RFI Management & Mitigation

Murray Lewis

Radio Frequency Interference (rfi)

unwanted manmade radio signals in data == rfi

The radio spectrum is coveted by many users

Commercial
Governmental
Military
Scientific

- ***So the Radio Spectrum must be shared and managed***
- ***While users are generally assigned a specific frequency band***
- ***They often contaminate adjacent spectrum with spurious and unnecessary emission == to serious rfi***

Global Arenas

FCC, NTIA: US Domestic Regulators

CORF: NAS Committee on Radio Frequencies

ITU & IUCAF: International

- **ITU regulations provide the protected RAS bands**
- **Allocate particular pieces of spectrum to particular classes of users**
- **Provide guidelines for interpreting spurious & out of band emissions**
- **Provide guidelines for interpreting "harmful levels" of emission**
- **Band-sharing coordination, etc**
- **Provisions for radio astronomy from space == need for foresight**

IUCAF: Unfettered voice of radio astronomers at the ITU

MOU with Russians re GLONASS

Rallying point in dealing with Iridium

Arecibo has Interests at

- ITU
  - resolution of the band by band issues
  - Development of INMARSAT above 1668 MHz
- ITU & FCC
  - 1400 MHz feeder links
- FCC
  - Iridium & its aeronautical deployment
  - Access to 14.47-14.5 GHz RAS band
  - (cognitive radios, UWB, BPL)

Puerto Rican Issues

- FCC Regulates PR
  - On September 26th, 1997 set up the PRCZ
  - Provides for the Observatory to comment on license requests to the FCC

- PR Spectrum Users Group (PRSUG)
  - Provides a forum for making contacts with Island Spectrum Managers
  - Provides notice of new developments
  - Eases coordination

- Current island changes
  - Naval exercises off Vieques have been discontinued (< RFI)
  - Proliferating cell phone towers

Coordination

- Iridium at 1612 MHz
  - via an MoU
- GPS at 1381 MHz
  - Coordination via an MoU
  - And notification of our schedule (with NRAO)
- Puntas Salinas (frequency-agile Radar)
  - Requires one-on-one coordination with every telescope schedule
  - Personal contact maintained through PRSUG

430 MHz intermods

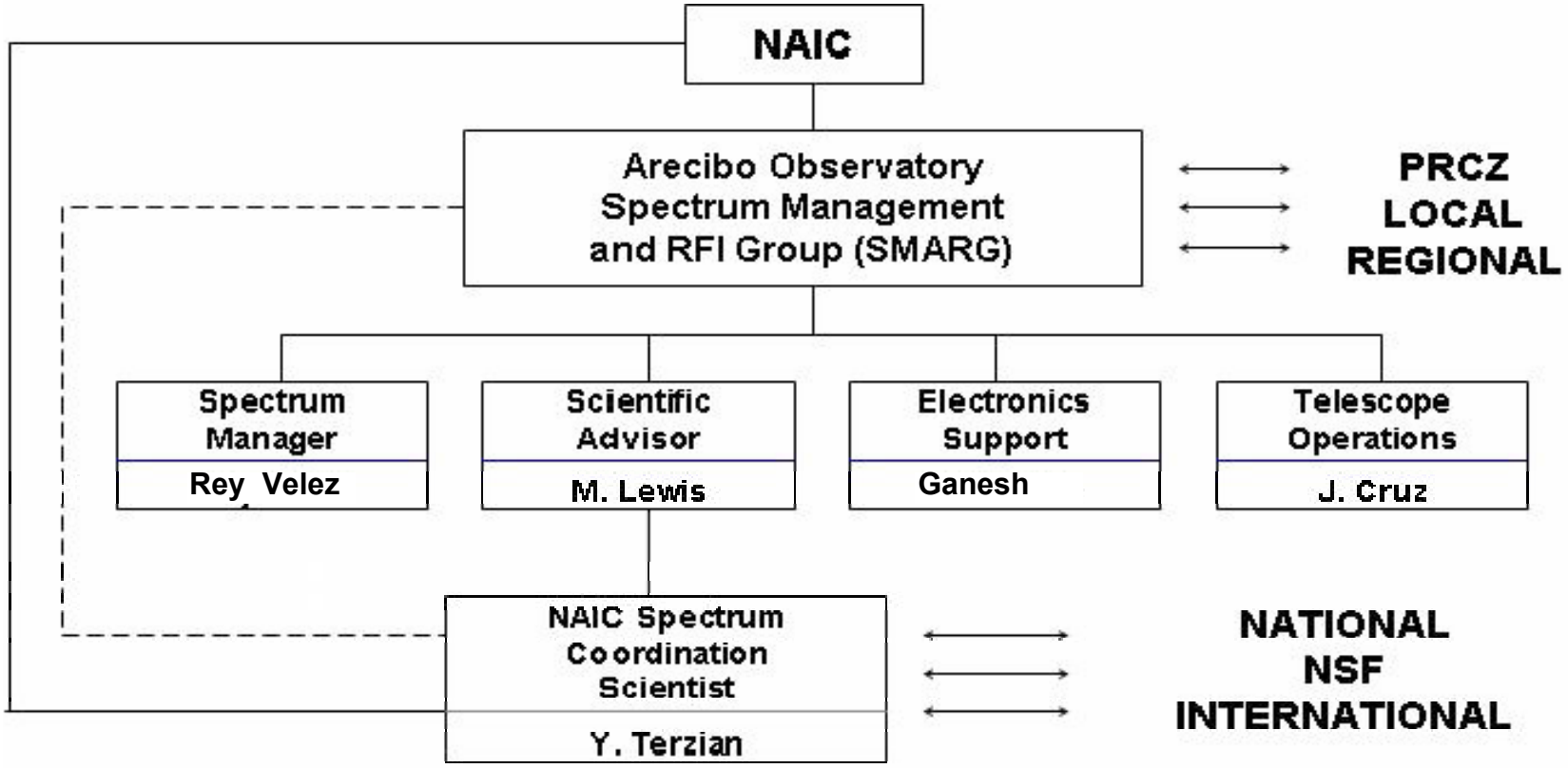
- **Channels 14 & 22 both came up to their licensed**
  - **Peak power**
- **That produced severe intermodulation products in our 430 MHz band in one polarization**
- **Cured pro tem by inserting four-stage tuned cavity filters in front of the cooled LNAs**
- **In Gregorian Tsys of 55-60 K increased by ~3 K**

Sources of RFI

RFI	*Source*	*Regulatory Body*
• *Global*	*Satellite, Aircraft*	*FCC, NTIA, ITU*
• *PR*	*Radar, TV, Comm.*	*FCC, & (PRSUG)*
• *Site*	*Inadvertent*	*Arecibo Staff*

- ***NAIC acts on RFI matters through an internal committee:***
  Spectrum Management and RFI Group (SMARG)
- ***Meets monthly, Minutes on the internal web***
- ***Attended by Site Director, Head Astronomy, & Yervant Terzian***
- ***Spectrum Management at Arecibo - ~2* FTE** **+**[Phil P. ~0.25 FTE]
  - Rey Velez (1 FTE), Murray Lewis (0.5 FTE), Engineers (~.25 FTE)

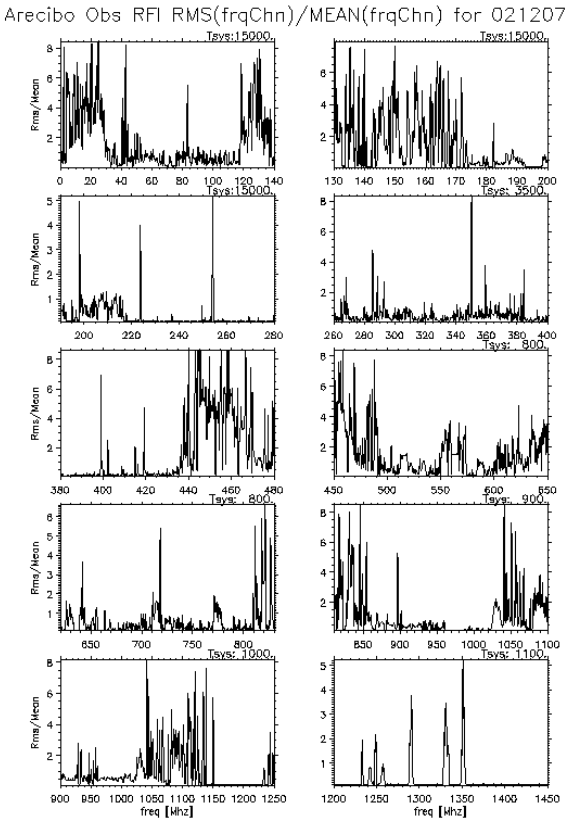
SPECTRUM MANAGEMENT

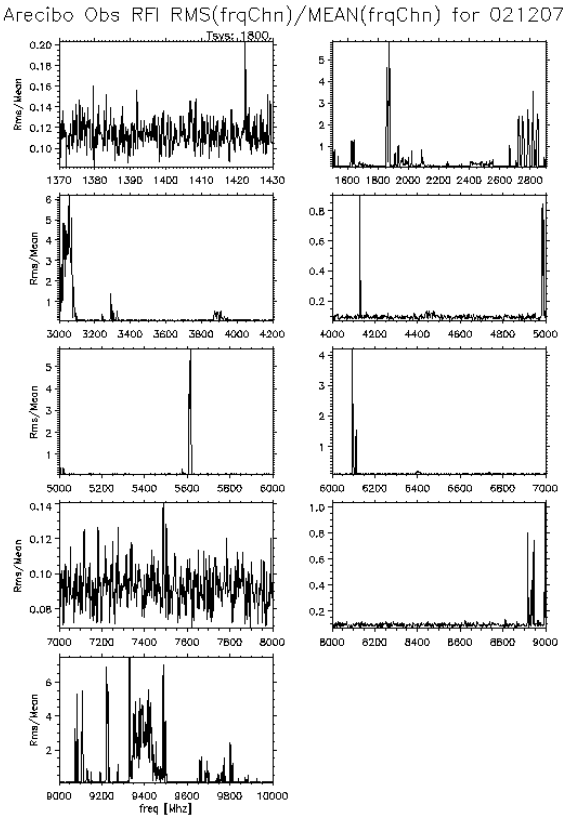


Information to users

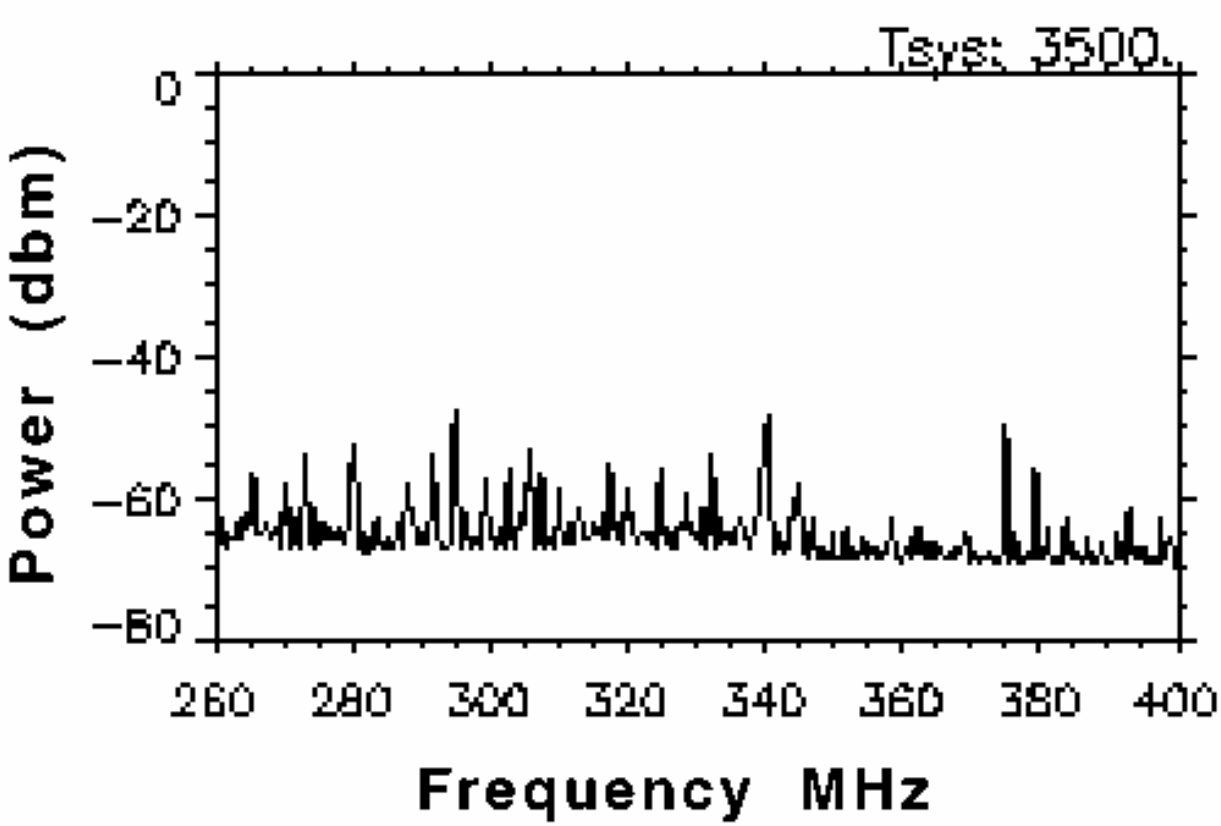
- **Hilltop Monitor Plots on web**
  - **from an omni-directional antenna**
  - **260 MHz - 10 GHz**
  - **Provides daily spectral averages**
  - **And occupation plots**
- **Through the Gregorian view**
  - **Reprocess observer's observations**
  - **Presented as spectral occupancy plots**

Details of Common/Unusual RFI Available on AO Web Page



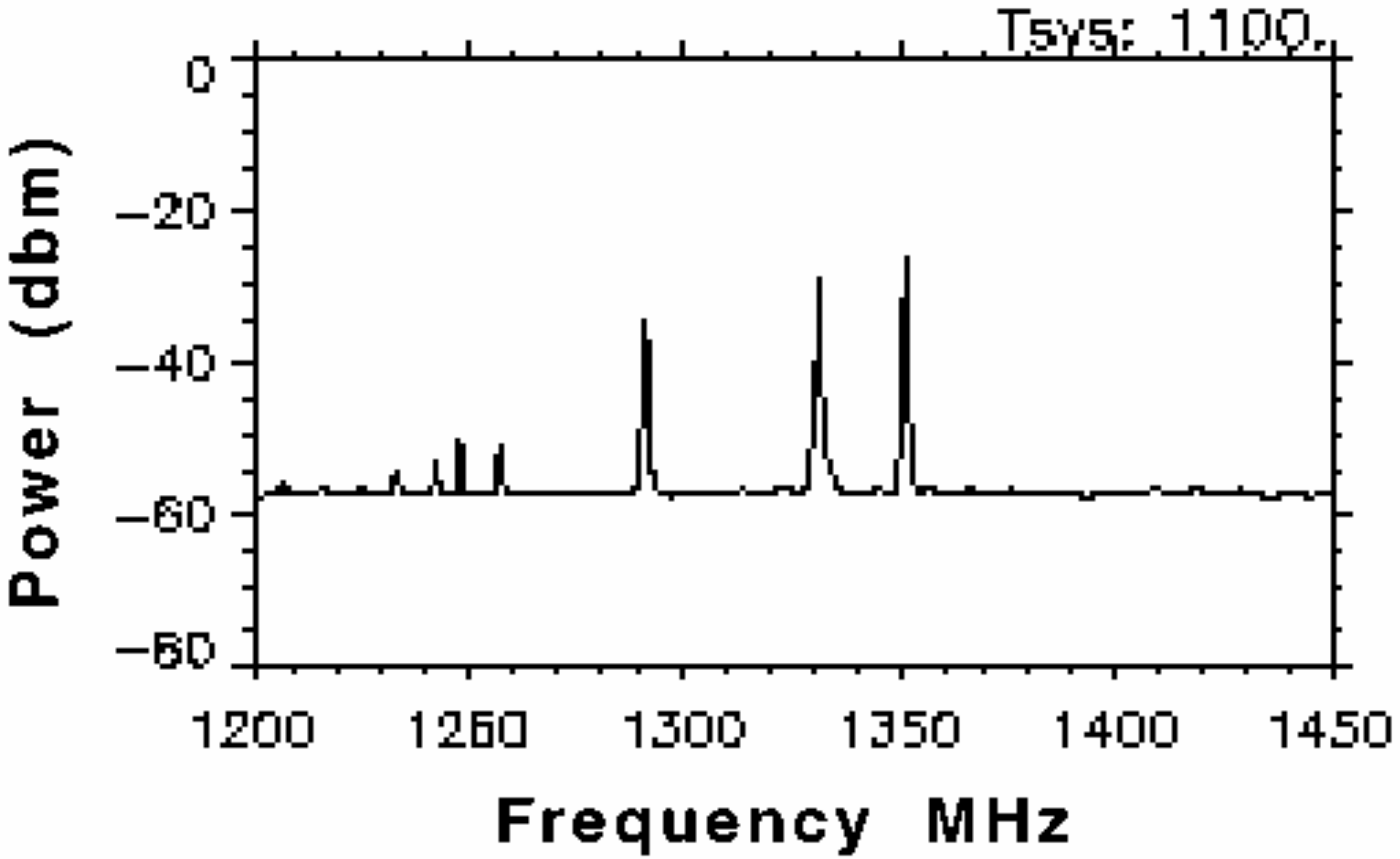


Output Hilltop Monitor

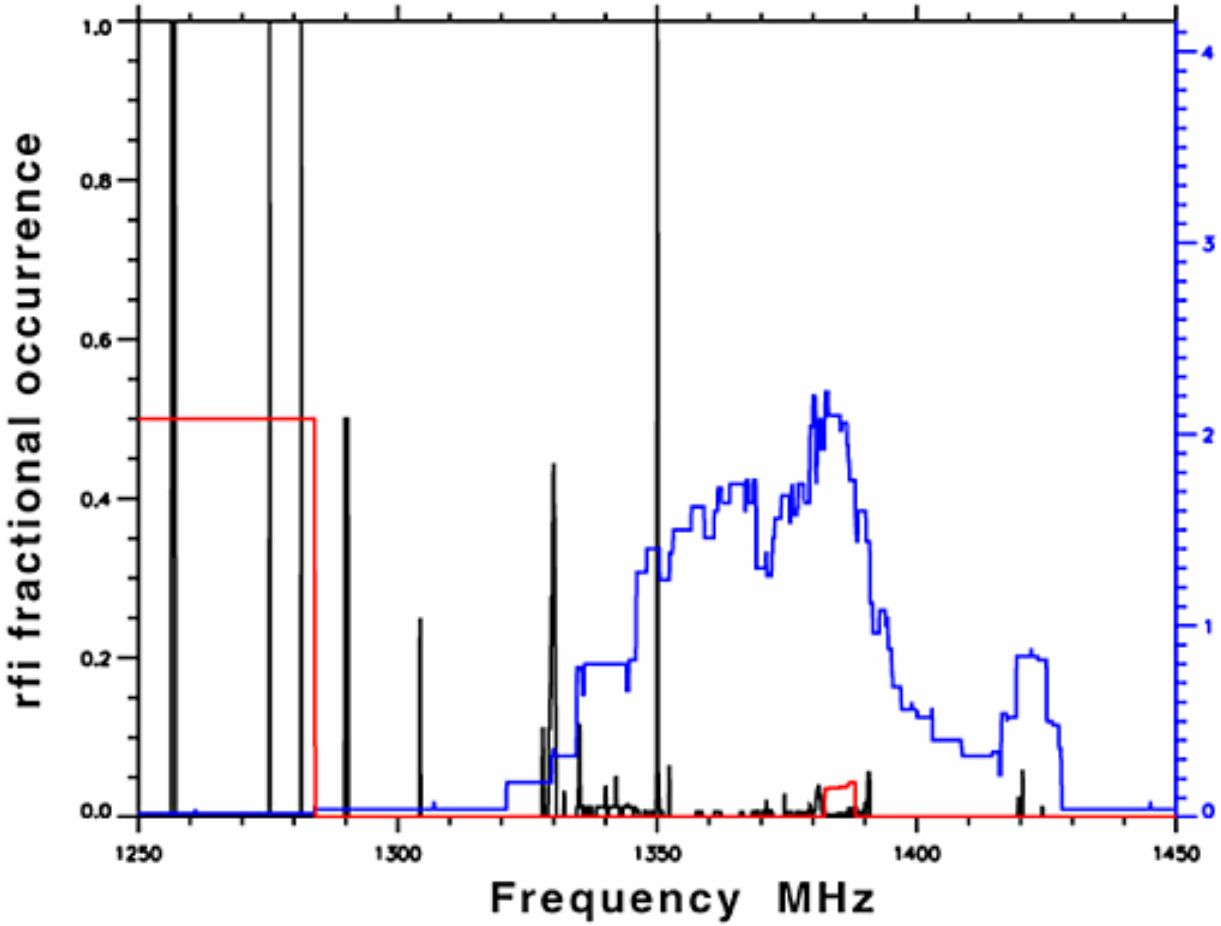


Daily average 30/10/2002

Hilltop Monitor 1200-1450 MHz

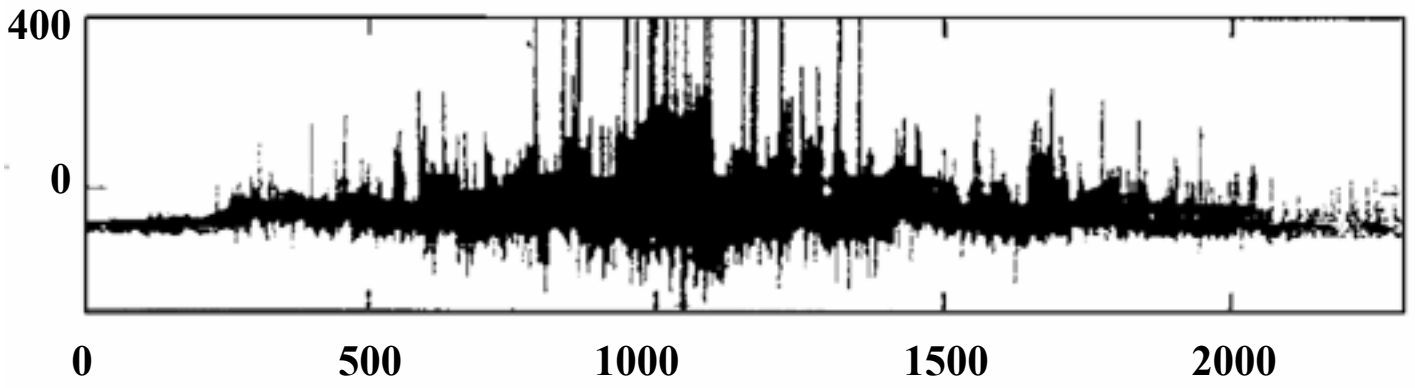


Fractional Occupation of 0.1 MHz bins

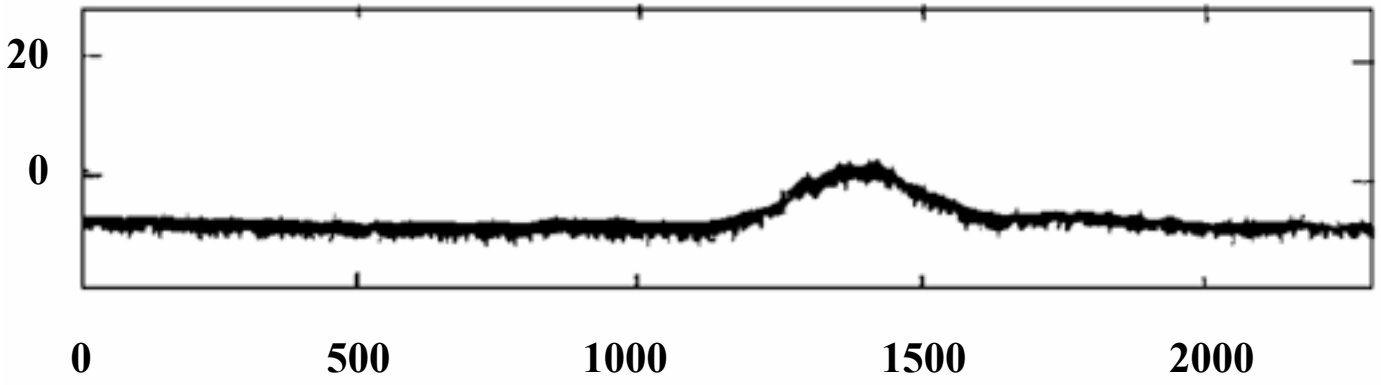


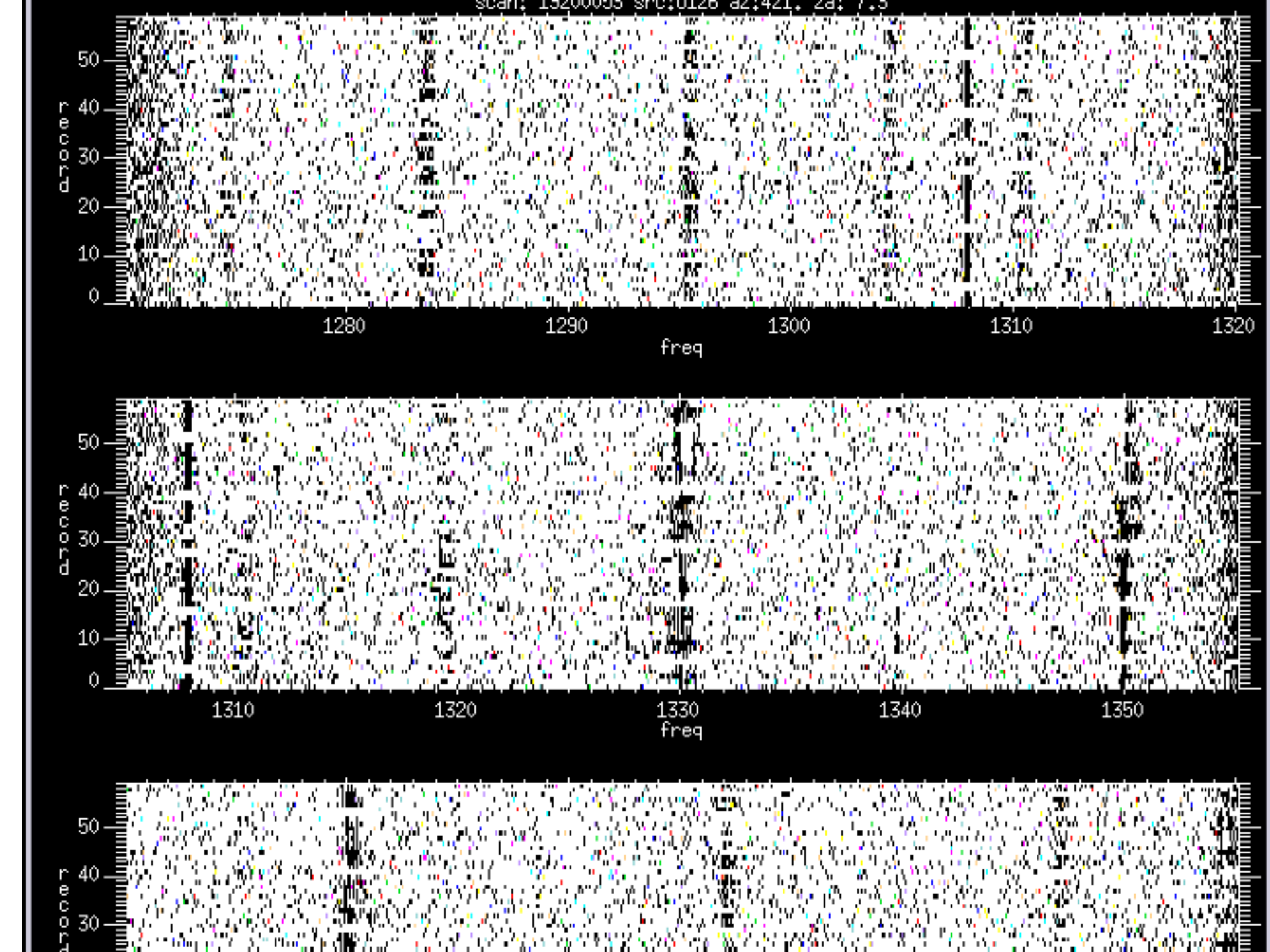
Mitigation

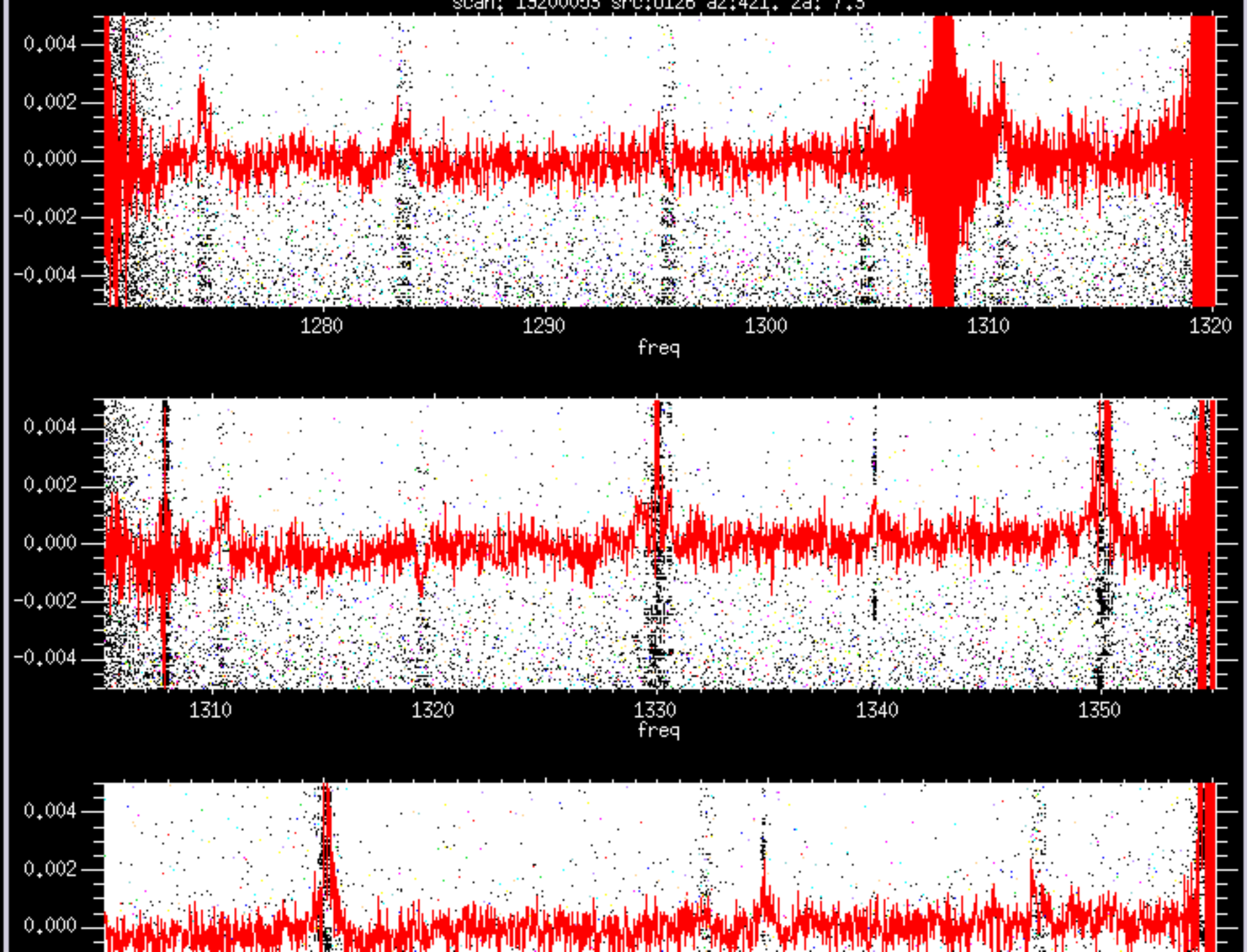
- **Radar Blanker**
  - **For San Juan Airport radars at 1330 & 1350 MHz**
- **Fast sampling and decimation**
  - **HI observers generally use at least 1 sec dumps**
  - **For ALFA deep survey, may use 1 msec dumps**



RATAN-500 1116+28




scan: 15200053 src:0126 a2:421. 2a: 7.3
record
freq
50
40
30
20
10
0
1280
1290
1300
1310
1320
1330
1340
1350


scan: 15200053 src:0128 az:421. za: 7.5
0.004
0.002
0.000
-0.002
-0.004
1280
1290
1300
1310
1320
freq
0.004
0.002
0.000
-0.002
-0.004
1310
1320
1330
1340
1350
freq
0.004
0.002
0.000

Observer's 2004 Concerns

- **Coordination**
  - **GPS --> ~1381 MHz**
  - **Puntas Salinas --> all 21 cm observers**
  - **Iridium (satellite OoB emission at 1612 MHz)**
  - **Globalstar (in-band aeronautical emission at 1612 MHz)**

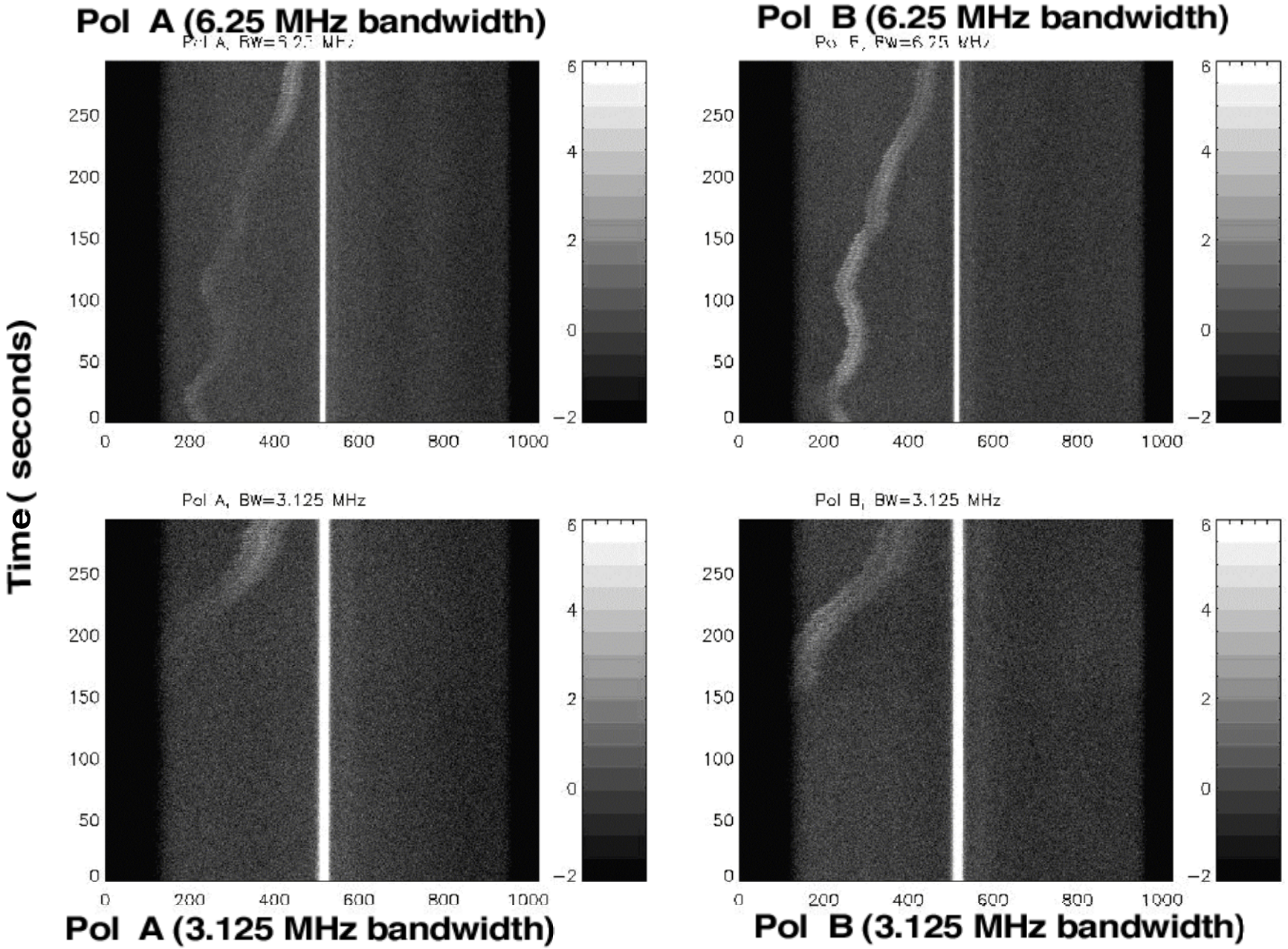
- **RFI problems**
  - **Particularly at L_band & 430 MHz**

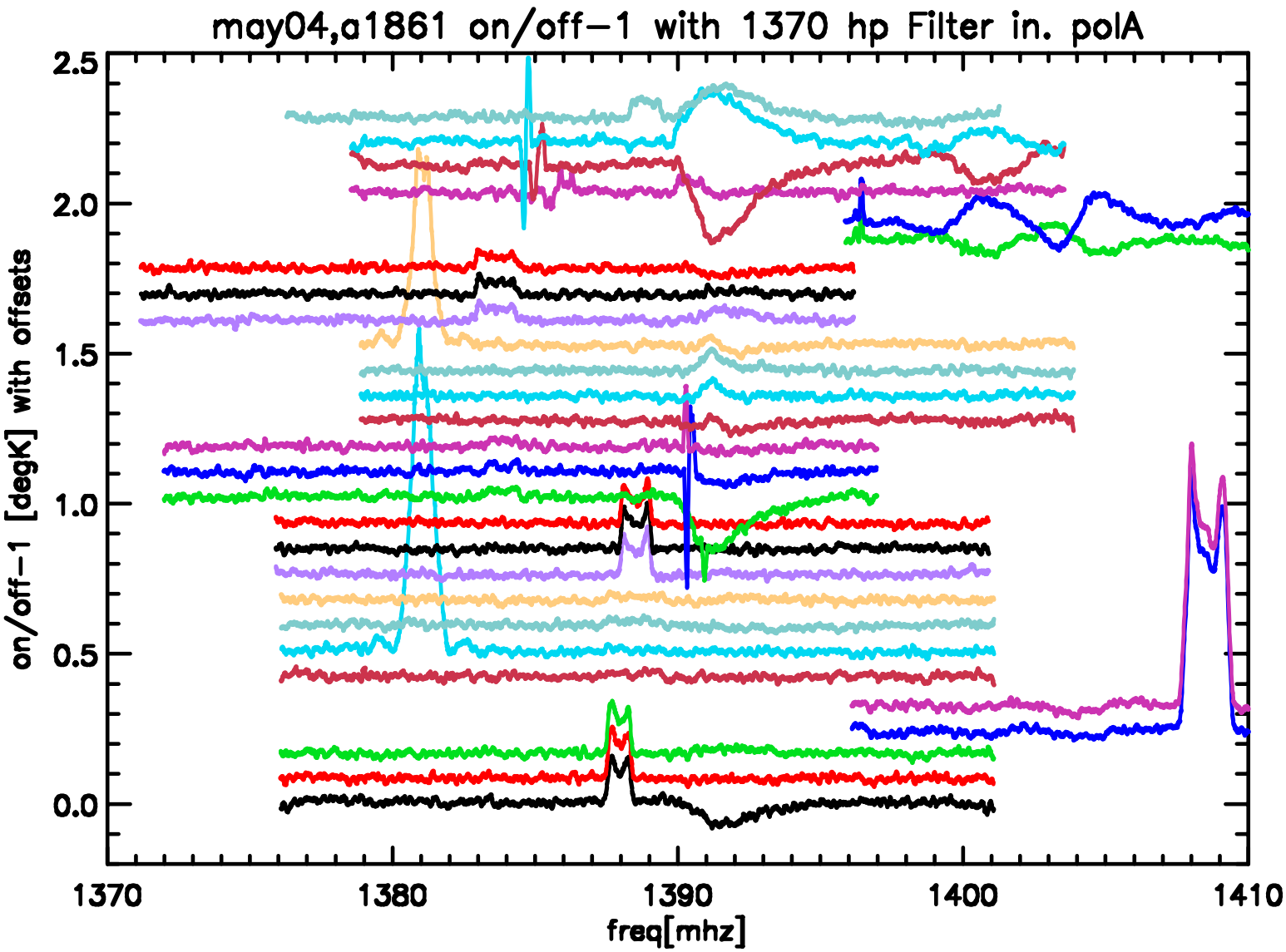
Site-Generated RFI

- We are often our own worst enemy == need for eternal vigilance
- Vet equipment as it is installed
  - Distomat control units
  - Video cameras
  - Tie-down boxes
  - Tertiary control units
- Monitor installed equipment
  - Deterioration of shielding due to oxidation of seals
  - Wear & tear on equipment seals
  - Installation of improvements to RFI shielding, etc
- Cell-phone detector at the Visitor center
  - Connected to the PA system
  - Concern with electronic-cameras

L_band woes

- **60 MHz wandering birdie**
  - **Solved about Xmas**
- **1381 MHz problem**
  - **New problem**
- **Break up of the baseline circa 1390-1400 MHz**
  - **Since May 2004**


Pol A (6.25 MHz bandwidth)
Pol B (6.25 MHz bandwidth)
Pol A, BW=3.125 MHz
Pol B, BW=3.125 MHz
Pol A (3.125 MHz bandwidth)
Pol B (3.125 MHz bandwidth)
Time (seconds)
CHANNEL (alias frequency)


may04,a1861 on/off−1 with 1370 hp Filter in. polA
on/off−1 [degK] with offsets
2.5
2.0
1.5
1.0
0.5
0.0
1370
1380
1390
1400
1410
freq[mhz]

Current Issues

Role in developing advanced mitigation

- **removal via polarization**
- **Reference beam(s) & adaptive filtering**
- **Robust statistics on high time-resolution**
- **cross-correlation of signals between ALFA pixels**