PANTHER – First Experimental Demonstration of Using Jovian Radio Bursts as an Illuminator of Opportunity for Passive Radar Echo Detection

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Motivation

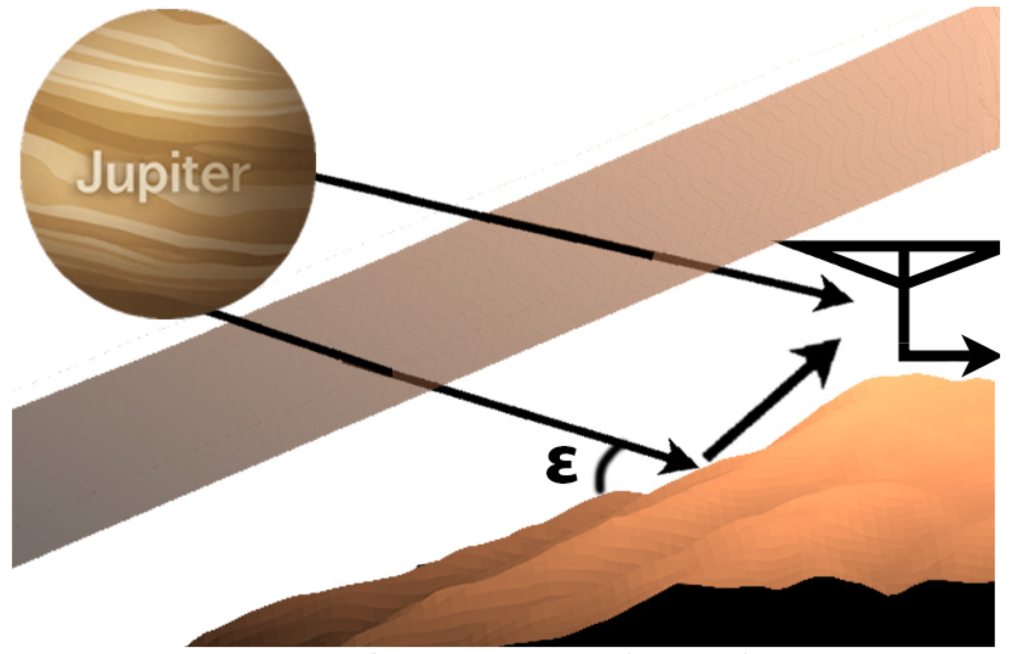

Fig. 1: Concept of Passive Radar Echo Detection and Geometry using Jovian radio Bursts.

In the spring of 2025, the PANTHER team identified a set of sequential dates with high probability of receiving Jovian bursts.

The experiment planned to observe Badwater Basin from the peak of Dante's View with a Jovian radio burst as a illuminator of opportunity.

Compared to prior experiments done using quiecent solar radio emissions to observe the basin, the Jovian Burst is not a continous source of emissions [1]. This constrains the experiment's geometry to the timing of emission windows which are fortunately predictable.

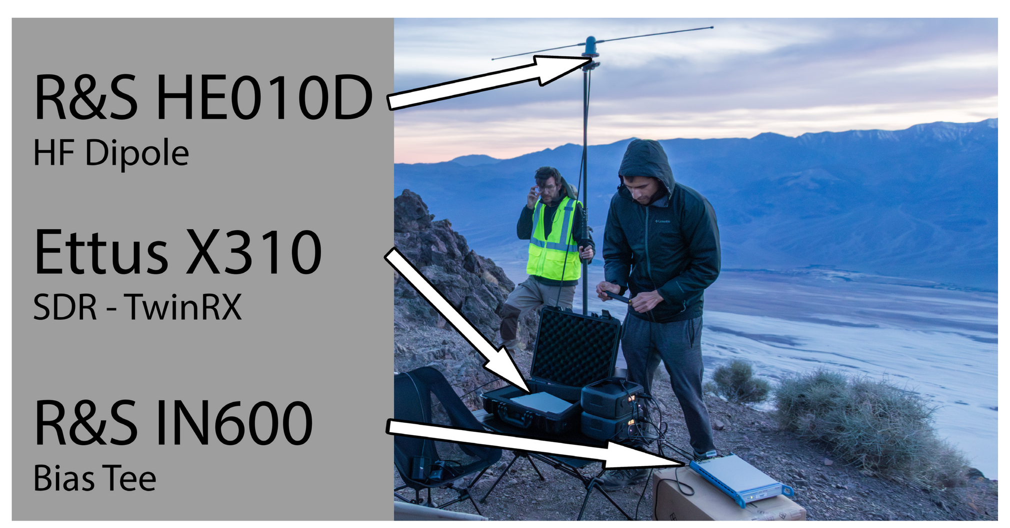

Fig. 2: Experimental setup and hardware.

Jovian Burst Probabilities, Predictions, and Source Locations

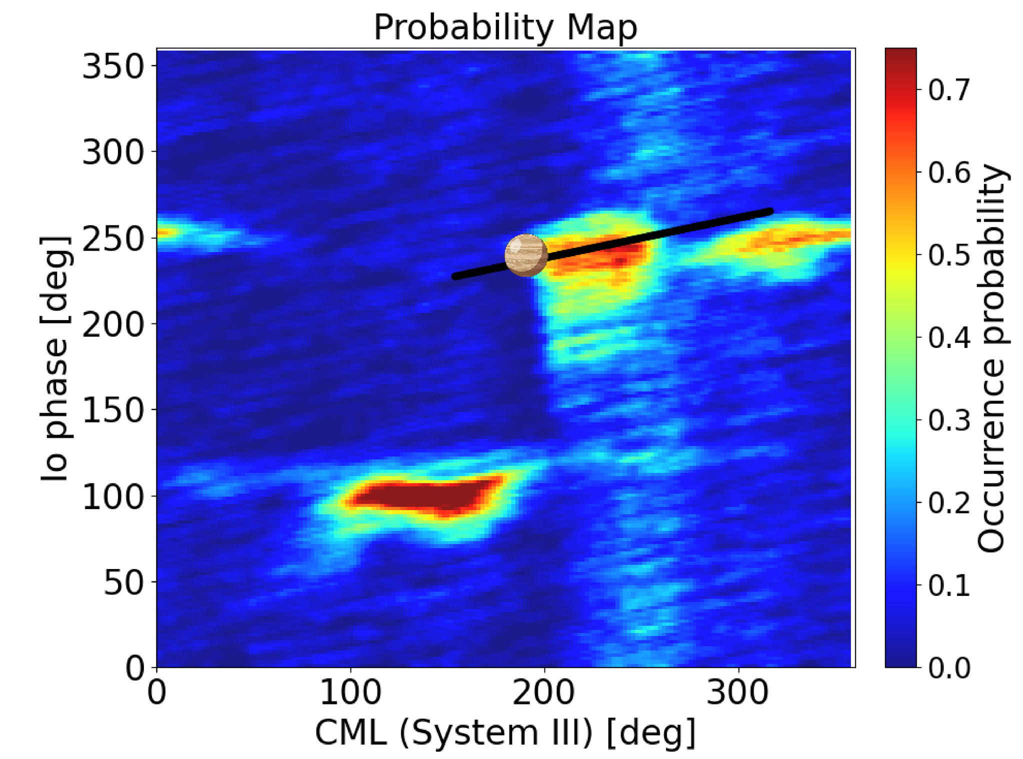

Fig. 3: Burst occurrence probability as a function of the phase of Io and Jupiter's CML [2].

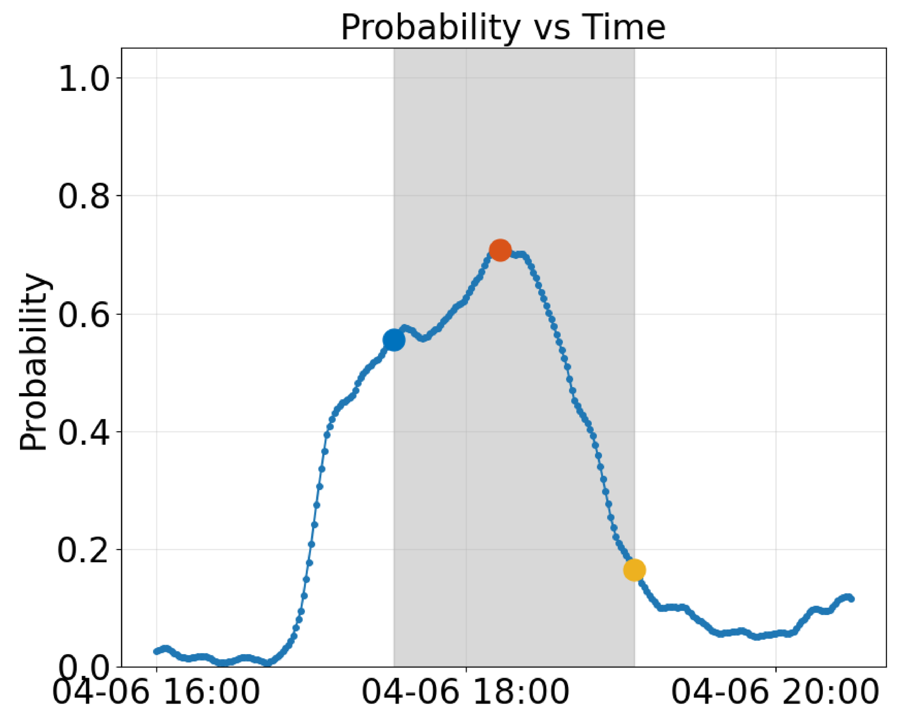

Fig. 4: Probability prediction segment during experiment at Dante's View.

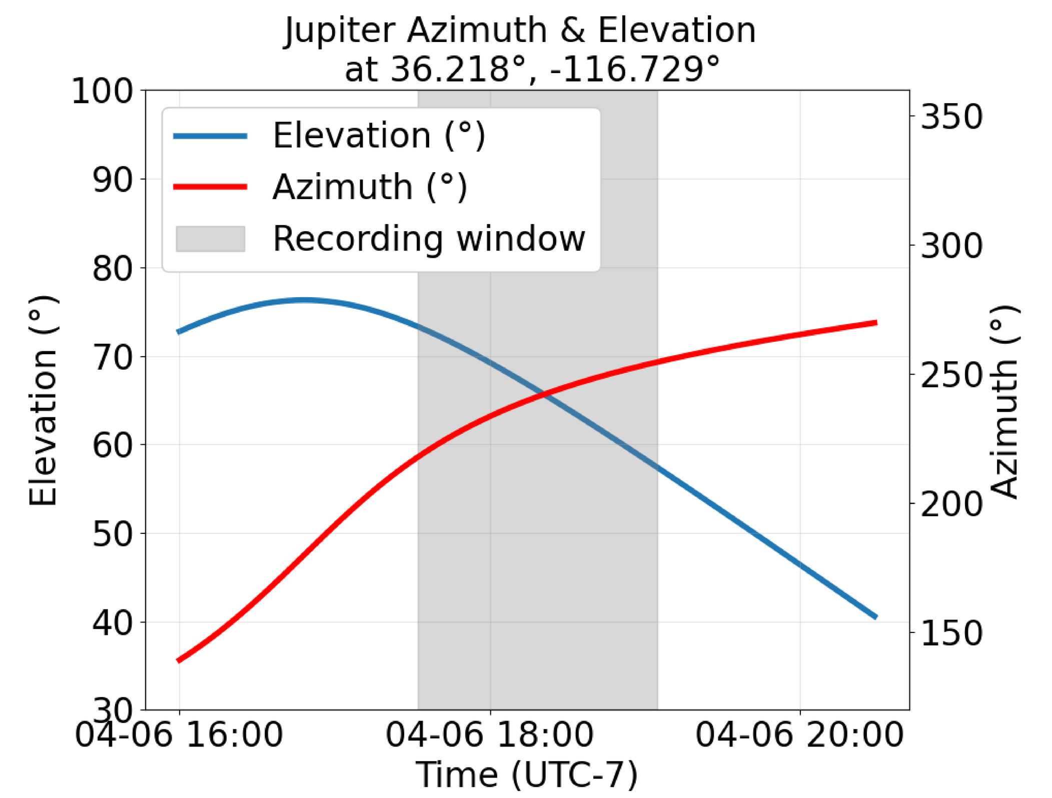

Fig. 5: Jupiter's Position in the sky during recording at test site.

Signal Recordings and Temporal Variability

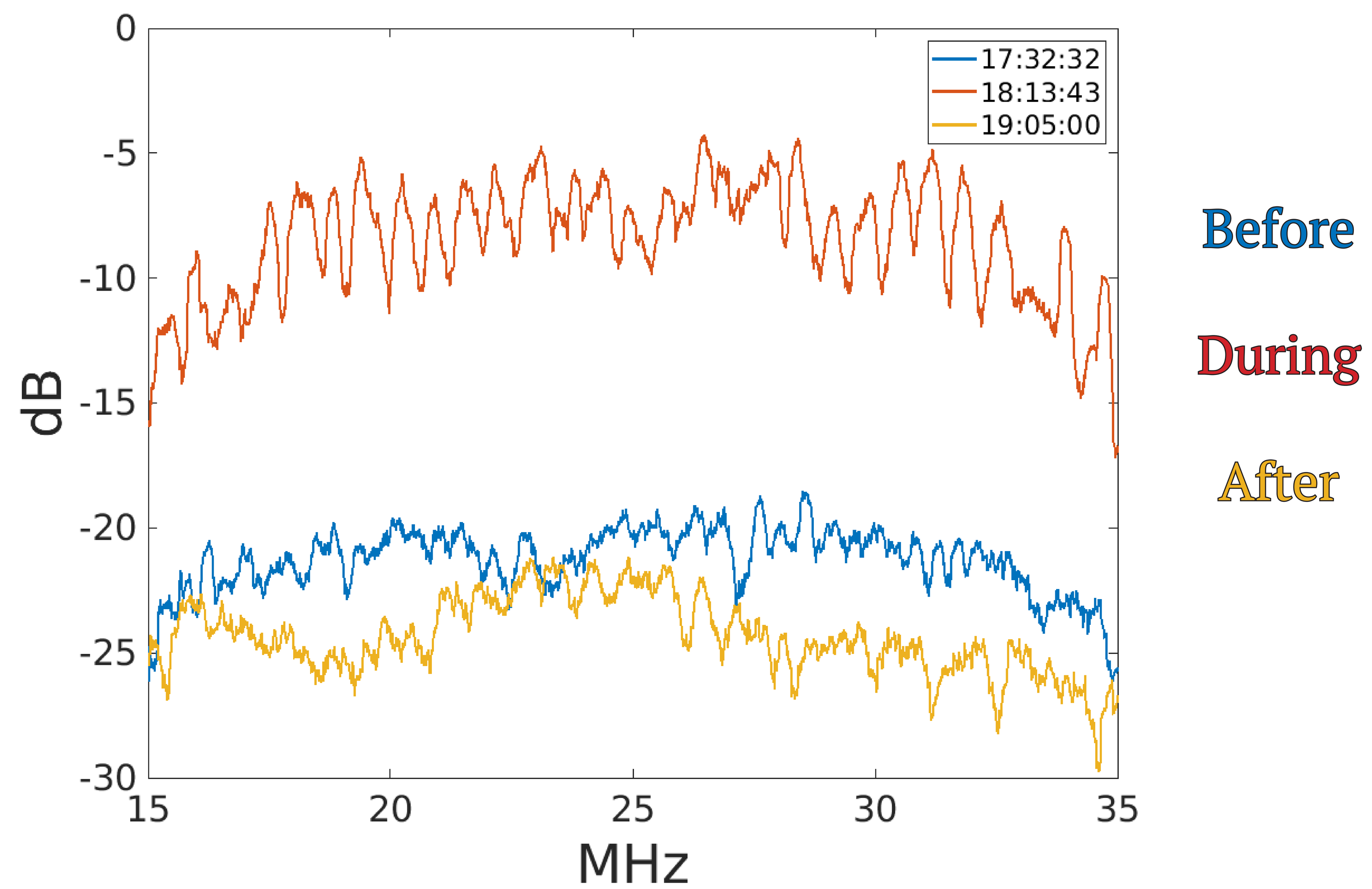

Fig. 6: Power spectral density before, during, and after burst activity.

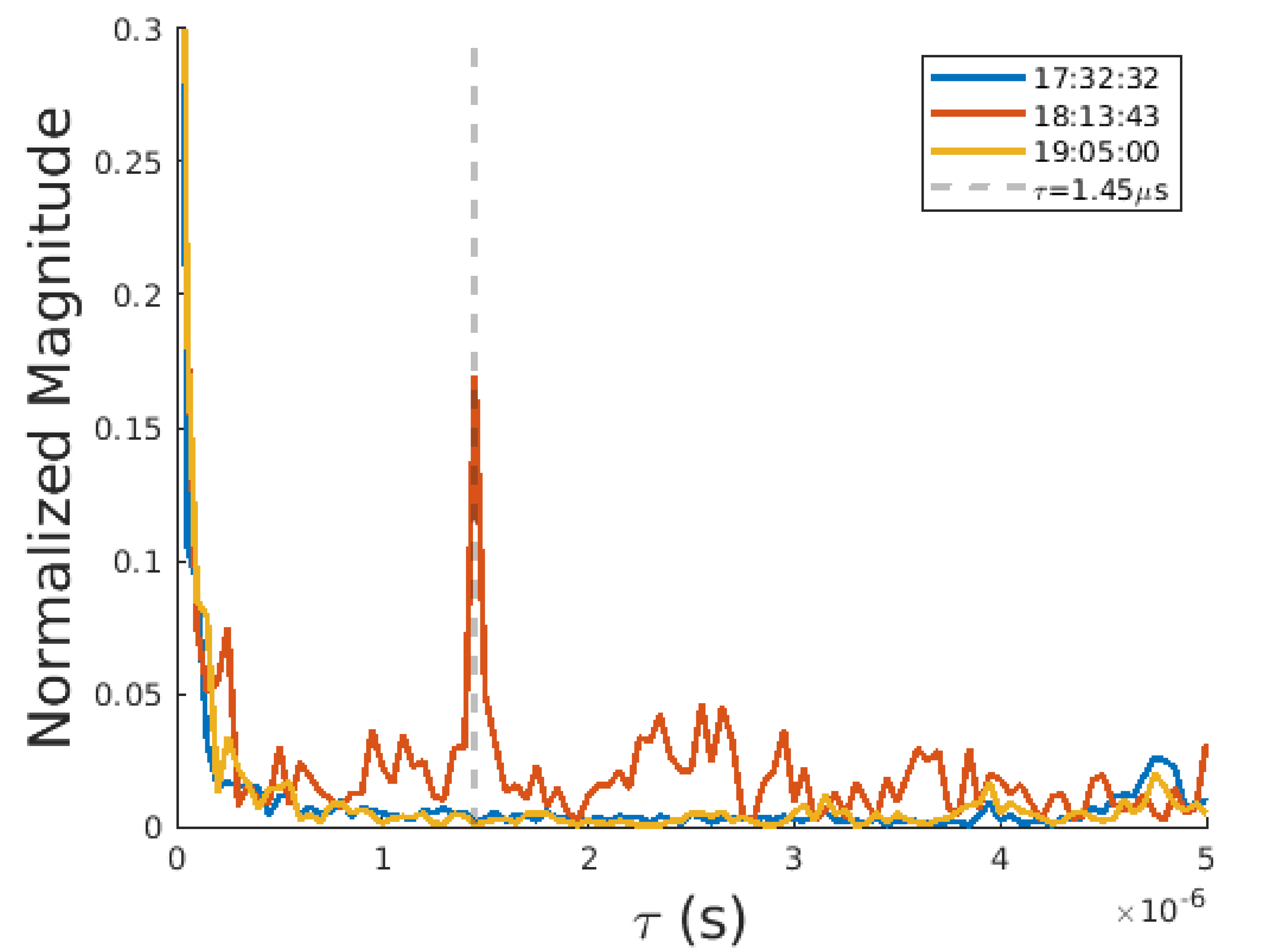

Fig. 7: Autocorrelation of recordings before, during, and after burst activity.

Our prediction indicated that burst activity should have started after 17:30 PM and ended around 19:00 PM. Just after 18:10 PM, the power spectral density increased significantly, indicating the burst activity had begun.
Autocorrelating the 18:13PM recording furthermore shows a sharp peak at 1.45 microseconds, indicating a reflection. The delay time indicates the reflection did not arrive from Badwater Basin, rather the reflection must have come from the hills of Dante's view.
This increased the geometric complexity from the ideal flat specular reflection of Badwater Basin.

Geometry & Delay Time Mapping

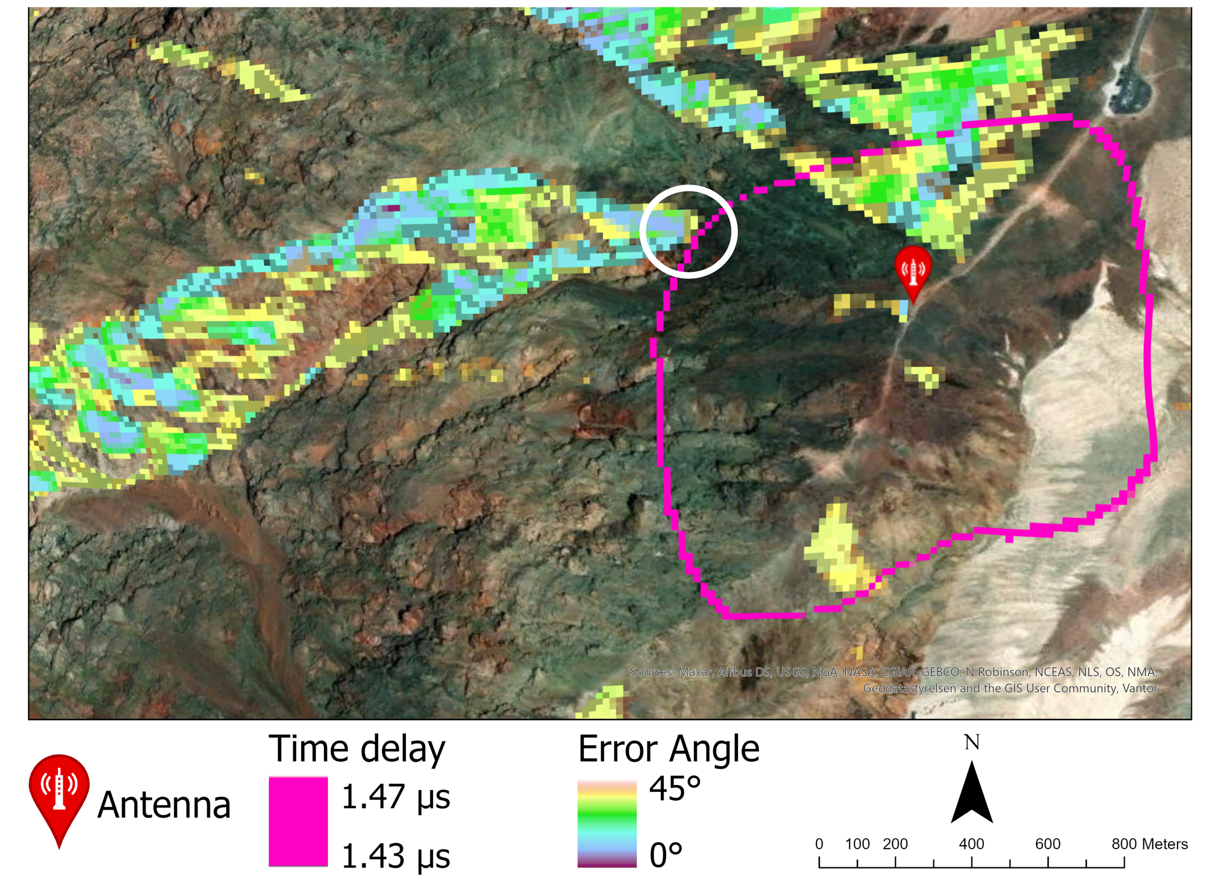

Fig. 8: Simulated path length time delay and surface reflection deviations at Dante's View, Death Valley, CA, USA.

Solving for the more complicated geometry required analysis of a DEM and computing pathlength difference from every pixel to the antenna location, and specular reflection vector of the pixel to gain insight into probable reflectors in Fig. 8.

Conclusion

This demonstrates the first experimental testing of Jovian radio bursts as an illuminator of opportunity for passive radar echo detection. We demonstrate the predictablity of burst activity and importance of ray-path geometry analysis to capture target reflections.

This demonstration acts as the foundation for future passive radar experiments using Jovian bursts scheduled for this summer in the Icelandic highlands.

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Acknowlegement: The Passive Autonomy, Navigation, Topography, and Habitability Exploration Radar (PANTHER) project was funded by the National Aeronautics and Space Administration (NASA) through PSTAR grant No. 80NSSC24K1261

[1] S. T. Peters et.al., "Passive Synthetic Aperture Radar Imaging Using Radio-Astronomical Sources," IEEE TGRS, vol. 59, no. 11, pp. 9144-9159, Nov. 2021,,[2] Statistical analysis of 26 yr of observations of decametric radio emissions from Jupiter, Marques et.al. A&A, 604 (2017) A17