Taking Full Advantage of SOFIA Airtime: Technologies to Maximize THz Receiver Performance

Eric Bryerton[1], Arthur Lichtenberger[1,2], Anthony Kerr[1], Matthew Morgan[1], Sri Srikanth[1] and Shing-Kuo Pan[1]

[1]National Radio Astronomy Observatory (NRAO) [2]University of Virginia Microfabrication Laboratory (UVML)

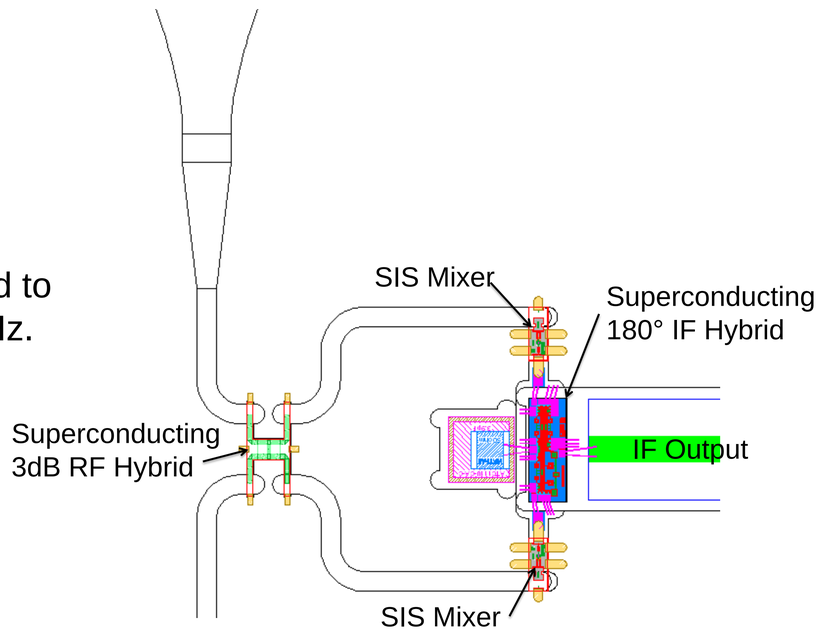
Given the broad spectral window accessible from SOFIA, and the limited time available for observations from an airborne platform, it is essential for instruments on SOFIA to have the best possible sensitivity and the widest bandwidth. In addition, separating lower and upper sidebands (effectively doubling the bandwidth as well as reducing atmospheric noise), and detecting both polarizations will permit the most productive use of SOFIA airtime. Observing efficiency can be even further improved by sampling more of the focal plane using array receivers. The NRAO and UVML are exploring all these areas of improvement in their current ALMA collaboration.

New Materials and Process Optimization

• Nb and NbTiN resonators were fabricated and measured using a cryogenic probe station. Measurement of resonant frequencies were used to precisely determine capacitance per unit length and surface inductance, greatly increasing accuracy of superconducting circuit designs.
• Recently delivered hot deposition system will allow better quality NbTiN films (higher energy gaps), single crystal Nb (low-loss tuning circuits), and new material exploration.
• Nb/NbTiN SIS mixers with AlN barriers are expected to yield quantum-limited noise (2-3 photons) up to 1.2 THz.

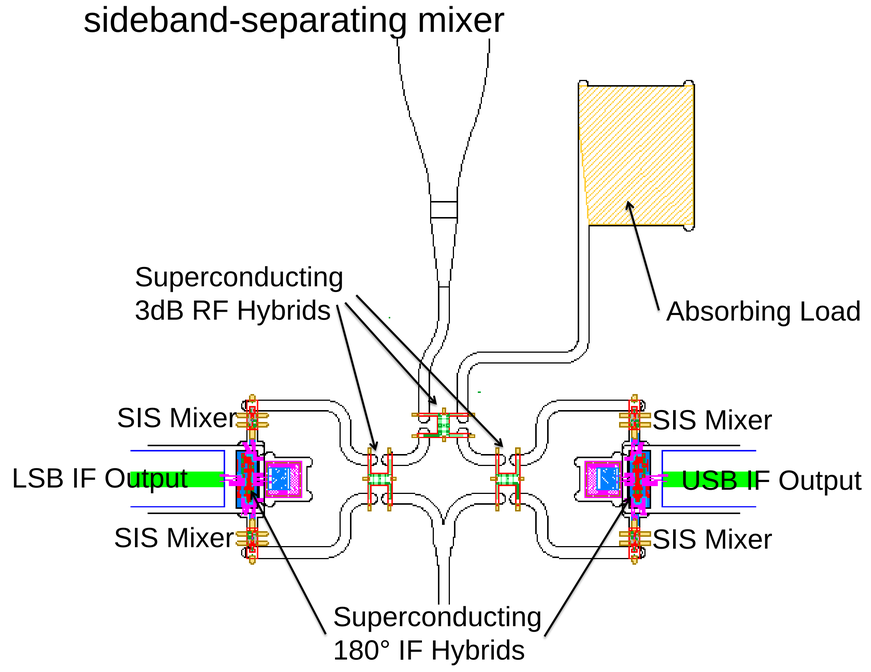
Balanced Mixers

• Rejection of LO noise
• 50-100 times less LO power
• 3dB greater dynamic range



Sideband-Separating Mixers

• Reject atmospheric noise in other sideband
• Eliminate need for LO frequency switching to identify spectral lines
• Below is shown a balanced *and* sideband-separating mixer

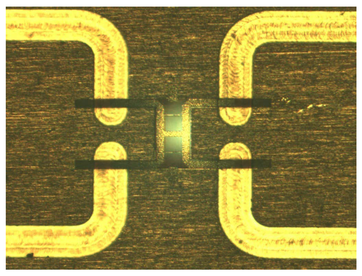


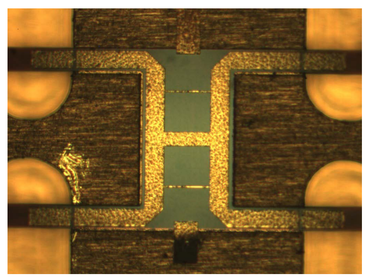
Silicon Membrane Beamlead Circuits

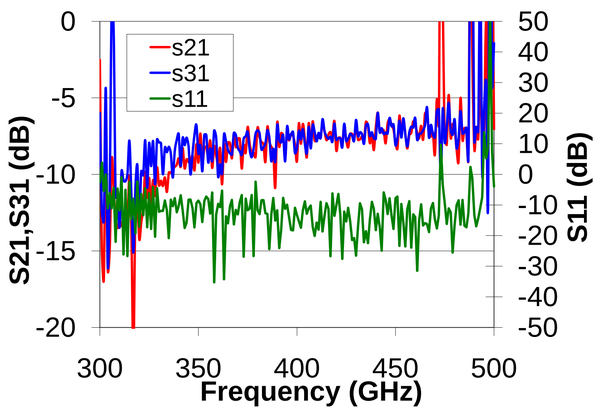
• 3μm thick Silicon substrate
• Can be cut to arbitrary shape
• Can be patterned with Nb or NbTiN
• Beamleads allow for easy and repeatable assembly
• Used in current design of SIS mixer chips and superconducting 3dB hybrid chips shown on poster

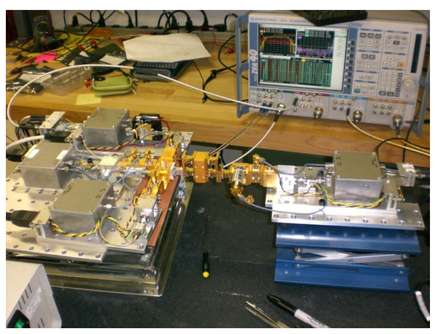
Drop-In Superconducting RF Hybrids

• For easy design and assembly of balanced and sideband-separating mixer modules (see above)
• Below is shown photographs and assembly of 375-500 GHz prototype (WR-2.1)







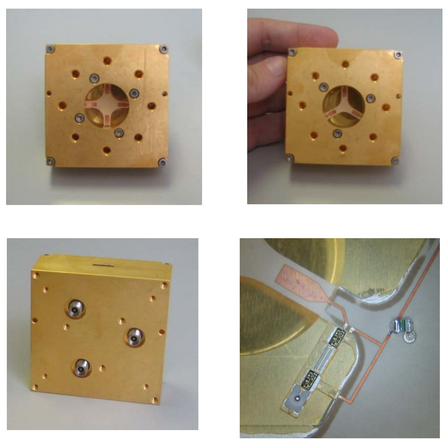


• High room temperature loss due to low resistivity of Si at room temp
• Phase balance also very good
• Block measured using VDI WR-2.2 VNA Extensions
• 4K measurements in progress

Dual-Polarization Detection

Planar Digital OMTs

X-Band Prototypes



• THz planar OMTs can use Si membrane with NbTiN metallization