**Introduction:** The OSIRIS-REx (Origins Spectral Interpretation Resource Identification Security Regolith Explorer) Mission is a planetary science mission to study, and return a sample from, the carbonaceous asteroid 1999 RQ36. It is the third mission selected under NASA’s New Frontiers Program, and is scheduled to be launched in 2016 under the leadership of PI Dante Lauretta at the University of Arizona and managed by NASA’s Goddard Space Flight Center.

**Instrument Overview:** The OSIRIS Visible and near-IR Spectrometer (OVIRS) is a point spectrometer with a 4-mrad field of view (FOV) that provides spectra over the wavelength range of 0.4 – 4.3 µm. It employs wedged filters (also called a linear variable filters) to provide the spectrum. A wedged filter is a two-dimensional spectral filter in which the wavelength of transmitted light varies in a well-defined fashion with position along one of the spatial dimensions. The OVIRS design is based on the New Horizons LEISA instrument design [1], but with simplified optics and extended wavelength range.

OVIRS spectra are measured with a resolving power R (=λ/Δλ) of 125 in the 0.4 to 0.9 µm spectral band (Δλ < 7.5 nm); R = 150 in the 0.9 to 1.9 µm spectral band (Δλ < 13 nm); and R = 200 in the 1.9 to 4.3 µm spectral band (Δλ < 22 nm). In addition, the spectral range from 2.9 to 3.6 µm is measured with R = 350 (Δλ < 10 nm, Δν < 10 cm⁻¹) to resolve key organic spectral features, such as those that have recently been observed on the asteroid 24 Themis ([2], [3]). The spectral resolution of the OVIRS filters is well within the state-of-the art. For example, LEISA employed filters of resolving power 240 from 1.25 to 2.5 µm and 560 from 2.1 to 2.25 µm [1].

The OVIRS spectral ranges and resolving powers were optimized to provide surface maps of mineralogical and molecular components including carbonates, silicates, sulfates, oxides, adsorbed water and a wide range of organic species. As a point spectrometer, OVIRS operates in a scanning mode, in which the rotational motion of the asteroid is combined with slews of the spacecraft about the OVIRS scan axis to sample a region of interest and build up global maps. In the expected operational scenario, OVIRS will provide full-disk asteroid spectral data, global spectral maps (20-m resolution), and spectra of the sample site (0.08 – 2-m resolution). The instrument provides at least two spectral samples per spectral resolution element (spectral double sampling) taking full advantage of the spectral resolution. OVIRS spectra will be used to identify volatile- and organic-rich regions. These data will be used in concert with data from the other OSIRIS-REx instruments to guide sample-site selection and provide an unprecedented global inventory of the composition and regolith structure of the asteroid’s surface.

**Figure 1. The OVIRS instrument**

**OVIRS Design:** OVIRS uses an off-axis parabolic (OAP) mirror to image the surface of the asteroid onto a field stop. The field stop selects a 4-milliradian angular region of the image. The light from this 4-milliradian area passes to a second OAP that recollimates it and illuminates the Focal Plane Assembly. Because the beam speed is low (~ f/50) this assembly, consisting of the array with the filter mounted in close proximity to it, is effectively at a pupil. Each detector element of the array “sees” the same spatial region of the asteroid but, as described below, different columns of the array “see” it at different wavelengths. The complete spectrum of the 4-milliradian spot is obtained in a single measurement. This is somewhat different than the case for some wedged filter spectral imagers, such as LEISA, where the spectrum of a given point is built up over several frames, e.g., [1].

In order to obtain the high SNR required for OVIRS on a very dark asteroid surface (albedo ~3%), at least 30 pixels will be averaged in each wavelength column. This conservative number, used in sensitivity modeling, is based on worst-case estimates of both spectral "smile" and scattering at segment boundaries. The actual number of pixels summed will be determined in instrument testing. The data will first be filtered using a pre-measured bad pixel map. To prevent cosmic ray events from contaminating the
spectra while still reducing the data volume, pixels will be averaged in subsets before transmission to the ground. Contaminated subsets will be removed in ground processing before summing the remaining subsets at each wavelength to obtain the final spectrum.

The detector array is thermally coupled to a two-stage passive radiator to obtain focal plane temperatures of ~105 K. This reduces the dark current sufficiently that dark current noise is never the dominant noise source with more than a factor of two margin. The camera enclosure shields its contents from radiation and contaminants and mounts to the OSIRIS science deck. A cold baffle in the optical path limits the thermal background signal from the instrument enclosure. In addition, small radiators will reduce the temperature of the optics enclosure itself to less than 160 K, further reducing thermal background noise. The thermal design is such that, except for very low asteroid surface temperatures and very low solar reflectance, the measurement noise is dominated by source photon noise. For very low asteroid signal, the primary noise term is the low read noise. This is the optimum design from a noise standpoint.

OVIRS will be calibrated prior to launch and the calibration will be checked throughout the mission. Spectral calibration will be accomplished using gratings to provide effective monochromatic scanned radiometric sources with R>2,000. Radiometric and relative response calibrations will be performed using NIST traceable calibrated blackbodies and flood sources. The quality of the point spread function will be assessed using collimated point and extended sources. The boresight pointing shall be measured with respect to an optical alignment cube on OVIRS.

In-flight radiometric calibration will rely on three methods: a calibrated onboard array of miniature black body sources (T ~700 K) placed at the OVIRS field stop and tungsten filament sources located after the secondary mirror, in-flight observations of the Earth and the Moon and absolute solar reflectance calibrations. The terrestrial and lunar calibrations will occur on the OSIRIS-REx flyby of Earth. The onboard solar reflectance calibrations will be carried out occasionally by using the spacecraft control system to point the solar calibration port at the sun. The combination of these methods will provide redundant radiometric calibration. It is expected that OVIRS will provide spectral data with at least 5% radiometric accuracy and no worse than 2% pixel-to-pixel precision. Because wedged filters are very stable, the spectral calibration is not expected to change in flight, however, the Earth and Lunar observations will also provide spectral calibrations. Spectral calibration is expected to be accurate to 0.25 of the halfwidth or better. The dark current and background flux will be measured using dark sky observations.

Instrument Scalability: Because the spectral pitch and spectral resolution of the wedged filters may be optimized to match the science requirements in different spectral regions, this design is very flexible. In addition, the point spectrometer design of OVIRS also permits great instrument simplification - it eliminates a dispersive element and the extensive foreoptics of a slit-type spectrometer or the scanning mechanism required with a Fourier transform spectrometer. The design preference depends somewhat on the application, however, and the planned concept of operations for the mission. In either the point spectrometer or line scan designs, however, the detector cutoff and wedge filter selection may be tuned over the desired spectral range to meet the science applications of the mission.

References:

Figure 2. New Horizons LEISA scans of Jupiter at near-IR wavelengths.