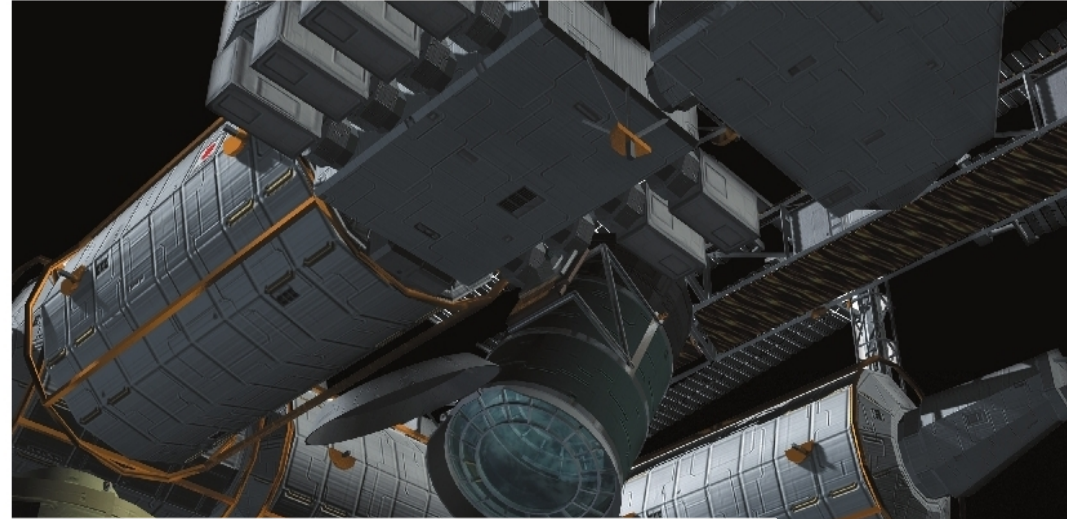


Extreme Universe Space Observatory onboard Japanese Experiment Module

# JEM-EUSO



# Carl Blaksley

On Behalf of the Franco-Japanese part of the JEM-EUSO  
collaboration

*Thanks to A. Santagelo, M Bertina, M. Casolino, et al. for slides and other  
materials*


*FJPPL 2012*





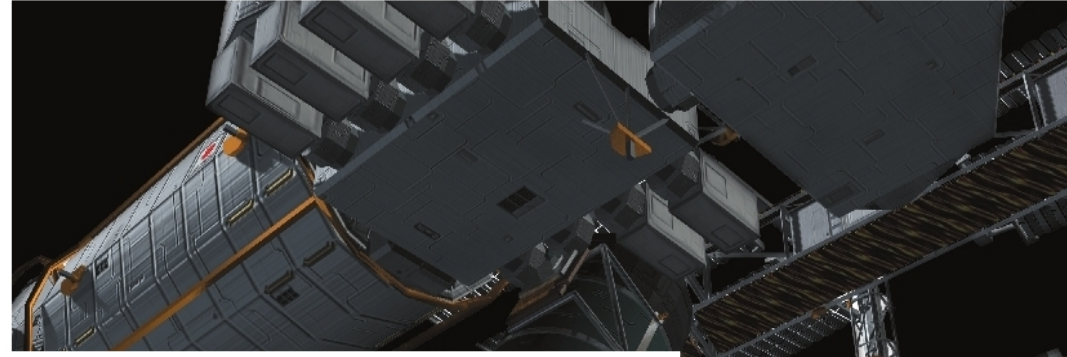
# I. JEM-EUSO

## The Collaboration and Context



Extreme Universe Space Observatory onboard Japanese Experiment Module

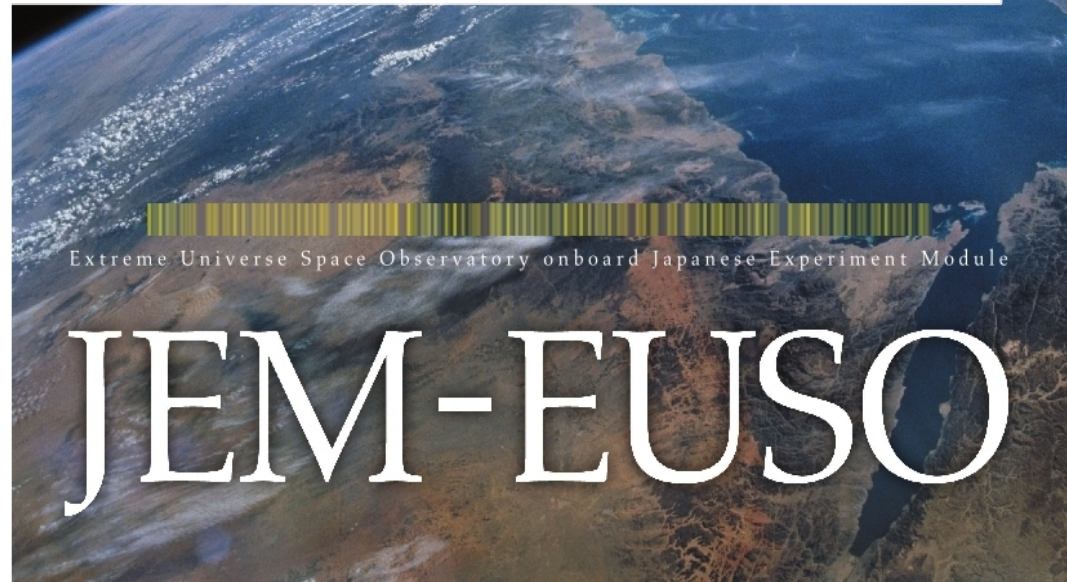
# JEM-EUSO



# I. JEM-EUSO



The Collaboration and Context  
More than 10 years of studies



The *Extreme Universe  
Space Observatory on-  
board the Japan  
Experiment Module (JEM)  
of the ISS*



Extreme Universe Space Observatory onboard Japanese Experiment Module

JEM-EUSO

The *Extreme Universe*  
*Space Observatory* on-  
board the Japan  
Experiment Module (JEM)  
of the ISS

**EUSO**



2001- 2004

Heritage of the ESA-EUSO study



Extreme Universe Space Observatory onboard Japanese Experiment Module

**JEM-EUSO**

# JEM EUSO Collaboration

- Japan, USA, Korea, Mexico, Russia
- In Europe: Bulgaria, France, Germany, Italy, Poland, Slovakia, Spain, Switzerland
- 77 Institutions, more than 250 researchers



# Franco-Japanese-Korean Collaboration

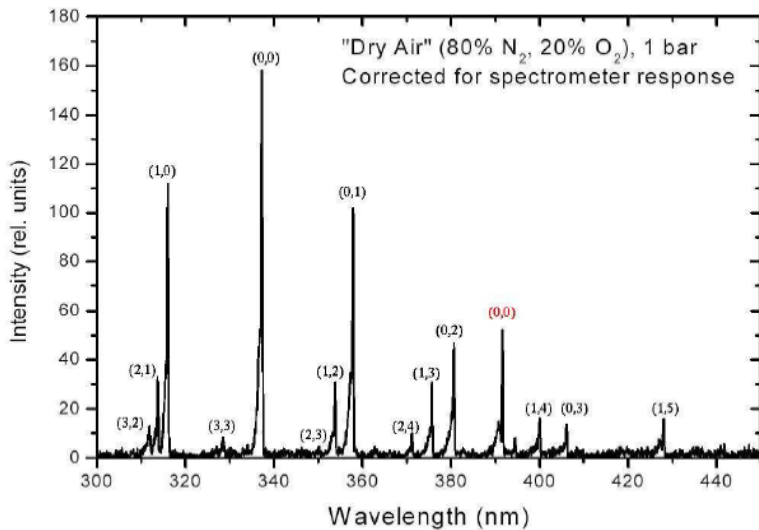
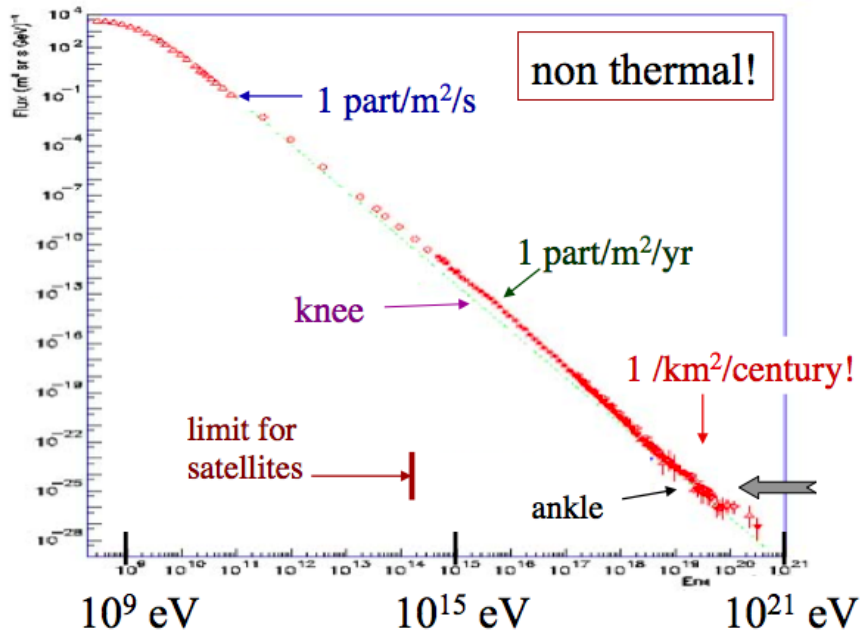
- *In Japan:*
  - *RIKEN: Leading institution*
  - *21 other institutions*
- *In France:*
  - *AstroParticule et Cosmologie (APC) (CNRS, IN2P3)*
  - *LAL, Orsay (CNRS, IN2P3)*
    - *IRAP, Toulouse (INSU, CNES)*
- *In Korea:*
  - *Ehwa W. Univ, Yonsei Univ, KASI, KAIST*

JLIM LUSO

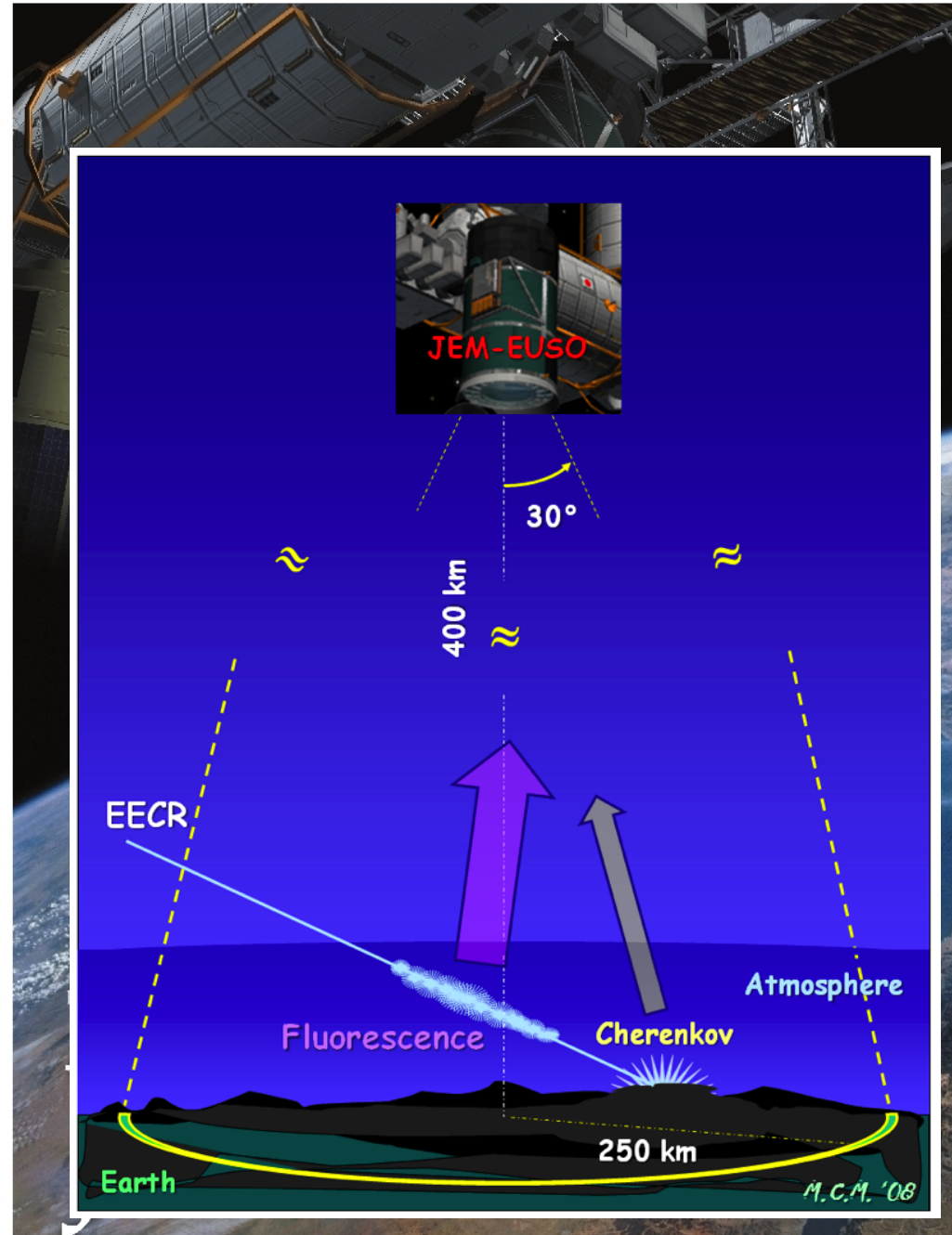
nt Module

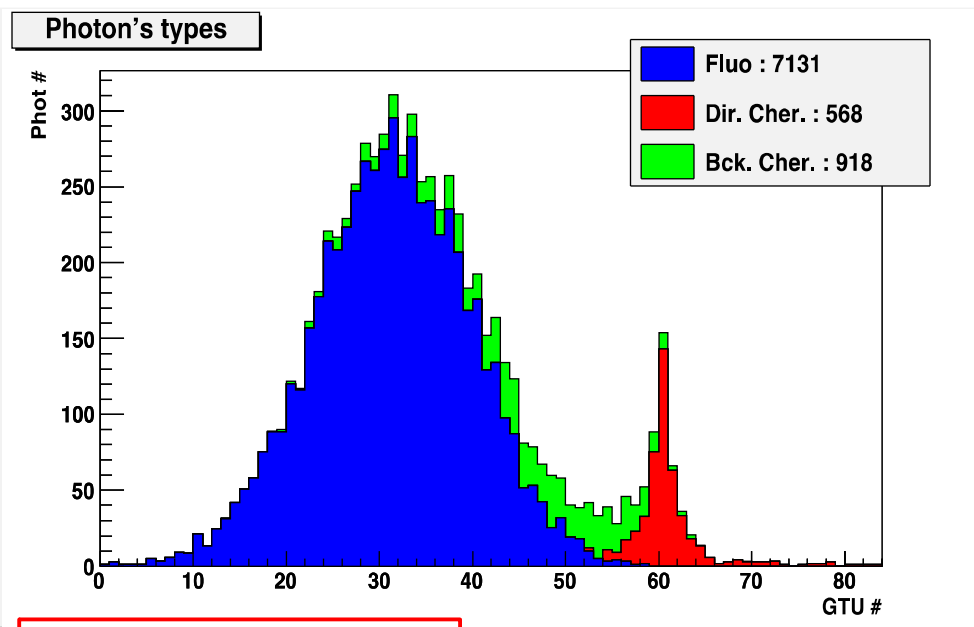


# Study of UHE Cosmic Rays from Space



330 – 430 nm, UV





GTU time units

- a) Fluorescence
- b) Scattered Cherenkov
- c) Direct (diffusively reflected Cherenkov)

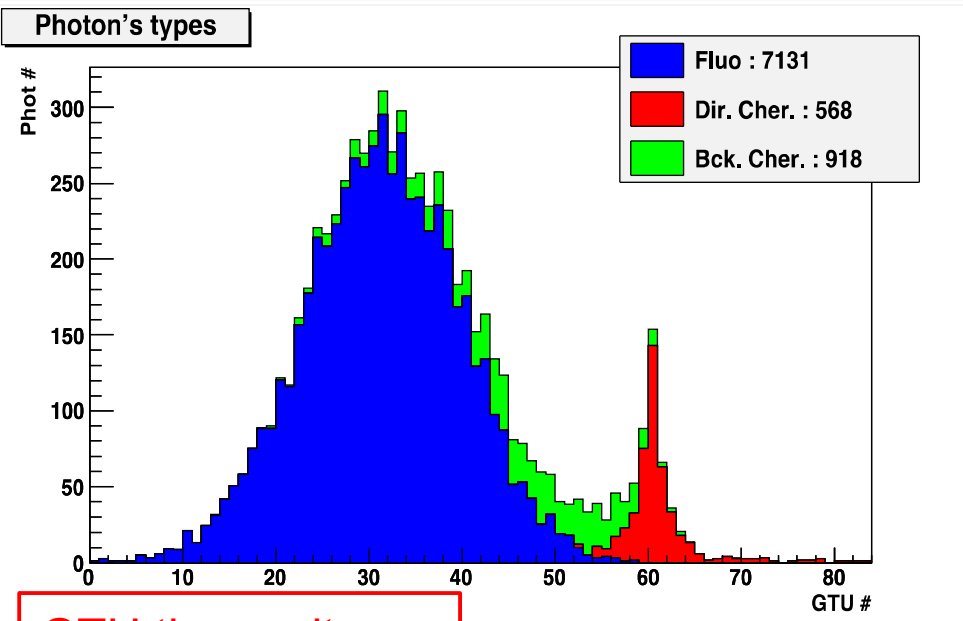
$p, 10^{20} \text{eV}, 60 \text{ deg}$

$$1 \text{ GTU} = 2.5 \mu \text{sec}$$

$$Back = 500 / (m^2 \text{ sr ns})$$

**FAST SIGNAL**  
*duration*  $\approx 50 - 150 \mu s$

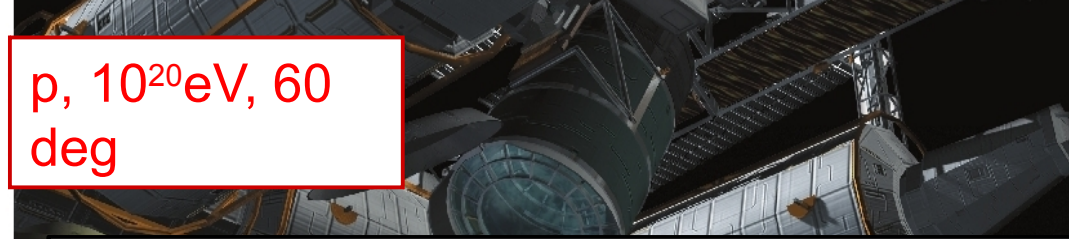




GTU time units

- a) Fluorescence
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- c) Direct (diffusively reflected Cherenkov)

p,  $10^{20}$ eV, 60 deg

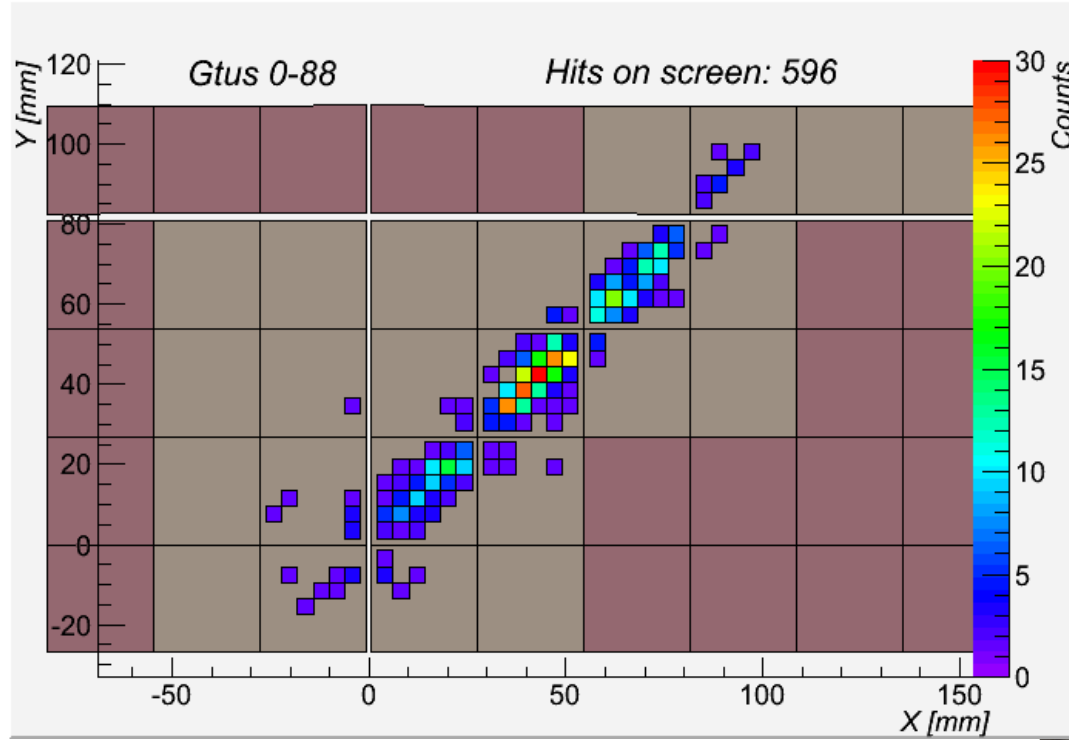


$1 GTU = 2.5 \mu sec$

$Back = 500 / (m^2 sr ns)$

**FAST SIGNAL**

$duration \approx 50 - 150 \mu s$



Simulation of the light profile observed at the entrance pupil (above) and of the observed shower image (using the ESAF code)

# (1) Main Scientific Objectives

- **Main Objective:** Astronomy and Astrophysics through the particle channel
  - *Identification of UHECR sources* by high-statistics arrival direction analysis
  - *Measurement of the energy spectra* of individual UHECR sources (spectral shape, flux, power)
  - High Statistics measurement of *the trans-GZK spectrum*



# (1) Main Scientific Objectives

- **Main Objective:** Astronomy and Astrophysics through the particle channel
  - *Identification of UHECR sources* by high-statistics arrival direction analysis (+multi-wavelength!)
  - *Measurement of the energy spectra* of individual UHECR sources (spectral shape, flux, power)
  - High Statistics measurement of the *trans-GZK spectrum*

Physics and Astrophysics at  $E > 5 \times 10^{19} \text{eV}$

JEM-EUSO

## (2) Exploratory Scientific Objectives

- **Exploratory Objectives:** new messengers
  - *Discovery of UHE neutrinos* by neutrino discrimination and identification via  $X_0$  and  $X_{max}$
  - *Discovery of UHE Gammas* by discrimination of  $X_{max}$  due to geomagnetic and LPM effect
- **Exploratory Objectives:** magnetic fields
  - *Constrains on the galactic and local extragalactic fields*



## (2) Exploratory Scientific Objectives

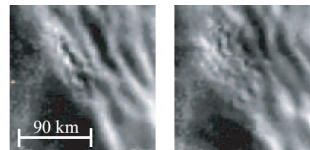
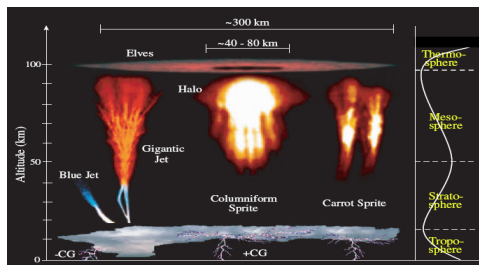
- **Exploratory Objectives:** new messengers
  - *Discovery of UHE neutrinos* by neutrino discrimination and identification via  $X_0$  and  $X_{max}$
  - *Discovery of UHE Gammas* by discrimination of  $X_{max}$  due to geomagnetic and LPM effect
- **Exploratory Objectives:** magnetic fields
  - *Constraints on the galactic and local extragalactic fields*



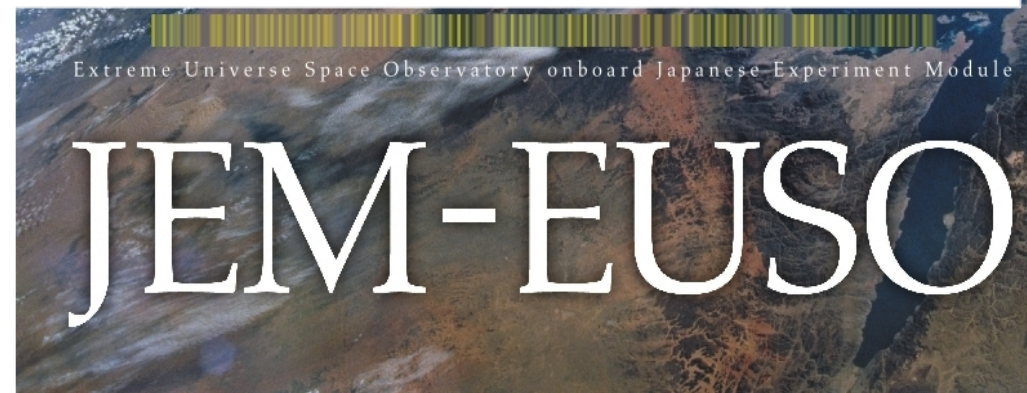
High discovery potential; tests of new physics models

# (3) Exploratory Scientific Objectives

- **Exploratory Objectives:** Atmospheric science
  - *Night-glow*
  - *Transient luminous events*
  - *Space-atmosphere interactions and climate change*



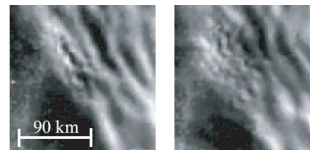
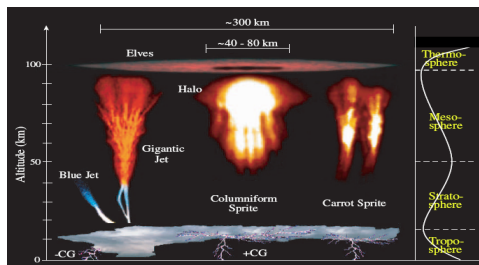
- **Exploratory Objectives:** Meteors and meteoroids





# (3) Exploratory Scientific Objectives

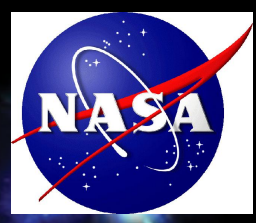
- **Exploratory Objectives:** Atmospheric science
  - *Night-glow*
  - *Transient luminous events*
  - *Space-atmosphere interactions and climate change*



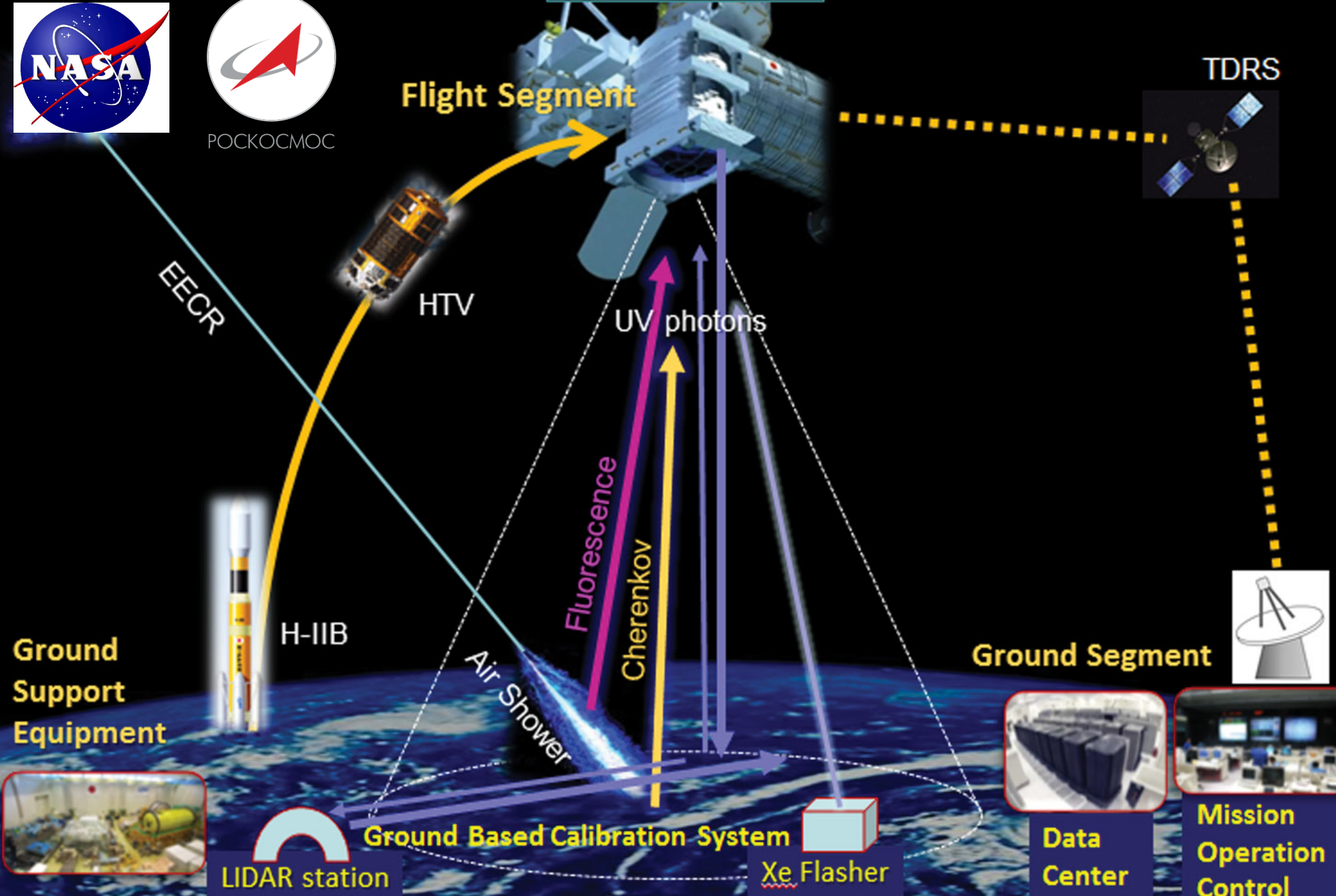
- **Exploratory Objectives:** Meteors and meteoroids



Fast monitoring of the atmosphere in the UV



# JEM-EUSO



Flight Segment

TDRS

EECR

HTV

UV photons

Fluorescence

Cherenkov

Air Shower

Ground Segment

Ground Support Equipment

H-IIB

Ground Based Calibration System

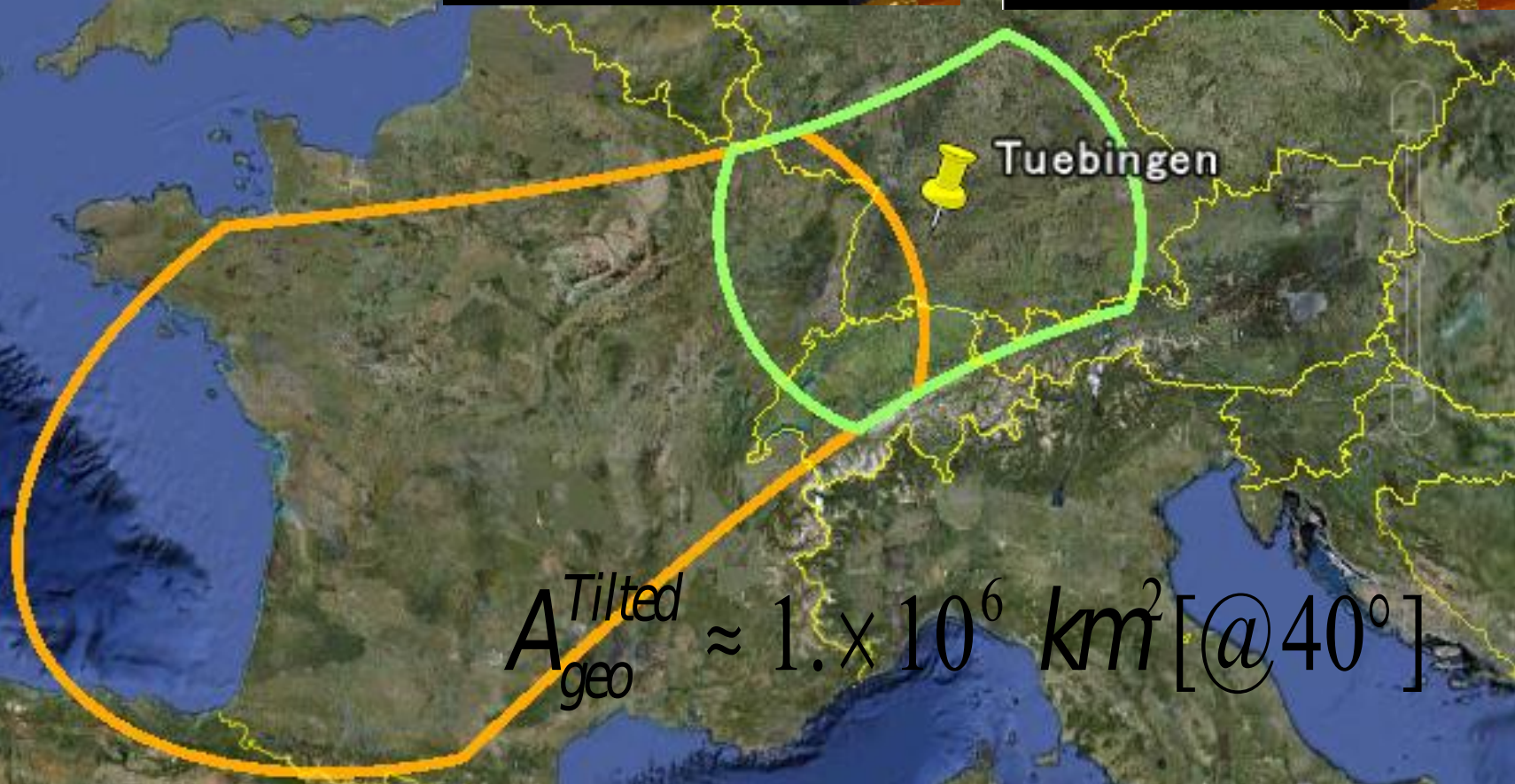
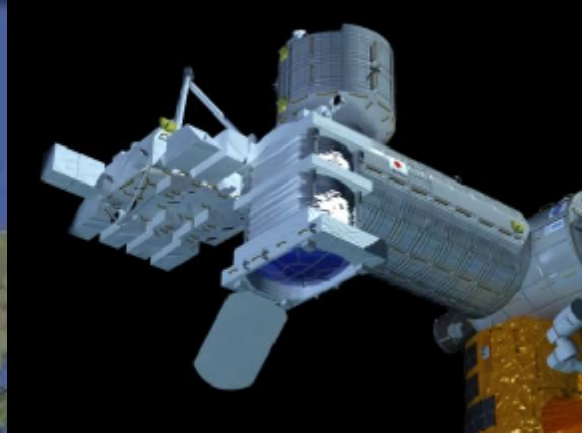
Xe Flasher

LIDAR station

Data Center

Mission Operation Control

$$A_{geo}^{Nadir} \approx 1.3 \times 10^5 \text{ km}^2$$



$$A_{geo}^{Tilted} \approx 1. \times 10^6 \text{ km}^2 [ @40^\circ ]$$

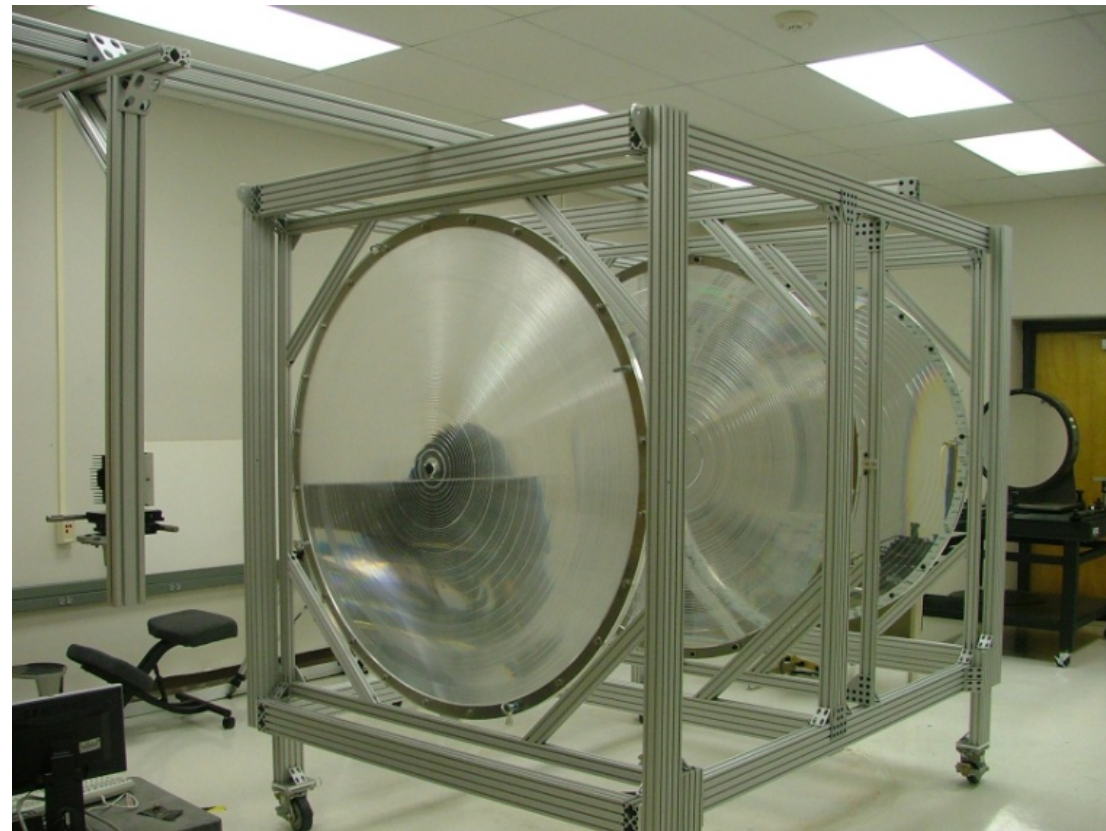
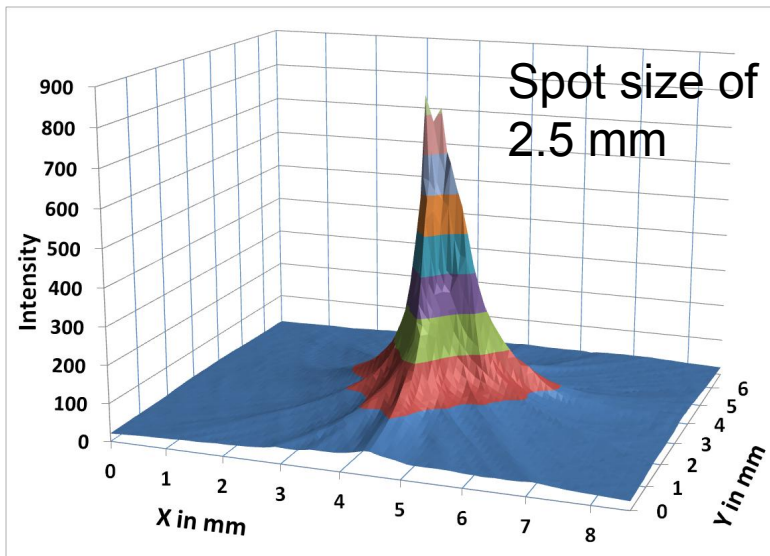
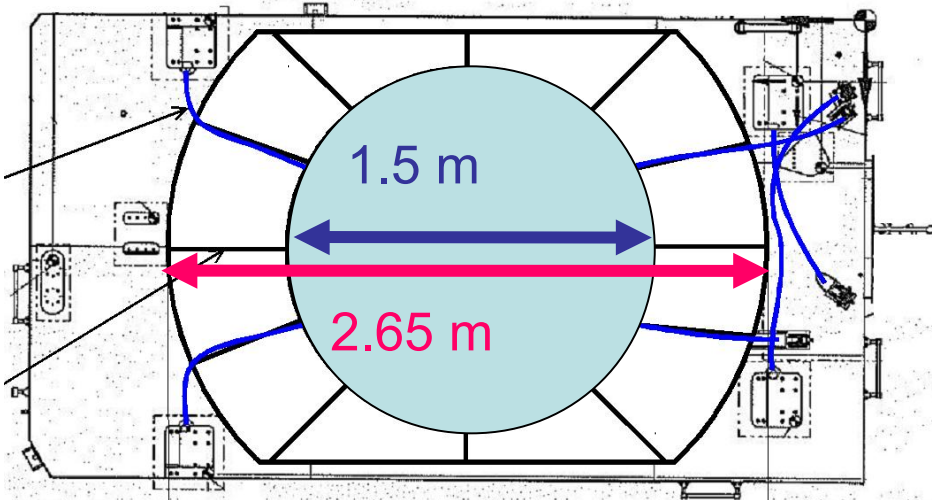
# The UV Telescope Parameters

Parameter	Value
Field of View	$\pm 30^\circ$
Monitored Area	$>1.3 \times 10^5 \text{ km}^2$
Telescope aperture	$\geq 2.5 \text{ m}$
Operational wavelength	300-400 nm
Resolution in angle	$0.075^\circ$
Focal Plane Area	$4.5 \text{ m}^2$
Pixel Size	$< 3 \text{ mm}$
Number of Pixels	$\approx 3 \times 10^5$
Pixel size on ground	$\approx 560 \text{ m}$
Time Resolution	$2.5 \mu\text{s}$
Dead Time	$< 3\%$
Detection Efficiency	$\geq 20\%$

# BBM of the Optics (Prototypes)

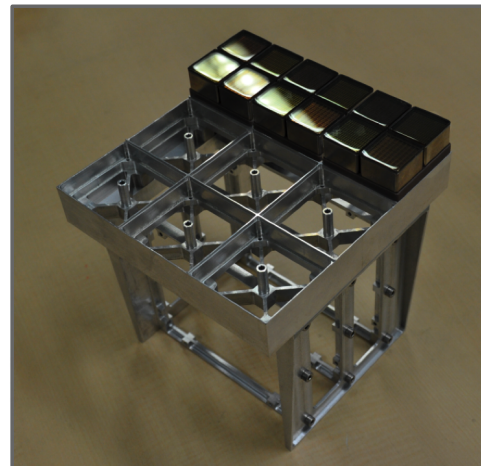
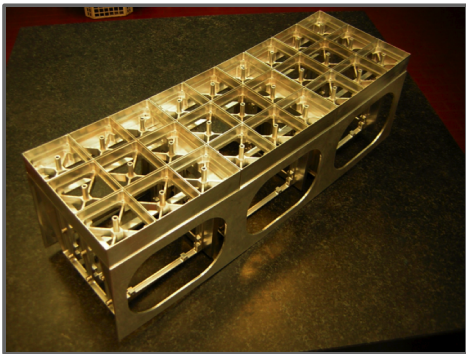
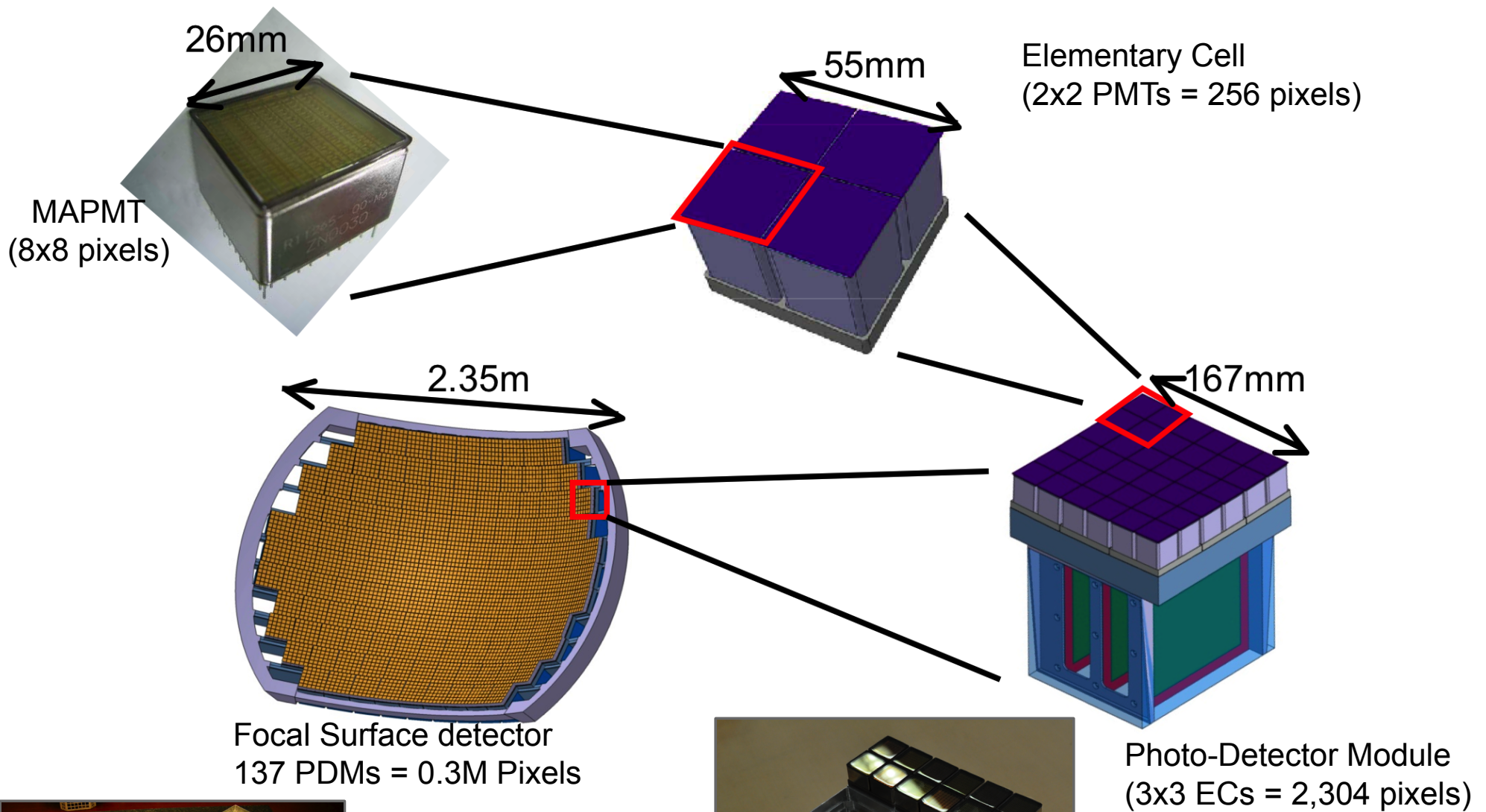


Large diameter Fresnel lenses manufactured in Japan and tested in the US at the University of Alabama Huntsville and MSFC (NASA)



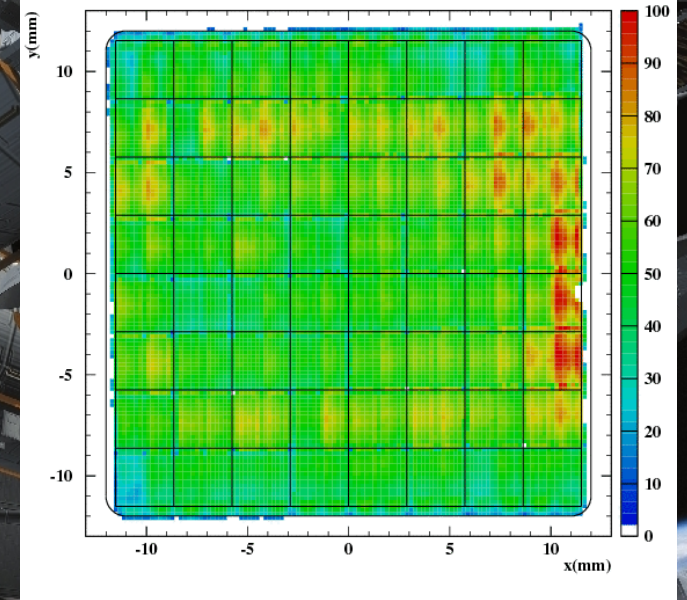
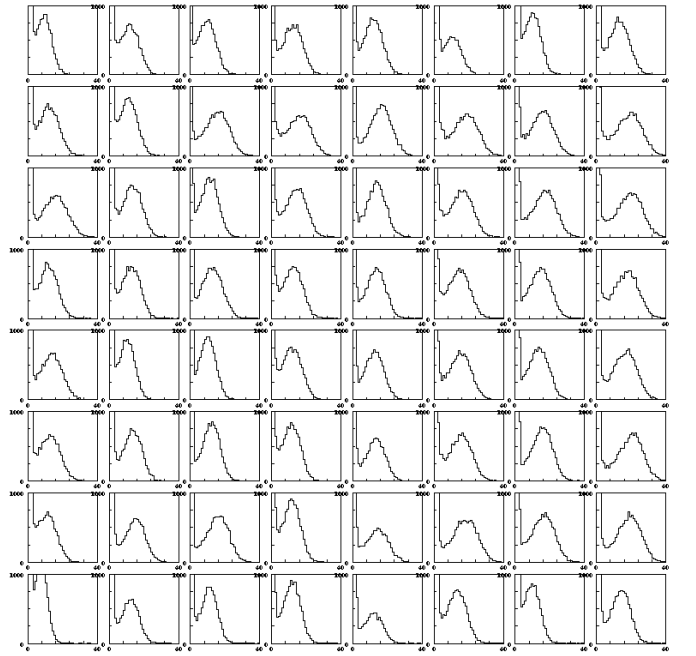
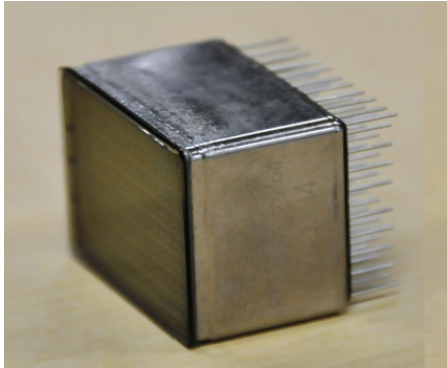
Tested performances already meet the requirements (or are close to it)

# Focal Surface



EUSO

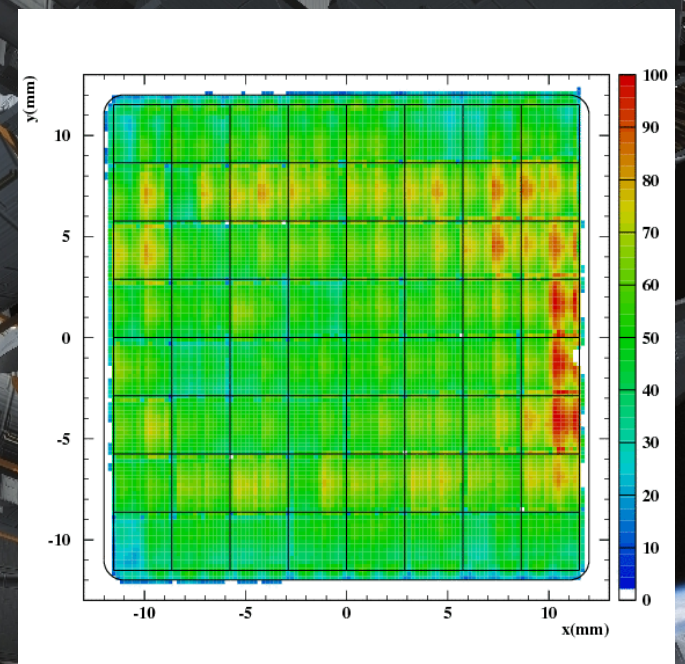
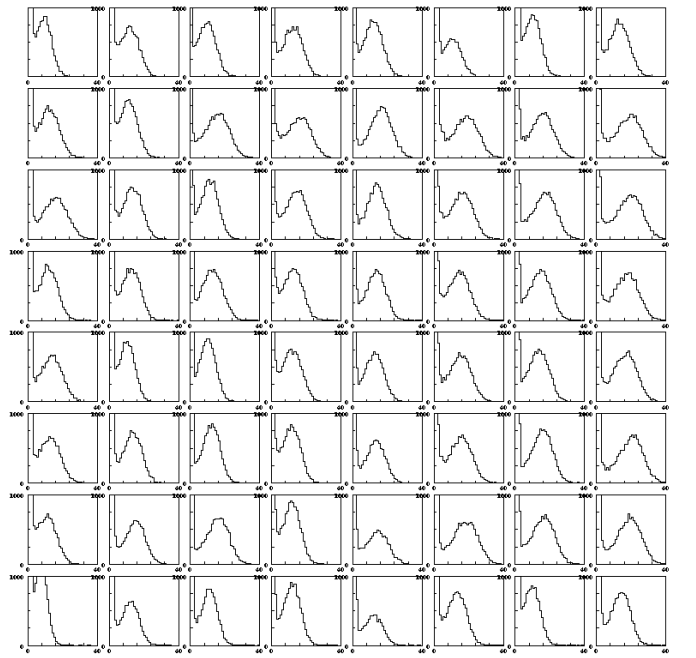
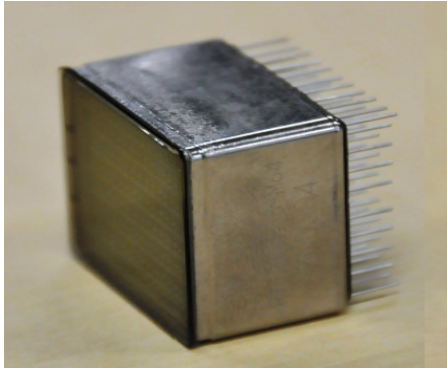
Hamamatsu R11265-03-  
M64  
64 pixel MAPMT



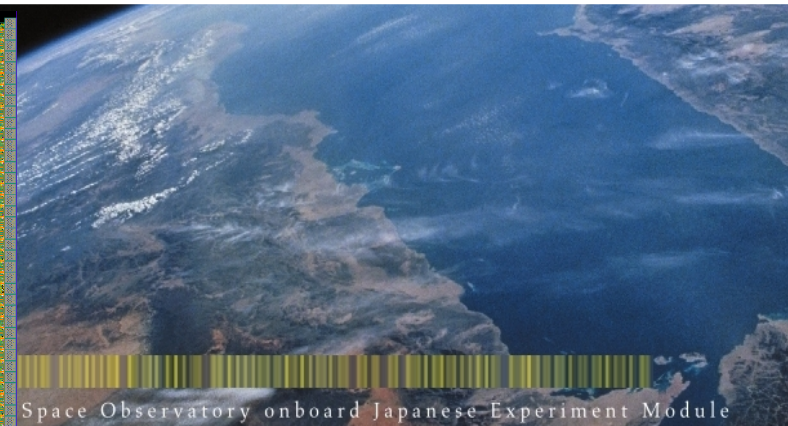
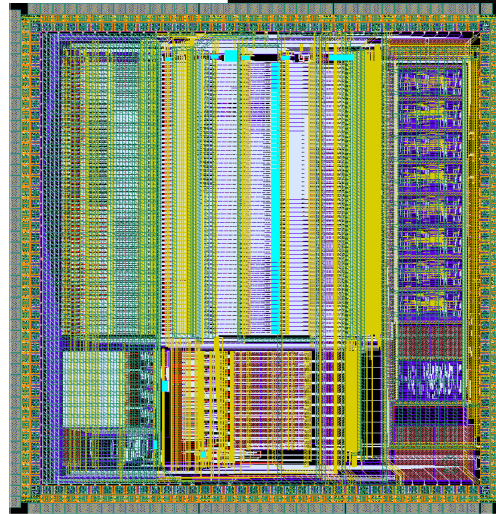
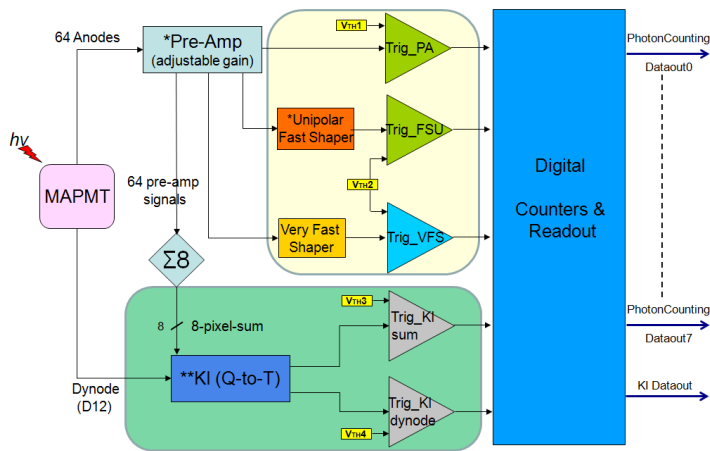
Single p.e. peak in all pixels; Gain uniformity of the MAPMT



# Hamamatsu R11265-03-M64 64 pixel MAPMT



Single p.e. peak in all pixels; Gain uniformity of the MAPMT

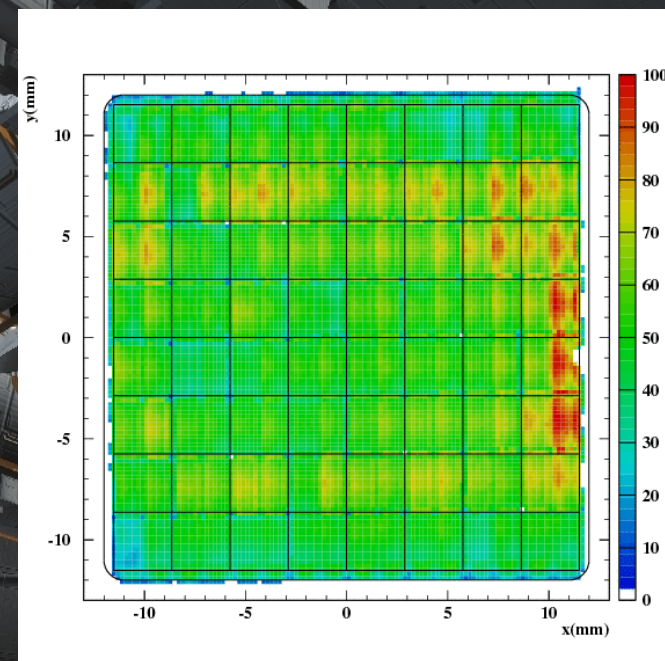
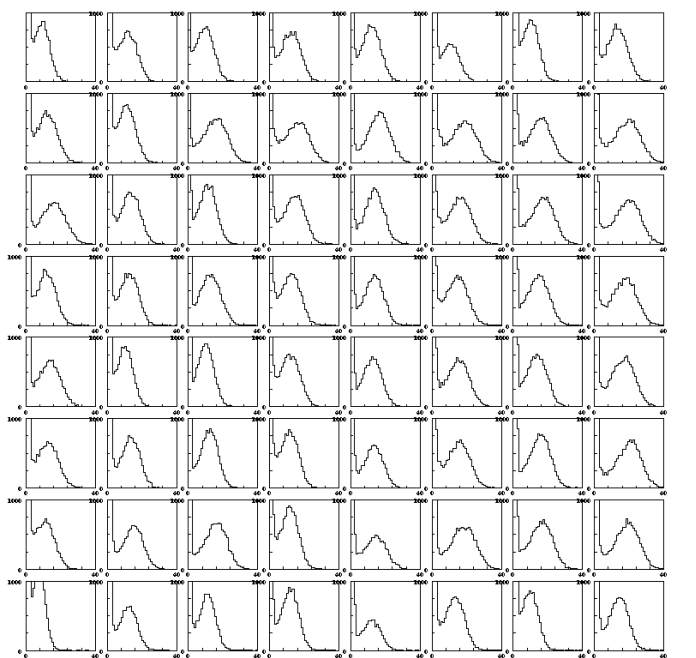
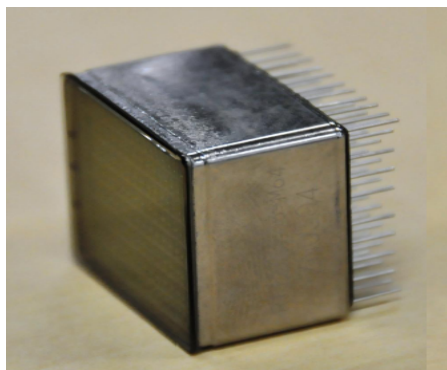


ASIC SPACIROC: from the design to a working prototype.

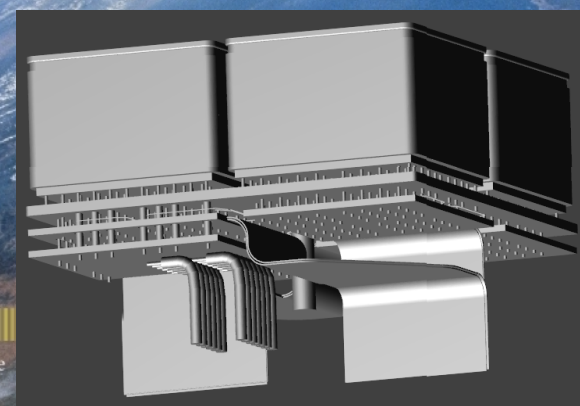
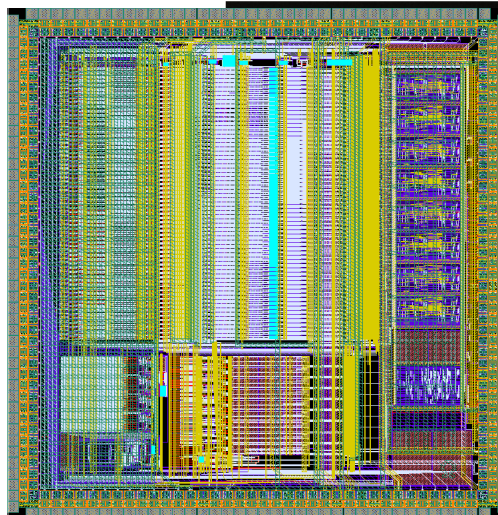
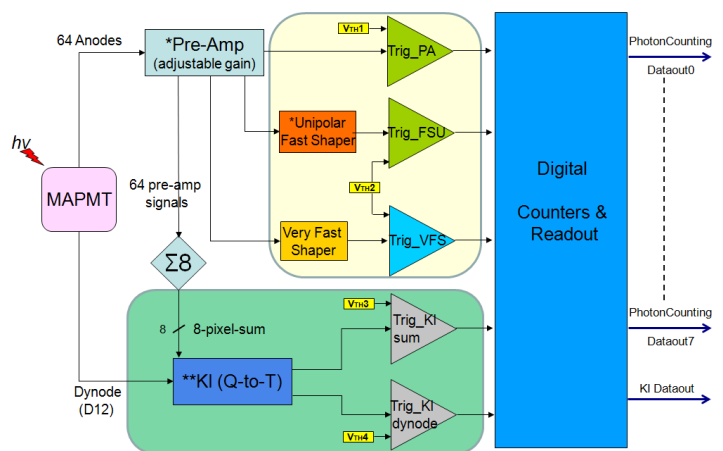
# EM-EUSO



# Hamamatsu R11265-03-M64 64 pixel MAPMT



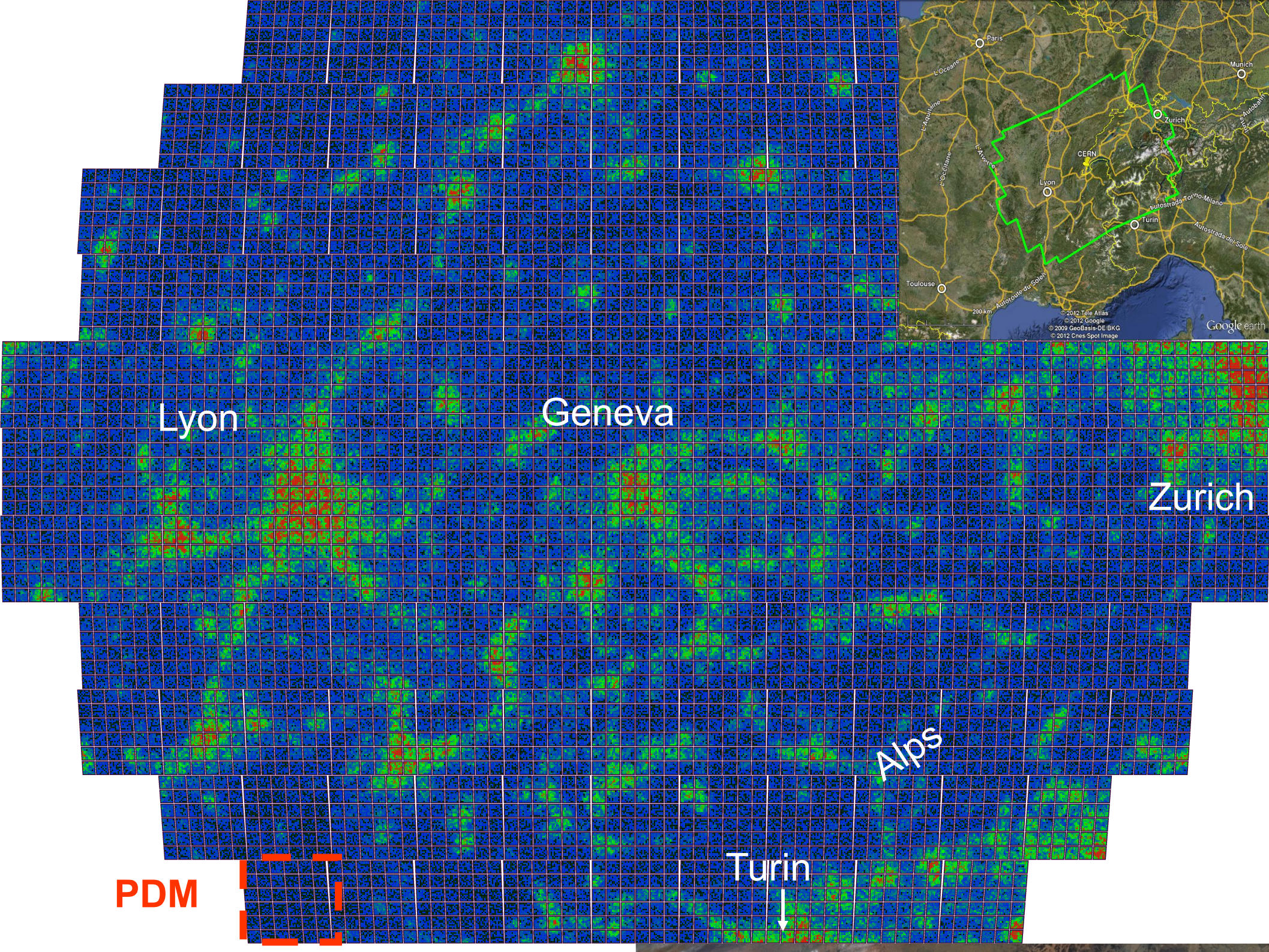
Single p.e. peak in all pixels; Gain uniformity of the MAPMT



ASIC SPACIROC: from the design to a working prototype.

EC integration!

EMULSO



Lyon

Geneva

Zurich

Alps

Turin

PDM

# Roadmap to JEM-EUSO

- 1)EUSO Balloon Campaign
- 2)TA-EUSO
- 3)JEM-EUSO



Extreme Universe Space Observatory onboard Japanese Experiment Module

# JEM-EUSO

# TA-EUSO

- Important collaboration with ICRR, Institute of Cosmic Ray Research, Tokyo University, Kashiwa campus
- Engineering test of the detector using one PDM and two lens system.
- Installation in winter 2012
- ***Cross-calibration tests at Telescope Array site, Utah***
  - Field calibration with TA FD
  - Laser (CLF)
  - electron beam (ELS)
- The observation of several showers (10s/yr) in coincidence with TA.

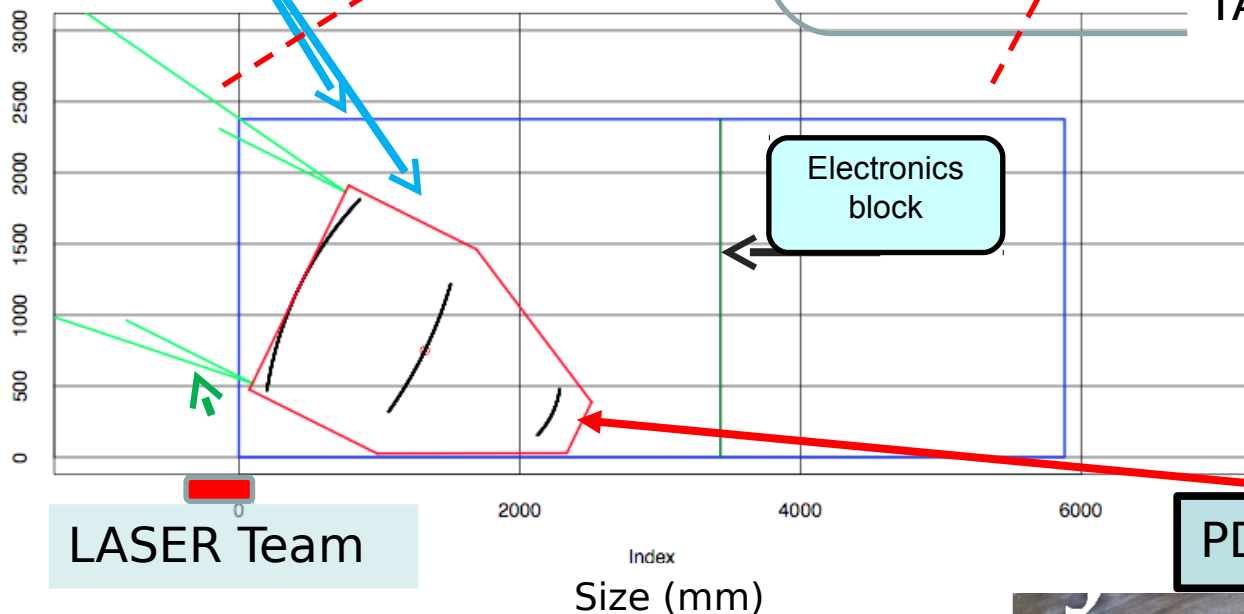


1m flat lens



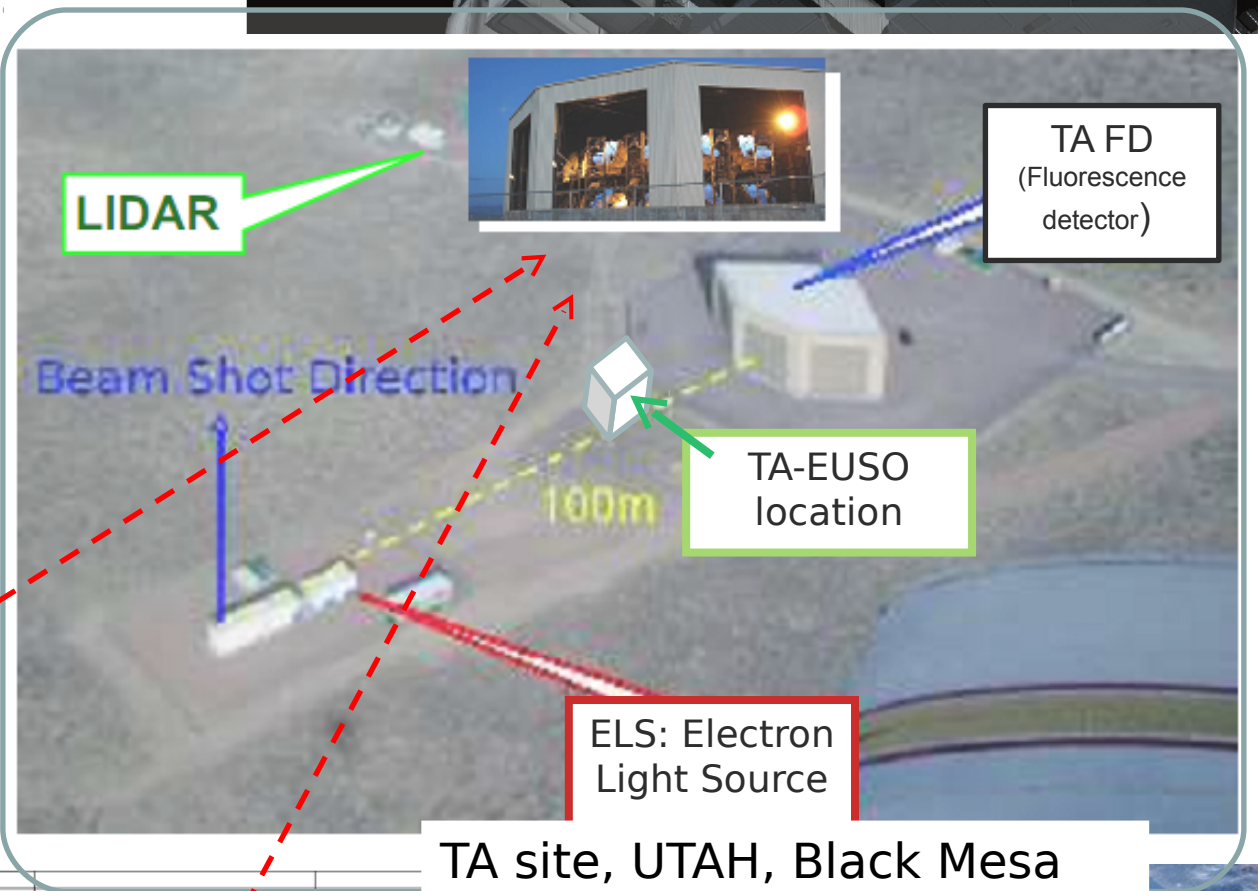
Lenses

Elev. ang = 26.25 deg  
FOV= 16.0 deg



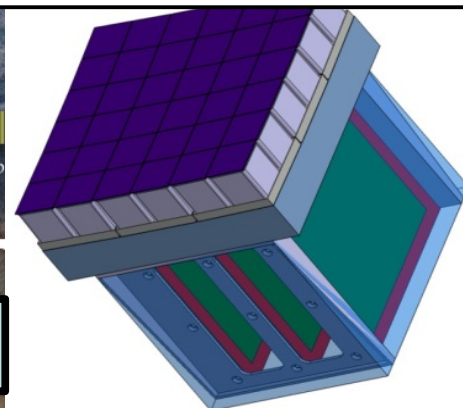
LASER Team

Index  
Size (mm)



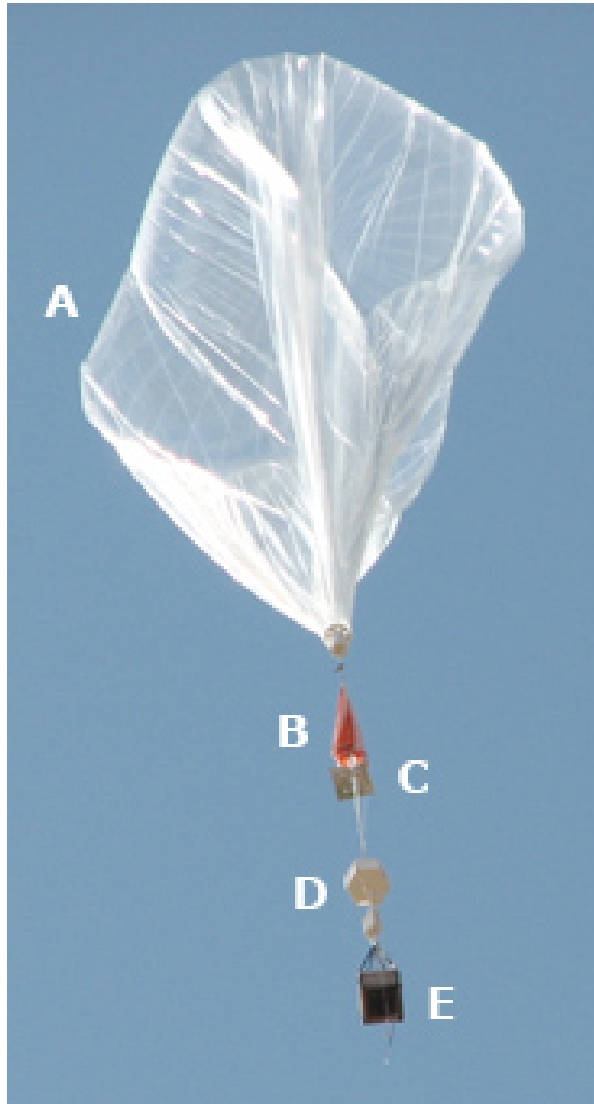
TA site, UTAH, Black Mesa

PDM detector block



PDM detector

# EUSO Balloon campaign



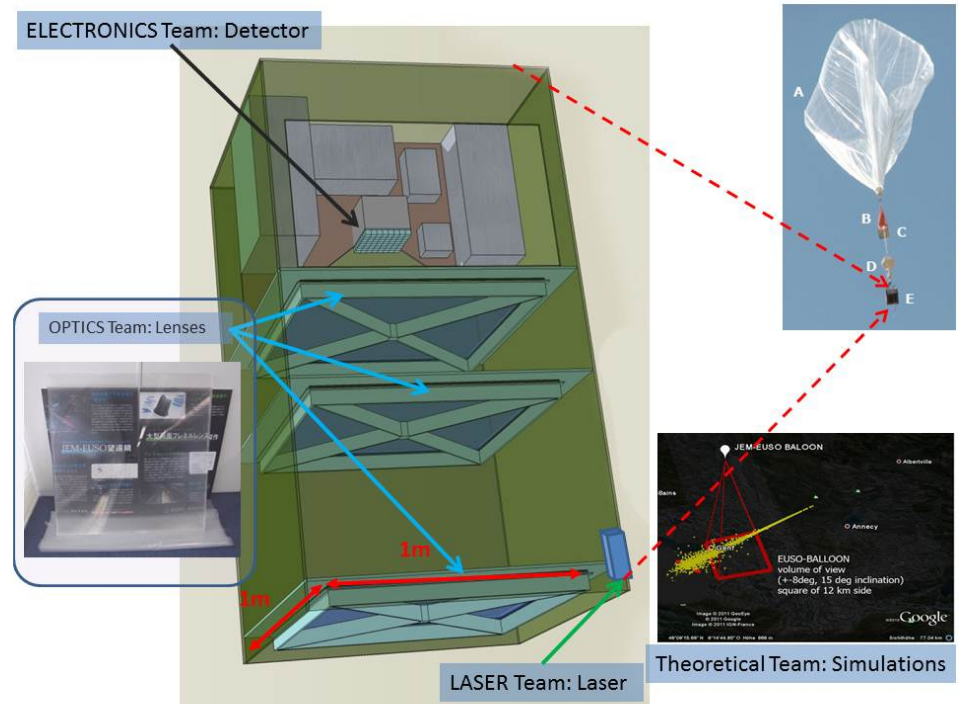
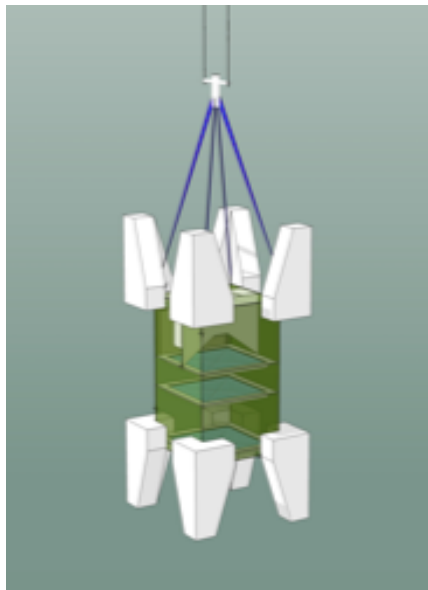
- Led by France
- Look down from the balloon with a UV telescope
  - 1 PDM + 3 lens system
- **Engineering test of Full JEM-EUSO**
  - **Same Hardware as far as is possible**
- UV-Background measurement
- Air-shower observations from 40 km altitude
- Approved by CNES
- Beginning of 2014, first of three launches

JEM-EUSO

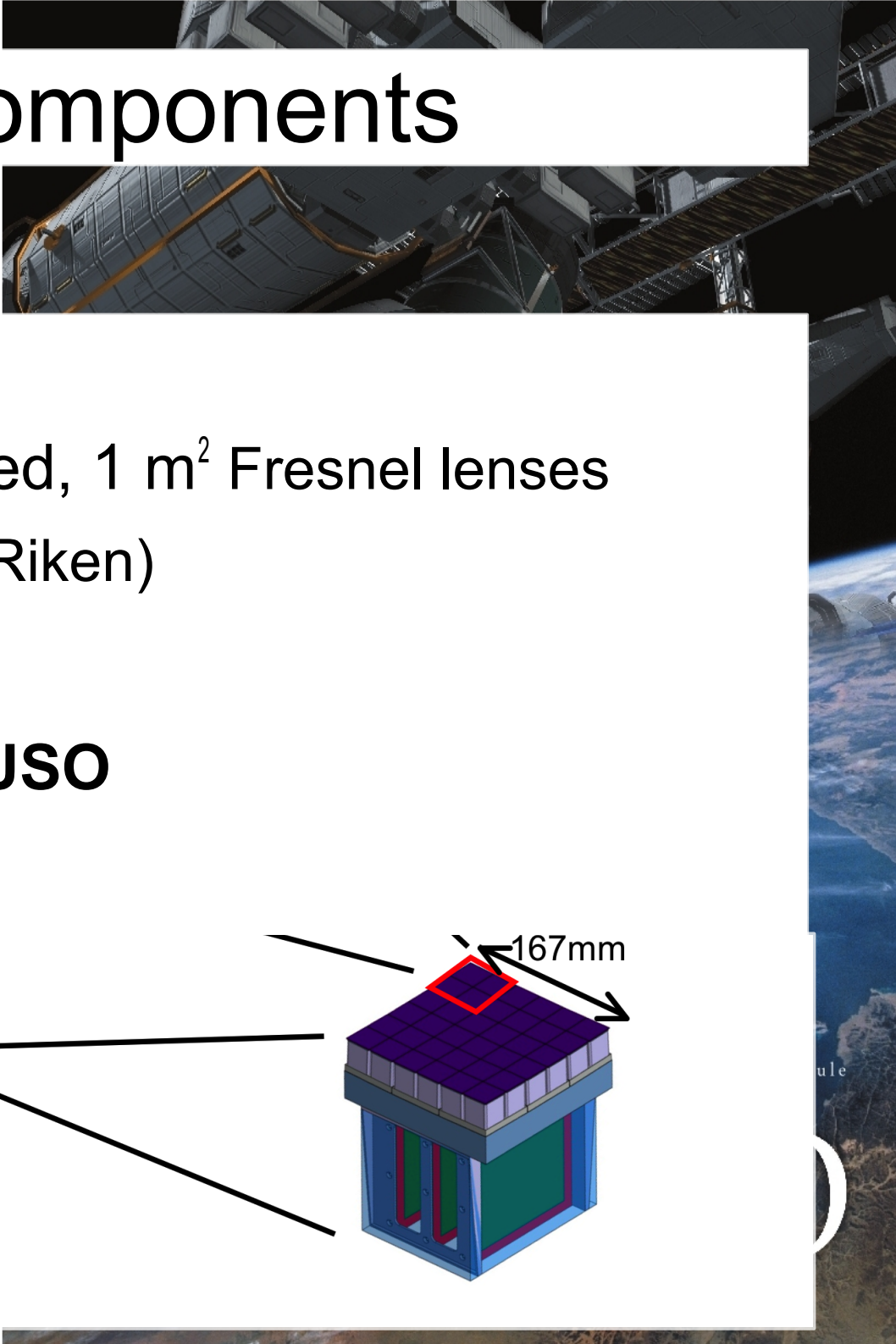
se-Experiment Module

# EUSO Balloon campaign

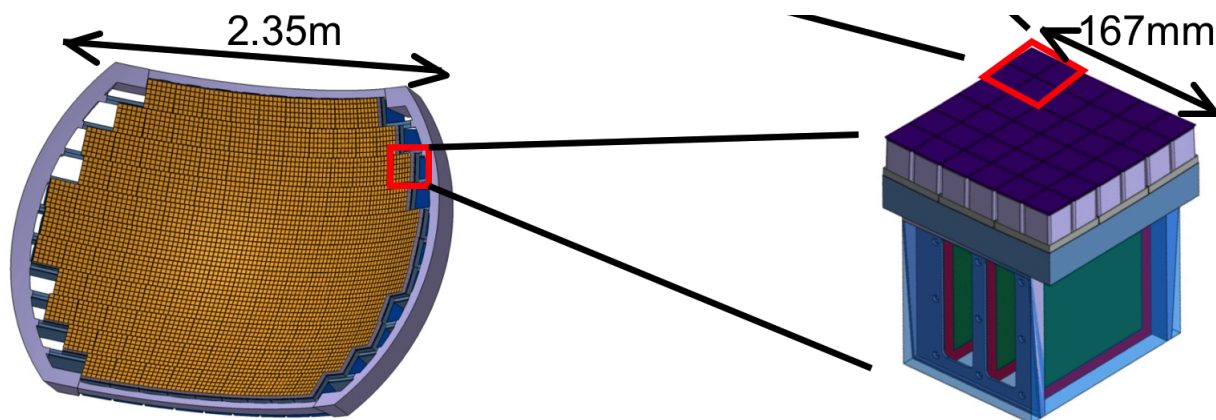
- Led by CNES and the French part of the Collaboration
  - APC and LAL + IRAP (Toulouse)
  - Phase A review 2<sup>nd</sup> February, 2012
    - Success, now in Phase B



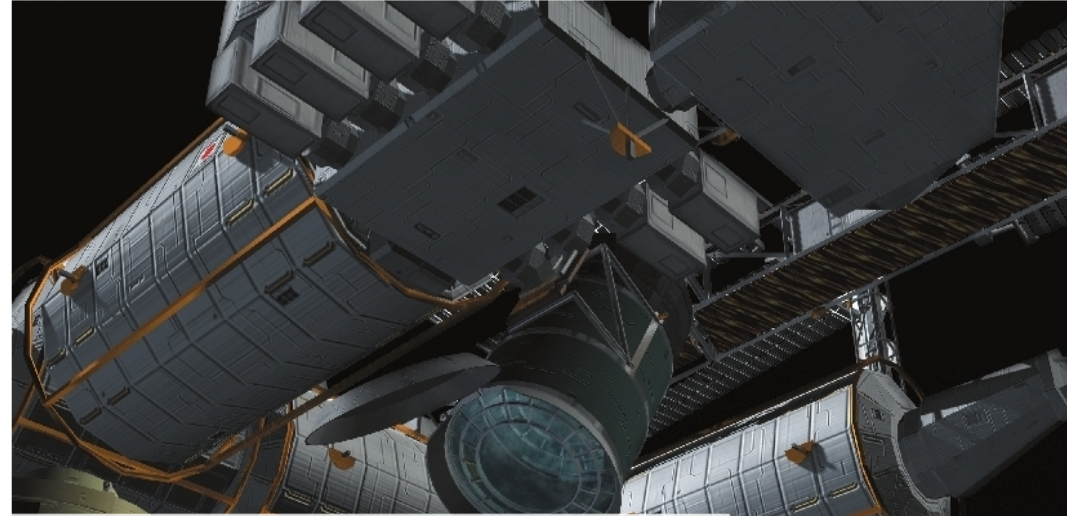
# Balloon Components



- Balloon lenses
  - Simplified, flat, one-sided, 1 m<sup>2</sup> Fresnel lenses
  - Manufactured in Japan (Riken)
- PDM – ASIC
  - **developed for JEM-EUSO**
  - Tested at APC/LAL







- **Then JEM–EUSO in 2017**  
(we hope!)



# Workplan and request to FJPPL

- Key contributions to the EUSO-Balloon
  - LAL: production of EC Units and interface with Hamamatsu PMTs (Japan) and PDM Boards (Korea): paid by CNES, but requires close interactions with Japan and Korea
  - APC: calibration of Japanese PMTs + HV supply and switches + liaison between CNES and Japan for lenses
  - APC and LAL: cross development of ASICs for JEM-EUSO and UFFO (Korean/Russian experiment)
- Request to FJPPL
  - Travel money for key interactions for JEM-EUSO and the Balloon
  - Total: 1950 k¥ (3 trips to Japan + 3 trips to France + 30 days of stay in France)
  - NB: funding from CNES for the Balloon: ~500 kEuros

JEM EUSO

On Behalf of the  
JEM-EUSO  
collaboration,

Thank you for Listening!



Extreme Universe Space Observatory onboard Japanese Experiment Module

JEM-EUSO

# Extra Slides



Extreme Universe Space Observatory onboard Japanese Experiment Module

# JEM-EUSO

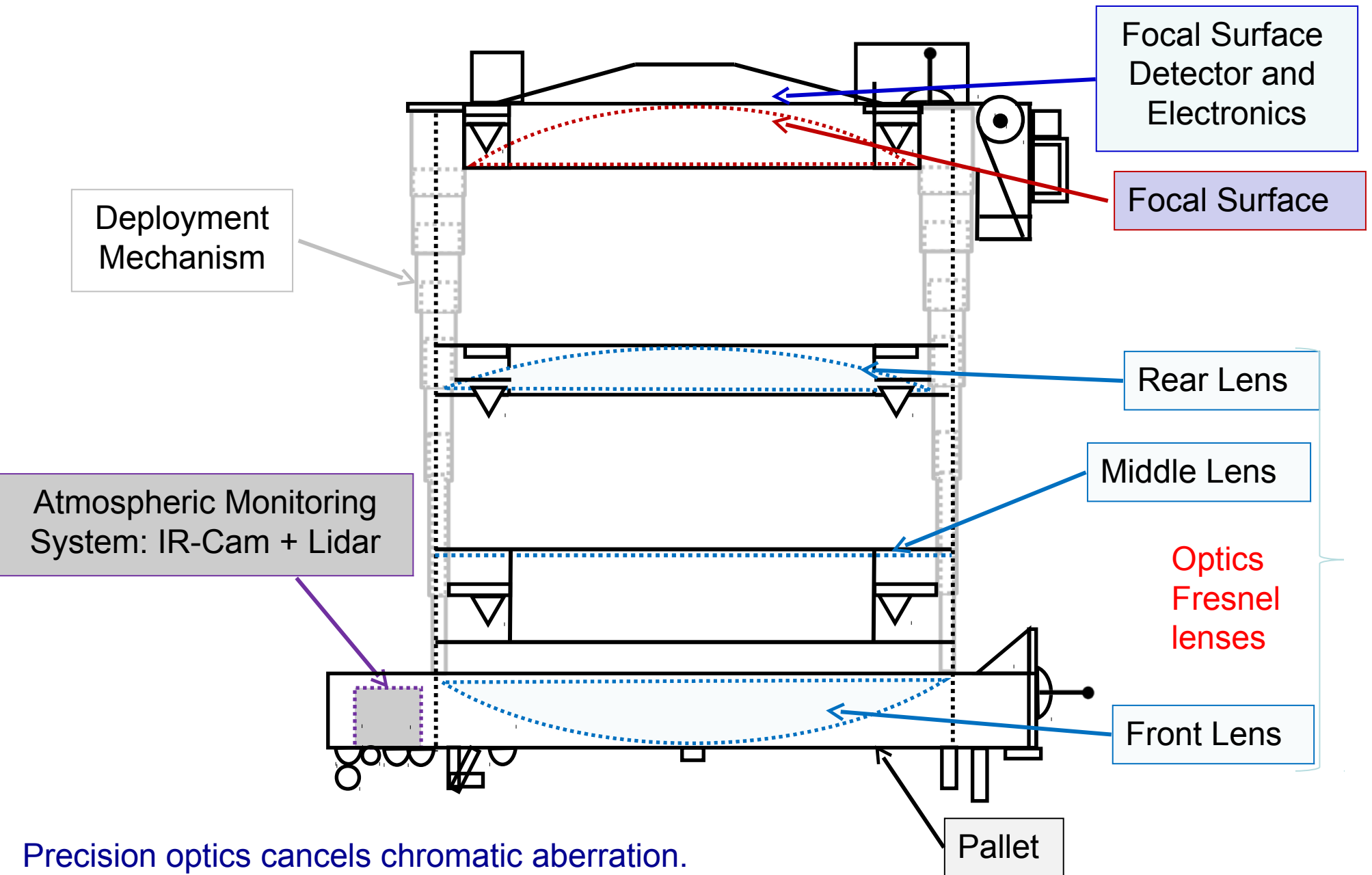
# ***Block Scheme***



Extreme Universe Space Observatory onboard Japanese Experiment Module

# JEM-EUSO

# Science Instrument: deployed

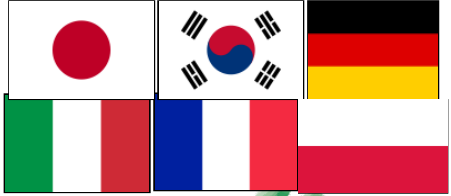


Precision optics cancels chromatic aberration.

Materials: PMMA+CYTOP

# Instrument and International Role Sharing

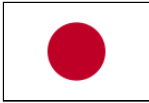
DAQ Electronics



Support Structure



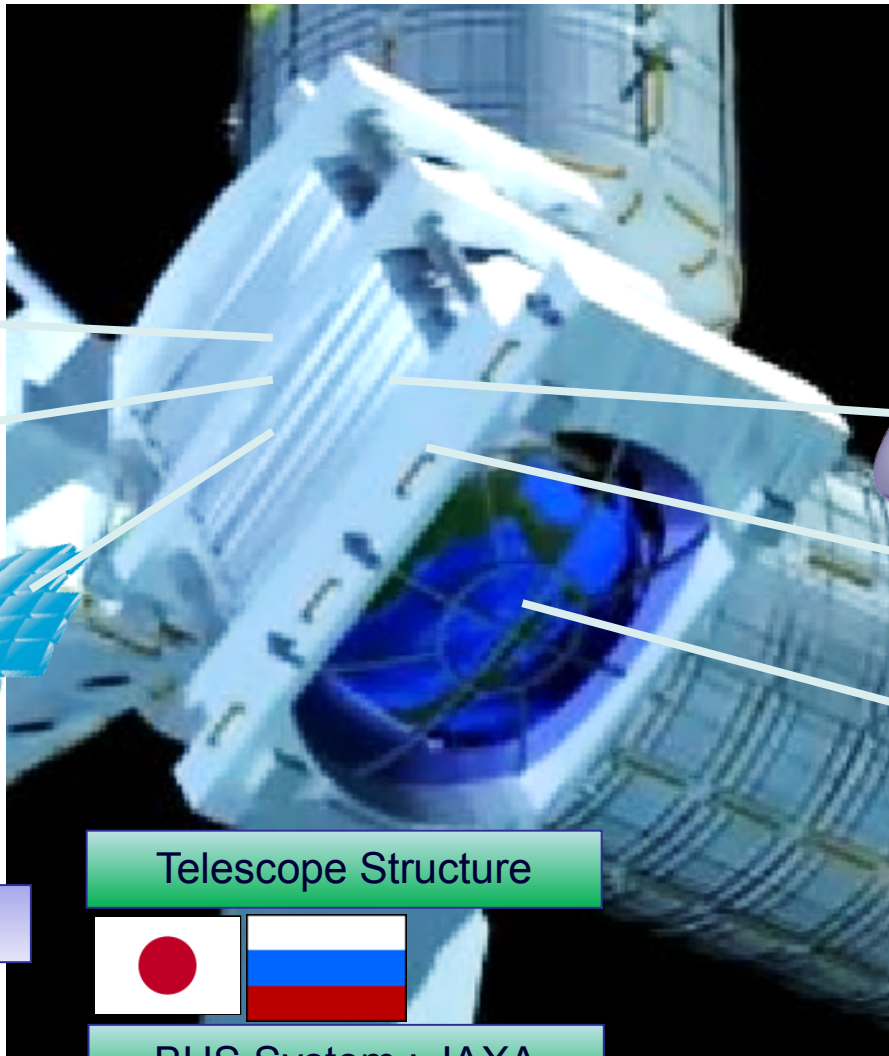
Focal Surface Detector



Housekeeping



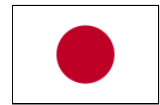
Simulation : Worldwide



Telescope Structure



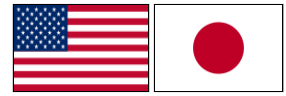
BUS System : JAXA



Atmospheric Monitoring



Optics



Rear Fresnel Lens



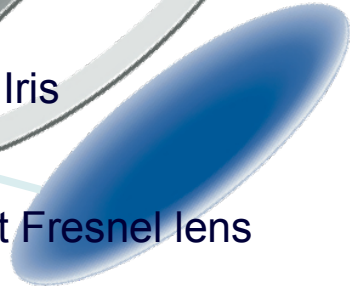
Precision Fresnel lens



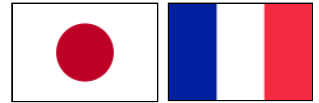
Iris



Front Fresnel lens



On-board Calibration

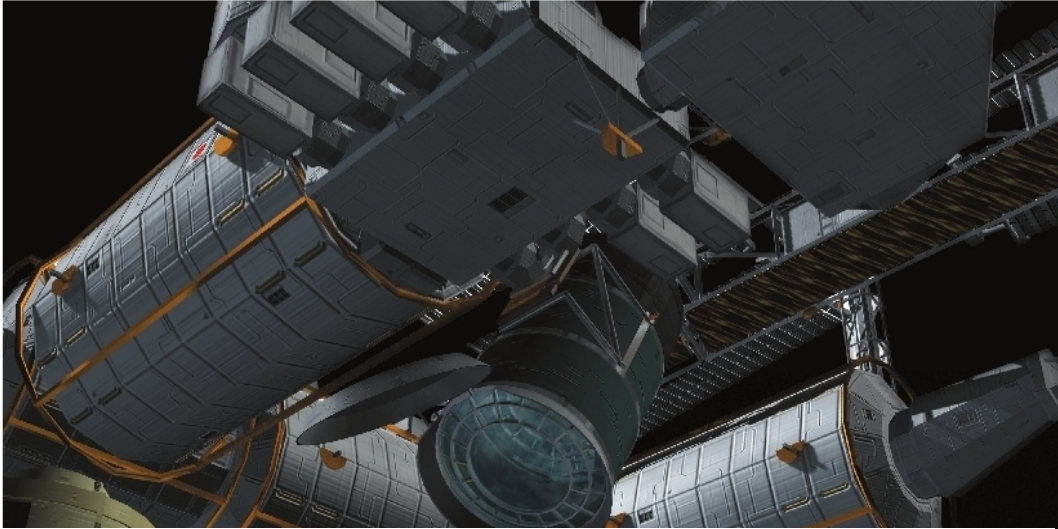


Ground Based Calibration



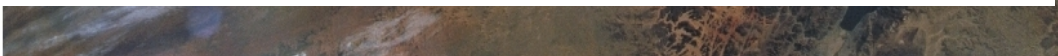
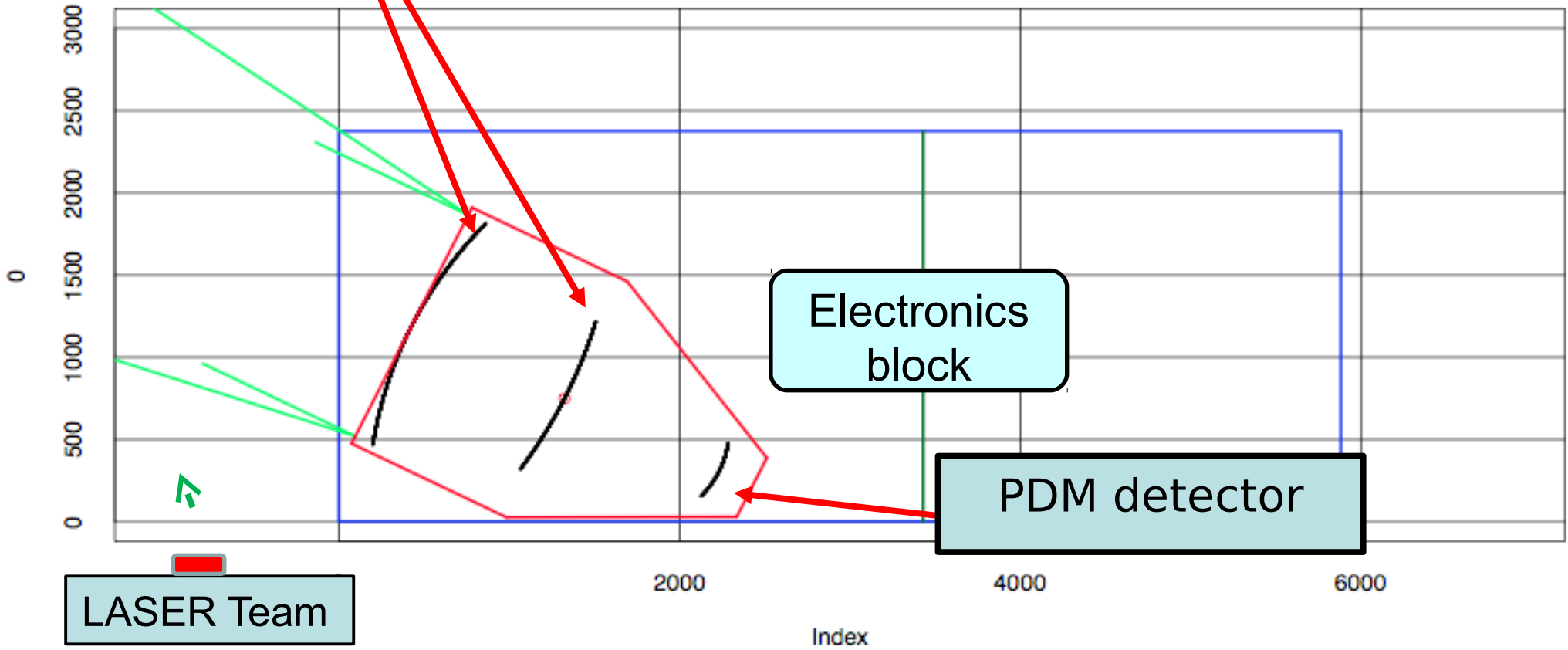
Ground Support Equipment



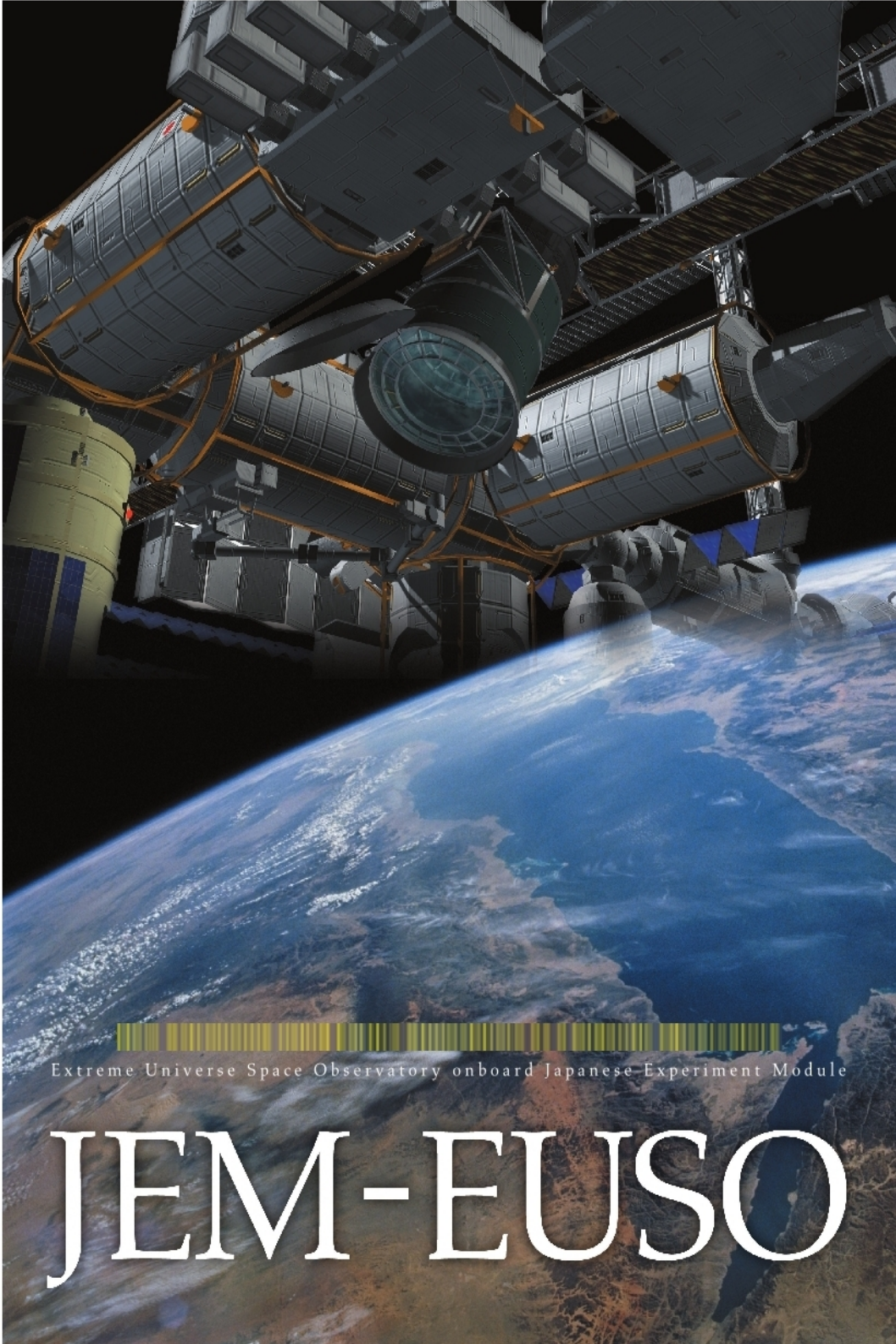


Lenses

Elev. ang = 26.25 deg  
FOV= 16.0 deg







Extreme Universe Space Observatory onboard Japanese Experiment Module

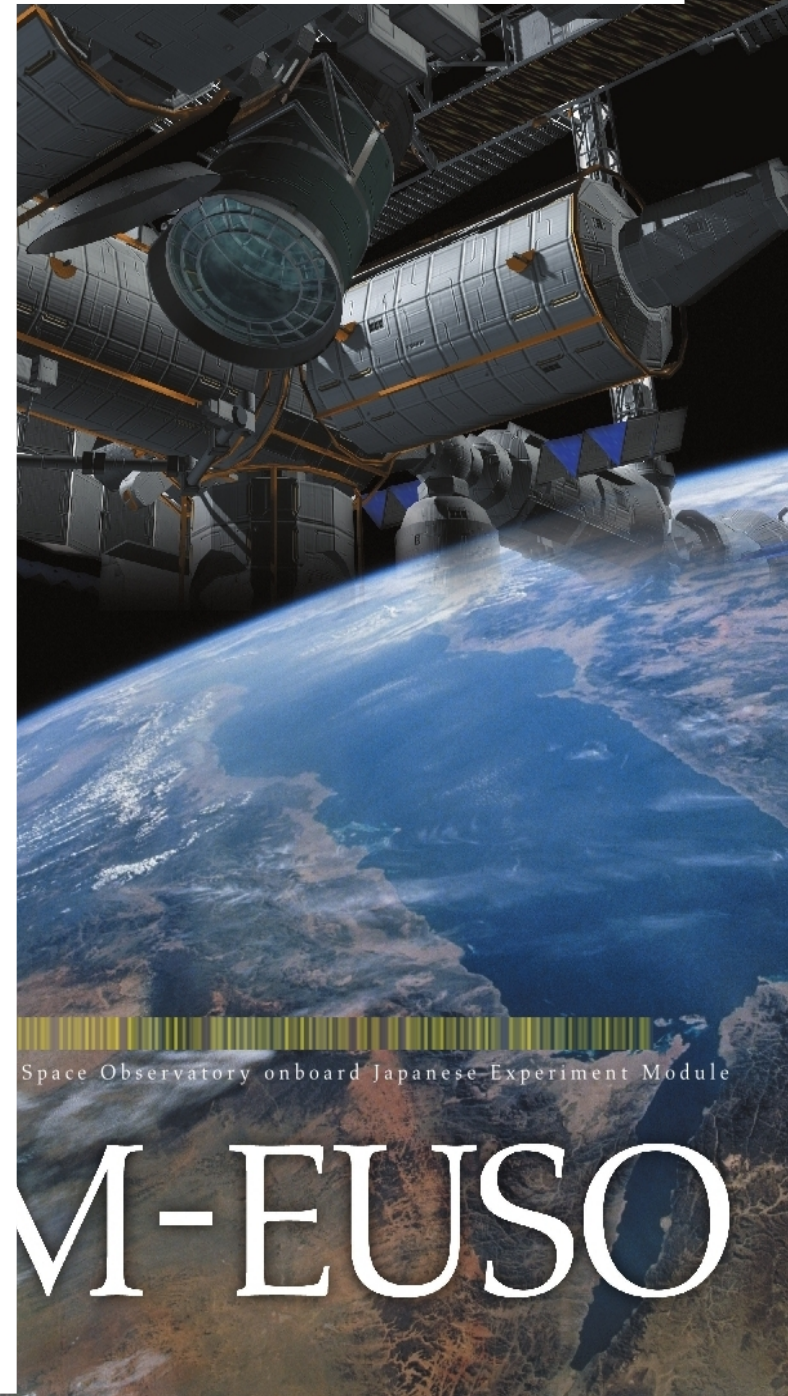
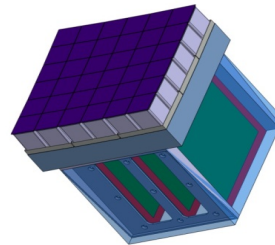
# JEM-EUSO

# ***Objectives of the EUSO system at TA site***

Engineering test of the detector using one PDM and two lens system.

Field calibration with TA FD

- Laser (CLF)
- electron beam (ELS)
- The observation of several showers (10s/yr) in coincidence with TA.

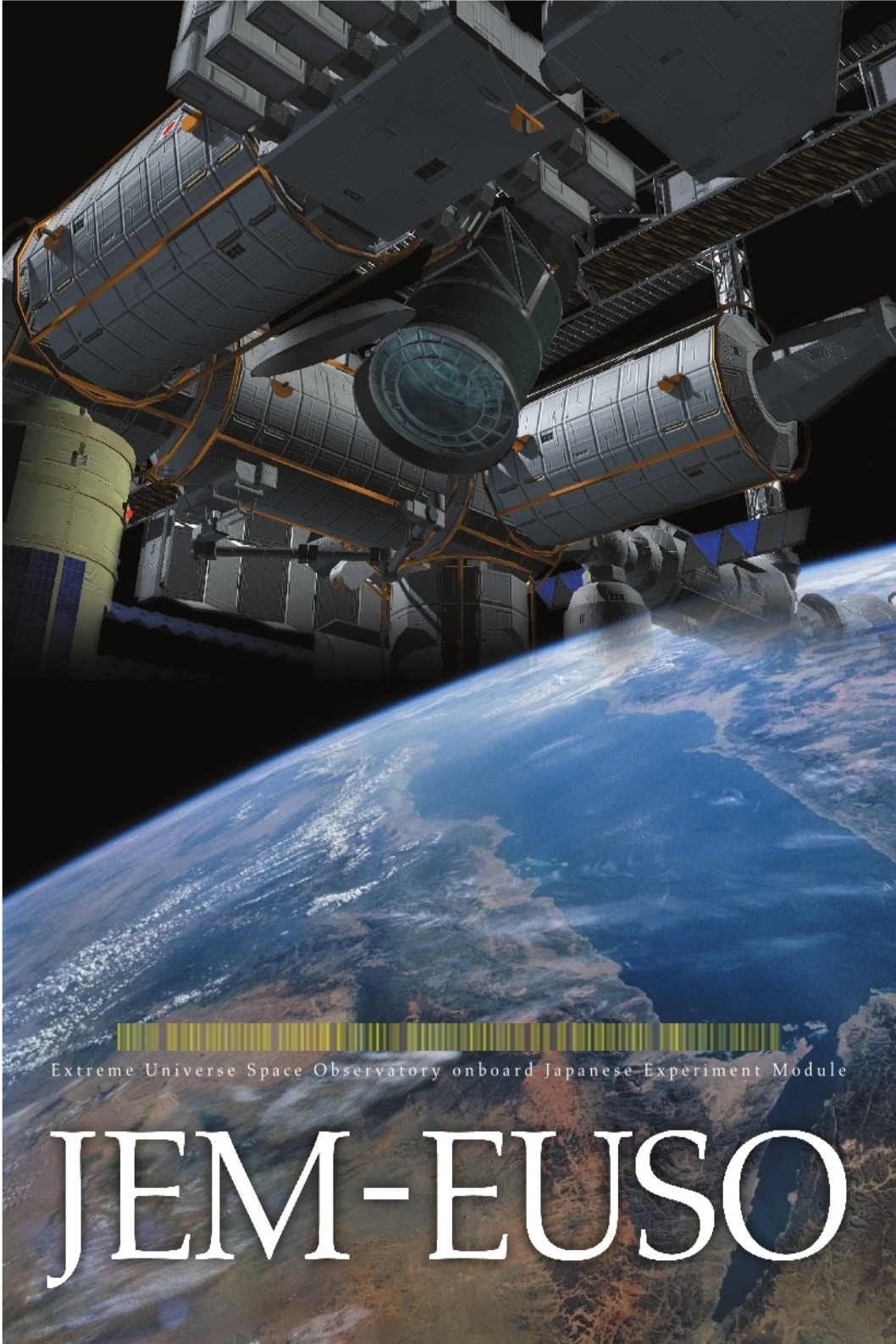


# *Tests and calibration at Telescope Array site, Utah*



ent Module



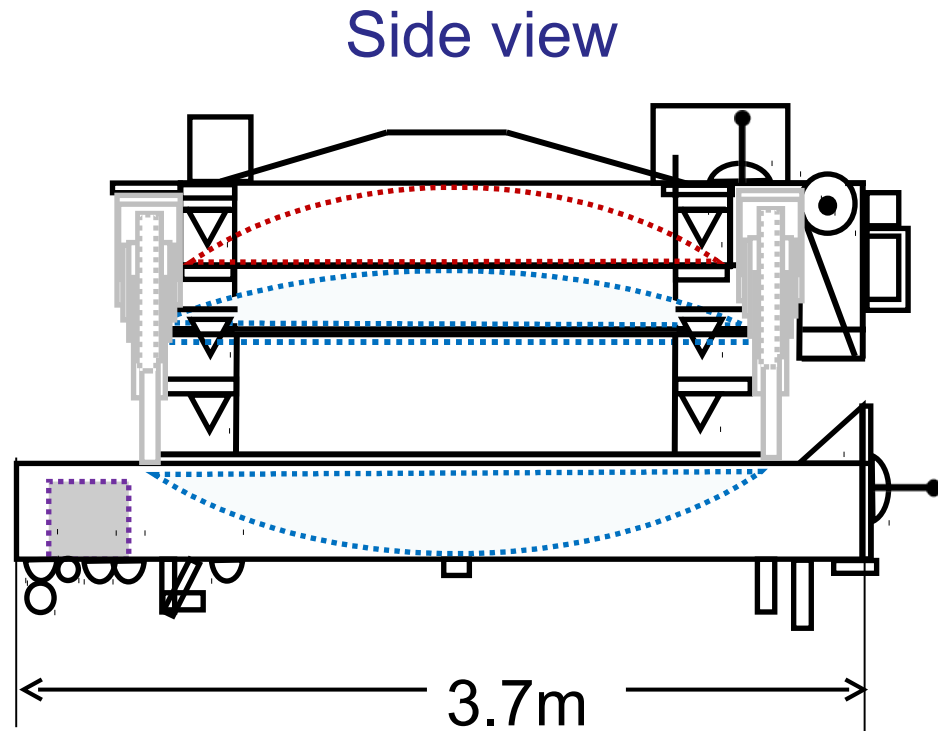
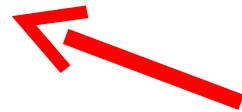


Extreme Universe Space Observatory onboard Japanese Experiment Module

# JEM-EUSO

# Science Instrument on HTV

H2B Transfer  
Vehicle (HTV)



JEM-EUSO Telescope will be deployed after it is attached at the ISS

HTV was successfully launched on September 2009