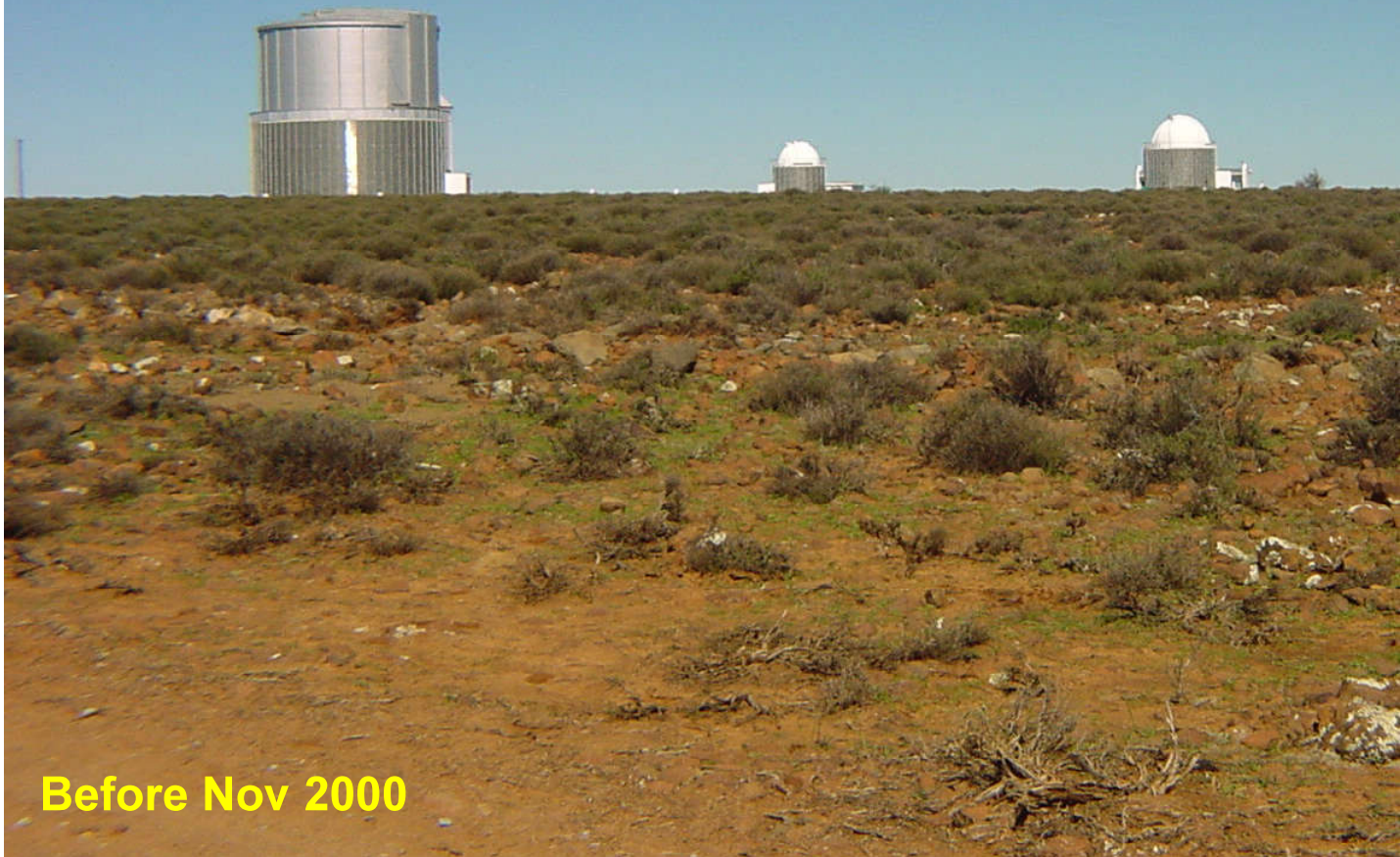


History of SALT:

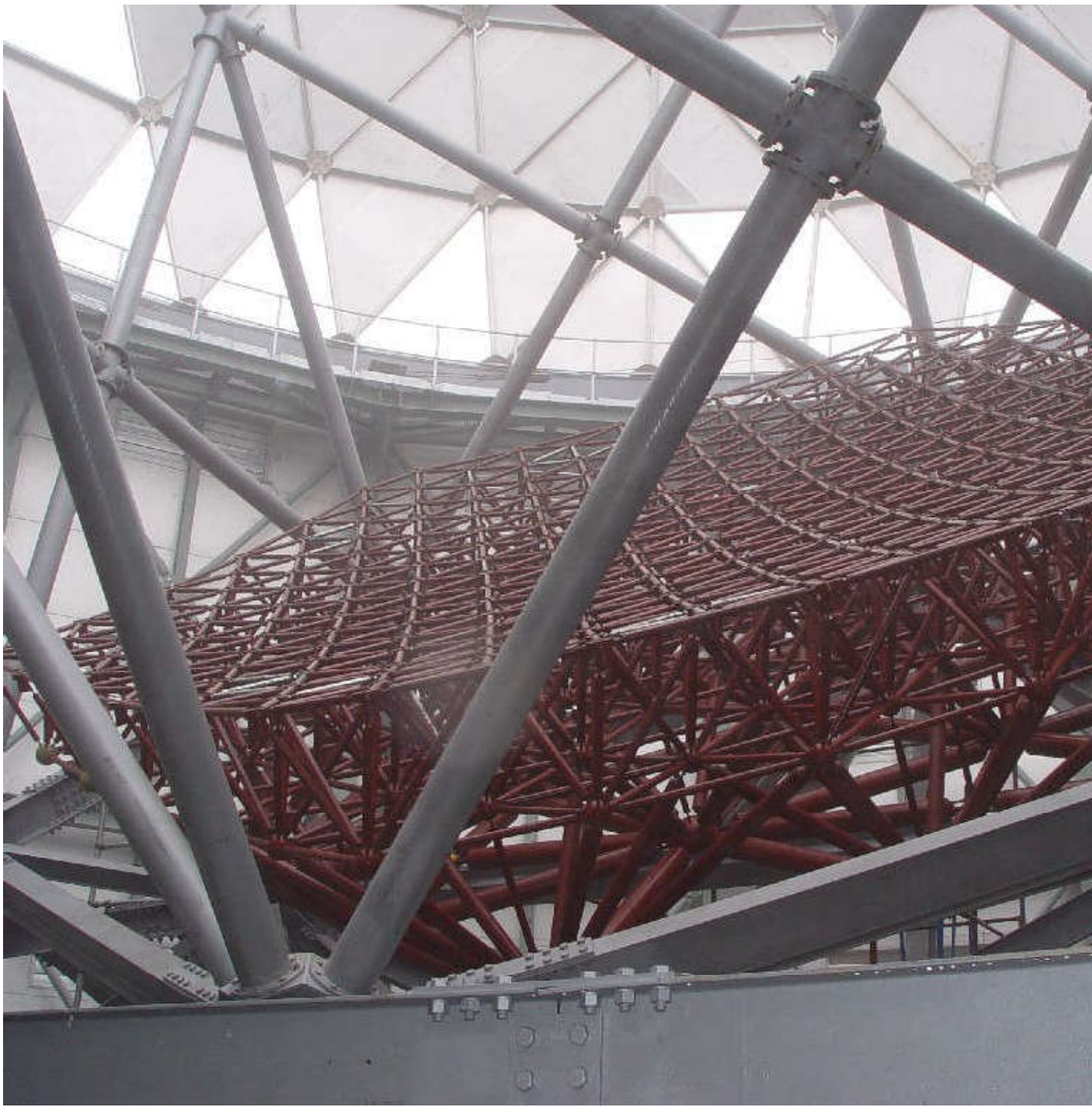
In the beginning....

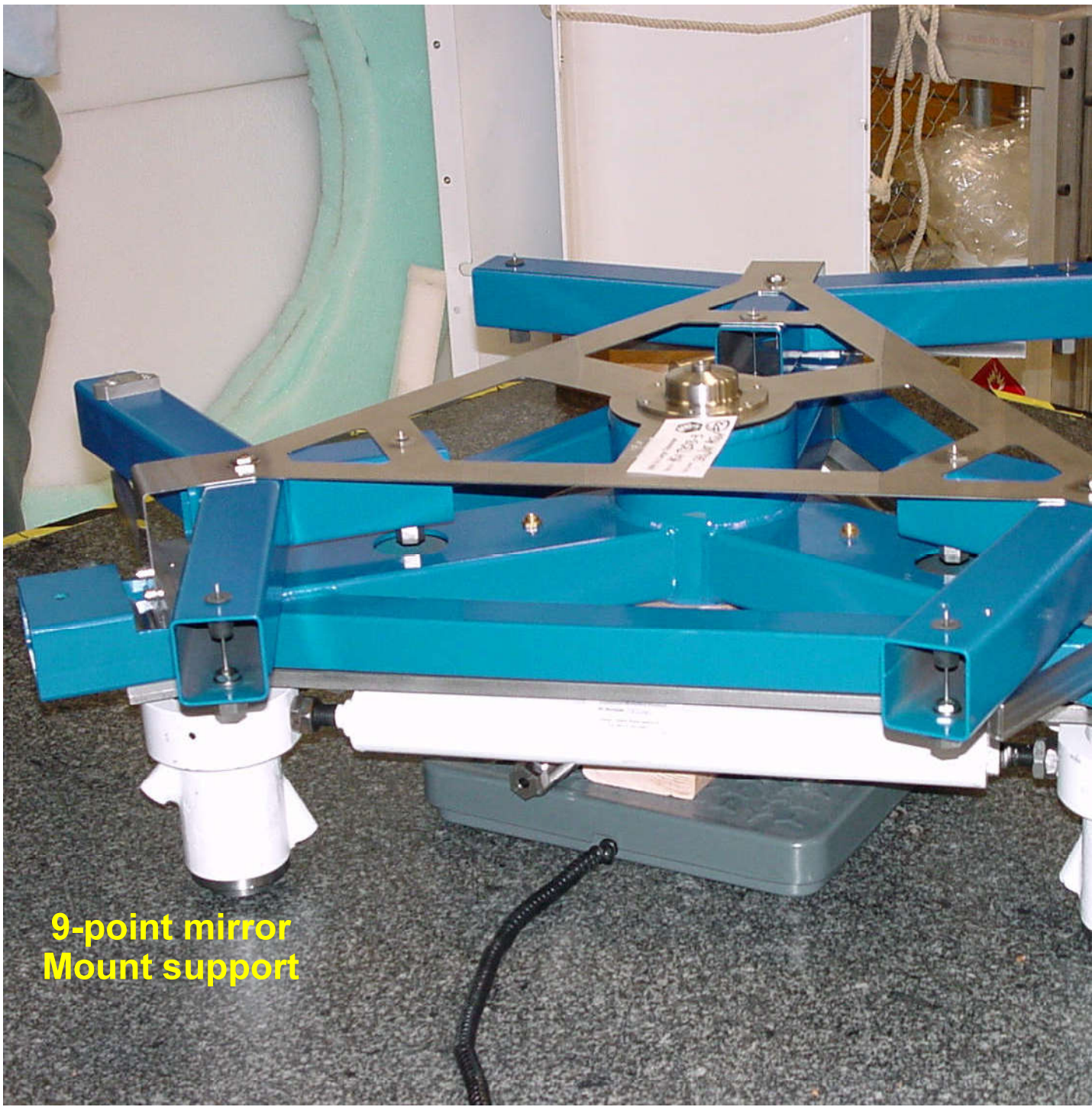
SALT site with existing SAAO telescopes



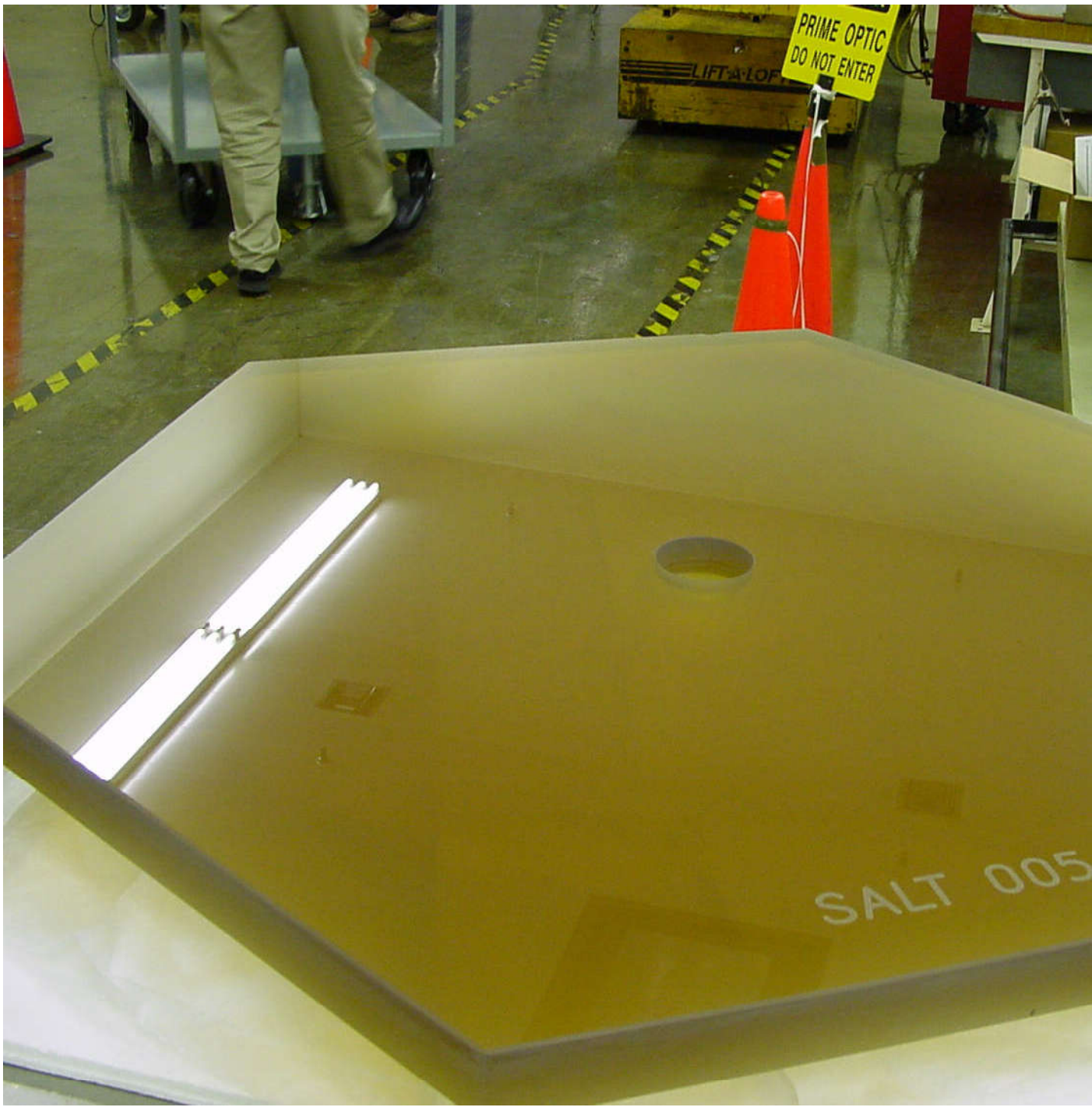
Before Nov 2000

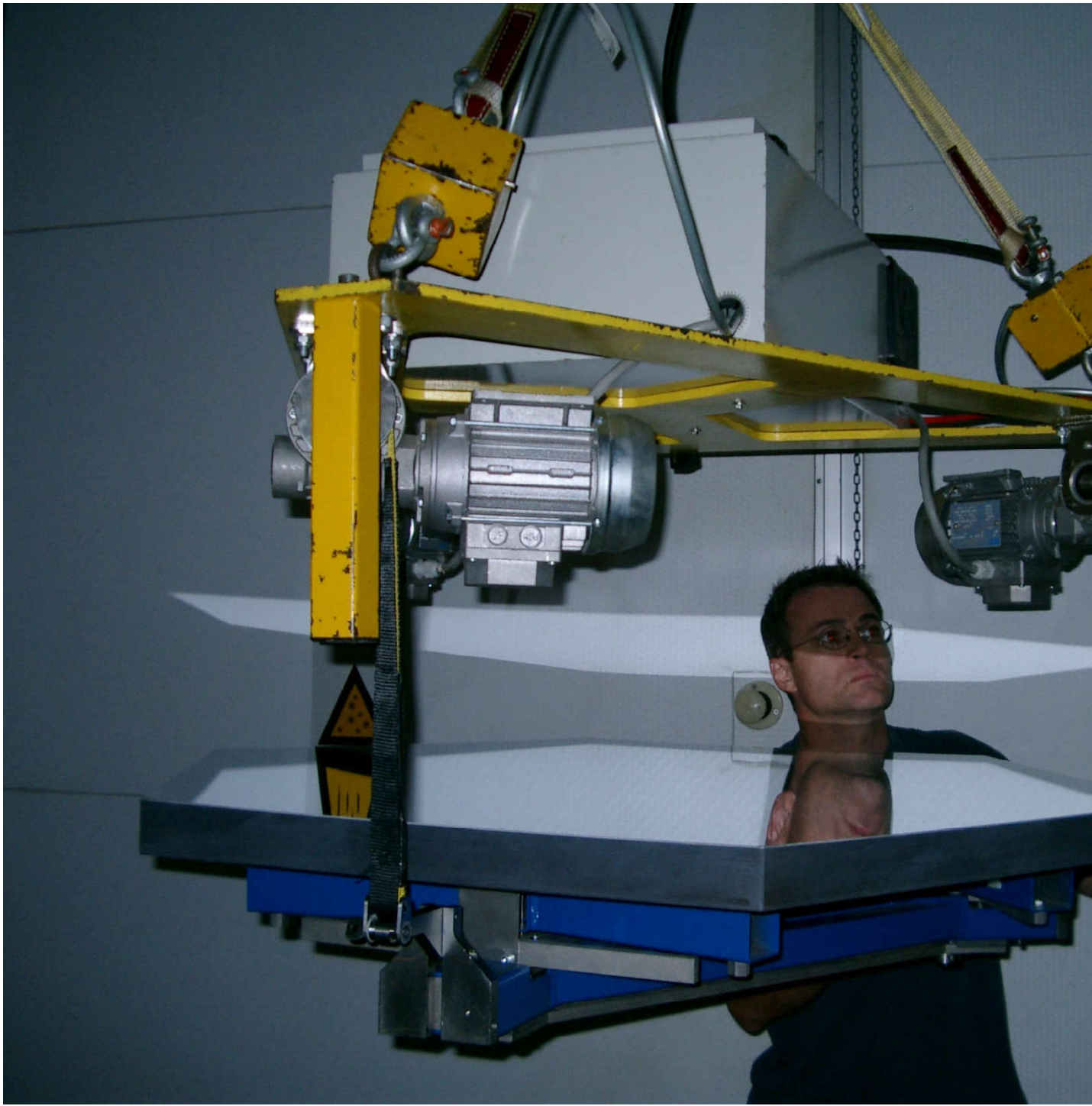






**9-point mirror
Mount support**





Prime



Completed (May 2015)

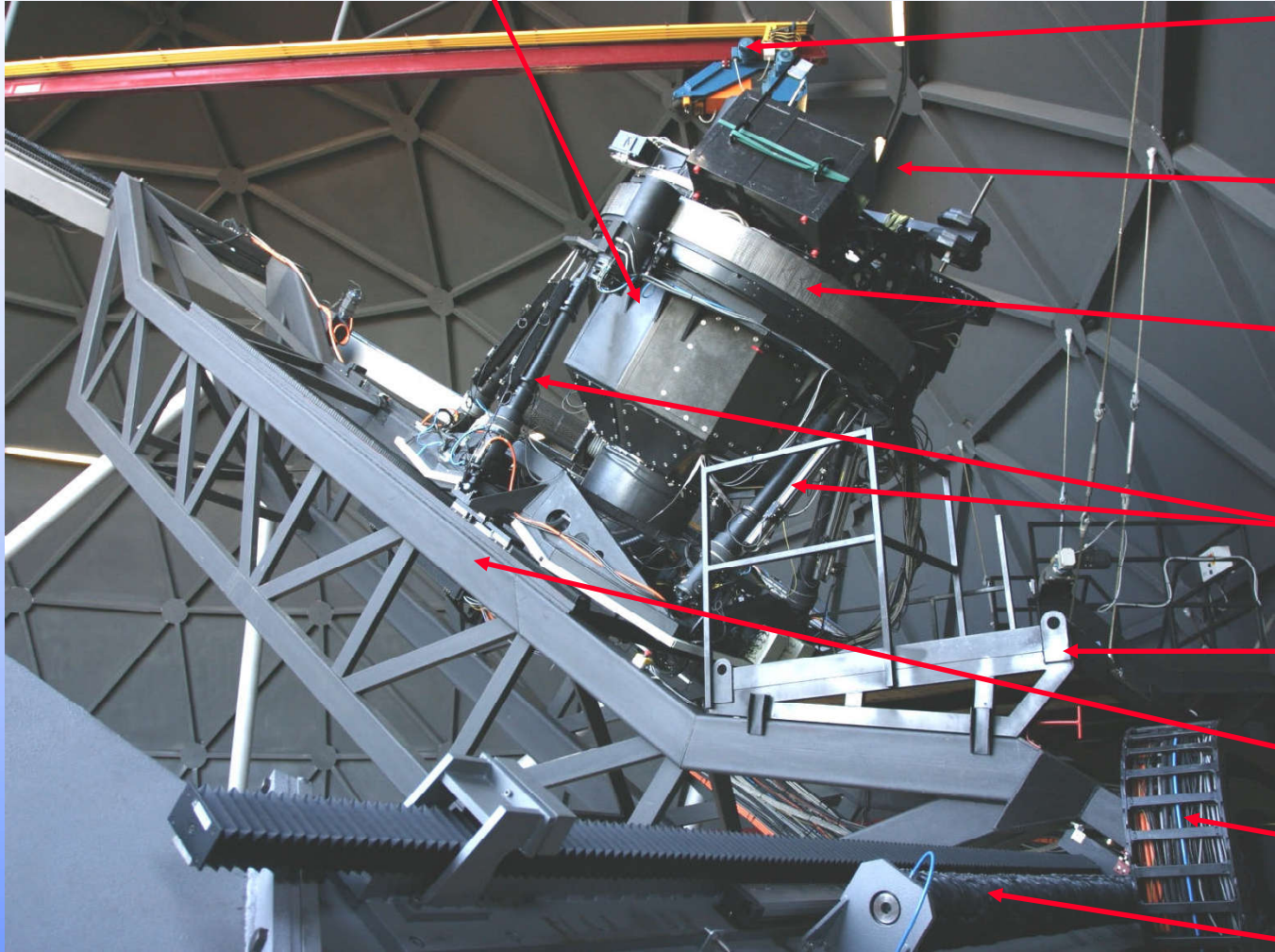


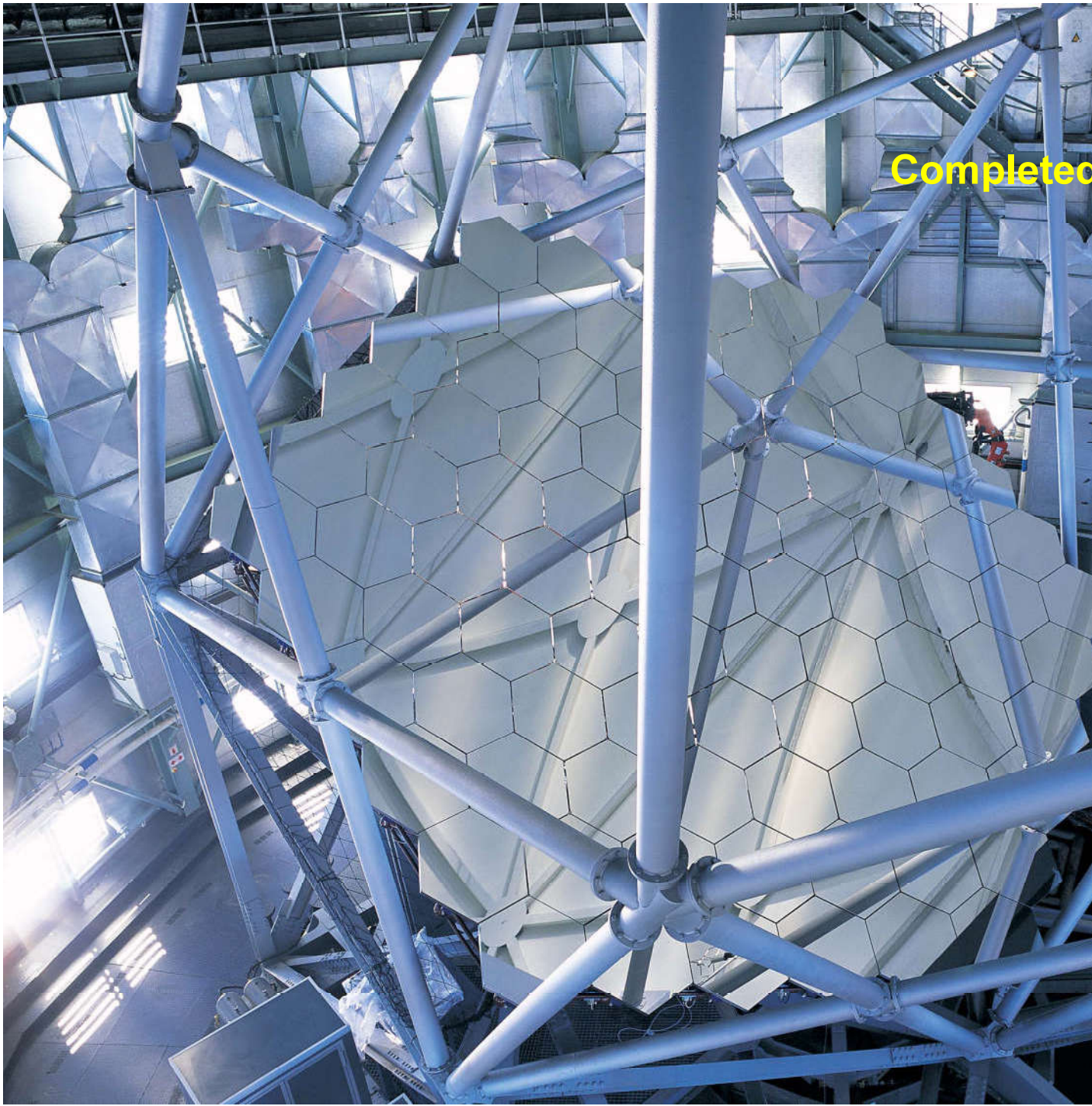
- Dome
- Shutter
- Tracker & Pay
- Structure
 - TUBE
 - BASE WEDG
 - MIRROR TRU
- Facility Building
 - CAT-WALK A
 - AIR CONDITI
 - VENTILATIO
- Primary Mirror



SALT instruments are all mounted on Primary Payload

Payload structure (rotating & non-rotating components) composite







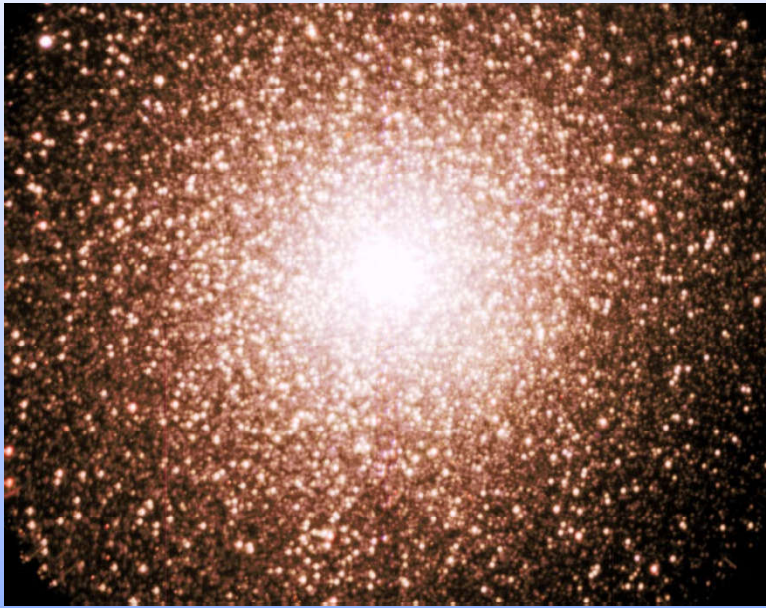


When was SALT completed?

Declaration of SALT “First Light”:

- **With all segments installed (May 05)**
- **With SALTICAM and filter set (Jul 05)**

**But, no active optics (edge sensors)
and no closed-loop guidance/focus**

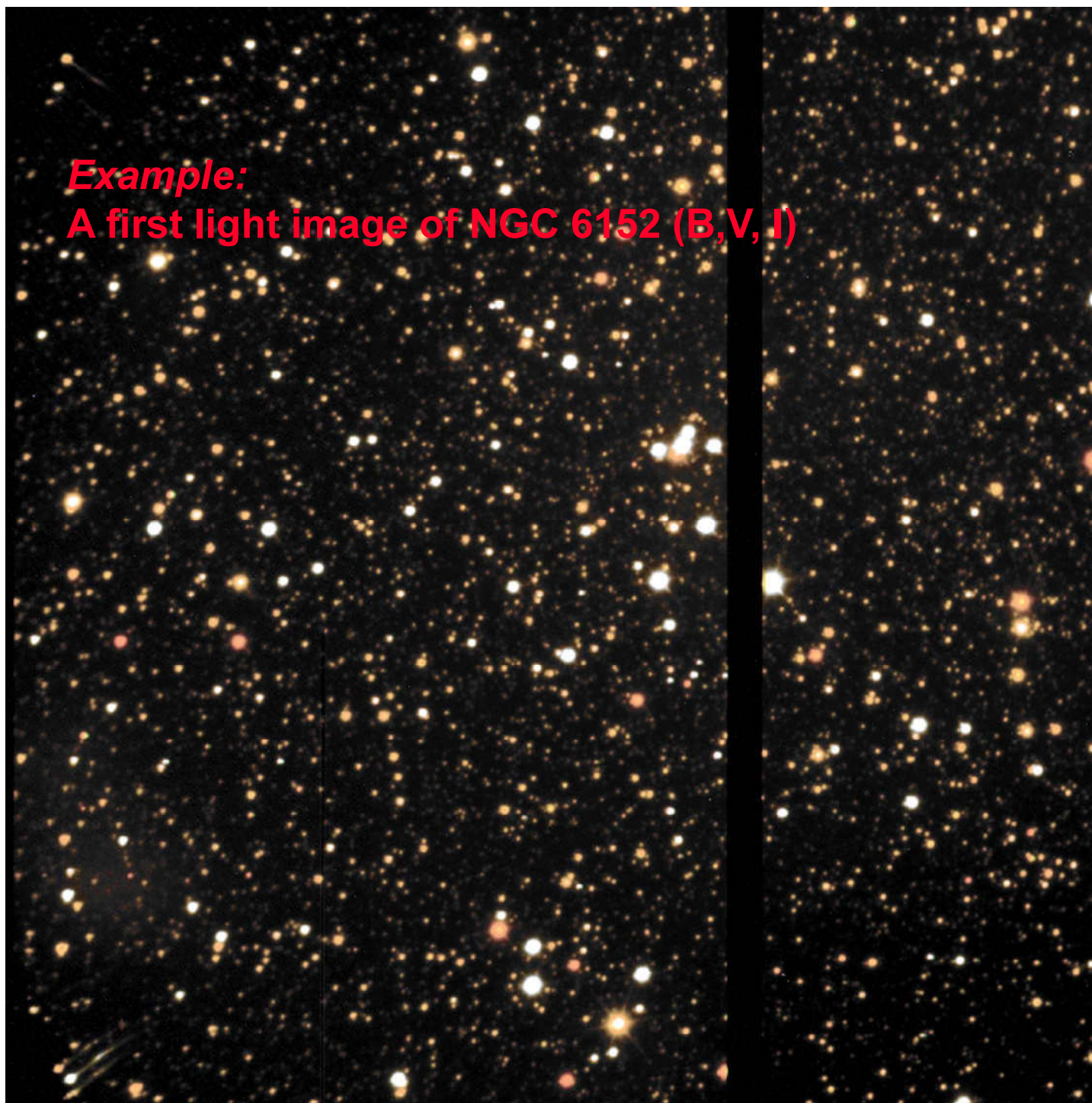


**47 Tuc:
Combined U,V,I (120 sec total)**



Lagoon Nebula: 180 sec

Example:
A first light image of NGC 6152 (B, V, I)



**The SALT Construction Phase was completed in Nov 20
SALT was inaugurated.**



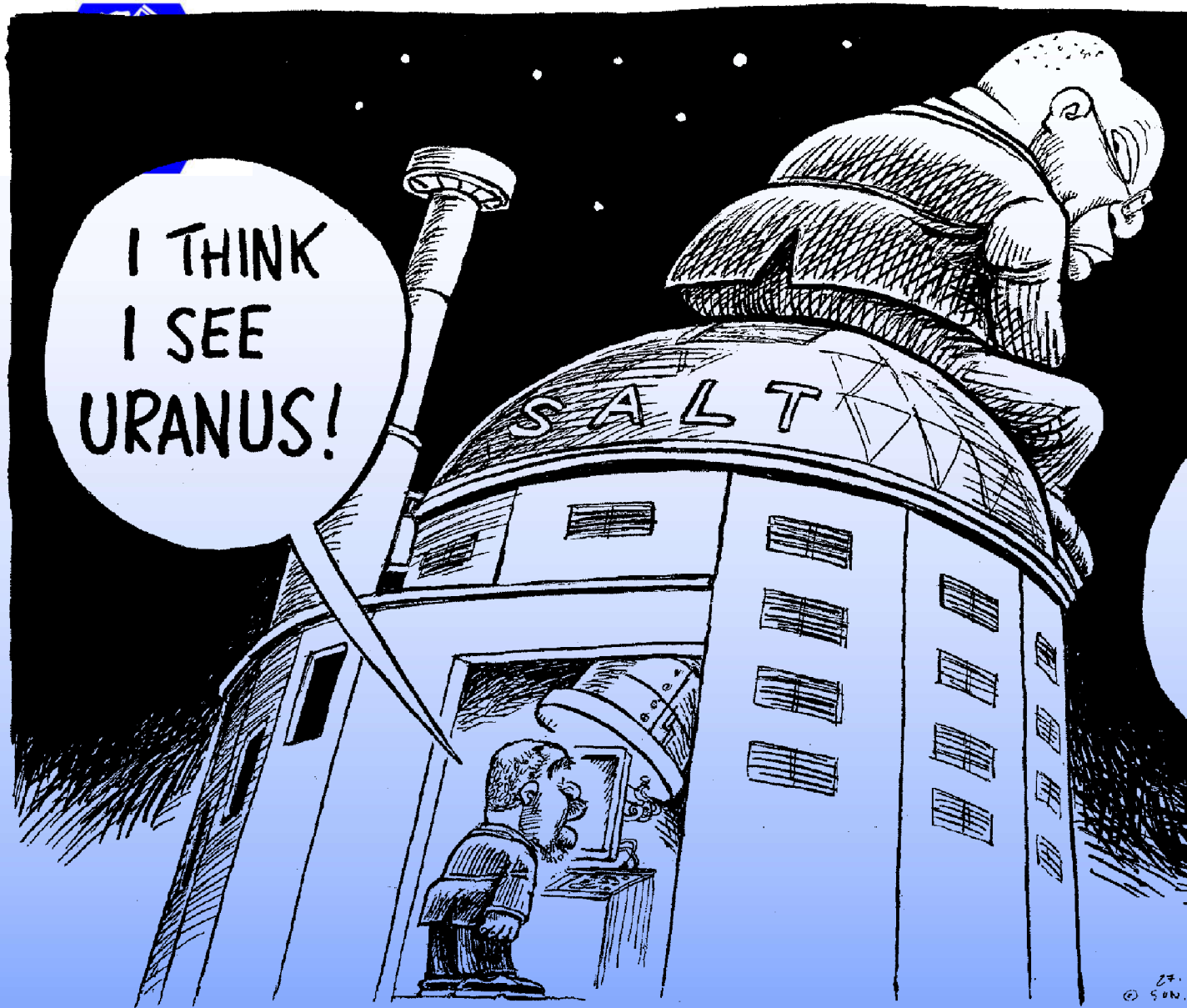
**SALT Inauguration: 10 Nov 2005
Opened by the South African
President (at the time),
Thabo Mbeki**



~2000 people attended inauguration, reflecting of the project



Has enjoyed media atte



27 November 2005

President Mbeki inaugurates the huge Southern African Large Telescope (SALT) in the Karoo

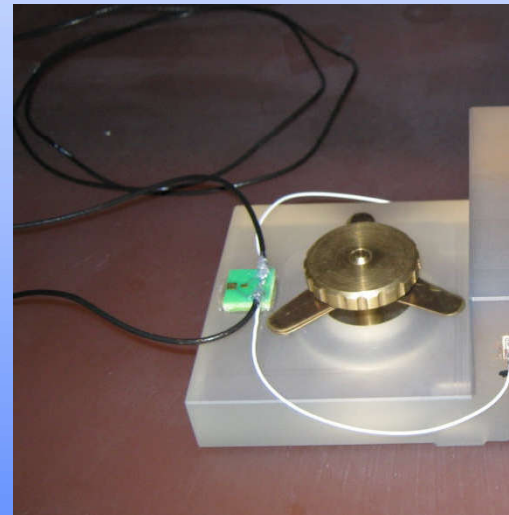
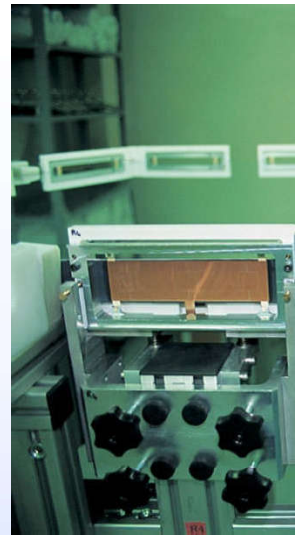
Then... The initial bad news:

- Commissioning & performance verification 2005-2006
- Two major problems were identified in 2006
 1. Poor telescope image quality (field dependent defocus aberrations)
 2. Spectrograph's poor throughput, particularly <400 nm
- Engineering work continued on major & minor problems (started in late 2005/early 2006, so all on-going issues have had to be handled by the SALT Operations Team and SAAO staff).
- Completion work on several SALT subsystems (mirror cleaning sensors, Payload) not fully completed by the Project Team
- **Another problem encountered was:**
 - Failure of the mirror edge sensing system to perform its function
- Science was undertaken for ~50% of time
- All problems fixed and full science operations began in**



Mirror Edge Sensors

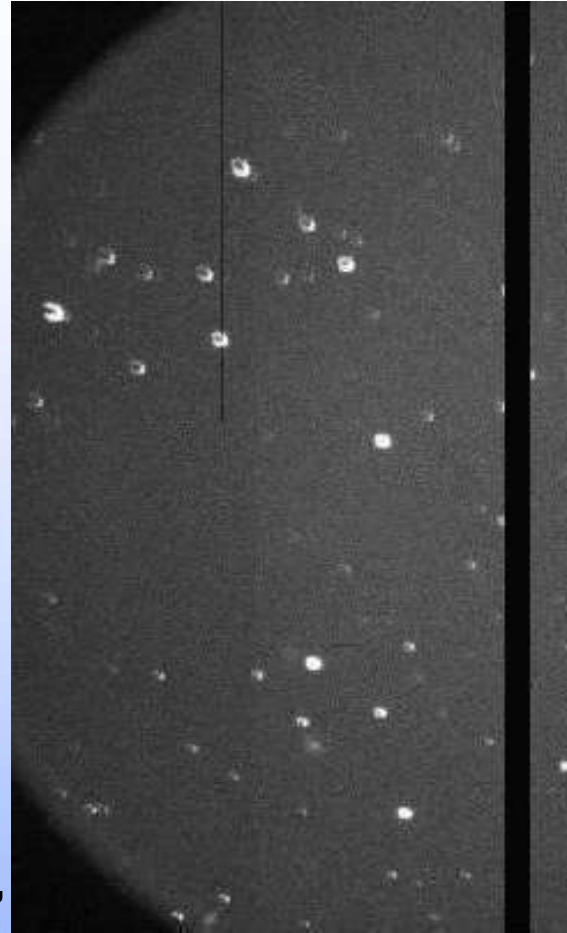
- **Reasons for failure of capacitive system**
 - *Behaviour of sensors in response to $RH > 60\%$ unpredictable and not repeatable from night to night despite similar conditions*
 - *Micro-condensation on the surface of sensors completely random*
 - *Absorption of moisture and high dust count in telescope on sensor reduces RH sensitivity*
 - *Extremely difficult to separate temperature from humidity effects*
 - *Likely long time constants involved (days?) precluding repeatable behaviour*
- **Now moving to inductive sensors (as developed for TMT)**
- **Contract began in July 2012**
 - *Expect delivery from mid-2013*





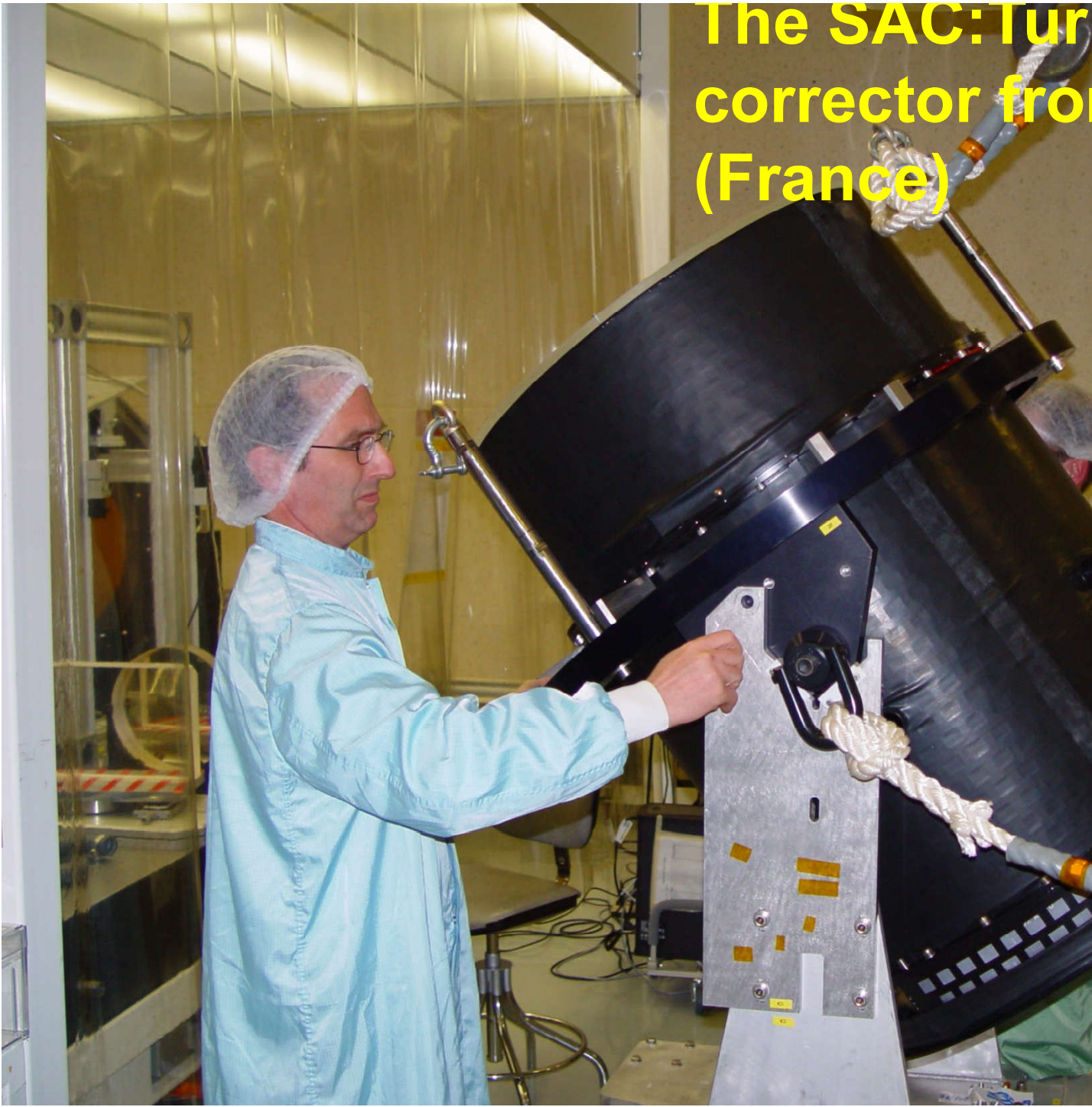
First Major Problem: The Poor Initial

- Images show field dependent aberrations (blur)
- ***Seriously compromises science capability.***
- Diagnosing cause was a long (>2 yr) process requiring a ***huge amount of effort, particularly heroic from Darragh O'Donoghue et al.***
- Cause traced to opto-mechanical mounting and interface problems
 - New interface has been designed, built, installed and tested



Finally cured by July 2010 after new SAC opto-mechan

The SAC:Tur
corrector from
(France)



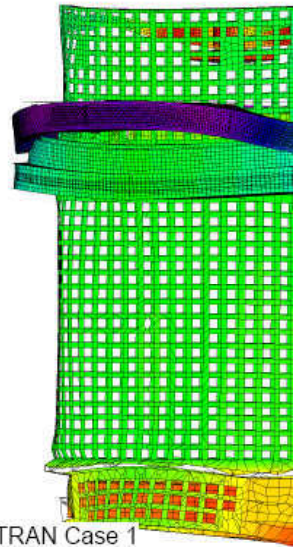


SAC Repair

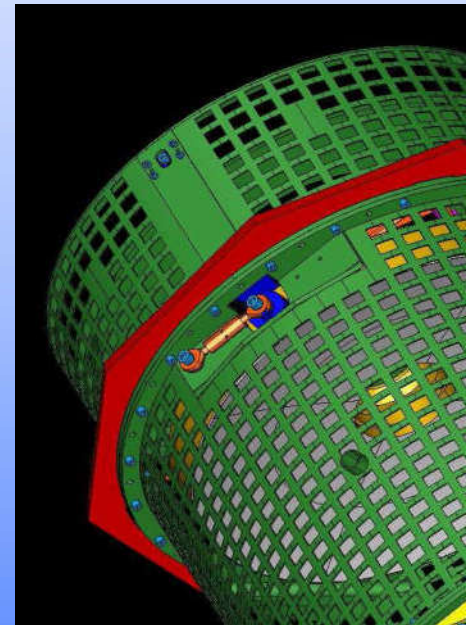
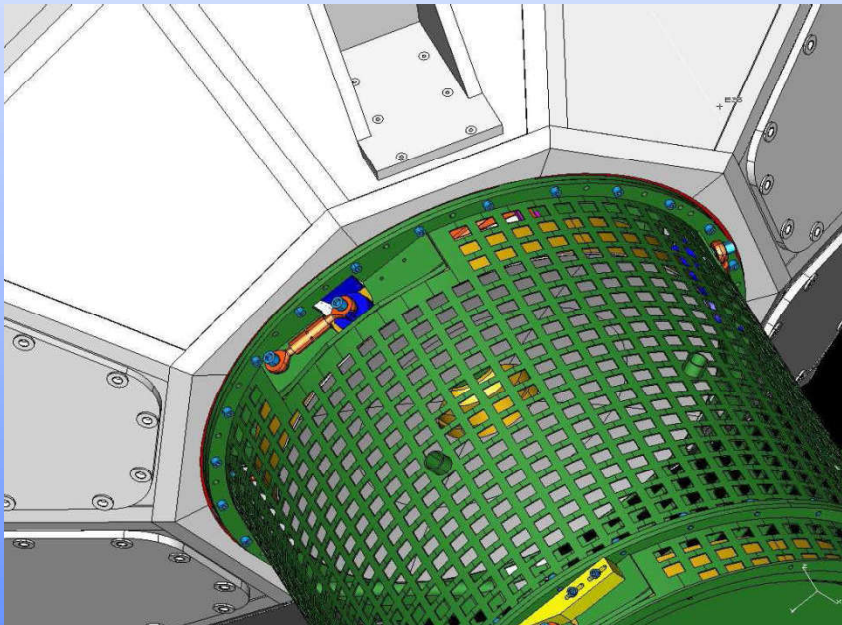
- **Interface**

- Lack of appreciation of the importance of this interface
- Warping caused by thermal mismatch
- “Minor” mechanical distortions have huge effect optically
- **25 bolts and no kinematic mount was a flawed design**

V1
L1
C3



Output Set: MSC/NASTRAN Case 1
Deformed(0.0000502): Total Translation
Contour: Total Translation





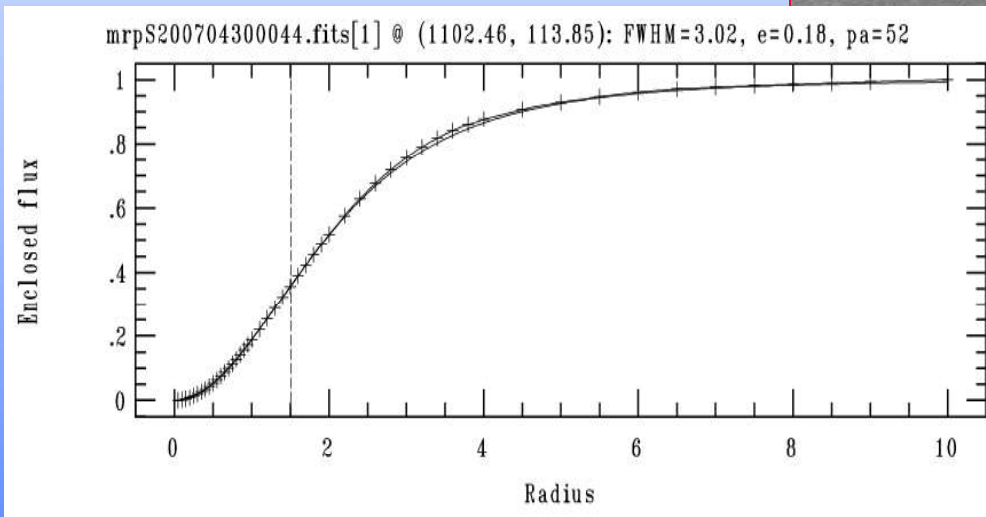
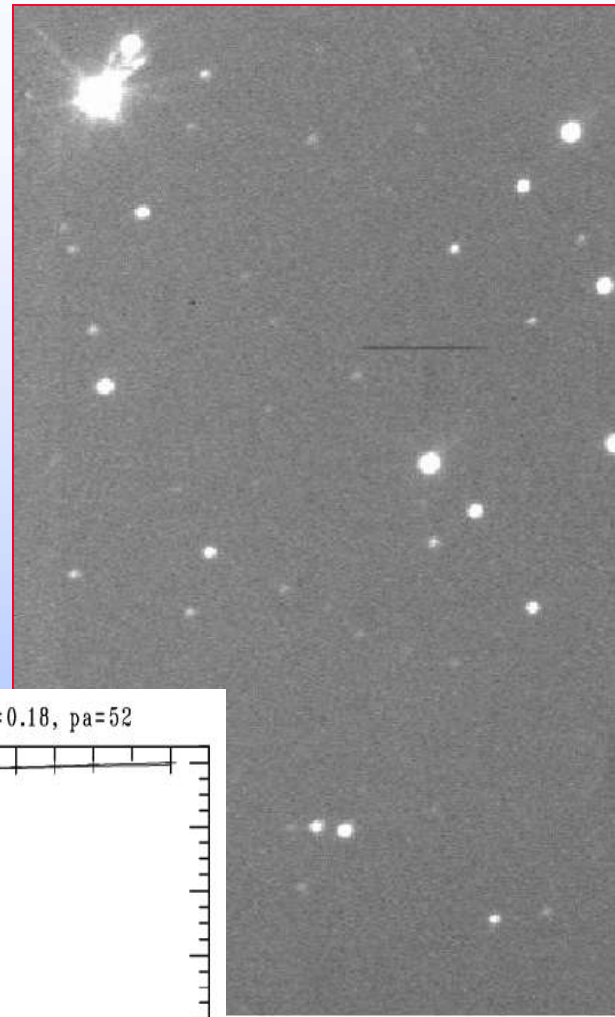
The Good News That

Good images did occur at times (e.g. some first-light images)...

Good images over a 1.5 - 2 arcmin FoV

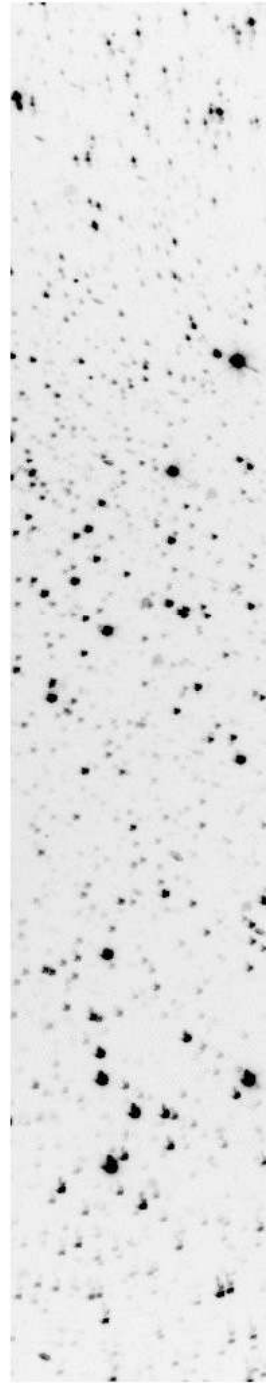
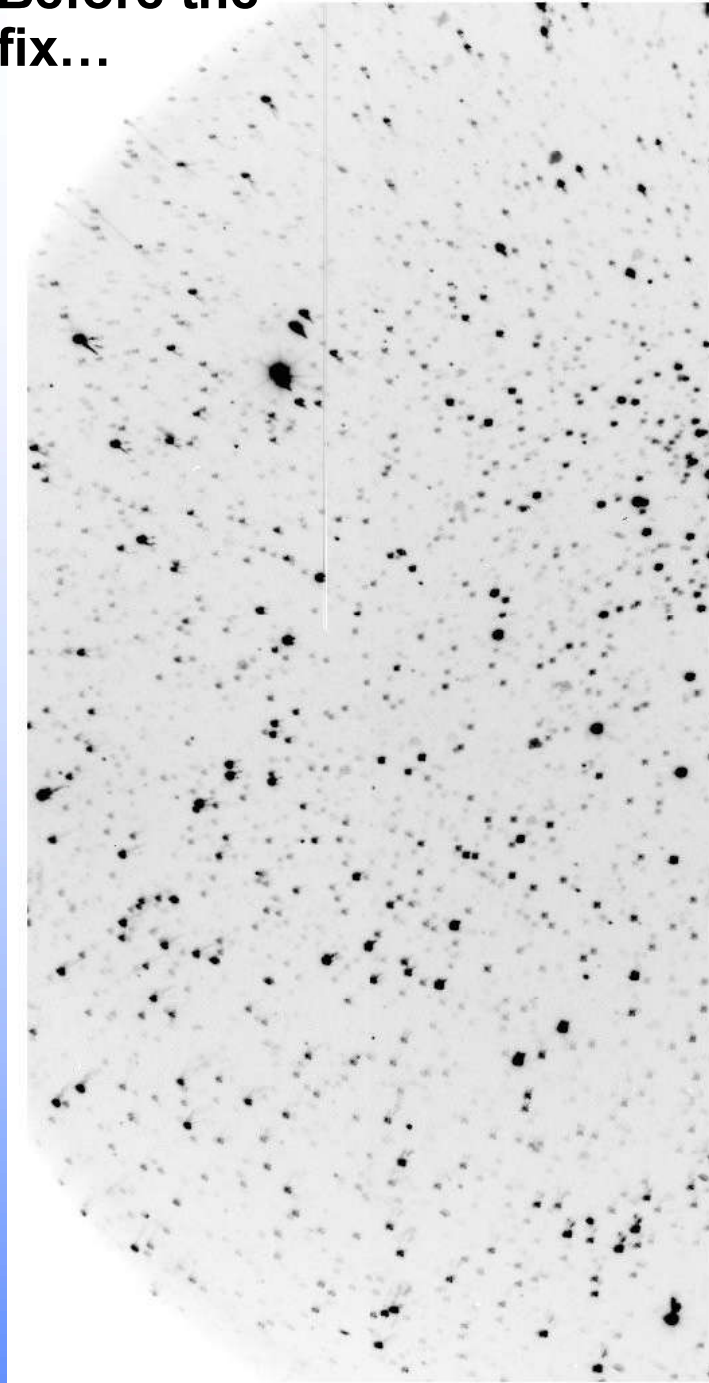
**e.g. good fit with a Moffat function
EE50 = 0.85 arcsec**

Implies nothing fundamentally wrong with the mirror figures



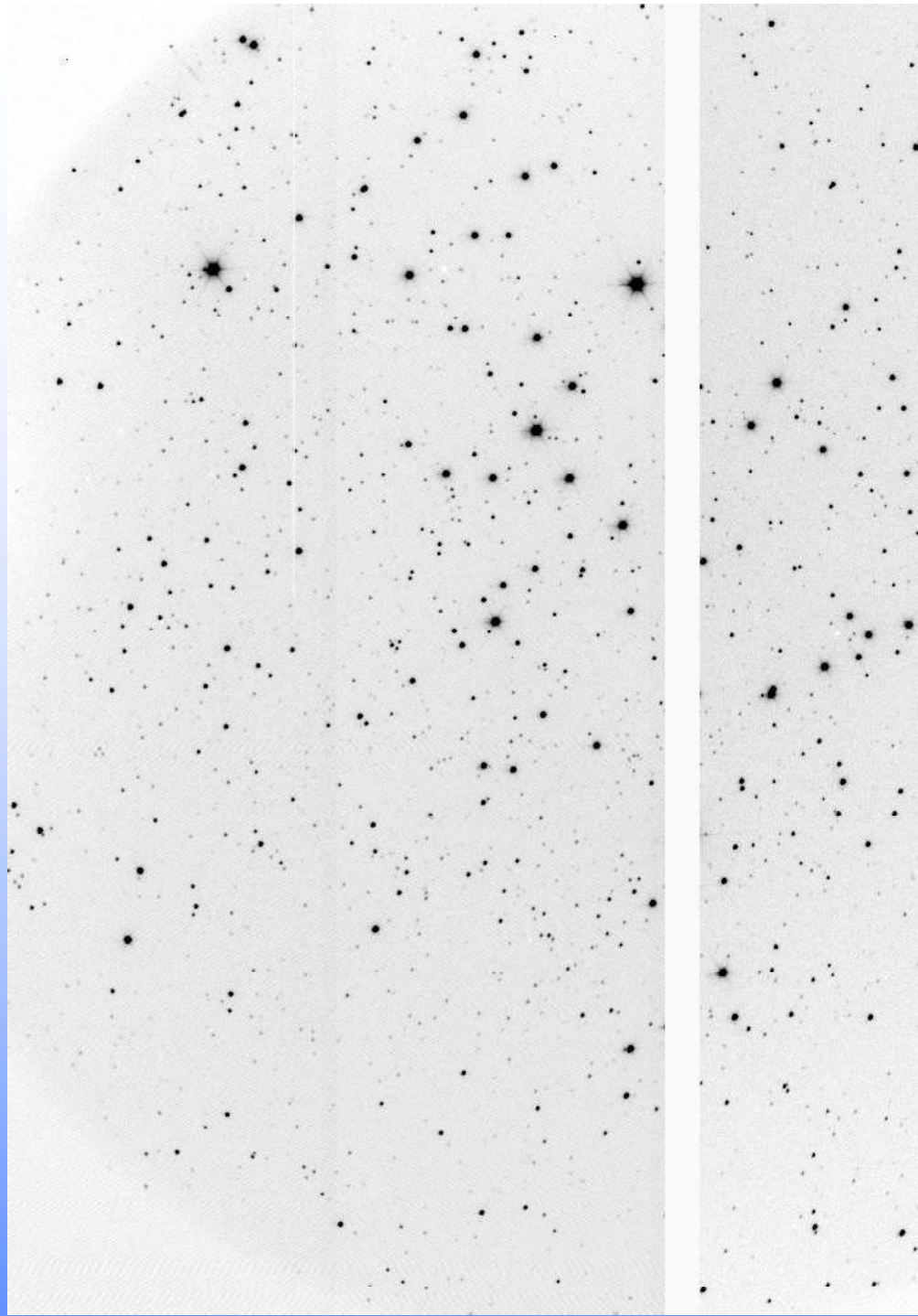


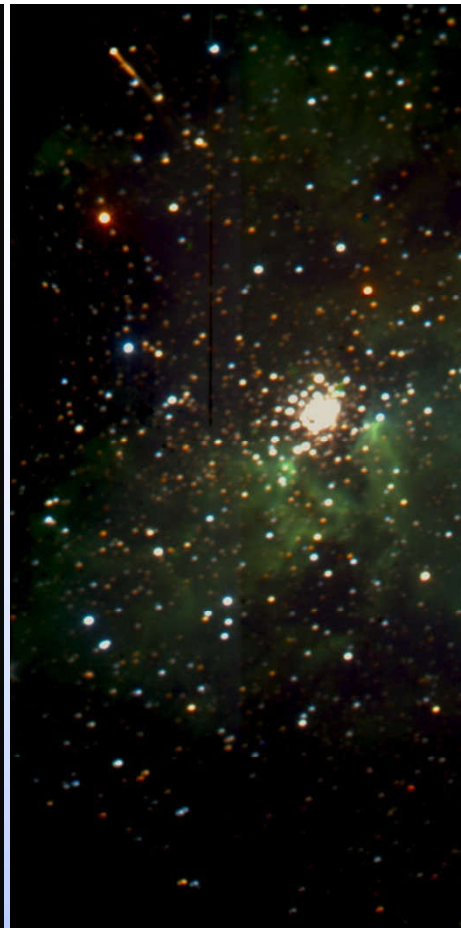
**Before the
fix...**





**After the fix...
12 Apr 2011**





SALTICAM Recommissioning



The Second Major Problem: RSS Th

RSS is *the* major “first generation” SALT science instrument

- Poor performance in UV/blue part of spectrum
 - **Where it was supposed to excel!**
 - **Significantly compromised science capability.**
- Optics removed and sent back to USA for repair in Nov 06
- Problem diagnosed as esoteric material incompatibilities
- Repairs have been difficult, time consuming & risky
 - Broken CaF₂ element; damaged NaCl lens
- *Reinstallation of repaired optics done in June 2009*
- *Instrument mods done to improve reliability*
- *Installed on 7 April 2011, re-commissioned most modes by Sep 2011, when full science began*





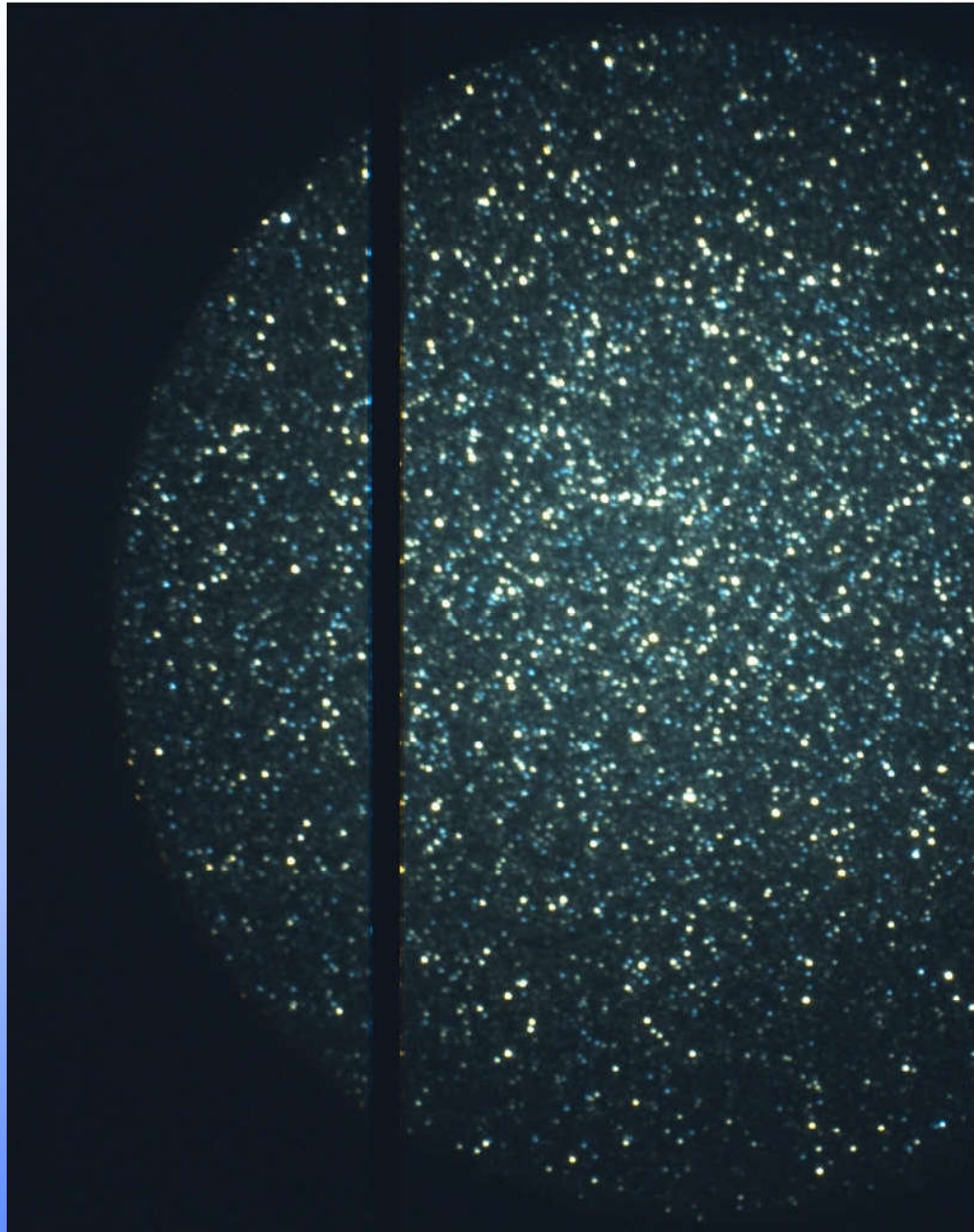
Repaired RSS

- Reinstalled on SALT on 7 April 2011
- First image on 9 April 2011
- Re-commissioning commenced
- Celebrations began!



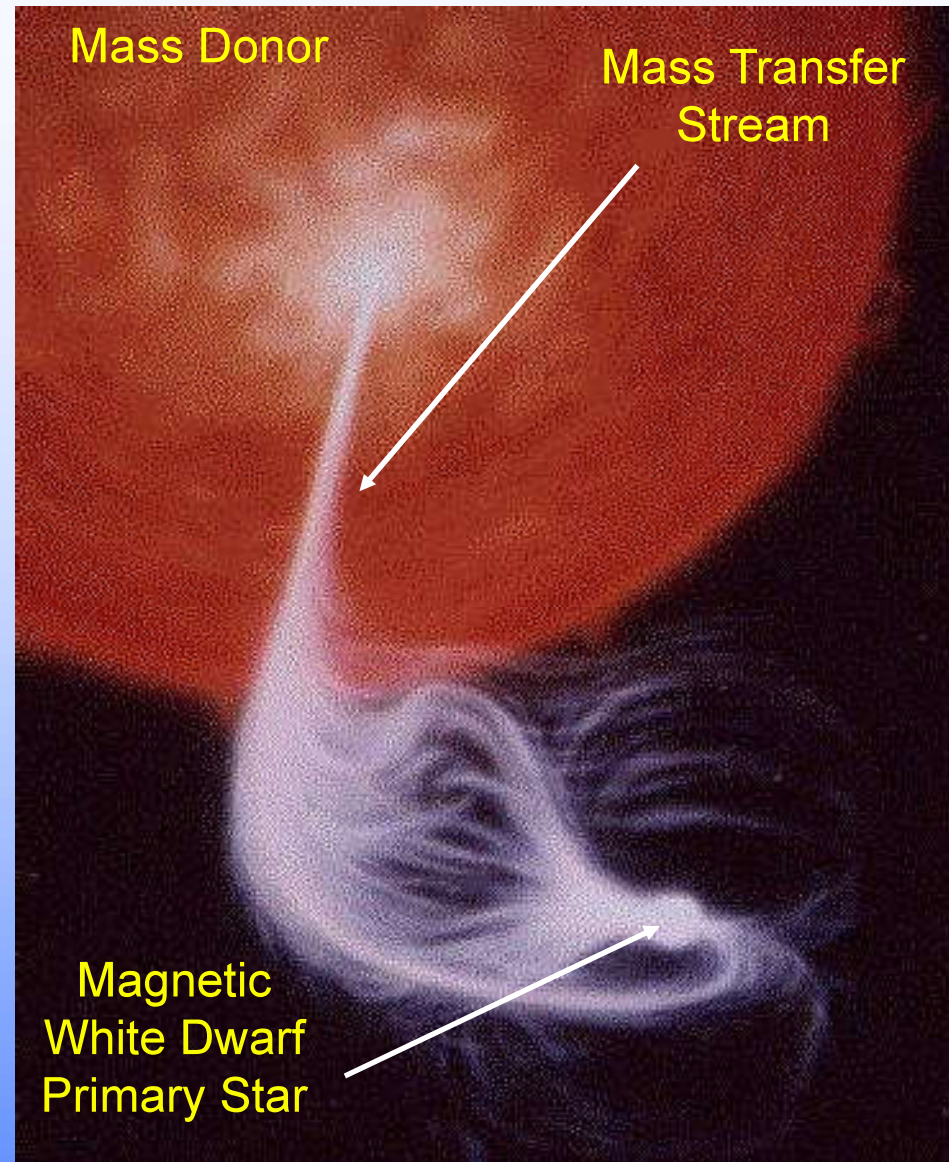


Image through repaired spec





First SALT Science: Observing magnetic cataclysmic variables with SALT +

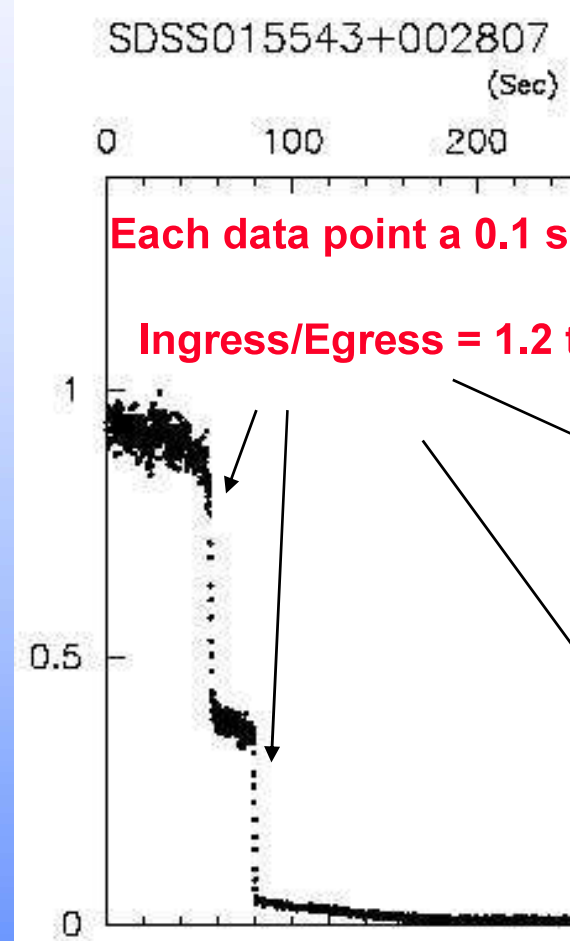
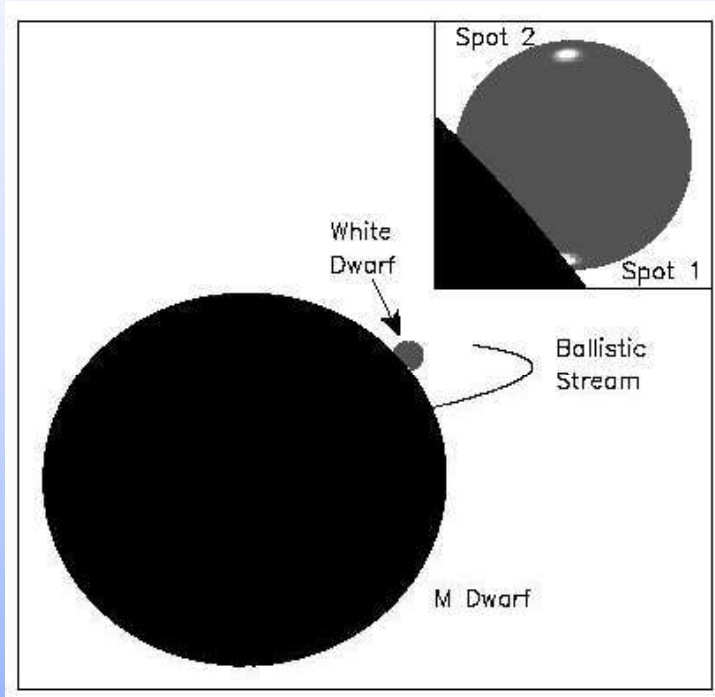


- Strongly magnetized ($\sim 10^2$ G) inhibits accretion formation, or disrupts it
- Magnetic field connects directly to magnetic white dwarf
 - diskless systems
 - disrupted disks
- Intermediate polars
- Multi- λ emission (X-ray, EUV, UV, optical) & mechanisms (thermal & non-thermal)
- Often discovered via X-ray emission from



SALT Science

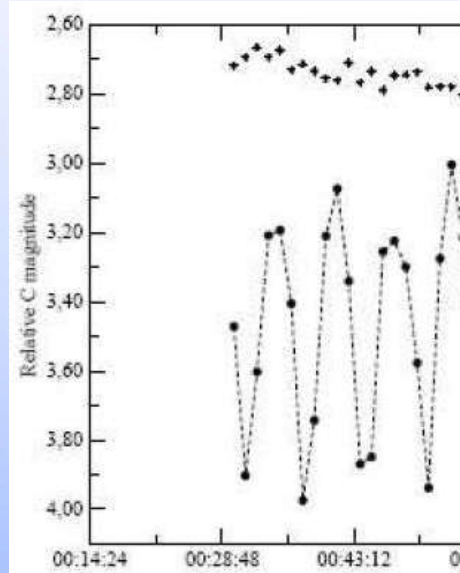
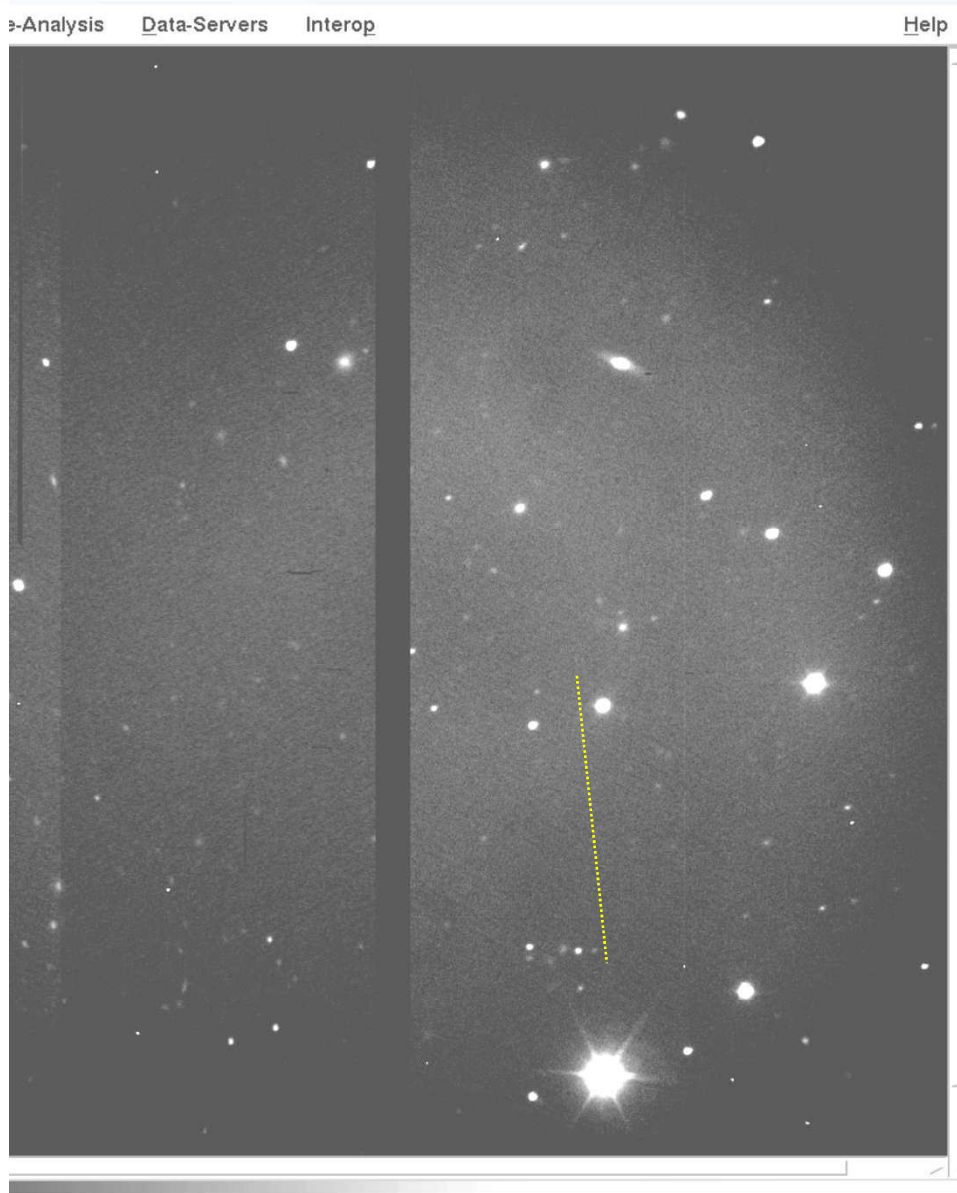
An example: a light curve of an eclipsing magnetic CV taken with SALTICAM





SALTICAM Observations of Asteroids

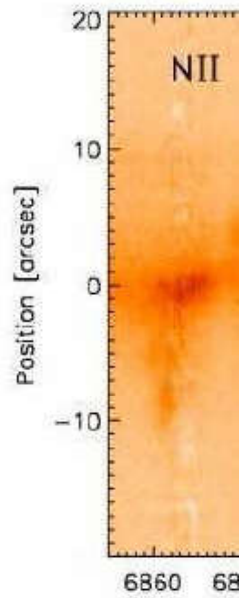
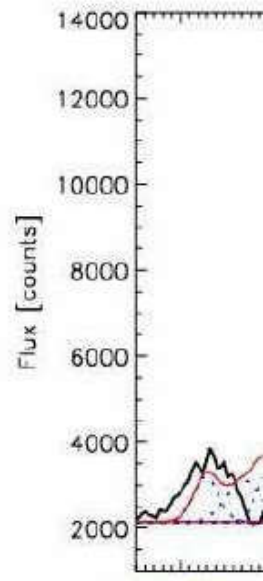
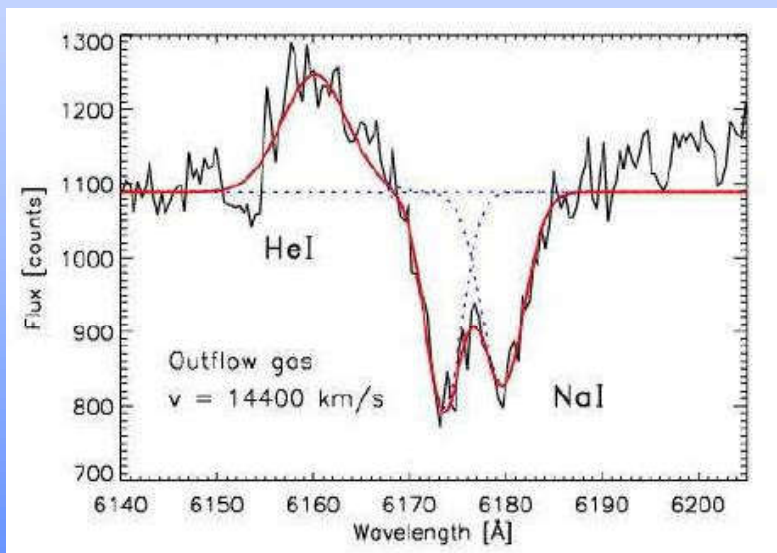
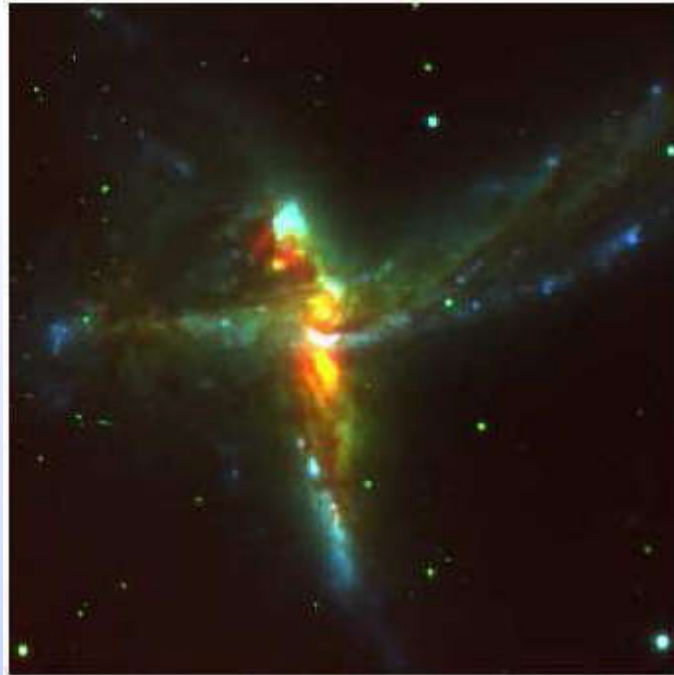
- Looking for New Objects
 - Potential threats
- Deriving spin periods



e.g. a $V=20.5$ asteroid
min period (1 m)



Anatomy of "The Bird": a triple galaxy c



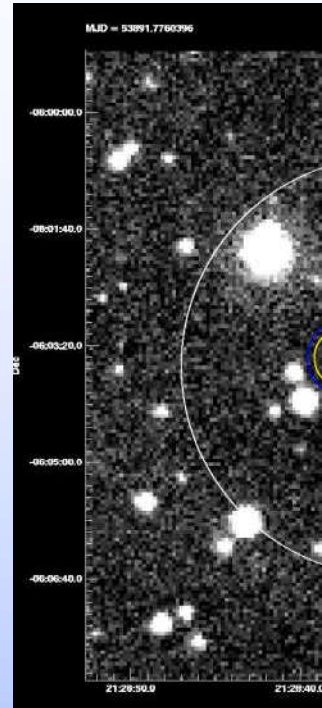
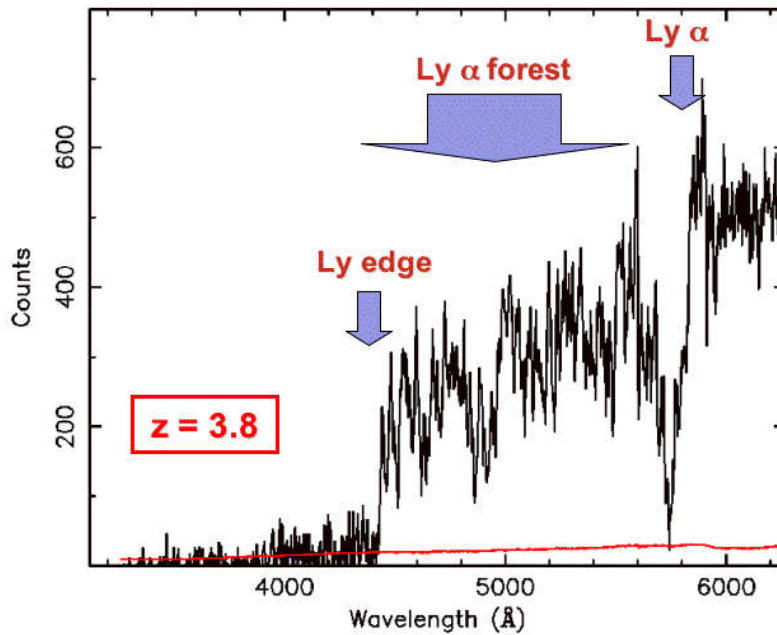


SALT observation of a Gamma Ray Burst (GRB 060605)

SALT Observations ~8 hours after alert

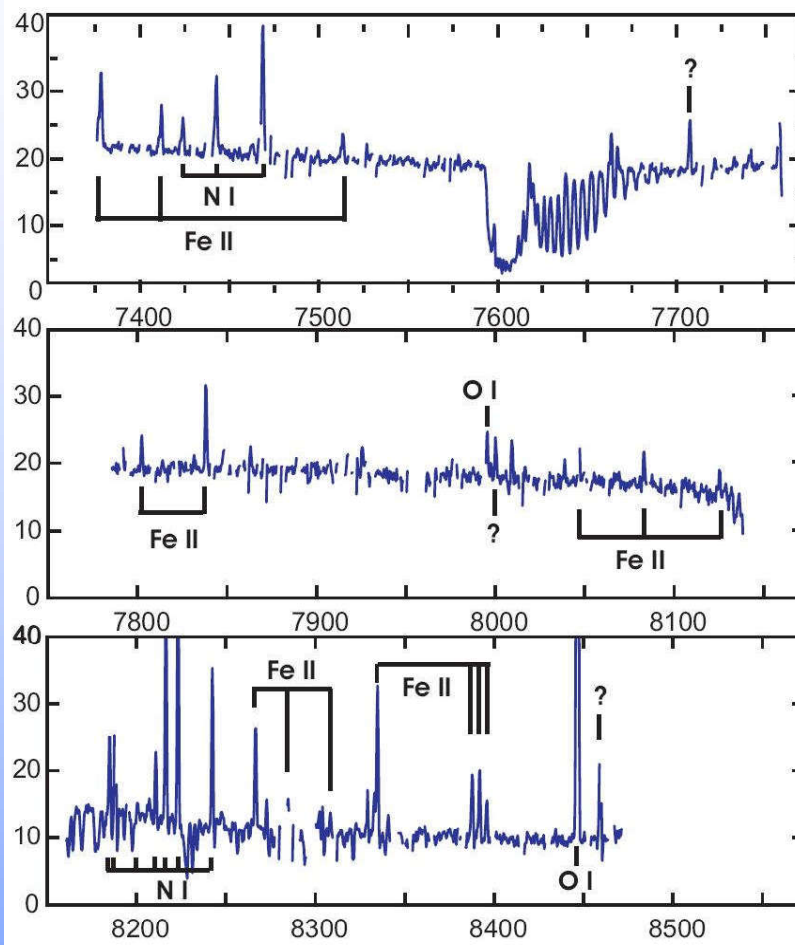
- MSSSO (Australia) obs. when $V \sim 15$

SALT obs. at $V \sim 20$





Detailed Spectroscopy of a Reflection



NGC2023:
Lines from photo-excitat



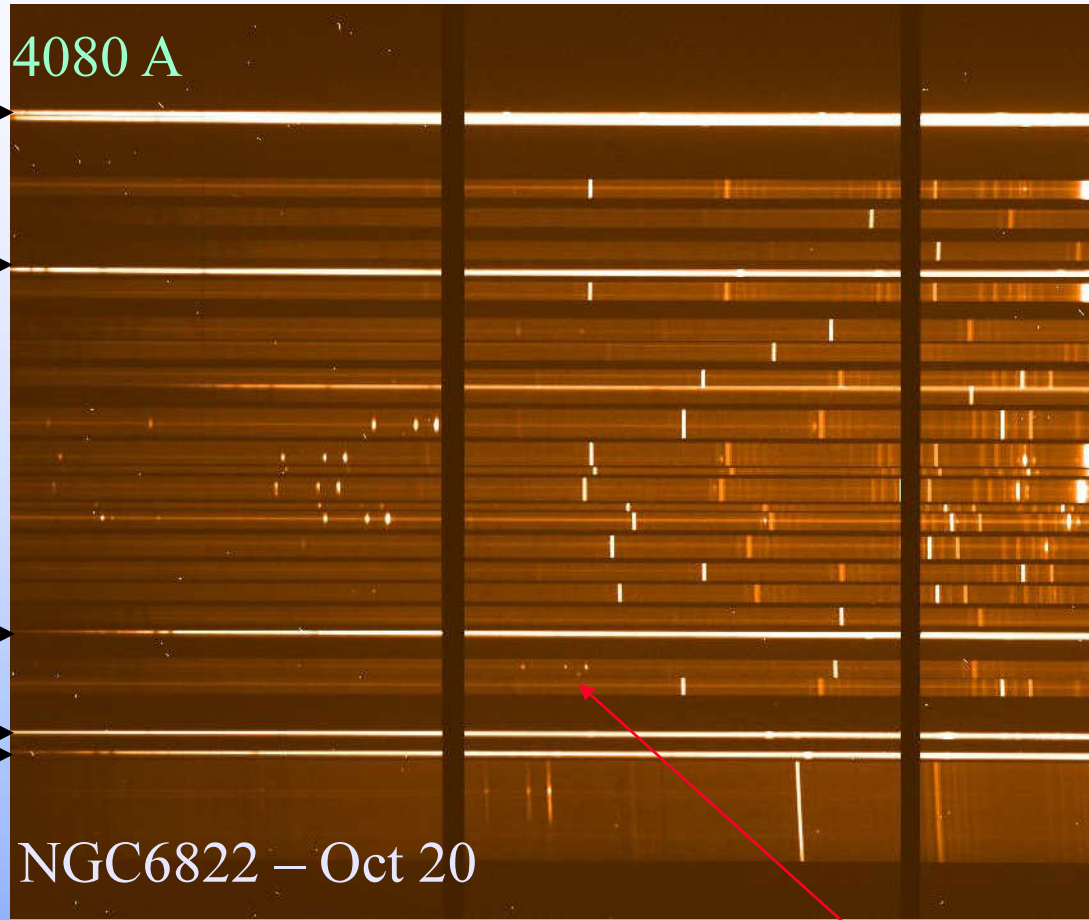
Multi-Object Spectroscopy Test Spectra

Position
Reference
Stars

4080 Å

NGC6822 – Oct 20

800 sec. See $H\beta$, OIII 4949 & 5007 triplet. Faintest PN

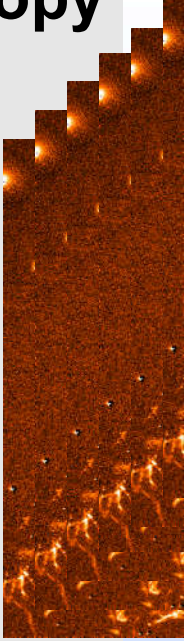
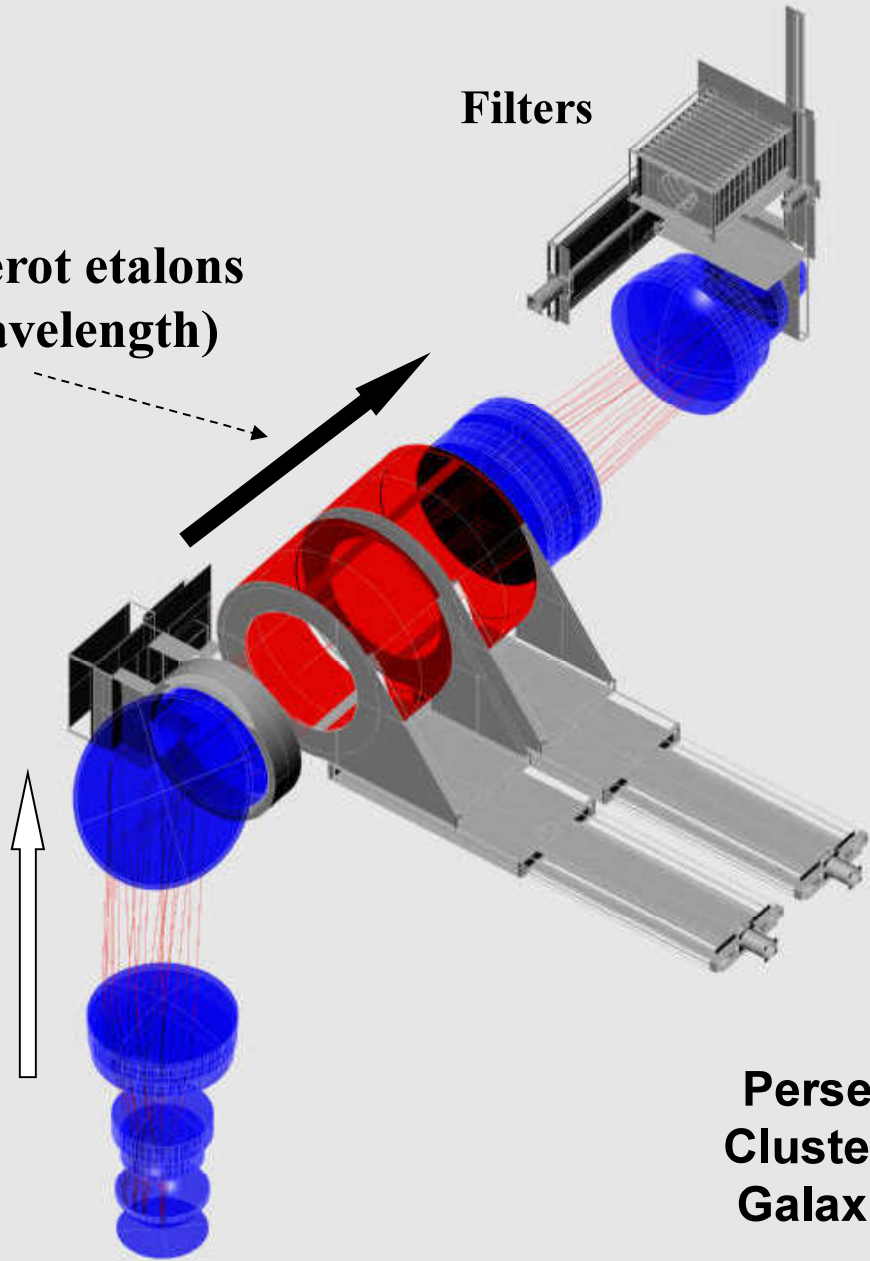




Fabry-Perot Imaging Spectroscopy

**Fabry-Perot etalons
(scans wavelength)**

Filters



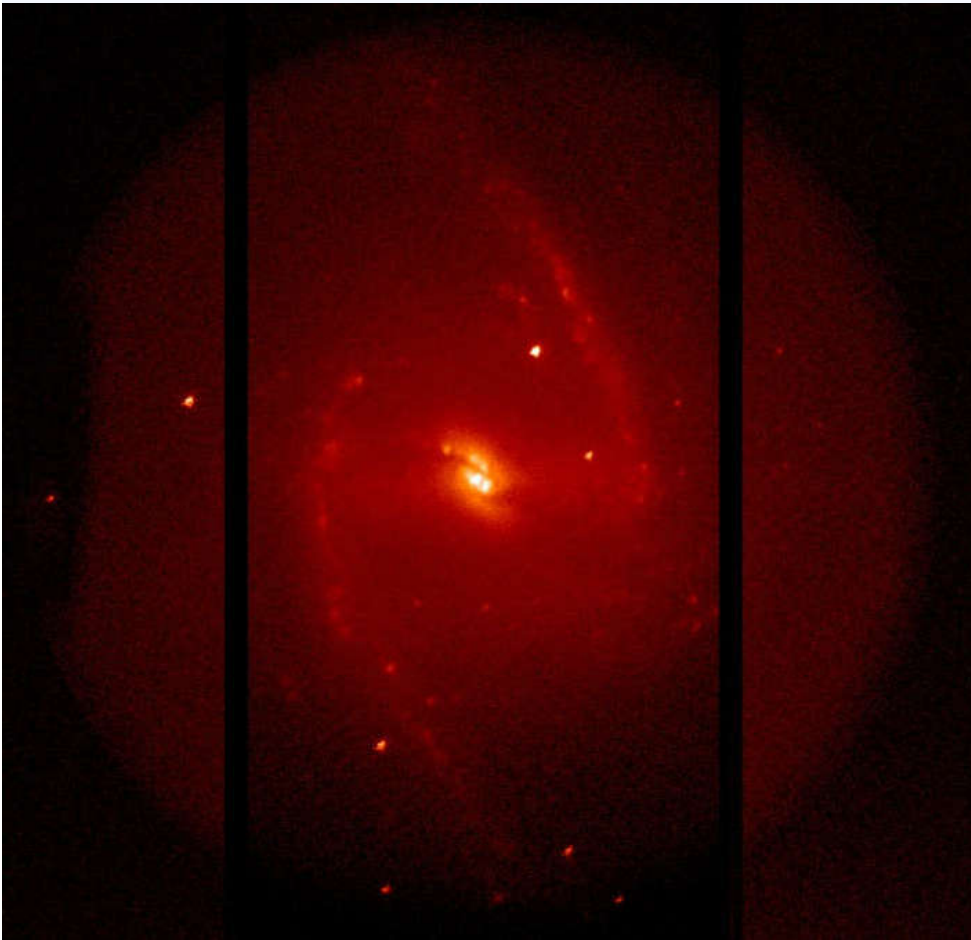
Pe

**Perseus
Cluster of
Galaxies**

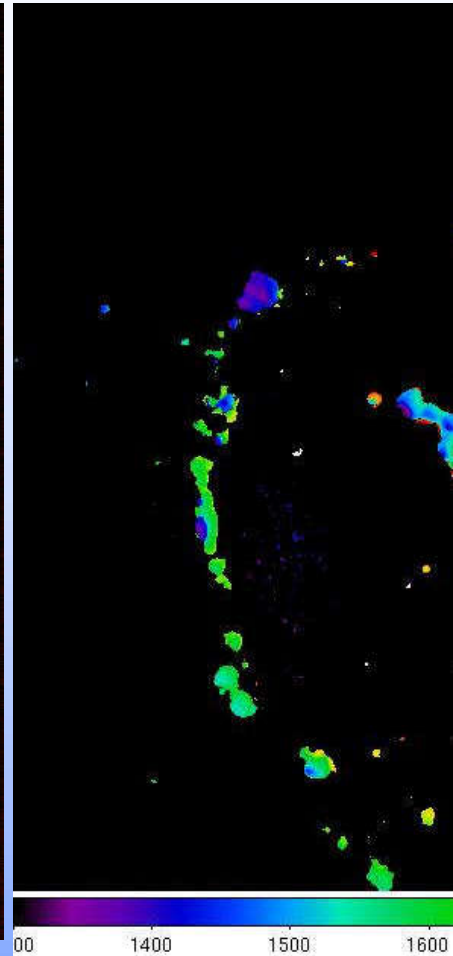




Fabry-Perot Commissioning Observations



H-alpha image



Velocity Map

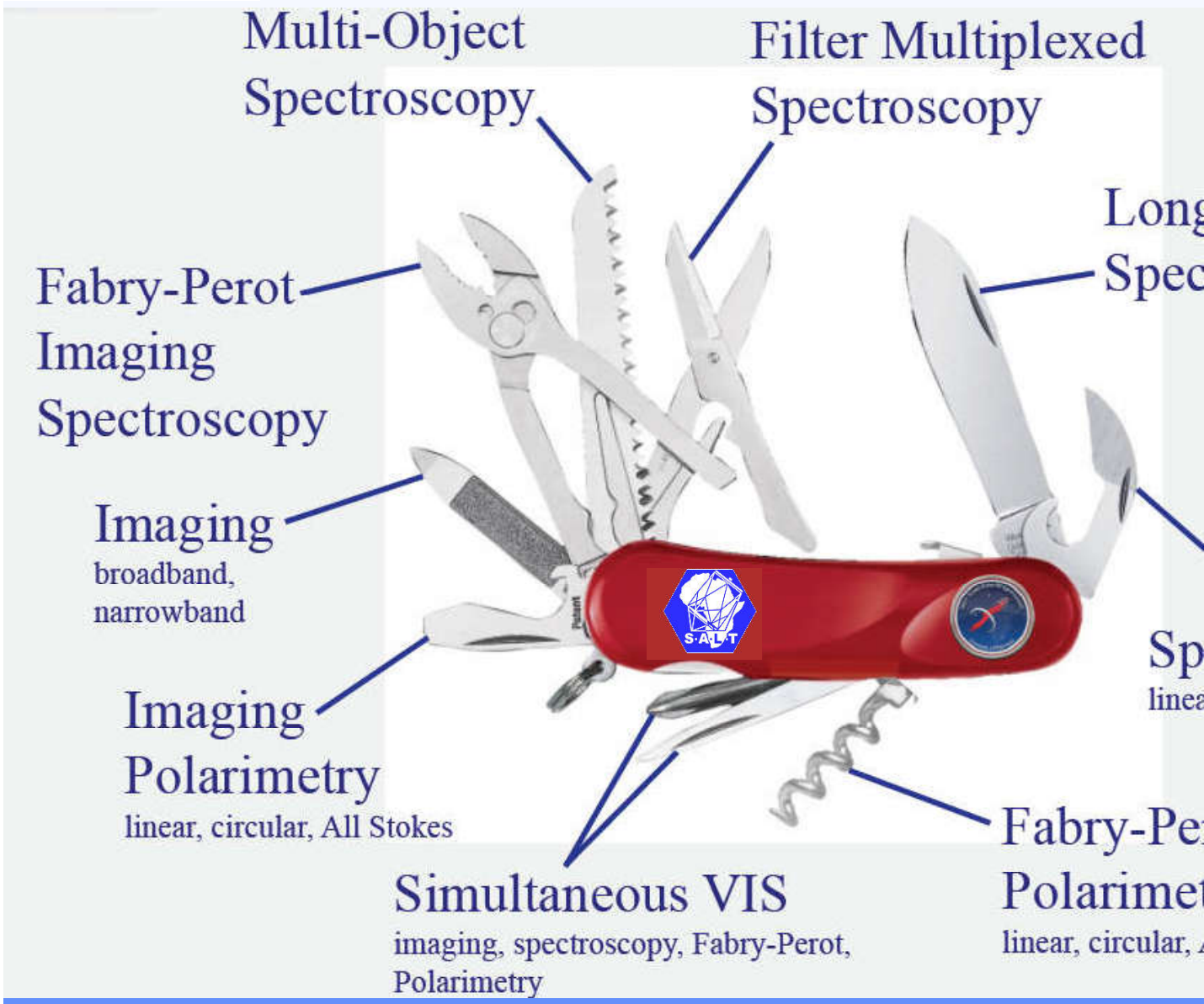


Future SALT Instruments

- **Already proceeding with a “Gen 1.5” instrument: a 1.7 μ m extension to RSS (giving simultaneous 320m coverage)**
- **Small “niche” instruments have/are being developed**
 - **A high-speed photon-counting camera from SSL (BVIT)**
 - **A low-order Adaptive Optics demonstrator experiment (SADCAM)**
 - » *Currently in process of characterizing Sutherland for Ground Layer A-O*
- **A White Paper on future instrumentation has been published**
 - **Beginning to discuss new instruments for SALT**



RSS UV-VIS-NIR: an ideal astron





SALT Completion Experience

SALT took ~1 year longer to build than initially estimated (completion date was 17 Dec 04), but even completion was not enough time to complete full acceptance testing and commissioning of the telescope and instruments.

Some reasons were:

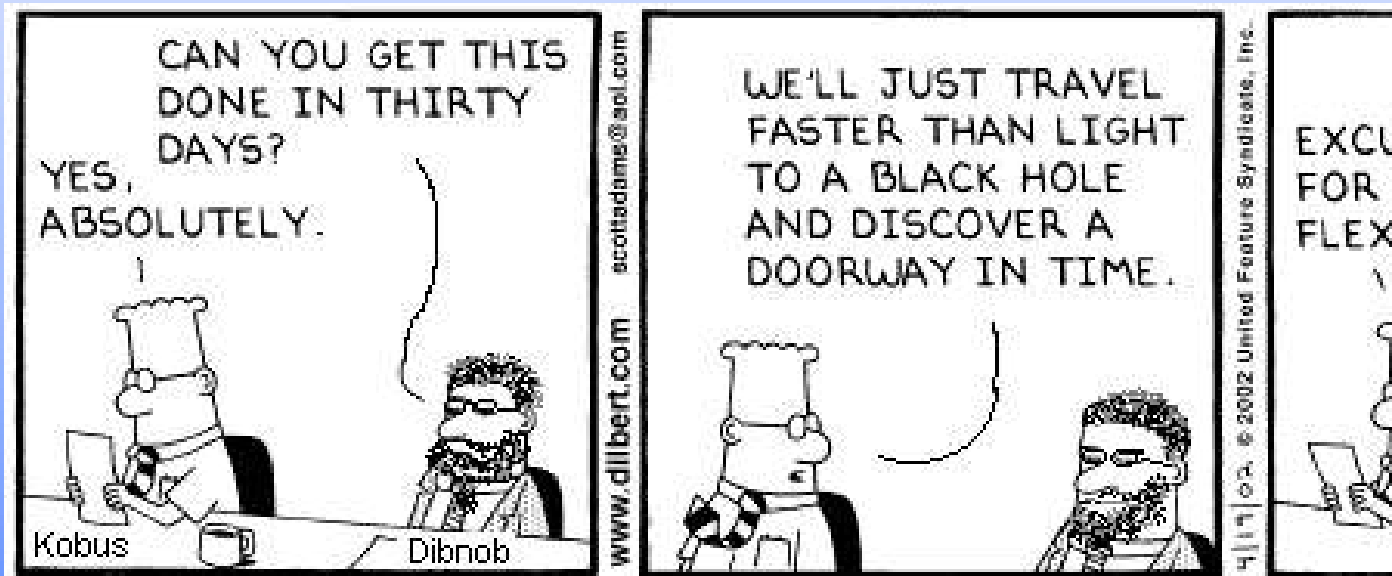
- First time inexperience
- Difficulty multi-tasking of dependent jobs and competing for people/resources/telescope time
 - *High-lighted too few people in some critical areas (e.g. engineering and design effort for Payload subsystems mounting opto-mechanics)*
- Lots of parallel tasks to be done and not always enough resources to do them
- Systems Engineering was a success, but... final hurdle (full acceptance testing) was not completed before Project End

My conclusion: In reality more people (2-3 Engineers per yr?) and more money (~20% more?) was needed.



Reality of Commissioning / Completion

- Underestimate of time to complete complex/first-time
 - Including the Prime Focus Payload
 - Science instruments (both took ~1 year longer than expected)
 - Not enough time for integration and thorough/comprehensive testing
 - A significant number of subsystems not completed (e.g., cleaning, SAMS)
 - » Handed over the Operations Team which became the "Operations Team"



Project Manager Project Scientist



Sometimes it was just too much!



FINAL REMARKS

- SALT completed construction phase, mostly by end- within budget and close to schedule (although some subsystems not completed).
- However, two major technical problems (image quality & throughput), and some minor problems, were encountered.
 - » After much time & effort, they have now been resolved
 - » First "sharp" (sub-arcsec) images on 9 Apr 2009
- Telescope re-commissioning commenced in July 2010 (including repair & reinstallation (autoguidance & autofocussing now in place))
- Instruments (SALTICAM, RSS) modified, re-installed & recommissioning completed

Full science operations began in Sep 2009

- SALT has rare & unique capabilities (Δt , UV, polarisation, etc.)
- Multi-wavelength opportunities (e.g. with MeerKAT, HESS)
- SALT is an excellent paradigm for a relatively inexpensive large telescope

Excellent opportunities for South African astronomers, SA-UK collaborators

THE END

