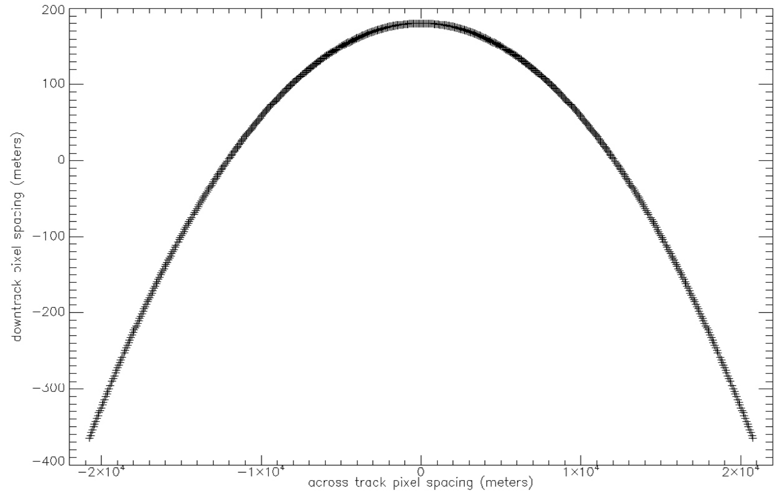

Figure 1. Preflight characterization of the curved slit projection in object space, showing the nominal pixel-center spacings after projection onto a horizontal surface from an elevation of 100 km.

curvature to occur inside the instrument, where it introduces spectral “smile,” differences in spectral response per band across the detector array, and the associated nonuniformity in the data, M^3 essentially put the “smile” outside the instrument in the projected image of the slit on the surface of the Moon. Figure 1 shows the preflight characterization of the slit projection curvature. This amounts to approximately 600 m of downtrack curvature across the nominal 24° and 42.5 km swath, or 1.4%. Depending on whether the Chandrayaan-1 spacecraft was flying forward (zero yaw) or backward (180° yaw), this slight bow in the projected slit either leads or follows the nadir location. While this curvature, or “spatial smile,” does introduce a slight systematic distortion to the raw Level 0 and Level 1B images, it is much better than having the equivalent “spectral smile” on the focal plane causing spectral/spatial nonuniformity resulting in data of compromised quality. Panoramic distortion and lunar topography already introduce irregularities in the surface grid of observed pixel centers. Extra distortion due to the slit projection curvature can be easily compensated, and its effects are fully included in our camera modeling and optimized selenolocation and ray tracing. In section 5, we report the derived inflight camera curvature model that resulted from a joint inversion of the observed data.

[10] The M^3 system was designed so that photons collected for all bands of a single spectrum came from the same local pixel area on the lunar surface. This requirement is critical, so that the observed spectra are meaningful and realistic. As with “smile,” this requirement leads to a design that provides a well-aligned rectilinear spatial/spectral dispersion pattern on the array, avoiding “keystone,” “twist” and “IFOV shift.” These aspects of the design are discussed in the companion paper [*Green et al.*, 2011]. Characterization of the across-track spatial response of M^3 was conducted by laboratory measurements during preflight calibration. These laboratory calibration data are available in the M^3 PDS archive. All data produced by M^3 met its strict uniformity requirements. The slight asymmetry of the response functions is a result of design tradeoffs involving the readout timing and noise sources.

[11] The downtrack response of the M^3 system is governed by the timing of the readout and the projected angle of the entrance slit. The slit was designed to have the same 700 microradian angle as the cross-track detector columns. This static response is then integrated downtrack through time for the duration of the instrument integration time. The nominal M^3 Target Mode integration time was 50 ms, giving approximately twenty Target Mode frames per second. Global Mode, combining two Target Mode frames, has approximately a 10 Hz effective frame rate. At the nominal 100 km altitude the Chandrayaan-1 spacecraft had a downtrack velocity of approximately 1400 m/s. The resulting M^3 pixel center spacings were thus designed to be nearly equidistant in the cross-track and downtrack direction: 70 m for Target Mode and 140 m for Global Mode. M^3 was designed to have overlapping swaths in adjacent orbit tracks. In the overlap areas M^3 could potentially be used to develop stereo models to derive lunar topography. Stereo use of M^3 data has not been addressed by this study.

3. Nominal Coverage Plan

[12] The original M^3 mapping plan for lunar coverage was based on the expected 2 year Chandrayaan-1 nominal mission. During that 2 year mission, M^3 planned to operate during four optical periods. Each optical period was defined as an approximately 3 month time span, when the solar zenith angle at the lit-side equatorial node of the orbit was less than 45°. The 2 month central section in each optical period, where the solar angle to the orbit plane (beta angle) was less than 30°, was expected to be the prime M^3 observation time span. This period, centered on the zero-beta noon-midnight orbit phase, provided maximum reflected signal and minimal cast shadows. Supplemental imaging was planned for the 30° to 45° beta angle “wing periods” on each side of each optical period. Figure 2 shows a schematic illustration of the orbit and illumination geometry for a single year, illustrating two optical periods 6 months apart.