

# **AVN Training HartRAO 2016**

**Radio Frequency Interference (RFI)**

# Overview

- Use and Regulation of the radio spectrum – the International Telecommunication Union – or ITU
- Allocation of frequency bands for Radio Astronomy and recommended
- Measurement of RFI
- Action needed in AVN countries

# The radio spectrum – a Valuable Resource

- The radio spectrum is regulated internationally by the International Telecommunications Union, *ITU*
- ITU, in consultation with member countries allocates frequencies for use by various users.
- Communication Authorities in individual countries develop their own band plans within this frame work, and issue licences to the various users of radio spectrum on a competitive basis.
- Typical users are radio and TV stations, cell phone service providers, telecommunication companies, airports (radar and aircraft communications), armed forces and many others.
- There is ever increasing demand for spectrum and it earns money for the communication authorities in each country. It is therefore a valuable resource.

# Radio astronomy and the radio spectrum

- Radio astronomers conduct several different types of observations:
  - Continuum observations which observe objects which have a continuous noise like spectrum over a wide range of frequencies. To characterise the spectrum individual band at regular intervals are required, from around 100 MHz to high frequencies in the 10s or even 100s of GHz.
  - Pulsars emit pulsed emission repeating at rates of hundreds of hundreds of times per second (millisecond pulsars) to periods of several seconds. Pulsar emission is strongest at low frequencies and the most common operating range is from about 600 MHz to 3 GHz.
  - A third type of observation is that of spectral lines from atoms and molecules, which emit at known frequencies, called spectral lines. Examples are hydrogen (1420 MHz), hydroxyl (OH at 1612, 1665, 1667 and 1720 MHz and also at higher frequencies around 5 and 6 GHz), methanol at 6.7 and 12.2 GHz and finally water vapour at 22 GHz.

# The radio astronomy portion of the spectrum

- Radio astronomers, as a community, and operating through the “Inter-Union Committee for Allocation of Frequencies” or *IUCAF*, have negotiated with the ITU for exclusive use of several frequency bands. Most countries active in radio astronomy have nominated a member to this committee.
- However, the demand for spectrum for commercial uses is so high that only a few frequencies have been exclusively allocated for world-wide use by radio astronomers. Most of frequency bands allocated for use by radio astronomers are shared with other users.
- It is therefore important for radio astronomers to have a good working relationship with their national communications authority and spectrum users operating in the vicinity of their observatory to ensure that harmful signal are not emitted in the bands used for radio astronomy.

# Frequencies likely to be used by the AVN

- Recommendation ITU-R RA.314-10 (06/2003) lists the preferred frequency band for radio astronomical measurements see, e.g. :

<https://www.itu.int/rec/R-REC-RA.314/en>

- There is a wide range of frequencies used by the radio astronomy community, and only a subset is currently needed for the AVN:
  - VLBI at 5 GHz: : 4926.49 – 5054.49 MHz
  - Methanol, single dish and VLBI: 6650- 6685 MHz

# Sources of RFI

- There are many sources of radio signals that can interfere with radio astronomy observations.
  - Radio and TV transmitters
  - Cell phones
  - WIFI and Blue Tooth in computers and other electronic devices
  - Electronic equipment using fast digital circuitry
  - Microwave ovens
  - Satellites – e.g. GPS, GLONASS (Russian GPS),
  - Motor vehicles, including ignition, engine management systems, remote locking, tracking devices etc

# Precautions to minimise RFI

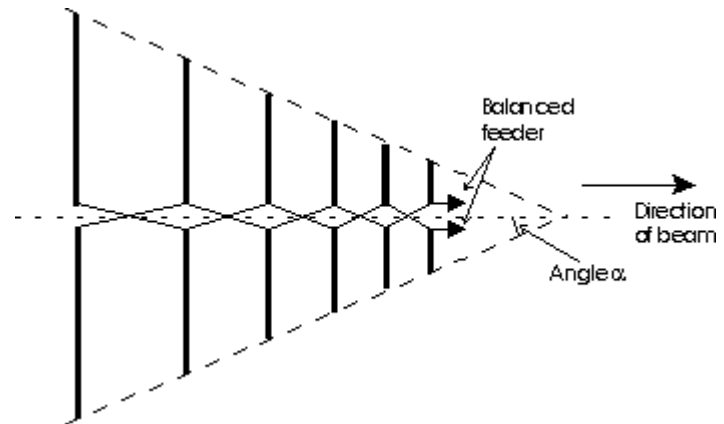
- A number of precautions can be taken to minimise the effect of RFI.
  - Remote location, away from cities and factories
  - Valley site, such as HartRAO, preferable.
  - Minimise local human activity
- Operate in protected radio astronomy bands.
- The AVN stations using existing facilities close to cities (e.g. Ghana and Zambia) will operate in an already established environment, so it will be important to thoroughly test these sites and locate potential sources of RFI.
- If potentially harmful RFI exists, discussions with the owner of the interfering source will be required to arrange for a change in frequency.



# Measuring radio interference

Searches for RFI are usually conducted using a **log periodic antenna** and an instrument known as **Spectrum Analyser**.

The spectrum analyser can either be a fixed instrument, or a small, portable battery driven unit may be used for “sniffing around”.



# Examples of RFI at HartRAO

Despite its location away from cities and industrial areas, and despite its location in a valley whose surrounding hills provide some degree of shielding, HartRAO experiences interference at a number of frequencies.

Examples are at **X-band** where the operating band is **8.1-8.9 GHz**.

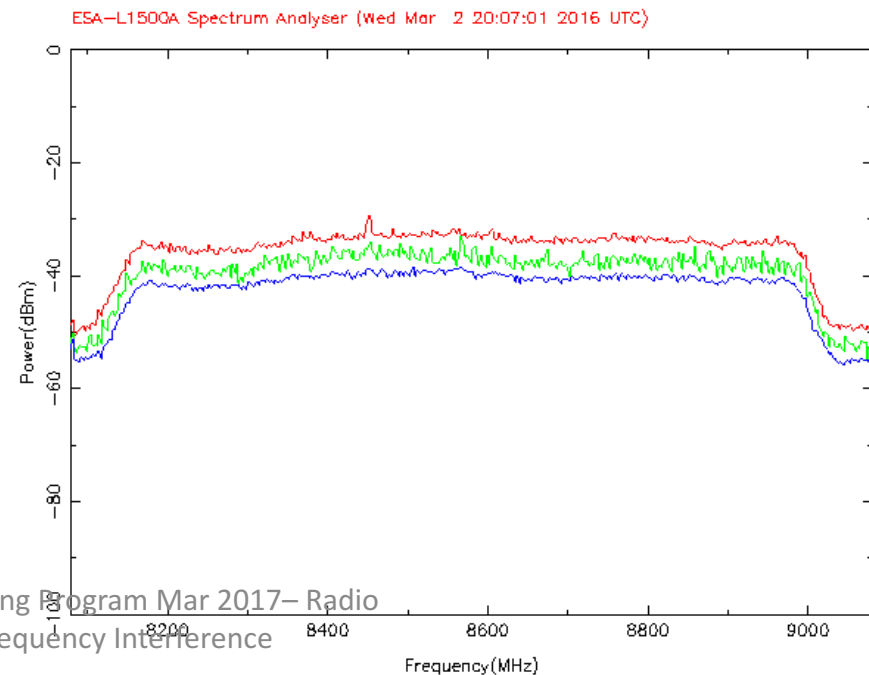
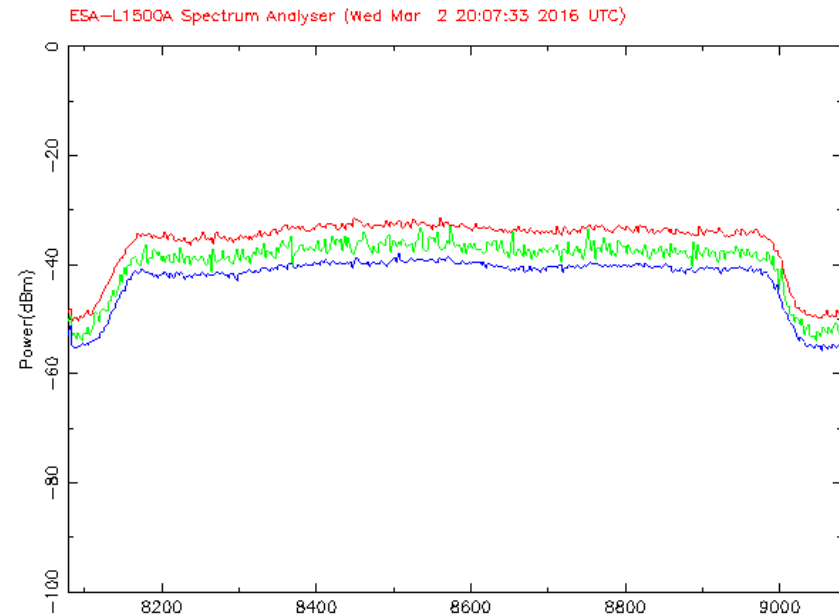
Upper figure shows the 800 MHz spectrum without interference. The green trace is a single scan, Red is average of 100 scans.

The lower figure shows weak interference in the averaged red scan.

This is sufficient to render a continuum observation worthless.

Radio astronomers have set a limit of 10% loss of data owing to RFI as just acceptable, and above 10% as unacceptable.

A number of scientific satellites, e.g. Remote sensing satellites like SPOT and LandSat, transmit in this band and cause interference at specific times of day.

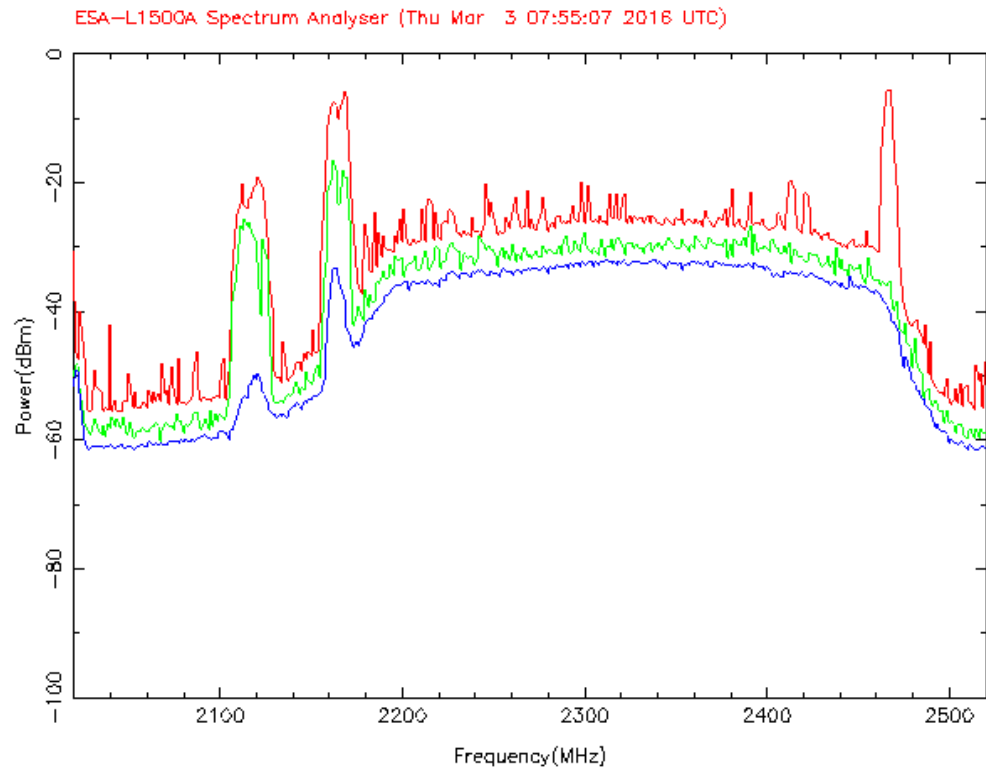


## RFI at S-band 2160-2400 MHz

This spectrum shows interference at 2160-2400 MHz, a frequency used for geodetic VLBI.

VLBI mitigates against interference because the same interference is not present at both sites, and does not therefore correlate.

However, it does affect the measurement of the system noise, and hence the calibration of the system, so it is important to minimise it.



## **RFI at HartRAO at S-band**

The band 2260 – 2400 MHz is used for geodetic VLBI.

This band is used for a number of communication applications, and is subject to RFI.

WIFI also operates in this band, which is why HartRAO requires that all wireless devices have WIFI turned off when on-site.

Examples are shown on right.

## RFI mitigation

If there is persistent RFI in a wide band continuum system, this can be mitigated by inserting a narrow band rejection filter at the interfering frequency, to eliminate its effect.

Such a filter is usually added in the IF portion of the receiver. It excises that part of the spectrum containing the interference. However reducing the bandwidth of a continuum receiver also reduces its sensitivity.

# Avoidance Zone for Mwembeshi Tower

Composite plot of Azimuth-elevation & Hour angle- Declination

