# Seventh International Symposium on Terahertz Technology

# Welcoming Remarks

Gordon Johnston, NASA HQ
Carl Kukkonen, JPL

University of Virginia, Charlottesville
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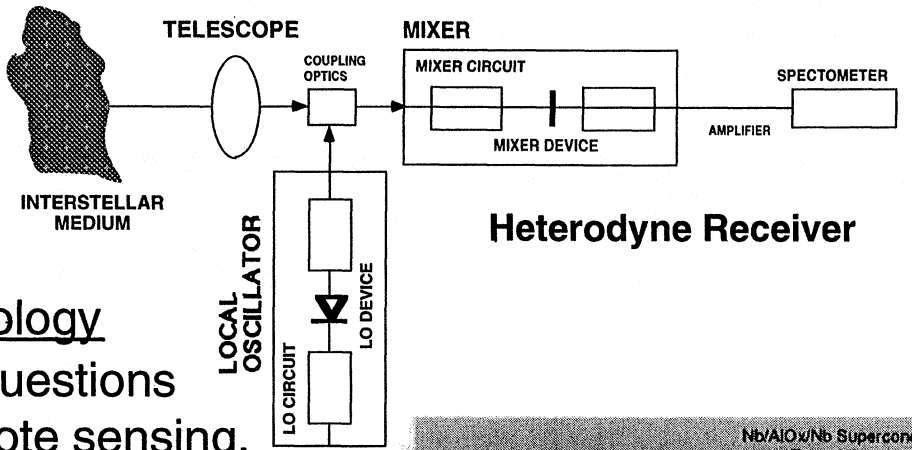
# Submillimeter Heterodyne Sensor




**Heterodyne Receiver**

<u>Why Submillimeter Technology</u>

Addresses fundamental questions of astrophysics, earth remote sensing, and planetary science

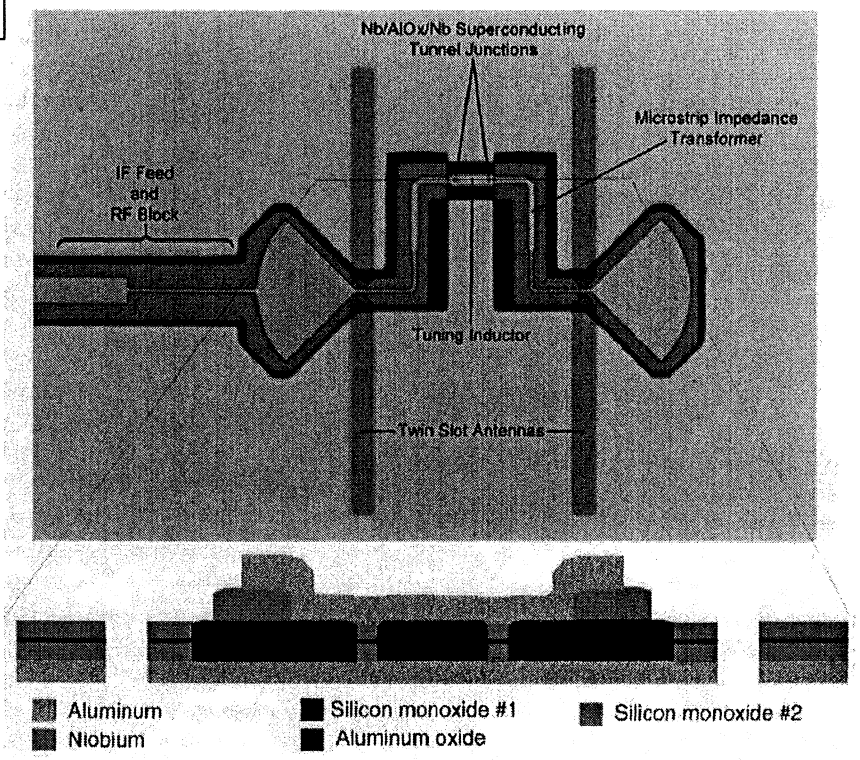
- Birth and death of stars
- Ozone depletion
- Water in the solar system

<u>Required data</u>

- Composition ($H_2O$, $O_2$,O, C) mass, density, temperature and velocity of material in interstellar medium

<u>Challenge</u>

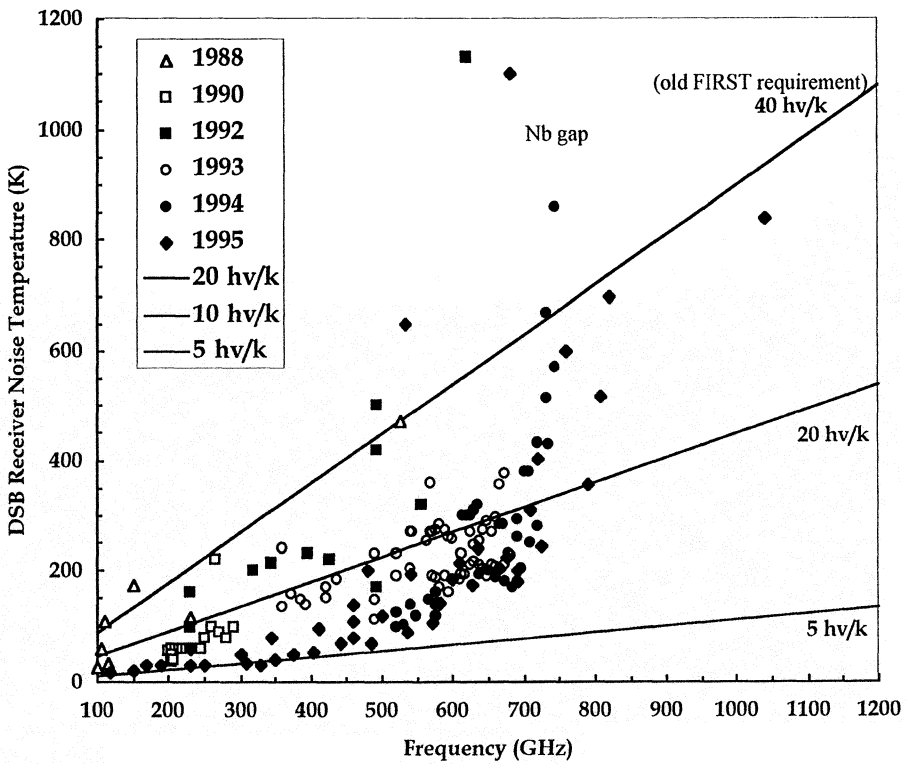
Demonstrate up to 2.5 THz Key Component Technology (mixer, LO)



# FIRST Technology Needs

- FIRST goals
  - Complete Spectrum of astrophysical sources from 480-1230 GHz
- Technical Challenges
  - Broadband, Fixed tuned Local Oscillators
    - » Multipliers
    - » Photomixer LO
  - Superconducting Mixers
    - » Remarkable progress to date as exemplified by Kukkonen Award

## Nb SIS Mixer Progress



# Code X Supported Technology Development for Earth Applications: Earth Observing System Microwave Limb Sounding

• MLS is one of the instruments intended for deployment on the NASA Earth Observing System Chem I platform in the 2002 time frame for:

(1) Global monitoring of stratospheric ozone and key molecular species which play a significant role in ozone depletion chemistry,
(2) Measurements of upper tropospheric water and stratospheric greenhouse gases which play a role in climate change and global warming
(3) Detection of volcanic pollutants in the lower stratosphere
(4) Measurements of chemical species through ice clouds and aerosols



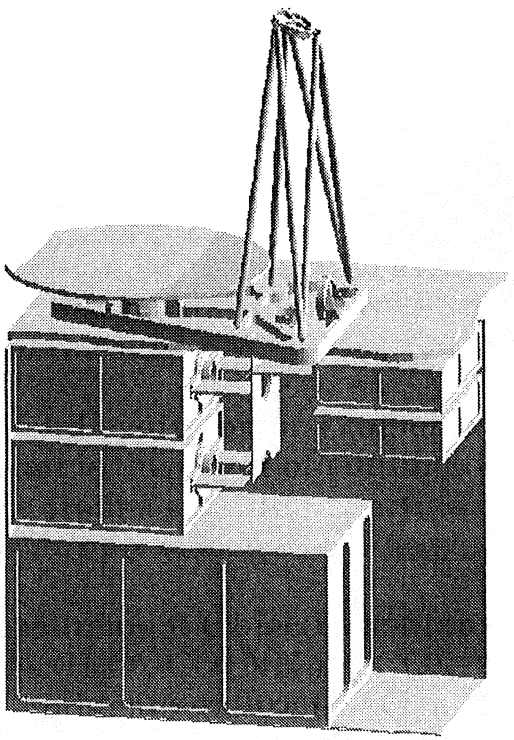
• To achieve the intended science objectives, MLS will make use of state-of-the-art millimeter and submillimeter-wave radiometer technology, developed by NASA's Office of Space Access and Technology. These include:

Planar Schottky-diode mixers and varactor multipliers up to 640 GHz
Low-noise MMIC front-end amplifiers up to 190 GHz
2.5 THz open-structure semiconductor mixers
High Tc superconducting hot-electron bolometer mixers up to 2.5 THz
Solid-state GaAs photomixer local oscillator sources up to 2.5 THz
Laser fed quantum-well mixers for power generation above 3 Thz

# Microwave Instrument for the Rosetta Orbiter

**PI: Sam Gulkis**
**Experiment Manager: Margaret A. Frerking**

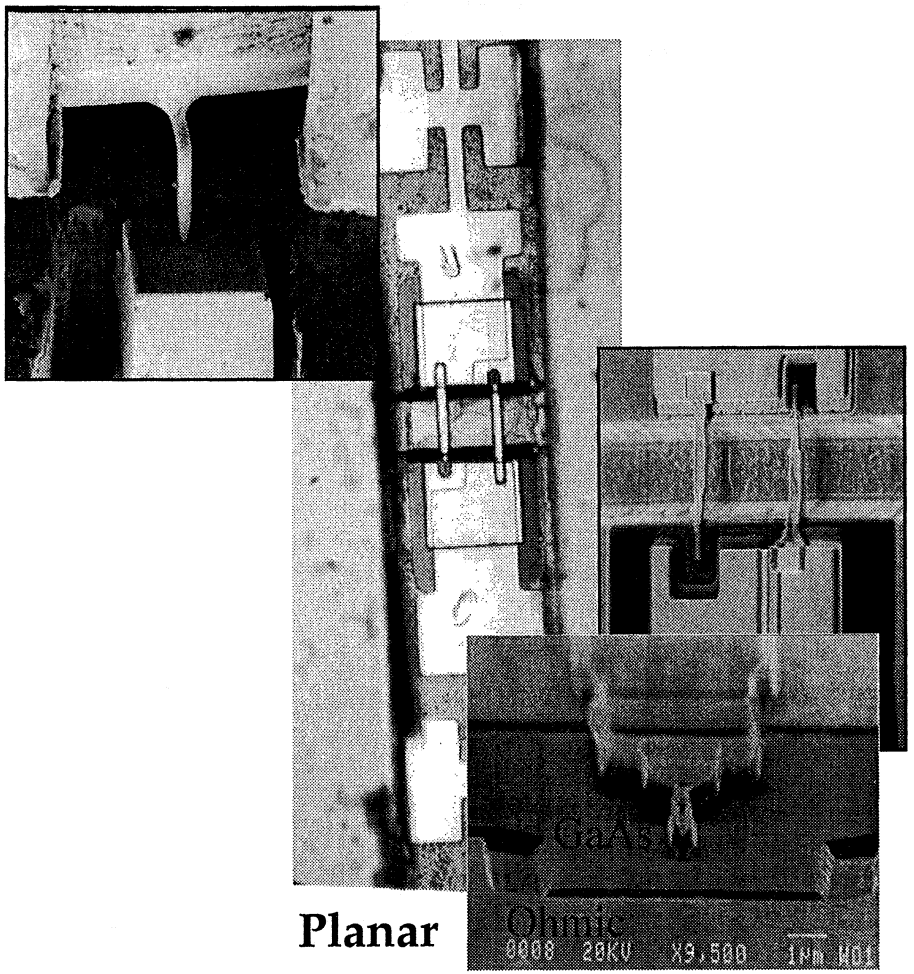
- The NASA Code X Submillimeter Sensors program is opening the submillimeter wave region for planetary exploration
- MIRO is based on technologies developed by NASA Code X Submillimeter Sensors Program
- Rosetta Mission: Orbit a comet beyond Jupiter and observe it through its closest approach to the sun
- Formation and evolution of a comet's coma and tail is the result of sublimation of water ice from a small cometary nucleus - Whipple (1950)
- MIRO Measurement Objectives: Map gas abundances ($H_2O$ , CO, $NH_3$, $H_2CO$), dynamics, and temperature from comet's quiescent through active stage



# Key Technologies for MIRO

- Submillimeter Wave Subharmonic Mixer with Two Planar Schottky Diodes
- Submillimeter Wave Multiplier with Four Planar Varactor Diodes
  - Both developed by Code X Submillimeter Sensors Program
- Replaces whiskered contacted diode used on UARS MLS
- Provides critical performance with enhanced reliability
  - Essential for Rosetta Mission which will be in space 9 years before 18 month observational period begins

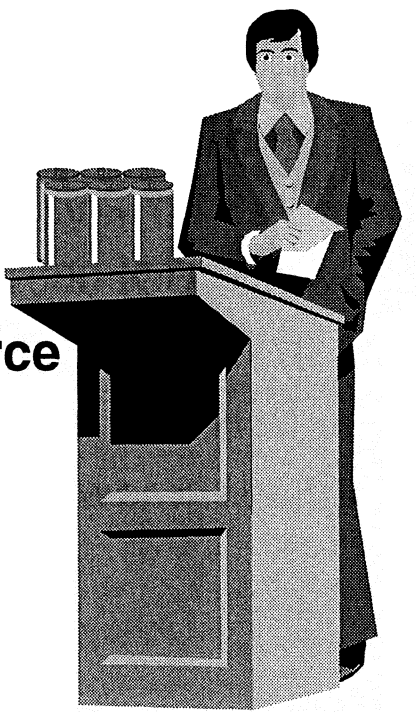
**Whisker Contact**



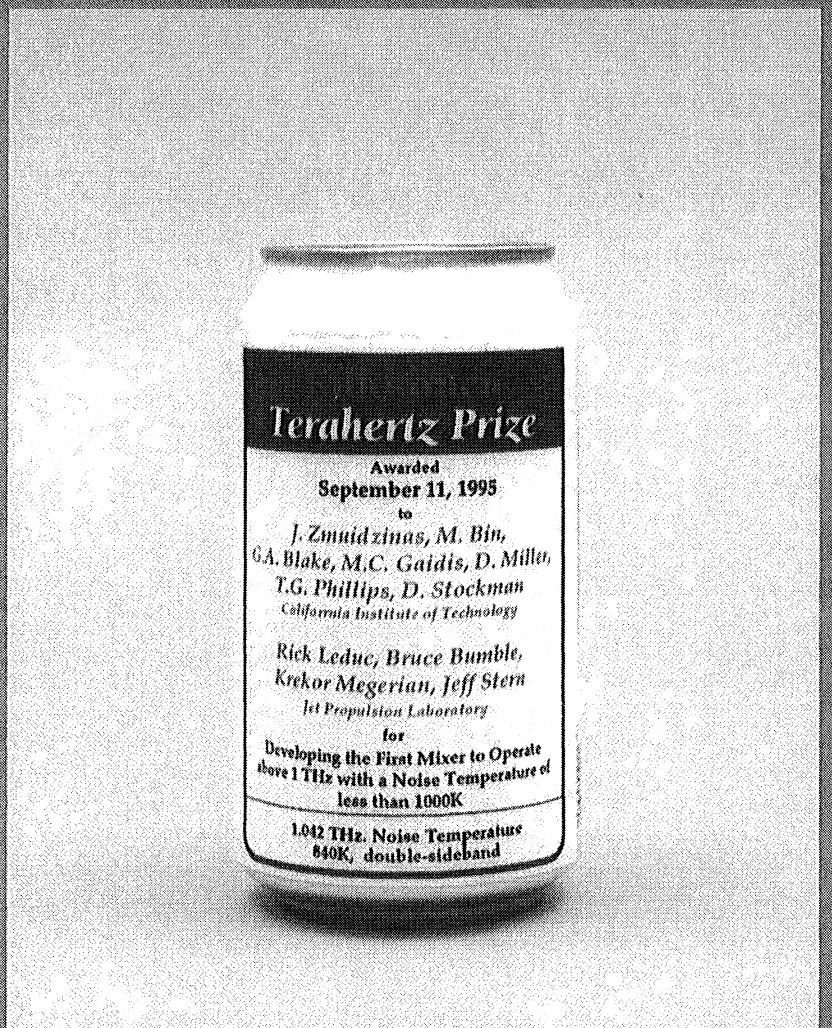

**Planar**

# Kukkonen Challenge

- **First SIS mixer with**
  - **Frequency > 1 THz**
  - **$T_{sys}$ < 1000 K DSB**
- **First Solid State Local Oscillator Source**
  - **Frequency > 1 THz**
  - **Output power > 100 microwatts**

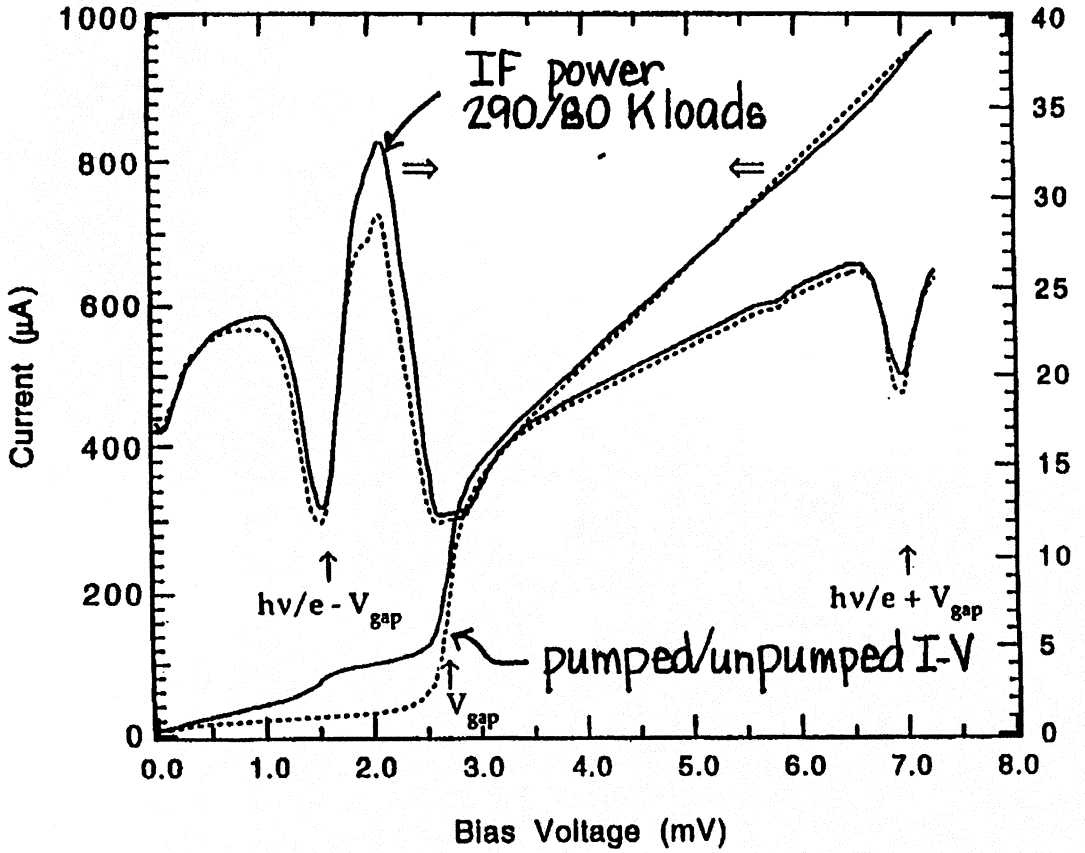


# Kukkonen Terahertz Prize




# Submillimeter Heterodyne Sensor Astrophysics

1042 GHz SIS Mixer
Bin et al. (1995)




$T_{rec}$ = 840 K (DSB)

uncorrected;
$T_{physical}$ = 2.5 K

**Nb/Al-Oxide/Nb junctions with aluminum (normal metal) tuning circuit**

**Note: First SIS mixer which out performs GaAs Schottky diode mixer by a large margin at 1 THz**