

# Laser beacons on the Moon: A proposed Lunar ranging experiment of the next generation

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Laser reflectors near the landing sites of Apollo 11, 14, and 15 and on the Lunochod 2 spacecraft are being used for Earth-Moon ranging up to the present day. However, owing to the tight link budget and the complexity of the observational task, only a handful terrestrial Laser ranging stations (e.g. Apache Point, US; Grasse, F) are capable to routinely carry out the measurements, currently possible at cm-level. We propose a next-generation Lunar ranging experiment. Lunar landers, as those currently discussed within ESA's Aurora program, shall carry laser "beacons" pointed at Earth, where Laser shots are to be received by multiple terrestrial ground stations. Owing to the Moon's librations, laser shots from a fixed mounted instrument on the Moon must be spread over a cone of approx. 20 deg pointed at the Earth's mean position. Alternatively, the laser must be mounted on a pivoted platform to maintain Earth-pointing. We estimate that the received pulse strength from a 50 mJ Laser (like the one that is currently being developed for the Laser Altimeter on BepiColombo, BELA) is 3 orders of magnitude larger than a ranging signal from Earth reflected from the largest of the Lunar retroreflectors (the approx. 0.5 m<sup>2</sup> Apollo 15 reflector). Such laser shots could be received by most existing Satellite Laser Ranging Stations having receiver mirror diameters larger than 1m. From the use of multiple stations, systematic measurement errors can be identified and removed. Using picosecond laser shots, measurement accuracies at mm-level can be accomplished. We propose to deploy Laser beacons near the poles or the Lunar limb as these locations are more suited for the tracking of Lunar librations in latitude and longitude, respectively, than the current ones close to the sub-Earth point. The experience from the past 35 years suggests that there is enormous science potential in Lunar ranging data to further our understanding of the Moon's internal structure and the dynamics of the Earth-Moon system. For example, from the tidal response at the expected mm accuracy, inferences can be made on a solid or liquid Lunar core and its size and oblateness. The experiment will probably also detect free global oscillations of the Moon as a response to large quakes or meteoroid impacts for a comprehensive modeling of elastic parameters of the Lunar interior. In addition, parameters from gravitational physics (e.g., stability of the gravitational "constant") or the Nordtvedt-effect (strong equivalence principle) could be modeled with vastly improved accuracy. This proposal has been put forward at the Workshop on European Lunar Polar Landers at ESA/ESTEC in December 15/16, 2005.