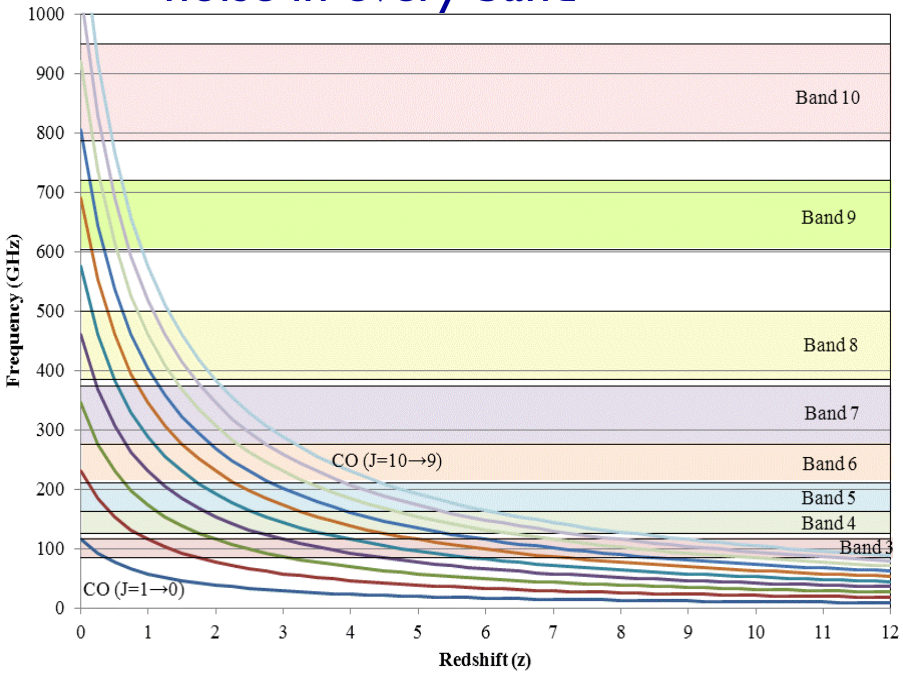
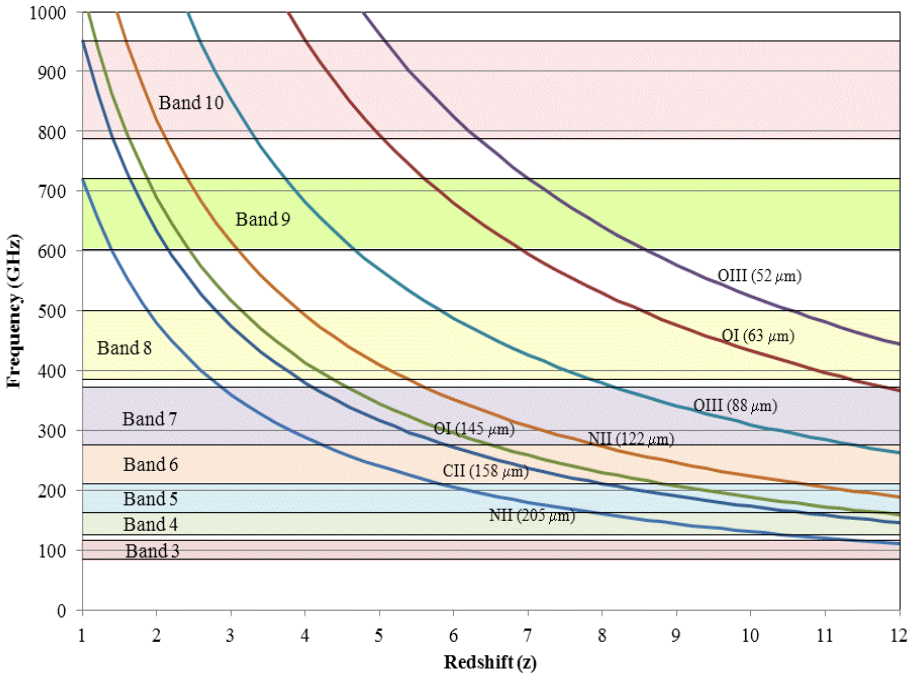
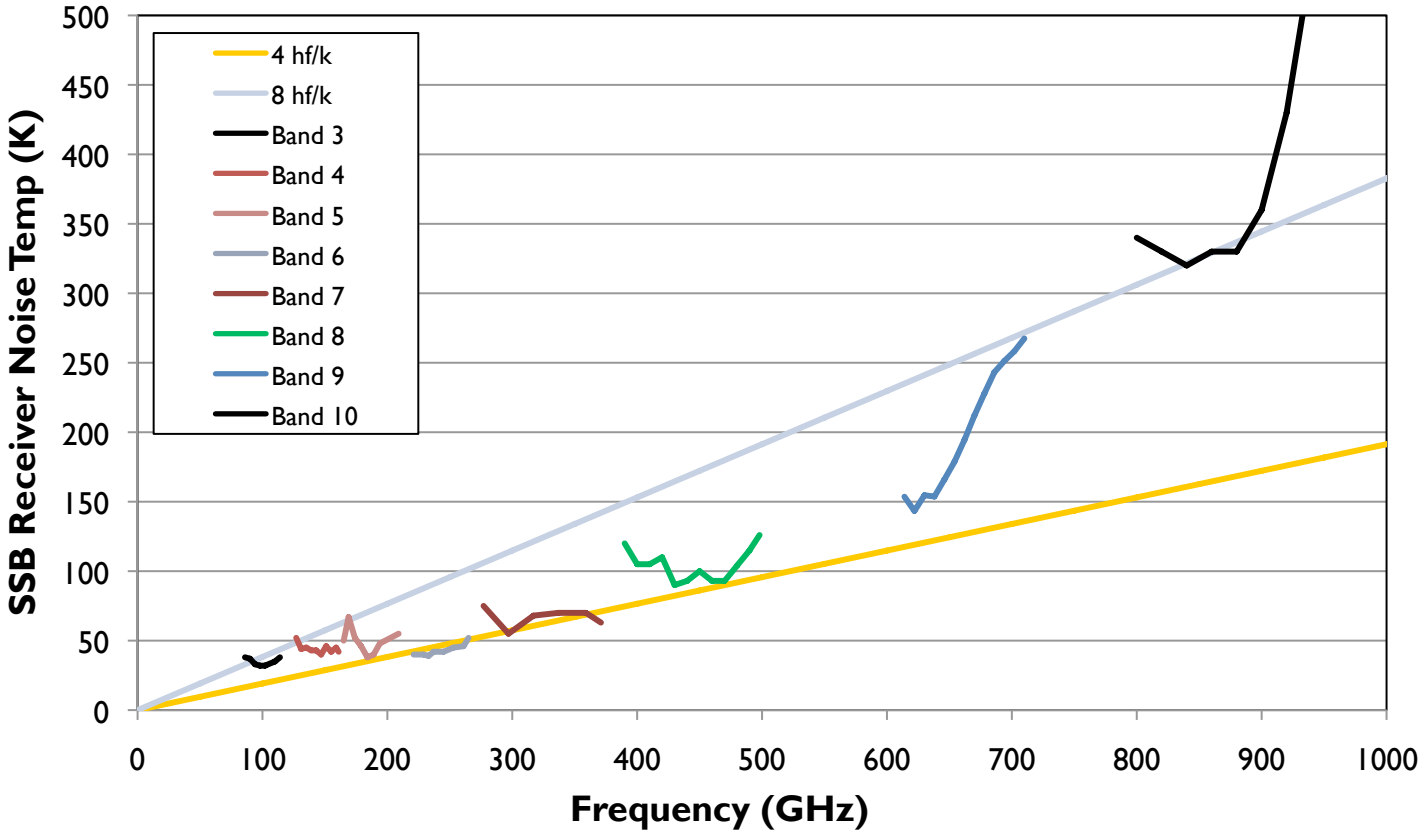
ALMA Development Proposal for Superconducting Circuits Foundry Support: "Enabling the Full Potential of ALMA"

- Why continued SIS mixer development?
- Eventually want full 4-12 GHz in each sideband with nearly quantum-limited noise in every band





Current ALMA Receiver Noise Performance



Science Traceability Matrix for High-z Galaxies

Key Science Drivers	Receiver Technical Requirements	Required SIS Mixer Developments
• **Trace star formation rates through the early history of galaxy formation via imaging of the continuum and far-infrared fine structure lines from the earliest galaxies.** • **Study the physics and energetics of the ISM in the earliest galaxies via imaging and kinematic studies of redshifted CO and far-infrared fine structure lines.**	In all frequency bands, larger instantaneous bandwidth with moderate spectral resolution.	Balanced sideband-separating mixers with 4-12 GHz IF for all bands.
	In all frequency bands, lower system noise temperature over widest possible tuning bandwidth.	For all bands, higher current density SIS mixers (e.g. using AlN barriers) for increased tuning bandwidth and lower loss tuning circuits. For band 10, requires development of SIS mixer with higher gap frequency, such as NbTiN; also developing sideband-separating mixer for band 10 to reject atmospheric noise from unwanted sideband.
	SSB or 2SB operation at bands 9 and 10 for improved kinematic studies in these bands.	Sideband-separating mixers for bands 9 and 10.

- Lower noise and broader IF bandwidth at highest possible frequency also critical for imaging of protoplanetary disks

Why North American SIS Foundry?

- UVML is currently only operational SIS foundry in North America
- Over $5M capital equipment at UVML used for SIS fabrication
- Without support, UVML will cease SIS mixer fabrication
  - Restarting will then take years
- If no NA foundry, NA community will need to rely on European or East Asian SIS foundries
- ALMA design studies ($100K) insufficient to maintain SIS foundry
- Will serve as NA community resource for enabling superconducting detector and circuit development
- Will support receiver development at all NA sub-mm facilities

Proposed SIS Capabilities

- Three capabilities available to North American Community:
  - Maintenance of current $Nb/Al_2O_3/Nb$ SIS mixer capability
    - Supply Band 3/6/7 mixers to other facilities (e.g. EHT)
    - Enable development of balanced and/or broader IF mixers using current generation junctions
  - High current density Nb/Al-AlN/Nb SIS process
    - Enables lower noise over broader tuning range
  - Development of High Frequency Nb/Al-AlN/NbTiN SIS process
    - Enables near-quantum-limited performance through Band 10 and potentially beyond
- With base funding place, anyone can then propose, as part of small design study, to utilize UVML foundry for prototyping superconducting circuits (mixers for new bands, new detector types, etc.)

Cost of Baseline Support

- $300K total per year
  - Funds 40% UVML director, 100% research scientist, and 50% research technician)
  - $3,600 per month in lab supplies, $650 per month in cleanroom user fees, and $45K per year in equipment maintenance
- Through MOA between NRAO and UVA, UVA overhead only applied to insurance and cleanroom fees (avoids $130K per year indirect costs!)

- **This is a very good deal for the NA Sub-mm Community and will enable the next generation of receivers**