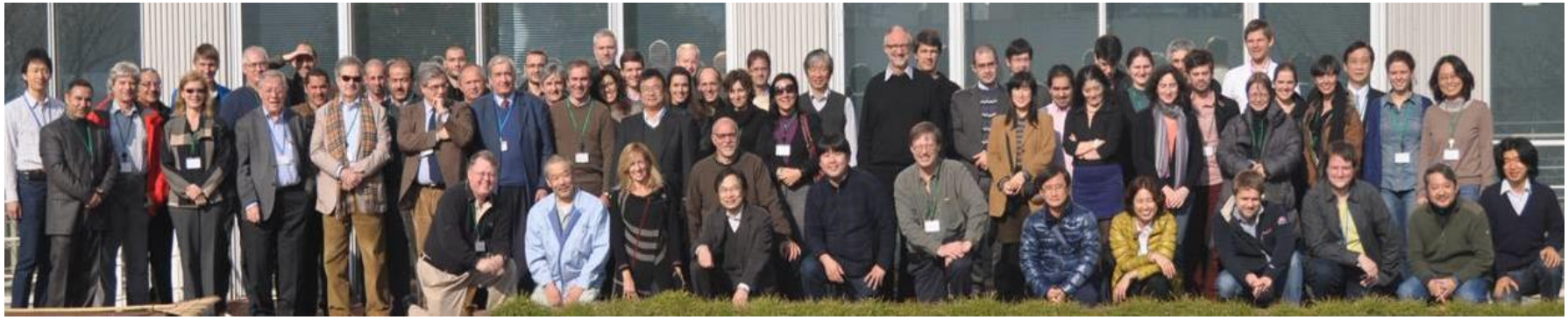
JEM-EUSO Collaboration,
16 countries, 87 institutions as on September 2014
"Doing astronomy by looking downward"

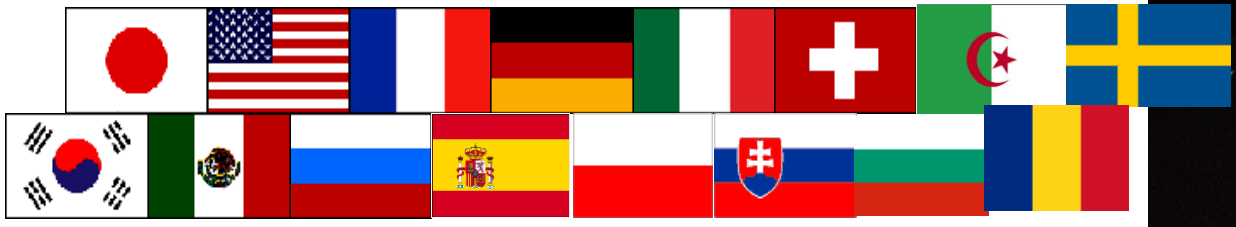
The JEM-EUSO Mission and Pathfinders Status.

F.S. Cafagna, INFN Sezione di Bari
on behalf of the JEM-EUSO collaboration

JEM-EUSO Collaboration



Scientists from 16 countries



"Doing astronomy by looking downward"

JEM-EUSO Scientific Objectives

JEM-EUSO Scientific Objectives

- **Study of Cosmic Particles at the Highest Energies**

JEM-EUSO Scientific Objectives

- **Study of Cosmic Particles at the Highest Energies**

- **Main Science Objectives**:
  - Identify UHE sources
  - Measure energy spectra of individual sources
  - Measure the trans-GZK spectrum

JEM-EUSO Scientific Objectives

- **Study of Cosmic Particles at the Highest Energies**

- **Main Science Objectives**:
  - Identify UHE sources
  - Measure energy spectra of individual sources
  - Measure the trans-GZK spectrum

- **Exploratory objectives**:
  - Discover UHE Gamma-rays
  - Discover UHE neutrinos
  - Study Galactic and Extragalactic Magnetic Fields
  - Discover Relics from the Early Universe

JEM-EUSO Scientific Objectives

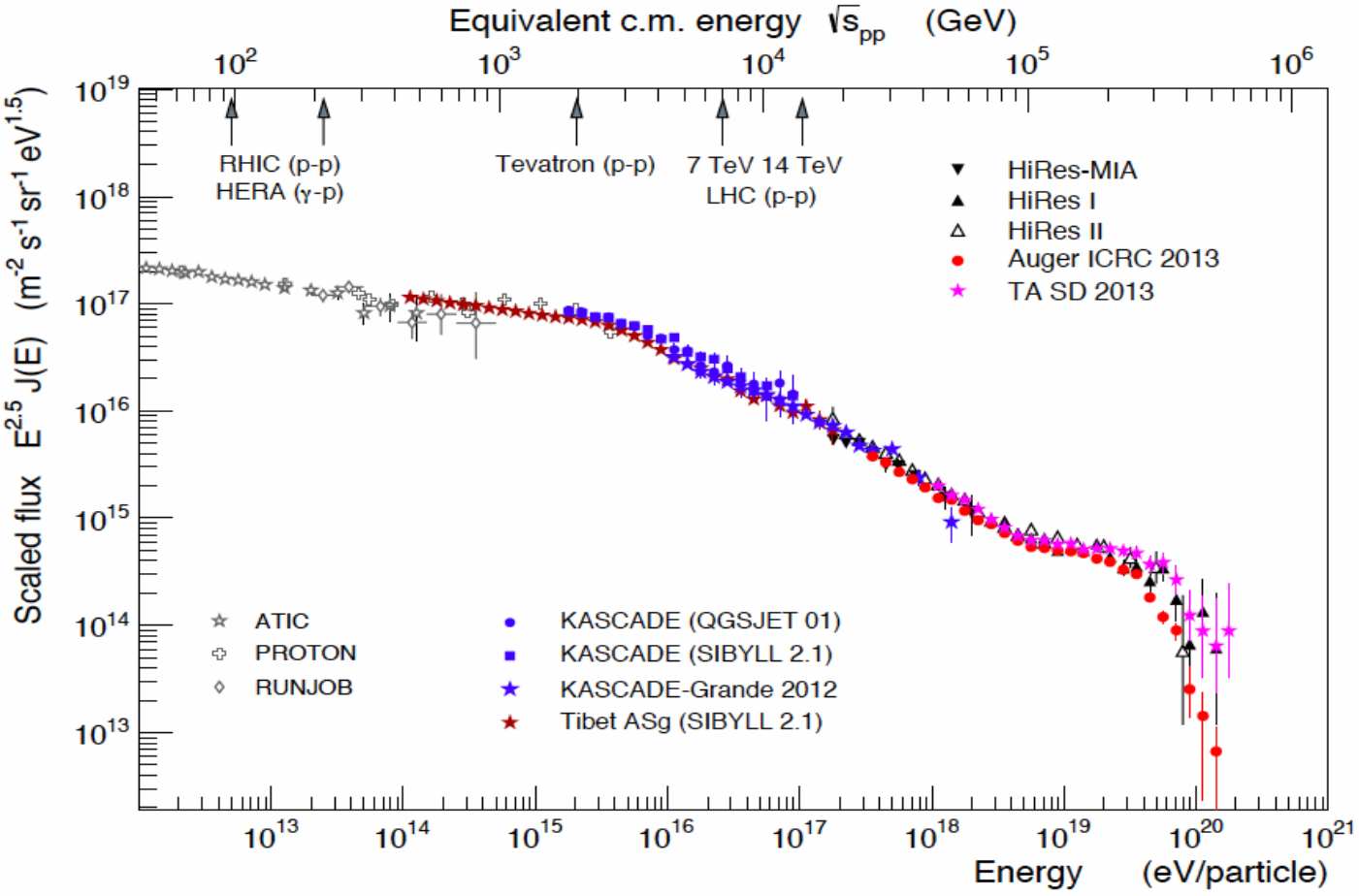
- **Study of Cosmic Particles at the Highest Energies**

- **Main Science Objectives**:
  - Identify UHE sources
  - Measure energy spectra of individual sources
  - Measure the trans-GZK spectrum

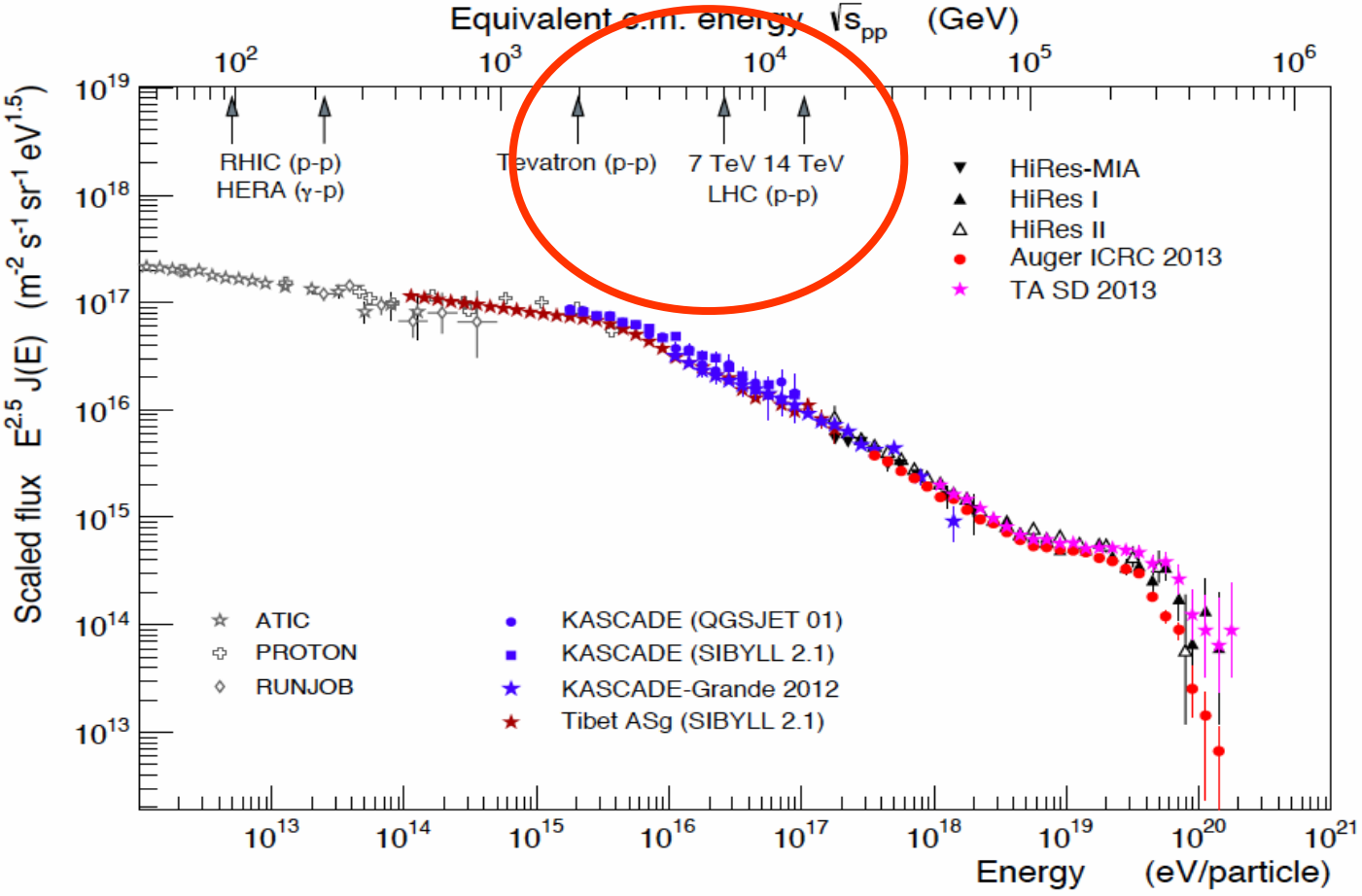
- **Exploratory objectives**:
  - Discover UHE Gamma-rays
  - Discover UHE neutrinos
  - Study Galactic and Extragalactic Magnetic Fields
  - Discover Relics from the Early Universe

- **Atmospheric Science**
  - Nightglow
  - Transient luminous events (TLE)
  - Meteors and meteoroids

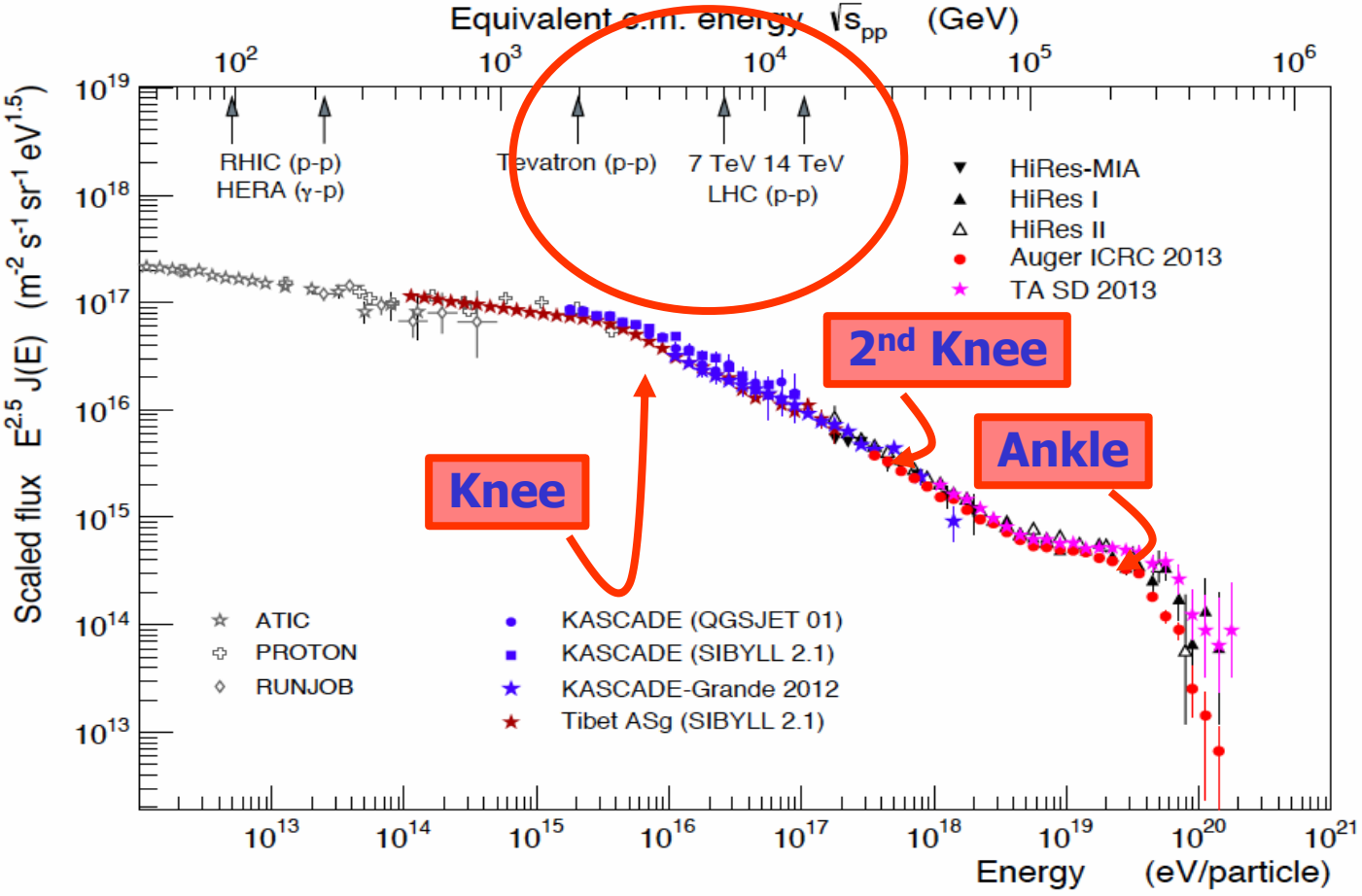
The UHE Cosmic ray spectra anatomy



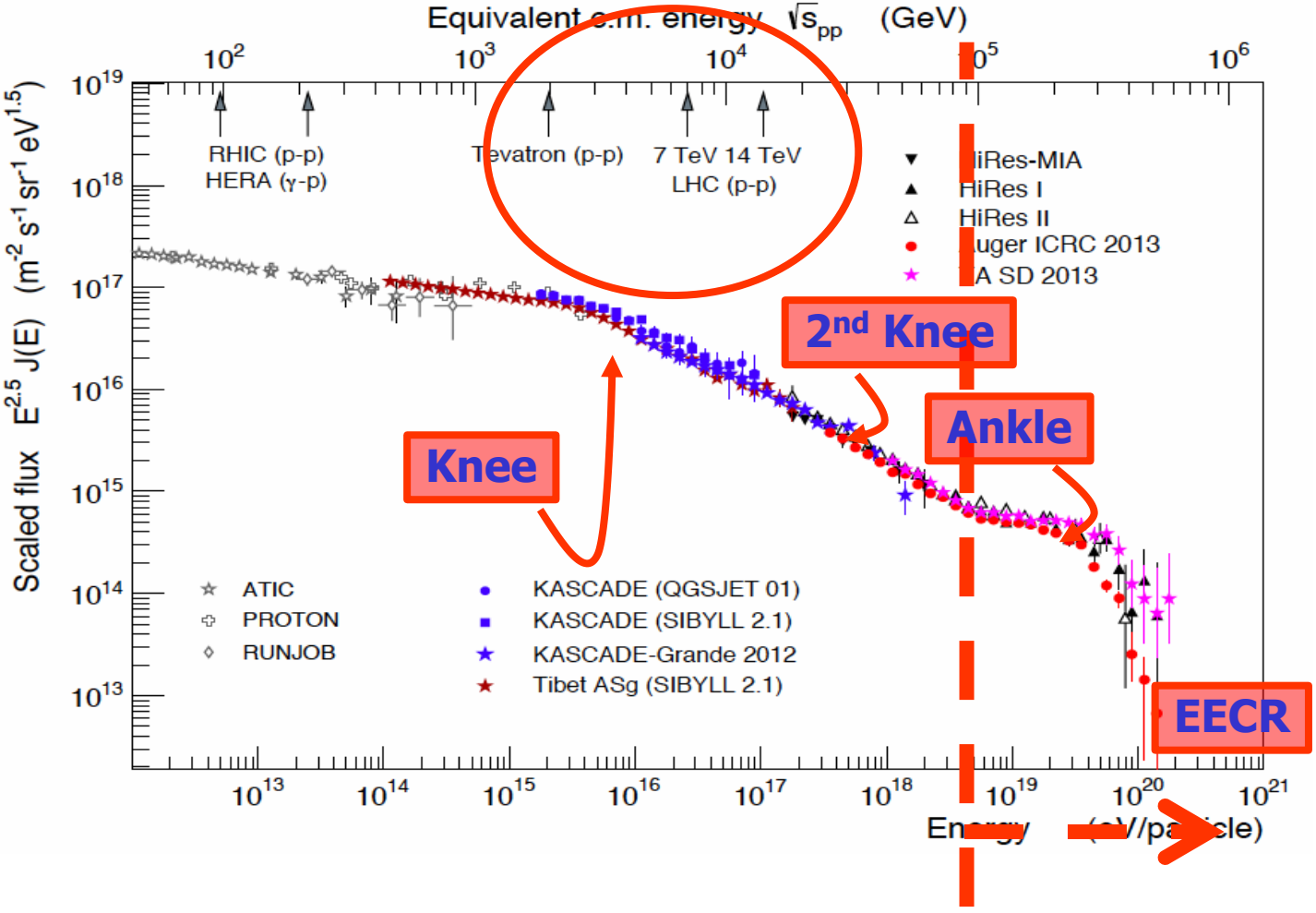
The UHE Cosmic ray spectra anatomy



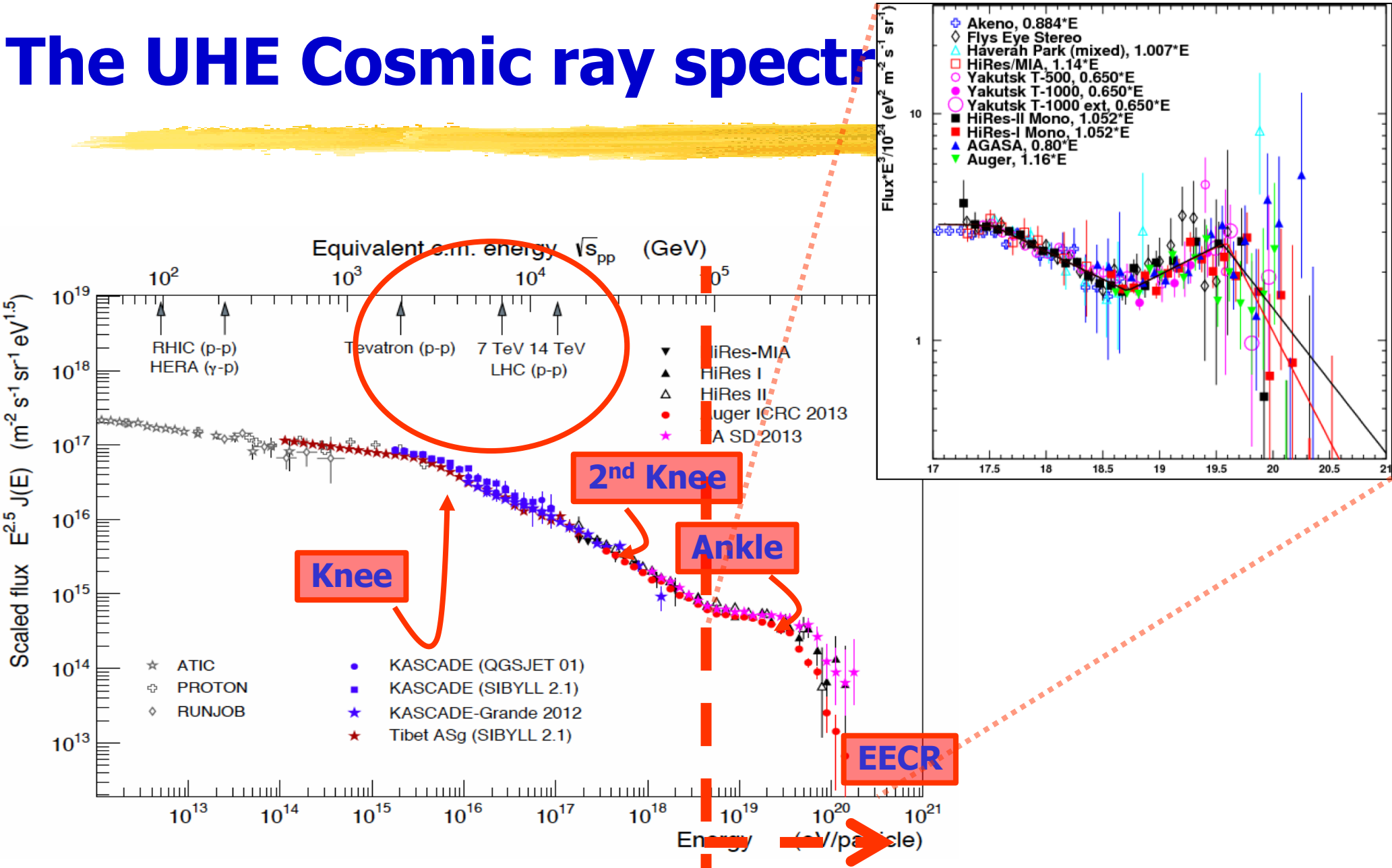
The UHE Cosmic ray spectra anatomy



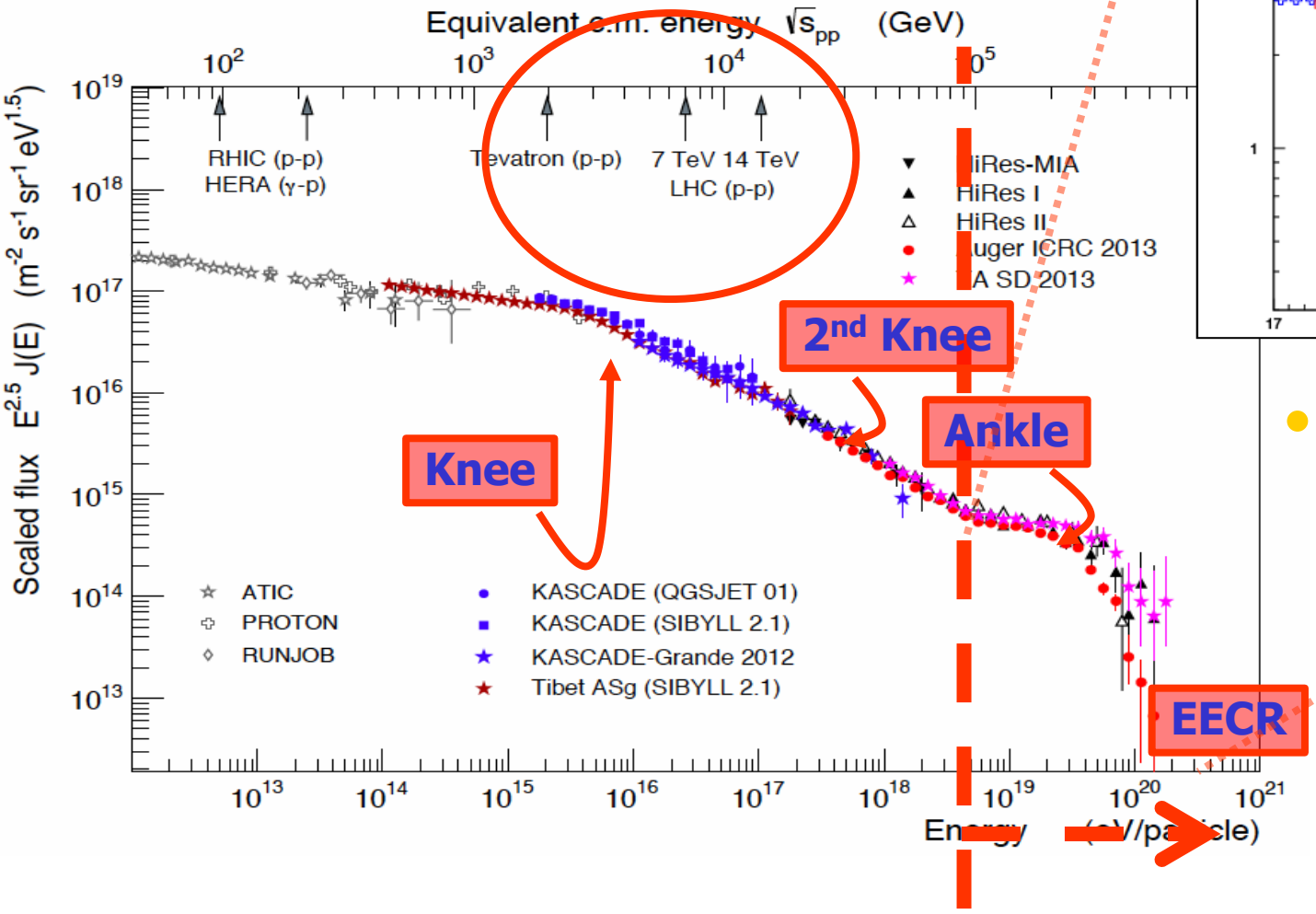
The UHE Cosmic ray spectra anatomy

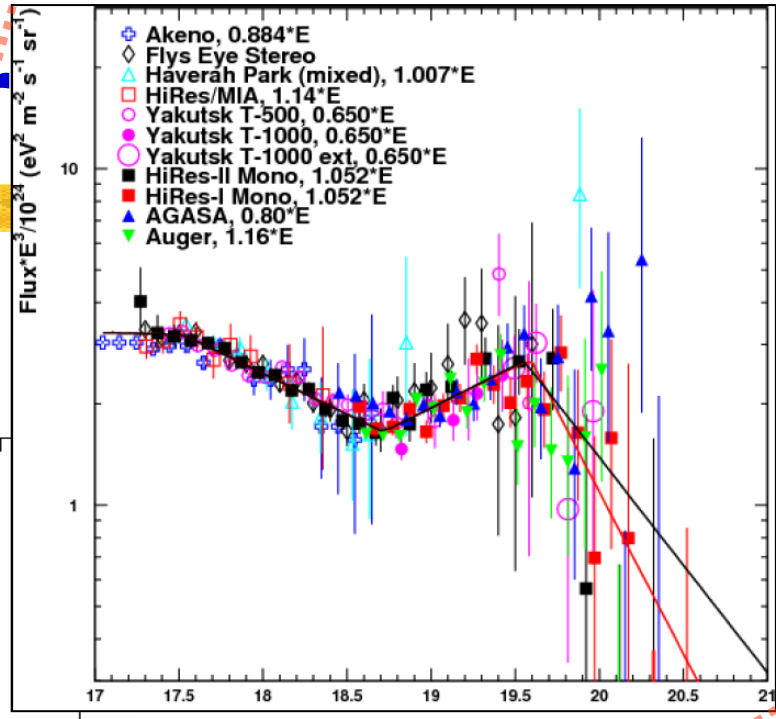


The UHE Cosmic ray spectr



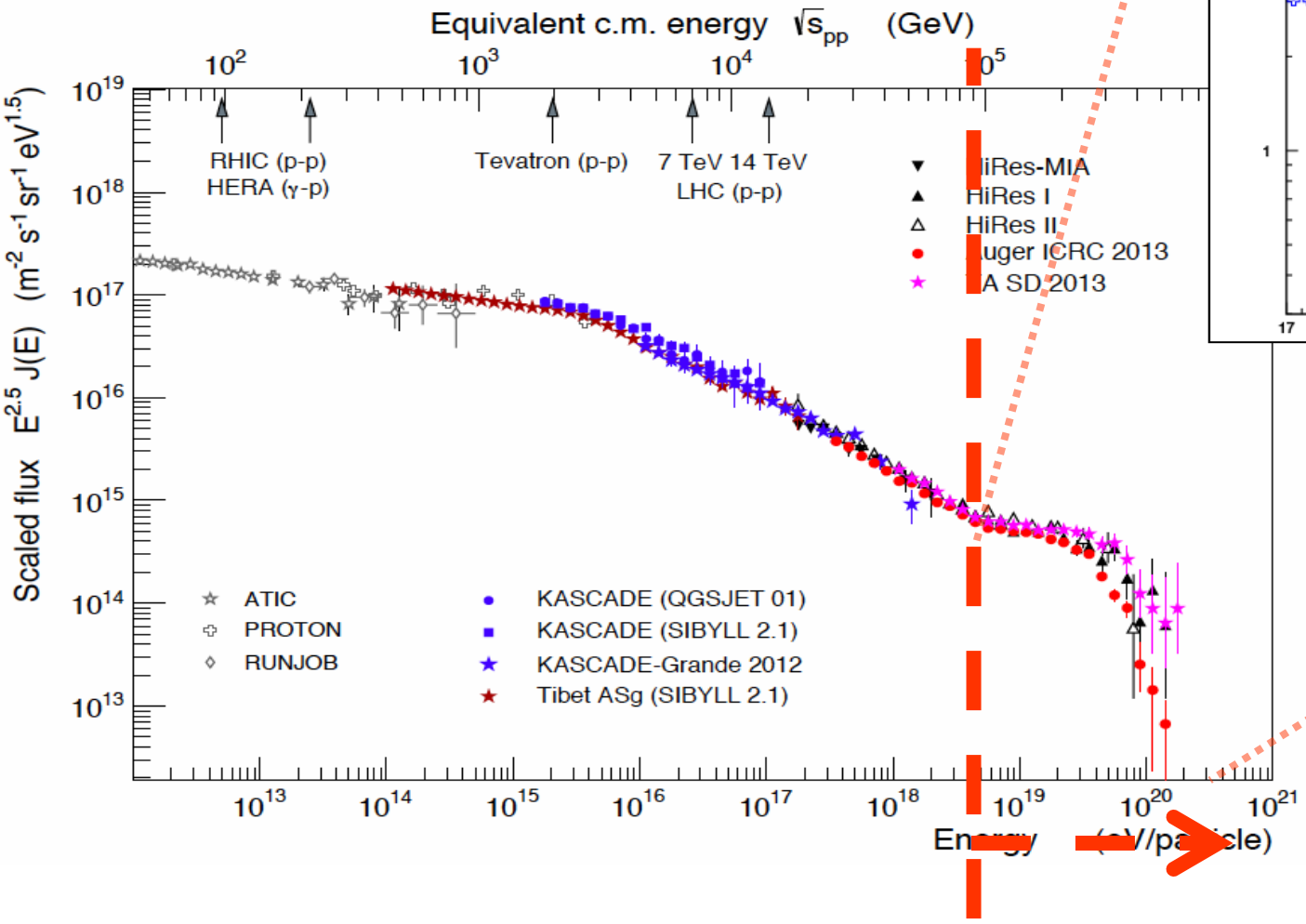
The UHE Cosmic ray spectr

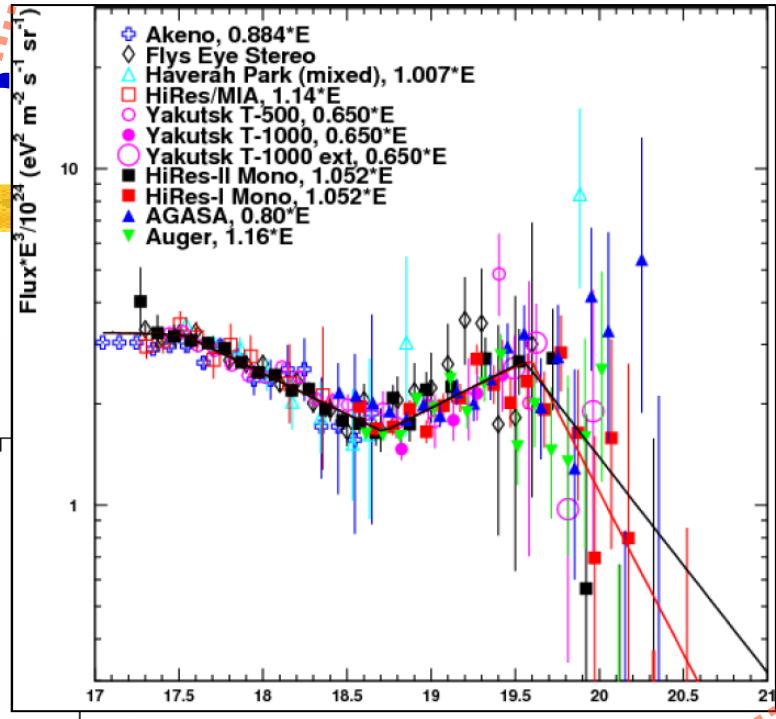




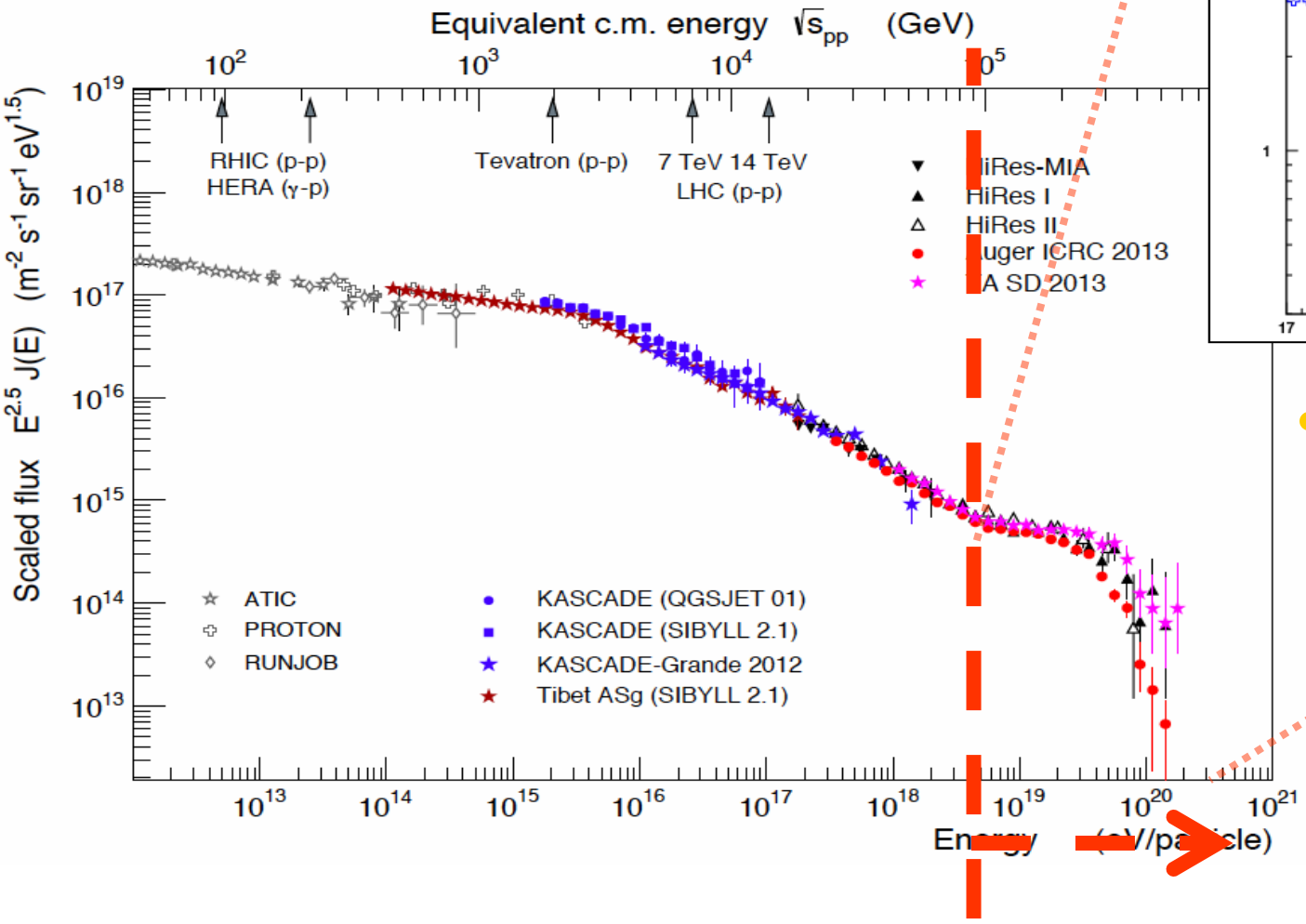
- EECR origin, mass composition and propagation mechanism (GZK effect) are still an open puzzle to be investigate studying the

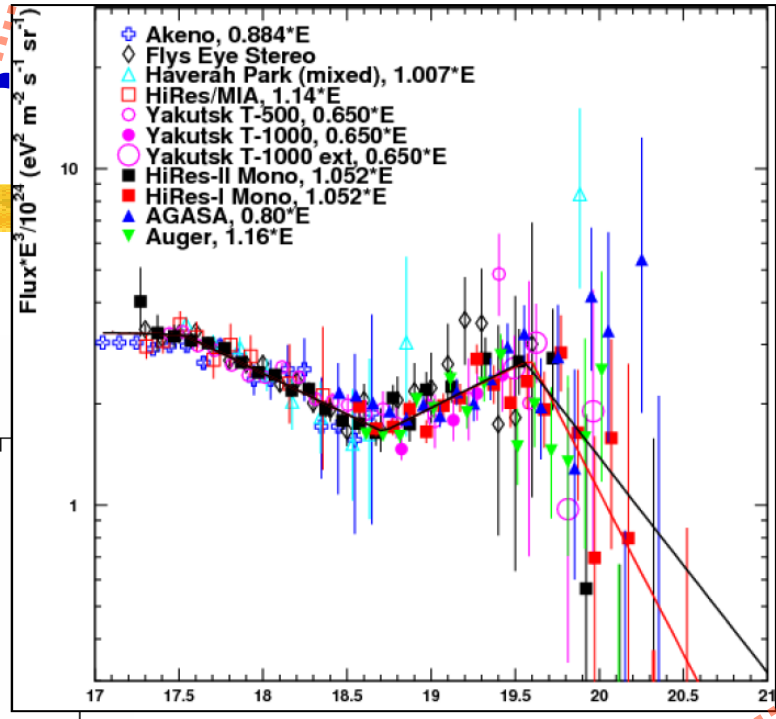
The UHE Cosmic ray spectr





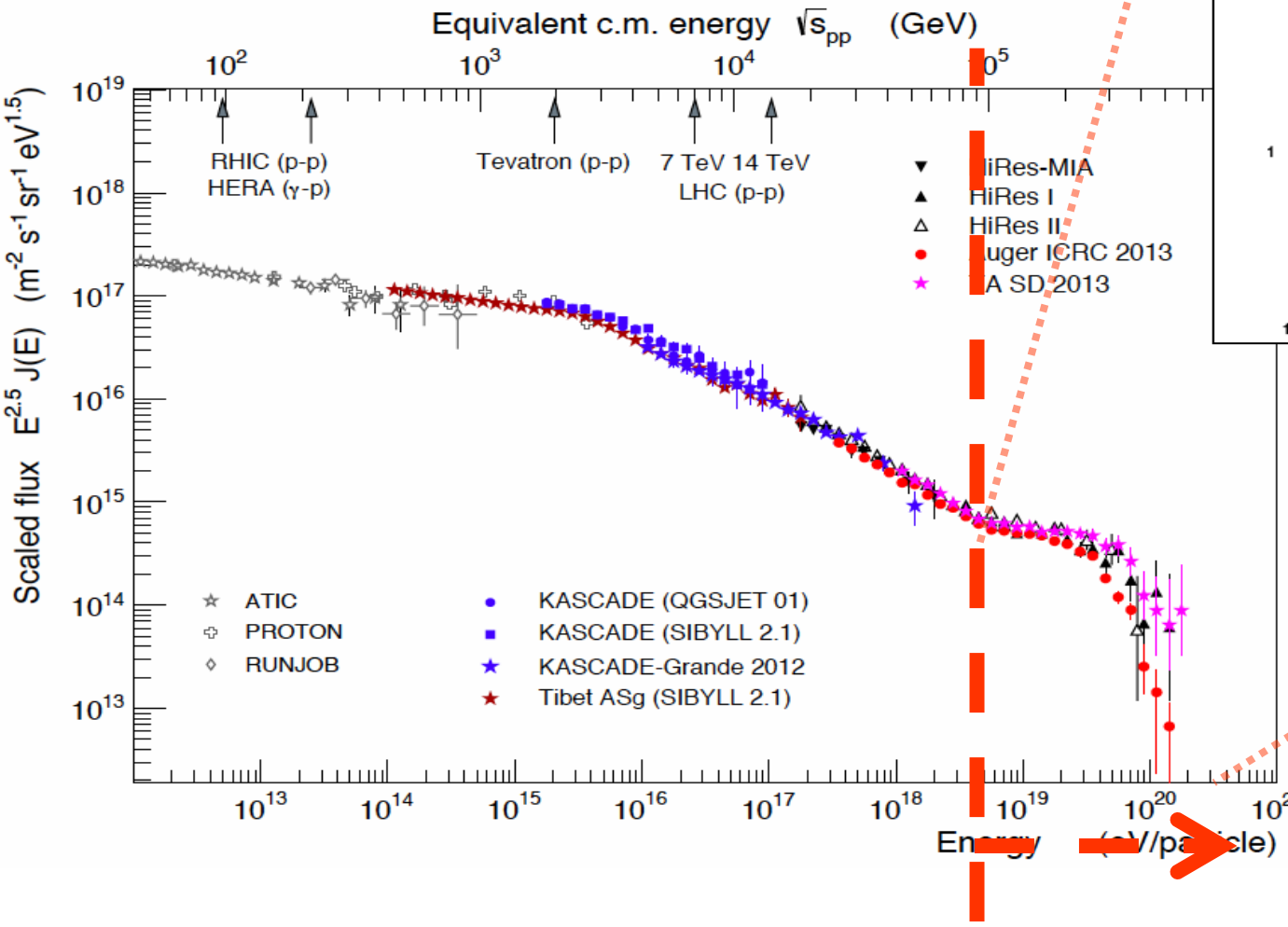
The UHE Cosmic ray spectr

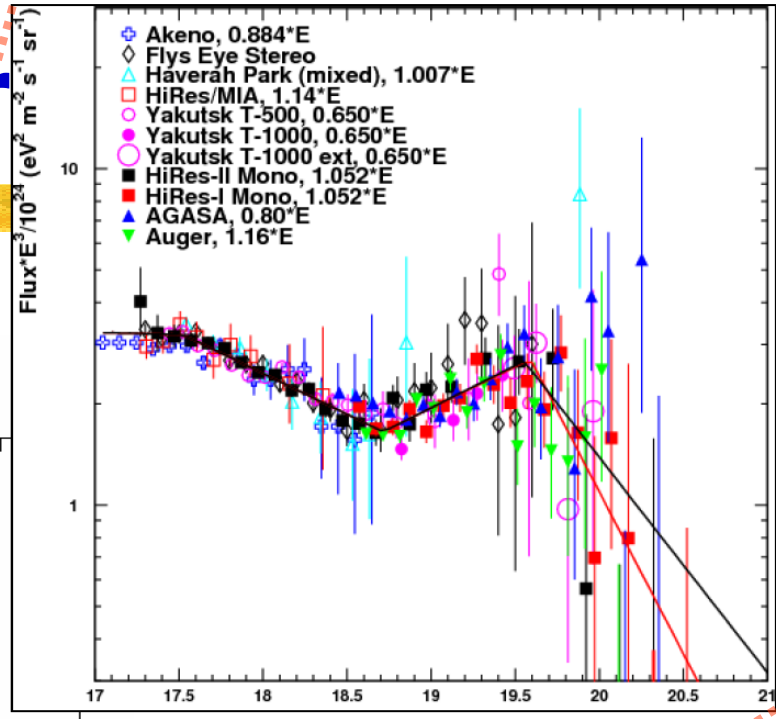




- Fluxes are extremely low and the challenge is to build an instrument able to detect a few particle per km^2 per century.

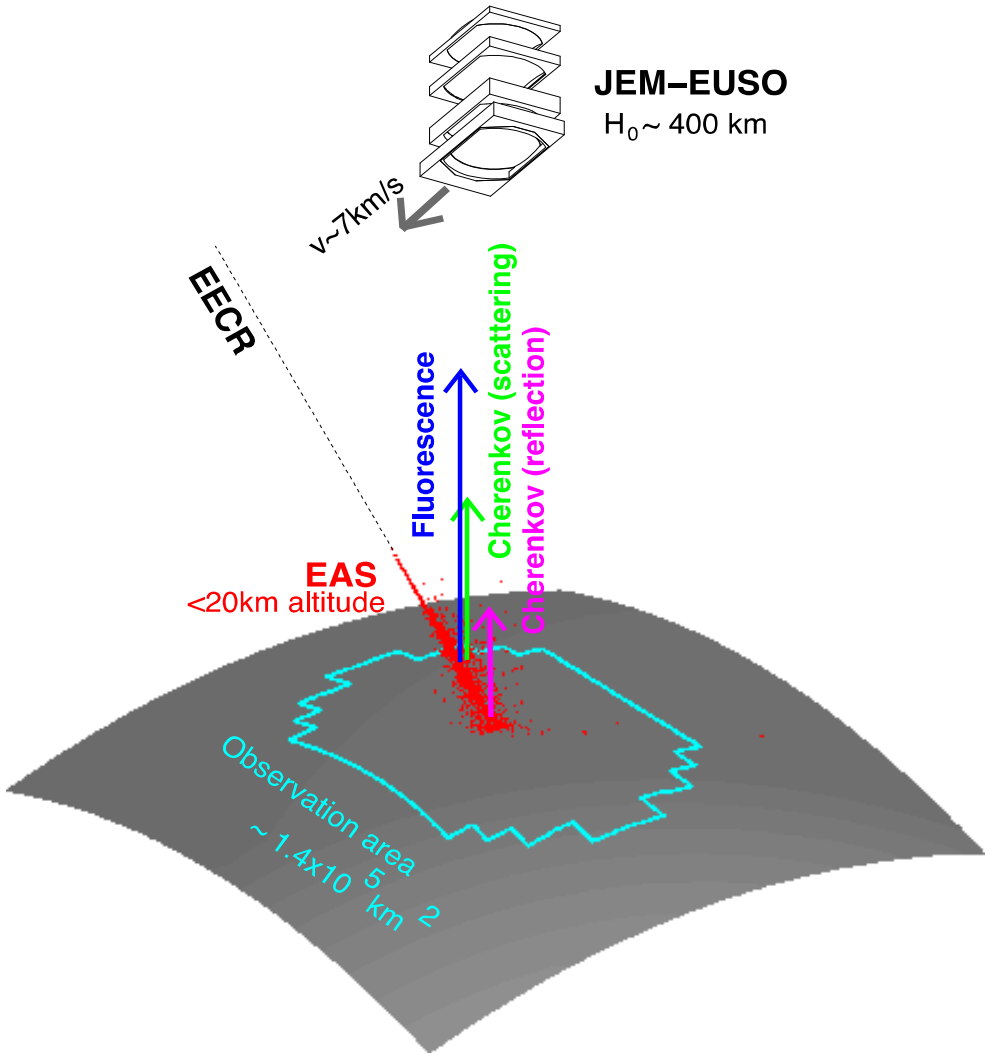
The UHE Cosmic ray spectr



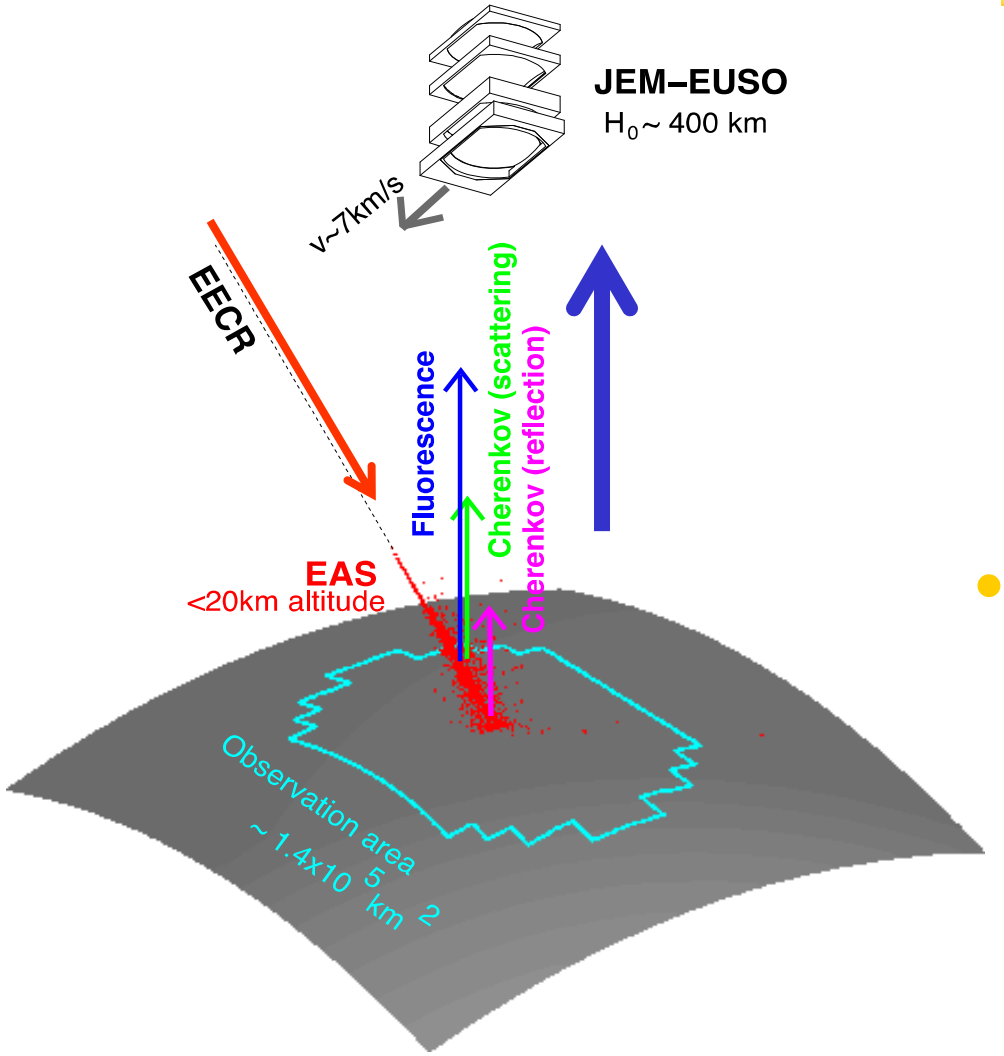


- Fluxes are extremely low and the challenge is to build an instrument able to detect a few particle per km^2 per century.
- Exposures with order of magnitude of: **10^6 km^{2}sr y,** are

The JEM-EUSO approach

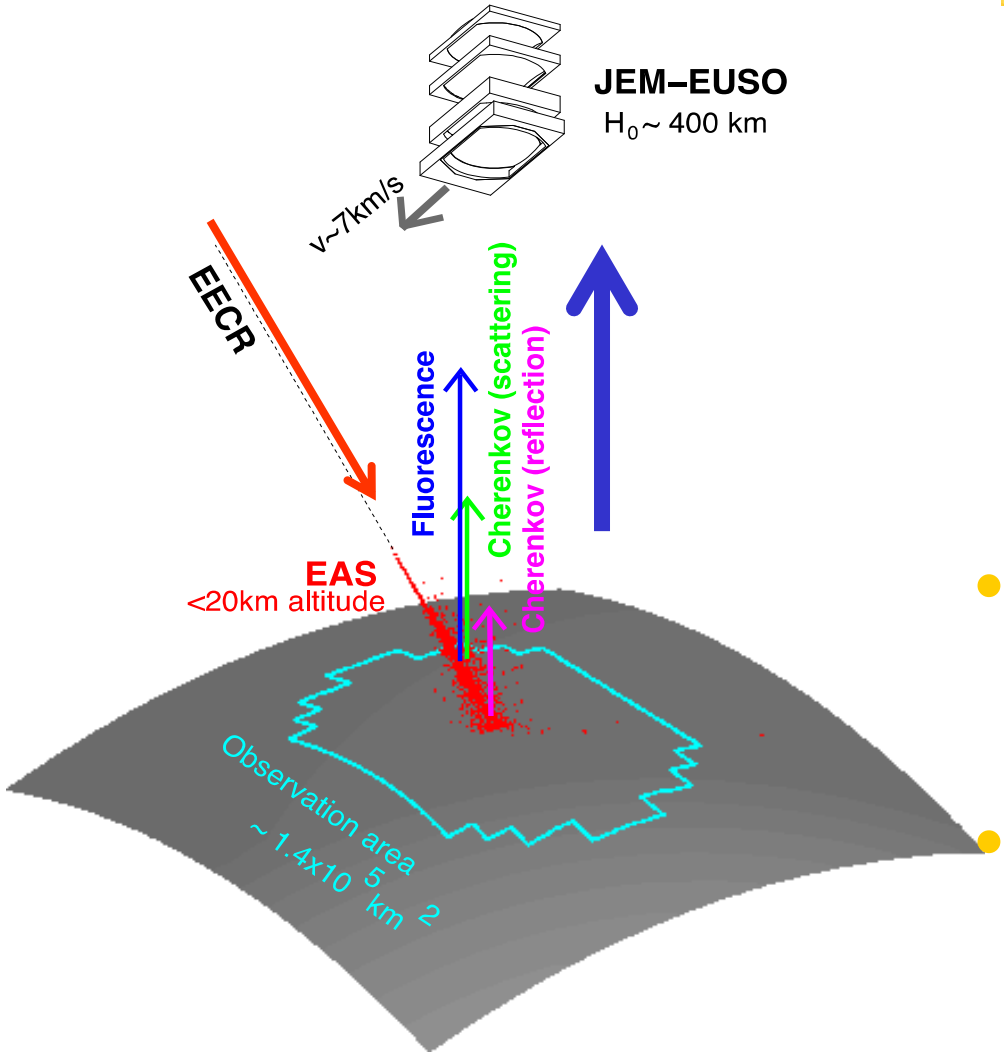


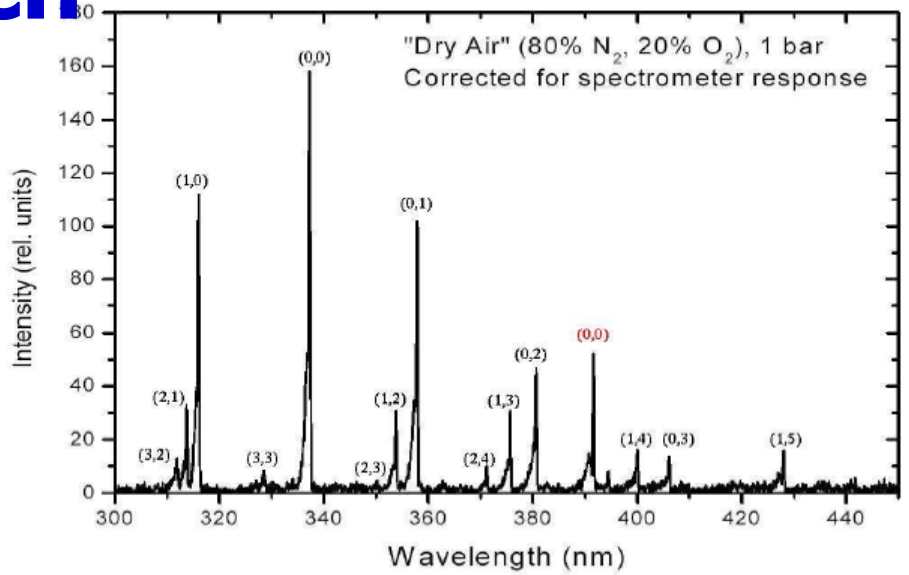
The JEM-EUSO approach



- Detect the fluorescence light, produced by the EECRs looking down the Earth from space.

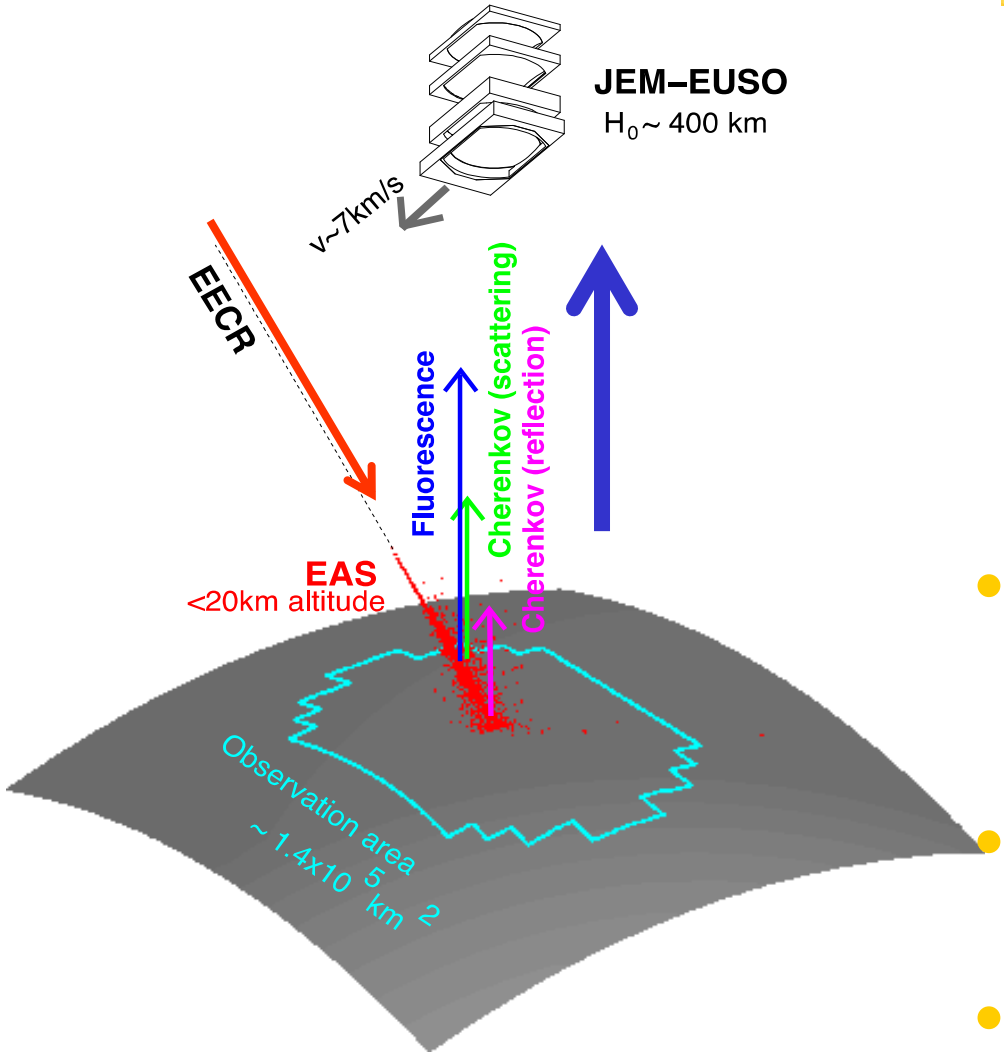
The JEM-EUSO approach

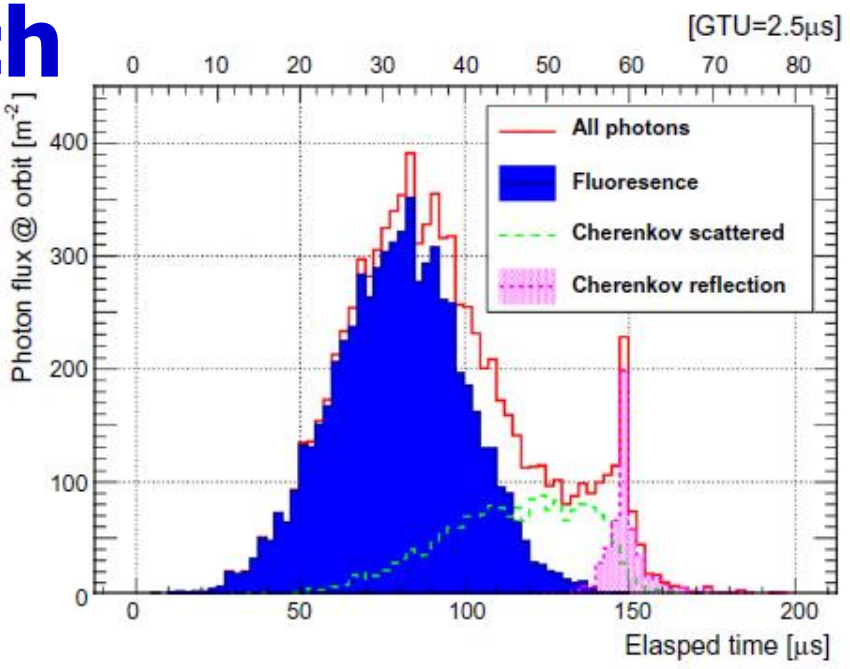




- Detect the fluorescence light, produced by the EECRs looking down the Earth from space.
- Near UV sensitivity is needed: 300 ÷ 430 nm …

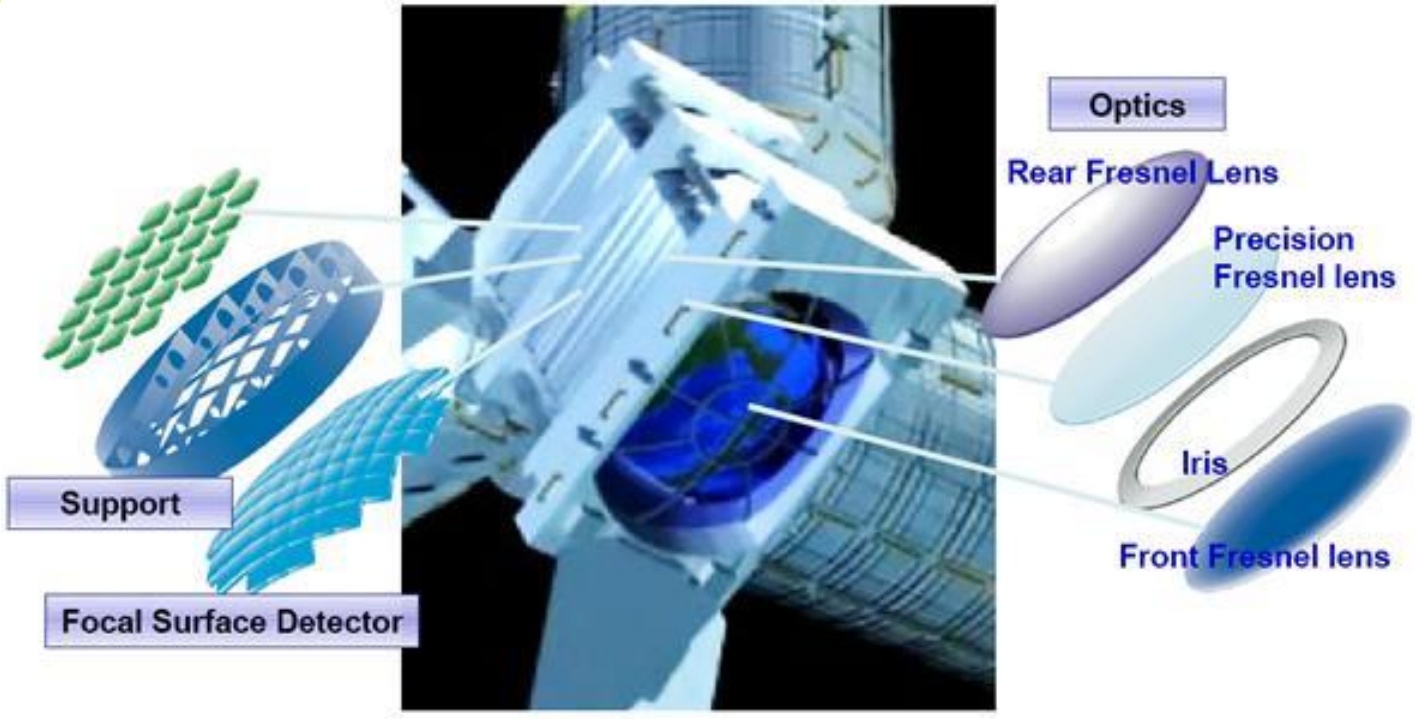
The JEM-EUSO approach



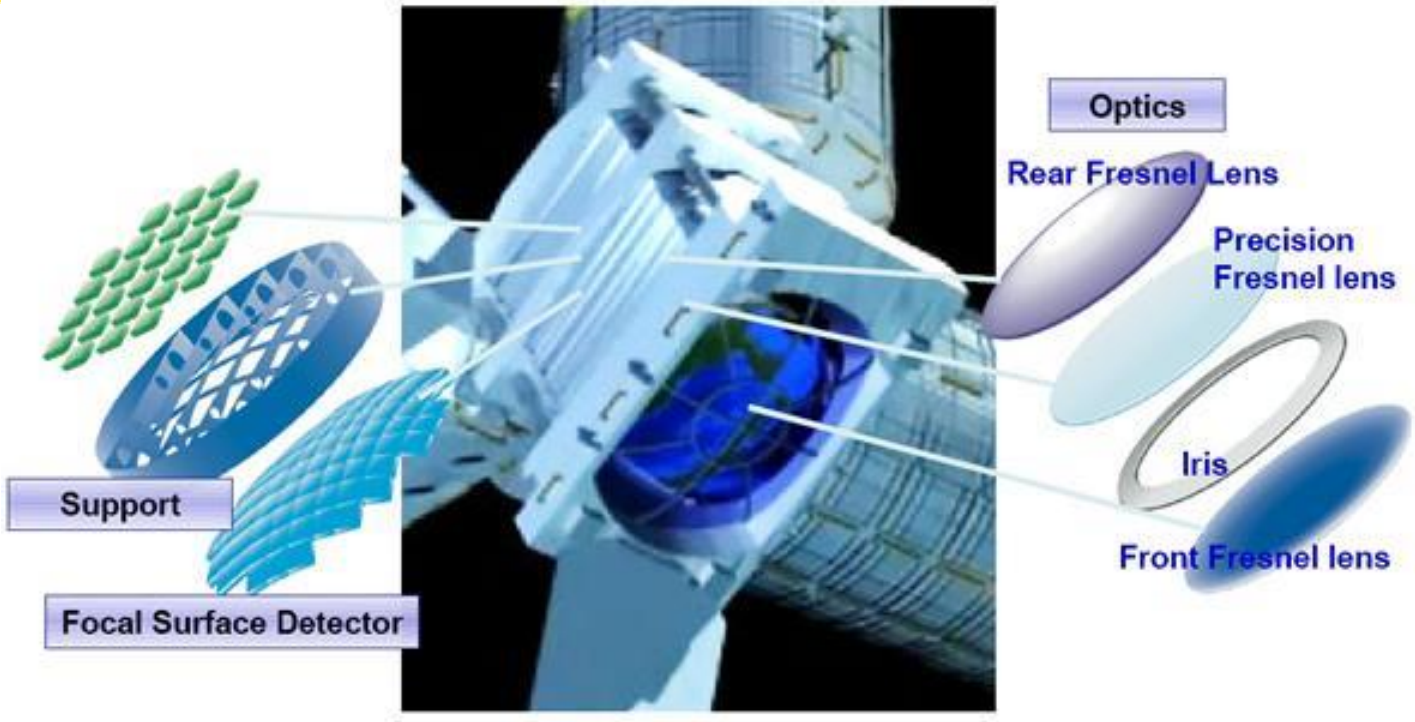


- Detect the fluorescence light, produced by the EECRs looking down the Earth from space.
- Near UV sensitivity is needed: 300 ÷ 430 nm …
- … spanning a max. time windows of 200 μs (at 400 km).

The JEM-EUSO approach

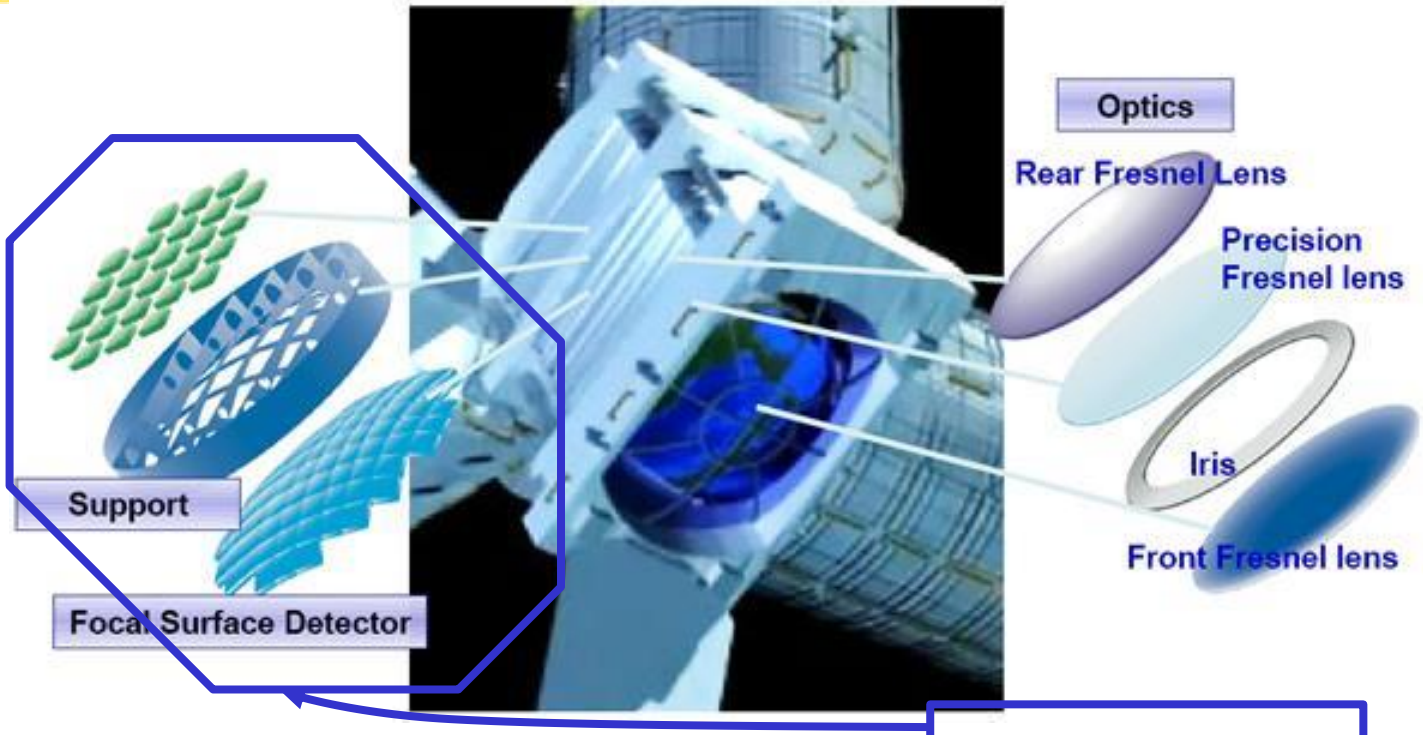


The JEM-EUSO approach



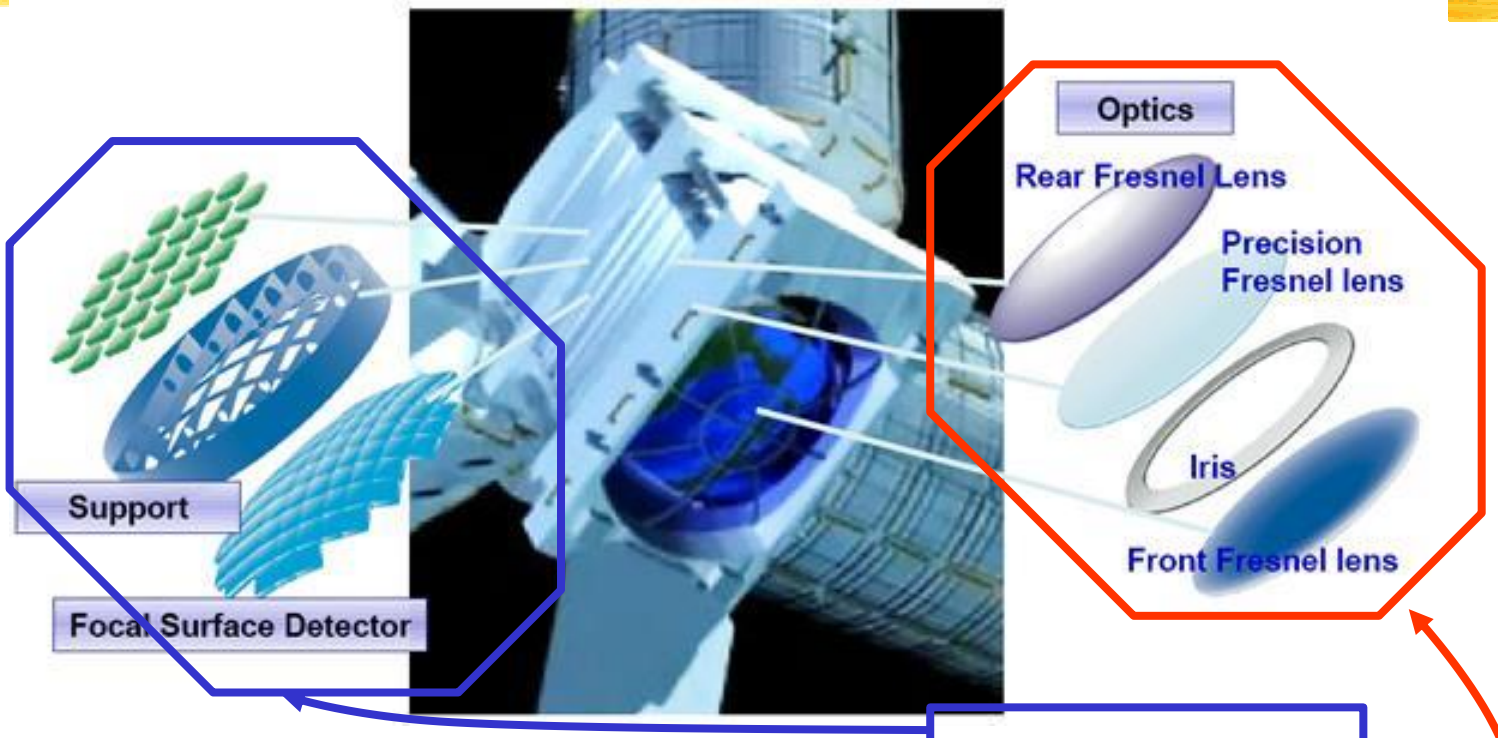
- Focus UV photons on a 2.35 m wide focal surface using the combination of 3 Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm.

The JEM-EUSO approach



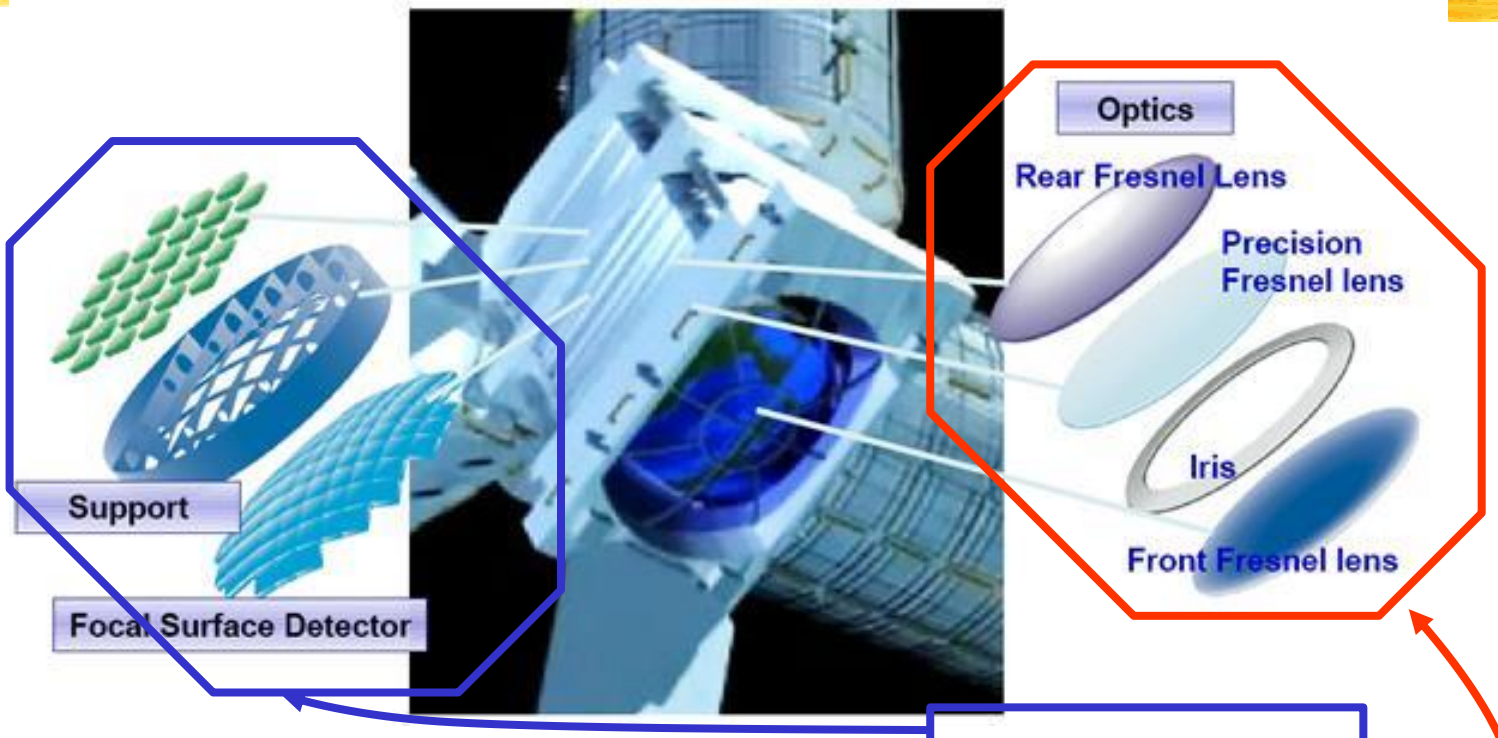
- Focus UV photons on a 2.35 m wide focal surface using the combination of 3 Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm.

The JEM-EUSO approach



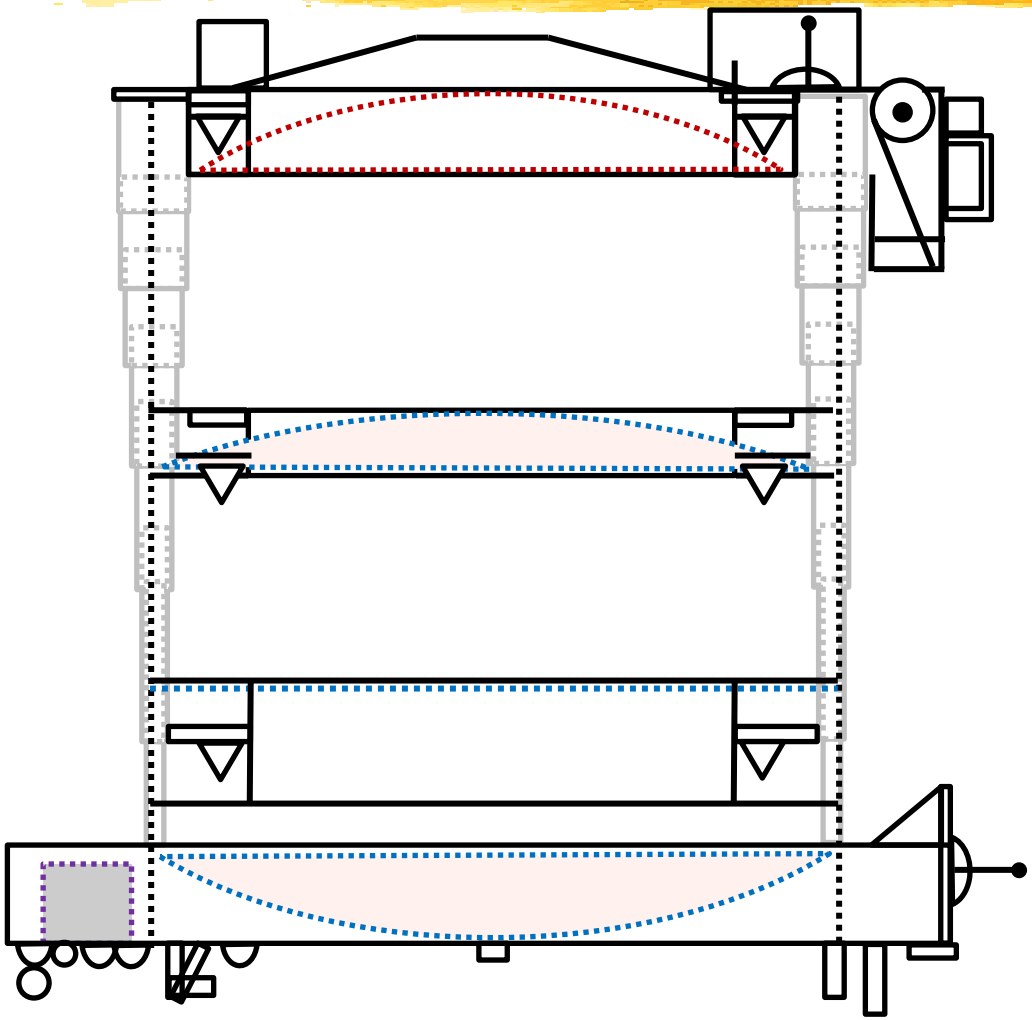
- Focus UV photons on a 2.35 m wide focal surface using the combination of 3 Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm.

The JEM-EUSO approach

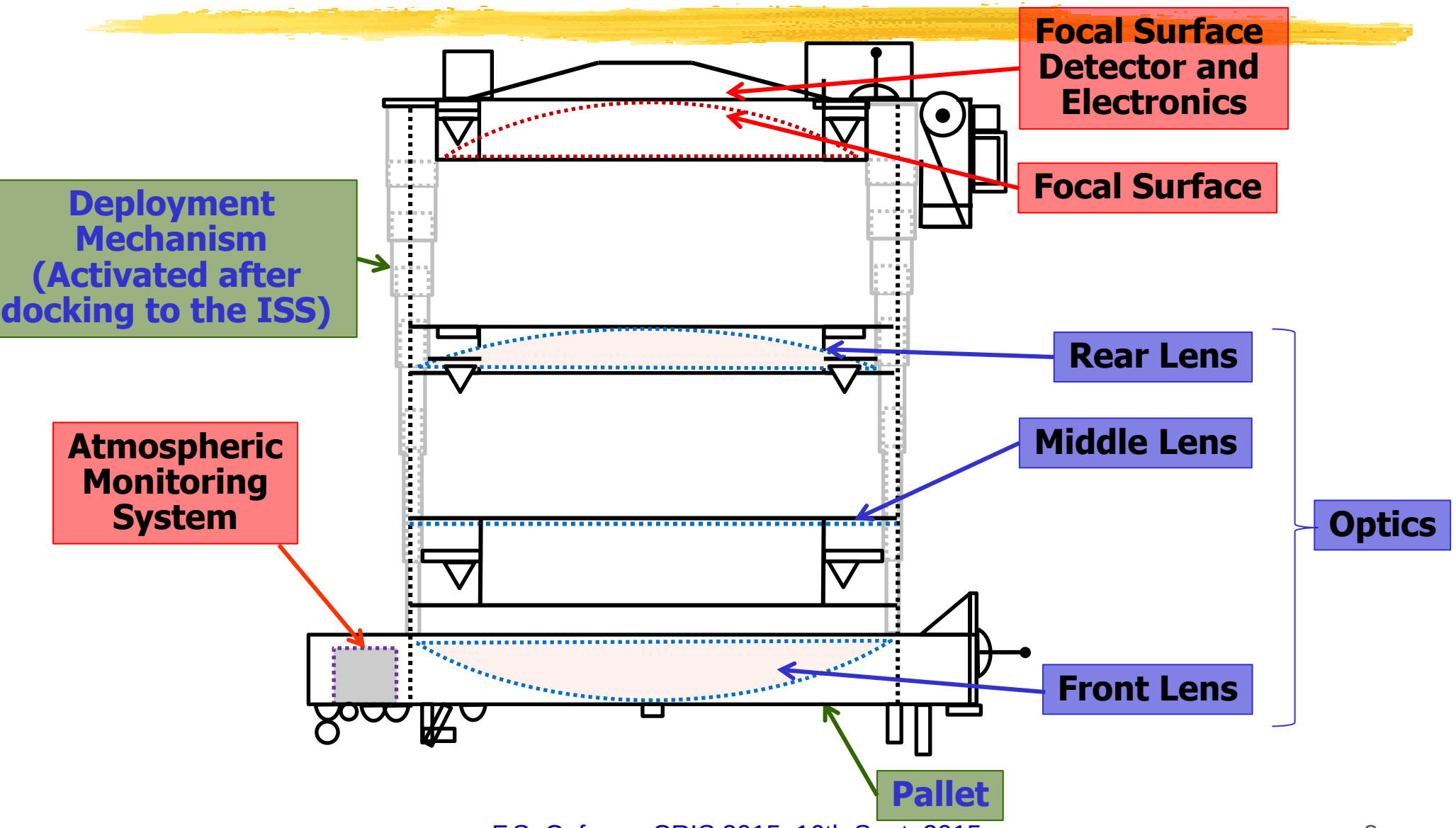


- Focus UV photons on a 2.35 m wide focal surface using the combination of 3 Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm.
- Take a snapshot of the focal surface every 2.5μs (GTU).

JEM-EUSO telescope



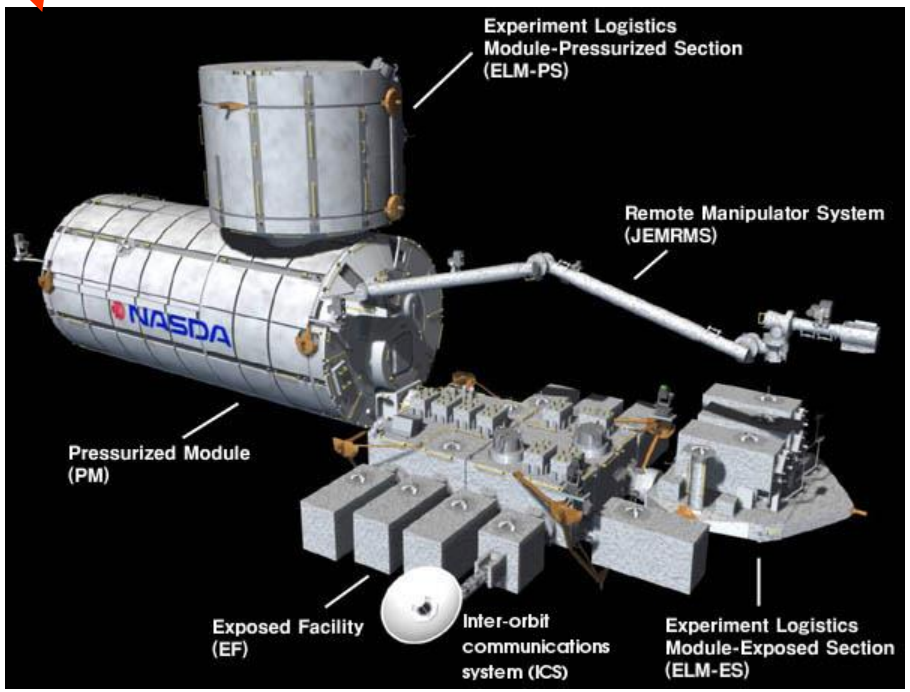
JEM-EUSO telescope

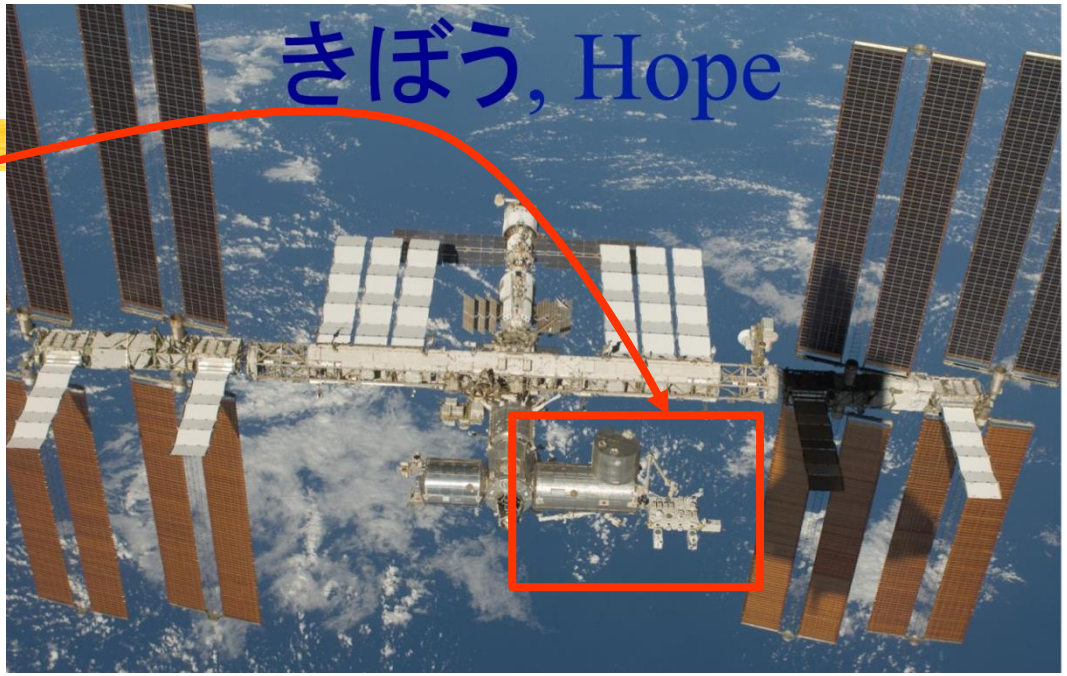


In the ISS

In the ISS

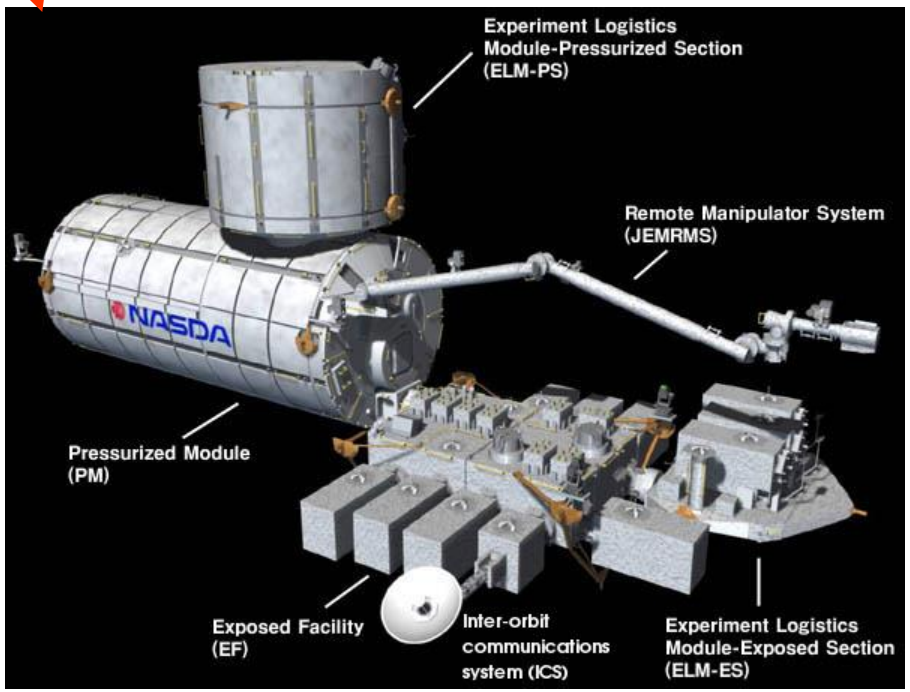
The Japanese Experiment Module (JEM), Kibo, on the ISS

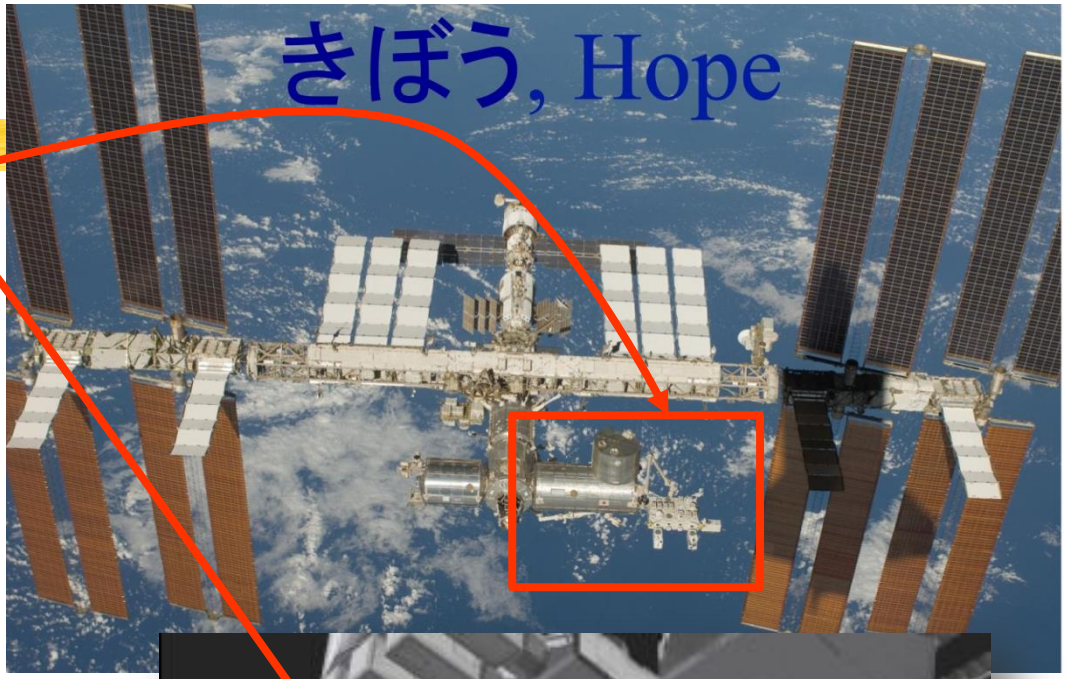




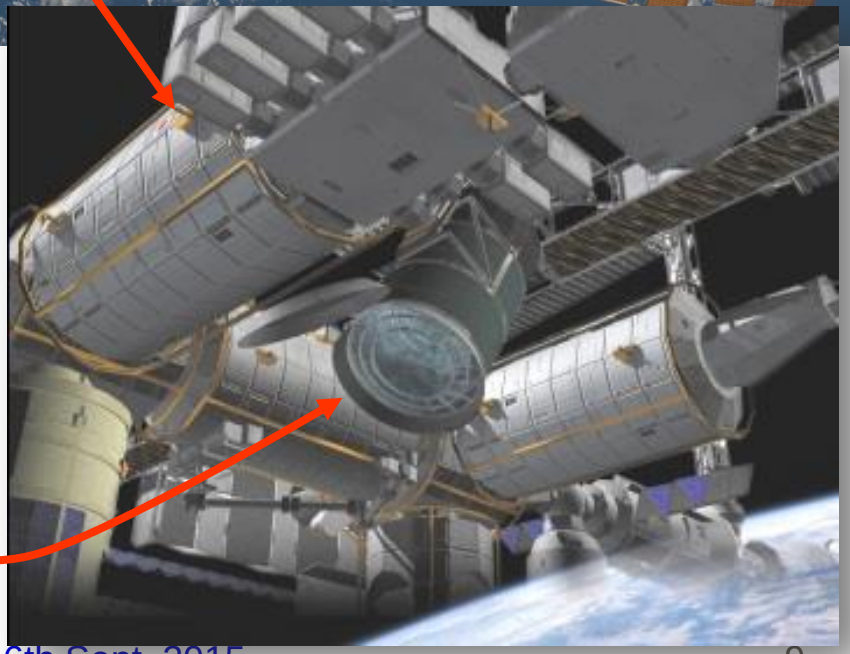
In the ISS

The Japanese Experiment Module (JEM), Kibo, on the ISS





The JEM-EUSO detector on the JEM exposed facility



Advantages in space

Advantages in space

- Far and almost constant distance of the shower;

Advantages in space

- Far and almost constant distance of the shower;
- Shower is fully contained in the FOV: observation of the entire profile;

Advantages in space

- Far and almost constant distance of the shower;
- Shower is fully contained in the FOV: observation of the entire profile;
- Possibility of observing in cloudy conditions (in most cases Xmax above the cloud-top)

Advantages in space

- Far and almost constant distance of the shower;
- Shower is fully contained in the FOV: observation of the entire profile;
- Possibility of observing in cloudy conditions (in most cases Xmax above the cloud-top)
- Less contamination by Cherenkov component;

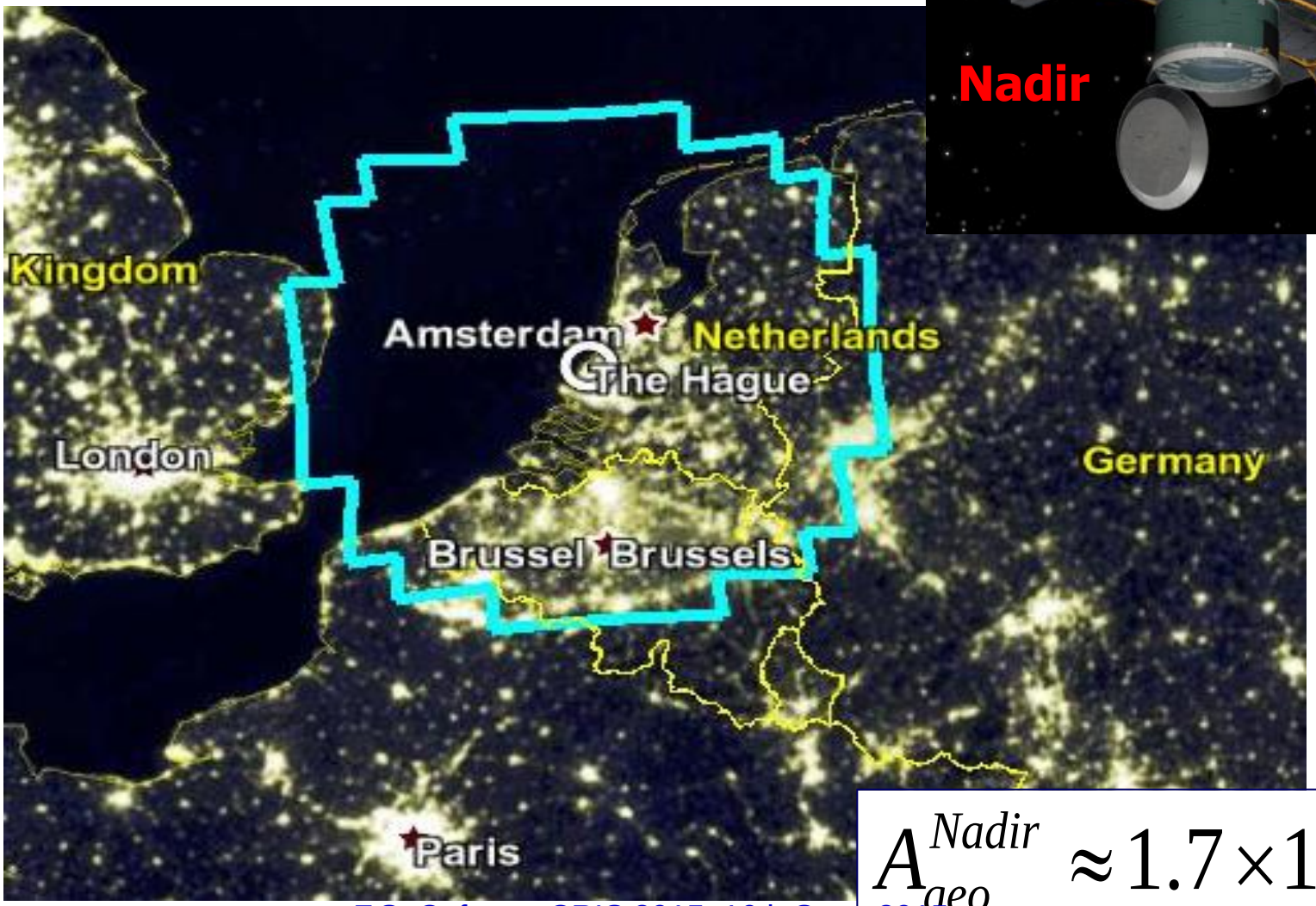
Advantages in space

- Far and almost constant distance of the shower;
- Shower is fully contained in the FOV: observation of the entire profile;
- Possibility of observing in cloudy conditions (in most cases Xmax above the cloud-top)
- Less contamination by Cherenkov component;
- Efficient gamma/hadron separation;

Advantages in space

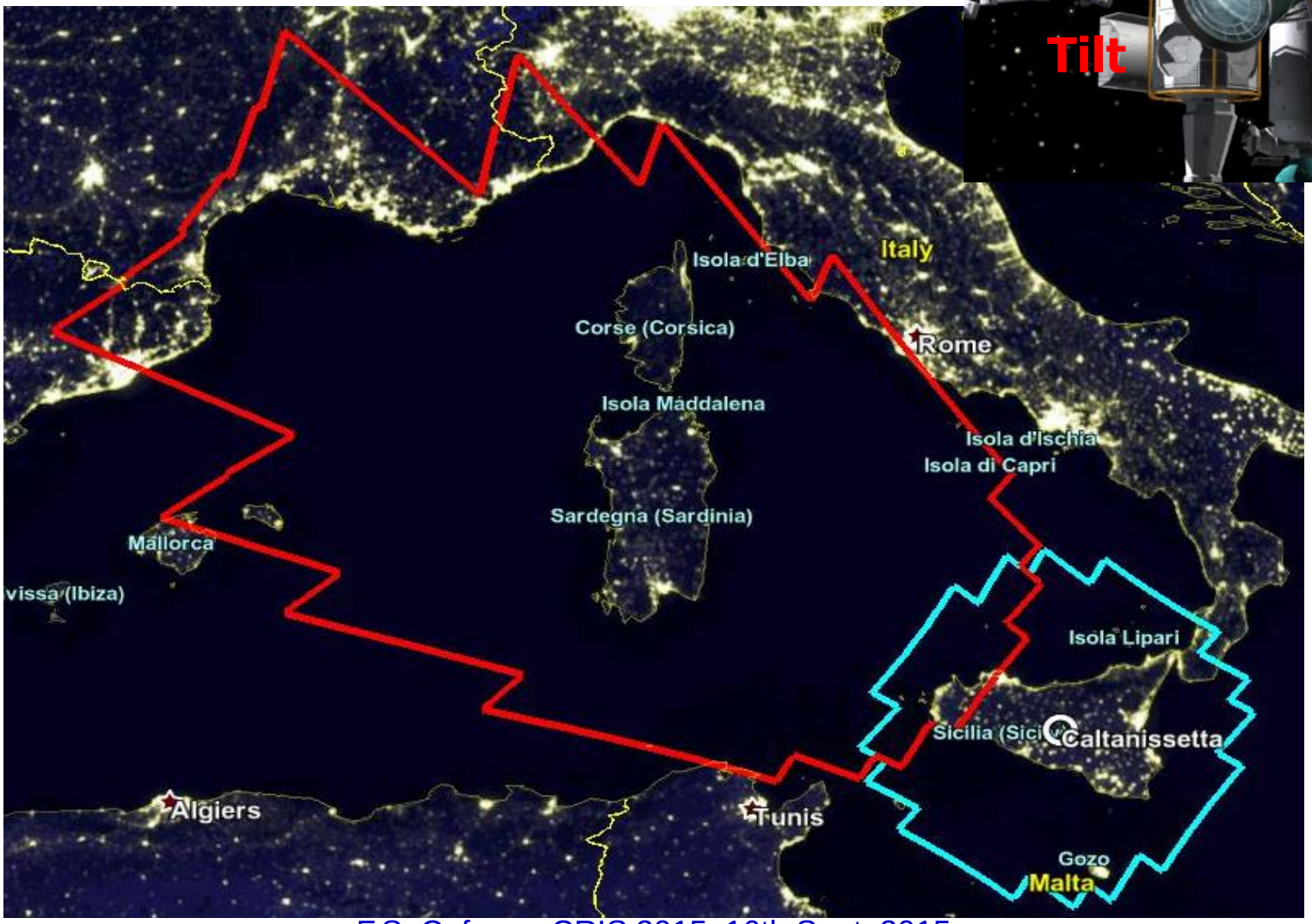
- Far and almost constant distance of the shower;
- Shower is fully contained in the FOV: observation of the entire profile;
- Possibility of observing in cloudy conditions (in most cases Xmax above the cloud-top)
- Less contamination by Cherenkov component;
- Efficient gamma/hadron separation;
- Measurement of neutrino showers at high altitude;

Advantage in space

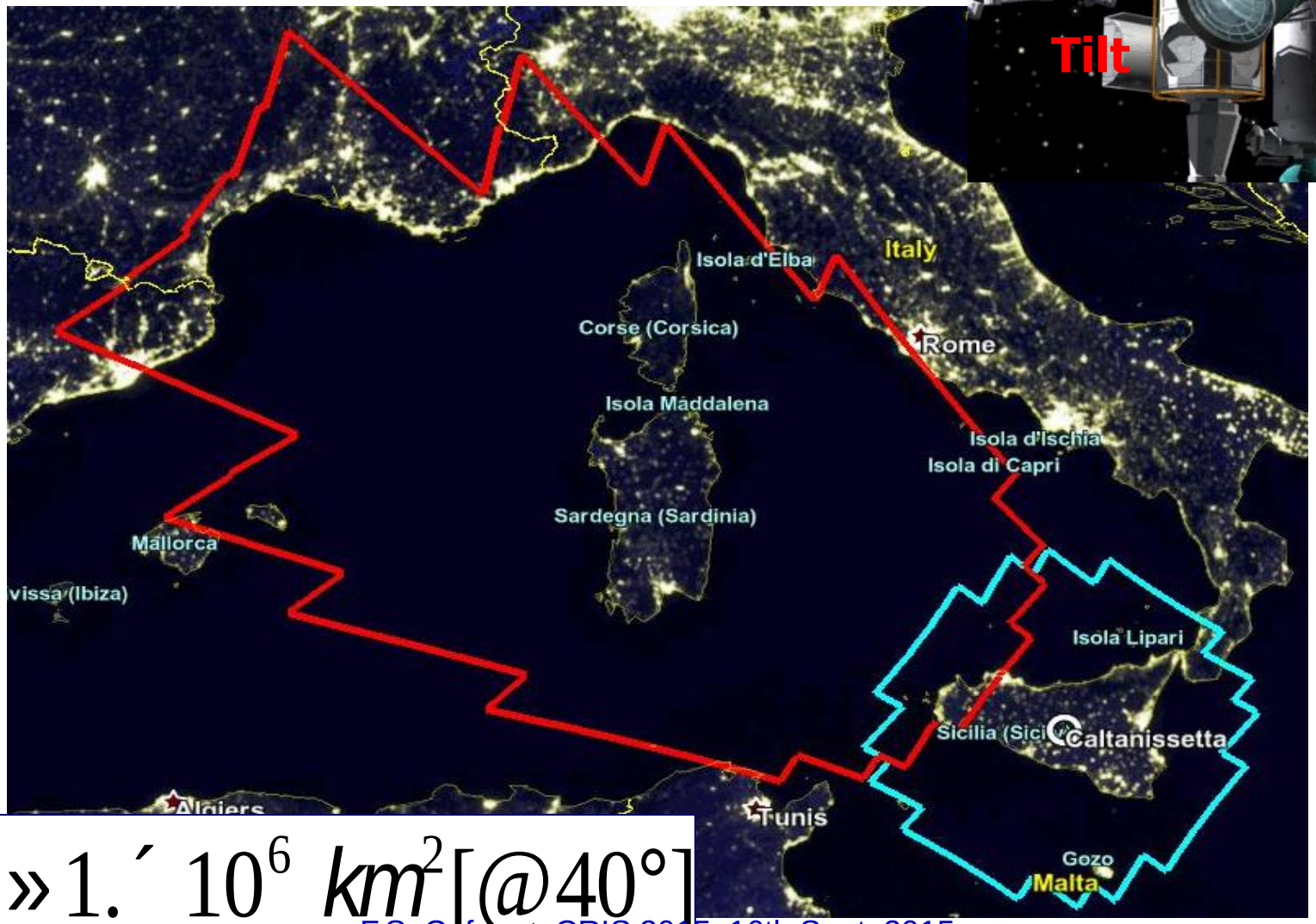


$$A_{geo}^{Nadir} \approx 1.7 \times 10^{5}\ km^{2}$$

Advantage in spac



Advantage in spac

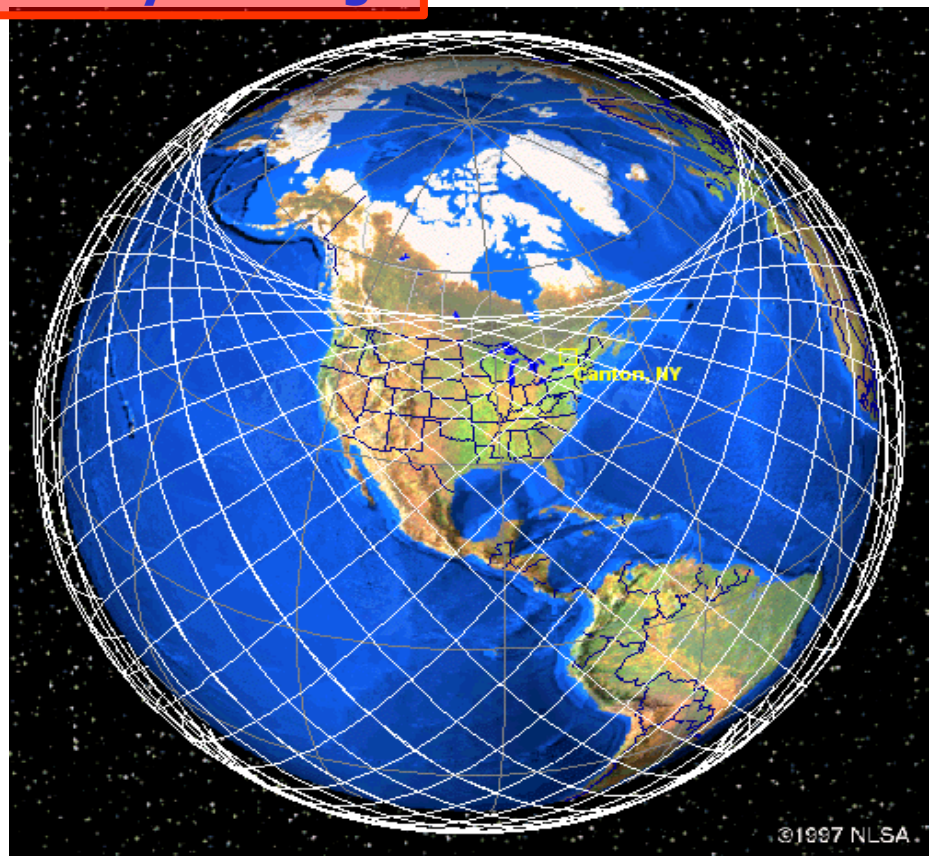


$$A_{geo}^{Tilted} \approx 1.\acute{}\ 10^{6}\ km^{2}[@40°]$$

Advantage in space

Orbit inclination: 51.6°
Oribt altitude: ~400km

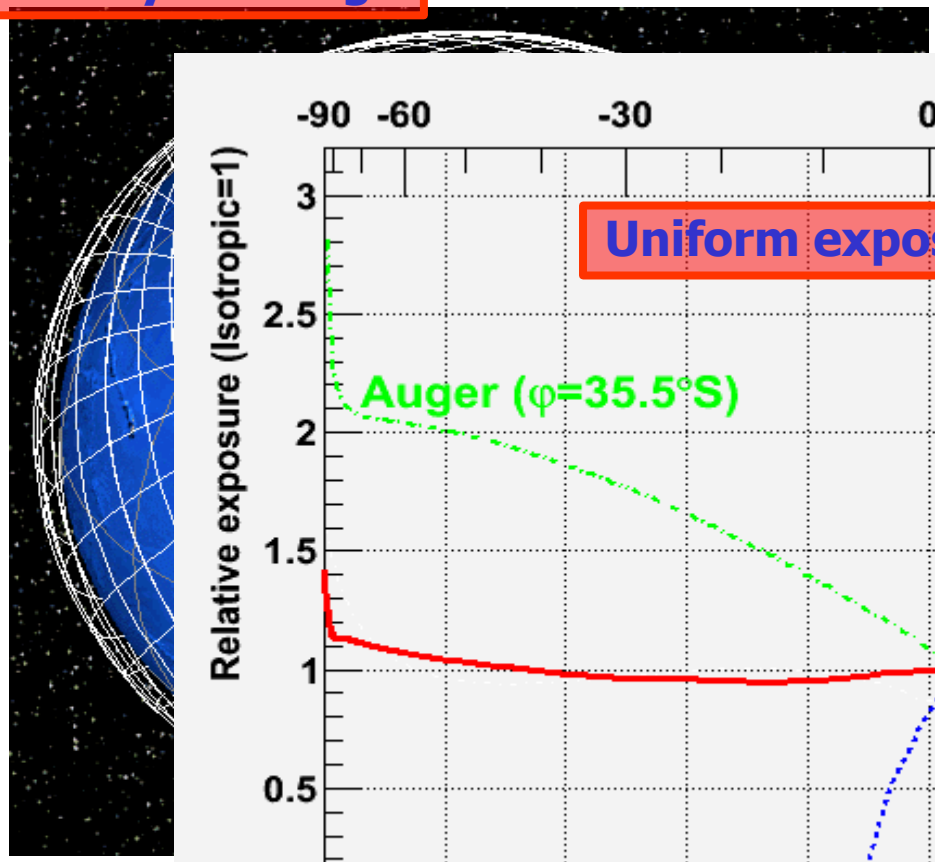
Full sky coverage

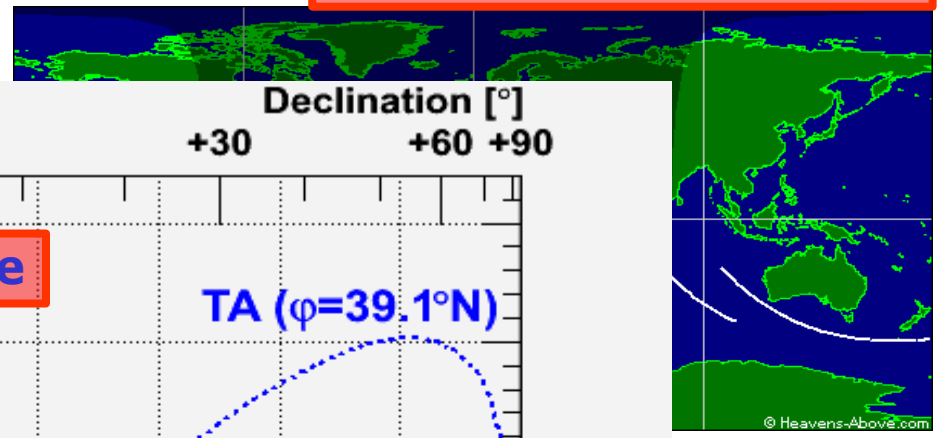


Advantage in space

Orbit inclination: 51.6°
Oribt altitude: ~400km

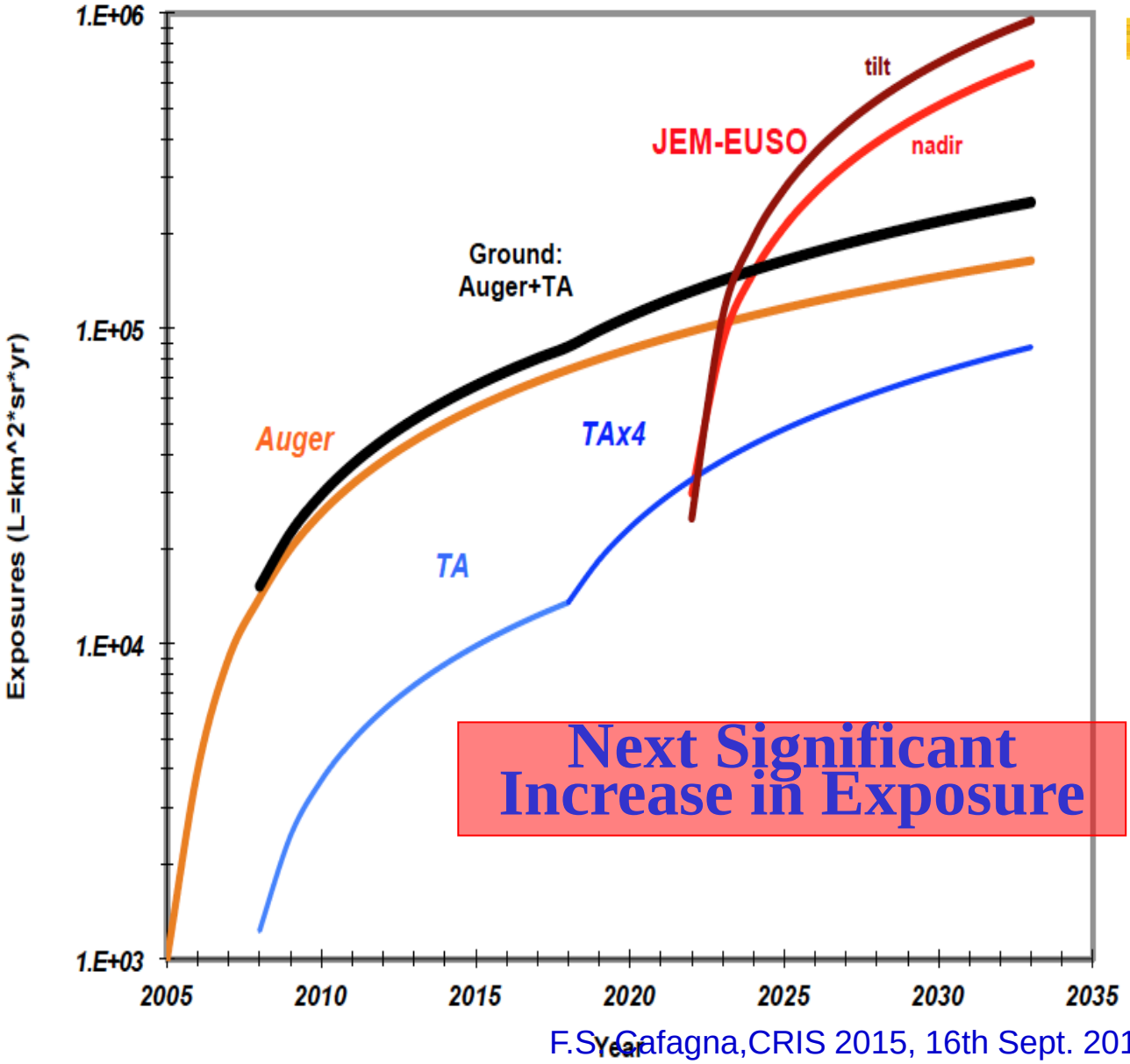
Full sky coverage





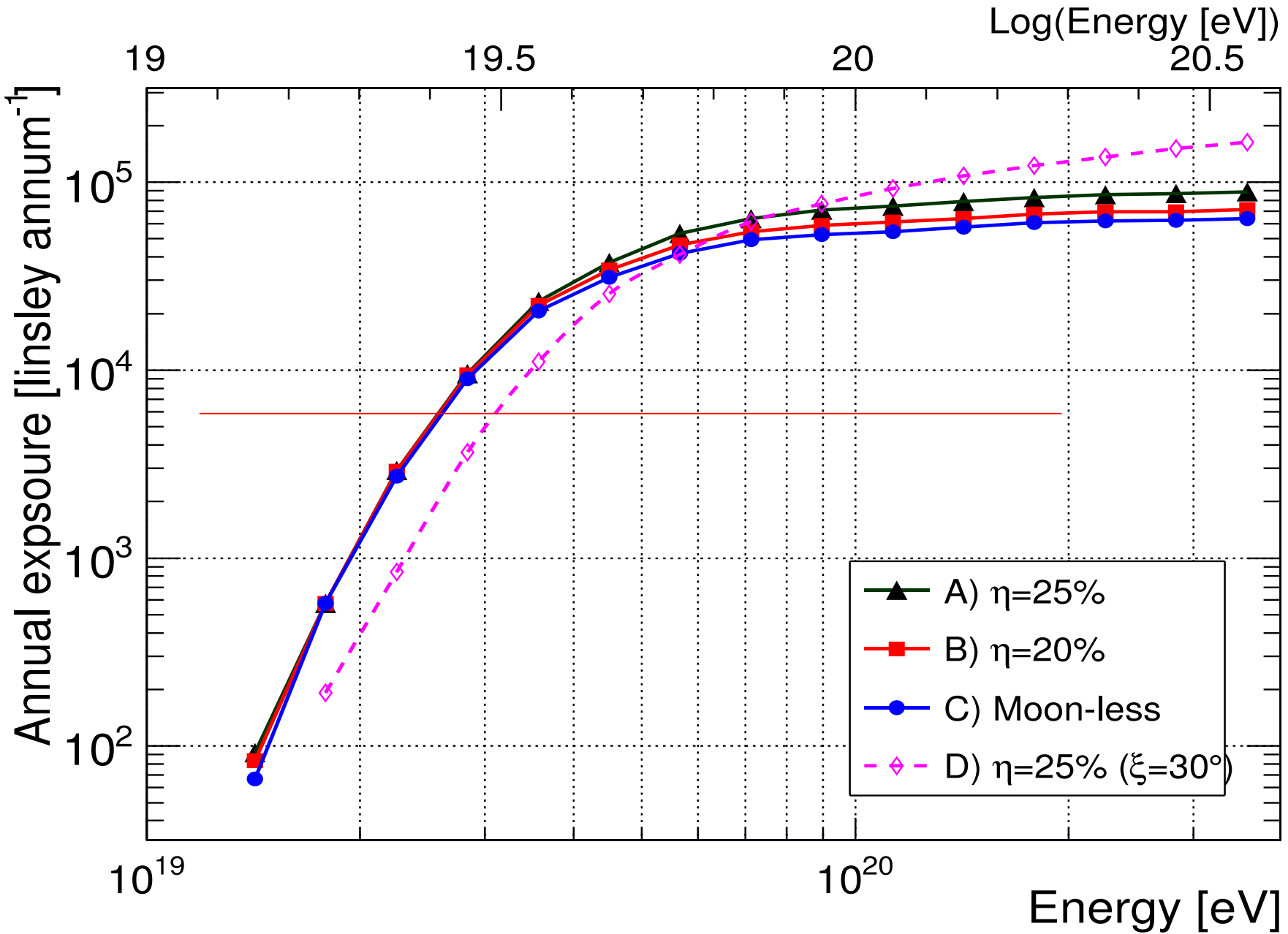
Uniform exposure

Advantage in space

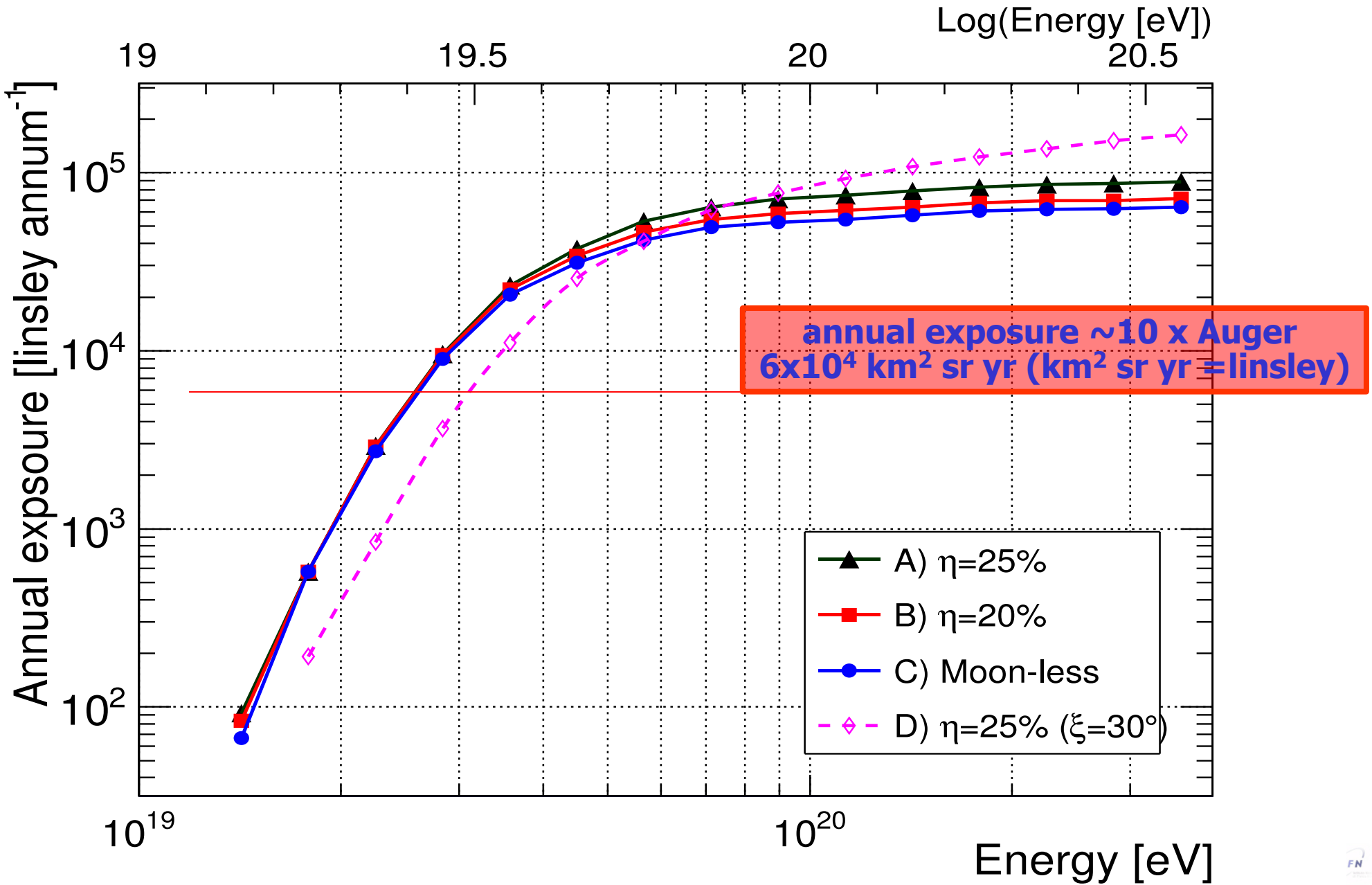


Next Significant Increase in Exposure

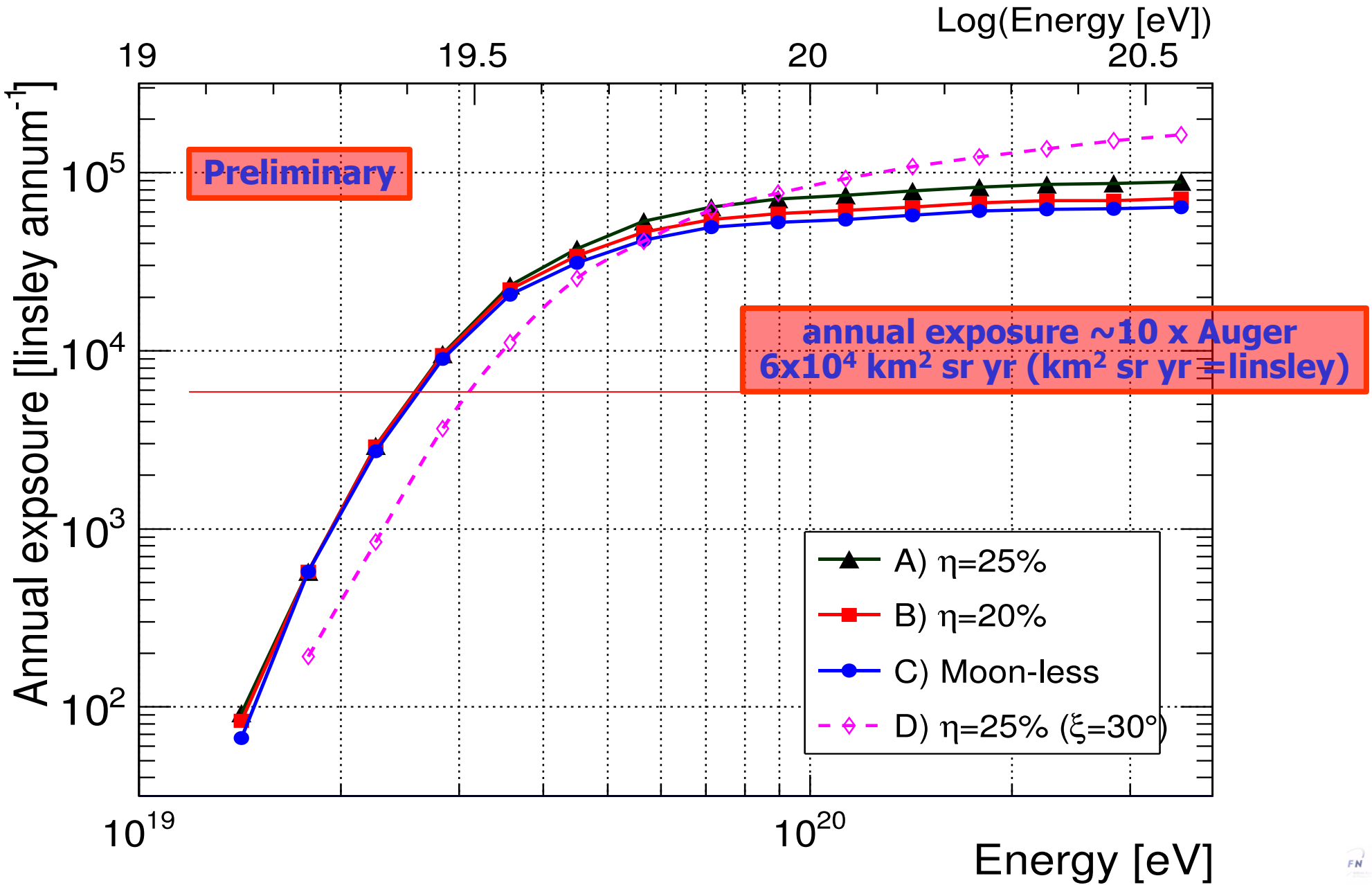
JEM-EUSO Annual Exposure



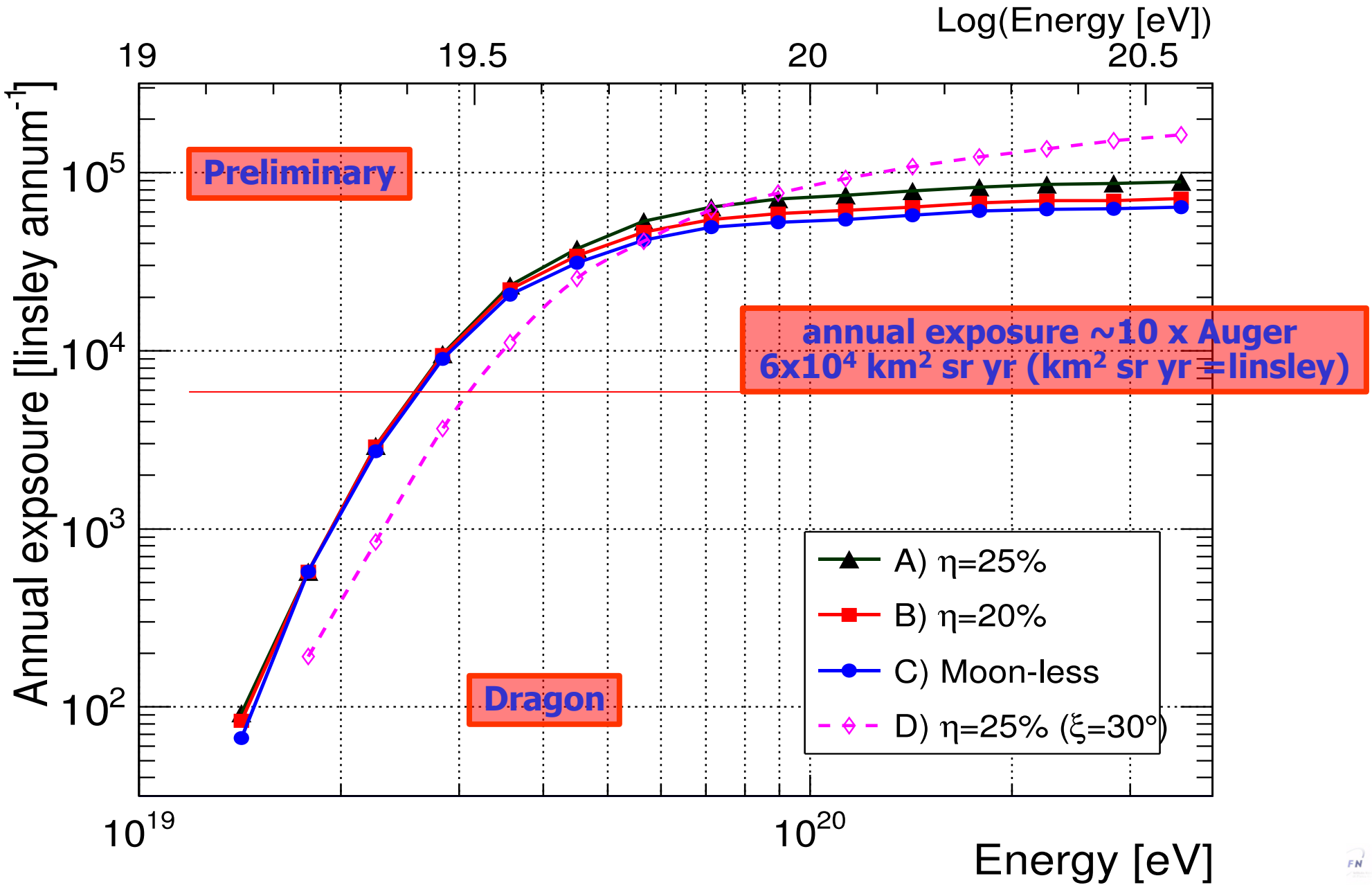
JEM-EUSO Annual Exposure

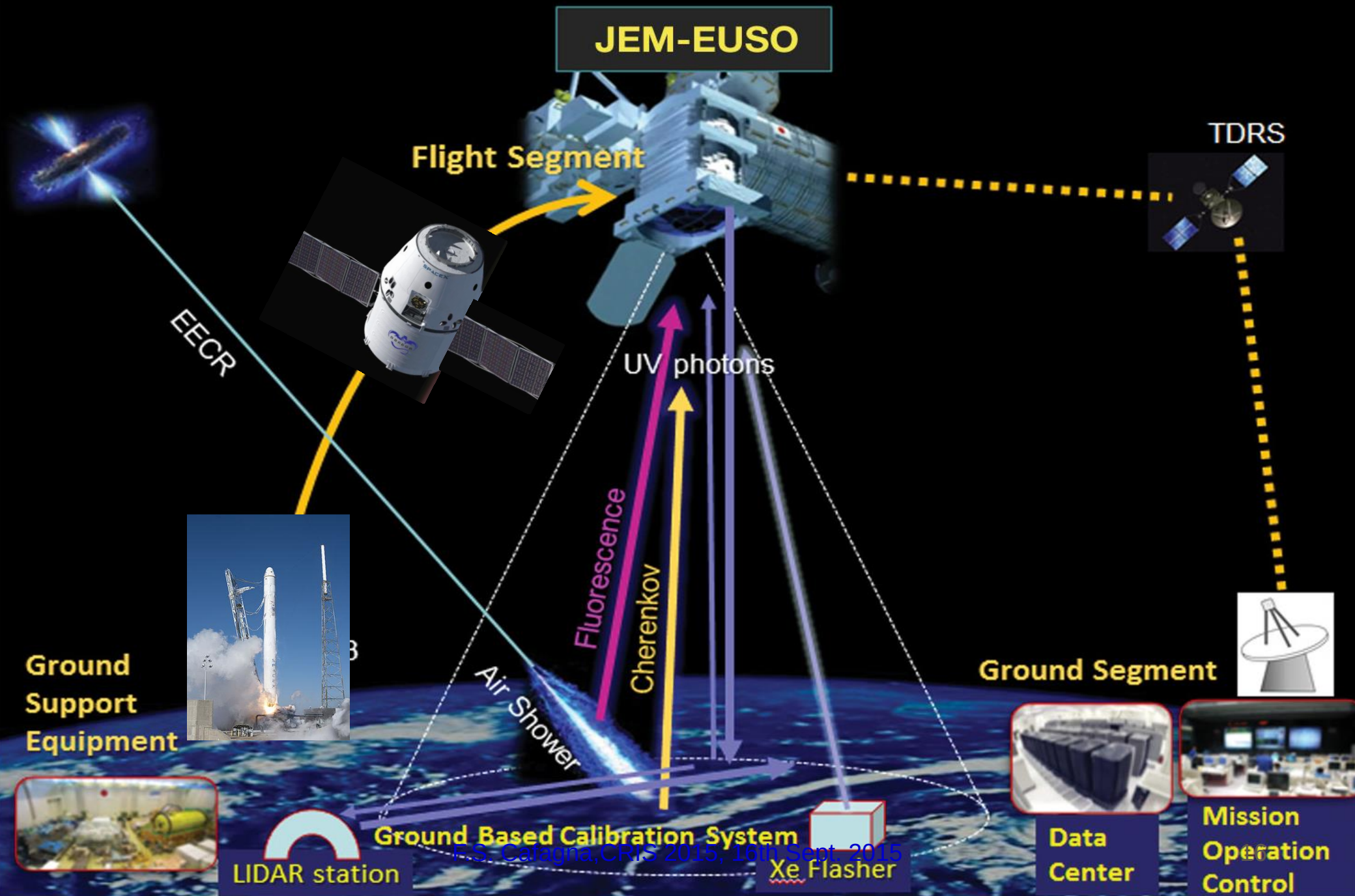


JEM-EUSO Annual Exposure

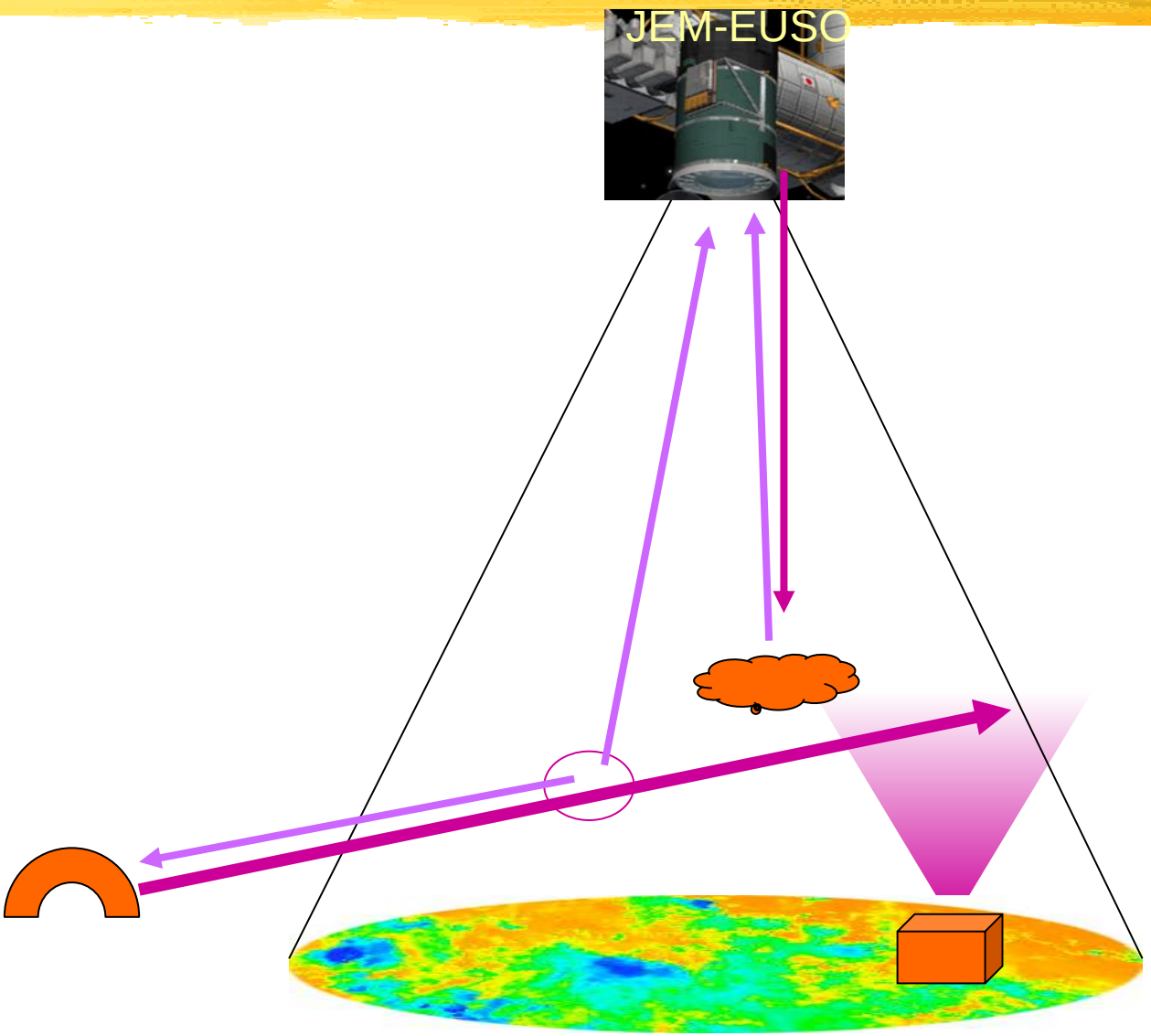


JEM-EUSO Annual Exposure




JEM-EUSO
Flight Segment
TDRS
EECR
UV photons
Fluorescence
Cherenkov
Air Shower
Ground Support Equipment
Ground Segment
Ground Based Calibration System
LIDAR station
Xe Flasher
Data Center
Mission Operation Control

Calibration an monitor

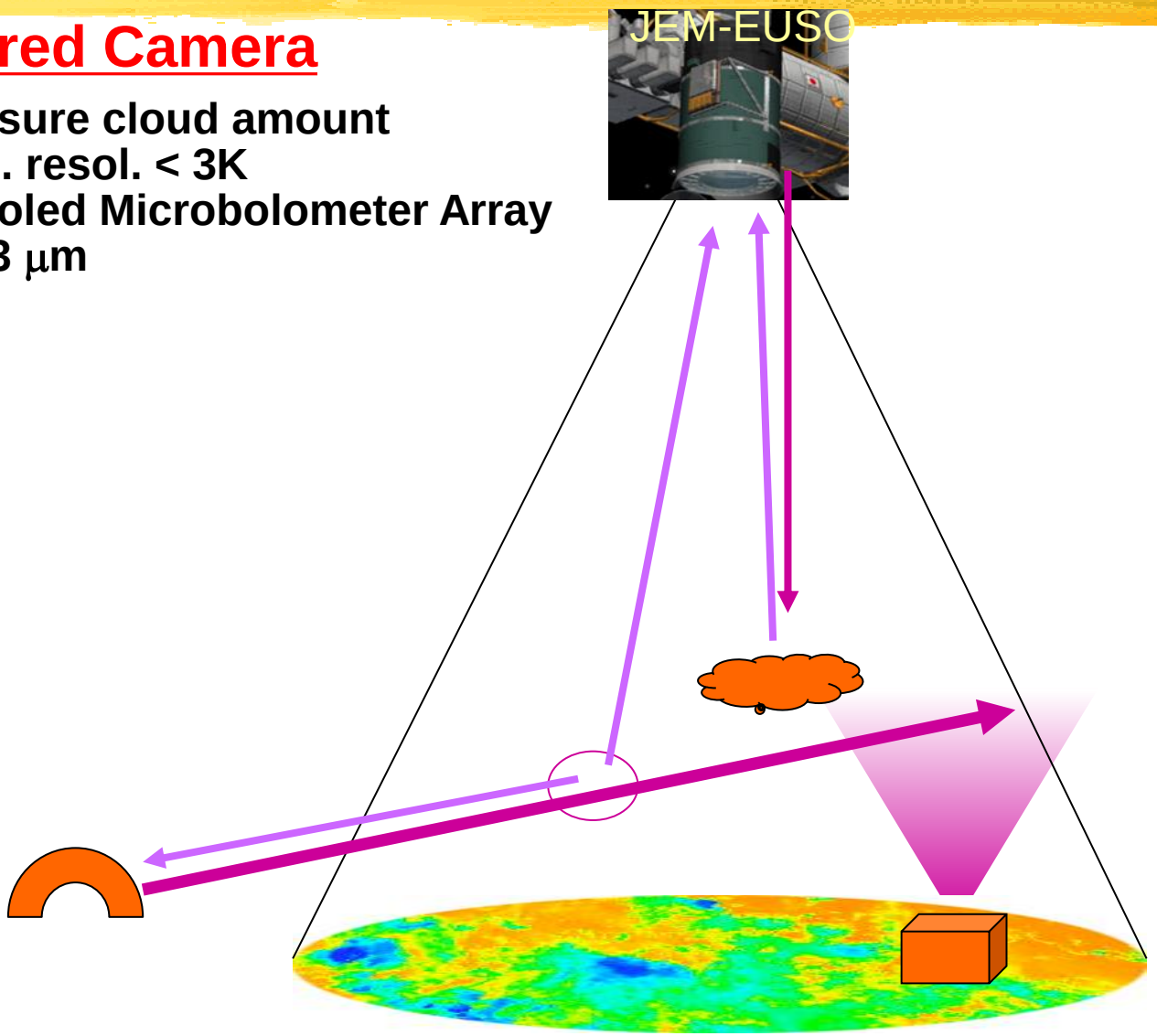


Calibration an monitor

Infrared Camera

To measure cloud amount

- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

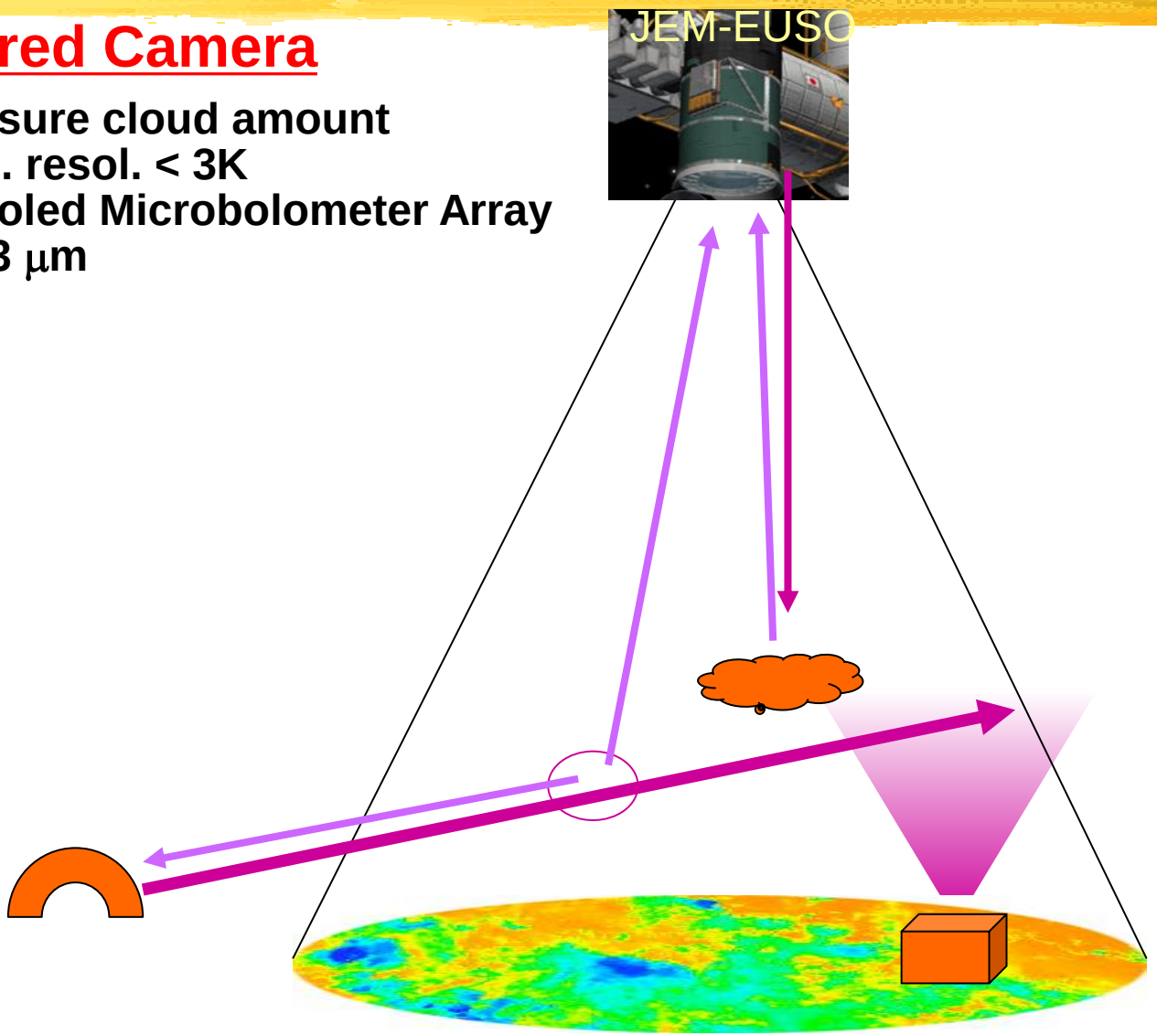


Calibration an monitor

Infrared Camera

To measure cloud amount

- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**



Calibration an monitor

Infrared Camera

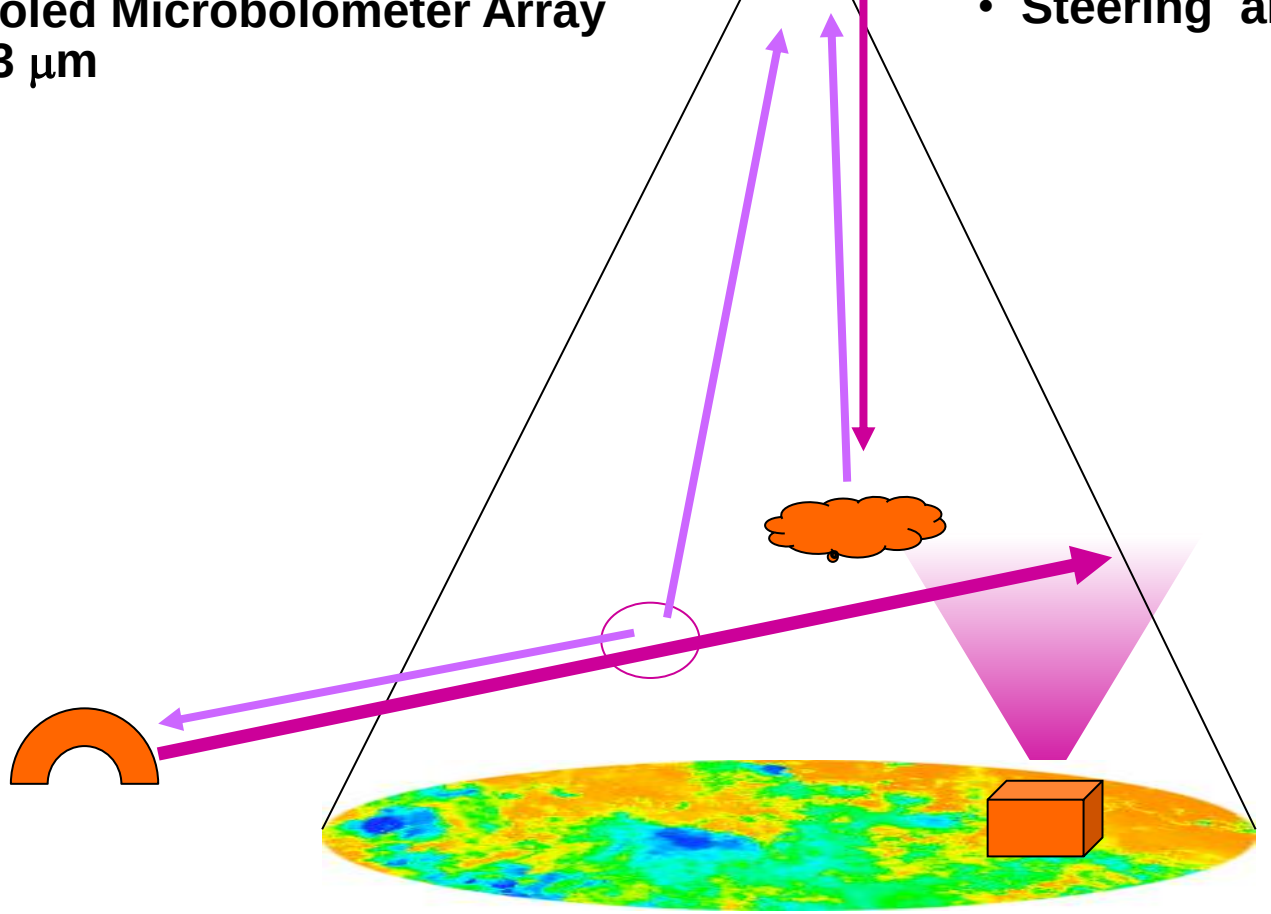
To measure cloud amount

- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m

- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**



Calibration an monitor

Infrared Camera

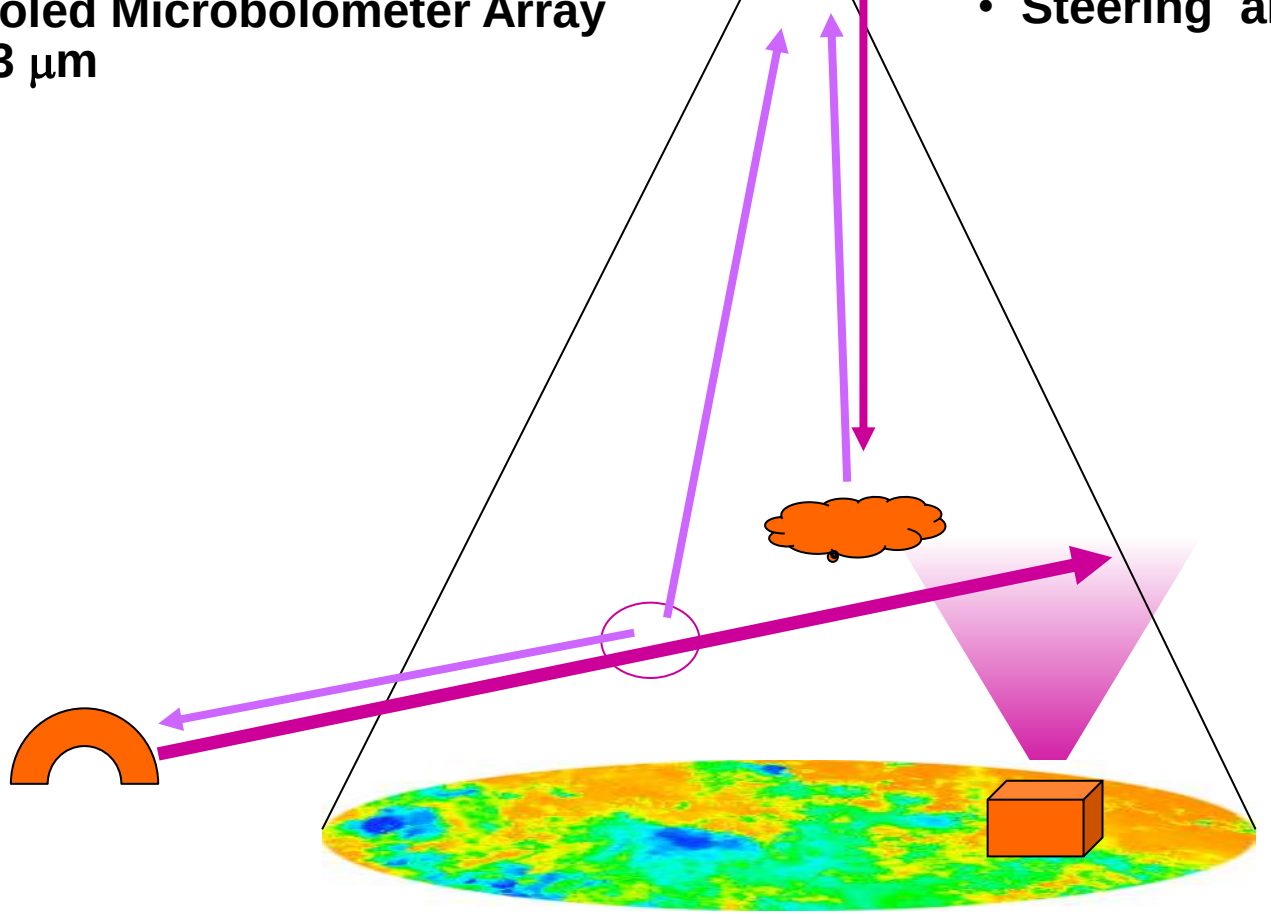
To measure cloud amount

- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m

- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**



Calibration an monitor

Infrared Camera

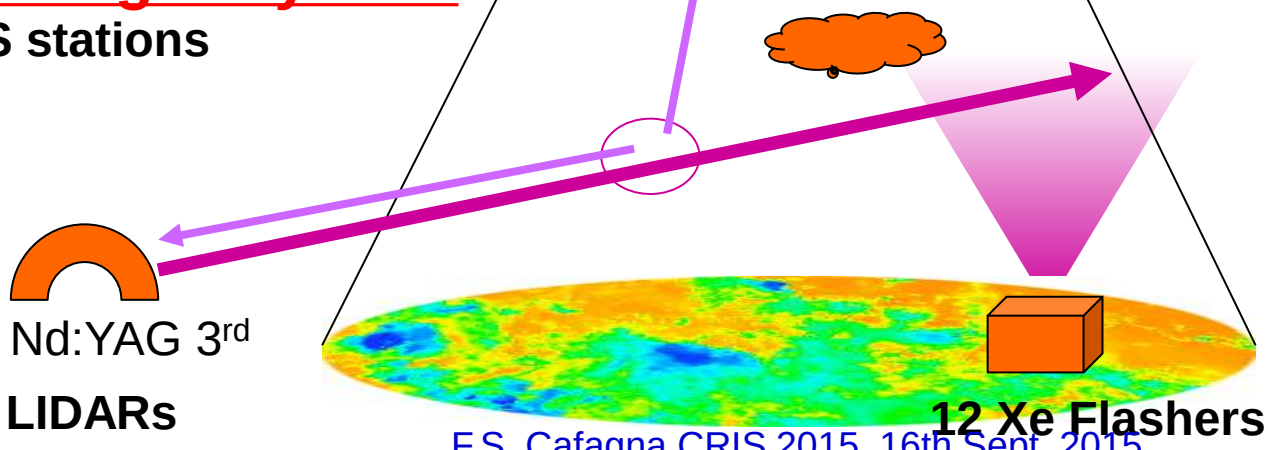
To measure cloud amount
- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m
- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**

Global Light System

12 GLS stations



Calibration an monitor

Infrared Camera

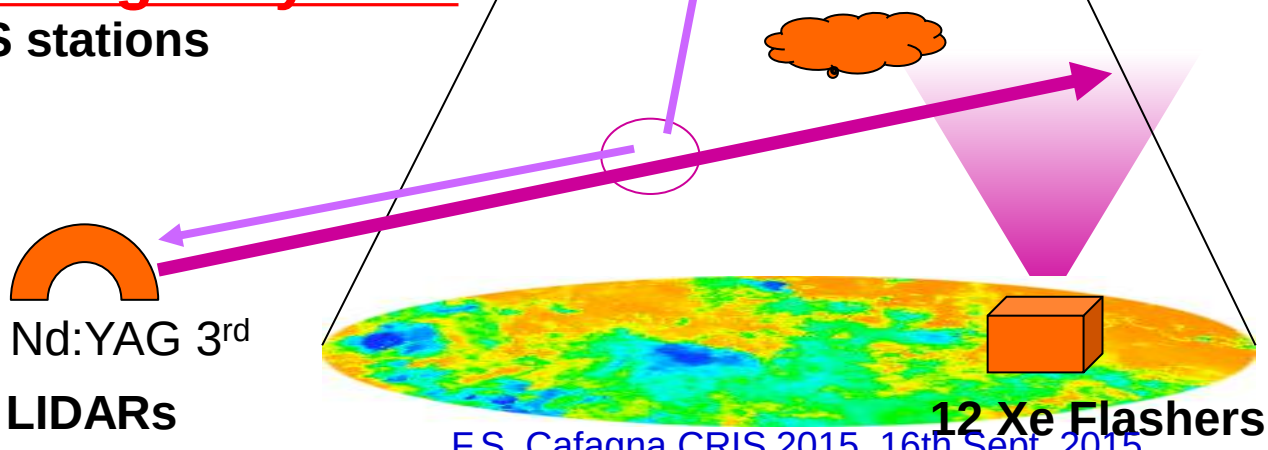
To measure cloud amount
- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m
- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**

Global Light System

12 GLS stations



Calibration an monitor

Infrared Camera

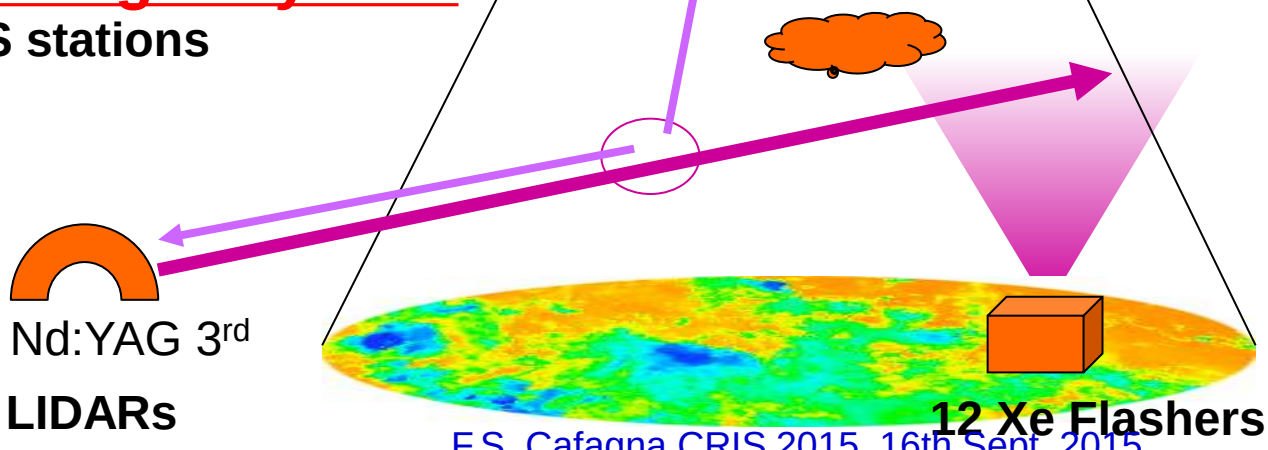
To measure cloud amount
- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m
- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**

Global Light System

12 GLS stations



Calibration an monitor

Infrared Camera

To measure cloud amount
- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

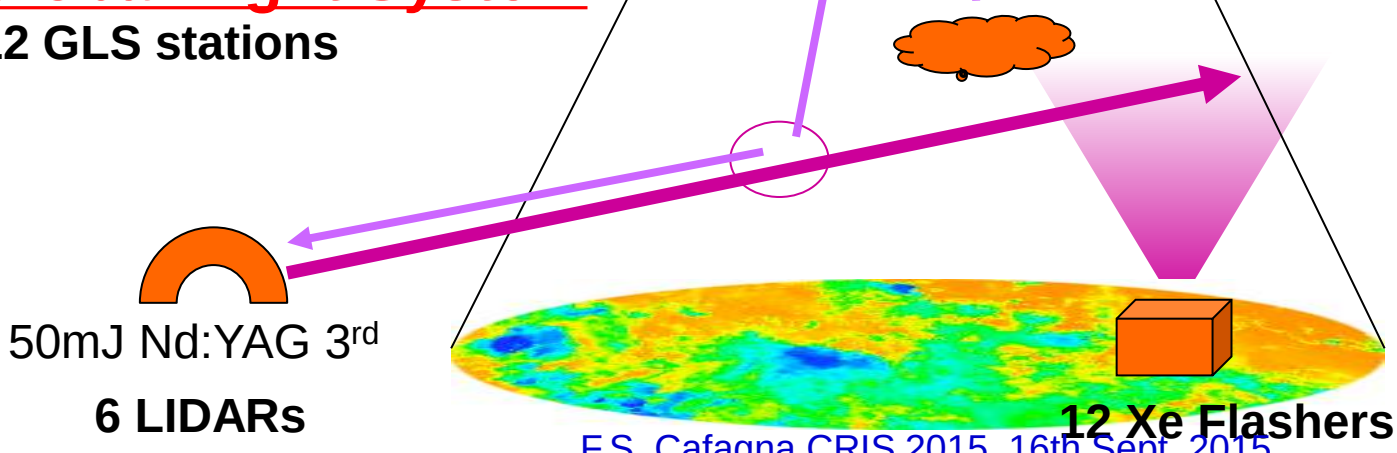
To measure cloud top altitude <500m
- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**

Onboard calibration

UV-LED + integ. spheres

Global Light System

12 GLS stations



Calibration an monitor

Infrared Camera

To measure cloud amount
- **Temp. resol. < 3K**
- **Uncooled Microbolometer Array**
- **10 -13 μm**

Onboard LIDAR

To measure cloud top altitude <500m
- **355 nm, > 1Hz, 20 mJ/pulse**
- **Steering angle ±30°**

Onboard calibration

UV-LED + integ. spheres

Global Light System

12 GLS stations

In-flight calibration

Use of moonlight

50mJ Nd:YAG 3rd

6 LIDARs

12 Xe Flashers

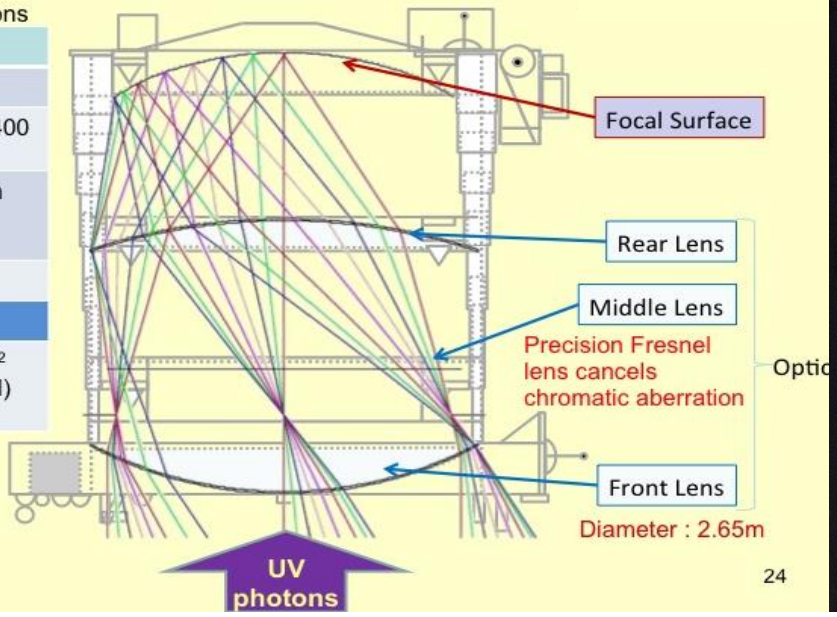
JEM-EUSO detector

- Three Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm, compose the optics block that focus the UV photons onto a 2.35 m wide focal surface.
- The middle lens is finely manufactured to cancel chromatic aberration (PMMA+CYTOP).

Optics design by ray tracing

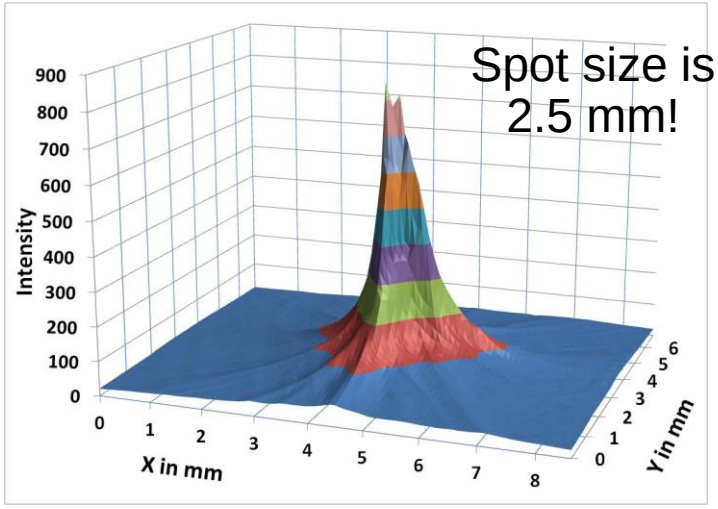
Simulation conditions

Optics	
FOV	±30
Optical bandwidth	330 ÷ 400 nm
Entrance Pupil Diameter	≥ 2.3 m
F/number	≤1
Focal surface	
Focal surface area	~4.5 m² (curved)



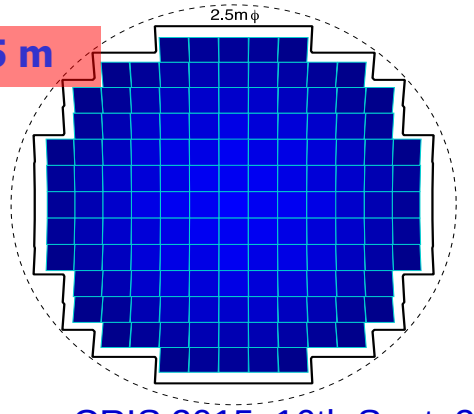
JEM-EUSO detector

- Three Fresnel lenses, made of PolyMethyl Methacrylate (PMMA), circular in shape with diameters varying from 1.9m to 2.65m, and a thickness of 10mm, compose the optics block that focus the UV photons onto a 2.35 m wide focal surface.
- The middle lens is finely manufactured to cancel chromatic aberration (PMMA+CYTOP).



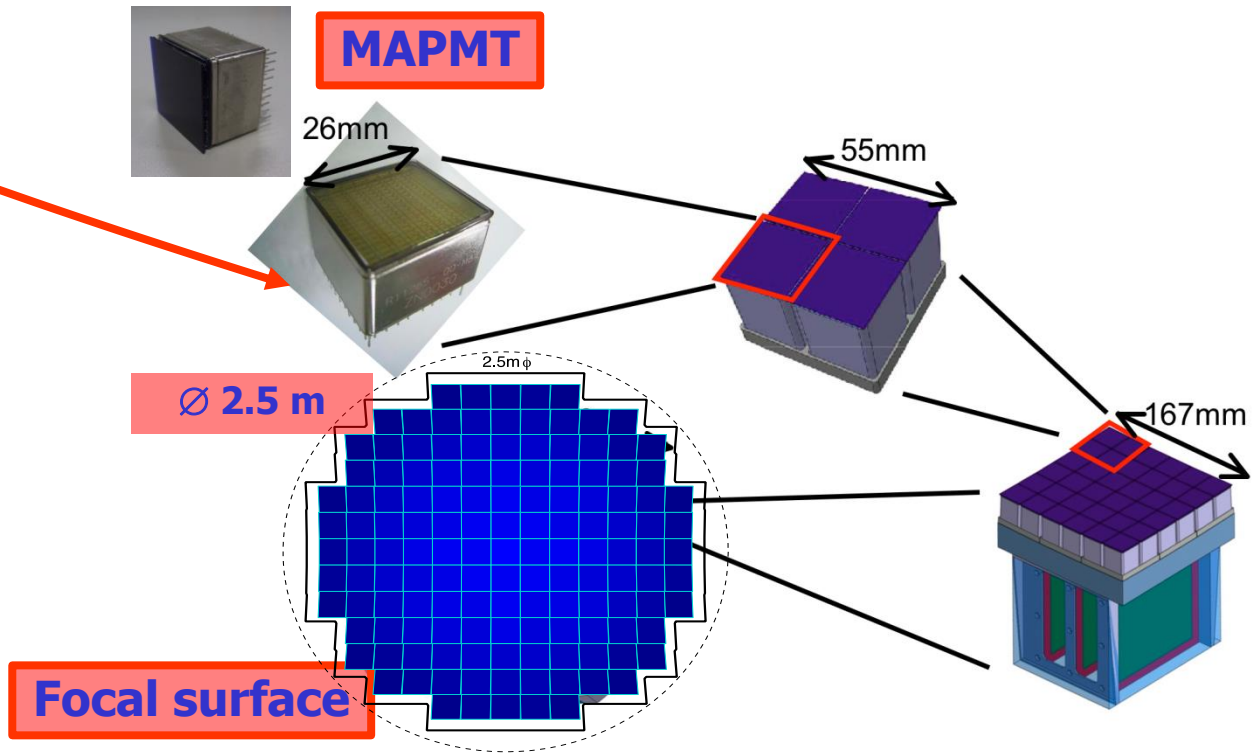
The focal surface

∅ 2.5 m



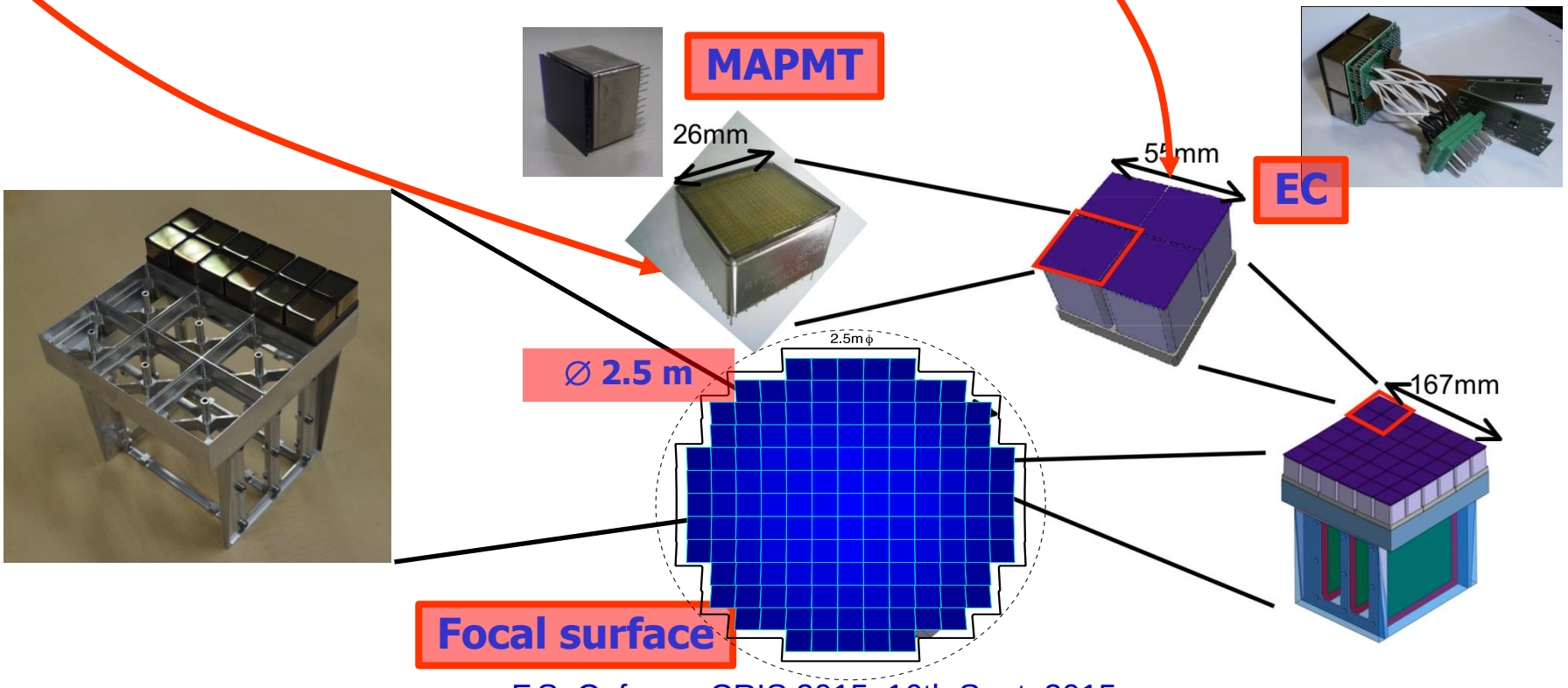
The focal surface

- The focal surface, houses 4932 Hamamatsu R11265-03-M64, Ultra Bialkali, 64 pixels, MAPMTs.



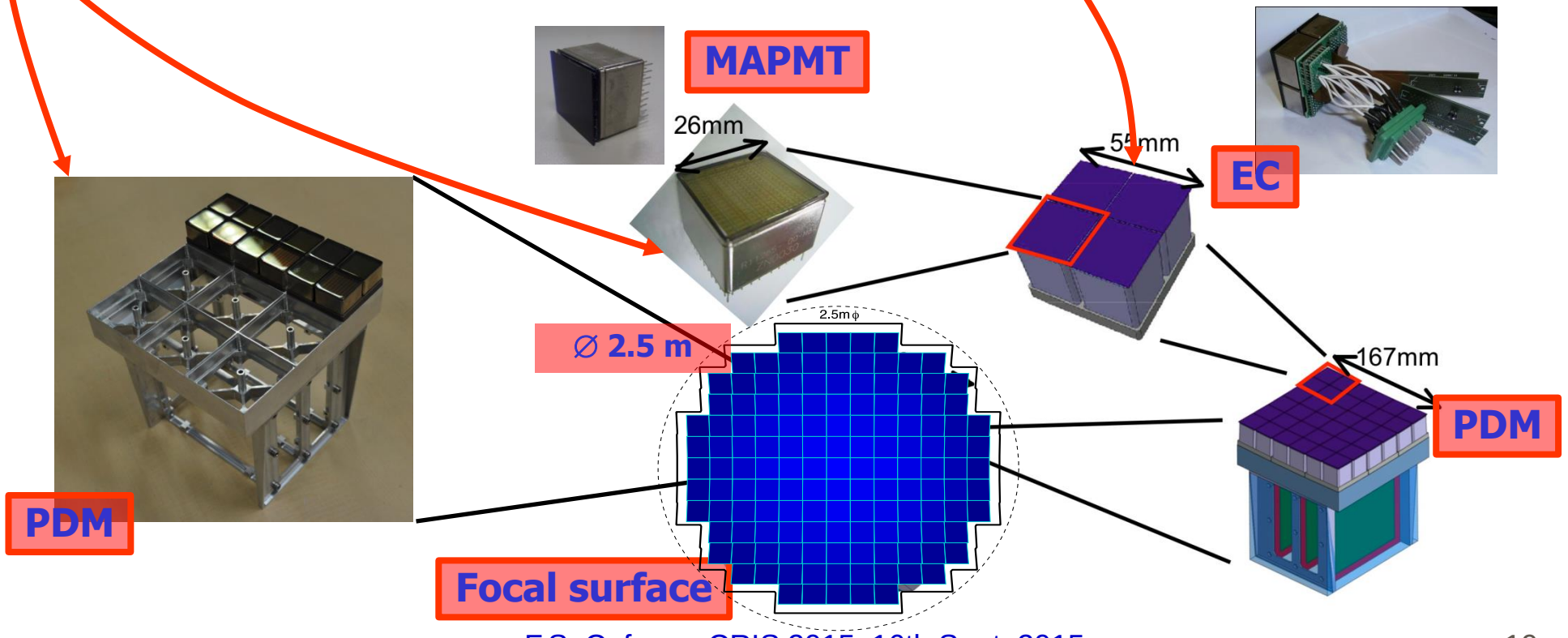
The focal surface

- The focal surface, houses 4932 Hamamatsu R11265-03-M64, Ultra Bialkali, 64 pixels, MAPMTs.
- MAPMTs are grouped by 4 into Elementary Cells (EC), that are grouped by 9 into a module Photo Detection Module (PDM).



The focal surface

- The focal surface, houses 4932 Hamamatsu R11265-03-M64, Ultra Bialkali, 64 pixels, MAPMTs.
- MAPMTs are grouped by 4 into Elementary Cells (EC), that are grouped by 9 into a module Photo Detection Module (PDM).
- 137 PDM are housed into the focal plane structure.



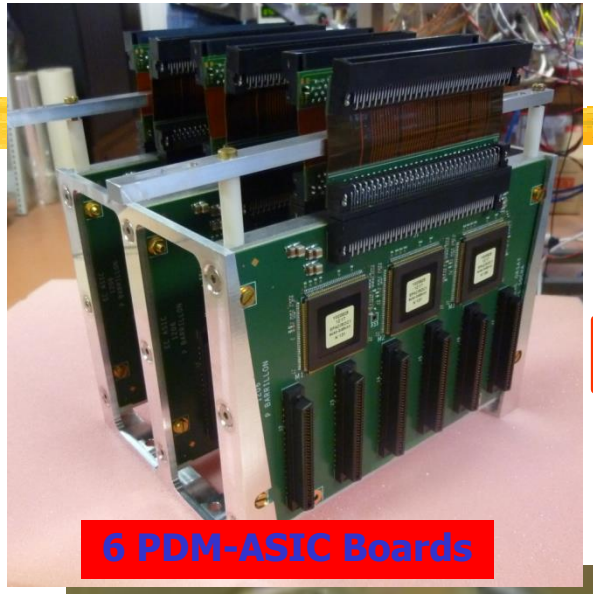
The PDM

The PDM

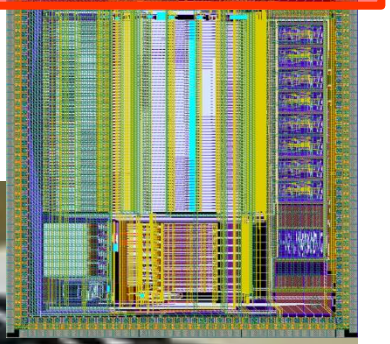
- Every MAPMT is read out by a custom ASIC, the SPACIROC.

The PDM

- Every MAPMT is read out by a custom ASIC, the SPACIROC.
- 6 ASICS are arranged in a board, the PDM-ASIC.

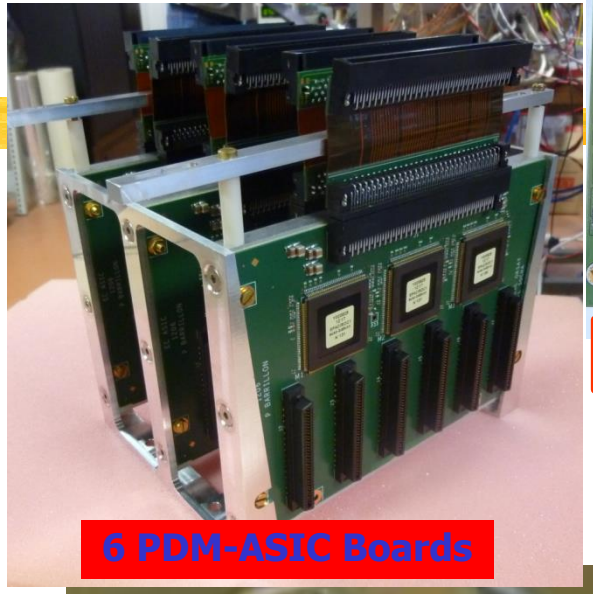


ASIC SPACIROC

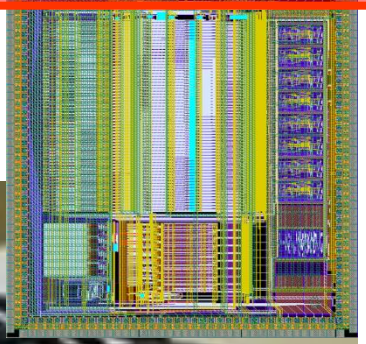


The PDM

- Every MAPMT is read out by a custom ASIC, the SPACIROC.
- 6 ASICS are arranged in a board, the PDM-ASIC.
- 6 PDM-ASIC are read out by the PDM board.

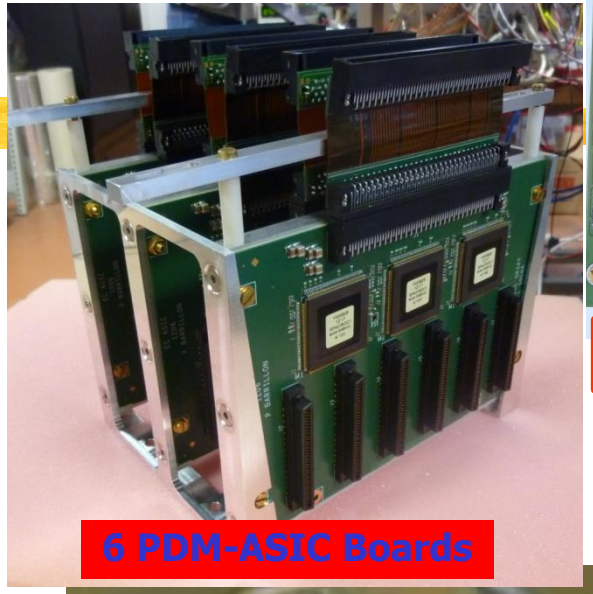


ASIC SPACIROC

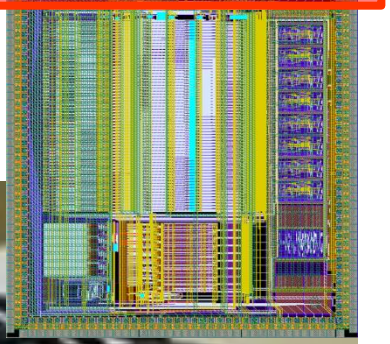


The PDM

- Every MAPMT is read out by a custom ASIC, the SPACIROC.
- 6 ASICS are arranged in a board, the PDM-ASIC.
- 6 PDM-ASIC are read out by the PDM board.
- These boards and the HV modules are housed in a PDM.

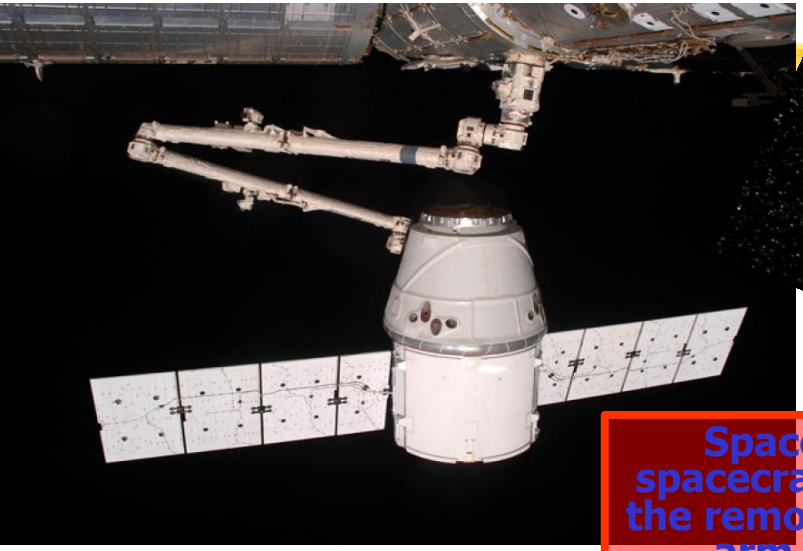


ASIC SPACIROC

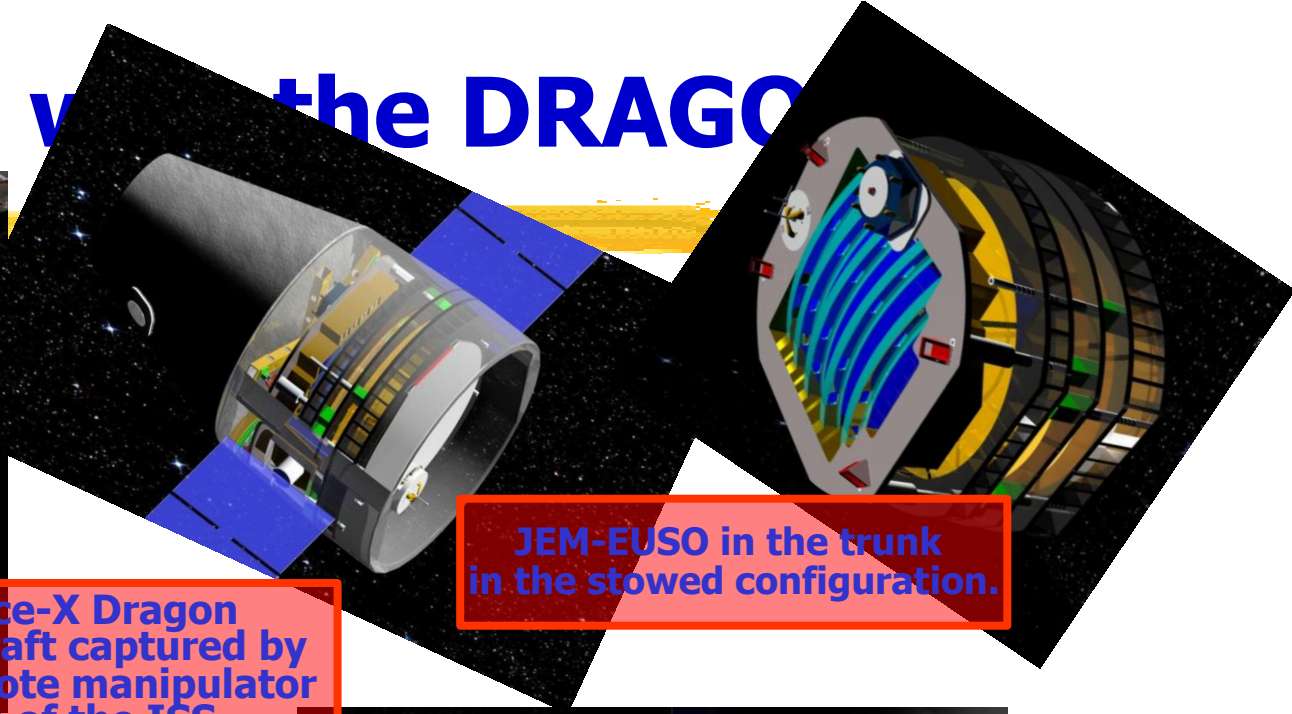


PDM integrated with FE boards

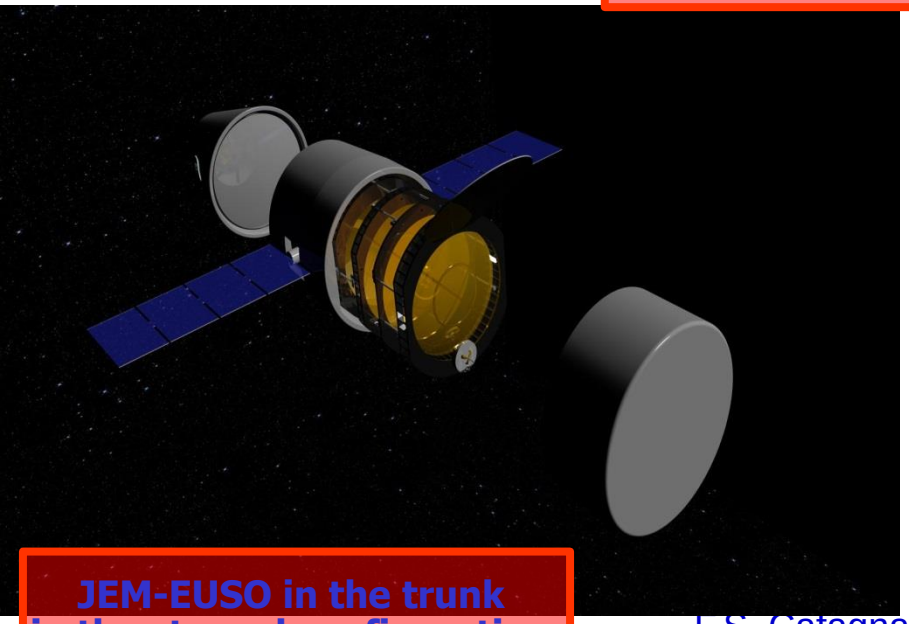
JEM-EUSO v the DRAGO



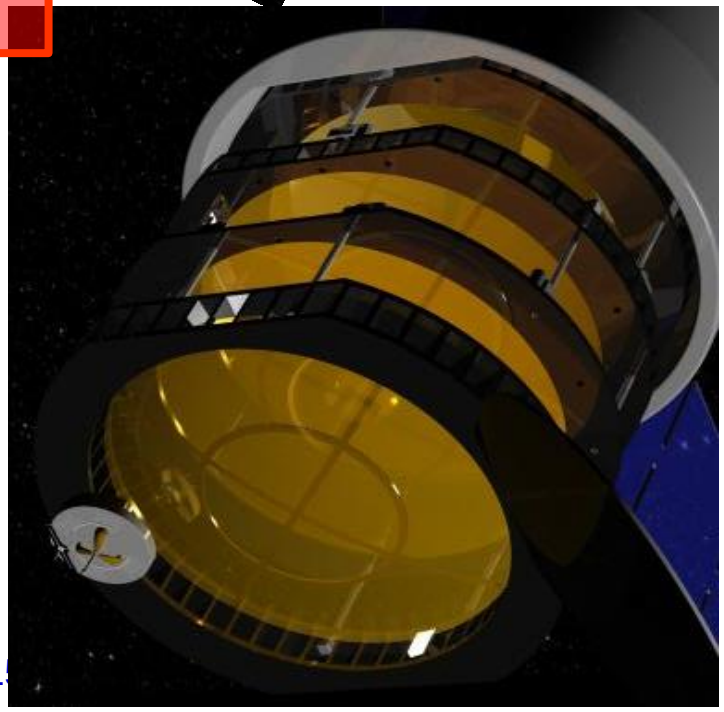
Space-X Dragon spacecraft captured by the remote manipulator arm of the ISS.



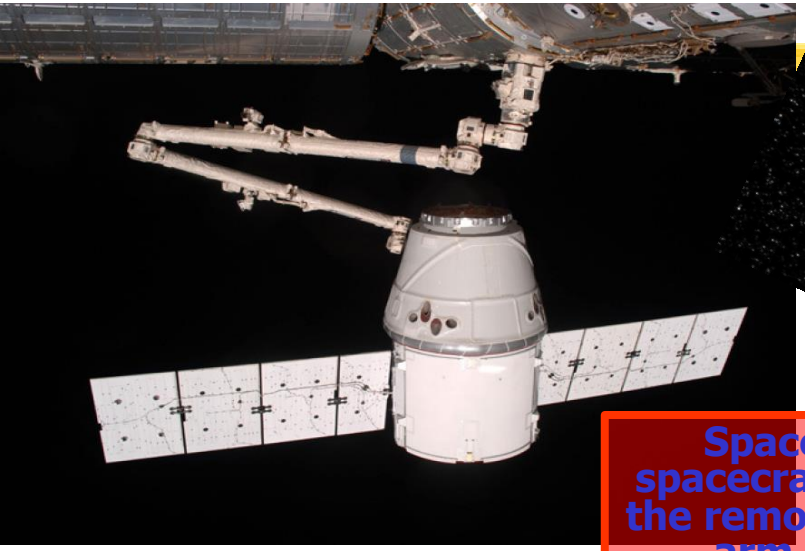
JEM-EUSO in the trunk in the stowed configuration.



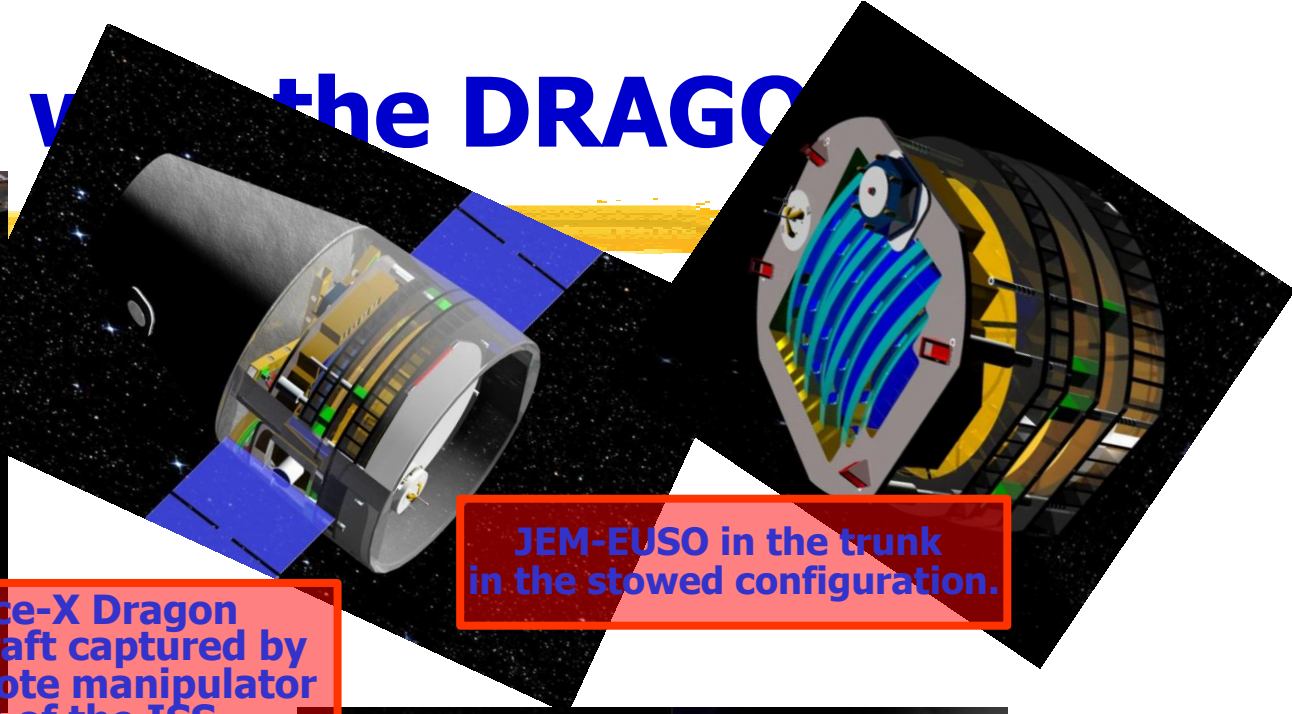
JEM-EUSO in the trunk in the stowed configuration.



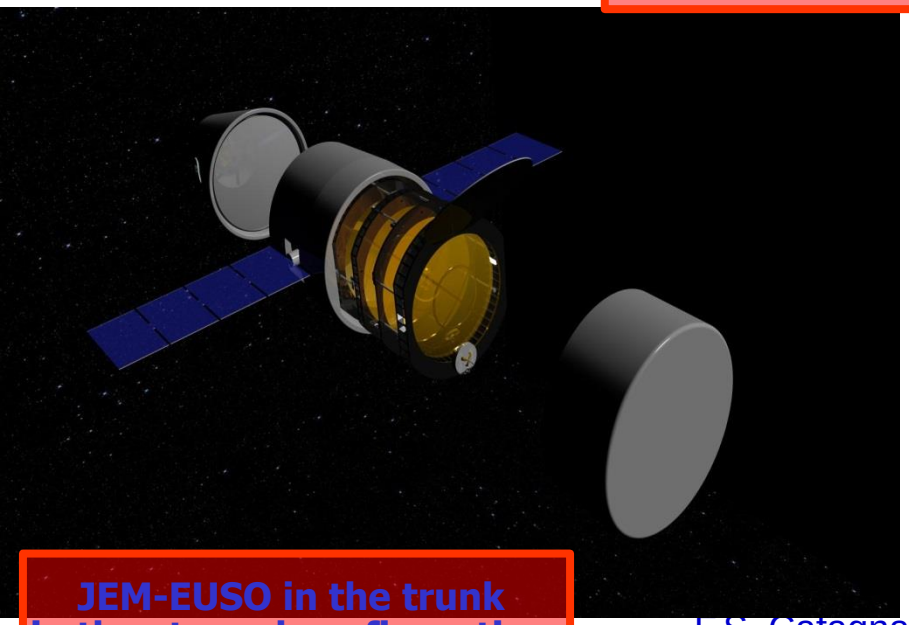
JEM-EUSO w[illegible]the DRAGO



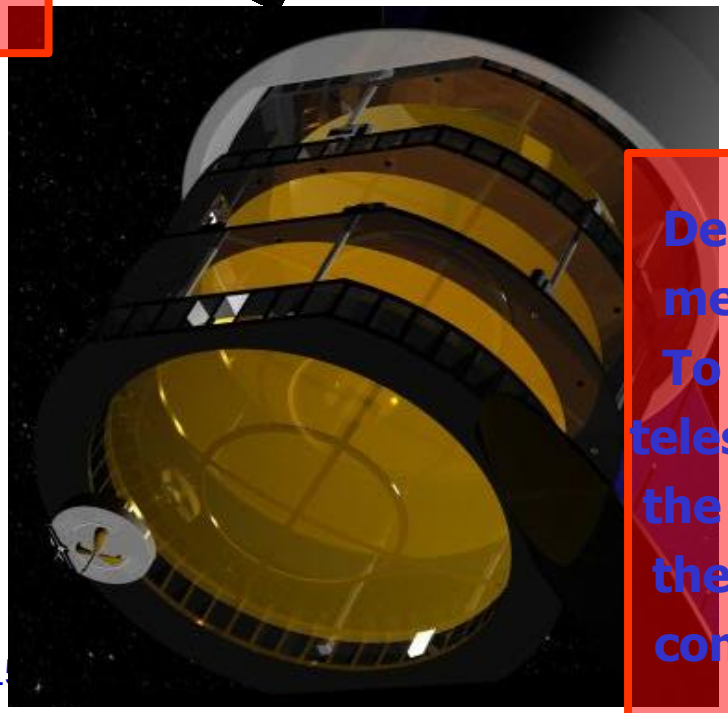
Space-X Dragon spacecraft captured by the remote manipulator arm of the ISS.



JEM-EUSO in the trunk in the stowed configuration.



JEM-EUSO in the trunk in the stowed configuration.



Deployment mechanism: To bring the telescope from the stowed to the deployed configuration

JEM-EUSO facts & figures

JEM-EUSO detector	
Field of View	±30°
Monitored Area	>1.3x10^{5}km^2
Telescope aperture	≥2.5m
Operational wavelength	290−430 nm
Resolution in angle	0.075°
Focal plane area	4.5 m^2
Pixel size	<3 mm
Number of pixels	≈3x10^5
Pixel size area on ground	≈560 m
Time resolution	2.5 μs
Dead Time	<3%
Detection efficiency	≥20%
Energy resolution	20 %(E>50 EeV) 5-10% (E> 300 EeV)
X_{max} resolution	100 g/cm^2 (E>50 EeV) 50 g/cm^2 (E>300 EeV)

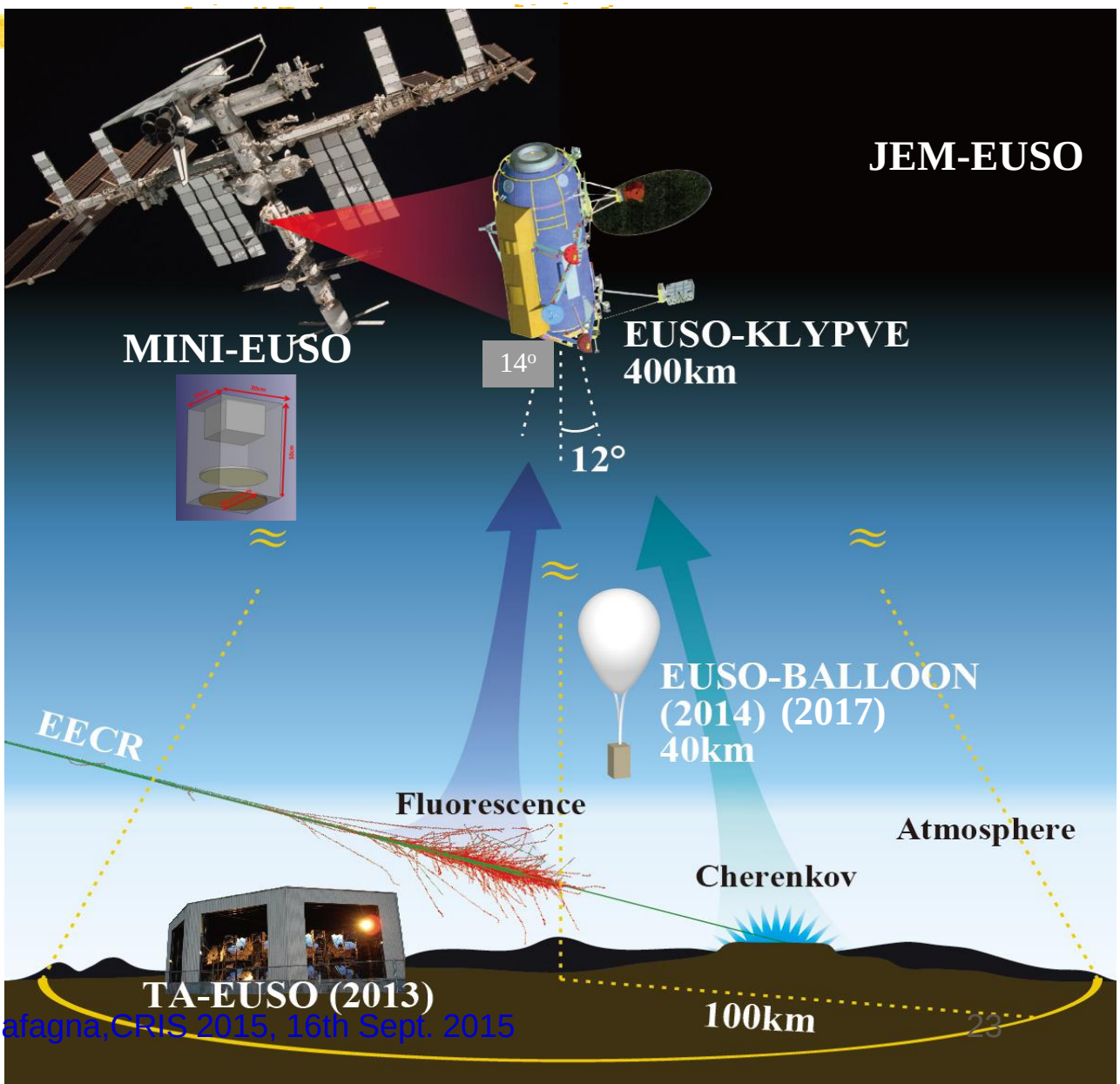
JEM-EUSO mission	
Launch date	2020
Mission lifetime	>4 years
Rocket	FALCON-9
Transport Veichle	DRAGON
Accommodation on JEM	EF#2
Mass	1100 kg
Power	926 W (352 non op.)
Data rate	285 kbps (and on board storage)
Orbit	400 km
Inclination of the orbit	51.6°
Operational Temp.	-10° to 50°

JEM-EUSO facts & figures

JEM-EUSO detector	
Field of View	±30°
Monitored Area	>1.3x10^{5}km^2
Telescope aperture	≥2.5m
Operational wavelength	290−430 nm
Resolution in angle	0.075°
Focal plane area	4.5 m^2
Pixel size	<3 mm
Number of pixels	≈3x10^5
Pixel size area on ground	≈560 m
Time resolution	2.5 μs
Dead Time	<3%
Detection efficiency	≥20%
Energy resolution	20 %(E>50 EeV) 5-10% (E> 300 EeV)
X_{max} resolution	100 g/cm^2 (E>50 EeV) 50 g/cm^2 (E>300 EeV)

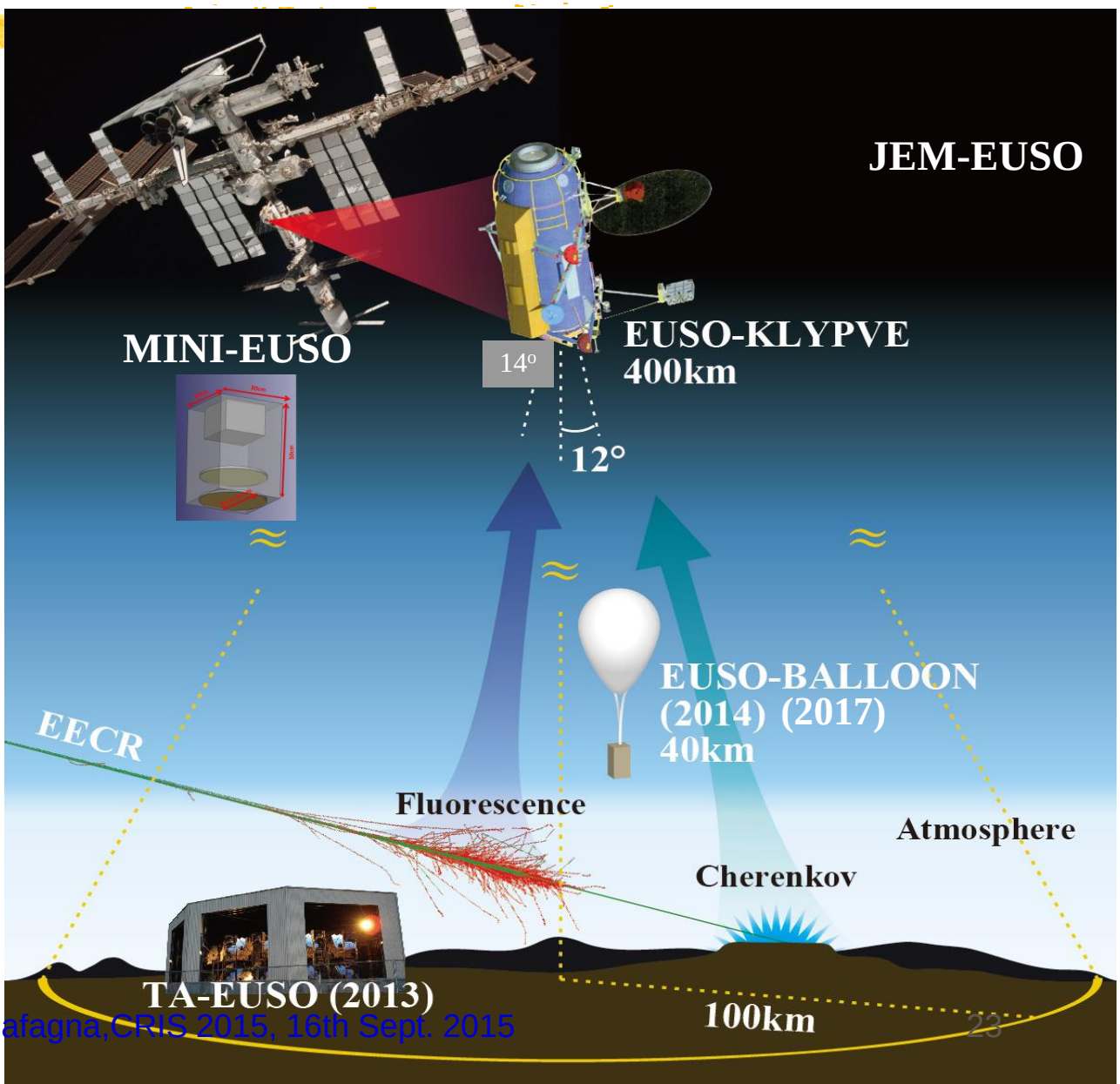
JEM-EUSO mission	
Launch date	2020
Mission lifetime	>4 years
Rocket	FALCON-9
Transport Veichle	DRAGON
Accommodation on JEM	EF#2
Mass	1100 kg
Power	926 W (352 non op.)
Data rate	285 kbps (and on board storage)
Orbit	400 km
Inclination of the orbit	51.6°
Operational Temp.	-10° to 50°

The EUSO program



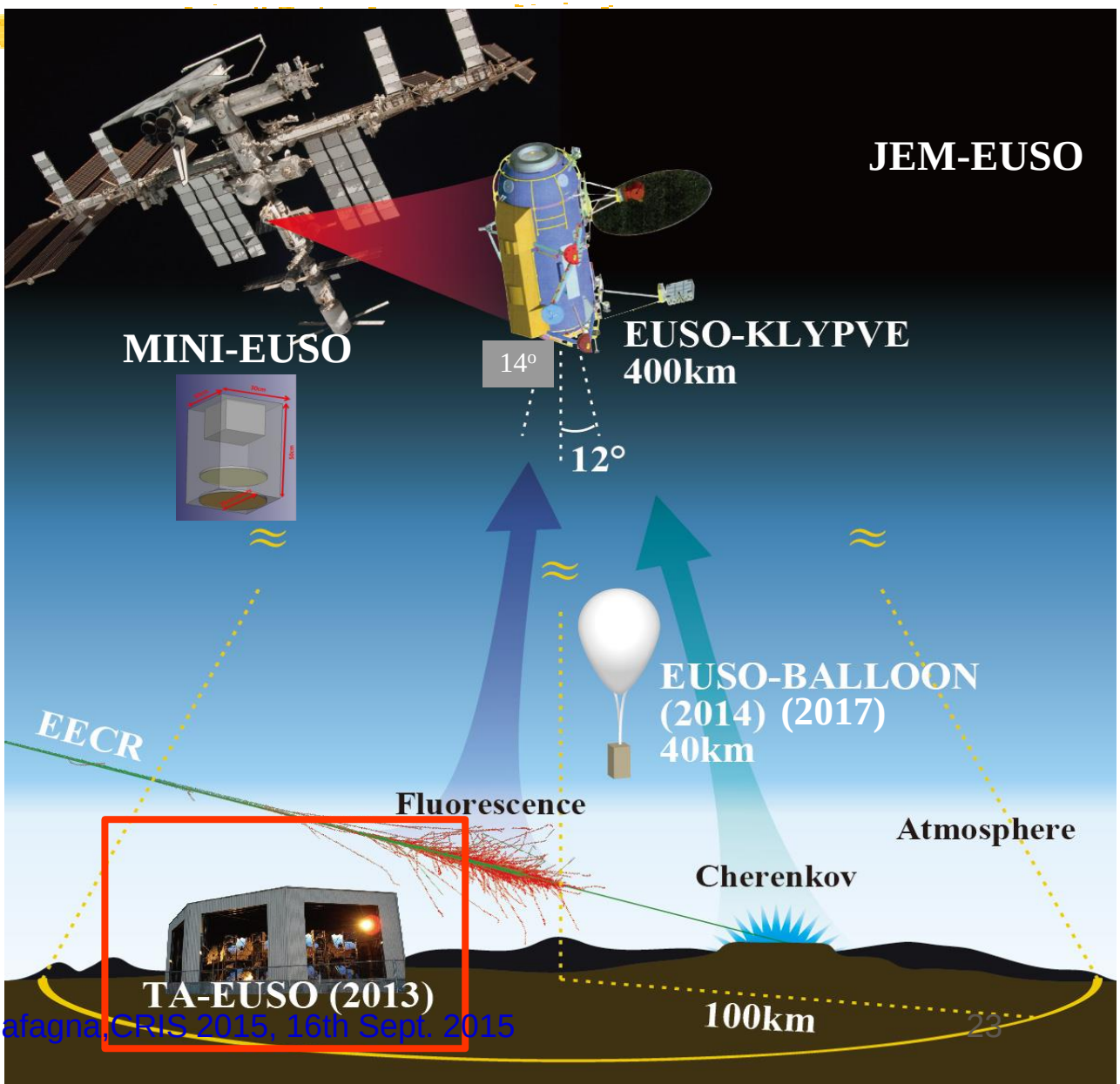
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;



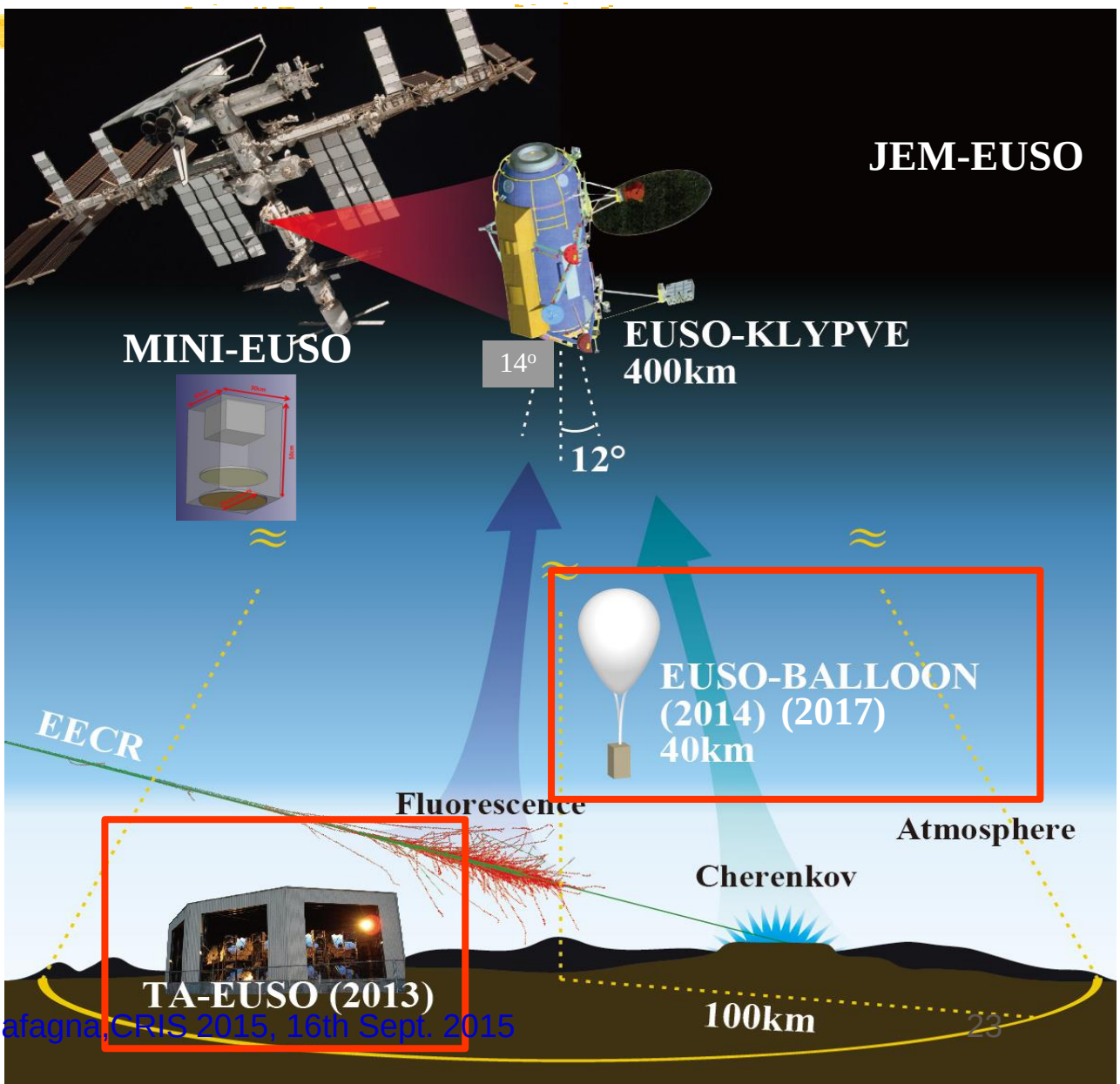
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;



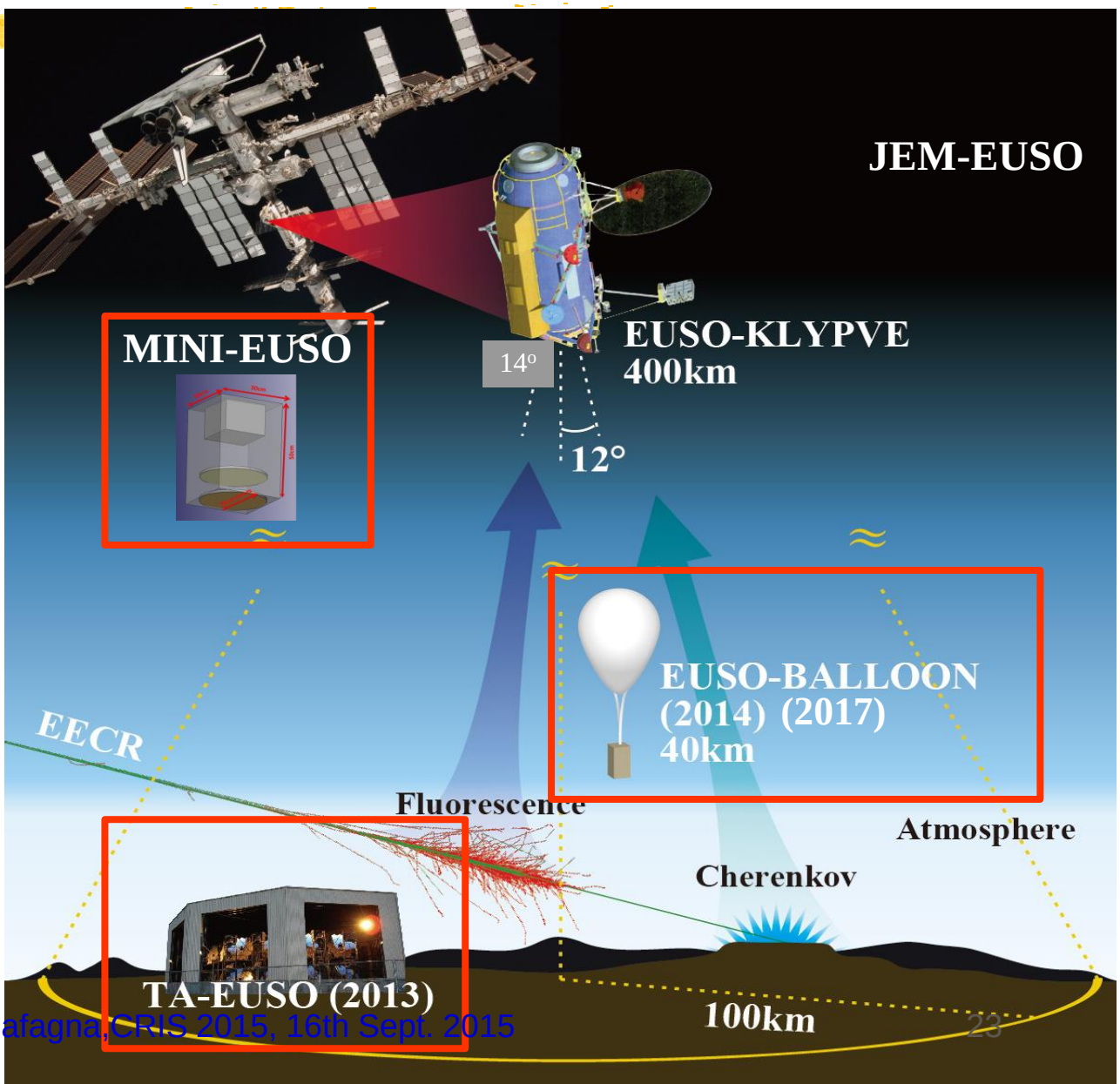
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;



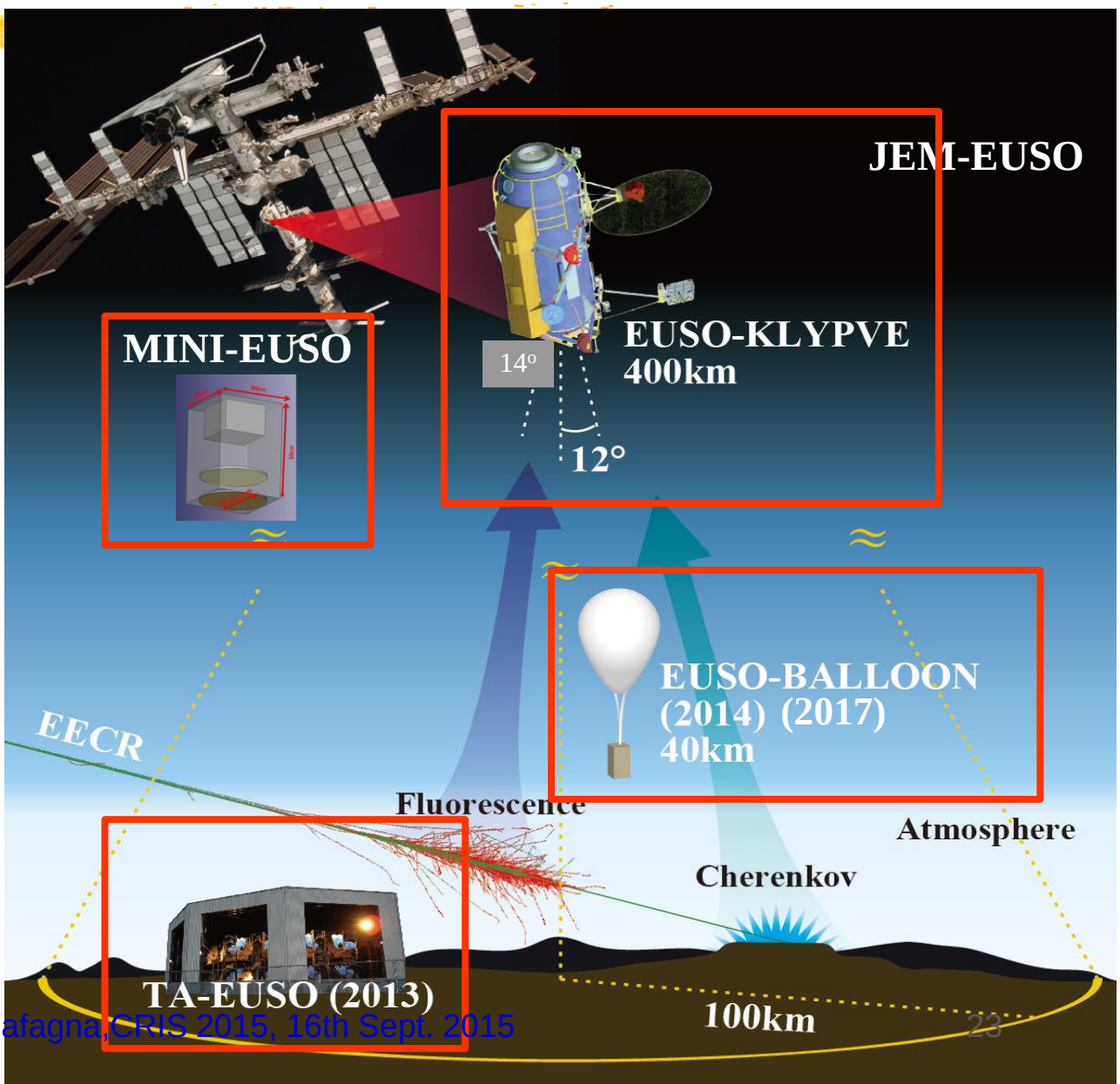
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;



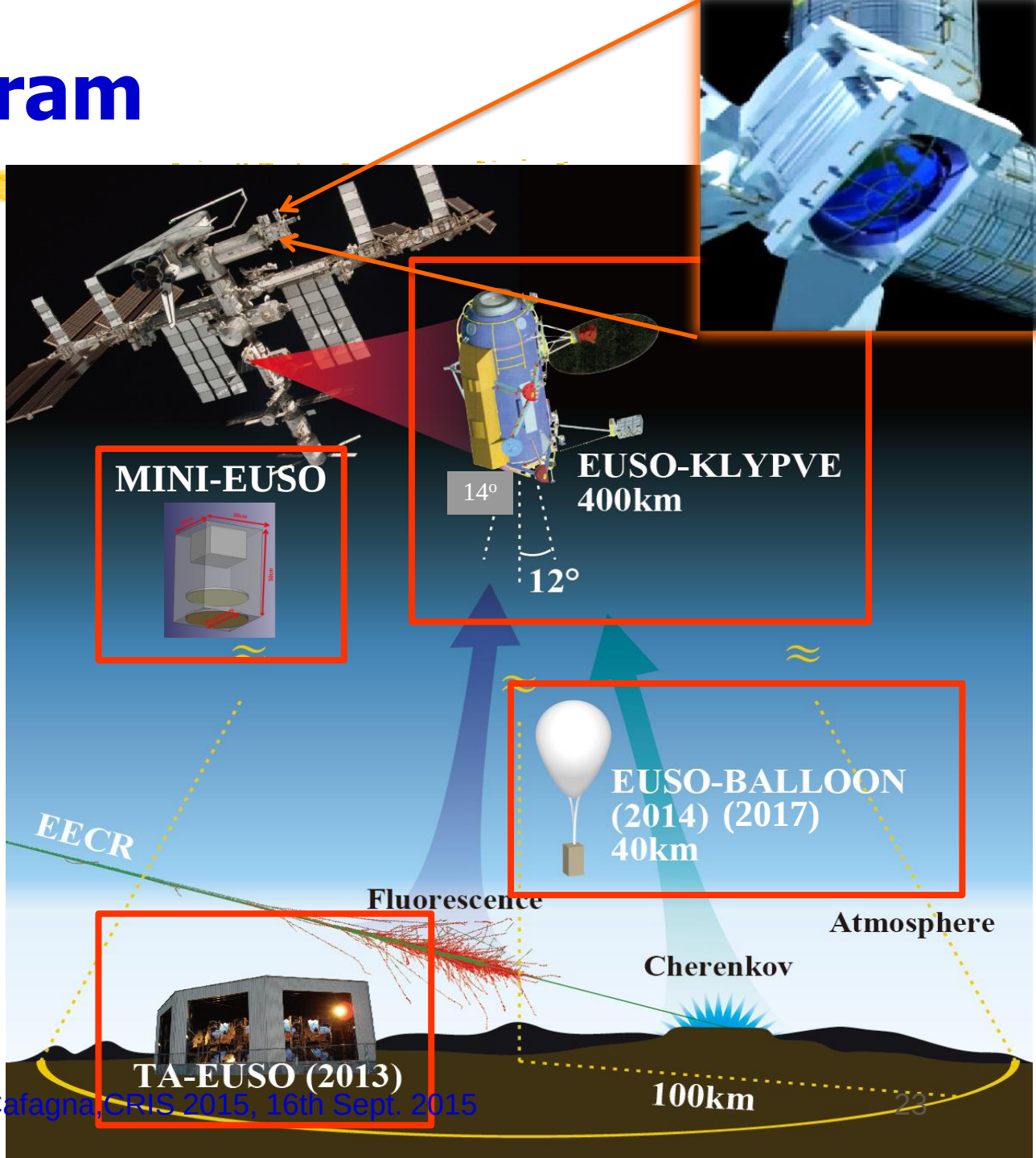
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;
- A precursor:



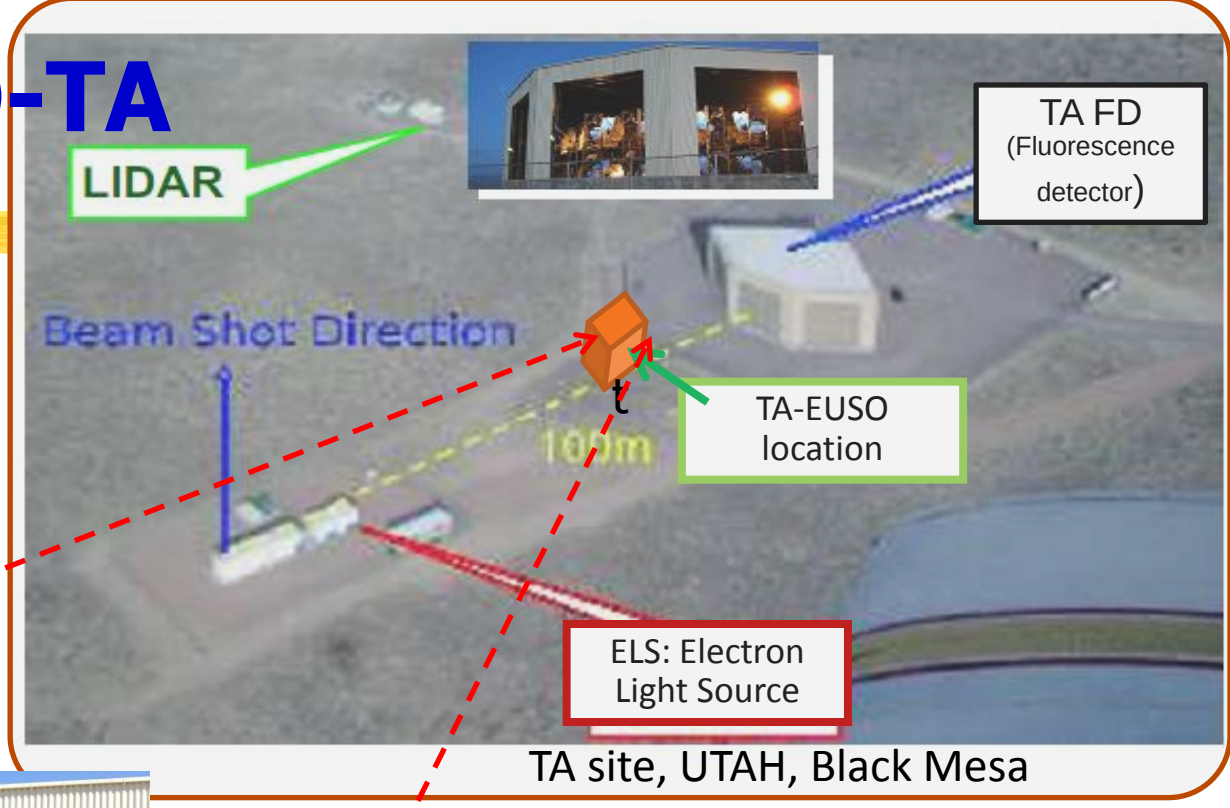
The EUSO program

- Three pathfinders:
  - **TA-EUSO**: a PDM and lenses at Telescope Array site, End 2014;
  - **EUSO-BALLOON & SPB**: a balloon borne PDM and lenses. 1st balloon flight from Timmins, Canada (French Space Agency CNES), done on Aug 2014. Long duration from NZ in 2017;
  - **MINI-EUSO**: a PDM and small lenses on the ISS, 2017;
- A precursor:



Pathfinder: EUSO-TA

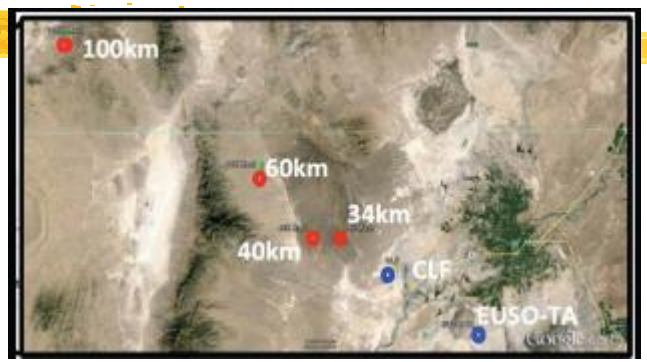
- Calibration and test of a PDM prototype of the JEM-EUSO telescope at Telescope Array site.
- Lenses already installed in 2013.
- 2015: data acquisition campaign started.
- 2016: continue data acquisition.



TA site, UTAH, Black Mesa

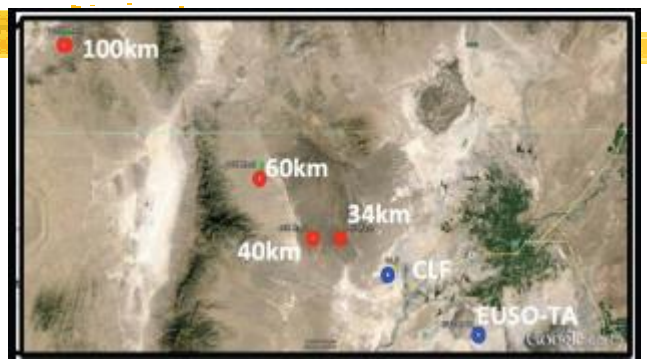
PATHFINDER: EUSO-TA

- About 150 inclined shots of the Colorado School of Mines laser has been used at 34, 40, 60 and 100km.

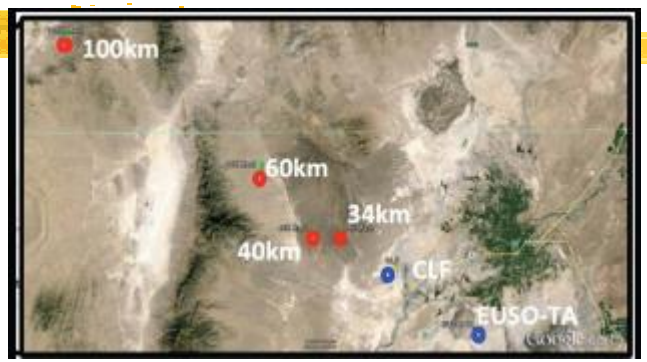


PATHFINDER: EUSO-TA

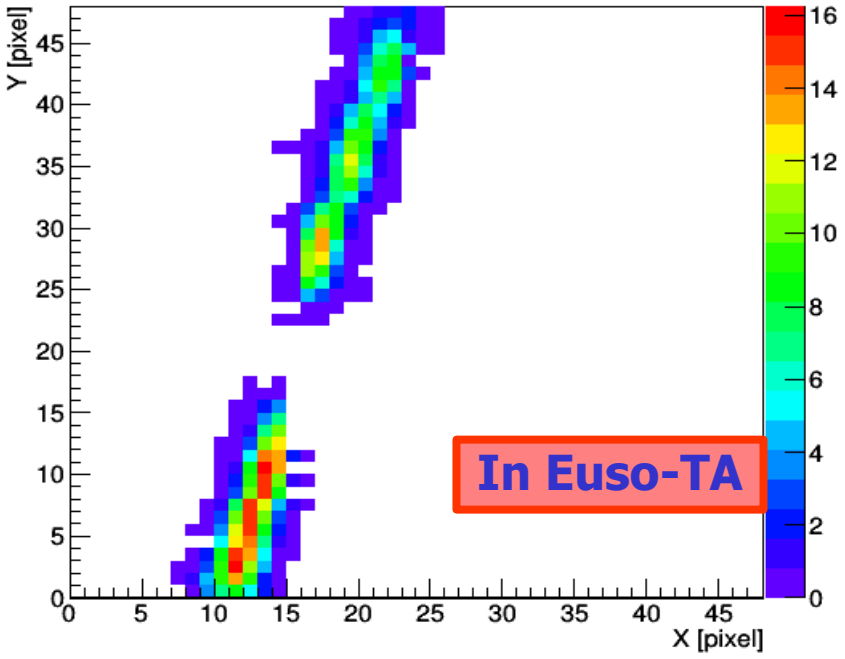
- About 150 inclined shots of the Colorado School of Mines laser has been used at 34, 40, 60 and 100km.
- Tracks are seen up to 100km.



PATHFINDER: EUSO-TA

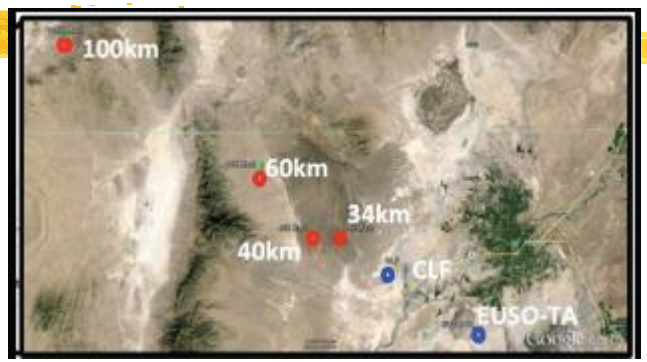


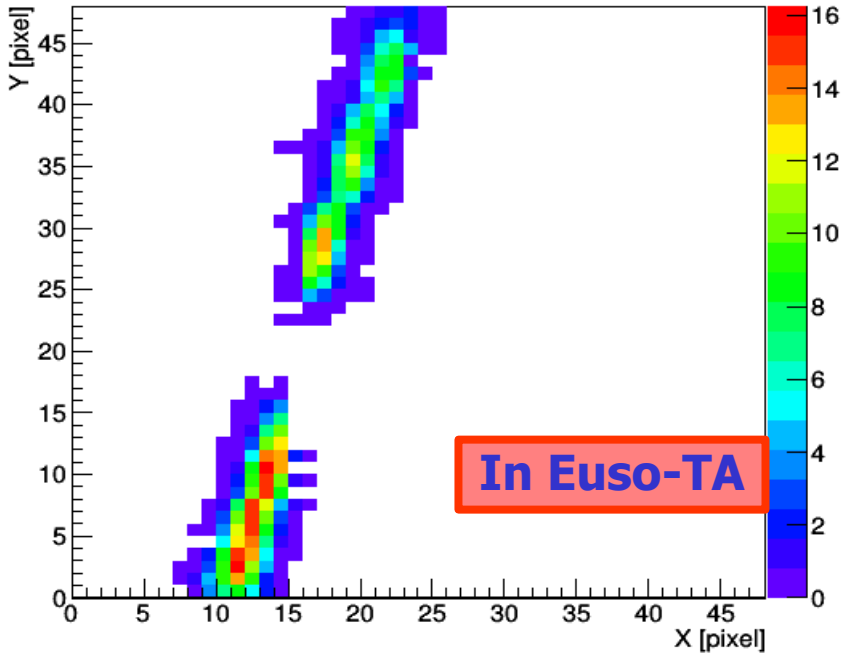
- About 150 inclined shots of the Colorado School of Mines laser has been used at 34, 40, 60 and 100km.
- Tracks are seen up to 100km.

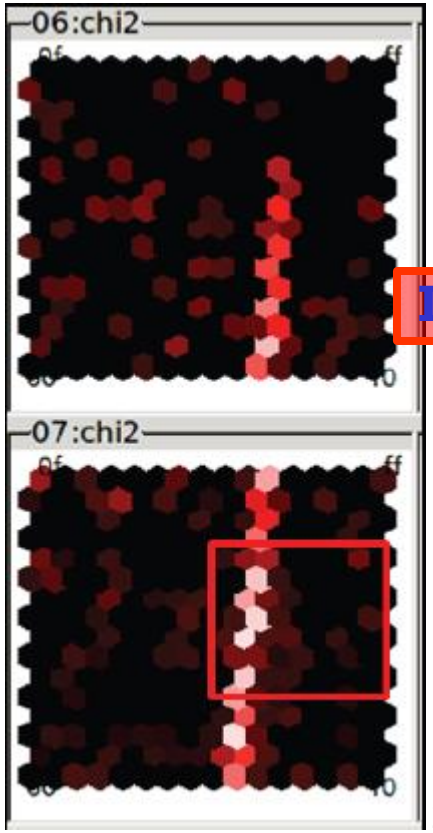


PATHFINDER: EUSO-TA

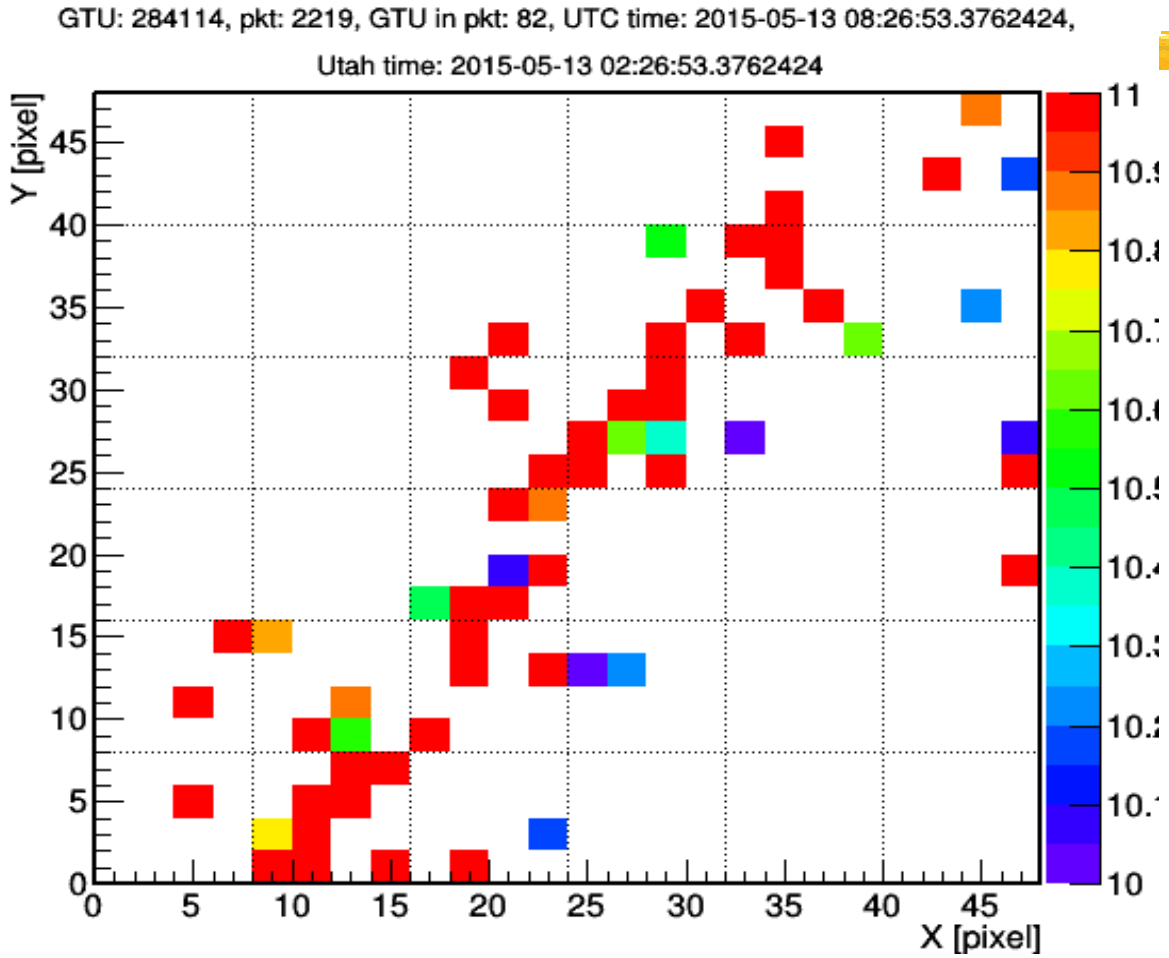
- About 150 inclined shots of the Colorado School of Mines laser has been used at 34, 40, 60 and 100km.
- Tracks are seen up to 100km.





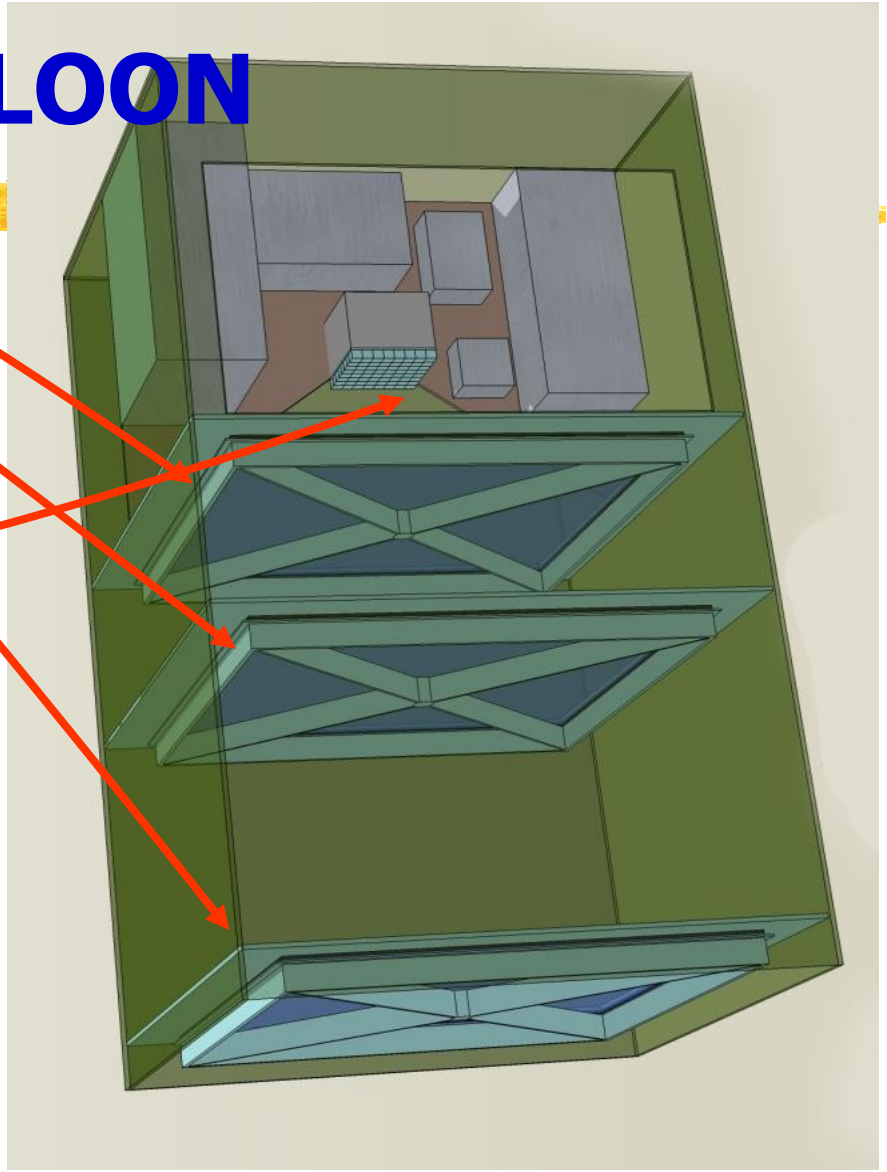


PATHFINDER: EUSO-TA



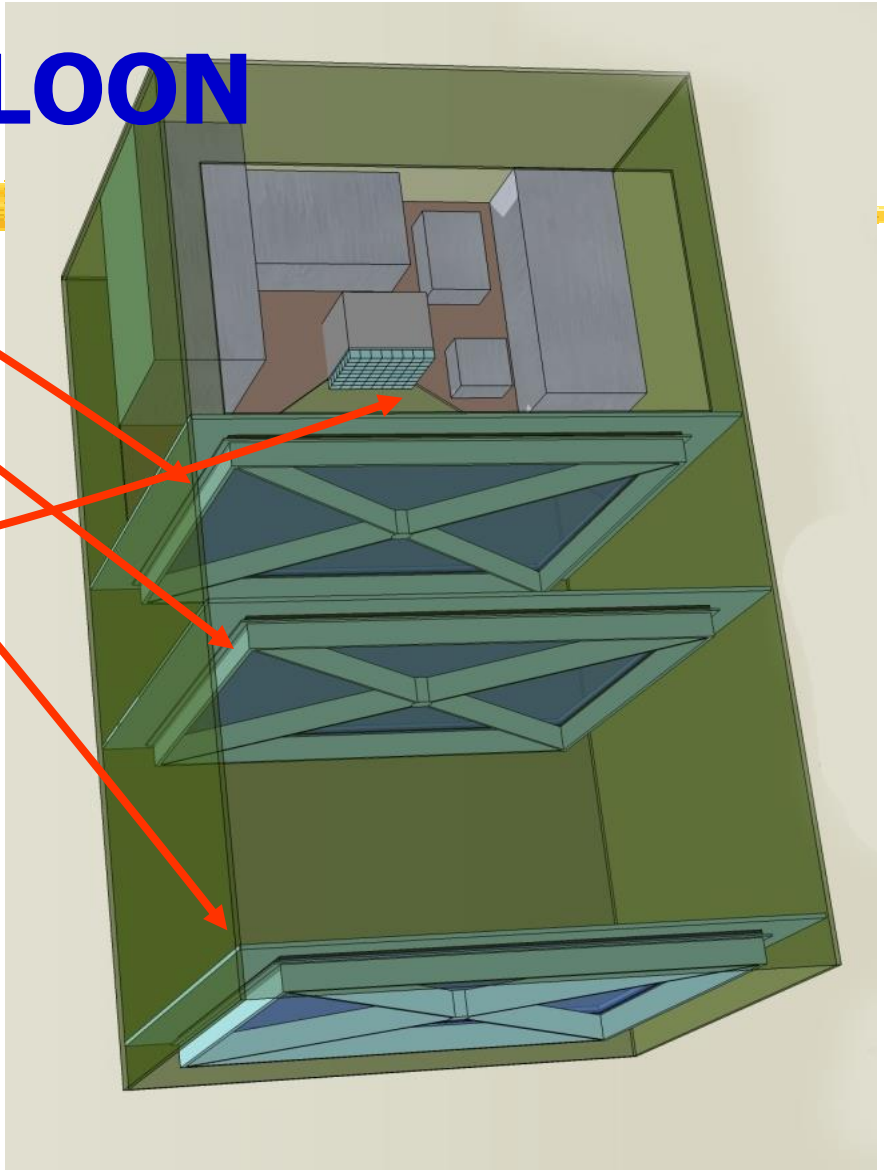
- **A real cosmic ray**: An UHECR event of low (~10^{18} eV) energy traversing at ~ 2.5 km distance from EUSO-TA visible as a track on a single GTU.

Pathfinder: EUSO-BALLOON



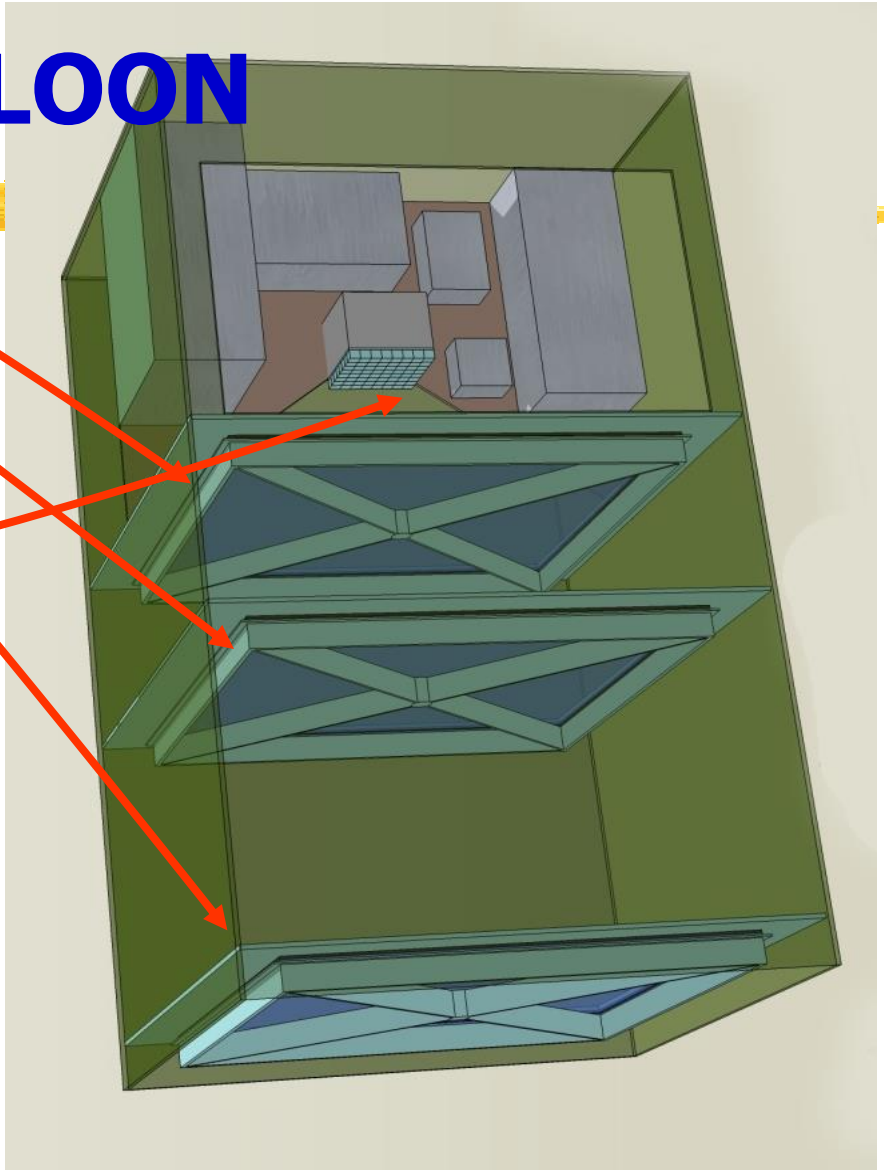
Pathfinder: EUSO-BALLOON

- Three lenses with a fully equipped PDM, CPU and slow control.



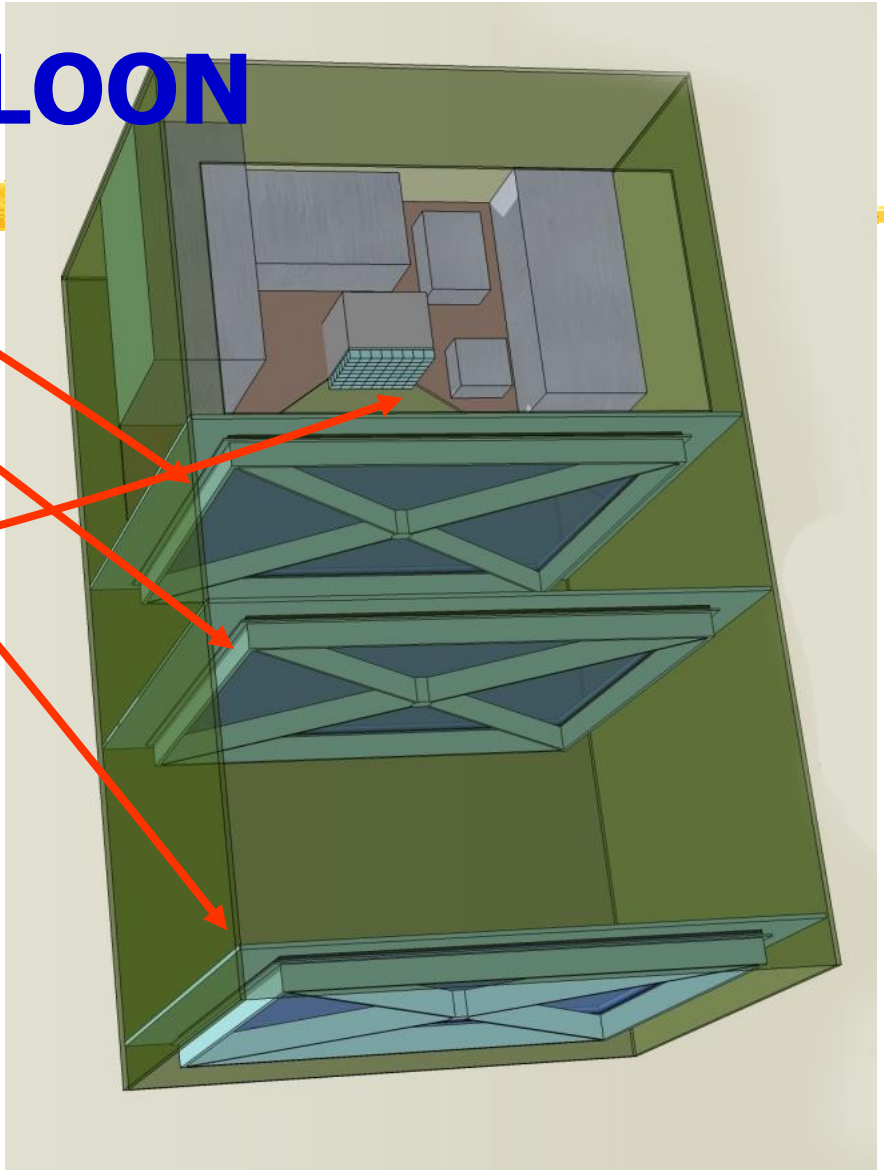
Pathfinder: EUSO-BALLOON

- Three lenses with a fully equipped PDM, CPU and slow control.
- Engineering flight and background studies.



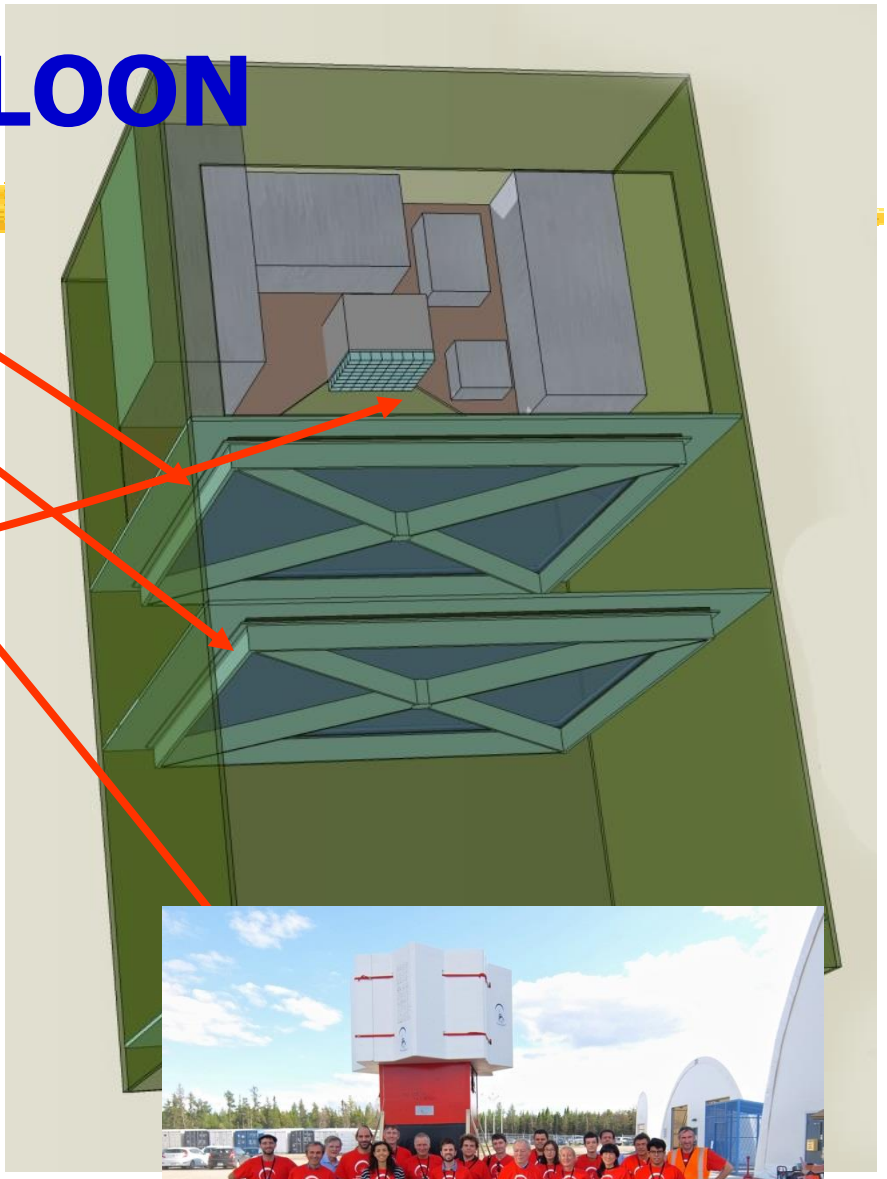
Pathfinder: EUSO-BALLOON

- Three lenses with a fully equipped PDM, CPU and slow control.
- Engineering flight and background studies.
- Using CNES facilities which is requiring qualification tests similar to the space ones.



Pathfinder: EUSO-BALLOON

- Three lenses with a fully equipped PDM, CPU and slow control.
- Engineering flight and background studies.
- Using CNES facilities which is requiring qualification tests similar to the space ones.
- Launched on the 25th of August 2014, from Timmins (CA).

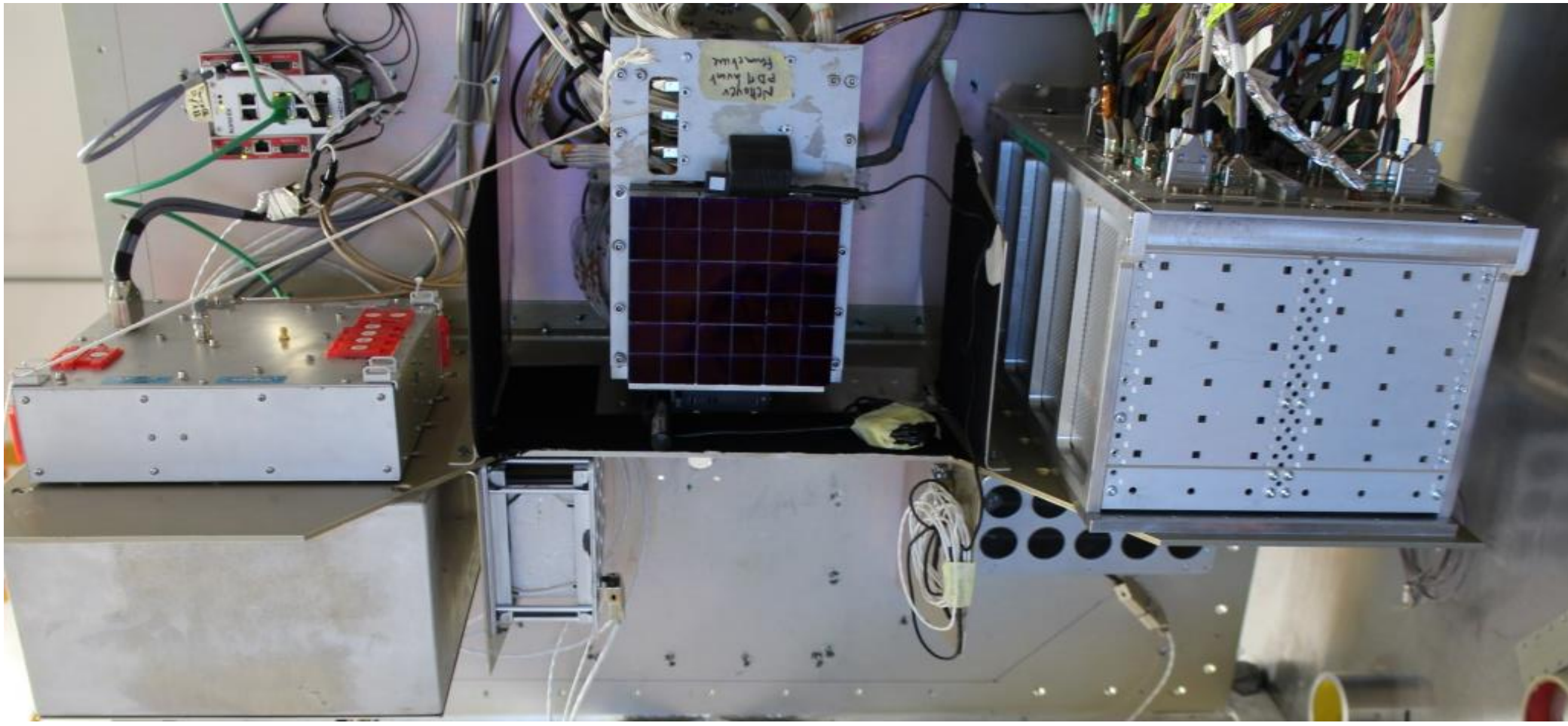


EUSO-BALLOON
Integration

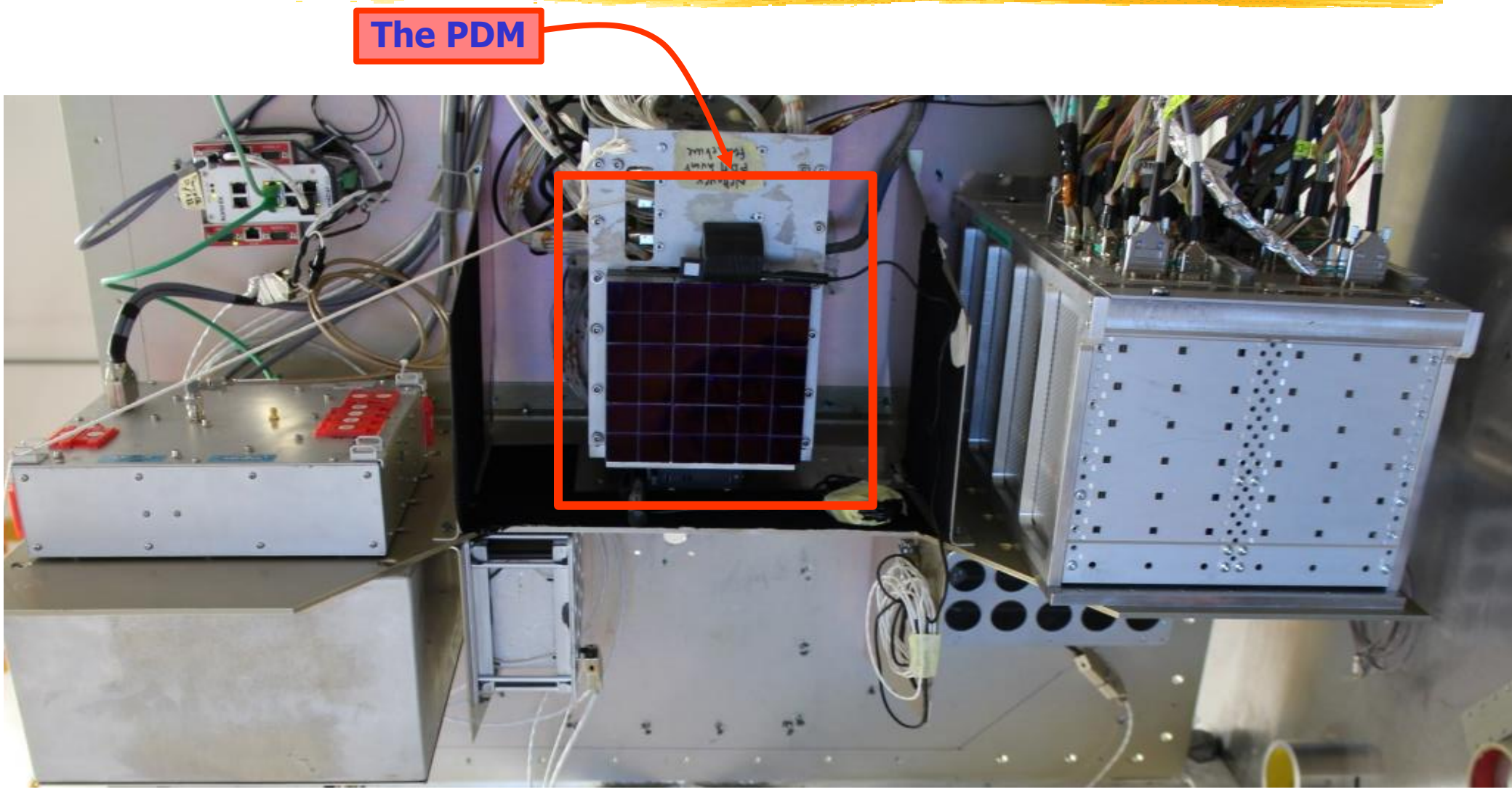
EUSO-BALLOON
Integration

The floating

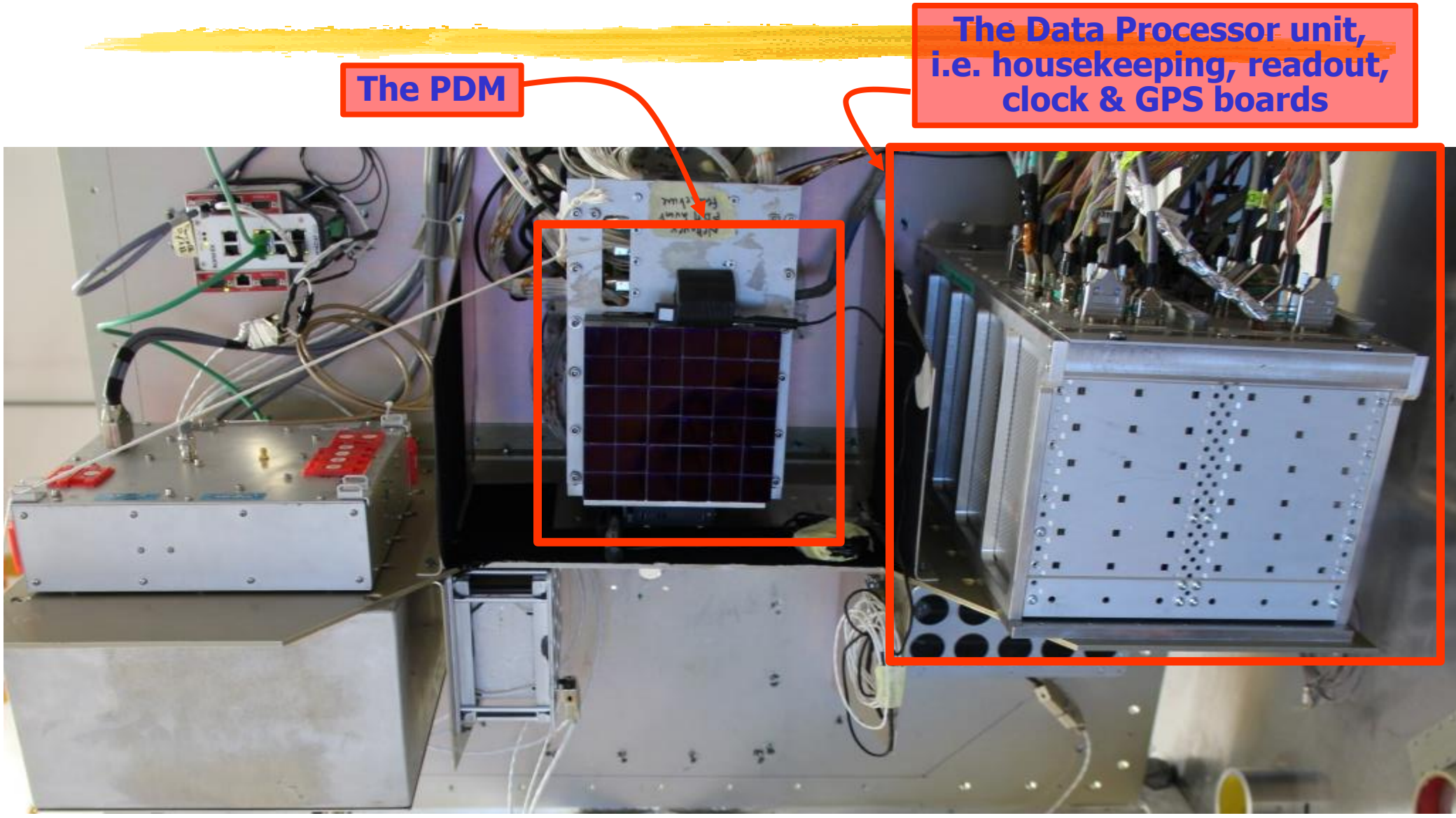
EUSO-BALLOON PDM



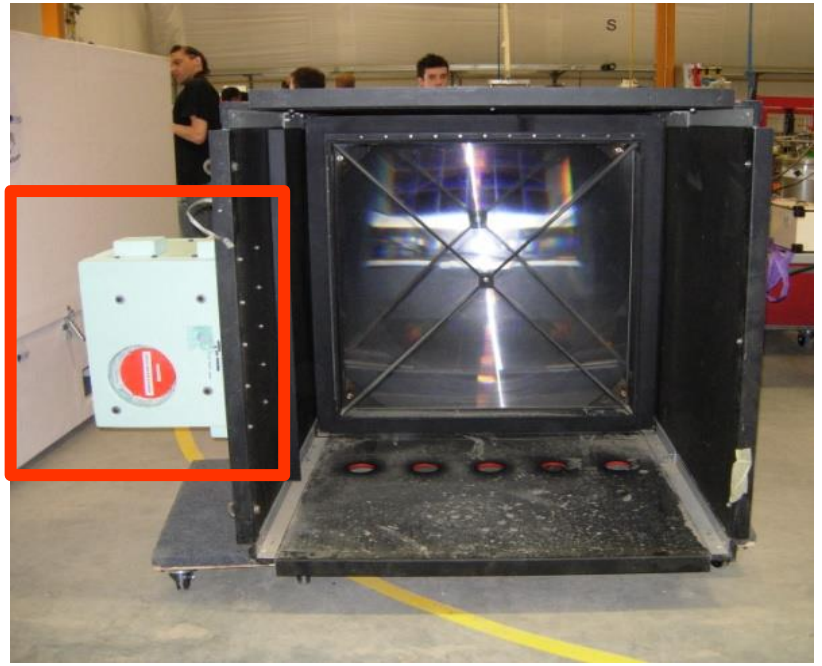
EUSO-BALLOON PDM



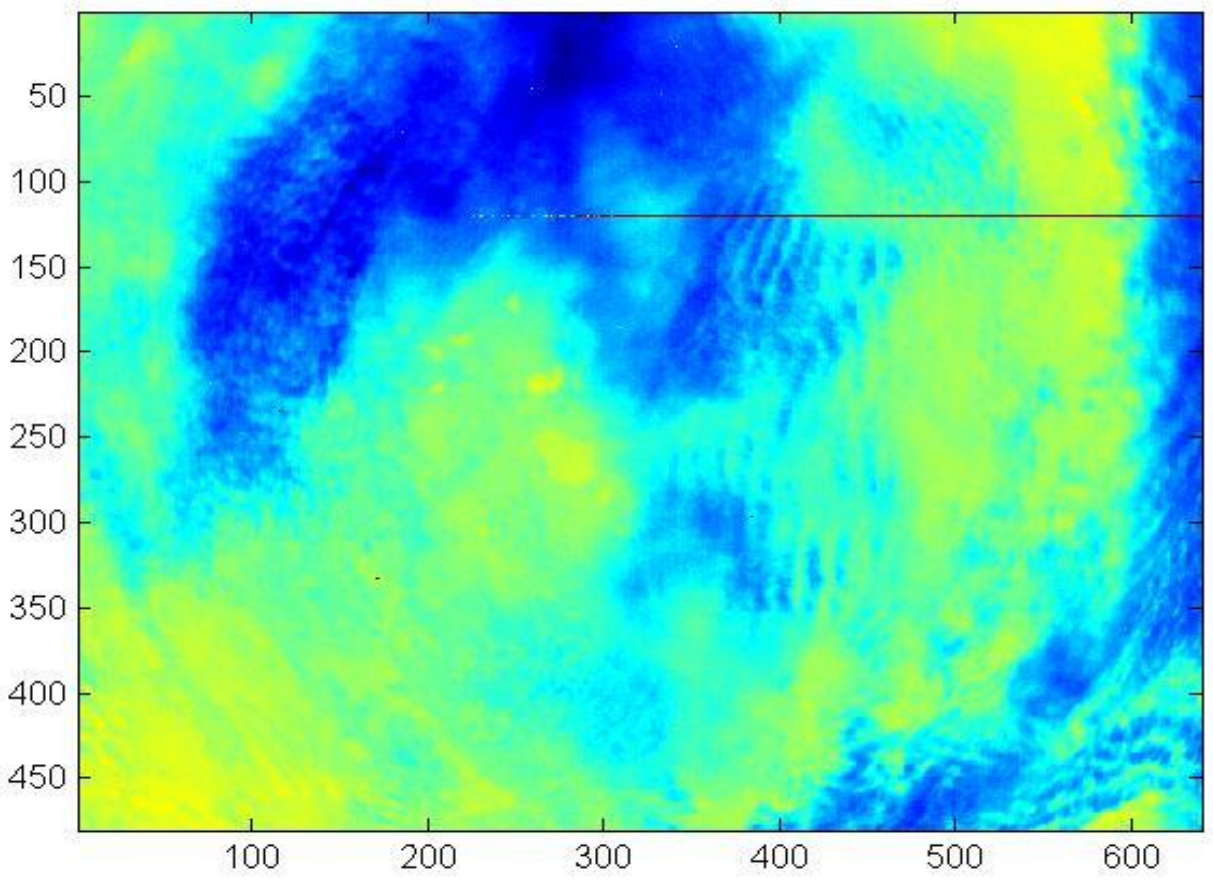
EUSO-BALLOON PDM



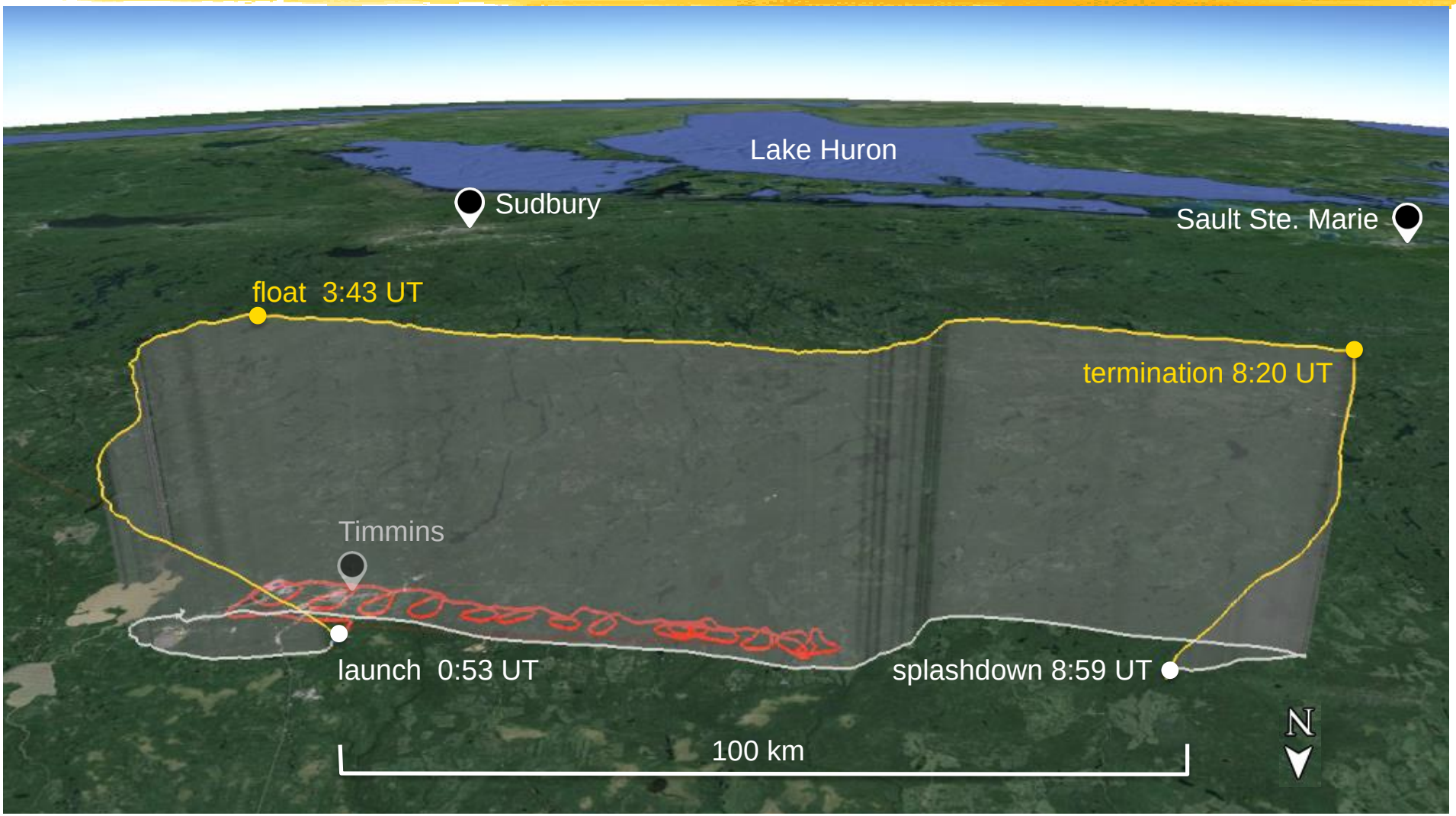
EUSO-BALLOON Infrared camera



EUSO-BALLOON Infrared camera

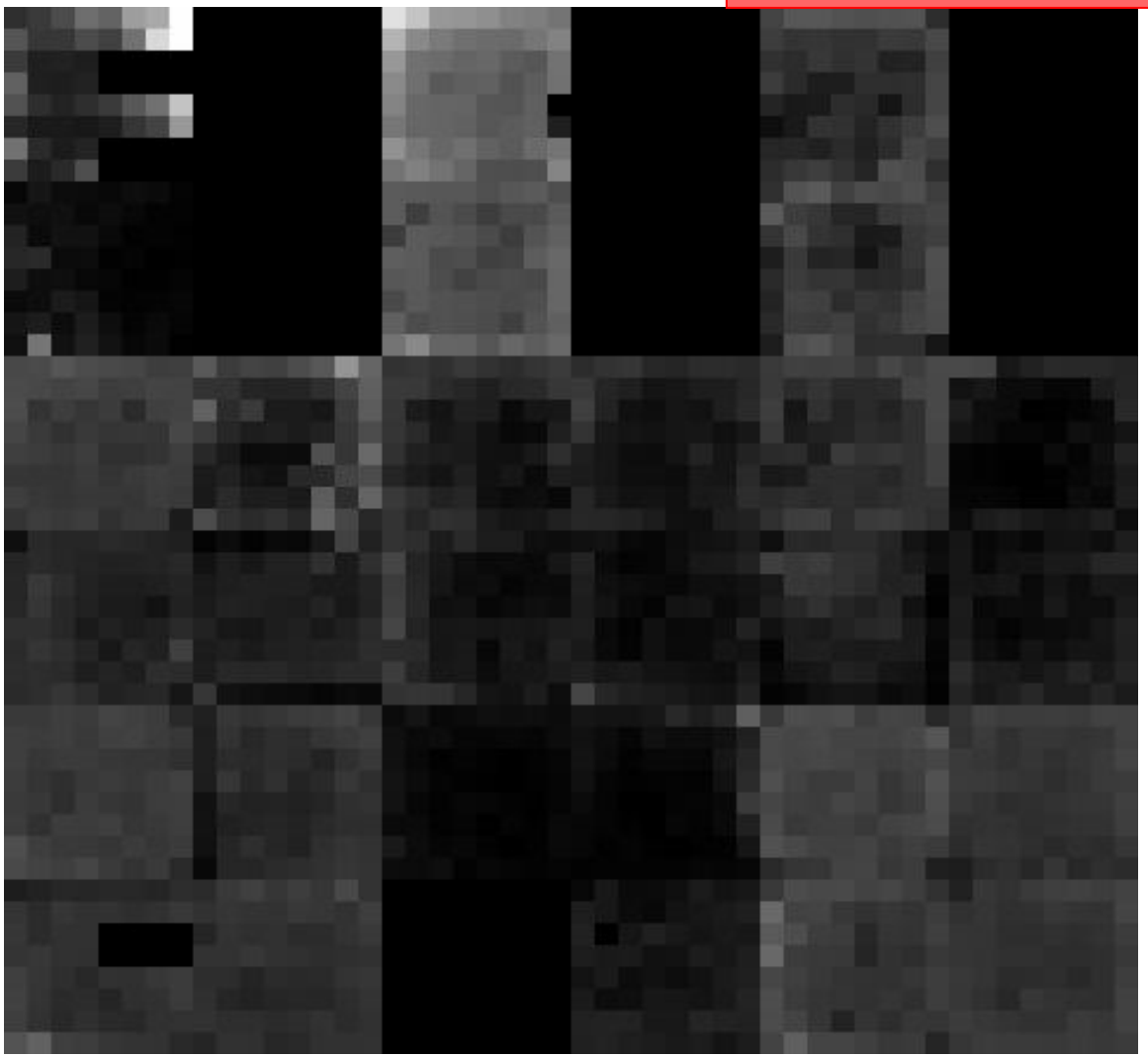


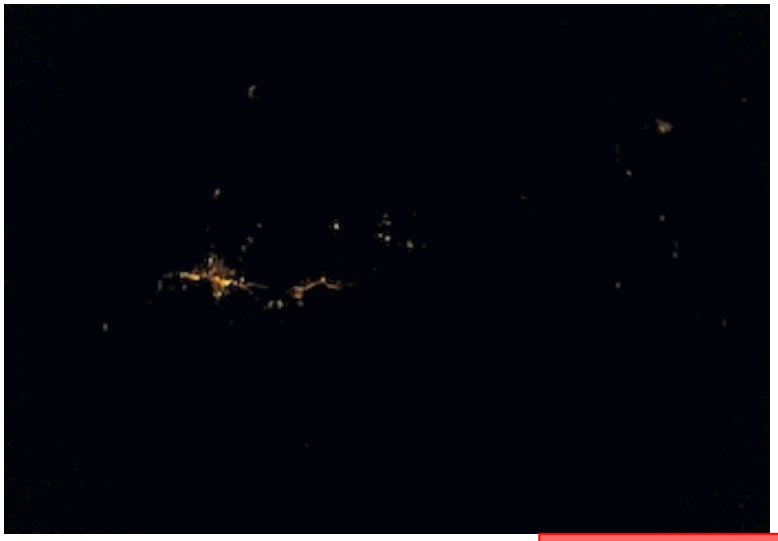
EUSO-Balloon: flight



Timmins city light as seen by the PDM

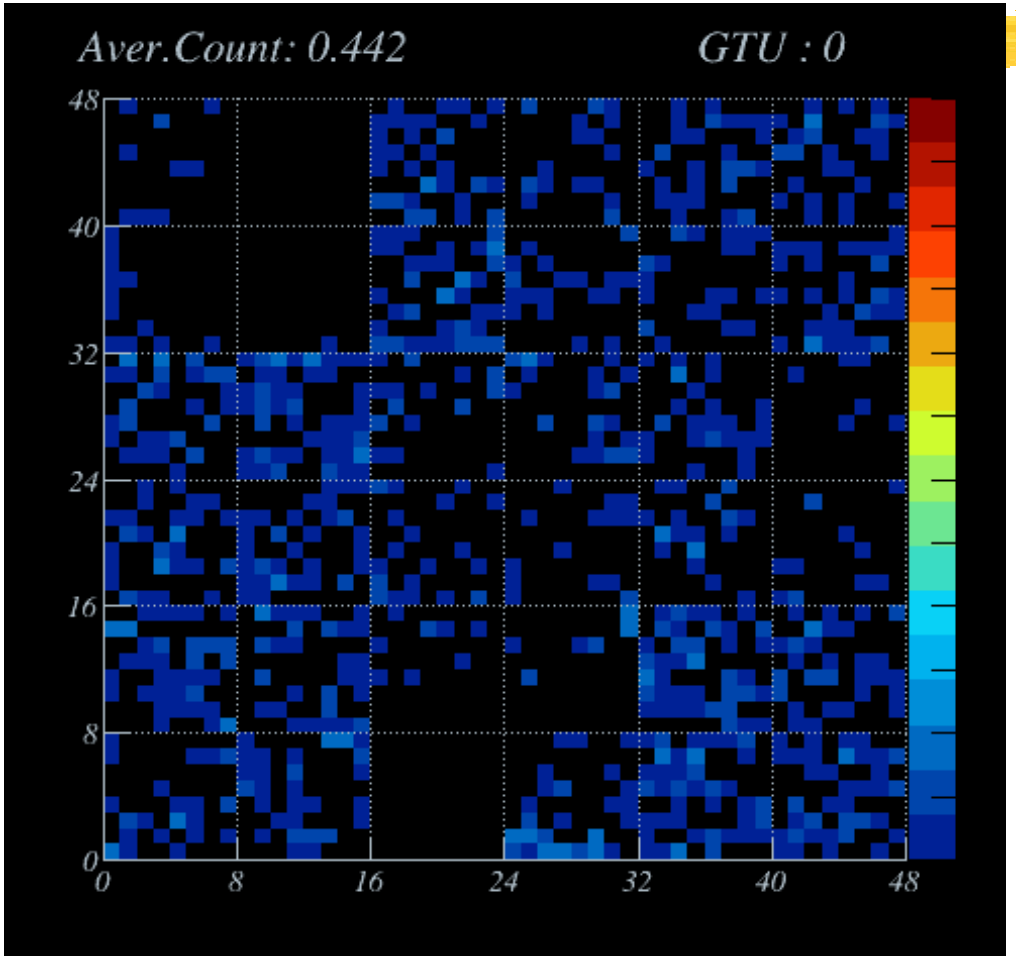
2hrs after launch (2:54~2:55 UTC) Balloon altitude 33.5km

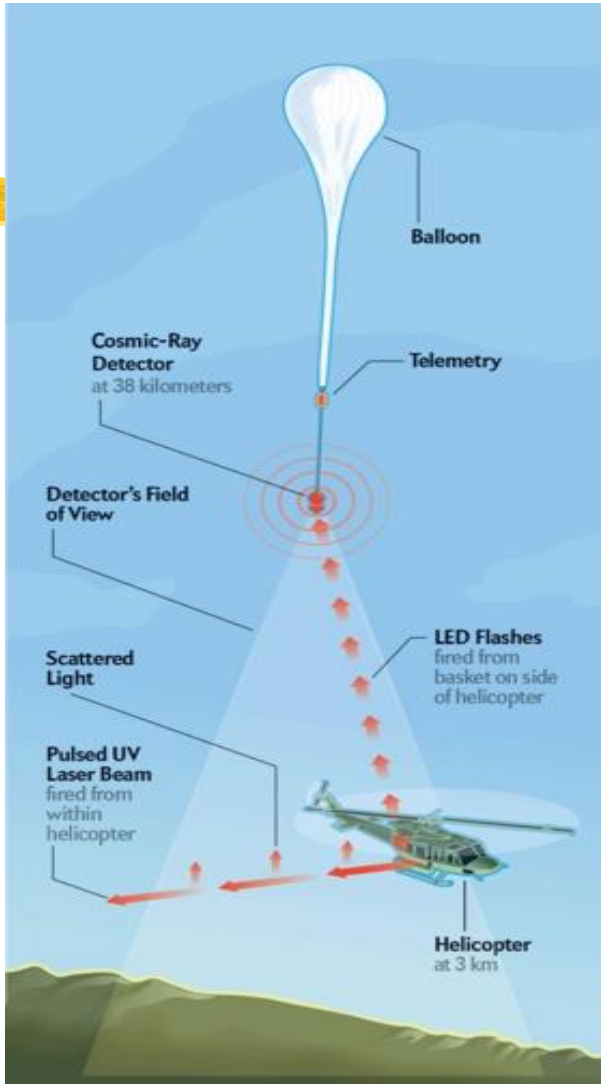




GoPro images

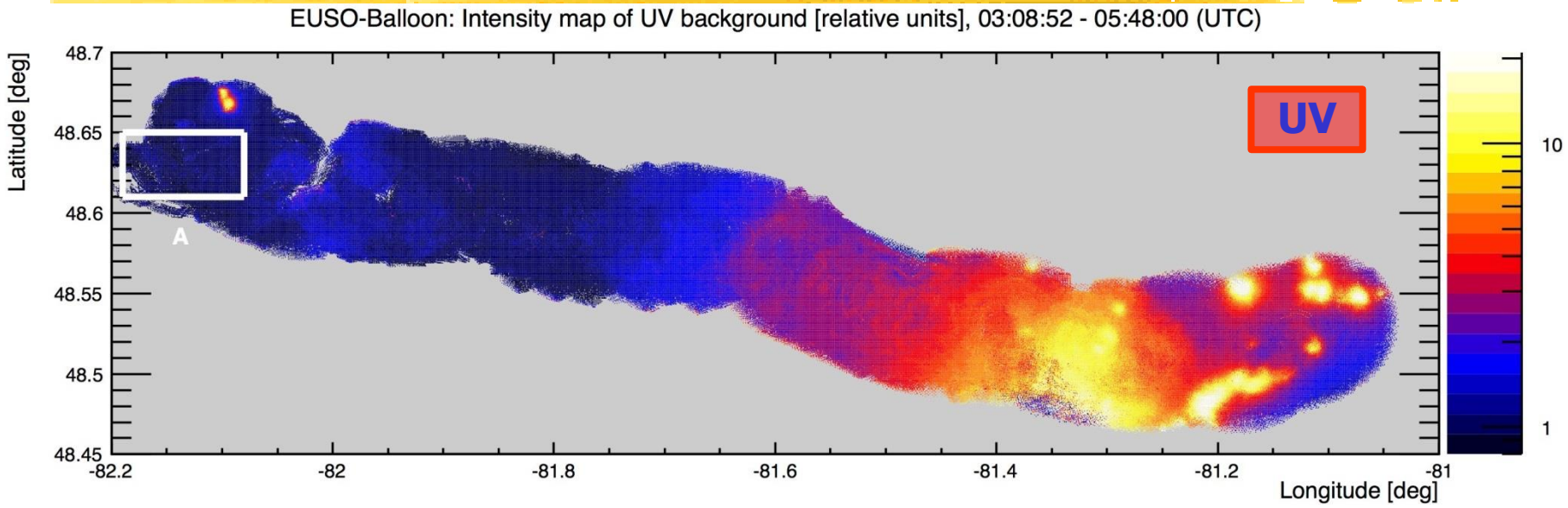
EUSO-Balloon calibration

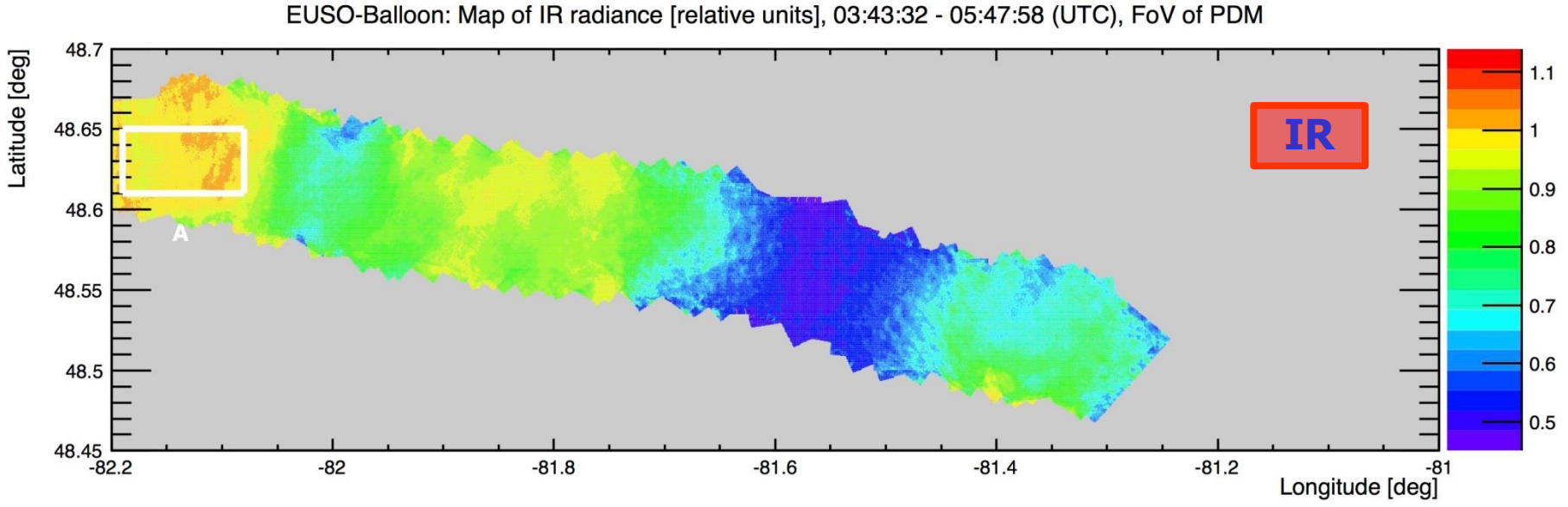




- An helicopter equipped with a Xenon Lamp (355nm) and UV LED (365nm).

EUSO-Balloon: UV & IR background





EUSO-Balloon: SPB

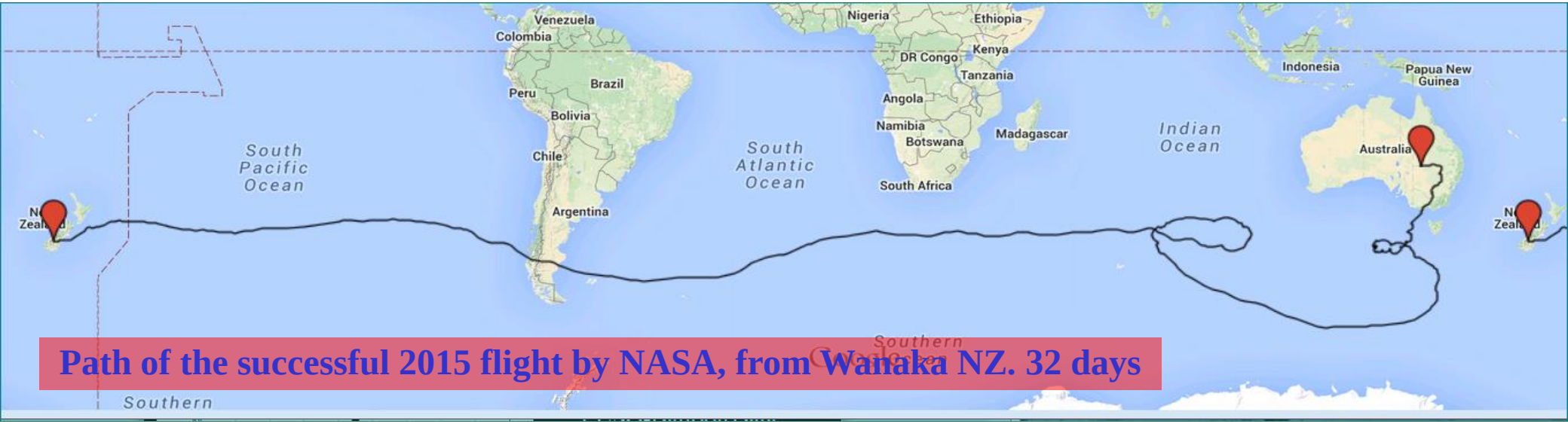
- Next Step: March 2017. Super Pressure Balloon (**SPB**). Ultra long duration flight: 20 nights.
- First observation of UHECRs from near space

Photon Threshold	Events/ hour	Events/ dark period
200	0.42	50
300	0.18	21
400	0.09	11

EUSO-Balloon: SPB

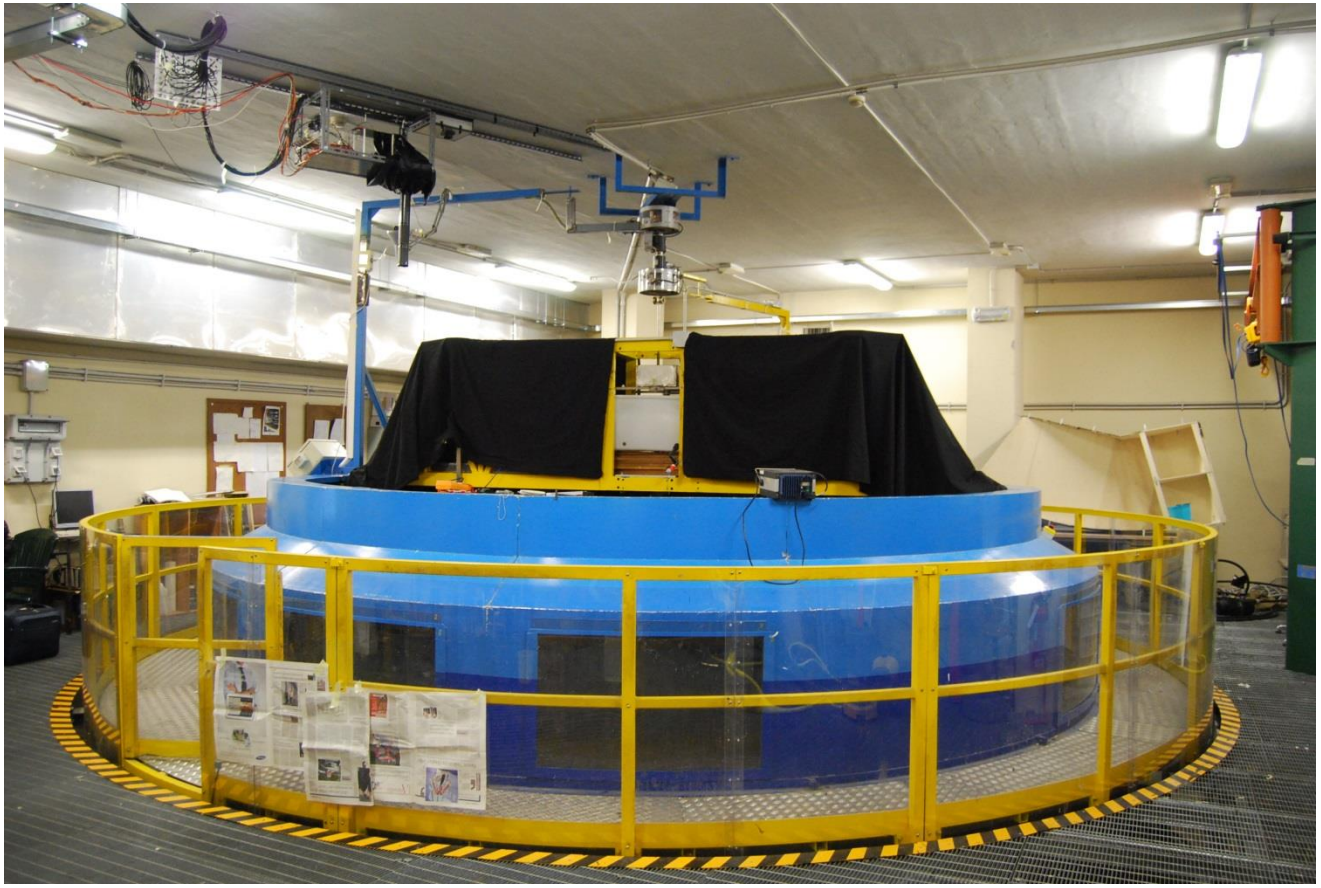
- Next Step: March 2017. Super Pressure Balloon (**SPB**). Ultra long duration flight: 20 nights.
- First observation of UHECRs from near space

Photon Threshold	Events/ hour	Events/ dark period
200	0.42	50
300	0.18	21
400	0.09	11

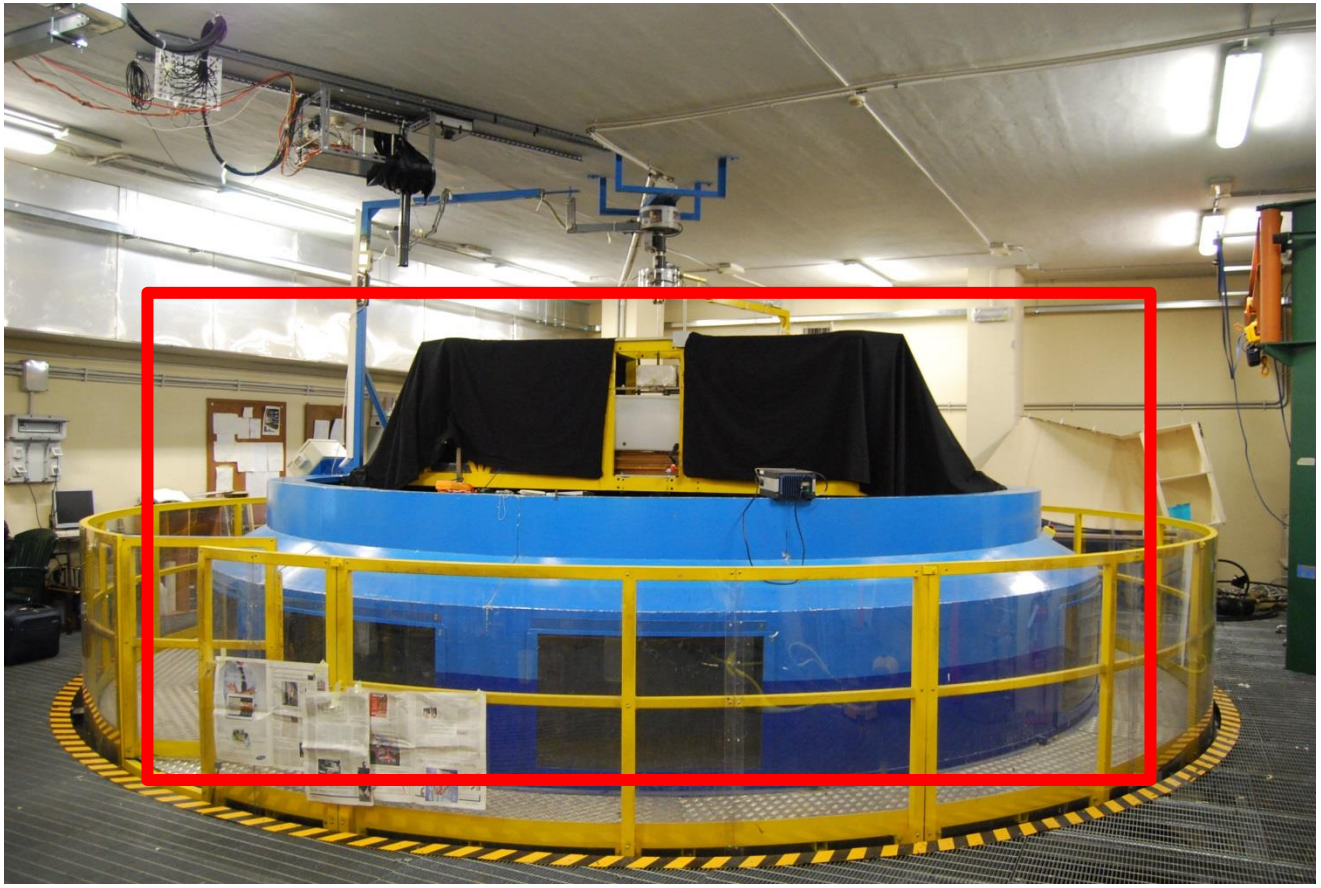


Path of the successful 2015 flight by NASA, from Wanaka NZ. 32 days

TURLAB



TURLAB

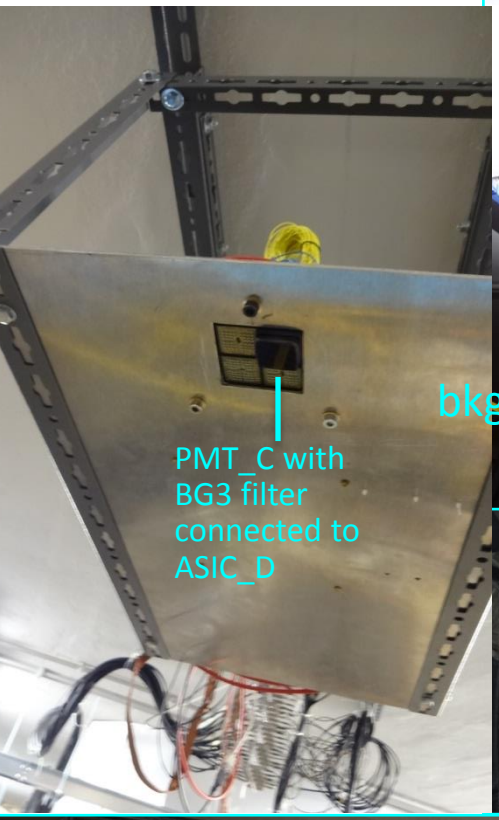


- A rotating platform used to emulate the effect of any Earth background.

TURLAB

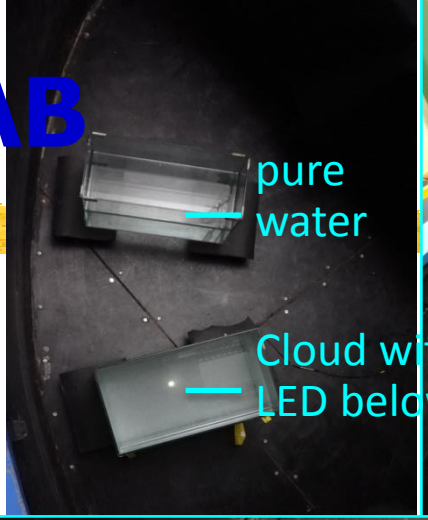
- A rotating platform used to emulate the effect of any Earth background.
- An EC and related electronics, ASIC board, DAQ, has been mounted and

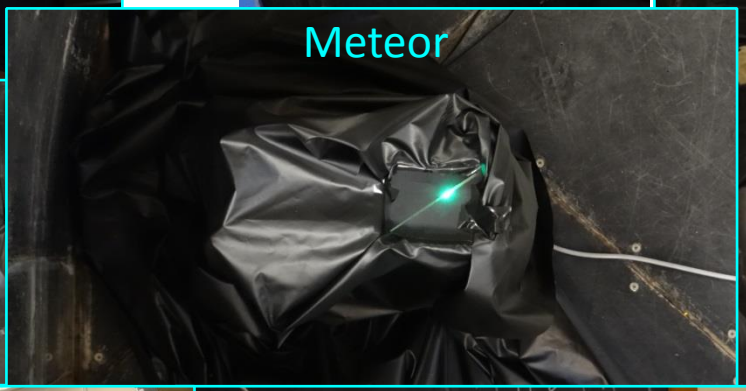
TURLAB

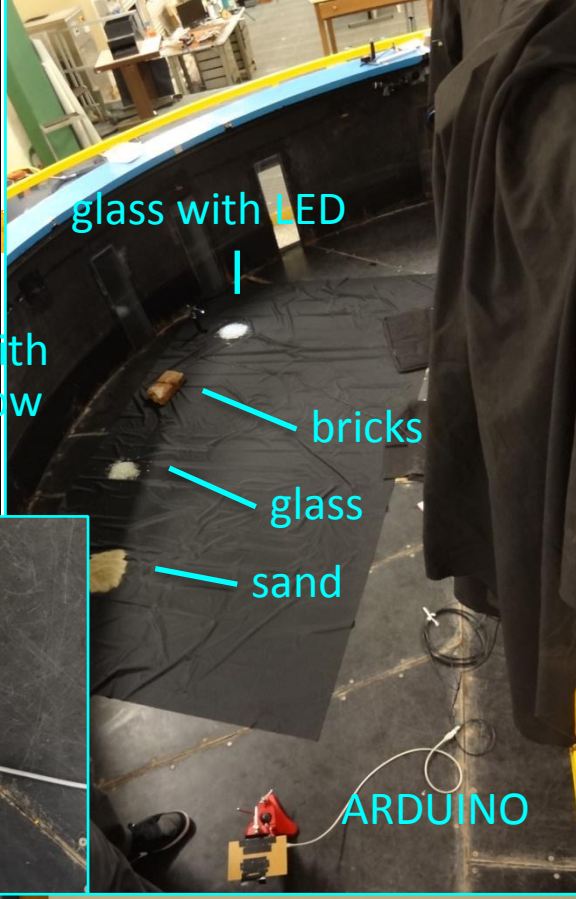

PMT_C with
BG3 filter
connected to
ASIC_D


bkg by "Super-LED" lamp

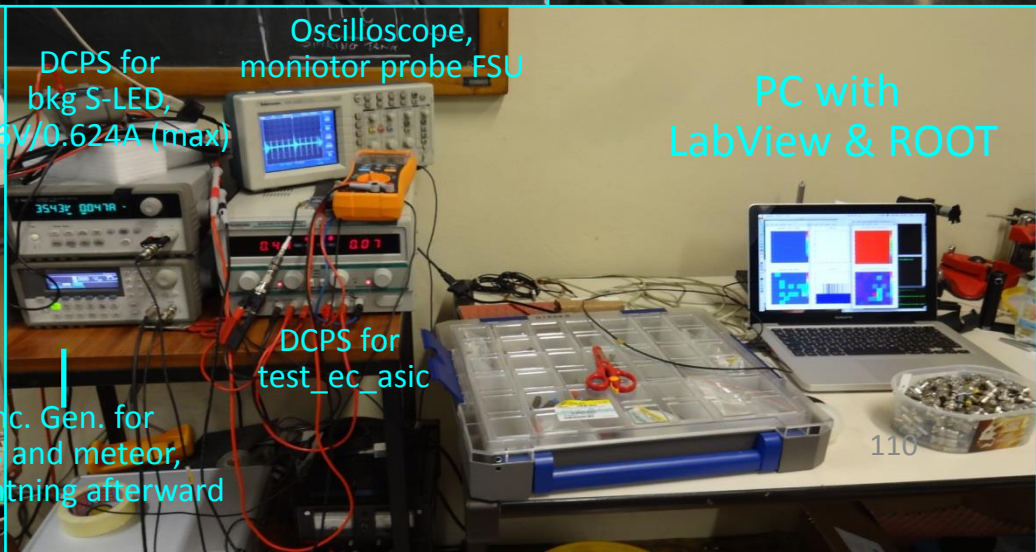

moss


pure
water
Cloud with
LED below


Meteor

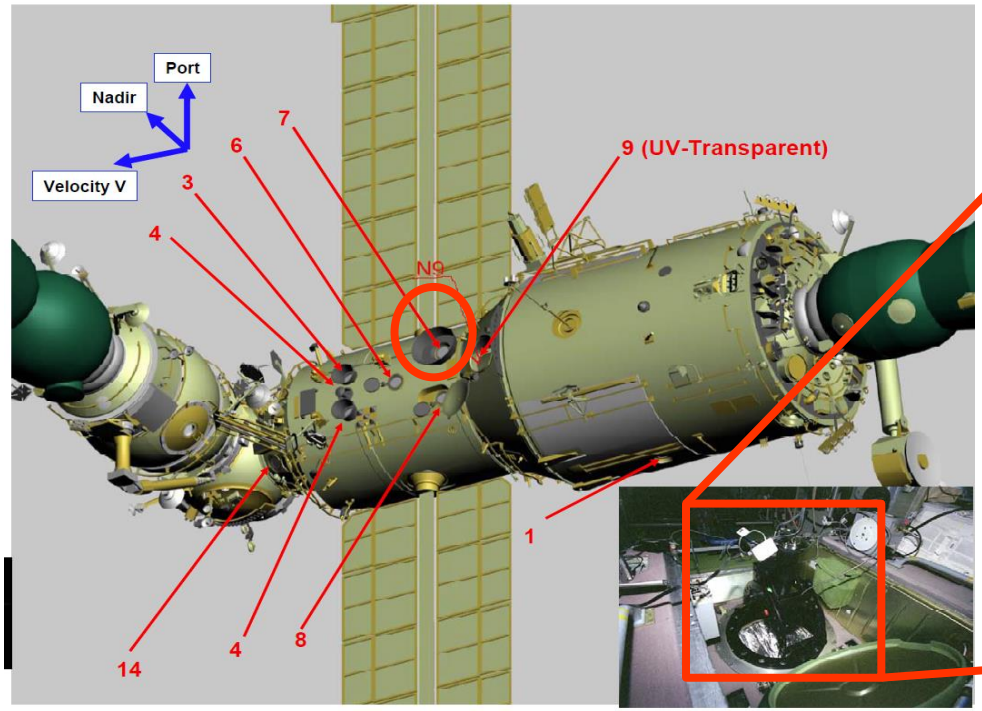

glass with LED
bricks
glass
sand
ARDUINO


Func. Gen. for
LEDs and meteor,
and lightning afterward


DCPS for
bkg S-LED,
36V/0.624A (max)
Oscilloscope,
moniotor probe FSU
PC with
LabView & ROOT
DCPS for
test_ec_asic

Pathfinder: mini-EUSO

- Approved by ASI (Italian Space Agency), and RKA (Russian space agency). Launch scheduled in 2017.
- A PDM and 2 smaller lenses (25 cm ø), to be exposed inside the ISS UV windows of the Russian module: Zvesda.
- First use of the PDM and lenses in space.
- Earth UV map and related studies from space.

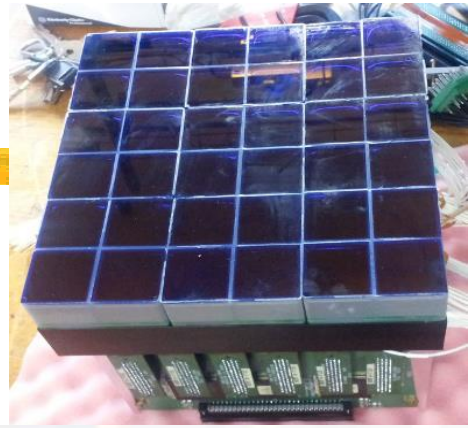


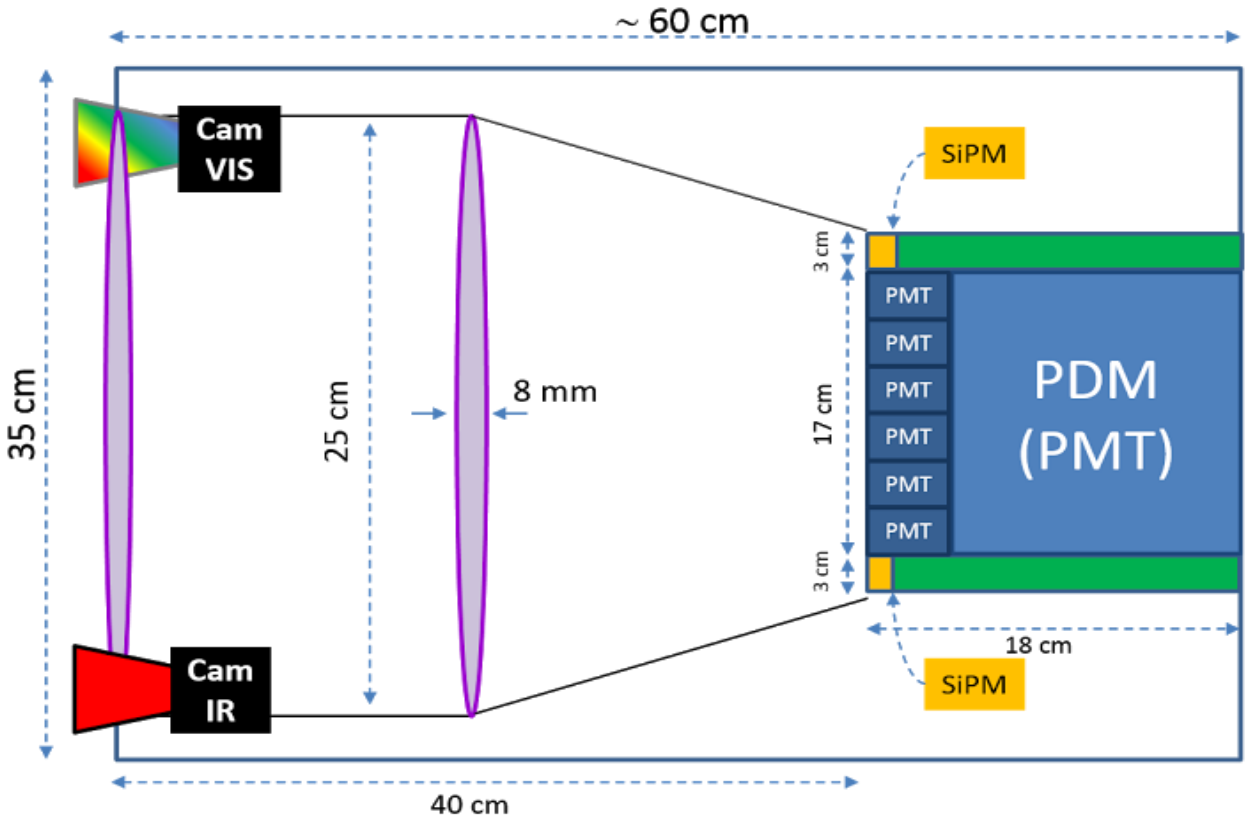
Mini-EUSO objectives

- UV emissions from night-Earth
  - Background from different lightning conditions, moon phases
  - Background from different inclinations
- Map of the Earth in UV
- Study of atmospheric phenomena
- Study of meteors and Search for Strange quark matter
- Raise the technological readiness level of the Hardware
- Use of Fresnel lenses in space
- Optimization of characteristics and performances of EUSO

Pathfinder: Mini-EUSO

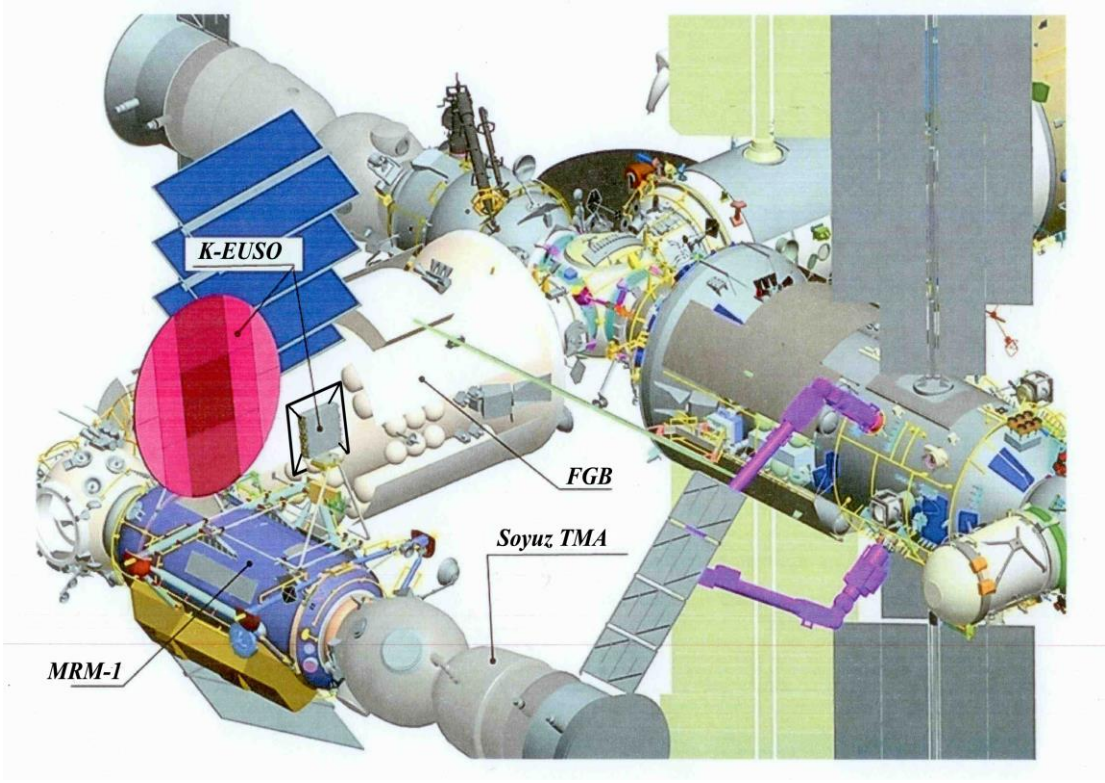
- Mini-EUSO instrument: a refractive optics based on two Fresnel lenses images UV light on 1 PDM (36 MAPMTs). A SiPM module is an option.





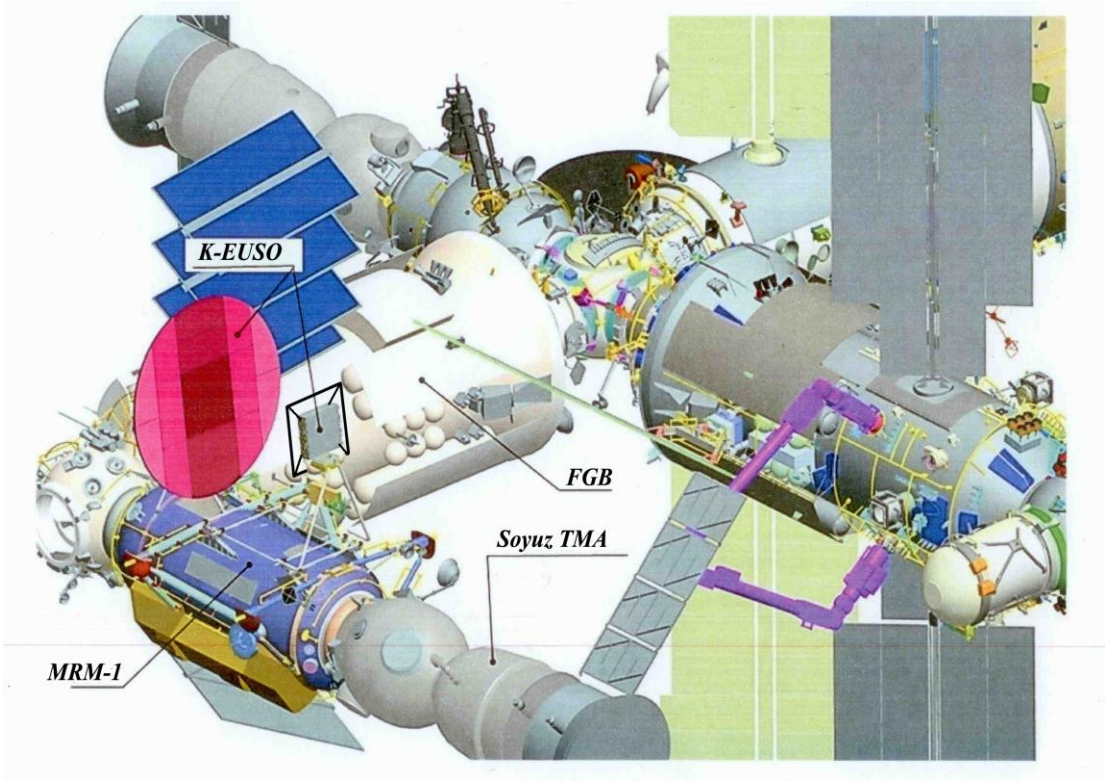
DAQ prototipe based on PC104

K-EUSO



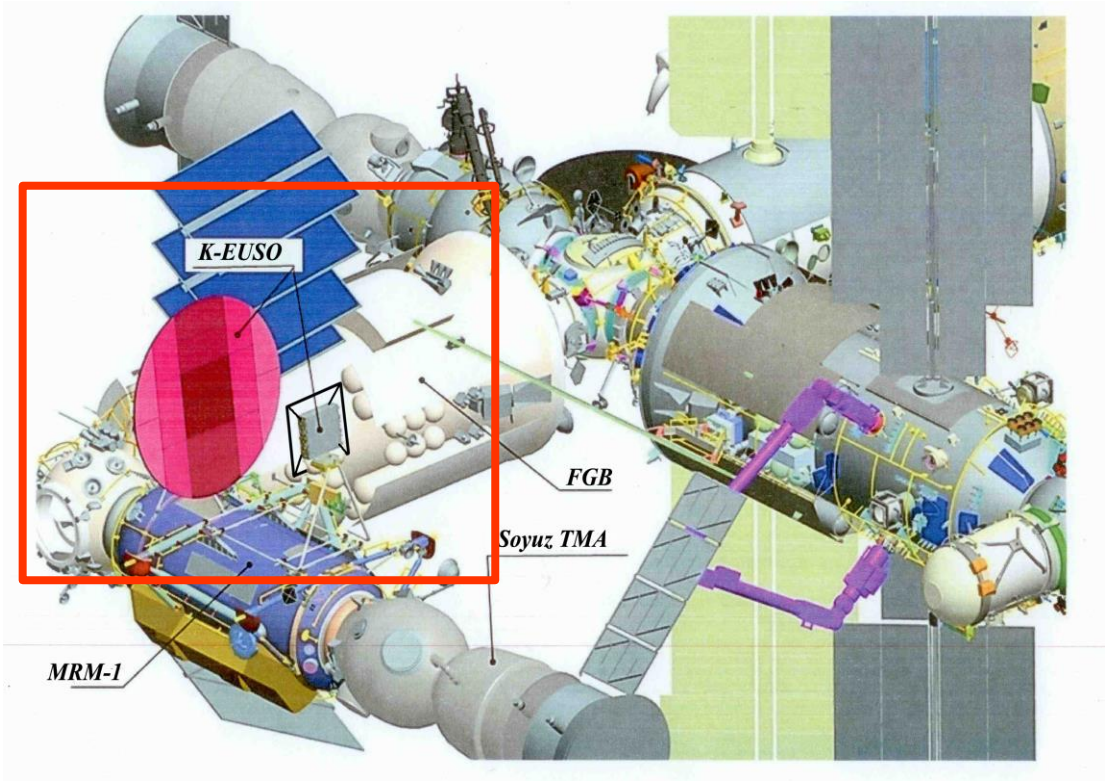
K-EUSO

- Improved version of the KLYPVE mission.



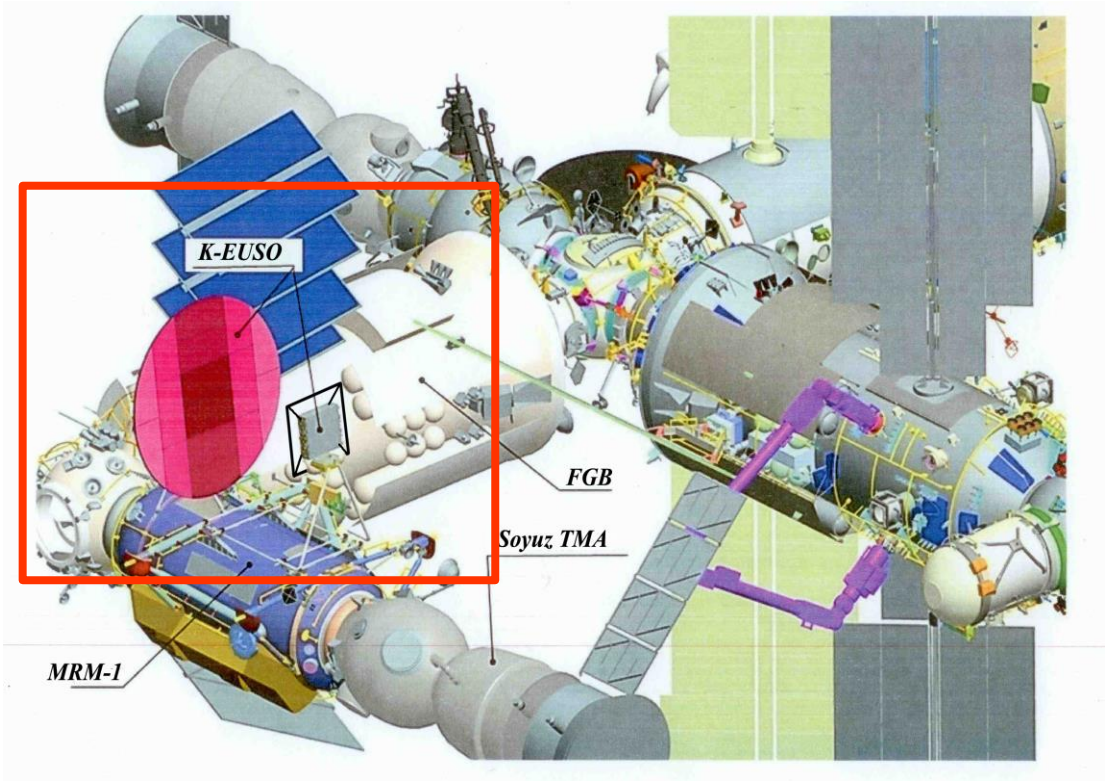
K-EUSO

- Improved version of the KLYPVE mission.
- KLYPVE, proposed by MSU, is included since 2013 in the Russian Federal Space Program. Sept. 2014 agreement signed MSU-Riken for science and role sharing, final agency approval Dec. 2014 ÷ Mar. 2015.



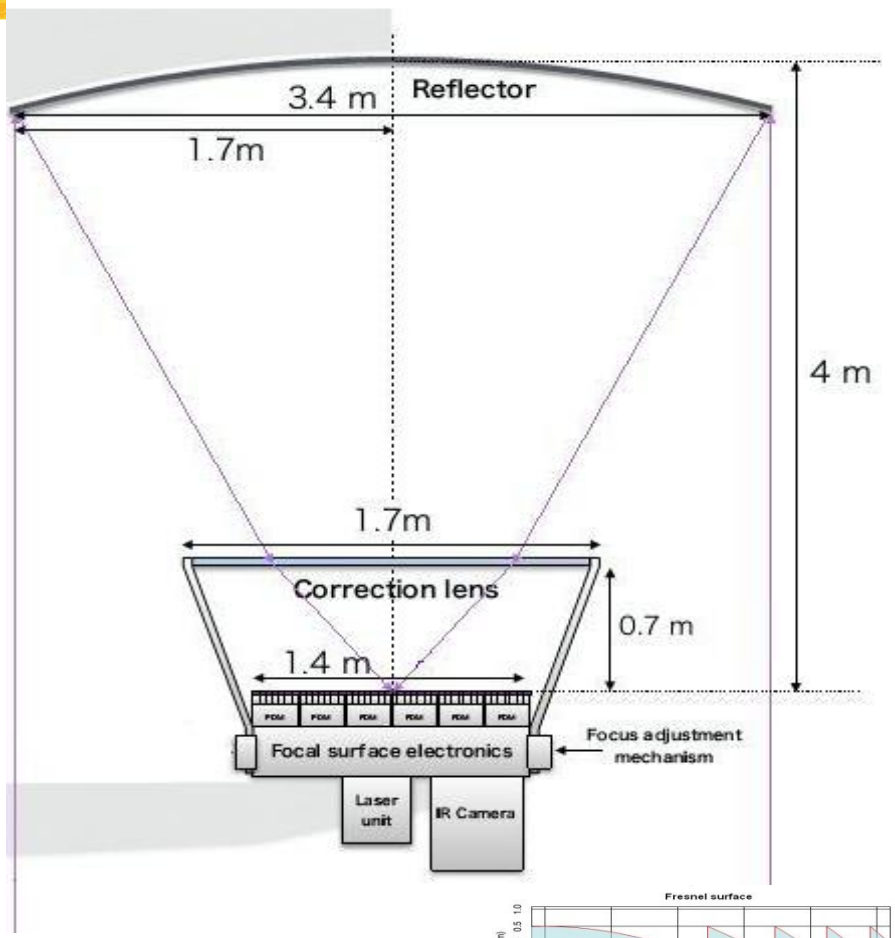
K-EUSO

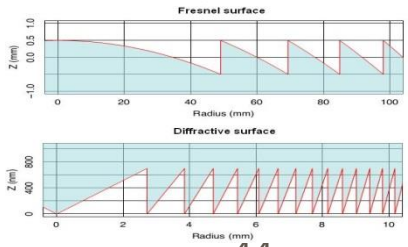
- Improved version of the KLYPVE mission.
- KLYPVE, proposed by MSU, is included since 2013 in the Russian Federal Space Program. Sept. 2014 agreement signed MSU-Riken for science and role sharing, final agency approval Dec. 2014 ÷ Mar. 2015.
- The original reflector proposal has been modified using a lens, different focal surface detector and laser.



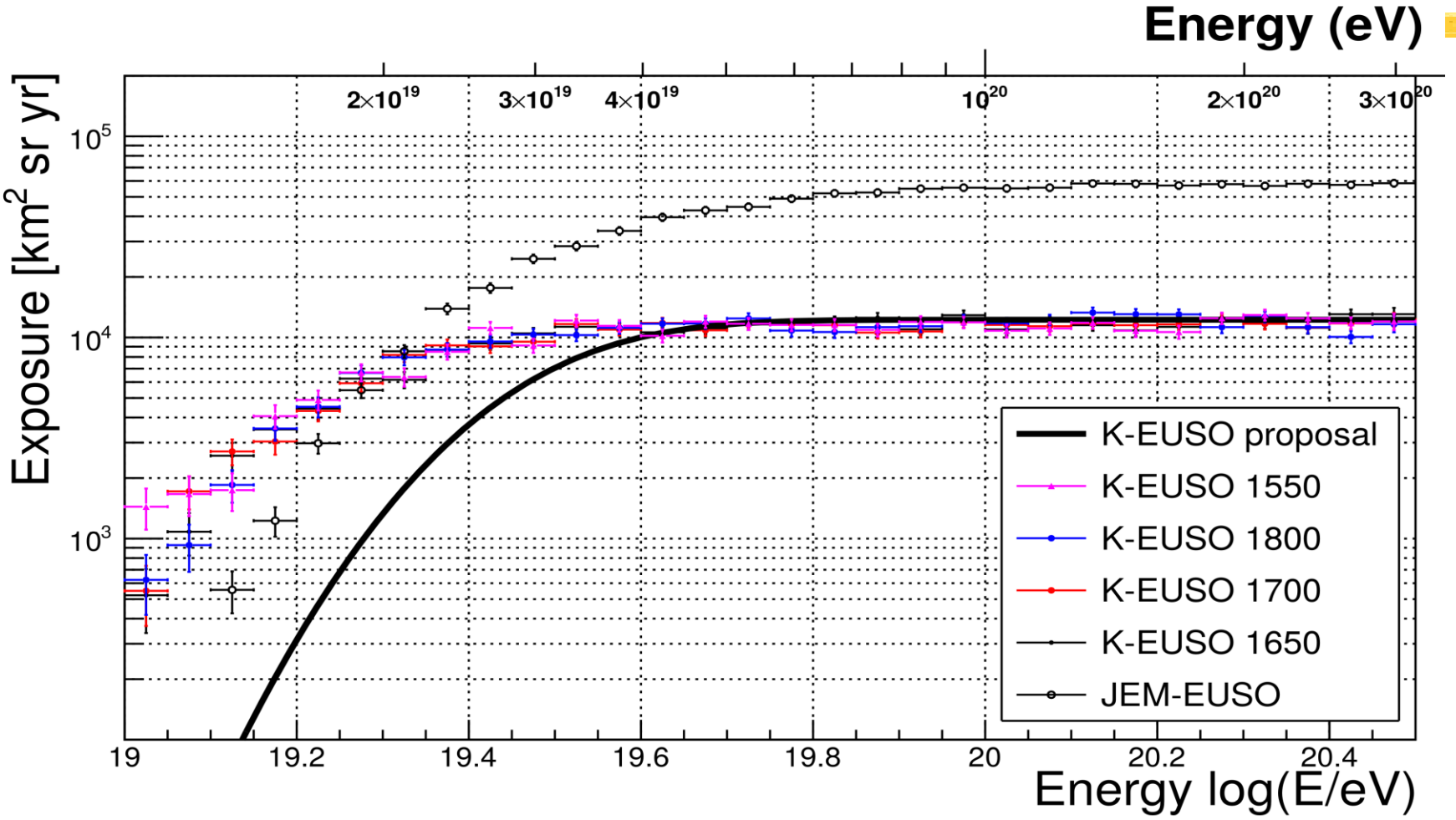
K-EUSO

- The original KLYPVE design, based on mirror (3.4m ø), has been modified adding a Fresnel correcting diffracting lens (1.7 m ø).
- The total length is 4 m.
- The Focal Surface concept is the JEM-EUSO's one: 52 PDMs, 1.2 x10^5 pixels.
- The UV telescope is complemented by an IR-CAM and a Laser Unit (for the LIDAR mode).
- FoV : ± 14°





K-EUSO exposure simulation (ESAF)



The expected annual exposure is about 2 times PAO's one

Conclusion

- JEM-EUSO is an ISS space-mission designed to explore the extreme energies of our universe and its fundamental physics through the detection of UHECRs with the highest possible statistics.
- It is the first space observatory with full-sky coverage which can achieve, depending on the mission lifetime, an exposure close to the $10^6 km^2$ sr year.
- Pathfinders:
  - EUSO-Balloon, has been launched in 2014, and an ultra long duration flight (SPB), is foreseen in 2017.
  - EUSO-TA is taking data since 2015.
  - mini-EUSO, will be installed in ISS on 2017.
- Precursor: KLYPVE-EUSO, is scheduled to be installed in ISS on 2018.
- JEM-EUSO mission: USA (PI A. Olinto) will submit a mission of opportunity (MOO) proposal for the next NASA MidEx mission call that will be available next year.

THANKS !!!