

SKA Low Frequency Aperture Array

Eloy de Lera Acedo (University of Cambridge)
on behalf of the

AADC: Aperture Array Design & Construction Consortium
Consortium leader: Jan Geralt bij de Vaate (ASTRON)
Project engineer: Andrew J. Faulkner (University of Cambridge)



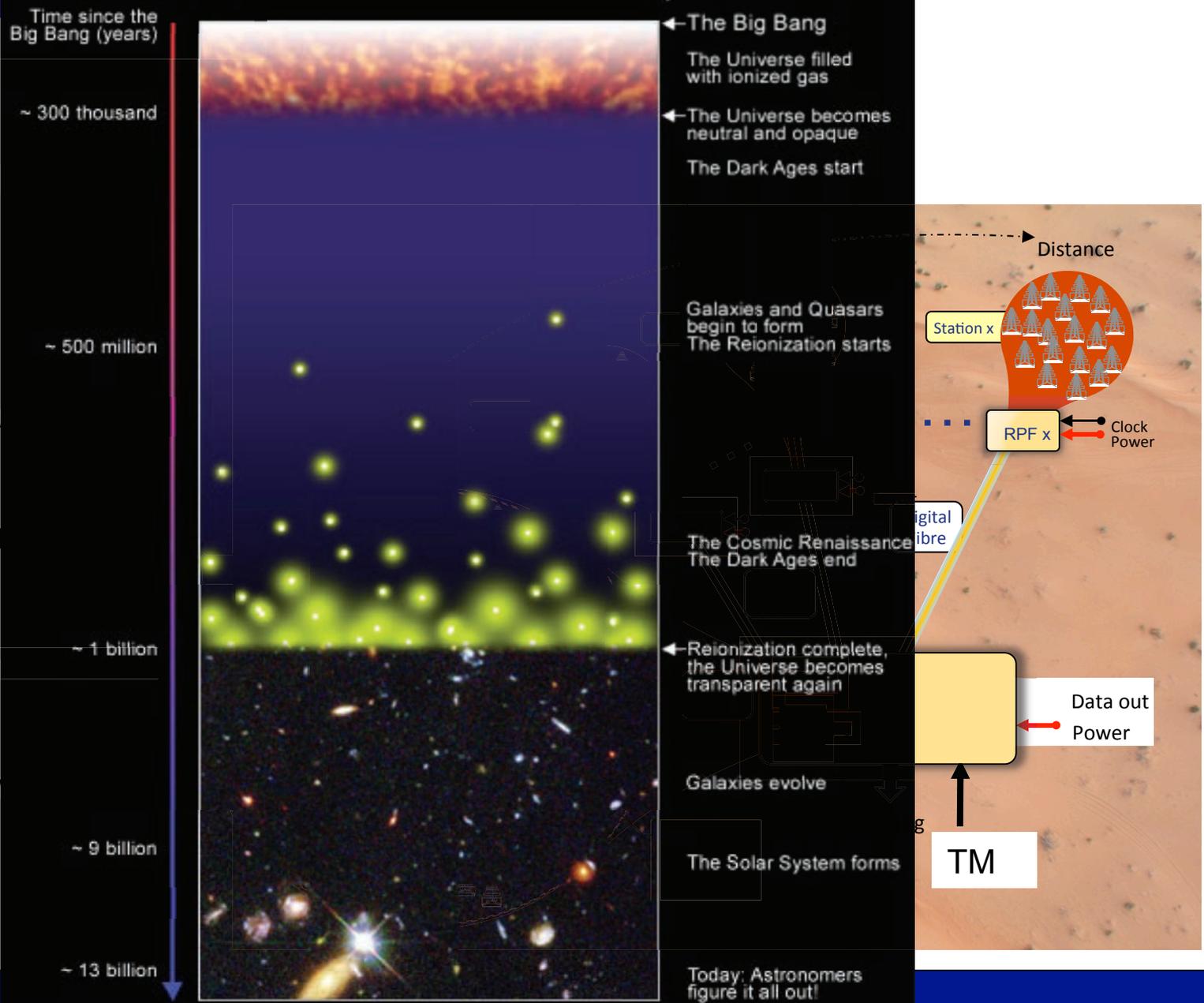
Overview

- LFAA and the AADC
- Recent history and progress
- Antenna arrays
 - Design
 - EM modeling
 - OSKAR Simulations
- Coming work

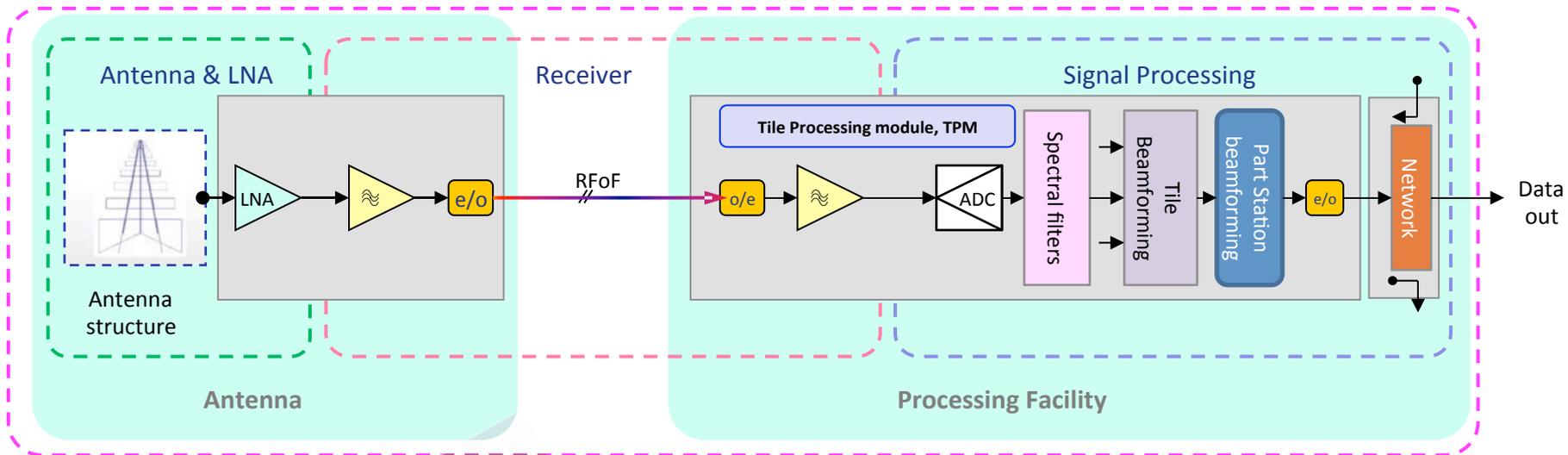
What is the Reionization Era?

A Schematic Outline of the Cosmic History

- 50-350 MHz
 - CD/EoR
 - Pulsars
- 0.4 Km²
- Longest baseline 3 Km
- 131,072 antennas
- 512 stations
- 95% in 'Inner Core' 3km
- Large central processing
- In Western Australia



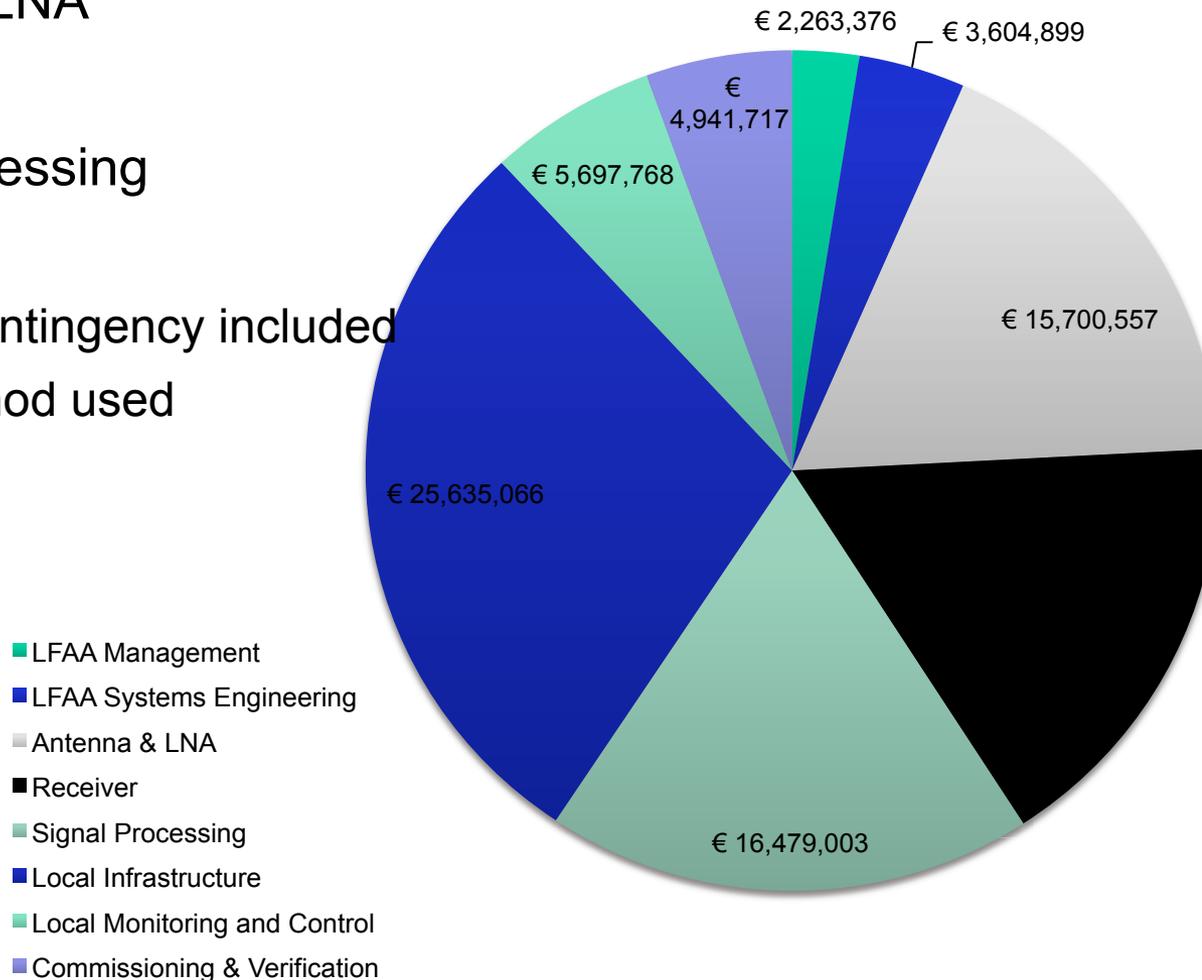
SKA-low signal chain



Costing after re-baselining

- €89M
 - 21% Antenna & LNA
 - 17% Receiver
 - 20% Signal Processing
 - 31% LINFRA
 - On av. 20% contingency included
 - ‘Sanders’ method used

LFAA Element Cost Distribution



AADC Consortium Members

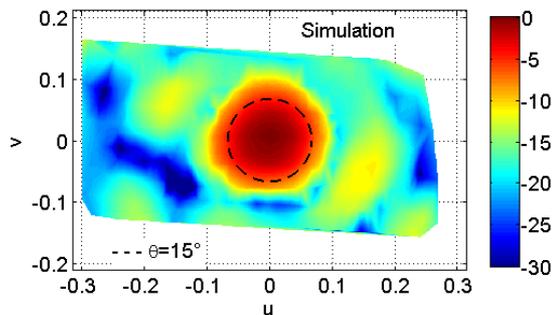
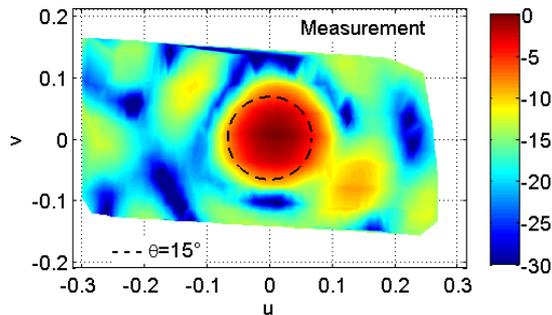
- ASTRON NL
- ICRAR Australia
- INAF Italy
- KLAASA (CETC38) China
- STFC UK *new!*
- University of Cambridge UK
- University of Oxford UK

- *New associate: Nice Observatory (Observatoire Cote d'Azur)*

- Located at Lord's Bridge
- Hexacopter beam test

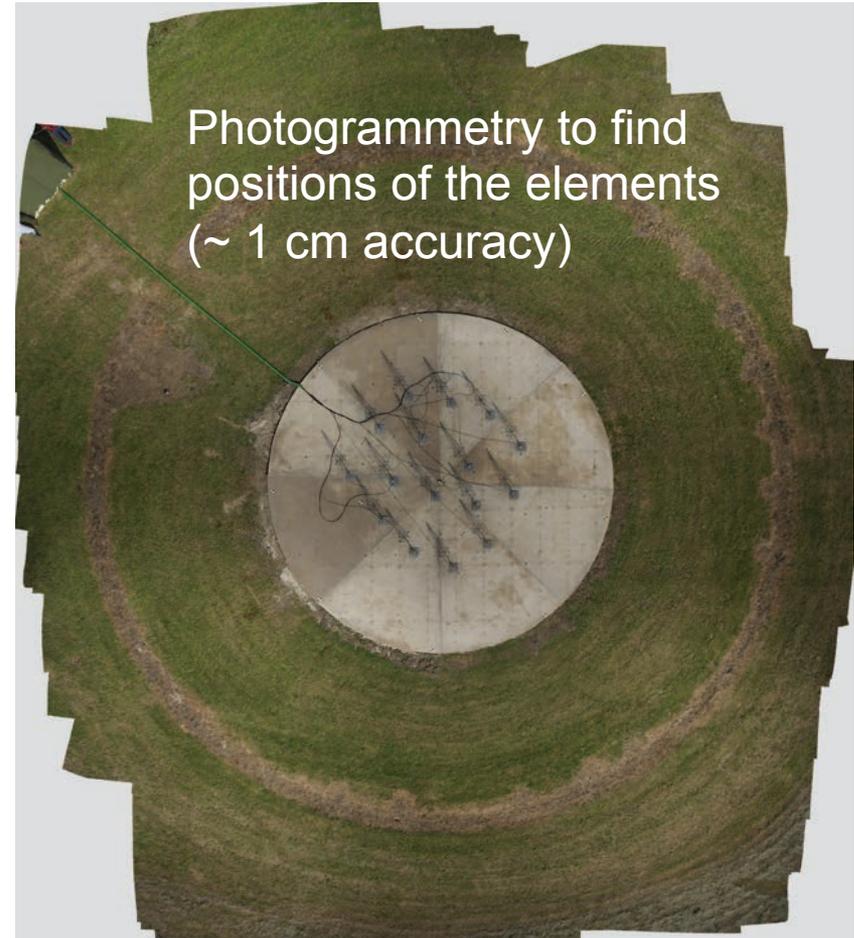
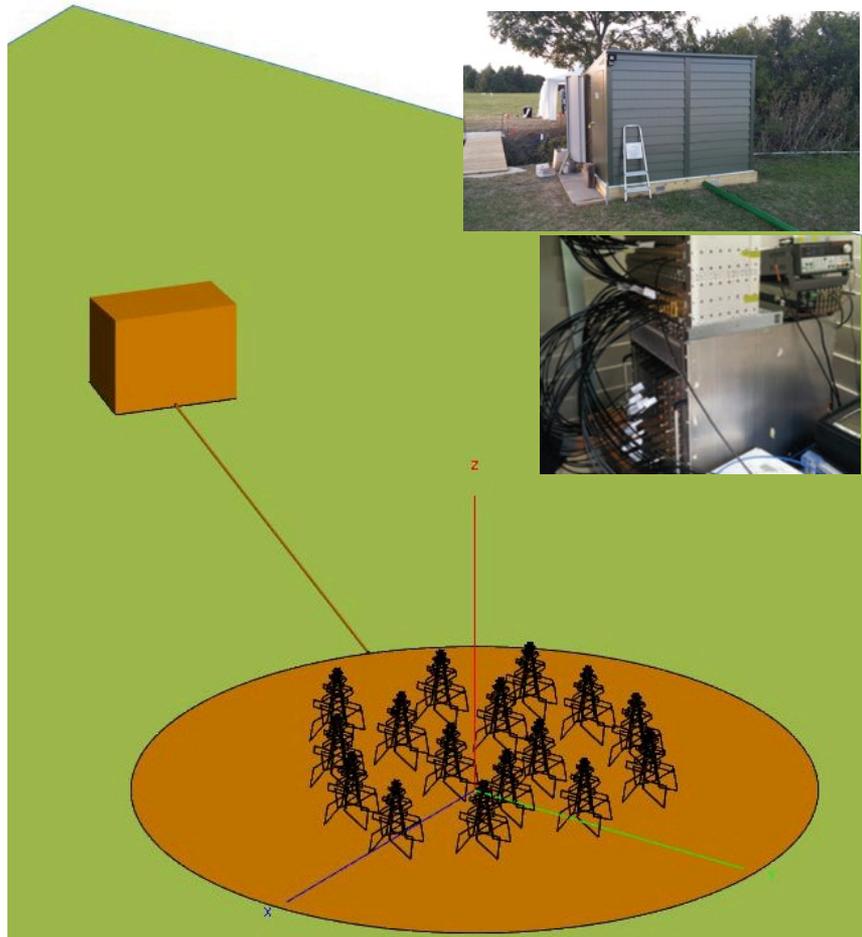


Normalized array pattern at 350 MHz
uv plane, 150 m height

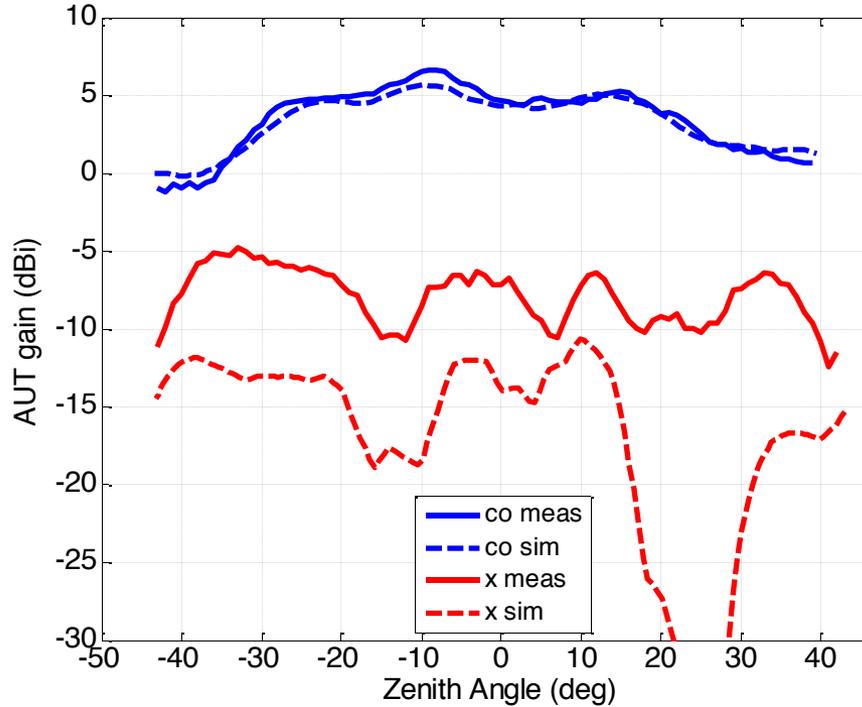


*In preparation for IEEE TAP

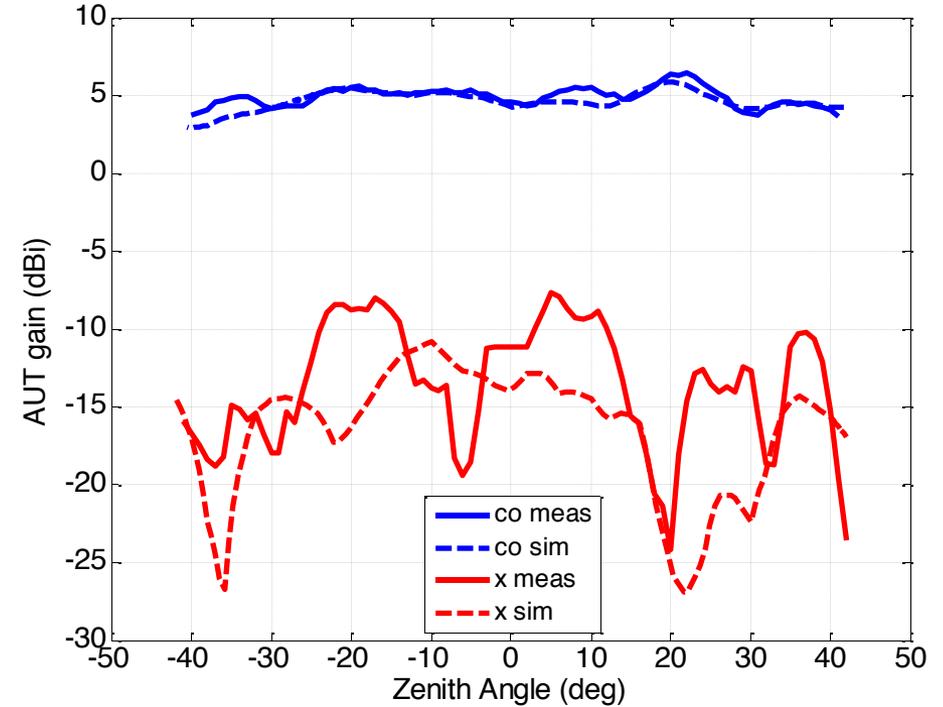
Hexacopter at Cambridge



Embedded-element pattern at 350 MHz (E-plane)

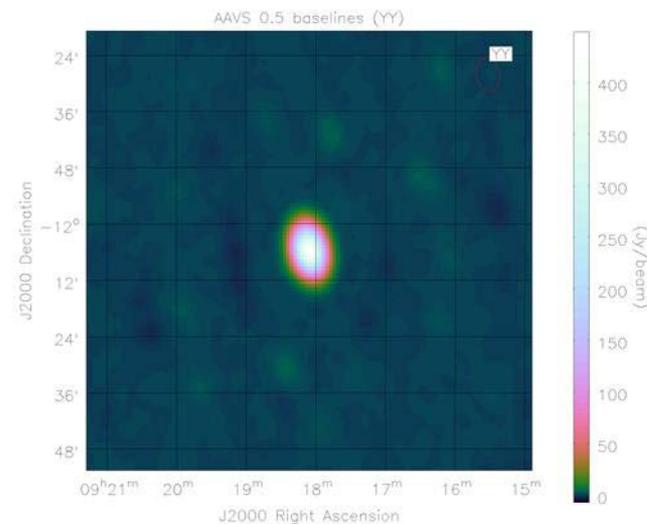
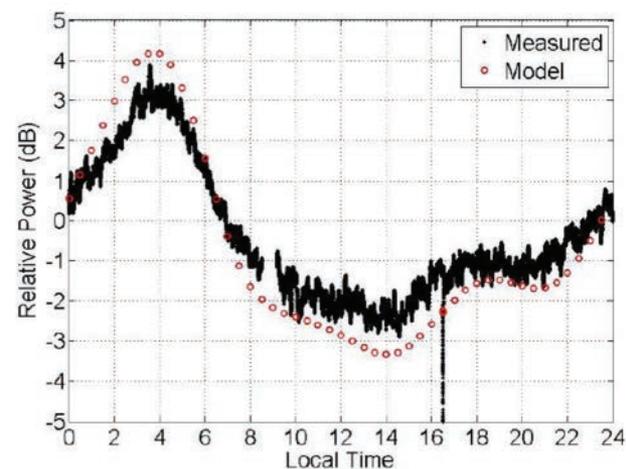
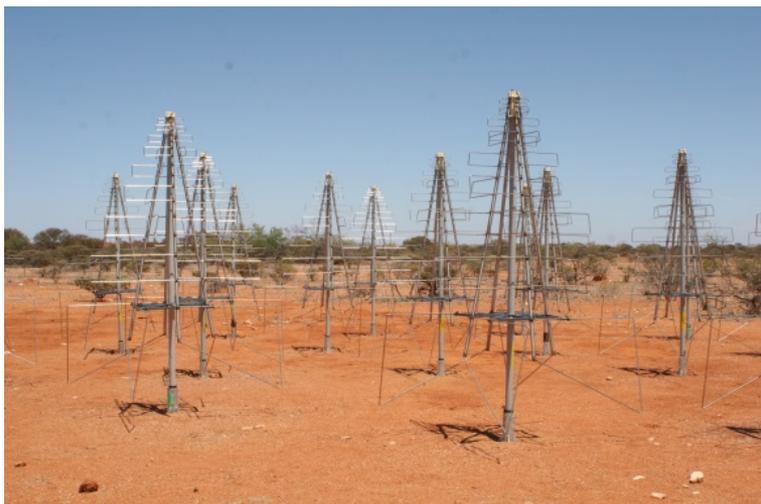


Embedded-element pattern at 350 MHz (H-plane)



Test arrays: AAVS0.5 (MRO, WA)

- 16 antennas connected to MWA back-end
- Hydra A
 - AAVS – MWA
 - 112 sec, 32MHz, around 119MHz
- Good initial verification of scalable LFAA design tools

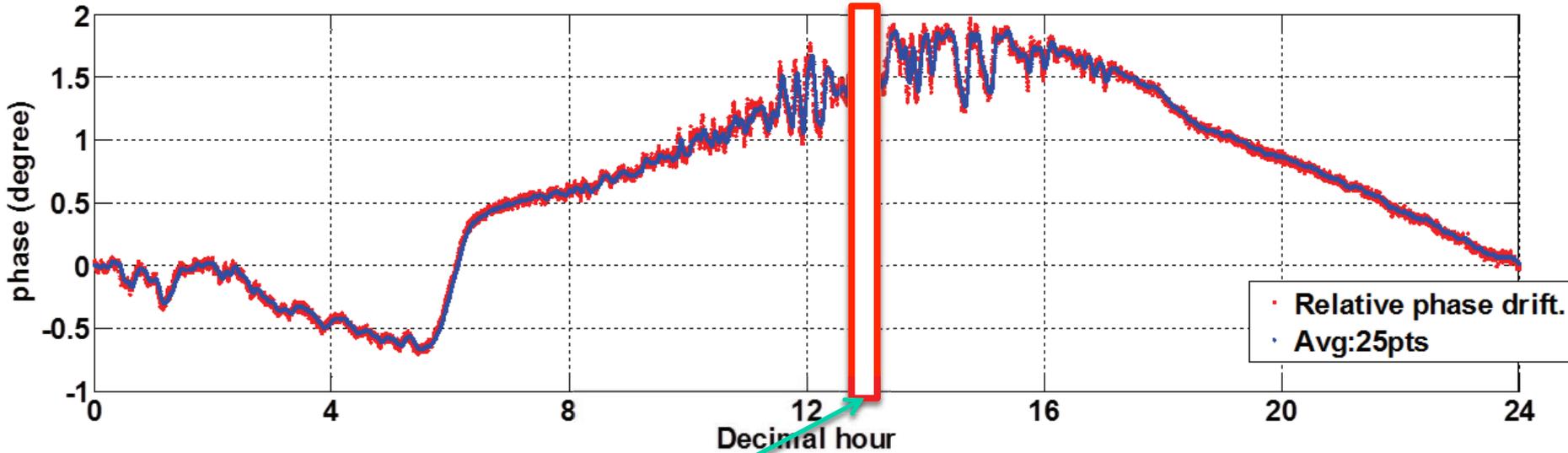


***IEEE TAP 2015, Sutinjo et al.**

Recent work



Relative Phase Drift at 160MHz starting from: "Sunday, 2 November 2014"00:00:09 to "Sunday, 2 November 2014"23:59:55



Worst-case 600-sec window:

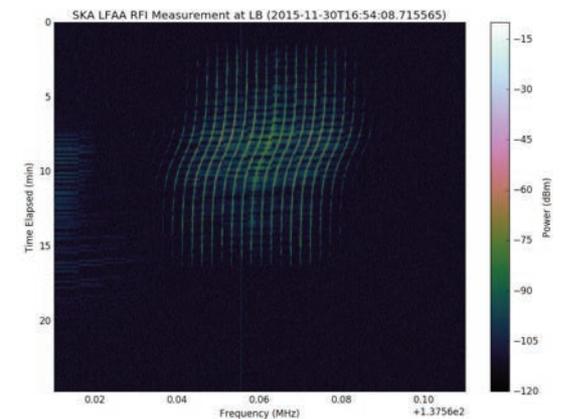
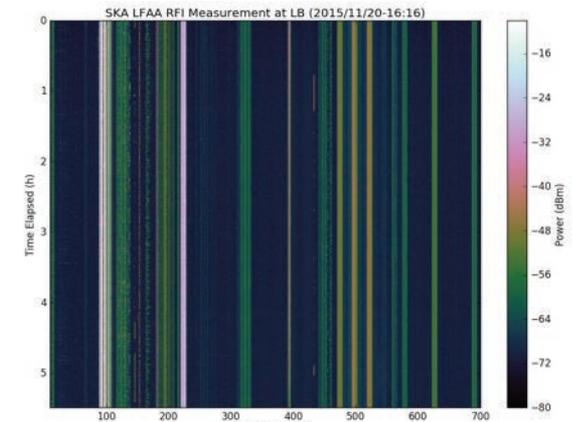
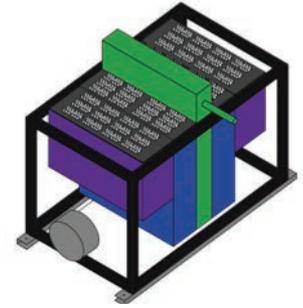
Max = 0.72° (phase)

Requirement@ 160 MHz = 1.2°

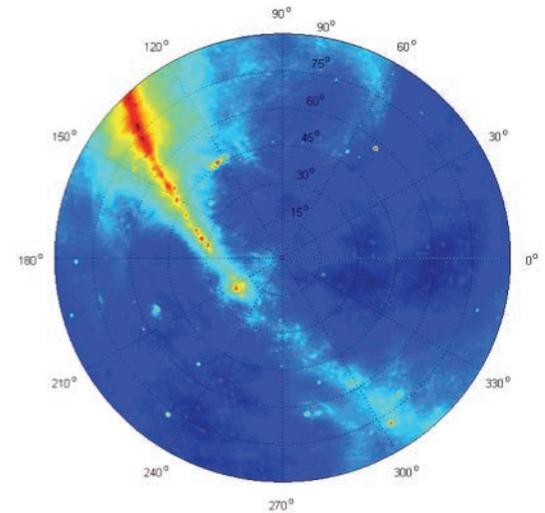
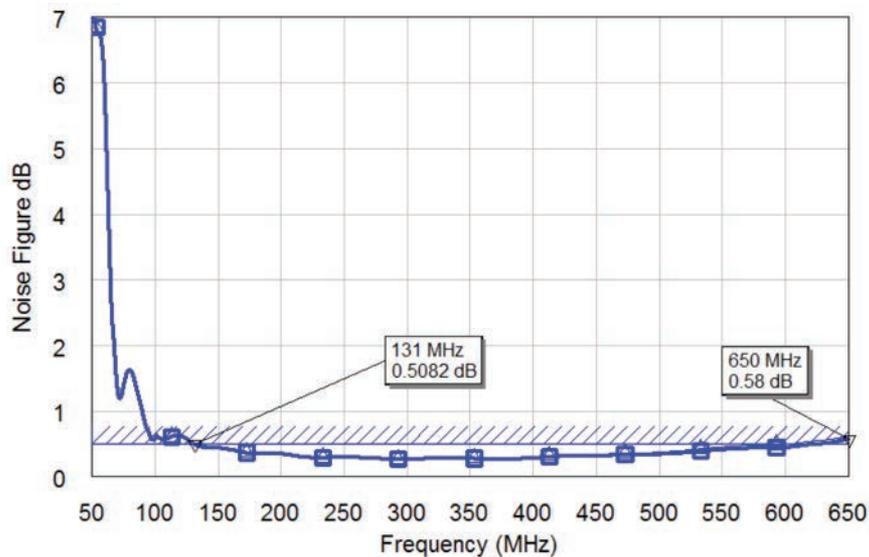
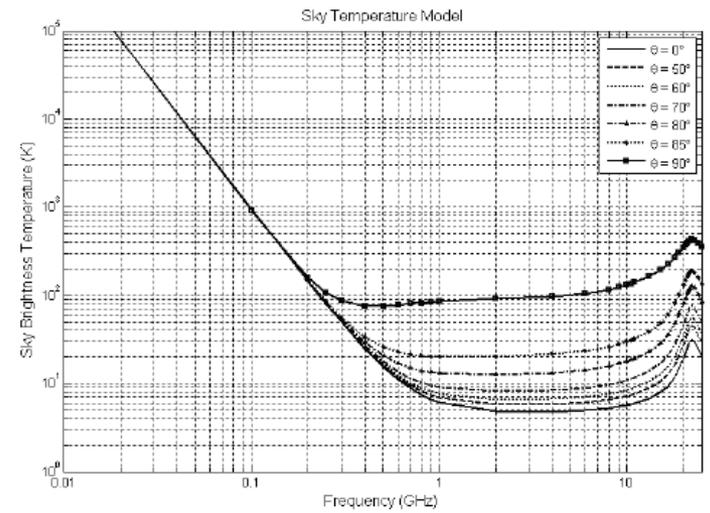
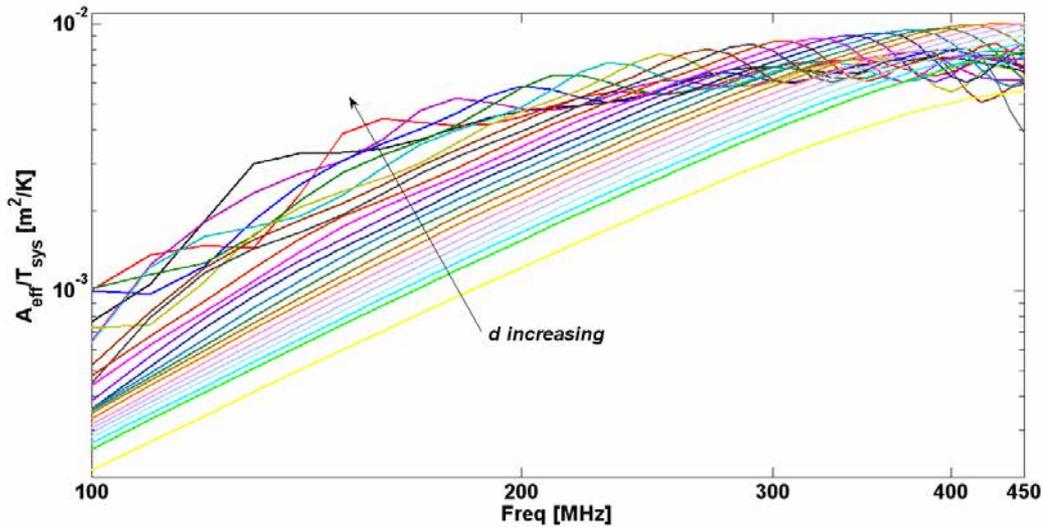
Surface laid is OK for 2 km, but not for more than a few kms.
Buried fiber cables are needed for very long runs

Recent work (cont'd)

- Antenna power unit and Interface
- Pre-AAVS1 (Cambridge): **SKALA-2 + TPM**



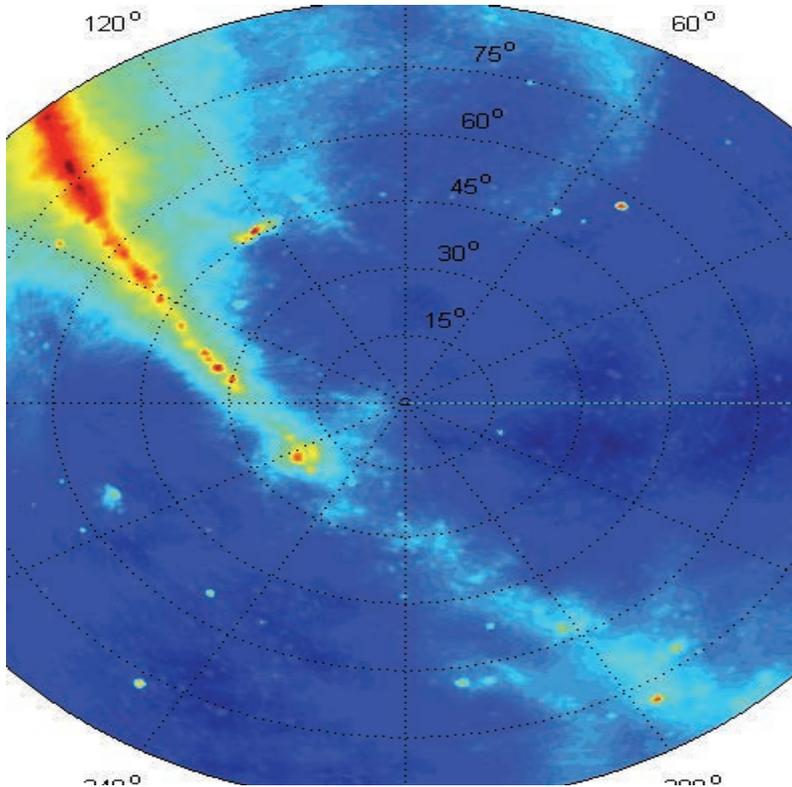
Antenna Arrays: Design



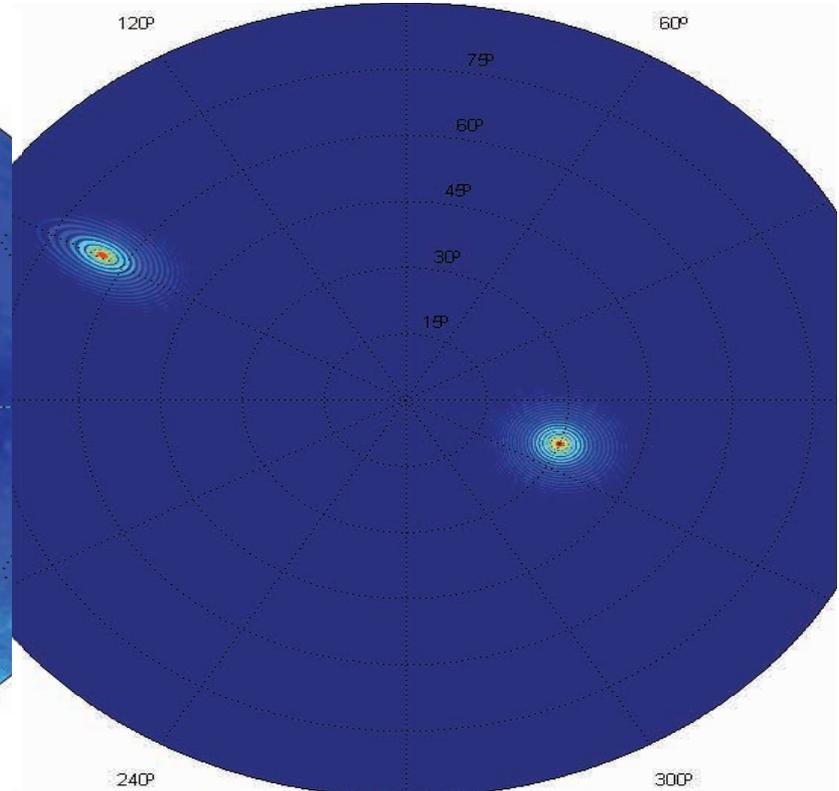
*IEEE TAP 2011, de Lera et al.

Antenna Arrays: Design

Sparse Regular Array Antennas



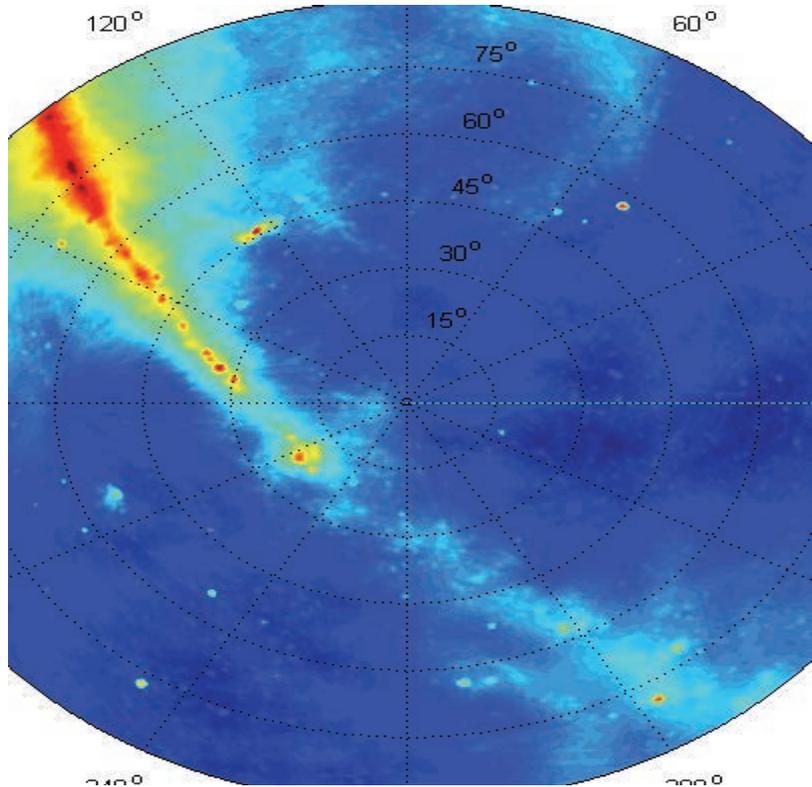
Sky (Haslam) Lat = 28.59S, Long = 115.45E
Date: 01/01/2020, Time 19.33h



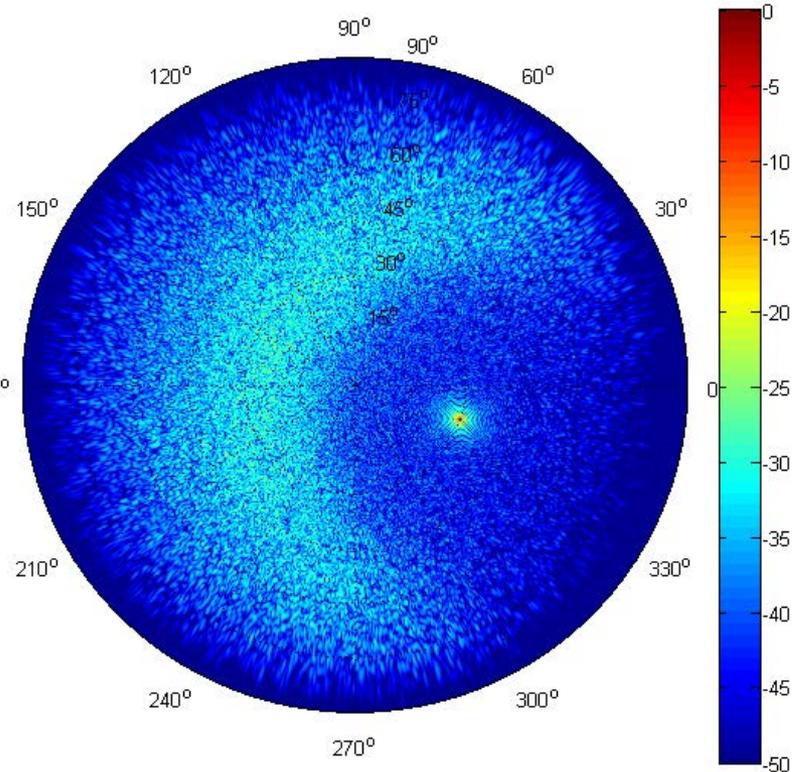
Triangular Lattice Beam
10,000 elements, $d = 0.8\lambda$

Antenna Arrays: Design

Sparse Random Array Antennas

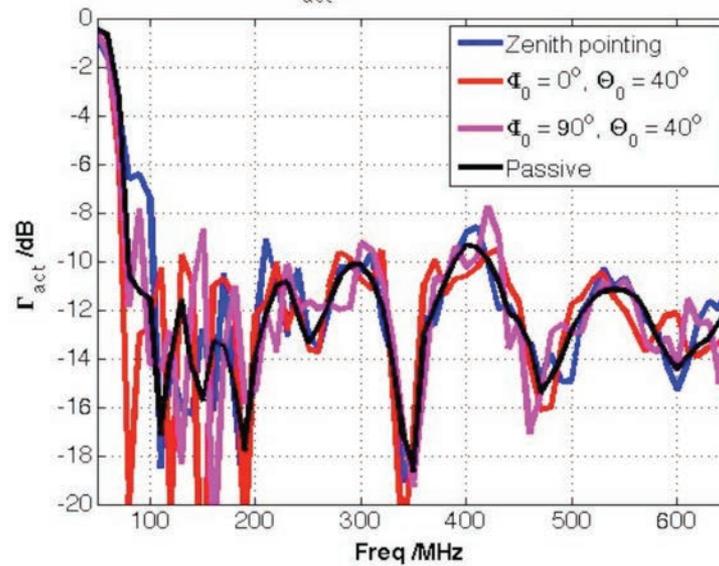
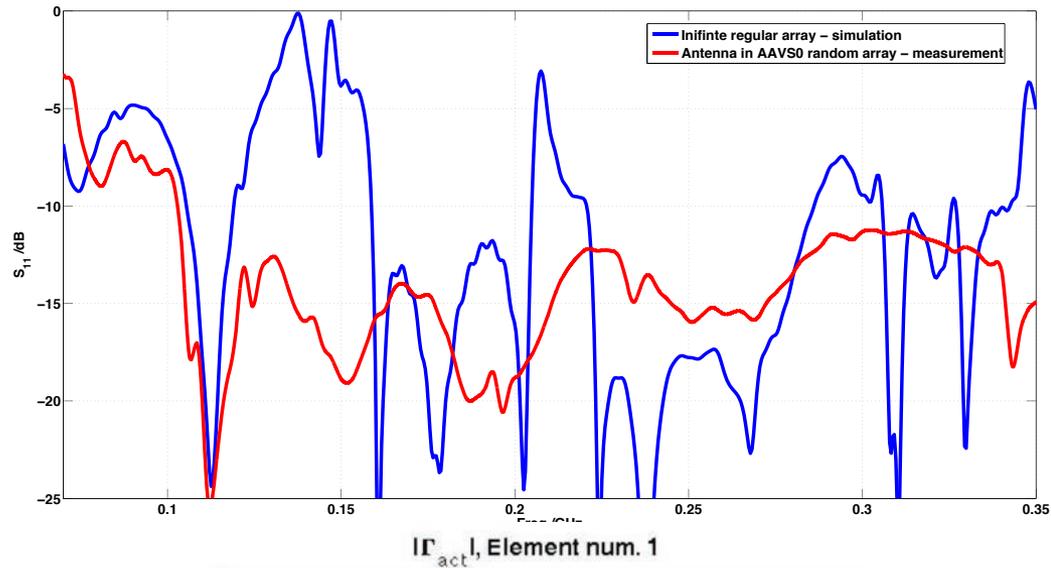


Sky (Haslam) Lat = 28.59S, Long = 115.45E
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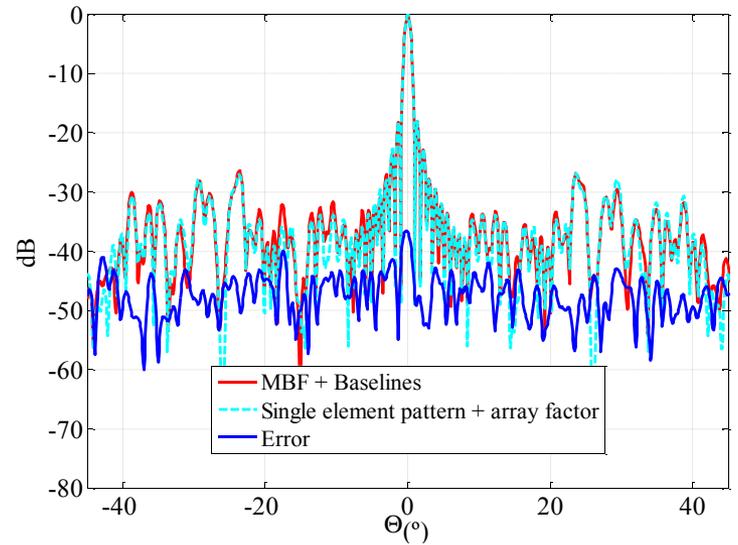
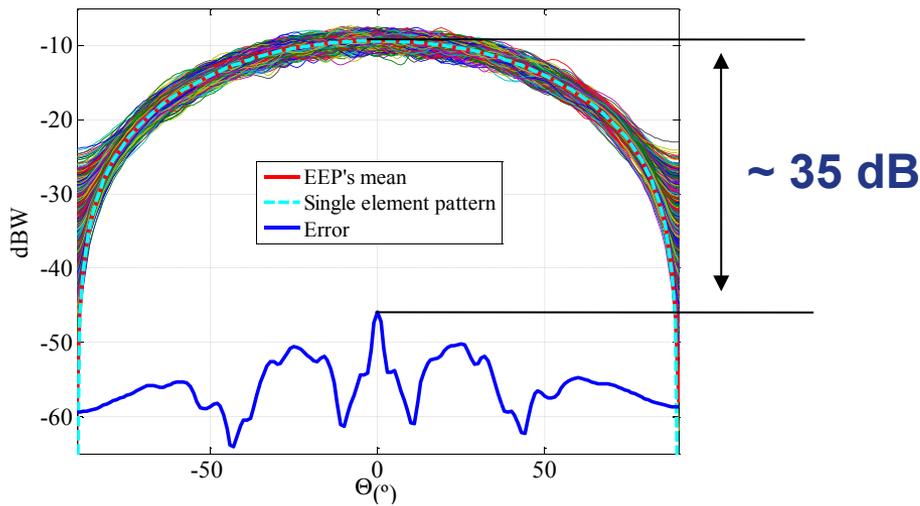
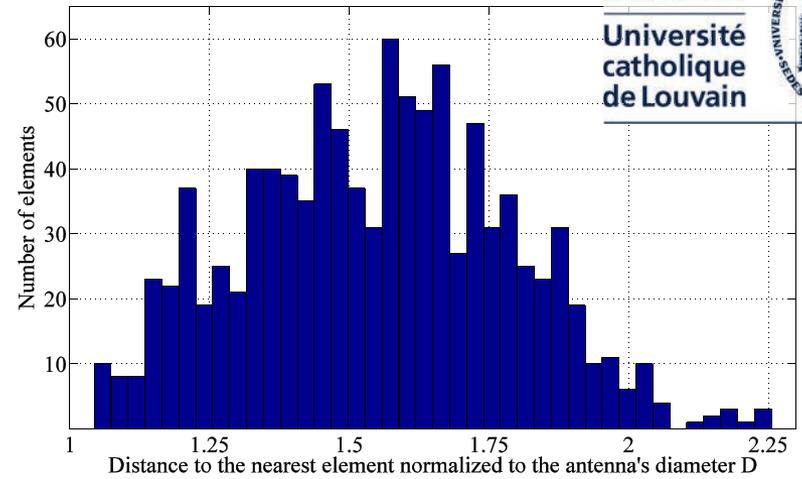
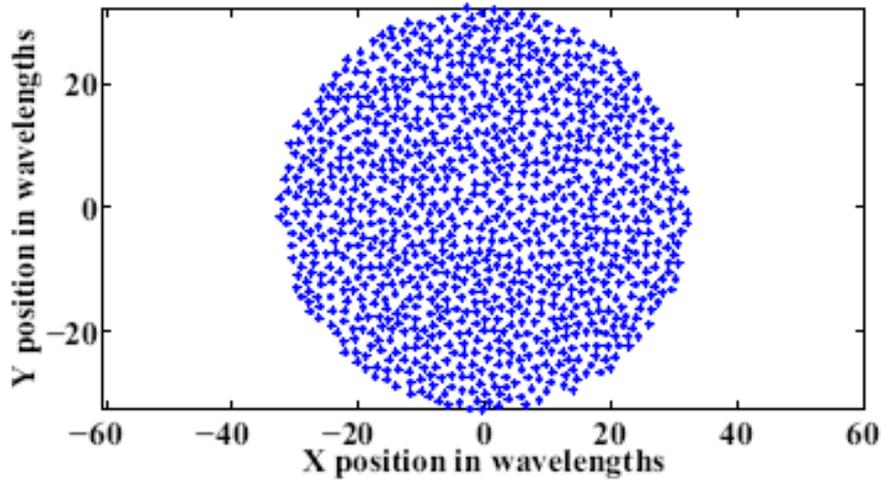


Random Lattice Beam
10,000 elements

Antenna Arrays: Mutual coupling

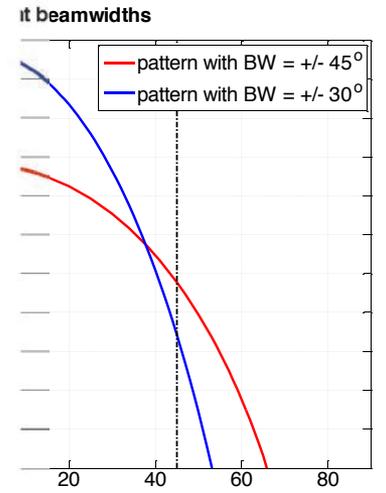
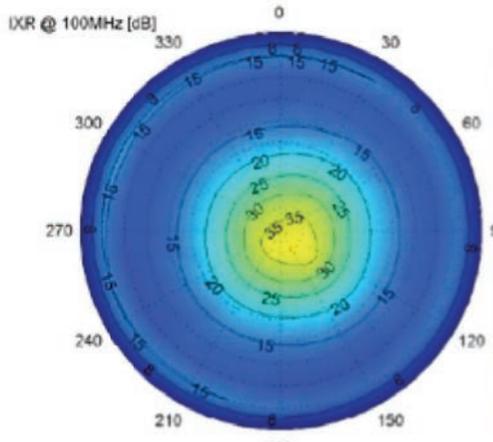
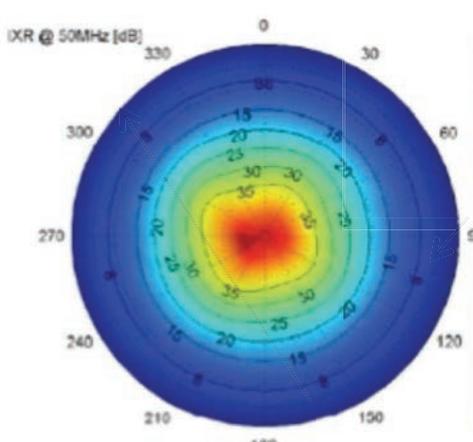


Antenna Arrays: Mutual coupling

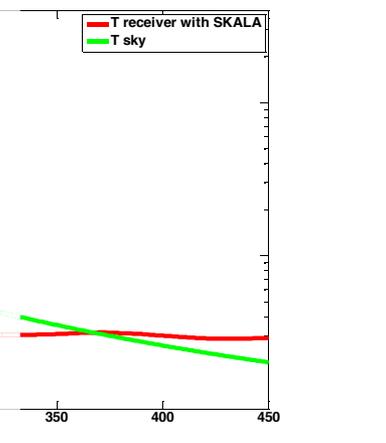
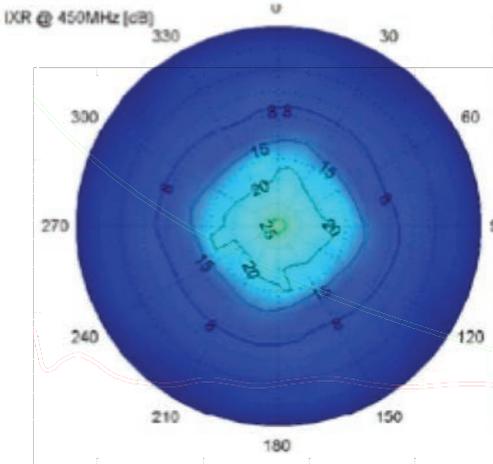
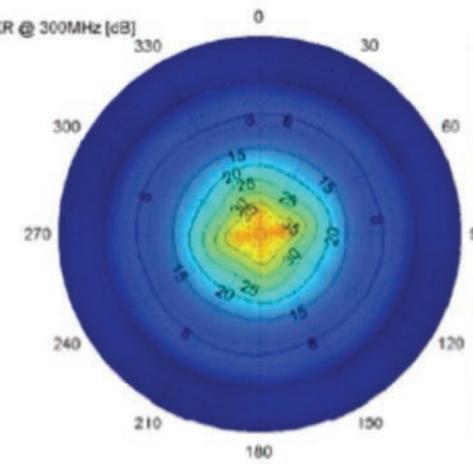


*IEEE APS 2011, Gonzalez et al.

Antenna Arrays: Element design



IXR



*SKALA1: EXPA 2015, de Lera et al.

Resonance found while measuring RFI at the MRO

LNA

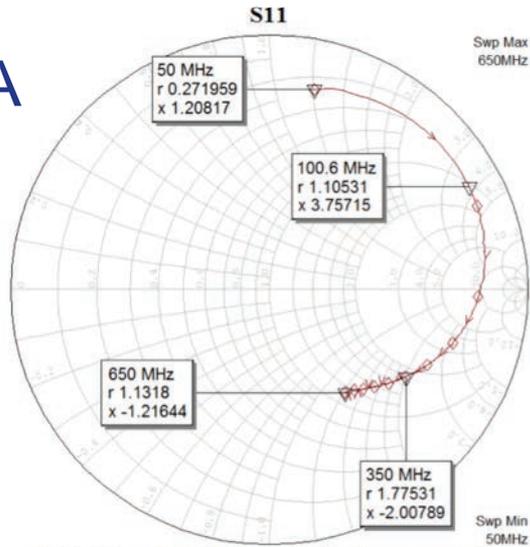


Fig. 5. LNA S_{11} in isolation including input network

Antenna

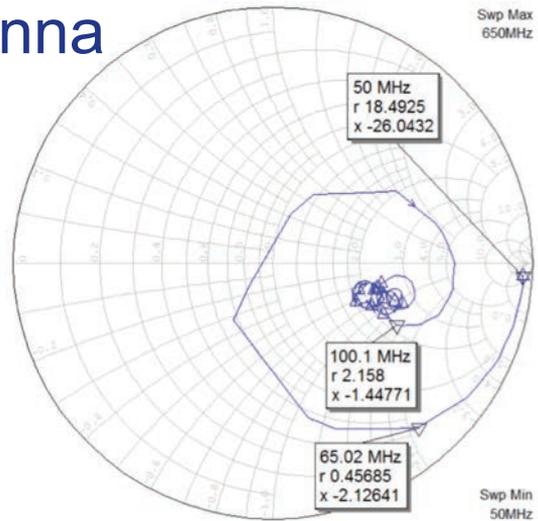
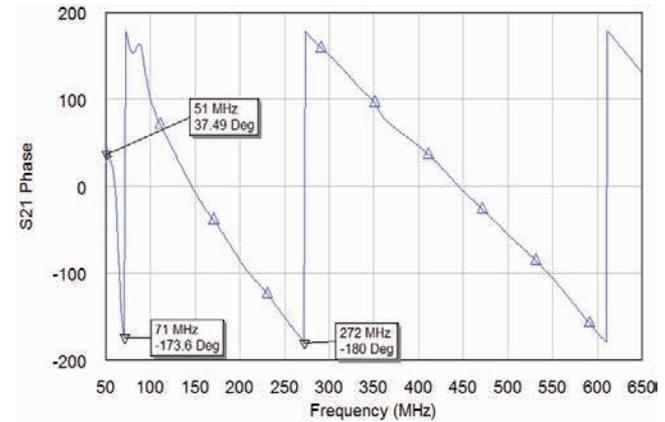
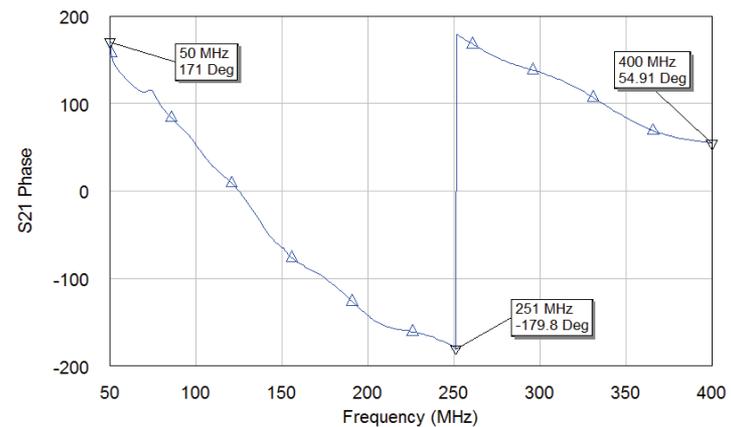


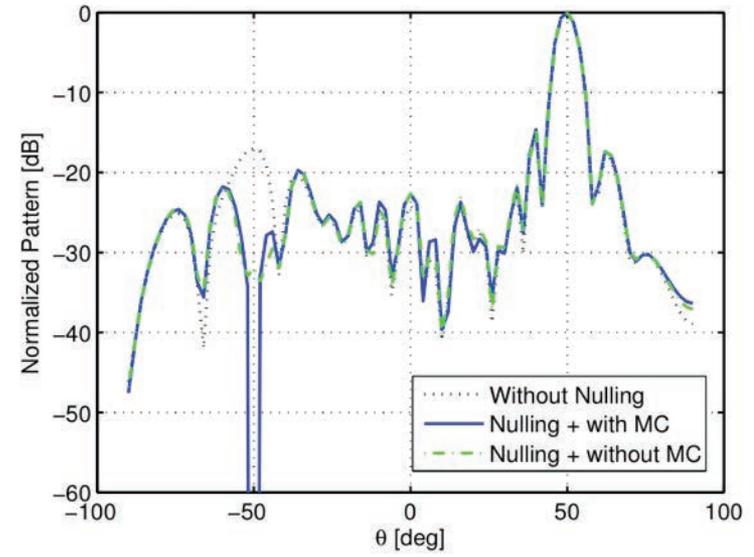
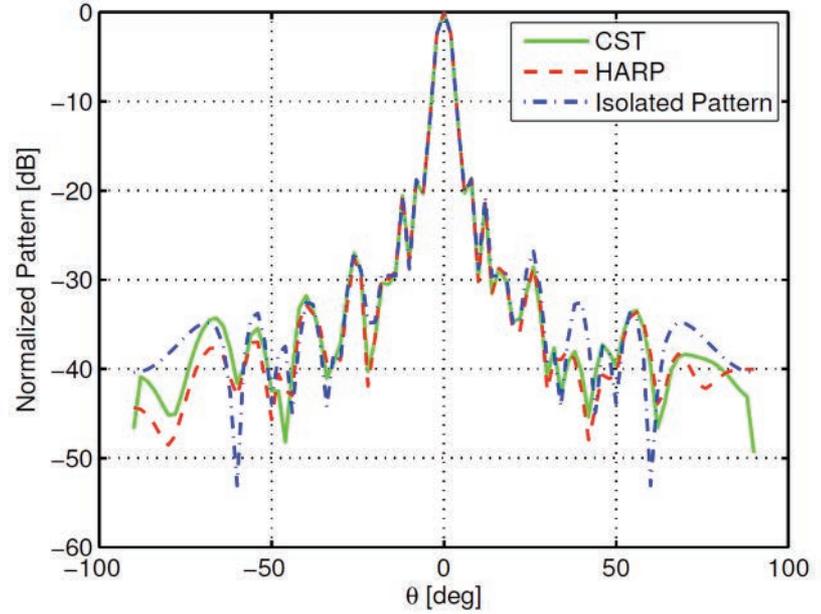
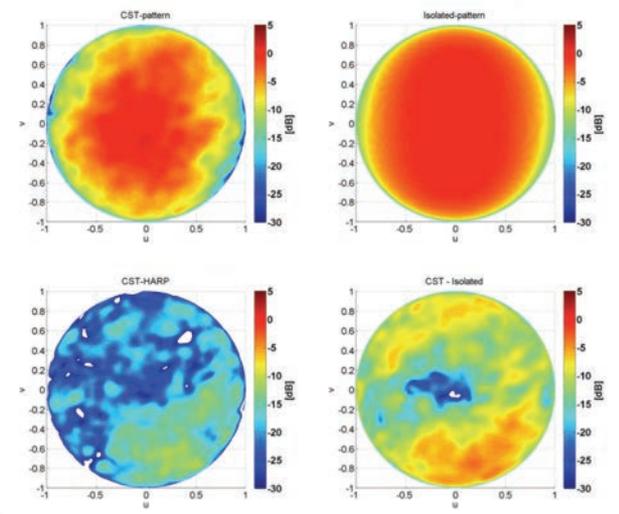
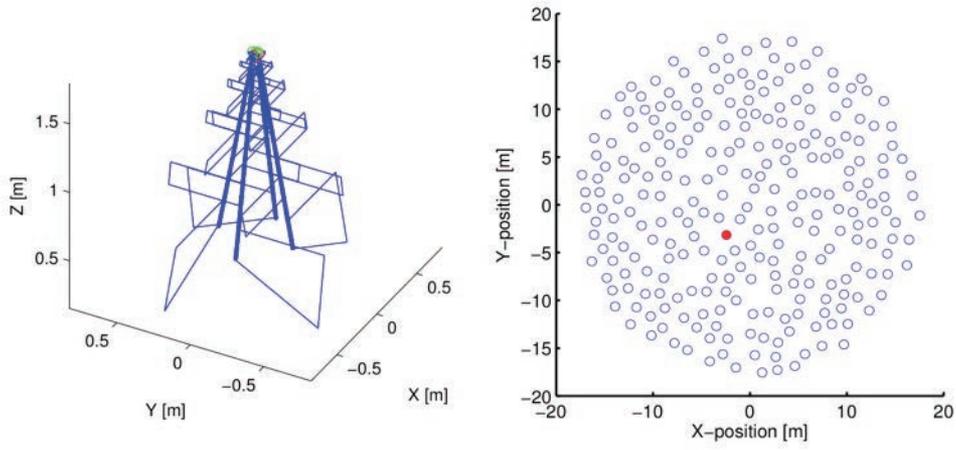
Fig. 6. Original antenna impedance as measured at Lord's Bridge



Optimization: Lower arm re-design and slight LNA re-match



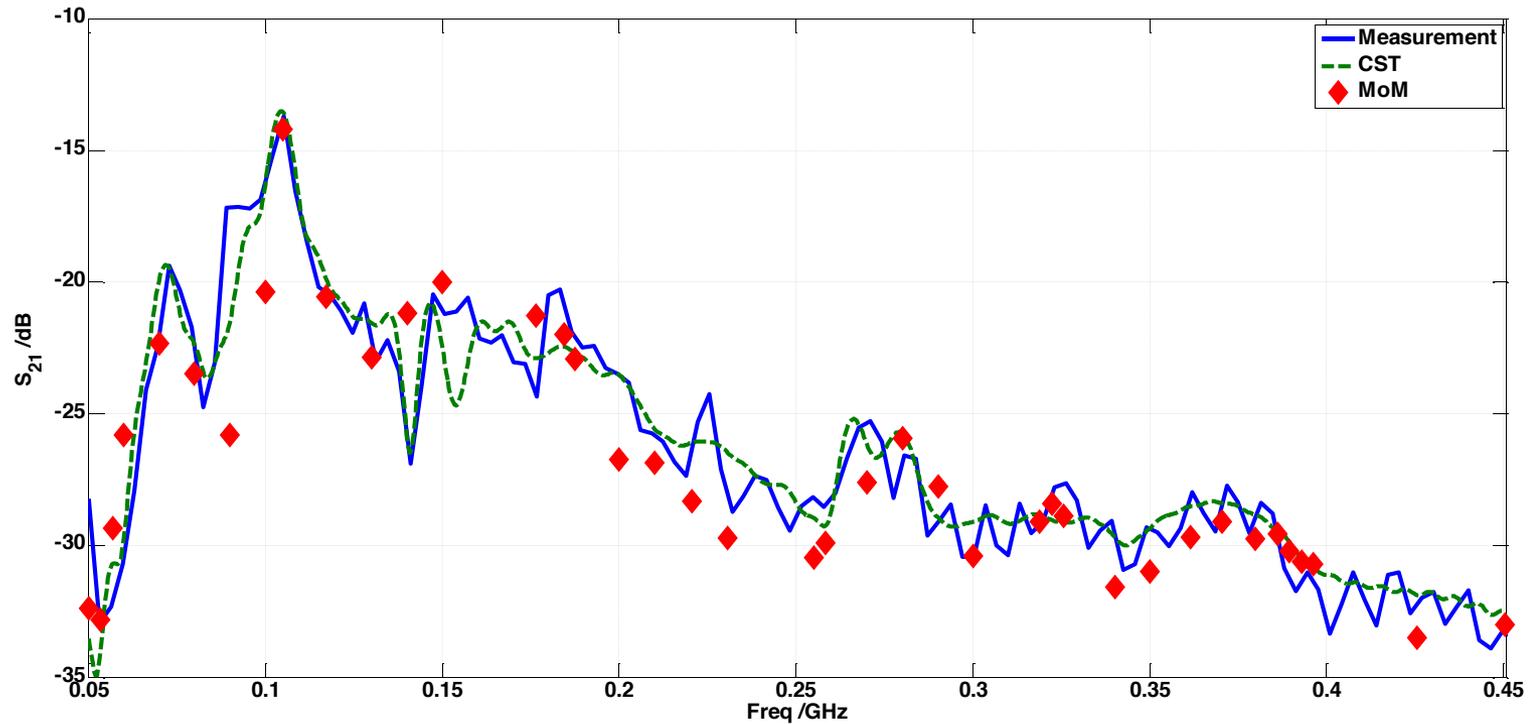
Antenna Arrays: EM modelling



***In preparation for IEEE TAP**

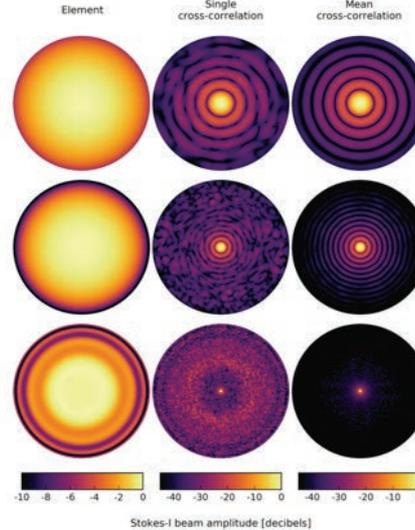
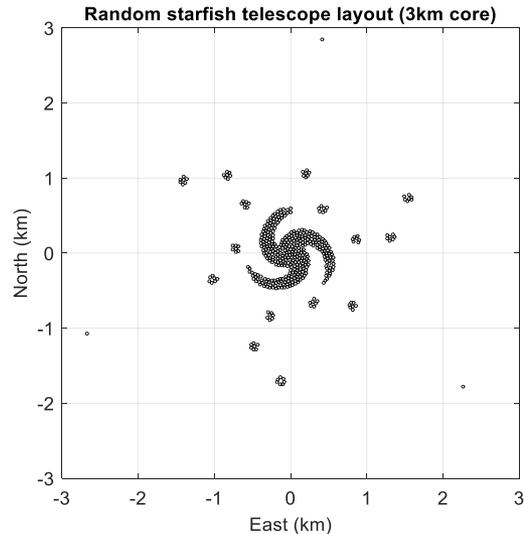
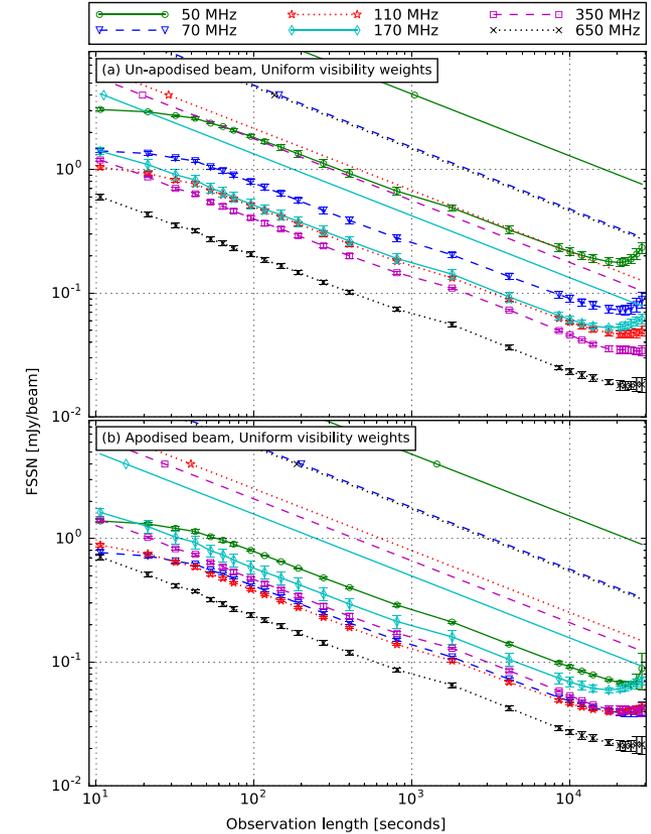
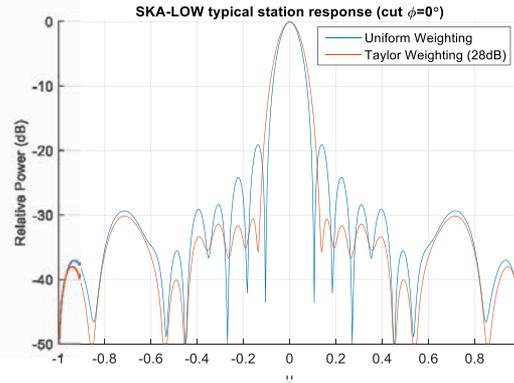
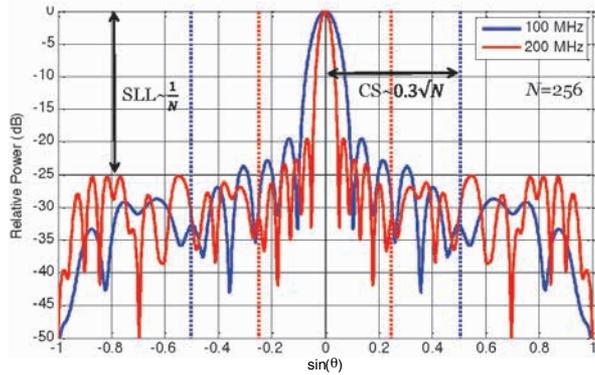
Antenna Arrays: EM modelling

3x3 array

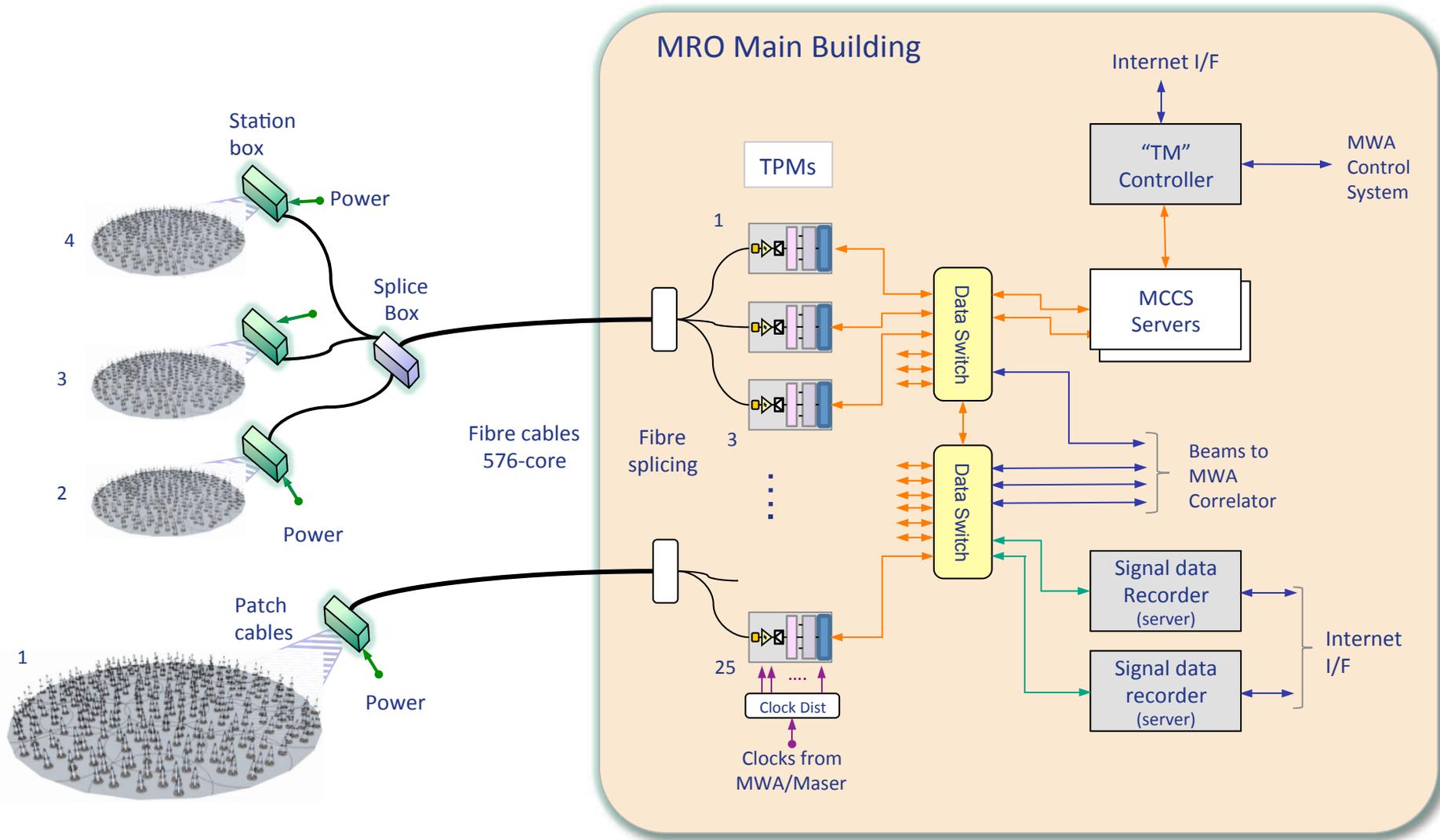


Antenna Arrays: OSKAR simulations

- In preparation for MNRAS. Oxford (B. Mort and F. Dulwich), Cambridge (N. Razavi and E. de Lera), Manchester University (K. Grainge)

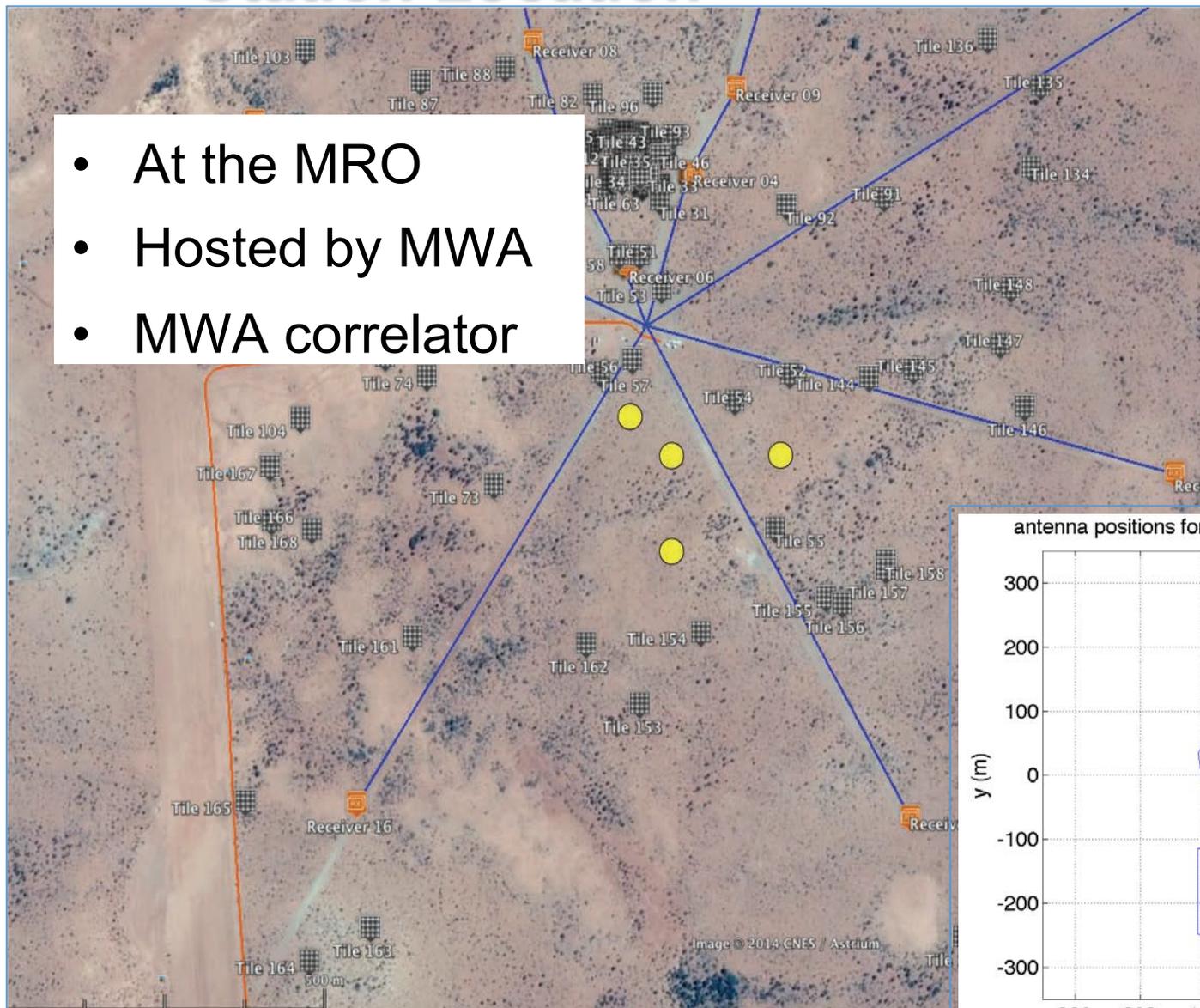


Coming work this year: AAVS1

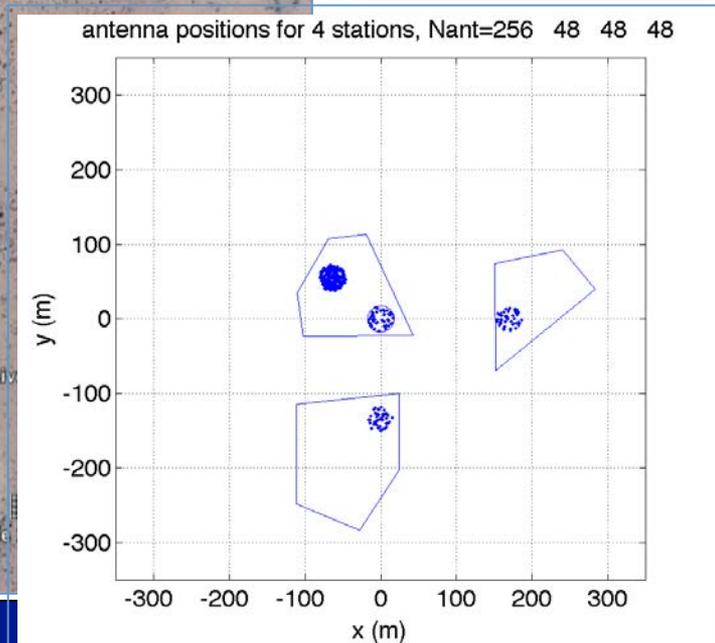


Station Location

- At the MRO
- Hosted by MWA
- MWA correlator



1: 256 antennas
2-4: 48 antennas



Thank you

- Questions?

