Observatories, Telescopes & Travels: a personal journey

David Buckley

Southern African Large Telescope
South African Astronomical Observatory
University of Cape Town
University of the Free State

Early Days

- First telescope (60mm refractor 7th birthday); frequent visits to planetarium at Canterbury Museum; lots of astronomy books (e.g. Patrick Moore's *Astronomy for Boys* (!)

- Joined Junior Section of the Canterbury Astronomical Society (CAS) from age ~15; eventually held position as Treasurer, Secretary & Editor

- Eventually bought a new equatorial refractor from proceeds of selling a model train layout & holiday jobs (raspberry & potato picking); then bought (for $20!) an old brass Dallmeyer 3" refractor (circa 1880) from high school (was about to be chucked out!)


First visit to CAS West Melton Observatory

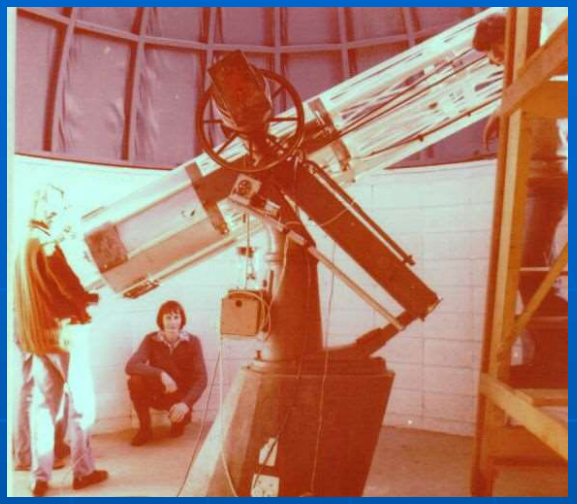
First Observing Experiences

- Visual observations of variable stars & comets

- First introduction to "serious observing" using photoelectric photometer (e.g. Asteroid Latetia, 3C273) on West Melton 16 inch

- First publication in *Sky & Telescope (Comet Bradfield and Aurora)*

- Some of us in the CAS have continued on in astronomy (e.g. Sean Ryan, U. Hertfordshire)



Start of Academic Studies: University of Canterbury

- BSc in physics & applied maths & MSc in astronomy

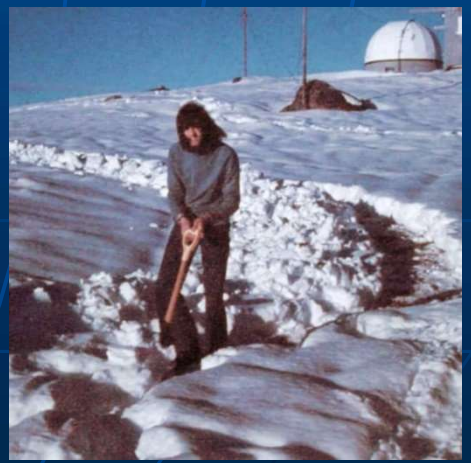
Other activities:

- Friday night observing at Townsend Observatory with 6" refractor (collapsed in 2012 earthquake, now restored)
- Planetarium lecturer
- Assisted Gary Nankivell (optical engineer) with final polish of new 1-m mirror

Masters Research at Mount John Observatory

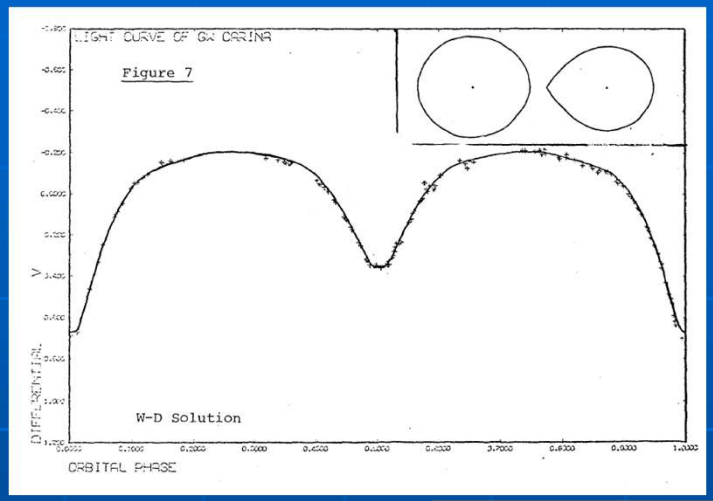
Mt John University Observatory set up in 1965 (UC, U. Florida, U. Penn)

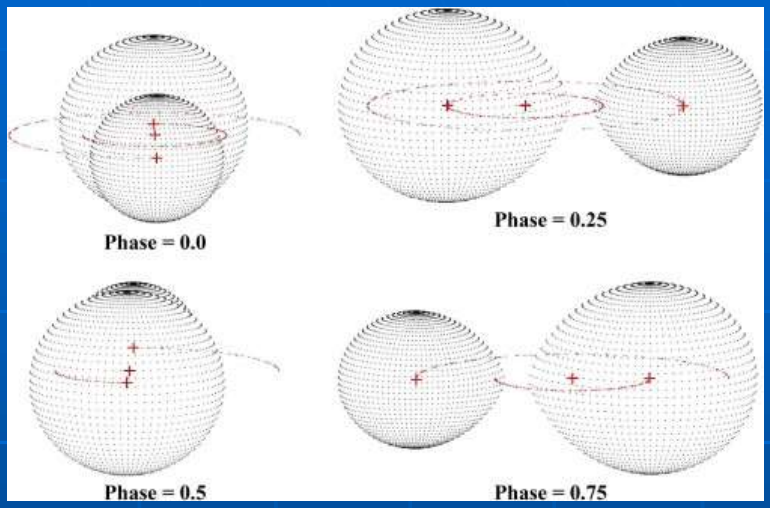
- MSc on light curves of bright, neglected eclipsing binaries (John Hearnshaw supervisor)
- Photoelectric photometry (OC and B&C 0.6-m)
- Modelling & synthetic light curves
- Learned the art and the demands of optical photometry (& a bit of spectroscopy)
- Learned to ski nearby



Masters Research at Mount John University

- Good quality light curves modelled using synthetic light curve modes
- All computation done of new "PRIME" main-frame using Fortran IV





OBSERVATIONS AND MODELS OF SOME NEGLECTED SOUTHERN ECLIPSING BINARIES*

DAVID A. H. BUCKLEY

* Paper presented at the Lembang-Bamberg IAU Colloquium No. 80 on 'Double Stars: Physical Properties and Generic Relations', held at Bandung, Indonesia, 3–7 June, 1983.

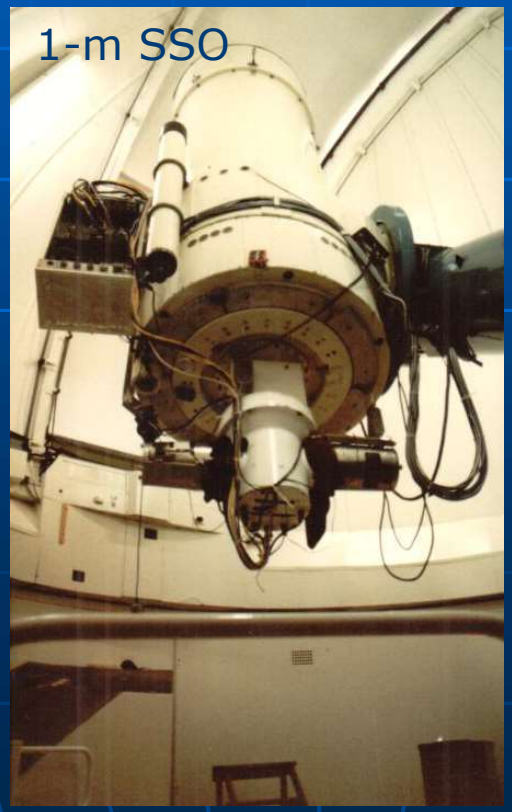
Astrophysics and Space Science **99** (1984) 191–197. 0004–640X/84/0991–0191$01.05.

Aside: Largest NZ telescopes today

- 1-m telescope completed in 1986
- High resolution spectrograph (HERCULES)
- 1.8-m MOA (Japan, NZ, US) completed 2004

Next step: PhD at the Australian National University at Mount Stromlo & Siding Springs Observatory (MSSO)

- PhD thesis on X-ray sources from the HEAO-1 satellite
- Part of MSSSO collaboration with MIT group (Hale Bradt & Ron Remillard)
- Follow-up optical (AAT & MSSSO) and X-ray (EXOSAT) observations of Galactic sources
- X-ray binaries, cataclysmic variables, active coronal stars (5 papers)
- Photometry & spectroscopy
- Modelling



An aside on HEAO-1:

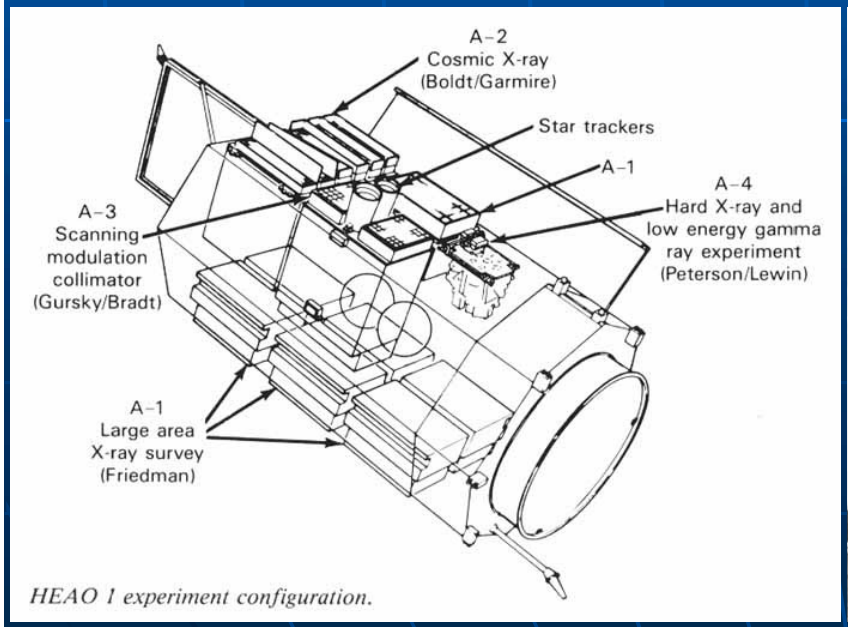
First of NASA's "great observatories" launched in 1977

4 different instruments

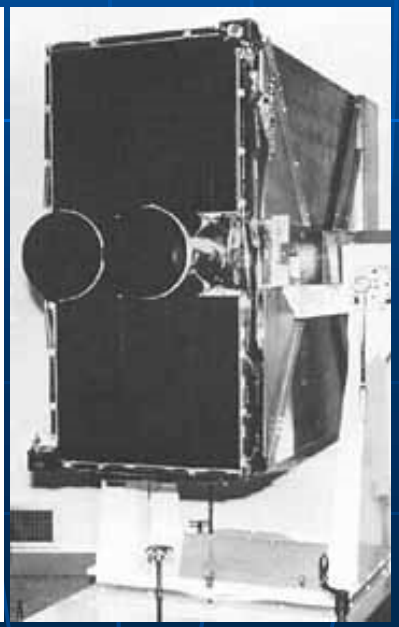
- A1: hard X-ray large area PCs
- A2: soft X-ray PCs
- A3: hard X-ray scanning modulation collimator
- A4: gamma ray detectors

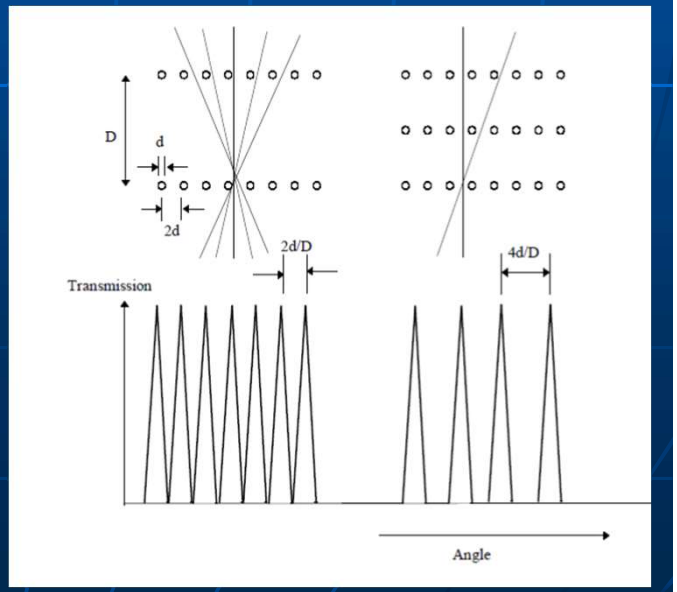
Not X-ray imaging!

- Detectors all proportional counters with collimators



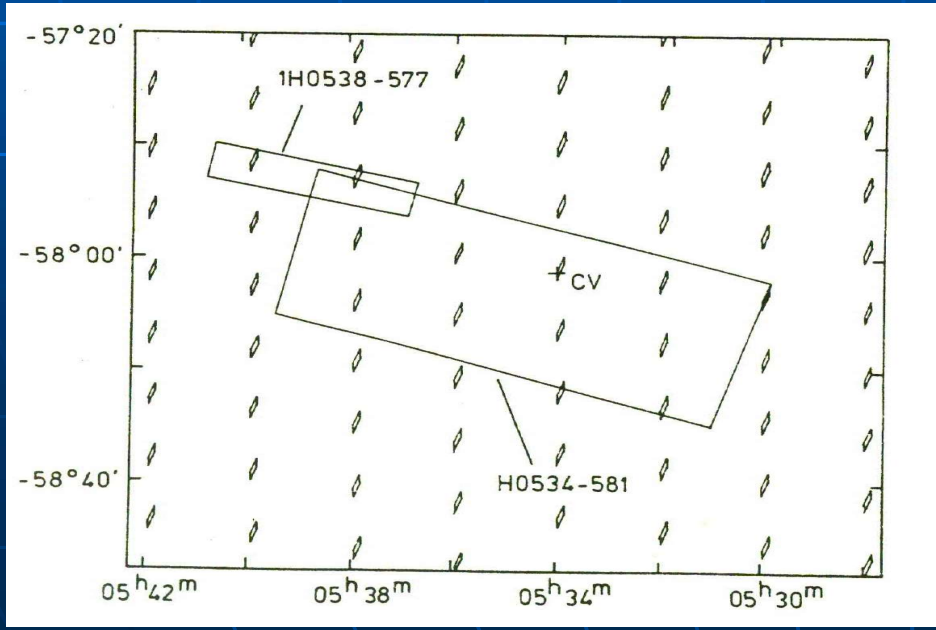
HEAO 1 experiment configuration.





Finding optical counterparts of HEAO-1 sources

- A3 produced a regular grid of possible non-unique error boxes
- 100's of ~1 x 2 arcmin over 4 x 4 degrees
- Any one of them could contain the source!
- Need to look at every error "diamond" to find likely counterpart (e.g. UV excess); eye-balling photographic plates
- PhD involved searching for and characterizing optical counterparts of ~3σ A3 sources; particularly Galactic objects
- *Example:* H0534-581 (TW Pic) a magnetic Cataclysmic Variable
  - Two Chapters & two papers
  - Most recently TESS has observed accretion gating evidence



THE ASTROPHYSICAL JOURNAL, 349:296–312, 1990 January 20

H0534−581: A NEW INTERMEDIATE POLAR?

D. A. H. BUCKLEY AND I. R. TUOHY
Mount Stromlo and Siding Spring Observatories, Institute of Advanced Studies, Australian National University

32 years later…

LETTERS
https://doi.org/10.1038/s41550-021-01494-x
nature astronomy

Check for updates

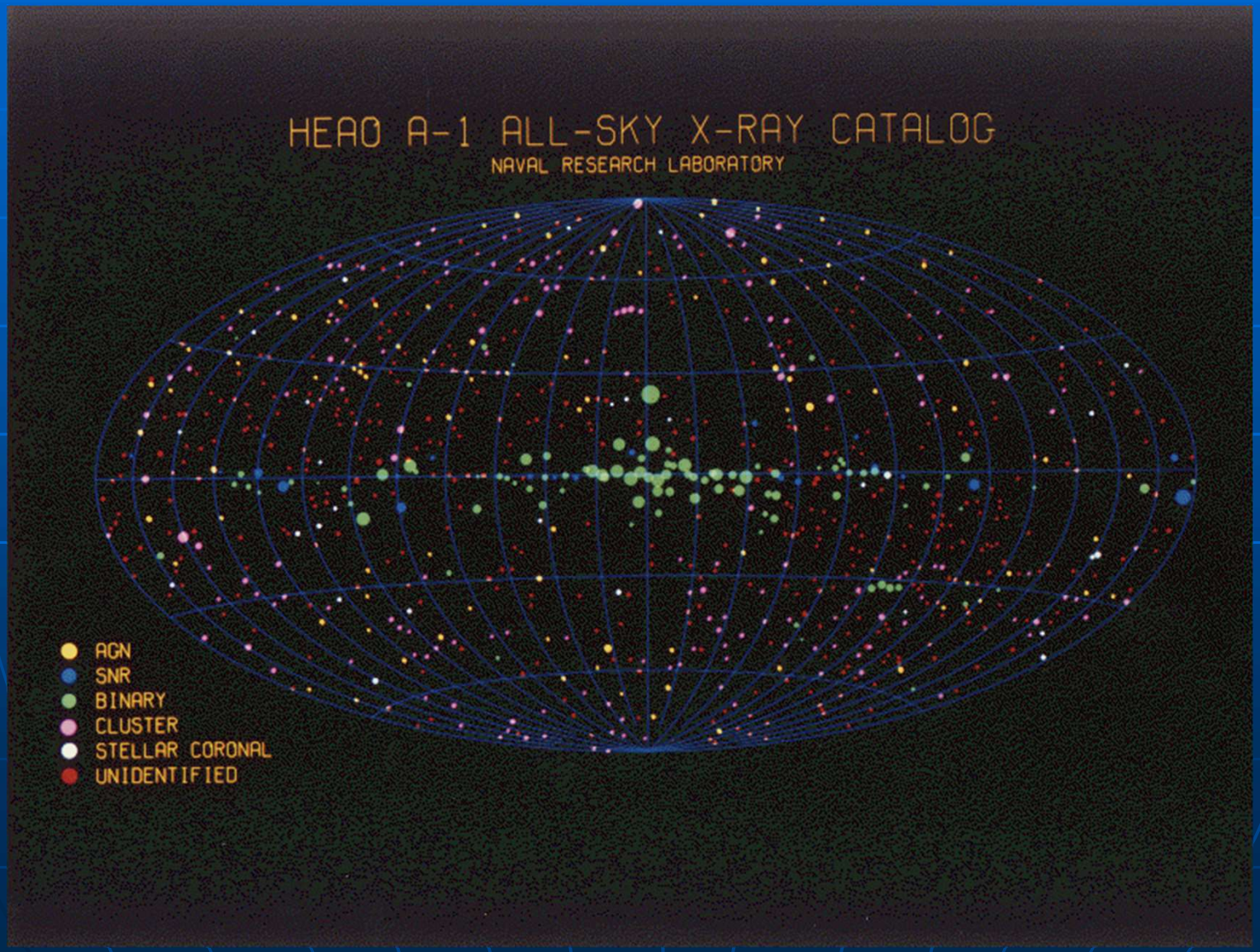
An accreting white dwarf displaying fast transitional mode switching

S. Scaringi[1✉], D. de Martino[2], D. A. H. Buckley[3,4,5], P. J. Groot[3,4,6], C. Knigge[7], M. Fratta[1], K. Iłkiewicz[1], C. Littlefield[8,9] and A. Papitto[10]

NATURE ASTRONOMY | VOL 6 | JANUARY 2022 | 98–102 | www.nature.com/natureastronomy

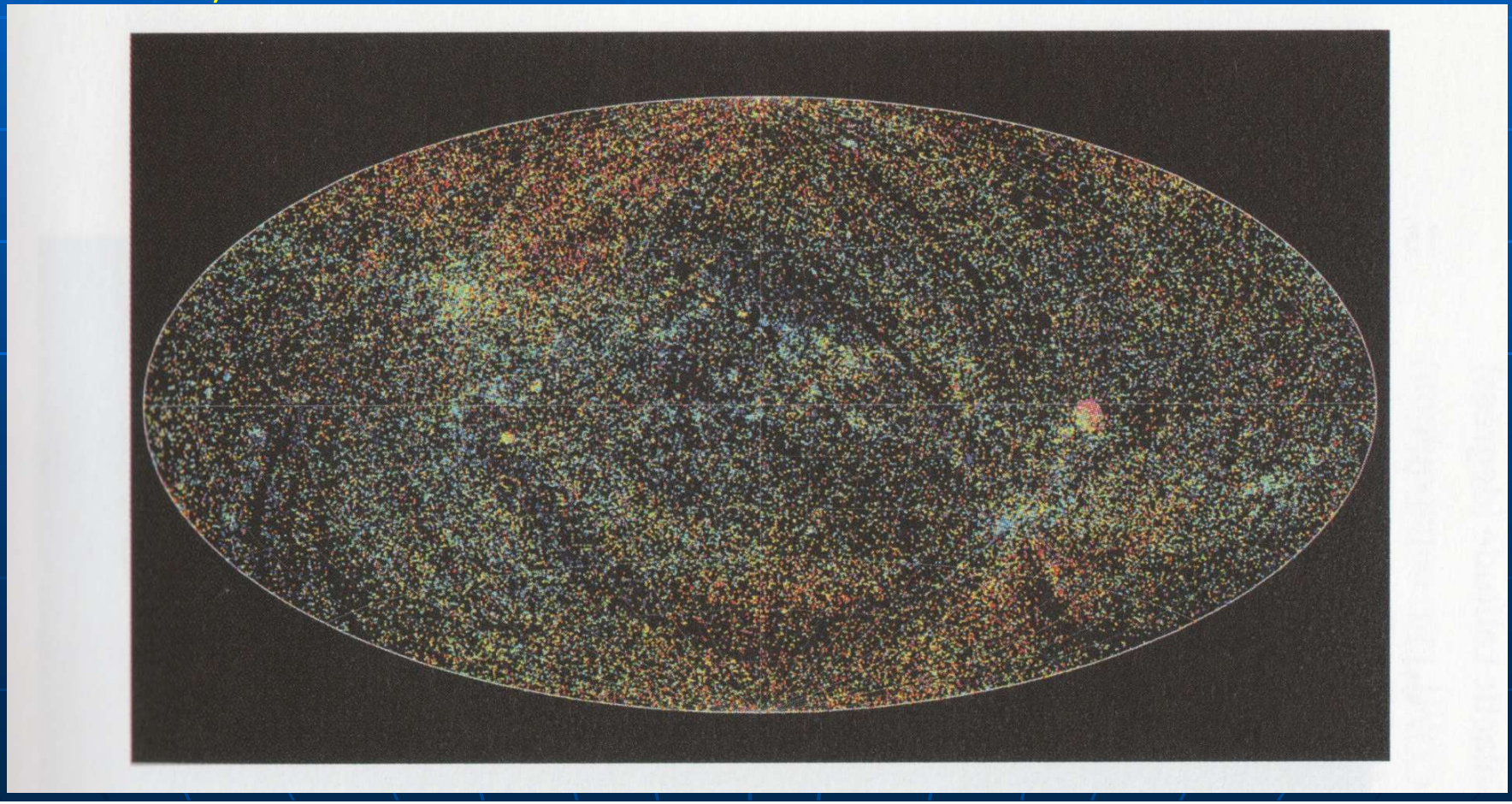
HEAO-1 Sky View

- *Total of ~1000 sources detected (0.2 – 25 keV)*



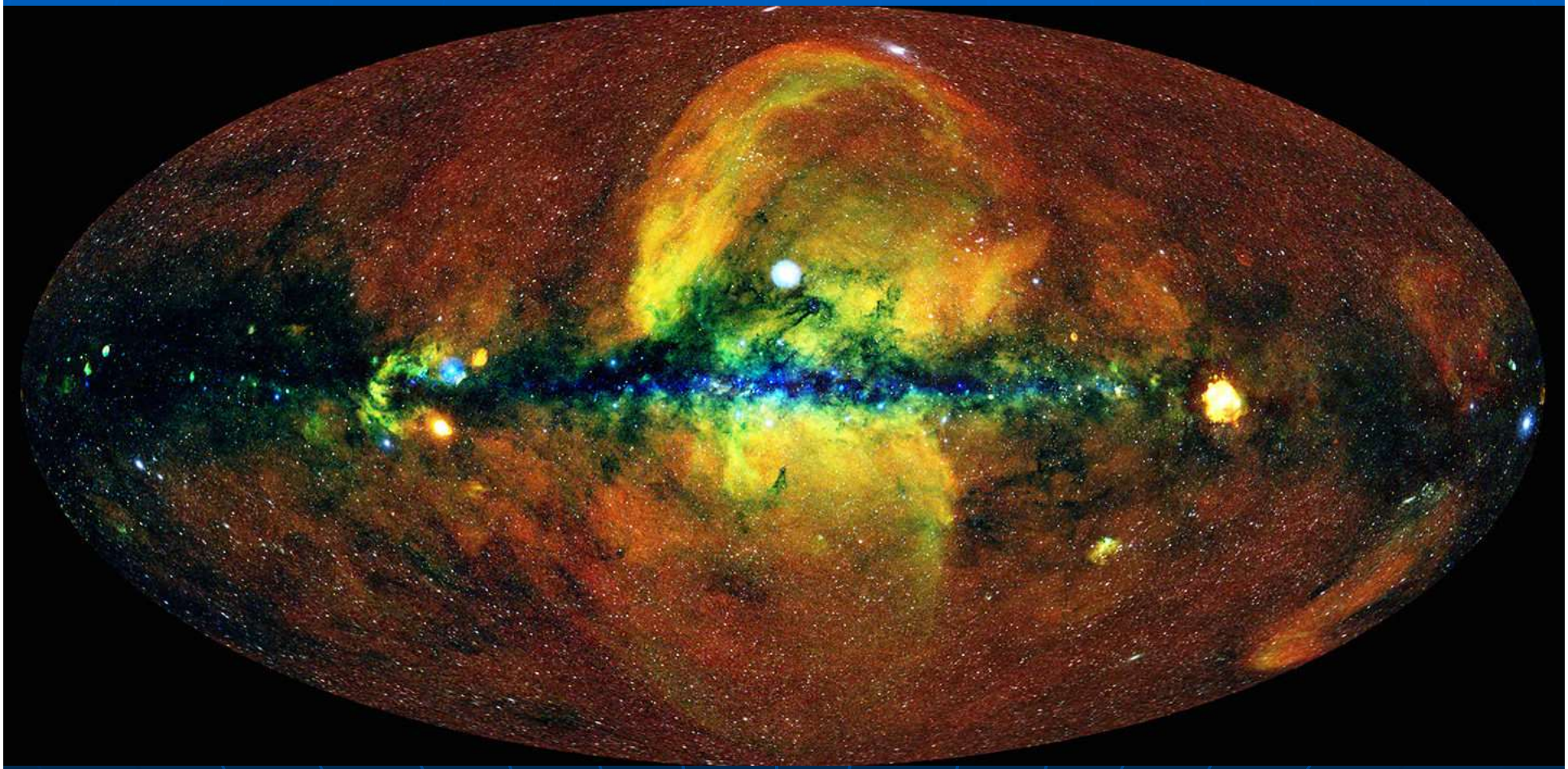
ROSAT View of the Sky

- Soft X-ray survey (0.2-2.4 keV) in early 1990's
- Also did first Extreme UV (EUV) survey
- Led a programme at UCT to find optical counterparts and follow-up (predominantly using SAAO facilities and also some in Australia)
- Over 70,000 sources



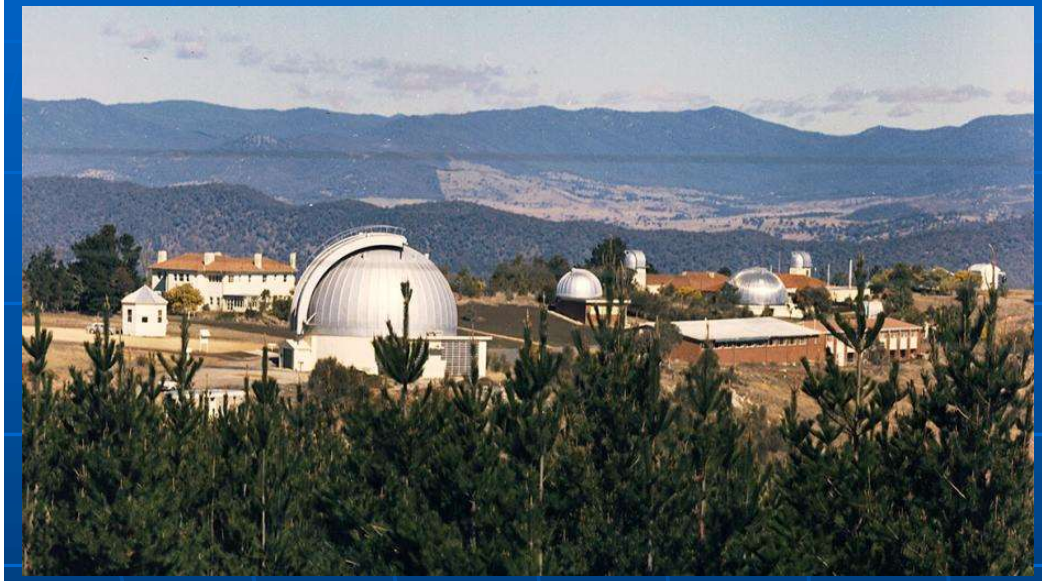
eROSITA View of the Sky

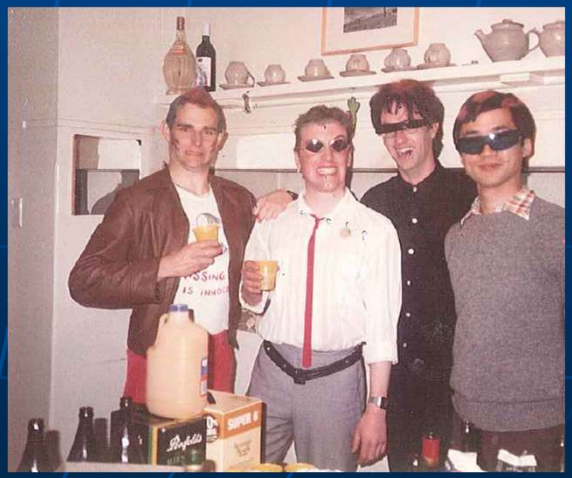
- The ultimate survey (4 years: 8 entire sky views) to date
- X-ray survey (0.2-10 keV) from 2019
- Survey suspended ½ way in March 2022 due to invasion of Ukraine



Mount Stromlo Observatory

- In out skirts of Canberra in a pine forest plantation
- Pleasant environment to work and live, with many students living in houses on site (lots of wild Australian animals!)





Mount Stromlo Observatory: Post 2003

- Massive fire destroyed telescopes, workshop, NIFS (instrument for Gemini packed for shipping), historic library & most houses

Mount Stromlo Observatory: today

- Eventually rebuilt (Phoenix!)
- state-of-the-art instrumentation and technology centre

South African Career

Late 1988 to mid-1991: took up postdoc at University of Cape Town (Brian Warner)

- *Research in magnetic CV, ROSAT sources, pulsating WDs, Be X-ray binaries*

1991 – 2022: astronomer at the South African Astronomical Observatory

Involvement in early days of the Southern African Large Telescope (SALT) Project

Different roles, including Project Scientist for SALT (1998-2005) and Astronomy Operations Manager (2005-2015), SALT Science Director (2010-2015)

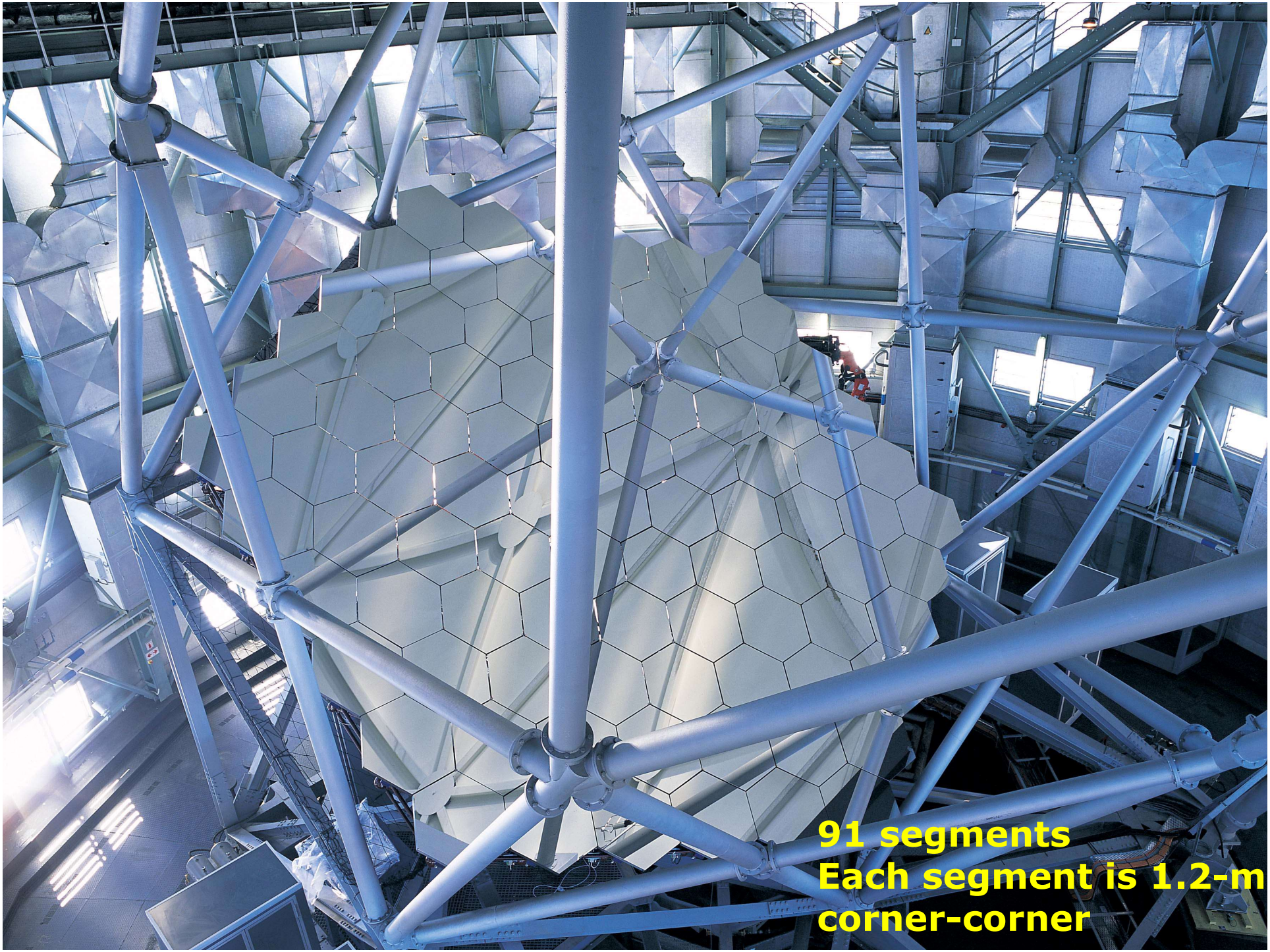
SALT Global Ambassador (2017-2022)

SAAO Darragh O'Donoghue Astronomer (2017-2022)

What is SALT? One of the "Big Five": 10-m Segmented Mirror Telescopes

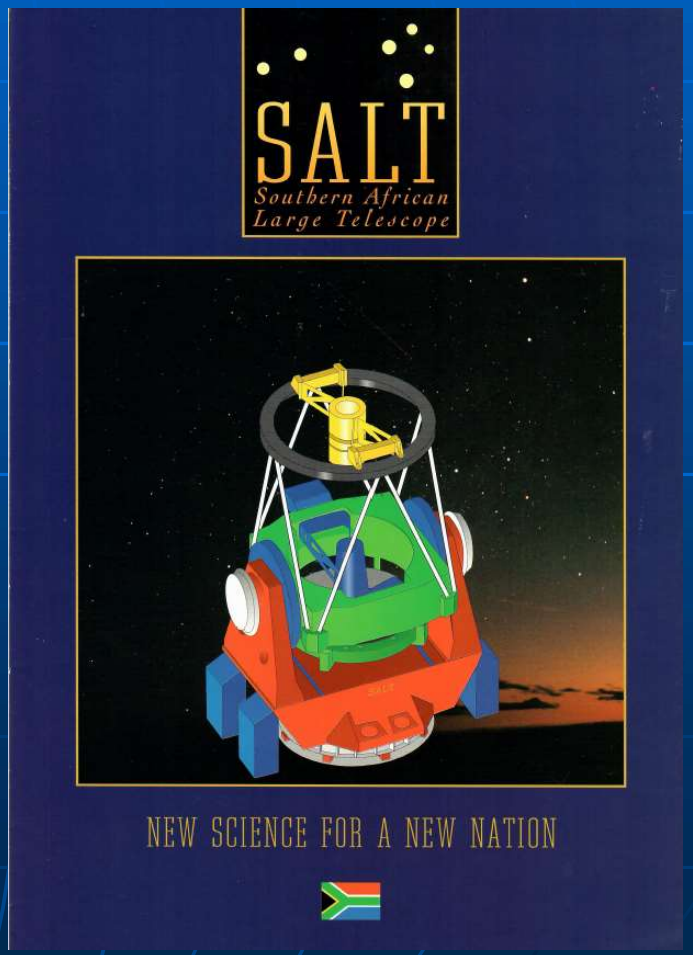
- Keck I (1993) & Keck II (1996): Hawaii, USA
- HET (1999): Texas, USA
- SALT (2005): South Africa
- GRANTECAN (2009): Canary Islands, Spain

These telescopes currently have the largest light grasp


91 segments
Each segment is 1.2-m
corner-corner

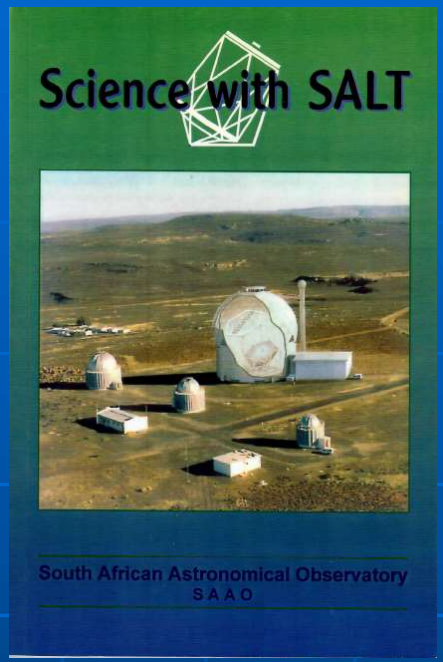
The First "SALT"

- SALT was initially (from mid-1990s) planned as a 3.5-m telescope (NTT copy) and a collaboration between South Africa, Germany (Max Planck Soc) and Namibia and would be sited on the Gamsberg Mountain (2350 m):
  - Capital costs of telescopes/instrument by Max Planck Soc.
  - Operations of telescope by SAAO
  - Infrastructure funding by Namibia
- One of the jobs assigned to me on joining SAAO
- Site testing visit 1994 (SAAO & ESO DIMM)
- But by 1995 project was dead



New SALT

- Came about following discussion with HET: “copy” of HET in the southern hemisphere
- Led to first “Science with SALT” workshop in March 1998
- Government’s intention to support SALT given in 1998/99 budget vote, contingent on raising of matching funds from partners
- Project unilaterally supported by all parties in Parliament
- SALT Project Scientist (David Buckley) appointed Nov 1998
- SALT Project Manager (Kobus Meiring) appointed July-1999
- Government gives the “green light” in Nov 1999
- SALT Project Team recruited from late 1999 to mid 2000
- Ground breaking in Sep 2000
- Completed & inaugurated Nov 2005

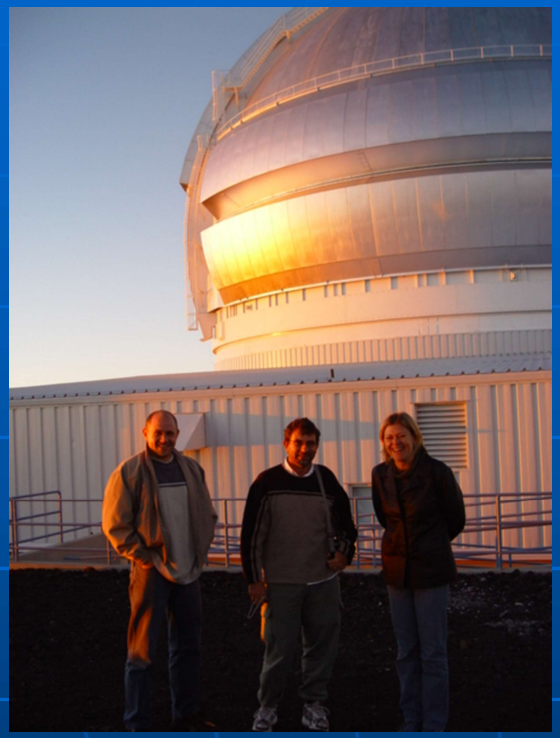


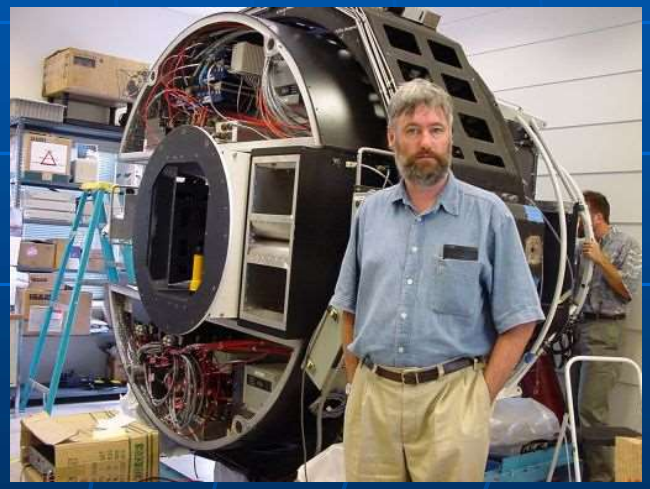
Designing SALT

- Starting point was the HET design, but improved in many ways
- Involved many visits to other observatories, telescopes, project teams (e.g. HET, Mauna Kea (Keck, Subaru), La Palma (WHT, INT, NOT), Grantecan Project)
- Lots of design reviews supported by external reviewers

Designing SALT

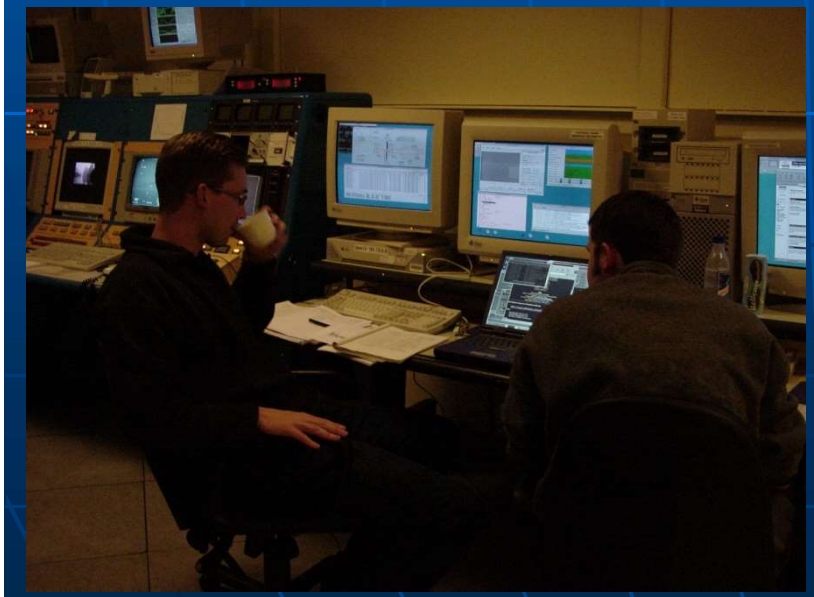
- Mauna Kea visit 2000





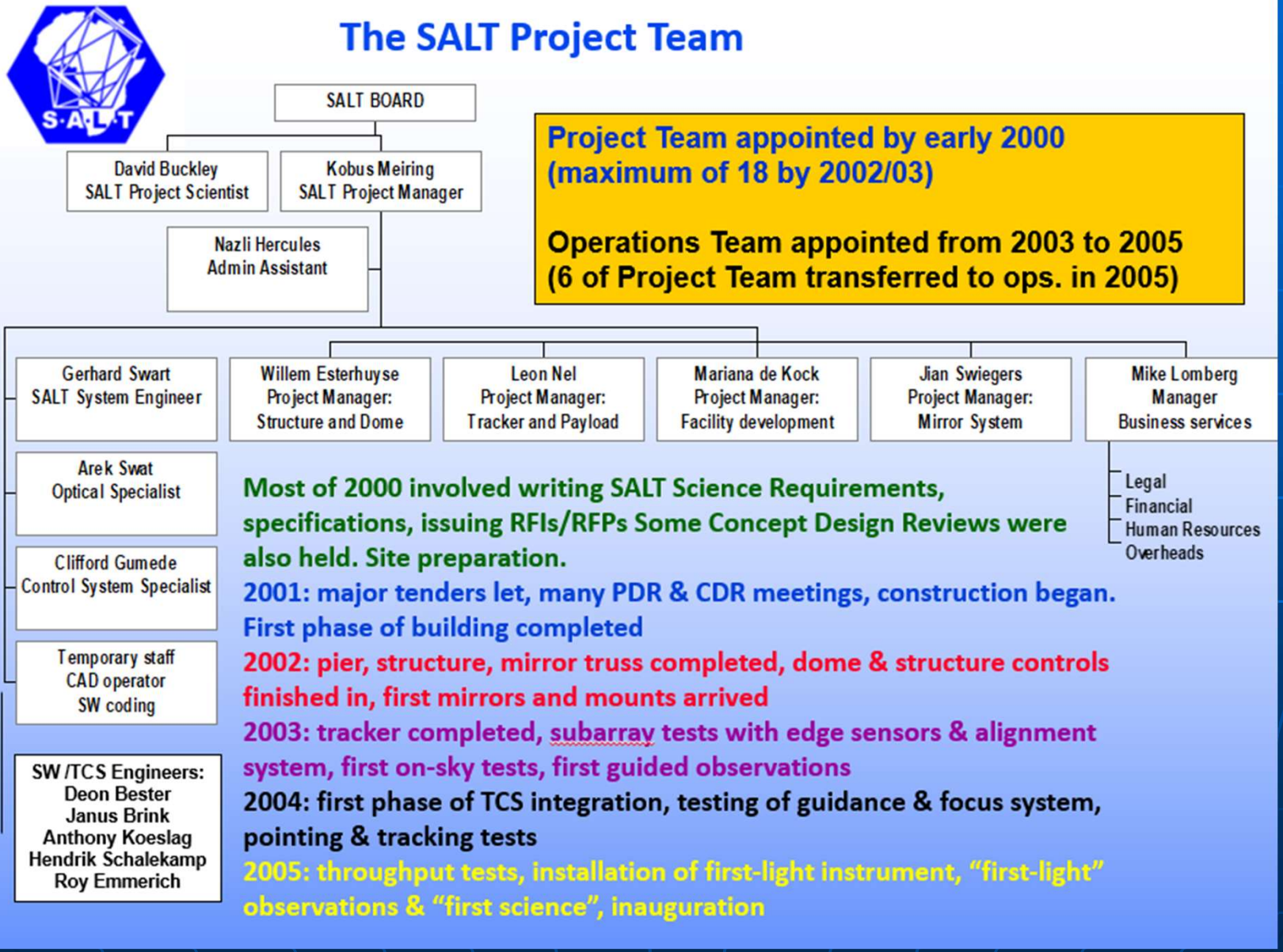
Designing SALT

- La Palma visit 2000 (observing & fact-finding)



Constructing SALT

The SALT Project Team



Project Team appointed by early 2000 (maximum of 18 by 2002/03)

Operations Team appointed from 2003 to 2005 (6 of Project Team transferred to ops. in 2005)

Most of 2000 involved writing SALT Science Requirements, specifications, issuing RFIs/RFPs Some Concept Design Reviews were also held. Site preparation.

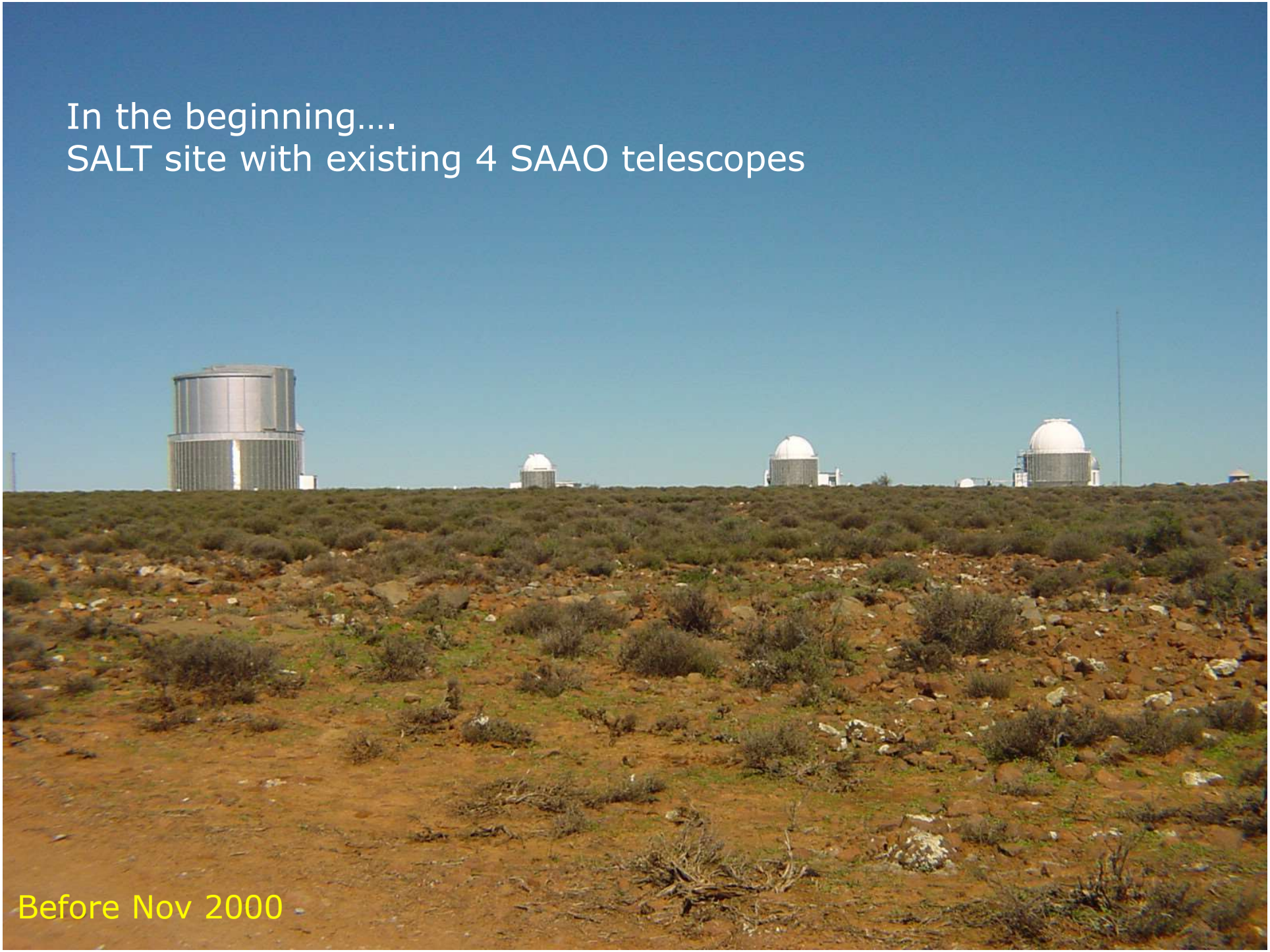
2001: major tenders let, many PDR & CDR meetings, construction began. First phase of building completed

2002: pier, structure, mirror truss completed, dome & structure controls finished in, first mirrors and mounts arrived

2003: tracker completed, subarray tests with edge sensors & alignment system, first on-sky tests, first guided observations

2004: first phase of TCS integration, testing of guidance & focus system, pointing & tracking tests

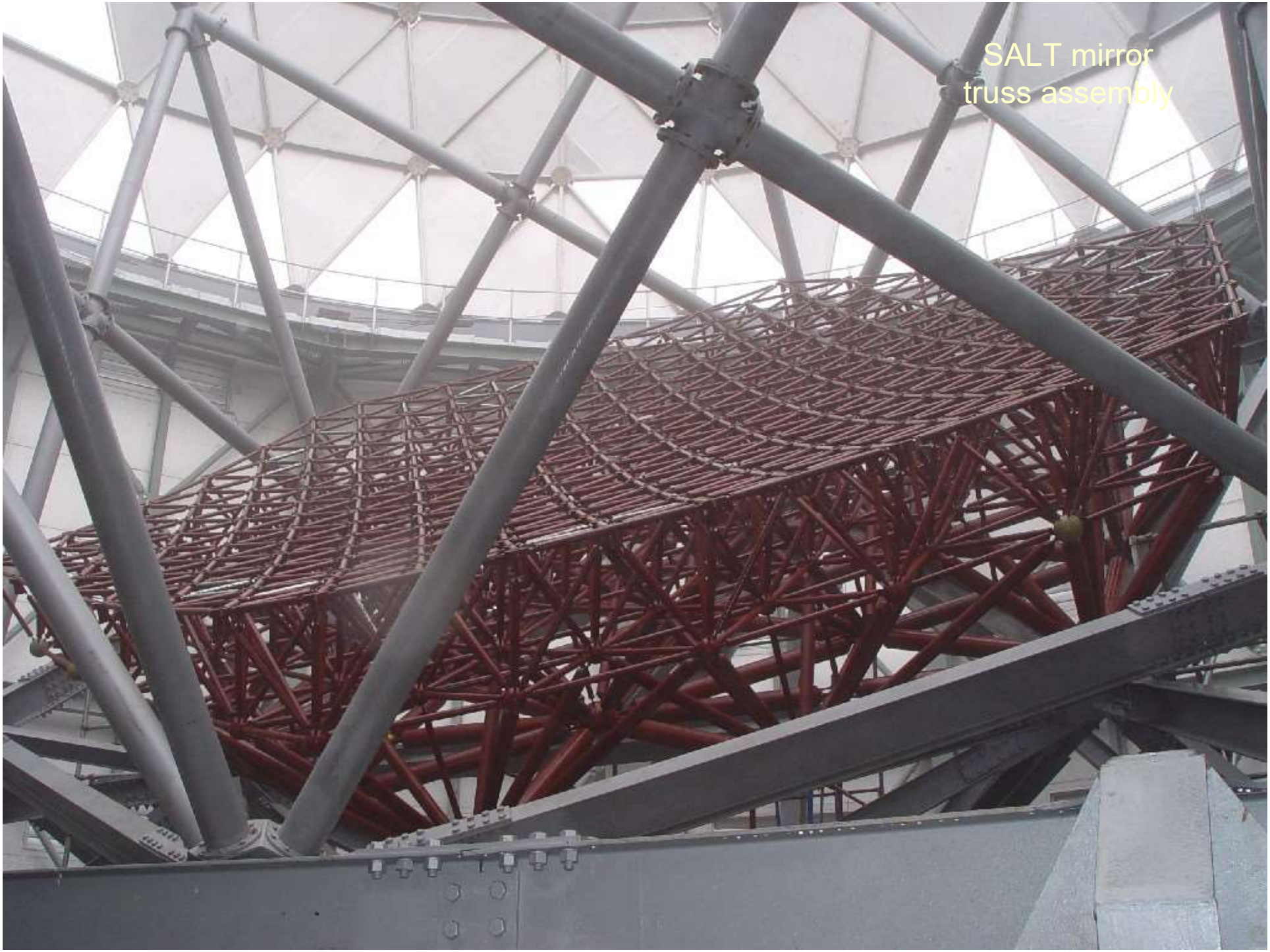
2005: throughput tests, installation of first-light instrument, "first-light" observations & "first science", inauguration

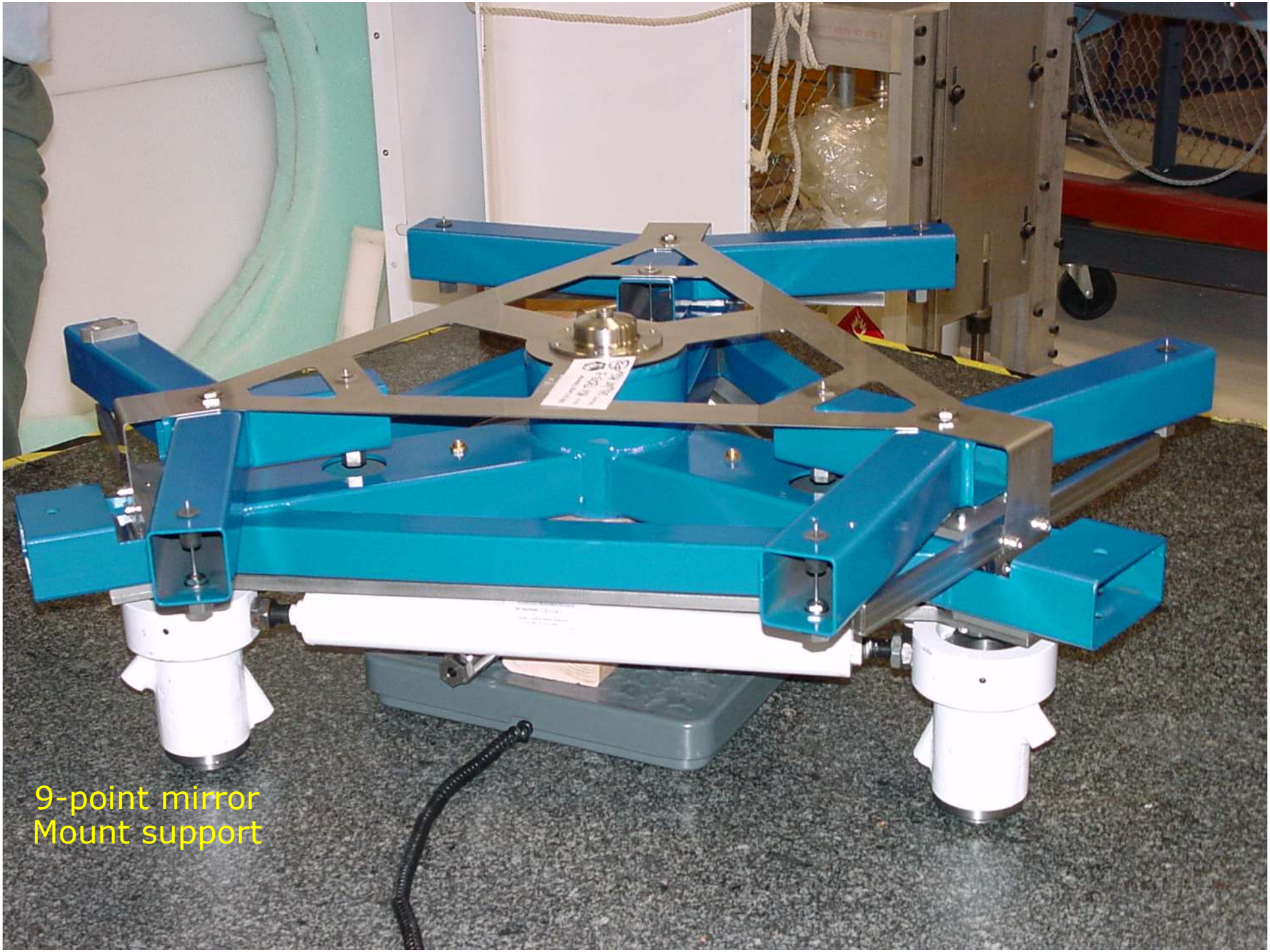

In the beginning….
SALT site with existing 4 SAAO telescopes
Before Nov 2000


1 April
2001

14 June 2001


Oct 2002


SALT mirror
truss assembly


9-point mirror
Mount support

Acceptance of first mirror blanks from LZOS (Russia; 2002-2004)

Installing First Batch of 7 segments (2003)

The SALT Construction Phase was completed in Nov 2005, when SALT was inaugurated.

SALT Inauguration: 10 Nov 2005
Opened by the South African President, Thabo Mbeki

~2000 people attended the inauguration, reflecting the high profile of the project

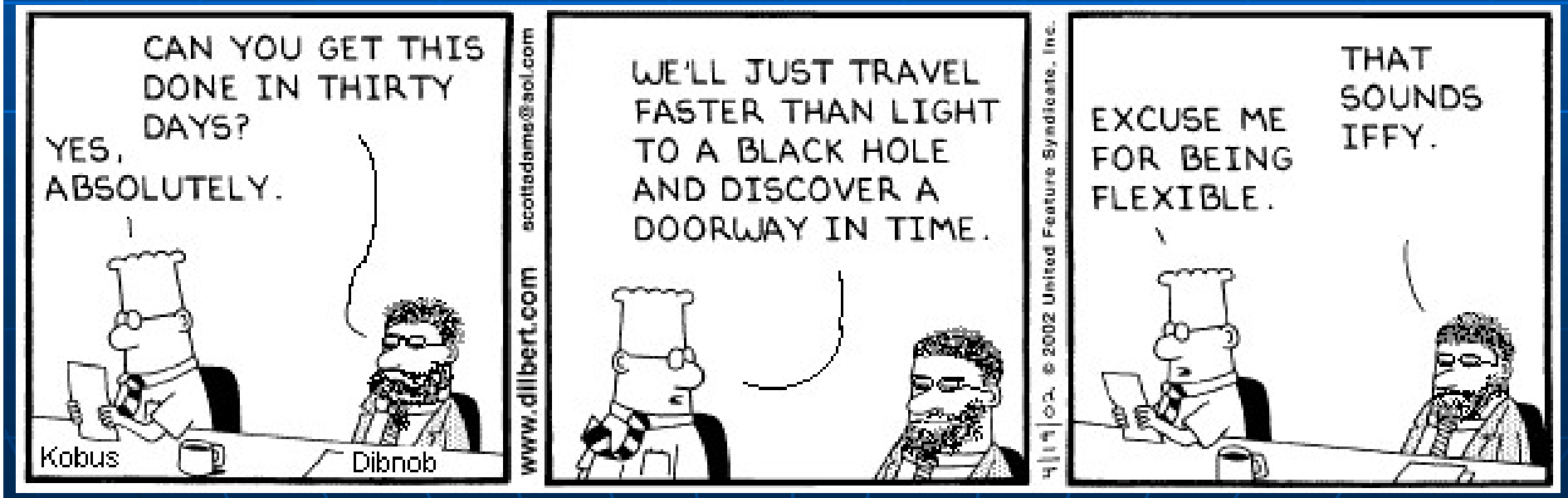
Enjoyed media attention….

Building SALT was sometimes just too much!

But also great fun!

Reality of Commissioning / Completion

- Underestimate of time to complete complex/first-time systems
  - Including the Prime Focus Payload
  - Science instruments (both took ~1 year longer than CDR estimates)
  - Not enough time for integration and thorough/complete testing
  - A significant number of subsystems not completed (e.g. mirror cleaning, SAMS)
    - Handed over the Operations Team which became a "Completion Team"
- Three serious commissioning problems
  - Image quality, spectrograph throughput, mirror edge sensors



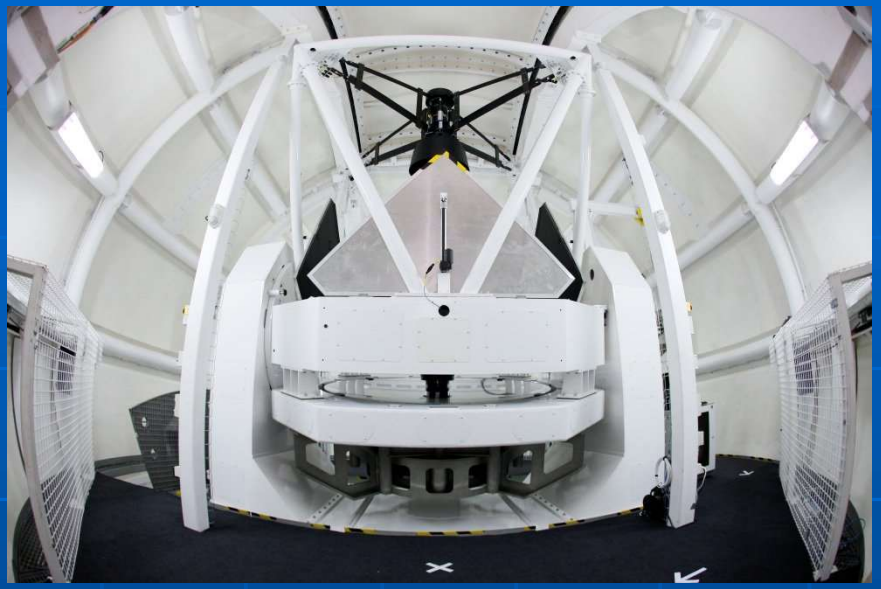
Project Manager Project Scientist

Life After SALT, or *with* SALT

- Most problems solved by 2011 when full science operations began
- After 2015 role in management of SALT Astronomy Operations ends
- Focused on exploiting SALT for research (e.g. started large SALT transient programme in 2016 involving many co-investigators)
- Research mostly on CVs, X-ray binaries & related objects
- Since 2019 involved in Rubin Observatory LSST as a South African PI Affiliate
- PI for several past and present bilateral and multi-lateral programmes (India, Russia, Germany, France, Kenya & BRICS)
- Student supervision/co-supervision (currently 6 PhD + 1 MSc) and lecturing
- Visiting more telescopes for both science and to help with new initiatives

Observing in Thailand

Two observing runs of high-speed photometry with *Ultraspec* on the 2.4m Thai National Telescope (TNT)

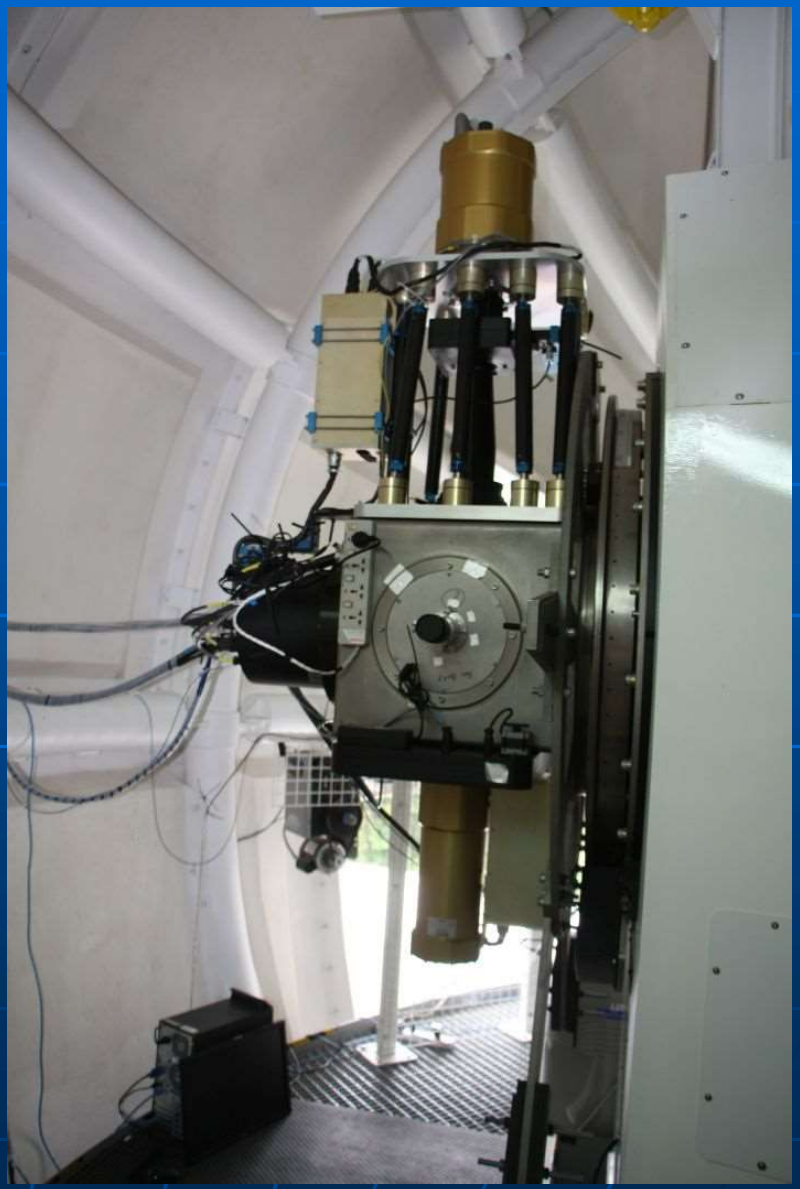


The Telescope/Observatory

- On the tallest mountain in Thailand (Doi Inathon; ~2500m)
- In a National Park in a jungle (no trees could be cut down)

- About 2.5h from Chiang Mai (HQ and remote operations centre)
- Modern efficient 2.4m telescope & smaller 0.4-m
- Operational since 2013
- Observing season Oct-May (Monsoon and poor weather other times)
- Collaboration on HS photometry of mCVs set up after visit to OAD/SAAO by Boonrucksar Soonthornthum (NARIT Director) & fellow Canterbury MSc student (not seen each other for ~33 years)

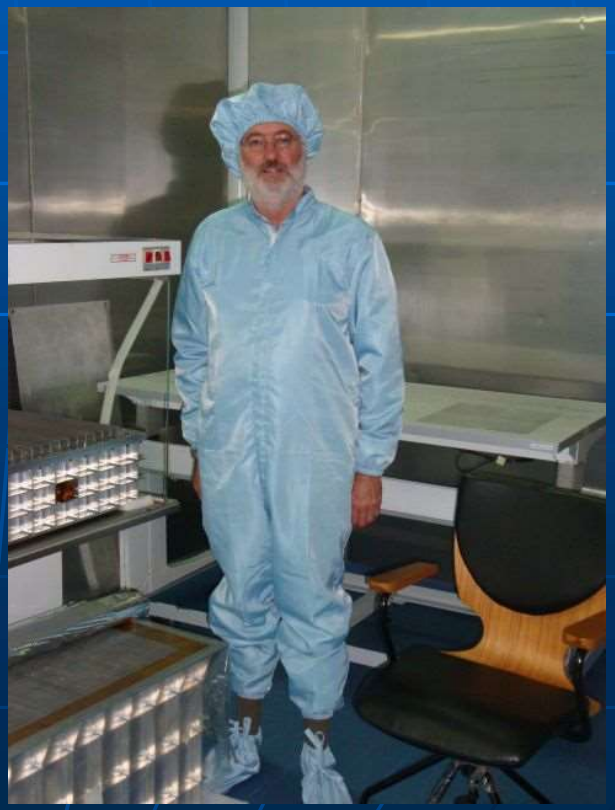
The Thai National Telescope



- Instruments:
  - 4k x 4k CCD imager
  - fibre fed medium R spectrograph
  - Ultraspec (EM-CCD) high speed photometer

A Passage to India

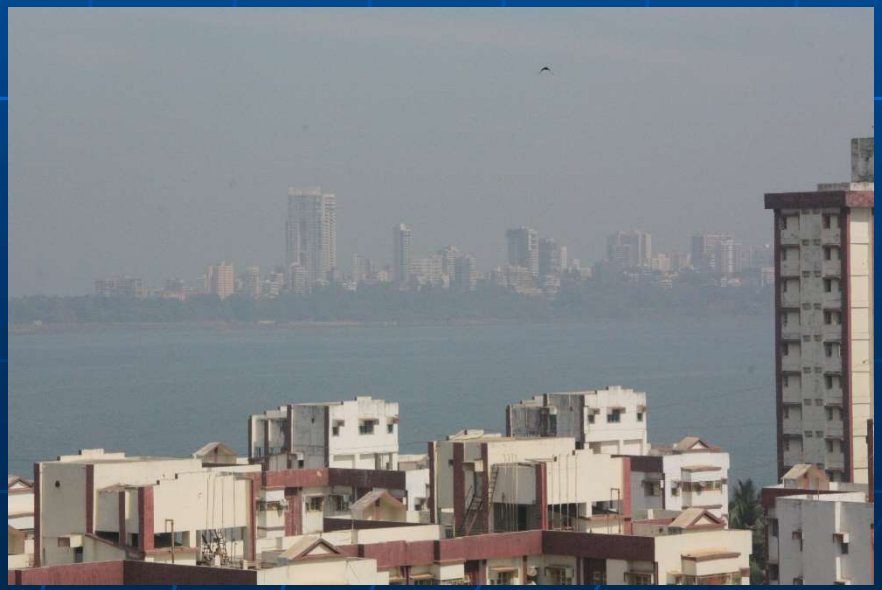
- Many visits to India since 2007
- Initially involving IUCAA joining SALT but also X-ray science meetings (IUCAA and Tata Institute)
- Contracted optics company in Pondicherry to produce SALT edge-sensor blocks (~2012)
- Senior C.V Raman Fellow in 2013 (ASTROSAT collaboration visit)



K.P. Singh & Dipankar Bhattacharrya

A Passage to India

- Mumbai & TIFR (conferences, collaboration visits)

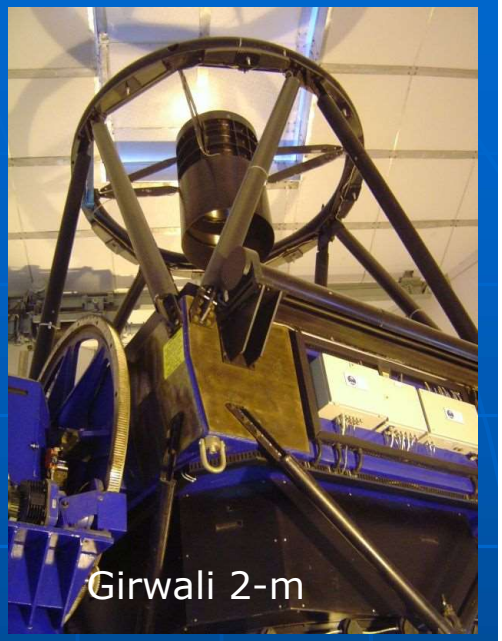


A Passage to India

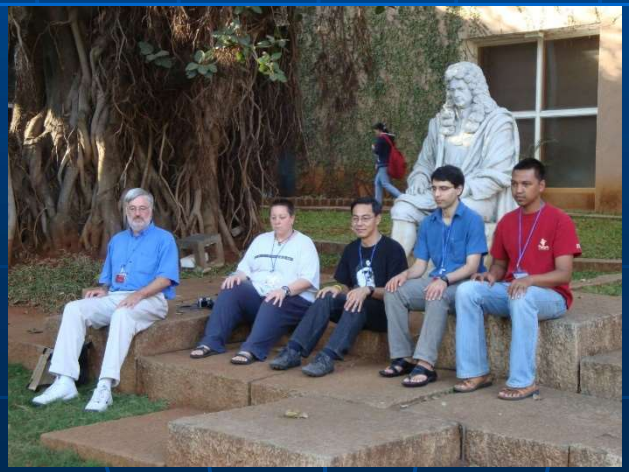
- Many visits to IUCAA in Pune (& nearby telescopes)


Girwali 2-m telescope


Giant Metre wavelength Radio Telescope (GMRT)


Girwali 2-m

At the Inter-University Centre for Astronomy and Astrophysics (IUCAA)



A Passage to India

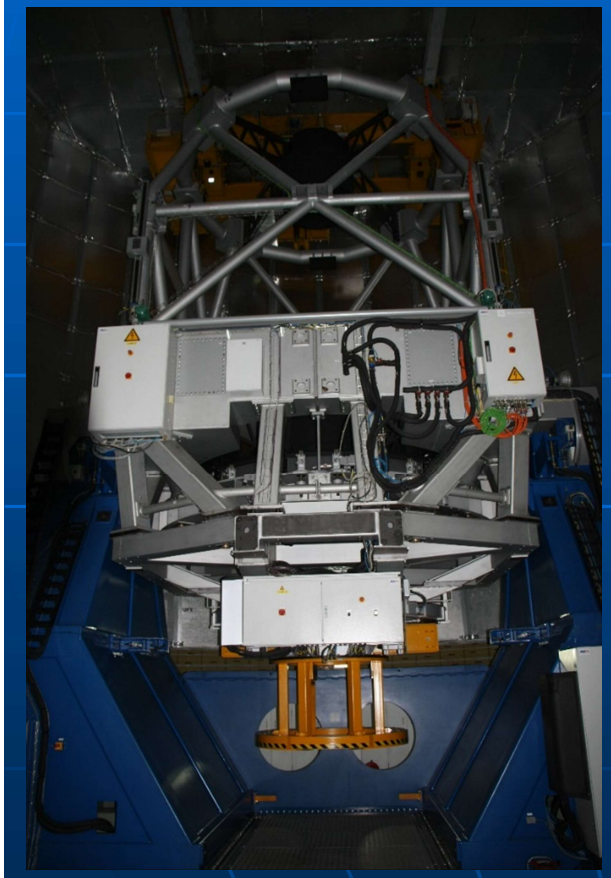
- Many visits to Aryabhatta Research Institute of Observational Sciences (ARIES) in Nainital (west of Nepal)

A Passage to India

- Also to Devisthal (site of new 3.4 m DOT, 1-m telescope & 4-m liquid mirror)
- Operated by ARIES and a few hours drive from Nanithal
- Spectacular scenery of distant Himalayan range

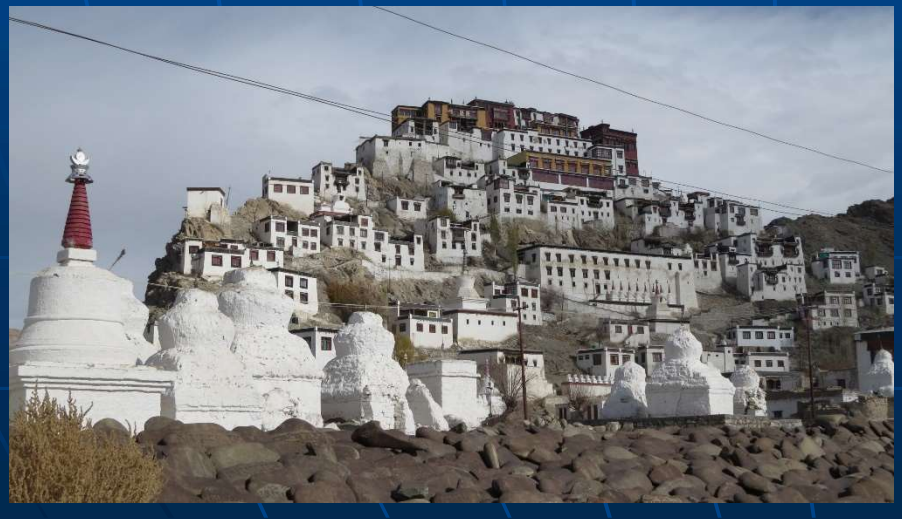
A Passage to India

- The 3.6 –m Devasthal Optical Telescope (DOT)
- The 4-m ILMT (liquid mirror telescope)
- Built on a peak shared by a Hindu temple



A Passage to India

- Visit to Hanle Observatory, 4500 m altitude in Himalayas in Ladahk province
- Last pre-COVID travel (Nov 2019)
- Flew to Leh from New Dehli
- Acclimatization day (school talk, visit to Buddhist temple, monastery, etc)



A Passage to India

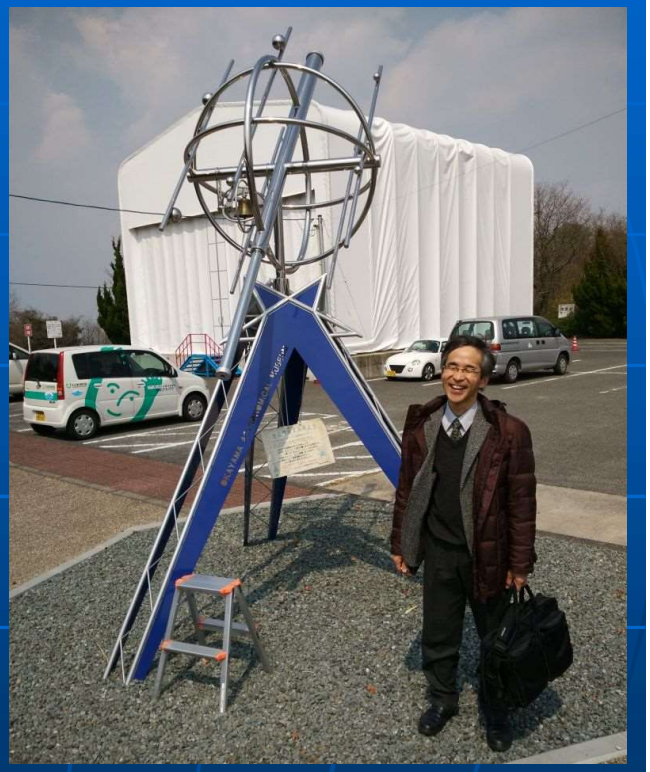
- Operated by Indian Institute of Astrophysics in Bangalore
- Observers use remote operations centre near Bangalore with satellite connection
- Hanle ~10 h drive from Leh, along part of the Indus river valley

A Passage to India

- Hanle Observatory: optical telescopes 2-m HCT, 0.7-m GROWTH
- Site for proposed 10-12 m NLOT

Visit to Okayama Observatory, Japan, 2017

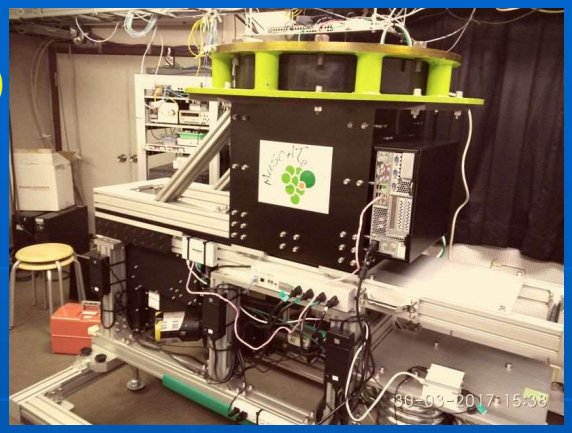
- To discuss details of new 3.8-m segmented mirror telescope (potential for similar telescope in South Africa).
- Visited other telescopes at the site

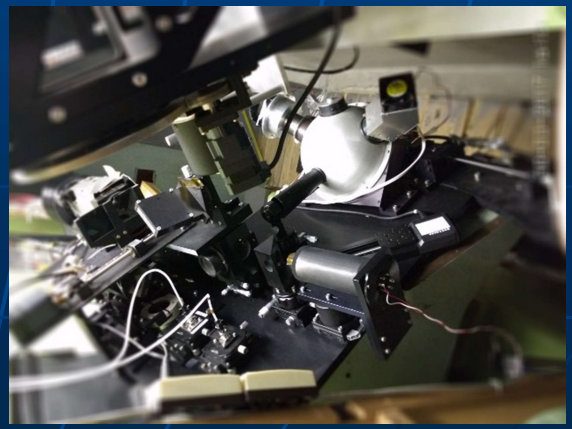


33 years before

Visit to Okayama Observatory, Japan, 2017

- 1.9-m telescope (sibling of the Sutherland 1.9-m)
- Variety of state-of-art instruments (IFU, IR, LFC, coudé)
- Gastronomy too!





Around the World

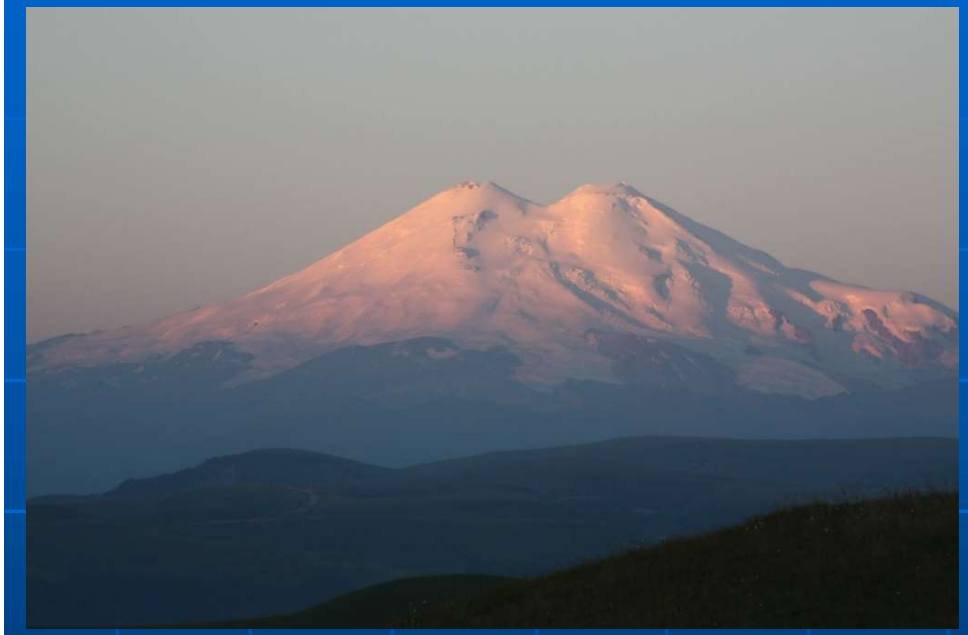
Many other observatories and telescopes visited

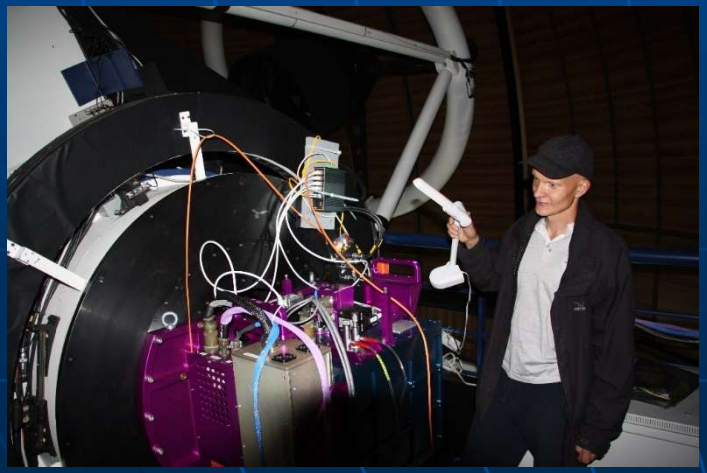
Russia: 6-m BTA in Caucasus Mountains (Zelenchuk)

- Visited in 2008 & 2010

Russia

- Russia: Caucasus Mountain Observatory of Sternberg Astronomical Institute
- 2.5 m telescope (2015 visit) undergoing commissioning





China

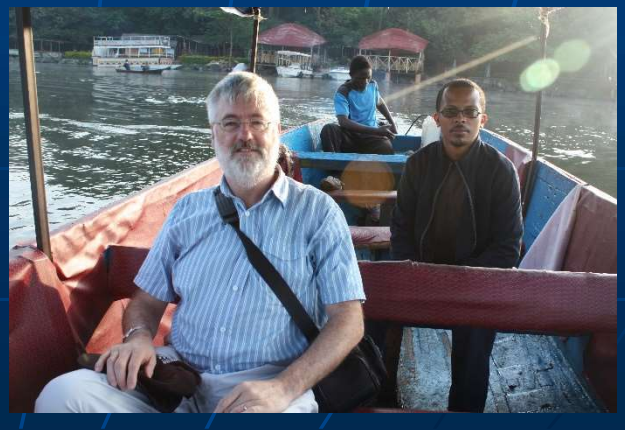
- Invited to LAMOST opening in 2008 & project review meeting
- Attended two ISSI-BJ X-ray workshops & visits to NAOC
- Visited Yunnan & Purple Mountain 2017 with South African delegation
- Big Data meeting in Shanghai

Out of Africa

Astronomy Capacity Building

- East African Astronomical Society meetings
  - Rwanda: 2014
  - Uganda: 2012
  - Ethiopia: 2011
  - Kenya: 2010

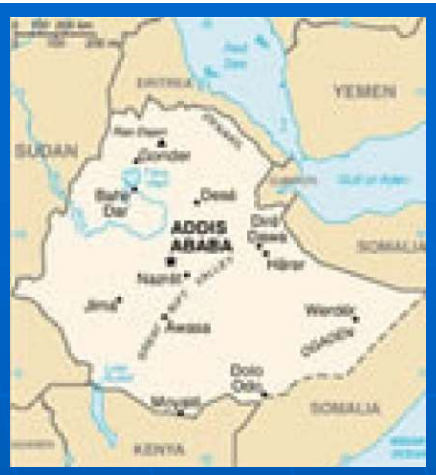
- Focussed workshops
  - Data reduction (e.g. SALT data)
  - Observing training
- Supported through variety of mechanisms (e.g. IAU)



- Chair of AfAS Science Committee (2019-2023)

Out of Africa

Ethiopian Developments



- Astronomy initiatives initiated from Addis Ababa University and Ethiopian Space Science Society (ESSS)
- Visit in 2009 to Addis, Lalibela & Bahir Dar
- Looking for potential sites (some up to 4000 m)
- Initiative to develop a multi-purpose observatory at Mt Entoto, near Addis Ababa
  - Public outreach
  - Student training
  - Astronomical research
- Entoto Observatory and Research Centre established 2012
  - Involves Universities
  - Government support
  - ESSS support
- Subsequent establishment of ESSI (Govt. funded)

Telescopes for Mt Entoto, Addis Ababa

- External advisor (on requirements and specs, RFQs, operations model)
- Two well instrumented modern 1.0-m telescopes were installed in 2013 (f/8; 45 acmin corrected FoV). Some challenges encountered.

Site Testing in Kenya

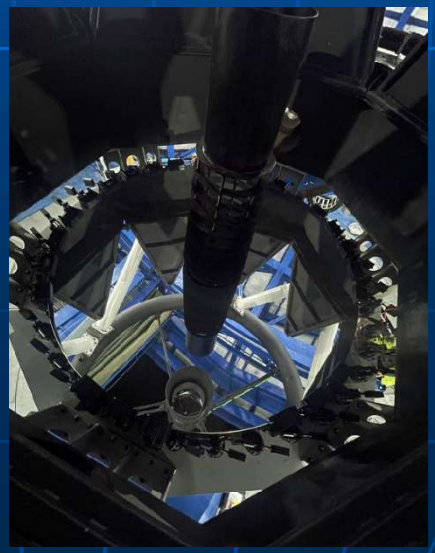
- Initiative to find a site for an optical telescope
- Started as SA-Kenya bilateral (2013) and expanded with UK involvement (ATC)
- Sites identified in north, near Lake Turkana (formerly Lake Rudolph) region
- First phase installing Automatic Weather Stations (e.g. Wamba)

Site Testing in Kenya

- Site visits by climbing and helicopter in 2018
- Potentially excellent sites (best equatorial?)

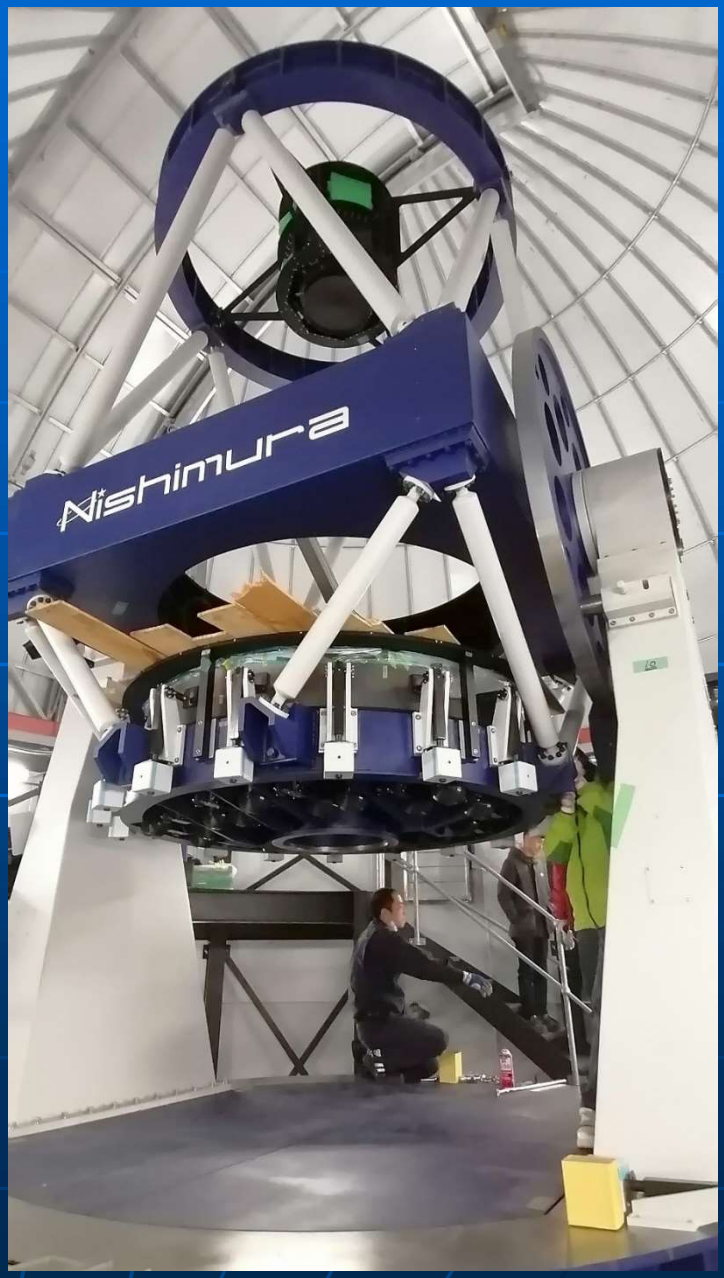
New 3.4-m Iranian Telescope

- From 2017 have served on International Advisory Board of the Iranian National Observatory (also members from UK, Europe and China)
- Attended design review in Aug 2017 when construction began
- Situated on 3600-m Mt Gargash, an excellent site with frequent sub-arcsec seeing.
- First light achieved in late 2022.



My Last* Telescope Project: PRIME

- PRIME is a wide field near IR telescope (Japan, US, South Africa)
- SAAO Project Manager for building design and construction (2017-2022)
- Installed in mid-2022 and being commissioning



** ever, or for now?*

Recent Telescope Networking Projects

- Involved in global projects to network existing and future ground-based telescope into AI "machines"
- Driven by transient & Big Data astronomy, particularly Rubin Observatory's LSST and SKA
- Leveraging SAAO's Intelligent Observatory (IO) project
- BRICS initiative
- African initiative


SAAO Sutherland plateau

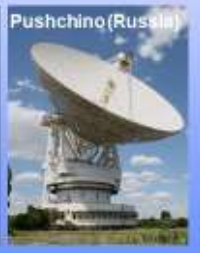

Rubin


SKA

Recent Telescope Networking Projects

Exploit Existing BRICS Facility Access

Exploit Existing BRICS Facility Access

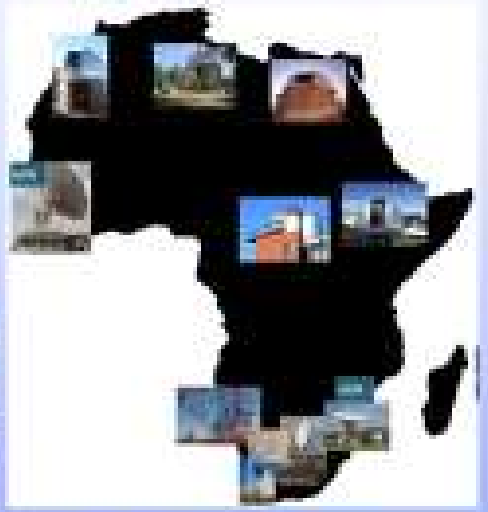


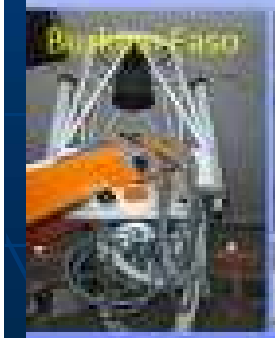
Recent Telescope Networking Projects

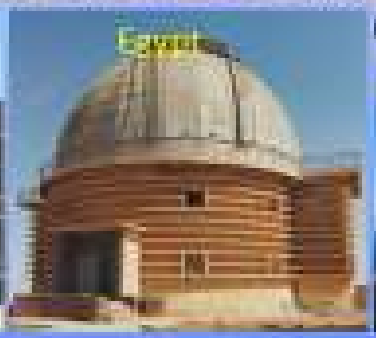
The African Integrated Observation System (AIOS)

An African-wide Optical Observation Network

- Expand an *Intelligent Observatory* concept into Africa
- Use existing facilities networked together
  - Morocco
  - Algeria
  - Egypt
  - Ethiopia
  - Burkino Faso
  - South Africa







Concluding Remarks

- My astronomy career has been immensely rewarding, productive & fun
- Culminated in SALT, challenging at times, but has been a real success
- Worked with and met some great people, including astronomers, scientists, engineers…, which has been a real privilege
- Have really enjoyed interacting with young researchers through supervising, lecturing & mentoring
- Telescopes and their instruments (over all wavelengths) are cool and learning about them and helping in their development has been just as rewarding as publishing papers
- Apart from all of my past supervisors, directors, board members, colleagues, collaborators, *I also acknowledge the forbearance, understanding and support of my wonderful loving family*