




# **Enabling technology developments (passive and coherent components, electronics)**

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Università degli Studi di Milano – Dipartimento di Fisica  
on behalf of the Italian CMB community



# Knowledge map



## Torino

- IEIIT – CNR (design development and testing of passive components)

## Milano

- UniMi (fabrication, bench and anechoic chamber testing, design)
- UniMib (bench testing, cryogenics, mechanic and electronic design and fabrication)
- IFP-CNR (anechoic chamber testing)

## Bologna

- IASF-INAF (passive components system development, cryogenics, horn and telescope design, calibrators,
- system engineering, AIV-AIT, RF design and tests, project control, thermo/mech design)
- IRA-INAF (coherent devices, RF testing)

## Roma

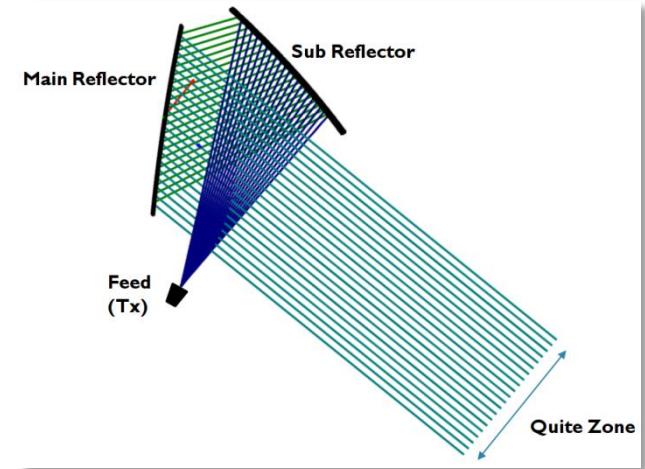
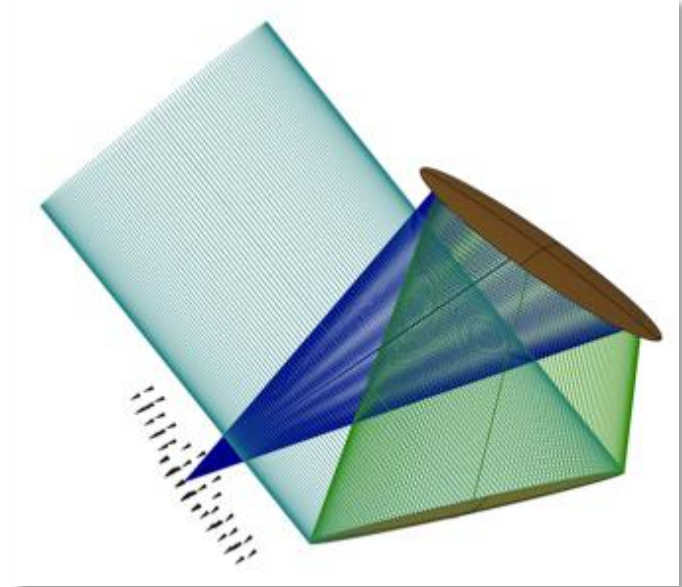
- La Sapienza (multimoded horns, optical simulations)



# Design and manufacturing of passive components

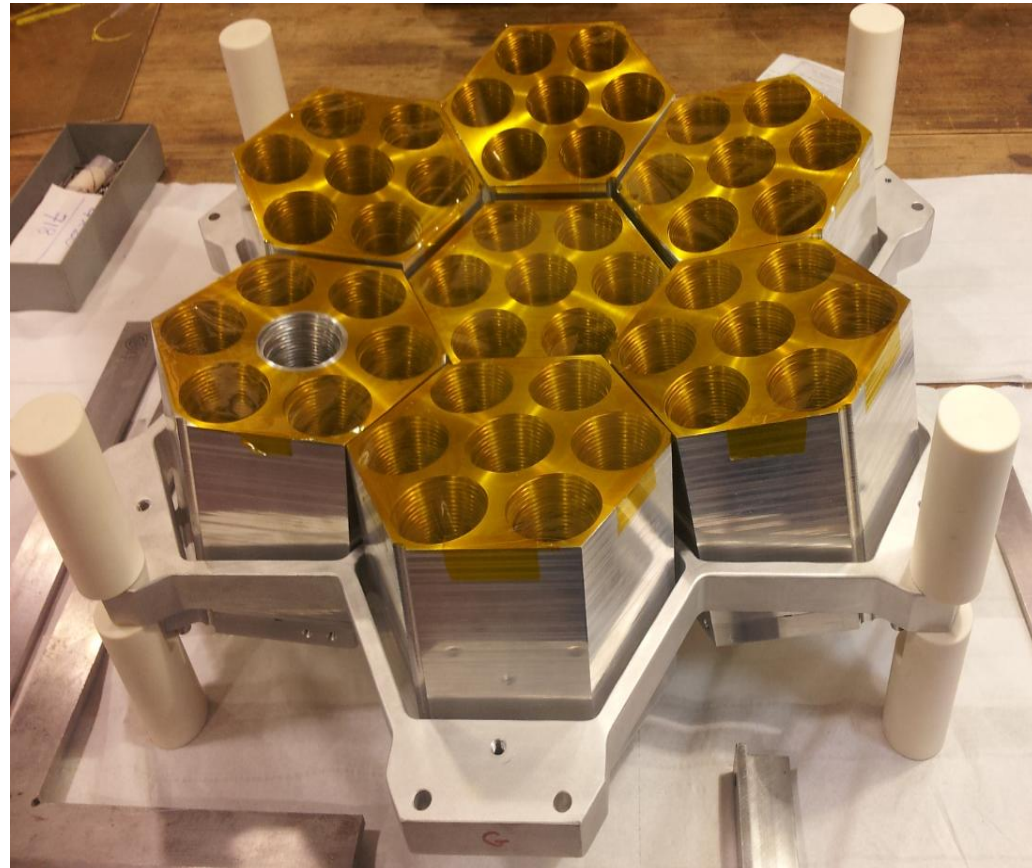
# Reflector telescope design

- LSPE-STRIP side-fed dragonian design (IASF-Bo)
- Optimized for low cross-polarization, key parameter for CMB measurements
- Dual reflector compact range for anechoic chamber in UniMi
- Currently being developed by COSPAL



# LSPE 43 GHz feed-horn array (49 elements)

- Corrugated dual-profiled design (IASF-Bo)
- Optimal performance in CMB polarization measurements
- Manufactured using “platelet” technique (UniMi)
- Guarantees high performance with low manufacturing costs
- Can be scaled to massive production of feed arrays



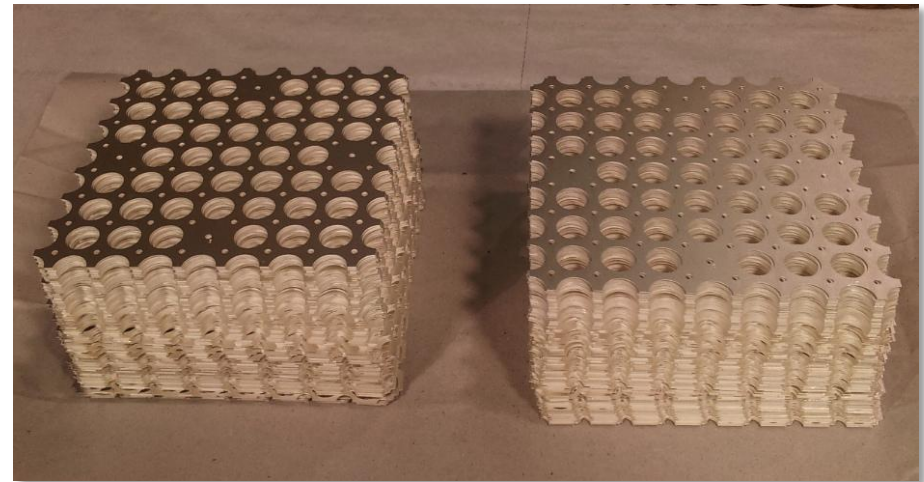
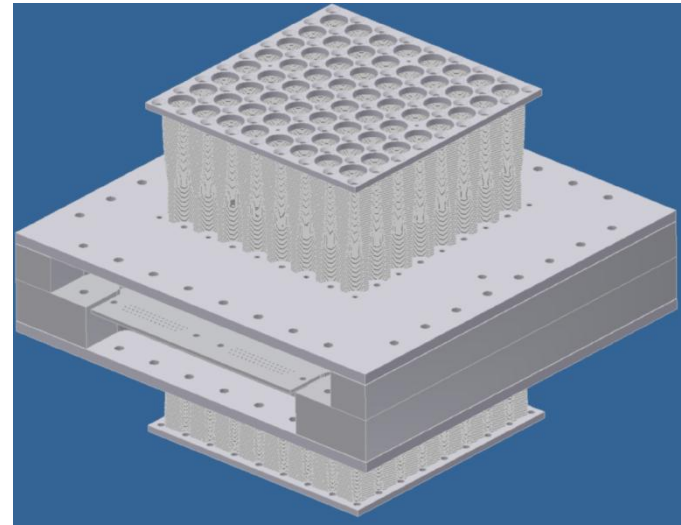
# SRT 40 GHz feed-horn array (19 elements)

- Dual-profiled design (R. Nesti, Arcetri-INAF) with integrated marker injectors (IEIIT – CNR)
- To be placed in the secondary Gregorian focus of the Sardinia Radio Telescope
- Realized using “platelet technique” (stacking of machined rings) - UniMi



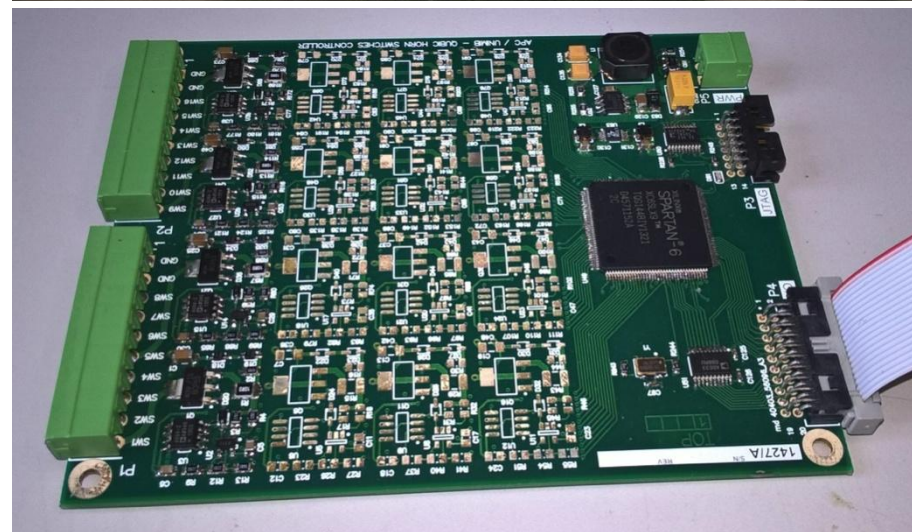
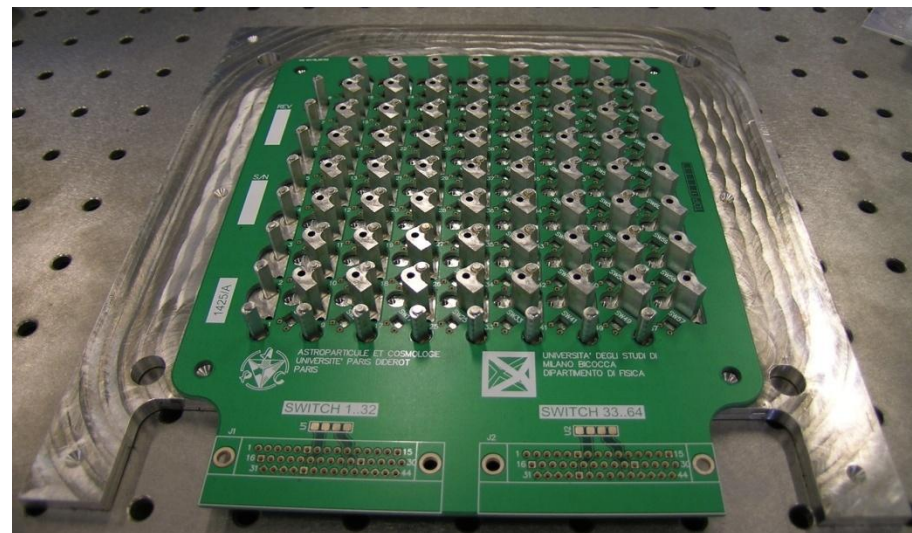
# QUBIC 150-220 GHz feed-horn array (400+400 elements)

- Dual-profiled design (B. Maffei, U. Manchester)
- Realized using chemically etched platelets (UniMi – Lasertech)
- Several small modules manufactured to test different materials
- Two modules of 64 horns each realized for QUBIC technical demonstrator



# QUBIC 150-220 GHz switch block

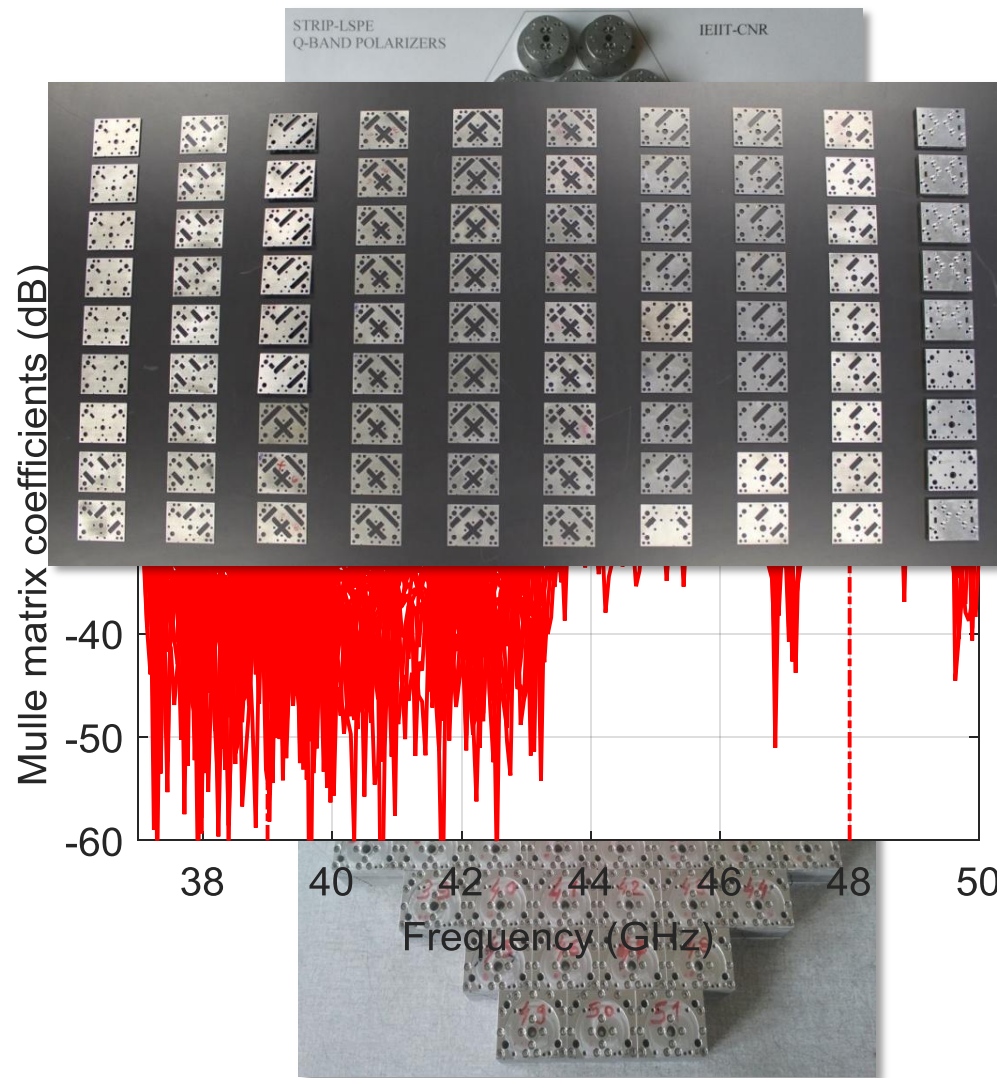
- Design by APC (Paris Diderot)
- Realized and tested in UNIMIB
- Operates and reads-out the positions of the QUBIC switches (64 for the prototype and 400 for the scientific module)





# LSPE polarizers and OMTs

- Circular polarizers and OMTs designed for the LSPE-STRIP instrument (IEIIT - Torino)
- OMT designed for platelet production
- Full 49-elements array produced and tested
- High purity in polarization discrimination (spurious polarization < -30 dB)



# LSPE polarizers and OMTs

- Same components designed also at 95 GHz (IEIIT – CNR)
- 7-elements array produced and tested: excellent polarization purity performance

Polarizer

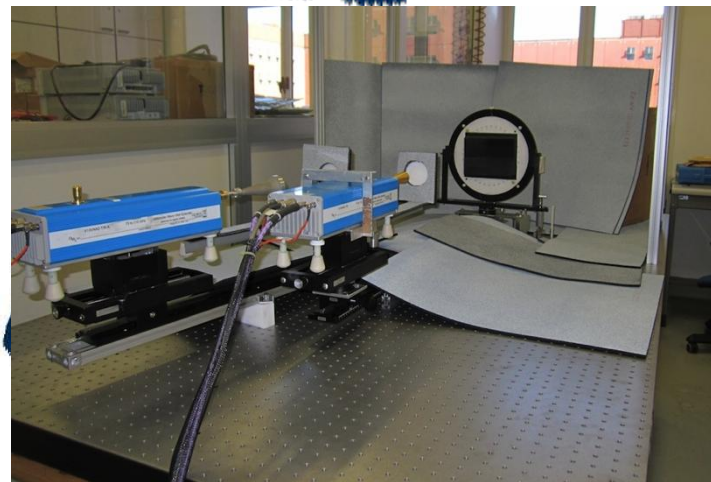
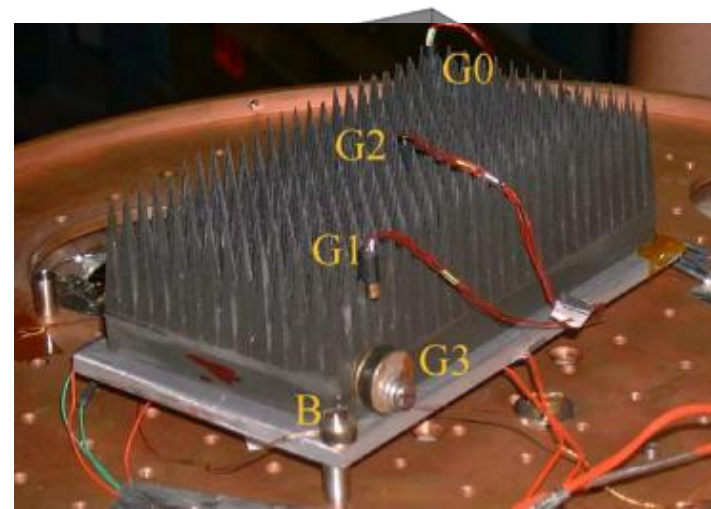


OMTs



# Calibrators development and testing

- Calibrators for in-flight operations and ground tests developed for Planck-LFI (IASF-Bo)
- High performance calibrators designed and developed for LSPE-STRIP (IASF-Bo)
- Each horn calibrated independently in polarization, with optimal emissivity and polarization purity
- Tests on materials at cryo-T, performance verification and product assurance (IASF-Bo)
- RF testing up to 170 GHz (UniMib)

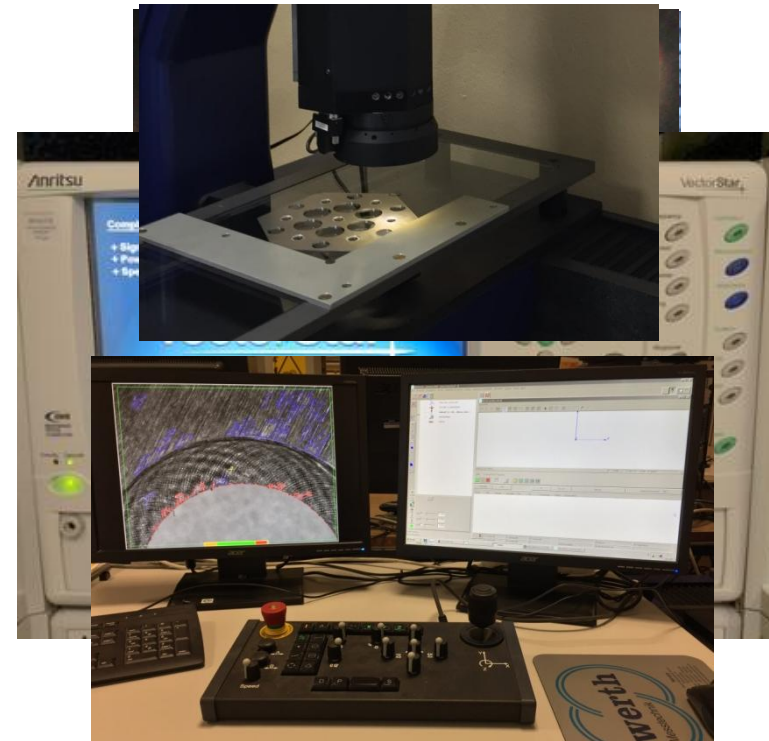




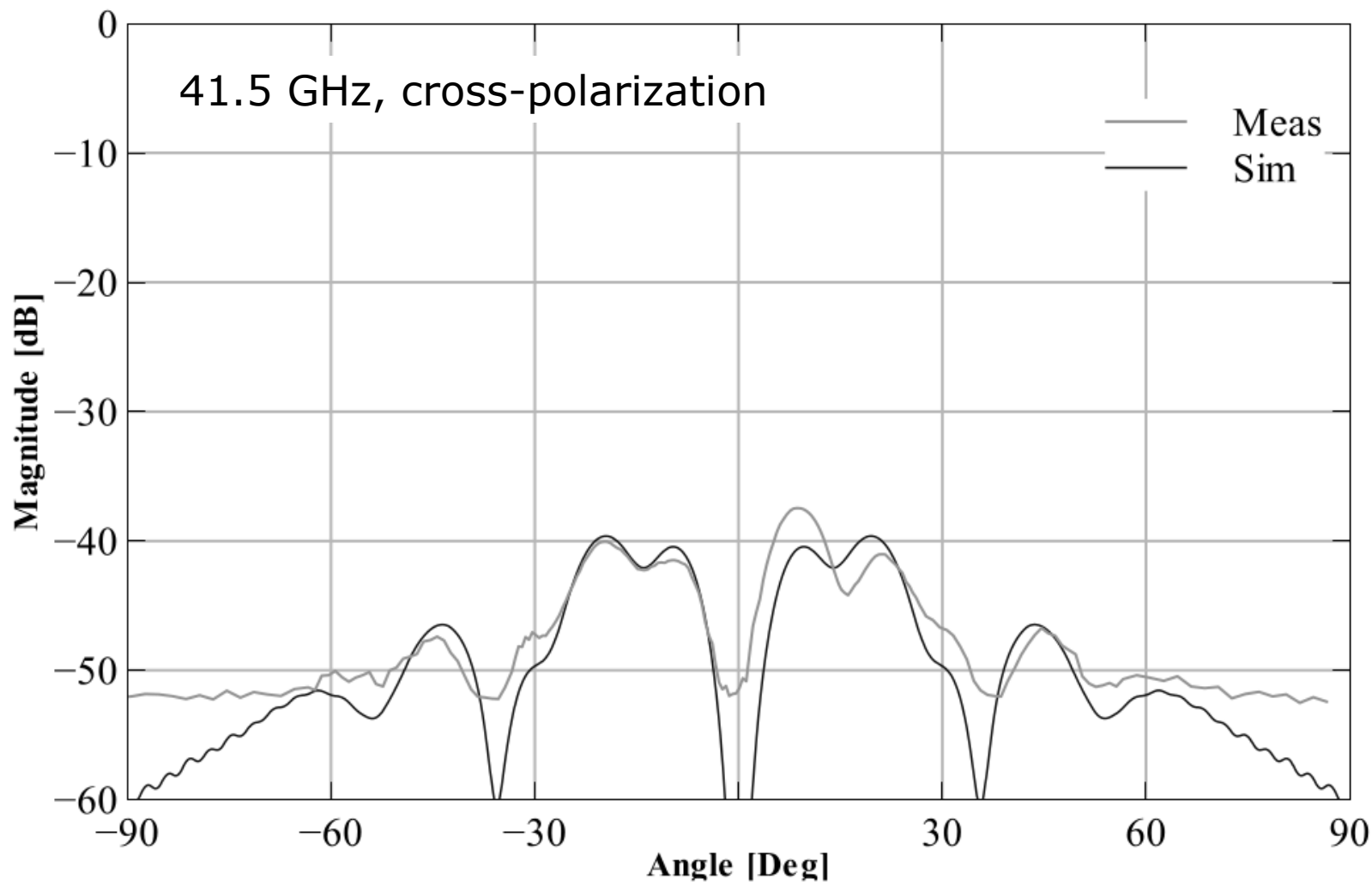
# Testing of passive components



- Small anechoic chamber for testing of microwave components (up to 30 kg)
- Large anechoic chamber for testing small payloads (up to 9 ton, compact range under development)
- Scalar and vector RF equipment up to 70 GHz (W band in progress)
- Precision metrological measurements (1.8  $\mu\text{m}$ )



# Measurements on Q-band SRT horns

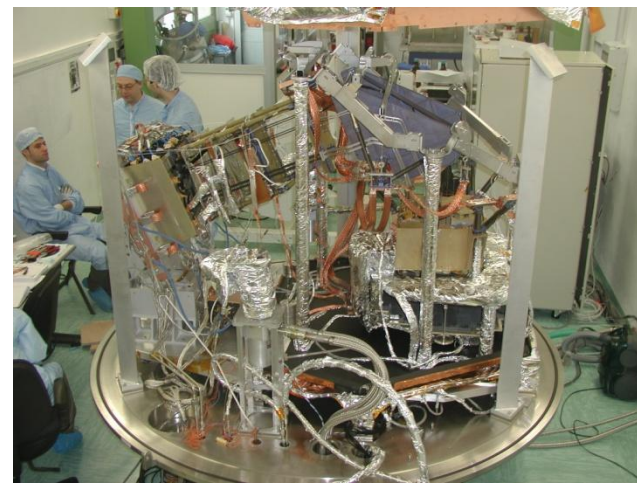


# Cryogenic laboratory at Univ. of Milano Bicocca

- Two oil-free vacuum facilities working in the range 4K – 300K
- Available volumes
  - 350x400x200mm<sup>3</sup>
  - 500x500x400mm<sup>3</sup>
- **Active** and **passive** components characterization (10 MHz - 170 GHz)



- Develop, integrate, characterize, calibrate complex instrumentation from microwave to (sub)mm-wavelength
- Two cryo-facilities and four coolers for testing components and small payloads down to 4 K
- RF testing equipment (scalar up to W band, vector up to V-band [in progress]) and bias unit
- Crane for loads up to 1 ton





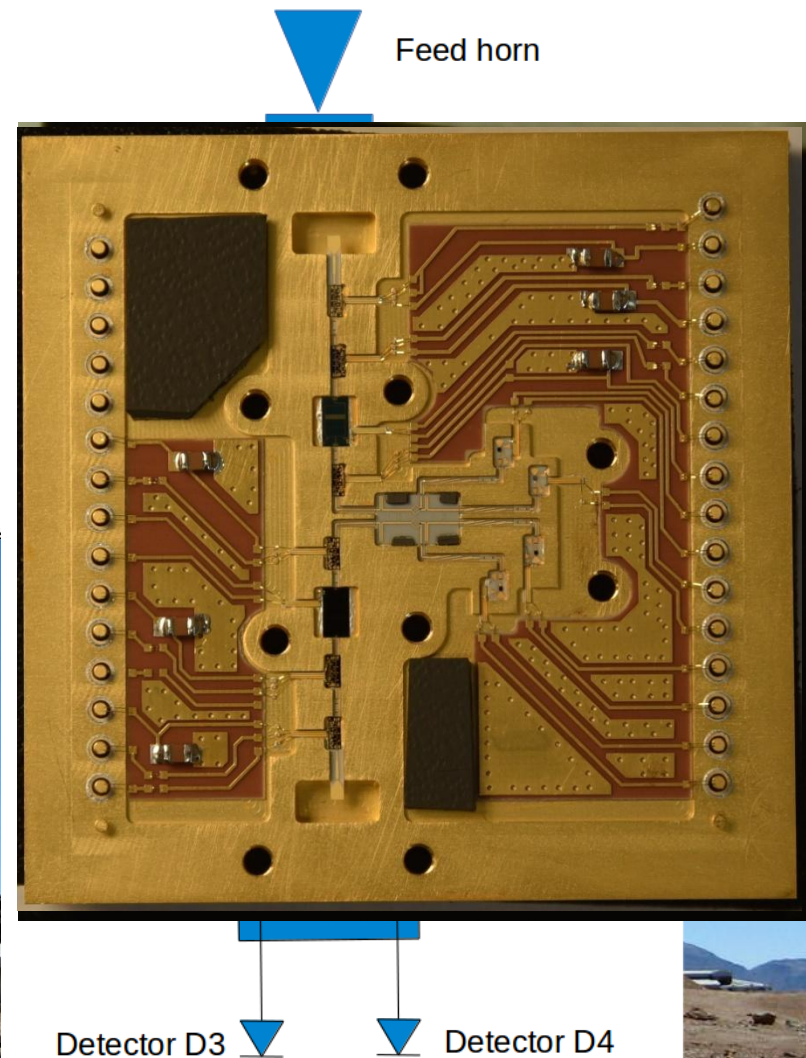


# Coherent detectors and electronics

# LSPE Q-band polarimeters

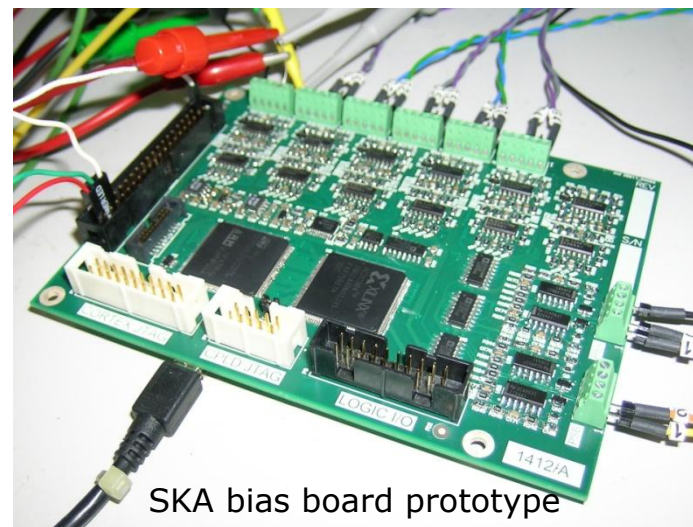
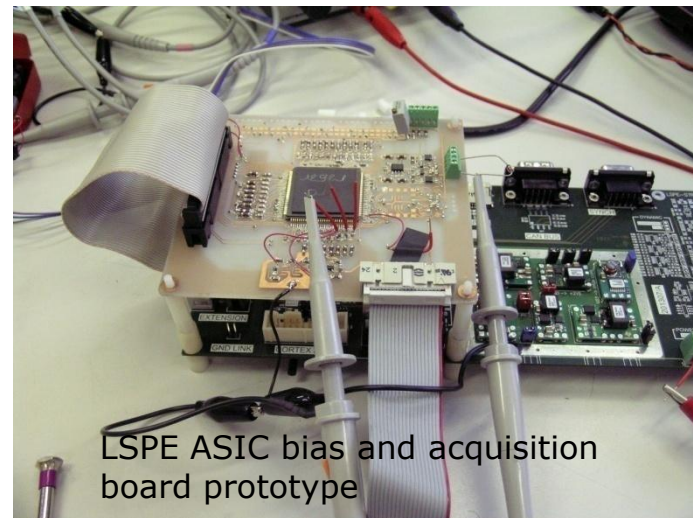
- Design and components by NASA-JPL
- Already deployed in QUIET experiment at Q and W-bands

5 cm

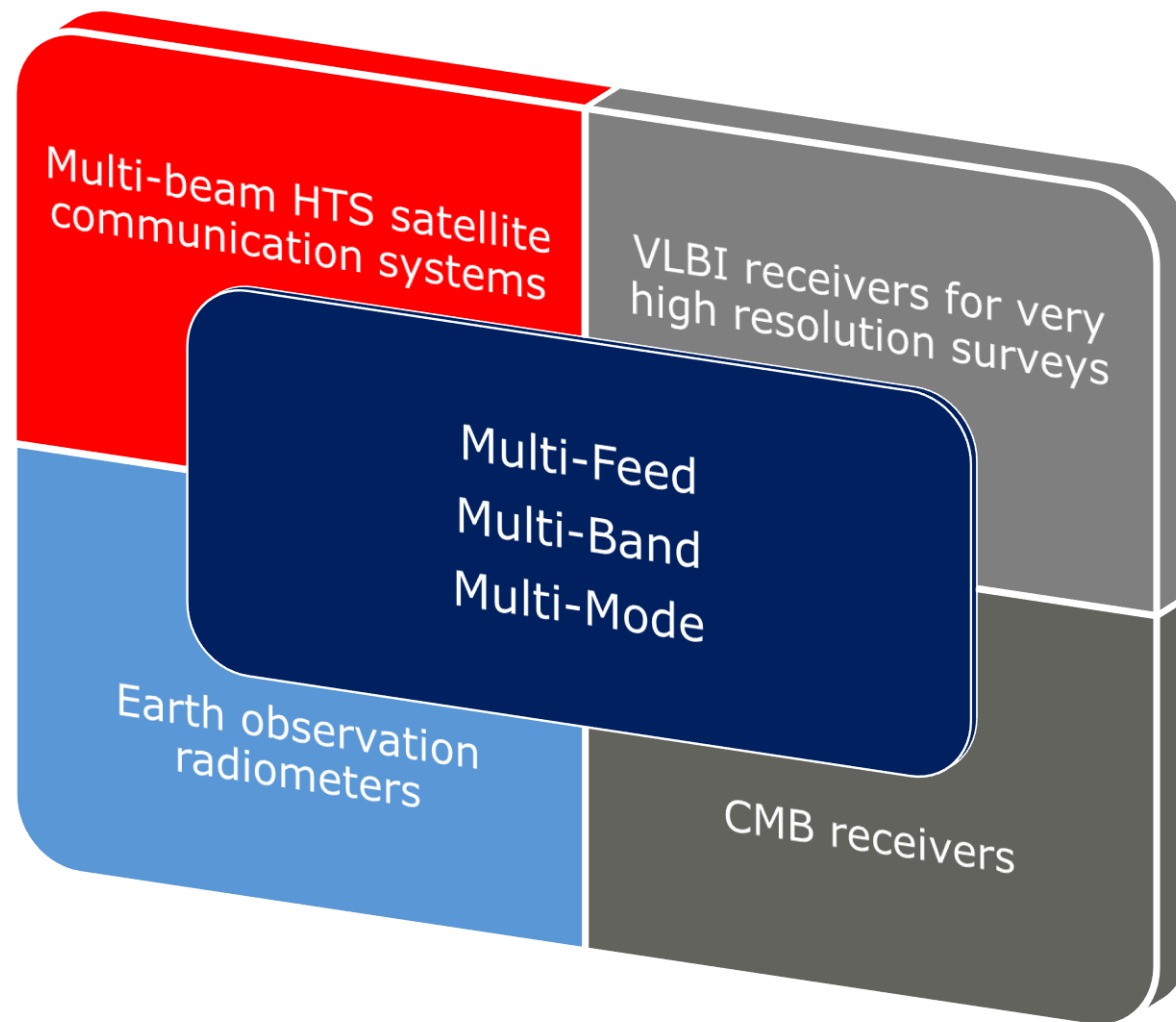


# Electronics development at UniMib

- LSPE-STRIP analogue and digital electronics (49 Q band Polarimeters: 294 LNAs, 196 ADCs, Data rate 4kHz)
- SKA SPF band 3-4-5 LNAs bias
- QUBIC switches driving and read-out electronics
- MKIDS readout electronics (ASI proposal and PRIN-2015)



# Future trends



# Thanks to...

The following people contributed to this talk with materials, comments and suggestions:

Gianluca Morgante (INAF-IASF, Bologna)

Oscar Peverini (CNR – IEIIT, Torino)

Fabrizio Villa (INAF-IASF, Bologna)

Mario Zannoni (UniMib, Milano)

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