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

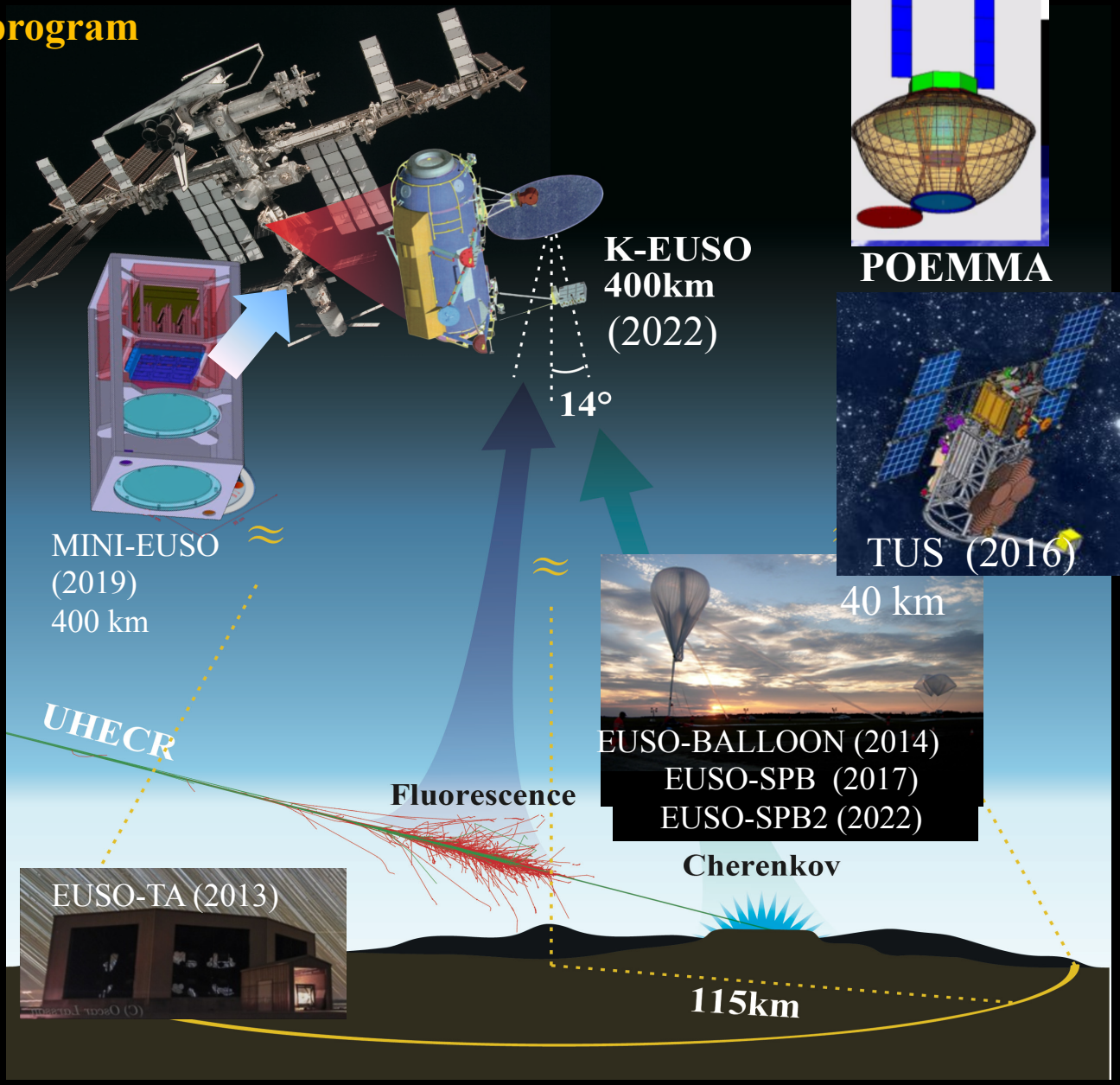
2. **EUSO-BALLOONS:** *1st balloon flight from Timmins, Canada (French Space Agency) Aug 2014; NASA Ultra long duration flight: SPB April 2017; NASA SPB-2 planned for 2022*

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

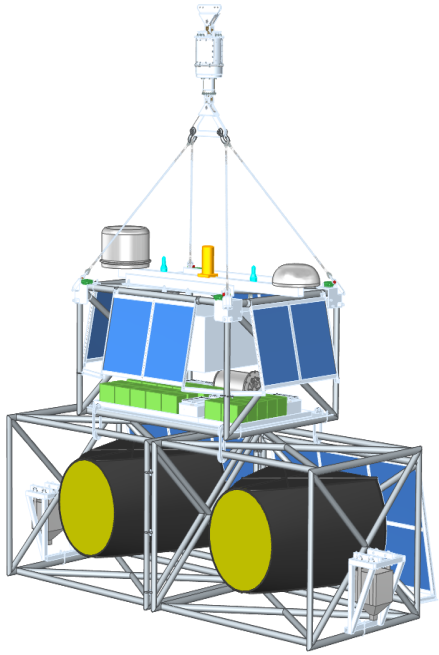
5. **K-EUSO (2022):** *on ISS Approved by Russian Space Agency – Phase A+*

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



JEM-EUSO collaboration 16 Countries, 93 Institutes, 351 people

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

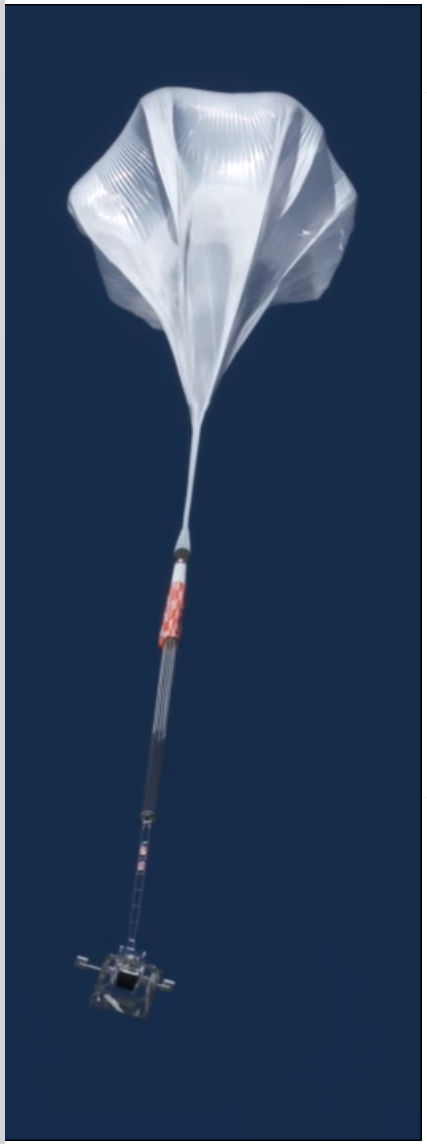


Il contesto scientifico e la strategia (USA-NASA)

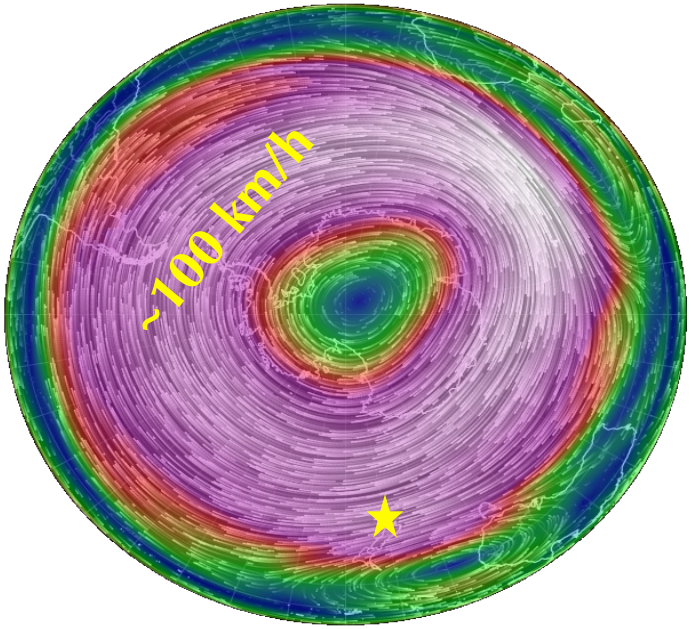
1. Obiettivo finale: realizzare una missione spaziale congiunta per lo studio dei neutrini cosmogenici e degli UHECR – EECR (E > 10^{19}-10^{20} eV)
(→ Progetto POEMMA/NASA Decadal survey)

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.

NASA's long duration balloon program from New Zealand

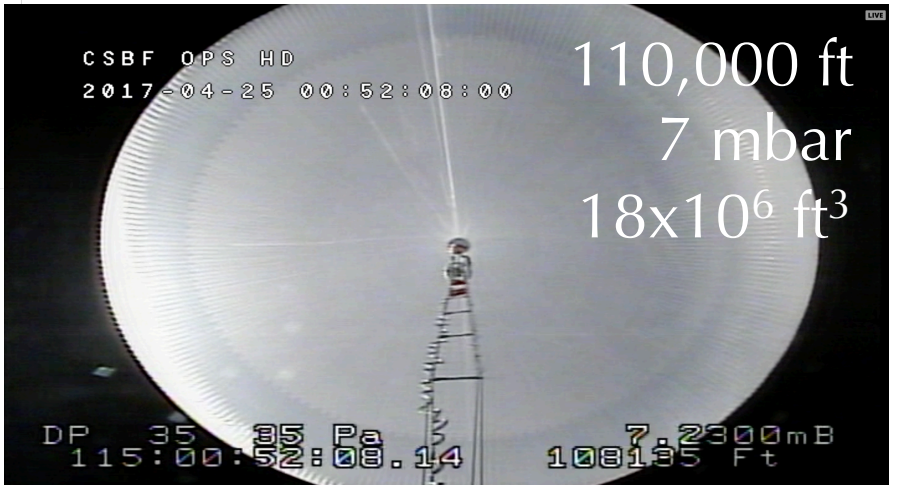


Goal: fly a "Ton of science" with a target flight duration of 100 days

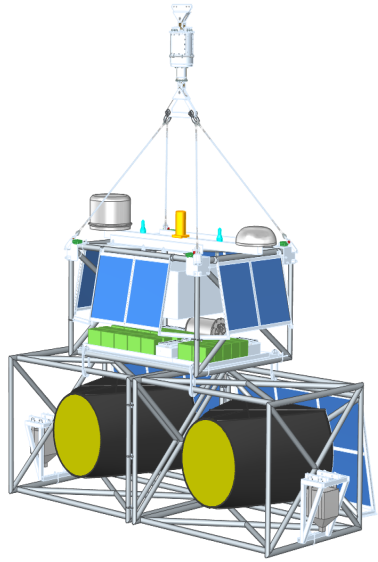


Stable wind pattern around South Pole (March – July)

3 flights since 2015 (including SPB1/2017)

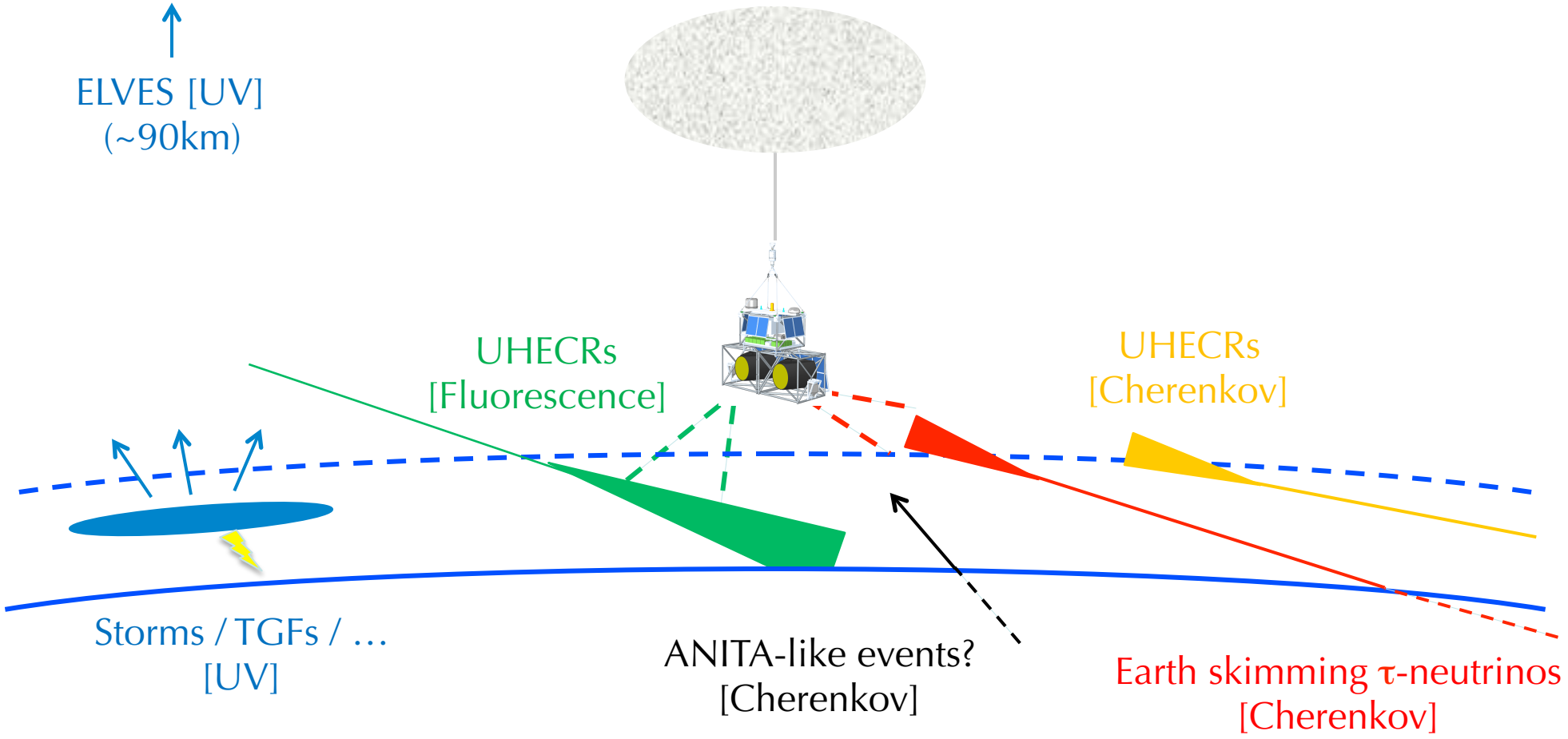


Science Goals of SPB2



- 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:

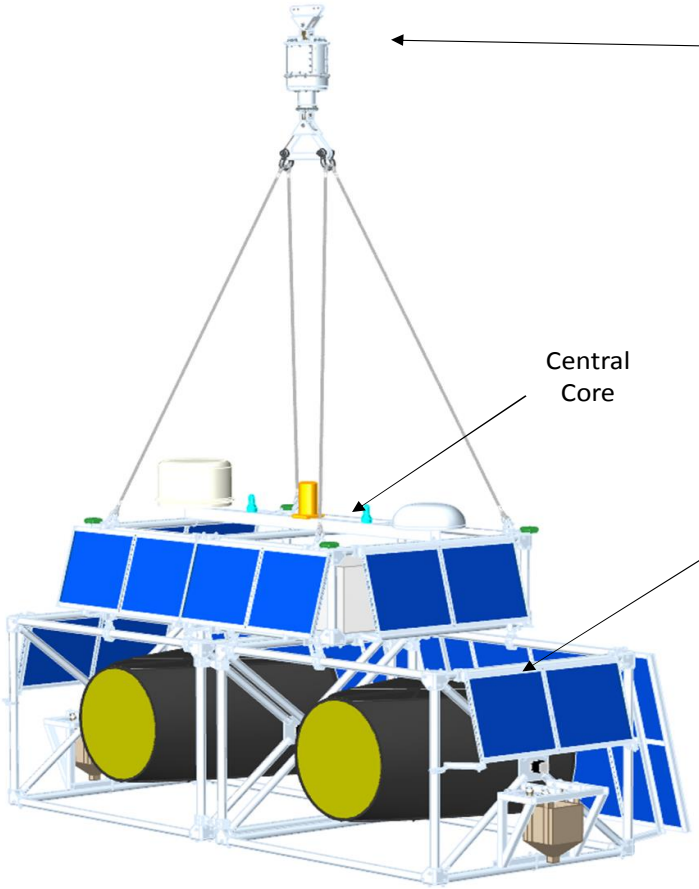
- One Fluorescence [MAPMT-based]
- One Cherenkov [SiPM-based]

fluorescence event timescale: up to 10's μs
Cherenkov event timescale: ~10ns

SPB2 Two Telescope Horizontal Mount

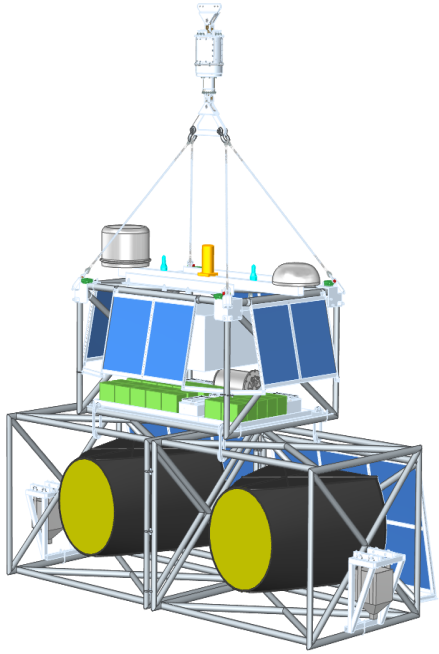
MSFC ES63

Naming conventions



Nov 27, 2018

Proposta alla Commissione II di Apertura di nuova sigla SPB2



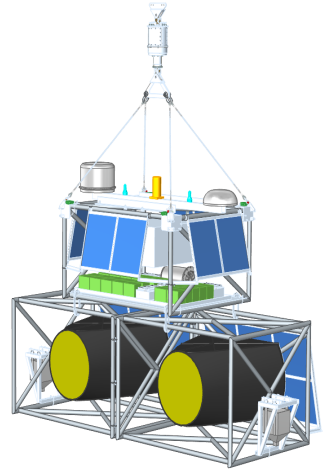
Il Gruppo Italiano proponente

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



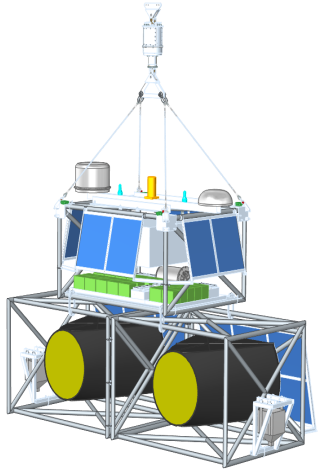
- Progetto Architettura di sistema per entrambi i telescopi
  - Data Processor/CPU
  - Housekeeping
  - Sistema di basse tensioni
  - Clock-board/Sincronizzazione
  - Telemetria
  - Interfacce tra i sottosistemi

- 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

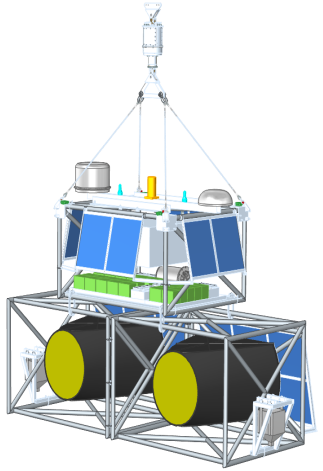
ASI – Thales Alenia Space

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 + 1 Prof. Ass. dell'Università UniNettuno Roma (Associazioni in corso)
(Meccanica, Elettronica, Simulazioni e Analisi)

TOT 2.2 FTE

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

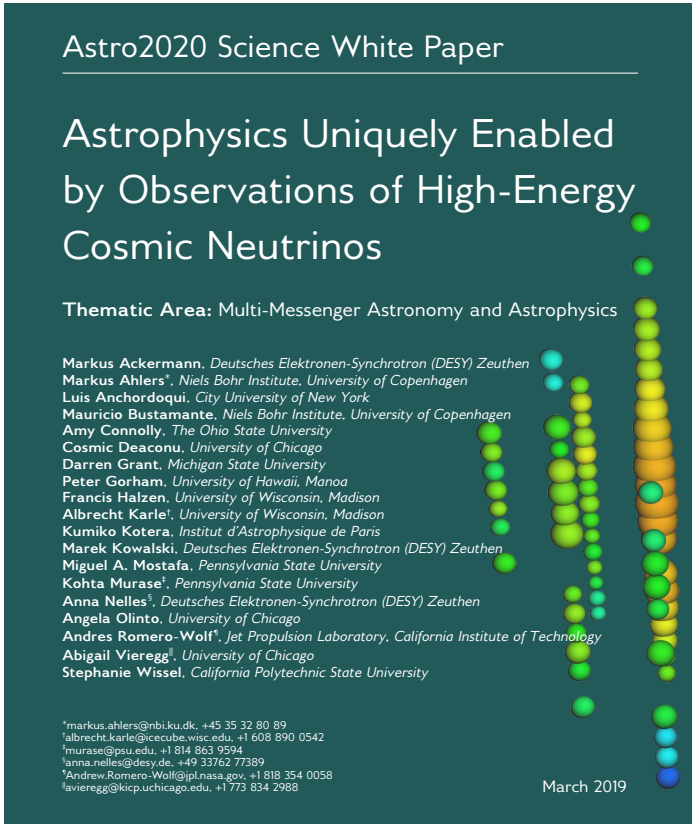
Richieste finanziarie per il 2020 in corso di preparazione, da concordare con le altre sedi

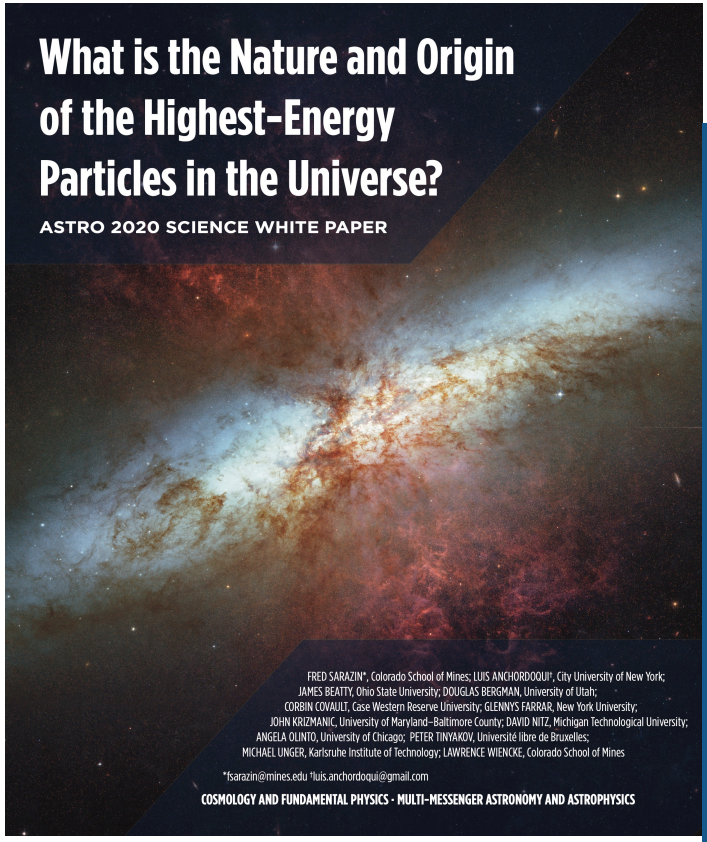
Nessuna richiesta specifica ai Servizi LNF

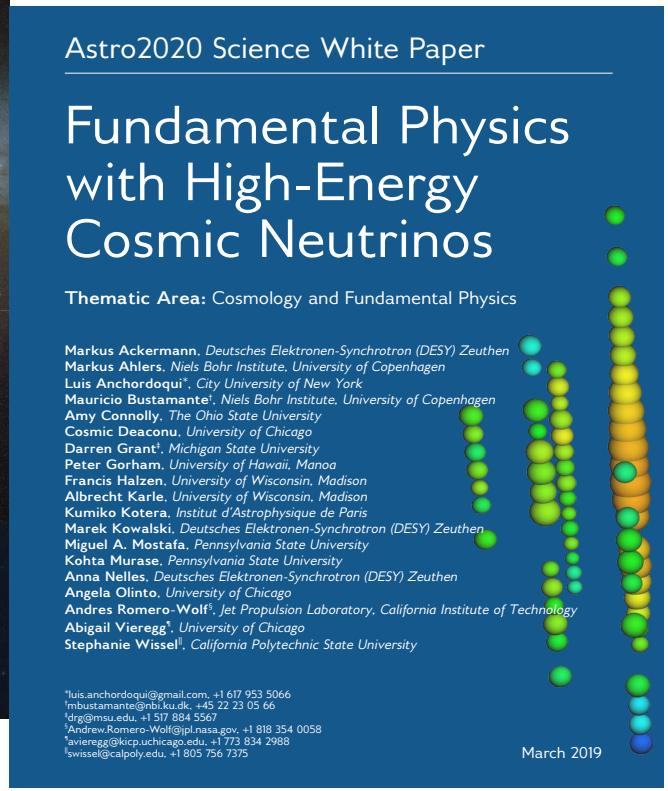
La strategia di lungo corso (fine anni ‘20)

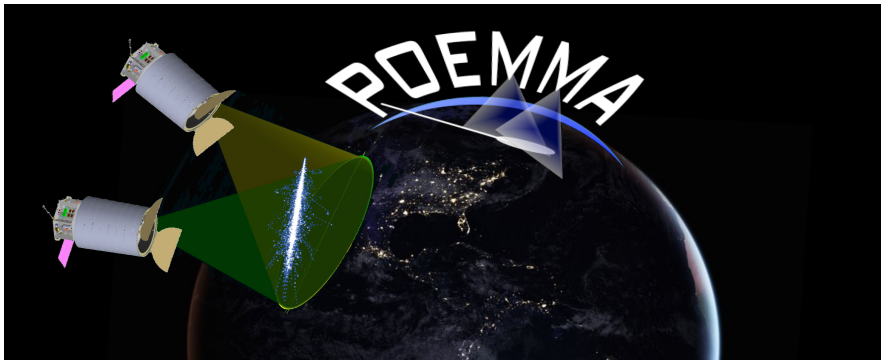
Progetto POEMMA/NASA Decadal survey

Astronomy and Astrophysics Decadal Survey









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]

[1]*The University of Chicago, Chicago, IL, USA*
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[4]*City University of New York, Lehman College, NY, USA*
[5]*University of Utah, Salt Lake City, Utah, USA*
[6]*Universita' di Torino, Torino, Italy*
[7]*NASA Marshall Space Flight Center, Huntsville, AL, USA*
[8]*INFN, Section of Turin, Turin, Italy*
[9]*RIKEN, Wako, Japan*
[10]*Colorado School of Mines, Golden, CO, USA*
[11]*Sorbonne Universités, Institut dAstrophysique de Paris, Paris, France*
[12]*NASA Goddard Space Flight Center, Greenbelt, MD, USA*
[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*

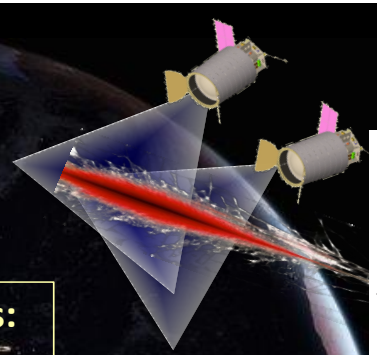
NASA Probe Studies for 2020 Decadal Survey

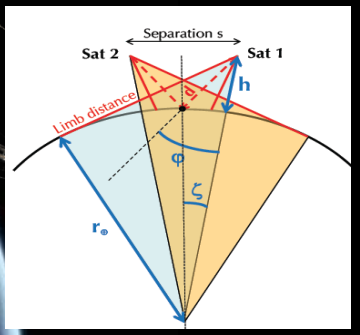
- NASA funding 10 Probe Class (below 1B$) Mission (18 mos) Studies in Preparation for the 2020 Decadal Survey
- PI responsible for the final report (due NLT Dec 2018)
- NASA will submit these studies to the Decadal Survey
- Decadal Survey Committee will have the option to prioritize any of these mission 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

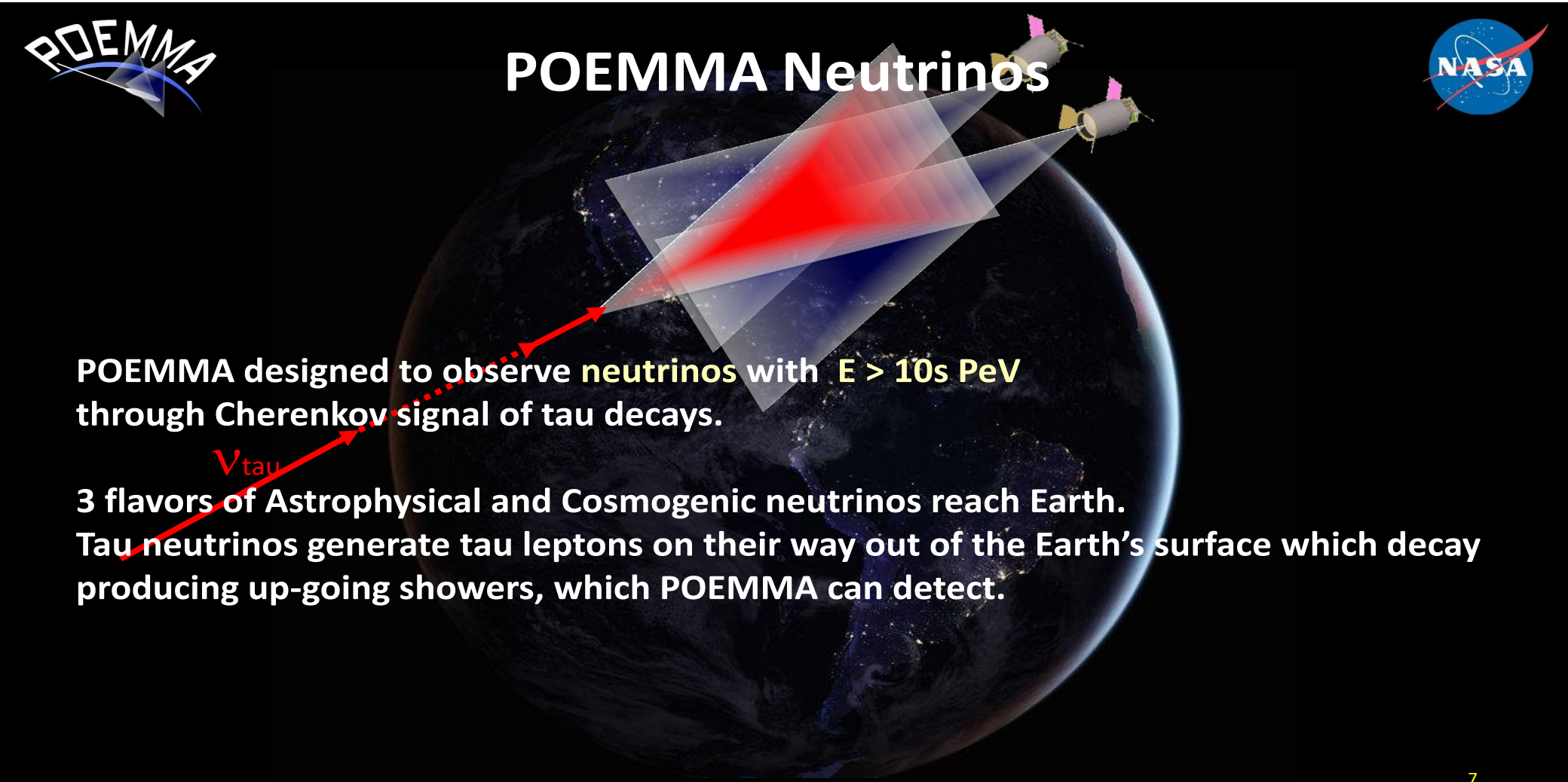




Stereo observation of the air fluorescence signal of EASs:

- 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 Neutrinos



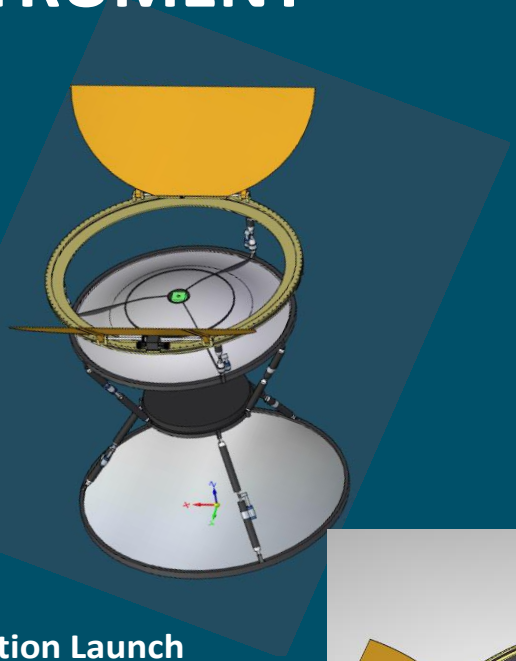
POEMMA designed to observe neutrinos with E > 10s PeV through Cherenkov signal of tau decays.

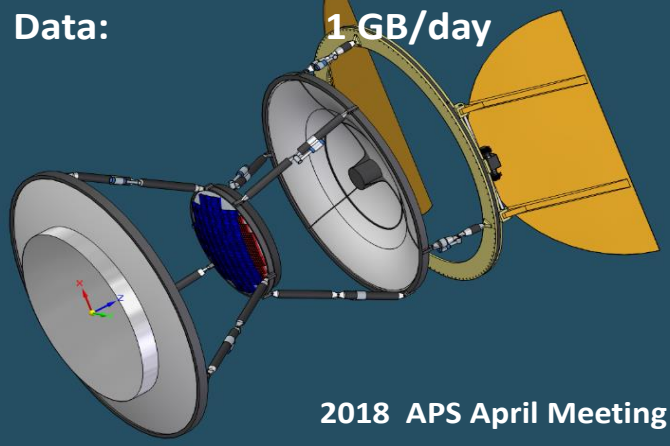
ν_{tau}

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.

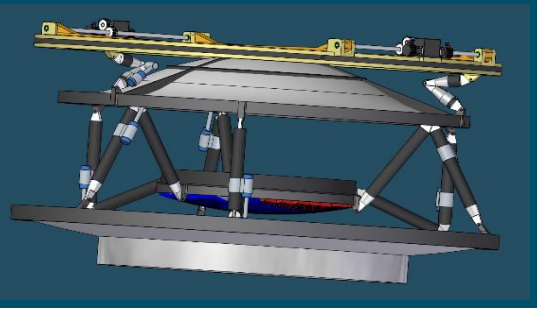
POEMMA INSTRUMENT

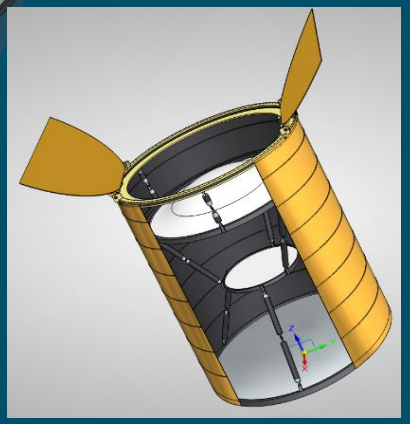
Two 4 meter F/0.64 Schmidt telescopes: 45 deg FoV
Hybrid focal surface (MAPMTs and SiPM)
3 mm linear pixel size: 0.084 deg pixel FoV
Instrument Mass: 1,547 kg
Primary Mirror: 4 meter diameter
Corrector Lens: 3.3 meter diameter
Focal Surface: 1.6 meter diameter
Optical Area$_{EFF}$: ~6 to 2 m2
Power: 550 W
Data: 1 GB/day





Stowed Configuration Launch

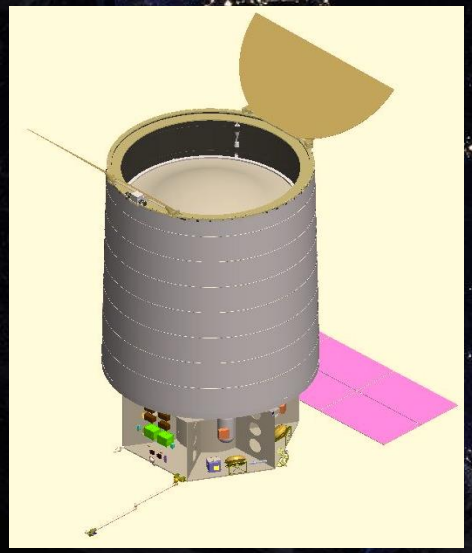


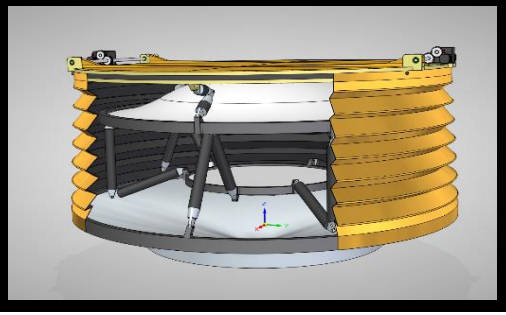


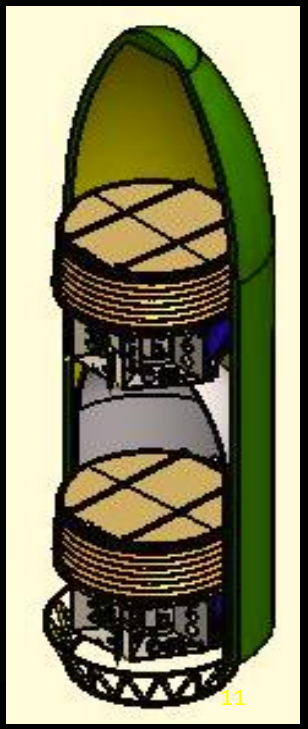
POEMMA MISSION

Class B Mission
3-year Prime Mission,
5-year Mission Goal
LEO 525 km, 28.5° 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