LASER RANGING EXPERIMENT ABOARD CHANDRAYAAN-1: INSTRUMENTATION AND PRELIMINARY RESULTS. J. A. Kamalakar[1], A. S. Laxmi Prasad[1], K. V. S. Bhaskar[1], P. Selvaraj[1], V.L.N. Sridhar Raja[1], Adwaita Goswami[1], K. Kalyani[1], K. Ravikumar[1], Y.K. Jain[1], D. A. Daniel[2] and N. S. Gopinath[2], [1]Laboratory for Electro-Optics Systems, Indian Space Research Organization, Bangalore-560058, India, [2] ISRO Satellite Center, Bangalore, India (kamalakar@leos.gov.in).

Introduction: India's first lunar explorer Chandrayaan-1 [1] with eleven scientific payloads was successfully launched on October 22, 2008 from ISRO Satish Dhawan Space Center. One of the scientific instruments of Chandrayaan-1, the laser altimeter-LLRI (Lunar Laser Range Instrument) is aimed at determining the topography of the lunar surface over a 2-year period from a 100-km polar orbit. The objective of LLRI is to further our understanding of the (1) global lunar topography including the polar regions, (2) lunar gravitational field and (3) geophysics of the moon. It will also supplement the terrain mapping and hyper spectral imaging payloads on board Chandrayaan-1 mission. In this paper, we present the instrumentation details, end-to-end testing of the payload, present status and preliminary results obtained by LLRI.

LLRI System Configuration: LLRI comprises a compact diode pumped Q-switched Nd: YAG laser transmitter with 10mJ pulse energy at 1064 nm wavelength and transmits laser pulses of width about 2 ns at 10 Hz repetition rate. The beam divergence is 0.32 mrad and the foot-print on lunar surface is typically 30m for a spacecraft altitude of 100km. LLRI receiver incorporates a 200mm Dall–Kirkham design telescope with a field of view of $\pm 0.025^0$, a spectral filter and a single-element avalanche photodiode (APD) hybrid detector. The main sub-elements of the receiver electronics are the detector, constant fraction discriminators (CFD) and time digitizer unit (TDU) [2]. The instrument dimensions are 470×380×280 mm, weighs 11kg and the mean power consumption is about 35W. Range accuracy between Chandrayaan-1 spacecraft and lunar surface is <5m. LLRI works on the time-of-flight (TOF) principle and the processed outputs of LLRI are used along with the orbital data of the spacecraft for generating accurate lunar topography.

Ground Testing and Functional Analysis: Ground testing of LLRI included in-line optical alignment from transmitter to receiver and various test procedures viz., range simulation techniques, thermo-vacuum and vibration tests and end-to-end testing both at the instrument as well as at spacecraft levels. Finally, LLRI performance was checked during field tests by receiving back-scattered signal bouncing from distant natural targets, such as, trees, buildings and hills on laser illumination from the transmitter. Range was computed from each target by measuring round-trip travel time of signal. LLRI performance was found to match all the desired specifications and proved its reliability during various tests [3]. A range plot generated by LLRI for a simulated delay of 53.3 μs by Ground Check Range Simulator is shown in Fig. 1 and Fig. 2 shows photograph of LLRI during field test.

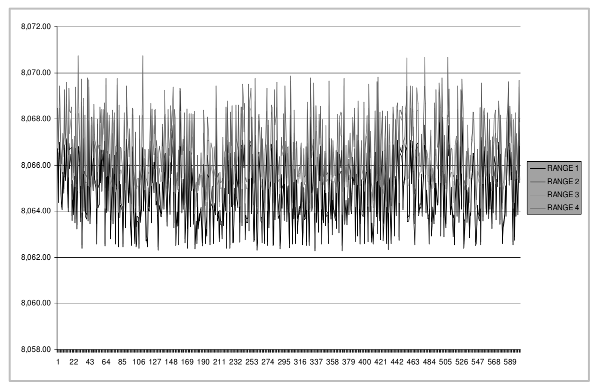


Fig.1 Range plot generated by LLRI for a simulated delay of 53.3 μs by GCRS (range-walk can also be seen in the plot)

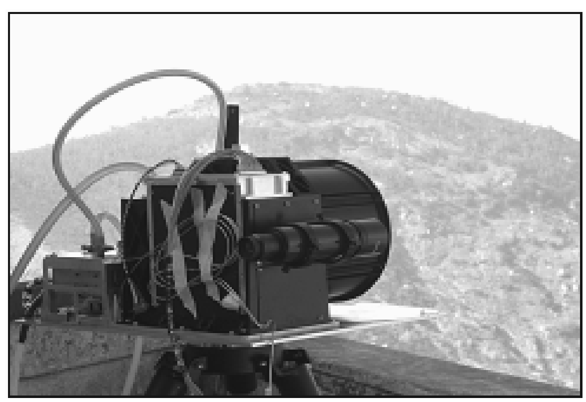
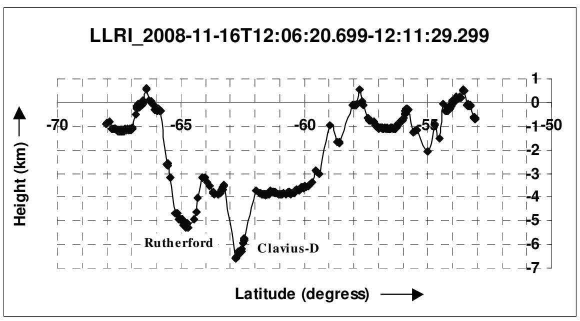


Fig. 2 LLRI testing at the Field site (Nandi Hills, Bangalore, India)

Current Status and Preliminary Results:

Prior to LLRI operation, health check of LLRI transmitter and receiver was performed. The first ranging experiment was carried out successfully on 16th November, 2008. The observations started after the selection of appropriate threshold levels for signal reception. The results indicated LLRI performance to be nominal.

Preliminary Results: Two examples of the topographic profile deduced from LLRI data are shown in Fig. 3. These two observations clearly demonstrate that in addition to the generating general profile, LLRI can also define precise topographic features. Digital Elevation Modeling is in progress to generate global topography by combining orbit and attitude data of the Chandrayaan-1 spacecraft.



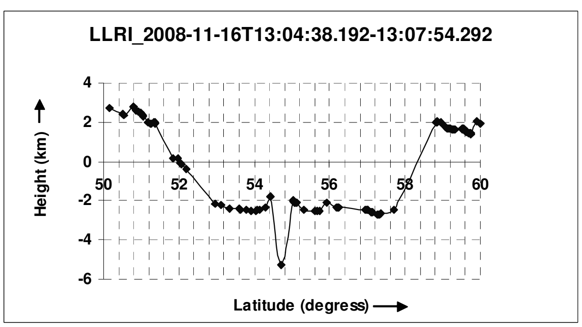


Fig. 3 Topographic profile of Clavius Crater [top panel] and D'Alemberts Crater [bottom panel]. A sub-crater Clavius-D and the Rutherford Crater are also seen clearly in the top profile. Horizontal axis is lunar latitude and Height is determined from the lunar mean radius (1737.4 km).

References:

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[3] J.A. Kamalakar et al. (2008), 'Lunar Laser Ranging Instrument (LLRI): A Tool for the Study of Topography and Gravitational Field of Lunar Surface, Current Science (In Press).