The multibeam receiver for SRT, the Sardinia Radio Telescope

Alessandro Orfei

INAF - Istituto di Radioastronomia, Bologna, Italy

SRT Technical Specifications

- 64 m diameter primary mirror; 7.9 m diameter secondary mirror
- Gregorian configuration with *Shaped Surfaces*
- Active Surface: Primary mirror adjustable with 1116 actuators

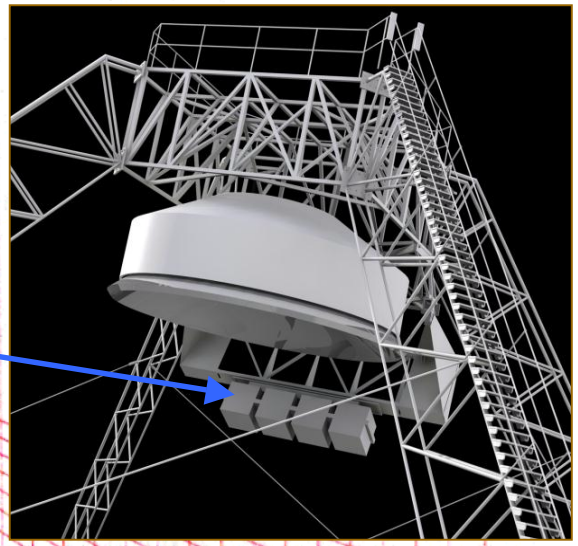
a) Compensate gravitational and thermal deformations

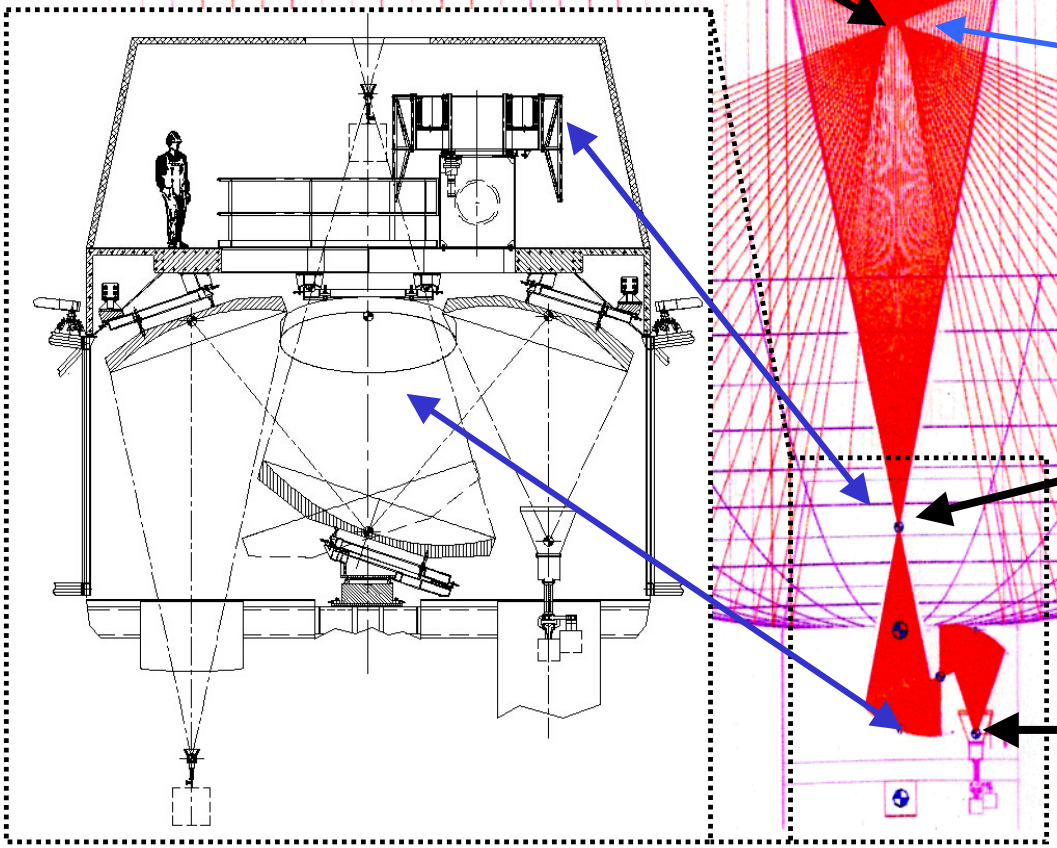
b) NEW: Convert *Shaped* surface of the primary to a *Parabolic* surface for extended frequency primary focus operation

- 0.3-100 GHz continuous frequency coverage
- Six focal positions:
  Primary, Gregorian, Four Beam Wave Guide
- Up to 20 dual polarization receivers:
  single feed, dual frequency, multibeam
- Primary surface accuracy: ≈150 μm RMS
- Max antenna efficiency: ≈ 60 %
- Pointing accuracy (RMS): 2 ÷ 5 arcsec

Optical Configuration and Ray Tracing of SRT

Primary Focus
F/D ratio=0.33
8 receivers
300MHz < *f* < 20GHz





Gregorian Focus
F/D ratio=2.35
8 receivers
7.5GHz < *f* < 100GHz

Beam Wave Guide Focus
F/D ratios=1.37 & 2.81
2+2 receivers
1.4GHz < *f* < 35GHz

Four Receivers are commissioned to test all types of focal positions:

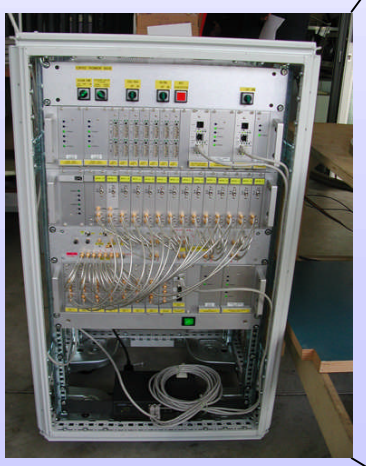
Focal position	Receiver type	Frequency band
Primary	Dual frequency	*P-band:* 305-425 MHz *L-band:* 1.3-1.8 GHz
Gregorian	Multibeam	*K-band:* 18-26.5 GHz
Beam Waveguide	Single feed	*C-band:* 5.7-7.7 GHz

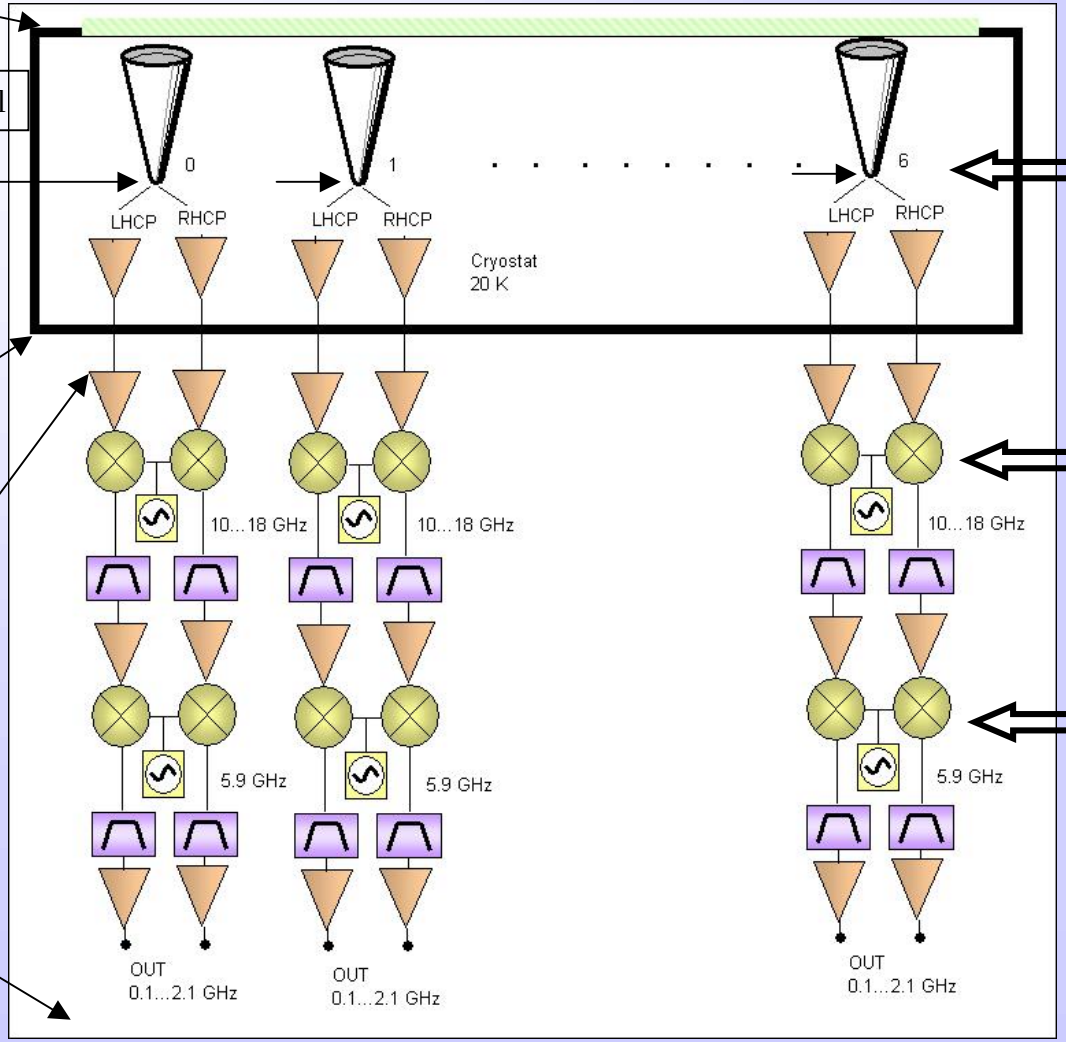
- Science capability: pulsars; VLBI; spectroscopy; continuum survey

THE MULTIBEAM:

K-band (18÷26.5 GHz; 11.3÷16.6 mm) for the Gregorian Focus

CIRCUIT SCHEMATIC



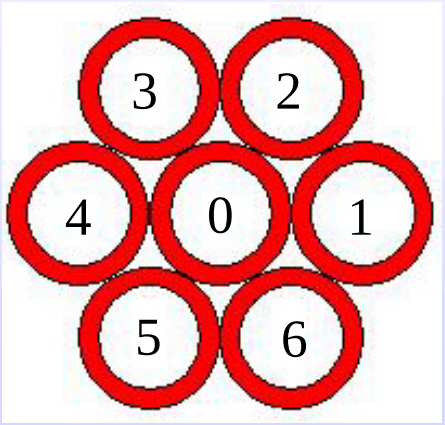


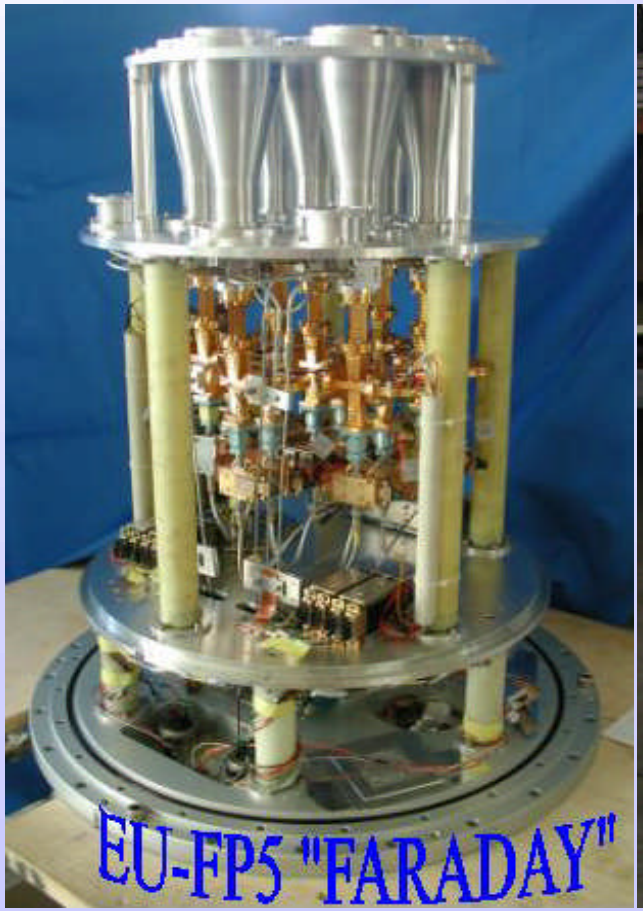
Amplification and Cal injection

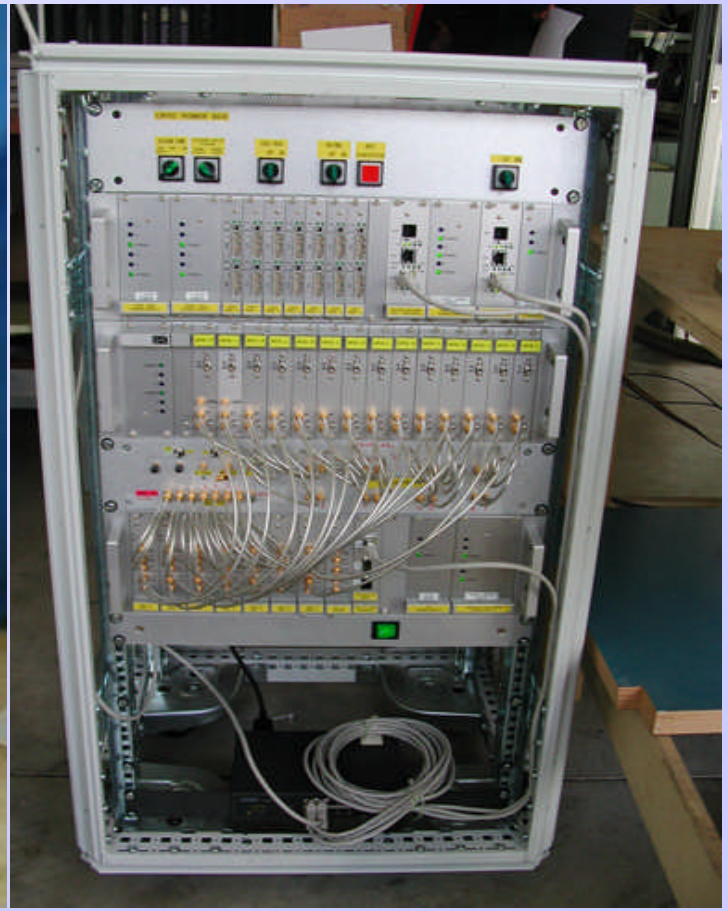
1st conversion

2nd conversion

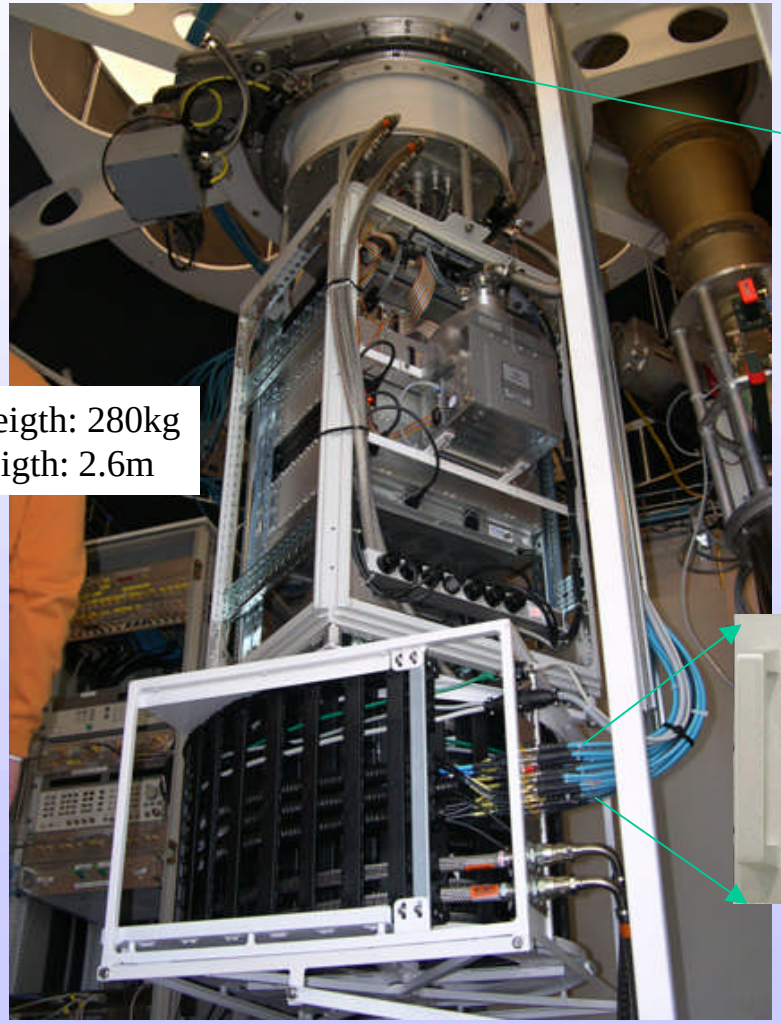
- 7 feed, hexagonal configuration with central feed
- 14 x 2 GHz IF outputs right and left polarization;
- Feeds and LNAs cooled at 20 K;
- Mechanical de-rotator to track the parallactic angle



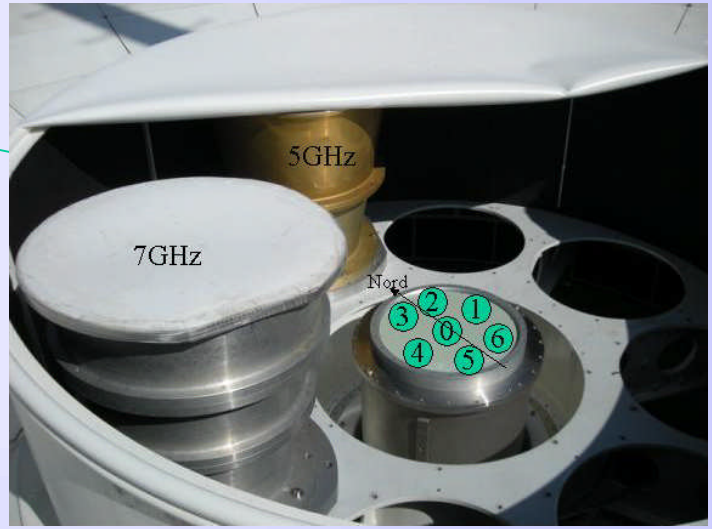




Multibeam + TP back-end installed at the secondary focus of the 32 m Medicina antenna for testing



Weigth: 280kg
Heigth: 2.6m



Total Power detector for Mfeed

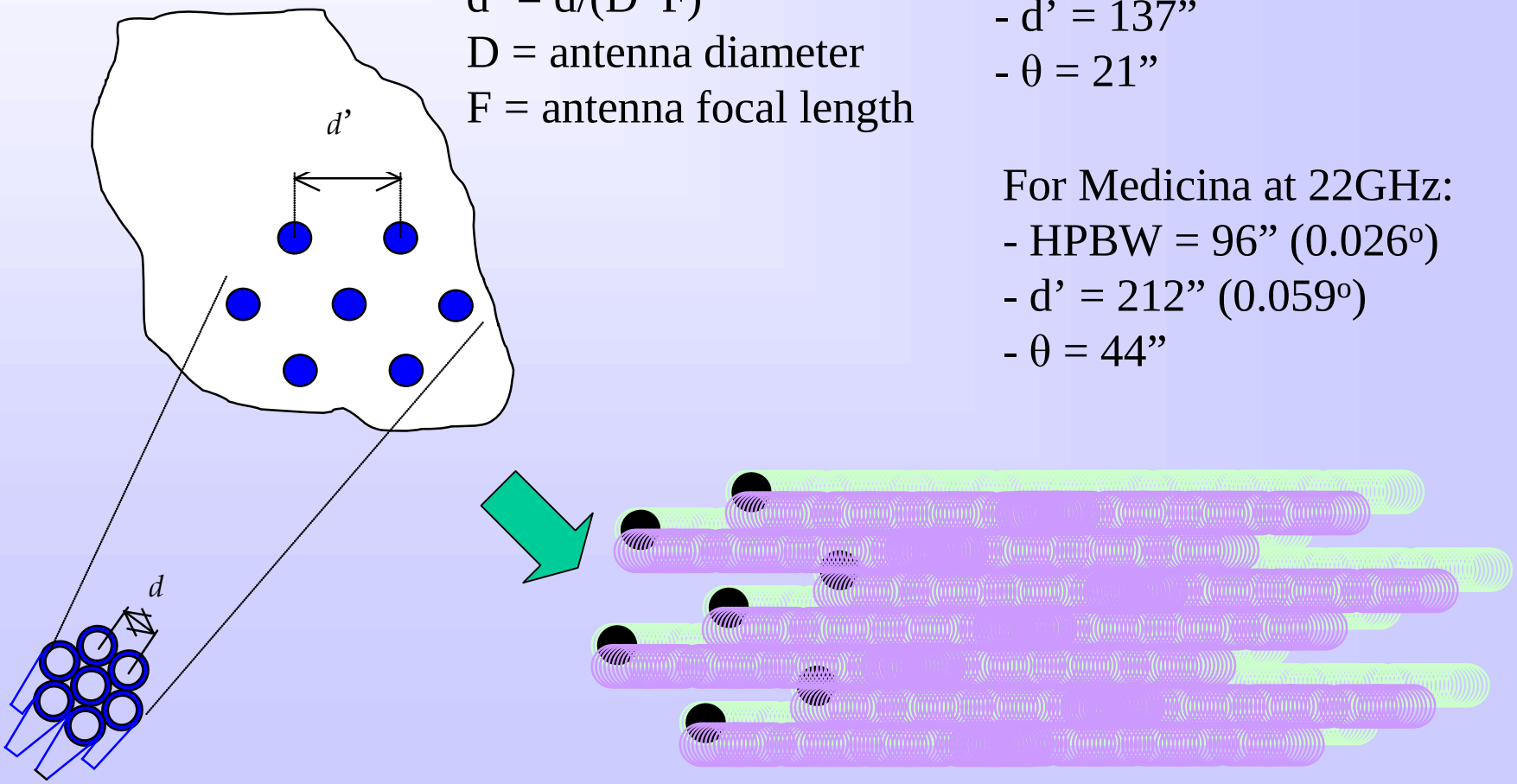
EXTENDED SOURCE SURVEY FUNDAMENTALS

Source sampling theorem: $\theta = 0.5*\lambda/D$

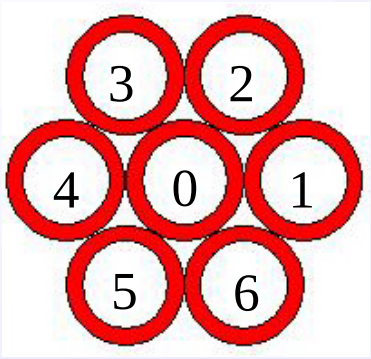
$d' = d/(D*F)$
D = antenna diameter
F = antenna focal length

For SRT at 22GHz:
- HPBW = 50”
- d’ = 137”
- θ = 21”

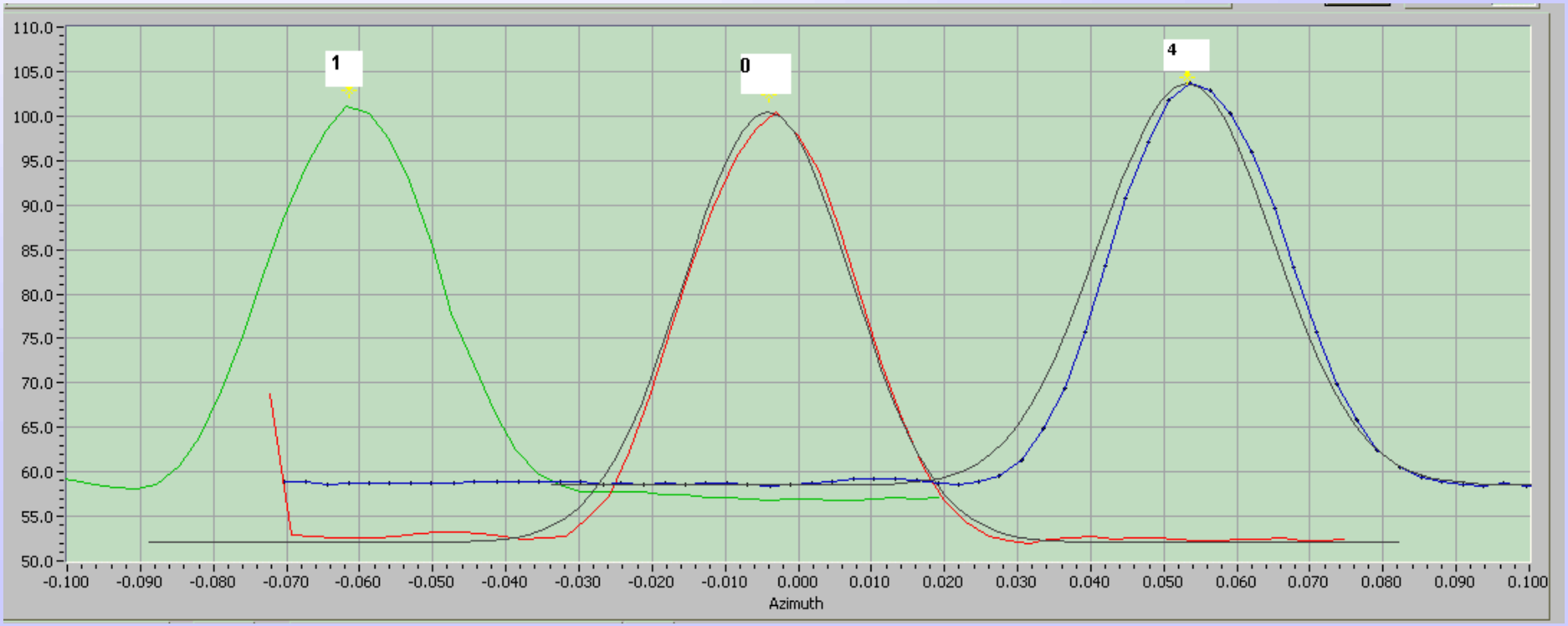
For Medicina at 22GHz:
- HPBW = 96” (0.026^o)
- d’ = 212” (0.059^o)
- θ = 44”

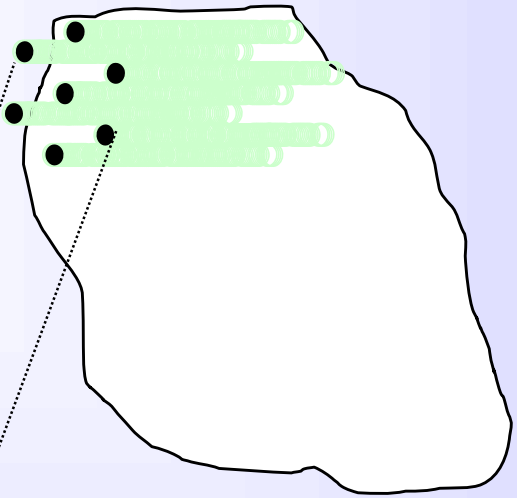


TRANSIT ON A POINTLIKE SOURCE



Beam separation = 0.059^{o}
HPBW = 0.026^{o}



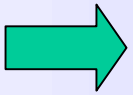


Survey characteristics at Medicina:

- observation band ≈ 18÷20 GHz
- Az scans at speed = 15º/min
- data capture every 50 msec (rotator tracking is not necessary)
- estimated sensitivity ≈ 50mJy/beam (at 5 sigma)
- estimated time for all-sky survey ≈ 30 days (including 50% overhead)
- antenna elevation = 45º

WHERE SURVEY NUMBERS COME FROM?

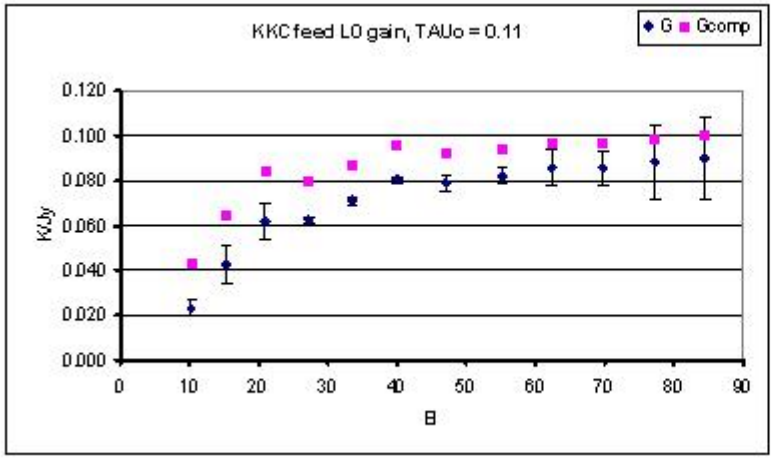
-Estimated time comes from
- Beam dimension
- Scan speed
- Elevation of the scan



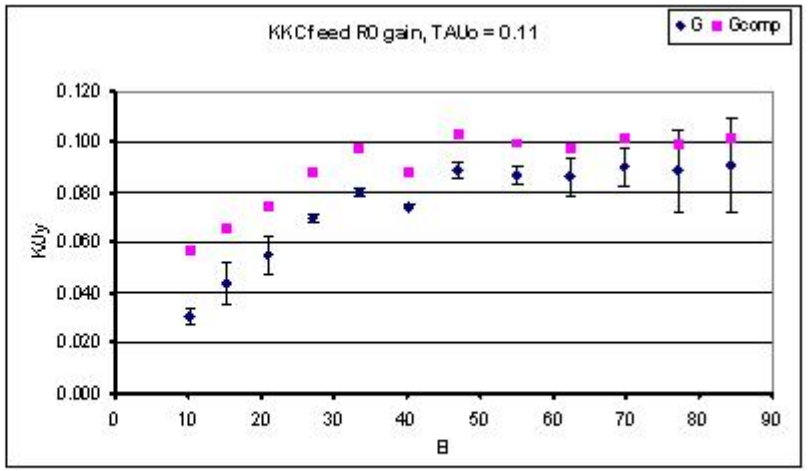
- HPBW = 108” (Medicina at 20 GHz)
- speed = 15º/min
- El = 45º

-Estimated sensitivity in Jy comes from
- Antenna Gain,
- Tsys,
- BW,
- Integration time per beam

Multibeam Antenna Gain

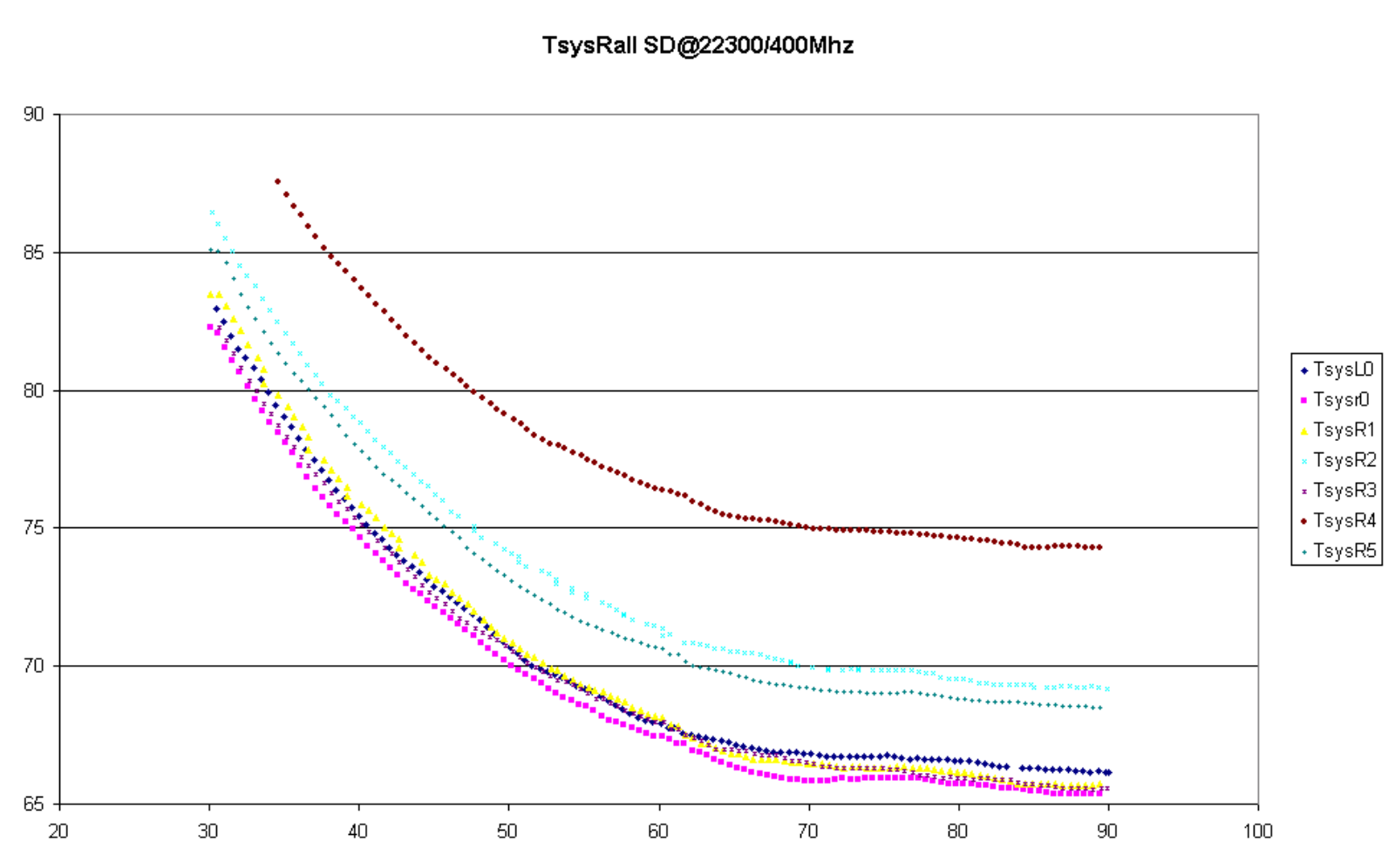


MISURE del 29set08

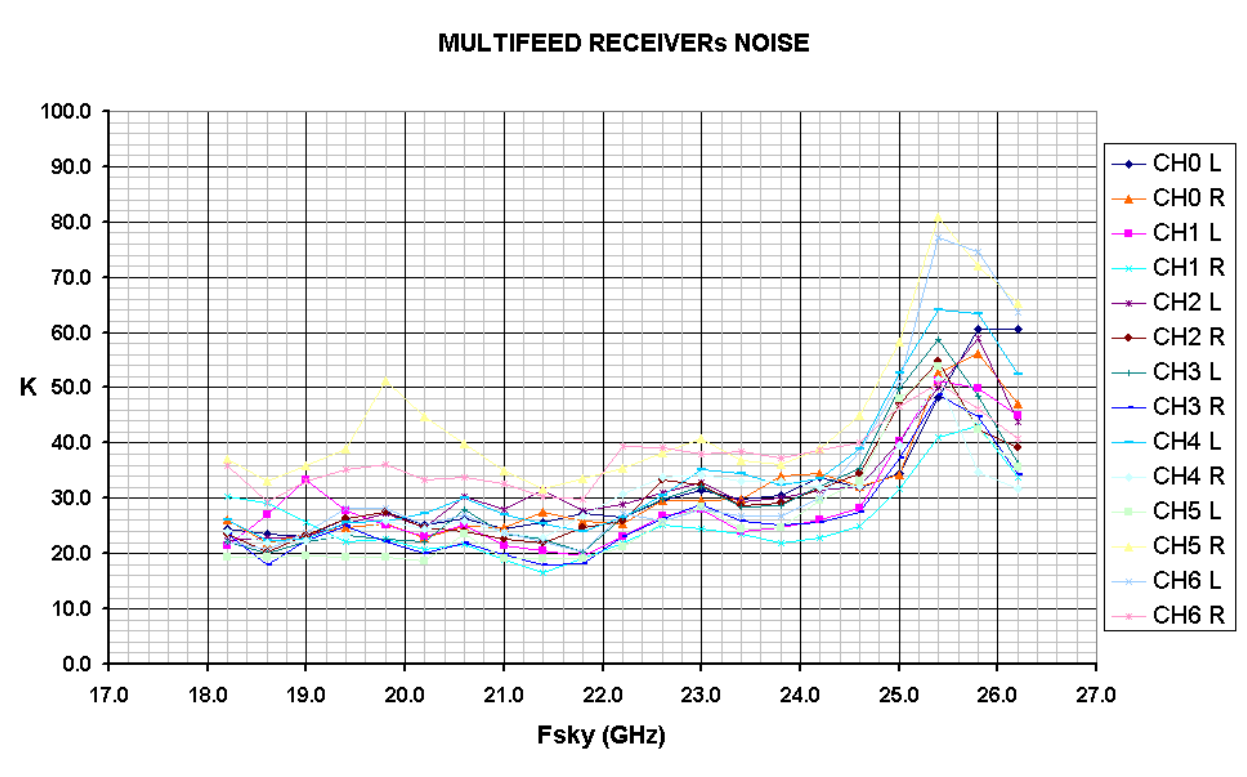


Multibeam System Temperature

at 22GHz, $\tau_o = 0.07$



Multibeam System Temperature



+

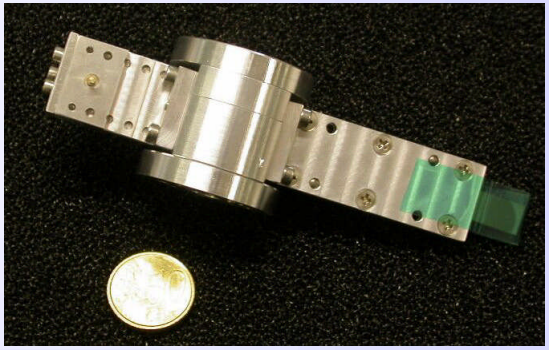
Atmosphere (τ_o=0.11) + spillover + 2.73

≈

(at 20GHz) 60K (at El= 45º)

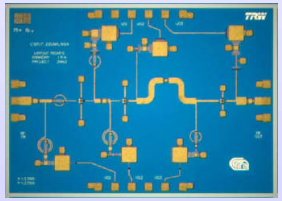
Multifeed receiver chain components

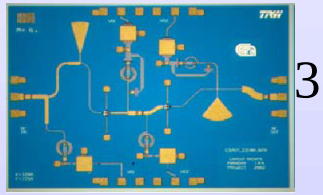
Feed system chain



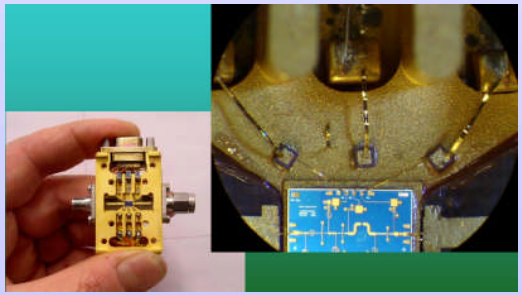
Directional Coupler

Pol-OMT

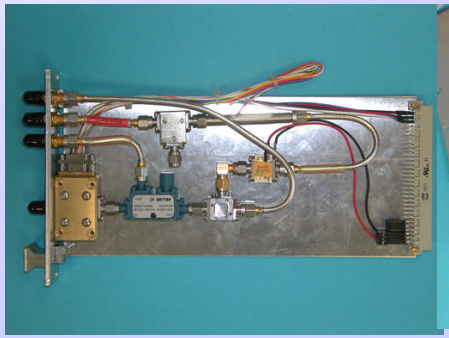




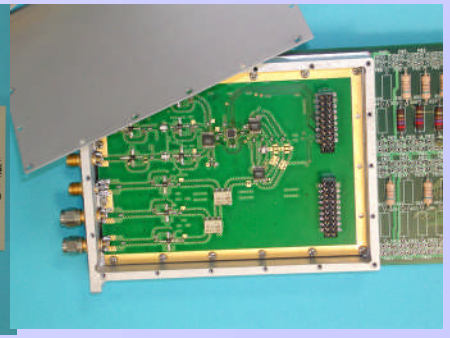
3 x 2.5mm



InP-MMIC LNAs



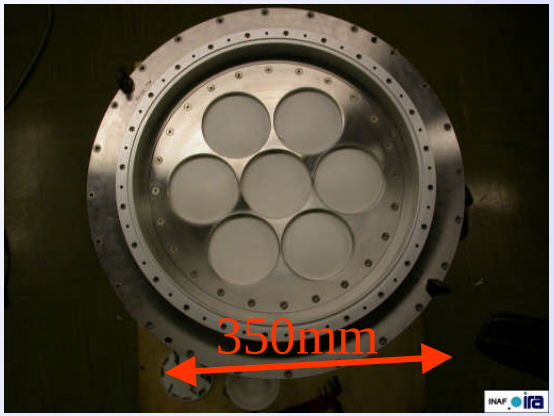
1st conversion:
18÷26.5GHz in
6÷8GHz out



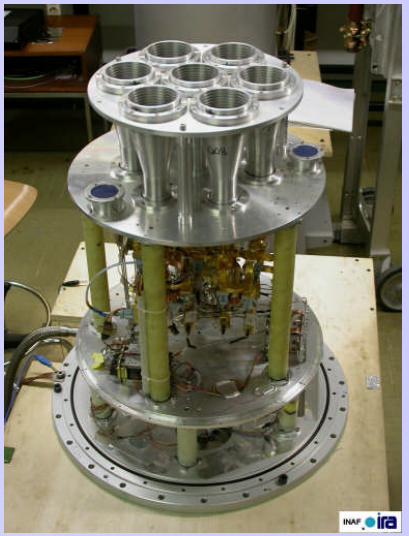
2nd conversion:
6÷8GHz in
0.1÷2.1GHz out

Multifeed: cryogenics

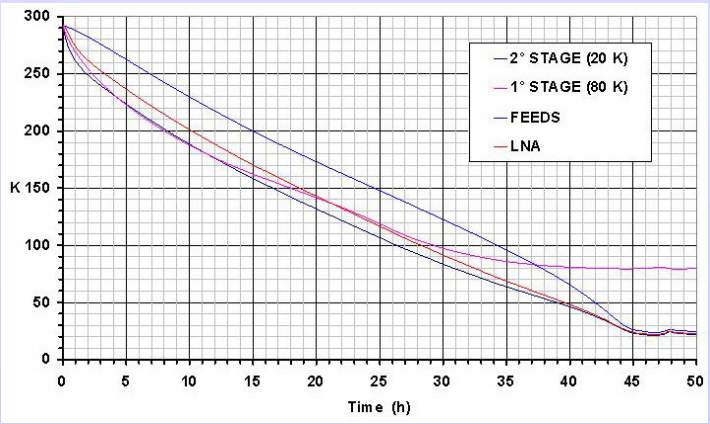
Volume: 80 litres

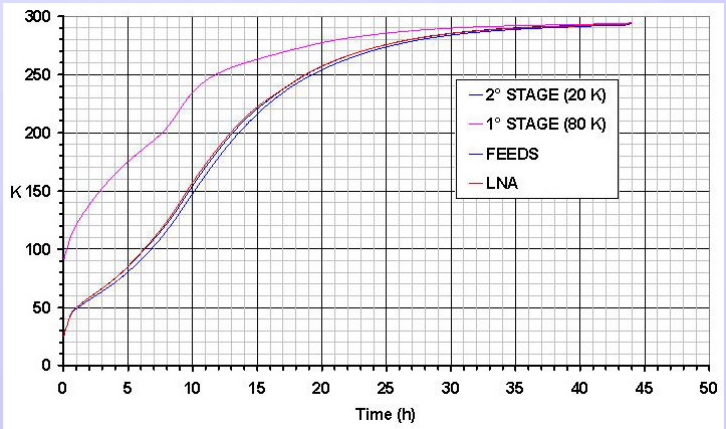


Windows : 100mm



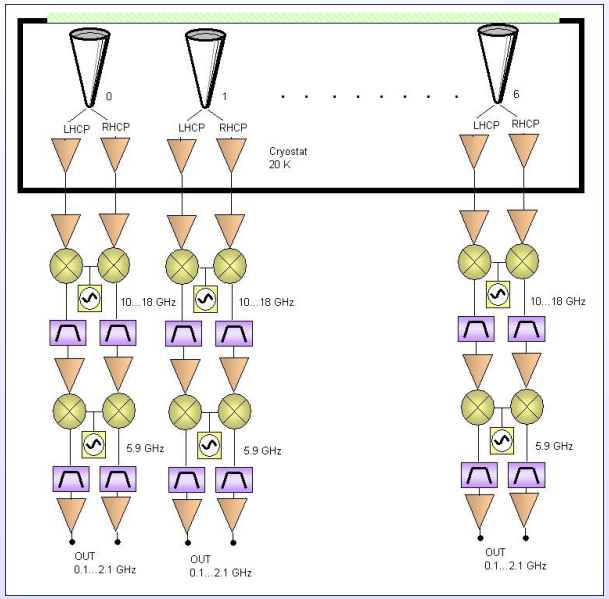
Superinsulation



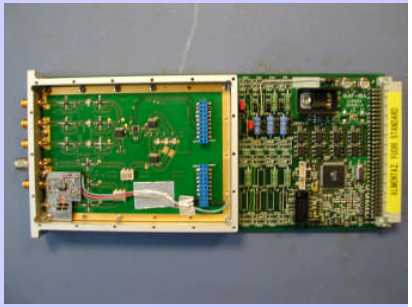


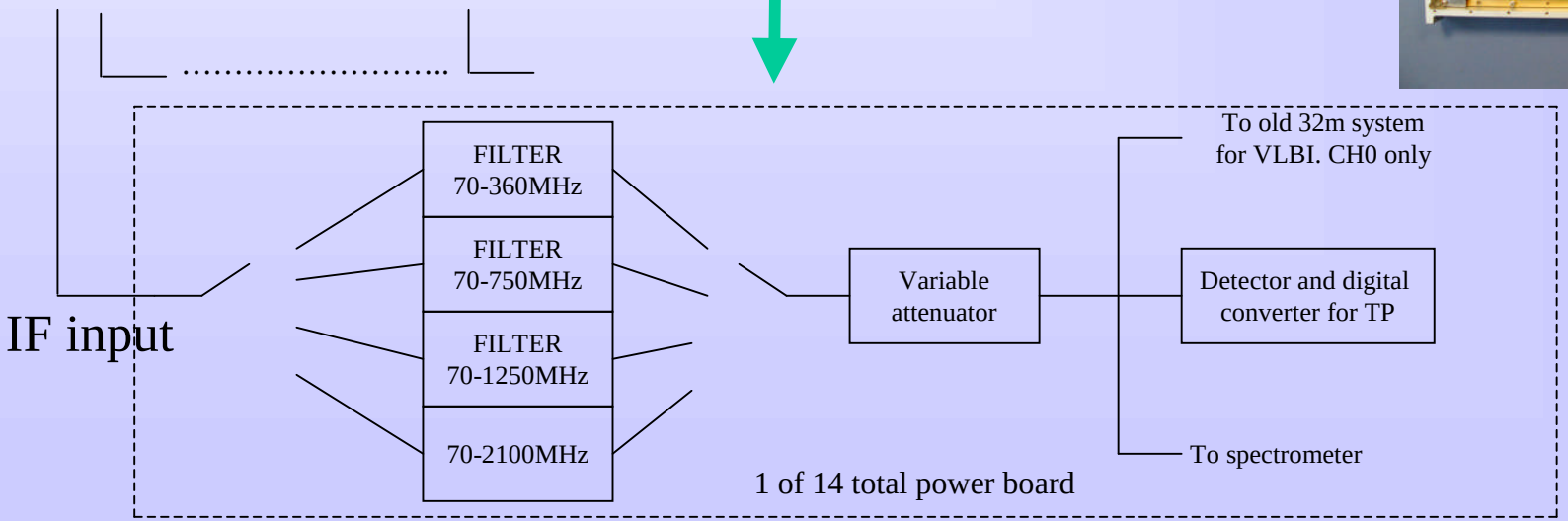
Cool down and warm up times

Total Power detector for Mfeed

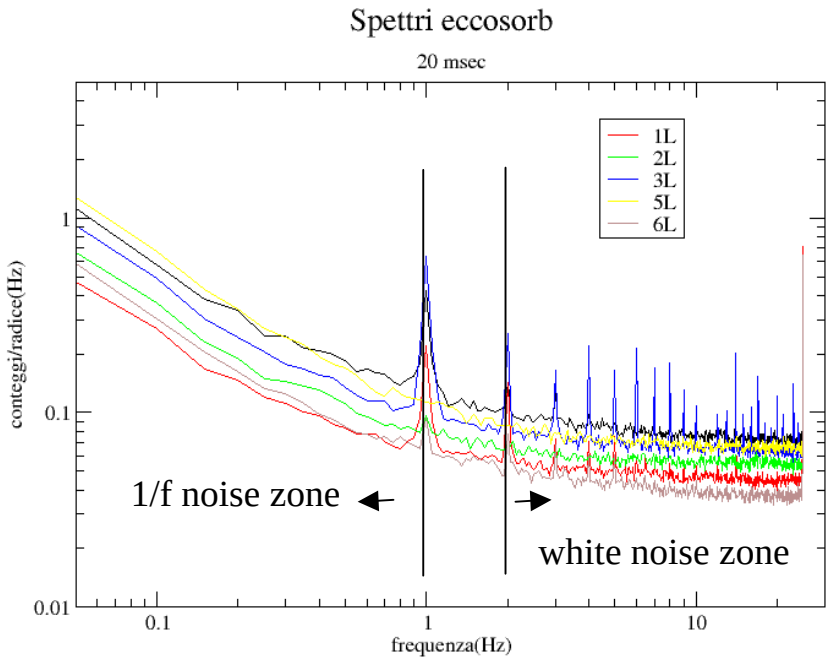


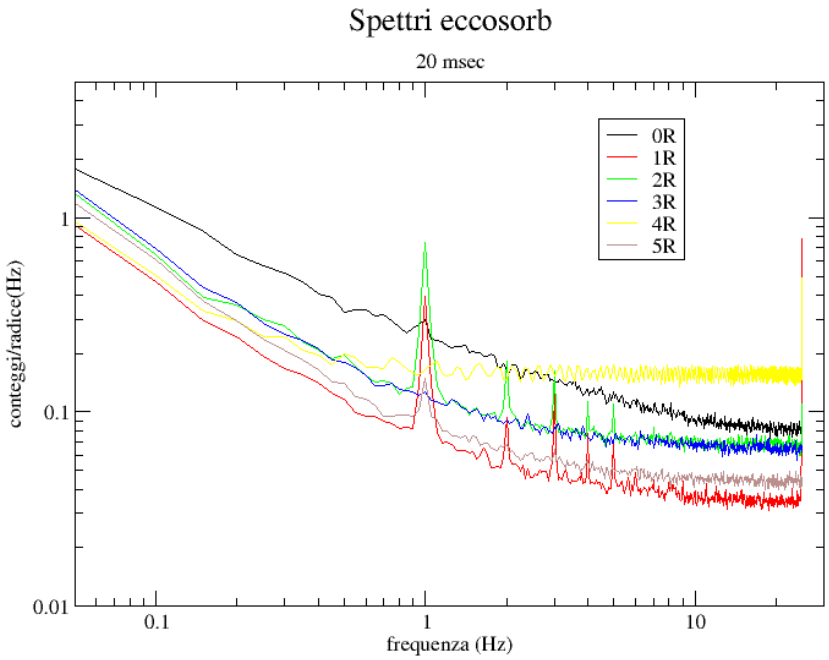
- 14 IF (0.1÷2.1GHz) inputs
- filters 300,700,1200, 2000 MHz remotely selectable
- remotely controllable variable attenuators
- cable equalizer
- V/f converters, integration time 0.001÷1 sec
- *Spectroscopy and TP at the same time possible*





Receivers stability (2GHz BW)





knee frequency ≈ 1÷2 Hz

New: A back-end exploiting the full band of the Multibeam

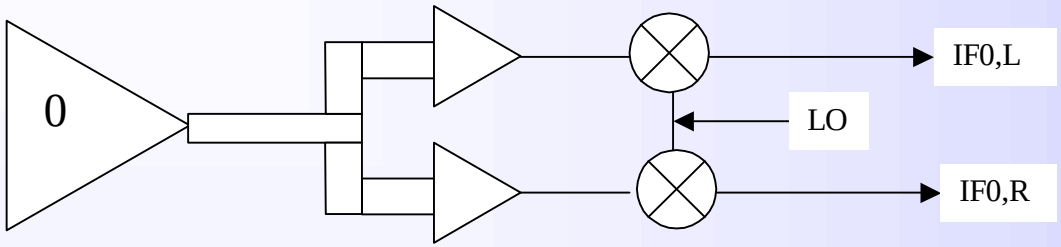
Aim: detection of full 8GHz BW for each of the 14 K-band Mfeed outputs

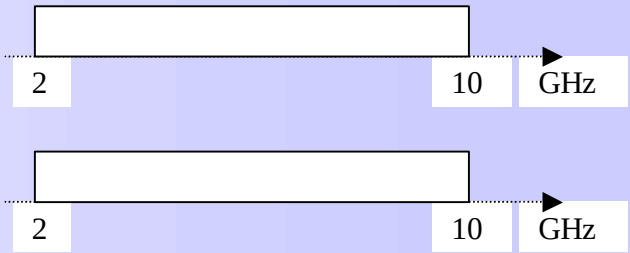
Actions:

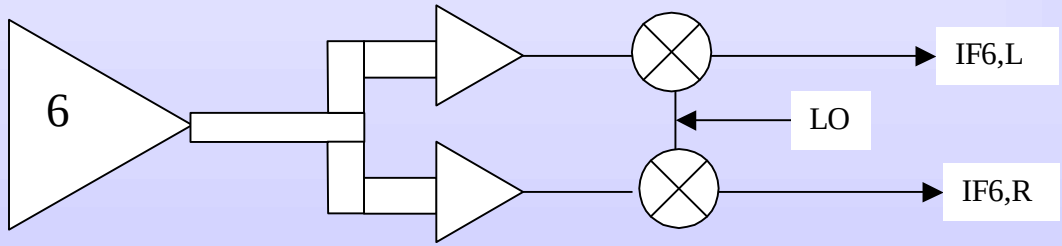
- DEVELOP A BACK-END ON A PRINTED CIRCUIT BOARD ABLE TO:
  - ✓ use commercial components in the < 12GHz frequency range
  - ✓ split a converted 18÷26GHz band in 8 sub-bands ~1GHz wide
  - ✓ make down conversion of each sub-band to get basebands ~ 1GHz
  - ✓ detect FULL STOKES parameters for each sub-band

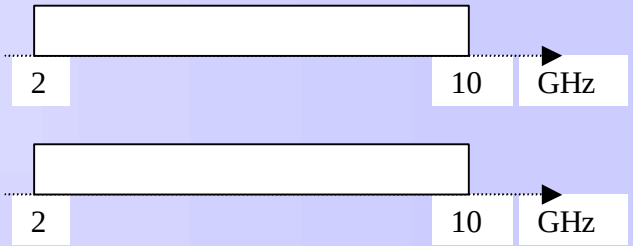
- eliminate the 2nd conversion (2GHz wide) in the receiver

FULL BAND MULTIBEAM OUTPUTs

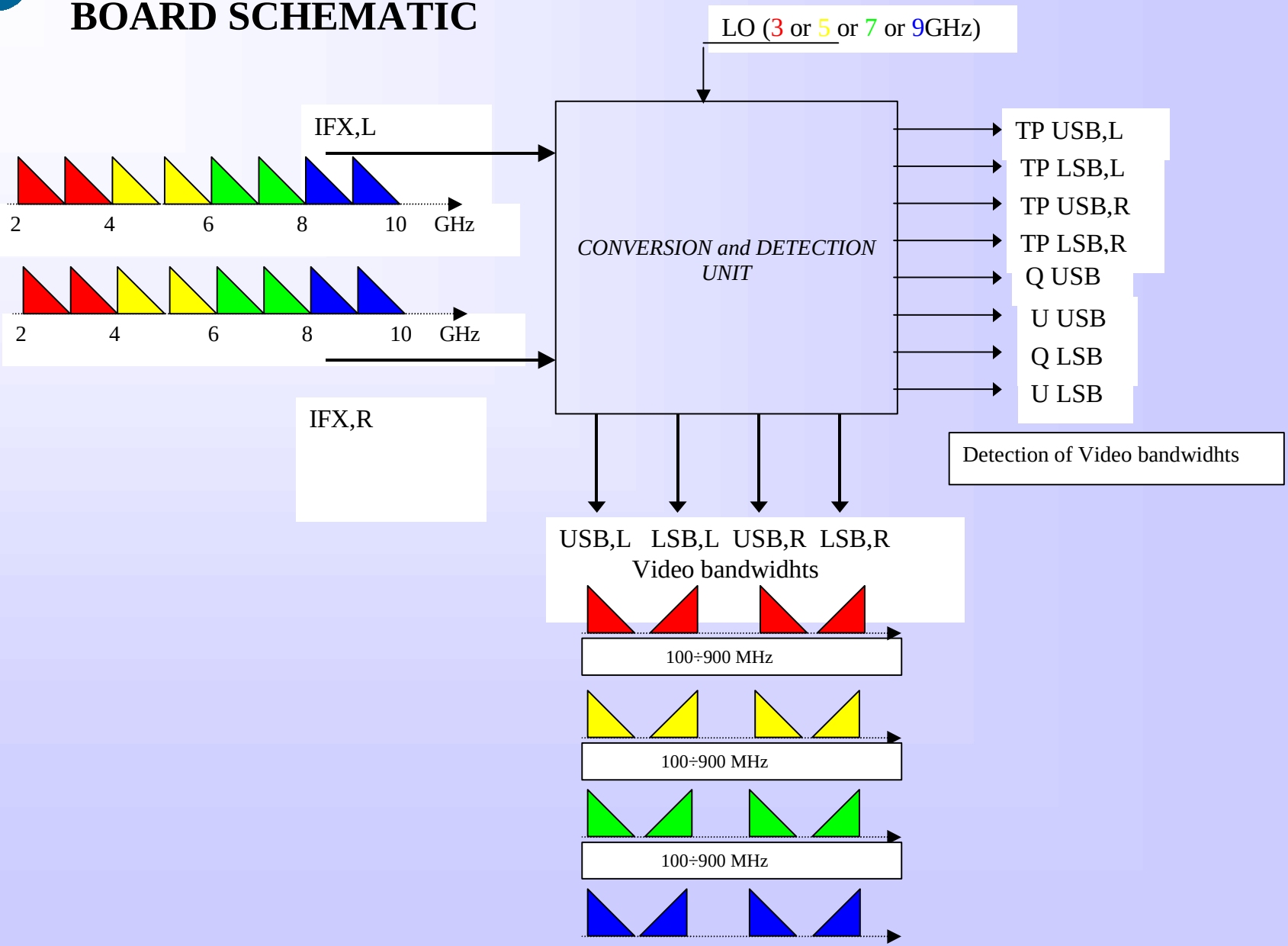








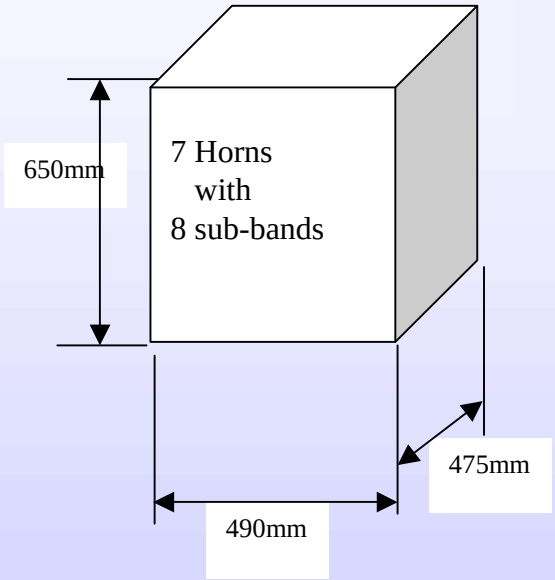
BOARD SCHEMATIC



THE END

Thanks!

RACK of BOARDS



THE RACK CONTAINS:

- 28 conversion/detection PCB boards
- 28 A/D digital PCB boards
- 4 LO distribution PCB boards
- 1 10MHz distribution PCB board
- 4 LO devices

RACK OUTPUTs:

- 4 LOs signals (at 3, 5, 7, 9 GHz)
- 1 10MHz ref.
- 28*4 videobands (100÷900MHz)
- 28*8 Stokes parameters (digital)