# Callisto spectrum measurements at IRSOL in Ticino

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# Callisto spectrum measurements at IRSOL in Ticino

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**Abstract.** During a planned measurement campaign in April 2007 spectrum measurements were done at different locations in canton Ticino Switzerland. This report describes the results of IRSOL observatory site above Locarno. Measurements were done with different broadband logarithmic periodic antenna 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 3GHz ($\lambda > 10cm$). The results are presented, compared with Bleien observatory and discussed in form of digitally zoomed spectrums in the most interesting frequency bands allocated for radio astronomy and other passive services. In terms of electromagnetic interference Locarno is worse than Bleien and thus not ideal for spectroscopic solar radio astronomy observations. But it is sufficient for single frequency observations on dedicated frequencies to determine quiet solar radio flux.

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

## 1. Introduction

In view of IHY and also in view of an intention to upgrade IRSOL observatory regarding radio astronomical instrumentation, a measurement campaign was planned and organized between IRSOL and ETH Zurich. The measurement took place from April 23th until 24th in Locarno Monti (IRSOL and Specola Solare Ticinese), the Verzasca valley (Sonognio and Brione) and in Altanca near Gotthard pass. For reference, an additional measurement was done at Bleien observatory to the end of the campaign.

### *1.1. Station description*

The observatory was founded and operated 1960 - 1984 by the Universitäts-Sternwarte Göttingen (USWG) in Germany. In 1984 the USWG left Locarno and transfered its observations to Tenerife (Canarian Islands). The instrumentation of Locarno was then largely used for the new telescope. Afterwards an agreement between the Deutsche Forschungsgemeinschaft and the private association AIRSOL for the cession of institute was carried out. In 1987 FIRSOL, a private foundation took over the observatory. In 1988 - 1992 the instrumentation was reconstructed and updated (new electronics, new grating etc.). In 1993 - 1995 research started again, instrument innovations and administrative work were carried out in order to be recognized and funded by the federal government and the canton Ticino. From 1996 to present days research and collaborations with other institutes, principally with the ETH-Zurich are going on. For instrumentation there are the main Telescope, a 45 cm aperture Gregory - Coude, evacuated, a Czerny- Turner spectrograph with 10 m focal length, a tuneable Fabry Perot system based on lithium niobate etalons, an adaptive optics system based on a 37 actuators deformable mirror and the polarimeter ZIMPOL, developed at ETH.

**Fig. 1.** Horizontally mounted logarithmic periodic dipole on a tripod at the terrace of IRSOL building in Locarno Monti.

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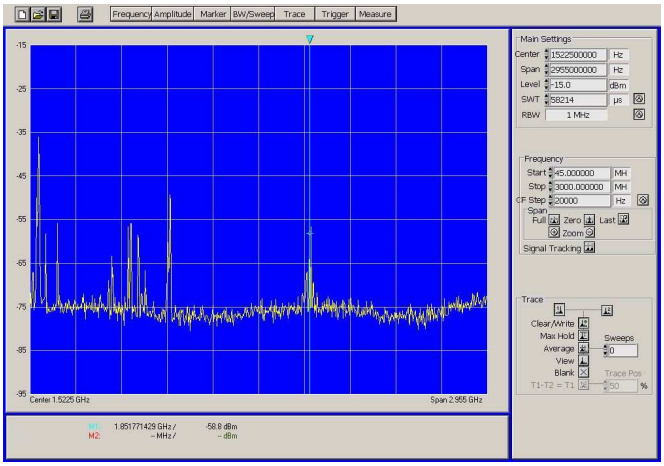


**Fig. 2.** Broadband measurements using Rohde&Schwarz Spektrometer up to 3GHz. The strongest signals which may lead to cross modulation are listed in table 3

| Coordinate | value |
|---|---|
| Latitude | 46° 10′ 40.6” North |
| Longitude | 8° 47′ 22.9” East |
| Height | 506 m asl |
| Local Time | GMT + 01h (MEZ) |

**Table 1.** Geographical coordinates of IRSOL telescope site.

| Abbreviation | description |
|---|---|
| Callisto | Radiospectrometer of ETH |
| CRAF | Committee on Radio Astronomy Freq. |
| DVB-T | Digital video broadcast terrestrial |
| ETH | Eidgenössisch Technische Hochschule |
| FM | Frequency modulation (Radio) |
| IHY | International Heliospheric Year |
| IRSOL | Istituto Ricerche Solari Locarno |
| rf | radio-frequency |
| TetraPol | TErrestrial Trunked RAdio (Police) |
| TV | Television |
| UHF | ultra high frequency |

**Table 2.** Acronyms mentioned in labels and comments.

| Frequency | Powerlevel [dBm] |
|---|---|
| 98.57 | -31.3 |
| 147.70 | -37.2 |
| 154.28 | -43.5 |
| 218.57 | -46.5 |
| 694.28 | -37.5 |
| 951.40 | -44.1 |
| 1890.00 | -56.4 |
| 2421.40 | -61.4 |
| Noiselevel | -72.2 |

**Table 3.** Power level of strongest transmitters measured at IRSOL.

### *1.2. Measurement instrumentation*

We used two different logarithmic periodic antennas directly connected via a low loss coaxial cable to the measuring instrument. One (CLP50-1300) covers the range from 50MHz up to 1300MHz and the second one (XSLP9142) covers the range from 800MHz up to 5GHz. The Callisto spectrometer e-C04 having a detector sensitivity of 25mV/dB including control cables and rf adapters was supplied by ETH Zurich. The frequency range of Callisto covers 45Mhz until 870MHz in three bands. 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 about 1msec. The frequency in the output data is expressed in MHz and the detector output is expressed in milli volts. Both are stored in a simple ASCII file which can be analyzed with any spread sheet like IDL or EXCEL. The second instrument was a spectrum analyzer Rohde&Schwarz FS300 for frequencies up to 3GHz. This calibrated spectrum analyzer was used to qualitatively measure the power level of the strongest transmitters, see table 3. At each location an additional measurement was done by applying a 50Ω resistor to the antenna terminal as a reference level to evaluate the power level in dB above this broadband load (termination resistor at ambient temperature in the order of 300Kelvin).

### *1.3. Acronyms*

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

## 2. Results

### *2.1. Comparative overview IRSOL versus Bleien, both Switzerland*

The total measured spectrum, see figure 9 was split into 6 sub spectra to better give comments on it. For plots, see figures 3, 4, 5, 6, 7, 8. The total spectrum 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 $26°C$.

### *2.2. Long time observation with CALLISTO*

Although the sun was not active at the time of observation we observed the sky for more than 15 minutes, see figure 10. This, to see wether cross modulation takes place or not by some strong transmitters in FM band, pager and Tetrapol system. No cross modulation was detected during the time of observation.

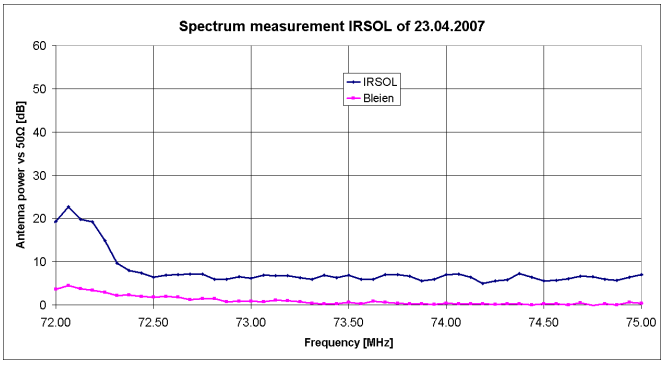


**Fig. 3.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. Comparable interference level, but higher background level at IRSOL probably due to local electronic devices. Shared use for the radio astronomy band 73MHz until 74.6MHz.

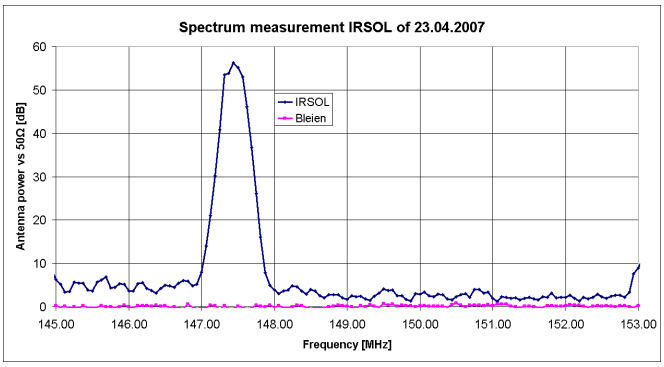


**Fig. 4.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. IRSOL interference level is much higher (+55dB) than at Bleien observatory due to a pager system. The frequencies 150.05MHz until 153Mhz are reserved for radio astronomy and they are free from interference. Primary use foreseen for radio astronomy.

## 3. Conclusions

Locarno in general and IRSOL as well as Specola Solare in paricular are suffering from broadband TV (DBV-T) and other broad band applications and are thus, not ideal as a host site for solar frequency agile spectrometers. But all reserved frequencies are still free from interference. These interference free frequencies could be used for single frequency observation to determine solar radio flux using resonant antennas rather than broad band antennas. The fre-

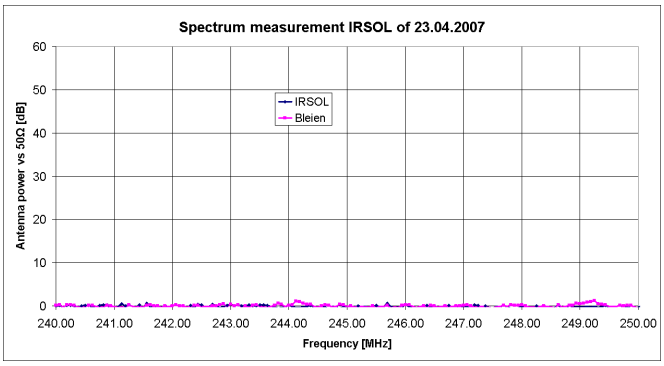


**Fig. 5.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. Comparable low interference level at both sites. The frequency 245MHz is a fixed frequency for the measurement of quiet sun flux but shared with other services.

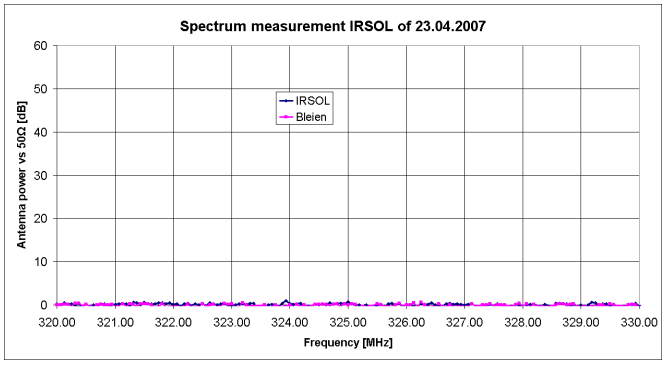


**Fig. 6.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. The range 322MHz until 328.6MHz is reserved for spectral observations (deuterium line) and free from interference. Primary use for radio astronomy.

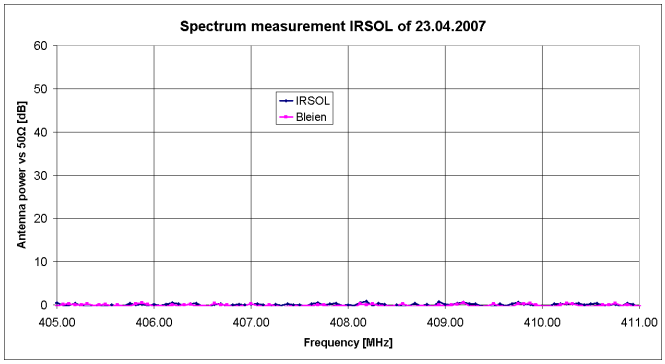


**Fig. 7.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. Comparable low interference level at both sites. The range 406.1MHz until 410.0MHz is reserved for radio astronomy services and free from interference. Primary use for radio astronomy.

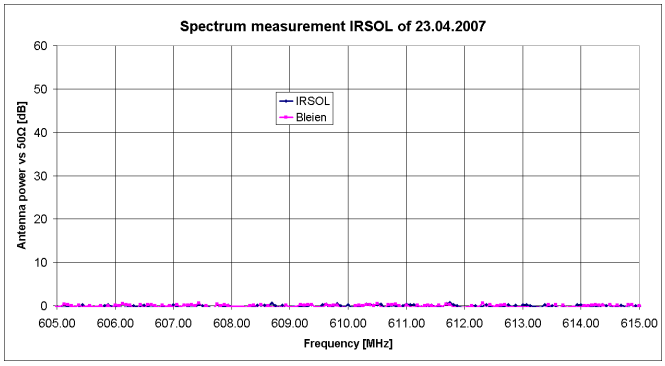


**Fig. 8.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory. Comparable, very low interference between these two sites. The range 608.0MHz until 614.0MHz is a non-exclusive band reserved radio astronomy services and free from interference.

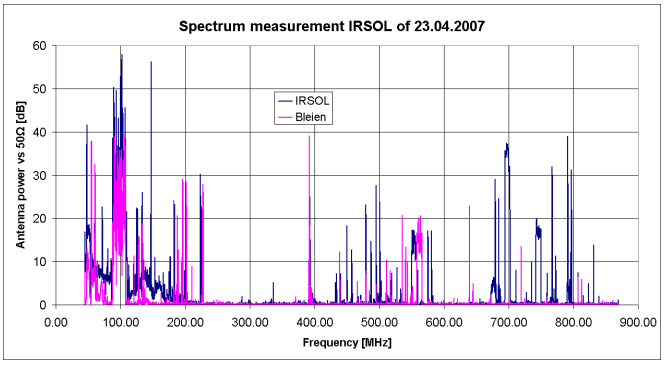


**Fig. 9.** Spectral overview measured at IRSOL (blue) and Bleien (purple) observatory showing all channels in TV band I, II, III, IV and V. In Locarno, the band V is used by DVB-T and thus almost no frequency can be use for observation. Very strong FM transmitters with up to 50dB power level. Also a very strong pager system at 147.5Mhz and TetraPol transmitter may lead to cross modulation when using a high gain preamplifier.

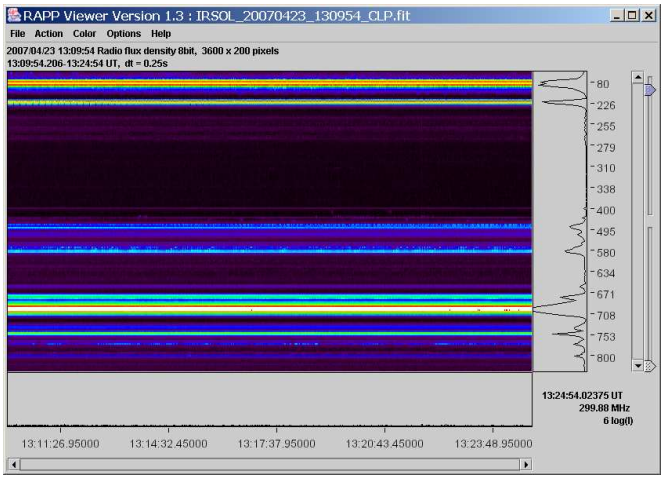


**Fig. 10.** One quarter of an hour observation using Callisto with 200 channels per spectrum at a time resolution of 250msec. One can see a pile of strong carries in FM- and TV bands but no cross modulation due to too strong nearby transmitters.

quency range above 1Ghz is almost interference free except GSM frequencies near 1800MHz and 2400GHz. But these signals are not strong enough (see table 3) to saturate a radio spectrometer like Callisto, Argos or Phoenix. The other places like Sonogno and Brione in Verzasca valley or Altanca near Gotthard pass are more radio quiet but not much better than Bleien.

## 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. IHY*

`http://ihy2007.org/`

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## References

Arnold O. Benz, Christian Monstein and Hansueli Meyer *CALLISTO, A New Concept for Solar Radio Spectrometers*, Kluwer Academic Publishers, The Netherlands, 2004.