POLARIMETRIC CALIBRATION OF DLR'S DUAL-BAND LX-TRANSPONDER AND FIRST POLARIMETRIC L-BAND SAR MEASUREMENTS

Anna Maria Büchner, Klaus Weidenhaupt, Jens Reimann, Sebastian Raab,

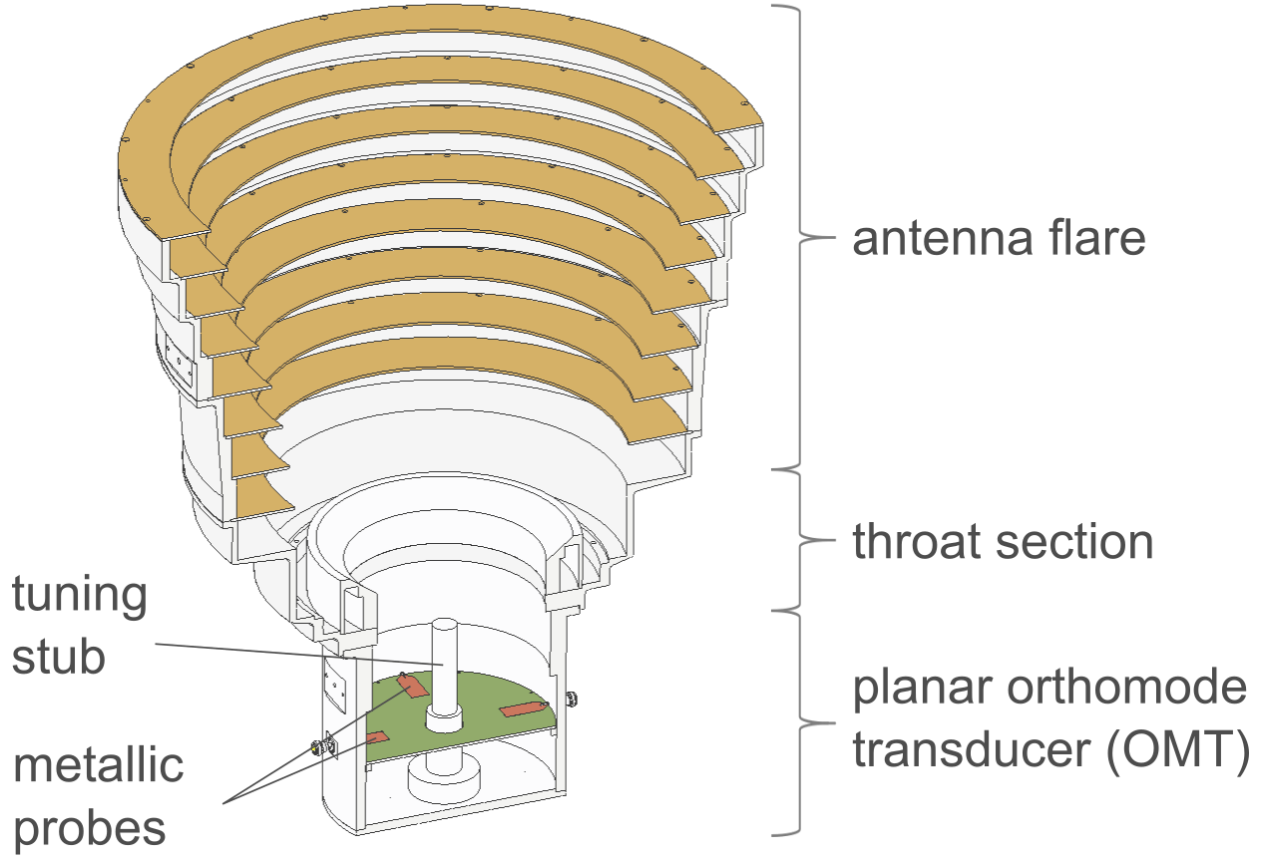
Matthias Jirousek and Marco Schwerdt

DLR

DLR SAR Calibration Center

LX-band Transponder Development

2019 Start of L-band development



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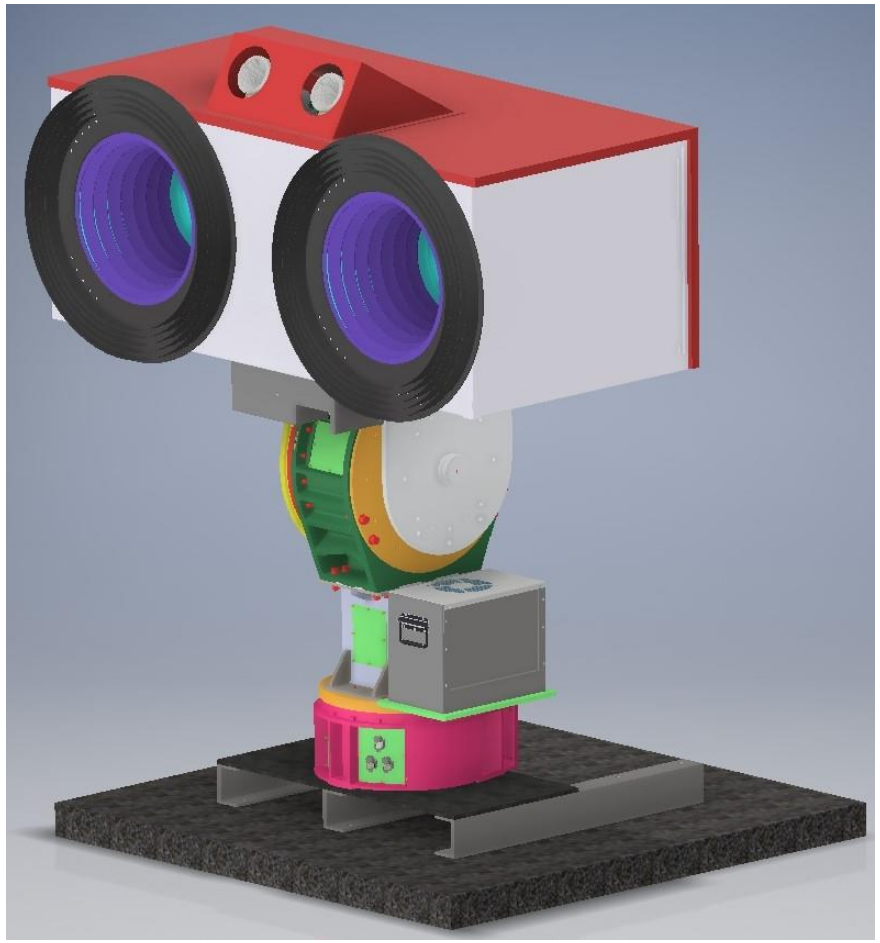
2020 Finalized transponder design



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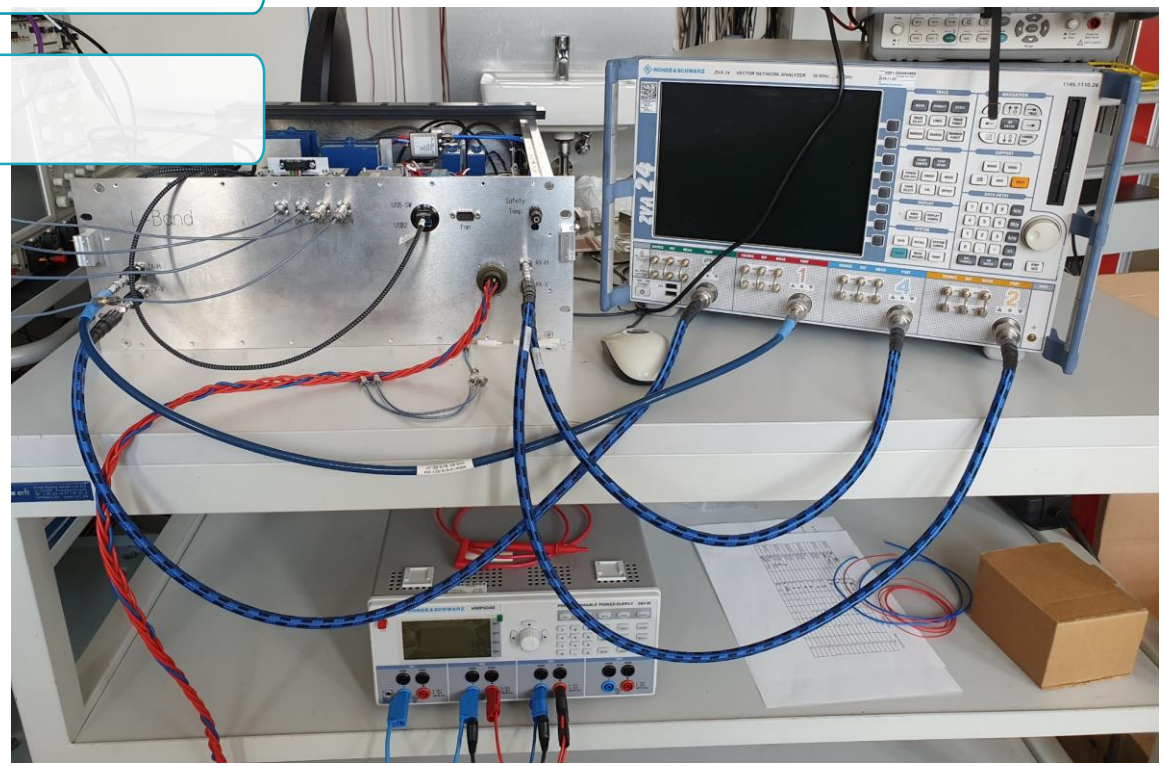
2021 Subsystem integration and test



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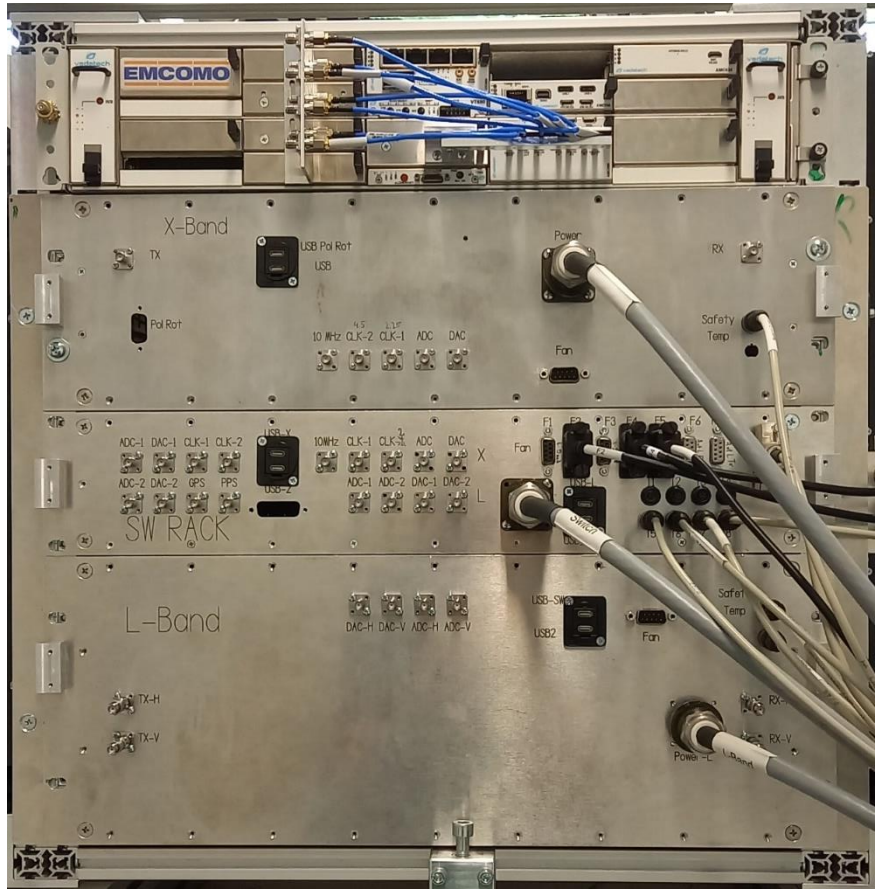
- 2020: Finalized transponder design
- 2021: Subsystem integration and test
- 2022: Start of complete system integration



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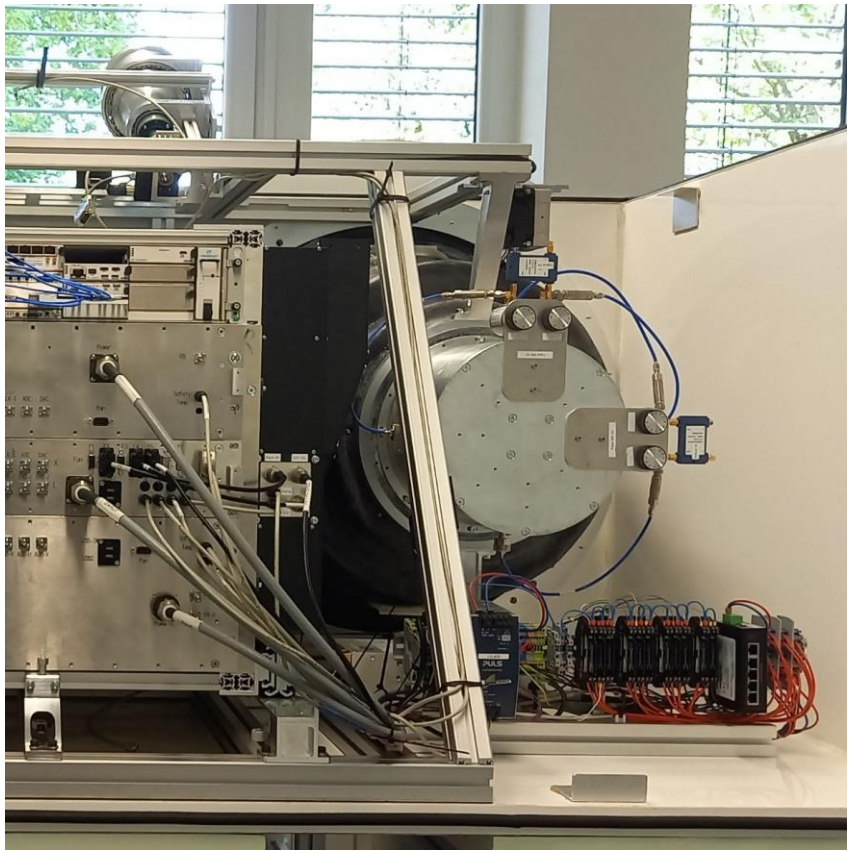

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- 2023: Completely operational and deployed at DLR
  Overpasses with TSX/TDX, SAOCOM and ALOS-2

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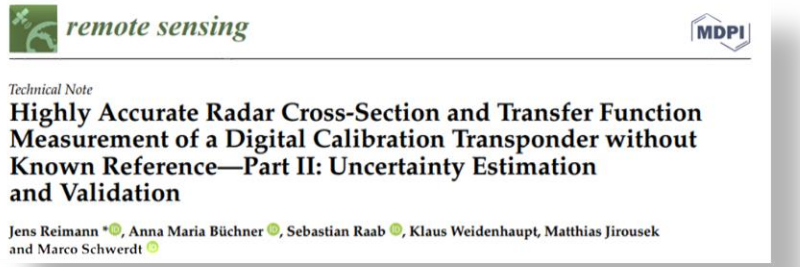
- 2024: External calibration of transponder

Transponder Characteristics

	Kalibri NG - X	Kalibri NG - L
Frequency band	X-band	L-band
Bandwidth	1200 MHz	85 MHz
Polarization	Single Adjustable	Quad Pol
RCS	57… 68 dBm²	52 … 62 dBm²
Abs. radiometric accuracy (1 σ)	Expected < 0.1 dB	Expected < 0.1 dB
Radiometric stability (1 σ)	< 0.05 dB	< 0.05 dB

X-band prototype calibrated with 0.07dB accuracy

See J. Reimann et al.: " Highly Accurate Radar Cross-Section and Transfer Function Measurement of a Digital Calibration Transponder without Known Reference—Part II: Uncertainty Estimation and Validation "


remote sensing

MDPI

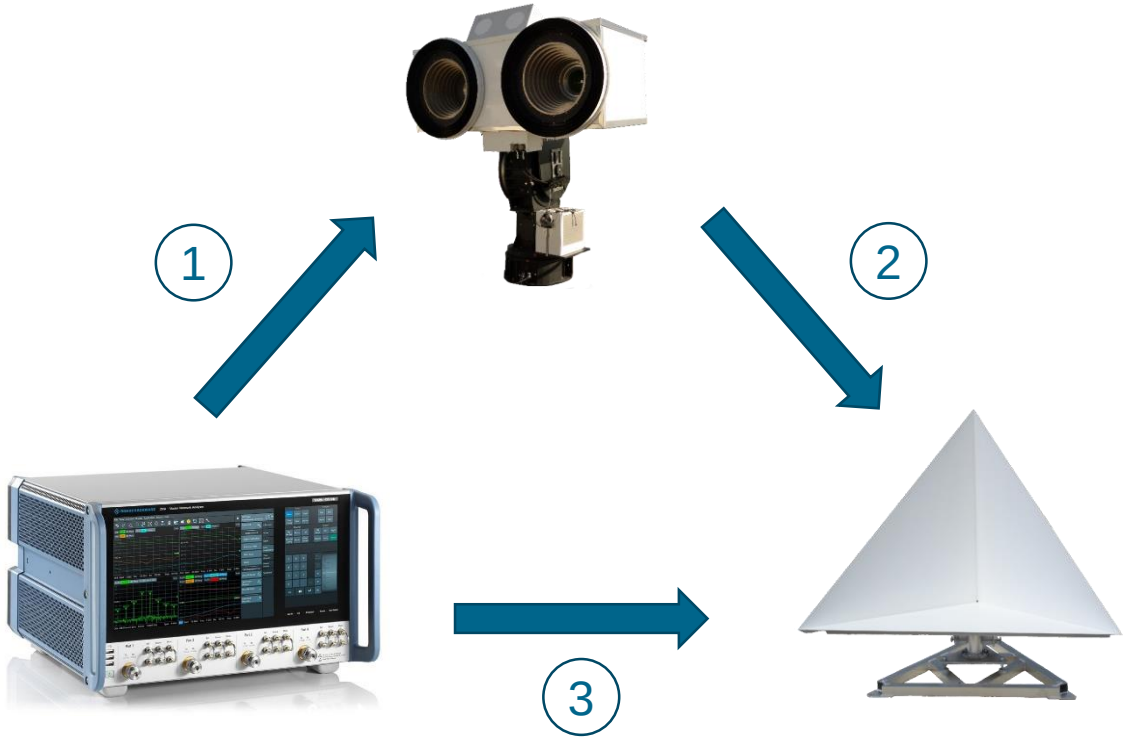
Technical Note

Highly Accurate Radar Cross-Section and Transfer Function Measurement of a Digital Calibration Transponder without Known Reference—Part II: Uncertainty Estimation and Validation

Jens Reimann *, Anna Maria Büchner, Sebastian Raab, Klaus Weidenhaupt, Matthias Jirousek and Marco Schwerdt

External Calibration

- DLR‘s „Three Transponder Method“ (3TM) used for transponder‘s absolute radiometric calibration



External Calibration

- DLR‘s „Three Transponder Method“ (3TM) used for transponder‘s absolute radiometric calibration
- Fully polarimetric system requires additional steps before 3TM can be conducted

→ Polarimetric calibration of the transponder

- Polarimetric calibration of the transponder made up of two parts
  1) Polarization alignment of the antennas
  2) Synchronization of the channels in magnitude, phase and delay

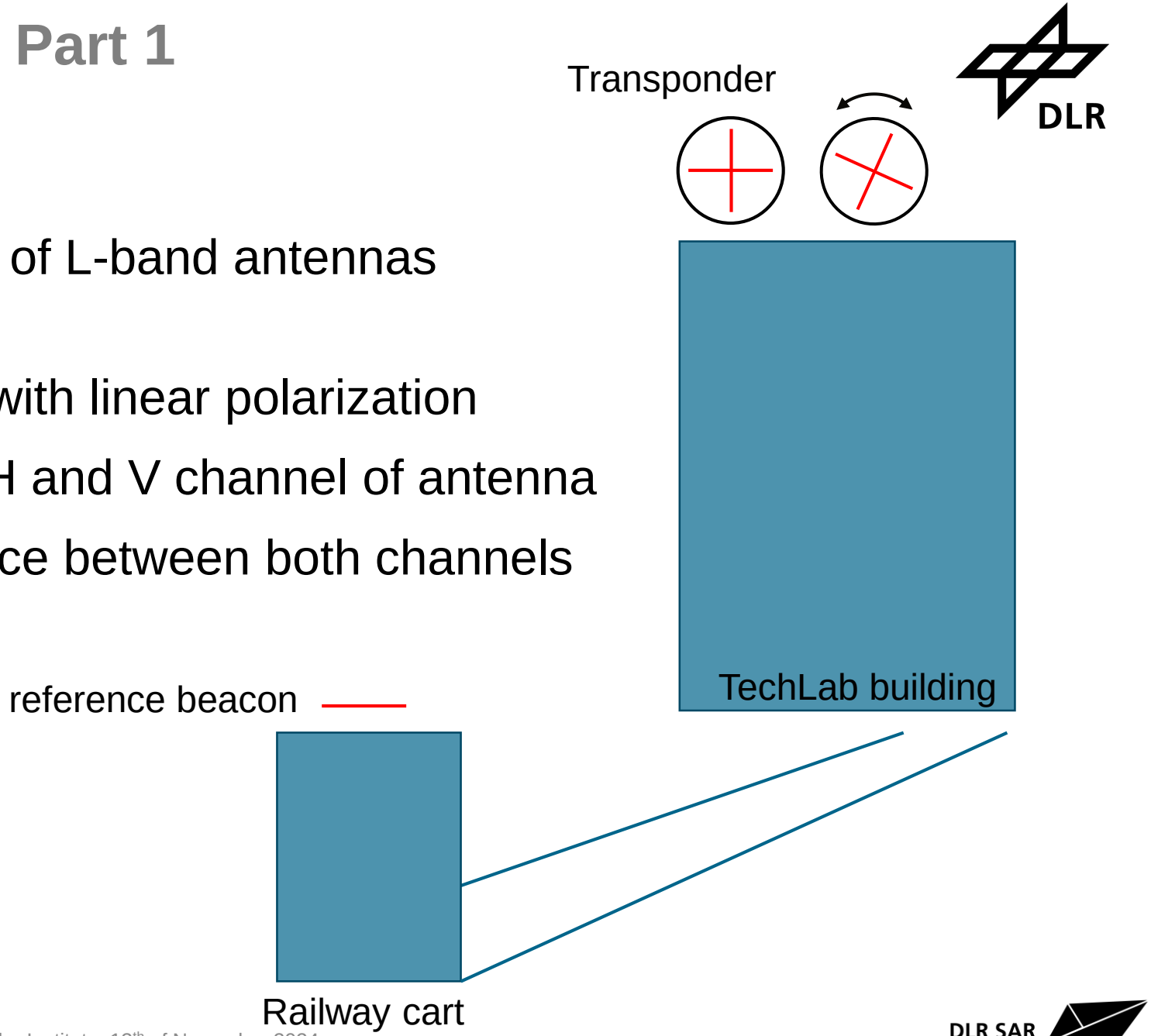
Polarimetric Calibration – Part 1

Electrical polarization alignment of L-band antennas

1. Electrical reference beacon with linear polarization
2. Continous measurement of H and V channel of antenna
3. Alignment until max. difference between both channels

approx. 45 dB

4. Repeat for second antenna



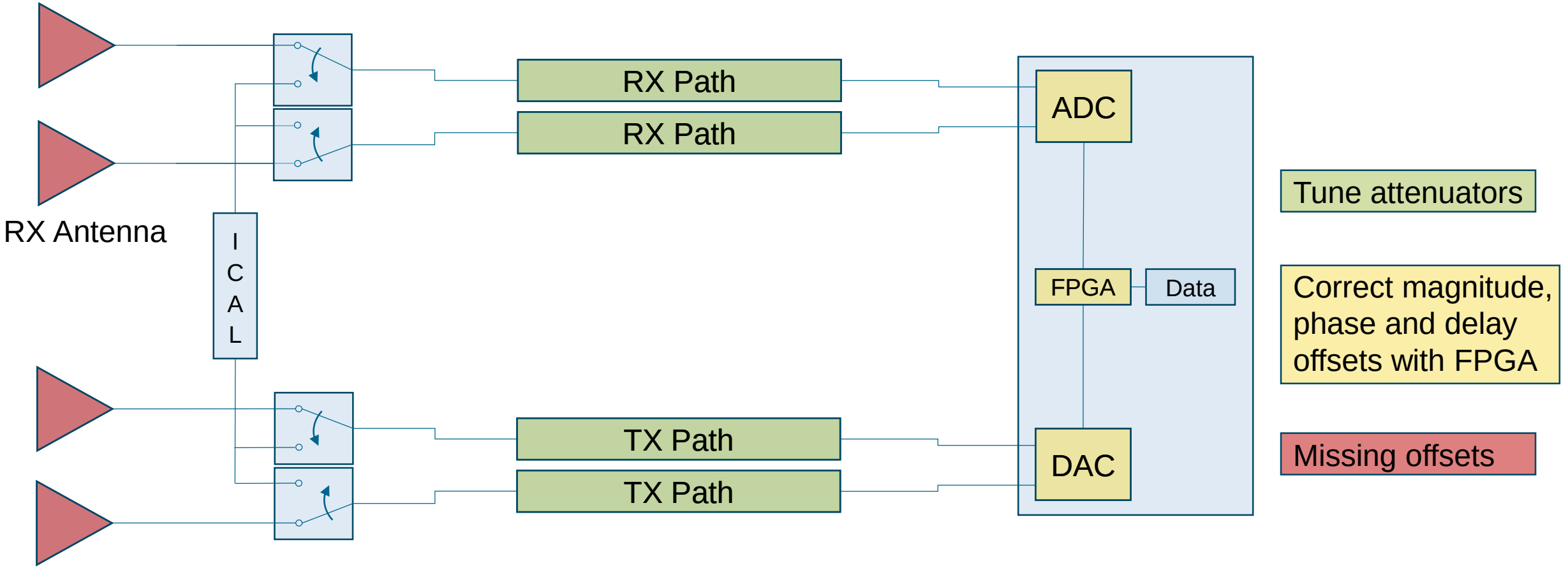
Polarimetric Calibration – Part 2

Channel synchronization

1. Internal calibration of transponder
   - Tune attenuators in all paths
   - Correct magnitude, phase and delay offsets with FPGA

Polarimetric Calibration – Part 2

Channel synchronization



Tune attenuators

Correct magnitude, phase and delay offsets with FPGA

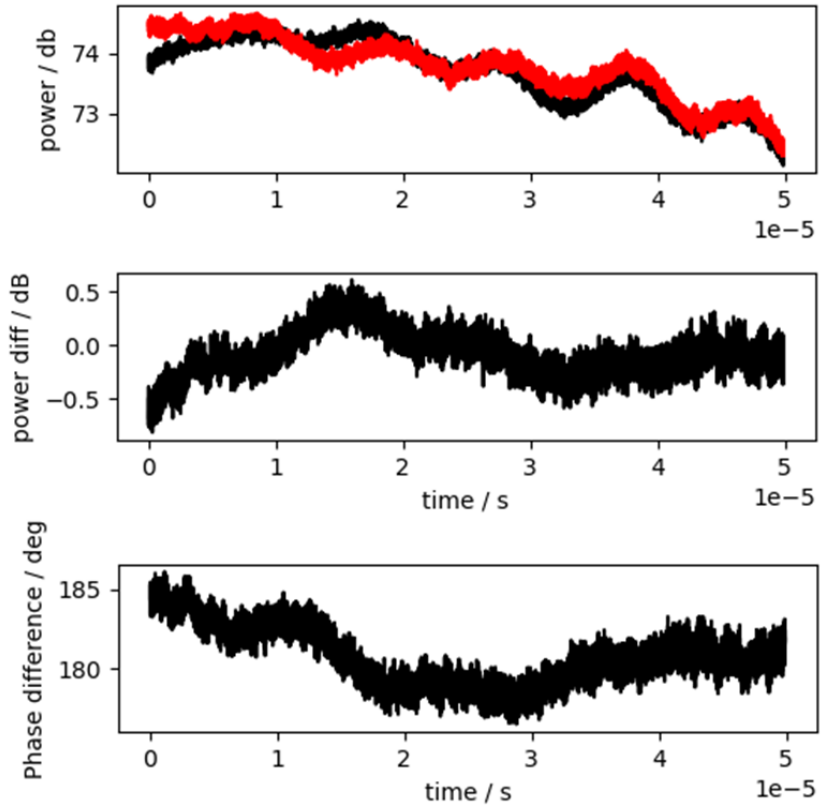
Missing offsets

Polarimetric Calibration – Part 2

Channel synchronization

1. Internal calibration of transponder
   - Tune attenuators in all paths
   - Correct magnitude, phase and delay offsets with FPGA
2. Reference beacon at 45° polarization
   - Signal should be the same for H and V polarization
3. Record data of both transponder channels
   - Offsets can be calculated from measured data
4. Repeat for second antenna

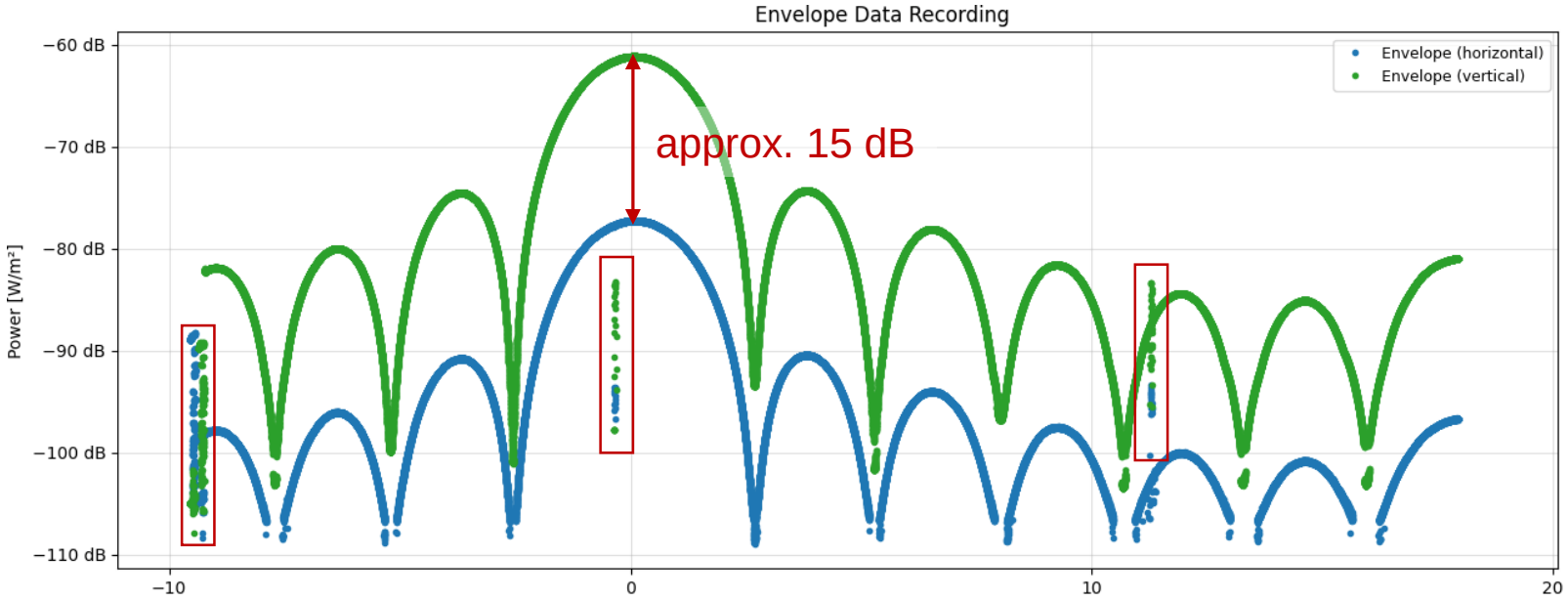
Results:



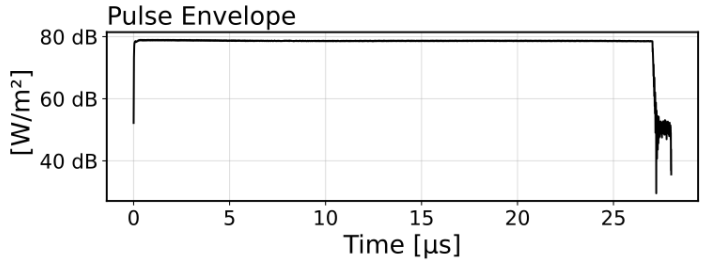
Remaining differences:
Power (mean): - 0.078 dB
Phase (mean): 180.74 deg

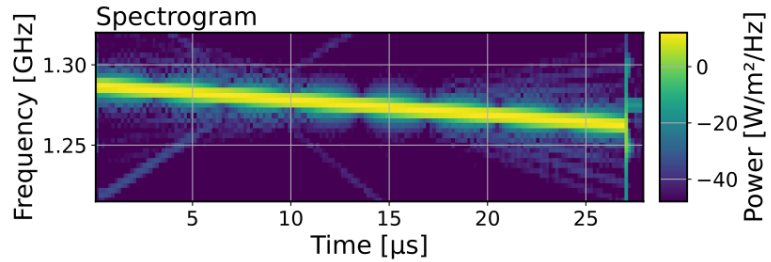
Acquisitions – SAOCOM

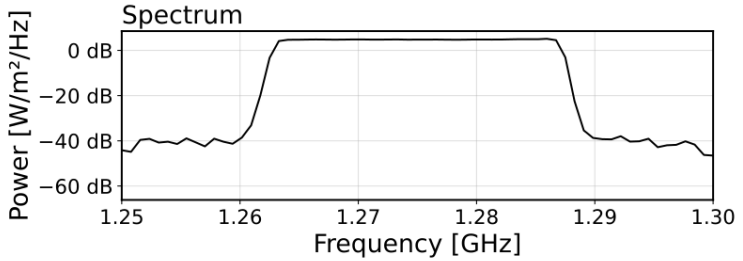
SAOCOM dual pol mode (TX: vertical)
TR not yet calibrated



Transponder:	lxbandprototype	Max. RMS value:	4999.5 ADc	4. Target Name:	targetVV
Center Time:	2024-08-24 17:22:04.539395 UTC	Mean PRF:	1857.010 Hz, σ: 0.267 Hz	4. Target Delay:	4.50 µs
Rx Channel:	l_horizontal	Mean Pulse Width:	27.082 µs, σ: 70.347 ns	4. Target RCS:	50.07 dBm²
Time of Maximum:	62.898 ms	1. Target Name:	targetHH	Alignment	100.4° az, 36.4°
Max. Power:	-77.25 dBW/m²	1. Target Delay:	2.50 µs		
Max. RMS value:	808.5 ADc	1. Target RCS:	50.01 dBm²		
Mean PRF:	1857.010 Hz, σ: 0.267 Hz	2. Target Name:	targetHV		
Mean Pulse Width:	27.057 µs, σ: 56.861 ns	2. Target Delay:	3.50 µs		
Rx Antenna Polarization:	l_horizontal: phi: 0.0 deg, tau: 0.0 deg	2. Target RCS:	50.31 dBm²		
Rx Channel:	l_vertical	3. Target Name:	targetVH		
Time of Maximum:	74.207 ms	3. Target Delay:	1.50 µs		
Max. Power:	-61.17 dBW/m²	3. Target RCS:	49.78 dBm²		







saocom

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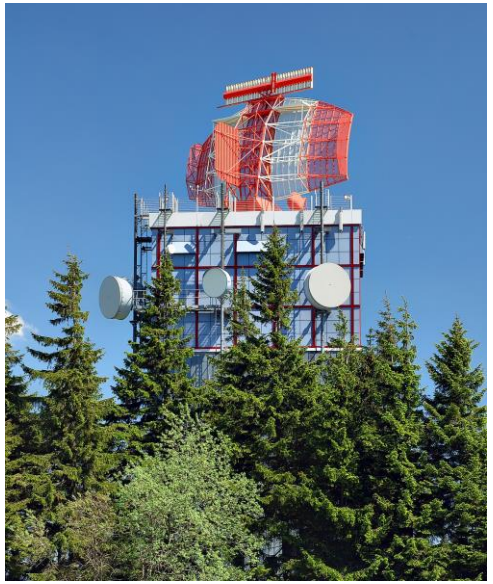
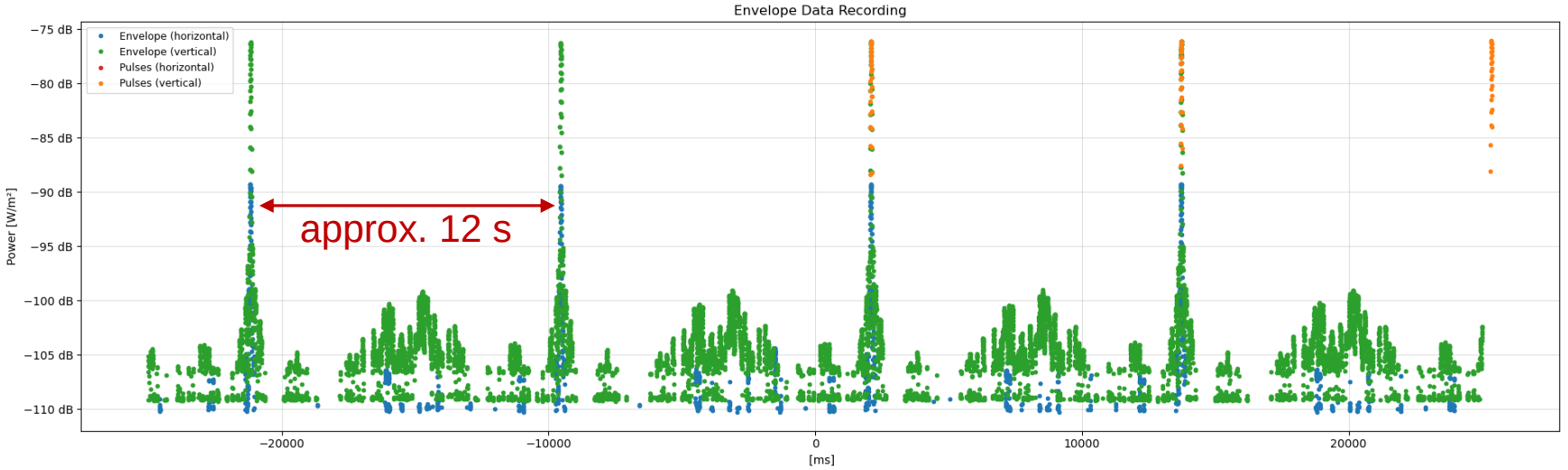
RFI

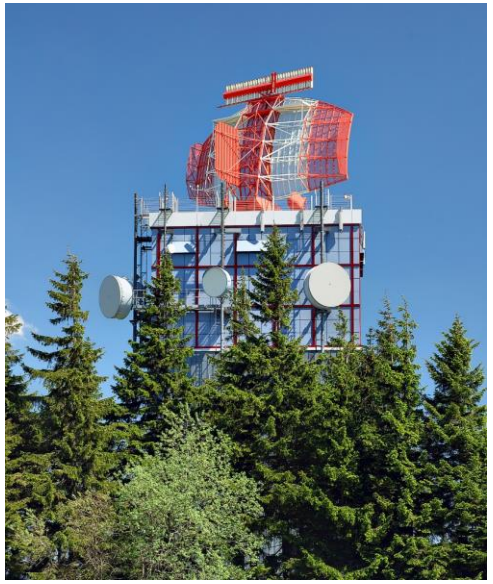

SRE-M Radar
LX Prototype
approx. 58km
Google Earth
Image © 2024 Airbus



RFI – SRE-M Radar

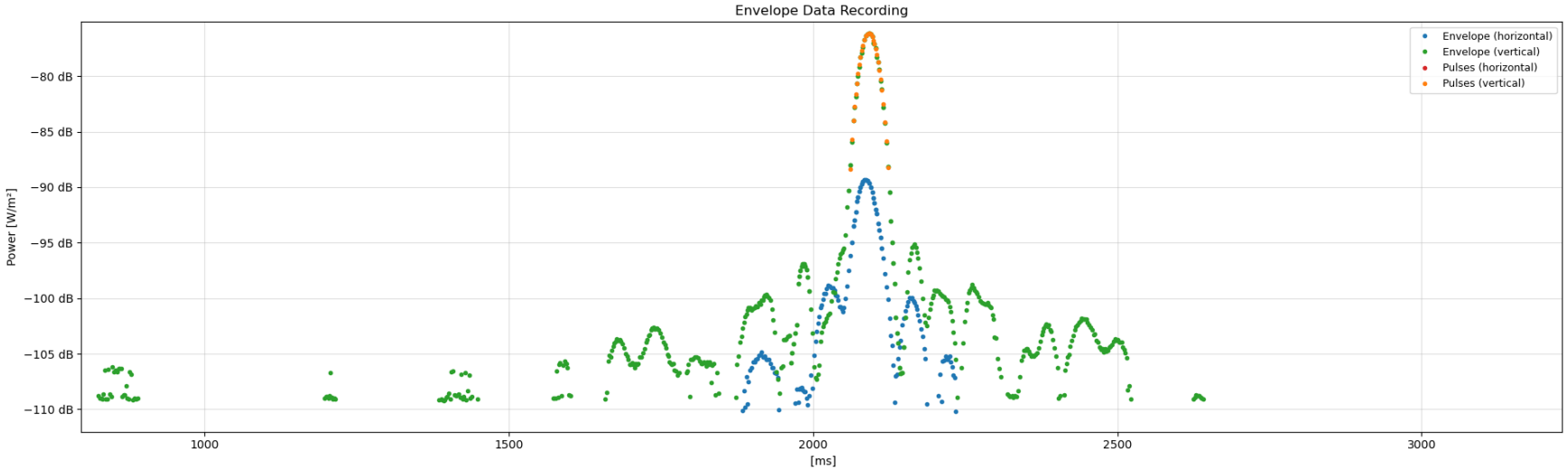


Transponder: lxbandprototype
Center Time: 2024-02-12 17:22:02.116343 UTC
Rx Channel: l_horizontal
Time of Maximum: -21172.450 ms
Max. Power: -89.28 dBW/m²
Max. RMS value: 256.5 ADc
Mean PRF: 2.635 Hz, σ: 126226.486 Hz
Mean Pulse Width: 1.751 µs, σ: 898.799 ns
Rx Antenna Polarization: l_horizontal: phi: 0.0 deg, tau: 0.0 deg
Rx Channel: l_vertical
Time of Maximum: 2092.184 ms
Max. Power: -76.10 dBW/m²
Max. RMS value: 1114.5 ADc
Mean PRF: 2.062 Hz, σ: 108.335 Hz
Mean Pulse Width: 2.262 µs, σ: 347.644 ns



Frequency range:	1250 – 1350	MHz
„Round-trip“ time:	11.60 – 11.80	s
Power:	> 2.5	**MW**

RFI – SRE-M Radar



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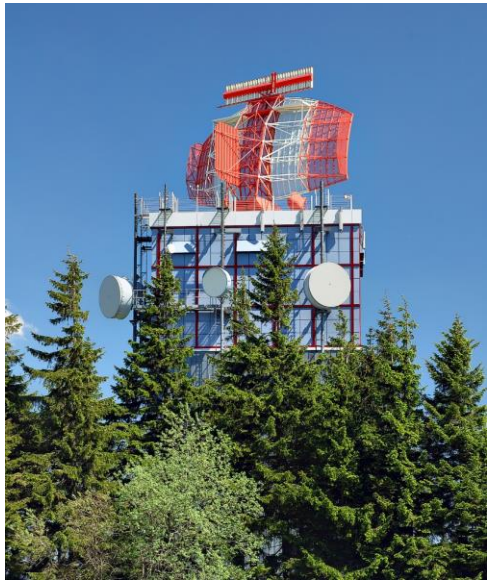
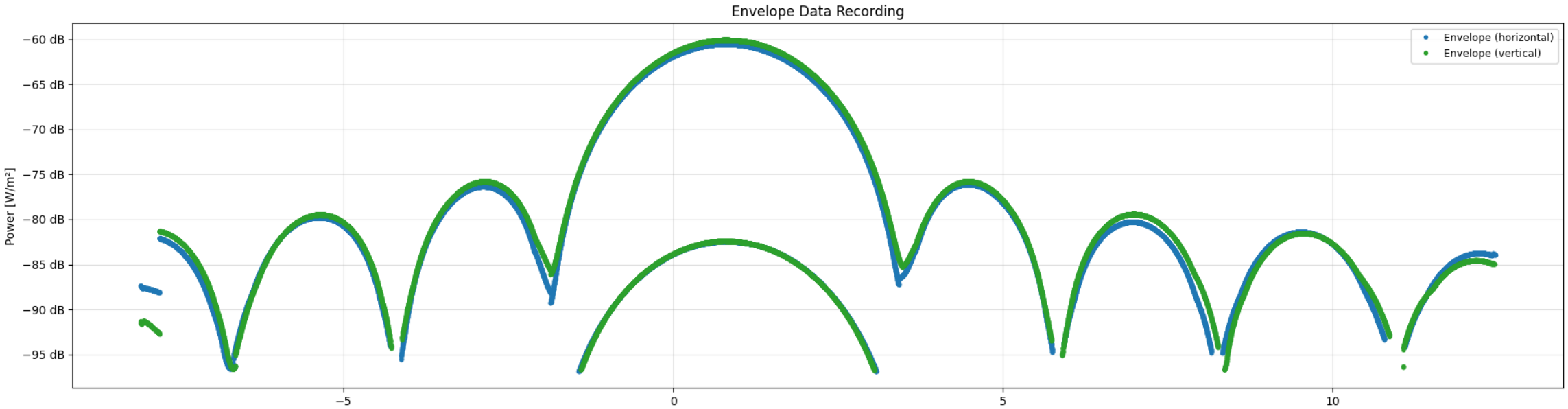


Frequency range:	1250 – 1350	MHz
„Round-trip“ time:	11.60 – 11.80	s
Power:	> 2.5	**MW**

Acquisitions – ALOS-2

ALOS-2 quad pol mode (TX: vertical, horizontal)
TR not yet calibrated



Transponder:	lxbandprototype	Mean PRF:	1305.198 Hz, σ: 0.136 Hz	4. Target Delay:	4.50 µs
Center Time:	2024-08-23 22:55:06.091211 UTC	Mean Pulse Width:	25.824 µs, σ: 78.430 ns	4. Target RCS:	50.15 dBm²
Rx Channel:	l_horizontal	1. Target Name:	targetHH	Alignment	258.3° az, 27.2° inc
Time of Maximum:	764.729 ms	1. Target Delay:	2.50 µs		
Max. Power:	-60.55 dBW/m²	1. Target RCS:	50.06 dBm²		
Max. RMS value:	5167.5 ADc	2. Target Name:	targetHV		
Mean PRF:	1305.198 Hz, σ: 0.136 Hz	2. Target Delay:	3.50 µs		
Mean Pulse Width:	25.816 µs, σ: 76.378 ns	2. Target RCS:	50.40 dBm²		
Rx Channel:	l_vertical	3. Target Name:	targetVH		
Time of Maximum:	834.834 ms	3. Target Delay:	1.50 µs		
Max. Power:	-60.08 dBW/m²	3. Target RCS:	49.82 dBm²		
Max. RMS value:	5287.0 ADc	4. Target Name:	targetVV		

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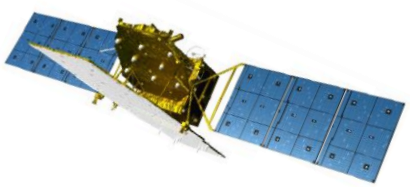

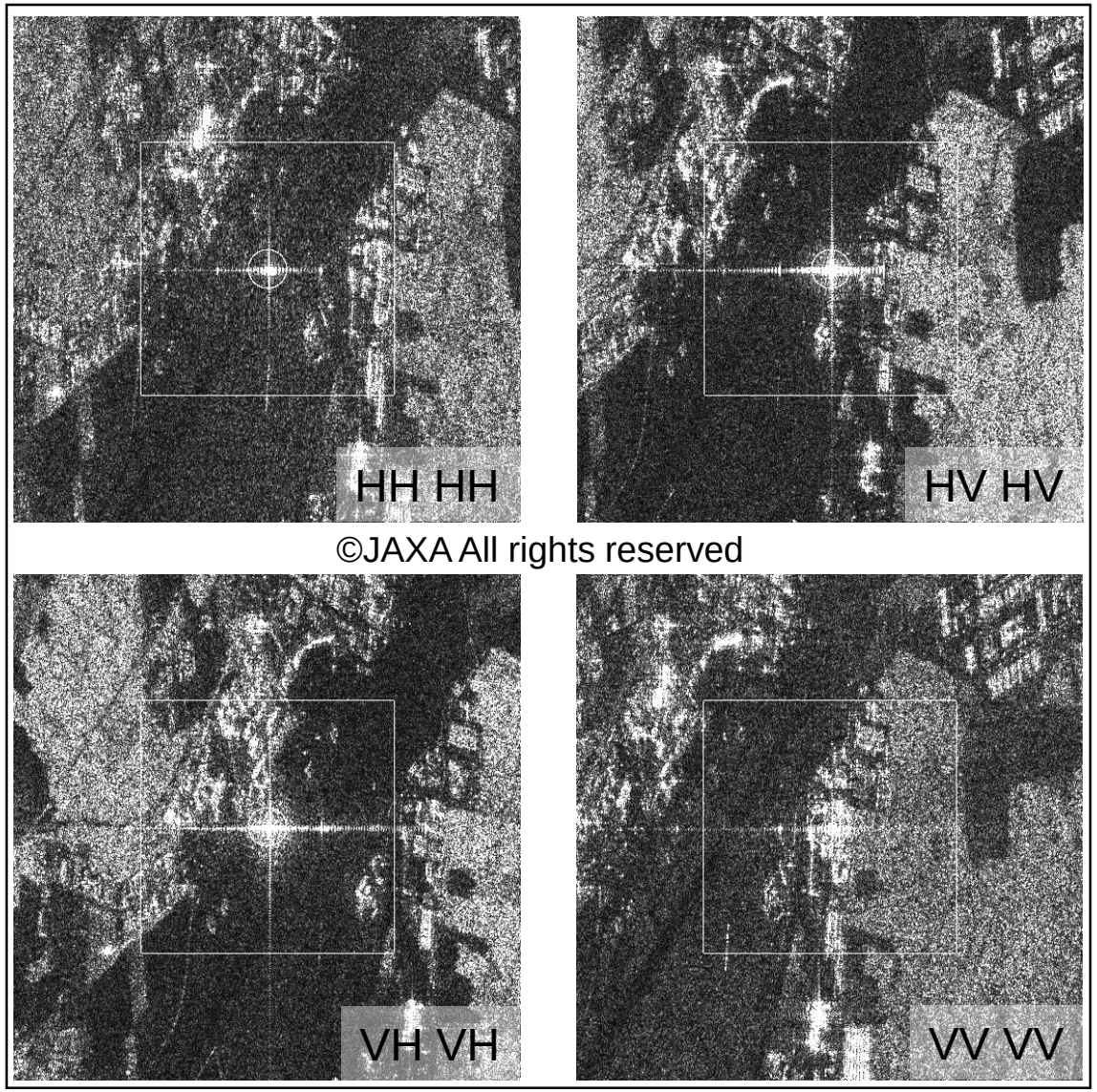

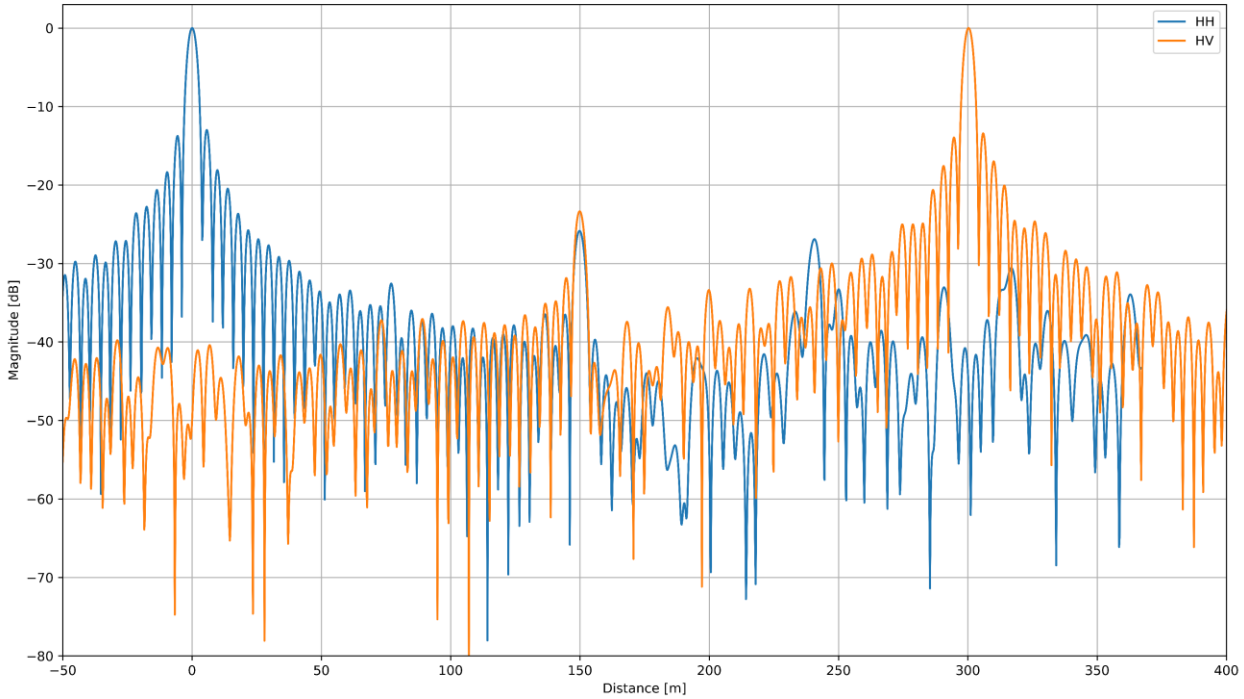

1 acquisition → 4 polarimetric signatures

Conclusions

- Successfull deployment of dual-band transponder at DLR
- Performed external polarimetric calibration
- First iteration of radiometric calibration („3TM“) has been completed (analysis ongoing)
- Successfull polarimetric SAR acquisitions with dual-band transponder and various missions