IVS IVTW 2024

RFI Monitoring with different techniques

Alexander Neidhardt[1]

D. Amberger[2], F. Kroner[1], G. Kronschnabl[2], M. Lier[2], Ch. Plötz[2], L. Rigon[1]

1) TUM, 2) BKG

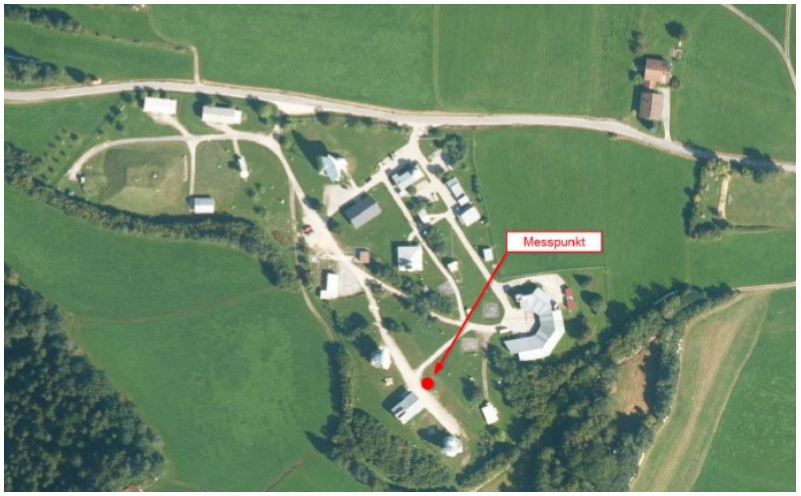
IVS IVTW 2024

RFI Monitoring

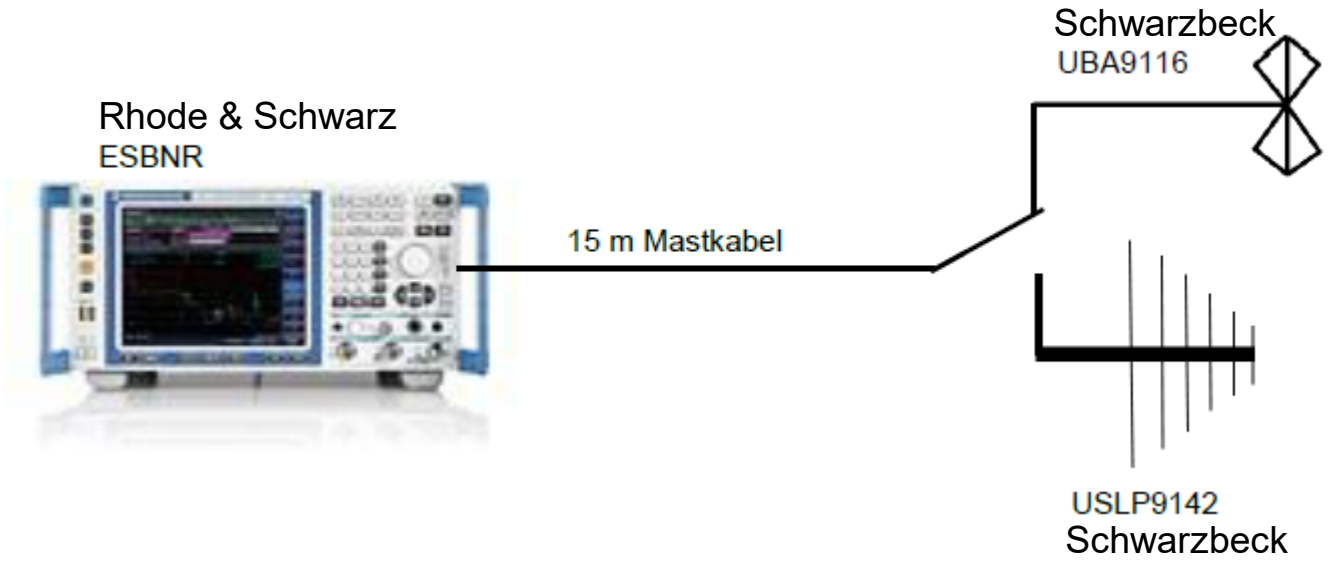
- **General situation … big jammers**
  - **Frequency occupation measurement BNetzA**
  - LTE/4G
  - 5G
  - Starlink
- RFI Monitoring
  - Equipment
  - VGOS
  - Legacy S/X
  - GENESIS
- Radio horizon with Solar Flux Telescope

General characterization … big jammers

Frequency occupancy measurement by BNetzA*



* Federal Network Agency



General characterization … big jammers

Frequency occupancy measurement by BNetzA

• 500-700 MHz: DVB-T2	-40 dBm
• 700-788 MHz: LTE- and 5G-signals up-/downlink	-81 dBm
• 788-862 MHz: LTE-signals up-/downlink	-77 dBm
• 862-960 MHz: LTE- und GSM-signals up-/downlink	-76 dBm
• 1000-1100 MHz: ADS-B- (Automatic Dependent Surveillance – Broadcast; secondary radar) and DME-signals (Distance Measuring Equipment) of air navigation radio	-70 dBm
• 1200-1300 MHz : radar signals	-78 dBm
• 1300-1400 MHz: air force radar on mountain „Gr. Arber“	-47 dBm
• 1400-1500 MHz: LTE-signals	-91 dBm
• 1700-1880 MHz: LTE-signals downlink	-73 dBm
• 1880-1920 MHz: DECT-signals in the surrounding area	-79 dBm
• 1920-2170 MHz: LTE-signals downlink, and unknown signal	-60 dBm
• 2400-2500 MHz: WLAN-signals in the surrounding area	-90 dBm

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2600 MHz: LTE/4G

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M I S S I N G P R O T E C T I O N

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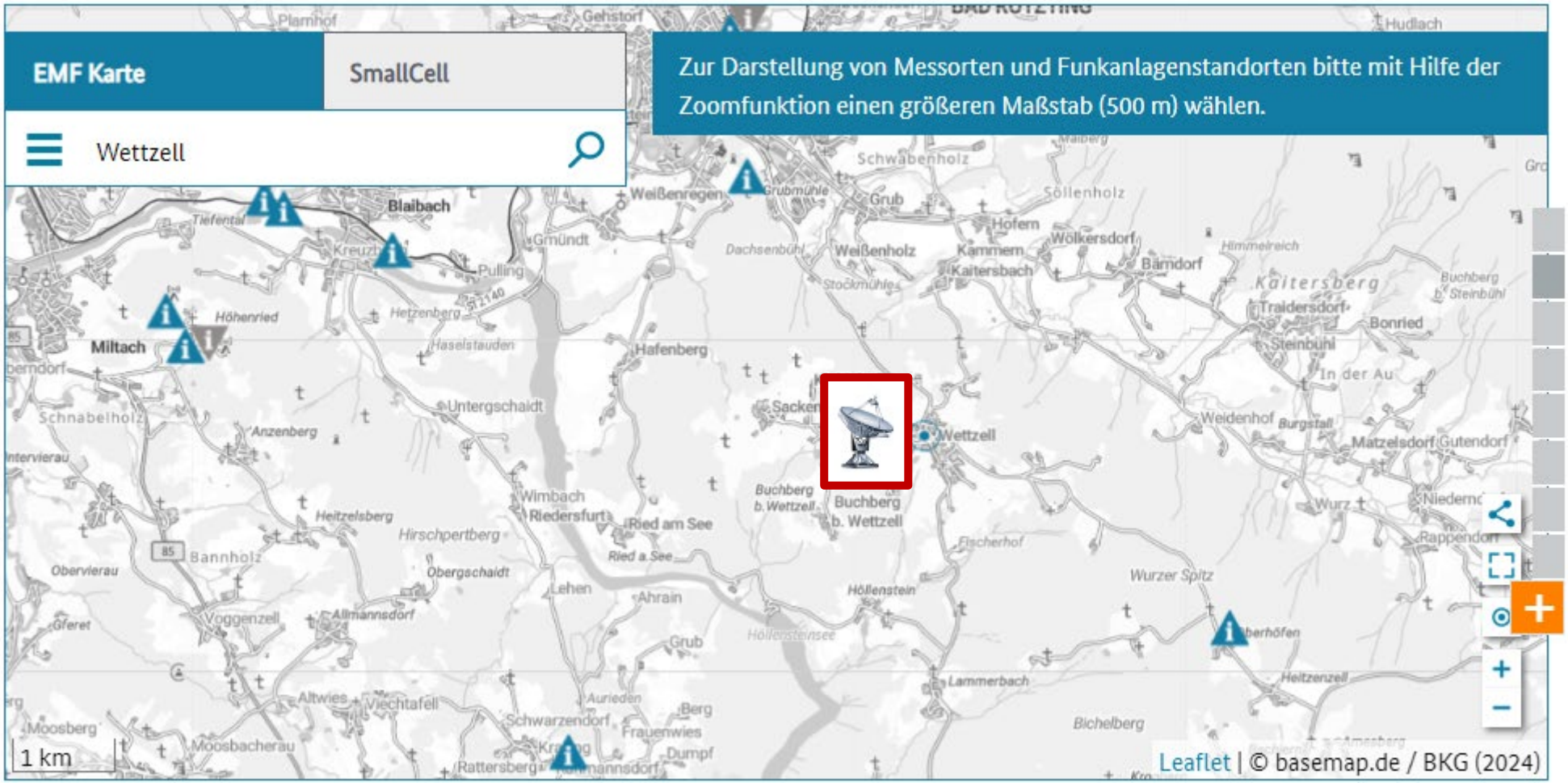
General characterization … big jammers

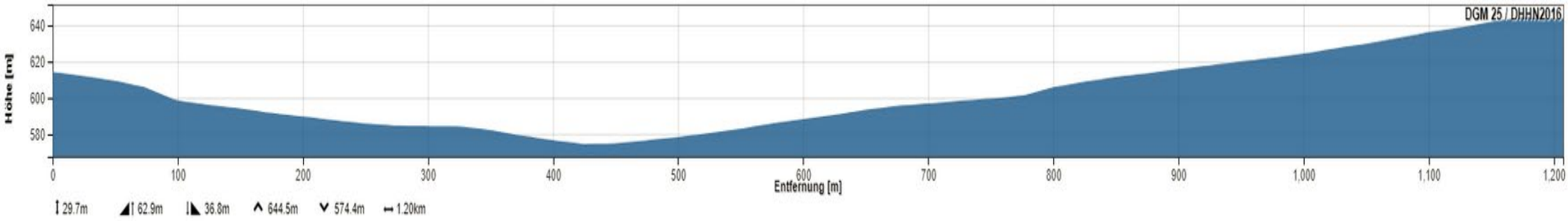
Current LTE/4G infrastructure

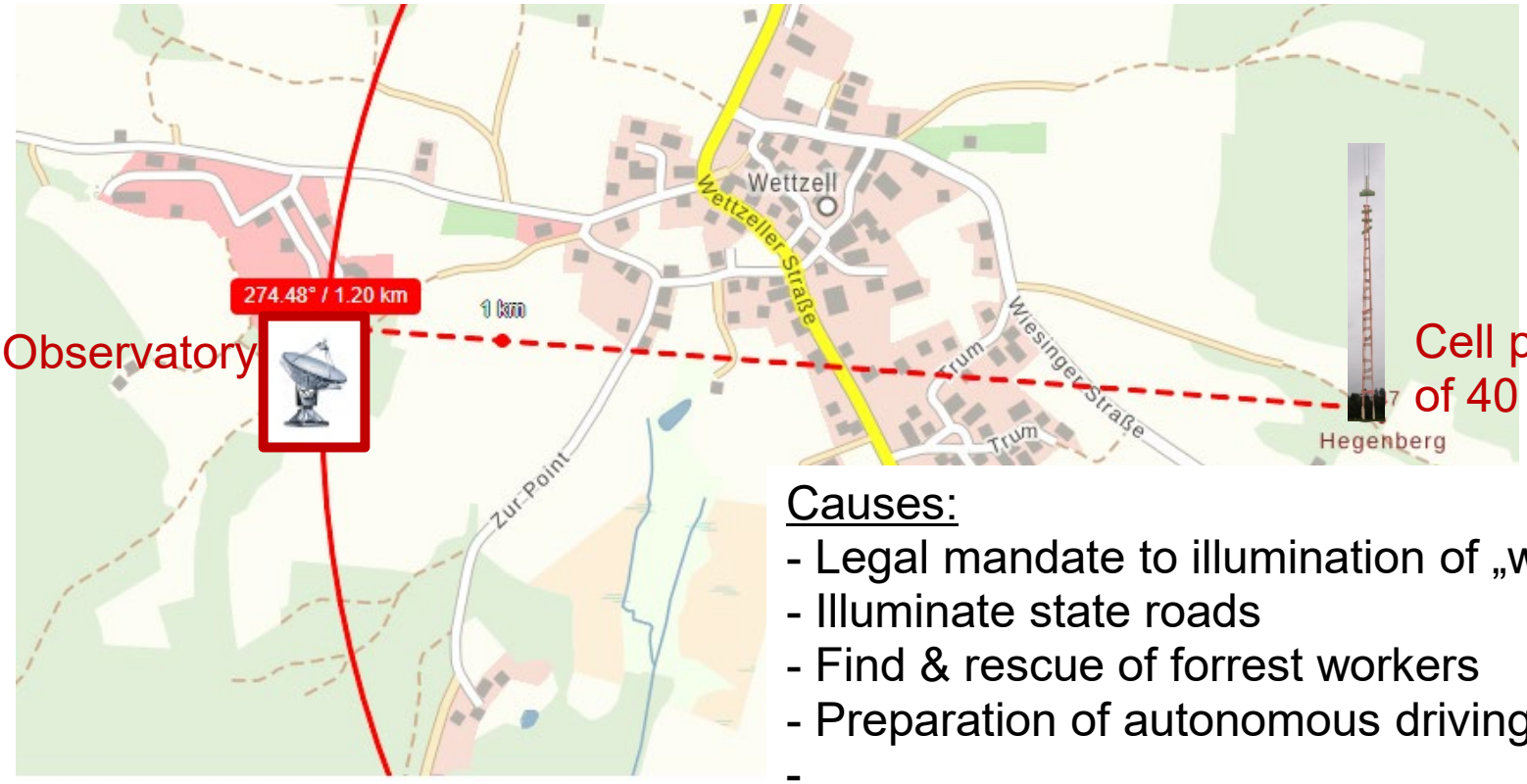


https://www.bundesnetzagentur.de/DE/Vportal/TK/Funktechnik/EMF/start.html

General characterization … big jammers

Expansion of the LTE/4G infrastructure





Observatory

Cell phone tower of 40 m height

Causes:

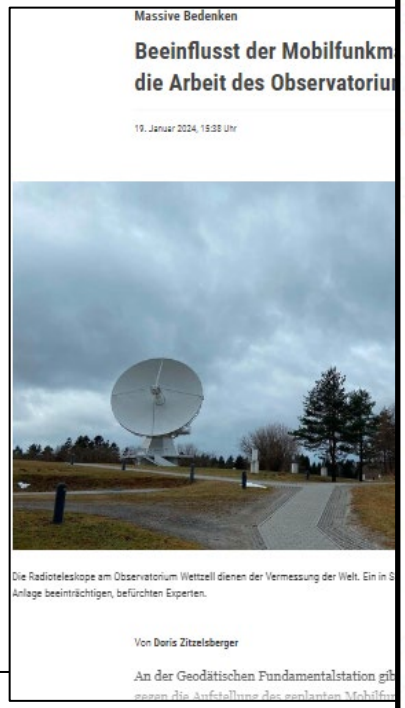
- Legal mandate to illumination of „white areas“
- Illuminate state roads
- Find & rescue of forrest workers
- Preparation of autonomous driving
- …

https://geoportal.bayern.de/bayernatlas/mobile.html?lang=de&topic=ba&catalogNodes=11&bgLayer=atkis

General characterization … big jammers

Expansion of the LTE/4G infrastructure

Press reports and public perception


Massive Bedenken

Beeinflusst der Mobilfunkm
die Arbeit des Observatoriu

19. Januar 2024, 15:38 Uhr

Die Radioteleskope am Observatorium Wettzell dienen der Vermessung der Welt. Ein in S
Anlage beeinträchtigen, befürchten Experten.

Von Doris Zitzelsberger

An der Geodätischen Fundamentalstation gib


Guter Rat ist teuer

Mobilfunkmast in Wettzell würde Betrieb des Observatoriums stören

11. Oktober 2024, 15:54 Uhr

Die Radioteleskope am Observatorium Wettzell dienen der Vermessung der Erde.

Von Doris Zitzelsberger

Der Handyempfang in Wettzell ist an vielen Stellen miserabel - und daran wird sich so schnell auch nichts ändern. Denn mittlerweile steht fest: Der seit mehreren Jahren von Vodafone geplante Mobilfunkmast würde den Betrieb des Geodätischen Observatoriums Wettzell (GOW) stören. Das bestätigen Messungen, die die Bundesnetzagentur durchgeführt hat.

Die Situation in Wettzell ist komplex: Zum einen sind da die weißen Flecken im Mobilfunknetz, die die Bundesregierung


Bürgerversammlung

Braucht Wettzell einen Mobilfunkmast?

27. April 2022, 16:26 Uhr aktualisiert am 27. April 2022, 16:26 Uhr

odafone) informierte die Bürger Wettzells über das Projekt Mobilfunkmast.

Von Lisa-Maria Rackl

Wäre es nach Bürgermeister Markus Hofmann gegangen, hätte er die Infoveranstaltung für die Bürger Wettzells bereits vor einem Jahr abgehalten, Corona aber machte dem Rathauschef einen Strich durch die Rechnung. Wie er am Dienstagabend gleich mehrmals betonte, war

PNP.de

Wissenschaft

Warten auf Mobilfunk in Wettzell: zeigen, ob Signal für Geodäsie „zu

19.01.2024 | Stand 19.01.2024, 11:26 Uhr | Kommentare

Stefan Weber

Redakteur | Lokalredaktion Cham (Bad Kötzting)

PLUS

nk für das Dorf Wettzell soll
" kommen und liegt doch noch in
erne

.09.2024, 16:20 Uhr | Kommentare

A A A

eber

okalredaktion Cham (Bad Kötzting)

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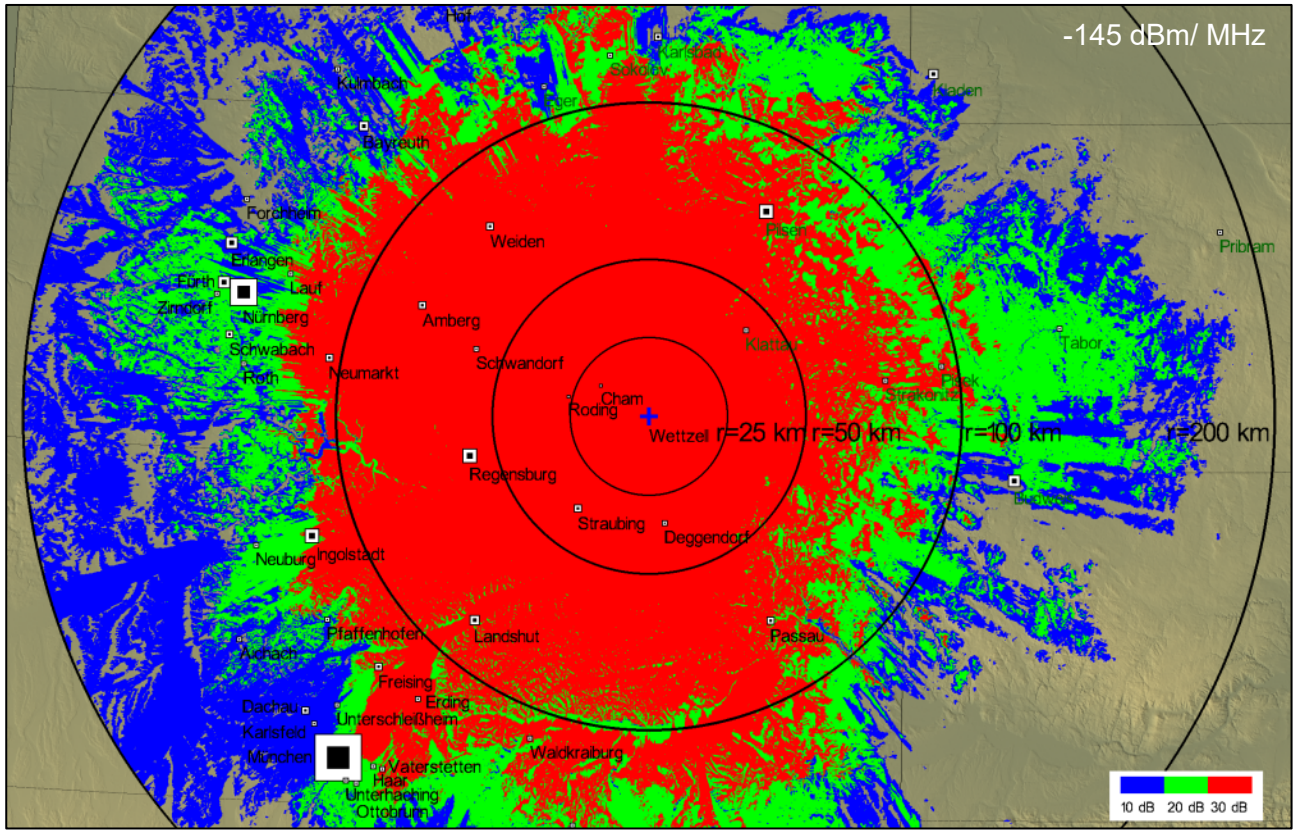
	2600 MHz: LTE/4G	
3600 MHz: 5G		

General characterization … big jammers

Expansion to 5G – radio compatibility study (B. Winkel; MPIfR)



RECOMMENDATION ITU-R RA.769-2

TABLE 3

Threshold interference levels for VLBI observations

Centre frequency (MHz)	Threshold level (dB(W/m² · Hz))
325.3	–217
611	–212
1413.5	–211
2695	–205
4995	–200
10650	–193
15375	–189
23800	–183
43000	–175
86000	–172

Critical areas (exceeded VLBI limit values) with 10-30 dB mitigation

Used software: pycraf
https://github.com/bwinkel/pycraf

Winkel, B.: Funkverträglichkeit zwischen 5G Mobilfunk und dem Geodätischen Observatorium Wettzell im Frequenzbereich 3.400 – 3.800 MHz. Stand: 28.03.2018; https://www.itu.int/dms_pubrec/itu-r/rec/ra/R-REC-RA.769-2-200305-I!!PDF-E.pdf

General characterization … big jammers

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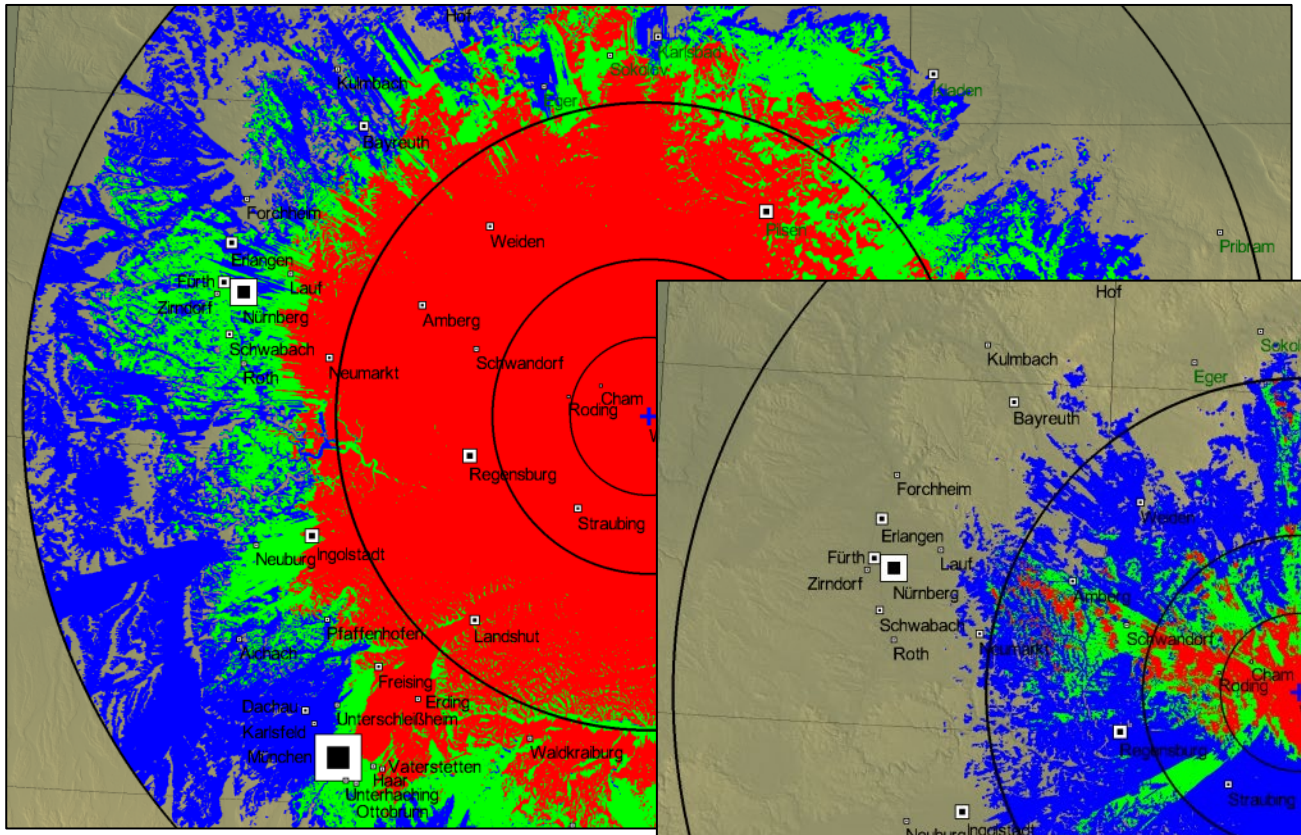
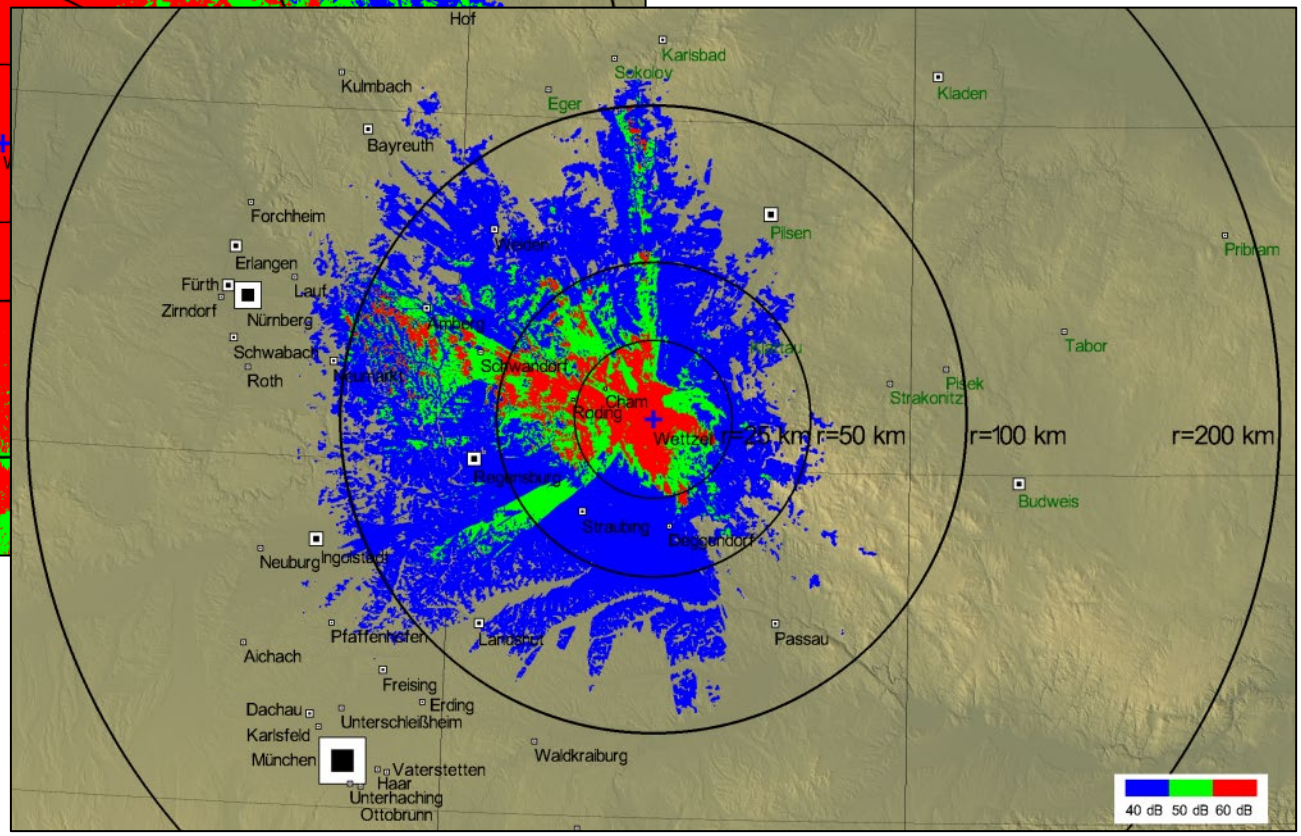


Critical areas (exceeded VLBI limit values) with 10-30 dB mitigation

Critical areas (exceeded VLBI limit values) with 40-60 dB mitigation



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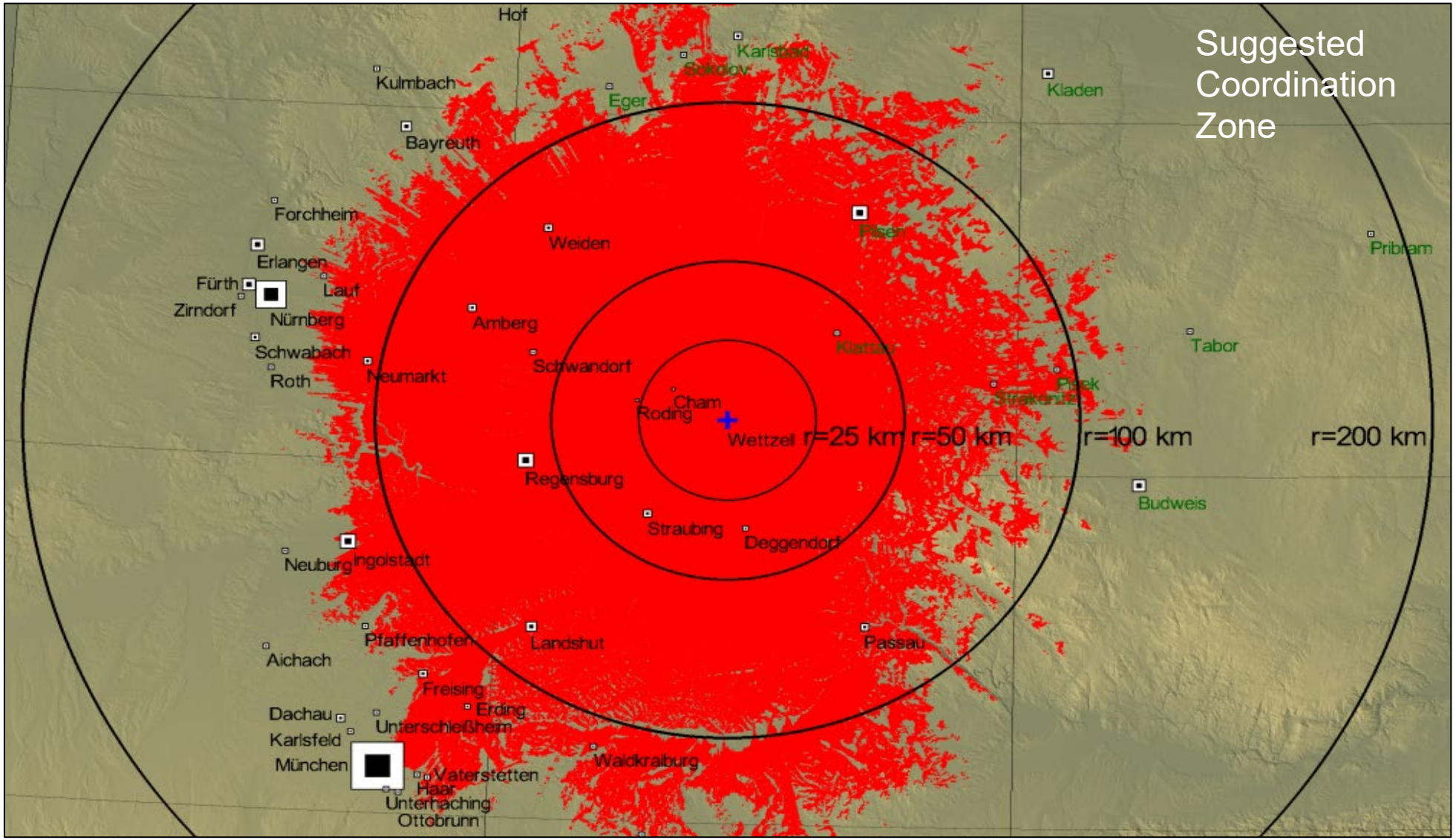

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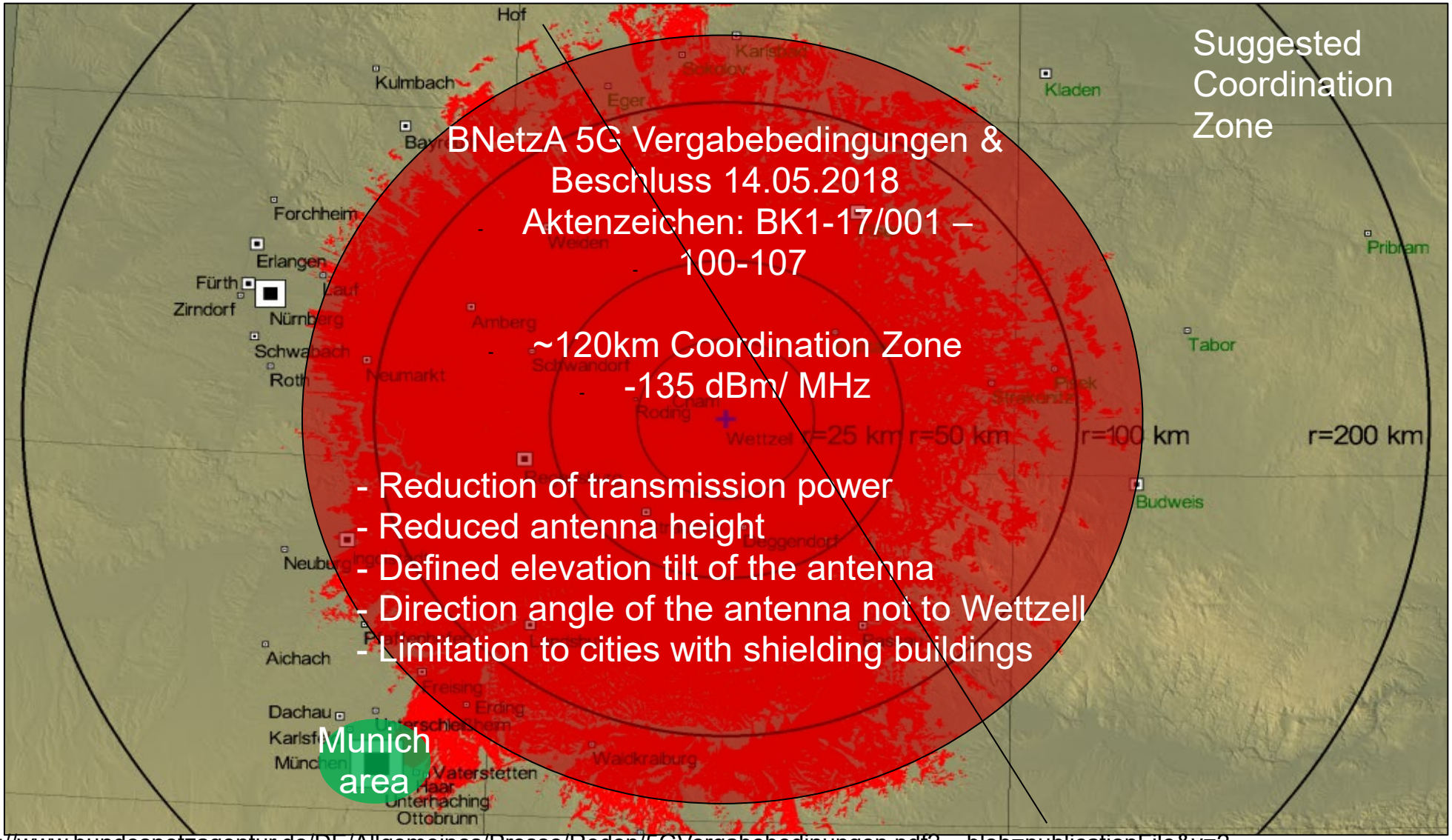

https://www.bundesnetzagentur.de/DE/Allgemeines/Presse/Reden/5GVergabebedinungen.pdf?__blob=publicationFile&v=2
https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK1-GZ/2017/BK1-17-0001/BK1-17-0001_Entscheidung_lundII_Download_BF.pdf?__blob=publicationFile&v=1

General characterization … big jammers

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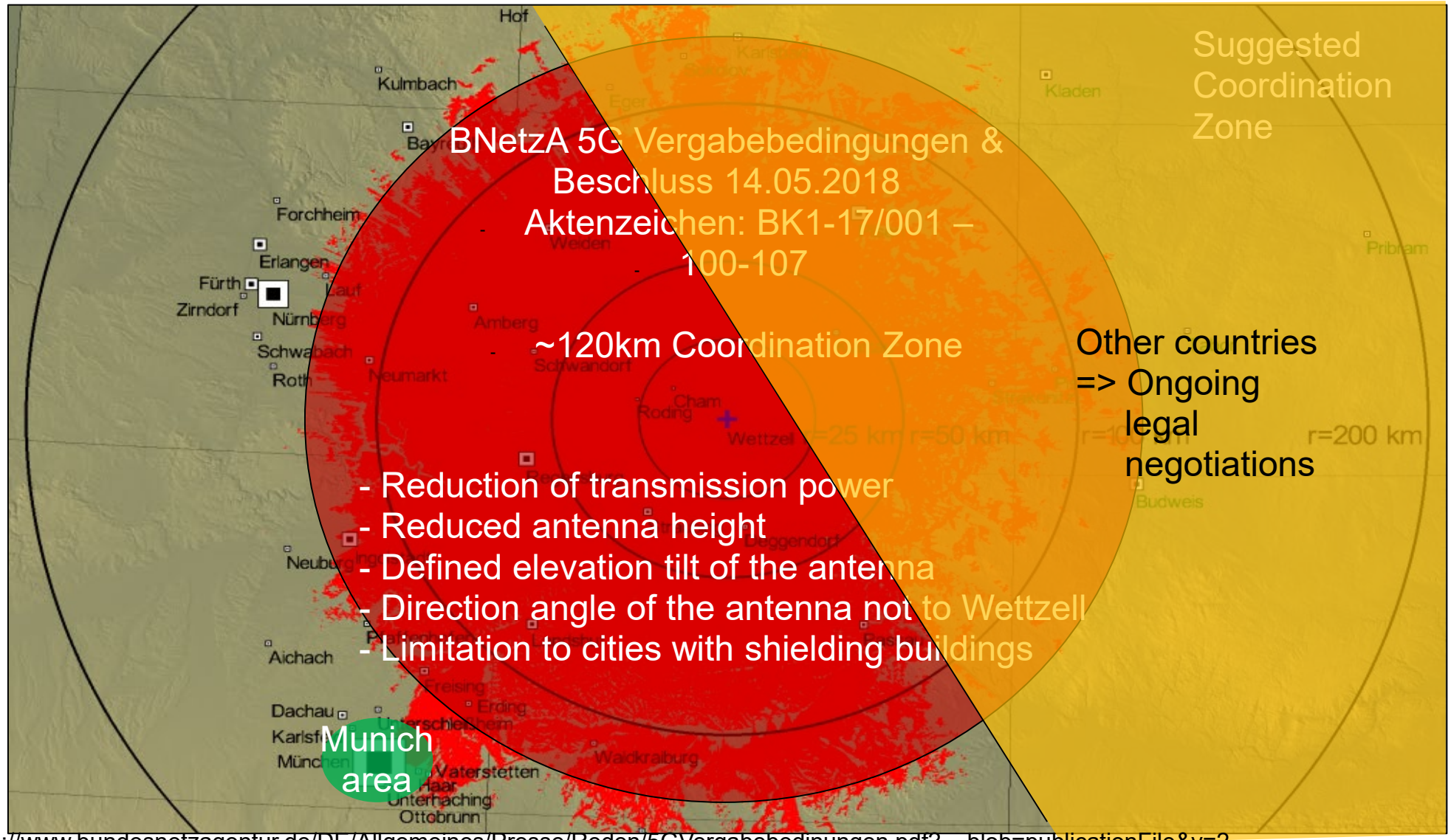

https://www.bundesnetzagentur.de/DE/Allgemeines/Presse/Reden/5GVergabebedinungen.pdf?__blob=publicationFile&v=2
https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK1-GZ/2017/BK1-17-0001/BK1-17-0001_Entscheidung_lundII_Download_BF.pdf?__blob=publicationFile&v=1

General characterization … big jammers

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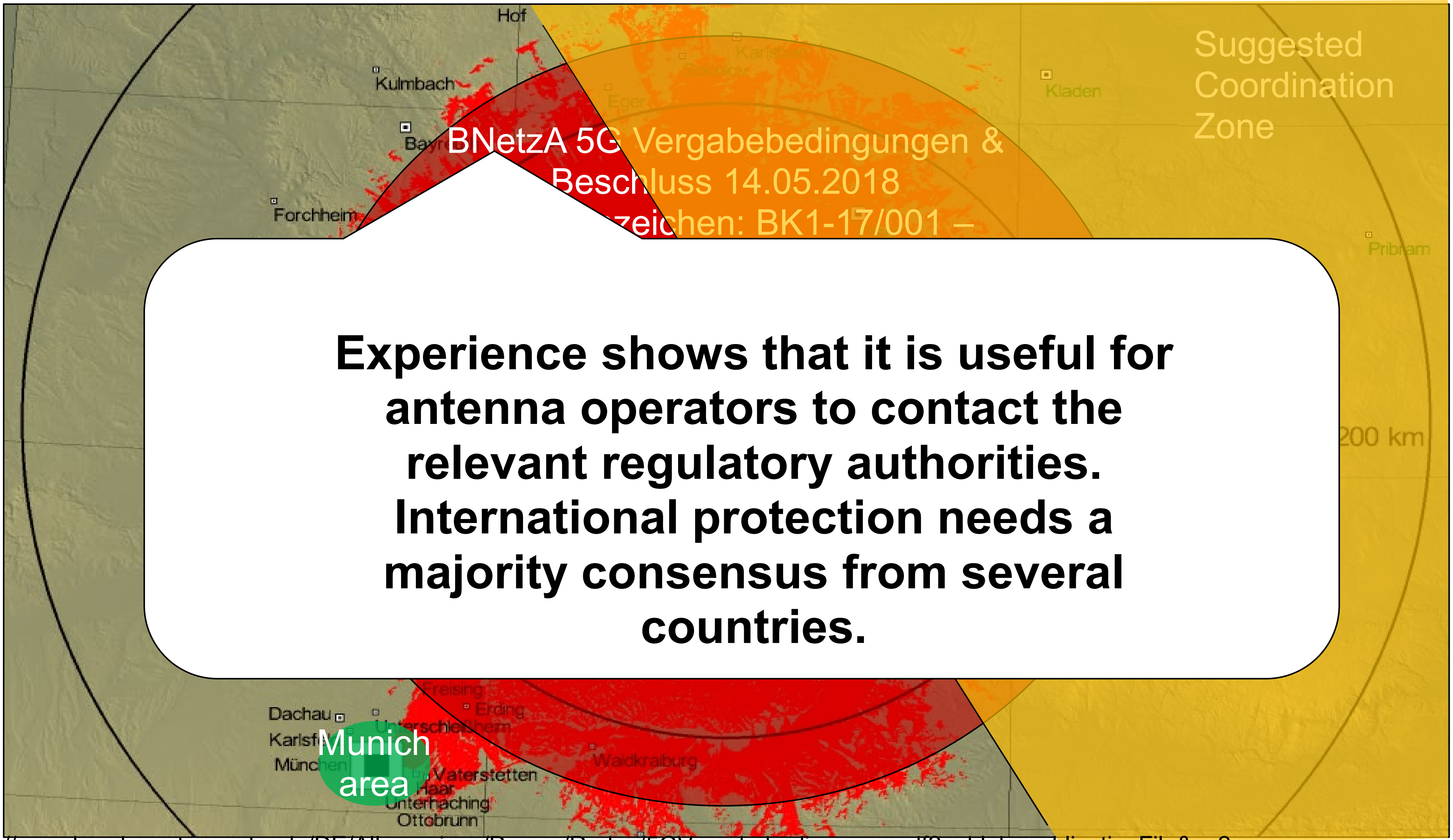

Experience shows that it is useful for antenna operators to contact the relevant regulatory authorities. International protection needs a majority consensus from several countries.

https://www.bundesnetzagentur.de/DE/Allgemeines/Presse/Reden/5GVergabebedinungen.pdf?__blob=publicationFile&v=2
https://www.bundesnetzagentur.de/DE/Beschlusskammern/1_GZ/BK1-GZ/2017/BK1-17-0001/BK1-17-0001_Entscheidung_IundII_Download_BF.pdf?__blob=publicationFile&v=1

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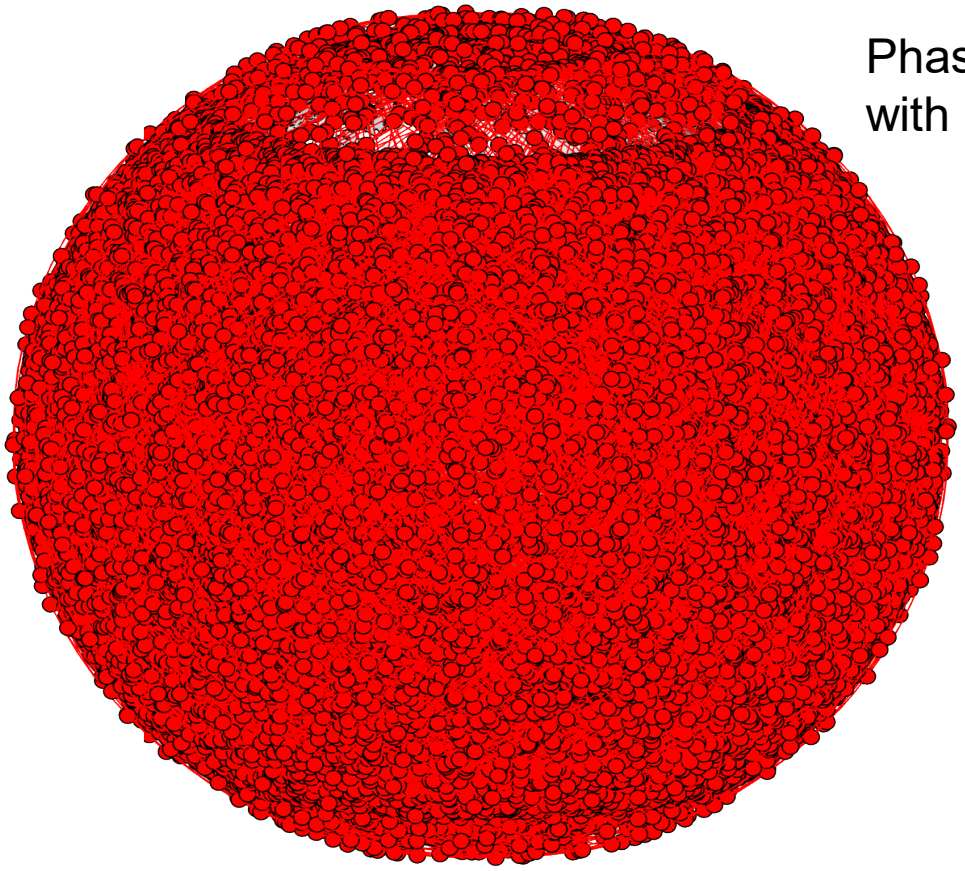
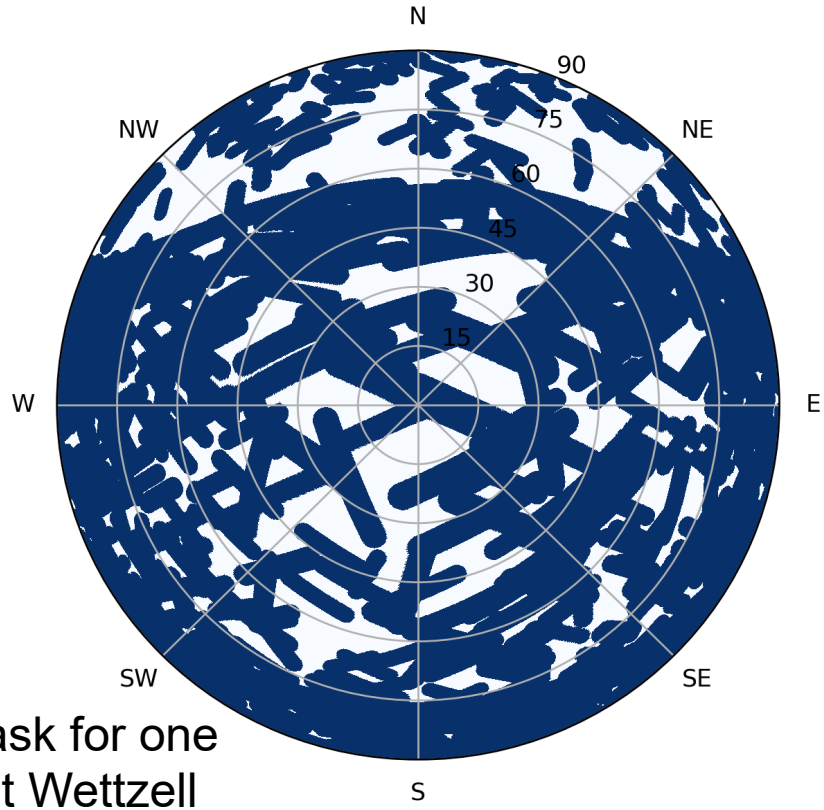
3600 MHz: 5G
10950-12700 MHz: Starlink downlink
14000-14500 MHz: Starlink uplink

General characterization … big jammers

Starlink



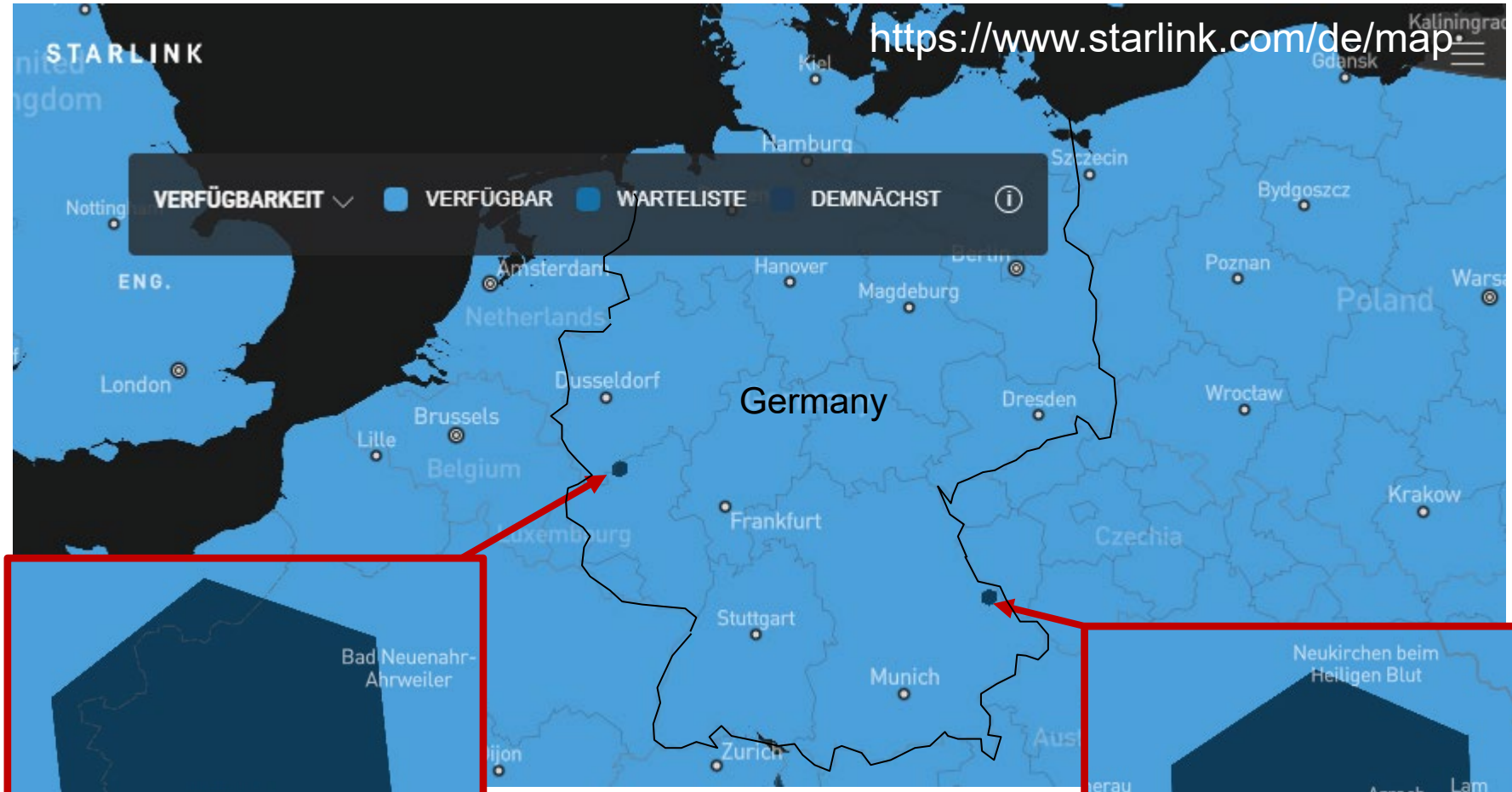
Phase 3: Mega-constellation
with 34408 Satelliten



Avoidance mask for one
scan 30 sec at Wettzell

General characterization … big jammers

Starlink



Protection zones

Effelsberg

But by should be 12.5km by regulations

Wettzell

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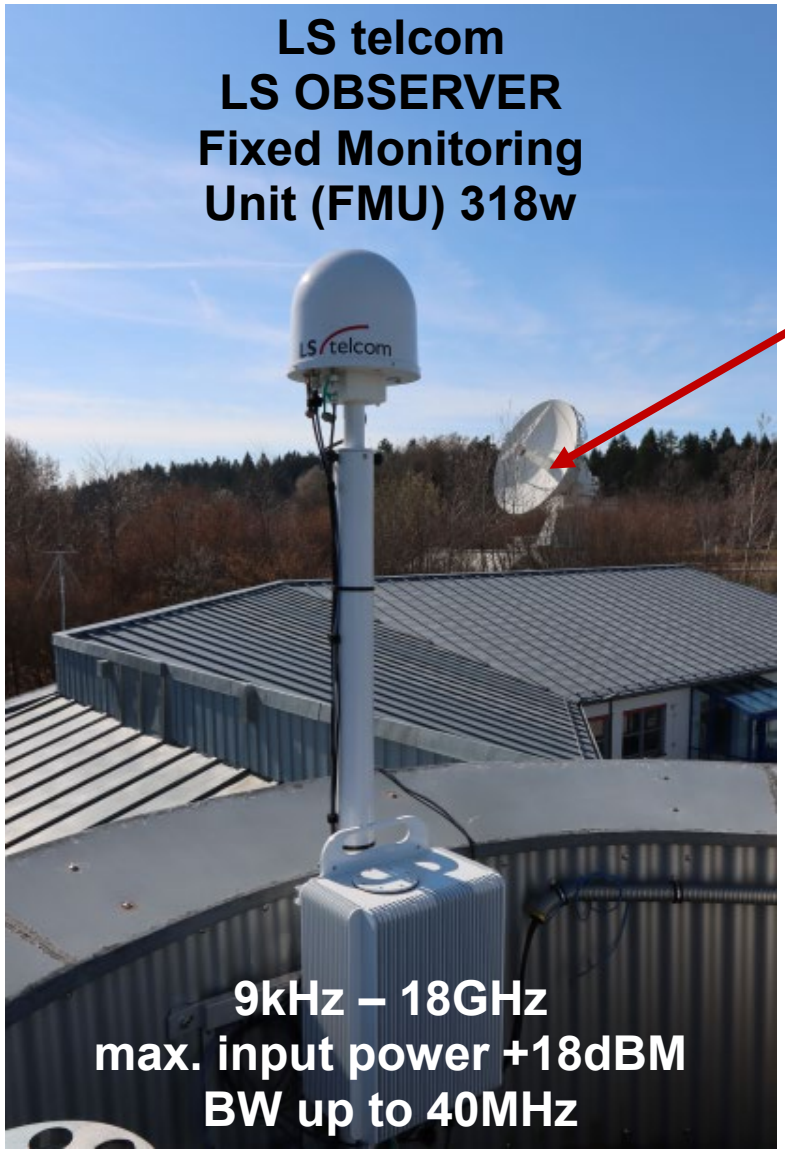
RFI monitoring: IVS VLBI modes

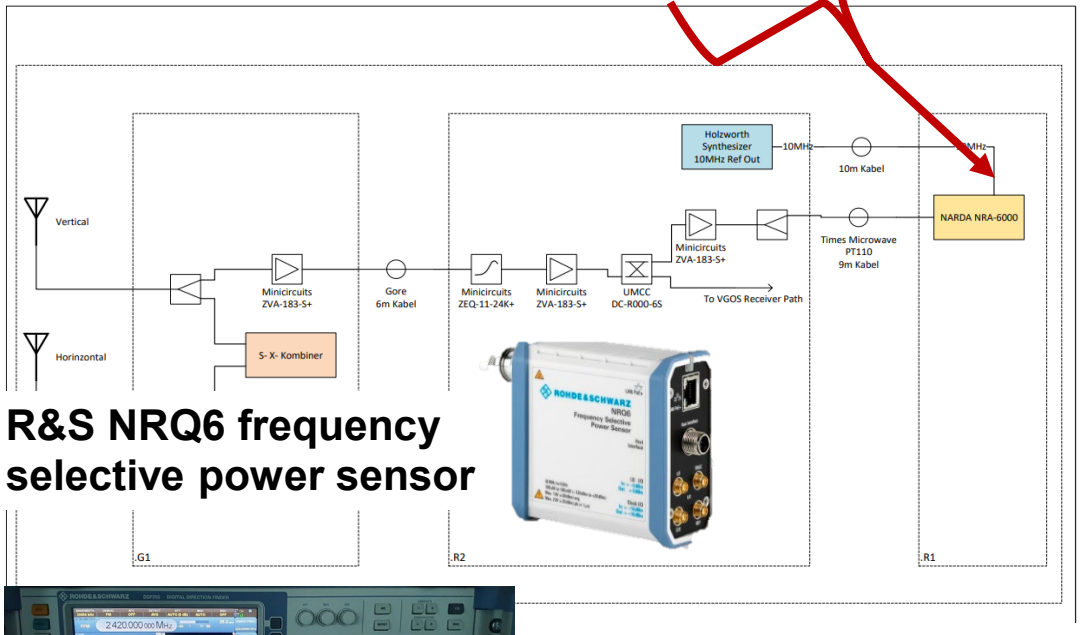
Standard equipment

LS telcom
LS OBSERVER
Fixed Monitoring
Unit (FMU) 318w



9kHz – 18GHz
max. input power +18dBM
BW up to 40MHz

Narda NRA 6000



R&S NRQ6 frequency selective power sensor

R&S DDF255 Digital Direction Finder

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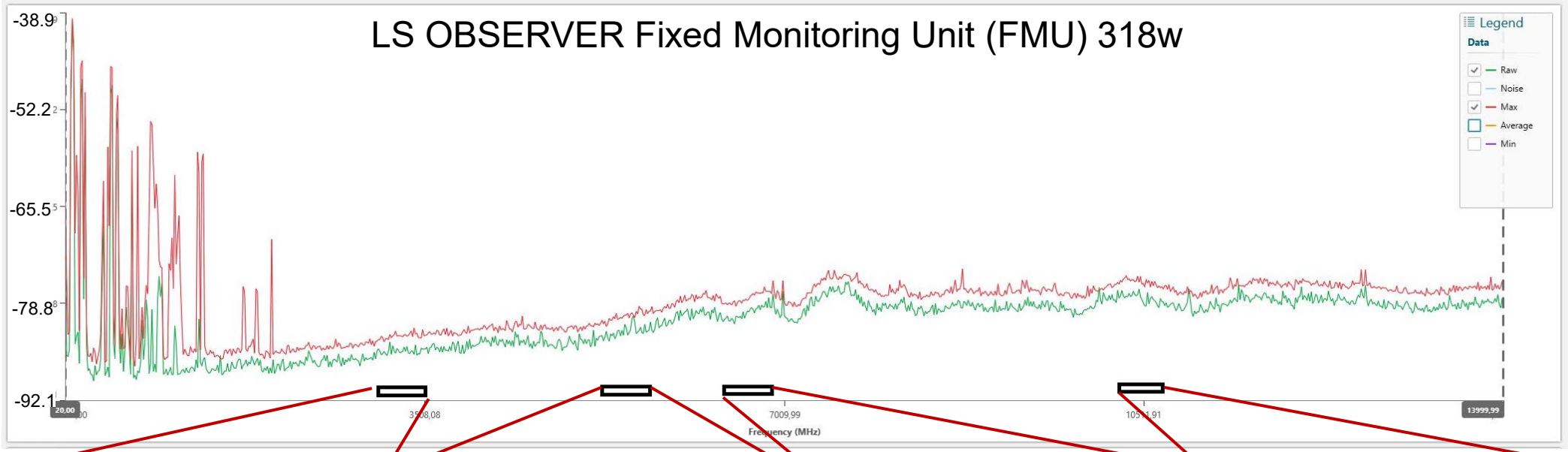
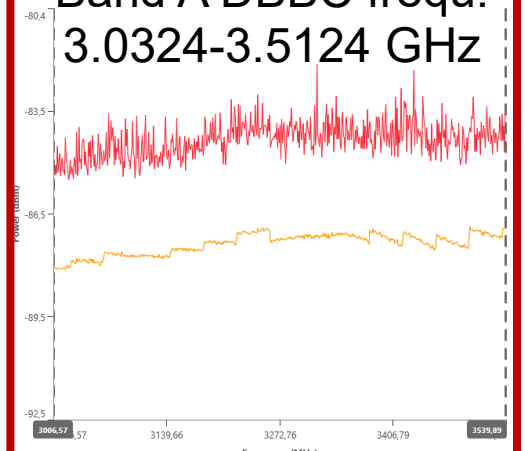
RFI monitoring: IVS VLBI modes

VGOS

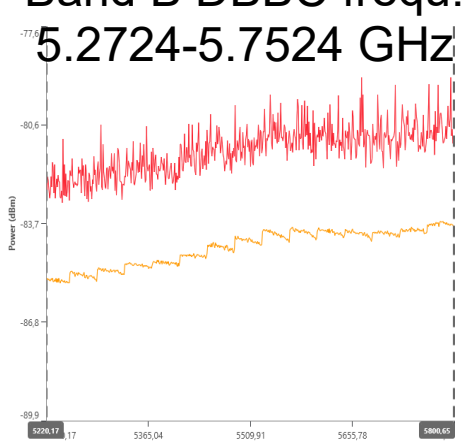


Band A DBBC frequ. 3.0324-3.5124 GHz



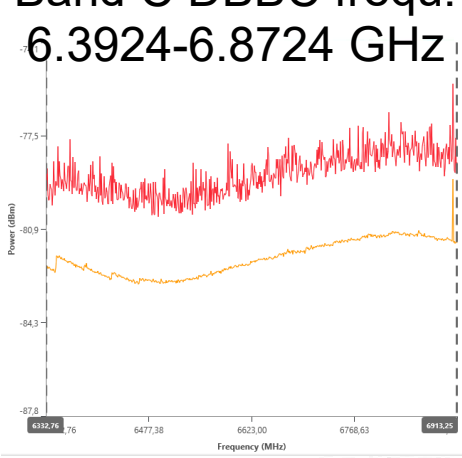
BW=0.480 GHz (0.512 GHz)

Band B DBBC frequ. 5.2724-5.7524 GHz



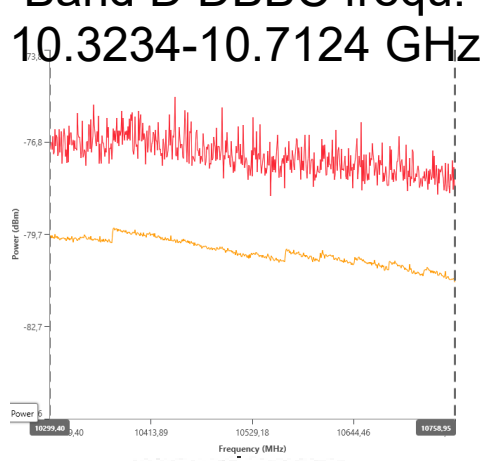
BW=0.480 GHz (0.512 GHz)

Band C DBBC frequ. 6.3924-6.8724 GHz



BW=0.480 GHz (0.512 GHz)

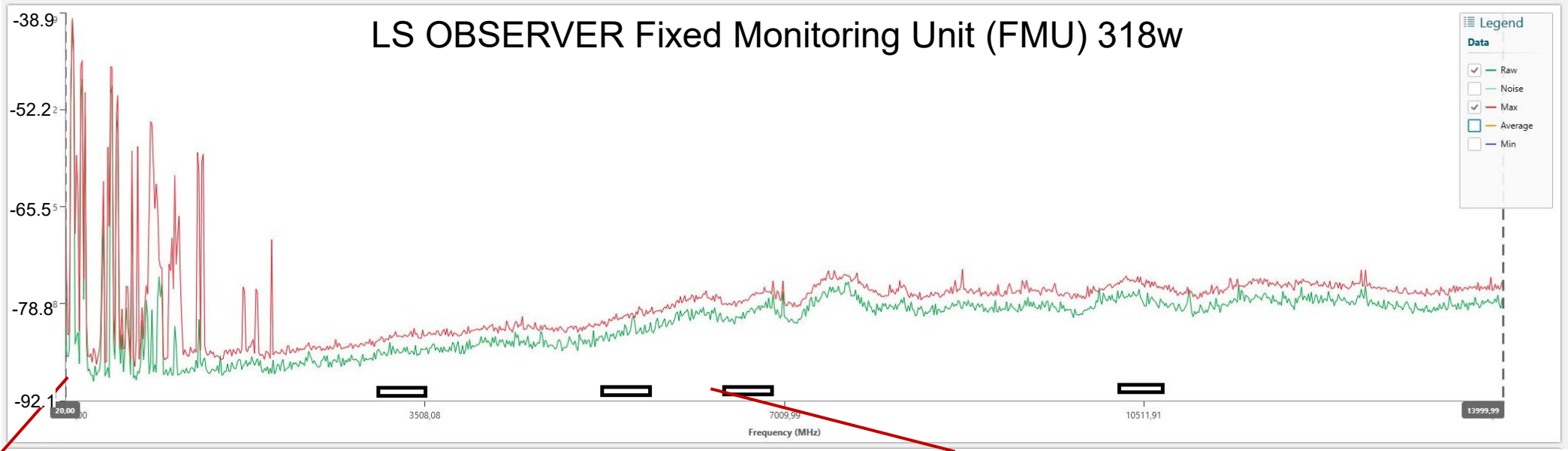
Band D DBBC frequ. 10.3234-10.7124 GHz

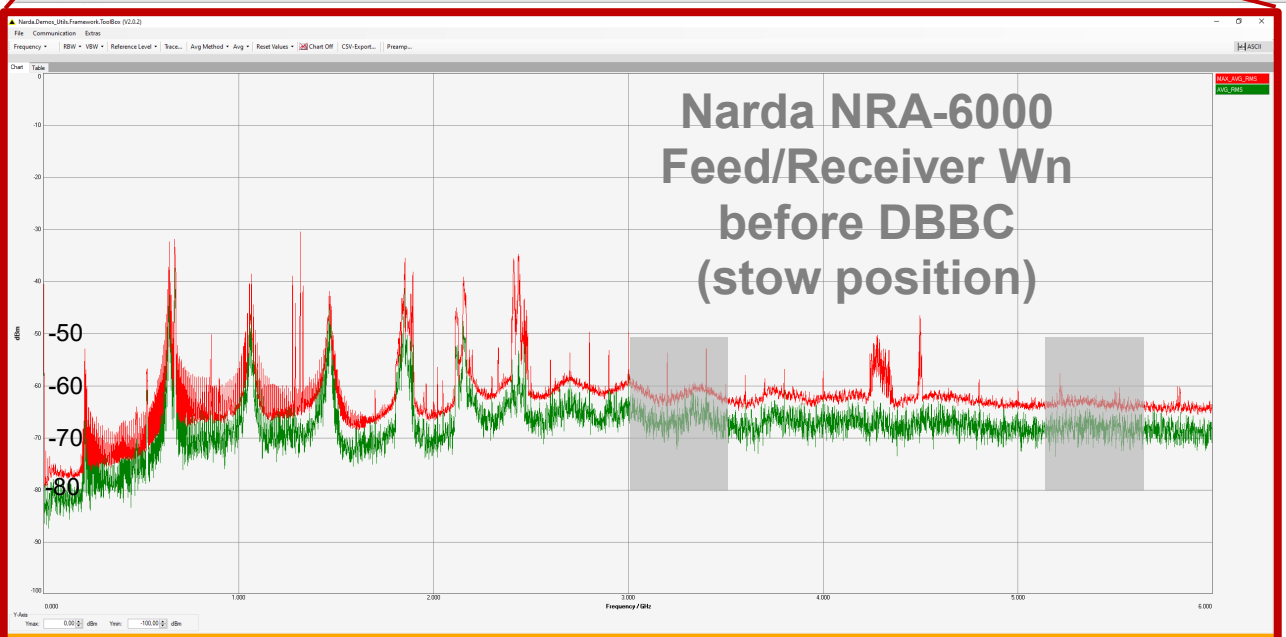


BW=0.480 GHz (0.512 GHz)

RFI monitoring: IVS VLBI modes

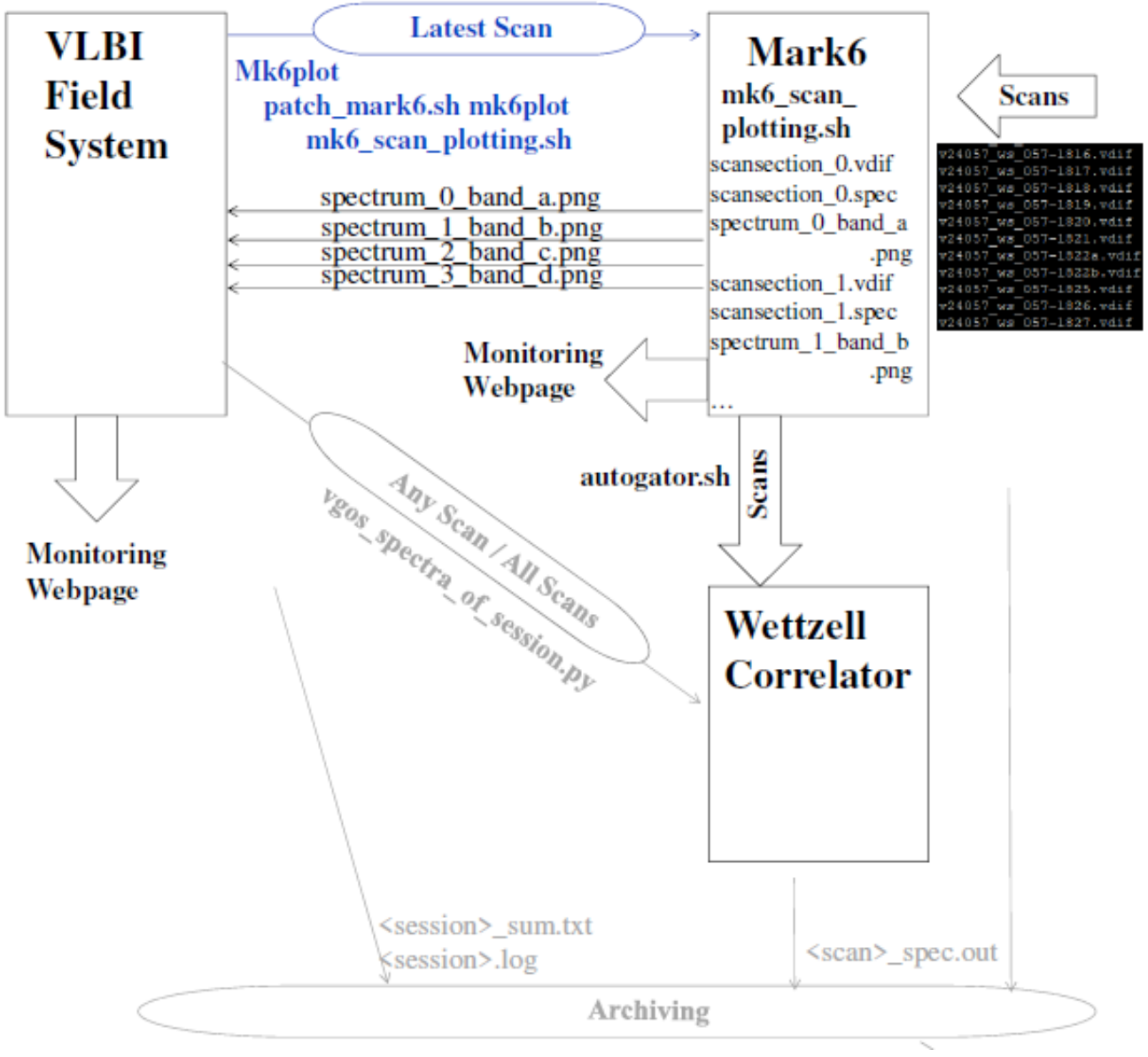
VGOS





RFI monitoring: IVS VLBI modes

VGOS – DiFX Onboard Methods



RFI monitoring: IVS VLBI modes

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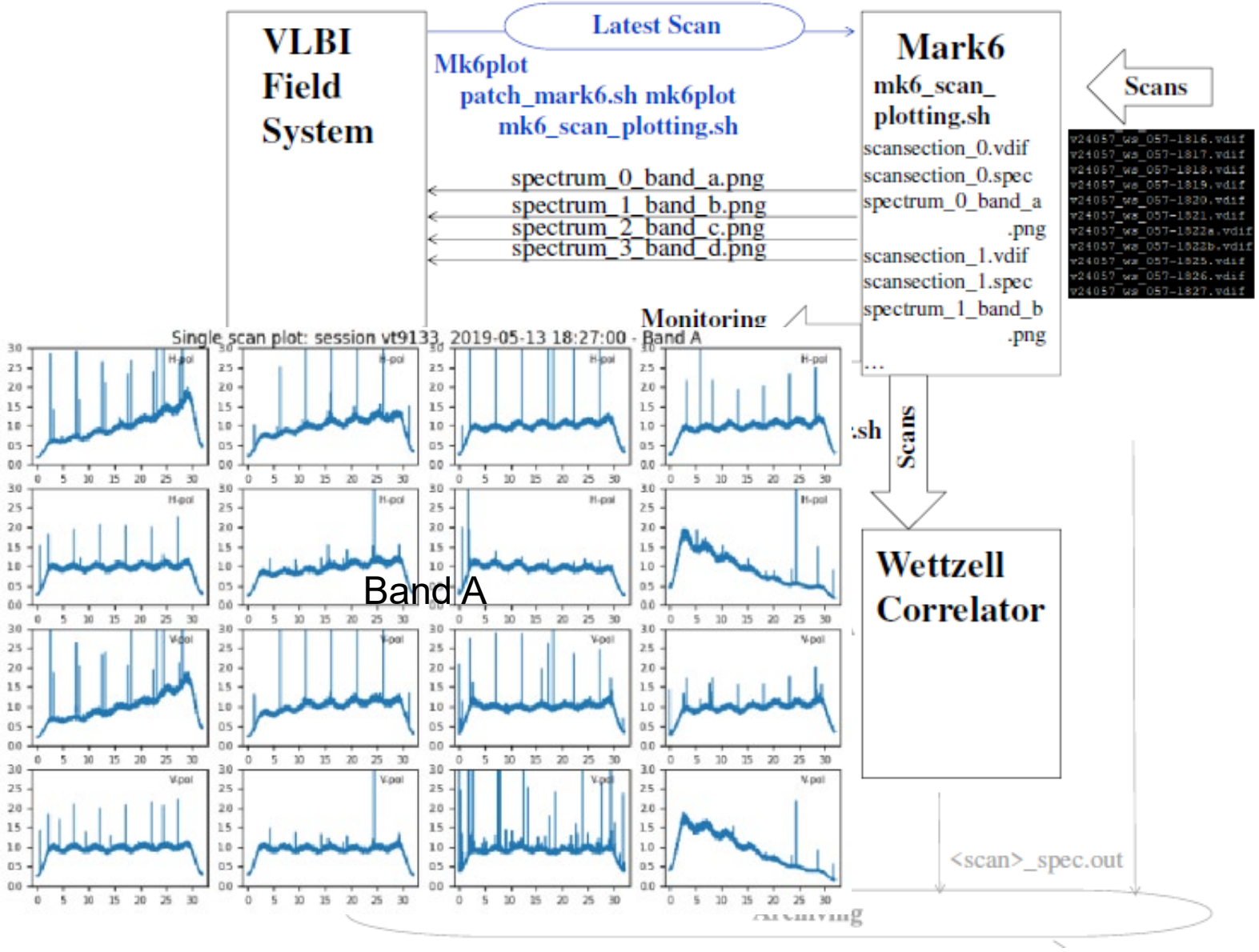


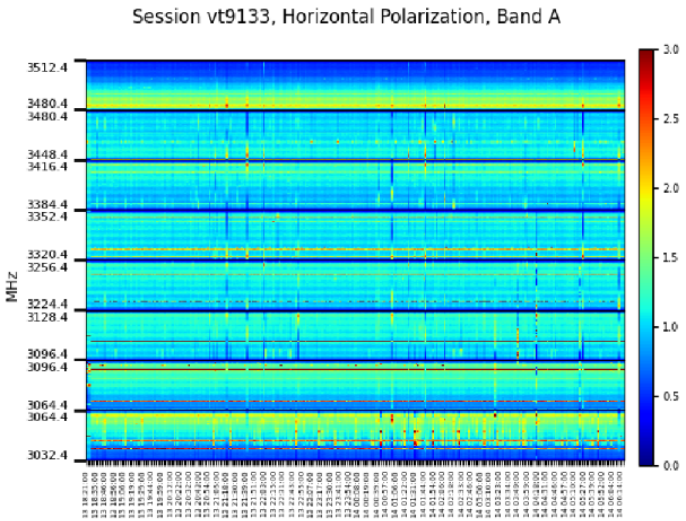
RFI monitoring: IVS VLBI modes

VGOS – DiFX Onboard Methods

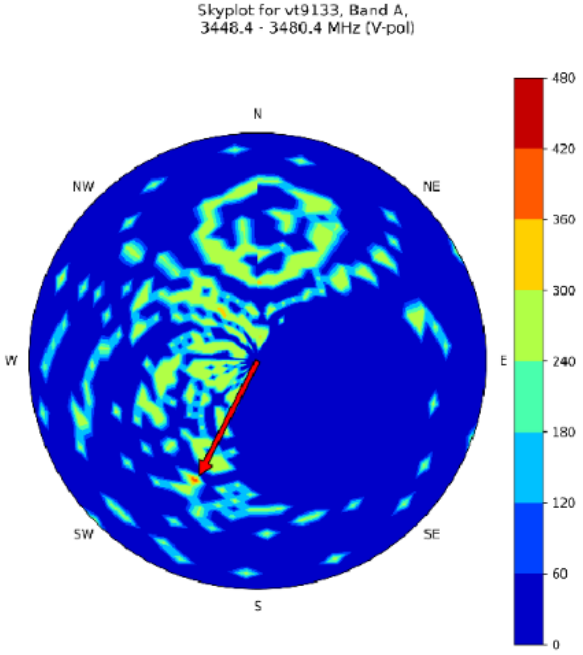
Archiving

RFI Monitoring main.py
(spectra_analysis.py)

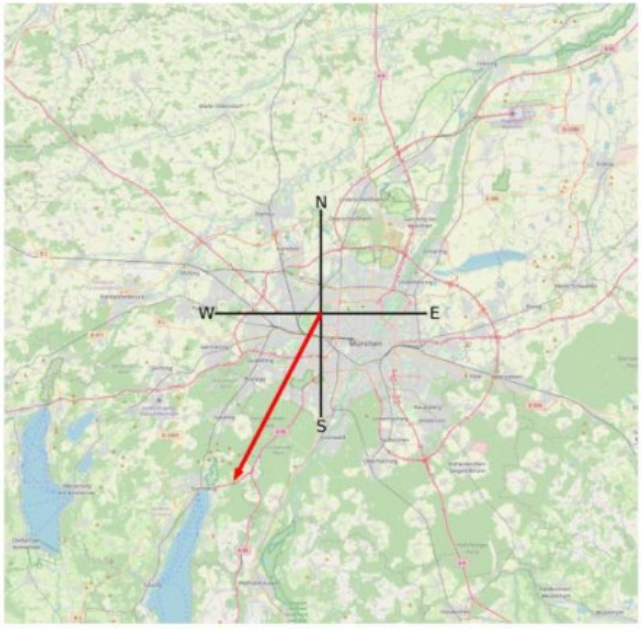
Spectrograms (waterfall plots) for a a sequence of scan



Combined, aggregated skyplots for a a sequence of scan



Map projection of direction finding



https://github.com/luca-rigon/RFImonitoring-tool

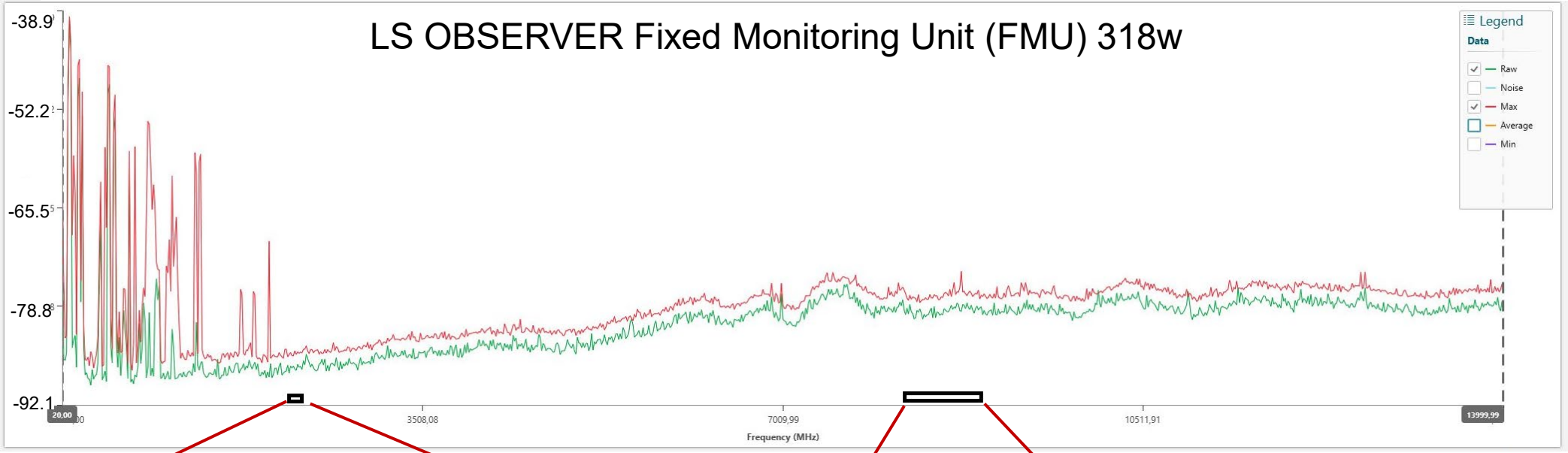
IVS IVTW 2024

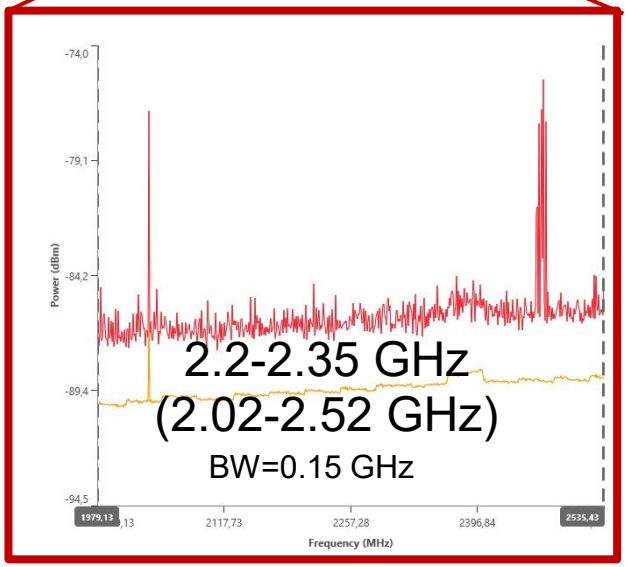
RFI Monitoring

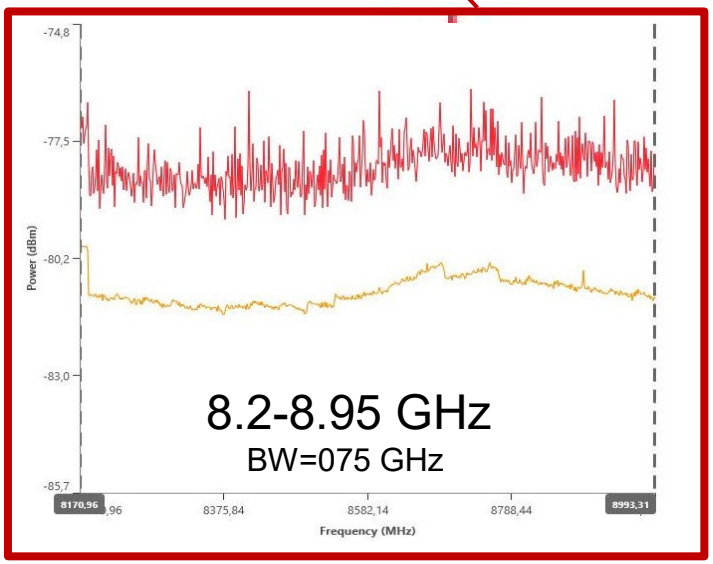
- General situation … big jammers
  - Frequency occupation measurement BNetzA
  - LTE/4G
  - 5G
  - Starlink
- RFI Monitoring
  - Equipment
  - VGOS
  - **Legacy S/X**
  - GENESIS
- Radio horizon with Solar Flux Telescope

RFI monitoring: IVS VLBI modes

Legacy S/X

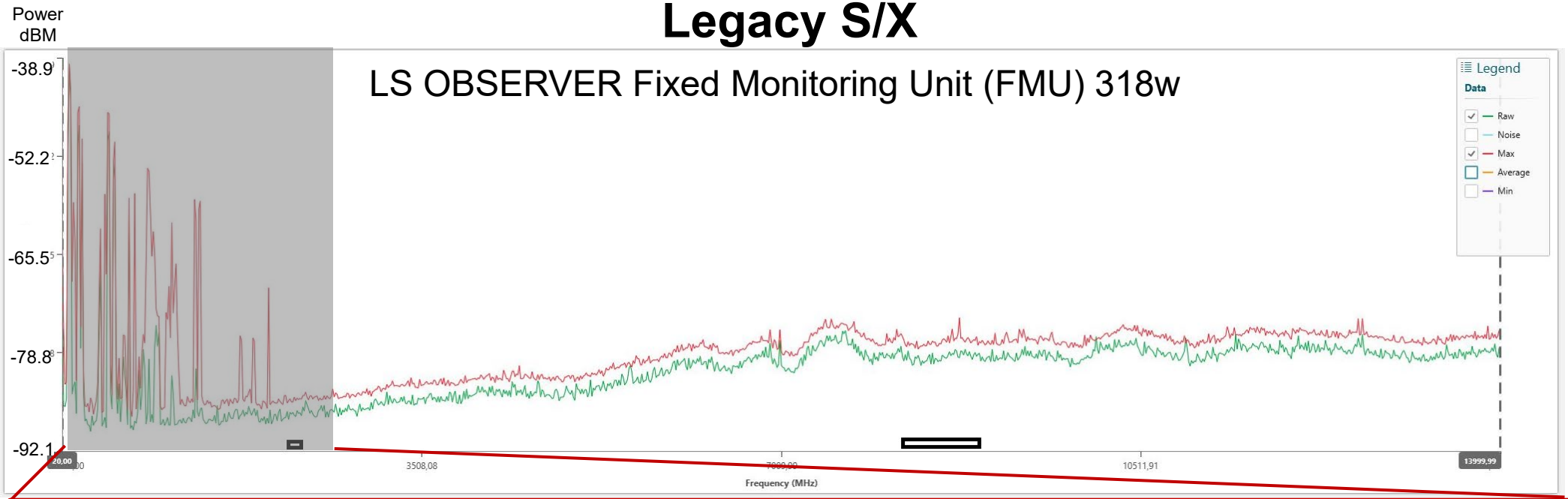


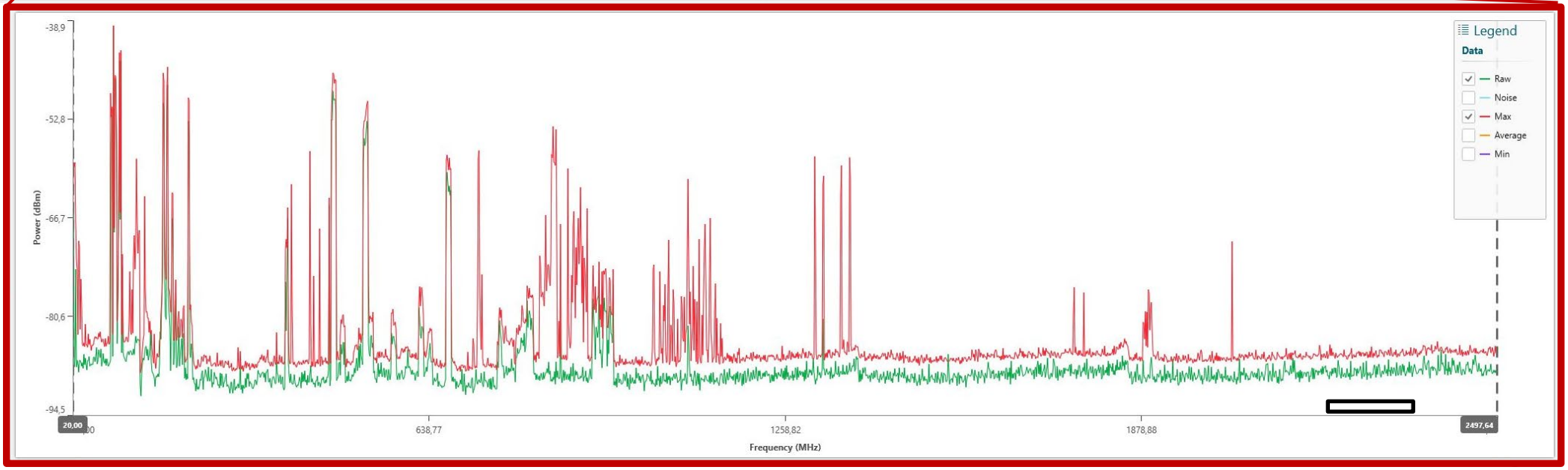




RFI monitoring: IVS VLBI modes

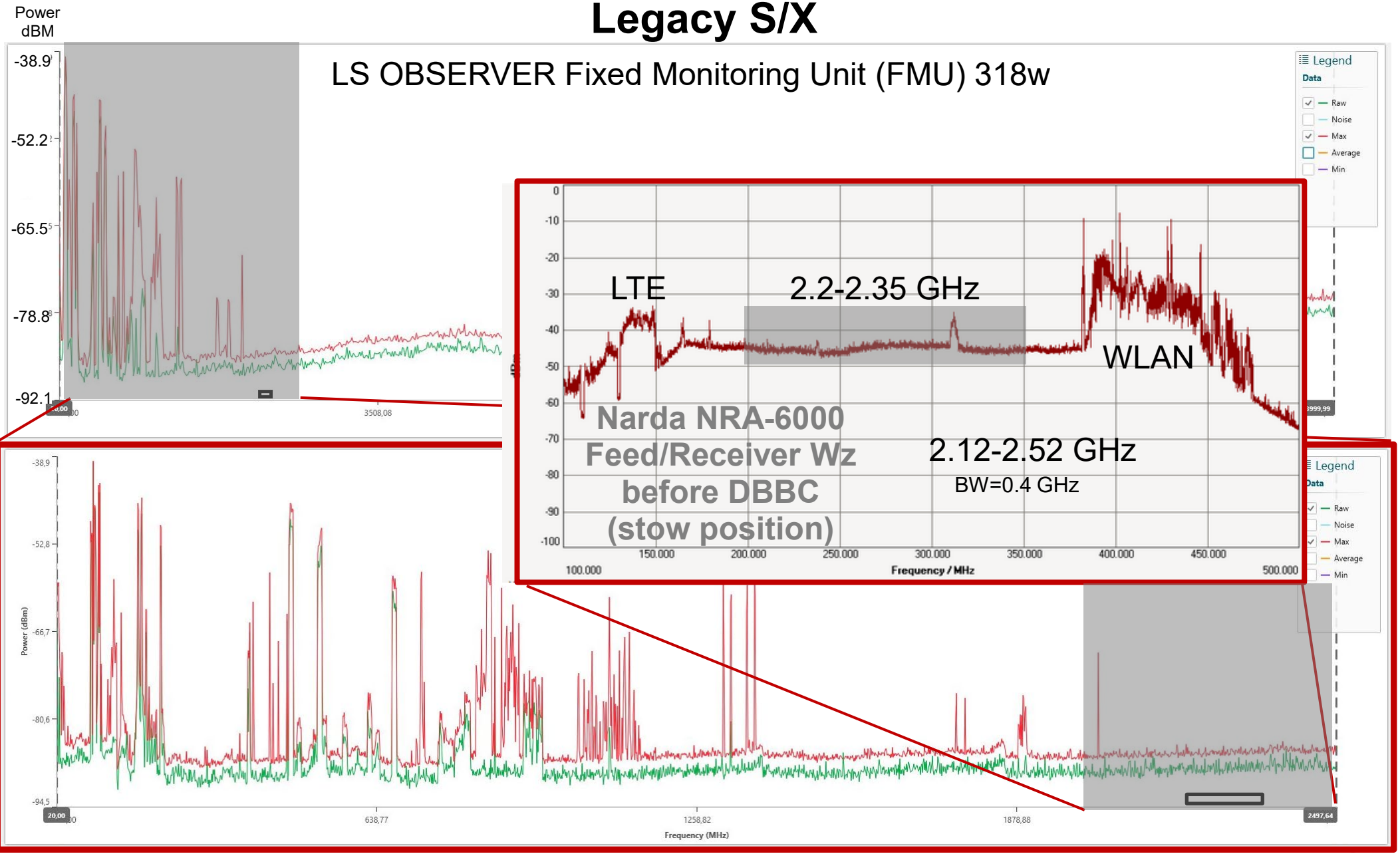
Legacy S/X





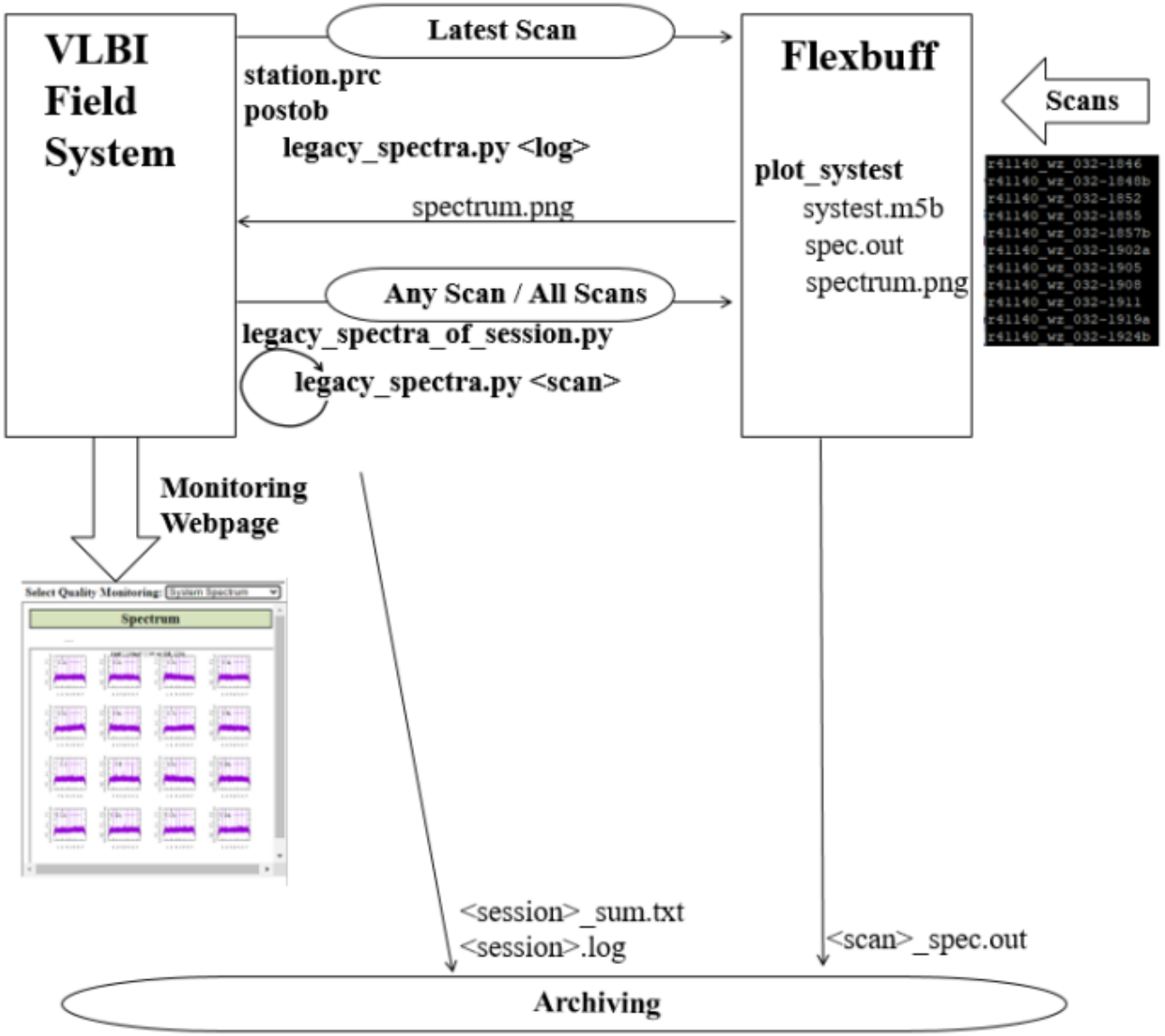
RFI monitoring: IVS VLBI modes

Legacy S/X



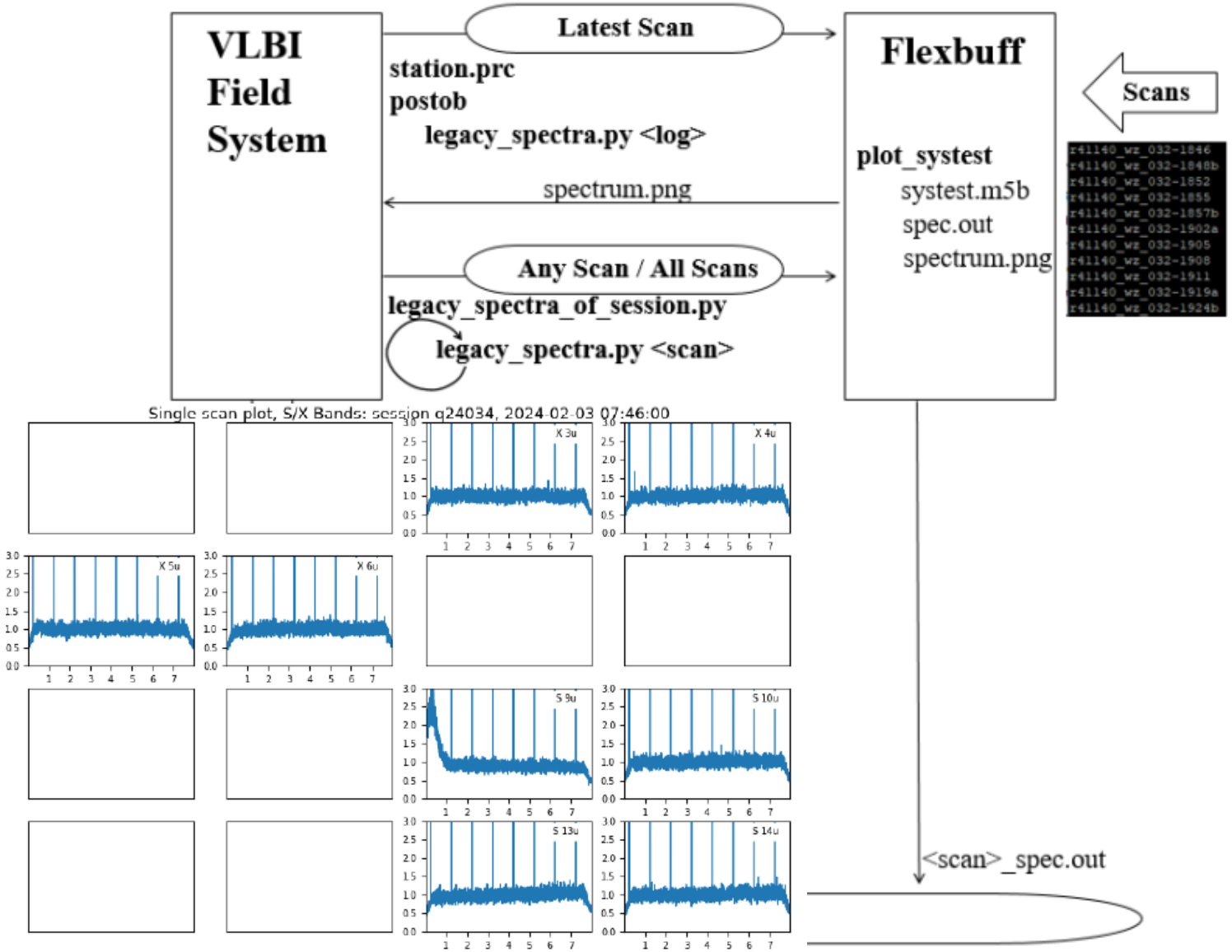
RFI monitoring: IVS VLBI modes

Legacy S/X – DiFX Onboard Methods



RFI monitoring: IVS VLBI modes

Legacy S/X – DiFX Onboard Methods



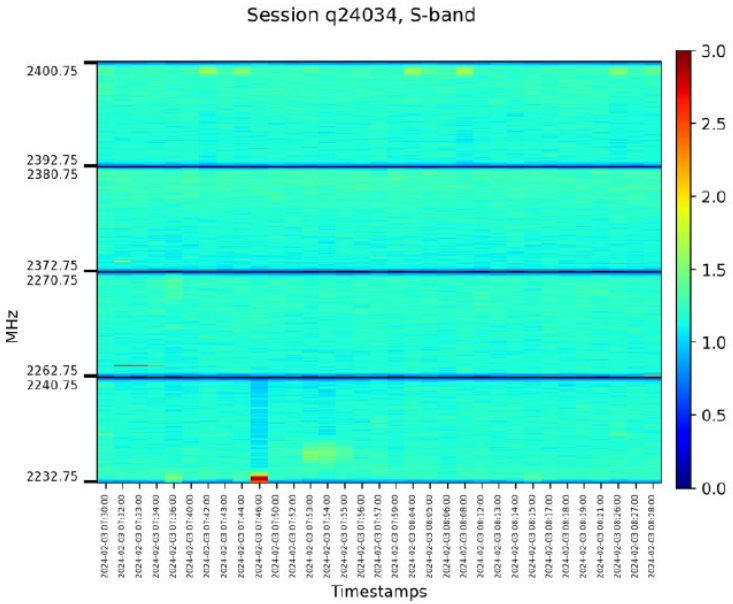
RFI monitoring: IVS VLBI modes

Legacy S/X – DiFX Onboard Methods

Archiving

RFI Monitoring main.py
(spectra_analysis.py)

Spectrograms (waterfall plots) for a a sequence of scan



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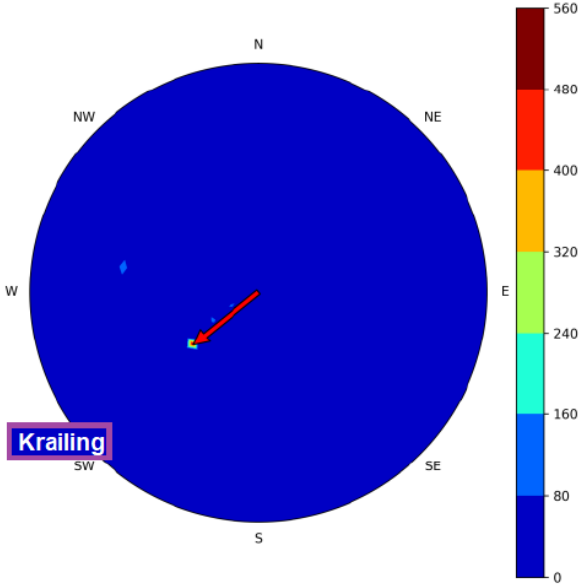

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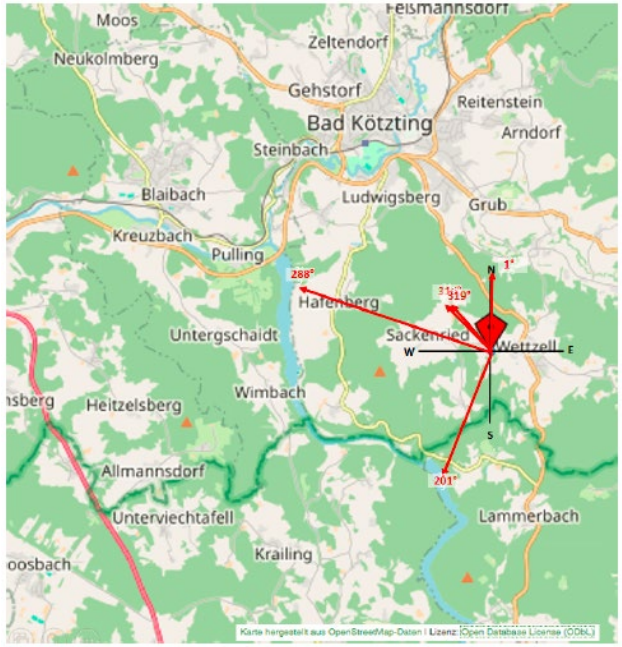

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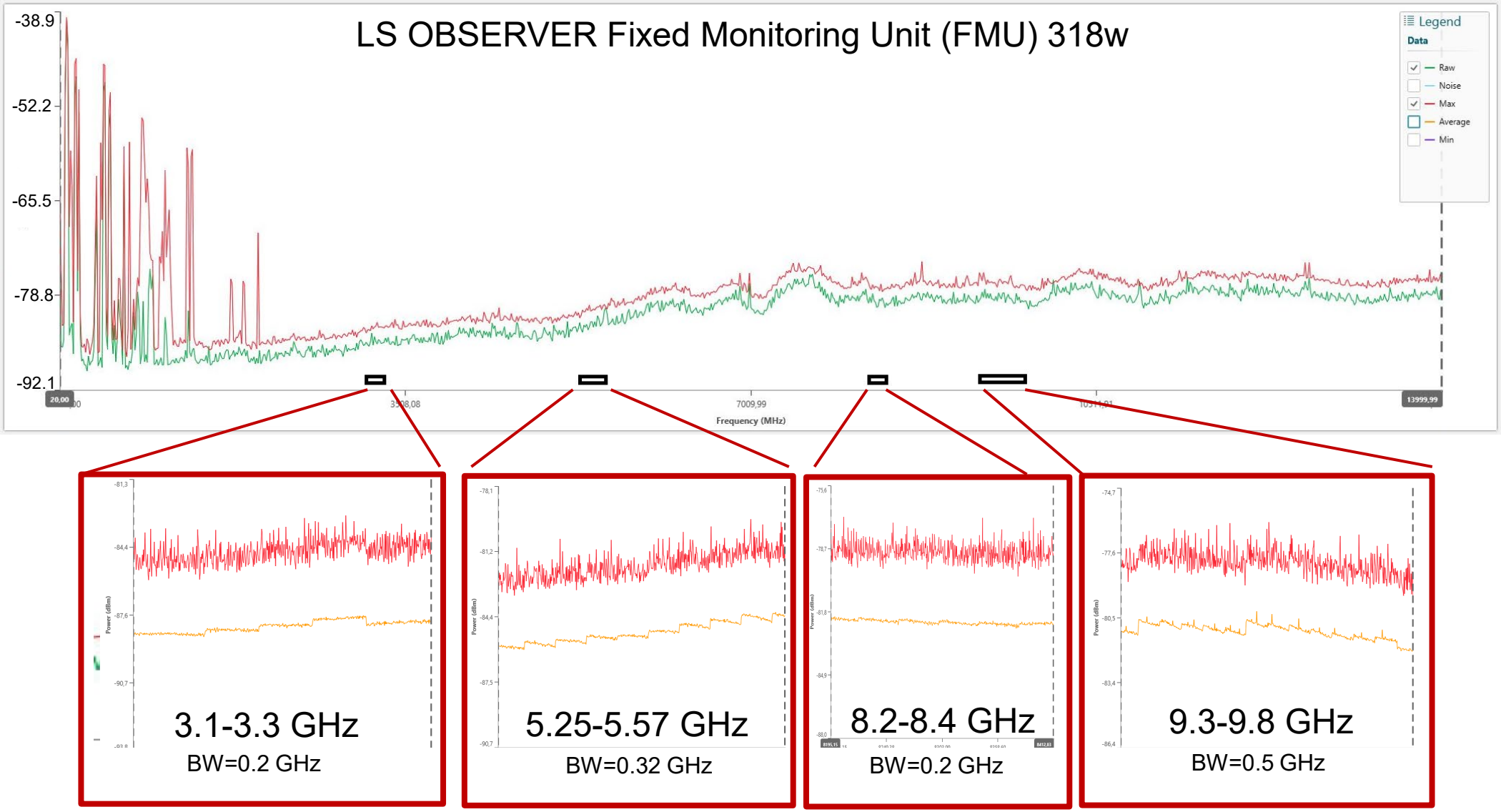
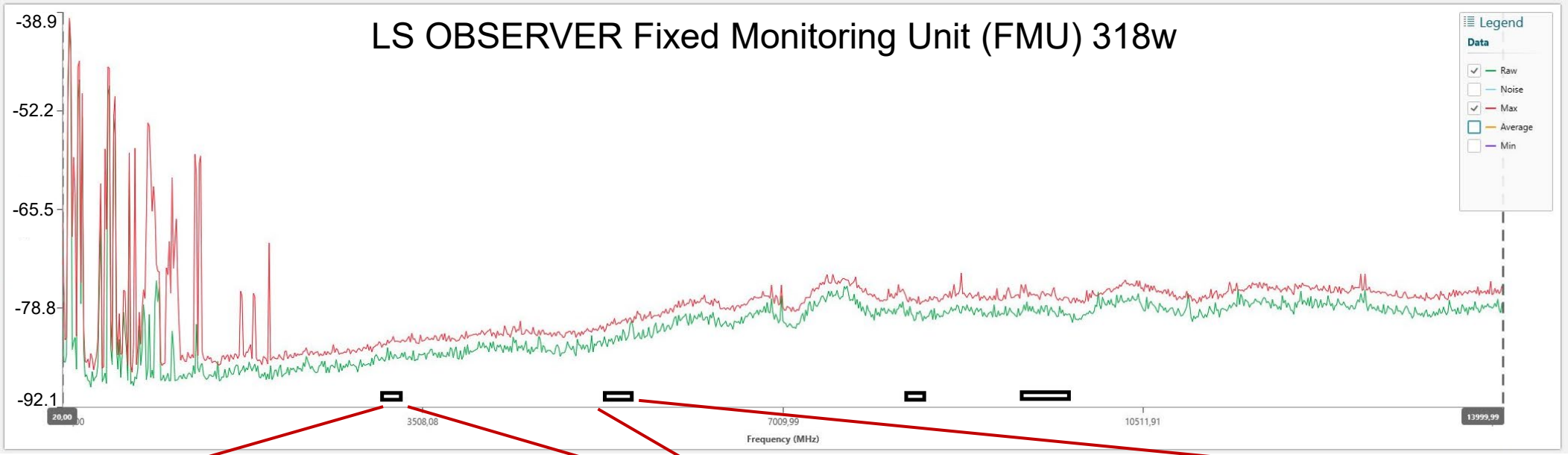
RFI monitoring: Future modes

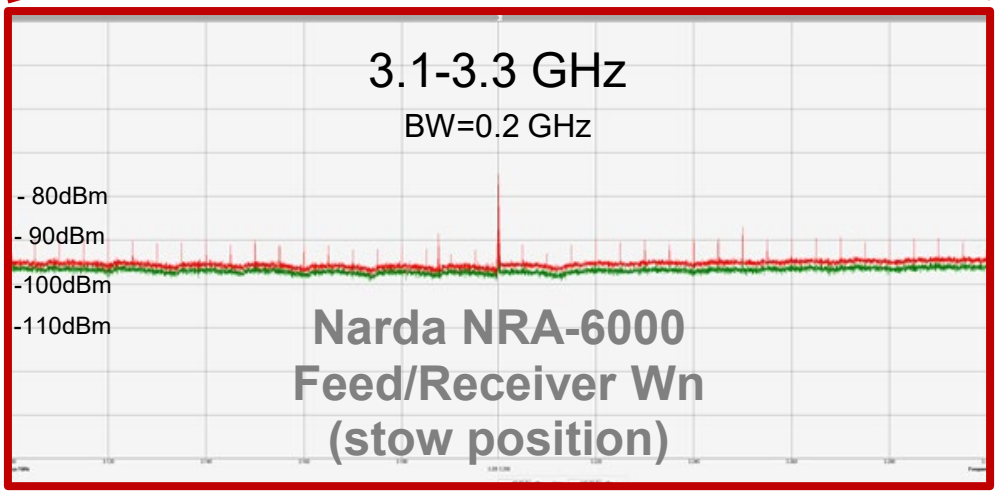
GENESIS

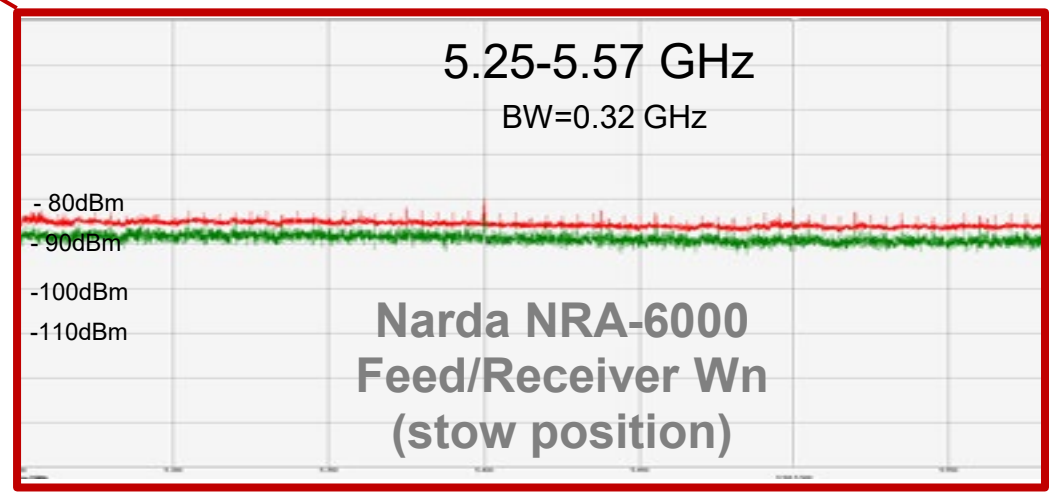


RFI monitoring: Future modes

GENESIS







IVS IVTW 2024

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- **Radio horizon with Solar Flux Telescope**

RFI monitoring: Future modes

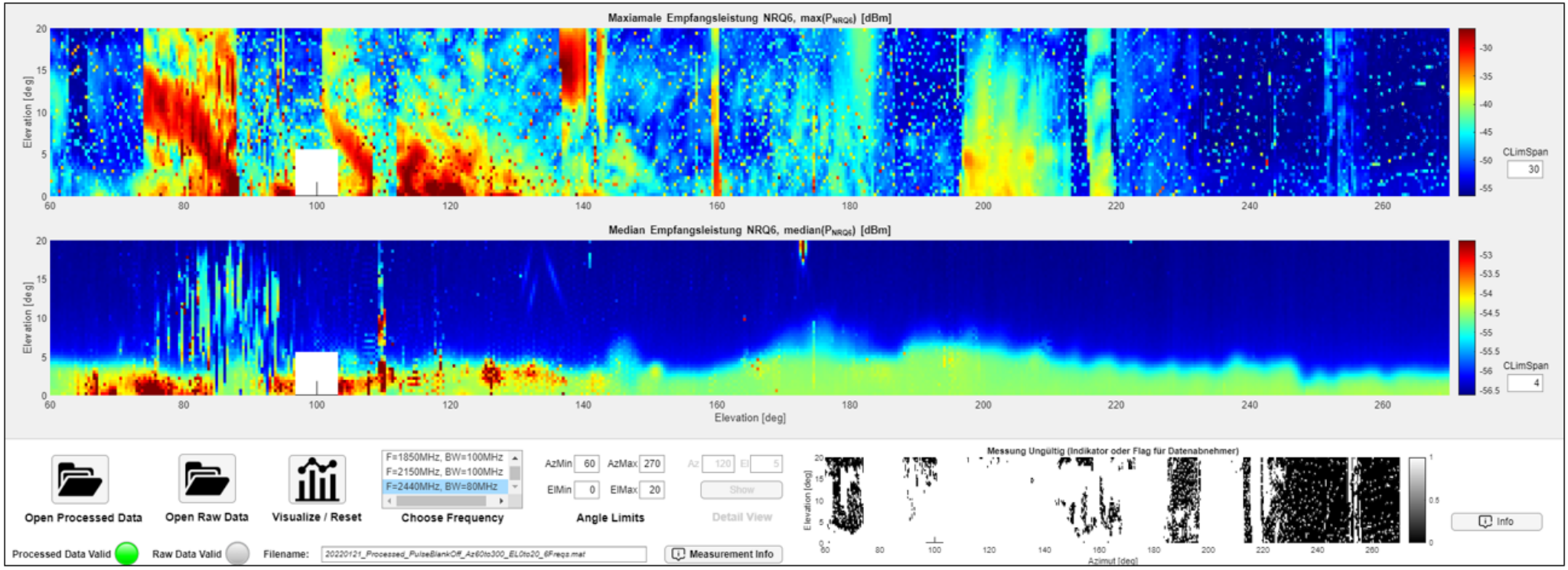
Scans of the radio horizon with the new Solar Flux Telescope

- 5m prime focus antenna
- Azimuth 0-360° Elevation 0-90°
- Max. speed 2 deg/sec
- Broadband 1-11 GHz
- 4 channel receiver with 80 MHz bandwitdh each, adjustable
- Frequency 1.4GHz, 2.8 GHz, 4.9 GHz, 10.6 GHz for solar flux

RFI monitoring: Future modes

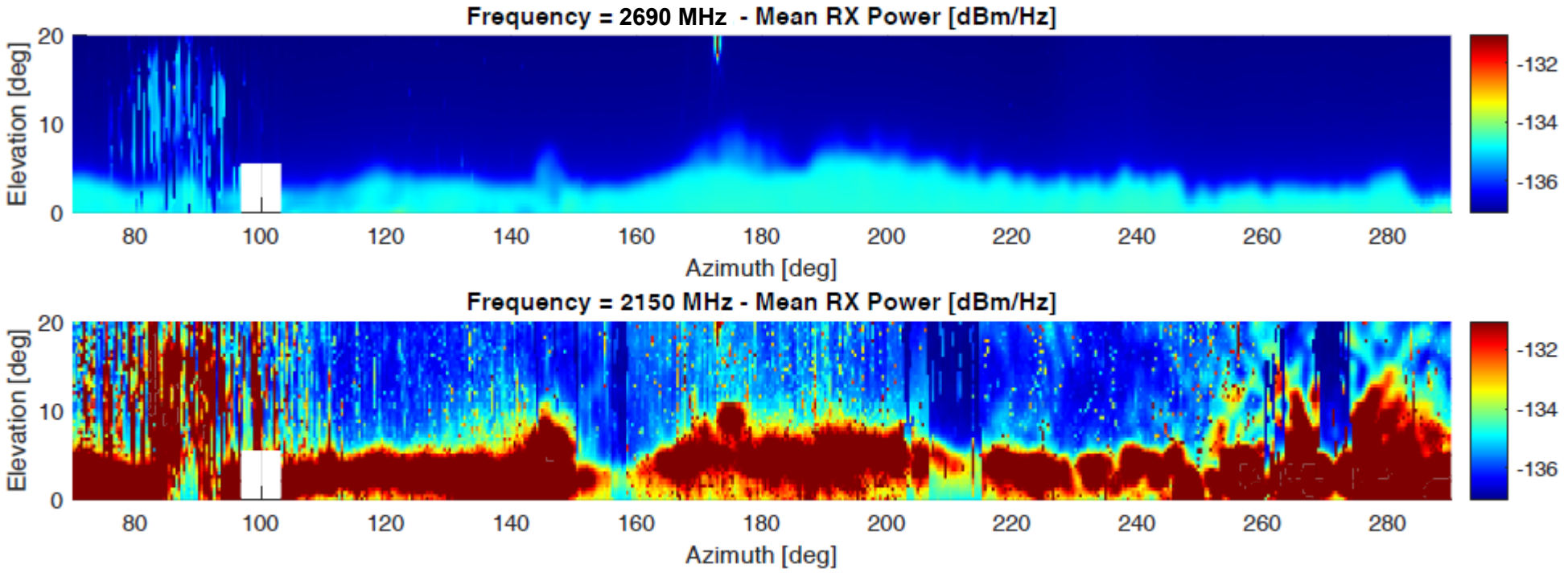
Scans of the radio horizon with the new Solar Flux Telescope

- Vermessung Radiohorizont in ISM-Frequenzband 2,4 GHz (F = 2440 MHz, BW = 80 MHz):



RFI monitoring: Future modes

Scans of the radio horizon with the new Solar Flux Telescope



IVS IVTW 2024

Thank you …