The JEM-EUSO International program

1. **EUSO-TA:** *Ground detector installed in 2013 at Telescope Array site (Utah): currently operational.*
   Future option for AUGER site

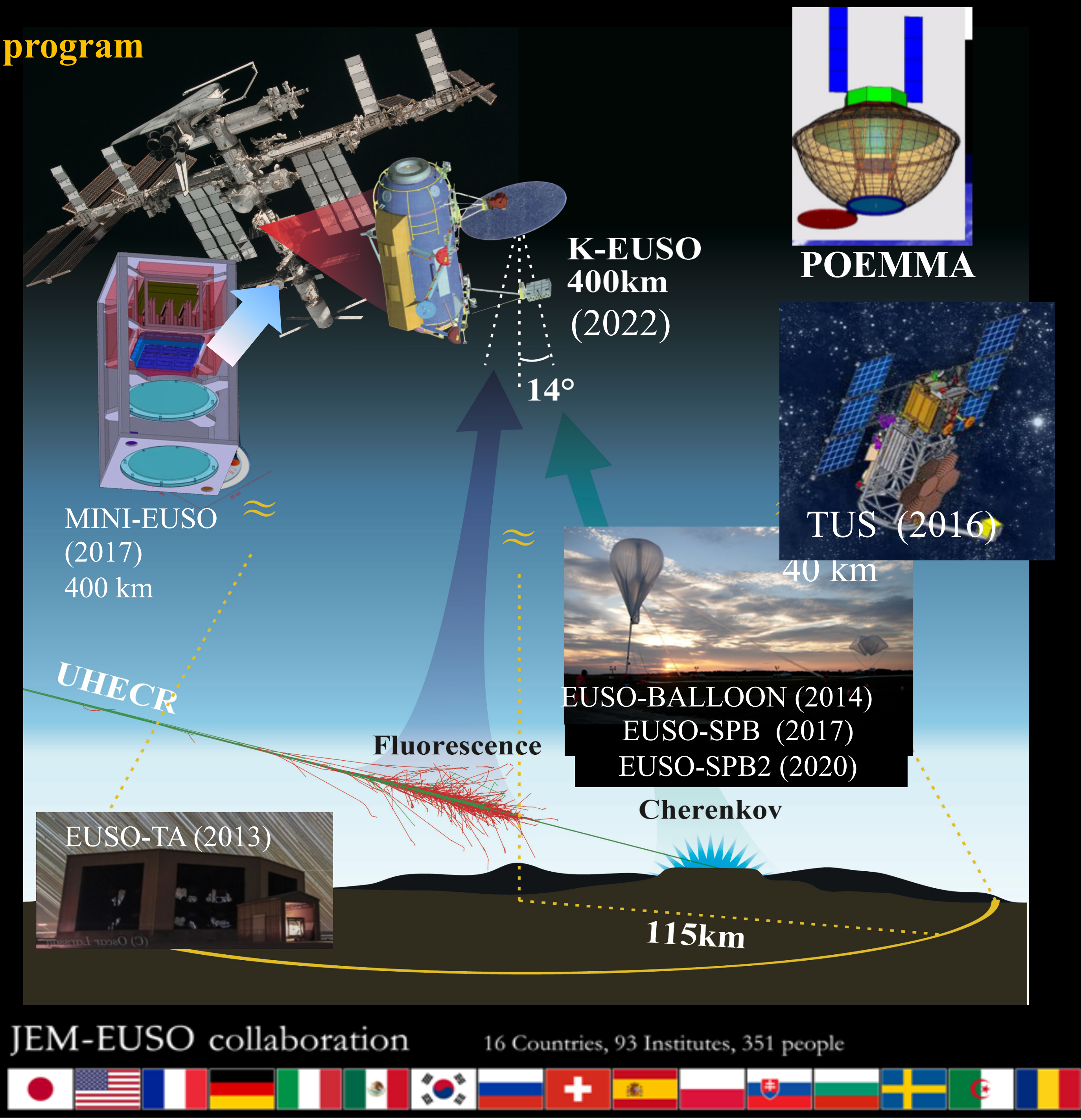
2. **EUSO-BALLOONS:** *1st balloon flight from Timmins, Canada (French Space Agency) Aug 2014; NASA Ultra long duration flight: SPB April 2017; NASA SPB-2 planned for 2022*

3. **TUS (Tracking Ultraviolet Setup)**
   Russia (launched 2016 on Lomonosov satellite)

4. **MINI-EUSO (2019):** *Precursor on International Space Station. Approved by Italian and Russian Space agencies*
   Launch: 22 August 2019

5. **K-EUSO (2022):** *on ISS Approved by Russian Space Agency – Phase A+*

6. **POEMMA (2025+):**
   NASA twin free-Flyer: UHECR and cosmogenic neutrinos
   Probe Of Extreme Multi-Messenger Astrophysics
   Selected as a NASA Study Phase – Proposal/CDR submitted



Sebbene il programma della Collaborazione Internazionale JEM-EUSO prosegua sulle linee appena descritte, la Commissione Scientifica Nazionale II INFN a Settembre 2017 ha deciso, a maggioranza dopo votazione, di chiudere la sigla JEM-EUSO-RD a partire dal 2019.

Tuttavia, le attività, finanziate da ASI e INFN, relative alla missione **Mini-EUSO**, il cui lancio è previsto nell’Estate del 2019, hanno potuto essere regolarmente svolte nel corso di quest’anno, con un supporto INFN approvato in Commissione II.

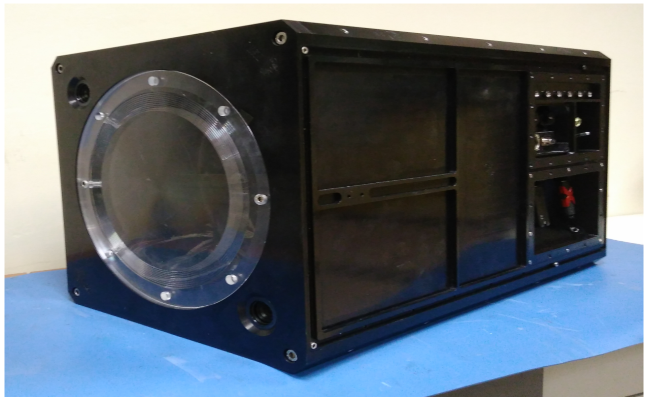
ASI Agenzia Spaziale Italiana

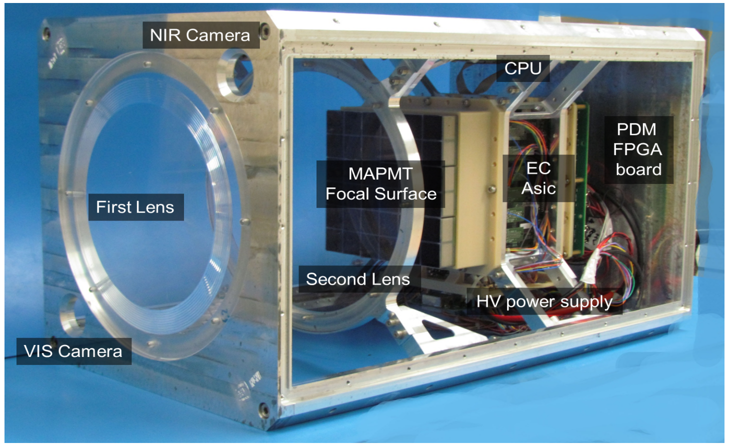
РОСКОСМОС

ЭНЕРГИЯ

INFN Istituto Nazionale di Fisica Nucleare

Aggiornamento Mini-EUSO





Mini-EUSO
Scientific objectives

- UV emissions from night-Earth
- Produce a high-resolution map of the Earth in the UV range (300 – 400) nm

key measurement for next larger missions

FoV 44°x44°

6.5 km resolution, from 2.5μs and above multilevel trigger

Noise from different lightning conditions, moon phase

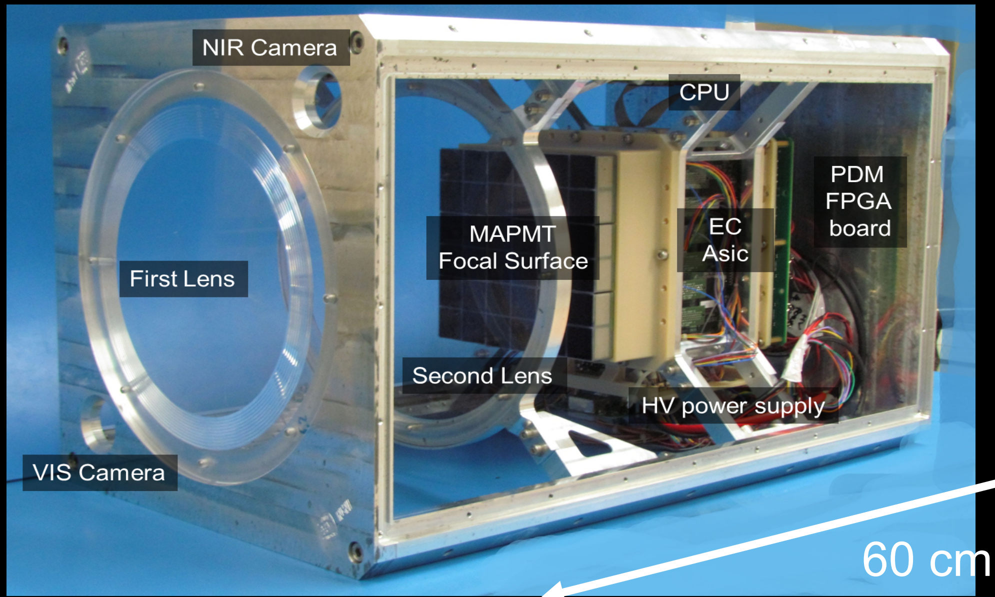
Noise from different inclinations

- *Transient Luminous Events (TLE's)*
- *Meteors and Strange Quark Matter*
- *Bioluminescence*
- *Space Debris Tracking*

The Mission: Mini-EUSO/UV-atmosphere on the International Space Station

- Approved & funded by Italian Space Agency and INFN: “Mini-EUSO”
- Approved & funded by Russian Space Agency Roscosmos: “UV-atmosphere”. Included in the long-term program of space experiments on the ISS
- To be placed in the Russian segment of the ISS at the Nadir looking, UV transparent window
- Launch: 22 August 2019 (Baikonur)

MINI-EUSO detector

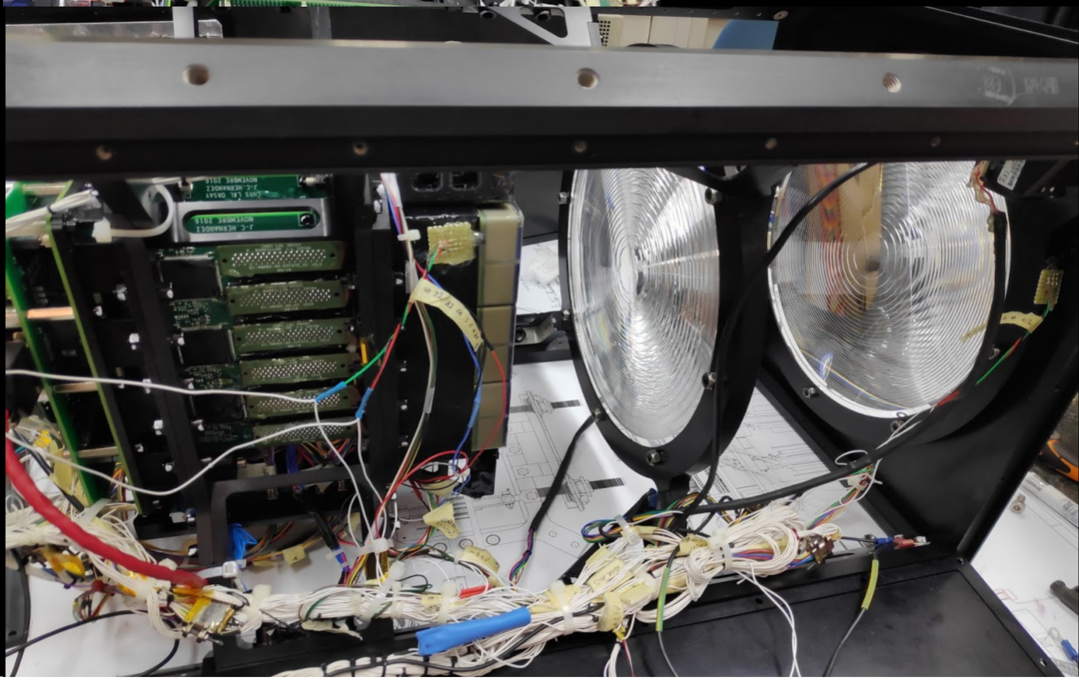


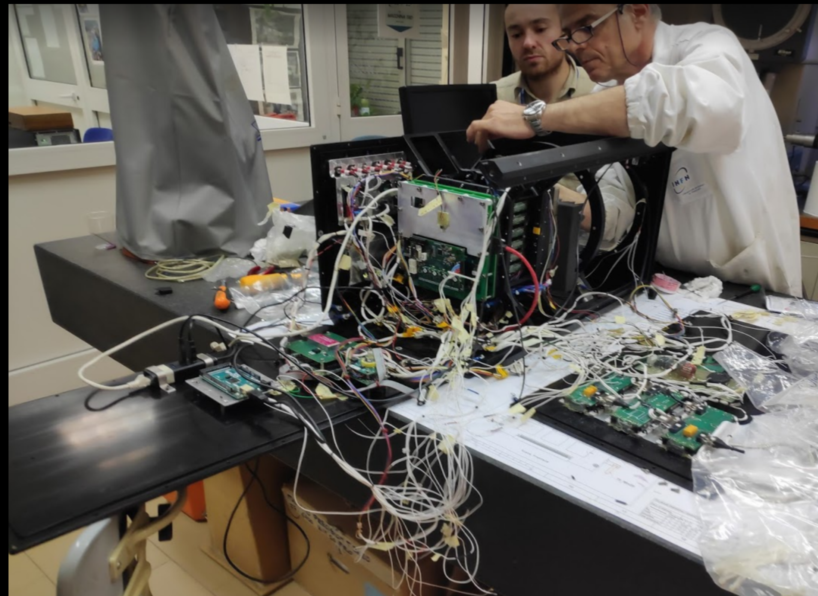
Engineering/Qualification Model
Open structure with main detector items

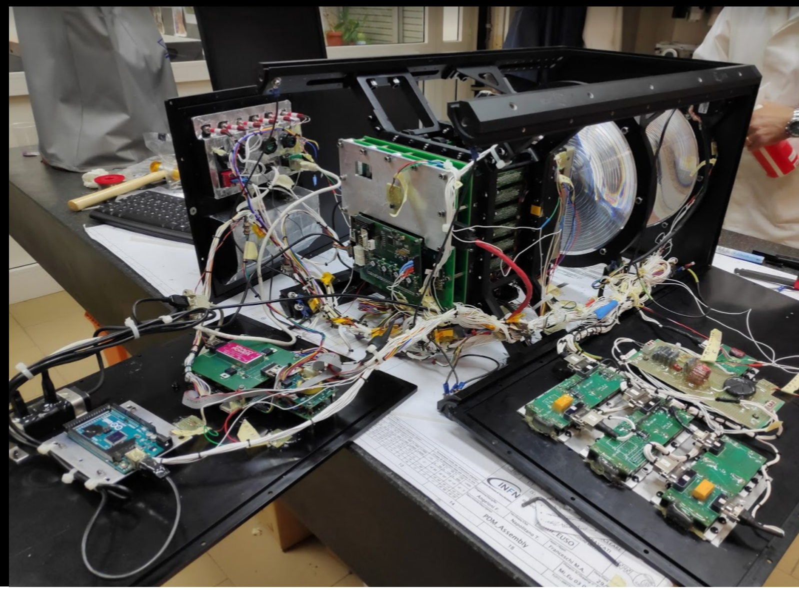
Engineering/Qualification Model
Closed and anodyzed.

Assembled and Integrated @ LNF SPCM

Integration of Flight Model (FM) in INFN Laboratories of Frascati
May 2019

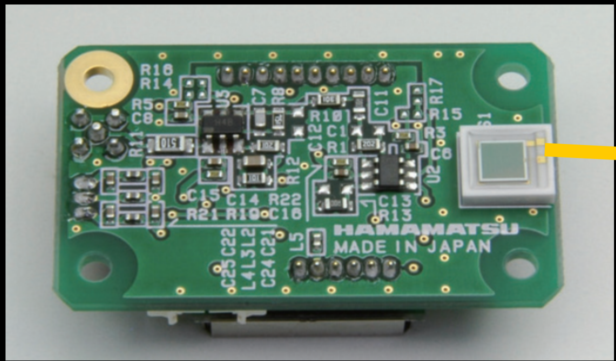






FM closed and integrated

Tests of SiPM in Mini-EUSO

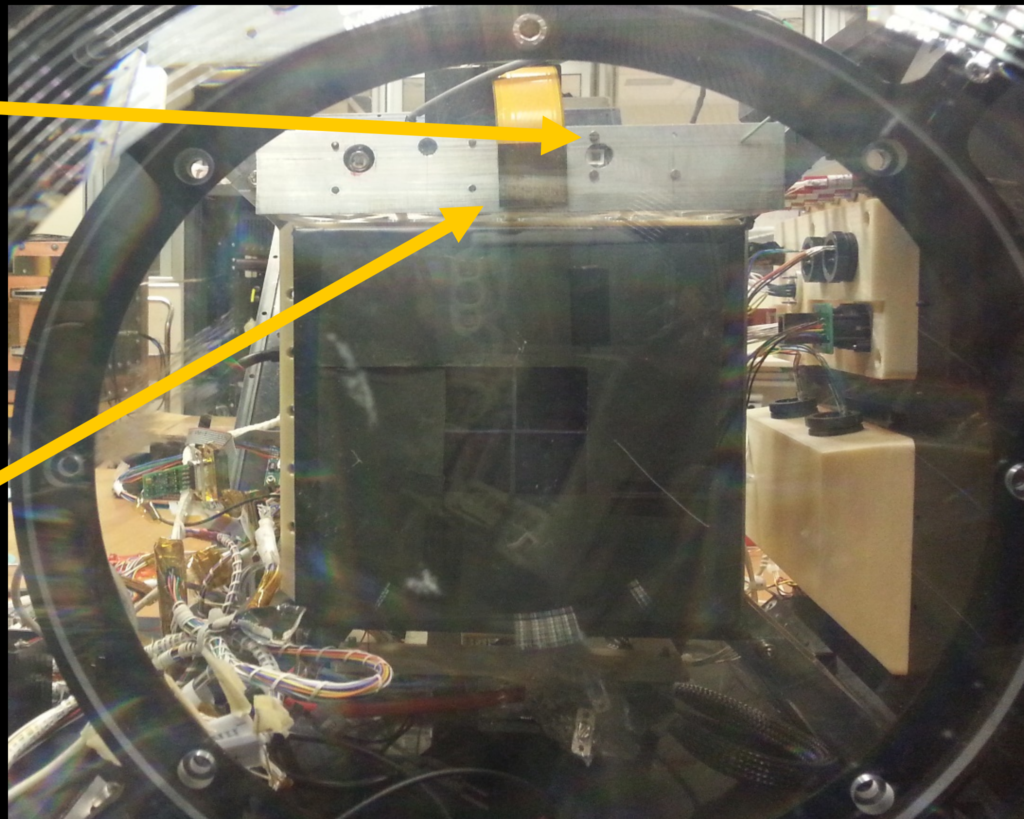


Single SiPm module
Hamamatsu C13365

MPPC C14047-3050EA-08
8×8 ch array

Read independently (asynchronous)

Used in day-night assessment



Xenon flashers as a calibration light source for Mini-EUSO (in collaborazione con l'esperimento GLARE-X di Gr. V)

LAMP

20 W XENON FLASH LAMP

OVERVIEW

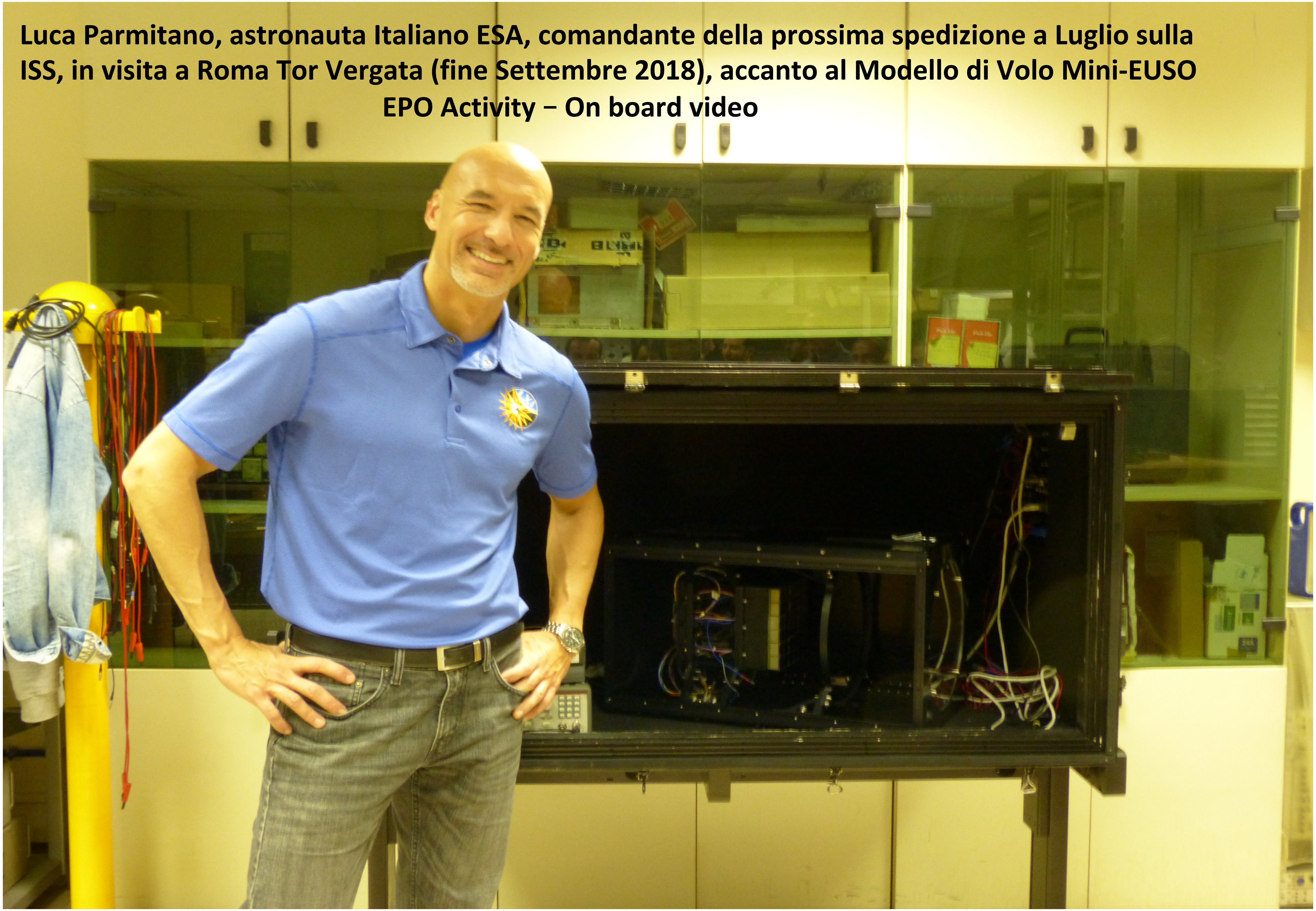
This 20 W xenon flash lamp provides optimal specification as a light source for medical / environmental analysis.
Applied electrodes to this lamp gives highly stable operation even under high voltage input. As a result, exhaustion of electrodes is reduced and high output, stability and long life is provided.

▲L11937

FEATURES

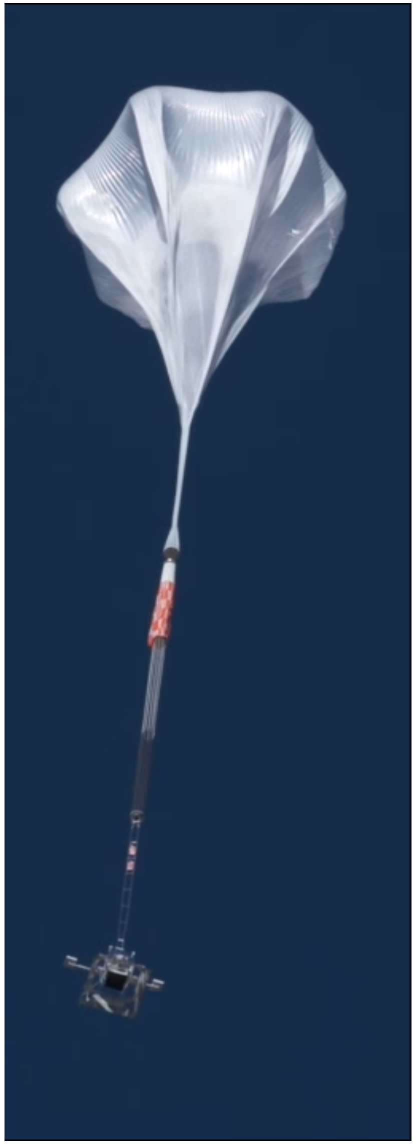
- **High stability: 1.0 % CV Typ.**
- **Long life: 1 × 10^8 flashes**
- **High energy input: 0.5 J** (maximum input energy per flash)
- **Mirror integrated high output type: 1.4 times**

20 W xenon flash lamp + trigger socket + power supply

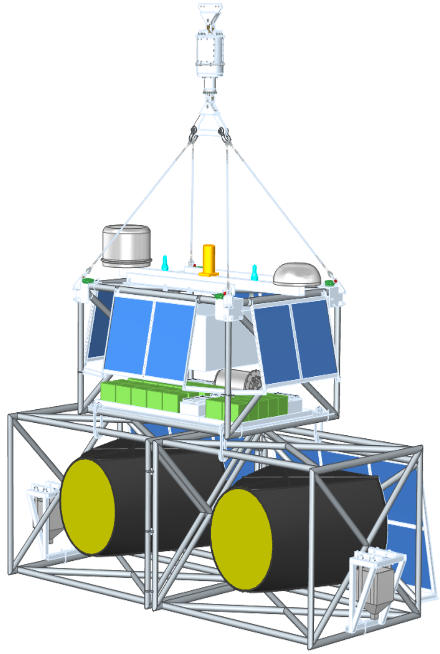


Luca Parmitano, astronauta Italiano ESA, comandante della prossima spedizione a Luglio sulla ISS, in visita a Roma Tor Vergata (fine Settembre 2018), accanto al Modello di Volo Mini-EUSO

EPO Activity − On board video



Proposta di partecipazione italiana alla missione NASA SPB2 Super Pressure Balloon-2

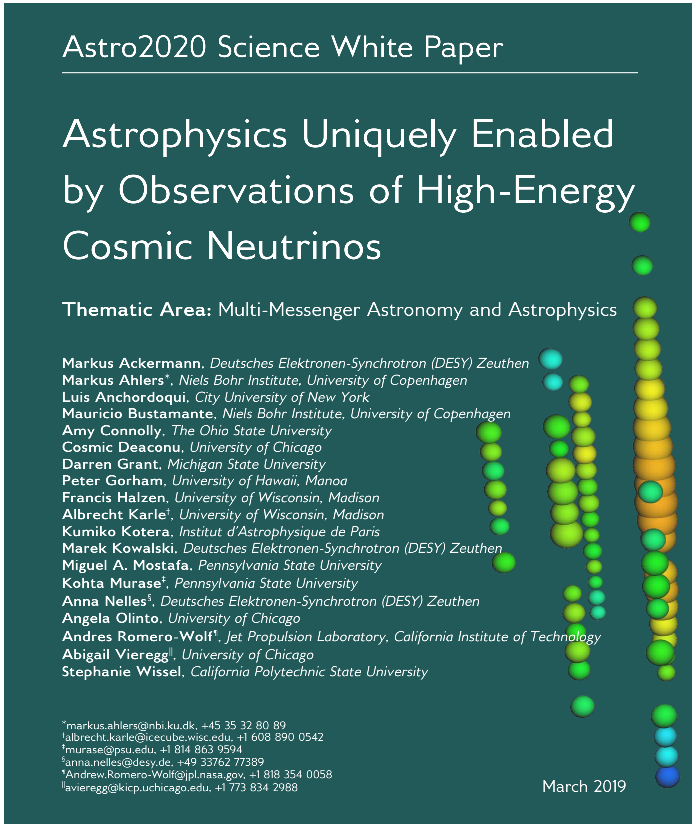


Il contesto scientifico e la strategia (USA-NASA)

1. Obiettivo finale: realizzare una missione spaziale congiunta per lo studio dei neutrini cosmogenici e degli UHECR − EECR (E > 10^{19}-10^{20} eV)
(→ Progetto POEMMA/Decadal survey)

2. Con un volo di pallone di lunga durata (SPB) di seconda generazione e a breve termine, verificare gli obiettivi scientifici e collaudare e validare le opzioni tecnologiche e strumentali.

Astronomy and Astrophysics Decadal Survey



Astro2020 Science White Paper

Astrophysics Uniquely Enabled by Observations of High-Energy Cosmic Neutrinos

Thematic Area: Multi-Messenger Astronomy and Astrophysics

Markus Ackermann, *Deutsches Elektronen-Synchrotron (DESY) Zeuthen*
Markus Ahlers[*], *Niels Bohr Institute, University of Copenhagen*
Luis Anchordoqui, *City University of New York*
Mauricio Bustamante, *Niels Bohr Institute, University of Copenhagen*
Amy Connolly, *The Ohio State University*
Cosmic Deaconu, *University of Chicago*
Darren Grant, *Michigan State University*
Peter Gorham, *University of Hawaii, Manoa*
Francis Halzen, *University of Wisconsin, Madison*
Albrecht Karle[†], *University of Wisconsin, Madison*
Kumiko Kotera, *Institut d'Astrophysique de Paris*
Marek Kowalski, *Deutsches Elektronen-Synchrotron (DESY) Zeuthen*
Miguel A. Mostafa, *Pennsylvania State University*
Kohta Murase[‡], *Pennsylvania State University*
Anna Nelles[§], *Deutsches Elektronen-Synchrotron (DESY) Zeuthen*
Angela Olinto, *University of Chicago*
Andres Romero-Wolf[¶], *Jet Propulsion Laboratory, California Institute of Technology*
Abigail Vieregg[‖], *University of Chicago*
Stephanie Wissel, *California Polytechnic State University*

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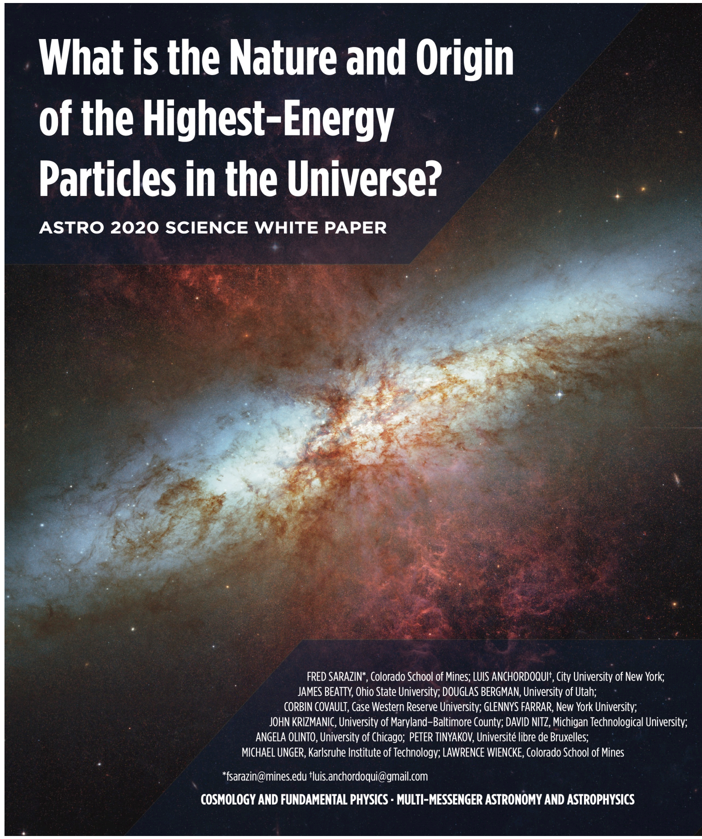
March 2019



What is the Nature and Origin of the Highest-Energy Particles in the Universe?

ASTRO 2020 SCIENCE WHITE PAPER

FRED SARAZIN[*], Colorado School of Mines; LUIS ANCHORDOQUI[†], City University of New York;
JAMES BEATTY, Ohio State University; DOUGLAS BERGMAN, University of Utah;
CORBIN COVAULT, Case Western Reserve University; GLENNYS FARRAR, New York University;
JOHN KRIZMANIC, University of Maryland–Baltimore County; DAVID NITZ, Michigan Technological University;
ANGELA OLINTO, University of Chicago; PETER TINYAKOV, Université libre de Bruxelles;
MICHAEL UNGER, Karlsruhe Institute of Technology; LAWRENCE WIENCKE, Colorado School of Mines

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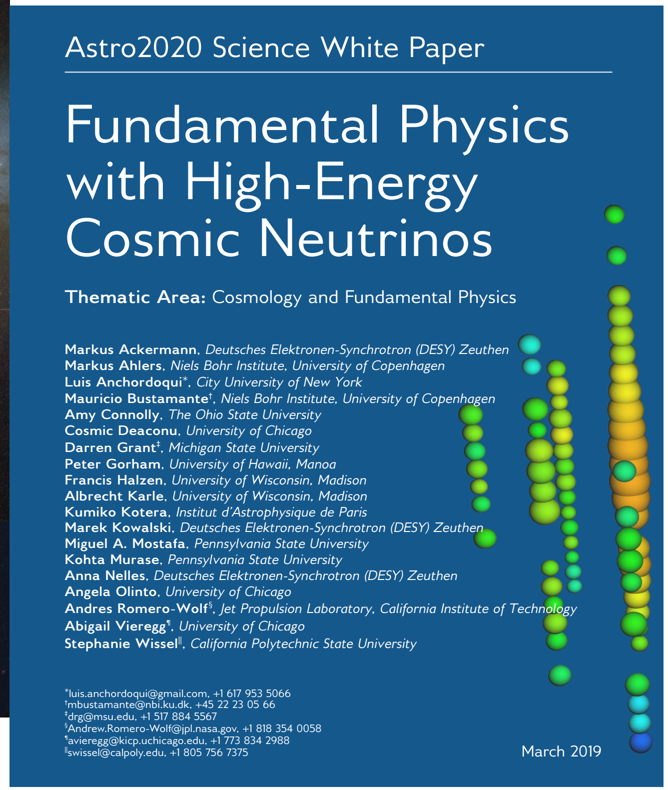
COSMOLOGY AND FUNDAMENTAL PHYSICS · MULTI-MESSENGER ASTRONOMY AND ASTROPHYSICS



Astro2020 Science White Paper

Fundamental Physics with High-Energy Cosmic Neutrinos

Thematic Area: Cosmology and Fundamental Physics

Markus Ackermann, *Deutsches Elektronen-Synchrotron (DESY) Zeuthen*
Markus Ahlers, *Niels Bohr Institute, University of Copenhagen*
Luis Anchordoqui[*], *City University of New York*
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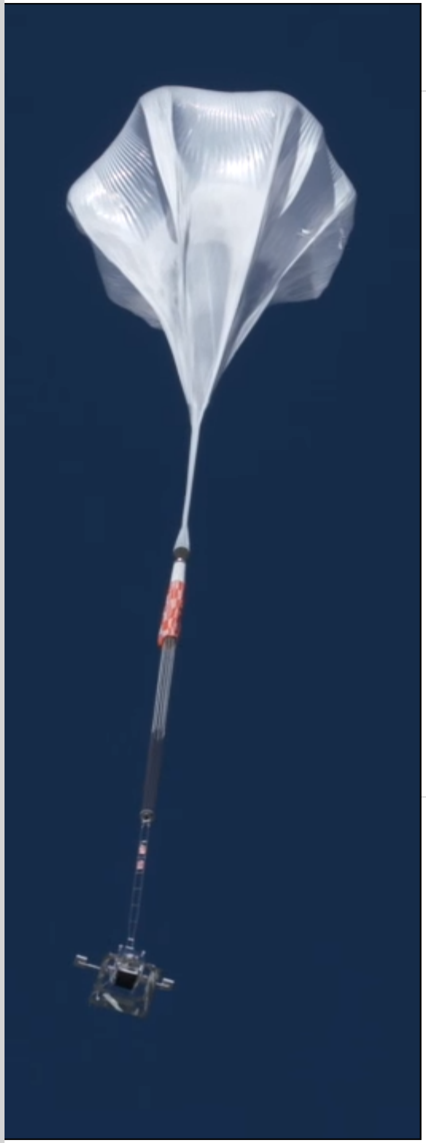
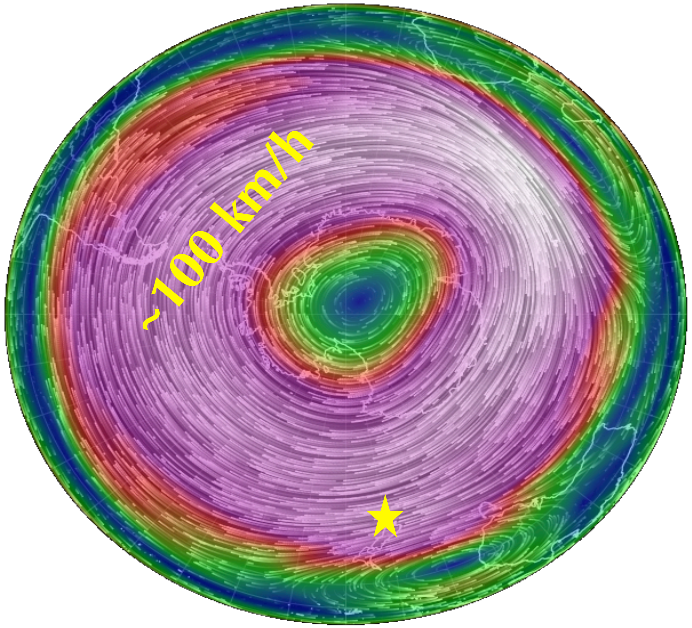
March 2019

NASA's long duration balloon program from New Zealand

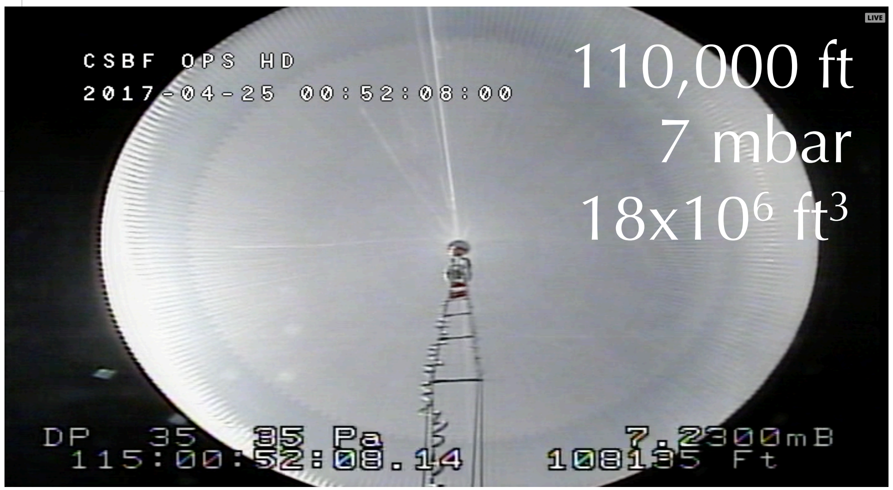


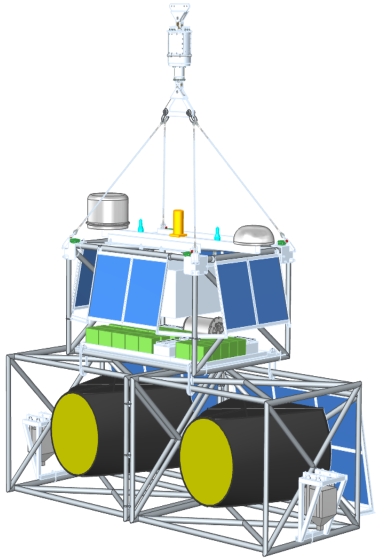
Goal: fly a "Ton of science" with a target flight duration of 100 days



Stable wind pattern around South Pole (March – July)

3 flights since 2015 (including SPB1/2017)

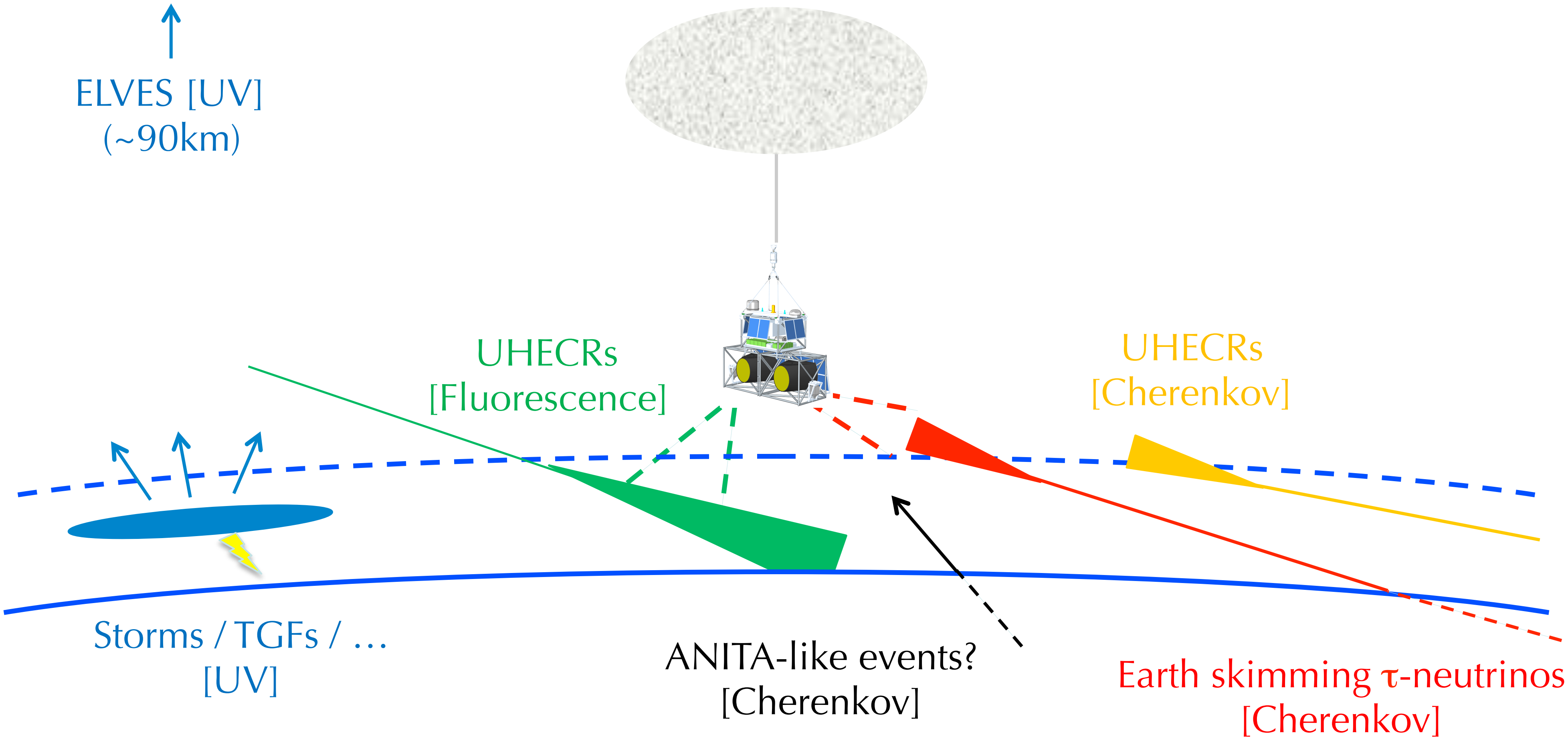




Science Goals of SPB2

- Detect Cherenkov from UHECRs from near space
- Detect Fluorescence emission from UHECRs from near space
- Measure the background for up-going τ decays from cosmogenic neutrinos
- Observe Fluorescence from High Altitude Horizontal Air showers (HAHAs)

SPB2 objectives



Two planned telescopes:

- One Fluorescence [MAPMT-based]
- One Cherenkov [SiPM-based]

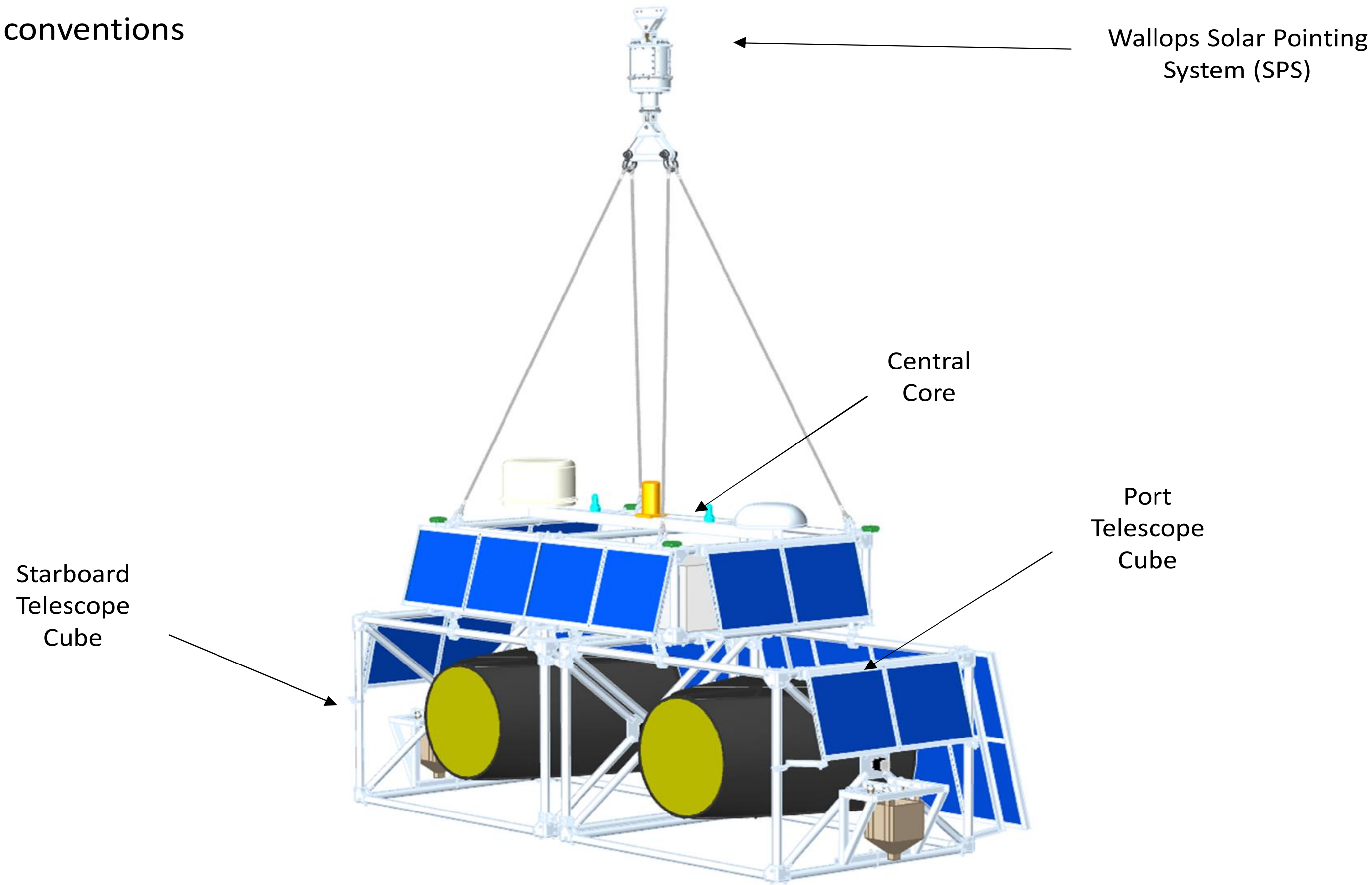
fluorescence event timescale: up to 10's μs

Cherenkov event timescale: ~10ns

SPB2 Two Telescope Horizontal Mount

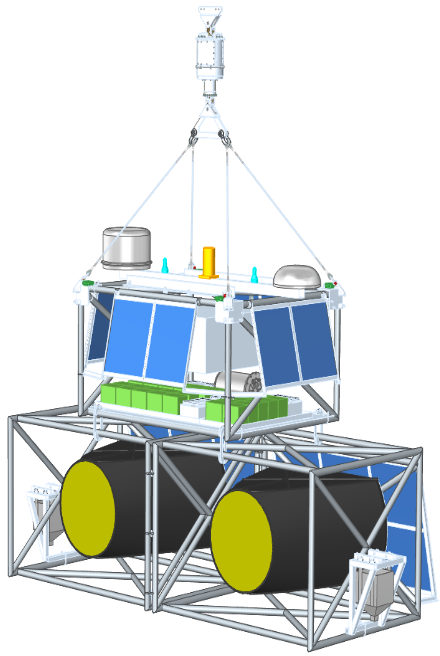
MSFC ES63

Naming conventions



Nov 27, 2018

Proposta alla Commissione II di
Apertura di nuova sigla SPB2



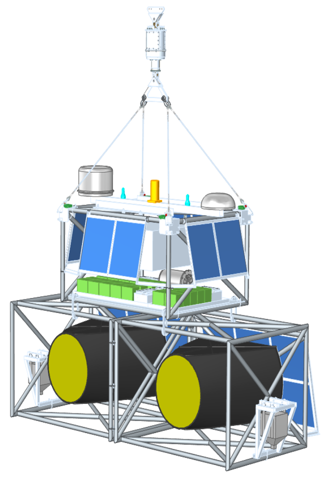
Il Gruppo Italiano proponente

Torino Univ. e INFN (M. Bertaina)
Roma Tor Vergata Univ. e INFN (M. Casolino)
INFN Laboratori Nazionali Frascati (M. Ricci, Resp. Naz.)
Napoli Univ. e INFN (G. Osteria)
Bari Univ. e INFN (F. Cafagna)
Catania Univ. e INFN + gruppo assoc. INAF Palermo (R. Caruso)

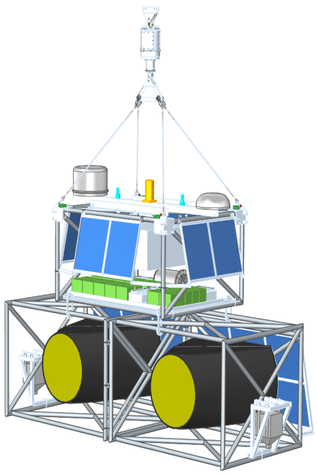
La Collaborazione Internazionale

USA e NASA (MSFC)
Francia
Giappone
Polonia
Russia
Svezia
Slovacchia

Ruolo e Responsabilità del gruppo italiano in SPB2



- Progetto Architettura di sistema per entrambi i telescopi
  - Data Processor/CPU
  - Housekeeping
  - Sistema di basse tensioni
  - Clock-board/Sincronizzazione
  - Telemetria
  - Interfacce tra i sottosistemi
- Trigger di vari livelli
- Simulazioni, Test di laboratorio (TurLab)
- Software di volo e del DAQ
- Possibile centro controllo e raccolta dati (ASI-SSDC)



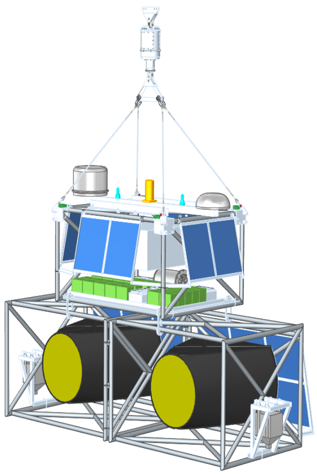
SPB2
Possibili Sinergie – Spin-off tecnologico

ASI – Thales Alenia Space

FBK Trento - Test e qualifica SiPM per lo spazio in condizioni reali e operative. Possibilità di inserire (come per Mini-EUSO) un layer di SiPM nel piano focale del Telescopio Cherenkov con chip (ASIC) dedicato.

Laboratori elettronica nelle Sezioni INFN e Dipartimenti (Torino, Napoli, Catania)

→ Innalzamento del Technological Readiness Level (TRL) dei rivelatori (qualifica spaziale)



SPB2
Tempistica – Milestones

2020 - Costruzione dei due telescopi (assemblaggio e test)
2021 - Integrazione (Prima metà)/Consegna a NASA Payload Integrato
2021 - Ottobre-Novembre: Mission Ready
2022 - Lancio a Primavera (Marzo-Aprile) dalla Nuova Zelanda (Wanaka): durata nominale almeno 30 giorni (da 60 a 100 gg. in condizioni ideali)

SPB2
Costi – Impegno finanziario per l'INFN

- Circa 3-400 kEuro ripartiti tre anni (2020-22)

- Supporto e contributo ASI da definire (contratti esterni → Thales Alenia)

- Costi complessivi missione per USA-NASA ~ 20 M$ (inclusi overhead)

Gruppo LNF:

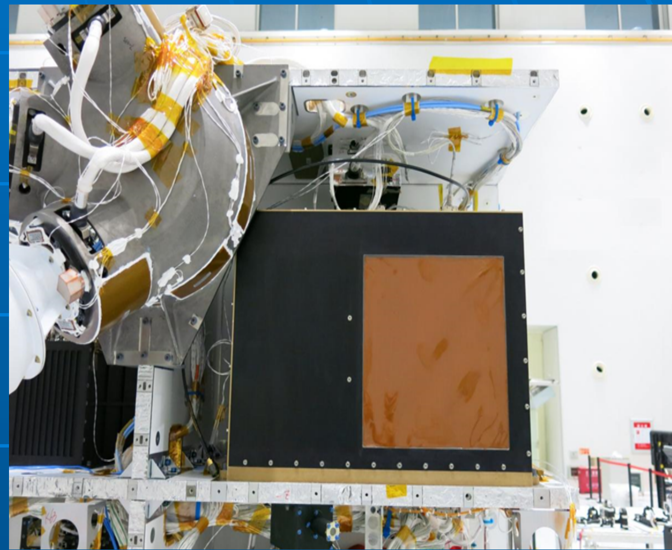
M. Ricci (Resp. Naz. e locale)
F. Ronga
2 ricercatori/tecnologi dell'Università UniNettuno Roma (accordi in corso)

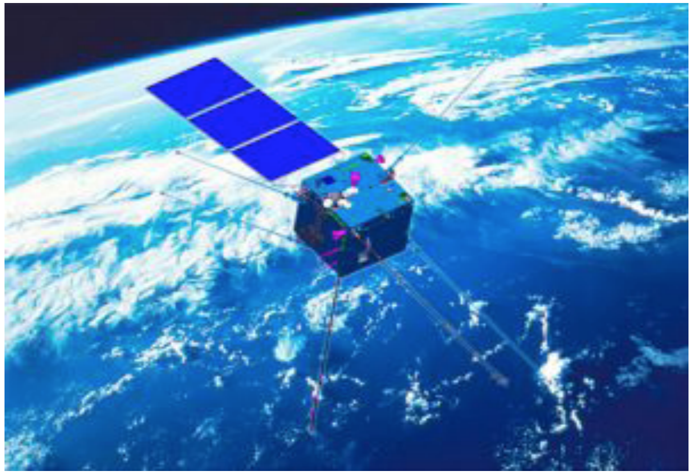
TOT 1.9-2 FTE

Attività 2020: telemetria e controlli; simulazioni e software di volo; interfacce Data Processor (in collaborazione con il gruppo di Napoli); supporto alle fasi di test e integrazione del Payload

Richieste finanziarie specifiche in corso di preparazione

CSES-LIMADOU MISSION





CSES-LIMADOU

Chinese Seismo-Electromagnetic Satellite

ASI INFN INGV project
Chinese National Space Age
China Earthquake Administra

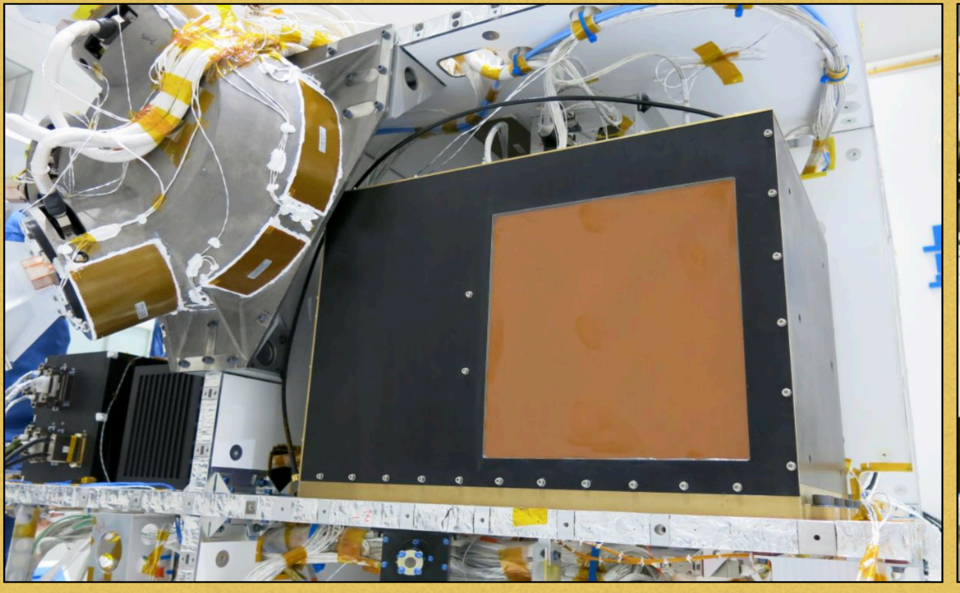
Main Scientific Objectives:
- Measurement from space of magnetospheric perturbations and correlations with seismic phenomena
- Interactions between Magnetosphere, Ionosphere and Earth

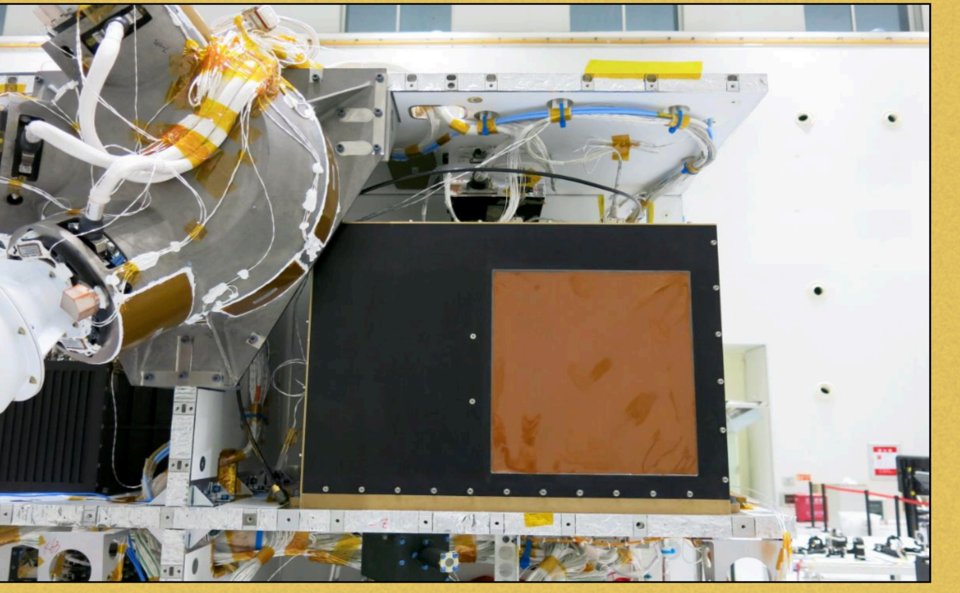
Instruments on board CSES Satellite:
- Magnetic Spectrometer
- Electric Field Detector
- High Energy Particle Detector
- Magnetic Field Detector
- Low-frequency e.m. wave detector

Launched 2 February, 2018

Jiuquan Satellite Launch Center, Gansu (Inner Mongolia)

Bologna
LNF
Perugia
Roma Tor Vergata
Trento
UniNettuno Roma
INGV
INAF/IAPS
IFAC-CNR Firenze





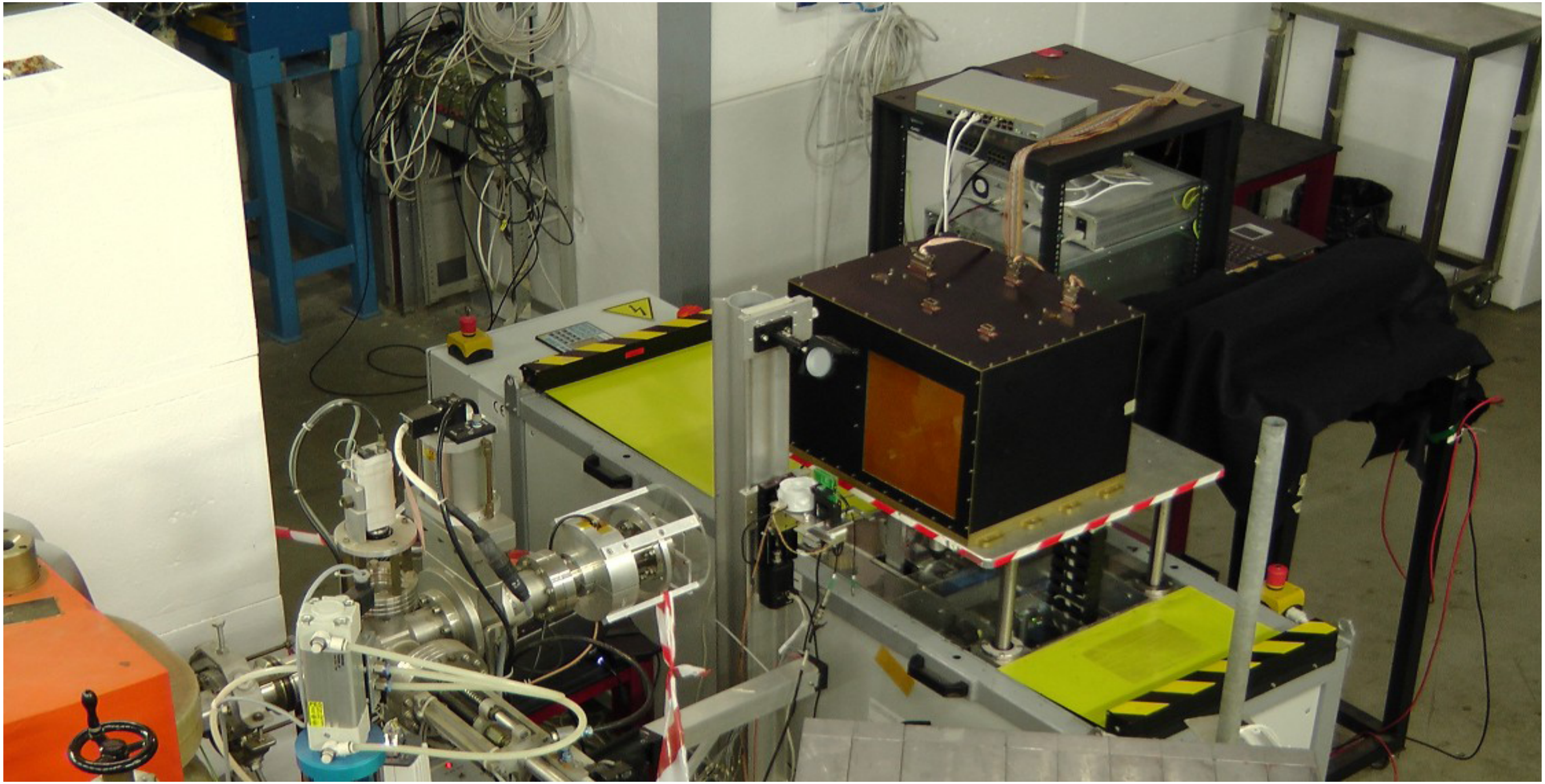
HEPD-FM on CSES Satellite

Parameter	Value
Energy range	Electron: 3-100 MeV
	Proton: 30-200 MeV
Angular resolution	<8°@ 5 MeV
Energy resolution	<10% @ 5 MeV
Particle Identification	>90%
Maximum Omni-directional Flux	10^7 $cm^{-2}s^{-1}sr^{-1}$ (accepted by trigger before pre-scaling)
Operating temperature	-10 °C - + 35 °C
Mass (including electronics)	< 43 kg
Power Consumption	< 43 W
Scientific Data Bus	RS-422
Data Handling Bus	CAN 2.0
Operation mode	Event by Event
Life span	> 5 Years

Main parameters of HEPD

CSES- LIMADOU High Energy Particle Detector (HEPD) Flight Model Electron Beam Test @ BTF, Frascati, 3-5 October 2016

→Energy: 30 MeV, 45 MeV, 60 MeV, 120 MeV



23 MARZO 2019

PROTOCOLLO DI INTESA
TRA
L'AGENZIA SPAZIALE ITALIANA
E
LA CHINA NATIONAL SPACE ADMINISTRATION
SULLA COOPERAZIONE RELATIVA ALLA MISSIONE "CHINA SEISMO-ELECTROMAGNETIC SATELLITE 02" (CSES-02)

Al gruppo italiano è stata affidata la piena responsbilità su:

HEPD-02 (High Energy Paticle Detector)
EFD-02 (Electric Field Detector)

Gruppo LNF:

M.Ricci (Resp.loc.)
B. Spataro
S. Bini (tecnologo)
2 ricercatori/tecnologi dell'Università UniNettuno Roma (accordi in corso)

TOT 1.7-1.8 FTE

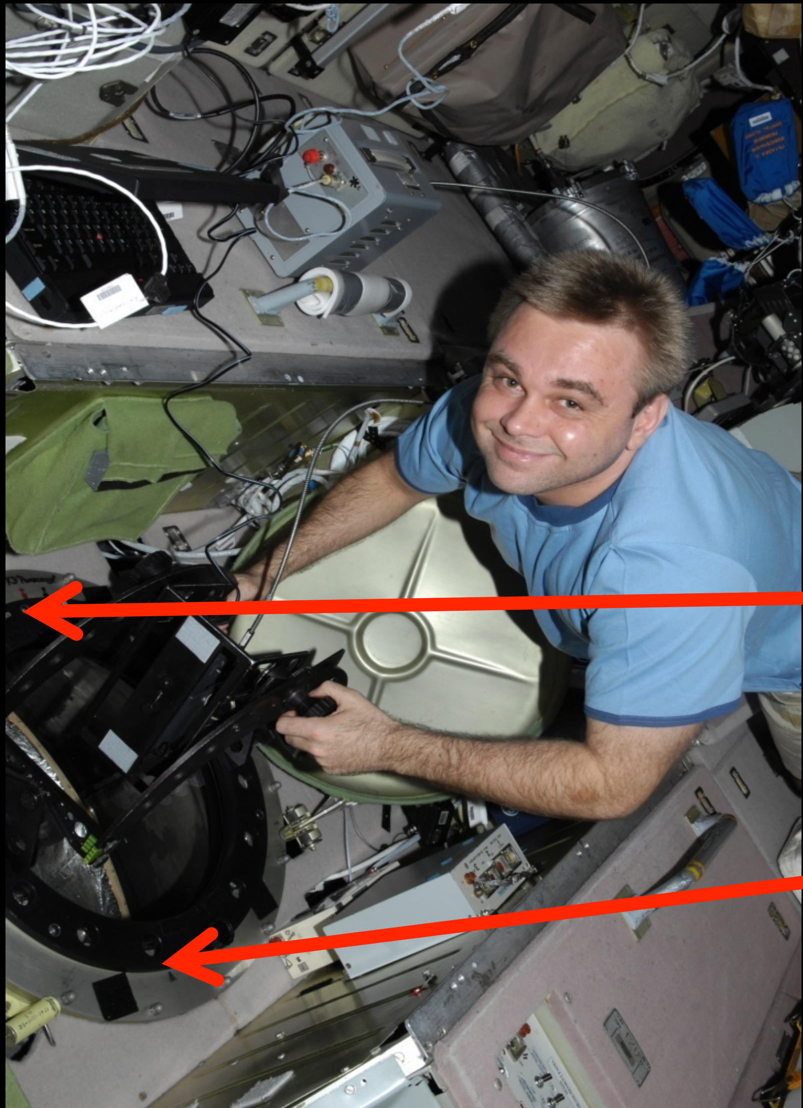
Iniziativa di sviluppo attività nei LNF

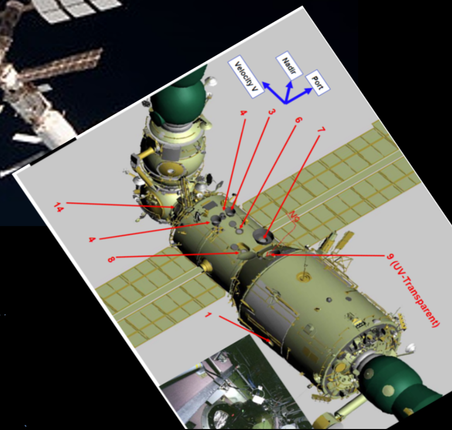
Nell'ambito del programma CSES-02: Attività sul Work Package per HEPD-02 per il sistema generale di alimentazione LVPS del rivelatore.
Progettazione, realizzazione e test nei LNF (Servizio Progettazione Elettronica, Resp. G. Corradi): accordi in corso

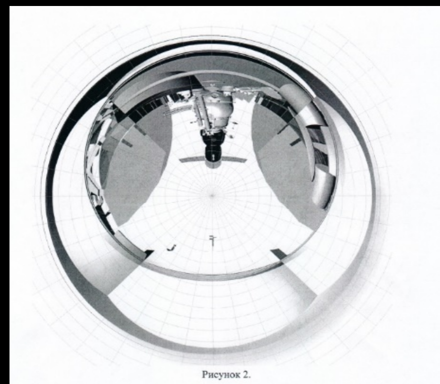
Richieste finanziarie specifiche in corso di preparazione

Backup Slides

Uv transparent window, Zvezda module





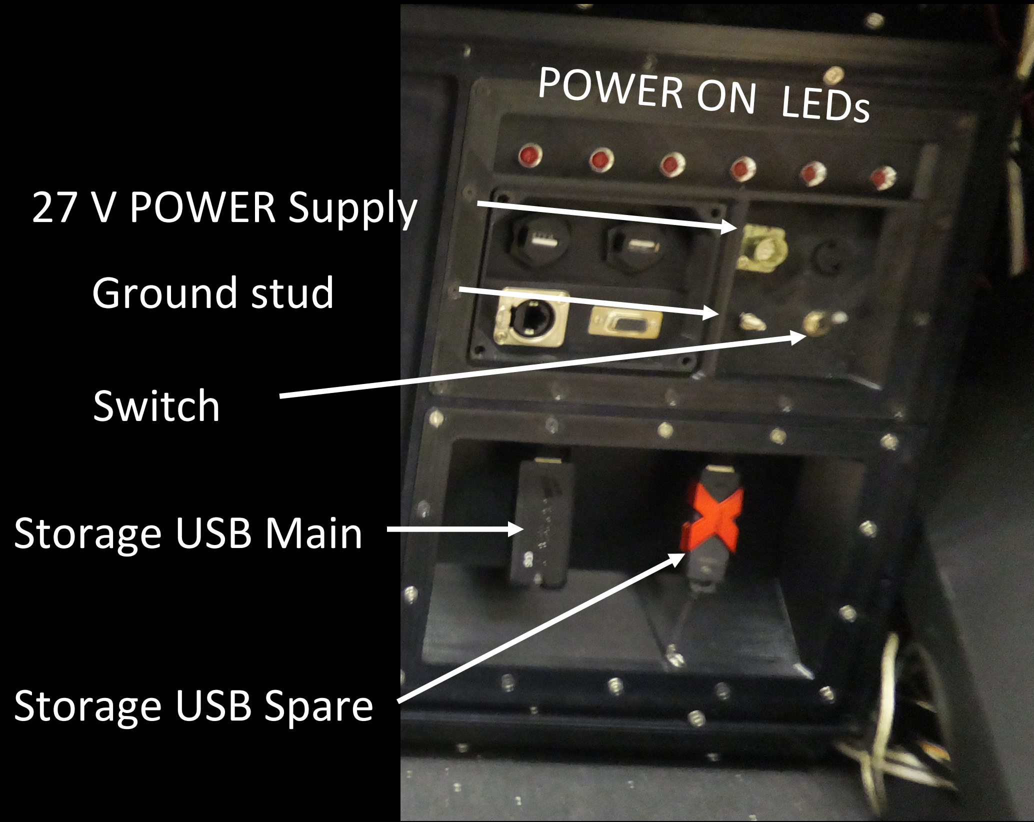


Field of view from window

Mini-EUSO Operations

START
- Connect 27V power supply
- Connect grounding cable
- Insert empty USB stick
- Turn on switch

STOP
- Turn off switch
- Remove and store USB stick
- Periodically copy selected files on station computer for later downlink



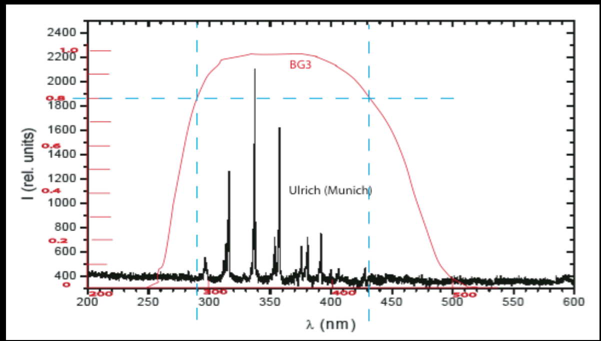
Mini-EUSO control panel
Unmarked connectors are not used in flight

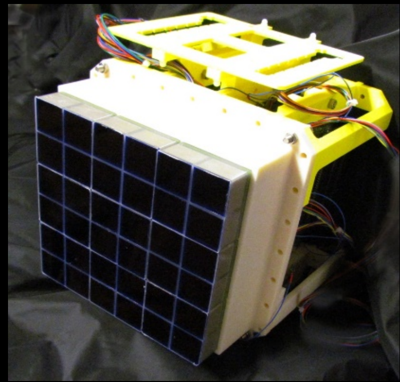
Additional ops include latch/unlatch of instrument
In case of Sunday science, possibility to analyze data

Sensors

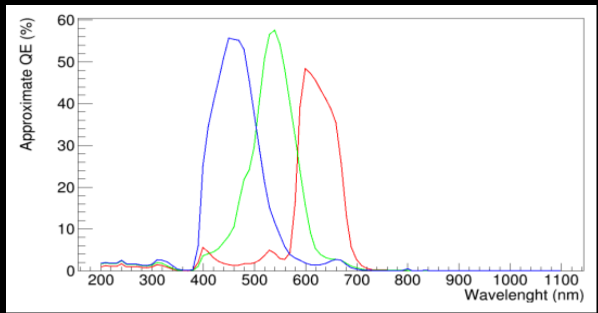
East Japan and Tokyo bay

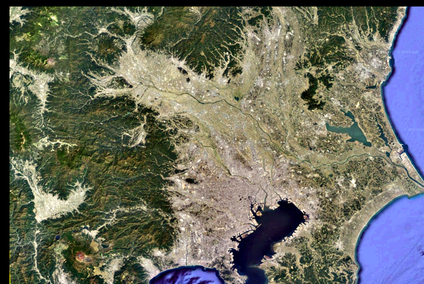
UV main camera
48*48 pixels
40 deg 243km 5km/pix
2.5mus and above



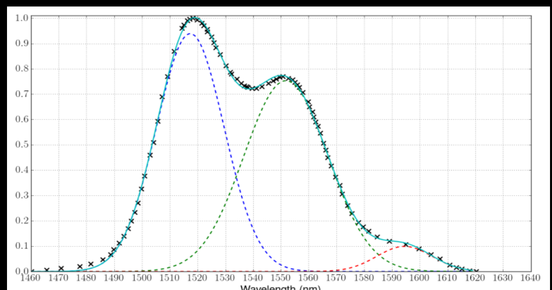


RGB camera
1280*960 pixels
33.2*24.8 degrees
231*174 km 180 m/pixel
1s

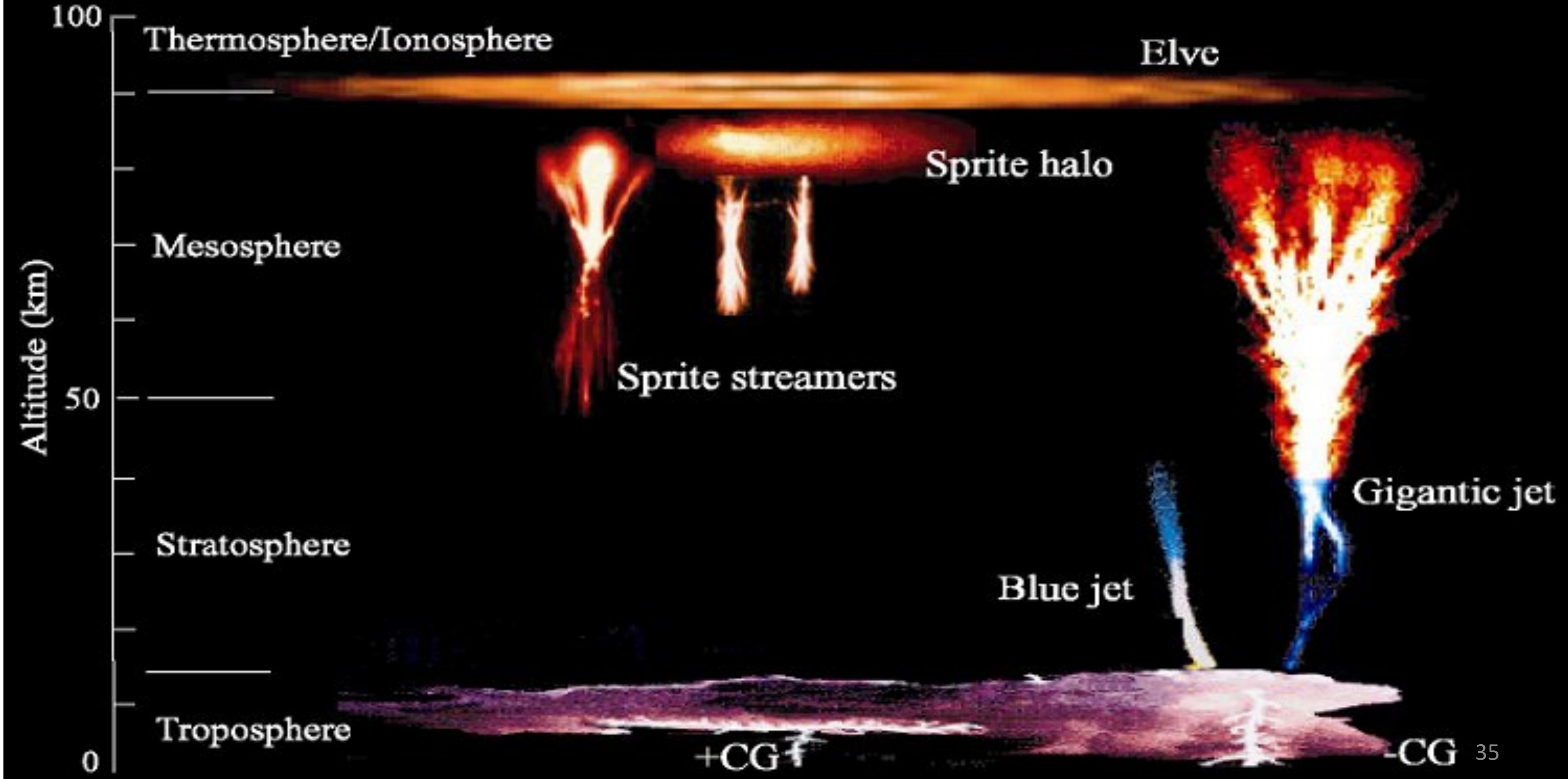




NIR camera
(BW with phosphor coating)
1280*960 pixels
33.2*24.8 degrees
231*174 km 180 m/pixel
4s



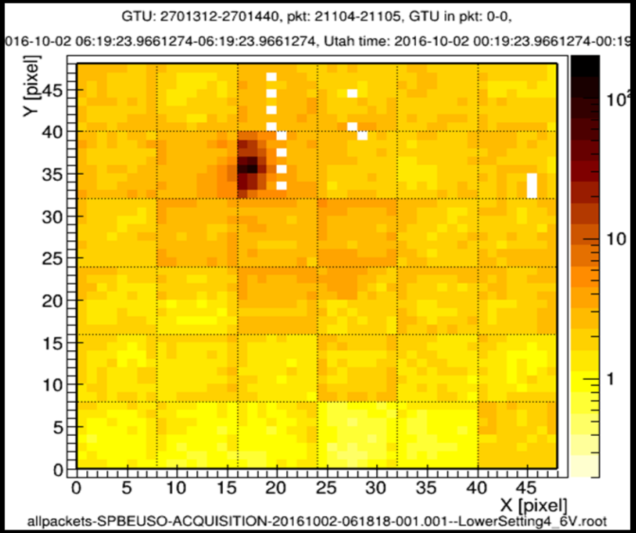
TLE and atmospheric effects μs-ms range

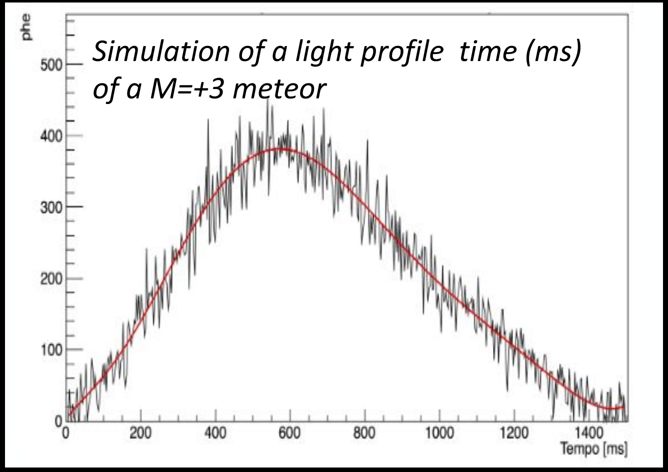


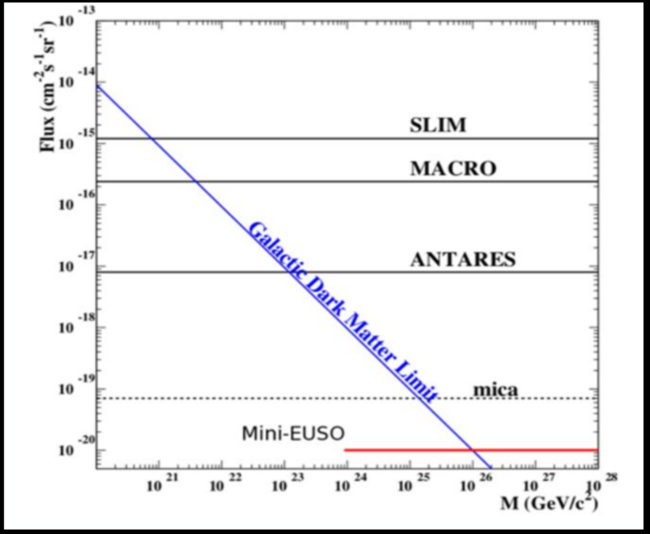
Meteors and Strange Quark Matter

Meteors: Slow events (few tens of km/s), Solar system speed

Strange Quark matter (very dense): longer signal, interstellar origin and speed (faster then meteors, but well below c)







Bioluminescence

Bioluminescence of animal and vegetal organisms

“White” or “Milky” sea phenomenon due to bioluminescent bacteria activity

Plankton

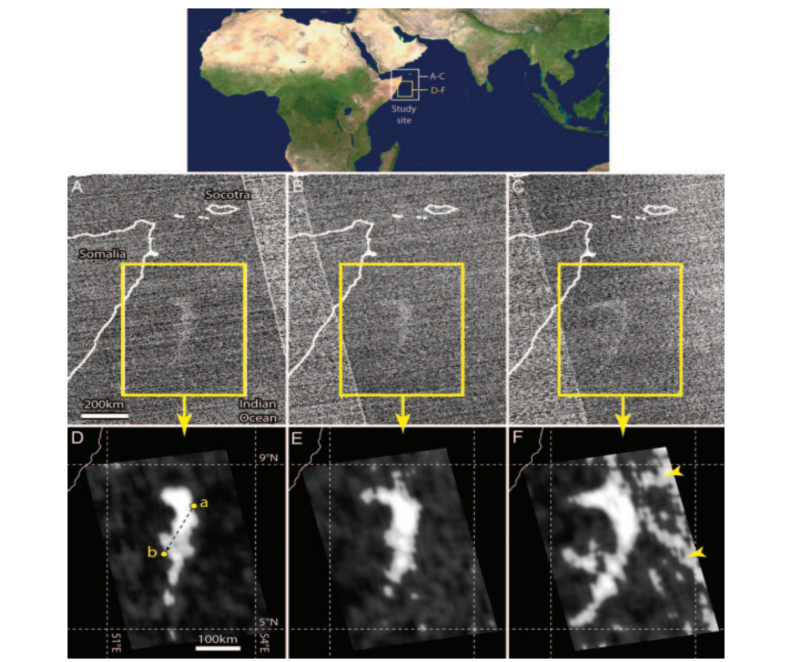


Fig. 1. Study areas (*Top*) corresponding to unfiltered (*A–C*) and filtered (*D–F*) satellite imagery on the night of the SS *Lima* observations. (*A* and *D*) Jan. 25, 1995, 1836 GMT. (*B* and *E*) Jan. 26, 1995, 1804 GMT. (*C* and *F*) Jan. 27, 1995, 1725 GMT. Arrowheads in *F* indicate low signal-to-noise ratio artifacts. Shown in *D* are the ship track (dashed line) and positions at time of first sighting on the horizon (point a) and exit from the glowing waters (point b), based on details of the ship report.

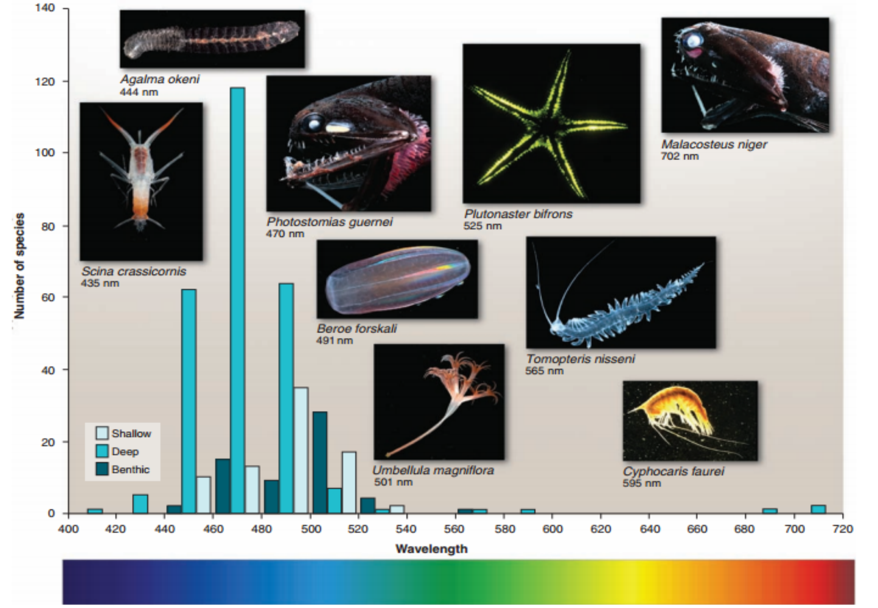
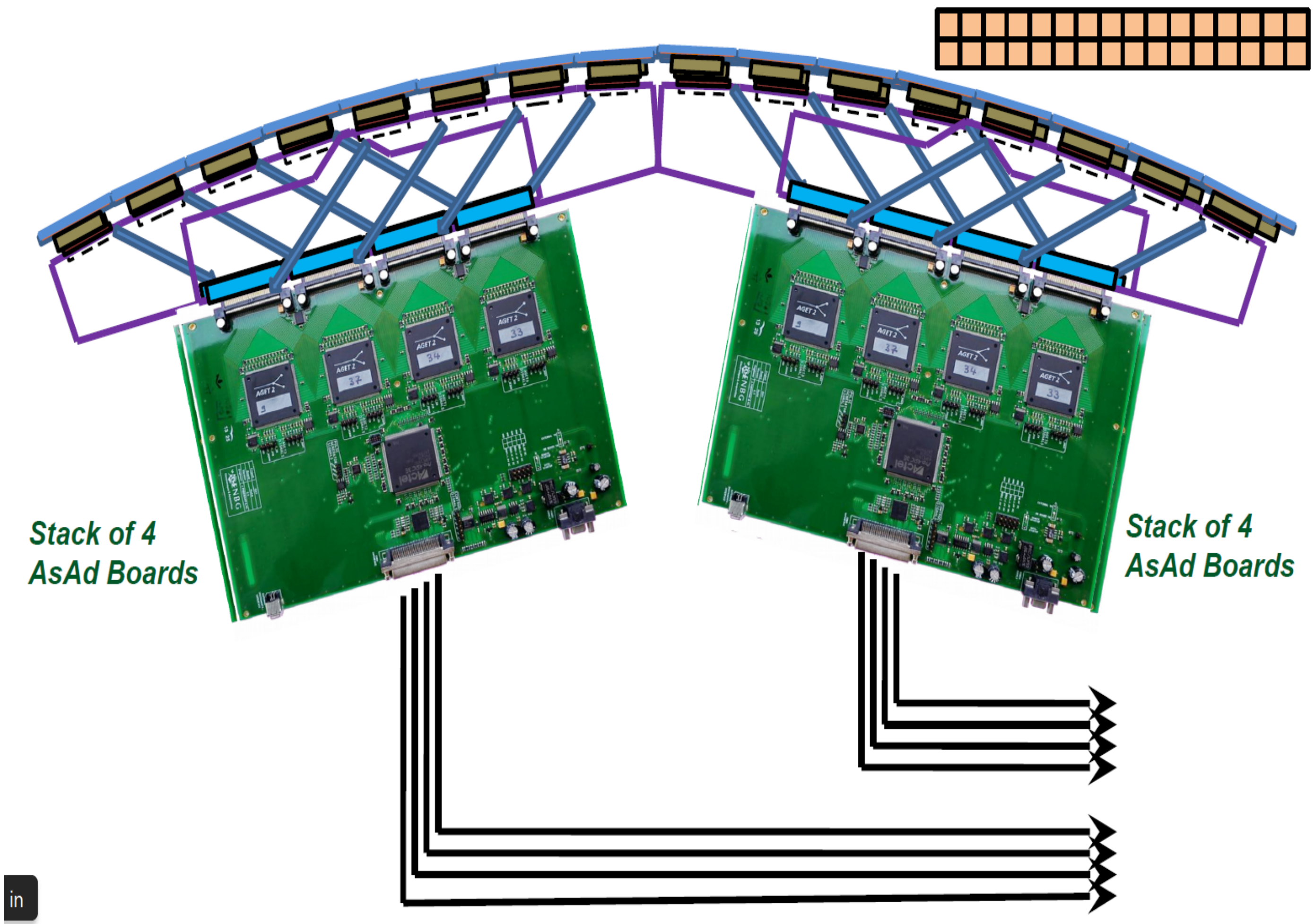
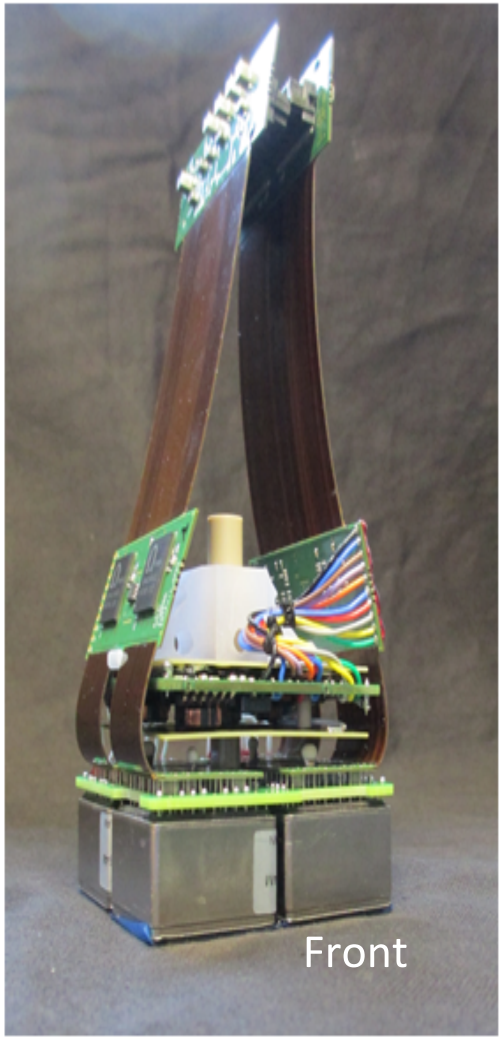


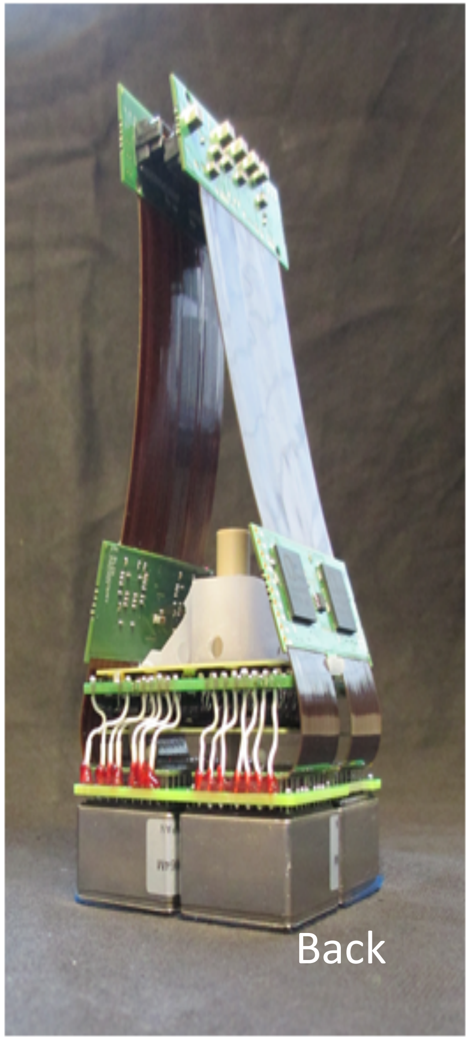
Fig. 1. The distribution of bioluminescence emission maxima varies by marine environment and organism type. Bioluminescent emissions extend over the full visible range and beyond. [Photo credits: J. Cohen for the photograph of *S. crassicornus*; P. Herring, *P. bifrons*; and P. Batson (DeepSeaPhotography.com), *C. faurei*]

N. Otte, J. Kuznetsov Cherenkov Focal Surface Option

Focal Plane Layout *(2 x 16 SiPM Sensors Option)*

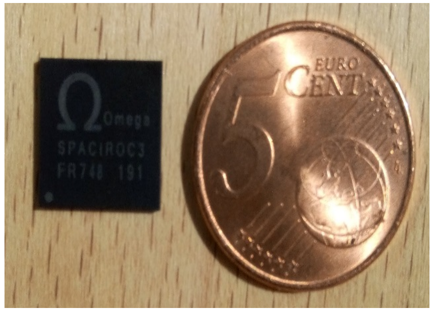






SPB2 Fluorescence Telescope: first MAPMT next generation Elementary Cell Unit, with integrated digitization

Sylvie Blin (OMEGA, IN2P3), (France)
Guillaume Prévôt (APC, IN2P3) (France)

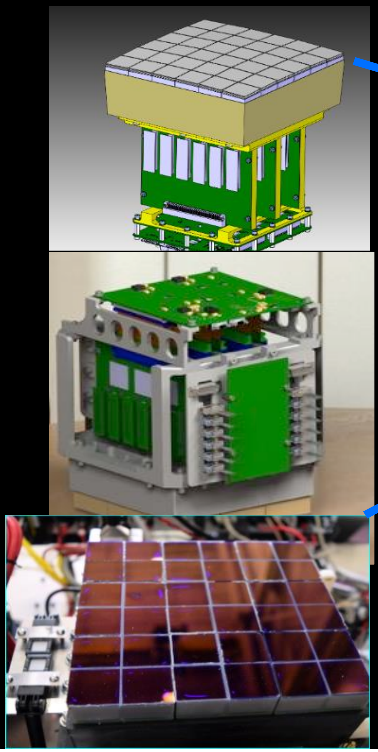


BGA packaged Spaciroc 3 ASIC

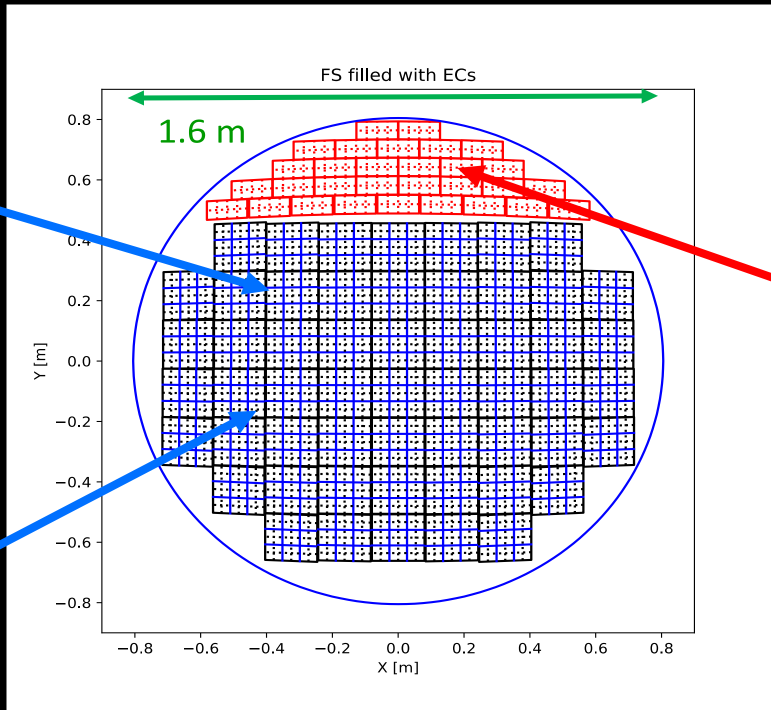
POEMMA

Hybrid MM Focal Surface

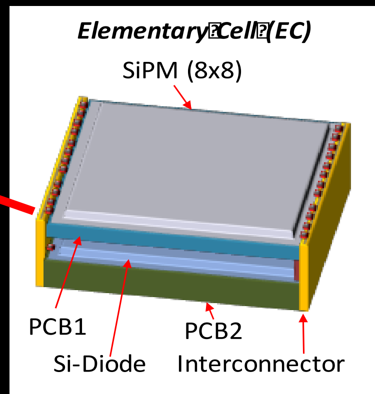
UV Fluorescence Detection using MAPMTs with BG3 filter



~ 150k 3 mm pixels



Cherenkov Detection with SiPMs



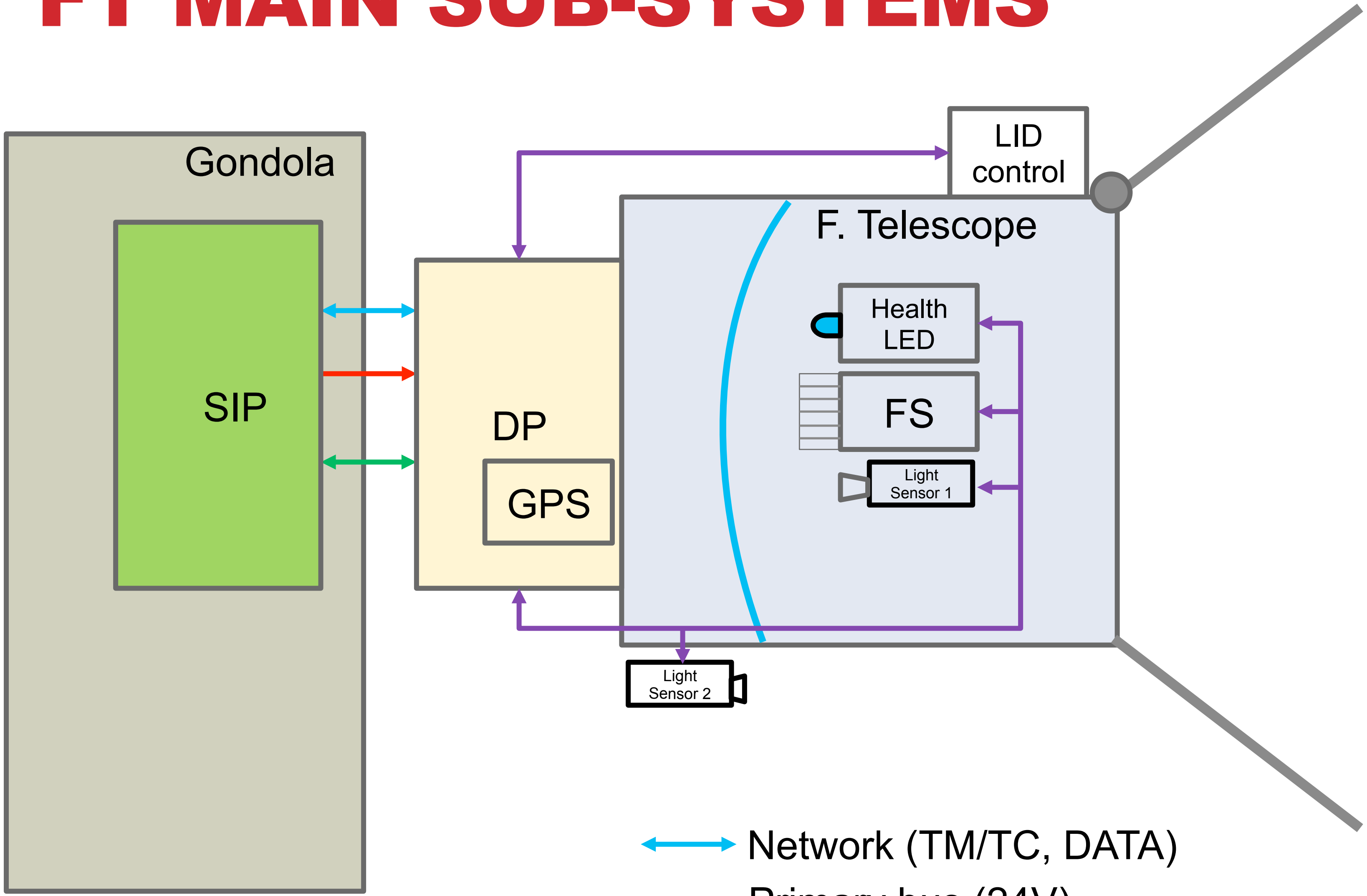
30 SiPM focal surface units
Total 15,360 pixels
512 pixels per FSU (64x4x2)

55 Photo Detector Modules (PDMs)= 126,720 pixels

1 PDM = 36 MAPMTs = 2,304 pixels

SPB2
FLUORESCENCE TELESCOPE ARCHITECTURE

FT MAIN SUB-SYSTEMS

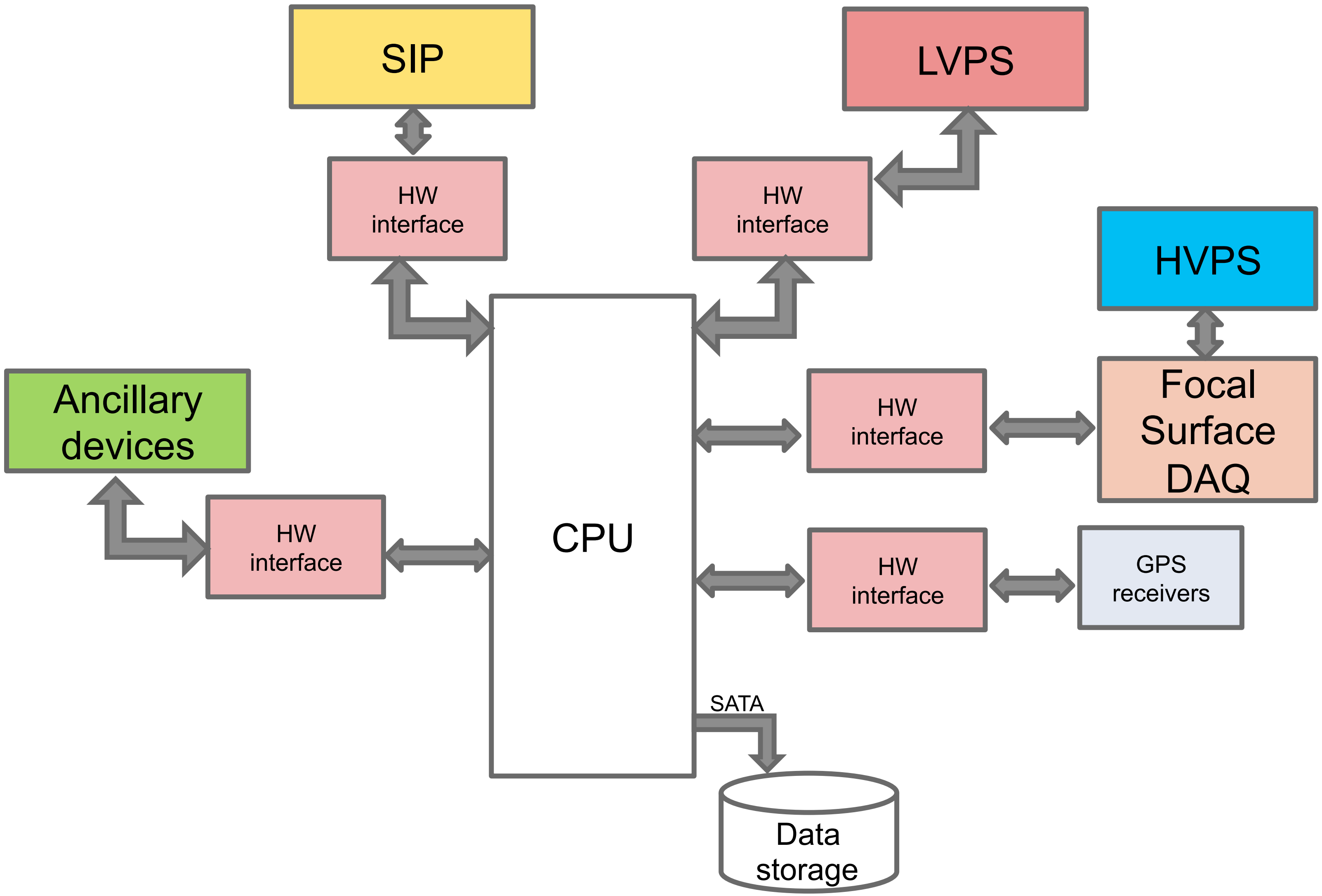


DP FUNCTIONAL REQUIREMENTS

DP Main tasks:

- **Main interface with Flight Computer (SIP) telemetry system**
- **Define Telescope operation mode (Day, Night, D-N-D transitions)**
- **Power ON/OFF (power cycling) the whole instrument by CPU commands.**
- **Configure the FE electronics**
- **Start/Stop of the data acquisition and calibration procedures**
- **Synchronization of the data acquisition**
- **Tag events with GPS time and GPS position**
- **Manage trigger signals (L1, external, GPS, by CPU command etc)**
- **Data selection/compression and transmission to Flight Computer (SIP)**
- **Monitor/Control/DAQ of some Ancillary Devices**
- **Monitor Voltages, Current and Temperatures (LVPSs, boards, FPGA's)**
- **Most of the DP architecture of the Florescence Telescope will be duplicated in the Cherenkov Telescope.**

CPU MAIN INTERFACES



Studies/Simulations for the SPB2 Cherenkov Telescope detector
Torino Group (M. Bertaina)

- Work done to design an ASIC board for the detection of Cherenkov photons from upward going showers induced by τ (presumably from ν_τ)

- → Main interest in the time information of the signal (not yet in the energy information)

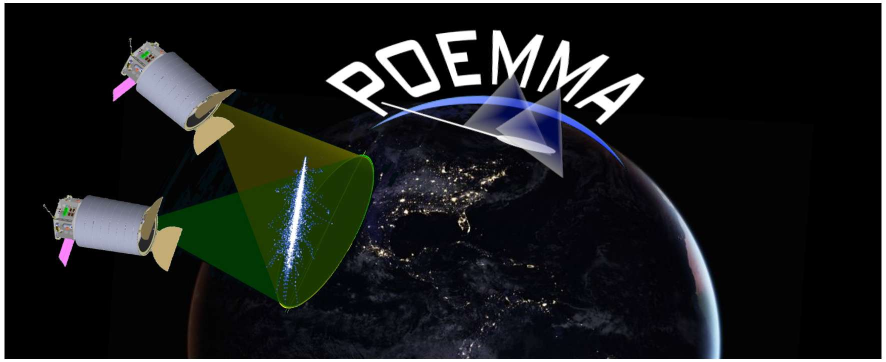
- Simulation of **Cherenkov photons from upward going τ**

- Generation of background photons with given background rates

- Simulation of a SiPM response → Analog signal

- Sampling and digitization of the analog signal

Il Futuro?



POEMMA: Probe of Extreme Multi-Messenger Astrophysics

A V. Olinto,[1] J. H. Adams,[2] R. Aloisio,[3] L. A. Anchordoqui,[4] D. R. Bergman,[5] M. E. Bertaina,[6] P. Bertone,[7] F. Bisconti,[8] M. Casolino,[9] M. J. Christl,[7] A. L. Cummings,[3] I. De Mitri,[3] R. Diesing,[1] J. Eser,[10] F. Fenu,[6] C. Guepin,[11] E. A. Hays,[12] E. G. Judd,[13] J. Krizmanic,[12] E. Kuznetsov,[2] S. Mackovjak,[14] J. McEnery,[12] J. W. Mitchell,[12] A. Neronov,[15] F. Oikonomou,[16] A. N. Otte,[17] E. Parizot,[18] T. Paul,[4] J. S. Perkins,[12] G. Prévôt,[18] P. Reardon,[2] M. H. Reno,[19] M. Ricci,[20] F. Sarazin,[10] K. Shinozaki,[6] J. F. Soriano,[4] F. Stecker,[12] Y. Takizawa,[9] M. Unger,[21] T. Venters,[12] L. Wiencke,[10] and R. M. Young[7]

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[13] *Space Sciences Laboratory, University of California, Berkeley, CA, USA*
[14] *Institute of Experimental Physics, Slovak Academy of Sciences, Kosice, Slovakia*
[15] *University of Geneva, Geneva, Switzerland*
[16] *European Southern Observatory, Garching bei München, Germany*
[17] *Georgia Institute of Technology, Atlanta, GA, USA*
[18] *APC, Univ Paris Diderot, CNRS/IN2P3, CEA/Irfu, Obs de Paris, Sorbonne Paris Cité, France*
[19] *University of Iowa, Iowa City, IA, USA*
[20] *Istituto Nazionale di Fisica Nucleare - Laboratori Nazionali di Frascati, Frascati, Italy*
[21] *Karlsruhe Institute of Technology, Karlsruhe, Germany*

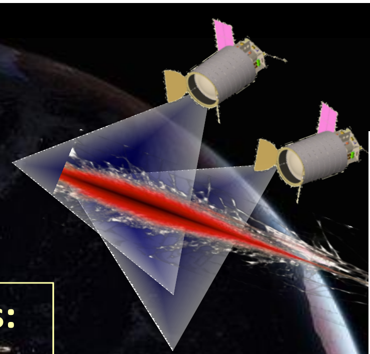
NASA Probe Studies for 2020 Decadal Survey

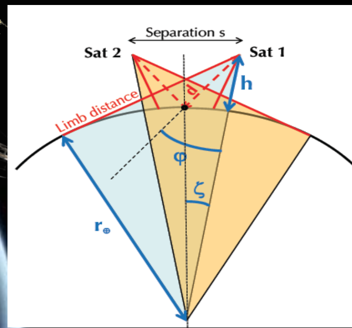
- NASA funding 10 Probe Class (below 1B$) Mission (18 mos) Studies in Preparation for the 2020 Decadal Survey
- PI responsible for the final report (due NLT Dec 2018)
- NASA will submit these studies to the Decadal Survey
- Decadal Survey Committee will have the option to prioritize any of these mission concepts, or recommend a competed line of Probes (similar to Explorers)
- Selection based on Science Merit (cost, schedule)

PI	Affiliation	Short title	Design Lab/Prog Office
Camp, J.	NASA's GSFC	Transient Astrophysics Probe	IDC/PCOS-COR
Cooray, A.	Univ. California, Irvine	Cosmic Dawn Intensity Mapper	TeamX/ExEP
Danchi, W.	GSFC	Cosmic Evolution through UV spectroscopy	IDC/PCOS-COR
Glenn, J.	Univ. of Colorado	Galaxy Evolution Probe	TeamX/ExEP
Hanany, S.	Univ. of Minnesota	Inflation Probe Mission Concept Study	TeamX/ExEP
Mushotzky, R.	Univ. of Maryland	High Spatial Resolution X-ray Probe	IDC/PCOS-COR
Olinto, A.	Univ. of Chicago	Multi-Messenger Astrophysics	IDC/PCOS-COR
Plavchan, P.	Missouri State Univ.	Precise Radial Velocity Observatory	No design lab funded/HQ grant
Ray, P.	Naval Research Lab	X-ray Timing and Spectroscopy	IDC/PCOS-COR
Seager, S.	MIT	Starshade Rendezvous	TeamX/ExEP

POEMMA

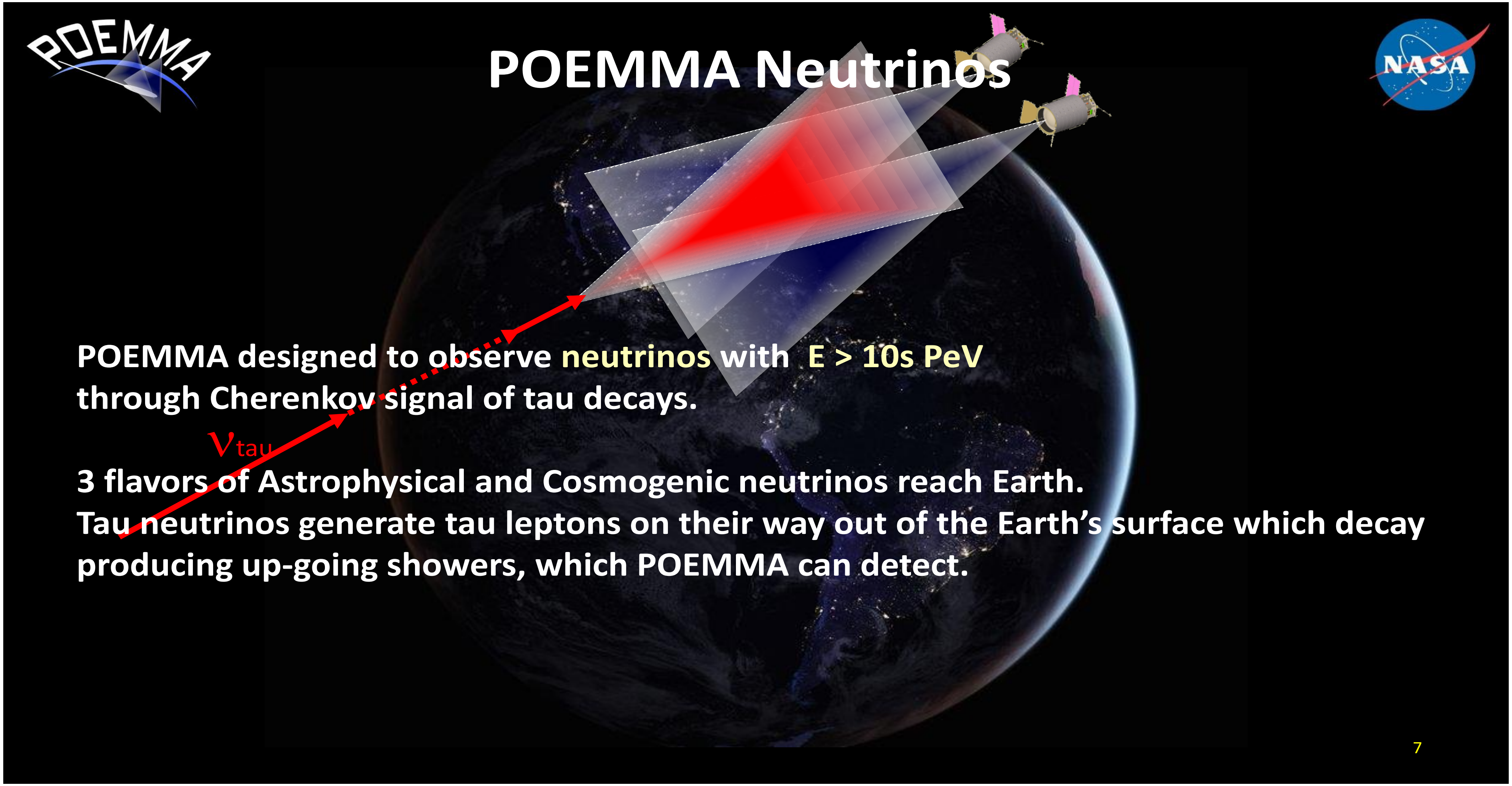
POEMMA UHECRs





Stereo observation of the air fluorescence signal of EASs:

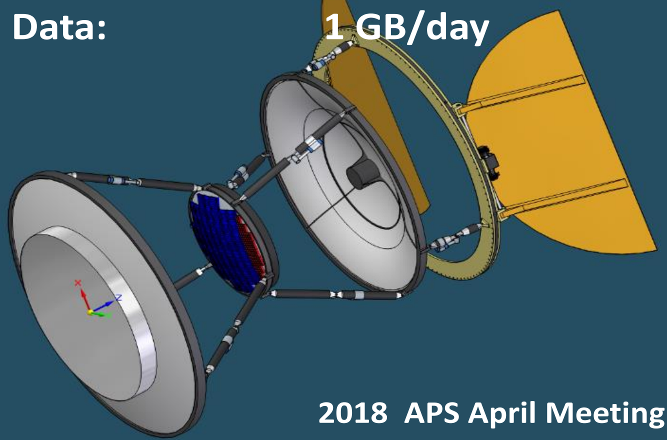
- **Achieve significant increase in exposure via space-based observations (x10 arrays; x100 fluorescence) with full-sky coverage**
- **Achieve good angular and energy resolution**
- **Achieve sufficient X_{MAX} resolution to perform UHECR composition measurements**


POEMMA
POEMMA Neutrinos
NASA
POEMMA designed to observe neutrinos with E > 10s PeV
through Cherenkov signal of tau decays.
ν_{tau}
3 flavors of Astrophysical and Cosmogenic neutrinos reach Earth.
Tau neutrinos generate tau leptons on their way out of the Earth’s surface which decay
producing up-going showers, which POEMMA can detect.
7

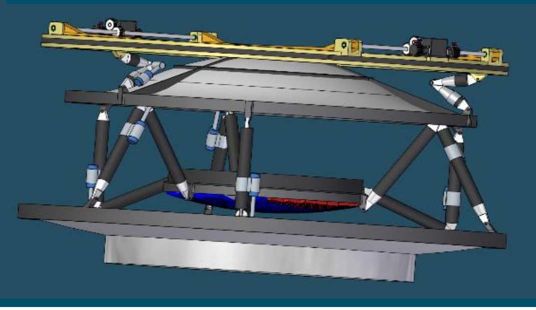
POEMMA INSTRUMENT

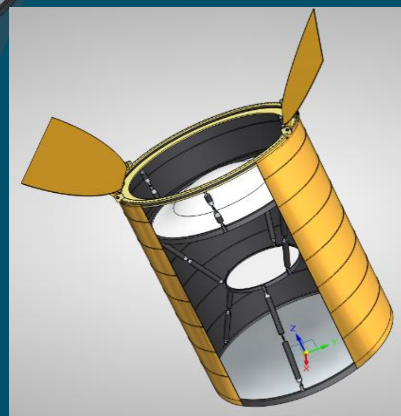
Two 4 meter F/0.64 Schmidt telescopes: 45 deg FoV
Hybrid focal surface (MAPMTs and SiPM)
    3 mm linear pixel size: 0.084 deg pixel FoV
Instrument Mass: 1,547 kg

Primary Mirror:	4 meter diameter
Corrector Lens:	3.3 meter diameter
Focal Surface:	1.6 meter diameter
Optical Area$_{EFF}$:	~6 to 2 m2
Power:	550 W
Data:	1 GB/day



Stowed Configuration Launch

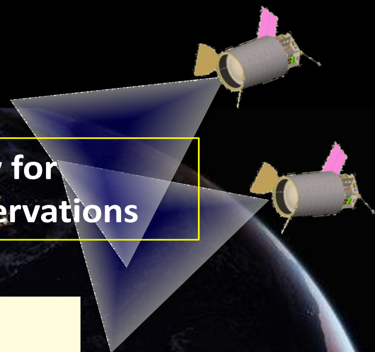


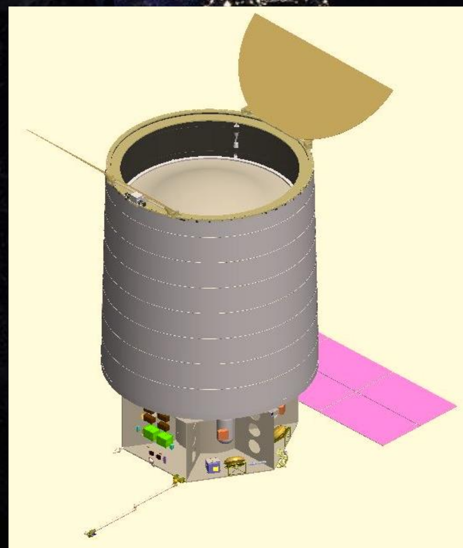


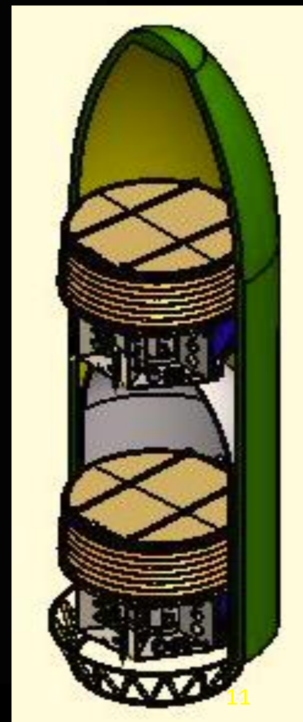
POEMMA MISSION

Class B Mission
3-year Prime Mission,
5-year Mission Goal
LEO 525 km, 28.5^{o} inclination
~1500 km to 25 km separation
Controlled re-entry/decommission
Phase A start 10/2023
(NASA HQ guidance)
Launch 11/2029
(MDL forecast)

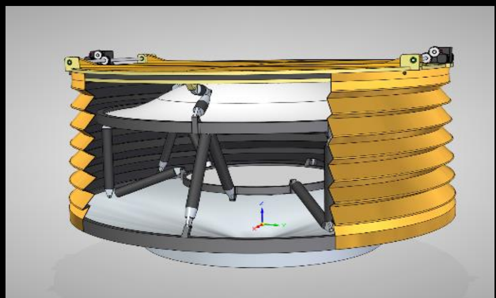
Spacecraft have ability to slew for transient event follow-up observations



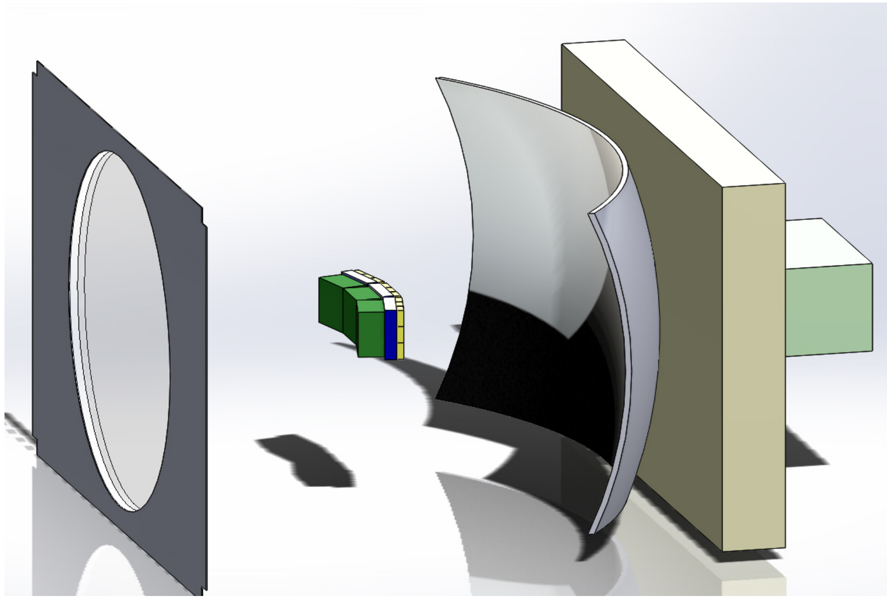




Dual Manifest
ATLAS V LPF



Optical specification

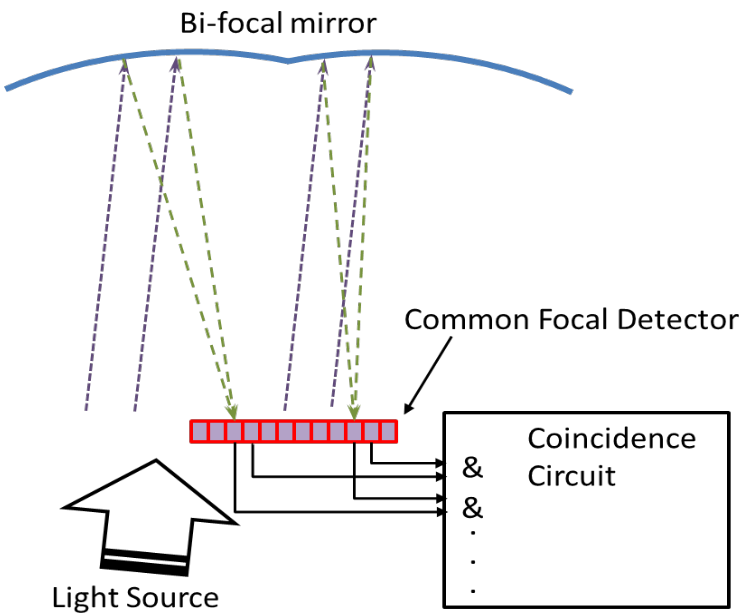


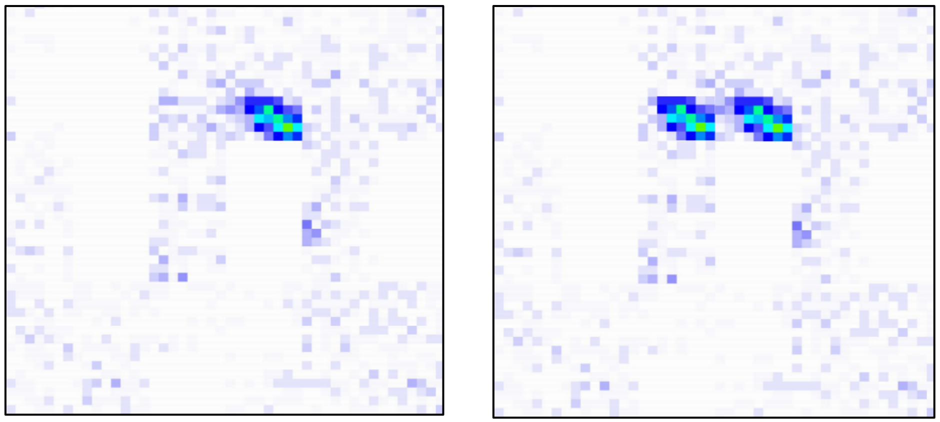
- Modified Schmidt design reflecting telescope
- Mirror size common to all 2 telescopes (see caveat in next slide)
- Pixel size: 3mm x 3mm
- Instantaneous Field of View: IFoV = 0.2º = 3.5mrad (per pixel full width)
- Effective Focal Length: EFL= 860mm
- Entrance Pupil Diameter: EPD = 970mm
- Collection area = 0.71m^2

Bi-focal mirror concept for the Cherenkov telescopes

- τ-decay induced showers are expected to be (very) rare. How to distinguish a real Cherenkov event from background (e.g. CR interacting directly in Focal Surface) with high confidence level?

- Bi-focal mirror concept to be tested in SPB2 as a possible way to reject background

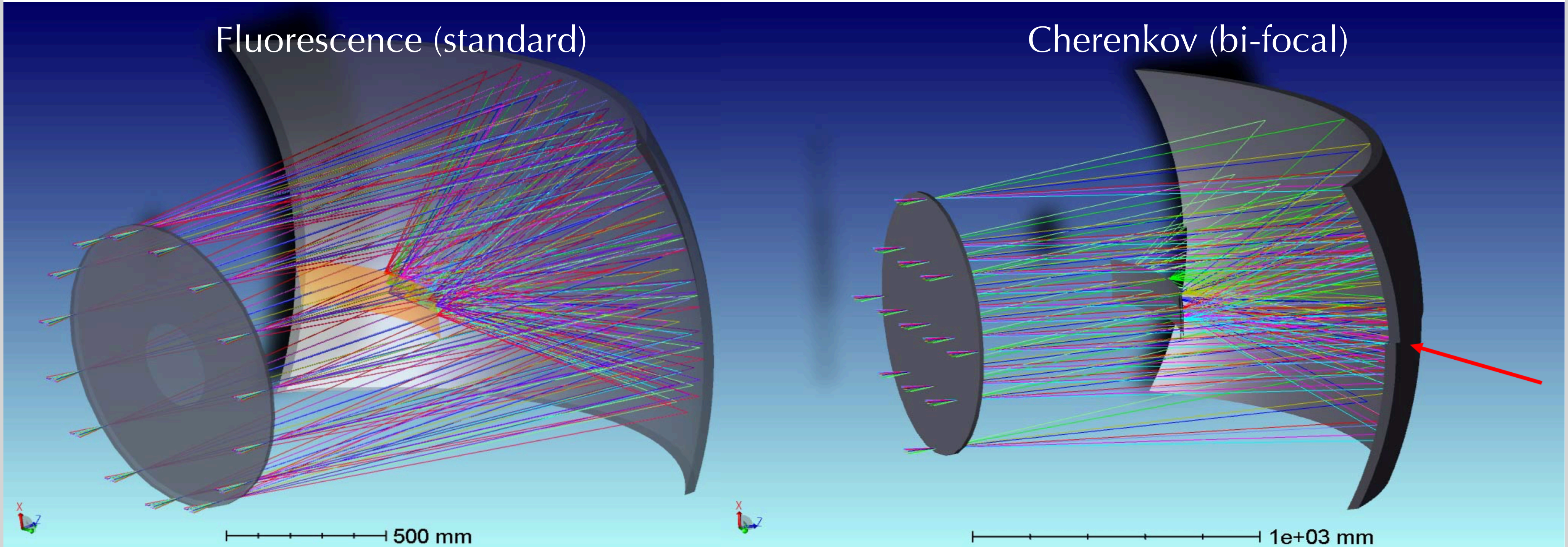




Standard mirror

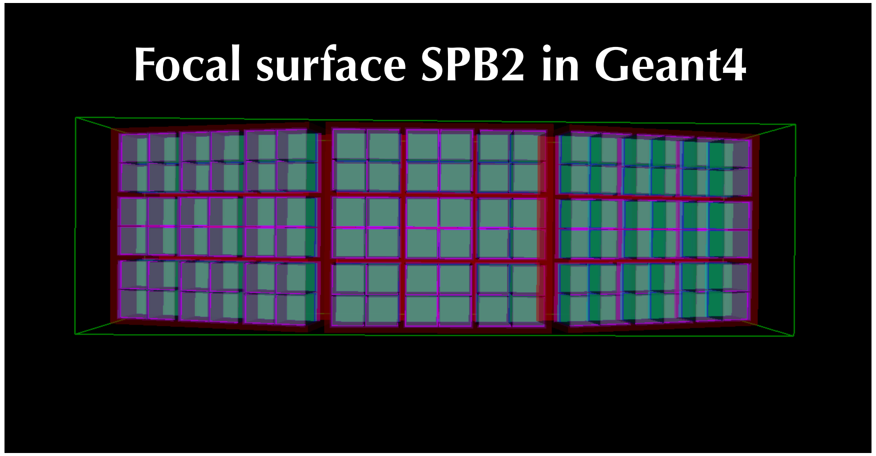
Bi-focal mirror

Bi-focal mirror concept for the Cherenkov telescopes

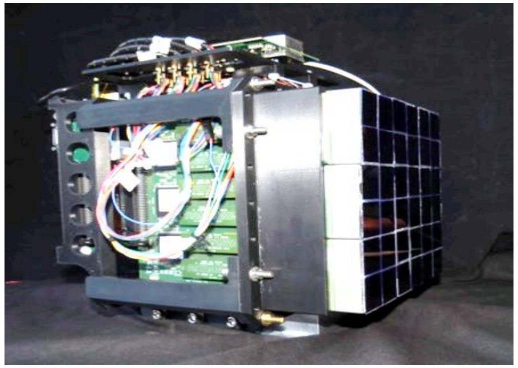


SPB2 fluorescence telescope – focal surface

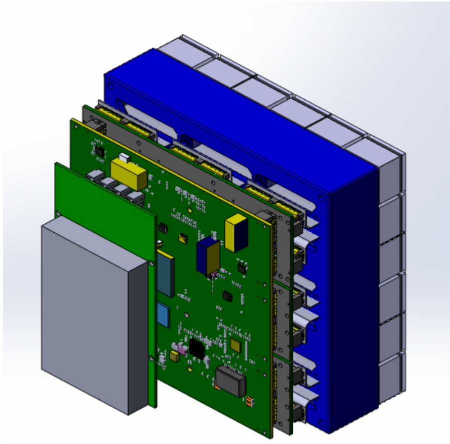
- Technology: Multi-Anode PMTs (Hamamatsu)
- Elementary cell (EC): 4 MAPMTs (8x8 pixels each / total: 256 pixels)
- Photo Detector Module (PDM): 9 ECs. Total: 2304 pixels
- **Planned SPB2 focal surface: 3 PDMs. Total: 6912 pixels**



PDM + elect. integration (SPB1)



PDM + elect. planned tighter implementation (SPB2)



SPB2

Technical Goals:

Test instrumentation and methods for POEMMA

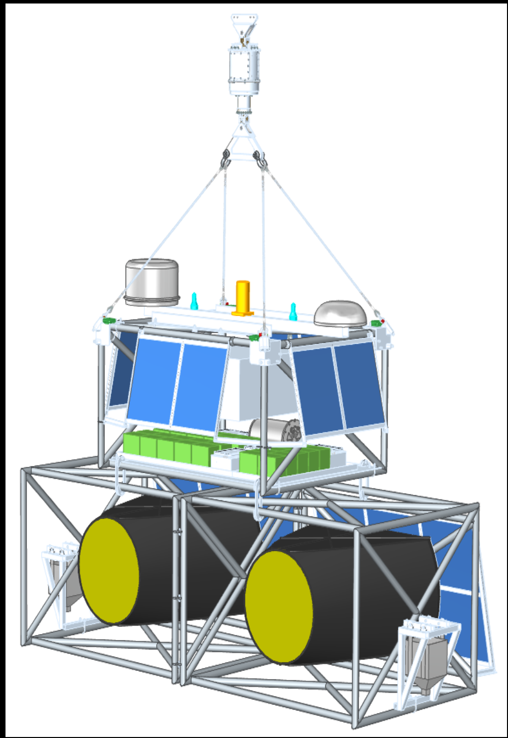
Two Telescopes
1 Cherenkov ~10 ns PeV Scale
1 Fluorescence 1 µs EeV Scale

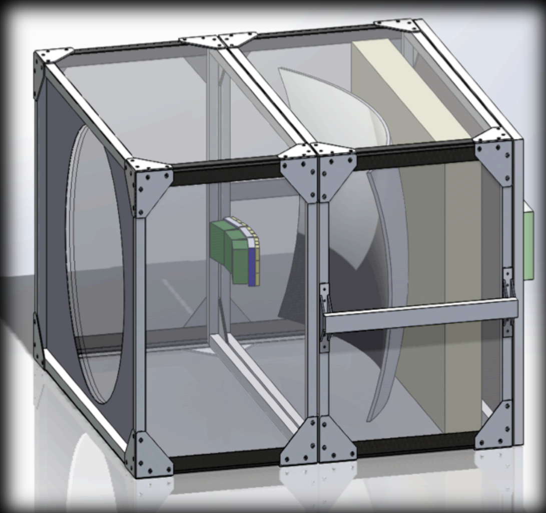
Schmidt Optics, same for all telescopes
Bi-Focal alignment for Cherenkov

Tilting, perhaps to NADIR (fluorescence)

SiPMs qualification for POEMMA
Ancillary Devices (IR camera, AMON)
In flight calibration with Stars (in POEMMA mission design)
Preflight field tests - US: Desert, Mountain

Long Stratospheric Flight 100 day target





Conclusioni e Prospettive

- Con il lancio di **Mini-EUSO** previsto per quest'anno, si porta a compimento una fase importante pluriennale di attività (legate al programma della Collaborazione Internazionale JEM-EUSO) con la prima missione spaziale sulla ISS.
I risultati, scientifici e tecnologici, potranno dare un contributo concreto a future missioni dedicate allo studio dei Raggi Cosmici dallo spazio, allo Space Weather e alle modalità di tracciamento e rimozione degli Space Debris.

- L'opportunità offerta dal volo di pallone **SPB2** risiede in molteplici aspetti, scientifici e tecnologici:

- effettuare, per la prima volta, misure di air-showers per mezzo di luce Cherenkov osservata dall'alto (top dell'atmosfera) e misurare, per mezzo della Fluorescenza, lo sviluppo degli air-shower orizzontali;
- verificare la possibilità di rivelazione di neutrini tau per mezzo di luce Cherenkov diretta;
- la misura del background nell'osservazione di leptoni tau up-going dal decadimento di neutrini cosmogenici contribuirà significativamente a indirizzare future missioni spaziali (vedi POEMMA);
- potenziale ricaduta in campo tecnologico avanzato con sviluppo e qualifica per lo spazio di rivelatori come i SiPM (e relativo FE), Data Processor e sistemi di lettura e trasmissione dati;
- sinergie con ASI e coinvolgimento Ditte Aerospaziali Italiane;
- ruolo rilevante del gruppo italiano in tutte le fasi della missione.