The SAAO Future
“An Intelligent Observatory”

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SAAO intro
SALT + SAAO facilities
Steps into the future
Strategic science areas
SALT 1.5 and 2.0
South African Astronomical Observatory – Cape Town

- The premier optical astronomy facility on the African continent
- Part of National Research Foundation
- Founded 1820
Sutherland observing station

400 km from Cape Town
Semi-arid Karoo region
Research telescopes
Support staff and facilities
Hosted facilities
Dark site, modest seeing
# Sutherland Telescopes
(our own or guest, many with SA access)

<table>
<thead>
<tr>
<th>Telescope</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>SALT ; 1.9 m ; 1.0 m ; Lesedi</td>
<td>imaging, med/high-R spect., high speed modes, MOS, FP, im/spec polarimetry, wide field imaging</td>
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<tr>
<td>IRSF</td>
<td>Japanese 1.4 m IR imaging / polarimetry</td>
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SAAO Instrument Suite

- 1-m telescope, Lesedi
- SHOC (Sutherland High-speed Optical Camera)
- WiNCam (Wide-field Near Infrared Camera; August 2010)
- 40-inch telescope
- SHOC (Sutherland High-speed Optical Camera)
- STE3/STEREO

SAAO Instrument Suite

- 74-inch telescope
  - SpUpNIC (Spectrograph Upgrade Newly Improved Cassegrain)
  - SHOC (Sutherland High-speed Optical Camera)
  - HIPPO (High-speed Photo Polarimeter)
  - GIRAFFE (high-resolution fiber-fed Echelle)
SAAO Instrument Suite

- 1-m telescope, Lesedi
- SHOC (Sutherland High-speed Optical Camera; commissioning & science mountings)
- WiNCam (Wide-field Nasmyth Camera; Aug. 2018)

High-throughput, low-resolution spectrograph (collaboration with Liverpool John Moores Univ.; Aug. 2018)
SAAO Instrument Suite

- 1-m telescope, Lesedi
- SHOC (Sutherland High-speed Optical Camera)
- WiNCam (Wide Field Camera; August 2007)

SAAO Instruments

- 40-inch telescopes
- SHOC (Sutherland High-speed Optical Camera)
- STE3/STE4 (Imaging cameras)
- WALOP (Wide Area Linear Optical Polarimeter; collaboration with IUCAA, arriving end 2018)

74-inch telescope

- SpUpNIC (Spectrum Upgrade Newly Installed Cassegrain)
- SHOC (Sutherland High-speed Optical Camera)
- HIPPO (High-speed Polarimeter)
- GIRAFFE (high-resolution fiber-fed Echelle)
SALT

The largest optical telescope in the Southern Hemisphere – 11-m primary mirror

On its 15\textsuperscript{th} Science Semester currently
SALT is working well right now, producing science ~50 papers per year very cost-effectively
TELESCOPES WORKING TOGETHER
Birth of multi-messenger astronomy
Multi-wavelength astronomy
Steps to the Intelligent Observatory

1. Remotely operable telescopes
2. Service mode capabilities
3. Robotic capabilities
4. Networked autonomous operations
Remote observing

• Have operated three telescopes simultaneously from Cape Town so far
• Remote obs is strongly encouraged
• Next step: from elsewhere
•Needs instrument selectors
Remote observing

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Remote observing

• Have operated three telescopes simultaneously from Cape Town so far
• Remote obs is strongly encouraged
• Next step: from elsewhere
• *Needs instrument selectors*
Service Mode Operations
Service Mode Operations
Service Mode Operations

- SALT has done this for a decade +
- Next on other telescopes individually; Then on a pool of telescopes
- Smart and flexible Observing queues; Simulations, data delivery
Robotic capabilities

Making Robotic telescopes is a large software effort. **Existing robotic ones in boldface. [upcoming]**

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Make the whole mountain top a Giant Transient AI machine

The ‘Intelligent Observatory Project’
Networked autonomous observations

- The ultimate goal
- Making Robotic telescopes of different sizes and types and modes work together smartly is a massive software effort
SAAO Future: strong Instrumentation & Software Development
SCIENCE STRATEGY –
FOCUS AREAS
I - Understanding fundamental physics and the nature of the universe

Transient and time-domain astronomy

- Long history in SA astronomy
- New era beginning: MeerKAT/MeerLICHT, SKA, LSST, and LIGO / VIRGO

Cutting edge of fundamental astrophysics
II - Tracking the flow of matter from stars and galaxies to us

Galaxy Evolution and The Baryon Cycle

• Spatially resolved spectroscopy. IFUs, ideally deployable. Will look for funding.

(DOTIFS: Chung, et al.)
III - Finding life in the universe

Exo-planets

“Cosmology has driven the construction of big telescopes for the past 100 years. The search for life will drive the construction of big telescopes for the next 100 years” - Chas Beichmann

We cannot afford to NOT be part of this field!

And we already have an instrument for it

(image: ESO/M.Kornmesser)
SALT Science Strategy – roadmap and lessons

• **Generation 1.5 Project (1-3 yr)**
  – Needed to rapidly start moving
  – Immediate funding sought – **successful**
  – Will buy time to attract more interest for next level

• **Generation 2.0 Project (5+ yr)**
  – Funding model – needs new investment, Partners and external
The SALT 1.5 Gen Project

- It is now funded by SARAO (SKA-SA)
- MaxE project
- HRS/High Stability:
  - LFC etc hardware, new iodine cell calibs
  - HS pipeline
- Rapid follow-up s/w development
- Secondments of SKA engineers and new hires
- Significant expansion of SAAO-based instrument development

1-5 m/s Pretoria 2018
Gen 1.5 MaxE (built at SAAO)
Gen 1.5

MaxE (built at SAAO)

Main purpose:

Efficient transient followup, e.g. radio transients, efficient redshift surveys <22 mag
The SALT 2.0 Gen Project

- Start with feasibility studies for 2.0
  - Mini-trackers
  - Large-format IFUs
  - Other?
- Continue with AI Observatory
- Make instrumentations decisions in a 1-2 yr timescale
- Attract new funding

Challenges

– Need solid strategy and plan and a unified community to convince funders. Keep process transparent.

– Need a long-term and comprehensive human resource planning

– Risks:
  • Human resources, tight timelines
  • Gen 2.0 funding may depend on success of Gen 1.5.

Rigorous project management and communication between astronomers and engineers required.
SALT and SAAO goals aligned to be competitive in the 2020s
- Transients and Time domain
- Galaxy evolution
- Exoplanets
- Instrumentation

A four-step process to an “Intelligent Observatory” focusing on building capability for
- Remote observing
- Service observing
- Robotic observing
- Fully autonomous multi-facility operations

SALT is working well. It is the most cost-effective large telescope science producer in the world.