RFI in Metsähovi - measurements and effects
RFI2010 Groningen, Netherlands

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Metsähovi Radio Observatory

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• separate research institute of Aalto University School of Science and Technology
• operational since 1974
• 13.7 m (45 feet) dish
• observation frequency bands S, X, K, Q, W
• continuum, VLBI, solar
Metsähovi location

- 60° N 24° E 60 m ASL
- around 35 km from main campus (45 km from Helsinki)
- nearest village around 10 km (Veikkola)
- nearest settlements 550 m (Radio Quiet Zone, RQZ)
## Observation frequencies

<table>
<thead>
<tr>
<th>band</th>
<th>MRO band [GHz]</th>
<th>LO</th>
<th>mirror frequency</th>
<th>other users</th>
<th>band definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>2.21 - 2.35</td>
<td>1.53</td>
<td>0.71 - 0.85</td>
<td>links wireless cameras</td>
<td>BPF after LNA</td>
</tr>
<tr>
<td>X</td>
<td>8.15 - 8.65</td>
<td>7.65</td>
<td>6.65 - 7.15</td>
<td>links DRS FMTV</td>
<td>BPF after LNA</td>
</tr>
<tr>
<td>K</td>
<td>21.0 - 22.0</td>
<td>22.20</td>
<td></td>
<td>sat down SRD links</td>
<td>continuum, DSB</td>
</tr>
<tr>
<td></td>
<td>22.4 - 23.4</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>21.98 - 22.48</td>
<td>21.48</td>
<td>20.48 - 20.98</td>
<td>SRD links</td>
<td>BPF after LNA</td>
</tr>
<tr>
<td>Q</td>
<td>35.3 - 36.3</td>
<td>36.80</td>
<td></td>
<td>radar links DRS sat down</td>
<td>continuum, DSB</td>
</tr>
<tr>
<td></td>
<td>37.3 - 38.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>W</td>
<td>86 - 98</td>
<td>81.75</td>
<td>66 - 78</td>
<td>navigation</td>
<td>BPF 80 - 98 GHz after LNA</td>
</tr>
</tbody>
</table>
RFI contamination prevention

- traditional rules: no wireless transmitters, fluorescent lamps, etc. obvious interferers
- receiver output is VLBI IF spectrum or balanced continuum DC signal
- double shielded RG-223, RG-214 RF & continuum to control room
  - screening 95%
- continuous monitoring feasible mainly at lower GHz (until recently)
- fibre connectivity and ethernet are also available
RFI monitoring equipment

- Preamplifier, ZX60-2531M-S (Mini Circuit)
- Cable, RG 214 (45 m)
- Spectrum analyzer, Agilent FieldFox
- Control via Ethernet (Telnet)
- Control commands + data saving
- Antenna directional control unit, Yaesu G-800 DX
- Control via Ethernet
- RS-232
- PC (Seti)
- PC (Data)

Control software (spektr3.pl)
IF band in 1999, 2003 and 2008

- average intensity over a period of one year
IF band in 1999, 2003 and 2008

- NMT 450 end, @450 Flash-OFDM startup
- television broadcast transition
Geo-VLBI S band

- observations at 2.21…2.35 GHz
- based on 24 days period of measurement (19.1. - 15.2. 2010)
- quiet on average, high peaks in max
Geo-VLBI S band

### Spectrum Analyzer

- **Ref Level**: -58.0 dBm
- **<8 Smp/Pt**
- **Preamp Off**
- **Atten**: 5 dB
- **Ext Gain**: 0.0 dB

<table>
<thead>
<tr>
<th>Amplitude</th>
<th>Trace Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>P</td>
</tr>
<tr>
<td>2</td>
<td>P</td>
</tr>
<tr>
<td>3</td>
<td>P</td>
</tr>
<tr>
<td>4</td>
<td>P</td>
</tr>
</tbody>
</table>

- **Auto Scale**
- **Ref Level**: -58.0 dBm
- **Elec Atten**: 5 dB
- **Scale/Div**: 2 dB
- **Scale Type**: Lin
- **Auto Range**: Off

**MKR1**: 790.895 0 MHz

-83.81 dBm
Household jamming transmitter

- based on 18 days period of measurement (18.2. - 10.3. 2010)
GSM

Picture 1

Picture 2
MH Mars RFI detection attempts

M0303 Wettzell No0004 2940s – 10ms timescale – BBC#01U – 2K FFT&histo – 16kHz/channel

1 x 2K FFT magnitude spectrum

250 x 2K FFT spectrogram

Steady S/C carrier and tones are not spotted in kurtogram

Typical spectral kurtogram from experiment... No luck (yet!) with broadband RFI @ 10ms $T_{\text{int}}$ nor at 15ms, 25ms, 100ms $T_{\text{int}}$ timescales.

Need longer observation to hit lightning.

But: principle applicable to ground RFI detection in software, without FPGA.

10ms power histogram of one 16kHz channel, straightforward to get mean, var, skew, kurt.
Conclusions & Future Work

- Current approach based on passive monitoring by frequency scanning
  - Time blanking, RFI free frequency selection
  - Persistent interferences are seen easily
  - Occasional spikes most probably unseen
- Maintaining proper shielding in cabling chain is important
- Future system: fast sampling, FFT, automatic focusing on interferences -> closer look + recording?
- Interference survey on upper bands
- Good contacts to regulatory authority (Ficora)