Bundesamt für Kartographie und Geodäsie

VLBI - DORIS compatibility tests at the Geodetic Observatory Wettzell

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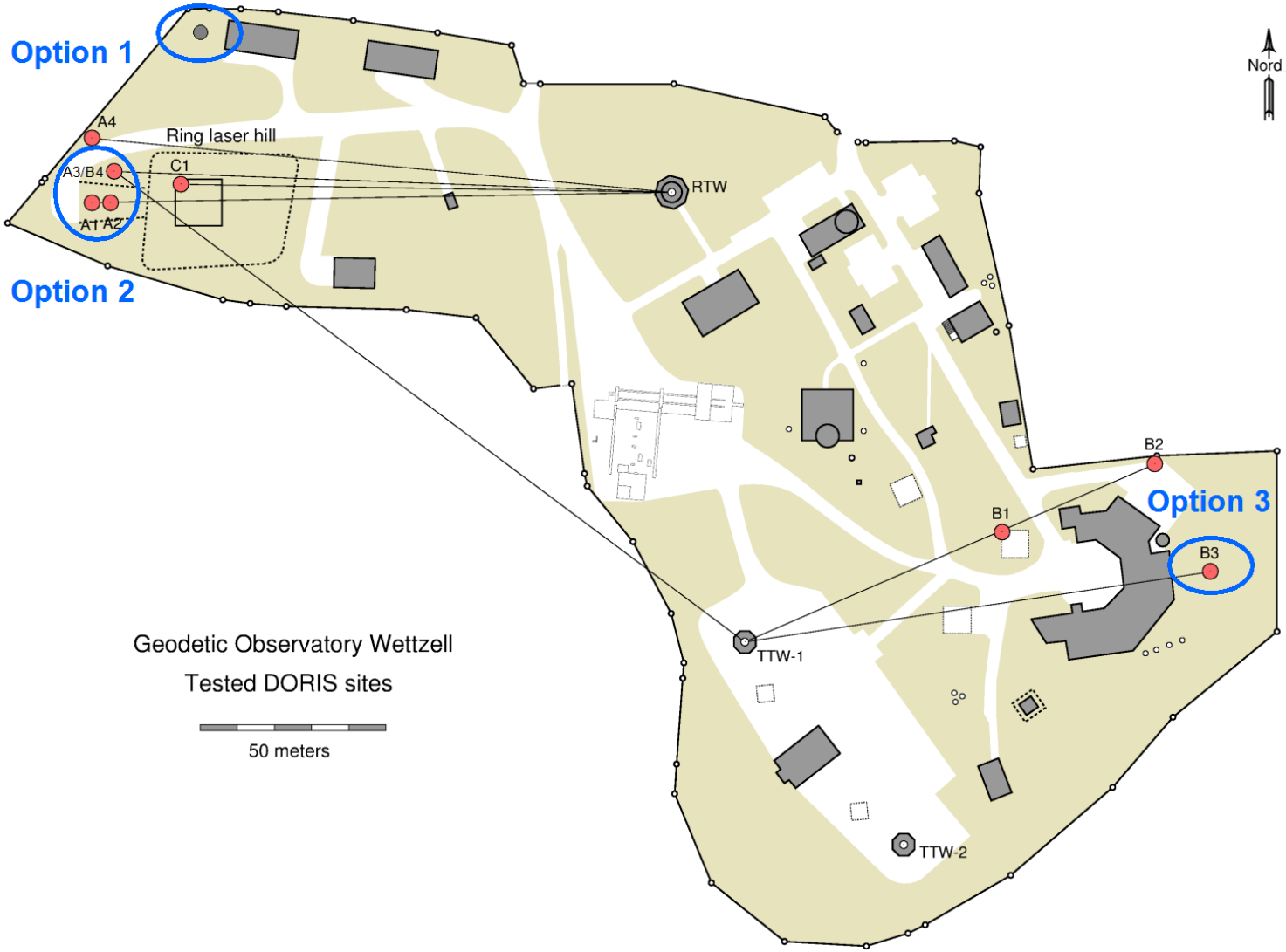
DORIS at Wettzell

- 2003: First operation
  - 03.2003 – 01.2004
  - Always stand-by during VLBI operation
- 2014: New IDS goals
  - Contribution to GGOS
  - Intensify scientific cooperation
  - Wettzell as co-location IDS station
- 2014 - 2015: Site investigation
  - Check different locations
  - Cooperation agreement CNES/IGN/BKG
  - Frequency clearance
  - DORIS-VLBI compatibility tests
- June 2016: Long term test
  - Check quality of DORIS and VLBI data
- Since Sept. 2016: Operation in nominal mode

Possible RFI with VLBI in S-Band

- Problem
  - Power of astronomical radio sources at the input of the VLBI receiving system: about -110 dBm
  - DORIS emission power (2 GHz): 40 dBm
  - LNAs (Low Noise Amplifiers) saturate at –40 ... –50 dBm
  - LNAs will be destroyed at –10 dBm
- Solutions
  - Big distance between antennas (Metsähovi, Hartebeesthoek) (contradicts principle of co-location sites)
  - Obstacles/RF-blockers between DORIS- and VLBI-antennas (Greenbelt)

Explored and tested sites

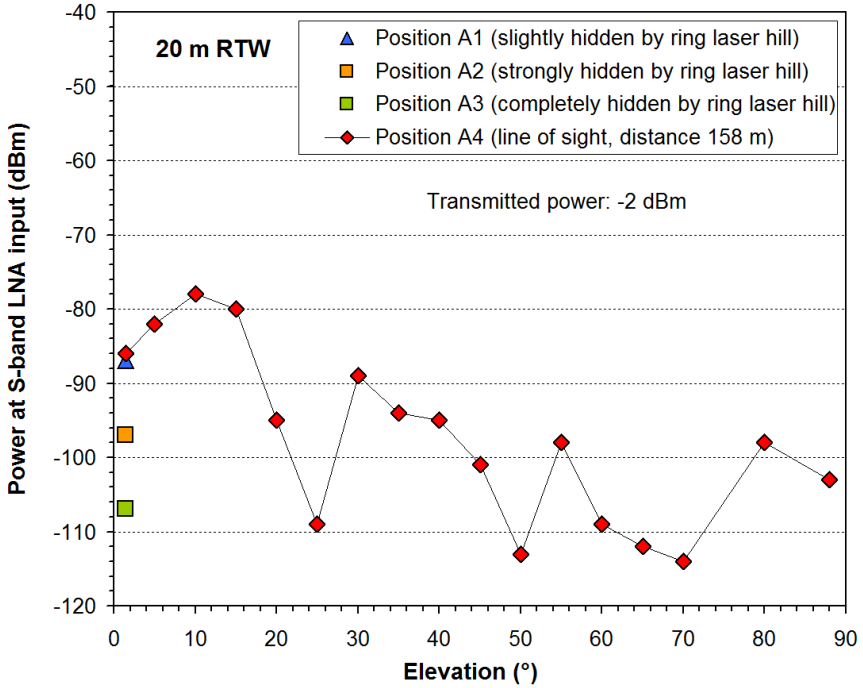


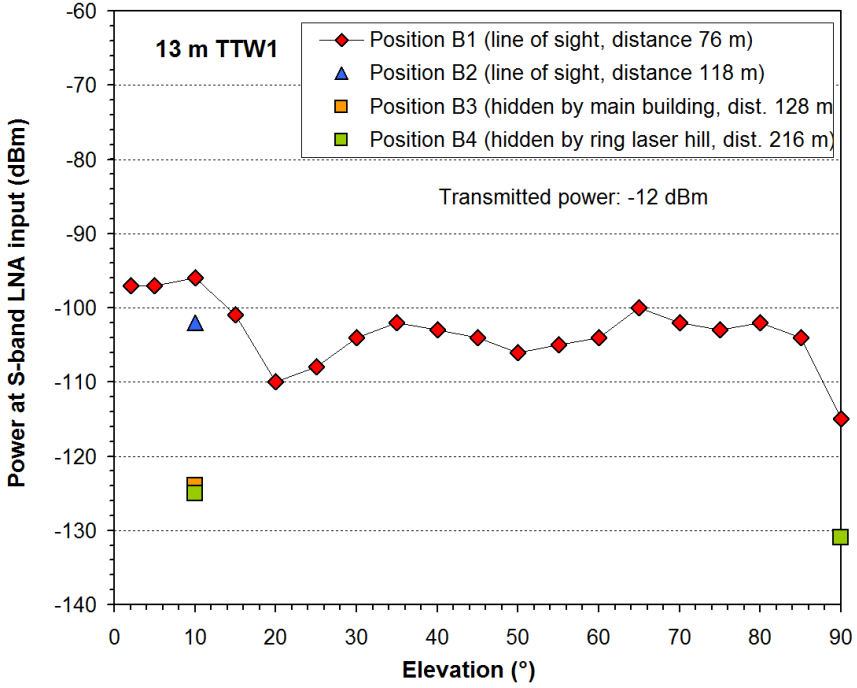
First test with low power

- Signal generator at DORIS antenna, 2036 MHz
- Transmitted power -2 / -12 dBm
- Spectrum analyzer at VLBI antenna waveguide
- Site investigations (effect of distance, obstacles)
- Different elevations of VLBI antenna

A4

B2

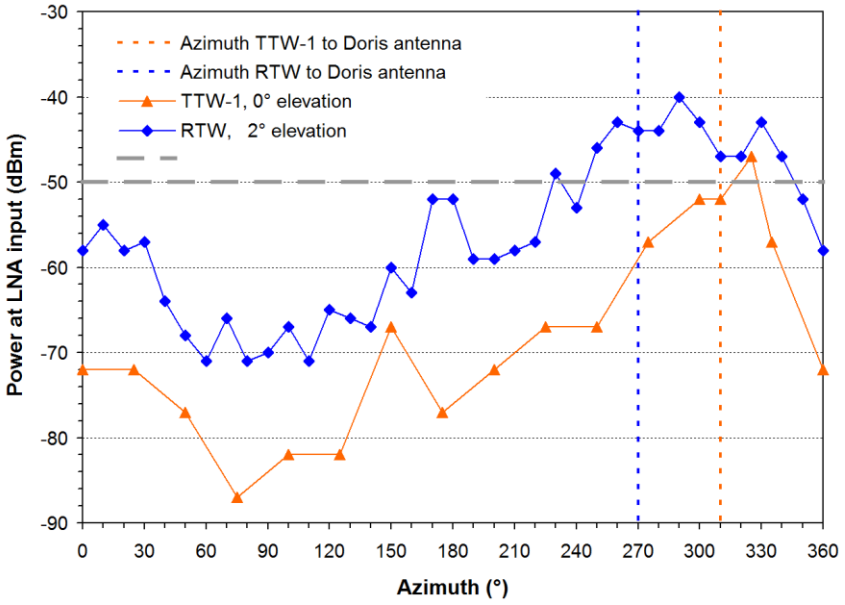




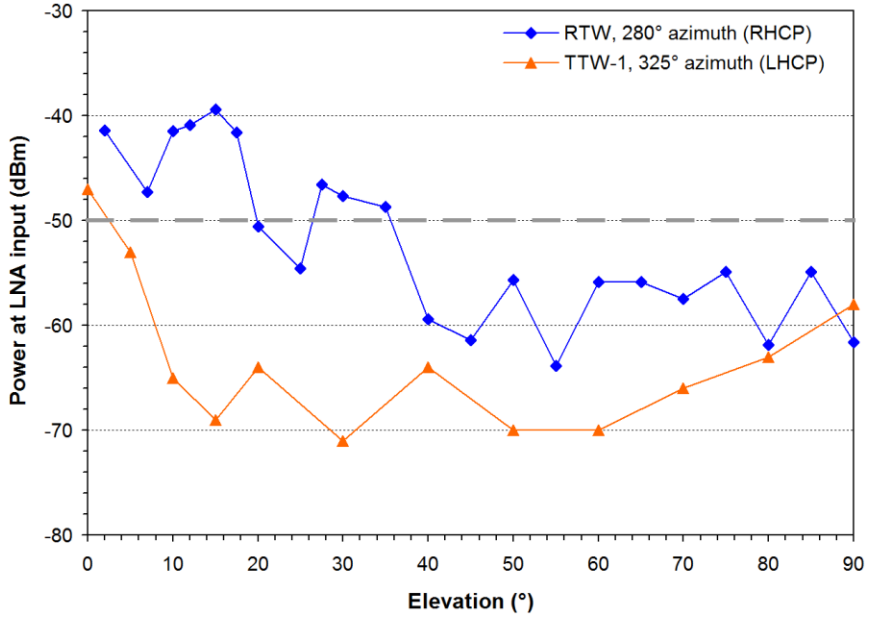
Second test under real conditions

- DORIS Beacon (+40 dBm at 2036 MHz)
- Site A3
  - 155 m to RTW
  - 215 m to TTW-1
- Varying VLBI telescope orientation

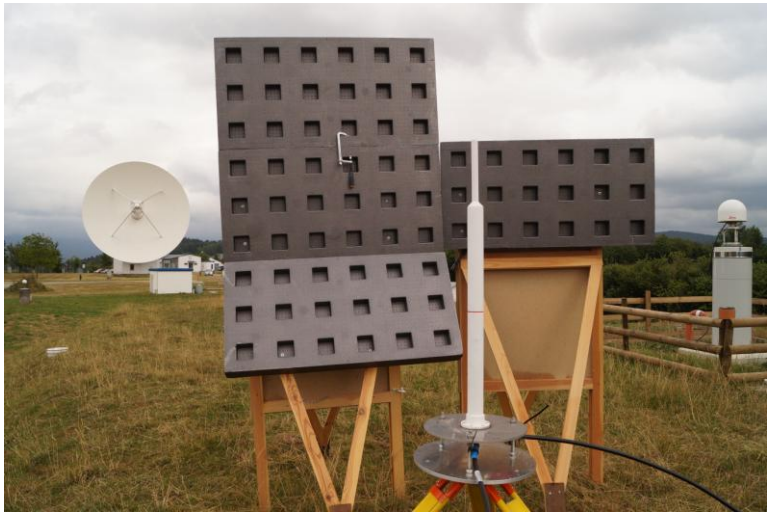
Azimuth dependence



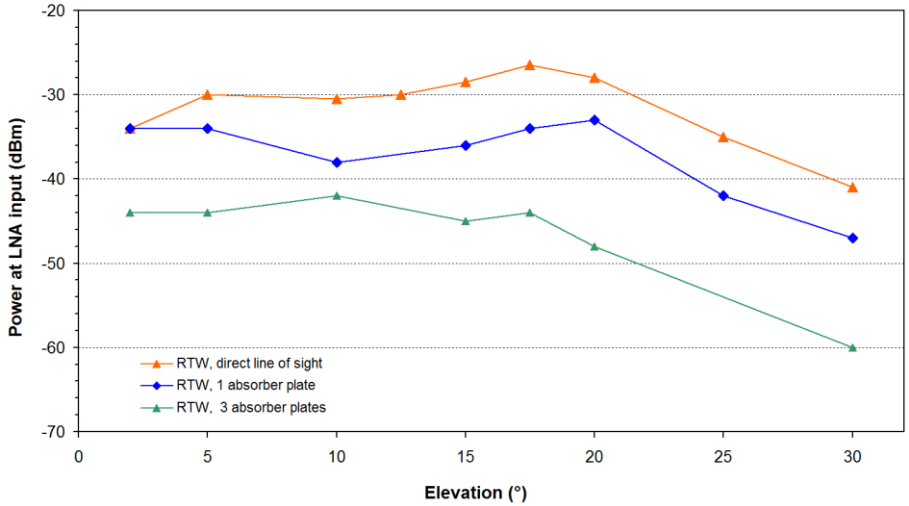
Elevation dependence



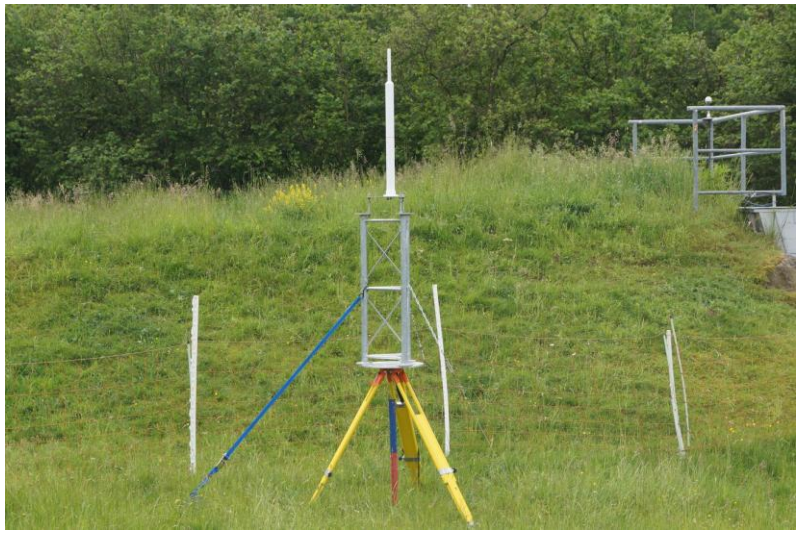
Second test: absorber plates



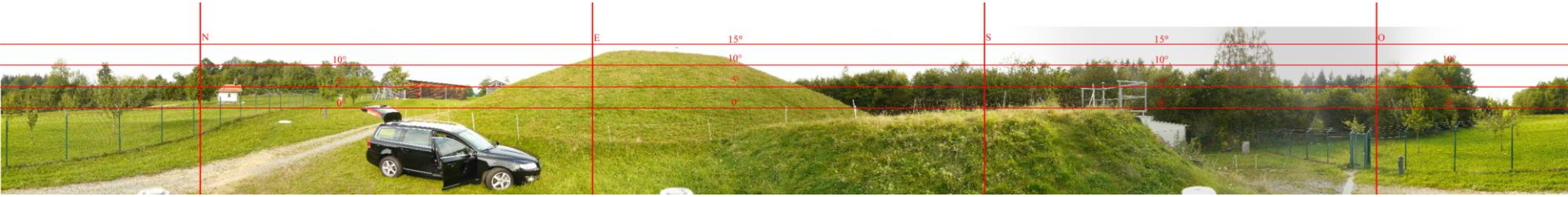
- 0, 1 or 3 absorber plates, type COMTEST MT65
- Site C1 (on top of hill, 130 m dist.)
- 20 m RTW pointing towards DORIS antenna, below main lobe



Long term test (1 month)



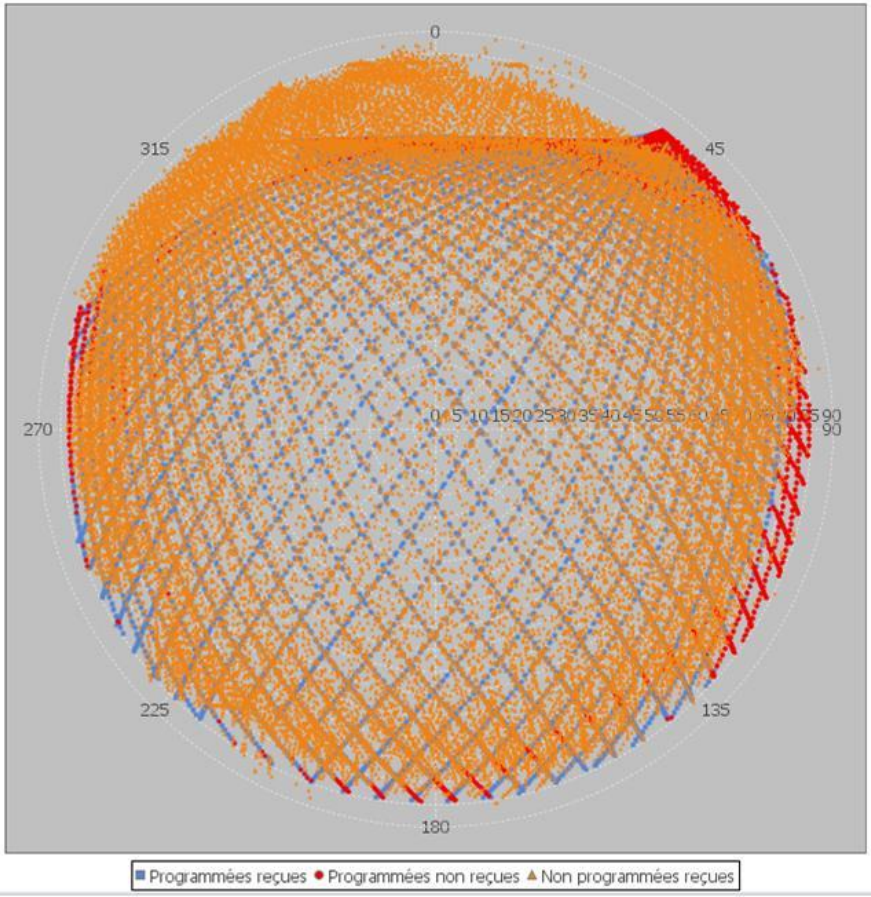
- Check DORIS and VLBI performance
- Site A3
  - 155 m to RTW
  - 215 m to TTW-1
  - 280 m to TTW-2
  - No direct line-of-sight
- Operation on demand
  - Beacon in stand-by when no satellite is visible



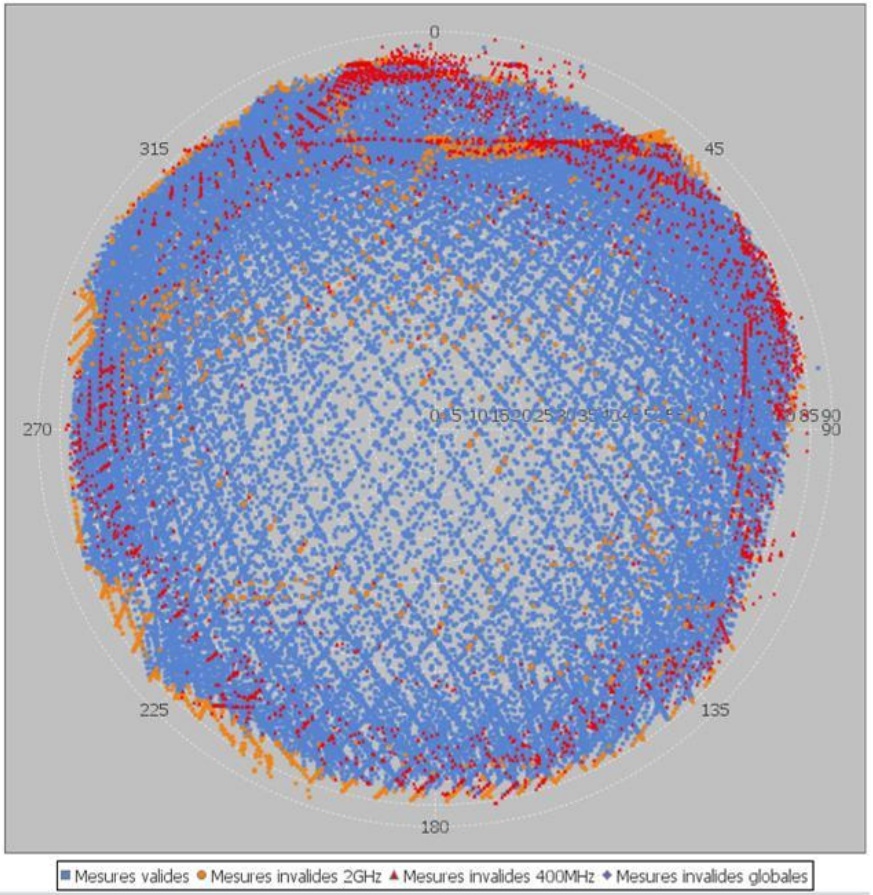
Panoramic view

Satellite reception

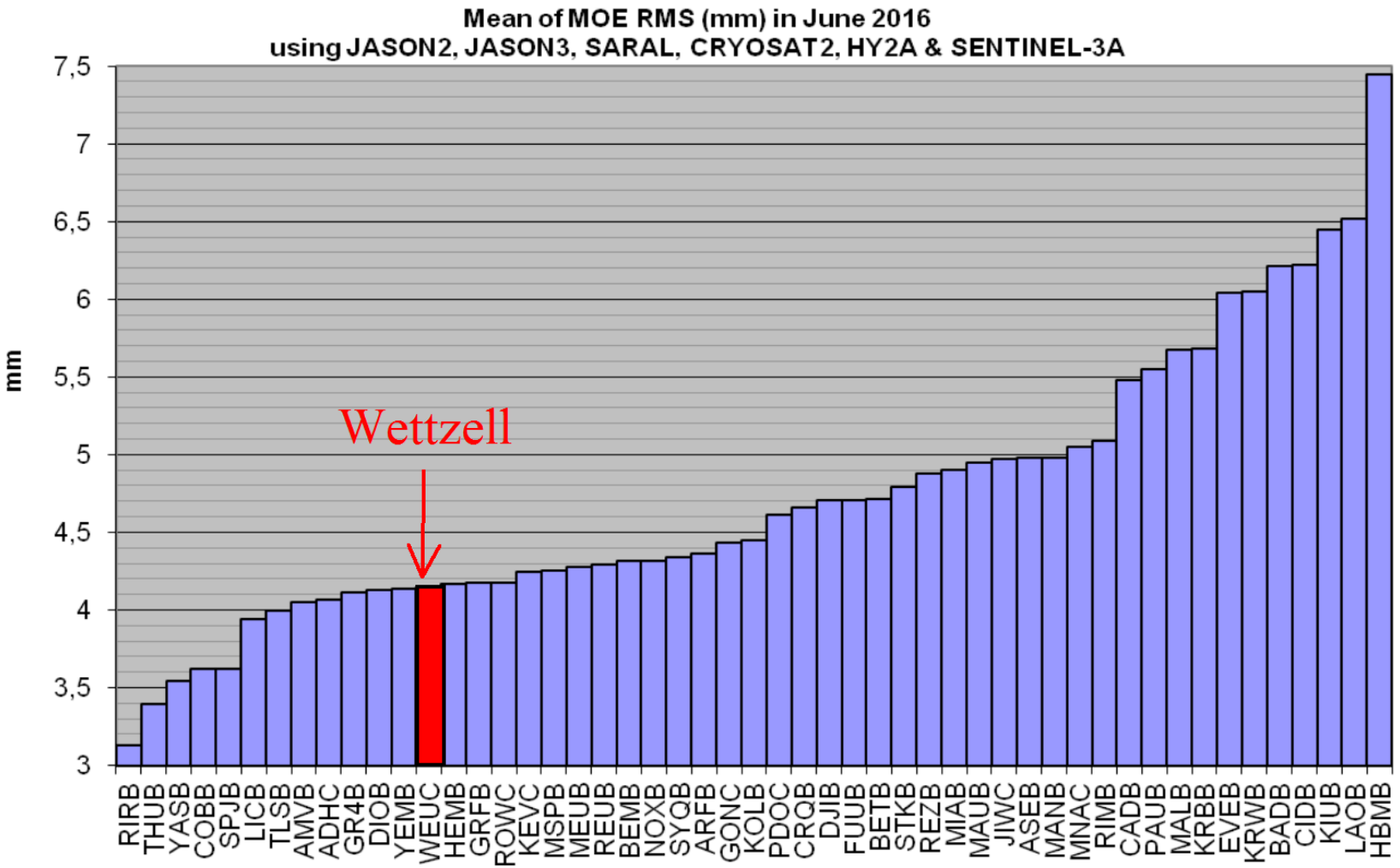
Visualisation géométrique de la réception pour la balise 232 du 01/06/2016 00:00 au 29/06/2016 08:18 pour tous les satellites



Visualisation géométrique de la réception pour la balise 232 du 01/06/2016 00:00 au 29/06/2016 08:18 pour tous les satellites

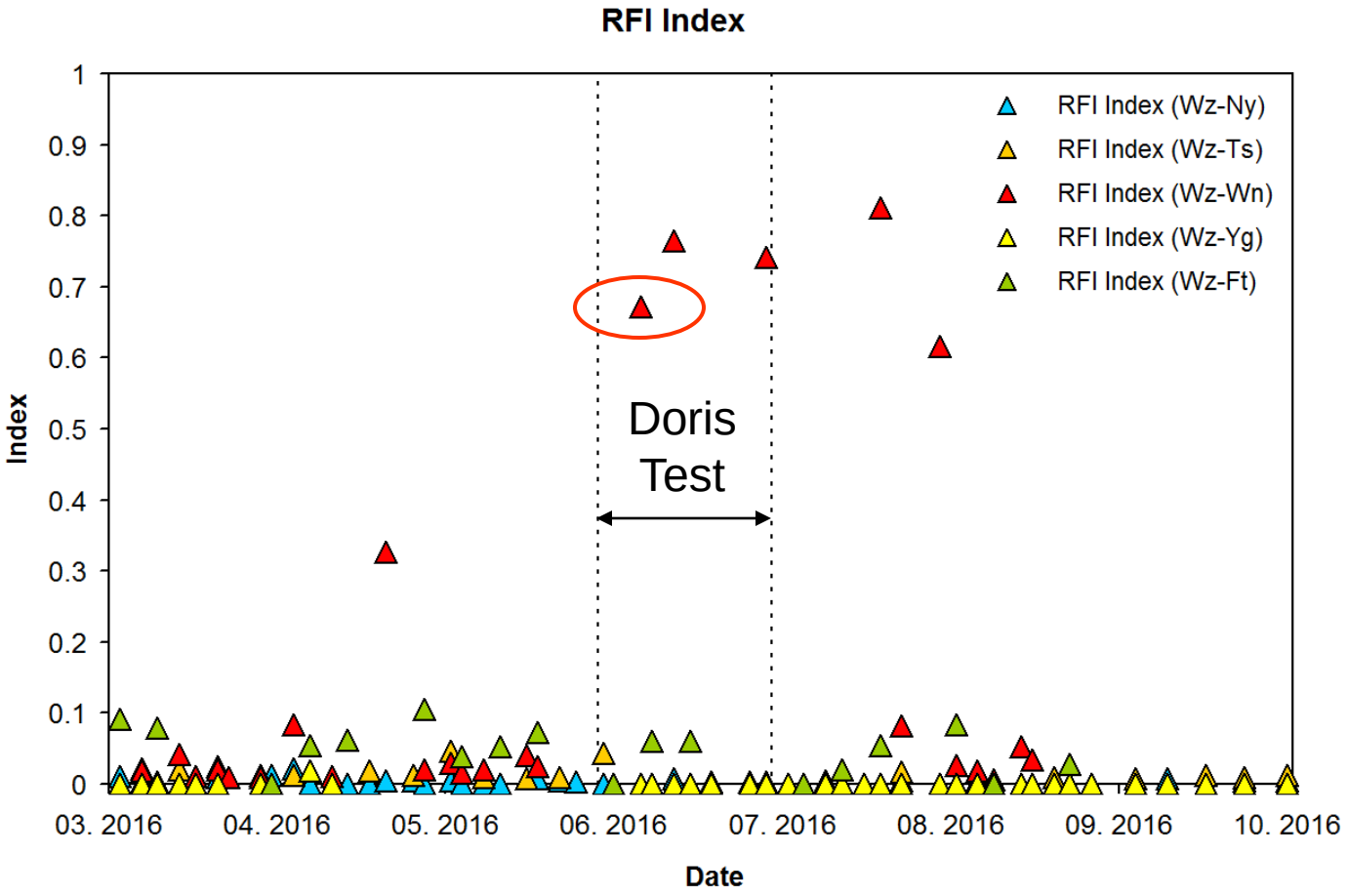


Mean MOE RMS

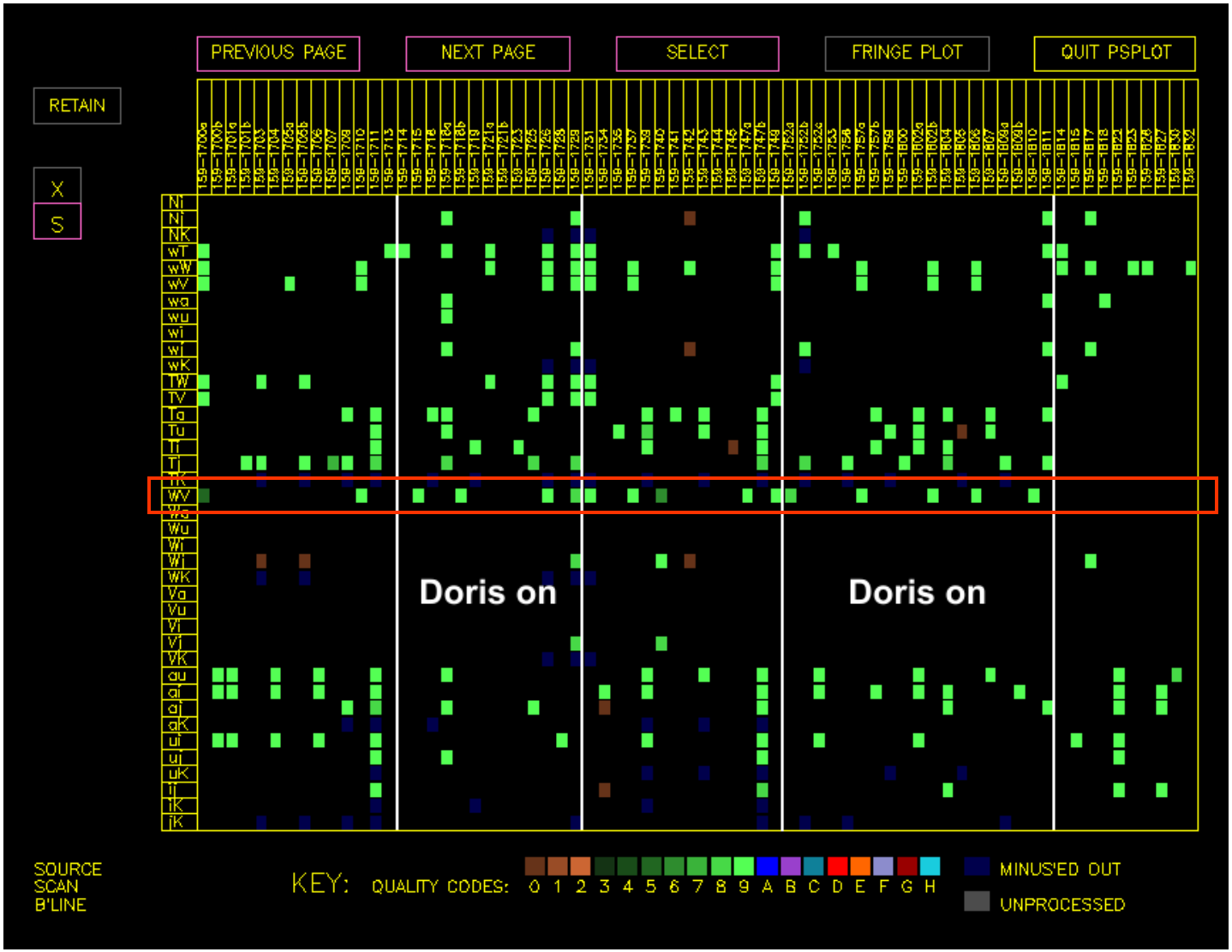

Mean of MOE RMS (mm) in June 2016
using JASON2, JASON3, SARAL, CRYOSAT2, HY2A & SENTINEL-3A
mm
7,5
7
6,5
6
5,5
5
4,5
4
3,5
3
Wettzell
RIRB
THUB
YASB
COBB
SPJB
LICB
TLSB
AMVB
ADHC
GR4B
DIOB
YEMB
WEUC
HEMB
GRFB
ROWC
KEVC
MSPB
MEUB
REUB
BEMB
NOXB
SYQB
ARFB
GONC
KOLB
PDOC
CRQB
DJIB
FUUB
BETB
STKB
REZB
MIAB
MAUB
JIWC
ASEB
MANB
MNAC
RIMB
CADB
PAUB
MALB
KRBB
EVEB
KRWB
BADB
CIDB
KIUB
LAOB
HBMB

VLBI correlation results

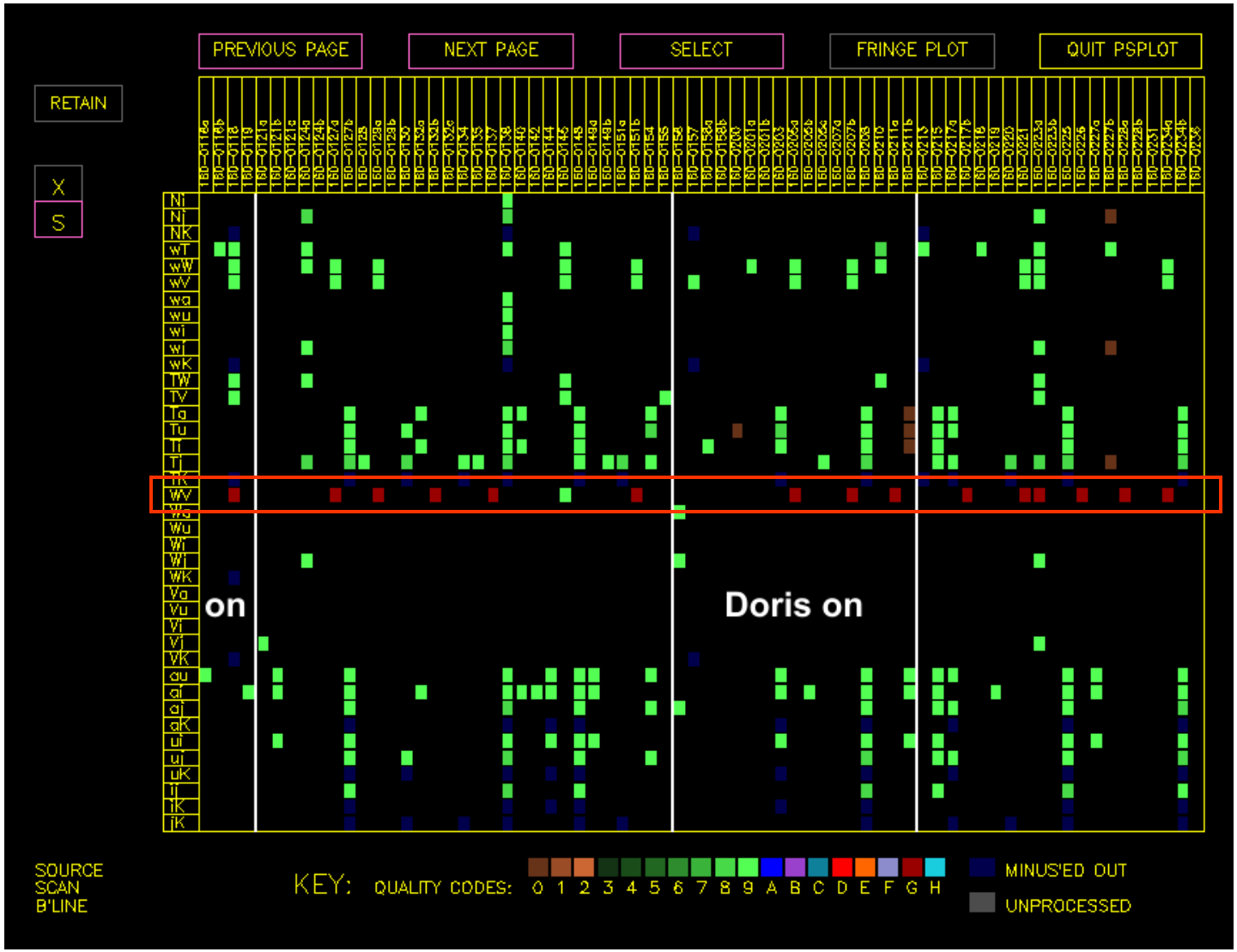
- R1 and R4 experiments from March till Oct. 2016
- RFI index: relative frequency of „G codes“
- Problem on local baseline: common RFI



R1-Experiment from June 07-08, 2016
Correlation Quality Codes (1)



R1-Experiment from June 07-08, 2016
Correlation Quality Codes (2)



Final installation

Local Survey

- After final installation
- Swetlana Mähler (BKG), Jean-Claude Poyard (IGN)
- 4 known reference pillars

Koordinaten nach der Ausgleichung

Lfd. NR.	Punkt	Y [m]	X [m]	Z [m]	dy Sy [mm]	dx Sx [mm]	dz Sz [mm]
1	25 *	136.79467	230.84429	608.44808	0.11	-0.43	0.59
					0.19	0.26	0.15
2	26 *	93.70182	181.97790	603.13150	0.12	-0.10	0.20
					0.18	0.15	0.12
3	39 *	149.63319	161.33573	605.59414	-0.31	0.63	-0.36
					0.24	0.41	0.28
4	220	114.11101	194.01997	604.23514	0.01	-0.03	0.04
					0.25	0.19	0.13
5	221	114.11100	194.01997	604.43514	0.00	-0.03	0.04
					0.25	0.19	0.13
6	222	114.11020	194.02012	606.14313	0.00	0.02	0.03
					0.23	0.19	0.13
7	1000	107.33650	197.26198	605.19033	0.10	-0.12	0.03
					0.20	0.17	0.12
8	1220 *	142.38968	184.39470	613.70487	0.08	-0.10	-0.43
					0.26	0.27	0.18
9	2000	111.12511	184.18271	607.73540	-0.01	0.07	-0.02
					0.19	0.16	0.12
10	WEUC	114.11022	194.02011	606.65877	0.02	0.01	-0.03
					0.23	0.19	0.13
11	Red_ring	114.10999	194.02003	606.65914	-0.01	0.03	0.14
					0.40	0.23	0.15

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Conclusions

- The 2 GHz DORIS signal may affect the VLBI S-band reception (2.1 – 2.4 GHz) by overloading or saturation of the LNAs
- The received power has its maximum in the direction of the DORIS antenna at low elevations (< 20°)
- The maximum gain lobe of the VLBI antenna must never point towards the DORIS antenna (LNA could be destroyed)
- A big distance between both antennas is good (> 400 m is sufficient)
- Obstacles between the antennas (hills, buildings, RF blocker) attenuate the signal up to ~ 20 dB
- Reflections at objects (fences, trees, buildings) strongly contribute to the total received power (RHCP ~ LHCP)
- VLBI correlation results: no effect on long baselines, RFI issues on the local baseline (WETTZELL-WETTZ13N) have been overcome
- DORIS @ Wettzell: a good compromise
  - VLBI: enough attenuation through distance and barrier
  - Operation on demand: 25% duty cycle, no effect on satellite reception
  - DORIS: elevation mask around 10°: acceptable
  - Co-location: excellent ties with VLBI, SLR, GNSS, SAR