

Reflectivity calibration of complex waveforms with WRS400

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VAISALA

Vaisala WRS400 X-band / SSPA

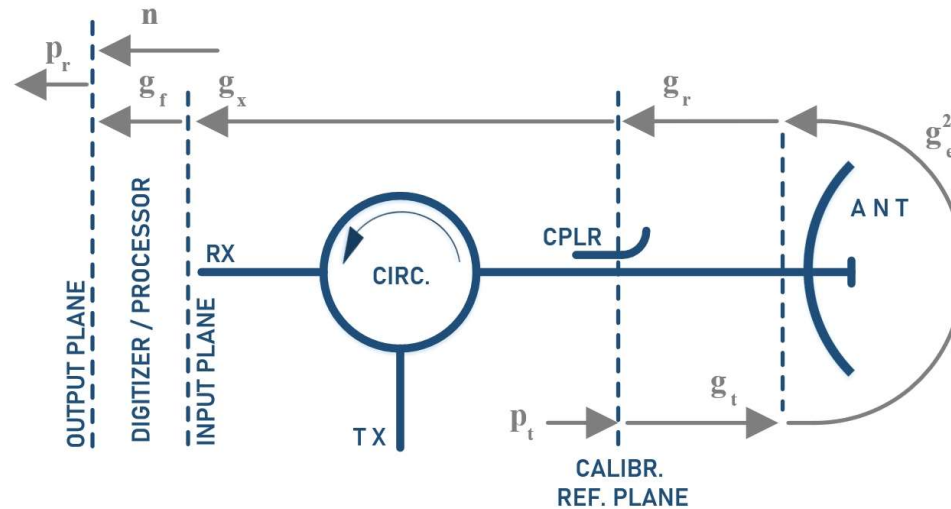


< 1.0°
45 dB
400W
90µs
NLFM
370kg

General

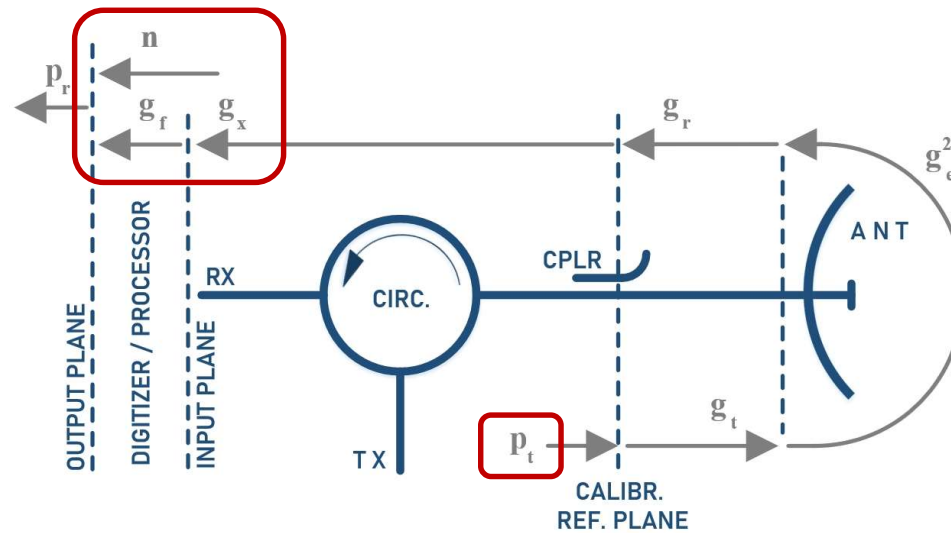
$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$

Calibration reflectivity Z_0



General

$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



Pulse energy

$$z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$

Thermal RF power sensor



Pulse energy

$$z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$

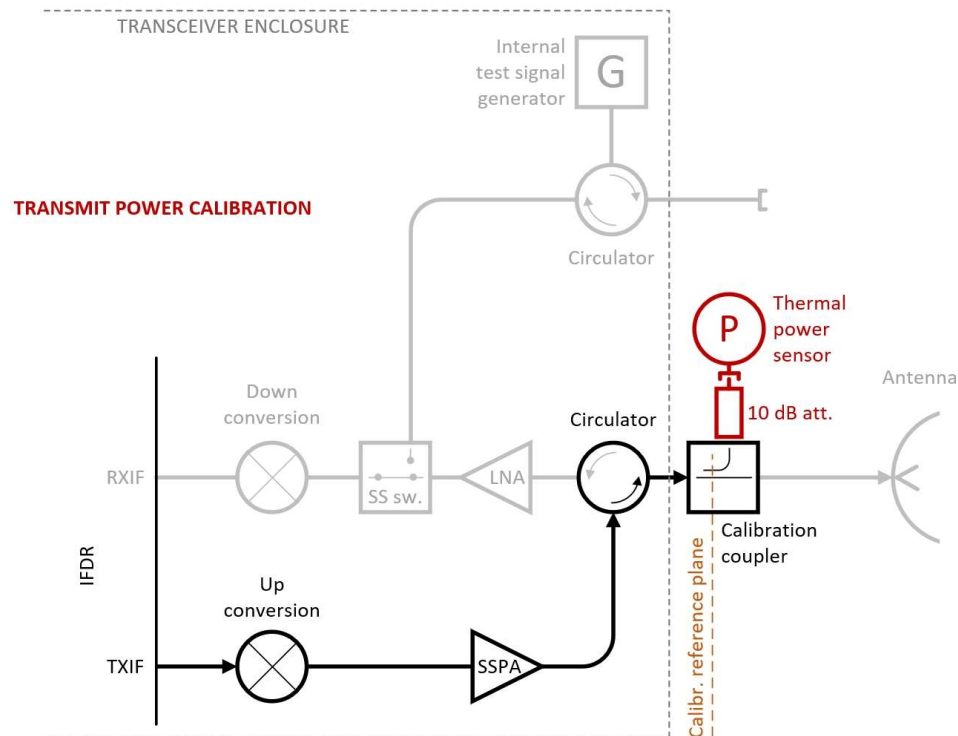
Energy of the pulse

(independent of exact length, shape
or waveform of the pulse)

$$e_p = p_t \tau = \frac{p_{ave}}{f_p \tau} \tau = \frac{p_{ave}}{f_p}$$

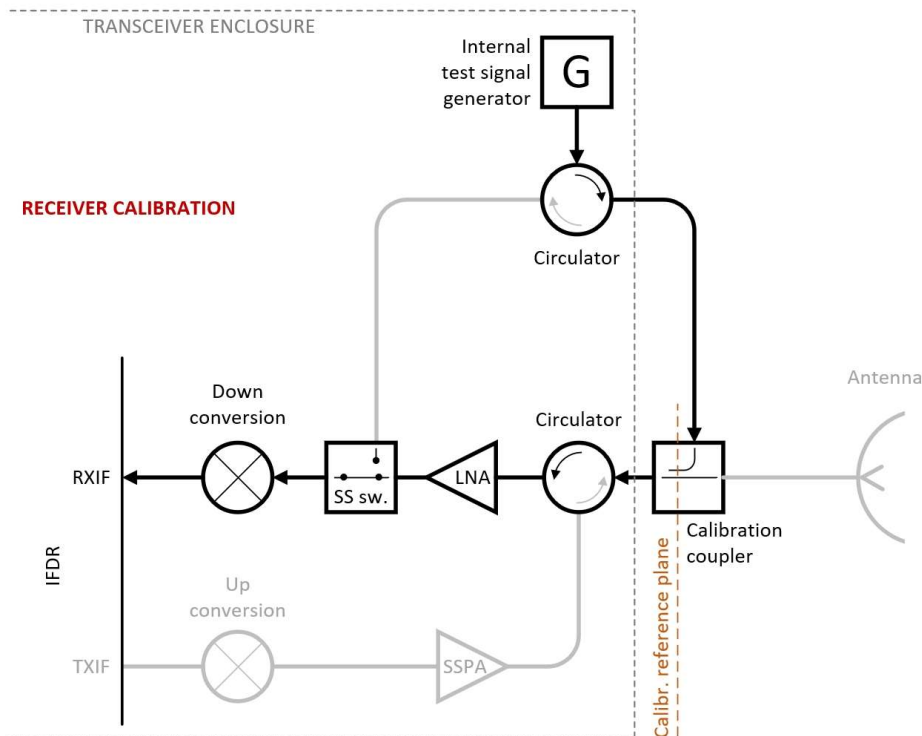
Pulse energy

$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



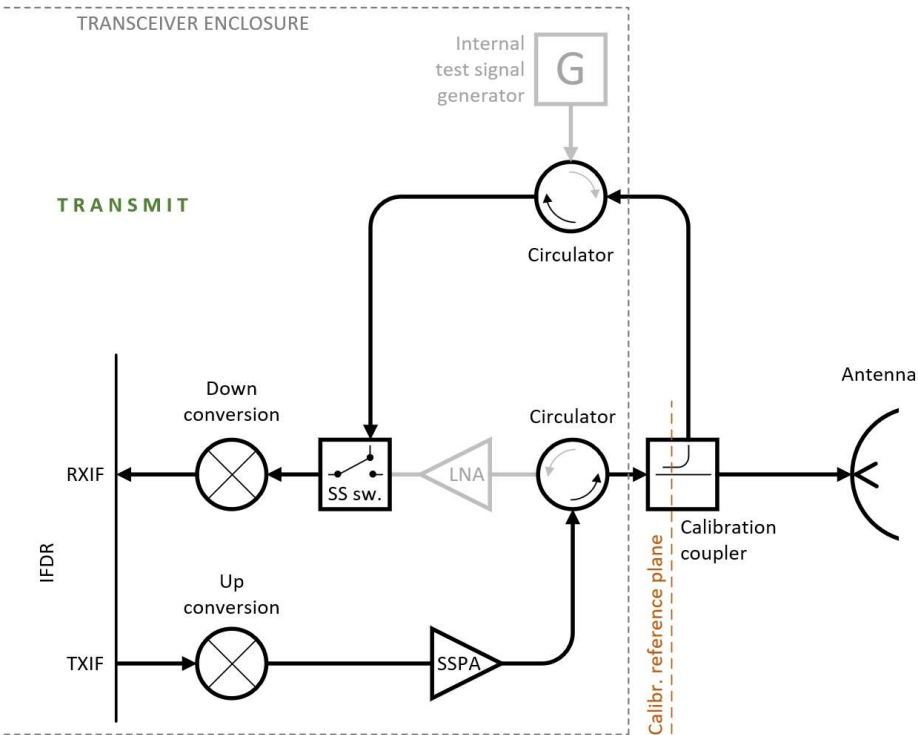
Analog gain of the receiver

$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



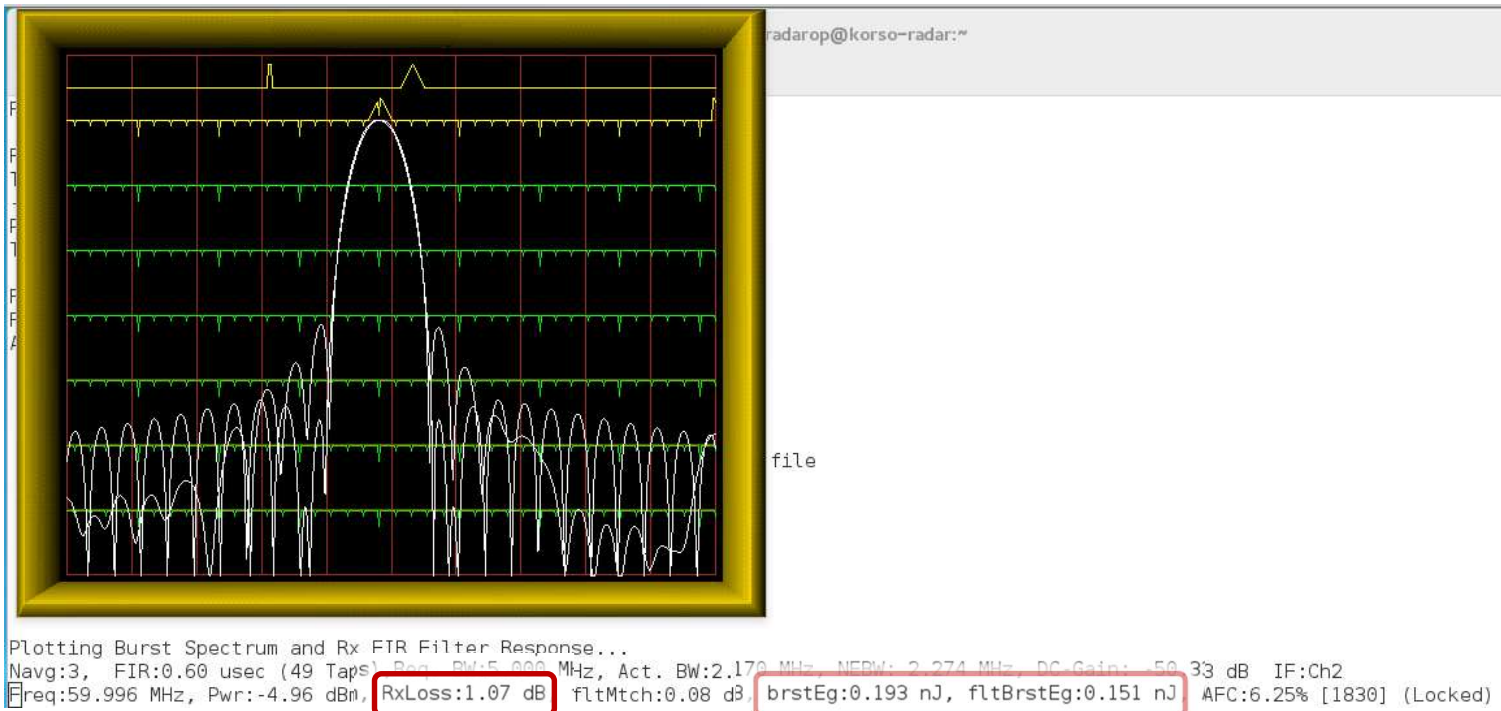
Digital filter loss

$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



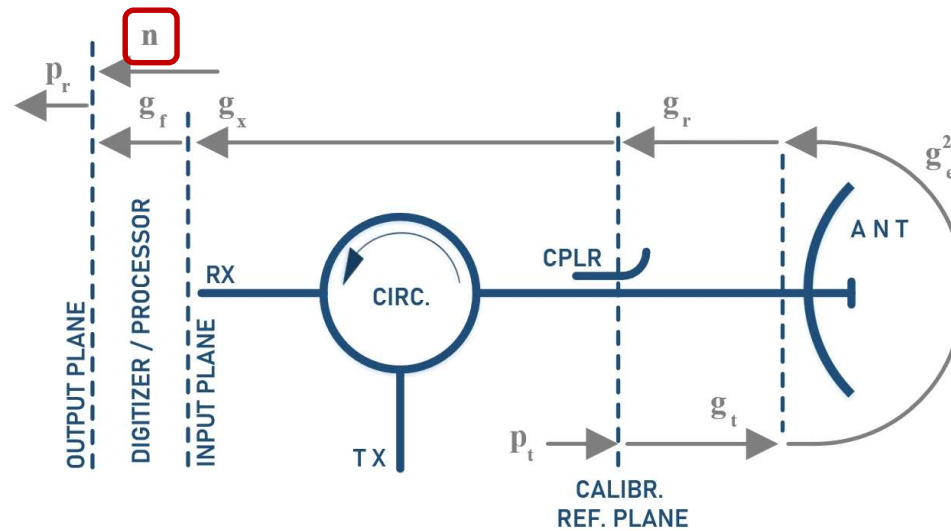
Digital filter loss

$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



Noise

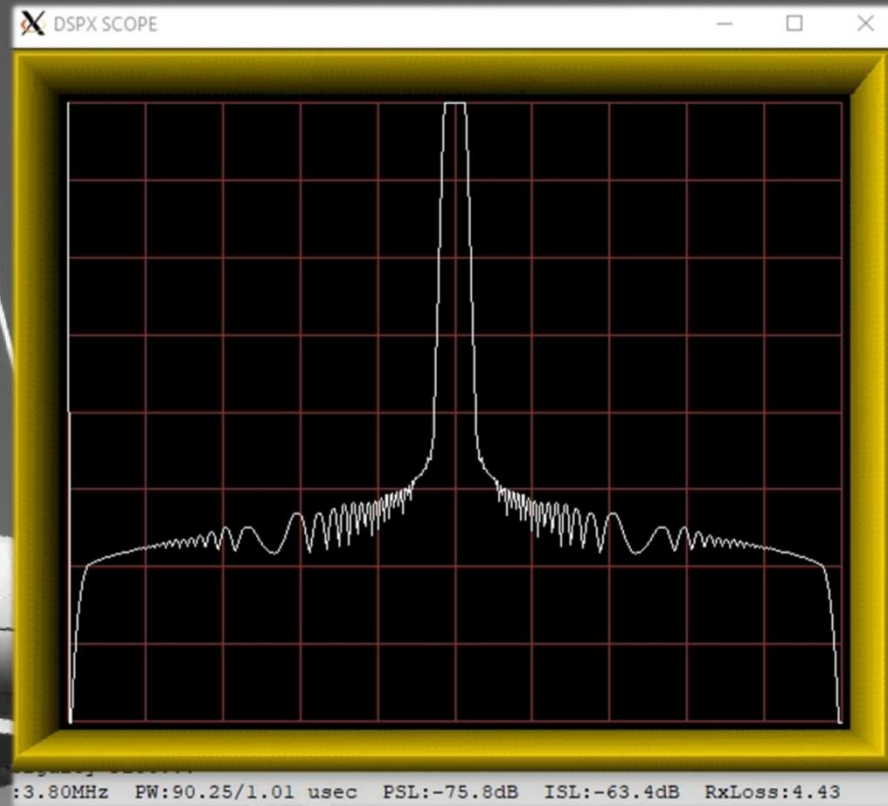
$$Z = \frac{p_r - n}{n} \frac{r^2}{r_0^2} \frac{1024 \ln(2)}{c \pi^3 |K|^2} \frac{\lambda^2 r_0^2 n}{p_t \tau g_t g_e^2 \theta \phi g_r g_x g_f}$$



WRS400 test case



WRS400 test case



Pulse length / us	Frequency / GHz	Modulation	BW / MHz	PSL / dB	ISL / dB	Range res. / m
4.0	9.648	CW	--	--	--	600 (150)
90.0 (→ 1.0)	9.652	NLFM	3.80	-75.8	-63.4	150

Calibration 2021-09-20

WRS400 test case

	CW	NLFM	
τ	4.0	90.0	<i>us</i>
p_t	0.48	0.41	<i>kW</i>
e_p	1.9	36.9	<i>mJ</i>
g_x	33.5	33.2	<i>dB</i>
g_f	-0.85	-4.60	<i>dB</i>
n	-82.2	-82.4	<i>dBm</i>
NEBW	0.42	0.41	<i>MHz</i>
Z_0	-33.1	-42.0	<i>dBZ</i>

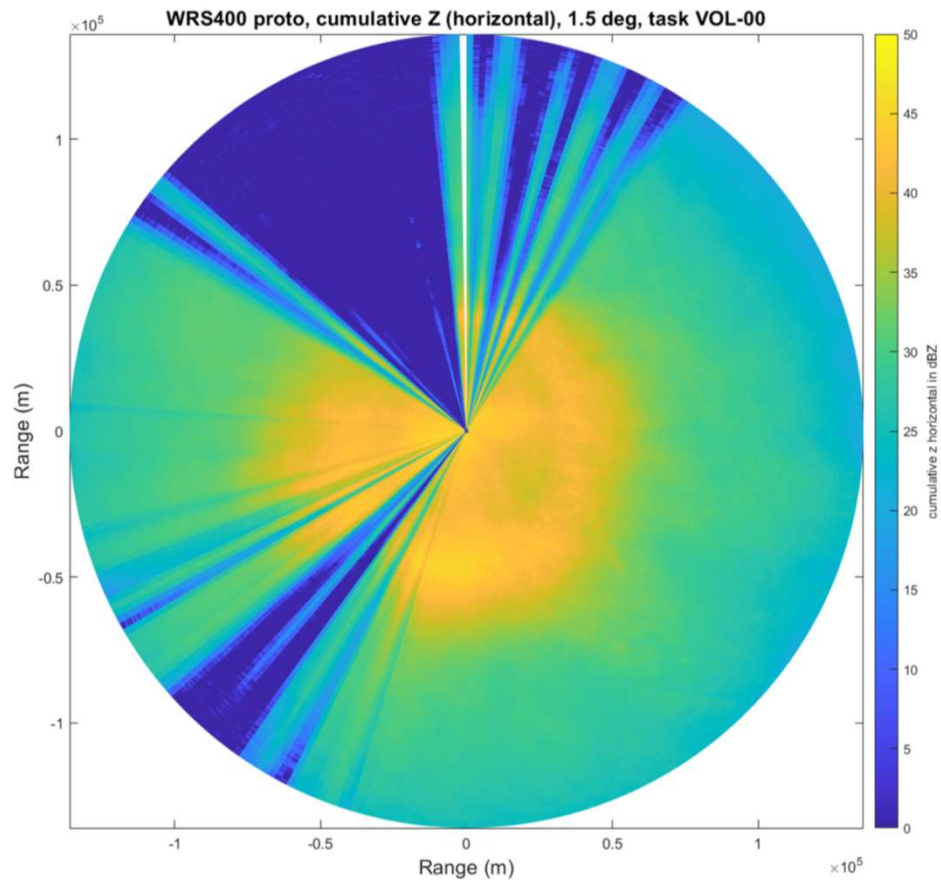


WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28...130km)
VOL-00	1.5°, full sweep	32	1000	150	4.0us	90.0us (→ 1.0us)

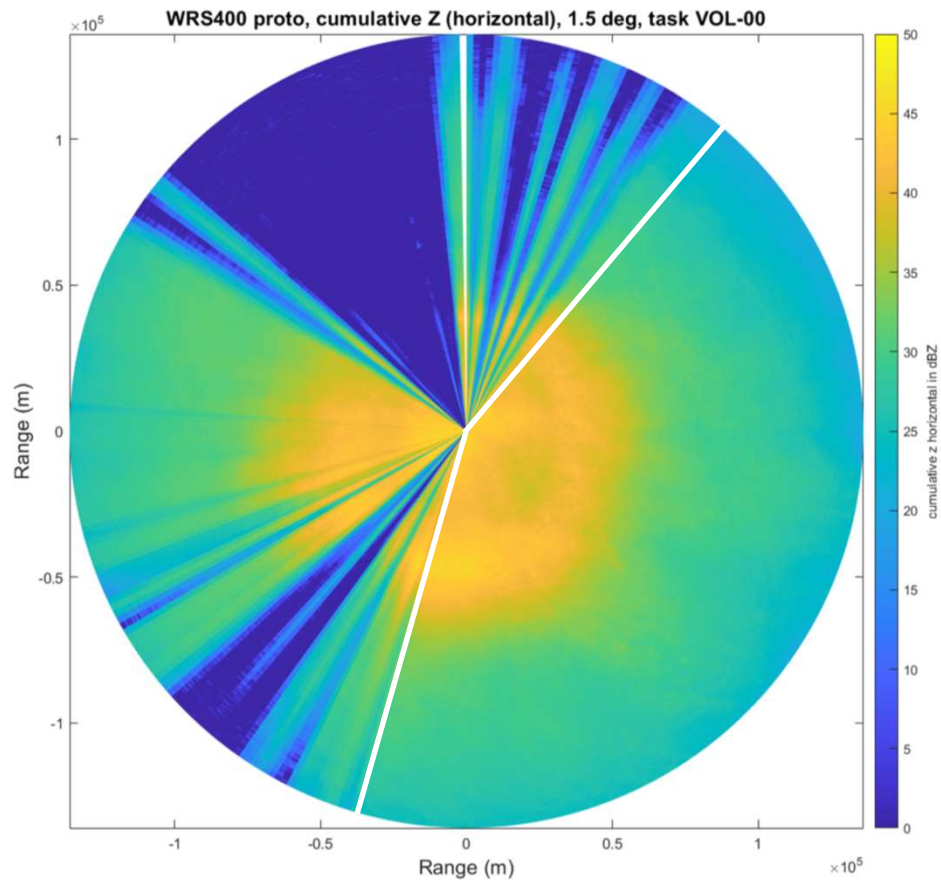
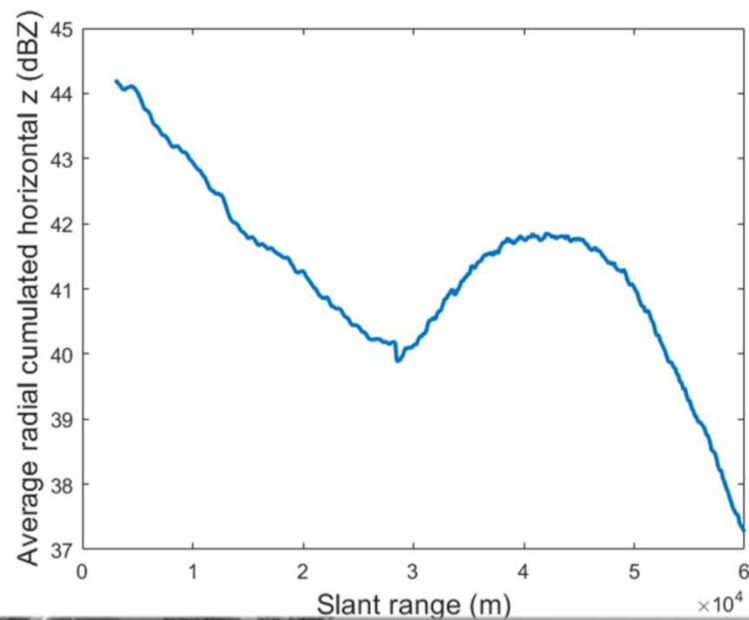
WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28...130km)
VOL-00	1.5°, full sweep	32	1000	150	4.0us	90.0us (→ 1.0us)

Cumulative Z from 290 sweeps between September 23rd and 25th 2021

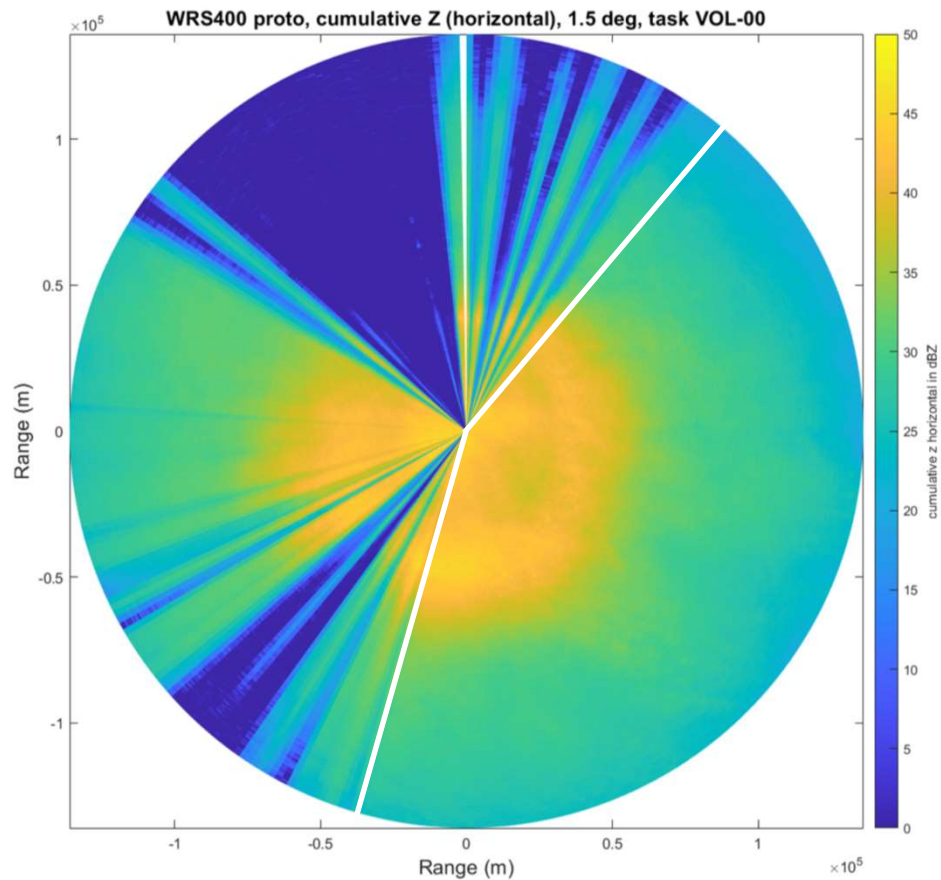
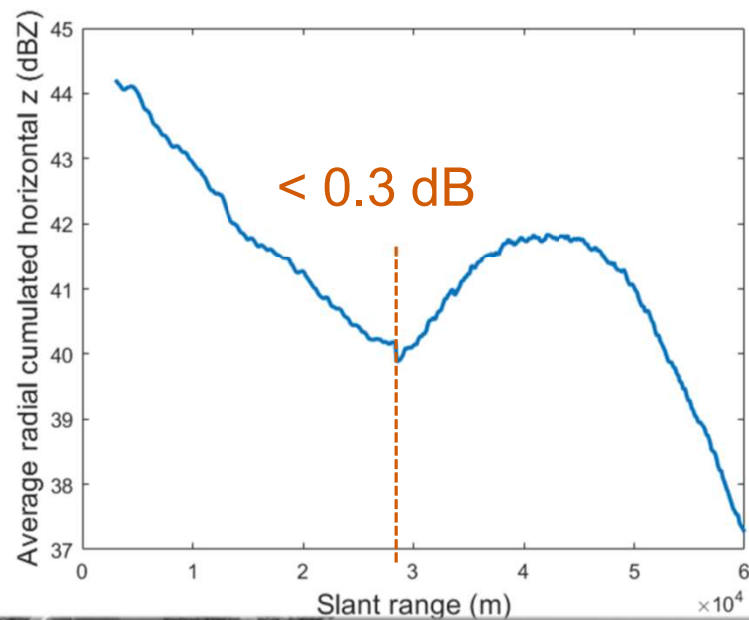
WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28...130km)
VOL-00	1.5°, full sweep	32	1000	150	4.0us	90.0us (→ 1.0us)

Averaged radial cumulative Z at azimuth sector 40°...195°

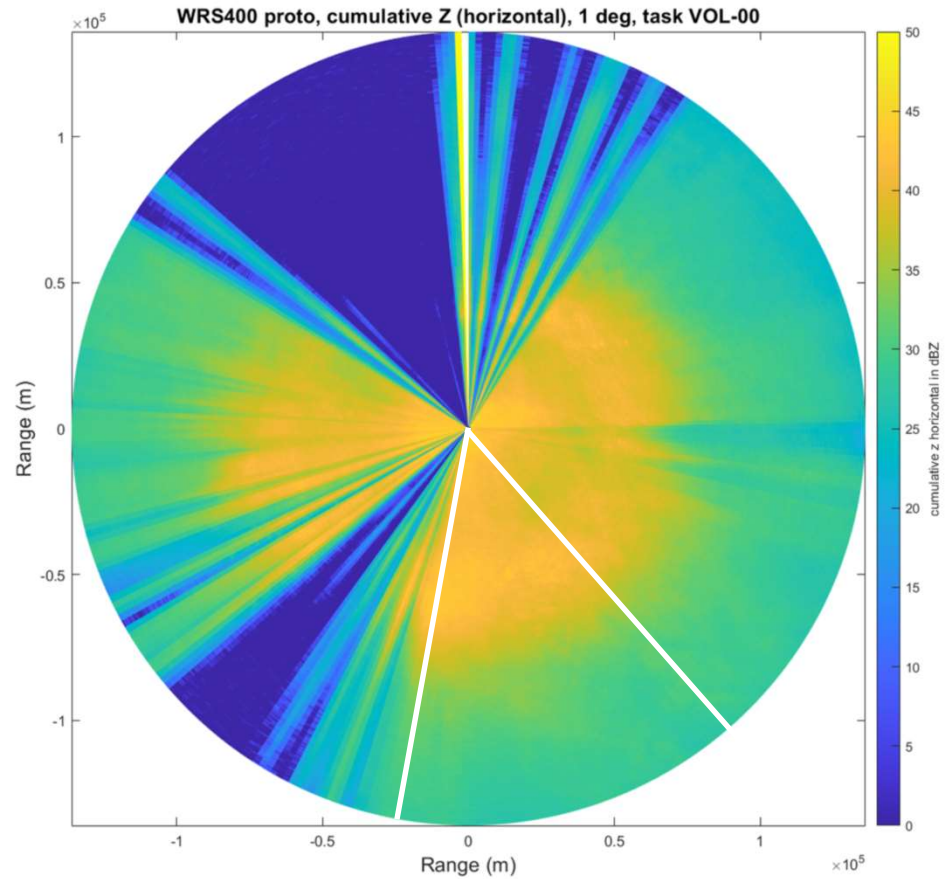
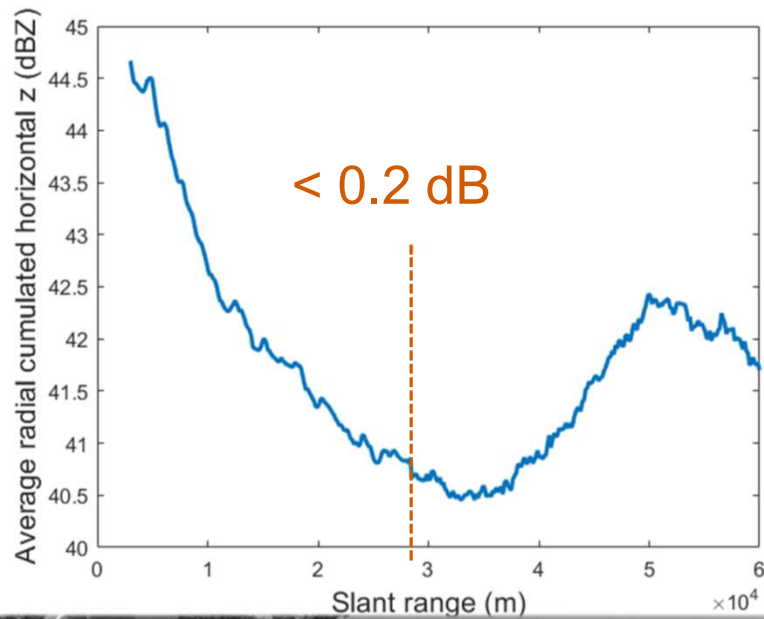
WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28...130km)
VOL-00	1.5°, full sweep	32	1000	150	4.0us	90.0us (→ 1.0us)

Averaged radial cumulative Z at azimuth sector 40°...195°

WRS400 test case



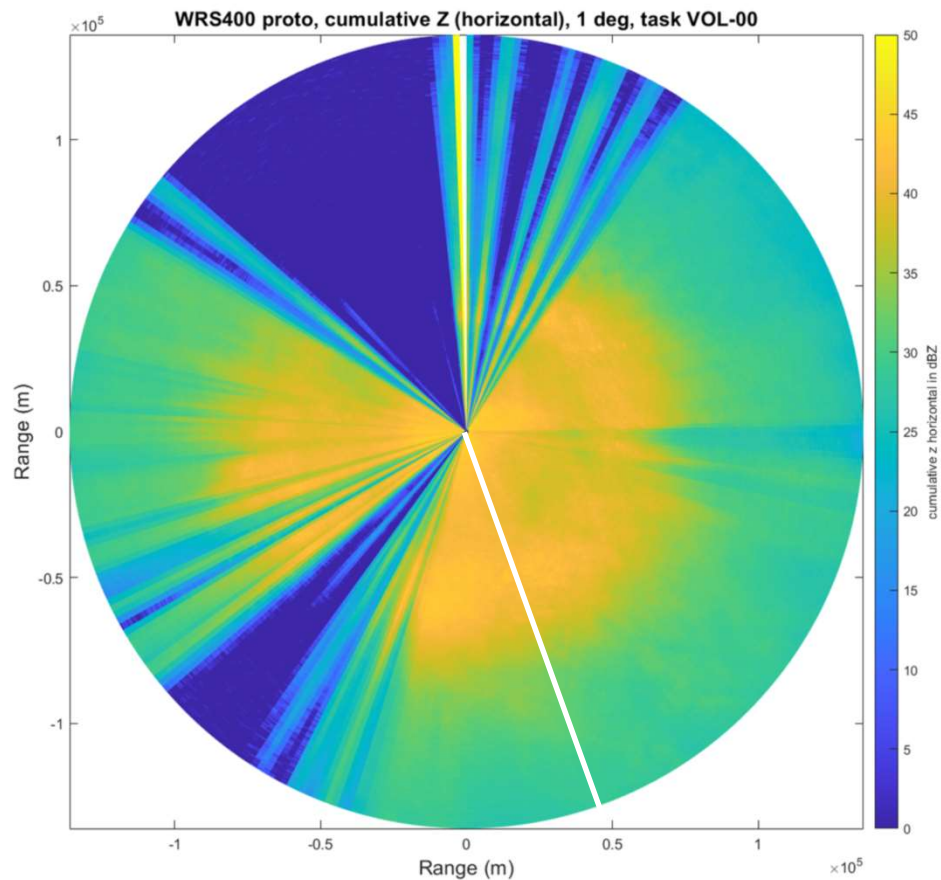
Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28...130km)
VOL-00	1.0°, full sweep	32	1000	150	4.0us	90.0us (→ 1.0us)

Averaged radial cumulative Z at azimuth sector 140°...190°

Thank You



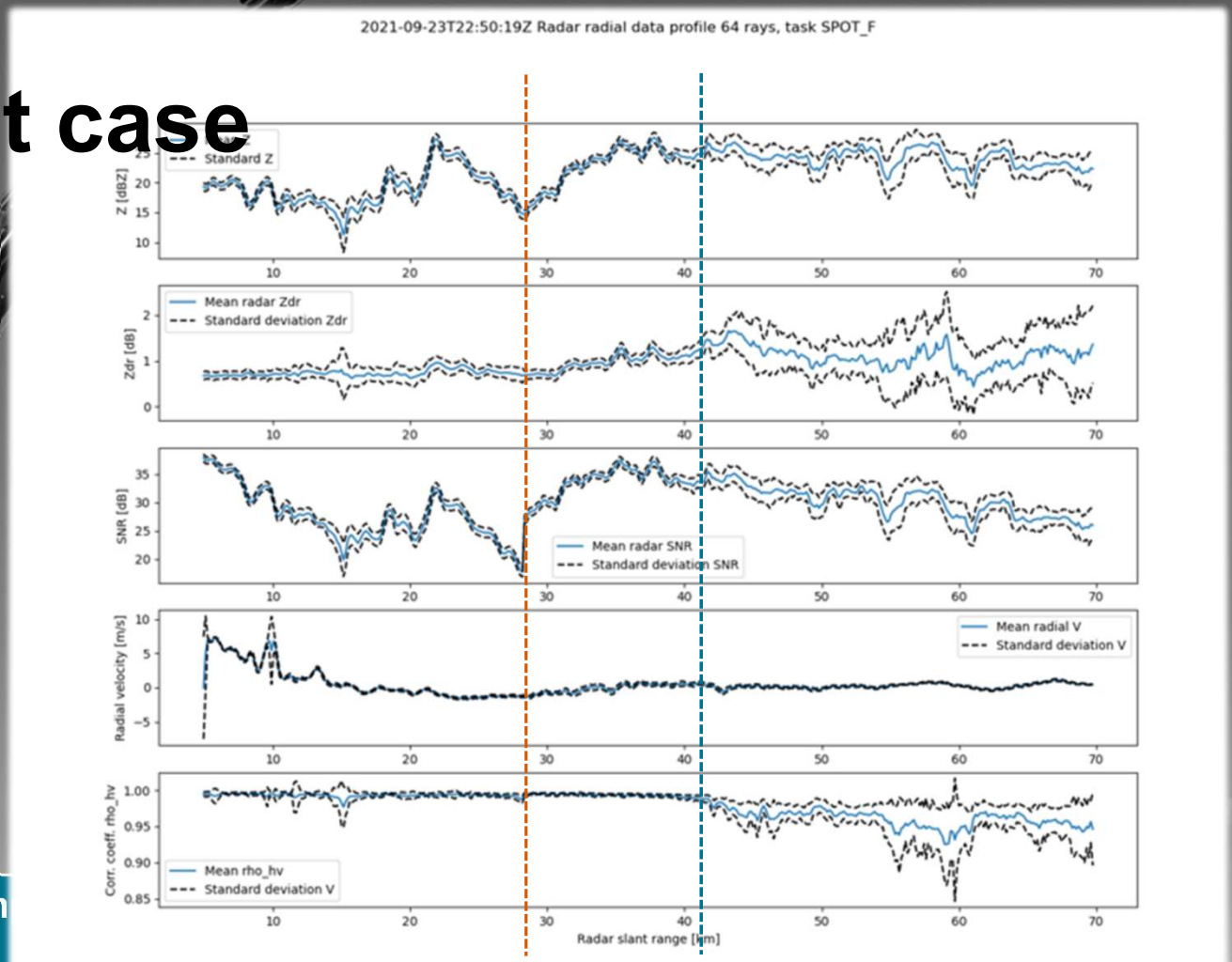
WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28km...)
SPOT	1.0°, fixed 160°	128	1000	150	4.0us	90.0us (→ 1.0us)

Radial average profile over 8 sec. integration time (64 x 128 samples)

WRS400 test case

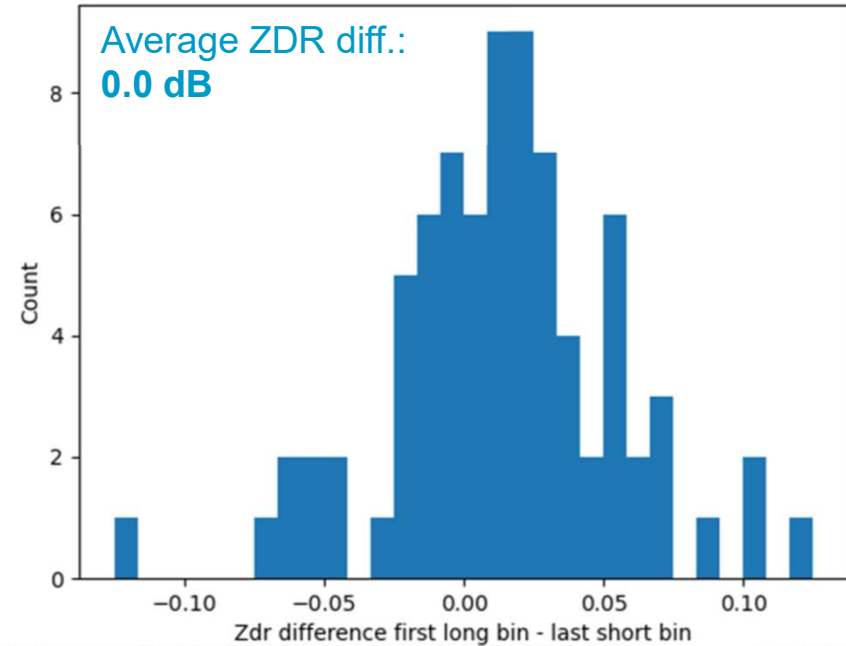
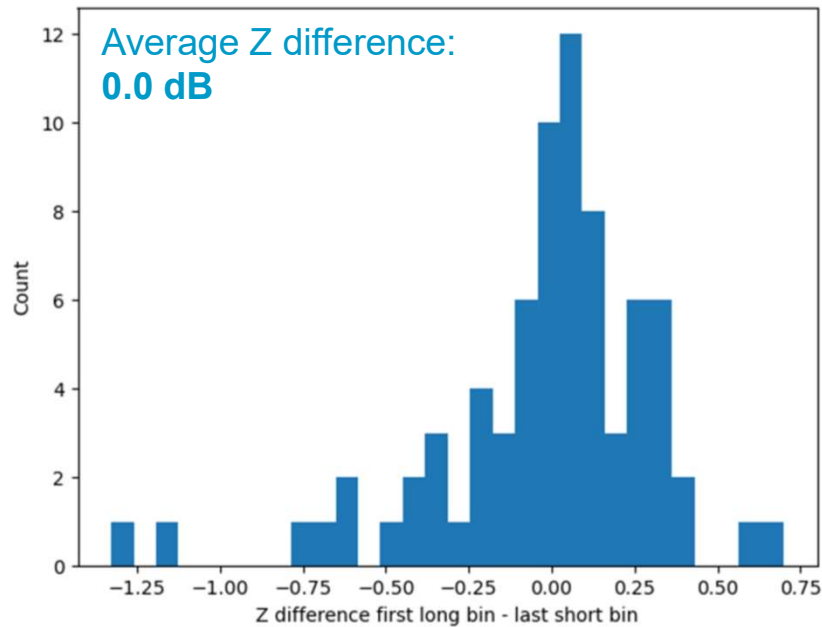


Scan name	EI, Az	Sam
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SPOT	1.0°, fixed 160°	128	1000	100	4.0us	50.0us (> 1.0us)
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Radial average profile over 8 sec. integration time (64 x 128 samples)

WRS400 test case



Scan name	EI, Az	Samp.	PRF / Hz	Range res. / m	Pulse length (r = 0...28km)	Pulse length (r = 28km...)
SPOT	1.0°, fixed 160°	128	1000	150	4.0us	90.0us (→ 1.0us)

Histogram over 172 radial average profiles between September 23rd and 25th 2021