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Development of an integrated timing and photon detection system for the HartRAO Lunar Laser Ranger

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The Hartebeesthoek Radio Astronomy Observatory (HartRAO) in South Africa is currently developing a Lunar Laser Ranger (LLR) system in collaboration with the Observatoire de la Côte d'Azur (OCA) and NASA. The station will improve the current LLR network, especially in the Southern Hemisphere; this station will also contribute towards our current understanding of fundamental physics and the Earth-Moon system. To better understand the Earth-Moon system, the measurements made by the station are required to be at sub-centimetre accuracy levels.

Timing and photon detection systems are fundamental components which can affect the accuracy of the measurements. We present a design of the timing and photon detection system for the LLR station. The design is modular and will allow addition of Satellite Laser Ranger (SLR) capability at a later stage. The preliminary design indicates that the timing sub-system will achieve picosecond-level (ps) timing resolution with an Allan deviation of 4 x 10⁻¹¹ at 1 second and a drift rate of 1 x 10⁻¹² per 24 hours. The expected random error contributions by the photon detection systems for LLR and SLR are ˜ 200 ps RMS and ˜ 52 ps RMS per photon respectively, if maximum errors are considered. These errors translate to ˜ 30 mm and ˜ 8 mm single shot for LLR and SLR respectively. These errors are introduced by electronic instabilities, thermal variations and jitter during ranging. Statistical effects during the computation of a normal point (an averaged number of single shots) reduce these errors significantly.

Implementation of the proposed timing and photon detection systems will contribute towards high accuracy measurements at sub-centimetre level.

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