THE RECEIVER SYSTEM-
MM REGIME

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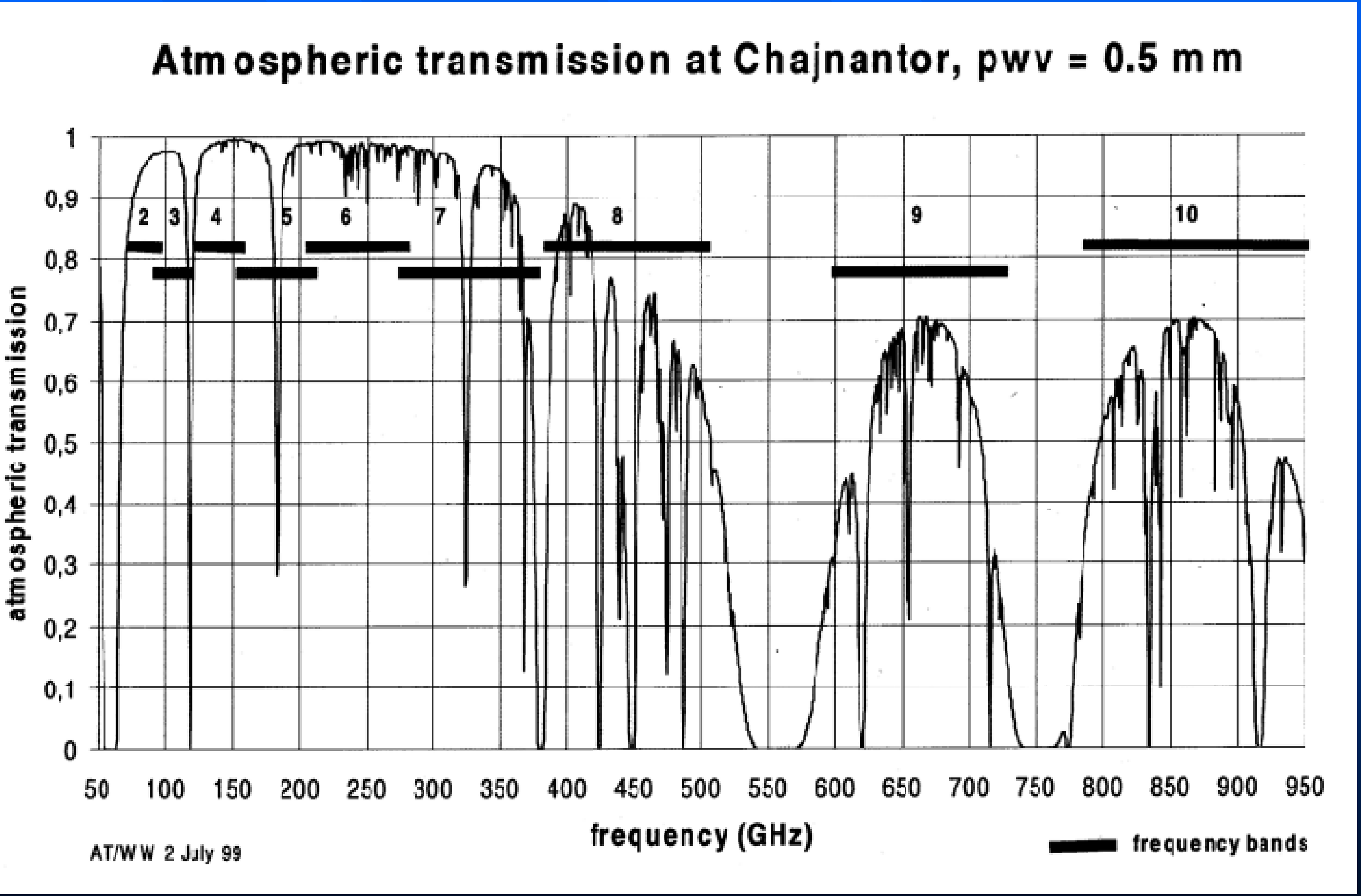
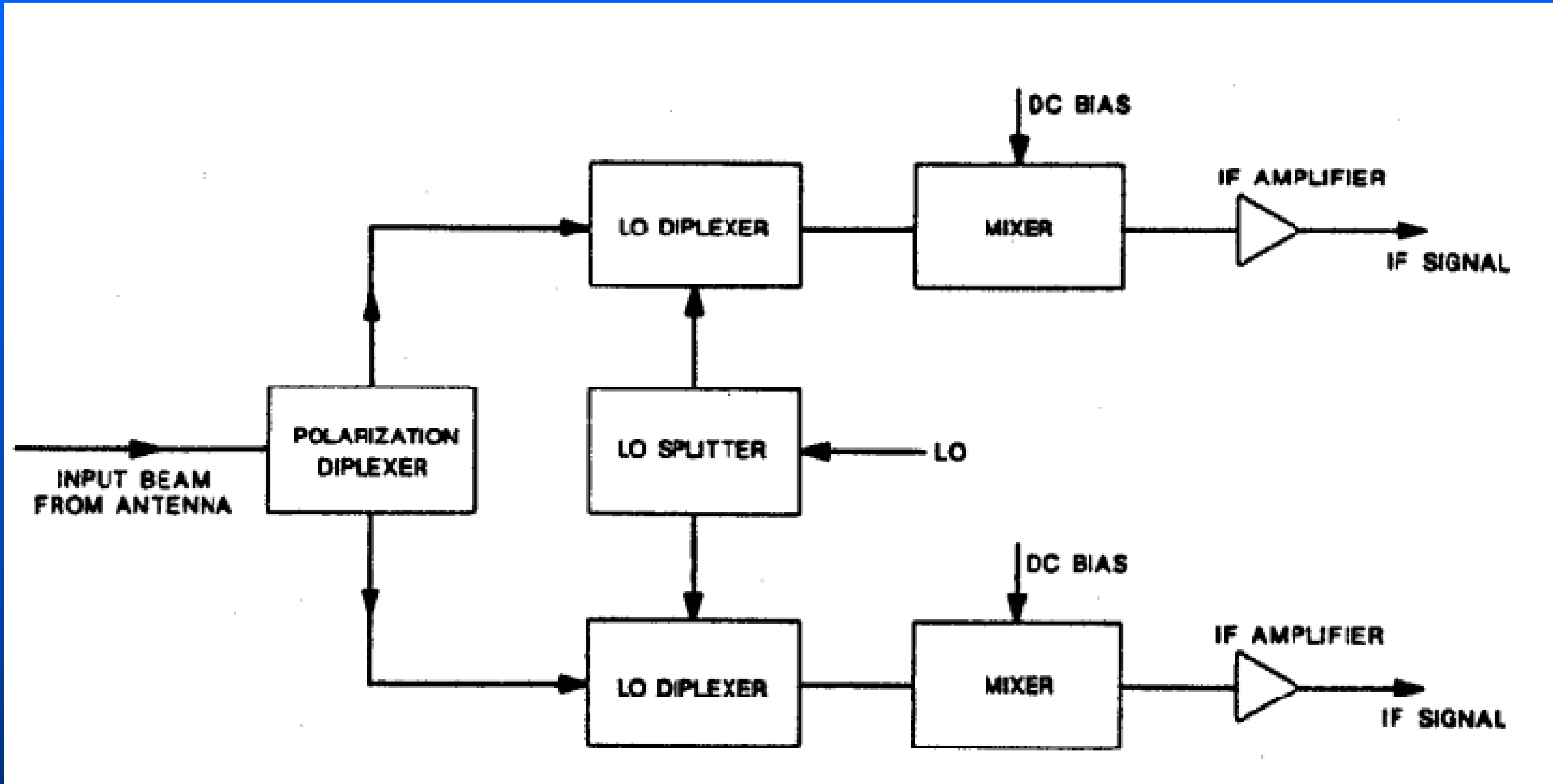
NAIC/NRAO School On Single Dish Radio Astronomy Techniques and Applications
Green Bank, WV 10 AUG 03 – 15 AUG 03

OUTLINE

1. The Atmosphere – Why Go To High, Dry Sites?
2. Technical Difficulties
3. Practical Receivers
4. The ALMA Project

Fig. 1


Atmospheric transmission at Chajnantor, pwv = 0.5 mm
atmospheric transmission
1
0,9
0,8
0,7
0,6
0,5
0,4
0,3
0,2
0,1
0
2
3
4
5
6
7
8
9
10
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
800
850
900
950
frequency (GHz)
AT/WW 2 July 99
frequency bands

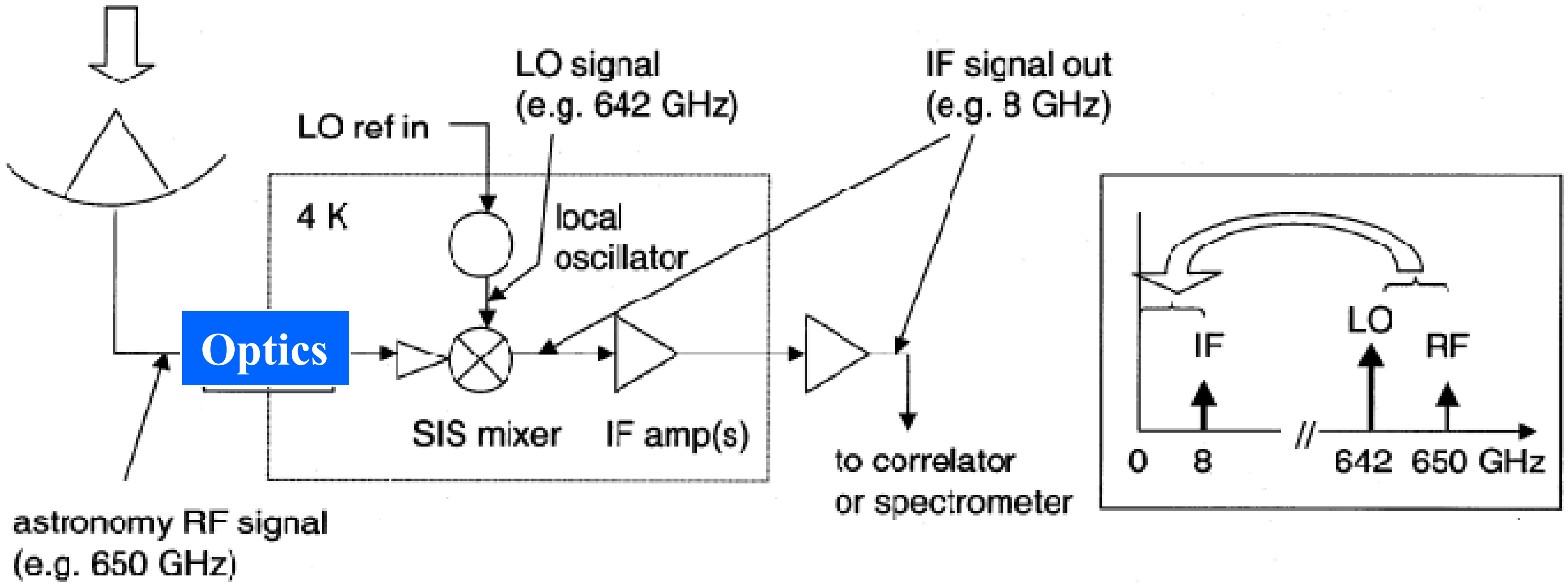


BLOCK DIAGRAM OF MM/SUB-MM RECEIVER

Principle of a mm/submm radioastronomy receiver

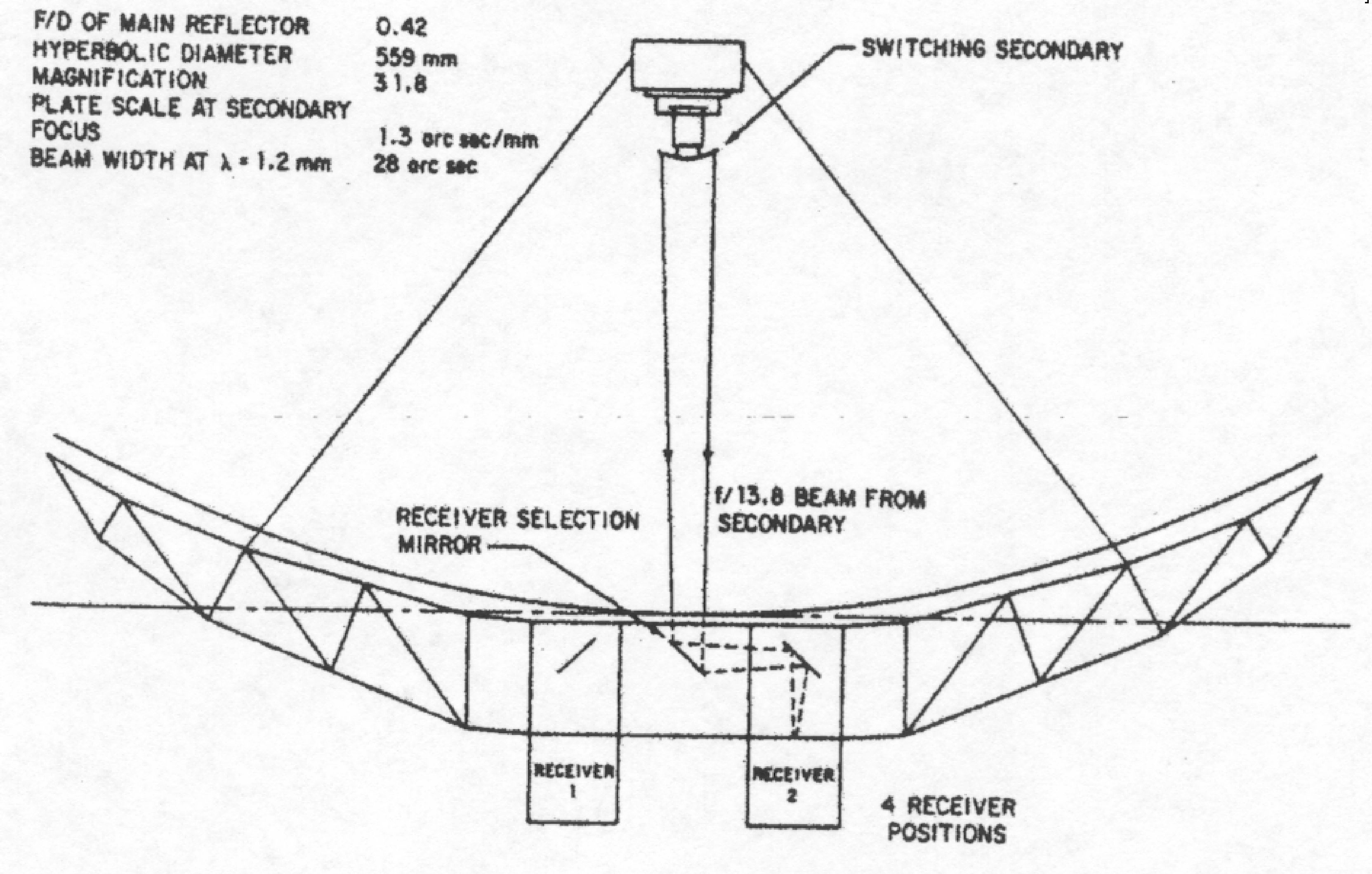
Heterodyne principle = mixing of two frequencies to produce difference signal

Radio frequency (RF) ⊗ local oscillator frequency (LO) → intermediate frequency (IF)



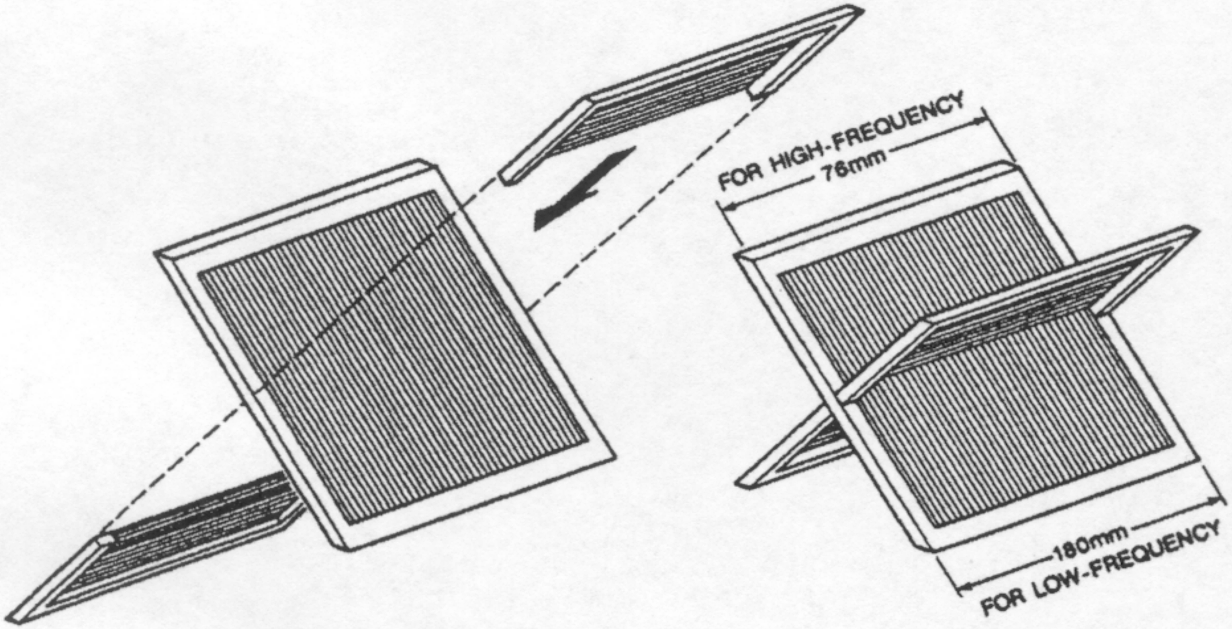
- SIS = Superconductor-Insulator-Superconductor (mixing element)
- sensitivity approaching quantum limit
- amplitude and phase measured

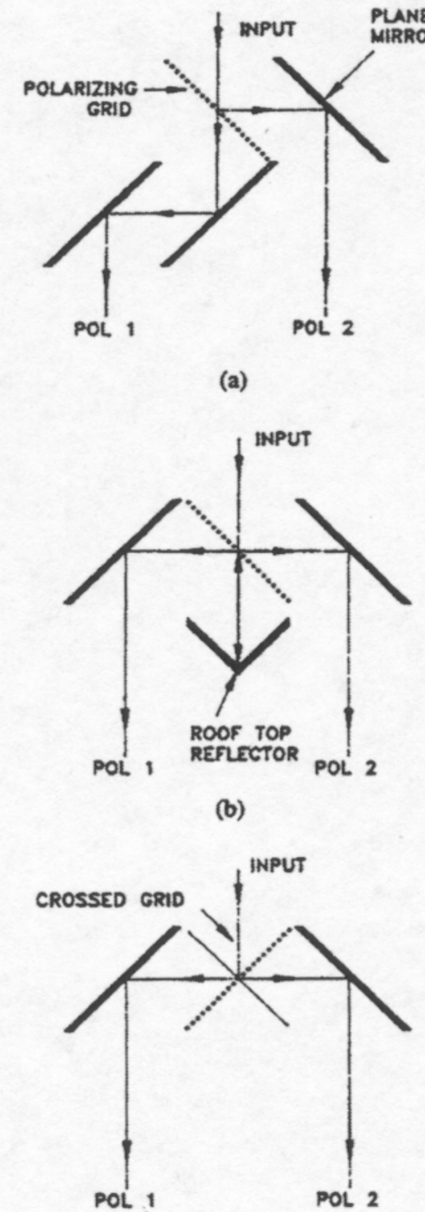
Fig. 4



ARRANGEMENT OF OPTICAL ELEMENTS ON AN ANTENNA EQUIPED FOR MM/SUB-MM RADIOASTRONOMY

Fig. 5





VARIOUS ARRANGEMENTS FOR POLARIZATION DIPLEXING

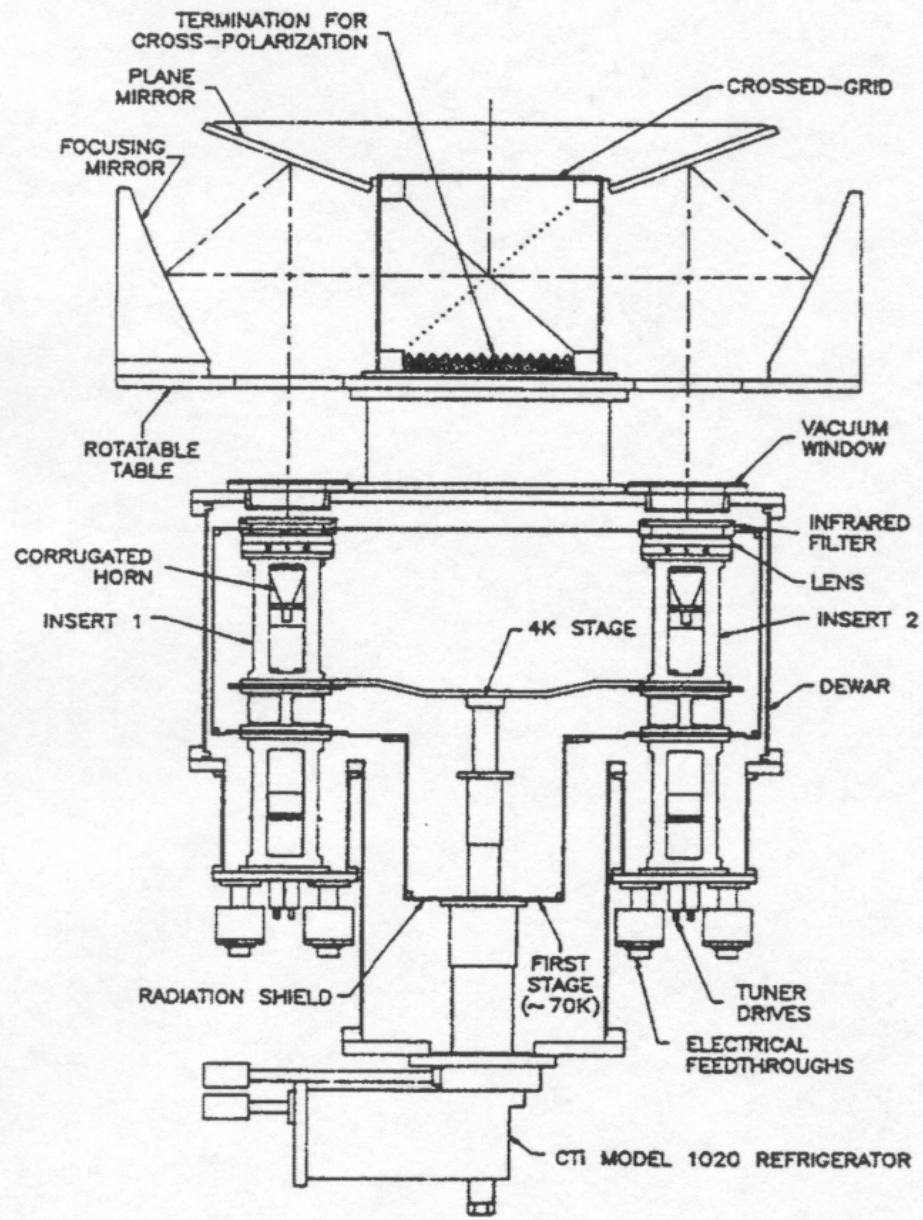

TERMINATION FOR CROSS-POLARIZATION
PLANE MIRROR
CROSSED-GRID
FOCUSING MIRROR
ROTATABLE TABLE
VACUUM WINDOW
INFRARED FILTER
CORRUGATED HORN
LENS
INSERT 1
4K STAGE
INSERT 2
DEWAR
FIRST STAGE (~70K)
RADIATION SHIELD
TUNER DRIVES
ELECTRICAL FEEDTHROUGHS
CTI MODEL 1020 REFRIGERATOR

Fig. 7

COMPACT REMOVEABLE RECEIVER "INSERT"

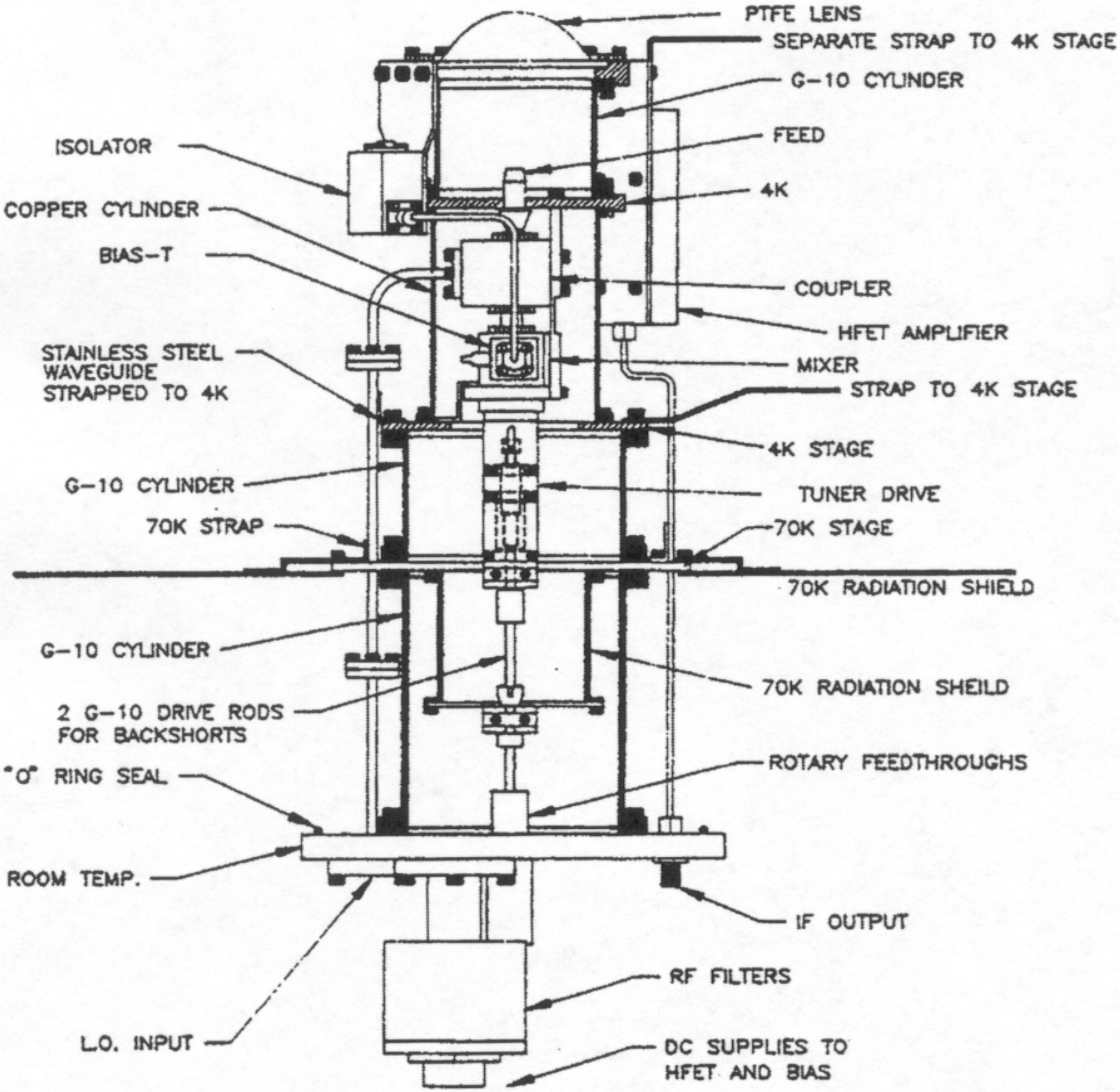


Fig. 8

4K CLOSED CYCLE REFRIGERATOR

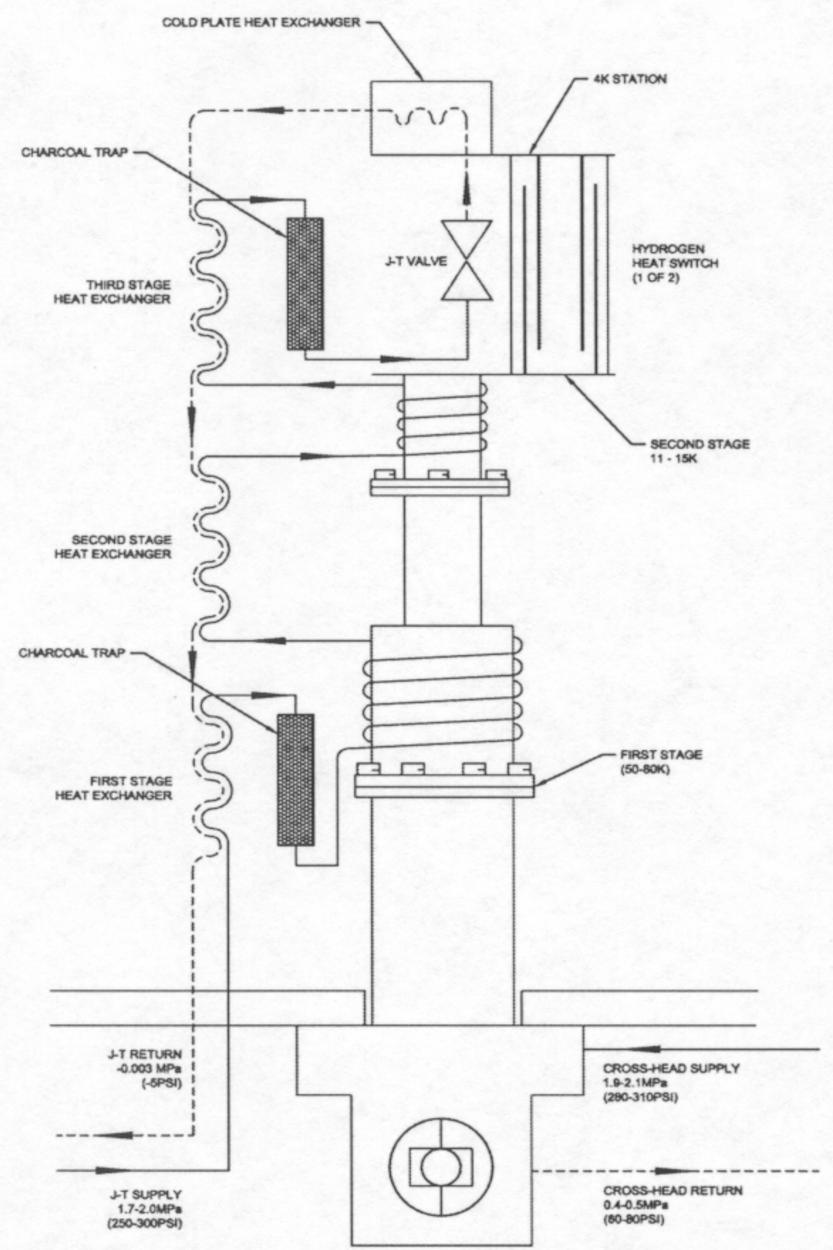
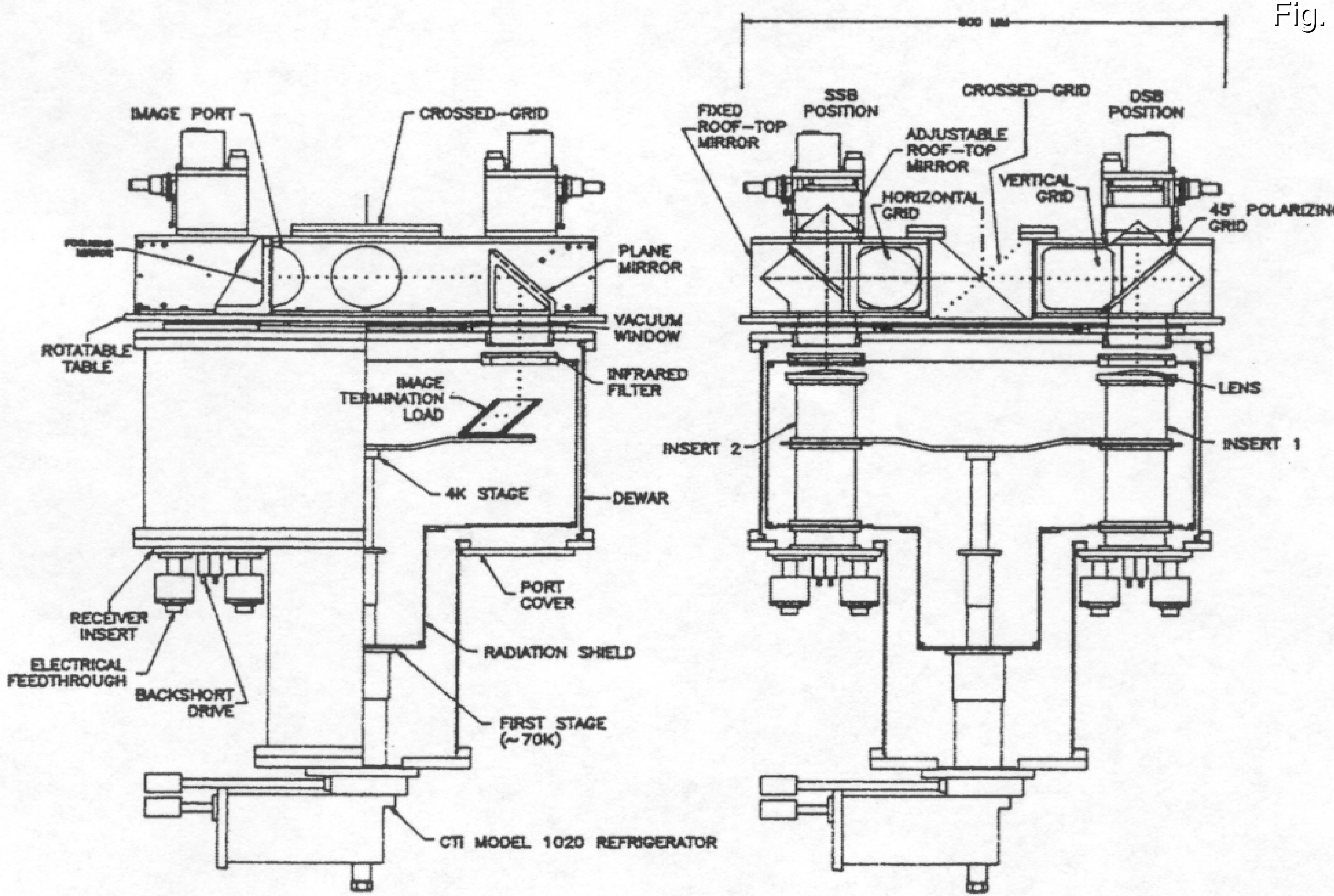


Fig. 9



HIGH FREQUENCY RECEIVER USING INSERTS

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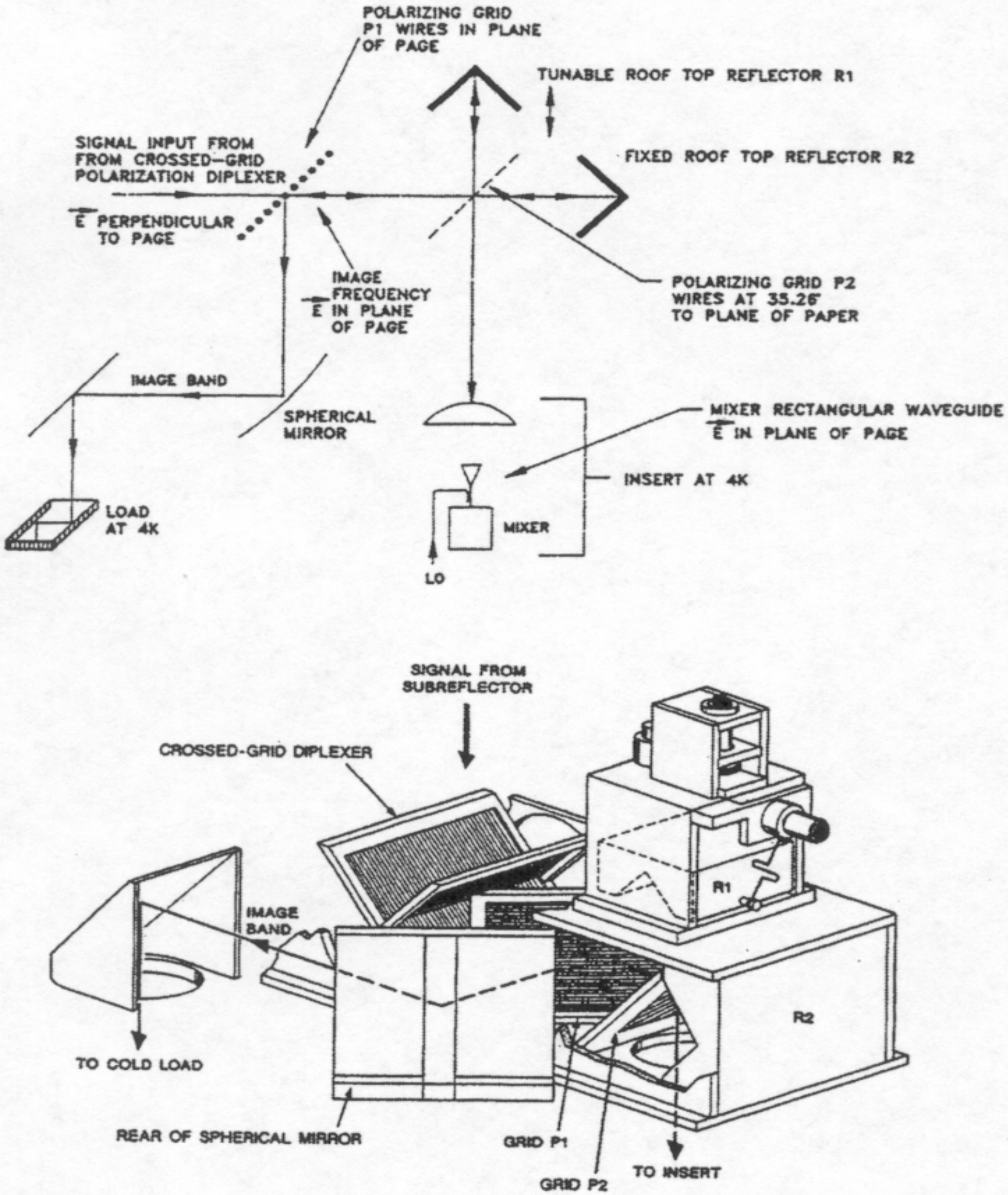
Fig. 10

OPTICS USED FOR SIDEBAND TERMINATION



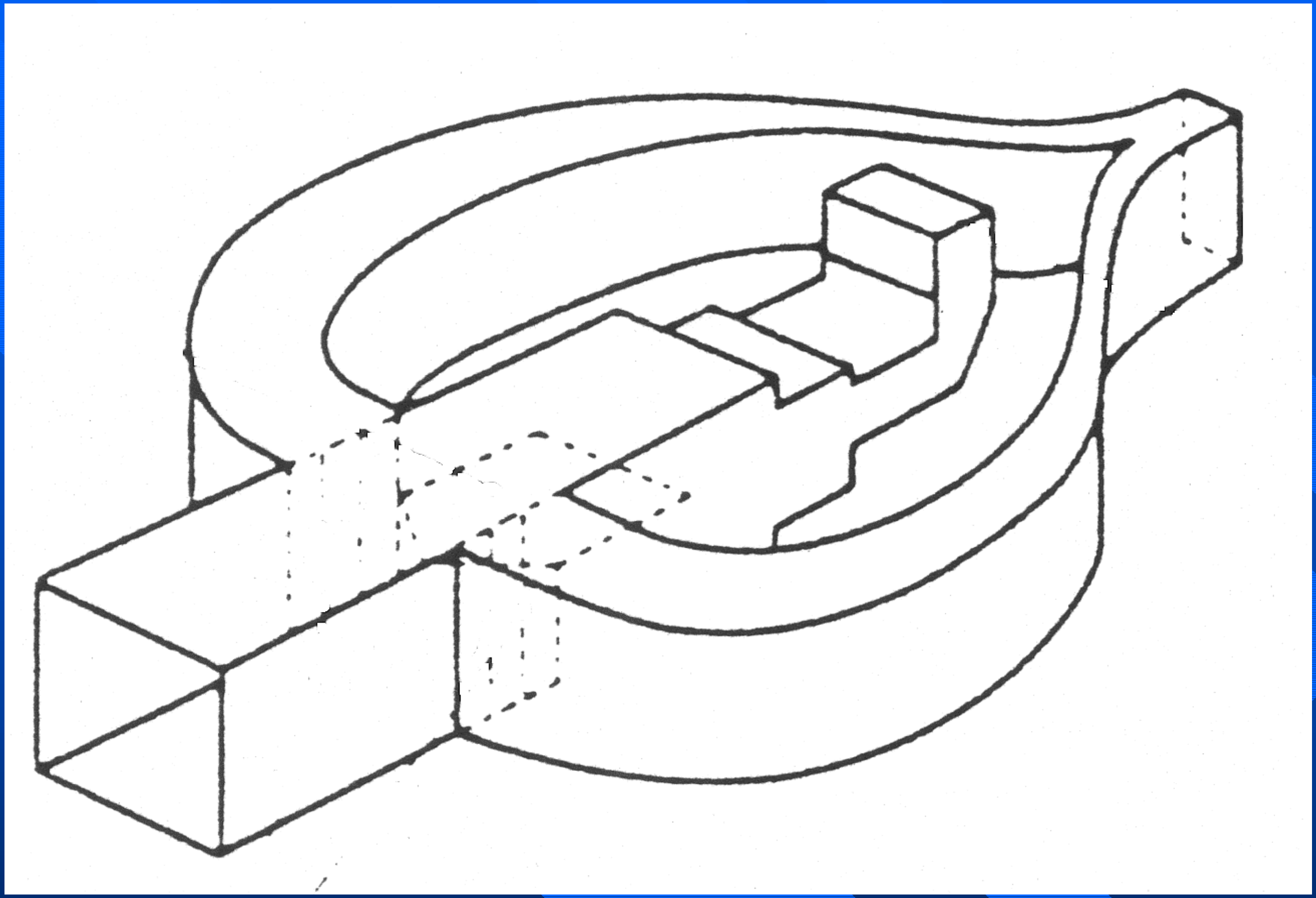
POLARIZATION DIPLEXERS (OMTs)

"A passive microwave component that separates orthogonal polarizations within the same frequency band."

Due to difficulty in machining and the absence of suitable analysis tools such diplexers in the past have used free standing wire grids.

However, today we may fabricate ortho mode transducers (OMTs) in waveguide and have good performance over a waveguide band.

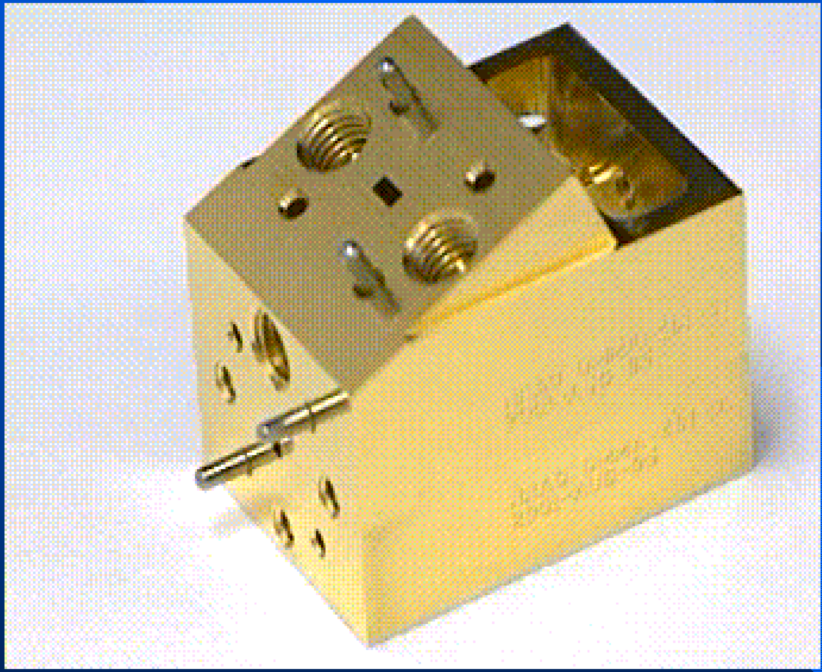
A design team here at NRAO has realized such OMTs up to 300GHz. The prospect is that we will extend these techniques up to 1000 GHz (1THz).

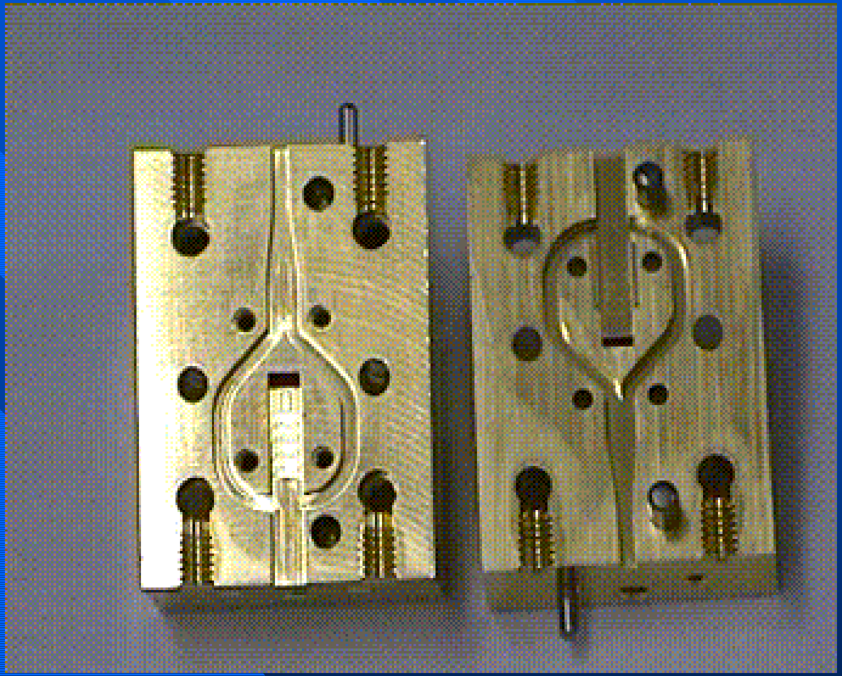


Polarization Diplexer Based on Bøifot

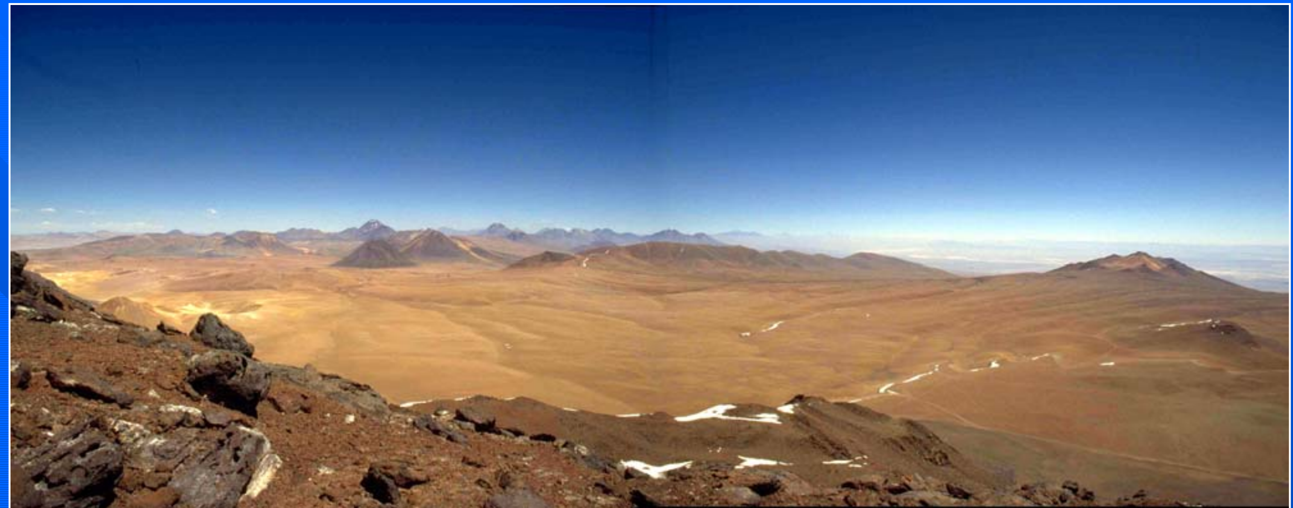
OMT Development

Band 3 OMT Views





ALMA


Toquepala
Villa Aroma
Ilo
Tacna
Oruro
Chinchorro
Arica
Lago de Poopó
Pisagua
Iquique
Humberstone
Uyuni
Oyahue
Tocopilla
Oficina Maria Elena
Pedro de Valdivia
Chuquicamata
Calama
San Pedro de Atacama
MMA Site
Punta Angamos
Mejillones
Antofagasta
Baquedano
Socompa
Balmaceda
Punta San Pedro
Taltal
Pueblo Hundido
Potrerillos
Chañaral
Caldera
Punta Morro
Copiapo
Huasco
La Serena
Coquimbo
Punta Lengua de Vaca
San Juan
Cerro Aconcagua
Mendoza
Los Andes
Viña del Mar
Valparaiso
Santiago
San Antonio
Rancagua
San Fernando
Pichilemu



Artist's Impression of ALMA
(Atacama Large Millimetre Array)

ESO PR Photo 24a/99 (8 June 1999)

© European Southern Observatory

Receiver Frequencies

Band	Lower (GHz)	Upper (GHz)
1	31.3	45
2	67	90
3	84	116
4	125	163
5	163	211
6	211	275
7	275	370
8	385	500
9	602	720
10	787	950

ALMA LO Approach

ALMA Photonic LO Approach

Round-Trip Phase Correction

The path length to each antenna is actively corrected by a round-trip phase correction scheme.

The active control is based on the output of an optical interferometer with a stable master laser source.

Line Length Corrector: Description

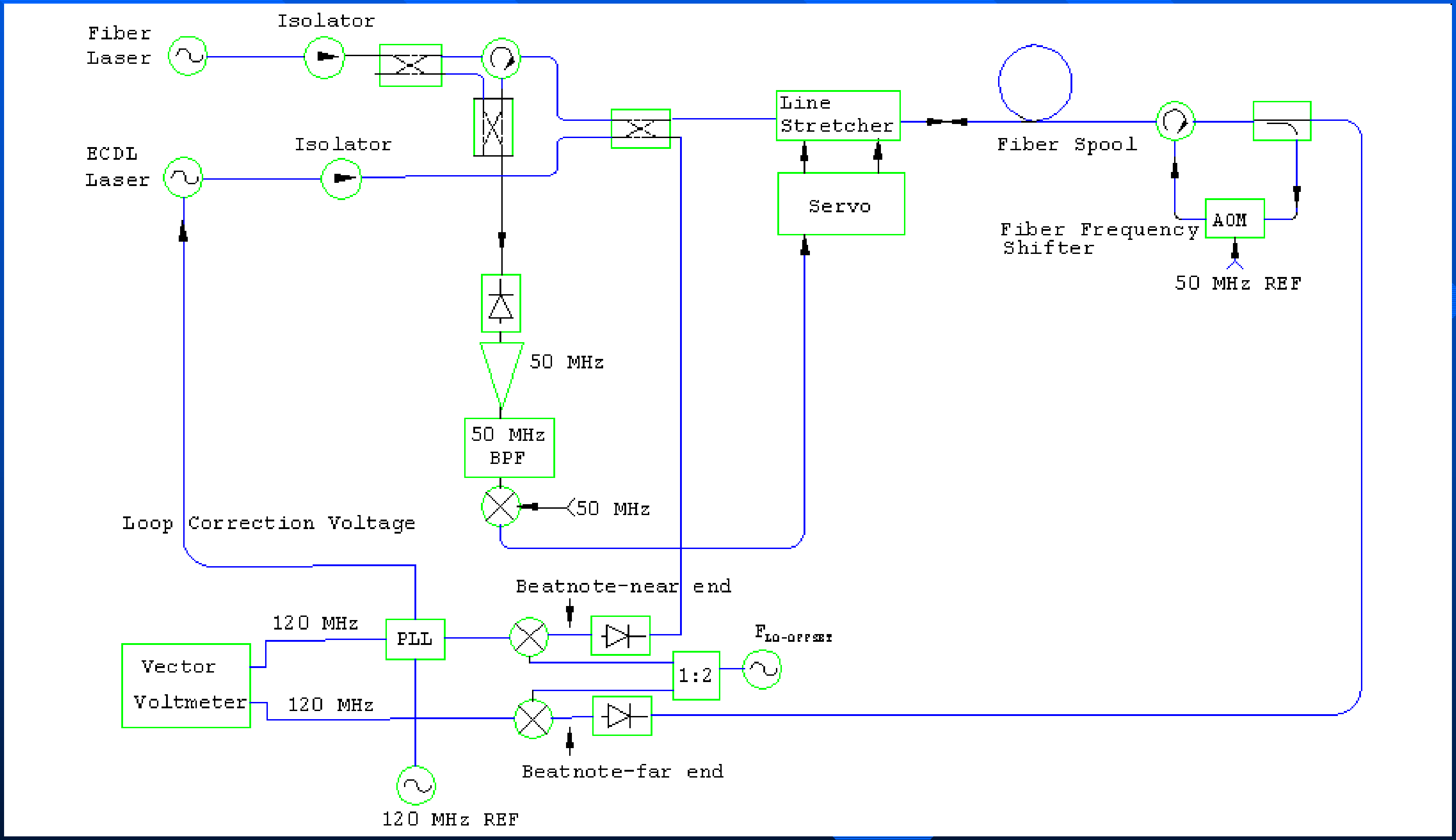
The line length corrector, together with the photonic reference receiver, forms an optical interferometer with a maximum of 50 km round-trip length.

The "short arm" of the interferometer is a sample of the master laser which is distributed to each of the 64 Line length corrector modules

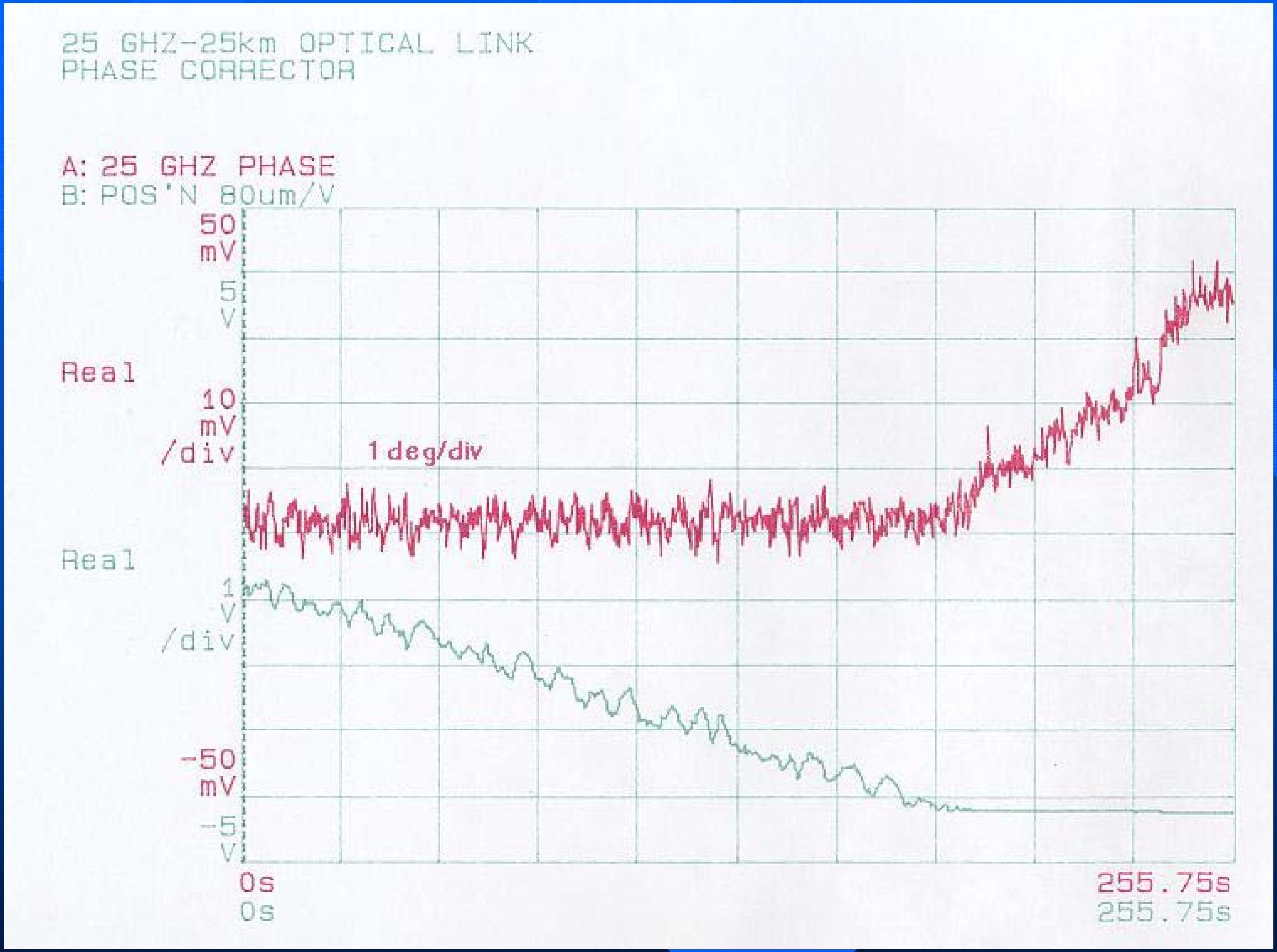
The Corrector compensates for changes in the fiber distribution length due to environmental effects.

The compensation is accomplished by insertion of fiber in an amount opposite to the environmental changes. This is done by stretching or heating the fiber.

Round Trip Correction by Optical Interferometer and Measurement of Phase Drift of Beatnote Transmitted over 25 km of fiber

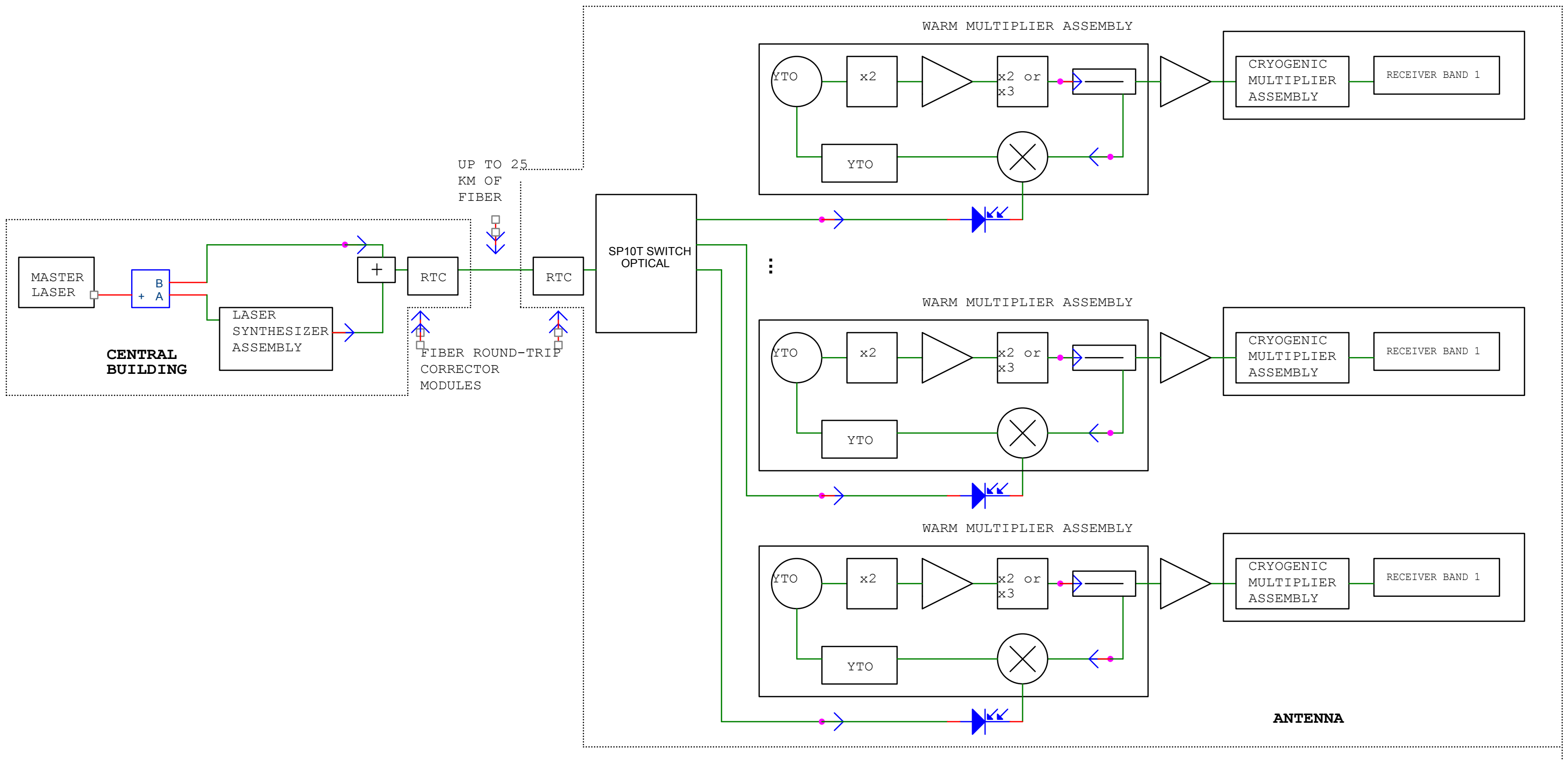


Line Length Corrector: Prototype Results



Phase Difference (at 25 GHz) and Stretcher Position plotted vs time

Photonic Reference Approach: ALMA Baseline Plan



Instrument Development

Laser Synthesizer: Photo

Laser Synthesizer: Photo