STUDIO: A FIRST STEP TOWARDS A STRATOSPHERIC BALLOON OBSERVATORY

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Introduction

For most astronomical measurements, observations in the ultraviolet (UV) at wavelengths below 320 nm are not possible from the ground because of atmospheric extinction by the atmosphere. Early on, observers started using stratospheric balloons as relatively flexible and affordable means to access ultraviolet wavelengths, thus overcoming most atmospheric limitations. [1]

STUDIO Mission

The **STUDIO** (**S**tratospheric **U**ltraviolet **D**emonstrator of an **I**maging **O**bservatory) mission consists of the development and construction of a versatile prototype gondola and telescope, which shall perform technology tests as well as deliver first scientific results from astronomical observations during its maiden flight planned for 2021. Its main optical payload includes a 50 cm aperture telescope to the back of which the Telescope Instruments Platform (TIP) will be attached. STUDIO is the prototype mission and the first objective of the research infrastructure project ESBO *DS* (European Stratospheric Balloon Observatory – *Design Study*) .

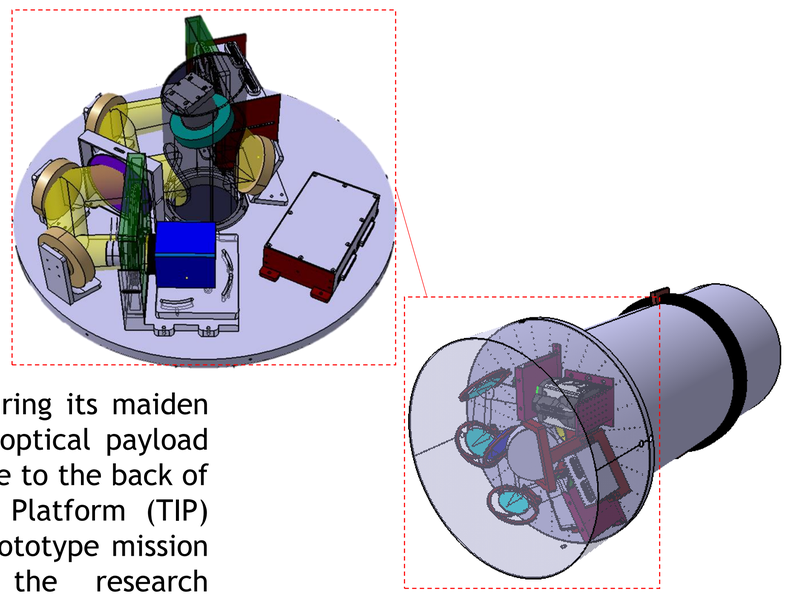


Figure1 : STUDIO Telescope and TIP

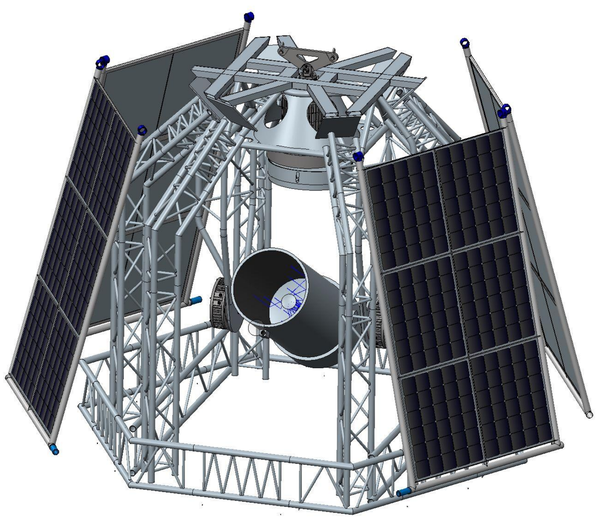


Figure 2 : Mechanical Gondola Structure [2]

The TIP will include a primary instrument for the UV to cover a scientific wavelength interval from 180 nm to 330 nm, as well as instrument to cover a complementary optical spectrum up to 1000 nm.

The gondola will provide a stabilization system of 40 arcsec in elevation and azimuth, while a fine image stabilization system employing a fast steering mirror is foreseen to compensate for the remaining jitter and achieve the one arcsec pointing stability required by the UV instrument. For this purpose a Commercial Off-The-Shelf (COTS) tip/tilt platform will be considered.

Scientific & Technical Motivation

Two science cases motivate the UV scientific part of STUDIO, namely:

- the search for variable hot compact stars in the Galactic plane, and
- the detection of flares from cool dwarf stars

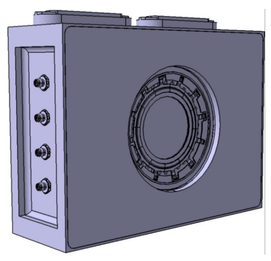
Technically the prototype will aim to:

- Demonstrate the maturity of critical technologies (e.g. safe landing and recovery)
- Demonstrate a next-generation UV instrument on the prototype
- Ensure the availability of a prototype instrument for scientific use after the end of ESBO *DS*

Payload and Instruments

In addition to the 50 cm telescope, the scientific instruments on board the TIP are:

1. An advanced photon-counting, imaging microchannel plate (MCP) detector that shall measure photons in the UV band from 180 nm to 300 nm. The detector will be capable of processing about 300 000 detected photons per second. The detector is currently being developed at the Institute Institute for Astronomy and Astrophysics Tübingen (IAAT), Germany. [3]



Detector size	39 mm diam	Pixel Scale	0.6 arcsec/px
Pixel size	19 µm x 19 µm	Field of View	20.6 arcmin
Pixel Array	2016 x 2016 px	Power Consumption	19 W (peak)
		Mass (detector head)	1.3 Kg

Figure 3 : STUDIO's UV detector characteristic

2. A visible light imaging instrument that will mainly serve as the tracking sensor in a closed-loop fine image stabilization system, but that will also be used as an auxiliary science instrument. Several COTS cameras have been considered for the project, including the PCO pco.edge 4.2, which was tested in-laboratory for its optical characteristics, on-sky and in thermal vacuum environment.
The camera, which was originally not vacuum compatible, was tested from -30 °C to +34 °C and was put through six pressure cycles at 3 mbar and no problems were encountered.

Sensor Type	sCMOS	Pixel Scale	0.21 arcsec
Detector size	13.3 mm x 13.3 mm	Field of View	7.04 arcmin
Pixel size	6.5 µm x 6.5 µm	Power Consumption	20 W (peak)
Pixel Array	2048 x 2048 px	Mass	700 g

Figure 4 : PCO pco.edge 4.2 camera picture & characteristics [4]

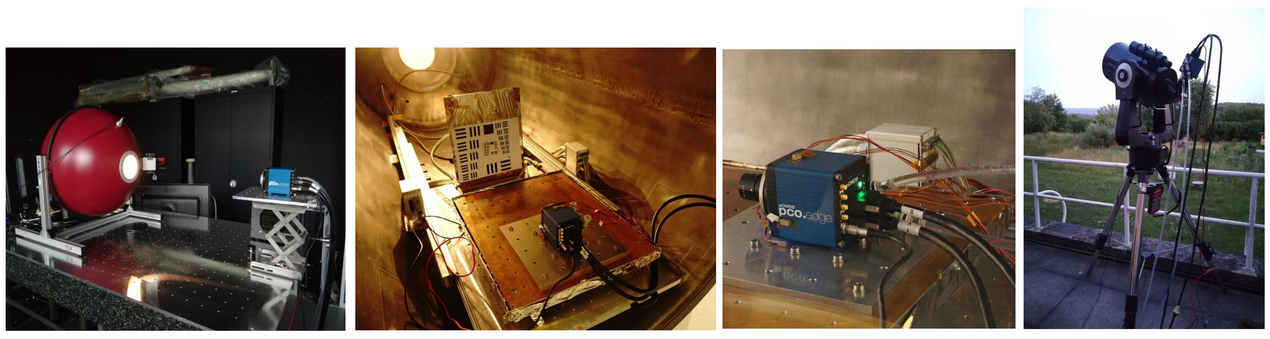


Figure 5 : Functional, environmental and on-sky tests of the pco.edge 4.2 camera

Additionally, the TIP will house one filter wheel for each instrument carrying Sloan u & GALEX NUV filters as well as an open position, a beam splitter and a Tip/Tilt mirror and platform used for the image stabilization systems. Free slots are left on the gondola for potential add-on instruments.

Long Term Objectives

The second objective of ESBO *DS* is the development of a strategy for the establishment and operation of a balloon-based observatory – including the study of the technical feasibility of balloon flights with larger systems:

- For the mid-term: 1.5 m telescopes for visible and near infrared observations e.g., exoplanet atmospheres via transit spectroscopy
- For the long-term: 5 m aperture class telescopes for high spatial and spectral resolution at far infrared observations

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References

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