LCROSS IMPACT OBSERVATIONS FROM THE MMT OBSERVATORY. M. Hastie[1] , V. Bailey[2], P. Hinz[2], S. Callahan[1],V. Vaitheeswaran[2], D. Gibson[1], D. Porter[1], and F. Vilas[1], [1]MMT Observatory, PO Box 210065, Univ. of Arizona, Tucson, AZ 85721 (mhastie@mmto.org), [2]Steward Observatory, PO Box 210065, Univ. of Arizona, Tucson, AZ 85721.

Introduction: On the morning of UT 9 Oct 2009, the MMT Observatory 6.5-m telescope watched with multiple instruments as NASA crashed the two LCROSS spacecraft into the Cabeus crater near the south pole of the Moon (Figs. 1, 2). The primary goal of the observations was to address the LCROSS mission's first science goal: "Confirm the presence or absence of water ice in a permanently shadowed region on the Moon". Our experiments were designed to detect within the plume the spectral signature of minerals created by the presence of water interacting with adjacent rock, and additionally to directly image the crater in order to monitor the time evolution of the plume. We also utilized the exceptional opportunity to reach out to the public, streaming science images and video as well as several feeds from webcams located throughout the observatory.

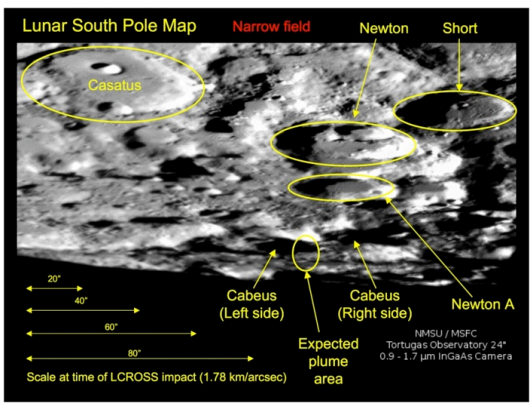

Fig. 1. Map of Lunar South Pole from NASA showing expected impact location.

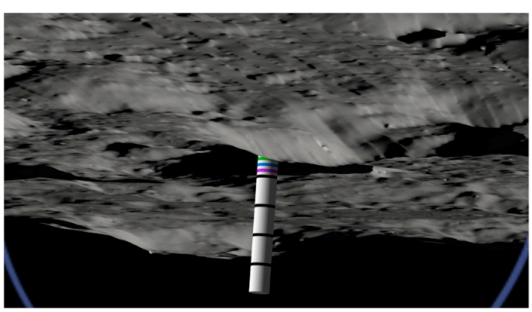

Fig. 2. Expected impact location. Black bands indicate elevations of 5, 10, 15, and 20 km.

Using the MMT in conjunction with Clio, a thermal infrared camera coupled with a low-resolution prism covering a spectral range of ~2.5 - 4.5 μm, we obtained spectra across the Cabeus crater throughout the event (Fig. 3). These spectra bracket 3 μm to identify the 3-μm absorption feature caused by adsorbed or interlayer water or both in minerals created by the process of aqueous alteration. Such minerals could be present in plume dust if water ice is present in the impacted crater. We acquired ~500 two-dimensional spectra of the Cabeus crater, emphasizing the shadowed portion of the crater.

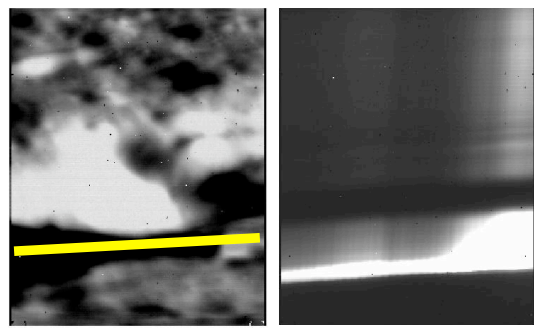

Fig. 3. (Left) Extracted spectrum from approximately 2.5-4.5 µm. (Right) Clio L' image of Cabeus prior to impact. Yellow line indicates approximate slit position.

Additionally, we trained three imaging cameras with varying fields of view (FOVs) on the impact area.

The CCD47 is a non-optimized imager with high temporal resolution and a moderate (20" square) FOV (Fig. 4). We used the CCD47 in its highest cadence mode (12.7 Hz), although this mode necessarily required exposures at lower spatial resolution (64 pixels square). By binning pixels, we could adjust the readout rate. We chose a low spatial/high temporal resolution mode in order to have the greatest capability to study the time evolution of the plume, particularly in the first moments after impact. We used a 0.7-μm (400-nm) medium band filter sensitive to the modeled flux at that wavelength, and which could delineate the 0.7-μm $Fe^{2+} \rightarrow Fe^{3+}$ charge transfer transition in oxidized iron in phyllosilicates, if combined with other broadband photometry. We acquire ~5000 images with the CCD47. Progress toward reduction of the Clio and CCD47 observations will be discussed.

Two non-filtered cameras (Stellar Cam – used to acquire objects with the primary telescope - and the Mount Alignment Telescope camera (MAT)) captured

images at video rate and were streamed live. Stellar Cam captured a FOV slightly larger than that of CCD47. The MAT camera is a 6" telescope mounted on the MMT telescope structure, and had the widest FOV.

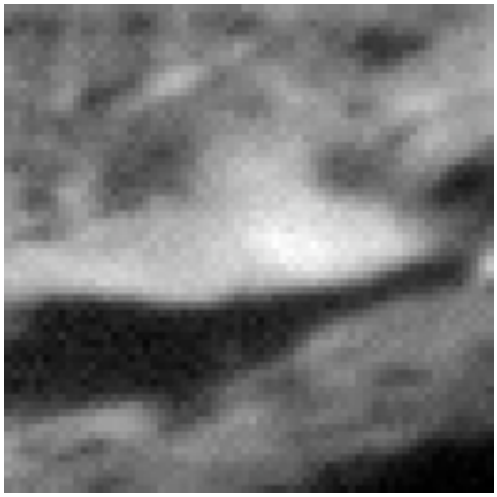

Fig. 4. CCD47 0.7 μm image of Cabeus.

As an observatory, we used this unique observing night to reach out to the public and give them a glimpse of the professional astronomy world. We streamed on the internet the live images coming from three of our science cameras as well as webcams around the observatory, and had thousands of viewers from around the world. We also piped feeds to a lecture hall at The Citadel Military College of South Carolina, where at least 80 people came bright and early to watch. Several MMT video feeds were also available on YouTube.

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