Toolbox for the Detection of Strong RFI Sources with Station Onboard Methods from DiFX

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Abstract RFI monitoring is an essential task. Besides professional hardware, like a direction finder and spectrum analyzer, every station and every correlator can use methods which come onboard with the DiFX software package. The tools can be extracted and used separately. We developed a toolbox with Python and Shell scripts using the "mark5access" library of the DiFX software, allowing a quick analysis using spectral power levels. Spectra data are extracted from real VLBI recordings of each scan. The developed Python scripts convert these data to spectrograms (waterfall plots), as well as skyplots even with directional information of the strongest sources on map projections. It is a straightforward method of checking and showing strong sources which are often hints to RFI and impacts from unwanted frequency occupations. It might also be a nice by-product of the correlators to offer such plots after each session processing. Nevertheless, it is a quick tool for station staff to check their environment.

Keywords m5spec, spectra, RFI sky plots

1 Introduction

Receiving unwanted signals with radio telescopes is an increasing issue. Over-saturation leads to complete failures in whole bands or destroys low-noise amplifiers. The results are high costs or even the end of a service at some areas. RFI monitoring with known software packages was introduced in "RFI monitoring using 'mark5access' spectra and Python programs" at the EVGA meeting in Bad Kötzting in 2023. It was shown that existing data can be used to get a first qualitative overview. Software like the "mark5access" library of the DiFX correlation software can be used to create spectra plots. A selection of plot data over complete sessions in combination with pointing information gives a suitable basis for creating sky plots showing the directions of the strong sources. The software was originally developed for VGOS bands. Now it has been extended to also support the different legacy bands.

The following paper explains the extension written in Python which creates spectra plots and sky plots especially for legacy systems.

2 General Processing

The processing is separated into two parts:

1. the generation of the spectra data files using a script wrapping "m5spec" with Python or Linux scripts,
2. and the conversion of the spectra data into different plots combining pointing information using a separate Python script.

The generation of the spectra data is currently processed on the recorder and is controlled by a script on the Field System PC. It uses "m5spec" of the "mark5access" library from the DiFX software. The spectra can be created after each scan or after the session for all scans of the whole session.

There are two different workflows representing VGOS and legacy systems. The script "mk6_scan_plotting.sh" for VGOS setups prepares

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separated VDIF files and runs “m5spec” on these files. This is possible because of the fixed number of bands and the pre-defined bandwidth settings. The legacy S/X software “legacy_spectra.py” is an extension of the original spectra plotting code from JIVE and reads the BBC-settings from the log file to define the correct number of used bands and each band’s bandwidth. Both tools can directly create spectra plots as PNG or as a plot window for a real-time view using GNU plot.

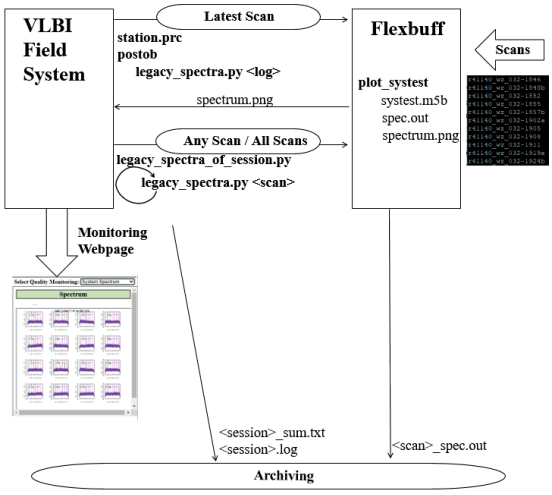

Fig. 1 New workflow for legacy S/X spectra generation.

All spectra files, either from VGOS or from legacy systems, are sent to an archive server for further processing after each session. An RFI monitoring “spectra_analysis.py” is then started (the current test version is named “main.py”). The program can manage both VGOS and legacy S/X. It can be used to reprocess the spectra plots for all bands. It can also stack a sequence of spectra plots into a spectrogram. Another option enables the creation of a sky plot combining the pointing from the session summary with the corresponding spectra data. Maximum values or mean values over a specific threshold can be tracked, so that the direction of the strongest source can be found and inserted as an arrow into the plot. Finally, the directional plot can be projected on a map to give a better localization.

3 Results

We currently work more and more with real data from different sessions, plot them over maps, and compare them to actual situations described, e.g., on frequency maps of the Federal Network Agency (BNetzA). Meanwhile, the software can not only show maps with the direction to the strongest source but also directions representing several strongest sources. A sample is shown in Figure 2 using VGOS data.

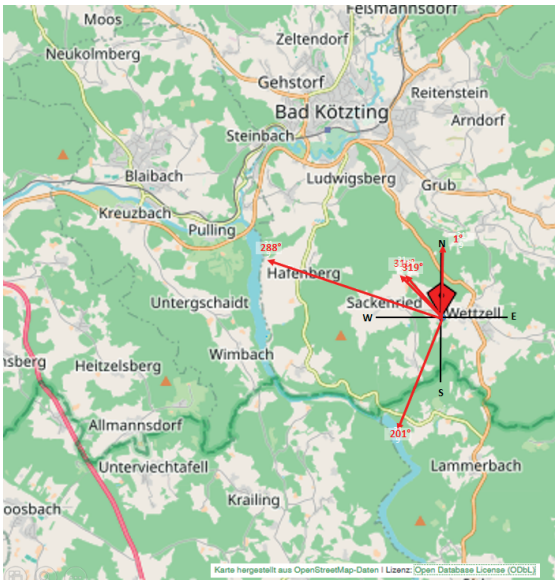

Fig. 2 The five strongest sources in band A (3,032–3,512 MHz) of a VGOS session as an overlay on a map of Wettzell.

The software is now also able to work with legacy S/X data, so that spectra plots of all channels can be created for one scan. Figure 3 shows a sample for a scan at 07:46 UT of session q24034 on February 3rd, 2024.

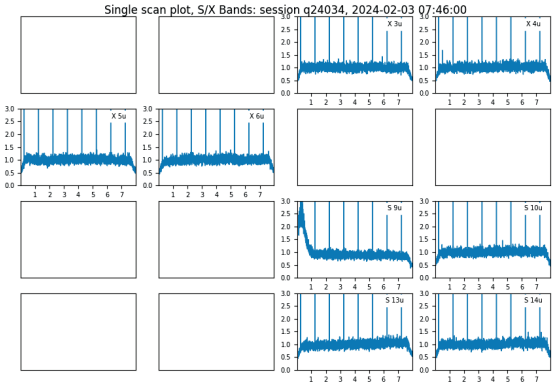

Fig. 3 Spectra plots for all S/X channels defined for the Intensive session “q24034”.

These spectra data can be stacked into a spectrogram to show the changes over time. Figure 4 shows a spectrogram for the whole session q24034 on February 3rd, 2024. The used frequency bands are described in Table 1.

Table 1 Frequencies used for q24034.

BBC	Band	Lower frequency	Upper frequency
03	X upper	8365.75	8373.75
04	X upper	8445.75	8453.75
05	X upper	8805.75	8813.75
06	X upper	8925.75	8933.75
09	S upper	2232.75	2240.75
10	S upper	2262.75	2270.75
13	S upper	2372.75	2380.75
14	S upper	2392.75	2400.75

The higher values around 2.4 GHz might come from wireless LAN.

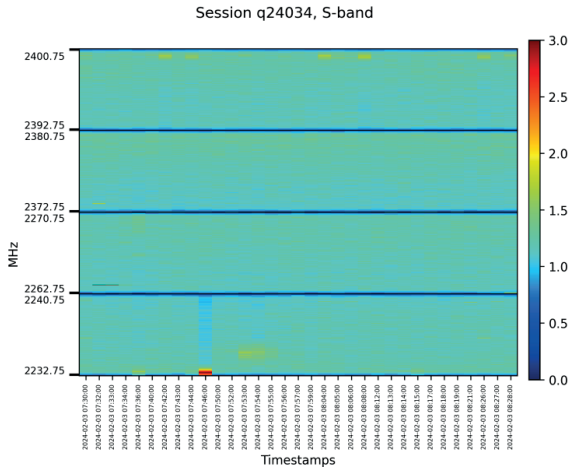

Fig. 4 Spectrogram for the whole Intensive session “q24034”.

Finally, it is now also possible to create directional plots of the strongest source or sources for legacy systems. Figure 5 shows such a plot with the strongest source appearing during a Q24 session. The direction fits well to an existing mobile communication station “Krailing”. Only the elevation of the signal is not clear and might point to another origin because also the frequencies do not completely fit to mobile communication. This needs more investigations and repeating experiments.

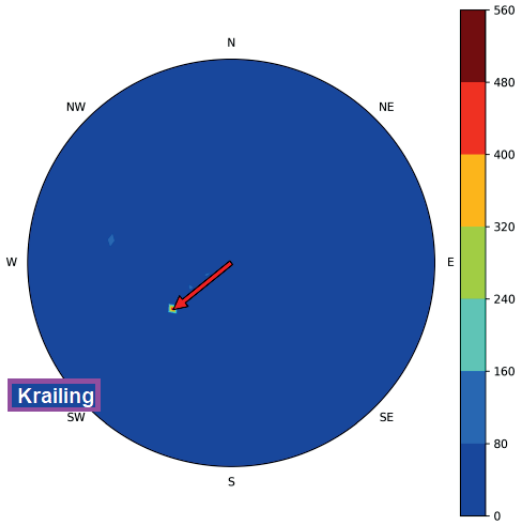

Fig. 5 Directional plot for S-band of the whole Intensive session “q24034”.

4 Conclusion and Outlook

The software reached a quite useful status. It can be downloaded from https://github.com/luca-rigon/RFImonitoring-tool and will be transferred to an official Git-repository and maybe its own server. The extension to process S/X bands is very useful for existing legacy antennas.

The next steps are:

- the verification of the functionality,
- the comparison with other RFI surveys,
- the repetition of output for more sessions,
- a further comparison to existing maps and data of senders and RFI sources,
- application of the software to other antenna locations.

Another step is, to convert the software developed as student projects to a solid toolbox and to test the workflows in real-world scenarios.

References

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