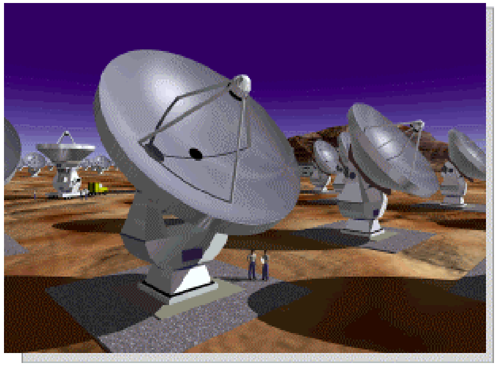


Atacama
Large
Millimeter
Array

Front End Design and Development for ALMA

Wolfgang Wild

ALMA European Receiver Team Manager

ESO, NOVA/SRON

Asia-Pacific Radio Science Conference
Tokyo 1-4 August 2001


ALMA Project

ALMA Front Ends

- D&D (Phase 1) to be followed by construction (Phase 2)
- Construction of 64 front ends (+ spares)
- D&D work with special attention to
  - Performance (quantum limited sensitivity)
  - Reliability (remote location)
  - Series produceability (70 units)
  - Cost
- Collaboration between North America, Europe, Japan


ALMA Project

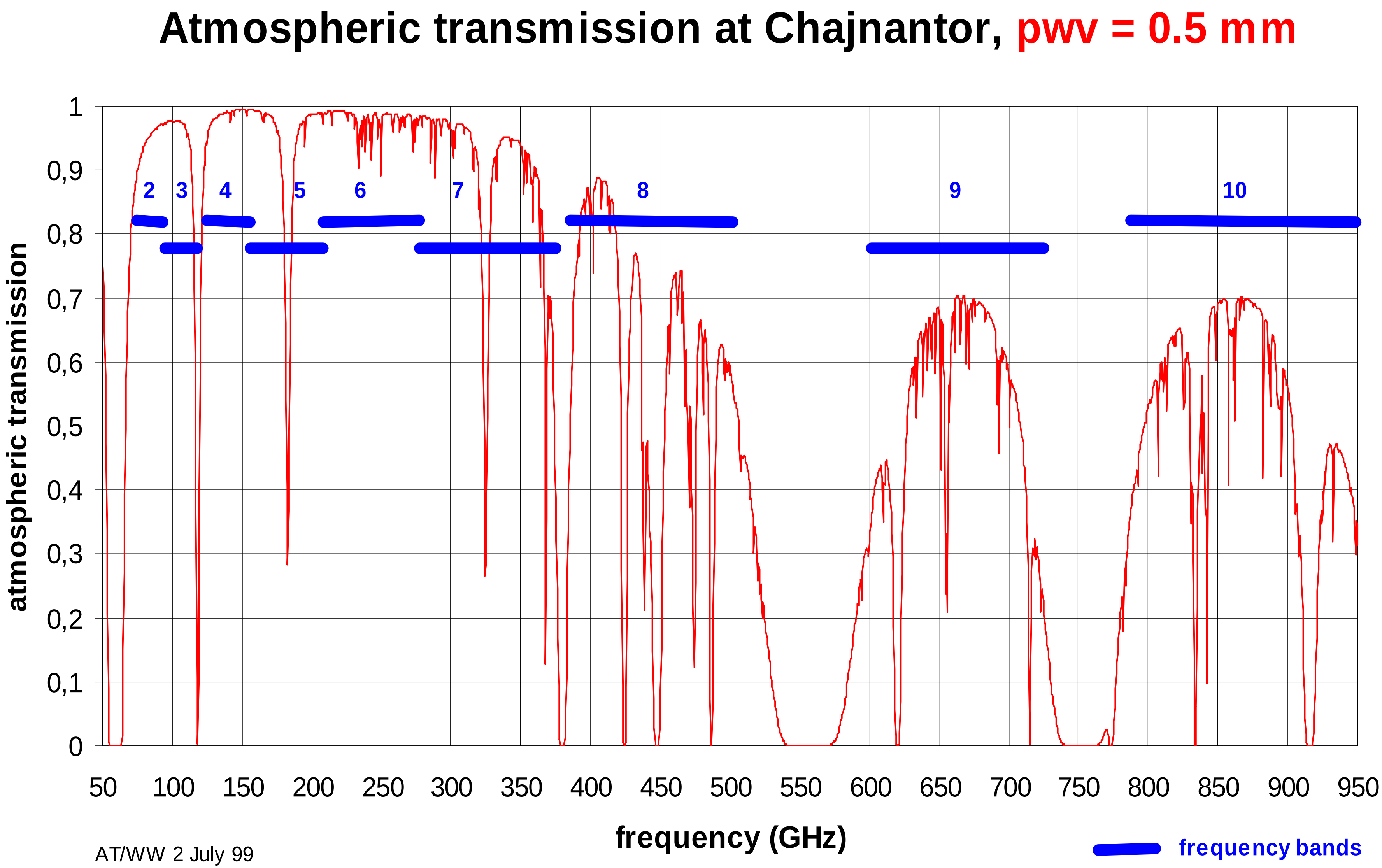
18 Institutions in 10 Countries

North America	Europe	Japan
NRAO (Charlottesville, Tucson, Socorro)	ESO OSO (Sweden)	NAOJ NRO
HIA Canada	RAL, MRAO (UK)	U of Tokyo
OVRO	NOVA/SRON (Netherlands)	U of Osaka
UCB	MPIfR (Germany)	
	IRAM (Germany, France, Spain)	
	DEMIRM (France)	Dedicated talk by Sekimoto et al.
	CAY (Spain)	
	Arcetri (Italy)	

ALMA Project

Main Front End Specifications

- Frequency coverage from 30 GHz to 950 GHz in 10 bands
- All bands dual polarization
- 8 bands use SIS mixers (→ cooling to 4 K)
- Sideband separating mixers where possible
- Highest possible sensitivity and stability
    - low receiver noise (close to quantum limit)
    - large detection bandwidth (IF 4 – 8 or 4 – 12 GHz)
- Highest possible reliability (→ avoid moving parts)
- Modular design



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

ALMA Project

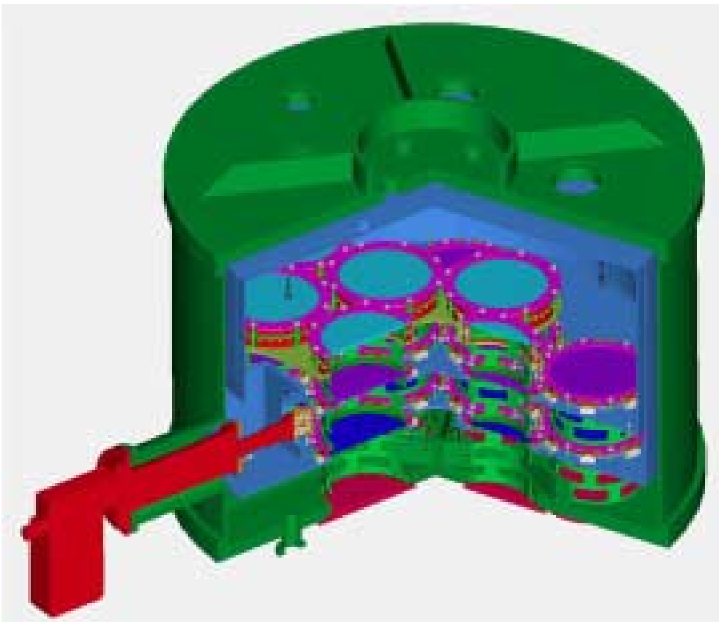
Overall Front End Concept

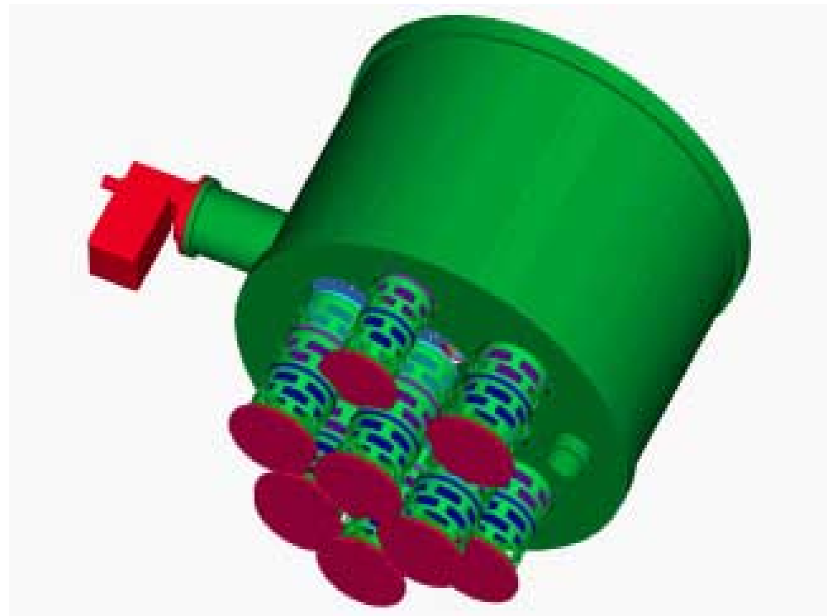
- All 10 bands in a single dewar
- Cooling to 70 K, 15 K, and 4 K
- Each band as a modular plug-in unit (“cartridge”)
- Final stage(s) of local oscillator inside cartridge
- No quasi-optical diplexers for sideband rejection
- Receiver bands share focal plane, no selection mirror

ALMA Project

Preliminary Dewar Design

RAL (UK)





- Diameter ~ 1 m
- Flexible thermal links
- External optics on top of dewar
- Cartridges plugged in from bottom

ALMA Project

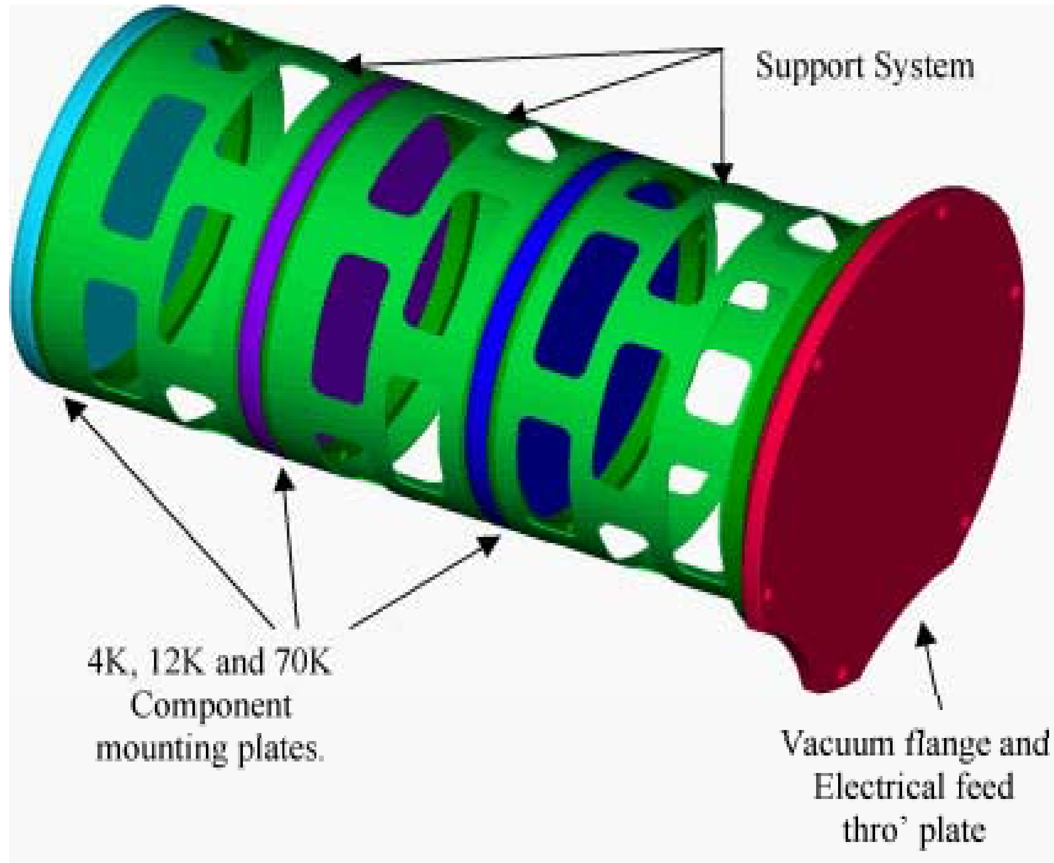
Band cartridge structure

RAL (UK)

Cartridge =
Self-contained
dual polarization
Receiver

Diameter 170 mm

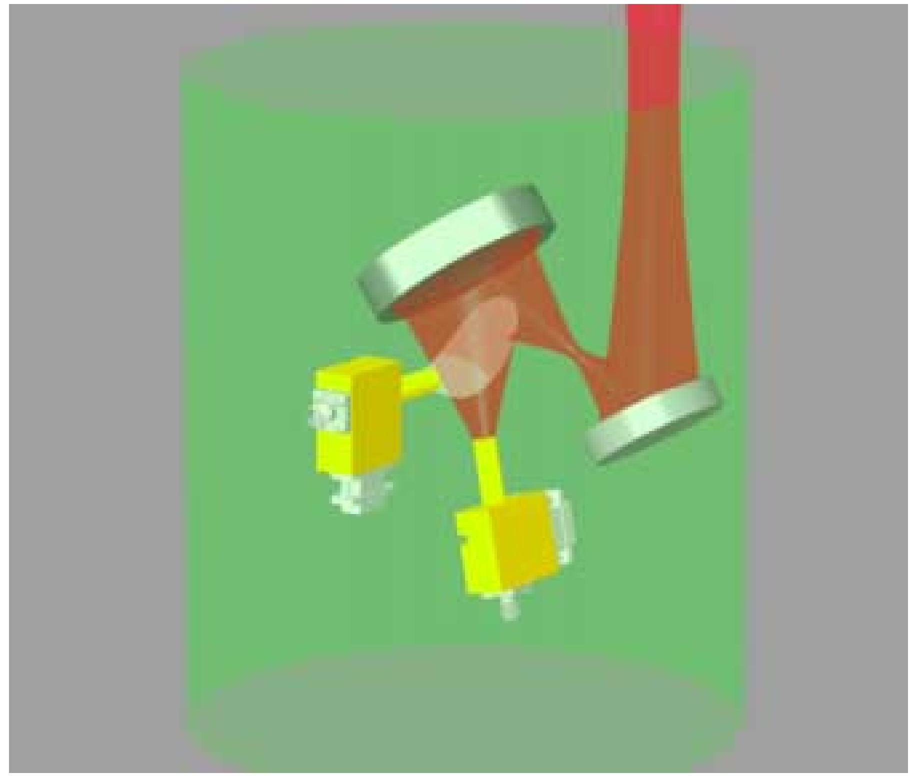
Input: RF, LO ref
Output: IF



Preliminary Cartridge Concept

Cartridge contains

- Optics
- 2 mixers
- IF amplifiers
- Local oscillator
- cables
- mounting



ALMA Project

Front End Optics

(IRAM, OVRO, SRON, RAL, NRAO, NAOJ)

Requirements:

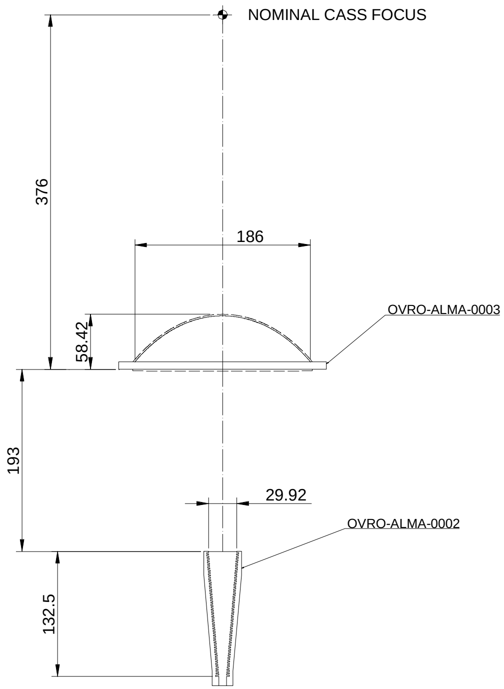
- Couple 10 bands to telescope
- Optimize performance
- Minimize number of components
- Optics in cartridge/cold where practical
- No on-site alignment
- No moving parts

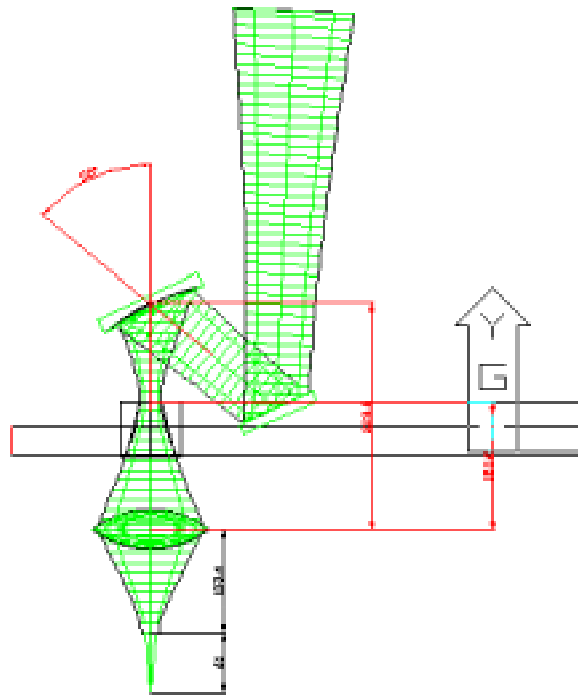
Design:

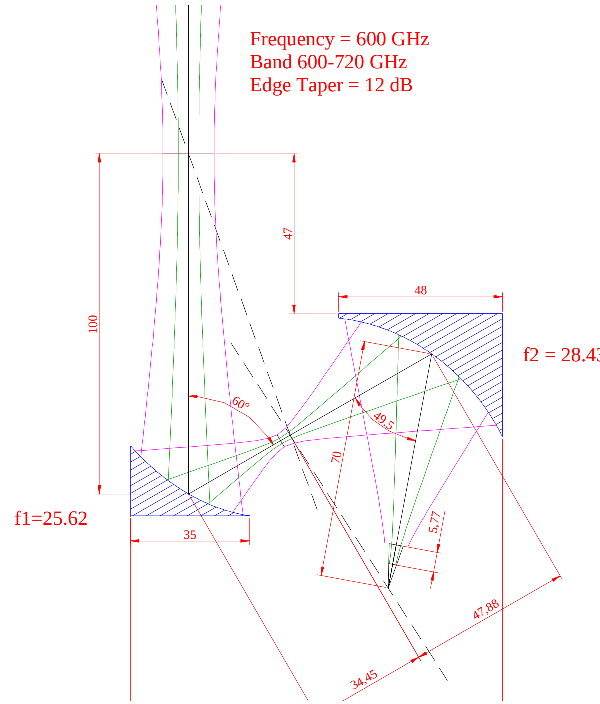
- Bands share focal plane
- Band selection by pointing
- 3 types of optics depending on frequency

ALMA Project

Three types of Optics







Style A (warm)
Bands 1 and 2

Style B (warm + cold)
Bands 3 and 4

Style C (only cold)
Bands 5 to 10

ALMA Project

Main Mixer Requirements

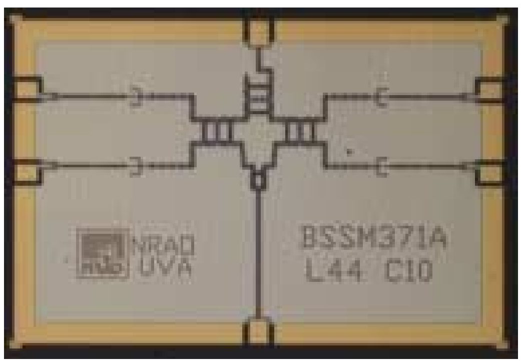
- Lowest possible noise temperature
- Large RF bandwidth (up to 30%)
- Large IF bandwidth (goal 4 – 12 GHz IF)
- High reliability (→ no moving backshorts etc.)
- High total power stability
- Balanced mixers where possible
- Sideband separating mixers where possible

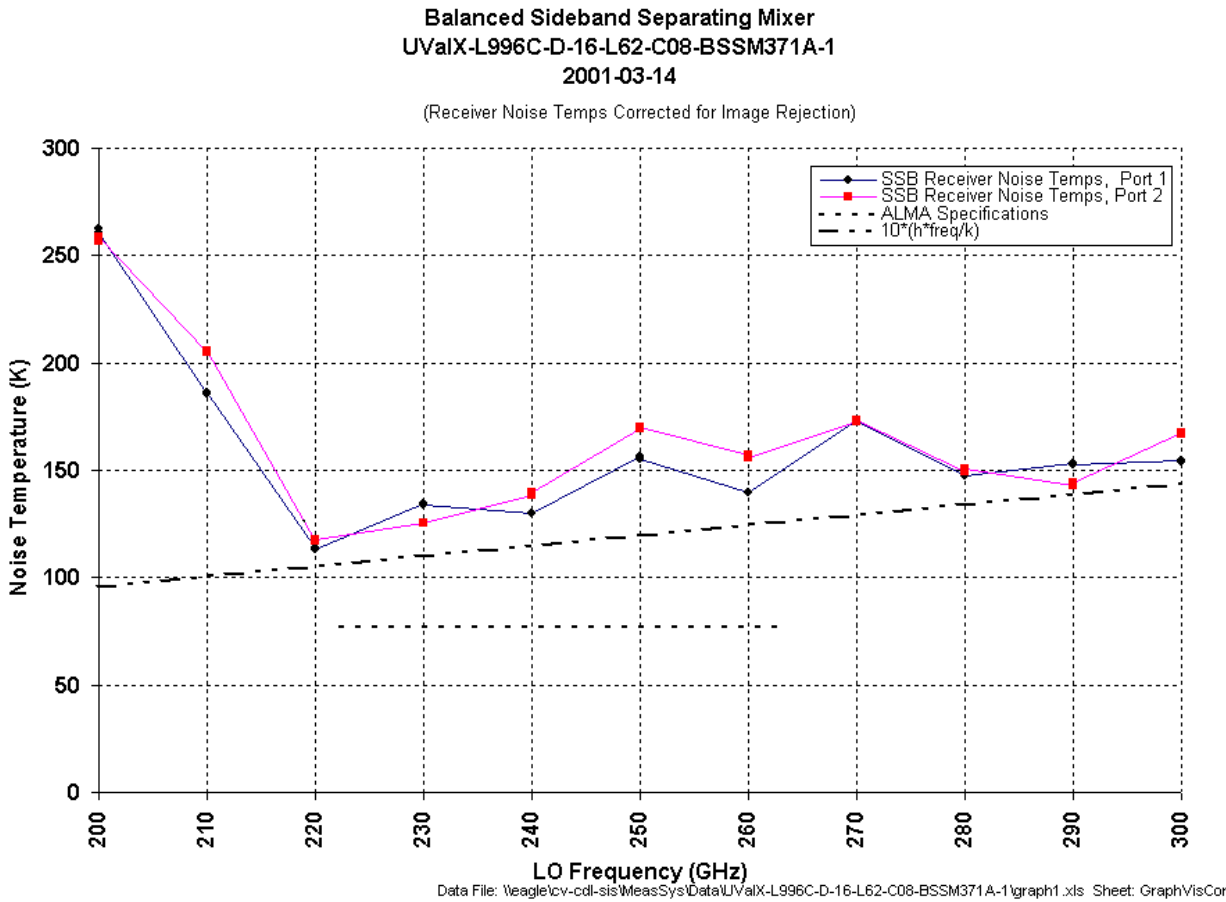
ALMA Project

Band 6 Mixer (211 – 275 GHz)

NRAO (USA)

Development of a sideband separating, balanced mixer



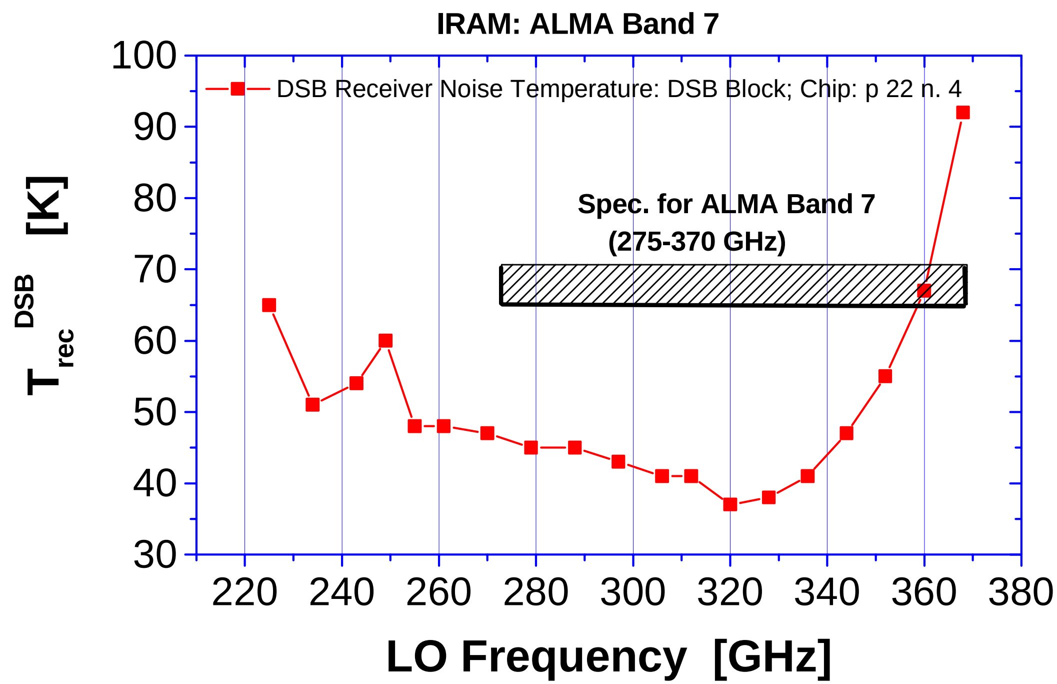


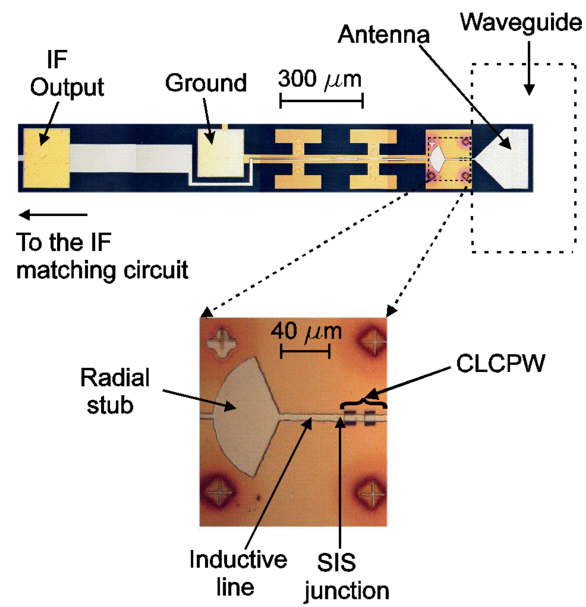
ALMA Project

Band 7 Mixer (275 – 370 GHz)

IRAM (France, Germany, Spain)

First measurement of Band 7 DSB SIS mixer

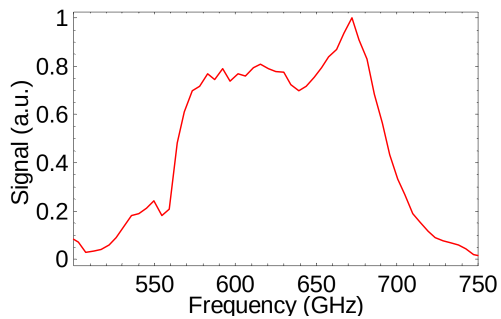


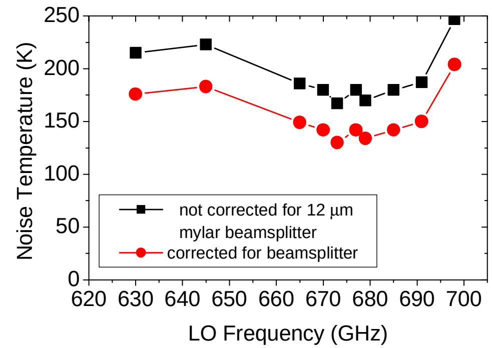


Band 9 Mixer (602 – 720 GHz)

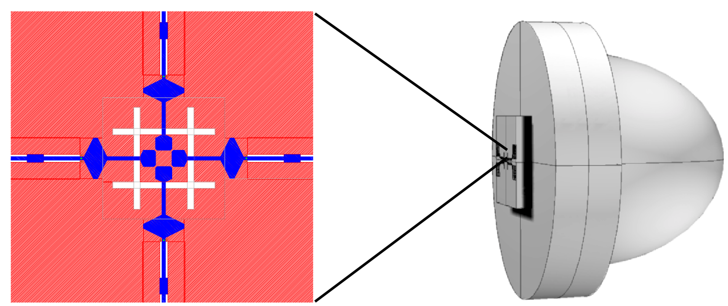
NOVA/SRON (Netherlands)

- Waveguide DSB mixer, $T_{noise} \approx 130 - 200$ K





- D&D of a balanced waveguide mixer using a magic T
- D&D of quasi-optical mixer

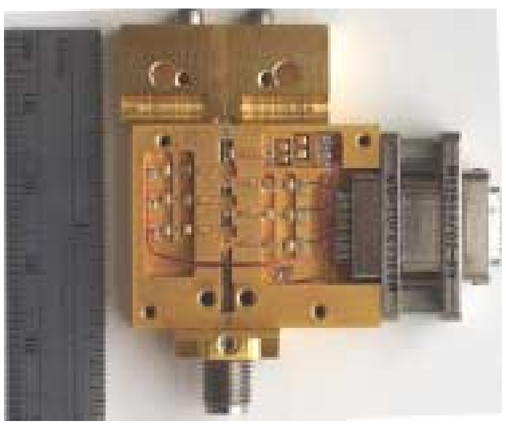


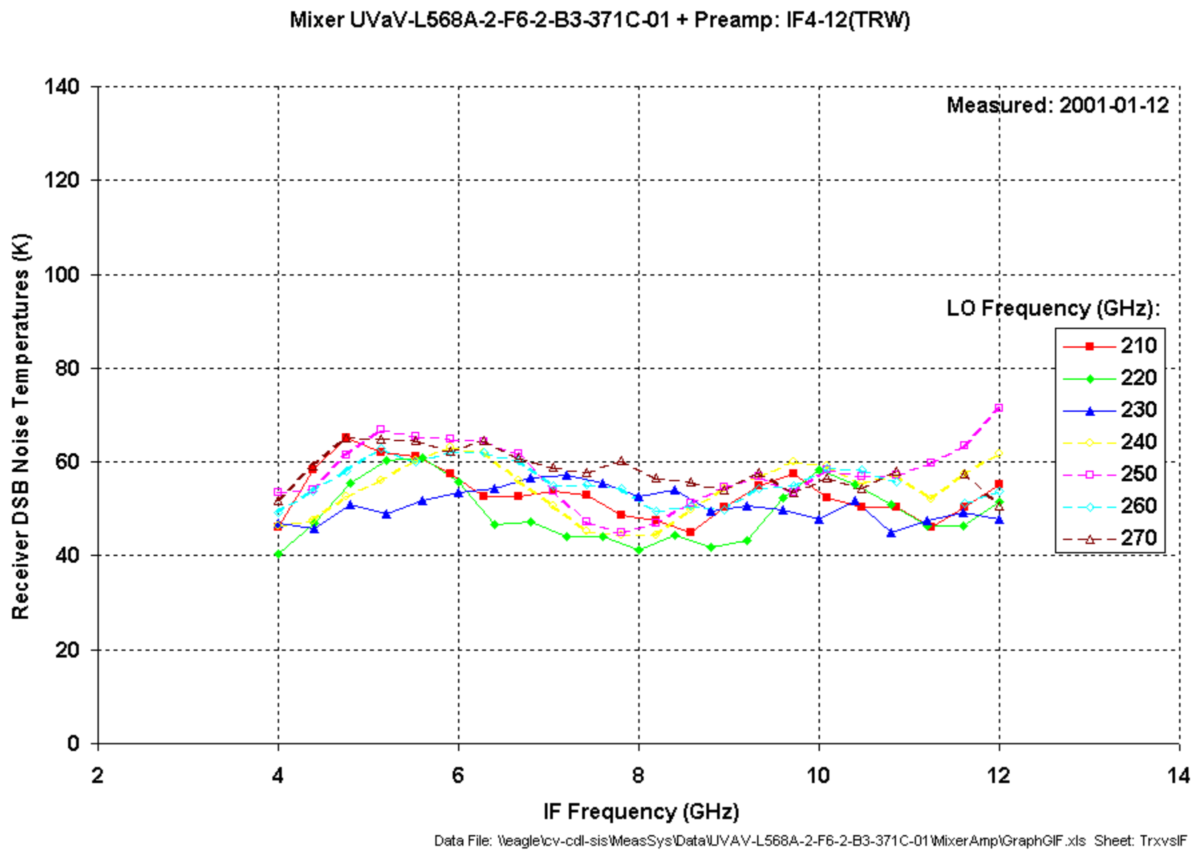
ALMA Project

Wideband 4 -12 GHz IF Amplifier

NRAO (USA)

Integration into SIS mixer






ALMA Project

ALMA Local Oscillator

Two schemes under development

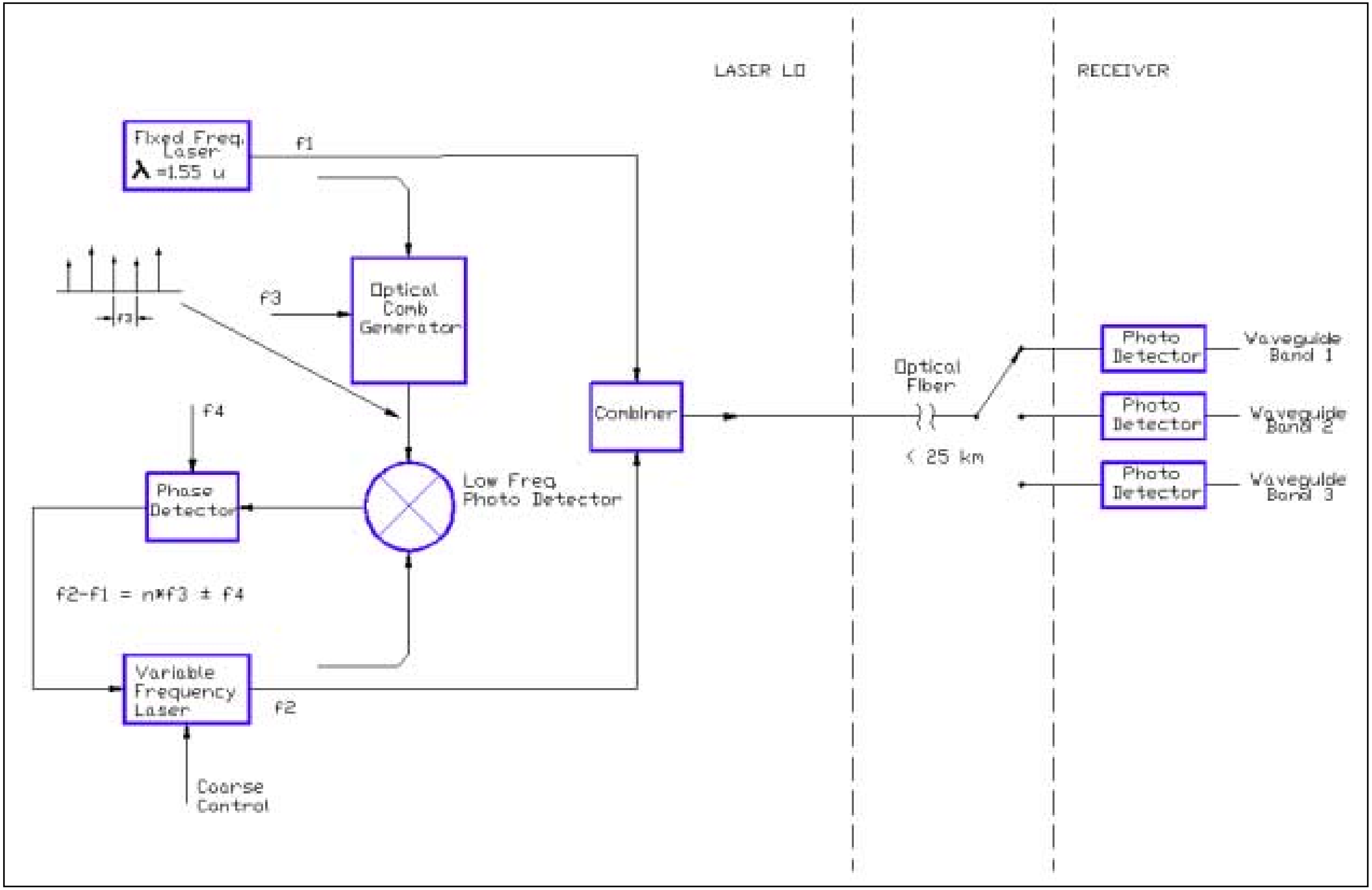
– Fixed tuned multiplier chain:

YIG oscillator + power amp + multipliers

– Photonic LO:

Mixing of two lasers with a high frequency photomixer to generate LO signal

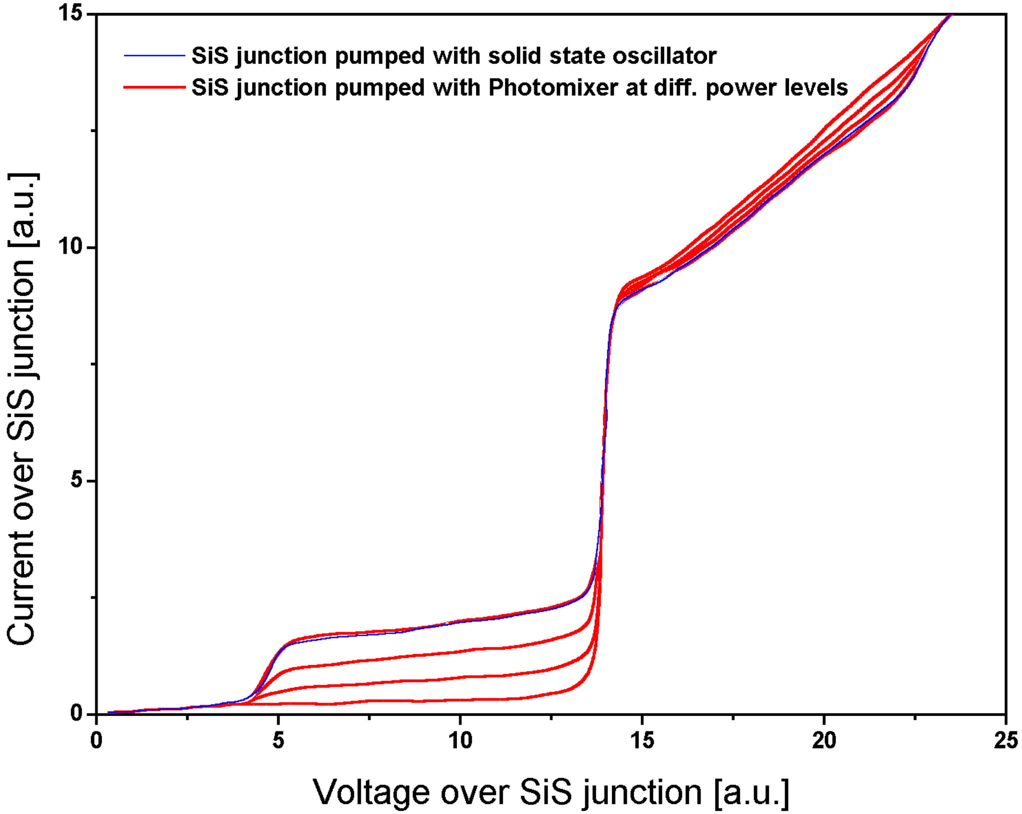
ALMA Photonic LO - Principle



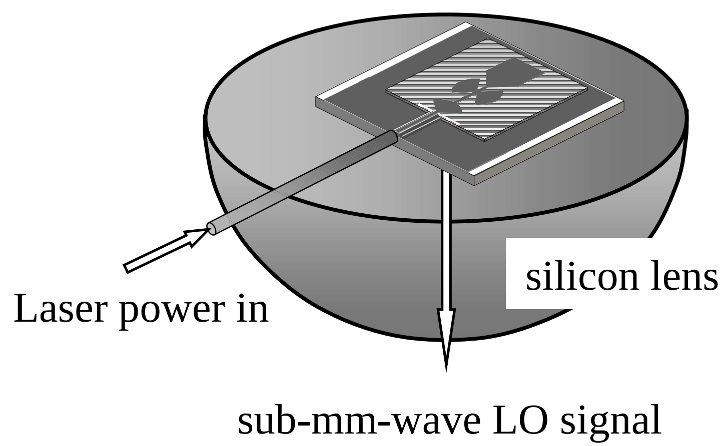
ALMA Project

Photonically Pumped SIS Mixer at 490 GHz

MPIfR, U of Duisburg (Germany)



- First demonstration @ 490 GHz
- Issue to consider
  - Output power
  - Noise properties




ALMA Project

Some of the Challenges

- New technologies: Sideband separating SIS mixers

  Local oscillator

  - fixed tuned multipliers
  - high frequency photomixer

  Industrial type fabrication
- Large quantities of components required:

  64 antennae x 10 bands x 2 polarizations = 1280
- International collaboration with many participants

ALMA Project

ALMA in 2010 …

Courtesy of NAOJ