WHAT IS A BRAND RECEIVER

"Digital" VLBI-receiver for the EVN (and other) telescopes

- Frequency range: 1.5 - 15.5 GHz
- Direct sampling – no down-conversion
- Sampling by a single sampler chip
- Data transport from receiver to backend via optical fibers
  - Bypass IF limitations of legacy antennas

- Allow multi-wavelength VLBI for astronomy
  - Fringe-fitting over whole band necessary (RadioNet JRA RINGS)
- Extend VGOS band

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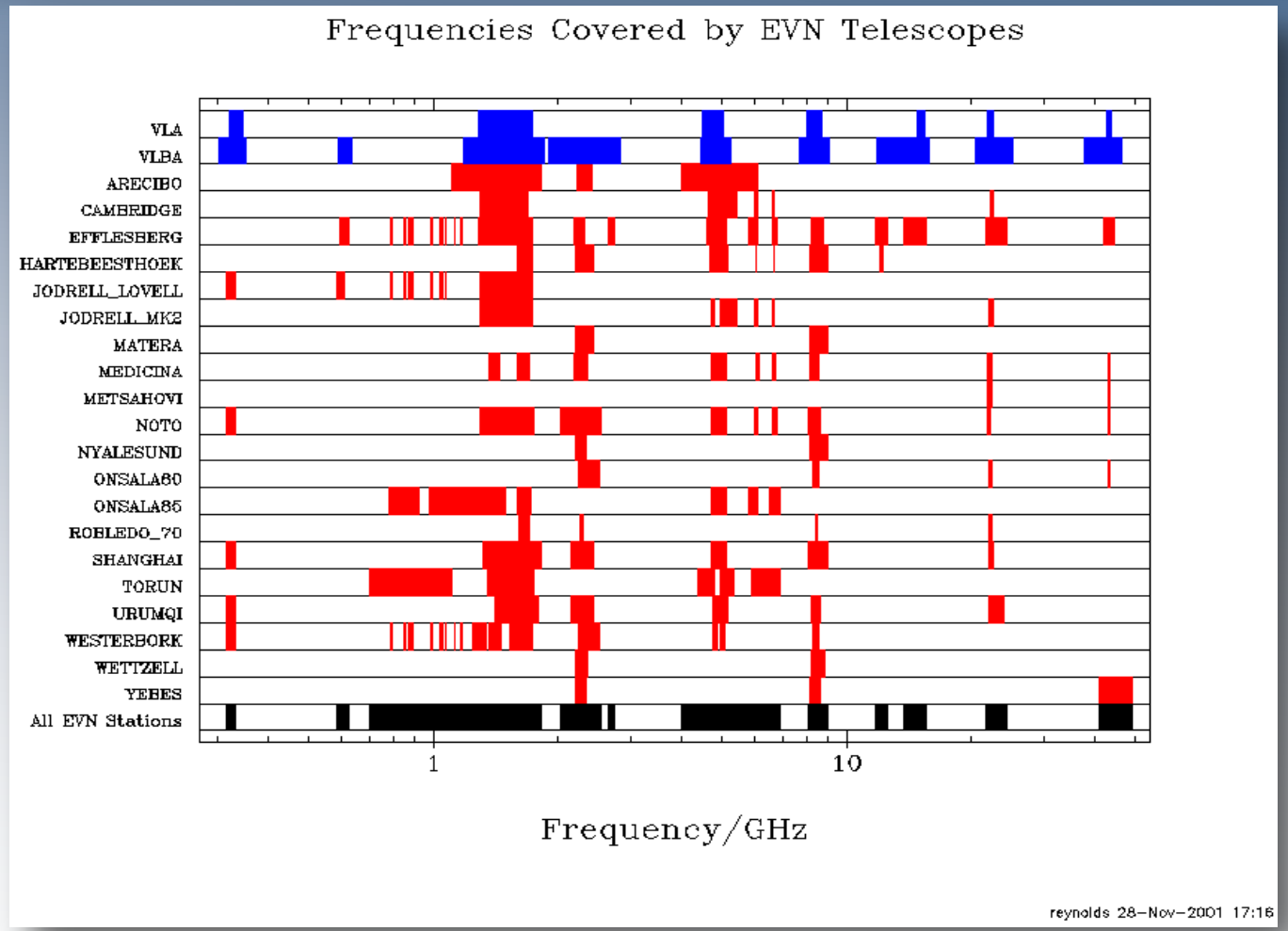
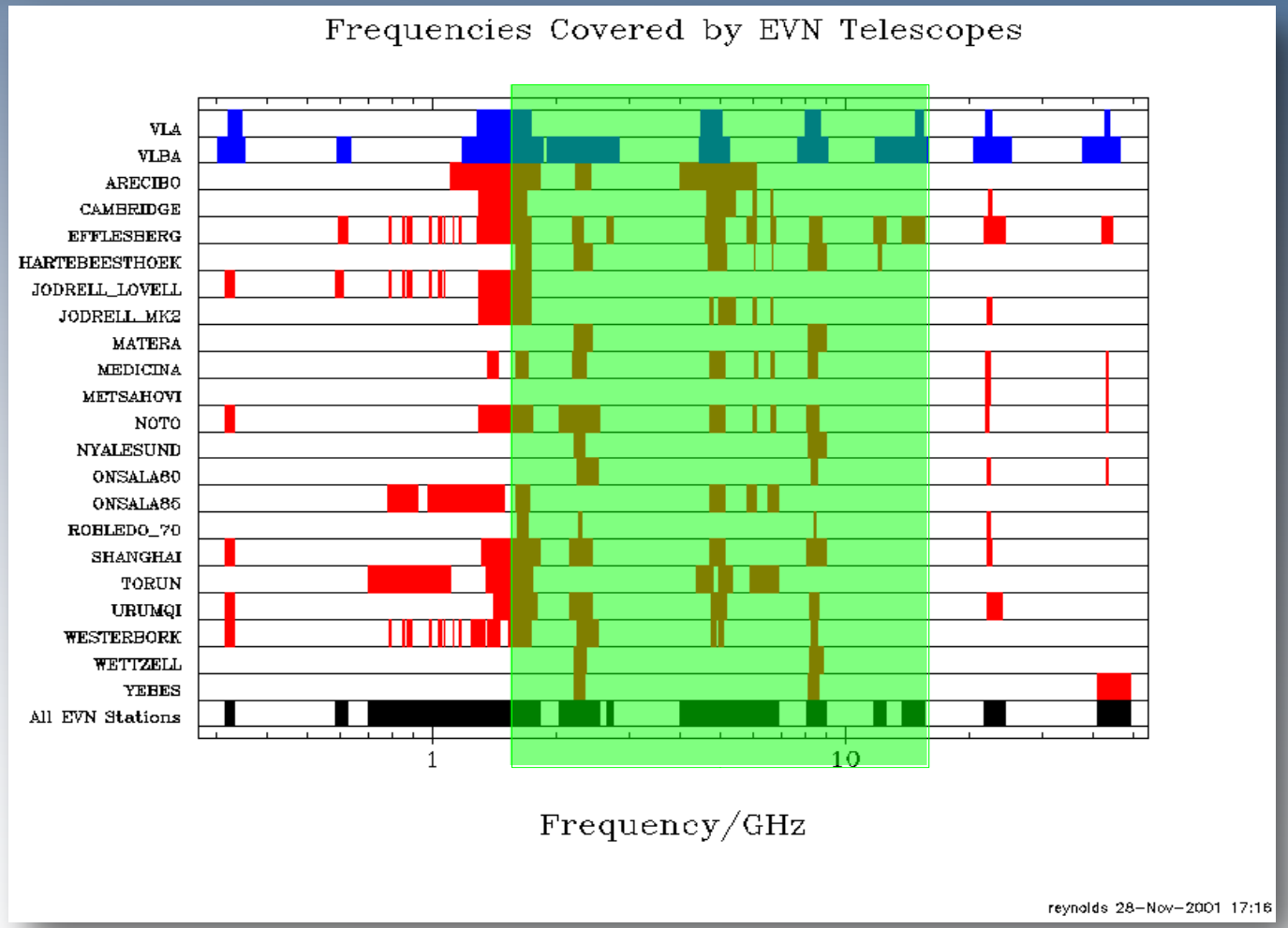
THE BRAND TEAM

W. Alef	MPIfR Bonn, Germany	Project Manager, VLBI test observations
G. Tuccari	INAF Noto & MPIfR Bonn	Project Engineer, BRAND architecture, HTSC filters, backend design, firmware, secondary focus study
J. Flygare, L. Pettersson	OSO, Sweden	Feed Horn, measurements of filter plus LNA
J.A. López-Pérez, F. Tercero, I. Malo, I. López-Fernández, C. Diez	IGN/UAH, Spain	LNAs, RFI, measurements of filter plus LNA, analogue polarisation conversion
C. Kasemann, M. Nalbach	MPIfR Bonn, Germany	Dewar, frontend integration, integration in Effelsberg tel.
M. Wunderlich, S. Dornbusch, A. Felke, H. Rottmann	MPIfR Bonn, Germany	Sampler & processing board layout, firmware, software, recording, correlation
J. Hargreaves, G. Schonderbeek, R. de Wilde	ASTRON, Netherlands	Digital polarisation conversion, software

EVN FREQUENCIES



EVN FREQUENCIES VS. BRAND



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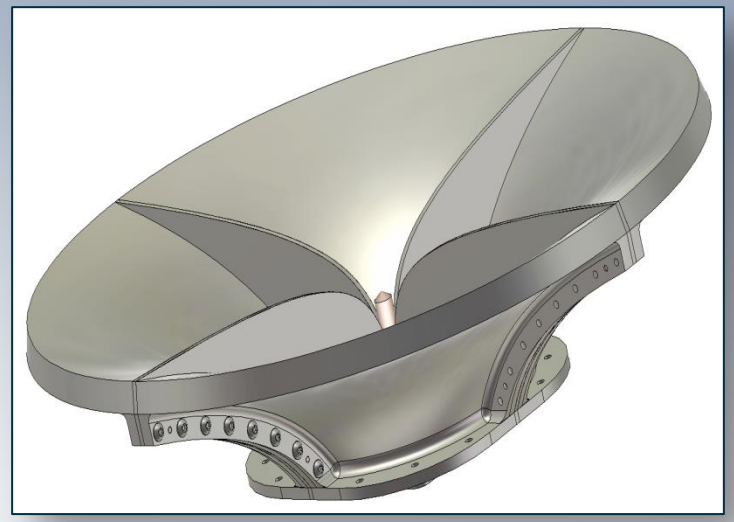
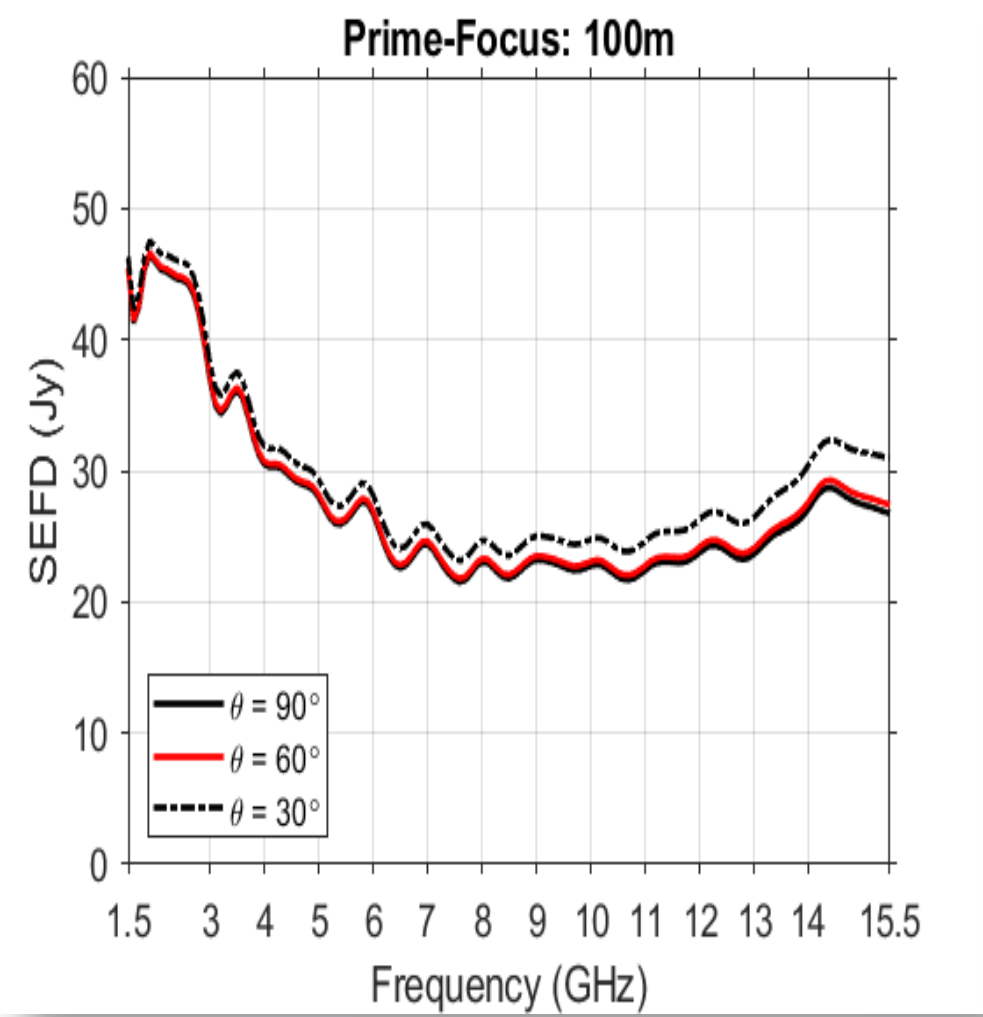
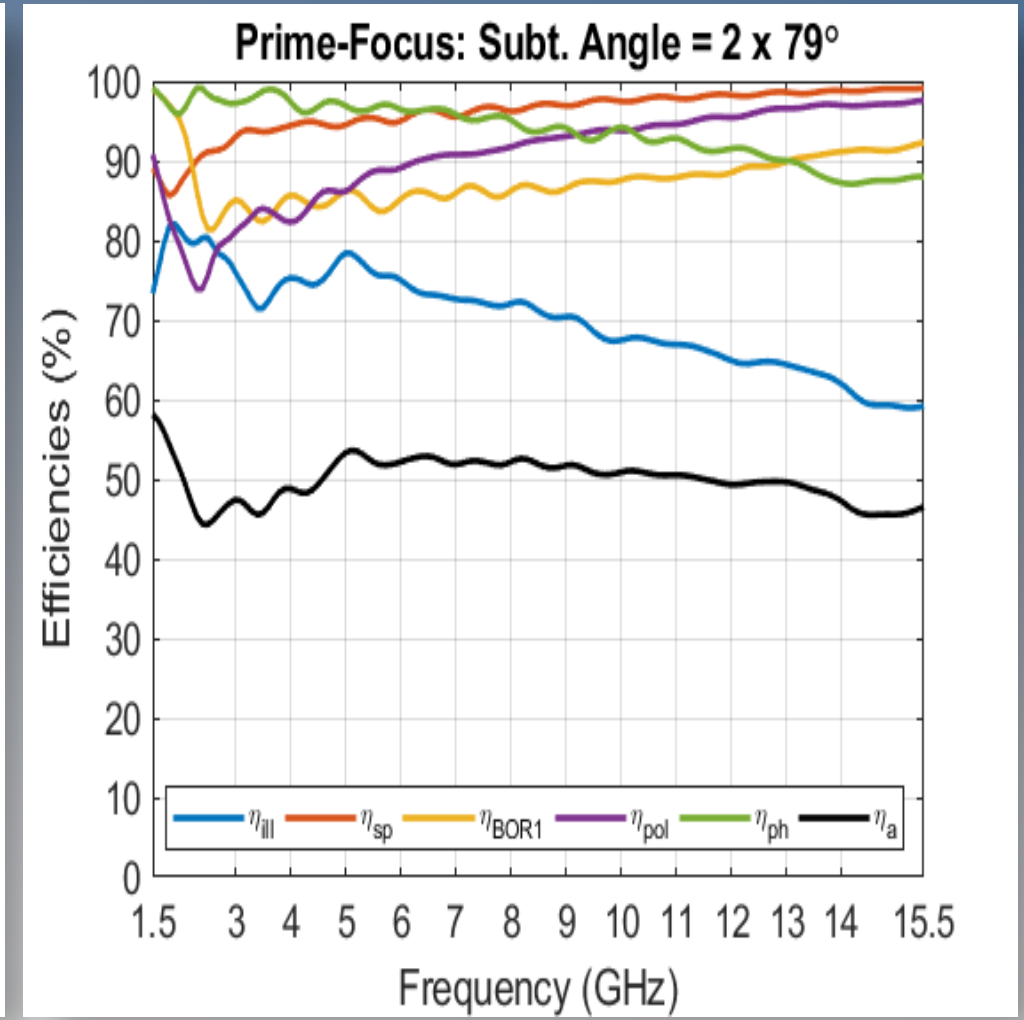
FEED HORN

- Feed horn designed by J. Flygare, M. Pantaleev, OSO
- Solution found for Effelsberg: QRFH feed with dielectric inset
- Antenna parameters:
  - Opening angle 160°
  - f/D = 0.3
- Feed characteristics (over whole band):
  - average aperture efficiency of 50%
  - input reflection better than -10 dB



FEED HORN: SEFD & EFFICIENCY





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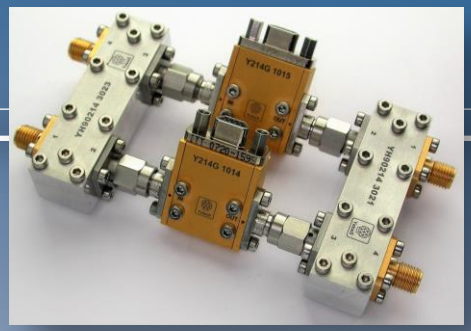
MANUFACTURED FEED HORN

HTS FILTERS

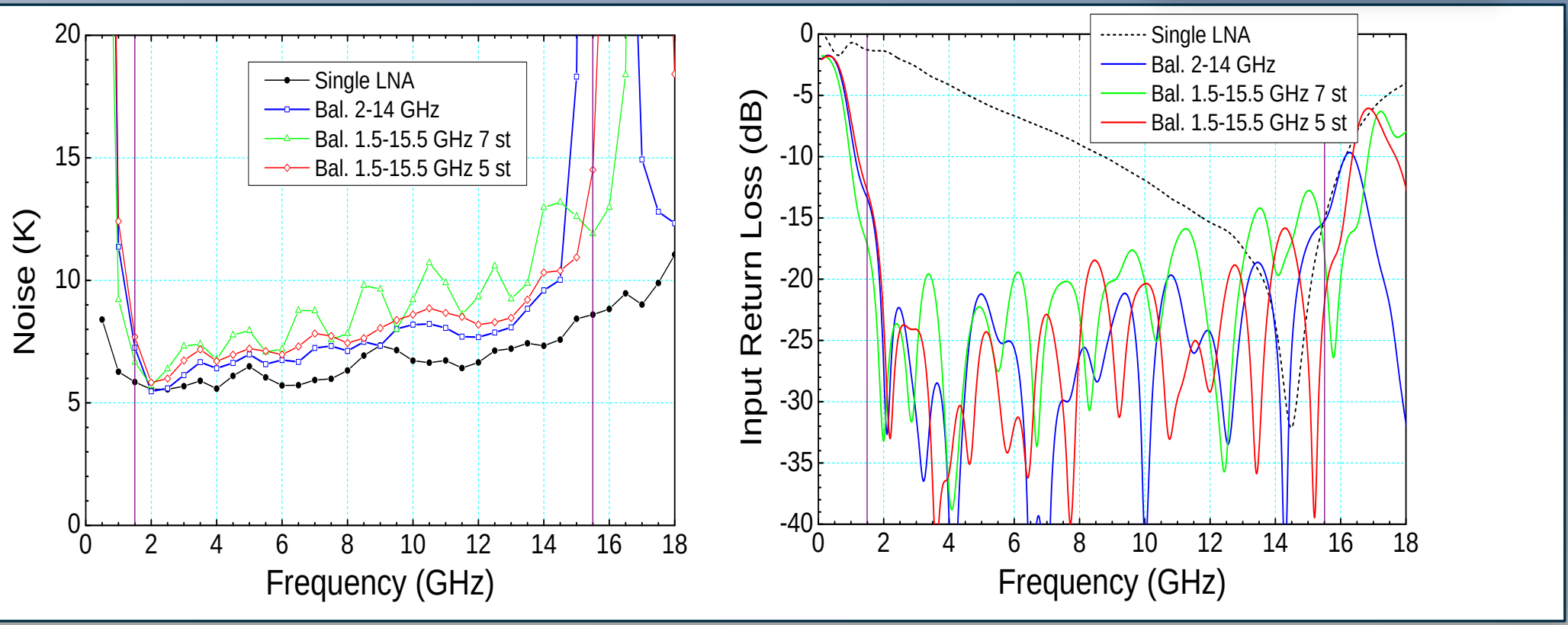
- High Temperature Superconductor Filters:
  - a high pass to cut below 1.5 GHz
  - 2 notches for strongest RFI → (1.8 GHz, 2.2 GHz)

- Filters realized as 2 separate devices

LNA



- Best solution from Yebes for that extreme bandwidth:
  - Balanced amplifier with 2 hybrids and 2 LNAs



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MEASUREMENTS OF FILTERS + LNA

3. HPF + Notch + U-cable + LNA

- Complete chain measurement without Coupler
- Filter resonances around 10 GHz and 14.5 GHz
- **Avg dTn = 2.13 K => Avg loss of HPF+Notch = 0.37 dB**

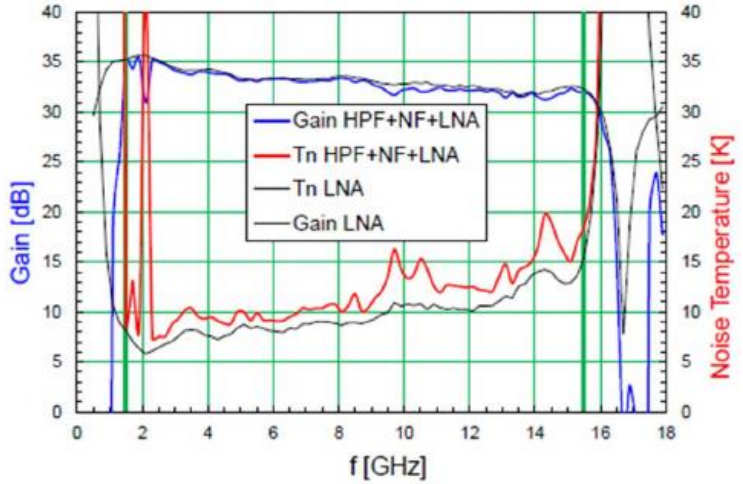
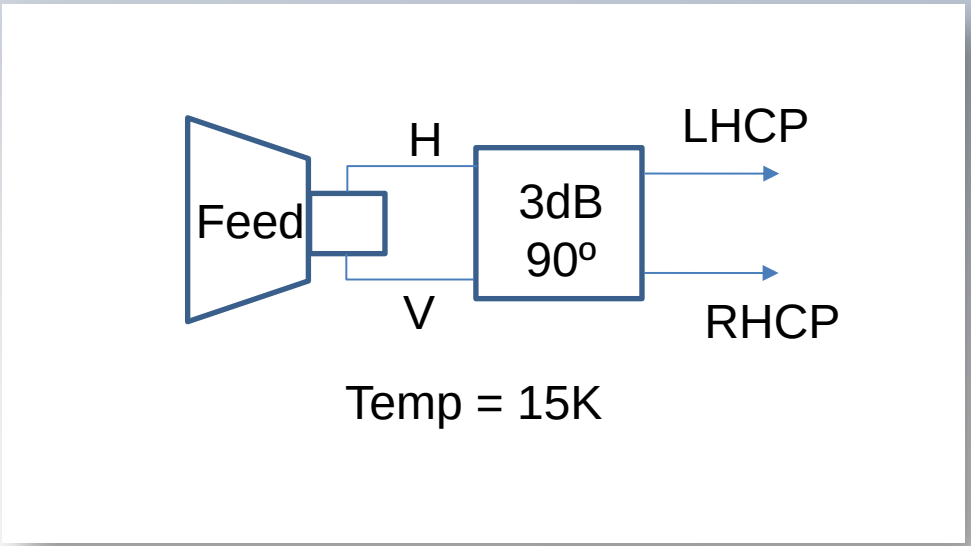


Figure 13: *Highpass filter + Notch filter + "U" cable + Balanced amplifier noise and gain compared to balanced amplifier alone. Note the various features introduced by the filters, best viewed in the figures corresponding to each filter.*

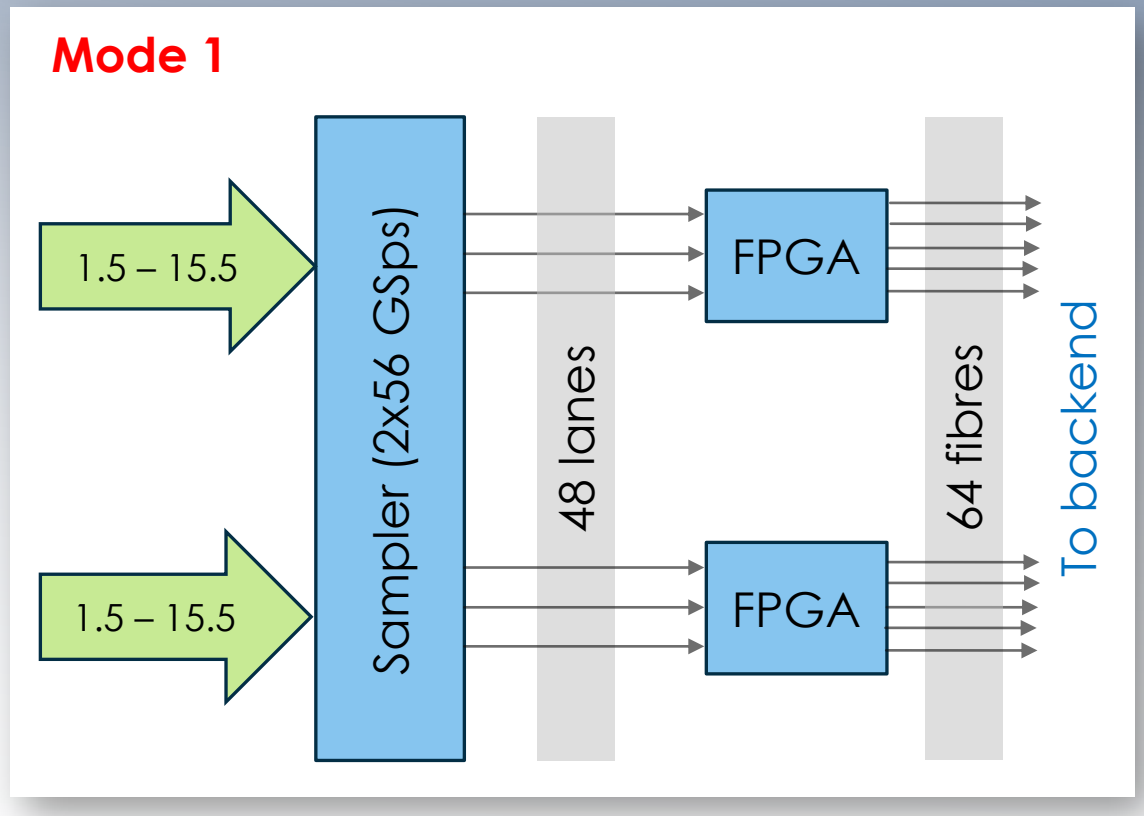
STATUS: POLARIZATION

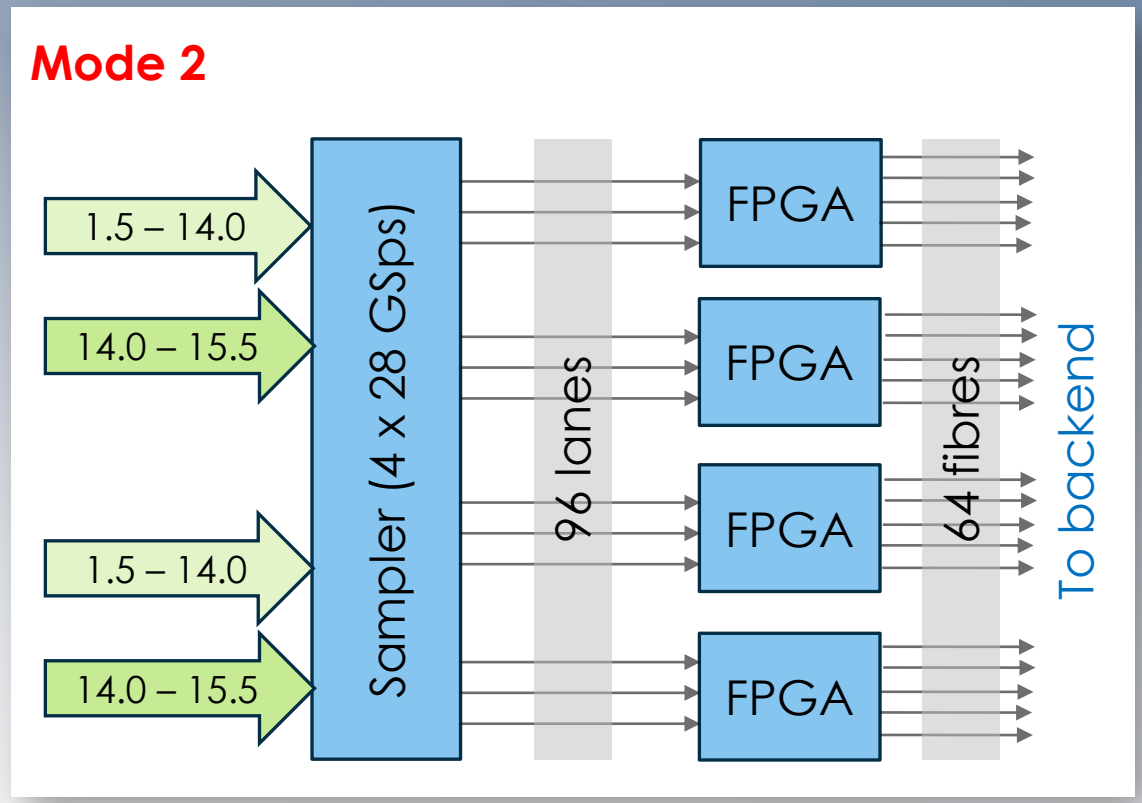
- Linear to circular polarization conversion can be achieved using 3dB/90° hybrid (same hybrid as for balanced LNA)
- Average noise penalty across the band < 2.5 Kelvin
- Yebes development for BRAND and VGOS



DIGITAL FRONTEND

- Sampler can process **128 GSps** (2 x 56 GSps or 4 x 28 GSps) from IRA and MPI
- Band formation of sampler output by FPGA





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DIGITAL RECEIVER -CONT

Mode 2

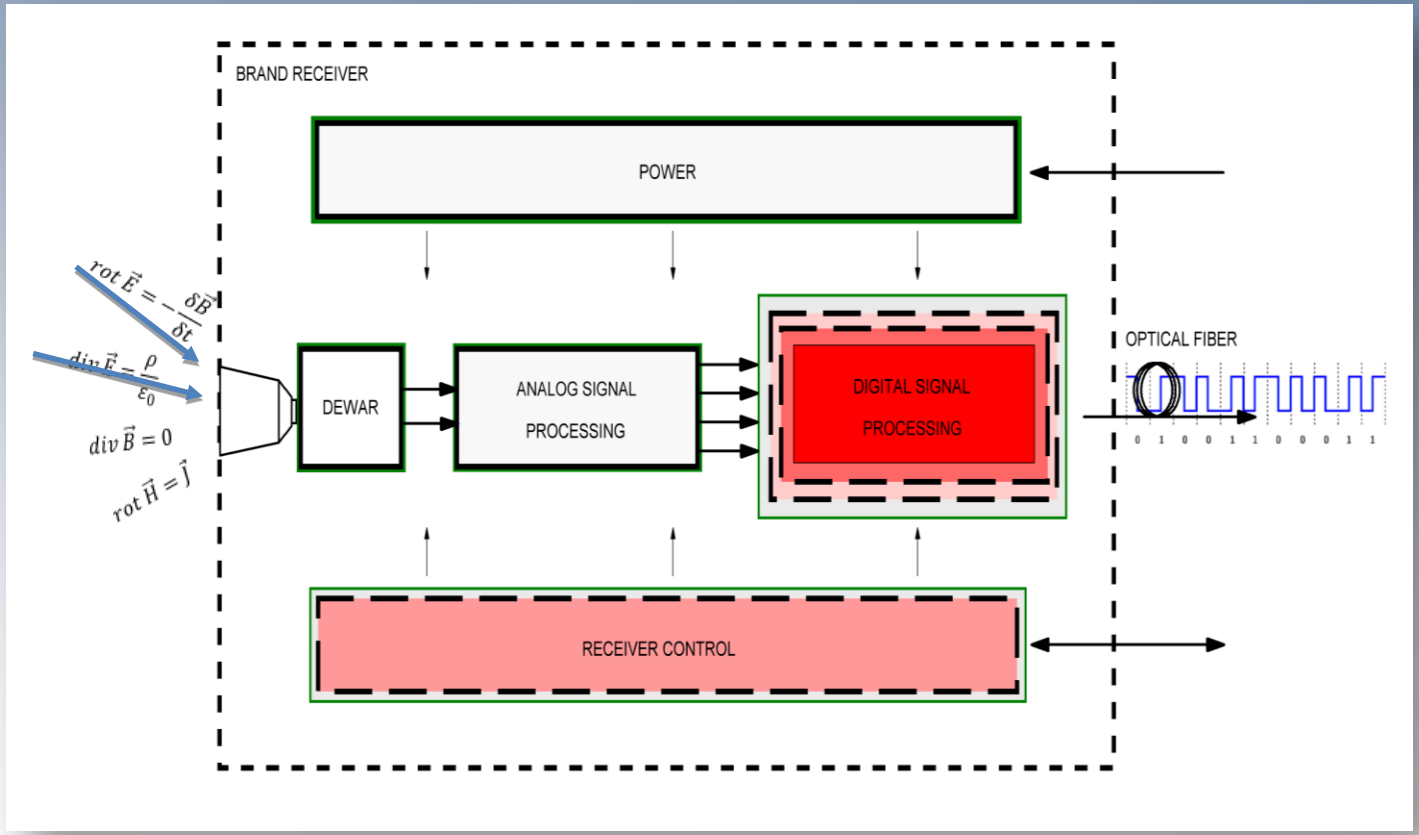
- Sampling on 4 ports with 28 GSps
- Avoids extreme sampling clock in FPGAs
- Requires splitting of analogue signal into
  - 1.5 – 14.0 GHz
  - 14.0 -15.5 GHz
- Very good filters are required to minimize aliasing effects at 14 GHz

Mode 1

Hardware can be changed to with moderate effort

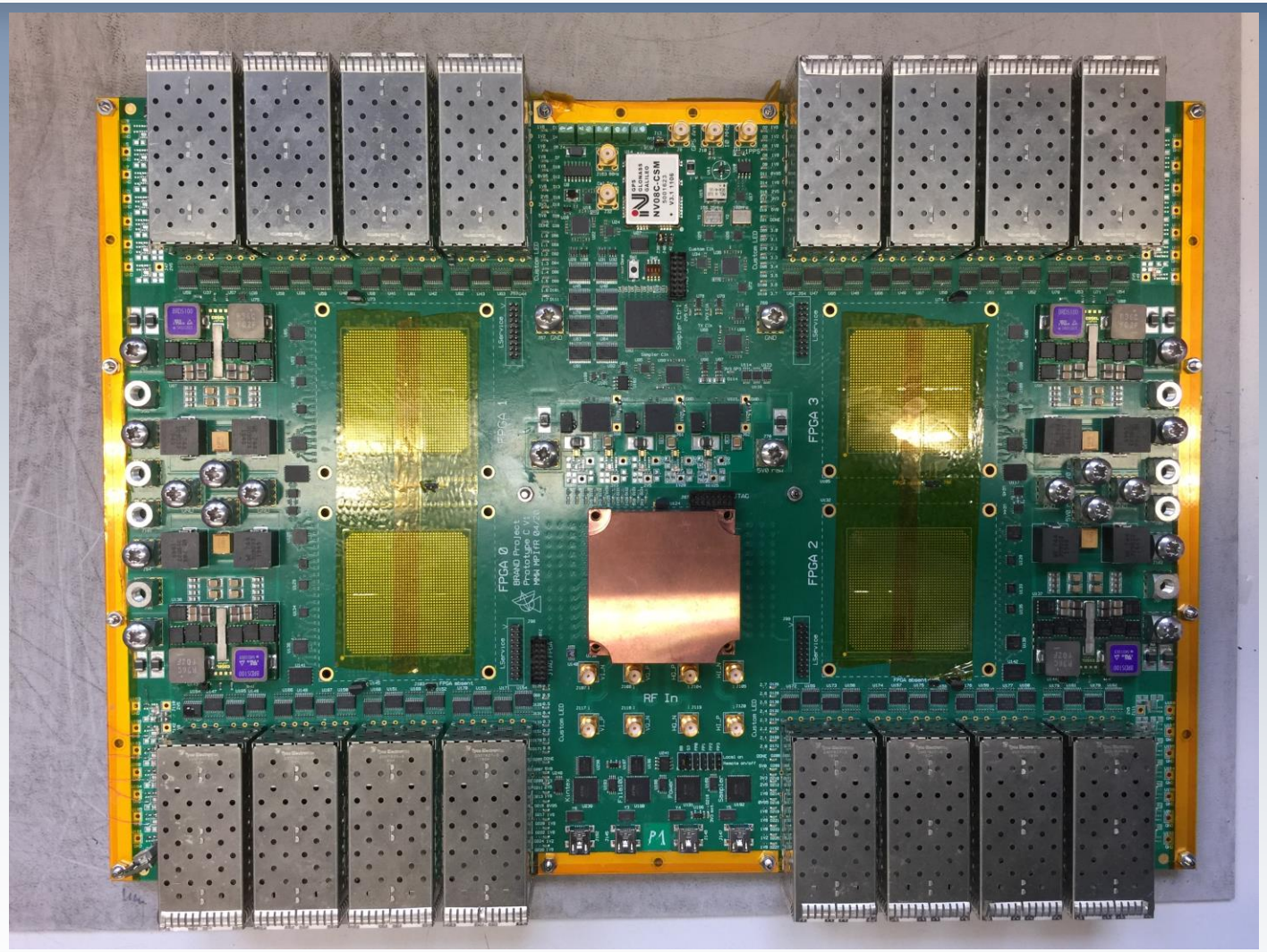
- 1.5 – 15.5 GHz
- No filters are required to minimize aliasing effects at 14 GHz

SIGNAL PROCESSING IN RECEIVER



- Receiver output: digital signal via optical fiber
- Strong shielding is required to avoid ‚internal RFI
- Good temperature management is needed to get rid of the resulting heat

DIFREND: DIGITAL FRONT-END BOARD



Input: 4 x 14 GHz
or
2 x 28 GHz

Sampling:
8-bit @28/56 GHz
1 Tbps to FPGAs

Output from FPGAs:
max 64 x 10 Gbps to accomplish DBBC3 digital input or direct recording

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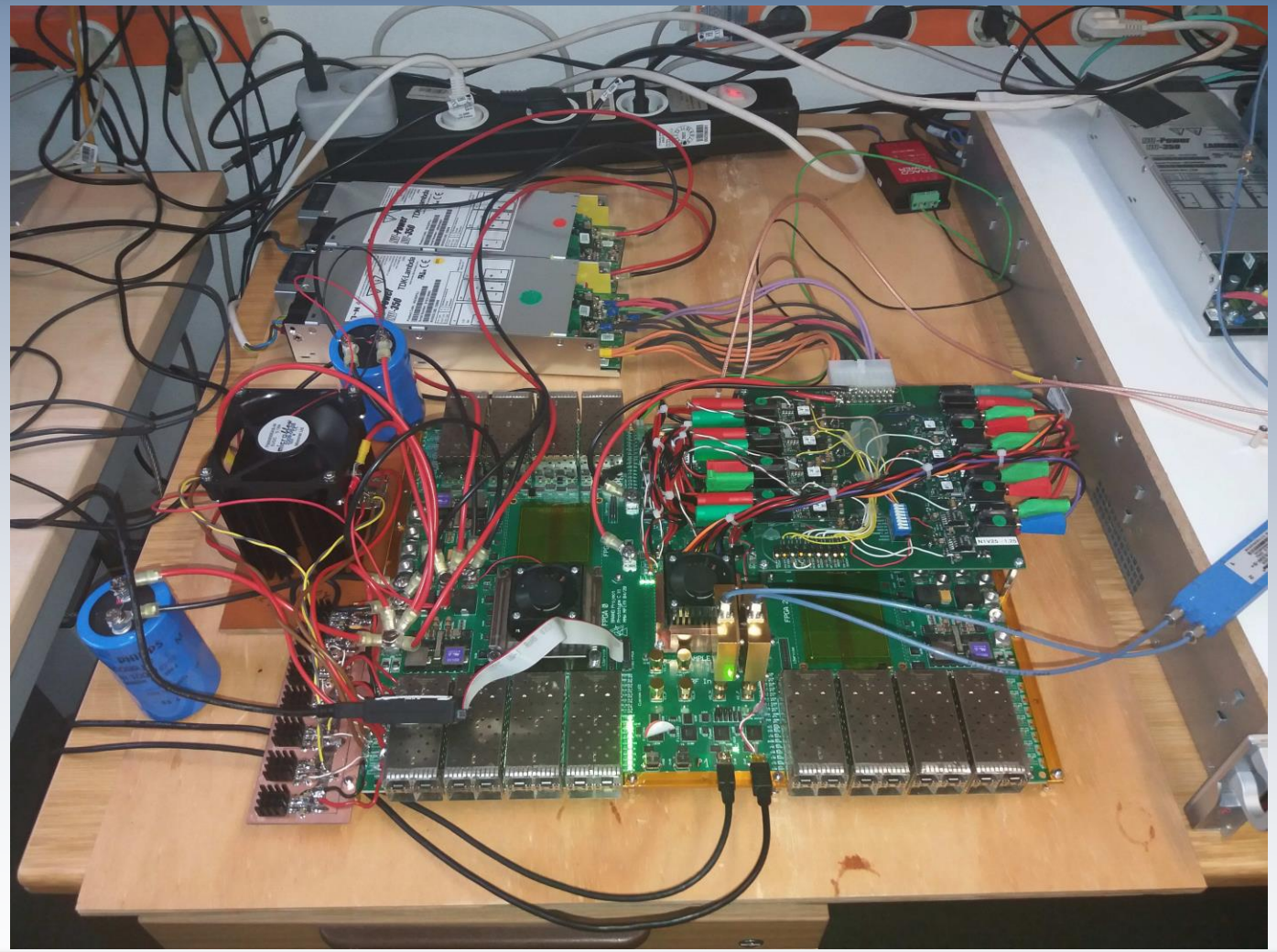
DIGITAL FRONTEND (DIFREND) IN THE LAB



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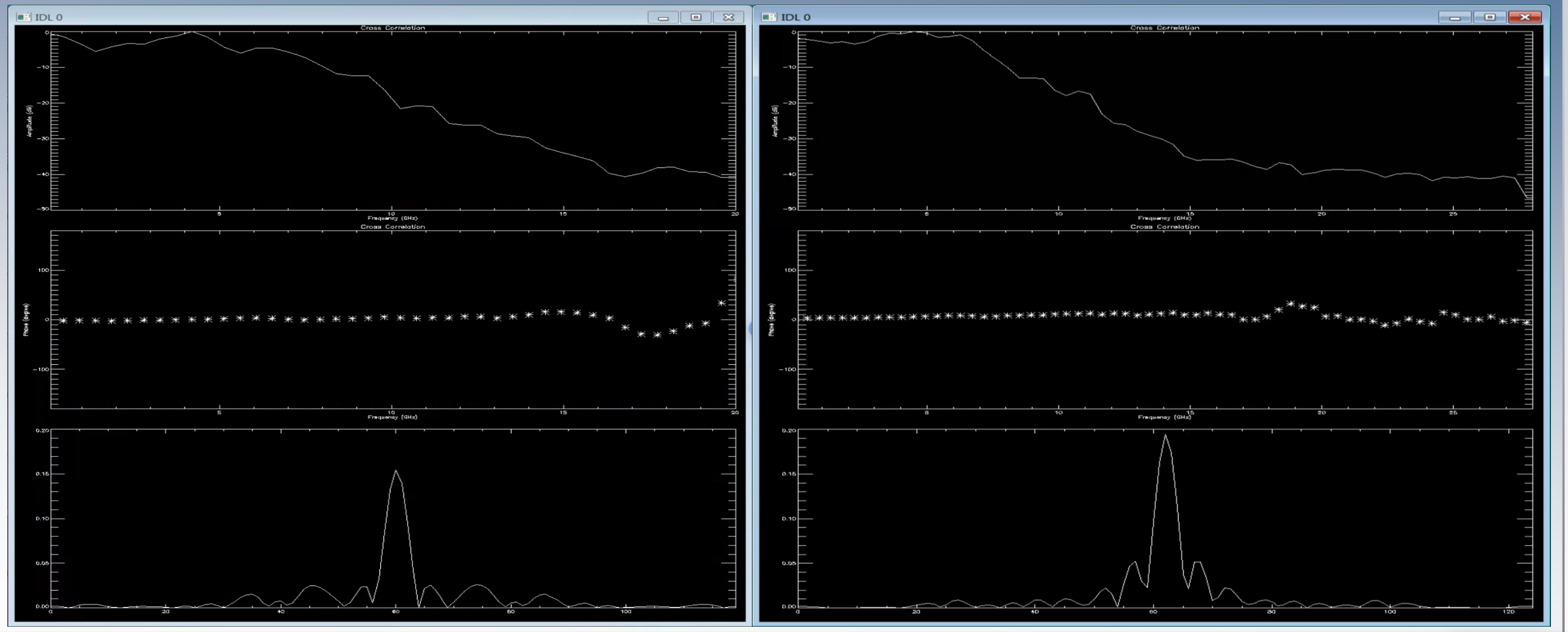
FRINGE TEST UP TO 28 GHZ

- Sampler fringe test has been successfully realized in laboratory with a noise source



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BRAND EVN DEVELOPMENT STATUS

- Analogue front-end of the Effelsberg prototype ready
- Digital front-end first prototype used for testing in the lab in two units
- Digital front-end second prototype under development
- Shielded box for very high level attenuation (> 100dB) and cooling under development
- Development of two BRAND prime focus receivers for Medicina and Noto under way

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