Characteristics of All-NbN Superconductor-Insulator-Superconductor Mixers for HSTDM

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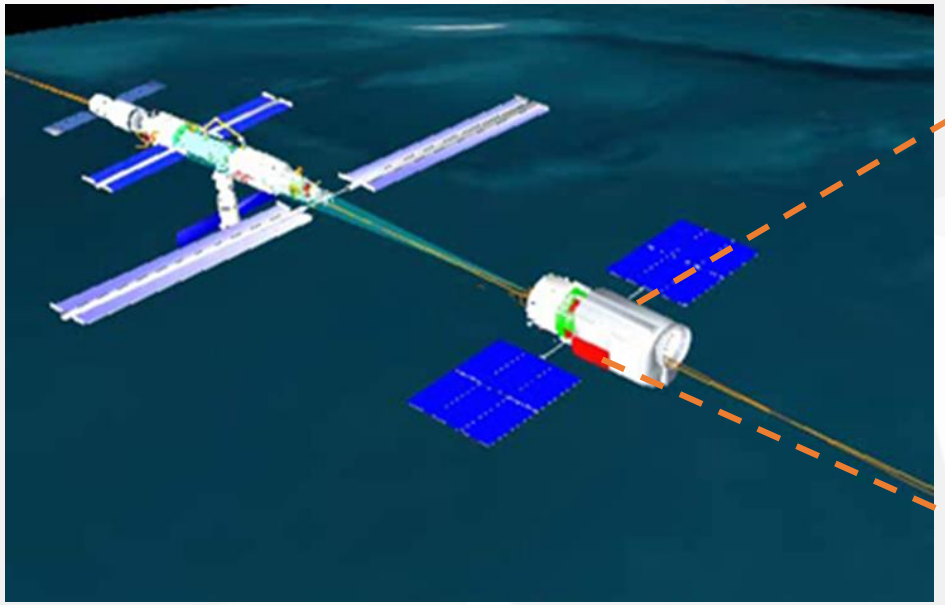
CONTENTS

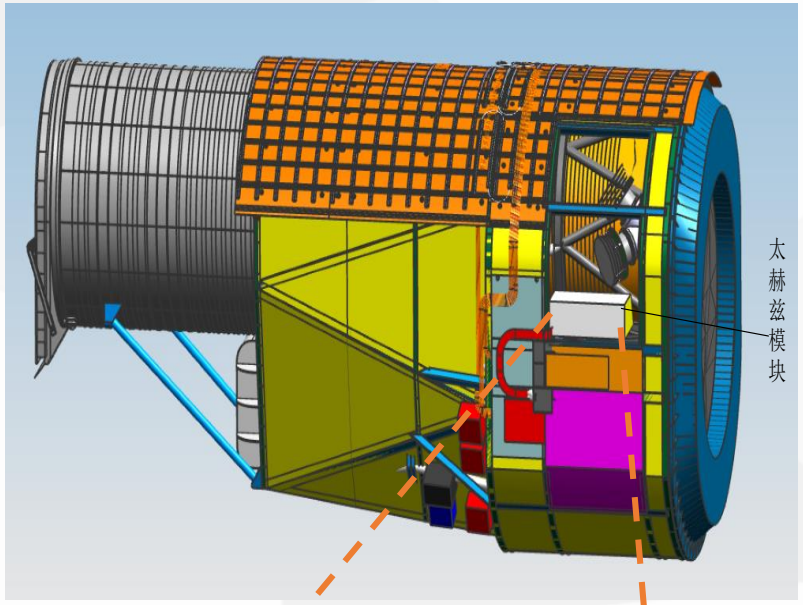
Part 1

Introduction

Why do this study

Chinese Space Station

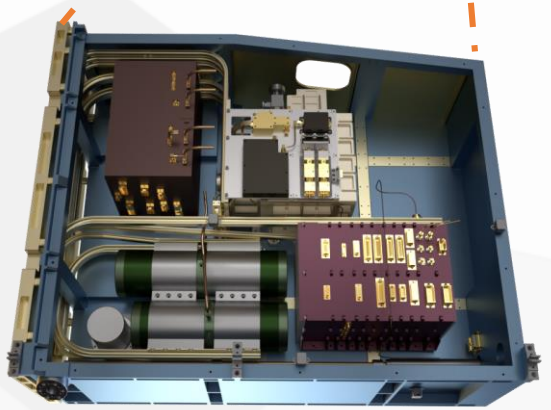




Optical facility

High-Sensitivity Terahertz Detection Module (HSTDM)

Receiver	All-NbN superconducting **SIS** mixer
Band	410-510 GHz
IF BW	0.1-1.1 GHz

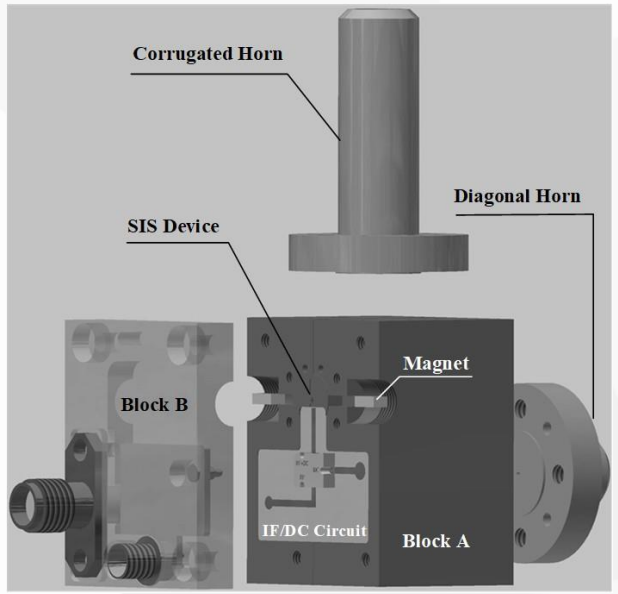


HSTDM

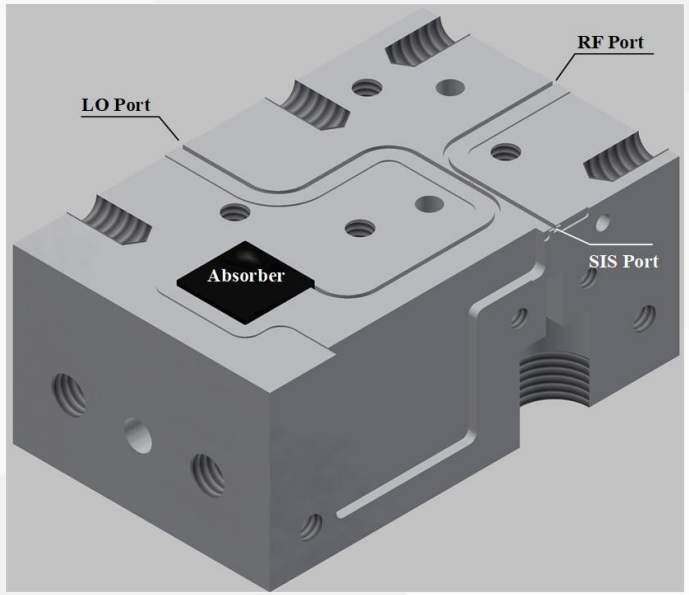
Part 2

Mixer Design

All-NbN SIS mixer design

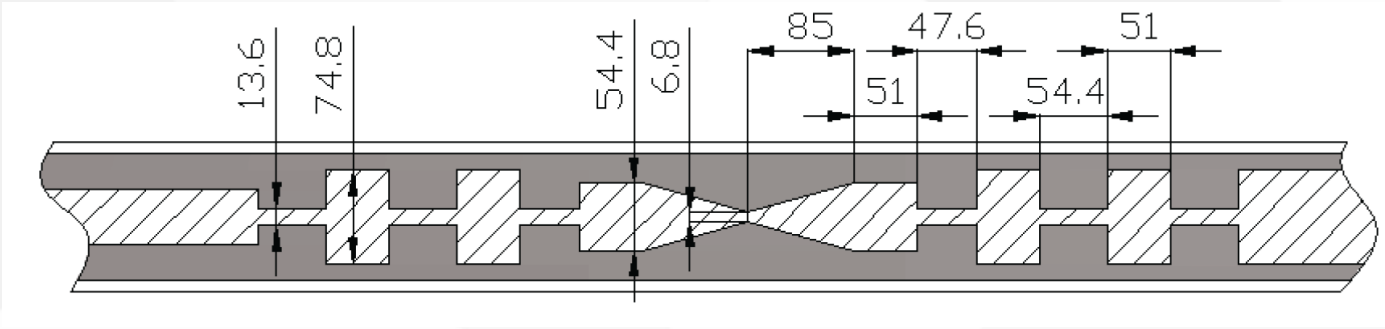


Schematic drawing of the all-NbN SIS mixer components



Schematic drawing of the coupler

Parameter	Value(μm)
Waveguide	510×255
Short cavity	0
Slot size	119×119
Chip size	102×51



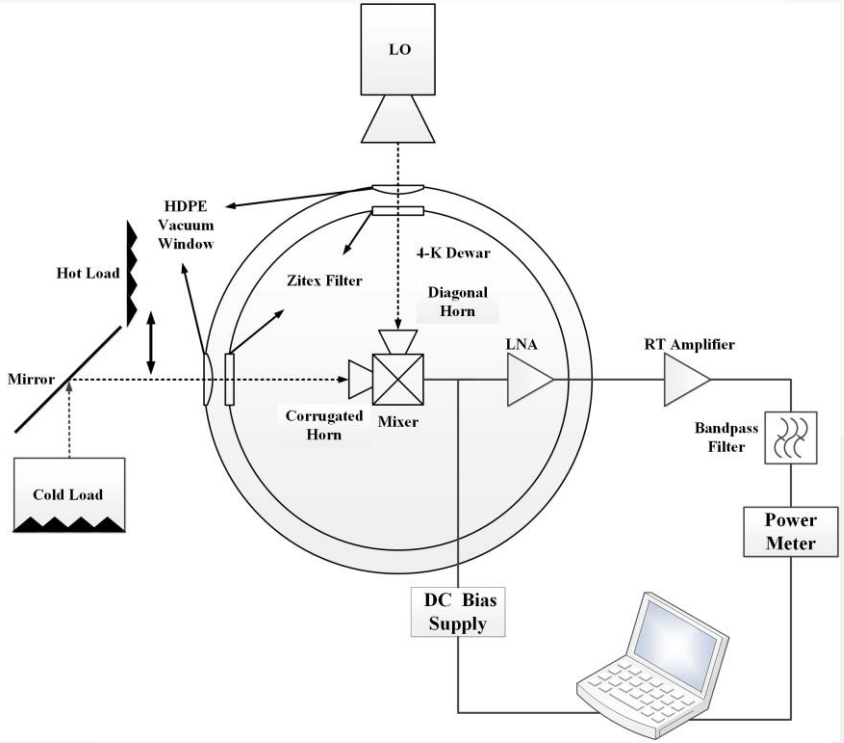
Design parameters of the all-NbN SIS chip

- NbN/AlN/NbN parallel-connected twin junctions
- NbN/MgO/NbN microstrip tuning circuit

Part 3

Test results

Test system

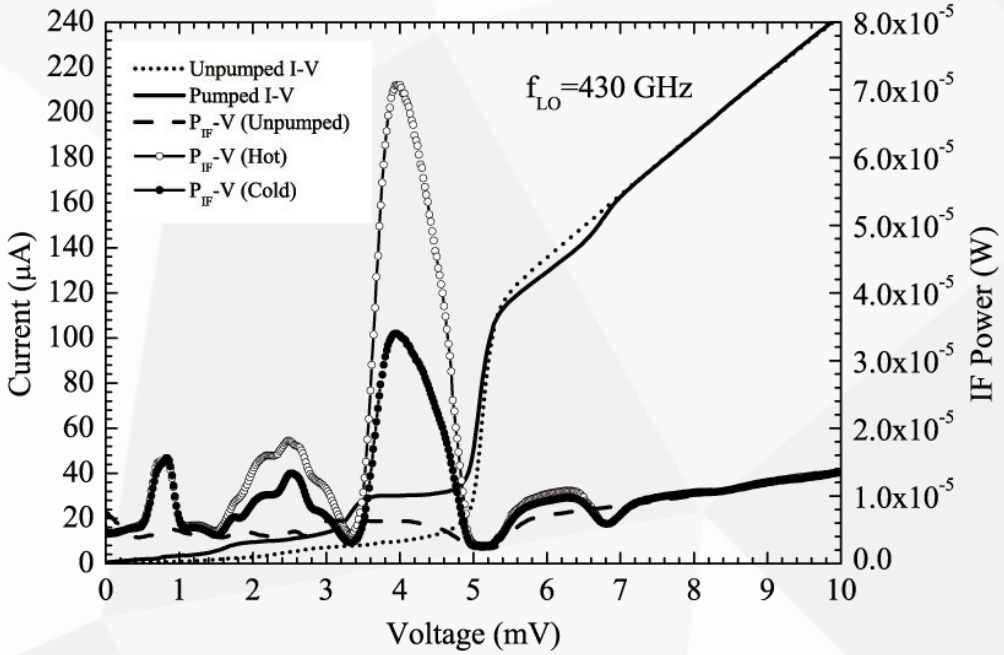


Schematic view of the ground test system

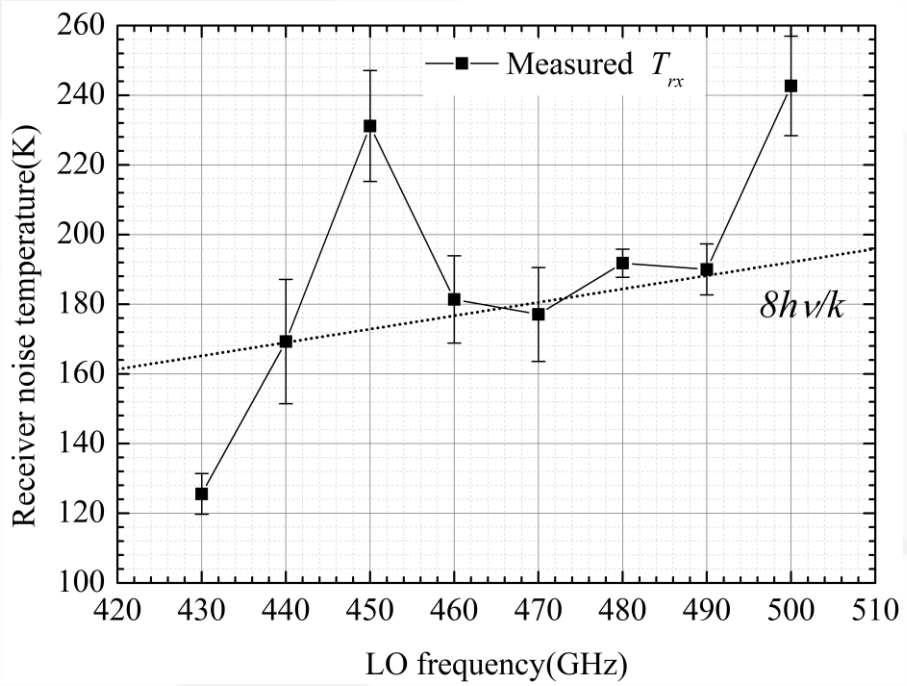
- Used diagonal horn and corrugated horn to couple LO and RF signals respectively
- Used magnet to suppress Josephson effect
- Measured in 4.2 K Dewar

IF component	Parameter	Value
LNA	Gain (dB)	30
	Bandwidth (GHz)	0.1-1.1
	Noise temperature (K)	<9
RT amplifier	Gain (dB)	30
	Bandwidth (GHz)	0.1-1.5
Filter	Center frequency (MHz)	780
	Bandwidth (MHz)	140

DC and noise characteristics

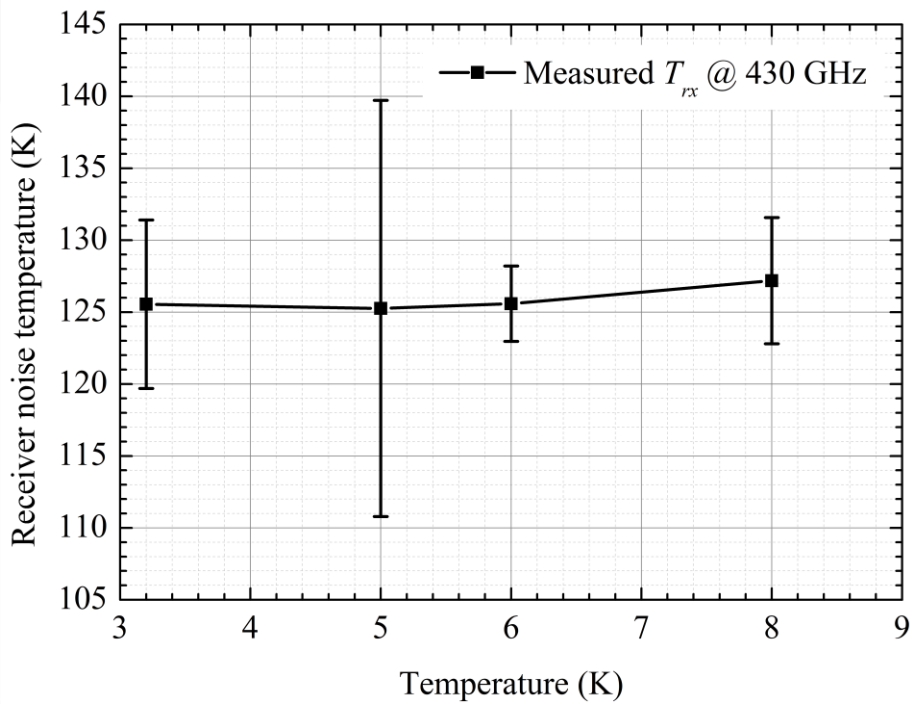


IF output power and junction DC current vs junction DC bias voltage for the all-NbN SIS mixer with and without the 430 GHz LO power



The measured uncorrected DSB receiver noise temperature (Trx) vs LO freauency for the all-NbN SIS mixer

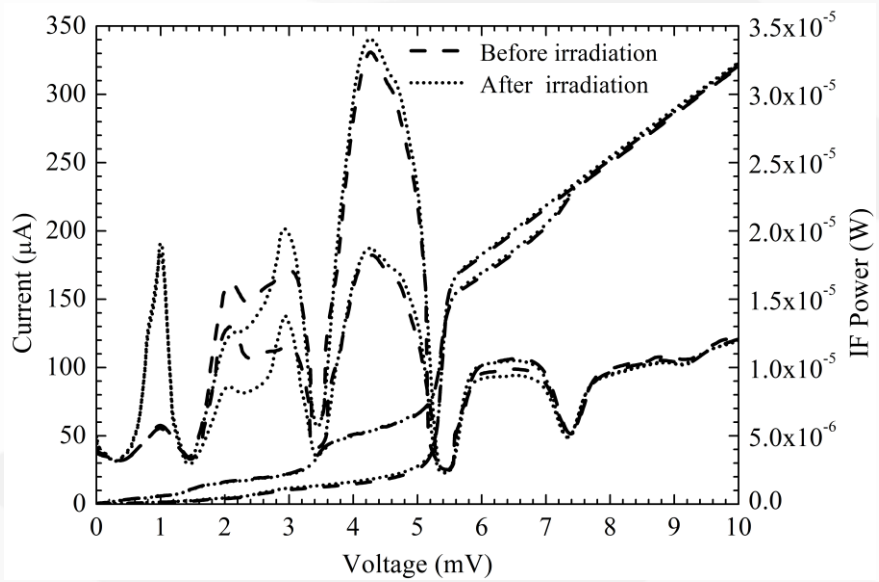
Test of space environment adaptability



The measured uncorrected DSB receiver noise temperatures (Trx) of the all-NbN SIS mixer at different bath temperatures when the LO frequency is 430 GHz

Space particle irradiation test

Radiation source	^{60}Co γ
Dose rate	0.1 rad(Si)/s
Total dose	20 k rad(Si)



The I-V and P-V curves of the all-NbN SIS mixer before and after the particle irradiation

Part 4

Conclusion

Conclusion

- We have developed a SIS mixer with NbN/AlN/NbN parallel-connected twin junctions (PCTJ) and NbN/MgO/NbN tuning circuit.
- The measured uncorrected DSB receiver noise temperatures (Trx) of the all-NbN SIS mixer in frequency range of 430-500 GHz is about eight times the quantum limit.
- It has very high noise stability below 8 K, and it also has good adaptability to space environment.

Thanks!