Radiation Stability Evaluation of Protein-Based Nanopores for Mars and Europa Missions

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Introduction: Exploration of our Solar System has revealed a number of locations that are now habitable or could have supported life in the past. One approach to finding life involves detection of informational polymers like deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) that are definitive biosignatures for life as we know it. Alternatively, structural variants of DNA and RNA, collectively termed xenonucleic acids (XNAs) have been shown in the laboratory to behave similarly. Nanopore-based sequencers differ from traditional sequencing technologies in that they do not explicitly require synthesis of DNA before or during analysis. Because of this, nanopore sequencers have been used for the direct sequencing of RNA, and could be used for the detection and analysis of other charged polymers. Here we describe results of exposing the MinION hardware, flow cells, and key reagents to ionizing radiation at doses relevant to Mars and Europa missions (10 to 3000 silicon-equivalent gray).

Methods: Performance of all components was assessed by sequencing samples of lambda phage virus genomic DNA. Flow cells were also evaluated using the platform quality control (QC) test to determine the quantity of viable nanopores. Sequencing data were also analyzed for performance metrics.

Results: Our results indicate that the MinION could be suitable for missions to Mars and other nearby targets with limited modification (Figure 1). Significant loss of performance across all MinION components at radiation doses consistent with those expected on a mission to the harsher environment of Europa suggests that design refinement would be required. It is possible that sequencers based on solid-state alternatives to protein nanopores could enhance radiation tolerance, but we were not able to determine the specific cause of flow cell failure.

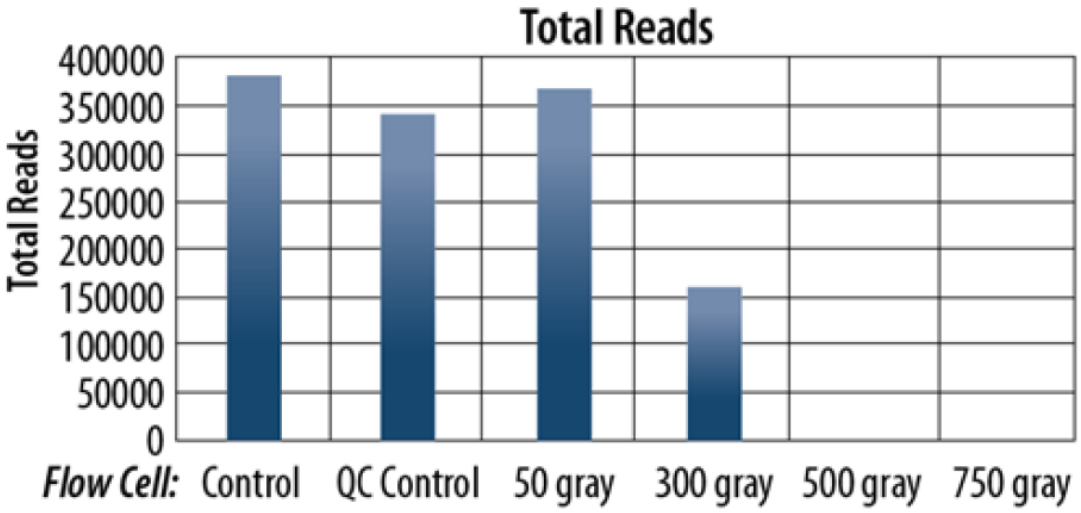

Figure 1. Comparison of the total reads produced on a MinION sequencer as a function of radiation dose the flow cells received.