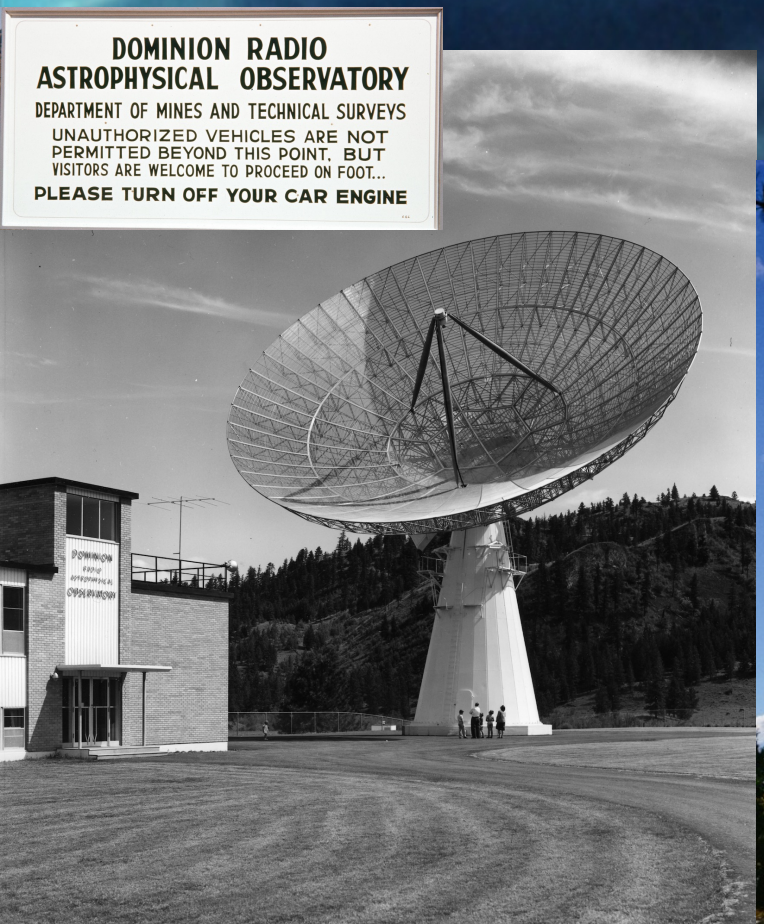
DRAO and ARO
The Foundations of Canadian Radio Astronomy

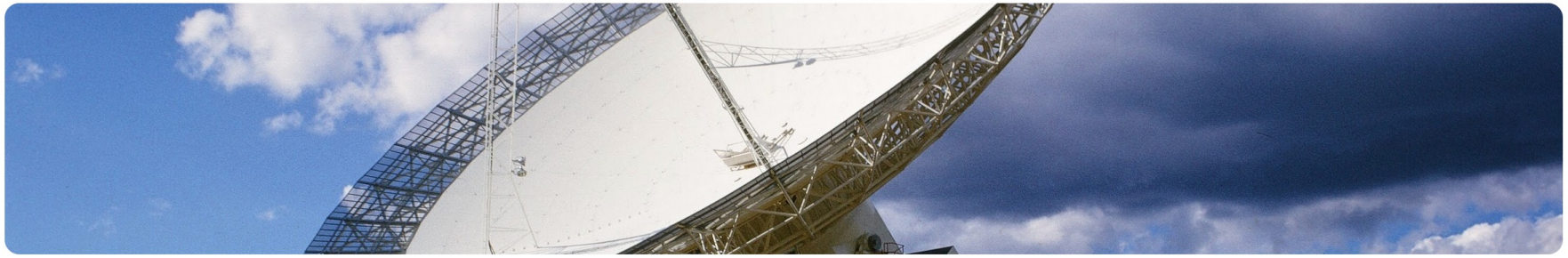
TIM ROBISHAW
DRAO



A Workshop on the History of Canadian Radio Astronomy

July 25-26, 2016

http://astroherzberg.org/radiohistory2016/



Canadian Radio Astronomy History

@canadianradioastronomyhist196 · 112 subscribers · 58 videos

Videos related to the history of radio astronomy in Canada. >

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For You

Dominion Radio Astrophysical Observatory (DRAO): 40th Anniversary Celebration

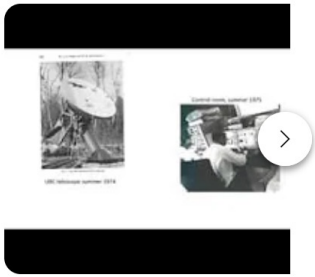
71 views • 3 years ago

1971 Rumford Medals

57 views • 7 years ago

Dominion Radio Astrophysical Observatory (DRAO): 1989 Video Footage

132 views • 3 years ago



Bill McCutcheon :: "The Developm Astronomy in Canada"

77 views • 7 years ago

"RADIO ASTRONOMY AND CANADA: FIFTY YEARS OF PROGRESS"

Tuesday, 22 December 1987

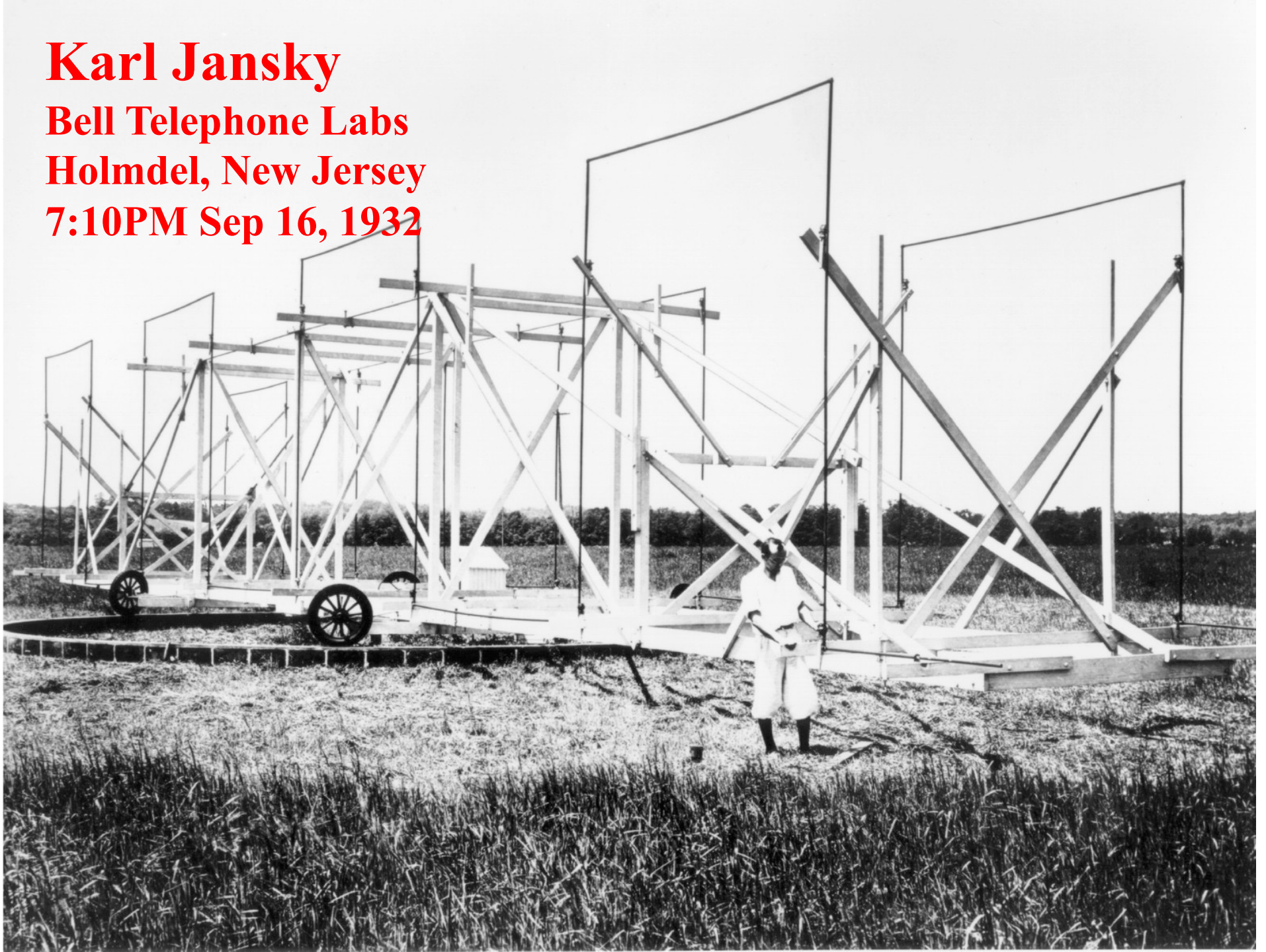
Room 3001, 100 Sussex Drive, Ottawa, Canada

Morning Session (9:00 am - 12:15 pm): Chairman: J.M. MacLeod (HIA, NRC)

Welcome: L. Kerwin (President, NRC)

Introduction: D.C. Morton (Director, HIA, NRC)

The 50th Anniversary of Grote Reber's Radio Telescope and his First Observations


Karl Jansky
Bell Telephone Labs
Holmdel, New Jersey
7:10PM Sep 16, 1932

New York Times
May 5, 1933

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.

Discovery of mysterious radio waves which appear to come from the centre of the Milky Way galaxy was announced yesterday by the Bell Telephone Laboratories. The discovery was made during research studies on static by Karl G. Jansky of the radio research department at Holmdel, N. J., and was described by him in a paper delivered before the International

Dr. Slipher concluded, at some distance above the earth's surface, and possibly produced by the earth's atmosphere.

The galactic radio waves, the announcement says, are short waves, 14.6 meters, at a frequency of about 20,000,000 cycles a second. The intensity of these waves is very low, so that a delicate apparatus is required for their detection.

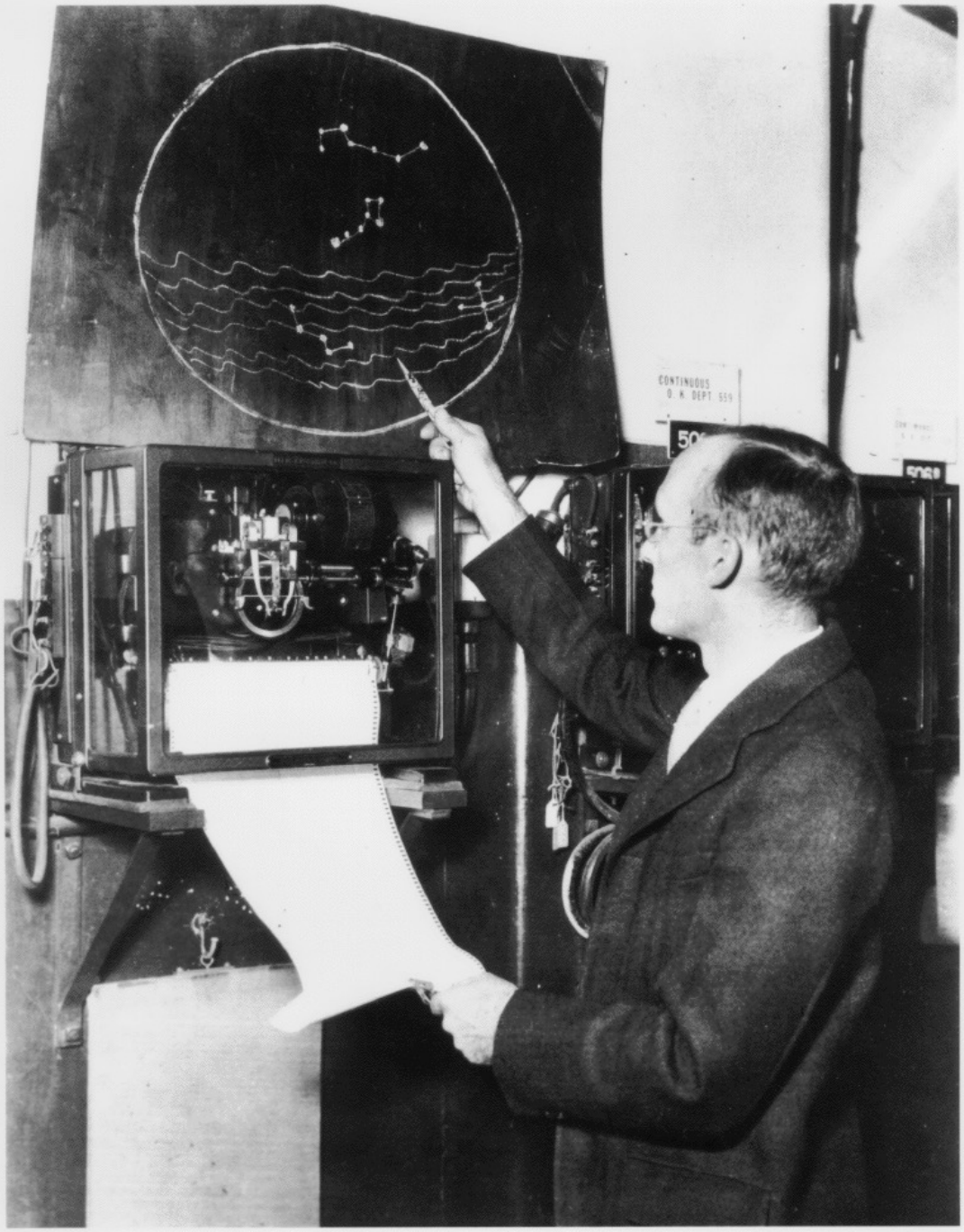
Unlike most forms of radio disturbances, the report says, these newly found waves do not appear to be due to any terrestrial phenomena, but rather to come from some point far off in space—probably far beyond our solar system.

If these waves came from a terrestrial origin, it was reasoned, then they should have the same intensity all the year around. But their intensity varies regularly with the time of day and with the seasons, and they get much weaker when the earth, moving in its orbit, interposes itself between the radio receiver and the source.

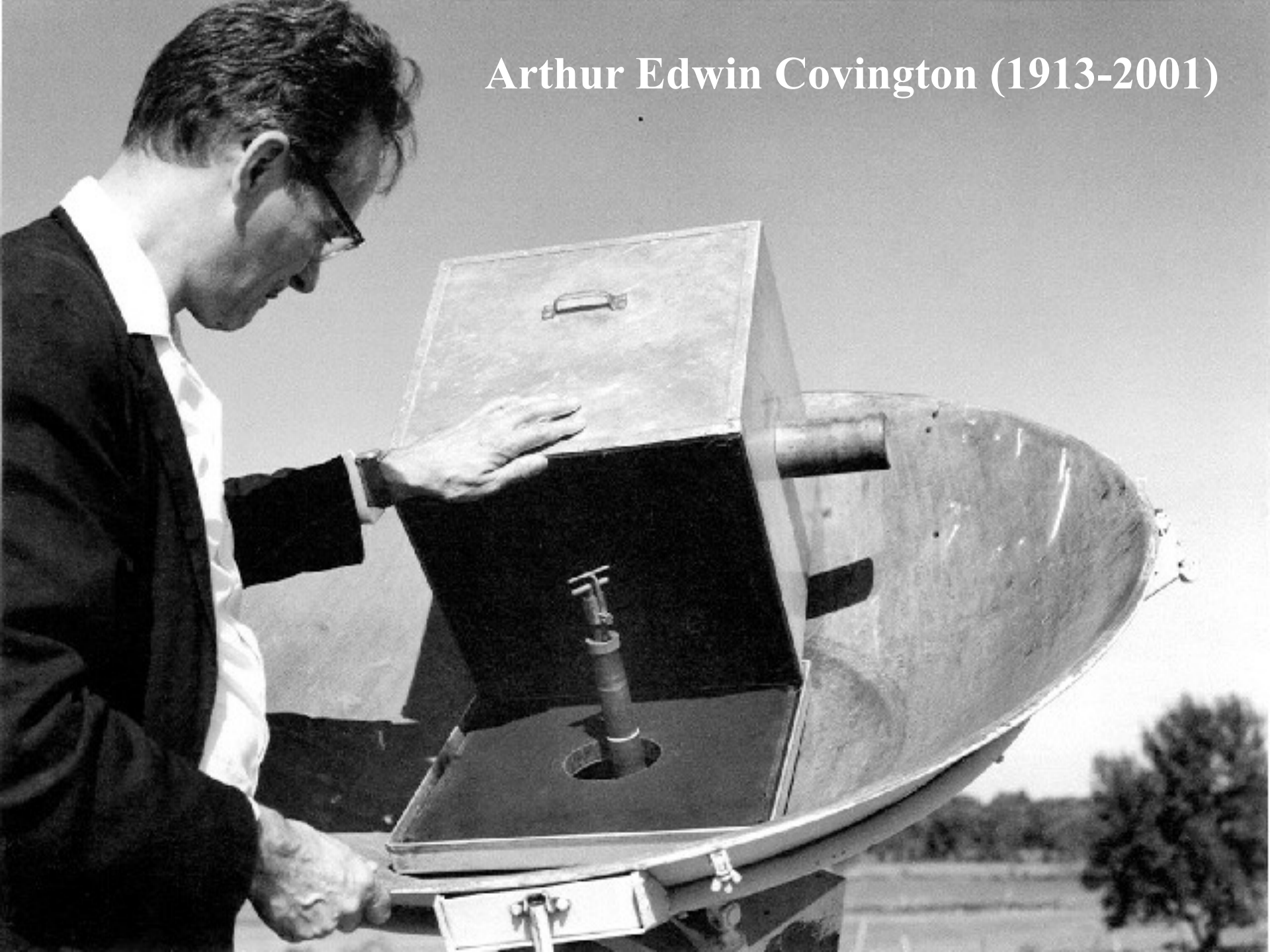
A preliminary report, published in the Proceedings of the Institute of Radio Engineers last December, described studies which showed the presence of three separate groups of static: Static from local thunderstorms, static from distant thunderstorms, and a "steady hiss type static of unknown origin." Further studies this year determine the unknown origin of this third type to be from the direction of the centre of the Milky Way, the earth's own home galaxy.

Direction of Arrival Fixed.

The direction from which these waves arrive, the announcement asserts, has been determined by investigations carried on over a considerable period. Measurements of the horizontal component of the waves were taken on several days



NRC Radio Field Station in Ottawa, 1943


Arthur Edwin Covington (1913-2001)

Canada's First Radio Telescope (48")

FIG. 2
10.7-CENTIMETER RADIOTELESCOPE
FRONT VIEW

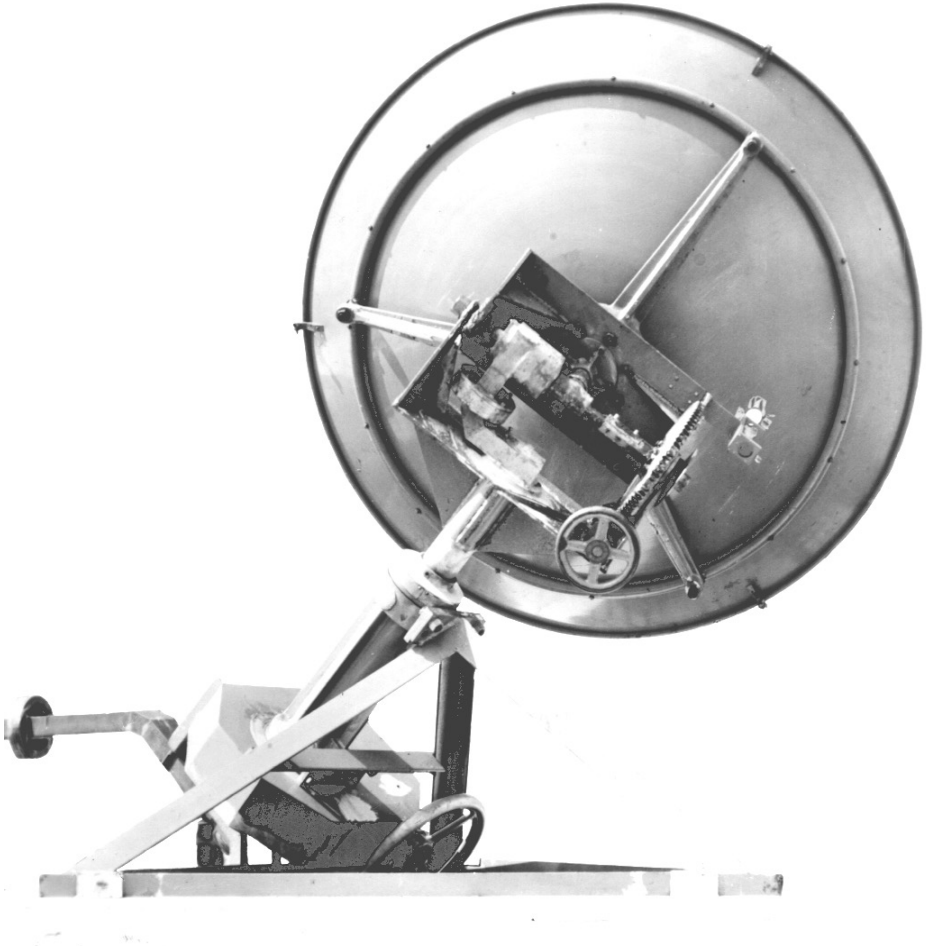
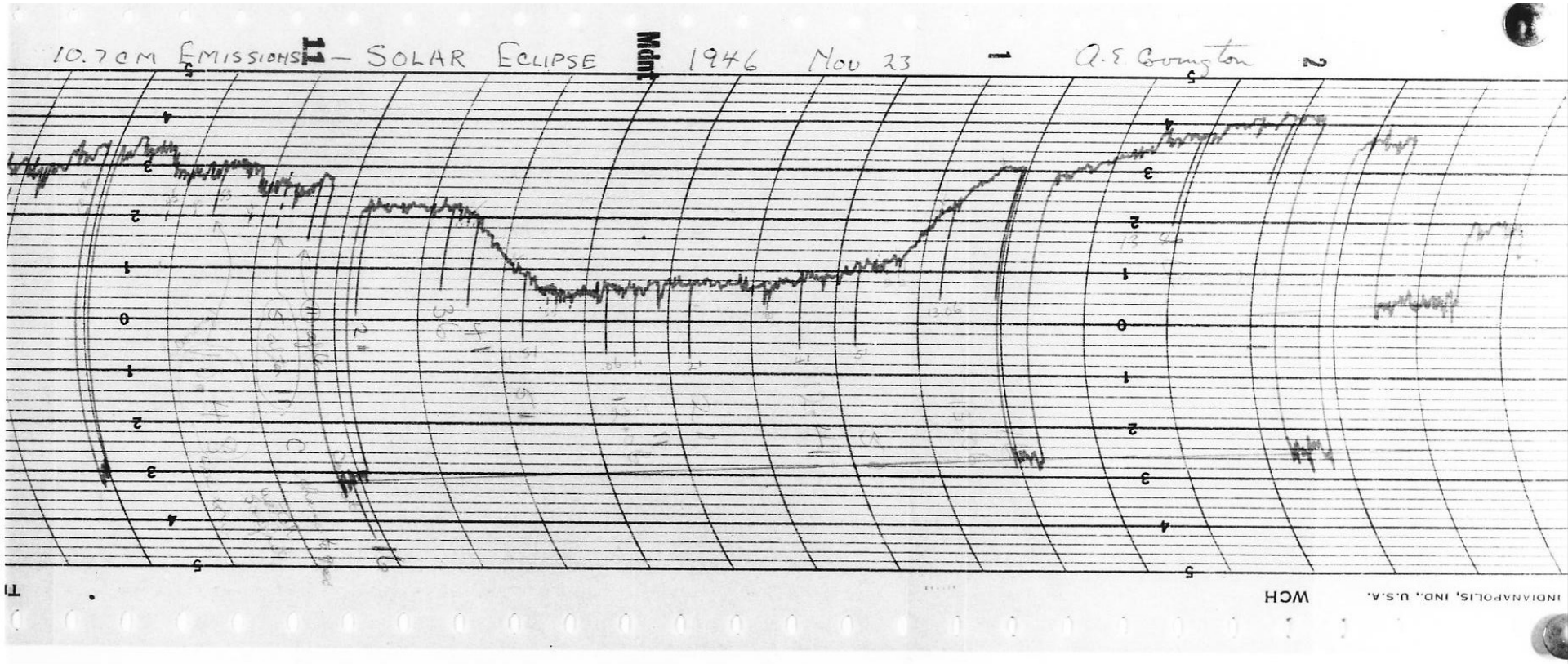


FIG. 3
10.7-CENTIMETER RADIOTELESCOPE
REAR VIEW

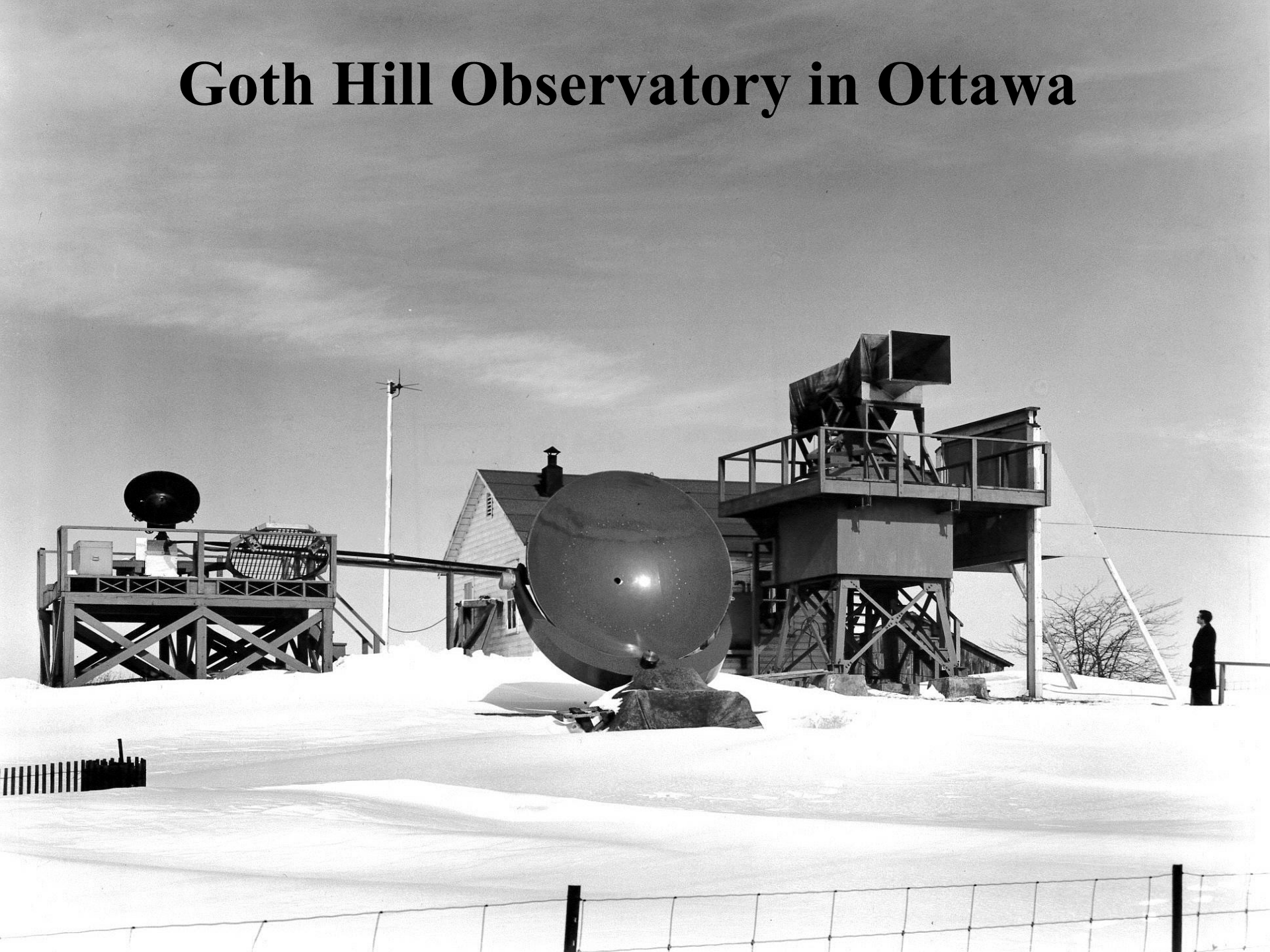
First observation of the Sun: 26 July 1946

Solar Eclipse: 23 November 1946

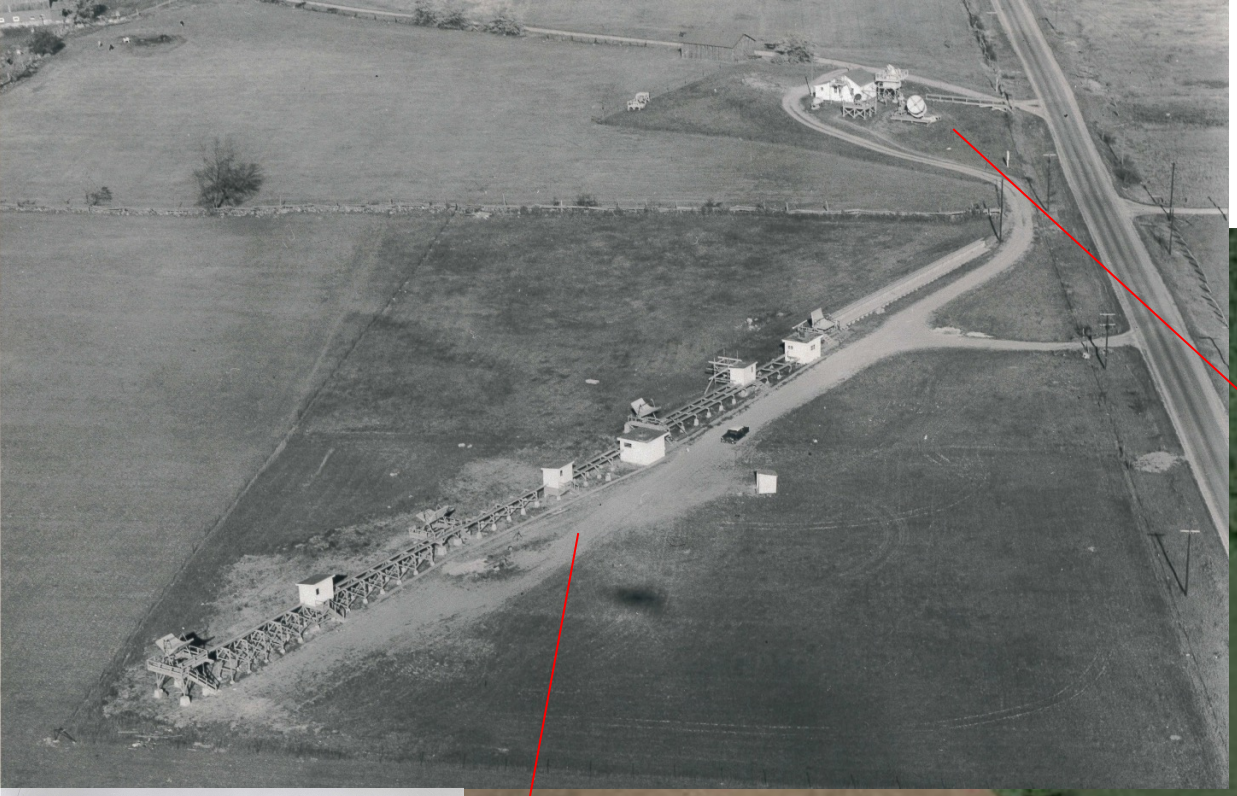


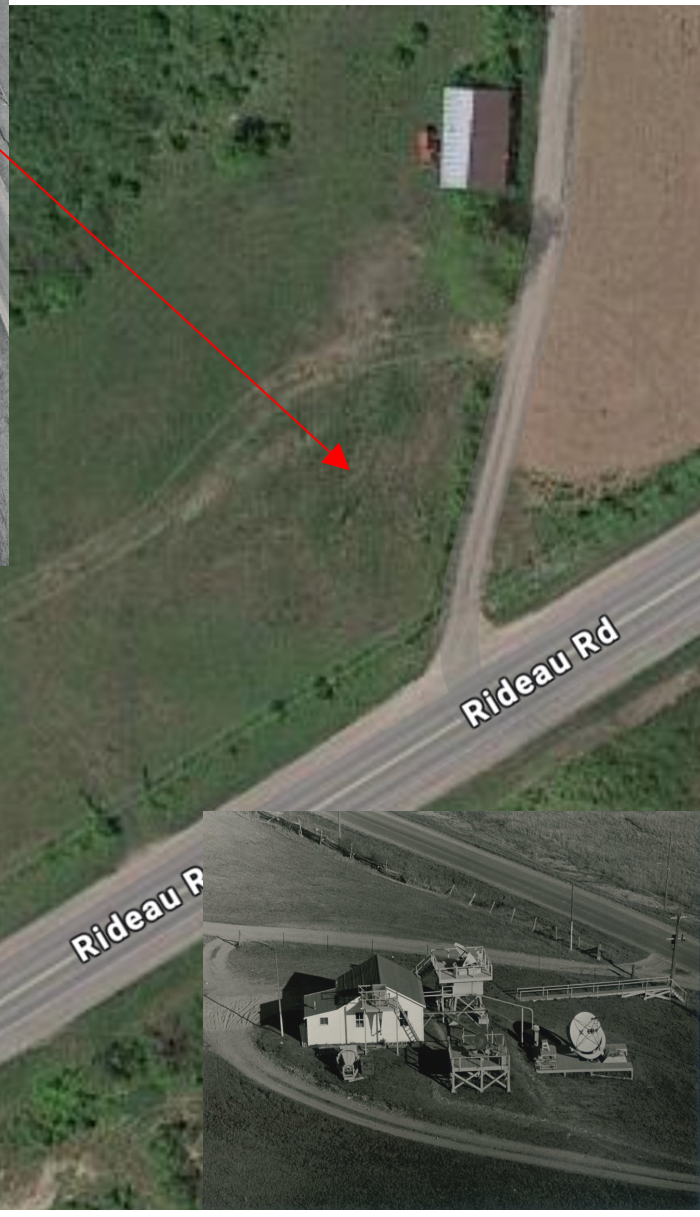
1.5 million K sunspot

Goth Hill Observatory in Ottawa



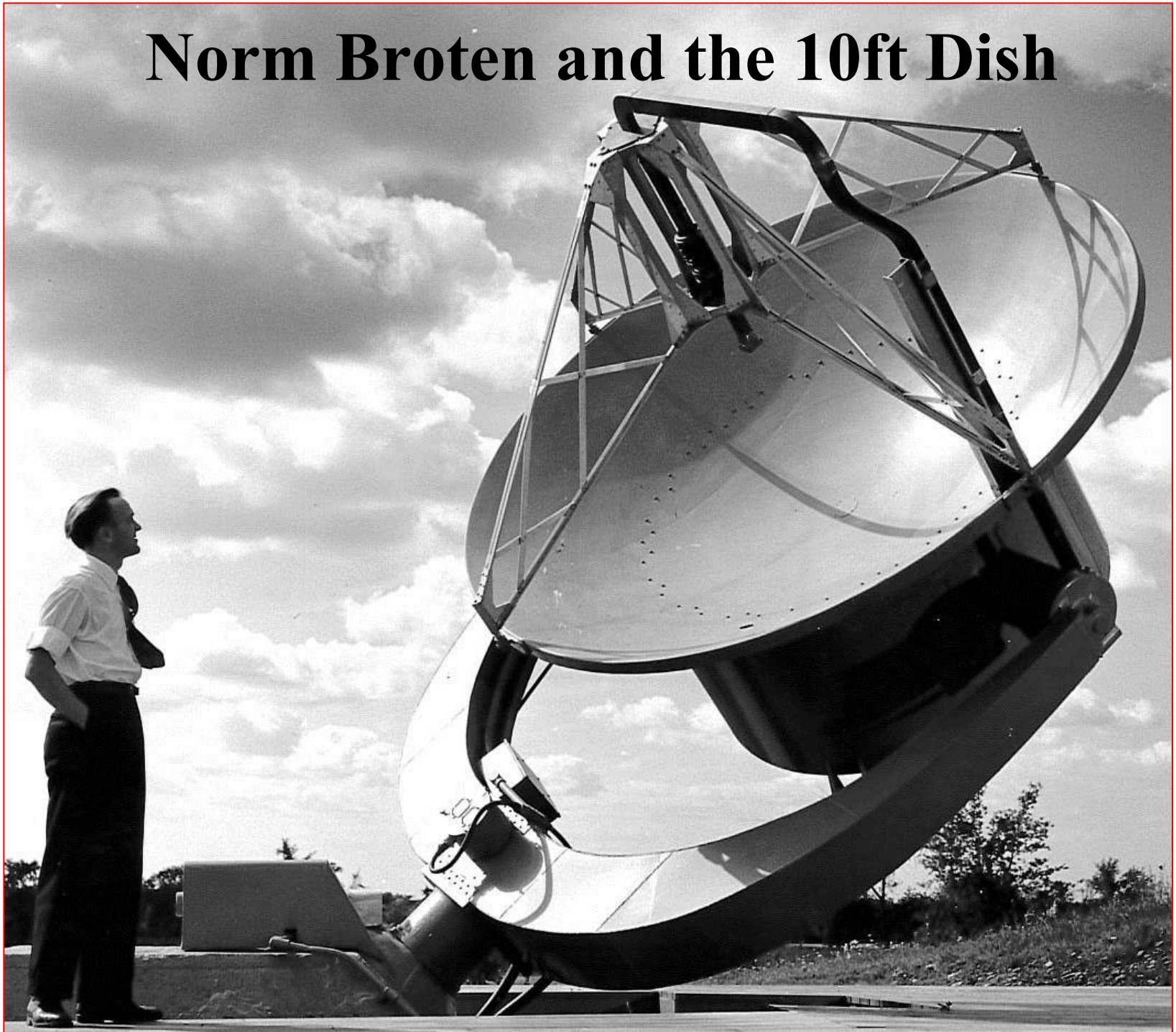
Goth Hill Radio Observatory






SOLAR RADIOMETER FOR OPERATION
IN THE 10-16 CM BAND

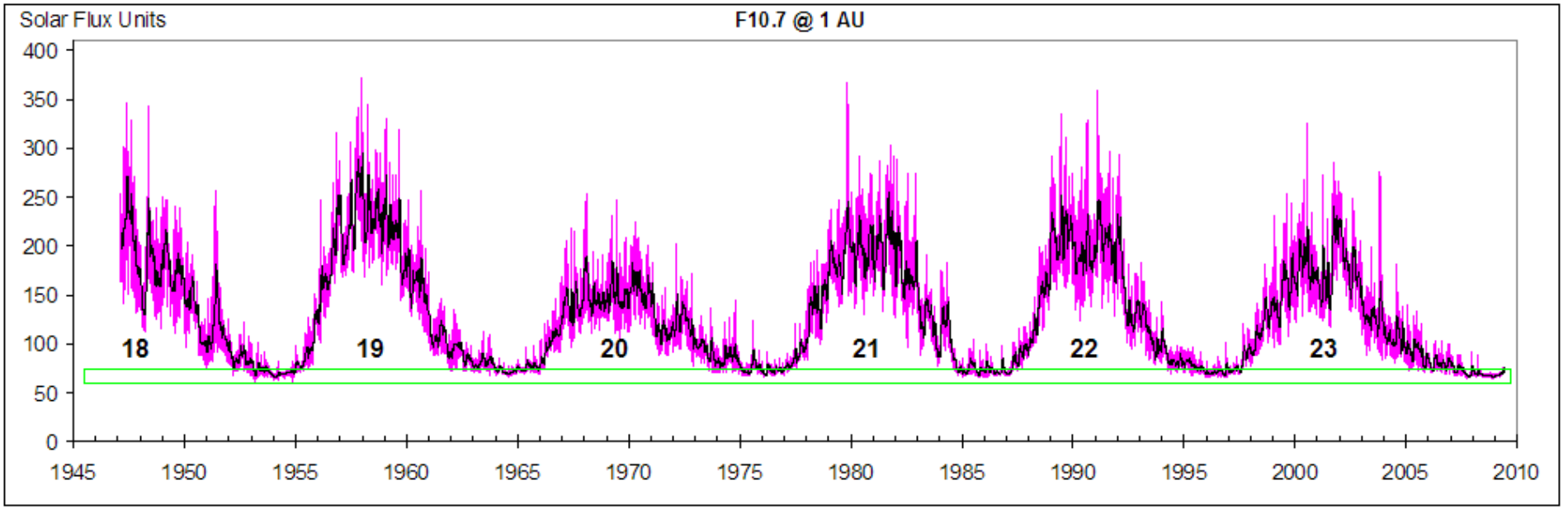
Norm Broten and the 10ft Dish



Calibration Horn Antenna

10.7-cm Solar Flux Monitoring Program

- **Started Feb. 1947 in Ottawa.**
- **Moved to ARO and DRAO in early 1960s.**
- **Continues today at DRAO…**



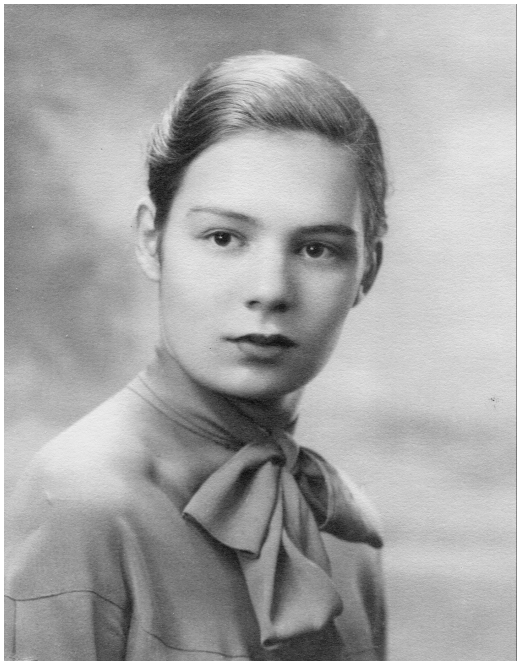
…operated until 1970.

10.7-CM RADIOTELESCOPE

BROAD-BAND RADIOTELESCOPE (10-15 CM)

150-CM RADIOTELESCOPE

GOTH HILL SOLAR NOISE OBSERVATORY



Gladys A. Harvey:

Canada's First Woman Radio Astronomer

- **Worked for NRC's REED 1948-1976**
- **Observer at Goth Hill and Algonquin**

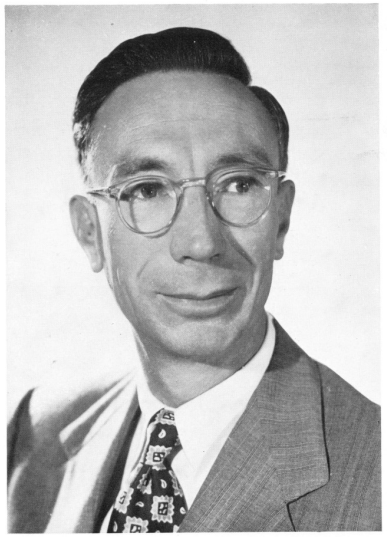
SOME RELATIONSHIPS BETWEEN 10.7-CENTIMETER SOLAR NOISE BURSTS, FLARES, AND SHORT-WAVE FADEOUTS

GLADYS A. HARVEY
Radio and Electrical Engineering Division, National Research Council, Ottawa, Canada
Received May 10, 1963; revised July 16, 1963

ABSTRACT

Relationships between 1953 solar noise bursts (10.7-cm), 4527 flares, and 928 short-wave fadeouts that occurred during concurrent observing periods from July, 1957, to December, 1960, are investigated. The bursts are those that have been unambiguously identified on the solar patrol records of the National Research Council, Canada, and published in the "Summaries of Outstanding Events at 2800 Mc"; the

Joe Pawsey: Founder of Australian Radio Astronomy



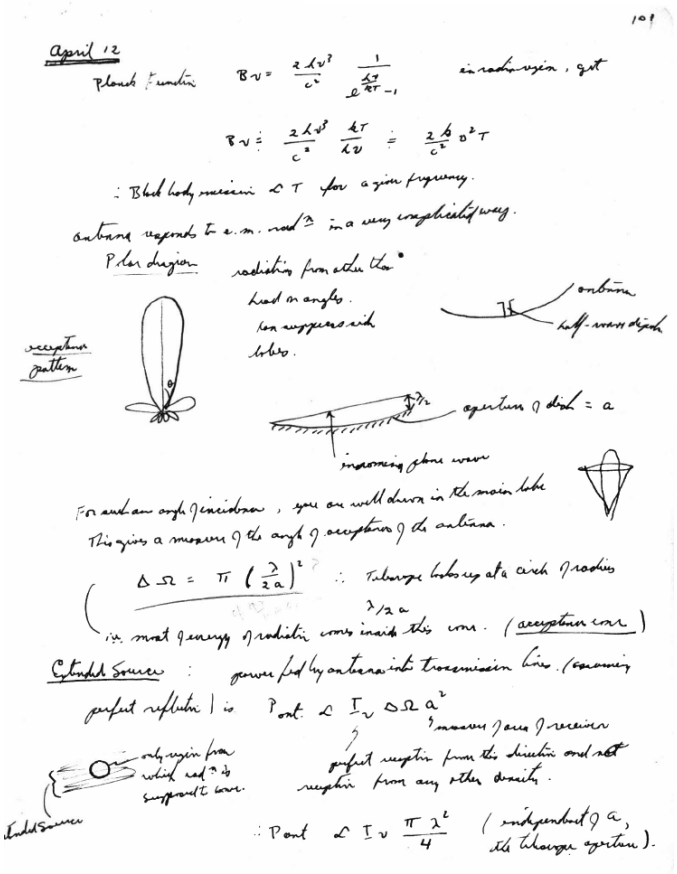
- **Married Canadian Lenore Nicoll in 1935.**
- **Three visits to NRC in Ottawa:**
  - **1941**
  - **1947, meets Arthur Covington…**
    - ***"At Ottawa, Covington is a young and inexperienced man working in relative isolation. He has got some thoroughly useful results by good honest work and perseverance."***
  - **1957, met with Don McKinley, Peter Millman, C.S. Beals, Norm Broten, and talked with Jack Locke about plans for DRAO.**

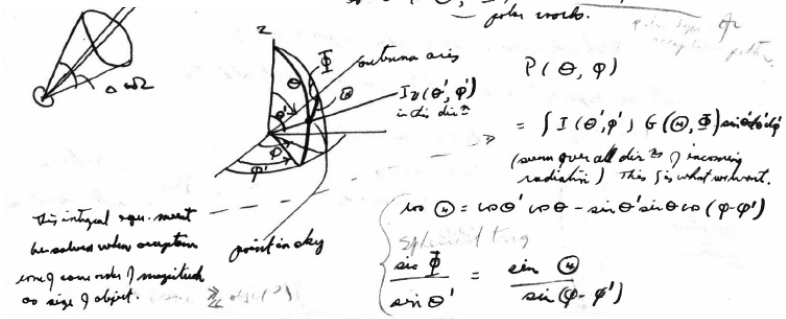
200 MHz sea-cliff interferometer at Dover Heights, Sydney

John Bolton (CSIRO) Gives Colloquia at NRC in 1950-51

Befriended Covington.

Notes from Vic Gaizauskas





Jack Locke

1956: Jack Locke arranges a 6-part colloquium series at Dominion Observatory in Ottawa on radio astronomy.

C.S. Beals

John Bolton

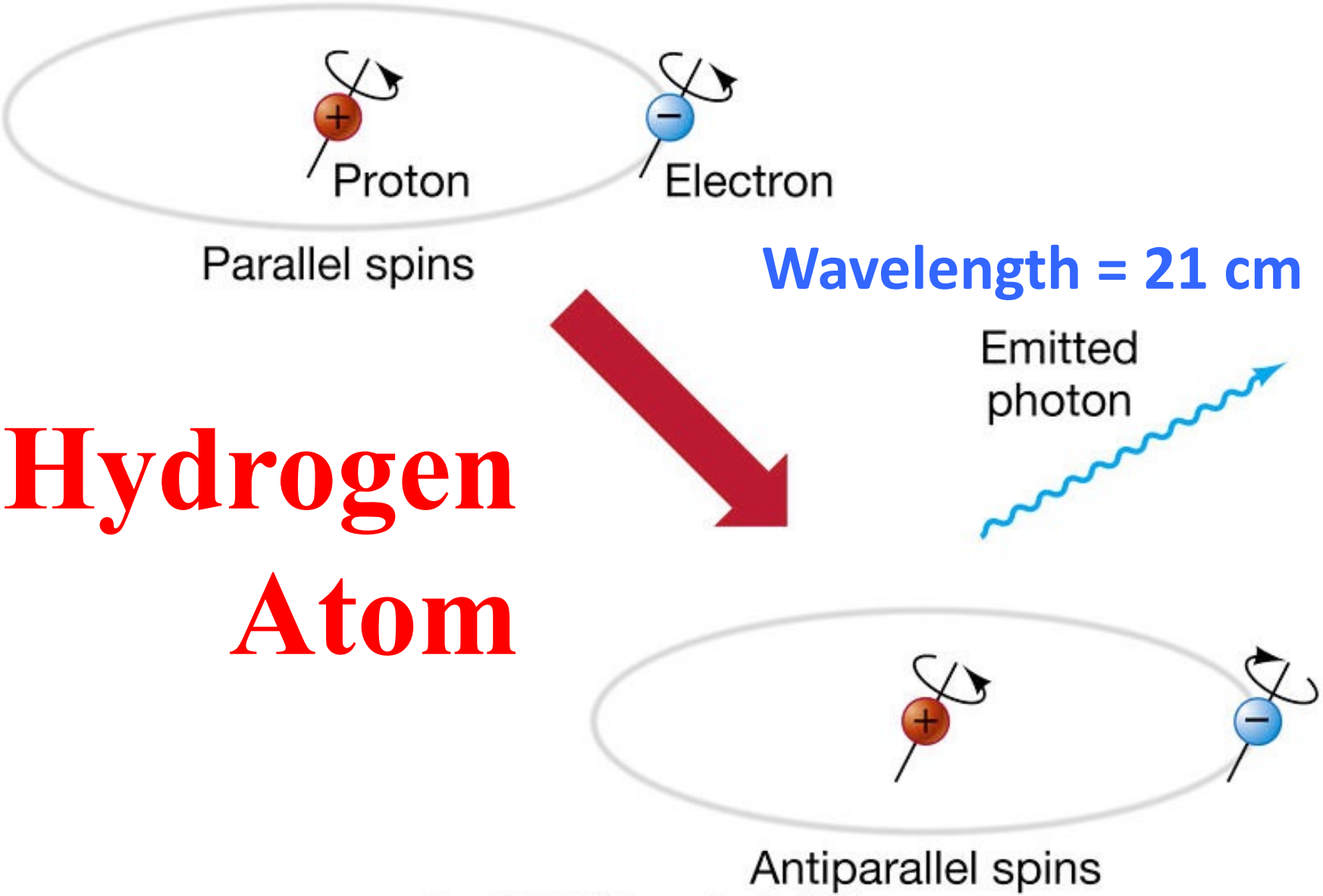
Beals invites Bolton (now at Caltech) to Ottawa again to give a colloquium on radio astronomy.

The 21-cm Line

1945:
Henk van de Hulst predicts atomic hydrogen in space should emit radio waves at 1420.4058 MHz, or 21 cm.

Six years pass with no discovery.

Hydrogen Atom



"Early visitors to the Radio Field Station and to Goth Hill whom I can recall… were"----- Appleton, Hey, Ratcliffe, Bolton, Friis, Pawsey and van de Hulst. "I was introduced to Pawsey during one of his early visits to the RFS by W.J. Henderson; they attended Cambridge at the same time…" When Pawsey saw the 10-30 cm horn in 1948 (for absolute flux determination), "he told me about the 21 cm hydrogen line prediction and wondered whether I could make … any observations for its confirmation. As it stood, the instrumentation was hardly suitable. This was the first time that I had heard of the prediction and is one occasion when I realized the magnitude of the difficulties of switching from one promising area to another. I readily gave a negative reply and realized that I would be continuing solar noise work…"

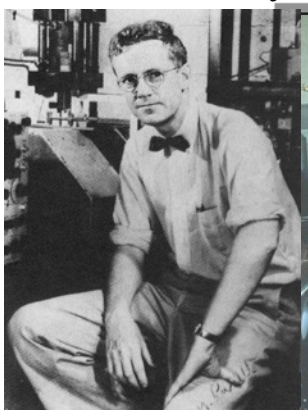
Arthur Covington in Woody Sullivan's, *The Early Years of Radio Astronomy*

The 21-cm Line

1945:
Henk van de Hulst predicts atomic hydrogen in space should emit radio waves at 1420.4058 MHz, or 21 cm.

Six years pass with no discovery.

March 25, 1951:
Harold "Doc" Ewen &
Edward Purcell
(1952 Nobel Prize for NMR)
…measure the 21-cm line using a horn antenna sticking out of window of Lyman Hall at Harvard.



April 28, 1956
Harvard, Massachusetts

April 30, 1956.

Dr. G.S. Hume,
Acting Deputy Minister.

Recent trips to American Astronomical Society, March 22-24;
Inauguration Ceremonies, Harvard 60 Foot Radio Telescope, April 28, 1956.

The major reason for two recent trips made by myself to scientific meetings or institutions (American Astronomical Society, March 22-24 - Inauguration Ceremonies, Harvard 60 ft. radio telescope, April 28, 1956) has been to gather information on radio astronomy and its possible future use by our Branch.

Radio astronomy as an active branch of science has arisen from the discovery that, in addition to visual and photographic light, the sun, the stars, the planets, the gas clouds of the galaxy and the external galaxies all emit radiation of the order of centimeters or meters in wavelength. This relatively long wave-length radiation is electromagnetic radiation similar in its fundamental aspects to ordinary light and with suitable receiving equipment may be used to gain astronomical information about the positions, motions and physical characteristics of the heavenly bodies.

At the meeting of the American Astronomical Society at Columbus, Ohio, March 22-24 the most important single subject was radio astronomy. Numerous papers were presented dealing with planetary, stellar and galactic radiation and a symposium was held dealing with instrumental problems and the interpretation of radio observations of both near and distant astronomical bodies.

The official opening of the new Harvard 60 ft. radio telescope on April 28 offered similar opportunities for studying the present position. A day of meetings were held and there were numerous opportunities for personal discussions with successful research workers in this field. In addition to these two meetings a series of six colloquia organized by Dr. J.L. Locke and devoted to the subject of Radio Astronomy has been held at the Dominion Observatory and attended by most of the scientists of the Ottawa area interested in this subject.

Without attempting to review the entire field it would appear for the type of astronomical studies occupying our major interest at Victoria, and to some extent at Ottawa namely galactic studies, that the introduction of radio techniques is very closely analogous to the revolution introduced into the practice of medicine by the use of X rays. Ordinary photographic and visual light is absorbed by the dust particles pervading the galaxy to such an extent that only a volume of space approximately 2,000 parsecs in diameter can be effectively examined. Making use of the long wavelength radiation (21 cm) produced by clouds of neutral hydrogen and presumably other atoms and molecules it is possible to penetrate to a distance 10 times as great.

While this does not make conventional astronomy obsolete any more than the introduction of X rays outmoded the direct use of the human eye, nevertheless it does place at a great disadvantage any major astronomical organization which does not have these techniques available.

Dr. G.S. Hume,
Acting Deputy Minister.

April 30, 1956.

Recent trips to American Astronomical Society, March 22-24;
Inauguration Ceremonies, Harvard 60 Foot Radio Telescope, April 28, 1956.

We are considering the impact of these new discoveries on the work of our Branch and will no doubt be discussing it with you in greater detail in the future. There are, however, one or two remarks I should like to make in the hope of getting your reaction to them.

1. It would appear that this is a period in history when it is neither safe nor polite for a country like ours to fall behind others in scientific development.

2. The continued progress of radio astronomy now seems inevitable and if the well qualified astronomers of our Branch do not take it up it will be done by others (e.g. the Electrical Engineering Branch of N.R.C.) at equal or greater cost to the country and lesser profit to astronomy.

3. While we are definitely behind other modern countries in this fast growing branch of science this is less of a disadvantage than it might appear. An effort began five years ago would almost certainly have loaded us up with inadequate and obsolete equipment. By starting now when many of the technical problems have been solved we may well be further ahead in the long run. We propose to spend the next few months in active study of instruments, techniques and costs in order to be able to place definite proposals before the Department.

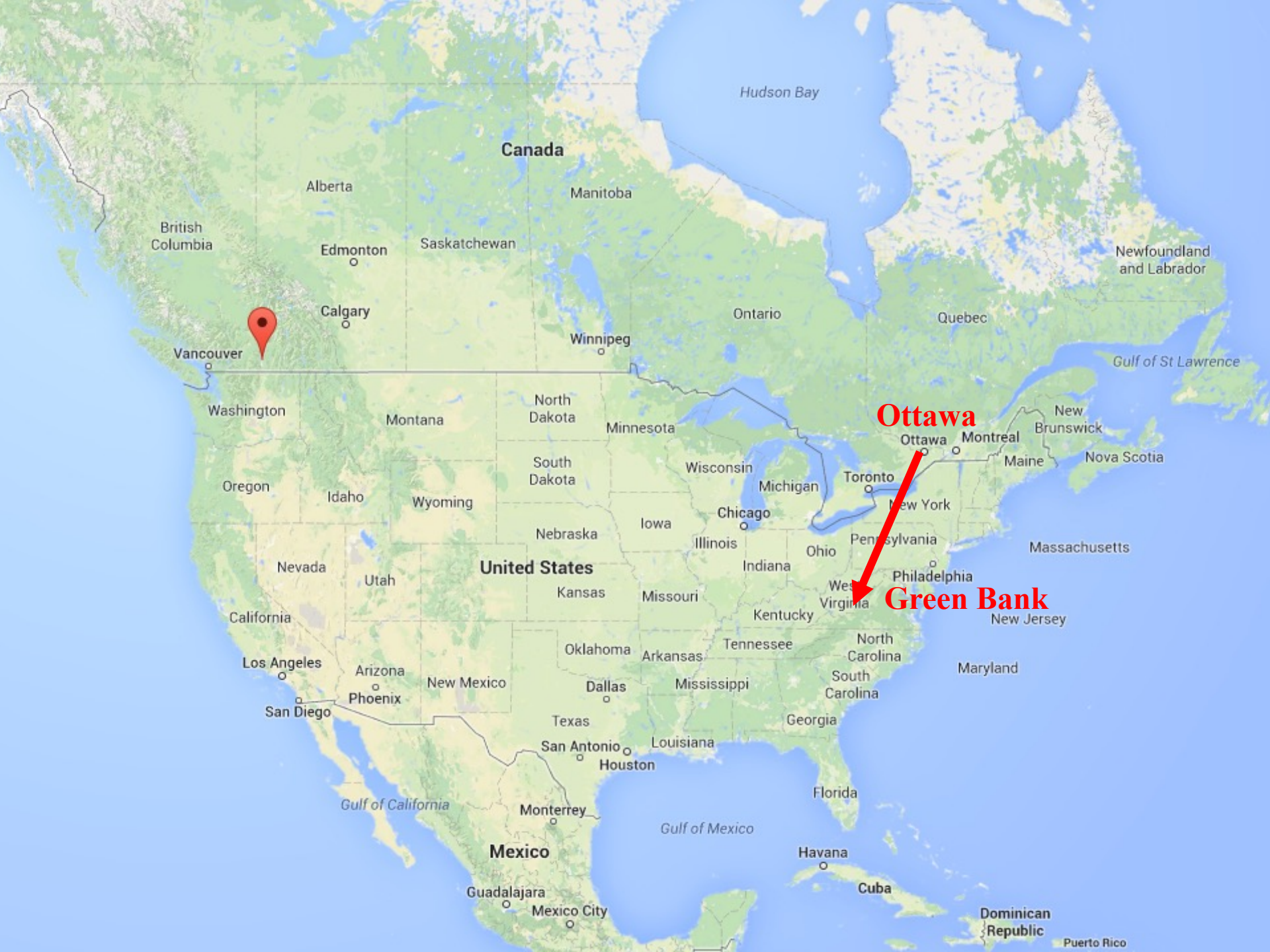
C. S. Beals

C.S. Beals,
Dominion Astronomer

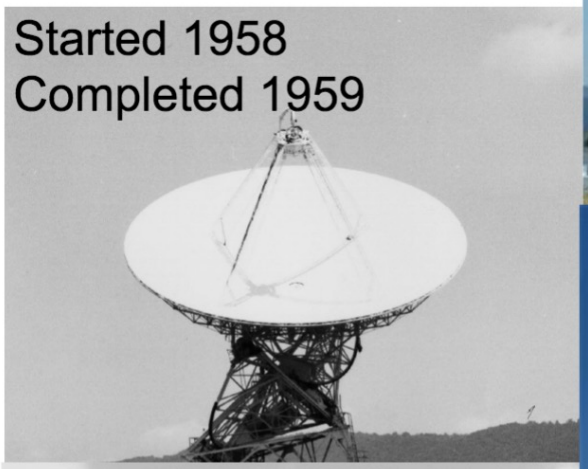
Where Should DRAO Be Built?

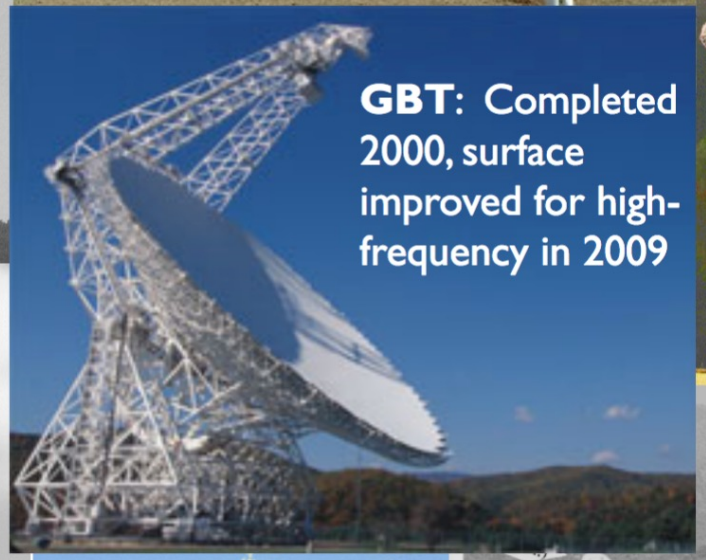
In March of 1957 Ed Argyle and I set out from Ottawa in a Travelall, with some field intensity measuring equipment which we had gathered together, to test a number of preselected sites in British Columbia. We went by way of Greenbank and Owens Valley, the purpose being to use the measured interference levels at these sites as a basis of comparison. We first visited White Lake in early June and found it to be the best of all the sites we had visited, both in terms of interference and in convenience. At the end of June we were joined by Nick Pattenson and George Aitken from NRC who made additional interference measurements and propagation tests in the 950 to 4000 MHz range. (Our own measurements were restricted to the 55 to 950 MHz range.) The NRC results confirmed the excellence of the site and a final decision to locate at White Lake was made following Dr. Beals's visit to the site in mid-July.

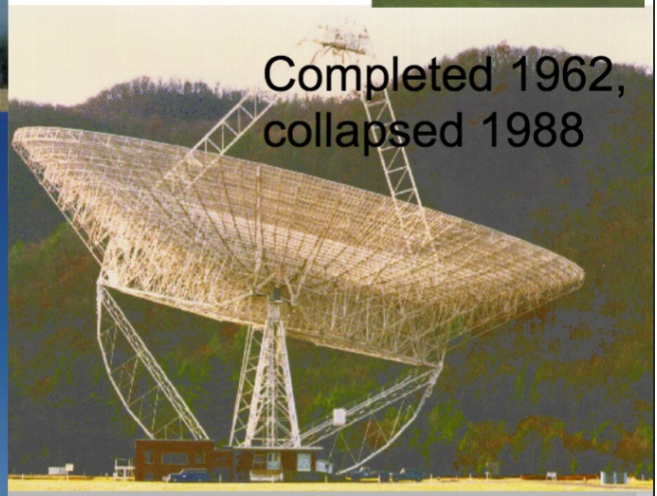
Jack Locke, 1st Officer in Charge

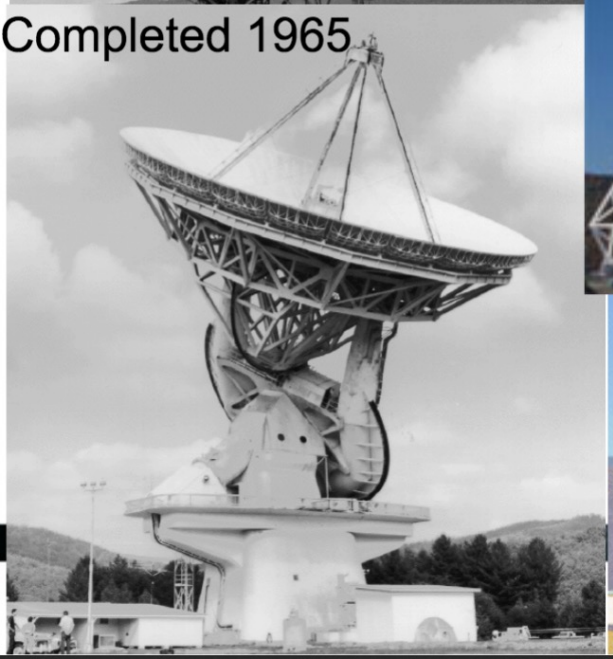

Ottawa
Green Bank
Hudson Bay
Canada
Alberta
Manitoba
British Columbia
Edmonton
Saskatchewan
Newfoundland and Labrador
Calgary
Ontario
Quebec
Vancouver
Winnipeg
Gulf of St Lawrence
Washington
Montana
North Dakota
Minnesota
Ottawa
Montreal
New Brunswick
Maine
Nova Scotia
South Dakota
Wisconsin
Toronto
Oregon
Idaho
Wyoming
Michigan
New York
Chicago
Iowa
Nebraska
Illinois
Pennsylvania
Ohio
Massachusetts
Nevada
Utah
United States
Indiana
Philadelphia
Kansas
Missouri
West Virginia
California
Kentucky
New Jersey
Oklahoma
Arkansas
Tennessee
North Carolina
Los Angeles
Arizona
New Mexico
Dallas
Mississippi
South Carolina
Maryland
Phoenix
San Diego
Texas
Georgia
San Antonio
Louisiana
Houston
Florida
Gulf of California
Monterrey
Gulf of Mexico
Mexico
Havana
Cuba
Guadalajara
Mexico City
Dominican Republic
Puerto Rico

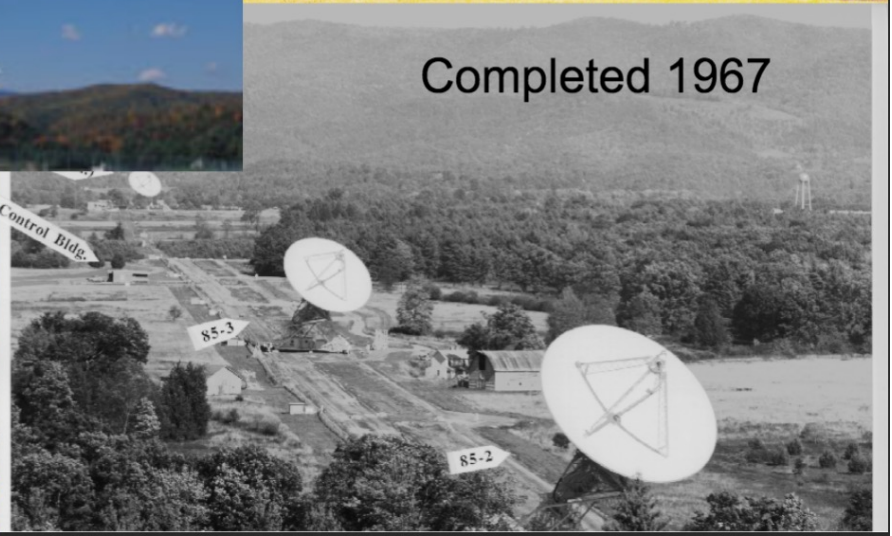
Green Bank, West Virginia, is the original site of the U.S. National Radio Astronomy Observatory, located in the 34,000 sq. km National Radio Quiet Zone











March 1957 Site Testing

March 1957 Site Testing

Penticton

Vancouver Island

Ottawa

Green Bank

Owens Valley

June 1957 Site Testing

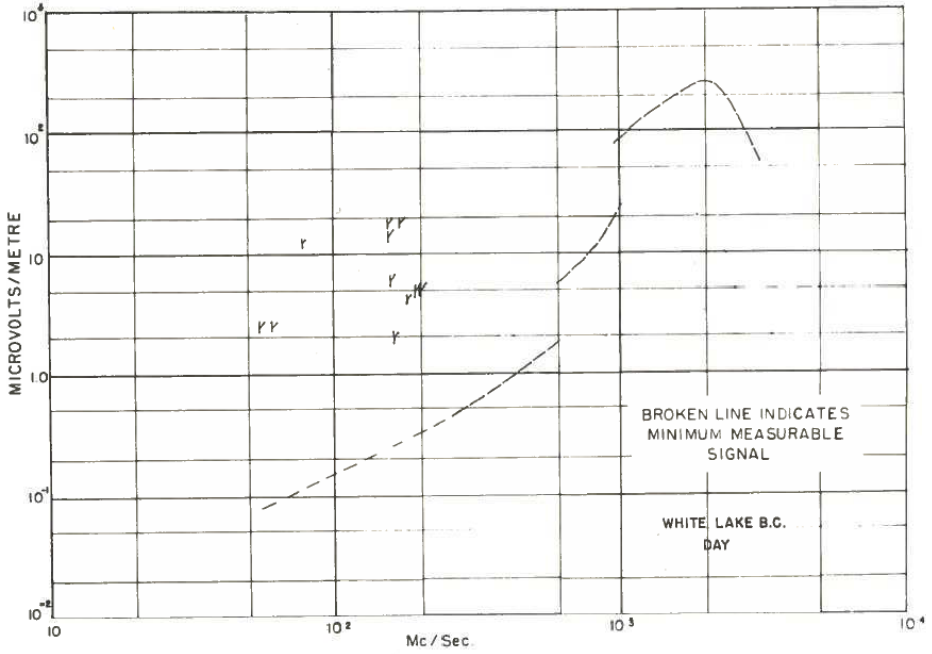
SITE SURVEY FOR A NATIONAL RADIO ASTRONOMY OBSERVATORY

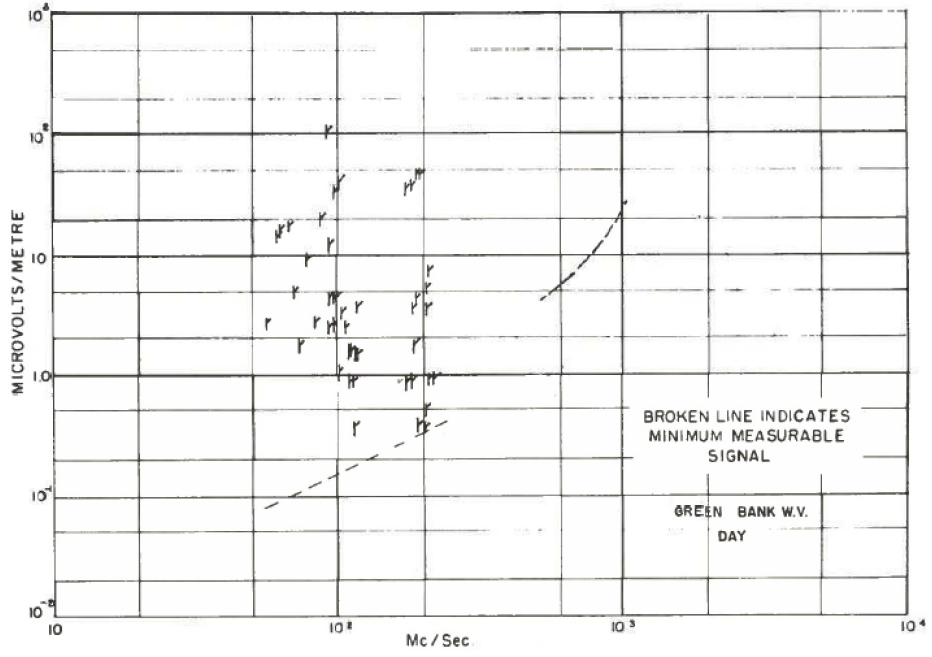
OTTAWA

C. F. PATTENSON, N. W. BROTEN, G. AITKEN

APRIL 1958

Locke and Argyle, during April and May, measured radio noise intensities in the 50 to 1000 mc/s band at two of the American sites: Greenbank, W.V., and Big Pine, Cal., so that comparison might be made between Canadian and American sites. Following this, they made preliminary measurements at several sites in British Columbia. During July and August, the combined NRC/Observatory group completed measurements at three of the most promising British Columbia sites and on the basis of these measurements, chose a site near Penticton as being the most suitable for the Dominion Observatory telescope. Subsequent to the loca-





PROBLEM:

The Dominion Observatory doesn't have a radio astronomer to become director of DRAO!

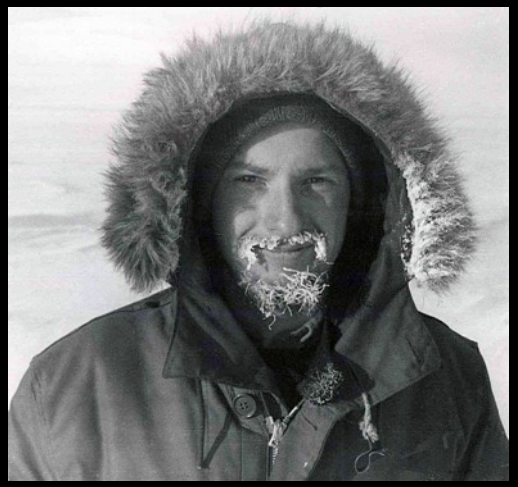
SOLUTION:

Make one!


John Galt
1944-1945
Royal Canadian Navy Volunteer Reserve
Signal Corps Training as Radio Artificer
(War ended, never sent abroad.)

1945-1949: University of Toronto (Physics)

Summer 1948: Night assistant at David Dunlap Observatory

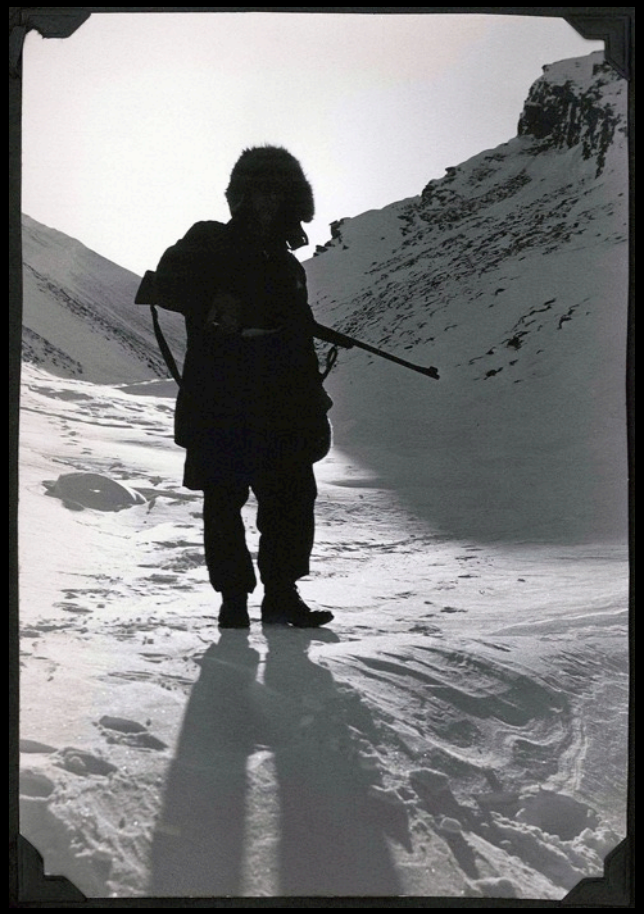


A photographic record of the year I spent in the Arctic operating the Dominion Observatory's Magnetic Station at Resolute Bay on Cornwallis Island.

John Galt.

1949-1950

Midnight sun near end of summer.



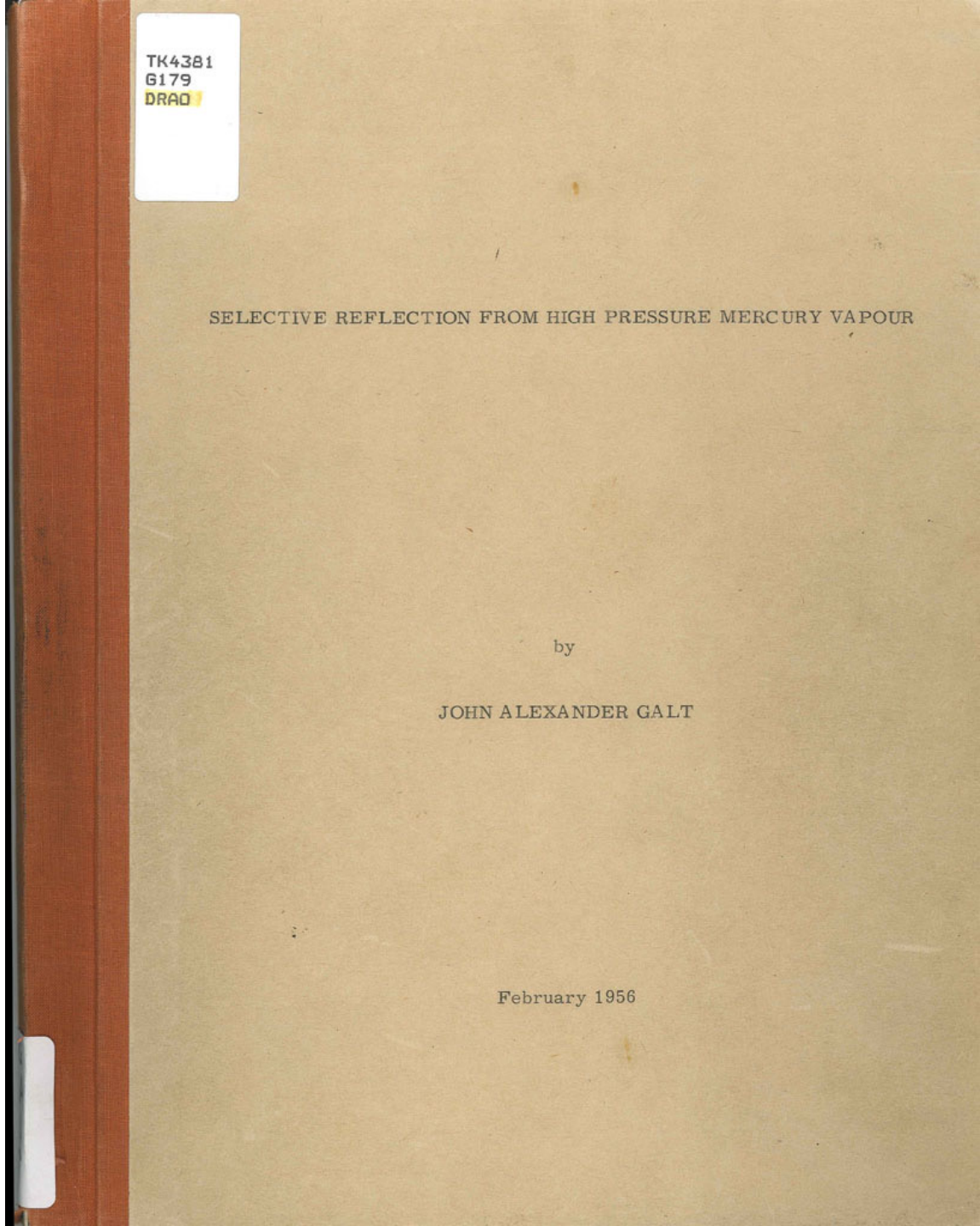

CANADA
DEPT OF MINES AND RESOURCES
DOMINION OBSERVATORY
MAGNETIC STATION

August

1950-1956
University of Toronto
PhD Physics

Summer 1952
Summer student at Dominion Astrophysical Observatory
Built photometer for Plaskett telescope with Ed Argyle

Summer 1954
Summer student at Dominion Astrophysical Observatory
June 29th solar eclipse expedition to Hansen, ONT "clouded out"



SELECTIVE REFLECTION FROM HIGH PRESSURE MERCURY VAPOUR

by

JOHN ALEXANDER GALT

February 1956

1956-1957

The miracles of science™

- **Worked at Dupont for a year.**
- **Missed research and didn't like the company.**
- **Applied to Leiden, Cambridge, and Jodrell Bank as a post-doctorate fellow.**
- **Lovell said, yes, you can come to Jodrell... but we're not sure about the money.**
- **Applied for Dominion Observatory radio astronomer position, was interviewed by Beals and Locke.**
- **Was offered the position, but observatory wasn't ready, so Dominion paid for John's "postdoc" at Jodrell Bank where he was to learn the ropes of radio astronomy before returning to Canada to be the first director of DRAO.**

1958: Jodrell Bank 250-ft Telescope

Bolton & Wild 1957
ApJ, 125, 256

John G. Bolton (1922-1993)

J. Paul Wild (1923-2008)

NOTES

ON THE POSSIBILITY OF MEASURING INTERSTELLAR MAGNETIC FIELDS BY 21-CM ZEEMAN SPLITTING

Measurement of the small magnetic field believed to exist in interstellar space has so far eluded both optical and radio techniques. However, the introduction of large radio reflectors offers the possibility of determining longitudinal fields in localized interstellar regions by observing the Zeeman splitting of the 21-cm line of neutral hydrogen.

In the presence of a weak magnetic field, the 21-cm line is split into three components, of frequency (Nafe and Nelson 1948)

$$\nu_0 \qquad (\pi), \quad \textbf{1420.4058 MHz}$$

$$\nu_0 \pm \frac{eH}{4\pi mc} \qquad (\sigma), \quad \textbf{1.4 Hz/μG}$$

where ν_0 is the undisplaced frequency of the line and H the longitudinal component of the magnetic field. Numerically, the frequency difference, $\Delta\nu$, between the two σ components is 2.8 Mc/s per gauss. Thus a magnetic field of 10^{-5} gauss, such as is believed to exist in the Galaxy, gives $\Delta\nu \approx 30$ c/s.

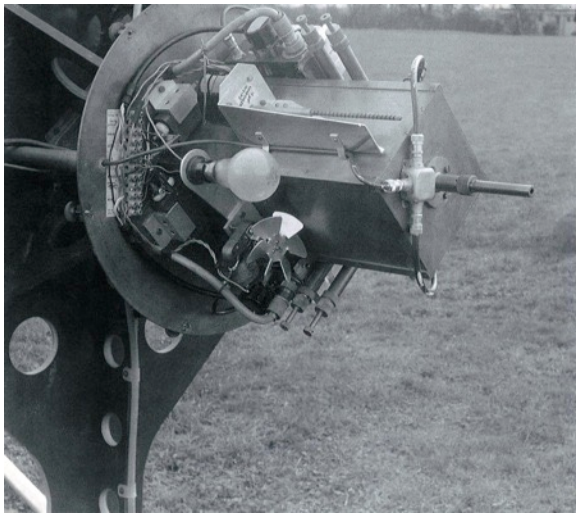
Under normal circumstances the detection of such small shifts in the galactic emission profiles would hardly be possible, owing to their large Doppler broadening. On the other hand, relatively narrow profiles have been observed in absorption. Hagen, Lilley, and McClain (1955) have reported three narrow absorption lines in the 21-cm spectrum of the discrete source in Cassiopeia, presumably due to three individual H I concentrations with different radial velocities. These lines have half-widths of about 10 kc/s, in the center of which the radiation is almost completely absorbed. It may reasonably be assumed that the magnetic field is sensibly constant in direction over any one of the H I concentrations responsible for the absorption lines.

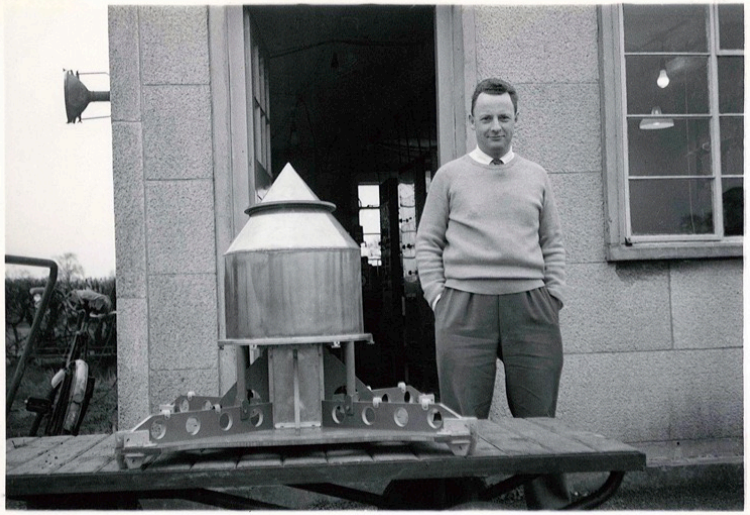
The detection of a Zeeman shift less than 1 per cent of the line width could be accomplished by using the radio analogue of the optical method currently employed by Babcock (1953) for measuring weak solar fields. The frequency of a narrow-band receiver is set on the edge of the line near the point of maximum steepness, and the polarization of the antenna is switched to receive the two circular components alternately. The output at the switching frequency is given, in units of antenna temperature, by

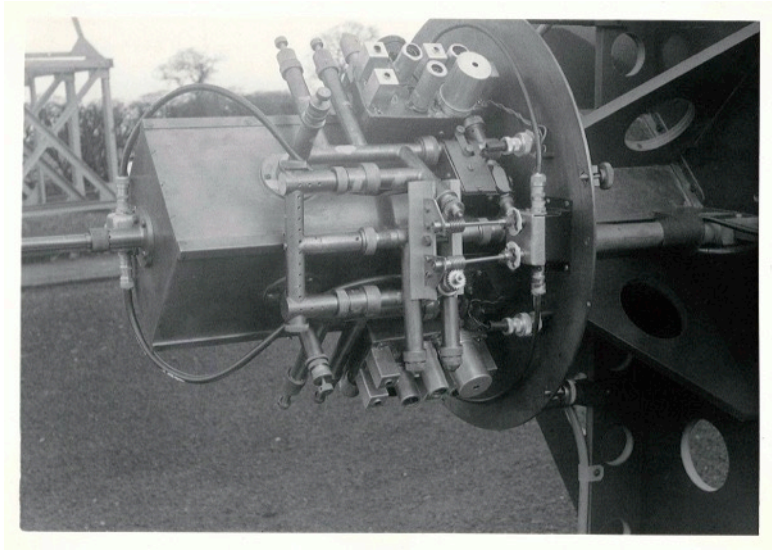
$$\Delta T = \frac{T_a \Delta\nu}{\mu},$$

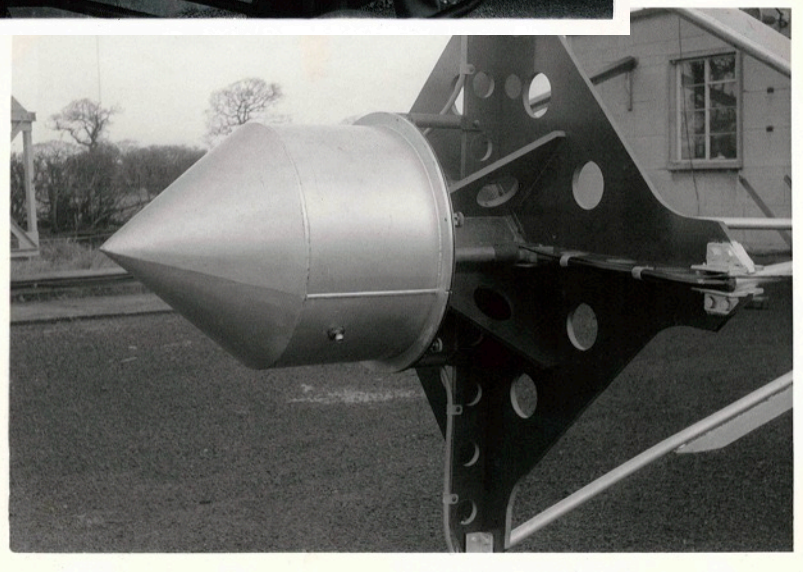
where T_a is the maximum decrease in antenna temperature of the absorption line, $\Delta\nu = 2.8 \times 10^6 H$ c/s is the difference in frequencies between the two σ components, and μ is the half-width of the absorption line, assumed of gaussian profile. Current results indicate values of T_a of the order of 1000° K if the Cassiopeia absorption lines are observed with a 150-foot reflector. Hence, with $\mu = 10$ kc/s, we should expect $\Delta T \approx 3 \times 10^5 H$ degrees. Current techniques permit the detection of $\Delta T \approx 1°$ K ($H \approx 3 \times 10^{-6}$ gauss), and instrumental improvements on this figure are likely in the future.

The First 21-cm Receiver for 250-ft Built by John Galt









AN ATTEMPT TO DETECT THE GALACTIC MAGNETIC FIELD USING ZEEMAN SPLITTING OF THE HYDROGEN LINE

J. A. Galt, C. H. Slater and W. L. H. Shuter*

(Received 1959 July 1)

Bill Shuter (1936-1995)

Summary

An attempt has been made to determine the strength of the galactic magnetic field by observing the inverse Zeeman effect on the 21 cm absorption line of neutral hydrogen. Preliminary measurements using the Cassiopeia A radio source have shown no detectable Zeeman effect. This indicates that the magnetic field component in the line of sight is less than 5×10^{-5} oersted at the point in the Orion spiral arm where the absorption occurs.

---

1. *Introduction.*—A general magnetic field can be postulated to explain interstellar polarization of starlight, the cosmic ray spectrum, and the stability of the spiral arm structure of the galaxy. According to Chandrasekhar and Fermi (**1**), a magnetic field of the order of 7×10^{-6} oersted may be expected although Davis and Greenstein (**2**) suggest fields up to 10^{-4} oersted.

Bolton and Wild (**3**) have suggested that the galactic magnetic field may be measured by observing the inverse Zeeman effect in the hyperfine structure of the 21 cm absorption spectrum of strong radio sources, using the radio analogue of Babcock's (**4**) method of measuring weak solar magnetic fields. The present paper reports an attempt to make this measurement.

* Now at the Dominion Radio Astrophysical Observatory, Penticton, British Columbia, Canada.

Maximum sensitivity will be obtained with narrow intense lines such as those observed in the absorption spectrum of Cassiopeia A (23N5A) by Hagen, Lilley and McClain (**5**) and by Muller (**6**). The absorption lines originate in individual neutral hydrogen clouds of the galaxy. The narrowest of these lines, which has a half width of about 18 kc/s and is associated with the Orion spiral arm, was studied in this experiment.

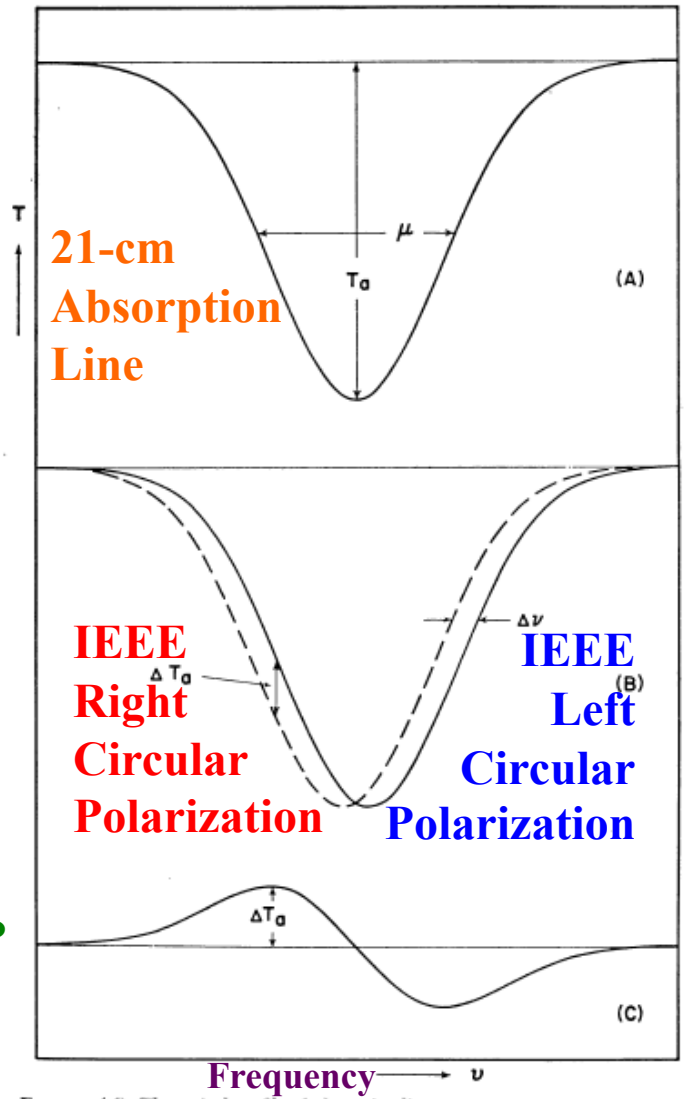


FIG. 1.—(*A*) *Theoretical profile of absorption line.*
(*B*) *Displaced polarized components of a Zeeman triplet (splitting exaggerated).*
(*C*) *Zeeman effect pattern obtained by subtracting the components in (B).*

Stokes V = RCP - LCP

This is the fingerprint of the Zeeman effect. If we see this, we can extract the magnetic field strength and direction in the hydrogen cloud!!!

February 1959: 26-m Arrives

Penticton Herald Feb. 19, 1959

RADIO TELESCOPE TRUCKED TO SITE

First truckloads of the 200-ton White Lake radio telescope are being moved from Okanagan Falls to the site three miles away. Here a huge casting and three spars move out, escorted by an RCMP patrol car. The 25 carloads must be moved now, while roads are hard enough to support heavy loads. Assembly will commence in May. (Herald Staff Photo)


DOMINION BRIDGE

Roy Hamilton John Galt Ed Argyle C. S. Beals (Dominion Astronomer)

Miriam Beals

OFFICIAL OPENING

MONDAY 20 JUNE 1960
AT 4·00 PM

PENTICTON B. C.

BACK ROW — Dr.T.R.Hartz, Dr.J.L.Yen, M.M.Thomson, Dr.G.Odgers
N.Broten, J.Grant, R.W.Tanner, Dr.K.O.Wright.

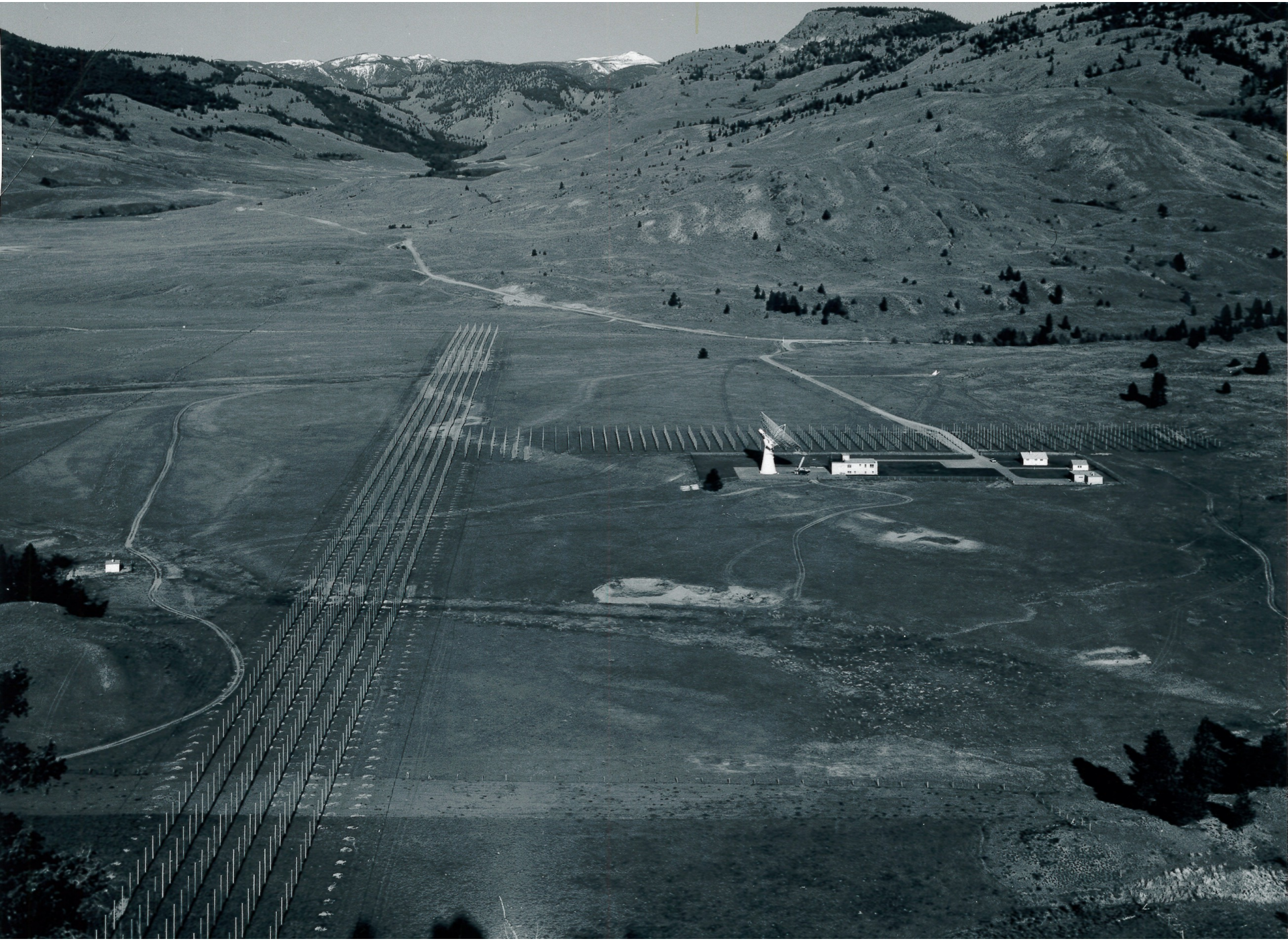
THIRD ROW — M.Pruesse, A.R.Hamilton, Dr.D.S.Heeschen, Dr.J.H.M
Dr.D.C.Rose, R.Grenzeback, Dr.J.W.Warren, Dr.R.M.C

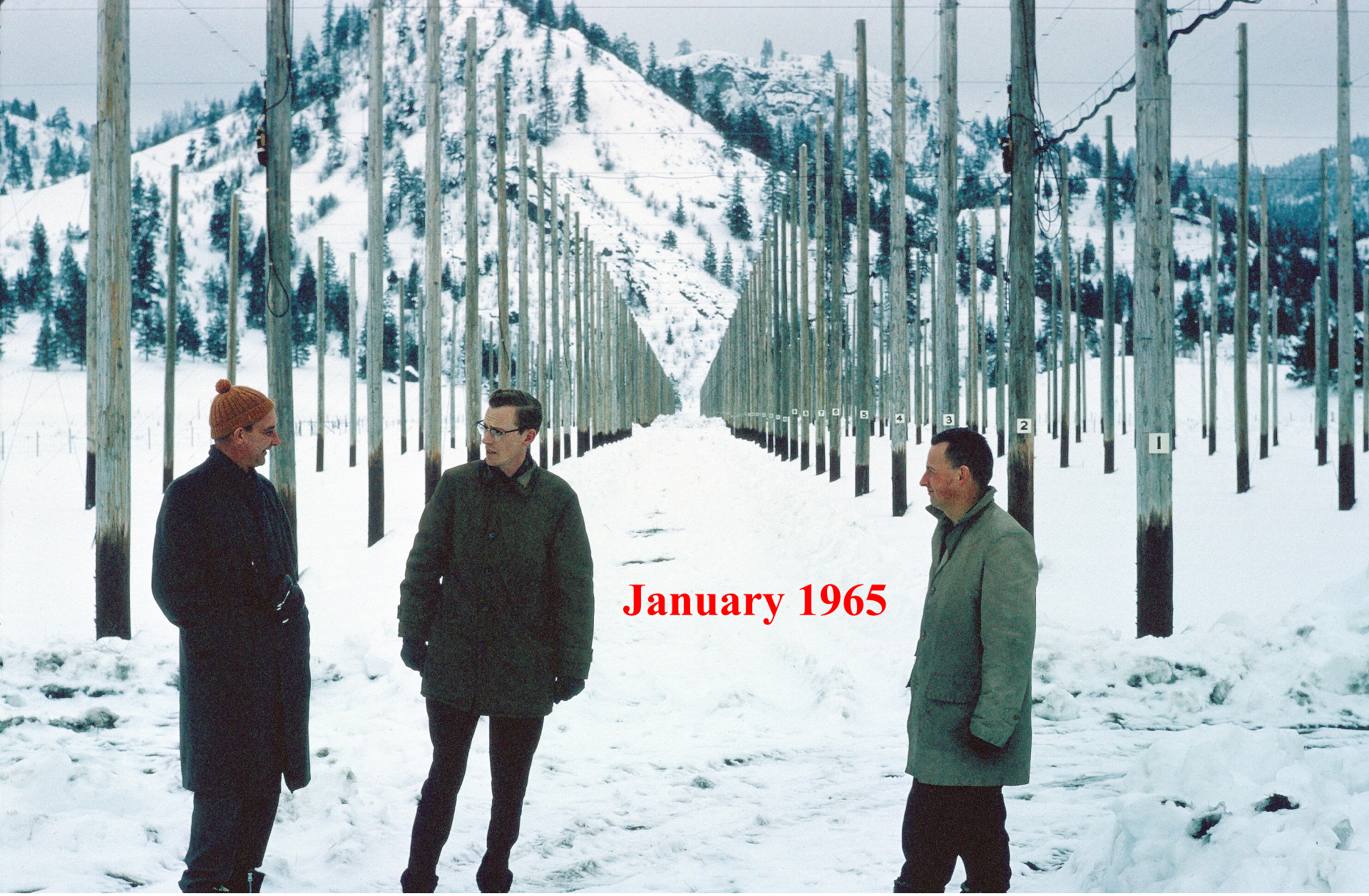
SECOND ROW — Miss M.Burland, Dr.C.H.Costain, Dr.B.W.Currie, P.E
Dr.W.Whelau, Dr.B.Oke, Dr.D.E.Hogg, Dr.J.C.Noyes,

FRONT ROW — Dr.P.M.Millman, A.E.Covington, Dr.R.M.Petrie, Mrs.
Dr.H.S.Hogg, Dr.C.S.Beals, Dr.G.A.Harrower, Dr.J.F.

ABSENT WHEN PICTURE WAS TAKEN — B.L.White, Dr.H.L.Welsh, J.M.Lansing

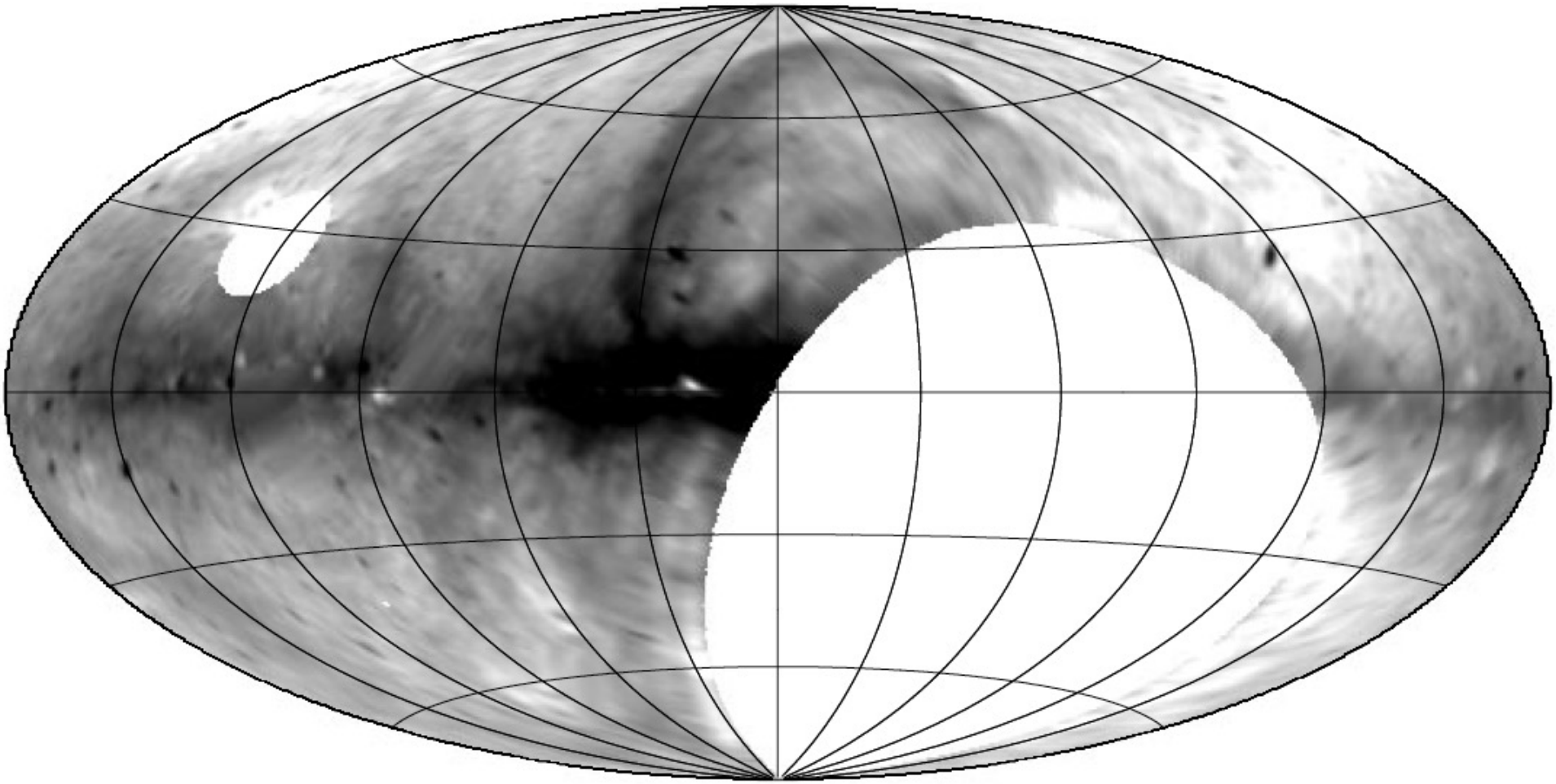
The 22.5 MHz Array





Bolton Costain Galt


September 1965
Carman Costain
1st Canadian to earn Ph.D.
in Radio Astronomy
Martin Ryle
PENTICTON B.C.

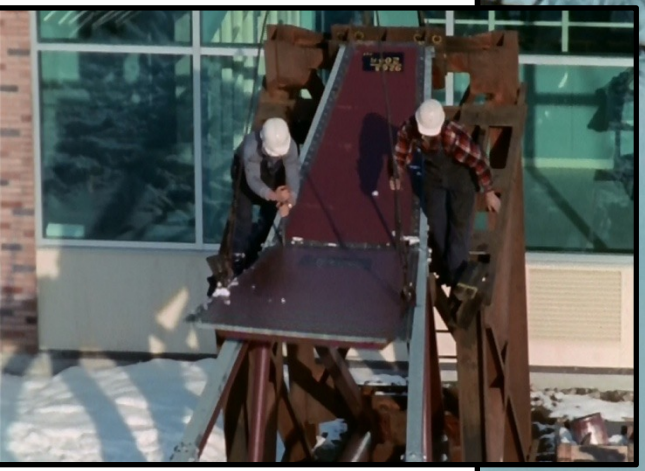


Algonquin Radio Observatory

"*To the Edge of the Universe*" (1969)

"To the Edge of the Universe"

Construction of Ribs



19 May 1966
ARO 150-ft "First Light"

19/5/66 (Thurs) * see after '21/5/66'

Polarisation vsly. investigated -ve rough power supply down, no obvious reason, diode replaced, repair work discontinued for "main line".

ED ph. readjusted by repeated instantaneous switch-ons of sidereal osc. — cause of ph. shift believed to be due to this ~~fact~~ as ~~another~~ ph. shift has always occured after loss of osc. while on line.

Z.A. ED characteristic established in detail.

Evening

A RADIO TELESCOPE IS BORN

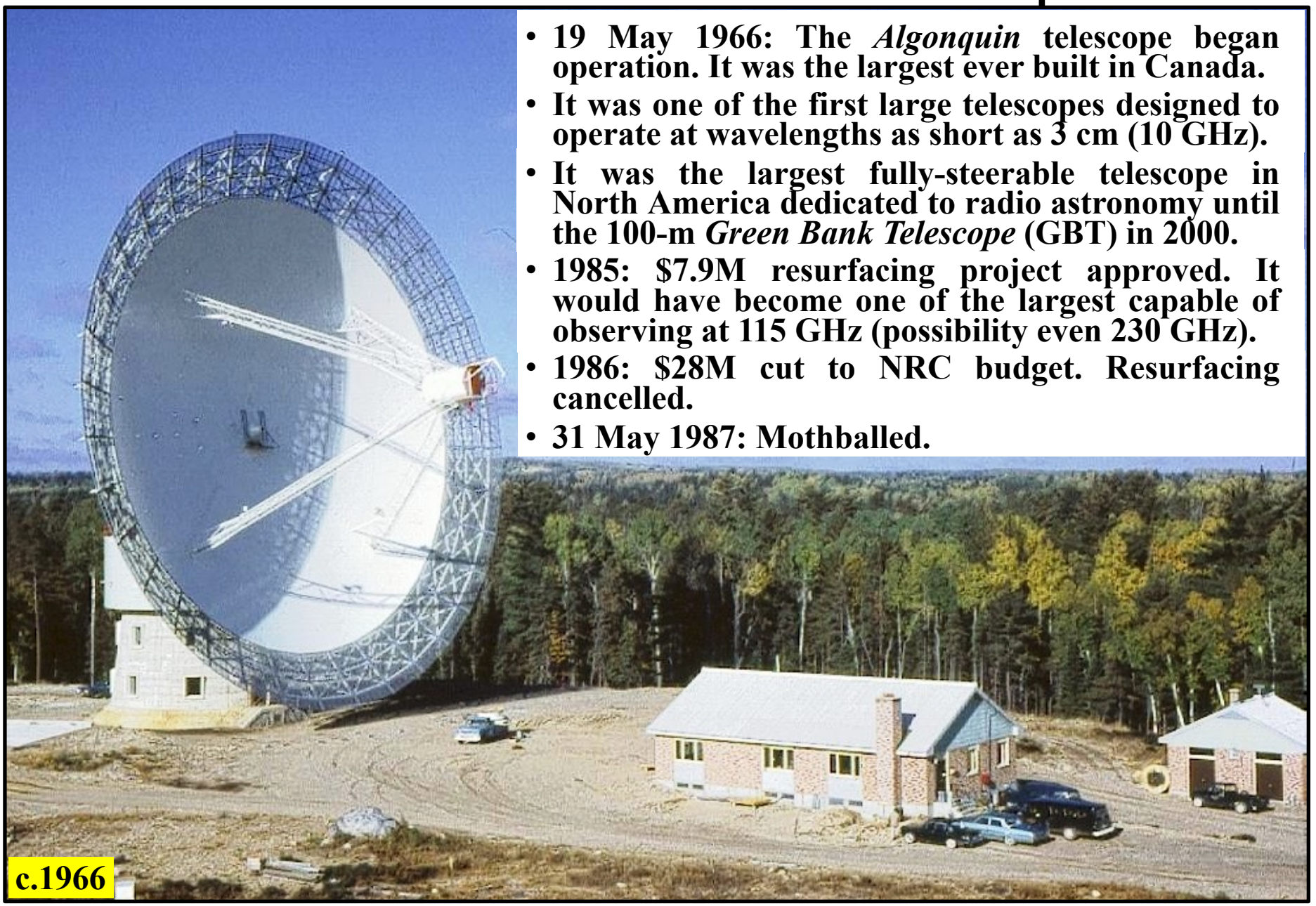
7.30pm to 12 pm. observations on 2 sources. Az. at low gain required some "nursing" otherwise successful.

http://www.arocanada.com/ARO/people/John_Kenneth_Ayre.htm

John MacLeod :: "Observational Highlights from the Algonquin Radio Observatory 1959–1986"

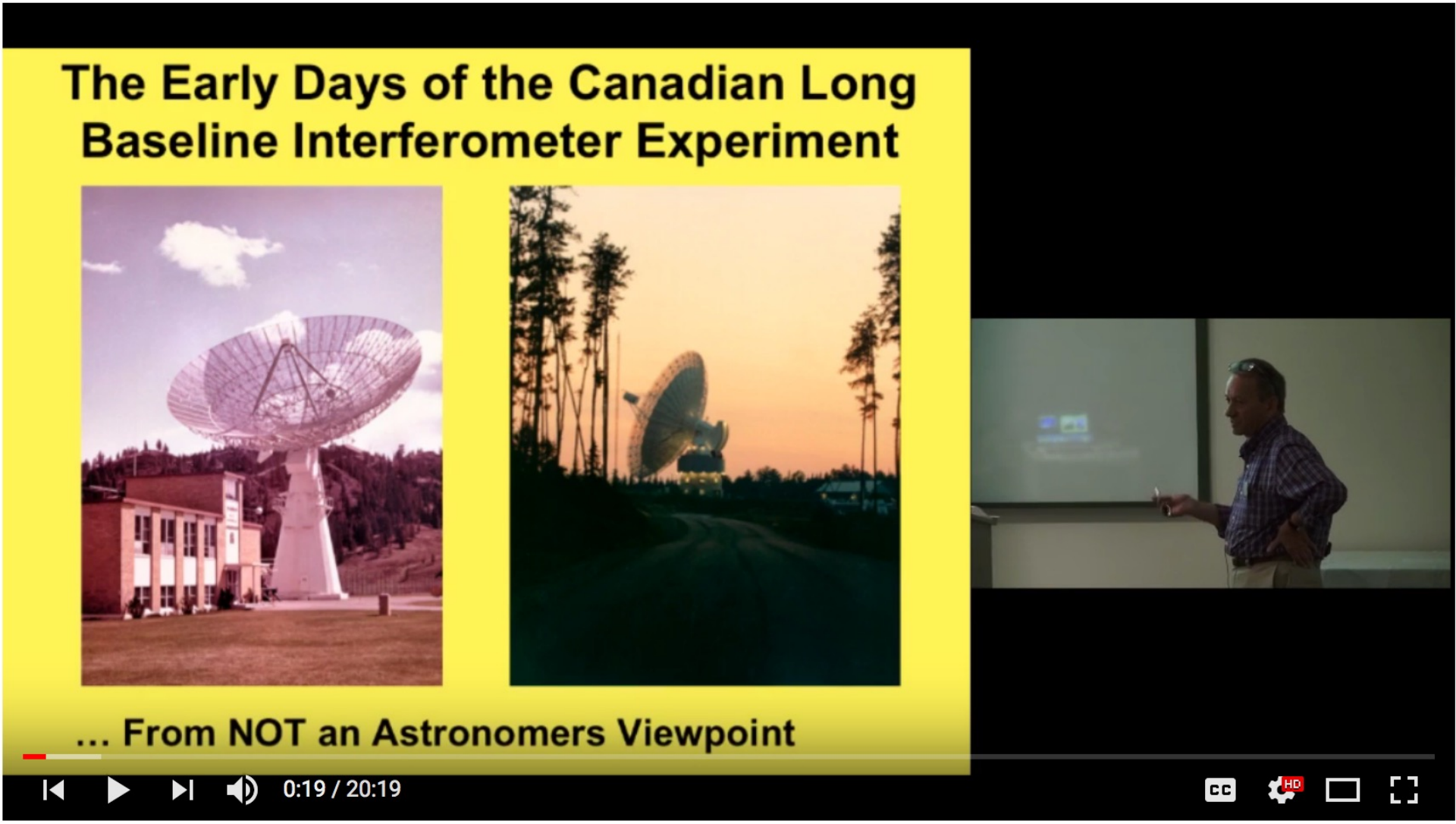
Bob Hayward :: "A Brief History of the Algonquin 150-ft Telescope"

ARO 150-ft / 46-m Telescope



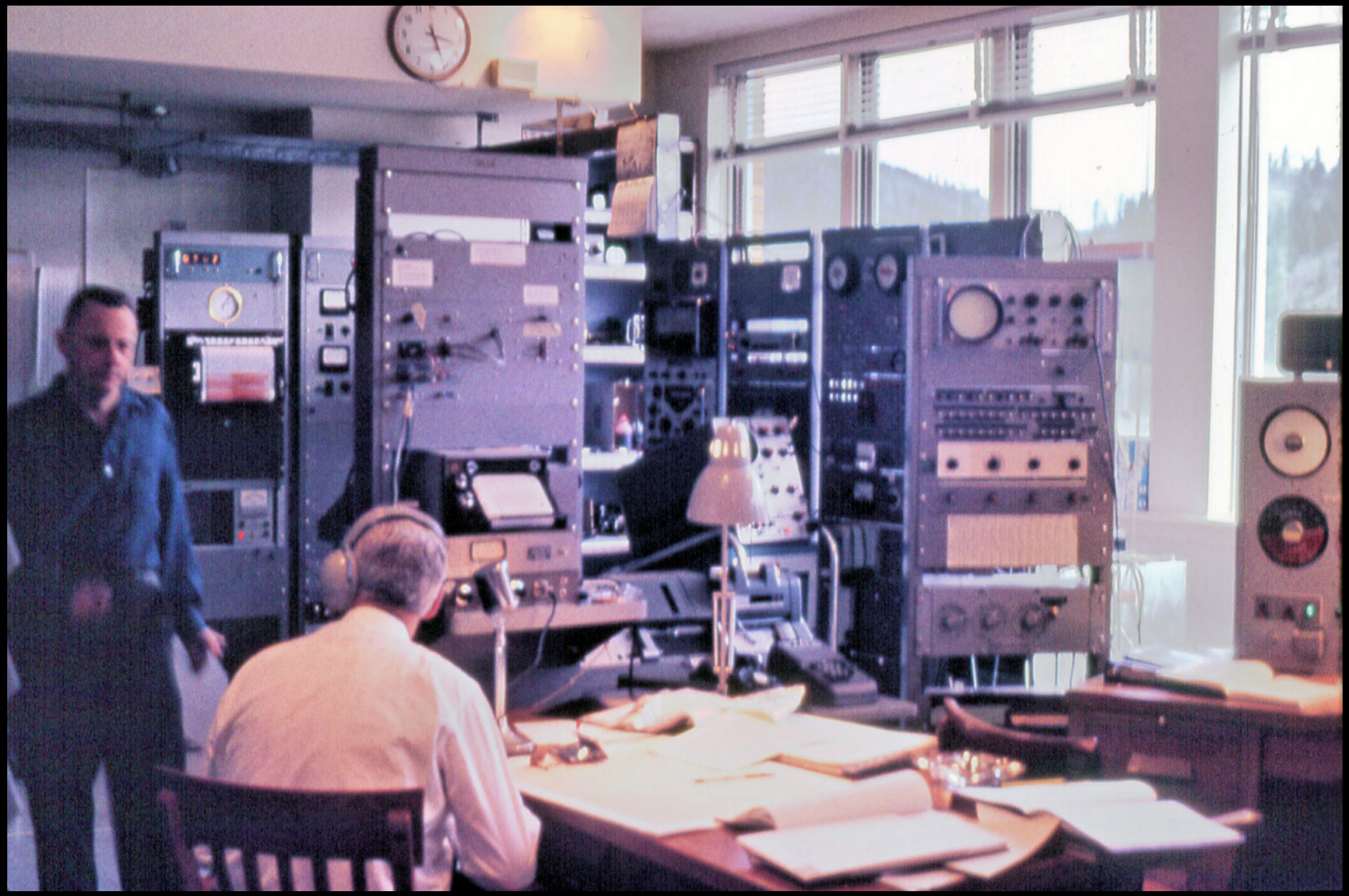
- **19 May 1966: The *Algonquin* telescope began operation. It was the largest ever built in Canada.**
- **It was one of the first large telescopes designed to operate at wavelengths as short as 3 cm (10 GHz).**
- **It was the largest fully-steerable telescope in North America dedicated to radio astronomy until the 100-m *Green Bank Telescope* (GBT) in 2000.**
- **1985: $7.9M resurfacing project approved. It would have become one of the largest capable of observing at 115 GHz (possibility even 230 GHz).**
- **1986: $28M cut to NRC budget. Resurfacing cancelled.**
- **31 May 1987: Mothballed.**

http://www.arocanada.com/images/1966_Ken_Site_3_nears_completion.jpg



Joseph Fletcher :: "The Canadian Long Baseline Interferometer"

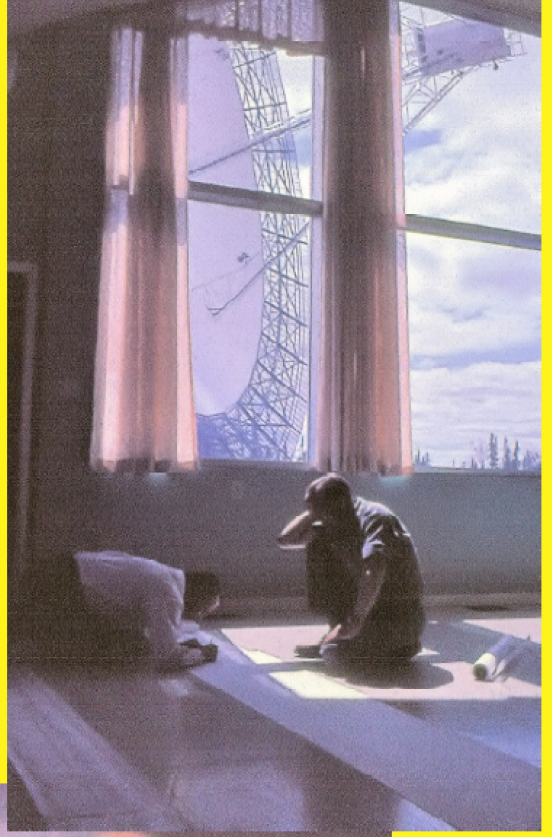
Putting atomic clock on the train at Chalk River.
Joseph Fletcher wearing the tie.



John Galt and Jack Locke in the DRAO control room

“Fringe Searchers” at work …

… Norm
Broten
>>> Allen
Yen
\\\ John
Galt



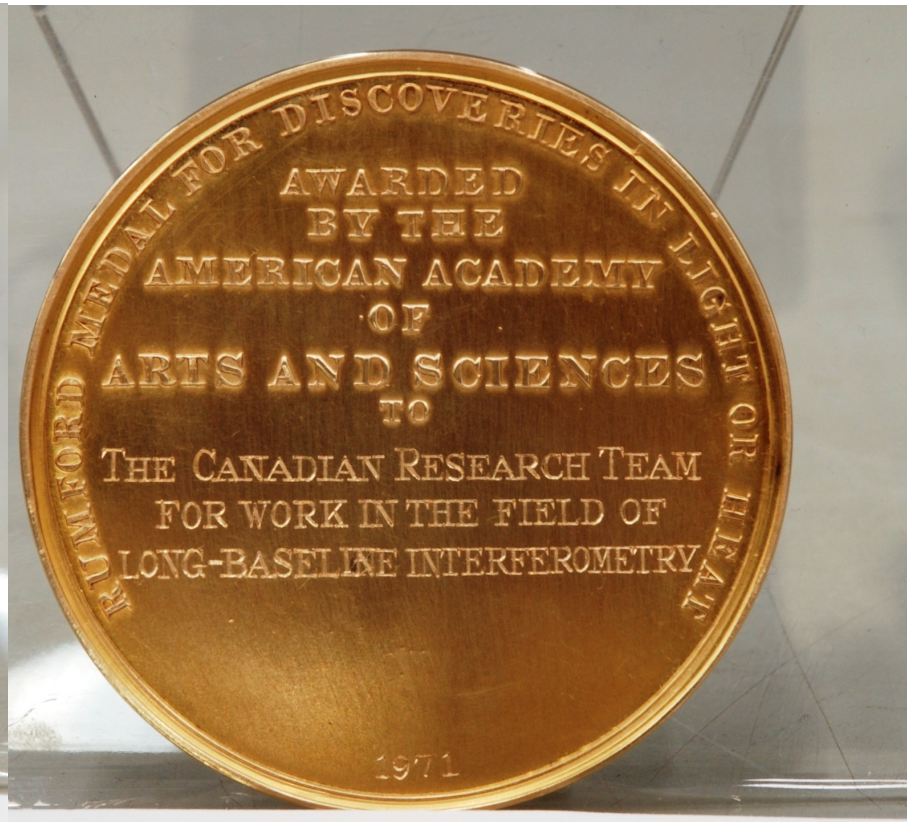
And finally SUCCESS ...

Leaving for Joint Canada/USA URSI Conference in Ottawa

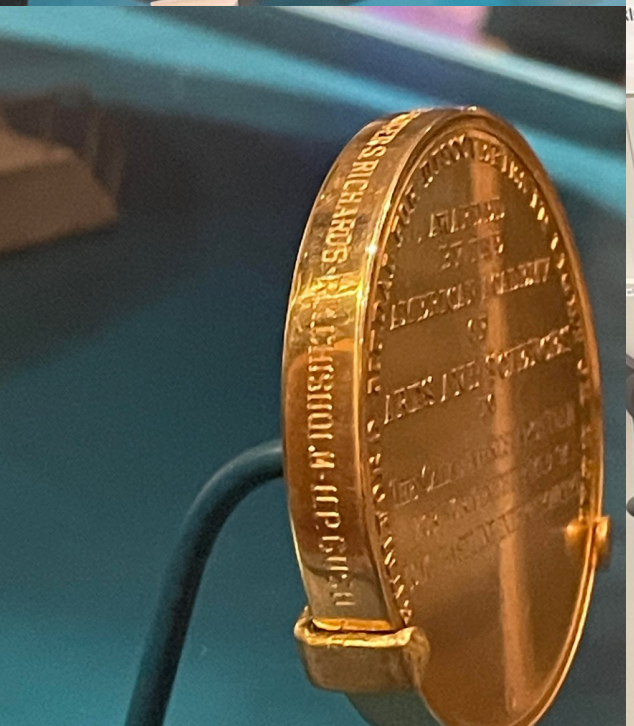
at 6 am, Monday morning, 22 May, 1967

American Academy of Arts and Sciences
1971 Rumford Prize

2003.0267 Rumford Medal
CR Nov 23, 2010

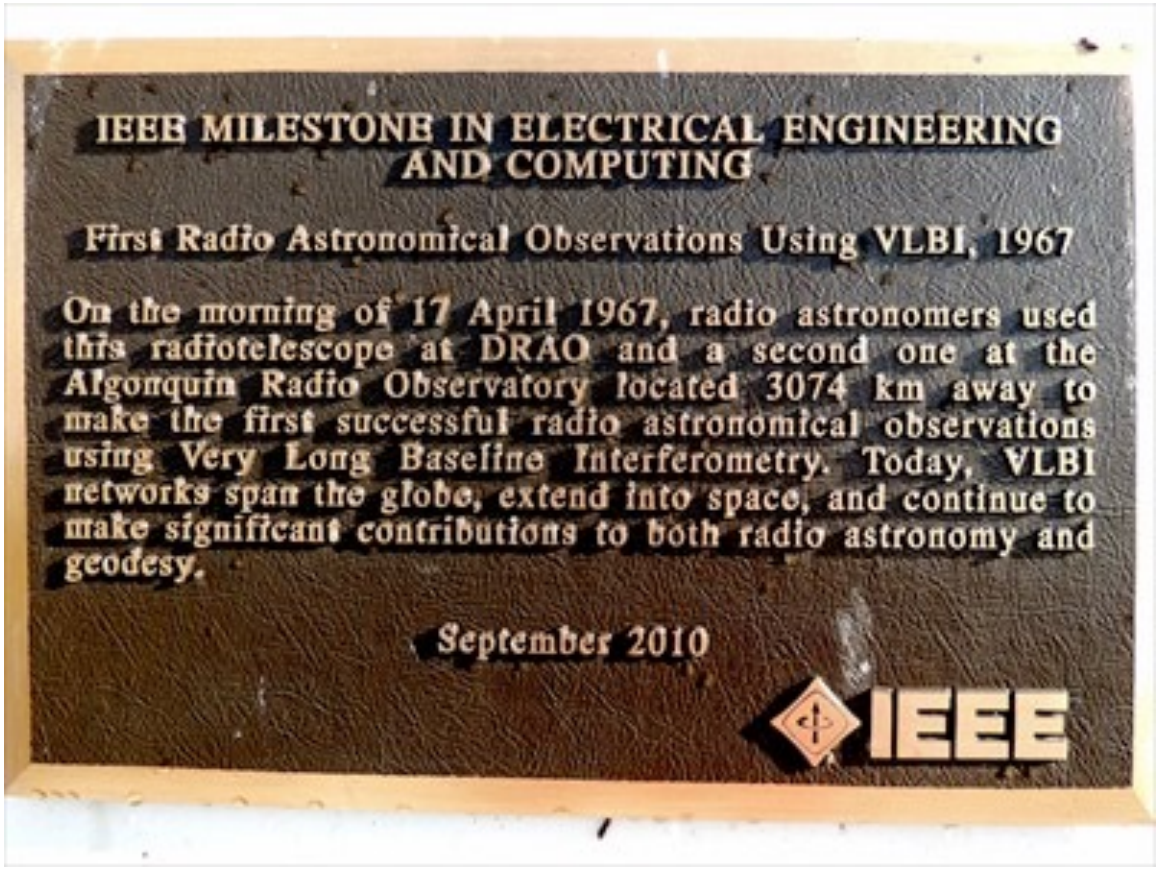


003.0267 Rumford Medal
R Nov 23, 2010




088
ZONE
C

Institute of Electrical and Electronics Engineers 2010 Milestone Award



- The Pacemaker
- The Integrated Circuit
- Liquid Crystal Display
- The Internet
- The Laser
- The Computer
- The Compact Disc
- The Mercury Spacecraft

PLATE VII

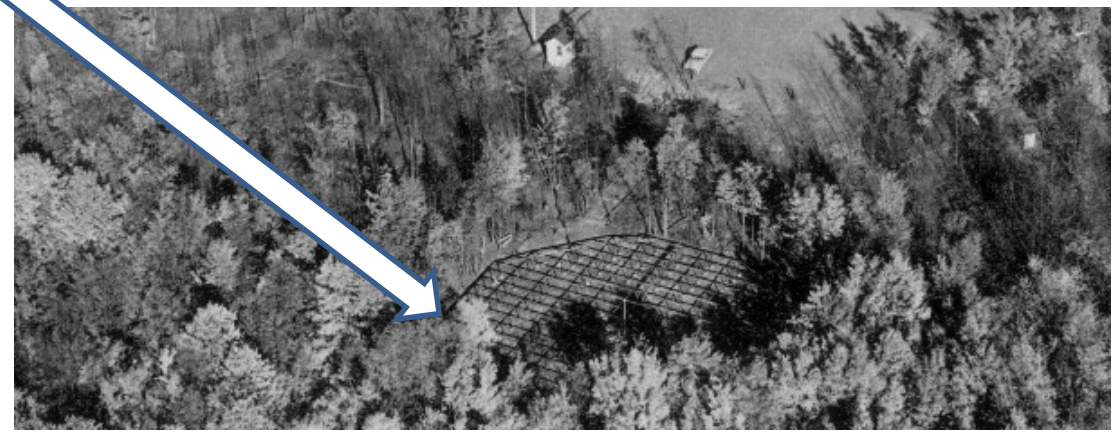
33 mc/s antenna for 20 kw meteor radar

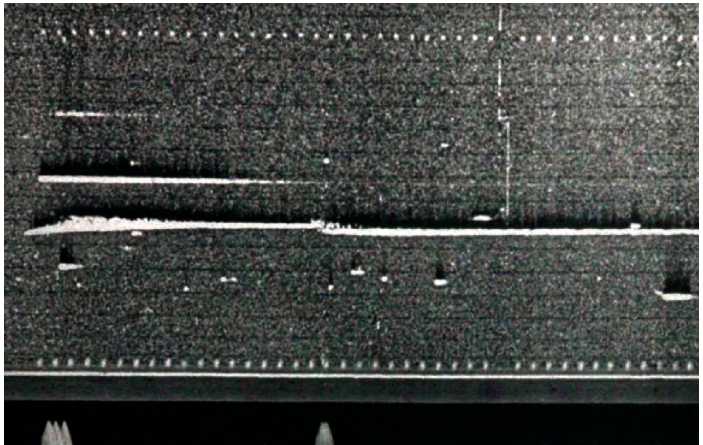
Peter M. Millman (1906-1990)

&

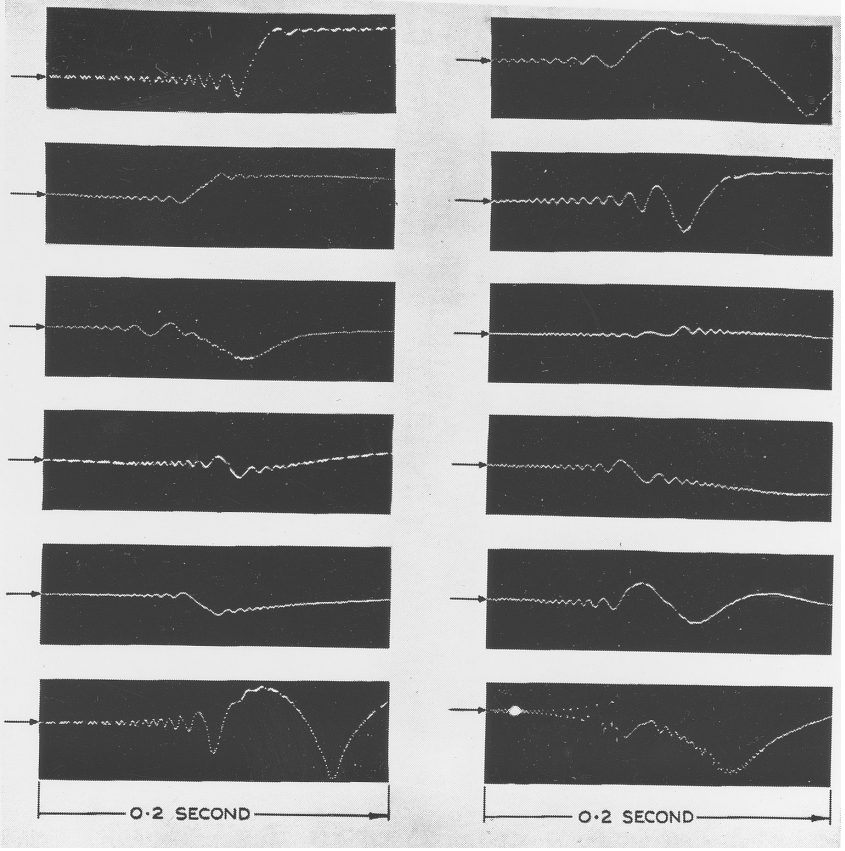
Donald R. W. McKinley (1912-1984)

ground reflector mats for radar antennas





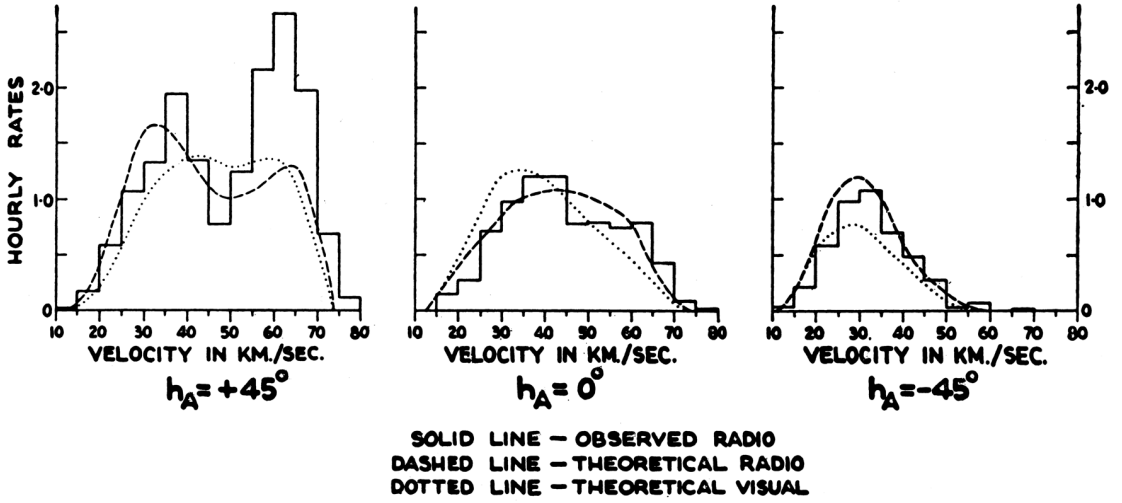
Delta Aquarid 1948
July 29

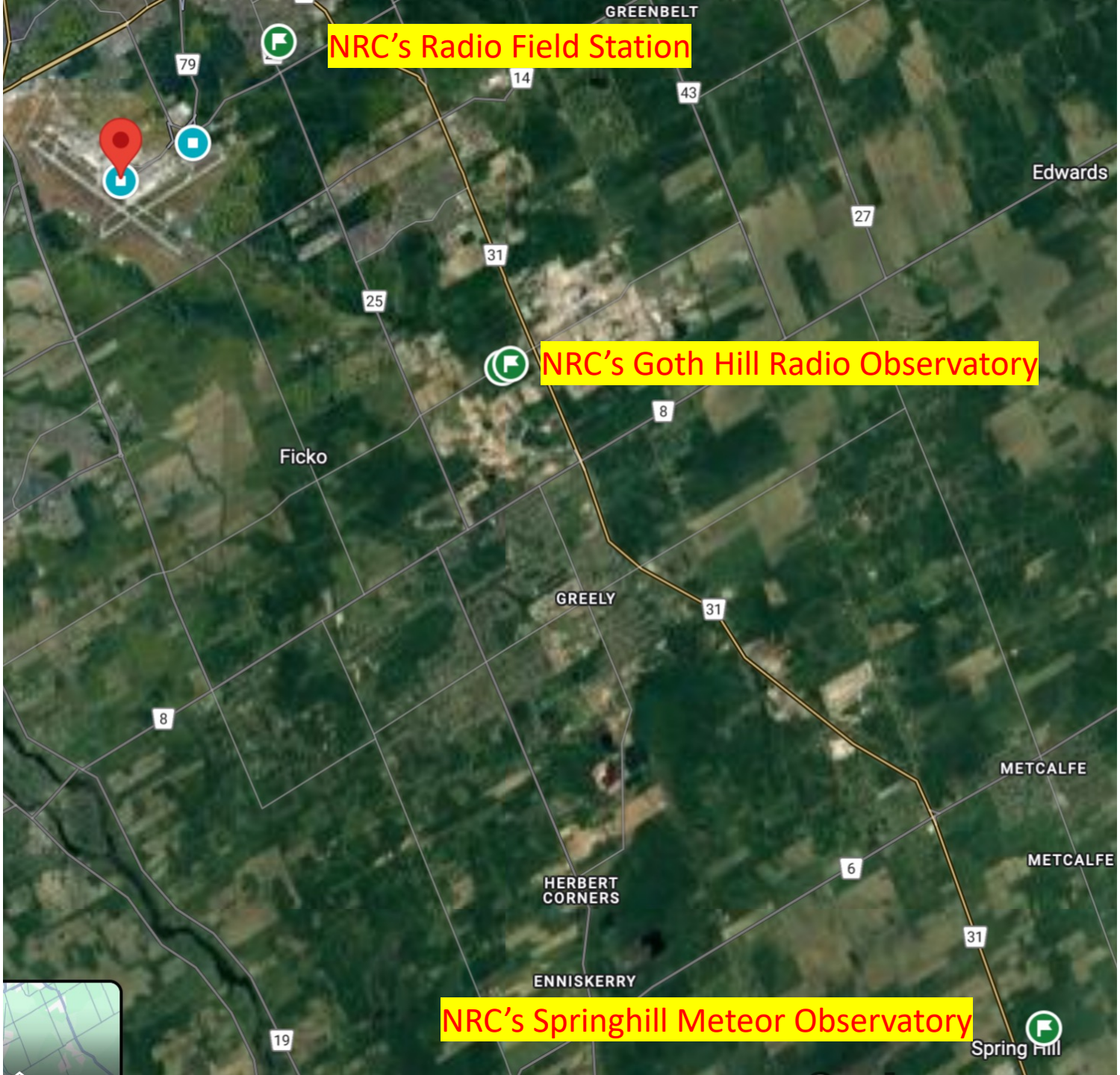


Meteor Echoes
= "Doppler Whistlers"

<u>No</u> interstellar meteors

McKinley (1951)




NRC’s Radio Field Station
NRC’s Goth Hill Radio Observatory
NRC’s Springhill Meteor Observatory
GREENBELT
Edwards
Ficko
GREELY
METCALFE
METCALFE
HERBERT
CORNERS
ENNISKERRY
Spring Hill
79
14
43
27
31
25
8
31
8
6
31
19

The DRAO Synthesis Telescope

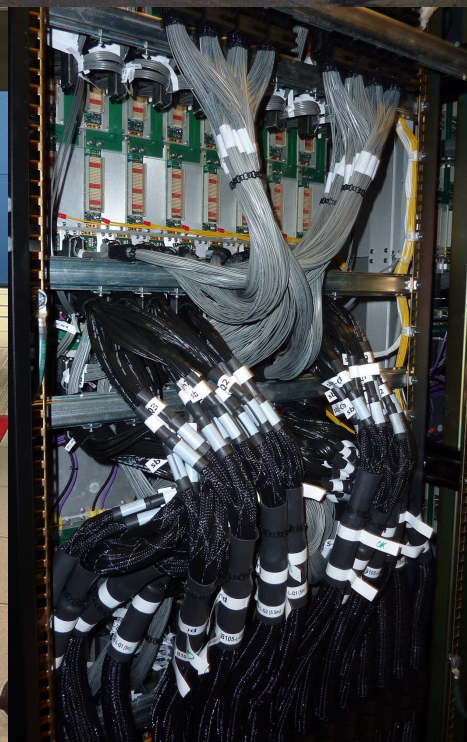

The Canadian
Galactic Plane Survey
180°
90°

VSOP:

VLBI Space Observatory Program

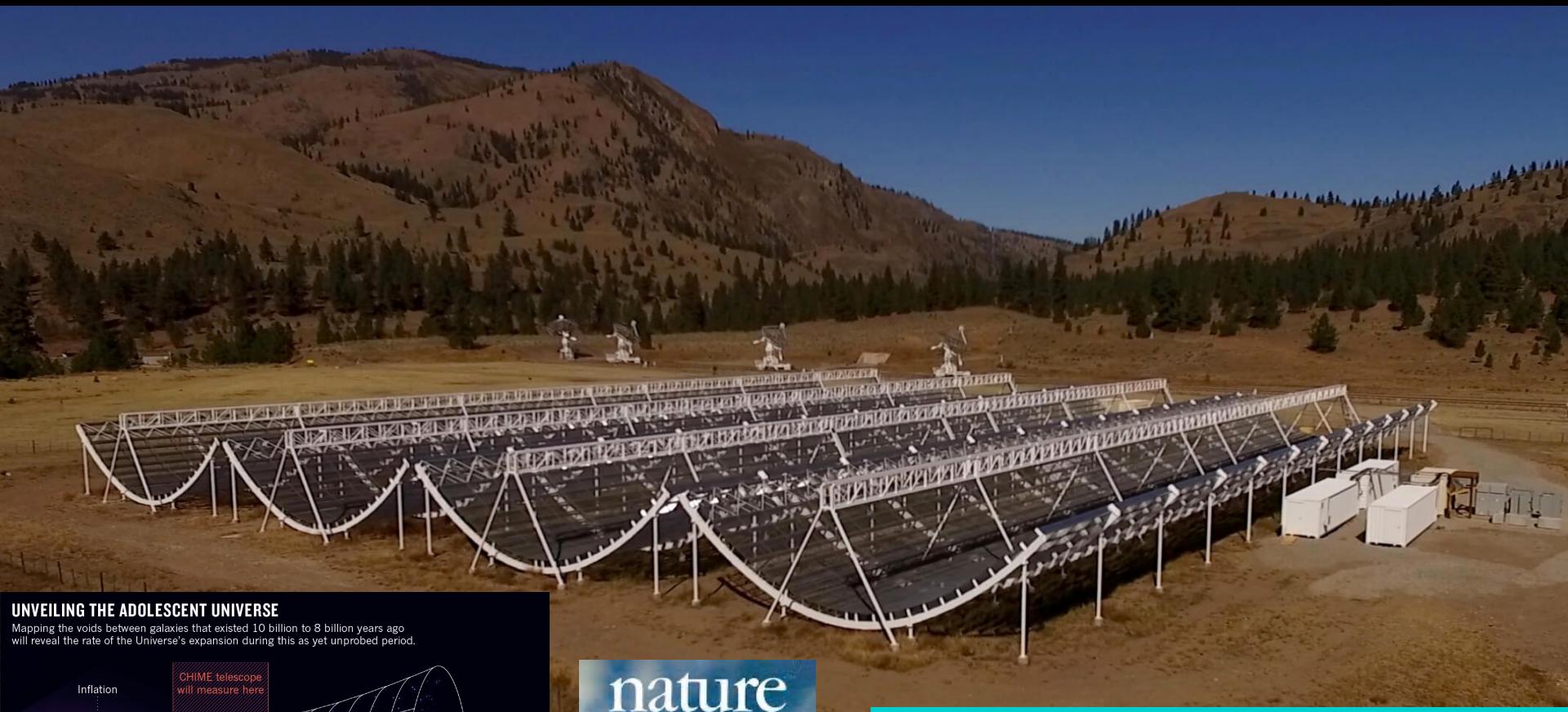
S2 LBI Correlator:
Employed VHS tapes

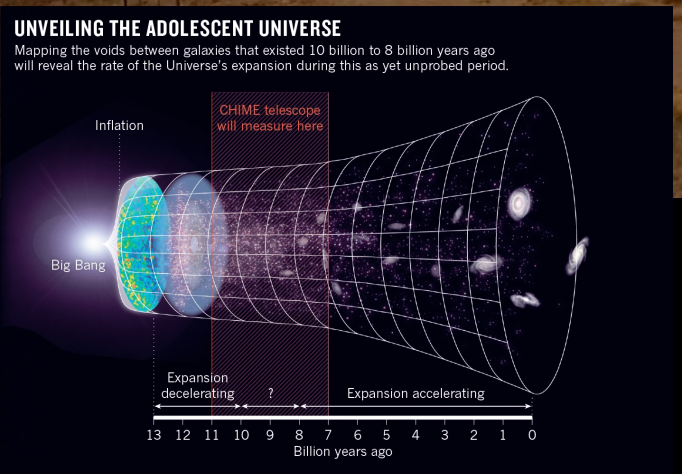
The Very Large Array (VLA)



CHIME

The Canadian Hydrogen Intensity Mapping Experiment is a revolutionary new Canadian radio telescope designed to answer major questions in astrophysics & cosmology.





UBC THE UNIVERSITY OF BRITISH COLUMBIA
McGill UNIVERSITY
UNIVERSITY OF TORONTO
Canada NRC·CNRC
Yale University
WestVirginiaUniversity.
PERIMETER INSTITUTE
Carnegie Mellon University
NRAO

CHORD

The Canadian Hydrogen Observatory and Radio-transient Detector

SKA

SQUARE KILOMETRE ARRAY

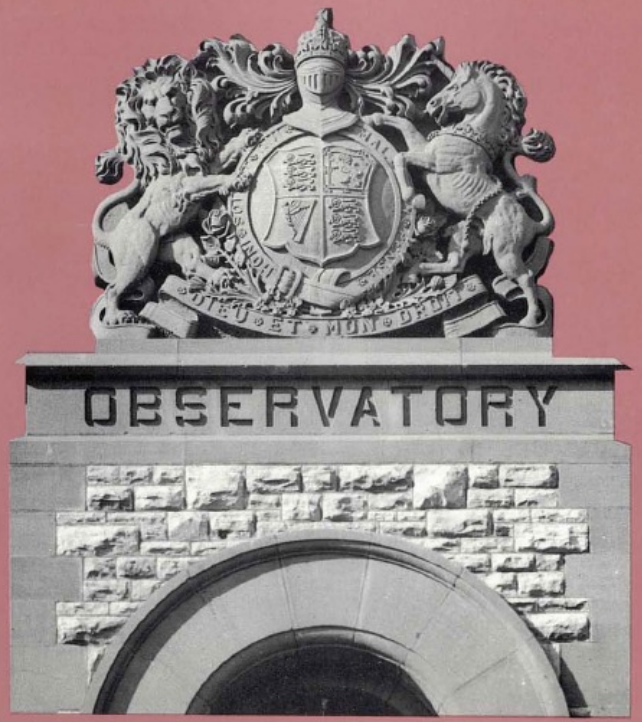
ngvla

Next Generation Very Large Array

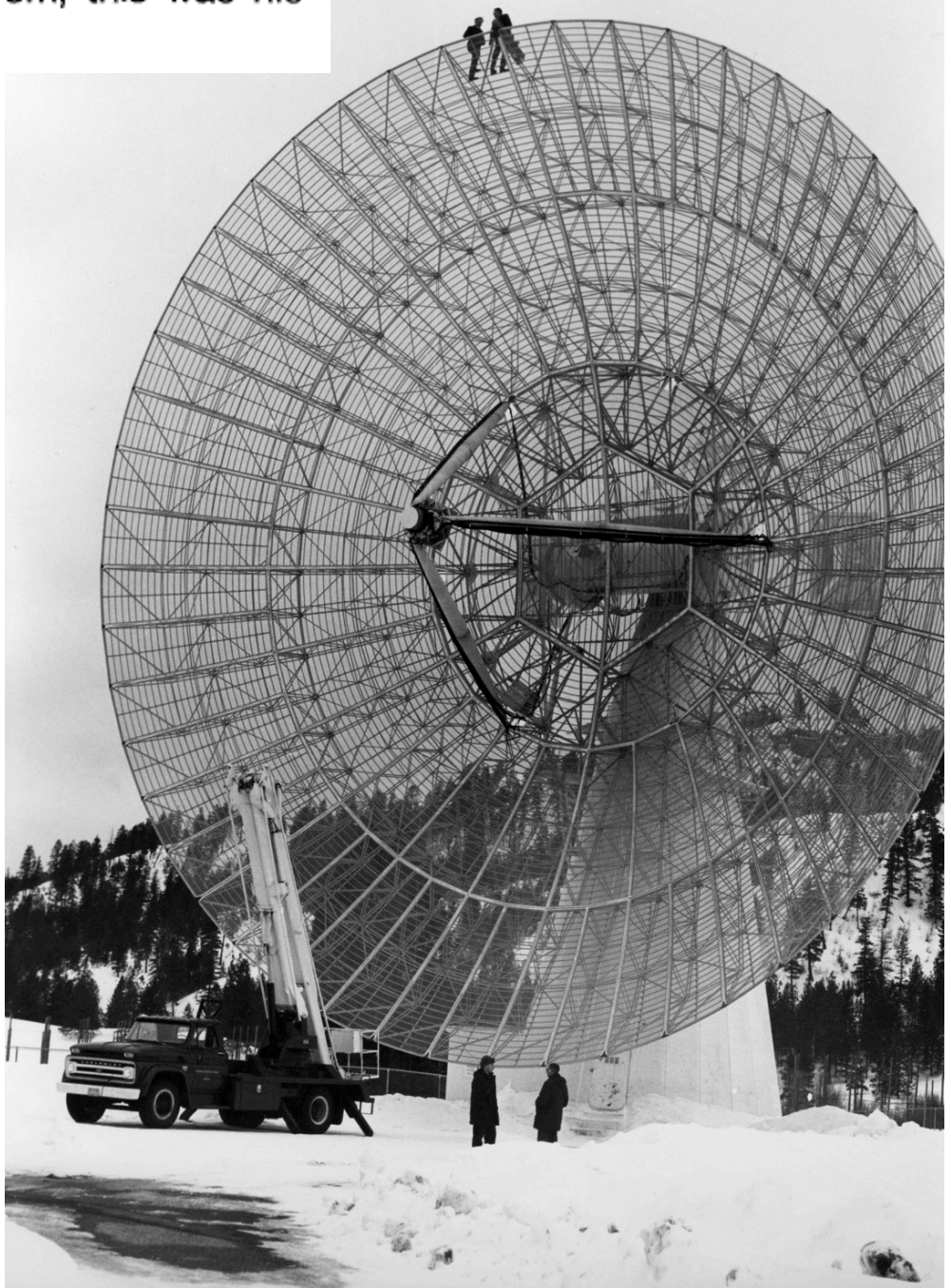
A close-up of the paraboloid. I asked Dr. Galt to give me a photograph showing him at work; this was his contribution.

THE HEAVENS ABOVE AND THE EARTH BENEATH

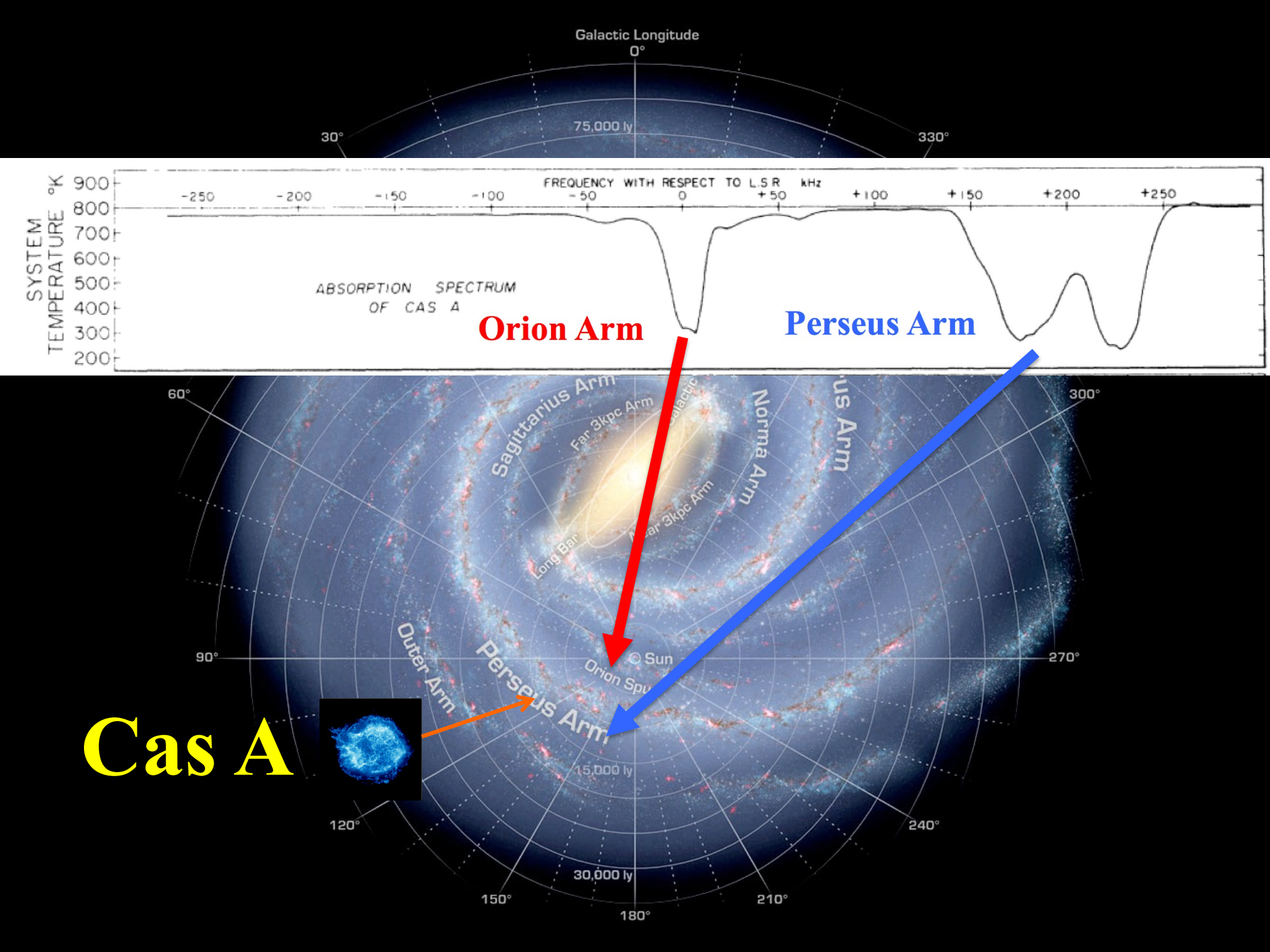
A History of the Dominion Observatories



Energy, Mines and Resources Canada
Énergie, Mines et Ressources Canada
Canada




TÉLESCOPE
JOHN A. GALT
TELESCOPE


Galactic Longitude
0°
30°
330°
75,000 ly
SYSTEM TEMPERATURE °K
900
800
700
600
500
400
300
200
FREQUENCY WITH RESPECT TO L.S.R. kHz
-250
-200
-150
-100
-50
0
+50
+100
+150
+200
+250
ABSORPTION SPECTRUM OF CAS A
Orion Arm
Perseus Arm
60°
300°
Sagittarius Arm
Far 3kpc Arm
Norma Arm
Long Bar
Outer Arm
Perseus Arm
Sun
Orion Spur
90°
270°
15,000 ly
120°
240°
30,000 ly
150°
210°
180°
Cas A

POSITIVE DETERMINATION OF AN INTERSTELLAR MAGNETIC FIELD BY MEASUREMENT OF THE ZEEMAN SPLITTING OF THE 21-cm HYDROGEN LINE

G. L. Verschuur
National Radio Astronomy Observatory,* Green Bank, West Virginia
(Received 17 July 1968) 9 Years & 2 Weeks

Fields of the order of 2×10^{-5} G exist in the Perseus spiral arm in the direction of the radio source Cassiopeia A.

July 4, 1968

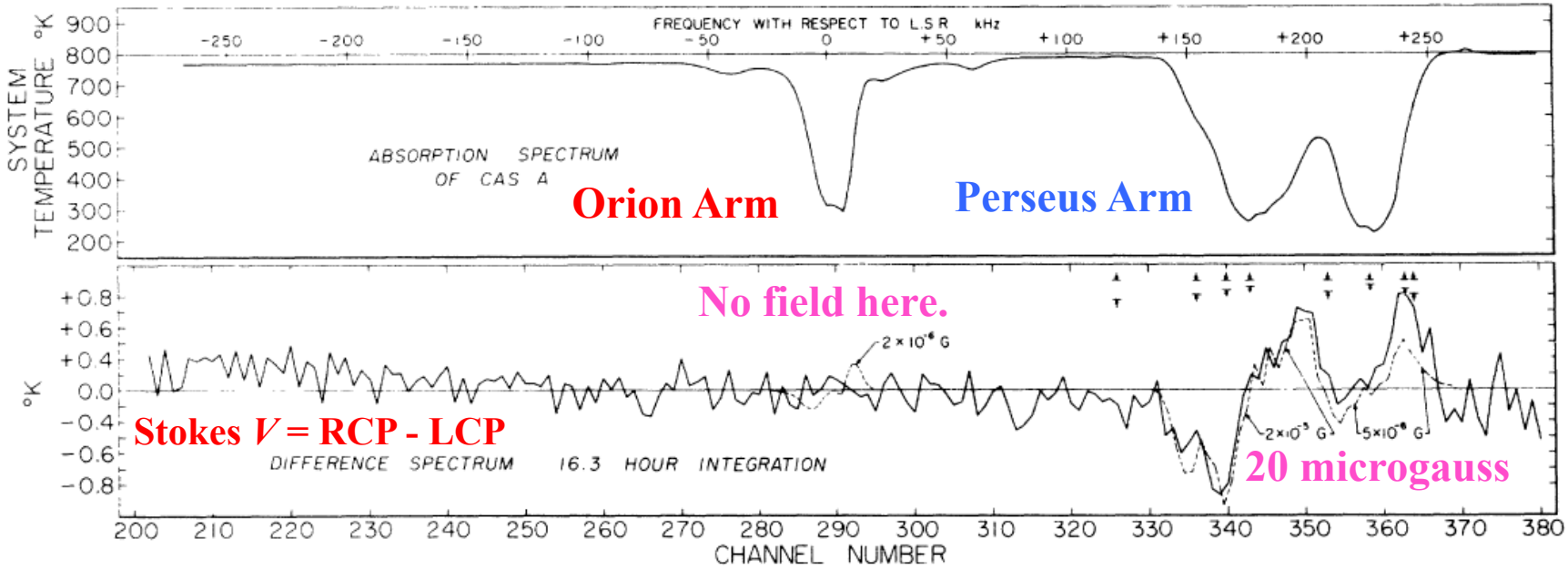
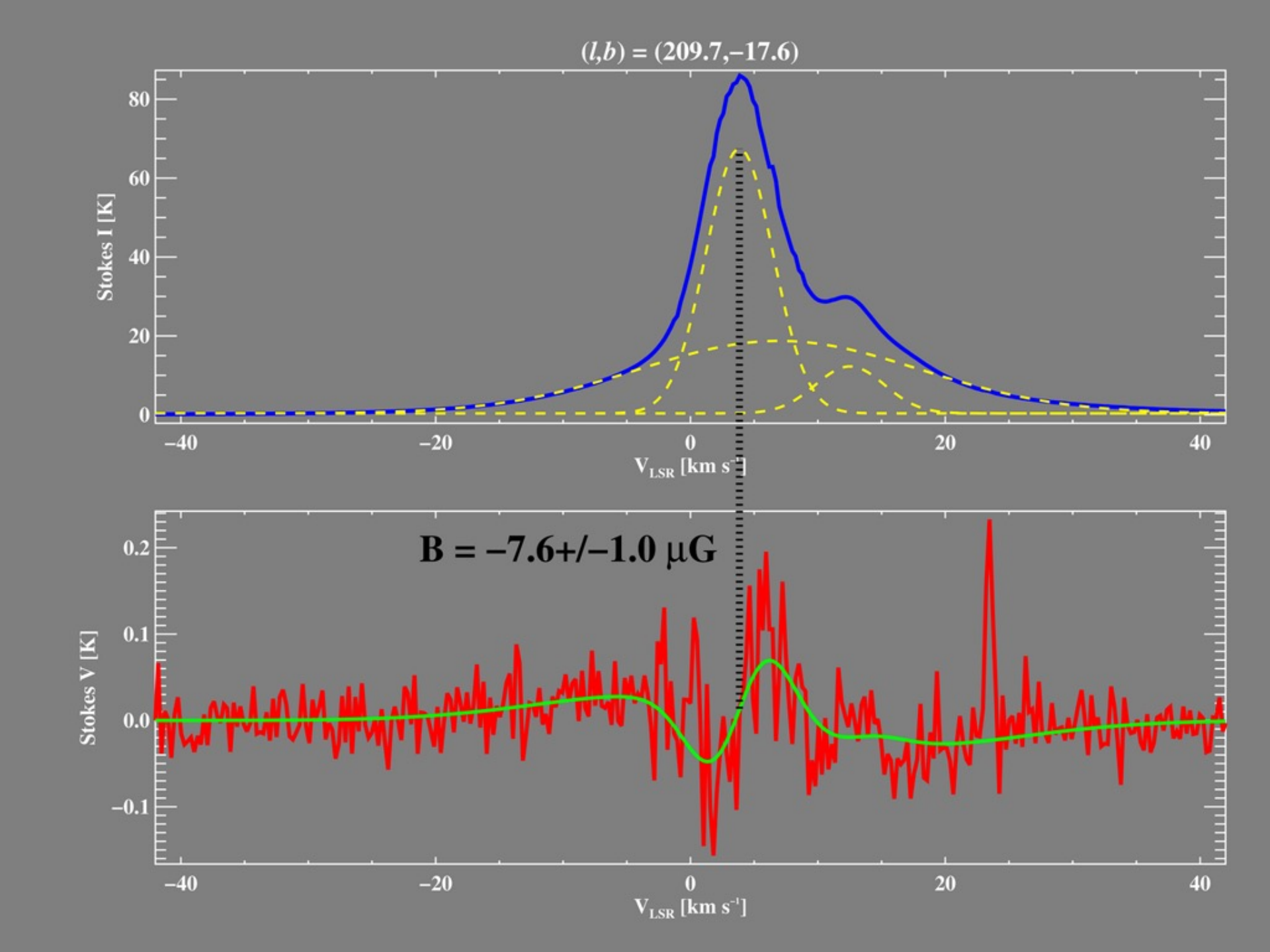
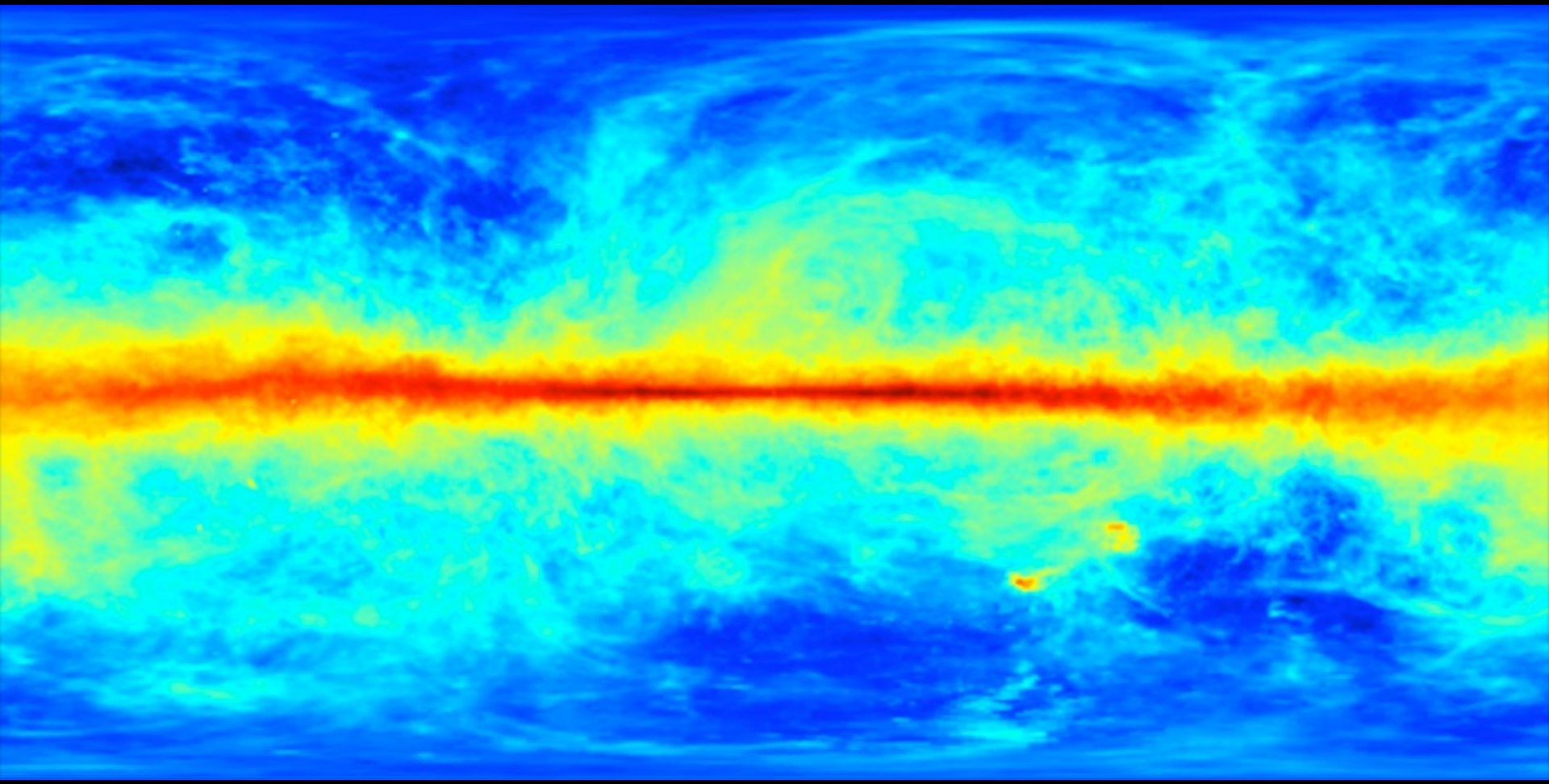


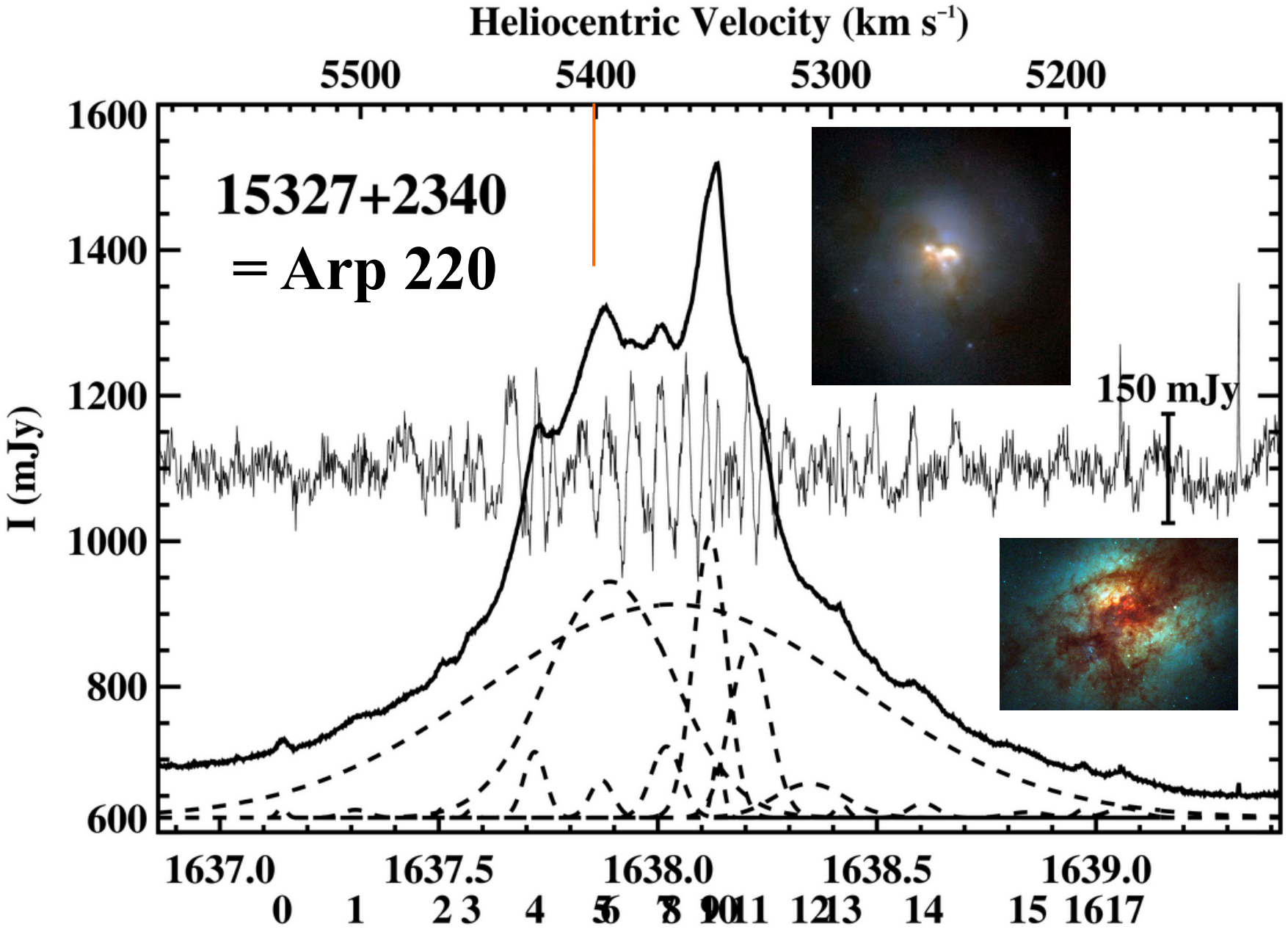
FIG. 1. The absorption spectrum of Cas A, together with the difference spectrum, right-hand minus left-hand polarization, incident on the feed representing 16.3 h of integration. Frequencies with respect to the local standard of rest are indicated. Arrowed bars represent expected peak-to-peak noise at various parts of the spectrum.


(l,b) = (209.7,−17.6)
Stokes I [K]
80
60
40
20
0
−40
−20
0
20
40
V_LSR [km s⁻¹]
B = −7.6+/−1.0 μG
Stokes V [K]
0.2
0.1
0.0
−0.1
−40
−20
0
20
40
V_LSR [km s⁻¹]

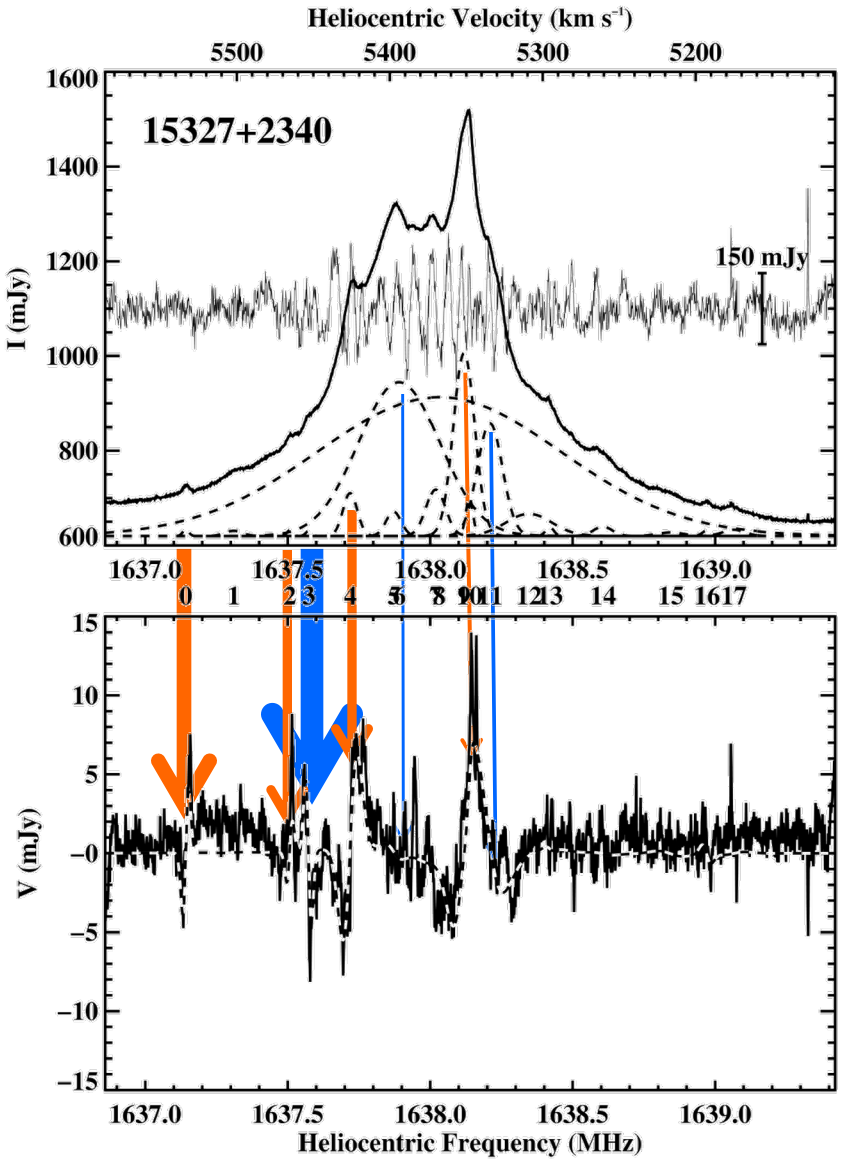
21-cm Line Emission Is Everywhere.



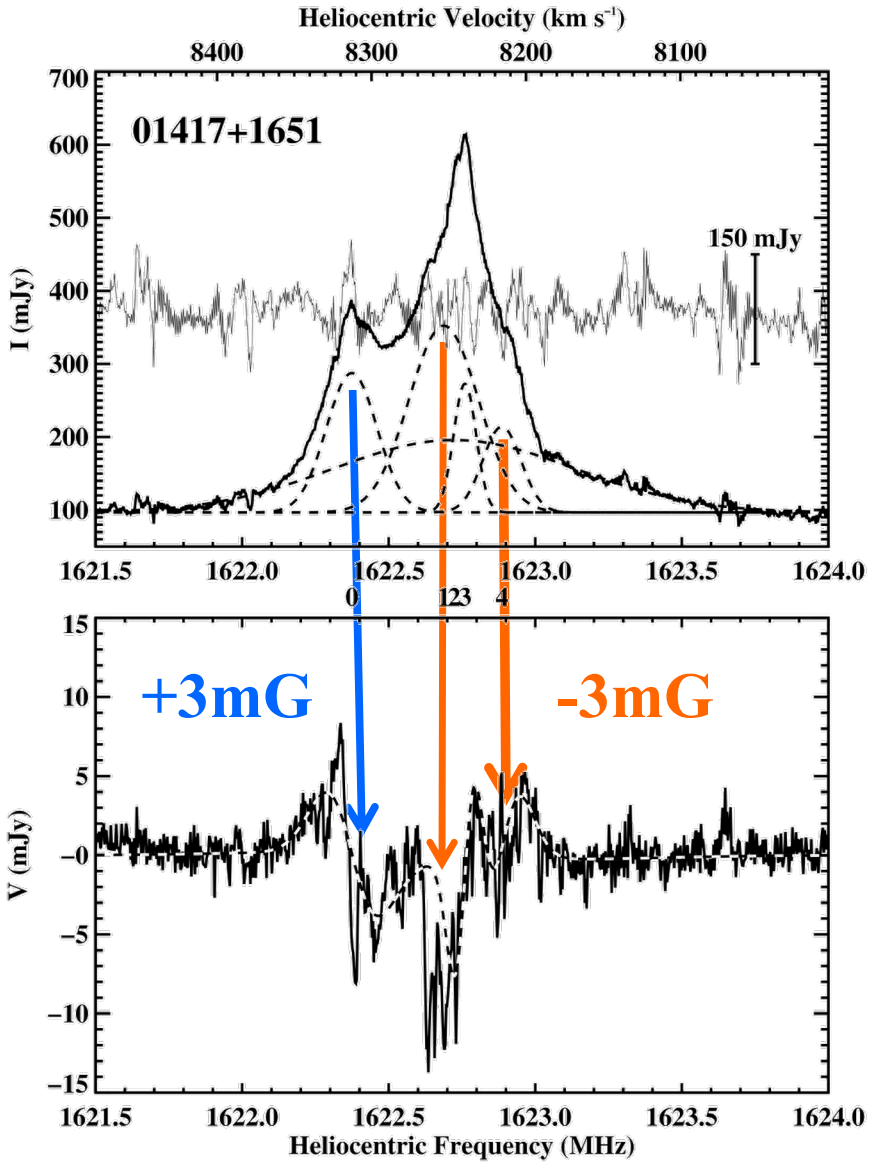
OH Megamasers

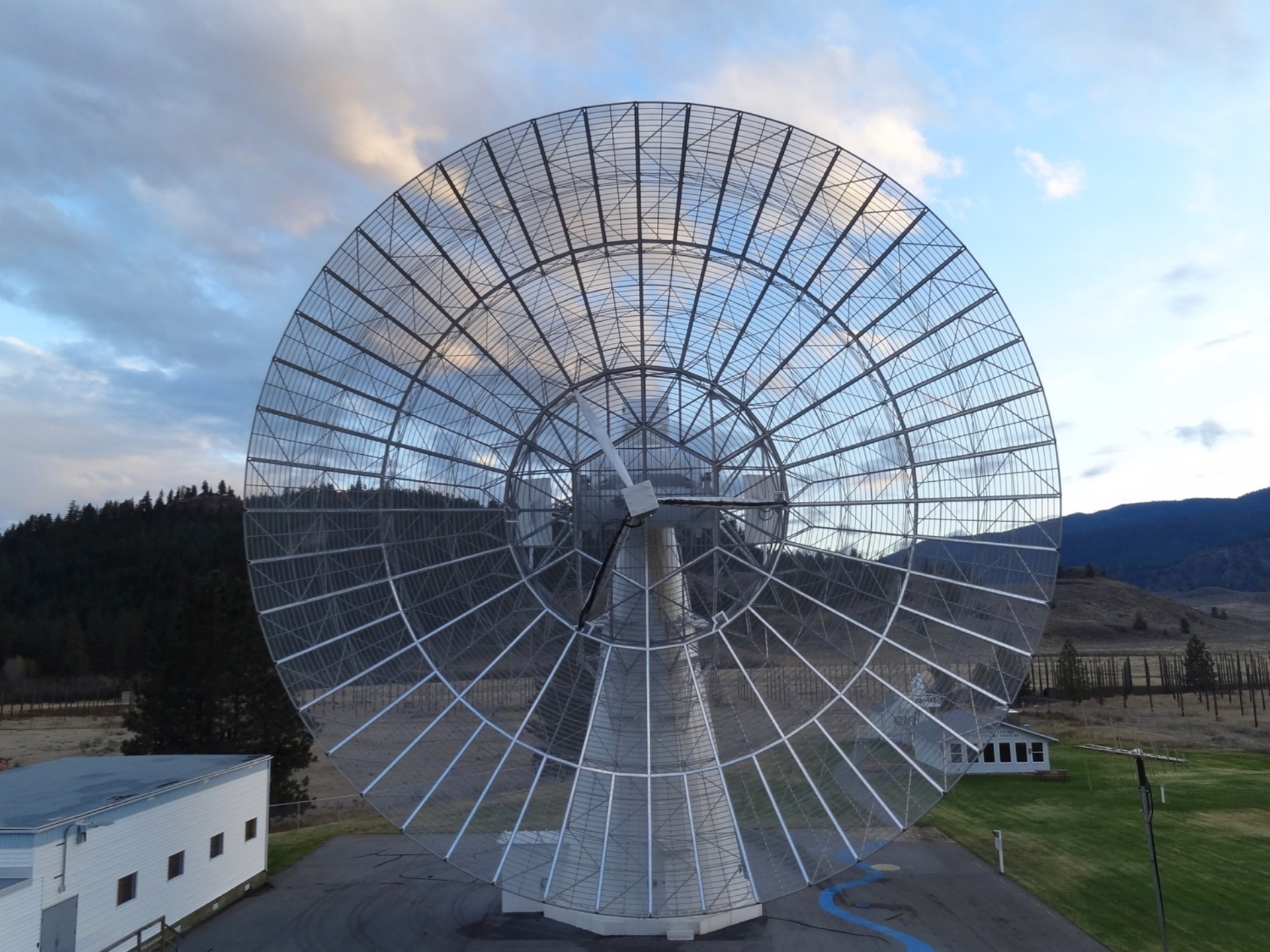


Arp 220



III Zw 35





New Eyes

900-1800 MHz

- **World's most sensitive radioastronomical receiver at 1420 MHz.**
- **Specially outfitted with best-performing L-band low-noise amplifiers produced by Frank Jiang at DAO.**

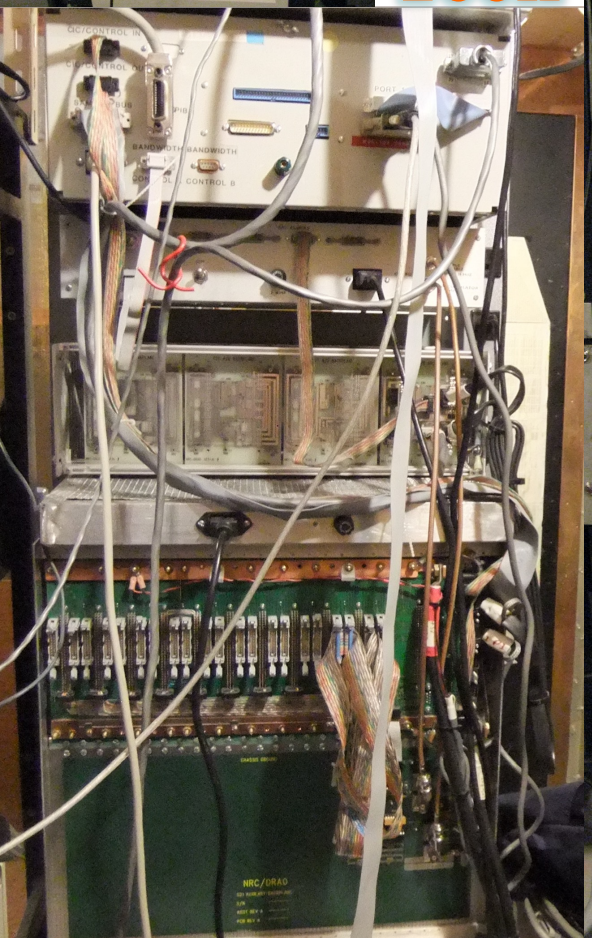
Designed for MeerKAT telescope in South Africa, an SKA pathfinder.

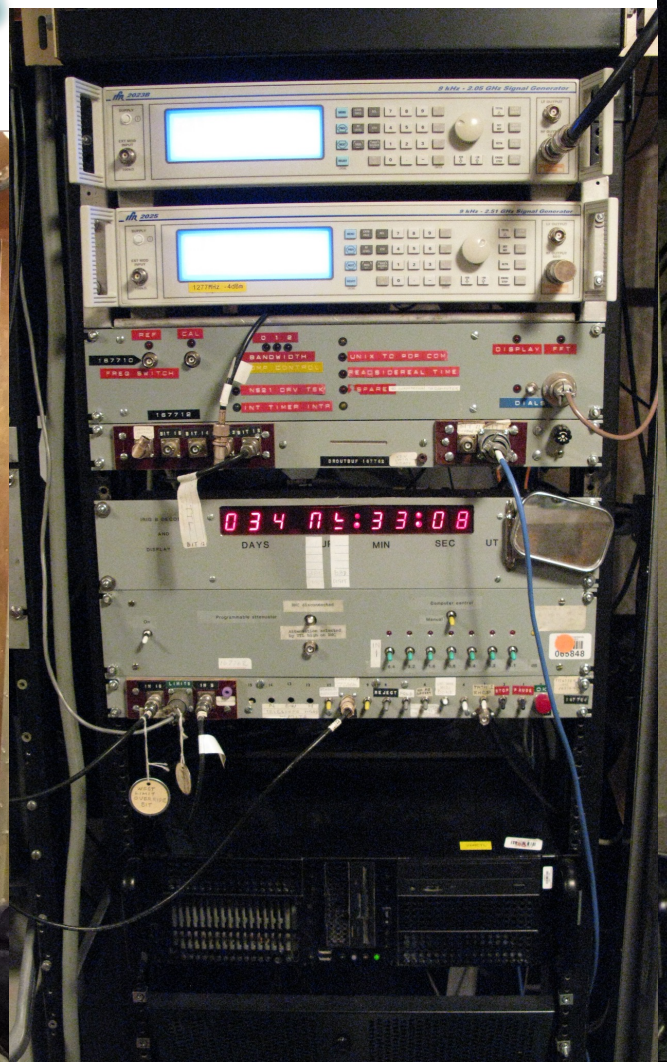
The Old Brain

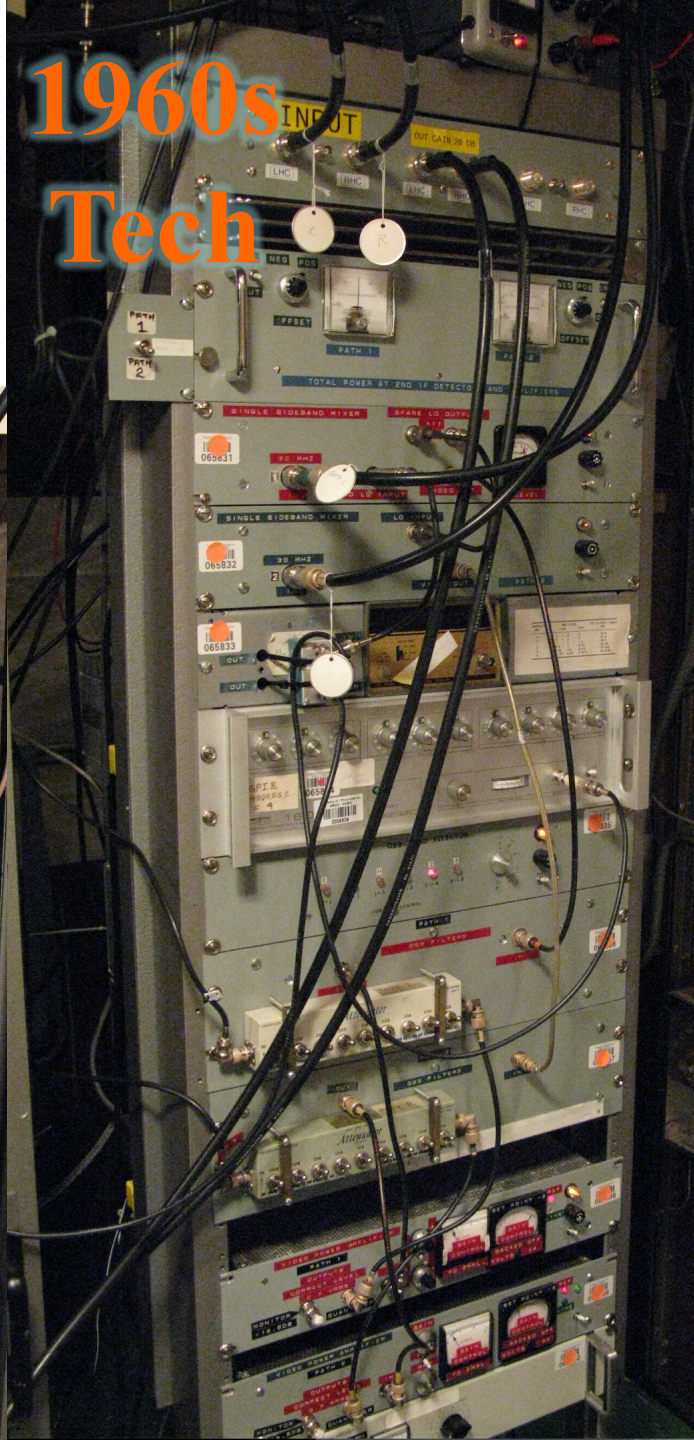
1 Spectral Line
512 Channels
over 4 MHz

1990s Tech

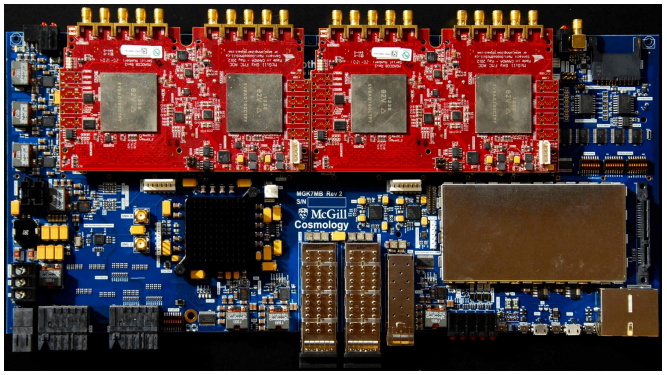
1960s Tech







The New Brain



CHIME IceBoard (Bandura et al. 2016)

- **1420 MHz Hydrogen Line 16,384 channels**
- **1612, 1665/1667, 1720 MHz Hydroxyl Lines**
  - **65,536 channels each**
- **40 Hydrogen Radio Recombination Lines**
- **40 Helium Radio Recombination Lines**
- **40 Carbon Radio Recombination Lines**
  - **40 x 1200 = 48,000 Channels**

All exhibit the Zeeman Effect!

Bandwidth of 900 MHz = 20-fold Upgrade!

125 Spectral Lines = 125-fold Upgrade!

9,000,000 Channels = 18,000-fold Upgrade!