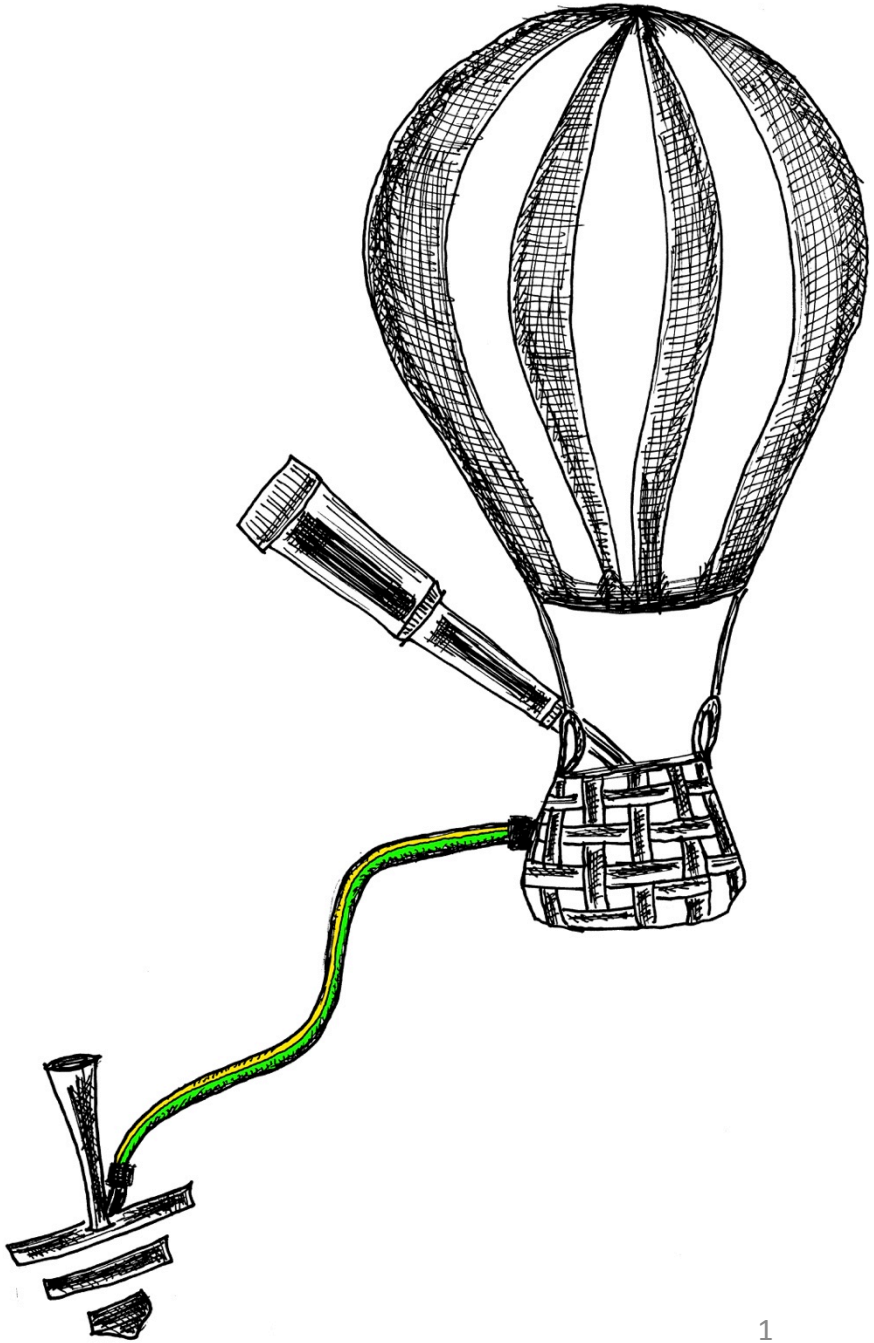
THE MEANING OF STRIP

- STRIP (STRatospheric Italian Polarimeter)
  - Balloon-borne experiment, 40000 m asl
- STRIP (Survey TeneRife Italian Polarimeter)
  - On-ground Experiment, 2500 m asl
- Strip as a name



STRIP IS A MIX OF DIFFERENT 'RECYCLED' PARTS

- TELESCOPE FROM CLOVER – OXFORD (UK)
- DETECTORS FROM QUIET – JPL (USA)
- SHILEDS AND SITE FROM VSA EXPERIMENT – IAC (SPAIN), UK
- REUSE MAKES THINGS APPARENTLY SIMPLE BUT NOT FROM SYSTEM ENGINEERING POINT OF VIEW
  - PARTS ALREADY CONSTRUCTED WITH DIFFERENT REQUIREMENTS FOR OTHER EXPERIMENTS, MAKING THE DEVELOPMENT AN 'EXPERIMENT' ITSELF.
- THE TECHNOLOGY CHALLENGE IS TO ATTACH TOGETHER PIECES OF HARDWARE TO 'FORM' A GIANT AND NOVEL INSTRUMENT TO CONTINUOUSLY OBSERVE THE SKY FOR AT LEAST 2 YEARS FROM GROUND

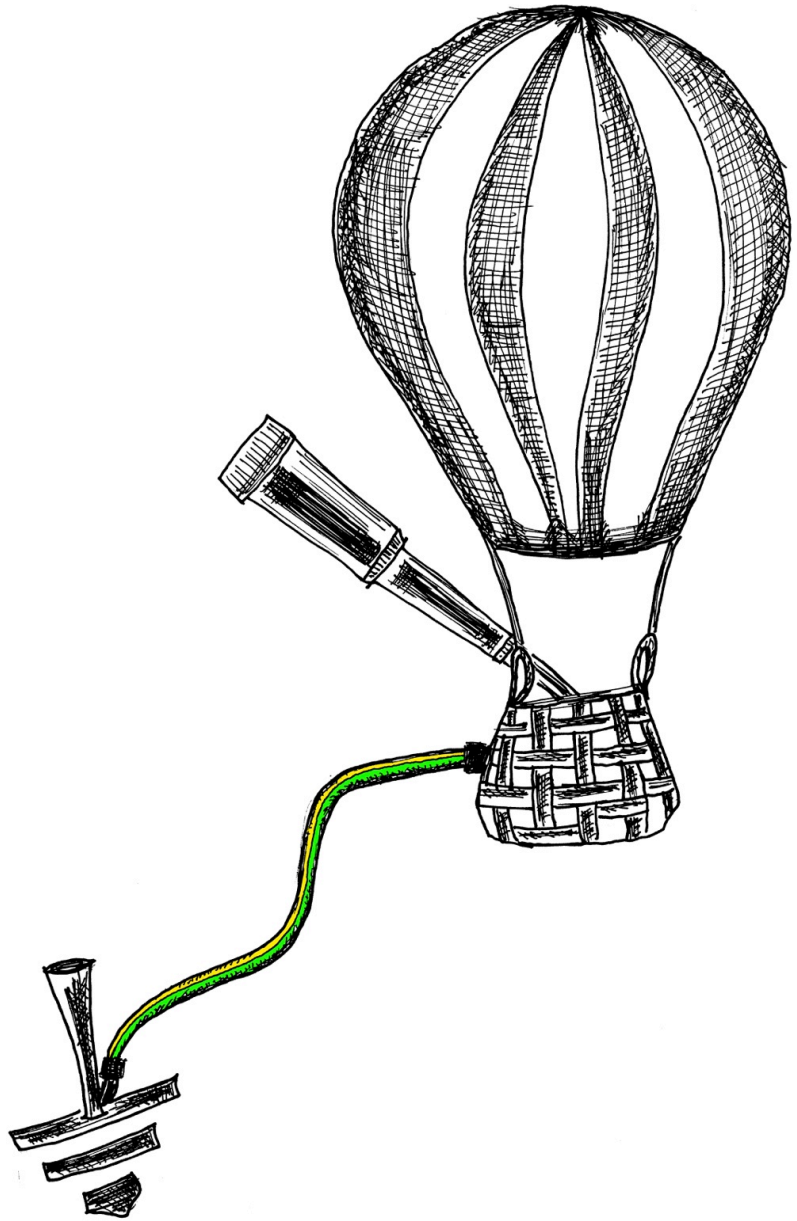
"HOW I DID IT"
BY VICTOR FRANKENSTEIN

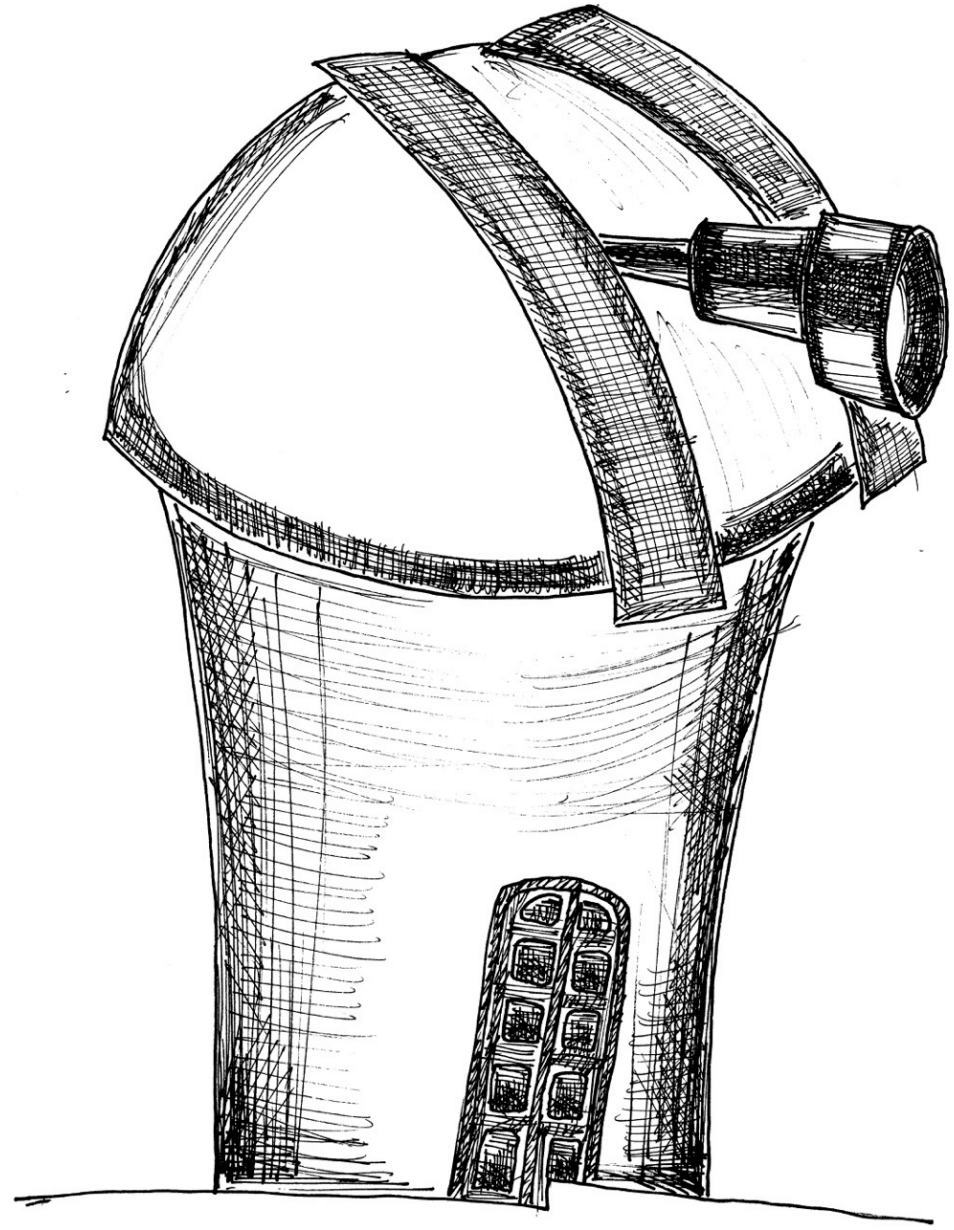
'Until, from the midst of this darkness, a sudden light broke in upon me -- a light so brilliant and wondrous, and yet so simple!'

'Change the poles from plus to minus and from minus to plus!'

'I alone succeeded in discovering the cause of generation of life.'

(M. Brooks et al., 1974, Young Frankenstein)





Cryowaves
è Bologna

INAF

LSPE STRIP

Presented by Fabrizio Villa
INAF / OAS – Bologna
Cryowaves Lab
On behalf of Strip Collaboration

Content of the presentation

- No science will be covered in this presentation
- Description of the project
- Description of Strip
- Status of Strip
- Schedule

The STRIP project

Development phase

- **LSPE ASI ‘Atto aggiuntivo’ + INFN**
  - **Principal Investigator:** M. Bersanelli (UNIMI),
  - **Program Manager:** A. Mennella (UNIMI)
  - **System Engineer:** G. Morgante (INAF)
  - **Telescope System Engineer:** F. Villa (INAF)
  - **Instrument Scientist:** M. Zannoni (UNIMIB)
  - **AIV Manager:** F. Cuttaia (INAF)

Commissioning and Observations

- **STRIP ASI/UNIMI agreement + INFN**
  - **Principal Investigator:** M. Bersanelli (UNIMI)
  - **Program Manager:** F. Villa (INAF OAS)
  - **System Engineer:** G. Morgante (INAF OAS)
  - **Instrument Scientist:** M. Zannoni (UNIMIB)
  - **Survey Scientist:** A. Mennella
  - **AIV manager:** F. Cuttaia (INAF OAS)

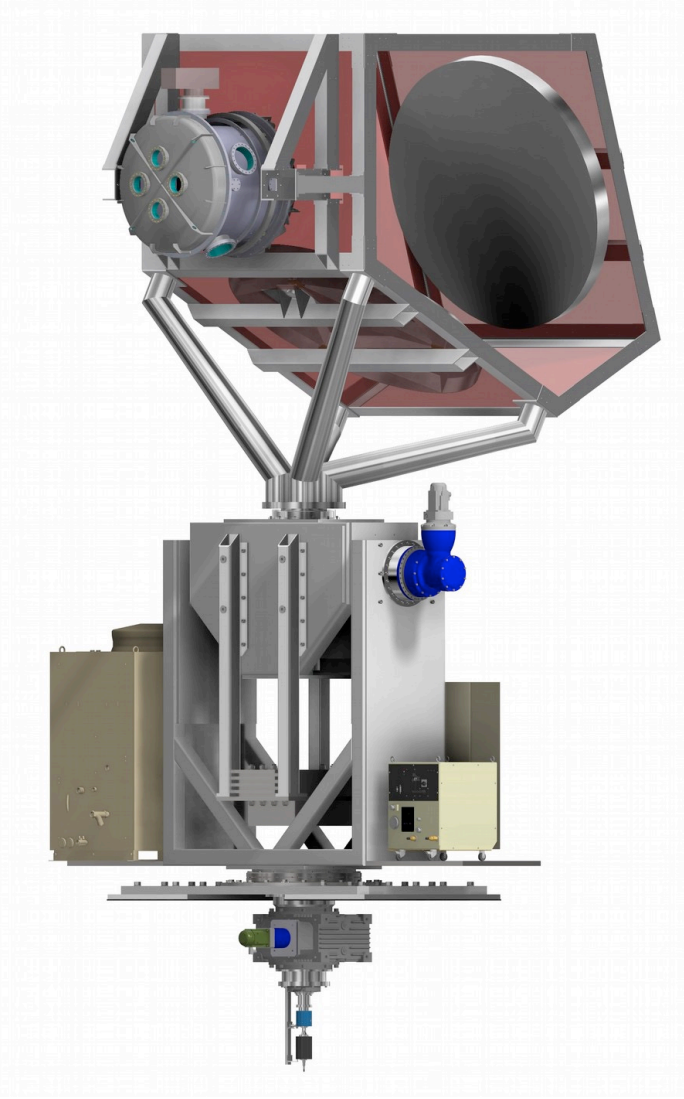
Scientific Reqs. and Objectives

STRIP-SCI-1	The primary objective of STRIP is to image polarised sources and the diffuse polarised emission over a large (~ 20% TBC) fraction of the sky at all angular scales larger than 0.5 degree with high signal-to-noise ratio per resolution element (~1 μK / 1° pixel). This will provide the necessary measurements to optimise the component separation to meet requirement SCI-1

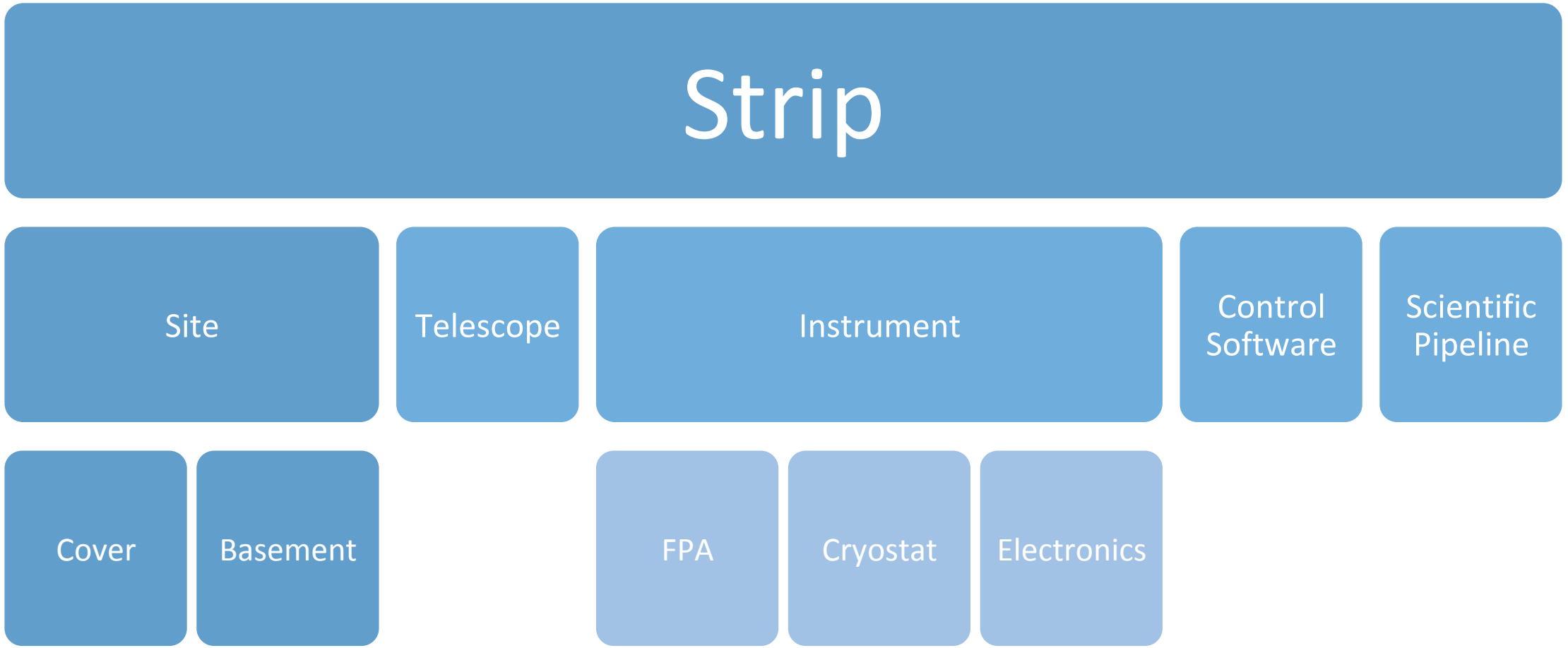
STRIP-SCI-2	The secondary objective of STRIP is to image the the polarised fraction of the CMB with a noise per resolution element of 1° of $\Delta Q(U) \lesssim 1.2\,\mu$K in Q band.

STRIP-SCI-3	The third objective of STRIP is to measure or set an upper limit to the atmospheric emission in polarization

	Q-band	W-band
Angular resolution (°)	at least 0.5°	
Observed sky fraction (%)	≥ 18	
Sensitivity per 1° pixel $\delta Q(U)_{deg}$ (μK)	≤ 1.2	≤ 4.5



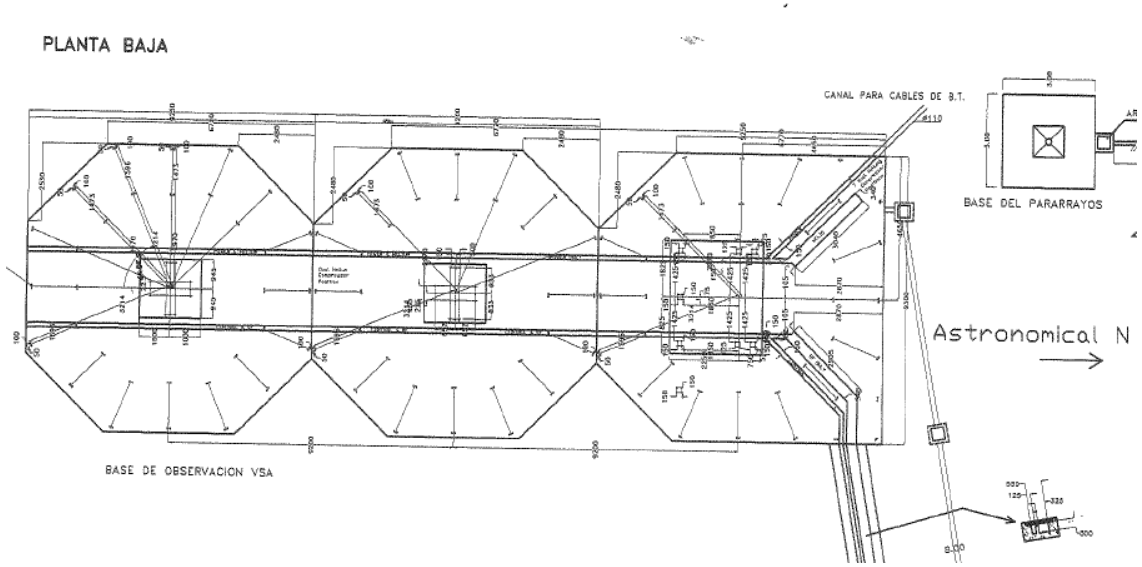
Strip observatory



Teide Observatory – IAC, Tenerife

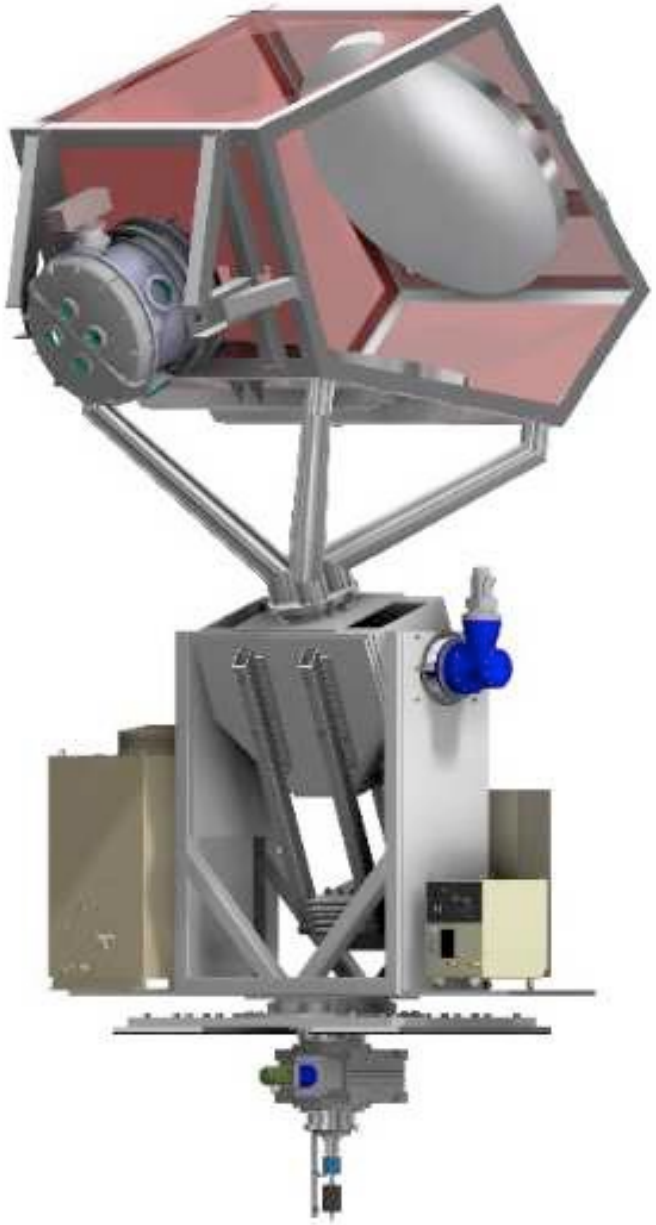
Basement, Cover and Site

- VSA basement modified for STRIP
  - Pit to stay within size requirement
- VSA External shields
  - Minimize Straylight from ground emission
  - Act as external wall for cover
  - Internal part to be modified
- Cover
  - Movable roof
- 1 FTE / year on site

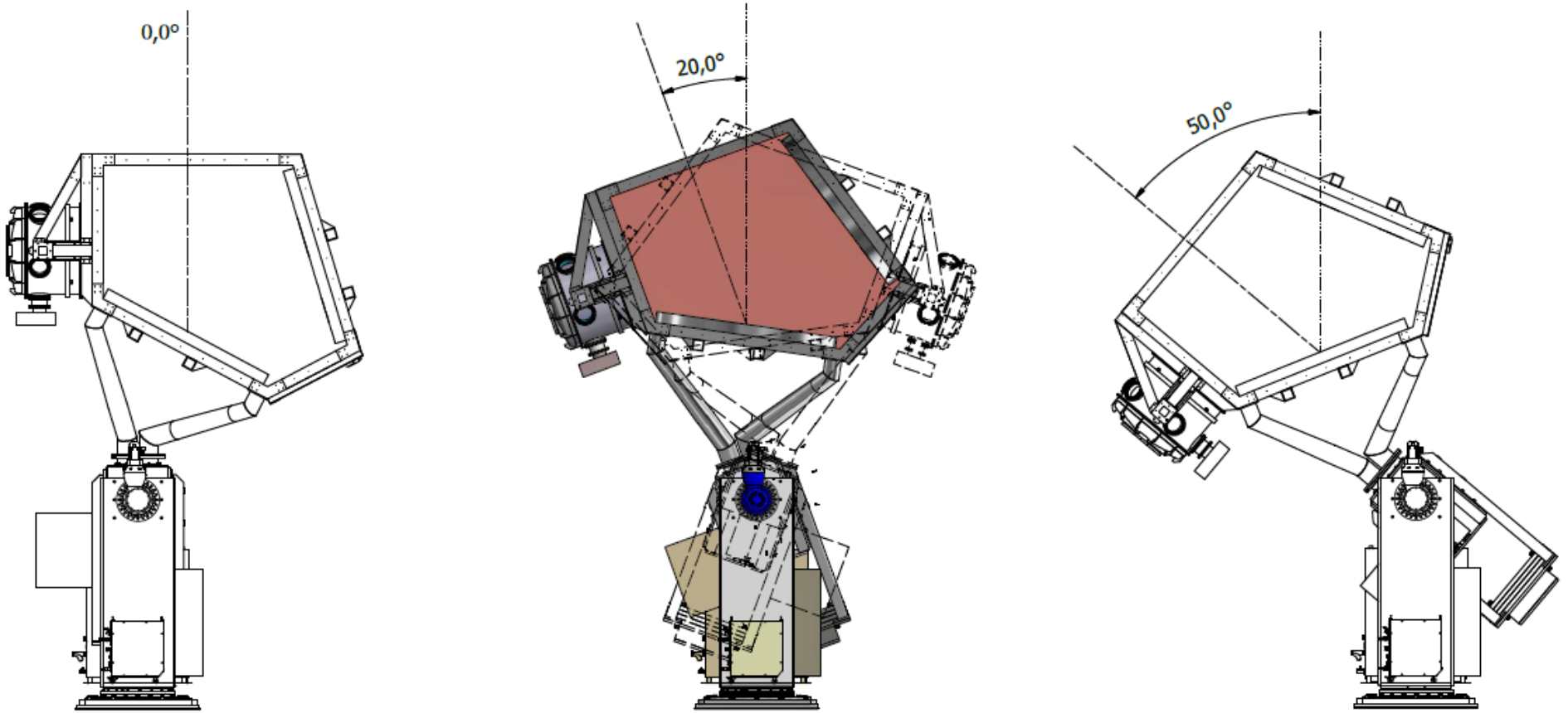


Telescope

- **3-AXES TELESCOPE MOUNT**
  - **Azimuth**
    - Fully rotating azimuth axis at 1 r.p.m.
  - **Elevation axis**
    - From -50° to +50°
    - fixed at 20° for nominal scanning
  - **Boresight axis**
    - Foreseen at the beginning
    - Fixed

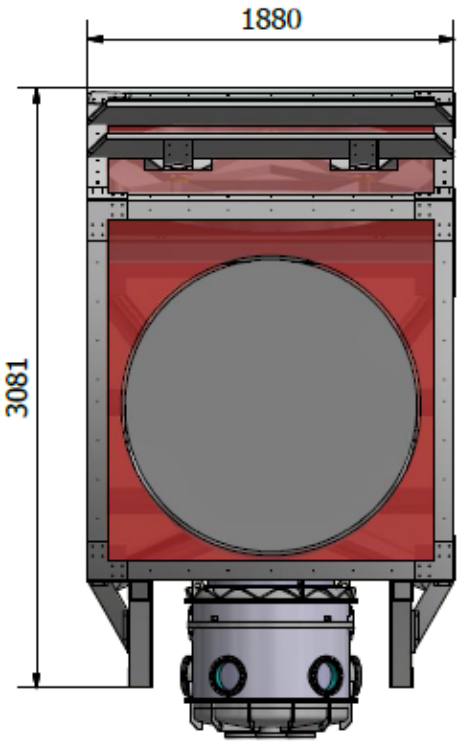


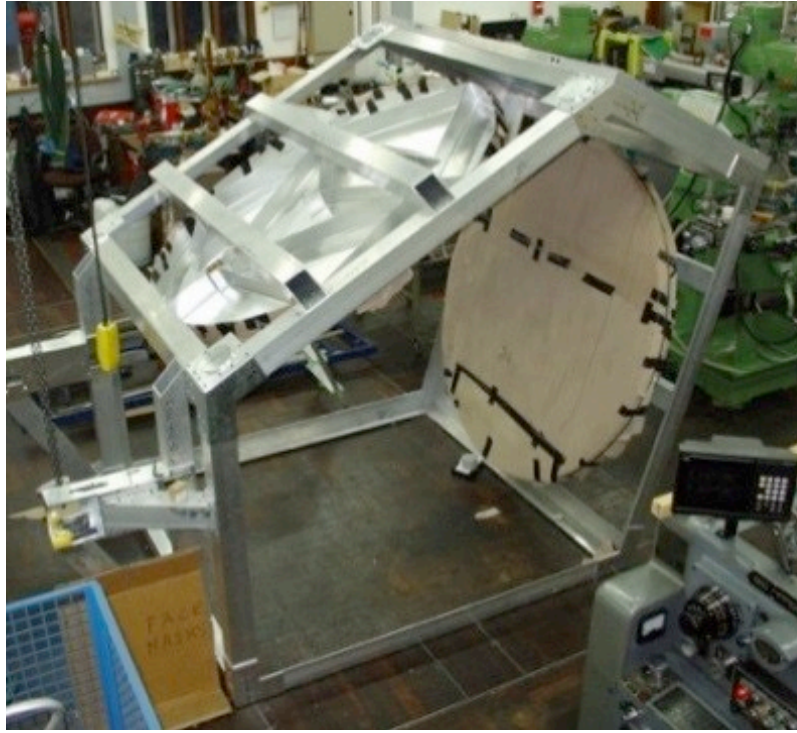
‘Observation’ modes

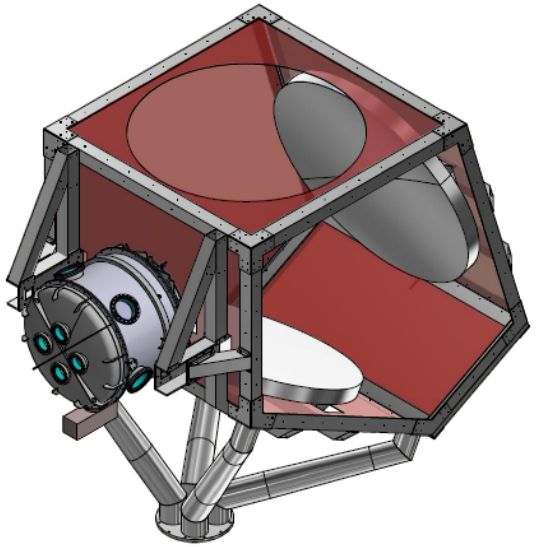


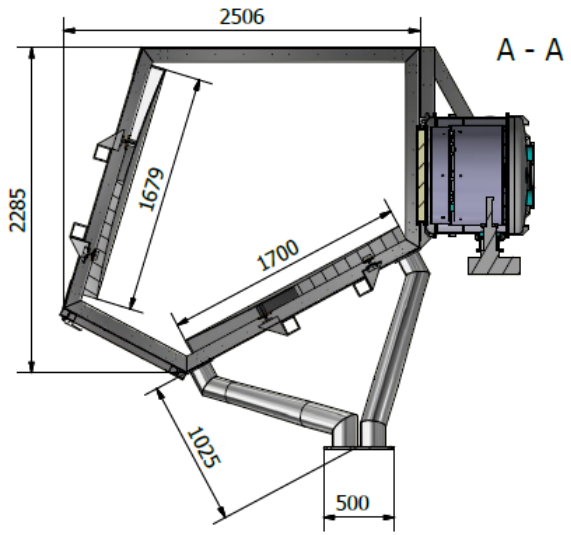
Strip Telescope

- **OPTICS**
  - **Crossed-Dragone**
  - 1.5 m Aperture
  - F/# = 1.8
- Aluminum Closed optical assembly coated with RF absorber inside





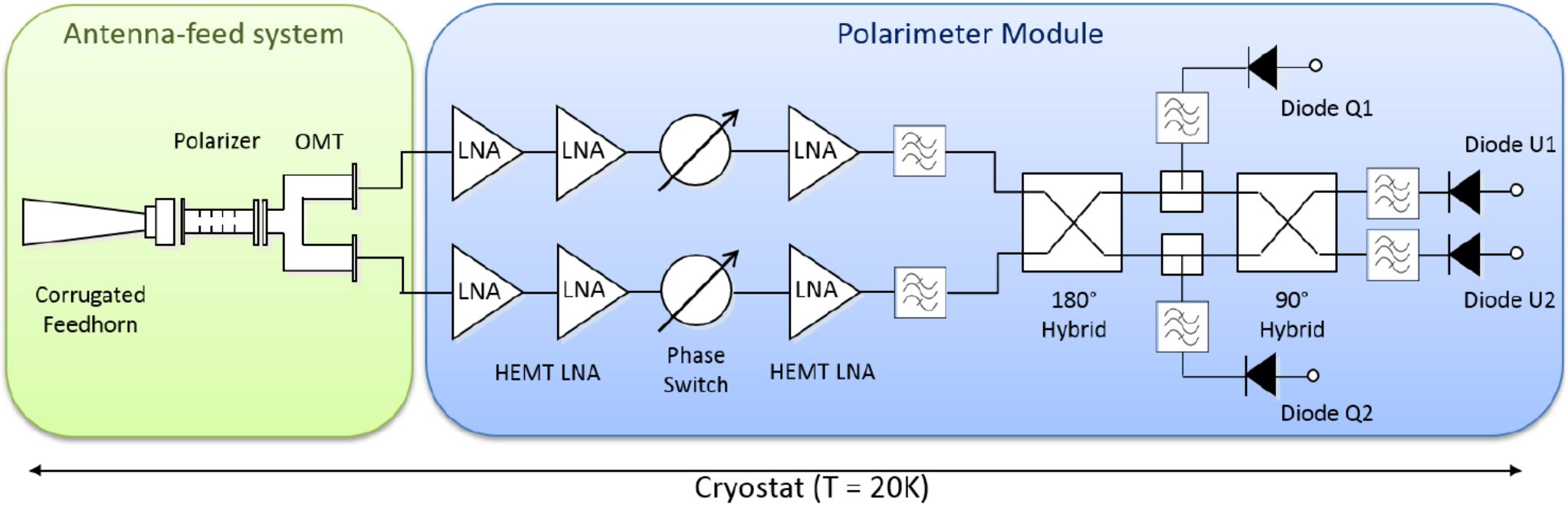




Detector's Array

- 49 Polarimeters in Q-band (39-48 GHz)
  - Corrugated horns + polarizer + OMT + polarimeter
- 6 polarimeters in W-band (86-104 GHz)
  - Corrugated horns + Septum polarizer + polarimeter
- Main frame
  - To support the array and to permit the cooldown to 20K
- Electronics
  - To bias the LNAs
  - To read scientific signals
  - To read temperature sensors and control heaters inside cryostat

Polarimeter Scheme



Corrugated feedhorns

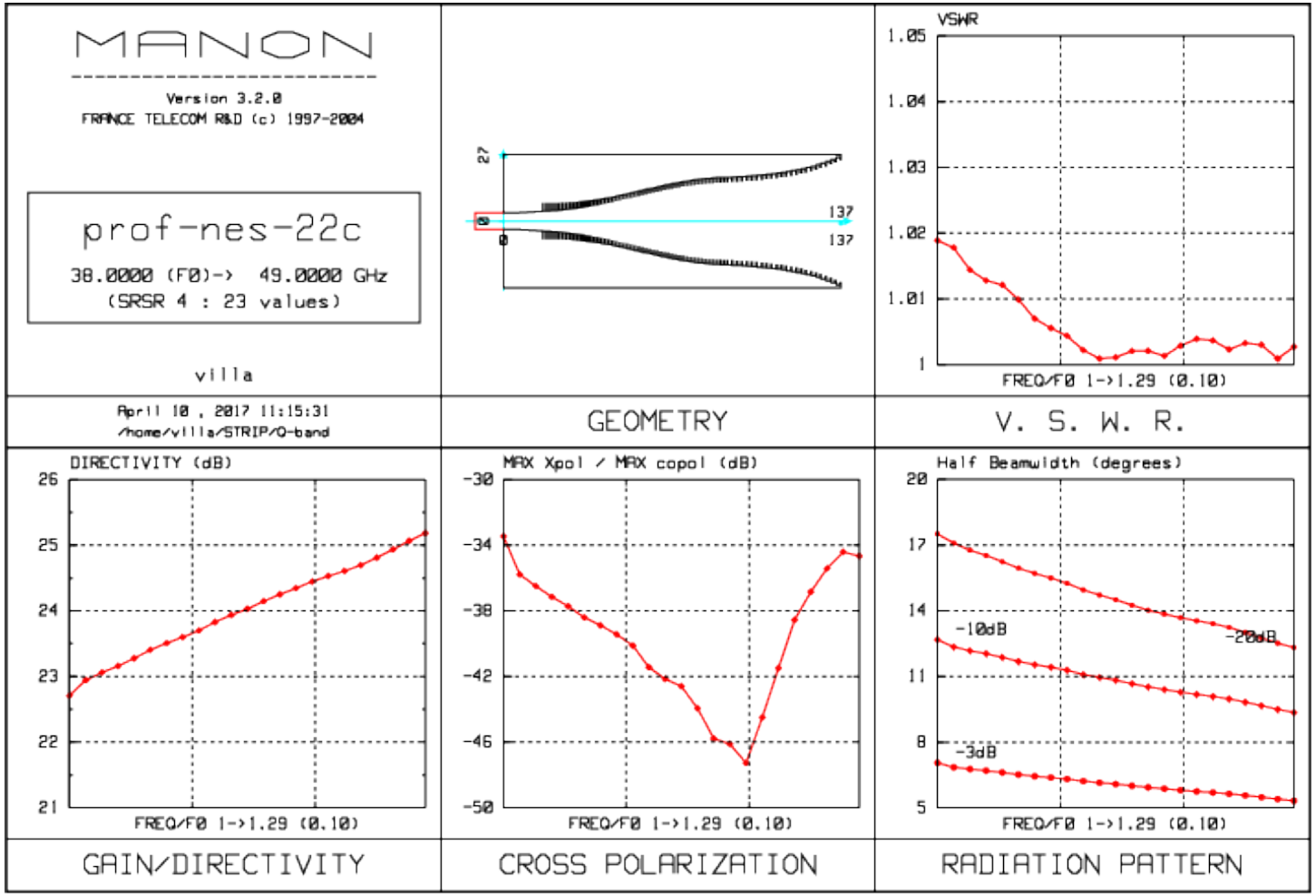
- Dual profile design

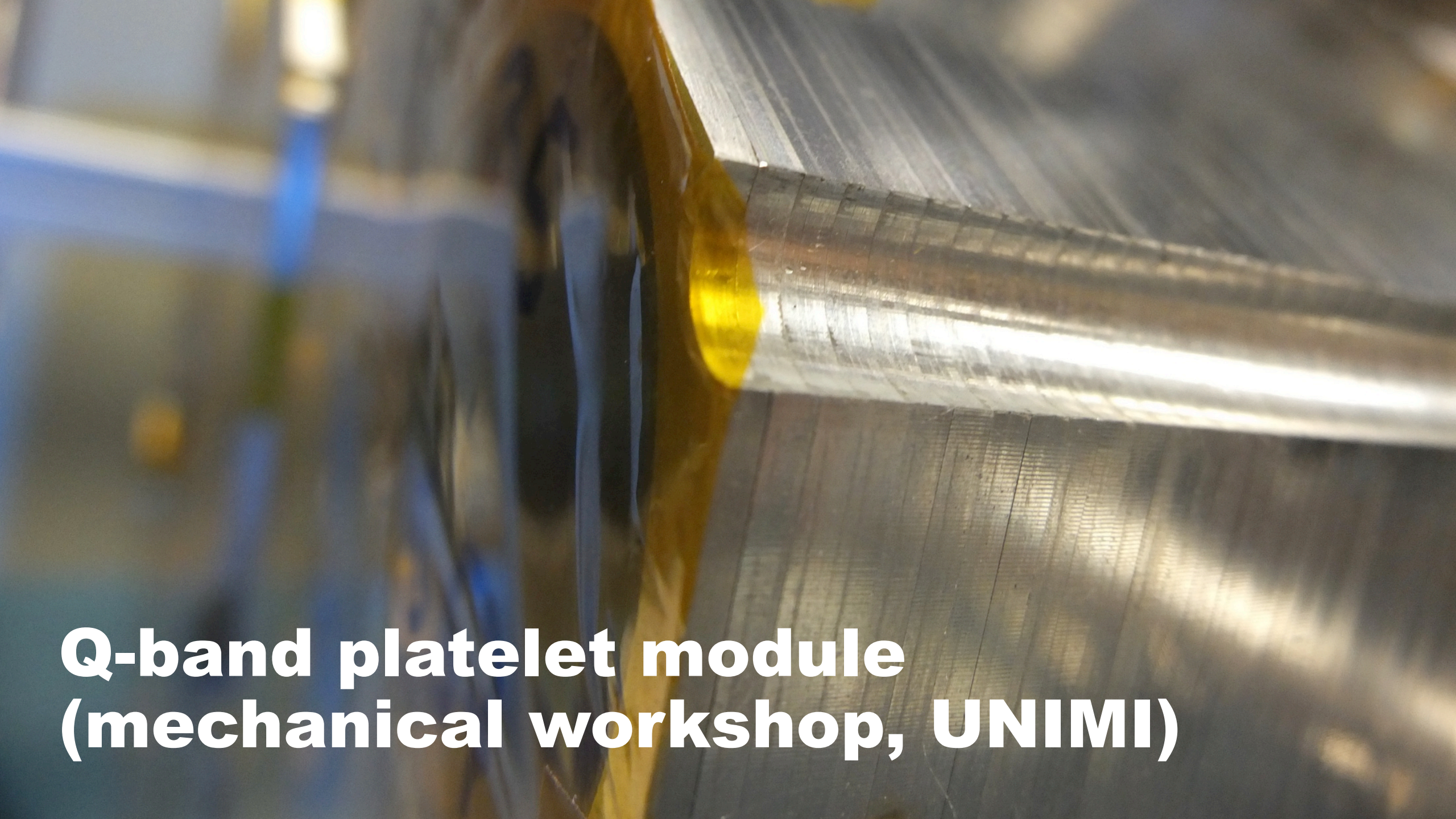
$$a(z) = a_i + (a_s - a_i) \cdot \left((1 - A) \cdot \frac{z}{L_{sin}} + A \cdot \sin\left(\frac{\pi z}{2L_{sin}} \right) \right)^2 ; for z < L_{sin}$$

$$\mathrm{a(z)} = \mathrm{a_s} + e^{\alpha(z - L_{sin})} - 1; \alpha = \frac{\ln(1 + a_0 - a_s)}{L_{exp}}; for L > L_{sin}$$

- Platelet technique
  - Long experience at UNIMI Mechanical Workshop
  - Less expensive than electro-formation technique even for single feed
  - Mitigation of EM performances because of constraints on plate thickness
    - Q-band corrugation with variable pitch
    - W-band constant throat / teeth ratio
- Aluminium machined for Q-band
- Aluminium etching technique for W-band (200 plates)

Q-band horn design (INAF/OAS)





Q-band platelet module (mechanical workshop, UNIMI)

Q-band horn meas. (UNIMI)

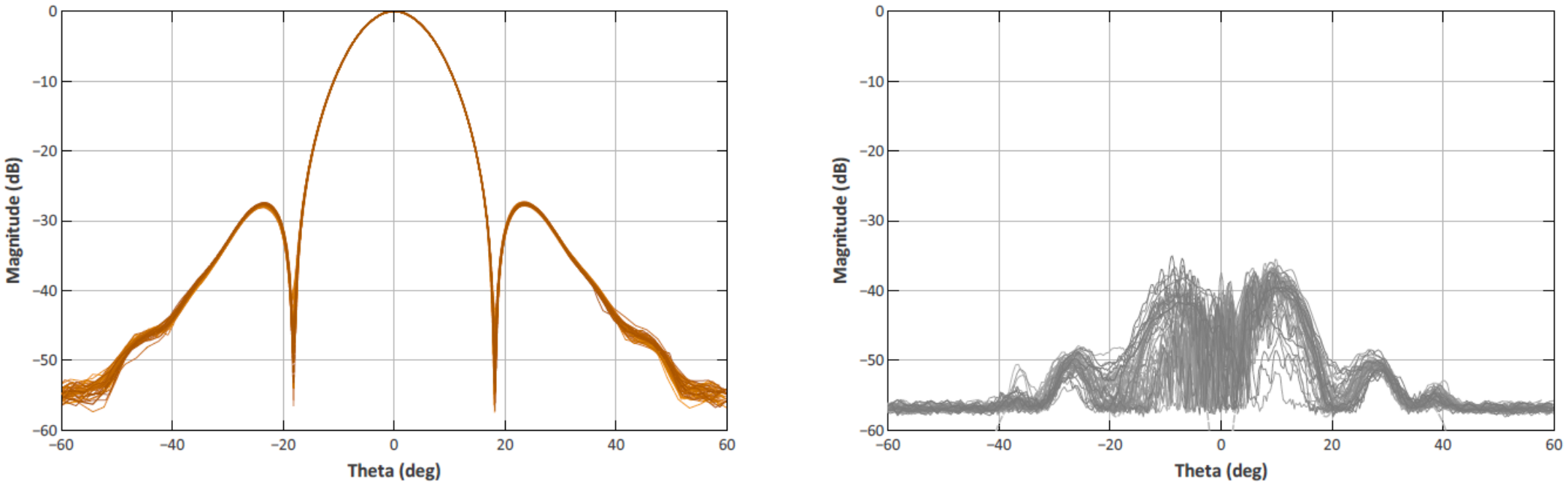
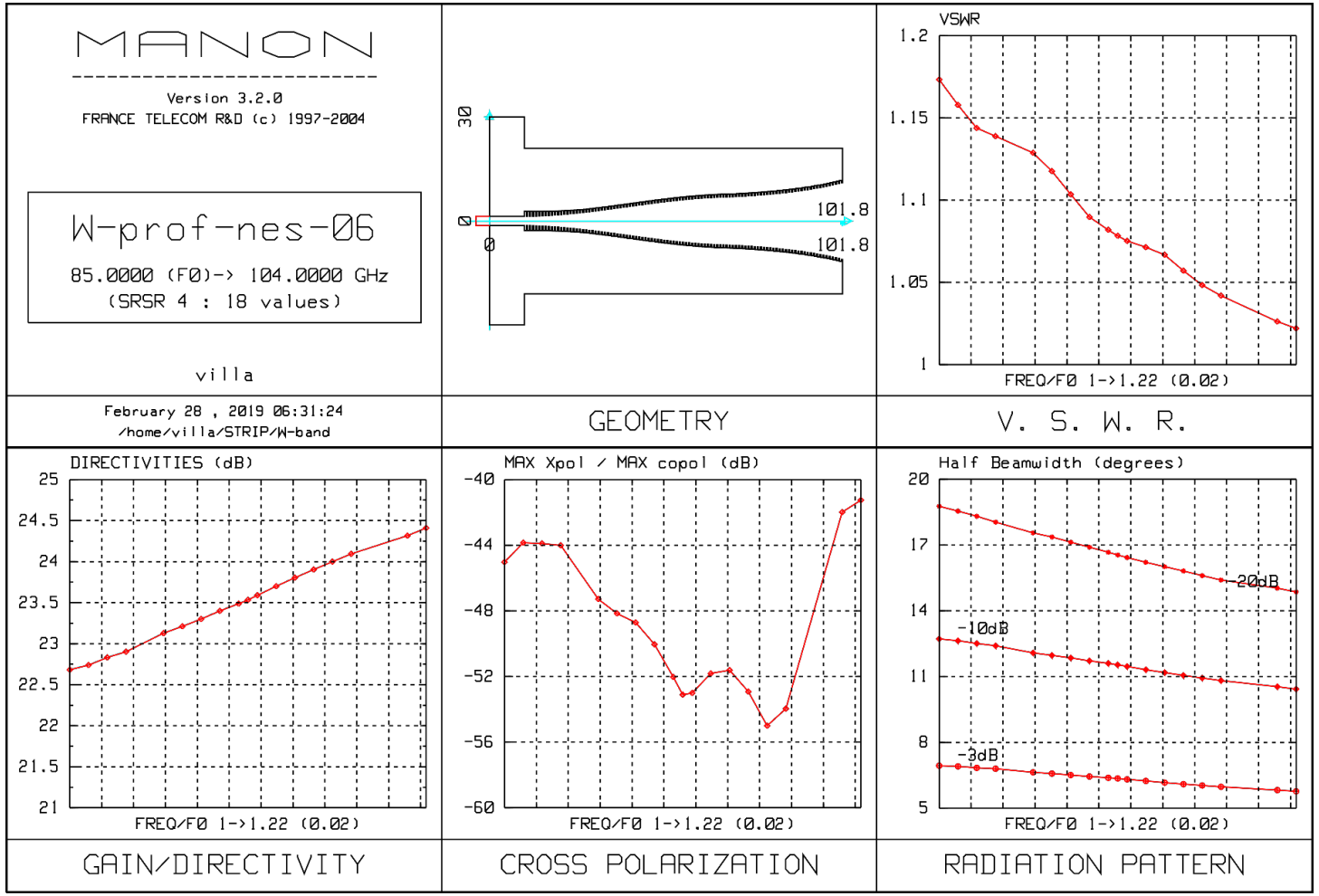


Figure 8. Measured radiation patterns of all 49 feedhorns at 43 GHz: normalized co–polar 45° plane (left) and cross–polar 45° plane (right).

W-band Horn design (INAF/OAS)



W-band horns and septum pol

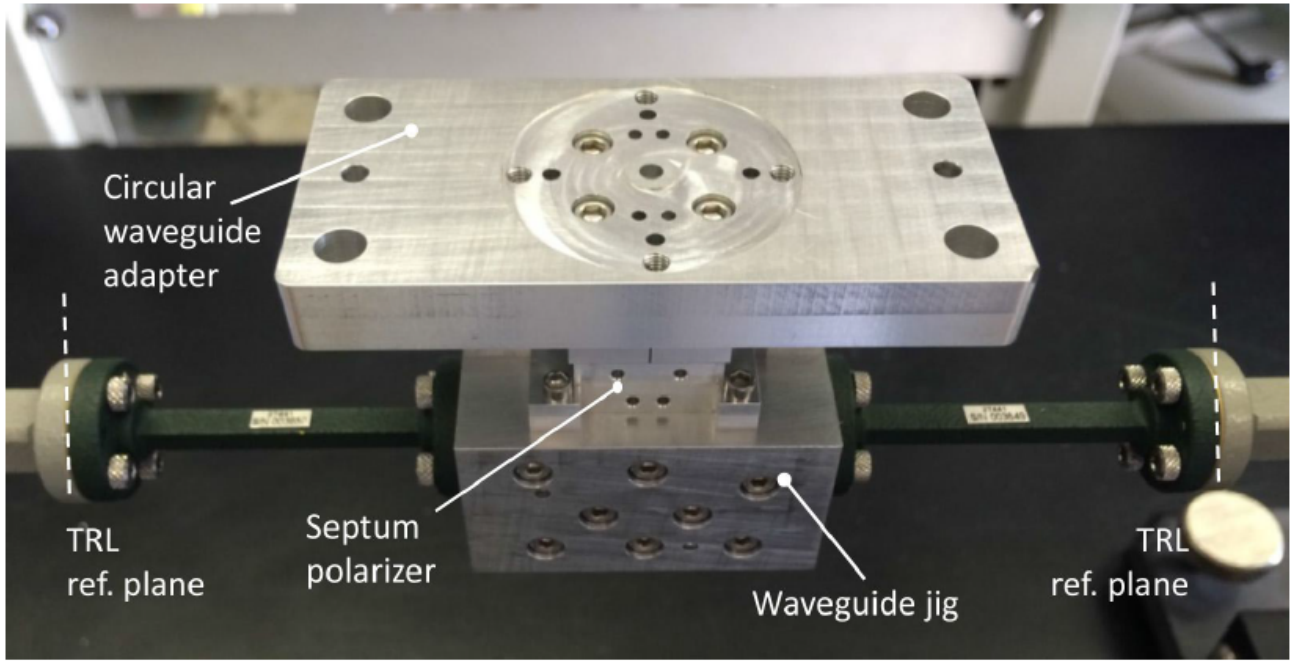
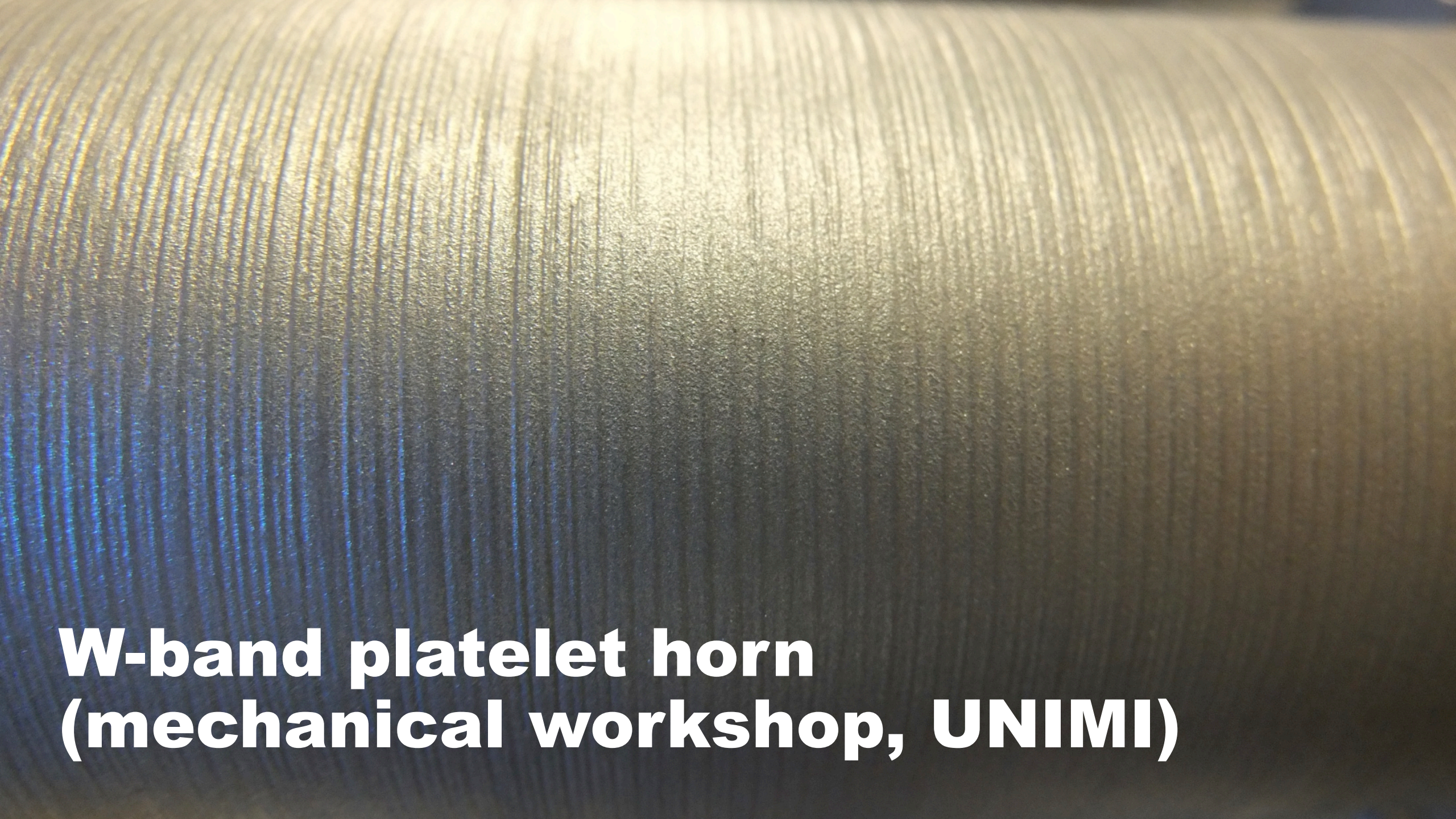
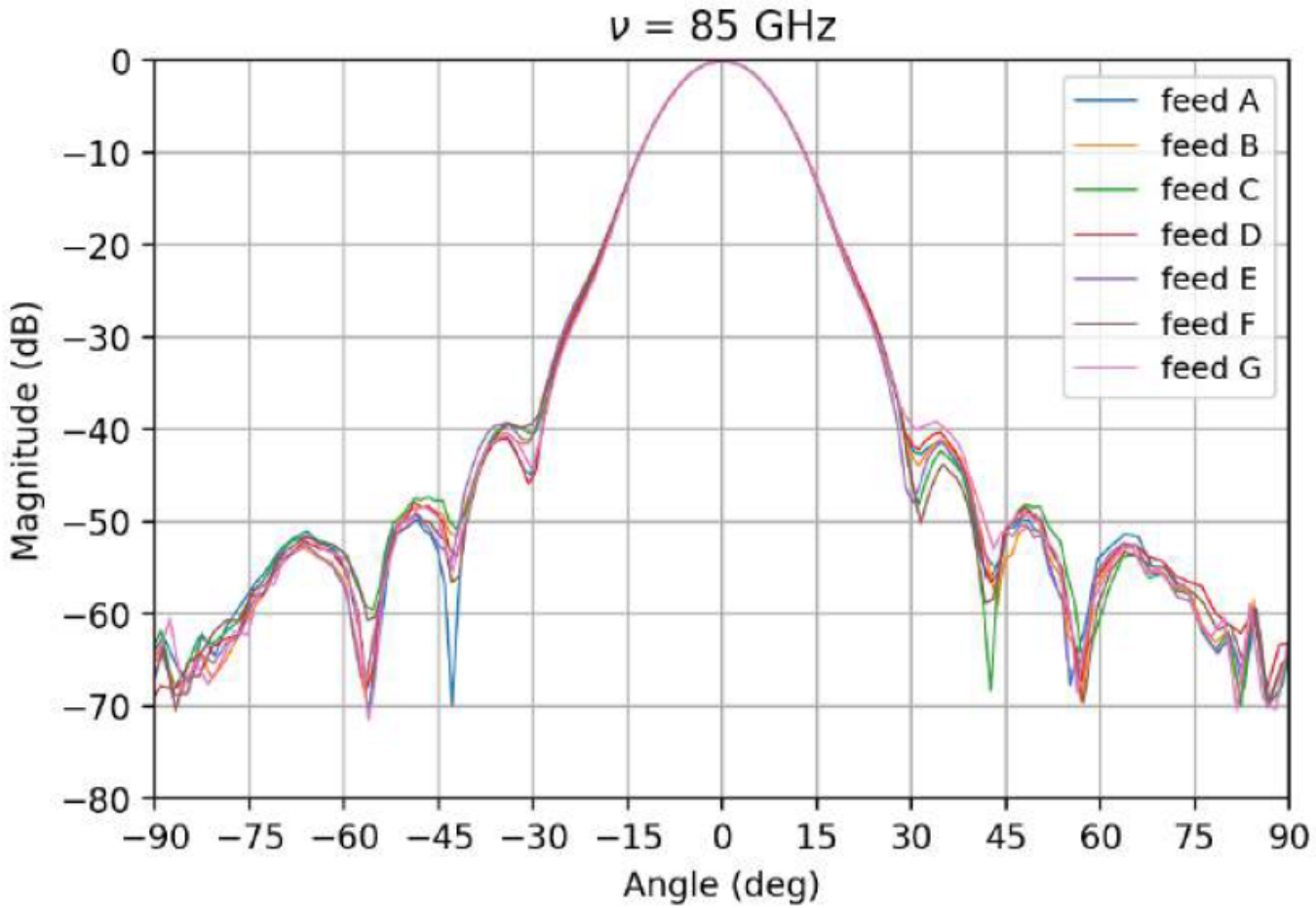


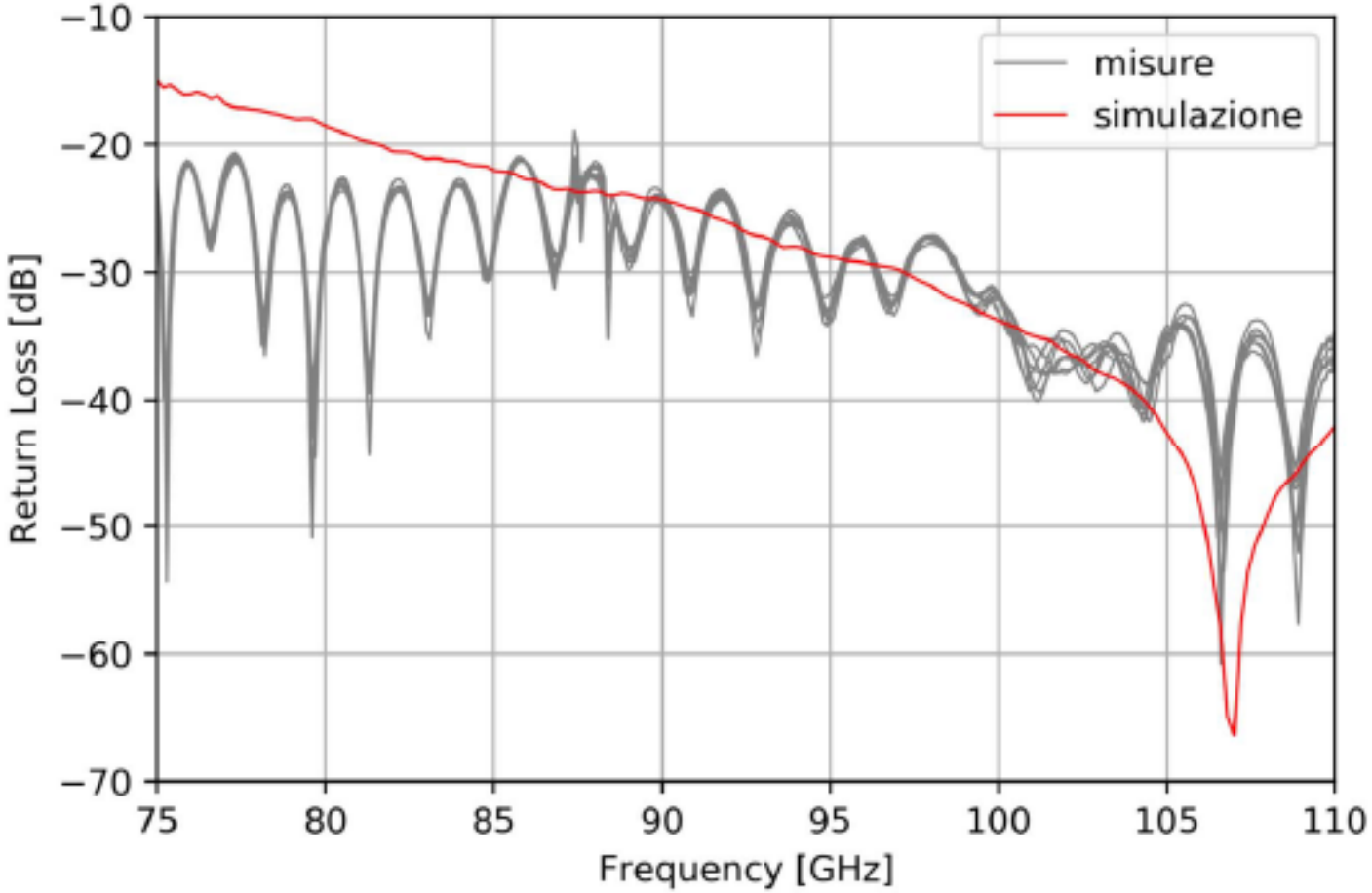
Figure 12. W-band passive components. *Left*: The six platelet feedhorns. *Right*: A septum polarizer during unit test characterization.


W-band platelet horn
(mechanical workshop, UNIMI)

W-band horn meas. (UNIMI)



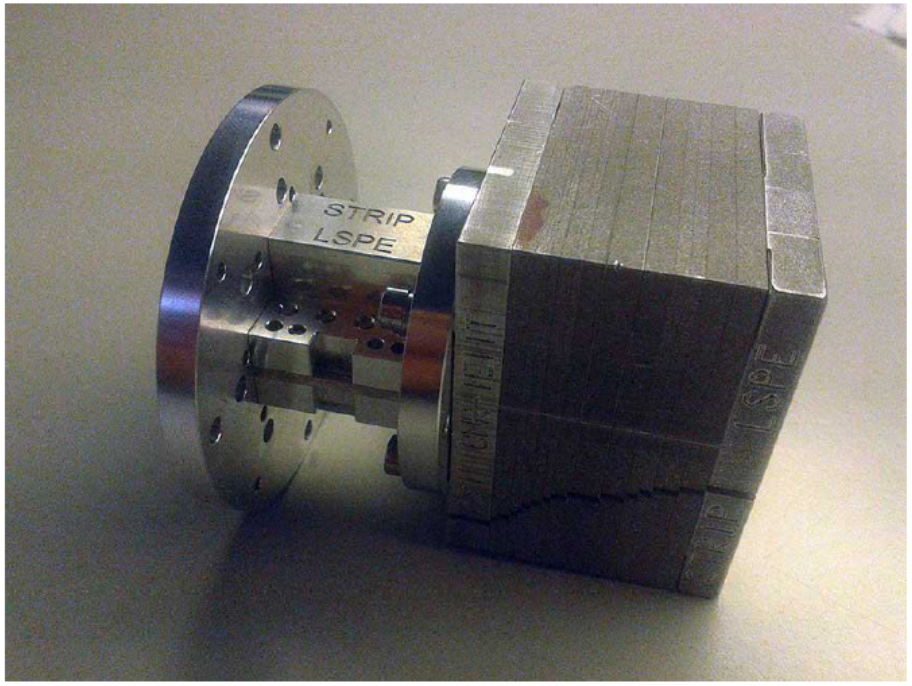
W-band horn meas. (UNIMI)

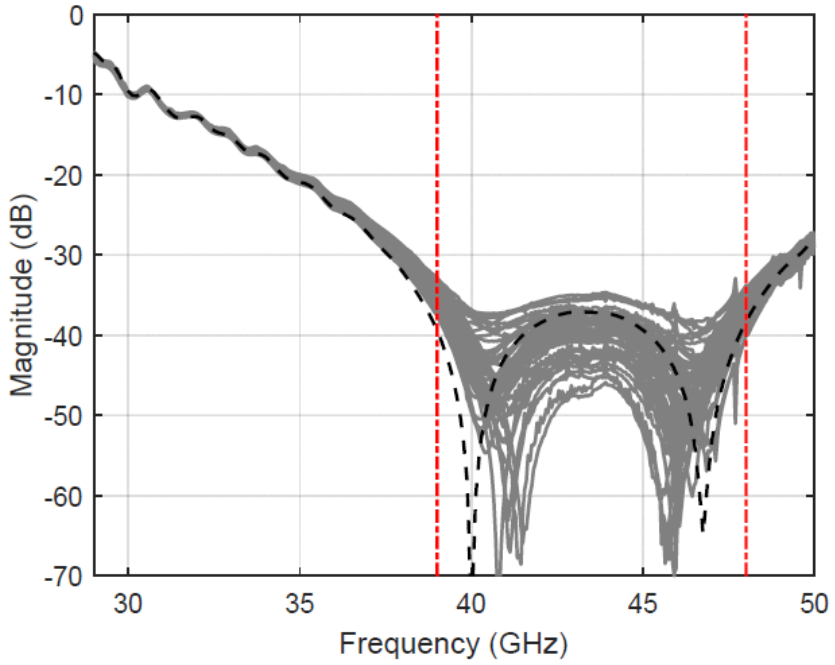


INAF ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO DI BOLOGNA

Q-band Polarizer and OMT

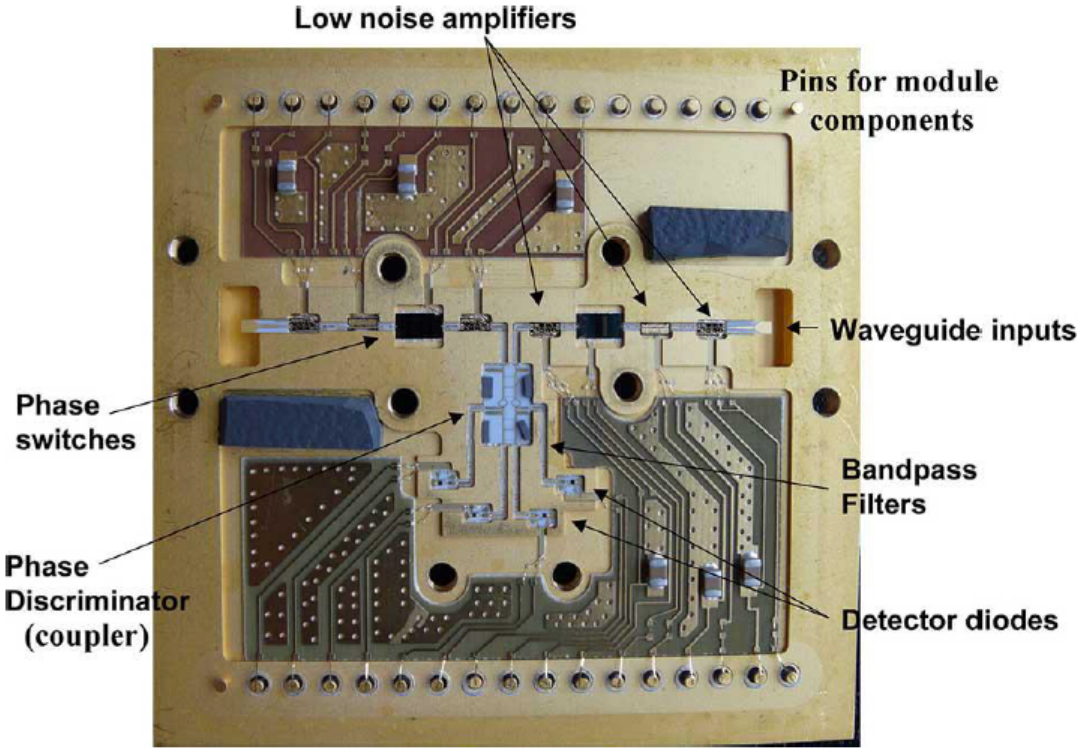
- Designed, procured, and tested @ CNR IEIIT, Torino

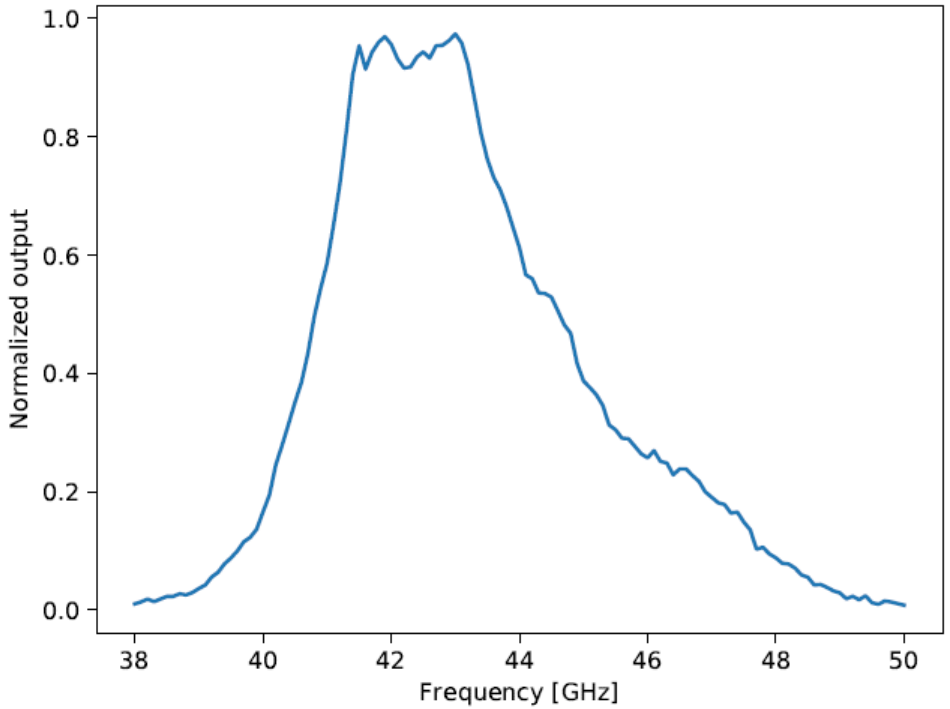




Q-band Polarimeter module

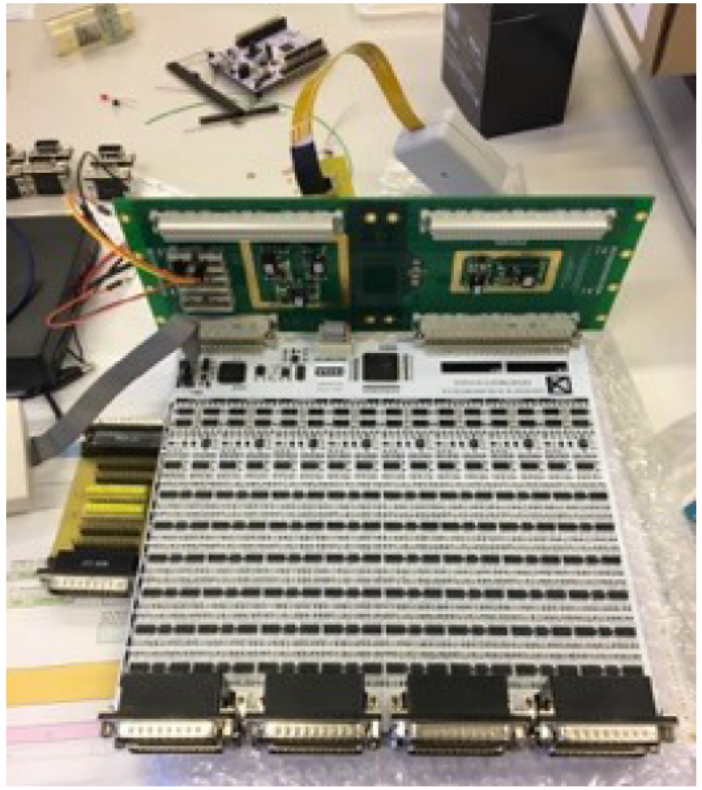
- Procured from JPL, tested @ UNIMIB Milano

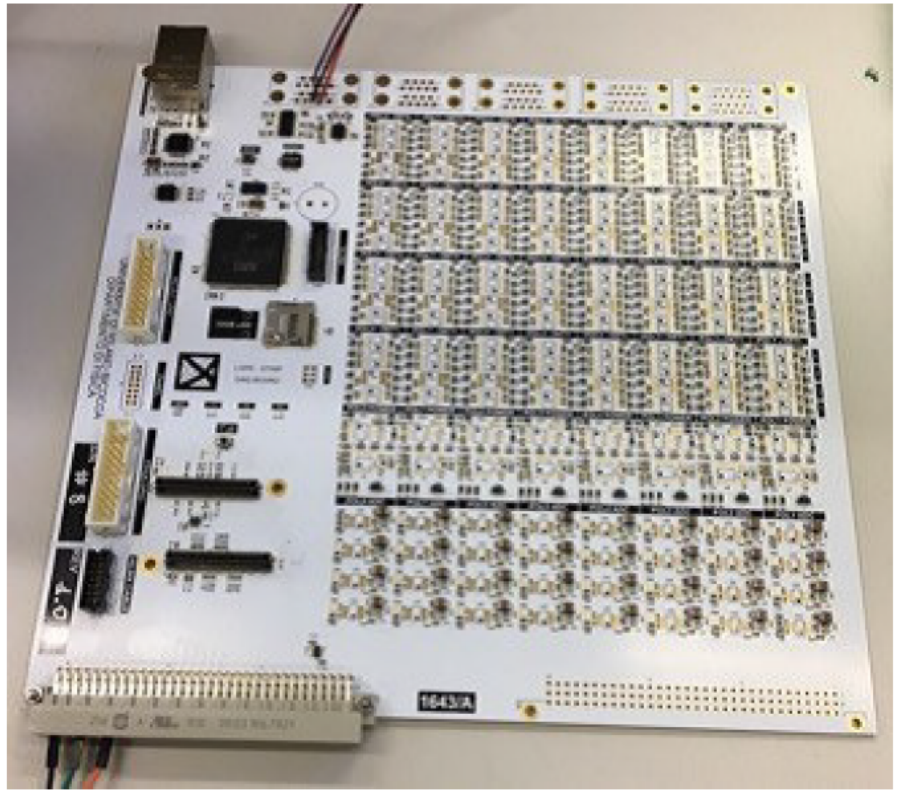




Electronics (Bias and Readout)

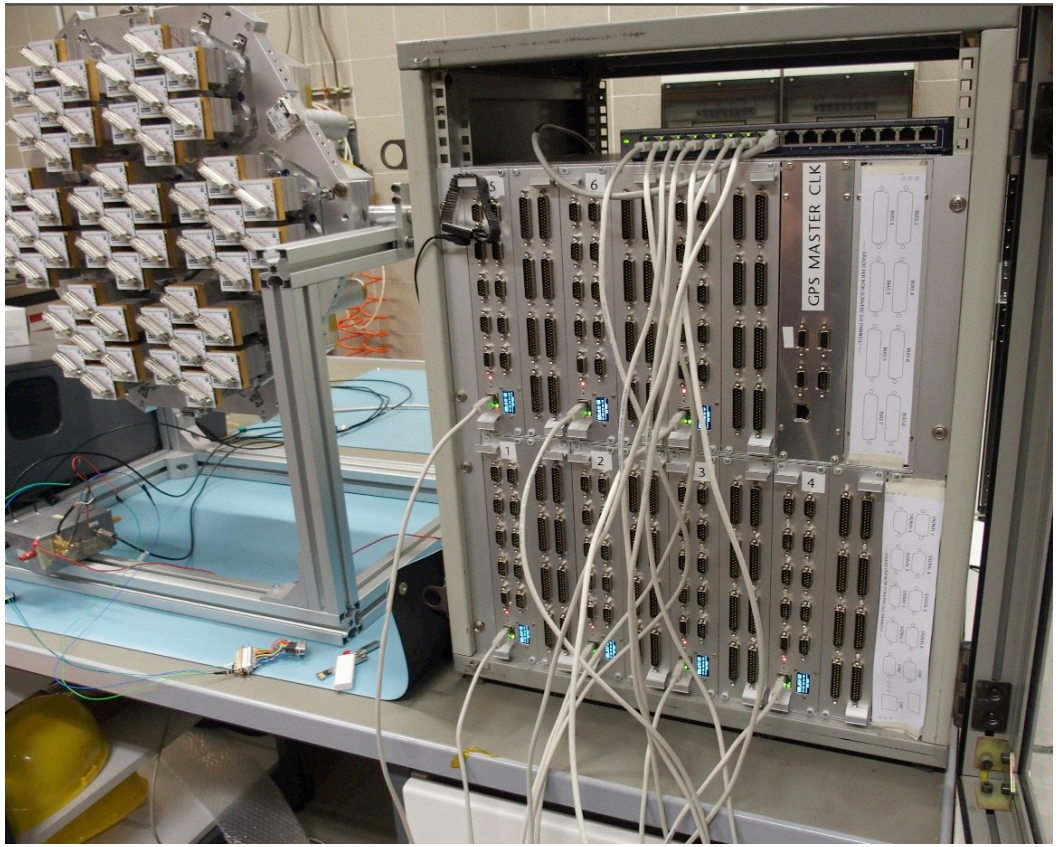
- Designed, procured, and tested @ UNIMIB Milano





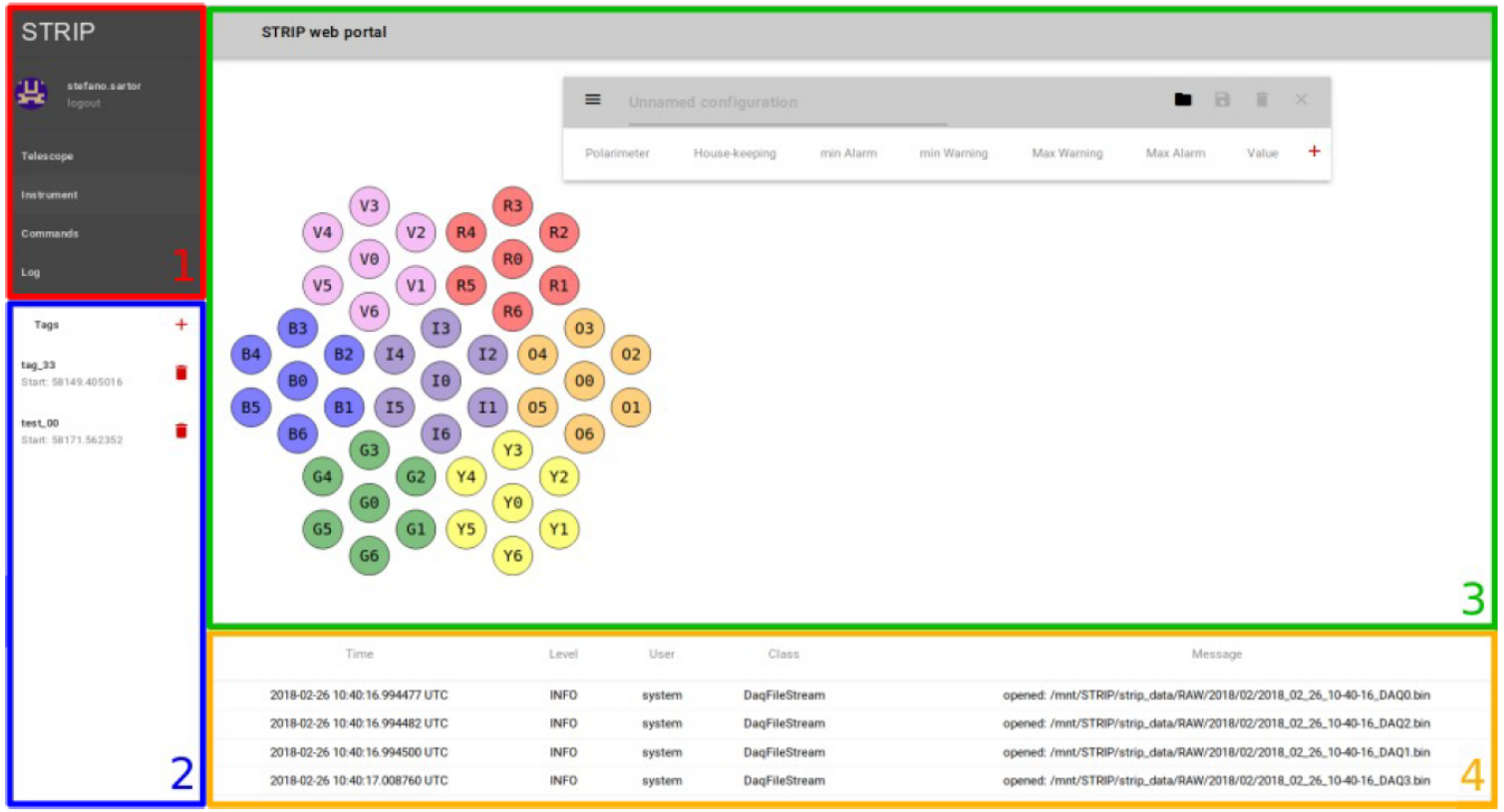
Electronics (Bias and Readout)

- Designed, procured, and tested @ UNIMIB Milano

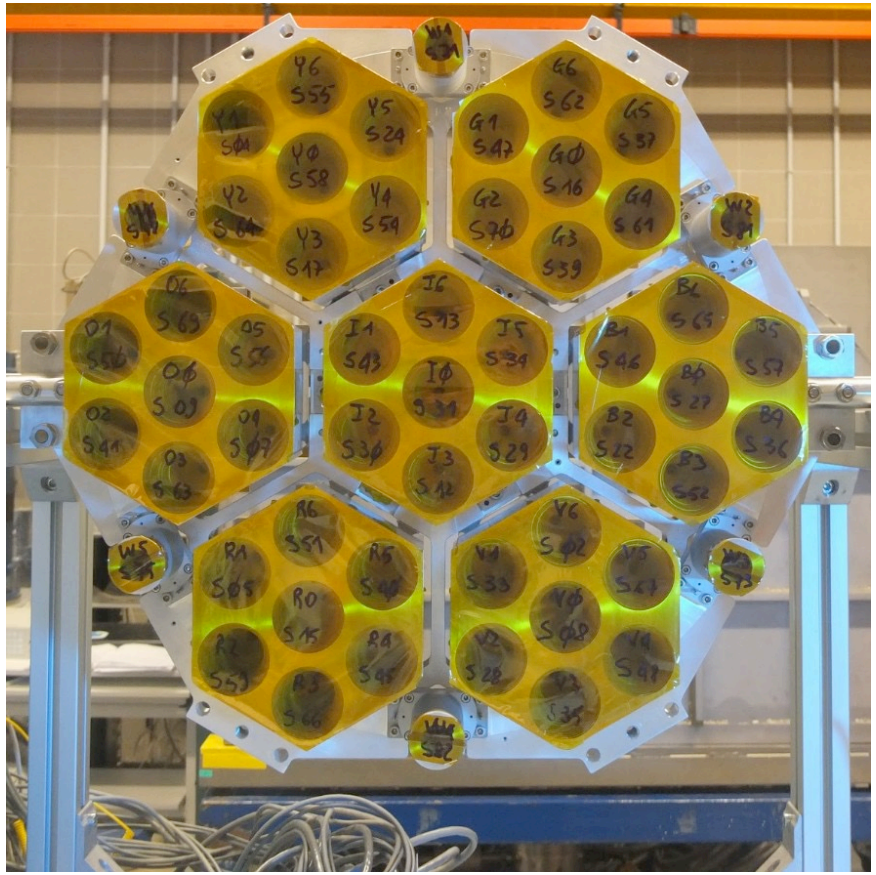


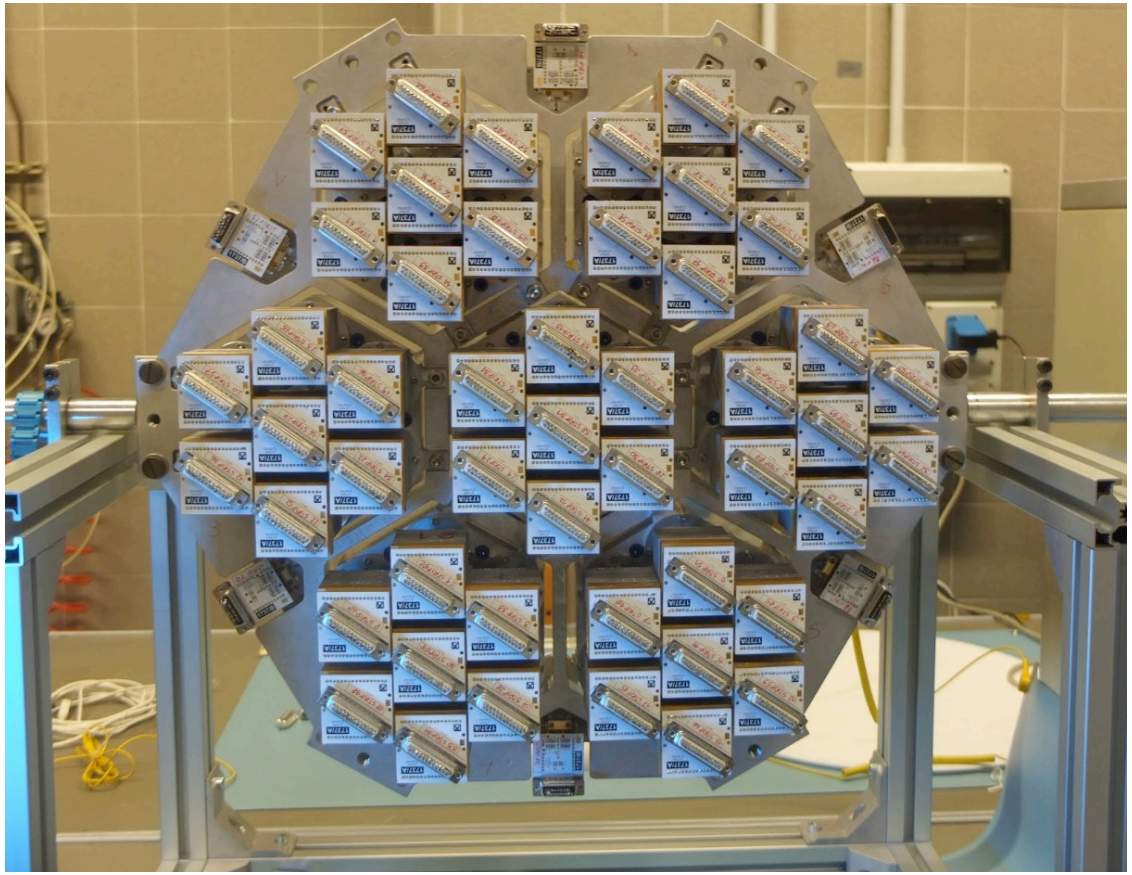
Control Software (web based)

- Developed @ INAF/OAT - Trieste

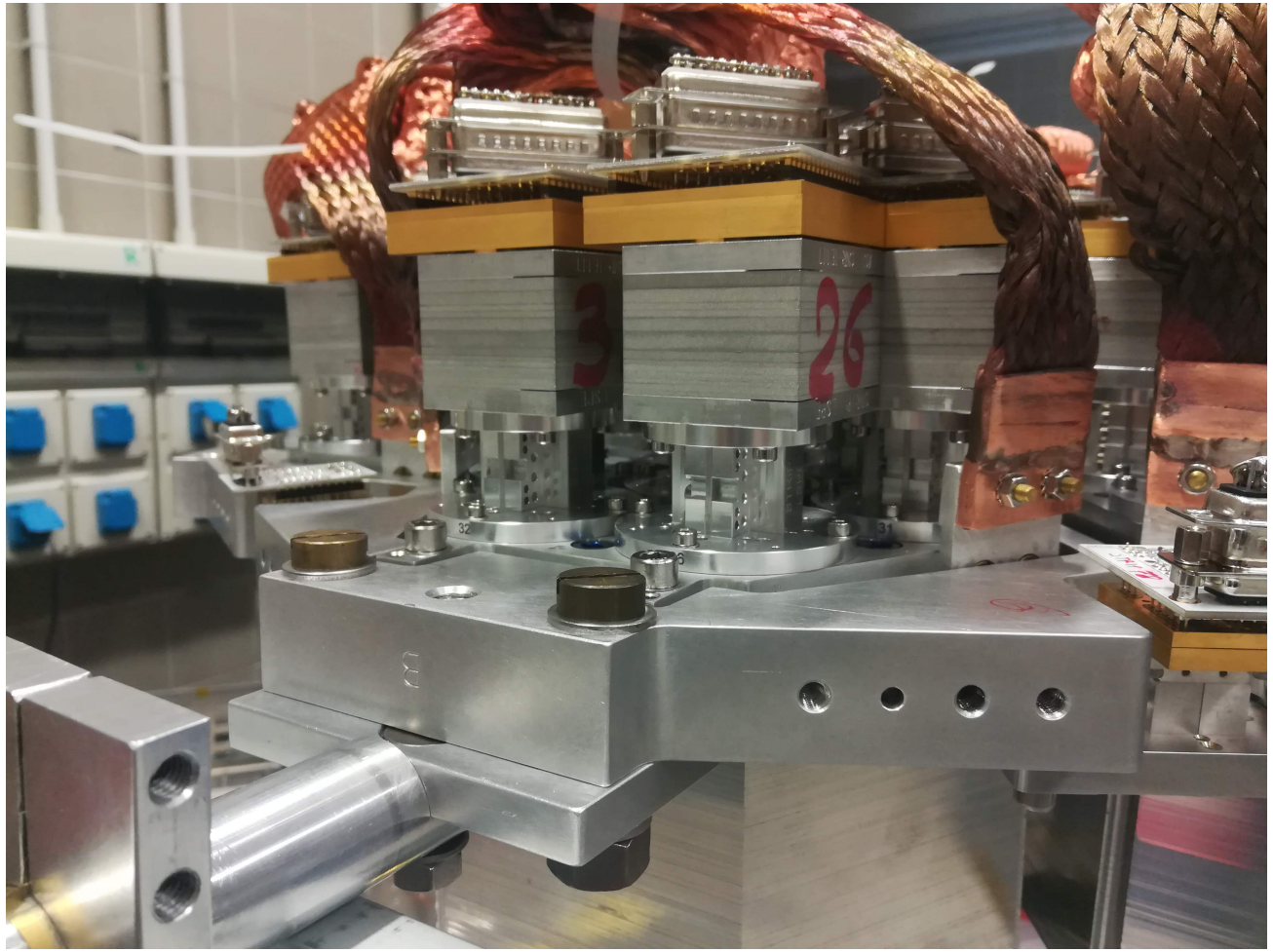


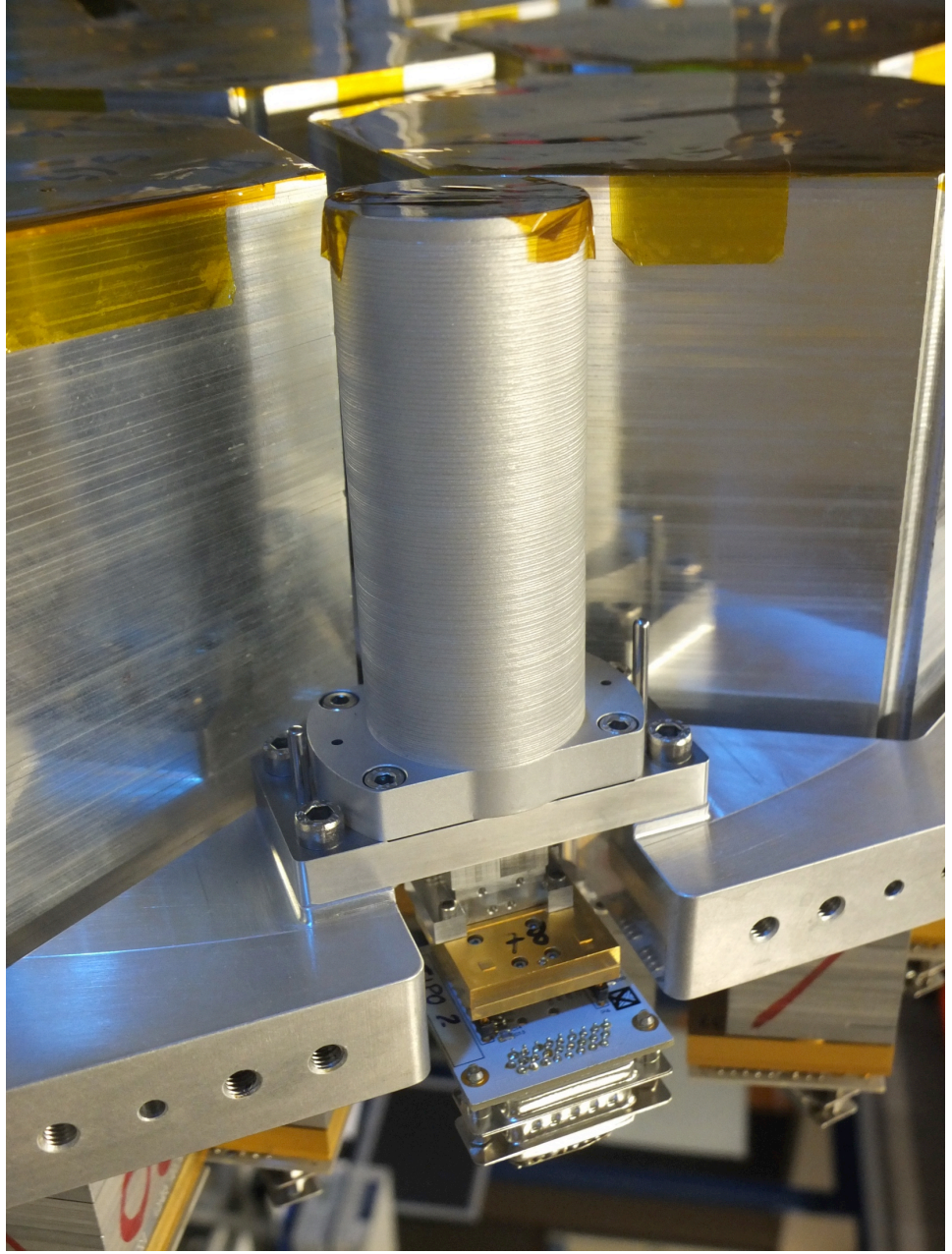
Focal plane Array



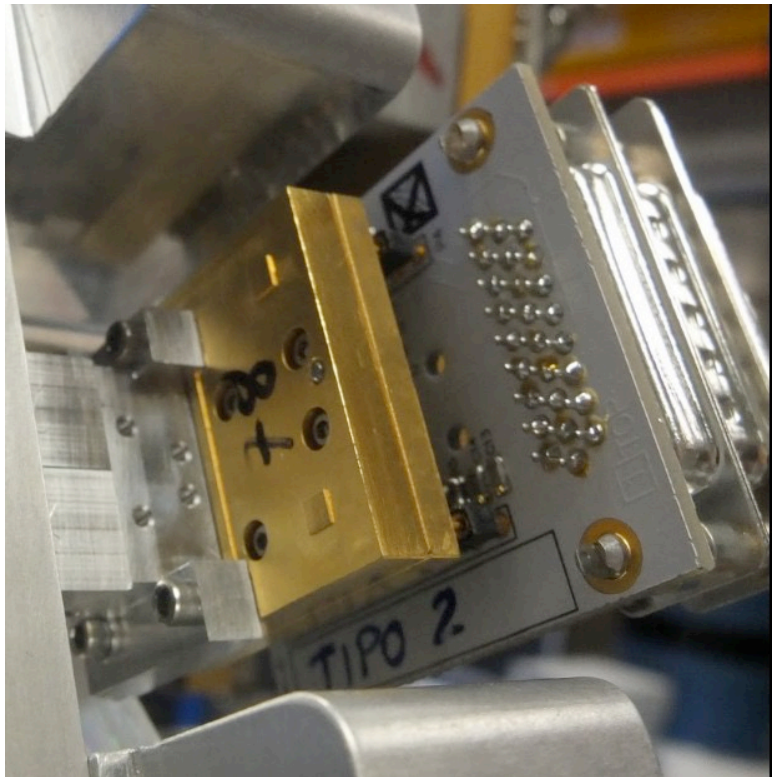


Focal Plane Array



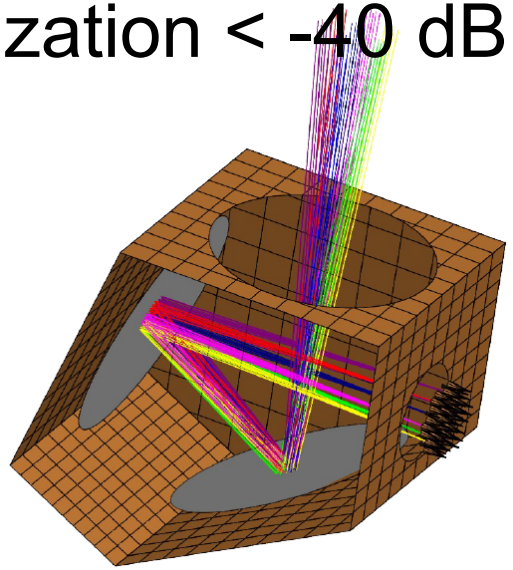


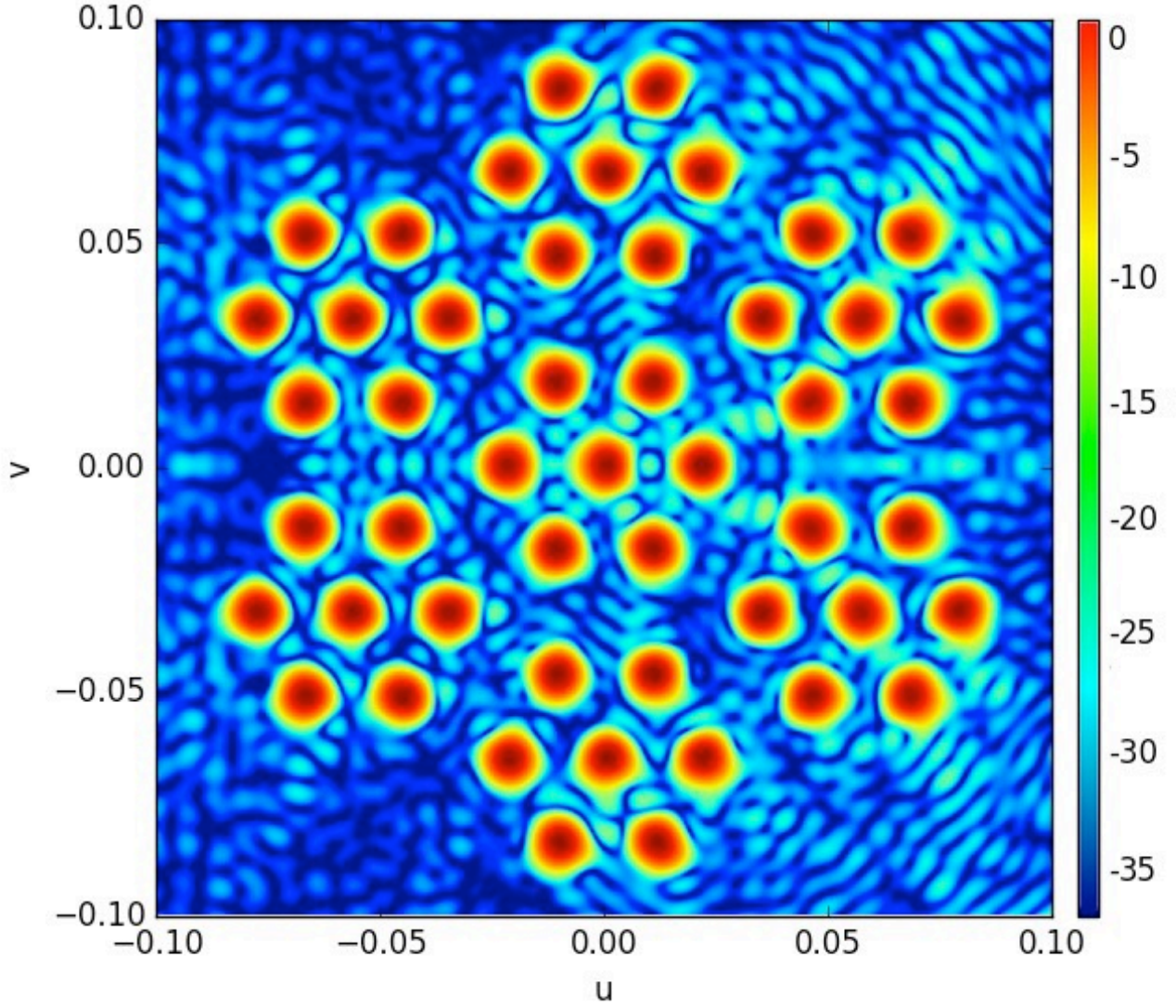
W-band and Q-band modules



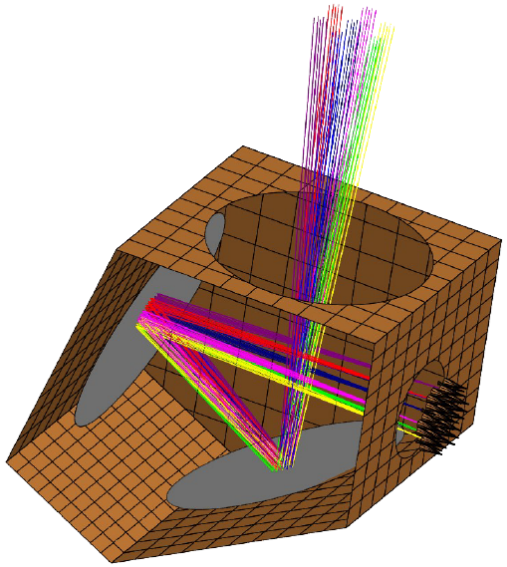
Optics sims

- **Q-BAND**
- FWHM ~ 21 arcmin
- Ellipticity 1.003 – 1.033
- Directivity ~ 54.7 dBi
- Cross-polarization < -40 dB

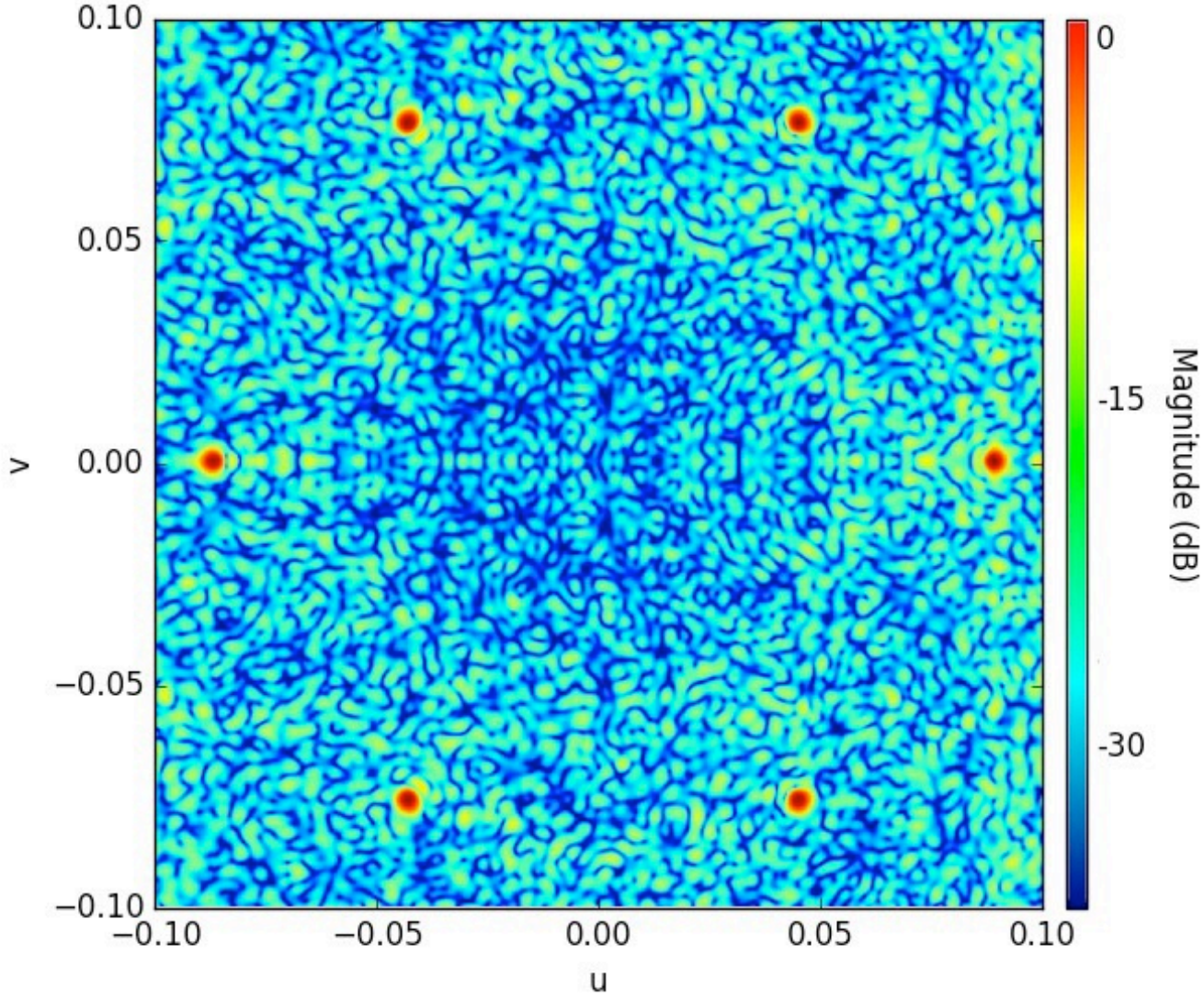




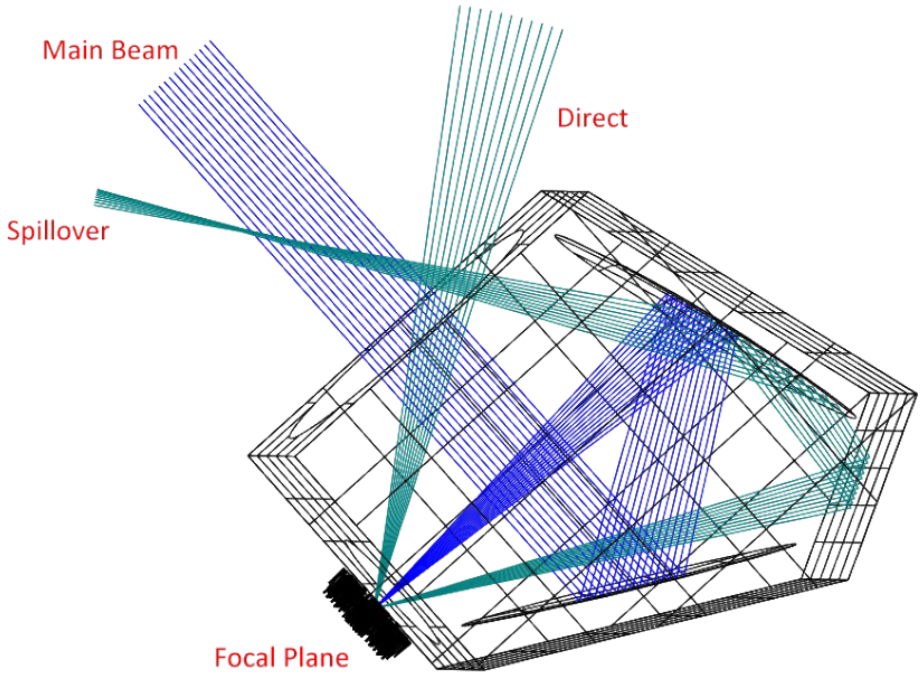
Optics sims

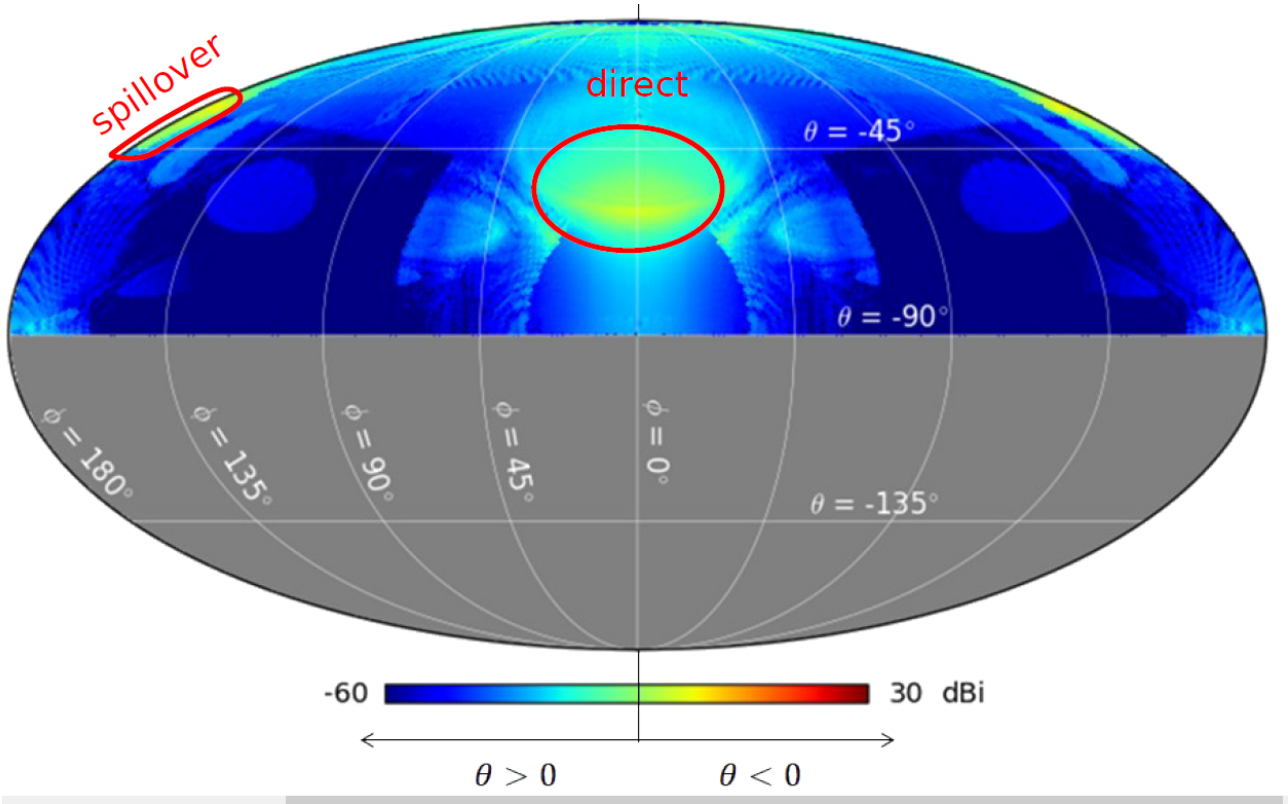


- **W-BAND**
- FWHM ~ 9.5 arcmin
- Ellipticity 1.006 – 1.041
- Directivity ~ 61.4 dBi
- Cross-polarization < -40 dB



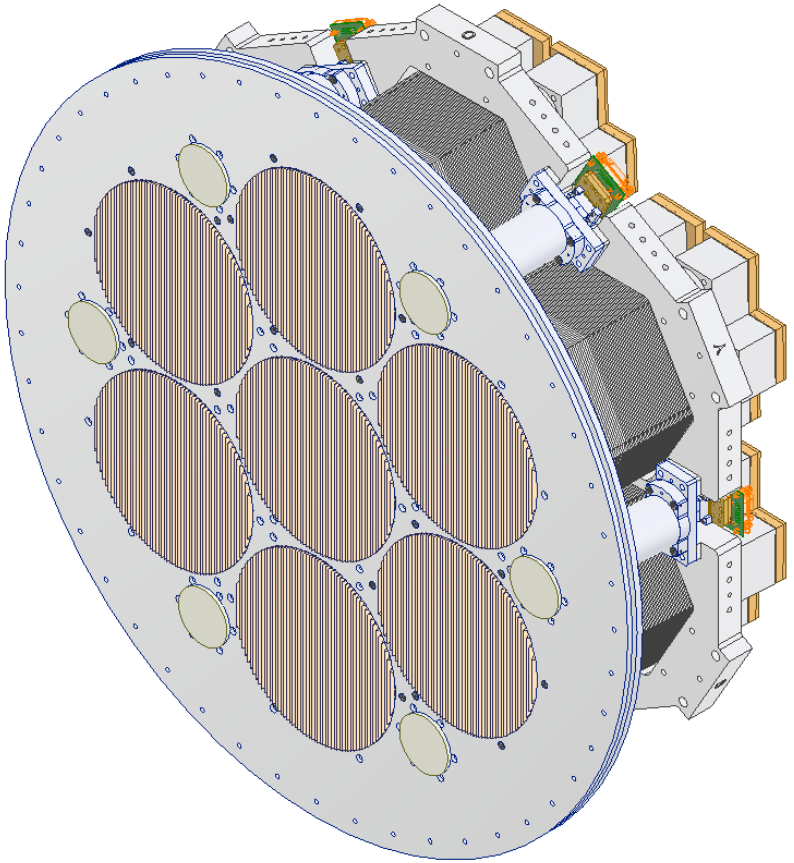
Typical far sidelobes response





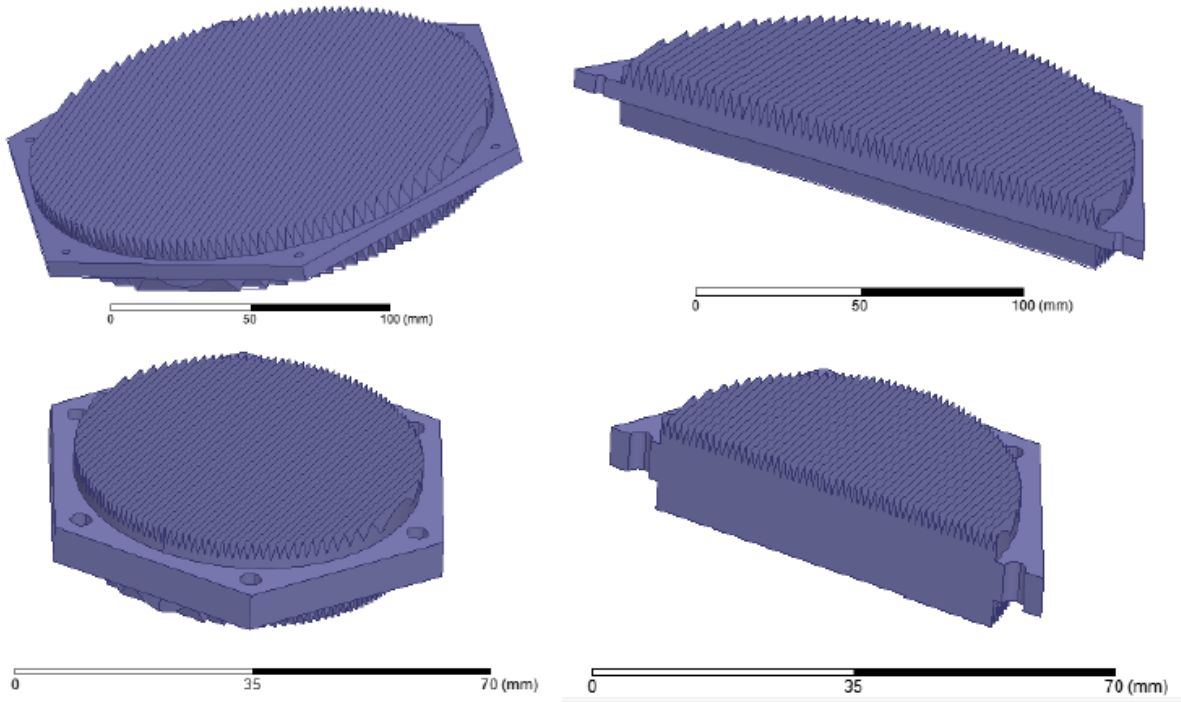
INAF ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO DI BOLOGNA

Filters and window (ALMA B23 heritage)



FACULTAD DE CIENCIAS FÍSICAS Y MATEMÁTICAS UNIVERSIDAD DE CHILE

Cerro Calán
Observatorio Astronómico Nacional

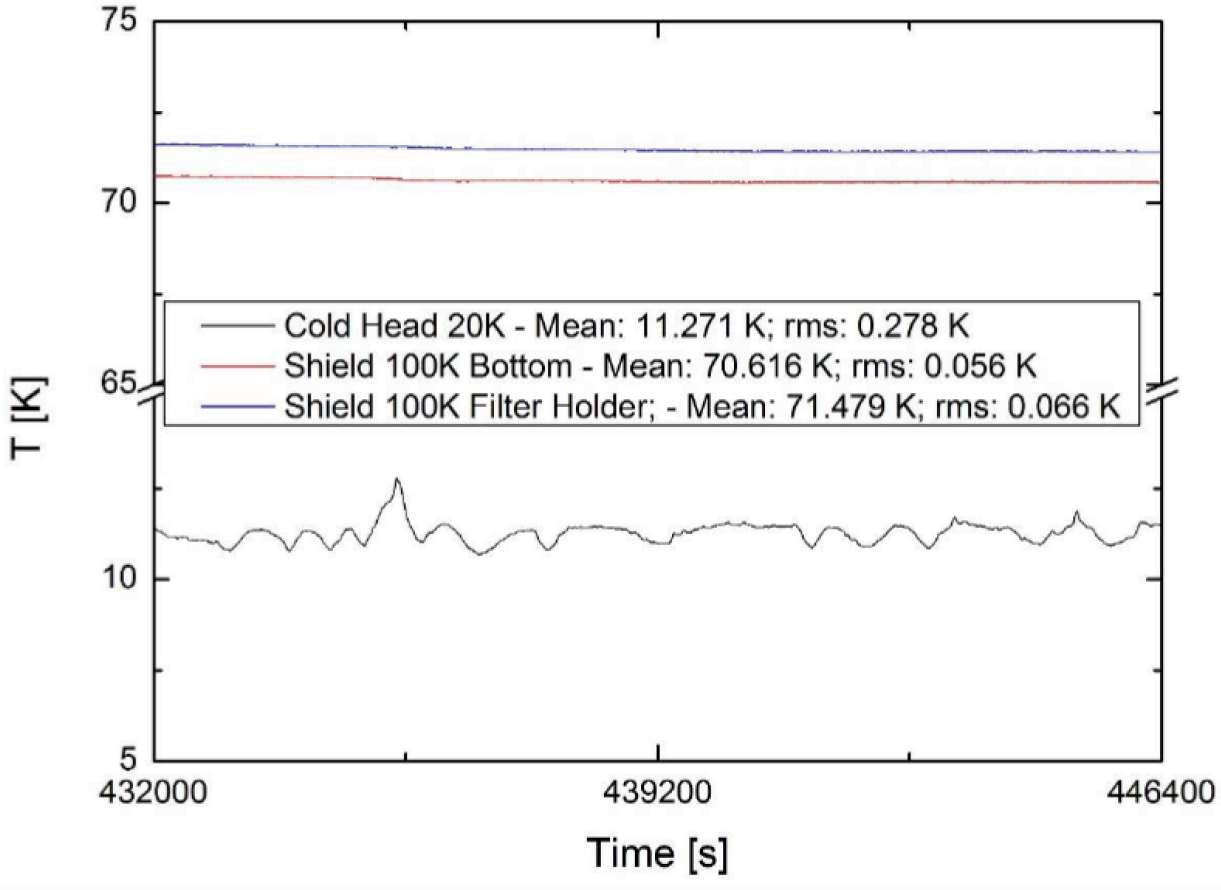


STRIP Cryostat

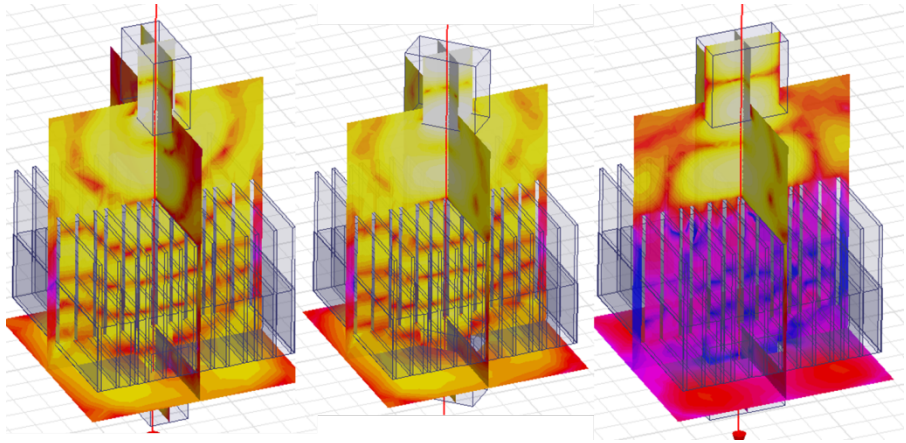
- Designed, procured, and tested @ INAF/OAS-Bologna

Cryostat TRB on Nov 2018

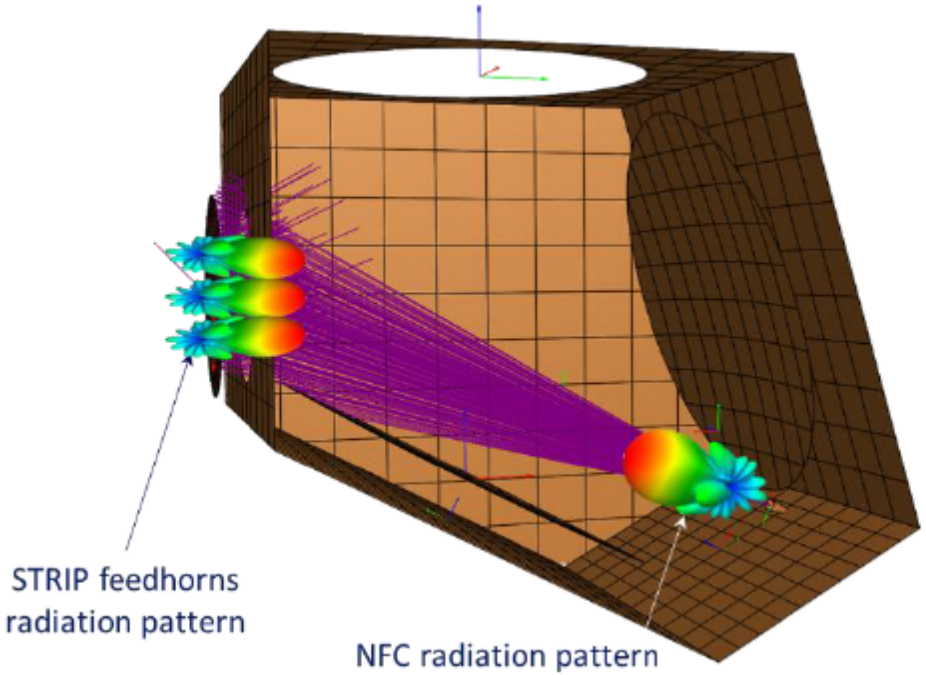
- Relevant performance requirement of the STRIP cryogenic system verified
  - the 20K cold head reached 11.3K (no load)
  - With 18W of power load, the T of the cold head was 18K
  - intermediate stage steady state at 71K (2 K uniformity)



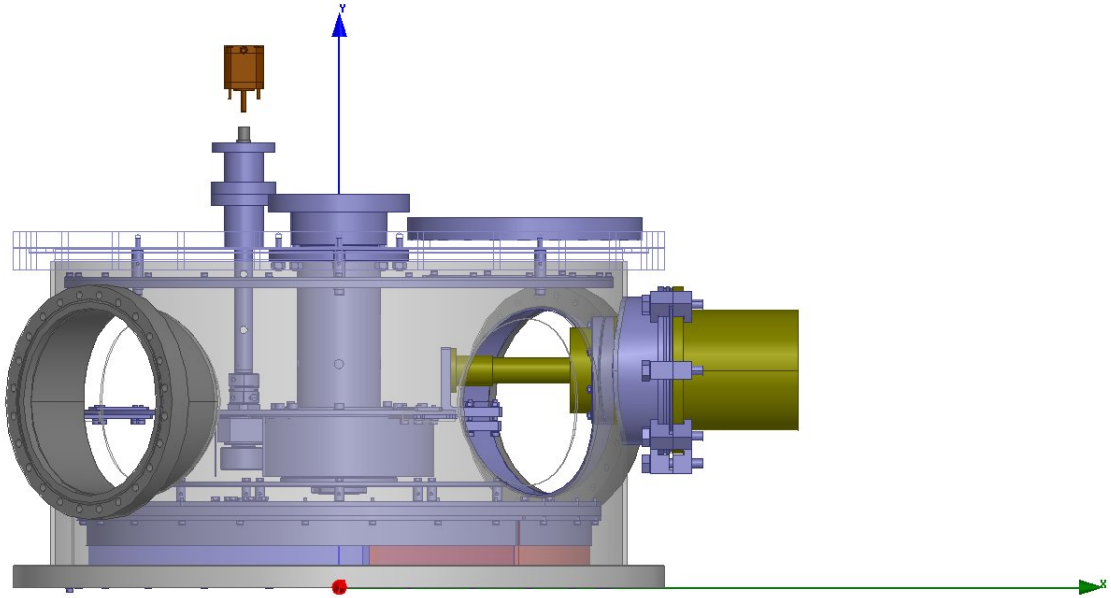
Calibration systems

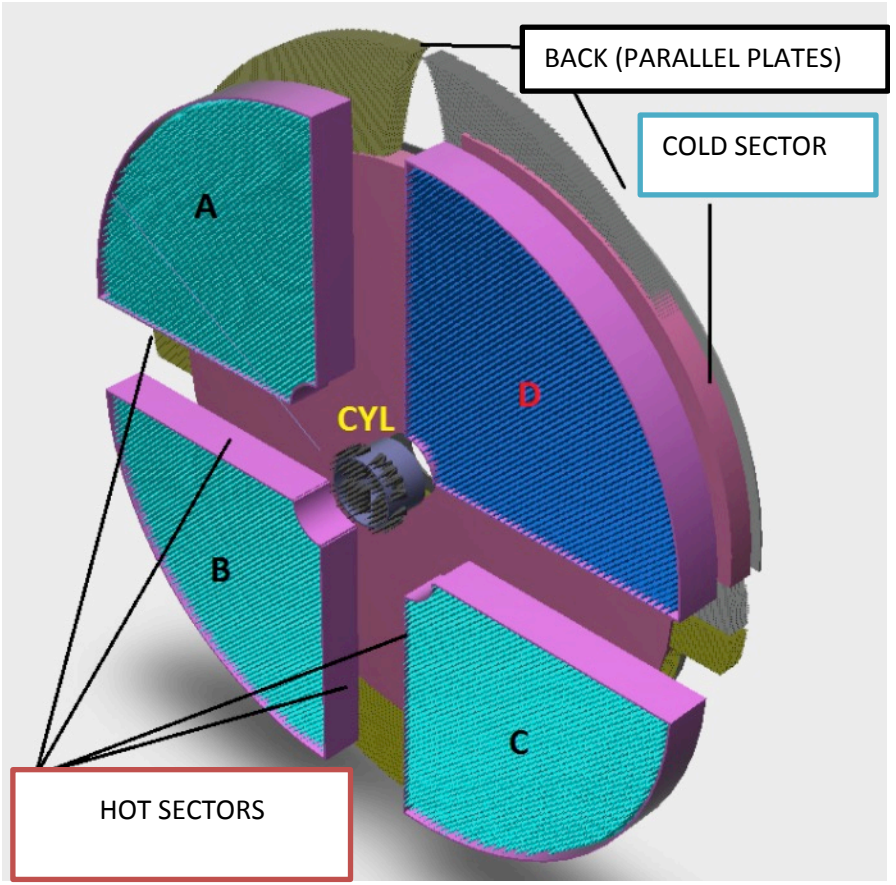


- Cryogenic Calibrator for system tests (INAF/OAS)
  - To provide a stable variable cryogenic reference calibrator in polarization
  - Invitation to tender open
- Near Field Calibrator (UNIMI)
  - To provide a stable reference signal injected toward the feeds for gain variation calibrations
  - Ready, under optimization



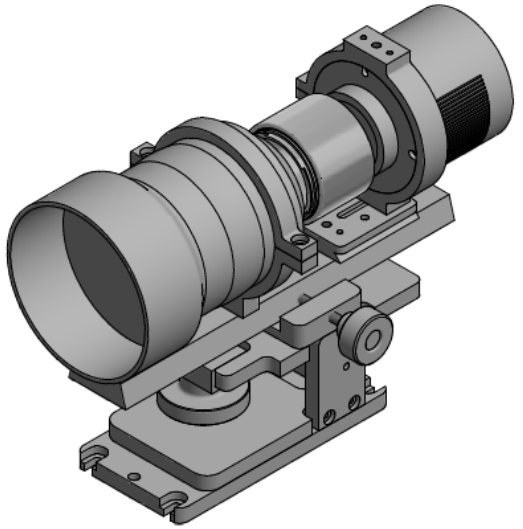
Cold Calibrator





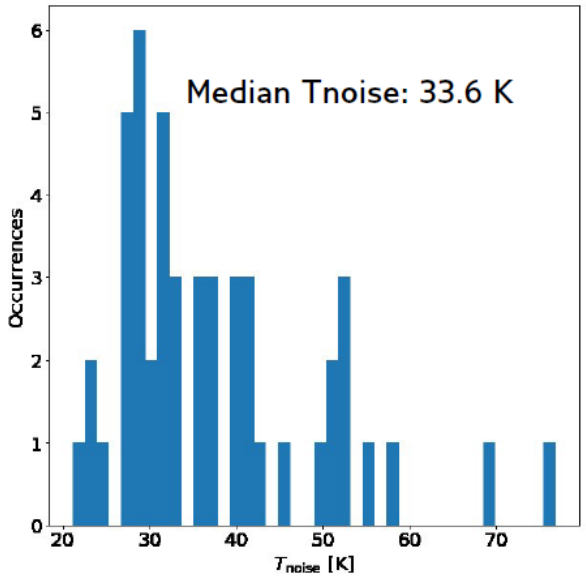
Beam Calibration

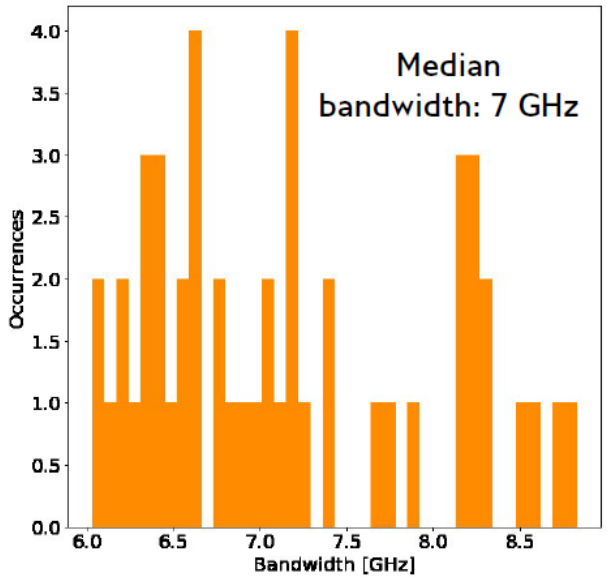
- Drone beam calibrator (CNR / IEIIT)
  - To provide RF source for beam measurements during commissioning and observation campaing
  - Ready, Under optimization
- Star Tracker (UNIMI / INF/OAT)
  - Pointing calibration
  - Ready, under optimization

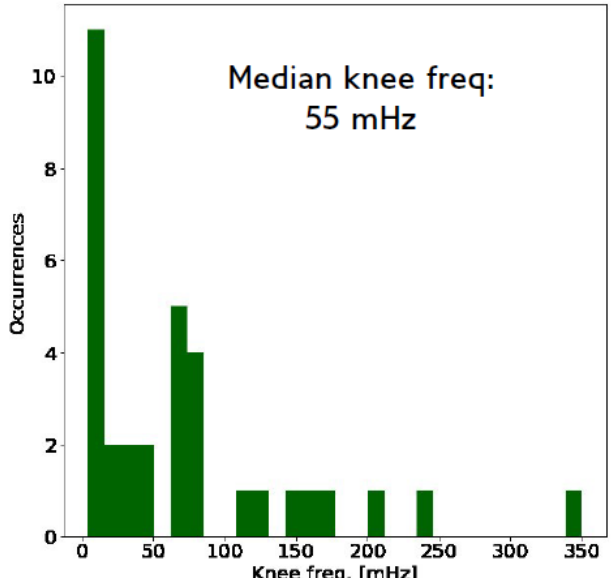


Performance Status unit level (polarimeter)

Preliminary – Before tuning optimization
(to be performed at system level)

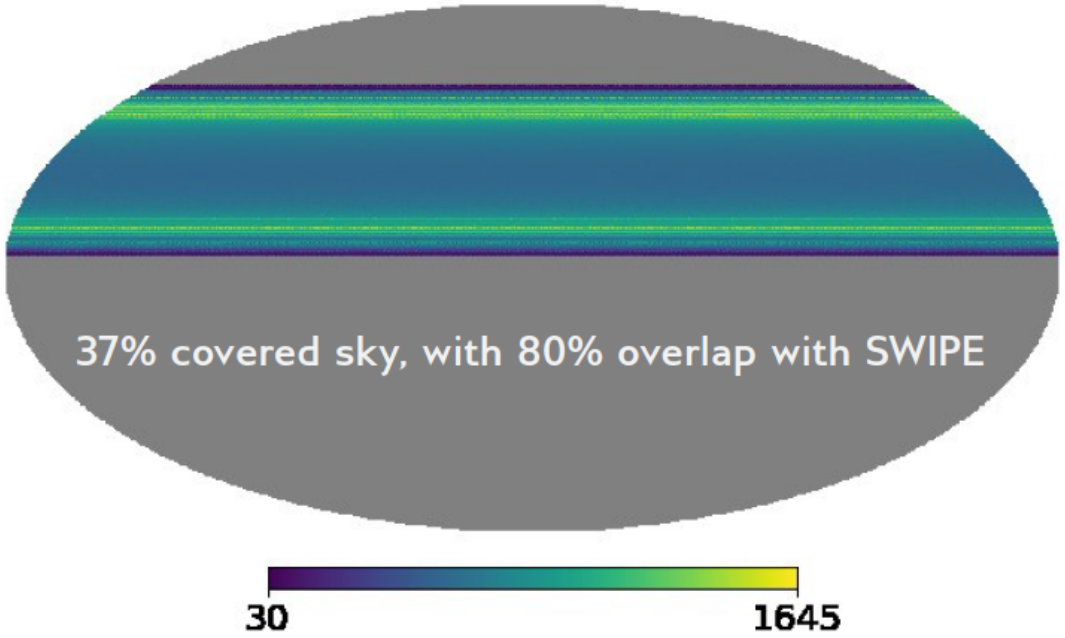






Expected performances

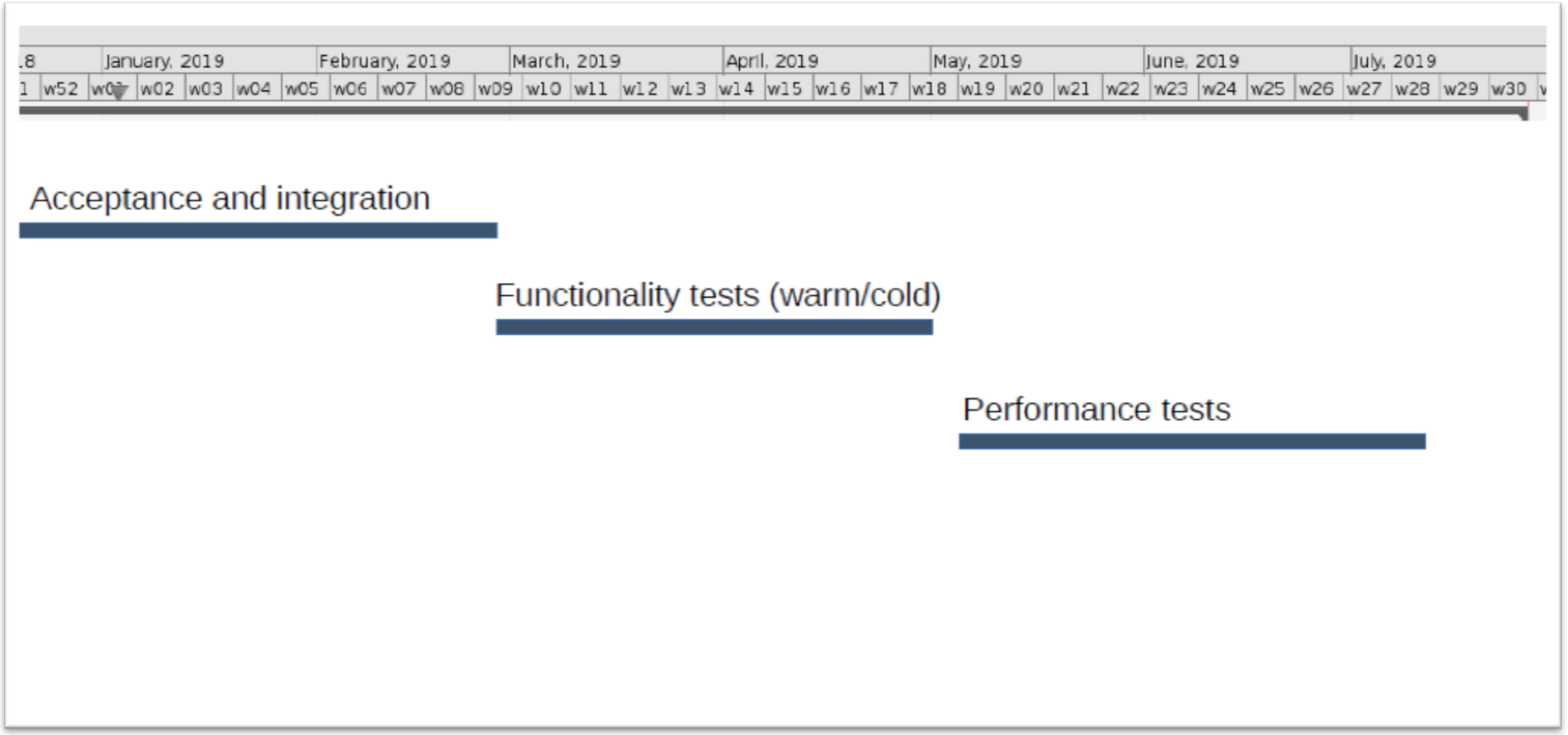
STRIP Q-band surveyed sky and hit count for one day observations



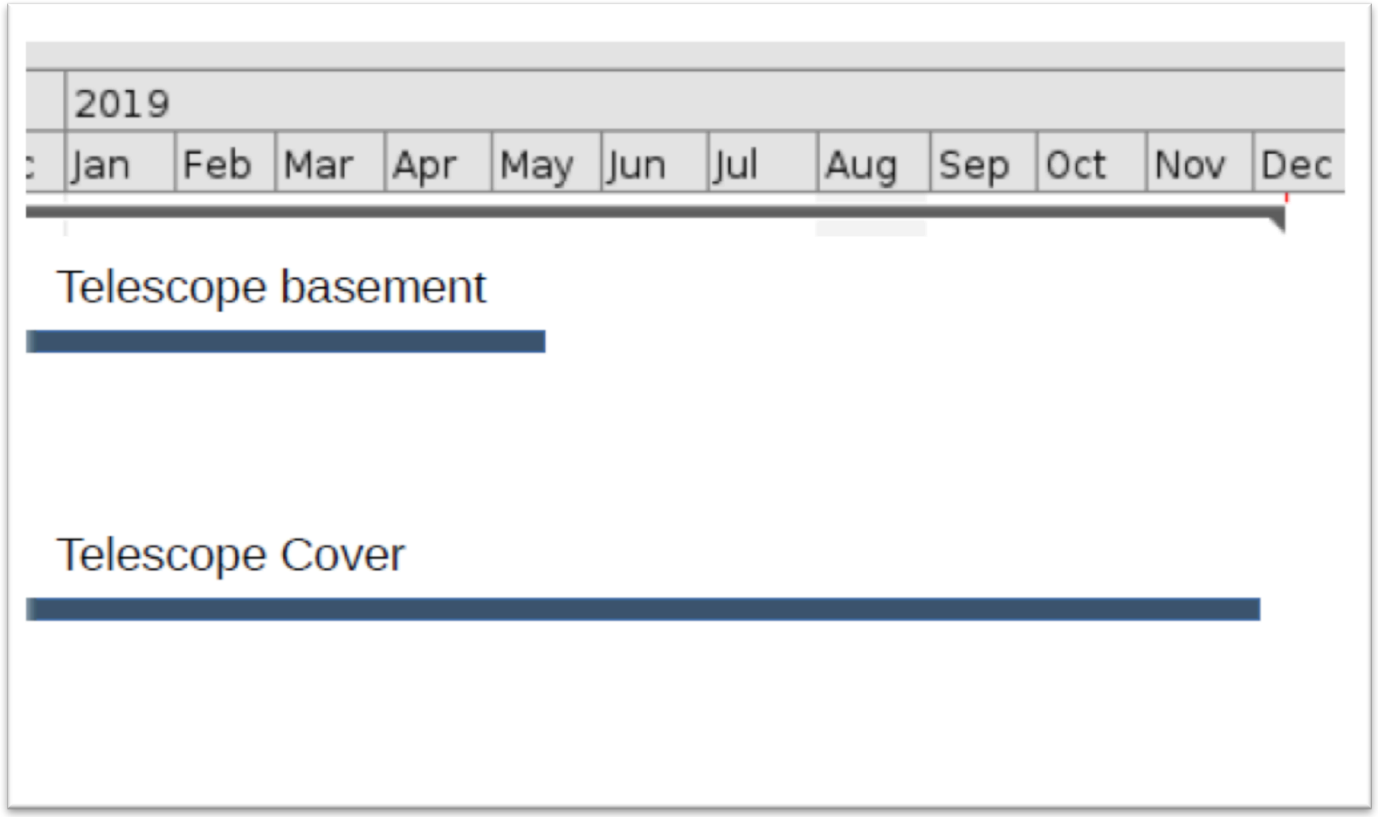
Expected final sensitivity (two years, 35% duty cycle)

- ΔQ/U ~ 1.7 μK.degree
- Estimated ~ 17 K noise temperature from atmosphere and optics (telescope, window, filters)

Instrument Schedule

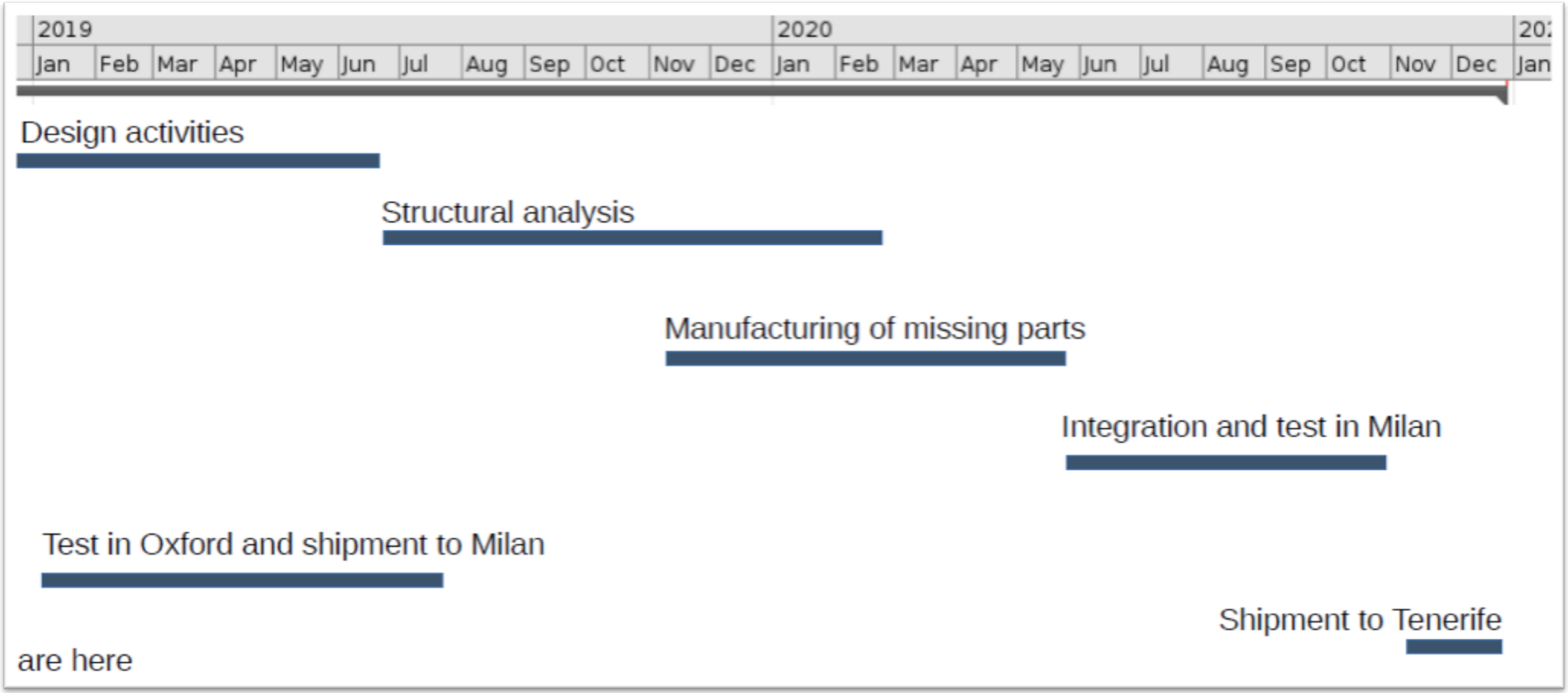


Site / Cover schedule



INAF ISTITUTO NAZIONALE DI ASTROFISICA
OSSERVATORIO DI ASTROFISICA E SCIENZA DELLO SPAZIO DI BOLOGNA

Telescope Schedule



Well...He looks quickly at the "Brain table," grabs a jar from under the glass dome nearest to him, and leaves.

On the glass dome, whose contents Igor has just taken, is printed:

DO NOT USE THIS BRAIN!

"ABNORMAL"