

How South Africa succeeded in hosting the largest optical telescope in the world, *but almost lost the Square Kilometre Array!*

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+ links with South Africa, Finland, India, Spain



South African Astronomical Observatory, Cape Town



We lived in the Director's House – on left here – from 2004-2011



The view from our stoop (patio)!



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Comet McNaught 2006
(Photo: Lisa Crause)

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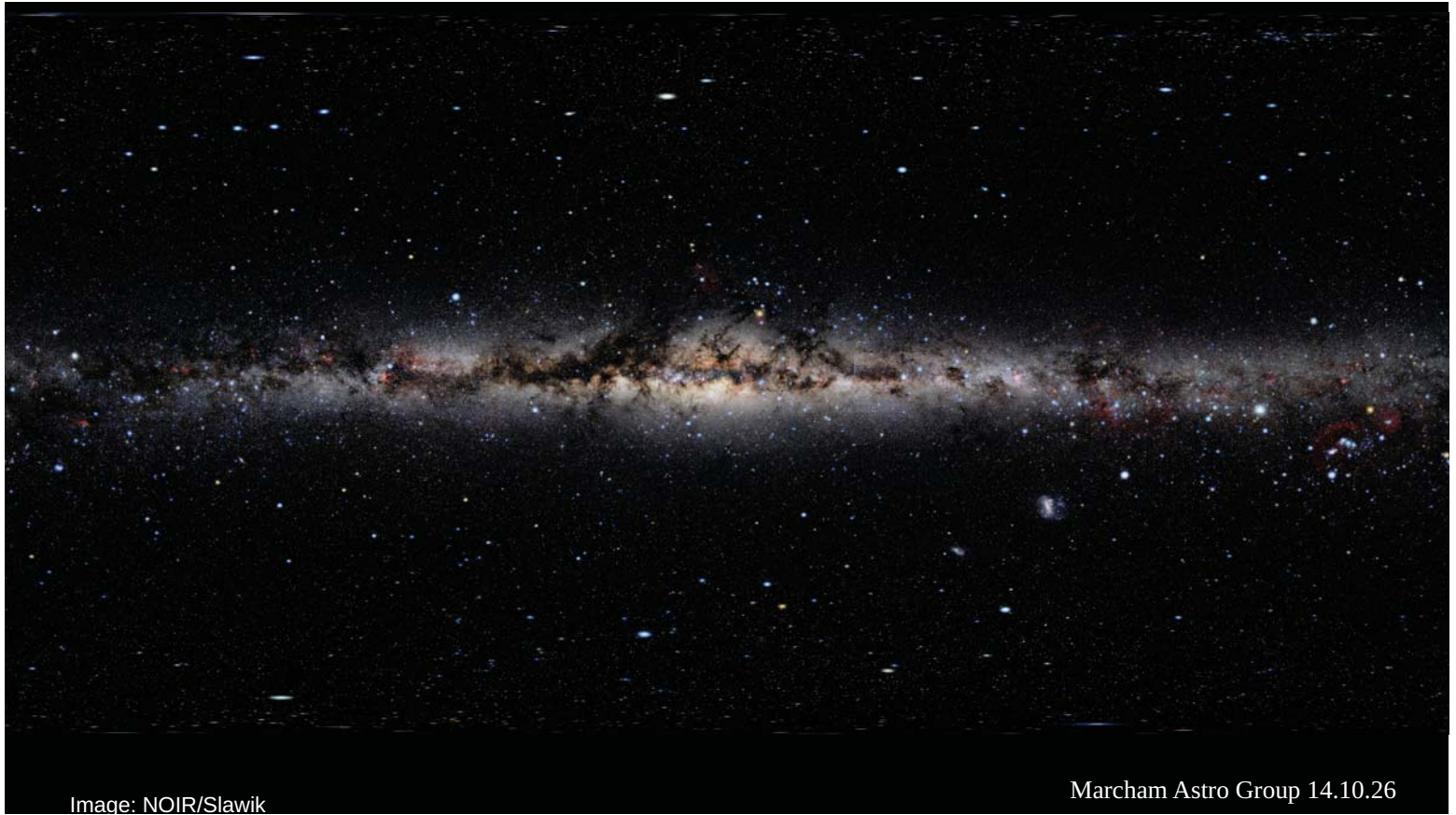


Image: NOIR/Slawik

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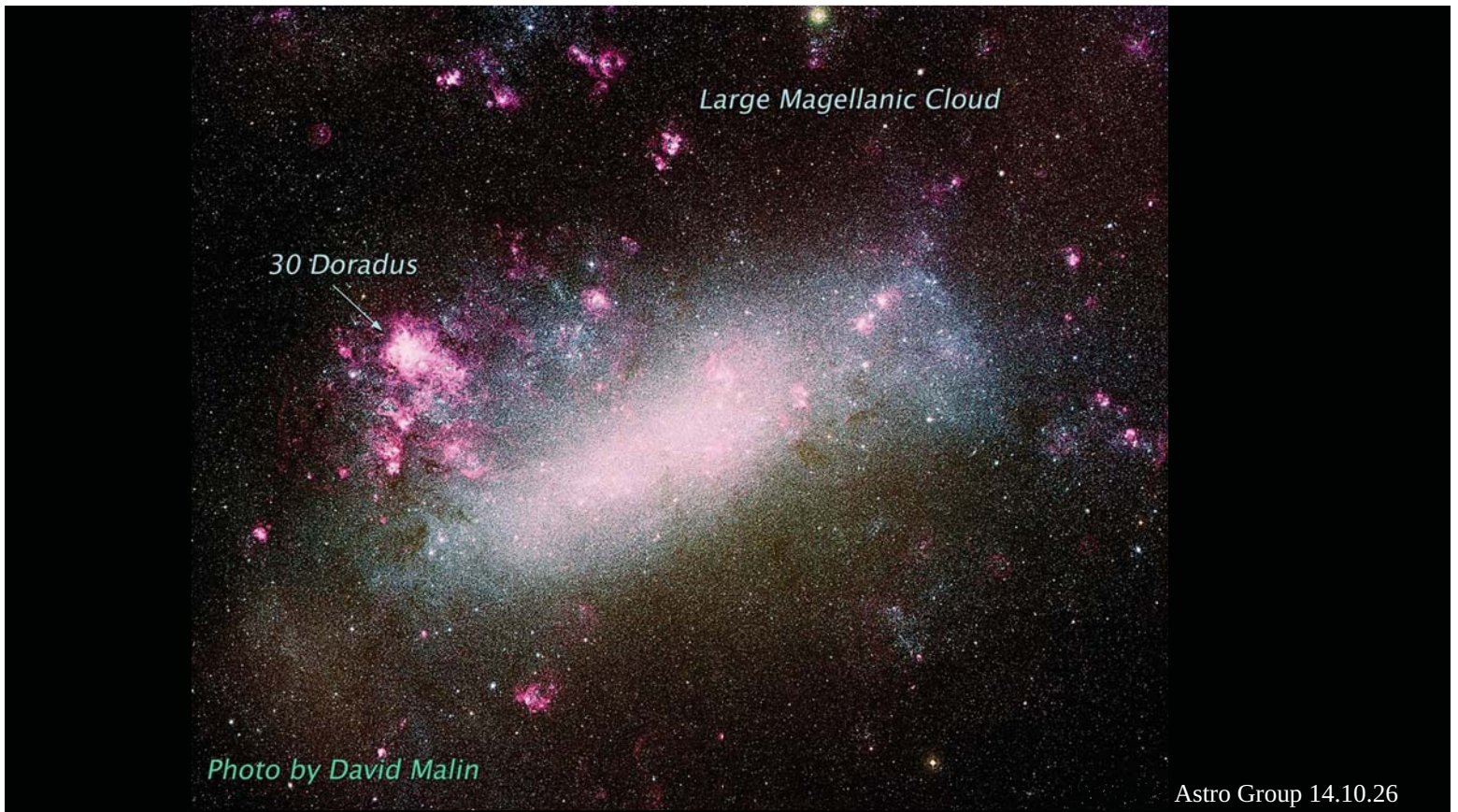


Photo by David Malin

Astro Group 14.10.26

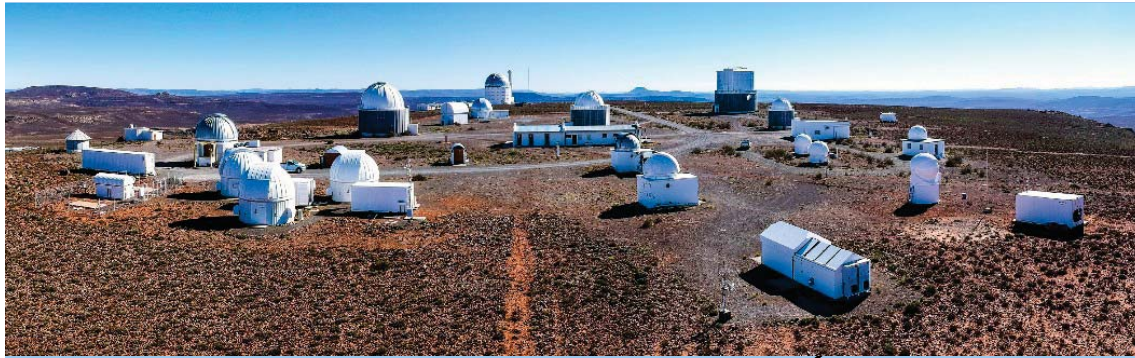


SAAO
Founded as the Royal Observatory at the Cape in 1820



- Headquarters in Cape Town (1820), observing facilities in Sutherland (1972)
- In 1994 → Research facility of the NRF (National Research Foundation), funded by DST

**A national resource for research, technology, education and training →
(2004) NASSP, driven by SALT → generate African astronomy PhDs!**



Sutherland site:
Very dark
astronomical site:

Aseasonal with 75% nights useable

~1800 m altitude

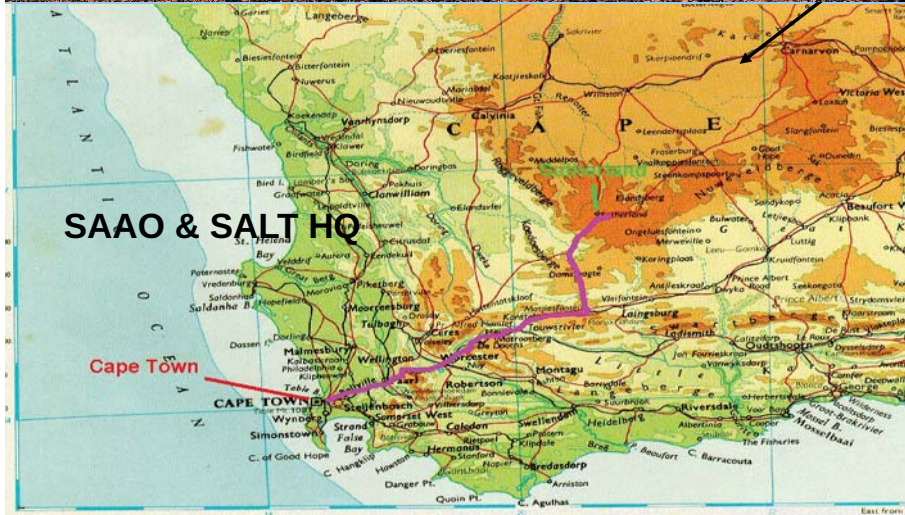


Photo: Willie Koorts

South African
Astronomical Observatory
(SAAO):
Host and operator of SALT



up 14.10.26



Photo: Steve Potter

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How did the SALT project begin?



In late-80s next-gen “very large telescopes” in design and construction.
But total cost of both Keck telescopes and their instruments ~\$300M! VLT similar.

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The Hobby-Eberly Telescope (HET) – led by
UTexas (Austin) + Penn State, Gottingen, Munich



- Aim: build 10m-class telescope for 10% of Keck-II i.e. <\$13M
- Actually cost ~\$16M, but they were close!
- To achieve this required new paradigm in large telescope design!
- HET completed in 1997 and in operation since 1999

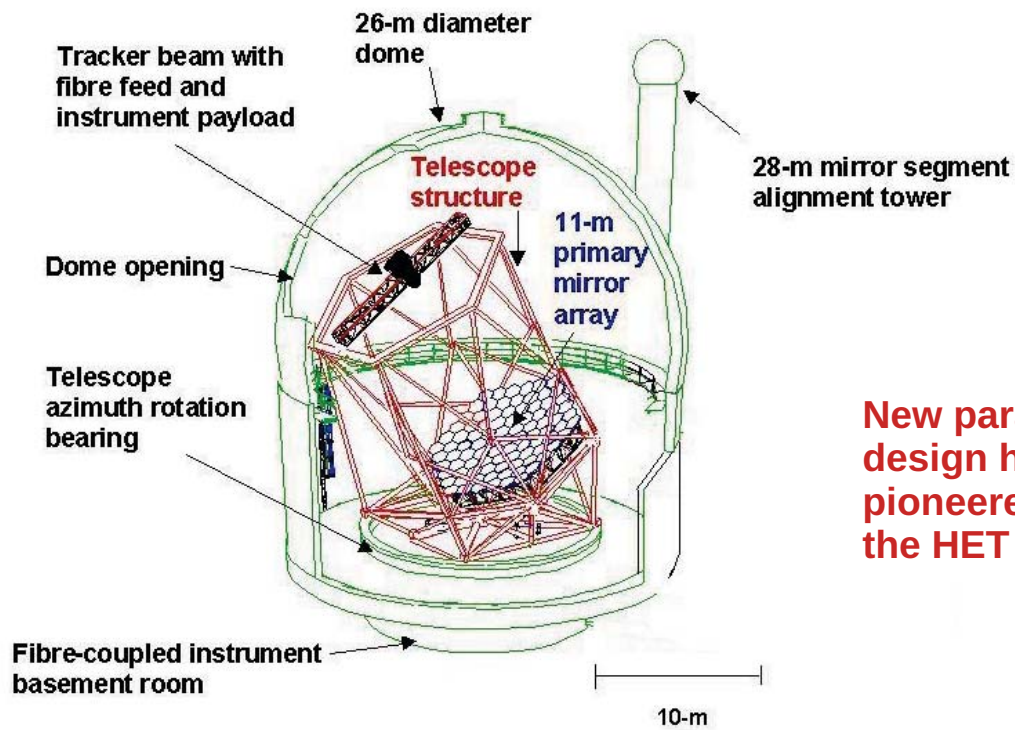
**Hobby-Eberly Telescope,
McDonald Observatory near
Fort Davis, Texas**

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up 14.10.26

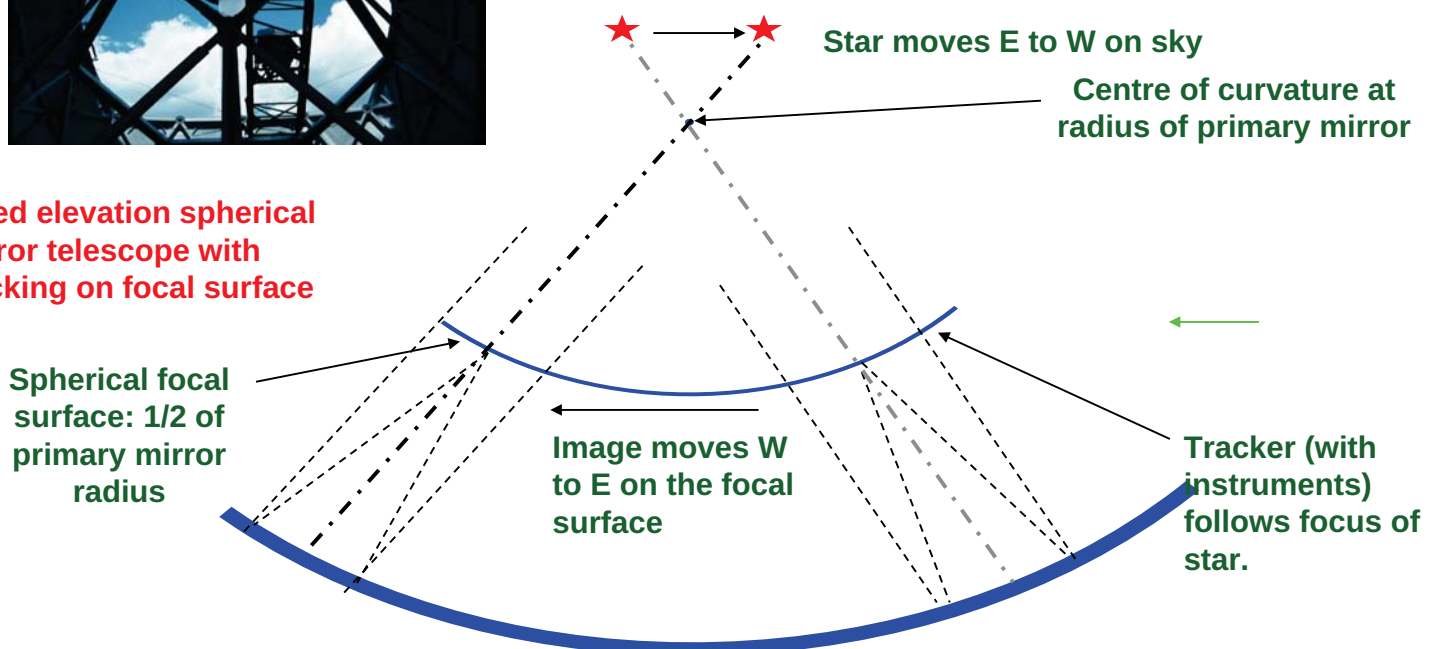
Southern African Large Telescope



New paradigm in design has been pioneered by the HET in Texas.



Fixed elevation spherical mirror telescope with tracking on focal surface



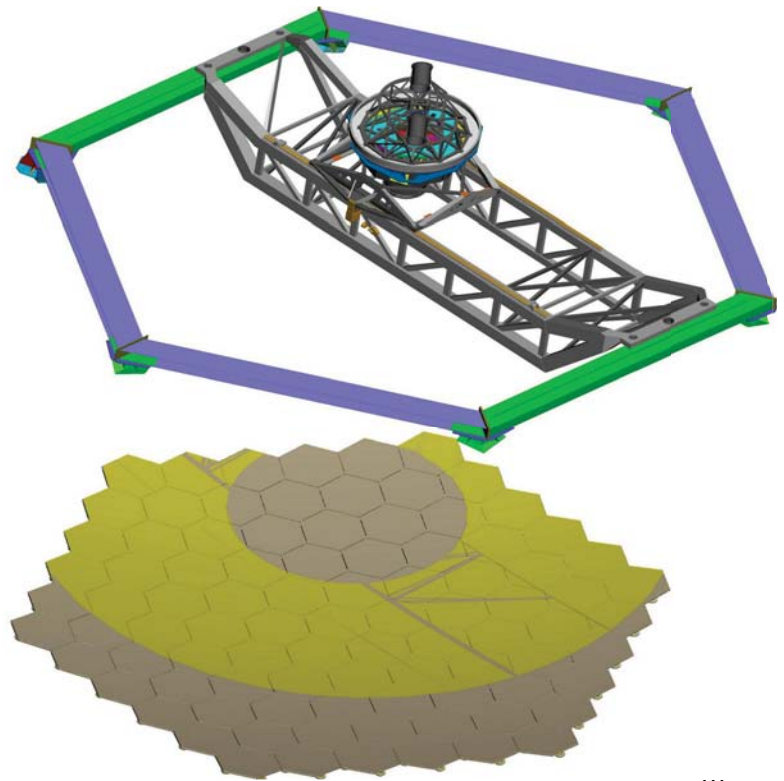
SALT Tracking Principle

Tracker off-centre → pupil partially on primary mirror. At worst, still a ~7m telescope.

With tracker centered on primary mirror, central obstruction (from Tracker etc), equivalent to a 8.5m telescope.

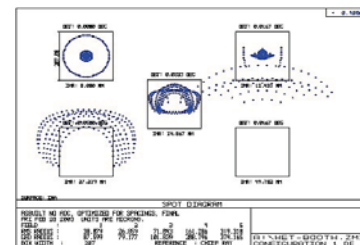
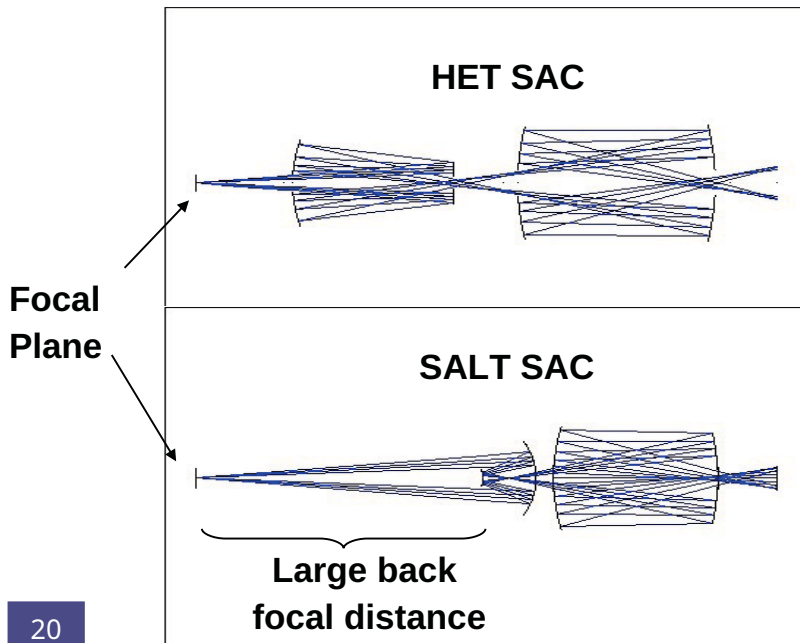
Pupil always under-filled and is $f(t)$

⇒ absolute photometry is difficult

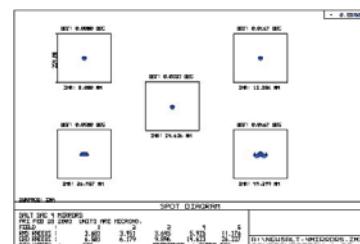


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Spherical Aberration Corrector

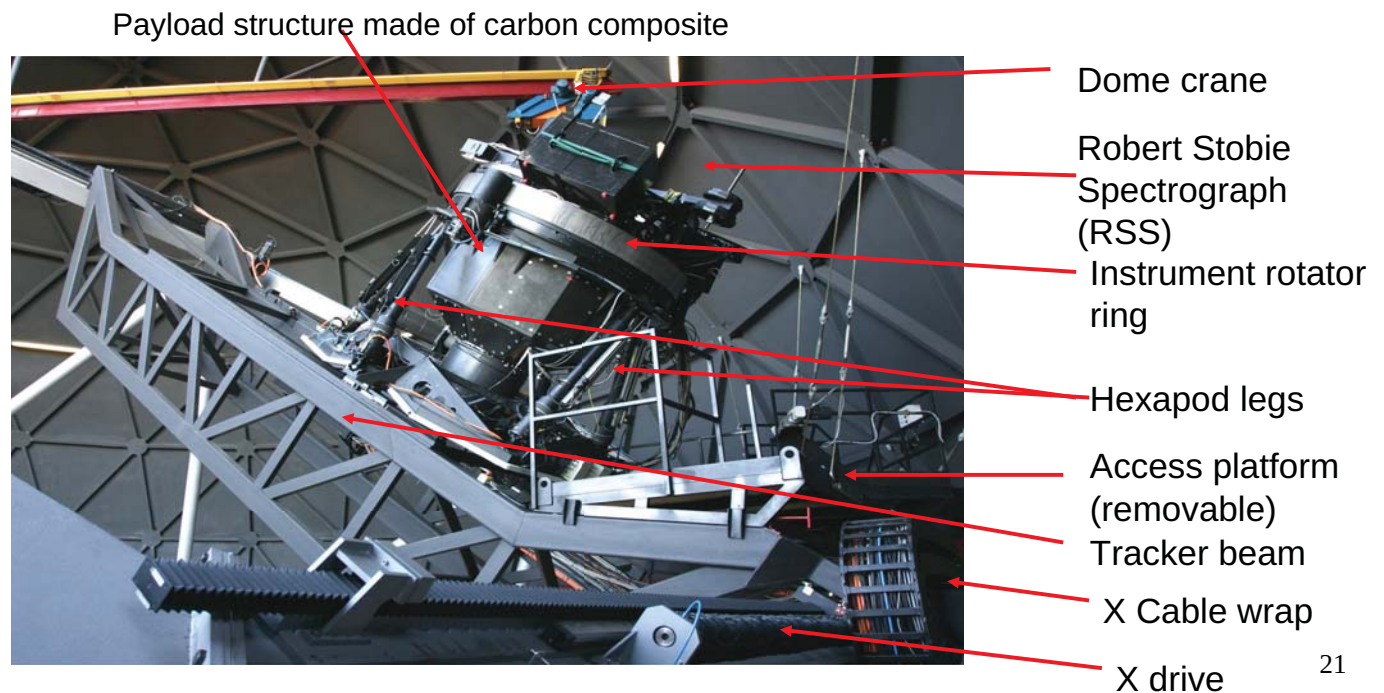


Spot diagrams



} One arcsec boxes

Facility Instruments are all mounted on Prime Focus Payload



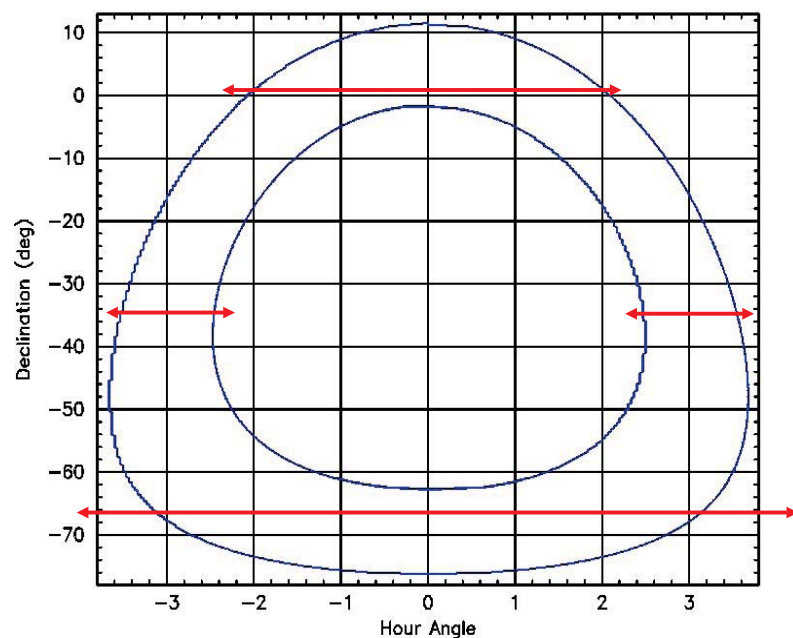
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Annulus of visibility for SALT:

12.5% of visible sky

Declination range:
+10° to -75°

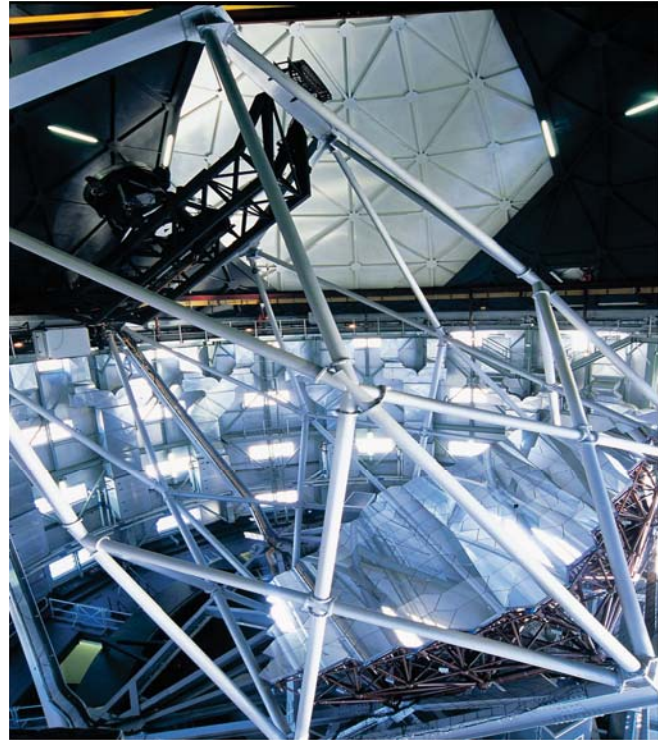
Observation time
available = time taken
to cross annulus



SALT: Tilted Arecibo-like Optical-IR Telescope modelled on HET

BASIC ATTRIBUTES

- PRIMARY MIRROR ARRAY
 - Spherical
 - 91 identical segments
 - Unphased (i.e. not diffraction limited 10-m, just 1-m)
 - Mirrors (*Sital*: low CTE ceramic) on steel structure
- TELESCOPE TILTED AT 37° (access to MCs)
 - Declination Coverage $+10^\circ < \delta < -75^\circ$
 - Azimuth rotation for acquisition only
 - Access to ~70% southern hemisphere
- OBJECTS TRACKED OVER 12° FOCAL SURFACE
 - Tracker executes all precision motions (6 d.o.f.)
 - Tracker contains Spherical Aberration Corrector (SAC) with 8 arcminute FoV (*Prime Focus*)
- IMAGE QUALITY
 - Telescope error budget of ~0.7 arc-second FWHM
 - Designed to be seeing limited (median = 0.9 arcsec)



Aug 28, 2010: It worked!!



Who owns SALT: the 8 shareholders

Total Cost is ~\$51M

~\$22M: telescope construction

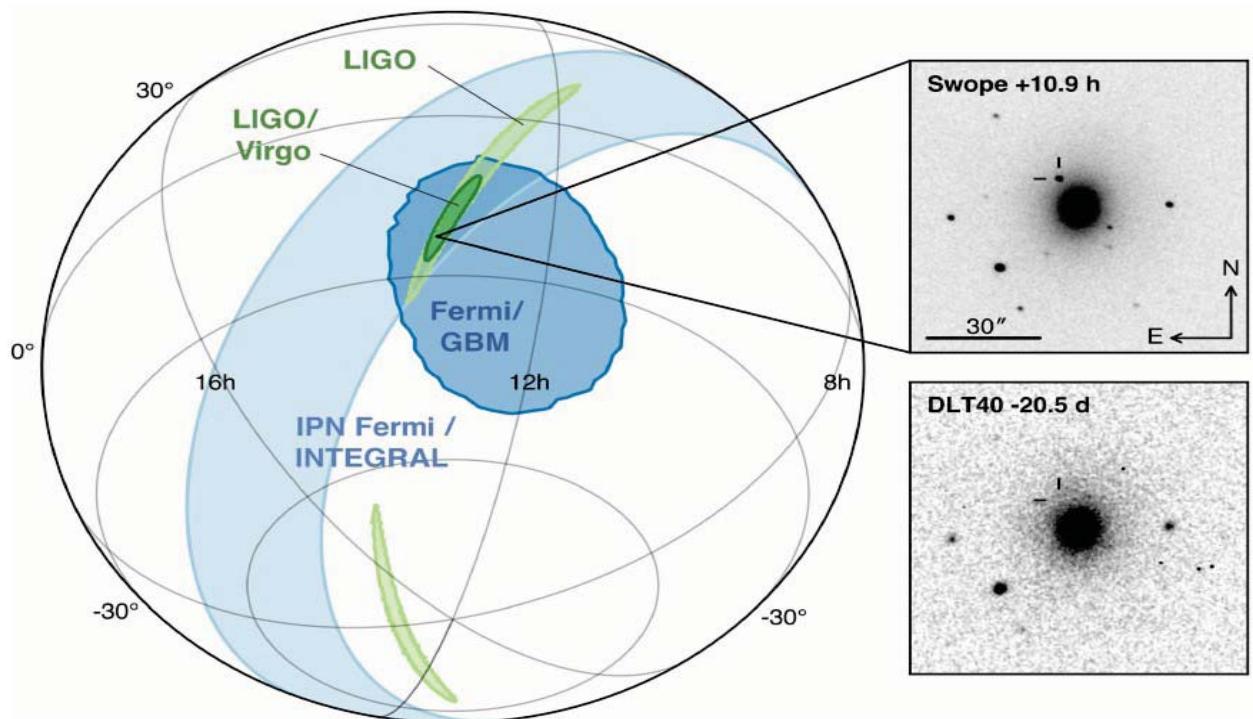
~\$9M: 3 first-gen instruments

~\$20M: 10 years operations

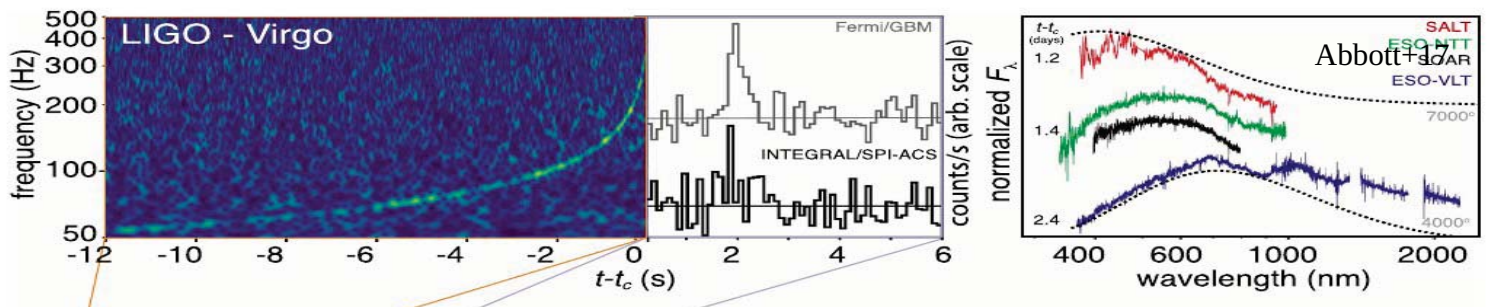
• National Research Foundation	44%
• University of Wisconsin	15%
• CAMK (Poland)	10%
• Rutgers University	11%
• Dartmouth College	10%
• Armagh Observatory	1%
• IUCAA (India)	7%
• AMNH	2%



GW170817



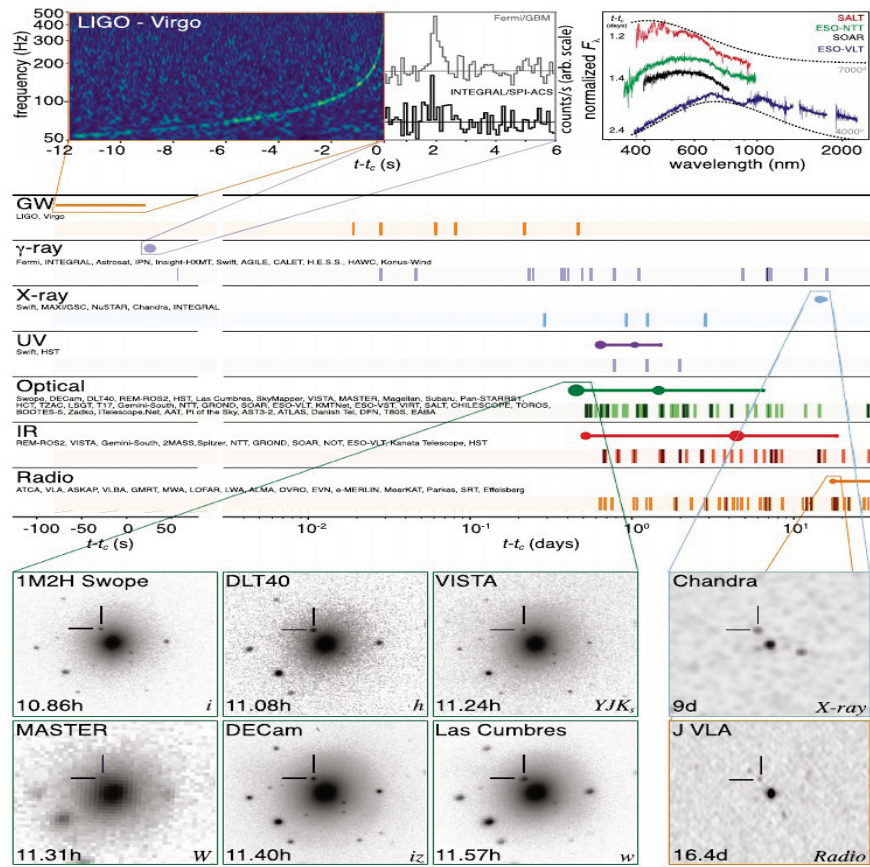
GW170817: SALT got the first spectrum!



<10 hrs after the GW event!

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SALT Inauguration: 10 Nov 2005



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Hartebeesthoek Radio Astronomy Observatory



MeerKAT



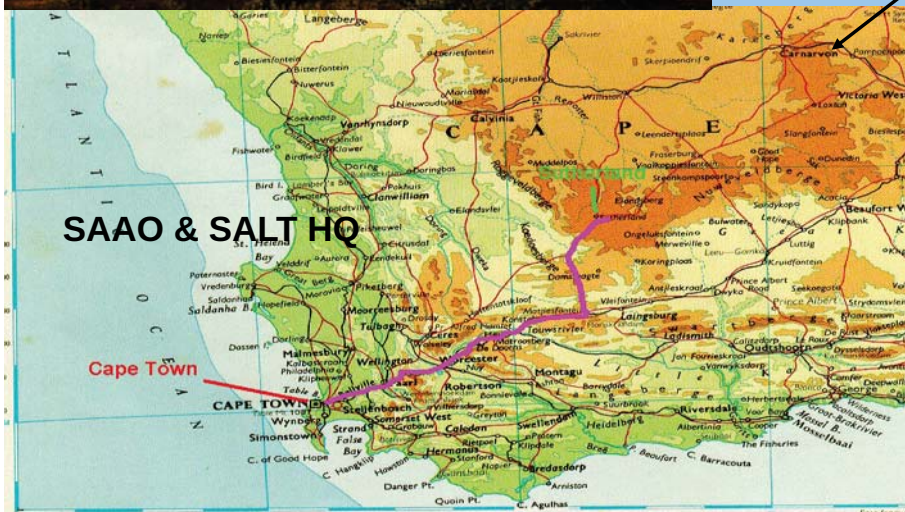
Photo: SARAO

Carnarvon site:
Very low population density
Radio-quiet zone

KAT-7

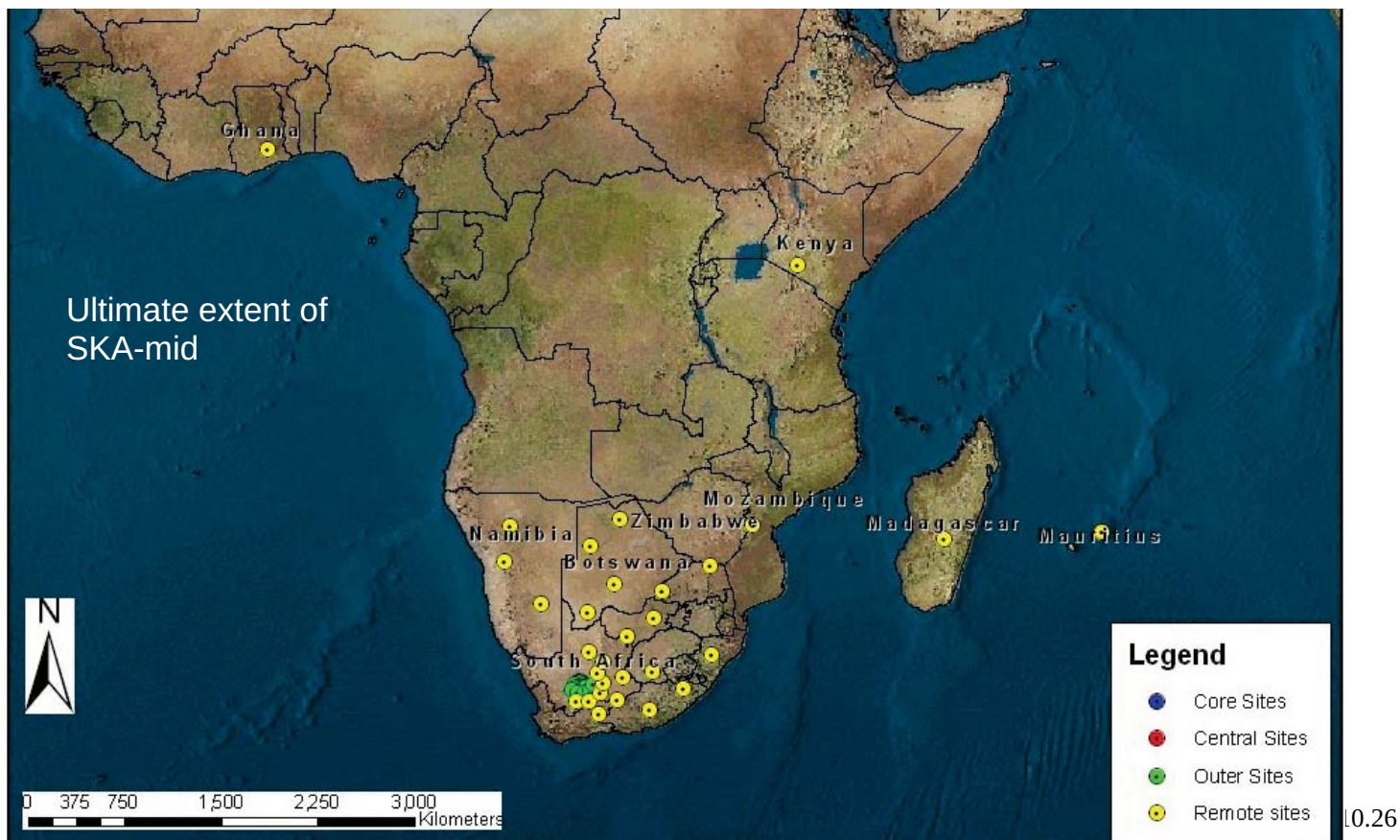


South African Radio Astronomy Observatory (SARAO):
Operator of MeerKAT
Host of SKA



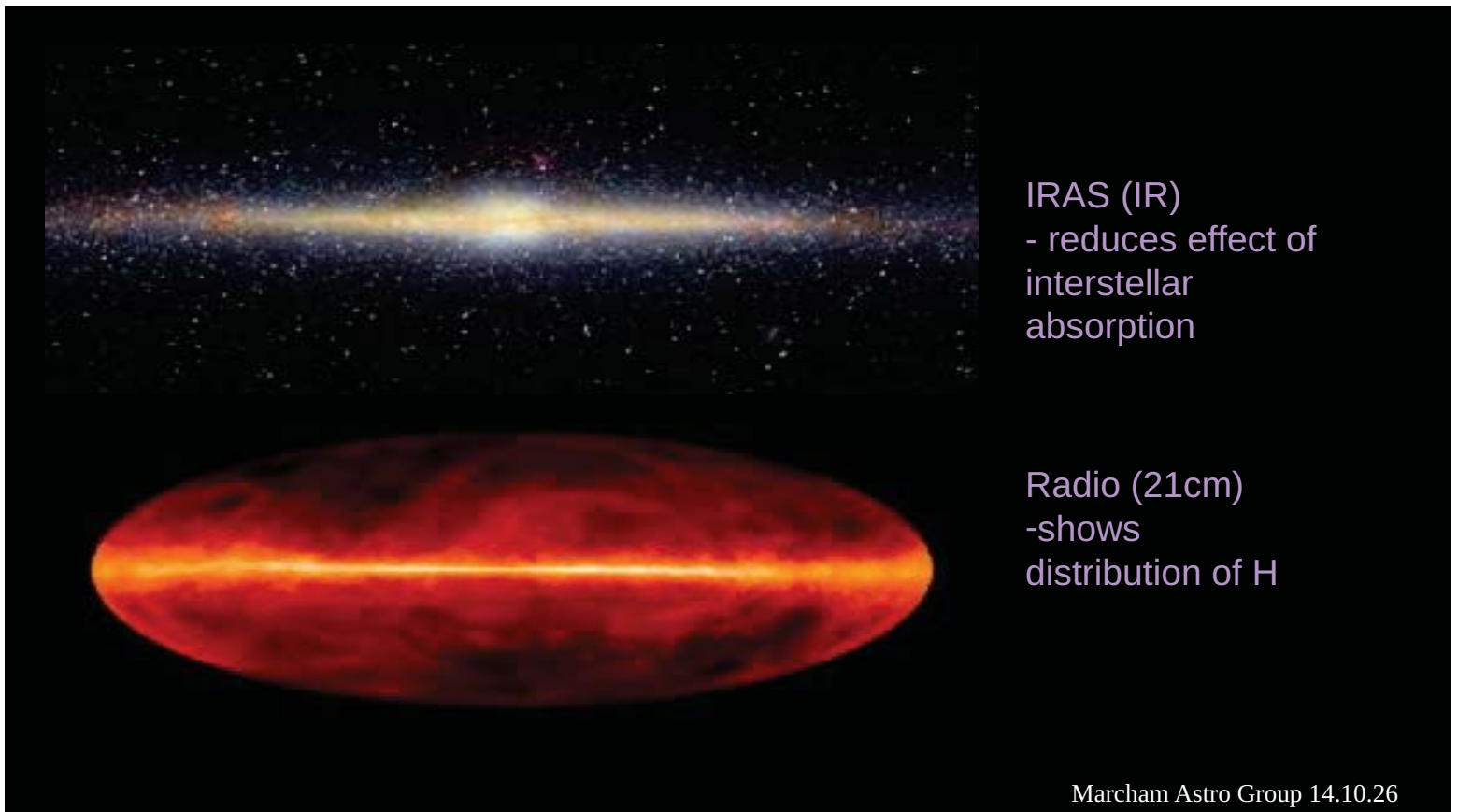
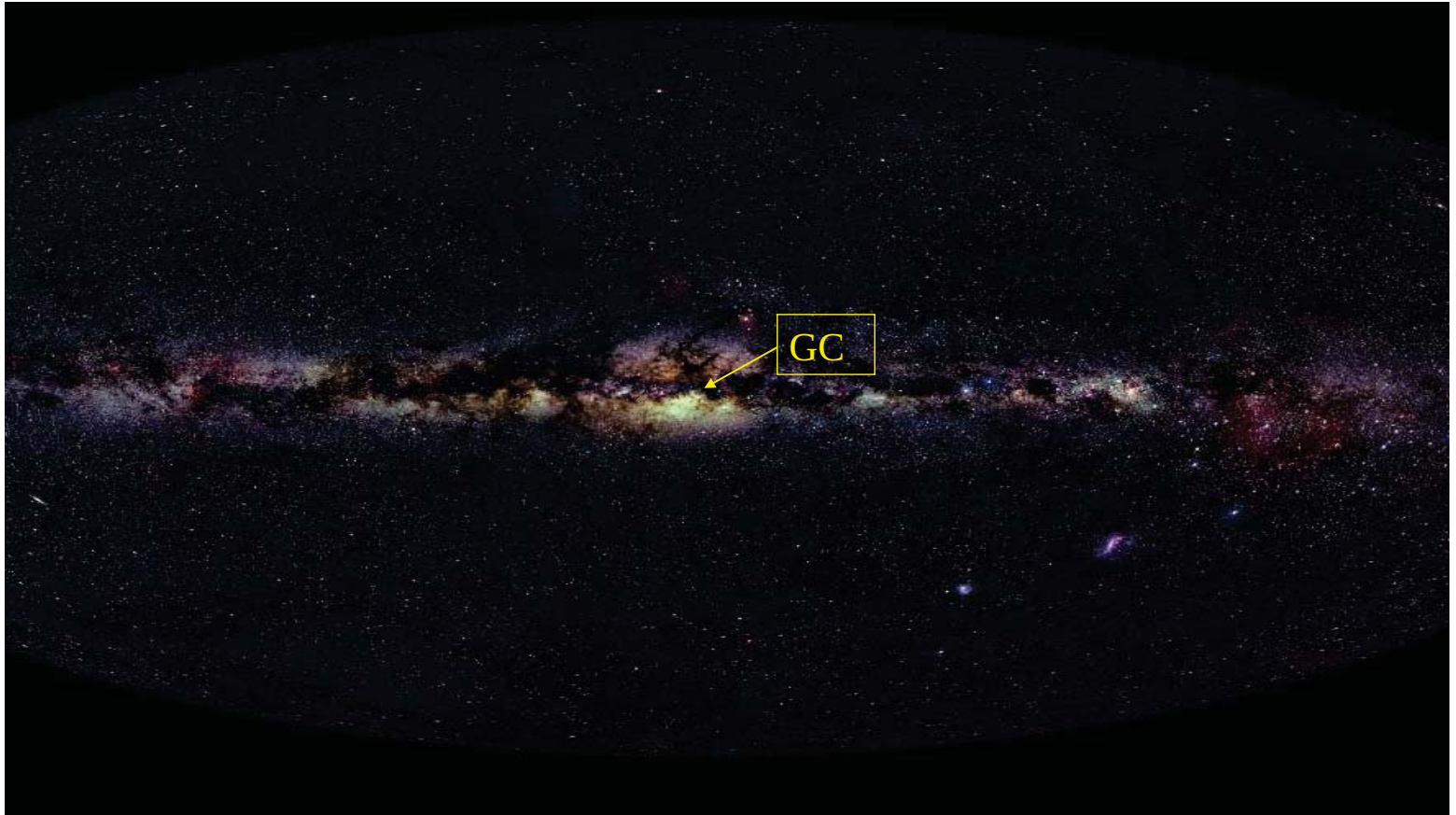
Bernie Fanaroff

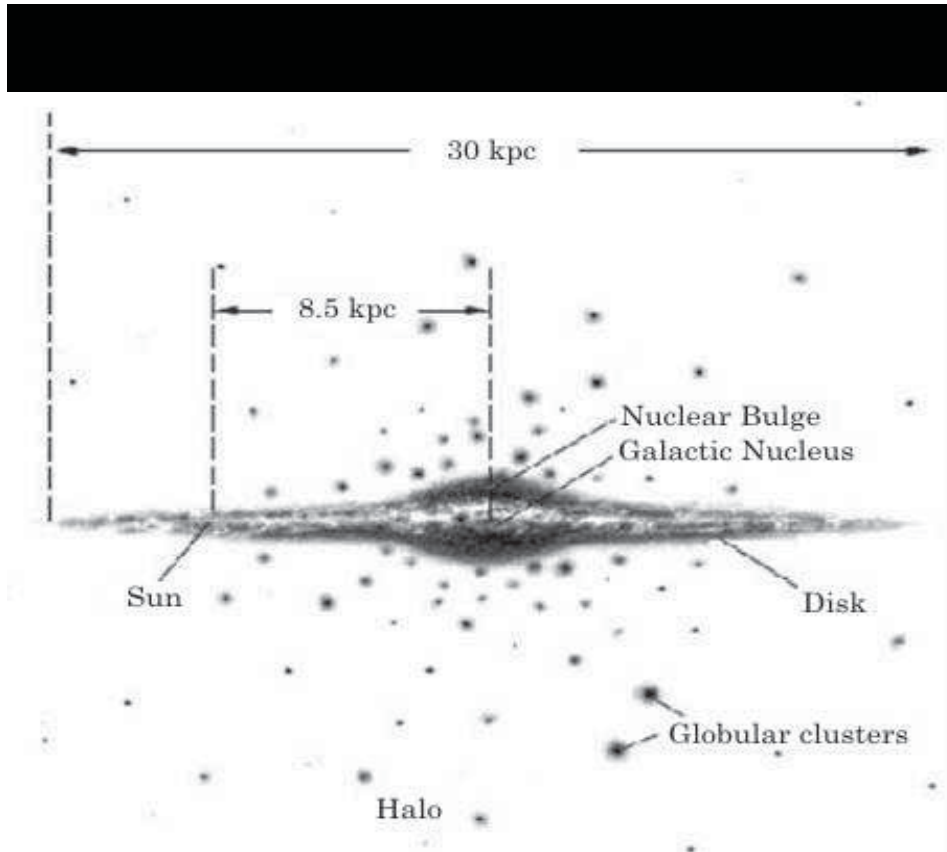




MeerKAT – 64x13.5m offset Gregorian dishes (48 within 1km diam core, rest out to 8km)





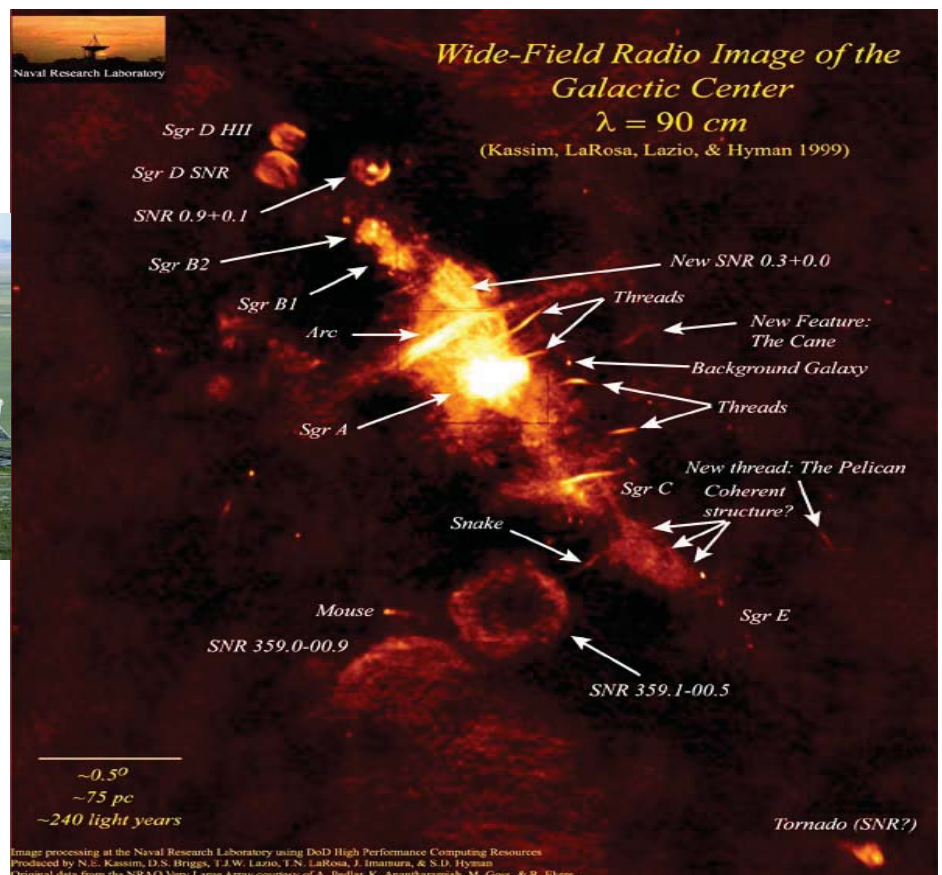


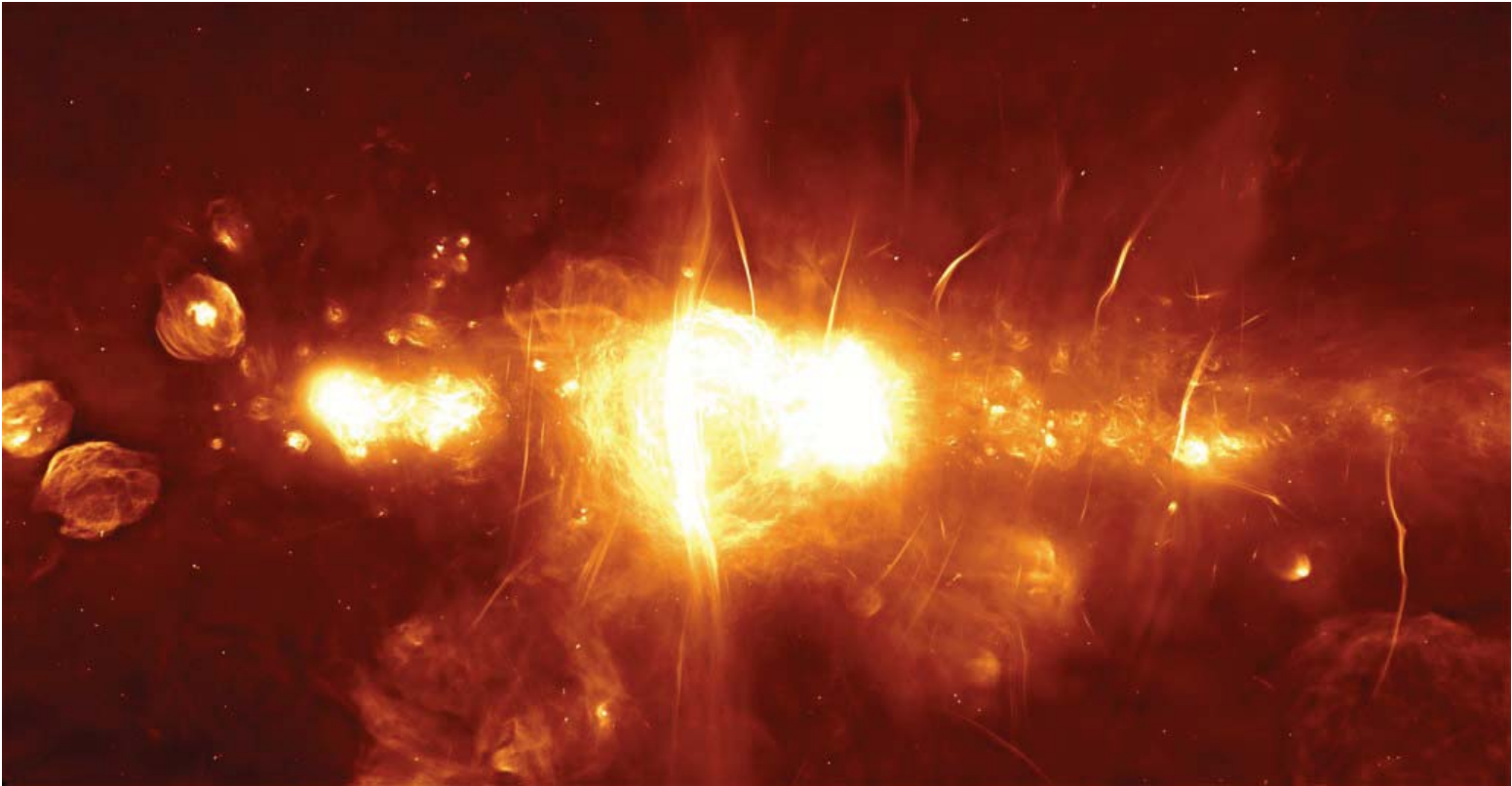
N.B. 1kpc = 3200 lt yrs



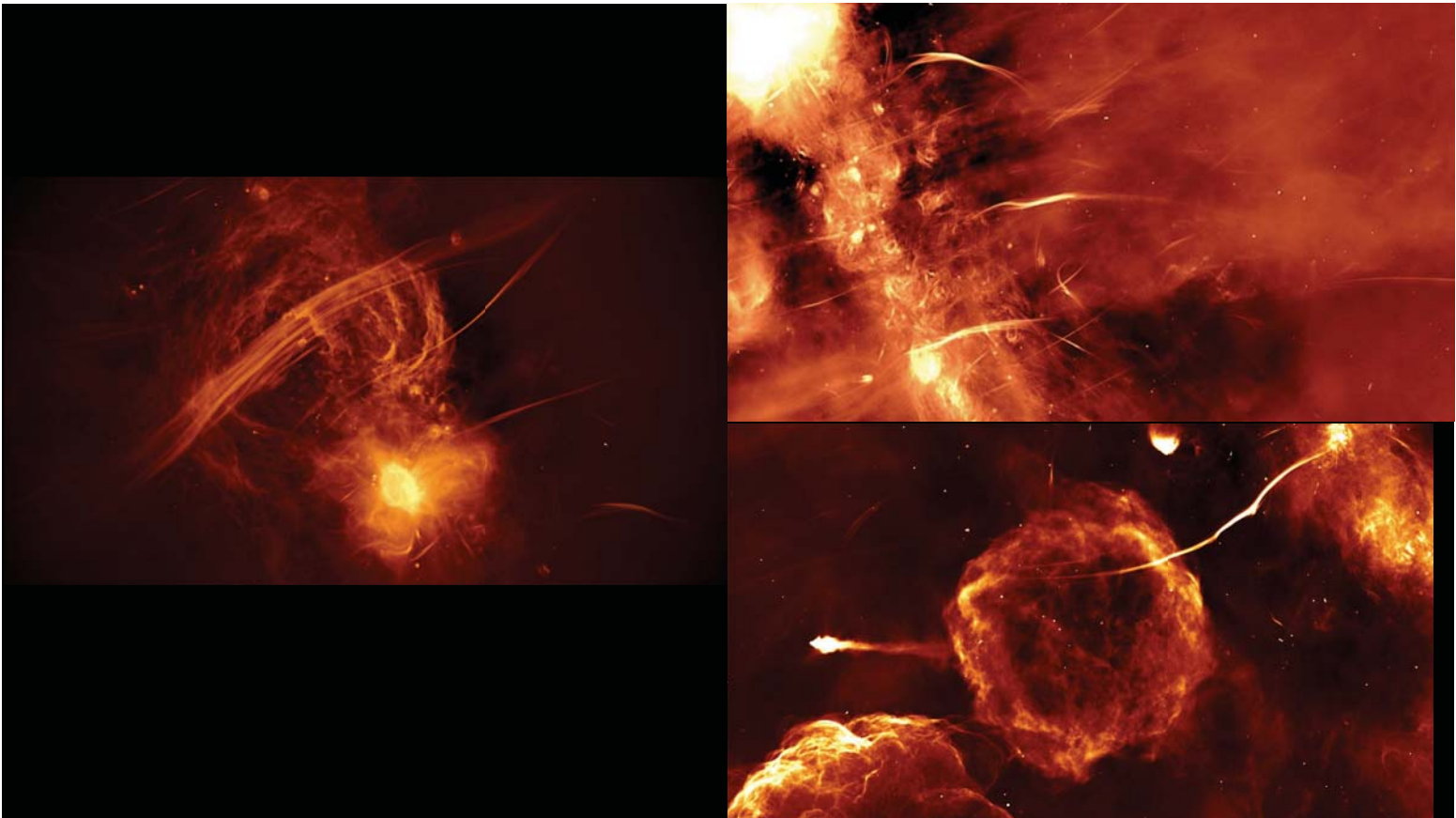
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Previous best radio image of Galactic Centre obtained with VLA in New Mexico



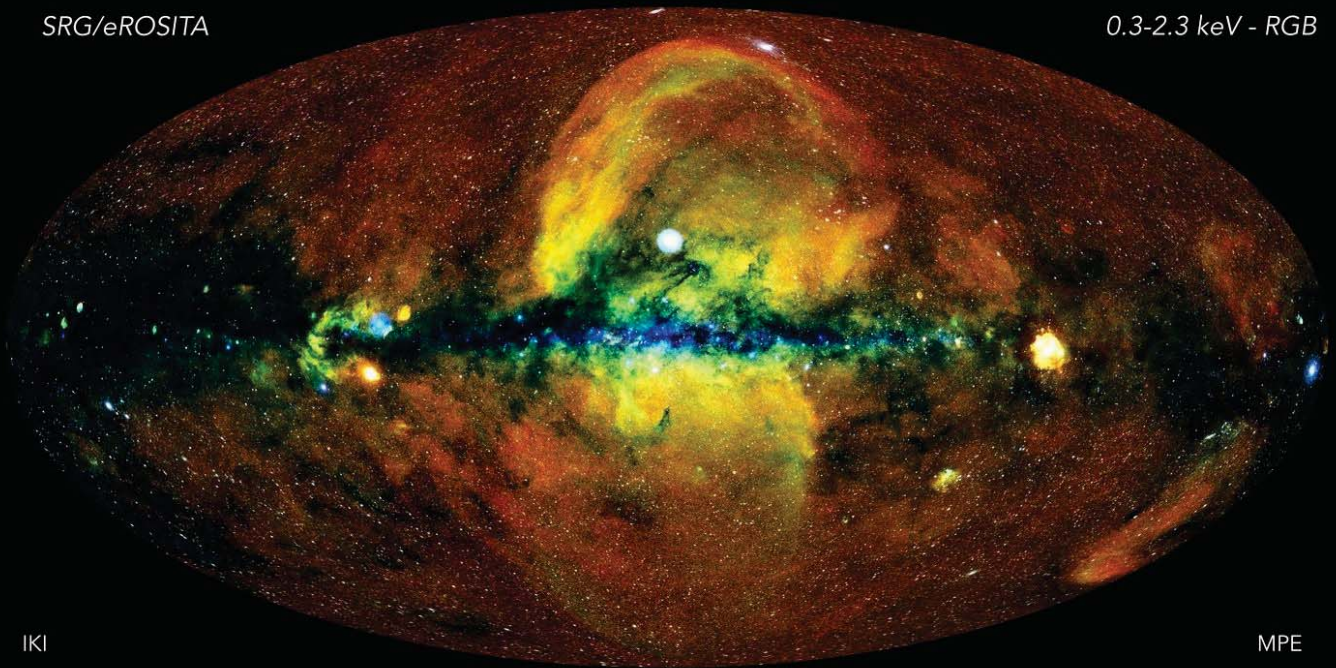


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SRG/eROSITA

0.3-2.3 keV - RGB



IKI

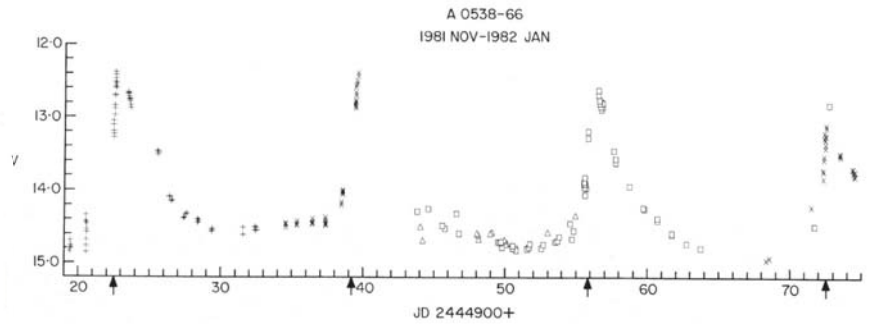
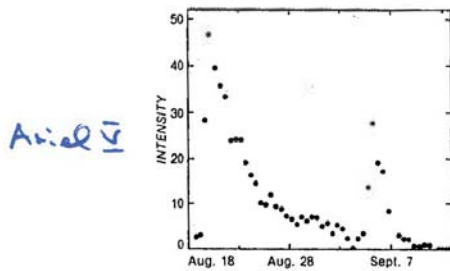
MPE

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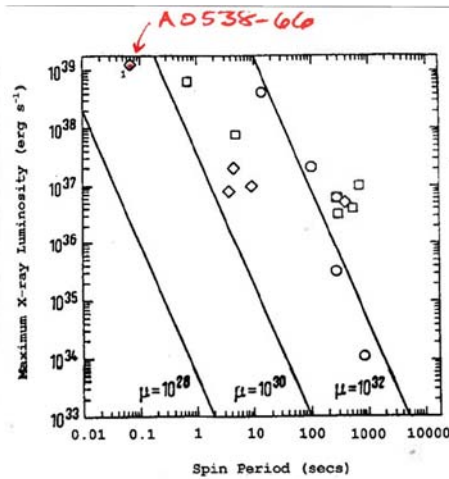
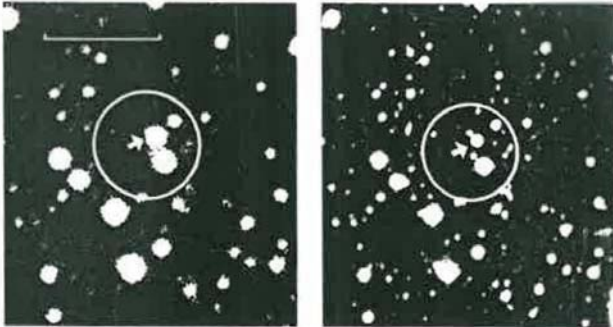
Be X-ray Binaries



A0538-66: Discovered by Ariel V in 1977



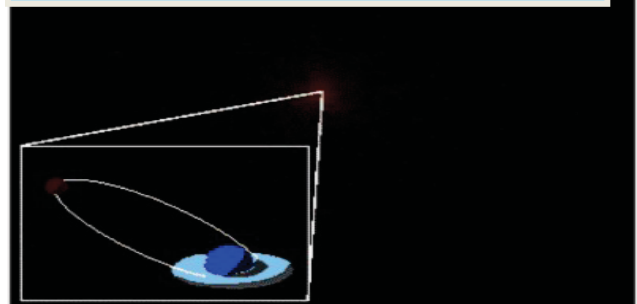
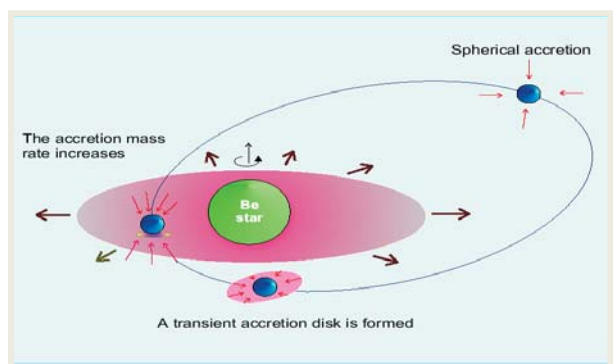
Densham+83 – activity that began in 1977

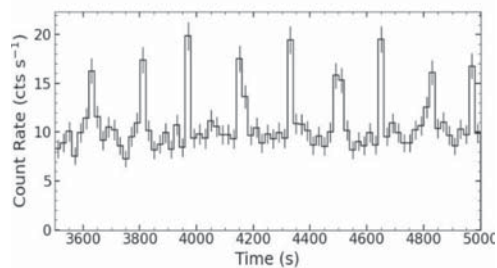
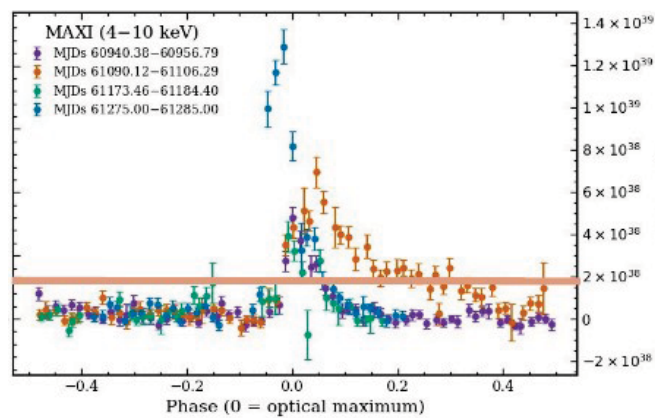
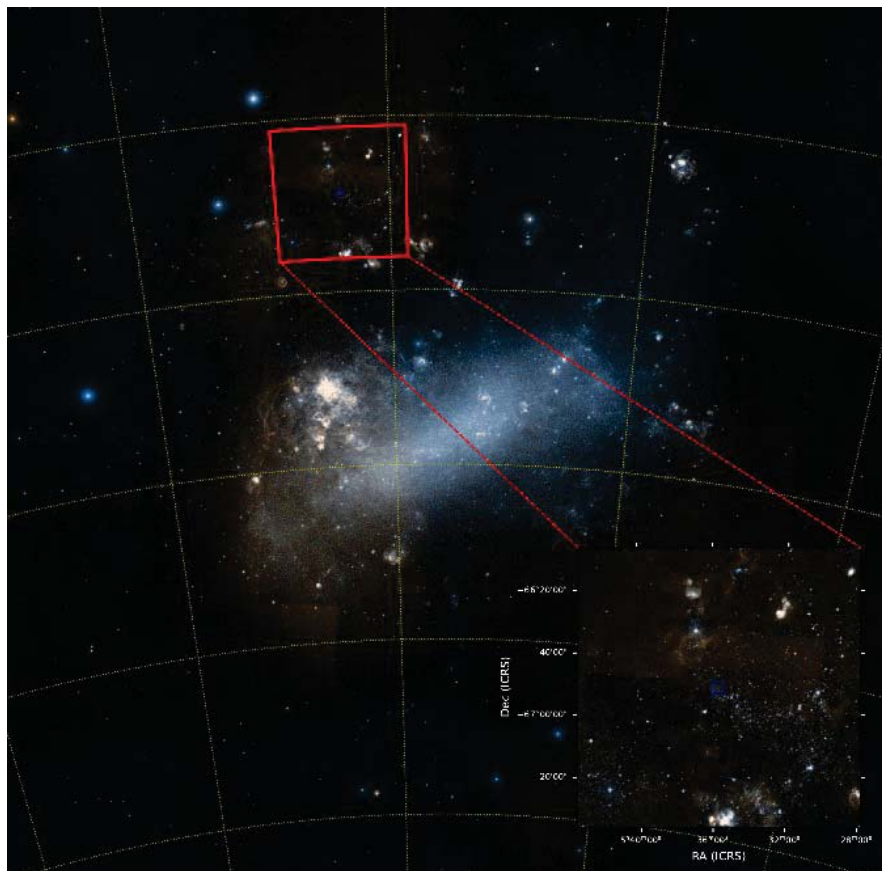


~70ms XR PSR +
 $L_x \sim 10^{39} \text{ erg/s}$
→ first ULX PSR!

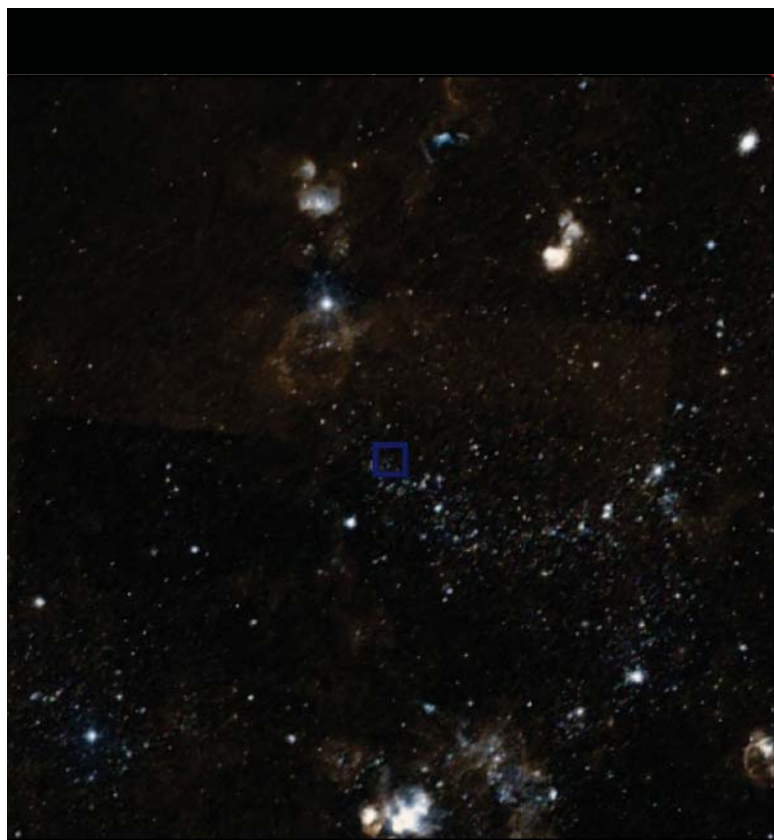
Types of periodicities seen in BeX

- Pulse period of the NS
- Non-radial pulsation of the Be star (~ hours)
- Orbital period (16-500 d)
- Super-orbital period (2-10 yrs) such as seen in A0538-66

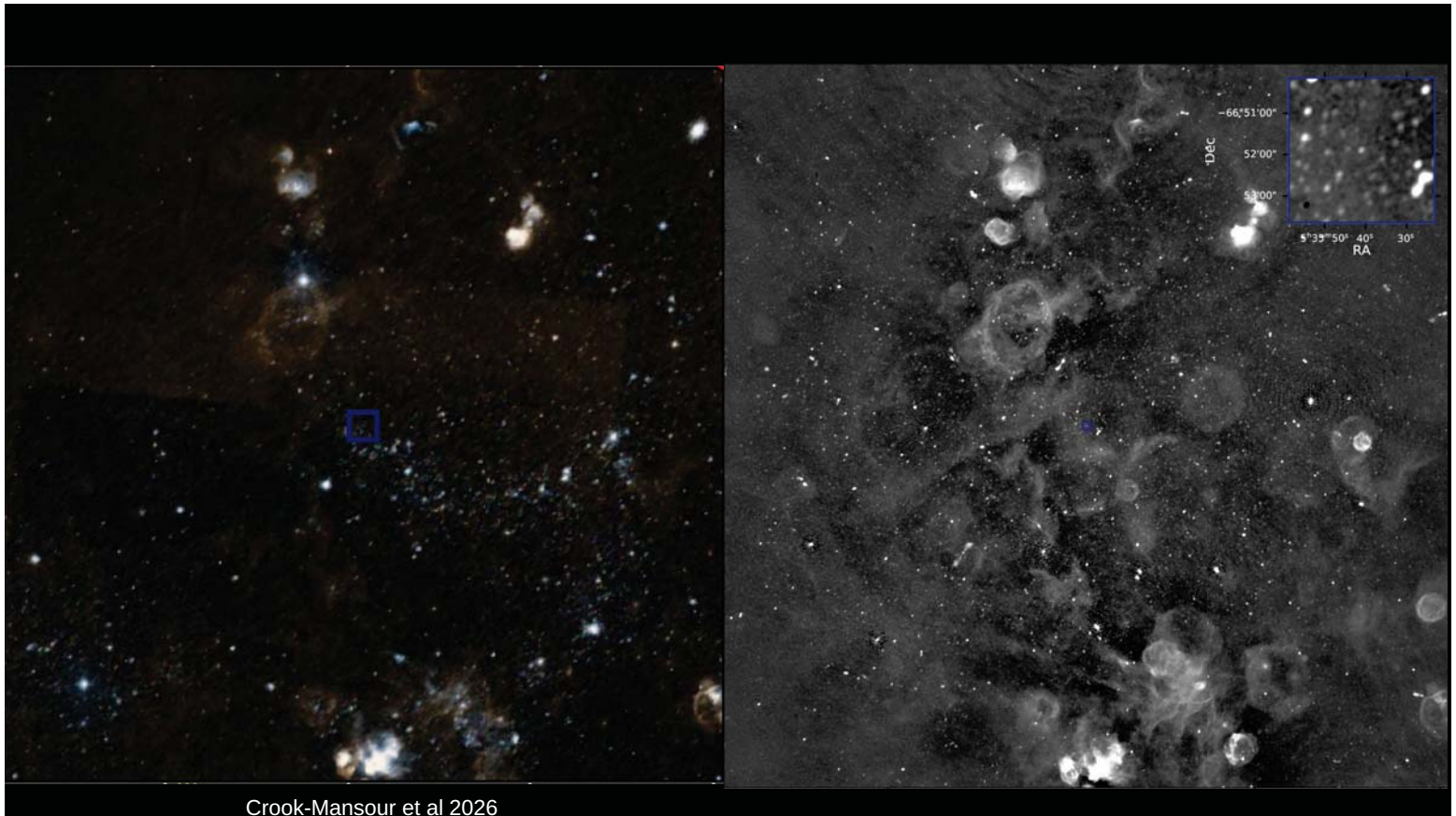




X-ray “bursts” every ~3 mins!
 69ms pulsar → magnetospheric “gate”
 Beri et al 2026



Crook-Mansour et al 2026



From Ian Glass' 2010 article
in MNRAS

Main issues:

- instructions/comms from NRF VP Facilities:
- (1) restructure SAAO so as to be run by Scientist/Administrator;
- (2) Science Minister to announce site of MeerKAT ops HQ at Ysterplaat, nr Canal Walk



The debacle attracted lots of media attention, as can be seen here in the lamp-post headline held by Prof Charles. (Picture: Anne Charles)



From Ian Glass' 2010 article
in MNASSA

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- (1) restructure SAAO so as to be run by Scientist/Administrator;
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**After 6 weeks – “cleared on all charges”!
In 2012, SA awarded SKA-mid!**



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“We trained hard . . . but every time we formed up teams we would be reorganised. I was to learn that we meet any new situation by reorganising. And a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralisation”

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“We trained hard . . . but every time we formed up teams we would be reorganised. I was to learn that we meet any new situation by reorganising. And a wonderful method it can be for creating the illusion of progress while producing confusion, inefficiency and demoralisation” — Petronius Arbiter, 210 BC.

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Legislation: Astronomy Geographic Advantage Act



- Empowers the Minister for Science and Technology to declare protected areas around strategic astronomy sites by publication in the Government Gazette.
- The Act empowers the Minister to prohibit over-flights
- The Act covers both radio and optical astronomy
- Three tiers of protected areas:
 - Core area – the physical area of the observatory / instrument
 - Central area – surrounds the core area. Minister prohibits certain activities / categories of activities in this area
 - Coordination area – Minister sets standards which activities must comply with
- Protected areas apply to existing and new activities
- Sizes of protected areas depend on the astronomical activity, but are large e.g. RFI for KAT!