The Submillimeter Mission (SMMM) Heterodyne Instrument

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SUBMILLIMETER MISSION HETERODYNE INSTRUMENT

SMMM Science Objectives

Complete submillimeter high resolution spectral line survey of 100 sources
- 40 molecular clouds in the Milky Way
- 30 galaxies
- 30 sources of opportunity

Sensitivity: Spectral line confusion limit ~2mK

Molecular Clouds
- Identify composition
- Study chemistry
- Determine physical conditions: temperature, density, mass
- Study dynamics: velocity structure, thermal mechanisms
- Detailed study of stellar evolution

Galaxies
- Spectroscopy of galaxies to z=2
  - Well known visible and IR lines red shifted into submm by Hubble expansion

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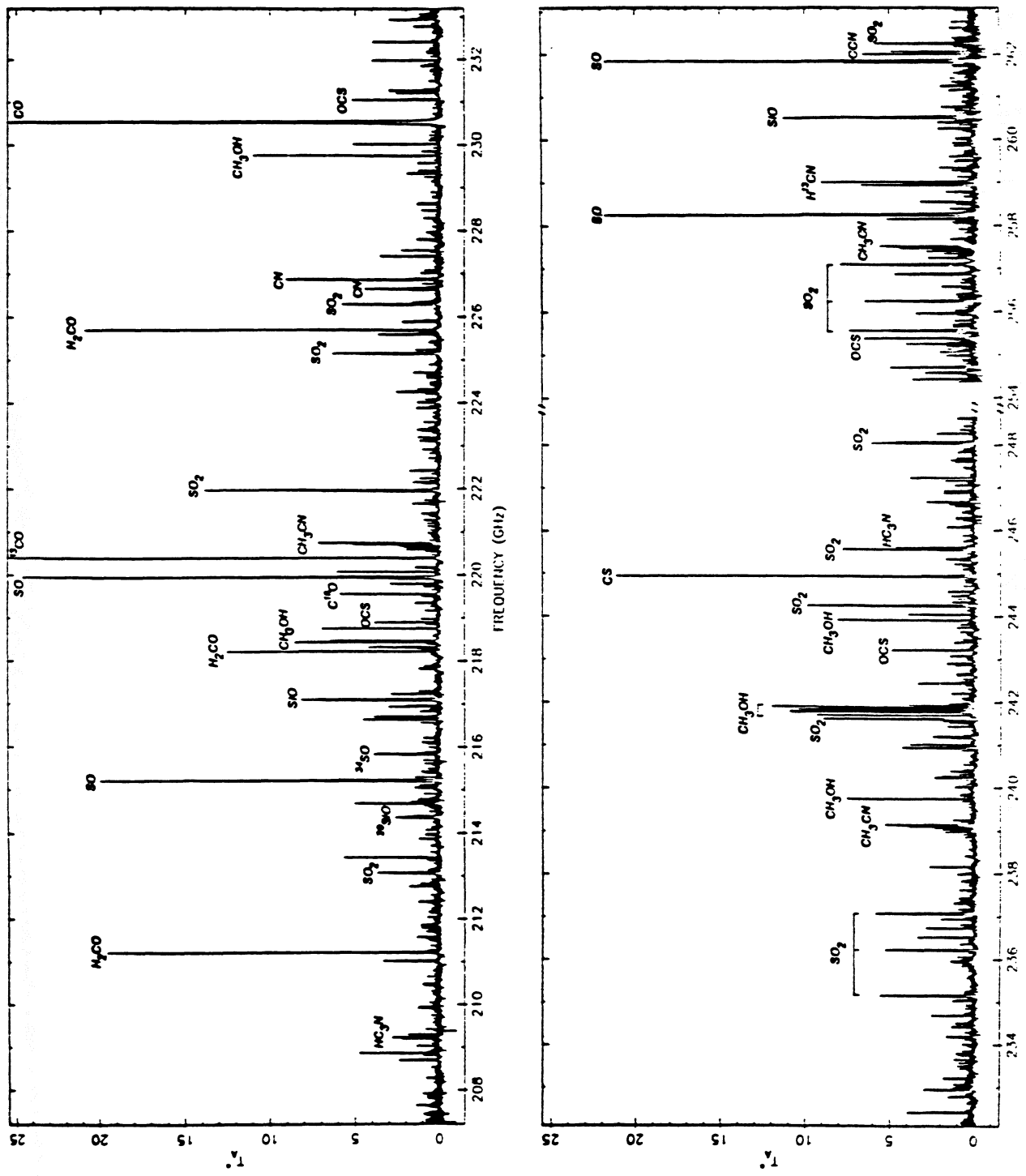
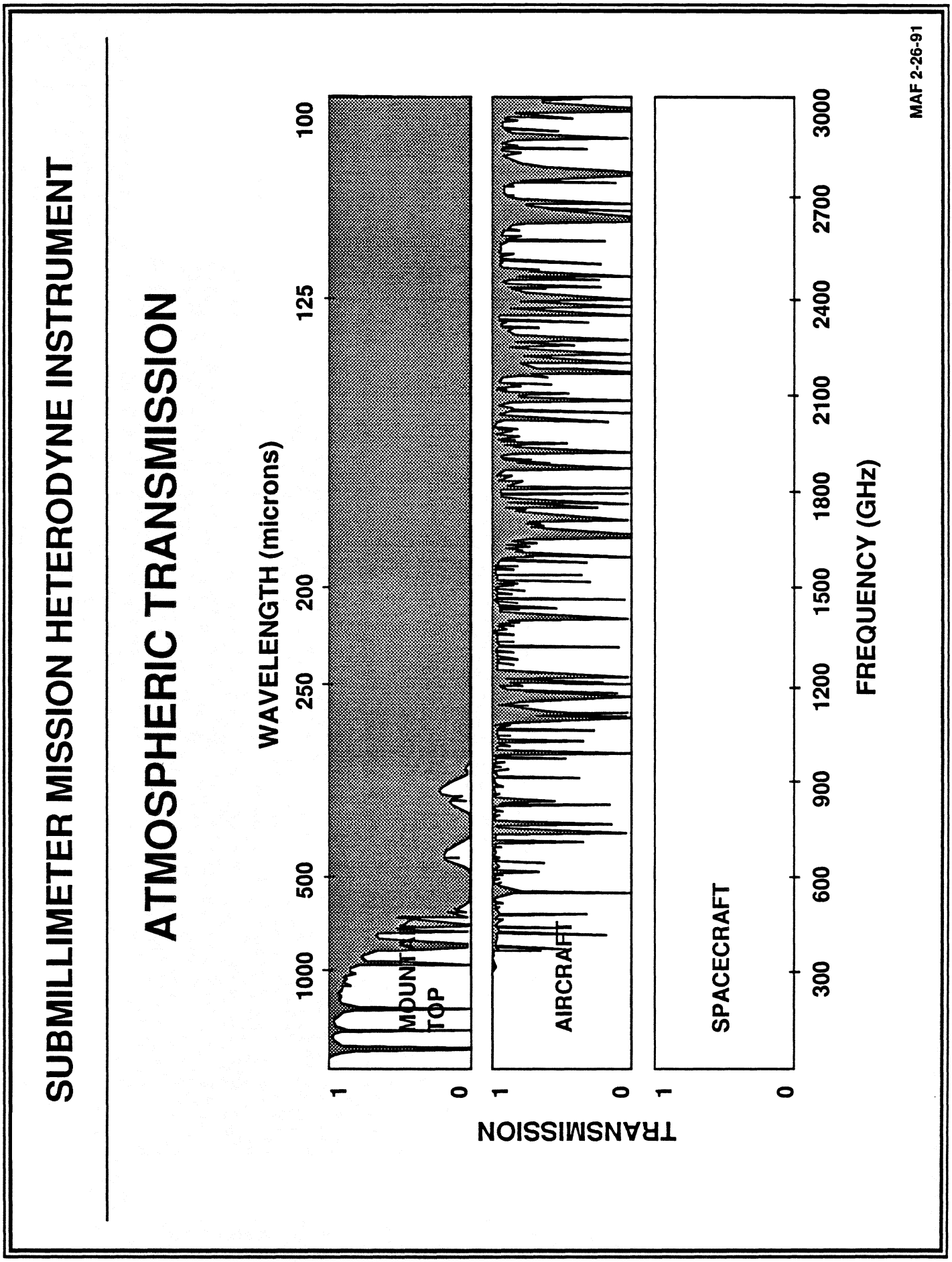


Figure 1.3: A compressed view of the OVRO spectral line survey of OMC-1.


SUBMILLIMETER MISSION HETERODYNE INSTRUMENT
ATMOSPHERIC TRANSMISSION
WAVELENGTH (microns)
1000
500
250
200
125
100
MOUNTAIN TOP
AIRCRAFT
SPACECRAFT
TRANSMISSION
1
0
1
0
1
0
300
600
900
1200
1500
1800
2100
2400
2700
3000
FREQUENCY (GHz)
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SMMM Description

Two Concepts:
Submm Explorer (SMME) and Submillimeter Imaging Line Survey (SMILS)
2.5 or 3.7 m diameter ambient temperature telescope

Liquid Helium cooled focal plane

SIS heterodyne receivers from 400 to 1200 GHz (SMILS)
500 to 1000 GHz and 1145 GHz (SMME)

100 - 300 μ (1000 - 3000 GHz) scanning Fabry-Perot spectrometer

Bolometer camera from 100 to 800 μ (SMILS only)

High elliptical orbit (900 to 70,000 km)

Two year lifetime

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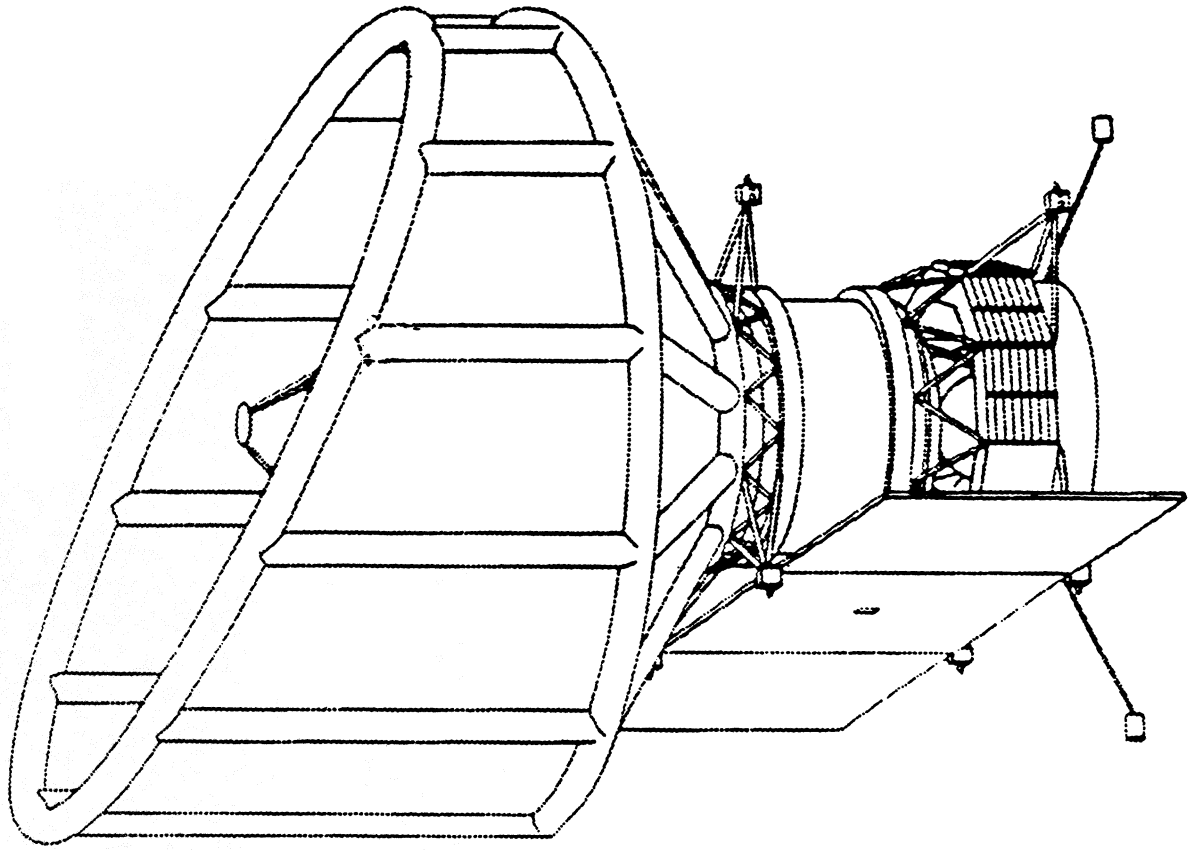
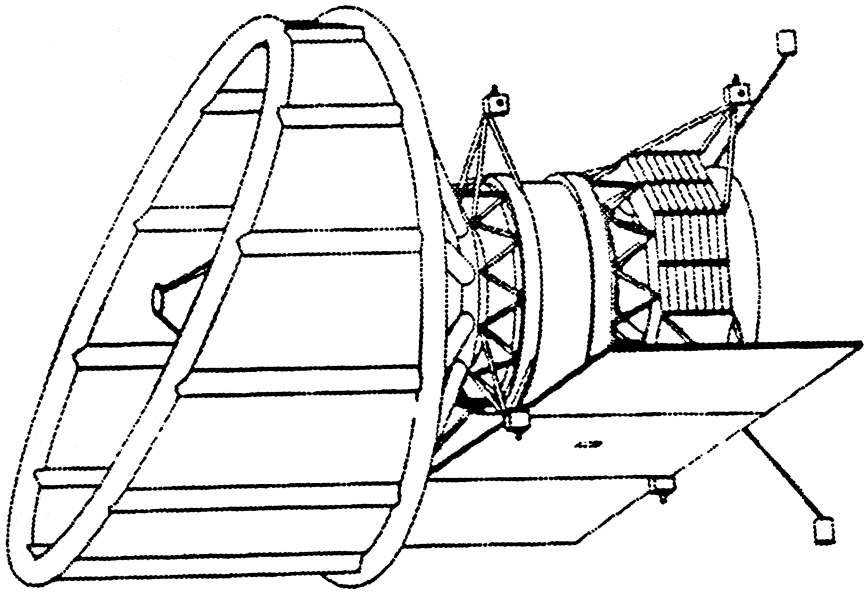
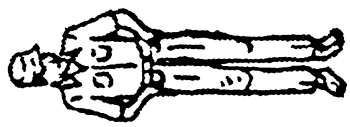


SUBMILLIMETER MODERATE MISSION (SMMM)

SUBMILLIMETER - IMAGING LINE SURVEY (SMILS)



SUBMM EXPLORER (SMME)



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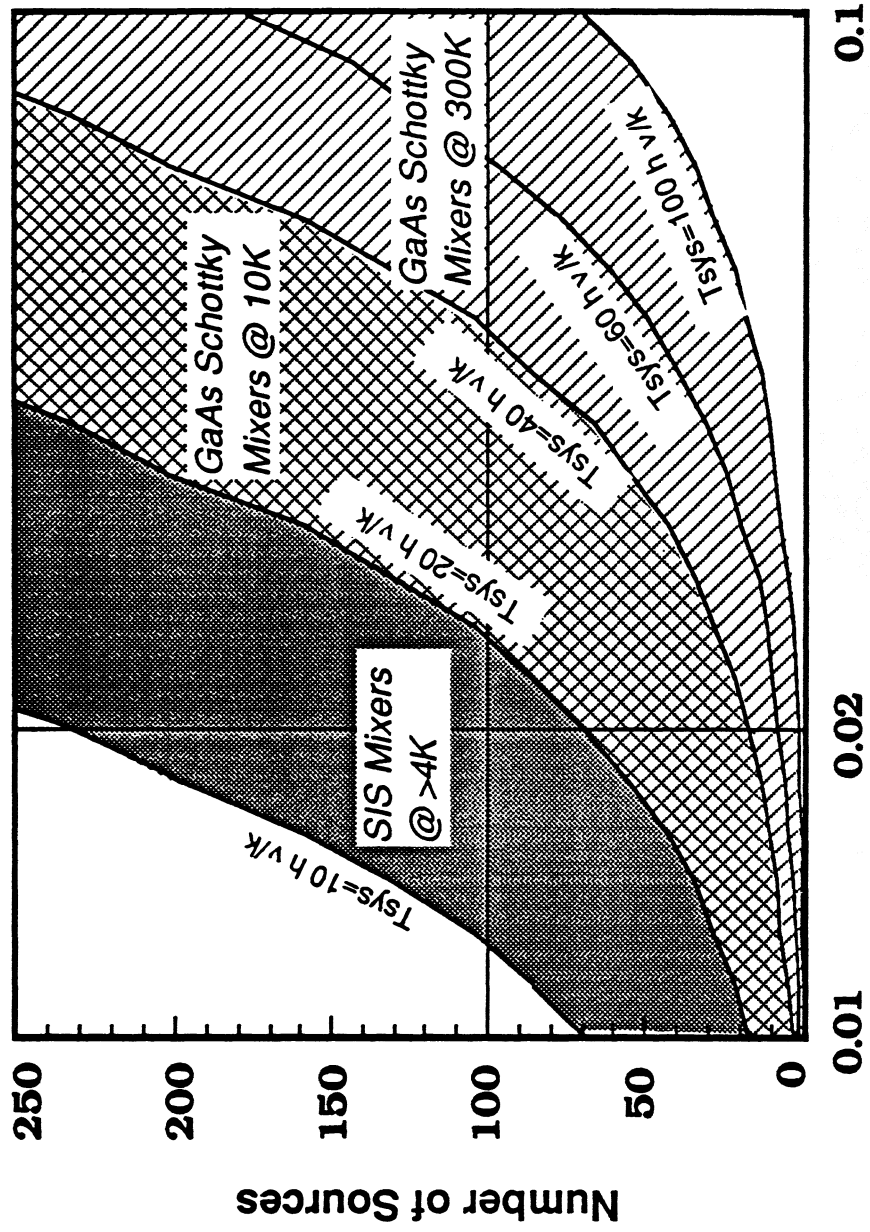
SMMM Sensitivity Tradeoffs



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Asumptions for SMMM Sensitivty Trades

For each source observe complete frequency range: 400 -1200 GHz
with 2 MHz frequency resolution

400,000 channels/source
Multiplex: 8000 channels simultaneously

Observing mode: position switching on and off source

Integration time blocks: 120 s

Sensitivity determined by DIcke Radiometer Equation

$1\ \sigma$ noise level = $\Delta T = \sqrt{2}\ T_{sys} / \sqrt{B\ \tau}$

Tsys = n hν/k
B = 2 MHz
τ = integration time at a given frequency

Included overhead for aquiring source, calibration, etc.

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SMILS Heterodyne Instrument Concept

Multiplex to increase signal through put - 16 GHz instantaneous RF bandwidth

Accomplished by:
- 2 receivers operate simultaneously
- Double sideband receiver
- 8 - 12 GHz IF bandwidth

Constained by:
- heat load on He bath
- power for local oscillators
- power for spectrometer

Reliability - no cold moving parts; minimize amb. temp. moving parts

- Mixers and multipliers fixed tuned - 10% operating bandwith
- Electrically tuned pump oscillators - 10% operating bandwidth
  - 10 receivers to cover 400-1200 GHz band

- Use frequency diplexers rather than switching mirrors

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Mixer Performance Requirements

Tsys(K)	20 hν/k
Double sideband operation	
Fixed tuned Operational bandwidth	10%
IF Band	8-12 GHz
Operating temperature	Liquid He

10 Mixers to cover frequency range 400 - 1200 GHz

400-450 GHz	710-790 GHz
450-510 GHz	790 -870 GHz
510-570 GHz	870-970 GHz
570-640 GHz	970-1080 GHz
640-710 GHz	1080-1200 GHz

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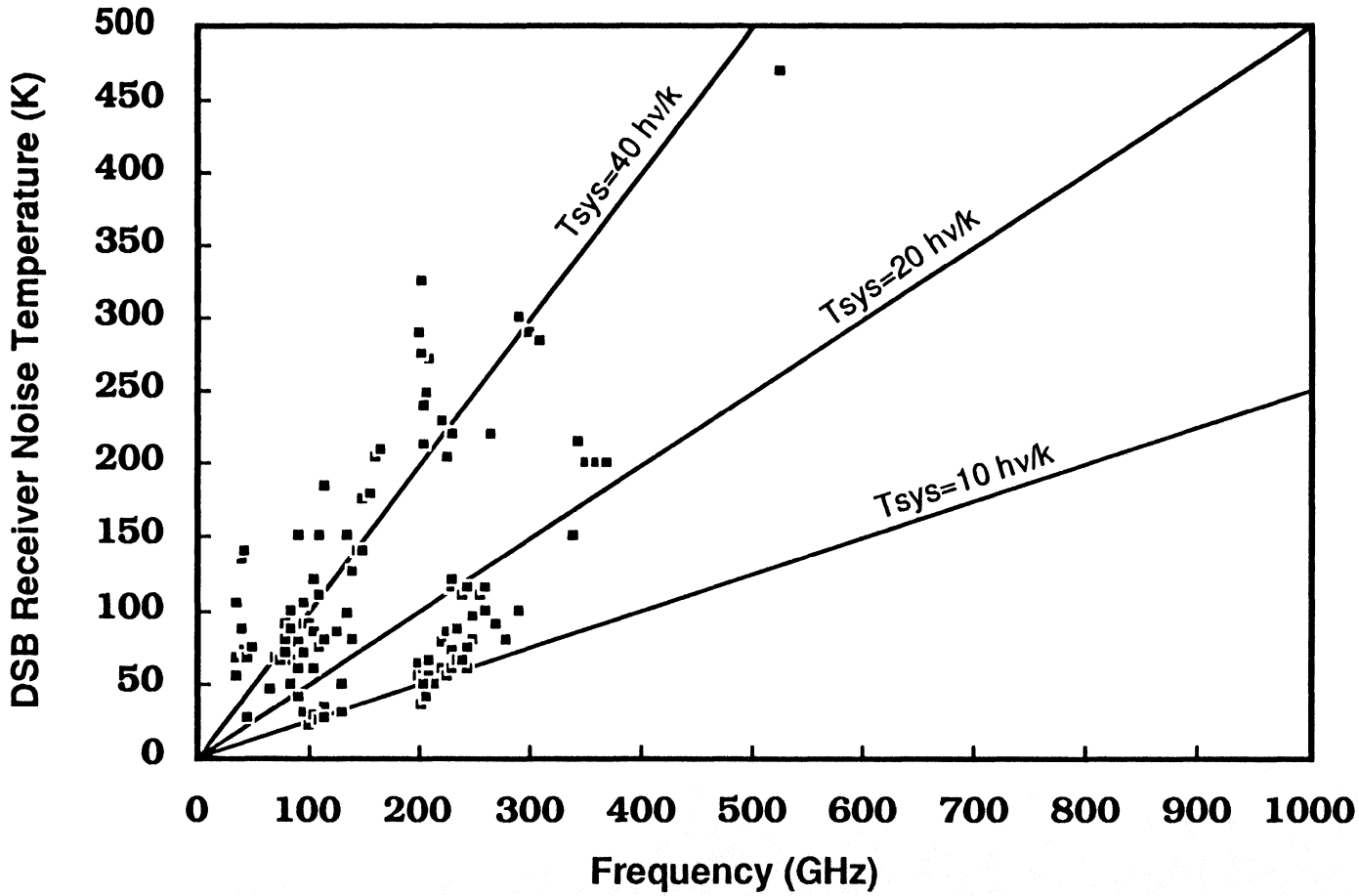
State of the Art for SIS Mixer Based Heterodyne Receivers

from AT&T Bell Labs, Caltech, Ecole Normale, Iram, JPL, Koln, NRAO, Nobeyama, Onsala



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Local Oscillator Performance Requirements

Operational Bandwidth with electrical tuning	10%
Output power at 1000 GHz	50 μW
Electrical tuning step size	2 GHz
Frequency stability	$1:10^7$
Frequency Knowledge	$1:10^8$
DC power per LO source	<10 W

10 Local oscillator sources to cover frequency range from 400 - 1200 GHz

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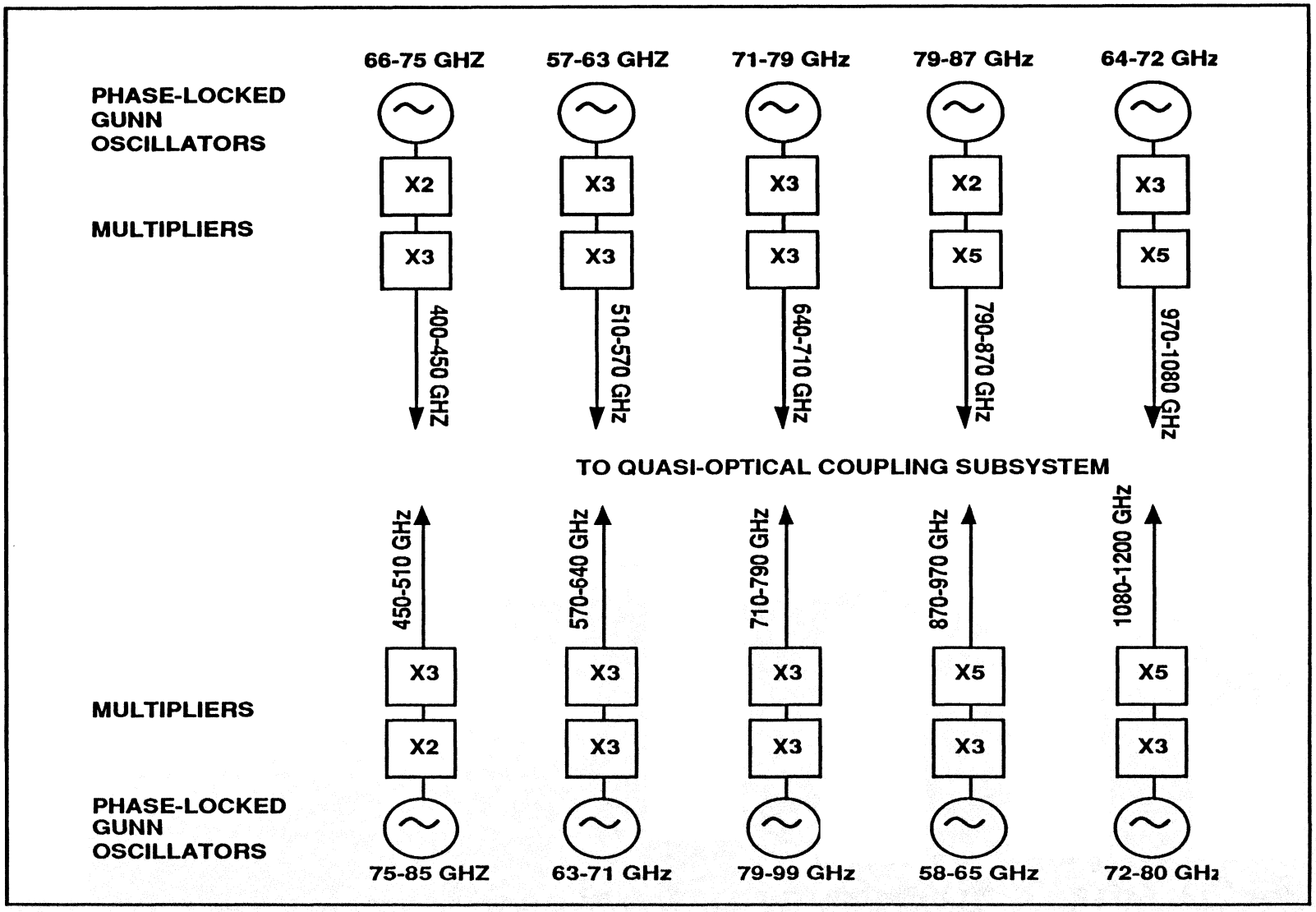
SMMM LOCAL OSCILLATORS



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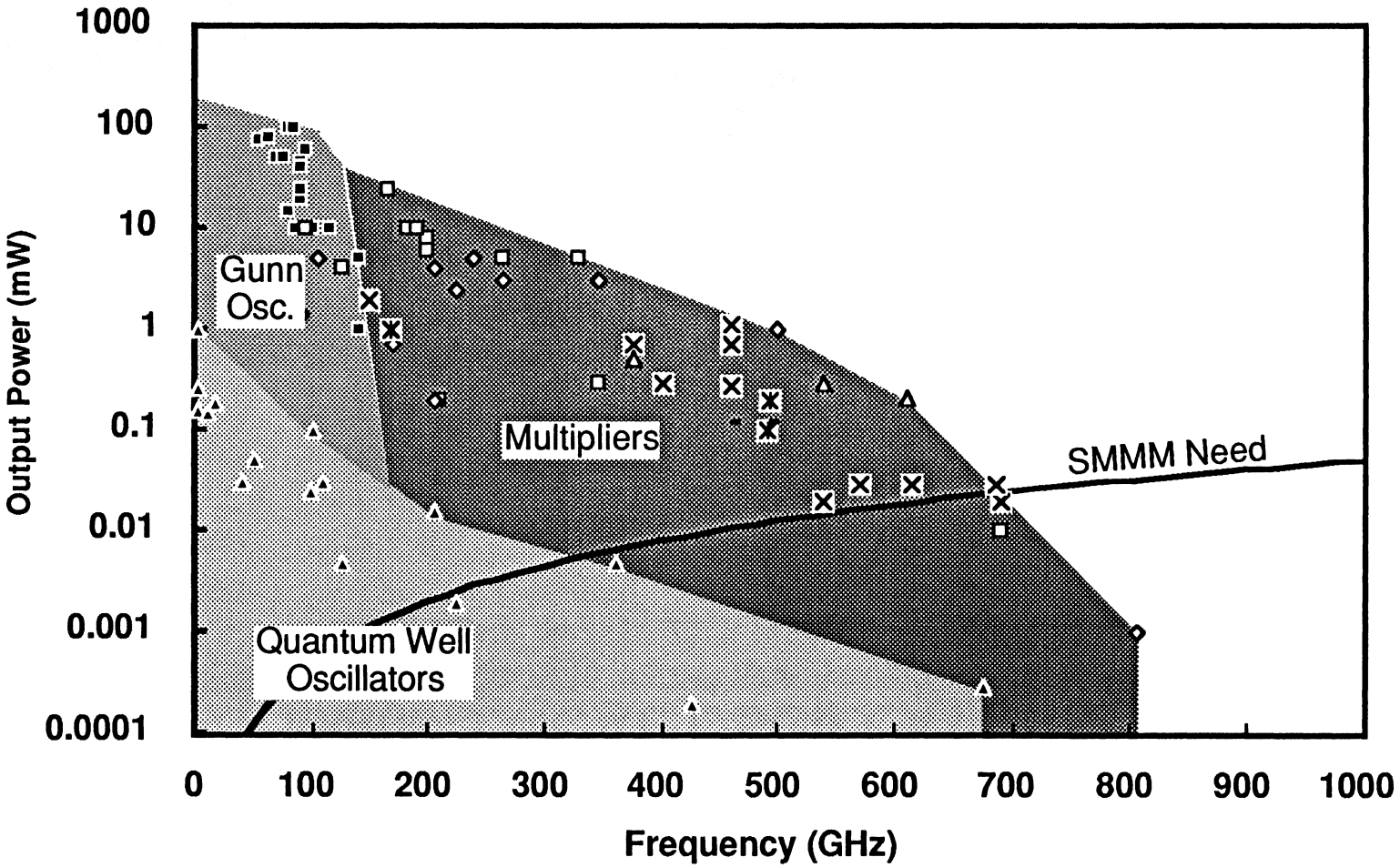
State of the Art for Solid State Local Oscillators

from Caltech, Chalmers, Helsinki, JPL, Koln, Lincoln Lab, Millitech,UCLA, U. Mass., Zimmermann



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Summary

SMMM Will provide a new view of the submillimeter wave universe

Give a complete, high resolution spectrum of
star forming regions in the Milky Way
galaxies

Poses technology challenges

SIS tunnel junction mixers
Solid state local oscillator sources

Extend frequency of operation to 1200 GHz with excellent performance

Broad band operation with no moving parts

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