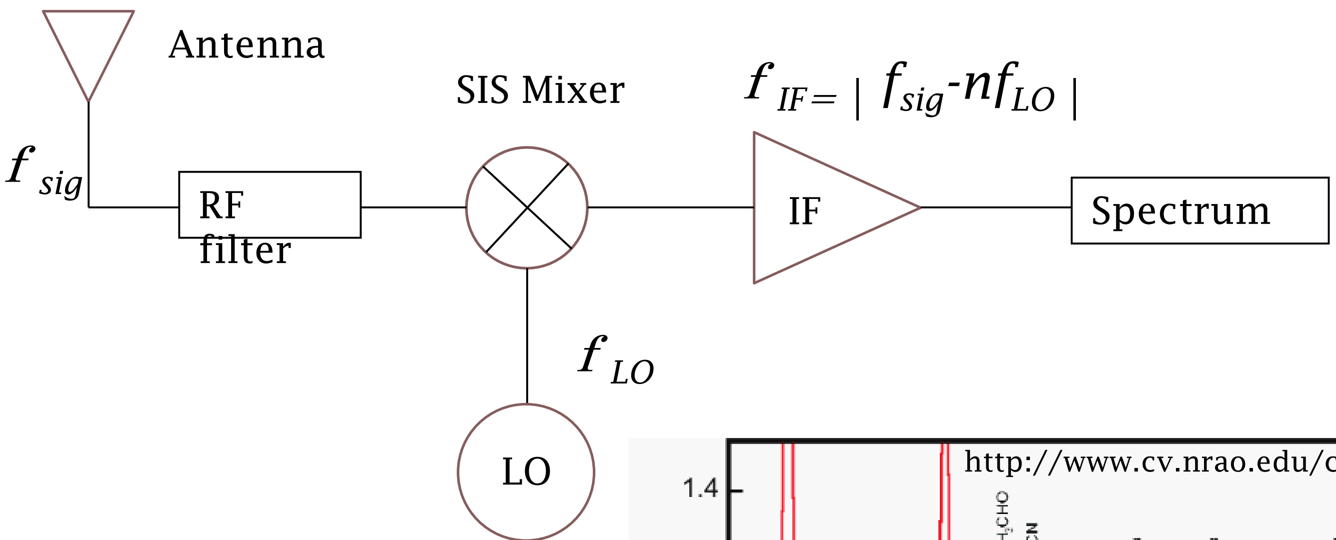
EAO Sub-mm Futures, May. 20-23, 2019

A Planar Integrated SIS Heterodyne Array for Wide FOV Observation

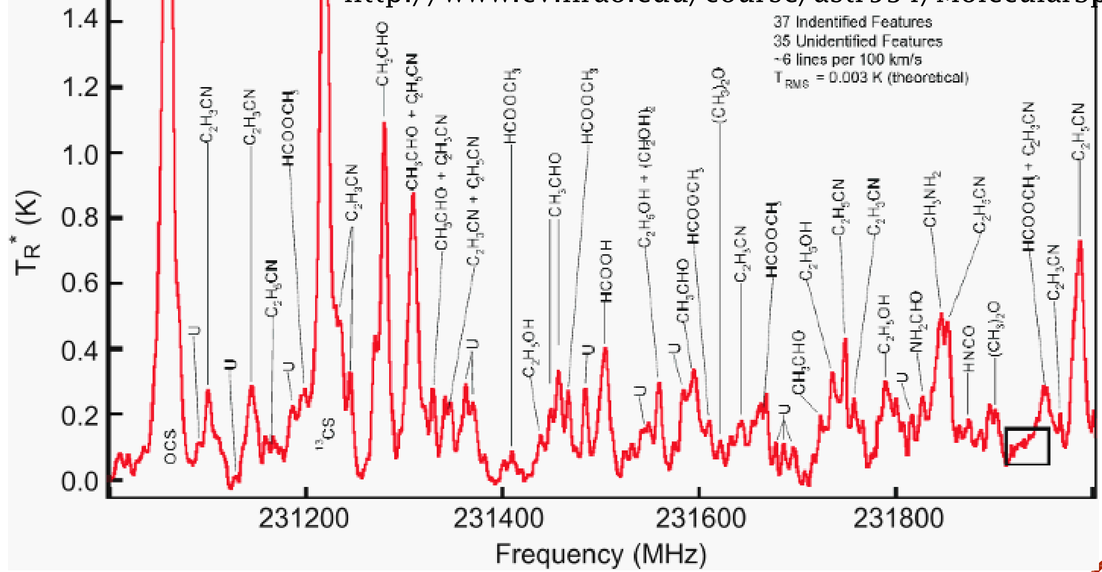
Wenlei Shan

on behalf of the development team

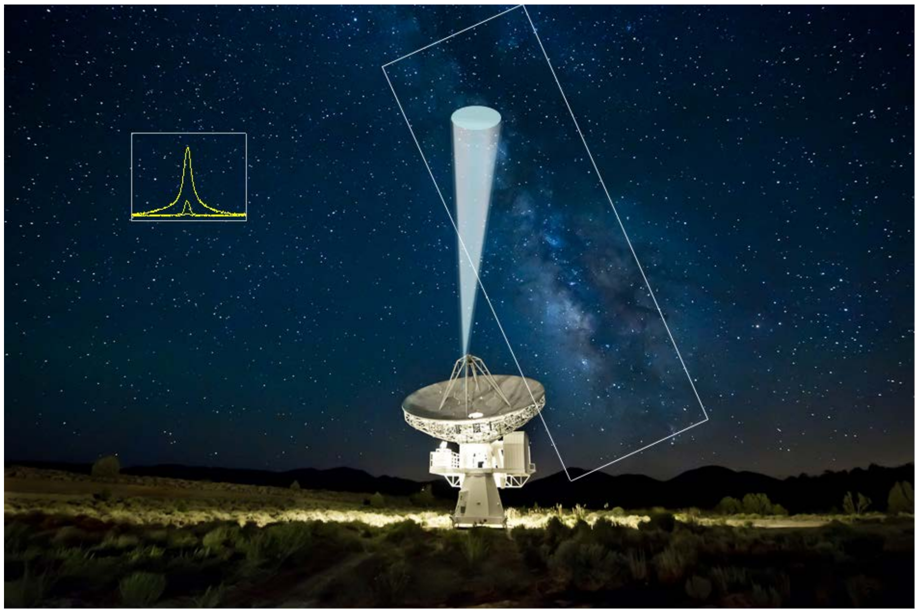
Heterodyne Receivers With SIS Mixer

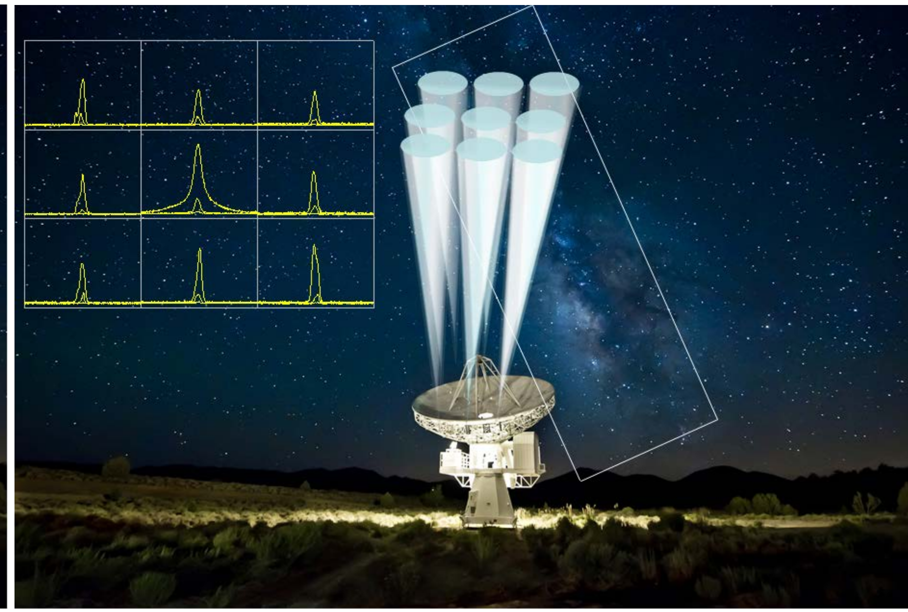


http://www.cv.nrao.edu/course/astr534/MolecularSpectra.ht

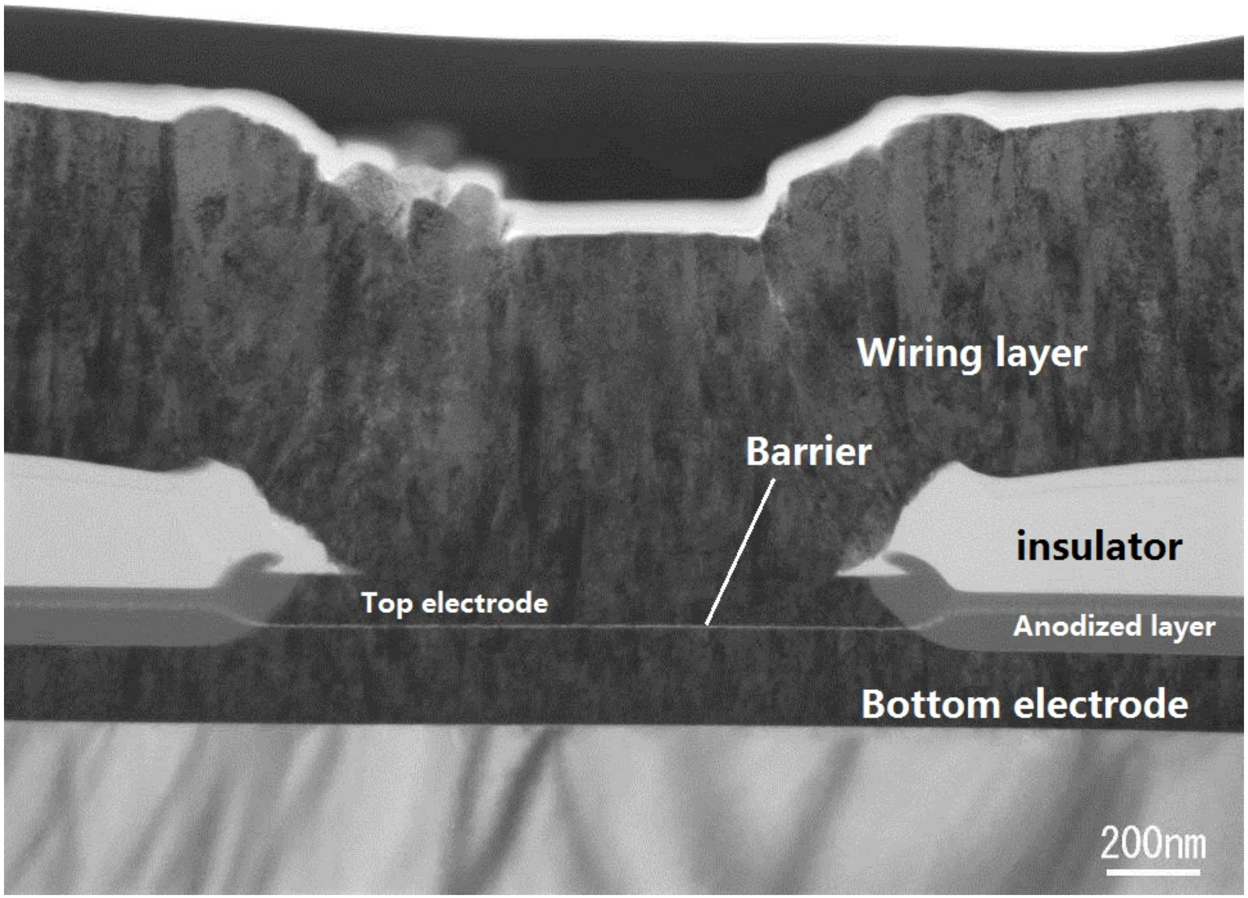


Combination of Large FoV and High Sensitivity

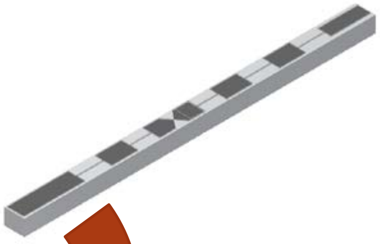


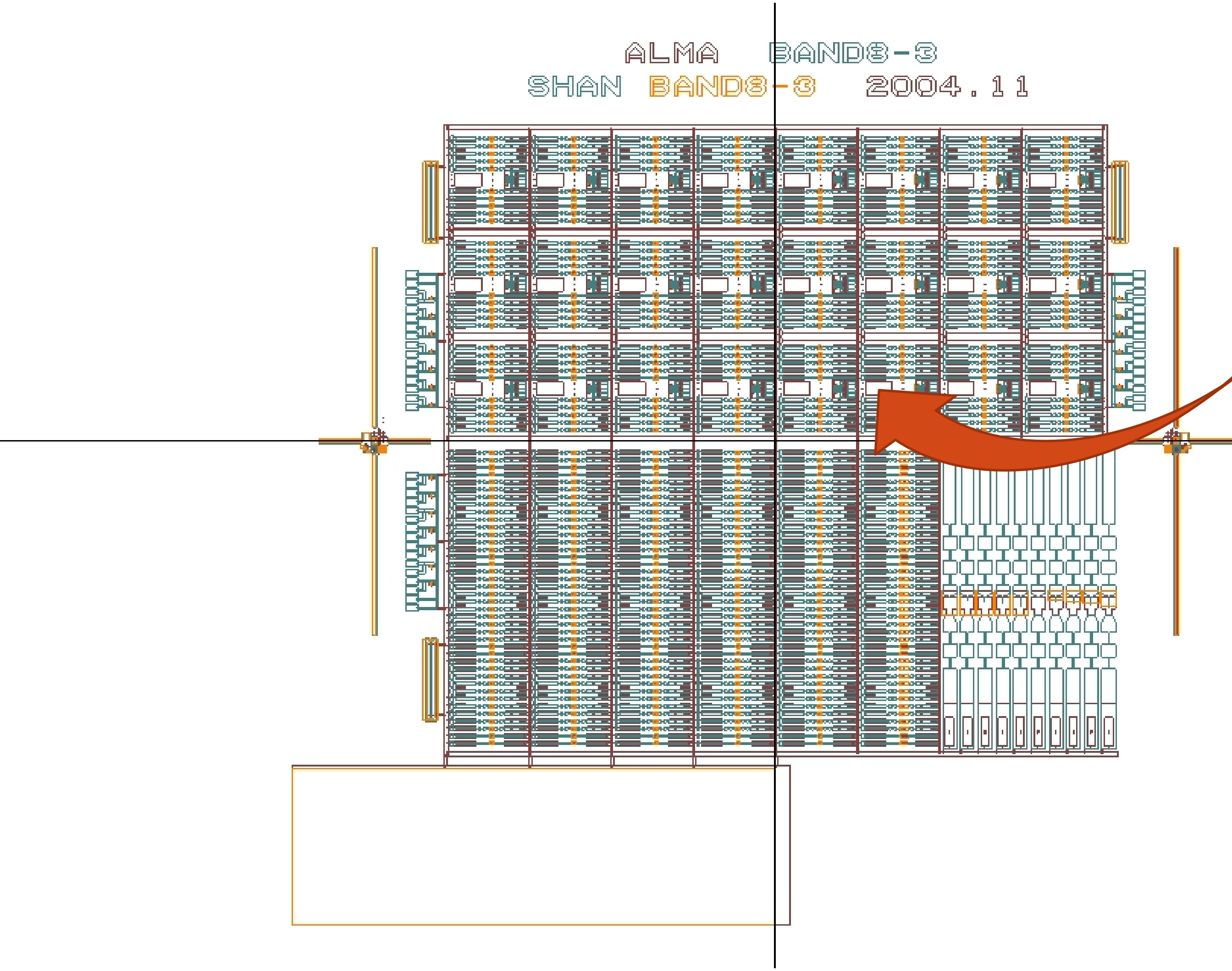


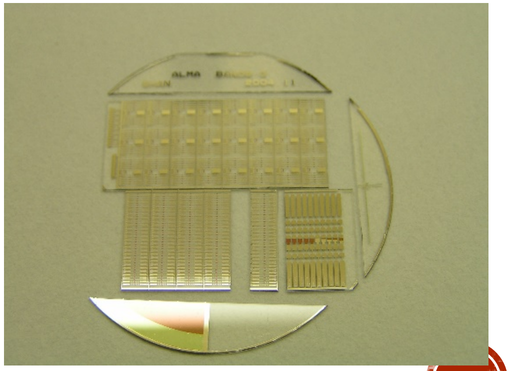
Very sensitive coherent detector: Superconductor -Insulator-Superconductor Tunnel Junction



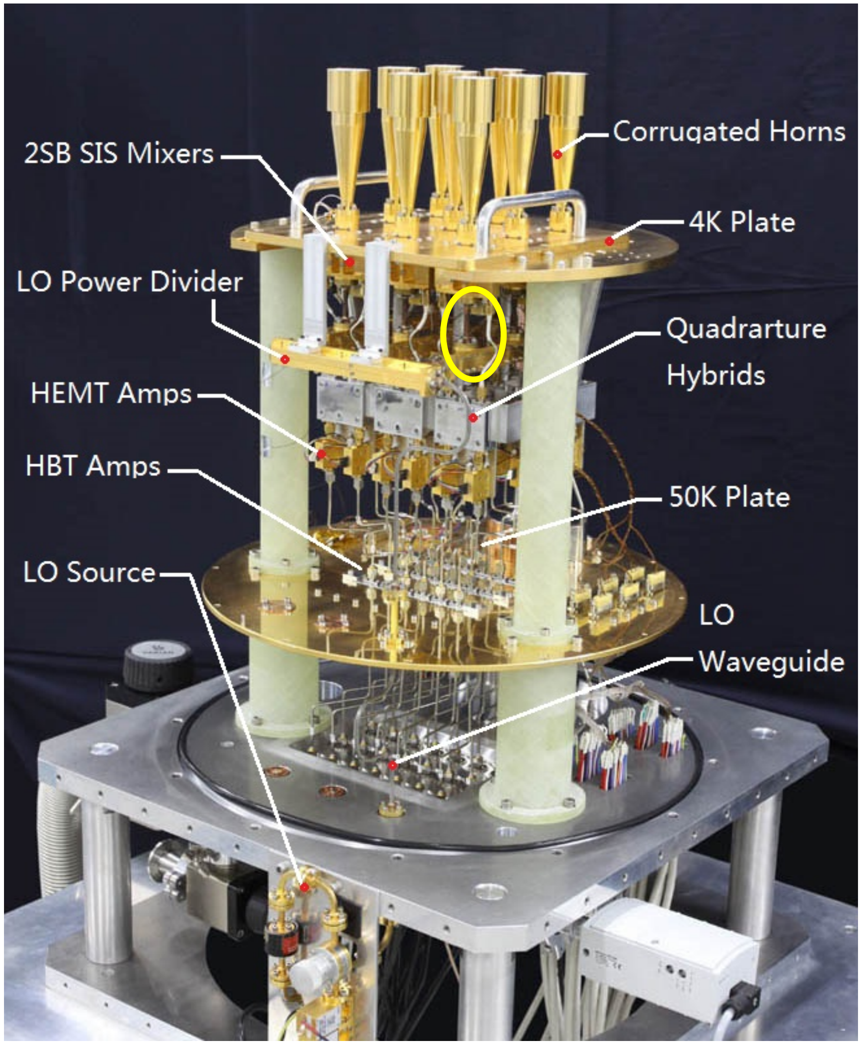
SIS Mixer Fabrication

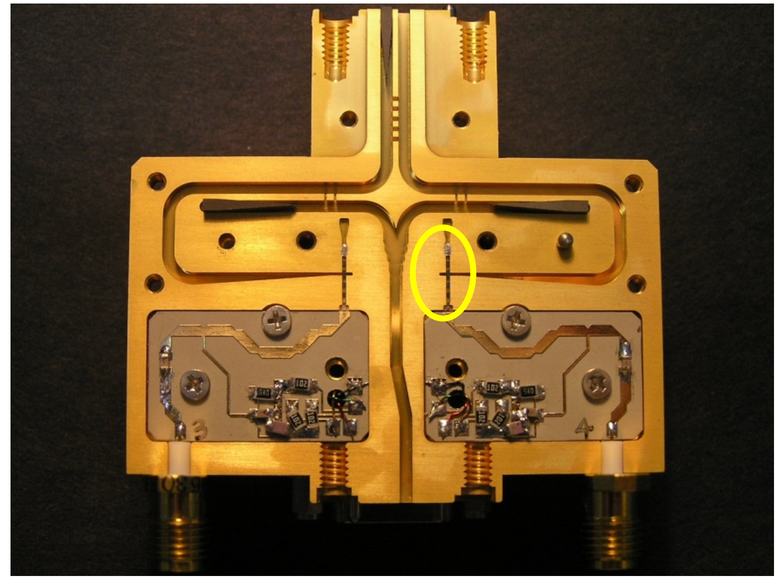


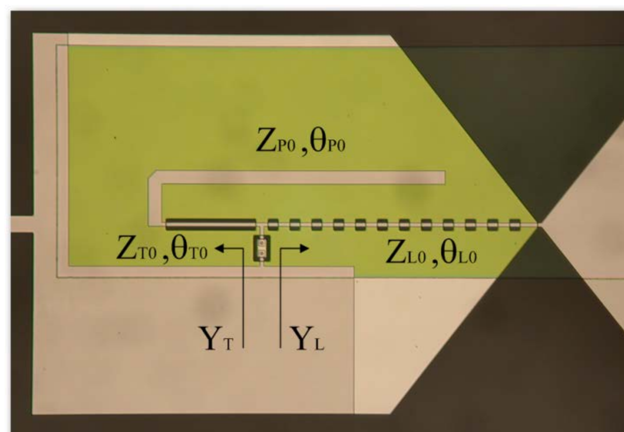




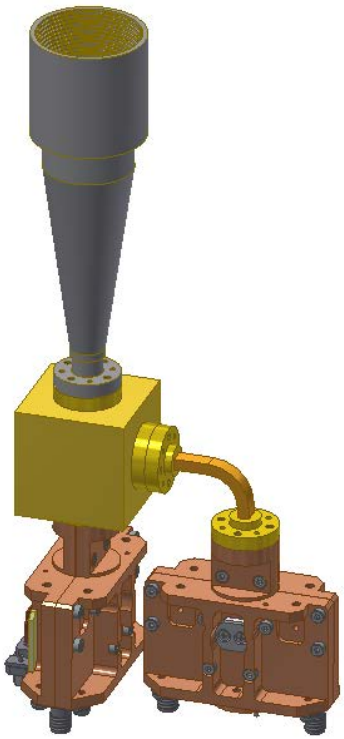
Superconducting Spectroscopic Array Receiver (SSAR) :Sideband Separation (2SB) SIS Mixers

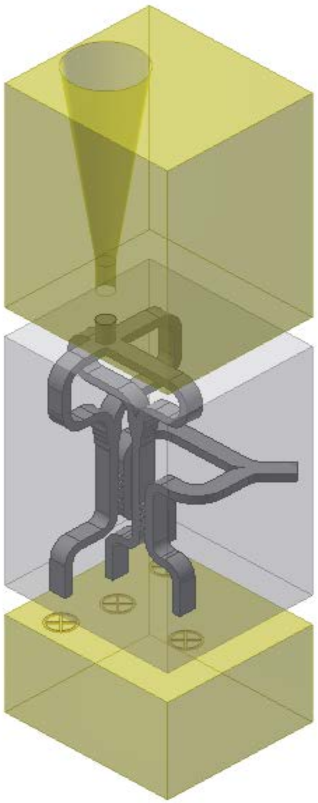


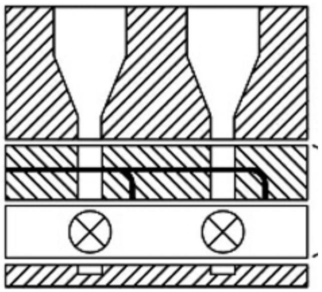


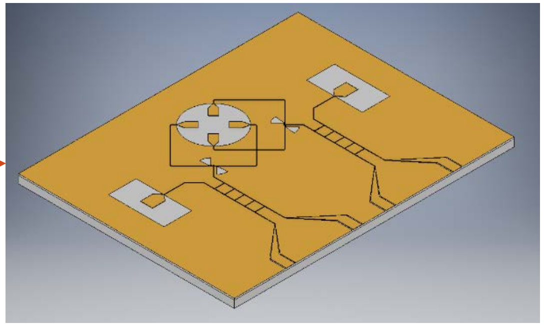


Integration of the frontend









Planarization

Integration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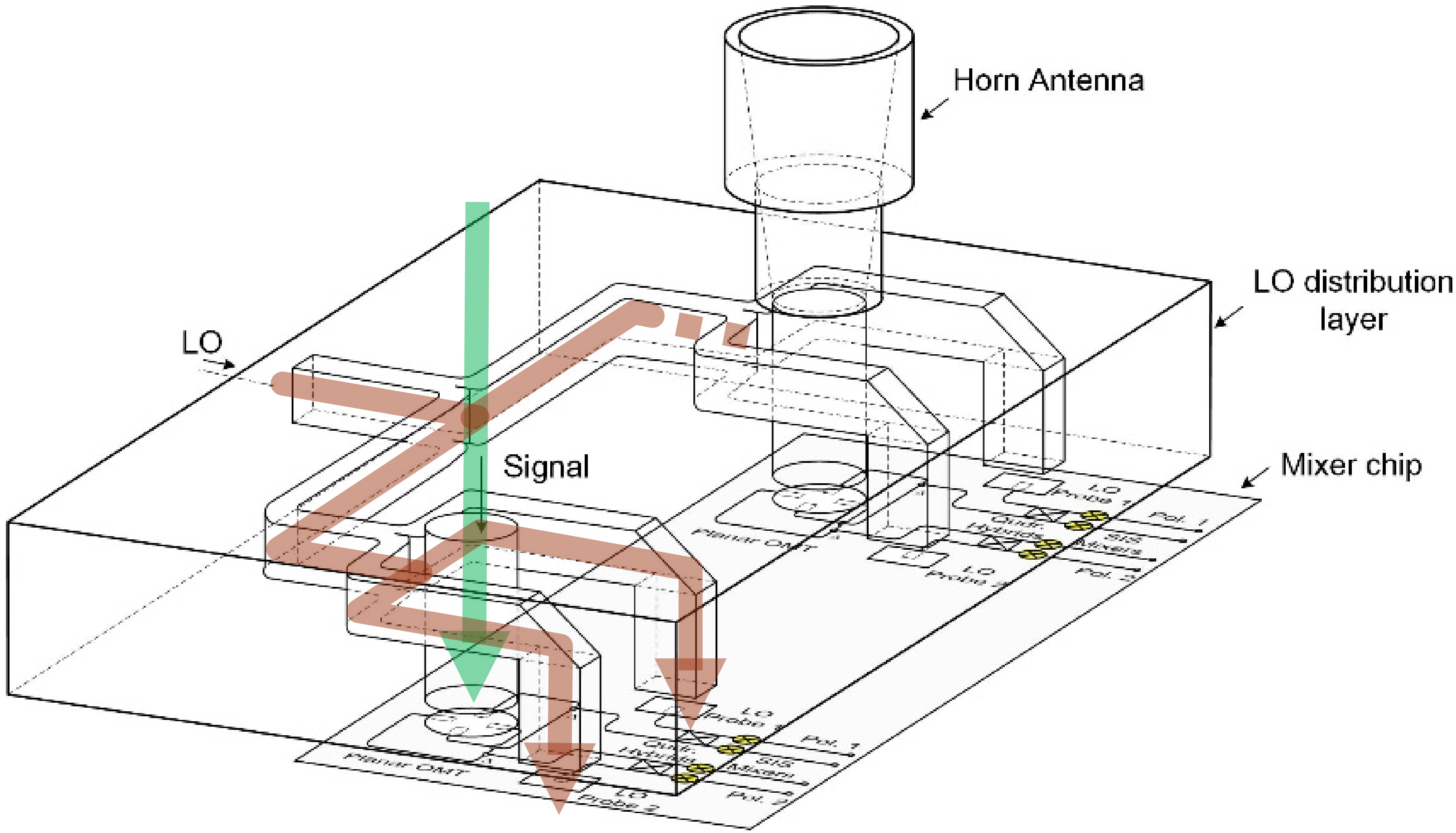
THz Letters

A New Concept for Quasi-Planar Integration of Superconductor-Insulator-Superconductor Array Receiver Front Ends

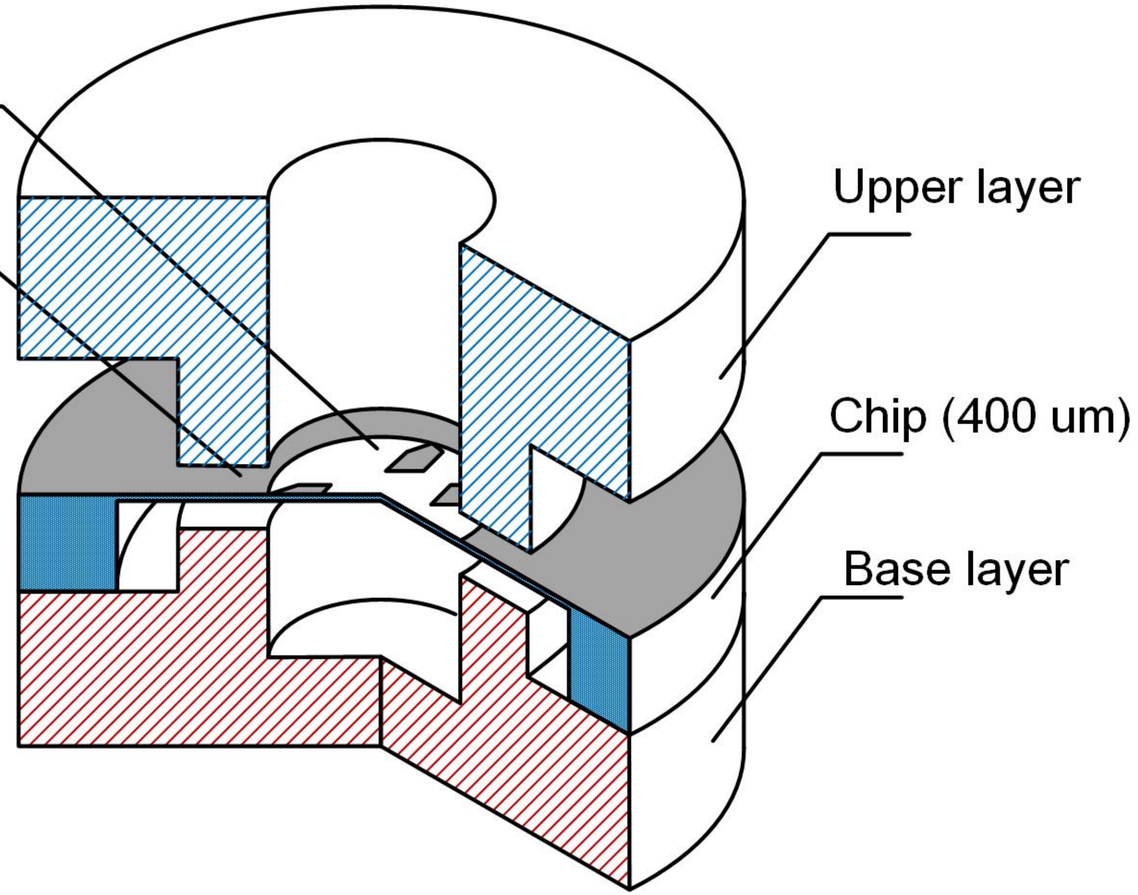
Wenlei Shan, Shohei Ezaki, Jie Liu, Shinichiro Asayama, and Takashi Noguchi

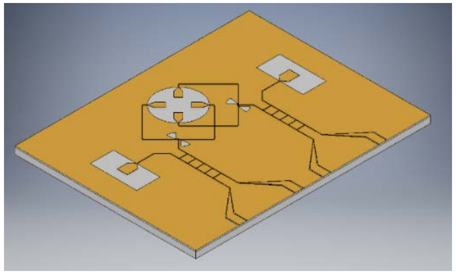
LO Distribution Concept Design

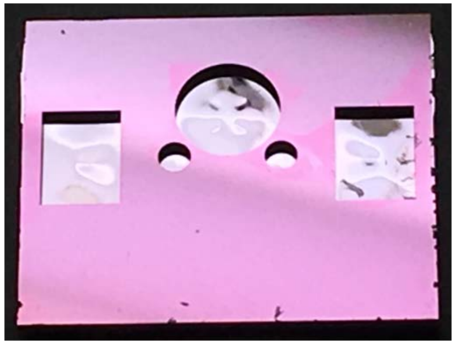


This approach eliminates the difficulty in machining waveguide structures, paves the road to a large amount of pixels.

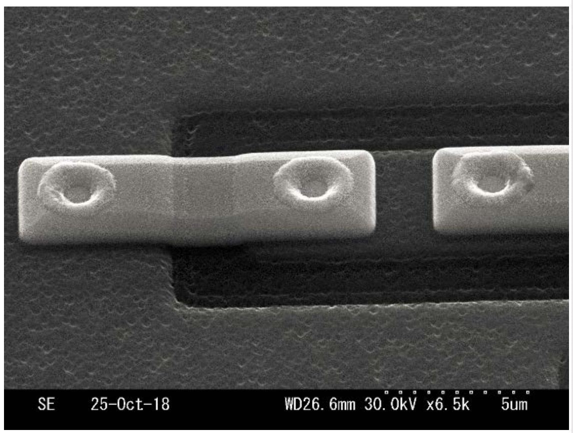
Membrane-based Waveguide Probes



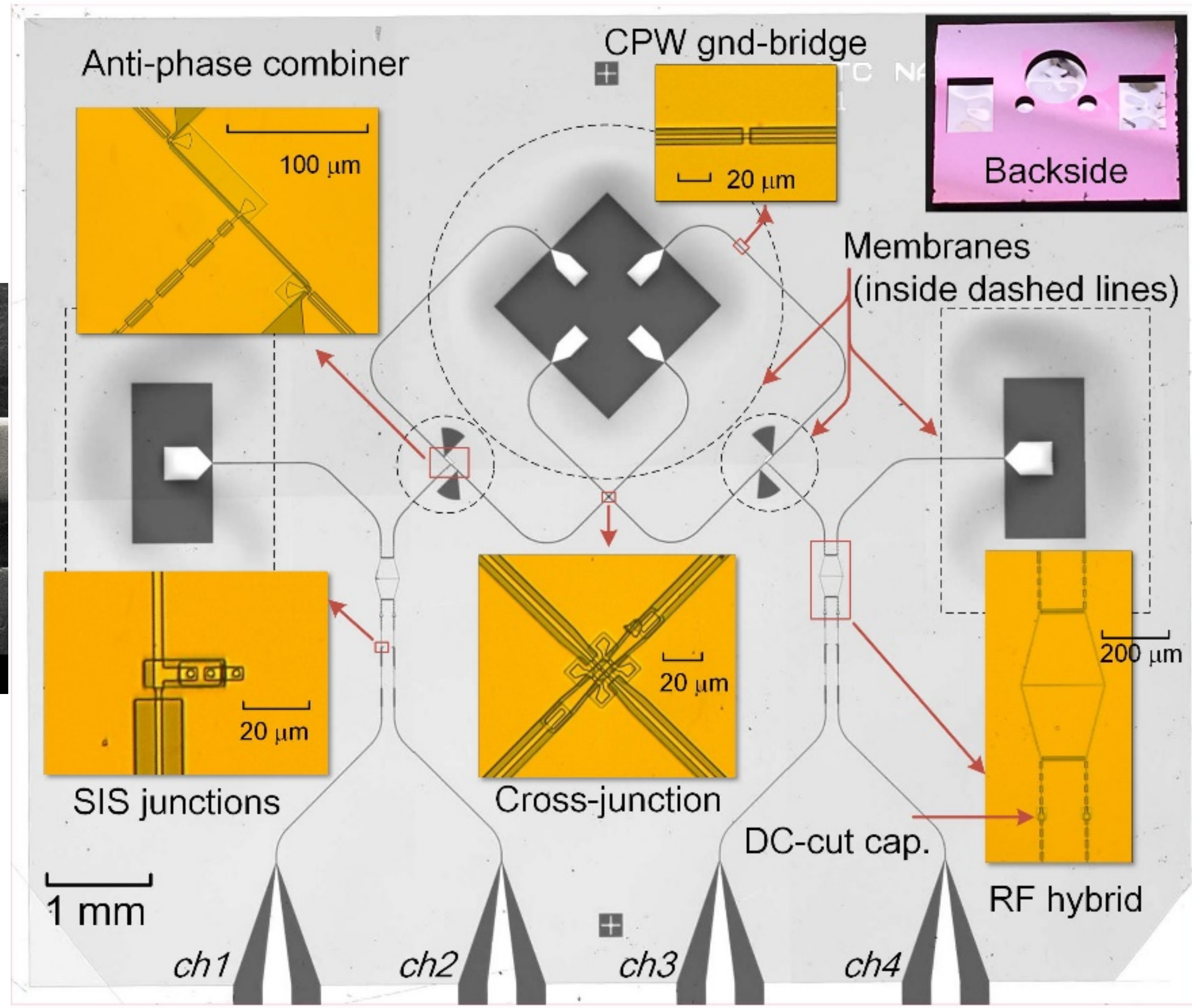




2mm Band Mixer Chip Layout

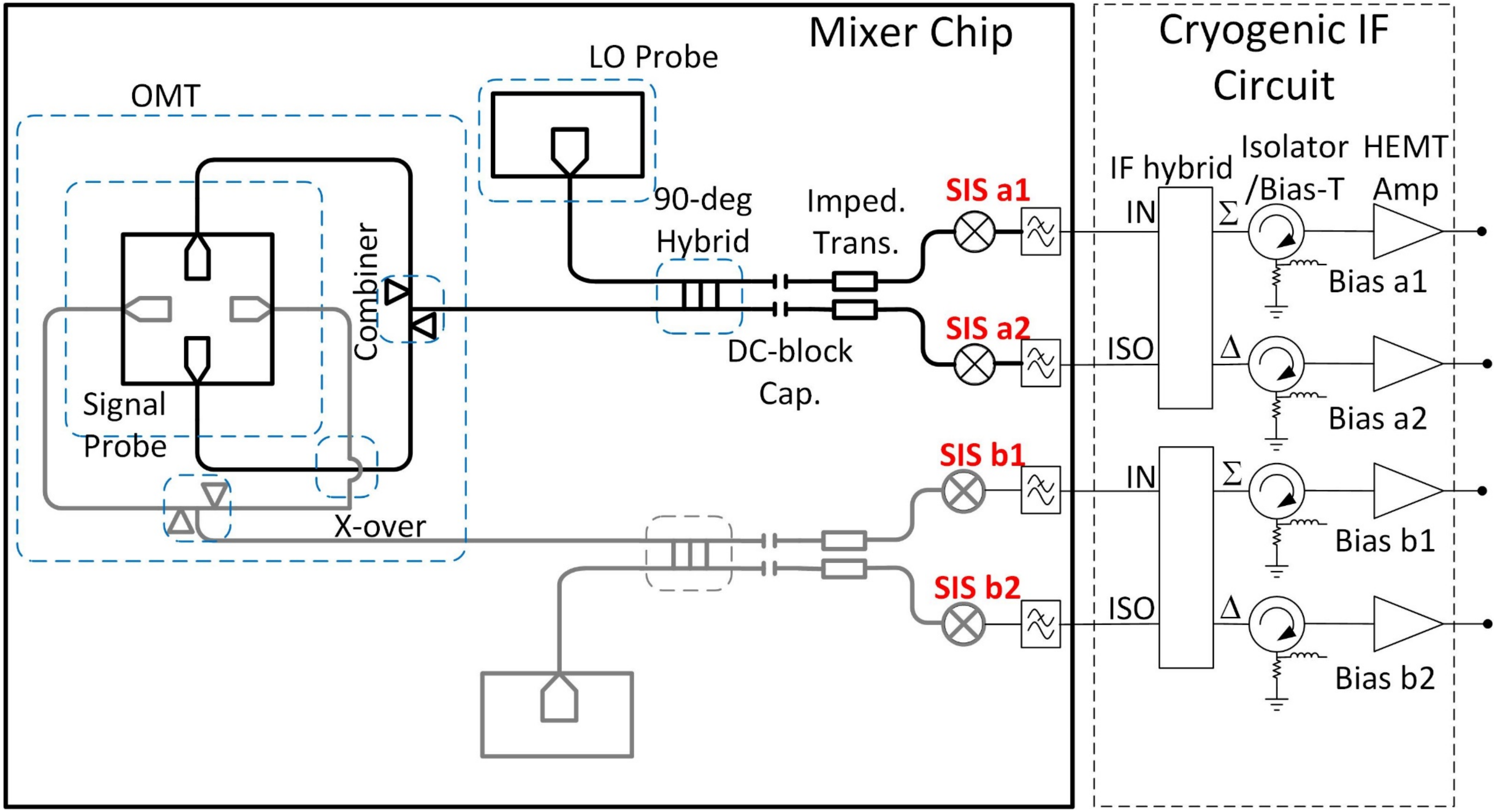


SEM image credit:
Shohei Ezaki, NAOJ



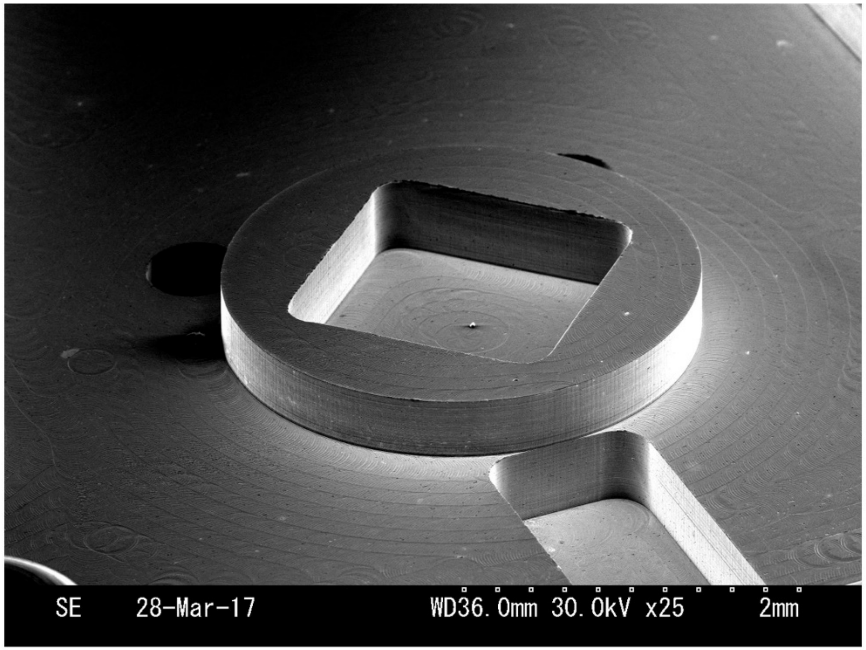
The size of this chip is 13 mm x 10 mm x 0.4 mm.

Circuit diagram of the mixer chip

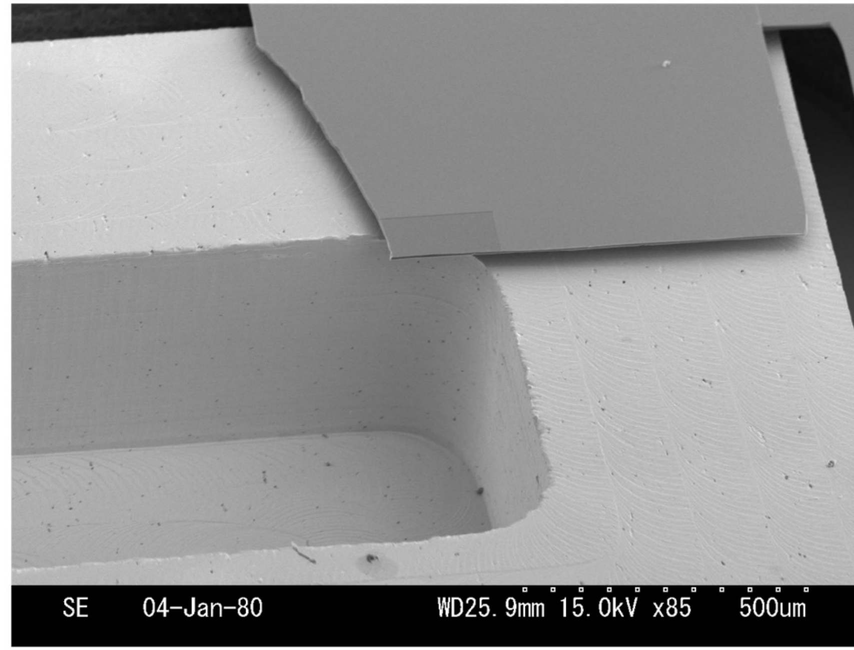


The mixer is configured as a balanced mixer.

Free-standing Membrane



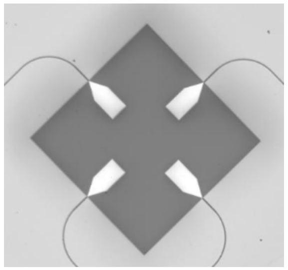
(a)



(b)

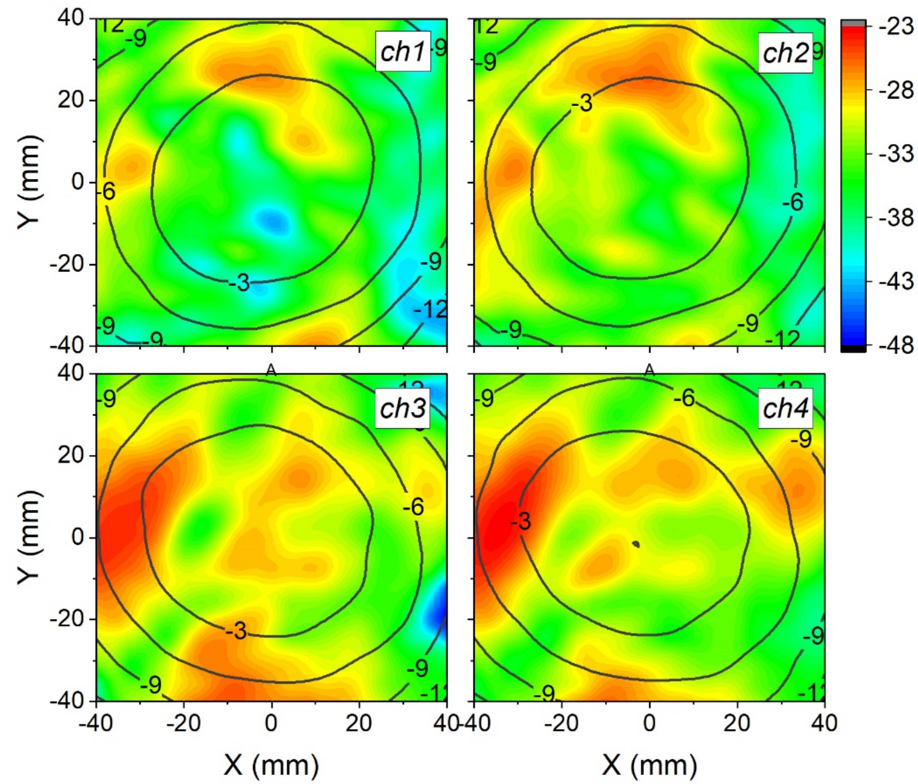
The SEM image of the backshort piece for (a) signal waveguide probe and for (b) the LO waveguide probe. The membrane about the LO waveguide backshort is inventively cracked to show the clearance between the membrane and the metal block.

Demonstration of Performance (OMT)



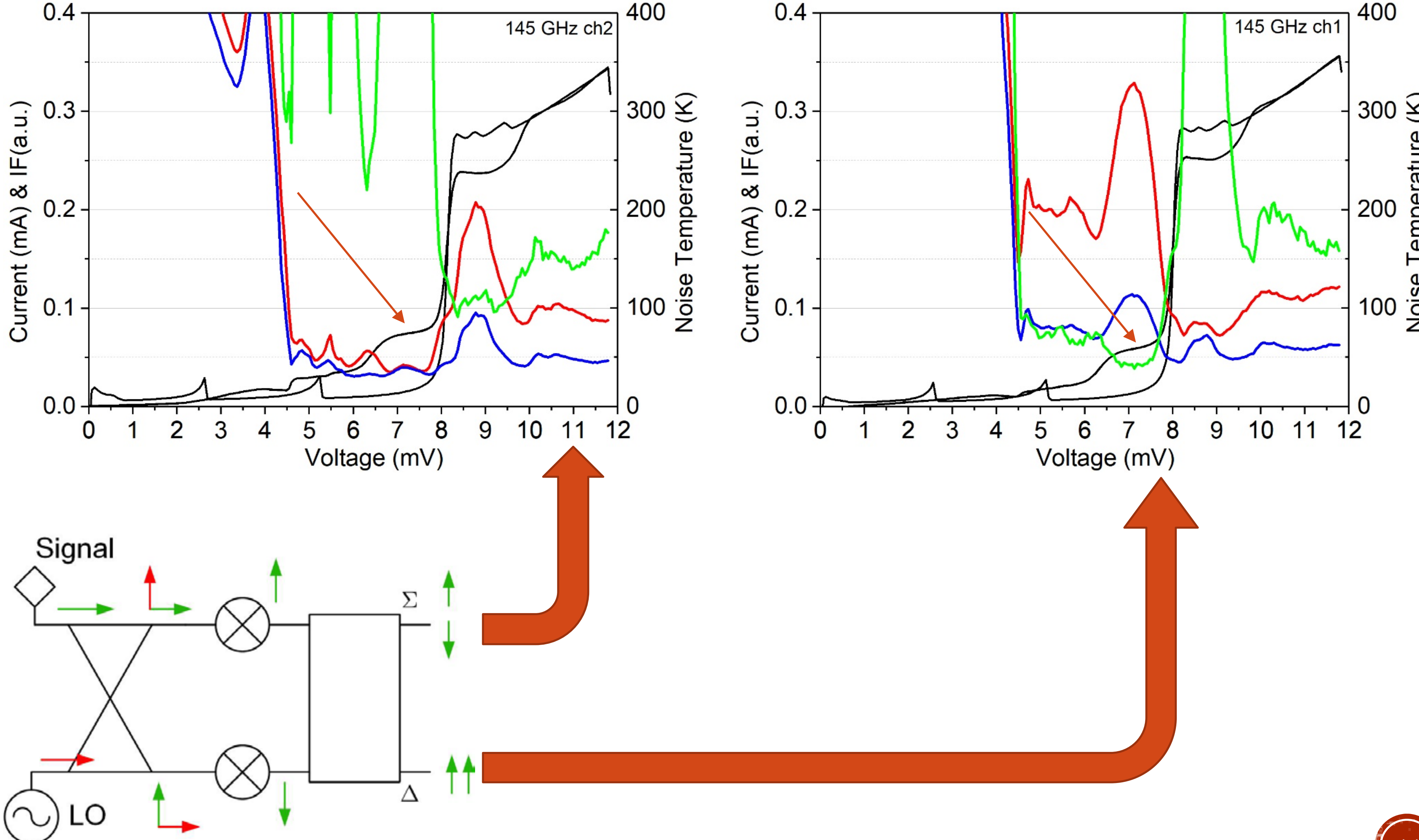
Planar OMT

Polarization selectivity measurement

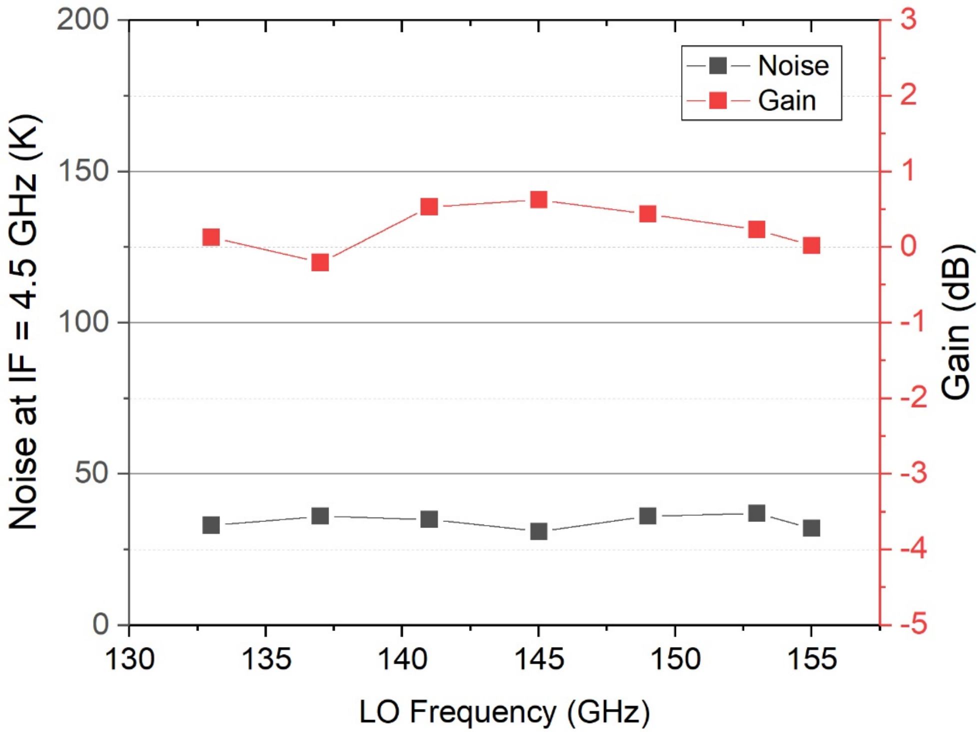


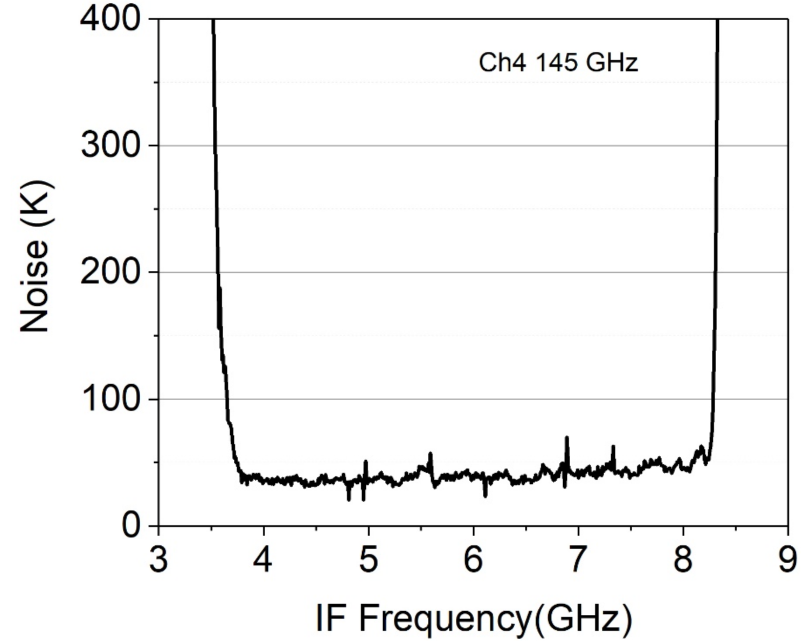
X-Polar level < -23 dB is achieved.

Balanced Mixing: Signal Selectivity



Balanced Mixer: Noise

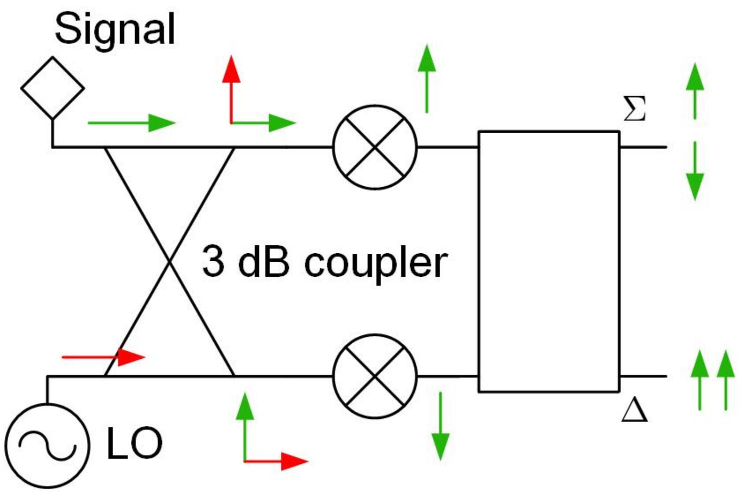




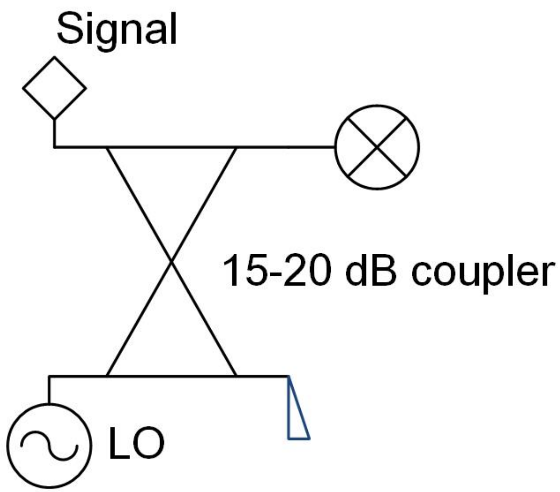
The low-noise performance is approaching ALMA specification.

NAOJ

Balanced Mixing: A solution of LO power requirement



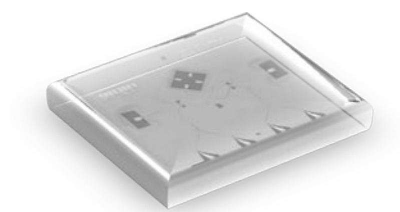
Balanced Mixer
(50% LO usage)



Single-ended Mixer
(1-5% of LO usage)

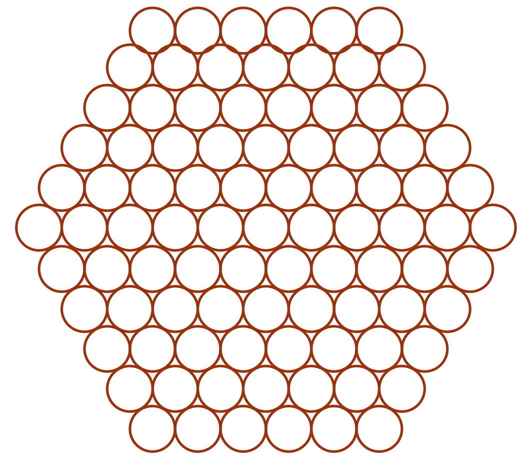
Freq. Range	LO Pw	Pw per Jun.	Jun per pixel	Max Num
140-220 GHz	3 mW	0.05 uW	8	7500
400-600 GHz	1.5 mW	0.36 uW	8	520
750-1000 GHz	0.25 mW	1 uW	8	31

Road Map of This Work

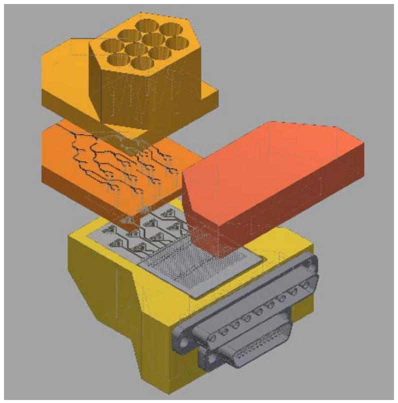


Single beam demonstration

Millimeter wavelength



Large format
For future single-dish telescopes



Sub-millimeter wavelength

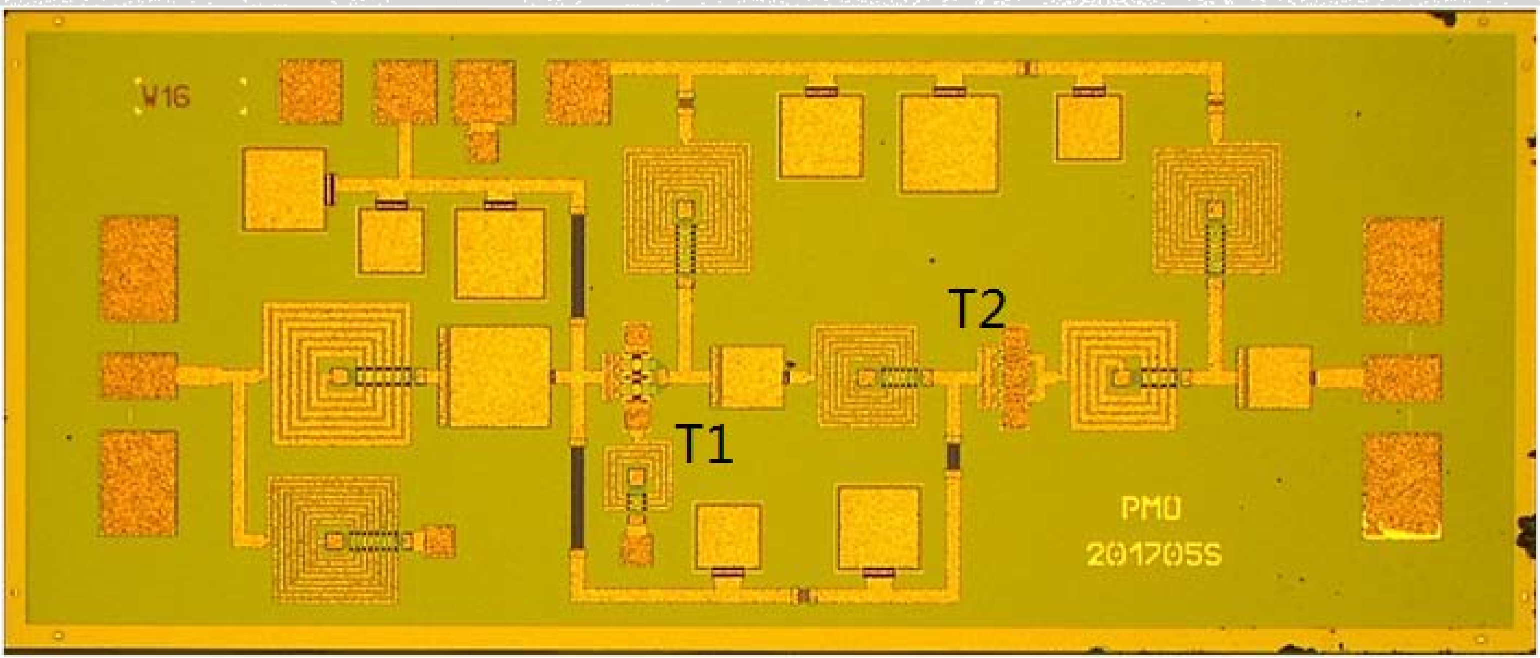
Compact array
For interferometers

Other Technical Challenges

- Wide FOV optics
- Low power-consumption and low-cost amplifiers
- Multiplexing of IF output (radio-over-fiber)
- Spectrometer technologies

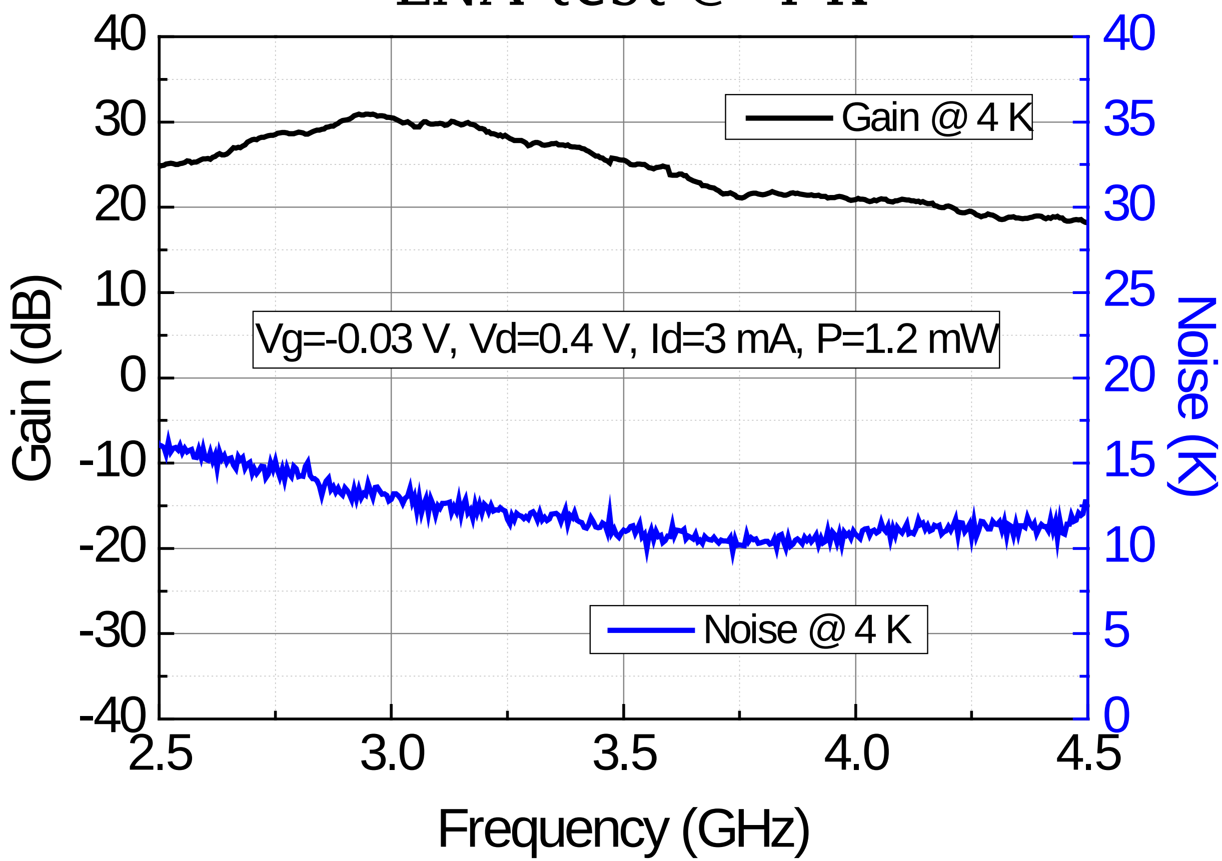
Reduction of LNA power from 20 mA to 1 mA

2.5-4.5 GHz low-power cryogenic MMIC LNA



The photograph of the GaAs LNA chip. Size is 1 mm×2.4 mm.

LNA test @ 4 K



- Band: 2.5-4.5 GHz;
- Average noise temperature of 12 K;
- Gain > 20 dB; Dissipation of 1.2 mW.

Conclusion

New concept is proposed and verified for SIS multibeam receivers.

The goal of this work is to implement this technology to the future large single-dish mm-submm radio telescopes and inteferometers.