The Intellectual and Technical Ancestry of Miller’s Early Career

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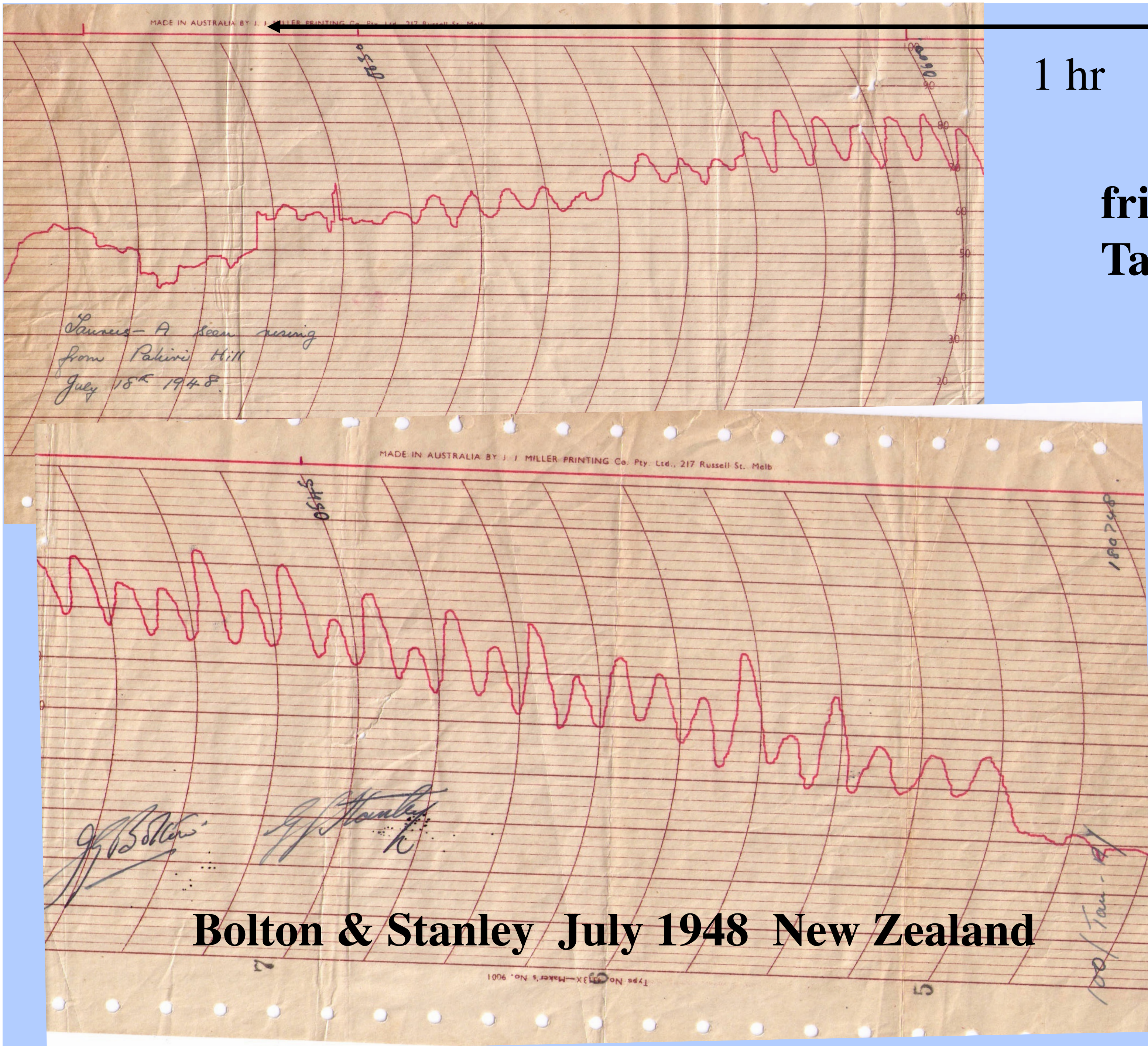
Millerfest, Durango 19 May 2011

Miller has gotten the history bug

1 hr

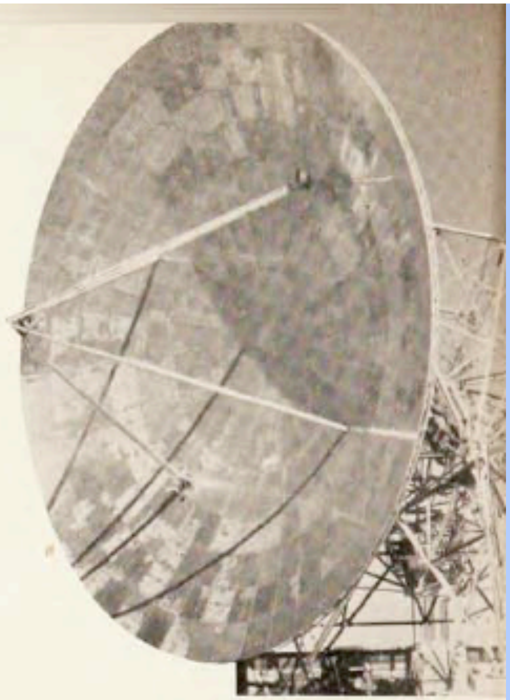
fringes for Taurus A



Bolton & Stanley July 1948 New Zealand

Sept. 1960 *Physics Today* (Miller age 19)

ASTRONOMERS *in TURMOIL*



By Otto Struve

THE great upheaval in science, which began with chemistry and physics a quarter of a century ago, has recently penetrated the field of astronomy and caused a state of turbulence, uncertainty, and chaotic expansion unknown in the history of mankind. On October 4, 1957, the first Russian sputnik was thrust into an orbit around the earth and the words "exploration of space" replaced the ancient word astronomy.

The explosion which we are witnessing today is mainly due to the sudden recognition by our people of the importance of what the popular writers call the conquest of space. It is characterized by the creation of large research centers such as those controlled by the National Aeronautics and Space Administration and the National Science Foundation and by government spending of very large sums of money for the support of research and training of personnel. This expansion in terms of large and expensive research tools cannot by itself generate a corresponding expansion in terms of ideas. But I believe that we are in fact living in a period of vigorous, though much more

pansions produce an impressive flow of new knowledge. But will a future historian be able to apply to our era what C. P. Haskins has recently said about the age of Newton: "Surely there has never been a greater period in the history of science than that of Newton. The time of his most important work, the mid-seventeenth century, has perhaps never been surpassed in the sheer brilliance and variety of its intellectual and cultural contributions. These were the years of the founding of the Royal Society and the French Academy, and of the works of a host of brilliant innovators in fields ranging from science through literature and all the arts." *? Or will he be more impressed by the purely technical side of mid-twentieth century science, by the team work of many competent but not especially brilliant scientists, by the evident confusion of ideas, by the competitive aspects of our research and its political overtones?

Let us consider some of the effects of this rapid transformation.

The Number of Astronomers Is Inadequate

(Miller was actually alive when cars were like this!)

Otto Struve in 1955

(1st NRAO Director, 1959)

Miller's world-line in a nutshell

1941 - North Carolina
1963 - Davidson College & Harvard
1967 - PhD, U. California, Berkeley
1967 - Radiophysics, Sydney
1970 - MPI Radioastronomie, Bonn (via sailboat *Cygnus A*)
1972 - Kapteyn Lab, Groningen

1974 - back to Sydney
1977 - back to Groningen

1986 - NRAO, Socorro (VLA)
2011 - Durango

OH ABSORPTION IN THE GALAXY*

W. MILLER GOSS†
Radio Astronomy Laboratory, University of California, Berkeley
Received April 26, 1967

ABSTRACT

A survey of northern hemisphere radio sources for 18-cm OH absorption has been completed using the 85-foot Hat Creek telescope of the University of California. The observations were made with the 100-channel receiver with frequency resolutions of 10 kHz (1.8 km/s) and 2 kHz (0.36 km/s).

Galactic OH absorption lines have been found in 26 galactic sources and two extragalactic sources (W7 and Cyg A): W1 (NGC 7822), W9 (Tau A), W10 (Orion A), W12 (NGC 2024), W14 (IC 443), W22 (NGC 6357), W28, W29 (M8), W30, W31, W33, W35 (NGC 6604), W37 (M16), W38 (M17), W41, W42, W43, W44, W47, W66, W67, W69, W72, W73, W80 (NGC 7000), and W81 (Cas A). Four of these

* Based on a thesis submitted to the University of California, Berkeley, in partial fulfilment of the requirements for the Ph.D. degree.

† Now at C.S.I.R.O. Radiophysics, Sydney, Australia.

Harold Weaver

1948

Hat Creek
85-ft

1962

Parkes 210-ft dish   1961

Frank Kerr
at the controls

URSI Sydney 1952

MPI f RA - Effelsberg 100-m dish (1972)

homologous deformation

Westerbork Synthesis Radio Telescope

1970 (10 + 2) 25-m dishes

Key early projects & collaborators & mentors

1967 - *Rev. Mod. Phys.* on "R.A. & ISM" (Dieter)

1967 - OH absorption survey (thesis, advisor: Weaver)

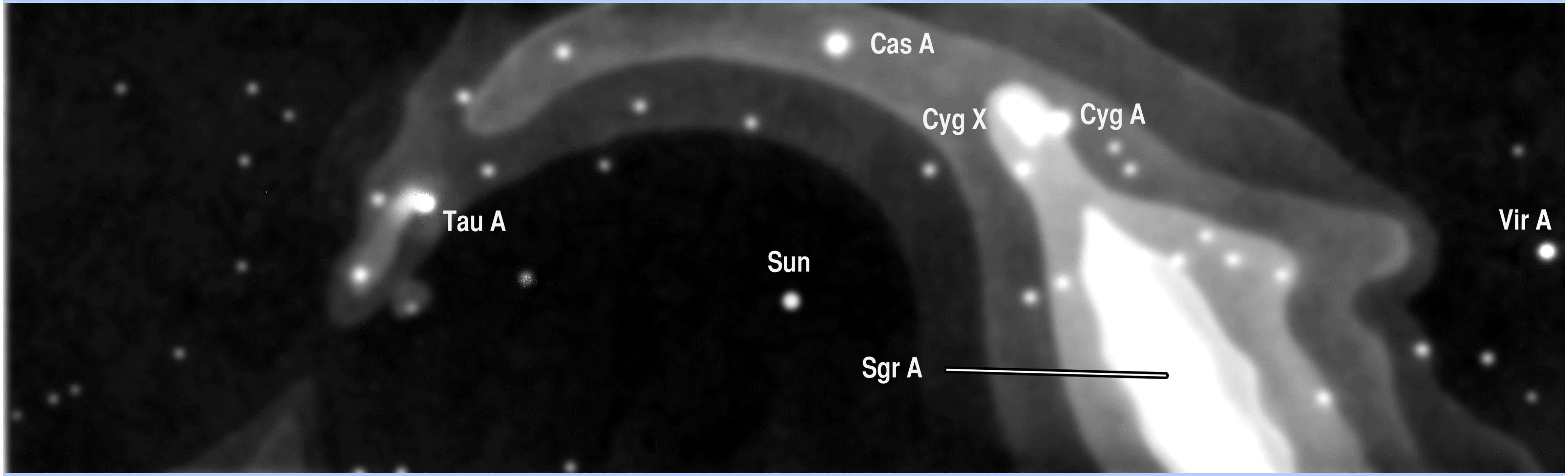
1970 - 408 & 5000 MHz galactic plane survey (Shaver)
- the 2 N. Americans help peace to be made between Mills (U. Sydney) and Radiophysics (Robinson)

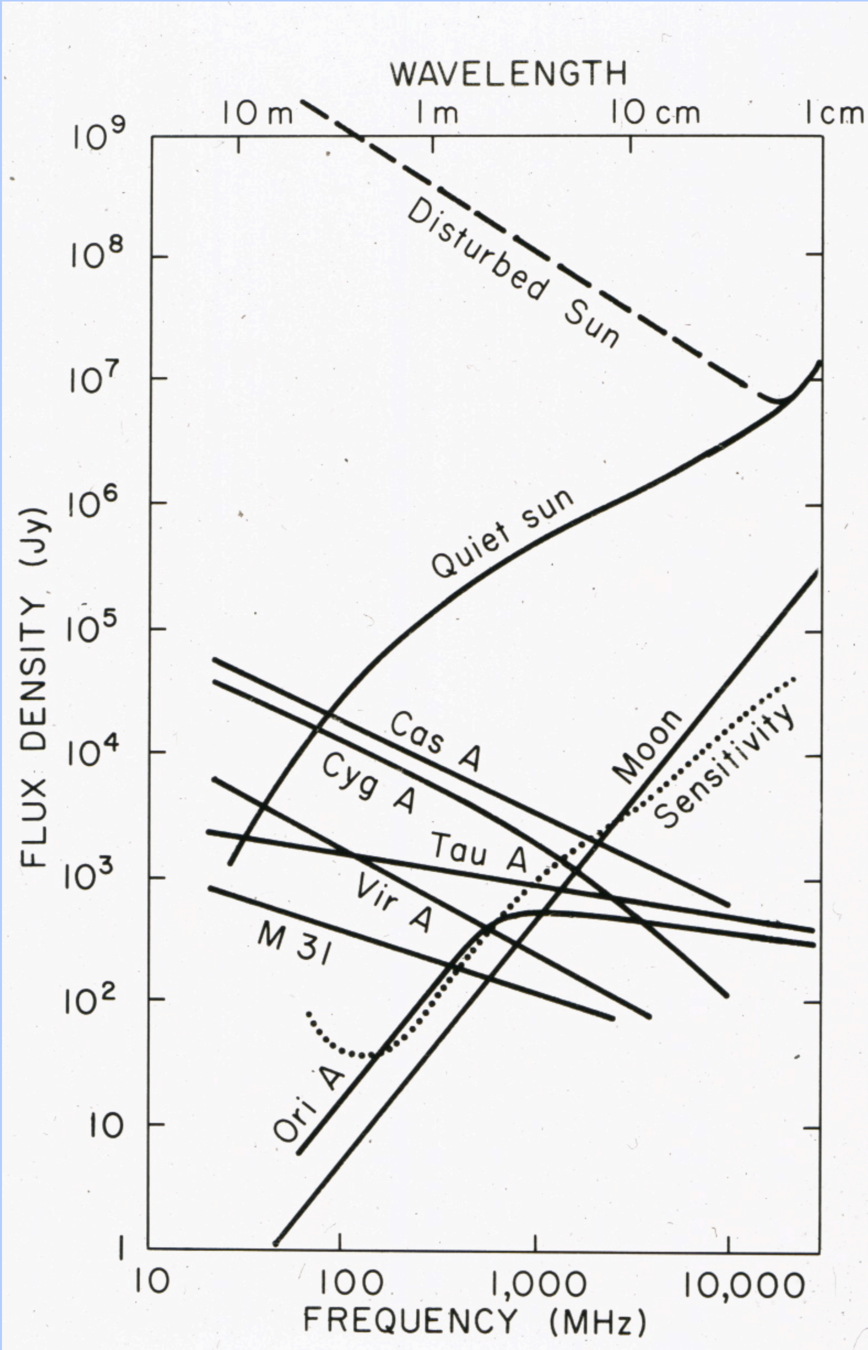
1970 - OH galactic plane survey (Robinson & Manchester)

1972 - Parkes H I interferometer (Radhakrishnan, Murray Brooks, Schwarz) [interf. had been used by Ekers]

- Christiansen & Frater also mentors for interf.)

The sky as viewed by *Homo radio*





- below 100 MHz, the sun is *not* the strongest source!

- at higher frequencies, most sources get weaker AND receiver sensitivity is much worse

Major historical themes and conclusions

#1 - first observers had **trouble establishing their legitimacy**, but eventually were accepted as radio *astronomers* using radio *telescopes*, researchers who inadvertently invented "optical astronomy"

- radio astronomy turned out historically to be **only the first stage of the opening of the electromagnetic spectrum** - X-ray, IR, UV, and gamma ray windows all followed on and were much more easily incorporated into astronomy because of the path that radio astronomy had already blazed

- overall, I call this opening of the entire electromagnetic spectrum **the 20th century's "New Astronomy"**, no less important than earlier New Astronomies of Galileo, Herschel, and the astrophysicists of the late 19th century, all triggered by new technologies

Other themes and conclusions

#2 - radio astronomers **did not create a new discipline**, but (slowly) merged into (traditional) astronomy

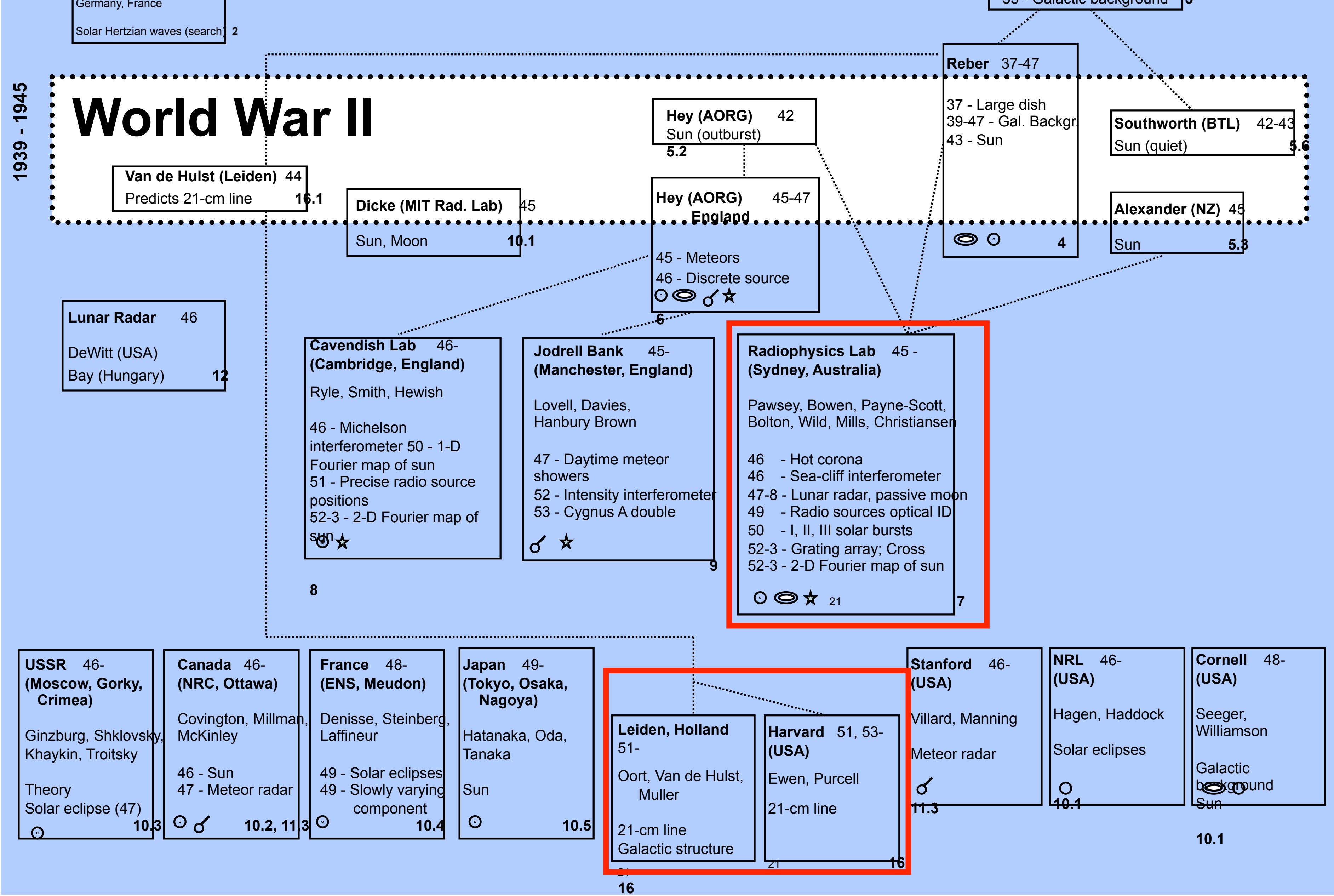
- they ironically sought to be part of **a visual culture** through

(a) striving to make radio images
(b) searching for optical identifications
(c) joining (visual) astronomy

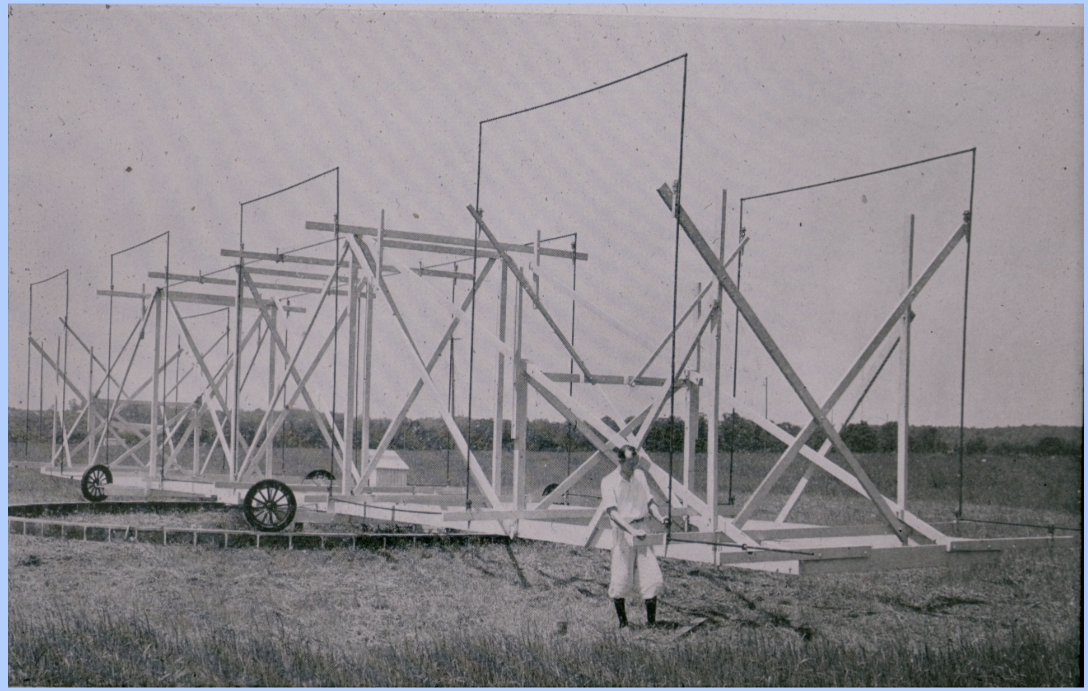
#3 - Radio astronomy was **"Technoscience"** - impossible to say whether science led technology or vice versa

#4 - early radio astronomy was **shaped by World War II and by the Cold War**

Early Radio Astronomy



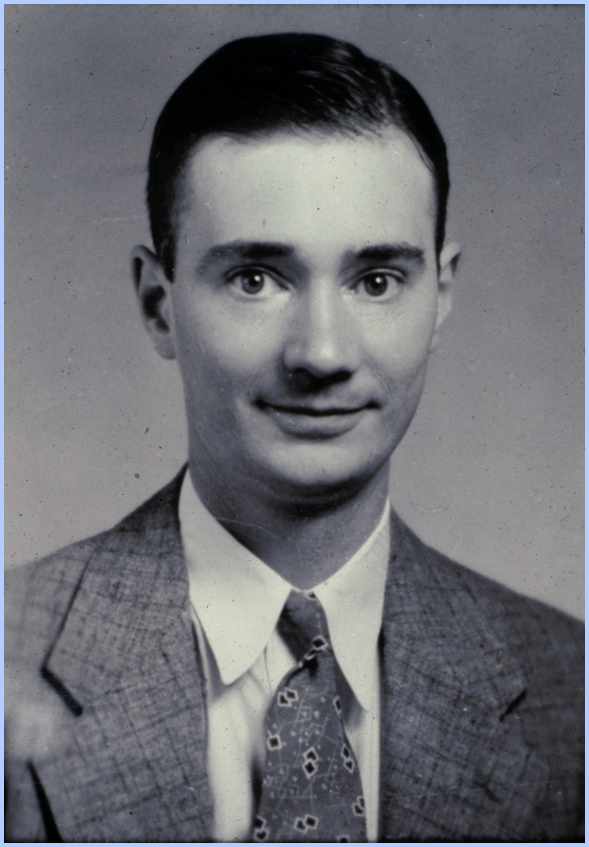
Karl Jansky 1932-35



Bruce array

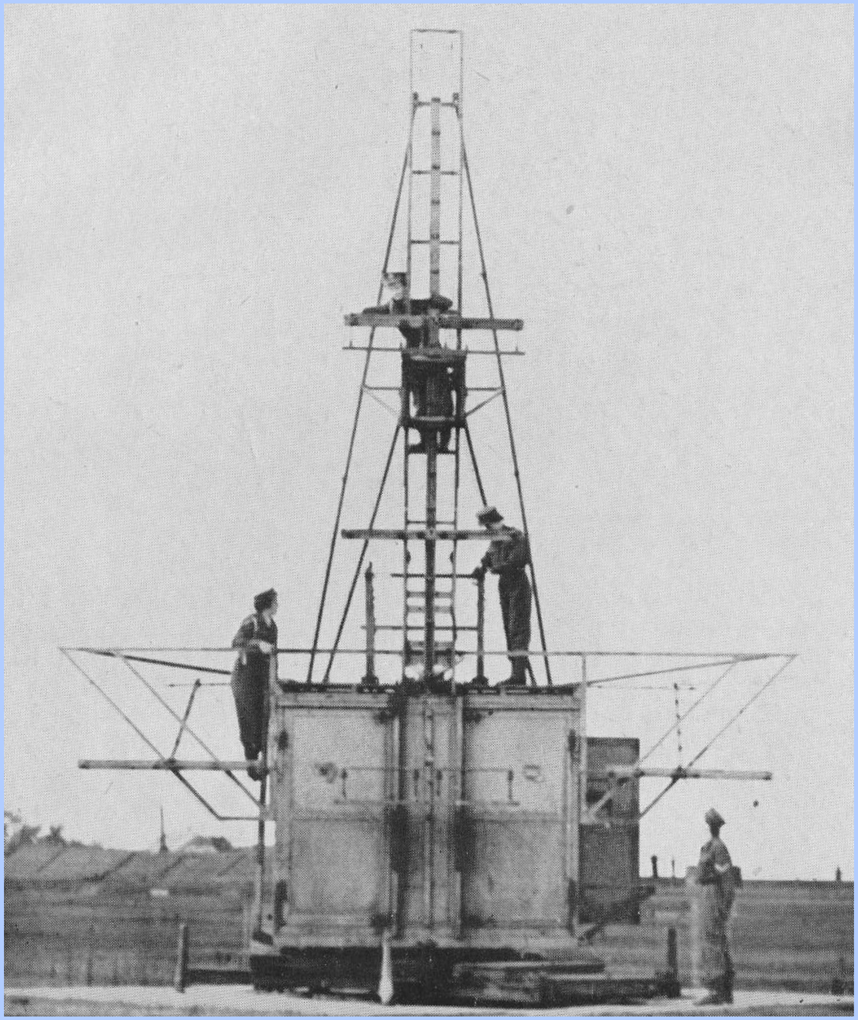
Grote Reber 1937-47

in his backyard, Wheaton, Illinois, USA



31-ft diam.
(8-meter)
paraboloid
“dish”

Detection of the Radio Sun - 1942

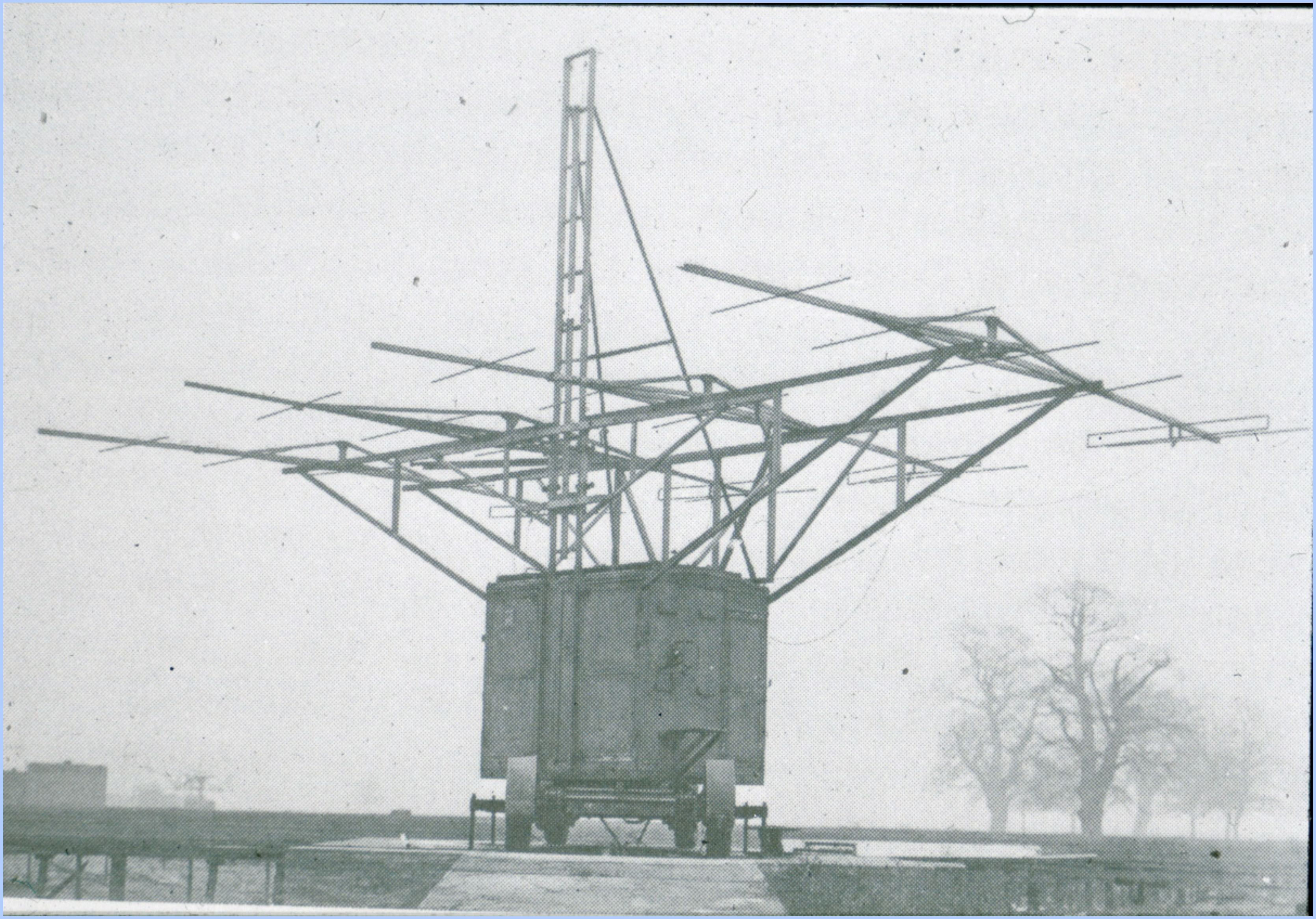


Army G.L. (Gun Laying) Mark II radar

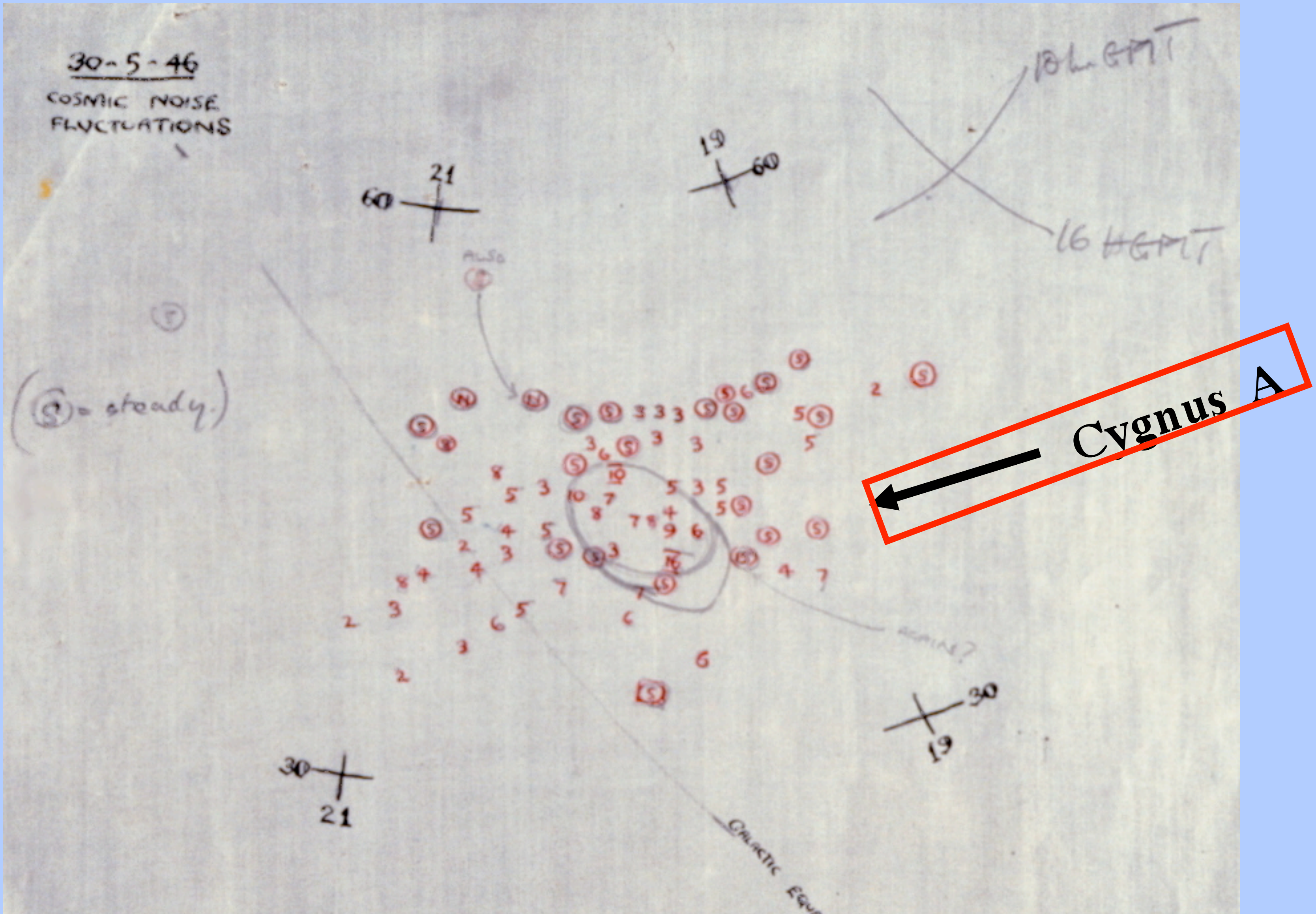
John Stanley Hey

Hey's AORG team 1945-48

64 MHz (5 m) in Richmond Park, London



"Cosmic noise fluctuations 30 May 1946"



Worksheet of John Phillips

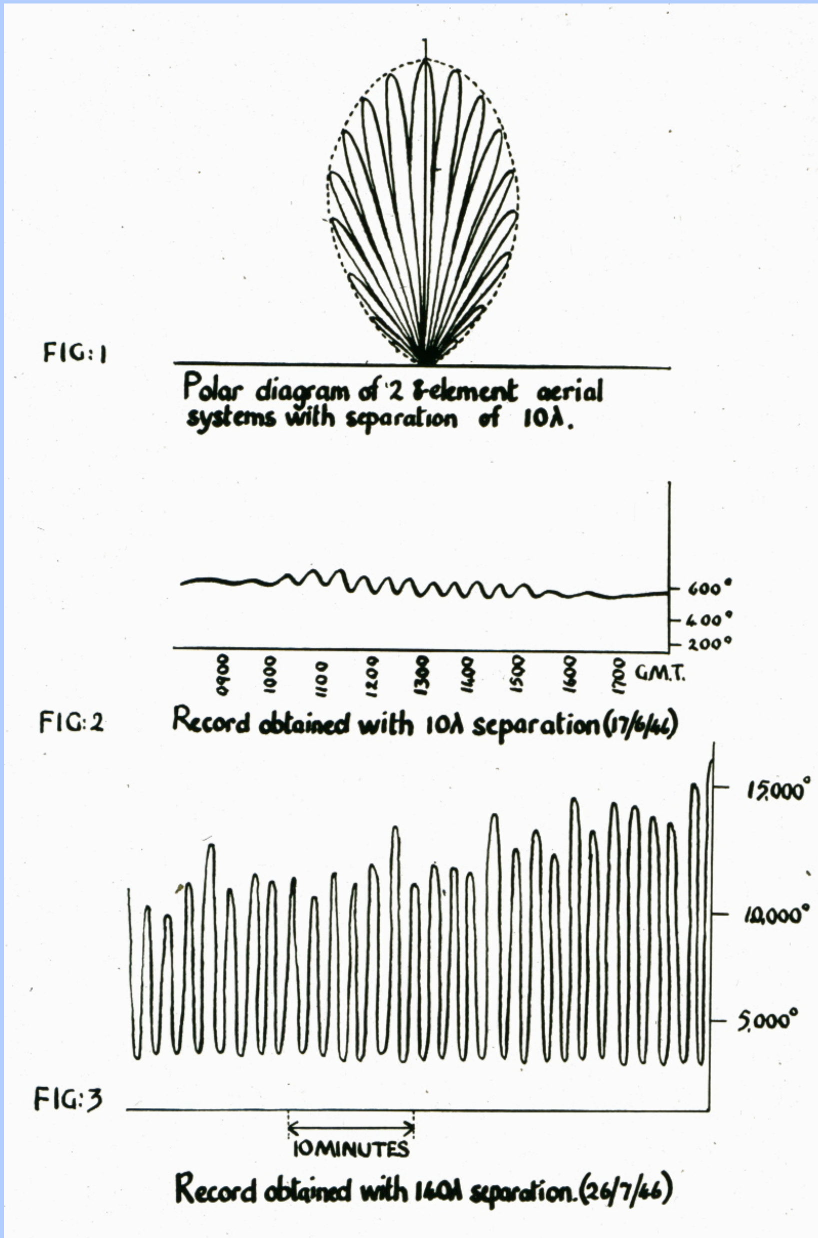
Meteor radar work
Jodrell Bank 1946 to ~1960

Bernard Lovell's group
1952

The "searchlight aerial",
a steerable Yagi array

Martin Ryle at the Telecommunications Research Establishment 1939-45

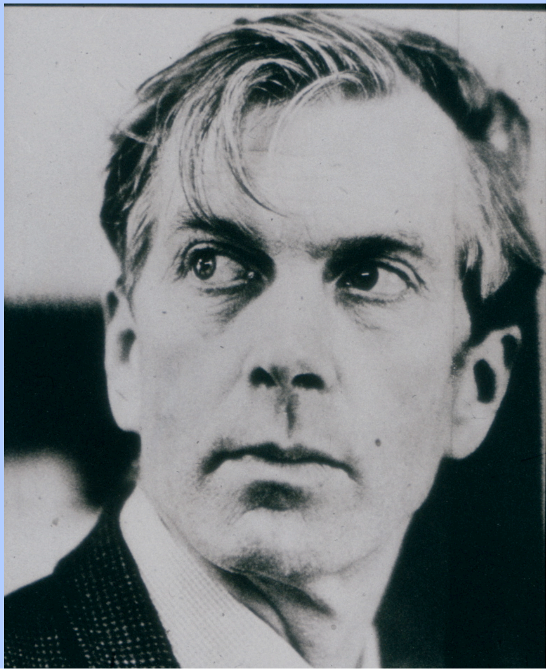
Michelson Interferometer



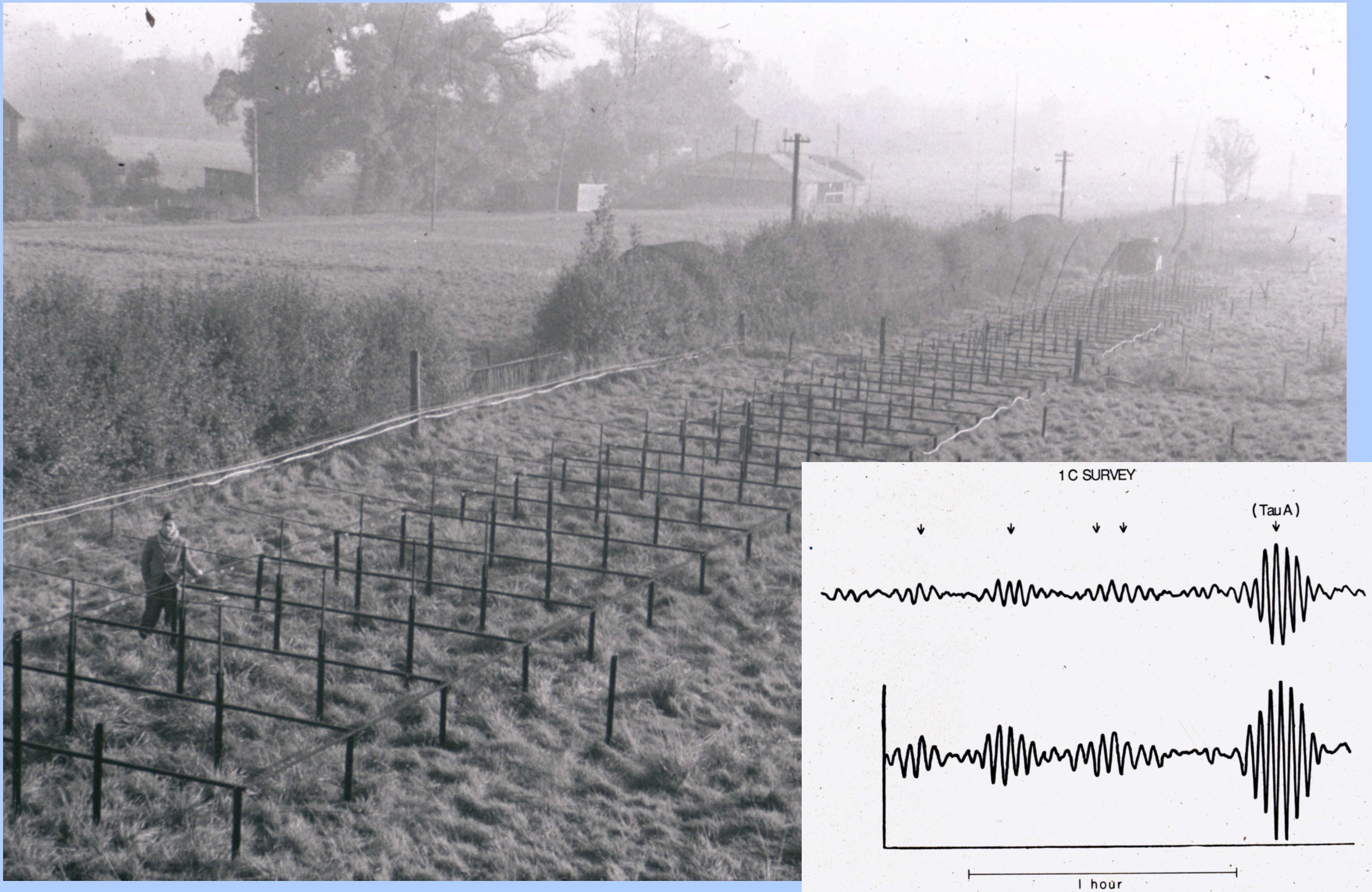
1946 *Nature*

Sun with 10λ separation
($\lambda = 1.5$ m)

Sun with
140λ separation

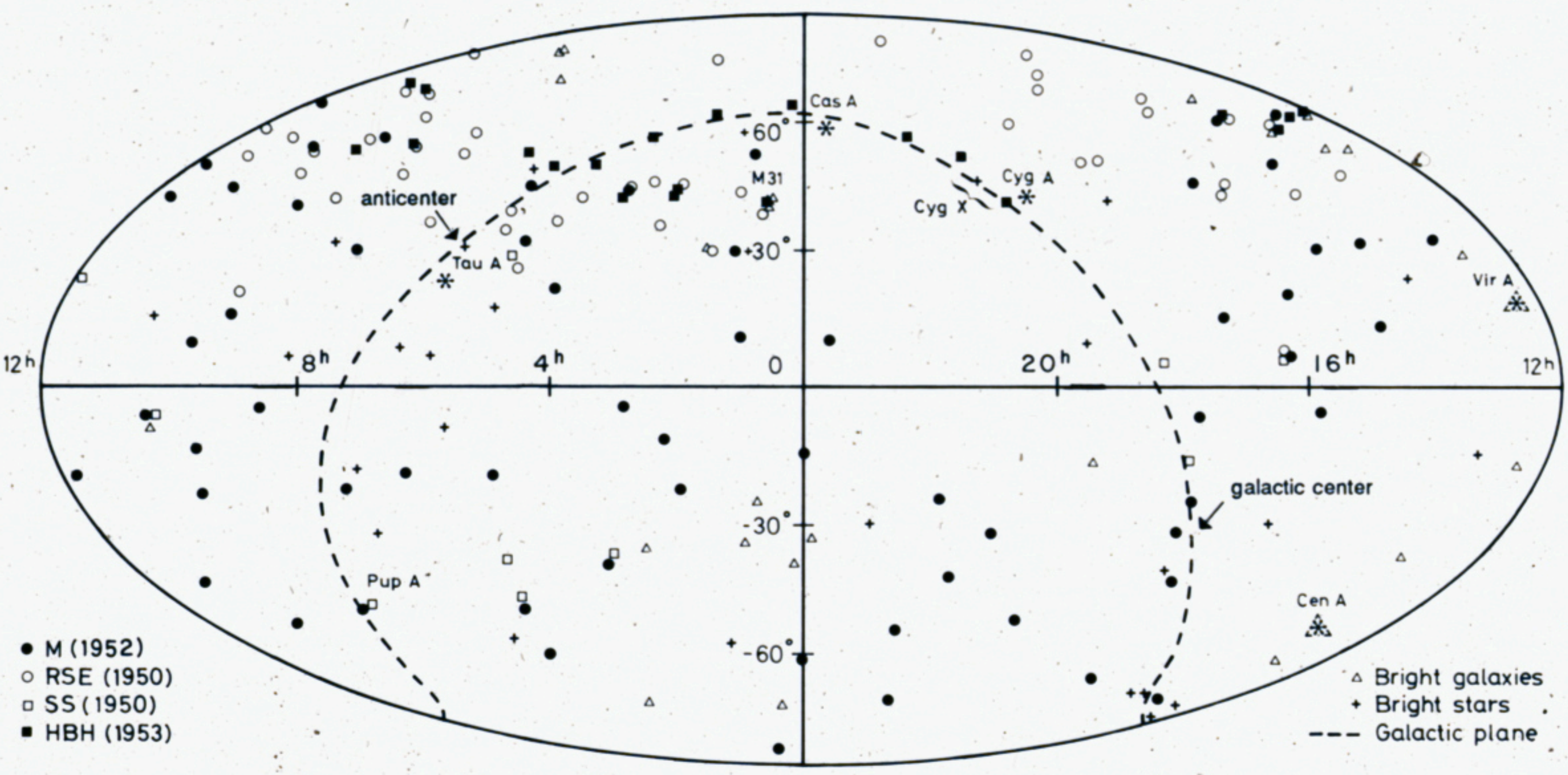


The "Long Michelson" 1C survey of 50 radio stars (1950)
81 MHz

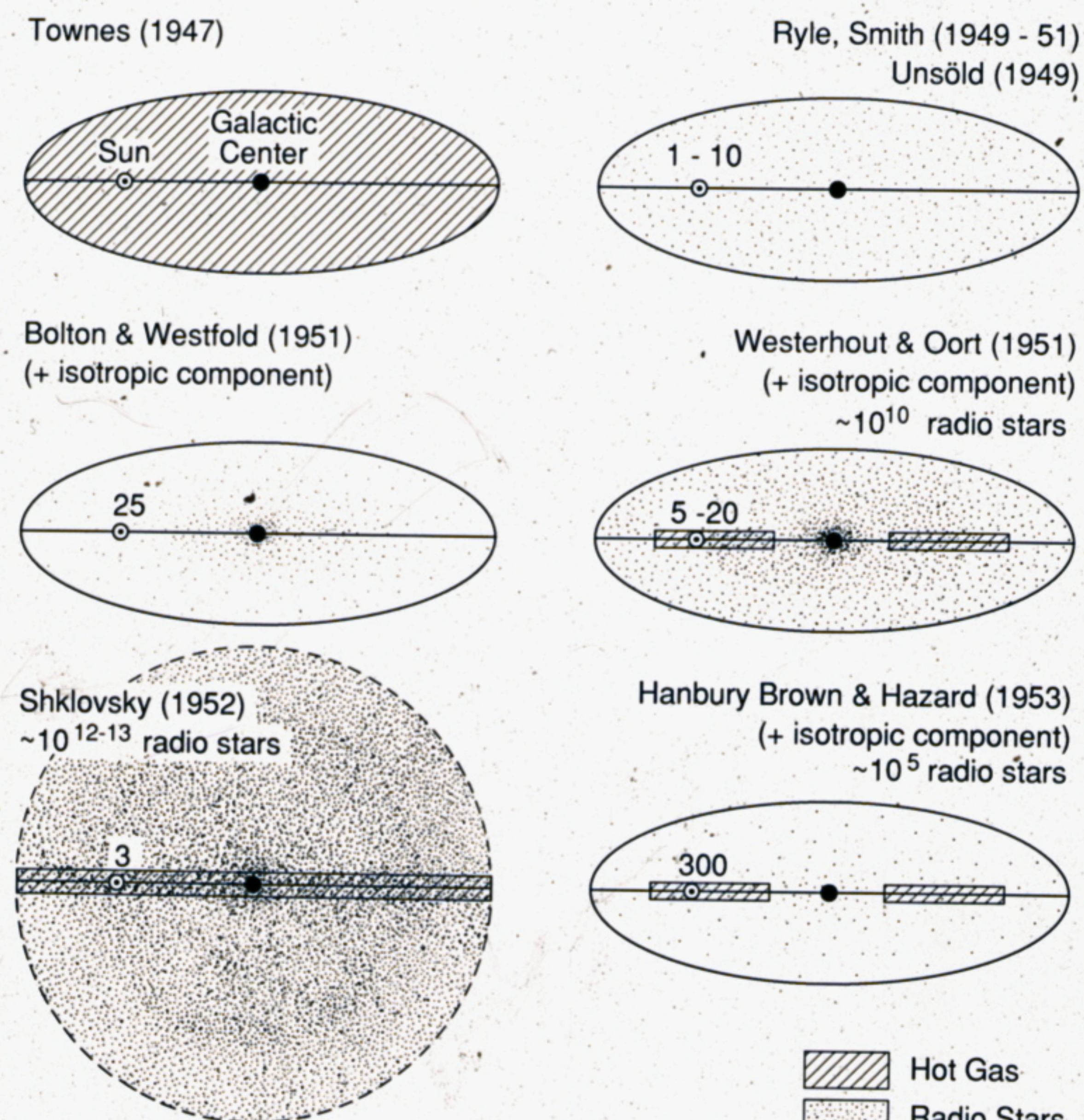


Ryle's group - 1954

EARLY RADIO STAR SURVEYS



EARLY GALACTIC NOISE MODELS



Pause: The introduction of terminology can provide insight….


«радиоастрономии»

"radioastronomy"

- Ginzburg (1947), a review in *Uspekhi Fizicheskikh Nauk*

"The above....observations and analysis reveal great astrophysical, geophysical and radio-technical interest in '**radio astronomy**' or 'radio astrophysics,' which we could call this new discipline."

<u>1948</u>

- Pawsey in a letter; then Ryle in a talk to the RAS followed by a short published review (Ryle also consulted his father about mixing up Latin and Greek derivatives)

- IAU sets up Commission 40 on "Radio Astronomy"

The adjective “astronomical” did *not* apply to radio matters:

“The ability to carry on one's observational research nearly independently of conditions of weather or of daylight appears peculiarly *unastronomical*.”

- Daniel Popper, 1952

“Detailed comparison of the radio observations with the *astronomical* data.”
[title of a section by Robert Hanbury Brown and Cyril Hazard (1952)]

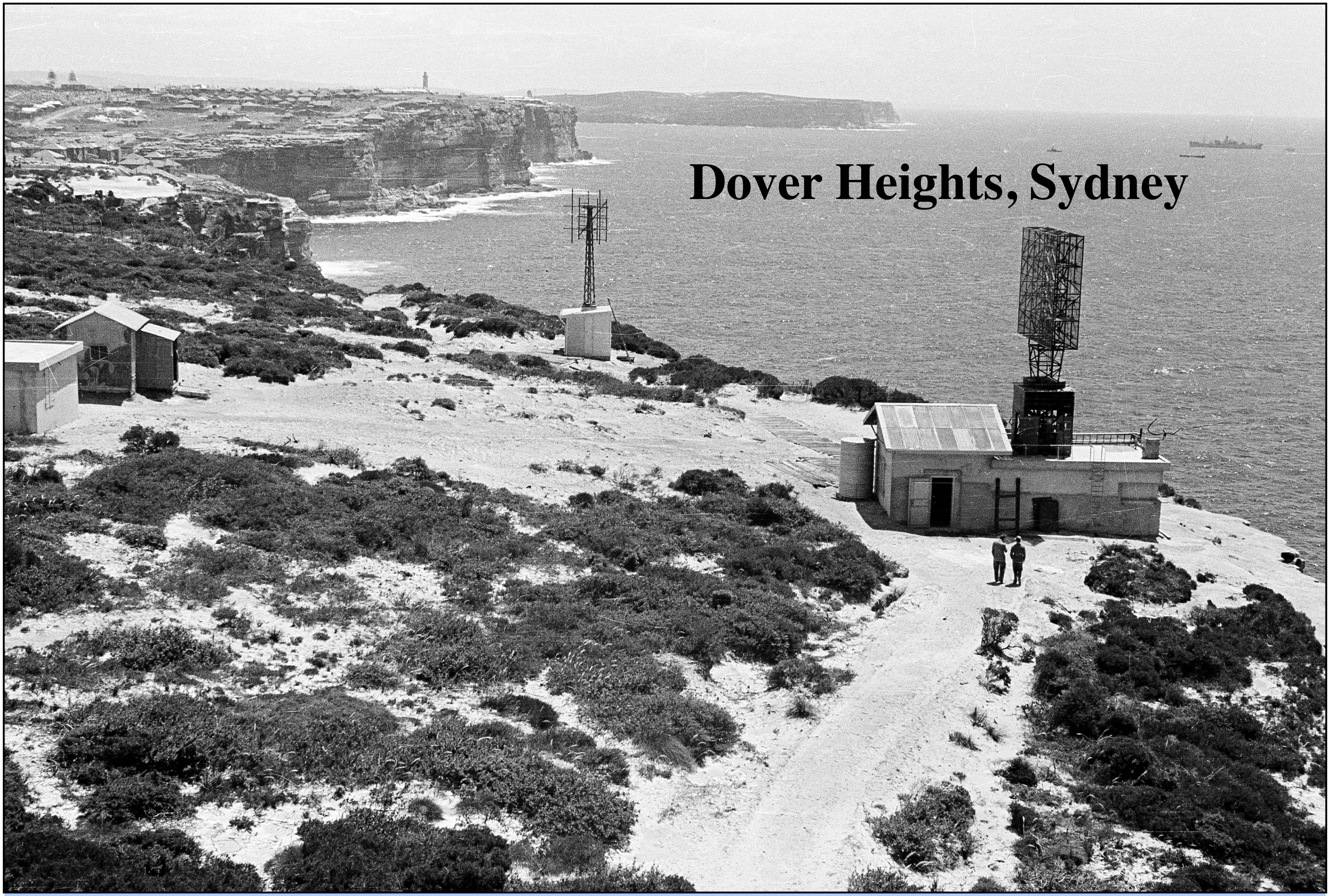
Terminology reveals two groups of unequal status

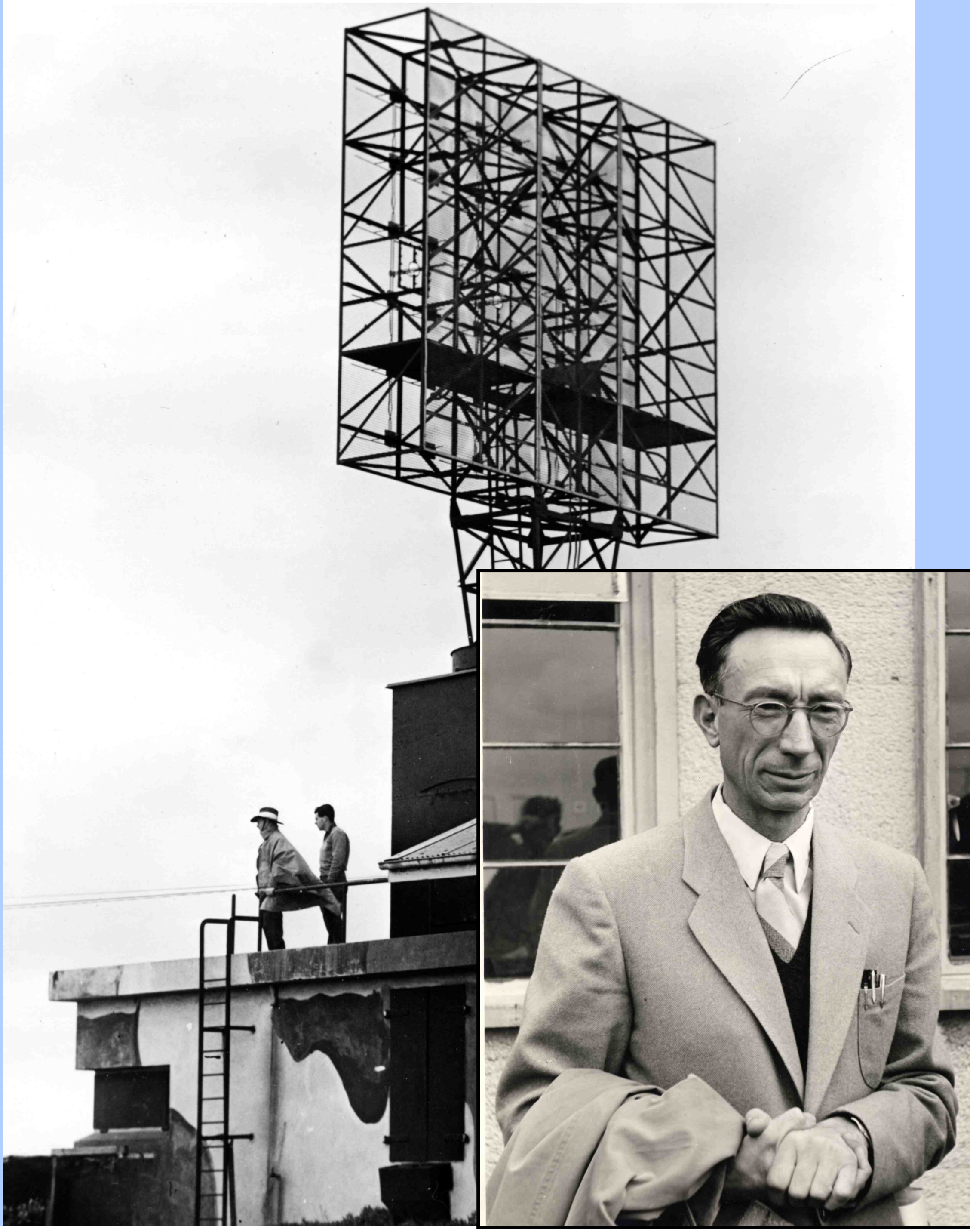
"radio engineers, radio physicists, radio-observing personnel, radio men, radio workers, radio technicians, electronic technicians, radio specialists, 'blind' astronomers, radio astronomers"

[the *blind* astronomers also did their *blind* astronomy using a *blind* telescope! (*New York Times*, 1952)]

Versus

"astronomers" or "astrophysicists," with rare qualifications such as "astronomers of the classical type, visual or photographic astronomers, astronomers in the traditional sense, general astronomers"


Dover Heights, Sydney



Typical air-warning radar in Sydney region (Dover Heights in 1941)

36 200-MHz dipoles

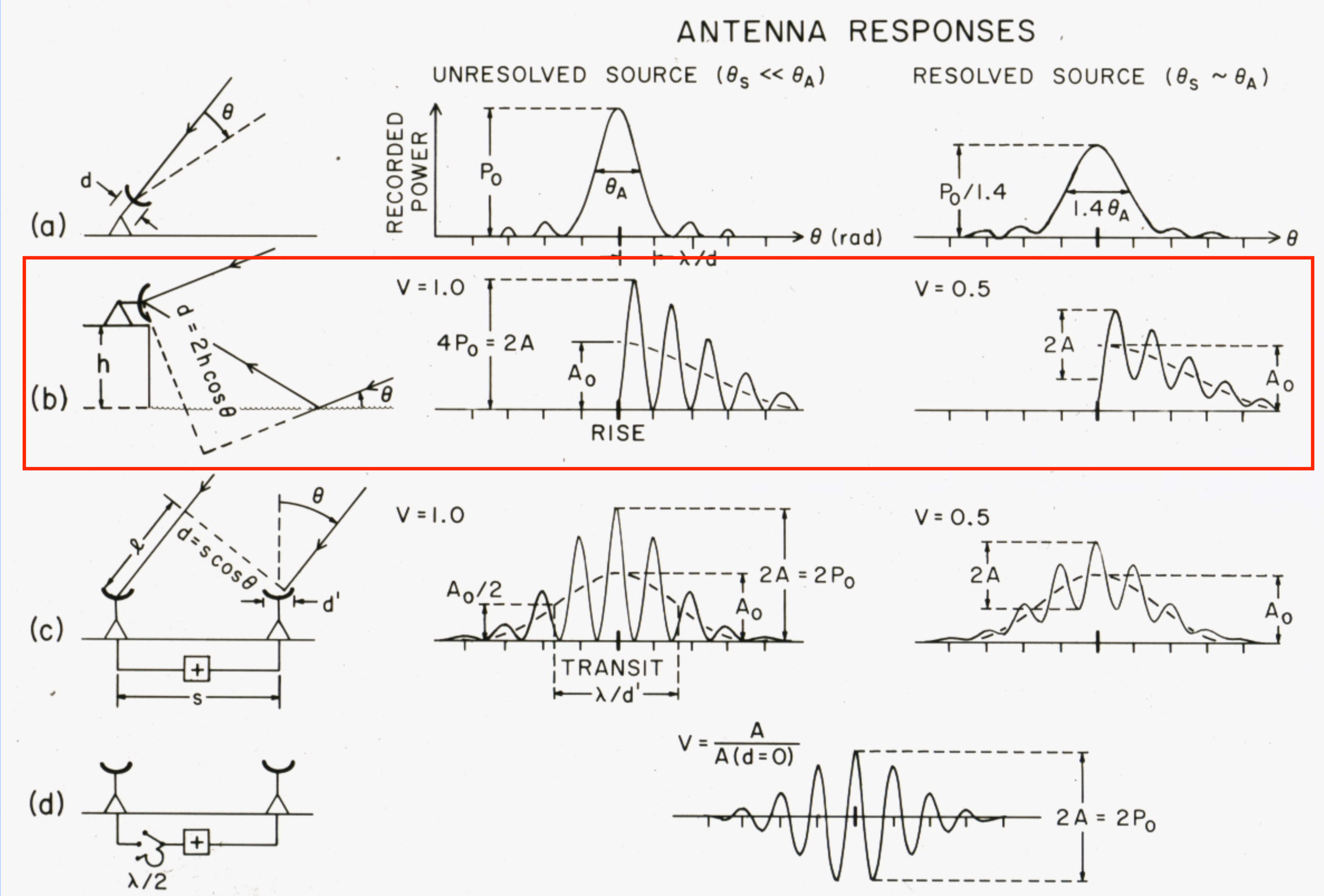
- first solar observations of rising sun (1945-6)

- Lloyd's Mirror effect, or sea cliff interferometer

Joe Pawsey (d. 1962)

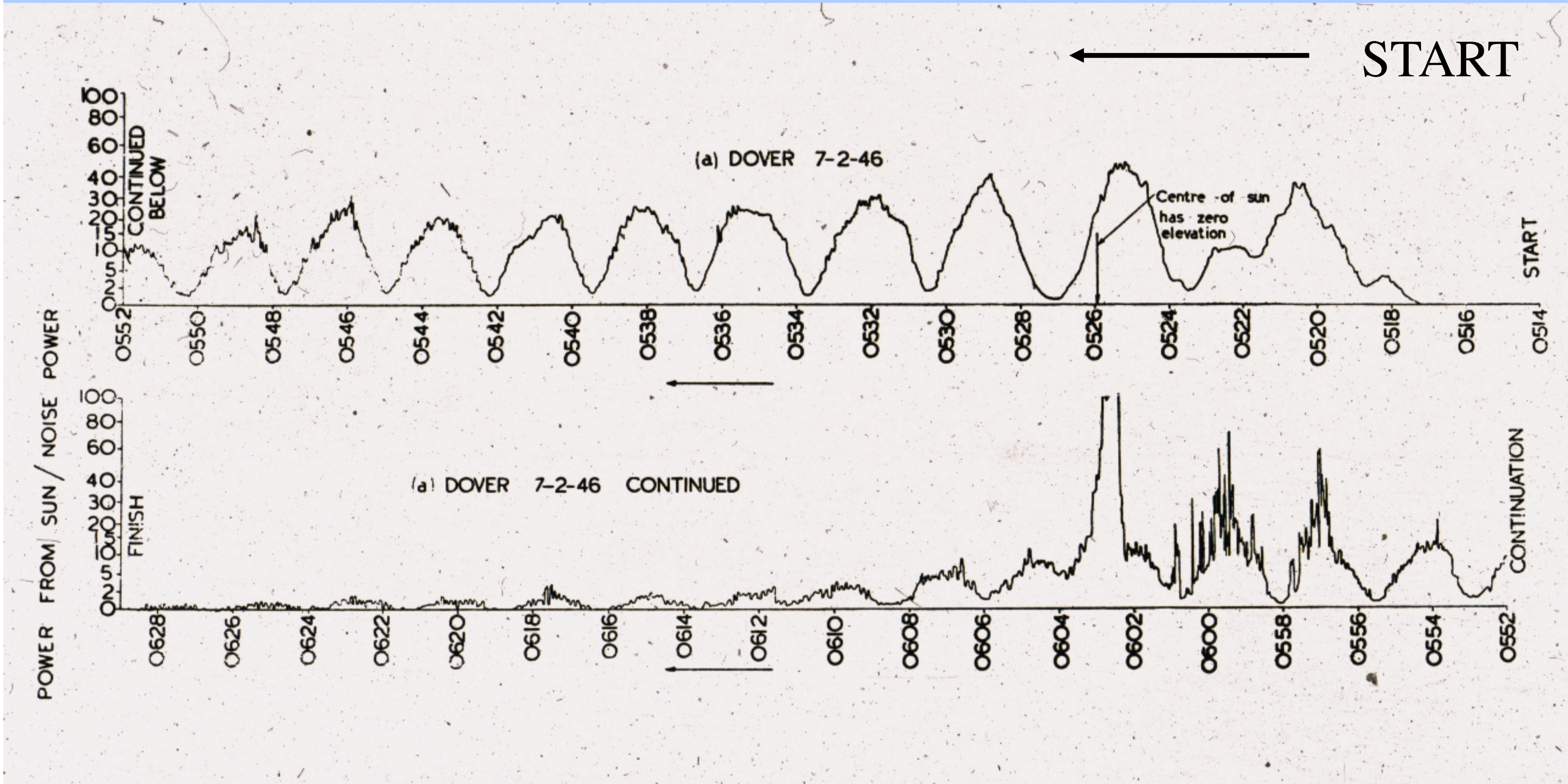
(Miller received the Pawsey Medal in 1976)

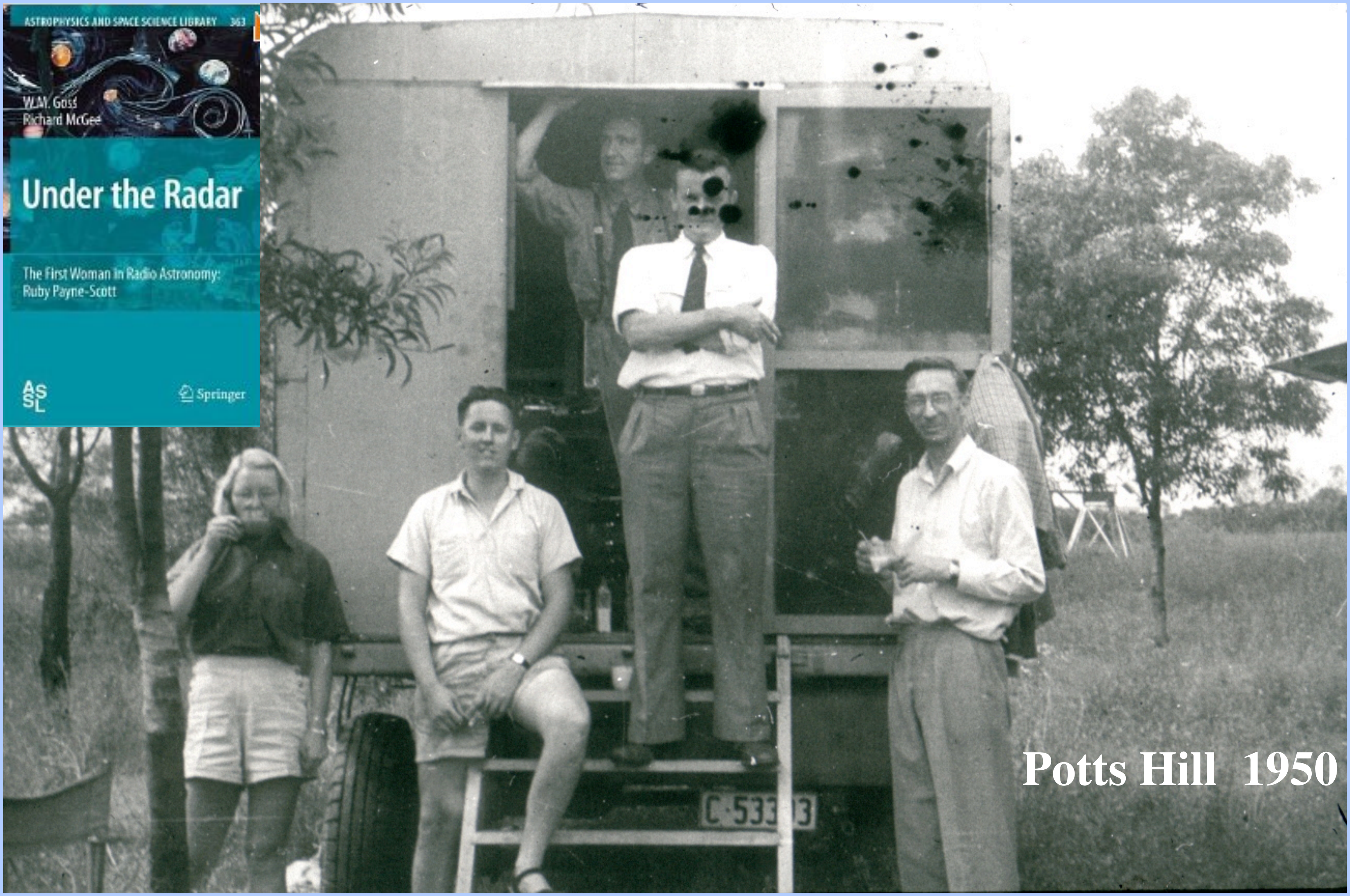
Sea cliff interferometer (Lloyd's mirror)



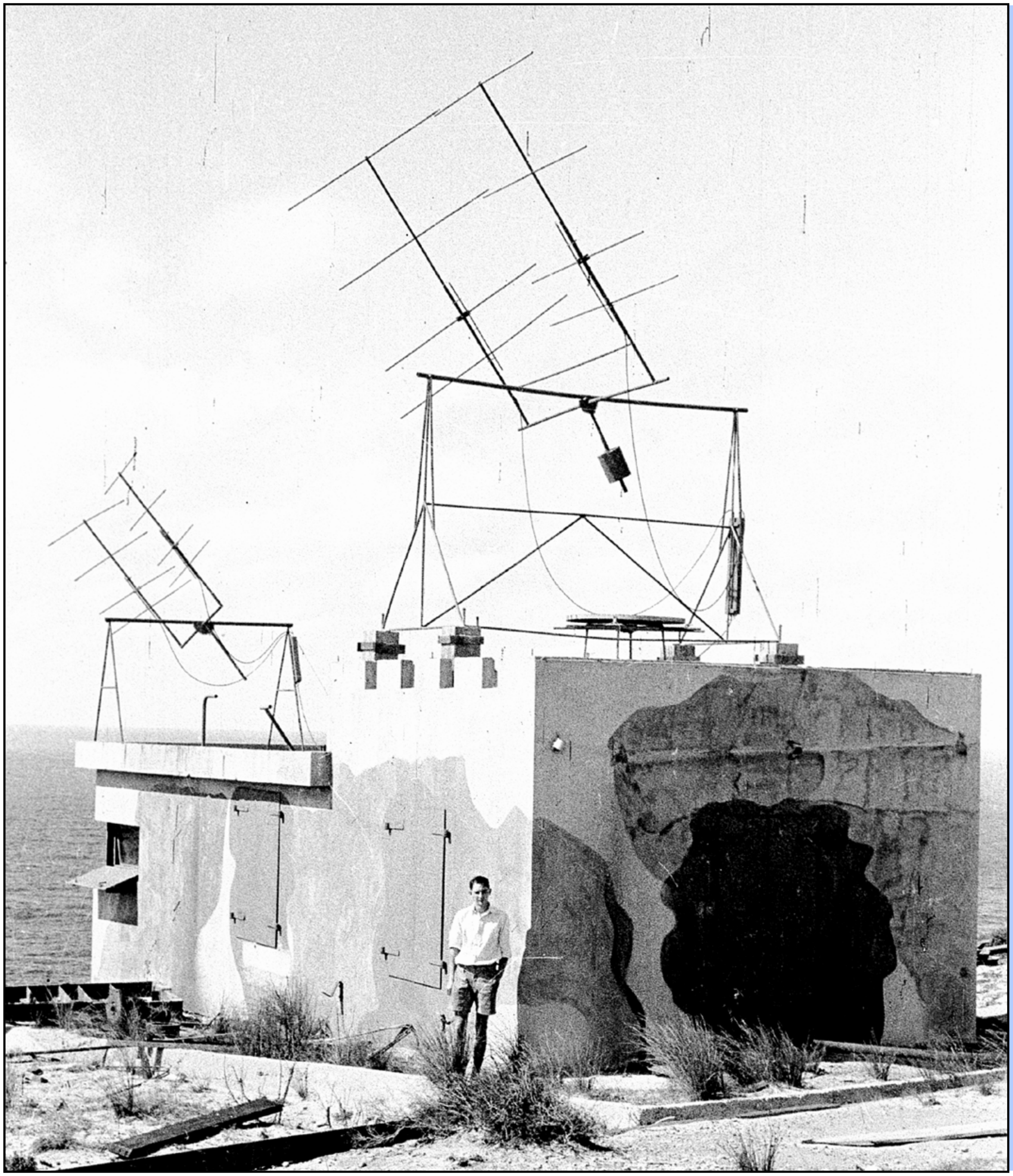
Sunrise on 7 Feb 1946
Pawsey, McCready & Payne-Scott (1947)

they stated the principle: image = FT (fringe visibility)





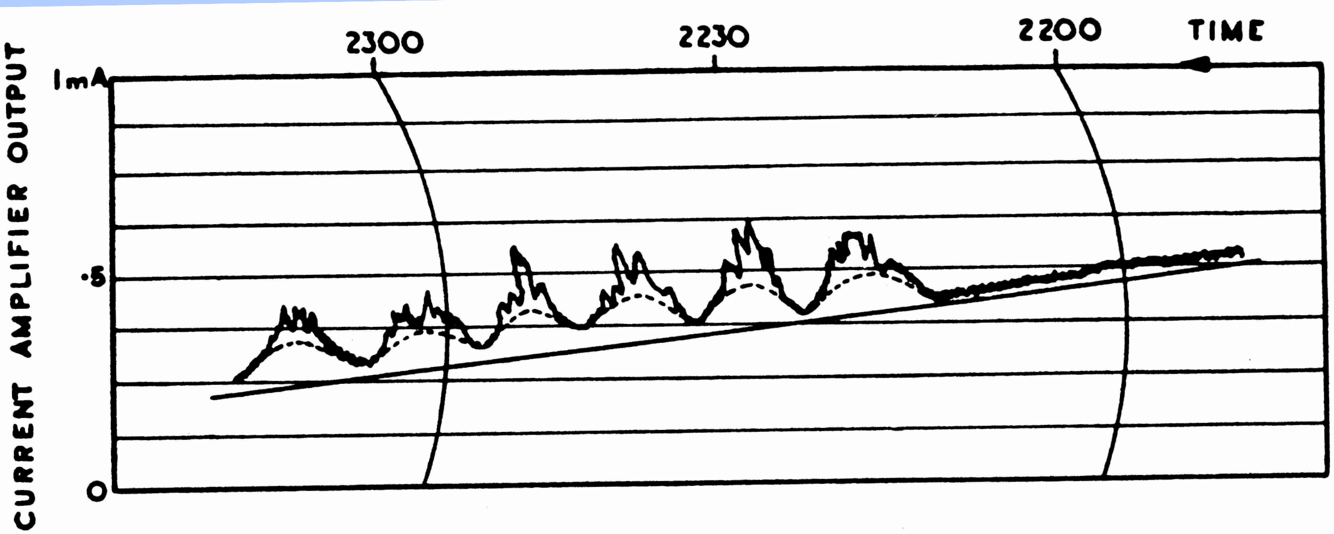
Ruby Payne-Scott Alec Little Joe Pawsey



Yagi aerials

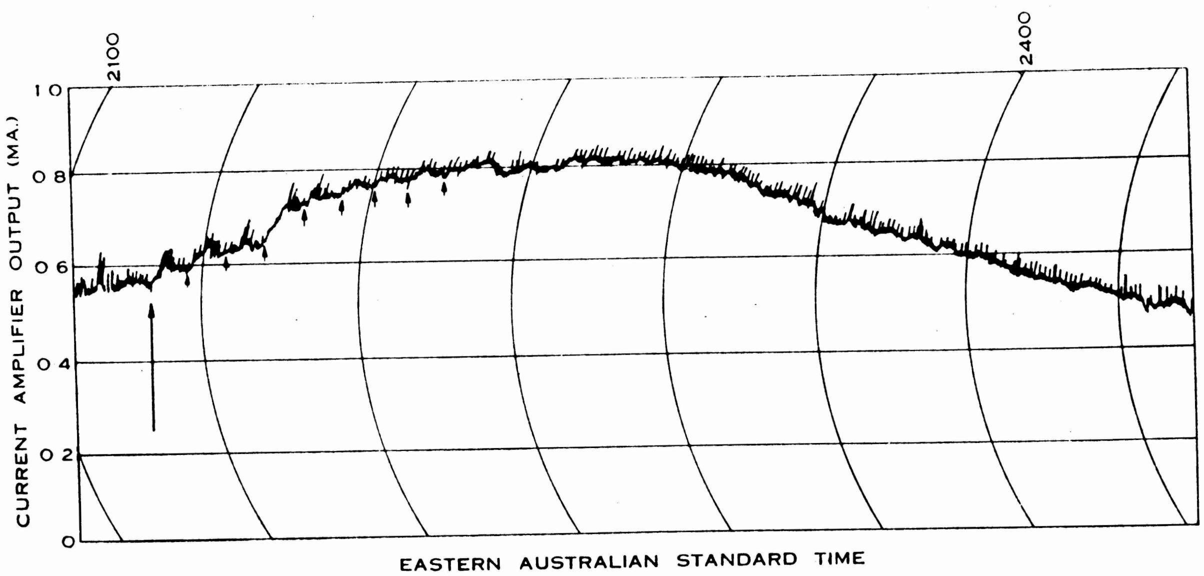
John Bolton
Dover Heights
Sydney 1946-48

Bolton and Stanley radio star fringes in 1947



Cygnus A

(note fluc's)



Taurus A

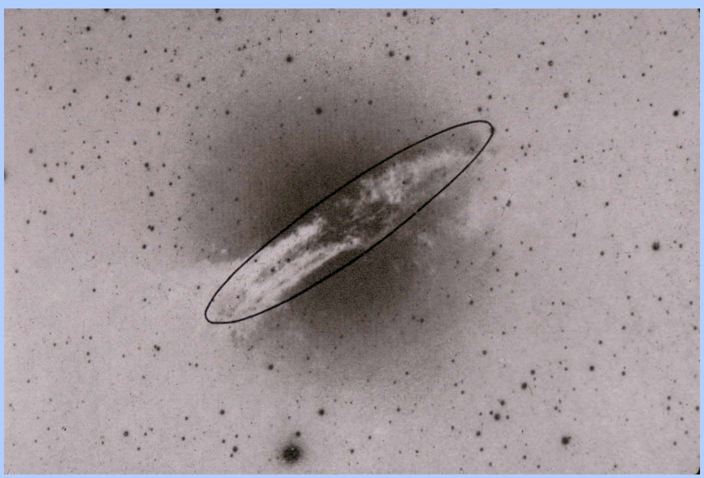
discovery record

(arrows = minima)

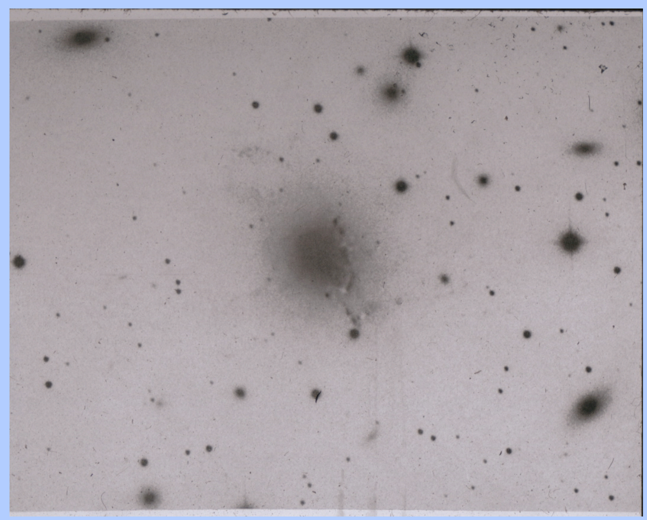
Early Optical Identifications

Bolton, Stanley and Slee (1949)

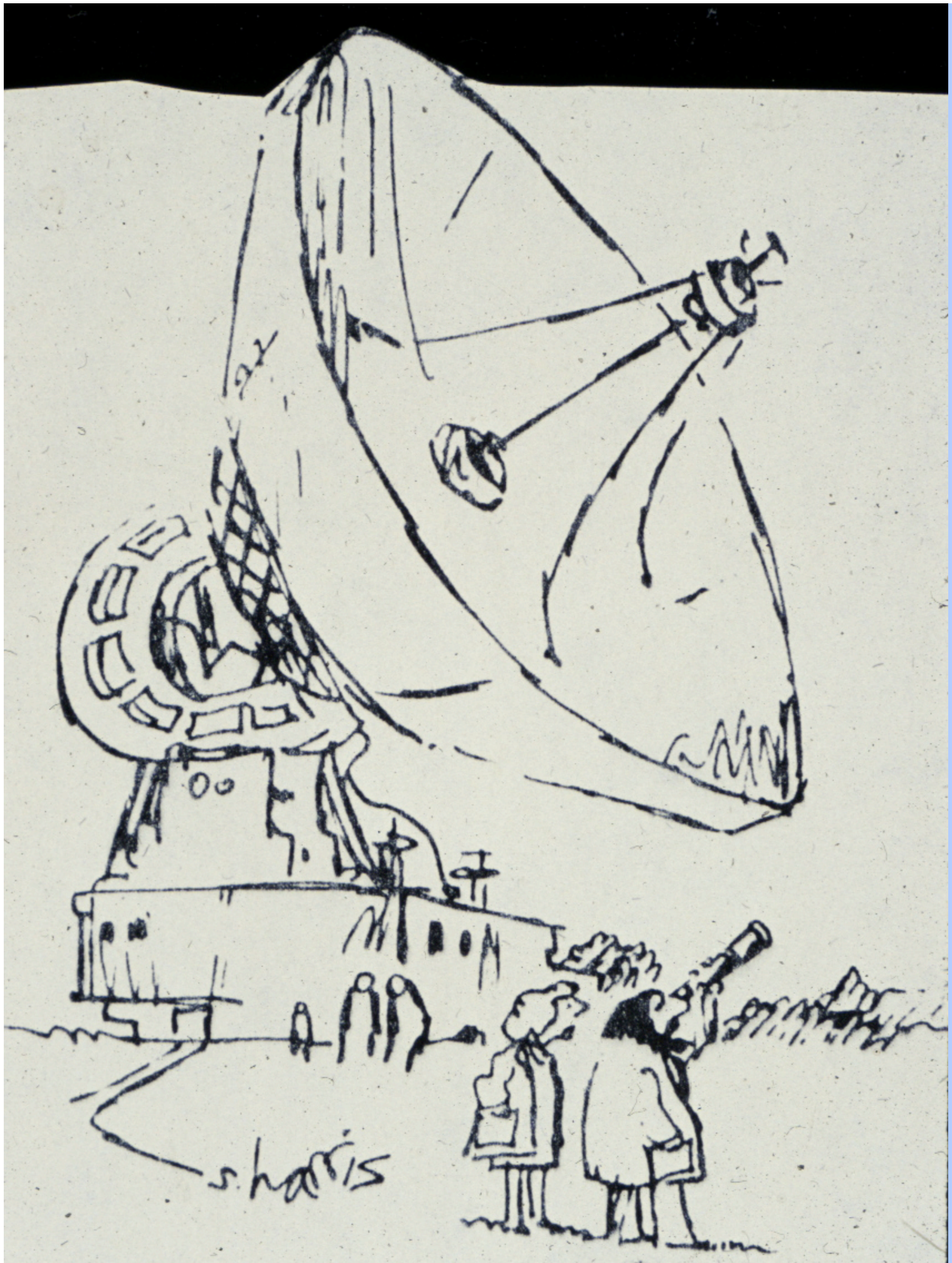
Taurus A



Centaurus A



Virgo A [Coma Ber A at first!]



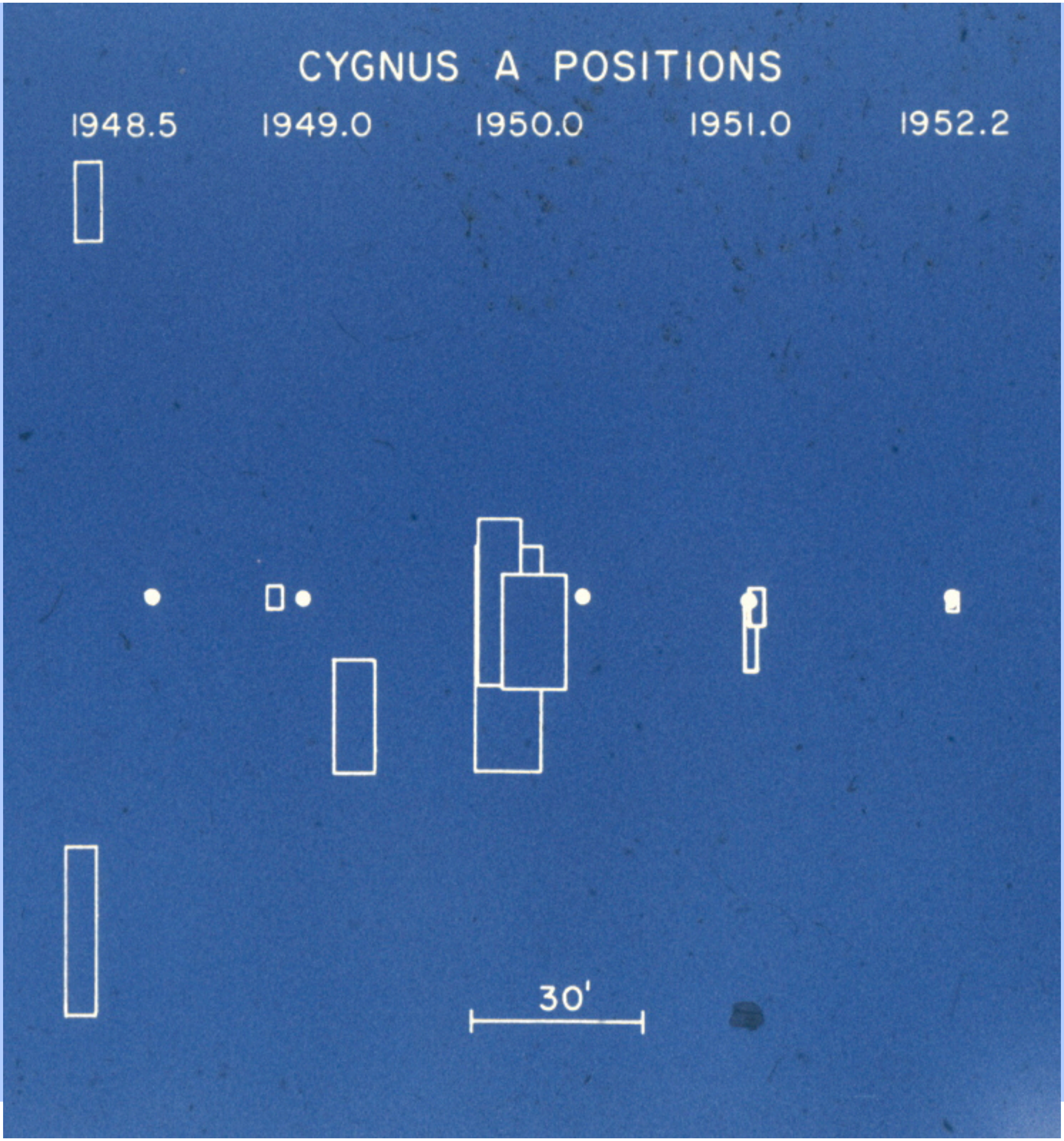
"Just checking."

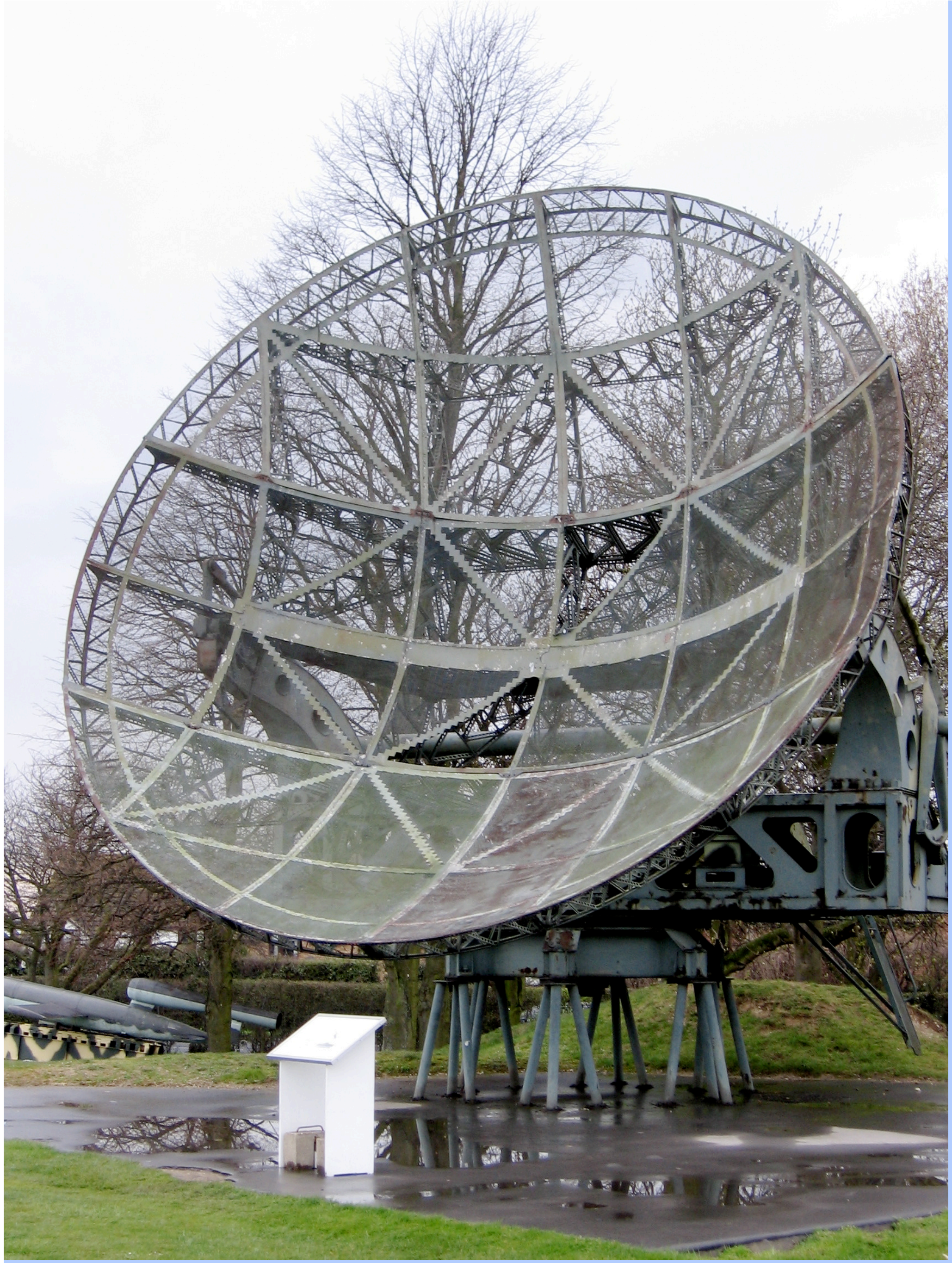
The epistemic priority given to the visual sense

e.g., "I see" = I understand

From a Bolton letter to Minkowski (1952):

I hope that you will send a photograph of the Puppis object when convenient. Photographs are much more satisfying than the evidence we get out of our machinery.


CYGNUS A POSITIONS
1948.5
1949.0
1950.0
1951.0
1952.2
30'

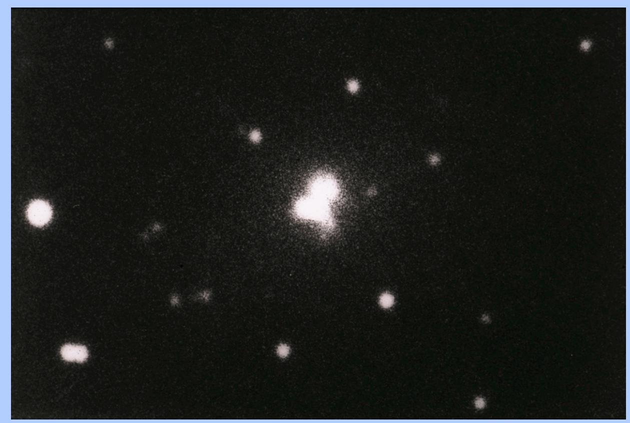


Graham Smith (1951)

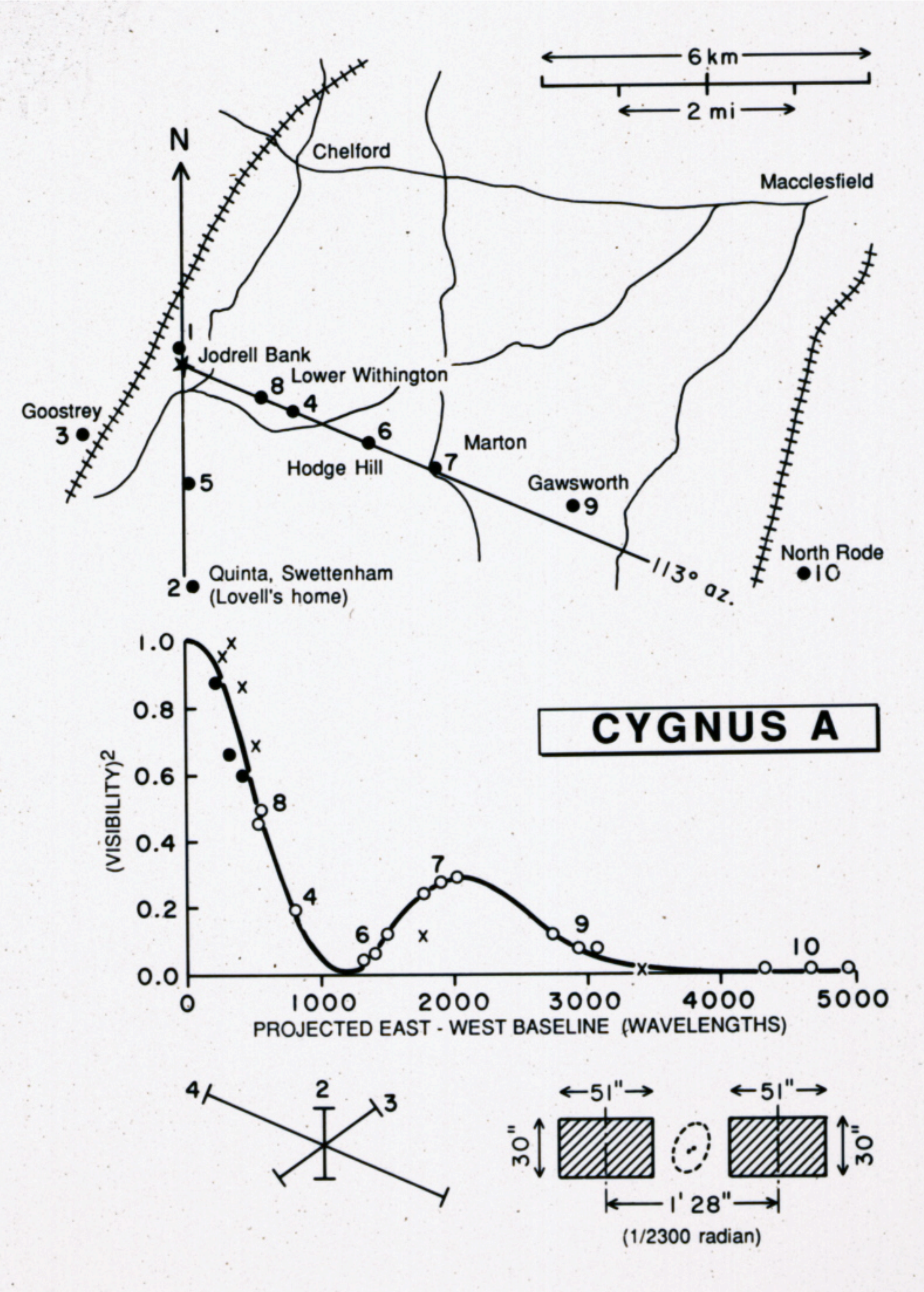
Precise positions (1´) using
2 Würzburg antennas

214 MHz   2000 K T_{sys}

200-inch Palomar photo
Baade & Minkowski (1951)



Cygnus A: colliding galaxies
receding at ~17,000 km/s

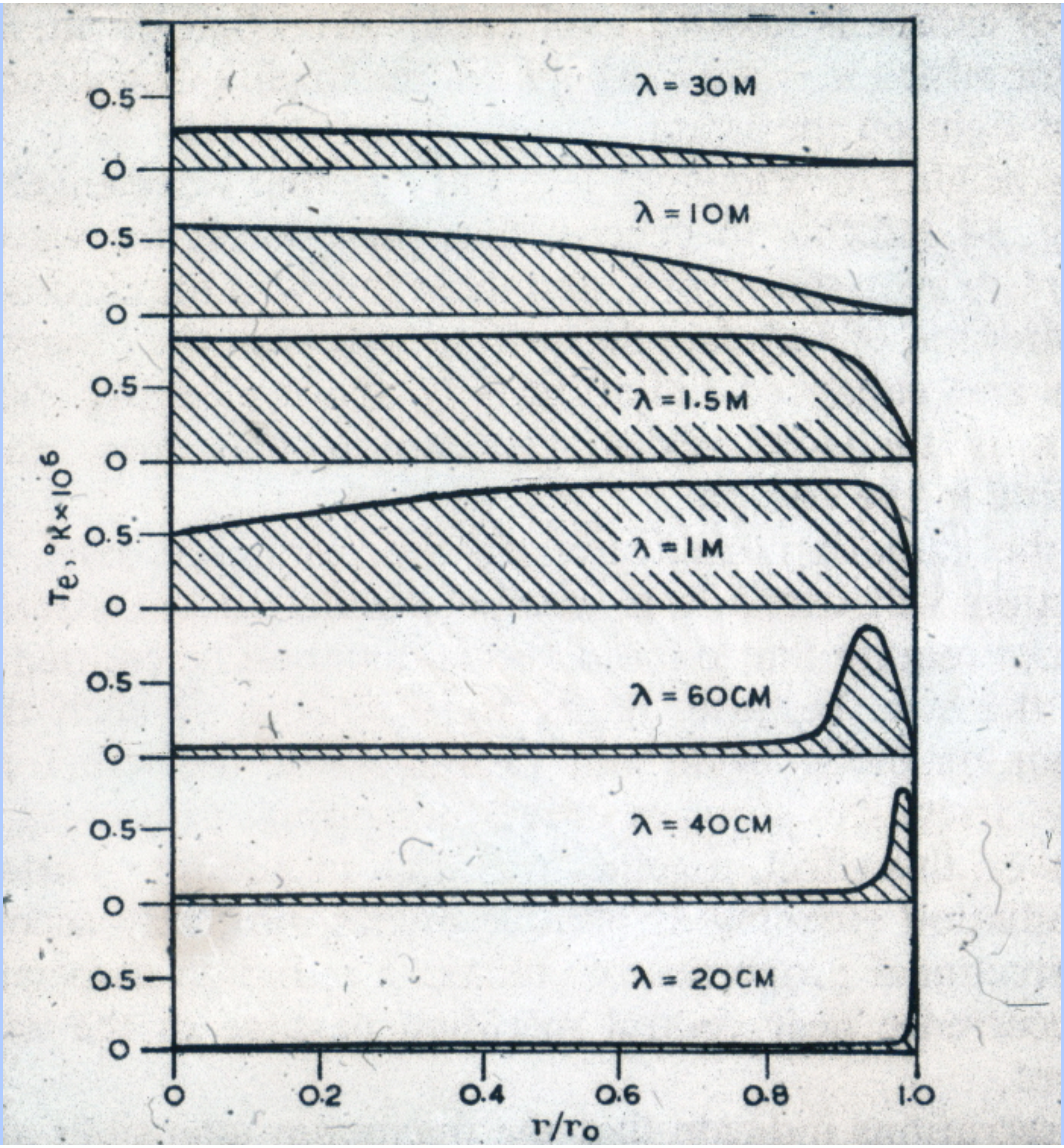


Long Baseline Interferometry
(~10 km radio-linked baseline)

Jennison & Das Gupta (1953)

Jodrell Bank, UK

Cyg A is a *double* source



The road to aperture synthesis

Martyn (1946)

predicted limb brightening

The push to images of better angular resolution - testing out ideas on the sun

at Cambridge, 3 successive students of Ryle

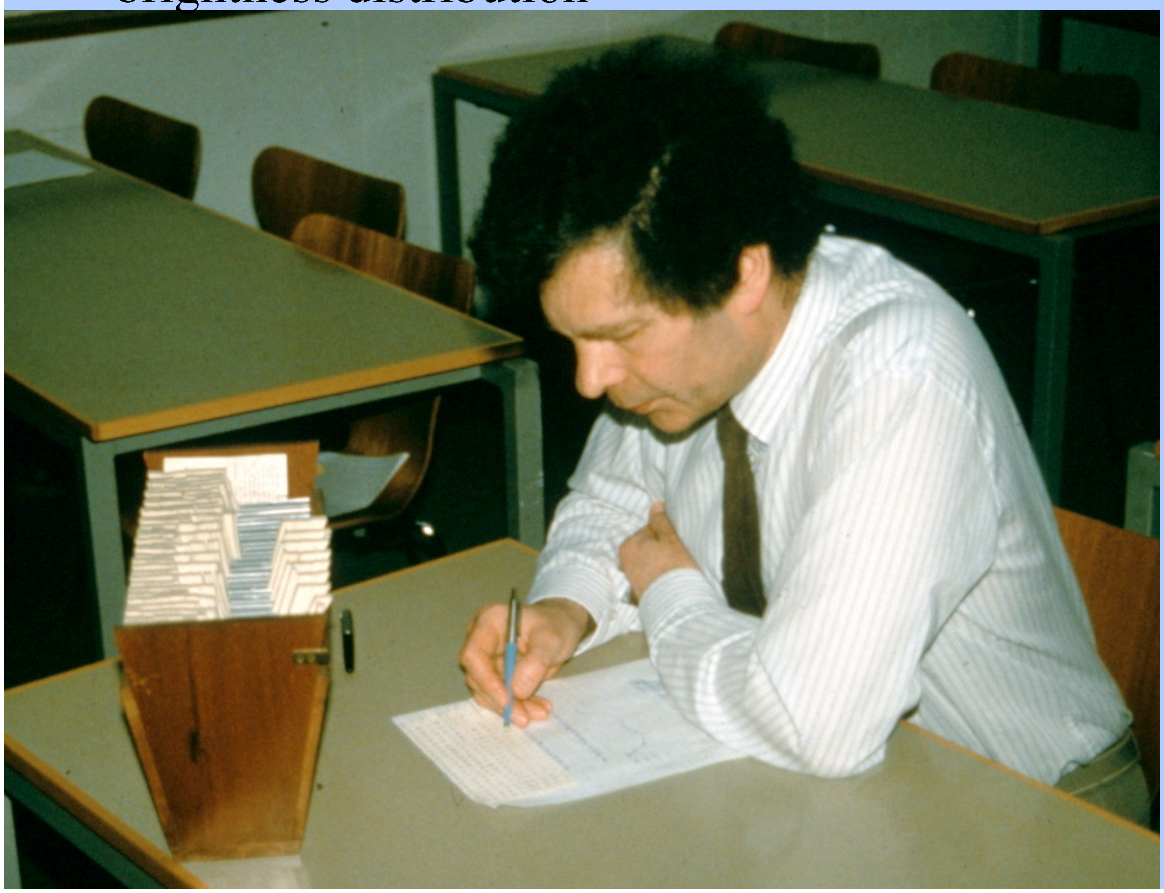
Stanier (1950) - 1-D at 500 MHz - 17 spacings out to 220 m
- limb-darkened sun

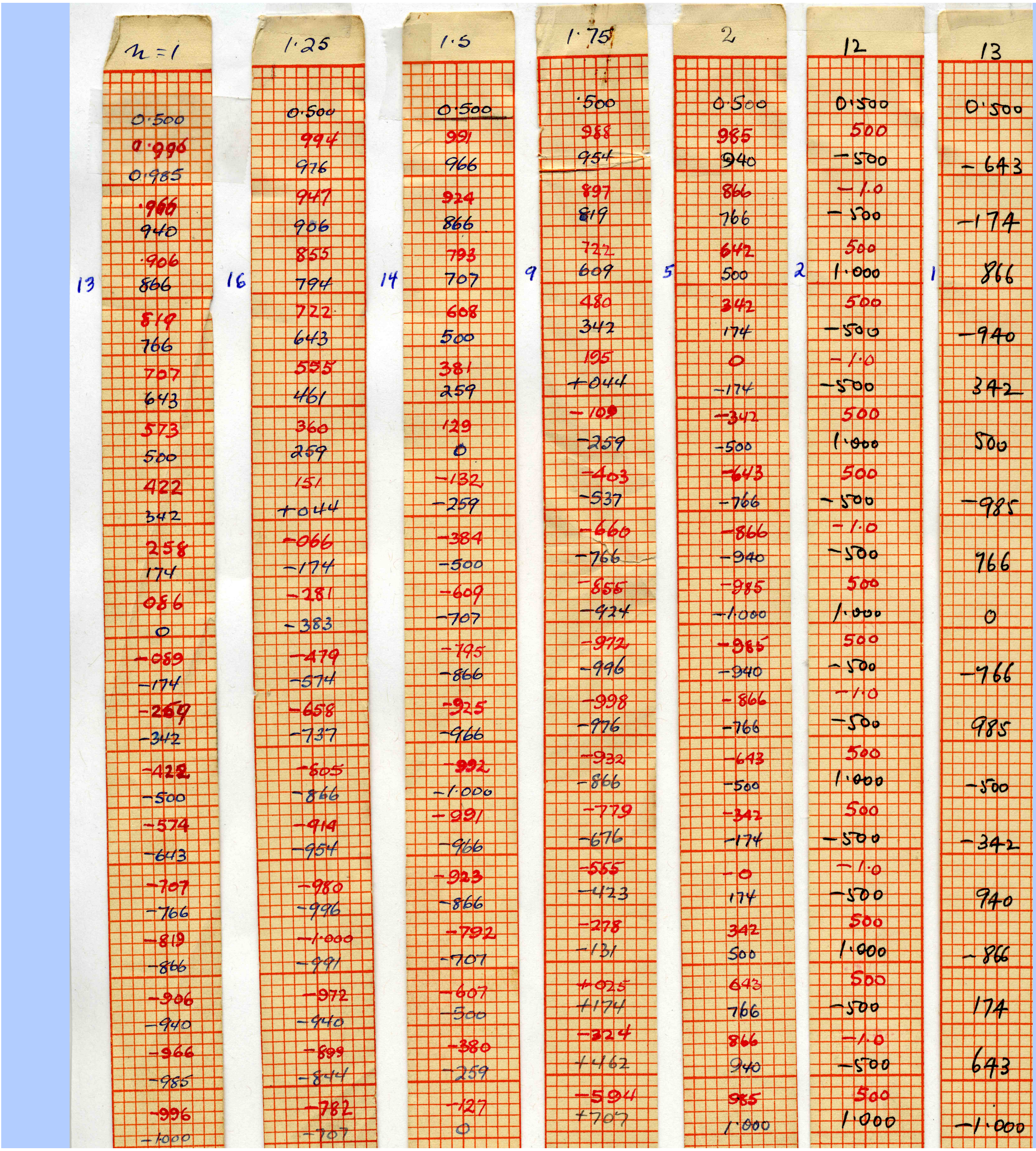
Machin (1951) - 1-D at 81 MHz

O'Brien (1951-3) - 2-D at 210 MHz
- on one day measured 43 spacings!
- polar diam 20% less than equatorial diam.
- also measured *phases* ; located one "hotspot"
- also did some earth-rotation synthesis

Peter Scheuer demonstrates how to use **Lipson-Beevers strips** (1988)
7000 cosine strips and 7000 sine strips in 2 wooden boxes

- cardboard strips printed with, for a given value of *A* and *n*, the values of *A* cos *nx* in (say) 3° increments of *x*.
- measure your visibilities, then pick out the right strips, line'em up, and add'em to calculate the sums needed for the terms in the Fourier integral for a brightness distribution





Homemade Lipson-Beevers strips

- Christiansen

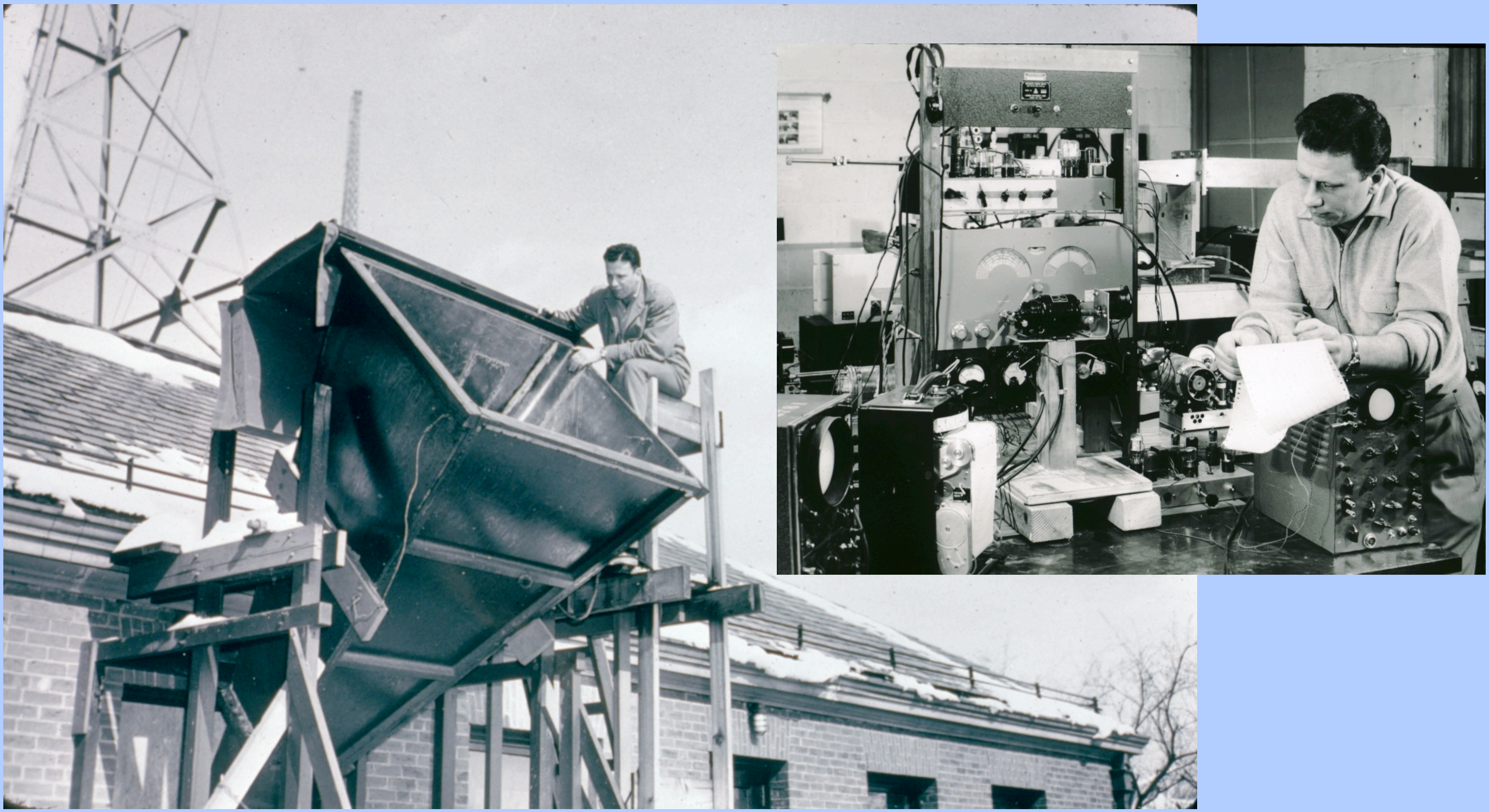
Christiansen
Grating Arrays

Potts Hill, Sydney

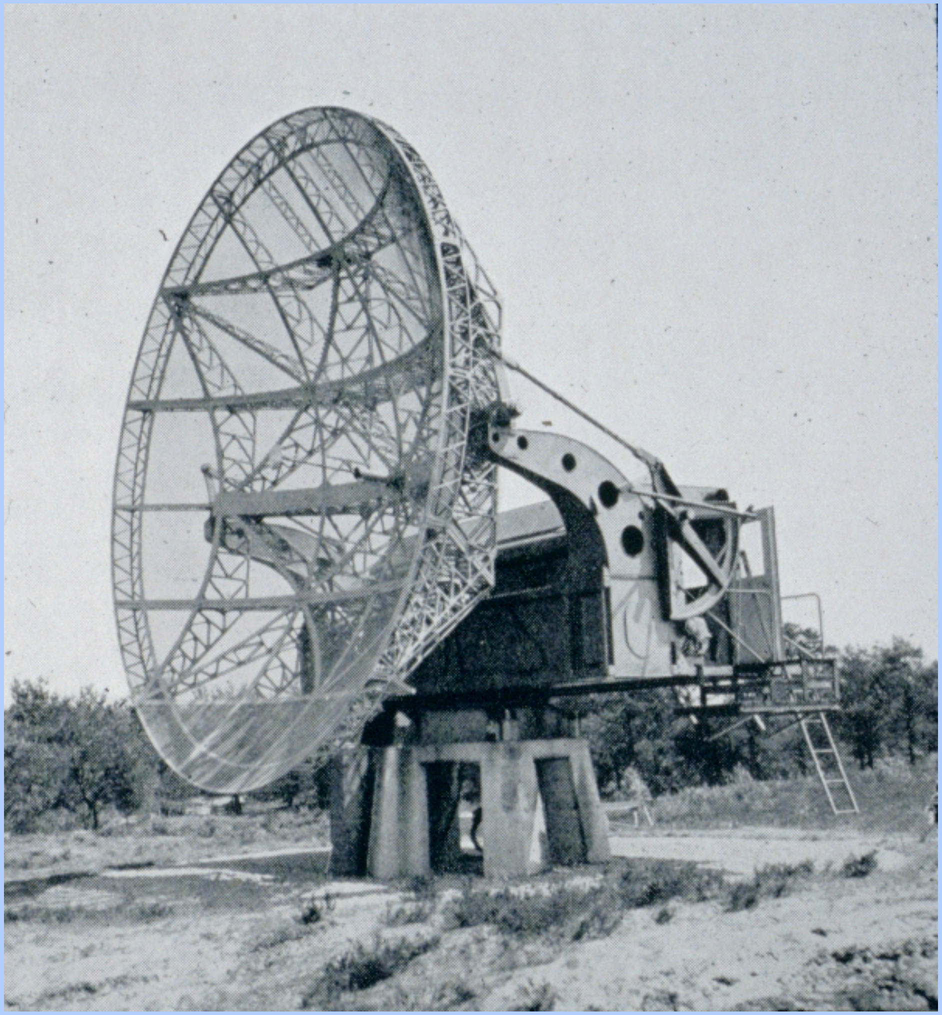
1952-56

21-cm Hydrogen Line

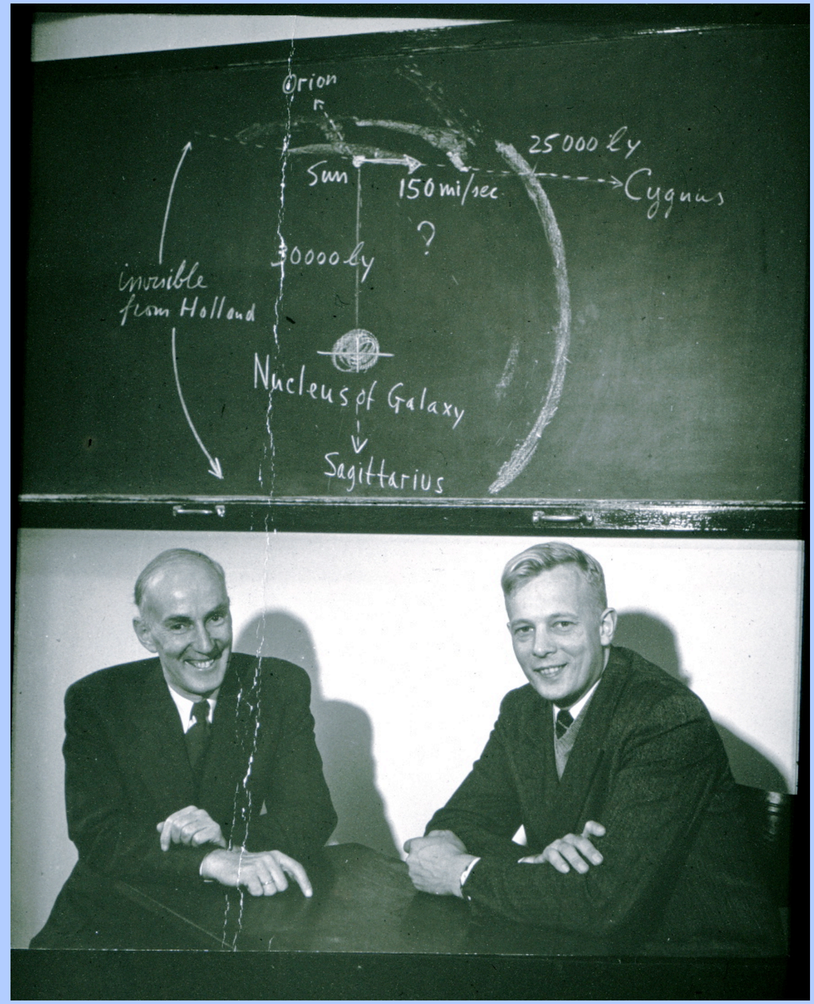
Ewen & Purcell (1951), Harvard
microwaves [very high frequencies]



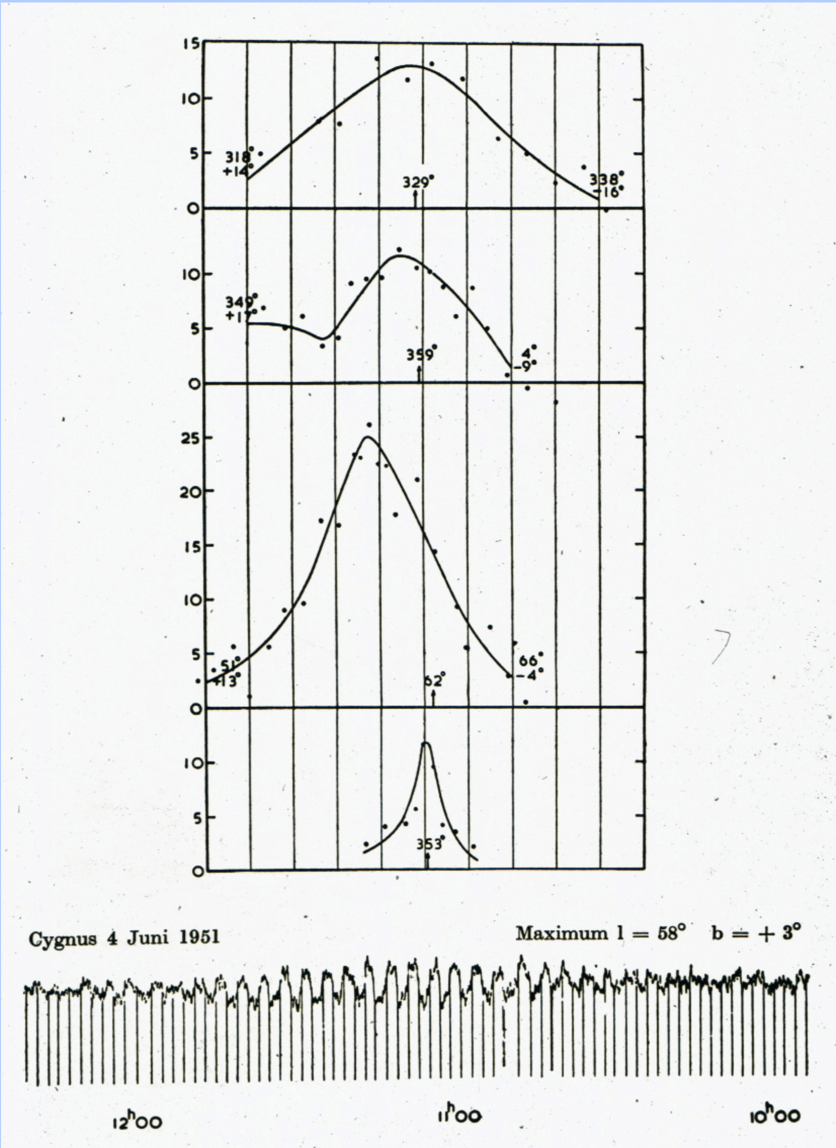
Leiden & Kootwijk



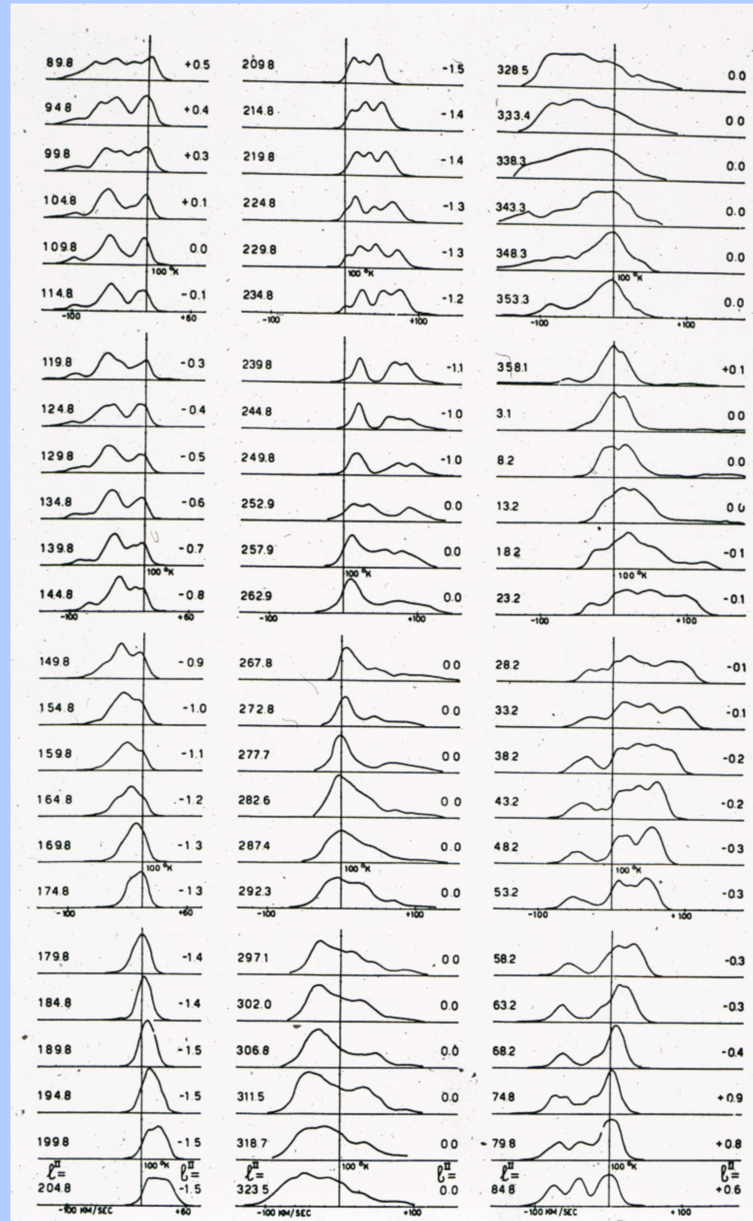
7.5-m-diam. Würzburg dish



Jan Oort & Henk van de Hulst

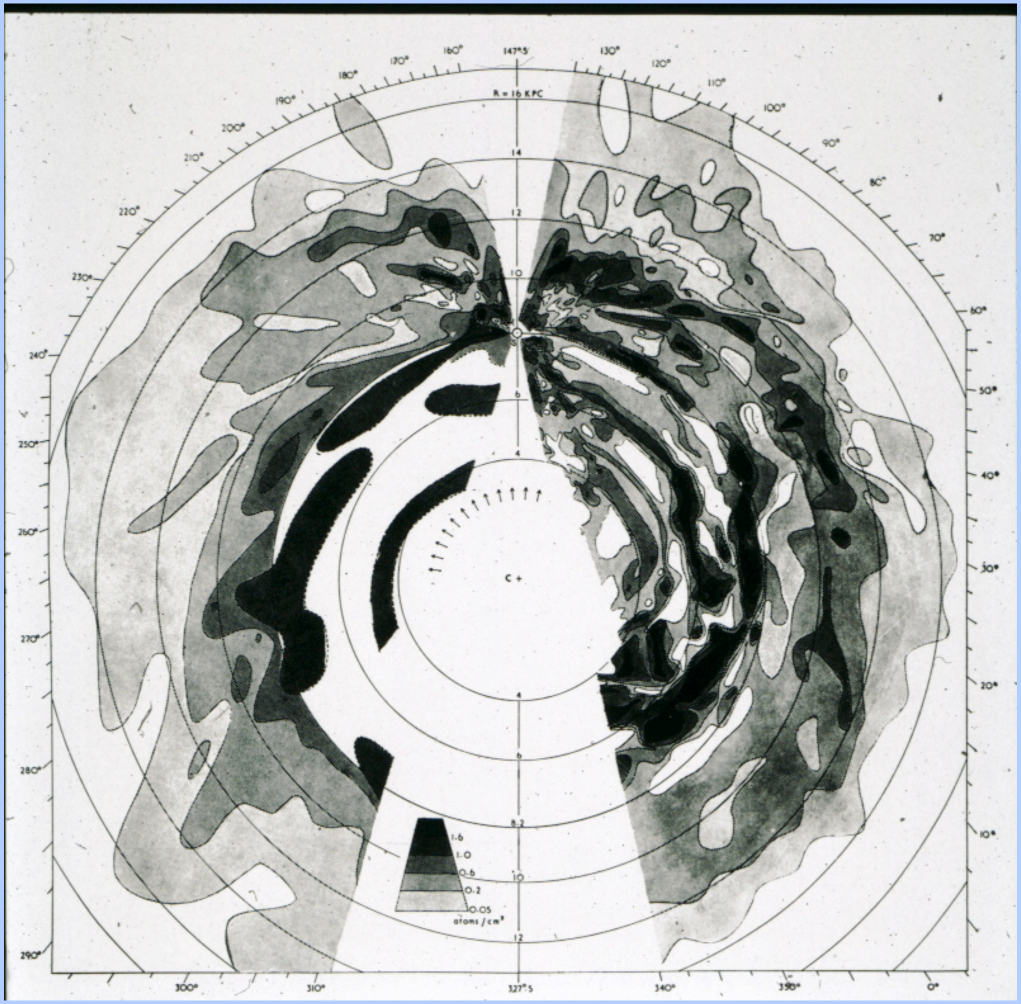


1951 *Nature*



1952-54 single-channel scanning!

The “21 cm Club” (Sydney, 1952): Frank Kerr, Paul Wild, Jim Hindman, Doc Ewen, Lex Muller, Chris Christiansen



1958 - Milky Way
hydrogen-line map

(new galactic coordinate system)

Sydney - 36-ft dish
Kerr & Hindman

And so we return to where Miller began….

Hat Creek 85-ft (1962)

Major historical themes and conclusions

#1 - first observers had **trouble establishing their legitimacy**, but eventually were accepted as radio *astronomers* using radio *telescopes*, researchers who inadvertently invented "optical astronomy"

- radio astronomy turned out historically to be **only the first stage of the opening of the electromagnetic spectrum** - X-ray, IR, UV, and gamma ray windows all followed on and were much more easily incorporated into astronomy because of the path that radio astronomy had already blazed

- overall, I call this opening of the entire electromagnetic spectrum **the 20th century's "New Astronomy"**, no less important than earlier New Astronomies of Galileo, Herschel, and the astrophysicists of the late 19th century, all triggered by new technologies

Other themes and conclusions

#2 - radio astronomers **did not create a new discipline**, but (slowly) merged into (traditional) astronomy

- they ironically sought to be part of **a visual culture** through

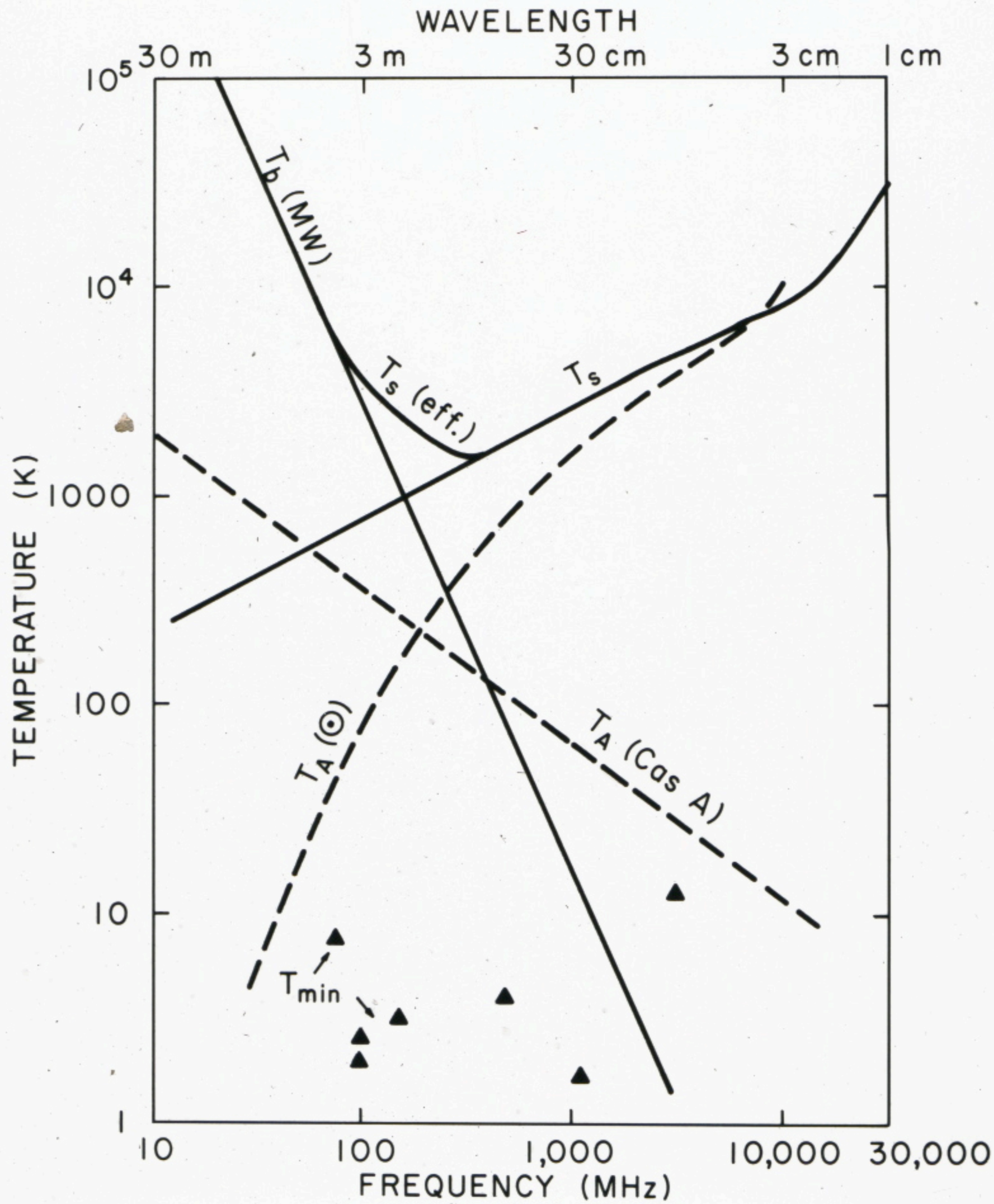
(a) striving to make radio images
(b) searching for optical identifications
(c) joining (visual) astronomy

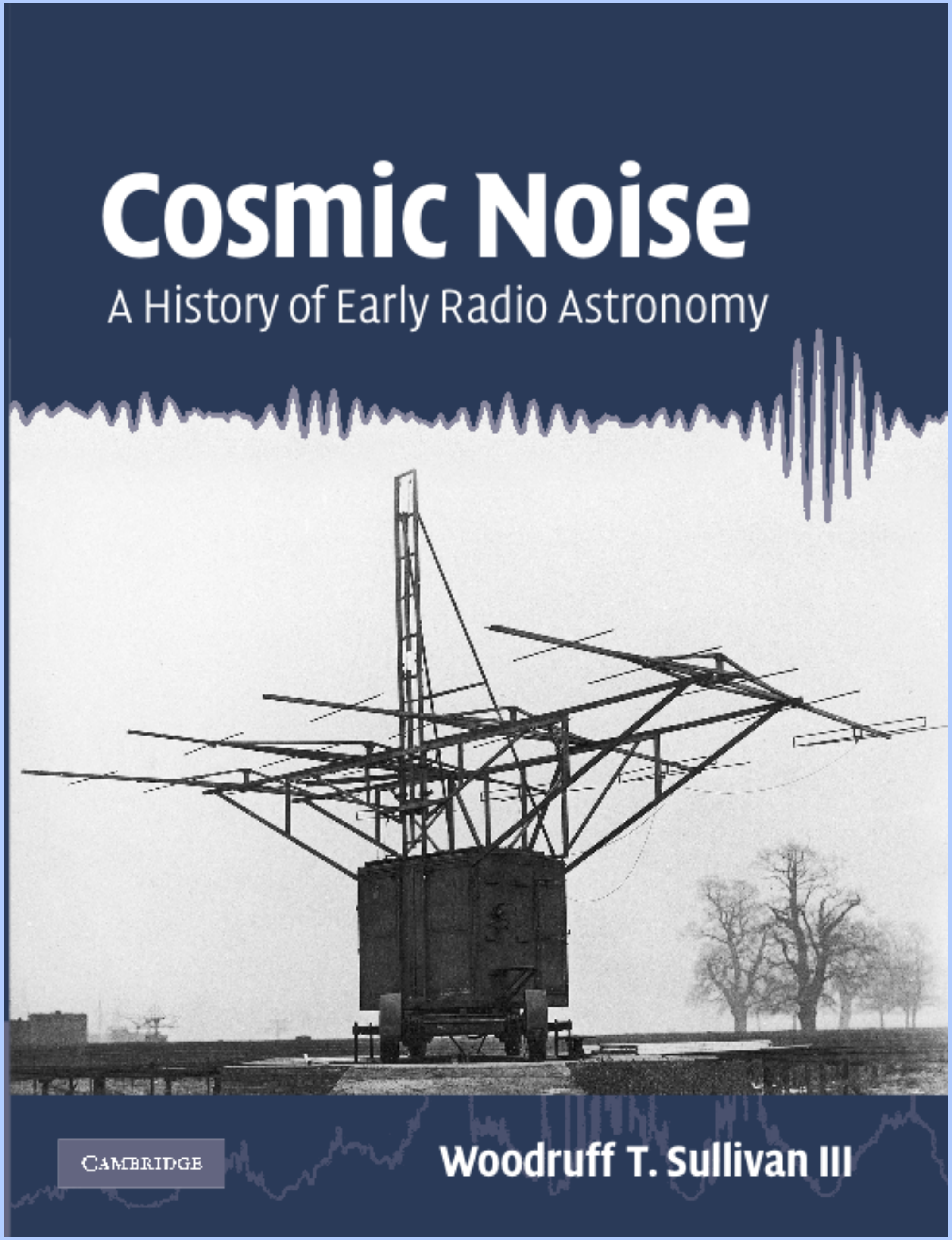
#3 - Radio astronomy was **"Technoscience"** - impossible to say whether science led technology or vice versa theme #4 - early radio astronomy was **shaped by World War II and then by the Cold War**

- in particular US radio astronomy lagged badly in the postwar decade despite a far higher level of funding than in the UK and Australia

- this funding was from the military, which shaped it to shorter wavelengths (microwaves), which was **not** where the most profitable science could be done; overseas groups realized this

- *eventually* (1960s) US could take advantage of this shorter wavelength regime and compete more effectively


WAVELENGTH
30 m
3 m
30 cm
3 cm
1 cm
TEMPERATURE (K)
10^5
10^4
1000
100
10
1
T_b (MW)
T_s (eff.)
T_s
T_A (☉)
T_A (Cas A)
T_{min}
10
100
1,000
10,000
30,000
FREQUENCY (MHz)



Available in airports and supermarket checkouts since 2009