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Controls to Manage RFI in a Radio Astronomy Environment

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Presentation Overview

Controls to Manage Radio Frequency Interference in a Radio Astronomy Environment



Introduction

RFI & EMI

RFI Characterisation

Measurements Propagation Modelling

RFI Controls

RFI Permits, CoCs & NCR

RFI Management Tools

RFI Dashboards & Measurement Reports Database





I. Haywood, F. Camilo et. al., Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, Nature, Vol. 573, pp. 235-237, 11 Sept. 2019

MeerKAT, MK+ and Square Kilometre Array

SKA

The SKA is set to be the world's largest and most sensitive radio telescope ever built [1]

AGA Area The SKA1-Mid located in Astronomy Geographic Advantage Area [3]



SKA Phase 1

SKA Phase 1 Mid Frequency Array will consist of approximately 200 dishes deployed at various spiral arm location in the core, incorporating the 64-dish MeerKAT precursor [2]

MK+

MeerKAT Extension (MPIfR) will consist of additional 20 telescopes based on SKA1 design



[1] Square Kilometre Array Organisation, [Online] <u>www.skatelescope.org</u>. Last visited Nov. 2019.

[2] *South African Radio Astronomy Observatory*, [Online], <u>www.ska.ac.za</u>. Last visited Nov. 2019.

[3] Astronomy Geographic Advantage Act, 2007, No. 21 of 2007, Government Gazette, Vol. 516, No. 31157, Cape Town, Republic of South Africa, 17 June 2008.



What is meant with "Core" and "Spiral Arms"?





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What is meant with "Core" and "Spiral Arms"?



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What is meant with "Core" and "Spiral Arms"?







What is meant with "Core" and "Spiral Arms"?







MeerKAT & HERA Receivers

- MeerKAT Telescope is a precursor for the SKA Mid Telescope
- Integrated into the mid frequency component of SKA Phase 1

MeerKAT Receivers:

- UHF Band :: 580 to 1015 MHz
- L-Band :: 900 to 1670 MHz
- S-Band :: 1750 to 3500 MHz



Guest Instruments:

Hydrogen Epoch of Reionization Array (HERA)

• VHF-Band :: 50 to 250 MHz





RFI & EMI (Astronomy Geographic Advantage Act – Radio Astronomy Protection Levels)

- AGA Regulations define Radio Astronomy Protection Thresholds
 - Physical Damage Levels (+10 dBm)
 - Saturation Levels (-100 dBm)
 - Continuum (ITU-R RA.769-2) & Spectral Line Protection Levels
 - $RBW_{Cont} = 1\% \cdot f_c \text{ and } RBW_{Spect} = 0.001\% \cdot f_c$
- Intentional transmitters (RFI)
 - Carrier Frequency
 - Vore) 🕅 Protection Levels (Core)
 - 📡 Saturation (Spiral Arms)
- Unintentional Transmitters (EMI)
 - Harmonics
 - General Electromagnetic Emissions
 - Protection Levels (Core + Spiral Arms)

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Presentation Overview

Process to take equipment to site: RFI Permits and Certificate of Compliance

Requirements for SARAO employees or contractors to bring equipment onto site:

• Be in possession of an **RFI Permit** or **Certificate of Compliance (CoC)**

Any person not in possession is required to obtain one from SARAO RFI Team.

Obtaining is done by the following:

- 1. Undertaking **measurements by SARAO RFI**, through appropriate agreement, in calibrated and controlled RFI facility, who will issue the permit **OR**
- 2. Undertaking **measurements by a third party** in a qualified measurement facility, using calibrated measurement equipment *in accordance with SARAO RFI Measurement Requirements, Procedures and Methodologies.* Such measurement reports shall be submitted to SARAO for consideration and issuing of relevant Permit or Certificate of Compliance. If not satisfactory (1) would be required to obtain Permit or CoC.



RFI / EMI CHARACTERISATION

I. Haywood, F. Camilo et. al., Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, Nature, Vol. 573, pp. 235-237, 11 Sept. 2019

RFI / EMI Characterisation

How do we qualify equipment that is required on site in the core?



RFI / EMI Characterisation

RFI Measurements [Reverberation or Anechoic Chambers, or In situ]



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RFI / EMI Characterisation

Propagation Modeling [Predictions and Measurements]





RFI CONTROLS

I. Haywood, F. Camilo et. al., Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, Nature, Vol. 573, pp. 235-237, 11 Sept. 2019

RFI Dashboard – RFI Monitoring Stations [Live View, Statistical Data Playback, RFI FoM]





RFI Dashboard – Permits, CoC & NCR Dashboard; **RFI** Reports Database; Detections Dashboards

Radio Frequency Interference Management Tools



SARAO RFI Controls Dashboard [Restricted User]



SARAO RFI Report Database [Restricted User]



SARAO RFI Detections Dashboard





Statistical Data Playback – Cellphone Uplink Detection







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"Controllable" Signal Detection (GSM Uplink/WiFi/Bluetooth)



Daily Automated RFI Reports





CONCLUSIONS

I. Haywood, F. Camilo et. al., Inflation of 430-parsec bipolar radio bubbles in the Galactic Centre by an energetic event, Nature, Vol. 573, pp. 235-237, 11 Sept. 2019

Conclusions

- The successful management of the protected radio quiet zone will be crucial to the success of the SKA project
- To take equipment to site: RFI Permit or CoC is required from SARAO RFI
- RFI Impact Assessment:
 - Measurements (reverberation chamber)
 - Calculate path loss available (ITU-R P.1546-4)
 - Calculate loss **required** to adhere to Telescope Protection Levels
 - Consider additional shielding (if required)
- RFI Controls & Management Tools to manage RFI culprits:
 - RFI Monitoring Stations
 - Live Views
 - Statistical Data Playback
 - Figure of Merit
 - RFI Permits, CoCs and NCRs (Automated notifications)
 - Detections Dashboards
 - Automated Daily RFI Reporting



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The South African Radio Astronomy Observatory (SARAO) is a National Facility managed by the National Research Foundation and incorporates all national radio astronomy telescopes and programmes. SARAO is responsible for implementing the Square Kilometre Array (SKA) in South Africa.

Contact information

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