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TERAOPTICS

ACST THINK AHEAD

# 10 Times Lower Power Requirement Sub-Millimeter Wave Receivers Operating at Room Temperatures


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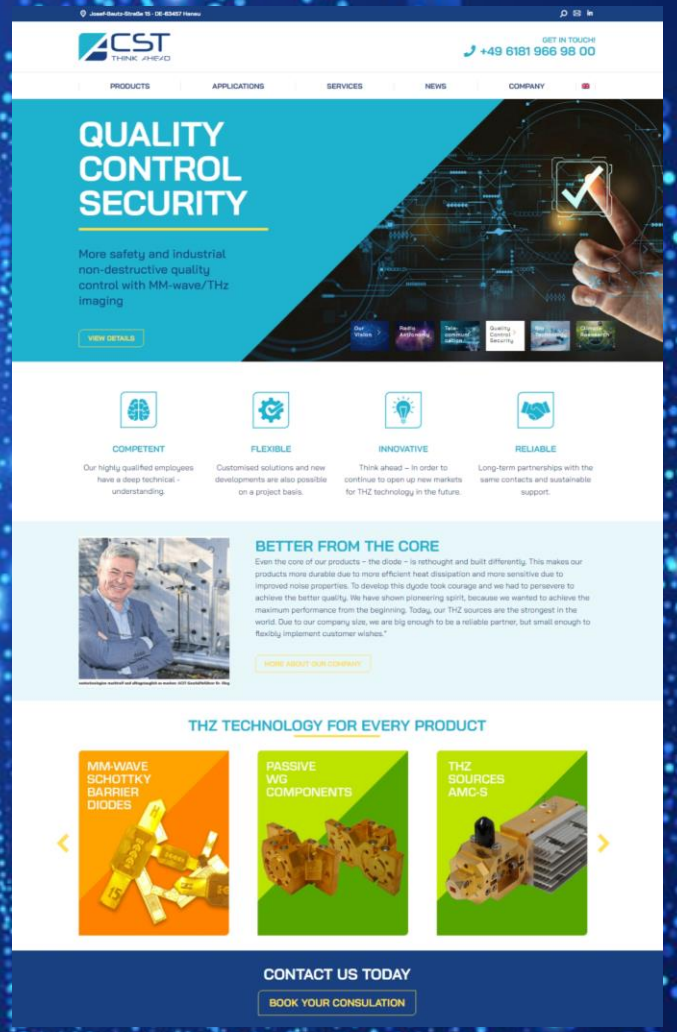

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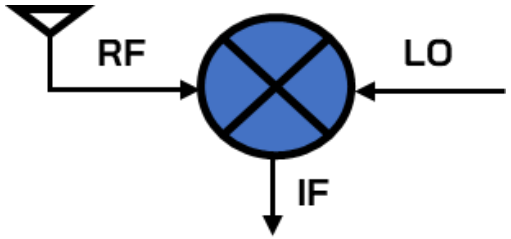
Element that plays a crucial role in heterodyne receivers

Responsible of the down-conversion

3 ports device with 2 inputs and 1 output

Different type of mixers depending on the RF/LO frequency relation:

- Fundamental ($f_{RF} = f_{LO}$)
- Harmonic ($f_{RF} = n * f_{LO}$)
- **Sub-harmonic ($f_{RF} = 2 * f_{LO}$)**



# Importance of Mixers in Heterodyne Systems



What to consider when choosing a mixer?

- Frequency Band
- Bandwidth → Narrow-Band vs Full-Band (Narrow-Band usually offers better performances requiring less LO power)
- Sensitivity
- LO power requirements
- Performances – (conversion loss/noise temperature)

# Different Receiver Technologies



**SIS & HEB mixers:**

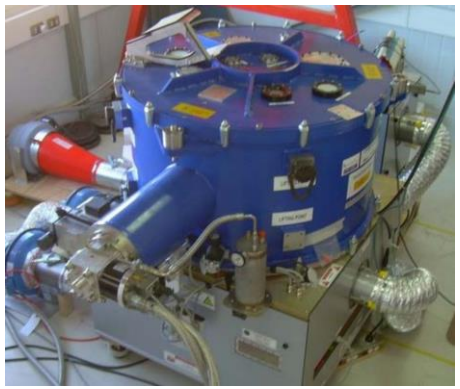
- Minimum input LO powers
- Outstanding Conversion Loss (1 – 10 dB)
- Need of cryogenic systems

**GaAs Schottky Diode Receivers:**

- Room Temperature Operation
- Great Conversion Loss (4 – 20 dB)
- Need of high LO powers

ALMA:

1 m diameter cryostat



| Mixer Type: | CL (dB) | Frequency (THz) | LO Power (mW) | Temp. |
|---|---|---|---|---|
| HEB | 10 | 0.4 - 5 | 0.001 - 0.01 | CT |
| SIS | 1-10 | Up to 1.4 | 0.01 - 0.1 | CT |
| GaAs Schottky | 4-20 | Up to 2.5 | 2 - 10 | RT |
| InGaAs Schottky | 7-20 | Potentially equal to GaAs | 0.1 - 2 | RT |

T. de Graauw, "The Atacama Large Millimeter/submillimeter Array," 2011 International Conference on Infrared, Millimeter, and Terahertz Waves, Houston, TX, USA, 2011, pp. 1-4, doi: 10.1109/irmmw-THz.2011.6105024.

# InGaAs Schottky Diode Mixer at 0.3 THz

InGaAs Schottky Diodes have been already used in direct detection in space applications
MetOp-SC

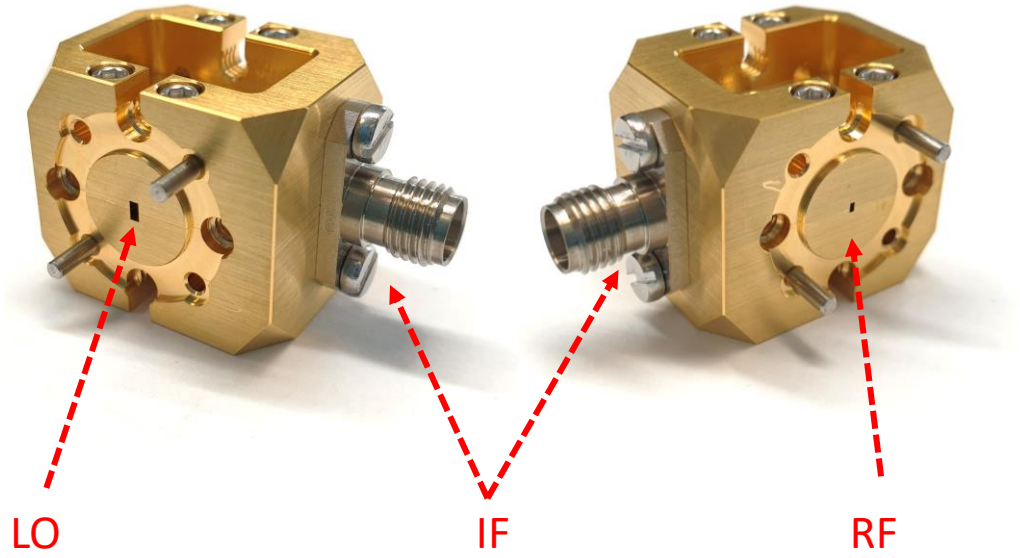
Reliability demonstrated

Mature technology translated to mixers

InGaAs Full-Band mixers:

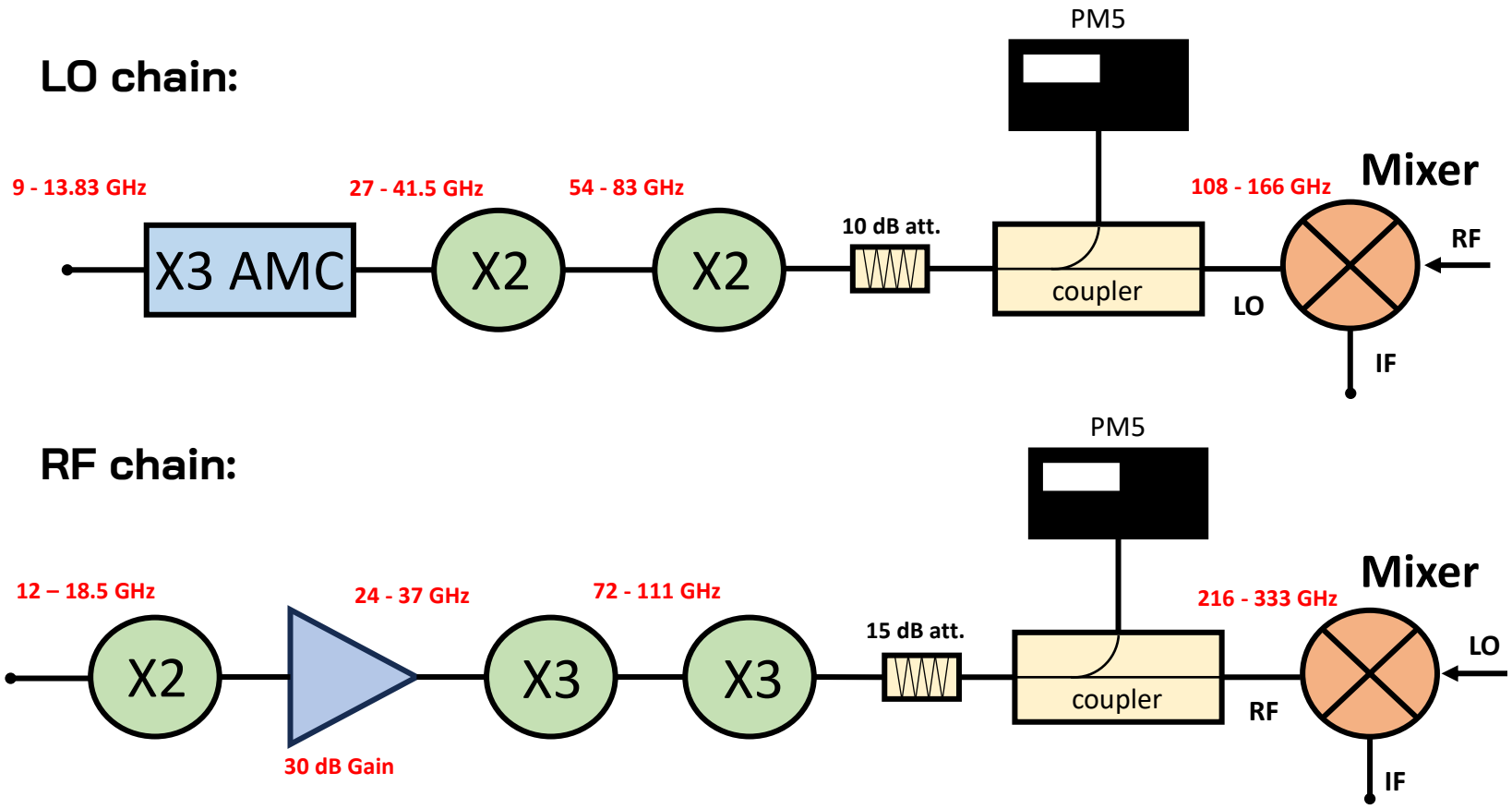
- Reduced LO power requirements as SIS and HEB technologies
- Room temperature operation as receivers based on GaAs
- Good performances

## Block and main characteristics of the presented mixer

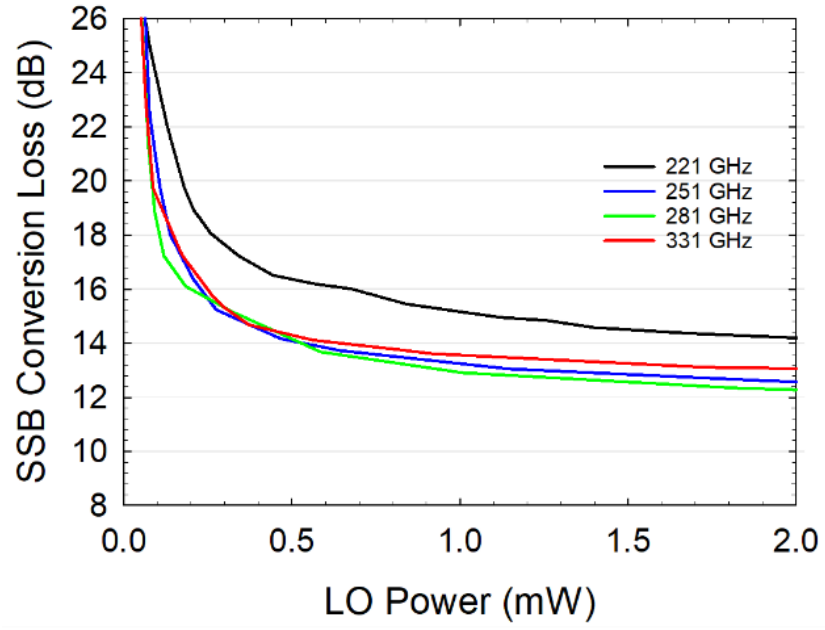


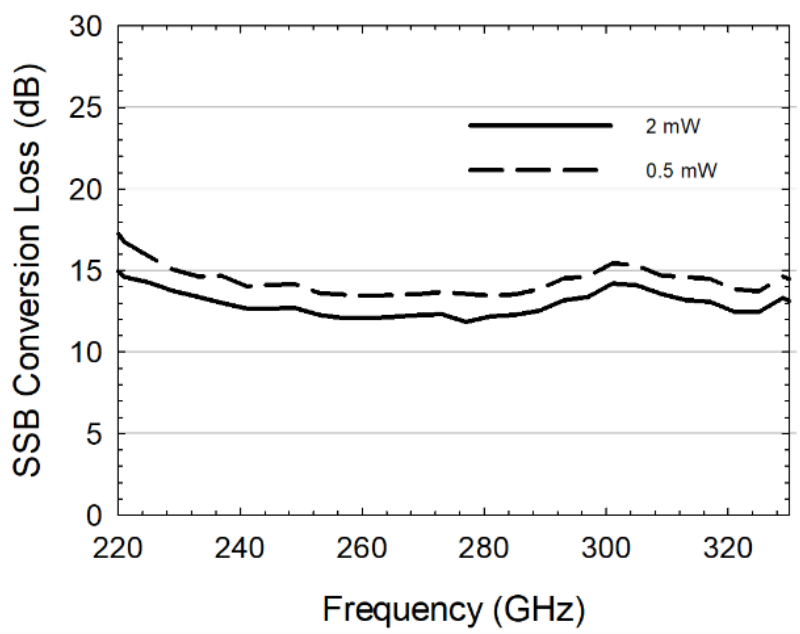

| Tech. Specifications | Min. | Typ. | Max. |
|---|---|---|---|
| LO Freq. (GHz) | 110 | | 165 |
| LO Power (dBm) | -4 | -1 | 1 |
| RF Freq. (GHz) | 220 | | 330 |
| RF Power (dBm) | | | -15 |
| IF Freq. (GHz) | 0 | | 40 |
| SSB Conversion Loss (dB) | 12 | | 15 |

## Setup to measure the conversion loss of the full-band mixer

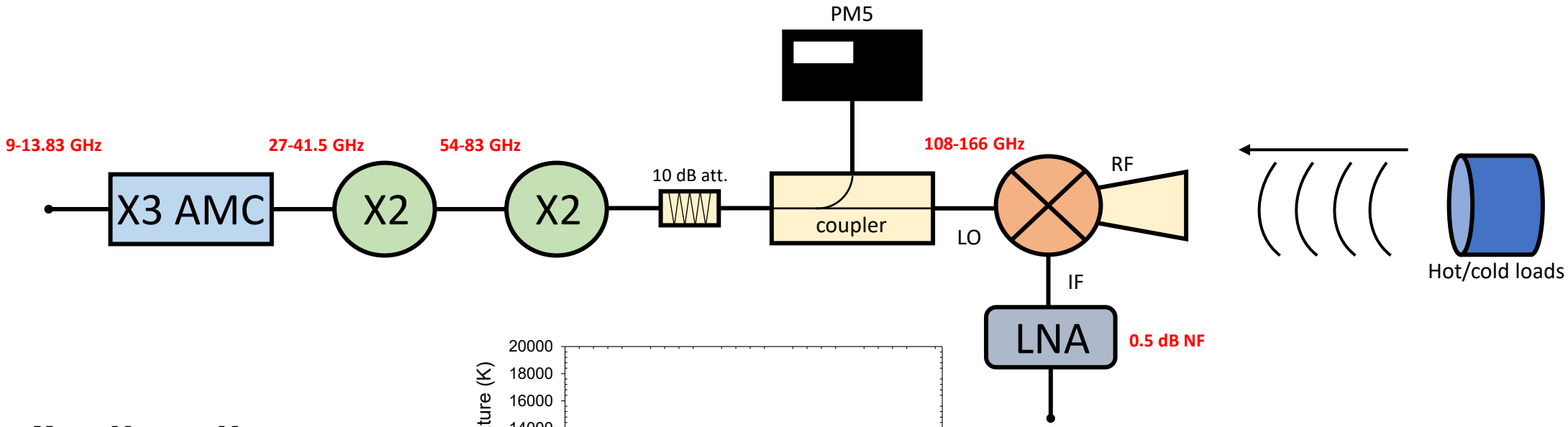



## Single side band conversion loss performances



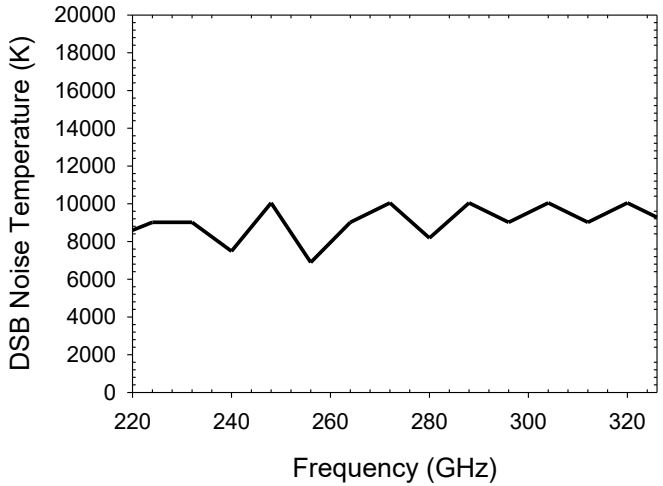



## Setup to measure the noise temperature of the full-band mixer



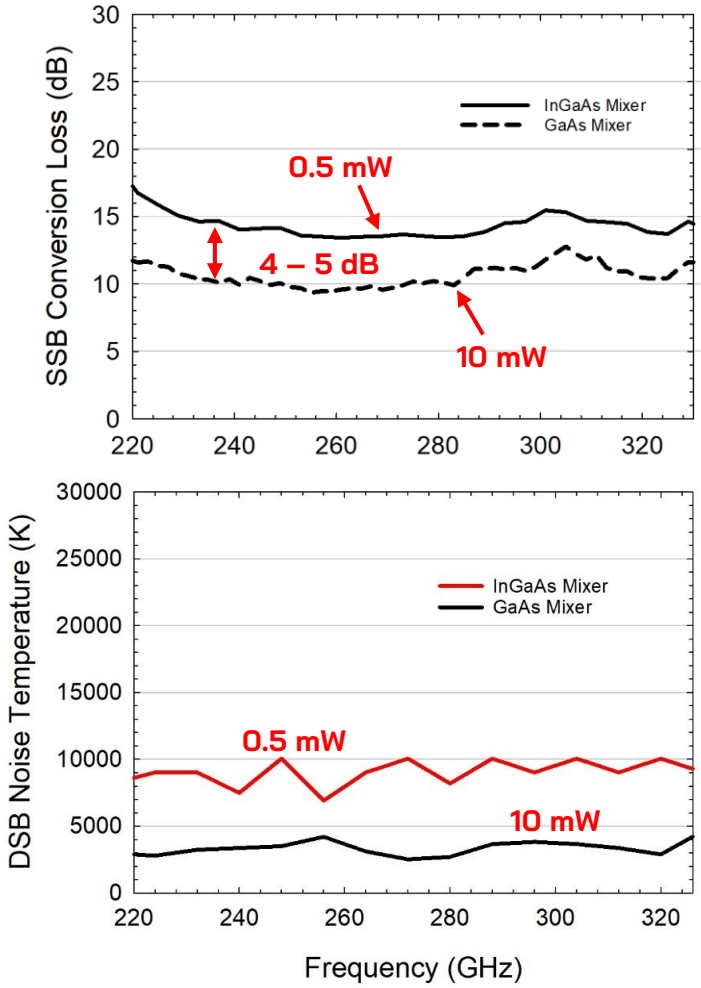

$$Y = N_{hot} - N_{cold}$$

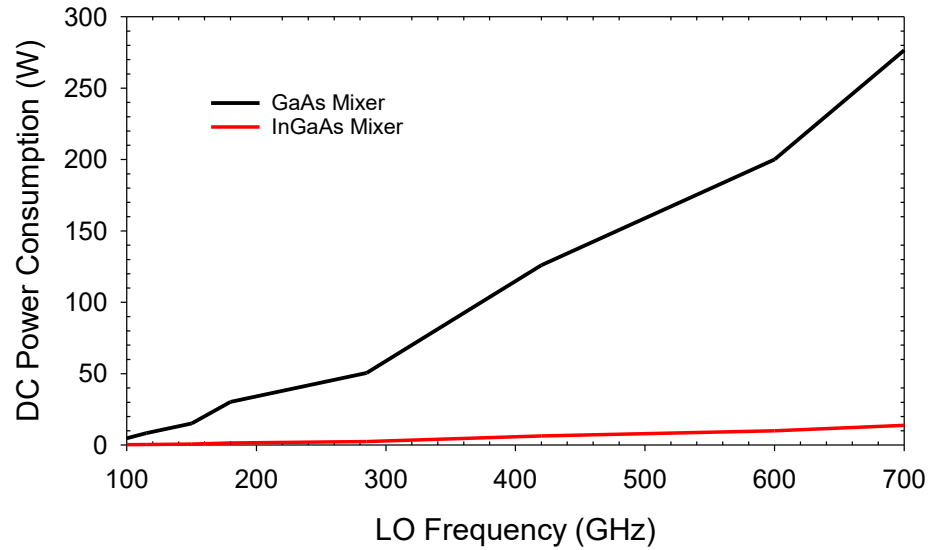
$$T_{DSB} = \frac{T_{hot} - Y * T_{cold}}{Y - 1}$$



# InGaAs Schottky Diode Mixer at 0.3 THz

## Comparative with GaAs



# Conclusions

- Advantages/disadvantages of SIS/HEB & GaAs Schottky Diode Receivers
- InGaAs Schottky Diode Receivers as an alternative solution
- Advantages of InGaAs Schottky Mixers:
  - Room temperature operation -> avoid the use of any cooling system
  - Low LO input powers -> reduced DC power consumption
  - Good performances-> huge margin of enhancement
  - Broad RF & IF bands

Thank you ☺