THE DEVELOPMENT MODEL OF VIR-MS: LABORATORY SPECTROSCOPY SUPPORTING THE DAWN MISSION. E. Ammannito[1,2], A. Boccaccini[1], A. Mazzoni[1], G. Piccioni[3], A, Coradini[1], M.C. De Sanctis[3], [1]INAF-IFSI Via Fosso del Cavaliere, 100, 00133, Roma, Italy, eleonora.ammannito@ifsi-roma.inaf.it, [2]CISAS, University of Padova, Via Venezia, 15, 53131, Padova, Italy. [3]INAF-IASF Via Fosso del Cavaliere, 100, 00133, Roma, Italy.

Introduction: The purpose of this abstract is to describe the laboratory set-up we have prepared to support the Dawn mission to minor planets 1 Ceres and 4 Vesta [1]. We have assembled and calibrated the DM (Development Model) of VIR-MS, the imaging spectrometer aboard such mission. VIR-MS combines two data channels in one compact instrument. The visible channel covers 0.25–1.0 µm and the infrared channel covers 0.95–5.05 µm.

The DM is an imaging spectrometer to be used in laboratory. This experiment has two purposes: it will be used as test bench for the behaviour of the flight instrument during the mission but in the meanwhile it will be used as spectrometer to collect data and prepare a data-base of reflectance spectra to be used for the interpretation of the measurements of VIR-MS. Originally the DM was ideated as the prototype of VIRTIS-M aboard the Rosetta mission, but, as well as the VIRTIS project went on bringing to the construction of VIRTIS on Venus Express and VIR-MS on Dawn, it became a laboratory facility to support such missions [2], [3]. Actually, it is a spectrometer with the same optical design of VIR-MS and VIRTIS but some mechanical changes. Such changes were decided in order to improve the usability of the new spectrometer in the laboratory. The most relevant changes between the two instruments are the absence in the DM of the IRFPA (InfraRed Focal Plane Array) and a different scanning motor for the primary mirror of the telescope. The former point makes the two experiments somehow different in a significantly way, however this choice was necessary in order to avoid the use of the DM inside a Thermo-Vacuum Chamber and a dedicated cooling system for the IRFPA. The latter point is a precise choice made during the designing phase: it was considered that the scanning unit of VIR-MS was designed specifically to operate in the space environment an it wasn't a good choice for a laboratory experiment. All the other aspects of the two spectrometers are the same especially from the optical point of view.

Set-up description: We will describe in the following the set-up we have created in our laboratory. It is composed by two different systems:

The DM. As well as VIR-MS, the DM is actually composed by two sub-system: a Shafer telescope coupled with an Offner grating spectrometer. The telescope is an optical element used to focus the light on the slit of the spectrometer that is the core of the DM. As the instrument uses a bi-dimensional focal plane aligned with the spectrometer's slit axis, the acquisition of a hyper-spectral cube is performed through a push broom acquisition mode by moving the scanning mirror of the telescope. The focal plane is a CCD of 288 spatial pixels and 384 spectral pixels. For further details about the characteristics of the DM and its optical design it is possible to refer to literature on VIR-MS as well as the one on VIRTIS and VIMS-V ([4], [5], [6]). The software used for the communication with the DM and for the acquisition of the data was developed in our institute and it was designed to handle hyperspectral data.

The optical bench. The role of the optical bench is to collimate the light beam coming from the source before it arrives on the primary mirror of the telescope. In order to obtain this result it was studied an optical system of three elements. A target that has the role to carry the sample to be measured; an off-axis parabolic mirror that is the real collimating element and a folding mirror that has no role in the optical concept of the system but it is used to deviate the collimated beam in order to get the best alignment with respect to the DM. The folding mirror is not critical from the optical point of view because at that point the beam is collimated, on the other side, the parabolic mirror and the target need to be aligned in order to get a collimating system. The idea using such elements is that a parabolic off-axis mirror collimate the light coming from its focus. It means that we need to put the target exactly on the focus of the mirror. The procedure performed to align the two elements is based on the use of an interferometer. Looking at the pattern it is possible to understand if the objective of the interferometer is on the focus of the mirror or not. The pattern on the output monitor of the interferometer must be straight line and well aligned.

The following table lists the properties of the setup:

Spectral Range (nm)	450-900
Spectral Resolution (nm)	1.20
Spectral Sampling (nm)	2.10
FOV (mm)	40*40
IFOV (mm)	0.25*0.25
Optical Magnification	1:10.87

DM calibration: As soon as we finished the alignment, we start the calibration of the system. Imaging spectrometers aboard of space missions required a detailed calibration procedure (eg [7], [8]), in the case of an experiment for laboratory purpose the procedure is much more easy especially because it is not necessary a radiometric calibration to get reflectance spectra. Thus, the aim of the calibration procedure is essentially to provide the spectral and geometrical properties of the system.

Spectral Calibration. The spectral properties were measured using an HgNe pencil lamp (Oriel Model n° 6034). In fig. 1 there is a plot of the acquired spectra. The identification of the two strong emission features with the lines at 546nm and at 579nm of the pencil lamp allow us to calculate the spectral range, sampling and resolution of the DM. We found a range of 450-900nm and a spectral sampling of (1.20±0.20)nm. Moreover, performing a Gaussian fit on the feature at 456nm, we get a spectral resolution of (2.10±0.20)nm.

Geometrical Calibration. We measured the geometrical resolution of the system using a standard target (USAF 1951 Resolution Targets from Edmund Optics). The image we have acquired is shown in Fig. 2. Such image is an RGB combination of three band. The image seems to be misaligned with respect to the horizontal direction, it is a consequence of the a misalignment of the target on the focal plane of the collimator and not to any geometrical distortion of the experiment. Analyzing the pattern on the image we found a spatial resolution on the target of (0.250 ± 0.25)mm in both directions, along the slit and along the scanning. Using the same image we could extimate the Field of View of the system to be roughly (40X40)mm.

Conclusion: Being provided both the spectral and geometrical properties of the system, the set up is ready to collect reflectance spectra of samples considered analogs of the two major target of Dawn: Vesta and Ceres. The availability for laboratory measurements of an imaging spectrometer similar to the one flying on Dawn will be helpful for the analysis an interpretation of data that will be acquired during the mission. We have already started a detailed investigations on an eucrite (Millbillillie) using laboratory spectroscopy [9], the DM will improve our capability to investigate the properties of the HEDs meteorites considered as Vesta analogs.

Acknowledgments: We are grateful to the Italian Space Agency (ASI) that have founded this study. We are grateful to the Galileo Avionica (GA) company for their support; in particular they have provided the optical design of the system and the interferometer for the alignement.

Referencies: [1] Russell, C.T. et al (2004) Planet. Space Sci, 52, 465-489. [2] Melchiorri et al. (2003), Rev. Sci. Instrum. 74, 3796. [3] Piccioni et al. (2000) Planet. Space Sci. 48, 411. [4] Reininger, F. et al (1996). Proc. SPIE 2819, 66. [5] Coradini et al (1998), Planet. Space Sci. 35, 1291. [6] Capaccioni et al (1998). Space Sci. 46, 1263. [7] Ammannito et al. (2006), Rev. Sci. Instrum. 77, 93109-093109-10. [8] Filacchione et al (2006), Rev. Sci. Instrum. 77, 103106-103106-9. [9] Ammannito et al. (2007) LPS XXXVIII Abstrac #1338,

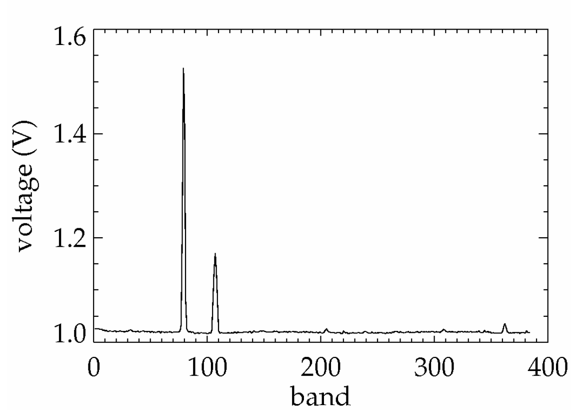

Fig. 1. HgNe pancil lamp acquired by the DM.

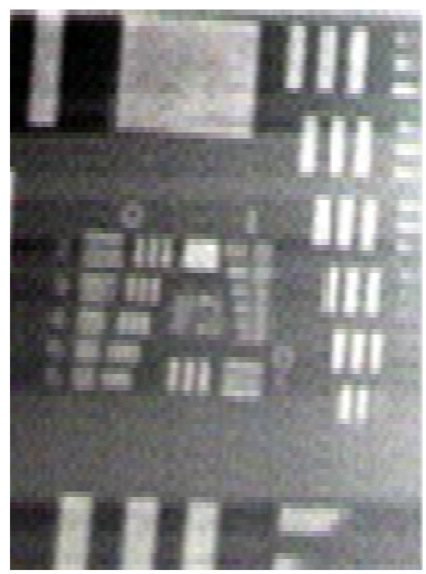

Fig. 2. RGB image of the geometrical calibration target (R @ 800nm, G @ 810nm, B @ 820nm).