

# Integrated strategies for monitoring and mitigation of RFI

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# ***The obvious, not to be forgotten (1)***

***The actual Data Loss depends on the destructive interaction between :***

- *Signal characteristics of the interferer*
  - ***Amplitude, Freq, BW, Time evolution,....***
- *Type of the RA observation*
  - ***Mode (Single dish, Interfer.), BW, Tau,....***
- *Efficiency of Mitigation technique put in place*
  - ***Backend type, matching with RFI and RA obs..***

## ***The obvious, not to be forgotten (2)***

### ***Huge power difference: more than 220 dB***

- *Few interferers up to tens of KW, now thousands B-BW at W level, vs RA sources down to milli and micro-Jansky.*

***RAstronomers** ask for what is beyond their rights*

- *when observing **OUT OF** the protected BANDS.*

***MITIGATION** is, in any case, a **detrimental** alternative to a spectrum totally free from RFI*

# ***Monitoring RFI: what is for?***

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- 1. Selection of a New Observatory Site***
- 2. Environmental mapping of the strongest signals***
- 3. Identification of (already detected) RFI***
- 4. “Ad hoc”, Routine and Statistical Estimations of RFI (band occupancies)***

# 1) Selection of a New Observatory Site

*Even if it is well known that logistic and political reasons might be the strongest constraints (or driving forces),*

## ***RFI surveying campaigns***

are nowadays **mandatory** before any site selection.

### **Non experimental activities:**

- RFI has to be evaluated even in a **forecast perspective**

### **Experimental activities:**

- Multiple setups or MOBILE UNIT ? cost vs long term
- **Down to what sensitivity level? RA-769, NOT or More?**

## 2a) Environmental mapping of the strongest signals

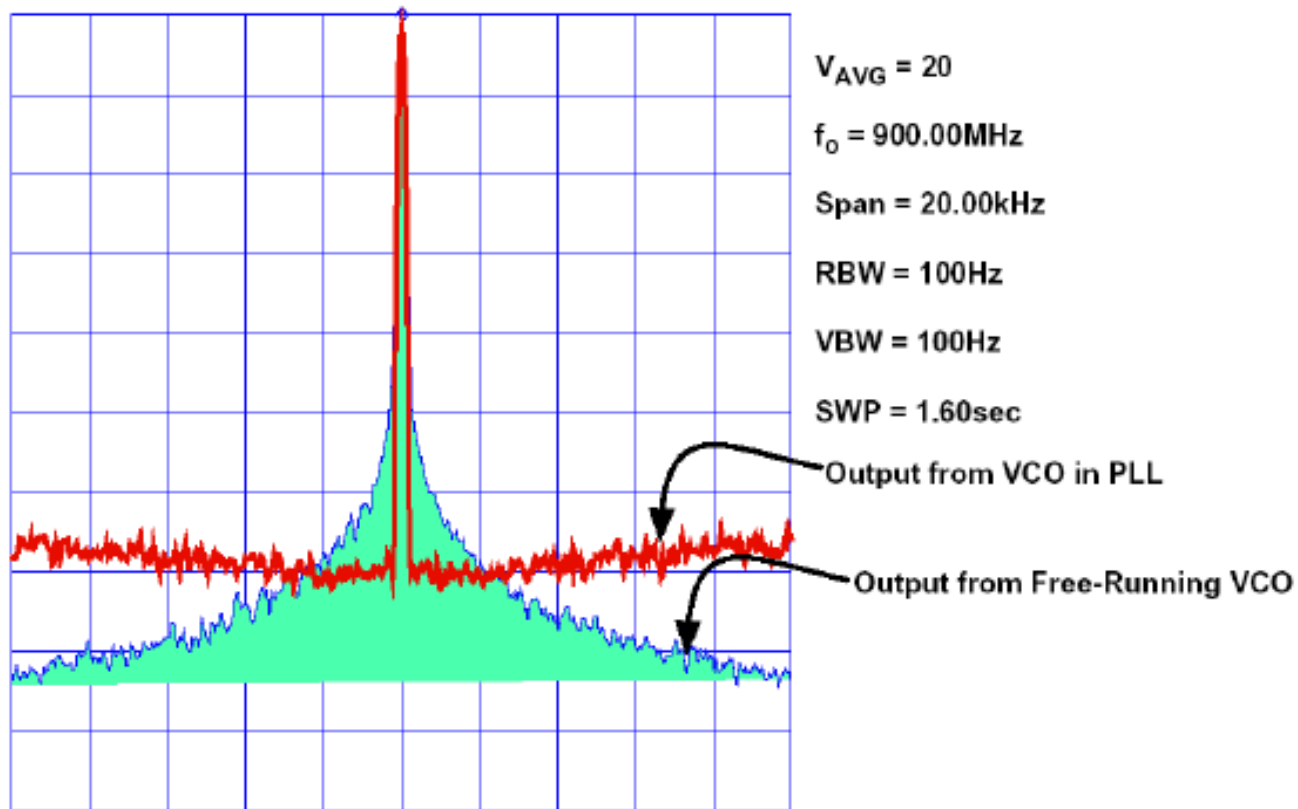
Modern receiver design shall take in very careful consideration its behaviour in presence of **Strong Signals** both **WITHIN** its **operational** bandwidth as well as **OUT** of it.

- **Front ends** are NOT the most critical ones, but still shall be analyzed for their linear dynamic range.
- Down-conversion **schemes** shall avoid “birdies” from mixing products with **all** signals collected.
- **FILTERING** parameters: 3/60db factor, ultimate rejection,...

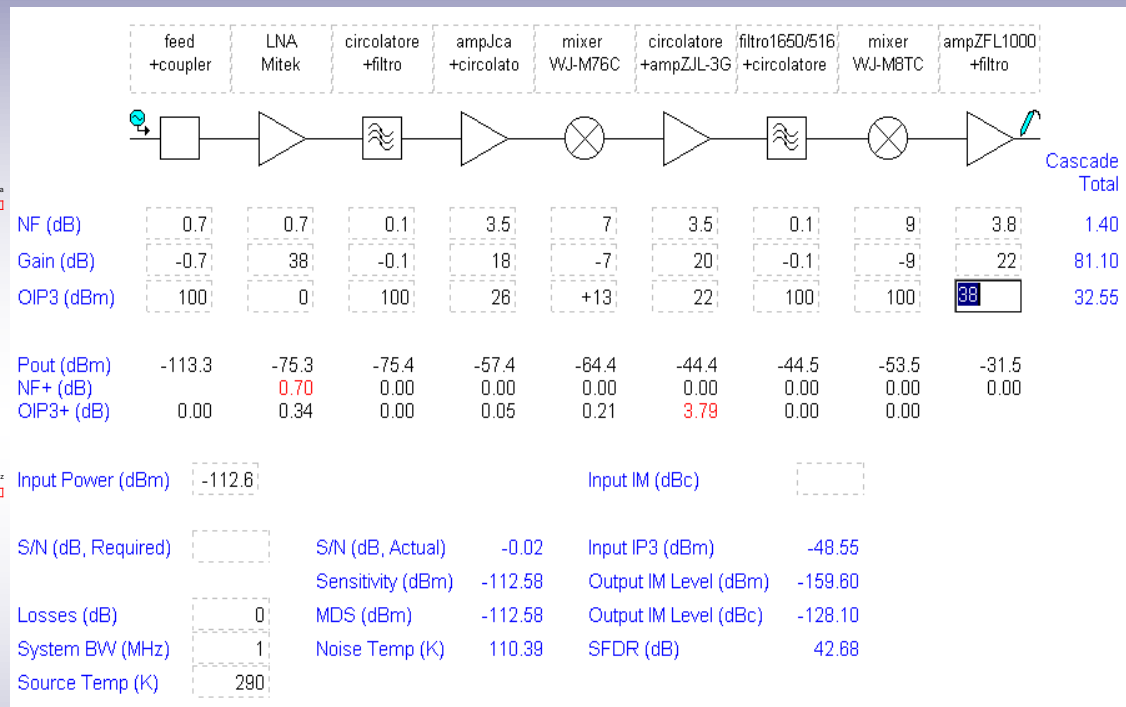
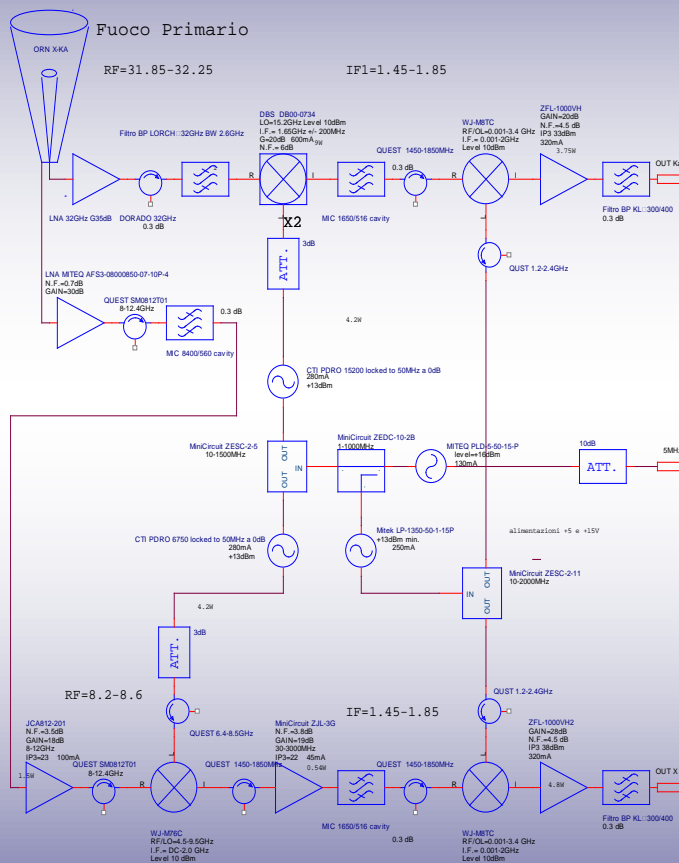
## 2b) Environmental mapping (antenna, total receiver chain)

- **Overall Dynamic Range** (=linear operation) depends on the **number** of the strongest peaks, their **distribution** at Sky or IF frequencies, their occurrence at different pointing angles of the radiotelescope (**antenna sidelobes + diffraction**) when entering into Front Ends, IF amplifiers, Backends; also important is the **resolution** (= # of bits) in AD conversions,.....
- **AGGREGATION** effects are related to the total power delivered to the amplifiers, but more precisely to the actual **VOLTAGES** applied to the active junctions (“small signal” operation vs Bias).

# ***Even Phase Noise can originate RFI !***



# *A dual X+Ka-band receiver for Prime Focus operation*



Mixing products (IF and LO frequencies), filters and amplifier gains are selected for best  $T_{sys}$ , Phase Noise and  $IP3$ . All oscillators are locked to an H-Maser.

# *A dual X+Ka-band receiver for Prime Focus operation*



- Tip and tilt adjustments of the feed
- Thick passive insulation
- Cooling Peltier radiator outside + fan within the receiver box
- Power supplies in a separate section

# ***Identification of (already detected) RFI***

***Assume that there is an RFI signal, now what?***

***✓ Is it a self interferer?*** Check all (new) instruments around

***✓ Is it “legal”?*** Check allocations+footnotes of the national band plan

***✓ If it is not:*** who has the duty to persecute it?

***National and Territorial Administrations are the only ones who have this right, but ..... they might need some facilitations:***

- ☐ ***Tell them its frequency, intensity, company NAME, location,...***
- ☐ ***Modern B-BW signal has **no Carrier** easily detectable!!!!***
- ☐ ***Decoding can be very difficult today (paying a licence?)***
- ☐ ***Localization requires a dedicated campaign: triangulations***
  - ❖ ***Need for a MOBILE unit***

# ***“Ad hoc”, Routine and Statistical Estimations of RFI***

**Very often a *Data Base* of the Spectral Occupancies is claimed to be the “obvious” information required by RAstronomers. But....**

***“Ad Hoc” surveys*** are in any way needed to cover special requests (new receiver, special interferer, etc...).

***Routine surveys*** are compulsory to check for new self-interferers, getting deeper sensitivities, combining the complementary products of a Mobile + a Fixed monitoring station.

## ***Statistical Estimations of RFI***

***can be the unique solution?***

# Match the RFI measuring strategies with the Observational needs (1)

What RAstronomers intend for Spectral Occupancy?  
Please answer, at least, to the following questions:

- 1. At which level of sensitivity? RA-769 or different?***
- 2. Over which pointing angles of the RTelescope?***
- 3. At what level of frequency resolution?***
- 4. With what time resolution (H24 as default)? (See 1!!)***

# Match the RFI measuring strategies with the Observational needs (2)

***Derive from the previous parameters  
the experimental setup that is needed:***

***i. Antenna system (maybe multiple)***

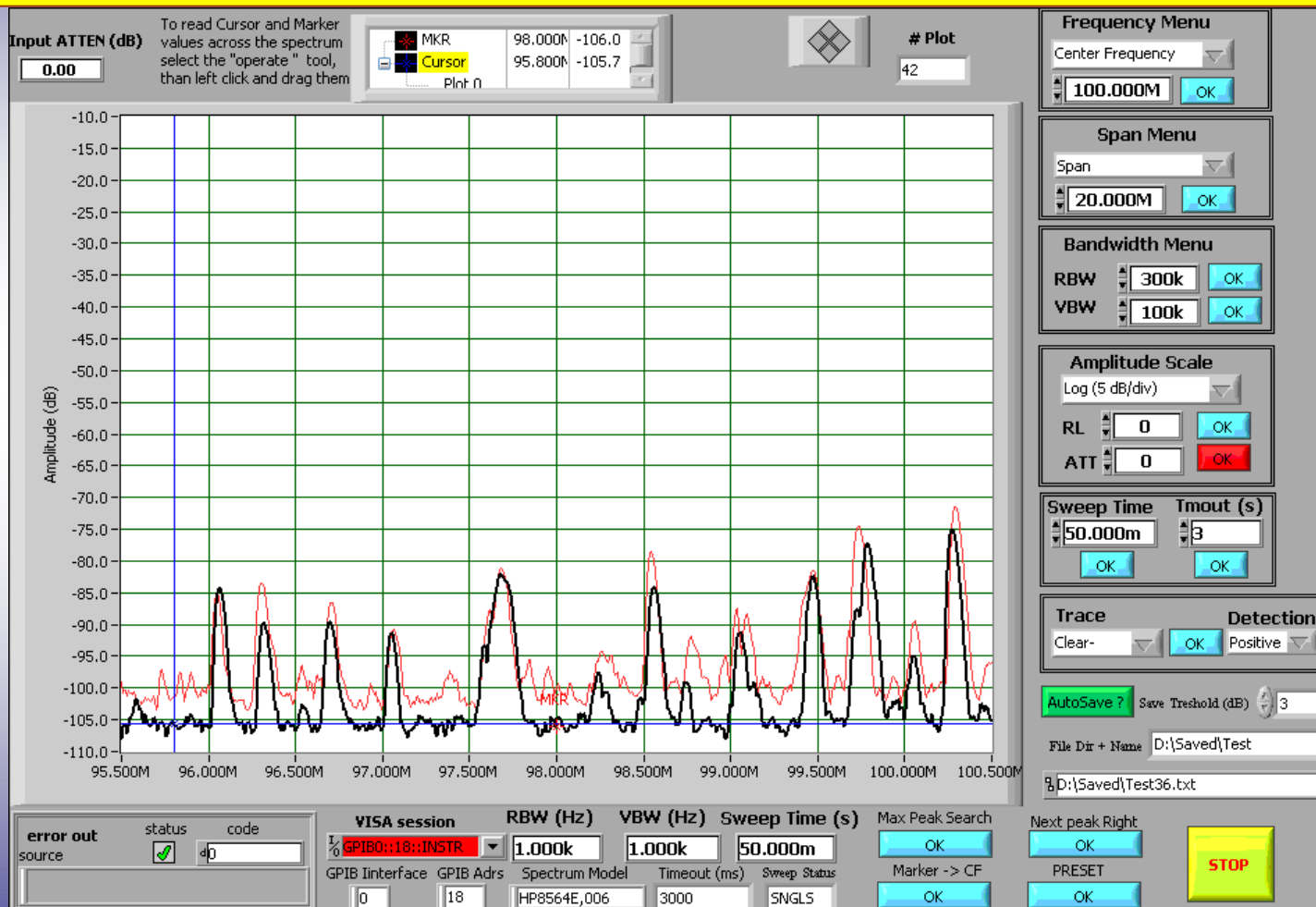
***ii. Type of Receiver***

***(Time Domain vs swept Spectrum Analyzer !!!)***

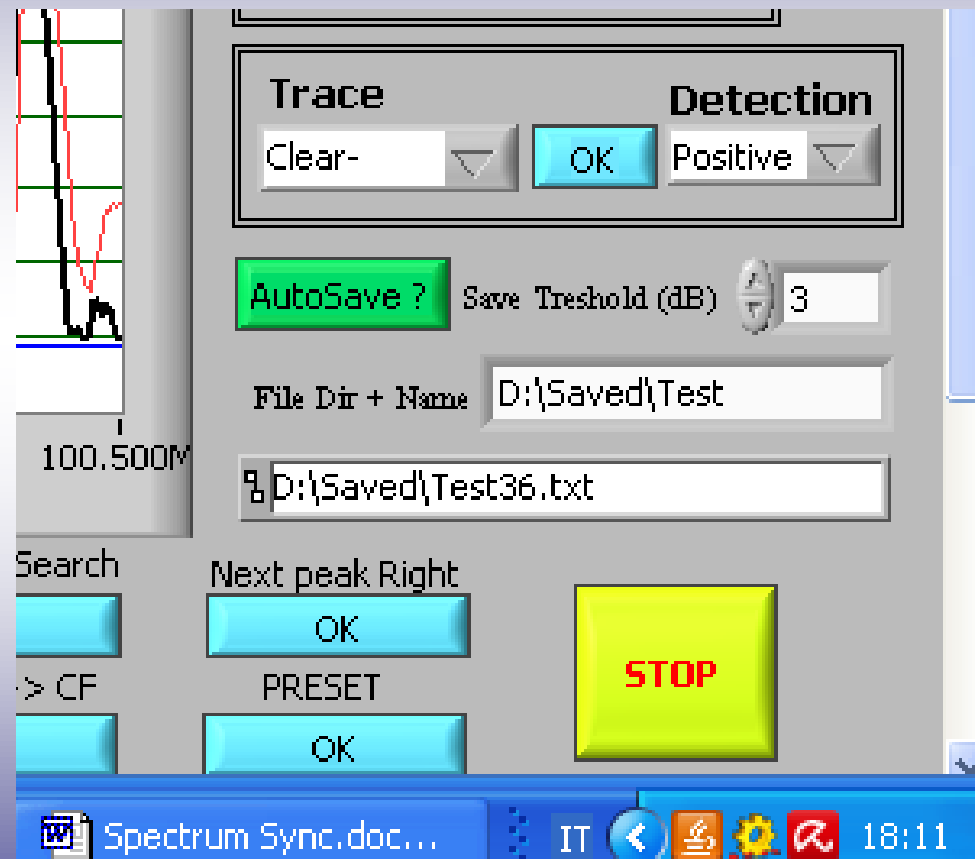
***i. Automatic DAQ Software ( see an example here)***

***ii. Accounting Software ( later presentation)***

# A LabView code example suitable for remote DAQ and auto-save (a)



# A LabView code example suitable for remote DAQ and auto-save (b)



# Match the RFI measuring strategies with the Observational needs (3)

Can RAstronomers *fill with numbers* the previous questions with only 3-4 Configurations suitable to satisfy at least a broad class of Observing Modes?

I try a few examples (**RA-769**):

*Single dish, total power*

*Single dish, Spectral Line*

**VLBI**

.....

# Spectrum Management, RFI monitoring, Mitigation

It would seem that they are different *temporal* steps for achieving the best usage of the available spectrum for a set of Observing Modes: after RA-769 there has been almost no synergies them.

*Apart from historical and technical reasons  
we are here now, to make it working!!!*