What’s needed to make reliable optical identifications of radio sources?

1) A reliable radio survey: The Parkes surveys were in full-swing

2) Accurate, arc-second quality radio position measurements

3) Deep optical sky surveys: The UK-Schmidt was operational in 1973

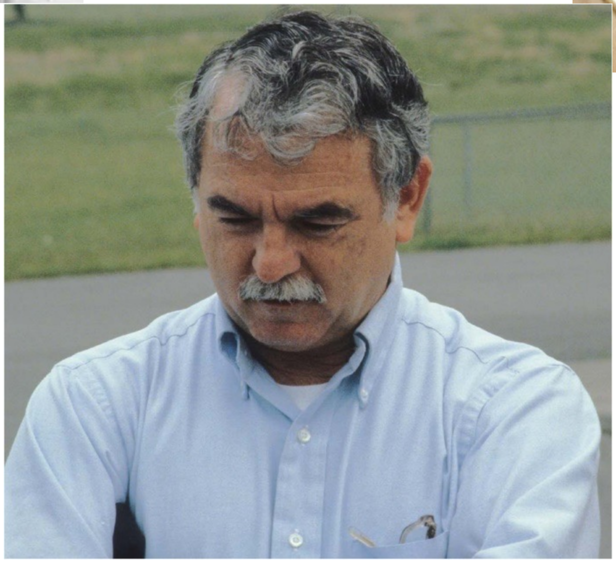
4) Able to make accurate optical position measurements: Readily available

5) A large optical telescope for spectroscopy: The AAT opened in 1974

In the mid-1970s in Australia, the ability to measure accurate radio positions was sorely needed!

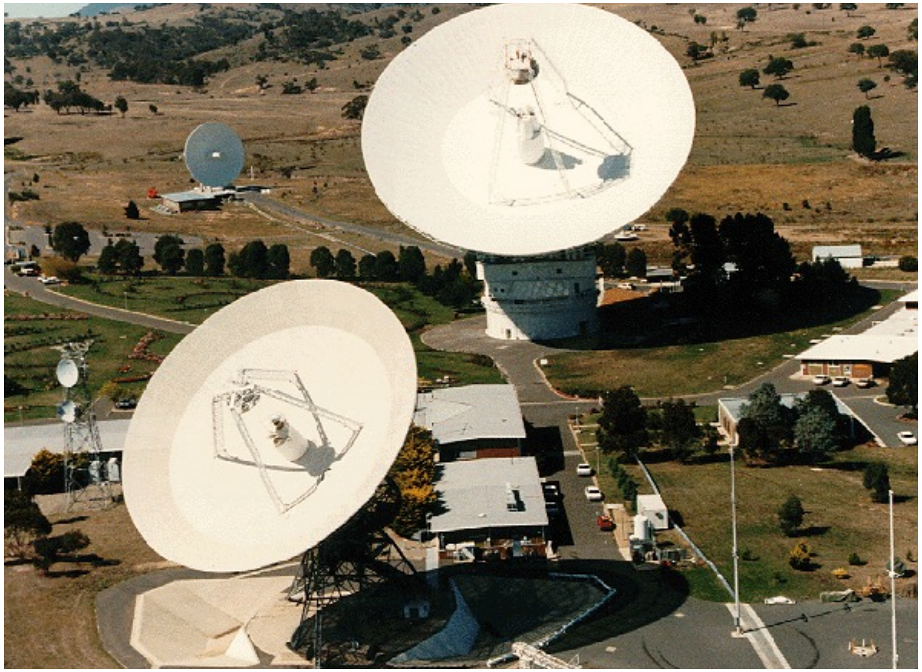
Paul Wild, Chief
CSIRO Radiophysics

Tom Reid, 1974
Tidbinbilla Director

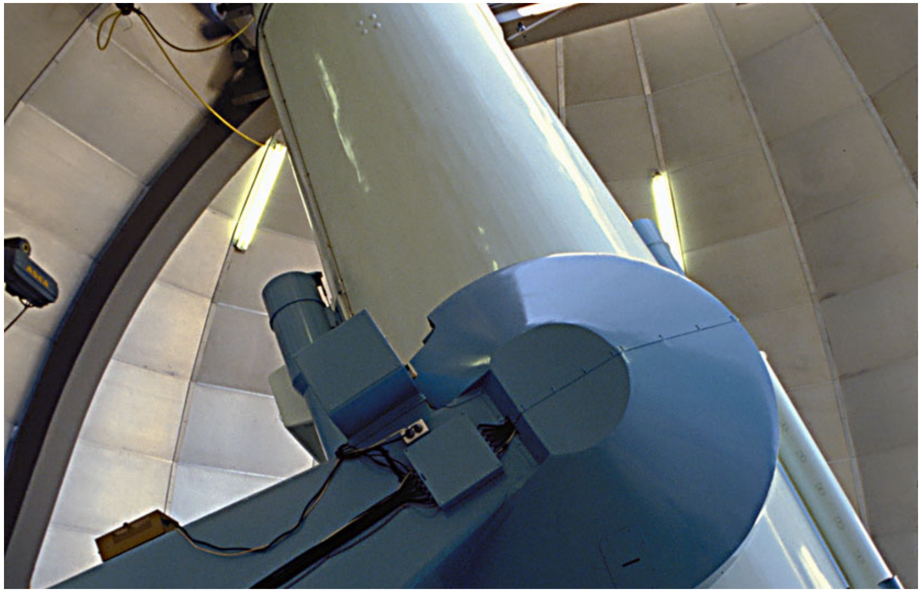


Sam Gulkis
Jet Propulsion Lab

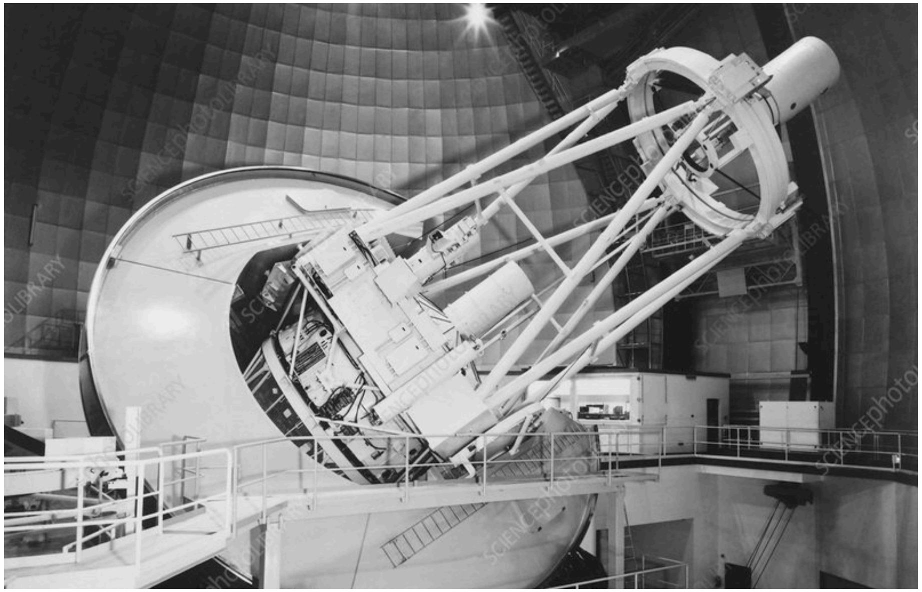
The Parkes radio telescope



Tidbinbilla 26 m and 64 m telescopes



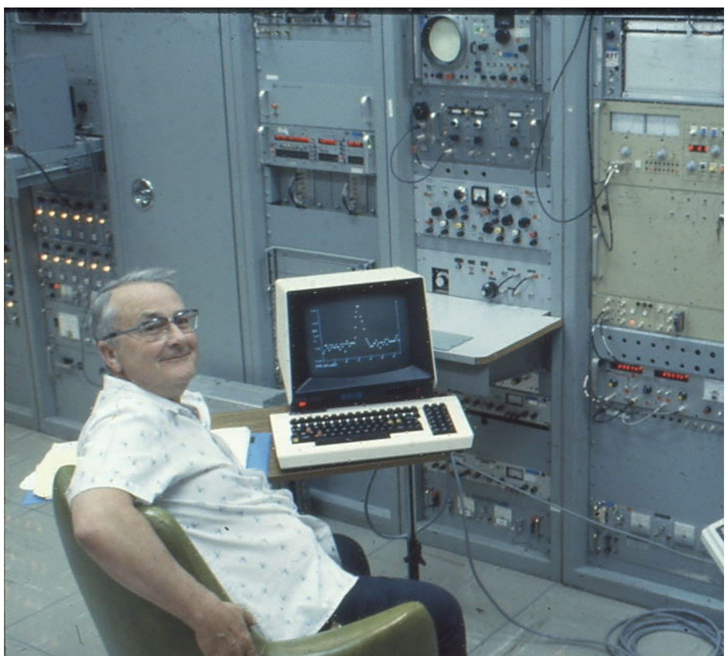
The UK Schmidt telescope



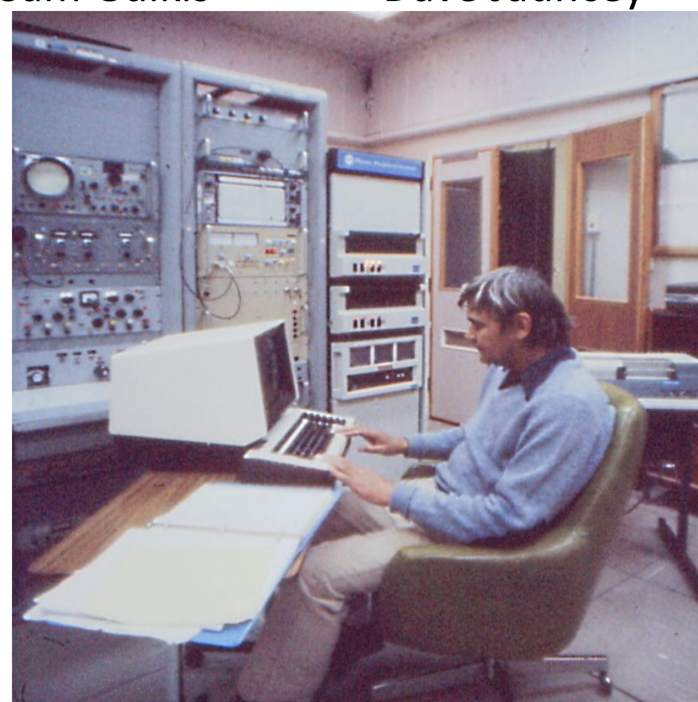
The Anglo-Australian telescope

Mike Batty

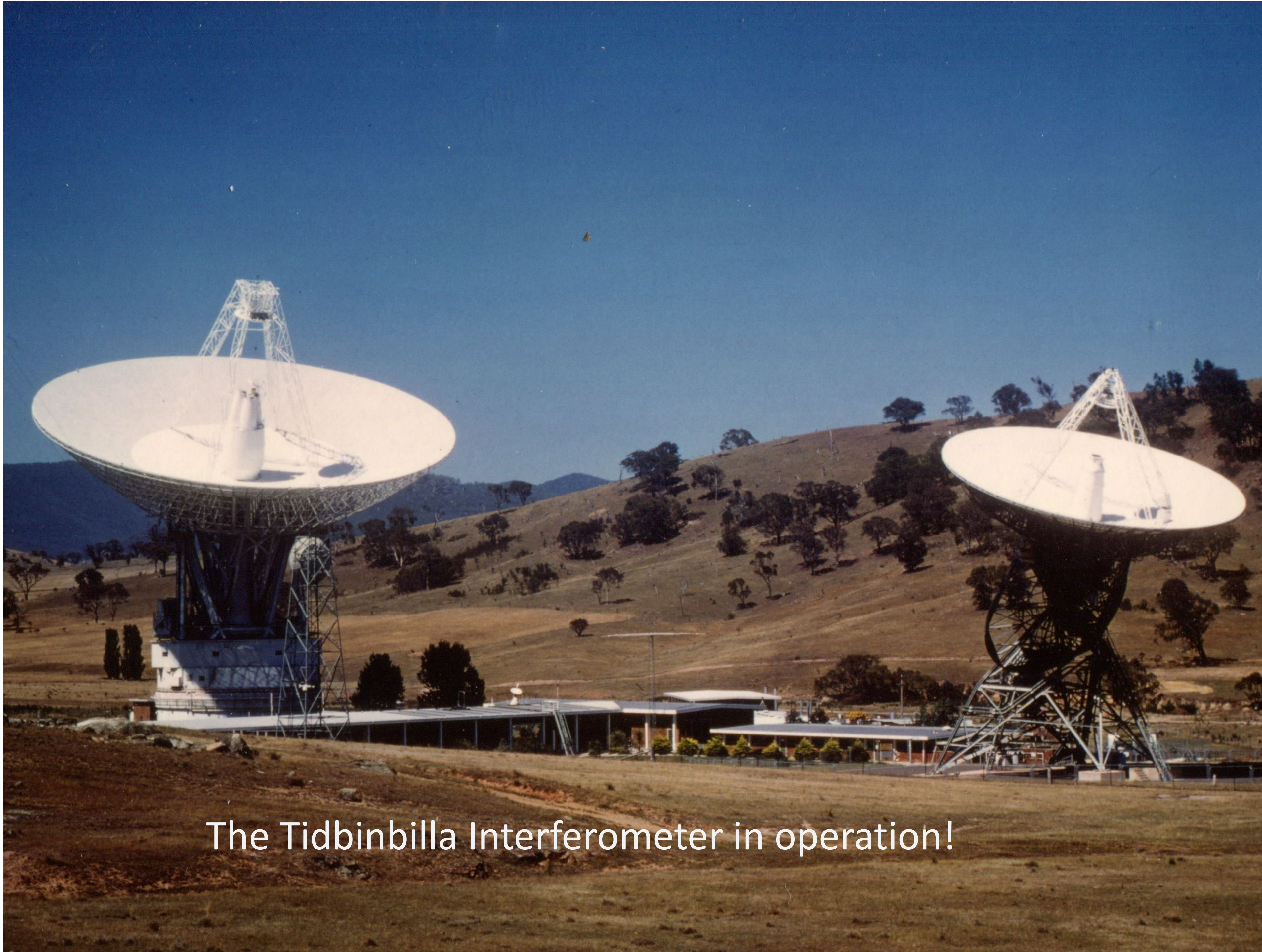
Sam Gulkis Dave Jauncey



Roy Livermore



Dave Jauncey



The Tidbinbilla Interferometer in operation!

The Tidbinbilla Interferometer

Batty, M.J., Jauncey, D.L., Rayner, P.T. & Gulkis, S, AJ., 87, 938, 1982

parameters are as follows:

Frequency of observation	2.29 GHz ($\lambda = 13.1$ cm)
Polarization	right circular
IF bandwidth	12 MHz
System temperature	20 K at zenith
Intermediate frequency	70 MHz
Detection sensitivity	50 mJy in 1 s (5σ)
Baseline length	194.6 m (1485λ, north-south)
Minimum lobe spacing	2.3 arcmin

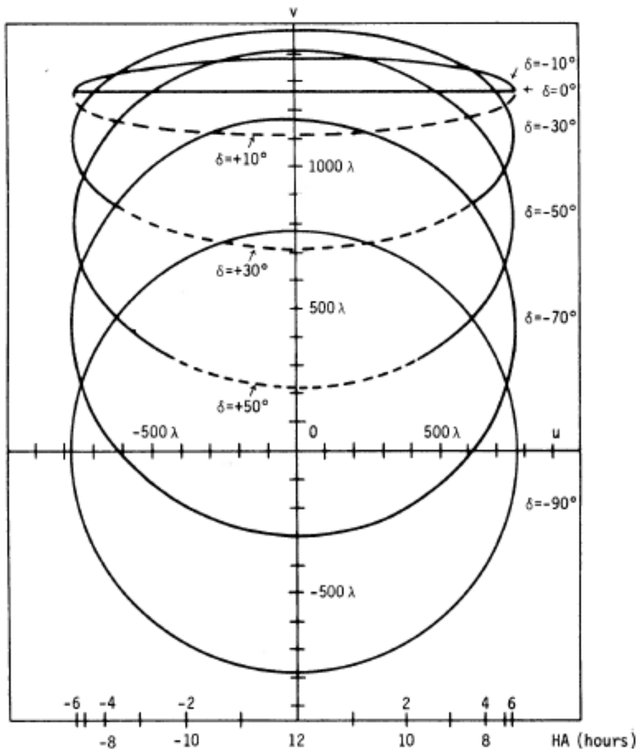


FIG. 1. The (u, v) plane coverage of the Tidbinbilla interferometer for declinations between $-90°$ and $+50°$. Tracks for positive declinations are shown as broken lines.

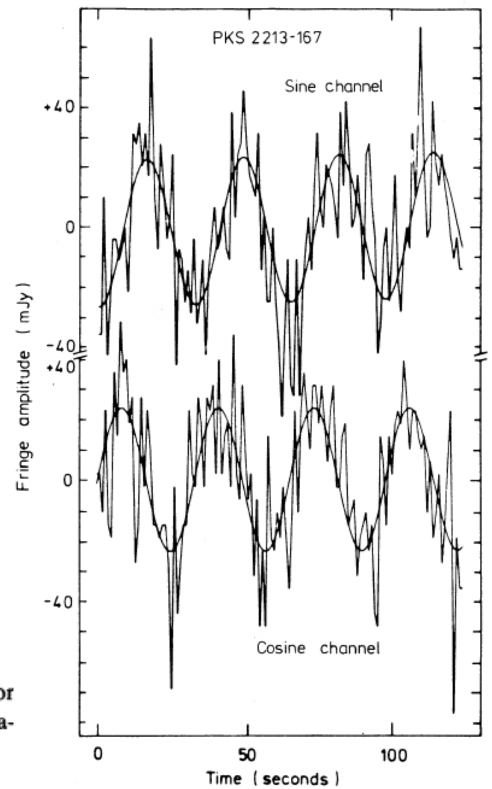
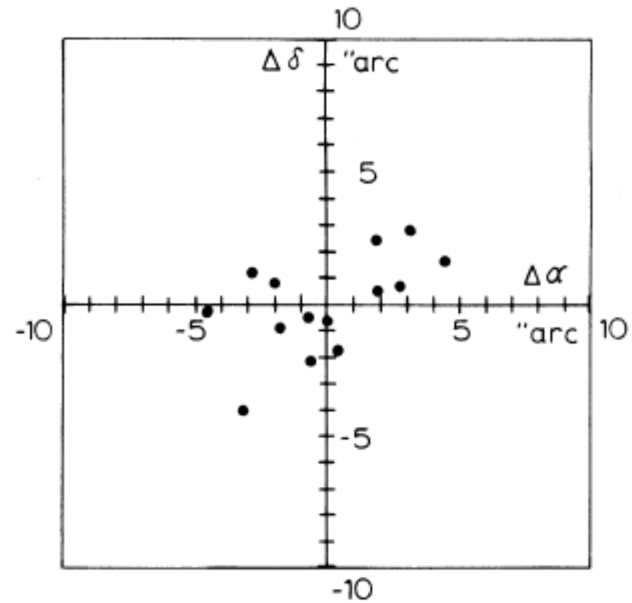
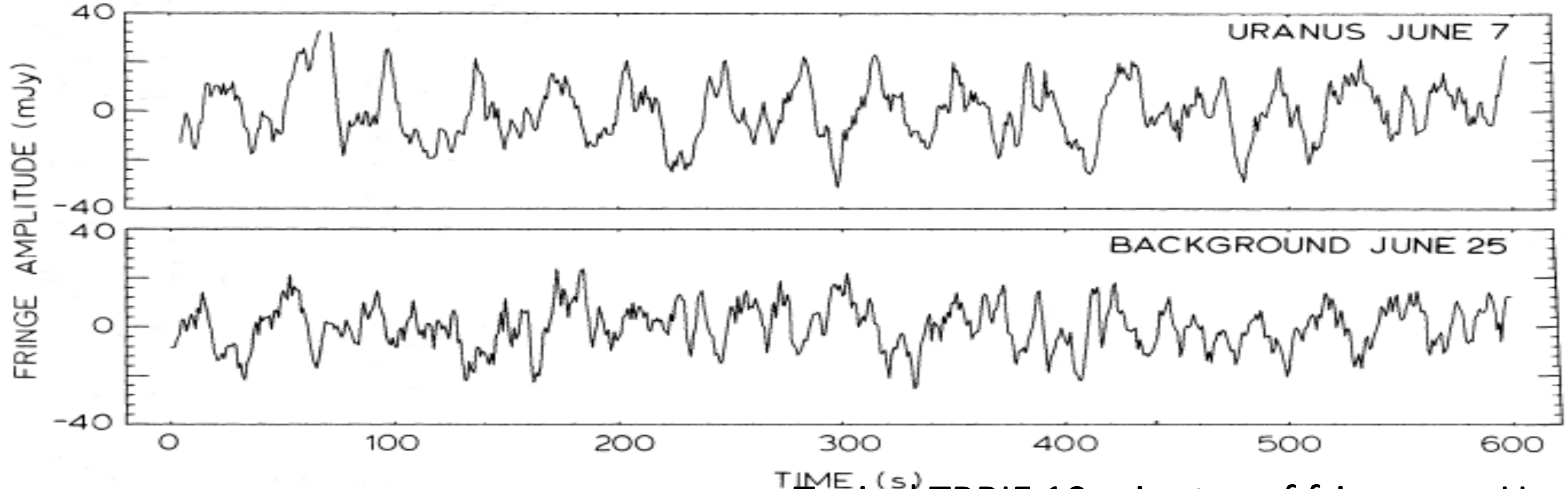


FIG. 4. A sample observational record showing fringes recorded on the source PKS 2213−167. Superimposed are the fringe functions of amplitude ~25 mJy fitted by the reduction program.



Radio-optical errors of 1."8 in dec and 2."7 in RA



Typical TBBIF 10 minutes of fringes on Uranus, and the corresponding background field.

Tidbinbilla Interferometer observations of Uranus in June 1979 at 13.1 cm, gave a mean of the 5 scan pairs, Of 11.7 mJy +/- 0.8 mJy. Plotted against earlier observations at a similar frequency, showed a significant variability.

Batty, M.J., Jauncey, D.L., Rayner, P.T. & Gulkis, S. ApJ., 243, 1058, 1981

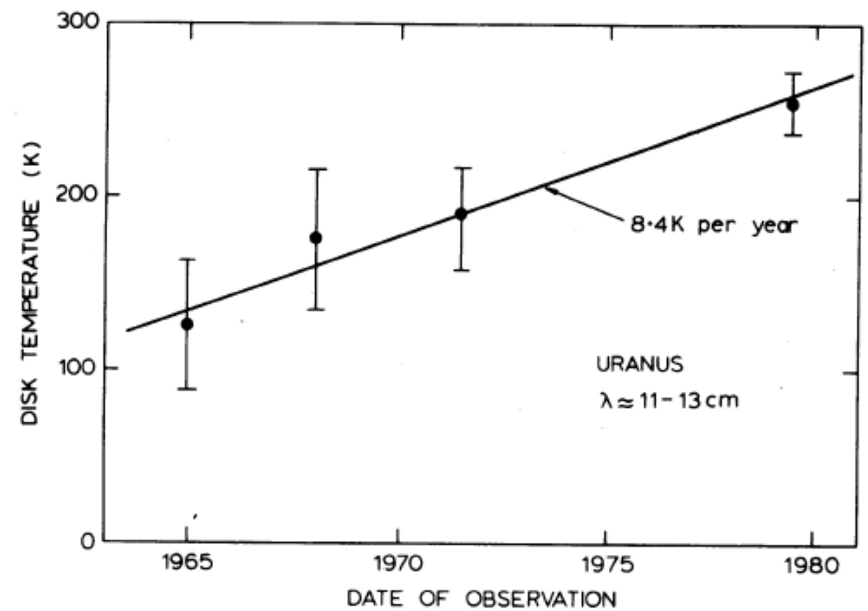


Figure 1. Variation in the observed disk temperature of Uranus near 13 cm wavelength. The plotted data are from Kellermann (1966), Gerard (1969), Webster *et al.* (1972) and the present work. The solid line corresponds to a weighted linear fit to the experimental data.

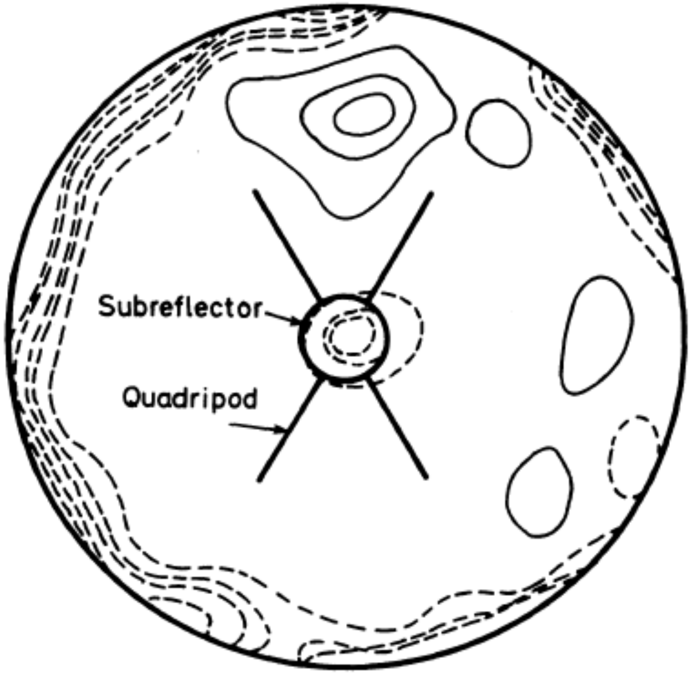


Figure 1. Contour plot of the surface error of the 64-m antenna derived from the 11 × 11 point holographic measurement. Continuous and dashed contours correspond to positive and negative features; the contour intervals are approximately (±) 1.3, 2.6, 3.3 and 5.2 mm. The vertical direction corresponds to changes in elevation.

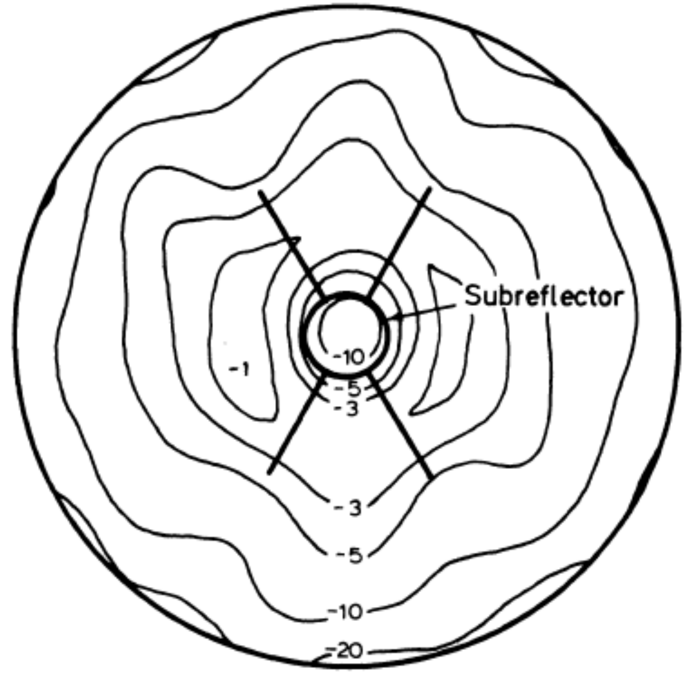


Figure 2. Contour plot of the amplitude of the 64-m antenna illumination function. Contour levels are marked in decibels.

Microwave Holographic Surface Measurement of the Tidbinbilla 64-m Antenna

Y. Rahmat-Samii, S. Gulkis, G.S. Levy, B.L. Seldel, L.E. Young, M.J. Batty & D.L. Jaunncey, Proc ASA, **5**, 270, 1983

Colour plots of the surface measurement of DSS 43, the Tidbinbilla 64-m Antenna as a reminder of the NASA Group Achievement Award given to this program.

Let’s now move on to the night of March 25-26 with Bruce Peterson and Ann Savage observing at the 3.9 m Anglo-Australian telescope at Coonabarabran….

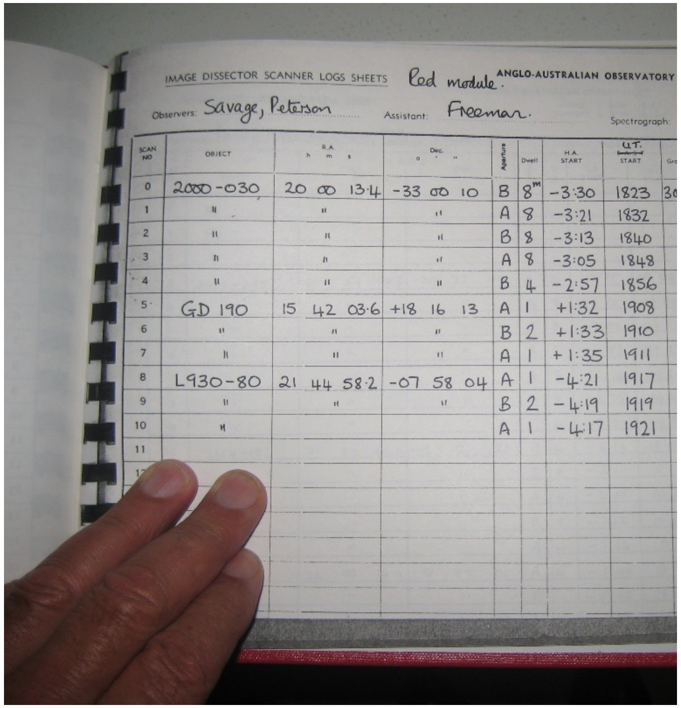
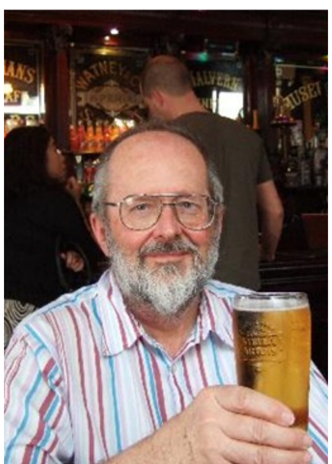
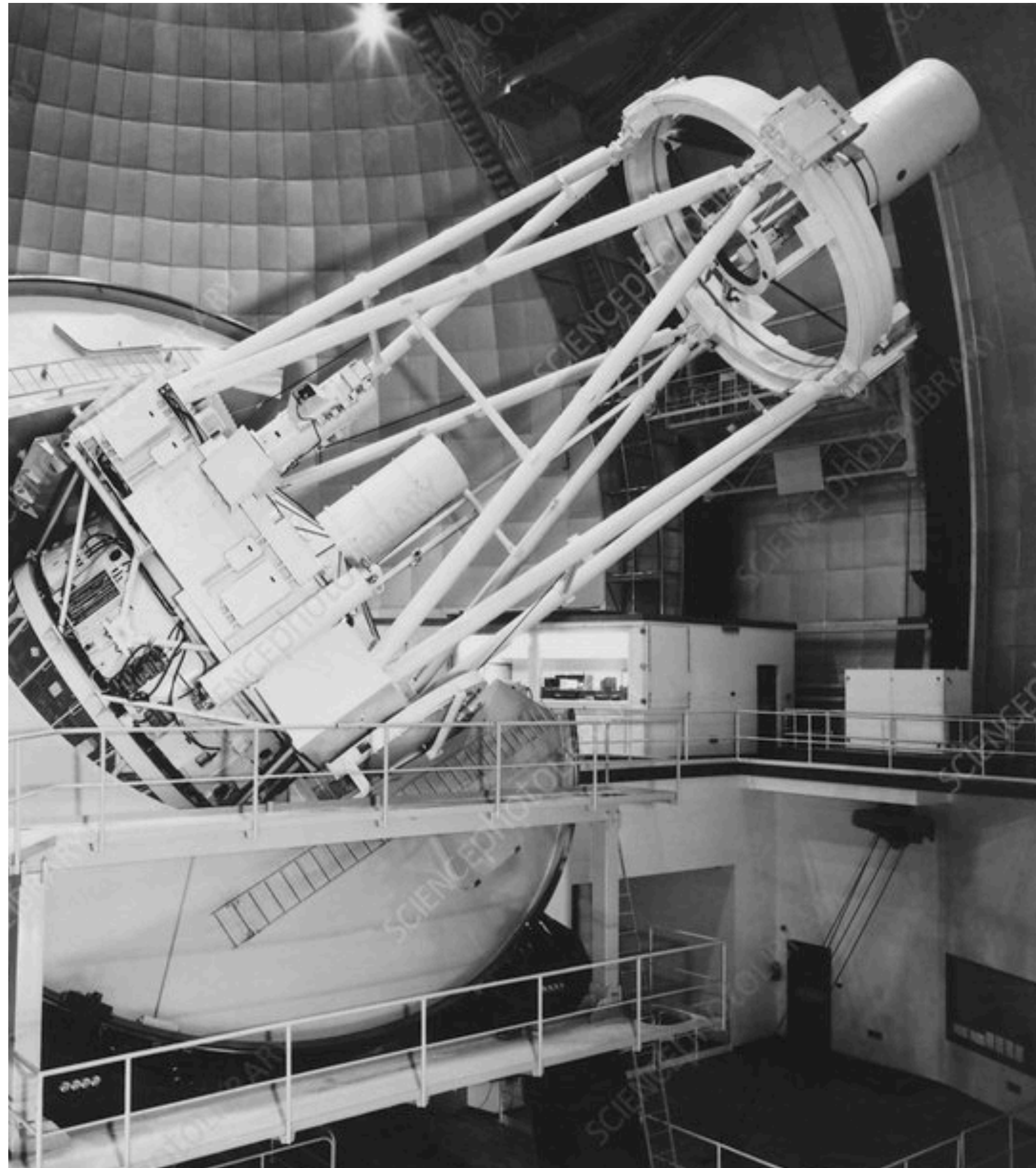


IMAGE DISSECTOR SCANNER LOGS SHEETS Red module. ANGLO-AUSTRALIAN OBSERVATORY

Observers: Savage, Peterson Assistant: Freeman. Spectrograph:

SCAN NO	OBJECT	R.A. h m s	Dec. ° ′ ″	Aperture	Dwell	H.A. START	U.T. START	Gr
0	2000-030	20 00 13·4	-33 00 10	B	8ᵐ	-3:30	1823	30
1	"	"	"	A	8	-3:21	1832	
2	"	"	"	B	8	-3:13	1840	
3	"	"	"	A	8	-3:05	1848	
4	"	"	"	B	4	-2:57	1856	
5	GD 190	15 42 03·6	+18 16 13	A	1	+1:32	1908	
6	"	"	"	B	2	+1:33	1910	
7	"	"	"	A	1	+1:35	1911	
8	L930-80	21 44 58·2	-07 58 04	A	1	-4:21	1917	
9	"	"	"	B	2	-4:19	1919	
10	"			A	1	-4:17	1921	
11								





In March 1982we identified PKS2000-330 as a quasar with z = 3.78, breaking a ten year record for the most distant known object in the Universe.

The optical identification was only possible because of the accurate radio position from the Tidbinbilla Interferometer.

Interestingly, PKS2000-330 was found to be **RED** on the UKST plates.

And all of the known z>3.0 Sources were found to posses flat/peaked radio spectra.

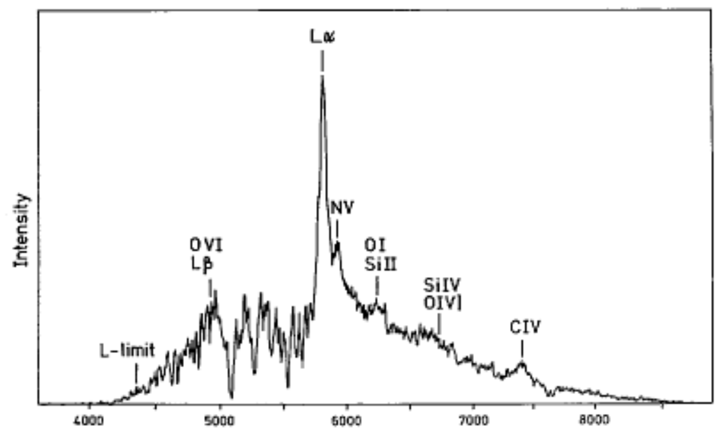


FIG. 2.—The optical spectrum of PKS 2000−330 obtained 1982 March 26 with the Image-Tube Dissector Scanner at the f/15 focus of the Anglo-Australian Telescope. Relative intensity is shown as a function of observed wavelength in Å. The spectrum has a resolution of ~ 10 Å. Identifications of the principal emission features and the position of the Lyman limit are shown. Many blended absorption features are seen on the short-wavelength side of the Lyα emission line. The absorption features are attributed to Lyα absorption in clouds along the line of sight to the QSO.

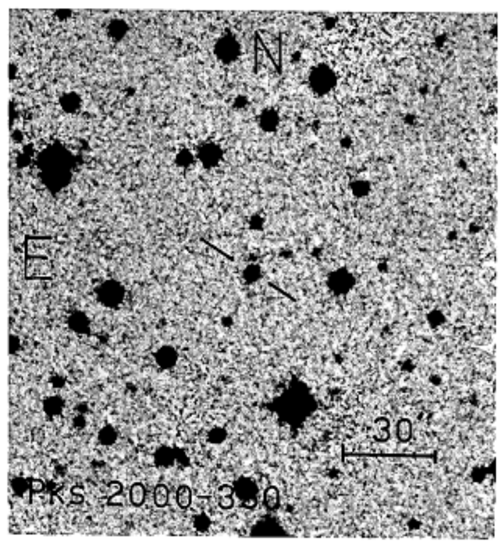
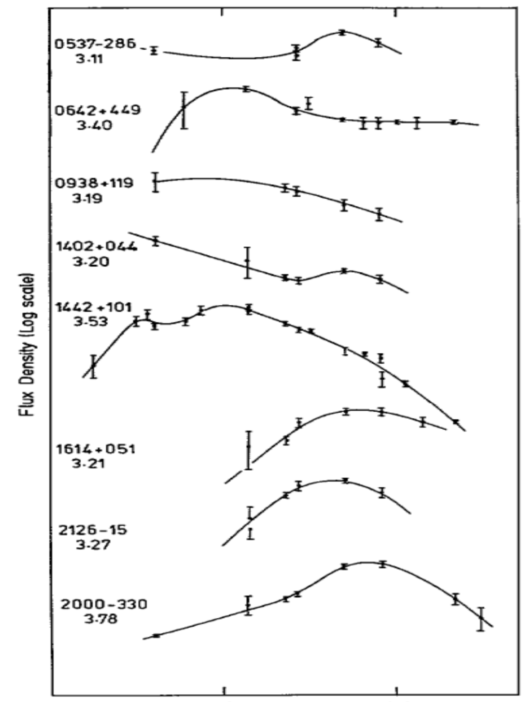


FIG. 1.—The optical counterpart of PKS 2000−330. The 19th magnitude QSO is in the center of the figure, indicated by the two bars. Note the faint, diffuse images 5" to the north and south of the QSO. The figure is reproduced from the SERC J Sky Survey film.

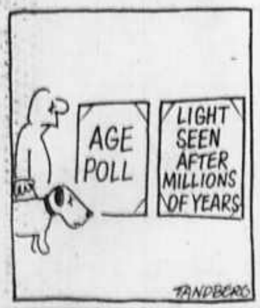


Peterson, B.A., Savage, A., Jauncey, D.L., & Wright, A.E., ApJ., **260**, L27, 1982

THE AGE

Wednesday 31 March 1982 250 Spencer St., Melbourne 60 0421 (Classified 60 0611) 66 Pages 128th Year 25c

New star extends the universe by 4500 million light years



From SIMON BALDERSTONE

CANBERRA. — A quasar (quasi-star) has been found 20,000 million light years from Earth, making it the most distant object discovered and shattering the theory that the edge of the universe had been seen already.

Australian and British astronomers, using radio and optical telescopes in Australia, discovered the quasar. They calculate the quasar to be the most luminous known object in the universe, pouring out the energy of 100 million million suns.

Such is the distance of the quasar — code-named PKS 2000-330 — that the light picked up by the scientists at the CSIRO's radio telescope at Parkes, New South Wales, last week would have left the star-like object 20,000 million years ago.

Before this, the most distant object known was a quasar 15,500 million light years away, discovered by American scientists nine years ago.

Announcing the discovery yesterday, the Federal Minister for Science and Technology, Mr Thomson, said it opened a new debate on the extent and age of the universe and rekindled the controversy about the nature of quasars.

Quasars are the most distant and luminous bodies known. More than 200 have been discovered, but the source of their intense radiation remains unknown.

They have spectrums — the wavelength of light — with a big "red shift." The red shift is directly proportional to distance. The farther the shift towards the longest (red) wavelength the farther the object is from Earth.

For 10 years, scientists have been trying to discover an object with a red shift greater than 3.53, the measurement of a quasar found in 1972.

"The lack of success had led to the idea building up strongly that 3.5 represented the edge of the universe. The theory was developed more or less by default, as no one had managed to find a more distant object," says Dr David Jauncey, of the CSIRO division of radiophysics.

The quasar discovered last week has a red shift of 3.78. It was found by Dr Bruce Peterson (of the Mount Stromlo, ACT, and Siding Spring, NSW, observatories), Dr Ann Savage (of the Royal Observatory, Edinburgh) and Dr Jauncey and Dr Alan Wright of the CSIRO.

Dr Jauncey says the controversy referred to by Mr Thomson has been the question of whether the red shift is a true measure of the distance of a quasar. He says he and his colleagues have not merely found one object.

"It's a big jump in the red shift, and we now believe we know how to find more of these quasars at this distance, if they exist," he says.

The idea of a flat universe, an edge, has gone. "The earliest questions were: How big is the Earth? How big is the Sun? How big is the universe? We can perhaps measure all three now," he said last night.

But it would take a radio telescope perhaps as big as Australia, or the world, to determine accurate the size of "PKS 2000-330". Measurements of closer quasars indicated they had "central engines" — the driving force — a few light years across.

An accurate radio position of the newest quasar was determined using the Tidbinbilla radio interferometer near Canberra. The Siding Spring installation near Coonabarabran, in NSW, was used to identify the object.

Finally, another telescope at Siding Spring obtained a spectrum which proved that the quasar was farther away than other known objects within the universe.

..Announcing the discovery yesterday, the Federal Minister for Science and Technology, Mr Thomson, said it opened a new debate on the extent and age of the universe..

"It's a big jump in the redshift, and we now believe we know how to find more of these quasars at this distance, if they exist." Dr Jauncey says

But it would take a radio telescope as big as Australia, or the world, to determine accurately the size of "PKS2000-330"…

THIS WEEK

Australian astronomy at the crossroads

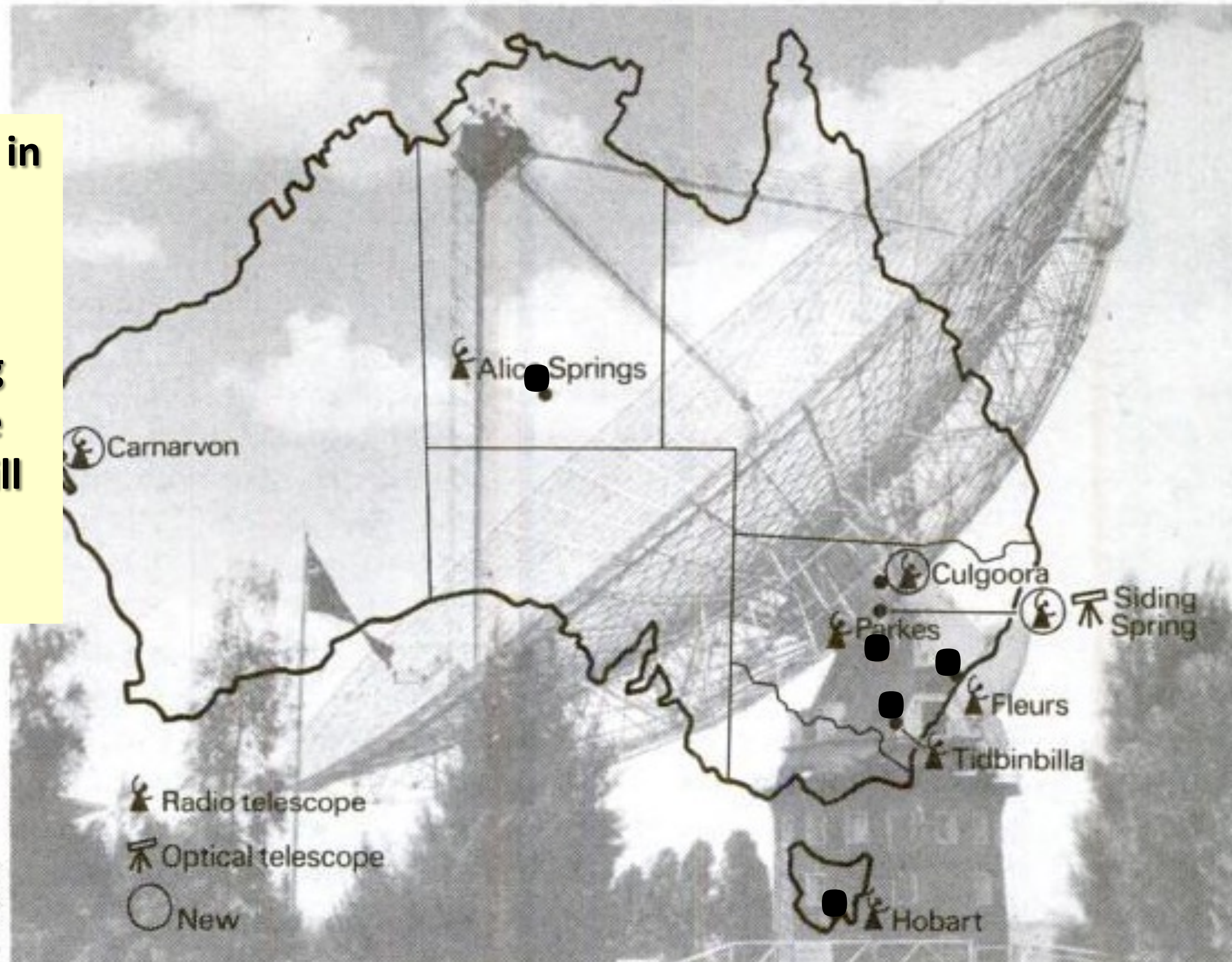
THE FUTURE of astronomy in Australia hangs in the balance and could be decided this week when Malcolm

The future of astronomy in Australia hangs in the balance.....

Australia needs more big radio telescopes, but the Government's budget will decide whether it gets them

(ANU) Mount Stromlo and Siding Spring Observatory, the universities of Sydney, Monash and New South Wales, the Commonwealth Scientific and I Research Organisation's (CSIRC physics Division, and the Angl lian telescope at Siding Spr astronomy has now entered th sive "big science" phase of sp scopes and very large arrays telescopes.

To keep ahead of the field, A astronomers are pinning their two ambitious projects. The f joint American / Canadian / A



CSRIO

Australia needs more big radio telescopes, but the government's budget will decide whether it gets them

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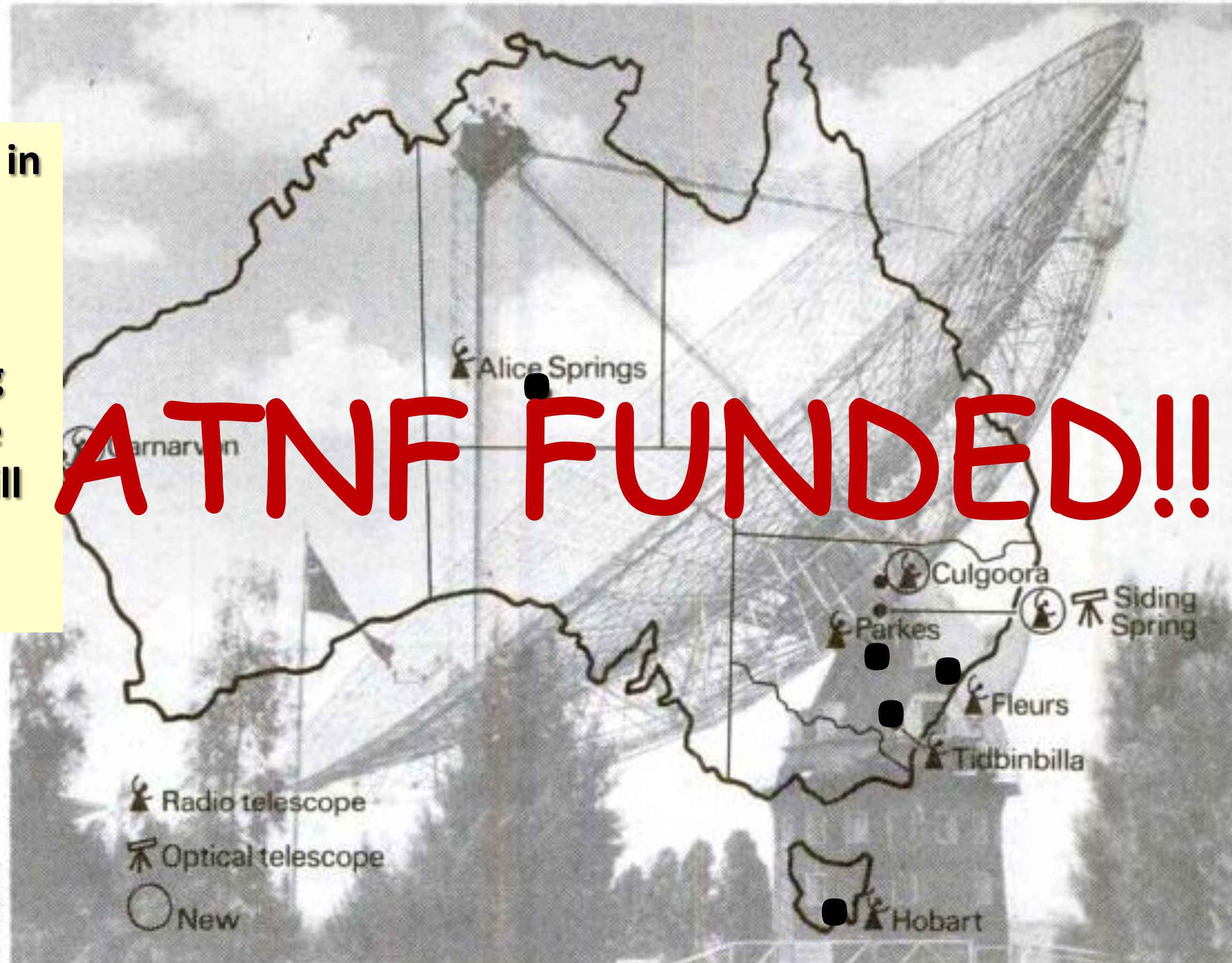


Australia needs more big radio telescopes, but the government's budget will decide whether it gets them

The rich absorption spectrum has a significant effect on the quasar colours. Once this was appreciated optical quasar searches became increasingly successful in finding high redshift quasars. Such multi-colour searches form the basis of the Sloan Deep Sky Survey.

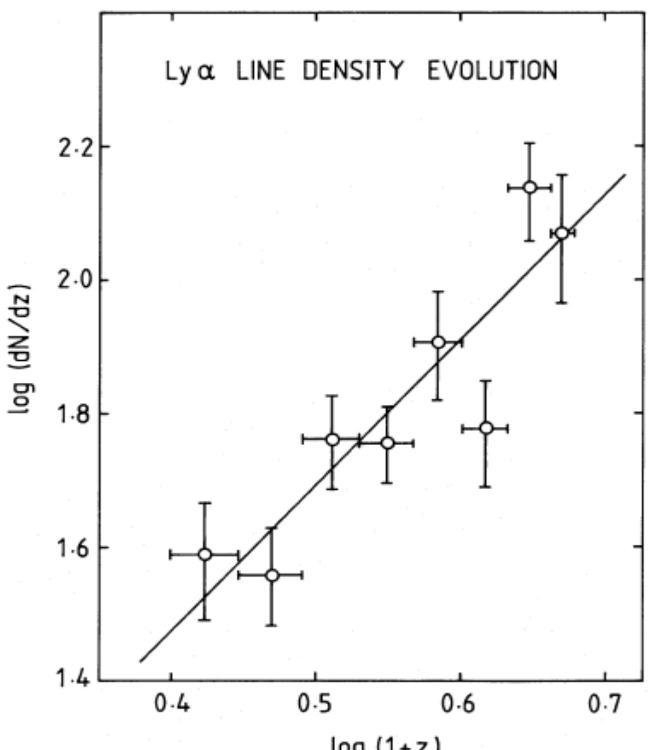
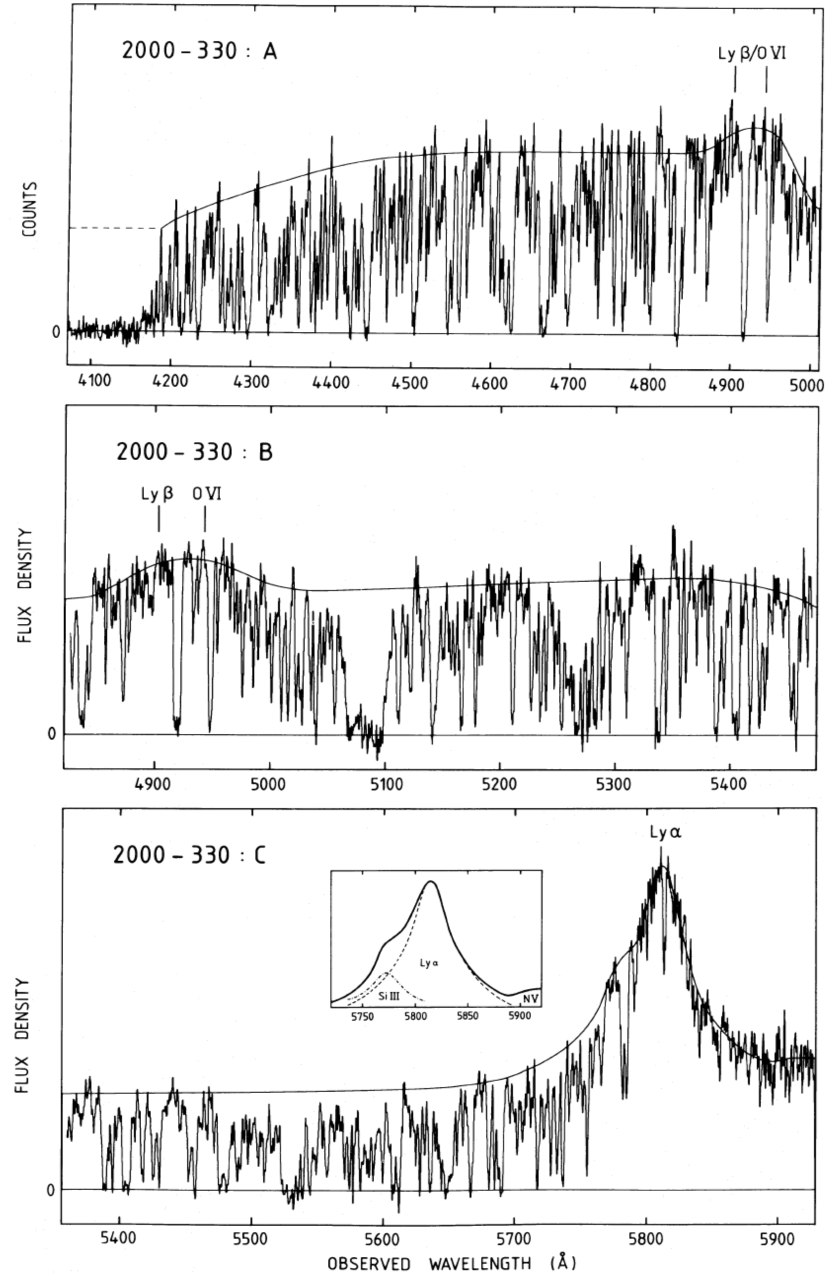


FIG. 1.—log dN/dz plotted as a function of log $(1 + z)$ for our Lyα sample with $W \geq 0.32$ Å. The grouping is solely for the purpose of presentation; the vertical bars are 1 σ errors, and the horizontal bars represent chosen ranges of Δz. The line drawn is the ML fit to the 277 lines of the Lyα sample.



Hunstead et al., ApJ., **305**, 496, 1986

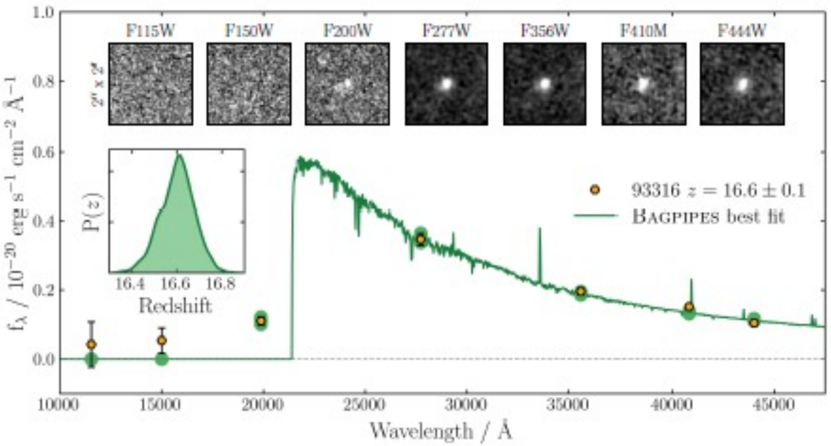


Figure 4. The highest-redshift object in our sample, CEERS 93316. The NIRCam photometric measurements are plotted in the SED plot as golden hexagons, while $2'' \times 2''$ postage-stamp images in each band are shown above the SED. The Bagpipes model we fit in Section 6.2 is shown in green. The posterior distribution for redshift is shown in the inset panel, which is centred on $z = 16.6$, but is fully consistent with the value of $z = 16.7$ quoted in Table 5 from Eazy. The fortuitous positioning of the F200W and F277W bands relative to the Lyman break allows such a precise redshift estimate. The rest-frame near-UV slope, $\beta = -2.2 \pm 0.1$ indicates no evidence for an unusual (i.e. Population III dominated) stellar population. The galaxy has a stellar mass of $\log_{10}(M_*/M_\odot) = 9.0 \pm 0.4$.

The highest redshift object in the sample is CHEERS 93316. The distinctive "break" at ~ 21,500 A implies a redshift of 16.7, as due to the Lyman forest.

MNRAS **000**, 1–12 (2022) Preprint 26 July 2022 Compiled using MNRAS LaTeX style file v3.0

The evolution of the galaxy UV luminosity function at redshifts $z \simeq 8 - 15$ from deep JWST and ground-based near-infrared imaging

C. T. Donnan[1★], D. J. McLeod[1], J. S. Dunlop[1], R. J. McLure[1], A. C. Carnall[1], R. Begley[1], F. Cullen[1]
M. L. Hamadouche[1], R. A. A. Bowler[2], H. J. McCracken[3], B. Milvang-Jensen[4,5], A. Moneti[3] & T. Targett[6]

[1]*Institute for Astronomy, University of Edinburgh, Royal Observatory, Edinburgh, EH9 3HJ, UK*
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[3]*Institut d'Astrophysique de Paris, UMR 7095, CNRS, and Sorbonne Université, 98 bis boulevard Arago, 75014 Paris, France*
[4]*Cosmic Dawn Center (DAWN)*
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Accepted XXX. Received YYY; in original form ZZZ