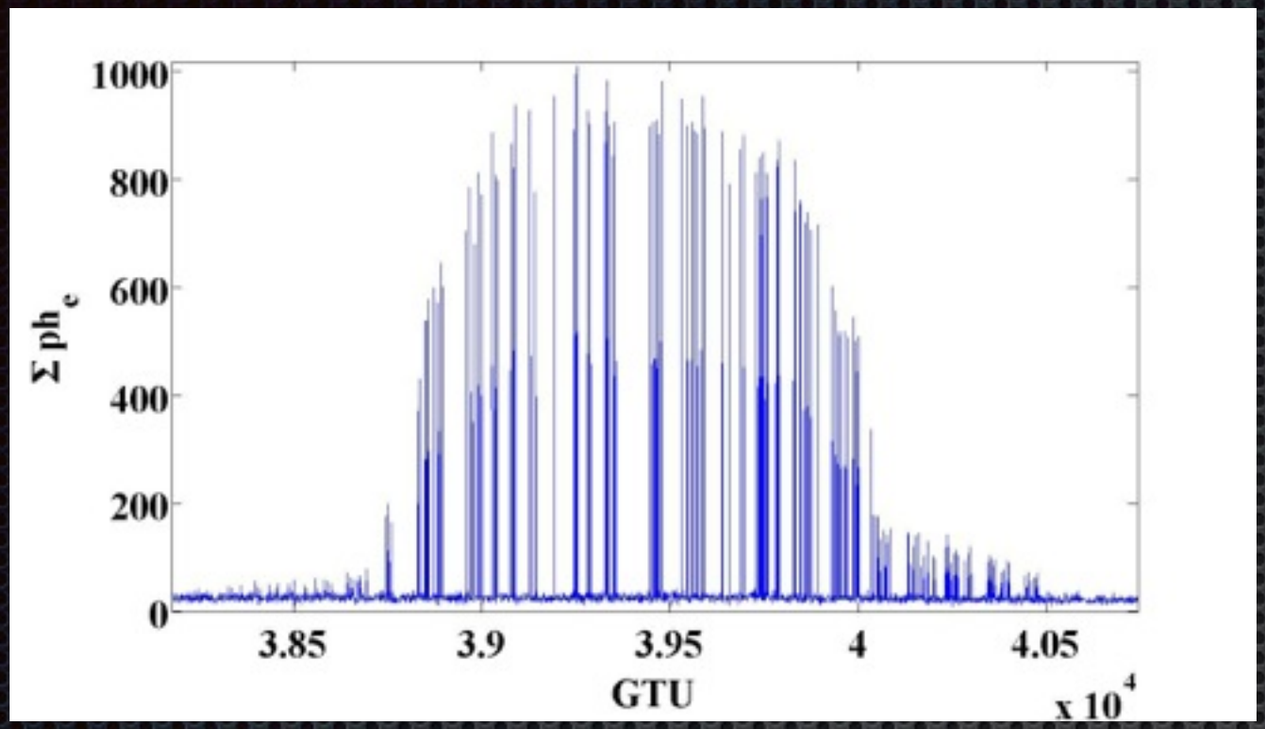
Possible Scenarios

changing tank speed:

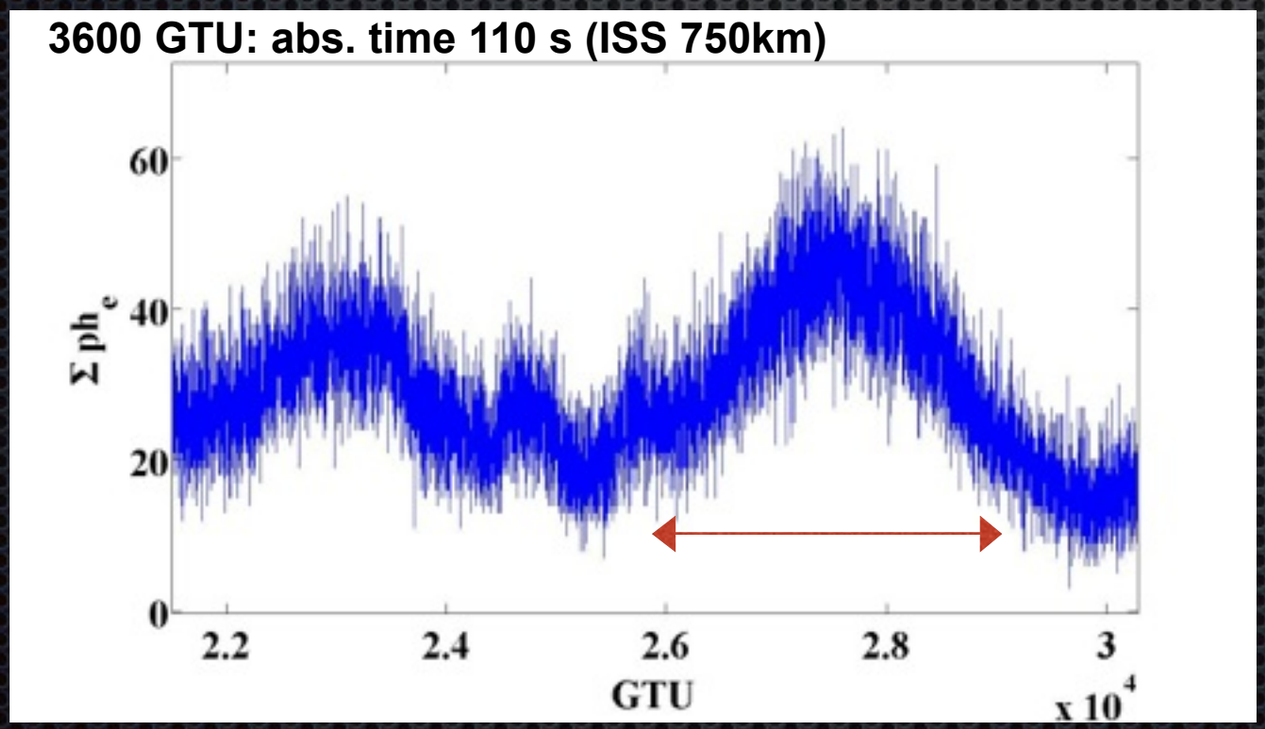
abs. time: 0.7 - 70 s
ISS: 5 - 500 km



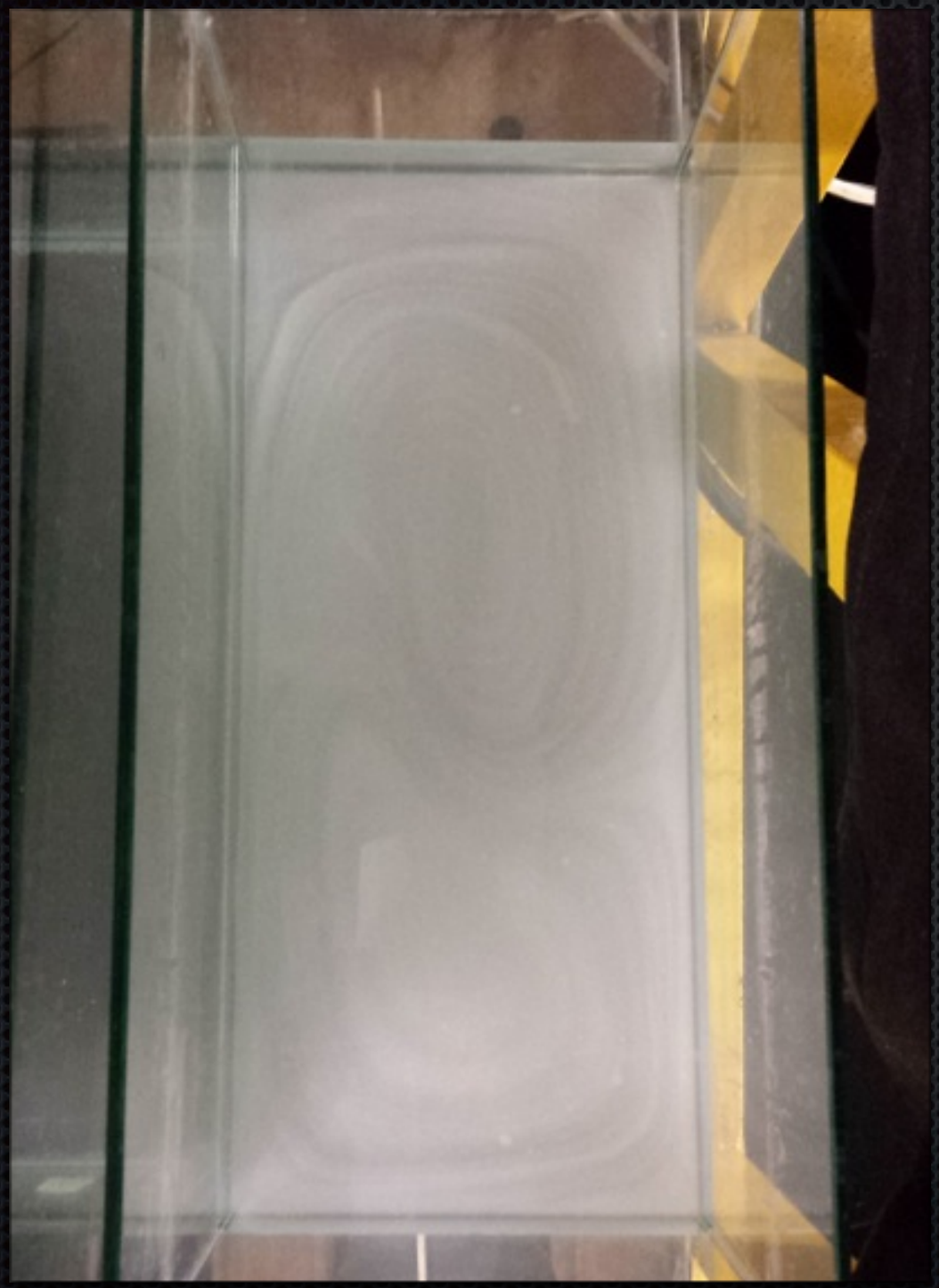




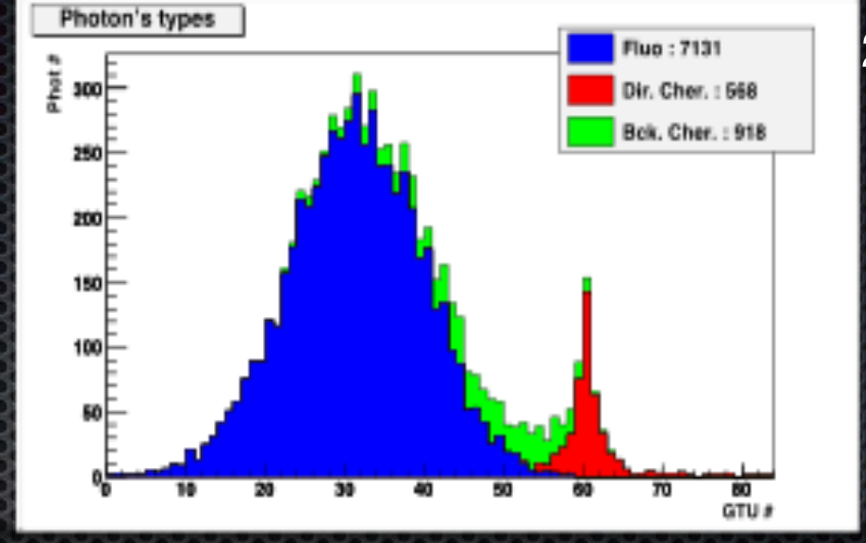
http://www.nasa.gov



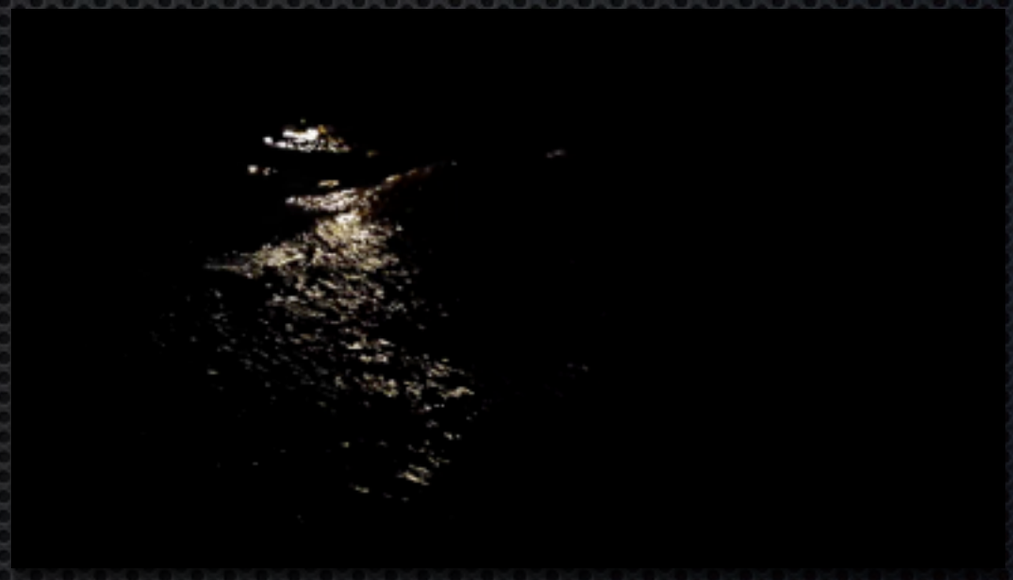
Clouds

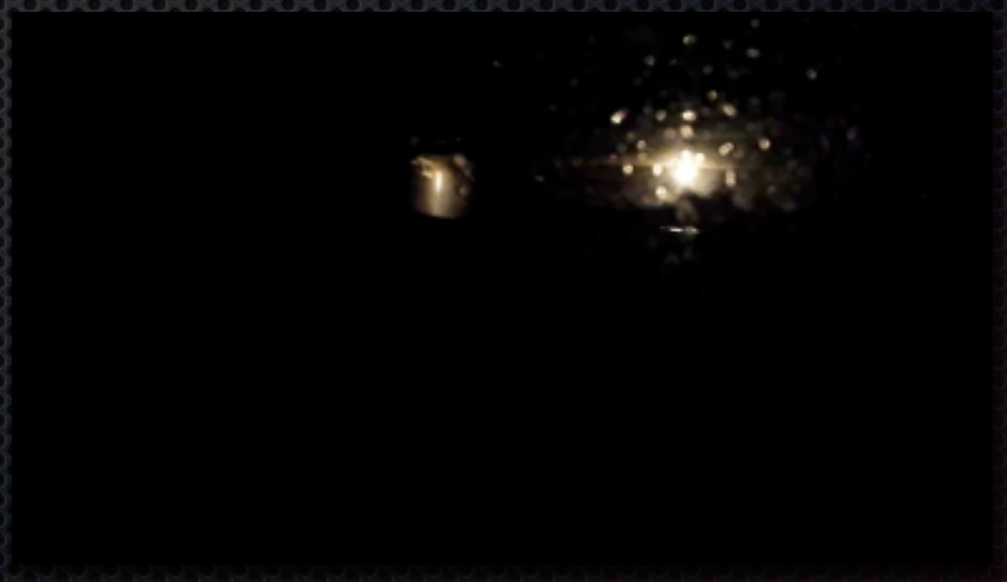


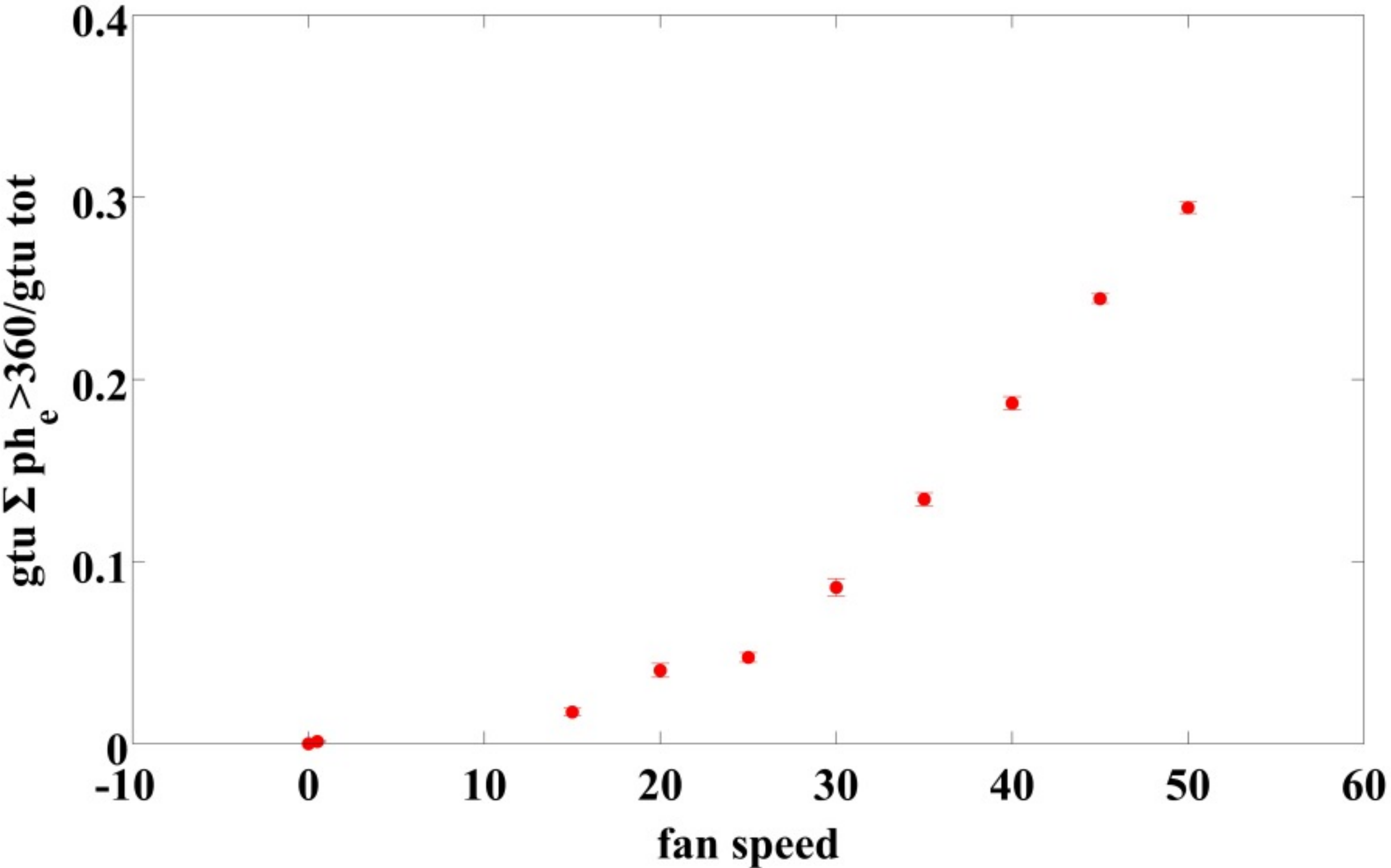
JEM-EUSO for wave watching?



- the tank can contain water
- 2 fans produce different conditions of wind
- **we can see waves with the MAPMT**





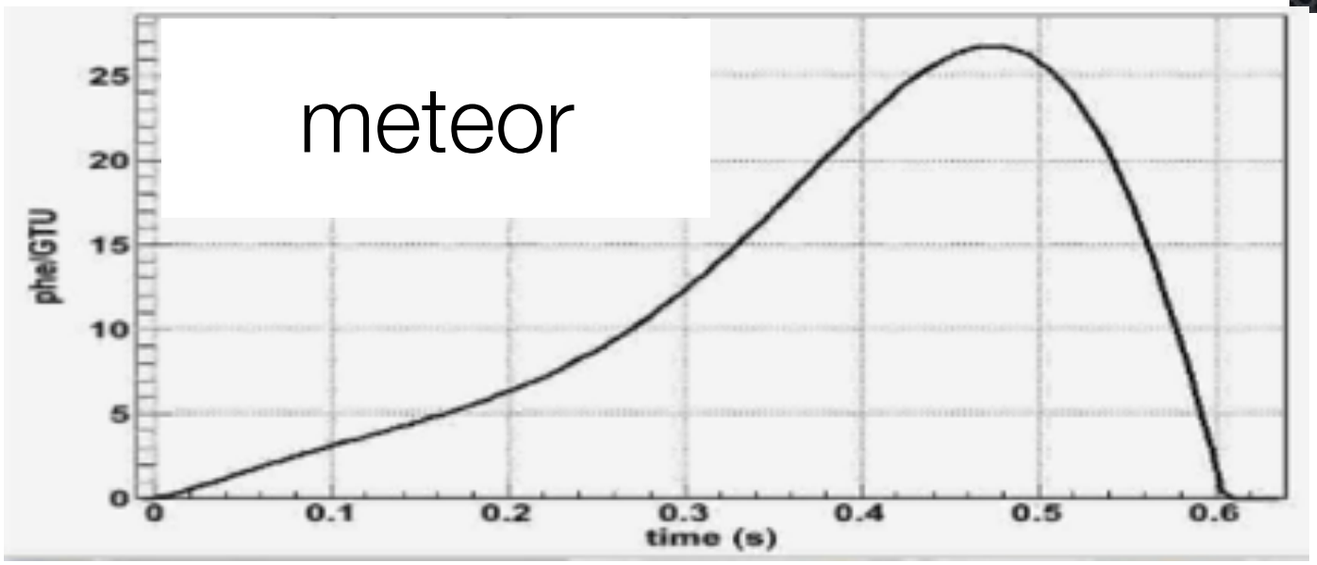


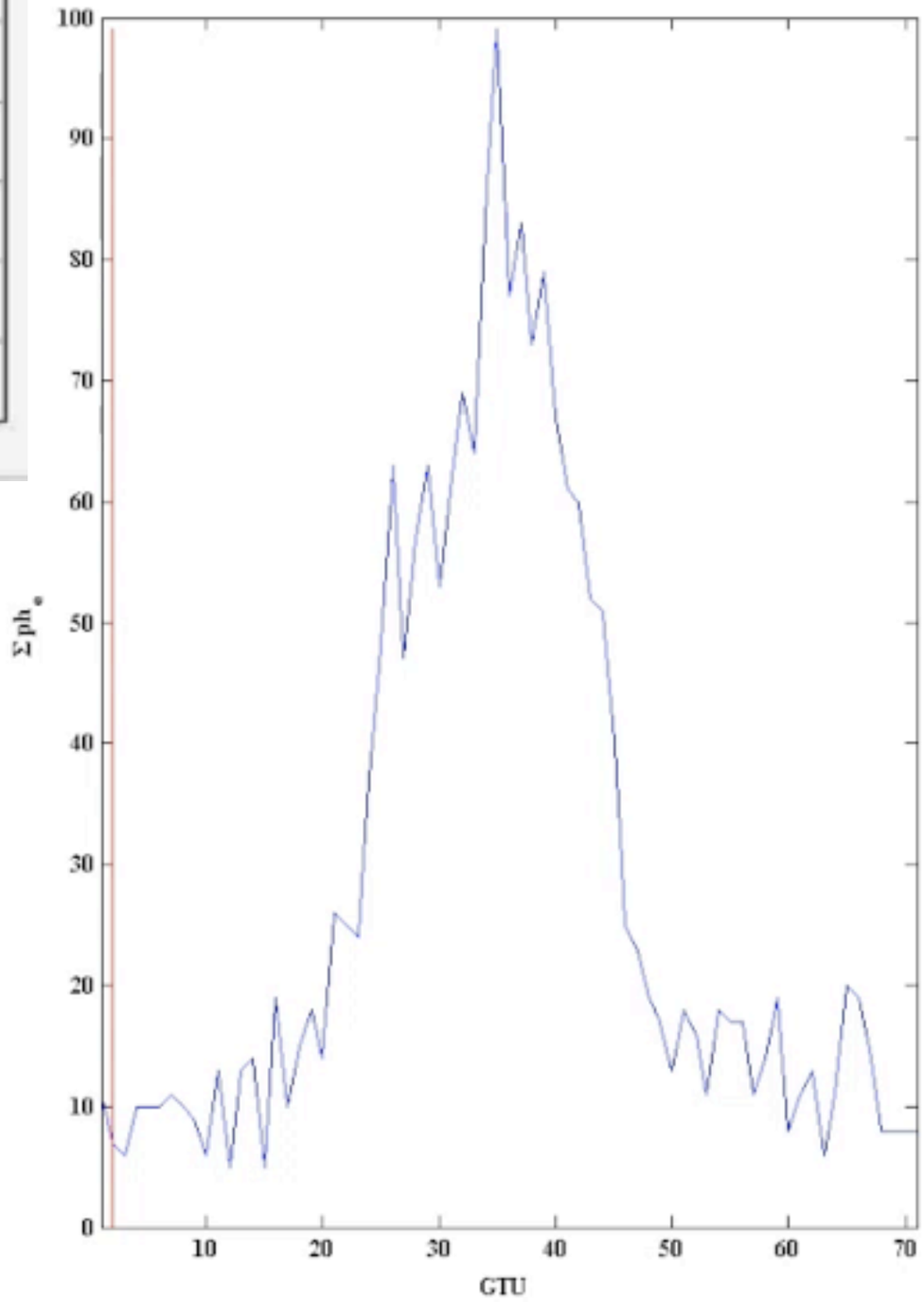
waves

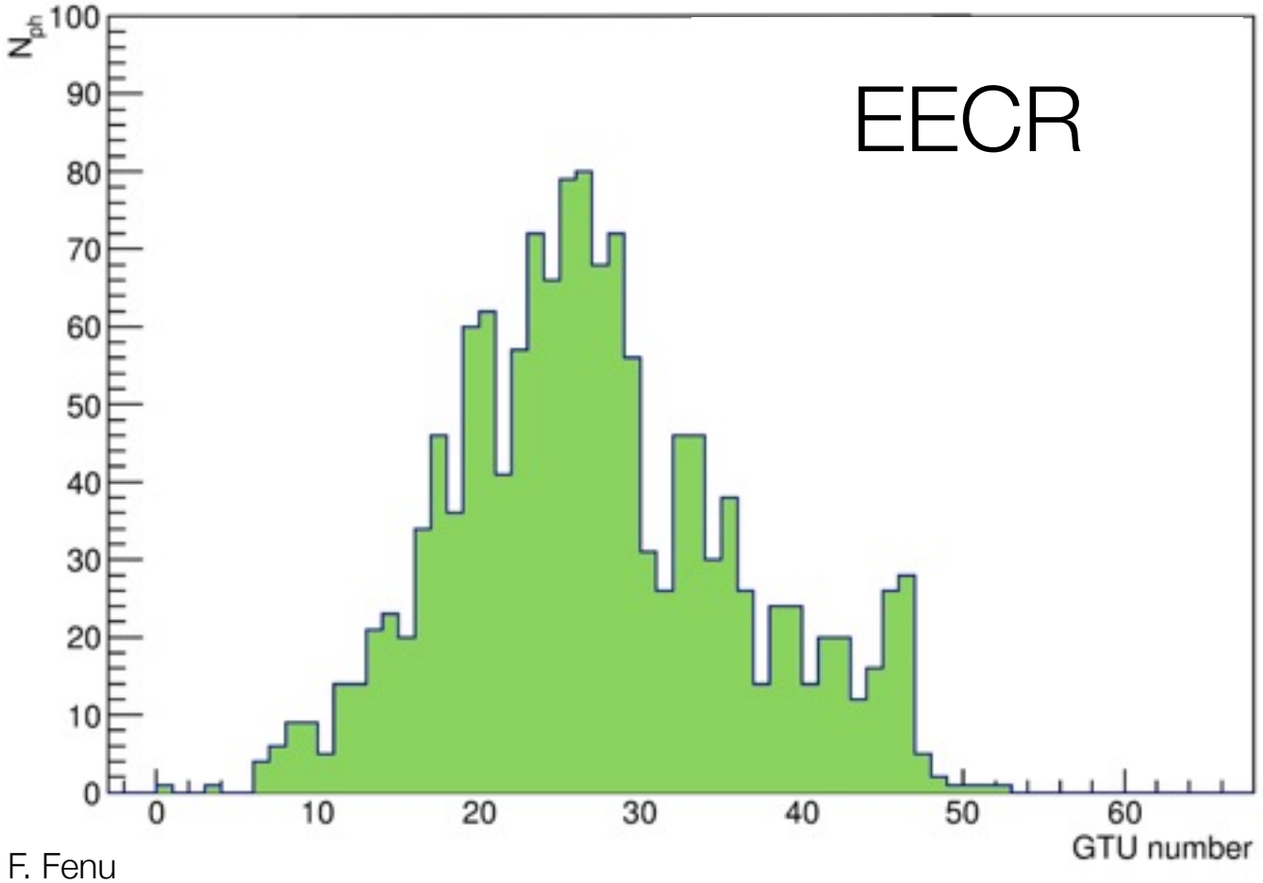
as wave height increases

we have non-Poissonian luminosity

20-30 GTU: 0.6-0.9 s



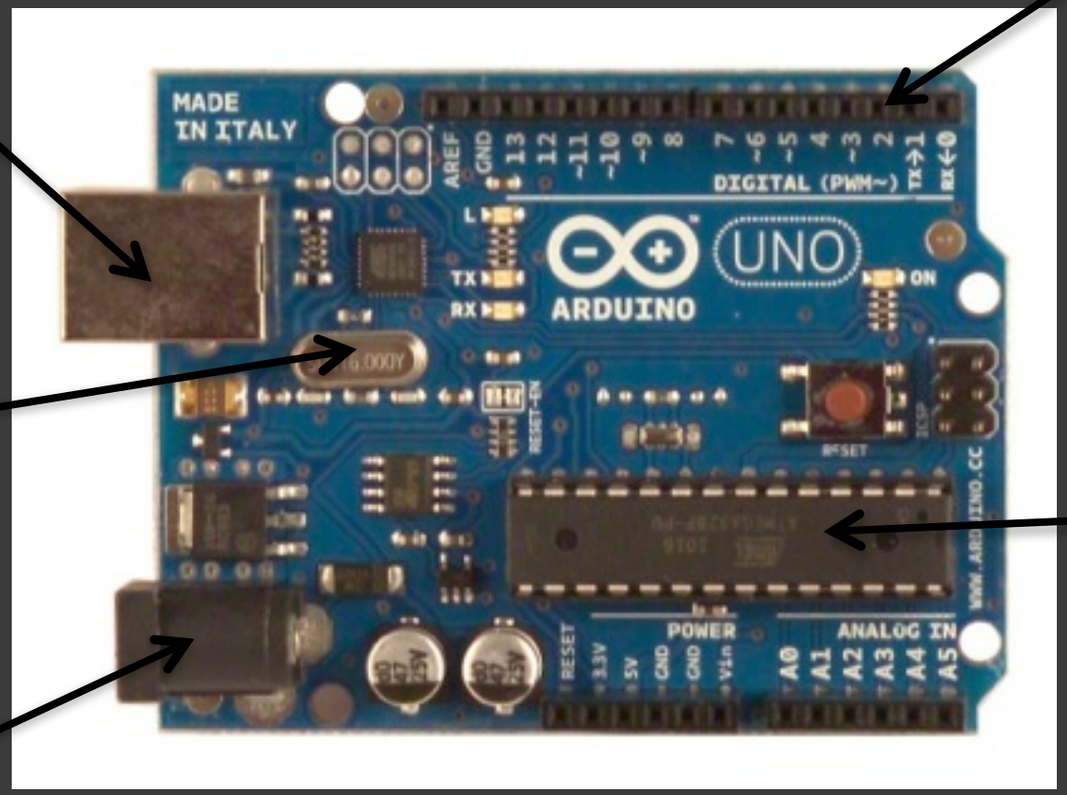




F. Fenu

ARDUINO

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



14 input/output digital pins and 6 analog input pins

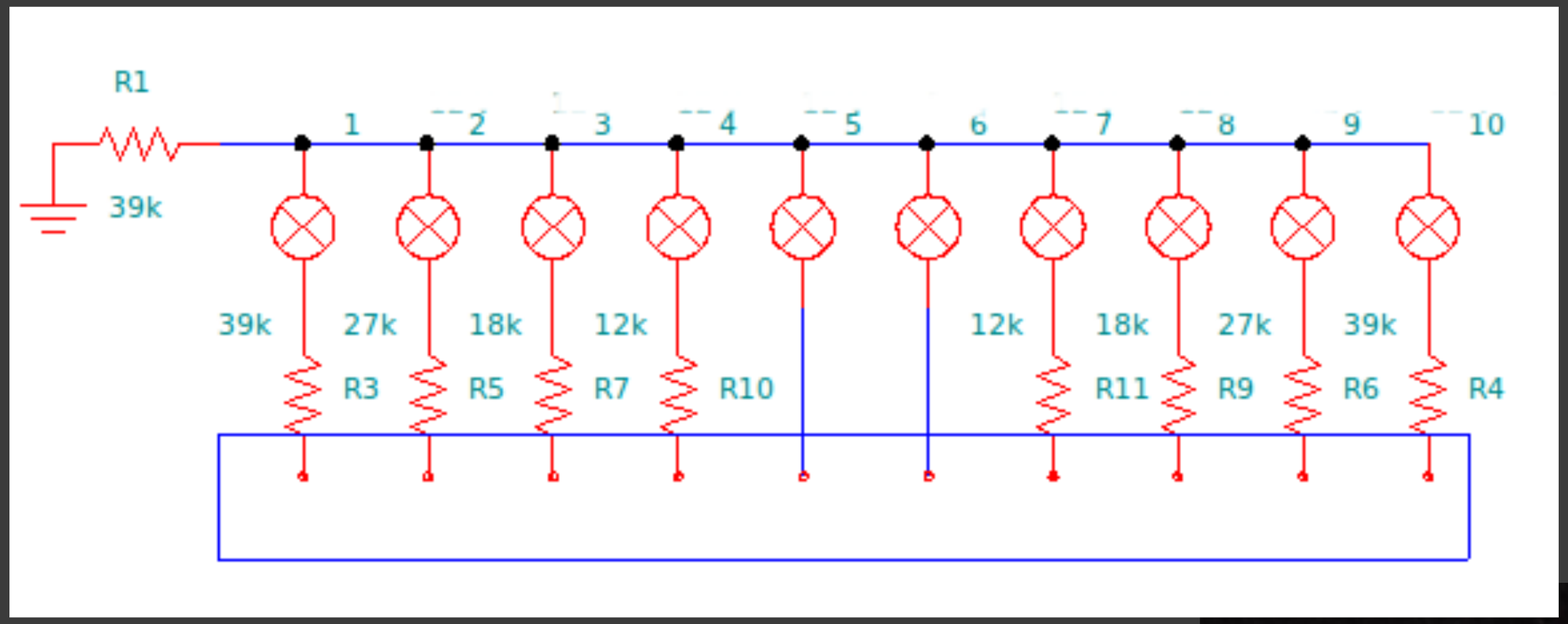
USB connection

Ceramic resonator

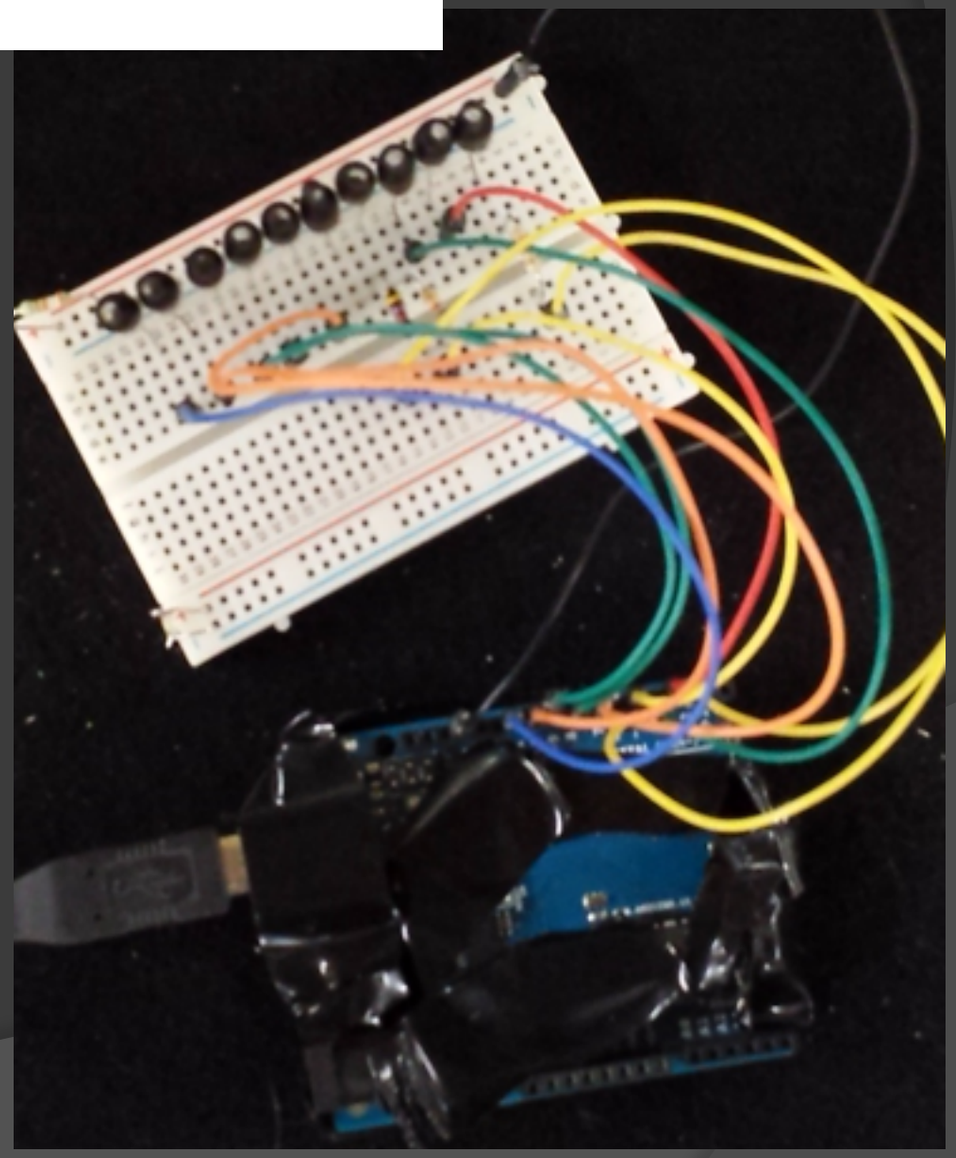
8-bit Atmel microcontroller @ 16Mhz;

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 pix 10^{11} data/s **very 2.5 µs**

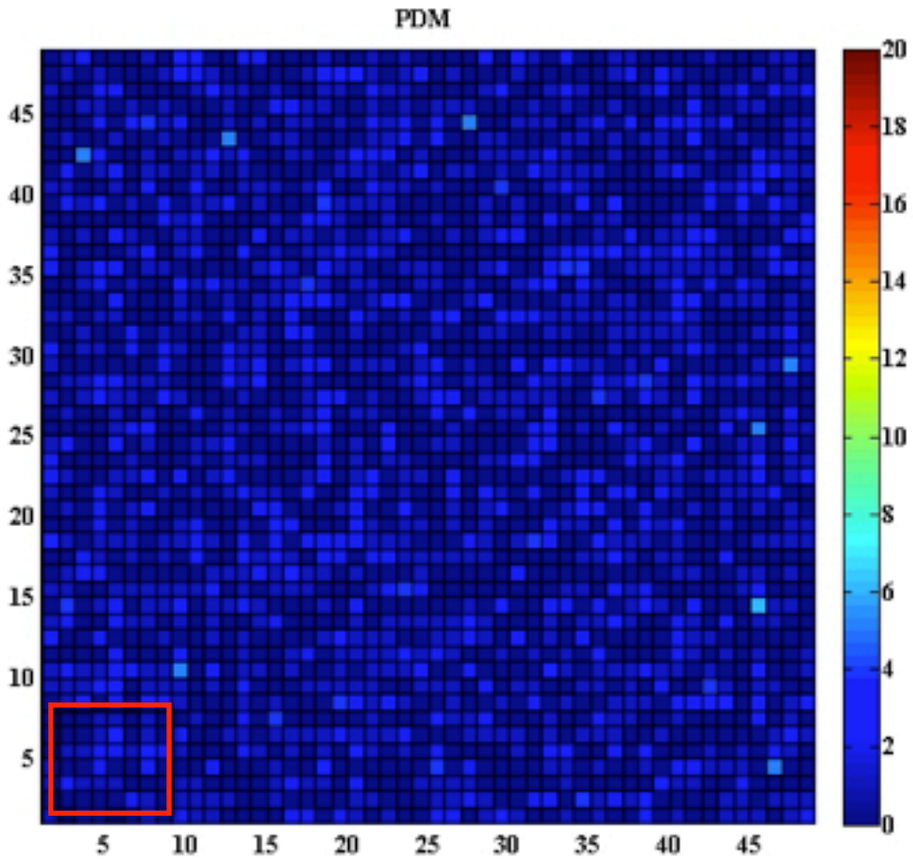
vs

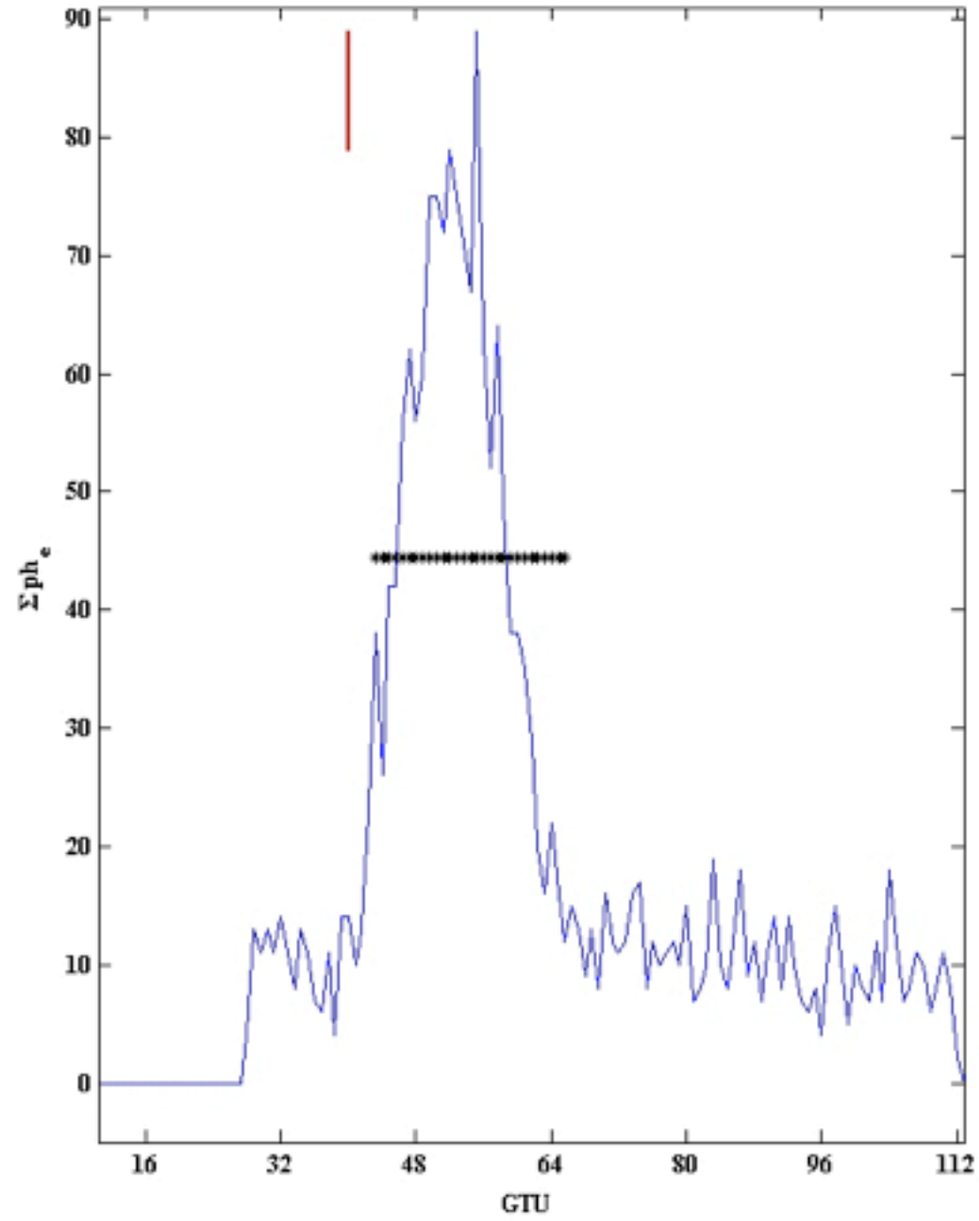
ISS data transferring 300 kbit/s

rejecting most of light background fluctuations

allowed acquisition rate:
few Hz/PDM

pre-trigger





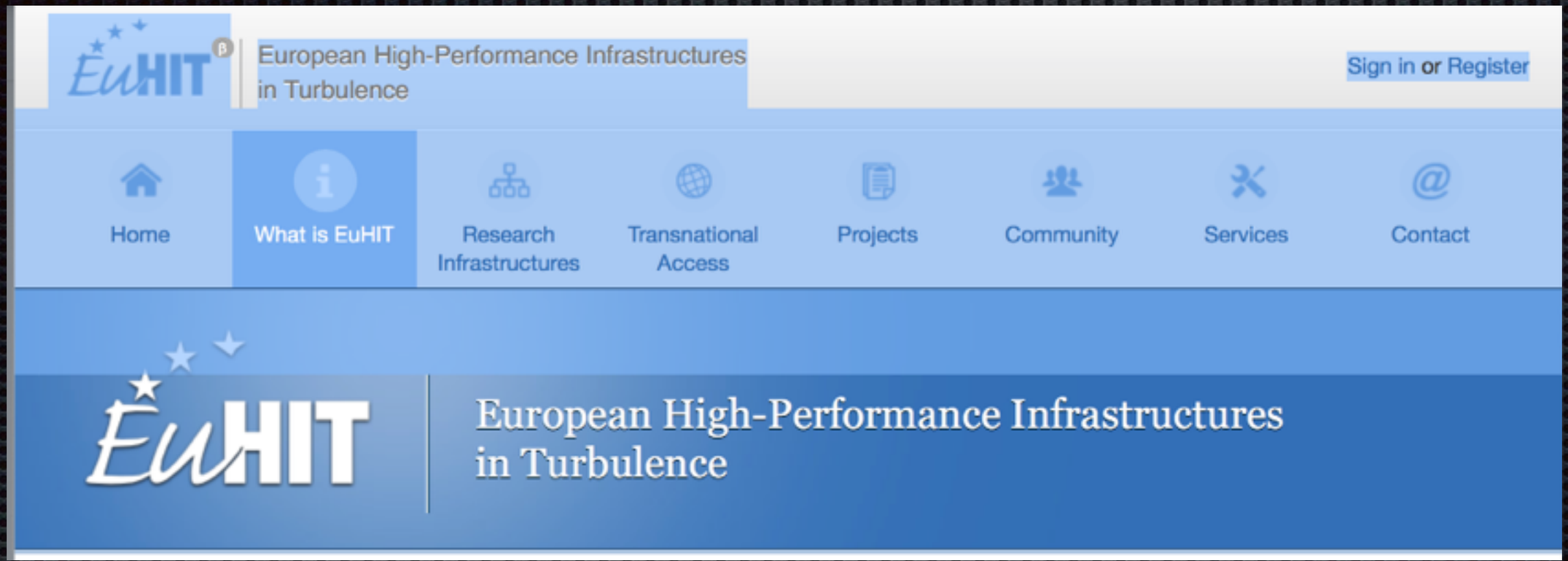
EECR

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



EuHIT is looking forward for proposals submitted by young scientists.

What is EuHIT?

EuHIT is an international scientific mobility programme for researchers engaged in the **turbulence research** which provides free transnational access to cutting-edge European facilities and scientific support of 21 partners representing both academia and industry.

It's primary goal is to significantly advance the competitiveness of the European turbulence research with special focus on providing the knowledge for technological innovation and for addressing grand societal challenges.

Who can participate?

EuHIT offers **free access** to the participating research infrastructures and grants for travel and subsistence costs. It is addressed either to individual researchers of all levels or teams of researchers having one Leader responsible for the implementation of the project.

The Leader and the majority of the team members must be affiliated at one of the research institutions of the European Union member or associated states.

Thank you !