



EUSO-SPB2: First Results of a Multi-Messenger Balloon Payload

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for the JEM-EUSO Collaboration

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EUSO-Balloon



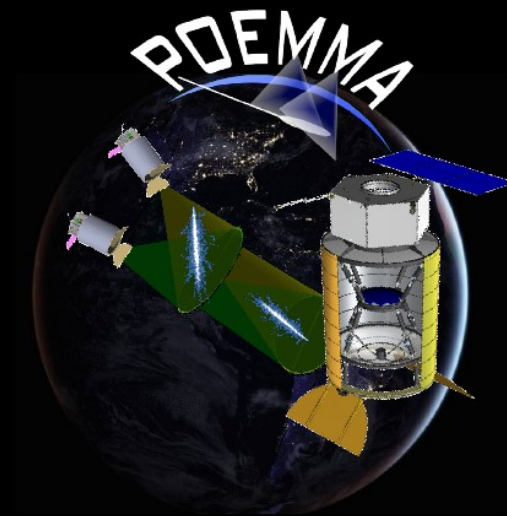
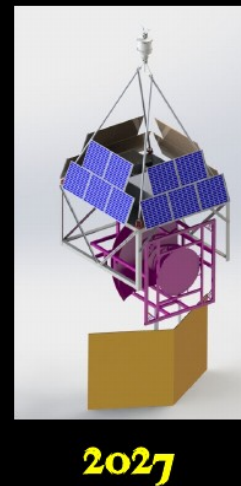
EUSO-SPB1



EUSO-SPB2



PBR





EUSO-Balloon



EUSO-SPB1

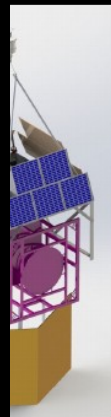


2017

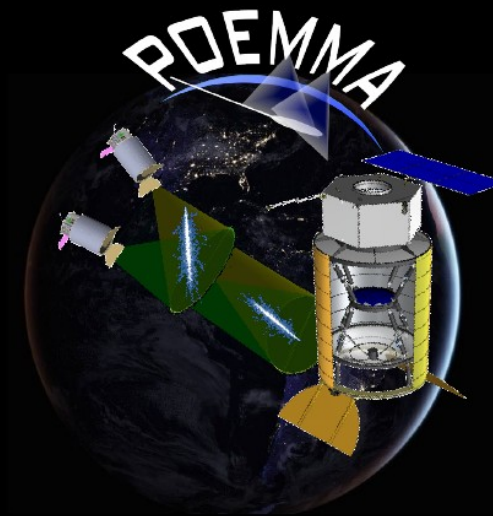
EUSO-SPB2



2023

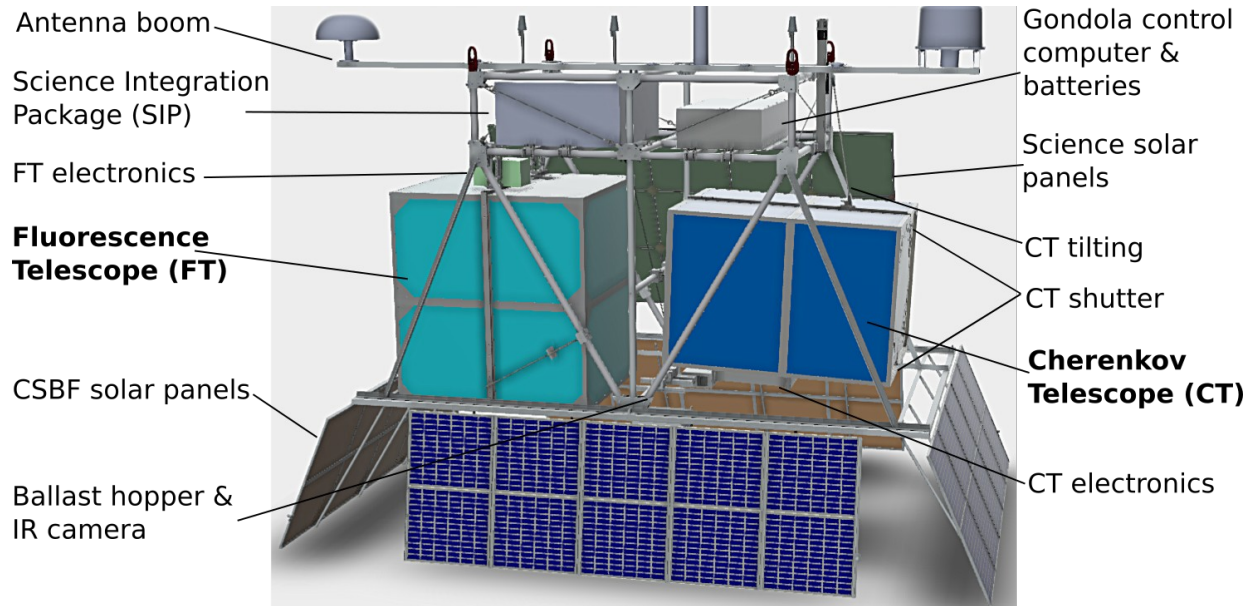


2023





The Payload

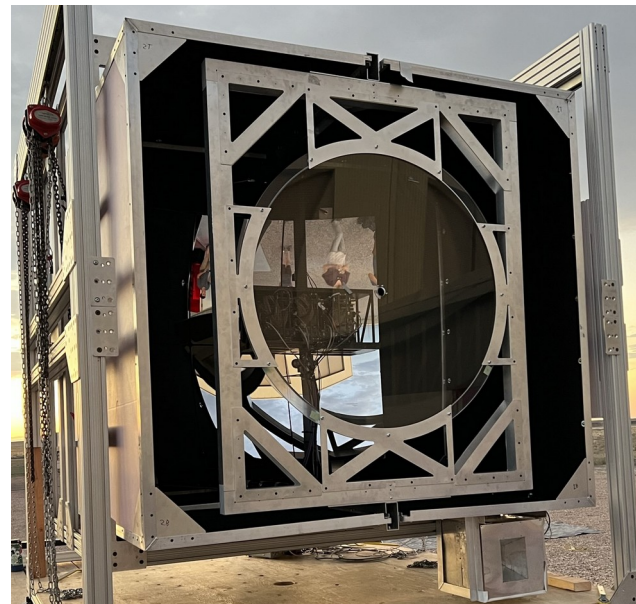
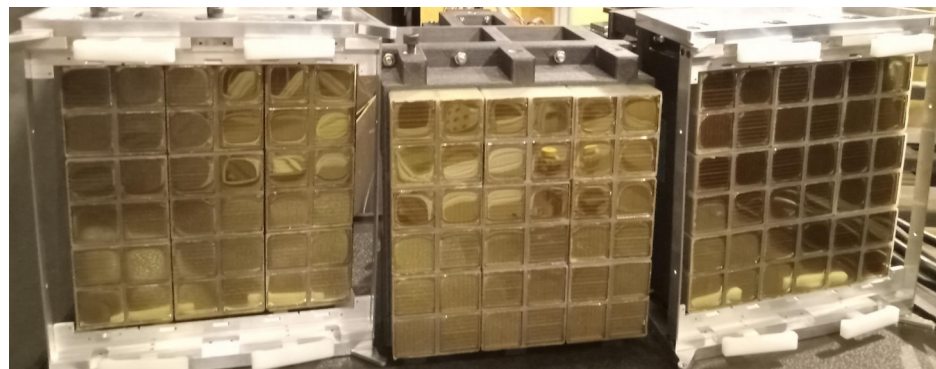


- 3000lbs of science
 - 2x 1m diameter telescopes
 - 1 IR camera

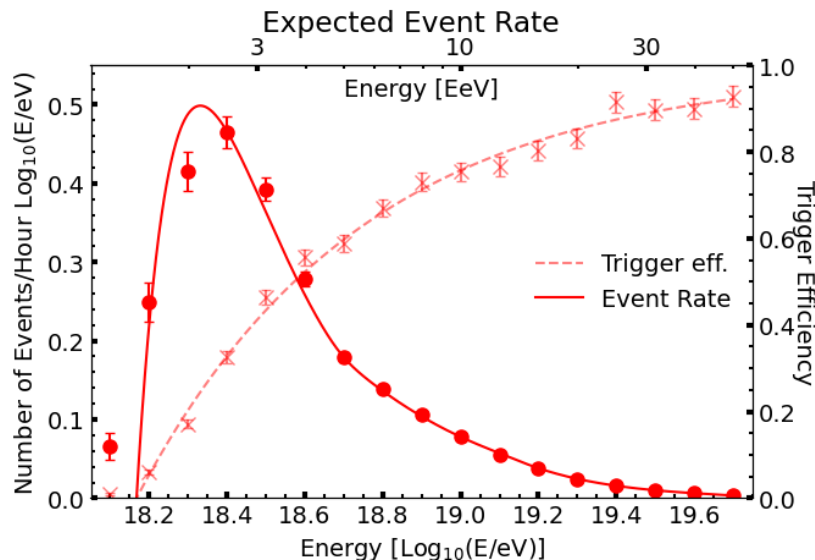
- LDB equipment:
 - Telemetry
 - solar panels
 - StarLink

	Institution	EUSO-SPB2 Science Team	Work Packages
US	U. Chicago	A. Olinto (PI), R. Diesing, S. Meyer, J. Eser	IR Camera (UCIRC), Gondola, ST
US	Mines	L. Wiencke (Dep. PI), F. Sarazin, G. Filippatos, V. Kungel, T. Heigbes, H. Wistrand, D. Fuhne	Telescopes:(Mech, Testing, Integ, Calib, Field Testing) Optical Test Stand, ST controller, Simulations
US	Iowa	Y. Onel, M. Reno	CT, FT LED systems, Neutrino ToO
US	MSFC	M. Christl, R. Young, P. Alridge	GCC system
US	UAH	P. Reardon, J.Adams, E. Kuznetsov,	Optics Design, Solar Power, CT subsystems,
US	Lehman U.	L. Anchordoqui, T. Paul	Optics PMTs, Simulations
US	Ga Tech	N. Otte, E. Gazda, M. Bagheri, O. Romero	FT camera development
AL	CDTA, CRAAG	M. Traiche (CDTA), M. FOUKA (CRAAG)	Optics Simulations
CZ	U. Olomouc	C Kerny, M. Pech, P. Schovanec	Mirror Segments for CT and FT
FR	APC	G. Prévôt, S. E. Parizot	FT camera Elementary Cells,
FR	OMEGA	S. Blin	Electronics -ASICS
IT	INFN & U. Napoli	G. Osteria, V. Scotti, L. Valore	CPU, Fluorescence Detector – DAQ, ...
IT	INFN & U. Torino	M. Battisti, M. Bertaina F. Bisconti, M. H. Miamoto K. Shinozaki	Simulations, lab testing, trigger algorithms
IT	INFN & Univ. Bari	F. Cafagna	Flight (telescope) Software, FT Camera Housing
IT	UTIU	C. Fornaro	Fluorescence Telescope DAQ Software
IT	LNF-INFN, Frascati	M.Ricci	Italian coordinator
JA	RIKEN	M. Cassolino, T. Ebisuzaki, Y. Takizawa	Optics(ACP), PMT testing
Mx	U. Mexico	G. Medina-Tanco	Thermal Modeling
POL	NCBJ	J. Szabelski, L. Petrowski	FT HV system, simulations
RU	MSU	P. Klimov, A. Belov	FT Camera zynq boards
SE	KTH	C. Fuglesang.	FT Camera structure (prototype)
SK	SAS	S. Mackovjak	UV/Vis Monitors

- Optimized for EAS detection via fluorescence
 - Modular camera with 6912px (MAPMT)
 - Single photo-electron counting
 - 290-430nm detection window (BG3)
 - Integration time of $1\mu\text{s}$
- Optics (Schmidt optics):
 - 1m diameter aperture
 - FoV $\sim 12^\circ \times 36^\circ$ ($\sim 36 \text{ km}^2$ on ground)
 - Pointing: nadir
- More details in <https://arxiv.org/pdf/2406.13673>

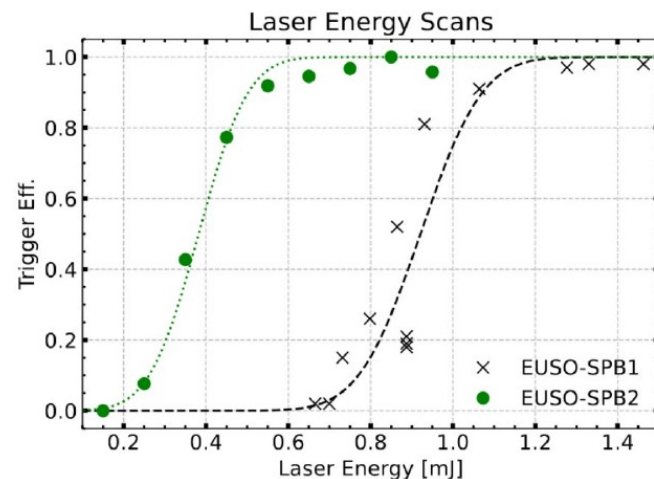
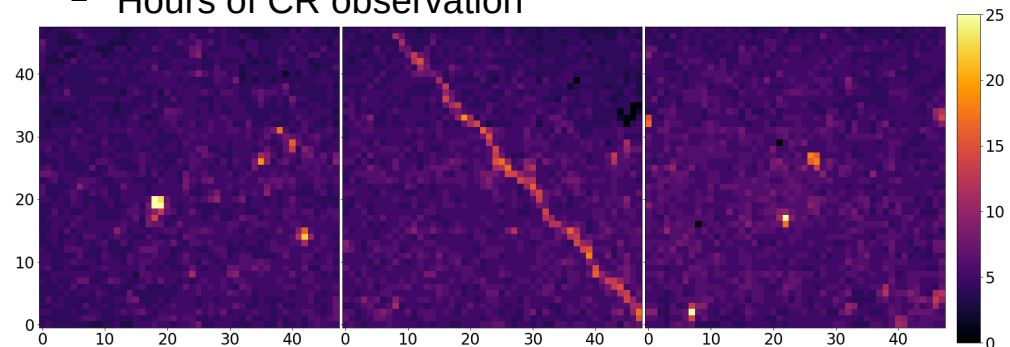


FT: Expected performance



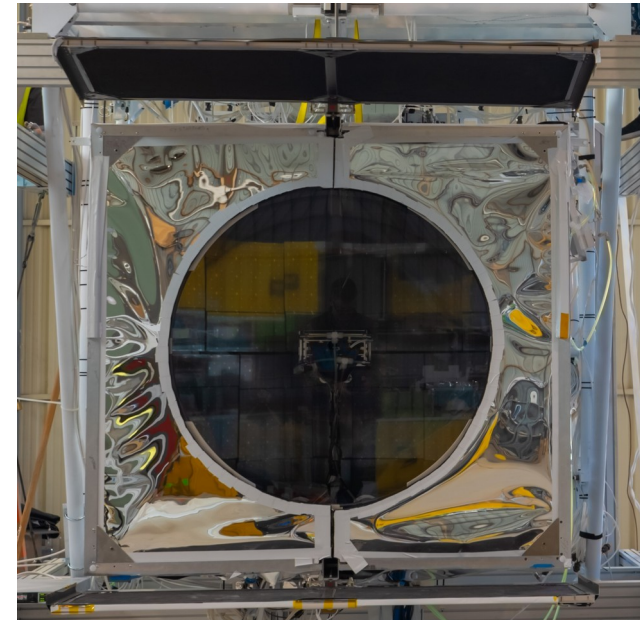
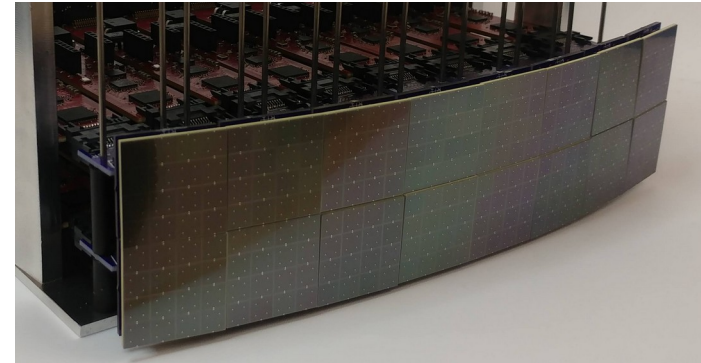
- Energy threshold: $\sim 1.5\text{EeV}$ with peak sensitivity at 2EeV
- **0.12 events per hour** ($<10\%$ are reconstructable: geometry, longitudinal profile contains X_{max})
- On board pre-selection using Neural Network ($\sim 90\%$ accuracy)

- Field tested in July/August with 10000 laser shots and LED events
 - Full end-to-end calibration
 - Hours of CR observation



Energy threshold around 2x better than EUSO-SPB1

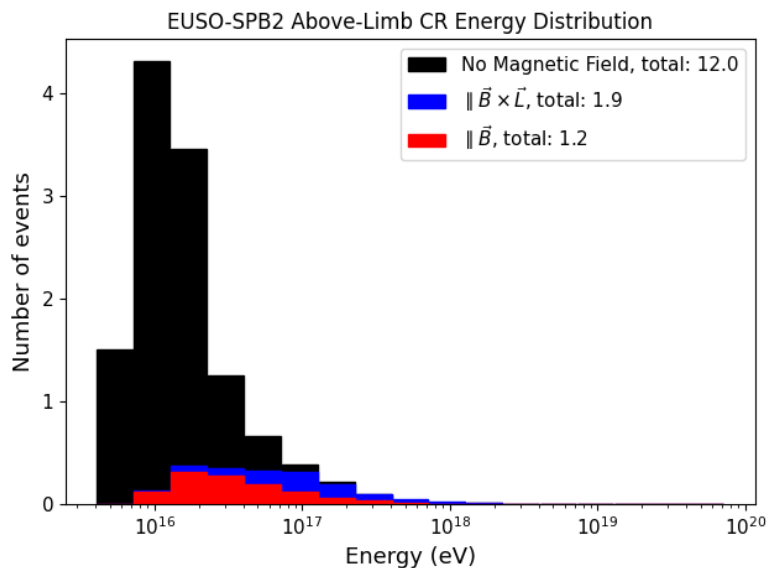
- Optimized for EAS detection via Cherenkov light (ultra fast signal)
 - 512 SiPM based pixels
 - 10ns integration time
 - 200-800nm spectral range
- Optics (Schmidt system)
 - 1m diameter aperture
 - FoV $\sim 6.4^\circ \times 12.8^\circ$
 - Bi-focal for distinguishing between external light and direct hits
- Pointing from 2.5° to -13.1° (0° is horizontal) and 360° in azimuth by NASA rotator to point at ToOs
- Technical details in [arXiv:2406.08274](https://arxiv.org/abs/2406.08274)



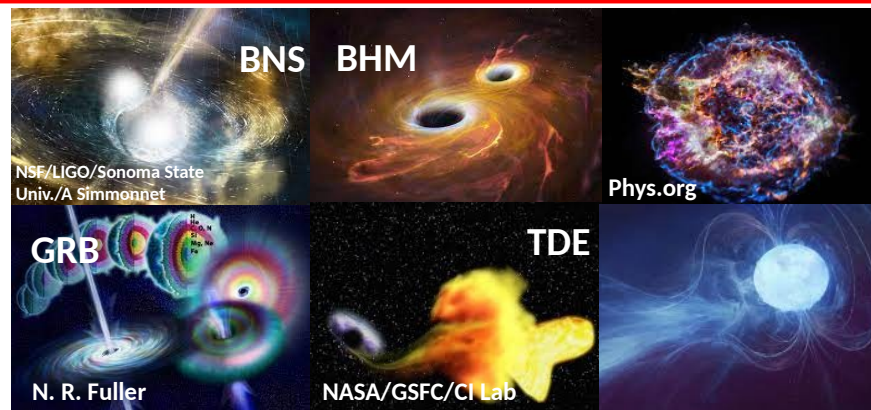
CT: Expected performance

Above the limb

- Simulation study using EASCherSim
- Low energy threshold of 10PeV
- Angular acceptance is energy dependent
 - Geometric energy filter



→ ~12 per hour

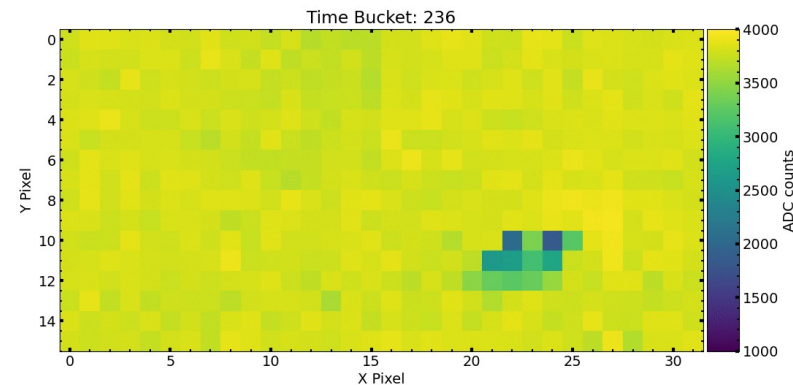


Below the limb

- EUSO-SPB2 not sensitive to the diffuse neutrino flux, but can observe transients by pointing
 - Galactic supernovae
 - BNS/BH-NS merger
 - Flaring Blazar/AGN
 - Nearby tidal disruption events
 - GRBs
 - Extra galactic supernovae
 - Other transients
 - Steady sources (e.g. TA hotspot)

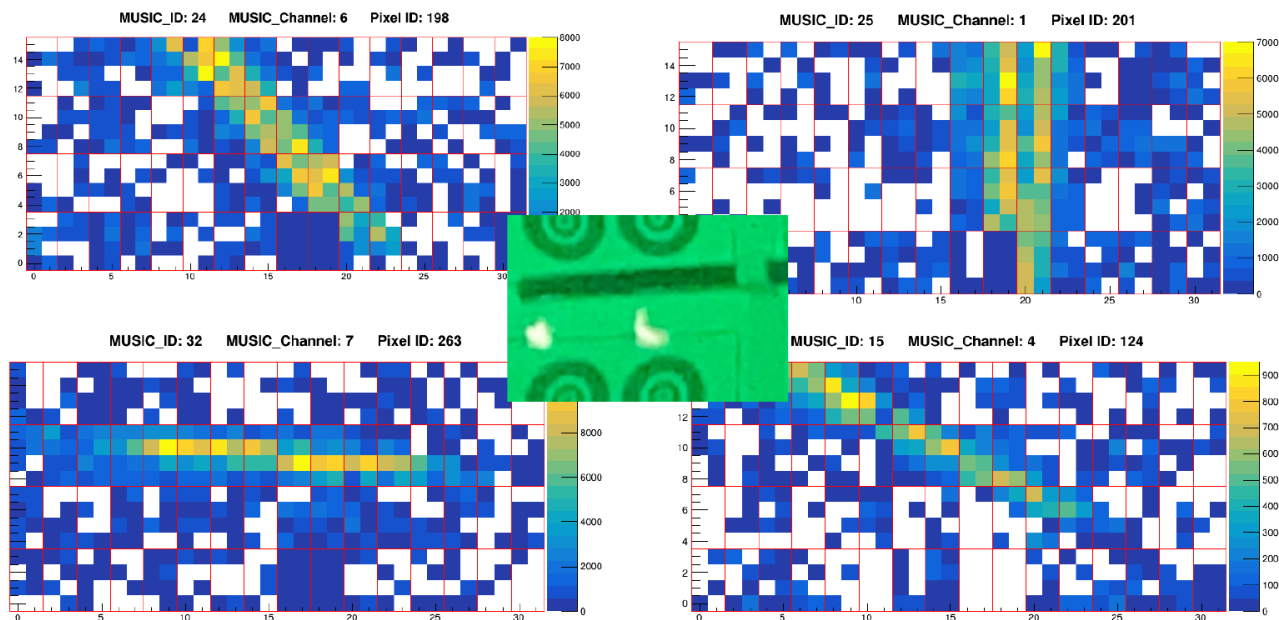
CT: Expected performance

- Field tested in Jan 2022
 - With 10000s laser shots and LED events
 - Observation of 1000s CR



Bi-focal CR event

- TeV Energy Scale
- Pointed vertical

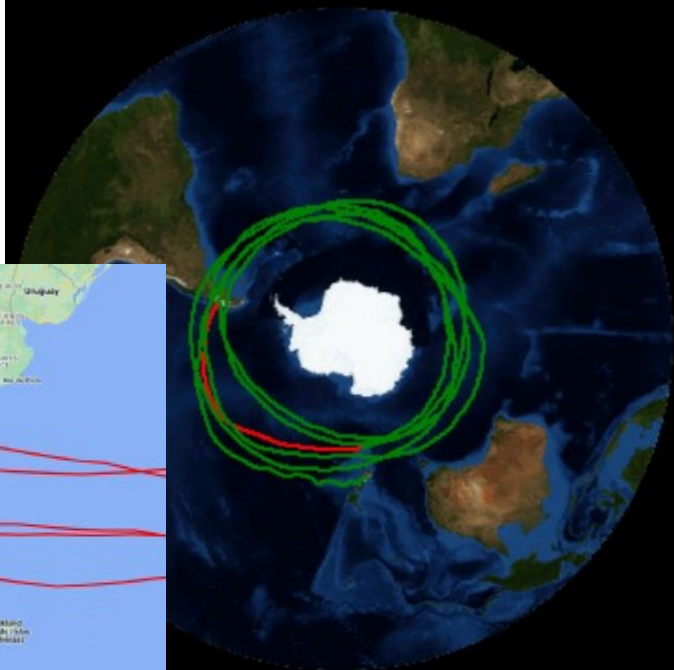


Field test laser tracks

- Pointed vertical and rotated in azimuth

The Flight Expectation

728NT - SN08 - SUPERBIT Balloon Tracking

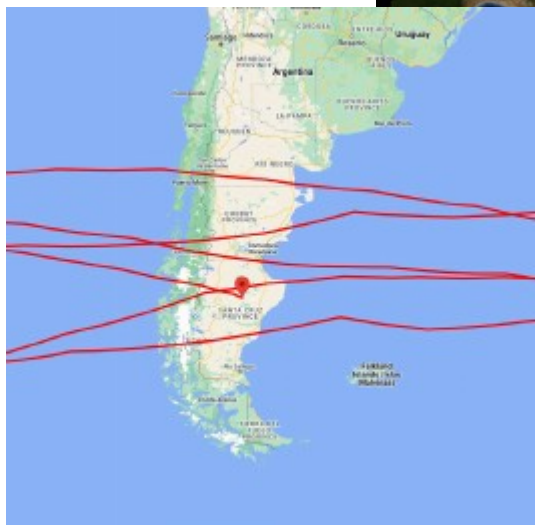


Flight Ended
Total Flight Time

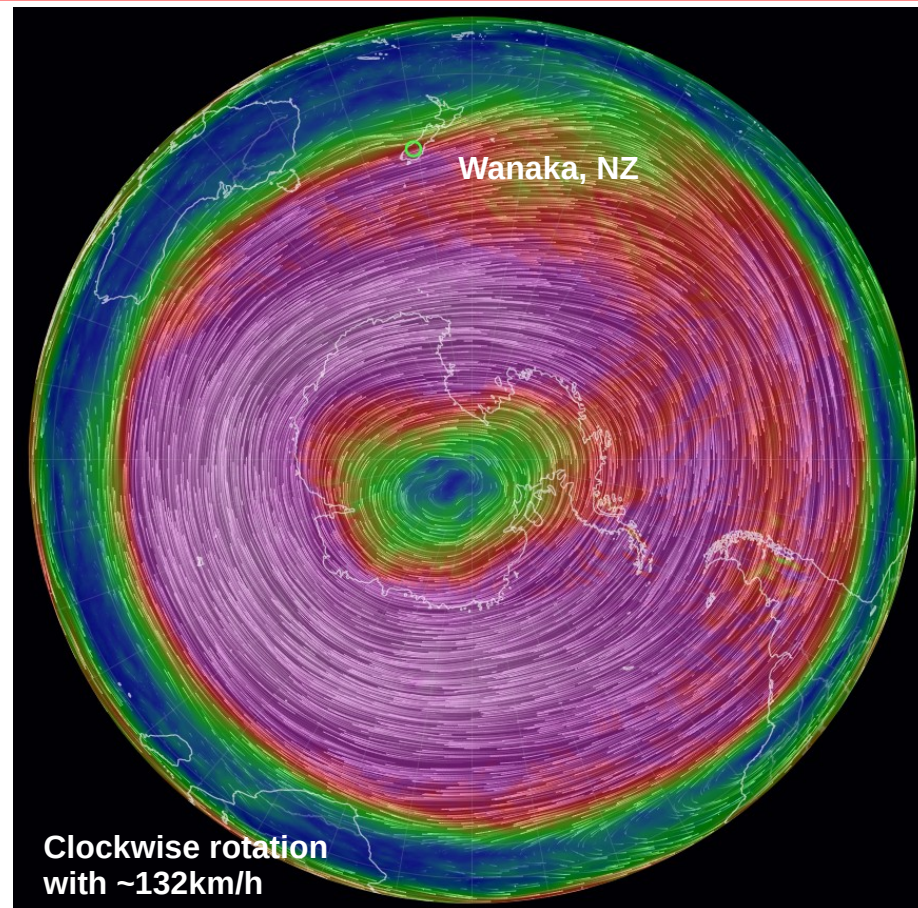
39 Days 13 hours 35 minutes

Launched April 15, 2023

- NASA Super-Pressure Balloons are designed with a flight duration up to 100days
- Launch from Wanaka, NZ
 - Allows circulation around the southern Ocean



The Launch: 13 May 2023



<https://classic.nullschool.net/#2023/05/13/1800Z/wind/isobaric/10hPa/orthographic=-180.00,-90.00,423/loc=169.254,-44.721>

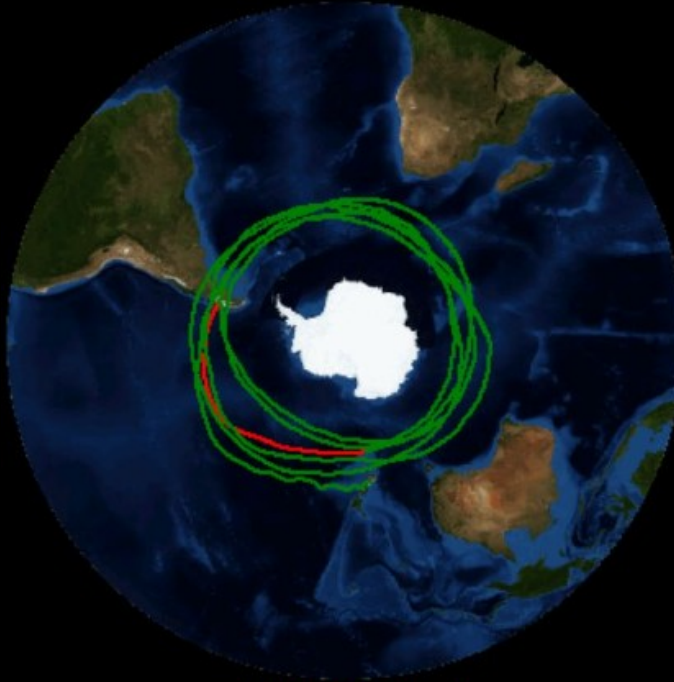


The Flight

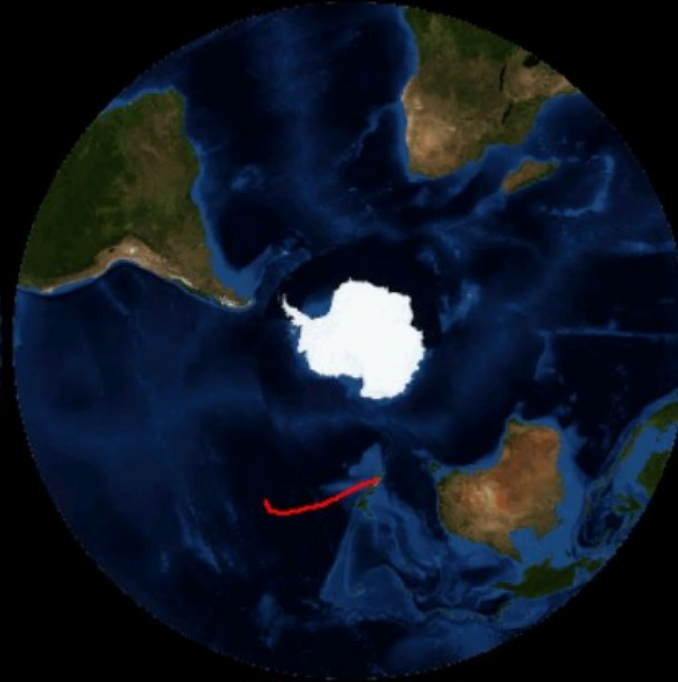


728NT - SN08 - SUPERBIT Balloon Tracking

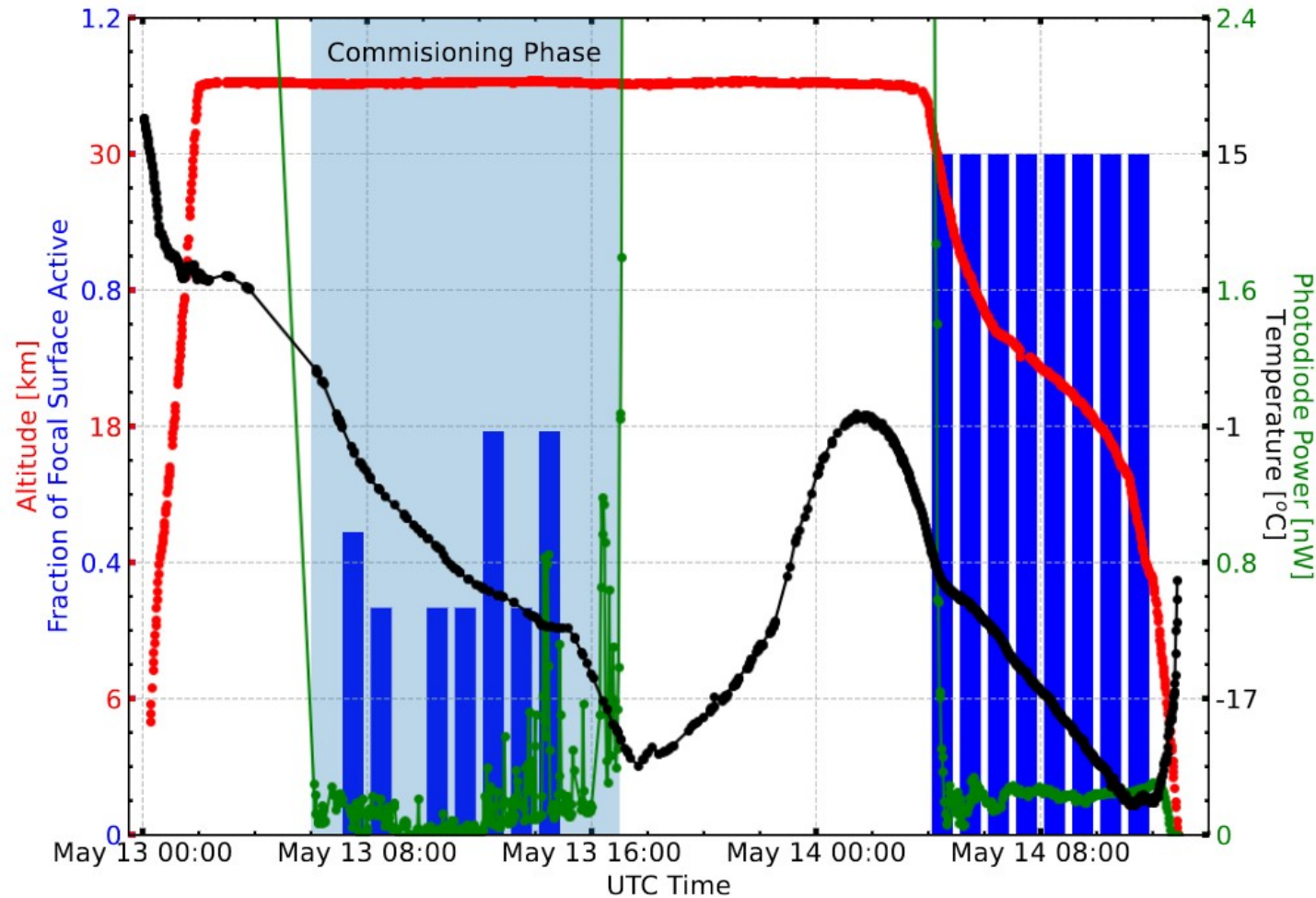
729NT - SN09 - EUSO 2 Balloon Tracking

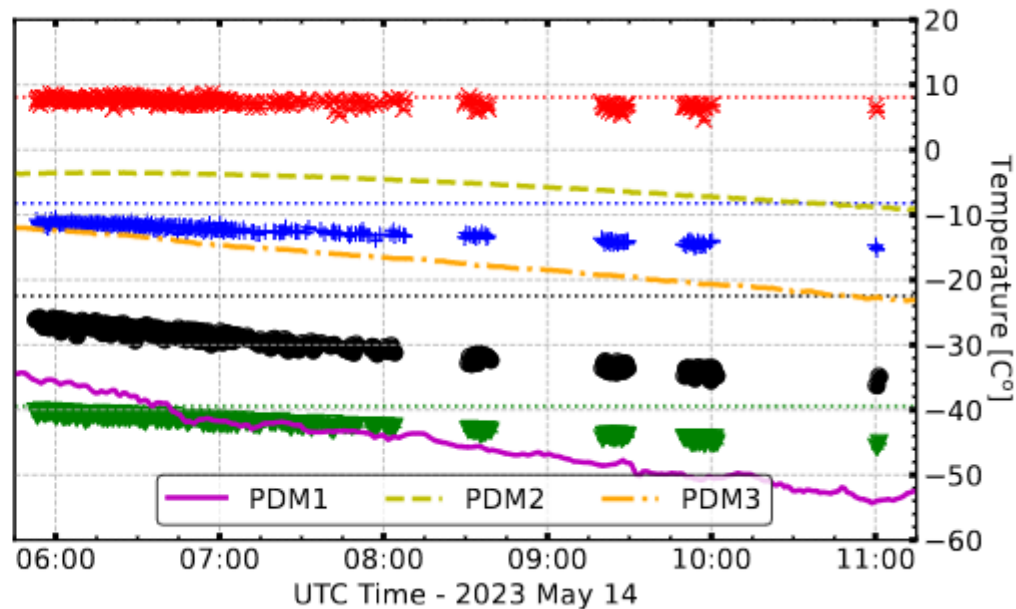
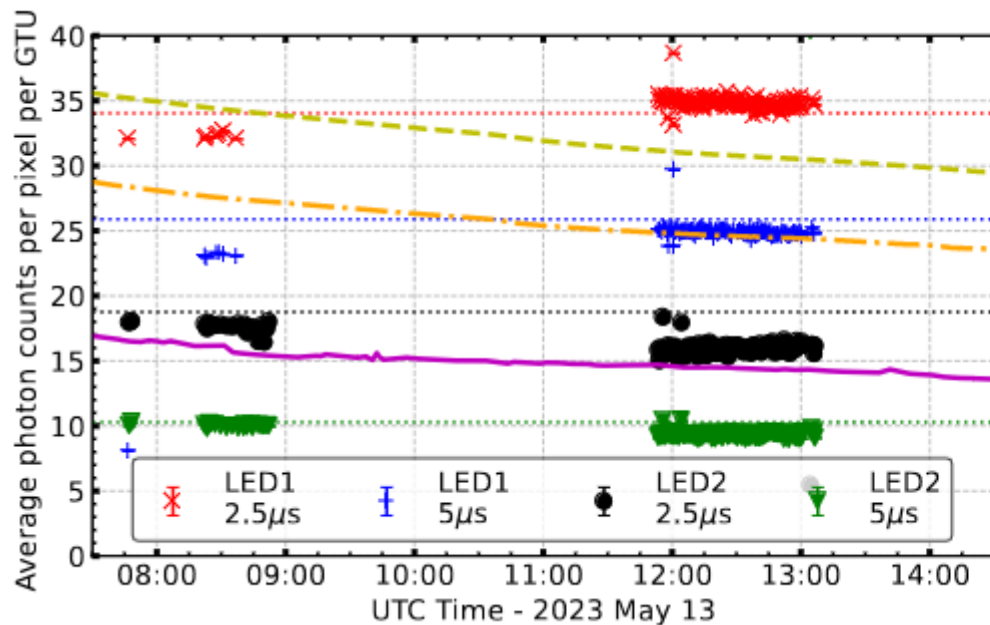


Flight Ended
Total Flight Time
39 Days 13 hours 35 minutes
Launched April 15, 2023



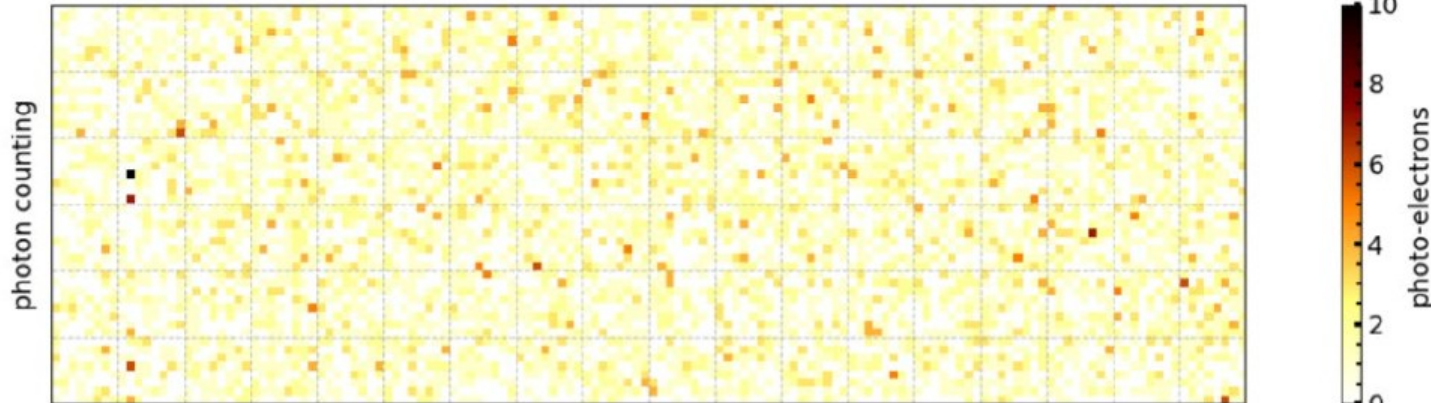
Flight Ended
Total Flight Time
1 day 12 hours 53 minutes
Launched May 13, 2023



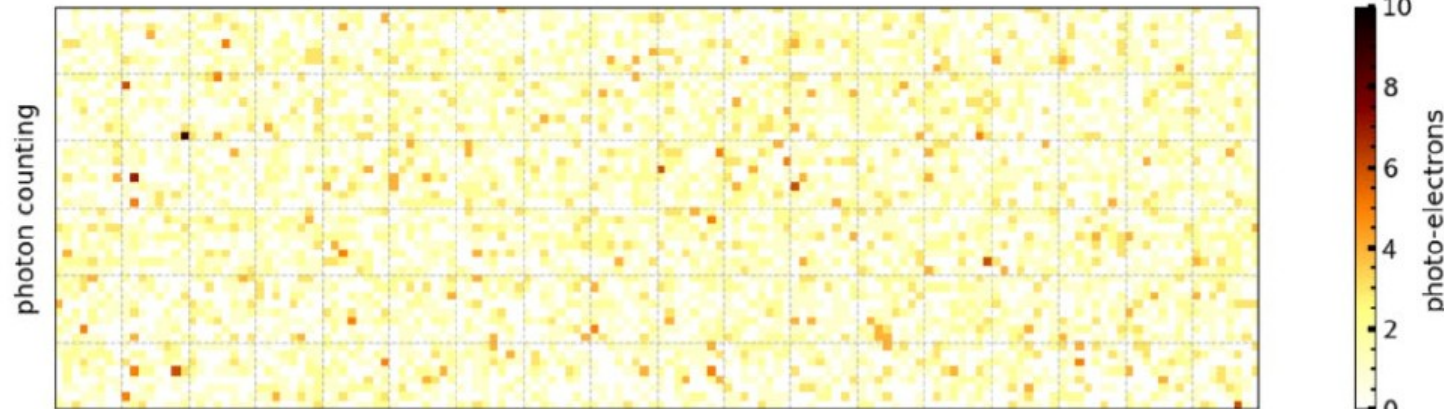


Very stable Instrument response during the flight
Performance as expected

Event #16040 ; UTC Time 14 May 2023 06:30:23.8608 ; GTU in packet 50



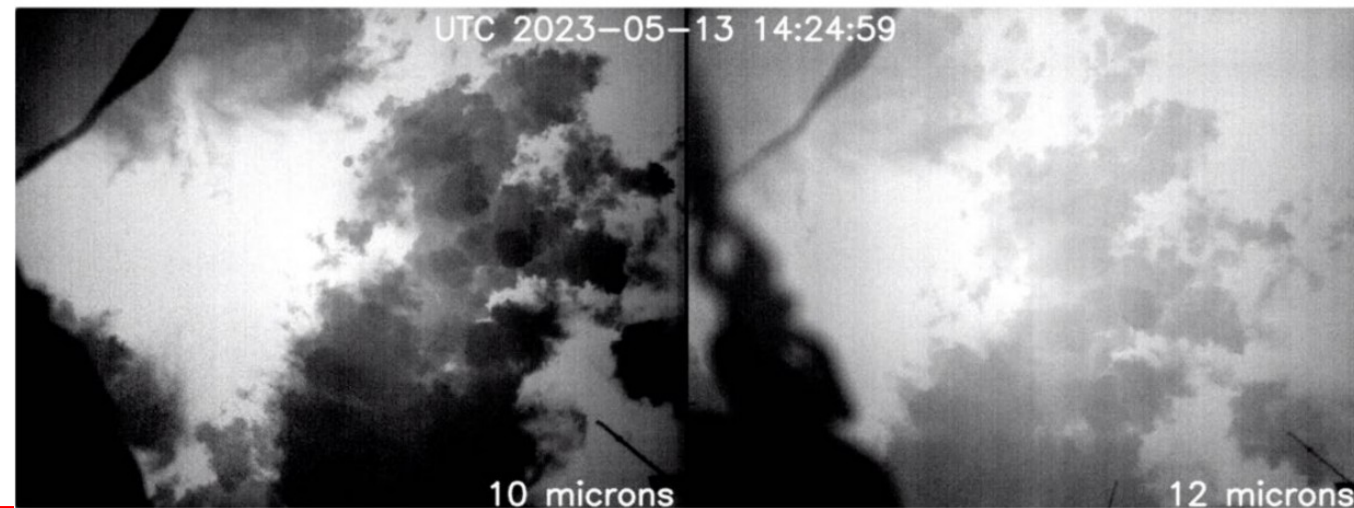
Event #16040 ; UTC Time 14 May 2023 06:30:23.8608 ; GTU in packet 53

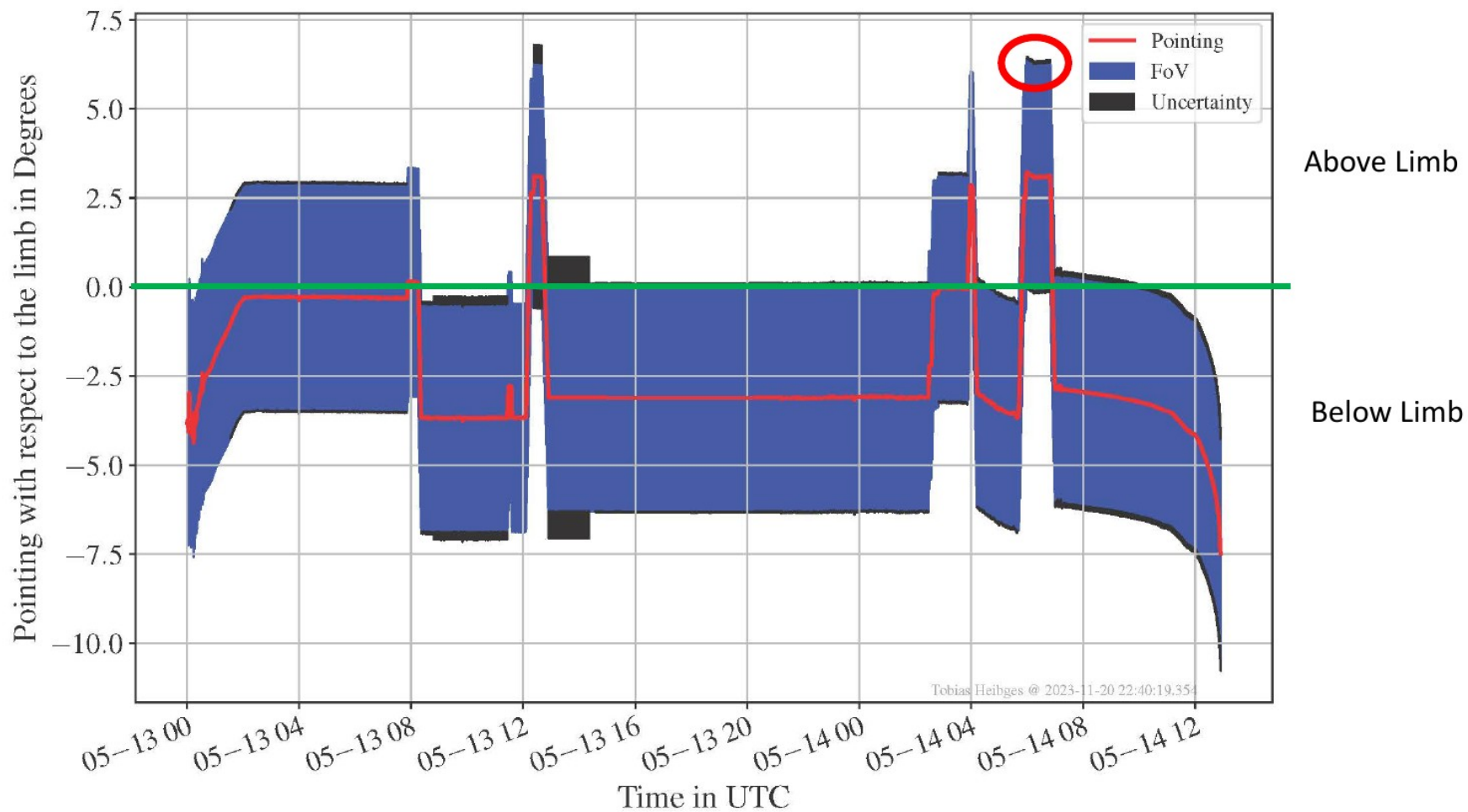


- Operated for 2 nights :
 - May 13th: 7 hours commissioning
 - May 14th:
 - Morning learned of bad leak in balloon
 - 5 hours (downloaded data)
 - More than 120000 triggers recorded and downloaded (thanks to StarLink)
- ➡ **FT performed well but no UHECR found** (consistent with expectation for flight duration)

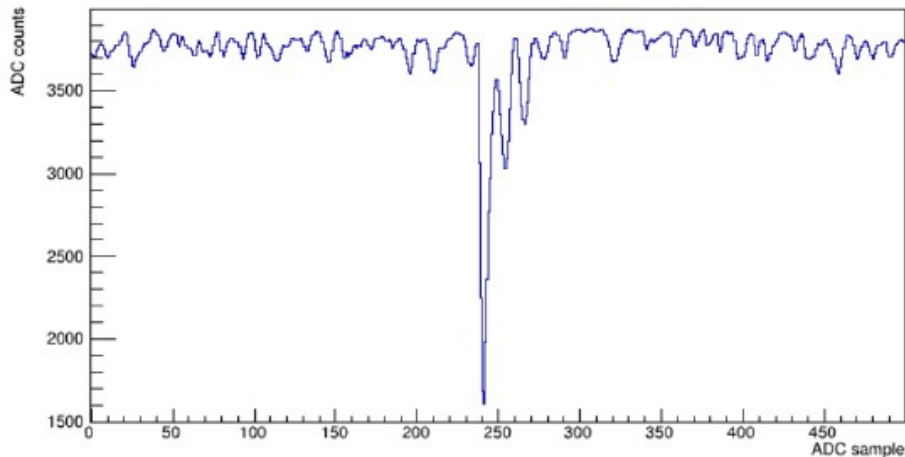
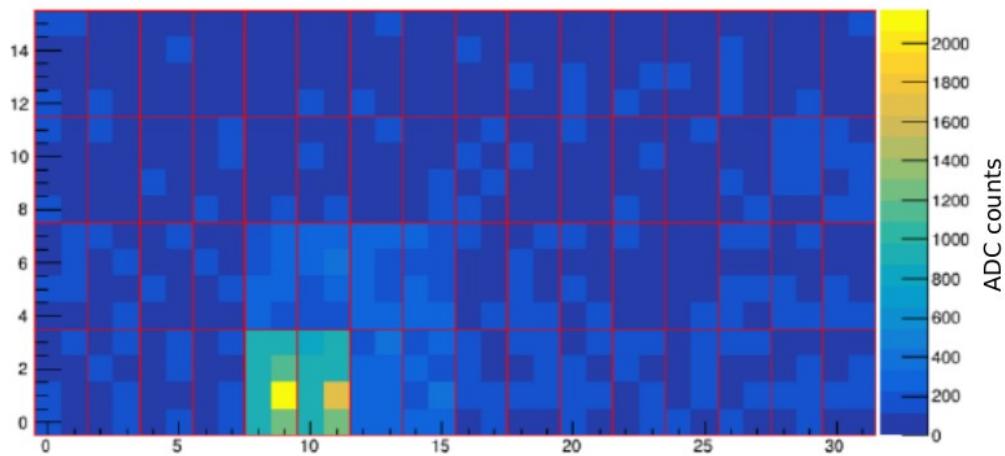


- UCIRC2 consisted of 2 IR cameras (10 & 12 micron) for cloud monitoring
- Picture rate was 1 every 2min
- Analysis of cloud top height ongoing





Tobias Heibges @ 2023-11-20 22:40:19.354



- Operated for 2 nights (first night mainly commissioning)
 - 31,269 Bifocal
 - 832 HLED
- Above the limb
 - 45min observation (2893 bifocal events)
 - 14 CR candidates found (consistent with Simulations)
- Below the limb
 - No ToO follow up due to time constraint
 - Important bg data measurement
 - No Neutrino candidate found

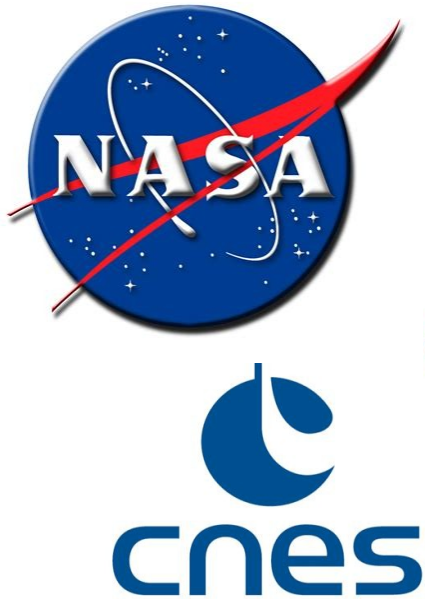
➡ Performed as expected



Summary



- Successful launch on May 13th as NASA SPB payload
 - Payload delivered on time within mass limits
- Premature termination after ~37 hours due to balloon leak and consequently loss of payload in the ocean
- FT:
 - 120000 triggers recorded and download
 - **Performed well**
 - No Cosmic ray candidate found (as expected given this short flight)
- CT:
 - 32000 triggers recorded and downloaded including 45min above the limb
 - **Performed well**
 - Several Cosmic Rays recorded
 - No time for ToO follow up
 - No neutrino candidates
- Various publication are in preparation or submitted to journals



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