

Section A: Overview of the Research Project Proposal

- 1) **Title of research project:** Antenna Array Measurement Techniques
- 2) **Research Category:** Engineering
- 3) **Academic Level of research project:** PhD
- 4) **Primary supervisor's details:**
 - a. **Full name:** Dr Jacki Gilmore
 - b. **Email address:** jackivdm@sun.ac.za
 - c. **University:** Stellenbosch University
- 6) **Research project abstract/summary:**

For next-generation radio telescopes using large antenna arrays, precise knowledge of antenna element performance within the array environment is essential for both design optimisation and operational tasks such as array calibration. However, physically measuring these systems is a complex, time-consuming process prone to errors. This project aims to develop advanced data processing algorithms to extract accurate array performance indicators from simplified measurement procedures.

Section B: Details of the Research Project Proposal

- 1) **Scientific/engineering merit: describe the objectives of the research project, placing them in the context of the current key questions and understanding of the field. Link the proposed project to one or more of the SARA0 research priority areas for 2026, and explain in some detail how the proposed research will contribute to the priority area(s).**

For next-generation radio telescopes using large antenna arrays, precise knowledge of antenna element performance within the array environment is essential for both design optimisation and operational tasks such as array calibration. However, physically measuring these systems is a complex, time-consuming process prone to errors.

This project seeks to develop advanced data processing techniques that extract key array performance indicators from simplified measurement procedures, minimising the risk of

measurement errors. To achieve this, the project will leverage multi-exponential analysis using Prony's method as its mathematical foundation.

Envisioned minor contributions:

- A review figures-of-merit of antenna arrays for radio astronomy.
- A review of mathematical frameworks like multi-exponential analysis in the context of antenna array measurements.

Envisioned major contributions:

- Development of simplified measurement techniques for antenna arrays.
- Development of data processing algorithms for antenna array measurements.

Link to Priority Areas:

- Antenna, receiver, (analogue and digital) signal processing, data analysis and data recording systems associated with radio telescopes and geodesy instruments supported and hosted by SRAO.
 - The project aims to develop data analysis techniques for antenna arrays.
- Hardware, software, and data analytic systems associated with the control and monitoring of radio telescopes.
 - The data analysis techniques are envisioned to be relevant to telescope operating tasks like calibration.
- Engineering aspects of the testing, qualification and commissioning of radio telescopes and their prototypes.
 - The main objective of the project is to develop measurement techniques for antenna arrays used in radio telescopes.

2) Feasibility: outline the methods that will be used to achieve the objectives.

Commercial electromagnetic simulation software will be used to model antenna arrays in, and manufactured and measured at in-house facilities.

3) Skills development: Describe the skills the student will develop from the research project

This PhD project will develop the student's technical and research skills in antenna engineering. The student will gain experience in antenna array design, including array synthesis, mutual coupling analysis, and beamforming techniques. The project will involve mathematical modelling of electromagnetic systems to support analysis, design and characterisation. Practical skills will be developed through RF and antenna measurements, including the use of vector network analysers, radiation pattern measurements, and calibration procedures. The student will also build competence in electromagnetic simulation software for full-wave modelling and design validation,

and strengthen their MATLAB skills for numerical modelling, data analysis, and visualisation of results.

- 4) Provide details (and confirmation) on the availability of required data / access to required equipment / availability of research facilities and other resources required.**

A well-equipped antenna test range, all the required software tools, and an established workshop with qualified technical staff are available in-house at Stellenbosch University.

- 5) Include expected milestones and associated time-frames towards attaining the overall objectives of the Project.**

Semester 1: The student will complete a thorough literature study on antenna array measurement techniques and multi-exponential analysis. A research proposal will also be completed for approval by an examination panel.

Semester 2-3: Preliminary theoretical algorithm design and advanced simulation will take part in this semester.

Semester 4: Algorithm refinement, example array design and manufacturing. Initial array measurements and data processing.

Semester 5: Additional measurements and algorithm stress testing.

Semester 6: Final data analysis, and writing of dissertation.

- 5) If relevant, describe any particular qualifications, academic abilities, skills and/or experience that a student should have in order to successfully deliver on the objectives of the research proposed.**

Not Relevant

Jacki Gilmore

Curriculum Vitae

+2782 232 4016
jackivdm@sun.ac.za

Personal Information

Surname Gilmore
First Names Jacki
Maiden Name Van der Merwe
Nationality South African
Gender Female

Education

2013 – 2015 **PhD (Electronic Engineering)**, Stellenbosch University
Graduated March 2016

2008 – 2009 **MScEng (Electronic) Cum Laude**, Stellenbosch University
Graduated March 2010

2004 – 2007 **BEng (Electrical & Electronic)**, Stellenbosch University

PhD Dissertation

title *Design of a Dual-Polarized Dense Dipole Array for the SKA Mid-Frequency Aperture Array*
supervisor Prof DB Davidson

Master's Thesis

title *The Effect of Mutual Coupling on the Noise Performance of Large Antenna Arrays*
supervisor Prof KD Palmer

Additional Postgraduate Courses and Short-courses attended

2016 **Antennas for Radio Telescopes**, Stellenbosch University
European School of Antennas

2013 **Radio Astronomy for Engineers**, Stellenbosch University
By Prof DB Davidson

2009 **Multi-field and Multi-beam science with the SKA**, University of Oxford
MCCT-SKADS Workshop

2008 **Antennas**, Stellenbosch University
By Prof KD Palmer

2008 **Radio-Astronomy: Fundamentals and New Instruments**, University of Alcalá
MCCT-SKADS Workshop

Languages

Afrikaans Native/Bilingual Ability
English Native/Bilingual Ability
German Conversational

Goethe-Zertifikat Level B2 Passed in 2009

Experience

Lecturing Experience

2021 – 2023 **Senior Lecturer**, *Stellenbosch University*

Undergraduate teaching responsibilities and approximate class sizes:

Systems and Signals 214 (Lectures, Practicals and Tutorials for 160 students)

Design E314 (Practicals for 220 students)

Electro-Techniques 143 (Module Convenor for 1000 students)

Electronics 365 (Lectures, Practicals and Tutorials for 100 students)

Electromagnetics 344 (Lectures, Practicals and Tutorials for 130 students)

Supervision of final-year projects.

Other undergraduate teaching-related experience and projects:

Took part in the restructuring of the module chain for Electronics. Was responsible for defining the module content for Systems and Signals 214

Ran various “Blended-Learning” projects.

Postgraduate Teaching:

Postgraduate Antenna Course

Postgraduate HF Simulation and Measurements Course

Research supervision of masters and doctoral students

2016 – 2021 **Lecturer**, *Stellenbosch University*

2015 – 2016 **Junior Lecturer**, *Stellenbosch University*

Research

2019 – 2023 **Associate Editor**, *URSI Radio Science Letters*

2017 – 2023 **Early Career Representative**, *International Union of Radio Science (URSI)*

Commission J - Radio Astronomy

2015 – present **Reviewer for International Journals**

IEEE Transactions on Antennas and Propagation

URSI Radio Science

URSI Radio Science Letters

2015 – present **Reviewer for International Conferences**

European Conference on Antennas and Propagation (EuCAP)

URSI General Assembly (GASS)

URSI Atlantic Radio Science Meeting (AT-RASC)

URSI Pacific Radio Science Meeting (AP-RASC)

Industry Experience

January 2013 **Consultant (Part Time)**, *Shrike Marine*, Cape Town

– March 2013 Oversee environmental qualification tests and compile configuration documentation for a military project.

October 2011 **Development Engineer**, *Shrike Marine*, Cape Town

– December 2012 Design and build electronic equipment for military applications. Write development specifications and compile and maintain other relevant configuration documentation.

June 2011 **Technical Support Engineer**, *Kathrein South Africa*, Stellenbosch

– October 2011 Provide technical support to sales personnel and clients on Kathrein products. Source products and suppliers for products outside the standard Kathrein portfolio. Provide technical insight into competitor products for comparison.

November 2009 **Researcher/Engineer**, *Stellenbosch University*, Stellenbosch

– May 2011 Design and build electronic equipment for medical applications.

Journal Publications

- 2025 V. V. Tonder, L. Schwardt, A. Faustmann, J. Gilmore, S. Büchner and M. Geyer, "Increasing Pulsar SNR by Using Spectral Kurtosis as a Radio Frequency Mitigation Technique", Journal of Astronomical Instrumentation (accepted)
- 2023 A Faustmann, L Schwardt, V van Tonder, J Gilmore, S Buchner, "Investigating the high time-resolution statistics of pulsar radio signals using spectral self-noise", Monthly Notices of the Royal Astronomical Society
- 2021 C. R. Wilke, S. J. Wijnholds and J. Gilmore, "Calibratability of Mid-Frequency Aperture Arrays with Self-Holography," in Journal of Astronomical Telescopes, Instruments, and Systems
- 2021 C. R. Wilke, S. J. Wijnholds and J. Gilmore, "Calibratability of Aperture Arrays Using Self-Holography," in IEEE Transactions on Antennas and Propagation
- 2020 A. Faustmann, J. Gilmore, V. van Tonder, M. Serylak, "A Bispectral Analysis of the Radio Emissions of Pulsar J0437-4715", Journal of Astronomical Instrumentation
- 2015 J. Gilmore and D.B. Davidson, "Suppressing Undesired Common-mode Resonances in Connected Antenna Arrays", IEEE Transactions on Antennas and Propagation

Conference Publications

- September 2025 J. Gilmore, "Determining Uniform Planar Array Mutual Coupling Terms Through Multi-Exponential Analysis," 2025 International Conference on Electromagnetics in Advanced Applications (ICEAA), Palermo, Italy, 2025, pp. 0173-0177
- August 2025 J. Gilmore, "Determining Uniform Linear Array Mutual Coupling Terms Through Multi-Exponential Analysis," 2025 URSI Asia-Pacific Radio Science Meeting (AP-RASC), Sydney, Australia, 2025, pp. 1-4
- August 2025 A. Bothma, J. Gilmore and P. G. Wiid, "Expanding the Lowest Usable Frequency of Reverberation Chambers Through Stirrer Design," 2025 URSI Asia-Pacific Radio Science Meeting (AP-RASC), Sydney, Australia, 2025, pp. 1-4
- August 2025 A. Bothma, J. Gilmore, P. G. Wiid and S. Tshongweni, "Reverberation Chamber Design Optimization," 2025 International Symposium on Electromagnetic Compatibility – EMC Europe, Paris, France, 2025, pp. 1142-1147
- July 2024 S. Manas and J. Gilmore, "Measuring the Noise Figure of Active Integrated Receivers Inside a Reverberation Chamber," 2024 IEEE International Symposium on Antennas and Propagation and INC/USNC-URSI Radio Science Meeting (AP-S/INC-USNC-URSI), Firenze, Italy, 2024, pp. 2565-2566
- October 2023 S. Snyman and J. Gilmore, "Wideband Antenna Design for Time Domain RFI Measurements," 2023 International Conference on Electromagnetics in Advanced Applications (ICEAA), Venice, Italy, 2023, pp. 399-402
- August 2023 V. van Tonder, L. Schwardt, A. Faustmann, J. Gilmore and S. Büchner, "Spectral Kurtosis applied to tied-array beamformer for pulsar observations," URSI GASS 2023 XXXVth General Assembly and Scientific Symposium, 2023, pp. 1-4
- March 2023 S. Manas and J. Gilmore, "Using a Reverberation Chamber to Estimate the Noise Figure of Integrated Low Noise Amplifiers," 2023 17th European Conference on Antennas and Propagation (EuCAP), Florence, Italy, 2023, pp. 1-4
- May 2022 V. van Tonder, L. Schwardt, A. Faustmann and J. Gilmore, "Bispectra of simulated GPS data for potential RFI mitigation," 2022 3rd URSI Atlantic and Asia Pacific Radio Science Meeting (AT-AP-RASC), 2022, pp. 1-4
- May 2022 A. Faustmann, L. Schwardt, V. van Tonder, J. Gilmore and S. Buchner, "A Short-Time Stationarity Test of Radio Signals From the Vela Pulsar Using Polyspectra," 2022 3rd URSI Atlantic and Asia Pacific Radio Science Meeting (AT-AP-RASC), 2022, pp. 1-4

- March 2022 S. Manas, J. Gilmore and E. Meyer, "A Local Hot-Cold Antenna Measurement System," 2021 51st European Microwave Conference (EuMC), 2022, pp. 510-513
- March 2021 Alexander Faustmann, Jacki Gilmore, Vereesè van Tonder, Maciej Serylak, "Higher-Order Spectral Analysis of Radio Pulsar Bursts Using MeerKAT", 2021 15th European Conference on Antennas and Propagation (EuCAP), Online
- August 2020 C. R. Wilke, S. J. Wijnholds and J. Gilmore, "Self-Holography- Slimming Down Calibration of Large Aperture Arrays," 2020 XXXIIIrd General Assembly and Scientific Symposium of the International Union of Radio Science, Rome, Italy
- August 2020 A. Faustmann, J. Gilmore "An Investigation of Nonlinear Adaptive Space-Time Processing for the Real-Time Detection of Extraterrestrial Transients", 2020 XXXIIIrd General Assembly and Scientific Symposium of the International Union of Radio Science, Rome, Italy
- September 2019 Helgard Oosthuizen, Jacki Gilmore "SLM 3D-Printed Active Phased Array for X-Band Satellite Communications", 2019 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), Granada, Spain
- September 2019 Kobus Kotzé, Jacki Gilmore "SLM 3D-Printed Horn Antenna for Satellite Communications at X-band", 2019 IEEE-APS Topical Conference on Antennas and Propagation in Wireless Communications (APWC), Granada, Spain
- September 2019 Kristian Zarb Adami, Andrew Faulkner, Eloy de Lera Acedo, Nima Razavi-Ghods, Hardie Pienaar, Jens Abraham, Edgar Colin-Beltran, Keith Grainge, Anthony K Brown, David Zhang, Laith Rashid Danoon, David Prinsloo, Rui Cao, Dirk de Villiers, Jacki Gilmore "The Mid-Frequency Aperture Array", 2019 International Conference on Electromagnetics in Advanced Applications (ICEAA), Granada, Spain
- March 2019 C.R. Wilke, S.J. Wijnholds, J. Gilmore "Performance Improvement of Self-Holography Based Aperture Array Station Calibration", 2019 13th European Conference on Antennas and Propagation (EuCAP), Krakow, Poland
- October 2018 D.B. Davidson, A. Sutinjo, R. Wayth, D. Ung, D.I.L. de Villiers, J.G. bij de Vaate, R. Baelemans, A.B. Smolders "Recent Progress on the Design of Aperture Arrays for Radio Astronomy", 2018 IEEE Radio and Antenna Days of the Indian Ocean (RADIO), Grand Port, Mauritius
- May 2018 C. R. Wilke, J. Gilmore "Quantization and Mutual Coupling Effects on Beamforming in Dense Phased Arrays", 2nd URSI Atlantic Radio Science Meeting (URSI AT-RASC), Gran Canaria, Spain
- May 2018 C.J Smale, J. Gilmore "Thermal Analysis of a Dense Dipole Array for the SKA Mid-Frequency Aperture Array", 2nd URSI Atlantic Radio Science Meeting (URSI AT-RASC), Gran Canaria, Spain
- September 2017 C. R. Wilke, J. Gilmore and D. B. Davidson "Reducing the maximum quantization scan error in dense phased arrays", 2017 International Conference on Electromagnetics in Advanced Applications (ICEAA), Verona, Italy
- June 2017 J. Gilmore, K.E. Wolff and M. Bladergroen "The night before the test: Electrical engineering students' use of online resources to prepare for assessment", 4th Biennial Conference of the South African Society for Engineering Education (SASEE), Cape Town, South Africa
- April 2017 J. Gilmore, C.R. Wilke and D.B. Davidson "Calculating the maximum quantization scan error in dense phased arrays", European Conference on Antennas and Propagation (EuCAP), Paris, France
- April 2016 J. Gilmore, D. B. Davidson and J. G. B. de Vaate, "Progress on the development of a dual-polarized dense dipole array for the SKA mid-frequency aperture array," 2016 10th European Conference on Antennas and Propagation (EuCAP), Davos, 2016, pp. 1-2.
- July 2015 J. Gilmore and D.B. Davidson, J.E. Noordam "A Dense Dipole Array for Mid-Frequency Aperture Arrays", 2015 IEEE International Symposium on Antennas and Propagation & USNC/URSI National Radio Science Meeting, Vancouver, Canada

April 2014 J. Gilmore and D.B. Davidson, "A Review of Full-Wave and Reduced-Order Modelling Methodologies for Dense Aperture Arrays", European Conference on Antennas and Propagation (EuCAP), The Hague, Netherlands

Postgraduate Supervision

Doctoral Students

Name of student	Nationality	Starting Date	Graduation Date (Projected if unfinished)	Project Title	Co-Supervisor
Cornelis Wilke	South African	January 2018	December 2021	Efficient Multi-Beam Calibration of Antenna Arrays	Prof. Stefan Wijnholds (ASTRON)
Lanche Grootboom	South African	February 2020	March 2027	Development of an Integrated Array Receiver for Radio Astronomy	Prof. Petrie Meyer
Alexander Faustmann	South African	January 2021	March 2023	Detection of Weak Radio Pulsars Using Non-Gaussian Statistics	Dr. Ludwig Schwaradt (SARAO)
Vereese van Tonder	South African	January 2021	December 2024	Radio Frequency Interference Mitigation for Pulsar Pipelines using Higher Order Statistics	Dr. Ludwig Schwaradt (SARAO)
Sean Manas	South African	March 2021	March 2027	Using a Reverberation Chamber as an Evaluation Tool for Integrated Receiver Systems	

Masters Students

Name of student	Nationality	Starting Date	Graduation Date (Projected if unfinished)	Project Title	Co-Supervisor
Cornelis Wilke	South African	January 2016	March 2018	Quantization Effects on Beamforming in Dense Phased Arrays	Prof. David Davidson
Corey Smale	South African	January 2017	March 2019	Thermal Analysis of a Dense Dipole Array for the SKA Mid-Frequency Aperture Array	
Helgard Oosthuizen	South African	January 2018	March 2020	Active Antenna Array Design using Additive Manufacturing Techniques	
Sean Manas	South African	January 2019	March 2021	Design of a Hot/Cold Antenna measurement facility	Dr Elmine Meyer (TU/e)
Dylan Fry	South African	January 2019	December 2021	Differential LNA Design for the SKA Mid-Frequency Aperture Array	Dr Elmine Meyer (TU/e)
Alexander Faustmann	South African	January 2019	PhD Upgrade: November 2020	Higher-Order Spectral Analysis of Radio Pulsar Bursts	
Millicent Mguni	South African	January 2019	March 2022	Portable RFI Detection System	Dr Gideon Wiid (CPUT) Dr Arno Barnard
Aneshka Bothma	South African	January 2020	March 2025	Reverberation chamber stirrer design	Dr Gideon Wiid (UCT)
Shane Hattingh	South African	January 2020	March 2023	Design of an Active Dense Dipole Array for the SKA Mid-Frequency Aperture Array	
Sandra Snyman	South African	January 2022	December 2023	Wide-Band Antenna Design for Time-Domain Measurements in a Reverberation Chamber	
Daniël Theron	South African	January 2025	December 2026	Design of a Patch Antenna Array for Satellite Communications	
Roche Faure	South African	January 2025	December 2026	Sensitivity analysis of CSRR sensor based on polynomial chaos expansion	Dr Leanne Bodenstein
Zulfik Salie	South African	January 2026	December 2027	Reconfigurable Planar Filtenna for Sub-Array Applications	Dr Leanne Bodenstein



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Electrical & Electronic Engineering
Elektriese & Elektroniese Ingenieurswese

26 February 2026

To whom it may concern

Confirmation of Data Collection Facilities for Postgraduate Research

This letter is to confirm that the Department of Electrical and Electronic Engineering at Stellenbosch University has the following software licences and data collection facilities available for postgraduate research.

Software Licences for Full-Wave Electromagnetic Simulations:

- Altair Feko
- CST Microwave Studio
- Ansys HFSS

Software Licenses for RF system design:

- AWR Microwave Office
- Keysight ADS

Software License for Asymptotic Electromagnetic Analysis:

- GRASP by TICRA

Software License for Data Analysis and Mathematical Modelling:

- MATLAB

RF Measurement Equipment and Facilities

- Vector Network Analysers
- Spectrum Analysers
- RF Signal Generators
- Oscilloscopes
- Anechoic Antenna Measurement Range
- Reverberation Chamber

Kind regards,

Dirk de Villiers