

Upcoming Improvements to the VLBA

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The Very Long Baseline Array (VLBA) celebrated 30 years of full science operations in 2023. The next few years will see several improvements to the VLBA. Novel techniques to improve the performance of the instrument are already being employed. New synthesizers are being deployed that will offer more tuning options than currently available. The aging ROACH Digital Back-ends (RDBEs) will be replaced as part of the VLBA New Digital Architecture (VNDA) project, which will bring many new features to the instrument. A new ultra-wideband receiver is also a real possibility, which could finally allow Ka-band observations on the VLBA.

Recent Progress

Interferometric Pointing

The VLBA pointing parameters have traditionally been maintained by using single-dish pointing scans. This is usually good enough for most high-frequency observations. However, observations at 80 GHz (3mm) benefit significantly from the improved pointing obtained from interferometric techniques. Recent improvements have enabled interferometric pointing at the VLBA.

Rail Height Monitoring

The VLBA azimuth wheels sit on a circular rail track. The exact height of the rails as a function of azimuth needs to be known to high precision to ensure proper pointing, especially at high frequencies. The rail height data is normally determined by the engineering team using surveying techniques. Recent tests have indicated that specially designed observations can reveal rail height changes between engineering trips. See VLBA Test Memo #75.

Real-time Observations

Since its first light over 30 years ago, the VLBA has stored all observation data on disk packs which needed to be shipped to Socorro for correlation. Recent advances in fiber networks has enabled the VLBA to begin sending data directly from the stations to Socorro for near real-time correlation. The bandwidth is still limited, but current capabilities allow for 256 Mbps to be transferred in real time for most stations. This data rate translates to 64 MHz of bandwidth in single polarization, or 32 MHz in dual polarization, for 2-bit samples.

Coming in 2024 & 2025

Weather Stations

New weather stations will be deployed to all VLBA sites throughout 2024 and into 2025. The new weather stations will provide improved weather monitoring for planning high frequency observations, and may be able to provide more advanced data for improved calibration.

GNSS Receivers

The VLBA is replacing its GPS receivers with more advanced GNSS receivers, which have access to satellites beyond GPS. This will provide improved timing accuracy, and may fundamentally change how timing is done at VLBA the stations.

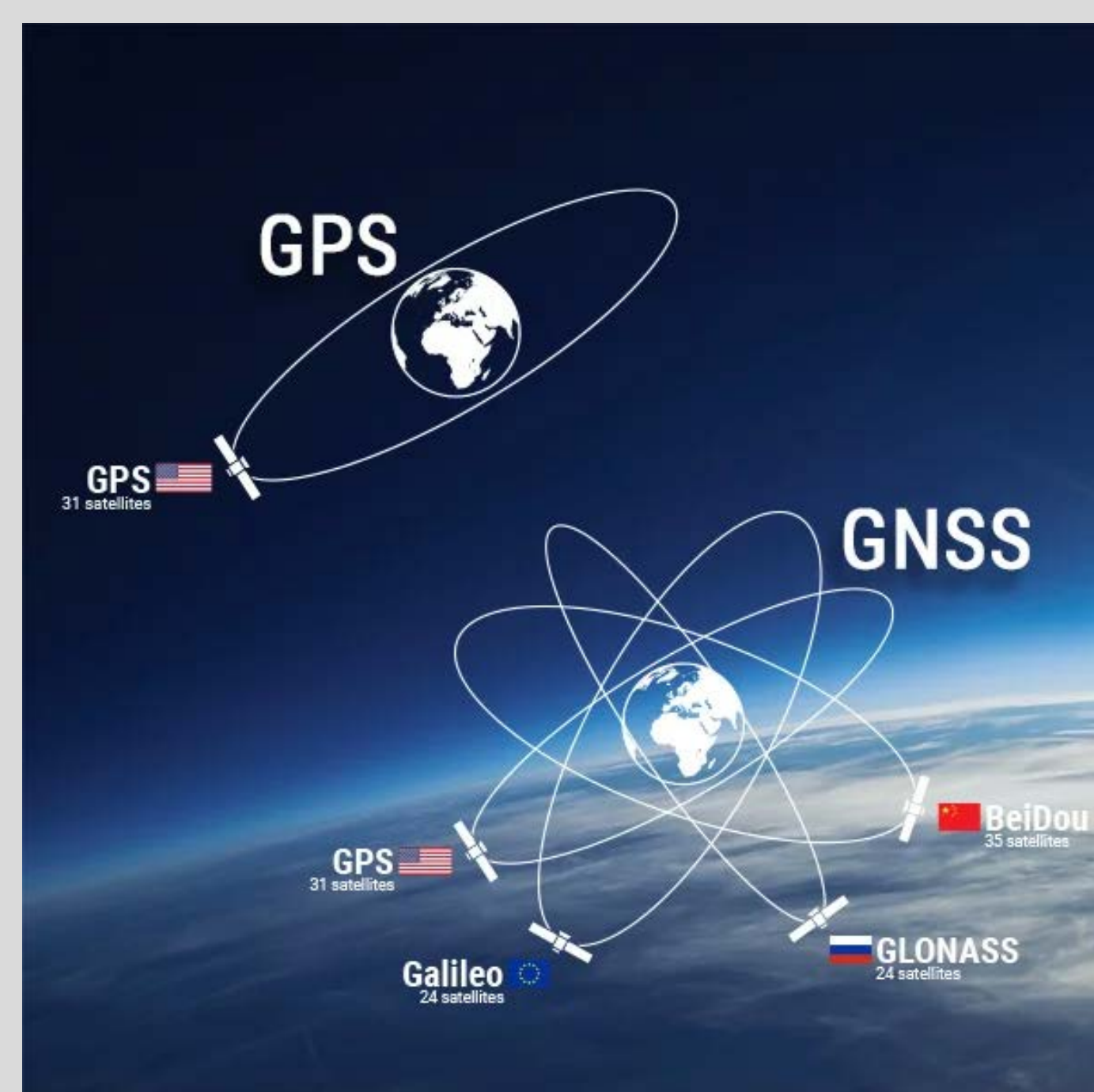
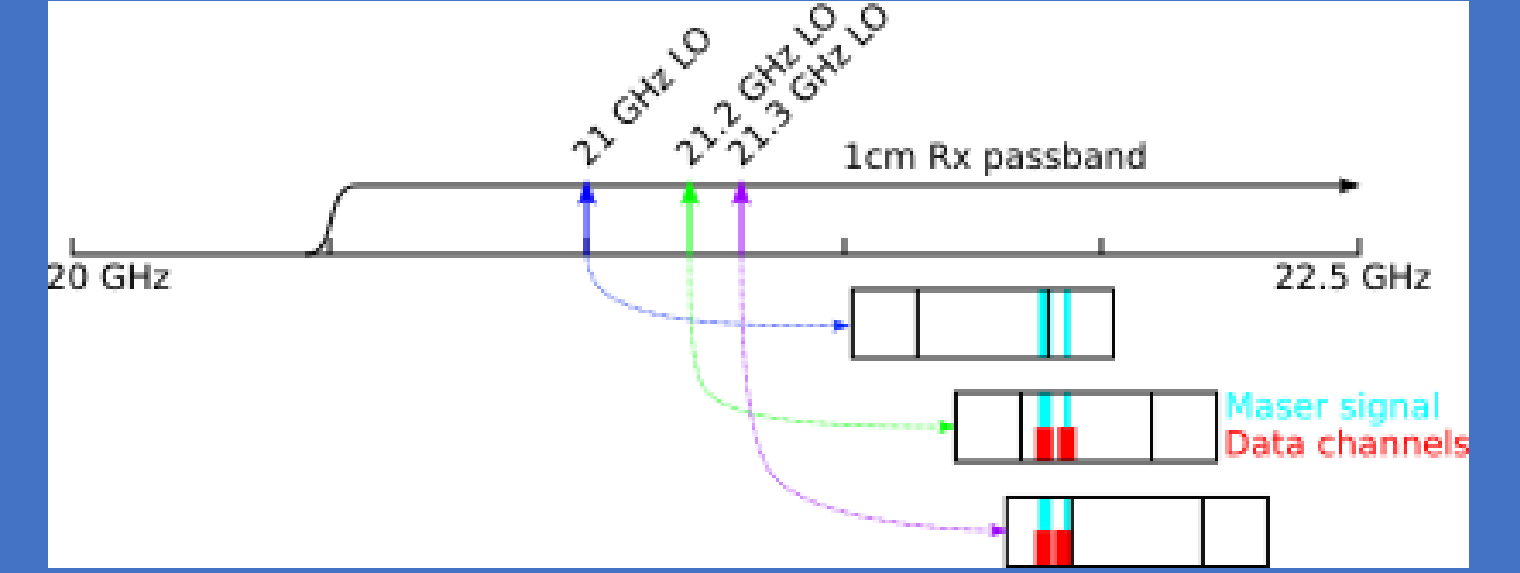


Image Credit: MOBATIME

New Synthesizers

The current synthesizers that set the local oscillator at the VLBA stations are limited in its tunings. They only allow center frequencies at alternating 200 and 300 MHz steps. This can be troublesome when trying to observe certain spectral lines, which may not sit in the center of the tuning band. New synthesizers are currently being deployed to the stations with much more flexible tuning options, enabling better spectral line setups and improved ability to avoid RFI.



Example of tuning options using the old synthesizers for two maser lines (shown in cyan) near 21.9 GHz. Black lines indicate zone boundaries. From VLBA Sensitivity Upgrade Memo #51.

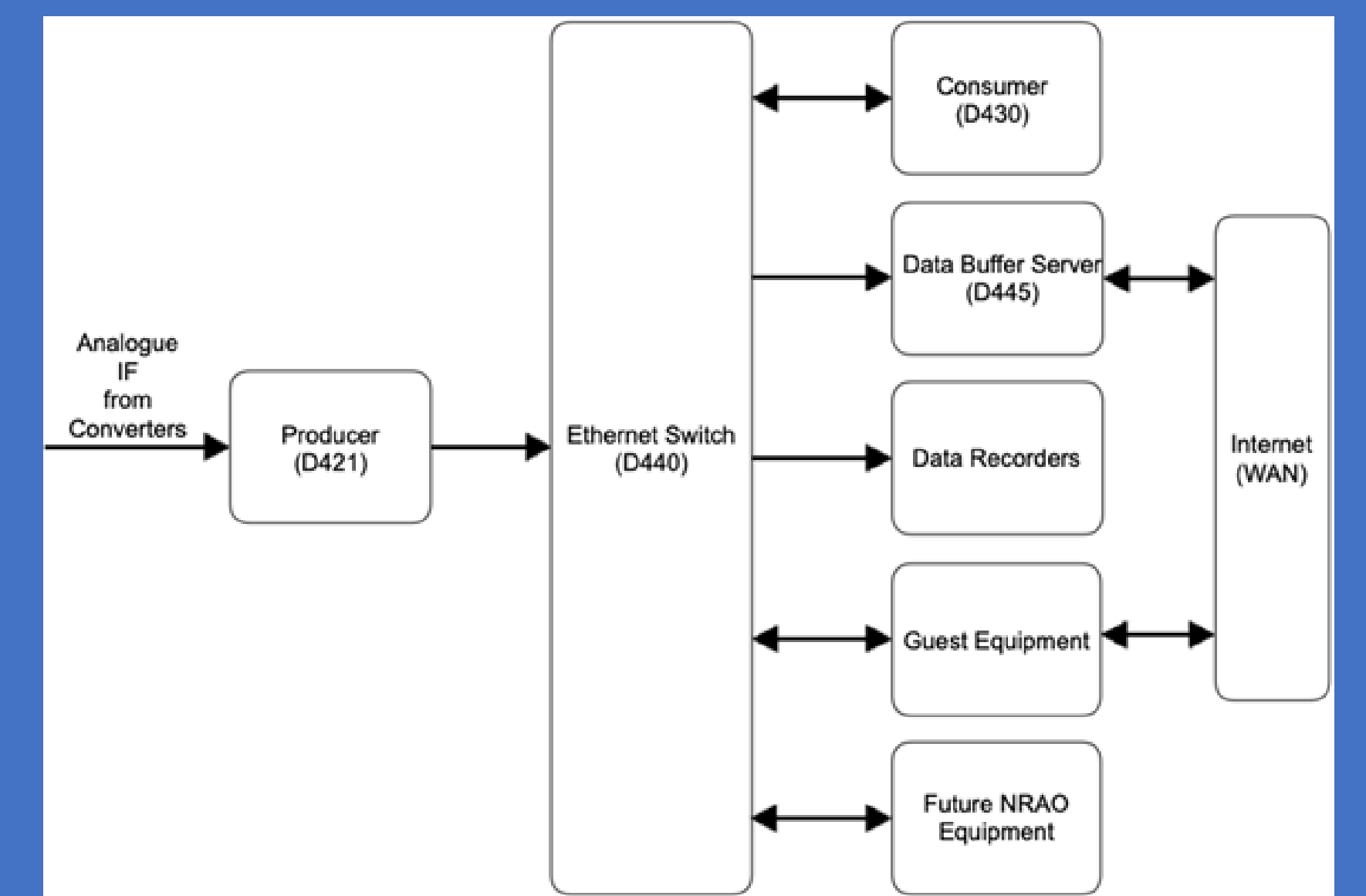
Several stations have the new synthesizers, and they will continue to roll out to the remaining stations throughout 2024 and 2025.

VNDA

The VLBA New Digital Architecture (VNDA) will replace the aging ROACH Digital Backends (RDBEs). VNDA will use modern, off-the-shelf components to simultaneously upgrade the backend system and provide for improved resilience. The system will be composed of a “producer”, which digitizes the incoming IF stream, and a “consumer” (or channelizer). All data will flow through an Ethernet switch.

Some key features of the VNDA system are:

- Increased observing bandwidth
- Higher sampling bit rate
- Improved timing stability
- Reduced operations footprint
- Ability to host guest equipment on site



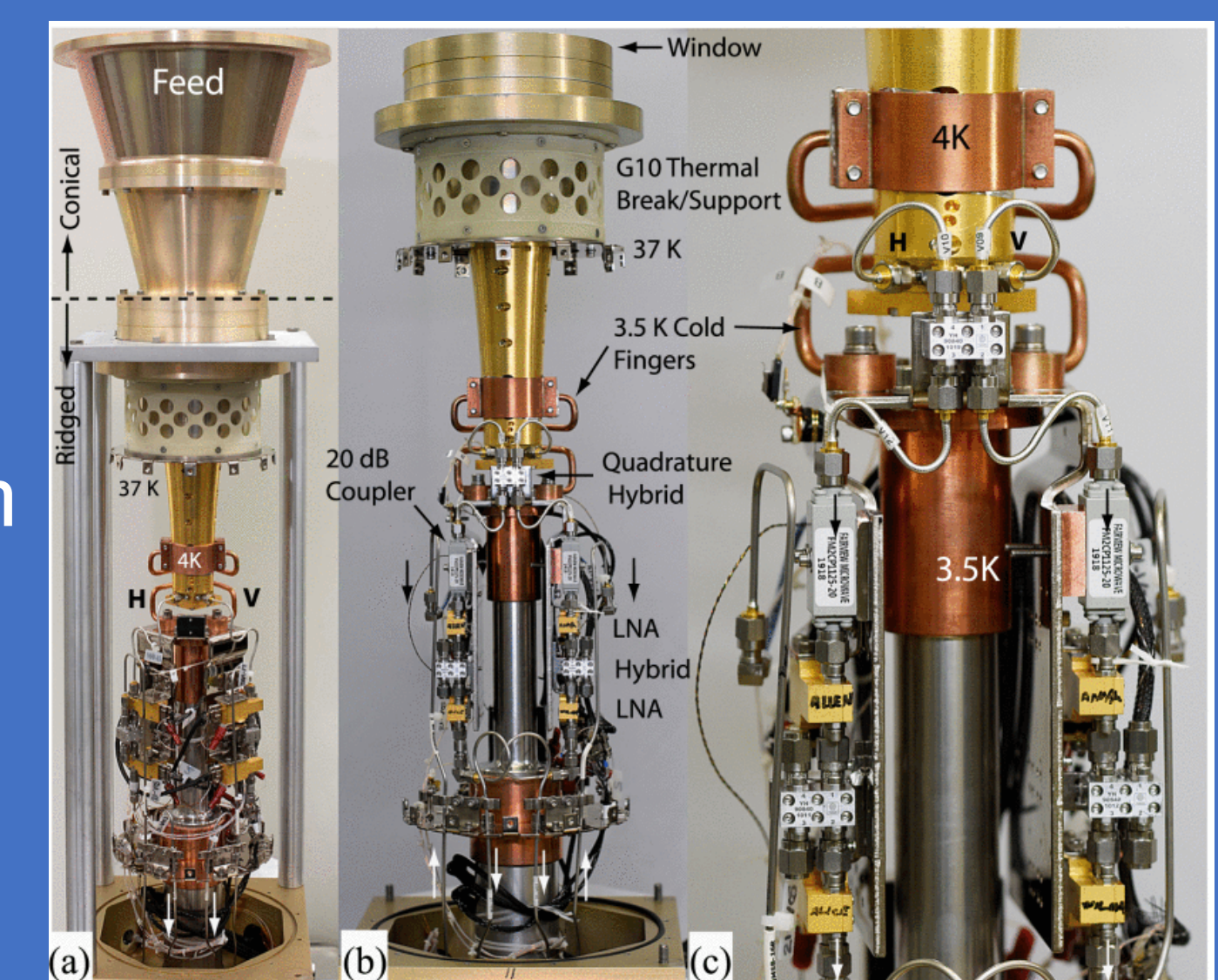
Simplified VNDA architecture

As of March 2024, VNDA has successfully completed the Zero Baseline Test, where a broadband noise signal was recorded via an RDBE and a VNDA prototype and then successfully correlated.

Ultra Wideband X-Ka Receiver

The VLBA recently tested a prototype ultra wideband receiver with a frequency range of 8 to 40 GHz. The prototype was designed and built at NASA’s Jet Propulsion Laboratory (JPL) and installed on the Owens Valley VLBA station. The results were very promising (see Kooi et al. 2023). The sensitivity of the prototype appeared to be comparable to the existing X-band and K-band receivers, and significantly better than the existing Ku-band receiver.

The US Naval Observatory (USNO), which funds 50% of the VLBA’s operational costs, has indicated strong interest in installing similar ultra-wideband receivers on each of the VLBA antennas. This could finally enable access to Ka-band frequencies (27 to 40 GHz) at the VLBA.



The prototype X-Ka receiver. Figure 17 from Kooi et al. 2023

References

- Clark, B. 2022, VLBA Test Memo #75
Kooi, J., et al. 2023, IEEE Journal of Microwaves, Volume 3, Issue 2
Linford, J., & Briskin, W. 2020, VLBA Sensitivity Upgrade Memo # 51



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