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Stellenbosch University's participation in MFAA

Prof David B Davidson, Stellenbosch University

Penticton, BC

13 Nov 2015

SKA 2015

Engineering Meeting

With corrections 20 Nov 2015



Fakulteit Ingenieurwese

Faculty of Engineering





- 8 full-time staff members in group including one research chair (Davidson).
- Profs Botha, Davidson, de Villiers, Meyer, Niesler.
- Drs Wiid and Beyers.
- Ms Gilmore.
- Around 20 post-grad students, including four post-docs, working solely on SKA-related topics.



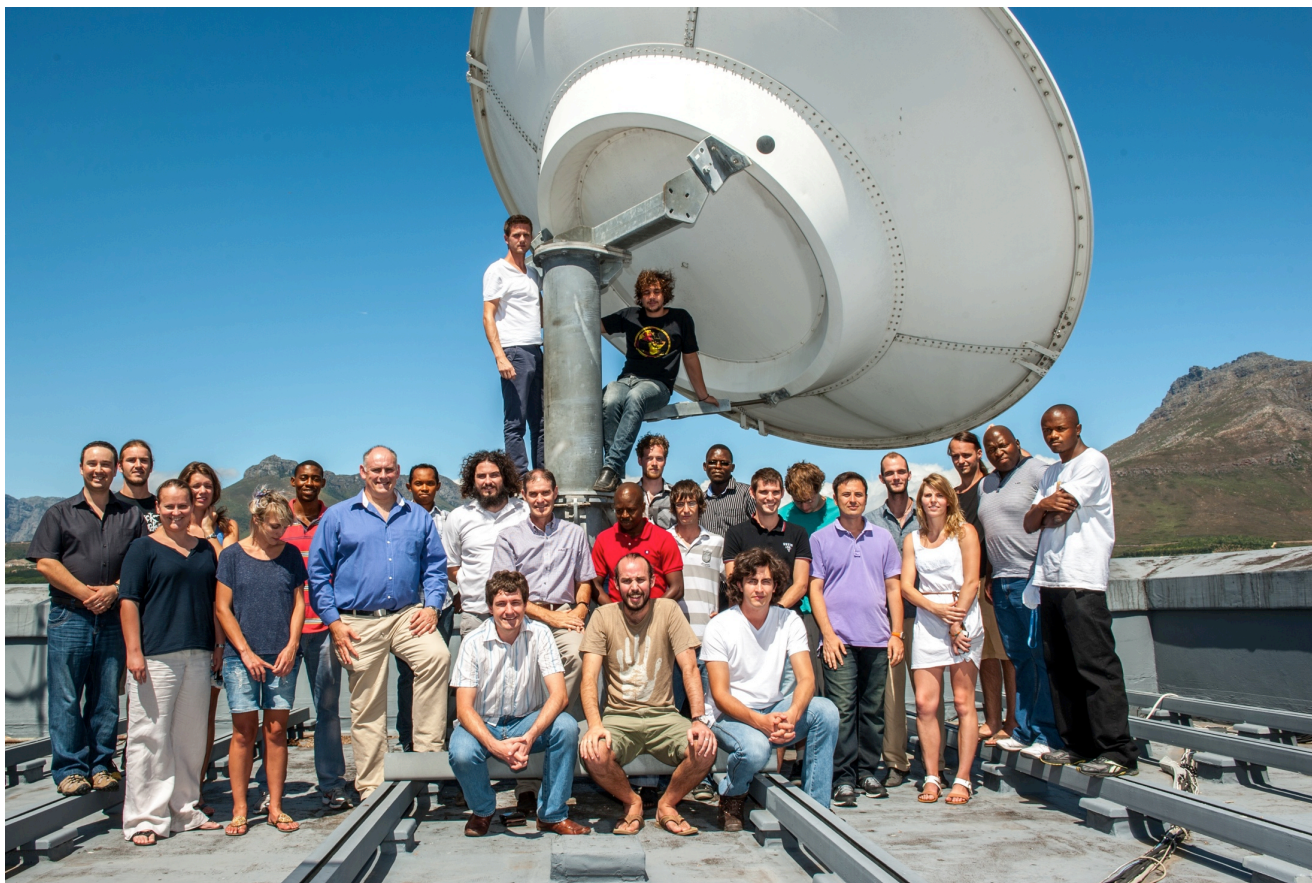
Current main fields of research at SU



- **Dish and front-end design (MeerKAT, SKA I-Mid, HERA)**
 - Staff: Davidson, de Villiers, Meyer.
 - Students: 1xPhD (Botes), 5xMSc (Steenkamp, Vermeulen, van Tonder, Venter, Kenned)
- **Aperture arrays (mainly MFAA – some LFAA-orientated work)**
 - Staff: Davidson, Gilmore (part-time PhD), Beyers.
 - Post-docs: 1/3 Ludick, Prinsloo
 - Students: 1x part-time PhD (Gilmore)
- **Computational electromagnetics (CEM) and multi-physics.**
 - Staff: Davidson, Botha
 - Post-docs: 1/3 Ludick
 - Students: 1x PhD (industry, not SKA funded)
- **Electromagnetic/radio frequency interference (EMI/RFI) and metrology**
 - Staff: Davidson, Wiid, Niesler. Consultant: Reader.
 - Post-docs: Andriambeloson, 1/2 Smith
 - Students: 2xPhD (Pienaar, Phiri), 4.5xMSc (Combrink, Kuja, 1/2 Steeb, Wolfaardt, Bester)
- **High performance computing**
 - Staff: Davidson
 - Post-docs: 1/3 Ludick.
 - Students: 0.5 MSc (1/2 Steeb)
- **Calibration and imaging.**
 - Staff: Davidson
 - Post-docs: 1/2 Smith
 - Students: 1xPhD (Mutonkole), 1xMSc (Hokwana)



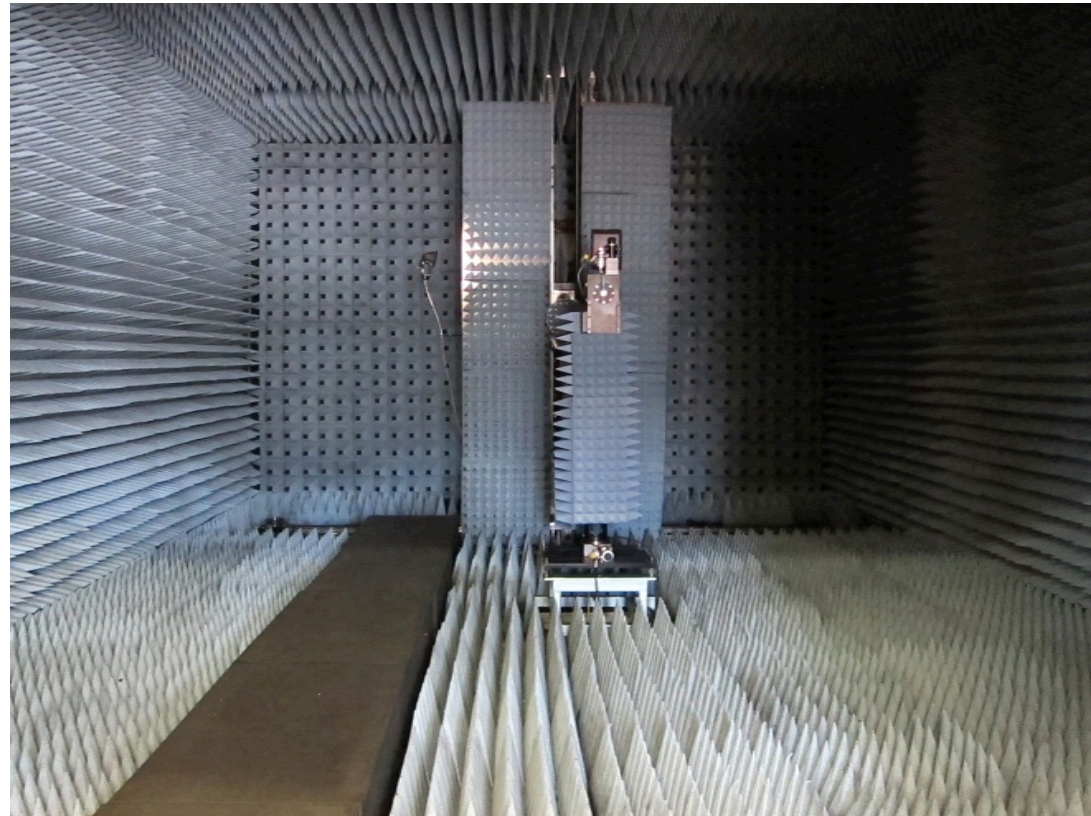
SKA-SA funded post-grad group (March 2013)





Major facilities

- Near field chamber upgraded Nov 2014 – planar and spherical (phi over theta) scanner – now fully operational.
- Nominal range 1-20 GHz.
- PNA-X is used as source/receiver – can also make free-standing measurements (noise option).
- Mode-stirred shielded room.





Recent publications



- A. Young, S. J. Wijnholds, T. Carozzi, R. Maaskant, M. V. Ivashina, and D. B. Davidson, "Efficient Correction for Baseline-Dependent Direction-Dependent Effects in Synthesis Imaging: An A-Stacking Framework", *Astronomy and Astrophysics*, vol. 577, p. A56, 2015.
- J. Gilmore and D. B. Davidson, "Suppressing Undesired Common-Mode Resonances in Connected Antenna Arrays", *IEEE Transactions On Antennas And Propagation*, Vol. 63, No. 11, November 2015, pp. 5245-5250.
- R. Lehmensiek, I. P. Theron, and D. I. L. de Villiers, "Deriving an Optimum Mapping Function for the SKA-Shaped Offset Gregorian Reflectors", *IEEE Transactions On Antennas And Propagation*, Vol. 63, No. 11, November 2015, pp. 4658-4666.
- P. Meyer and D. S. Prinsloo, "Generalised Multimode Scattering Parameter and Antenna Far-Field Conversions", *IEEE Transactions On Antennas And Propagation*, Vol. 63, No. 11, November 2015, p. 4818-4826



Current main collaborations



- Formal:
 - SKA-SA (Funding for research chair, staff and students at Stellenbosch)
 - MeerKAT HPC – Stellenbosch, SKA-SA, CHPC, Univ Cape Town
 - Relevant South African industries – especially EMSS-Antennas and Altair (formerly EMSS-SA).
 - MIDPREP (ASTRON, Chalmers, Stellenbosch, Rhodes and UCT).
 - MFAA consortium (Stellenbosch now full member)
 - NSF-PIRE - full application submitted mid May (Brigham Young Univ, NRAO).
 - HERA analogue consortium (not funded).
- Informal:
 - Western Cape, Rhodes, Pretoria & KwaZulu-Natal universities.
 - Cambridge
 - Manchester
 - Oxford (limited interaction presently)
 - Mauritius
 - ICRAR (Australia)
- Davidson also serves on new (South African) Astronomy Advisory Council.



Main contributions to MFAA – Dense Dipole Array



- Dense dipole array – originally inspired by Jan Noordam’s “bathmat” concept (ASTRON).
- 1st prototype – 2014 – single pol only.
- Common mode rejection feed structure designed (Published Nov 2015 T-AP).
- 2nd prototype – 2015 – dual pol.
- Current status: 450-1500 MHz Dual-pol prototype built, testing in progress.
- Tile approx 1m^2 ; $10 \times 10 \times 2$ elements – fed in broadside pairs, $\cong 150\ \Omega$.
- Most elements passively terminated; embedded performance tested.

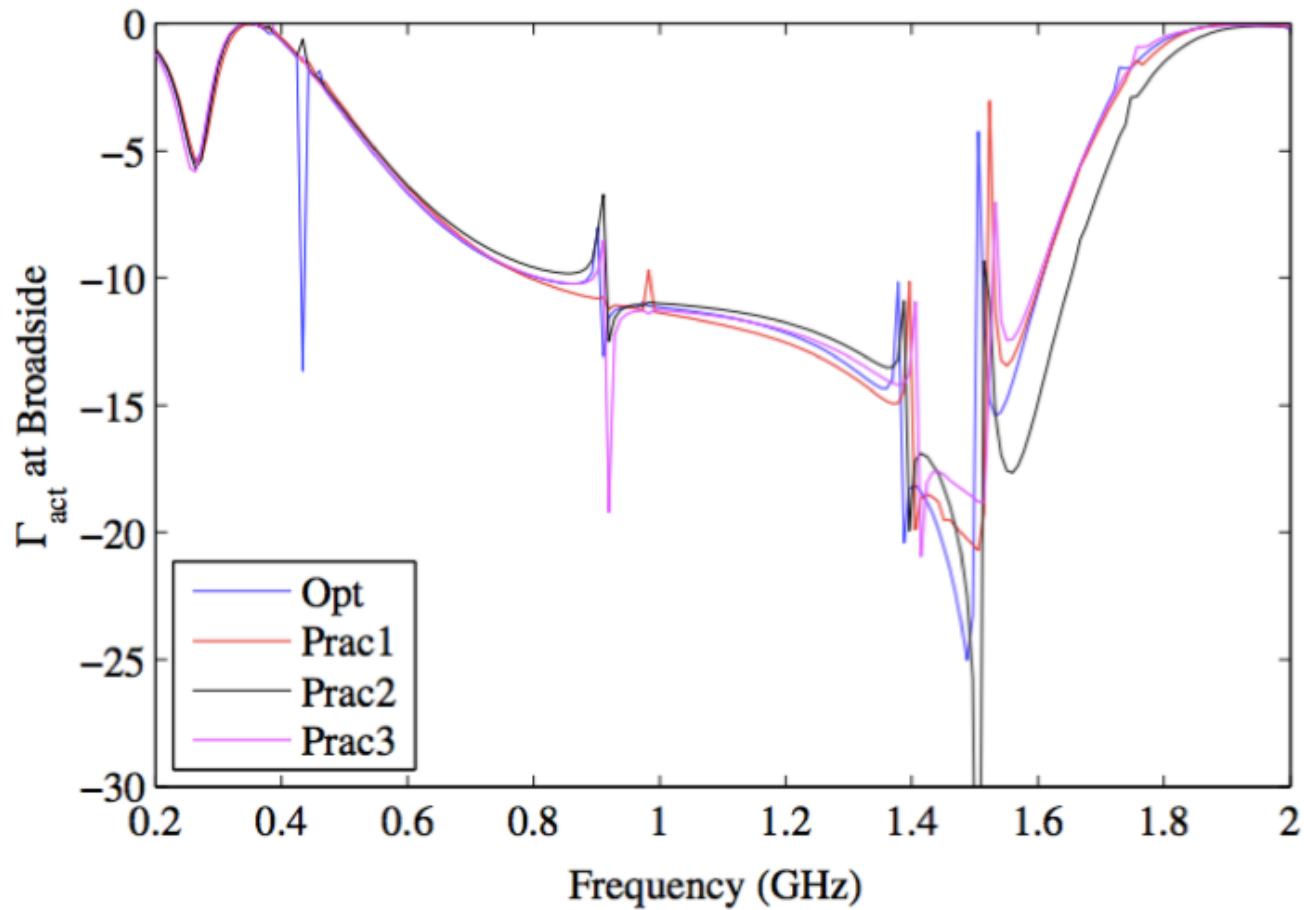


Figure 1.2: Active reflection coefficient for the optimal- and three practical parameter sets.

- Multi-mode antenna developed by Prinsloo, Meyer, Maaskant and Ivanshina.

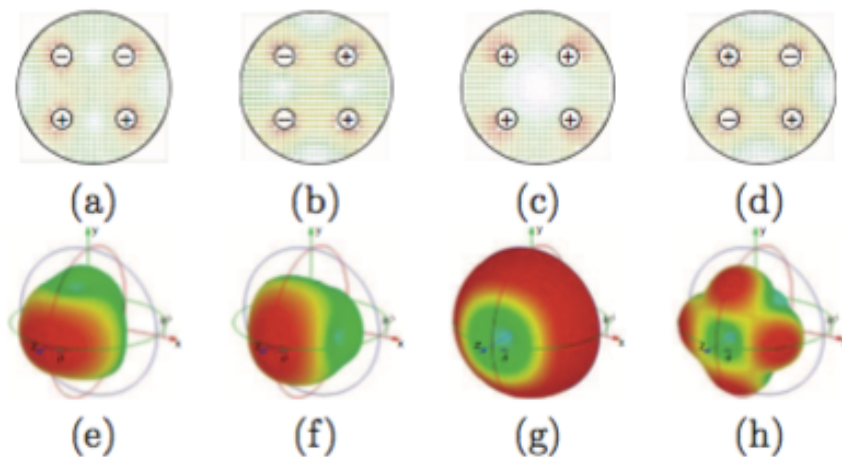


Figure 1: QMA excitation modes (a) MM_1 , (b) MM_2 , (c) MM_3 , and (d) MM_4 with respective radiated far-field patterns of modes (e) MM_1 , (f) MM_2 , (g) MM_3 , and (h) MM_4 .

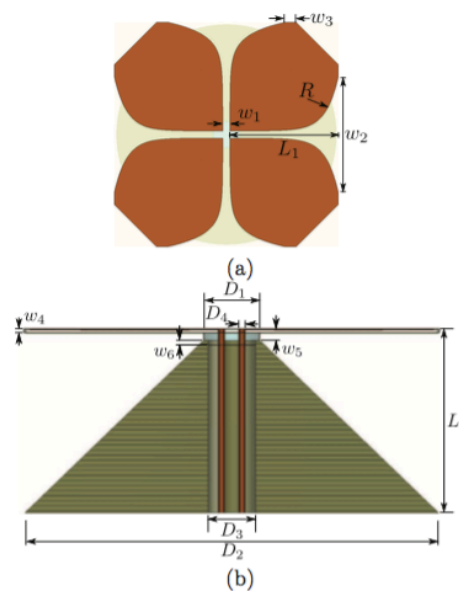


Figure 2: Conical QMA with integrated tapered slot antennas (a) top view of printed bow-tie elements with integrated TSAs (b) side view showing quadraaxial feed.