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The Data Processing Pipeline and Science Analysis of the Sun Radio Interferometer Space Experiment

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The Earths Ionosphere limits radio measurements on its surface, blocking out any radiation below 10 MHz. Valuable insight into many astrophysical processes could be gained by having a radio interferometer in space to image the low frequency window, which has never been achieved. One application for such a system is observing type II bursts that track solar energetic particle acceleration occurring at Coronal Mass Ejection (CME)-driven shocks. In this work we create a data processing pipeline for the pathfinder mission SunRISE, a 6 CubeSat interferometer to circle the Earth in a GEO graveyard orbit, and evaluate its performance in localizing type II bursts with a simulated CME. Traditional radio astronomy software is hard coded to assume an Earth based array. To circumvent this, we manually calculate the antenna separations and insert them along with the simulated visibilities into a CASA MS file for analysis. We model the response of different array configurations over the 25 hour orbit, combining an ephemeris for the Sun with simulated recovered positions of spacecraft using GPS localization to get the array geometry into the correct frame for processing. We include realistic thermal noise dominated by the galactic background at these low frequencies, as well as new sources of phase noise from positional uncertainty of each spacecraft. To create realistic virtual type II input data, we employ a 2-temperature MHD simulation of the May 13th 2005 CME event, and superimpose realistic radio emission models on the CME-driven shock front, and propagate the signal through the simulated array. Data cuts based on different plasma parameter thresholds (e.g. de Hoffman-Teller velocity and angle between shock normal and the upstream magnetic field) are tested to get the best match to the true recorded emission. We test simulated trajectories of SunRISE and image what the array recovers, comparing it to the virtual input, finding that SunRISE can resolve the source of type II emission to within its prescribed goal of 1/3 the CME width more than 99% of the time with 5 or 6 spacecraft, and 97.5% of the time with 4 spacecraft.