Paper ID: 97591
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IAF SPACE EXPLORATION SYMPOSIUM (A3)
Interactive Presentations - IAF SPACE EXPLORATION SYMPOSIUM (IP)

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LUNAR SUBSURFACE NAVIGATION THROUGH MUON-DERIVED POSITIONING

Abstract

Navigation on the Moon within locations where satellite navigation signals are challenging to receive, either from shadowing in craters or blocked entirely when underground in lava tubes, will be a challenge for future missions.

Even on Earth, while there is ubiquitous Global Navigation Satellite System (GNSS) derived positioning offered (e.g. GPS, Galileo, BeiDou) there are numerous instances where navigation is challenged from built environemnts degrading hte signal reconstruction precisionm, blocked in specific locations (be it minesite or undeground carparks), or compromised due to adversarial attacks.

To resolve these issues, a novel solution has been developed that utilises naturally occurring highly penetrating particles, known as muons, which are coincident between the reference detectors of known location and the mobile unit, which can then triangulate its position relative to these.

For the Moon, it is unclear whether muons are available at all due to the absence of an atmosphere entirely.

In this study, we utilise particle physics simulations to explore the generation mechanisms of muons from the collision of galactic cosmic ray primaries within the lunar regolith. We find that muons are generated within the first 2 meters of regolith, providing a muon flux sufficient to navigate with at depths down to 10 meters within lava tubes or even through steep crater walls.

We outline a high-altitude balloon flight to demonstrate the concept of off-world, muon-derived navigation with relevance for future exploration of the Moon in the near term.