Subject: Installation Instructions, 94.5 GHz Holography Beacon	**Date:** 2023.11.20 DK2023.001revNC	**From:** Derek Kubo
To: Ming-Tang Chen	**cc:** Tim Norton, Satoki Matsushita, Nimesh Patel	**Location:** Hilo Office

1. Introduction & History

The holography system was last known to be functional in March of 2020 at the beginning of the covid pandemic when we were frustratingly close to producing a high-resolution map of the primary surface (including the secondary and optics to the W-band science receiver). *Figure-1* shows a coarse map of the primary dish surface that was posted by TKS on March 3, 2020, https://gltblog1.wpengine.com/?p=4177.

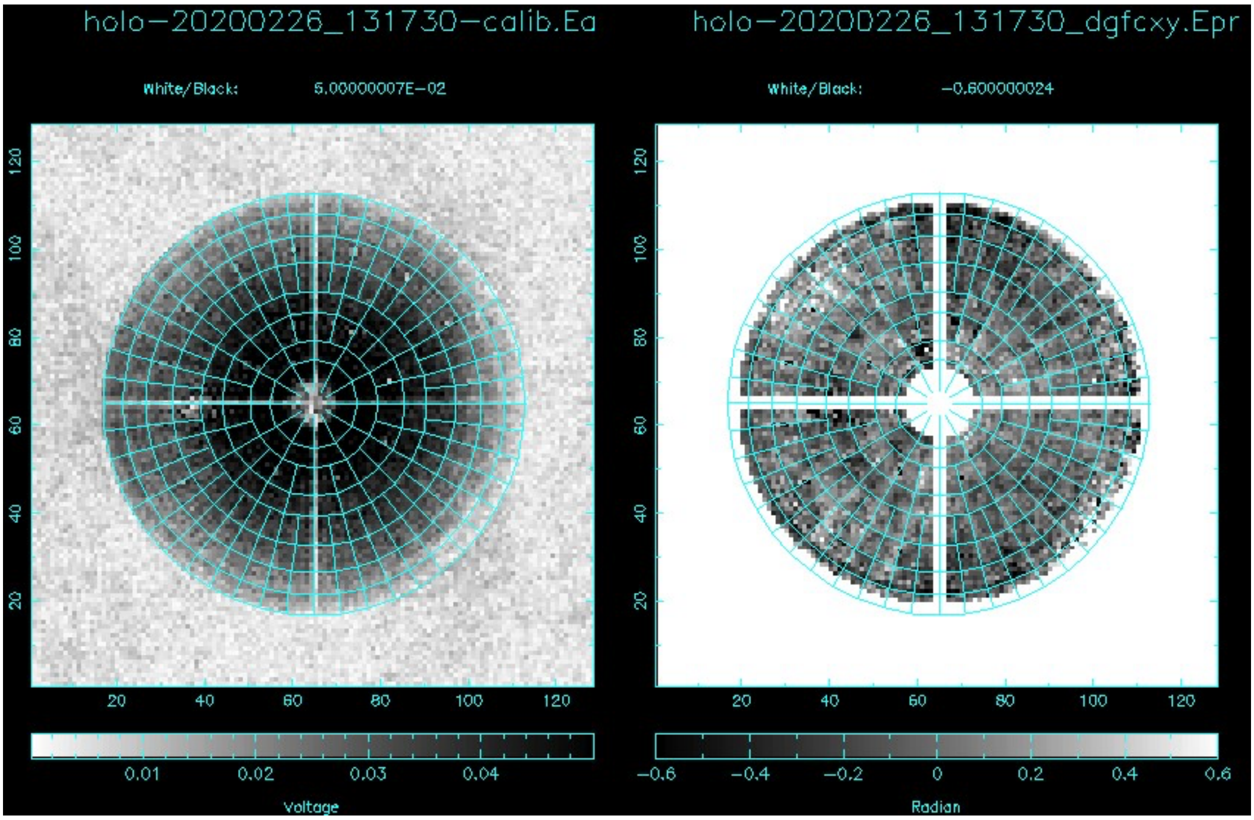

Figure-1. Coarse map of primary surface obtained by holography, refer to the log entry above for technical details.

Following this effort, I generated this log entry summarizing our efforts to optimize the holography system. https://gltblog1.wpengine.com/?p=4259

Below is a timeline of events between having a working system in March of 2020 and non-functional as of this writing:

December 1, 2021: The first indication of a hardware problem with the holography system. The beacon was readily detected, and the vector voltmeter (HP 8508A, VVM) locked immediately indicating sufficient transmitter signal strength and reference receiver sensitivity. However, Satoki had reported that the beam pattern was severely distorted. https://gltblog1.wpengine.com/?p=4834

May 1, 2022: I climbed the tower and found that the window for the transmitter was missing and surmised the anomalous beam pattern observed by Satoki was caused by ice buildup on the window. This buildup of ice may have torn the entire window off. https://gltblog1.wpengine.com/?p=5027

May 2, 2022: The window was replaced but I did not test the transmitter prior to reinstallation onto the tower. In hindsight a poor decision, but I was extremely pressed for time with my primary goals for this trip. https://gltblog1.wpengine.com/?p=5044

October 29, 2022: Satoki reported that the transmitter beacon was not functional. The beacon was removed and confirmed then brought back to Taipei to effect a repair. https://gltblog1.wpengine.com/?p=5429

May 23, 2023: Beacon repaired in Taipei by Johnson and company and reinstalled onto tower. Estimated beacon output power prior to horn -8 dBm. https://gltblog1.wpengine.com/?p=5642

September 18, 2023: Beacon not detected by telescope, went to South Mountain and verified that the beacon is not functional (discovered later due to intermittent PLL unlock). This intermittent PLL lock/unlock problem exists as of this writing. When unlocked the beacon is either not present or out-of-band and is unusable for holography. https://gltblog1.wpengine.com/?p=5731

September 29, 2023: In addition to the beacon being intermittent, the SNR received by the reference receiver is short by ~15 dB and prevents the VVM from locking. This shortage could be from the transmitter, receiver, or a combination of both.
https://gltblog1.wpengine.com/?p=5814

2. Replacement of Holography Beacon

One potential solution to mitigate the existing intermittent transmitter beacon on the South Mountain tower is to replace it with the photonics version proposed for the "near field holography system" for use at Summit Station. It requires the installation of the Laser Synthesizer (LS) chassis into the holography rack located inside Bldg-1975, running a single-mode fiber from the LS through a conduit between Bldg-1975 and the tower, and the installation of the Photonics transmitter unit onto the tower. A simple diagram of the interconnection is show in *Figure-2*.

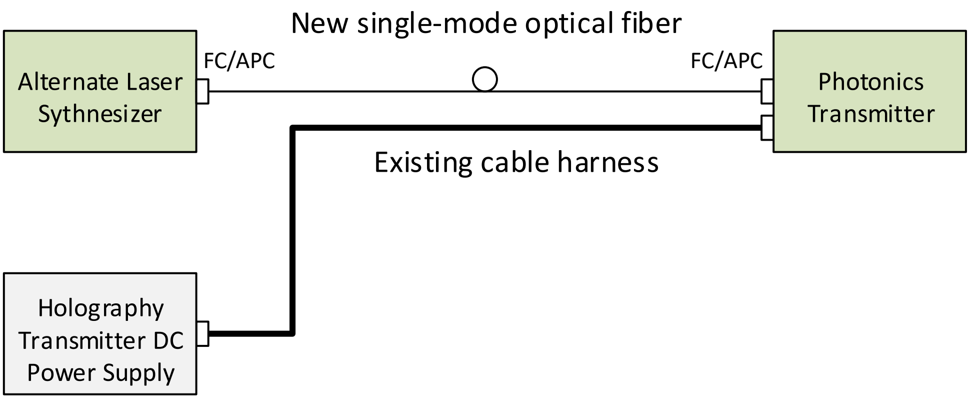

Figure-2. The installation of the "near field" beacon consists of items shaded in green and include the Alternate Laser Synthesizer chassis which will reside in the holography rack inside Bldg-1975, the Photonics Transmitter on the tower, and single-mode fiber between the Alternate Laser Synthesizer and Photonics Transmitter.

The Laser Synthesizer is a self-contained 3U rack mountable chassis that requires a 120 VAC power source. This Laser Synthesizer is presently located within the Maser House and a photo of it is provided in *Figure-3*. The optical output is via an FC/APC connector located on the rear panel. Note that this unit is too heavy to support itself from the front panel and requires the installation of a pair of supporting L-brackets into the rack. A pair of these L-brackets are located inside the Receiver Trailer along the right wall near the lab benches. I marked these L-brackets with a Sharpie pen indicating where they need to be cut to fit into the existing rack within Bldg-1975.

The transmitter unit consists simply of a photomixer and waveguide horn and is shown in *Figure-4*. This transmitter unit is currently in Hilo for repackaging into a weather tight assembly. We are planning to use the existing power connector to provide the 28 VDC heater power and +12 VDC for the photomixer DC bias (regulated down to 3.3 VDC). Our current configuration utilizes two double-AA batteries and a series 500 Ohm potentiometer to adjust the DC current for the photomixer (optimal value -16 mA). This optimum current is a function of both optical power and DC voltage and requires adjustment of the potentiometer in-situ to account for fiber loss. Exactly how we are going to accomplish this, i.e., monitor current and adjust the potentiometer, is not yet determined. A photo of the tower with the current transmitter installed is shown in *Figure 5*. It is noted here that the transmitter E-field polarization shall be in the vertical direction.

And finally, there is the fiber connection between the Laser Synthesizer and transmitter unit. The 200-meter spool of yellow unjacketed single-mode fiber can suffice for testing but may not survive a storm at the ridge of South Mountain. My suggestion is to pull the fiber from Bldg-1975 (spool side kept inside the building) through the existing conduit and up the tower. Tie off or tape the fiber every foot so there is minimum dangling up the tower.

Figure-3. *Rear view of the Laser Synthesizer located within the Maser House. The yellow spool on top consists of 200 meters of single-mode fiber with FC/APC connectors on each end. Though this fiber is not protected by a jacket it may be used temporarily to test the effectiveness of the beacon on the tower.*

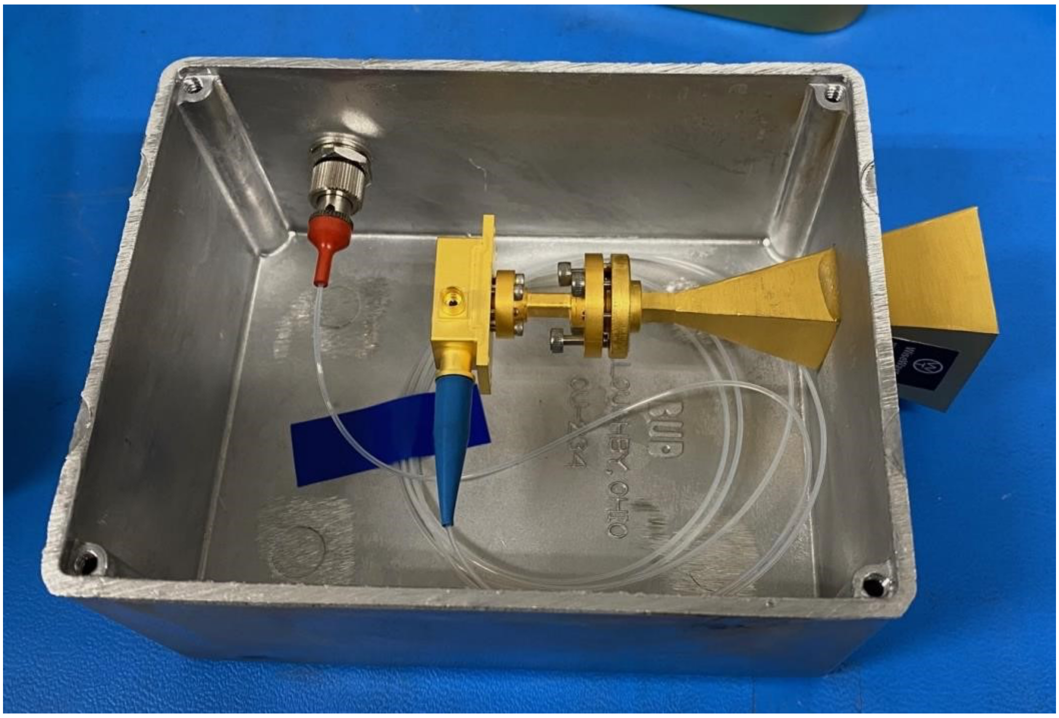

Figure-4. Transmitter consisting of photomixer and waveguide horn. The optical input is provided by the FC/APC connector at the top. The small MMCX connector on the photomixer is for DC bias. This unit will be repackaged for weather proofing and will accept the existing circular DC power connector.

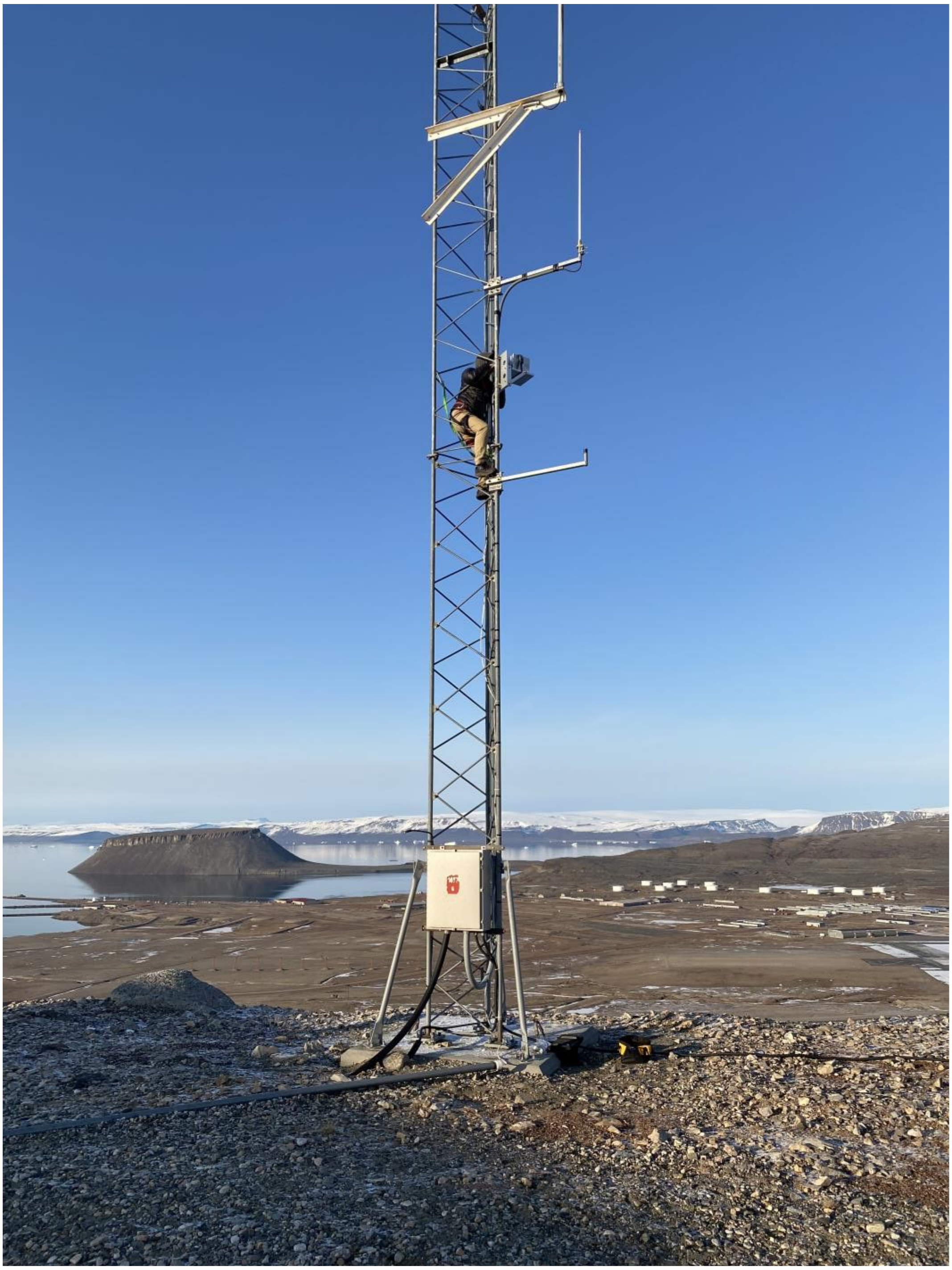

Figure 5. *Current transmitter on tower located approximately 3.5 meters above the base. Note the above ground metal conduit carrying the DC power cable from Bldg-1975 located about 30 meters from the tower.*

3. Summary

Use of the Laser Synthesizer is overkill for this application as it was designed to produce an extremely low phase noise reference LO for the ALMA system. However, it is what we have for now and can be redesigned later to be simpler in function and lower cost. We know that this hardware is not intermittent in operation and the simplicity of the transmitter lends itself to the harsh environment of Greenland. One aspect that we currently don't know is whether this transmitter generates enough signal power to overcome what we believe to be 15 dB of shortage to lock the VVM. We have configured the test hardware in our Hilo lab answer these questions and will proceed on a success-oriented path. Refer to *Figure-6* for a photo of the test configuration.

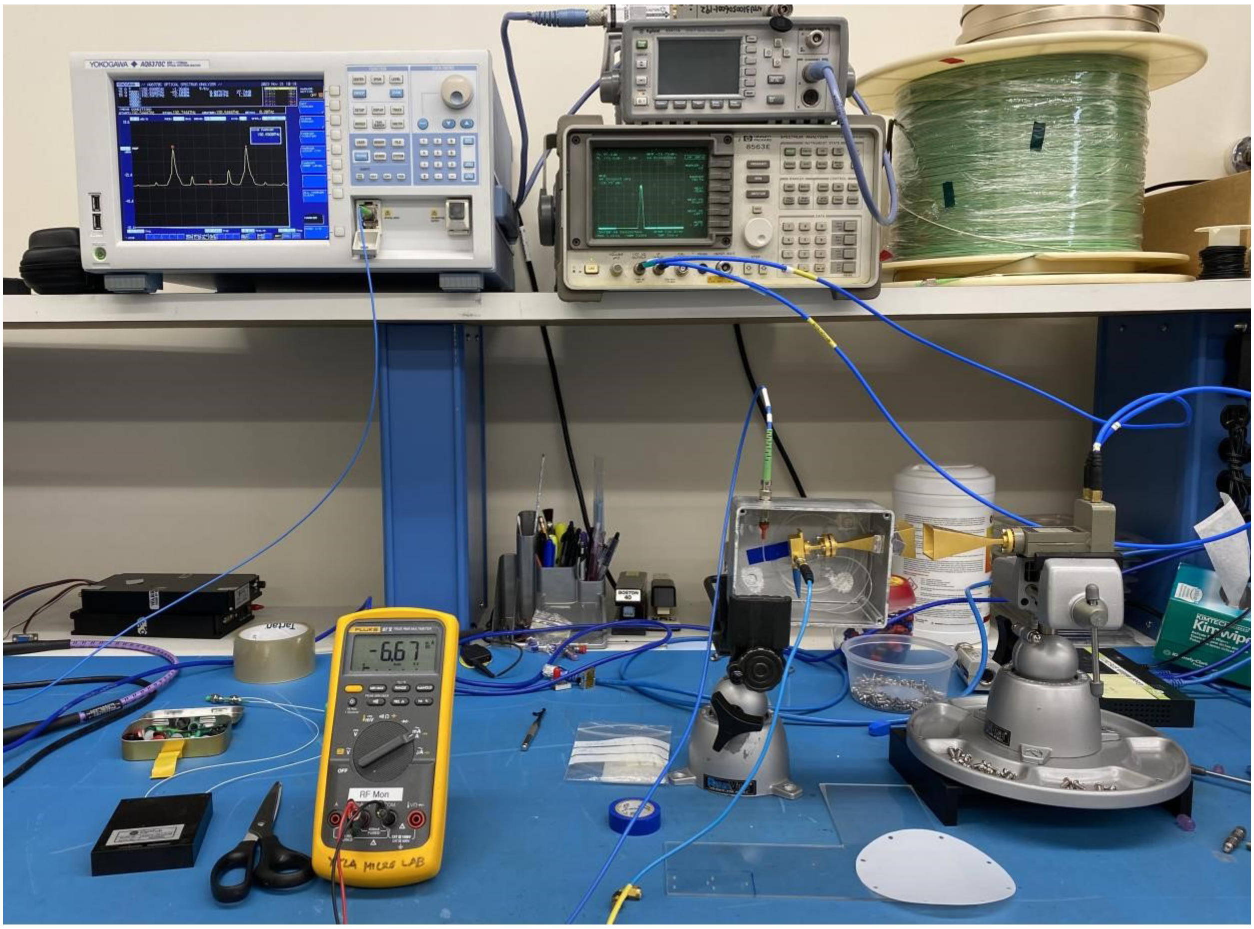

Figure-6. *Test setup for repackaging of the transmitter unit. Here we are testing different windows to protect the waveguide horn from the external elements. The optical spectrum analyzer on the upper left shows a pair of optical tones centered at 192.643 THz and separated by 94.500 GHz. The RF spectrum analyzer on the right shows the desired 94.500 GHz tone generated by the photomixer. The Fluke DVM is used to monitor DC current through the photomixer.*