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A stand-alone polarimetric acquisition system for producing a long-term skylight dataset

Léo PUGHON^{1,2}, Jocelyn MONNOYER^{1,2}, Stéphane VIOLLET¹, Vincent AUBRY², and Julien R SERRES^{1,3}

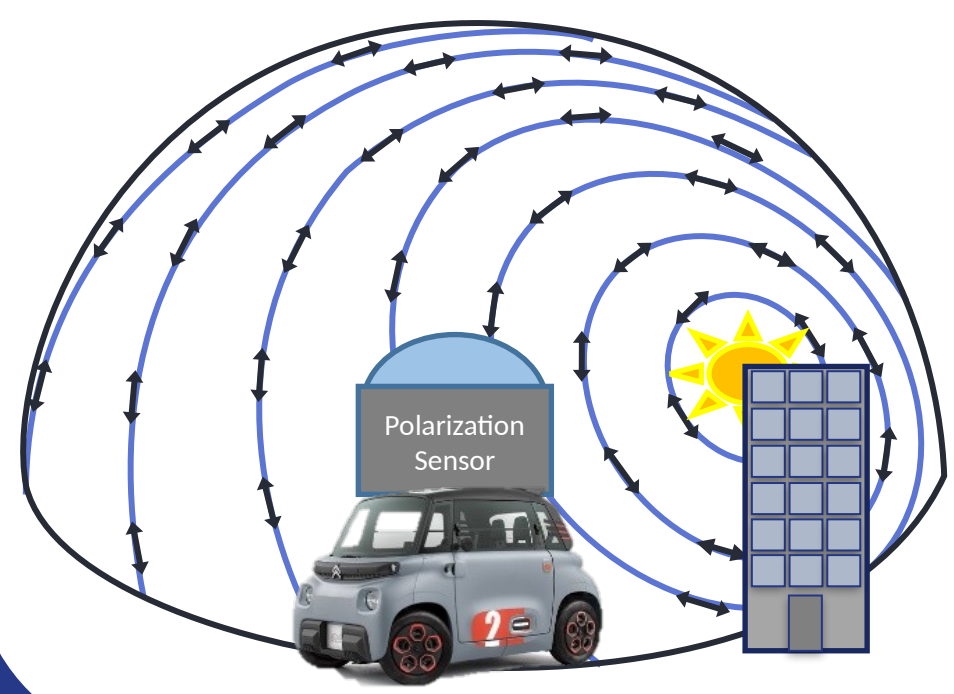
¹Aix Marseille Univ., CNRS, ISM, Marseille, France

²Stellantis, Velizy-Villacoublay, France

³Institut Universitaire de France, Paris, France

Context

In nature, some **desert ants** [1] are able to **navigate without GPS** using a heading derived from sun position by measuring skylight polarization.



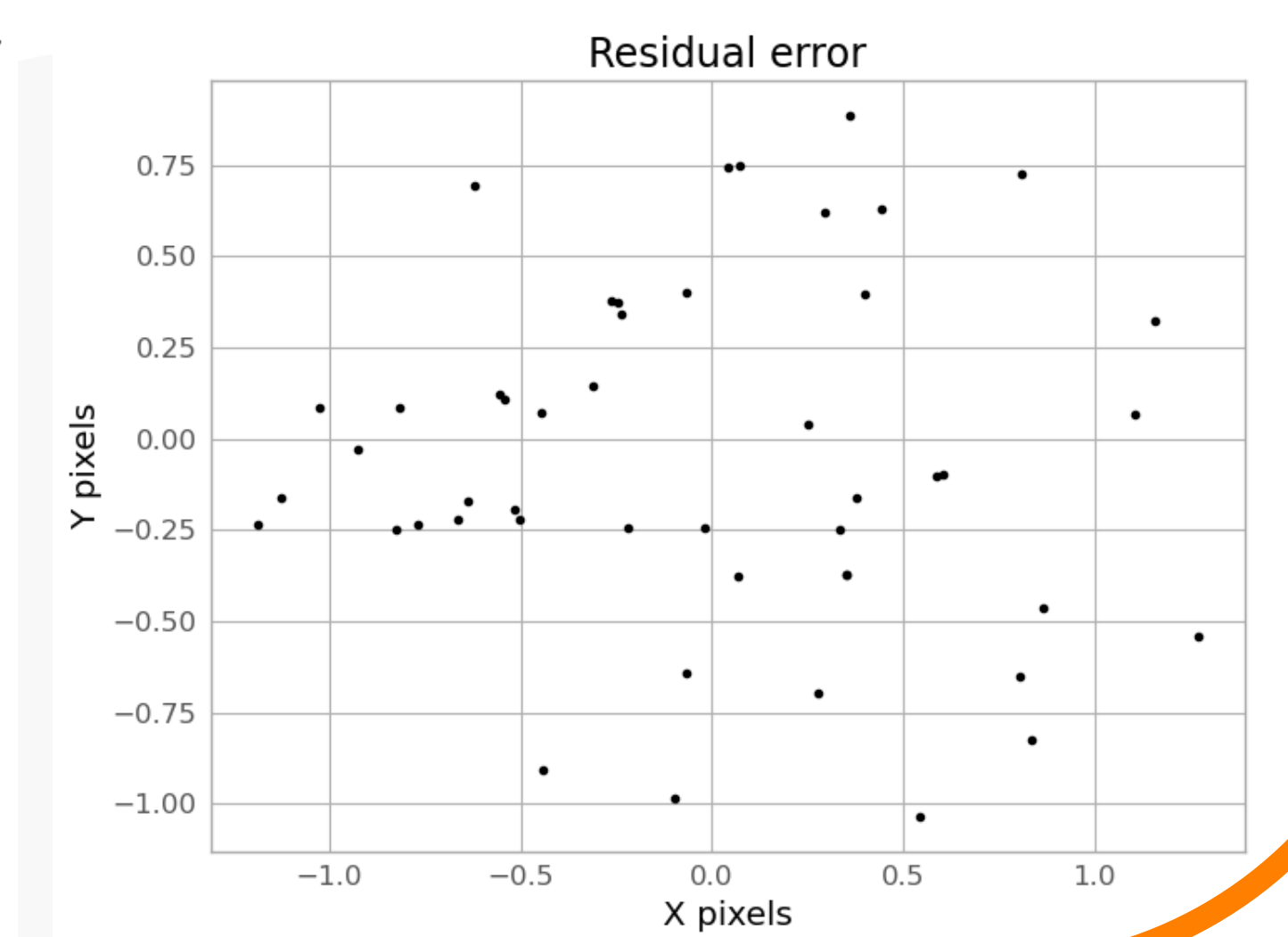
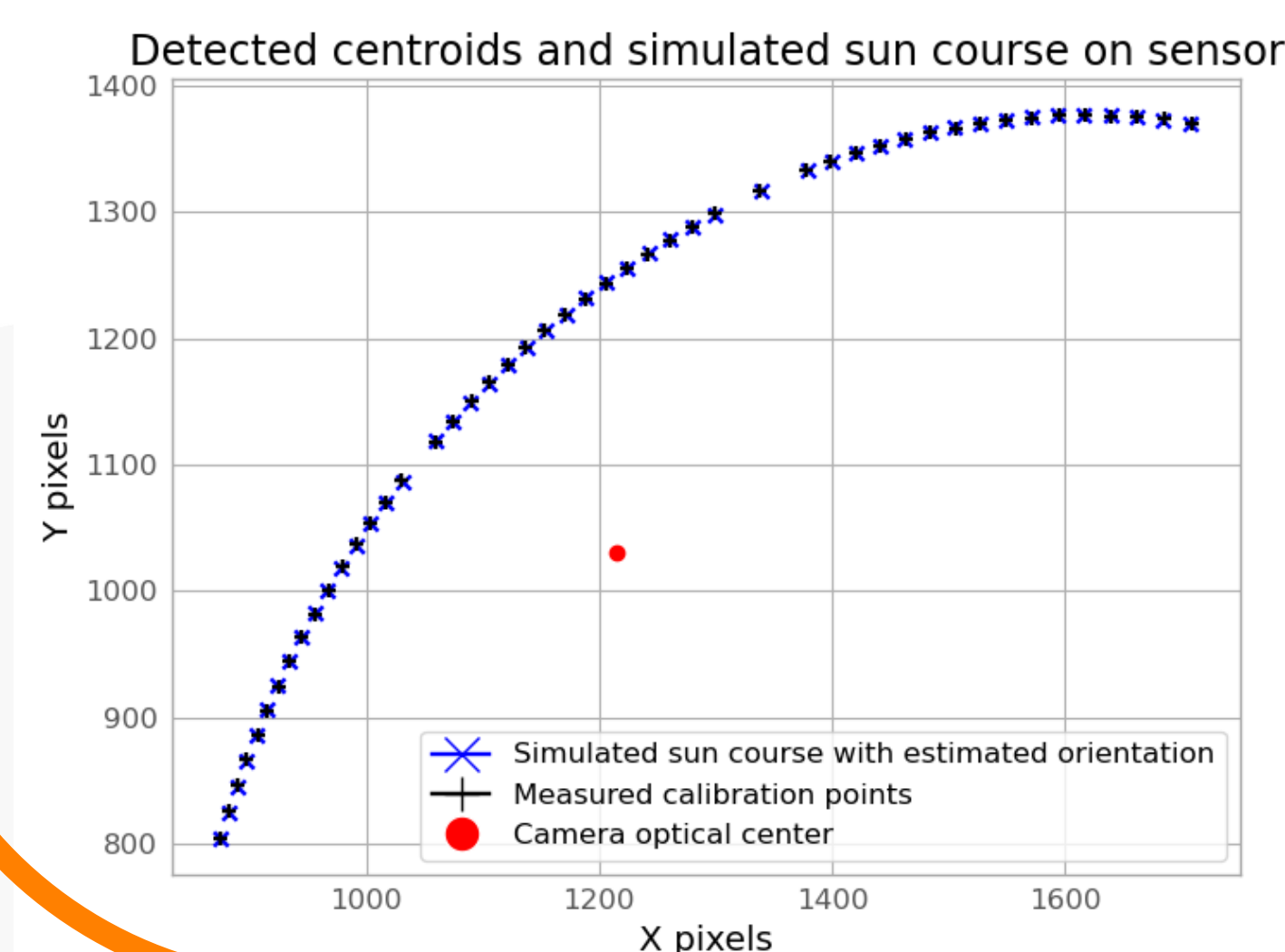
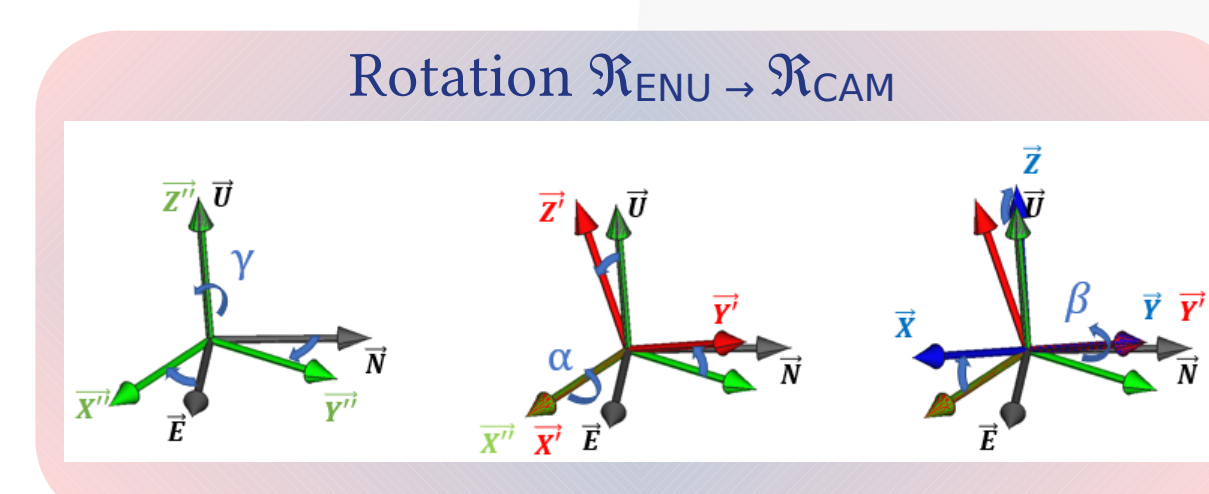
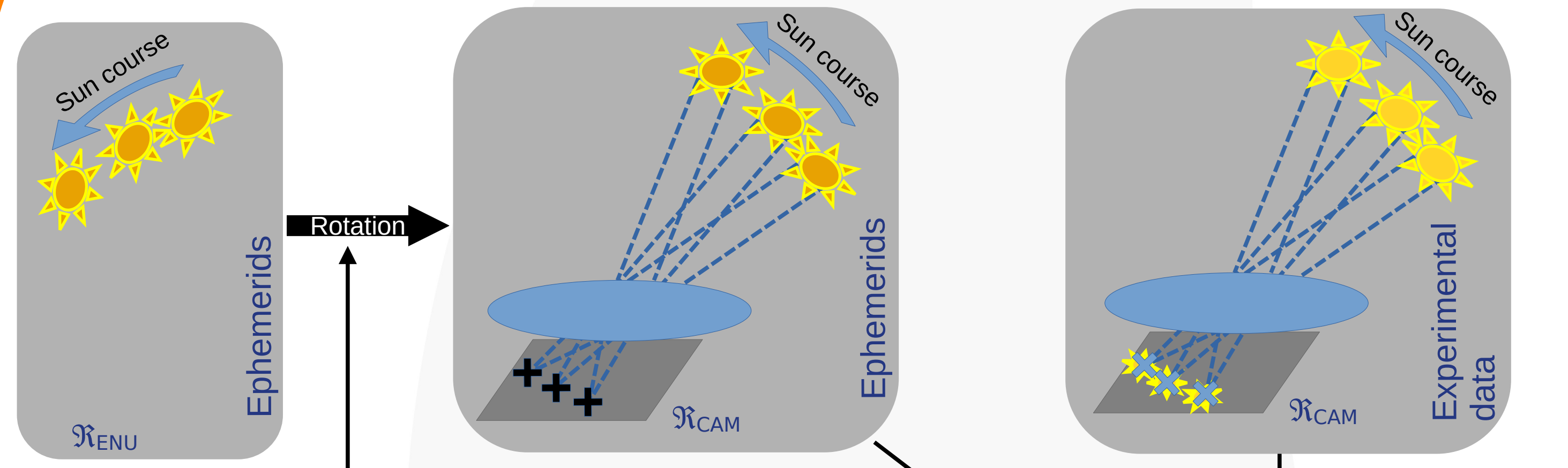
How does varying weather change the skylight polarization pattern?



Goal: create a long-term database of the skylight polarization in a fixed location

Orientation calibration

→ **Camera frame** (\mathcal{R}_{CAM}) orientation measured in respect to the local **East-North-Up** (\mathcal{R}_{ENU}) **frame**. To do this, we chose to compare the **sun course** measured on the sensor with sun ephemeris provided by the Astropy Python package [4]



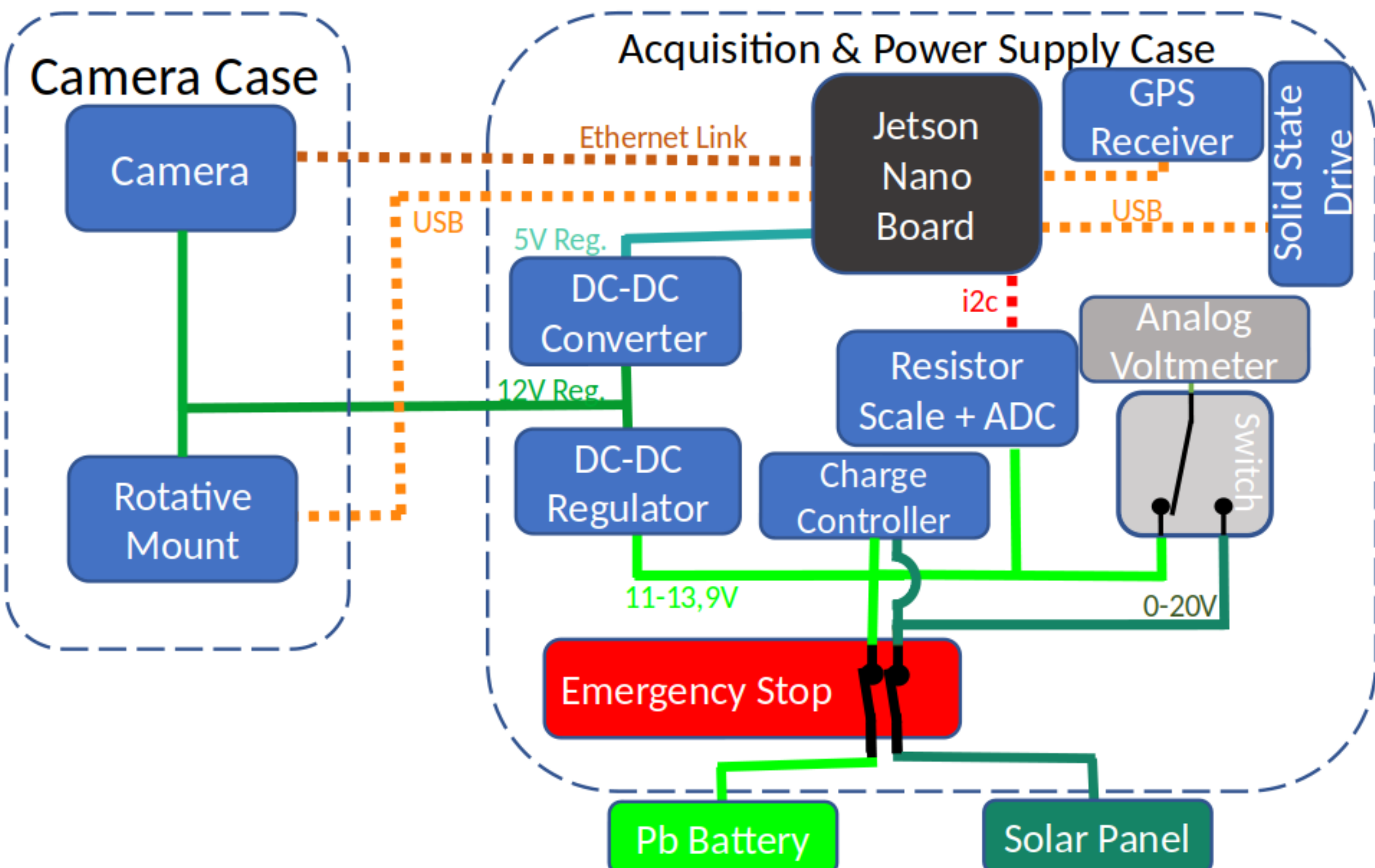
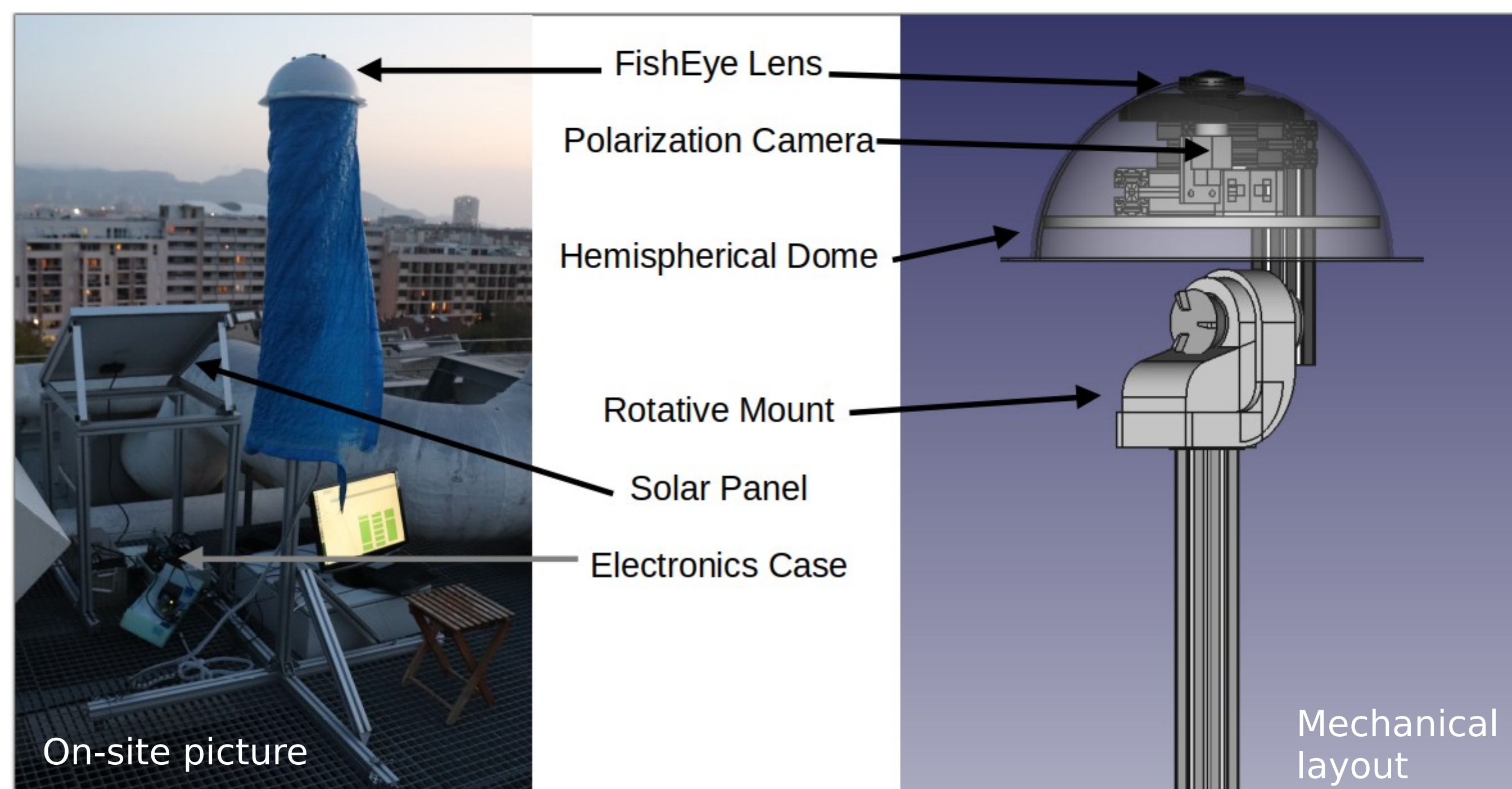
Methods

State-of-the-art for skylight polarization imaging use a **Division of Focal Plane (DoFP)** sensor with a fisheye lens. [2]

→ We use a color-polarization camera (Sony IMX250MYR sensor) fixated on a rotative telescope mount with a fisheye lens (Fujinon FE185C057HA-1)

90°	45°	90°	45°
135°	0°	135°	0°
90°	45°	90°	45°
135°	0°	135°	0°

Camera left on a distant roof → Wide view angle and vandalism-free, with weather protection and autonomous solar power source.



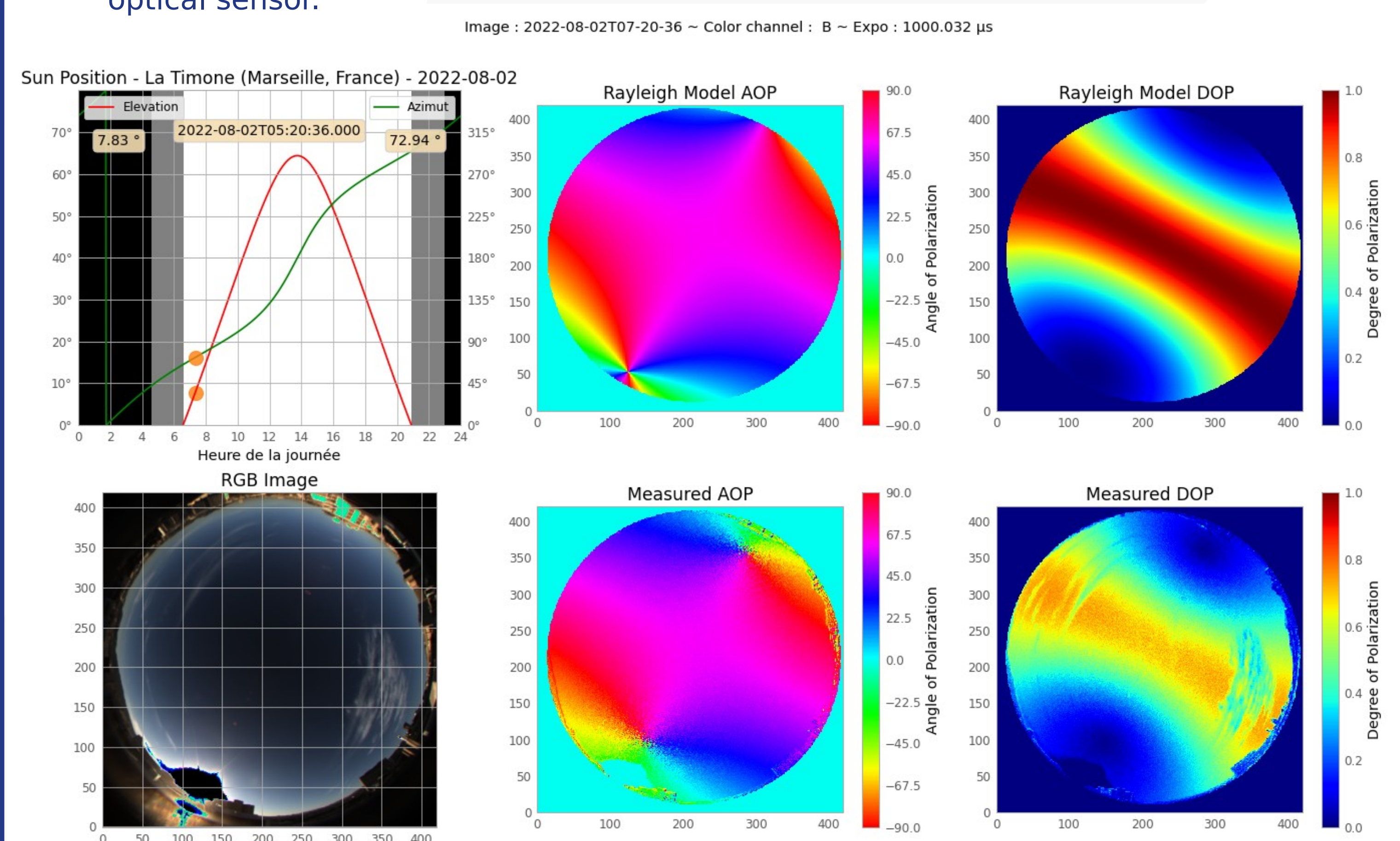
The hardware architecture of the setup.

Results

→ Several thousands of images were taken between 2022-07-29 and 2022-08-25.

→ One image acquired every 10 minutes with several fixed and auto-adaptive exposure times. Camera orientation was assumed to be constant over time.

→ Comparison with Rayleigh model of sky simulated for similar time, location and optical sensor.



Dataset taken from a laboratory rooftop in Marseille, France (43.286990365824785°N, 5.403361407820939°E).

Database is available here:
<https://doi.org/10.57745/610QTS>

- Stand-alone system based on a polarimetric camera for building a database of images.
- Open-source tool in Python to visualize and compare the real images with simulated images obtained with the Rayleigh model.
- Our database could be useful for testing and developing neural network-based and classical image processing, or to validate models of the polarized skylight patterns in various outdoor conditions.

[1] G. Horváth et D. Varjú, Polarized Light in Animal Vision. Berlin, Heidelberg: Springer Berlin Heidelberg, 2004. doi: 10.1007/978-3-662-09387-0.

[2] F. Kong, Y. Guo, J. Zhang, X. Fan, and X. Guo, Review on bio-inspired polarized skylight navigation. Chinese Journal of Aeronautics, 2023

[3] Newville, Matthew et al. LMFIT: Non-Linear Least-Square Minimization and Curve-Fitting for Python, 2014

This work made use of Astropy (<http://www.astropy.org>), a community-developed core Python package and an ecosystem of tools and resources for astronomy

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