

The SAAO Future

“An Intelligent Observatory”



Petri Väisänen

© Willie Koorts

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

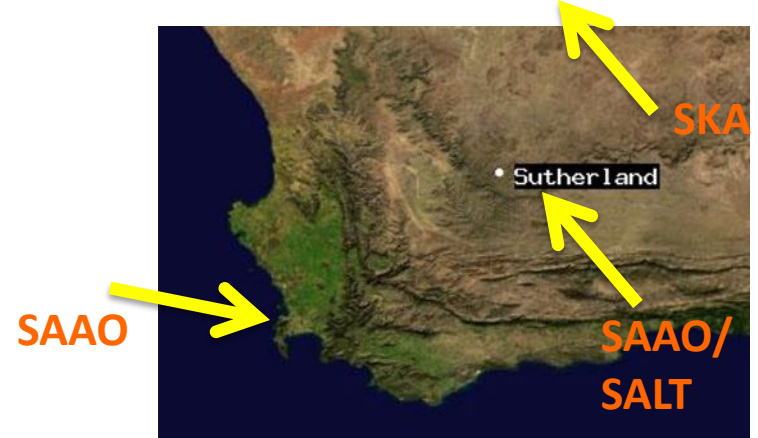
Semi-arid Karoo region

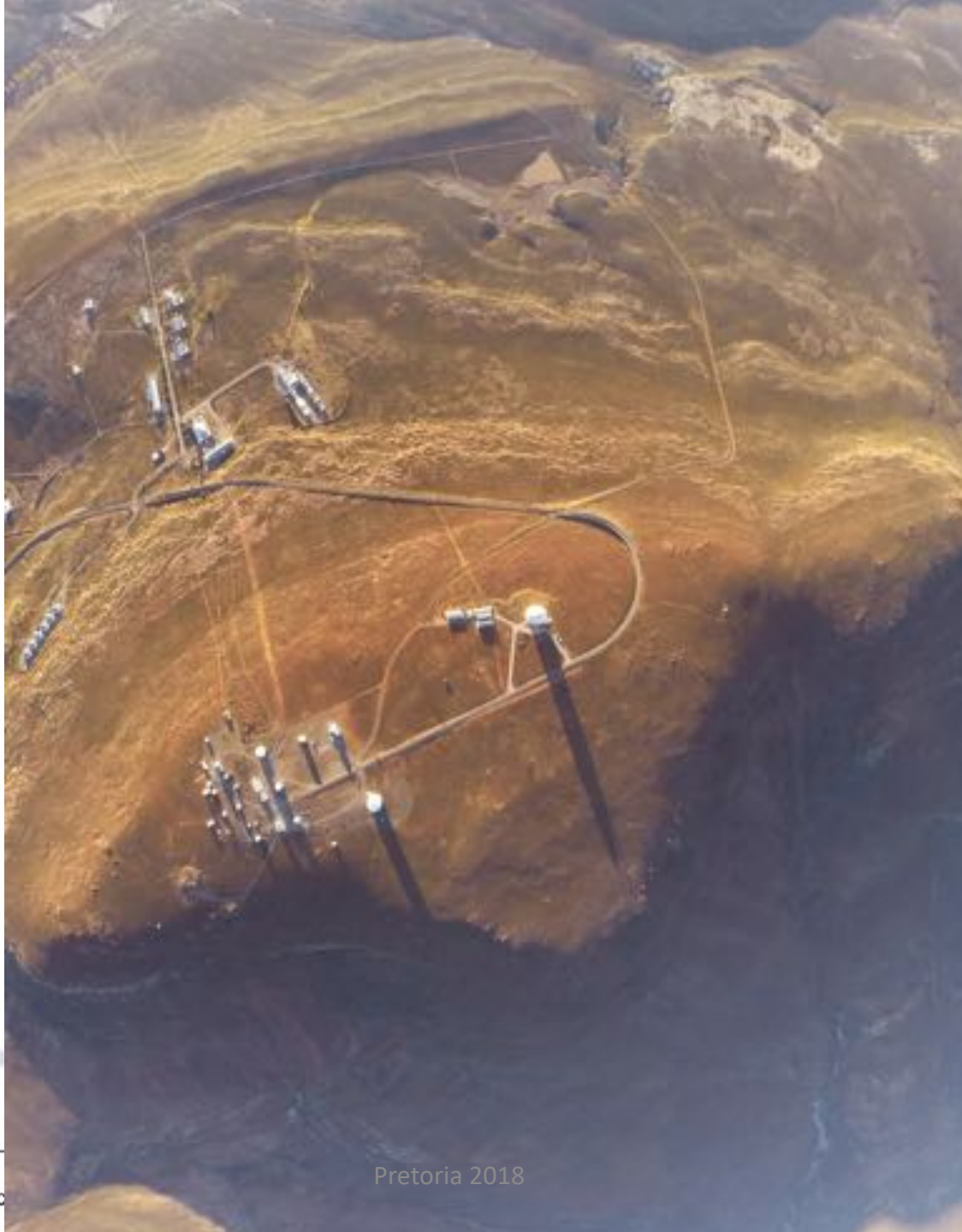
Research telescopes

Support staff and facilities

Hosted facilities

Dark site, modest seeing





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science
& technology

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Sutherland Telescopes

(our own or guest, many with SA access)

SALT ; 1.9 m ; 1.0 m ; Lesedi

**imaging, med/high-R spect., high speed modes,
MOS, FP, im/spec polarimetry, wide field imaging**

IRSF

KMTNet

MONET

Las Cumbres (LCO)

SOLARIS

MASTER

MeerLICHT

ASAS-SN

SuperWasp

KELT-South

SANSA

Bison

ATLAS

PRIME

Japanese 1.4 m IR imaging / polarimetry

Korean 1.6 m 2° field exoplanet search

German 1.2m planet search & teaching

USA 3x 1m optical robotic

Polish 2x 0.5 m exoplanet search

Russian 2x 0.45 m transient search

0.65 m shadows MeerKAT

USA + International transient search

UK exoplanet search

USA exoplanet search

South African space debris, atmosphere

UK solar telescope

USA 0.5 m near Earth asteroids and transient search

Japanese 1.8 m, wide field NIR imaging; HR spectrograph



SAAO Instrument Suite

Slides:
A.Sickafoose

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 I

- 40-inch tele
- **SHOC** (Su
- **STE3/STE**

SAAO I

- 74-inch telescope
 - **SpUpNIC** (Spec
 - **SHOC** (Sutherla
 - **HIPPO** (High-sp
 - **GIRAFFE** (high-resolution fiber-fed Echelle)



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SAAO Instrument Suite

Slides:
A.Sickafoose

- 1-m telescope, Lesedi



- **SHOC** (Sutherland High-speed Optical Camera; commissioning & science mountings)

- **WiNCam** (Wide-field Nasmyth Camera; Aug. 2018)

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

- 40-inch telescope
 - **SHOC** (Sutherland High-speed Optical Camera; commissioning & science mountings)
 - **STE3/STI** (Sutherland Telescope 3/4; commissioning & science mountings)

SAAO Instrument Suite

- 74-inch telescope
 - **SpUpNIC** (Sutherland Telescope Upgrade Newly Installed Cassegrain)
 - **SHOC** (Sutherland High-speed Optical Camera; commissioning & science mountings)
 - **HIPPO** (High-speed Polarimeter)
 - **GIRAFFE** (high-resolution fiber-fed Echelle)



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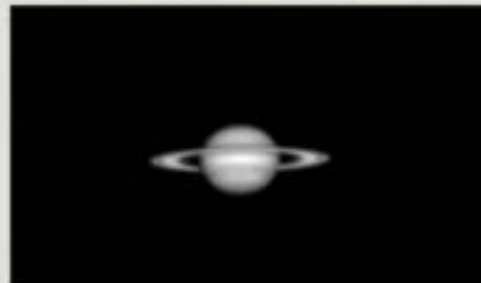


SAAO Instrument Suite

Slides:
A.Sickafoose

SAAO Instrument Suite

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



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SALT

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

On its 15th Science Semester currently



SALT is working well right now, producing science
~50 papers per year *very cost-effectively*



TELESCOPES WORKING TOGETHER



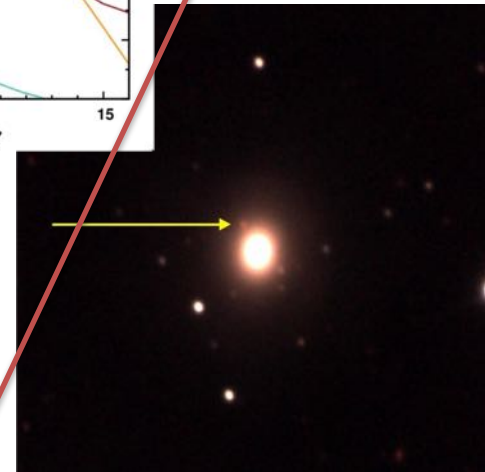
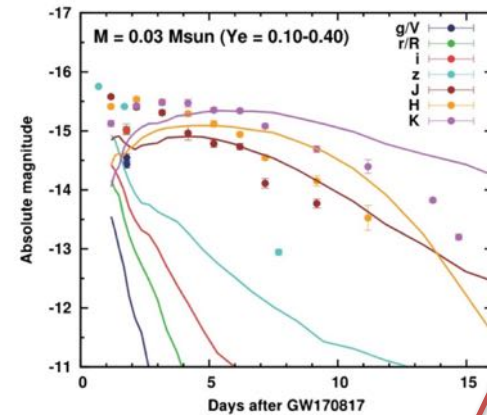
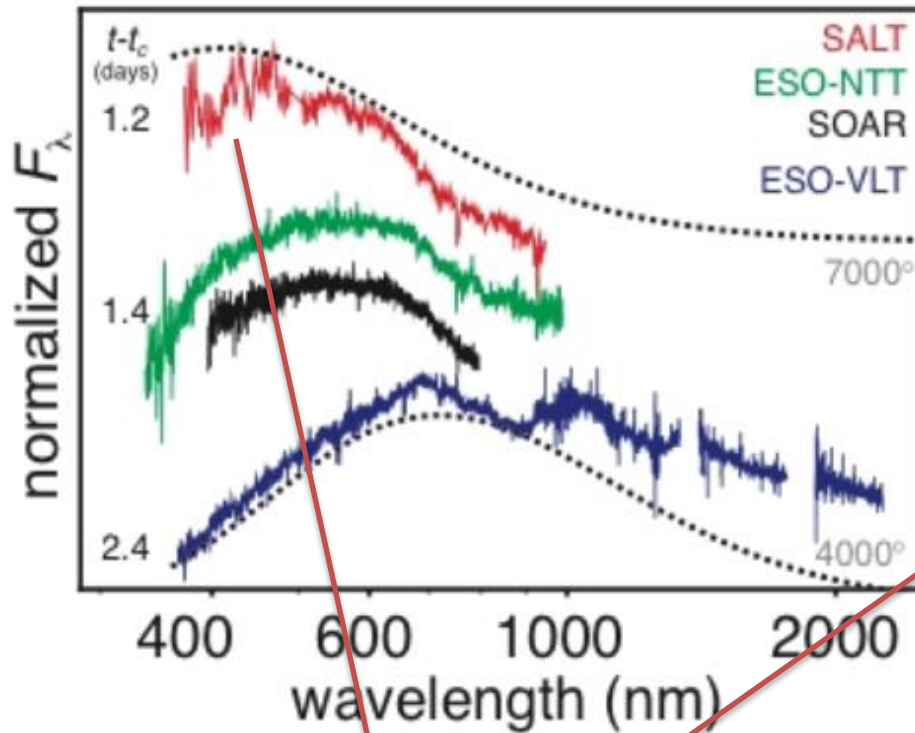
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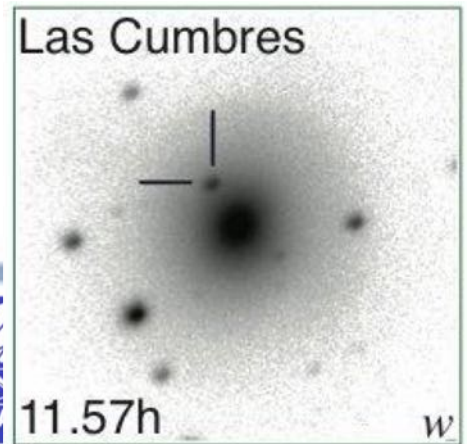
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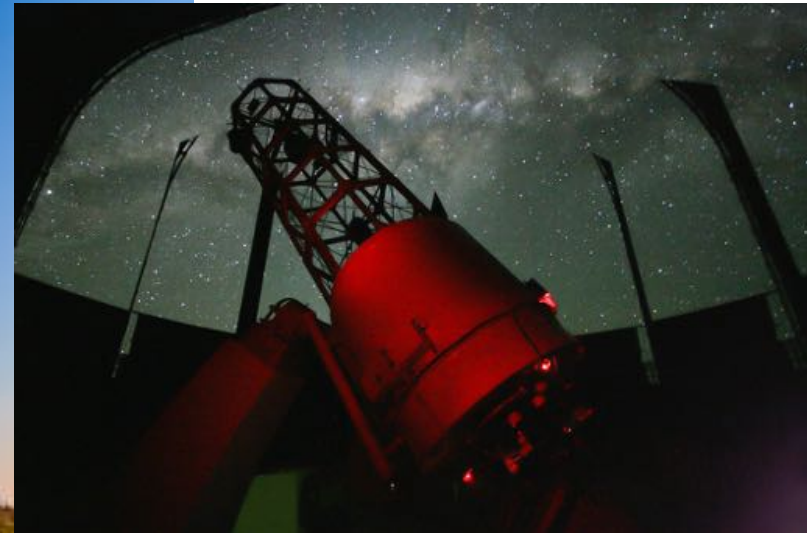
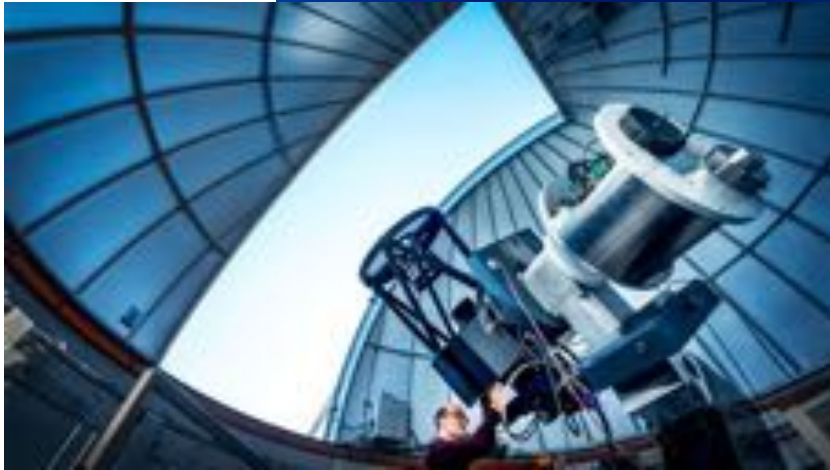
Birth of multi-messenger astronomy



KMTNet



Multi-wavelength astronomy



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Science and
REPUBLIC



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



1m

1.9m



Remote observing

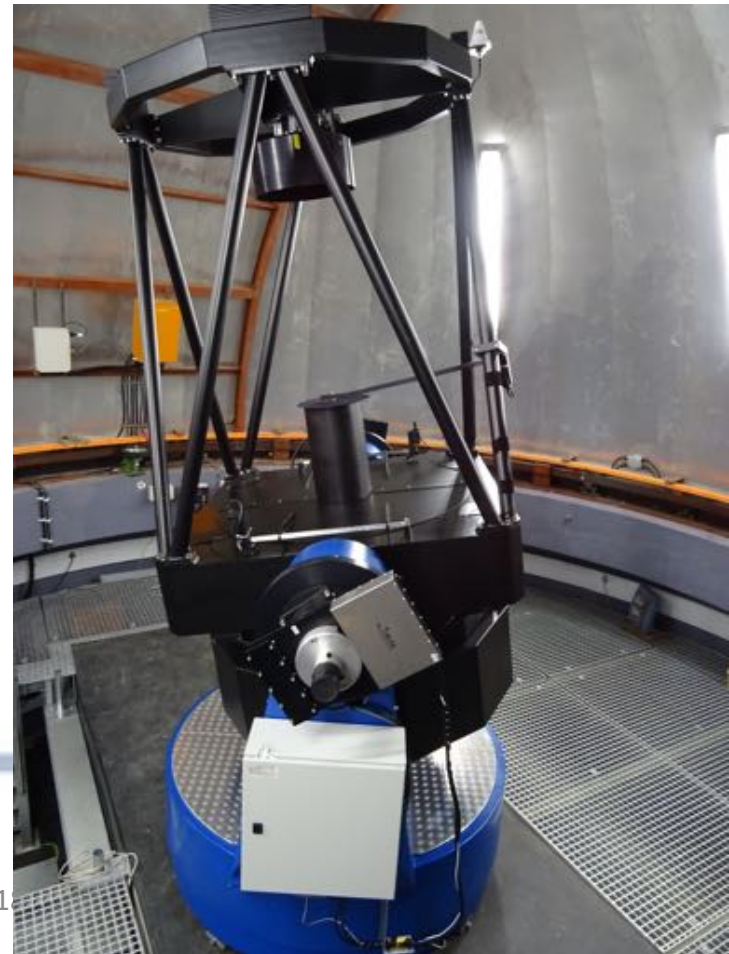
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Remote observing

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

1m
Lesedi



Service Mode Operations

SALT



Service Mode Operations

OPTI - v7.3.2

File Edit Generate Tools Window Help

TABULAR SCHEDULE PROJECT VIEW TIME RESTRICTED BLOCKS CALIBRATIONS

Select database: SDB

Select semester: Current

Select RSS Mode: ANY

Select Detector Mode: ANY

Display inactive targets? Track time - ObsTime? [ON]

Avoid CCR? [ON]

Find central track? [ON]

Select RSS Mode: ANY

Select Detector Mode: ANY

Current SALTSCAM filters only? [ON]

Current RSS only? [ON]

SELECT TIME:

Time: 19:30:11

Date: 12/11/2018

Use lunar phase tonight? [ON]

Min angular distance to Moon: 30.00

Moon Distance Filtering? [ON]

Lunar phase tonight: 15 0 90 180 270 360

Select lunar phase range: 10 20 30 40 50 60 70 80 90 100

Seeing Range: 0.00 10.00

Refresh RSS installed filters, detectors and masks

Refresh SALTSCAM current filters

UPDATE "Available Targets" NOW

Available Targets:

Block ID	Completion	Days/Interval	Score	Block Name	Proposal Code	Target	Proposal	Priority	RA (J2000)	Dec (J2000)	Wabs	NDone	Last Observed	WabsDays	ObsTime	MaxSeeing	Transparent	PI	MaxMag
76645	5.35	42	16.375	SIP100	2018-2-SP-001	SIP100	Large S	0	1	0	1	0	0	0	1970	3	Thin cloud	Buckley	15
76708	6.75	122	13.897	EC 04013-4017 H	2018-2-SC3-033	EC 04013-4017	Science	2	1	0	1	0	0	0	2050	2.5	Thin cloud	Jeffery	14.5
76620	5.35	36	13.539	SIP11.1_HRS	2018-2-SP-001	SIP11.1	Large S	2	1	1	10	0	0	0	2375	3	Thin cloud	Buckley	15
74740	0.00	107	0.593	TYC 8868-2101-1	2018-2-SC3-007	TYC 8868-2101-1	Science	3	2	0	1	0	0	0	2075	4	Thin cloud	Gilgan	11.97
74761	0.00	82	0.401	SV En	2018-2-SC3-025	SV En	Science	3	1	0	1	0	0	0	1861	4	Thin cloud	Gilgan	10.27
74703	0.00	39	0.243	RR Cat	2018-2-SC3-025	RR Cat	Science	3	1	0	1	0	0	0	1090	4	Thin cloud	Gilgan	10.08
75341	20.69	41	0.338	SIP11.1-2018-2-P	2017-1-PLT-004	SIP11.1	Science	3	1	0	1	0	0	0	1642	4	Any	Townsend	14.9
75343	20.69	42	0.339	SIP145-2018-2-P	2017-1-PLT-004	SIP145	Science	3	1	0	1	0	0	0	1642	4	Any	Townsend	14.7
75347	20.69	36	0.373	SIP15.3-2018-2-P	2017-1-PLT-004	SIP15.3	Science	3	1	0	2	0	0	14	1642	4	Any	Townsend	14.3
75348	20.69	45	0.373	SIP1062-2018-2-P	2017-1-PLT-004	SIP1062	Science	3	1	0	2	0	0	18	1742	4	Any	Townsend	14.2
75360	20.69	43	0.317	Acv205-2018-2-P	2017-1-PLT-004	Acv205	Science	3	1	0	1	0	0	0	1542	4	Any	Townsend	13.8
76205	0.00	29	0.595	OGLE 39C-12CEP	2018-2-PLT-007	OGLE 39C-12CEP	Science	3	1	0	2	0	0	20	2075	3	Thin cloud	Macaulis	14.4

ADD ALL TO SCHEDULE

ADD TO SCHEDULE

Schedule:

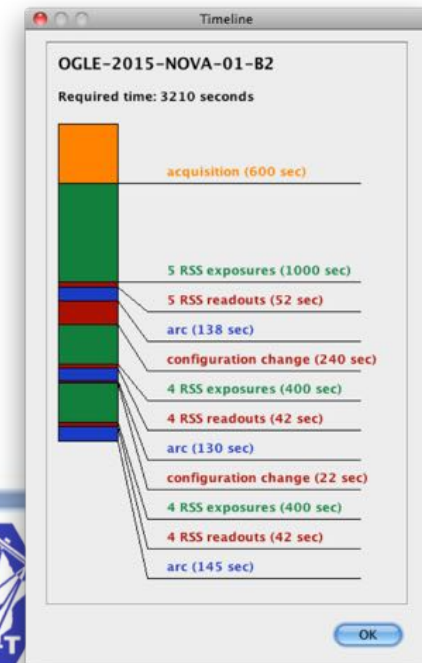
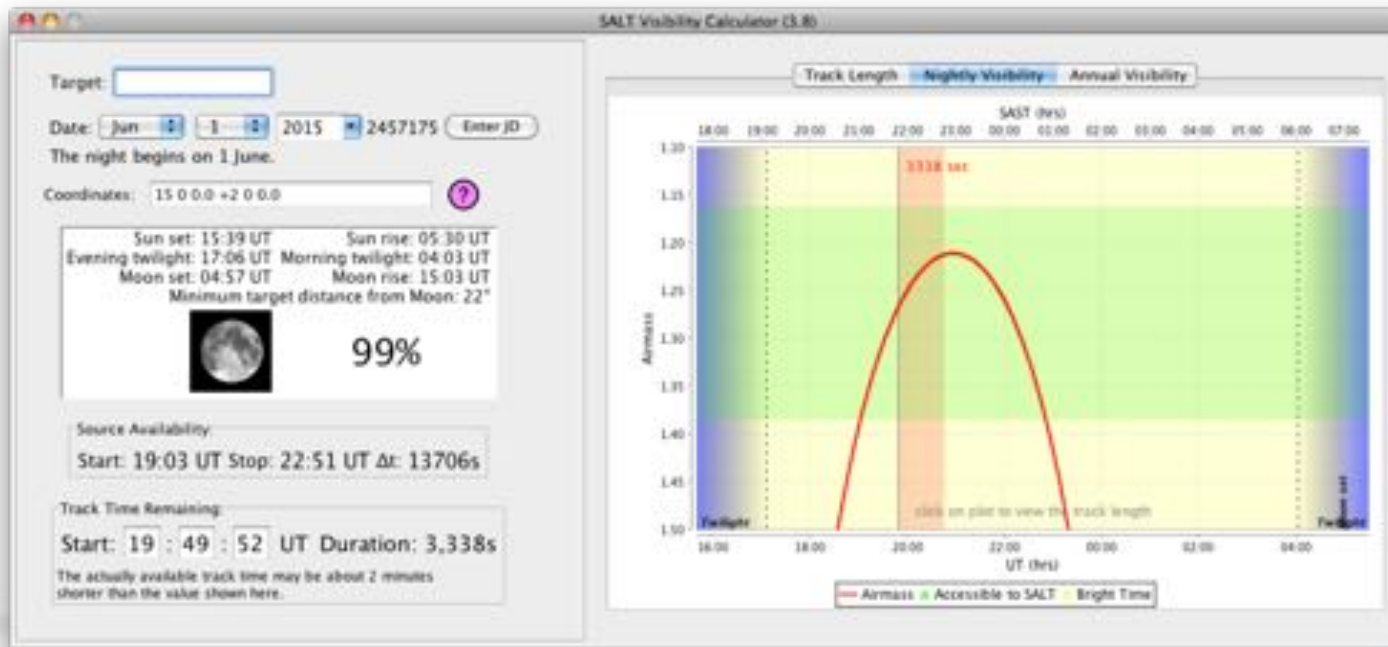
Block ID	Block Name	Code	Priority	Completion	PI	Target	RA	Dec	Era	Type	Mag	ObsTime	MaxSeeing	Moon	Transparent	PI
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Taskbar: Start, TimeSyncMoni..., TimeSyncMoni..., WebSARPH..., HRS JPE.vi, OPTI, OPTI - v7.3.2, nrs-OCS, nrs-OCS v2.0.0, tpc.salt - Rem...



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]

IRSF	Japanese 1.4 m IR imaging / polarimetry
KMTNet	Korean 1.6 m 2° field exoplanet search
MONET	German 1.2m planet search & teaching
Las Cumbres (LCO)	USA 3x 1m optical robotic
SOLARIS	Polish 2x 0.5 m exoplanet search
MASTER	Russian 2x 0.45 m transient search
[MeerLICHT	0.65 m shadows MeerKAT]
ASAS-SN	USA + International transient search
SuperWasp	UK exoplanet search
KELT-South	USA exoplanet search
SANSA	South African space debris, atmosphere
Bison	UK solar telescope
[ATLAS	USA 0.5 m near Earth asteroids and transient search]
PRIME	Japanese 1.8 m, wide field NIR imaging; HR spectrograph





Make the whole mountain top a Giant Transient AI machine **The 'Intelligent Observatory Project'**



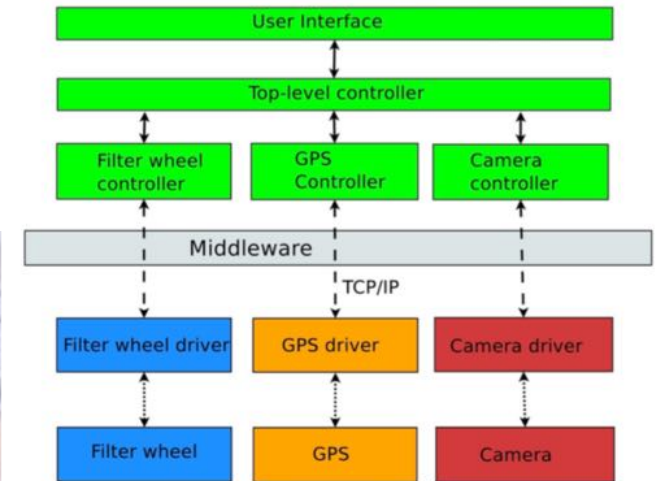
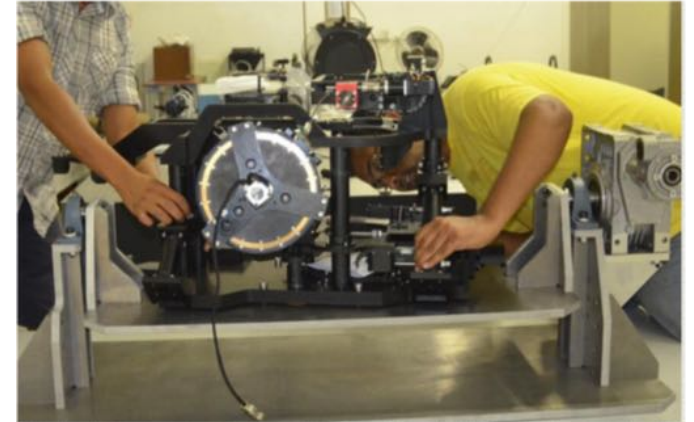
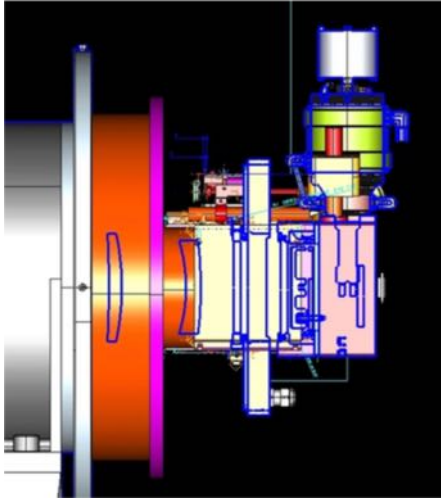
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Networked autonomous observations

- **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



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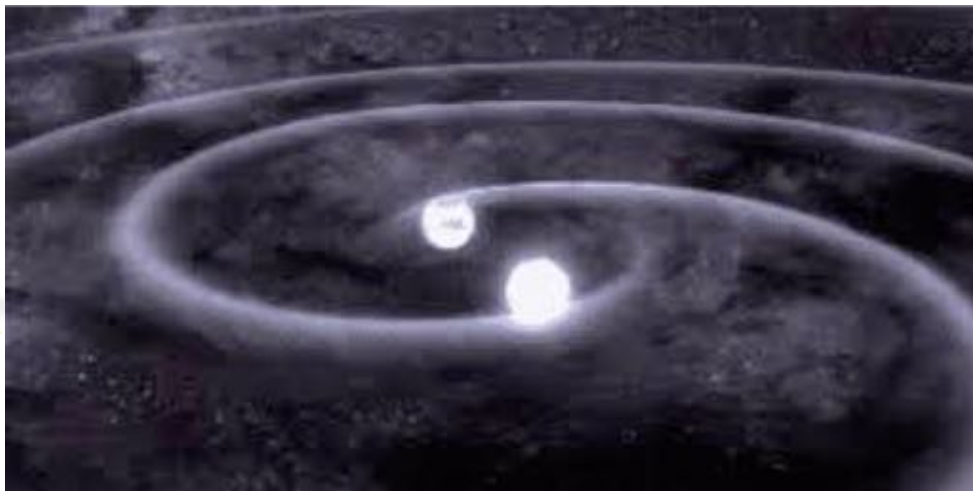


*I - Understanding fundamental physics and the
nature of the universe*

Transient and time-domain astronomy

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

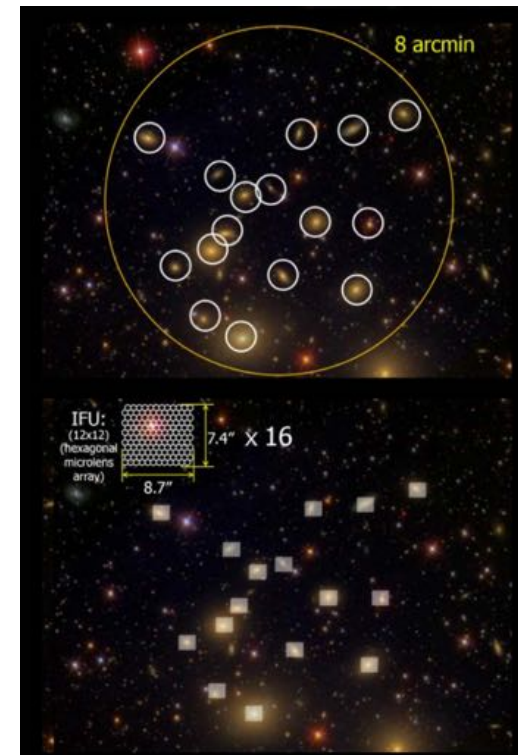
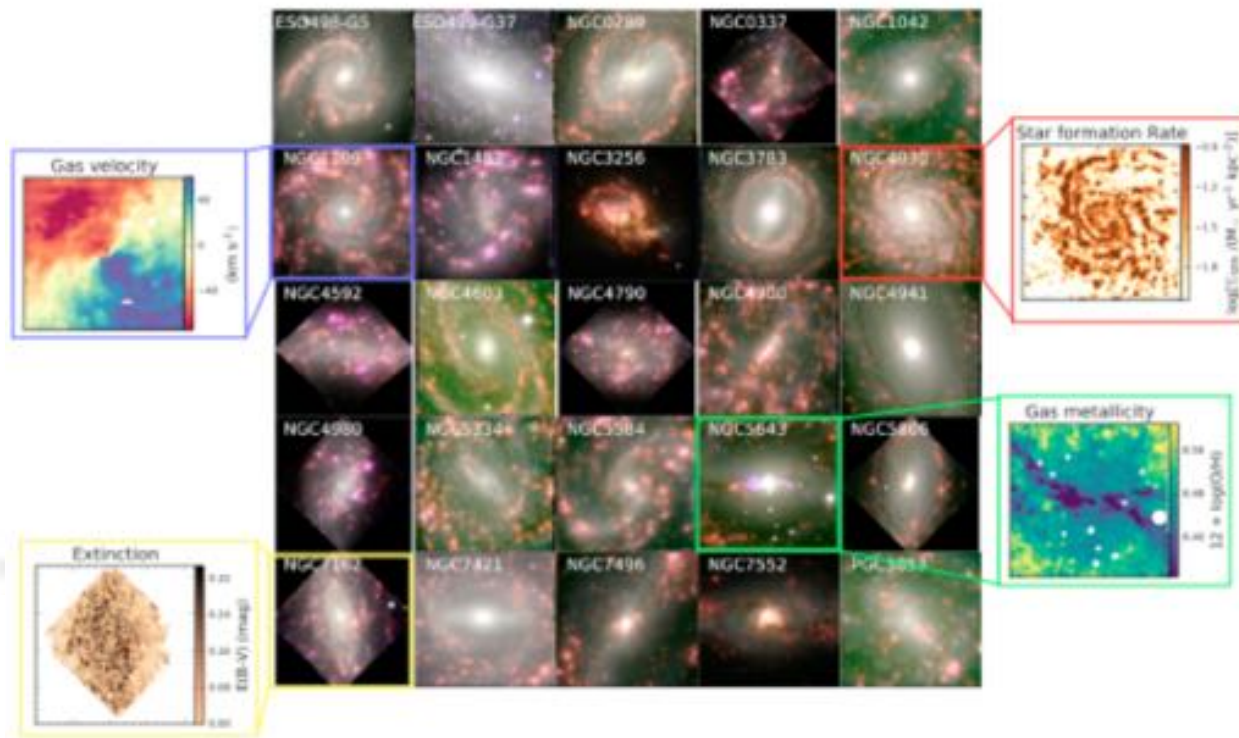
Cutting edge of fundamental astrophysics



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

Proxima Centauri


Alpha Centauri AB

Proxima b



(image: ESO/M.Kornmesser)

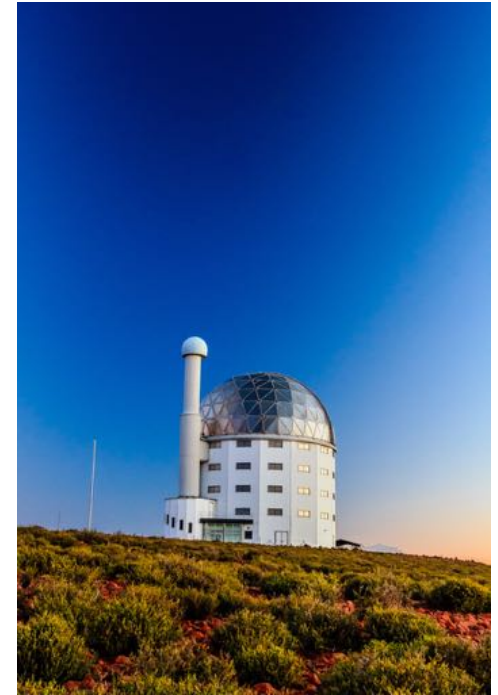
SALT Science Strategy – roadmap and lessons

- **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

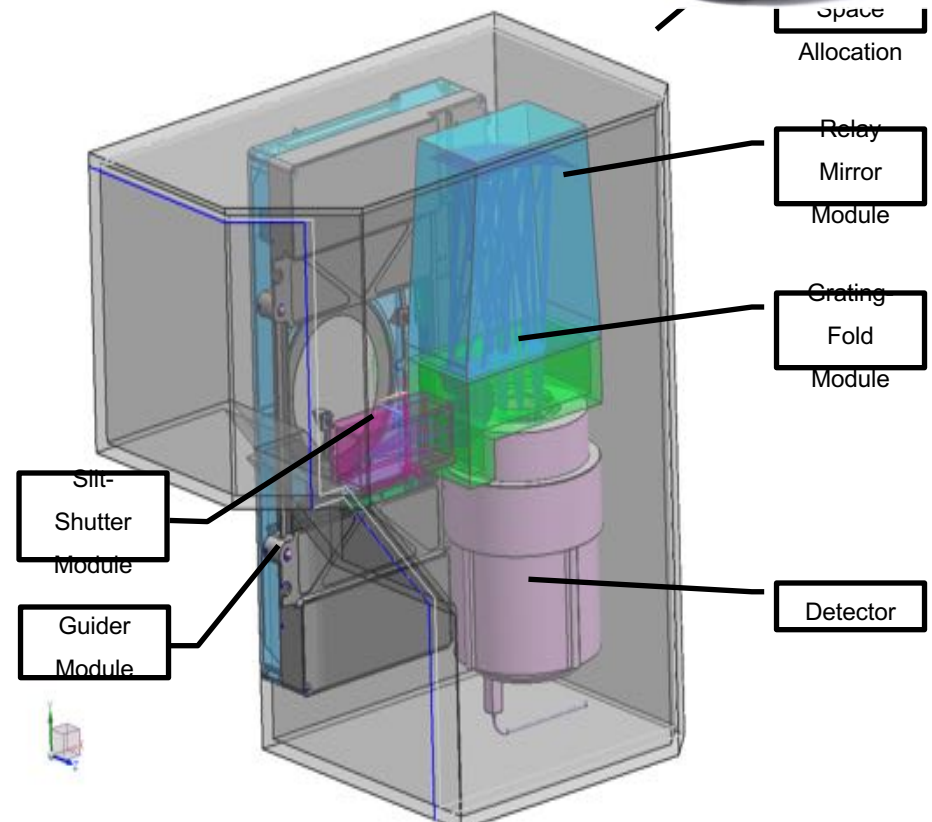
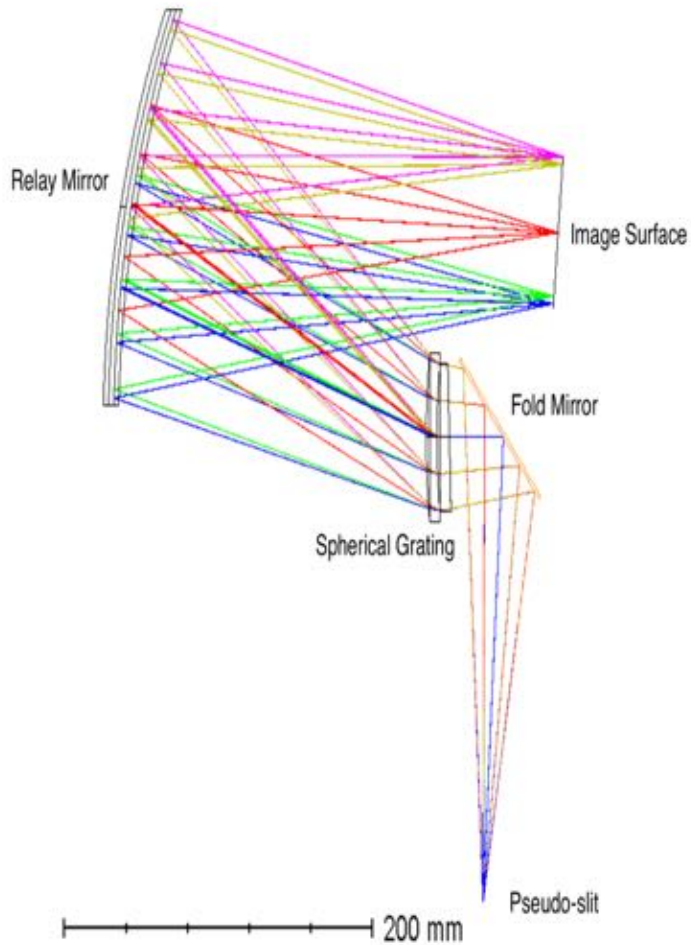
- It is now funded by SARAQ (SKA-SA)
- **MaxE project**
- **HRS/High Stability:**
 - LFC etc hardware, new iodine cell calibs
 - HS pipeline
- **Rapid follow-up s/w development**
- Secondments of SKA engineers and new hires
- Significant expansion of SAAO-based **instrument development**

1.5 m/s



Gen 1.5

MaxE (built at SAAO)

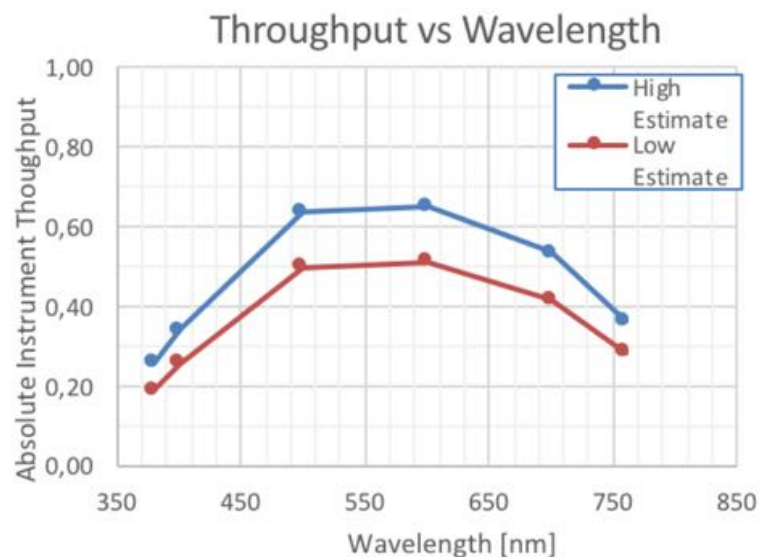
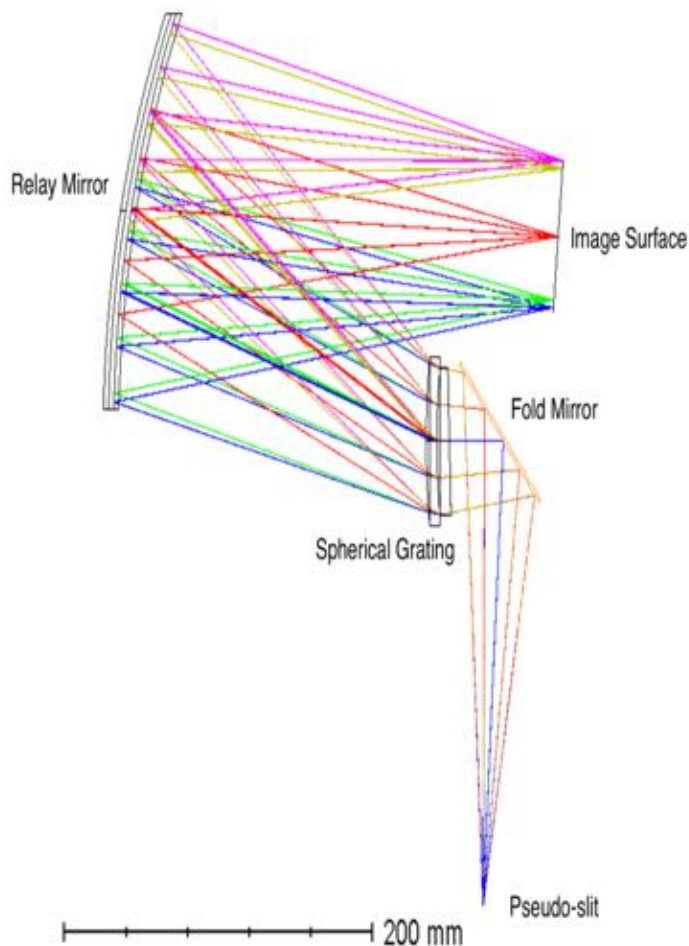


Gen 1.5

MaxE (built at SAAO)

Main purpose:

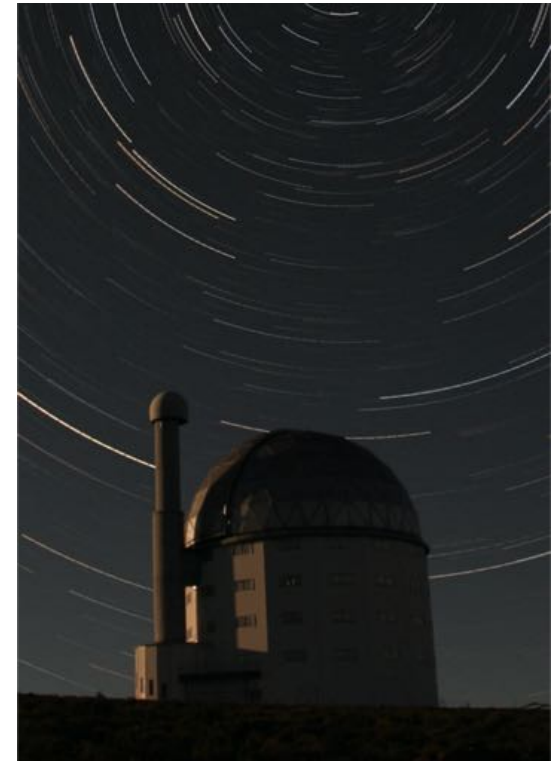
**Efficient transient
followup, e.g. radio
transients, efficient
redshift surveys <22 mag**



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

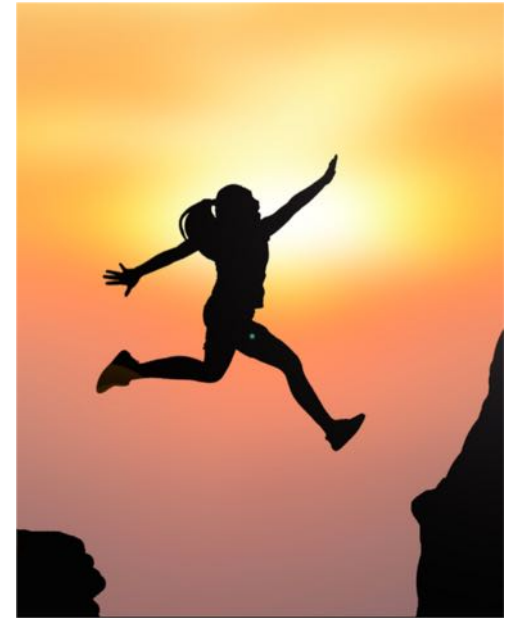
Booth et al. arXiv: 1808.00138
(SPIE, 2018)



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.



Summary

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.

