Installation and calibration of a phase shifter at the DWD Hohenpeißenberg research radar

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Introduction

- C-Band EEC DWSR5001C/SDP
- STAR-mode
- no means to control the TX phase

- November 2020: phase-shifter kit from EEC was integrated into MHP radar

Why integrating a phase shifter in the research rardar:

- optimal usage of CDR (-Proxy DR)
- new options for microphysical retrievals (riming, hail size detection)

- assess data quality issues related to PHIDP in the radar network

Calibration of phase shifter

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After the installation of the phase shifter:

- near field calibration with horn antenna
- far field calibration with horn antenna

Sequence of of measurements

LDR (linear) / STAR (linear) / CDR (circular, 90° phase) - Mode

Schematic picture

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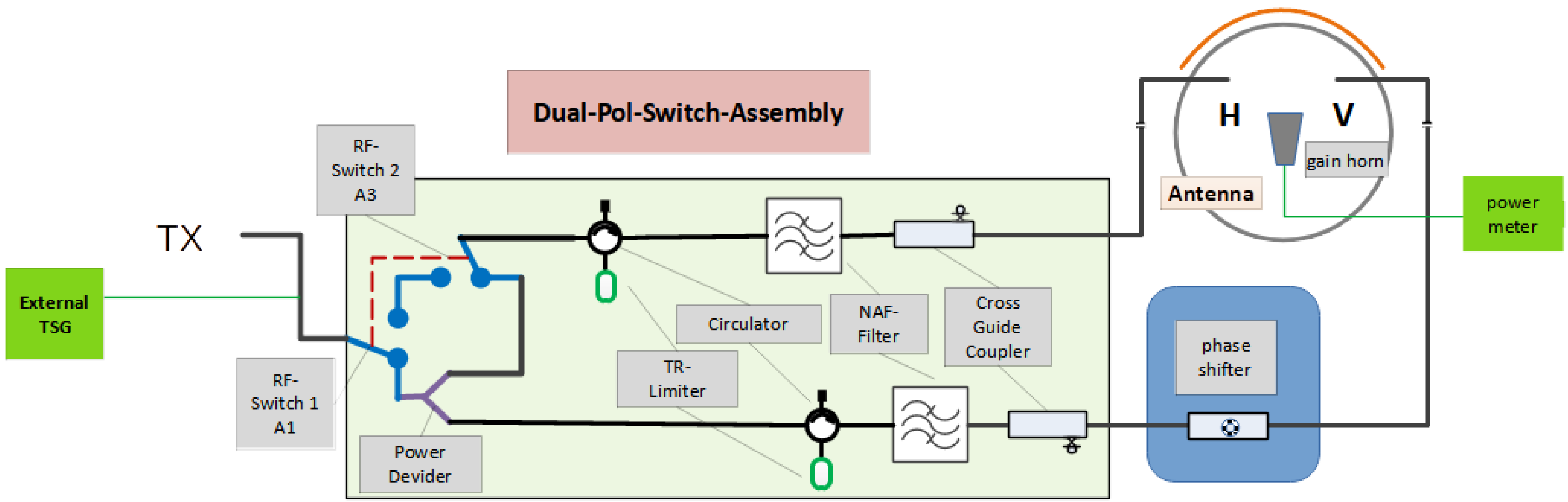
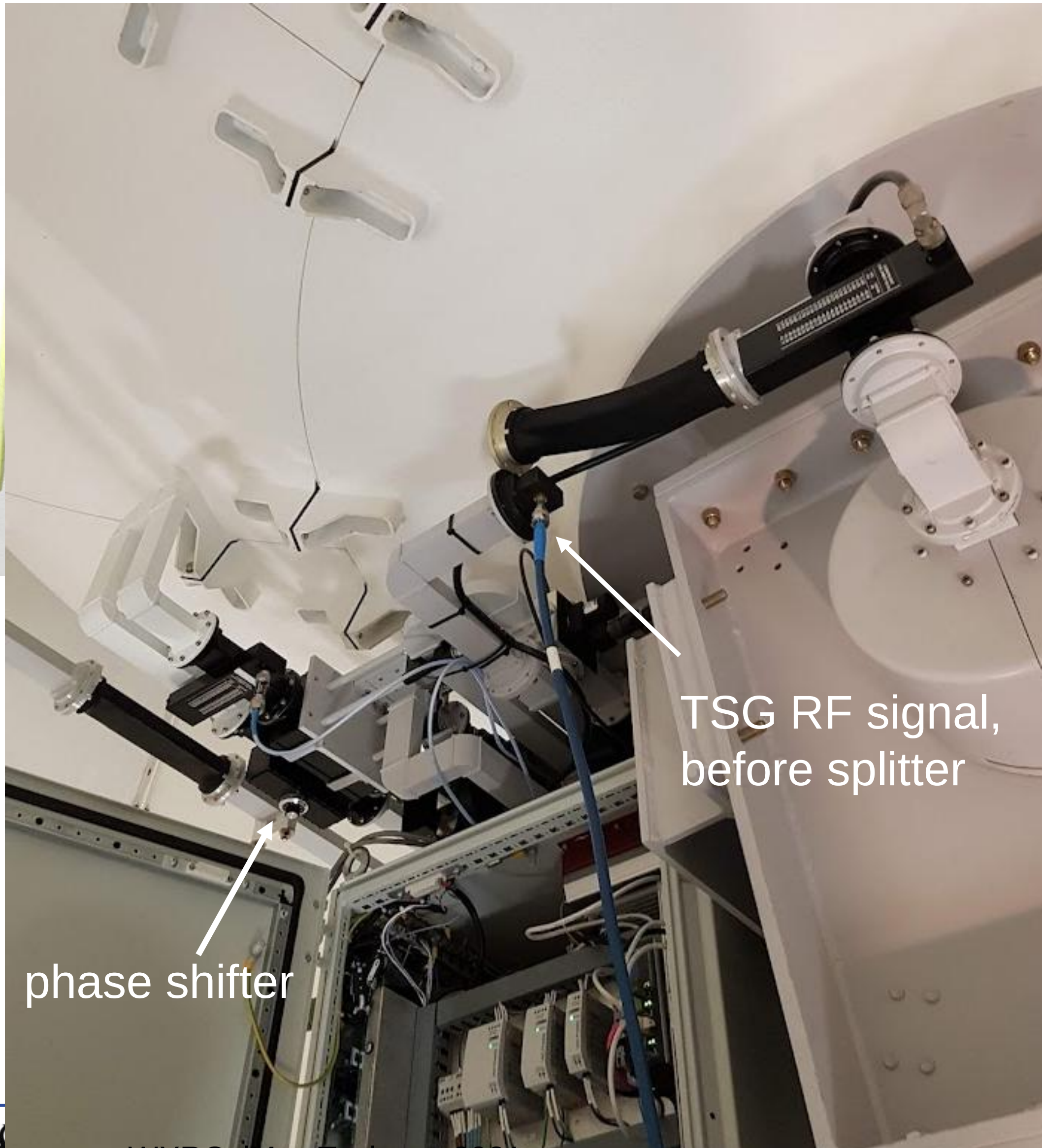
setup of near field adjustment of the phase shifter



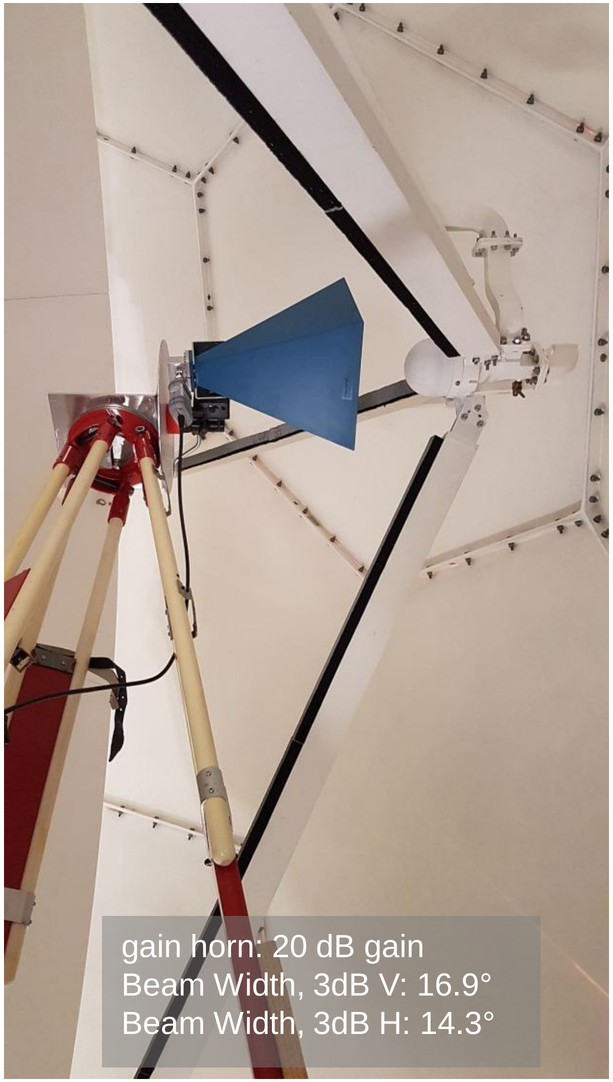
The phase shifter

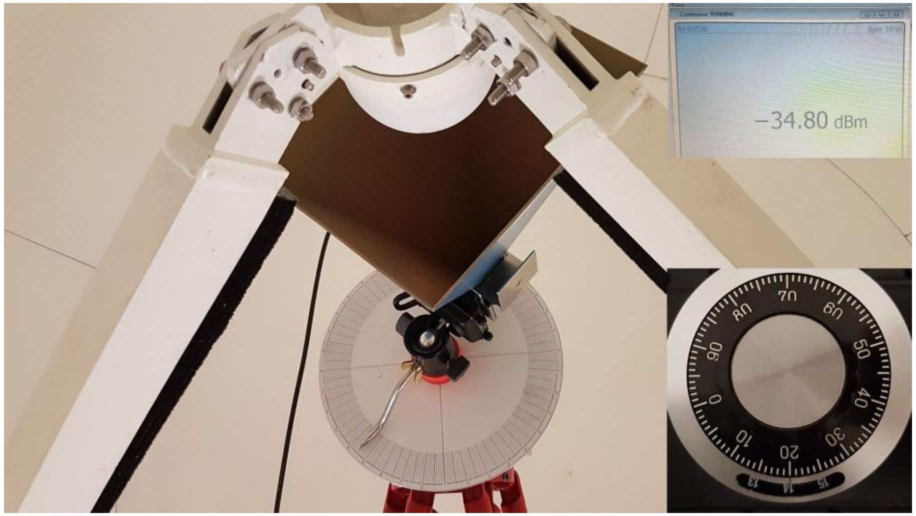


additional wave guide loss due to phase shifter: 0.2 dB

phase shifter allows phase settings between 0° and 180°
nominal accuracy: ~ 1°

phase shifter near field adjustment





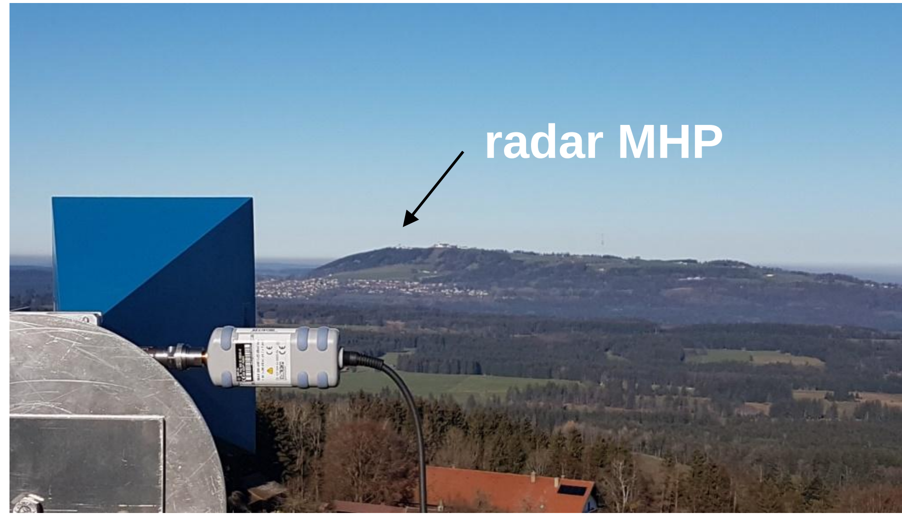
Feed horn @ 45°
systematic adjustment of phaseshifter to obtain minimum power

LDR-Mode: -34.8 dBm

STAR-Mode: -30 dBm

peak power in STAR-Mode: -3 dBm

Far field measurements

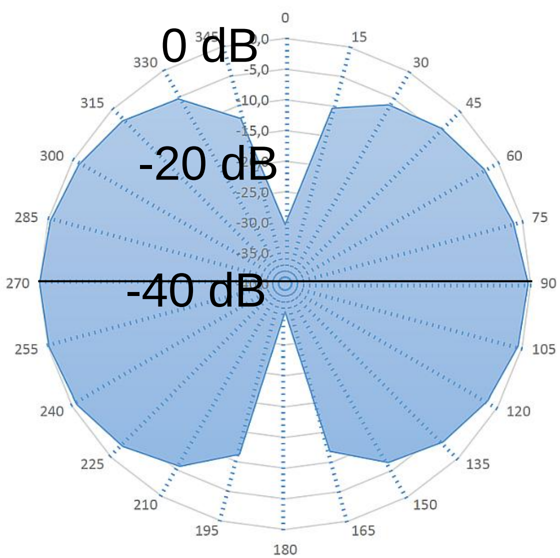


distance to radar : 8.42 km
azimuth 169°, elevation -0.6°

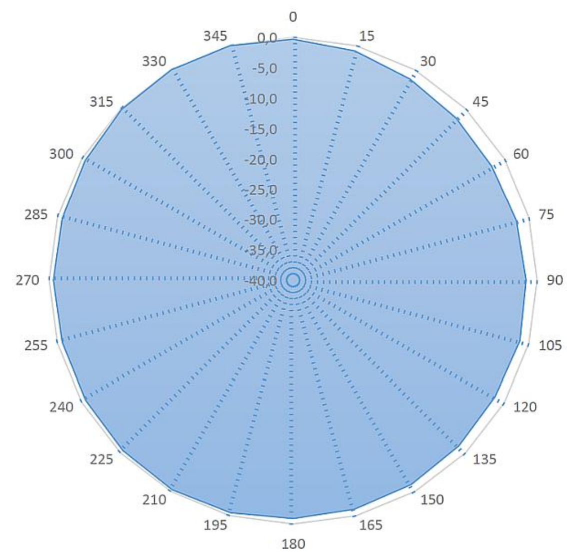
measurement sequence:
radar transmits in LDR / STAR / CDR / STAR mode
on the receiving side: power measurement with gain horn, rotation of gain horn in 15° steps.

Far field results

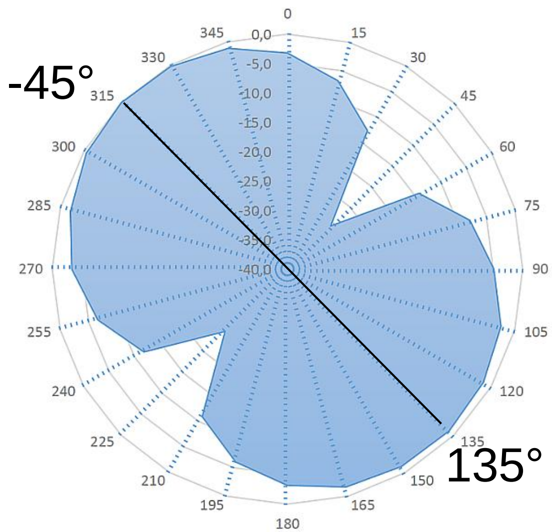
LDR (TX phase 0°)



CDR (TX phase 90°)



STAR (TX phase 0°)



log scale representation

expected power distribution.

weather data: CDR/STAR mode data only

Weather data

Experimental data of a precipitation event (29.9.2021)

typical sequence: two ppi @ 0.8 followed by two RHI @ az = 90°

TX phase settings: 0° – 10° – 20° – 40° – 70° – 90° – 70° – 40° – 20° – 10° – 0°

ZDR calibration verified by birdath data: -0.05 dB

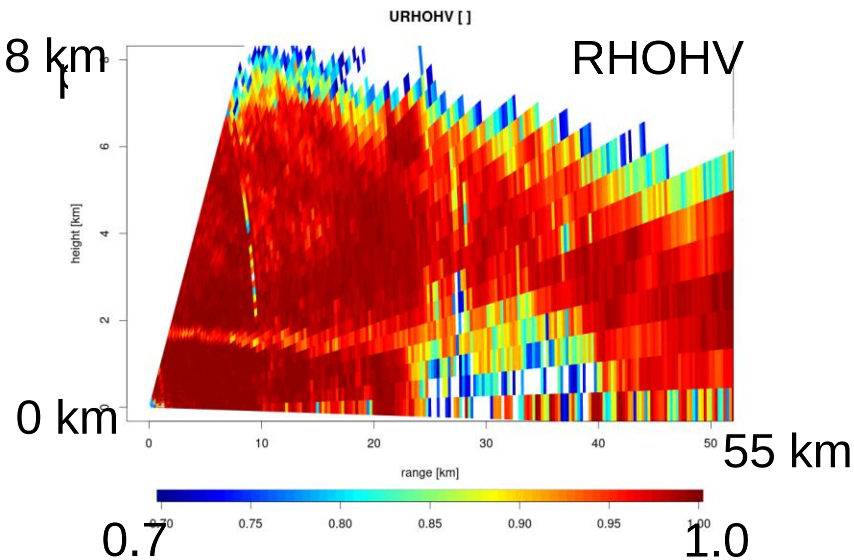
Weather: stratiform rain, melting layer at ~ 1800 m above the radar

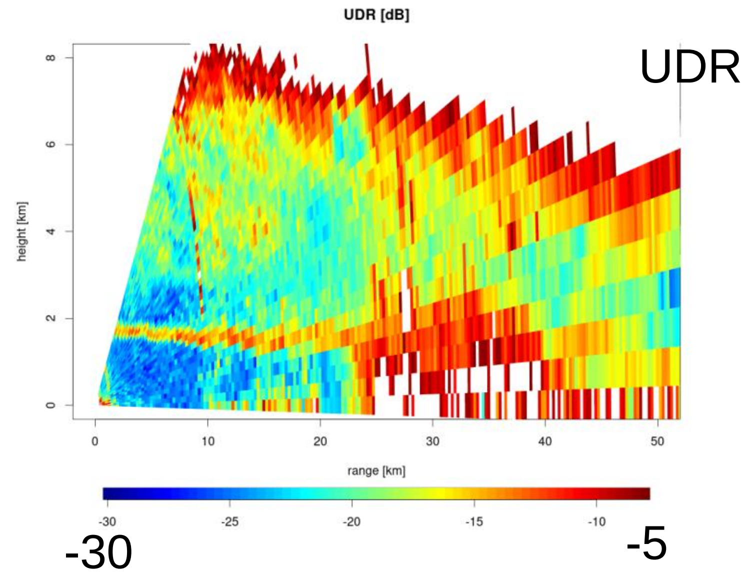
Depolarization ratio
(Ryzhkov et al., 2017)

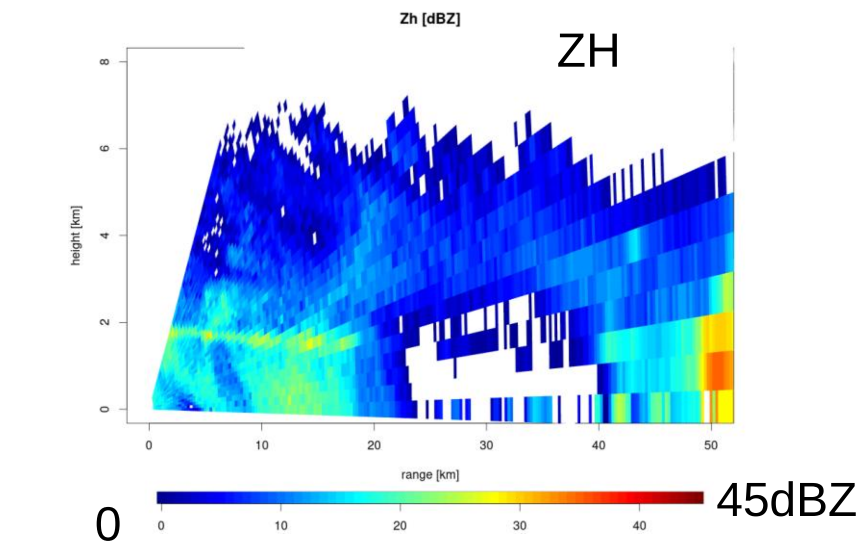
$$D_r = \frac{1+Z_{dr}^{-1}-2\rho_{hv}Z_{dr}^{-1/2}}{1+Z_{dr}^{-1}+2\rho_{hv}Z_{dr}^{-1/2}}$$

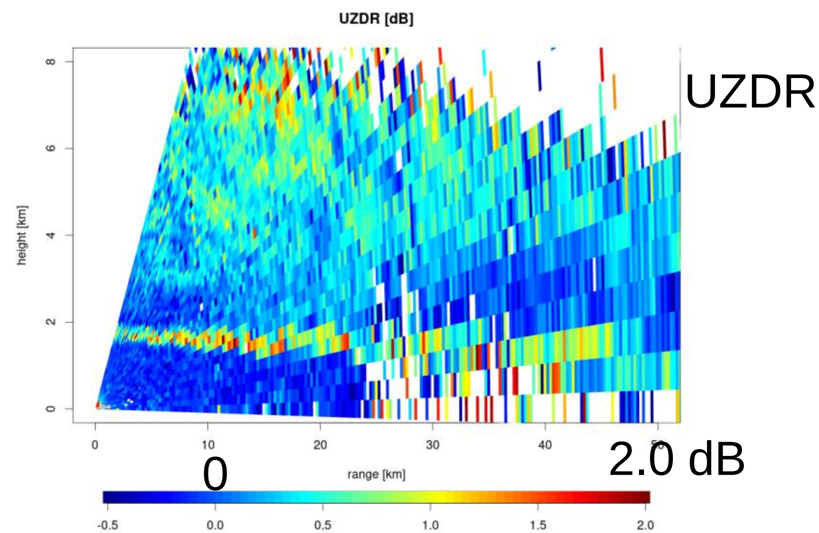
$$UDR = 10log_{10}(D_r)$$

Weather data: RHI, STAR mode









Weather data

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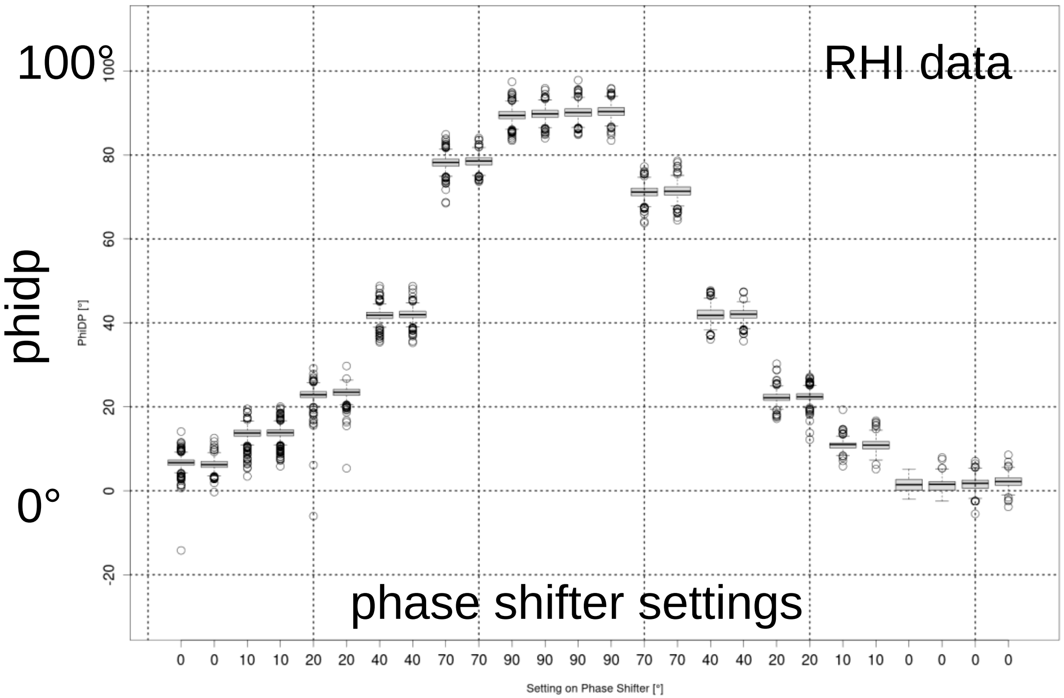

0°-10°- 20°- 40°–70° - 90° - 70°-40°-20°-10° 0°

- overall expected phase variation
- however, differences up to 10° for identical settings; further investigations are needed
- possibly wet radome effect visible

example difference (0°):

in the beginning: 6°
at the end: 1.5°

average over first 20 valid range bins with:
SNR > 10 dB
RHOHV > 0.9

UDR as a function of UZDR

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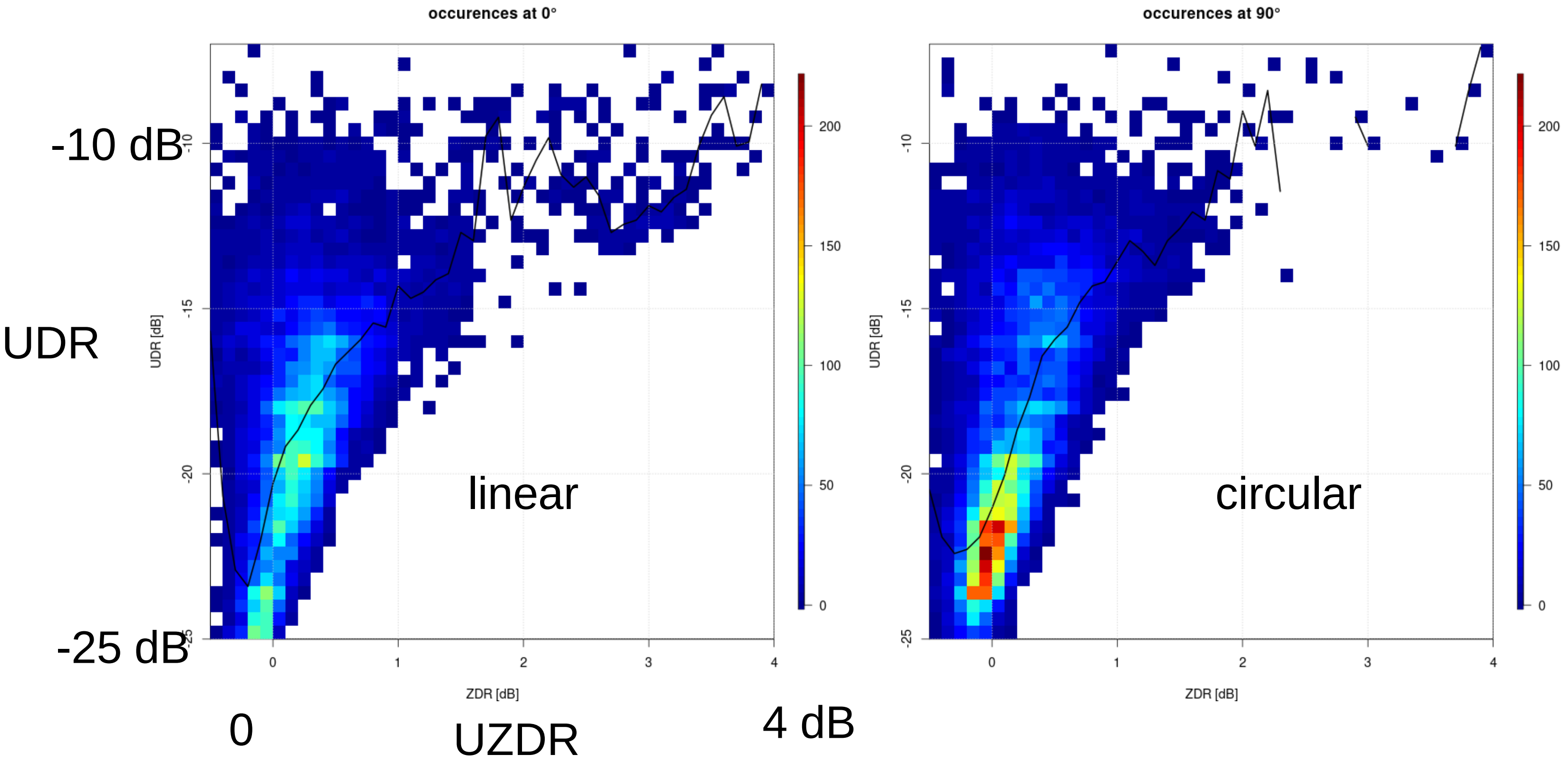
from RHI data, 10 < Zh < 30 dBZ, RHOVH > 0.8



about 3 dB larger UDR values for circular polarization, consistent with Ryzhkov, et al. 2017

Conclusions

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- a phase shifter has been implemented in the Hohenpeißenberg research radar
- TX phase adjustment using a gain horn measurement in near field of the feed and in the antenna far field (LDR / STAR / CDR- mode)
- First evaluation using weather data gave insights in the usage of the the phase shifter, further case studies are needed.
- Investigations on DR (CDR) measurements for microphysical retrievals (e.g. riming, hail size) are under way.
- DR as a CDR proxy is computed in the signal processor; it will be available with next the SW release for the DWD radar network,

Literature:

Q. Cao, M. Knight, A. V. Ryzhkov, P. Zhang and N. E. Lawrence, "Differential phase calibration of linearly polarized weather radars with simultaneous transmission/reception for estimation of circular depolarization ratio," in *IEEE Transactions on Geoscience and Remote Sensing*, vol. 55, no. 1, pp. 491-501, Jan. 2017

Ryzhkov, A., Matrosov, S. Y., Melnikov, V., Zrnic, D., Zhang, P., Cao, Q., Knight, M., Simmer, C., & Troemel, S. (2017). Estimation of Depolarization Ratio Using Weather Radars with Simultaneous Transmission/Reception, *Journal of Applied Meteorology and Climatology*, *56*(7), 1797-1816.