# Instrumentation Developments for VGOS at IGN-Yebes Observatory

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24th EVGA meeting, March 17-19, 2019, Gran Canaria, SPAIN
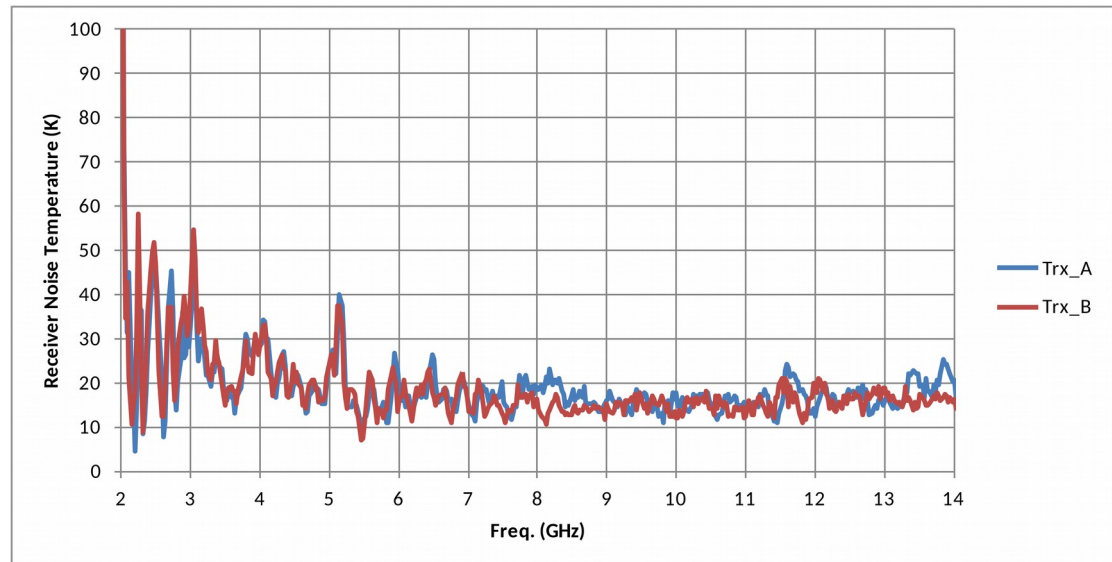
VGOS receivers: NMA & FGI
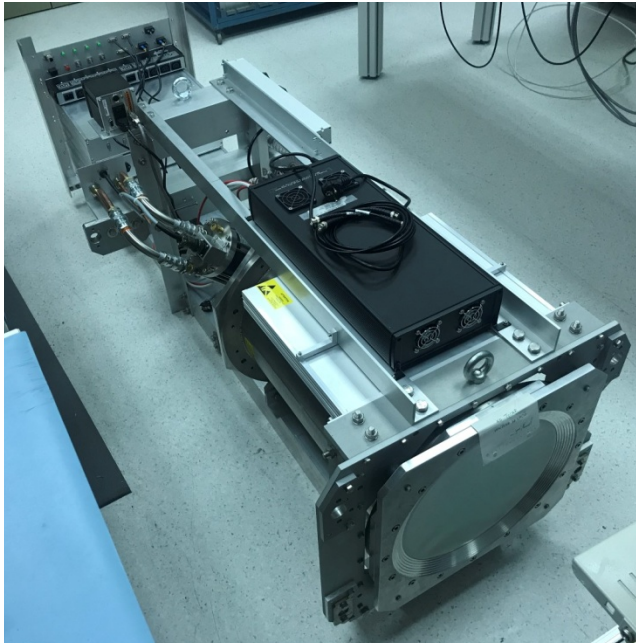
NMA (2 BB receivers)
- 1st delivery scheduled for June 2019

FGI (1 BB receiver):
- Delivery September 2019

Trx < 25 Kelvin where no RFI
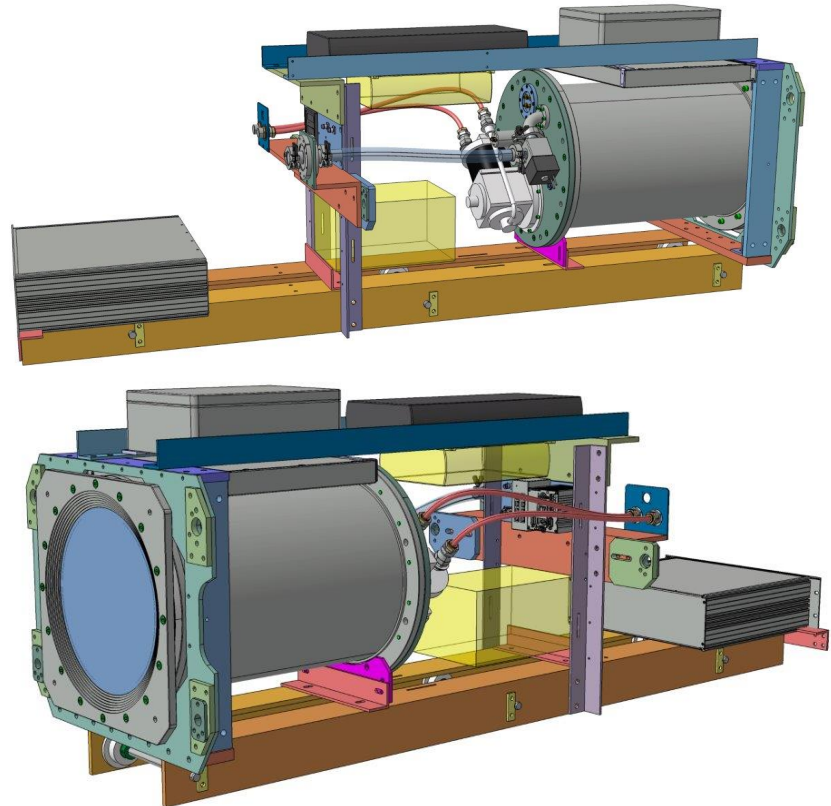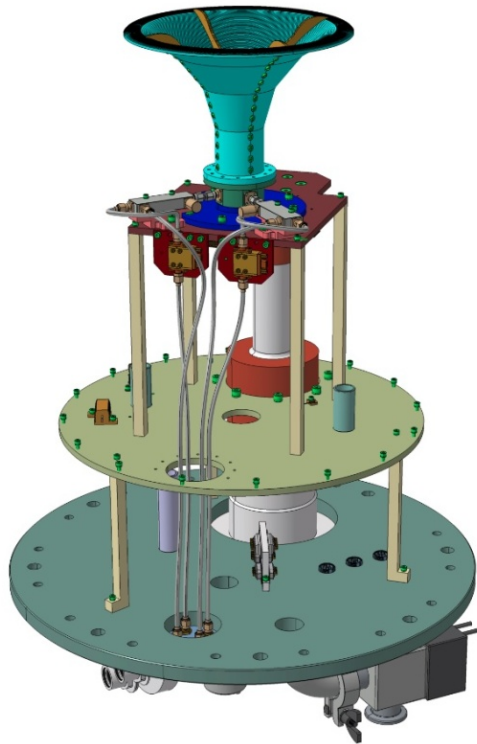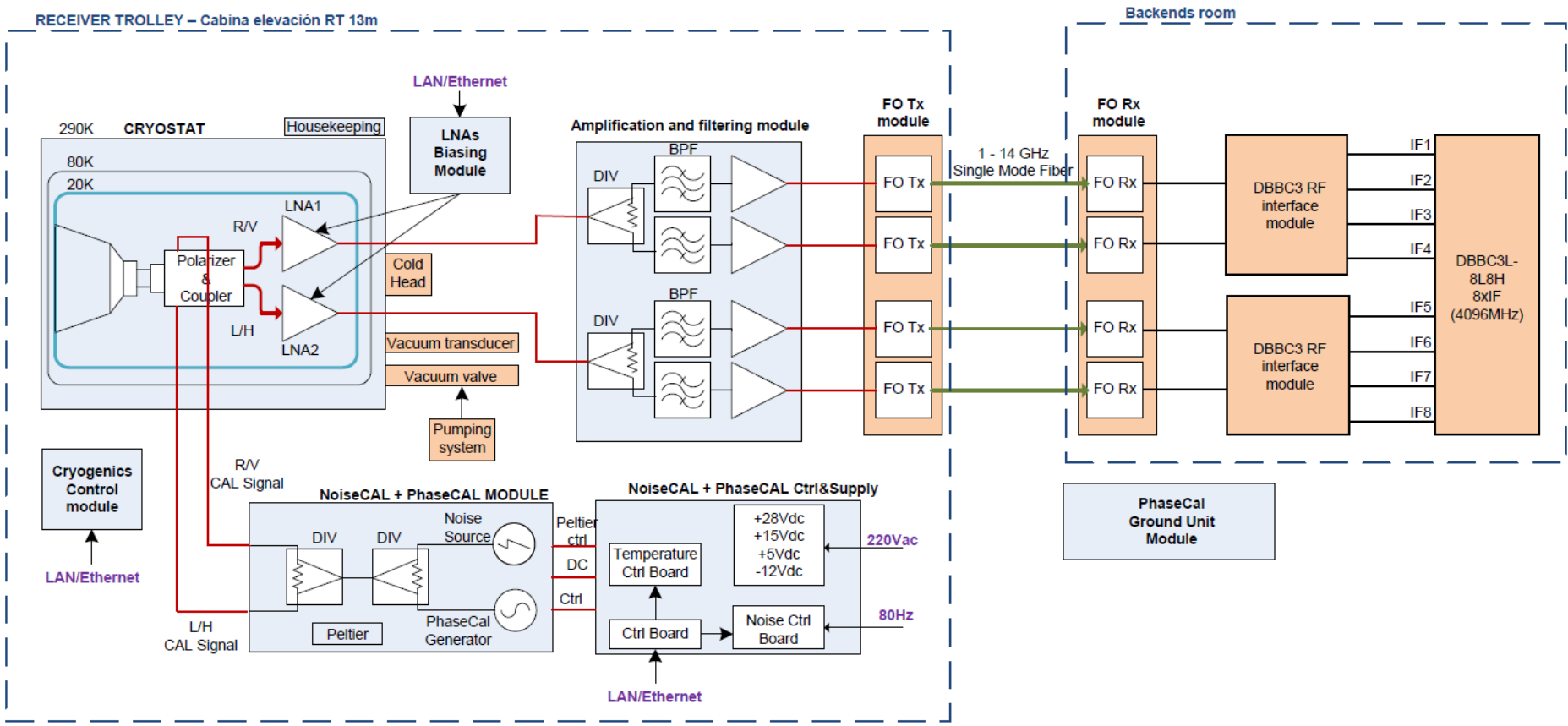
VGOS receivers: Santa María

- Contracted with Spanish company: TTI-Norte
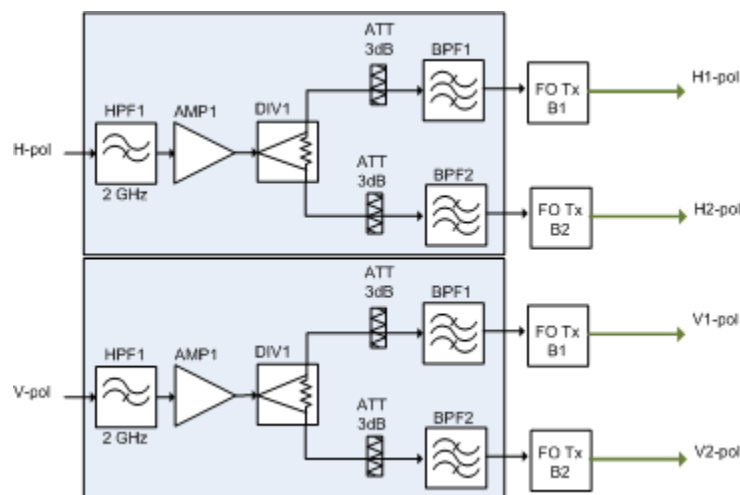
- Delivery: summer 2019

VGOS receivers
Block diagram

VGOS receivers
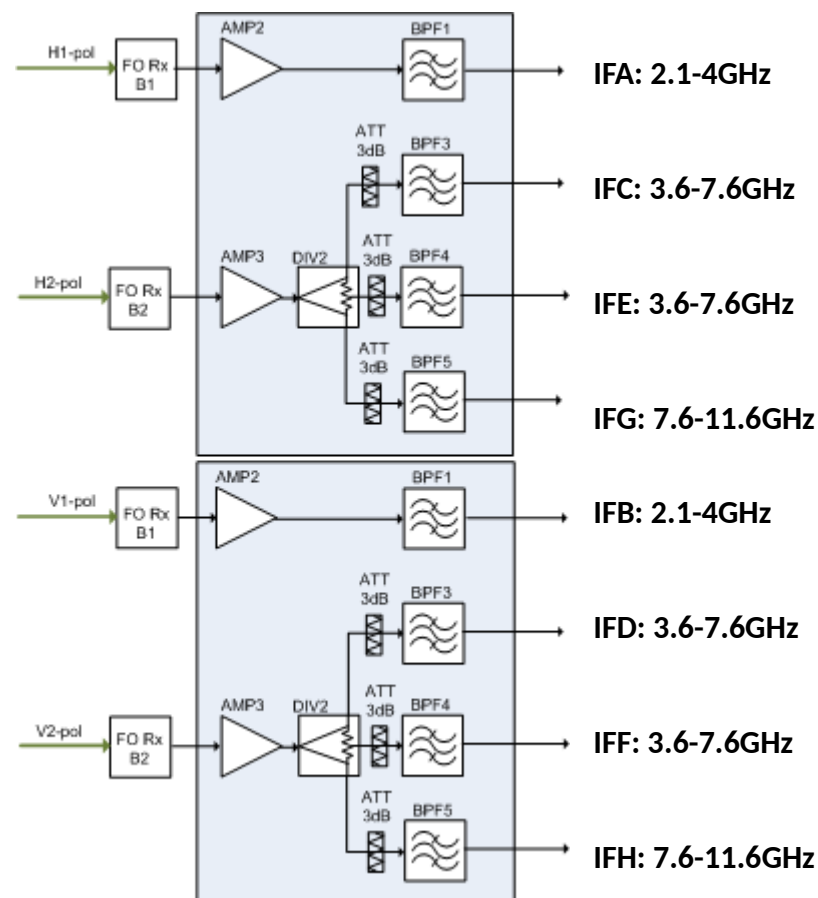## Filtering and pre-amplification units

- Signal conditioning for DBBC3
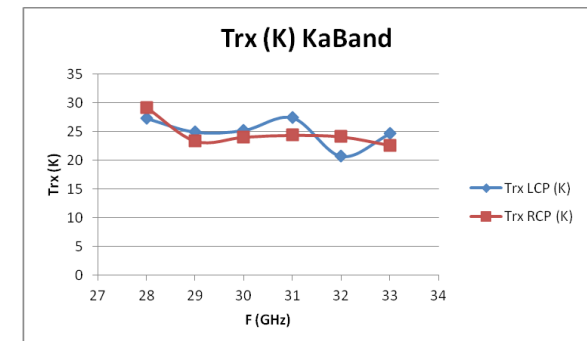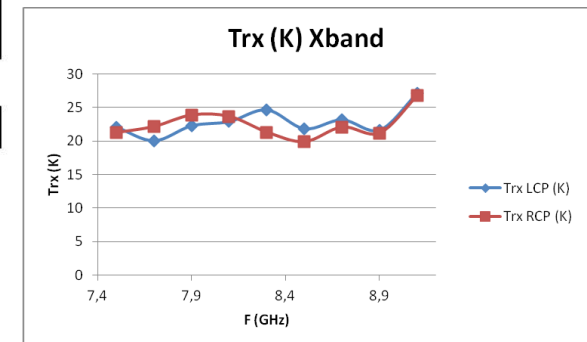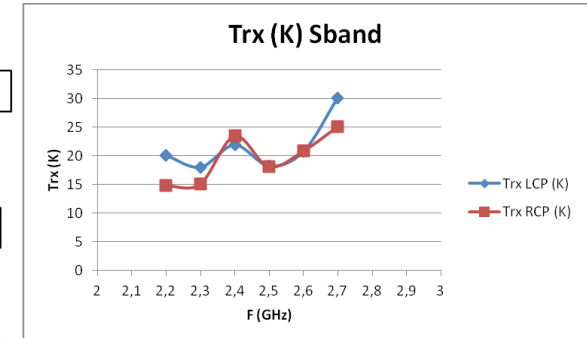- Under construction for NMA and FGI

Similar to Hasytack scheme:
- Low band: 2.1 – 5.6 GHz
- High band: 3.6 – 11.6 GHz

Tri-band receivers

FRONT VIEW

Power Supply connections

TEMEPRATURES MONITOR

LNAs BIASING MODULE

VACUUM WINDOW

Tri-band feed

Cold stage

Intermediate stage

Cold Head

Trx (K) Sband

Trx (K) Xband

Trx (K) KaBand
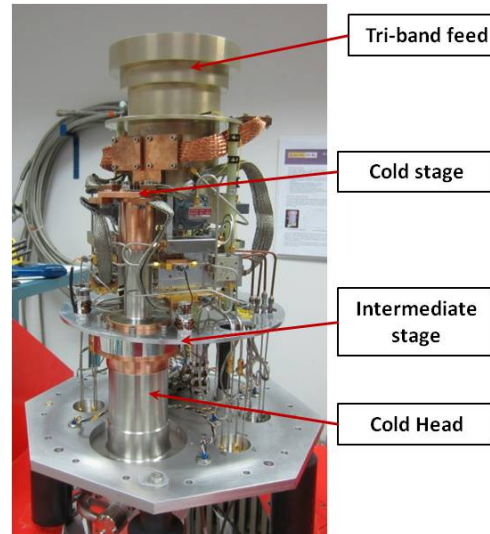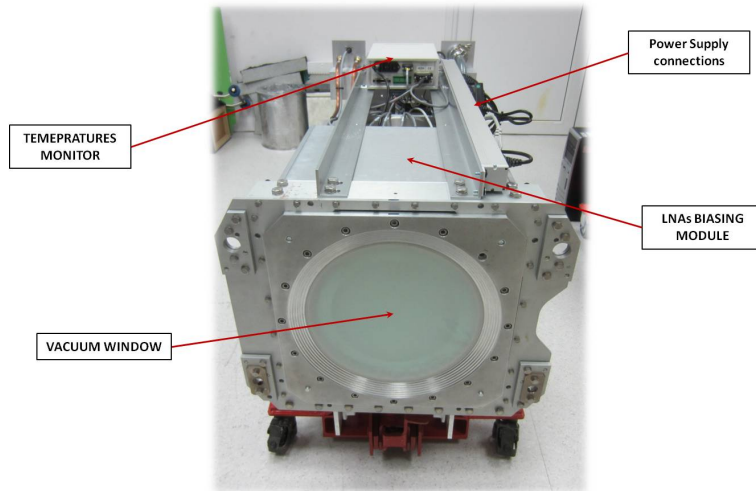
Three tri-band receivers built at Yebes:

- First receiver for Yebes VGOS antenna (2015 - 2016)
- Tri-band receiver for Ishioka station
- Tri-band receiver for Santa Maria VGOS station

Tri-band receiver support to NMA

SIDE I VIEW

Cold head
Power supply cable

Vacuum
Transducer

Ka band Tamb
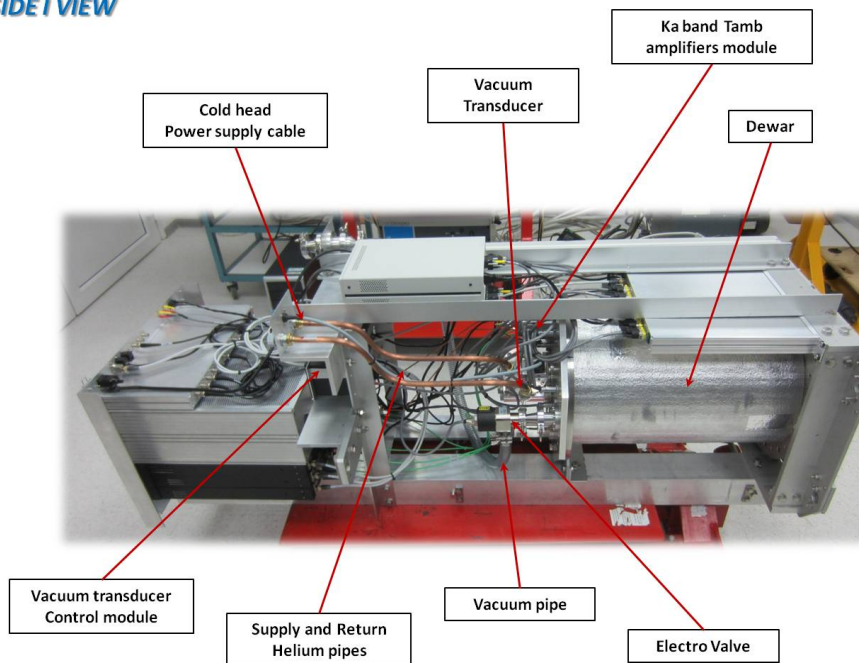amplifiers module

Dewar

Vacuum transducer
Control module

Supply and Return
Helium pipes

Vacuum pipe

Electro Valve

Installation in VLBI2 antenna: April 2017
Installation in VLBI1 antenna: March 2018

Control software & observation support

VGOS receiver installation in VLBI2 antenna around june/july 2019.

Special care with RFI from ship radars from the fyord !!! Two X-band LNAs were destroyed.

QRFH revisited

- Based in Calech design. Modified profile & interface

- Wideband antenna 2.3-14 GHz.

- Dual linear polarization

- Manufacturing easiness

- 2 output coaxial conectors
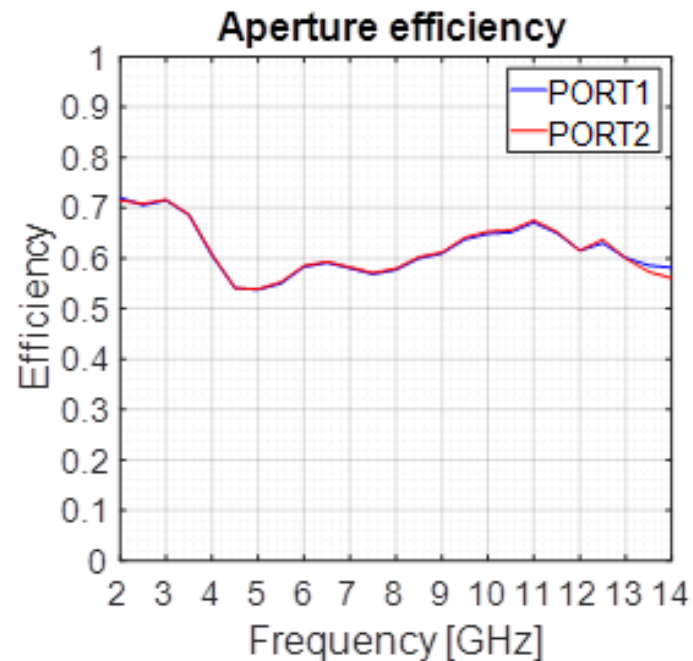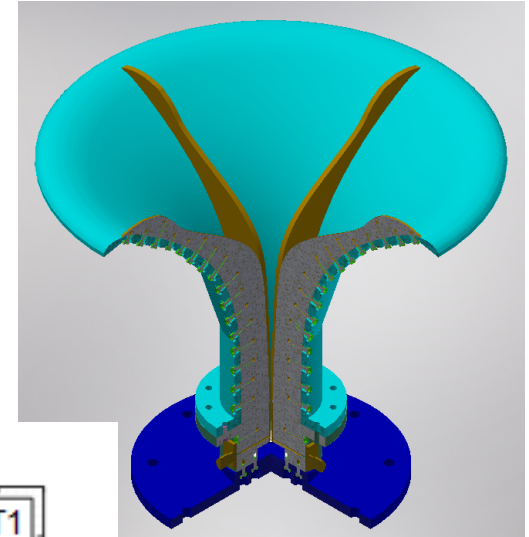
Linear to circular polarization conversion using hardware (1)
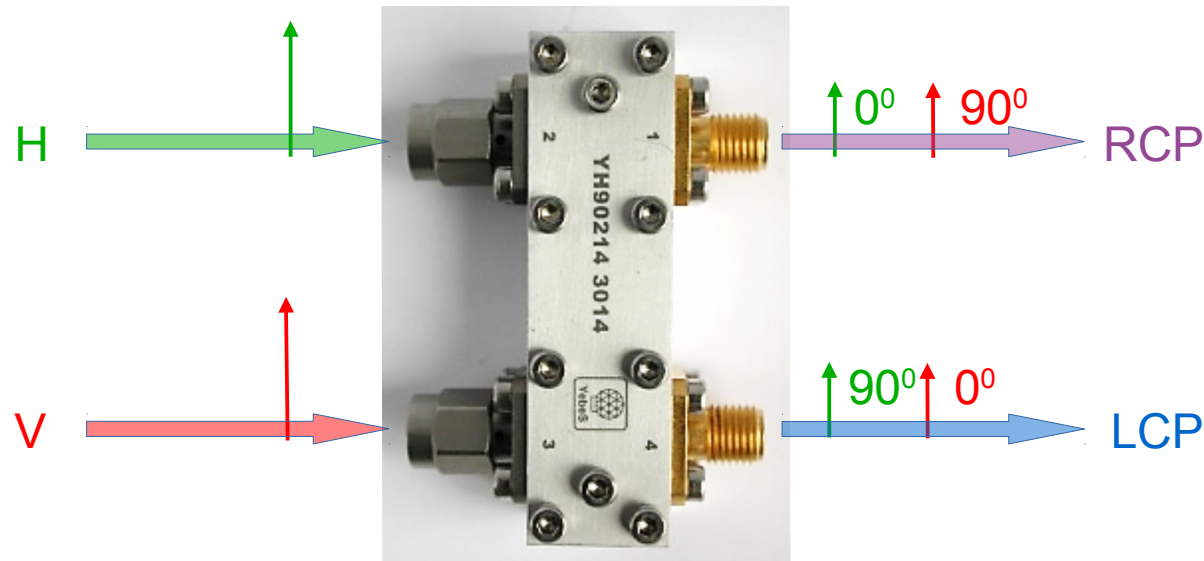
- 3dB/90° microwave hybrid
- Degradation of LNA average noise by 1.5 K along the 2-14GHz band
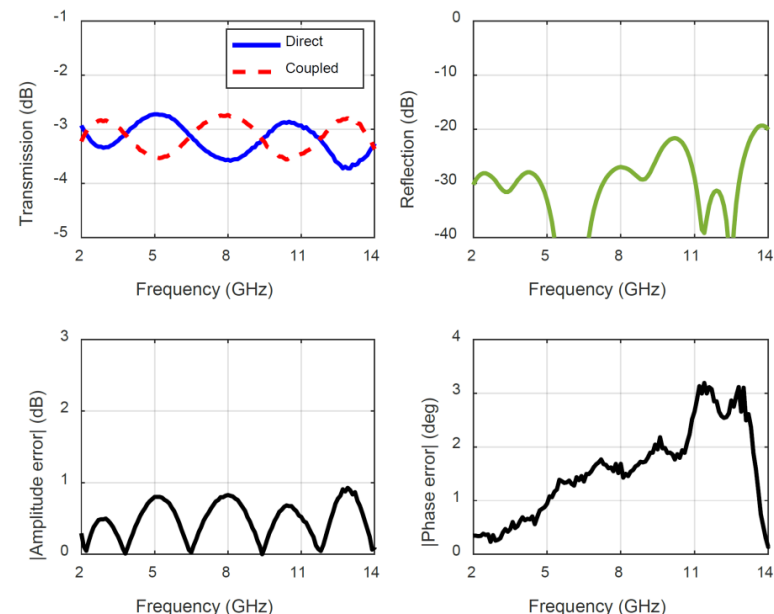- XP < -25 dB.   Axial Ratio < 1 dB

Linear to circular polarization conversion using hardware (2)

Multi-octave stripline hybrids developed at Yebes:

- Bandwidth: 2-14 GHz (1.5 – 15.5 GHz also available)
- Amplitude unbalance < 0.9 dB
- Phase unbalance < 3 deg
- Optimized for cryogenic operation

Hybrid performance

Length of lines is critic, but can be controlled

Linear to circular polarization conversion using software

PolConvert & global fringe fitting efforts by Iván Martí Vidal

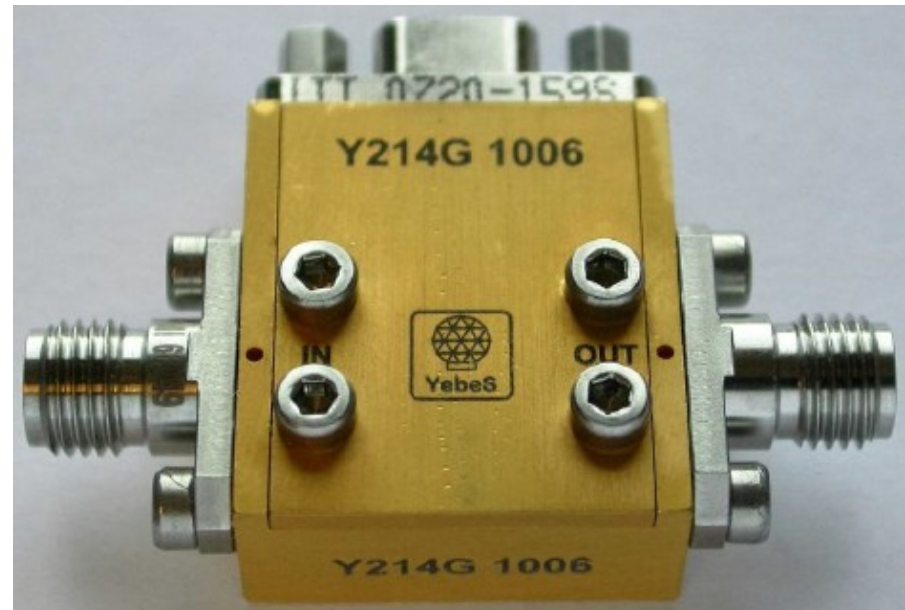Part of EU-VGOS effort (collaboration with European partners)

See Walter Alef's on EU-VGOS talk for further details

Yebes ultra-wide band LNAs (1)
Single-ended version

- Hybrid

- Small/compact size

- Usable in 0.5-18 GHz

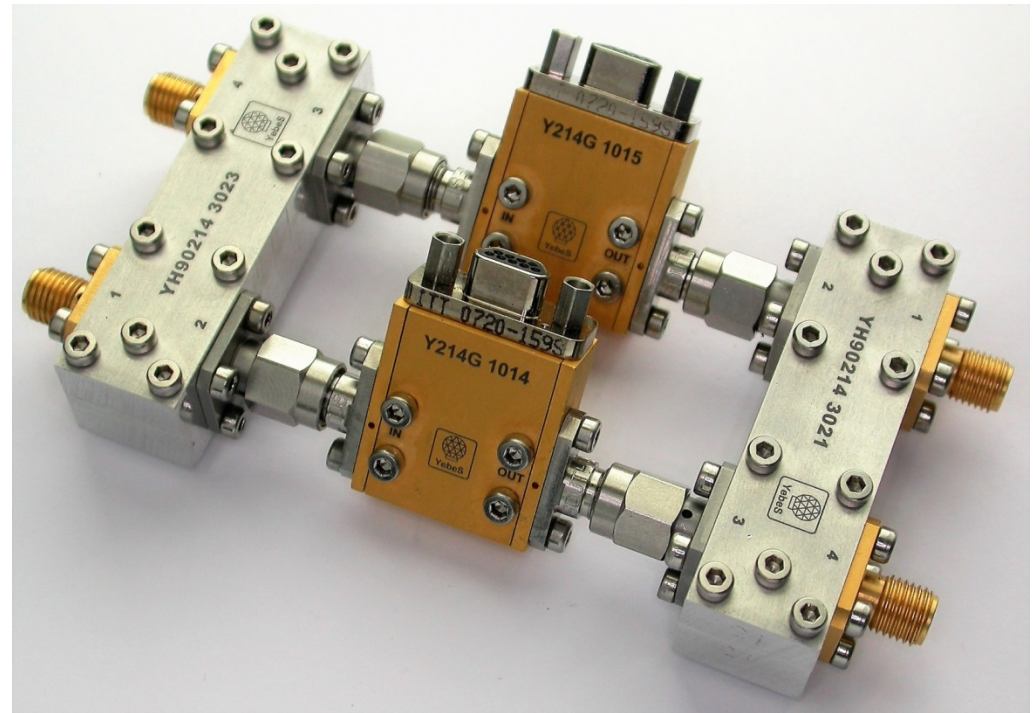| Band	2-14 GHz
Tn	6.1 K (ETH)
Gain	33.9 dB
IRL	-1.5 dB
ORL	-16.9 dB
Power	36 mW

20 x 22 x 9 mm (excl. conn.)

Yebes ultra-wide band LNAs (2) Balanced version

- Using 3dB/90° hybrids

- Very low noise penalty

- Drastic improvement of input reflection

- Balanced versions for 2-14 GHz and 1.5-15.5 GHz available

| Band	2-14 GHz
Tn	7.6 K (ETH)
Gain	33.8 dB
IRL	-21 dB
ORL	-23 dB

PhaseCal Developments (1)
Cable Delay Measurement System (CDMS)

Follows Haystack legacy approach (**A.E.E. Rogers**) integrated in a single board inside a 19"/1U rack
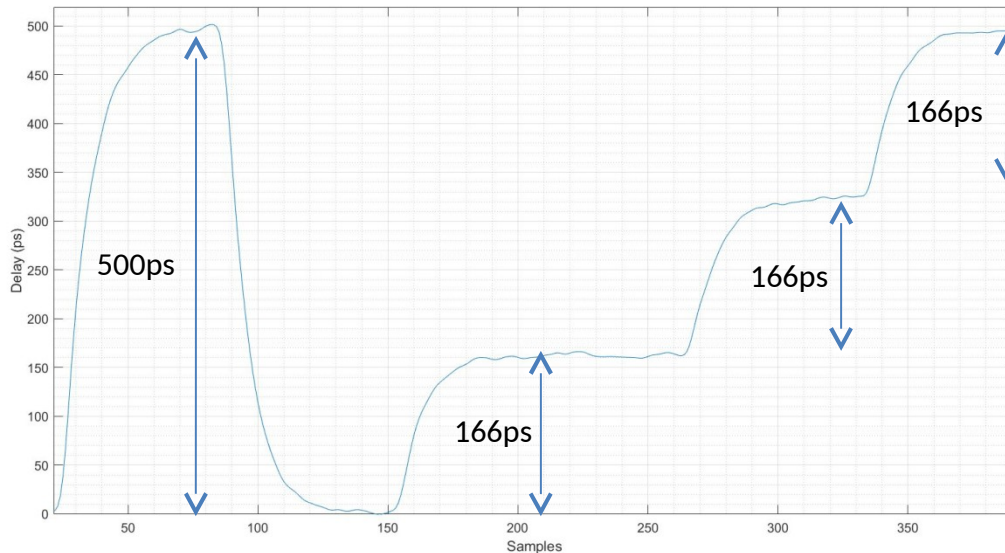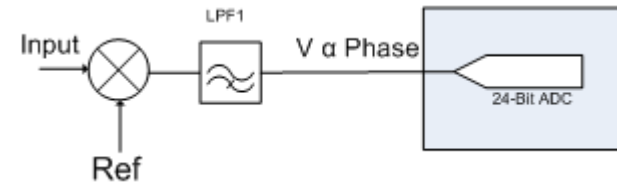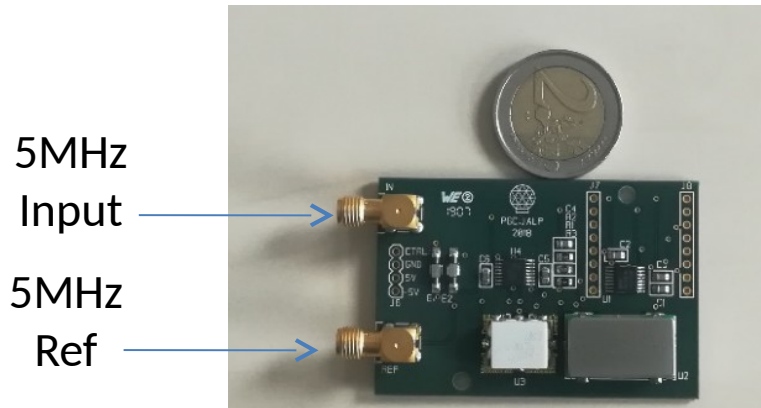

Subsystems:

- Phase Detector / Modulating Generator
- 5MHz – 25Hz Generator
- Start / Stop Generator
- Cable Multiplexer

- Units developed at Yebes labs for:
  BKG, AGGO, NMA and FGI
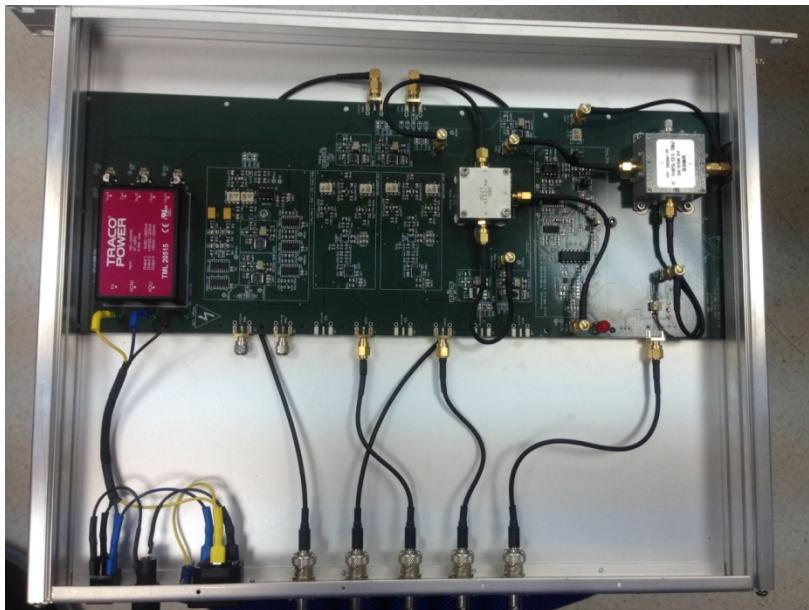
IT REQUIRES A FREQUENCY COUNTER

PhaseCal Developments (2)
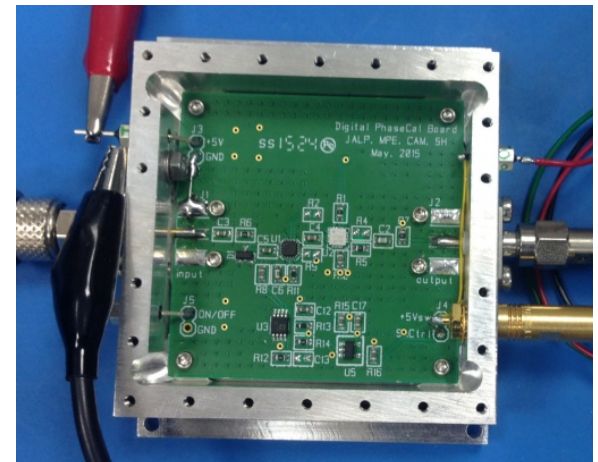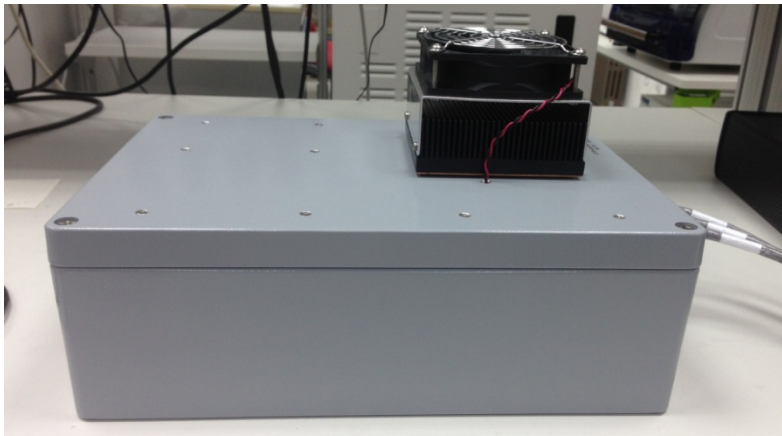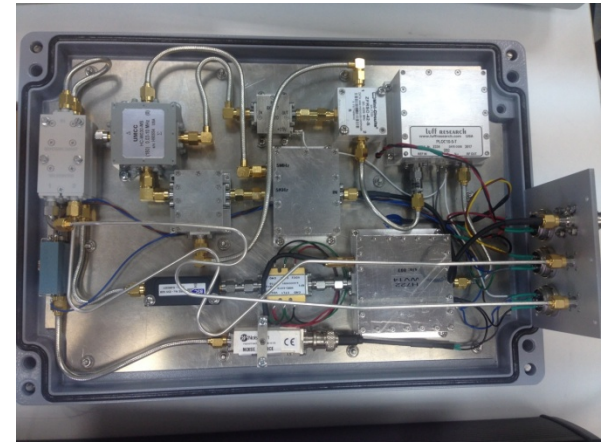# New CDMS under test

5MHz Input

5MHz Ref

- Phase detector at 5MHz
- 24-bit ADC
- RMS: 5 ps (0.003 deg)

NO FREQUENCY COUNTER

ONLY A RASPBERRY PI

500ps

166ps

166ps

166ps

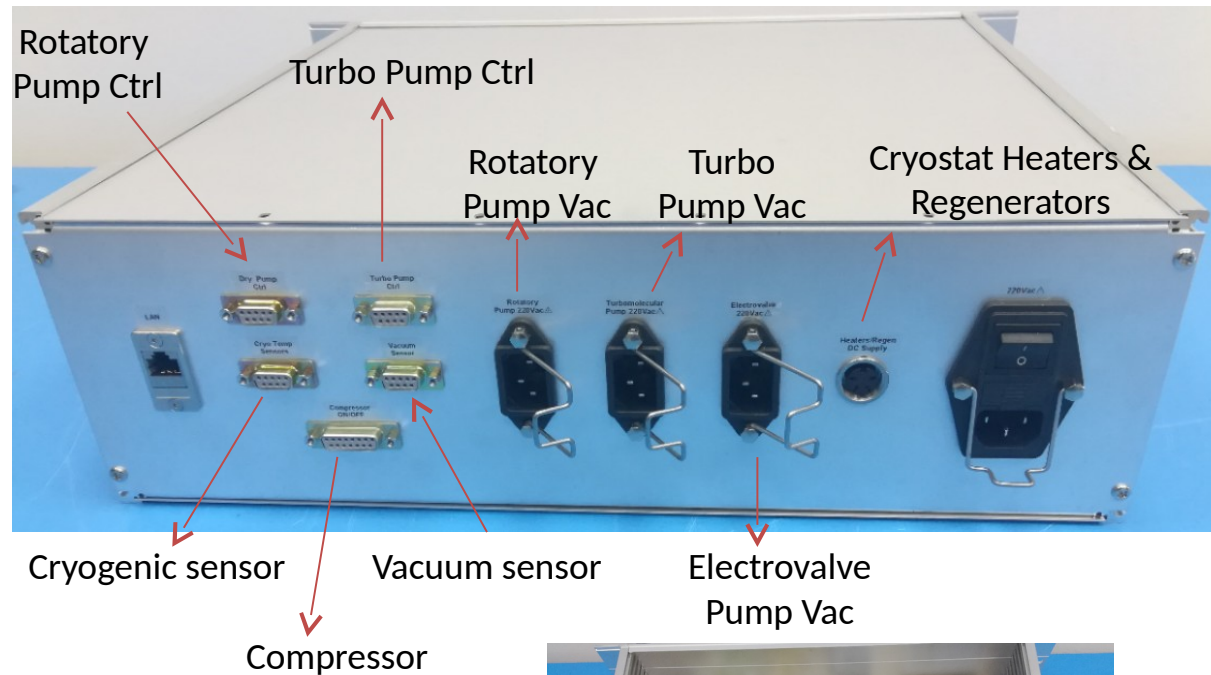# PhaseCal Developments (3)
Noise & Phase Cal Unit

- At the receiver trolley (Front-end). Shorter cables

- 2-14 GHz

- Pulse spacing: 10MHz

- Pulse Generator: based on Hitite Ultrafast logic gates (**Haystack approach**)

- NoiseCal can be switched at 80 Hz rate

- Temperature stabilization: Peltier cooler and passive insulation.

- Units developed at Yebes labs for: BKG, AGGO, NMA and FGI

Cryogenics & vacuum control System

Rotatory Pump Ctrl

Turbo Pump Ctrl

Rotatory Pump Vac

Turbo Pump Vac

Cryostat Heaters & Regenerators

Cryogenic sensor

Vacuum sensor
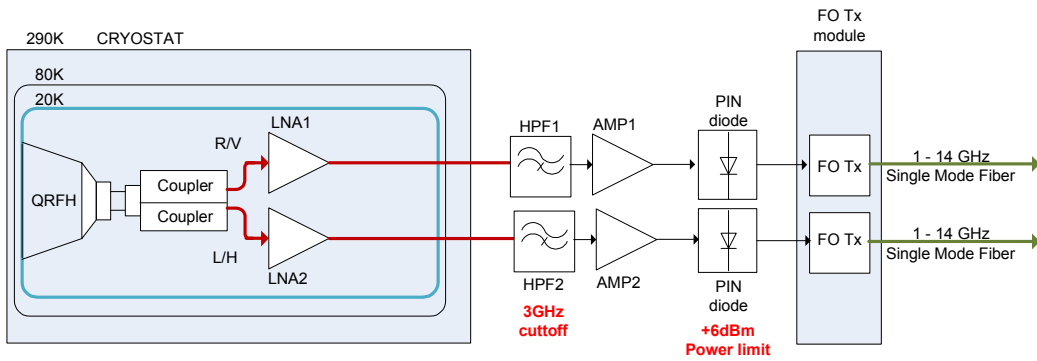
Electrovalve Pump Vac

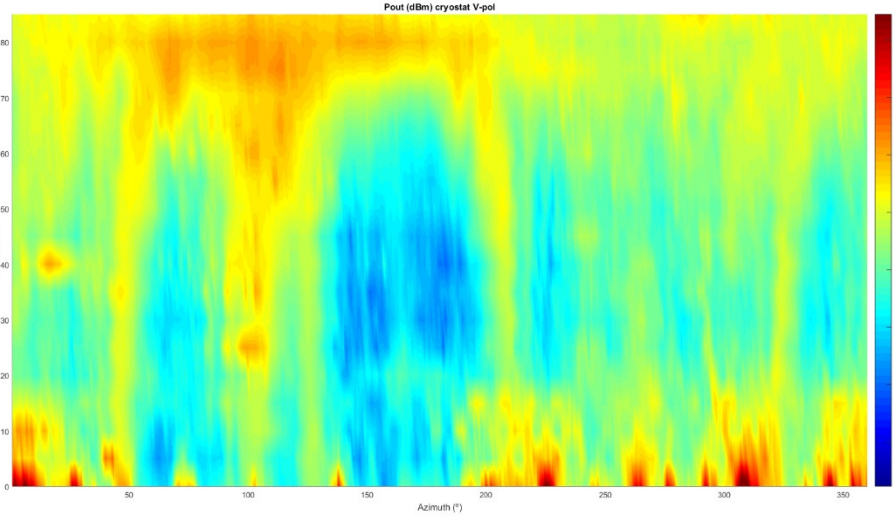Compressor

LAN remote monitor and control of:

- Rotatory Pump
- Turbo Pump
- Cryogenic temperature sensors
- Vacuum sensor
- Compressor
- Electrovalve
- Heat Resistors
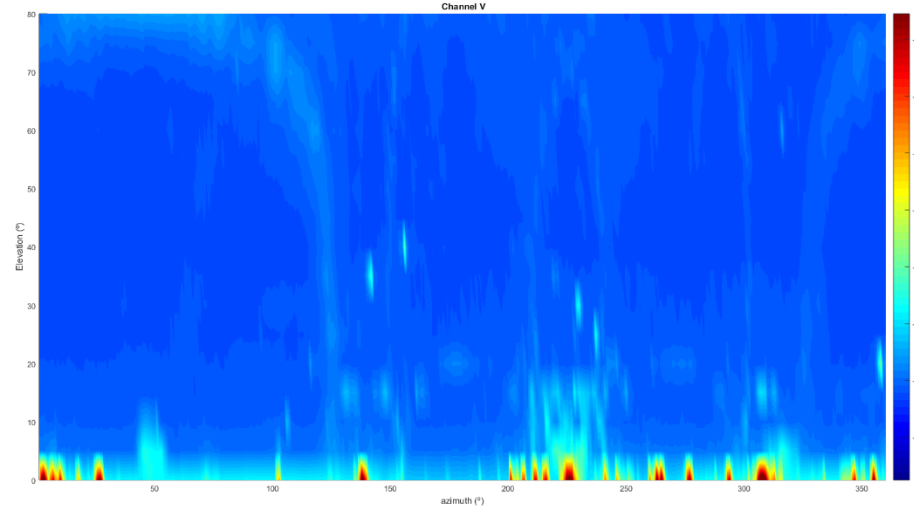- Regenerators
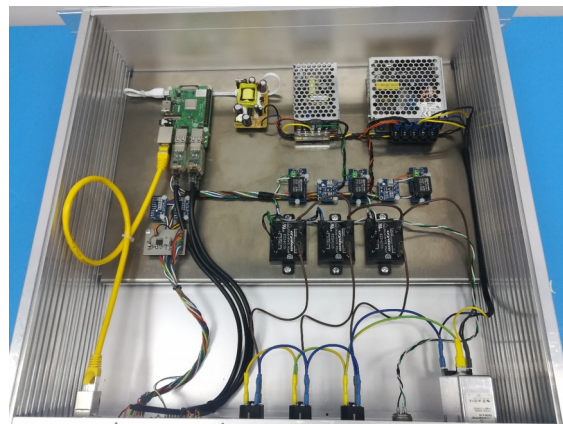
RFI at VGOS band in Yebes

Elevation over Azimuth RFI power maps

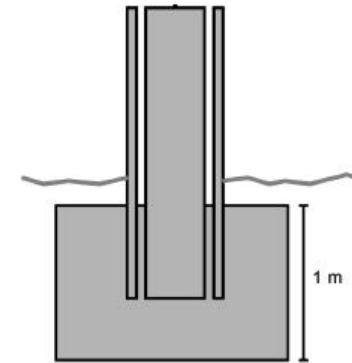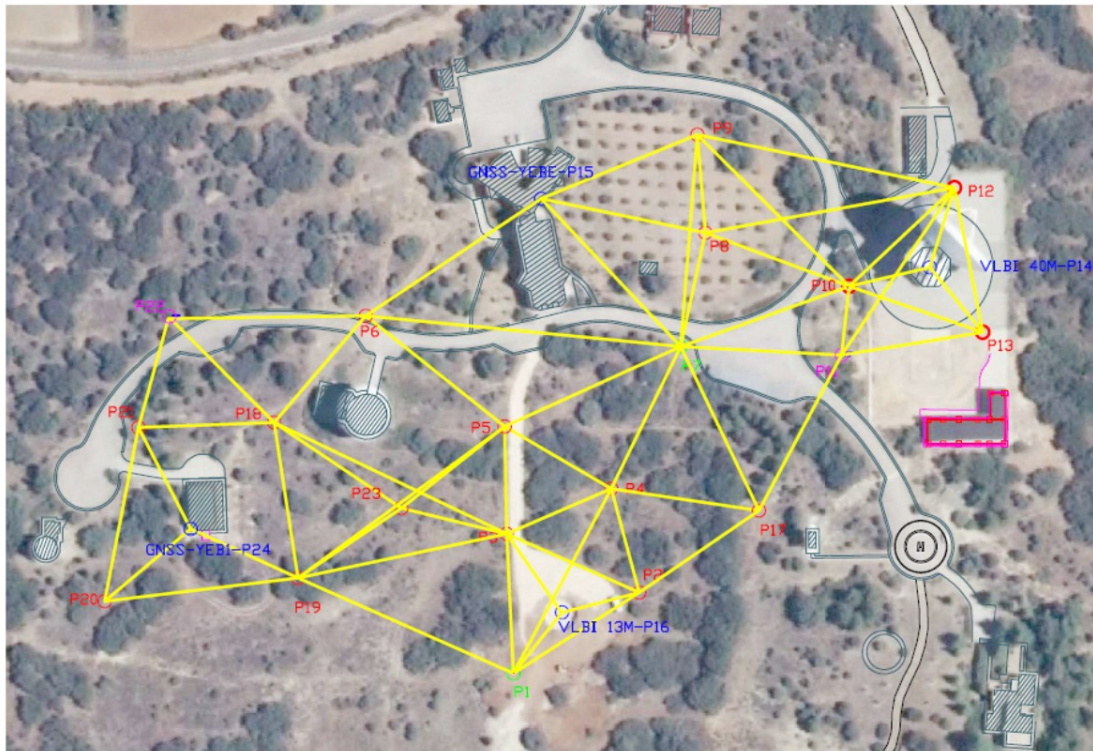a) Original situation without RFI filters

Tsys ≈ 70K

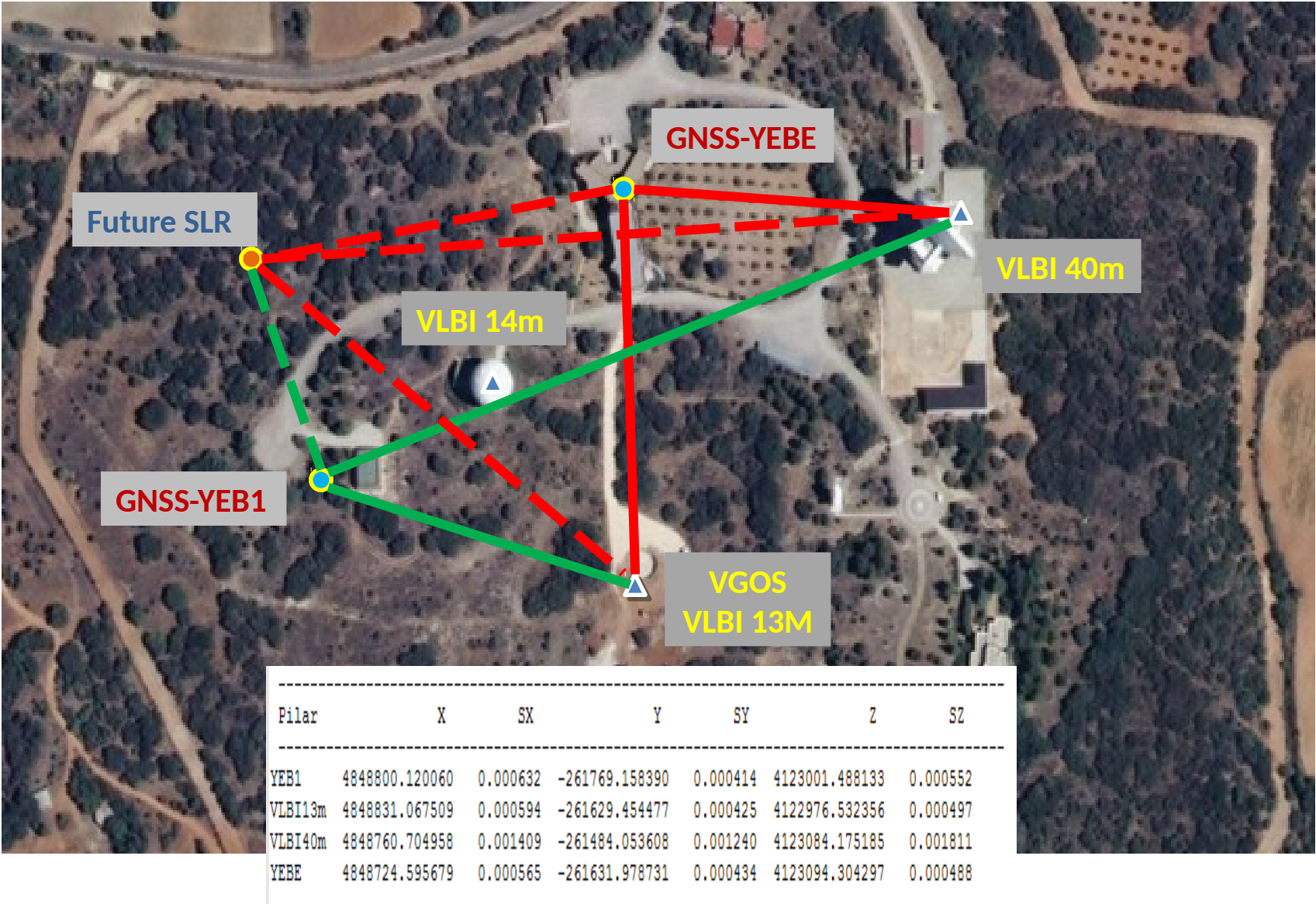b) New situation with filters and pre-amplifier

Tsys ≤ 50K

Local Tie. Network of pilars

- 20 Reinforced concrete pillars of 30 cm in diameter and 1.30 m high.
- Isolated 5 cm of a protective tube which provides thermal and climatic stability.
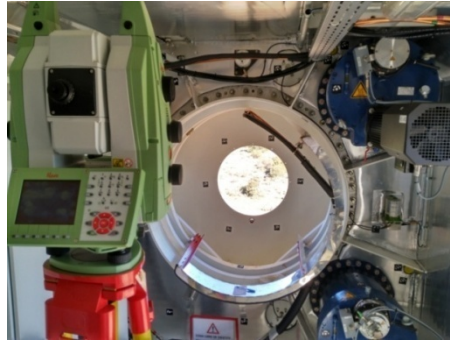
Local Tie (1)


```
----------------------------------------------------------------------------------------
Pilar         X            SX          Y            SY           Z            SZ
----------------------------------------------------------------------------------------
YEB1     4848800.120060  0.000632  -261769.158390  0.000414  4123001.488133  0.000552
VLBI13m  4848831.067509  0.000594  -261629.454477  0.000425  4122976.532356  0.000497
VLBI40m  4848760.704958  0.001409  -261484.053608  0.001240  4123084.175185  0.001811
YEBE     4848724.595679  0.000565  -261631.978731  0.000434  4123094.304297  0.000488
```

Thank for your attention

Invariant Reference point of the RT measurements

Inside the cabin

Outside the cabin