LASSI: keeping the Green Bank Telescope in shape

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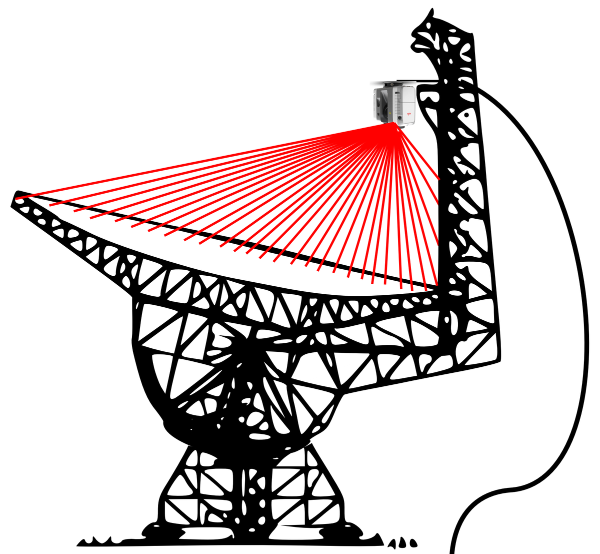
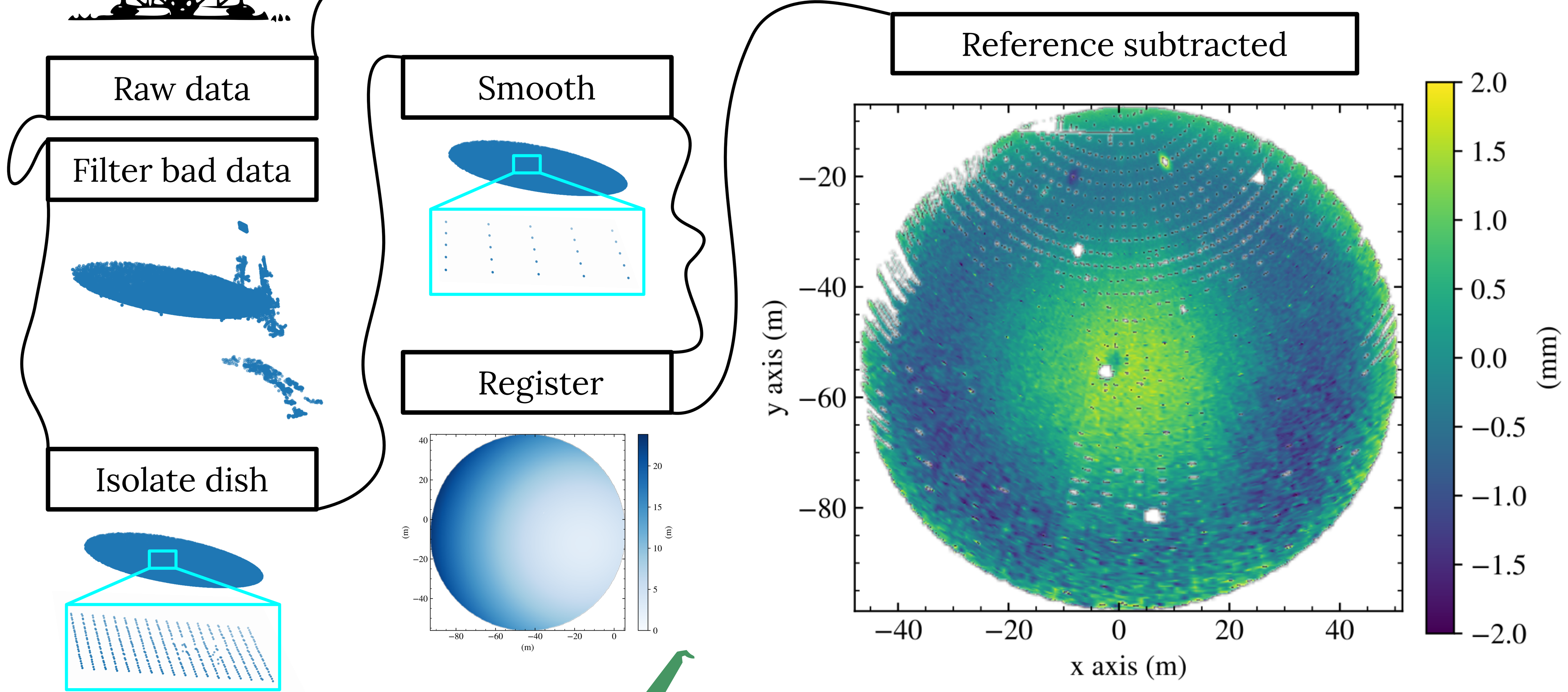
Summary:

The Green Bank Telescope (GBT) is a 100 m antenna that operates across three orders of magnitude in wavelength, from 1 m to 2.7 mm. Operations at the shortest wavelengths are enabled by an active surface consisting of 2009 panels which can be adjusted with micrometer precision using 2211 actuators. The actuators compensate for thermal distortions using out-of-focus holography, which in ~20 minutes can correct the surface to an error of 230 microns. The Laser Antenna Surface Scanning Instrument (LASSI) uses an off the shelf terrestrial laser scanner (TLS) that in three minutes generates millions of data points which describe the GBT's primary reflector. Using this point cloud LASSI is able to detect thermal distortions of ~75 microns in less than 10 minutes, thus enabling the correction of thermal distortions faster and with a similar accuracy than that obtained using out-of-focus holography. This should ultimately improve the efficiency of observations above 25 GHz and enable routine use of the GBT during day time at these frequencies.

Data processing:



During data processing,
- 20×10^6 points are reduced to 26×10^4.
- Bad actuators and retro reflectors are masked.
- Scans are registered to a single reference frame.



Results:

We have mounted the TLS on the GBT and used it to scan the GBT's primary reflector. During the scans we commanded the active surface to reproduce known Zernike polynomials. By subtracting a reference scan from the scans with Zernike polynomials we were able to identify the polynomials and measure their coefficients (Figure 1). We tested three different polynomials and four coefficient values for a total of 12 combinations. Some of the scans were performed during the day, highlighting the potential of LASSI to enable observations above 25 GHz during the day time.

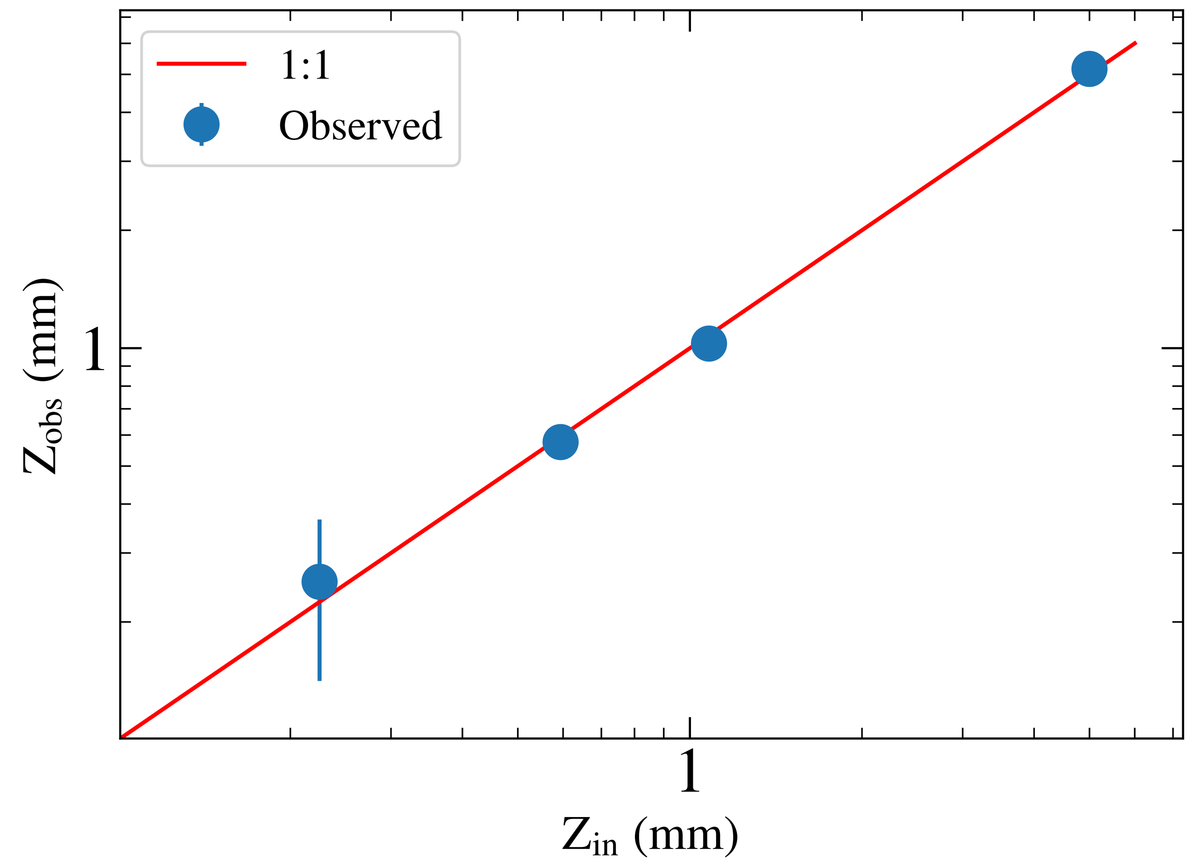


Figure 1: Observed Zernike polynomial coefficient versus commanded Zernike polynomial coefficient. This plot shows that we are able to identify deformations in the GBT's primary dish using the TLS. Most of the thermal deformations on the GBT's primary can be described in terms of Zernike polynomials.

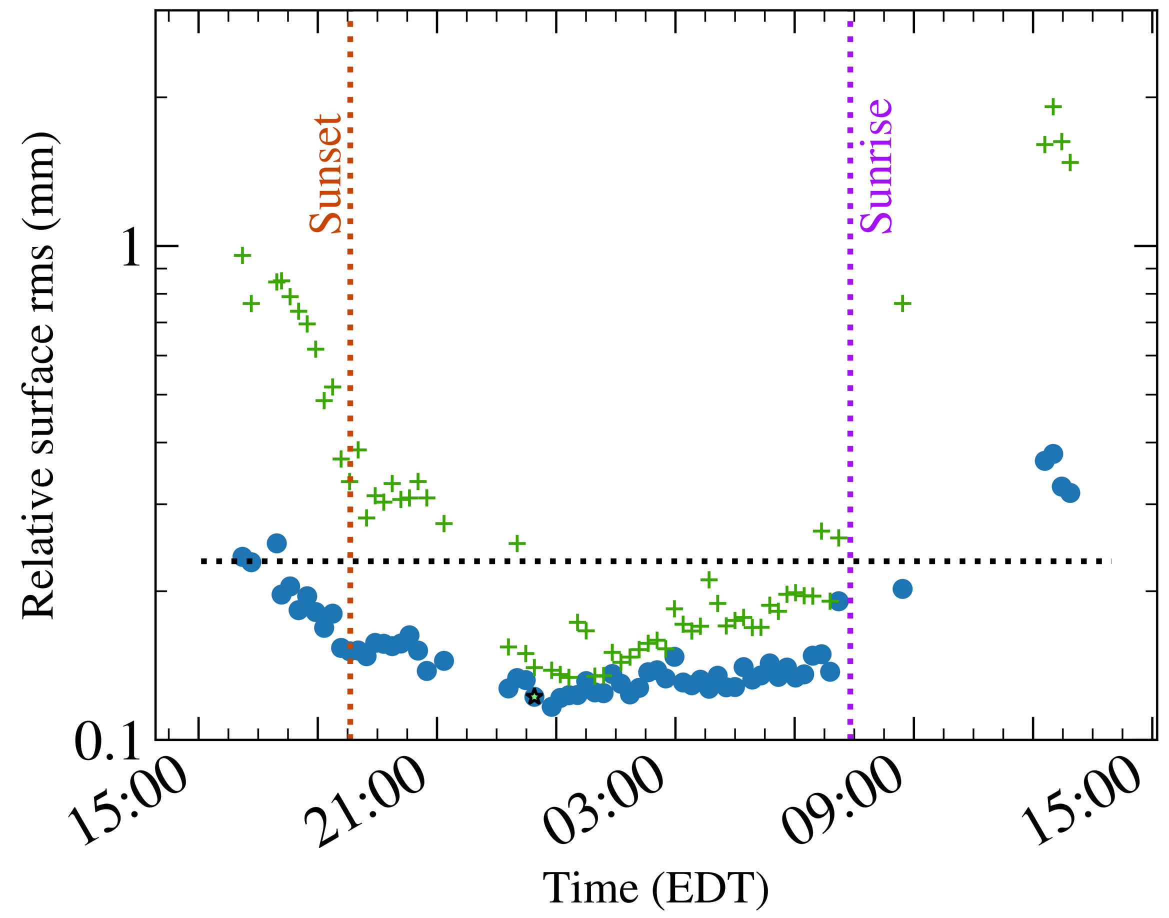


Figure 2: Surface rms relative to a reference scan. The green plus signs show how the surface accuracy of the GBT changes during a day, changing faster when the Sun is above the horizon. The blue points show the surface rms after we remove the thermal deformations. The removal of the thermal deformations has only been performed in software so far. The black dotted line shows the 230 micron surface rms required for efficient 3 mm observations.

Future work:

Before LASSI becomes a part of science operations by the end of 2021 we will:
- Correct the dialed deformations using the active surface.
- Permanently mount the TLS on the GBT.
- Conduct commissioning observations, including measuring the aperture efficiency.

LASSI ("Enhancing GBT Metrology to support high resolution 3mm molecular imaging for the U.S. Community") is supported by the National Science Foundation under Award Number AST-1836009. Green Bank Observatory is supported by the National Science Foundation and is operated by Associated Universities, Inc.