RFI Monitoring at the MeerKAT site

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Outline

- Overview of current methods
- Student projects:
 - RFI monitor for MeerKAT (C. Schollar)
 - **RFI detection (**P. Hillebrand)
 - Visualisation (G. Nothnagel)
 - RFI classification (D. Czech, K. Wolfaardt)
- Outlook
- MeerKAT update

Overview: RFI Monitoring at the MeerKAT site

- 2 RFI trailers: mobile spectrum and transient measurement system (used for SKA site decision)
- Handheld spectrum analysers
- KAT-7 [Sean Passmoor, SKA-SA]

KAT-7 RFI monitoring

- Horizon scan ~twice a week
- Use cross-correlated products
- Automated RFI detection

KAT-7 RFI monitoring



(S. Passmoor)

Overview: RFI Monitoring at the MeerKAT site

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- Handheld spectrum analysers
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=> only sporadic, no continuous record

RFI Monitor Prototype

Collaboration between SKA SA (J. Manly), Stellenbosch Engineering (H. Reader et al), plus UCT (C. Schollar MSc. project), resulted in an RFI monitoring system being set up at the MeerKAT site...

Aims:

- Set up an RFI monitor
- RFI detection & info dissemination
- Data archiving



RFI Monitor Prototype - Hardware

RATTY (ReAl Time Transient analYser)

- ROACH based spectrometer
- Data collection scripts (in Python)
- Tuneable accumulation time from $18.2\mu s$ to 21 hrs
- Dell PowerEdge server
- Rohde & Schwarz HL033 Antenna
 - Directional
 - 50MHz to 2 GHz



_ ROACH board and DELL server¹that perform processing.

(C. Schollar)

RFI Monitor Prototype - System Design

- Use RATTY to gather spectra
 - From 50MHz to 850MHz currently
 - Using 1 second accumulation
- Calculate hourly statistics and archive



(C. Schollar)

RFI Monitor Prototype - Event Detection

- Use Median Absolute Distance algorithm
- Threshold of 6-sigma from the median
- Creates an RFI mask
- Extract RFI events and archive



Visualisations - 1-second Spectrum



(C. Schollar)

Visualisation - RFI Mask



Spectra from 10:35:35 to 10:45:34 on 25/11/2013

(C. Schollar)

Extension of the original project: RFI detection + visualisation (Computer Science Honours project)

Detection & flagging

Development & implementation of various algorithms to automatically detect and flag RFI in monitor data

Pippa Hillebrand

Visualisation

Based on output from detection algorithms, visualise monitor data & highlight RFI

Gerard Nothnagel

RFI Monitor Prototype - **RFI** Detection

- Investigation and adaption of two RFI detection algorithms:
 - SumThreshold algorithm (adapted from LOFAR)
 - $\boldsymbol{\cdot}$ Very time intensive on high-resolution data
 - =>
 - Variable Window algorithm
 - Size of the window = f(stdev in data)

RFI Monitor Prototype - Visualisation

The main visualisation is the waterfall chart, which displays the large dataset

compactly

Waterfall Chart





Occupancy Plot from 02:00:00 to 02:59:24

Open Controls





(G. Nothnagel)

RFI Monitor Prototype - Visualisation

Lowering the threshold results in more RFI detected and updates occupancy plot:



(G. Nothnagel)

RFI Monitor Prototype - Next Generation

- RTA3 (RealTime Analyser)
 - ROACH2
 - 4 bands:
 - 0 0.9 GHz
 - 0.6 1.2 GHz
 - 0.86 1.7 GHz
 - 1.8 2.7 GHz
 - 2s integration
 - Same antenna
 - Same RFI detection and visualisation

RFI Monitor Prototype - Next Generation



(C. Schollar)

RFI Monitor Prototype - Next Generation



dBm

(C. Schollar)

RFI Classification

- Daniel Czech (UCT) & Kolijn Wolfaardt (U Stellenbosch)
- Observing campaign:
 - RTA3
 - measure RFI from various objects on site

RFI Classification - Measurements

Typical duration of the measurement: 1ns - 1µs



(D. Czech)

RFI Classification

- Daniel Czech (UCT) & Kolijn Wolfaardt (U Stellenbosch)
- Observing campaign:
 - RTA3
 - measure RFI from various objects on site
- Methods:
 - Principal components analysis to find clustering information
 - K-nearest neighbour classifier
 - Gaussian Mixture Model classifier

RFI Classification - PCA



(D. Czech)

RFI Classification - PCA



Bhattacharyya Distance

White: indistinguishable Dark: well separated components

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RFI Classification

- Feature extraction technique (still in development):
 - Bin time domain data
 - FFT
 - Normalise
 - Select bin with largest total power
 - => feature vector

RFI Classification - GMM Classifier



(K. Wolfaardt)

RFI Classification - Implementation

- Use database of high-resolution RFI IDs
 - Cross-match with observed RFI
- Possible problems for cross-id:
 - Antenna effect
 - Low resolution data
 - Faint data
 - Confused signals
- Advantage: quickly find 'new' RFI

- Use omni-directional antenna
 - If we get 3 we can triangulate the location of RFI events
- Make monitoring website available to community
- Include other RFI detection as modules
- Make KAT-7 monitoring website available (another UCT student project)
- Next step: RFI subtraction...
- Full RFI monitor (better antenna; direction finding) will come for SKA, possibly earlier

Summary

- Permanent RFI monitor prototype (available)
 - Simple antenna, to be upgraded to omni-directional (and multiple antennae)
 - Coverage of lower MeerKAT bands (<2.7 GHz)
- Website with monitoring data (soon)
 - interactive
 - Visualisation of spectra
 - Modular RFI detection
- RFI detection/masking (available)
- RFI classification and identification (under investigation)
- RFI subtraction (future)

MeerKAT



MeerKAT



- A1 & A2 installed
- A3 & A4: end of the month
- A1:
 - receiver,
 - testing ~80% done
- A2:
 - receiver and fibres end of month
- Array 1 release: 2016

MeerKAT

