

The Fresnel optics of the EUSO-Balloon/SPB Pathfinder, modelling, characterisation and flight data Analysis



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The JEM-EUSO Mission

The Extreme universe space observatory on board Japanese Experiment Module:

- Space Observatory designed for the Observation of Ultra High Energy Cosmic Rays
- Explore regions of higher uncertainties in the cosmic ray spectrum $E > 3 \times 10^{19}$ eV
- Increase of UHECRs statistics by observing from above
- Solve biggest mysteries about their origin (Galactic, extragalactic??)

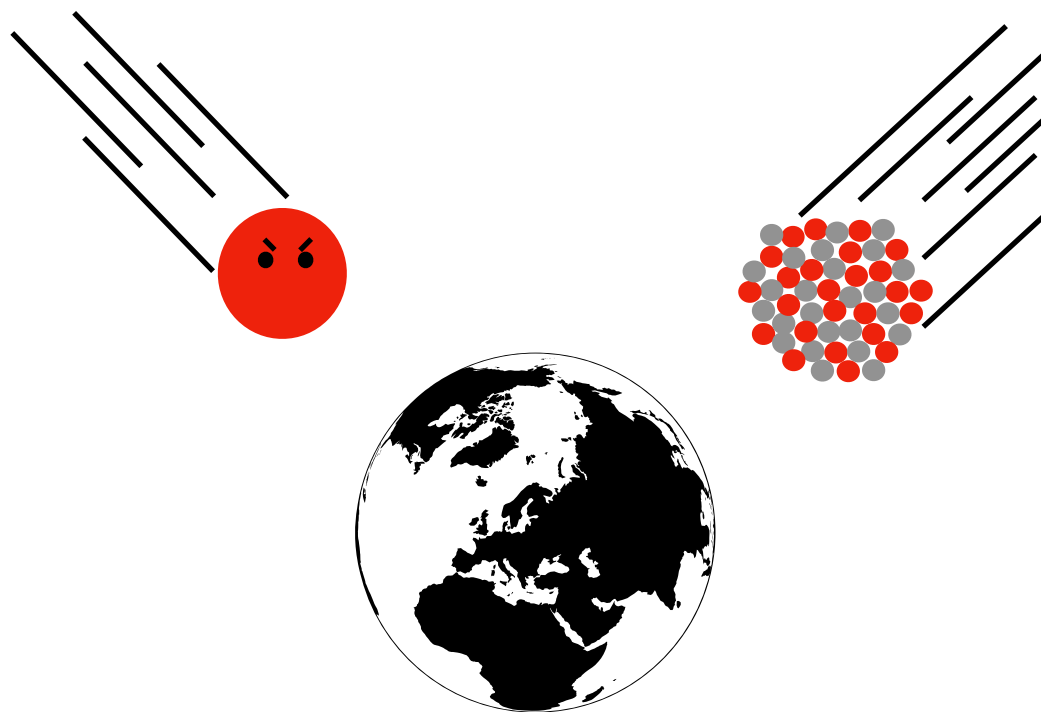


Cosmic Rays

Subatomic particles travelling at relativistic velocities

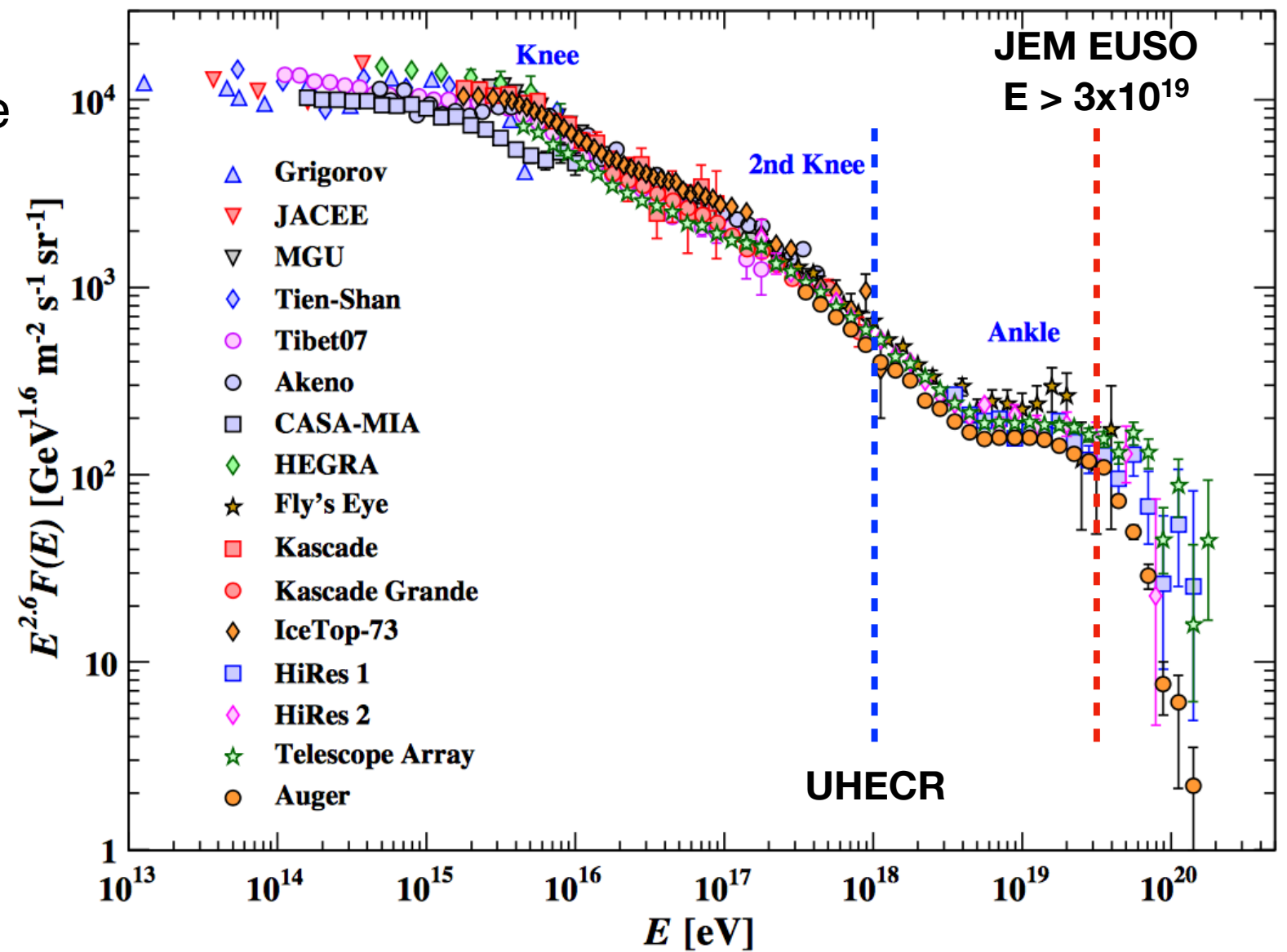
Mostly atomic nuclei from H $\rightarrow$ Fe

Constantly bombarding earth!



(Not to scale)

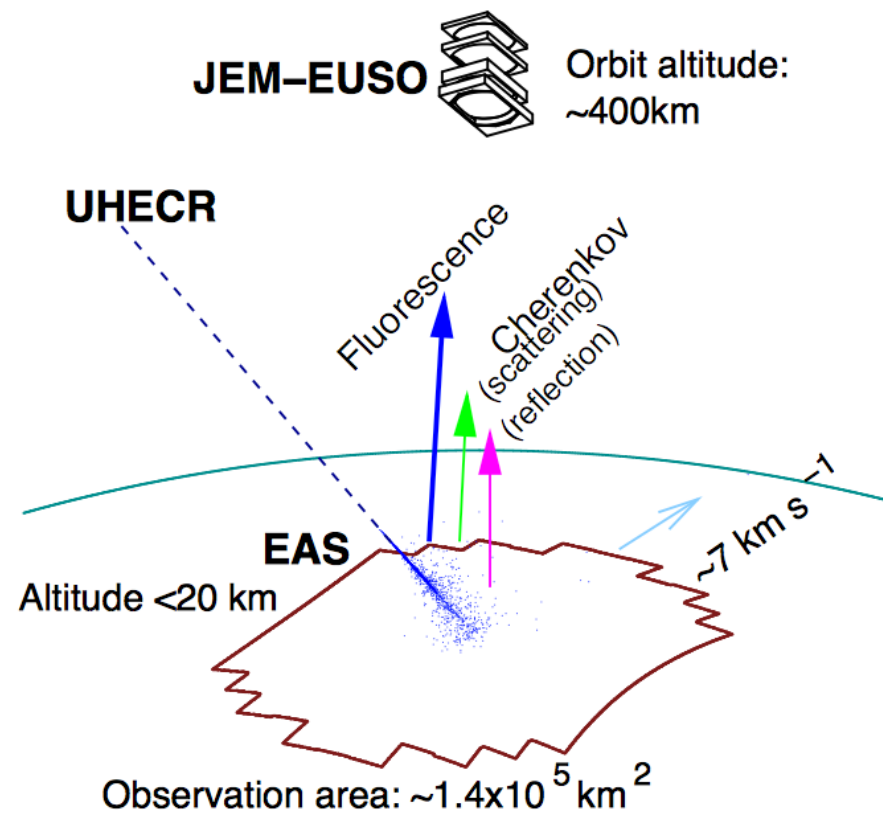
Cosmic Ray Spectrum



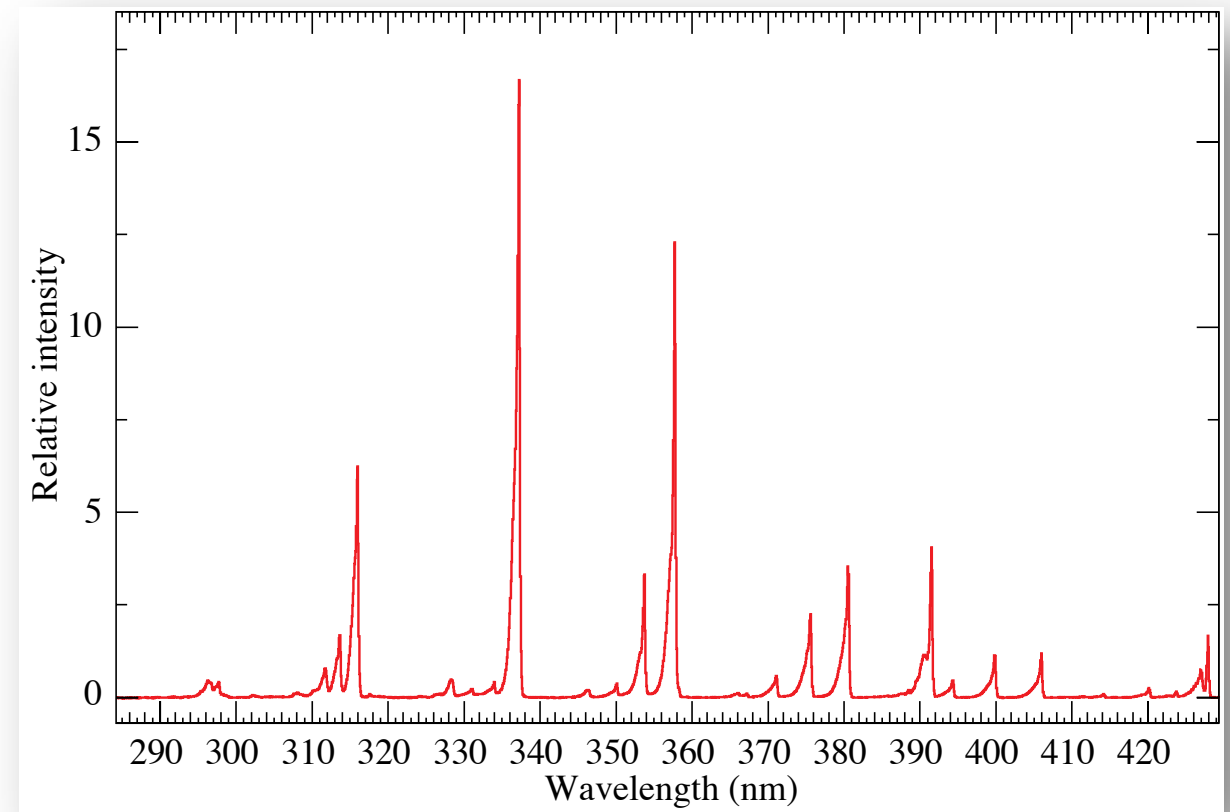
UHECR's: $E > 10^{18}$

Detection Technique

Observational Principle



Air fluorescence Spectrum



Detection of UHECRs by using the atmosphere as a giant calorimeter!

UHECRs produce an atmospheric cascade of particles (Extensive air showers) which induce fluorescence of air molecules in UV spectrum → UV Telescope!

Ultrafast detector: 400,000 fps

Pathfinders needed to test technologies & characterise UV bg → EUSO-Balloon, EUSO- SPB

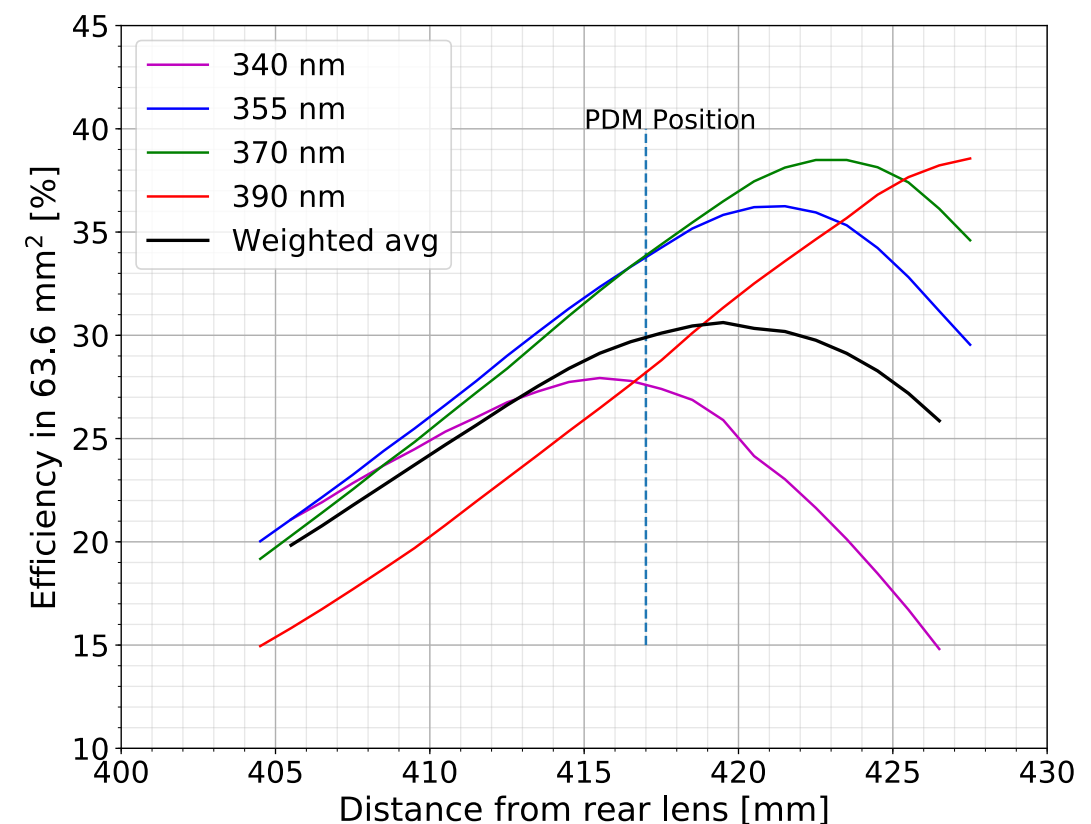
The Optical System

Composed of 2 Fresnel Lenses optimised for UV Air Fluorescence Wavelengths

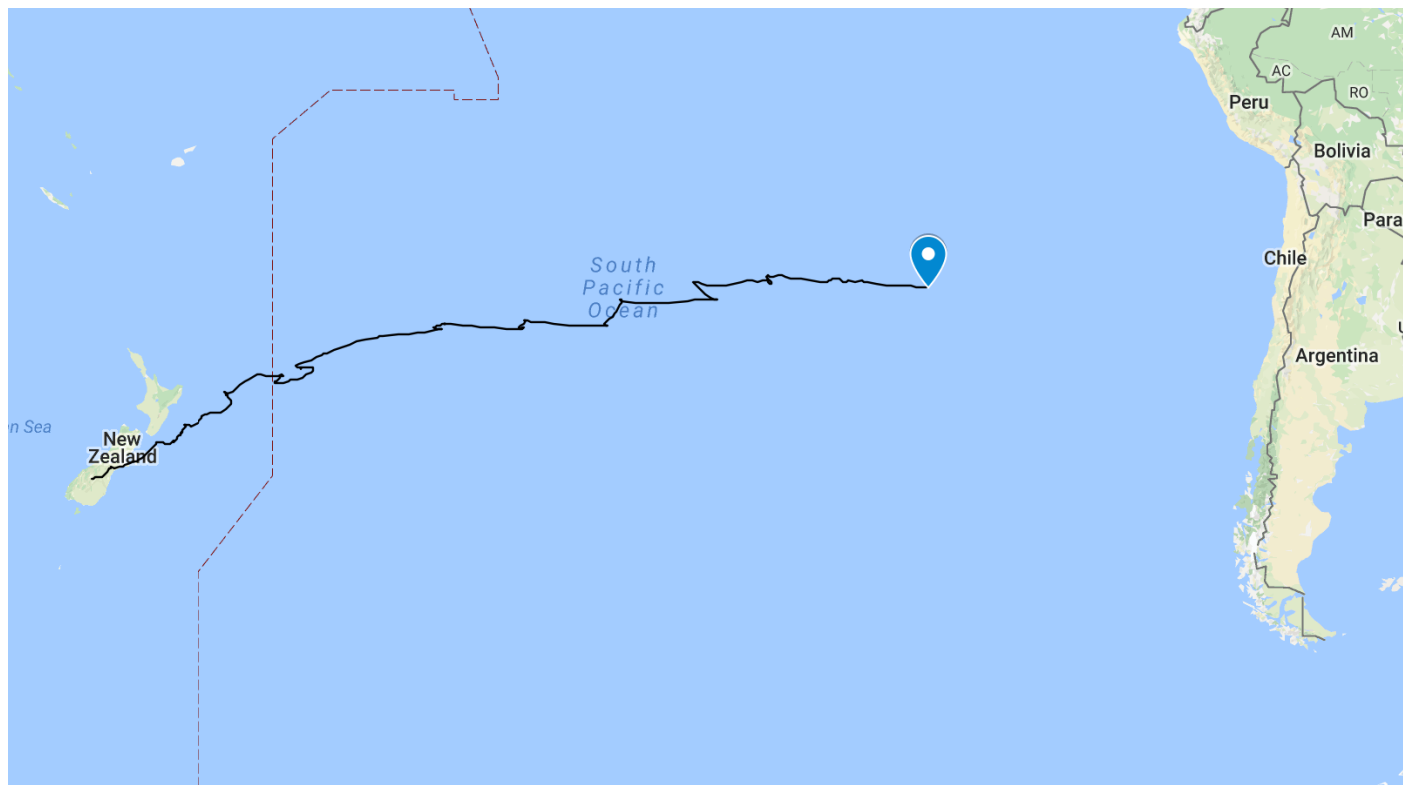


Tested in the Colorado School of Mines to determine the efficiency of the system and the optimal position of the detector.

Discrepancies between simulation model and characterisation —> Improvement of optical model needed



Balloon Launch Campaign



- Launch campaign in Wanaka, NZ
- Final tests and integration of subsystems (Optics, Detector, Software)
- Corroboration of Parkinson's Law: "work expands so as to fill the time available for its completion"
- Launched the 25th of April, 2017
- Leak on the balloon developed on 3rd night
- After 12 days of flight the instrument splashed down in the pacific ocean (Goal = 100 😞)

Data Analysis

Detector:

Array of 6 x 6 Photomultiplier tubes

Photon counting capabilities

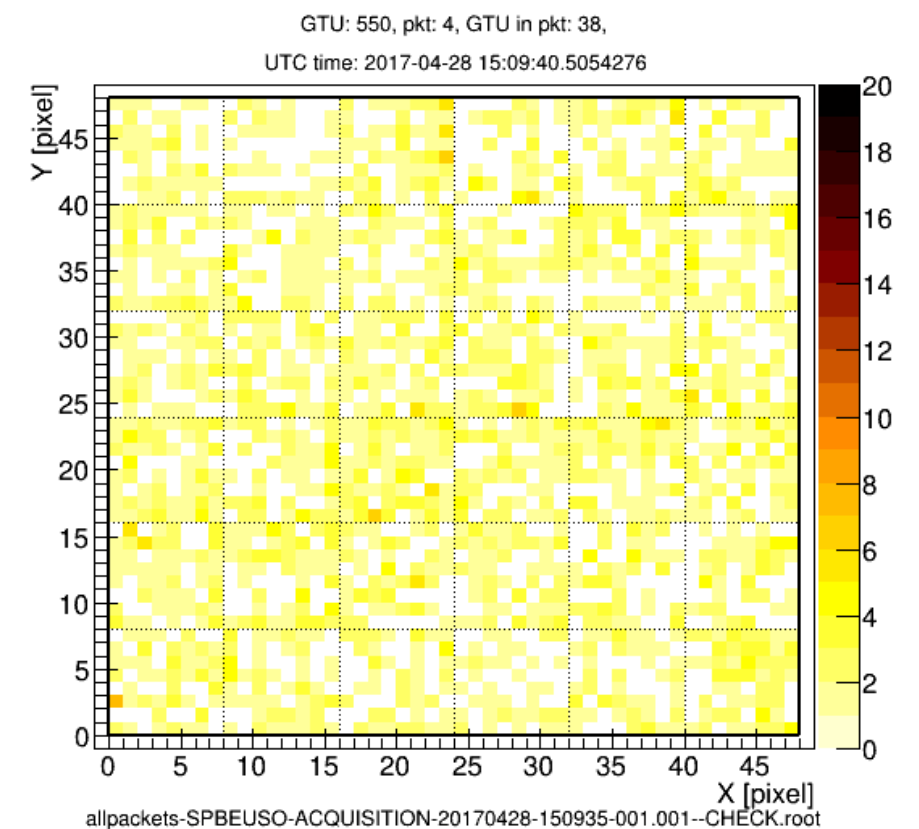
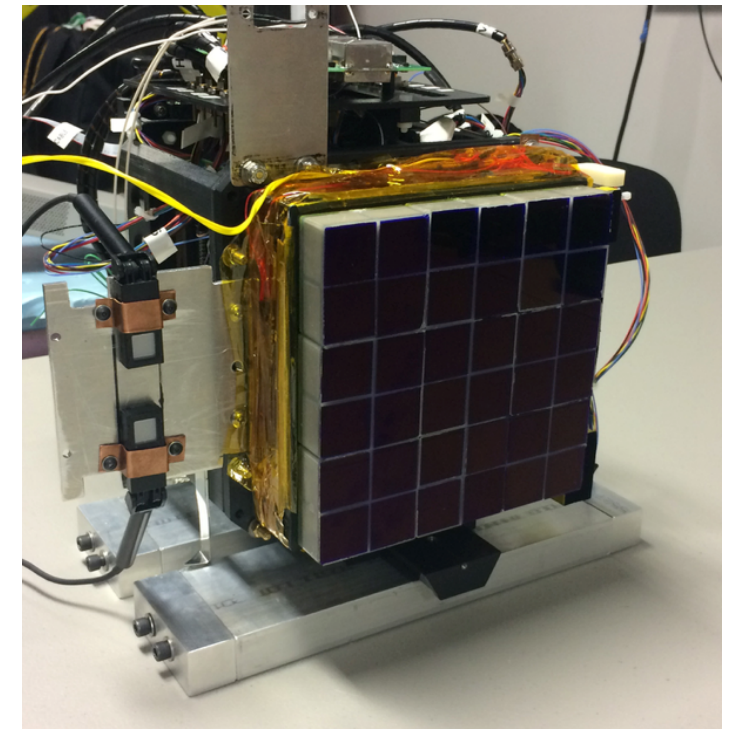
Gate time unit = $2.5 \mu\text{s}$ ~ 400k pictures per second

40 hrs of data recovered

Data analysis in progress!

Looking for:

- 1 - Air showers (hopefully)
- 2 - Other kind of events (airplanes, shooting stars, UFOs, etc.) to calibrate trigger algorithm



Conclusion and Perspectives

Data analysis is the main focus of thesis at the moment.

First official presentation of data results in the International Cosmic Ray Conference (ICRC).

Fresnel Optics still not very well understood, model needs improvement.

Optics will be tackled when data analysis is over!



Questions??



QUIZ TIME!

At what energy (eV) can we consider cosmic rays as UHECRs??

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10^{18} eV