Tunable All-Solid-State Local Oscillators to 1900 GHz

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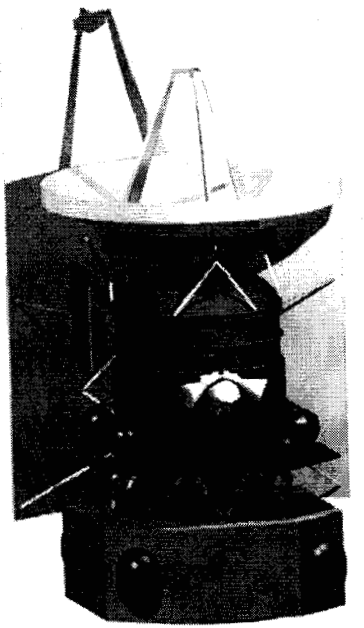
- Matt Dickie – Schottky device fabrication

Contracts / Collaborators

- Contract with UMass, Dr. Neal Erickson
  - Development of 140 GHz – 1.9 THz frequency multipliers
  - Delivery of misc. hardware including power meters, directional couplers, etc.
- Contract with Radiometer Physics, Meckenheim, Germany
  - 600 GHz planar tripler
  - Delivery of misc. hardware including submillimeter horns, optics, etc.

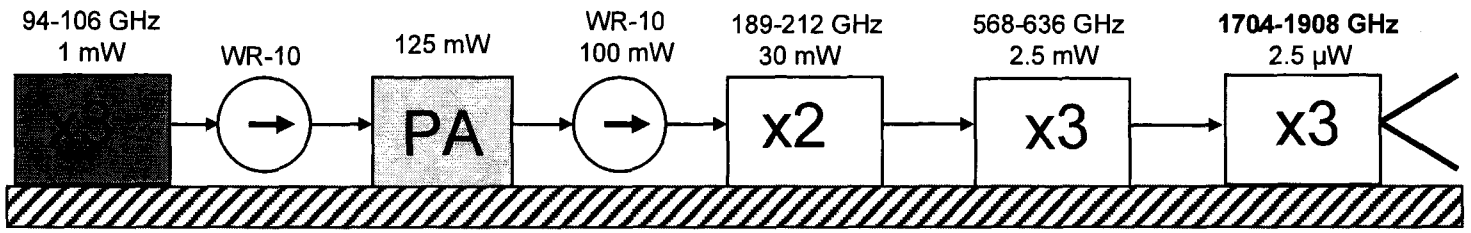
Background / Motivation

- Herschel Space Observatory
  - 3.5 meter passively cooled telescope
  - Covers 60 – 670 μm (450 GHz – 5 THz)
  - Launch in 2007
  - Three science instruments: PACS, SPIRE, and HIFI
- Band 6 of the Heterodyne Instrument for the Far-Infrared (HIFI)
  - Solid-state LOs will pump hot electron bolometer (HEB) mixers
  - Covers 1408 – 1908 GHz to observe spectra in the interstellar medium
    - N^+ at 1461 GHz
    - H_2O at 1661, 1670, and 1717 GHz
    - OH lines from 1834.7 to 1837.8 GHz
    - C^+ at 1900.5 GHz
  - Broken up into 4 sub-bands



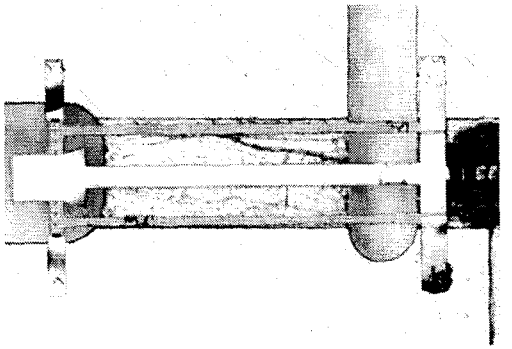
➔ The purpose of these sources is to pump HEB mixers from 1.4 to 1.9 THz

1.7 – 1.9 THz Configuration



- Fundamental oscillator multiplied up to 100 GHz
- Power amplifier produces 100 to 230 mW
- Frequency multiplier chain
  - Planar GaAs Schottky diodes
  - Multi-diode, balanced configurations
  - Monolithic devices in low-loss waveguide circuits
  - No mechanical tuners
  - Fixed-tuned bandwidth typically > 10%

Schottky Devices for Band 6

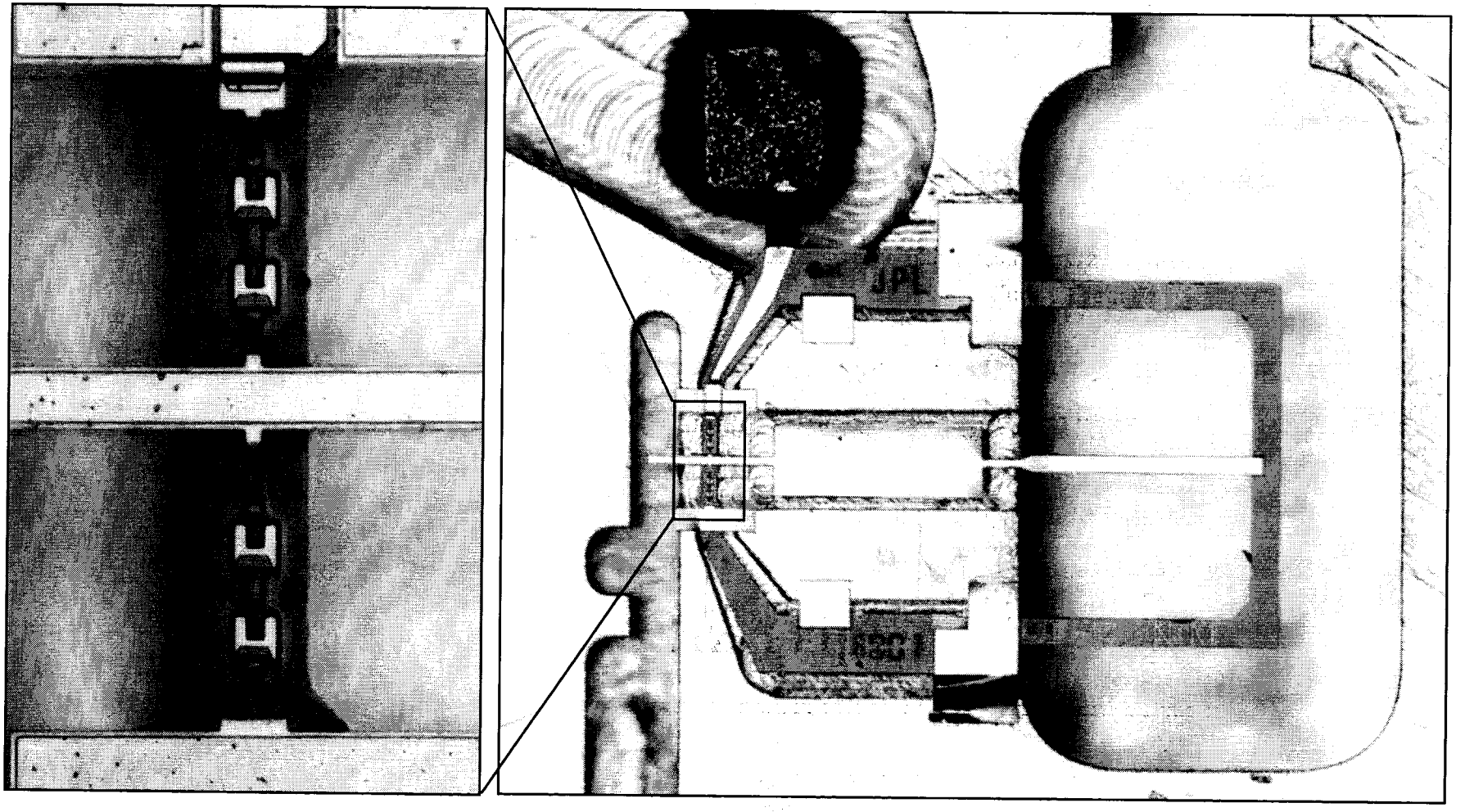


- Based on planar GaAs Schottky diodes
- Multi-diode balanced configurations
- Mostly doublers, plus a few triplers
- Low frequency multipliers (< 1 THz) on "substrateless" process
- High frequency multipliers on membrane process
- See previous publications for more info

- Tested substrateless devices
  - 150 GHz doubler
  - 300 GHz doubler
  - 190 GHz doubler
  - 375 GHz doubler
  - 750 GHz doubler
  - 200 GHz doubler
  - 400 GHz doubler
  - 800 GHz doubler
  - 600 GHz tripler

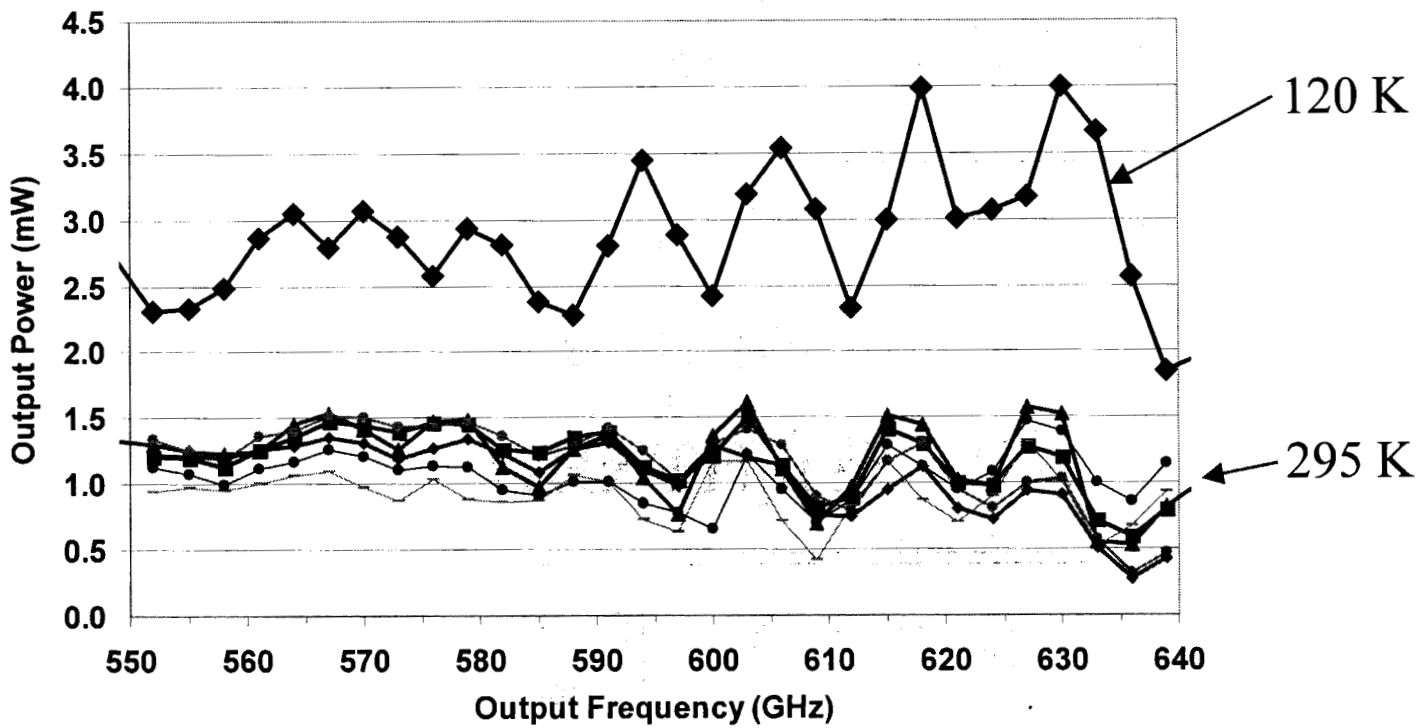
- Membrane devices being tested for Band 6
  - 1.5 THz doubler
  - 1.6 THz doubler
  - 1.8 THz tripler

600 GHz Tripler



600 GHz Tripler

- Consistent broad-banded performance
- 295 K measurements with 23 mW input
- 295 K efficiency 4-8%
- Chain improves dramatically when cooled to 120 K
- 120 K efficiency 7-13%



Manufacturing Challenges

- Below 600 GHz (500 μm)
  - Device yield high (> 50%)
  - Machining specialized & high precision
  - Assembly and test somewhat specialized
  - Performance repeatable *if* tolerances carefully controlled
- Above 1.2 THz (250 μm)
  - Device yield low (< 50%)
  - Devices tiny, fragile, difficult to handle
  - Very small features difficult to machine
  - Very tight machining and assembly tolerances (< 5 μm)
  - Limited test equipment and techniques
  - All processes highly specialized
  - Large variation in performance from block to block
- For continued progress...
  - Designer must increasingly consider tolerances and manufacturing issues
  - Improved manufacturing technologies needed

Summary

- Broadband, tunerless, planar, all-solid state, flight qualified sources demonstrated to 1908 GHz
- Produced 24 μW continuous power at 1.78 THz
- Novel 4-anode tripler produced 4 μW at 630 GHz
- Three quarters of 1400-1900 GHz band covered with > 2.5 μW
- Wide range of tunerless planar sources demonstrated from 140 to 1900 GHz

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