

RADIOBLOCKS WP2

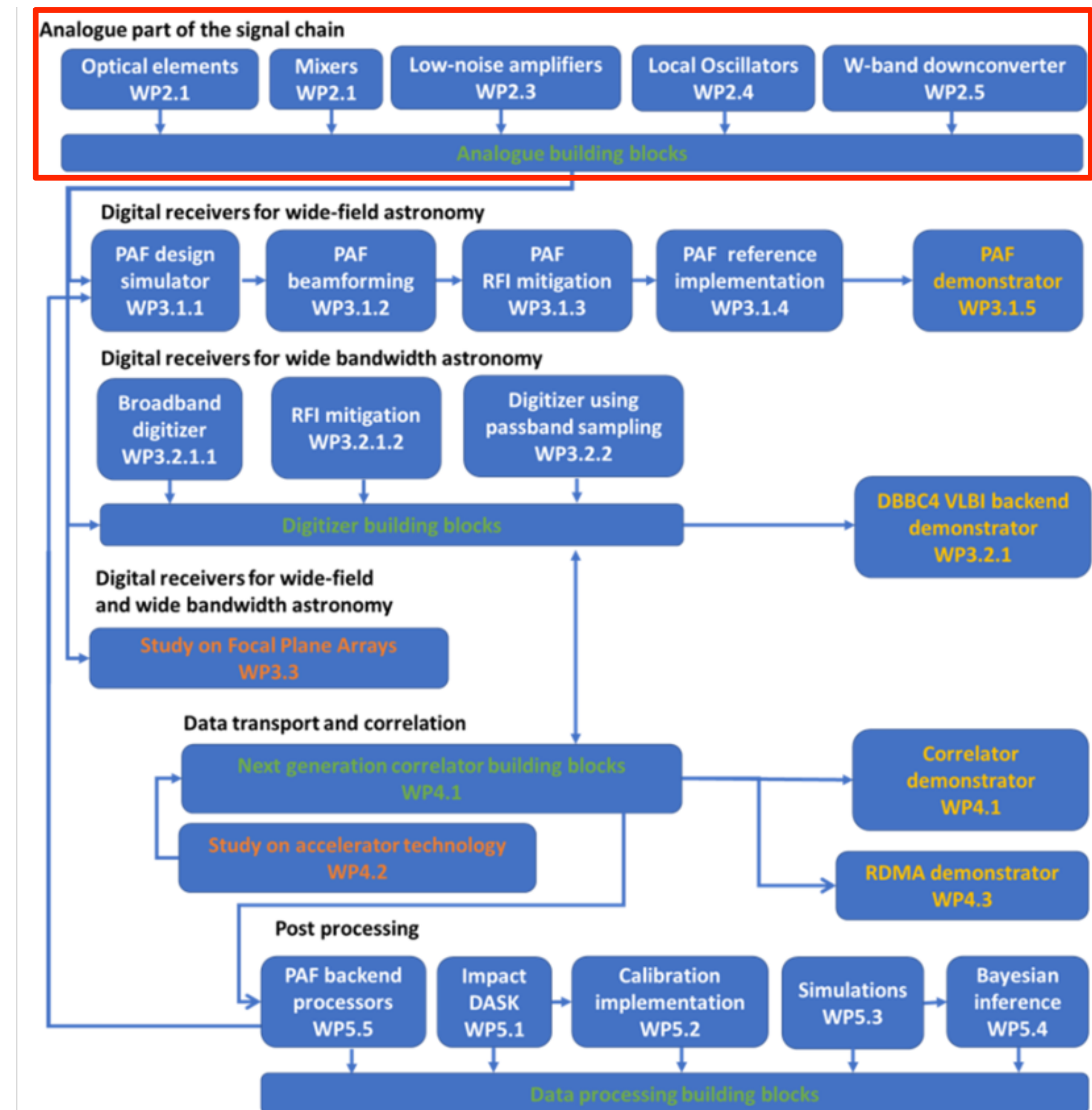
Status 2.5 years into the project

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WP2 Coordinator

WP2: Novel detectors and components

- Key Objectives: Components for future receivers of ALMA, NOEMA, IRAM-30m, and others. **Analog parts** of the signal chain: Optical elements, detectors, low noise amplifiers, enhancing their **performance** with support by **industrial partners**. Develop and test prototypes. Create **toolbox** for future receivers.
- 17 European Partner Institutes & companies: IRAM, Fraunhofer-IAF, MPG, GARD/Chalmers, UOXF/Oxford, RUG/Groningen, UKRI, TUD/Delft, UNIMAN/Manchester, CNIG, UCO/Köln, INAF, OBSPARIS, ESO, HES-SO, [Lytid](#), [TTI Norte](#)
- Budget: 1.8 MEuro
- Timeframe: 4 years (3/2023 - 3/2027)



WP2 Partners



WP2:
17 Partner Institutes
6 Main Tasks:

WP2.1: Optical Elements:
TUD, RUG, OBSPARIS, UNIMAN, INAF

WP2.2: SIS-Mixers:
GARD, RUG, UCO, UOXF

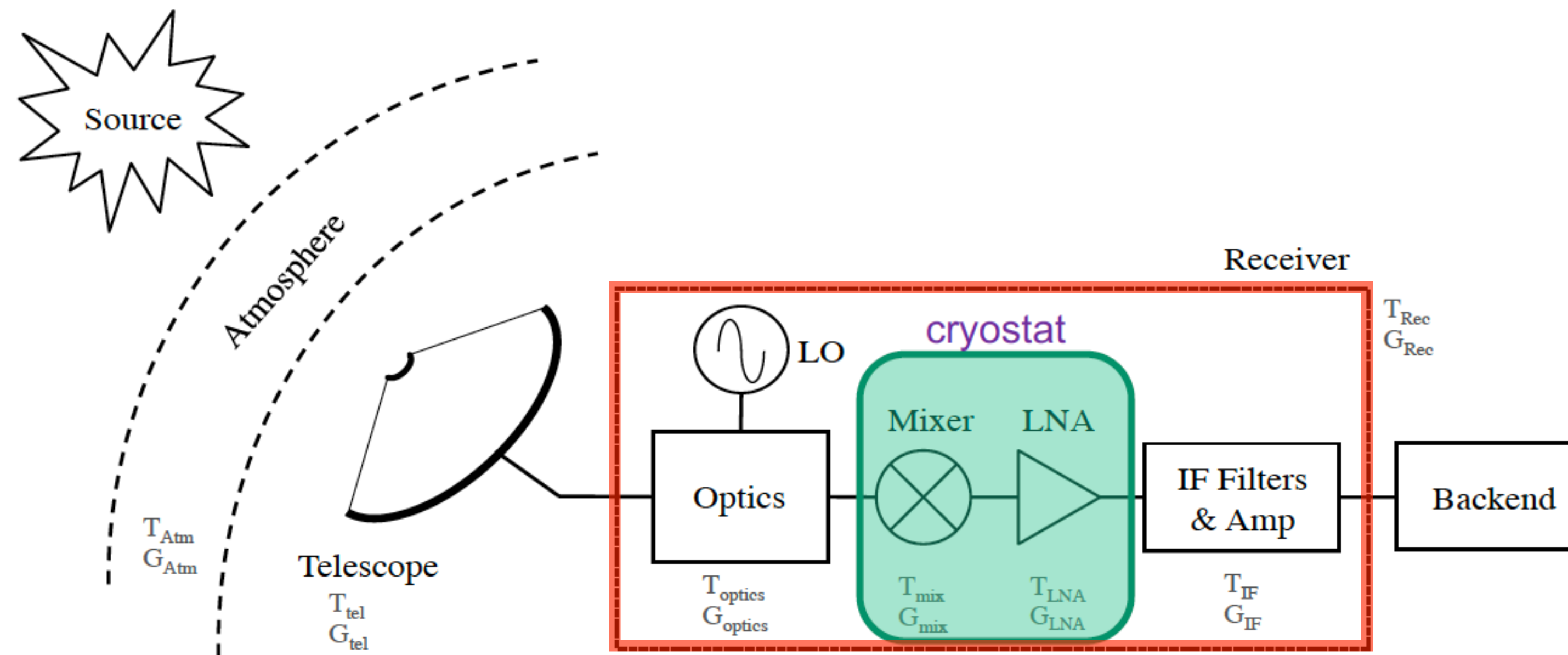
WP2.3: Low Noise Amplifiers (LNAs):
UNIMAN, CNIG, UKRI, MPG, IAF,
GARD, UOXF, TTI Norte

WP2.4: Local Oscillators (LOs):
OBSPARIS, UCO, Lytid

WP2.5: W-band module:
IAF, MPG, IRAM

WP2.6: Filters for LNAs:
HES-SO, CNIG, IRAM

WP2: Six main tasks along the signal chain:



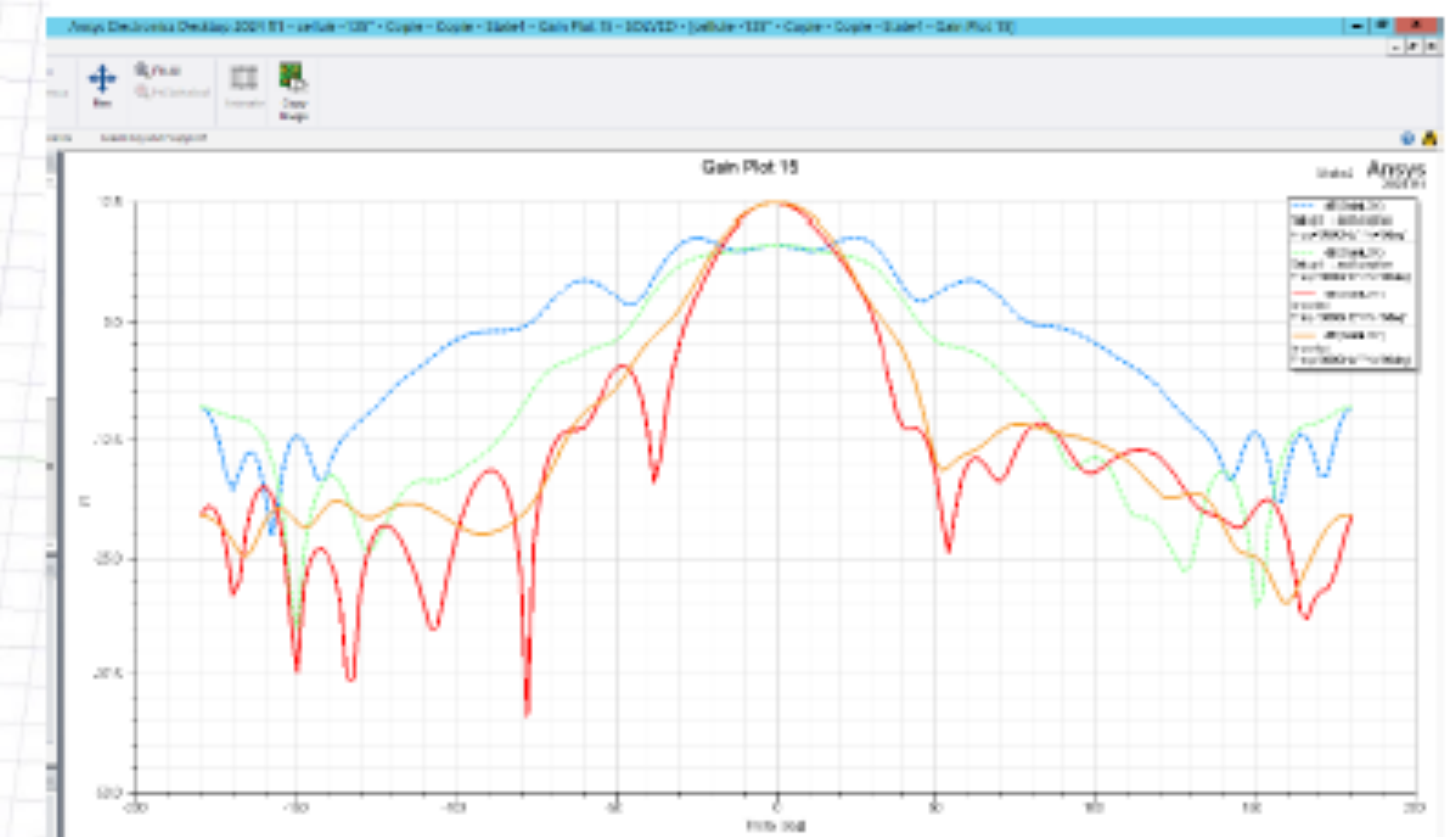
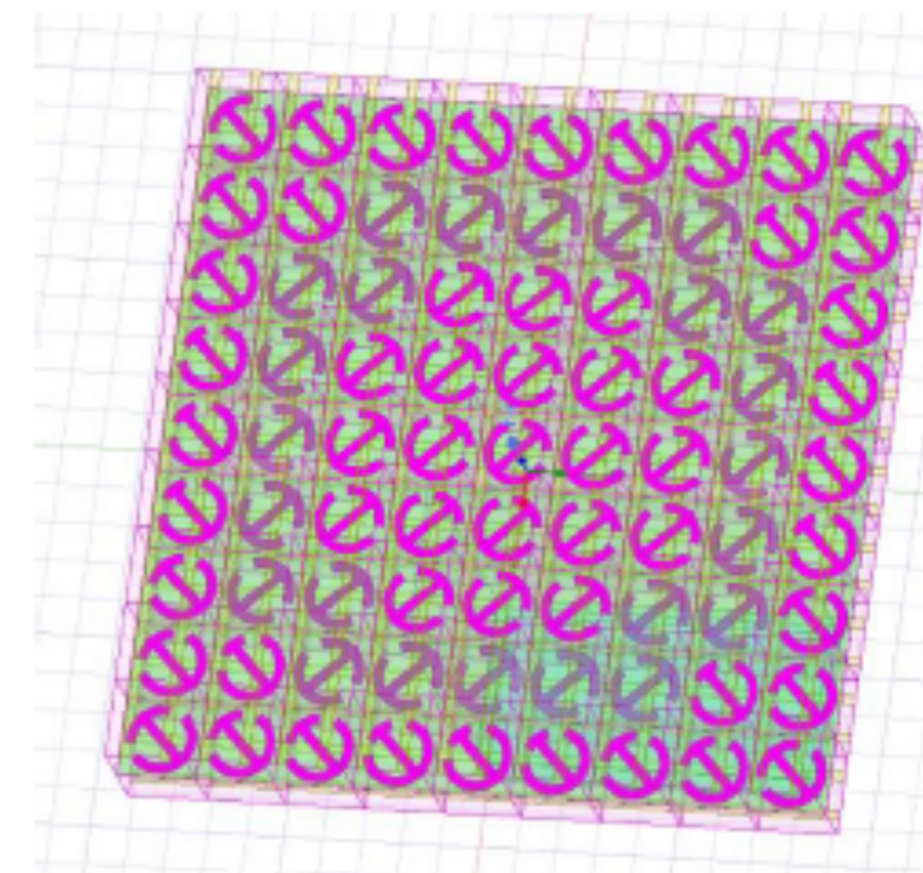
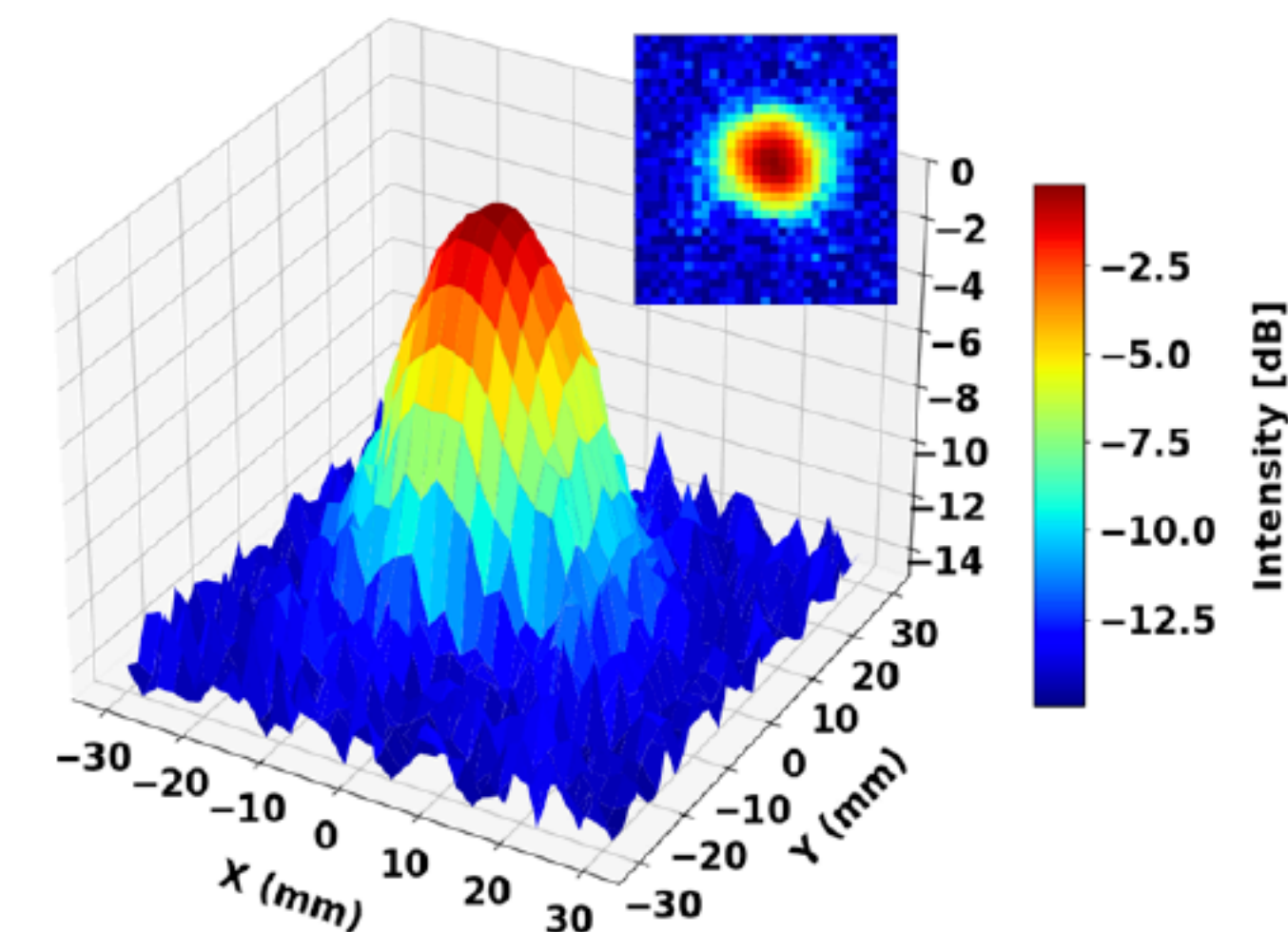
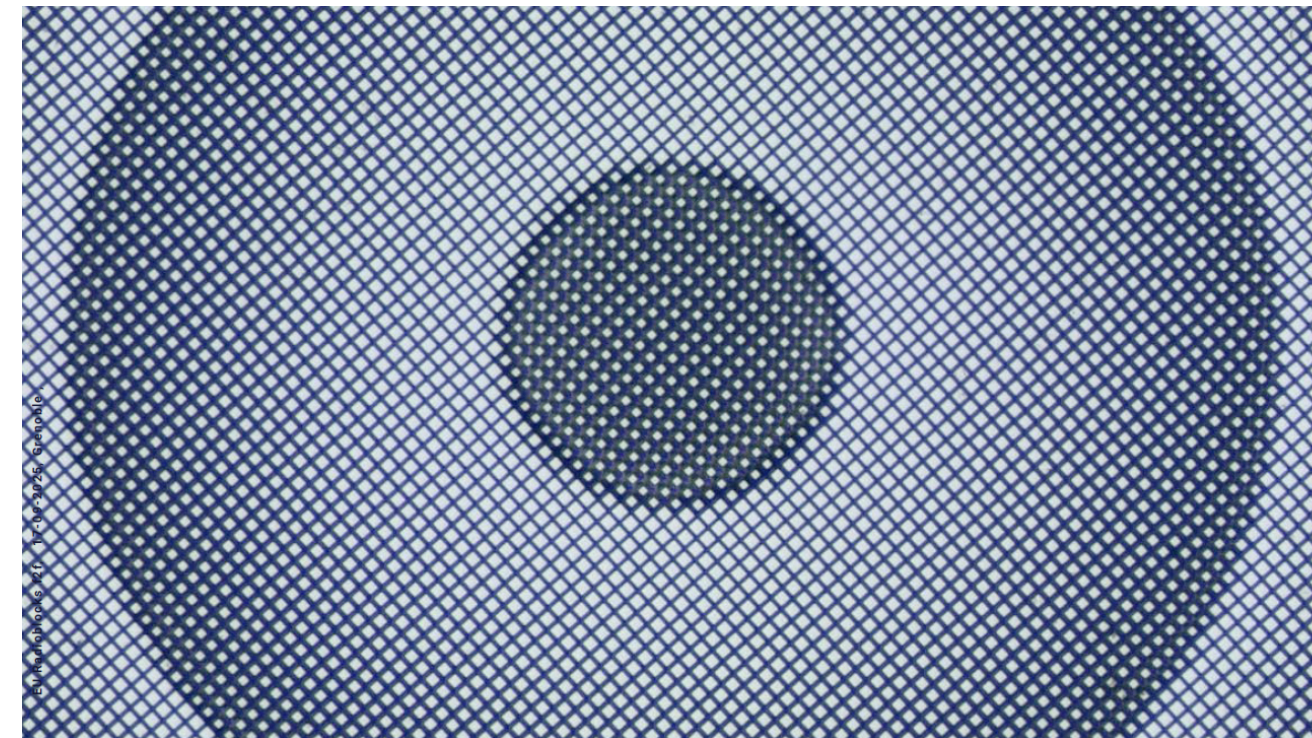
- + WP2 develops all key components along the receiver signal chain: Lenses, horns, SIS mixers, RF and IF amplifiers, W-Band downconverter, local oscillators, filters.
- + **Parameter space for improved performance: bandwidth, sensitivity, power consumption, compactness, inter-operability, resilience against RFI,**
- + Development timeline (similar for each component): Simulate, Design, Fabricate, Test, Analyze, Report and Publish
- + **Links to next-generation ALMA and NOEMA receivers, African Millimeter Telescope, Focal Plane Arrays, ...**

WP2: Status after face-to-face meeting at IRAM/Grenoble on 17-Sep-2025

Going from **simulations** and **designs** to **fabrication, assembly, integration,**
measurements, iteratively **testing** and **improving**
 while **reporting** and **discussing**

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- **(Task 2.1.1) RF windows, lenses, filters**
 - Development of nearly reflection less flat lenses over large bandwidths
 - Si metalens-coupled HEB mixer **tested** by TU Delft / SRON. Pillar height 110-150 μ m, pillar width 7-12 μ m. Power coupling efficiency $\sim$ 25%. **Measured** beam profiles Gaussian. Trec=1800K @ 1.63THz. **Improvements** under discussion. Results submitted to App.Phys.Lett..
- **Designing** and **Simulation** of flat metalenses at Obs.Paris.



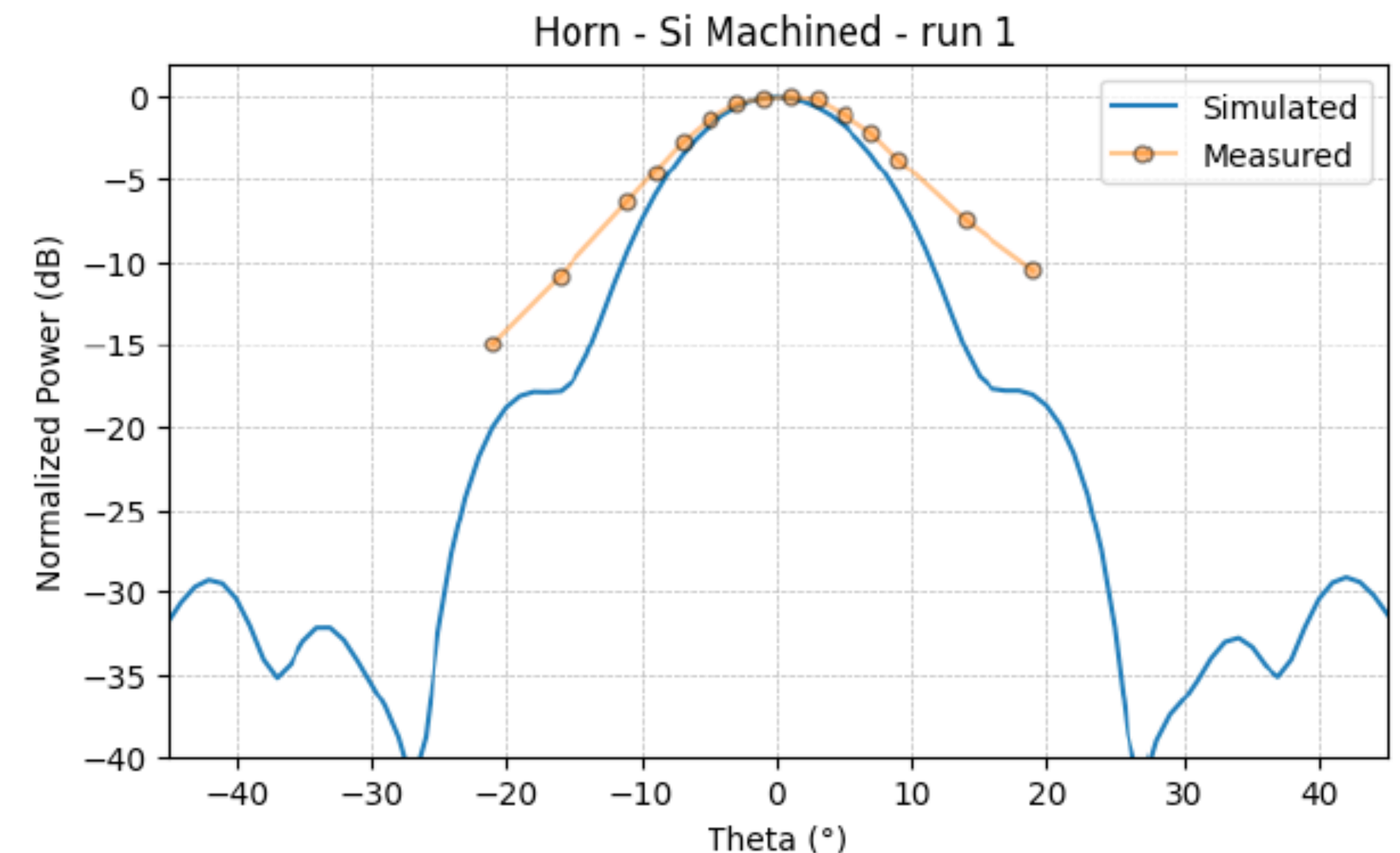
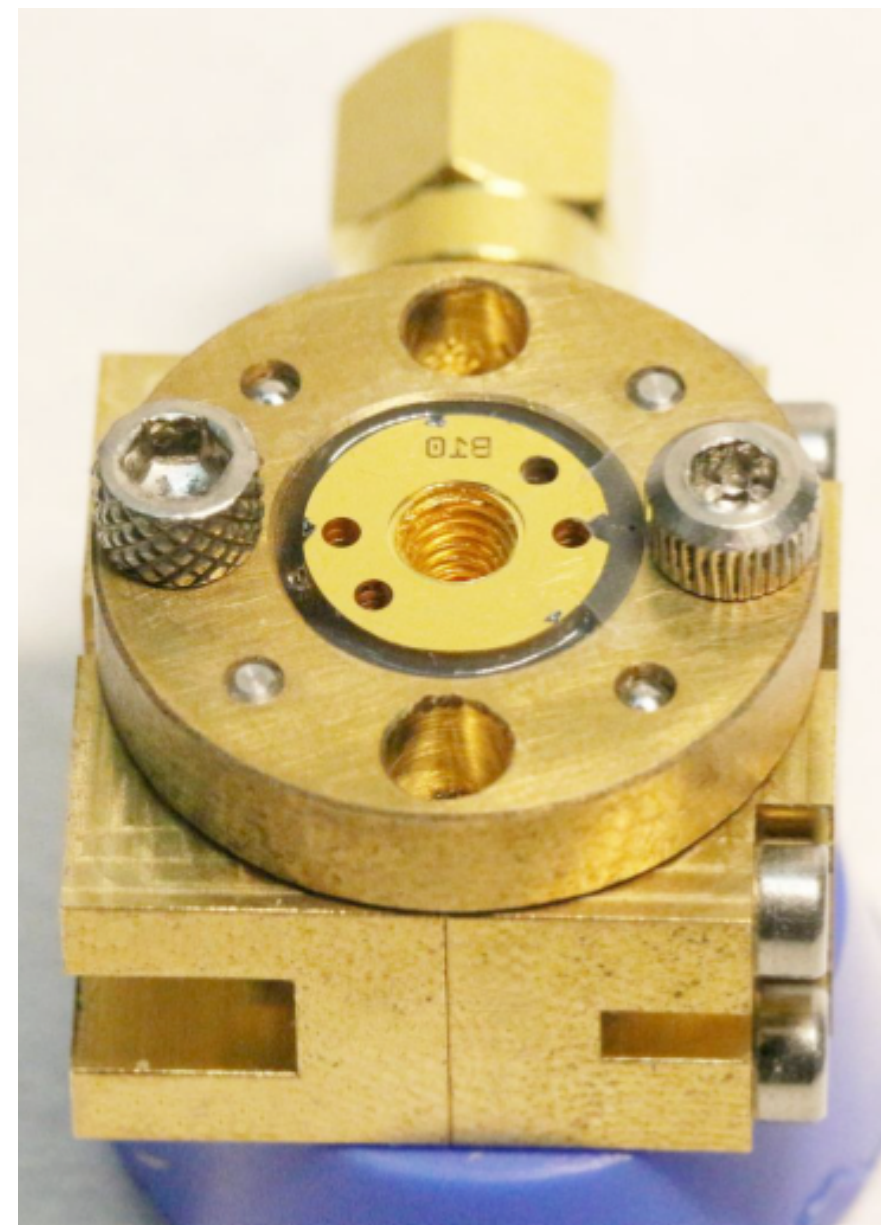
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• (Task 2.1.2) Orthomode-Transducers

- Planar technology from 100 GHz to 650 GHz, separate polarizations, optimum pointing
- **OMT designed to cover ALMA Band 6 (211-275GHz) by NOVA/RUG**, based on optimization of ALMA band 5 OMT. To be produced by GARD/Chalmers and tested at NOVA. Also possible contribution to **AMT**.
- Design study to combine two LNAs in a single block **for future multi-pixel receivers**, positioned immediately following the OMT. Study by UoManchester.

• (Task 2.1.3) Horns

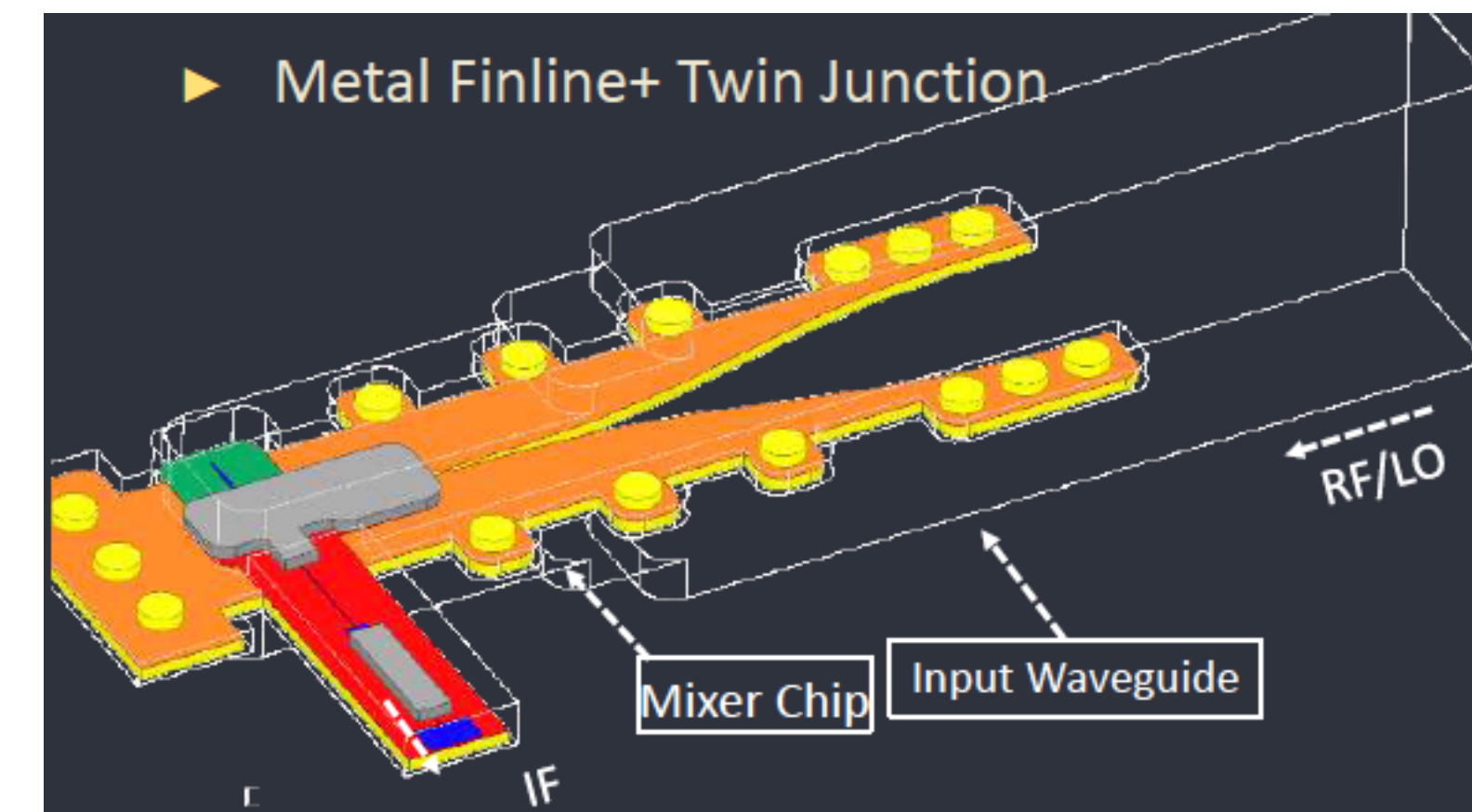
- High performance corrugated horns, silicon micromachining: new technology for easier manufacturing.
- Si-based corrugated horns designed by ObsParis. Si-micromachining: photolithography, deep reactive ion etching (DRIE). Compact structure for large arrays. Several fabrication runs were performed. **First prototype has been assembled. Simulations and measurements at 600GHz on the way.**



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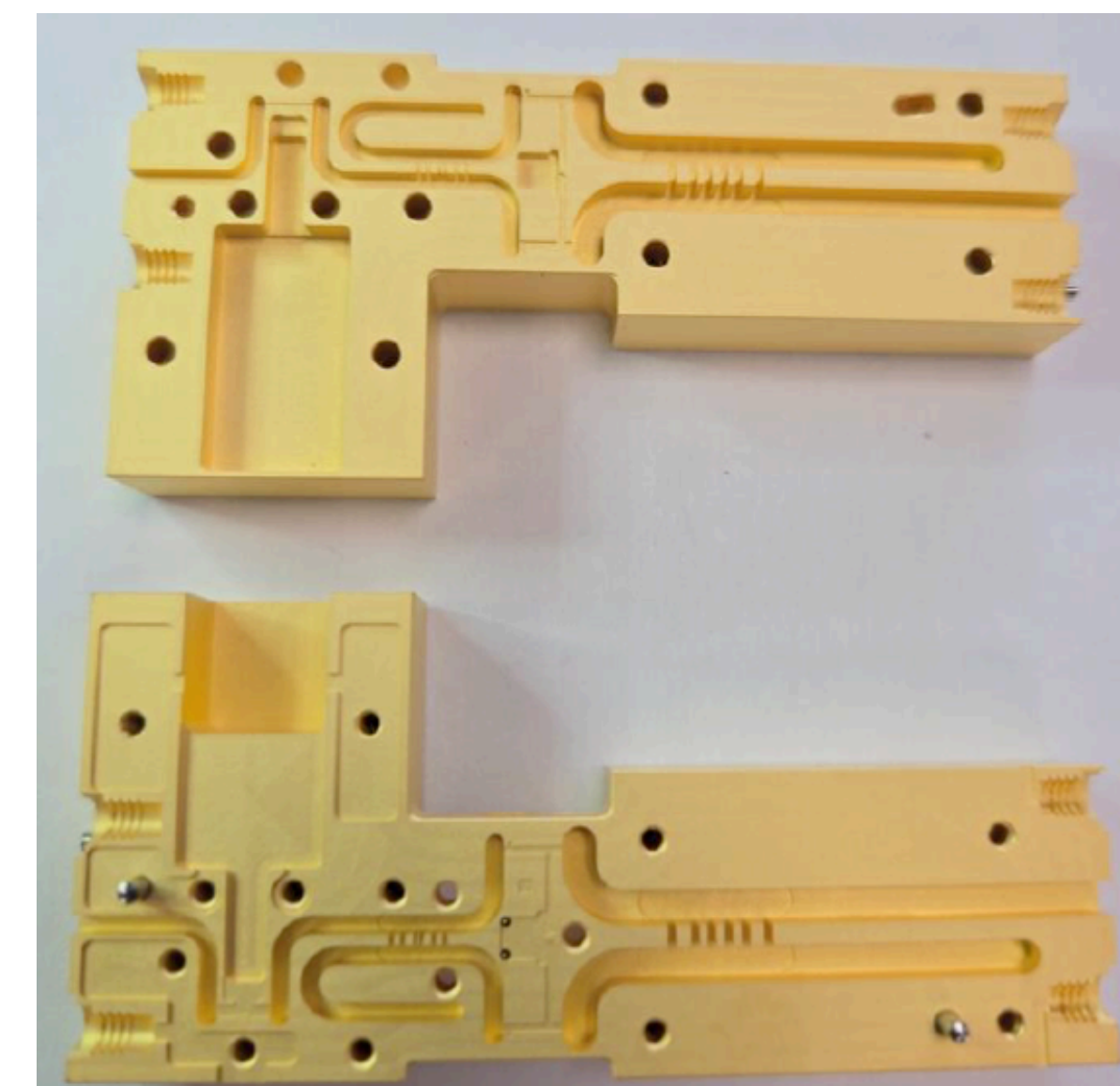
- **(Task 2.2) SIS mixers**

- Development of increased RF and IF bandwidths, flexible design, exploring new materials
- Collaborative effort involving GARD, RUG, UCO, UOXF
- GARD is investigating different designs 211-375 GHz
- Development partially for AMT, CHAI array @ CCAT-prime



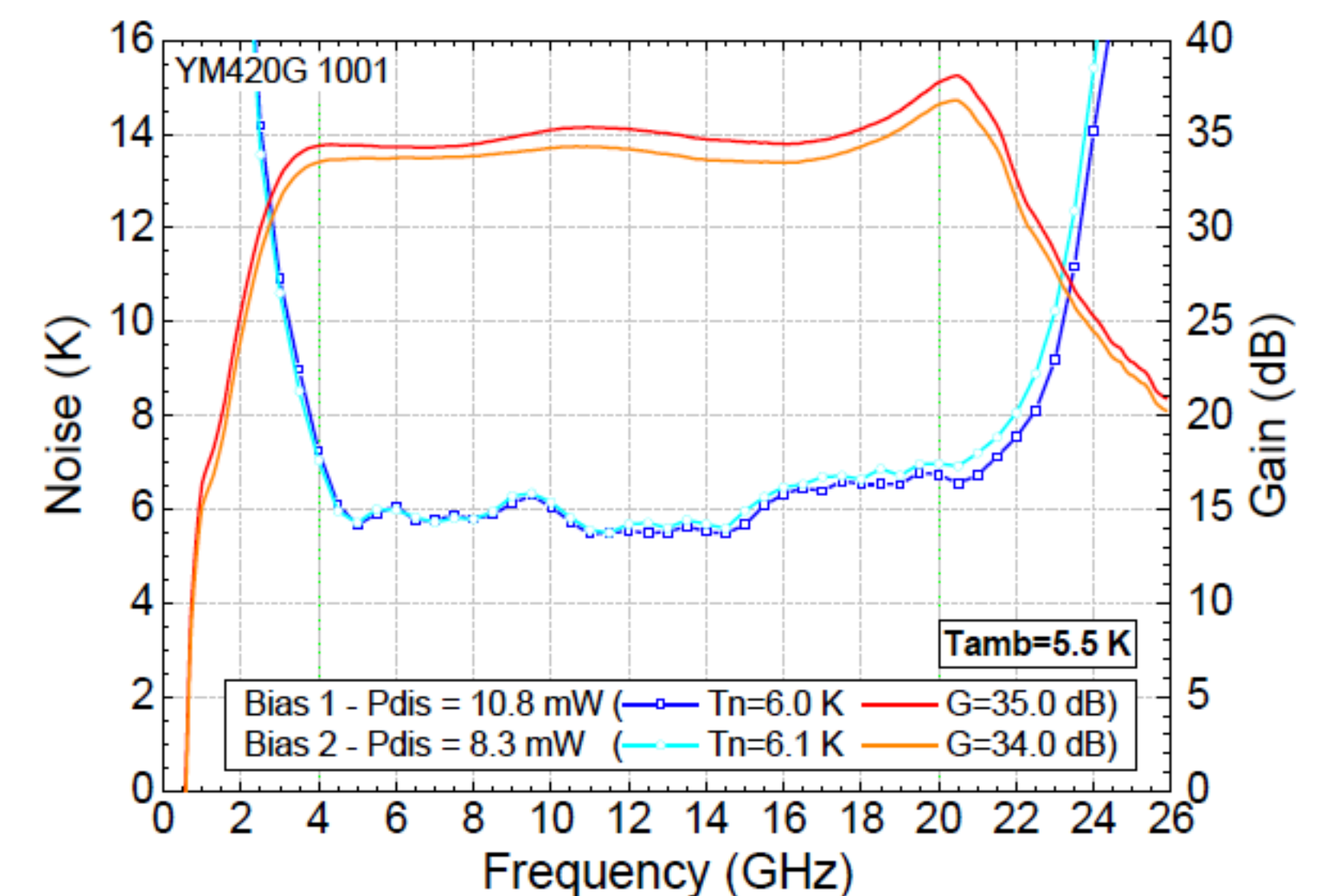
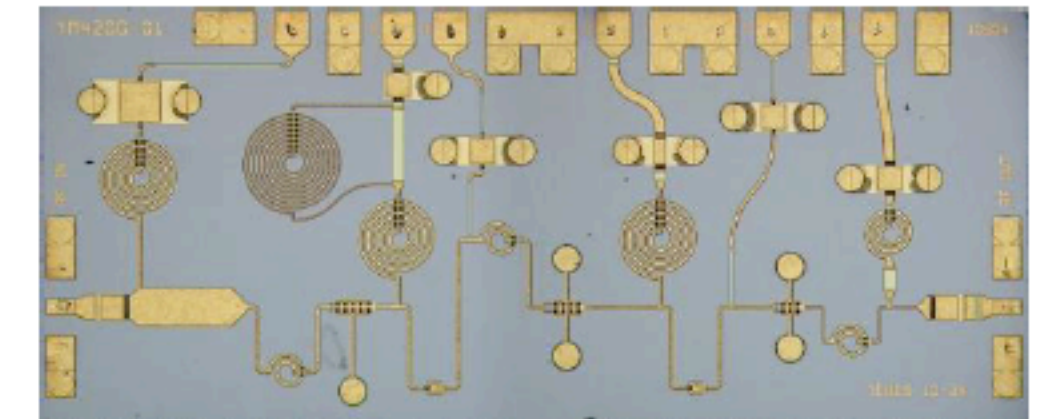
- **(Task 2.3.1) RF LNAs**

- RF LNAs up to 150 GHz. IF LNAs: expanding bandwidth, exploring new technologies
- Integrating LNA and Subharmonic Image Rejection Mixer (SHIRM) into **single block** by UniMan & STFC RAL. Manufactured. Assembly and measurements expected by end of 2025.



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- **(Task 2.3.2) IF LNAs** (CNIG (coordinator), MPG, IAF, UOXF, GARD, TTI Norte)
 - Now considering 3-30 GHz band at Yebes.
 - 4-20 GHz InP MMIC LNA designed by Yebes and fabricated at DIRAMICS.
Measurements are on the way.
 - LNA design transfer to **TTI CELESTIA**. One prototype to be selected for fabrication.
- Parallel work on large bandwidth (18-50 GHz) LNAs by IAF, MPG
- IF hybrid chips developed, fabricated, and cryogenically tested by Chalmers. Refinements planned.



4-20 GHz MMIC LNAs designed by Yebes and manufactured by DIRAMICS.

WP2: Status after face-to-face meeting at IRAM/Grenoble on 17-Sep-2025

- **(Task 2.4) Local Oscillators**
 - Increasing power and efficiency
 - Developing powerful LO at 346 GHz led by ObsParis (to support FPAs in the future):
amplifier (Lytid, 86GHz), 1st doubler to 173 GHz (RAL), 2nd doubler to 346 GHz (ObsParis).
Lytid found suitable amplifier chips with doubler, design model, optimizations underway
 - **Measurements planned for end of 2025**
- **(Task 2.5) W-Band downconverter module**
 - Block conversion of 67-116 GHz RF band with fixed LO. After investigation, an LO at ~124GHz is planned. Several mixer MMIC have been designed and fabricated at IAF.
 - **Optimization** of conversion loss, RF to LO isolation, required LO power, reduction of ripples. MPIfR designed waveguide to microstrip transition.
 - **Team organized workshop at the IMS2025.**
 - **Breadboard Down-Converter Evaluation:** Measurements, RF characterization, Reporting planned for 9/2026 and later
- **(Task 2.6) Tunable filters**
 - band reject filters to suppress RFI. Integration in the front-ends before the LNAs. Micro-actuators. Cf. WP3.
 - 2-3GHz single cavity filter designed by HES-SO. Produced by mechanical contractor TMH.
 - Planned: **measurements to compare with simulations.**
 - Collaboration with OAN/Yebes: Filter for C-Band 5GHz to suppress radar signal at Azores radiotelescope.
 - Collaboration with IRAM: **NOEMA water vapour sensors at 22GHz and possibly also suppress car radars at 76 GHz**

- Industry Partners of WP2
 - **TTI-Norte** (50kEuro) collaborating with Yebes on IF LNAs. Status: Yebes is in frequent contact with TTI-Norte. They shall produce a MMIC based on best design.
 - **Lytid** (50kEuro) collaborating with Observatoire de Paris on Local Oscillators. Status: Work on 77-90 GHz amplifier as 1st element in LO chain has started.
- Other partners from Industry:
 - **DIRAMICS** working with Yebes on design of MMICs.
 - HES-SO has contacts to Industry to build micro-mechanical parts of tunable filters.

Deliverables (brief description and month of delivery)

- D2.1:** Report on RF lenses summarizing the simulation, design, fabrication and possible test. (Task 2.1.1, month 48)
- D2.2:** Prototype test report (Task 2.1.2, month 48)
- D2.3:** Report on the simulation, design, fabrication and possible test of novel horns. (Task 2.1.3, month 48)
- D2.4:** Joined test report on coordinated prototype components: a 2SB mixer aiming 4-18...20 GHz IF and RF~200...400 GHz (GARD), on a small size single chip balanced SIS mixer around 460 GHz with integrated IF for FPA applications (UCO), Design and measurement report of SIS mixers and prototype of SIS mixer modules (UOXF), 650 GHz (2-20 GHz) 2SB mixer (RuG) interfaced with LNA. (Task 2.2, month 48)
- D2.5:** Design report on ultra wideband integrated LNA sideband separating mixers. (Task 2.3.1, month 48)
- D2.6:** Joined report on development and tests of prototypes: an mHEMT IF LNA (Fraunhofer-MPG), an ultra-wideband InP IF LNA (CNIG), SPAs and prototype of amplifier modules (UOXF), wideband cryogenic LNAs (TTI). (Task 2.3.2, month 48)
- D2.7:** Final report on local oscillator fabrication, tests and their analysis. (Task 2.4, month 48)
- D2.8:** Test report on a downconverter module with full instantaneous RF bandwidth. (Task 2.5, month 48)
- D2.9:** final report on configurable filter. (Task 2.6, month 48)

- + We need to prepare one report per task.
- + Due-date for all 9 reports is month 48, i.e. towards the **end of 2026**.
- + Some reports are **design reports**, some are already aimed at **prototype test** reports.

Comments

- + During the 2nd reporting period, the focus has shifted from simulations and designs to **fabrication** and **testing** for several of the tasks.
- + Rich Dissemination:
 - + Participation at Conferences, e.g.
 - + International Symposium on Space Terahertz Technology (ISSTT),
 - + International Microwave Symposium (IMS),
 - Organization of workshop at IMS2025 by F.Thome
 - + 10 Publications for Periodic Report #2
- + Selection of next meetings
 - + WP2 January 2026 via zoom
 - + SPIE July 2026: mm/submm/FIR detectors in Copenhagen chaired by Zmuidzinas & Gao
 - + WP2 September 2026 face-to-face
- + Risks:
 - + no time ? The plan is to report on the work done, what was achieved, and on possible future steps.
 - + overspending ? —
 - + underspending ? All have been reminded to not underspend.

Beyond 3/2027, beyond WP2 and RADIOBLOCKS my impression

+ how do you see your results to be implemented after the project?

+ The teams and institutes plan to continue developing and improving the prototypes. For some tasks there are plans to go beyond.

+ how do you see the radioblocks collaboration after the end of the project?

+ The team will continue to meet at the regular conferences, but the **extra layer of communication fostering collaboration** will be missing without such coordinated EC project.

+ would it be good to continue similar developments in a similar project?

+ Con: Meetings and reports coming with such EC project distract from main work ?

+ Con: Financial support may be short ? Partners with 50kEuro over 4 years have difficulties to focus and contribute ?

+ Pro: Collaborative effort allows for **networking, sharing experience, worries, solutions** within WP2, but also between WPs. Conferences do not fully replace such EC project.

+ In the future, instead of creating a toolbox of “blocks”, we could aim (again) at more integrated development of complete receivers. This would allow for more focussed, tighter coordination, albeit higher pressure to reach goals.