SEAQUEing High-Altitude Entanglement

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Satellite nodes offer promise as one ingredient in future quantum networks, enabling efficient transport of quantum information over global-scale connections, due to the potential for much lower losses than all-fiber networks. The Space Entanglement and Annealing QUantum Experiment (SEAQUE), the first American-led quantum space payload, was launched to the International Space Station (ISS) in November 2024. Mounted on the MISSE platform, SEAQUE features a waveguide-based polarization-entanglement source within a compact 6U payload (20 × 30 × 10 cm); see Fig. 1. A novel single–liquid-crystal state tomography method enables entanglement verification and tests of Bell's inequalities (Fig. 2a).

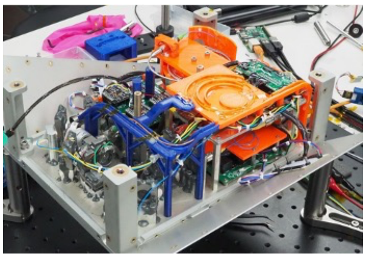

Fig. 1: *SEAQUE package prior to launch.*

The Si avalanche photodiodes (APDs) used to detect the photons incur radiation damage in space, leading to increased dark counts. However, we can attempt to repair this damage in real time, using a combination of thermal and optical annealing. For the latter, we have incorporated the ability to shine ~1 W of laser power onto some of the APDs. We will present the quantum technologies implemented in the experiment, highlighting Bell tests performed in space, along with a public demonstration allowing participants to choose measurement bases for the CHSH test and directly interact with a space-based quantum experiment. We will also discuss the fairly encouraging results of the in-situ detector annealing (Fig. 2b). Notably, SEAQUE will be the first space entanglement source scheduled for return to earth, allowing a full system 'autopsy'.

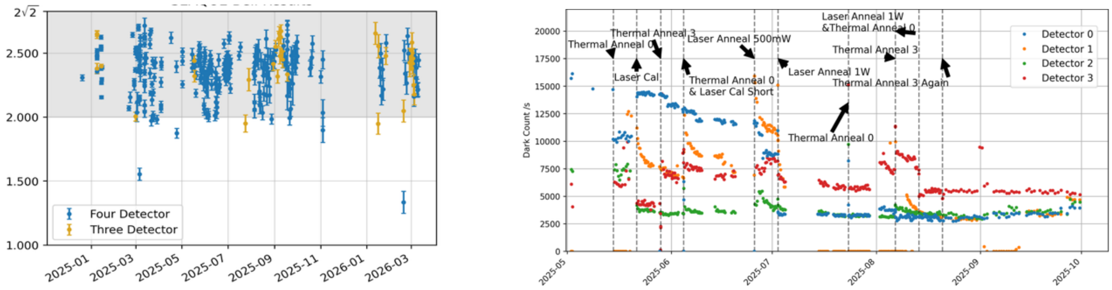

Fig. 2: *a) Measured tests of Bell's inequalities, where 3-detector data corresponds to tests where one of the detectors was inactive. b) Measured detector dark counts throughout the SEAQUE mission lifetime, including several thermal and optical annealing attempts.*

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