Science and mission status of EUSO-SPB2

J. Eser[1], A. Olinto[1], L. Wiencke[2] et al.
for the JEM-EUSO Collaboration
[1]University of Chicago
[2] Colorado School of Mines

EUSO-SPB2 at the ICRC

- 389. An overview of the JEM-EUSO program and results *(15/07, Bertaina)*
- 403. The Fluorescence Telescope on board EUSO-SPB2 for the detection of Ultra High Energy Cosmic Rays *(15/07, Osteria)*
- 330. Expected Performance of the EUSO-SPB2 Fluorescence Telescope *(16/07, Filippatos)*
- 1091. Overview of Cherenkov Telescope onboard EUSO-SPB2 for the Detection of Ultra-High Energy Neutrinos List all contributions *(14/07 Bagheri)*
- 490. Model independent search for macroscopic dark matter with EUSO-SPB2 *(16/07 Paul)*
- 614. The EUSO@TurLab project in view of Mini-EUSO and EUSO-SPB2 missions *(16/07 Bertaina)*
- 489. UCIRC2: EUSO-SPB2's Infrared Cloud Monitor *(16/07 Diesing)*
- 867. EUSO-SPB2 Telescope Optics and Testing *(21/07 Kungle)*
- 1002. Detection of Above the Limb Cosmic Rays in the Optical Cherenkov Regime Using Sub-Orbital and Orbital Instruments *(15/07 Cummings)*
- 248. EAS Optical Cherenkov signatures of tau neutrinos for space and suborbital detectors *(14/07 Reno)*

The Science Goals

Fluorescence: UHECRs EeV

First observation of UHECRs from near-orbit altitude with the fluorescence technique

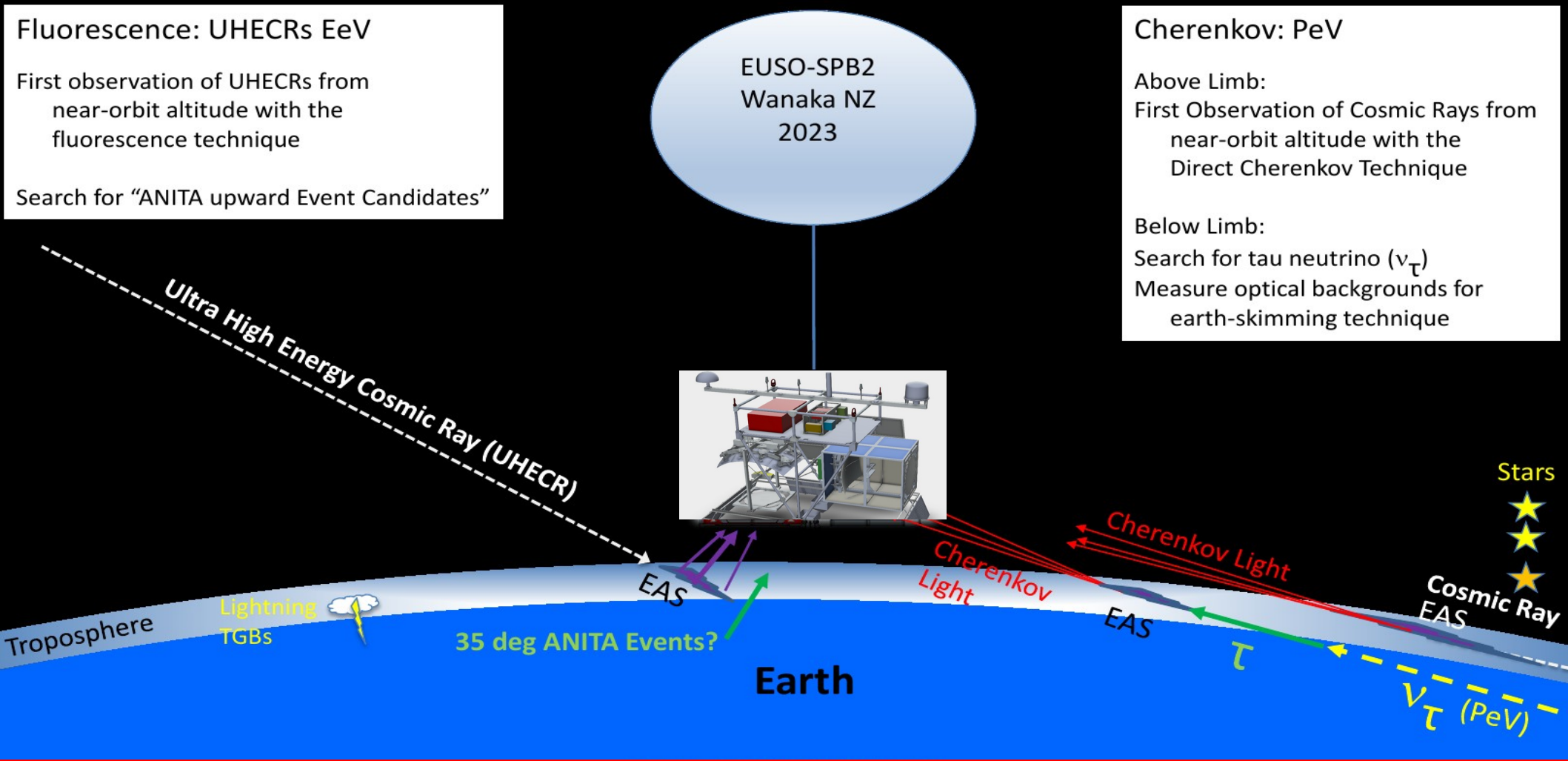
Search for "ANITA upward Event Candidates"

EUSO-SPB2
Wanaka NZ
2023

Cherenkov: PeV

Above Limb:
First Observation of Cosmic Rays from near-orbit altitude with the Direct Cherenkov Technique

Below Limb:
Search for tau neutrino (ν_τ)
Measure optical backgrounds for earth-skimming technique



The Timeline

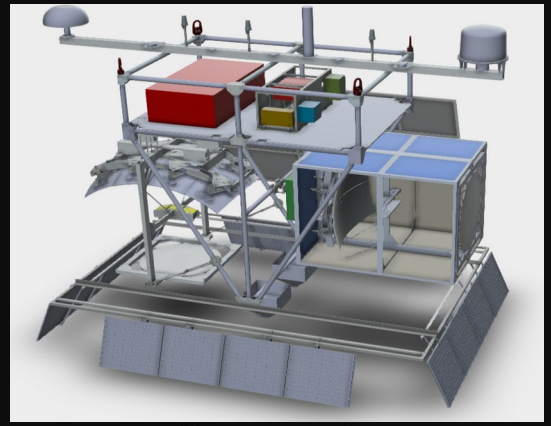
EUSO-Balloon

2014 Timmins

EUSO-SPB1

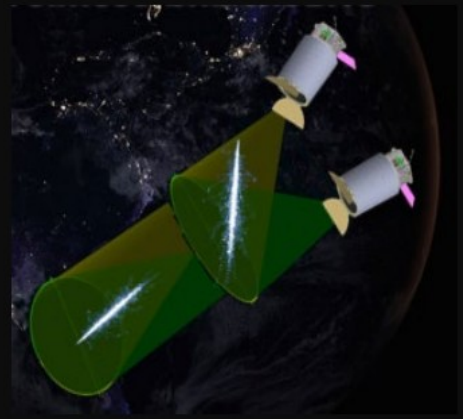
2017 Wanaka

EUSO-SPB2



(2023) Wanaka

POEMMA

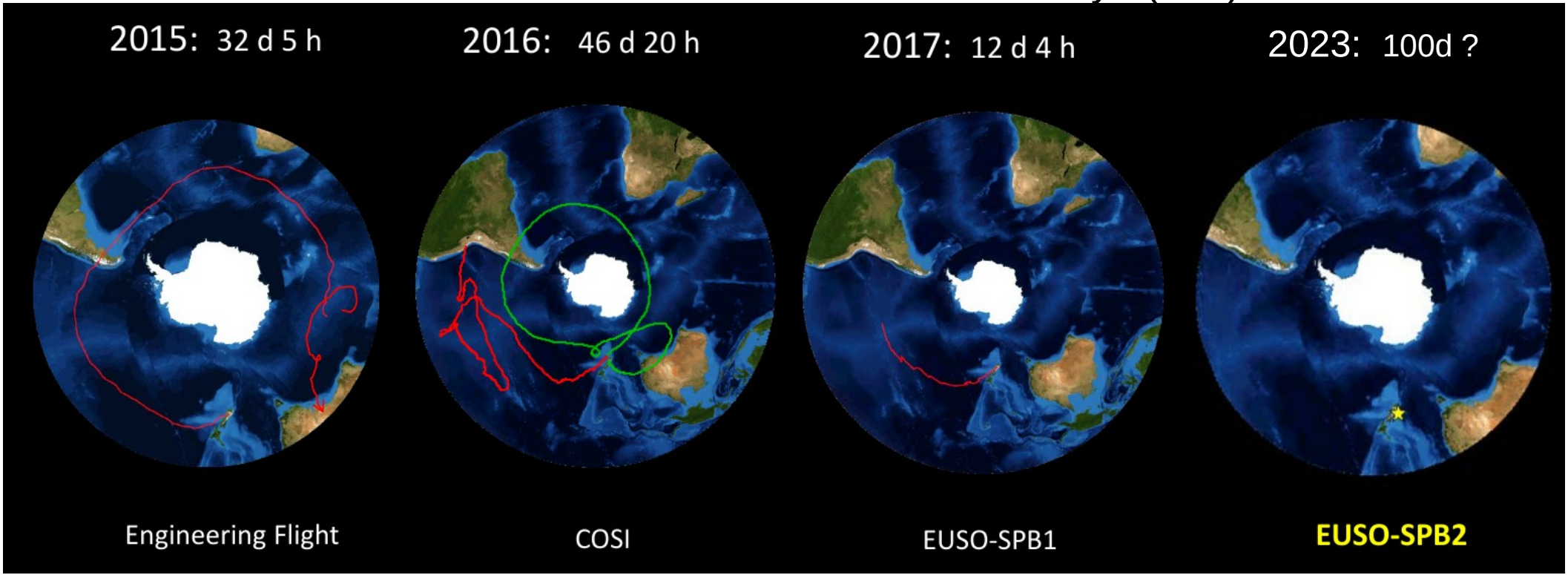


(2029) Earth Orbit

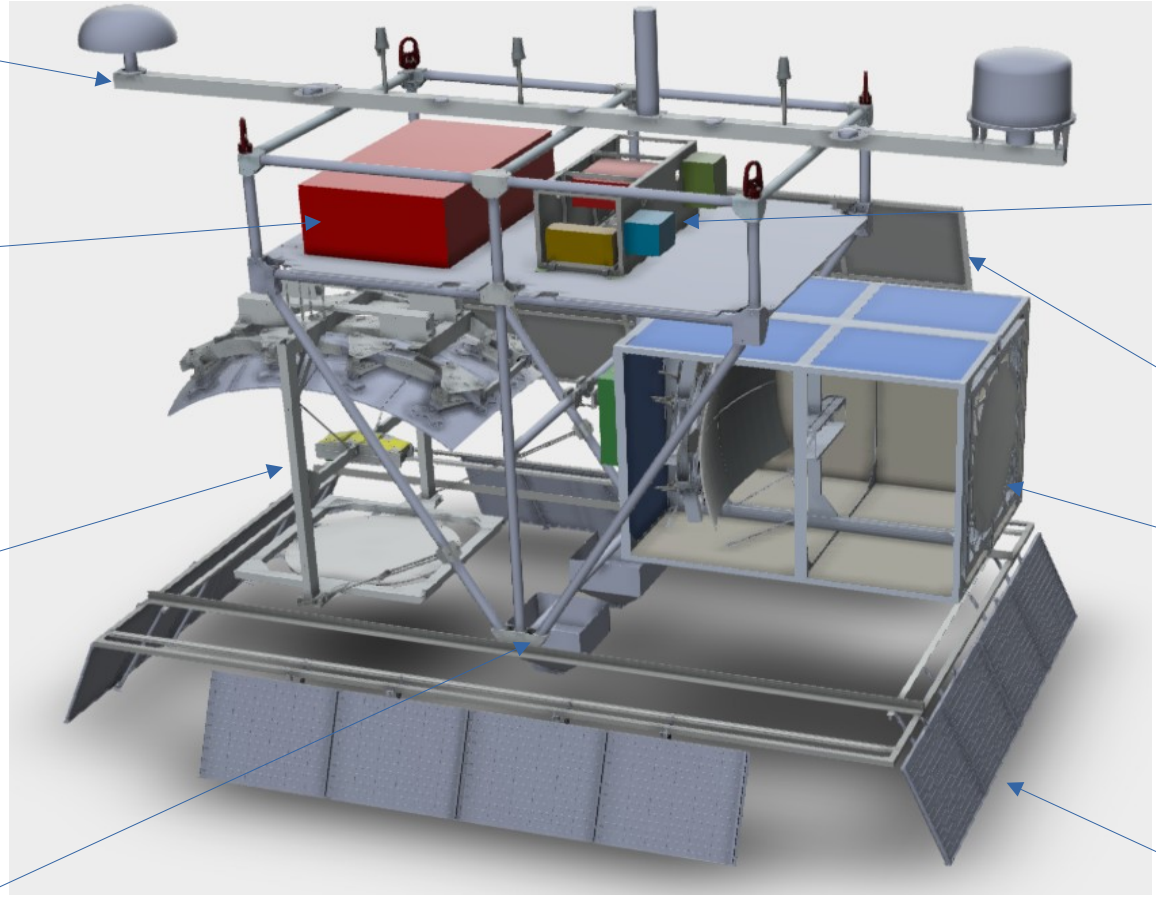
K-EUSO

The Mission

- Launch 2023 from Wanaka, NZ
- Payload of SPB: 33km
- Up to 100day flight
  - 500h of operation (20% duty cycle)
  - Min 14 days (70h)



The Instrument



Antenna Boom

Battery-Box
(GCC+batteries)

Fluorescence
Telescope (FT)

Ballast Hooper(2x)

SIP

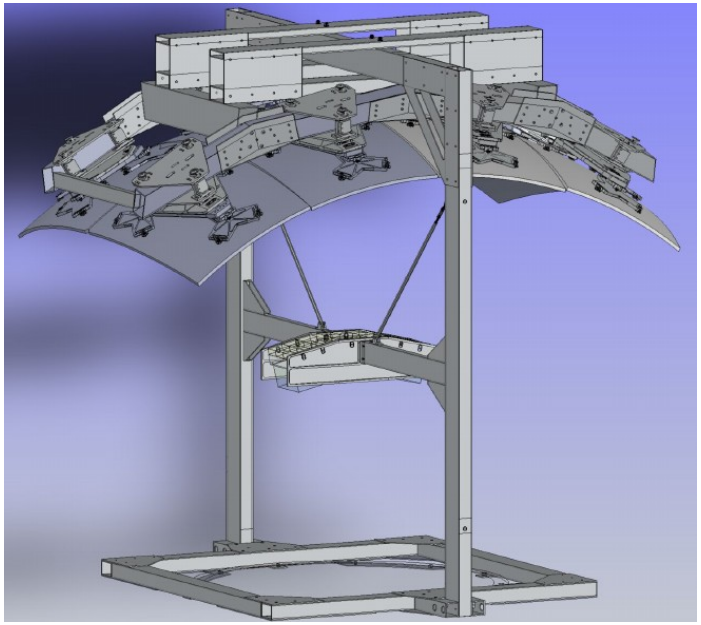
Science solar panels

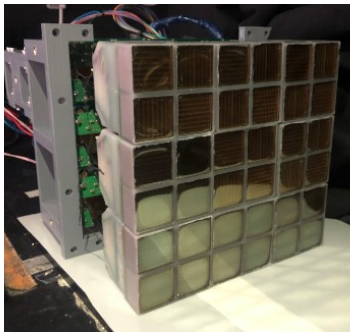
Cherenkov
Telescope (CT)

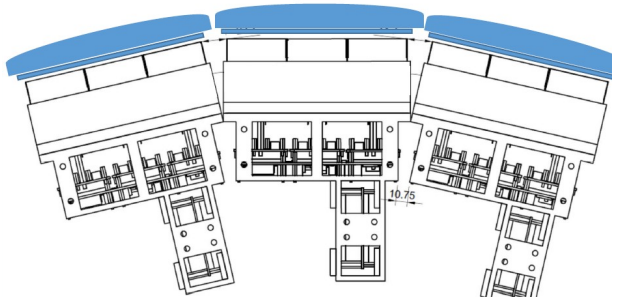
CSBF solar panels
(4 each side)

The Fluorescence Telescope

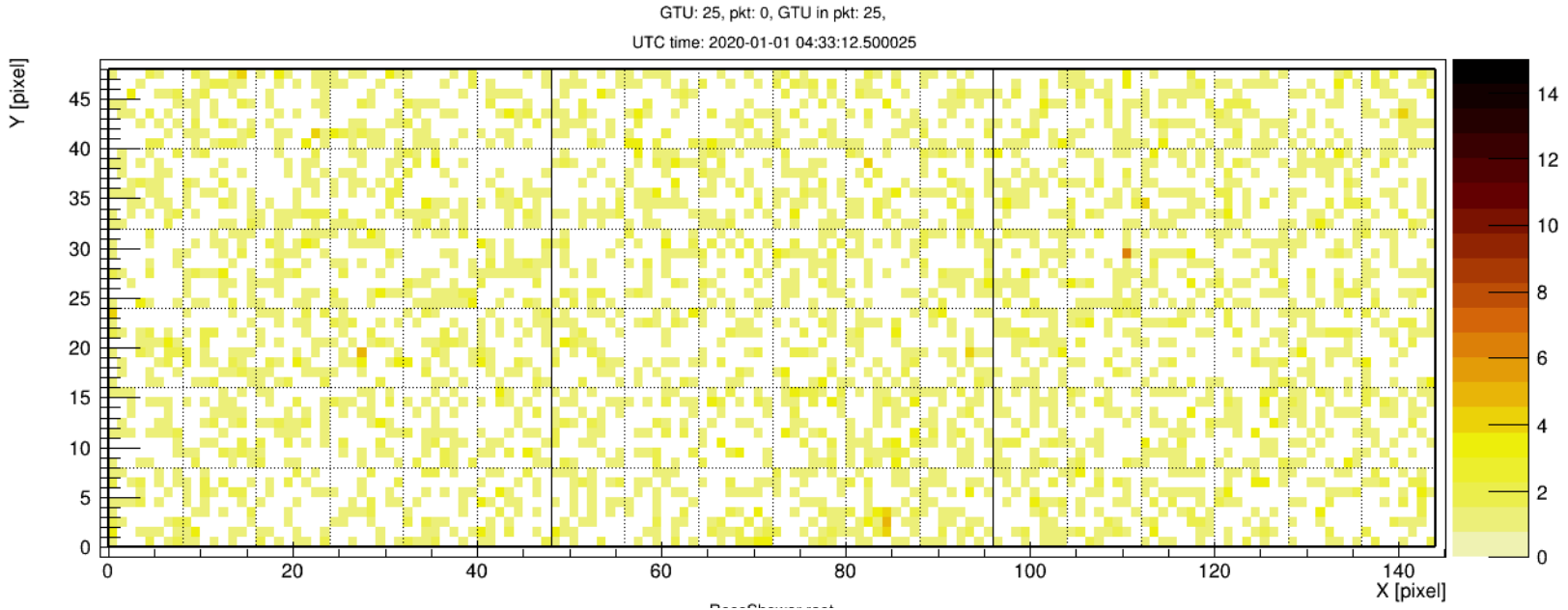
- **First observation of UHECR via fluorescence from suborbital space**
- Optics:
  - Schmidt system
  - 1m diameter aperture
  - FoV ~12x36deg (~36 km^2 on ground)
  - Nadir pointing
- Camera:
  - 3 PDMs with each 2304px (MAPMT)
    - Single photo-electron counting
  - 290-430nm detection window (BG3)
  - Integration time of 1µs
- See G. Osteria, 403, 15/07







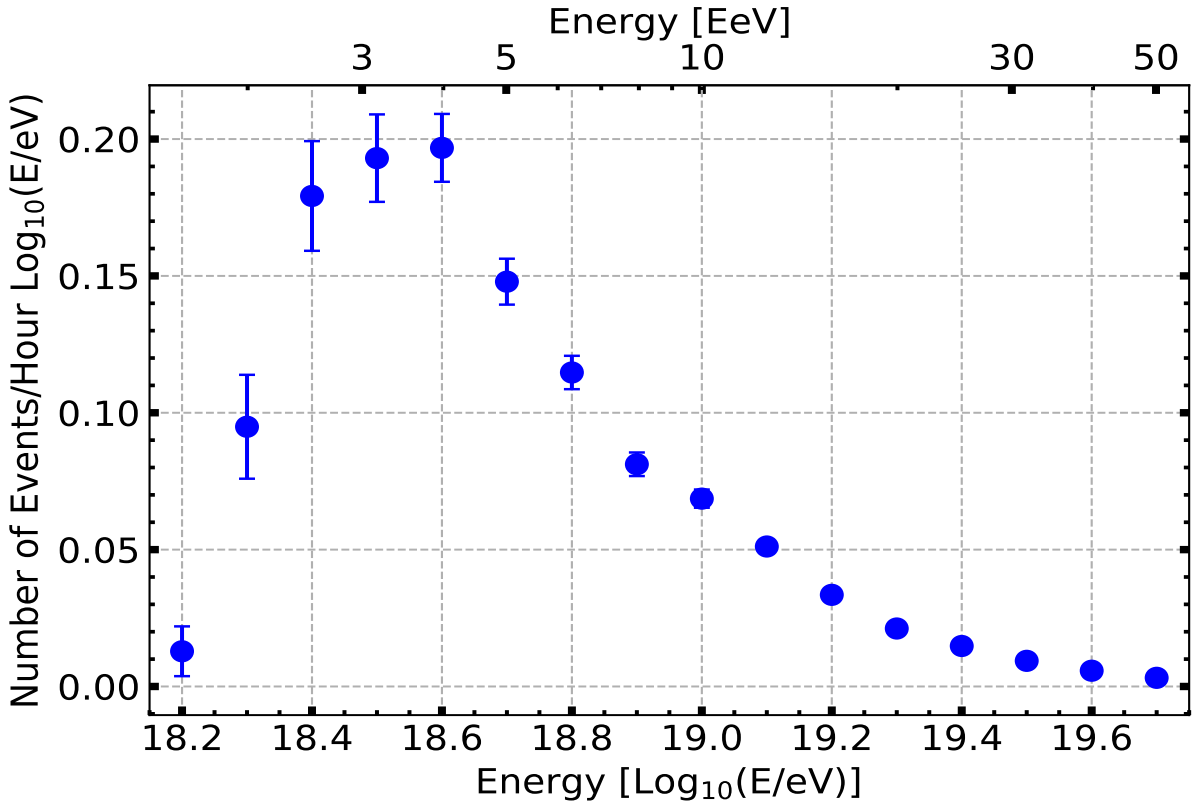
FT Science



E: $10^{18.5}$eV
θ: 57deg

- Extensive simulation study to estimate event rate and reconstructability
- Energy threshold: ~2EeV with peak sensitivity at 4EeV
- See G. Filippatos, 330, 16/07

FT Science

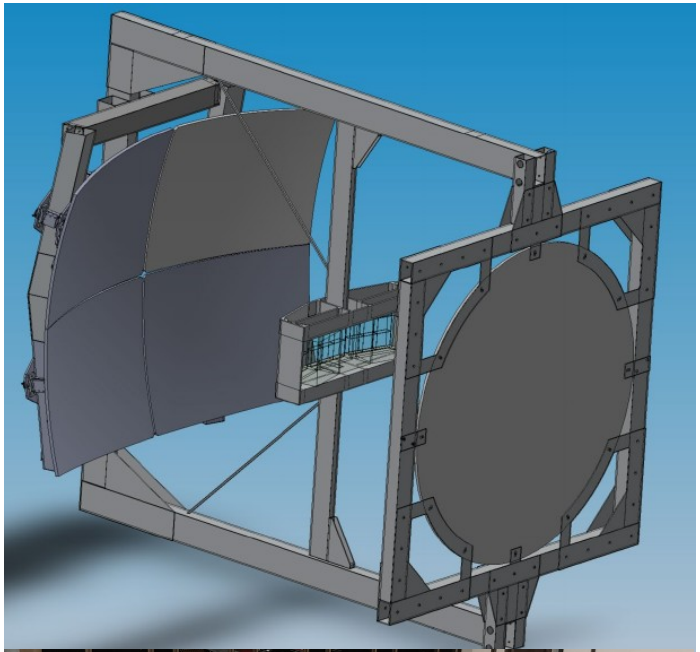


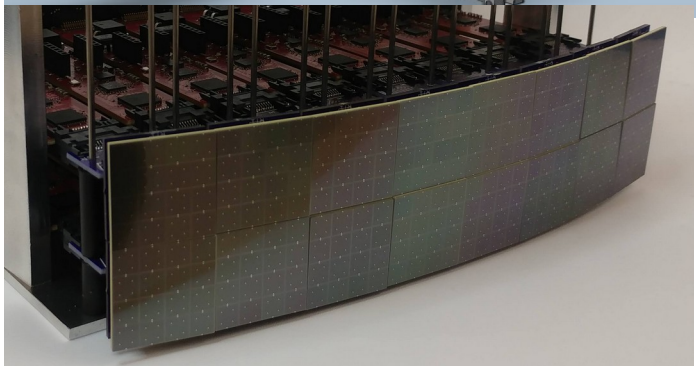
G. Filippatos

- **0.6 events per day**
- <10% are reconstructable (preliminary)

The Cherenkov Telescope

- **BG measurements, Neutrinos from ToO, above-the-limb CR**
- Optics:
  - Schmidt system
  - 1m diameter aperture
  - FoV ~ 6.4 deg x 12.8 deg
  - Bi-focal for noise reduction
  - Pointing +/-10 deg around Earth's limb
- Camera:
  - 512 SiPM based pixels
  - 10ns integration time
  - 200-800nm spectral range
- See M. Bagheri, 1091, 14/07





CT Science: Background measurements

- First time data taking with a Cherenkov telescope from suborbital space

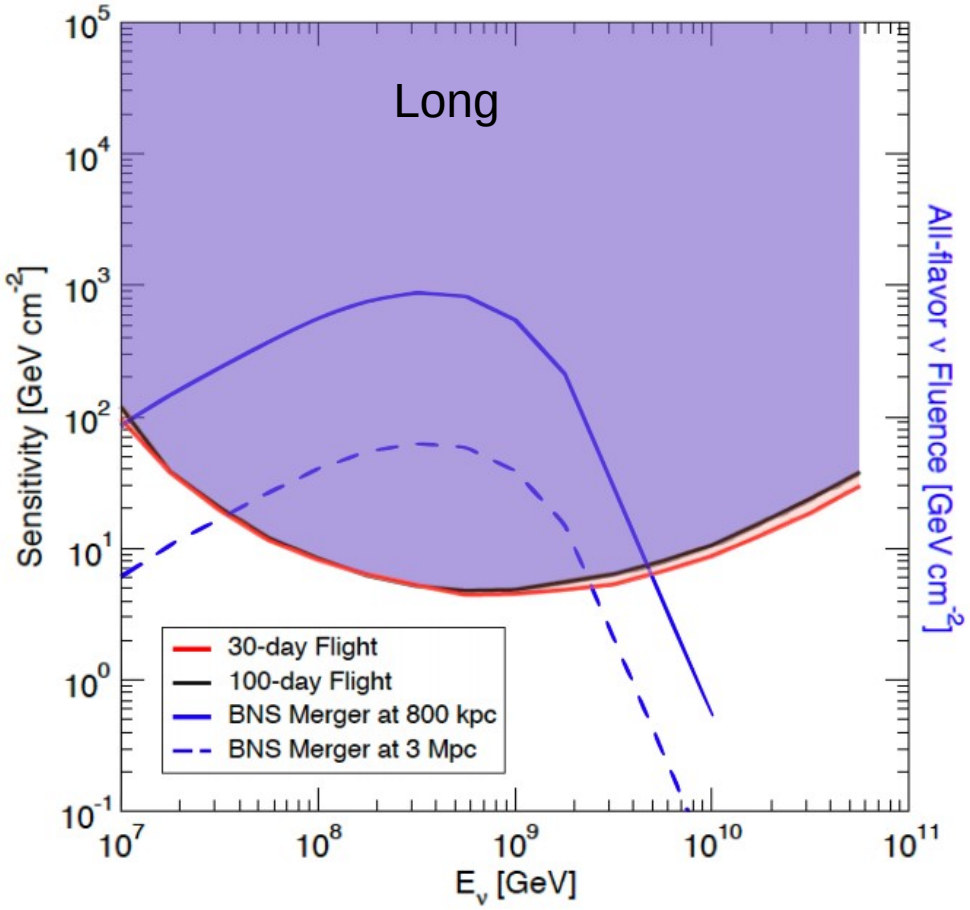
➔ **Background unknown**

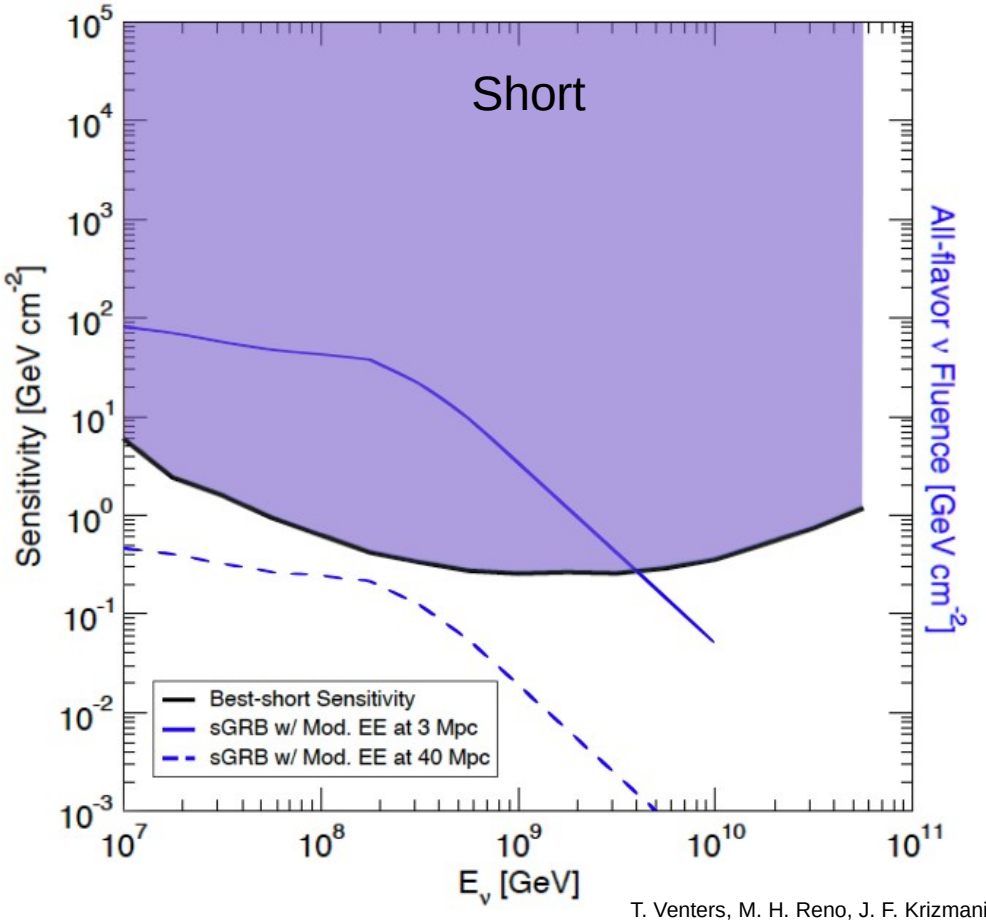
- Night sky Background below and above the limb
  - Depending on time and position in sky
- Search for known and unknown sources
  - Artificial flashes
  - Fast atmospheric events
- Signal of direct cosmic ray hits
  - Bi-focal optics will help eliminate these

CT Science: Target of Opportunity

- Detection of neutrinos from astrophysical event (e.g. Binary Neutron star mergers)
- Two scenarios are considered
  - Long Burst: days or weeks (sun and moon taken into account)
    → Average over time
  - Short Burst: ~1000 s (no sun and moon effect considered)
    → best aperture and averaging over 1000s seconds after
- No tracking of source in field of view
- See H. Reno, 248, 14/07

CT Science: ToO

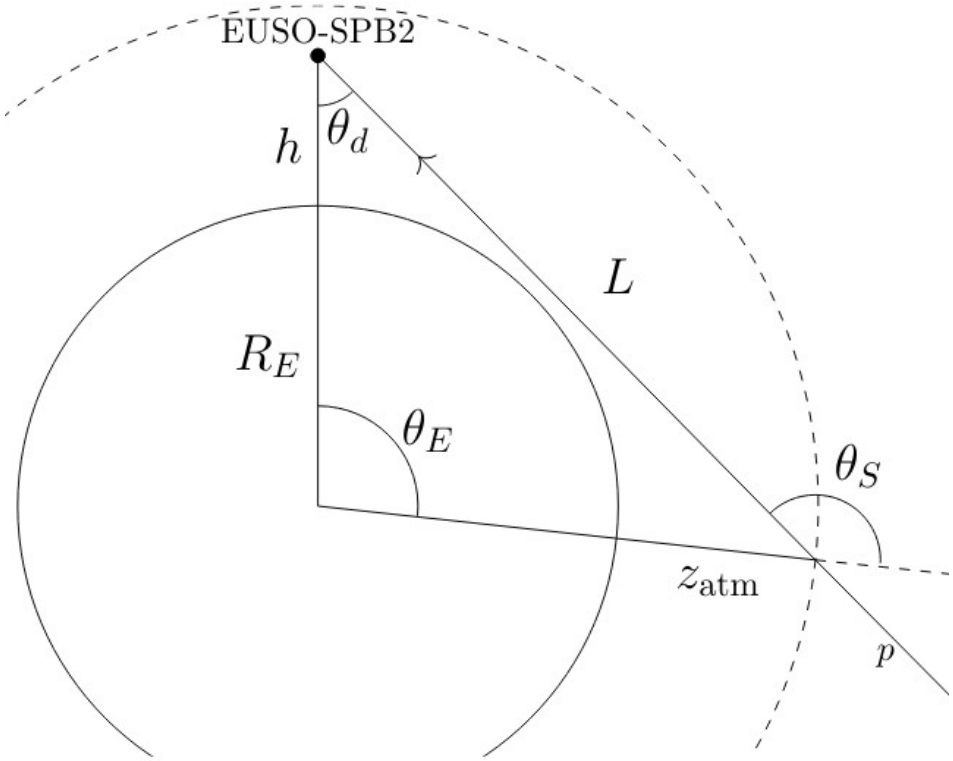




T. Venters, M. H. Reno, J. F. Krizmanic

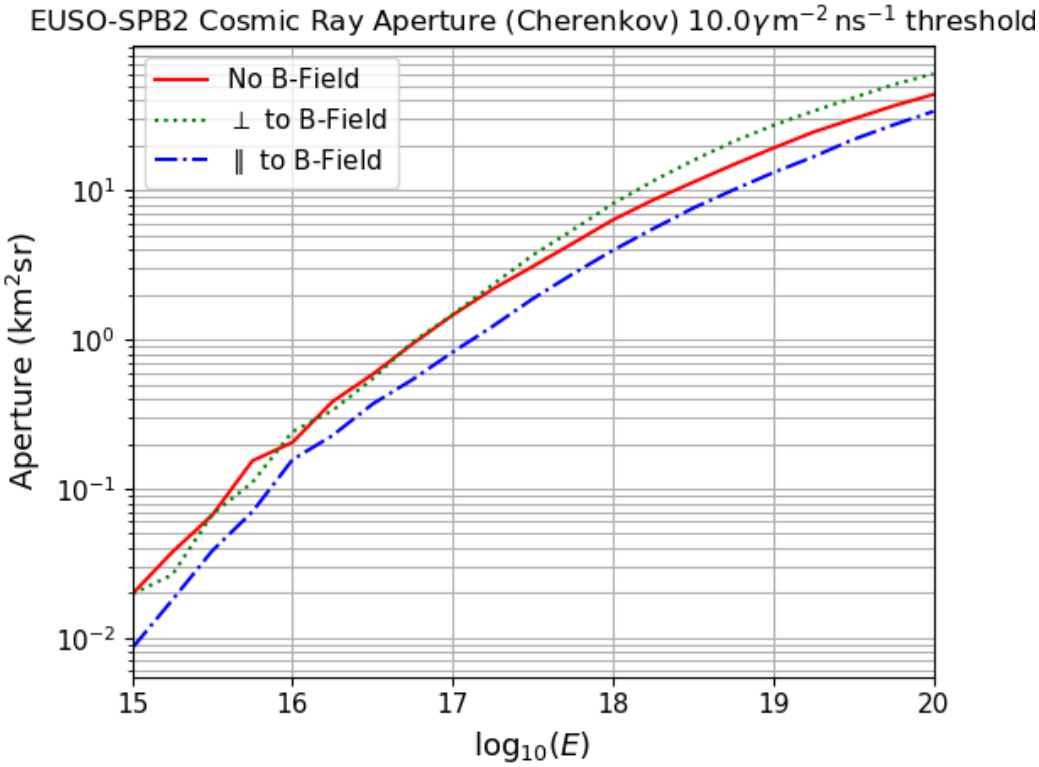
- Note models are fluences (time integrated “out”)

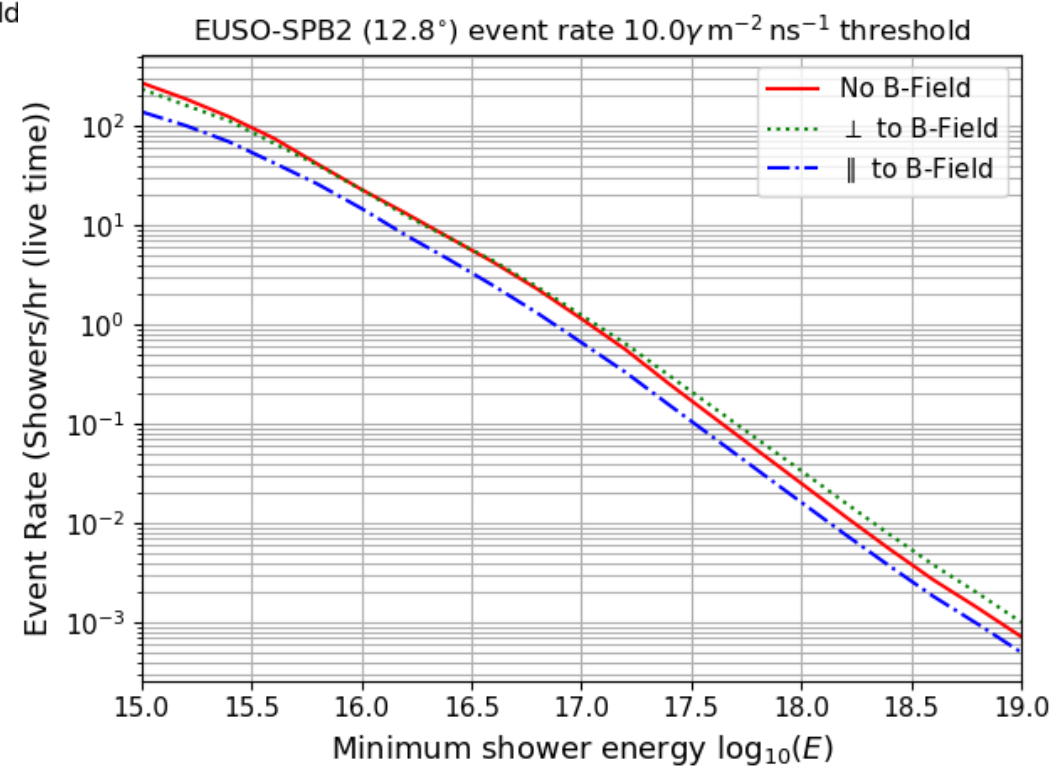
CT Science: Above the limb CR



- CT observing above the limb (limb is at 86deg)
- Signal very similar to upwards going neutrino induced showers
  - Fast (~10ns) and bright
  - Allows to validate detection approach
  - Provides data to develop and optimize trigger and detector performance
  - Essential in the development of reconstruction procedures
- See A. Cummings, 1002, 15/07

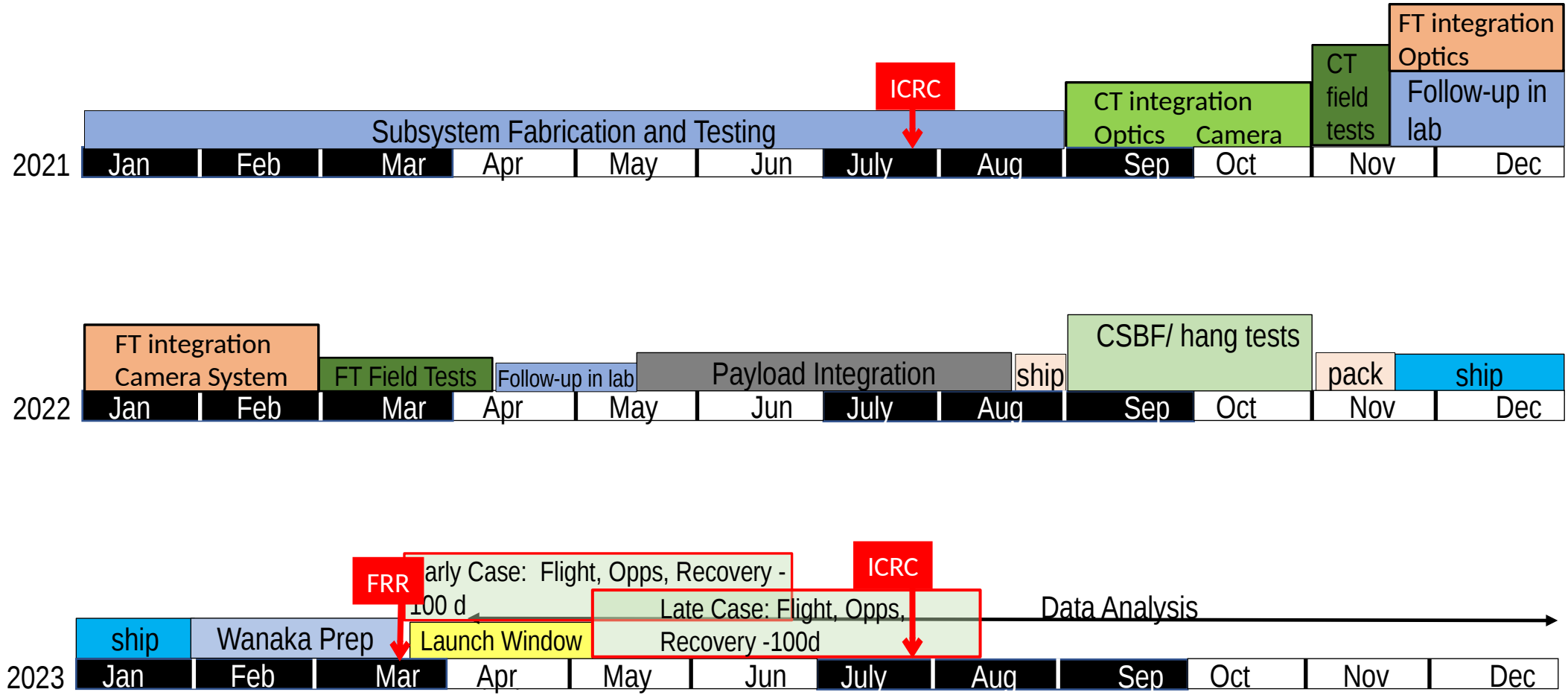
CT Science: Above the limb CR





- **100 events/h above E=1PeV**
- Guaranteed signal with significant statistics

Schedule


2021
Jan
Feb
Mar
Apr
May
Jun
July
Aug
Sep
Oct
Nov
Dec
Subsystem Fabrication and Testing
ICRC
CT integration Optics Camera
CT field tests
FT integration Optics
Follow-up in lab
2022
FT integration Camera System
FT Field Tests
Follow-up in lab
Payload Integration
ship
CSBF/ hang tests
pack
ship
2023
FRR
arly Case: Flight, Opps, Recovery -100 d
ICRC
Late Case: Flight, Opps, Recovery -100d
Data Analysis
ship
Wanaka Prep
Launch Window

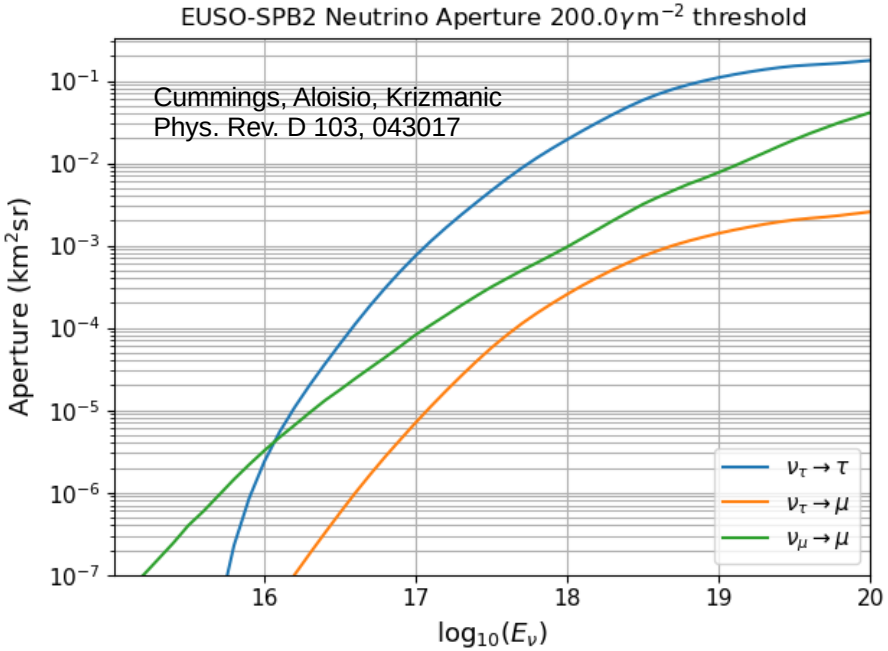
Conclusion

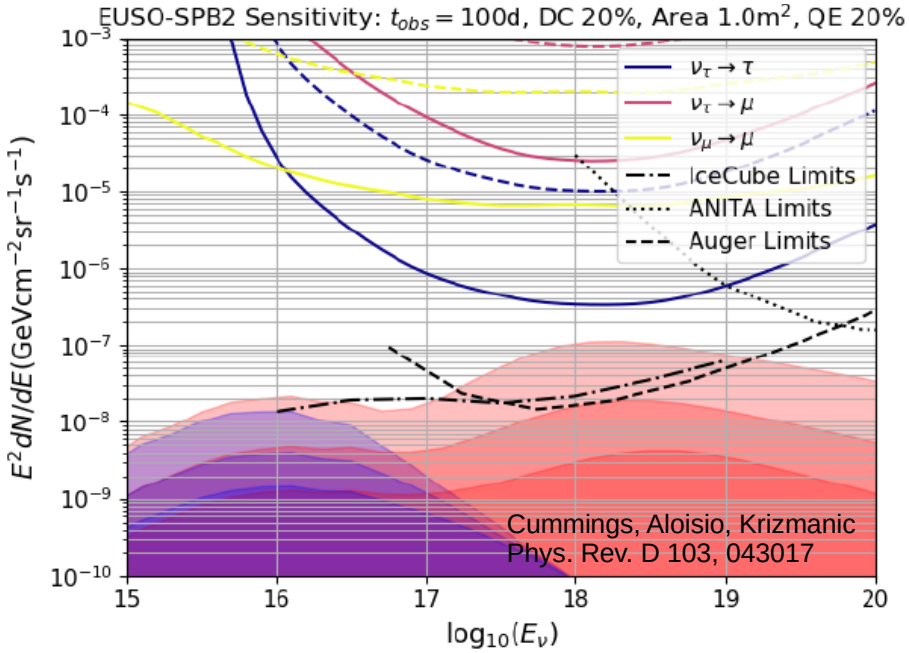
- EUSO-SPB2 is the next step towards space based UHECR observation
- Preparations are on going for a planned **launch in 2023** from NZ as an SPB payload
- **First observation** from UHECR via fluorescence from suborbital space
  - 0.12 tracks per hour from UHECR
- **First time** of Cherenkov Telescope in suborbital space
  - first time background for upwards going neutrino events
- 100 events per hour from above the limb direct cosmic rays in the CT
- EUSO-SPB2 could detect neutrinos from astrophysical event
  - BUT no sensitivity to the diffuse neutrino flux

- POEMMA target launch at 2030 as a dual satellite probe class mission
  - will open two new Cosmic Windows (UHECR above 20EeV, neutrinos from ToO)
  - will benefit from the EUSO-SPB2 design and flight

Backup

CT Science: Cosmogenic Neutrinos

- 



	$\nu_\tau \to \tau$	$\nu_\tau \to \mu$	$\nu_\mu \to \mu$
100d, 12deg, 200ɣ/m^2	1.3×10^{-2}	2×10^{-4}	6.7×10^{-4}