EUSO-SPB2 Telescope Optics and Testing

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COLORADO SCHOOL OF MINES

Objective

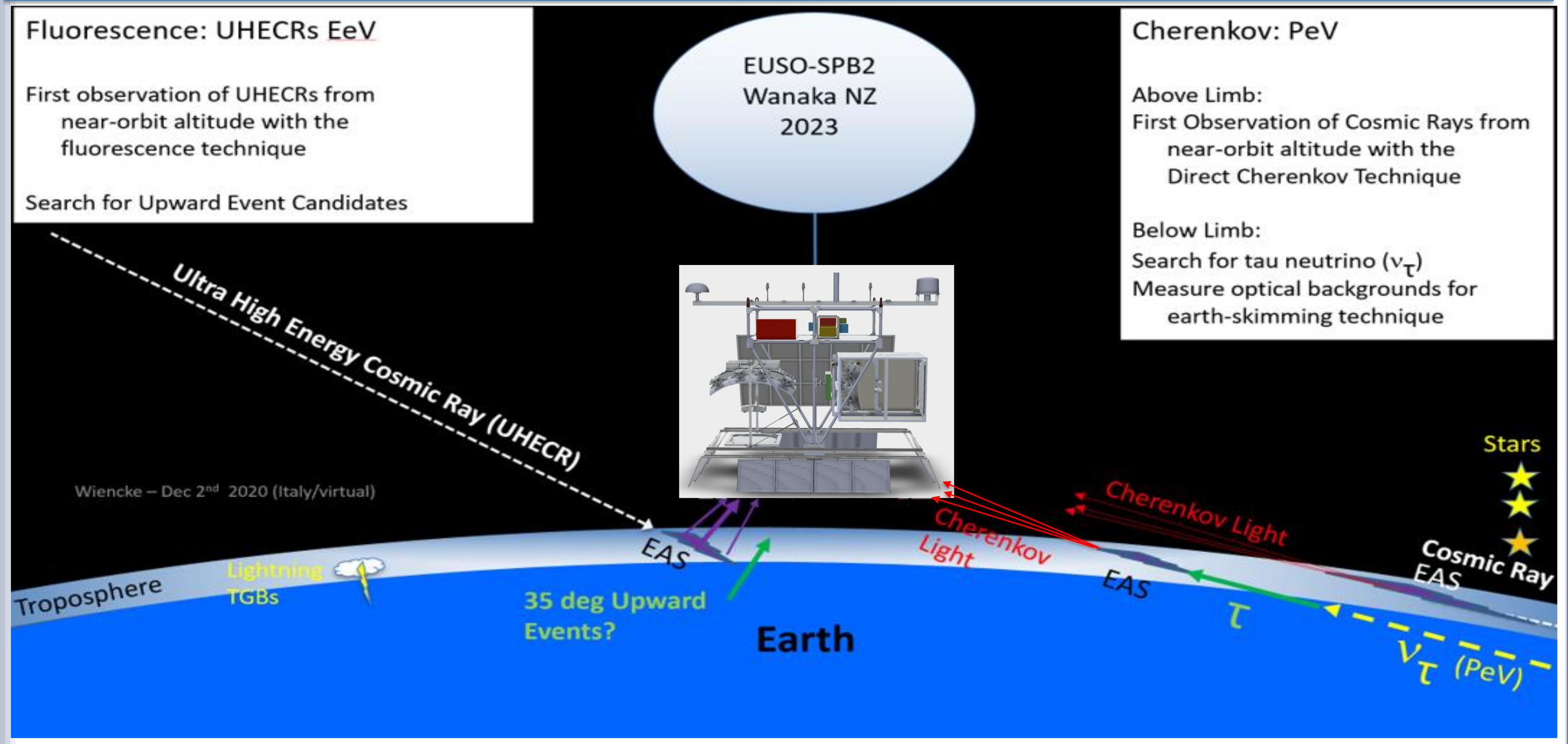

Figure 1: EUSO-SPB2 mission objective. First three ever observations of UHECR from near-orbit altitude with the fluorescence-, direct Cherenkov-technique, and search for tau neutrinos.

The **EUSO-SPB2** [1] will make the first observation of **UHECRS** from near-orbit attitude.

- Below the limb the **Cherenkov telescope** will search for tau neutrinos **ντ**.
- EUSO-SPB2 is primarily a technological and scientific pathfinder for **POEMMA** [2] (Probe Of Multi-Messenger Astrophysics).

Optics:

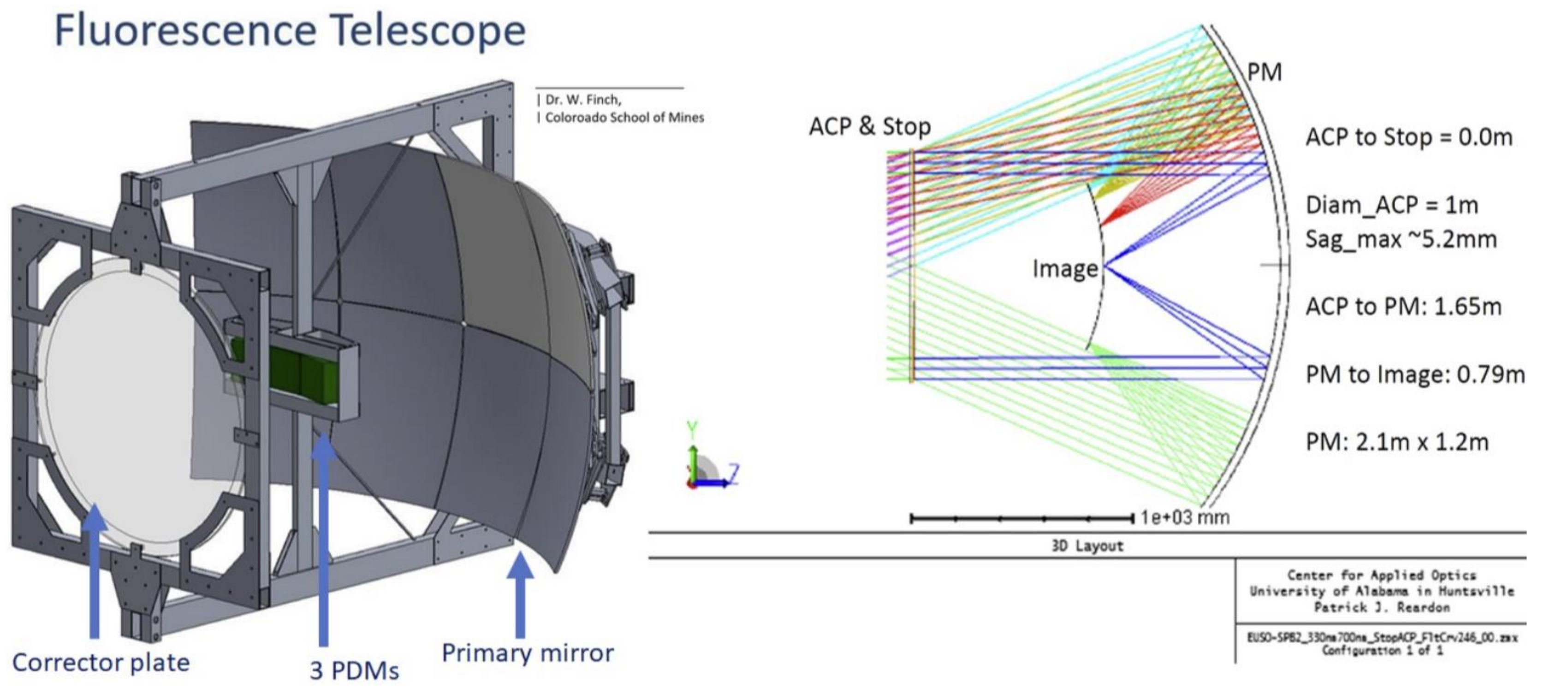

Figure 2: The fluorescence telescope design on the left and the corresponding raytracing model on the right

EUSO-SPB2 telescopes are a **modified Schmidt design** using a segmented spherical mirror.

- The fluorescence telescope has 3 photo detector modules (PDM) with a curved image surface, so that field correcting or flattening lenses are necessary to achieve a very small spot.
- The mirror segments of the **Cerenkov telescope are aligned for bi-focal** focusing so that light from outside the telescope makes two spots on the camera. This **distinguishes between direct cosmic ray hits** on the camera that produce one cluster of activated pixels.

Optomechanical hardware and laboratory tests:

The main goal of the laboratory tests carried out at Colorado school of Mines are to determine the

- **Point Spread Function (PSF)** and
- **Optical Efficiency**

of both telescopes, via the use of a **fabricated 1-m parallel test beam system**. Before that a **list of tests** will ensure that the mounted mirror segment are strong and stable, the spherical mirrors installed and focused in the telescopes and that the parallel beam system is working. After the PSF and optical efficiency characterization in the parallel beam, with no camera installed, a full telescope lab test with the 1-m parallel beam and camera will be carried out.

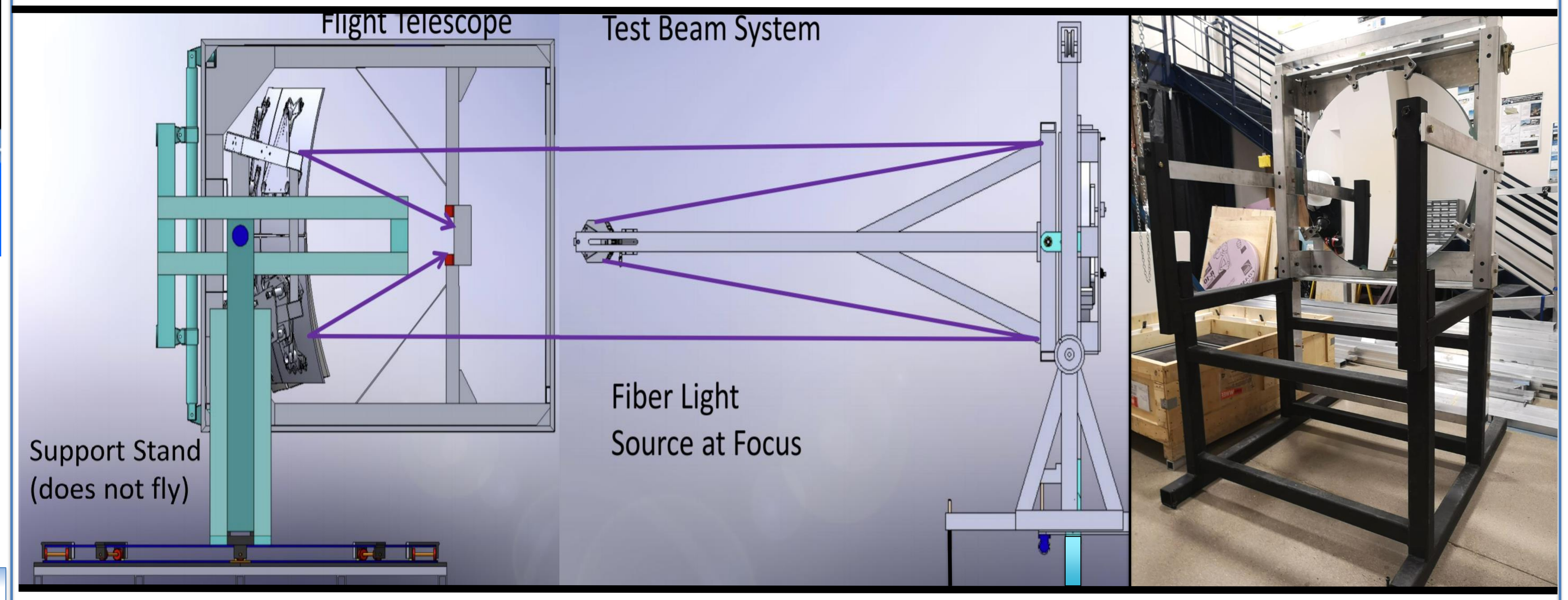

Figure 3: Test hardware and test stand for the 1-m test beam system. A schematic configuration of the fluorescence telescope on a supporting stand on the left and a 1-m parabolic mirror on the right. The fiber light source at the focus will have a new customized holding stand.

As part of the **operational design requirement of NASA t**he mirror segment attachment system is tested in the lab. The **mirror segments are epoxy glued** to the metallic frame with EC-2216 adhesive on Kovar joints. The glue joints are **stress tested** under a static uniformly distributed load, in operational **atmospheric conditions**, i.e., in a thermal chamber for temperature below -40°C, and in a low-pressure environment of <7 mbar

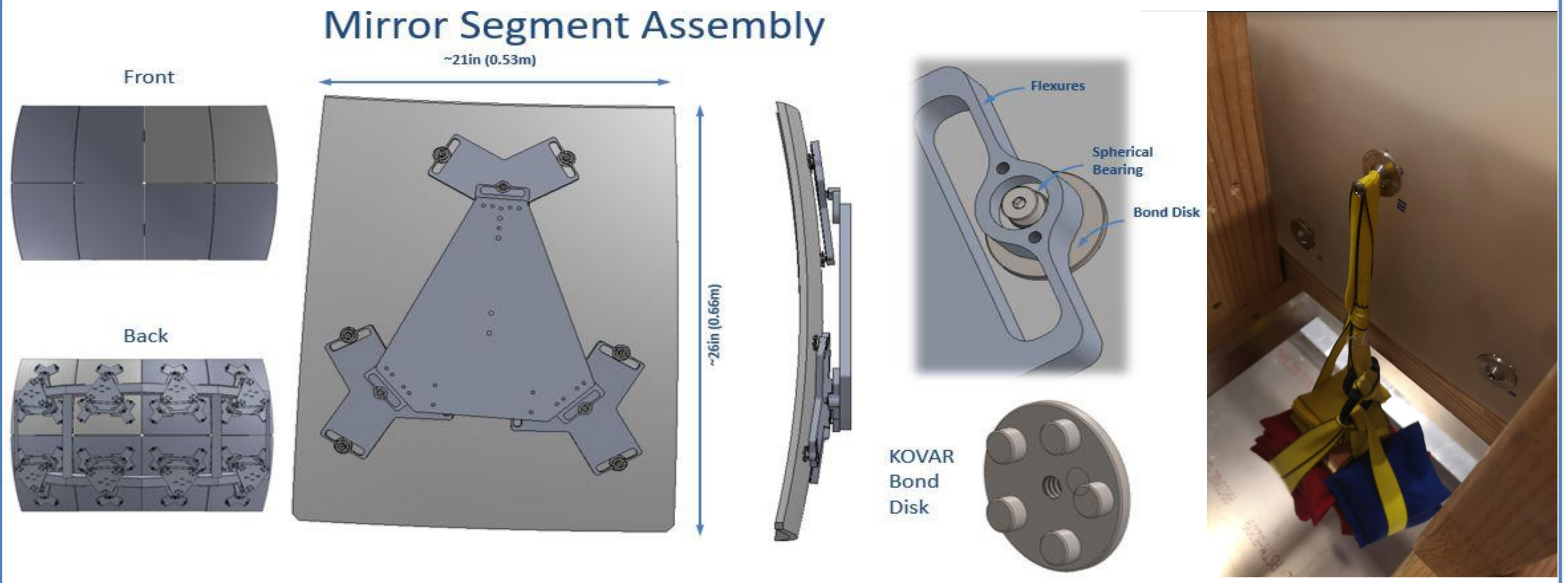

Figure 4: Mirror segment assembly. Each mirror segment is epoxy glued to 9 Kovar bond disks with EC2216. The photo shows a glue joint shear stress test with 42 lbs. load.

EUSO-SPB2 specifications:

Table 1: The EUSO-SPB2 hardware specification for both telescopes.

EUSO-SPB2 specs		
Telescopes	Fluorescence FT	Čerenkov CE
Wavelength Sensitivity	UV 300-420 nm	no filter (300-900 nm)
Energy Threshold	EeV	PeV
Sensor Type	MAPMT (Hamamatsu)	SiPM (S14521-6050CN)
Field of View	3x(11x11)°	(6.4x12.8)°
Pixel FOV	(0.2x0.2)°	(0.4x0.4)°
Time frame	1000 ns/bin	10 ns
Pointing (zenith angle)	nadir	Earth's limb ±10

Field campaign:

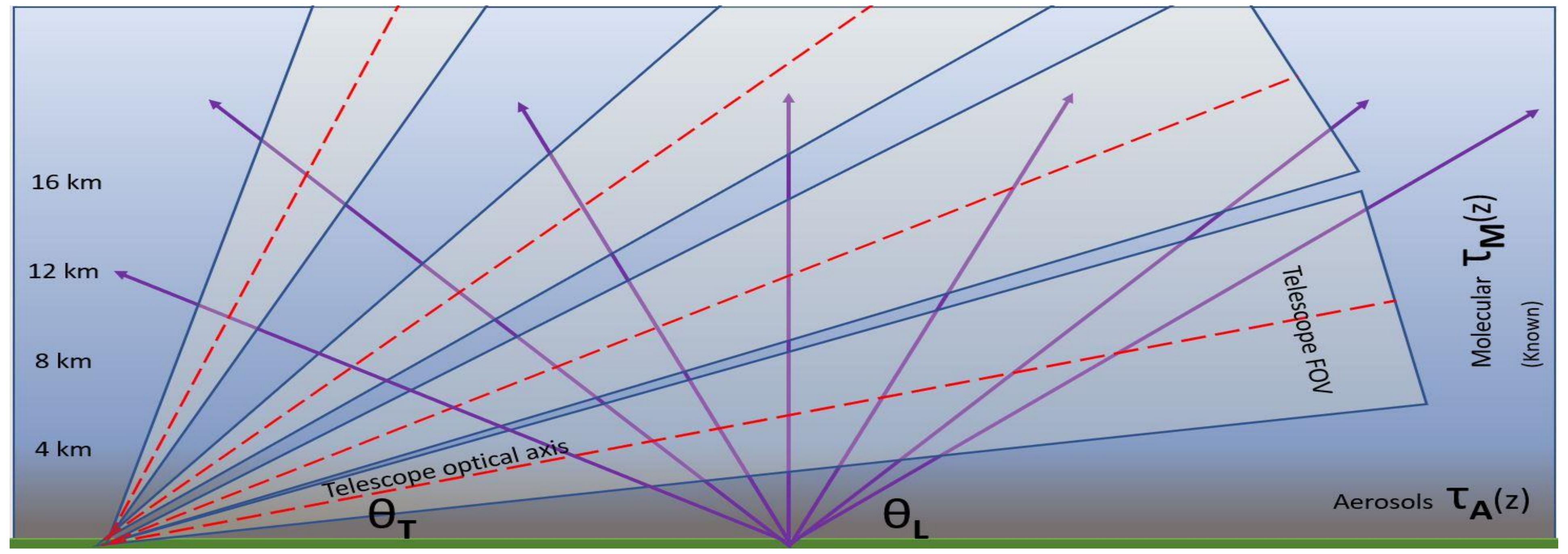

Figure 5: Field test configuration with the steerable telescope on the left and the steerable laser on the right with different inclination angles, θ_T and θ_L. The laser beam crosses the telescopes field of view high above the aerosol layer

The fully assembled telescopes will be **field tested at dark sites** in Utah to check the detectors performance at moonless nights. The goals include the:

- **Field of View (FoV)**
- **Angular Resolution** and
- **Energy Trigger Threshold.**

The campaign will include an **absolute photometric calibration** of the fully integrated instruments with the help of a bi-dynamic Lidar configuration, in which a **high-energy pulsed UV laser** system and the telescope are steerable.

Adopted **Monte Carlo laser simulations** have been made to predict the detectors performance, find a **correlation** and parametrization **between laser energies and UHECR energies**.

A newly developed calibration method with a **correction for aerosol attenuation** will be tested first time.

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References

[1] L. Wiencke et al.. The Extreme Universe Space Observatory on a Super-Pressure Balloon II Mission. PoS, ICRC2019:466, 2019.

[2] A.V. Olinto et al. The POEMMA (probe of extreme multi-messenger astrophysics) observatory. *Journal of Cosmology and Astroparticle Physics*, 2021(06):007, jun 2021.