Callisto spectrum measurements in Badary (Russian Federation)

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Abstract. During a measurement campaign in winter 2006 spectrum measurements were done at different locations in India and Sibiria. This report describes the results of Badary solar radio telescope (SSRT) site in Sibiria (Russian Federation). Measurements were done with a broadband logarithmic periodic antenna of the site connected to a Callisto spectrometer designed and built by ETH Zurich (Benz, 2004). This measurement campaign shall be the technical basis to decide how to continue concerning spectroscopic measurements below 1GHz with existing antennas and/or new ones. The results are presented, compared with Switzerland and discussed in form of digitally zoomed spectrums in the most interesting radio astronomy frequency ranges. In terms of electromagnetic interference Badary is much better than Switzerland and thus ideal for low frequency solar radio astronomy observations (spectroscopy).

Key words. Callisto, spectrum, cross modulation, interference.

1. Introduction

In view of IHY and also in view of an intention to upgrade SSRT station, a measurement campaign was planned and organized between SSRT Irkutsk and ETH Zurich. The measurement took place between Dec. 11th and Dec. 15th 2006 at the SSRT observatory in Badary.

1.1. Station description

The Siberian Solar Radio Telescope (SSRT) is among the largest astronomical instruments. It is located in a wooded picturesque valley separating two mountain ridges of the Eastern Sayan Mountains and Khamar-Daban, 220 km from Irkutsk. It is a crossed interferometer, consisting of two arrays of 128x128 parabolic antennas 2.5 meters in diameter each, spaced equidistantly at 4.9 meters and oriented in the E-W and N-S directions. The main maxima of the radio telescope's multidirectional beam are arranged at intervals in some excess of the Sun's apparent size at the instrument's working wavelengths $\lambda = 5.2cm$. The length of each linear baselines of the interferometer is 622.3 meters. For geographical coordinates see table 1.

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Fig. 1. Linear polarized, logarithmic periodic dipole mounted at one of the interferometer dishes in Badary. The dish in front of the observatory automatically tracks the sun day by day.

1.2. Measurement instrumentation

We used the commercial linear polarized, logarithmic periodic antenna of type CLP5130 covering the frequency range from 50MHz up to 1300MHz. It was connected via a preamplifier KUHNE KU515B having about 20dB gain and a low loss coaxial cable to the observatory. The

Fig. 2. S. Lesovoi (left) and A. Maslov (right) standing in front of the CALLISTO spectrometer (small box bottom left of the PC in the cabinett).

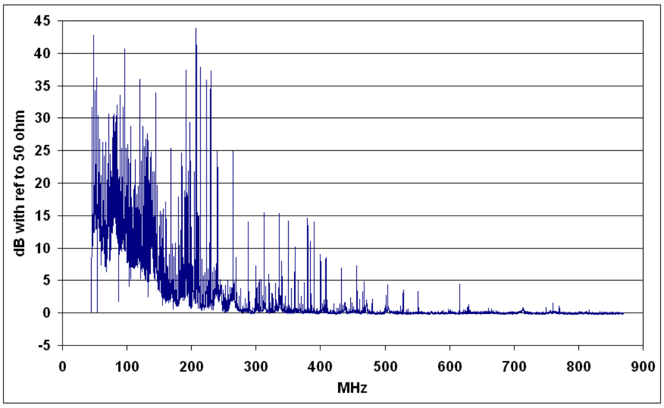

Fig. 3. Total Callisto-spectrum of January 23th 2007 at SSRT in Badary covering frequency range 45MHz until 870MHz in steps of 62.5KHz.

Coordinate	value
Latitude	51.8° *North*
Longitude	103.2° *East*
Height	2000 m asl
Local Time	GMT + 07h

Table 1. Geographical coordinates of SSRT telescope site in Badary.

Abbreviation	description
Callisto	Radiospectrometer
CME	Coronal Mass Ejection
CRAF	Committee on Radio Astronomy Freq.
DVB-T	Digital video broadcast terrestrial
ETH	Eidgenössisch Technische Hochschule
FM	Frequency modulation (Radio)
IHY	International Heliospheric Year
rf	radio-frequency
RISC	Reduced Instruction Set Computer
SSRT	Siberian Solar Radio Telescope
SWR	standing wave ratio
TV	Television
UHF	ultra high frequency

Table 2. Acronyms mentioned in labels and comments.

Callisto spectrometer e-C03 having a detector sensitivity of 25mV/dB including control cables and rf adapters was supplied by ETH Zurich. The channel resolution is 62.5KHz, while the radiometric bandwidth is about 300KHz. The sampling time is exactly 1.25msec per frequency-pixel while the integration time is in the order of 1msec. The frequency in the overview data file is expressed in MHz and the detector output is expressed in milli volts. Both are stored in a simple sequential ASCII file which can be analyzed with any spread sheet like IDL or EXCEL. Callisto is externally synchronized using a GPS system. The spectra (T0 and Sky) in Badary were taken January 22th 2007 while the comparison spectra from Bleien 50km south of Zurich (Switzerland) were taken on January 25th 2007.

1.3. Acronyms

Different acronyms used in labels and text are described in table 2.

2. Results

2.1. Comparative overview Badary/Russia versus Bleien/Switzerland

The measured total spectrum, see figure 3 was split into 7 sub spectra to better give comments on it. For plots, see figures 4, 5, 6, 7, 8, 9 and 10. The total spectrum in figure 3 is composed of 13200 channels 62.5KHz apart. In all plots shown below 0dB is referenced to the background noise level given by a 50Ω termination resistor at ambient temperature of about $20°C$. While the Russian instrument is connected via a 20dB preamplifier, in Switzerland it's not possible to use a preamplifier due to the fact of several nearby high power transmitters which saturate Callisto.

2.2. Observation of a bright flare with CALLISTO

Occasionally the sun was very active during installation and configuration. Thus, during that time a couple of flares were recorded with Callisto. A very bright one was NOAA-event number 4600 (X-flare class X3.4) on

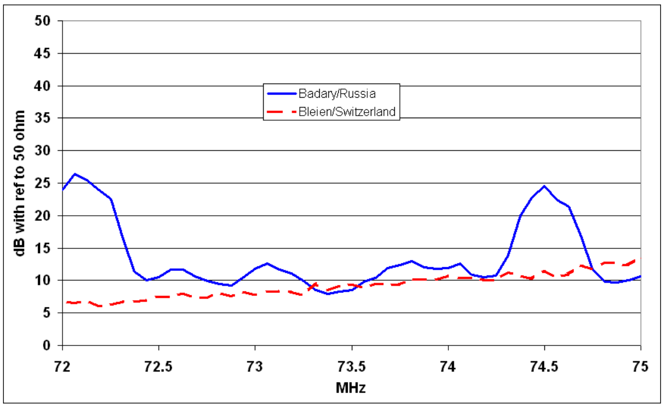

Fig. 4. Spectral overview measured in Badary (blue plot) and Bleien observatory (red plot). Comparable interference level, but higher interference levels due to local electronic devices in Badary. Shared use for the radio astronomy band 73MHz until 74.6MHz.

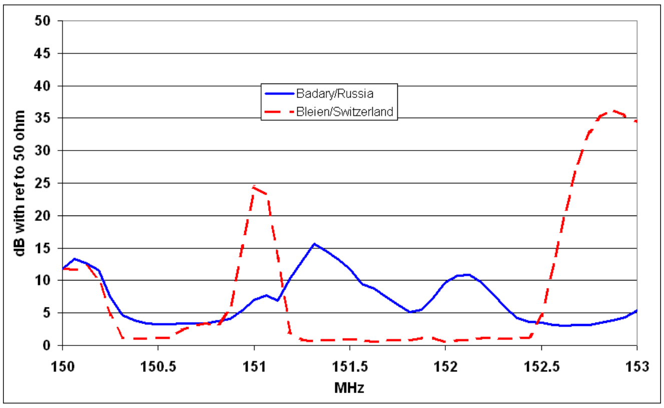

Fig. 5. Spectral overview measured in Badary and Bleien observatory. Bleien interference level (red plot) is much higher (+10dB) than in Badary (blue plot). The frequencies 150.05MHz until 153Mhz are reserved for radio astronomy. Primary use for radio astronomy.

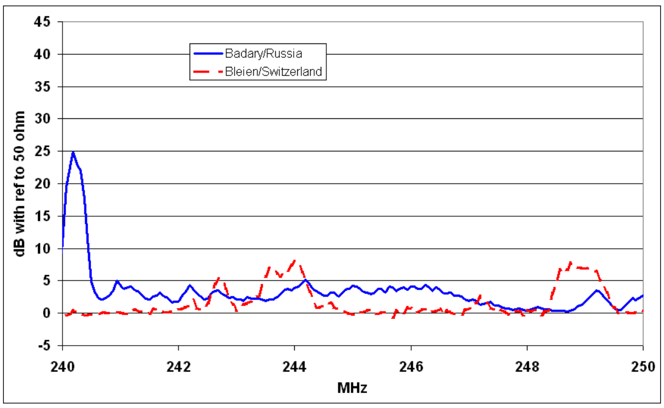

Fig. 6. Spectral overview measured in Badary (blue plot) and Bleien (red plot) observatory. Badary signal level at 240MHz is about 20dB higher than in Switzerland due to local interference and preamplifier. 245MHz itself is free of interference at both places. The frequency 245MHz is a fixed frequency for the measurement of quiet sun flux but shared with other services.

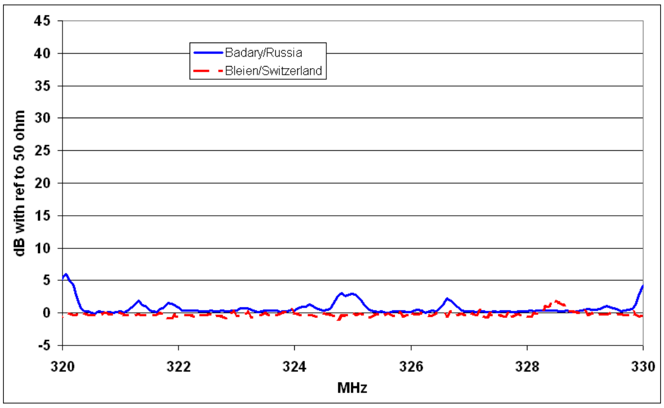

Fig. 7. Spectral overview measured in Badary (blue plot) and Bleien (red plot) observatory. The whole range is rather quiet. The range 322MHz until 328.6MHz is reserved for deuterium line observations. Primary use for radio astronomy.

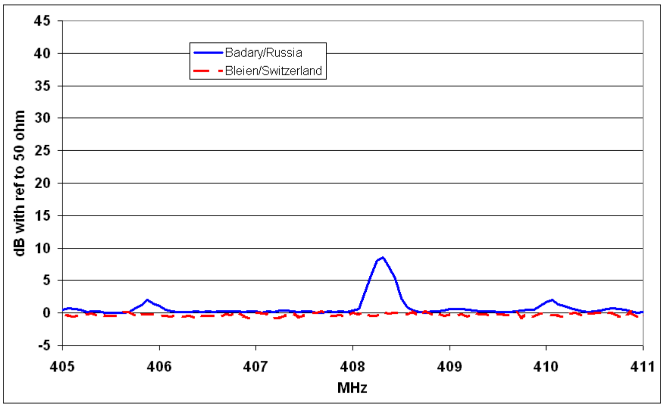

Fig. 8. Spectral overview measured in Badary (blue plot) and Bleien (red plot) observatory. Comparable low interference level in both countries. Single carrier near 408MHz in Badary. The range 406.1MHz until 410.0MHz is reserved for radio astronomy services. Primary use for radio astronomy.

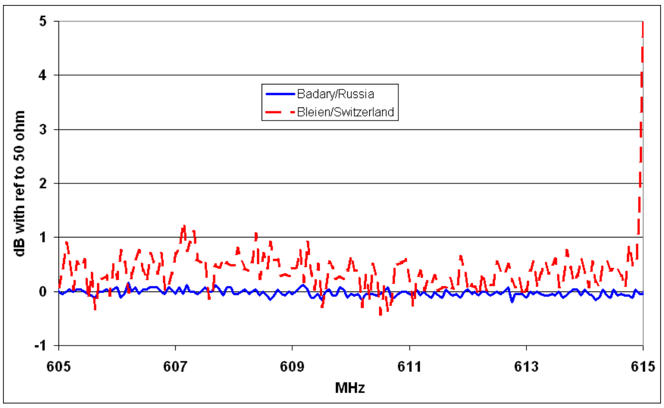

Fig. 9. Spectral overview measured in Badary (blue plot) and Bleien (red plot) observatory. Comparable, very low interference in countries. Be aware of lower dB-axis in this plot compared to all others plots in this paper. The range 608.0MHz until 614.0MHz is a non-exclusive band reserved radio astronomy services.

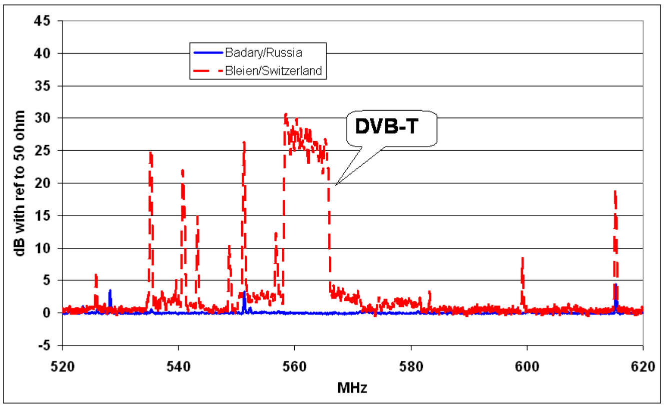

Fig. 10. Spectral overview measured in Badary (blue plot) and Bleien (red plot) observatory showing UHF TV band. In Switzerland the range between 550MHz and 575MHz is more and more used by DVB-T and thus no frequency can be use for observation in this sub band. In Badary (blue plot) there is no single analog TV channel thus, the whole range can be used for radio astronomy.

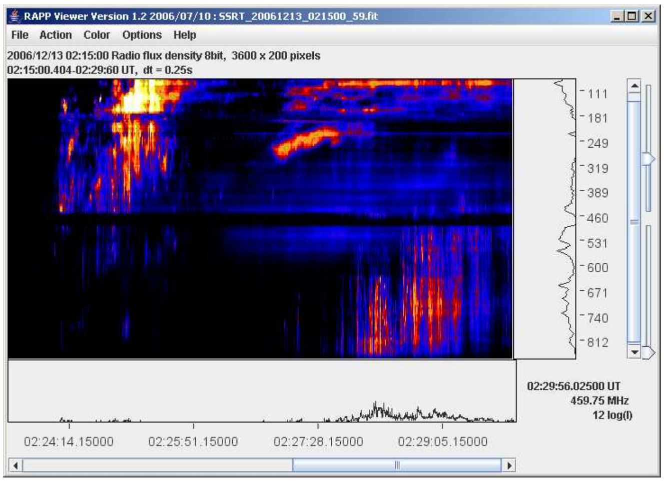

Fig. 11. Observation of complex X3.4 flare in radio frequency range on December 13th after 02:154UT. It was recorded by NOAA as event number 4600. The frequency original program covered the whole spectrum of Callisto.

December 13th between 02:14 and 02:30, see figure 11. All strong transmitters are excluded in the spectrum which is the main advantage of the frequency agile spectrometer Callisto.

3. Conclusions

Badary is not yet suffering from DBV-T and other broad band applications and is thus, an ideal place for a solar frequency agile spectrometer. All reserved frequencies are still free from interference. Most of the strong interferences are home made by local electronic devices and local oscillators. To mitigate self induced interferences we strongly recommend not to remote switch antennas electronically. But when needed anyway, then low pass filters and shielded cables should be used. As soon as one wants to install a second system which is not frequency-

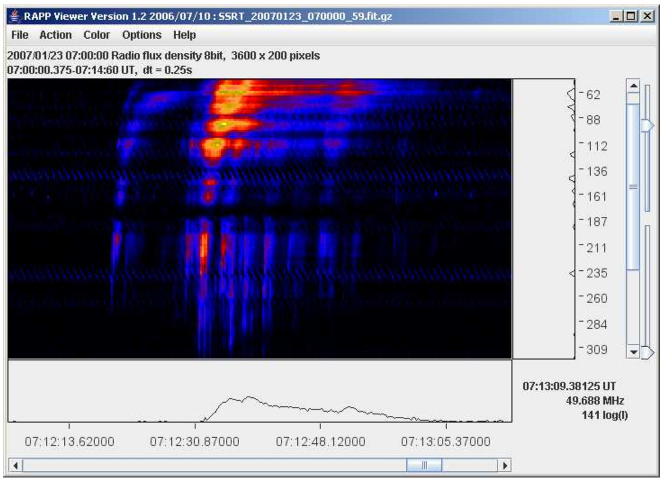

Fig. 12. Observation of type II solar radio flare on January 23th at 07:12UT. It was recorded by NOAA as event number 7740. The flux at 245MHz was 2600 sfu, reported by Learmonth station. The latest frequency programm 'frq00256.cfg' was optimized to observe CME radiation to a maximum frequency of 440MHz.

and phase locked to the main receiving system it will suffer from electromagnetic interference from the neighboring system. One should try to shield all local oscillator components and also all IF components to prevent leakage of rf into the receiving antenna of CALLISTO. It is strongly recommended to move the logarithmic periodic antennas as far away as possible from the institute to reduce local interferences.

4. Relevant internet addresses

4.1. CRAF

http://www.craf.eu

4.2. Callisto

http://www.astro.phys.ethz.ch/instrument/callisto/callisto_nf.html

4.3. e-Callisto

http://www.astro.phys.ethz.ch/instrument/callisto/ecallisto/applidocs.htm

4.4. SSRT

http://ssrt.iszf.irk.ru/

4.5. ETH

http://www.astro.phys.ethz.ch/rapp/

4.6. X3.4-flare

http://www.sec.noaa.gov/ftpdir/indices/events/20061213events.txt

4.7. Type II flare

http://www.sec.noaa.gov/ftpdir/indices/events/20070123events.txt

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