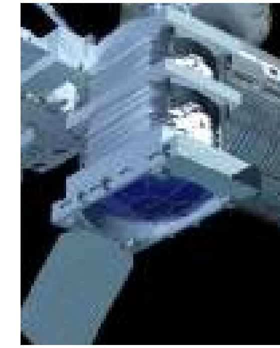
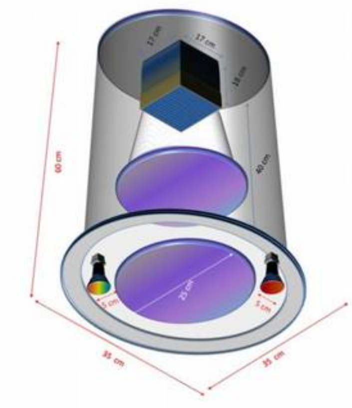
Eksperymenty satelitarne JEM-EUSO i POLAR – promieniowanie kosmiczne najwyższych energii.





Jacek Szabelski
Zakład Astrofizyki
Narodowego Centrum Badań Jądrowych
Pracownia Fizyki Promieniowania Kosmicznego
Łódź
http: //ncbj.u.lodz.pl

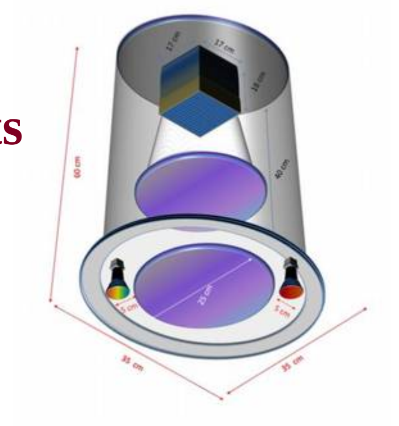
Seminarium Fizyki Jądra Atomowego,
IF UW, 16 marca 2017 r.

POLAR –
GRB polarisation
at TianGong2
since August 2016

SPB-EUSO
NASA's Super
Pressure Balloon,
start in ~10 days

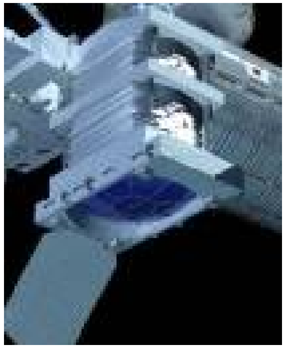
EUSO-Balloon
1 night flight
from Timmins, Ontario
in August 2014

Mini-EUSO
for UV measurements
from ISS, launch
later 2017



TA-EUSO tests with
Telescope Array
at Utah, since 2015

JEM-EUSO
the main target,
2 tonnes telescope
at ISS (?)



For all these experiments we have designed
high voltage power supply units (HVPS),
for POLAR we made HVPS EM model,
for EUSO family we have made test models and flight models of HVPS

Plans for further actions

New experiments:

1. **POLAR-2 – improved but similar detector to POLAR, free flyer satellite experiment with leading Chinese role, collaboration with Swiss and Europe.**
2. **KLYPHE – EUSO – new version of JEM-EUSO detector, with JEM-EUSO Collaboration and Russian leading role**
3. **EUSO – SPB2 – proposal for the UHE CR (ultra high energy cosmic ray) measurements using NASA's Super Pressure Balloon technology, with US leading role.**

POLAR data analysis (participation in Collaboration).

Further participation in *-EUSO tests:

A) **Continuation of participation in EUSO-TA measurements and data analysis, modernisation of EUSO-TA detector, invitation of students for shifts and data analysis.**
B) **Data analysis from SBP-EUSO – measurements of CR EAS (Extensive Air Shower) with energies above 1E18 eV are expected.**
C) **Data analysis from Mini-EUSO.**
D) **Development of HVPS system (high voltage power supply) – towards large detector, further optimisation of power consumption.**

(Tentative) plan of this talk

1) Most energetic events in the Universe
2) Energy balance of GRBs (gamma ray bursts)
3) Compton scattering – the method
   for γ-ray polarisation measurements
4) POLAR detector
5) POLAR expected results (polarisation vs. no-polarisation)
6) Ultra high energy cosmic rays (UHE CR) – unknown origin
7) EUSO method to measure UHE CR
8) Telescope description
9) Test experiments (balloons, desert, ISS)
10) Summary

Four hypothetical astrophysical types of ultra high energy cosmic ray sources

astrophysics/astronomy

- galaxy cluster accretion shocks,
- AGNs – active galactic nuclei
- pulsars,
- GRBs – gamma ray bursts.

Another (unlikely) option

astrophysics/cosmology

so called “top – down” mechanism of UHE CR production:
decay of very heavy particles, unknown yet.

POLAR Experiment

POLAR ***is a Compton polarimeter devoted to study the prompt emission of Gamma Ray Bursts in the energy range 50–500 keV.***
(N. Produit, et al., NIM (2005))

Compact detector (~30 kg, sensitive volume ~30x30x18 cm^3)
Field of view: ~1/3 of half sky
Minimum detectable polarisation (MDP): < ~10%
expected gain: ~10 strong GRB / year

- **mounted on Chinese spacelab TG-2**
- **launched in Sept. 15, 2016**
- **lifespan: ~ 3 years**

What is interesting in GRBs ?

GRBs are the most energetic events
in the Universe
observed in electromagnetic radiation.

GRBs are observed on average once per day, nowadays.
The first detection in 1967.

- Basic observations are made from satellites which see short lasting pulses of gamma ray photons (keV energies).
- Each pulse from one direction. Pulses arrive always from different direction.
- Pulse lasts from ~10 milliseconds to a few hours.
- Gamma ray flux intensities within a pulse are always different.

The sources type, origin, mechanism of production are unknown.

What is interesting in GRBs ?

GRBs are the most energetic events
in the Universe
observed in electromagnetic radiation.

Still, more energetic known events
in the Universe are:

1. Big Bang – origin of the Universe
2. sources of gravitational waves
   (recently observed)

GRBs are observed on average once per day, nowadays.
The first detection in 1967.

- Basic observations are made from satellites which see
  short lasting pulses of gamma ray photons (keV energies).
- Each pulse from one direction. Pulses arrive always from different direction.
- Pulse lasts from ~10 milliseconds to a few hours.
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GRB astro-physics

Cosmic X-rays can not penetrate the Earth's atmosphere,
so measurements have to be done at satellites or stratospheric balloons.

GRBs are always observed from different directions on the sky,
and this suggests that the emission process is catastrophic,
i.e. the source can do it only once (e.g. extremely huge explosions (?)).

The size of the emitting object is limited by the short time of the GRB.

GRBs are at cosmological distances.

Sometimes it was possible to measure GRB optical afterglow redshift.
The largest z was 9.4 (as most probable, but $z > 7$).
At $z = 7$ age of Universe was $0.76 \cdot 10^9$ yrs (now it is $13.83 \cdot 10^9$ yrs)
light was travelling $1.23 \cdot 10^{23}$ km = 4000 Mpc.
The nearest GRB was about 40 Mpc from us.

GRB astro-physics - energy

Our Sun power for the reference:

Luminosity of the Sun $L_\odot = 3.8 \cdot 10^{26}$ W $= 2.4 \cdot 10^{45}$ eV/s =

$= 6.9 \cdot 10^{7}$ (kg/s) $\cdot c^2$ = 69000 (tons/s) $\cdot c^2$

(Sun mass $M_\odot = 2 \cdot 10^{30}$ kg)

Distance from Earth = 1 AU = $1.5 \cdot 10^{8}$ km

At the Earth distance the Sun power density = 1350 W/m^2

For GRB at 200 Mpc, and for POLAR visible burst (min. 1000 gammas):

POLAR effective area is about 11 cm^2,

therefore 1000 γ / 0.0011 m^2 $= 9.1 \cdot 10^{5}$ γ/m^2.

Average gamma energy is about 100 keV,

so during such GRB energy density is $9.1 \cdot 10^{10}$ eV /m^2 $= 1.46 \cdot 10^{-8}$ J/ m^2

If the source emitted isotropically,

then it emitted $7 \cdot 10^{42}$ J $= 7.7 \cdot 10^{31}$ kg $\cdot c^2$ = 39 $M_\odot \cdot c^2$ (within time of burst).

If GRB are emitted in a cone of angular diameter 0.5° (like the Sun or the Moon),

then during above burst energy emitted $= 3.3 \cdot 10^{37}$ J = 0.00018 $M_\odot$,

but we see only one GRB of 210000 GRBs emitted in other directions.

(looks impossible !)

GRB astro-physics – energy, cont.

For GRB at 200 Mpc, and for 1000 γ at 11 cm^2 (POLAR effective area), we have following required energies:

isotropic emission: $E = 7 \cdot 10^{42}$ J = 39 $M_\odot$, we might see all GRBs,

emission in 30° cone, $E = 1.2 \cdot 10^{41}$ J = 0.66 $M_\odot$, we see 1/59 GRBs,

emission in 20° cone, $E = 5.3 \cdot 10^{40}$ J = 0.29 $M_\odot$, we see 1/132 GRBs,

emission in 8° cone, $E = 8.5 \cdot 10^{41}$ J = 0.05 $M_\odot$, we see 1/820 GRBs,

emission in 2° cone, $E = 5.3 \cdot 10^{38}$ J = 0.0029 $M_\odot$, we see 1/13000 GRBs,

emission in 0.5° cone, $E = 3.3 \cdot 10^{37}$ J = 0.00018 $M_\odot$, we see 1/210000 GRBs

Isotropic emission (in 4π) requires extremely large, and extremely compact objects.

Emission in the cones (like jets) requires smaller, but still large energy to be released inside the cone, only. Many events would miss the Earth (POLAR), but cones can not be too small, as we would see afterglows of them.

GRB astro-physics - emitting object size

GRB lasts short time.
Therefore emitting object size (as we “see” it) has to be smaller than (GRB length x speed of light).

20% of GRBs are shorter than 2 s.

Light from the Sun needs 500 s to get to us.

Sun radius $R_{\odot} = 7 \cdot 10^5$ km

Sun diameter = $14 \cdot 10^5$ km= $14 \cdot 10^5$ km/($3 \cdot 10^5$ km/s) $\cdot$ c = 4.7 s $\cdot$ c

The distance to the Moon is 356000 km – 407000 km,
so light travels 1.2 s - 1.35 s that distance.

Why do we need to measure GRB gamma-ray polarisation?

How to measure GRB gamma-ray polarisation?

Why do we need to measure GRB gamma-ray polarisation?

Because it was not yet measured (sufficiently well).

**Gamma-ray flux (light curve) is being measured,
energy spectra, directions, time,
in some cases afterglow in visible light can be measured, which provides opportunity to measure distances.**

Our interest: ***GRBs are so energetic events, that they are possible candidates for cosmic ray sources. Gamma-ray emission spectrum is non-thermal, so flux of energetic particles is required.***

How to measure GRB gamma-ray polarisation?

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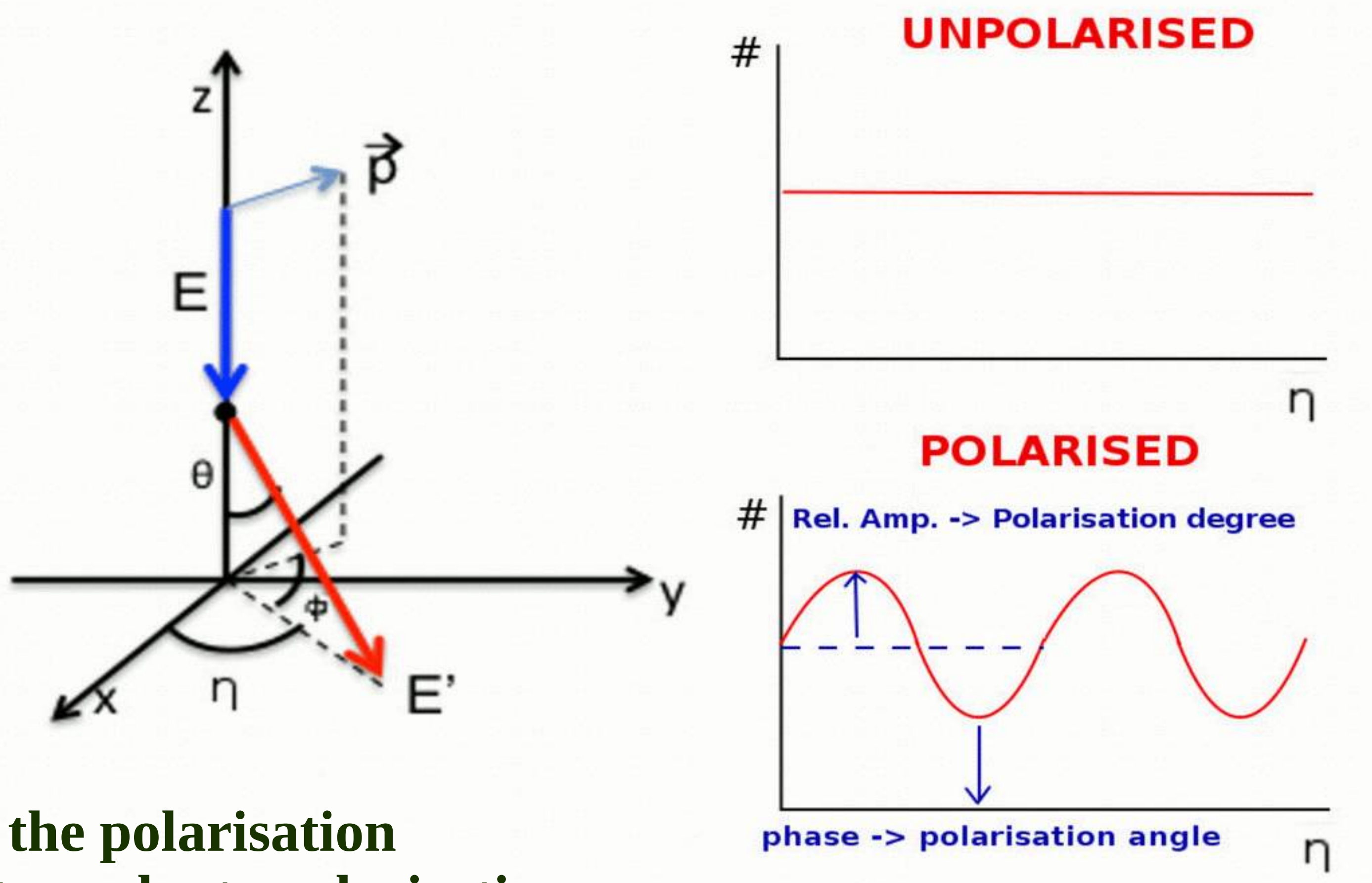
How to measure GRB gamma-ray polarisation?

Through measurements of azimuthal asymmetry of Compton scattering.

Compton scattering – Klein-Nishina formula

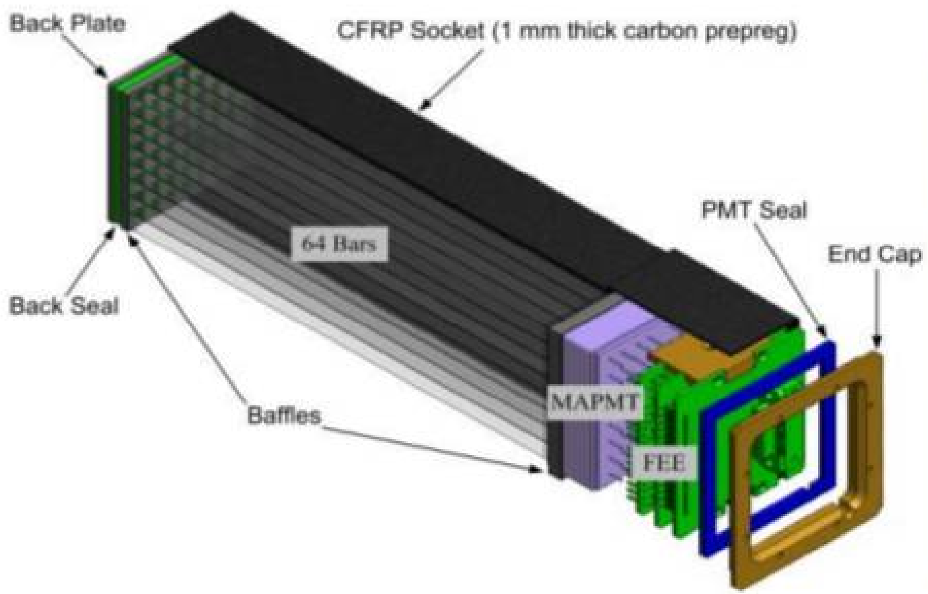
$$\frac{d\sigma}{d\Omega} = \frac{r_o^2}{2}\frac{E'^2}{E^2}\left(\frac{E'}{E} + \frac{E}{E'} - 2\sin^2\theta\cos^2\phi\right).$$

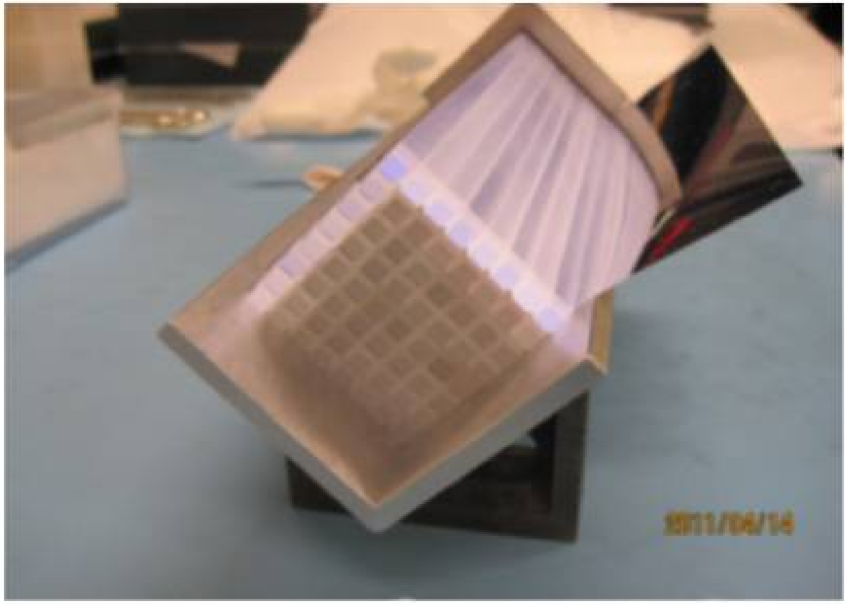


Relative amplitude is the polarisation degree measure. But to evaluate polarisation degree of the gamma flux, comparisons of measured anisotropy with simulation are necessary.

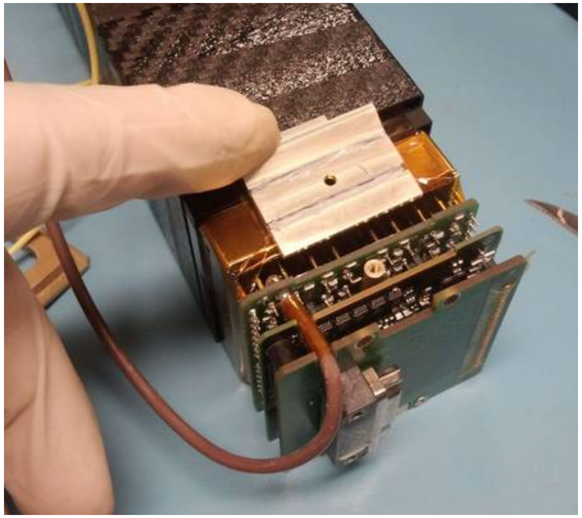
POLAR - detector for Compton scattering asymmetry measurements

POLAR uses a segmented scintillator array to measure the Compton scattering angle
In total 1600 plastic scintillators (BC409), 5.8 × 5.8 × 176 mm.
Each group of 64 scintillators is read-out using a single MAPMT (64 anodes photomultiplier, H8500 by Hamamatsu).
Total there are 25 MAPMTs each with its own FE electronics.

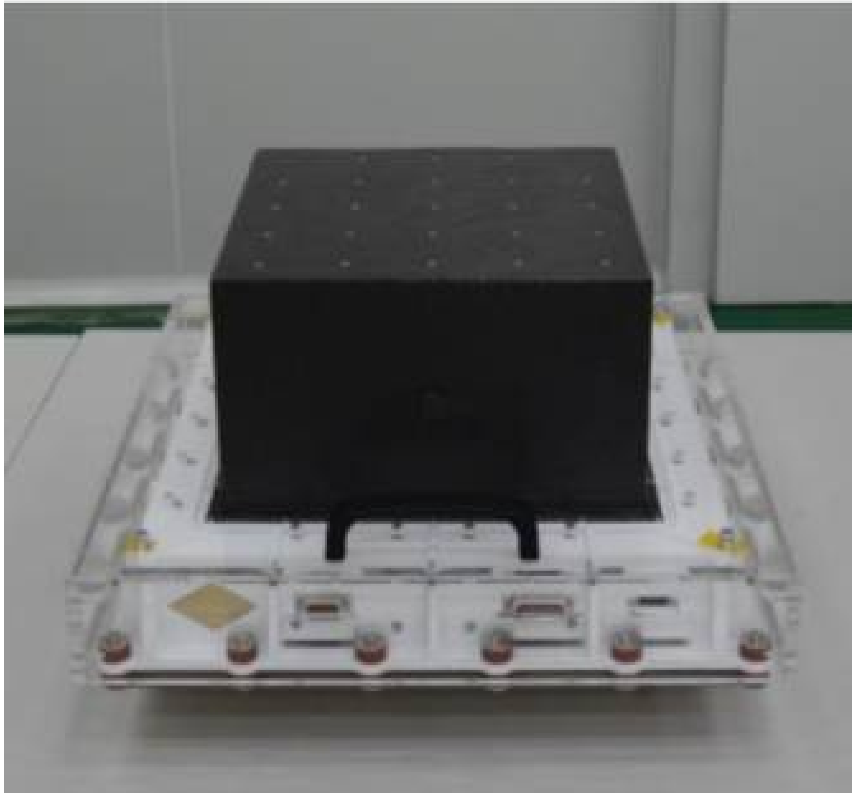




POLAR Experiment



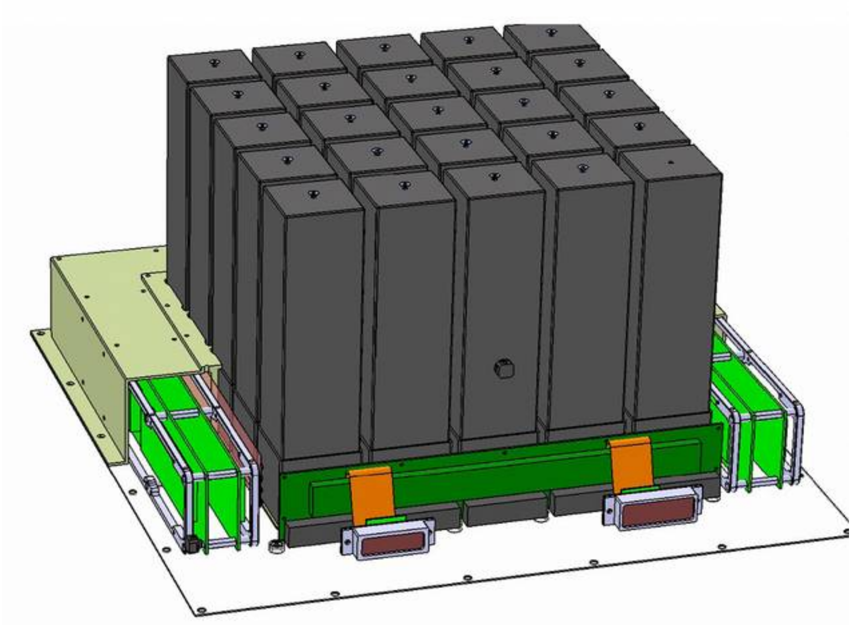
Module:
scintillating bars
with MAPMT
are in carbon
cover,
FE is visible

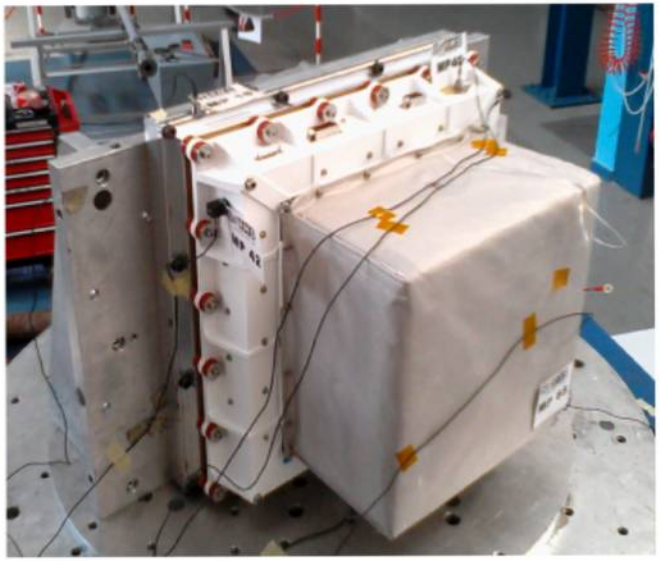


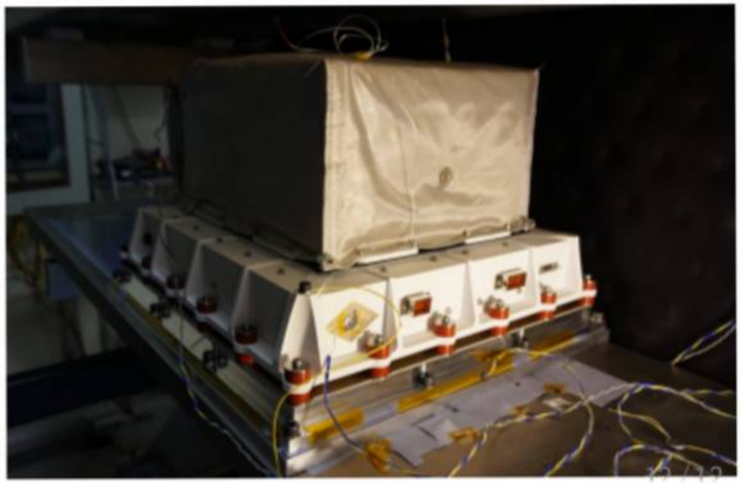
64 anodes photomultipliers,
H8500 by Hamamatsu

In POLAR we have 25 PMTs HAMAMATSU R10551-00-M64

POLAR detector



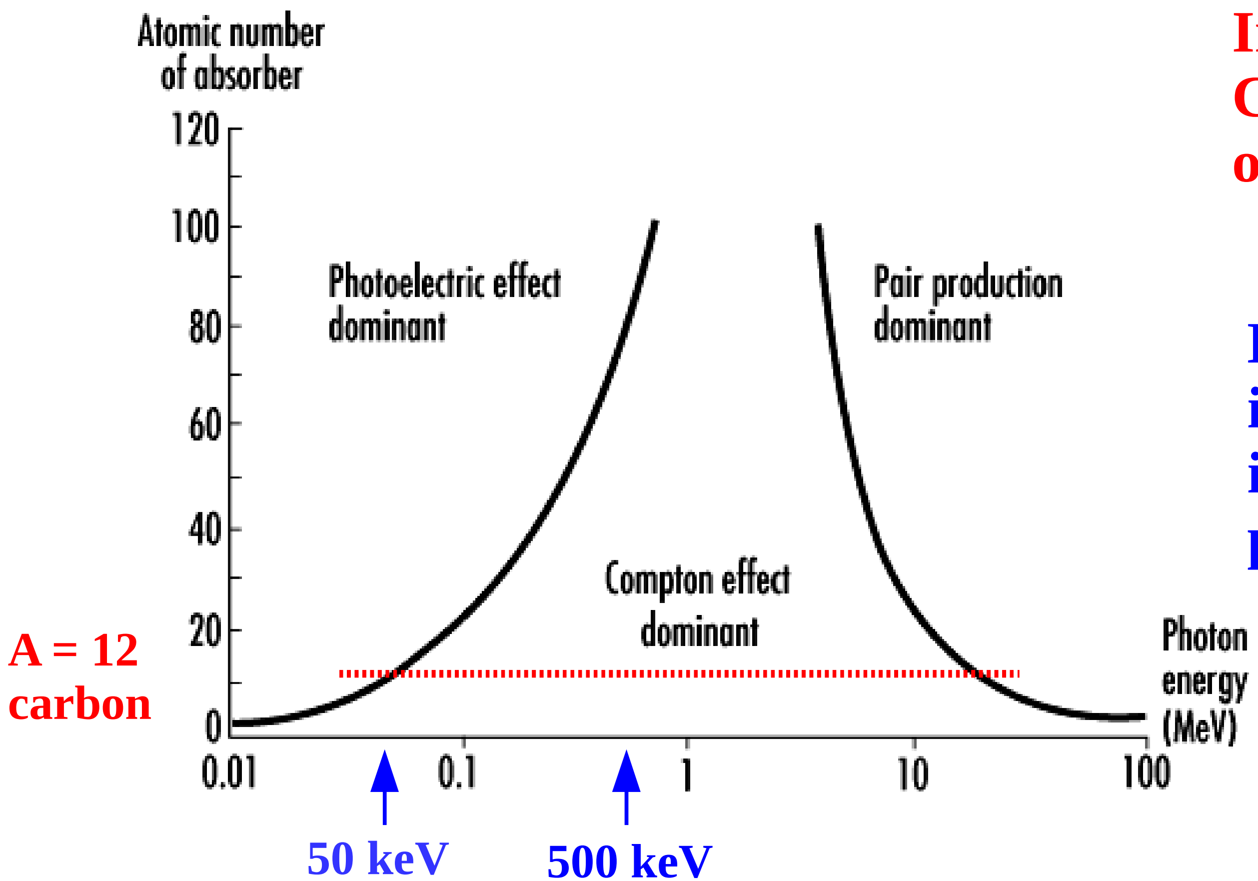




at Terni (Italy) vacuum thermal tests

How to measure gamma polarisation: Compton scattering

POLAR is measuring polarisation of gamma rays
in energy range 50 – 500 keV
by measuring azimuthal asymmetry in the first gamma interaction.

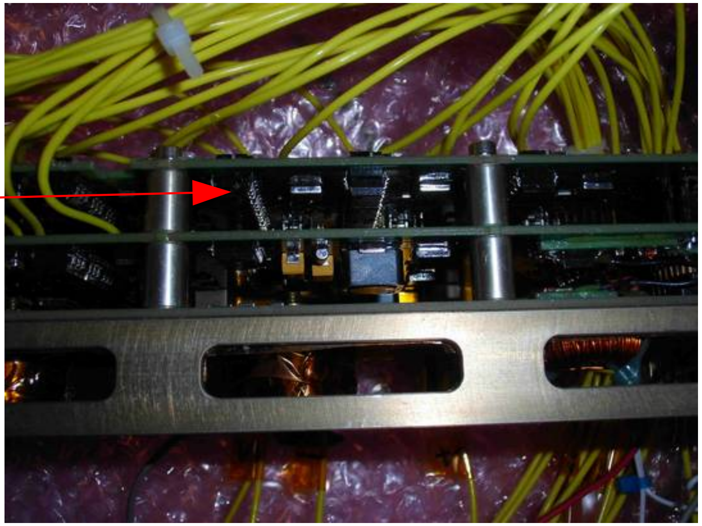


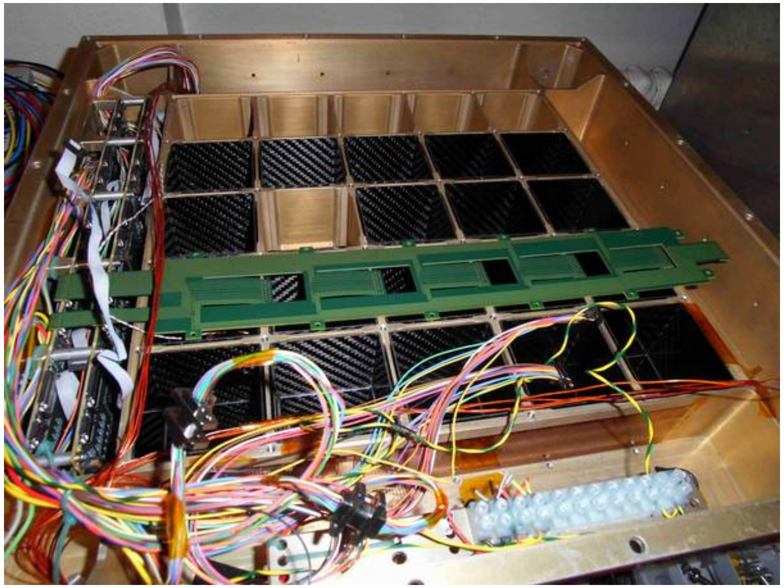
Interesting process is
Compton scattering
of gammas on electrons

Higher energy limit
is due to background
induced by charged cosmic ray
particles.

POLAR HVPS designed in NCBJ-Łódź, made by AoT, Zurich, Switzerland

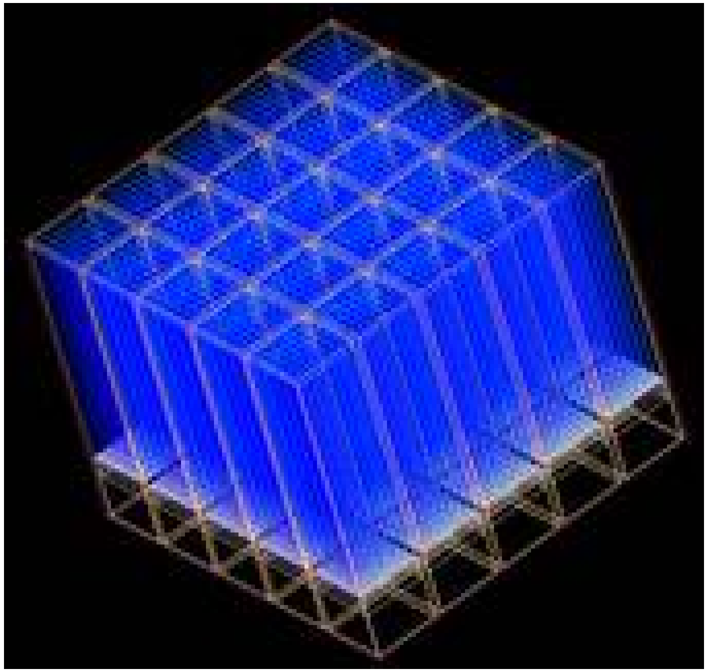
separate
“current sources”
to set individual
HV for each
MA PMT



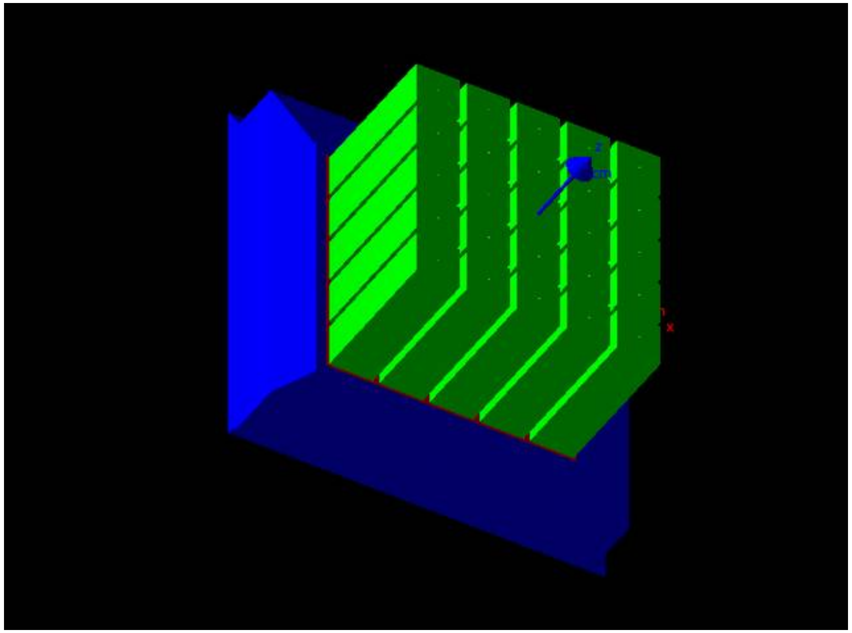


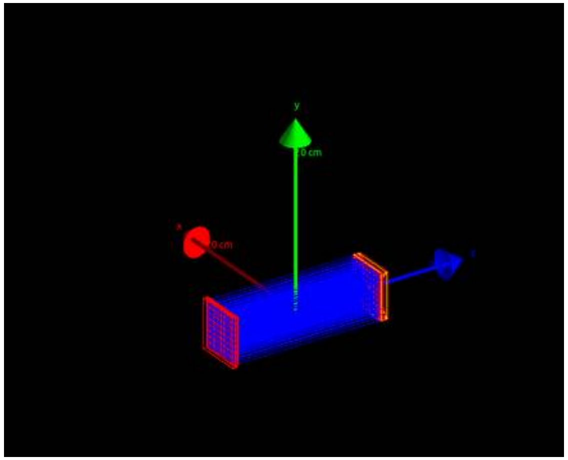
4-fold
redundancy
in HV generators

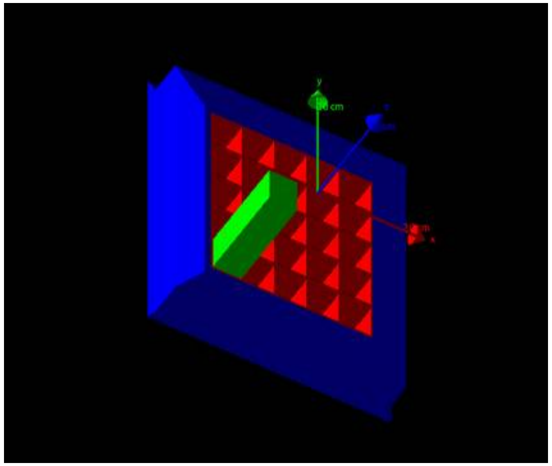
POLAR - detector for Compton scattering asymmetry measurements



Geant4 simulations are necessary to evaluate measured polarisation.







POLAR calibration at ESRF in Grenoble (2015)

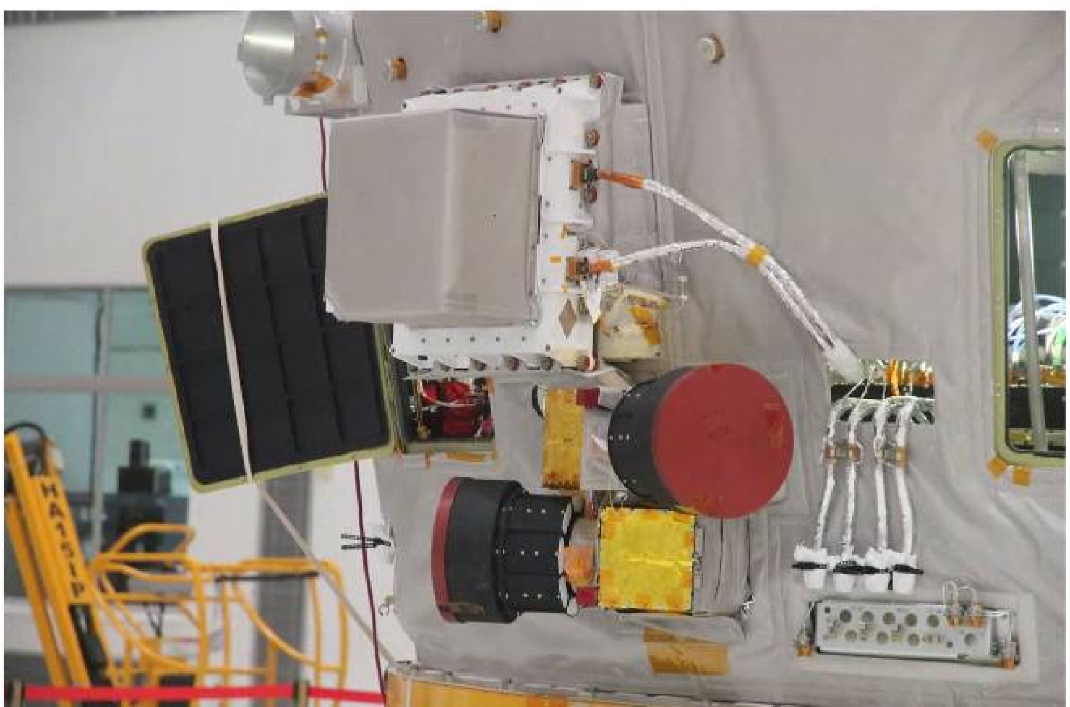
The ESRF - the European Synchrotron Radiation Facility

100 % polarised gamma beam, beam size 0.5 cm x 0.5 cm,
photon intensities: 10^3 phs/s – 10^4 phs/s
4 gamma energies: 60 keV, 80 keV, 110 keV, 140 keV

POLAR fixed to TG-2

POLAR has been mounted: OBOX

OBOX on TG2



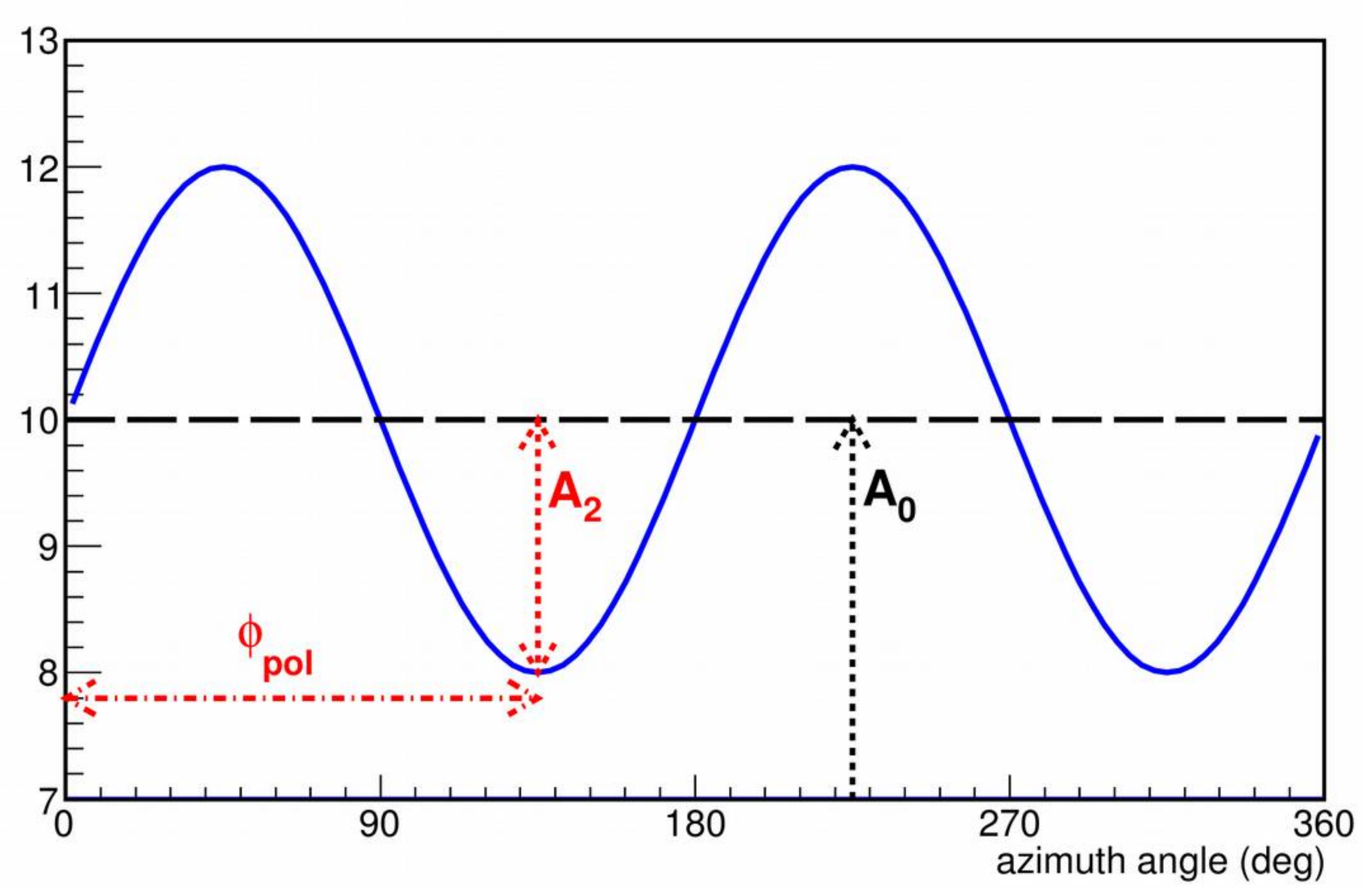
Experiment goes to space

Launch on the September 15, 2016,
from the Chinese Jiuquan Satellite Launch Center.
Rocket: Chang Zheng-2F
Module: Tiangong-2 (TG-2) – test space laboratory.

basic definitions

polarised beam Compton scattering → sin(2·φ) dependence

A2 – sinus amplitude
A0 – average value
A2/A0 – polarisation level (for γ-beam),
or relative amplitude (for measurements)



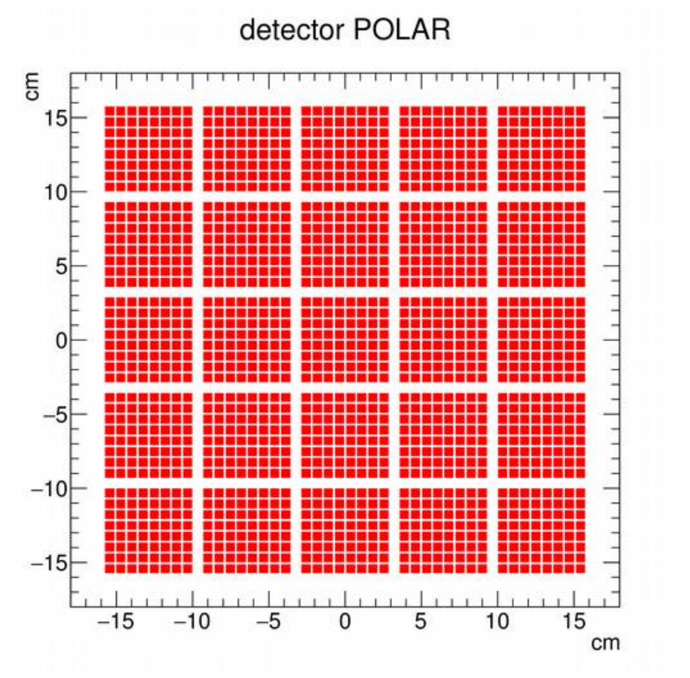
GRB polarisation measuremnts

To measure GRB polarisation degree we have following scheme:

1. **pair of scintillation bars measured during GRB are selected,**
2. **azimuth angle is evaluated,**
3. **azimuth angle distribution is made,**
4. **with Fourier analysis (or equivalent) A0, and A2 (period 180^{o}) are evaluated,**
5. **relative modulation A2/A0 is evaluated,**
6. **from comparison with Monte-Carlo simulation results (made for the same directions, spectrum, background etc., and for 100% polarisation) GRB polarisation degree can be evaluated.**

This looks relatively simple, but there is a problem uniformity of detector response.
We are still working on that.

POLAR is measuring 1-3 GRB light curves every week.



GRB polarisation

Most of GRB emission models predict measurable polarisation degree. For models with jets, polarisation degree might depend on relative angle between gamma flux direction (to us) and jet direction. But polarisation degree distributions (for different GRBs) are different for different models.

Result with no polarisation would be probably the most interesting. However, the described method always gives positive result to A2/A0, so we can only set an upper limit for low level polarisation. This limit depends on the number of events measured during GRB.

Cosmic rays

Astrophysics (primary cosmic rays):

- energetic stable particles
- energetic – non-thermal energy distribution
- energy range up to about 1e20 eV (is there a limit ?)

stable particles:

- protons, nuclei, electrons, gammas, neutrinos, anti-protons, positrons

Secondary cosmic rays:

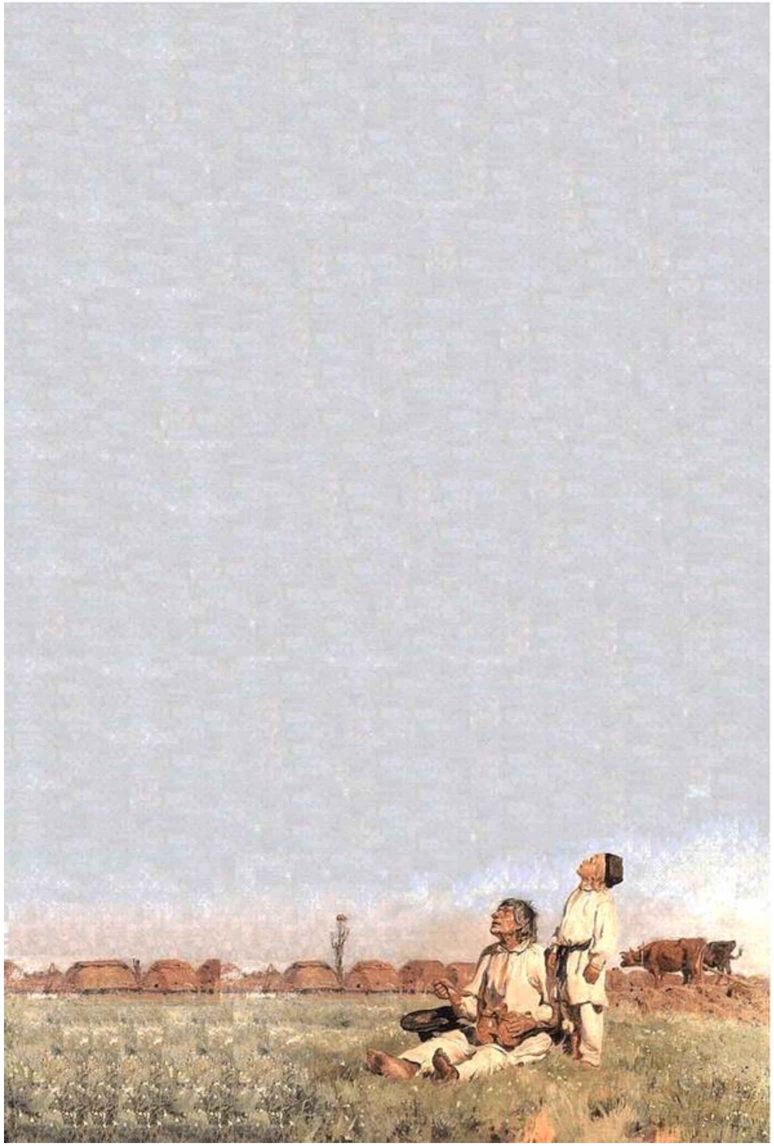
- secondary energetic particles in atmosphere generated by primary cosmic rays
- coherent events: EAS (extensive air showers)
  - cascades of gammas, electrons/positrons, muons and hadrons
- muons

ground level observations of EAS (extensive air showers)

The atmosphere is a target/detector

Particles in EAS:

photons	(10 x Ne)
electrons + positrons	(Ne)
muons	(0.1 x Ne)
hadrons	(0.01 x Ne)
neutrinos	



animation: T.Wibig

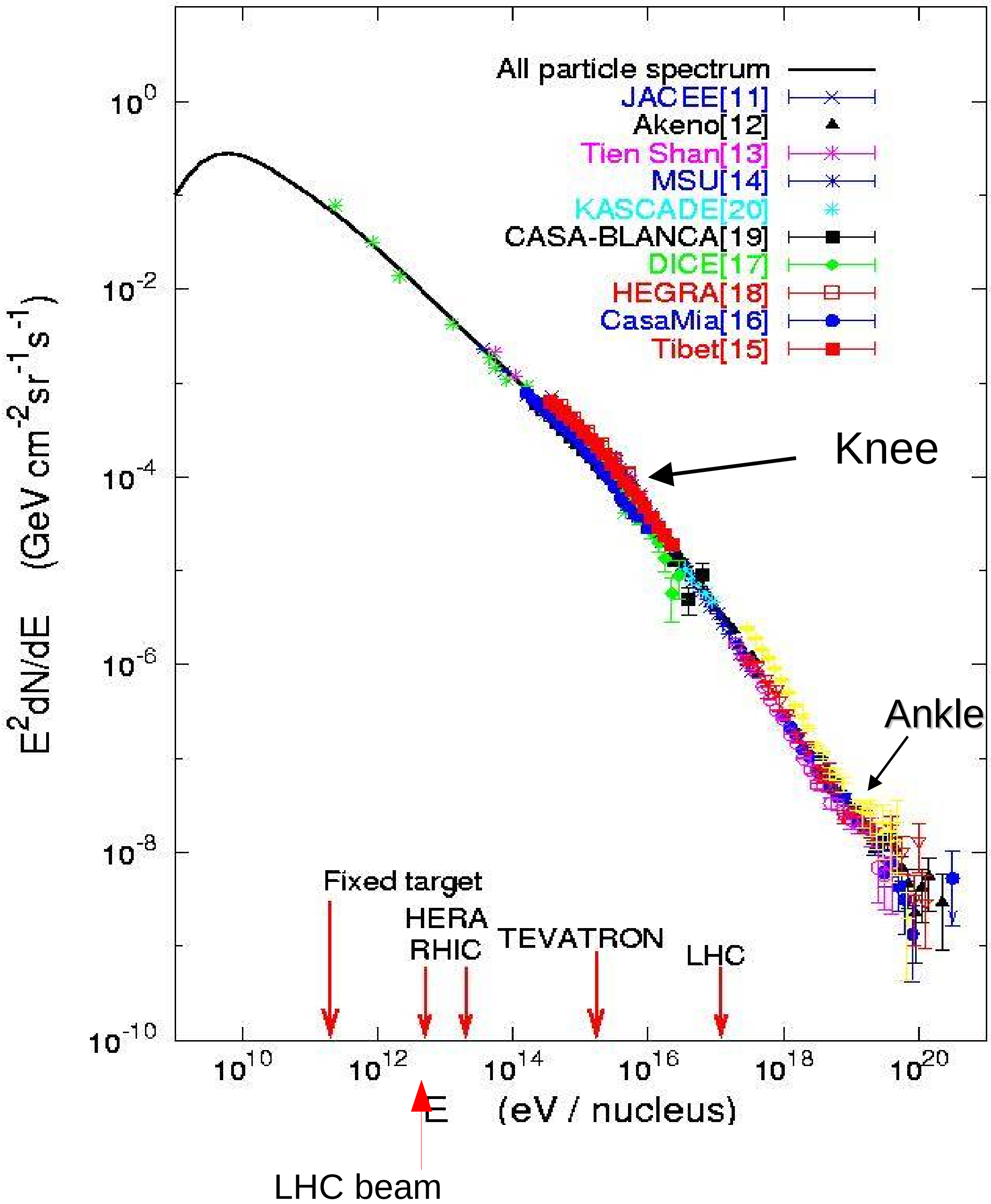
EAS particles move with a speed nearly c – light speed in vacuum (i.e. might be faster than light in the atmosphere)

typical EAS lasts about 30 microseconds (i.e. about 10 km/c)

Cosmic ray energy spectrum

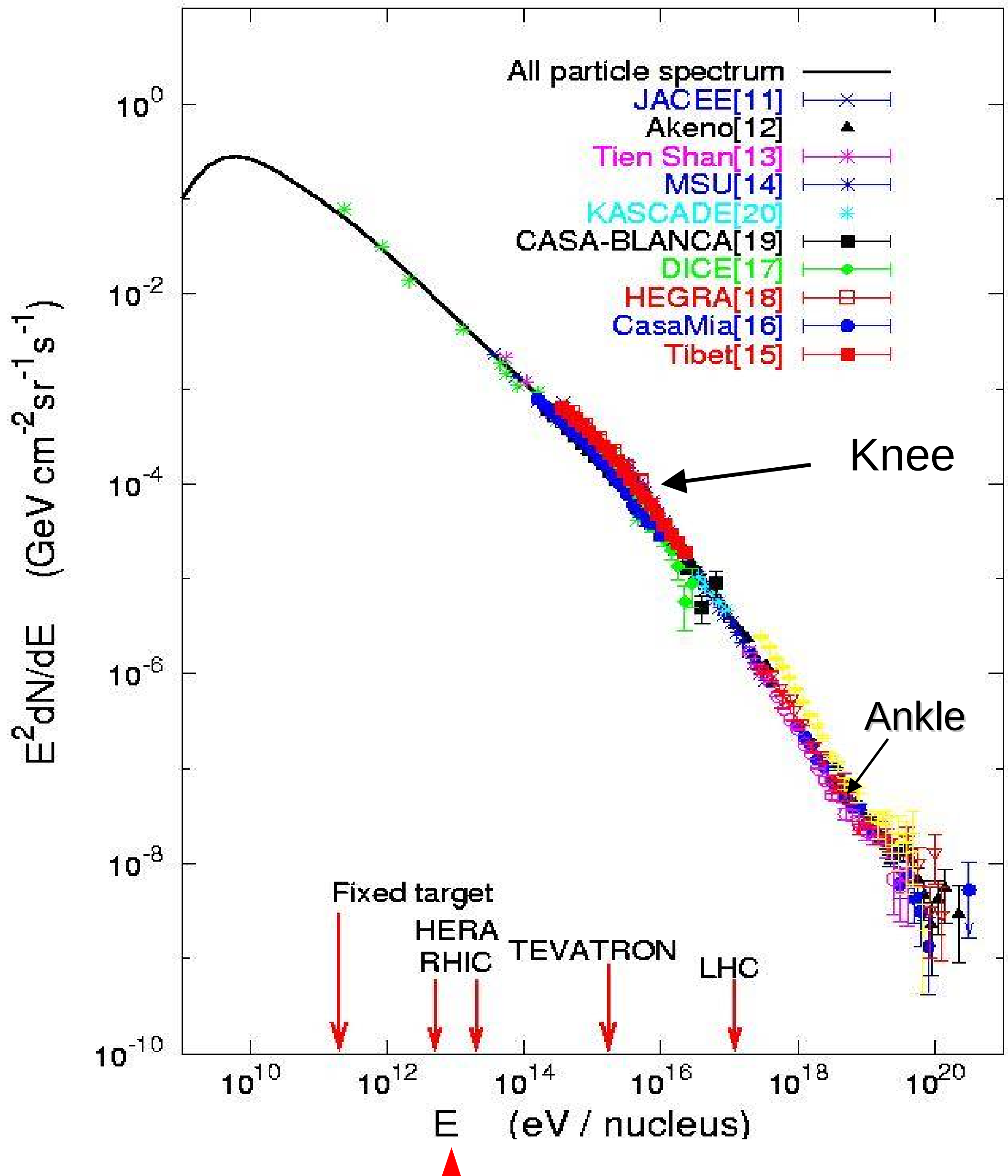
Direct measurements
on balloons and satellites
up to 1e15eV
(limited by:
exposure
energy estimation)

Above 1e14 eV
EAS measurements
(problems with:
mass determination
energy estimation)



The Cosmic Ray energy spectrum

physics



LHC beam

Stable charged particles, atomic nuclei.

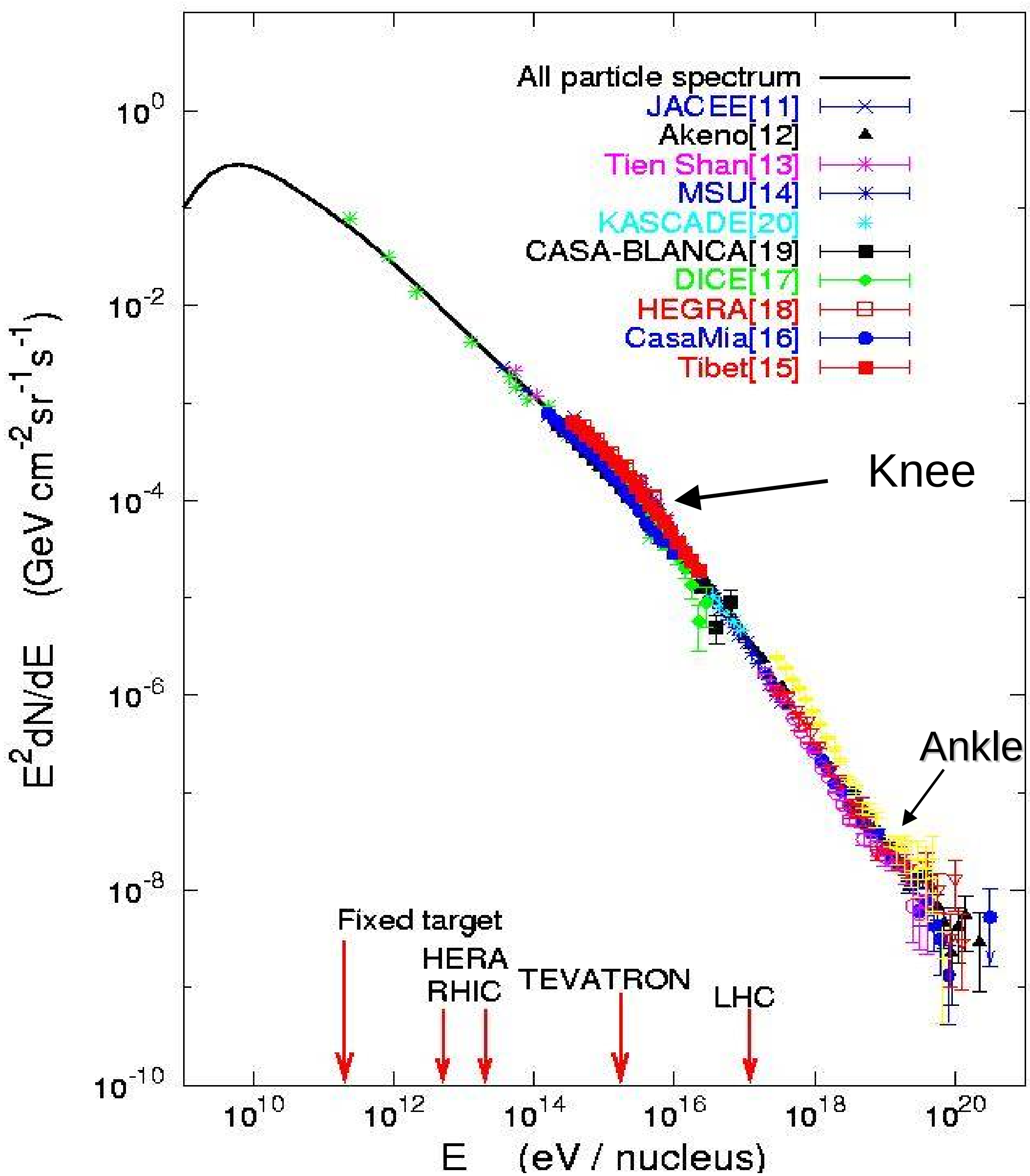
<u>Nonthermal</u> energy spectrum.

Proton in LHC beam at CERN (will) have max energy 7E12 eV.

The highest measured Cosmic Ray particle energies are about 3E20 eV.

Nature does provide particles accelerated to energies $40 \cdot 10^6$ times higher than LHC physicists at CERN do

The Cosmic Ray (CR) energy spectrum



LHC beam

The main scientific problem of CR:

- **How Nature made them ?**
- **Where they were made ?**
- **Where do they come from ?**

Particles have electric charge so Galactic and extragalactic magnetic fields bend their trajectories.

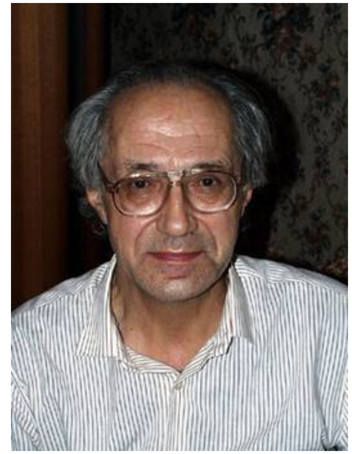
We do not know CR sources from direct measurements .

We measure photons emitted in the vicinity of CR sources from high energy CR interactions with matter or magnetic field (vide observations of nonthermal radio emission, infrared – IR, UV, X and gamma).

The GZK Effect

Kenneth Greisen

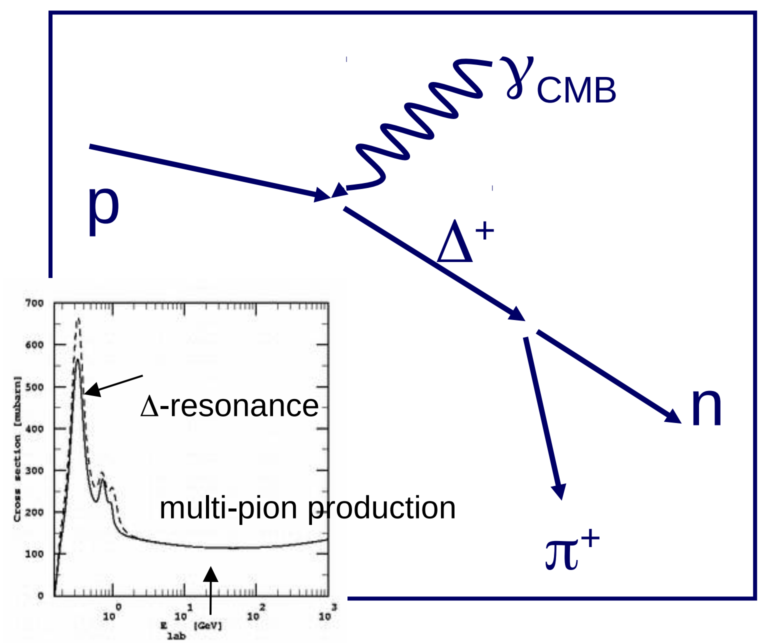
George Zatsepin



Vadim Kuz'min

Greisen (1966) and, independently Zatsepin & Kuz'min (1966)

range of CR < 50 Mpc ($E_{CR} > E_{GZK}$)



$$E_{th} = \frac{2 m_N m_p + m_p^2}{4 e} \rightarrow 5 \cdot 10^{19}\,\mathrm{eV}$$

$$p + \gamma \rightarrow n + \pi^+$$

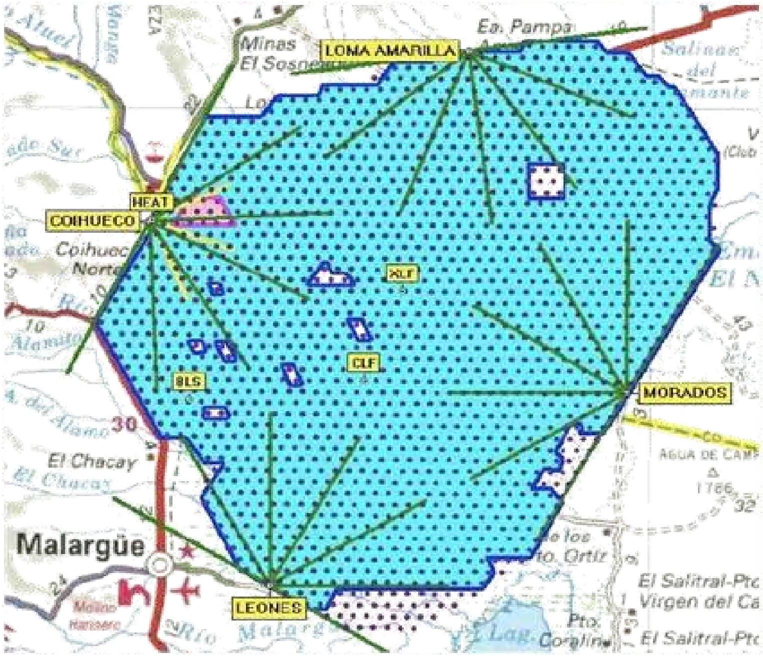
$$p + \gamma \rightarrow p + \pi^0$$

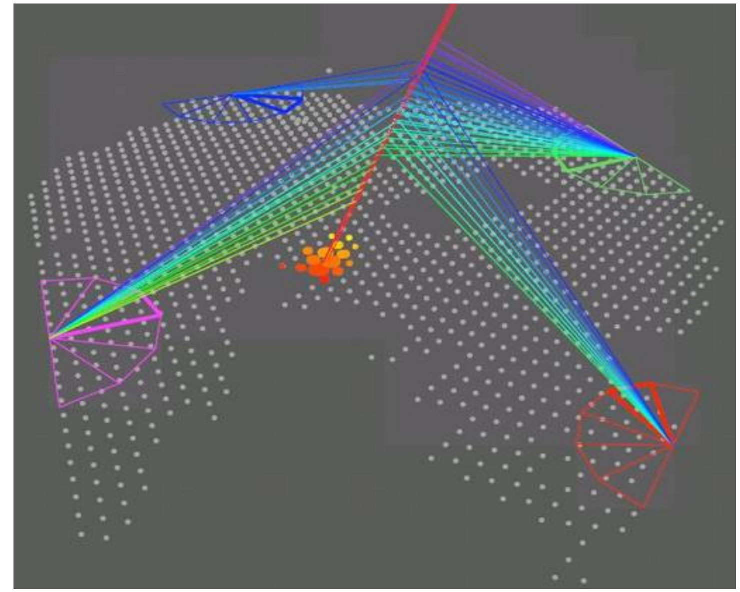
$$p + \gamma \rightarrow p + e^+ + e^-$$

method

PAO – Pierre Auger Observatory (South hemisphere)

very large area detector
using atmosphere as target,
and observing EAS





FD & SA measurements

Expected 25 EAS/ year
(E > 5.5 10^{19}eV)

FD – only during clear dark nights

3000 km^2 7000 km^2 sr yr (θ<60°)

FD – fluorescence detectors
SA – surface array

Still, too small detector area (too low statistics)
to provide significant result of UHE CR source problem.

Larger exposure (statistics) is needed to enable experimental solution

- Measurements of energy spectrum (GZK cut-off)
- Measurements of primary particle masses (sources and GZK cut-off)
- Measurements of direction of the events (search for point-like sources, isotropy/anisotropy)

(Statistics is more important than spatial resolution)

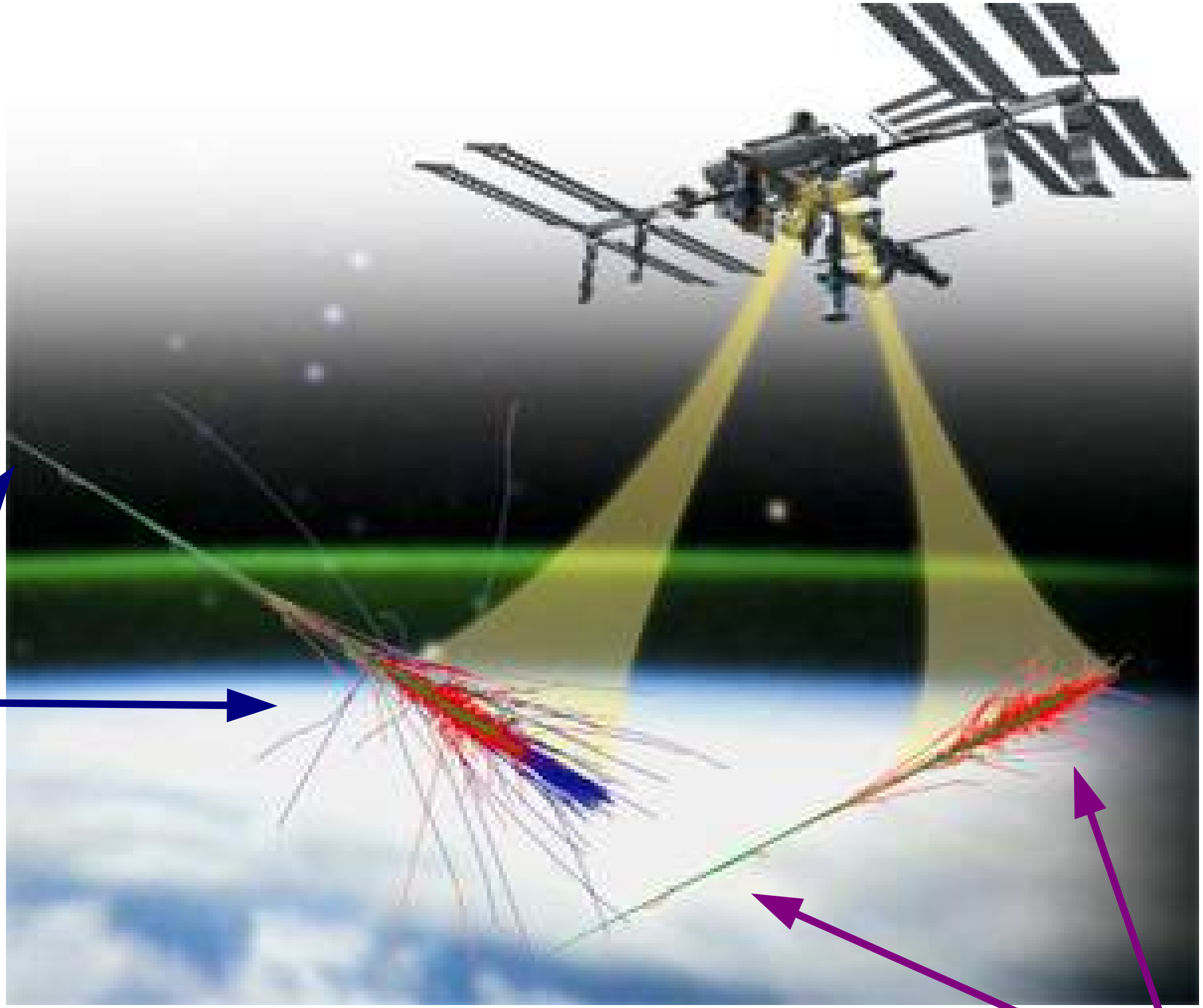
Observations from space !!

method

ISS – altitude about 400 km

JEM-EUSO: fast camera
400 000 frames per second
to measure events lasting about 30 μs

above 300 000 pixels



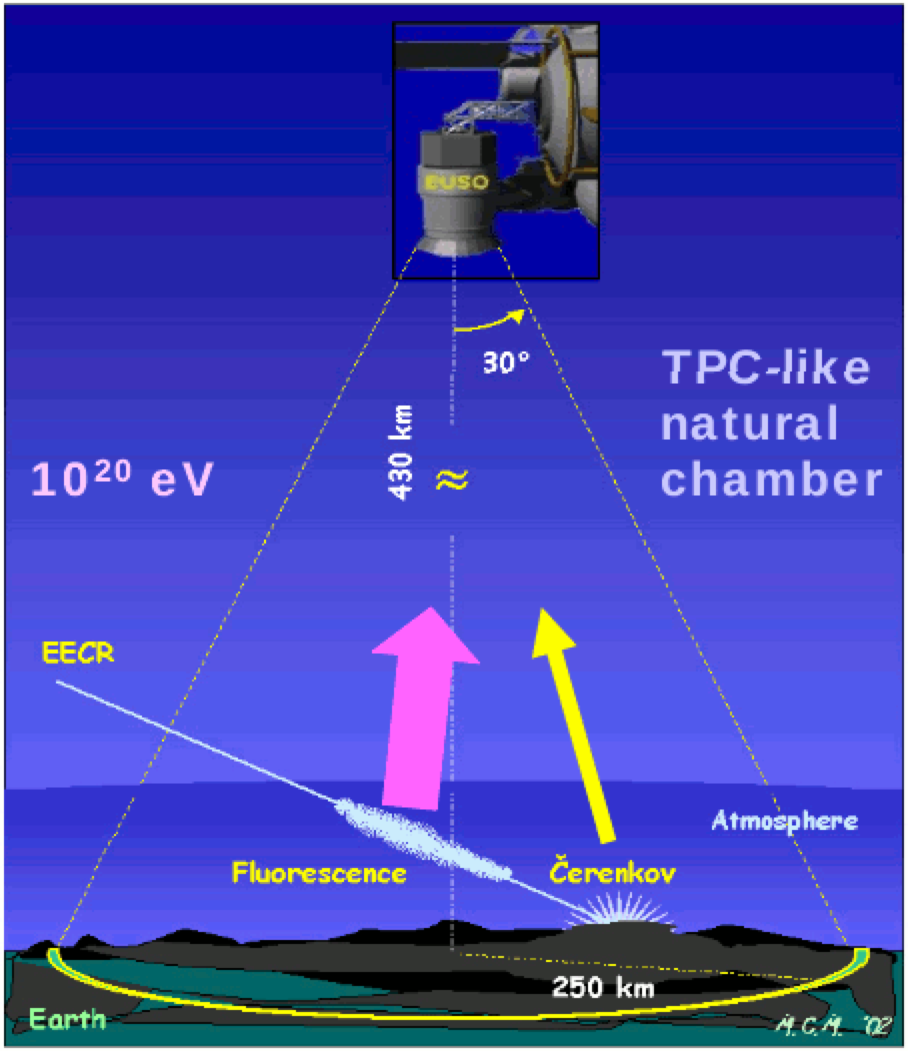
EAS

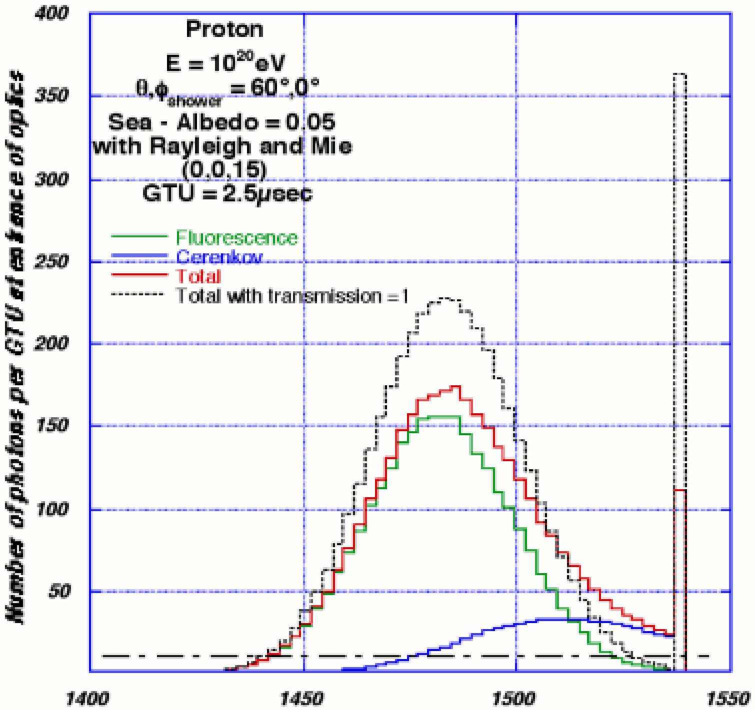
neutrino shower

particles excite N_2, and N_2 emits UV light

Principle of EUSO

- first *remote-sensing* from space, opening a new window for the highest energy regime

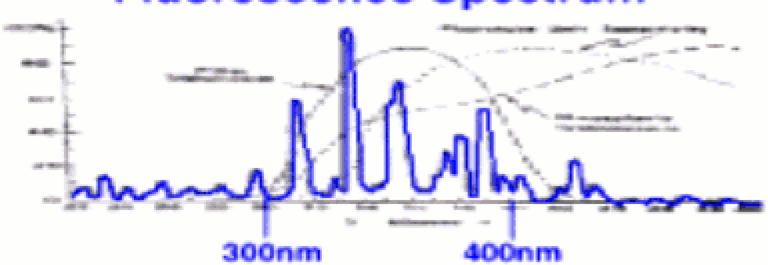




Cf: Ground-based arrays < 0.01 EUSO

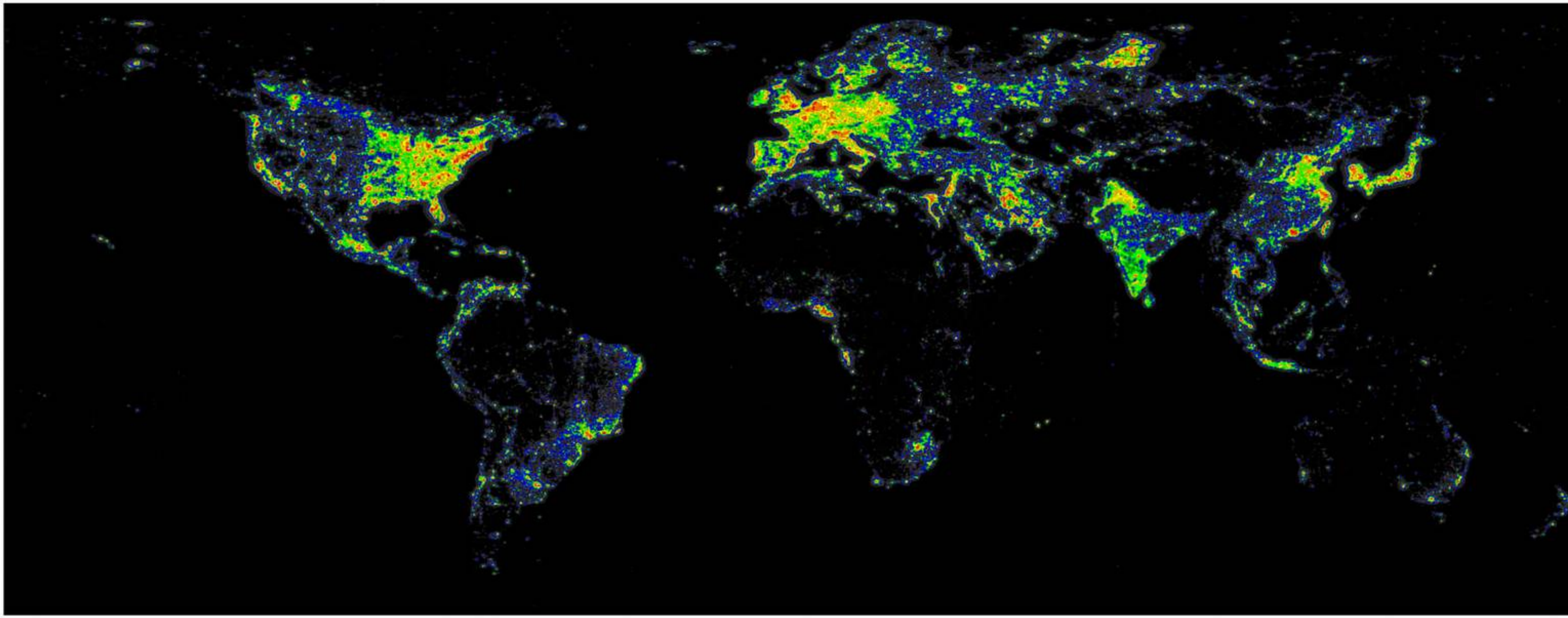
(1) Scintillator array,(2)Fluorescence telescope array

Fluorescence Spectrum



From College de France: better data now

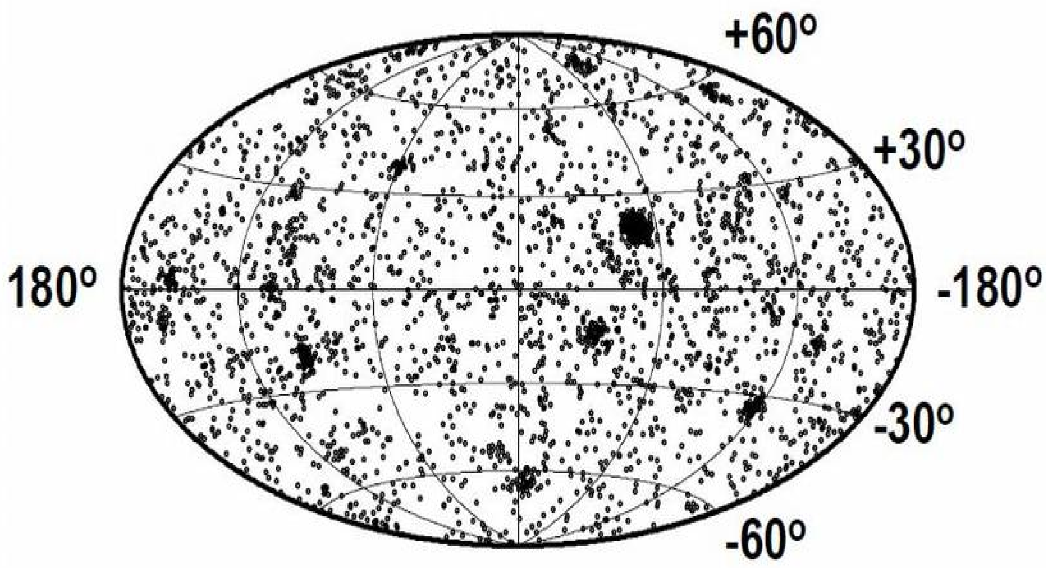
Light pollution of the Earth



http://darksitefinder.com/maps/world.html

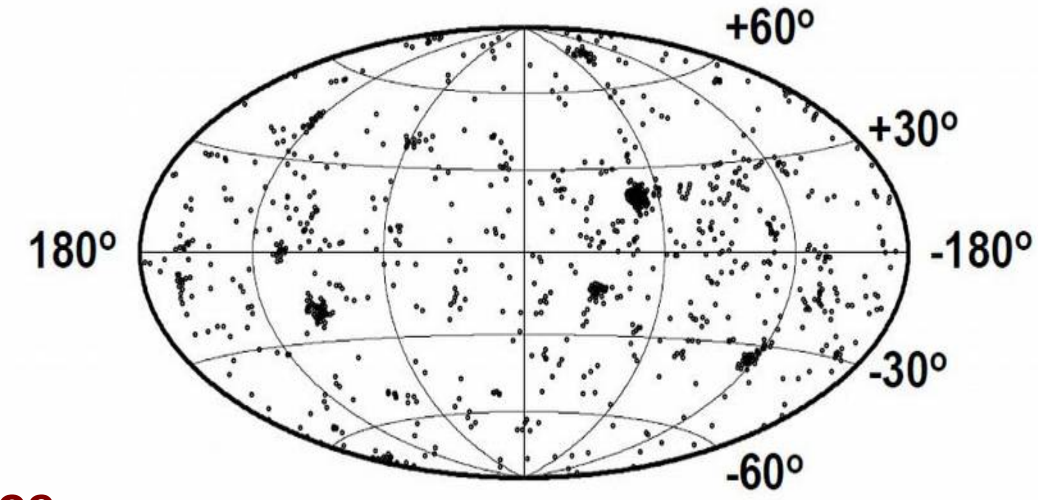
Simulations assuming that AGNs are CR sources

JEM-EUSO astrophysics



3000 events
$E > 5\ 10^{19}$ eV

1000 events
$E > 7\ 10^{19}$ eV



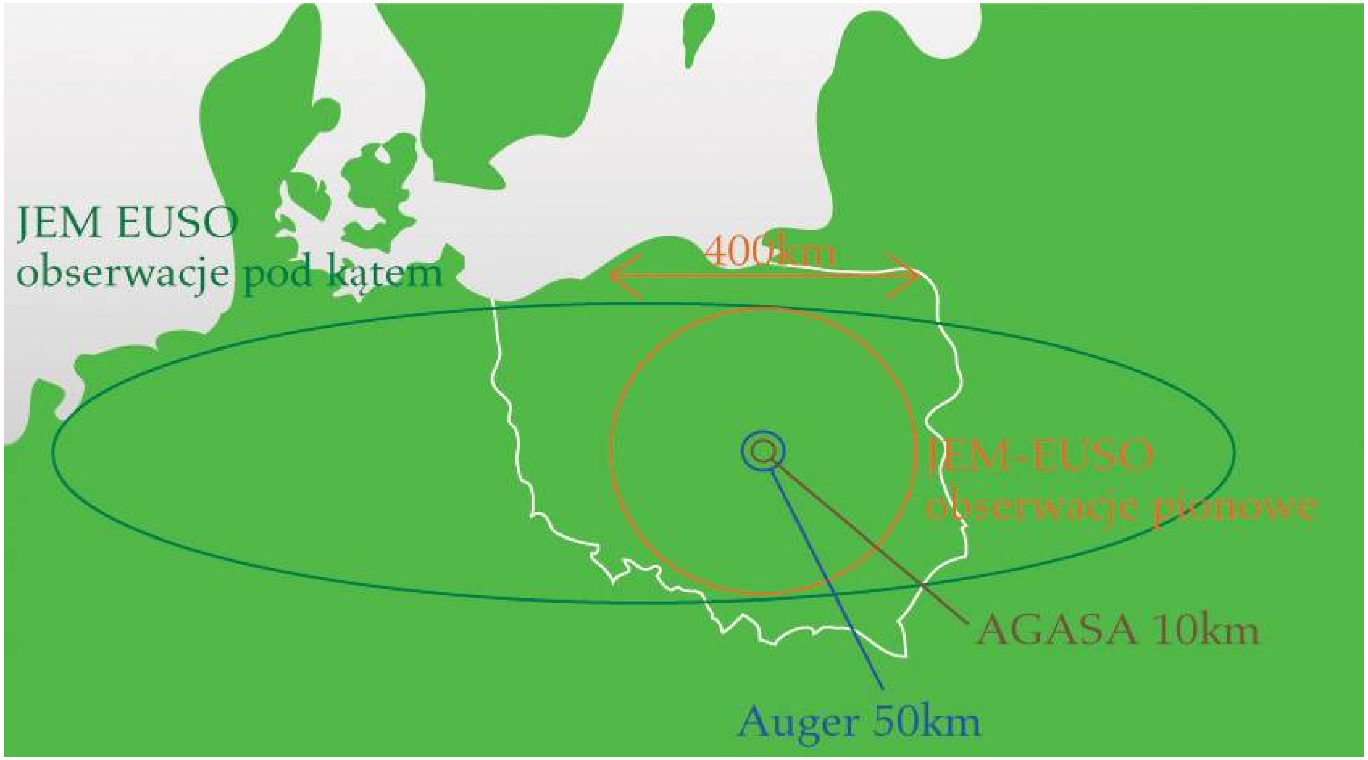
Assumptions about magnetic field in the Galaxy and in extra galactic space are essential in these simulations.

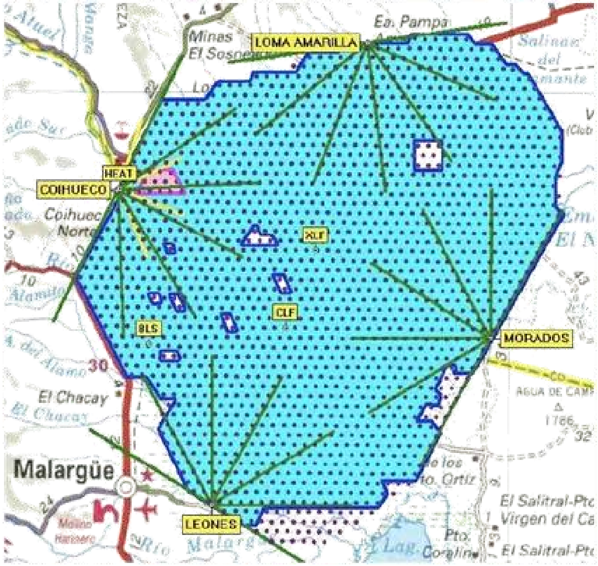
particle astronomy ?

Discovery of UHE CR sources would provide information (at least limits) about magnetic fields.

JEM-EUSO observation areas (nadir and tilt)

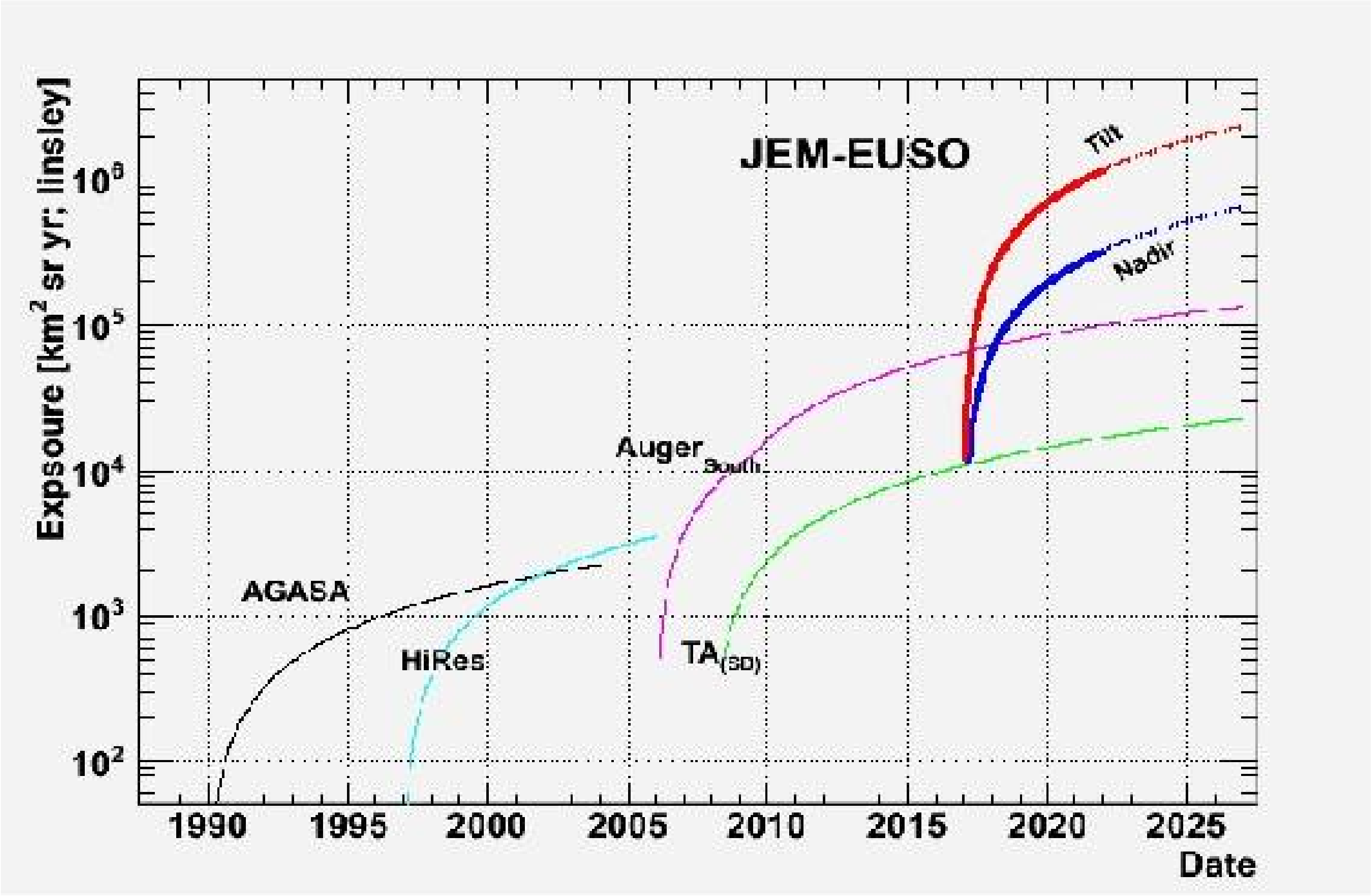
JEM=EUSO:
nadir: 350 EAS/yr
(E>5.5 10^{19} eV)



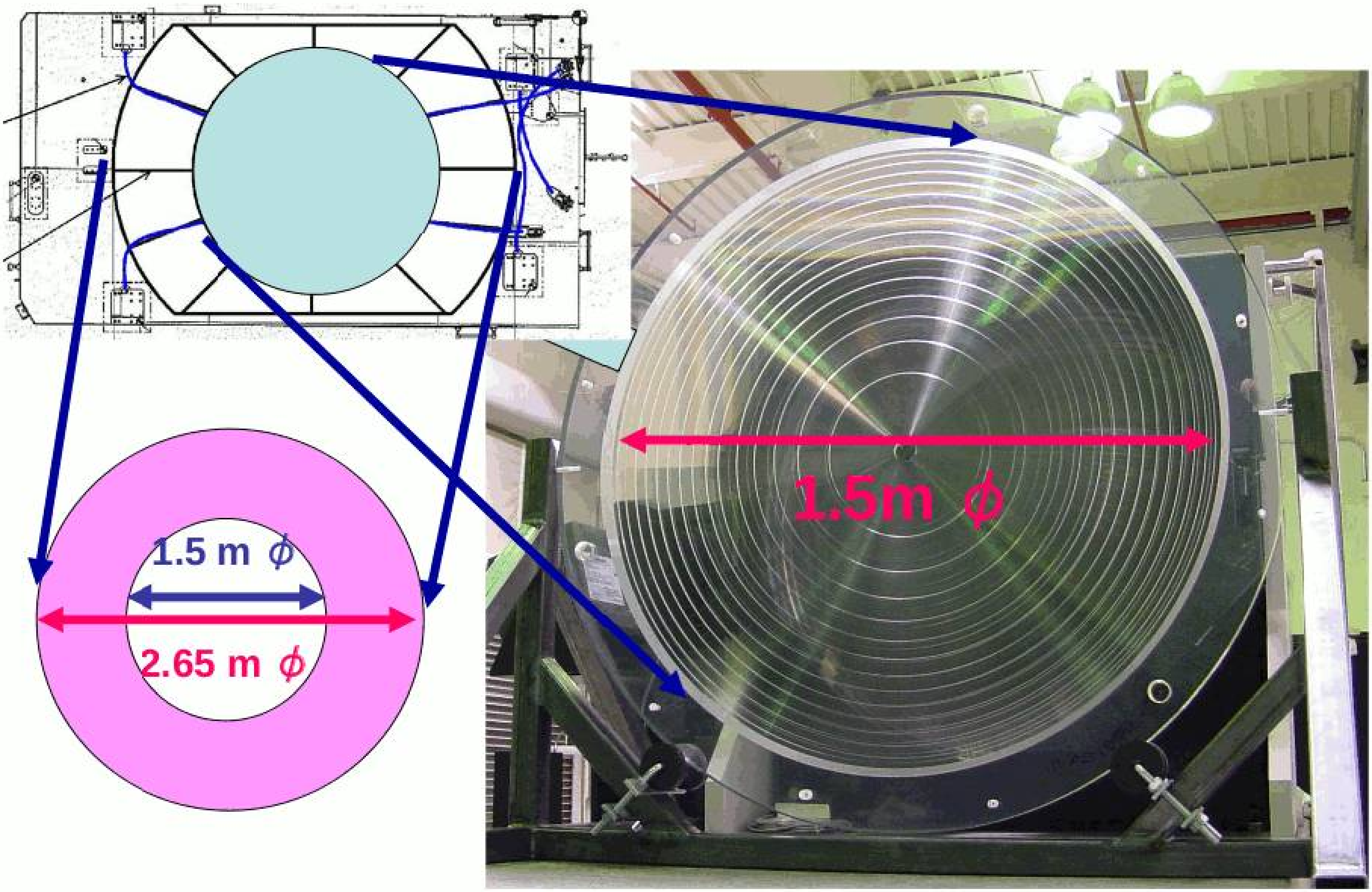


PAO – Pierre Auger Observatory
(South hemisphere) – 3000 km^2, 7000 km^2 sr
25 EAS/yr (E>5.5 10^{19} eV)

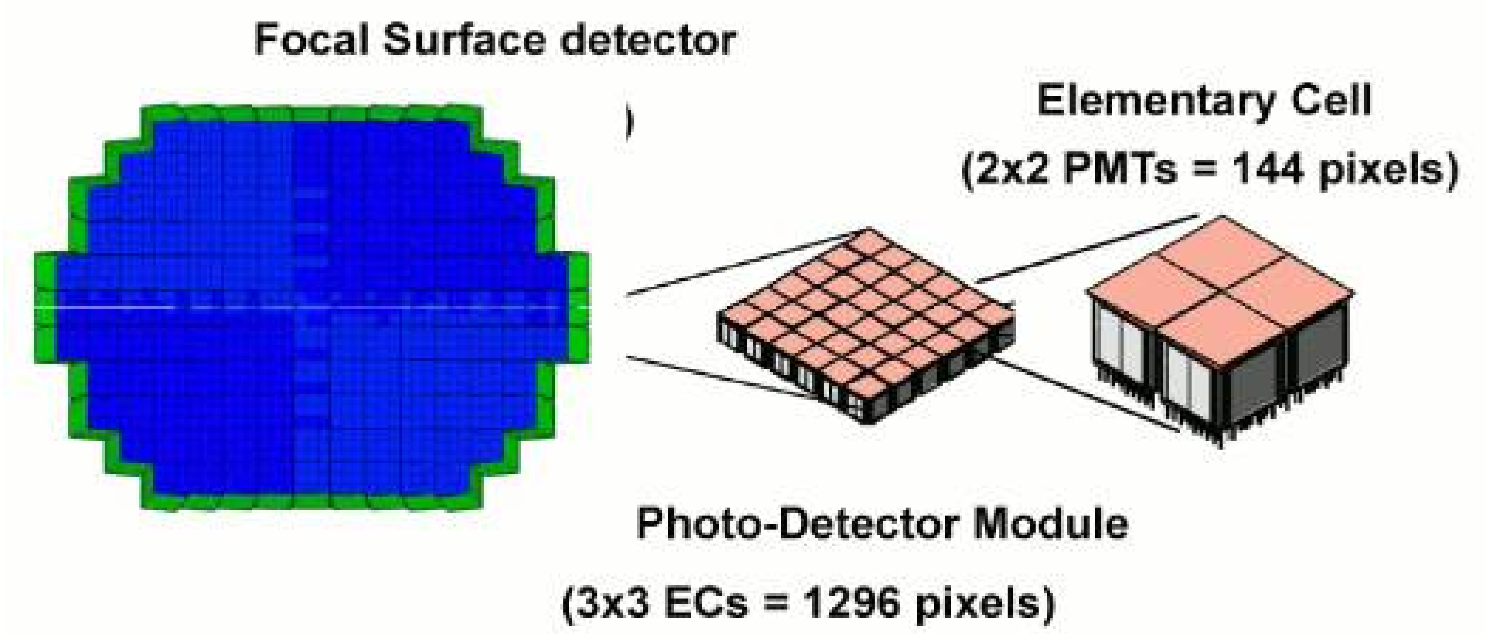
Porównanie ekspozycji

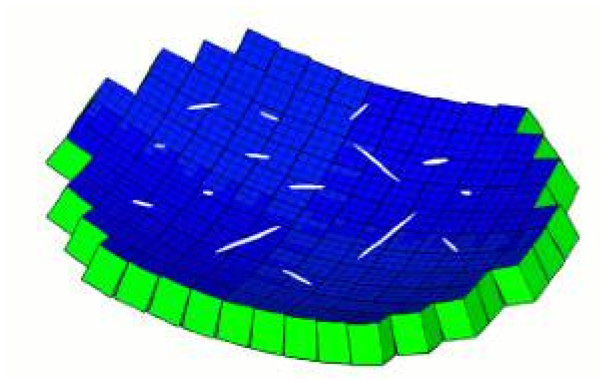


Soczewki Fresnela



multianode photomultipliers, layout at focal surface



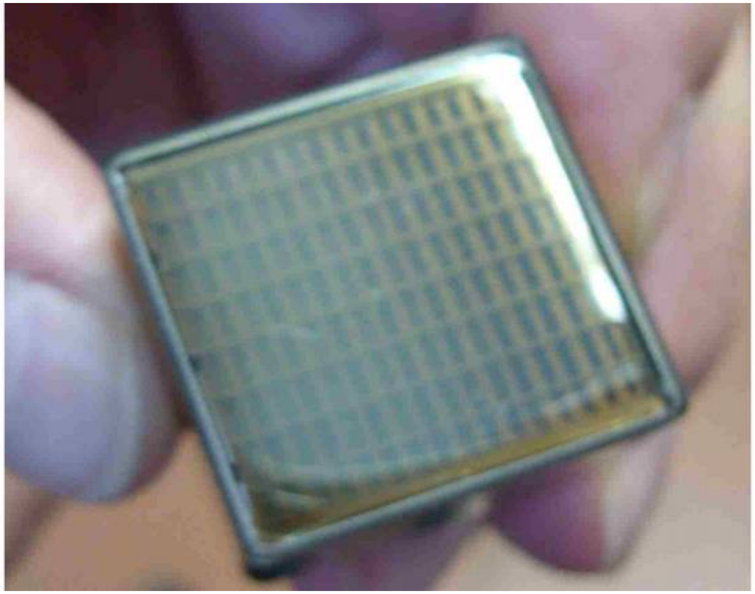


FC – Focal Surface = 137 PDM
PDM – Photo-Detector Module = 36 MAPMTs
MAMPT – multi-anode photomultiplier
= 64 pixels
1 pixel = 500m x 500m
at Earth ground level

photomultiplier (PMT)
multianode photomultiplier (MAPMT)

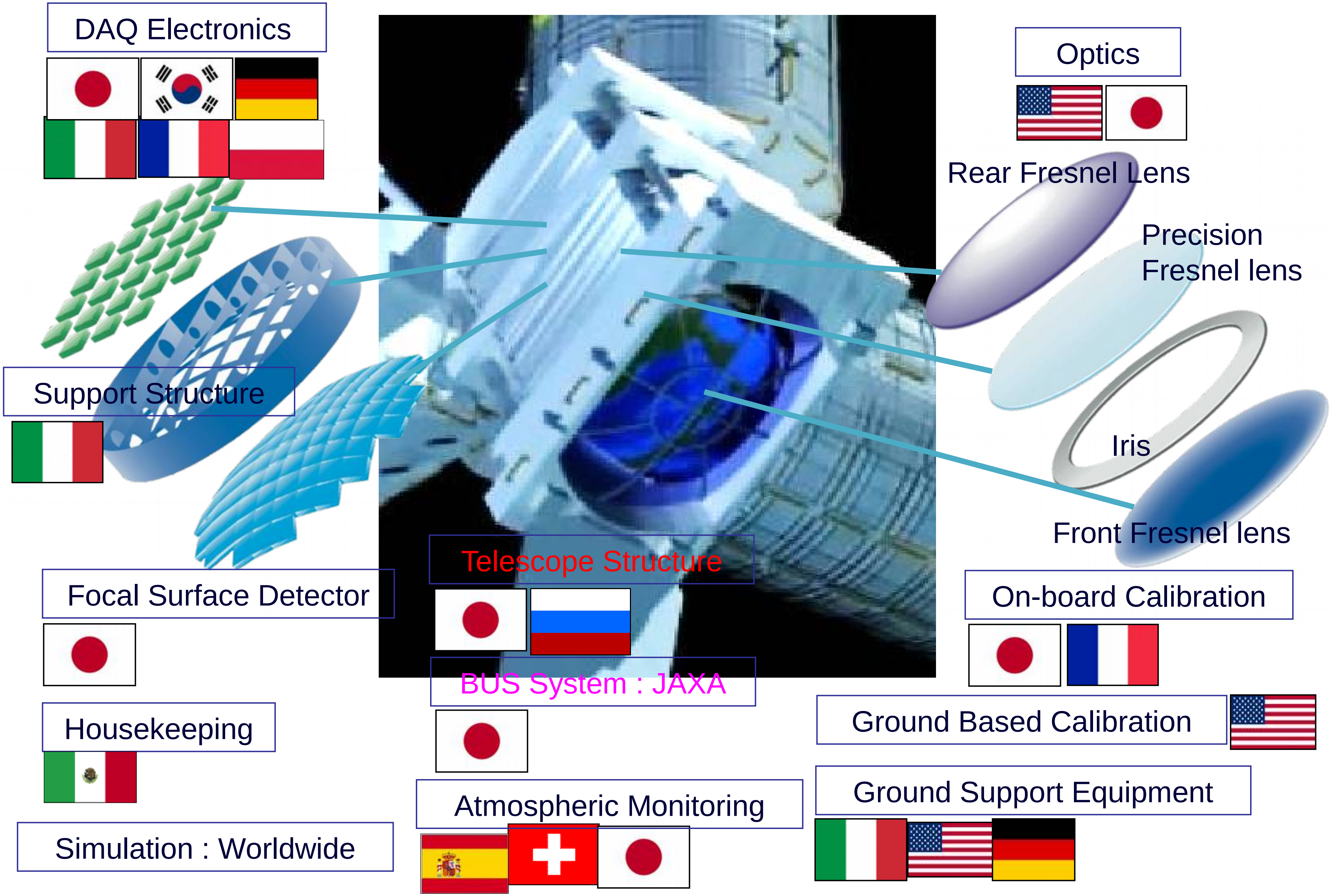
photon ➔ photo-electron (pe) ➔10^6 electrons at anode

New MAPMT – M64 – 64 anodes (pixels)



JEM-EUSO elements and task sharing

collaboration



JEM-EUSO: atmospheric phenomena observations

(some events produce too much light and are danger for detector, but switching system allows for their observations/measurements with photon counting)

- **meteor observations (slow trigger, bright objects), contribution to hazard estimations + science**
- **lightnings observations (last milliseconds, very bright objects), evolution measurements with very good time resolution**
- **TLE – transient luminous events (extremely bright, last milliseconds) evolution measurements with very good time resolution**
- **UV background (albedo, reflected UV from stars, atmospheric night emission) very accurate measurements**

✔ **very good time resolution (GTU = 2.5 μs)**
✔ **very good signal dynamics: 0 – 1 000 000 (due to HV switches)**
✔ **absolute calibration (due to single photon counting)**

EUSO tests

The JEM-EUSO like telescope is very expensive, therefore tests are essential

Many laboratory tests, including vacuum in APC or CNES

EUSO-Balloon – method test at 3 mbar (~40km), equipment test, HV test, UV background measurements, performance tests (trigger, fast moving objects detection, optics)

TA-EUSO – tests at the Telescope Array (UHE CR detector, Utah desert), calibration, performance tests

TA-EUSO – test in Utah – Telescope Array

Main goals/tasks of test:

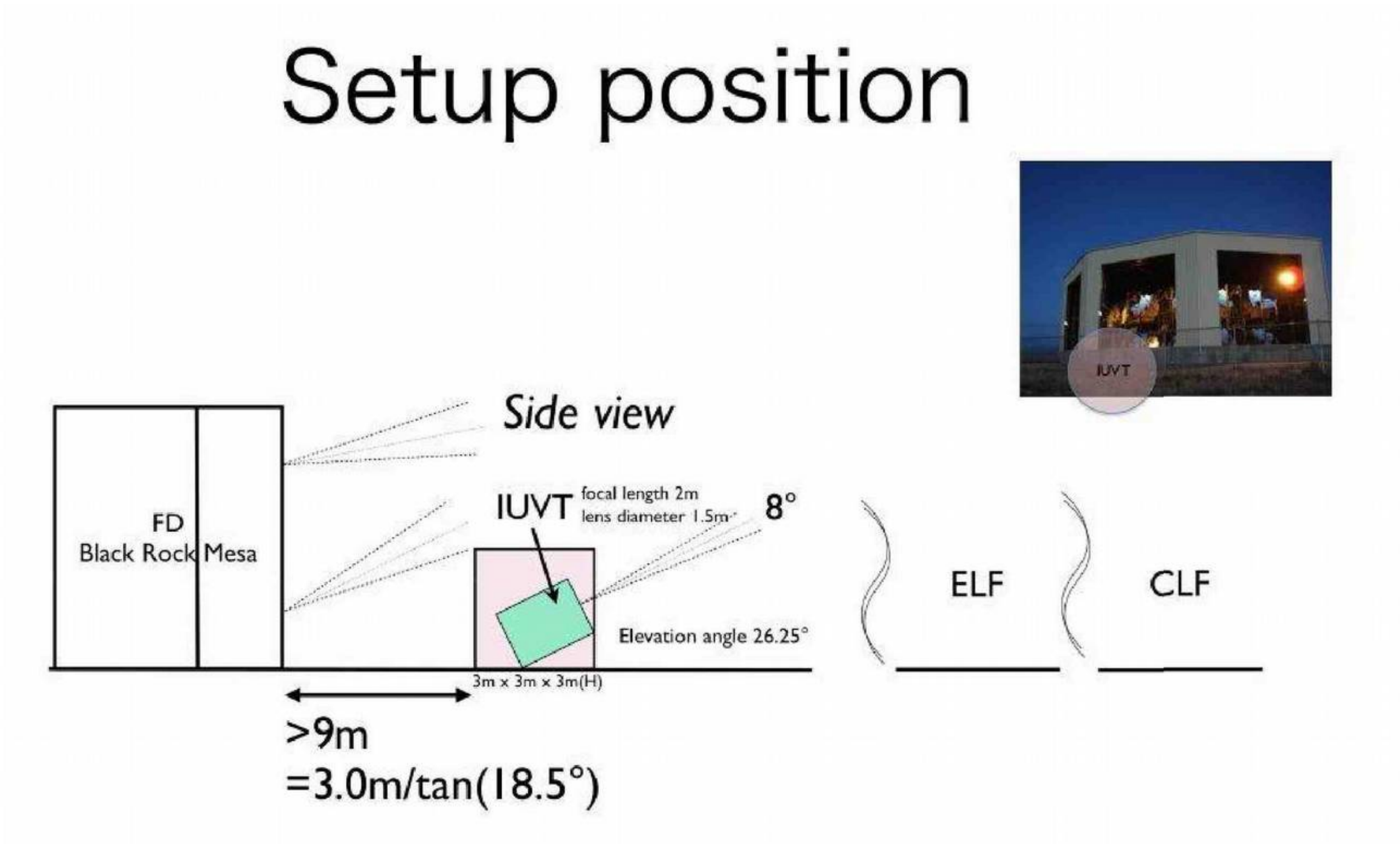
- Calibration by comparison with FD TA (for NSB – night sky background),
- Calibration on LIDAR flushes and electron beam – absolute calibration
- Measurements of a few EAS in coincidence with TA.

Similar tests at PAO are possible

TA-EUSO @ Black Rock Mesa

Electron Light Source at 100m
Most nearby SD is at ~3.5 km
Central Laser Facility ~21km

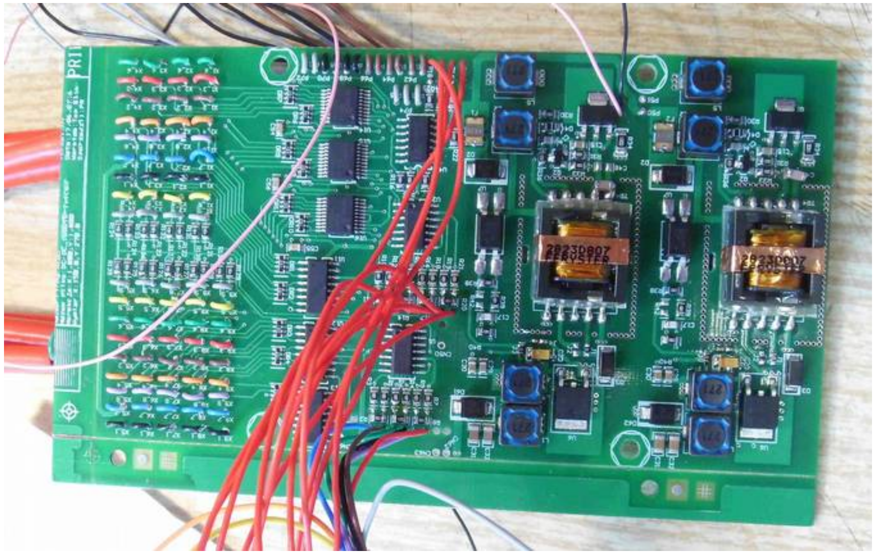
EUSO TA – test in Utah – Telescope Array

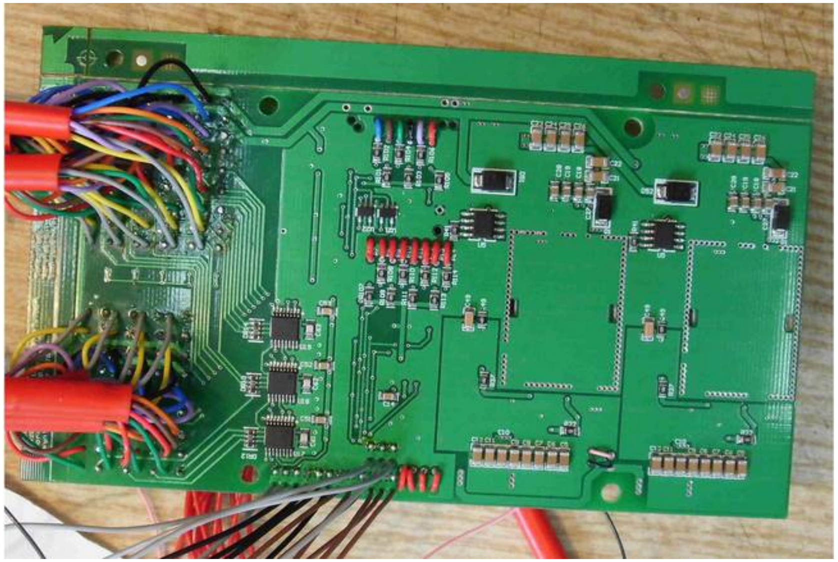


As in EUSO-Balloon: 36 MAPMT (PDM) and similar optics, elevation of EUSO TA can be set in a range 5º – 25º.

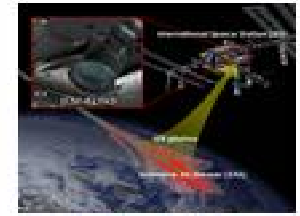
NCBJ-Łódź provides HVPS

SPB,Mini – EUSO: HVPS, designed and made in NCBJ-Łódź



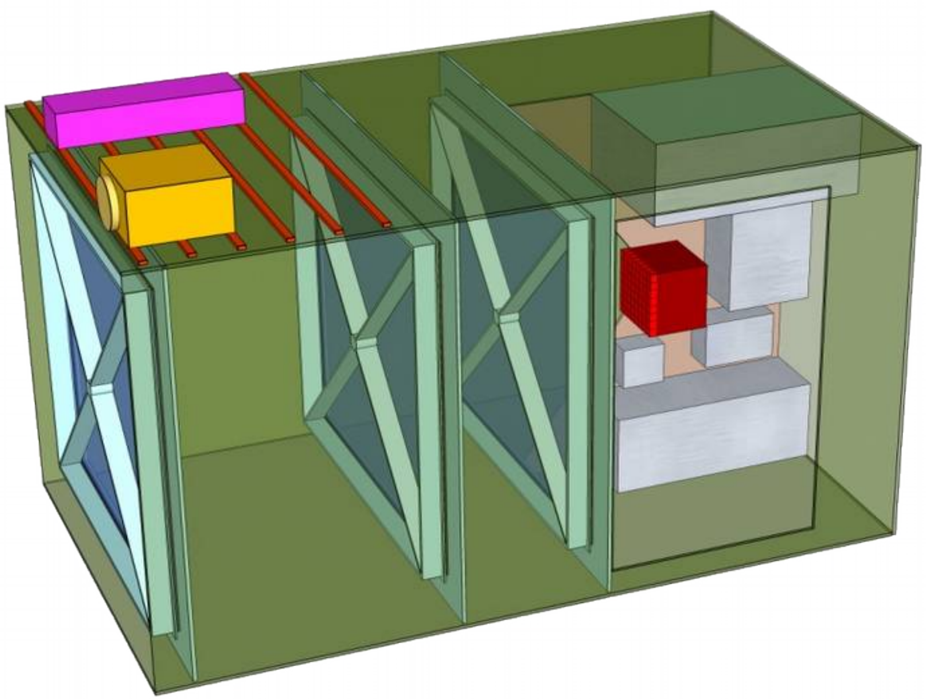


EUSO BALLOON



JEM-EUSO

EUSO-Balloon – test teleskop



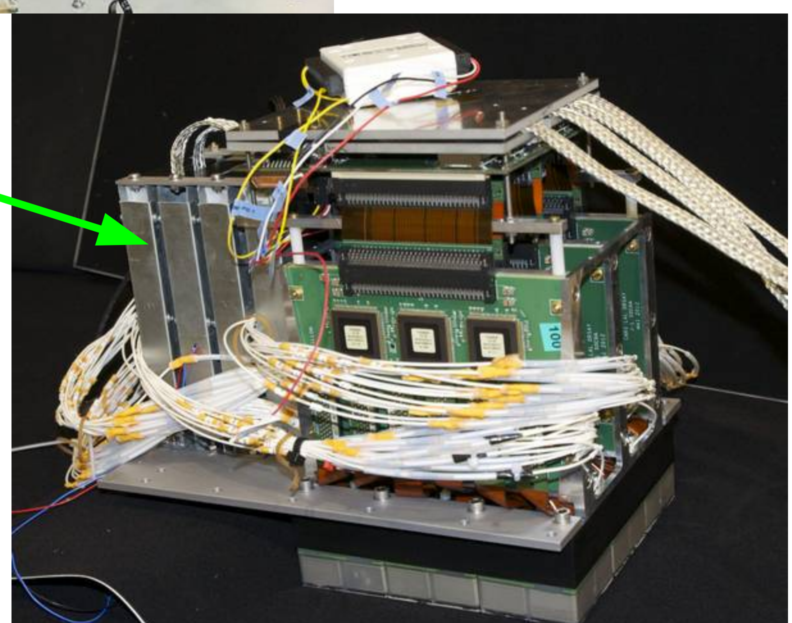
The first flight:
new moon, 24 August 2014
Timmins, Ontario, Canada

NCBJ – Łódź: HVPS system:
HV power suppliers + fast switches

EUSO-Balloon detector

EUSO-Balloon

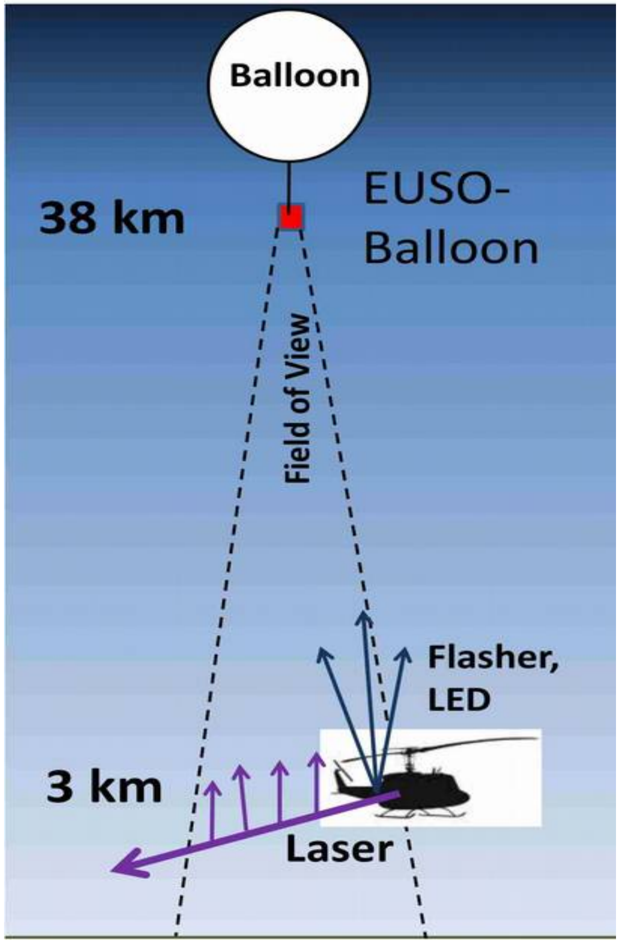
HVPS



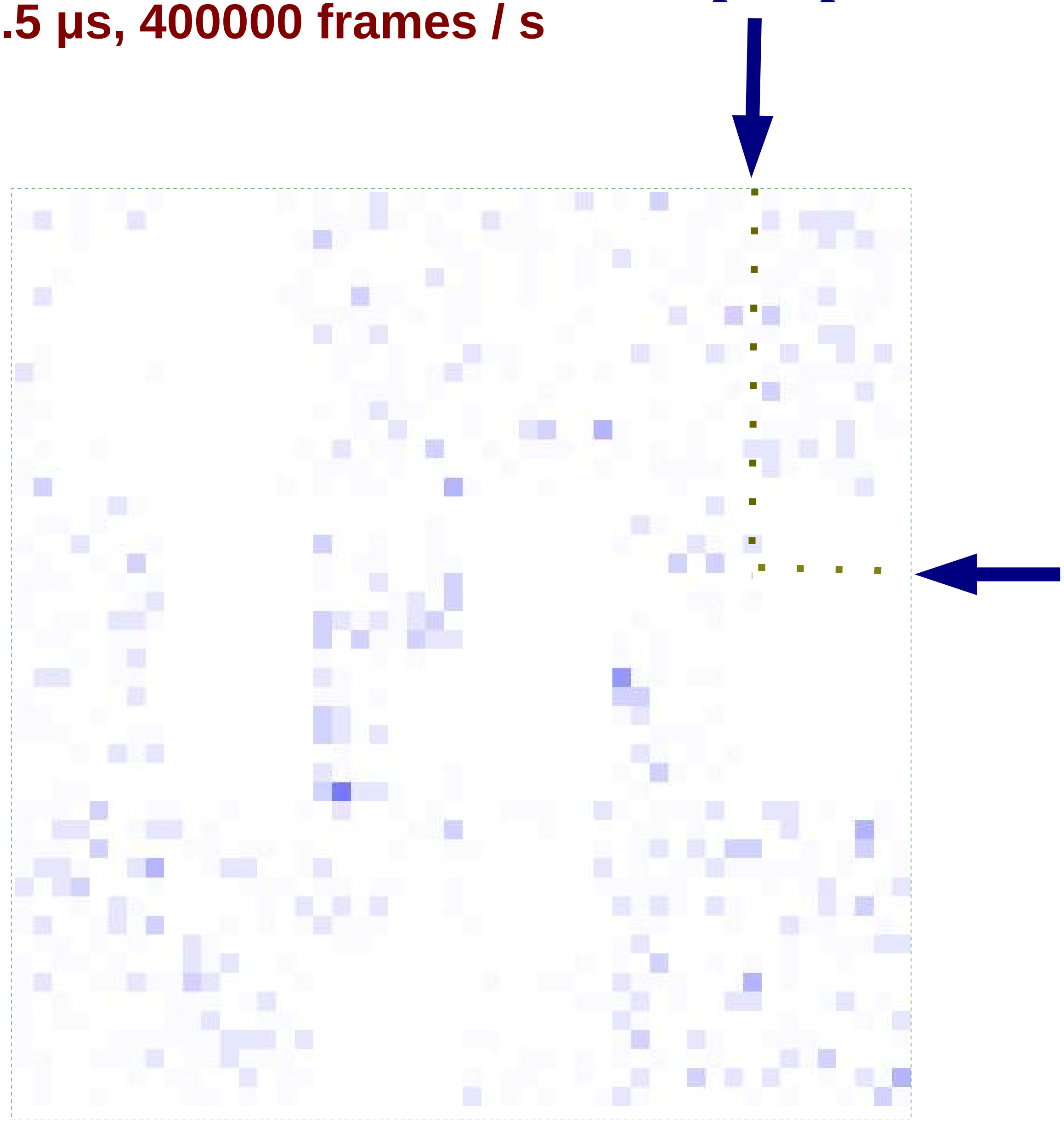
The flight: new moon, 24/25 August 2014, Timmins, Ontario, Canada

source with light speed

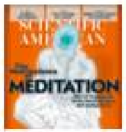
one frame time = GTU
GTU – gate time unit
2.5 μs, 400000 frames / s



helicopter position



SCIENTIFIC AMERICAN™



See Inside

The new detector passes tests involving a helicopter, balloon and lasers

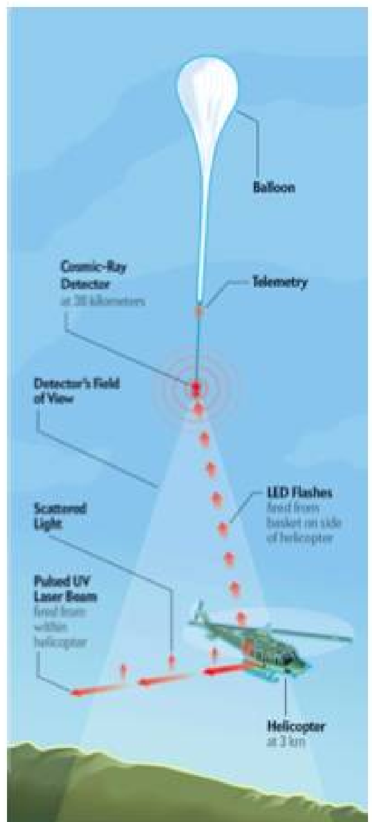
Oct 14, 2014 | By Debra Weiner

Cosmic rays, traveling nearly at the speed of light, bombard Earth from all directions. The electrically charged particles are the most energetic component of cosmic radiation—yet no one knows where they come from.

Astrophysicists speculate that high-energy cosmic rays may have emerged from supermassive black holes in faraway galaxies or possibly from decaying particles from the big bang.

Whatever their origin, these rays crash into Earth's atmosphere about once per square kilometer per century. The impact produces an air shower of tens of billions of secondary, lower-energy particles that in turn excite nitrogen molecules in the atmosphere. The interactions produce ultraviolet fluorescence that lights up the air shower's path. Scientists are trying to use such paths to measure the direction and energy of cosmic rays and reconstruct their trajectories back millions of light-years into space to pinpoint their source.

Seeing these extreme events is rare. Earth-based observatories can spot cosmic- ray collisions only if they occur directly above the detectors. The Pierre Auger Observatory in Argentina, which houses the world's largest cosmic-ray detector and covers an area roughly the size of Rhode Island, records about 20 extreme-energy particle showers a year.



This summer in Timmins, Ontario, scientists tested the prototype of a new cosmic-ray telescope.

Stephen Rountree

More In This Article

Which Ray?: Conflicting Data on High-Energy Cosmic Rays Leave Their Source--or Sources--Unresolved

Hoping to improve the odds of observing the rays, a team of scientists from 15 nations came together more than a decade ago and designed a cosmic- ray telescope for the International Space Station (ISS). On the Japanese Experimental Module, the Extreme Universe Space Observatory (JEM-EUSO) will record ultraviolet emissions with a wide-angle, high-speed video camera that points toward Earth. With such a large observation area, the camera will see more air showers. The team originally hoped to launch EUSO in 2006. But troubles on Earth—first the space shuttle *Columbia* disaster in 2003, then the Fukushima nuclear meltdown in 2011 and now the turmoil in Ukraine—have delayed its deployment until at least 2018.

The science, however, marches onward. In August the team launched a prototype of the telescope 38 kilometers into the stratosphere onboard a helium- filled balloon. For two hours, researchers followed below in a helicopter, shooting a pulsed UV laser and LED into the telescope's field of view. The test was a success: the prototype detected the UV traces, which are similar to the fluorescence generated by extreme energy cosmic-ray air showers. In 2016 astronauts will transport a shoebox-size prototype called Mini-EUSO to the ISS and see how it fares at the altitude of the full mission.

This article was originally published with the title "Catching Some Rays."

Super Pressure Balloon - EUSO
Asembly and tests @ Palestine, TX

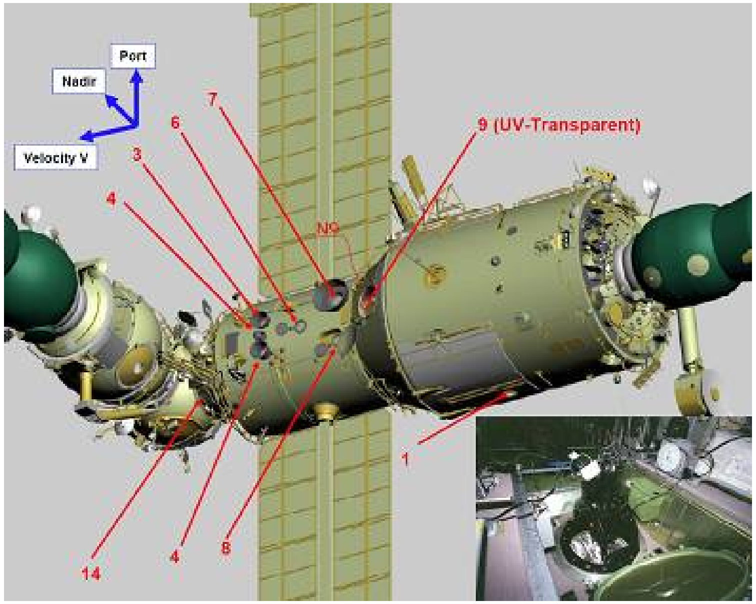
Now this equipment is
in Wanaka, New Zealand.

It should measure several
EAS with energies
above 1E18 eV, by measurements
of fluorescence light from the top
for the first time.

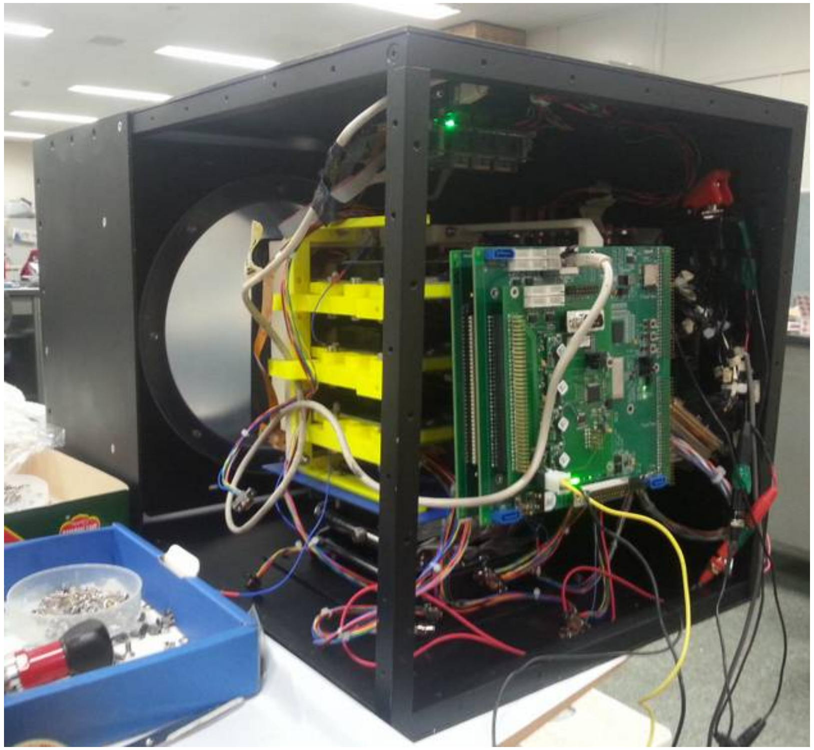
The launch to the very long flight at about 35 km altitude
is scheduled for 25th of March – in 10 days.

The last and the longest so far NASA's SPB flight lasted 34 days.
The maximum flight duration is estimated for about 100 days.

Mini-EUSO



Zvezda@ISS:
UV window transparency >80%
transparency range 300-400nm

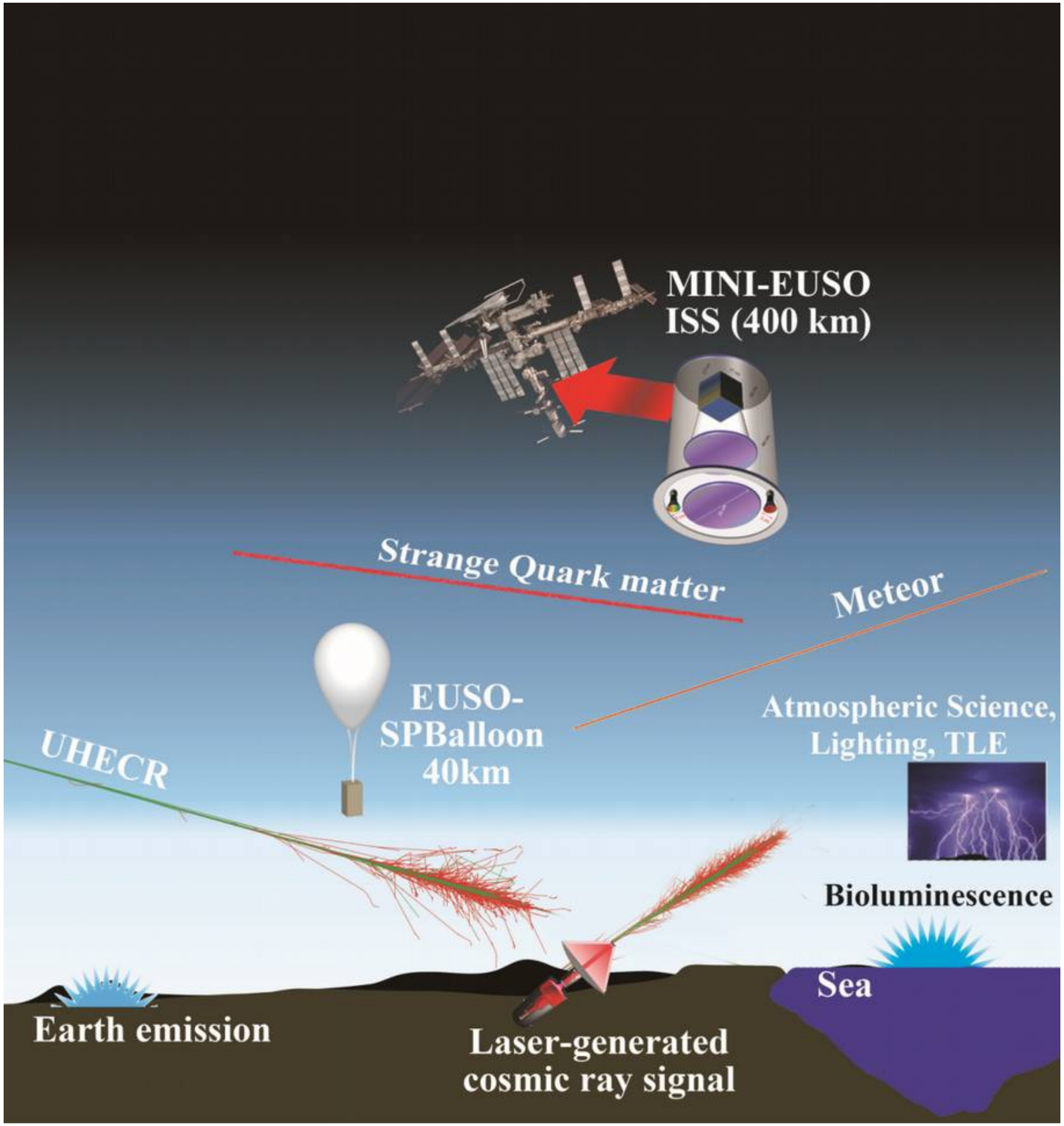


30 kg, 60W
UV: 300-450 nm
37 x 37 x 62 cm^3

MINI-EUSO on the International Space Station

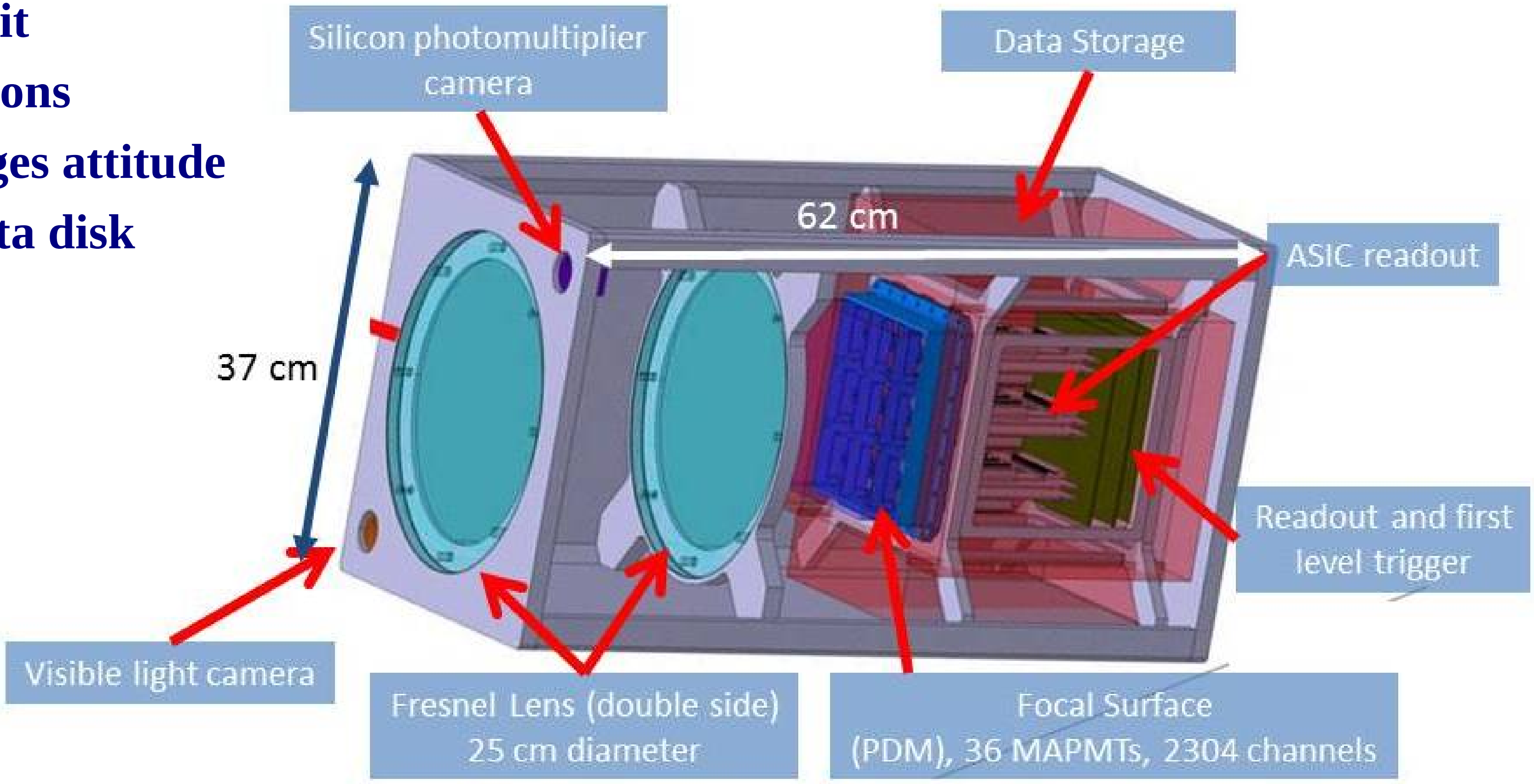
PI: M. Casolino
Russian PI: P. Klimov
Designed, built and integrated in RIKEN

Approved & financed by Italian Space Agency
Approved & financed by Russian Space Agency
Funding from JAXA
Inside the ISS
2 Fresnel lenses and one PDM
60W @ 27V
30kg not incl SSD



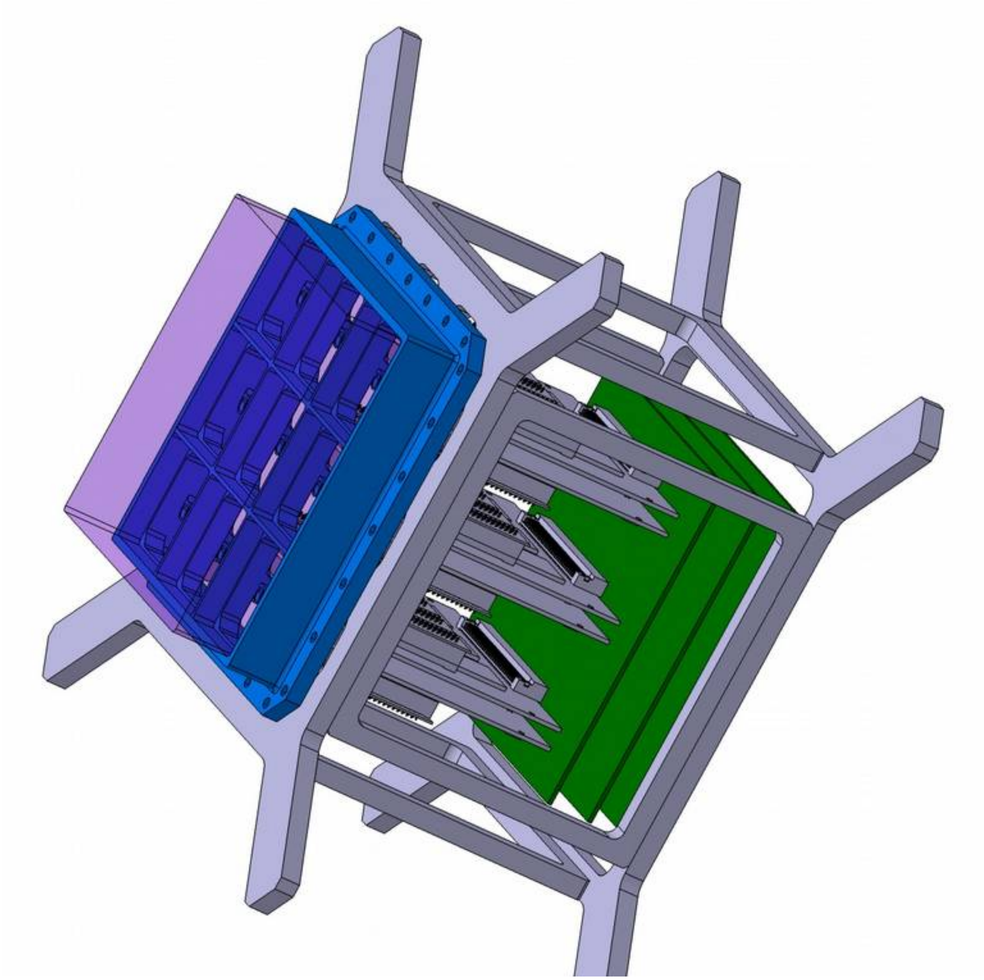
Detector Operations – Mini EUSO

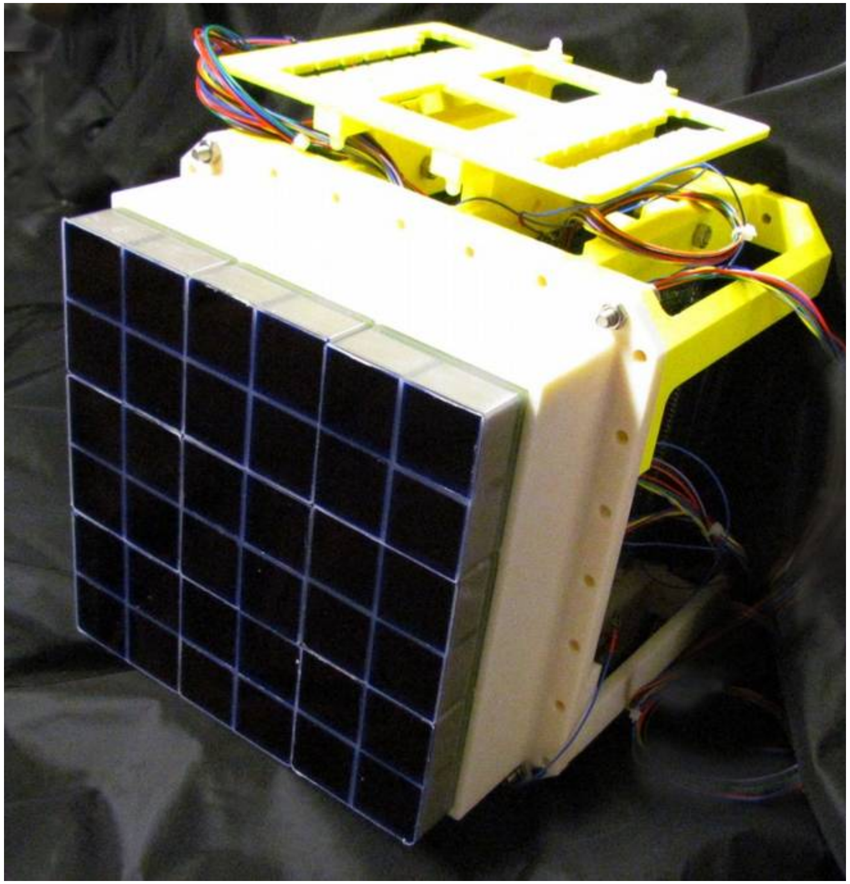
- Night observations
- About 40% orbit
- Nadir observations
- Off if ISS changes attitude
- Exchange of data disk



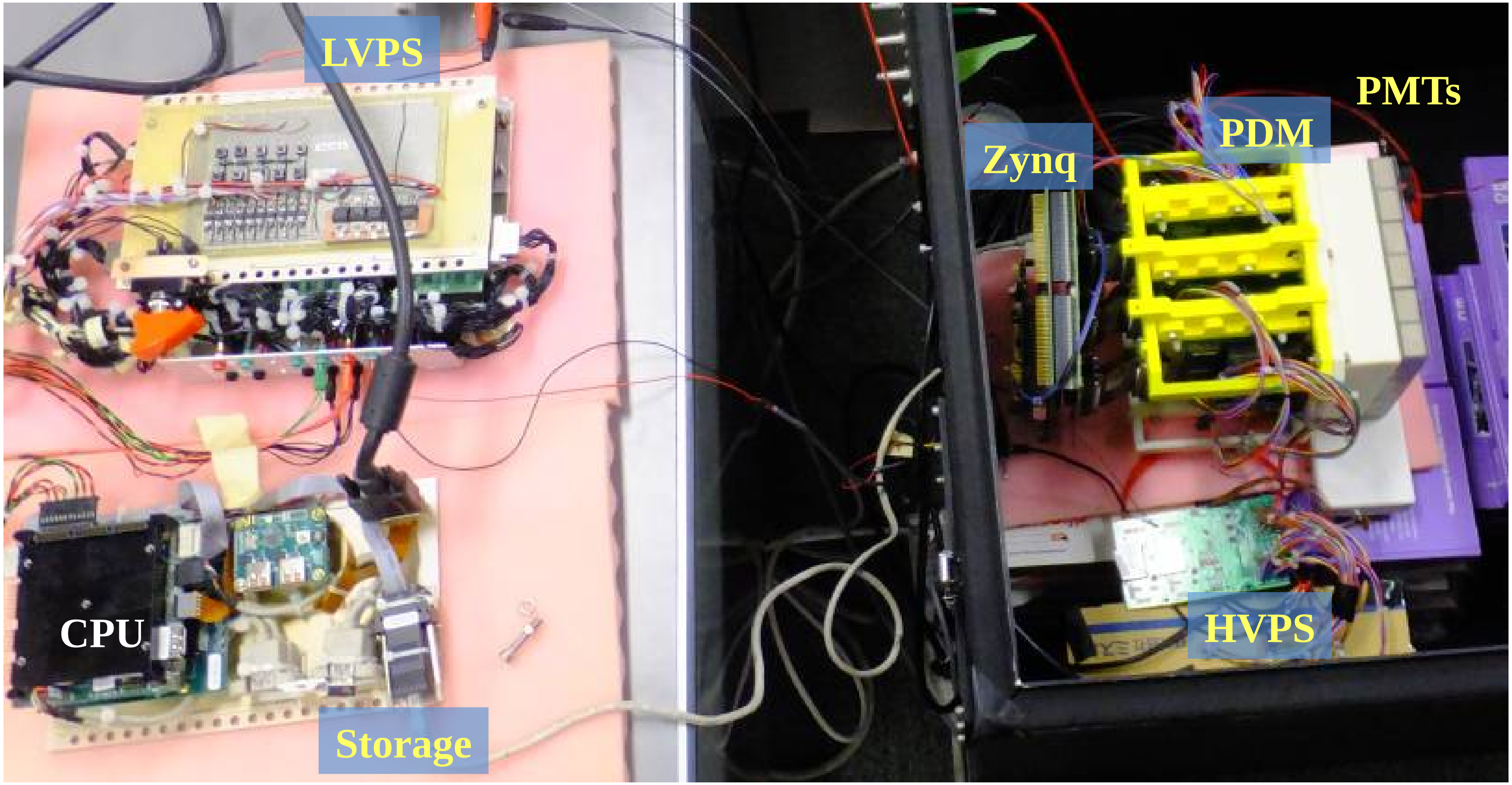
Mini-EUSO: PDM – Photo Detection Module

36 MAPMT in 9 EC (Elementary Cells)
MAPMT – 64 anodes PMT





Mini-EUSO laboratory tests at RIKEN (Jan. 2017)



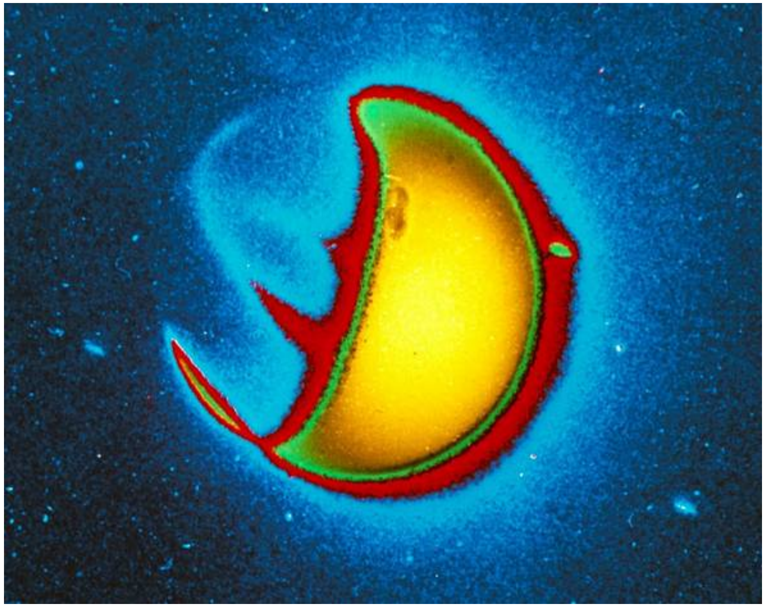
Mini-EUSO Scientific objectives

UV emissions from night-Earth

- ***6.5 km resolution, from 2.5μs,***
  and above +-51° latitude;
- ***Lightnings + TLEs***
- ***Background from different conditions:***
  moon phase, year
- ***Noise from different inclinations***

Map of night time Earth in UV

Data will be made available



Apollo 16
1050-1260 Å and 1200-1550 Å.

Summary

For the last 8 years our group focused experimental activity at the space experiments.

We hope that results of measurements would improve our knowledge about UHE CR sources,
but we still need to wait for them (results), and working hard.

The main problem is man power. We are looking for students, and young scientists, but also for experienced scientists interested in cosmic experiments and data analysis.