SETA: AN IMAGING SPECTROMETER FOR MARCO POLO MISSION. M.C. De Sanctis[1], G. Filacchione[1], F. Capaccioni[1], G. Piccioni[1], E. Ammannito[2], M.T. Capria[1], A. Coradini[2], A. Migliorini[1], E. Battistelli[3], G. Preti[3]
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Introduction: The MarcoPolo NEO sample return M-class mission has been selected for assessment study within the ESA Cosmic Vision 2015-2025 program. The Marco Polo mission proposes to do a sample return mission to Near Earth Asteroid [1]. With this mission we have the opportunity to return for study in Earth-based laboratories a direct sample of the earliest record of how our solar system formed. The landing site and sample selection will truly be the most important scientific decision to make during the course of the entire mission. For this reason, a powerful complement of on-board science instruments are needed to support the fundamental objectives of the mission. Among these, the imaging spectrometer is a key instrument being capable to do:

- Characterize the mineralogical composition of the entire asteroid;
- Analyze the of the landing site and the returned sample in its own native environment;
- Establish the broadest possible scientific context for the target asteroid within our current understanding of the solar system.

Scientific Objectives: Aim of SETA experiment is to perform imaging spectroscopy in the spectral range 400-3300 nm for a complete mapping of the target with a spectral sampling of at least 20 nm and a spatial resolution of the order of meters. SETA shall be able to return a detailed determination of the mineralogical composition for the different geologic units as well as the overall surface mineralogy with a spatial resolution of the order of few meters. These compositional characterizations involve the analysis of spectral parameters that are diagnostic of the presence and composition of various mineral species and materials that may be present on the target body. Most of the interesting minerals have electronic and vibrational absorption features in their VIS-NIR reflectance spectra. Identification of these related mineral phases requires a moderate spectral resolution. The presence of organic materials may be more difficult to identify.

SETA Concept: The SETA design is based on a pushbroom imaging spectrometer operating in the 400-3300 nm range, using a 2D array HgCdTe detector. This kind of instrument allows a simultaneous measurement of a full spectrum taken across the field of view defined by the slit's axis (samples). The second direction (lines) of the hyperspectral image shall be obtained by using the relative motion of the orbiter with respect to the target or by using a scan mirror. The SETA optical concept is mostly inherited from the SIMBIO-SYS/VIHI (Visible Infrared Hyperspectral Imager) imaging spectrometer aboard Bepi Colombo mission [2] but also from other space flying imaging spectrometers, such as VIRTIS (on Rosetta and Venus Express) and VIR (on DAWN) [3,4].

Seta is based on a modified Schmidt optical scheme both for Telescope and Spectrometer (substituting aspherical correcting plate with an achromatic doublet; all spherical elements having null optical power). Overall optical layout of the telescope plus spectrometer assembly is reported in the following figure 1.

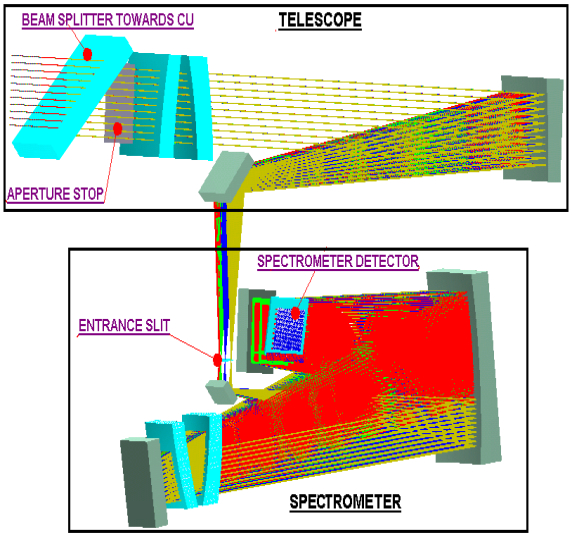

Figure 1. SETA optical concept.

The telescope is based on a modified Schmidt design, having aperture and focal length chosen to obtain the desired spatial scale on the detector while being diffraction limited all over the range. The telescope is joined to the spectrometer's entrance slit. The spectrometer is designed in Littrow configuration thus adopting a flat dispersing grating.

The present SETA design could foresee a scanning mechanism which could be necessary to point the target or for introducing or correcting the observation speed.

SETA general parameters and performances are listed in the following table.

Optical	Schmidt telescope, Littrow spectrometer; magnification 1X;CaF2 corrective lenses
Entrance pupil	50x25 mm (across x along track) (40 mm equivalent)
f/#	120 mm
FOV	0.014°x3.6° (across x along track)
Spectral range and sampling	0.4-3.5 (cutoff) µm; 10 nm/band
Optical performances	Slit curvature (smile) corrected at 2 µm; residual 1/10 pixel at shortest and longer wavelengths; Keyston: <1 pixel on overall spectrum

Table 1. SETA general parameters

The SETA mass estimation is based on extrapolation from existing devices. Specifically we have estimed the mass budget on the present design of VIHI for BepiColombo (see Table 2).
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Optical Head (with baffle)	1.2 kg
Margin+ FPA cooling and thermal control system(*)	0.5 kg
Scan Unit (flat motor resolver + electronics) mirror	0.6 kg
TOTAL	1.7 kg

Table 2. SETA mass budget. (*) provisional figure, depending by the selected thermal control of the FPA.

SETA Radiomatric Performances: Due to the rather high cut-off wavelength, some requirements on the instrument temperature are envisaged. A detailed radiometric analysis to evaluate all the background contributions will be performed during the next phase of the project. A preliminary evaluation is reported in the following plots, using the following assumptions:
Integration Time= 0.5 sec;
Detector Temperature= 150 K;
Telescope Temperature= 200 K;
Spectrometer Temperature= 180 K

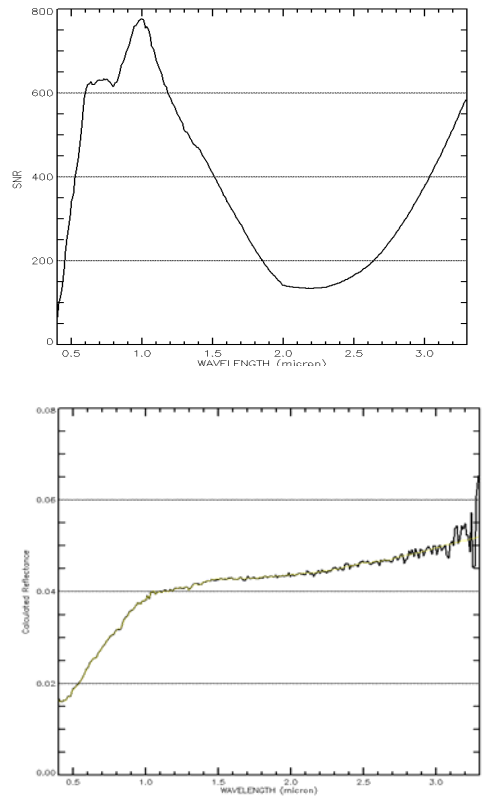

Figure 2. Perihelion case with integration time of 0.5 sec: a) S/N; b) simulated deconvolved reflectance (black line) and target reflectance (yellow).

References:

[1] Marco Polo Payload Definition Document (2008), SCI-PA/2008.002/Marco-Polo, ESA
[2] E. Flamini, et al., *Planetary and Space Science*, in press.
[3] A. Coradini et al. (2007), *Space Science Reviews, 128, 529–559.*
[4] Russel et al. (2007), *Earth Moon Planet, 101, 65–91*

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