

RFI2004

Workshop on Mitigation of
Radio Frequency Interference
in Radio Astronomy

Dominion Radio Astrophysical Observatory
Penticton BC Canada
July 16-18, 2004

Report on RFI2004

Steve Ellingson, Virginia Tech
Wim van Driel, Obs. de Paris / IUCAF



**Workshop on Mitigation of
Radio Frequency Interference
in Radio Astronomy**

Objectives of the Workshop

- **Present and discuss the “latest and greatest” in the field of RFI mitigation technology**
 - **Update to similar workshop sponsored by IUCAF in Bonn 2001**
 - **Alternative to RFI working group sessions held at annual international SKA meetings of previous years**
- **Improve understanding and inspire collaboration between the communities of observing astronomers and research engineers**
- **Consider what this means for SKA design**
- **Consider what this means for SKA-related regulatory efforts**

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Participation

- 79 registered attendees
- 31 oral presentations (2 invited)
- 4 poster presentations
- Excellent representation
 - Across international boundaries
 - Across organizational boundaries
 - Scientists ↔ Engineers
 - “Mitigators” ↔ “Regulators”

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**Thanks to DRAO
(Dewdney, Tapping,
Morgan, Veidt,...)**

**and the WOC
(Briggs, van Driel,
Boonstra, Jeffs,...)**

and the participants

**for making this
a success!**

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Program

- **Friday, July 16**
 - Introductory Session (Ekers, Briggs, Fisher)
 - Regulatory Session (van Driel, Gergely, Tzioumis)
 - Radar and Iridium
 - Applications
- **Saturday, July 17**
 - Precorrelation Array Techniques
 - Postcorrelation Array Techniques
 - Characterization & Algorithms
 - Mitigating RFI at RF
- **Sunday, July 18**
 - Directed discussion (van Driel)

Sessions

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**Technical
Program**

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**Regulatory
Issues**



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Workshop Product

- **Web-based proceedings**
 - <http://www.vt.edu/~swe/rfi2004> (will change soon)
 - **Program / Abstracts** available now
 - **Presentations** available shortly
 - **Papers** available shortly
- ***Radio Science* special section, est. Fall 2005**
- **Summary in *Experimental Astronomy* special section on SKA2004**

Some Impressions

- **RFI Mitigation technology continues to show great promise** – many exciting demonstrations presented: L-band radar, DME, Digital TV, Iridium, ILS, Strong HF, ...
- **There is much useful stuff to be learned** from the signal processing community: Kalman Filtering, Eigendecomposition methods, Subspace/projection methods, Cyclostationarity...
- **The “tried and true” methods still apply** and can be greatly improved: Blanking, Exploiting RFI phase closure, Automation of data editing
- **A full-court press is underway**: LOFAR, ATA, Nancay, WSRT are all implementing *serious* RFI mitigation HW

Some More Impressions

- **Much of the success achieved is not surprising in retrospect:**
 - “We tend to forget how much hand-tuning goes into our algorithms”
 - We tend to choose problems we think we can solve
- **We are peeling only the first layers of the “RFI onion”...**
 - We are becoming very good at mitigating moderate RFI, but that may not be the toughest part of the problem
 - What forms of RFI lies at the extreme limits of sensitivity...?
- **Successes remain anecdotal.**
 - Much more field experience with real astronomy required
 - “Comfort level” is currently low (toxicity? Operational issues?)

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Even More Impressions

- Propagation of mitigation processing artifacts into the product?
- Need an analytical framework to understand results of brute force simulations... RFI processing (and other effects!)

What this means for SKA...

- RFI mitigation will be more important for SKA than for other telescopes not necessarily because it will be more sensitive, but because it will produce more data
 - Exceptions, too: High redshift HI, High fractional-BW observing below 1 GHz
- Need to work on automating the simple, effective things that are done manually now...
- Correlator dump times $<$ or \ll 10 ms will be *very* important
- Mitigation should not be improvised later, it should be designed in.
 - At least, incorporate appropriate “hooks” into the system



RFI 2004
regulatory
recap

SKA spectrum management

The task of accommodating all competing services and systems within the finite usable range of the radio spectrum

Global:

Radio Regulations of the International Telecommunication Union (ITU) provide the global framework for spectrum management

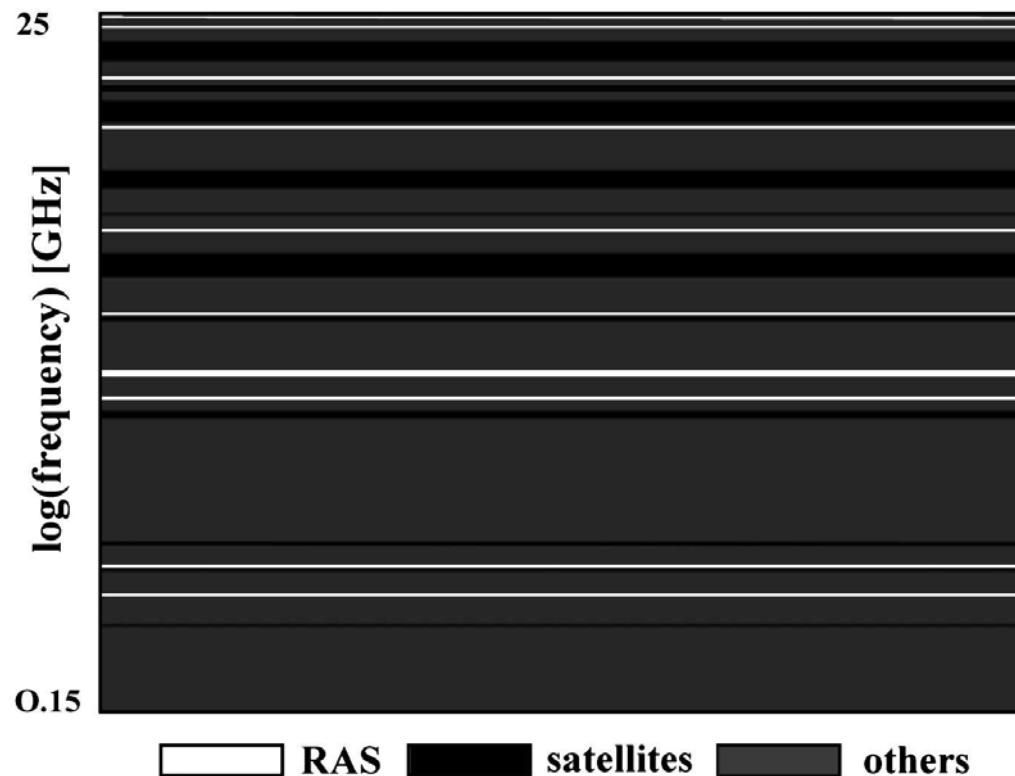
National:

National frequency Administrations regulate spectrum use, in accordance with the ITU Radio Regulations

- including the implementation of an **SKA Radio Quiet Zone**

Enabling the “new radio astronomy”

Can mitigation techniques, *including regulatory measures*, deal with the RFI environment, with the SKA in 2020 in the 0.1-25 GHz frequency range?



Allocated frequency bands in 0.15-25 GHz range

RFI 2004: Regulation

The time has come define the regulatory protection criteria *we* want for the SKA – regulators want *levels* on emissions by other spectrum users at potential SKA sites (*and soon*)

National: Discussions with Australian and South African Administrations:

- they define and regulate national Radio Quiet Zones
(can limit terrestrial transmitters only, not satellites)

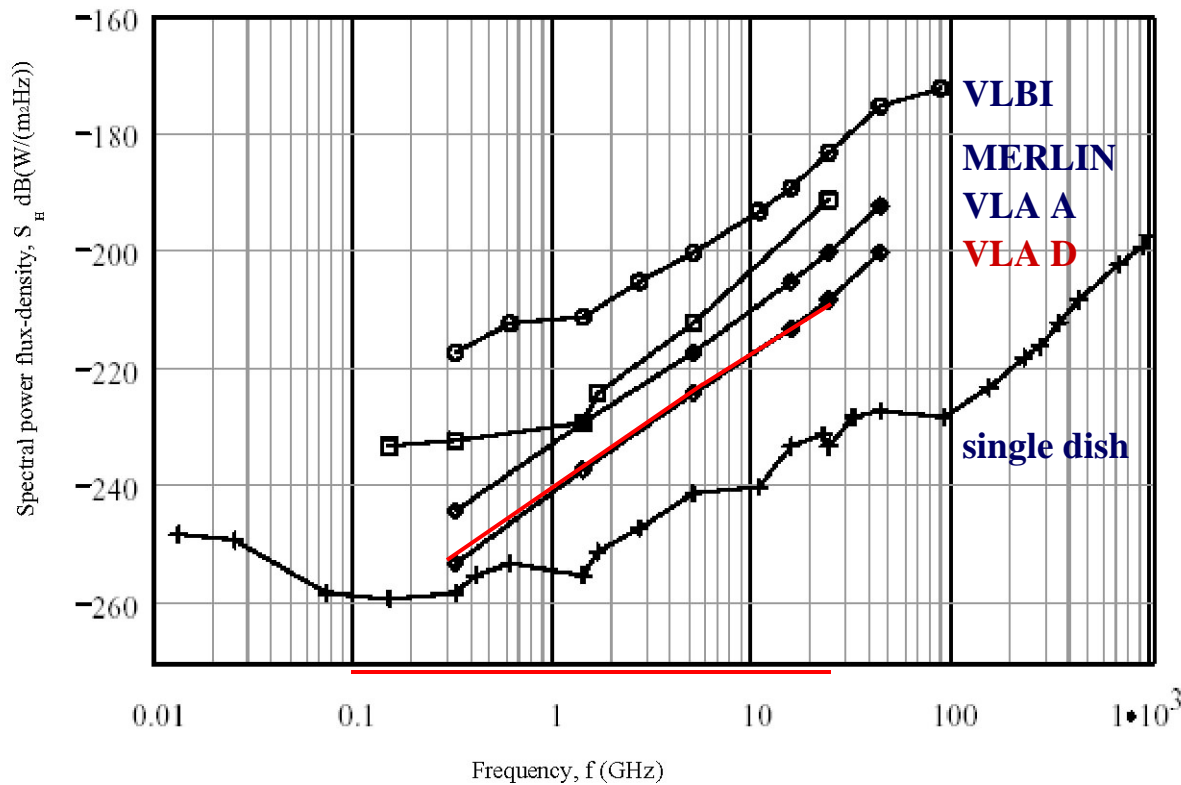
Global: Question on Radio Quiet Zones accepted at the ITU:

- get ITU Recommendation on Radio Quiet Zones,
for guidance to national frequency Administrations

RFI2004: Basic protection criteria for the SKA
are based on those for linked interferometers in *Rec 769*
(Recommendation RA.769 in ITU Radio Regulations)

Propose SKA Regulatory Subcommittee

SKA regulatory protection criteria



**Rec 769 power flux density threshold levels
for interference detrimental to radio astronomy:**

**as for the VLA-D, ~15 dB above the Rec 769 single-dish levels,
for protection in a Radio Quiet Zone in the entire 0.1-25 GHz range.**

RFI 2006

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