An Update on Research Activities at the Group for Solar Energy Thermodynamics

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STERG Symposium – 13 July 2017

Presentation Outline

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- Introduction to GSET
- Broadband Radiometry
- Thermal Systems Analysis
- Concentrator Development
- The SERAFF Solar Furnace
- Future Activities

- GSET is a small research group, with fairly limited financial and human resources
- Academic staff compliment: Jean Pitot (lecturer) and Dr Michael Brooks (senior lecturer)
- Current postgraduate student complement: two MSc Eng students
- Our research focuses on:

Broadband Radiometry

Thermal Systems Analysis

Concentrator Development

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Measurement Equipment

- Two active ground stations at UKZN (Howard College and Westville campuses)
- Howard College: Eppley PSPs, perforated band system, Eppley NIP, Kipp and Zonen CH1, CMP11s and CUV5 ultra violet sensor (280 to 400 nm)
- Westville: SOLYS tracker, CMP11s and CH1

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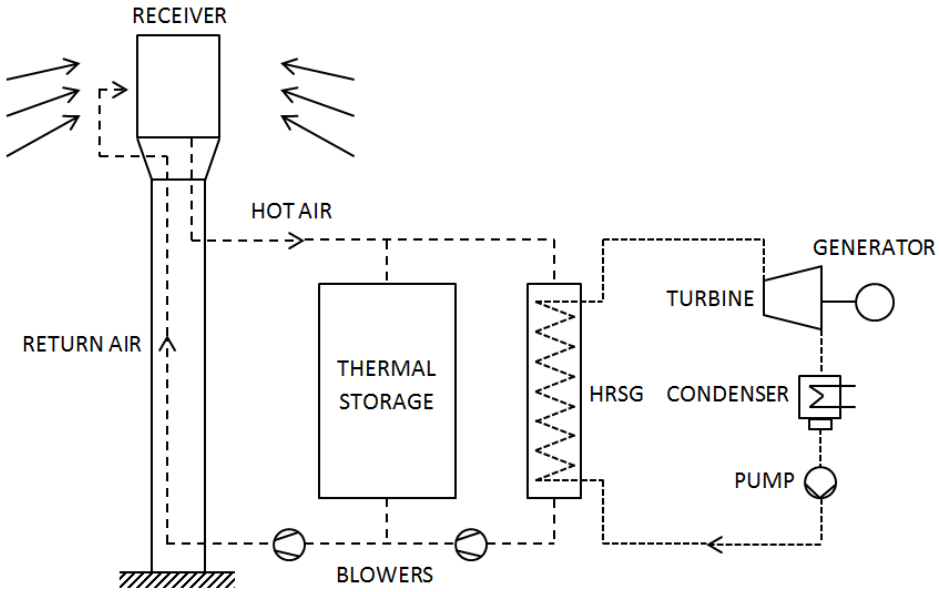
Southern African Universities Radiometric Network (SAURAN)

- Over 4 years of data now available
- GSET remains active on SAURAN steering committee

Code	Name	Location	Latitude °	Longitude °	Elevation	Data Record (Years/Months)							
						Topography	2010	2011	2012	2013	2014	2015	2016	2017
KZH	University of KwaZulu-Natal Howard College	Durban, South Africa	-29.87098	30.97695	150 m	Roof of Desmond Clarence building	0	0	0	11	12	12	12	7
KZW	University of KwaZulu-Natal Westville	Durban, South Africa	-29.81694	30.94492	200 m	Roof of Physics building	0	0	0	9	12	12	12	7

Performance Modelling of an Open Volumetric Receiver CSP Plant Incorporating Rock Bed Thermal Storage



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Performance Modelling of an Open Volumetric Receiver CSP Plant Incorporating Rock Bed Thermal Storage

- AIM: develop better understanding of how large OVR plants with rock bed storage perform
- Three main modelling tasks:
  - Assessing thermodynamic interaction between receiver, air distribution system and power block
  - Assessing viability of LTE assumption in modelling rock beds
  - Performance of annual plant parametric studies
- Modelling undertaken using EES and SolarPILOT

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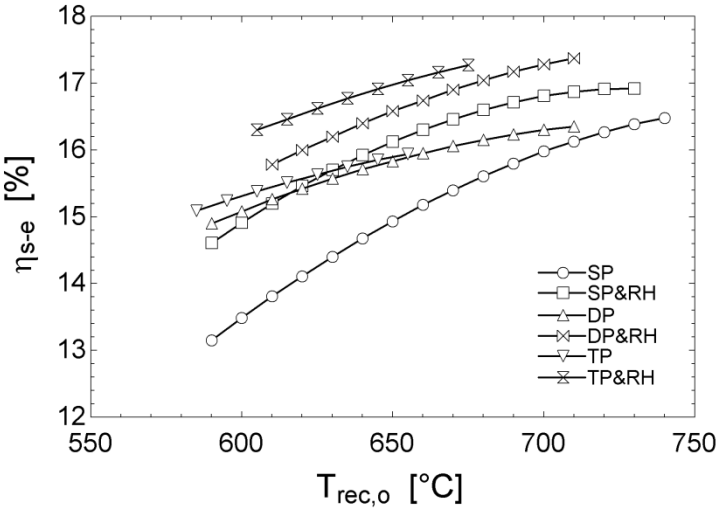
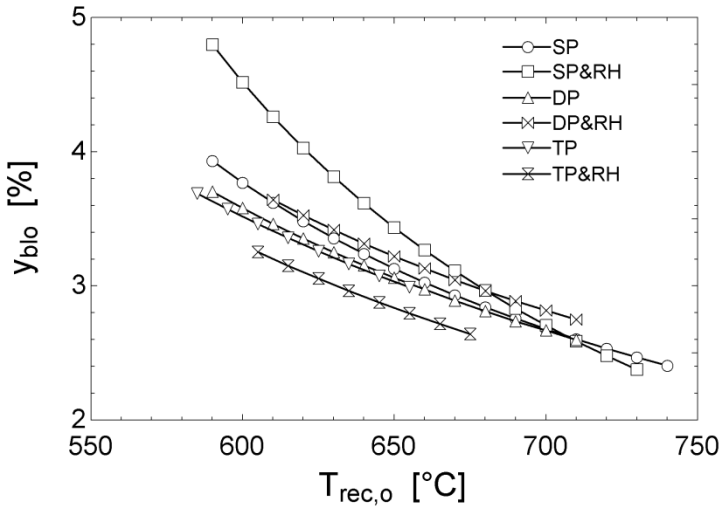
Performance Modelling of an Open Volumetric Receiver CSP Plant Incorporating Rock Bed Thermal Storage





Performance Measure	LTE Model	LTNE Model	Deviation
Exergy Yield [J]	5.75E+14	5.73E+14	+0.4 %
Generation Time [h]	1055	1062	-0.7 %
Blowing Work [J]	3.42E+12	3.50E+12	-2.1 %
Simulation Time [s]	6234	19047	-67 %

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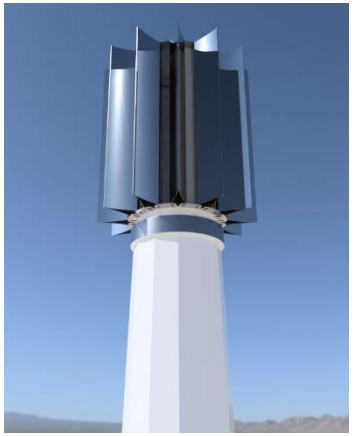
Thermofluid Performance Characterisation of Recessed-Absorber Open Volumetric Receivers (Mathew Jo Mathew)

- Currently, OVR performance limited by incomplete air re-entrainment
- AIM: assess the potential for ARR improvement by recessing absorber module within CPC
- CFD-based modelling with STAR-CCM+
- Discussed in greater detail in Mathew's presentation later this afternoon



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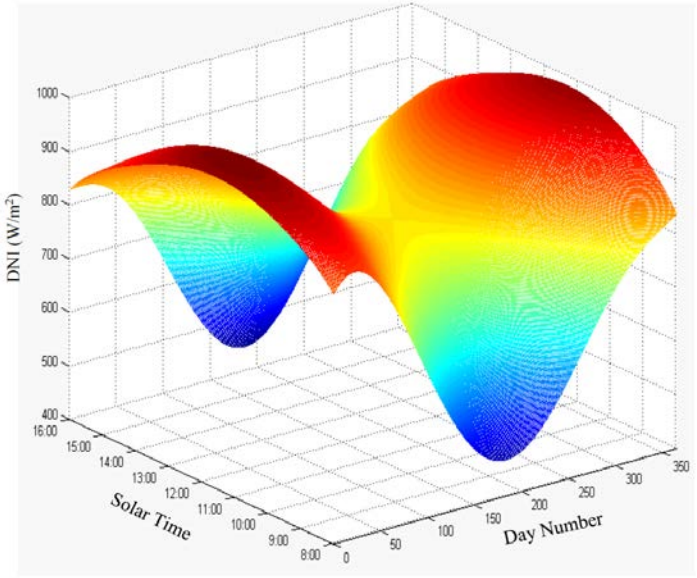
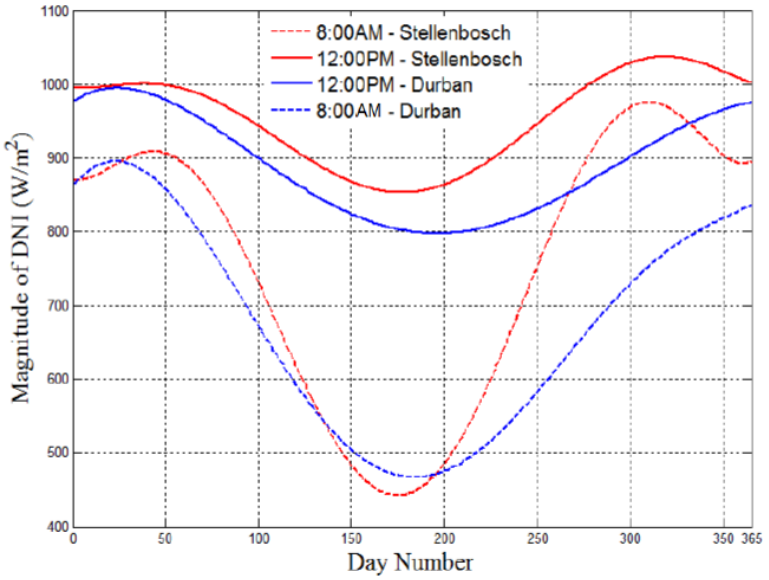
Development of a Solar Furnace Heliostat (Preyen Perumall, 2016)

- Non-concentrating 9 m^2 heliostat → first piece of the SERAFF puzzle
- Azimuth: slew drive; Elevation: linear actuator
- Labview/NI control system

Development of a Solar Furnace Heliostat (Preyen Perumall, 2016)

- Temporal Direct Normal Irradiance Topograph (TDT): new technique for clear sky solar resource prediction





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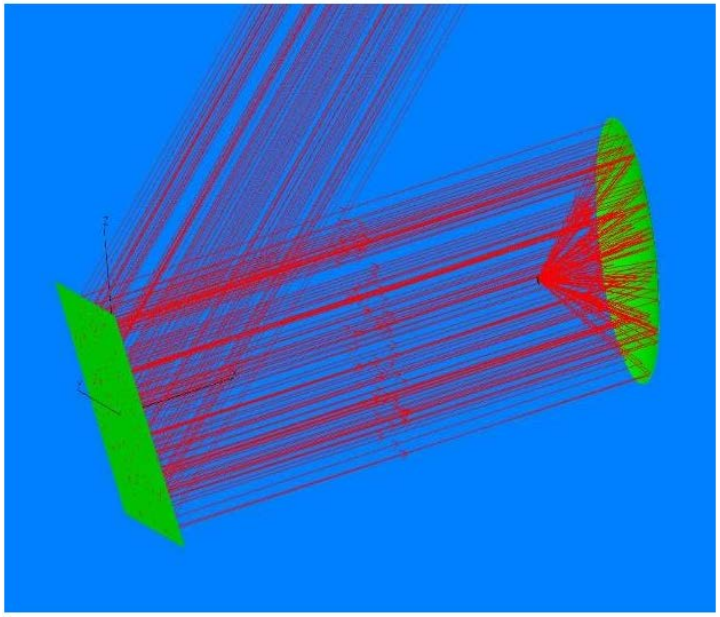
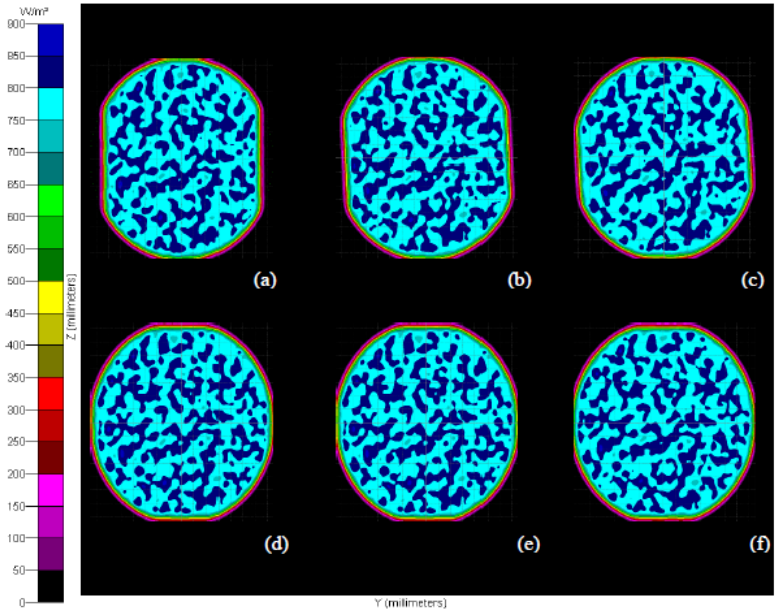
Development of a Solar Furnace Heliostat (Preyen Perumall, 2016)

- Ray-tracing for optical performance analysis





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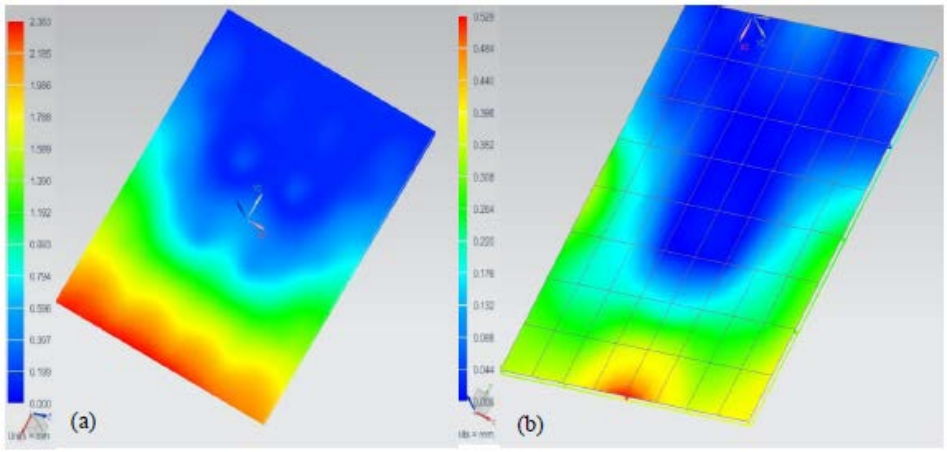
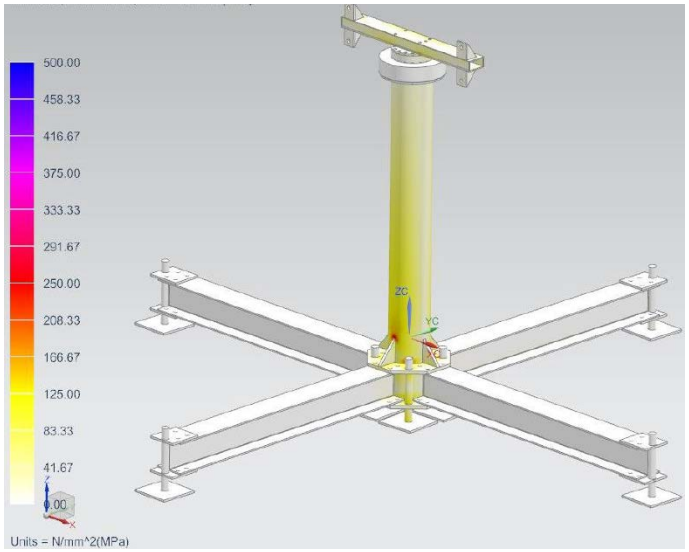
Development of a Solar Furnace Heliostat (Preyen Perumall, 2016)

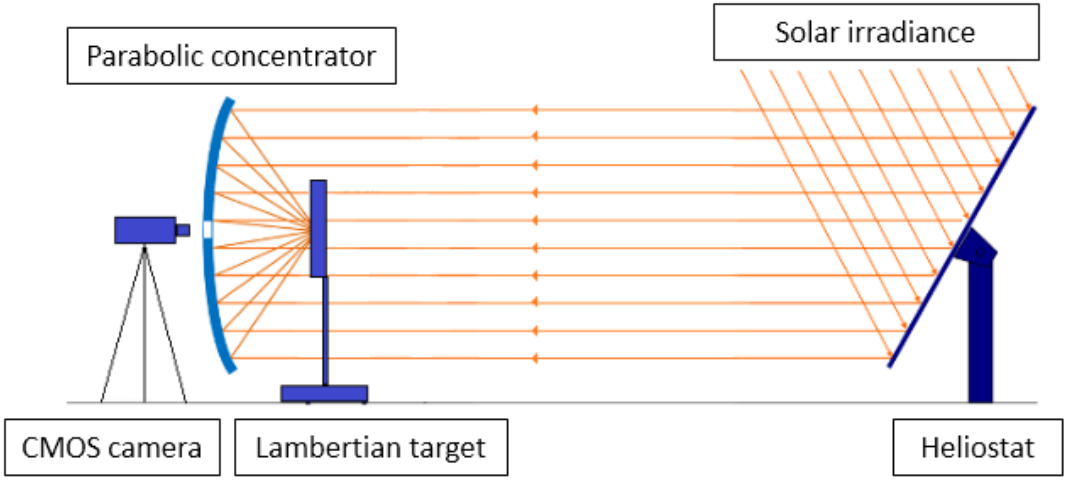
- FEA for optical deflection and survivability predictions





Development of a High Concentration Solar Flux Sensor (Brandon van Bakel)

- Developed to support SERAFF operations
- Flux image generation using CMOS camera
- To evaluate: total incident radiation; max. and avg. concentrations; optical efficiency; misalignment errors



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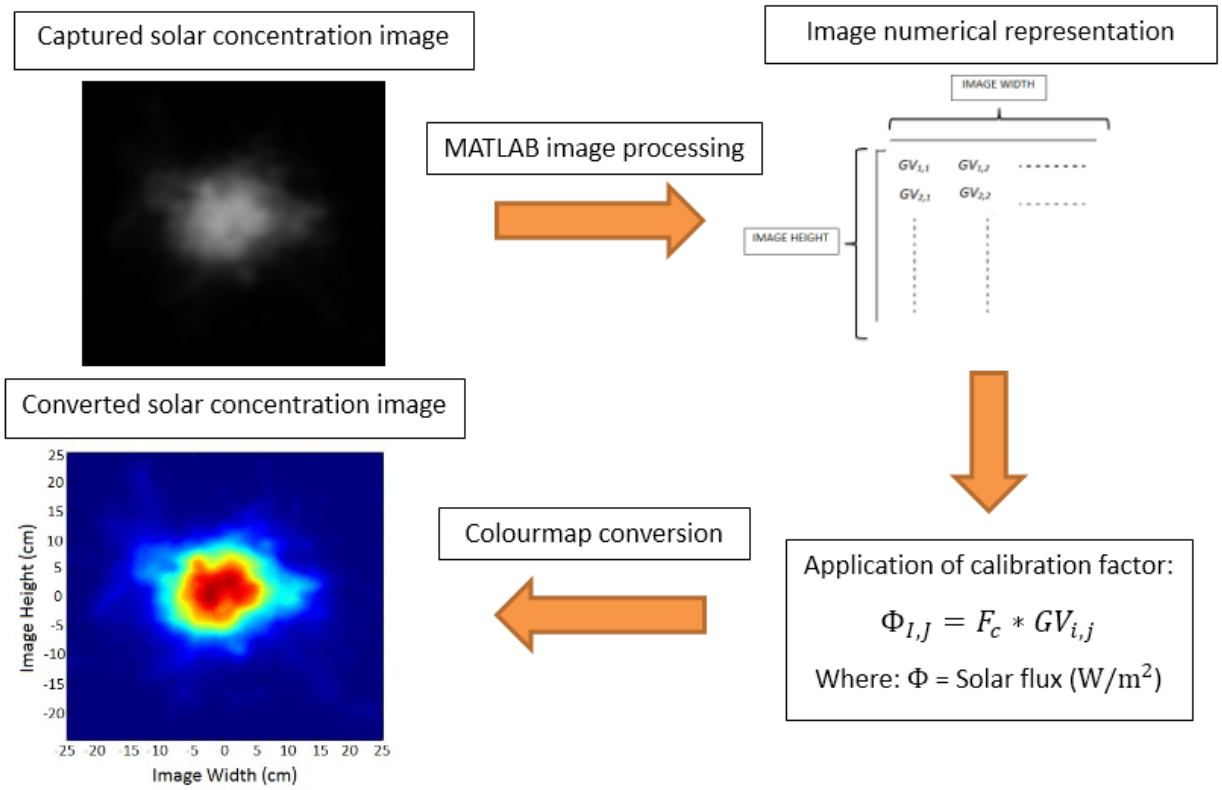
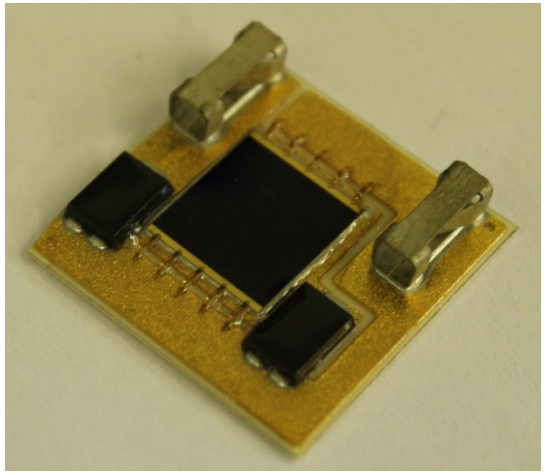
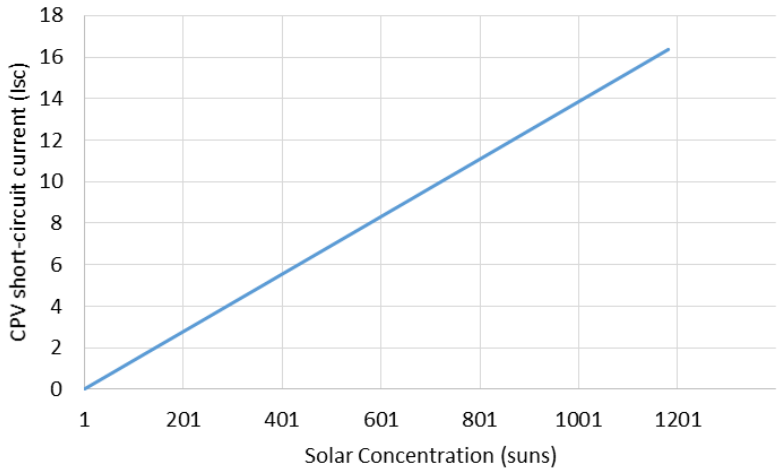


Development of a High Concentration Solar Flux Sensor (Brandon van Bakel)

- Image calibration with concentrating triple-junction PV cell (1 to 1182 suns)
- Co-calibration with Gardon gauge





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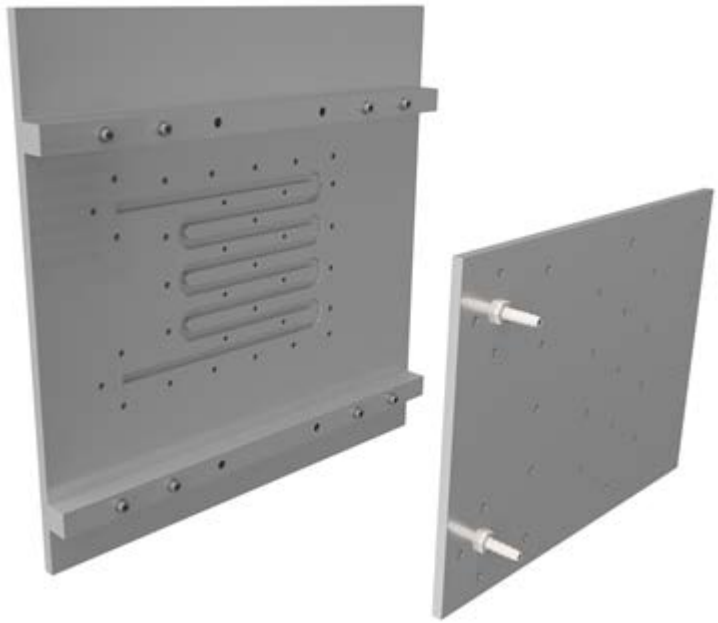
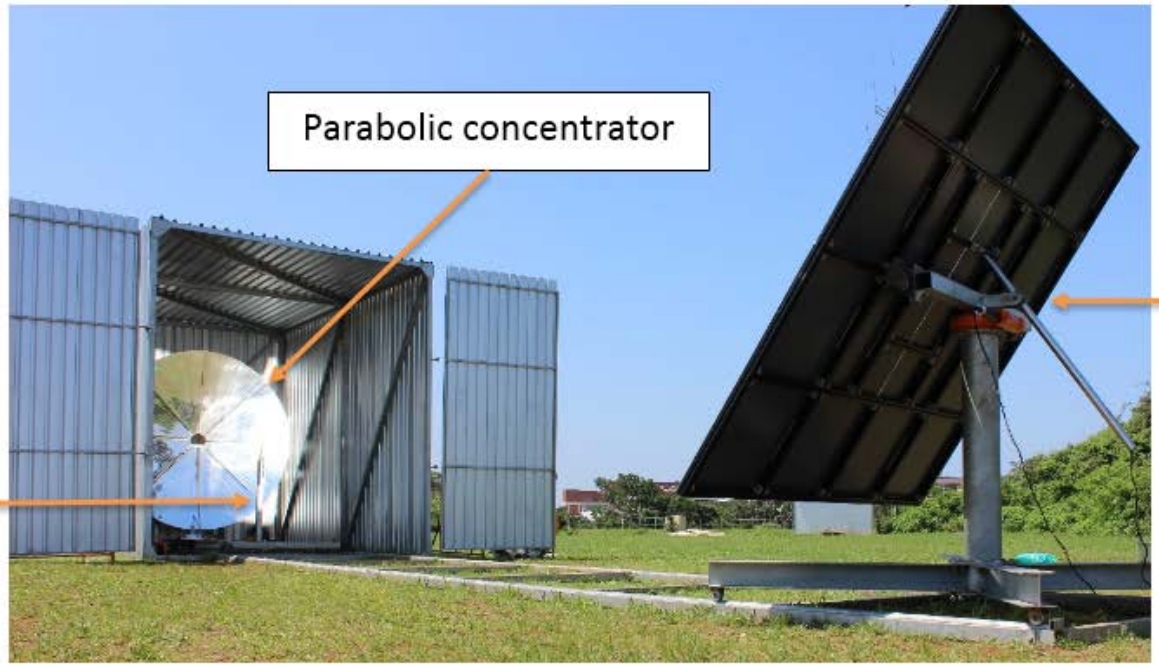


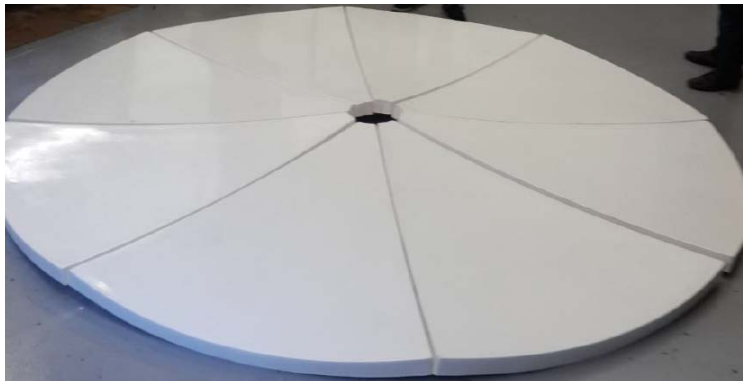
Solar Research Amplified Flux Facility (SERAFF)

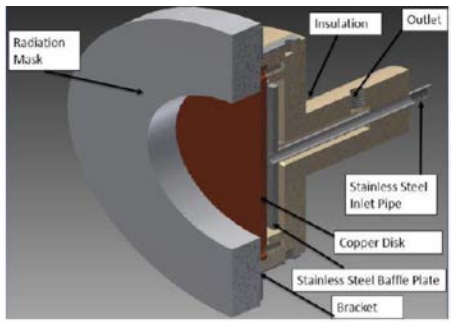
- GSET's flagship project
- Current capacity: at least 4 kW; eventual capacity: at least 5 kW
- Peak flux: approx. 2 MW/m; spot size: approx. 12 cm



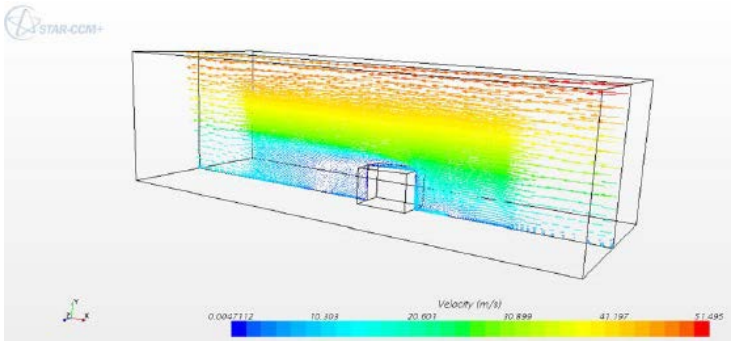
Location at Howard College Campus

2015 FYP Developments

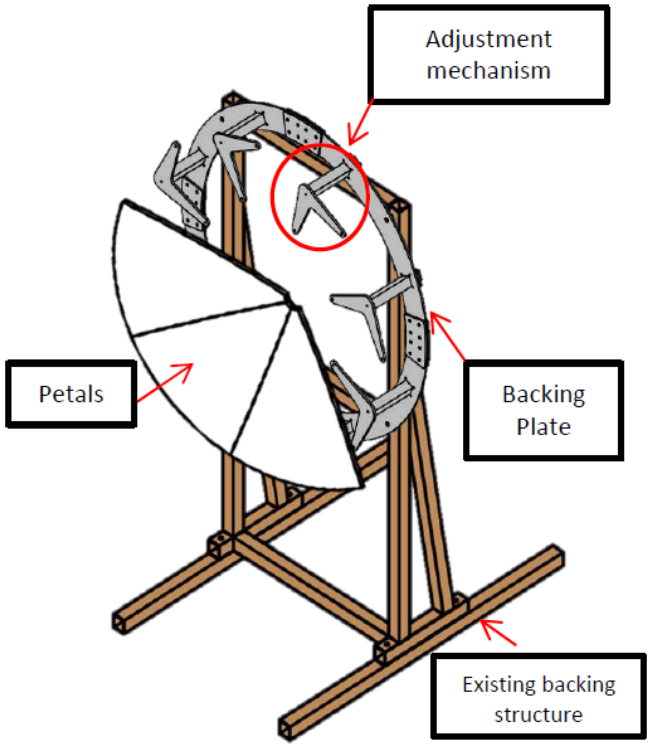


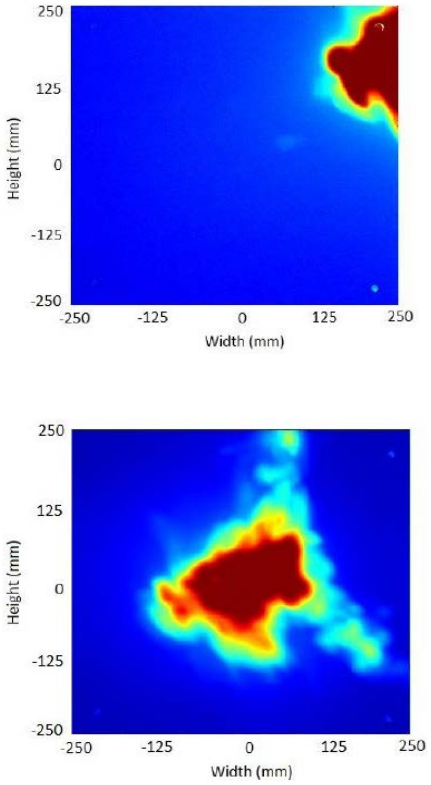


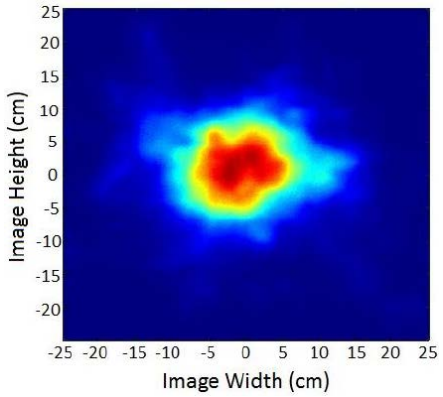
2015 FYPDevelopments



2016 FYP Developments







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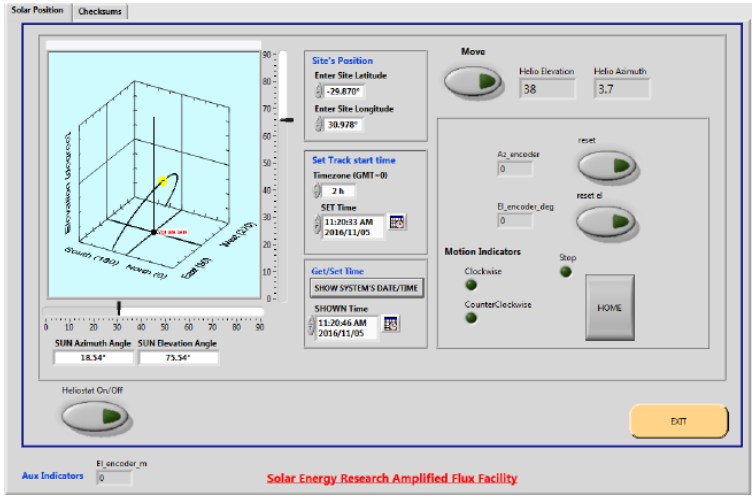
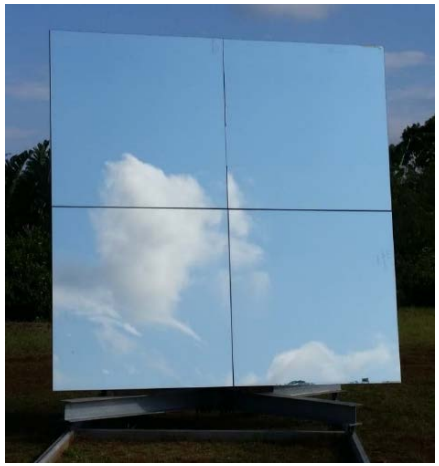
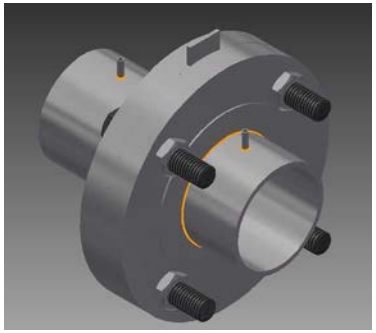




Current Developments

- Open volumetric receiver test rig
- Off-grid PV power supply
- Unified DAQ&C system



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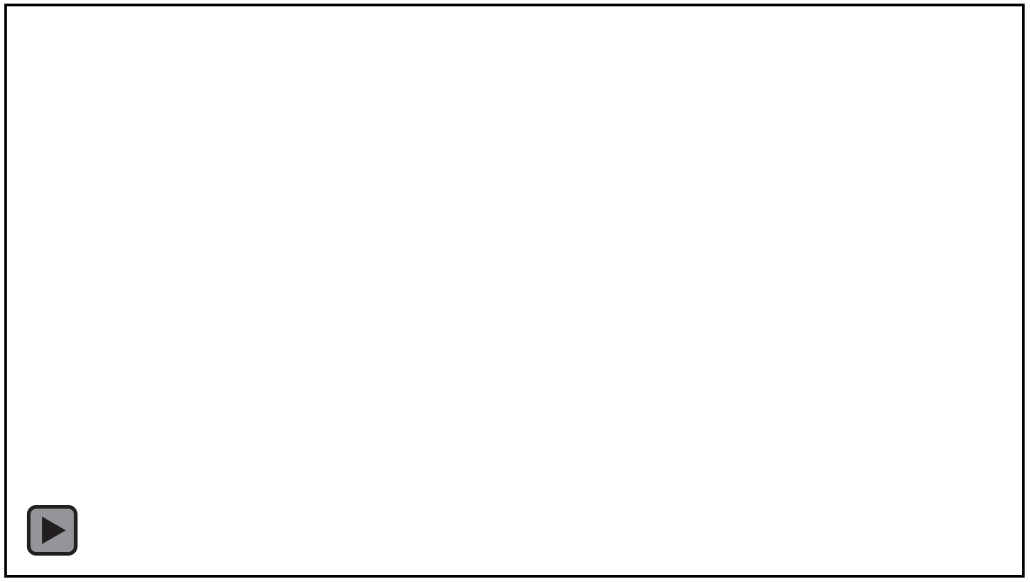
- SERAFF: heliostat and primary concentrator upgrades; collaborative work
- Broadband Radiometry: UV resource assessment
- Thermal Systems Analysis: modelling and testing of novel OVR absorbers; OVR ARR enhancement; modelling of novel OVR configurations and OVR-based solarised gas turbine plants



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Please join us in Durban for SASEC 2018!

Provisional Dates: 25 – 27 June 2018

SASEC2018

5th Southern African Solar Energy Conference
June 2017 | Durban, South Africa