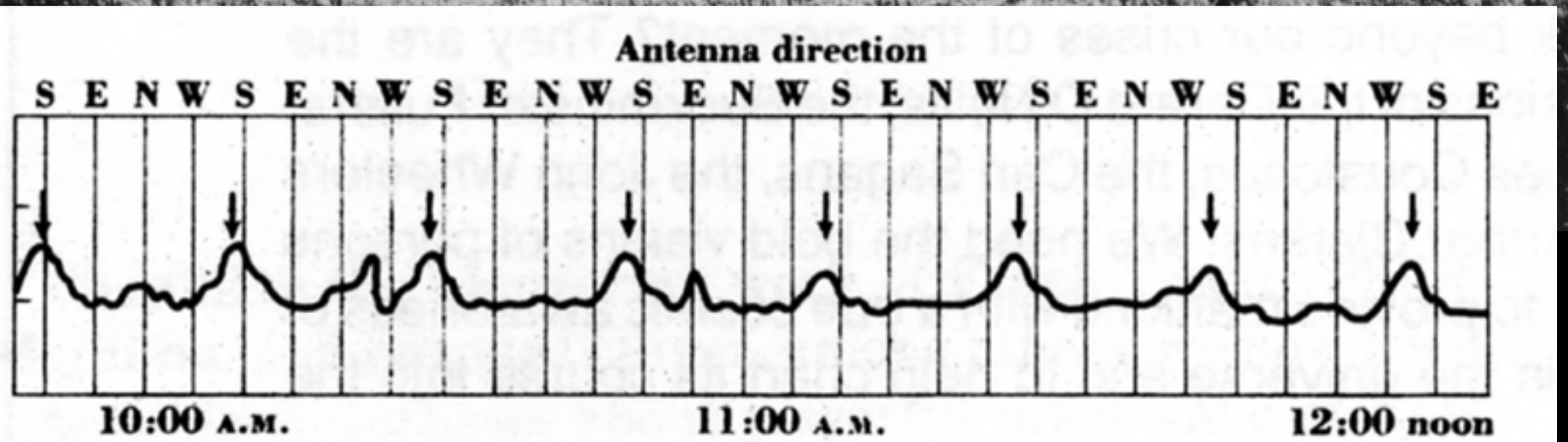
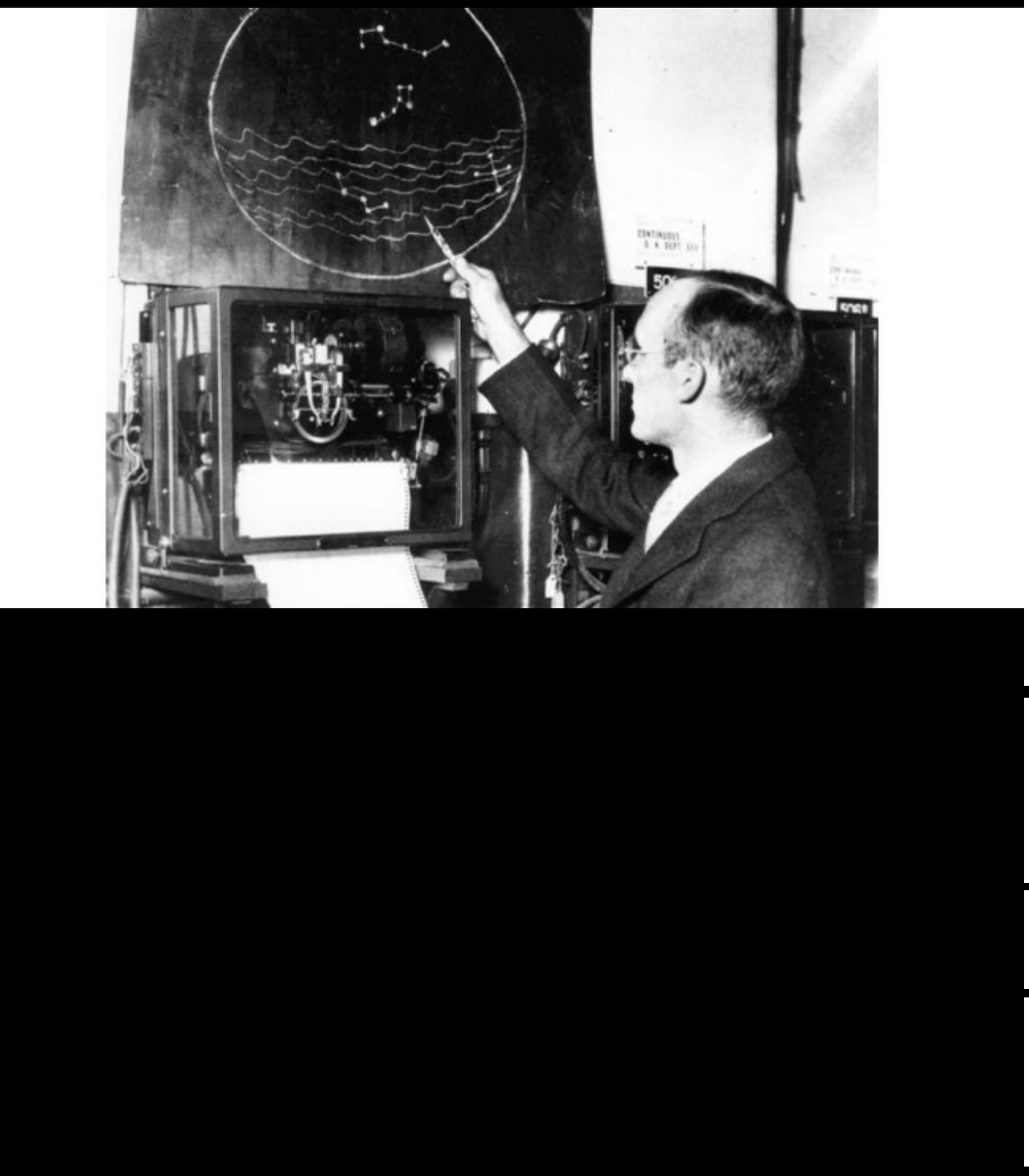
Radio Astronomy
Past, Present, Future

Whose idea was this?

Felix J. “Jay” Lockman
Green Bank Observatory

Karl Jansky
1932
20.5 MHz





NEW RADIO WAVES TRACED TO CENTRE OF THE MILKY WAY

Mysterious Static, Reported by K. G. Jansky, Held to Differ From Cosmic Ray.

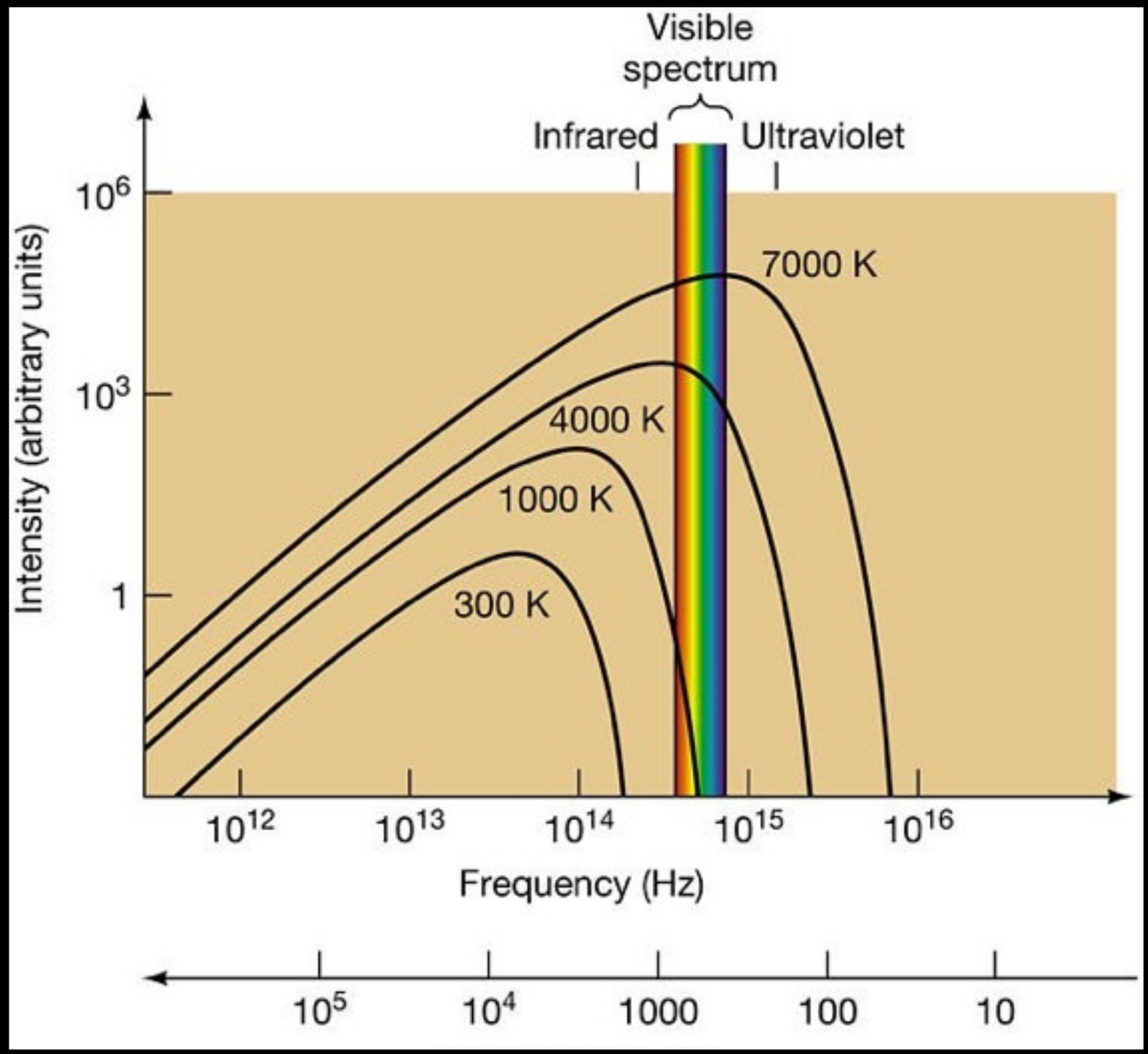
DIRECTION IS UNCHANGING

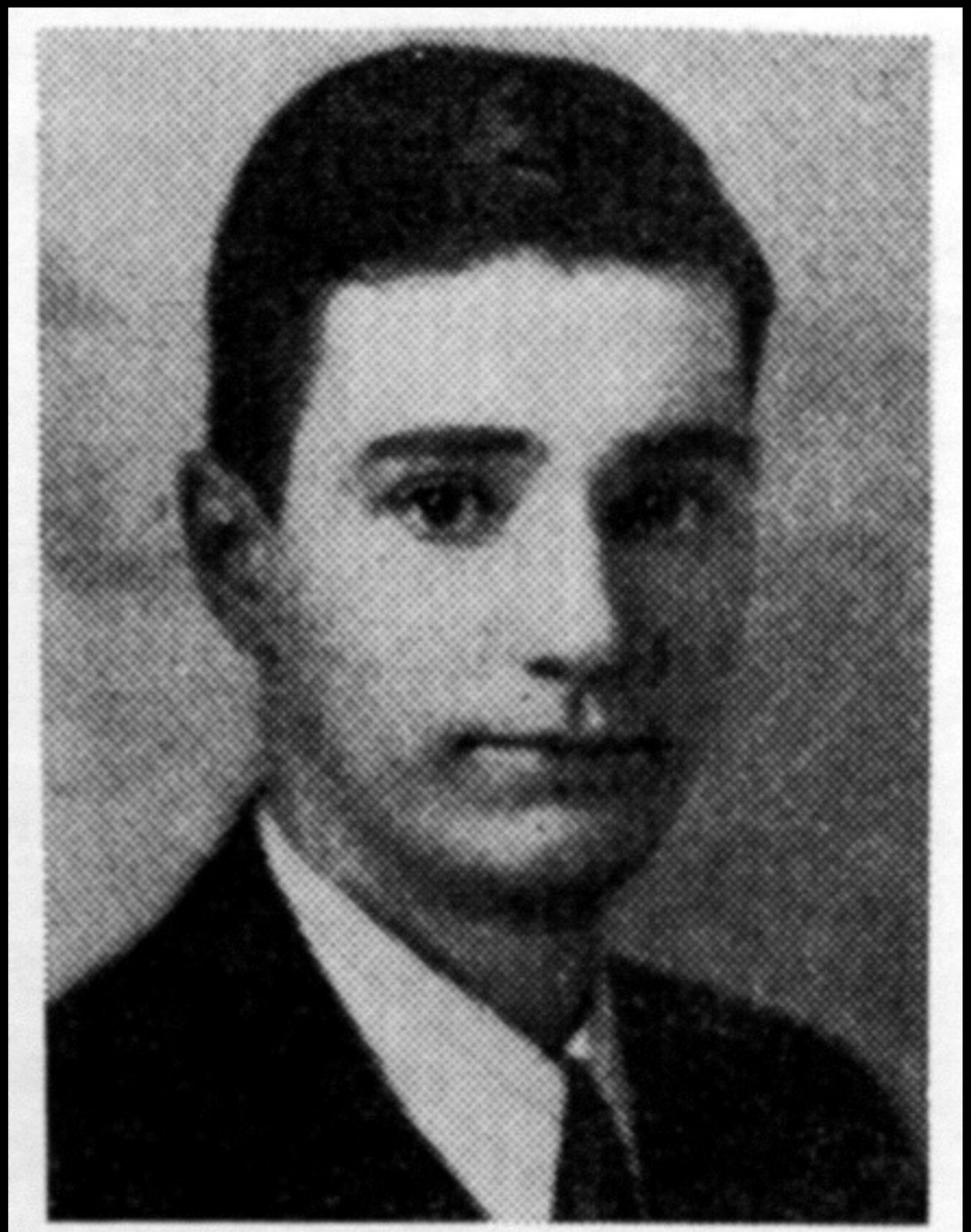
Recorded and Tested for More Than Year to Identify It as From Earth's Galaxy.

ITS INTENSITY IS LOW

Only Delicate Receiver Is Able to Register—No Evidence of Interstellar Signaling.

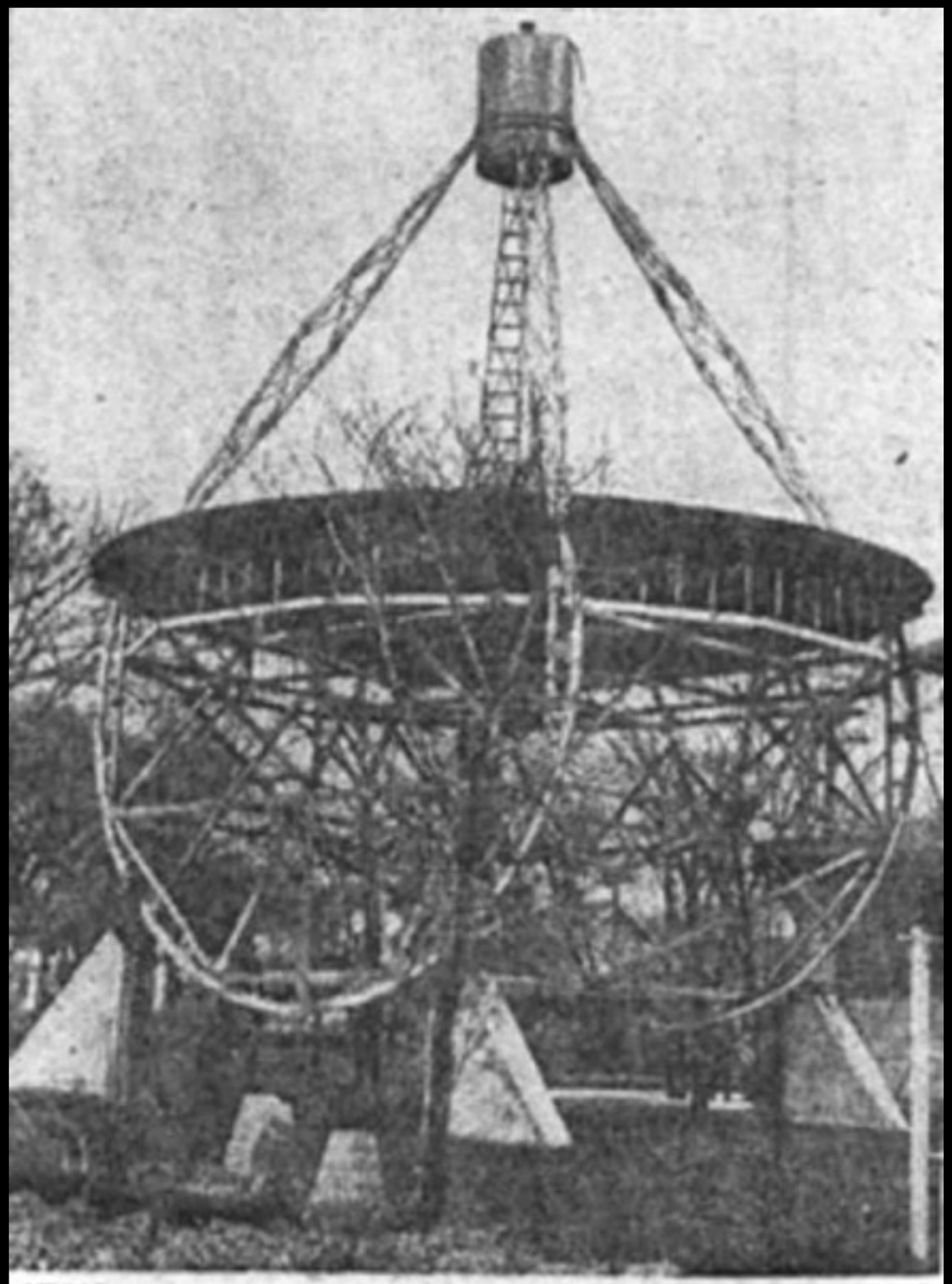
Jansky


Visible
spectrum
Infrared
Ultraviolet
10^6
10^3
1
Intensity (arbitrary units)
7000 K
4000 K
1000 K
300 K
10^{12}
10^{13}
10^{14}
10^{15}
10^{16}
Frequency (Hz)
10^5
10^4
1000
100
10



Grote Reber circa 1940.

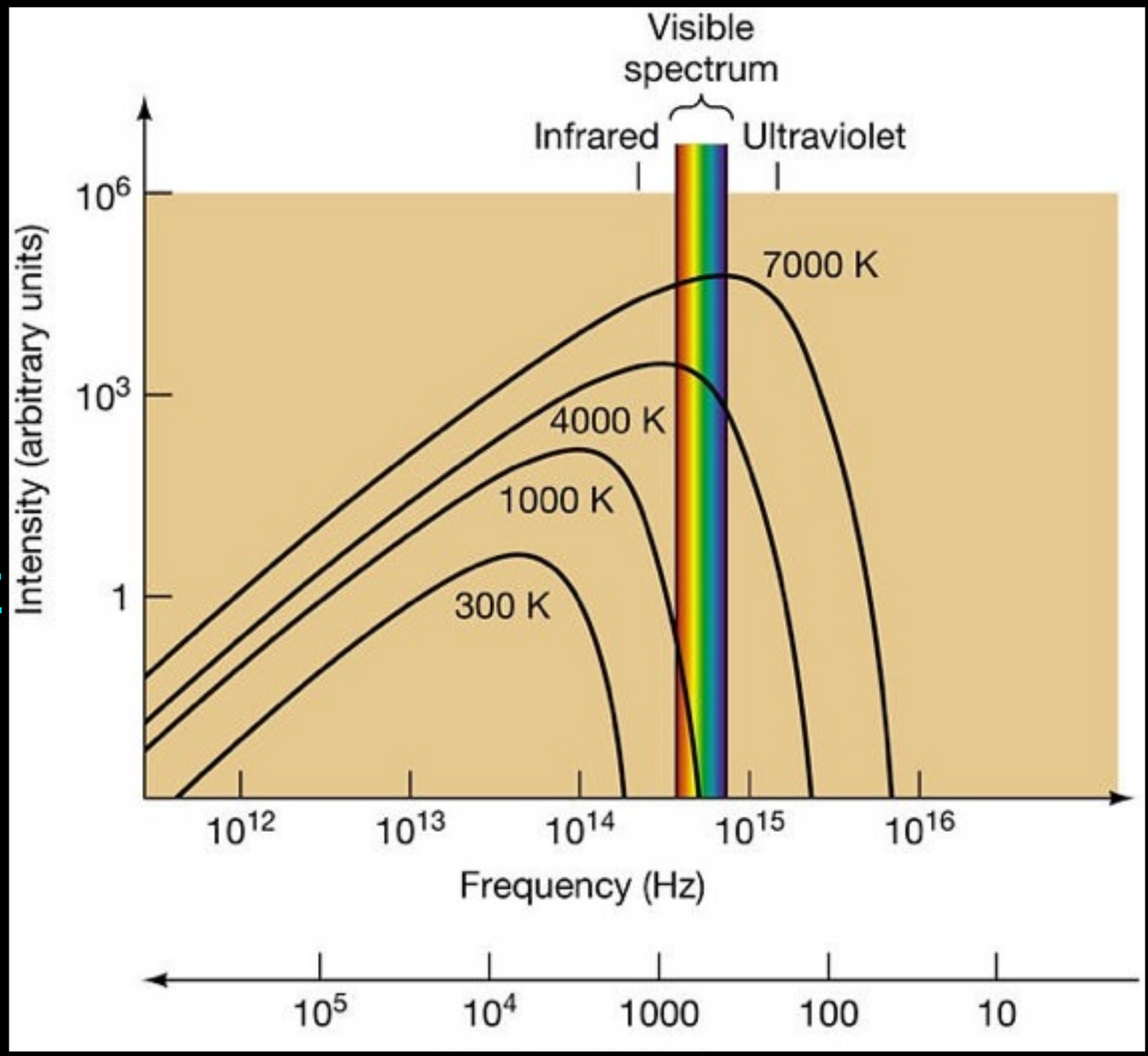
Wheaton
Illinois
1936



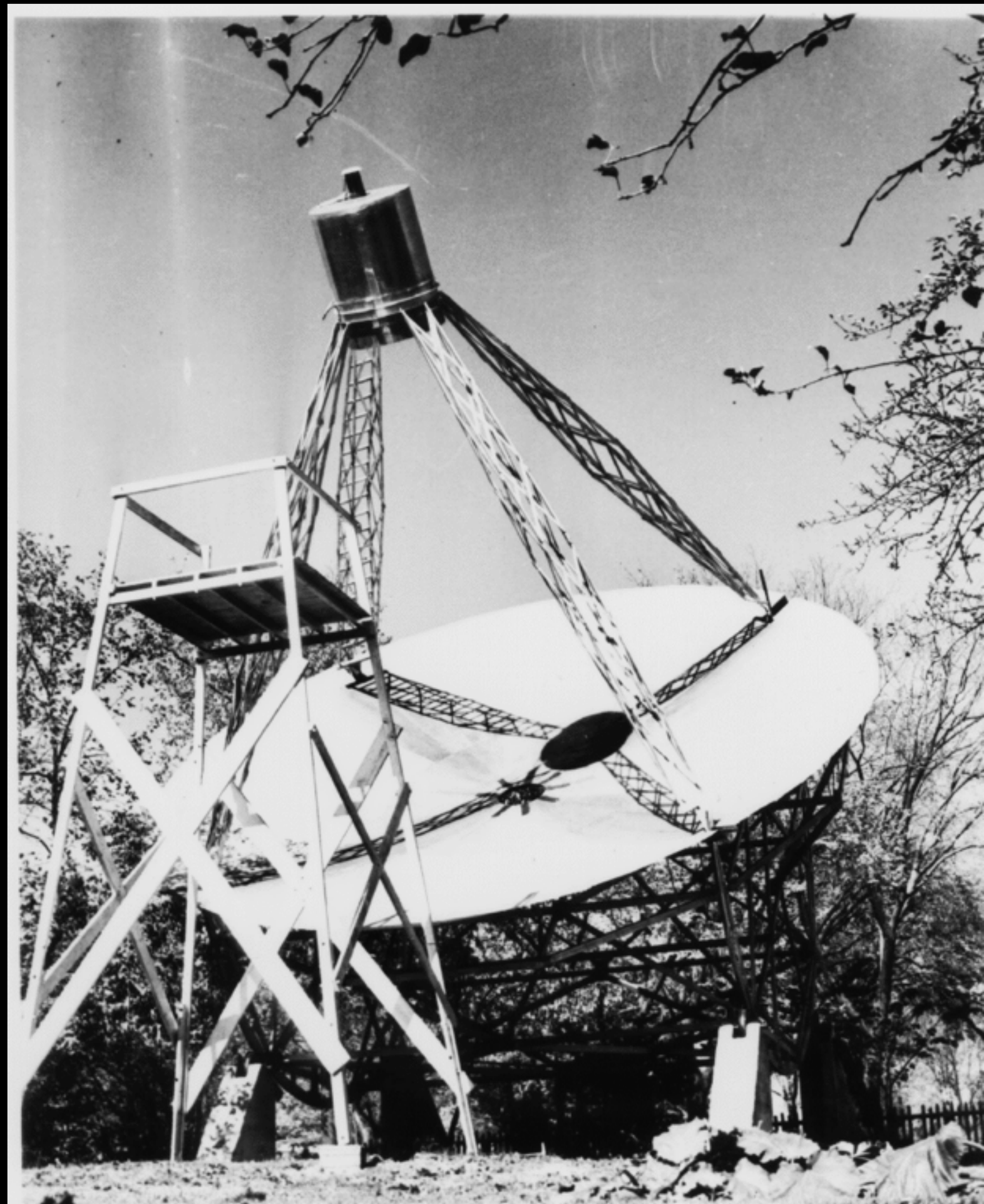
"What is it?" All Wheaton ponders purpose of 3-story mystery contraption erected by Peter Reber in his yard.

Jansky

3.3 GHz



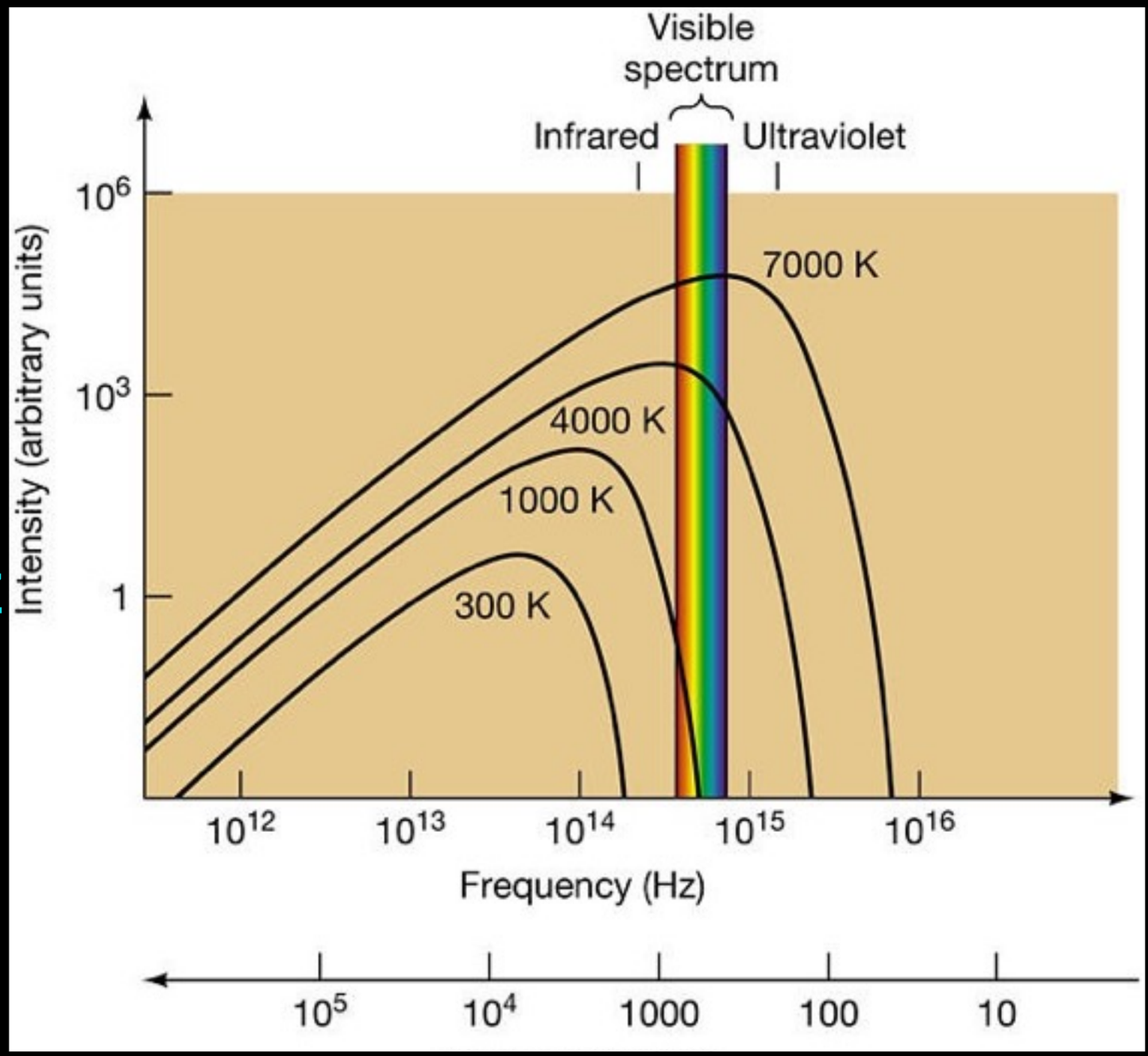
Wheaton
Illinois
1936



Jansky

3.3 GHz

0.9 GHz



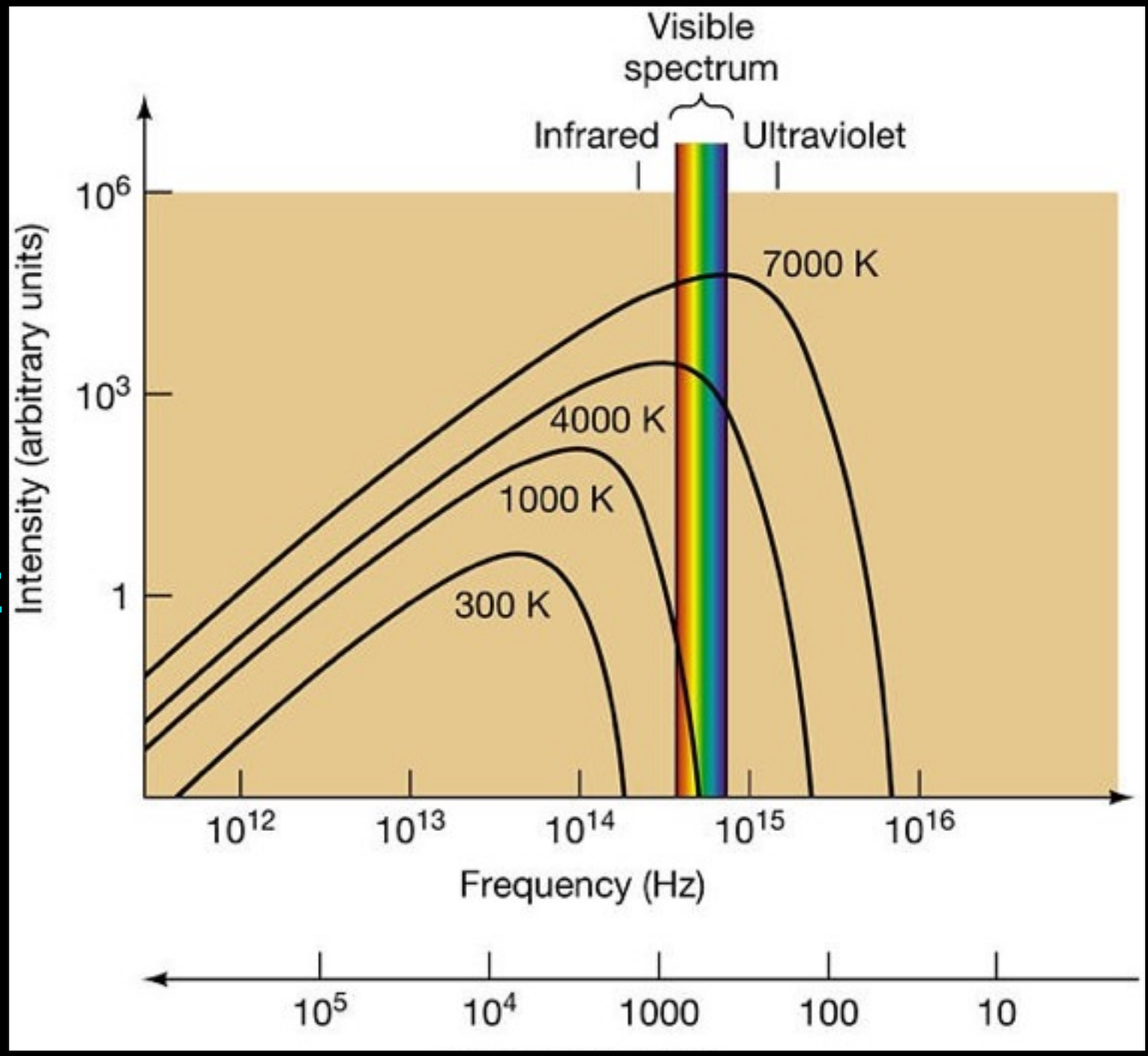
Jansky

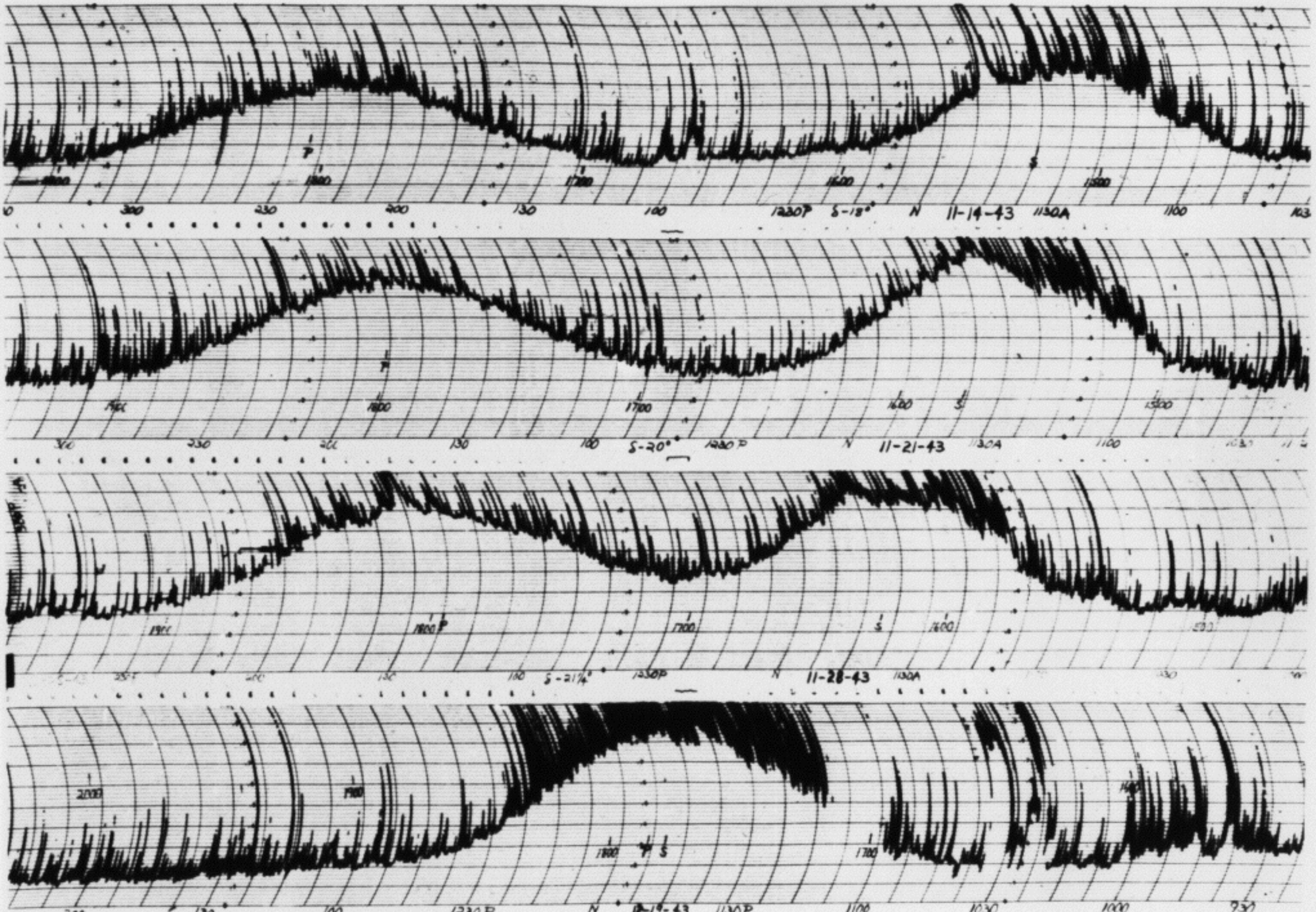
0.02 GHz

0.16 GHz

3.3 GHz

0.9 GHz



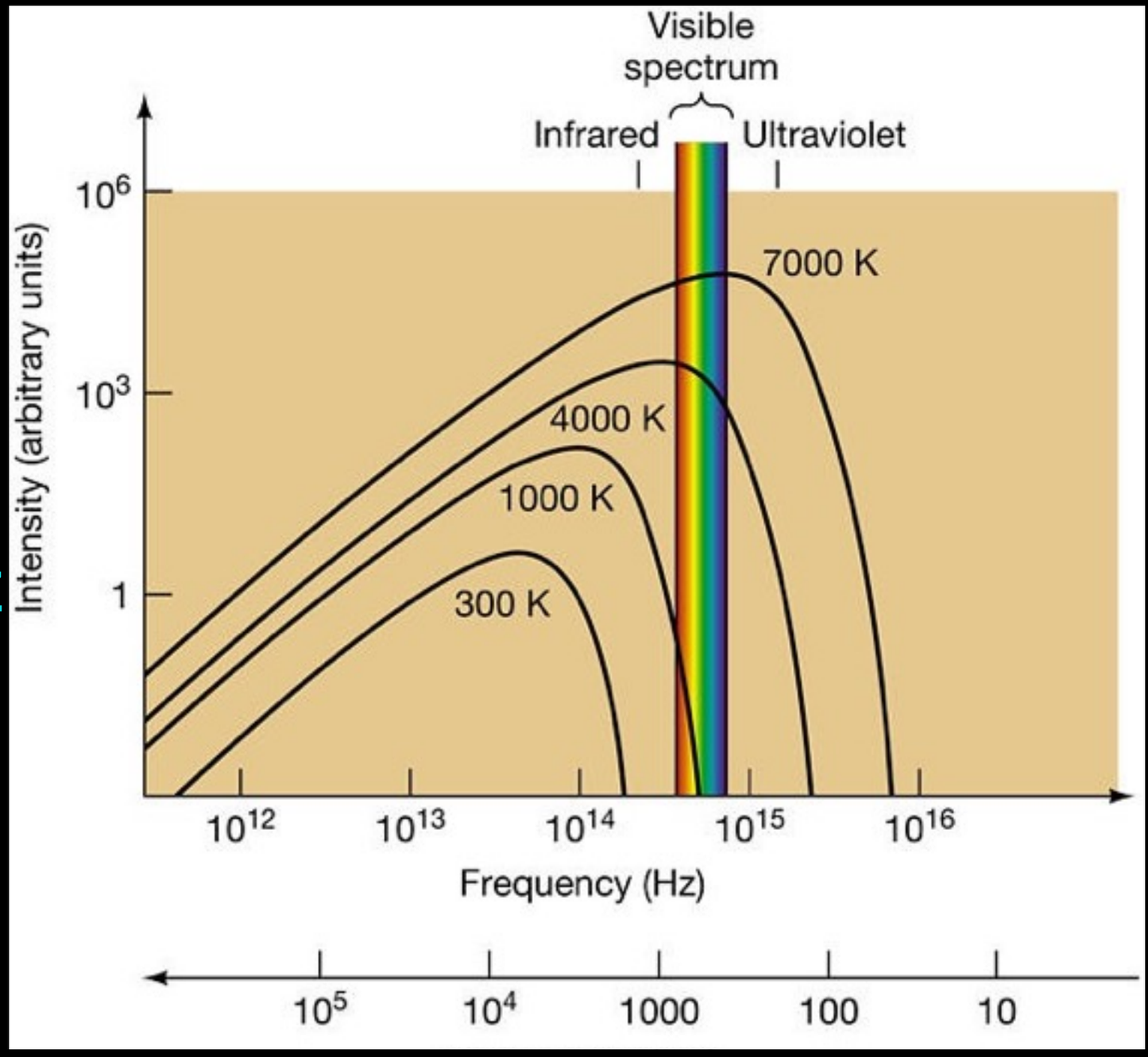

11-14-43
11-21-43
11-28-43

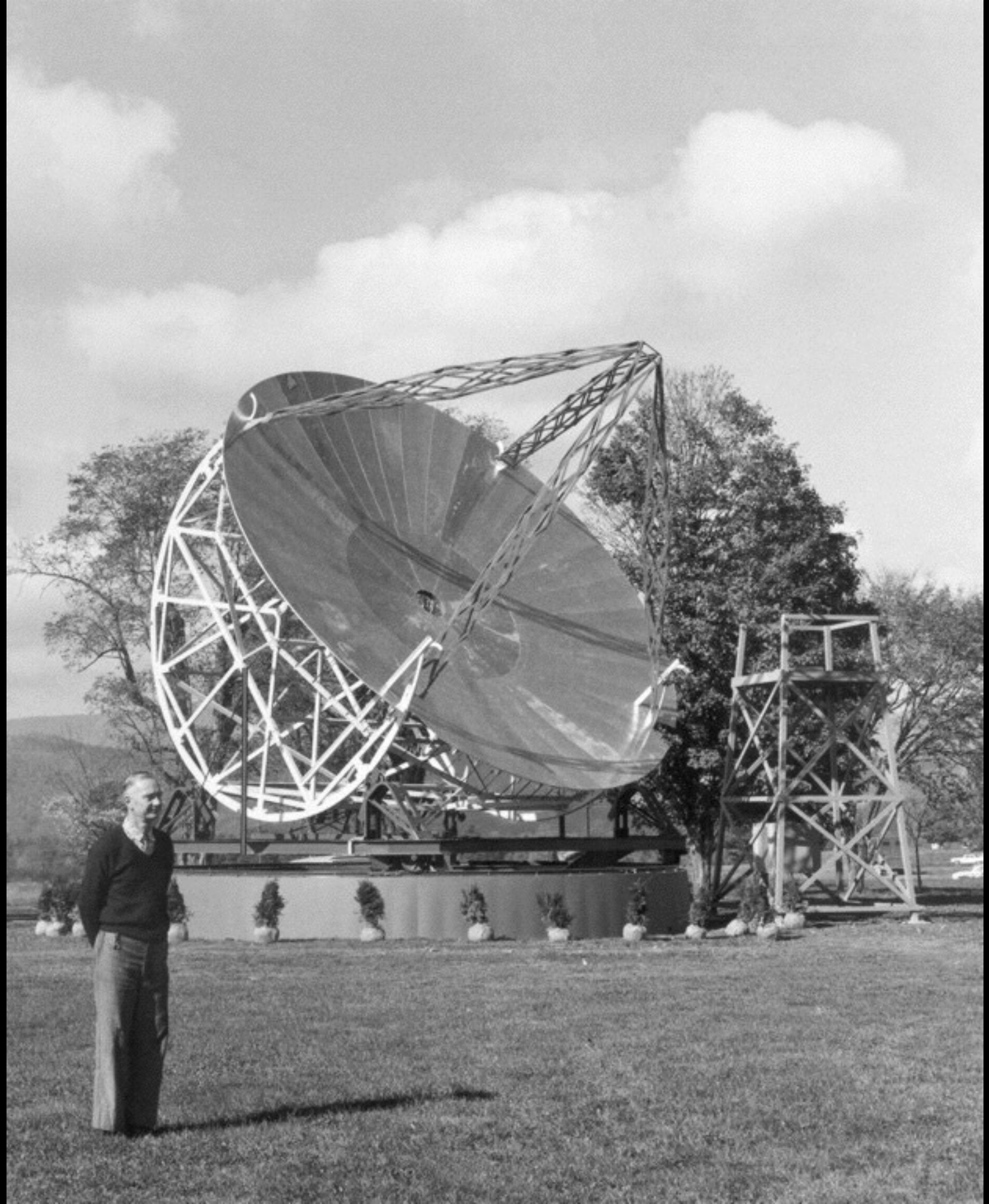
Jansky

0.16 GHz

3.3 GHz

0.9 GHz





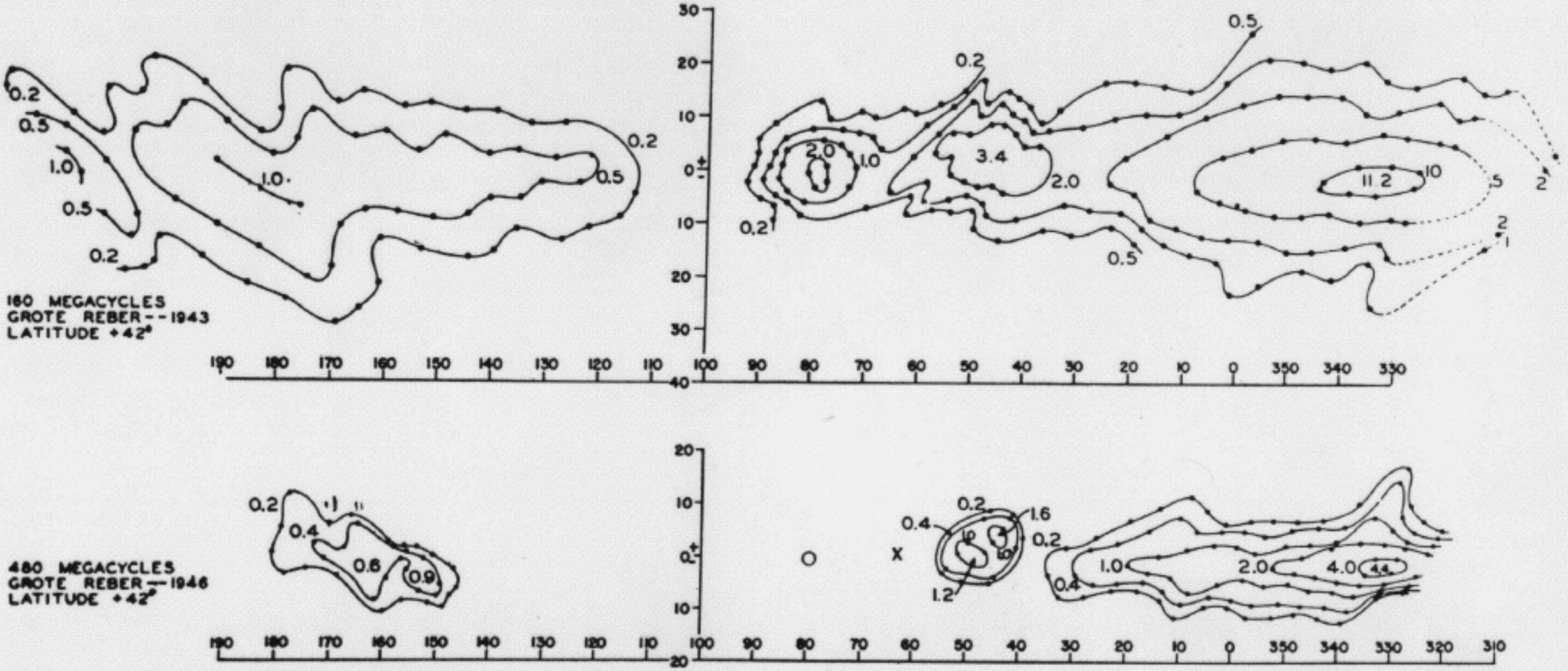


FIG. 7—Contours of constant intensity at 160 MHz and 480 MHz, taken at Wheaton, Illinois.

COSMIC STATIC

GROTE REBER
Wheaton, Illinois
Received May 8, 1944

ABSTRACT

Cosmic static is a disturbance in nature which manifests itself as electromagnetic energy in the radio spectrum arriving from the sky. The results of a survey at a frequency of 160 megacycles per second show the center of this disturbance to be in the constellation of Sagittarius. Minor maxima appear in Cygnus, Cassiopeiae, Canis Major, and Puppis. The lowest minimum is in Perseus. Radiation of measurable intensity is found coming from the sun.

Ruby Payne-Scott

Sydney
Australia
1942

Sydney
Australia
1942

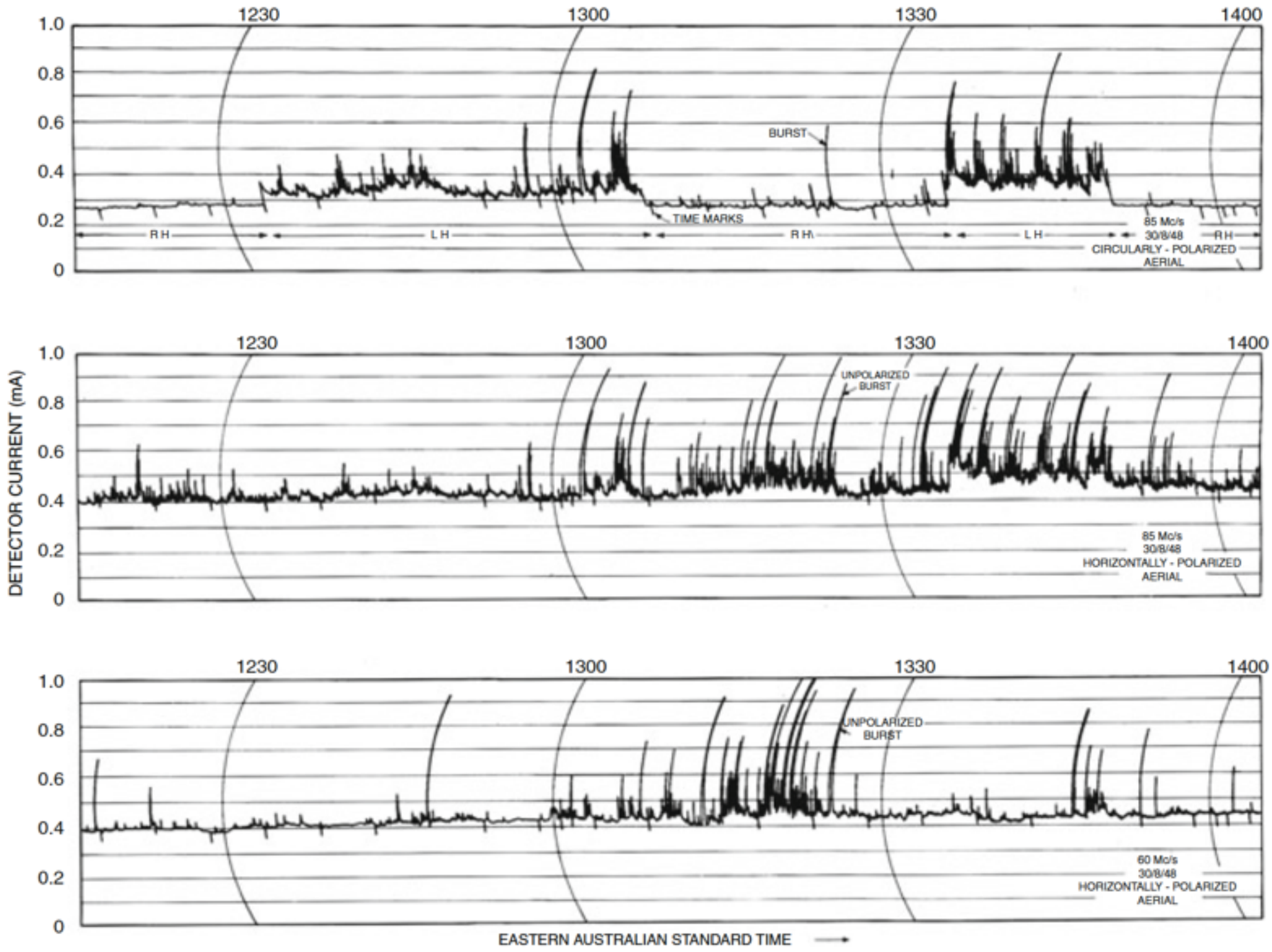


Fig. 9.3 An example of a Type I event (called enhanced radiation by Payne-Scott) observed at

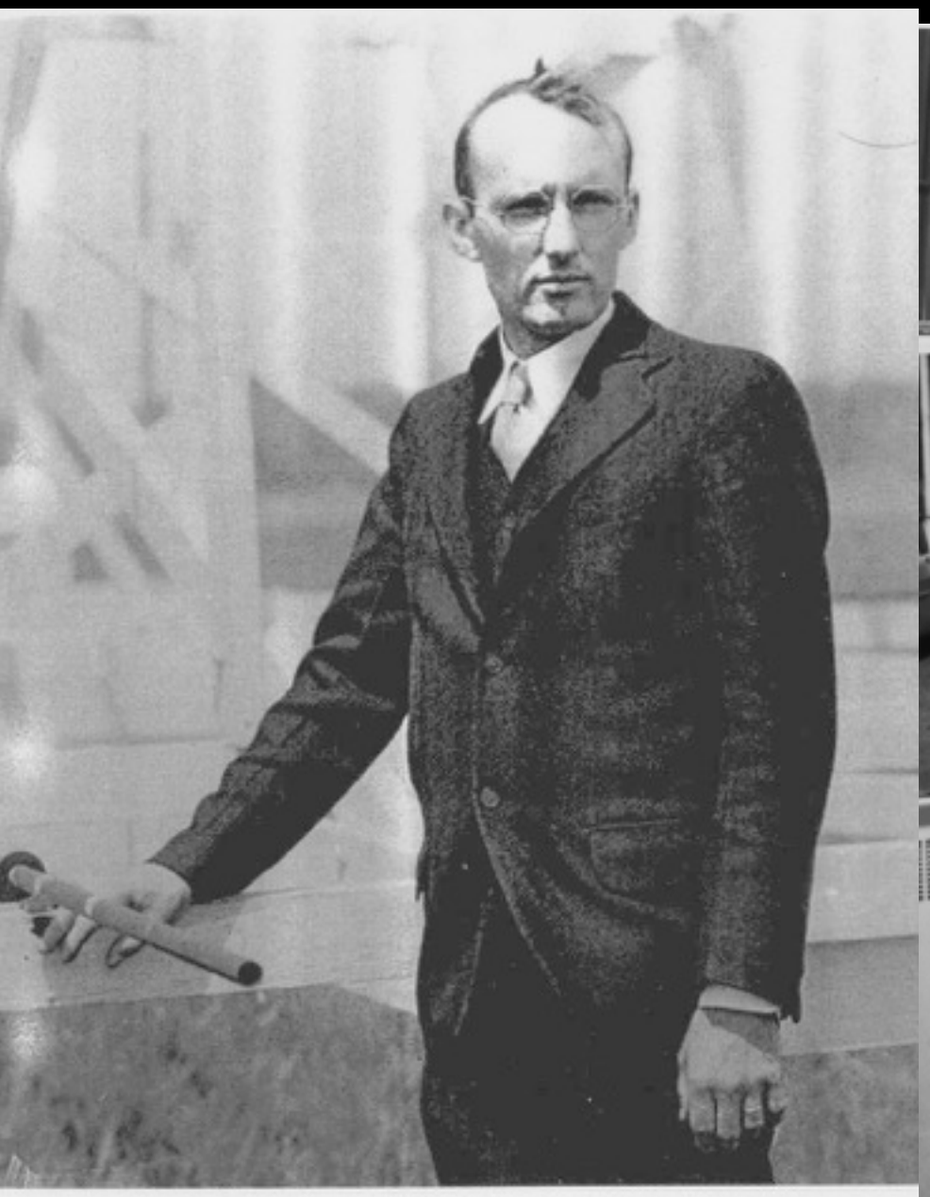


FIG. 1—Karl Guthe Jansky, about 1933.

The New York Times

Overlooked No More: Ruby Payne-Scott, Who Explored Space With Radio Waves

Payne-Scott helped establish the field of radio astronomy by using radio waves to detect solar bursts, but she was forced to resign after she got married.

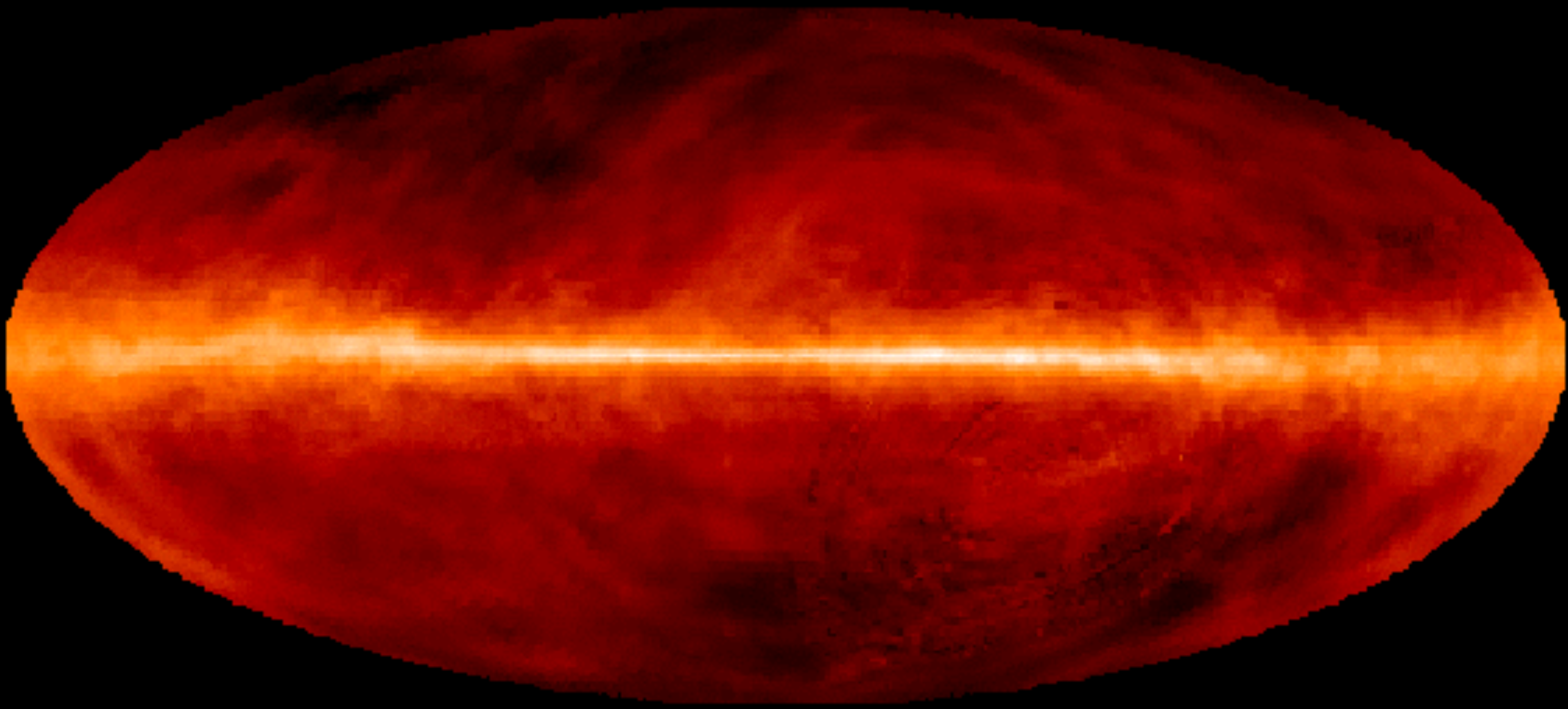
Aug. 29, 2018

Since 1851, obituaries in The New York Times have been dominated by white men. With Overlooked, we're adding the stories of remarkable people whose deaths went unreported in The Times.

Jan Oort (1900-1992)

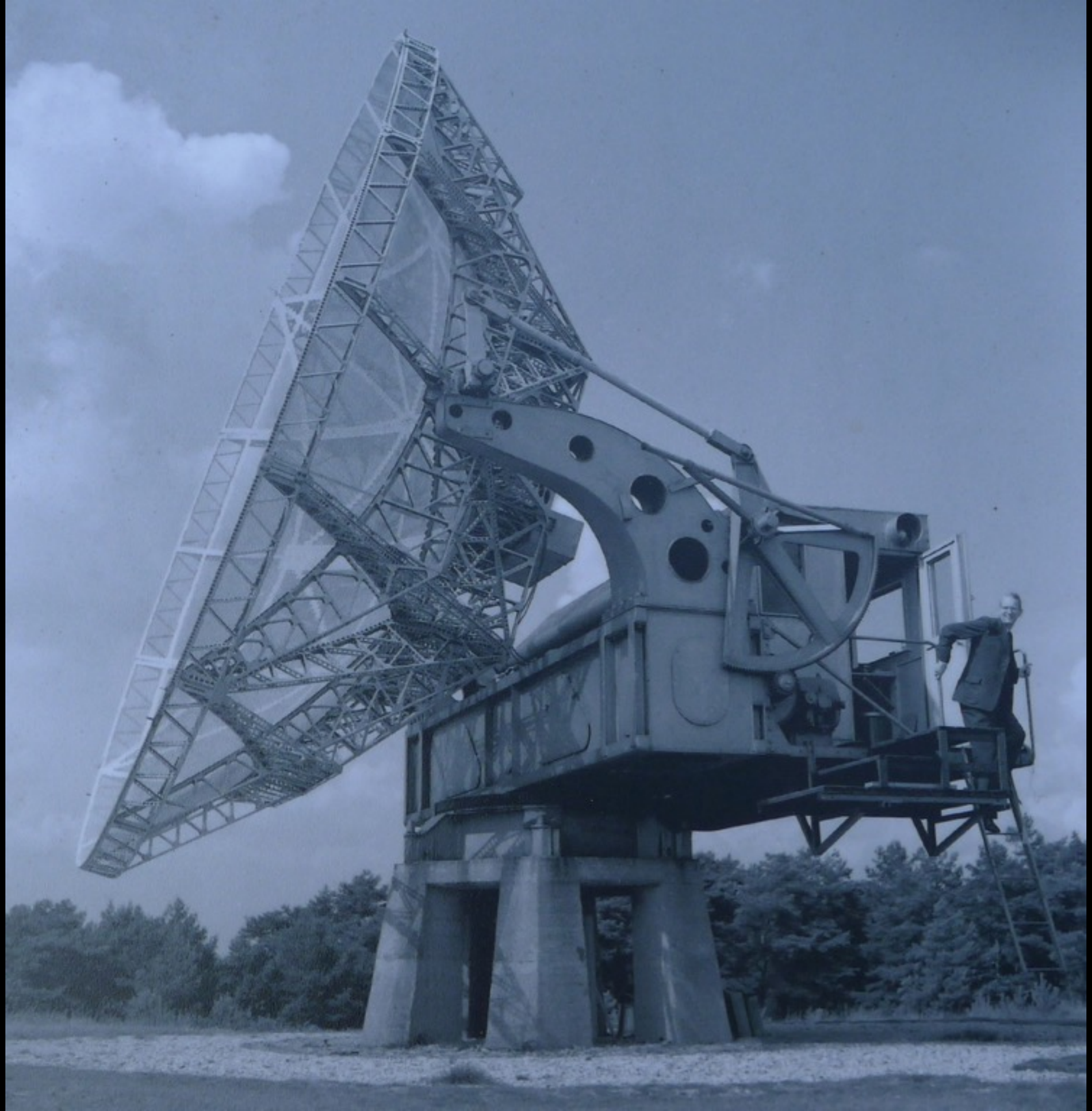
Hendrick van de Hulst

“Doc” Ewen
1951



2. In discussion with H.C. van de Hulst, at the reception on the occasion of Oort's quadrennial jubilee as a staff member of Leiden Observatory, 1964.

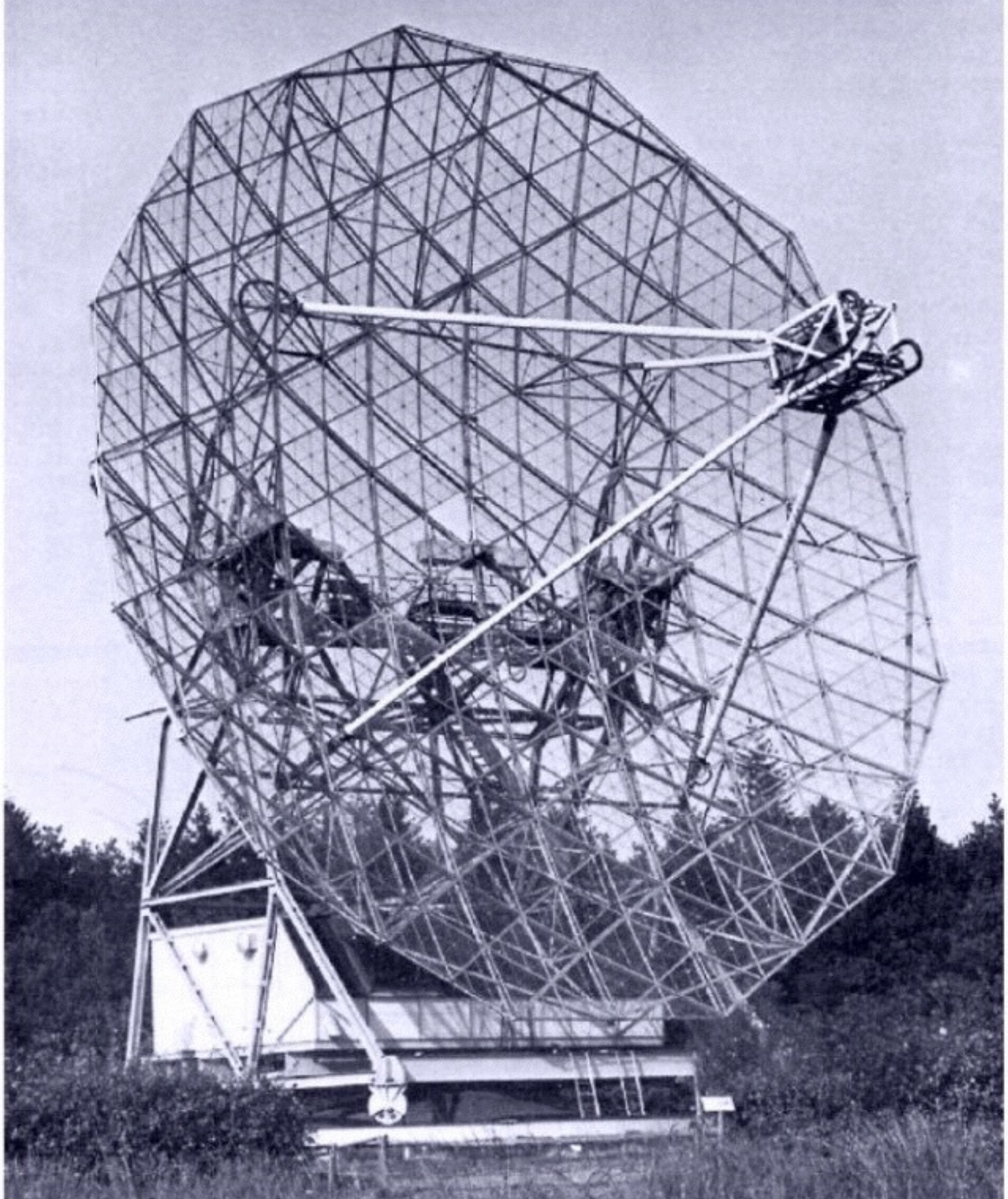
Kootwijk 1952



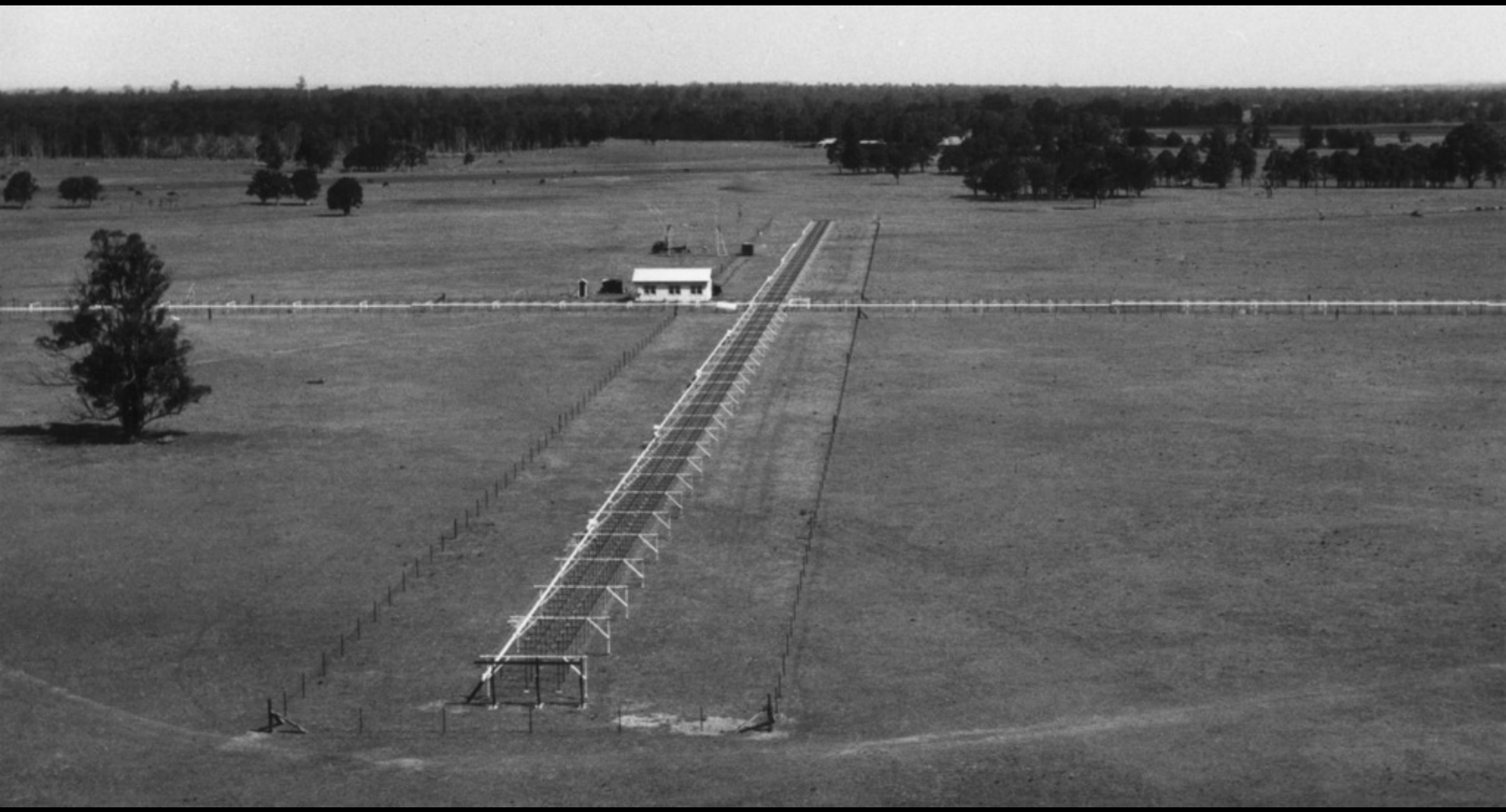
1952

Figure 15 - The Potts Hill Antenna

Dwingeloo
1956

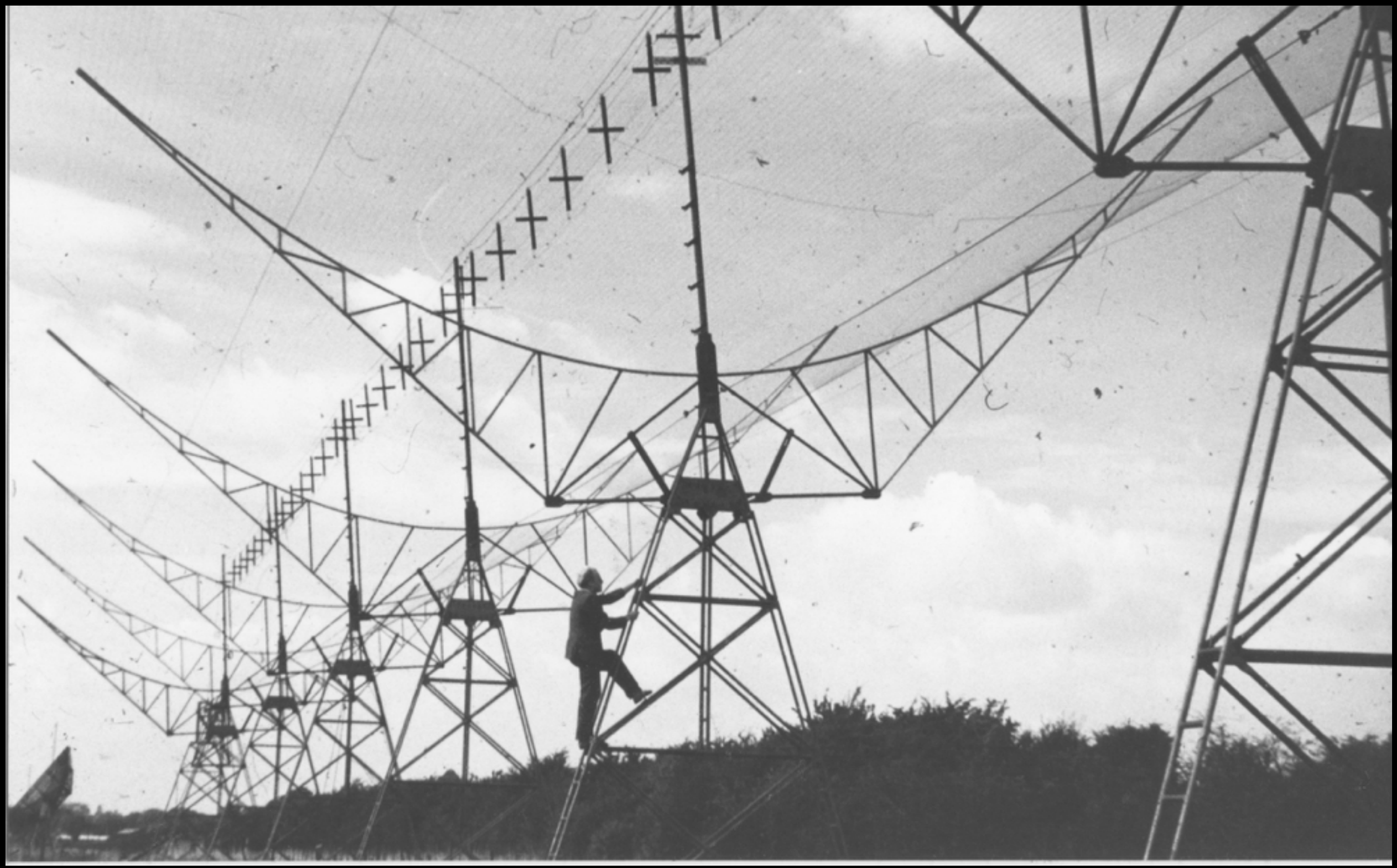


Mills Cross 1954 — Australia



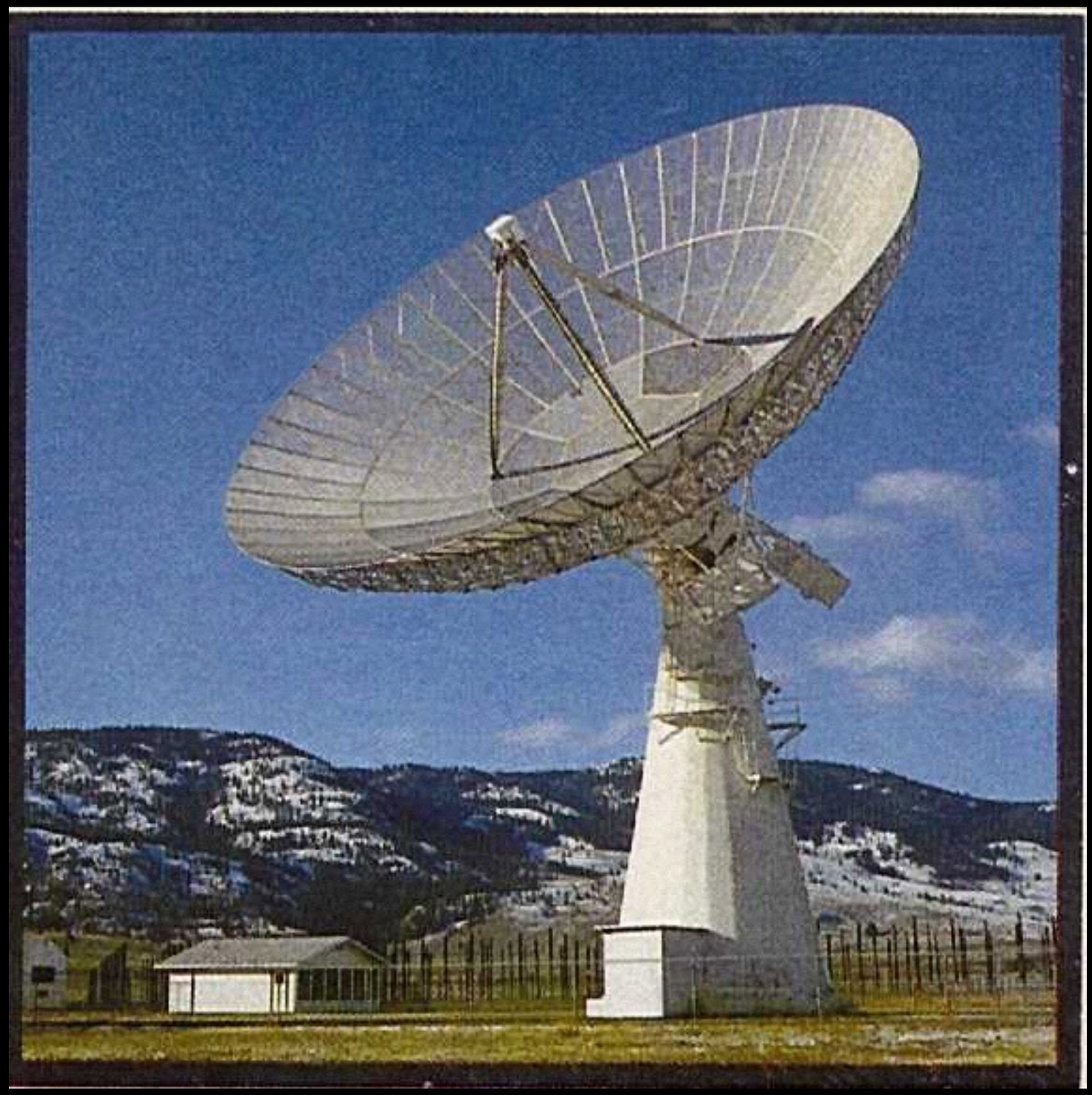
Jodrell Bank 250 foot, 1957 — Manchester England

3C Aerial with Graham Smith 1959— Cambridge

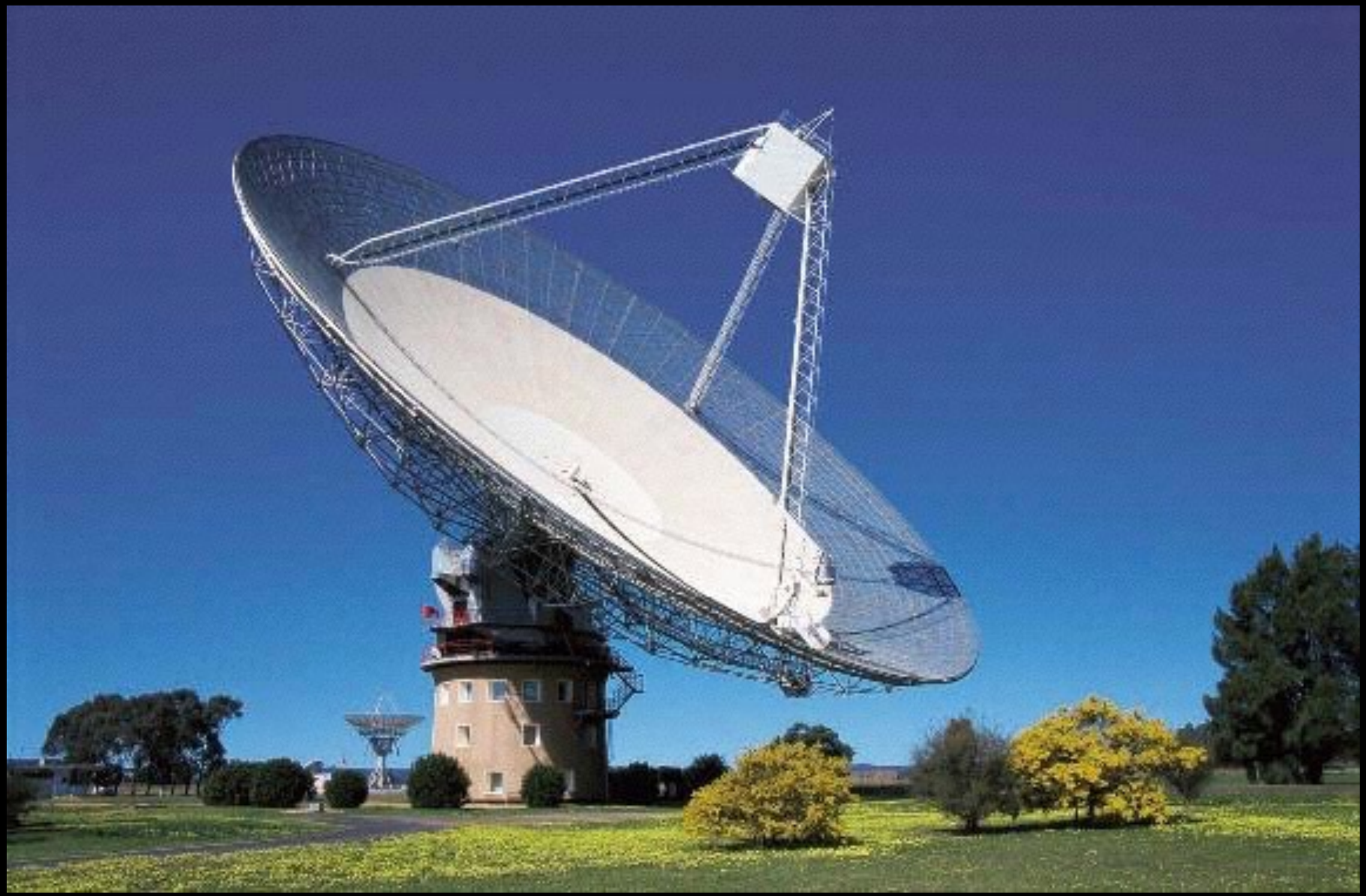


Burke-Franklin Array 1955

Penticton 26 meter telescope, Canada 1961



Parkes 210 foot, Australia 1961



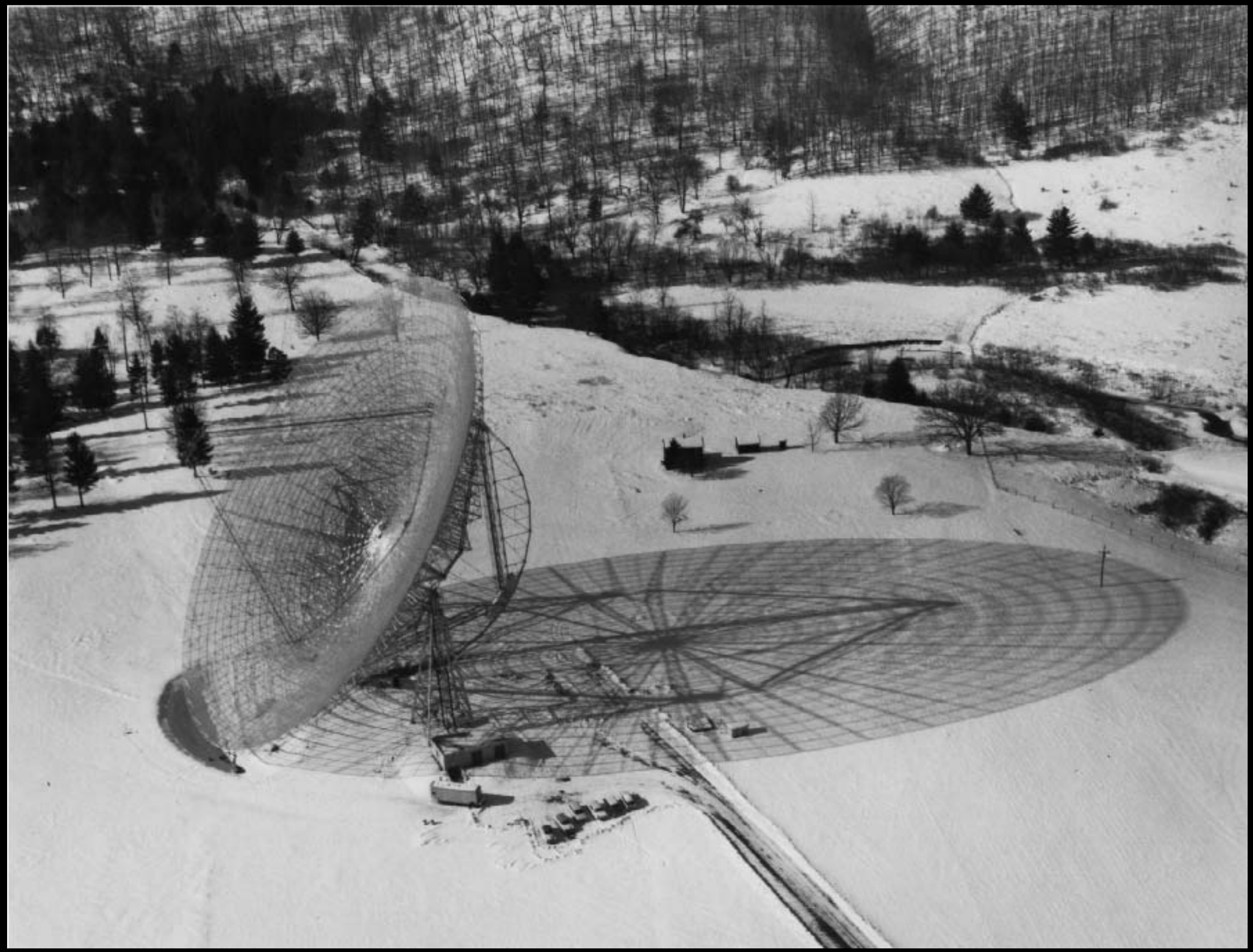
Arecibo 1000 foot telescope, Puerto Rico — 1963

Nancay telescope —France 1965

Hewish Array 1967 — Cambridge

81.5 MHz — 4.5 acres

Green Bank 300 foot telescope 1962—West Virginia



Green Bank 140 foot telescope 1964 —West Virginia

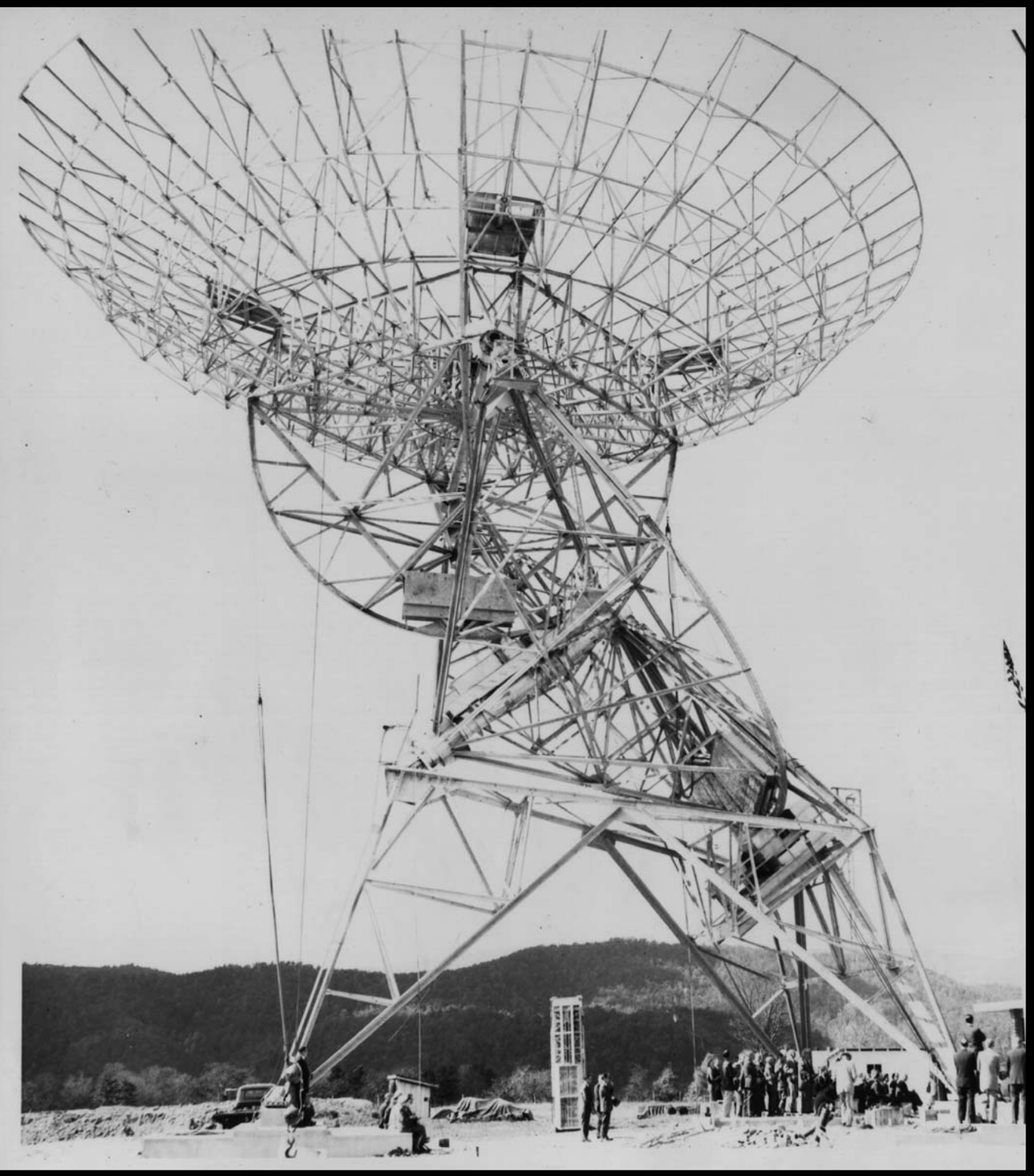
Cambridge 1 Mile telescope 1964 — England

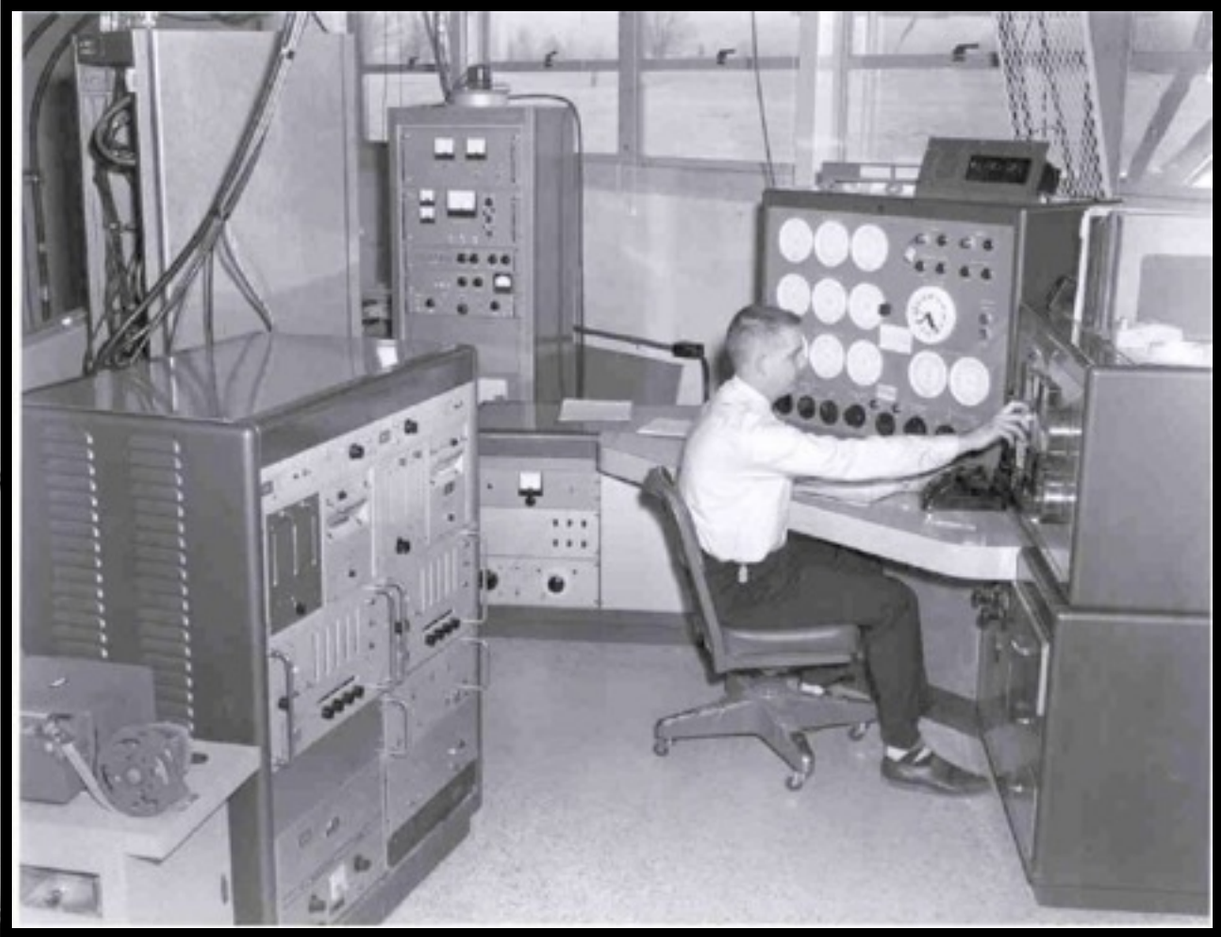

NSF

The National Radio Quiet Zone 1956

Finding Green Bank, Dec 1955

NRAO's first telescope
The Tatel 85-foot

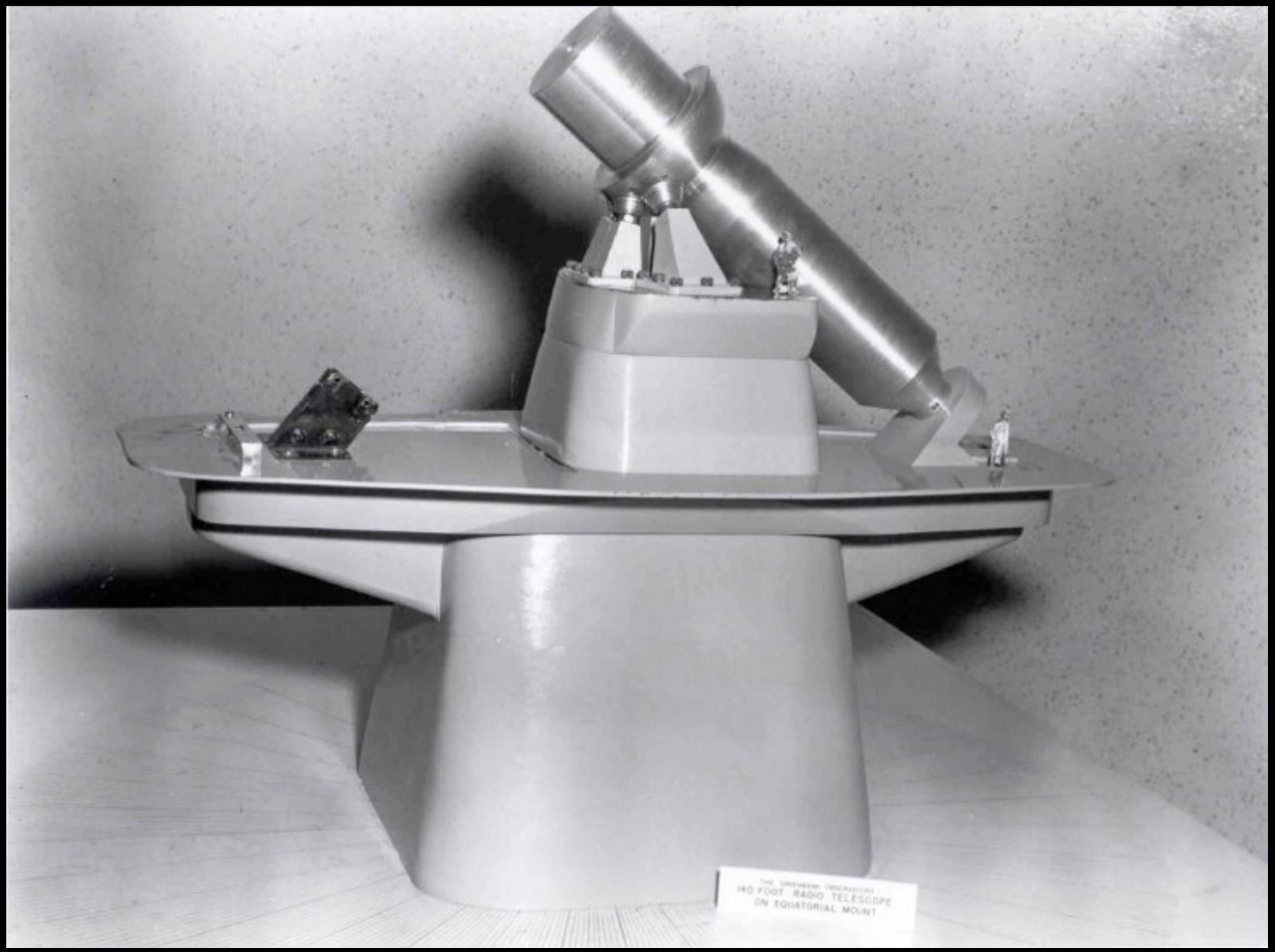




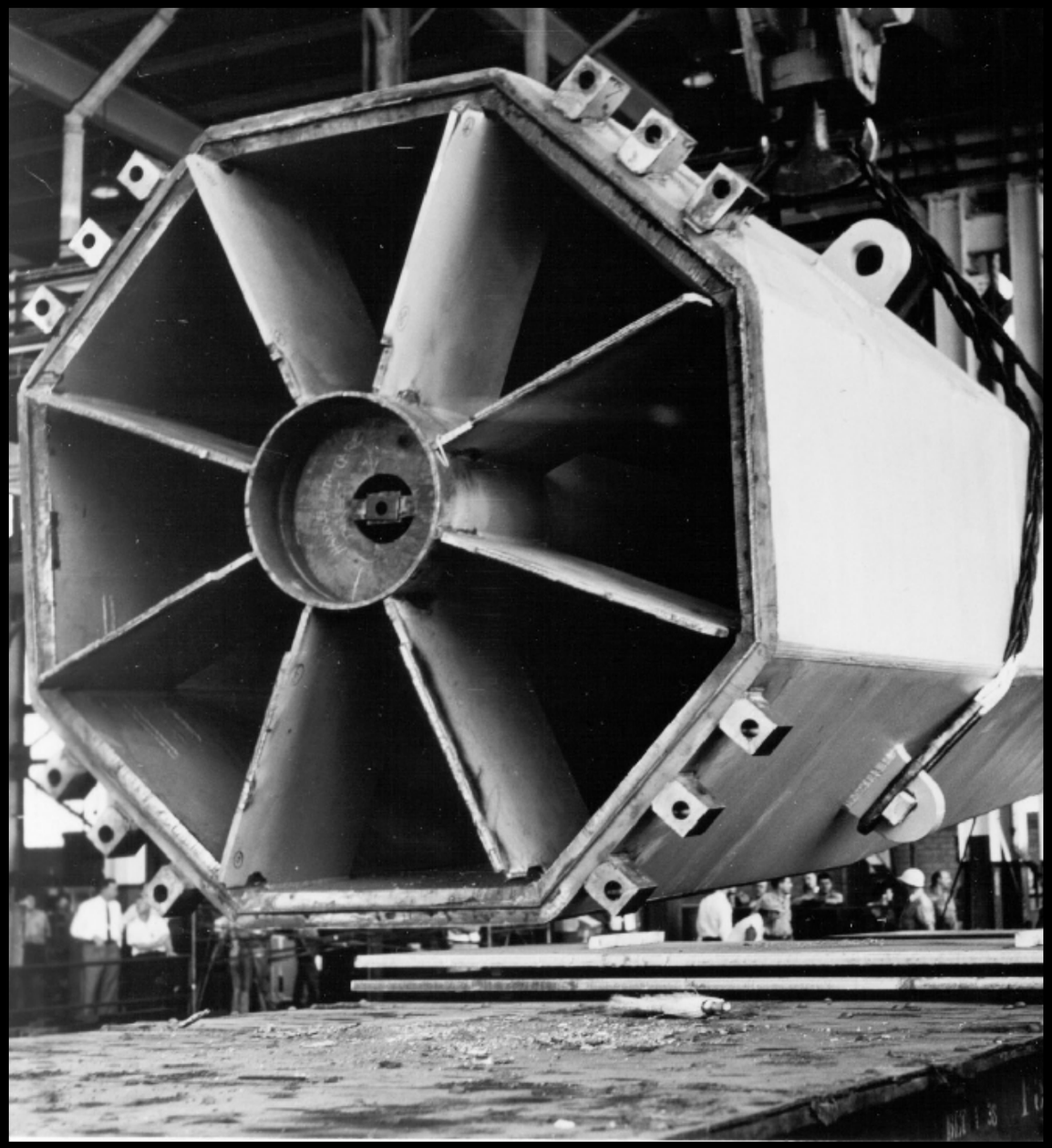
Dedication October 16, 1958

The 140-Foot Telescope

The 140-Foot Telescope



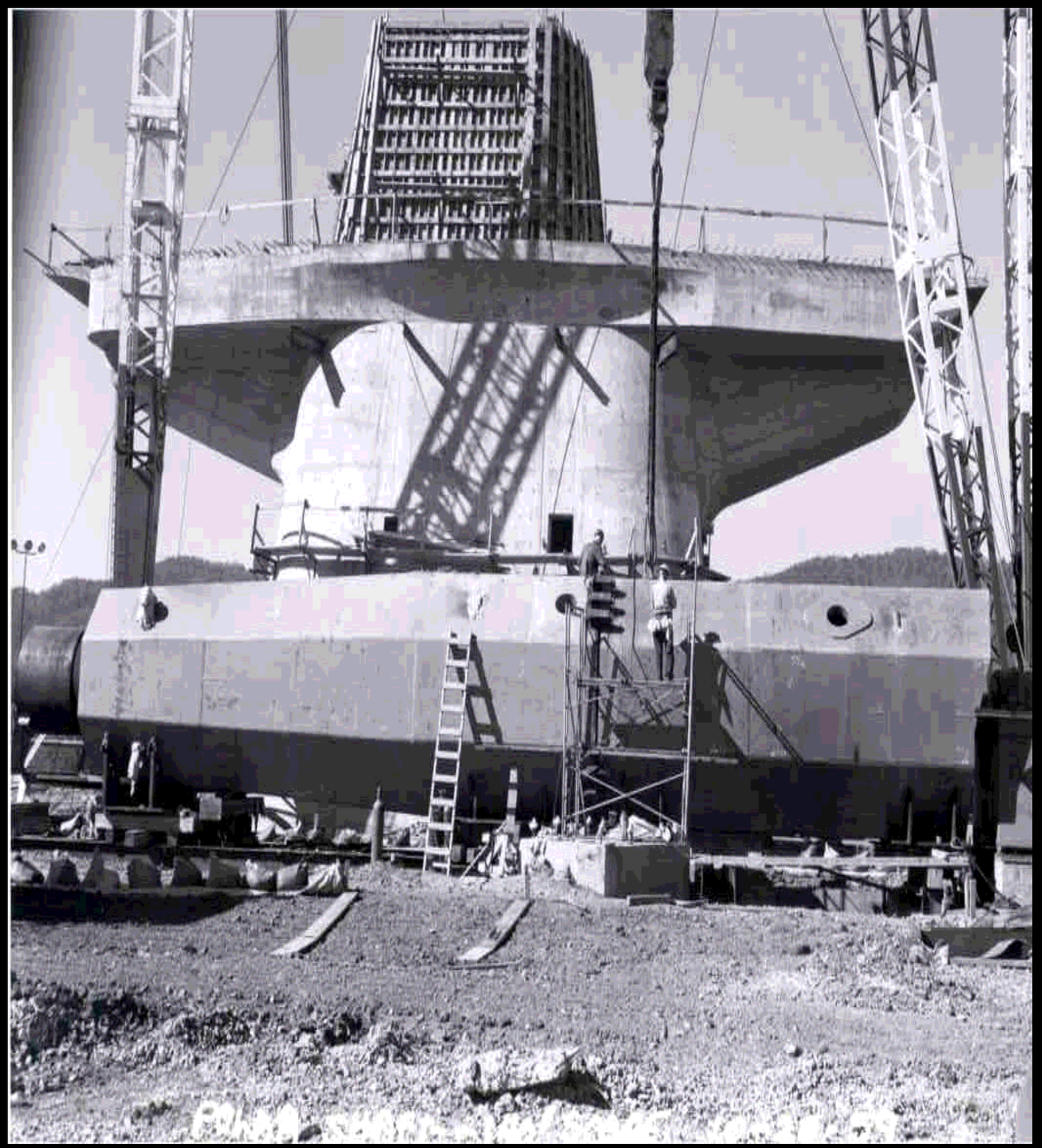
The 140-Foot Telescope



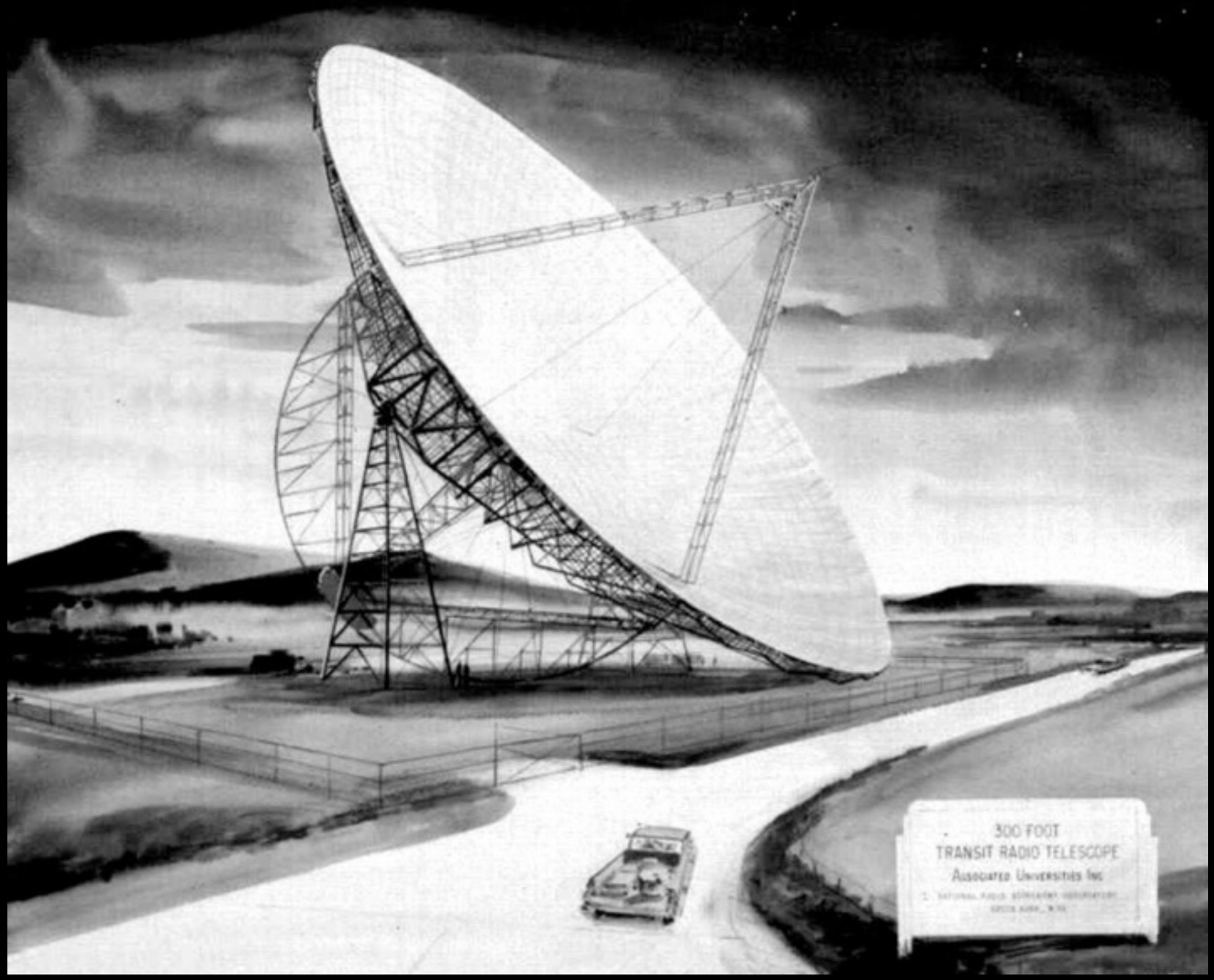
the first polar shaft

The 140-Foot Telescope

polar shaft being welded at Green Bank before a problem was discovered with the steel...



The 300-Foot Telescope



The 300-Foot Telescope

1960: Study of various design concepts

1960 - Oct: 300-ft “transit” concept chosen -- project begins

1960 - Nov: Bob Hall designs 300-ft transit telescope

1960 - Dec to 1961 March: Design refined

1961 - March: Construction Bids Requested

1961 - April: Contract for construction signed

1961 - May: Groundbreaking

1961 - Dec: Steel Work Completed

1962 - Spring: Surface attached; electronics installed

1962 - Sept: 300-ft Telescope Completed

Total time: 23 months
Total Cost: $1.2M

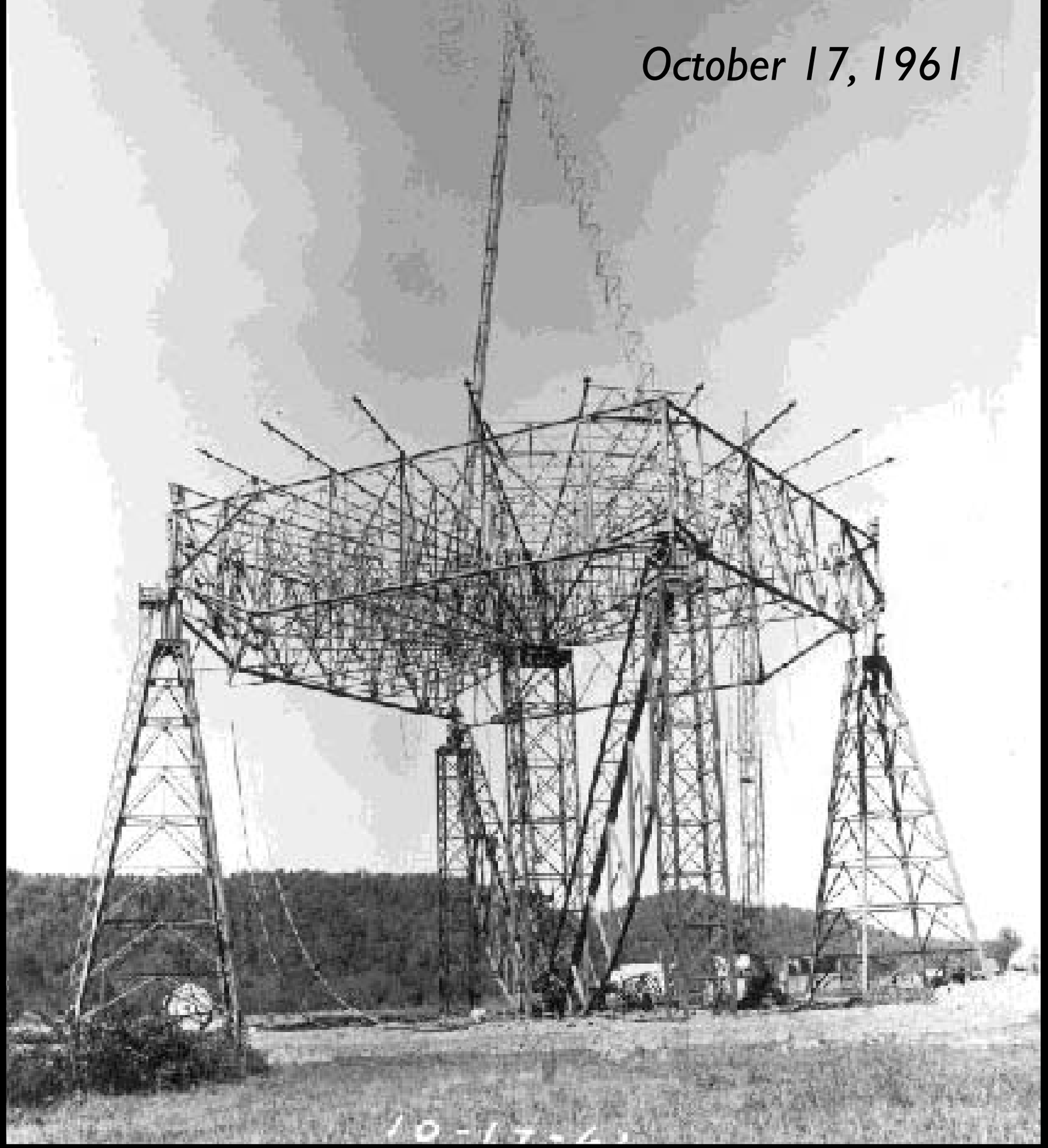
March 1961

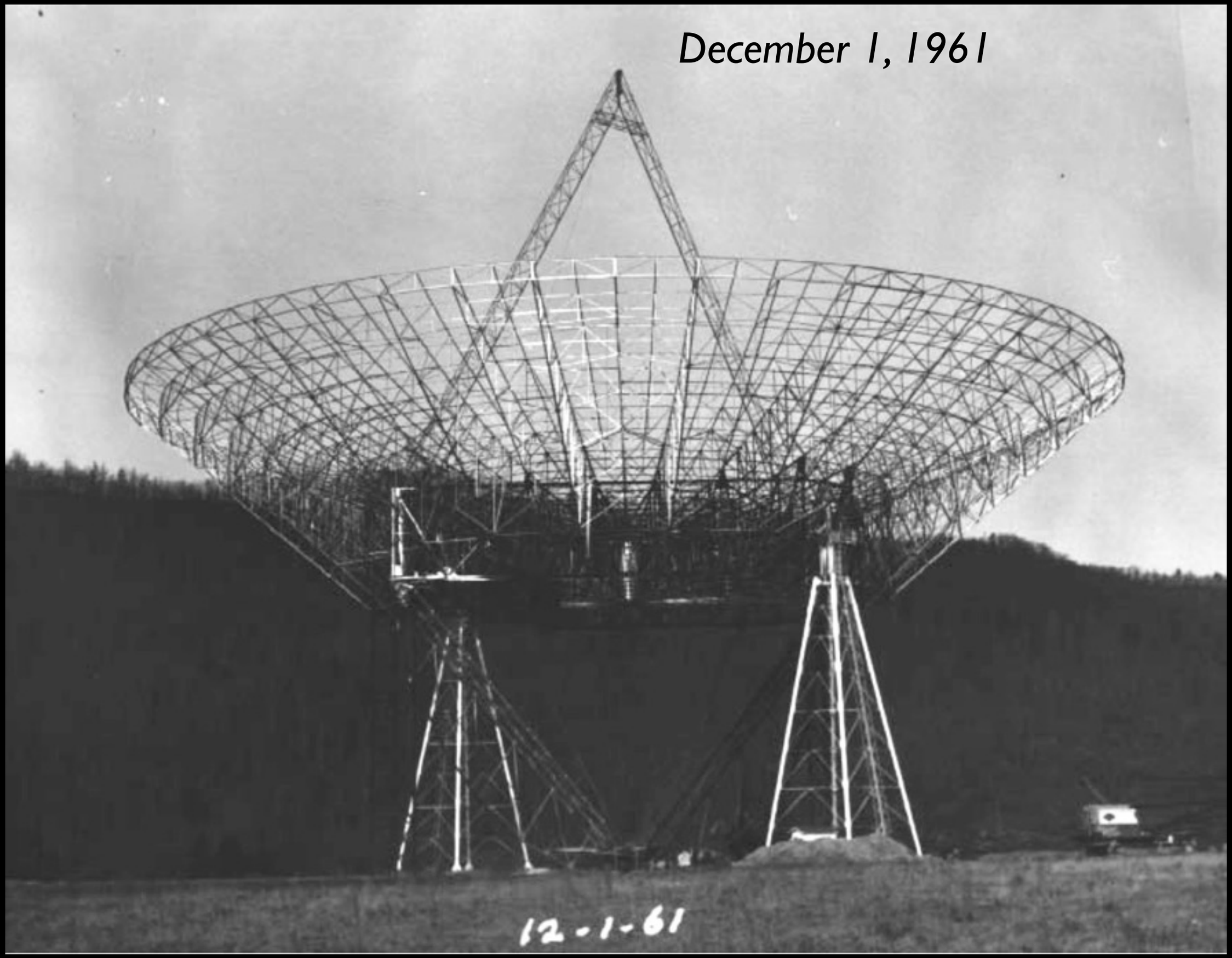
May 1961

early October 1961

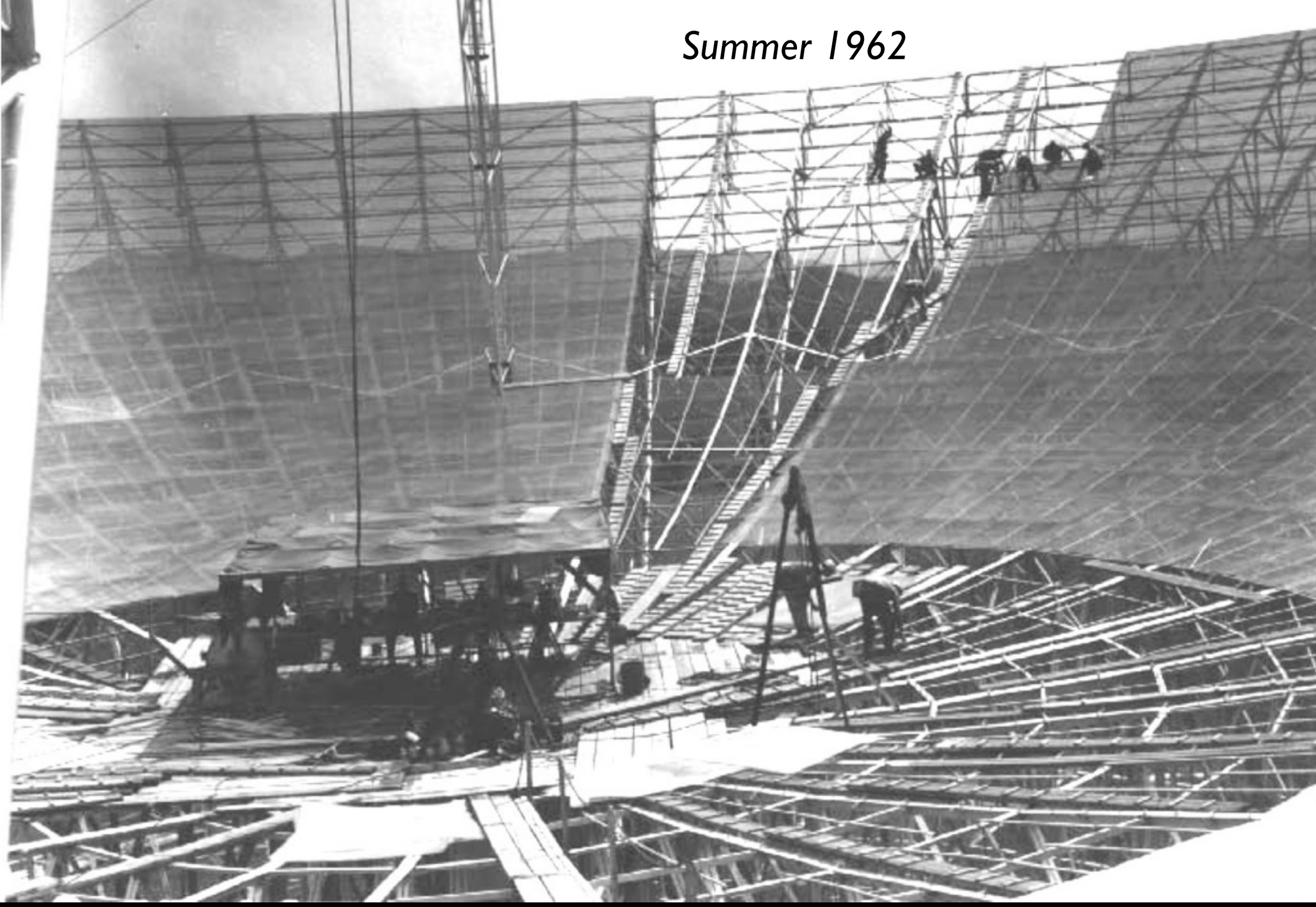
10-6-61

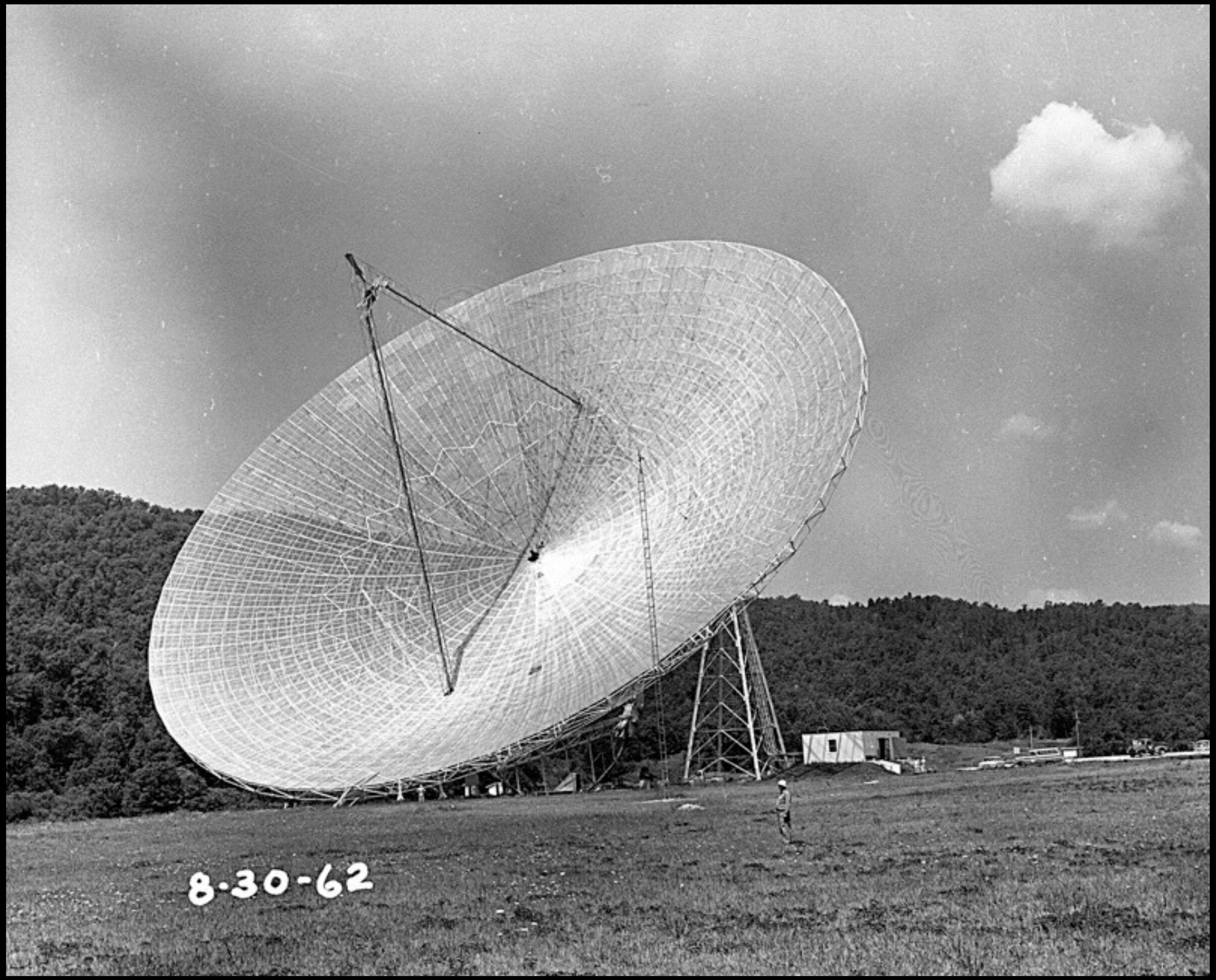
October 17, 1961




December 1, 1961
12-1-61

Summer 1962

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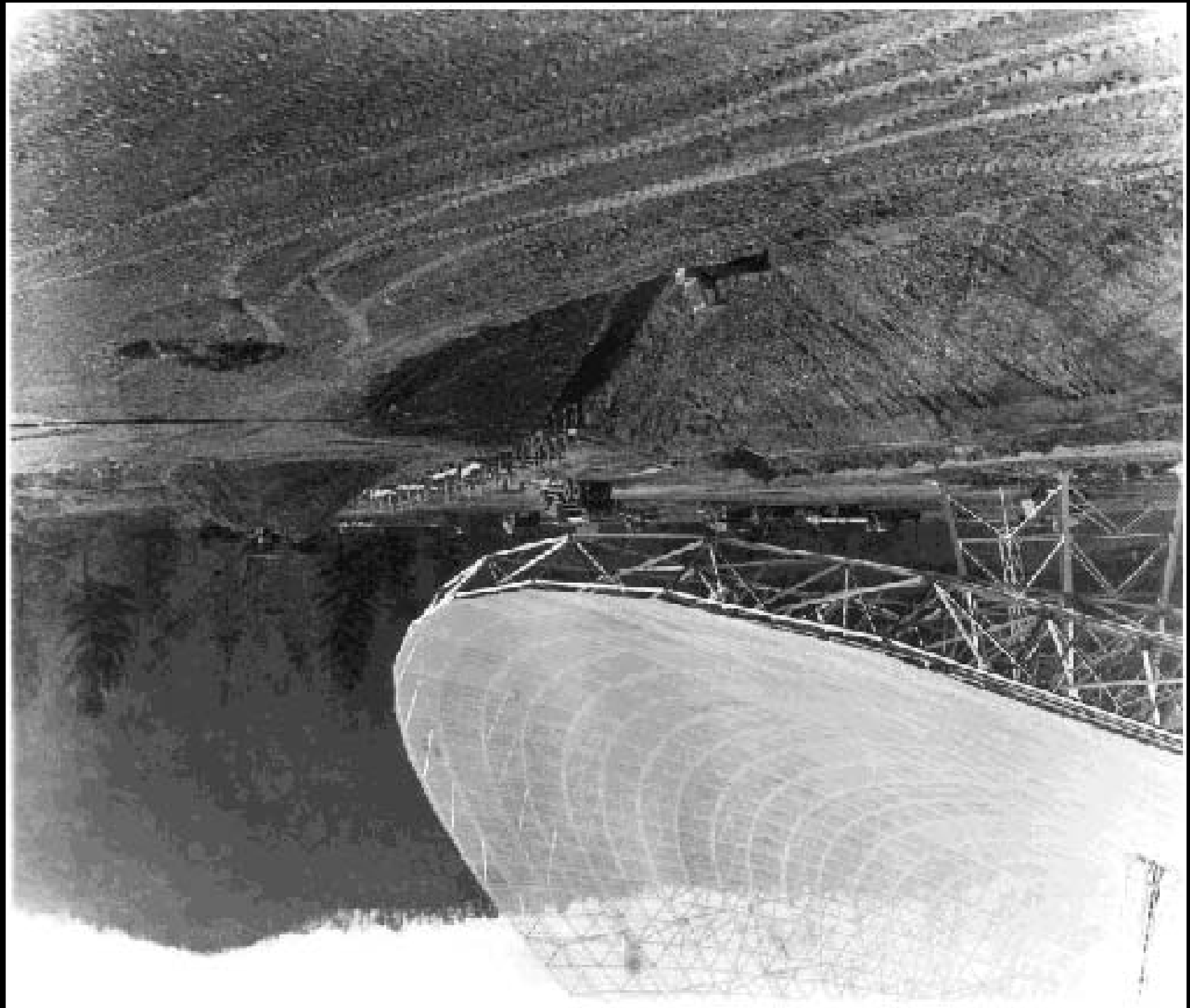
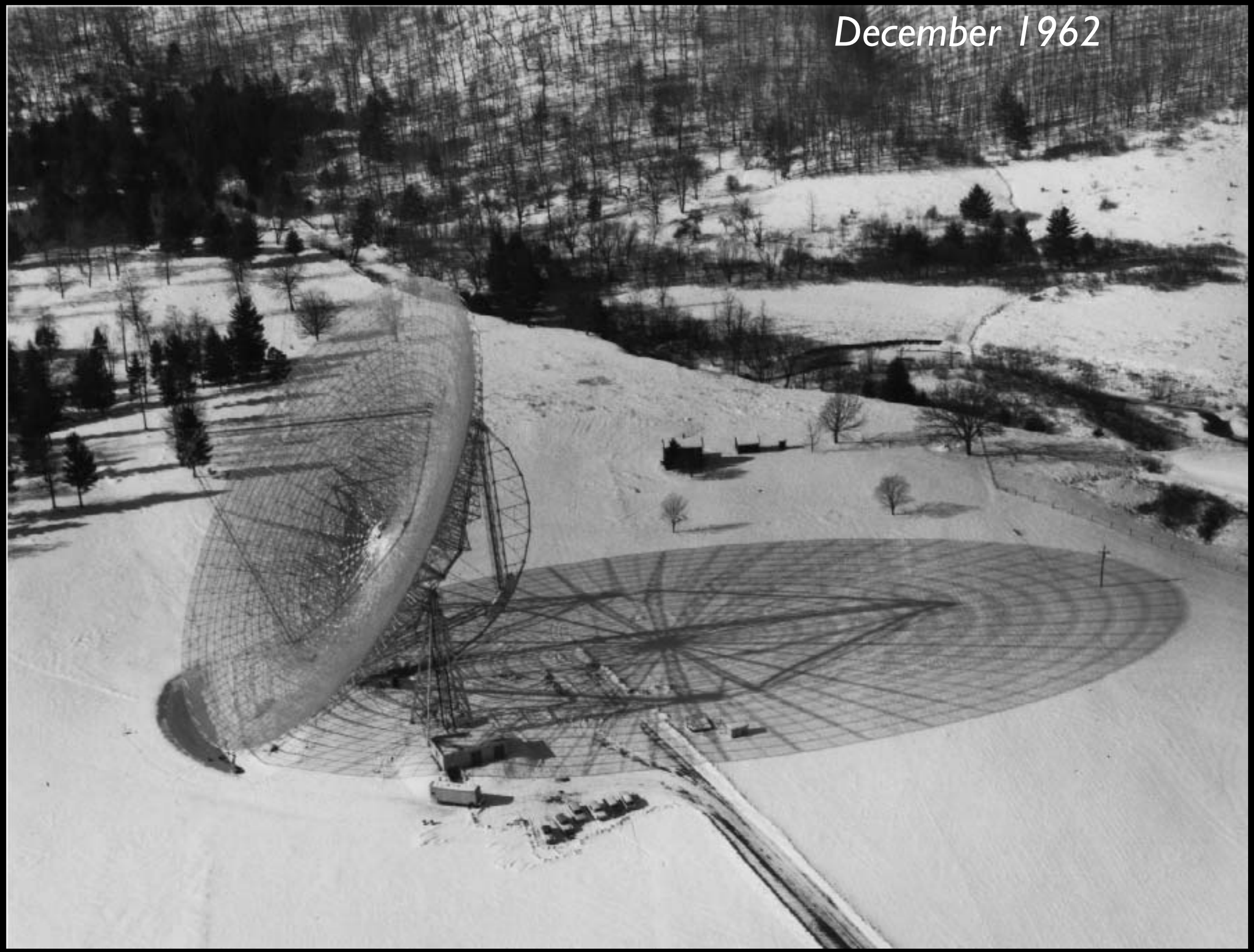
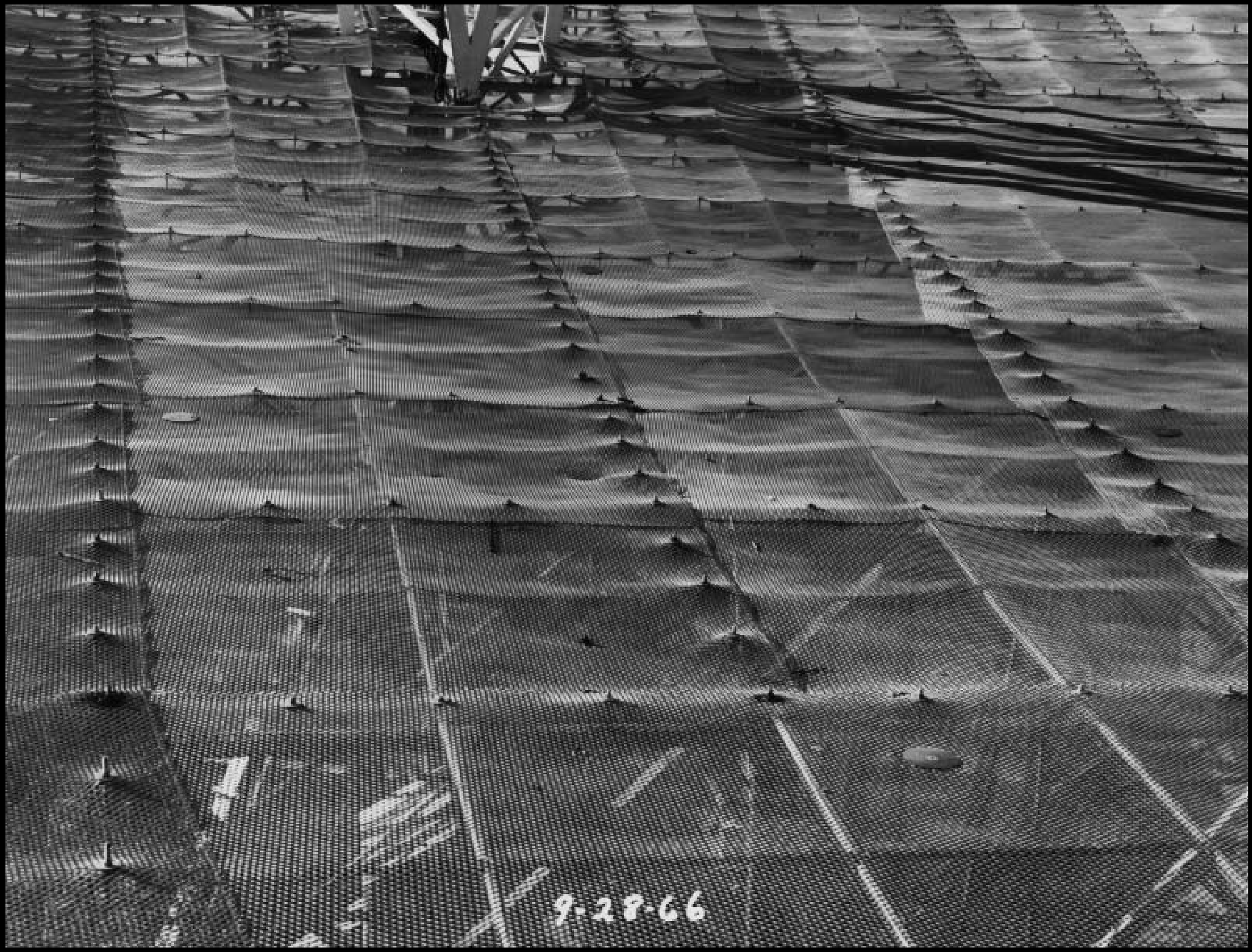
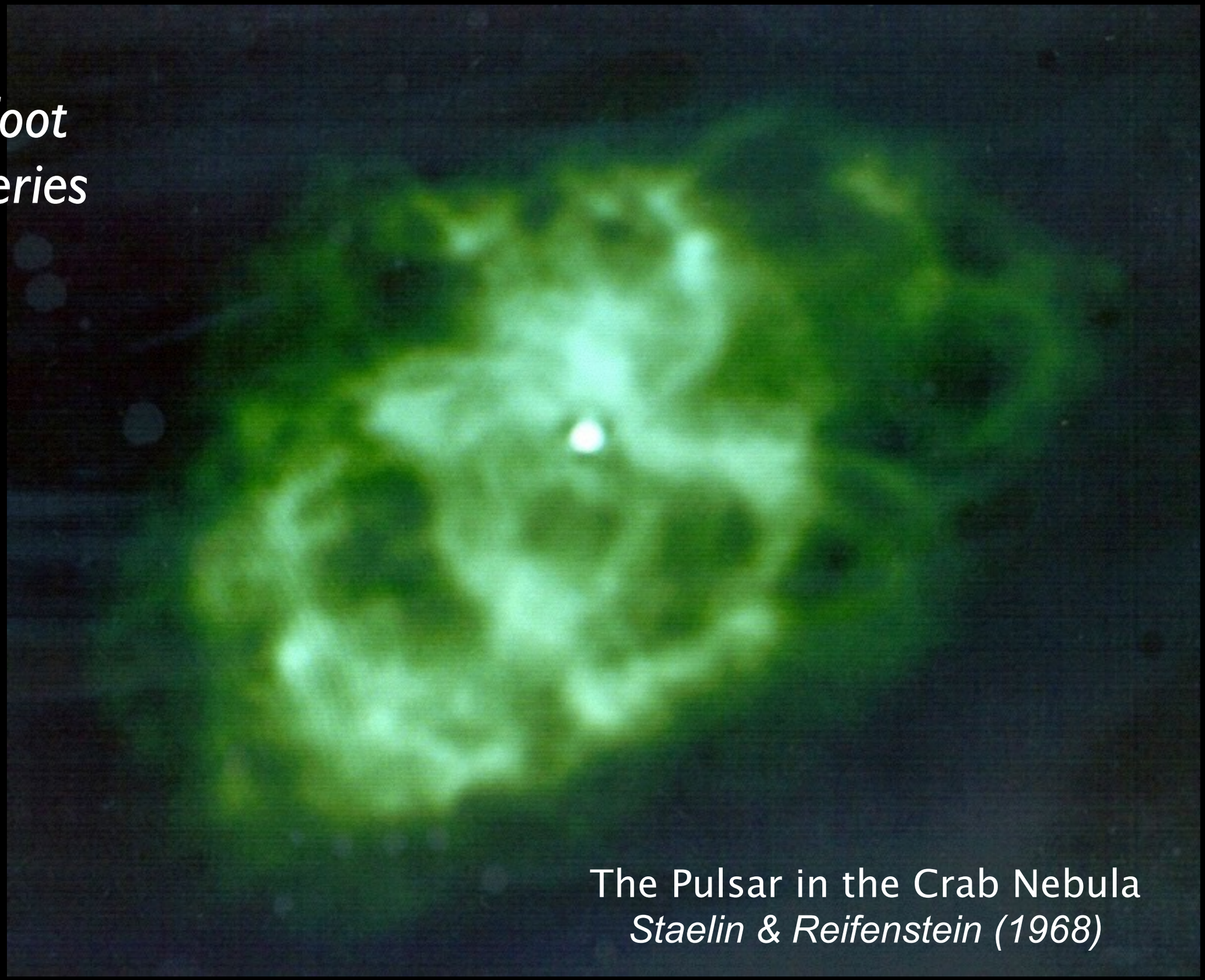



December 1962


9-28-66

New Surface 1972

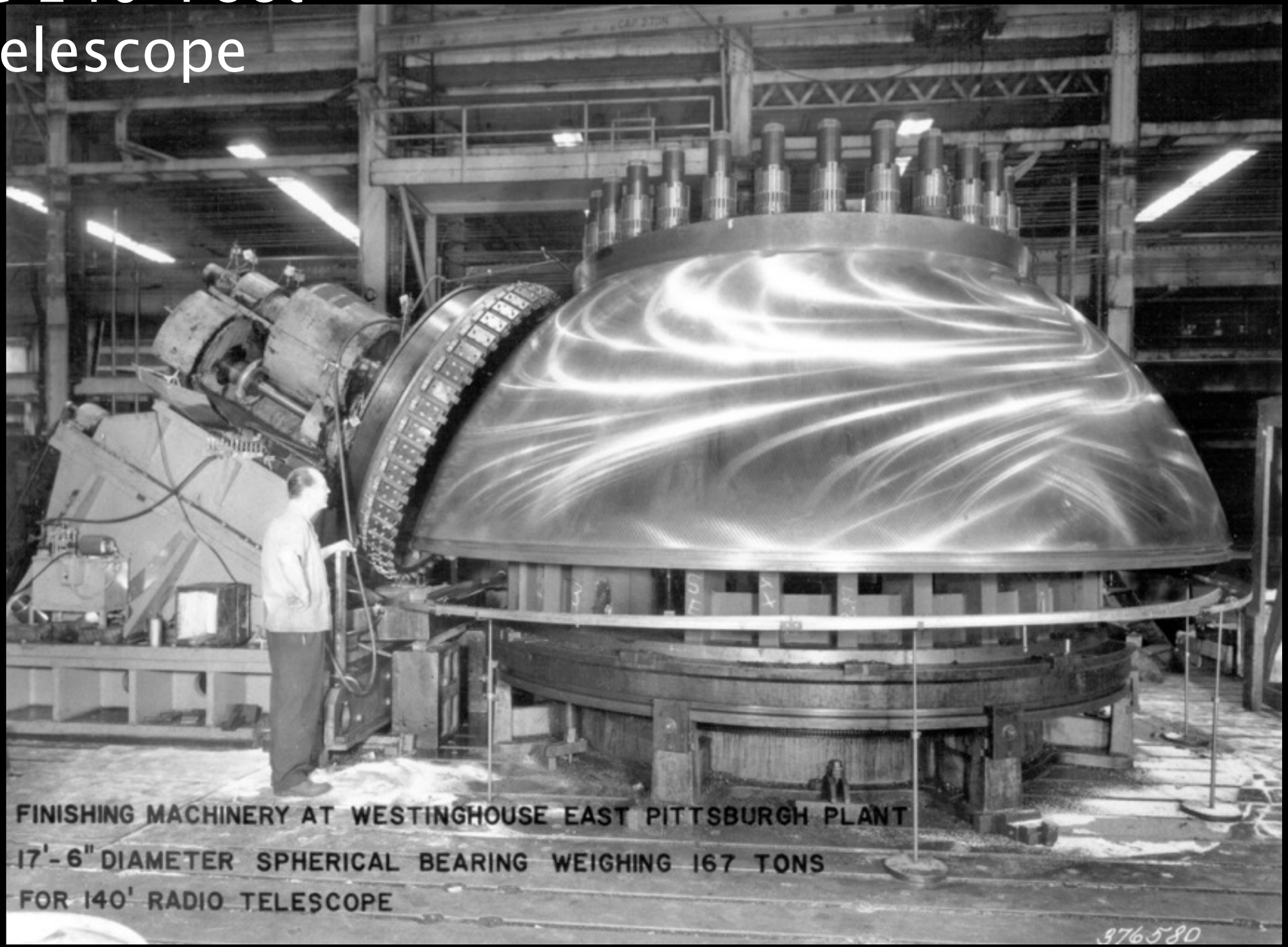
300-Foot Discoveries



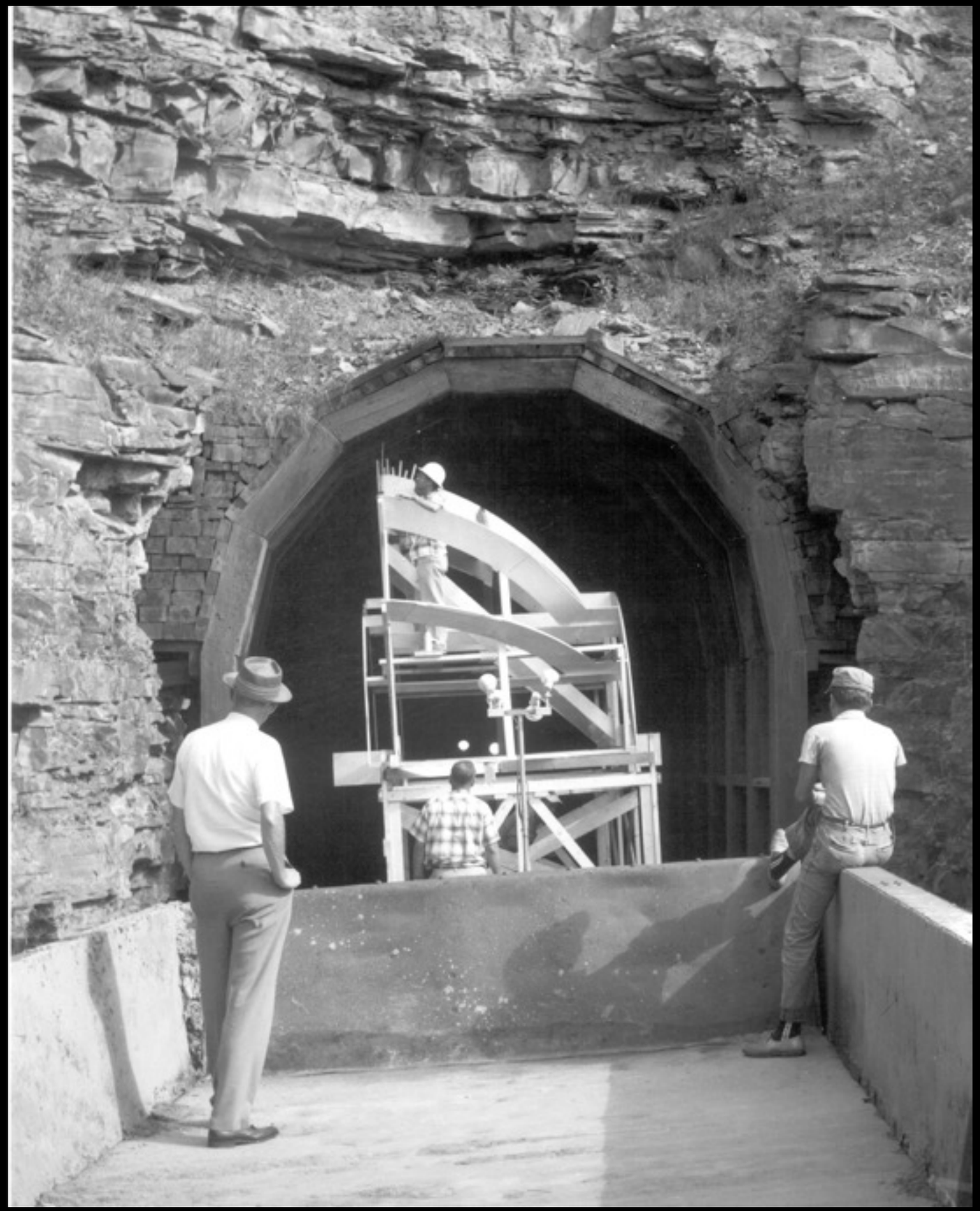
The Pulsar in the Crab Nebula
Staelin & Reifenstein (1968)

300-Foot Discoveries

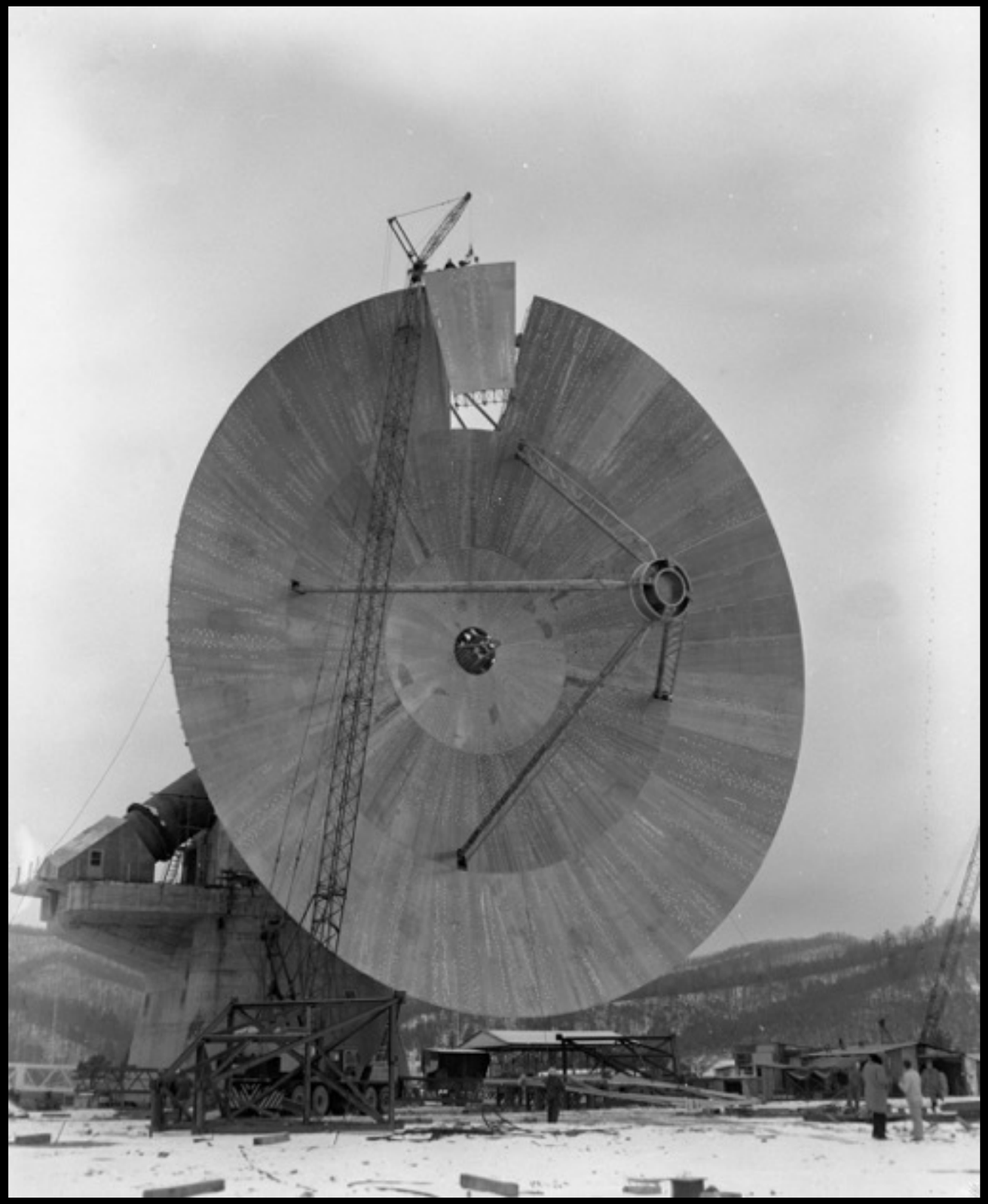
The 140-Foot Telescope



The 140-Foot Telescope



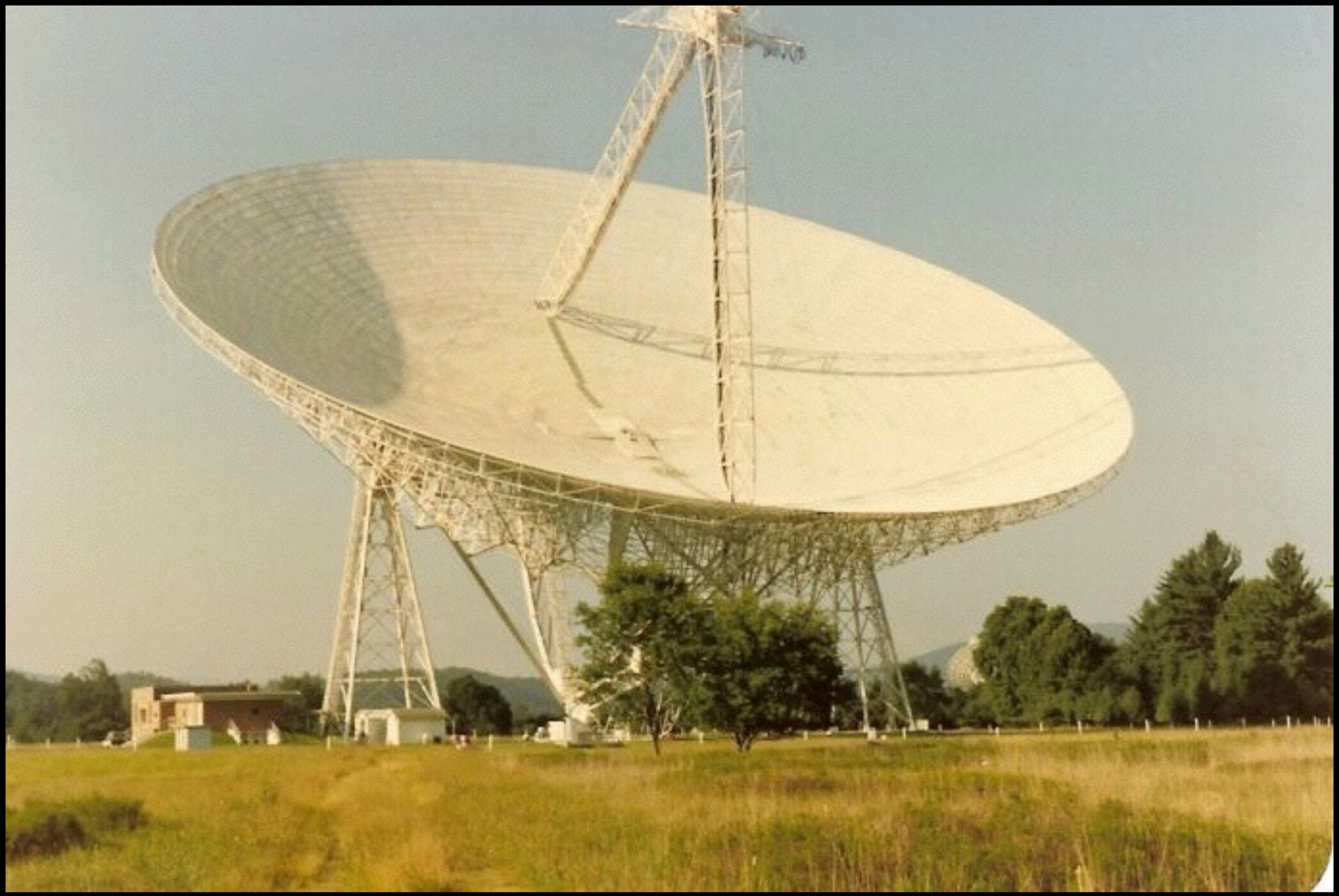
The 140-Foot Telescope



Finished at last
1965

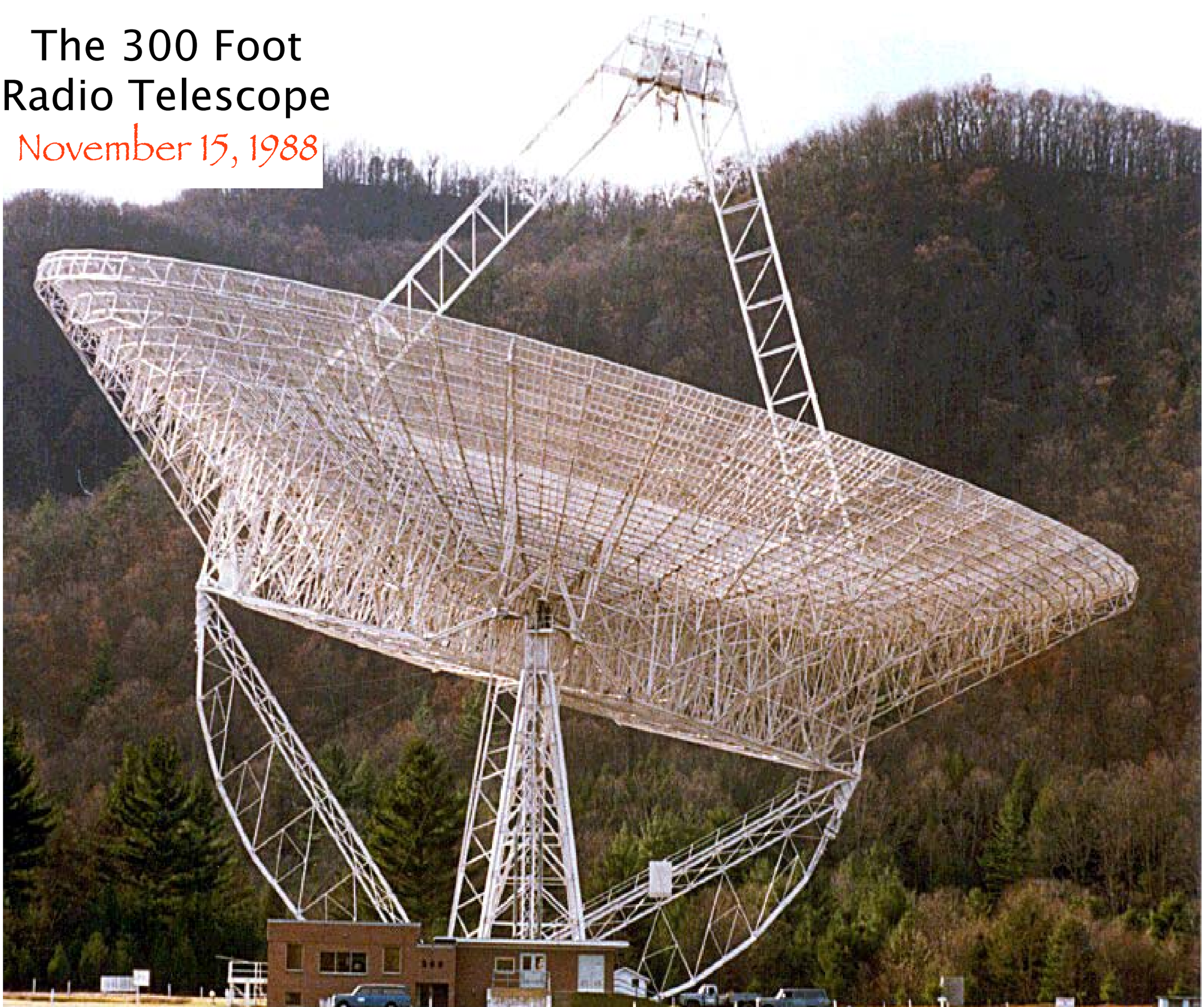
The 140-Foot Discoveries

Radio Recombination Lines



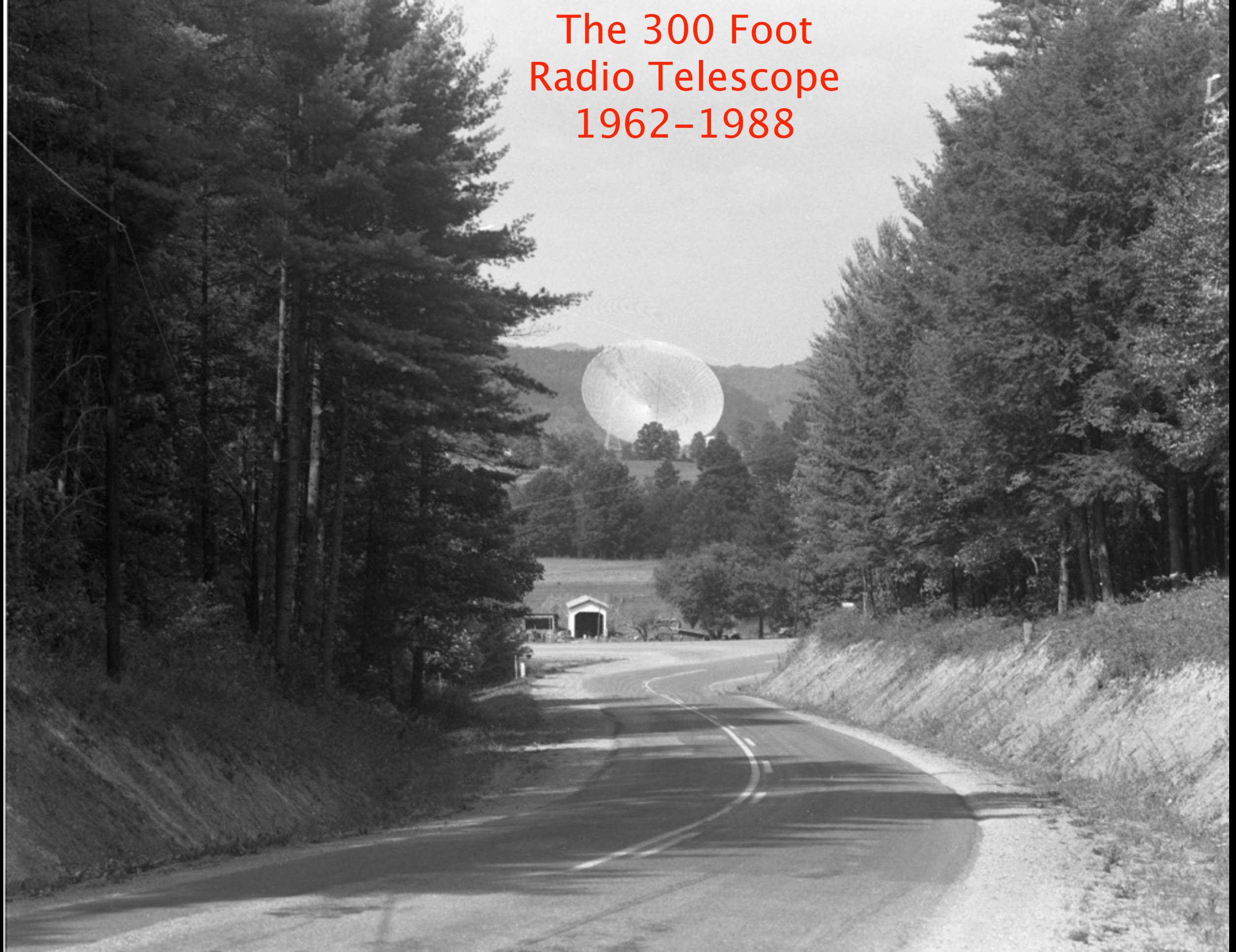
The 300 Foot Radio Telescope

November 15, 1988



November 16, 1988

The 300 Foot Radio Telescope 1962–1988



100 meter Effelsberg 1972 — Germany

http://www.mpifr-bonn.mpg.de/en/effelsberg

Green Bank Telescope 2002 — West Virginia

Bell Labs Horn-reflector 1962 — New Jersey

A MEASUREMENT OF EXCESS ANTENNA TEMPERATURE AT 4080 Mc/s

Measurements of the effective zenith noise temperature of the 20-foot horn-reflector antenna (Crawford, Hogg, and Hunt 1961) at the Crawford Hill Laboratory, Holmdel, New Jersey, at 4080 Mc/s have yielded a value about 3.5° K higher than expected. This excess temperature is, within the limits of our observations, isotropic, unpolarized, and free from seasonal variations (July, 1964–April, 1965). A possible explanation for the observed excess noise temperature is the one given by Dicke, Peebles, Roll, and Wilkinson (1965) in a companion letter in this issue.

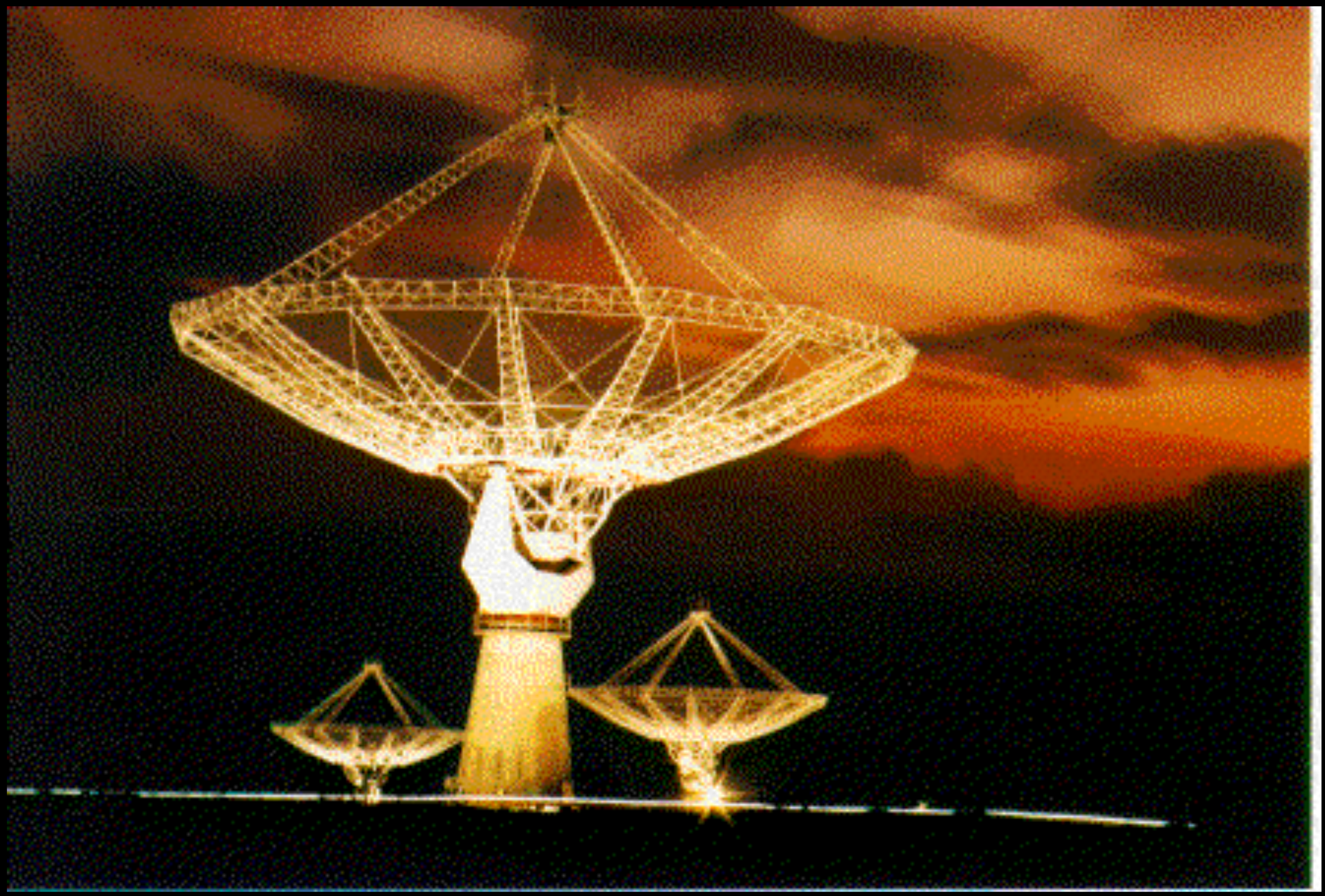
The Big Bang!

The Very Large Array 1980 — New Mexico

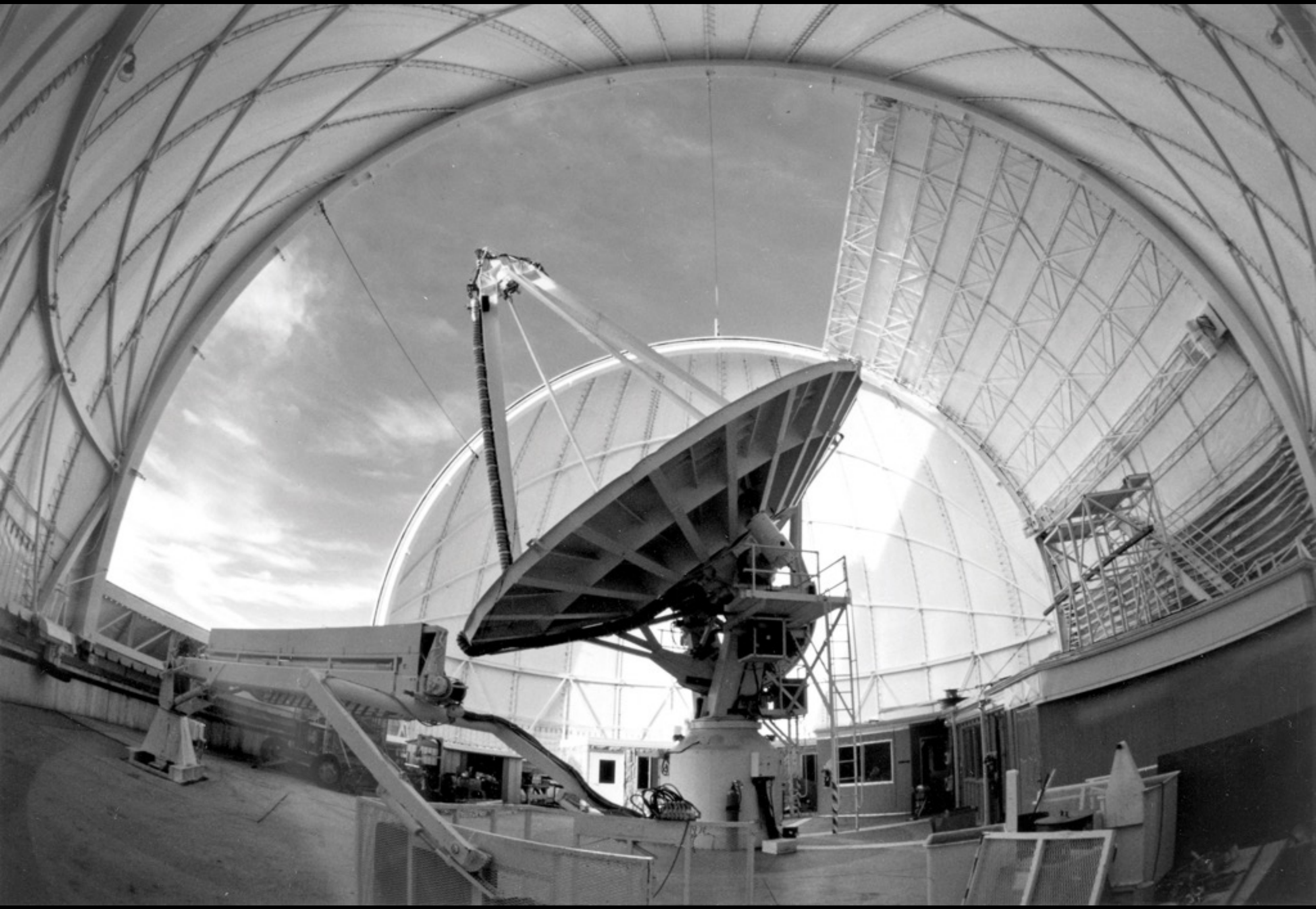
27 x 25m 1.2 - 50 GHz

VLA A configuration

GMRT 30 x 45m ~1998 — Pune India



NRAO 36-foot telescope ~1971 — Kitt Peak Arizona



Columbia University Mini — 1978

1.2 m

IRAM 30m 1980 — Spain

LMT 50m ~2018 — Puebla Mexico

CARMA 2008 — Inyo Mountains California

6 x 10.4m + 9 x 6.1m + 8 x 3.5m

ALMA 50 x 12m 2011 — Chile

NOEMA 2020 — France

12 x 15m

Future

Future

Future

ajor science goals of the SKA that have emerged from initial discussions.

1999

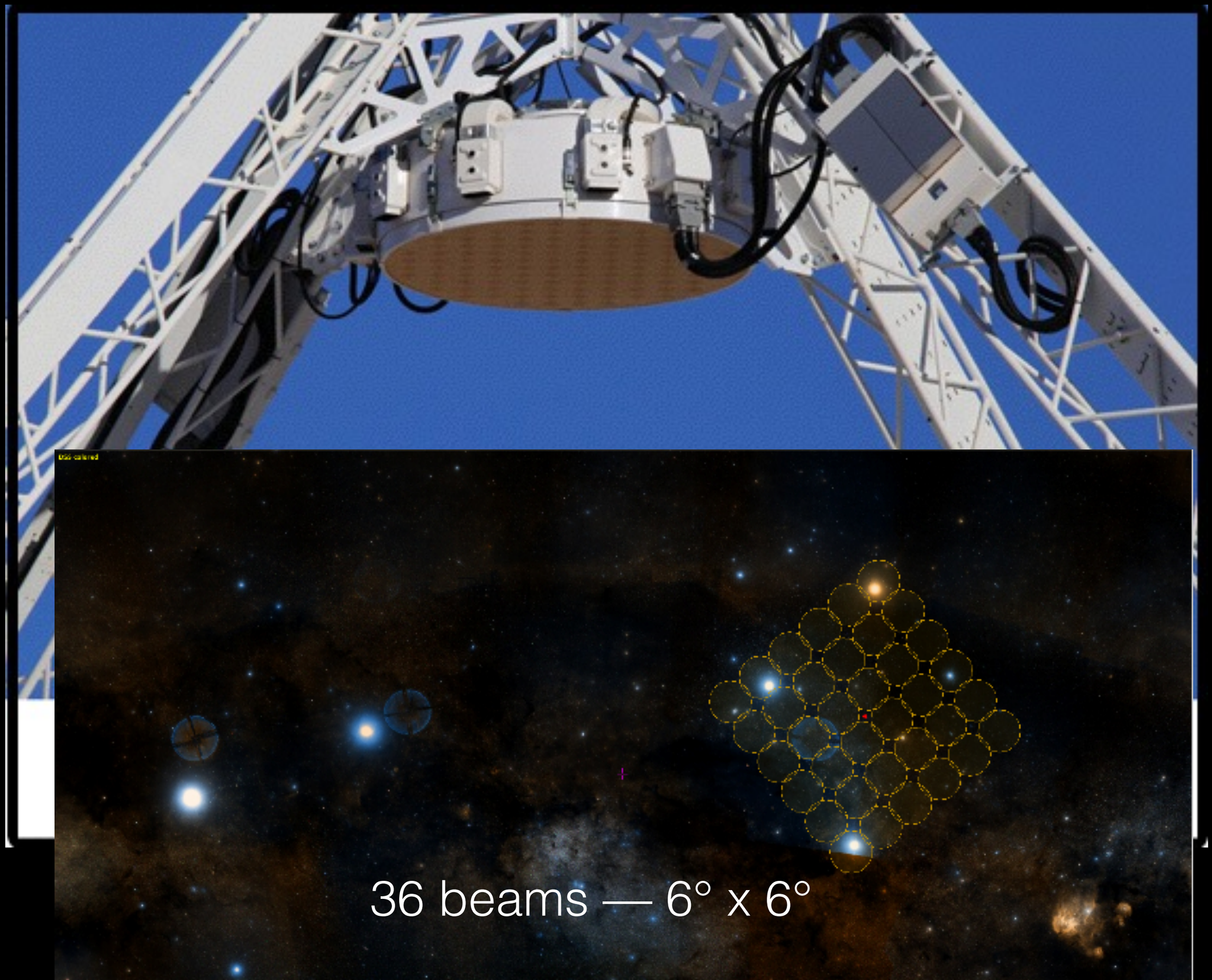
Table 1. Scientific Specification for the Square Kilometre Array

Parameter	***Goal***
A_{eff}/T_{sys}	2×10^4 m^2/K
Frequency range	0.15 – 20 GHz
Imaging Field of view	1° at 1.4 GHz
Number of instantaneous beams	100
Maximum primary beam separation	
Low Frequency	100°
High Frequency	1° at 1.4 GHz
Angular resolution	0.1″ at 1.4 GHz
Brightness sensitivity	1 K at 1.4 GHz
Number of spectral channels	10^4
Number of simultaneous frequency bands	2
Image dynamic range	10^6 at 1.4 GHz
Polarisation Purity	–40 db

SKA Low — Western Australia

ASKAP 2018 — Western Australia

0.7 - 1.8 GHz 36 x 12m 7”


36 beams — 6° x 6°

MeerKAT 2020 — South Africa

1 - 10 GHz 64 x 13.5m 11” - 43”

ajor science goals of the SKA that have emerged from initial discussions.

1999

Table 1. Scientific Specification for the Square Kilometre Array

Parameter	***Goal***
A_{eff}/T_{sys}	2×10^4 m^2/K
Frequency range	0.15 – 20 GHz
Imaging Field of view	1° at 1.4 GHz
Number of instantaneous beams	100
Maximum primary beam separation	
Low Frequency	100°
High Frequency	1° at 1.4 GHz
Angular resolution	0.1″ at 1.4 GHz
Brightness sensitivity	1 K at 1.4 GHz
Number of spectral channels	10^4
Number of simultaneous frequency bands	2
Image dynamic range	10^6 at 1.4 GHz
Polarisation Purity	–40 db

2019

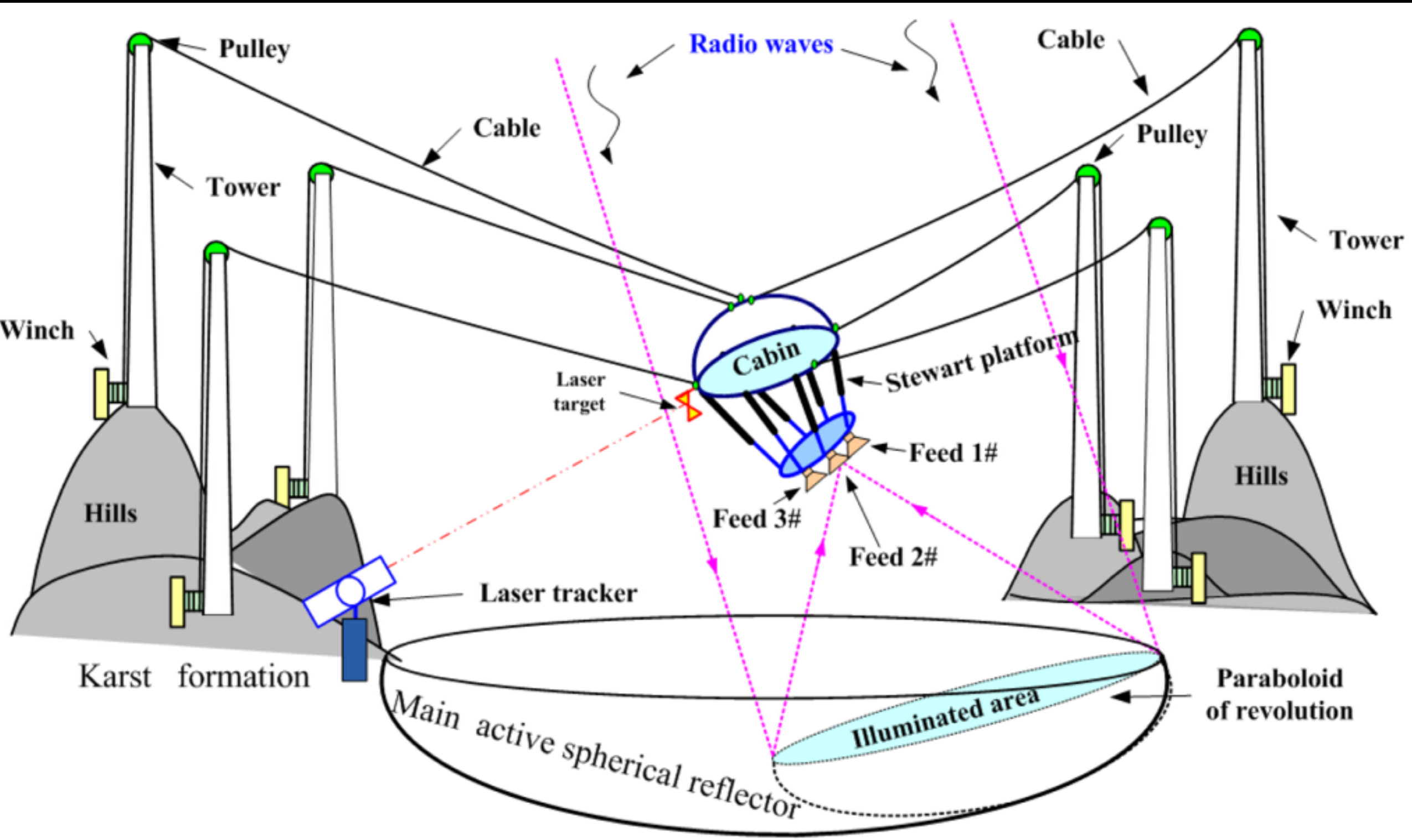
133 x 15m + MeerKat ~10^3 m^2/K

FAST

Arecibo 1000 foot telescope, Puerto Rico — 1963

Arecibo focal assembly

http://www.mdpi.com/machines/machines-04-00020/article_deploy/html/images/machines-04-00020-g001.png



HI “Intensity Mapping”

Ui-Le Pen, Jeffrey B. Peterson et al.

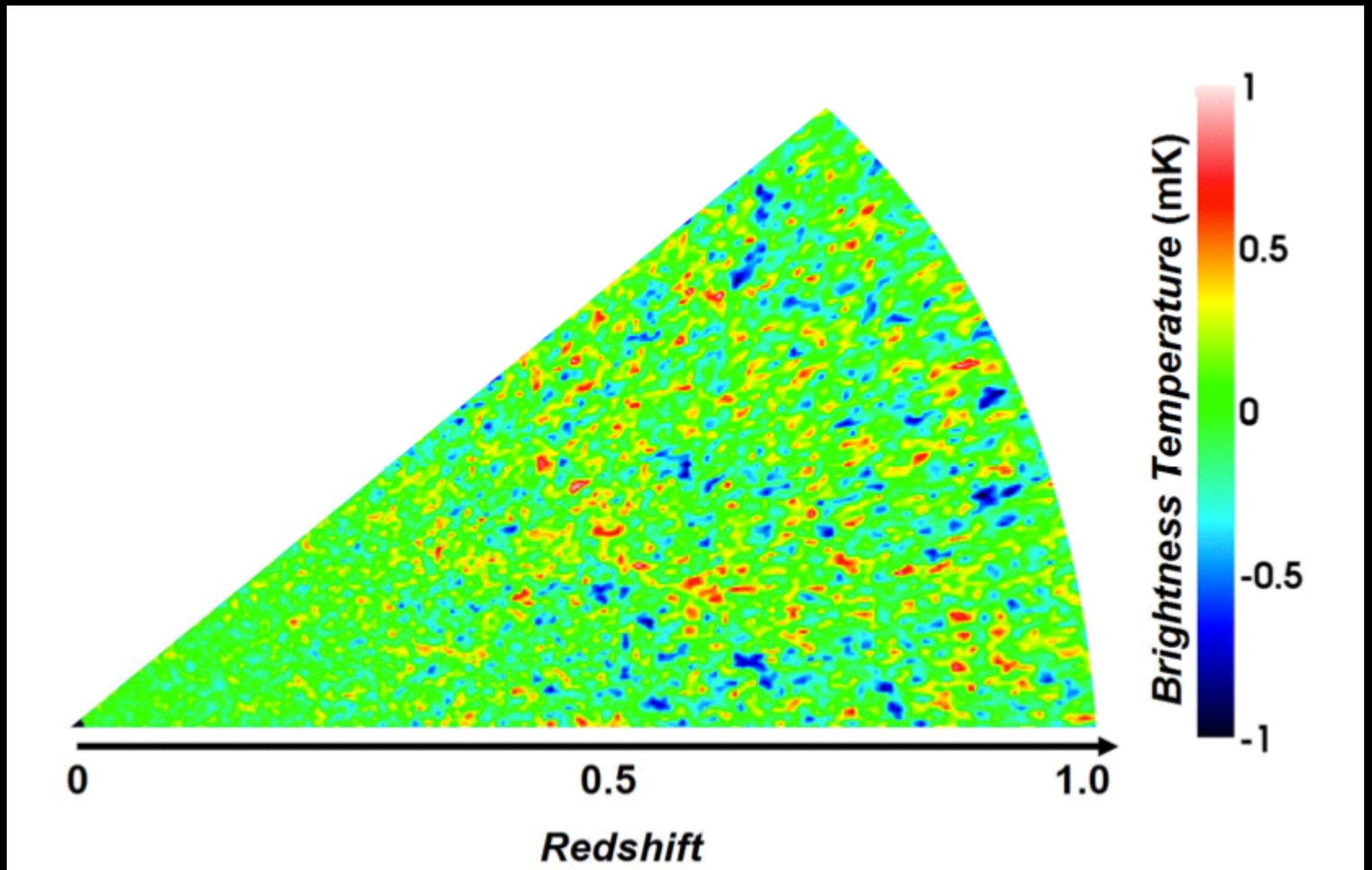
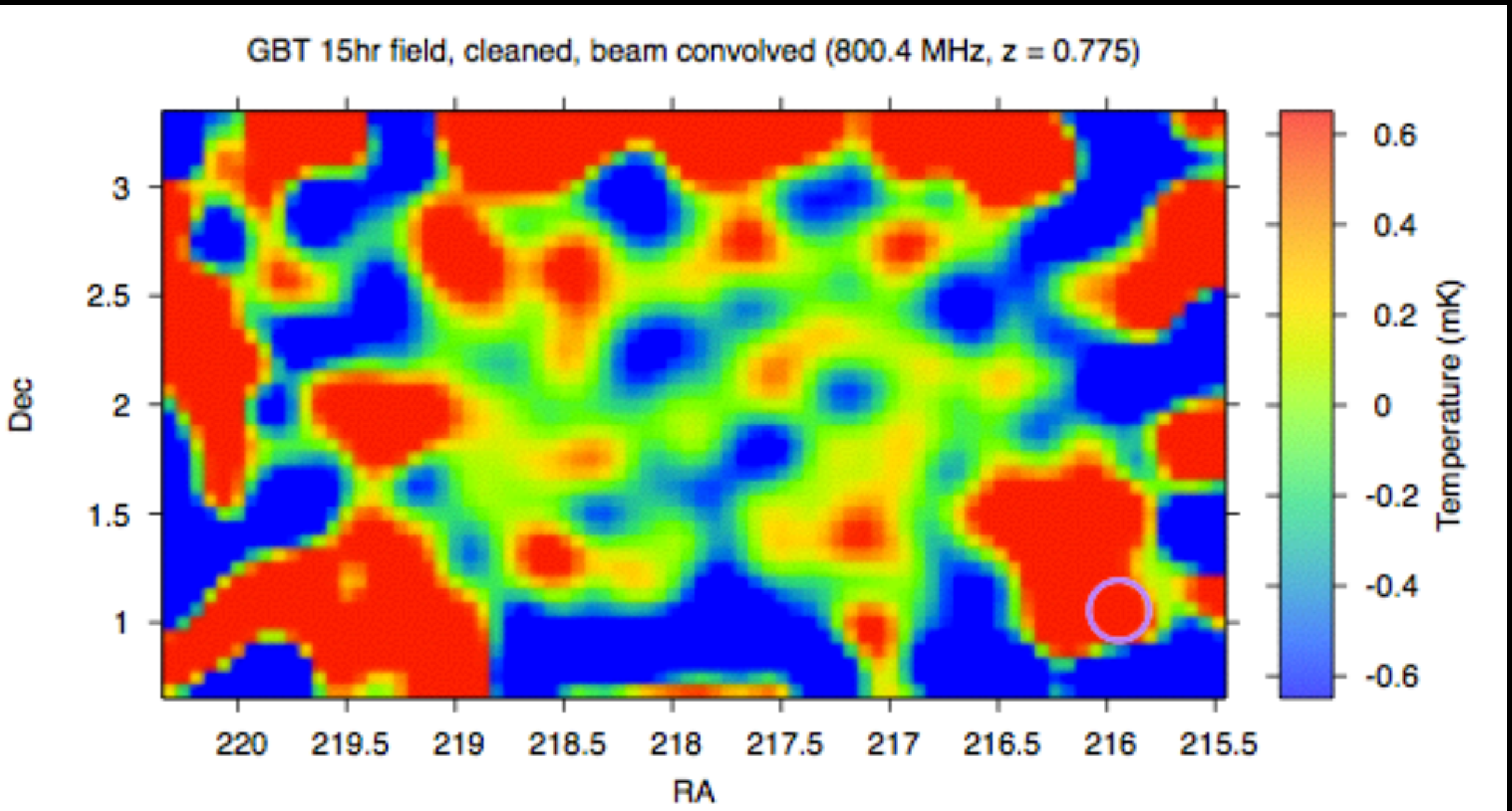


Figure 2: Simulated fluctuations in the brightness temperature of 21cm emission from galaxies in a slice through the universe. The emission is smoothed over 8/h Mpc. The redshift, z, translates to frequency: ν=1.42GHz/(1+z). *Red indicates overdensity and blue underdensity.*



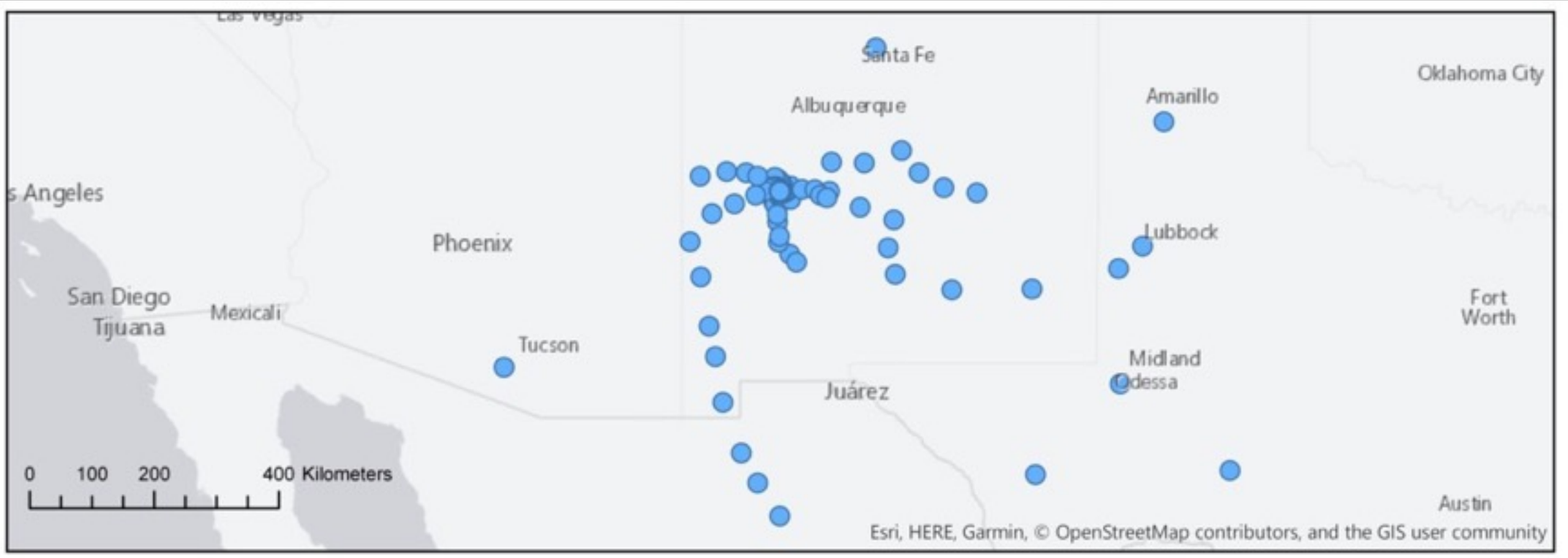
Masui et al. (2013)

CHIME — Penticton B.C.

400 - 800 MHz 4 x 20m x 100m

1.31 Tb/s

ngVLA


Las Vegas
Santa Fe
Albuquerque
Oklahoma City
Amarillo
s Angeles
Phoenix
Lubbock
San Diego
Tijuana
Mexicali
Tucson
Fort
Worth
Midland
Odessa
Juárez
0 100 200 400 Kilometers
Austin
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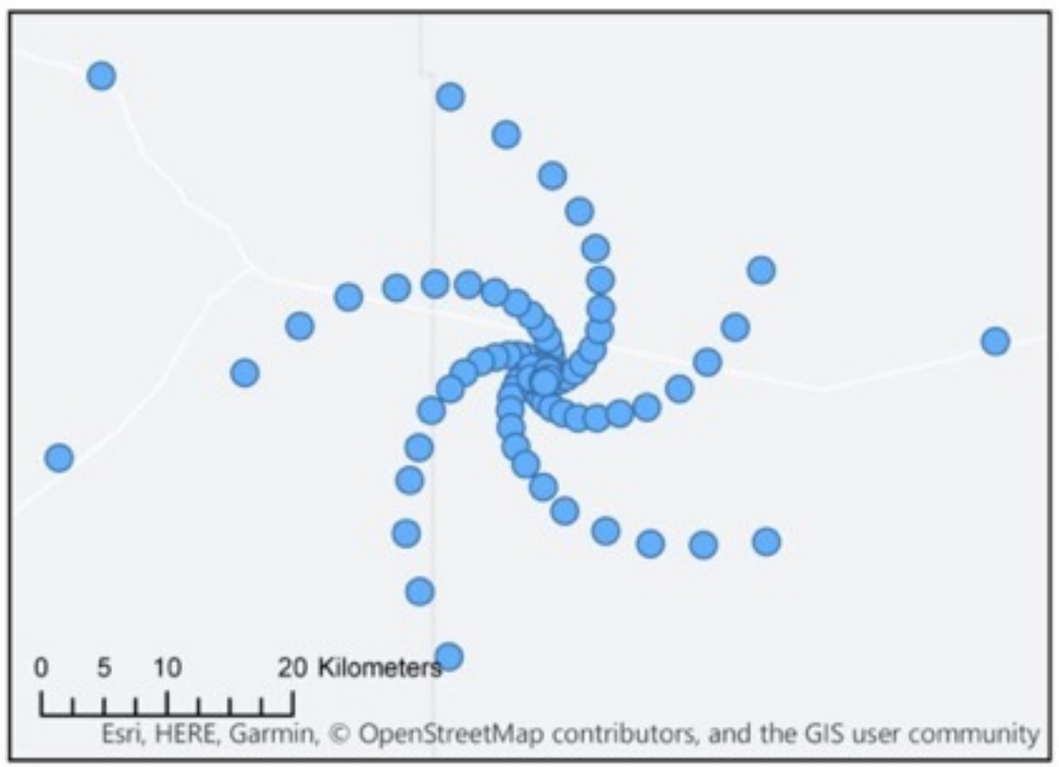
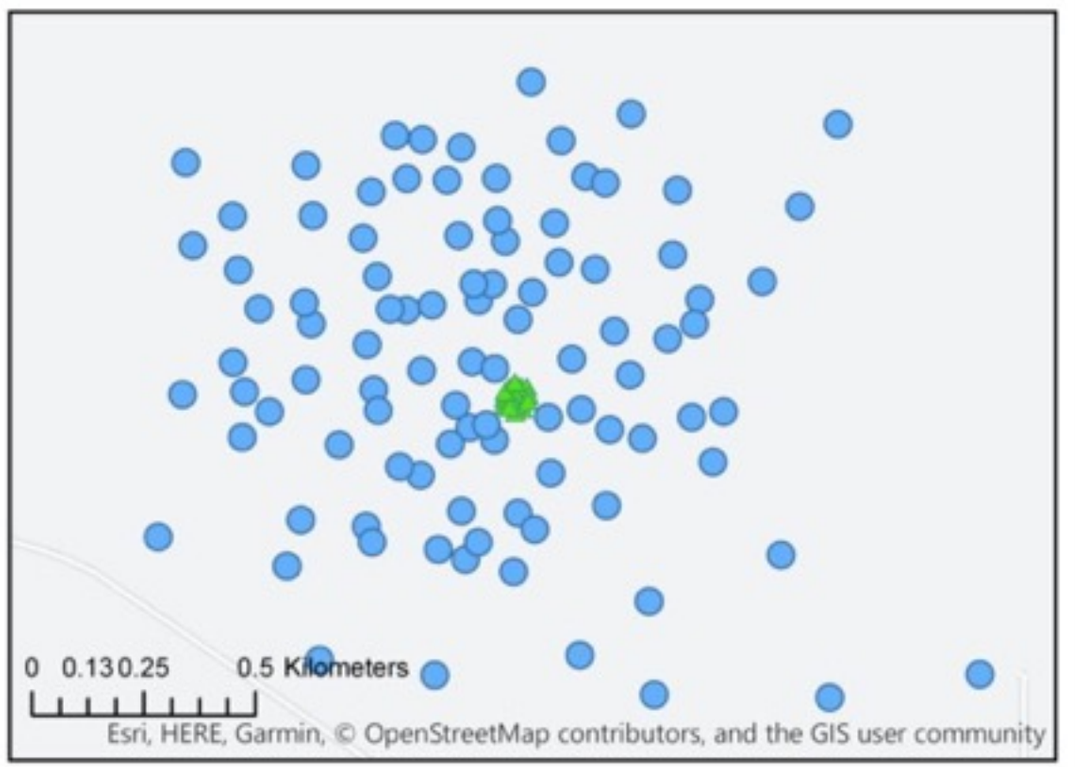

0 5 10 20 Kilometers
Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community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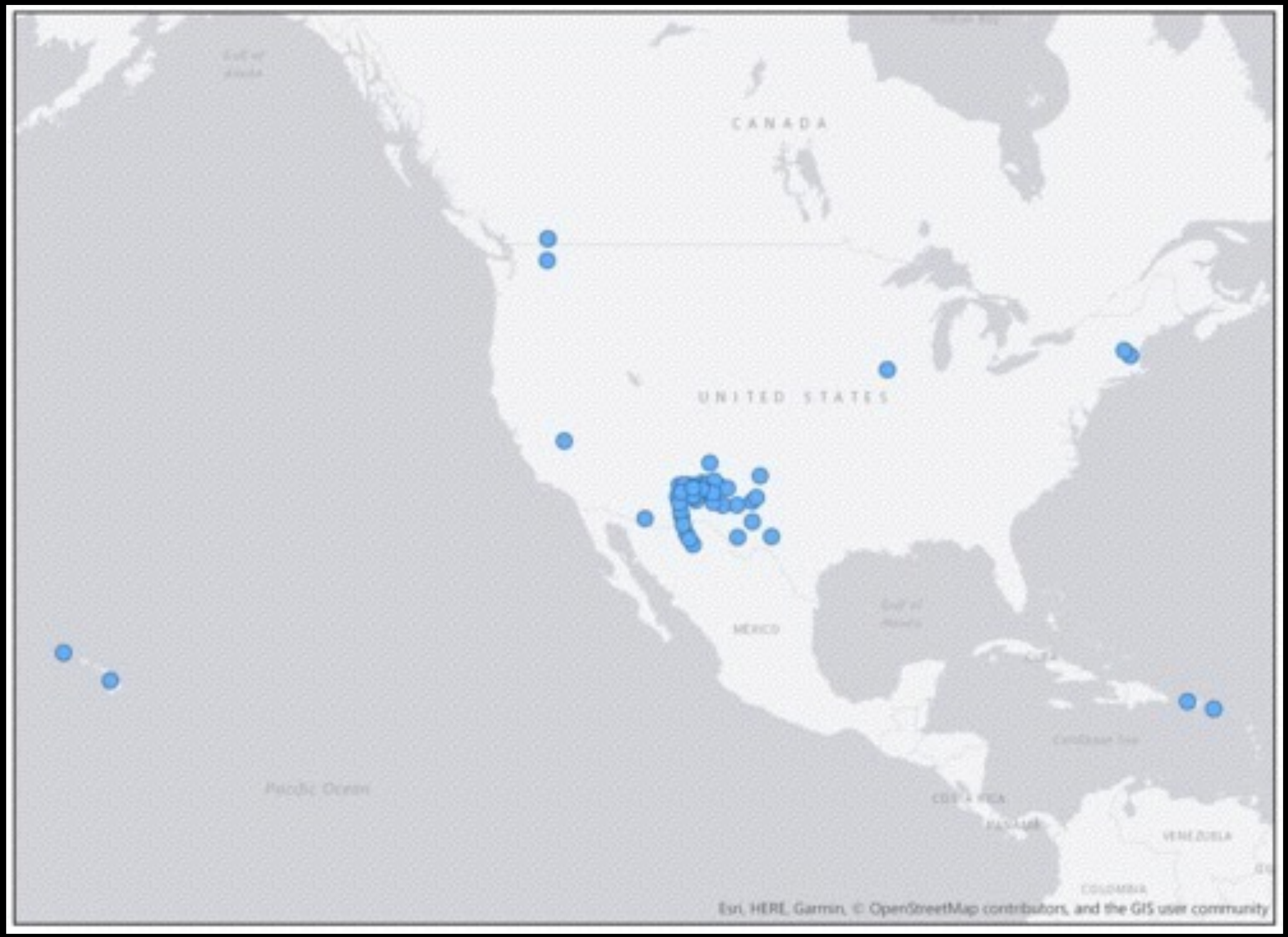
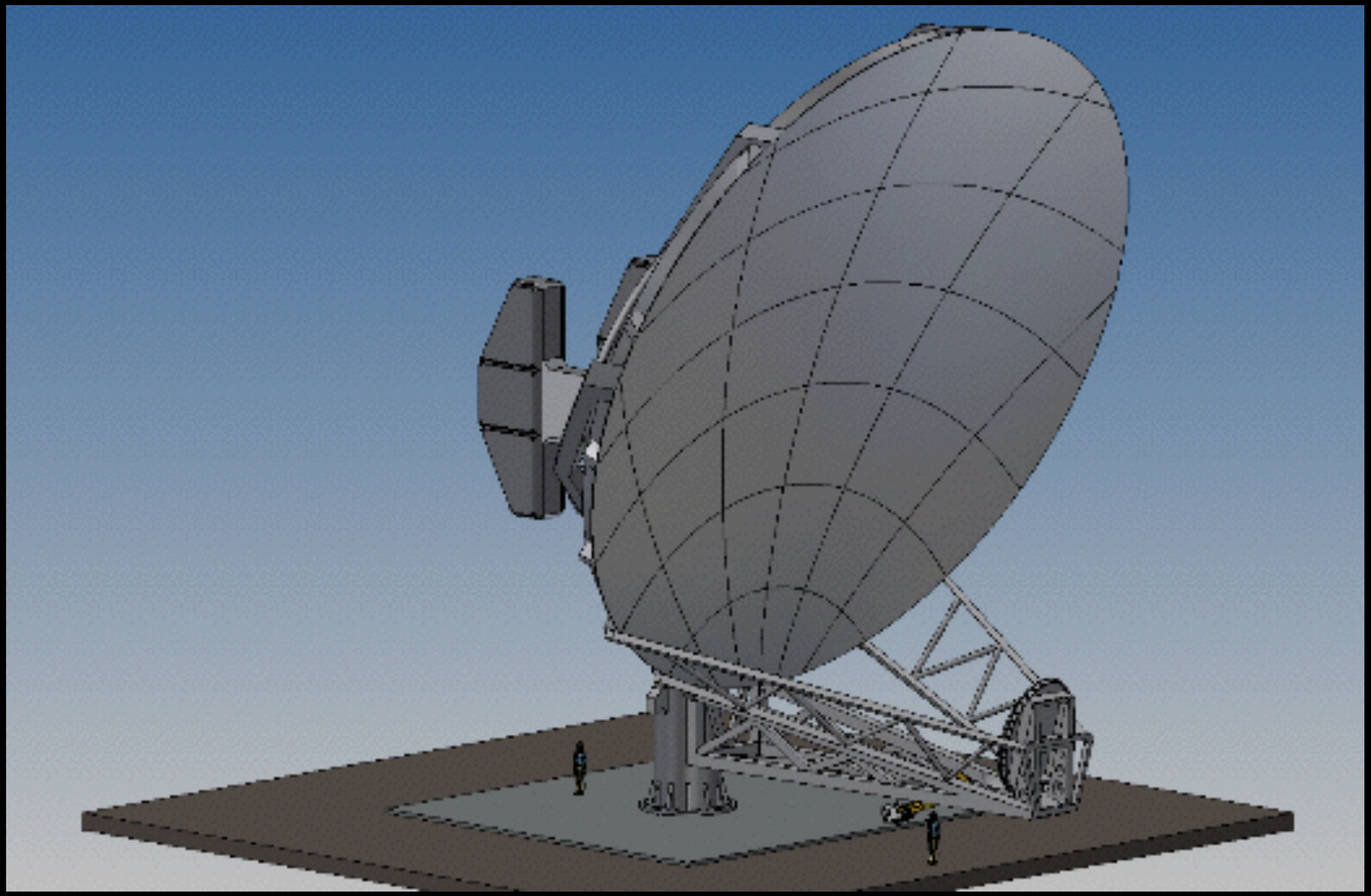
ngVLA



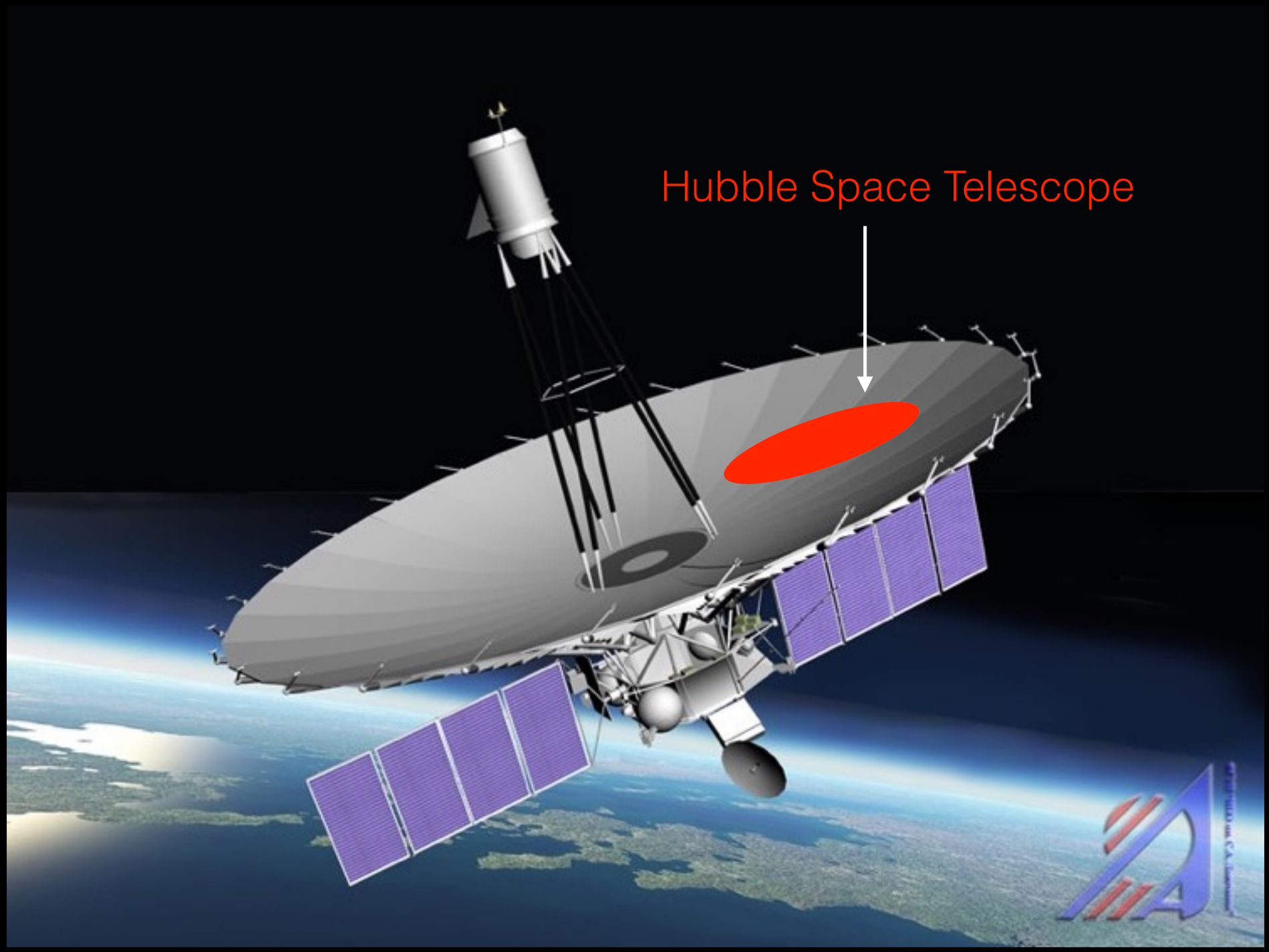
1.2 - 116 GHz 214 x 18m ~1 mas

ngVLA



1.2 - 116 GHz 214 x 18m 160μ

RadioAstron 10m



DARE — TBD