BRAND RECEIVER

WHAT IS

"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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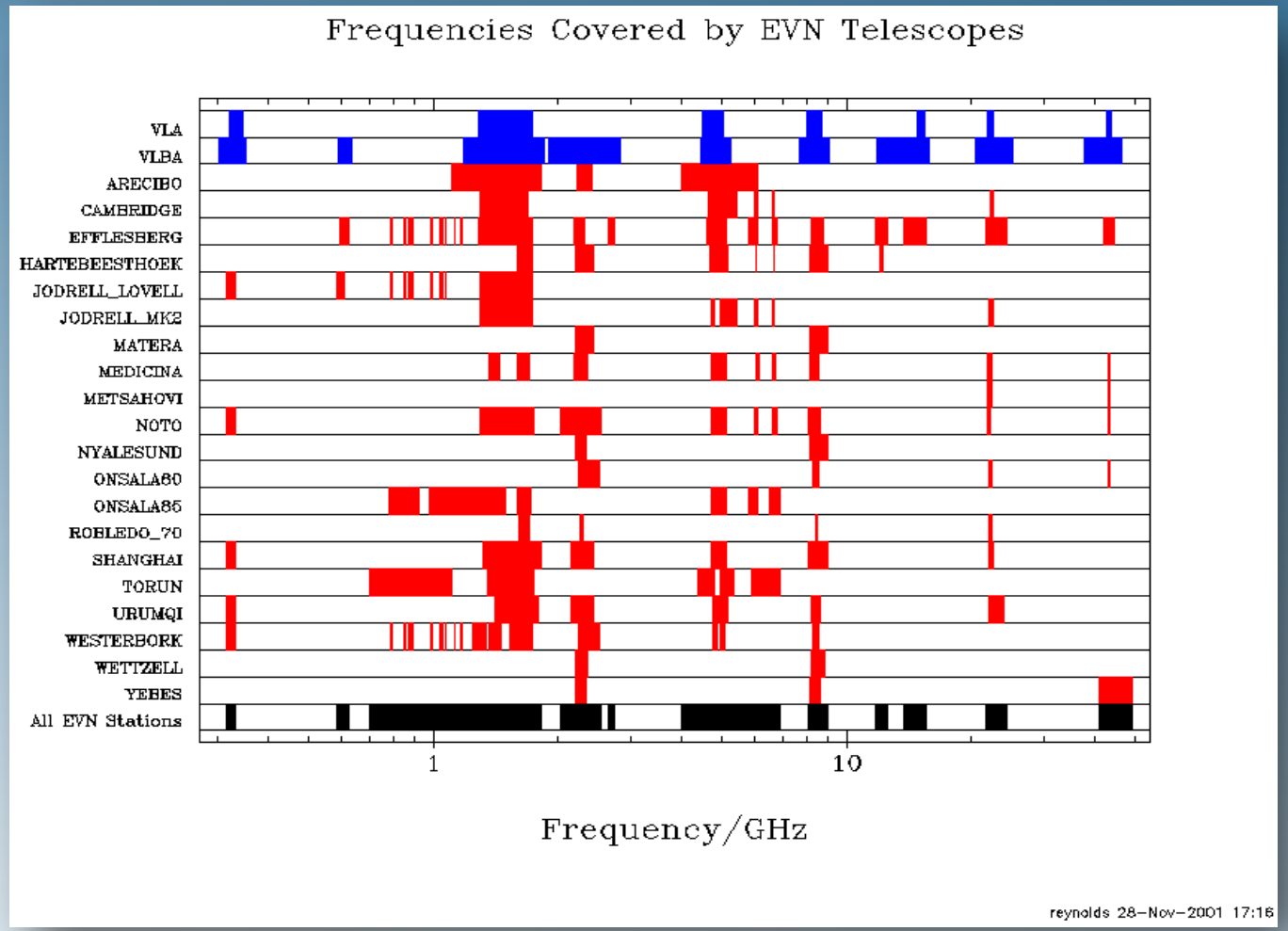
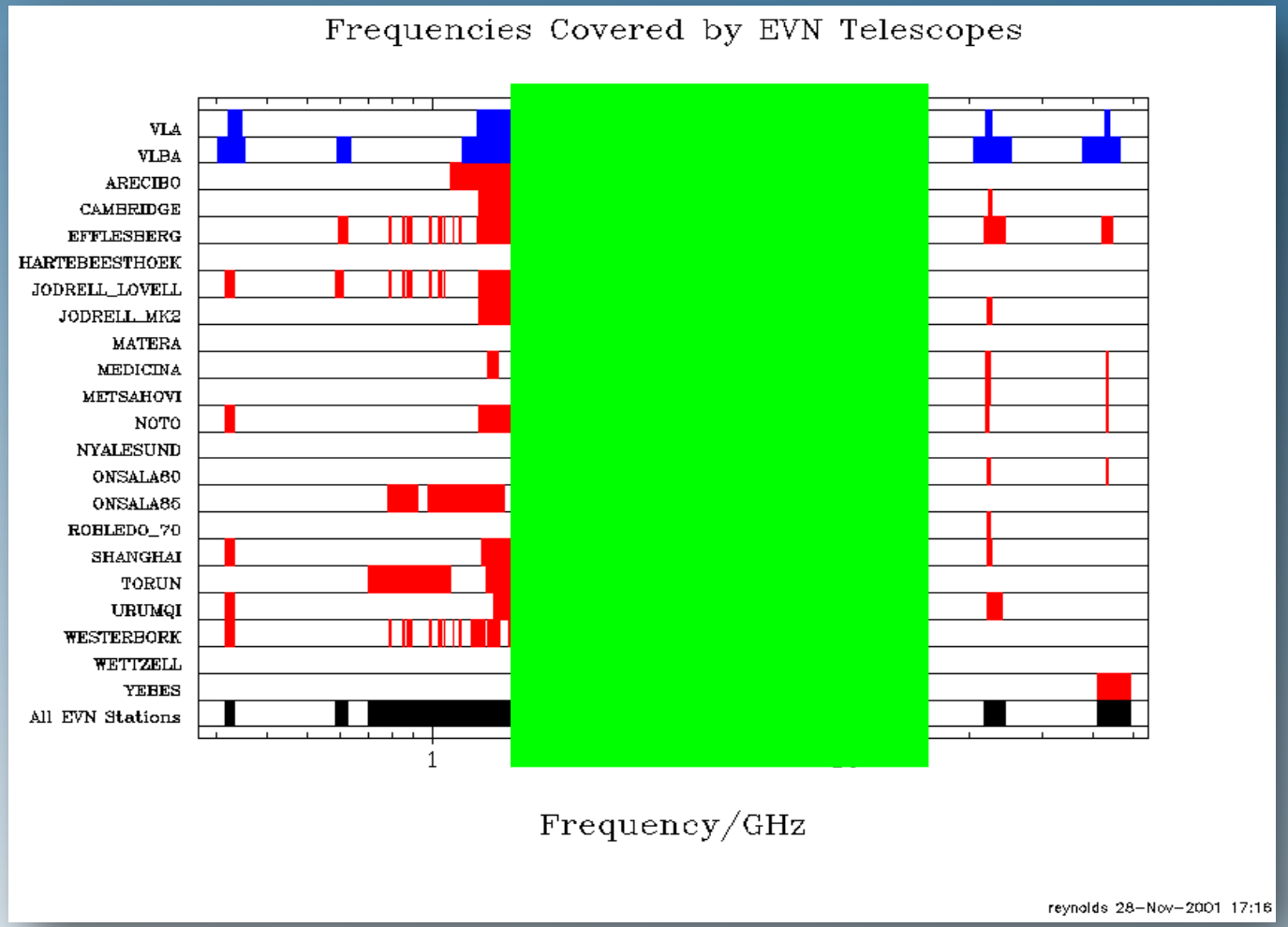
THE BRAND TEAM

G. Tuccari	INAF-IRA Bologna, Italy & MPIfR Bonn, Germany
W. Alef, M. Wunderlich, S. Dornbusch, A. Felke, H. Rottmann, C. Kasemann, M. Nalbach	MPIfR Bonn, Germany
J. Flygare, L. Pettersson	OSO, Sweden
J.A. López-Pérez, F. Tercero, I. Malo, I. López-Fernández, C. Diez	IGN/UAH, Spain
J. Hargreaves, G. Schonderbeek, R. de Wilde	ASTRON, Netherlands

EVN FREQUENCIES

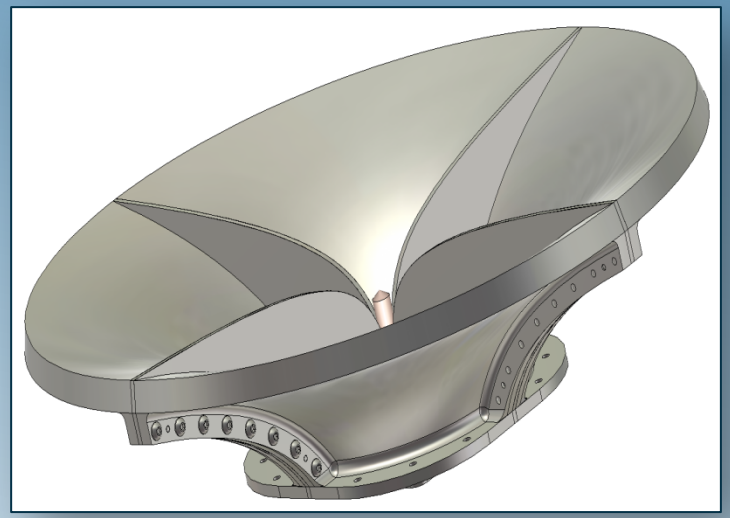


EVN FREQUENCIES VS. BRAND

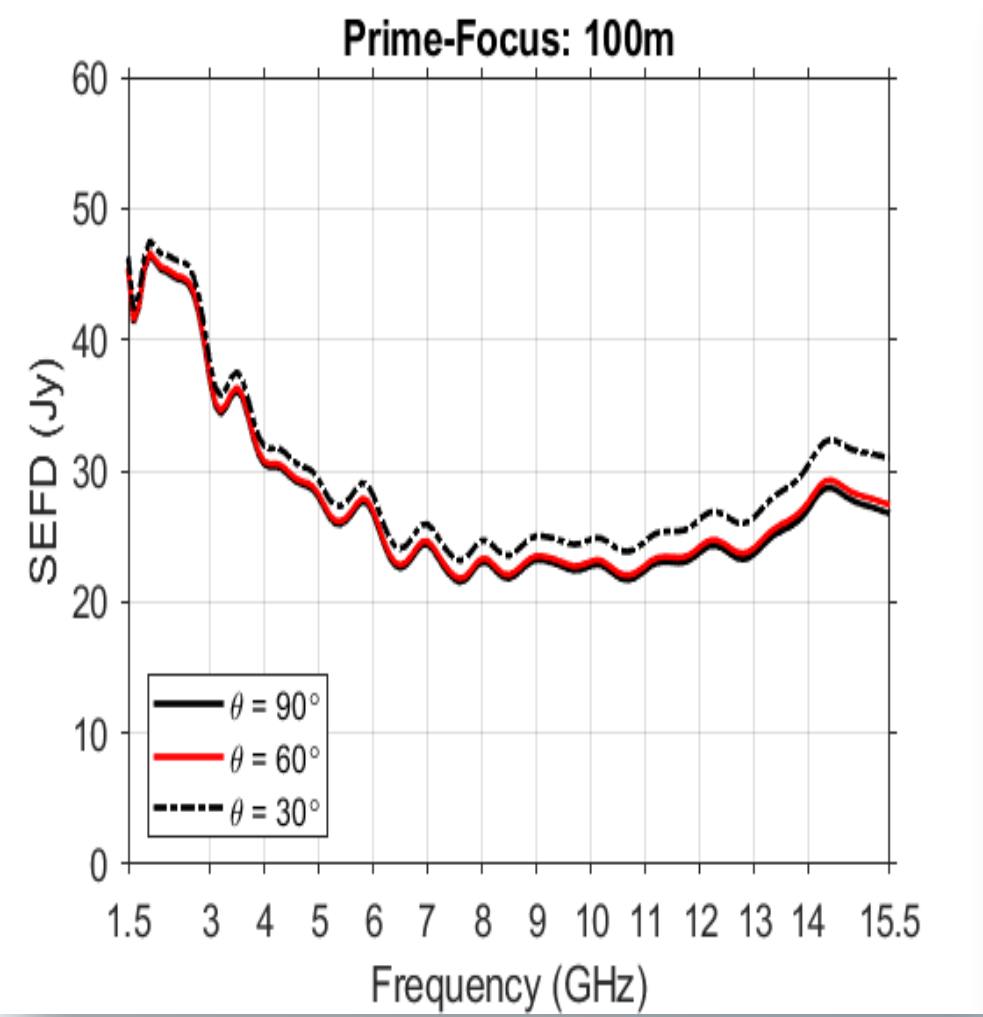


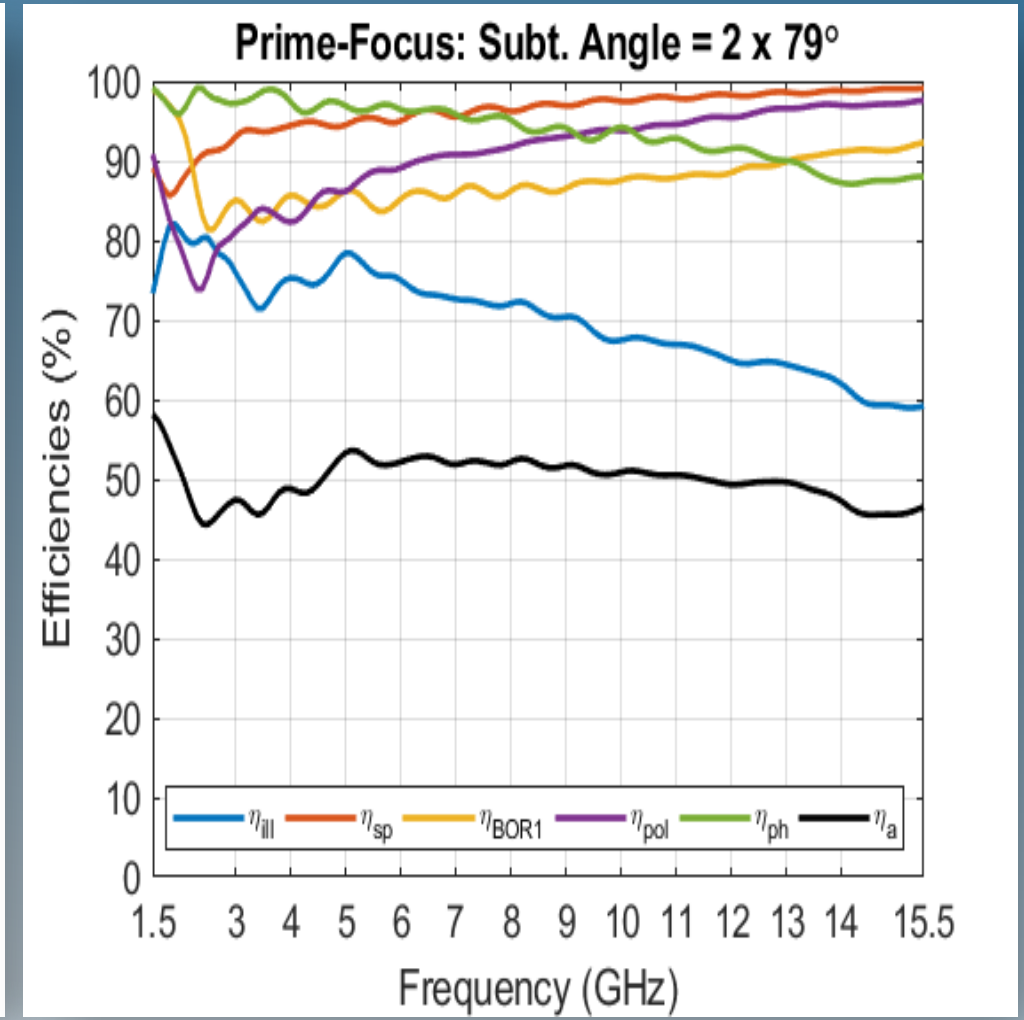
FEED HORN

- 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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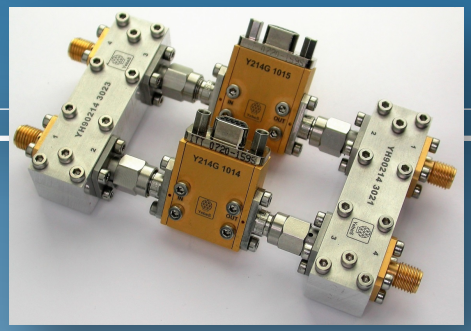
MANUFACTURED FEED HORN

HTS FILTERS

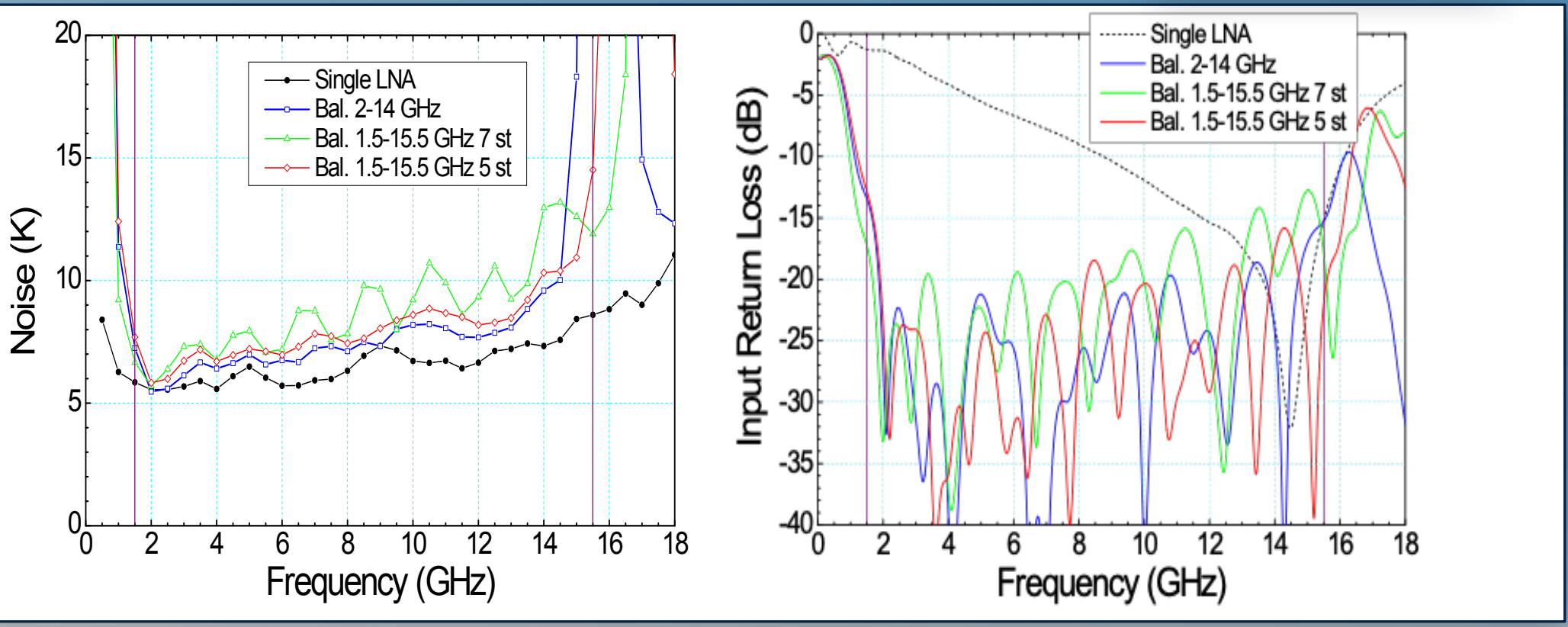
- High Temperature Superconductor Filters:
  - a high pass to cut below 1.5 GHz
  - 2 notches for strongest RFI → (1.8 GHz, 2.2 GHz)

- 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**

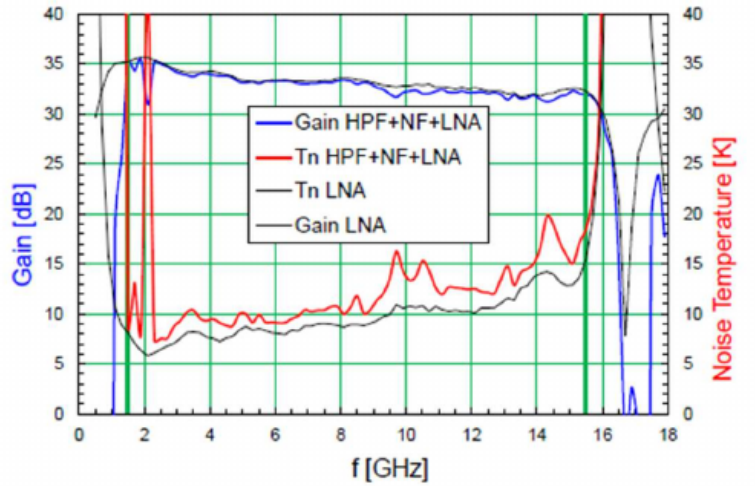
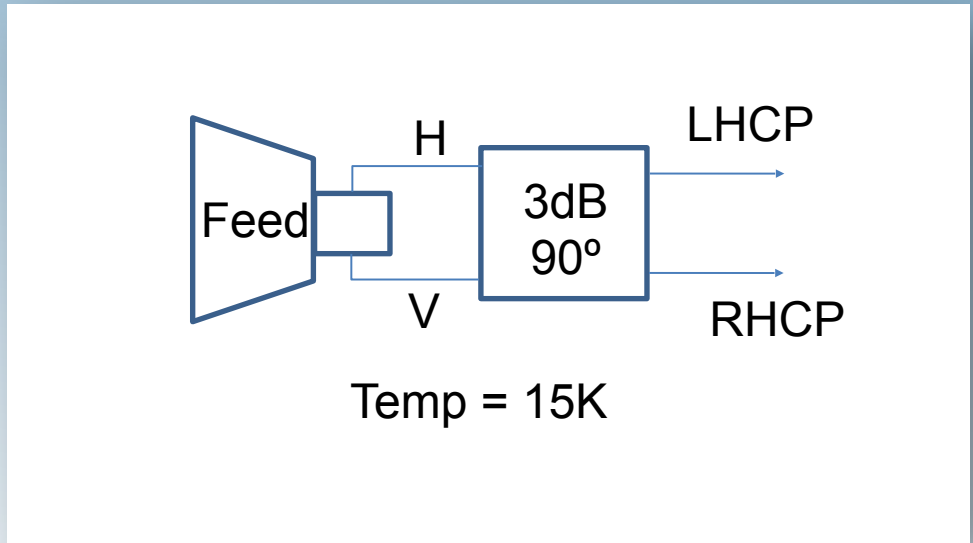
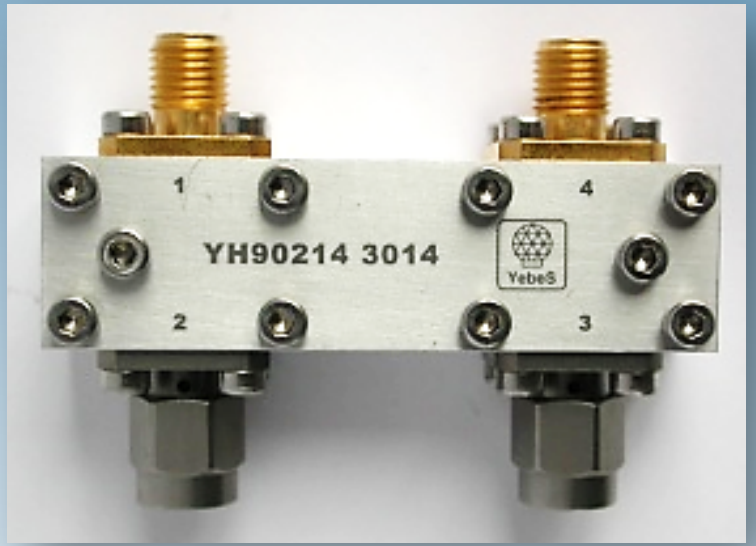


Figure 13: *Highpass filter + Notch filter + "U" cable + Balanced amplifier noise and gain compared to balanced amplifier alone. Note the various features introduced by the filters, best viewed in the figures corresponding to each filter.*

STATUS: POLARIZATION

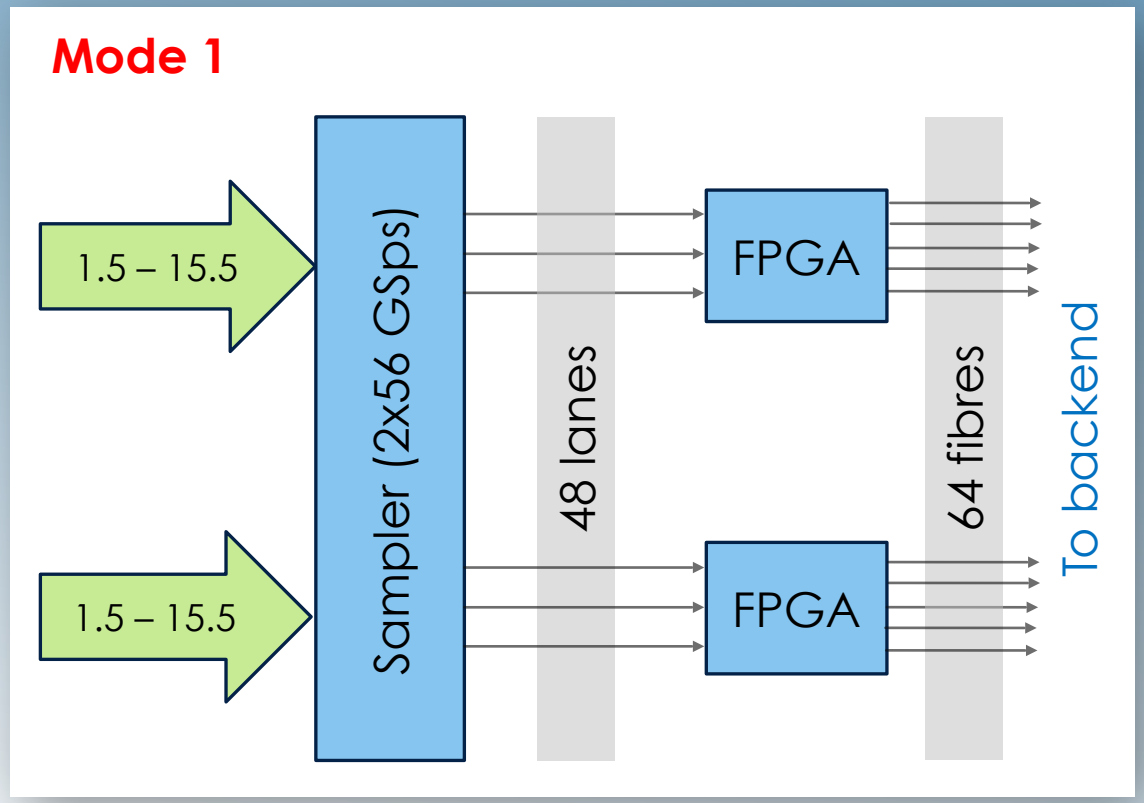
- Linear to circular polarization conversion can be achieved using 3dB/90° hybrid (same hybrid as for balanced LNA)
- Average noise penalty across the band < 2.5 Kelvin
- Yebes development for BRAND and VGOS

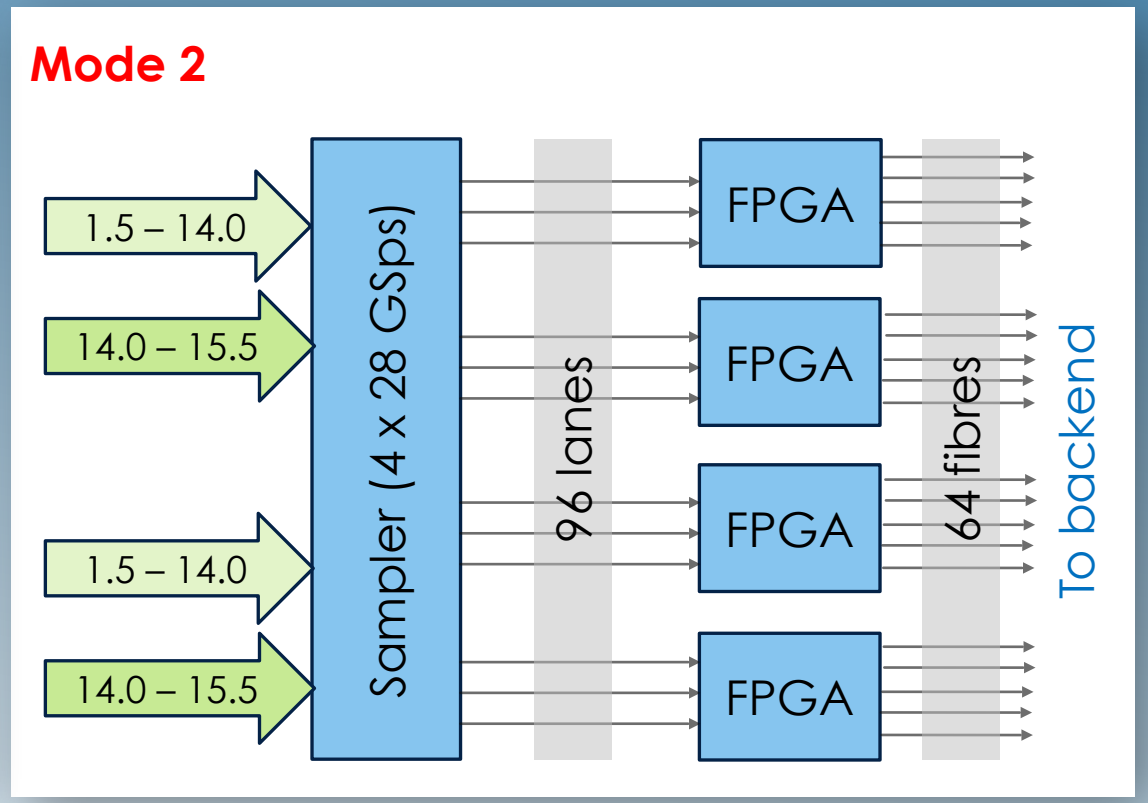




DIGITAL FRONTEND

- 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

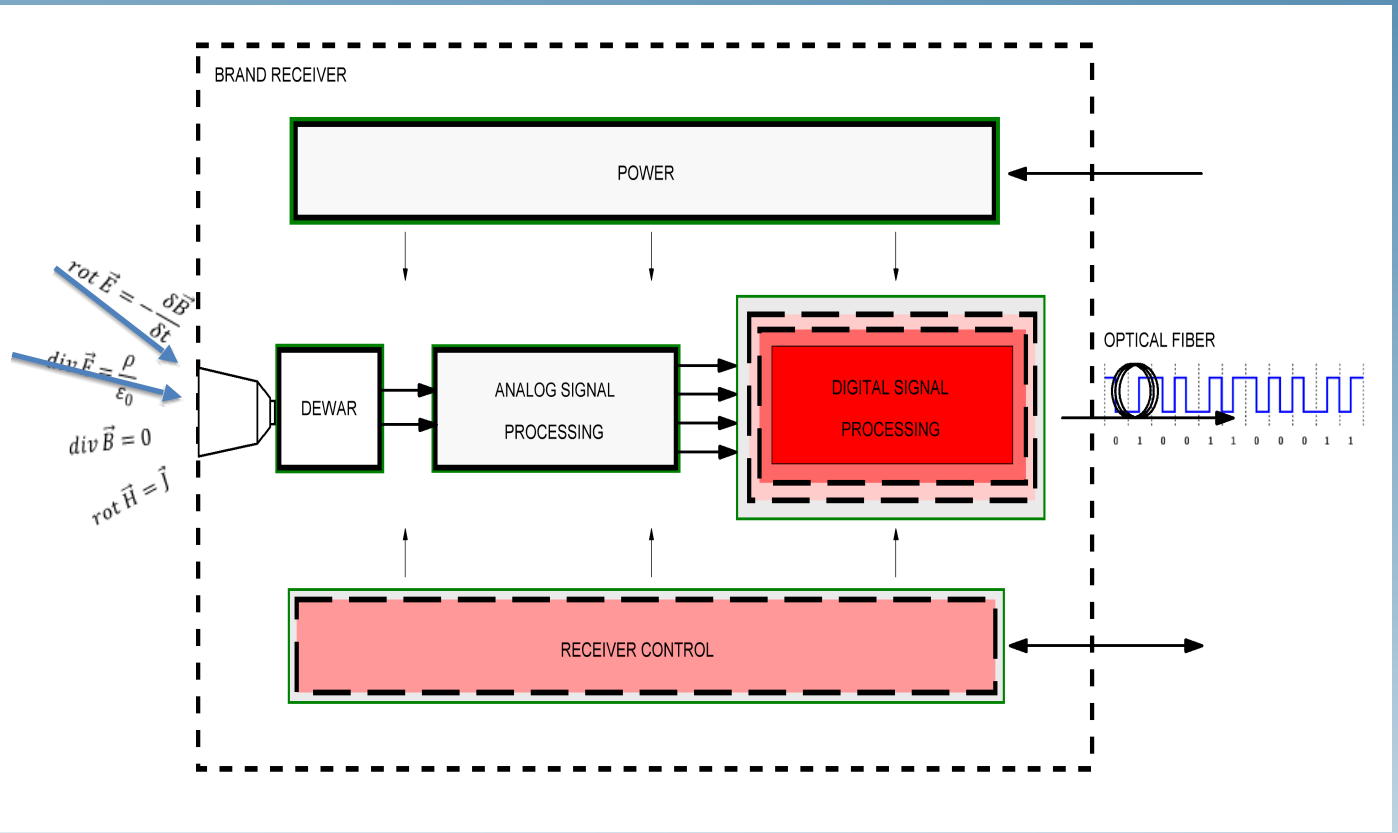
- Sampling on 4 ports with 28 GSps
- Avoids extreme sampling clock in FPGAs
- Requires splitting of analogue signal into
  - 1.5 – 14.0 GHz
  - 14.0 -15.5 GHz
- Very good filters are required to minimize aliasing effects at 14 GHz

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

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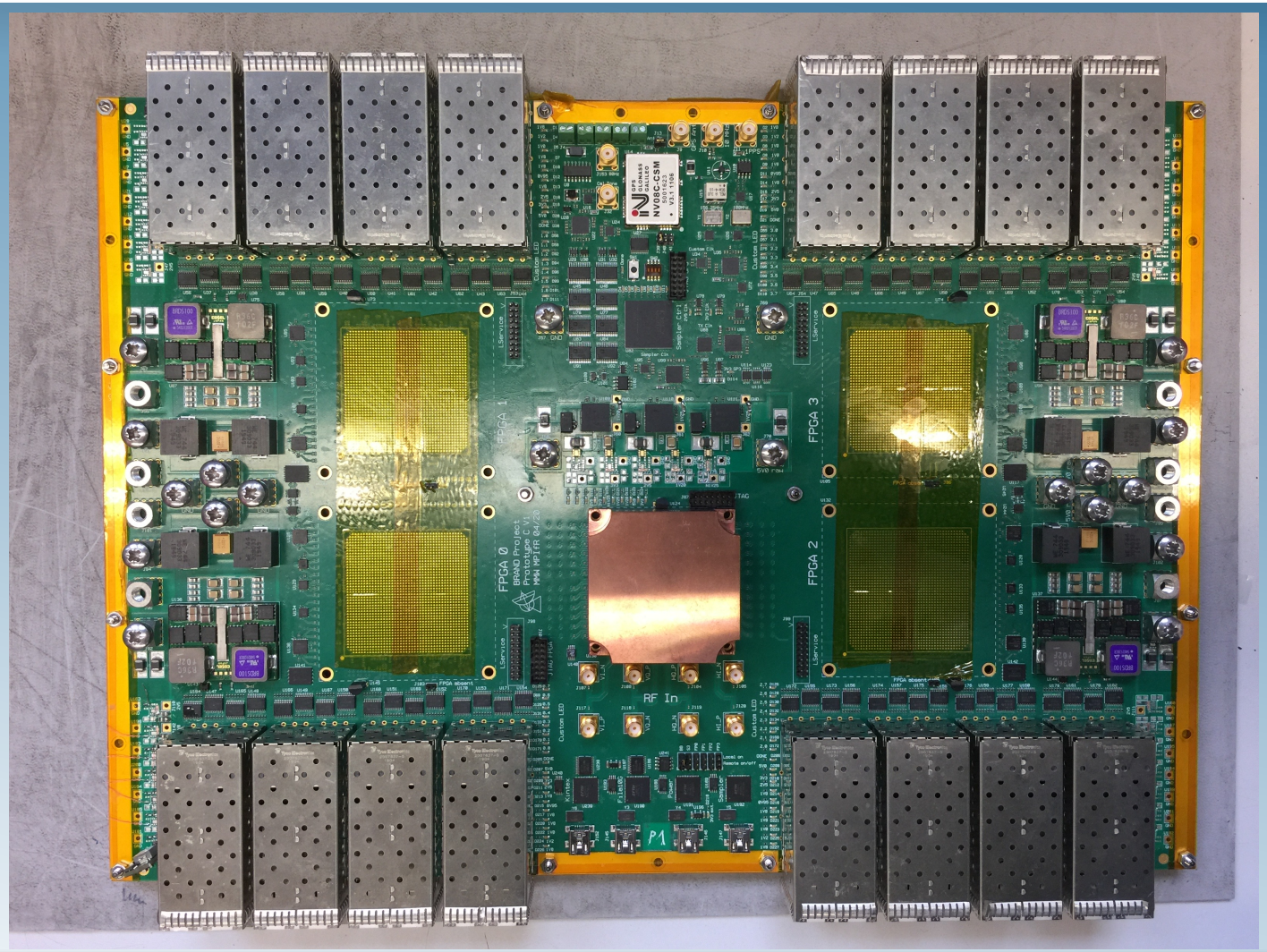
DIFREND: DIGITAL FRONT-END BOARD



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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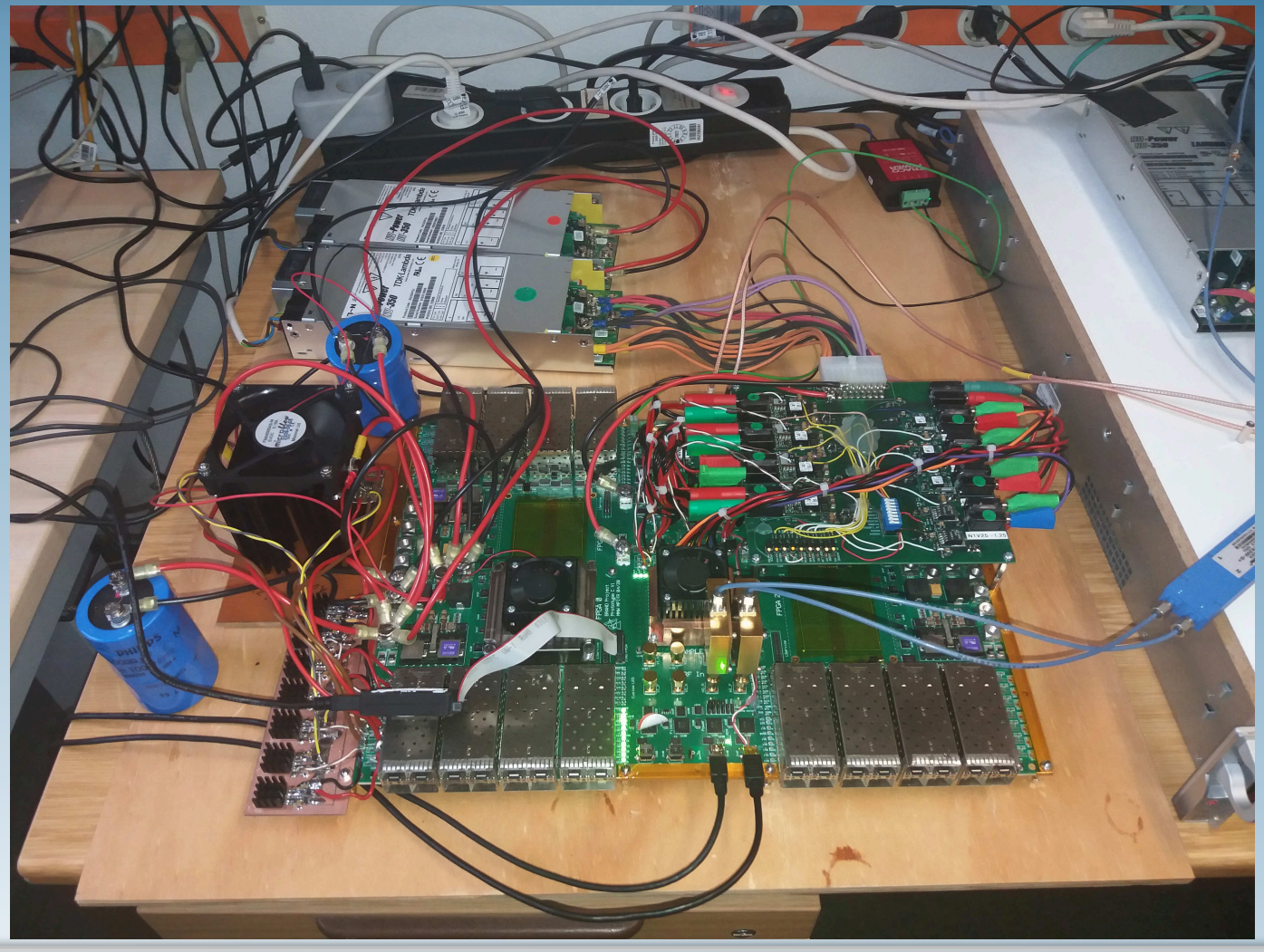
DIGITAL FRONTEND (DIFREND) IN THE LAB



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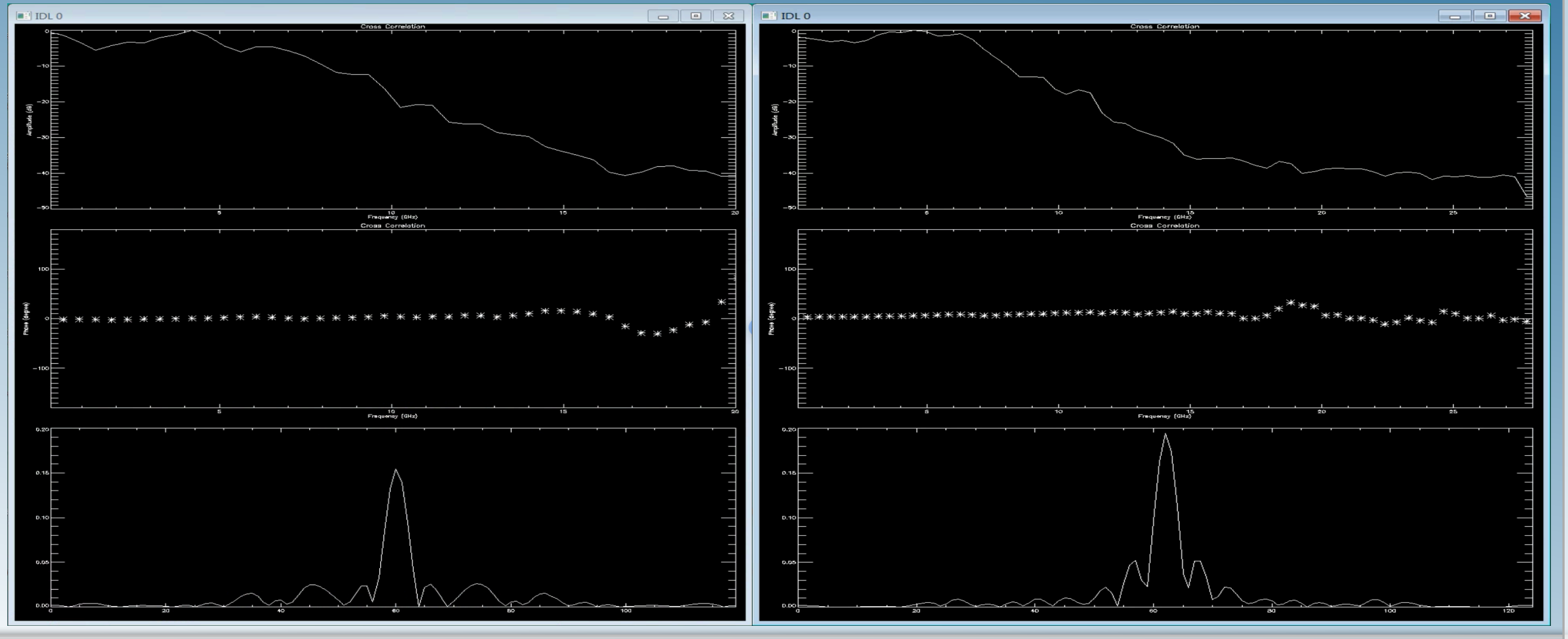
FRINGE TEST UP TO 28 GHZ

- 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) has been defined and is under construction
- Development of two BRAND prime focus receivers for Medicina and Noto under way