

Radio Frequency Interference

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ATNF Radio School 2015, Narrabri

Radio Frequency Interference

- RFI : *unwanted detectable portion of a desired observation that has the potential to either degrade or inhibit the successful conduct of the observation* - Ellingson & Lewis, 2006
- Classified as *internal* or *external* RFI
- Sub-classified as *continuous* or *intermittent* RFI
- Sub-sub-classified as “*strong*” or “*weak*” RFI
- Sub-sub-sub-classified as *stationary* or *moving*
- ...

⇒ RFI is a critical aspect of radio astronomy

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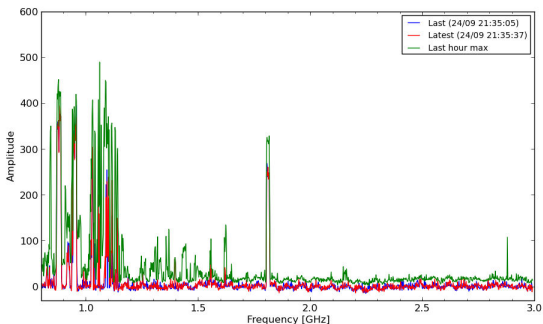
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⇒ RFI is a critical aspect of radio astronomy

Radio spectrum

- Observable window \approx 30 MHz - 300 GHz
- Well exploited frequencies for man-made applications
- Man-made emissions $\approx 10^9$ times stronger than weak cosmic sources
- Example here in Narrabri:

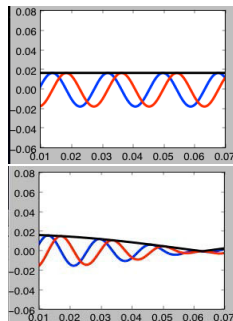


Impact on radio astronomy

- Mask signal of interest
- Mislead observation interpretation
- Loss of data
- Calibration
- System deterioration



Craig Anderson

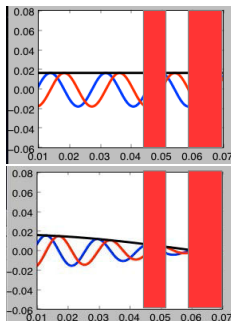


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What types of RFI?



What types of RFI?

RFI : *spatially* structured noise
(+*temporal* and/or *spectral* structure)

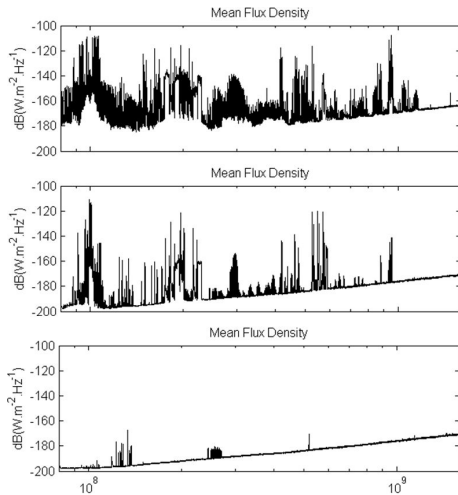
Examples:

- Active users : communication, RADAR, DVB/DAB, geo-location...
- Intermodulation products : potentially any (strong) active user at any frequency
- Physical phenomena : lightnings, power lines...
- Self-RFI : local oscillators, computers, screens...

What solution?

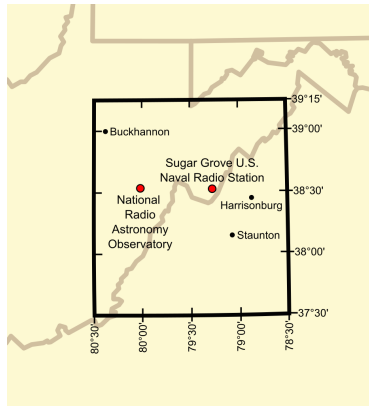
- Pro-active solutions:
 - Radio Quiet Zones
 - Frequency allocation
 - Coordination / management
 - Shielding
- Reactive solutions:
 - Flagging / blanking / excision
 - Temporal cancellation
 - Spatial cancellation

Radio Quiet Zones (Sydney / Narrabri / MRO)

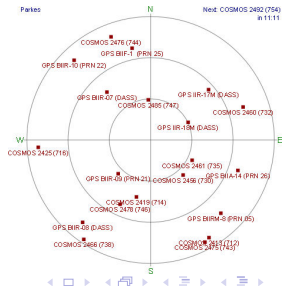
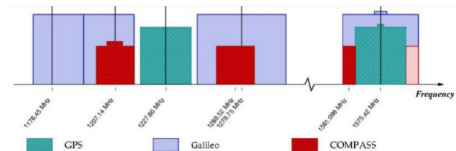
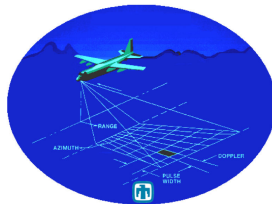


Radio Quiet Zones (2)

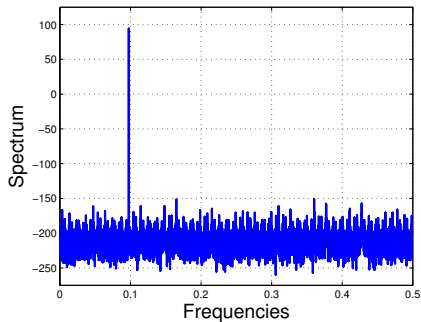
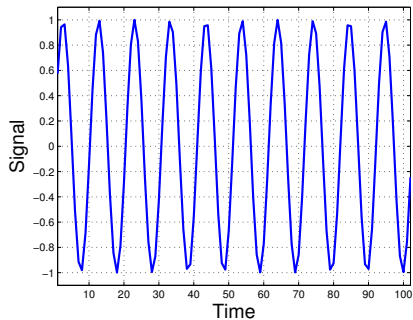
- Radio Quiet Zone \neq remote and isolated zone
- Radio *Quiet* Zone \neq radio *silent* zone
- Admissible data loss : 2% single / 5% multi



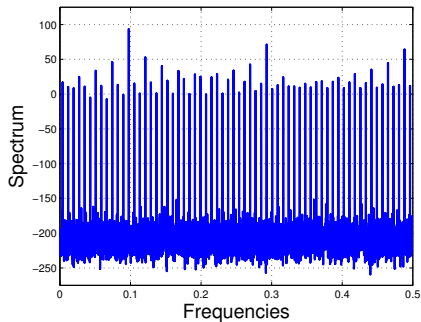
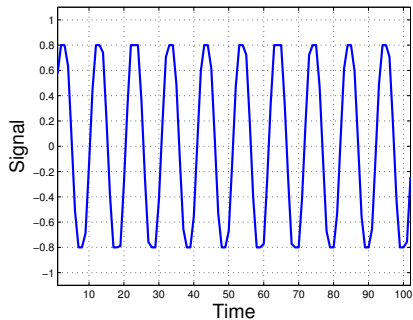
Radio Quiet Zones (3)



Example : Intermodulation products

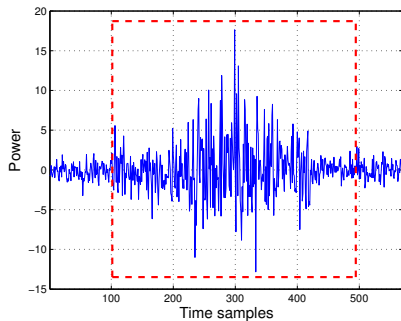


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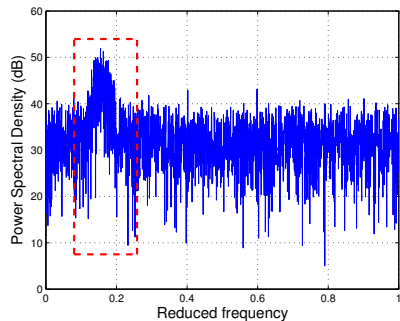
Reactive RFI mitigation

- Time domain processing
 - Flagging / Blanking*
- Frequency domain processing
 - Digital (adaptive) filters*
- Spatial domain processing
 - Adaptive beamforming / Projection*



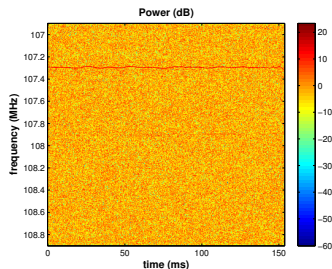
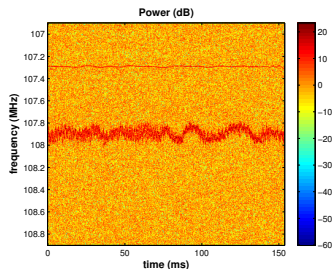
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Digital (adaptive) filters
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Adaptive beamforming / Projection



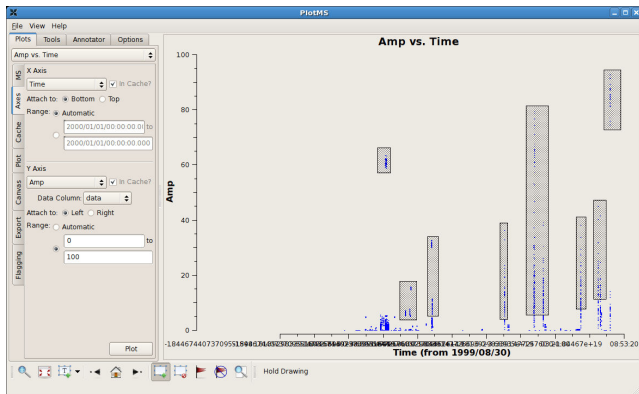
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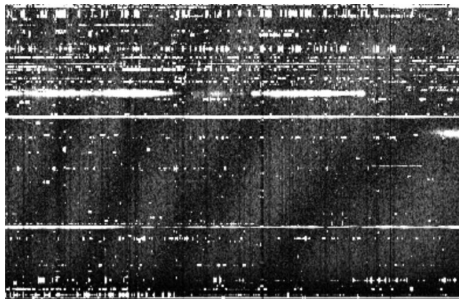
Flagging / blanking approach

- Manual or automatic detection of corrupted Time-Frequency slots
- Non-detection leads to erroneous results
- Loss of data
- Non-applicable to continuous RFI

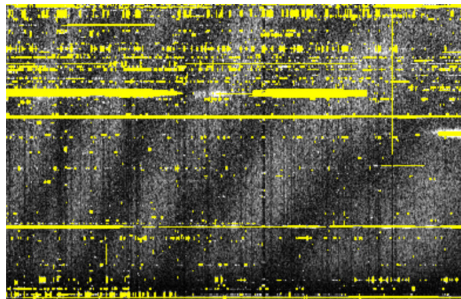


Automatic flagging

Before:



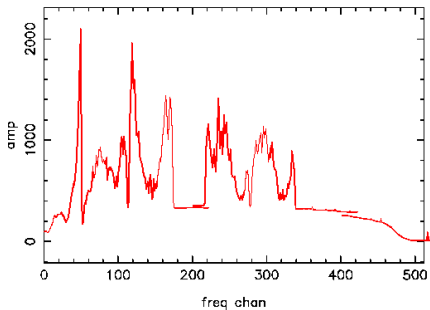
After:



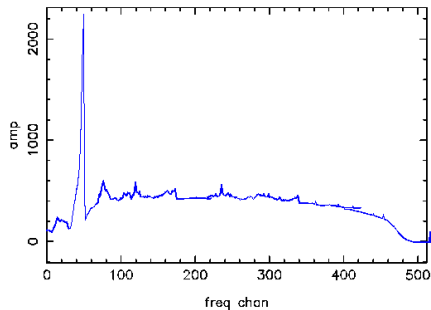
A. Offringa

Temporal cancellation

Full spectra, row ../rfi-2009/s090604_005218.rf



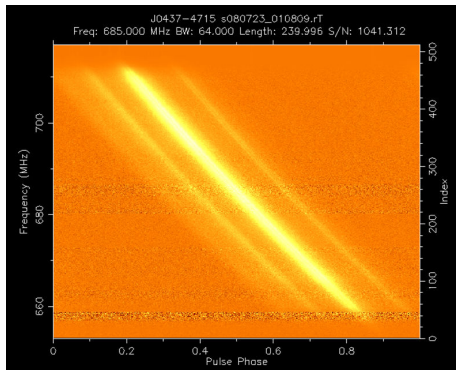
Full spectra, filtered ../rfi-2009/s090604_005218.rf



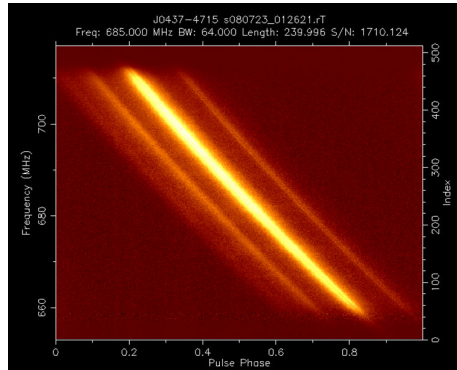
M. Kesteven

Temporal cancellation (2)

Filter off:

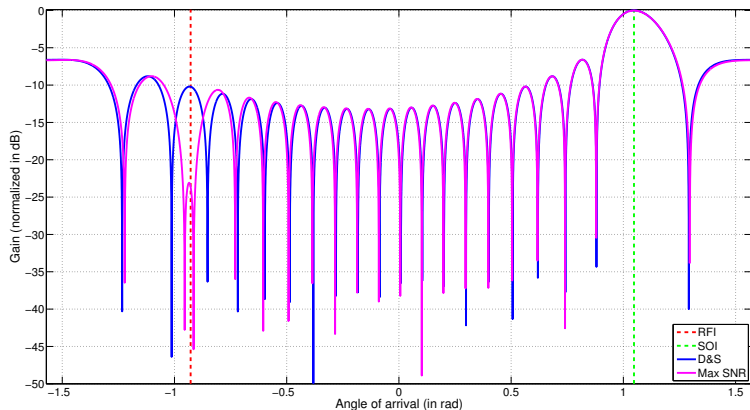


Filter on:



M. Kesteven

Temporal / spatial cancellation



Spatial cancellation

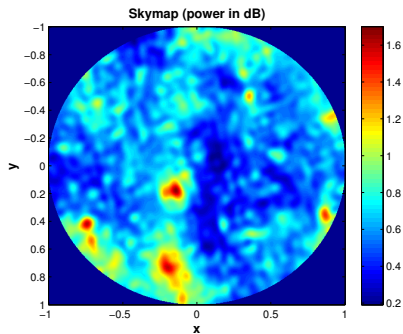


Spatial cancellation

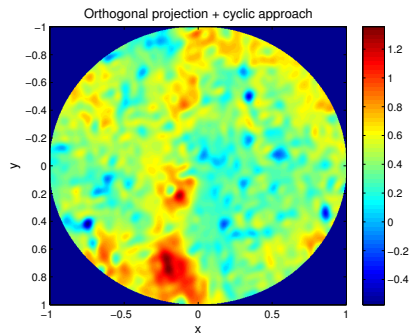


Spatial cancellation (2)

Before processing:



After processing:



Conclusion

- RFI is an important part of radio astronomy
- Situation is getting worse (new technologies, spectrum sharing...)
- Some moderately to highly red shifted HI science is threatened (navigation satellites)
- Flagging is necessary, but inadequate due to data loss
- Approaching critical cases : active RFI mitigation becomes necessary