THE MAPPING IMAGING SPECTROMETER FOR EUROPA (MISE): PERFORMANCE AND CALIBRATION

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Introduction: The Mapping Imaging Spectrometer for Europa (MISE) on the Europa Clipper Mission was designed and is being built as a high-optical- throughput push-broom imaging spectrometer high signal, low noise measurements within the challenging Jovian radiation environment around Europa. MISE will map the surface composition of Europa from global scale (10 km / pixel) down to local scale (7.5 m/pixel) at 10 nm spectral sampling over a spectral range of 0.8 to 5 μm [1].

Instrument Design: MISE consists of a f/1.4 Dyson spectrometer with a CaF2 dispersive element and a 3-mirror, off-axis telescope that views through an articulated two-sided flat mirror with ± 30º of motion projected onto the ground. The spectrometer grating and slit are manufactured using an electron beam machine at the JPL Micro Devices Laboratory. The focal plane assembly is a mechanically cooled HgCdTe 320×480-pixel CHROMA manufactured by Teledyne. MISE is controlled by a Data Processing Unit (DPU), which includes the spacecraft communication interface, power supply, scanner electronics, on-board memory, and data processing. Planned on-board processing includes identifying and discarding radiation noise and aggregating the cleaned spatially oversampled data into final high-SNR spatial-spectral frames [2].

MISE is designed to provide sufficient SNR in individual spectra for conducting detailed compositional analyses over its full spectral range. Operating over a spectral range of three octaves, observing a surface whose reflectance varies with wavelength from ~ 80% to as low as a few percent, and a solar radiance that decreases by more than two orders of magnitude from the shortest to longest wavelengths, the MISE instrument is a design in optimization. The grating is blazed in such a way to maximize efficiency at the longer wavelengths where both the Sun is dim and where the hydrated surface of Europa is dark. The two-sided scan mirror is for two purposes. The specular side performs spacecraft motion compensation and to precisely scan the surface for spatial oversampling, nominally 20x for 'global observations' acquired above 2000km from the surface, 7x for 'regional observations' obtained between 125 to 2000 km from Europa, and 3x for 'local observation below 125 km. The diffuse side is used to provide periodic solar radiometric calibrations. The scan mirror can also be rotated to a 'closed position' to enable the collection of 'dark frames' when sufficiently close to Europa that scanning off-Europa is not possible.

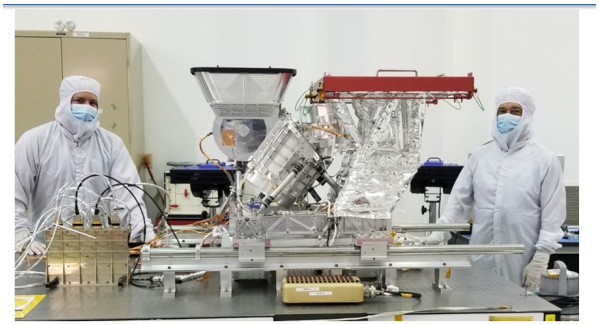
Table 1. MISE Instrument Performance	
Spectral Range	0.8 to 5.0 μm
Spectral Sampling	10 nm
Spectral Resolution	10 nm
Spatial Sampling	250 μrad
Field of Regard	±30º along track, 4.3º cross track
Detector Temperature	87K
Spectrometer Temperature	92K
Telescope Temperature	165K
Scan Mirror Temperature	195K
Integration Time	53.4ms
Bit depth	16 bit
Gain	26 e/DN
Read noise	2.34 DN
Absolute Radiometric Calibration	
Relative Radiometric Calibration	
Wavelength Calibration	
Scattered Light	
SNR requirement* (margin)	100, 2, 20 (236%)
*800-2600 nm, 2600-3200 nm, 3200-5000 nm	

Instrument Calibration: Radiometric calibration is a critical step in instrument performance providing quantitative wavelength and spatially dependent measurements of illumination intensity, ie. of Europa's surface. MISE is unique because it will not only be calibrated before launch, but the calibration is designed to be updated during the

mission at laboratory-level precision.

Absolute and Relative Radiometric Calibration. The radiometric calibration controls the SNR achieved by MISE. Results of radiometric calibration will be presented at the conference. Predicted SNR on Europa is provided in Table 1, along with relevant instrument performance parameters. Achieving the predicted instrument temperatures will be verified under Thermal-Vacuum testing that will occur in mid-January 2023. Recent modifications to the MISE instrument to reduced radiated emissions is expected to increase the operating temperatures of MISE. The temperature of the FPA controls the thermally induced electrons and the temperatures of the optics control the thermal background signal. Both 'signals' will produce shot noise.

Wavelength Calibration. Accurate understanding of the wavelengths at which the received illumination is measured is essential to rigorously interpreting the composition of Europa's surface. The achieved wavelength calibration will be reported at the conference.



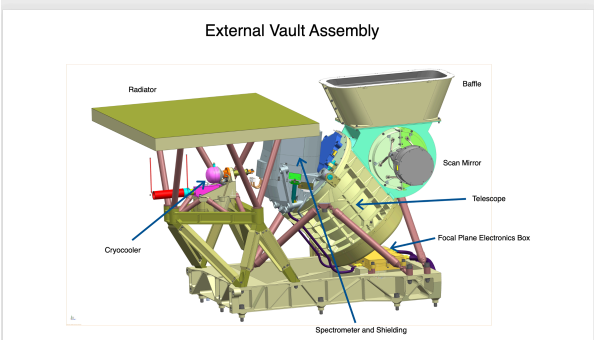


Figure 1. Integrated external vault assembly to be located on top of the Europa Clipper Spacecraft vault of the MISE Instrument and Diagram illustrating key components.

References: [1] Bender et al. (2019) *Proc. SPIE 11130, Imaging Spectrometry XXIII: Applications, Sensors, and Processing,* https://doi.org/10.1117/12.2530464
[2] Seelos et al 2023, This meeting

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