THE VENUS EMISSIVITY MAPPER (VEM) CONCEPT. J. Helbert[1], D. Wendler[1], I. Walter[2], T. Widemann[3], E. Marcq[4], A. Maturilli[1], S. Ferrari[5,1], M. D'Amore[1] , N. Müller[6], M. D. Dyar[7], and S. Smrekar[6], [1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany (joern.helbert@dlr.de), [2]Institute for Optical Sensorsystems, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany,[3]LESIA,[4]LATMOS, [5]Department of Earth and Environmental Sciences, University of Pavia, Via Ferrata 1 - 27100 Pavia, Italy, [6]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena CA, 91109, [7]Dept. of Astronomy, Mount Holyoke College, South Hadley, MA 01075.

Based on experience gained from using the VIRTIS instrument on VenusExpress to observe the surface of Venus and the new high temperature laboratory experiments, we have developed the multi-spectral Venus Emissivity Mapper (VEM) to study the surface of Venus. VEM imposes minimal requirements on the spacecraft and mission design and can therefore be added to any future Venus mission. Ideally, the VEM instrument will be combined with a high-resolution radar mapper to provide accurate topographic information, as it is done on the VERITAS mission [1].

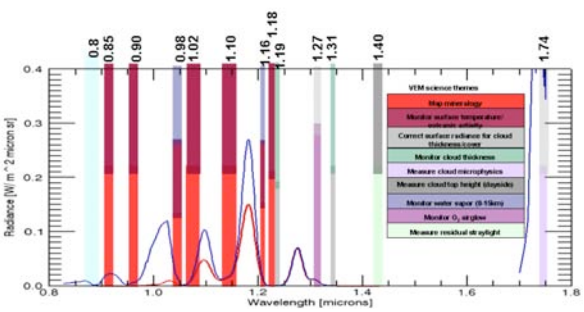

Figure 1. Highlands (red) and lowlands (blue) surface radiance spectra of Venus, with VEM filter locations superimposed, from [2].

The permanent cloud cover of Venus prohibits observation of the surface with traditional imaging techniques over most of the visible spectral range. Fortunately, Venus' CO_2 atmosphere is transparent in small spectral windows near 1 μm (**Figure 1**). Ground observers have successfully used these windows during the flyby of the Galileo mission at Jupiter and most recently for the VMC and VIRTIS instruments on the ESA Venus Express spacecraft. Observations have revealed compositional variations correlated with geological features, but existing data sets contain only a few channels. VEM offers an opportunity to gain significant information about surface iron-bearing mineralogy by virtue of having five different channels for surface observations.

Surface mapping by VIRTIS on VEX: The VIRTIS instrument on the ESA mission Venus Express (VEX) was the first instrument to routinely map the surface of Venus using the near-infrared windows from orbit [3-5]. The instrument is the flight spare of the VIRTIS instrument on the ESA Rosetta comet encounter mission [6]. Originally designed to observe a very cold target far from the Sun, it was adapted to work in the Venus environment. The instrument's main purpose on VEX was to study the structure, dynamics and composition of the atmosphere in three dimensions. However, the idea of surface studies was introduced very late in the mission planning and VIRTIS was never specifically adapted for this purpose. For example, the wavelength coverage was not optimal and only the long wavelength flank of the main atmospheric window at 1.02μm could be imaged. Despite these issues, VIRTIS was an excellent proof-of-concept experiment and far exceeded our expectations. It provided significant new scientific results and showed, for example, that Venus had volcanic activity in the very recent geological past [7].

The VEM concept: VEM is focused mainly on observing the surface, mapping in all near-IR atmospheric windows using filters with spectral characteristics optimized for the wavelengths and widths of those windows. It also observes bands necessary for correcting atmospheric effects [8]; these bands also provide valuable scientific data on cloud thickness, cloud opacity variations, and H_2O abundance variations in the lowest 15 km of the atmosphere.

VEM is a pushbroom multispectral imaging sys-

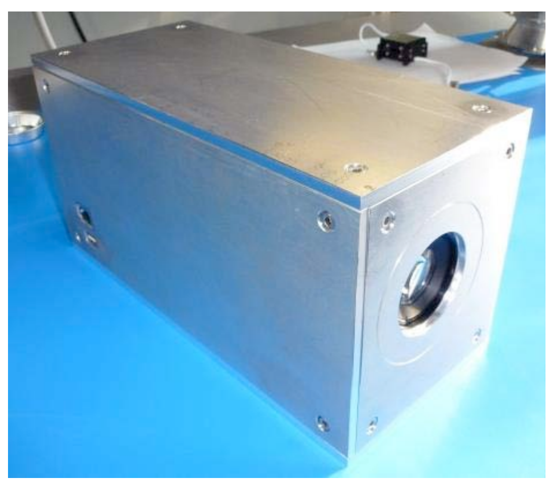

Figure 2. Breadboard for VEM used for first testing.

tem. A baffle protects VEM from scattered light. Telecentric optics image the scene onto the filter array. This image is relayed by a four-lens objective onto the detector. The field of view (FOV) of the optics is 30º, yielding a swath width of 113 km at an altitude of 215 km to provide comprehensive sampling of the surface emissivity and repeat coverage between tracks.

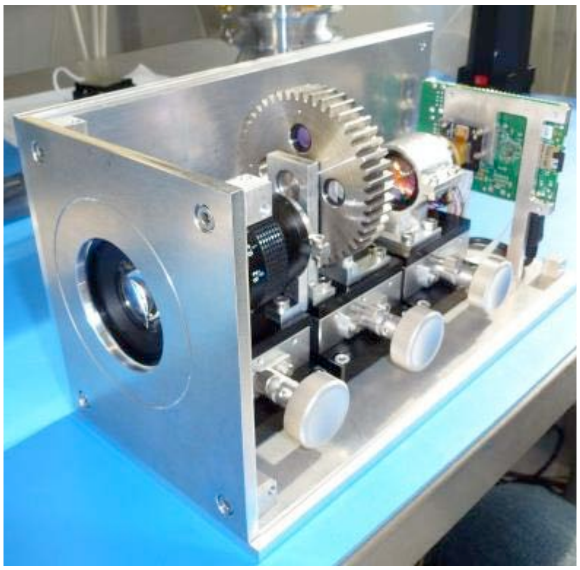

Figure 3. First VEM breadboard with telecentric and relay optics, however using filter wheel instead of filter array.

To split the light into several bands, VEM uses a multilayered dielectric-coating ultranarrow-band filter array instead of a grating to maximize the signal to the detector. The filter array is located at an intermediary focus of the optical path. We image each band onto the 17 512-pixel rows of the detector. The surface bands are spatially sandwiched between the cloud bands to provide calibration before and after each surface data acquisition.

To minimize VEM development risk, a model philosophy with a prototyping approach has been utilized. Combined with the extensive test program planned using test facilities at DLR in Berlin, this ensures that performance issues are identified early and can be mitigated without endangering the development schedule.

A first very simple breadboard [8] for VEM has been set up (**Figure 2,3**) and is currently used for testing with the high temperature chamber at PEL [8-10] measuring Venus analogs at typical Venus surface temperatures (**Figure 4**).

Conclusion: Observing the surface of Venus in the near infrared requires a dedicated instrument. VIRTIS observations have successfully demonstrated that important information can be extracted from the windows in the visible portion of the spectrum, but the design of the instrument limited its use for surface investigations. Deploying an instrument like VEM in orbit or on an aerial platform will provide new insights into the mineralogy of Venus. In combination with a high-resolution radar mapper that provides accurate topographic data as planned for the VERITAS mission or for the ESA EnVision mission proposal, this will allow a global mapping of the surface composition at a spatial scale of approximately 50 km [11,12]. Combining the near infrared data with radar derived geological information will allow further conclusions on the evolution of Venus to be drawn.

Figure 4. VEM breadboard on the high temperature chamber at PEL [9,10].

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