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Senior Engineer - RFI

Measurement Infrastructure & Instrumentation

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5th IUCAF Spectrum Management Summer School
Stellenbosch, South Africa :: 2 to 6 March 2020



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



SARAO
South African Radio
Astronomy Observatory

Presentation Overview

Measurement Infrastructure and Instrumentation



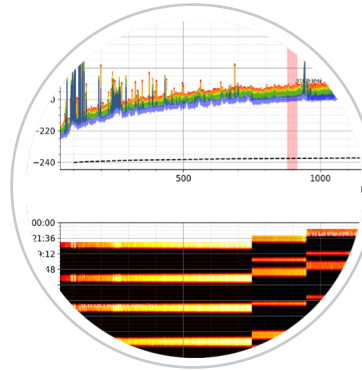
Introduction

Infrastructure
for RFI & EMI
Measurements



RFI Qualification

Reverberation Chambers
Anechoic Chambers



RFI Monitoring

Fixed & Mobile RFI
Monitoring Stations
ComRAD

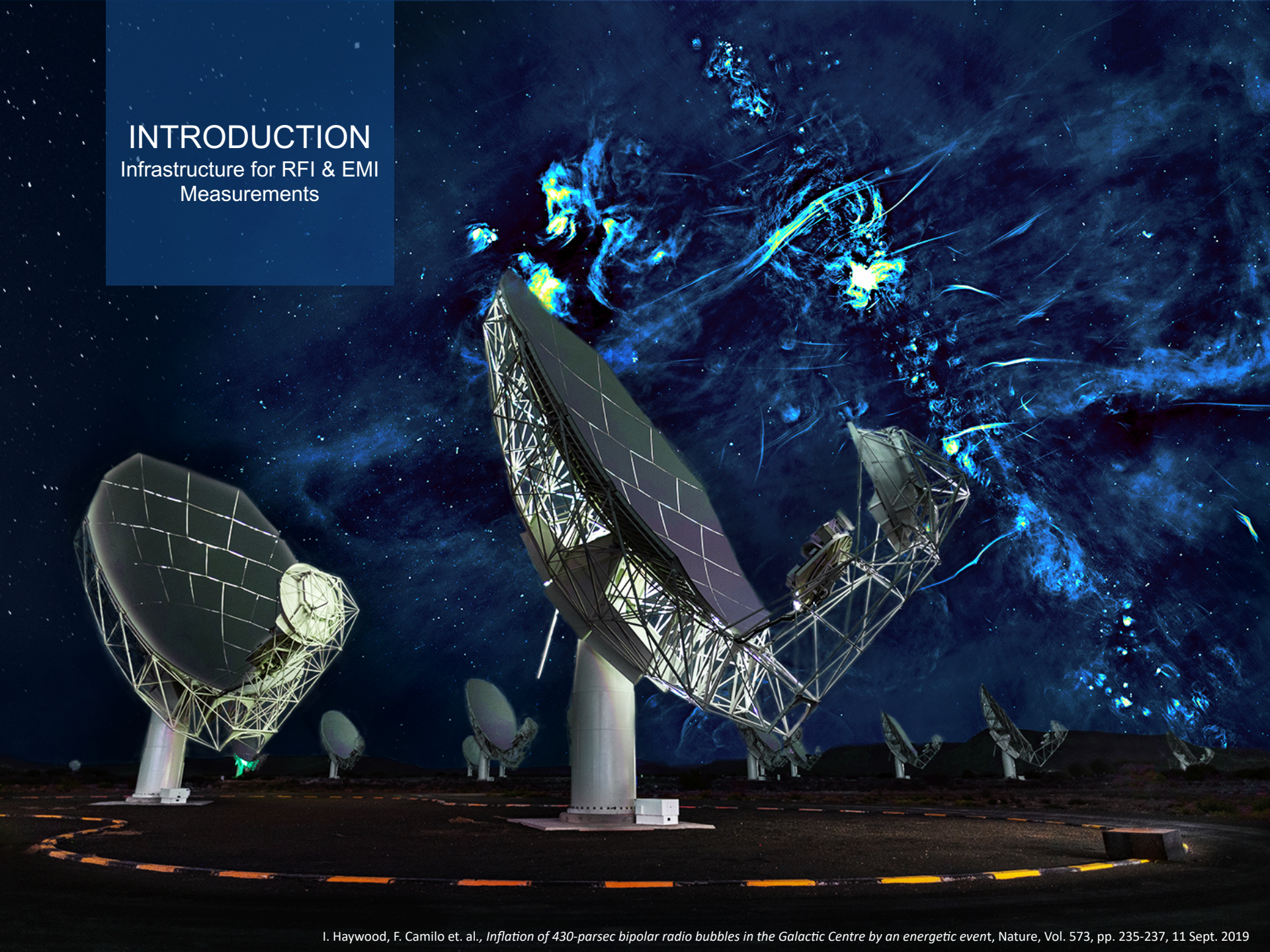


RFI Dashboards

RFI Management Tools &
Database

INTRODUCTION

Infrastructure for RFI & EMI
Measurements



RFI & EMC Measurements

What Infrastructure is Required for SARAO?

1. RFI Qualification

- a. Reverberation or Anechoic Chambers
 - i. Required to measure to Telescope Protection Levels

2. RFI Monitoring

- a. Fixed and Mobile Monitoring Stations
 - i. Statistical data feeds into RFI Database
- b. MeerKAT Telescope
- c. COMRAD
 - a. Passive RADAR Aircraft Tracking

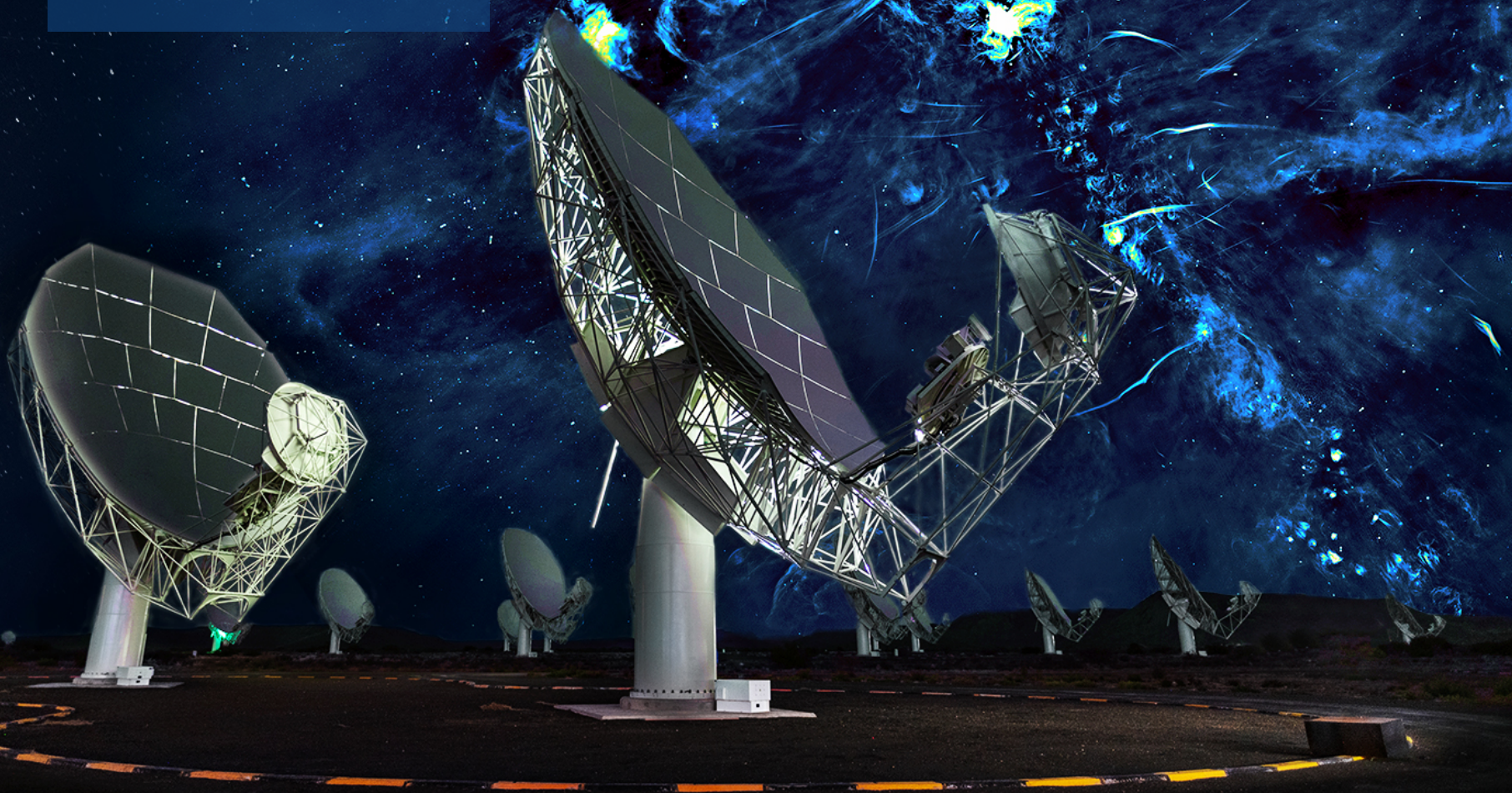
3. RFI Characterisation

- a. RFI Facility or In Situ Measurements
 - i. Data and Reports feed into RFI Database

4. RFI Hunting

- a. Mobile RFI Monitoring Station
- b. Direction Finding
- c. On the Ground Measurements

RFI FACILITIES EMC CHAMBERS



EMC Chambers

Facilities available to SARAO for RFI Qualification

1. EMC Facilities for RFI Qualifications

- a. Reverberation Chambers
 - i. Cape Town (Operational)
 - ii. Site Karoo (end of 2020)
- b. Screened Room (to be upgraded to Reverb Chamber)
 - a. Denel Houwteq
- c. Anechoic Chamber
 - a. Denel Houwteq
- d. Universities:
 - a. Stellenbosch (Reverberation Chamber + Anechoic Chamber)
 - b. CPUT (Reverberation Chamber)

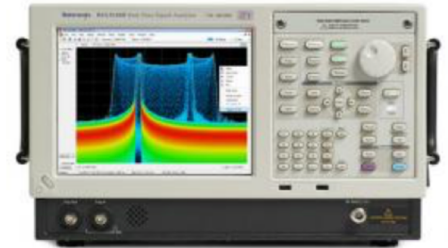
2. RFI Monitoring Stations

- a. Fixed Monitoring Stations
 - a. Core Operational :: ASC, HERA & Losberg
- b. Mobile Monitoring Stations
 - a. RFI Measurement Vehicle

EMC Chambers

SARAO Reverberation Chamber :: Cape Town

Total Emitted Power for DUT
(EIRP)



Tektronix RSA5115B
Real Time Spectrum Analyser
15 GHz; 165 MHz Acq. BW

Measurements in the SARAO Reverberation Chamber in Cape Town, South Africa

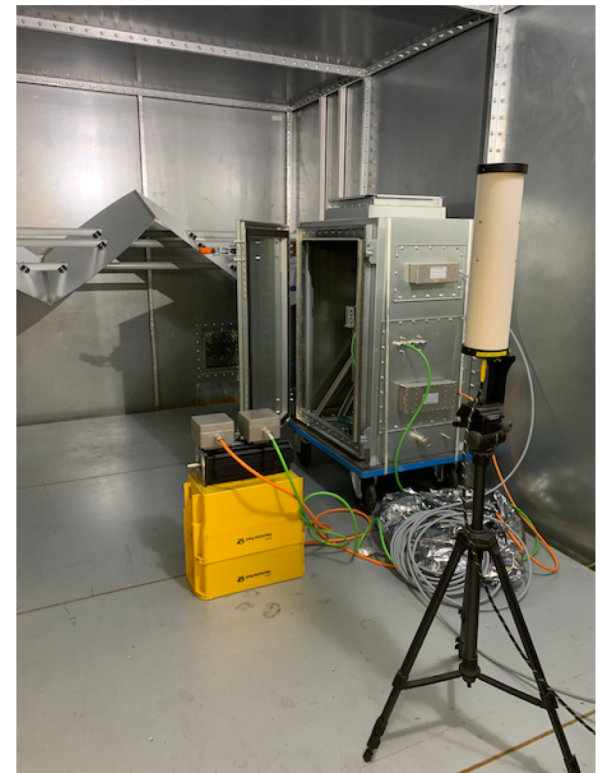
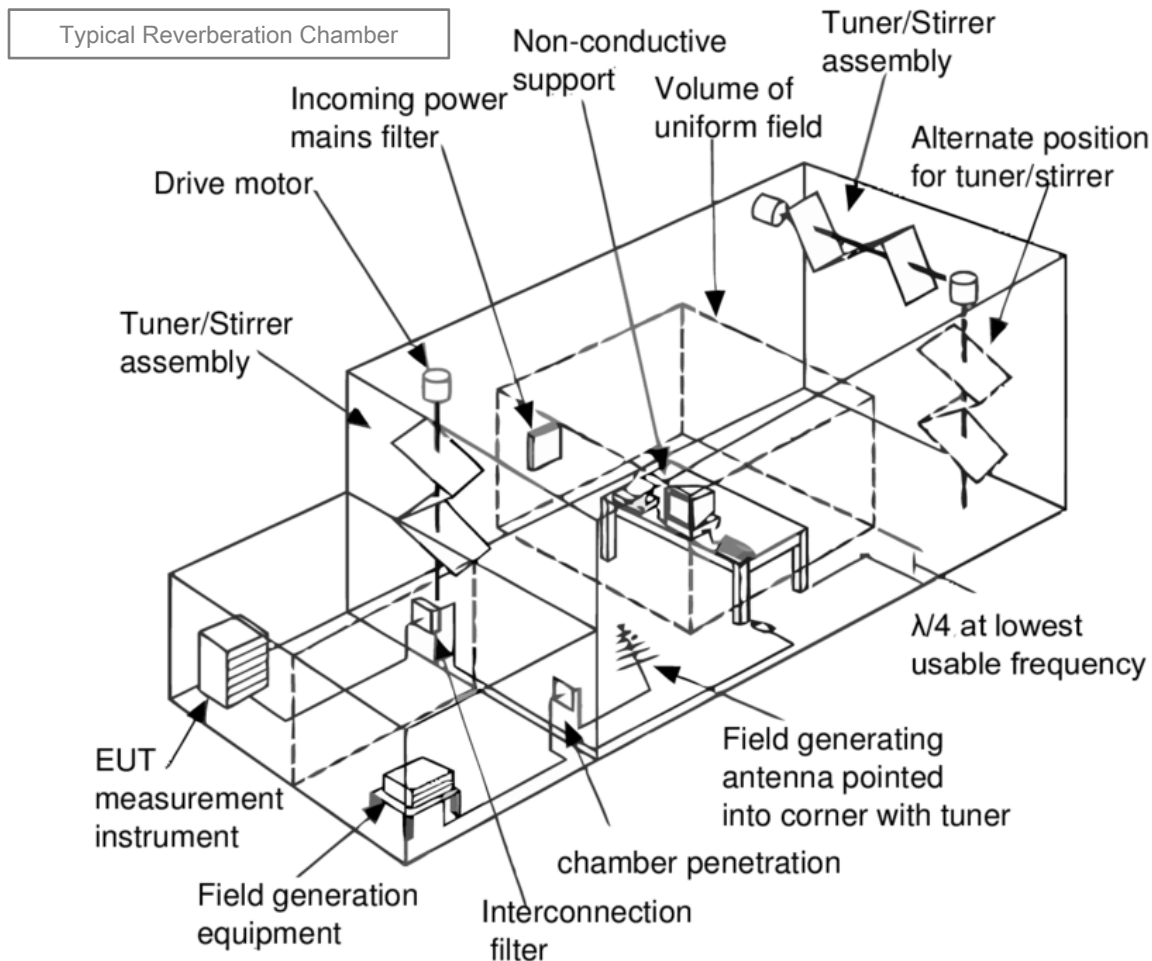


RTA-3.6
Real Time Transient Analyser
20 MHz to 3 GHz, 800 MHz Inst. BW

DUT

EMC Chambers

Reverberation Chamber

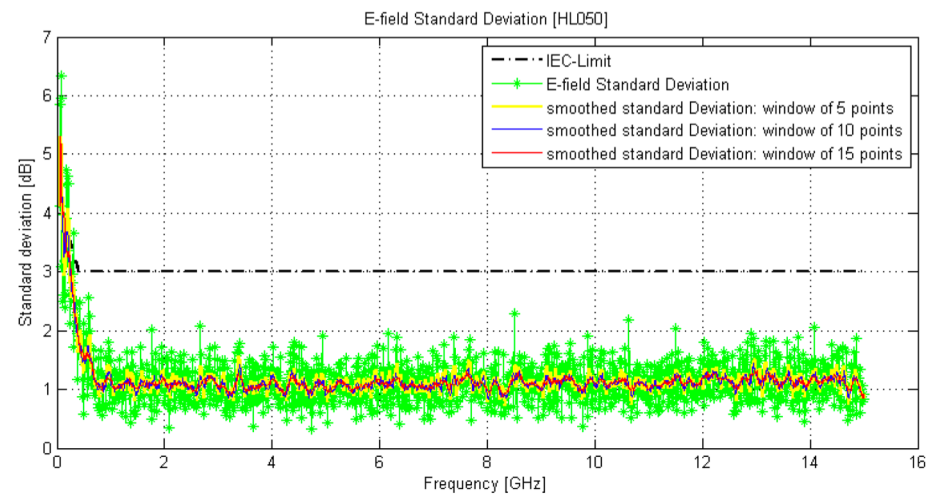
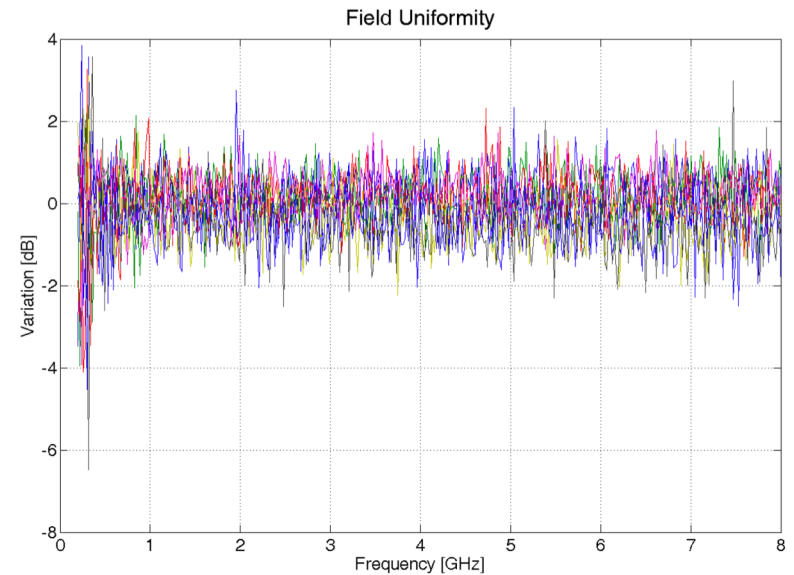
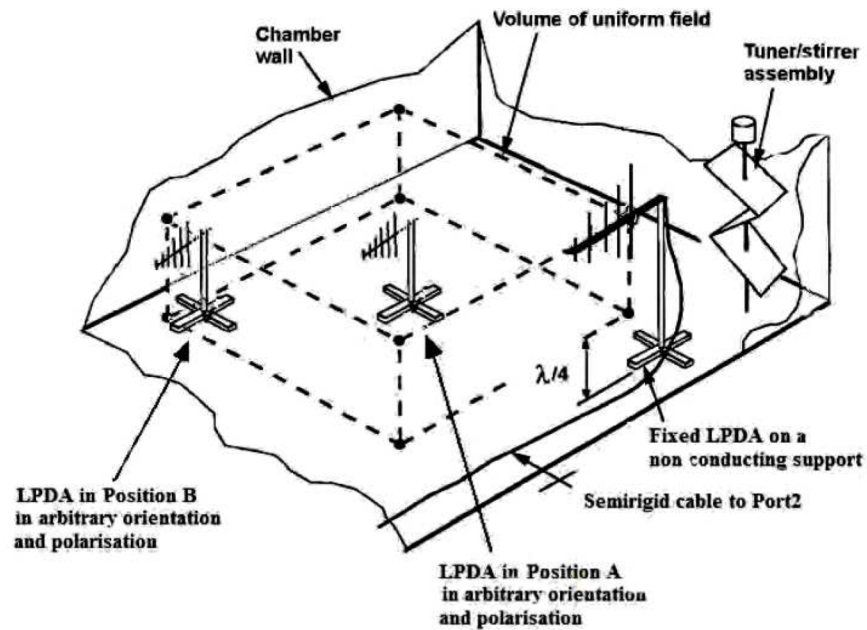


SKA1 DISH RFI Measurements:: MPIfR

EMC Chambers

Reverberation Chamber

Working Volume Calibration :: Field Uniformity



EMC Chambers

Anechoic Chamber



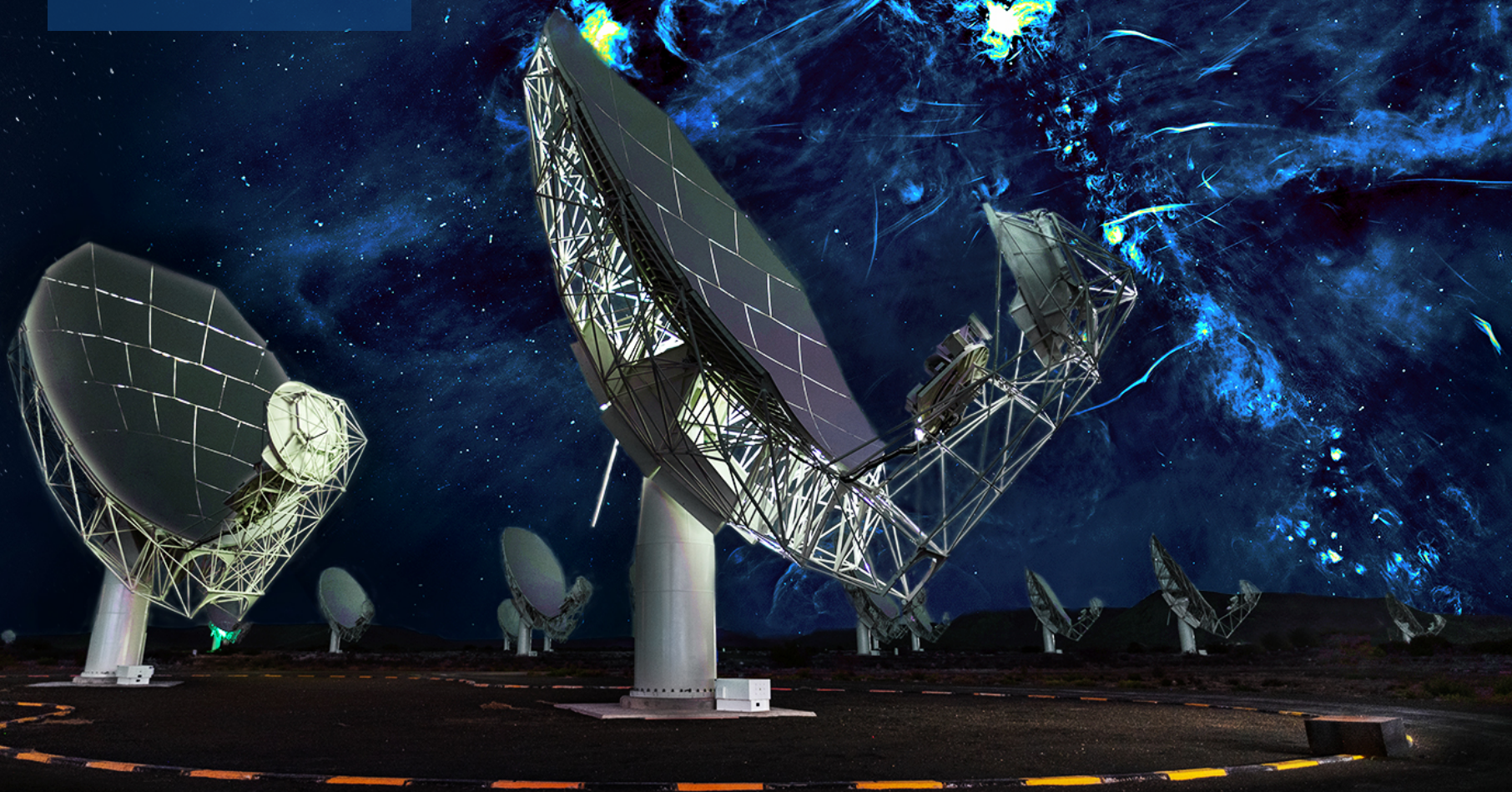
Denel Houwteq :: Anechoic Chamber

EMC Chambers

Reverberation vs. Anechoic Chamber

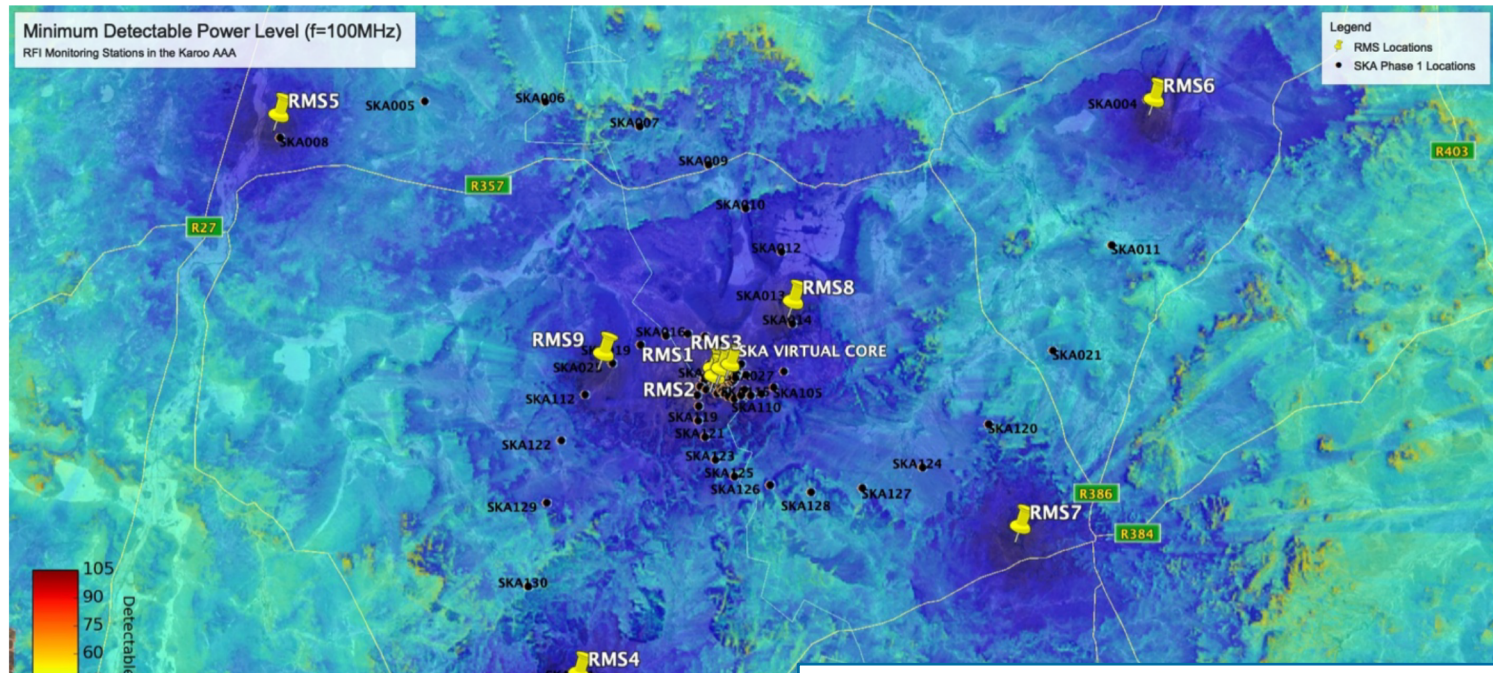
	Reverberation Chamber	Anechoic Chamber
Directivity of Antenna	Independent of antenna gain	Dependent on gain and directivity
DUT Radiation Pattern	Independent of DUT radiation pattern	Have to be in main-beam of DUT radiation pattern
Measurement Distance	Independent of distance	Requires far-field distances
Antenna Polarisation	Independent of antenna polarisation	Vertical and horizontal polarisation
Measurement	Total emitted power level from DUT	E-field
Tests	Radiated Emissions and Susceptibility	Radiated Emissions (requires high power for immunity)
Time	Much quicker tests	Slower (device rotation, antenna polarization etc.)

RFI MONITORING

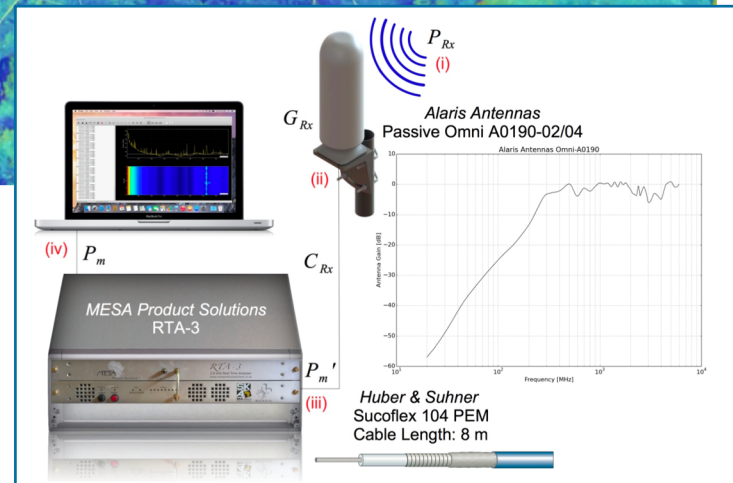


RFI Monitoring

Fixed Monitoring Stations

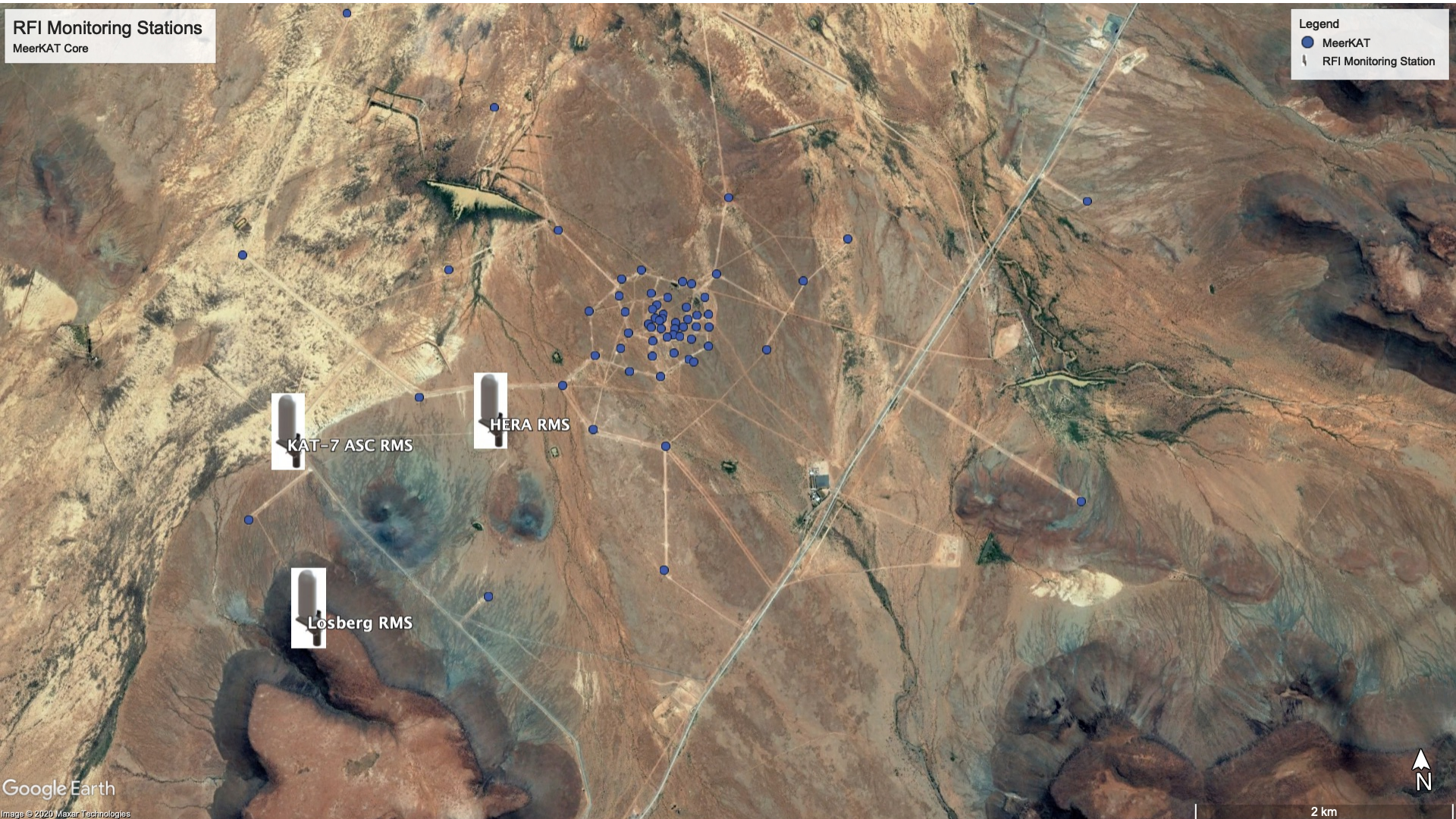


RMS #	Location Description		GPS (Lat, Lon)
RMS 1	ASC Container (KAT-7)	✓	(-30.721823°, 21.411314°)
RMS 2	Losberg Container	✓	(-30.733854°, 21.414010°)
RMS 3	HERA Container	✓	(-30.721821°, 21.426810°)
RMS 4	Williston Spiral	✗	(-31.205889°, 21.161461°)
RMS 5	Brandvele Spiral	✗	(-30.313822°, 20.608208°)
RMS 6	Copperton Spiral	✗	(-30.290278°, 22.224224°)
RMS 7	C-BASS Site	✗	(-30.971244°, 21.980129°)
RMS 8	COMRAD Station #1	✓	(-30.615004°, 21.558941°)
RMS 9	COMRAD Station #2	✓	(-30.697813°, 21.208559°)



RFI Monitoring

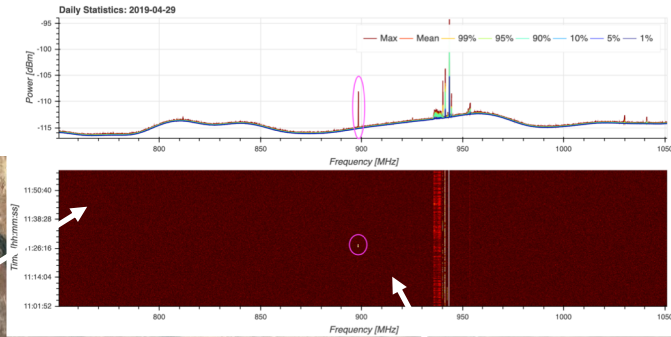
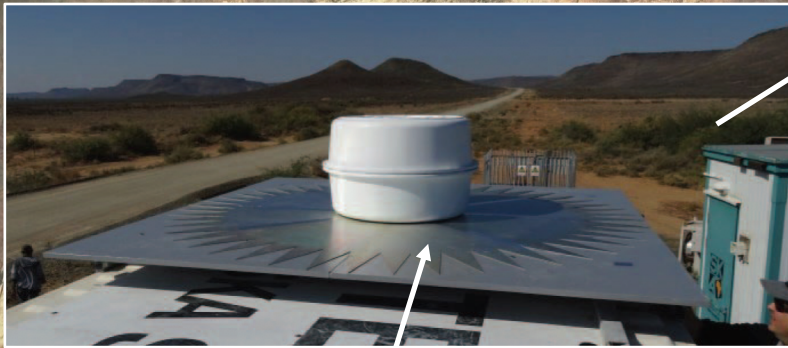
Fixed Monitoring Stations



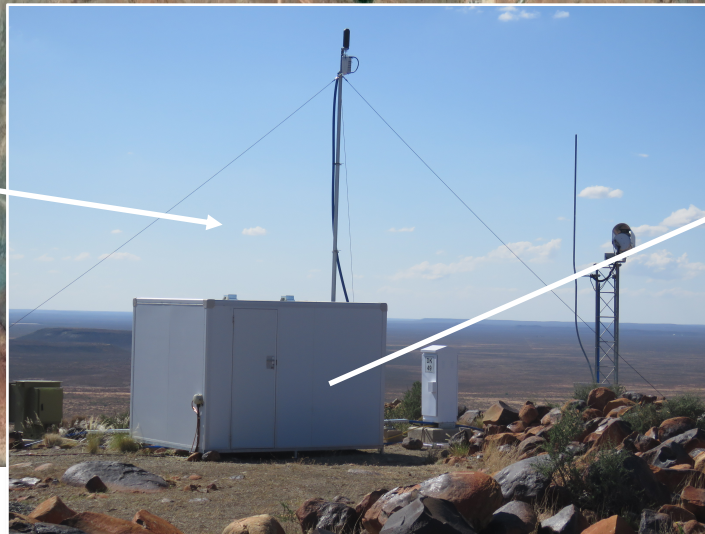
RFI Monitoring

Fixed Monitoring Stations

RFI Monitoring Stations
MeerKAT Core



Legend
● MeerKAT
RFI Monitoring Station



Google Earth

Image © 2020 Maxar Technologies

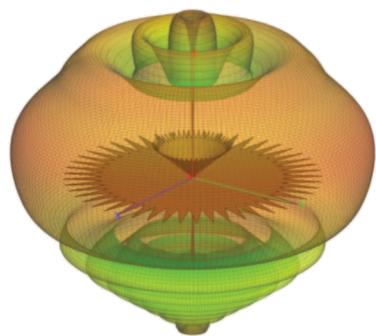
2 km

RFI Monitoring

Fixed Monitoring Stations



RTA-3.6 Real Time Analyser



Serrated edges min. reflections

RTA-3.6 Real Time Analyser

Input Impedance	50 Ω
Instantaneous Dynamic Range	90 dB
SFDR	50 dB
Freq Range	20 MHz to 2.5 GHz [Band 1: 20 to 800 MHz] [Band 2: 750 to 1050 MHz] [Band 3: 900 to 1650 MHz] [Band 4: 1550 to 2000 MHz] [Band 5: 1950 to 2550 MHz]
Instantaneous BW	800 MHz
Min. Noise Floor	-125 dBm
DANL (1 GHz)	-171 dBm
File Format	HDF5
Acq Time	70 μ s to 86 min
ADC Resolution	10 bit
TD Transients	16 μ s (32768 samples or resolution 0.5 ns)



Omni-directional Antenna



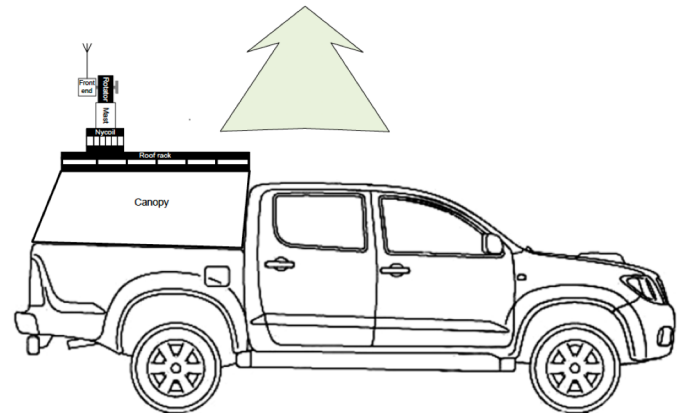
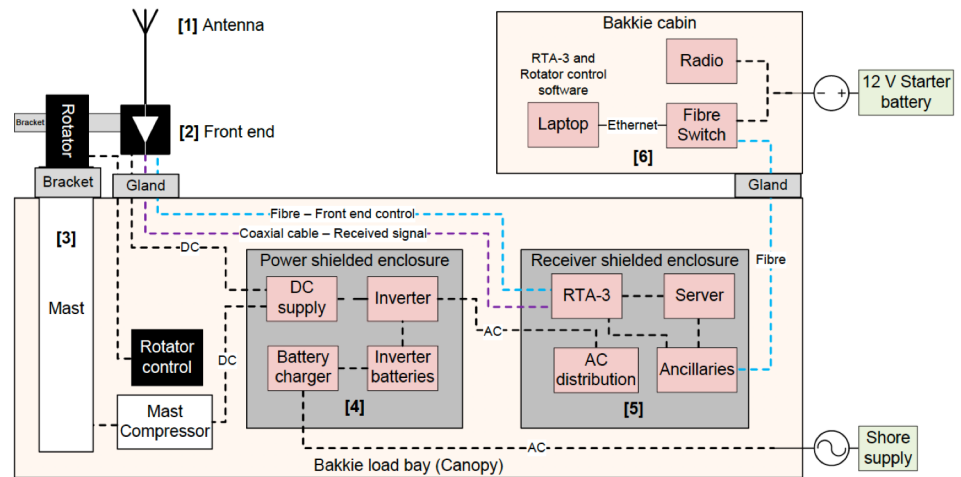
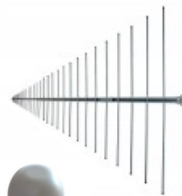
Discone Antenna



Hyperband Conical Antenna ("PROTEA")

RFI Monitoring

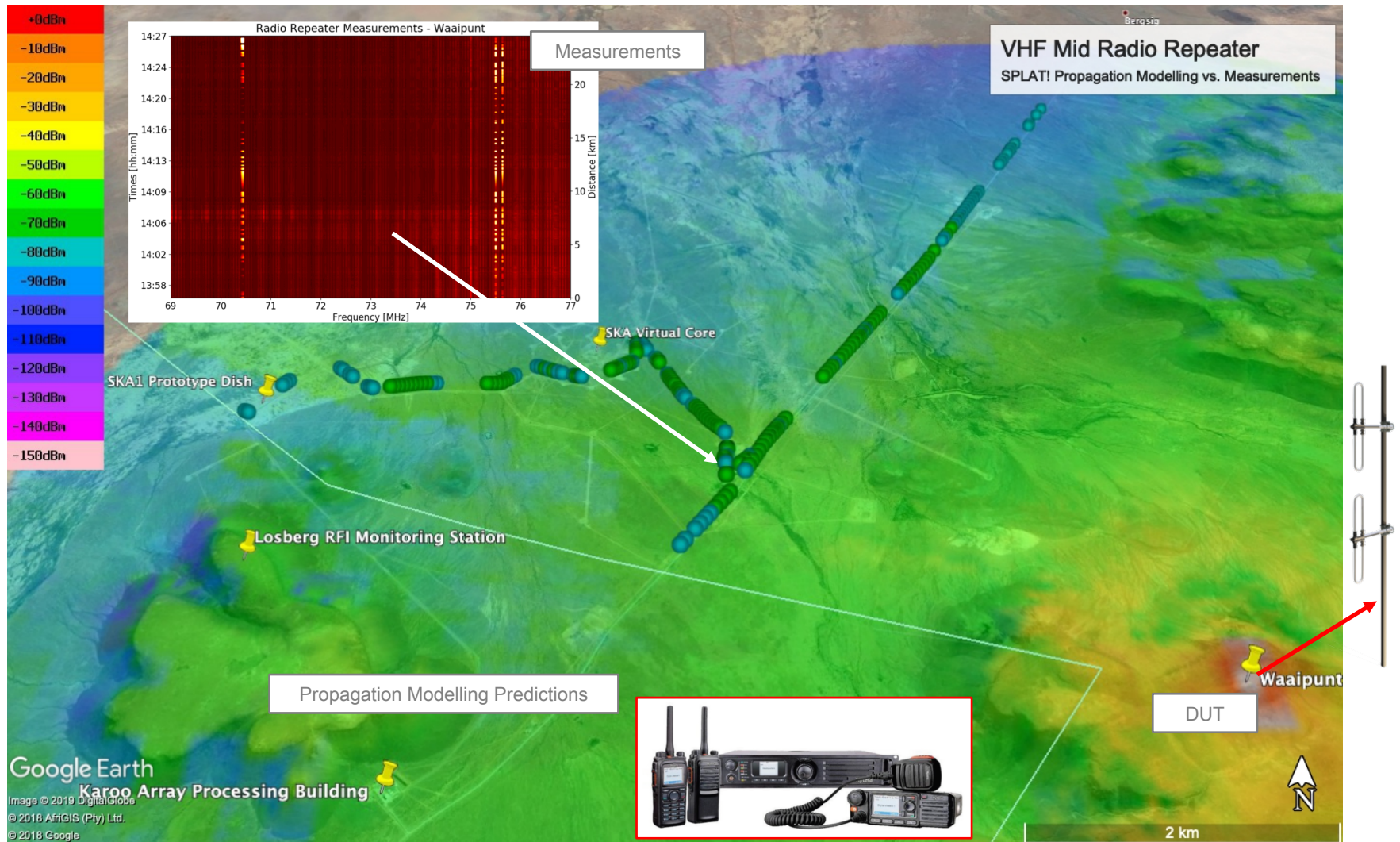
Mobile Monitoring Stations (coming very soon)



Final work on shielded enclosure for instruments, power and cooling system

RFI / EMI Characterisation

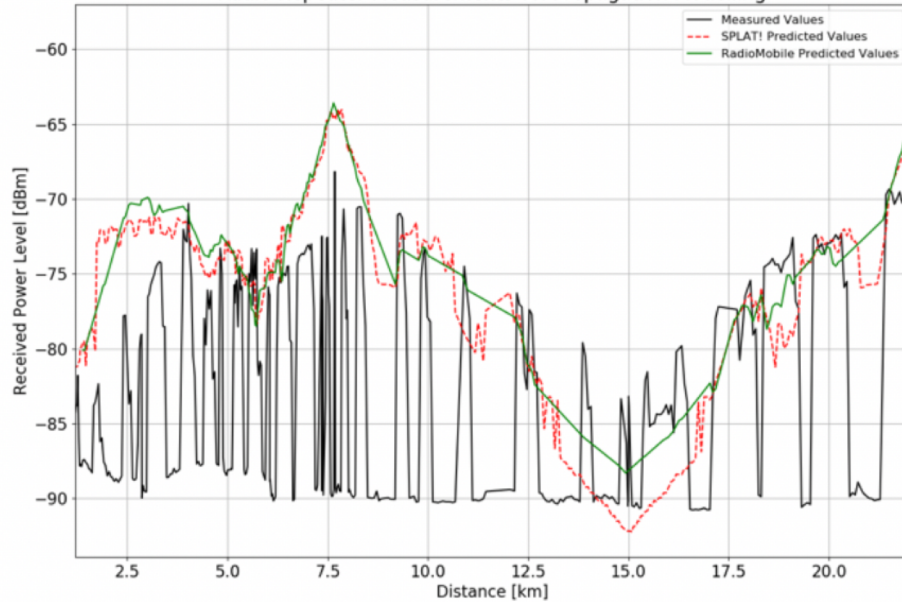
Propagation Modeling [Predictions and Measurements]



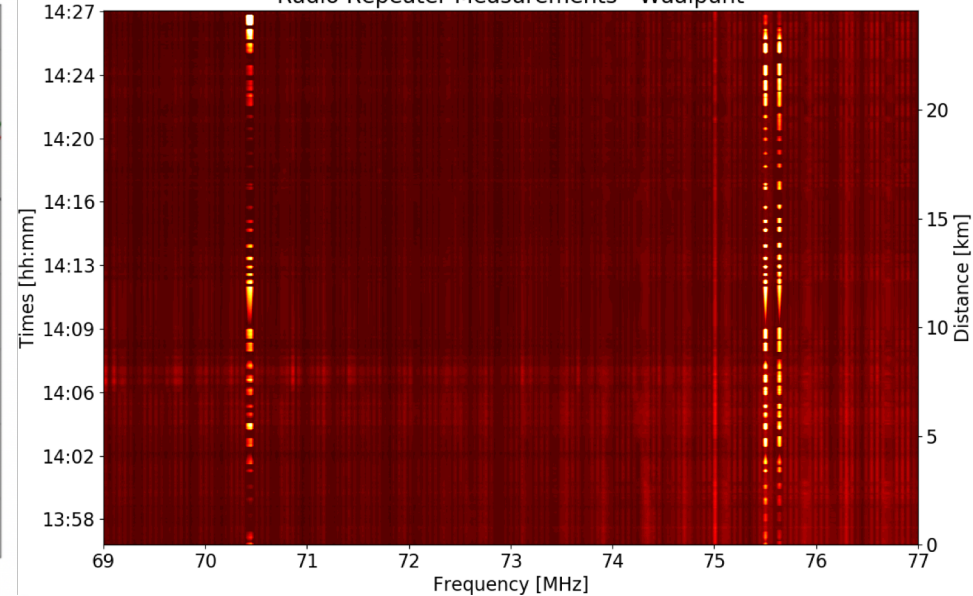
RFI / EMI Characterisation

Propagation Modeling [Predictions and Measurements]

Radio Repeater Measurements vs. Propagation Modelling

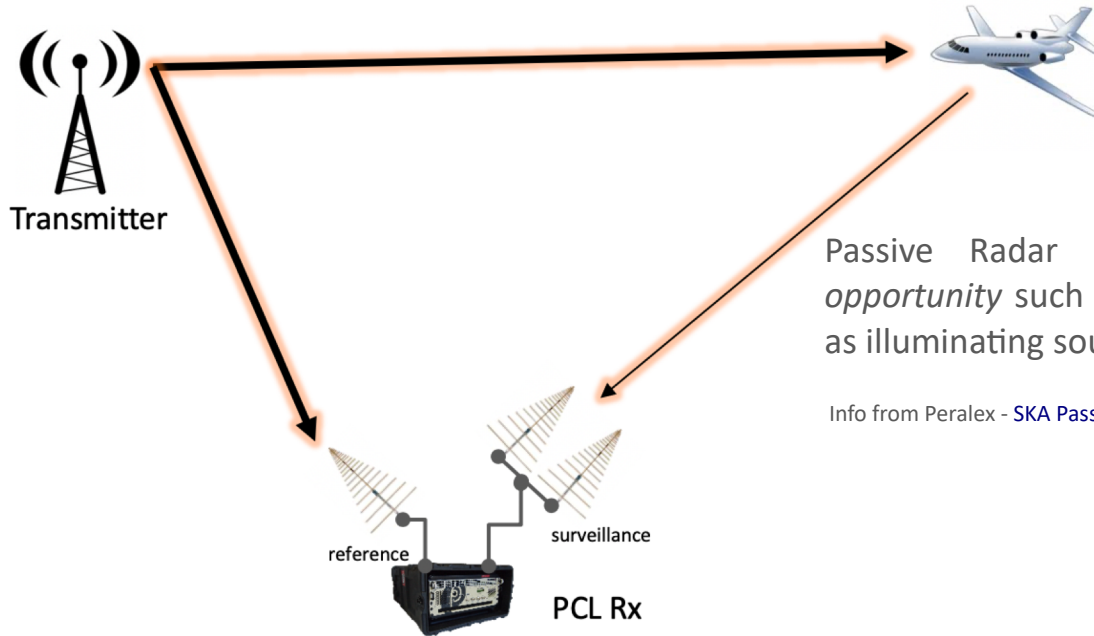


Radio Repeater Measurements - Waaipunt



ComRAD

Commensal RADAR



Passive Radar (PR) exploits existing *transmitters of opportunity* such as commercial FM or DVB-T2 transmitters as illuminating sources for detecting and tracking aircraft.

Info from Peralex - [SKA Passive Radar Deployment](#) – Progress Update April 2019

Passive Radar and the SKA

- Radio quiet zones are a unique application for PR
- The Square Kilometre Array (SKA) Radio Telescope is a key example
- Radio reserves require air surveillance
 - Commercial and agricultural aircraft radios are a source of RF interference (RFI)
 - Active radar is not suitable as it introduces additional RFI

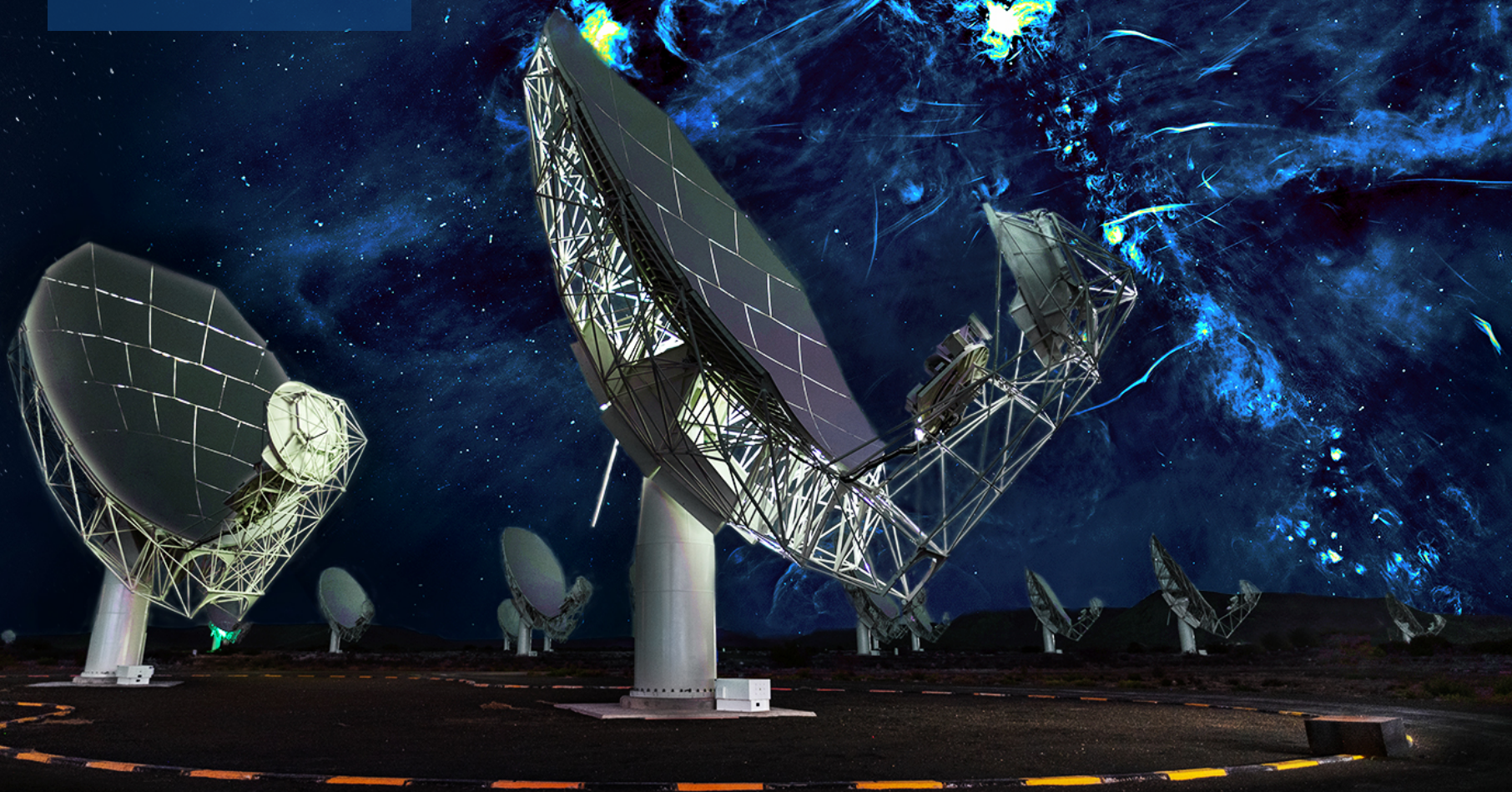
ComRAD

Commensal RADAR



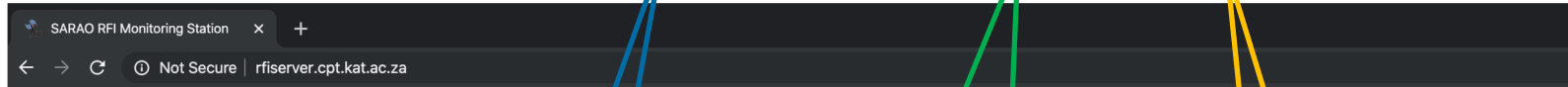
Info from Peralex - [SKA Passive Radar Deployment](#) – Progress Update April 2019

RFI MANAGEMENT TOOLS

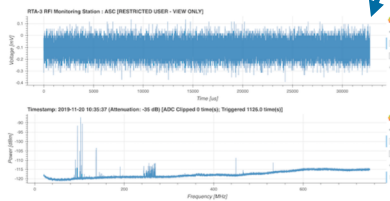


RFI Management Tools

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

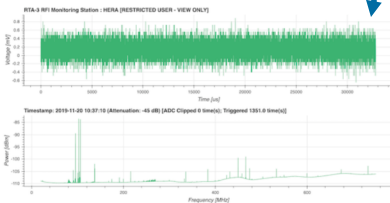


Radio Frequency Interference Monitoring - ASC

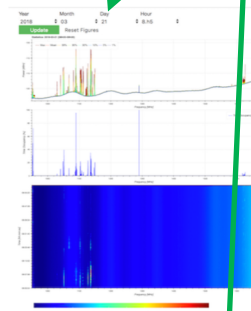


[Live View \[Restricted User\]](#)

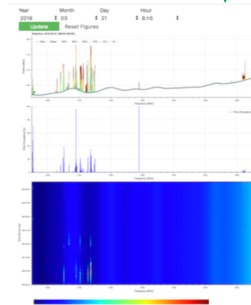
Radio Frequency Interference Monitoring - HERA



[Live View \[Restricted User\]](#)



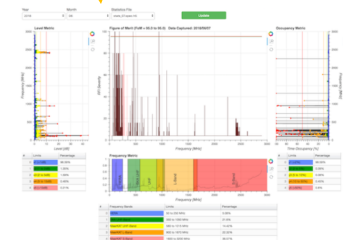
[Statistical Data Playback](#)



[Statistical Data Playback](#)



[RFI Figure of Merit \(FoM\)](#)



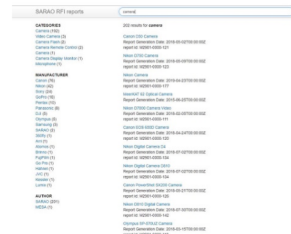
[RFI Figure of Merit \(FoM\)](#)

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](#)

RFI Management Tools

RFI Database

SARAO RFI reports

camera

01/01/2008 to 02/03/2020

FILTERS

219 results for **camera**

CATEGORIES

- Camera (202)
- Optical Pointing Camera System (7)
- Video Camera (3)
- Camera Flash (2)
- Camera Remote Control (2)
- Camera (1)
- Camera Display Monitor (1)
- Microphone (1)

MANUFACTURER

- Canon (81)
- Nikon (44)
- Sony (27)
- GoPro (11)
- Pentax (10)
- Panasonic (8)
- DJI (5)
- Olympus (5)
- EO (4)
- Samsung (3)
- SARAO (2)
- 360fly (1)
- Arri (1)
- Atomos (1)
- BFR Digital (1)
- Brinno (1)
- EasyCAP (1)
- FujiFilm (1)
- Go Pro (1)
- Hahnel (1)

AUTHOR

Digital Camera
Report Generation Date: 2019-04-18T00:00:00Z
report id: M2901-0000-176

Digital Camera
Report Generation Date: 2019-03-20T00:00:00Z
report id: M2901-0000-168

EO Optical Pointing Camera
Report Generation Date: 2019-09-18T00:00:00Z
report id: SSA-0008J-027

Canon D50 Camera
Report Generation Date: 2018-05-02T00:00:00Z
report id: M2901-0000-121

Nikon D750 Camera
Report Generation Date: 2018-05-09T00:00:00Z
report id: M2901-0000-123

Nikon Camera
Report Generation Date: 2019-04-23T00:00:00Z
report id: M2901-0000-177

Nikon Digital Camera
Report Generation Date: 2019-02-18T00:00:00Z
report id: M2901-0000-163

Digital Camera
Report Generation Date: 2020-01-06T00:00:00Z
report id: SSA-0008J-052

MeerKAT 62 Optical Camera
Report Generation Date: 2015-06-25T00:00:00Z

Nikon D7000 Camera Video
Report Generation Date: 2018-02-05T00:00:00Z

Radio Frequency Interference Report

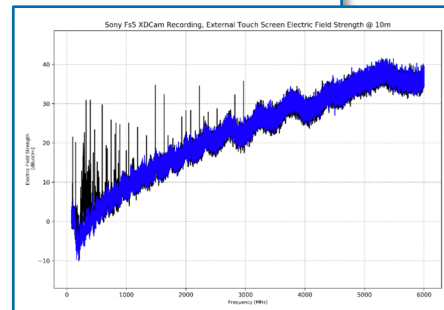
NRF National Research Foundation

SARAO South African Radio Astronomy Observatory

Client : Eaton De Jongh
Email : eaton.dejongh@gmail.com
Project : SKA
Type : RFI PERMIT

RFI MEASUREMENTS: Sony a6500, Sony a7S Mark II, Sony FS5 XDCam 4K

Document Number.....M2901-0000-176
Revision.....01
Classification.....Commercial in Confidence
Author.....Jason Fynn
Date.....26/04/2019



SKA South African Radio Astronomy Observatory

SARAO RFI Notice Type A

RFI Permit No RFI1807-0030-001

Date Issued 2019/03/26

Valid Until 2019/09/30

Part 1: Description of RFI Source / Culprit

1.1. Short description of equipment	Auxiliary equipment used during construction.
1.2. Equipment make / brand name and Model	See Table 1 in Report M2901-0000-167
1.3. What will the equipment be used for?	Construction of SKA1 DISH Prototype
1.4. Will the equipment be Permanent or Temporary?	Temporary
1.5. Date deployed to site	2019/03/01
1.6. Date to be removed from site (if applicable)	2019/09/30
1.7. Contact1 Name and Organisation	Henk Niehaus SKAO
1.8. Contact1 email	henk@ska.ac.za
1.9. Contact2 Name and Organisation	Thomas Kusel SARAO
1.10. Contact2 email	tkusel@ska.ac.za

Part 2: RFI Test

2.1 RFI Test - Test Facility	On Site Measurement (Losberg)
2.2 RFI Test date	2018/07/01
2.3 RFI Test report reference	M2901-0000-167

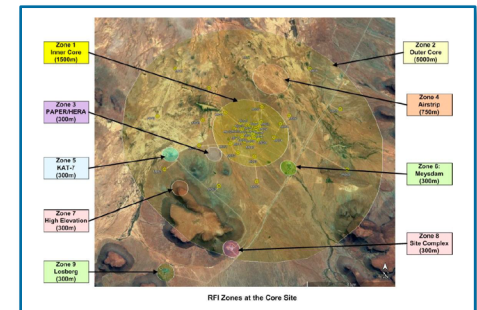
Part 3: Restrictions on Location and Use

3.1 This equipment may be used within the following zones, subject to other restrictions listed below

No	Zone 0: Within 20m from Antenna	No	Zone 1: Inner Core (1500m)
Yes	Zone 2: Outer Core (5000m)	No	Zone 3: PAPER/HERA (300m)
N/A	Zone 4: Airstrip (750m)	No	Zone 5: KAT-7 (300m)
N/A	Zone 6: Meydum (300m)	N/A	Zone 7: High Elevation Site (300m)
N/A	Zone 8: Site Complex (300m)	N/A	Zone 9: Losberg (300m)
N/A	Zone 15: Surrounding Farms	N/A	Zone 16: Klerfontein

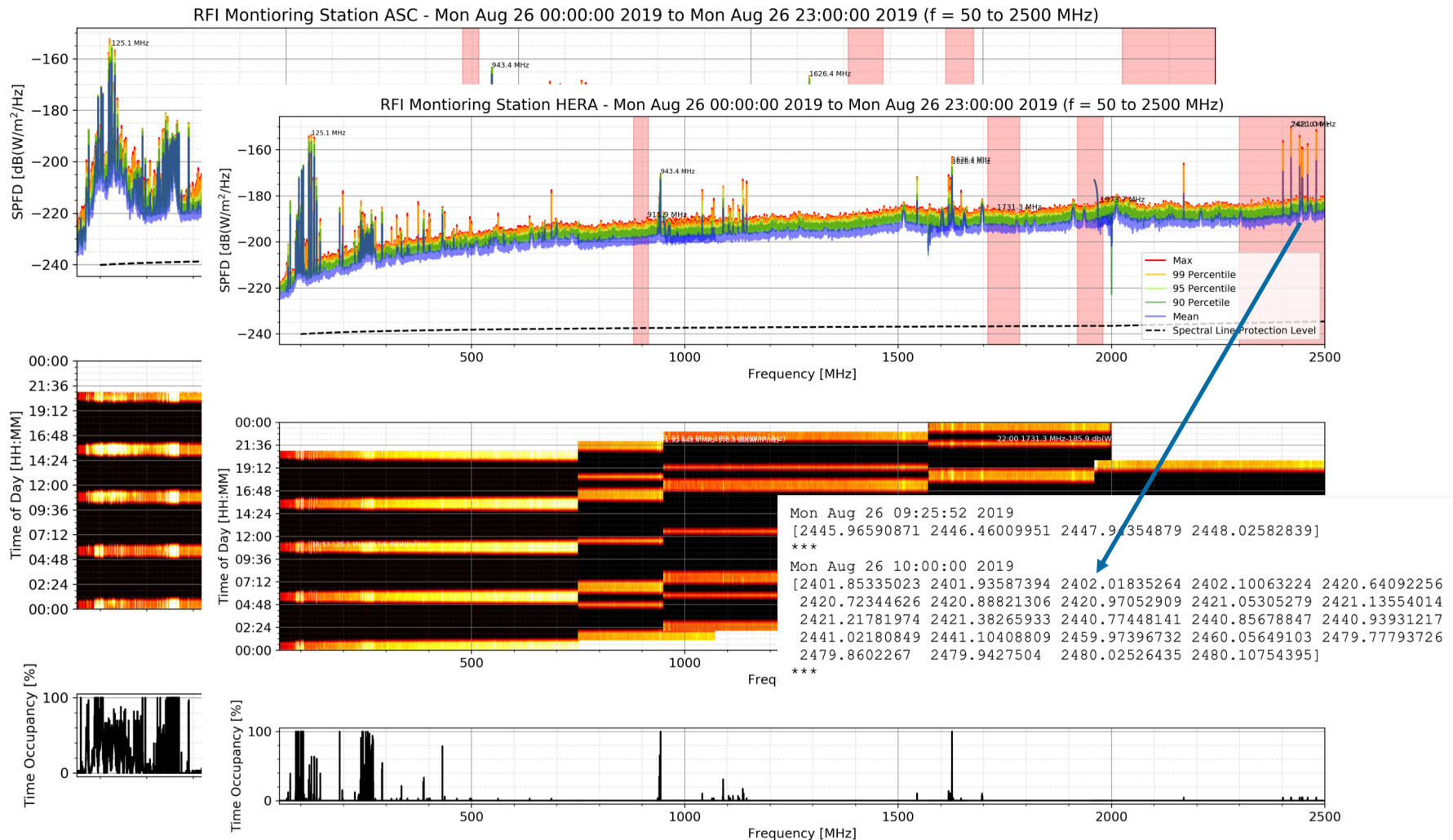
3.2. Restrictions on Day / Night use As set out in Section 3.5 of this permit

3.3 Do Not use after (time) Sec. 3.5 3.4 Do Not use before (time) Sec. 3.5

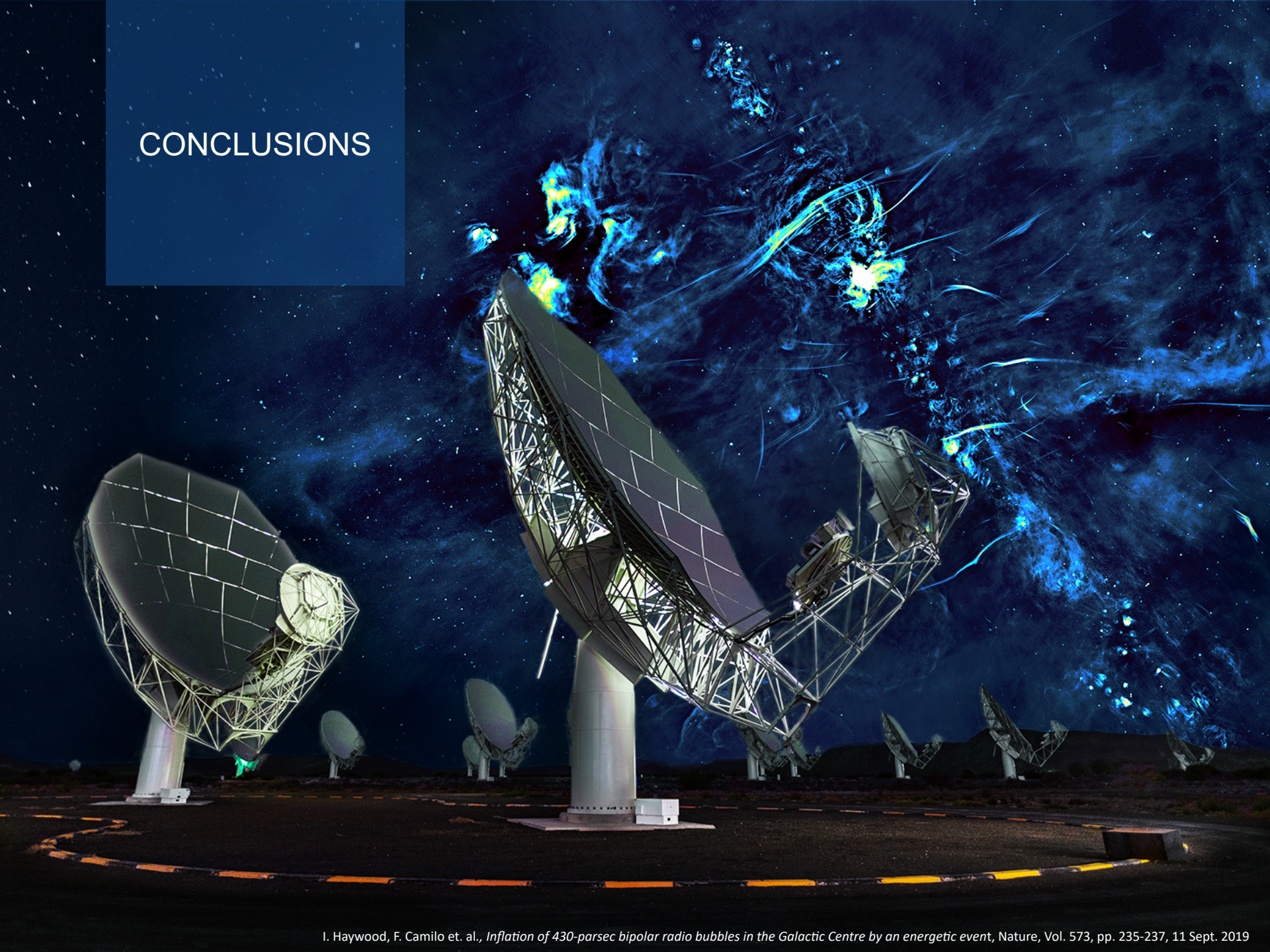


RFI Management Tools

Daily Automated RFI Reports



CONCLUSIONS



Conclusions

- Various instrumentation & infrastructure:
 1. RFI Qualification
 - i. Reverberation Chambers
 - ii. Anechoic Chambers
 - iii. Screened Rooms
 2. RFI Monitoring
 - i. Fixed Monitoring Stations
 - ii. Mobile Monitoring Stations
 3. RFI Management
 - i. Management of CoC's and RFI Permits
 - ii. Statistical Data
 - iii. RFI Database
 - iv. RFI Detection



science
& technology

Department:
Science and Technology
REPUBLIC OF SOUTH AFRICA



National
Research
Foundation



www.ska.ac.za

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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