SPACE PROBES OF THE HIGHEST ENERGY PARTICLES: POEMMA & EUSO-SPB

CD











Theory Pierre Auger Obs. **EUSO POEMMA** FAST Fermi Observatory **VERITAS** CTA **HELIX ANITA** ARA GNO **BEACON**

Cronin

5



2010s

WHAT ARE THE SOURCES OF THE ULTRAHIGH ENERGY COSMIC RAYS (UHECRS)? WHAT IS THE COSMOGENIC NEUTRINO FLUX?

WHAT ARE THE SOURCES OF ICECUBE NEUTRINOS?

Neutrino

20205

WHAT ARE THE SOURCES OF THE EXTRAGALATIC UHECRS?

WHAT IS THE COSMOGENIC NEUTRINO FLUX?

Proton

WHAT ARE ALL* SOURCES OF ICECUBE NEUTRINOS?

Neutrino

*In addition to blazar TXS 0506+056

2020s

WHAT ARE THE SOURCES OF THE EXTRAGALATIC UHECRS?

WHAT IS THE COSMOGENIC NEUTRINO FLUX?

WHAT ARE ALL SOURCES OF ICECUBE NEUTRINOS?

Neutrino

- SPECTRUM E>>50 EEV

Proton

- Composition E>>50 EeV
- ANISOTROPIES POINTING
- MULTI-MESSENGER COINCIDENCE







SPACE PROBES OF THE HIGHEST ENERGY PARTICLES:



EUSO-SPB1



THE EARTH'S ATMOSPHERE AS AN EXTREME ENERGY PARTICLE OBSERVATORY



POEMMA

NADIR FOR UHECR: Radius 200-400 km

LIMB FOR NEUTRINOS: RADIUS 2.6-3.7 10³ KM



POEMMA: PROBE OF EXTREME MULTI-MESSENGER ASTROPHYSICS

BASED ON OWL 2002 STUDY, JEM-EUSO, EUSO BALLOON & SPB EXPERIENCE, AND CHANT PROPOSAL

POEMMA: STUDY COLLABORATION

University of Chicago: Angela V. Olinto (PI)

NASA/MSFC: Mark J. Christl (deputy PI), Roy M. Young, Peter Bertone, Jeff Apple, Gary Thornton, Brent Knight, Kurt Dietz, Mohammad Sabra

University of Alabama, Huntsville: James Adams, Patrick Reardon, Evgeny Kuznetsov, J. Watts Jr., J. Tubbs, M. Mastafa

NASA/GSFC: John W. Mitchell, John Krizmanic, Jeremy S Perkins, Julie McEnery, Elizabeth Hays, Floyd Stecker, Stan Hunter, Jonathan Ormes, Tonia Venters

University of Utah: Doug Bergman, John Matthews

Colorado School of Mines: Lawrence Wiencke, Frederic Sarazin

City University of New York, Lehman College: Luis Anchordoqu, Thomas C. Paul

Georgia Institute of Technology: A. Nepomuk Otte

Space Sciences Laboratory, University of California, Berkeley: Eleanor Judd

University of Iowa: Mary Hall Reno

Jet Propulsion Laboratory: Insoo Jun, L. M. Martinez-Sierra

Vanderbilt University: Steven E Csorna

APC Univerite de Paris 7: Etienne Parizot, Guillaume Prevot

Universita di Torino: Mario Edoardo Bertaina, Francesco Fenu, Kenji Shinozaki

University of Geneva: Andrii Neronov

RIKEN, Japan: Yoshiyuki TAKIZAWA

Gran Sasso Science Institute: Roberto Aloisio

SCIENTISTS FROM 16+ INSTITUTIONS FROM OWL, JEM-EUSO, AUGER, TA, VERITAS, CTA, FERMI, THEORY

POEMMA INSTRUMENT

Two 4 meter F/0.64 Schmidt telescopes; 45 deg FoVHybrid focal surface (MAPMTs and SiPM)Instrument Mass: 1,547 kgPrimary Mirror: 4 meterCorrector Lens: 3.3 meterFocal Surface: 1.6 meterAperture:6 to 2 m2Power:550 WData:1 GB/day

POEMMA

HYBRID MM FOCAL SURFACE

UV FLUORESCENCE MAPMTS WITH BG3 FILTER: <u>JEM-EUSO: 1 US</u>EC SAMPLING

CHERENKOV DETECTION WITH SIPMS:

20 NSEC SAMPLING

FOV 2° above limb

Separation s

Sat 1

Sat 2

POEMMA MISSION

Mission Lifetime: **3** years (5 year goal) 525 km, 28.5° Inc **Orbits: Orbit Period:** 95 min Satellite Separation: ~25 km - 1000+ km Satellite Position: 1 m (knowledge) Pointing Resolution: 0.1° Pointing Knowledge: 0.01° Slew Rate: 8 min for 90° Satellite Wet Mass: 3860 kg Power: 2030 W Data: 1 GB/day Data Storage: 7 davs Communication: S-band (X-band if needed) Clock synch (timing): 10 nsec

Operations:

- Each satellite collects data autonomously
- Coincidences analyzed on the ground
- View the Earth at near-moonless nights, charge in day and telemeter data to ground
- ToO Mode: dedicated com uplink to reorient satellites if desired

POEMMA: Exposure History

POEMMA

NADIR FOR UHECR: Radius 200-400 km

LIMB FOR NEUTRINOS: RADIUS 2.6-3.7 10³ KM

POEMMA: UHECR and Neutrino Sky Coverage

UHECR Stereo Mode

5 year

Calcs & plots by K. Shinozaki

Neutrino Mode: SiPM part of focal plane

Calcs & plots by C. Guépin & F. Sarazin

OPTICAL CHERENKOV SIGNAL FROM TAU NEUTRINOS PEV \rightarrow HIGHEST ENERGIES

arXiv:1710.05839

GW170817 follow up w ANTARES, ICECUBE, AUGER

POEMMA

UHECR AND NEUTRIND OBSERVATIONS

EUSO Balloon: 1st flight and first light on 24-25.8.2014

100

- 120

EUSO-SPB Extreme Universe Space Observatory on a Super Pressure Balloon

EUSO-SPB Extreme Universe Space Observatory on a Super Pressure Balloon

Ultrafast Camera: Photo-Detector Module (PDM) (3x3 ECs = 36 MAPMTS ; 2,304 pixels)

EUSO-SPB Extreme Universe Space Observatory on a Super Pressure Balloon

EUSO-SPB Launch, April 24,

2017 23:51 UTC

NASA completed its third mid-latitude Super Pressure Balloon (SPB) flight at May 7 3:40 UTC, after 12 days, 4 hours and 34 minutes aloft.

Why New Zealand?

Wanaka South Island New Zealand

air flow at ~30 km June 9th 2017

https://earth.nullschool.net/#current/wind/isobaric/1 0hPa/orthographic=180,-90,300

Cameron Beccario

Bifocal Design

Cherenkov Telescopes FoV 5° X 45° bi-focal mirror FoV 5° X 45° normal mirror Focal Surface 7cm x 70cm

Fluorescence Telescope FoV 15° X 45° normal mirror

Corrector Plate: 1m² Image resolution: ~ few mm Pixel size: ~3mm square

Challenges/Opportunities: Space qualified SiPMs, ultra-fast ASICs, corrector lens development, bifocal mirror SPB stability

SPACE PROBES OF THE HIGHEST ENERGY PARTICLES: POEMMA & EUSO-SPB

EUSO-SPB2

THE EARTH'S ATMOSPHERE AS AN EXTREME ENERGY PARTICLE OBSERVATORY

EUSO-SPB1 LAUNCH FROM WANAKA, NZ April 24, 2017

ありがとう

PDEMMA

UHECR AND NEUTRIND OBSERVATIONS

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