Towards a European Stratospheric Balloon Observatory – The ESBO *Design Study*

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1. Introduction

The idea of using stratospheric balloons to overcome the obstruction of Earth's atmosphere for astronomical observations is not new. Despite considerable advantages over space-based missions, however, the use of balloon-based telescopes is limited. It seems likely that the main reasons are a combination of

- challenges associated with large balloon payloads (e.g. safe payload recovery and precise pointing), and
- the specialized expertise required for large stratospheric balloon missions that most astronomical research groups do not have.

While a visible trend towards providing more specialised equipment for balloon-based telescopes exist, a true observatory organisation that offers observing time and regular flights is missing. Following up on the H2020 project ORISON, we aim at complementing the current scientific ballooning landscape by forming such an observatory institution that offers regular flights of reusable platforms for astronomical telescopes and instruments in form of the European Stratospheric Balloon Observatory (ESBO).

2. ORISON, ESBO, and ESBO *DS*

The **ORISON feasibility study** showed

- the general feasibility of an observatory-type balloon-based research infrastructure and
- large interest among European astronomers

ESBO represents the idea of a larger observatory infrastructure, providing

- regular flights,
- open access to observation time and instrument flight opportunities, as well as
- safe return, reusability, and reflight.

The ongoing **ESBO *Design Study* (ESBO *DS*)** serves for

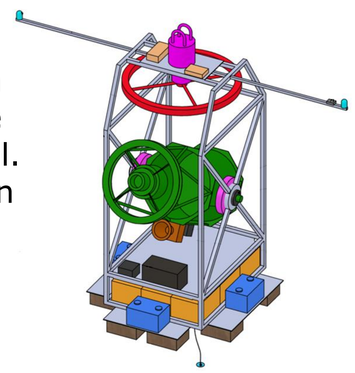
- technology demonstration of critical elements
- the conceptual design of ESBO, including technical aspects, but also an operations concept and governance framework.

3. STUDIO – the UV/vis Prototype

The Stratospheric Ultraviolet Demonstrator of an Imaging Observatory (STUDIO) is the ESBO *DS* prototype that will serve as a technology demonstrator for ESBO and as a testbed for a new microchannel plate (MCP) UV detector. The critical technologies to be demonstrated particularly include:

- Multi-step versatile, highly precise image stabilisation;
- Modular and scalable gondola and support systems;
- Systems for safe recovery.

3.1 Payload and Gondola



The STUDIO payload comprises a 50 cm aperture telescope with a beam splitter for a visible and an ultraviolet channel. The main instrument is an imaging and photon counting MCP detector developed by the Institut für Astronomie und Astrophysik Tübingen to cover the wavelength band from 180 to 330 nm.

The gondola and its coarse pointing system are based on former designs of the Swedish Space Corporation and will provide pointing stabilization down to ca. ± 40 arcsec in elevation and azimuth. A closed-loop fine image stabilisation within the optical system employing a fast steering mirror and the visible camera as guiding sensor will provide the further stabilization down to ± 0.5 arcsec on the image plane.

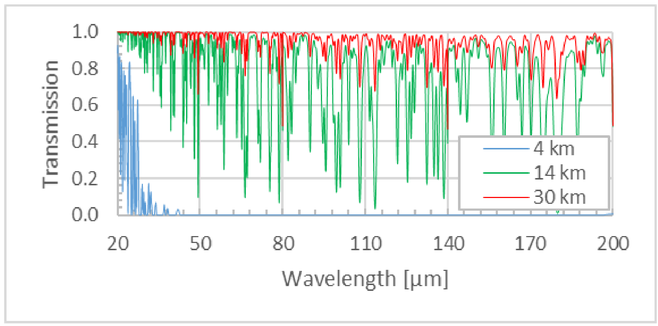
3.2 UV Science

STUDIO will allow astronomical observations below 320 nm that are not possible from the ground due to atmospheric extinction by ozone. Lightcurve measurements in the band from 180 to 330 nm will allow the study of the two main science cases:

- Search for variable hot compact stars in the Galactic plane;
- Detection of flares from cool dwarf stars.

4. FIR Plans and Motivation

The far infrared (FIR) regime equally suffers from atmospheric extinction and is inaccessible from the ground.



With Herschel as the last FIR space telescope out of service, the airborne Stratospheric Observatory for Infrared Astronomy (SOFIA) currently is the only facility that can observe this wavelength region.
However, observations in the FIR region provide vital information for astrophysicists and astrochemists, who are longing for new observatories with better angular resolution, more observational capacity (spectral coverage and time), and higher sensitivity. ESBO *DS* will study how the first two needs can be addressed by a balloon-borne observatory in the 5 m aperture class, i.e. doubling SOFIA's angular resolution.

5. Outlook

The plans for ESBO foresee a step-wise development. The current prototype and conceptual design under ESBO *DS* will be concluded in 2021 and lead to the STUDIO prototype flight, likely from Esrange, Sweden, shortly thereafter. Further scientific and technology test re-flights of the modified STUDIO payload and gondola are foreseen thereafter. ESBO *DS* will also serve to develop a user group for further payloads, also for a mid-sized flight infrastructure to be potentially added in the 2023/2024 timeframe. Regular operation of the 5-m-class far infrared flight system is regarded as realistic in a 15 year timeframe.

ESBO *DS* has received funding from the European Union's Horizon 2020 research and innovation programme under Grant Agreement No 777516.

For more information, visit us at: http://esbo-ds.irs.uni-stuttgart.de