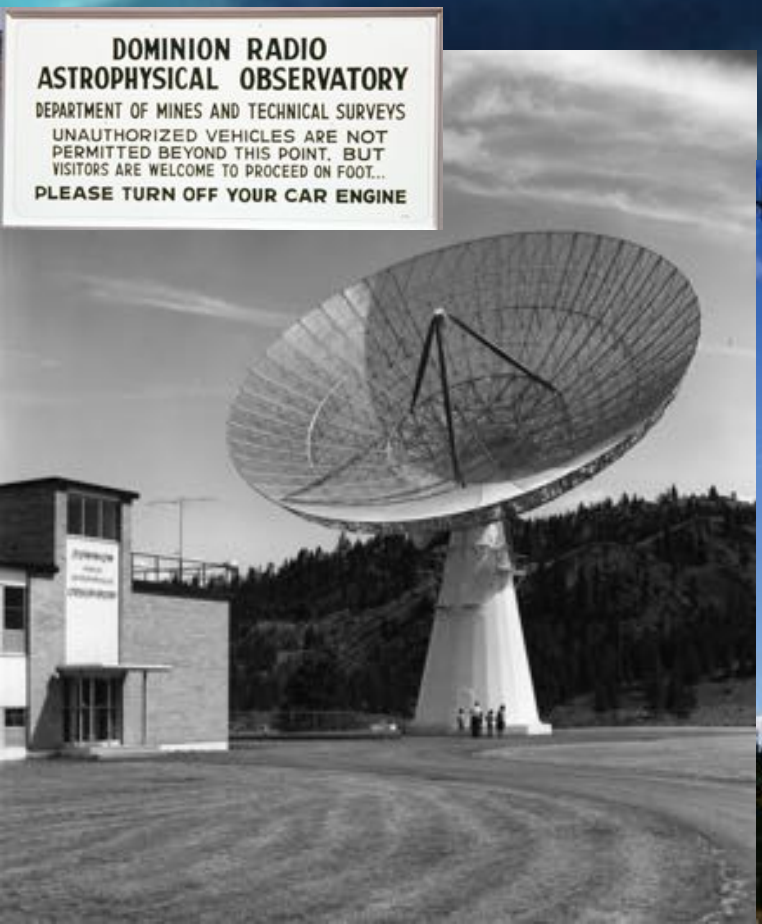
History of Canadian Radio Astronomy

TIM ROBISHAW
DRAO



A Workshop Celebrating the Career of John A. Galt

September 22-23, 2015

RICHARD A. JARRELL

THE COLD LIGHT OF DAWN

A History of Canadian Astronomy

Richard Jarrell

(1946-2013)

20+ Hours of Interviews with
20 Early Canadian Radio Astronomers
Preparing book on CAN Radio Astro.

A Workshop on the History of Canadian Radio Astronomy

July 25-26, 2016

http://astroherzberg.org/radiohistory2016/

Jasper's Canadian Radio Astronomy History

- **Grew up in the Ottawa valley.**
  - **Household mantra: "This works so well we must take it apart to see why."**
- **1963: Graduated Queen's University Engineering**
  - **2 summers working at National Research Council in Ottawa**
- **1965: MSc U Toronto Electrical Engineering**
  - **Don MacRae & Allan Yen**

4.10 Measuring the CMBR energy spectrum

4.10.1 Jasper V. Wall: The CMB – how to observe and not see

Jasper Wall served as Director of the Royal Greenwich Observatory and of the Isaac Newton Group of Telescopes, La Palma. He is now Visiting Professor, University of Oxford, and Adjunct Professor, University of British Columbia.

MEASUREMENTS OF ABSOLUTE SKY BRIGHTNESS TEMPERATURES AT 320 AND 707 MHz

By J. V. Wall,*† T. Y. Chu,*‡ and J. L. Yen*

[*Manuscript received September 9, 1969*]

Abstract

Measurements of absolute sky brightness temperatures have been carried out over limited regions of the sky at 320 and 707 MHz. At both frequencies low resolution horn antennas were used with Dicke switched receivers. Zero levels were determined with a substitution load at the temperature of liquid nitrogen. The antenna temperatures were reduced to full beam brightness temperatures by removing ground, side lobe, and atmospheric contributions.

The results indicate a change in spectrum in this frequency range consistent with addition to the galactic nonthermal radiation of isotropic radiation having a thermal spectrum and a brightness temperature of 3°K. A power law spectral index of $-0{\cdot}45 \pm 0{\cdot}15$ is obtained for the galactic nonthermal emission.

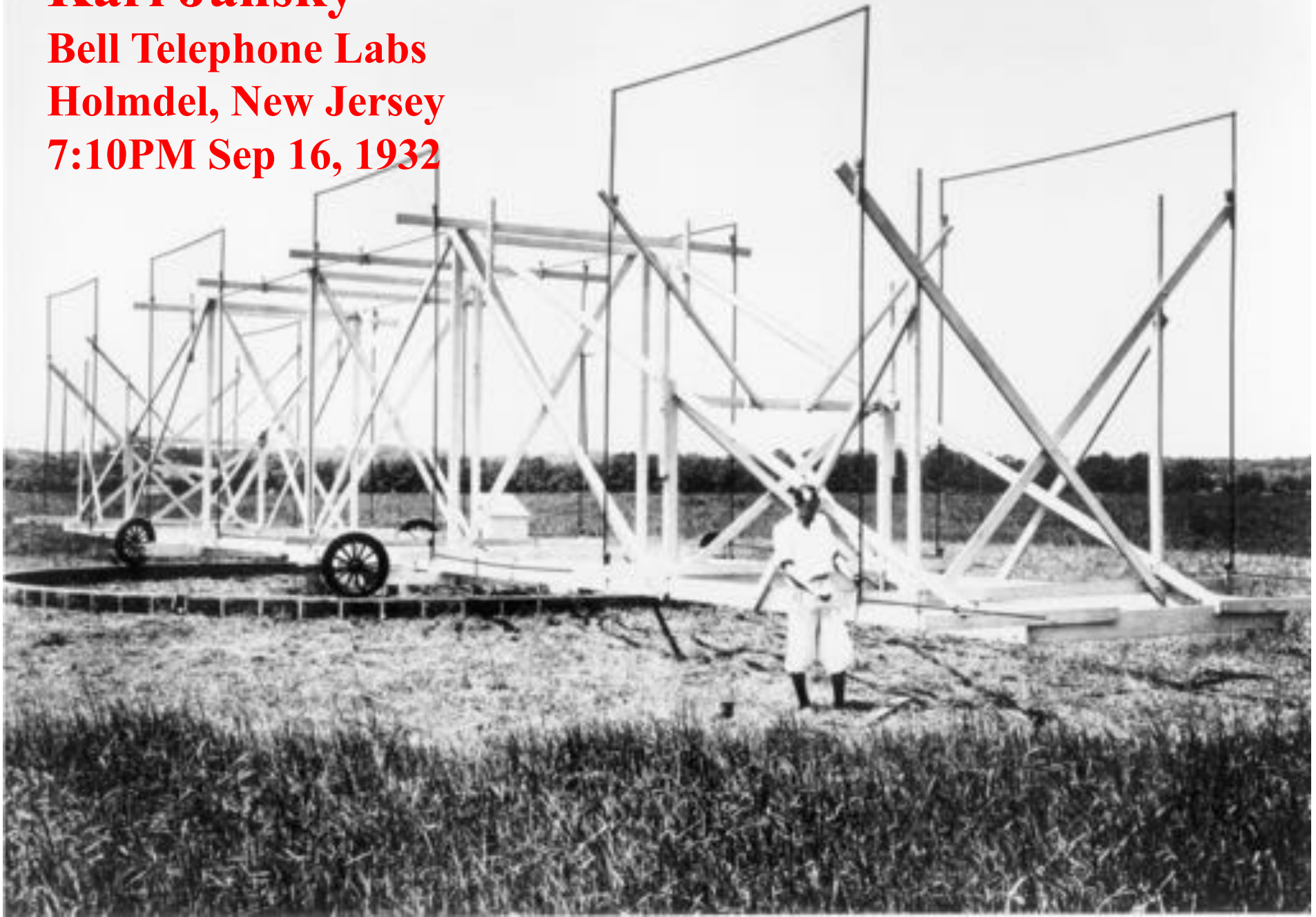
- **1965: Moved to Australia**
  - **PhD work at ANU**
  - **Supervised by John Bolton**
  - **18+ months at Parkes**
  - **July 1969 Apollo 11 Landing**

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. Stopher 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

Canada's First Radio Telescope (48")

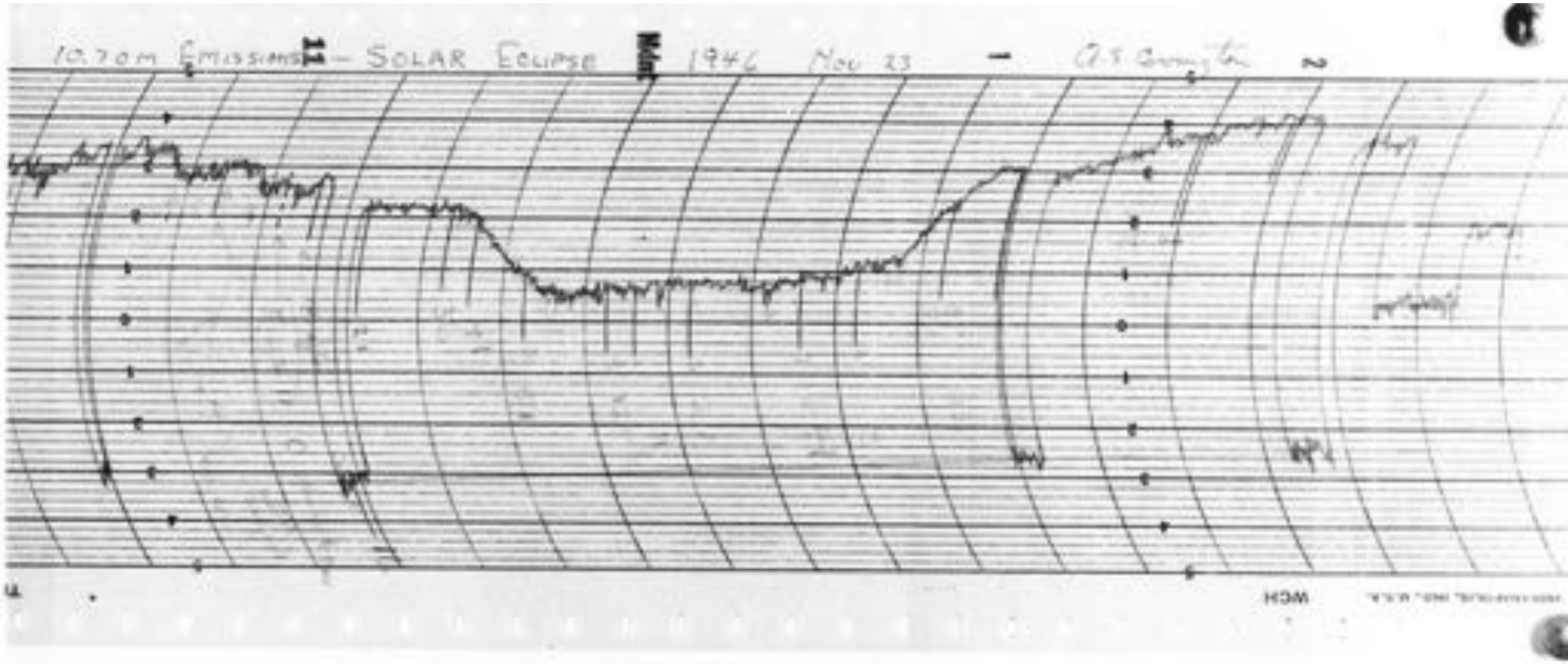
FIG. 2
10.7-CENTIMETER RADIOTELESCOPE
FRONT VIEW

FIG. 3
10.7-CENTIMETER RADIOTELESCOPE
REAR VIEW

First observation of the Sun: 26 July 1946


Arthur Edwin Covington (1913-2001)

Solar Eclipse: 23 November 1946



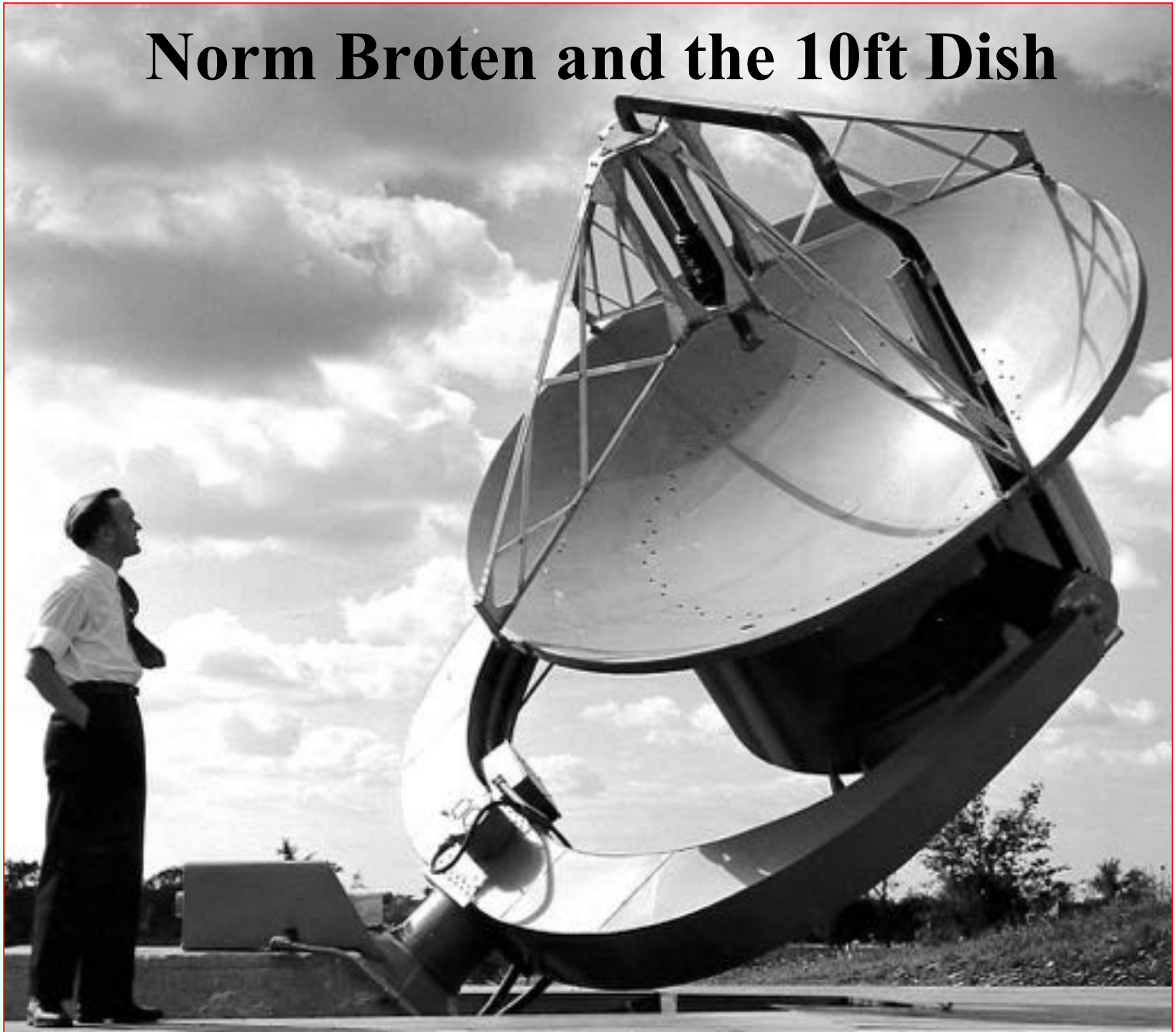
1.5 million K sunspot

Goth Hill Observatory in Ottawa


SOLAR RADIOMETER FOR OPERATION
IN THE 10-16 CM BAND

Calibration Horn Antenna

Norm Broten and the 10ft Dish



…operated until 1970.

GOTH HILL SOLAR NOISE OBSERVATORY

Gladys A. Harvey

- **The First Canadian Woman in Radio Astronomy**
- **Worked at NRC Radio and Elec. Eng. Division.**
- **Started at Goth Hill in 1948.**

Interview with Gladys Harvey
August 10, 1991

M: I'm speaking today with Gladys Harvey north of Victoria who worked at the National Research Council for some years with the solar radio programme. Could we begin, first, just tell me something about your origins and your educational background?

August 1957

IMPULSIVE AND LONG-ENDURING SUDDEN ENHANCEMENTS OF SOLAR RADIO EMISSION AT 10-CM. WAVE-LENGTH*

By A. E. Covington and G. A. Harvey
Radio and Electrical Engineering Division, National Research Council of Canada, Ottawa, Ontario

Abstract
The two basic types of simple 10-cm. enhancements of solar radio emission are described and related to suggested non-thermal and thermal mechanisms of emission.

Astrophysical Letters, 1972, Vol. 11, pp. 147–149

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

A Search for Rapidly Varying Radio Sources

G. A. HARVEY, B. H. ANDREW, J. M. MACLEOD, and W. J. MEDD *Astrophysics Branch, National Research Council, Ottawa, Ontario, Canada*

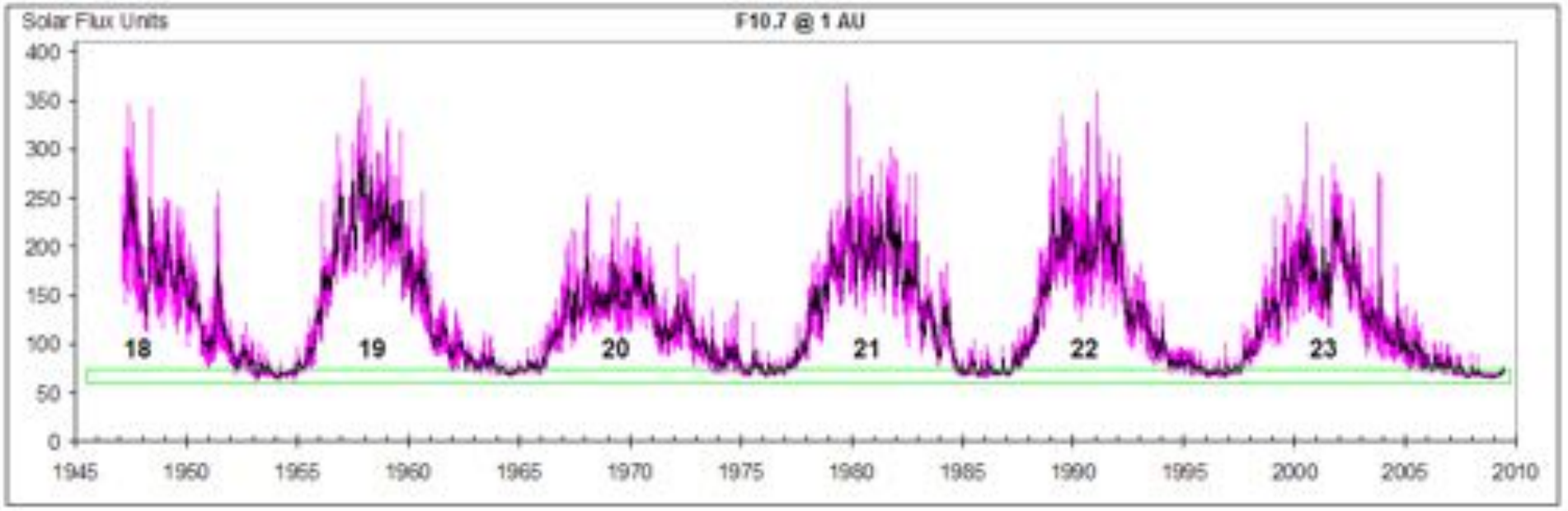
An attempt to find new, rapidly-varying radio sources was made during the period October–November 1971. Nineteen sources were studied, but no new rapid variables were discovered.

22 June 1949: The AAS meets in Ottawa.
Grote Reber visits the 10.7-cm radiometer at Goth Hill.

Photo Credit: Grote Reber

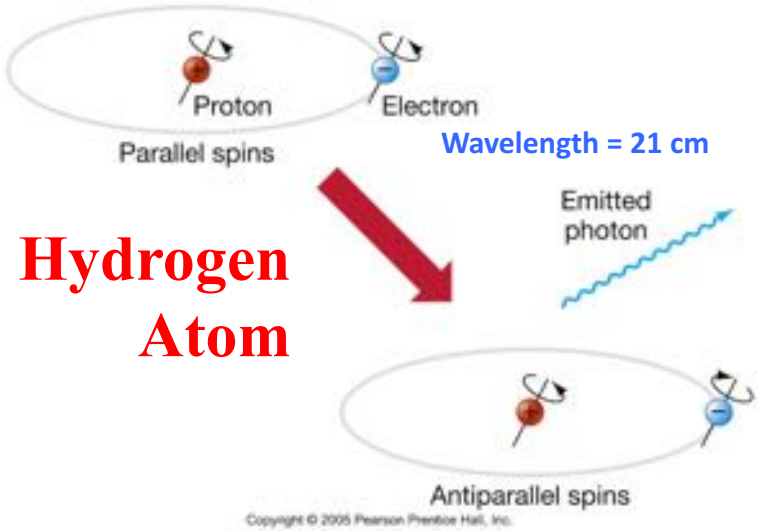
10.7-cm Solar Flux Monitoring Program

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



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.



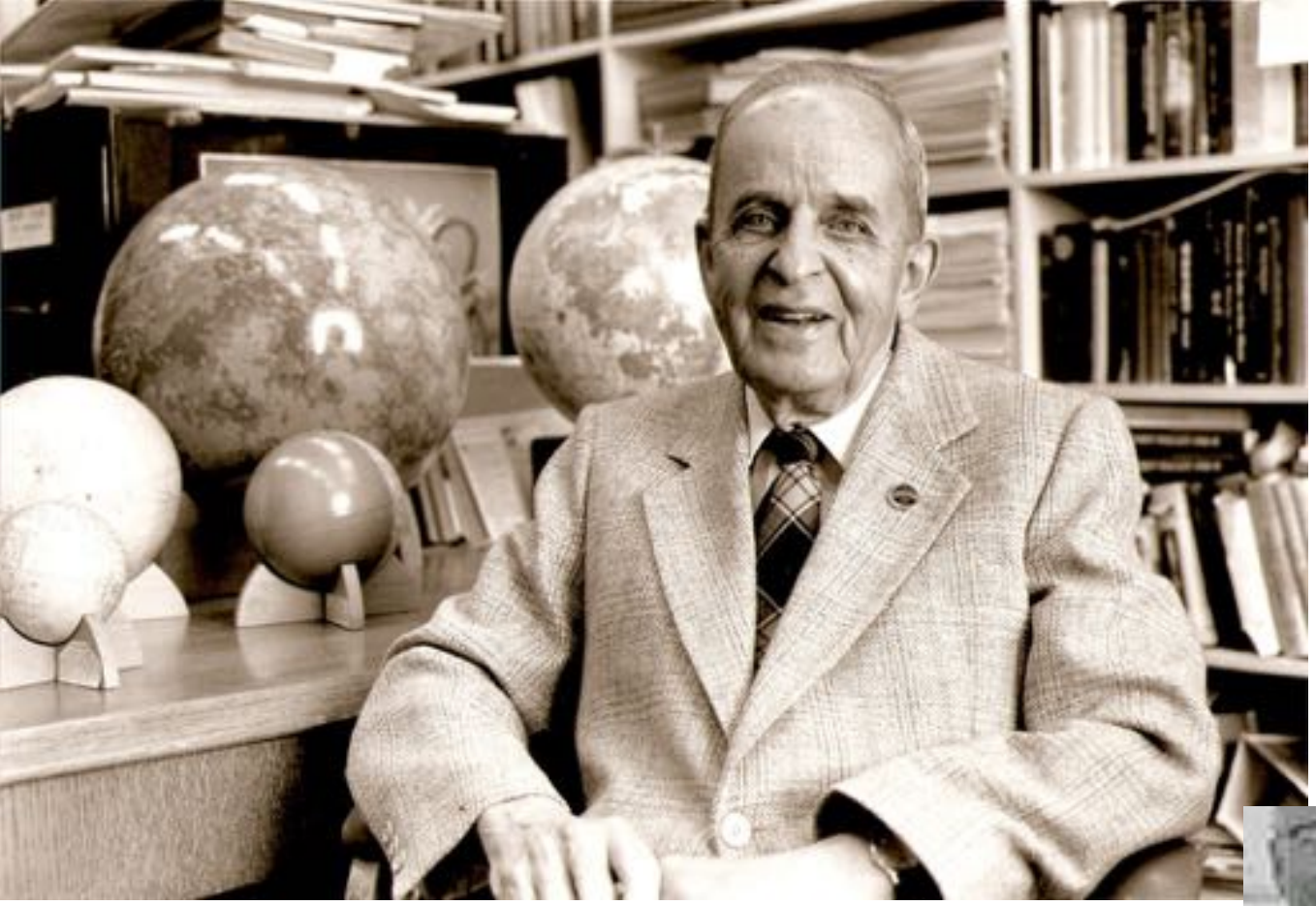
"Early visitors to the Radio Field Station and to Goth Hill whom I can recall… were"----- Appleton, Hey, Ratcliffe, Bolton, Friis, Pawsey and van de Hulst. "I was introduced to Pawsey during one of his early visits to the RFS by W.J. Henderson; they attended Cambridge at the same time…" When Pawsey saw 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*

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

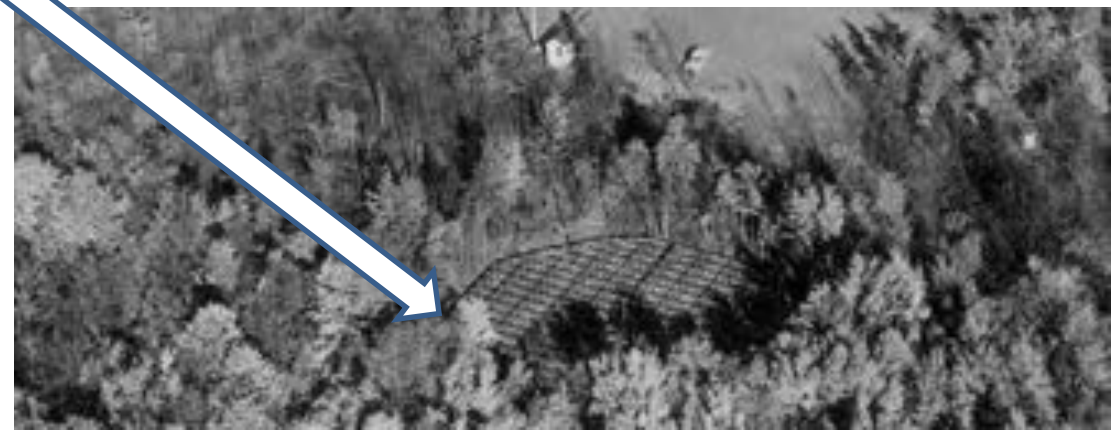


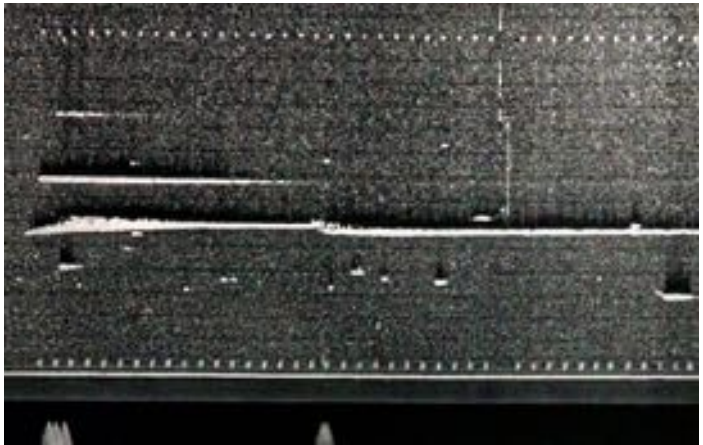
Peter M. Millman (1906-1990)

&

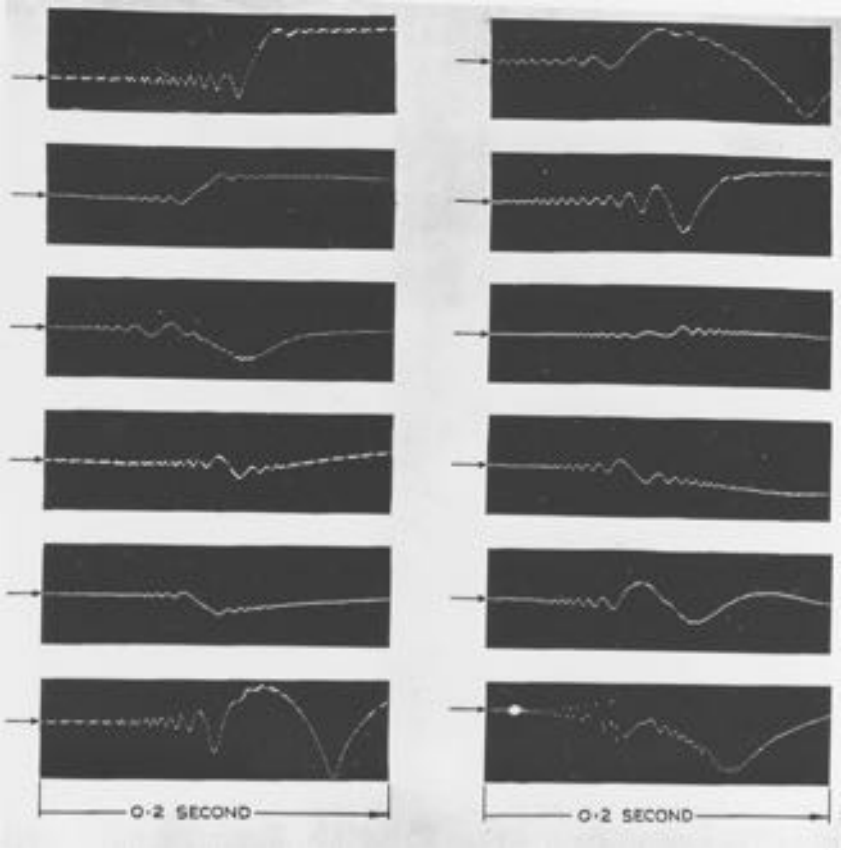
Donald R. W. McKinley (1912-1984)

ground reflector mats for radar antennas





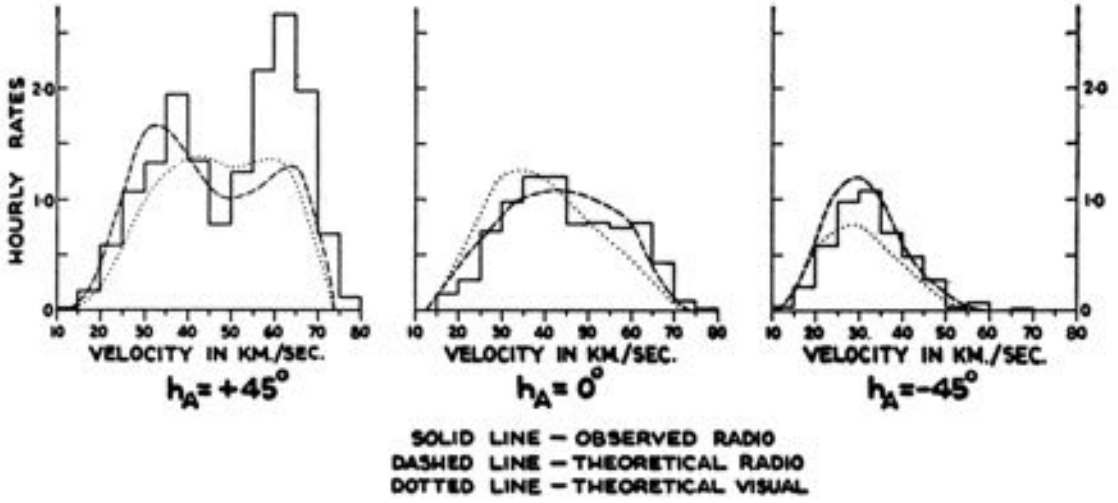
Delta Aquarid 1948
July 29



Meteor Echoes
= "Doppler Whistlers"

<u>No</u> interstellar meteors

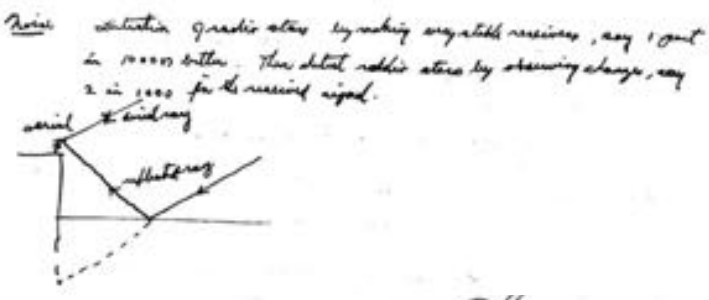
McKinley (1951)

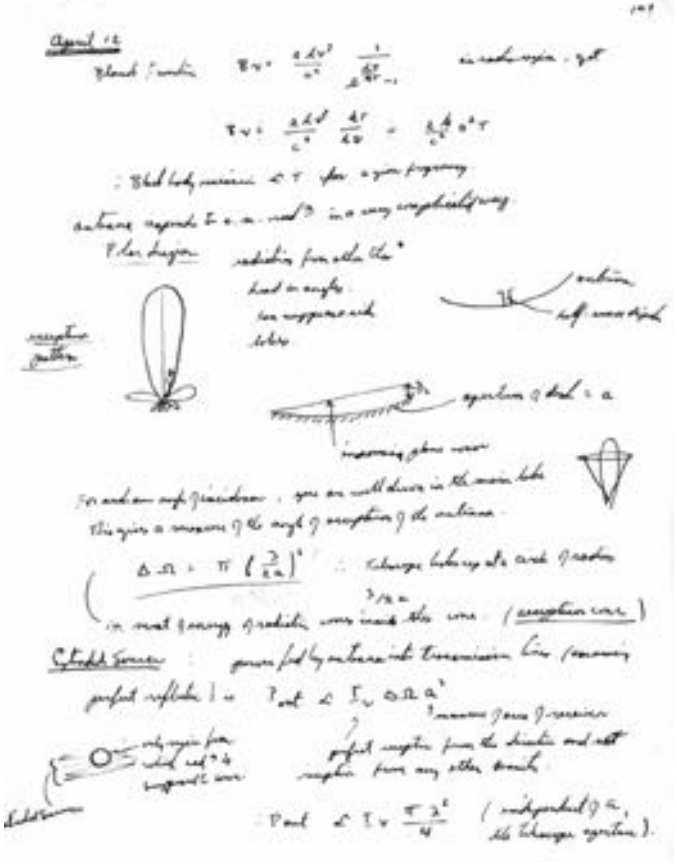


John Bolton (CSIRO) Gives Colloquia at NRC in 1950-51

Befriended Covington.

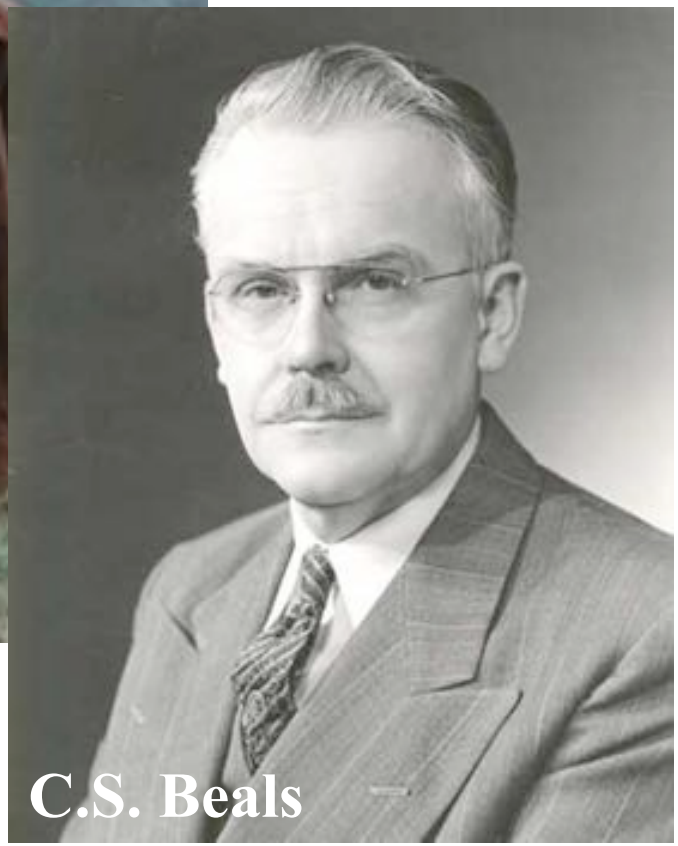
Notes from Vic Gaizauskas





Jack Locke

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



Dominion Astronomer C.S. Beals sees John Bolton speak about radio astronomy at March 1956 AAS Meeting in Columbus, OH

Jack Locke

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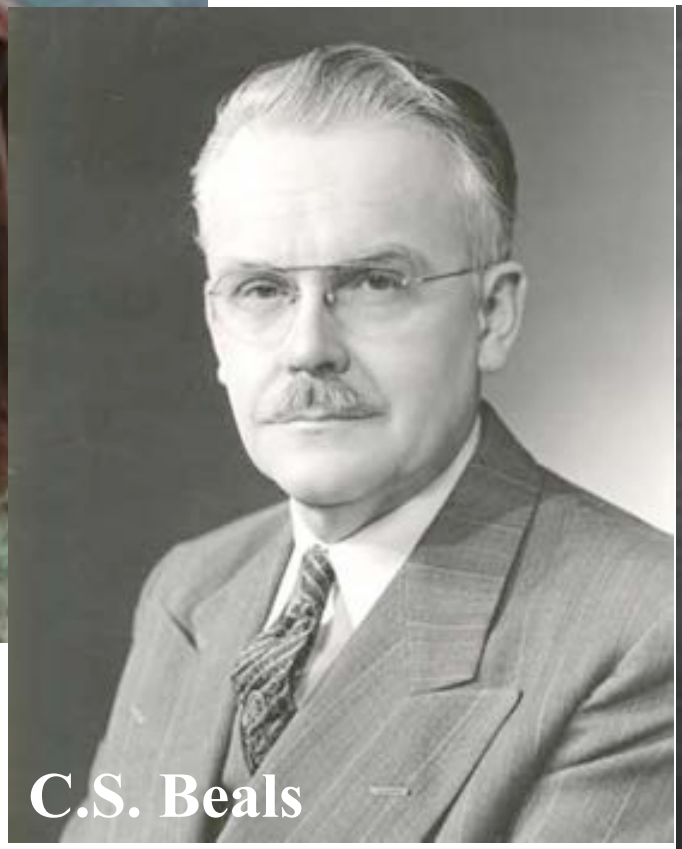

C.S. Beals

John Bolton

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

62 Years Ago

"In the summer of 1956, when Helen Hogg came through Ottawa, a meeting was called with McKinley, Beals, Harrison (in place of Parsons), and myself to discuss the future of Canadian radio astronomy."


Arthur Covington

Arthur Covington
1990 Interview
with
Richard Jarrell


Helen Hogg

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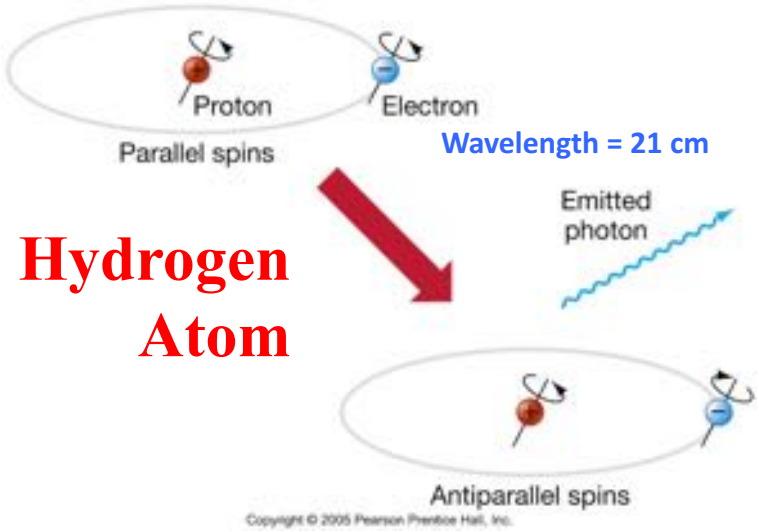
Henk van de Hulst predicts atomic hydrogen in space should emit radio waves at 1420.4058 MHz, or 21 cm.

Six years pass with no discovery.



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. C.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. C.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.

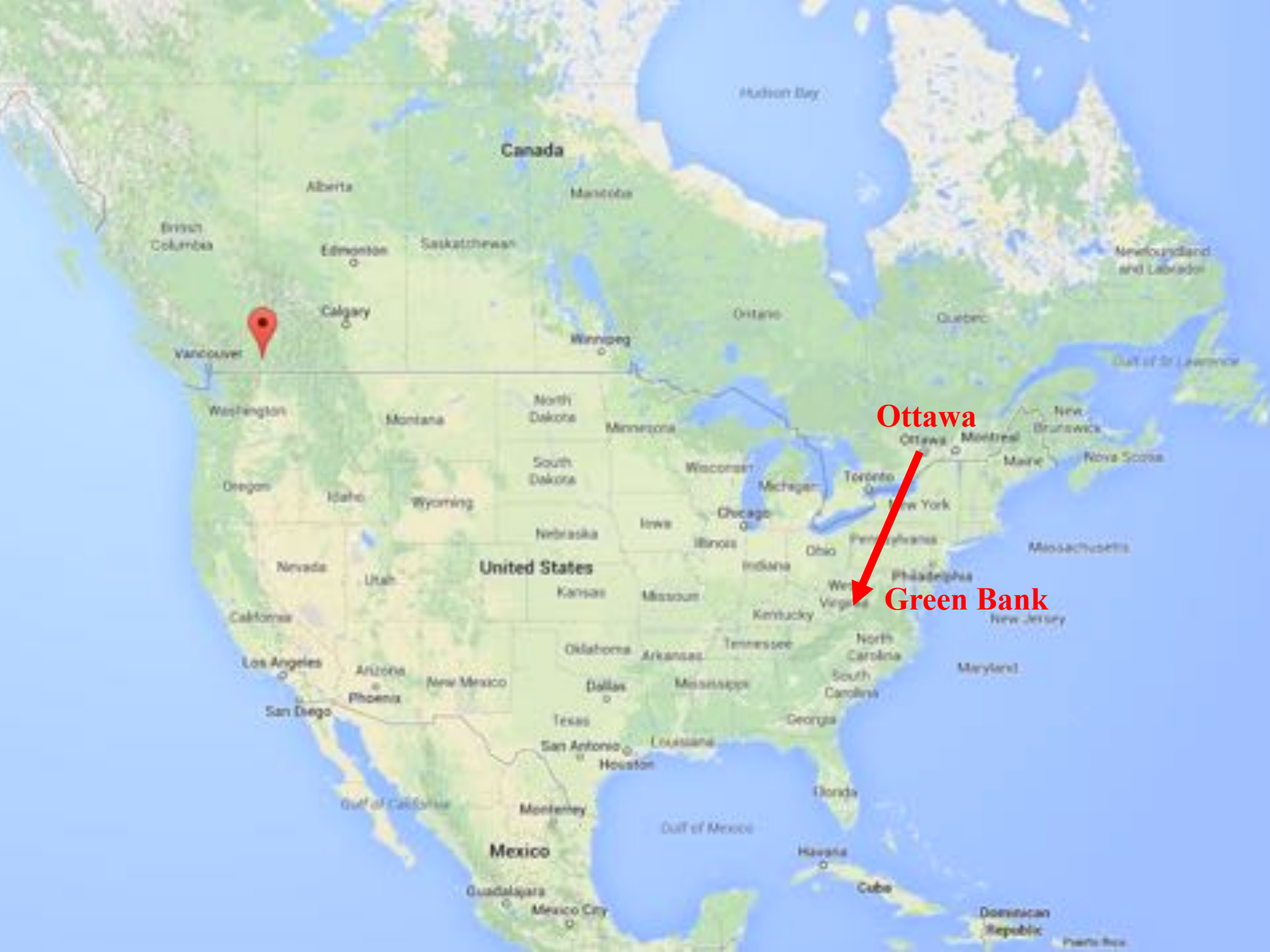
C. S. Beals

C.S. Beals,
Dominion Astronomer

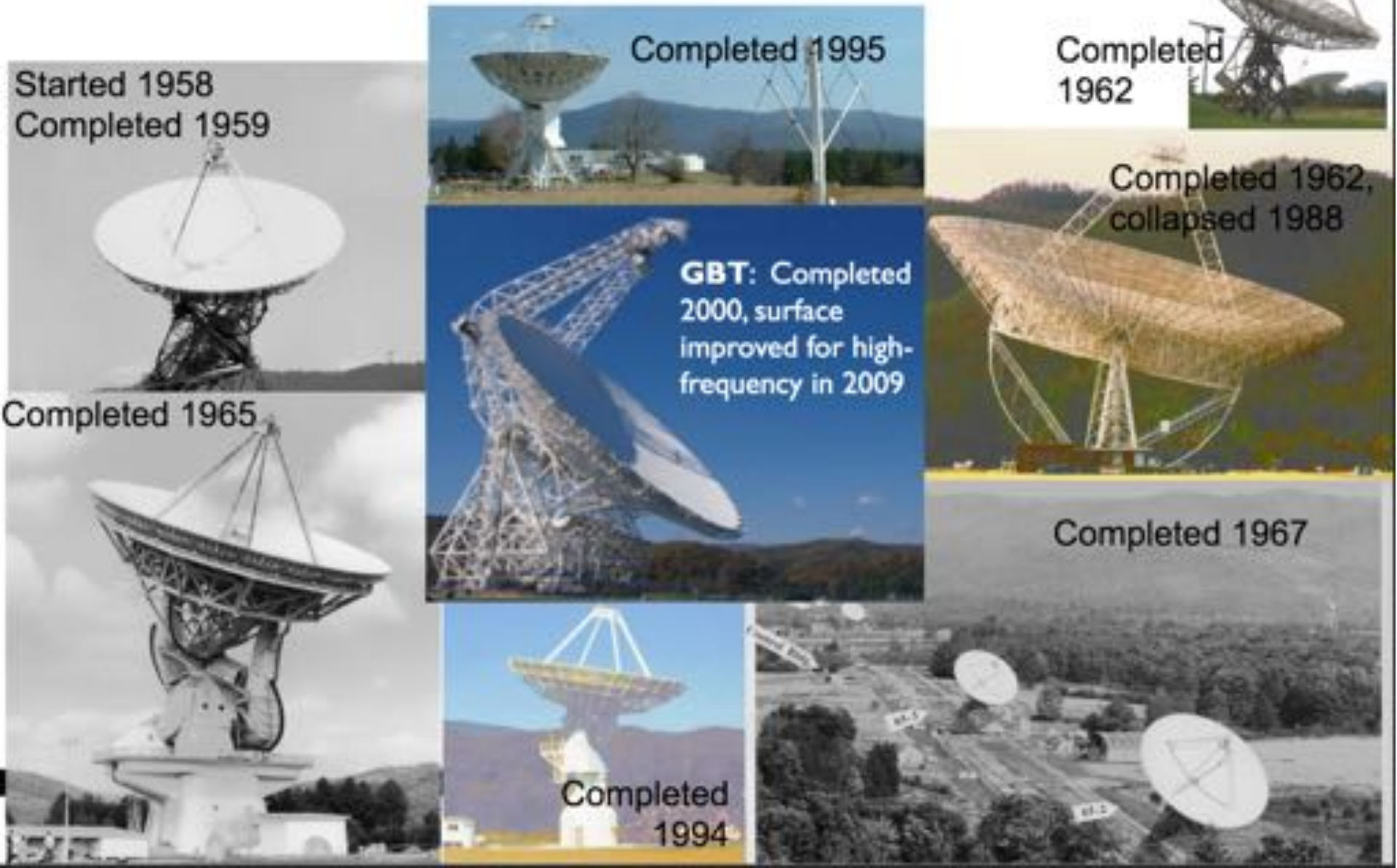
Where Should DRAO Be Built?

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

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

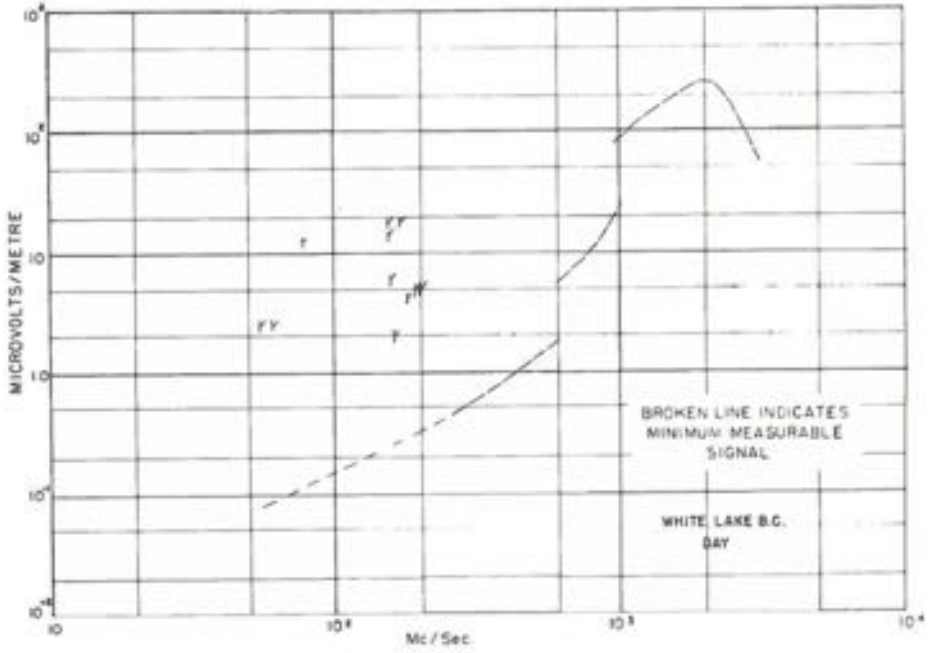
SITE SURVEY FOR A NATIONAL RADIO ASTRONOMY OBSERVATORY

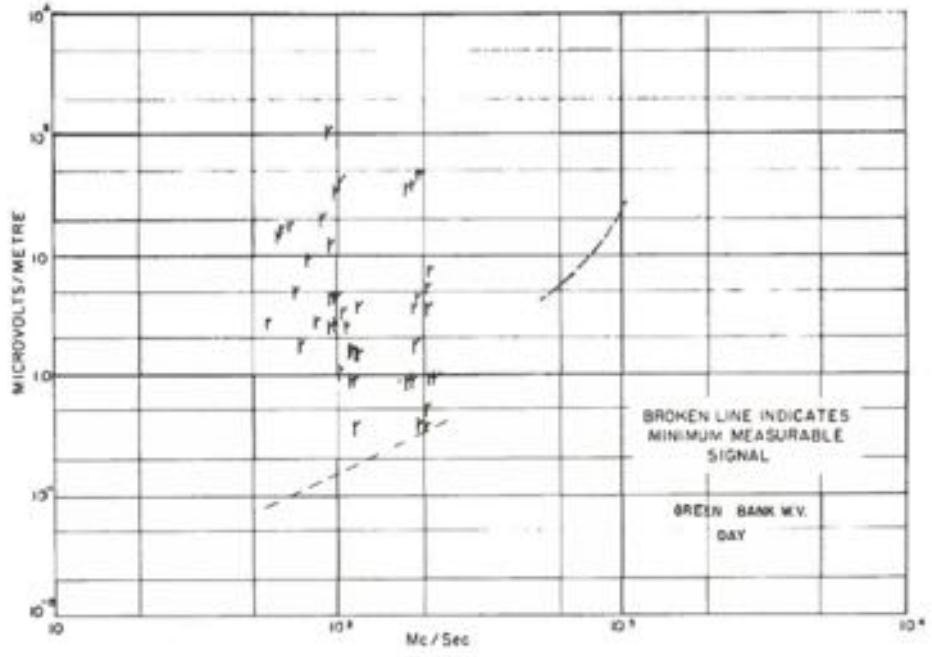
OTTAWA

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

August

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.

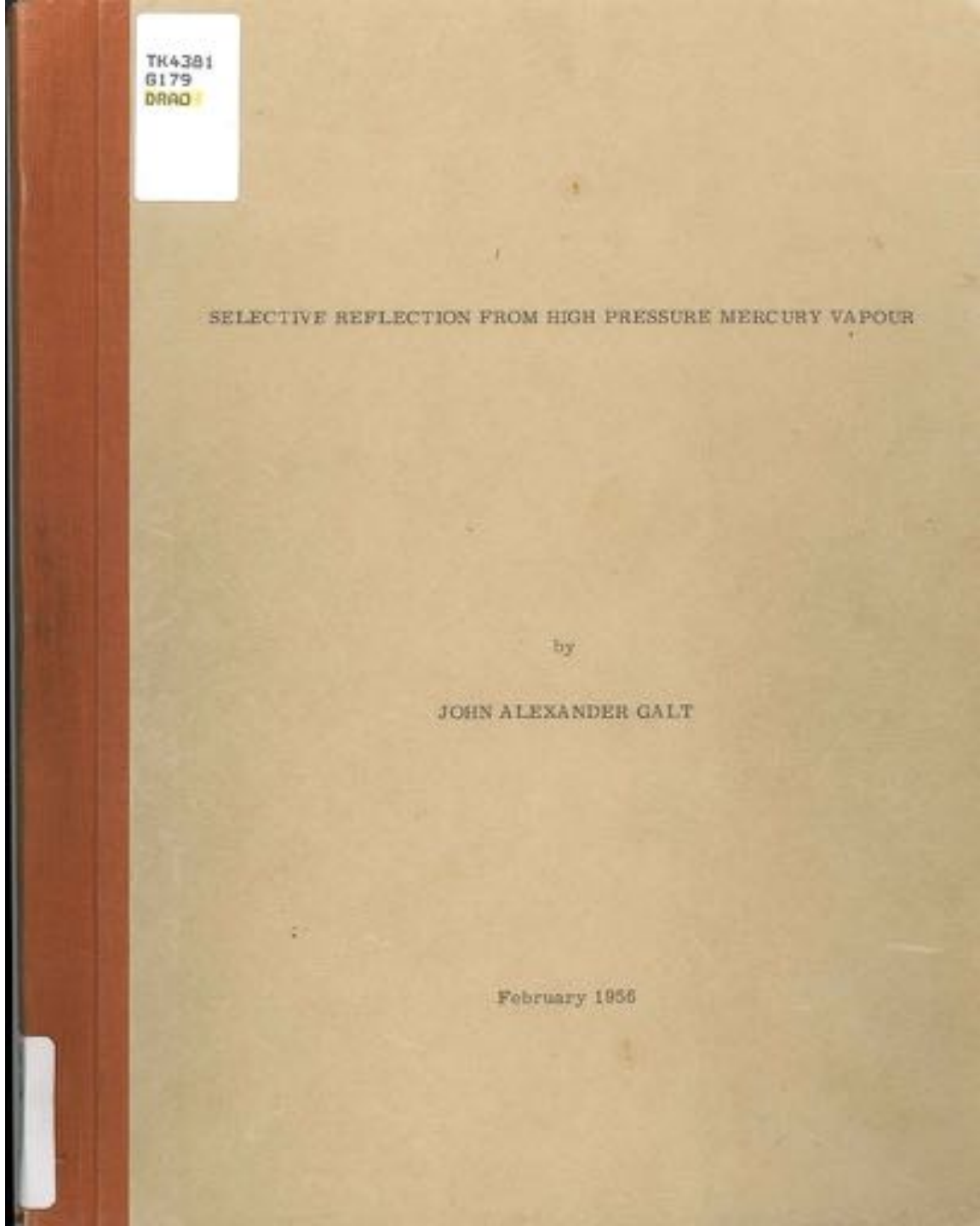
1949-1950

Midnight sun near end of summer.

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"



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^{-6} gauss, such as is believed to exist in the Galaxy, gives $\Delta\nu \approx 30$ c/s.

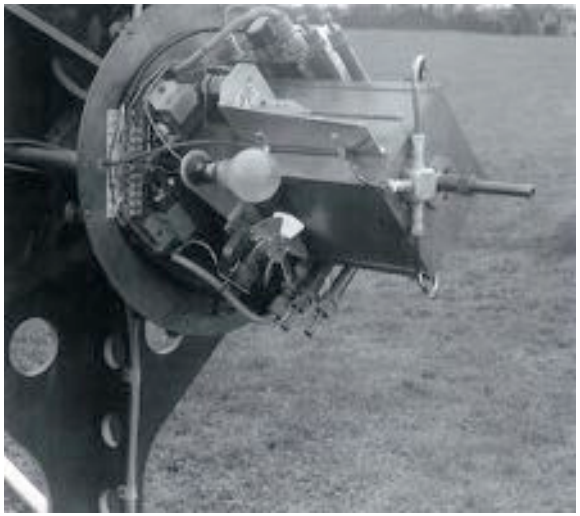
Under normal circumstances the detection of such small shifts in the galactic emission profiles would hardly be possible, owing to their large Doppler broadening. On the other hand, relatively narrow profiles have been observed in absorption. Hagen, Lilley, and McClain (1955) have reported three narrow 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.

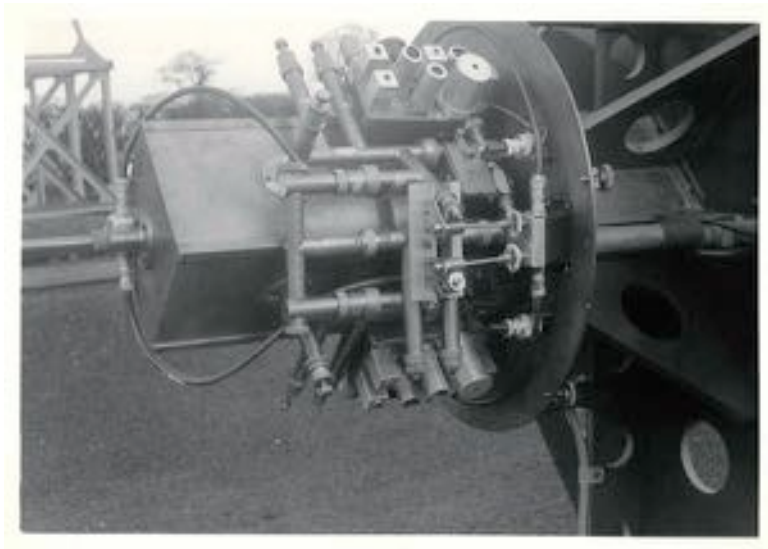
The detection of a Zeeman shift less than 1 per cent of the line width could be accomplished by using the radio analogue of the optical method currently employed by Babcock (1953) for measuring weak solar fields. The frequency of a narrow-band receiver is set on the edge of the line near the point of 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 $\Delta T \approx 3 \times 10^6 H$ degrees. Current techniques permit the detection of $\Delta T \approx 1$° K ($H \approx 3 \times 10^{-4}$ gauss), and instrumental improvements on this figure are likely in the future.

The First 21-cm Zeeman Receiver 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.

8. *Conclusions.*—No significant Zeeman effect has been detected and it is probable that the longitudinal component of the magnetic field in the clouds of neutral hydrogen which produce absorption is less than 5×10^{-3} oersted. It should be noted that the line of sight in the direction of Cassiopeia A is inclined at an angle of about 45° to the Orion spiral arm so that, if the general magnetic field is aligned with the arm, then the corresponding upper limit to the field must be raised by a factor of $\sqrt{2}$ over that quoted.

9. *Acknowledgments.*—The authors wish to thank Professor A. C. B. Lovell

Lovell Visits Penticton

April 15, 1966

Astronomers Swap Ideas

By LYNNE FRANCIS

PENTICTON — An informal exchange of scientific ideas was the order of the day for Sir Bernard Lovell, eminent radio-astronomer from Jodrell Bank, England, and his Canadian colleagues at the Dominion Radio Astrophysical Observatory near here Thursday.

Sir Bernard arrived in the Okanagan Valley early Thursday morning and proceeded to the observatory site in a secluded valley 11 miles from Penticton. There he spent several hours with the observatory's 15-man staff discussing their own team work in the field of radio astronomy.

The observatory's director, Dr. John Galt, has worked with Sir Bernard at the Jodrell Bank site of the world's largest radio telescope.

Although much of the discussion centred around data too complicated for laymen, the two scientists found they had a common problem — man-made interference which frequently spoils radio-astronomical measurements.

SECLUDED SITE

Sir Bernard said the Jodrell Bank site in Cheshire was chosen because of its relative seclusion. He added, however, that despite the six-mile zone around the station, the 250-foot "dish" is still subject to interference from nearby residential areas and aircraft radios.

The Penticton observatory is surrounded on all sides by hills. Although the scientists there experience little interference from the city, they still run into difficulties from radio and radar transmitters, automobile ignition systems and electric motors.

One staff member added the radio waves from outer space are often scattered by high flying aircraft and frequently interference can be tracked to radar

See Page 44—ASTRONOMERS

TWO SCIENTISTS MEET TO EXCHANGE IDEAS
Dr. John Galt, left, and Sir Bernard Lovell

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)

February 1959: 26-m Arrives

OFFICIAL OPENING

MONDAY 20 JUNE 1960
AT 4·00 PM

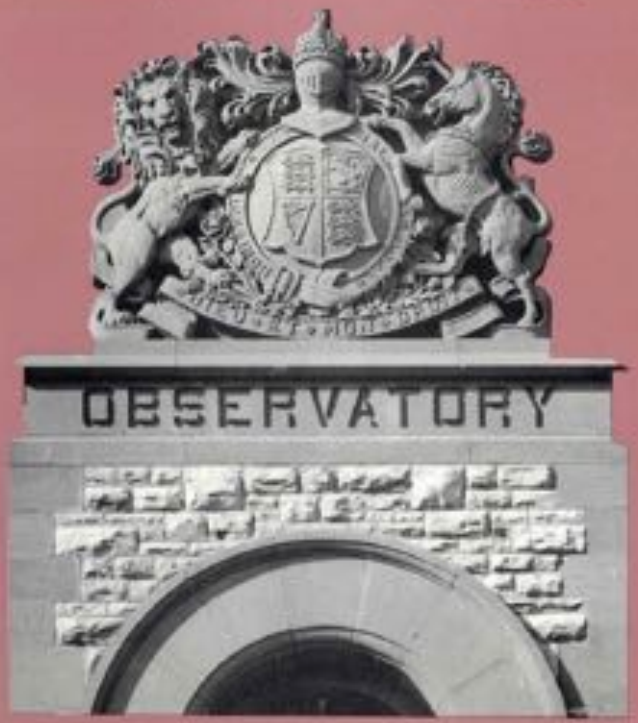
PENTICTON B. C.

BACK ROW	Dr.T.R.Hartz, Dr.J.L.Yen, M.W.Thomson, Dr.G.Odgers, W.J.Medd, Dr.J.A.Galt, F.Park, W.Broten, J.Grant, R.W.Tanner, Dr.K.O.Wright.
THIRD ROW	M.Pruesse, A.R.Hamilton, Dr.D.S.Heeschen, Dr.J.W.Meek, D.R.Hanson, Dr.D.W.R.McKinley, Dr.D.C.Rose, R.Crenzebeck, Dr.J.W.Warren, Dr.R.W.Chisholm.
SECOND ROW	Miss M.Burland, Dr.C.M.Costain, Dr.B.W.Currie, P.E.Argyle, Miss B.Northcott, Dr.H.P.Cush, Dr.W.Whelan, Dr.R.Cke, Dr.D.E.Hogg, Dr.J.C.Noyes, Miss J.Stilwell, W.H.Stilwell.
FRONT ROW	Dr.P.W.Millman, A.E.Covington, Dr.R.M.Petrie, Mrs.Petrie, Dr.J.L.Locke, Dr.W.Schmidt, Dr.H.S.Hogg, Dr.C.S.Beals, Dr.G.A.Harrower, Dr.J.F.Heard, Mrs.Noyes.
ABSENT WHEN PICTURE WAS TAKEN	B.L.White, Dr.H.L.Welsh, J.M.Lamsinger, N.Penfield, S.M.Neddermeyer.

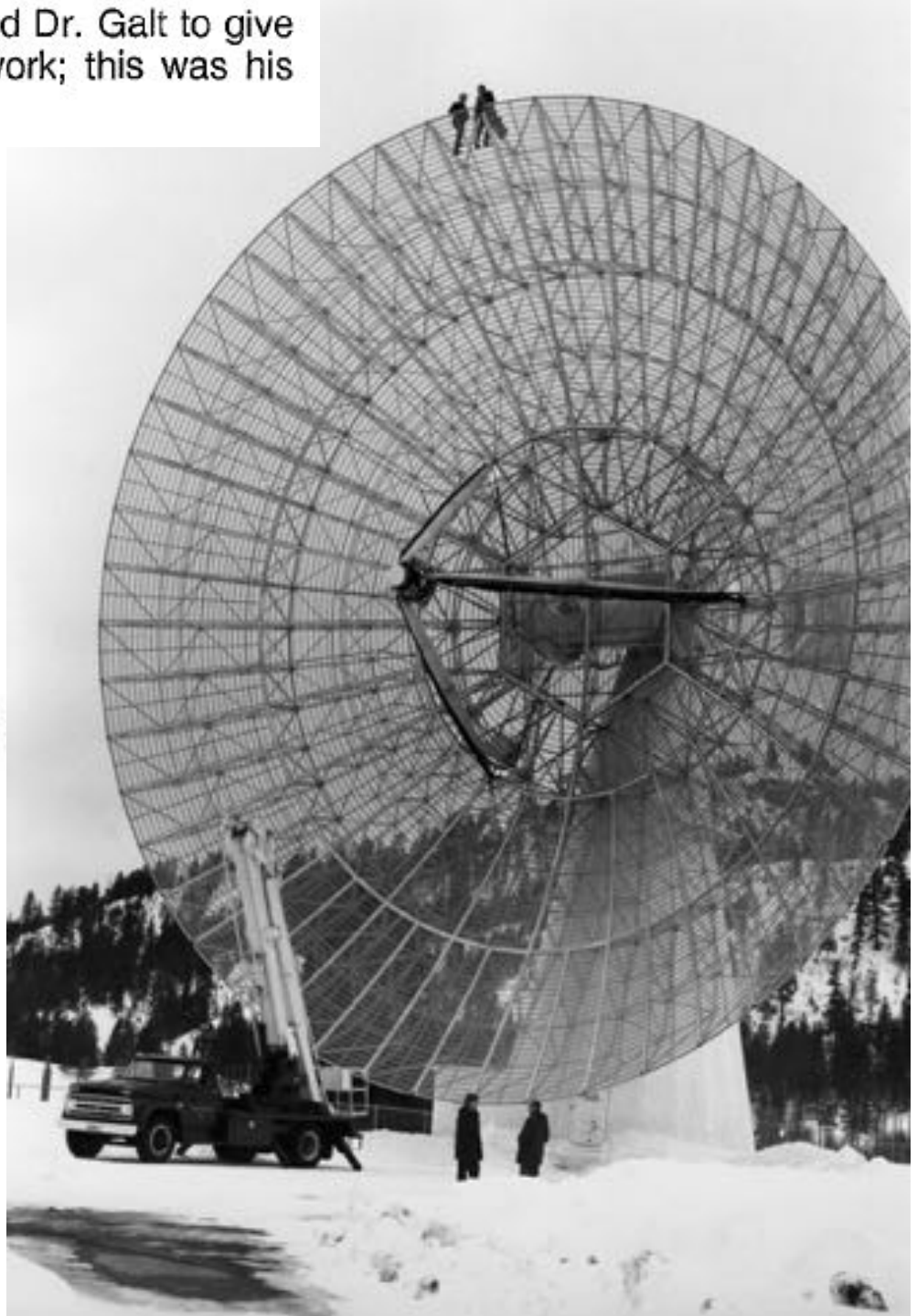
A close-up of the paraboloid. I asked Dr. Galt to give me a photograph showing him at work; this was his contribution.

THE HEAVENS ABOVE AND THE EARTH BENEATH

A History of the Dominion Observatories



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



Tuesday, February 17, 1959 THE PENTICTON HERALD

Radio Telescope 'Ear' To Take Pulse of Space

By BILL STAVDAL
(Herald Staff Reporter)

turn of the earth dims the stars and sends most astronomers home

ment for the Department of Mines and Technical Surveys. Dr. Locke

200 TON INSTRUMENT

Built in Cohasset, Massachusetts, the 200-ton instrument arrived in Penticton Monday aboard 23 freight cars. Another two cars will soon follow through to Okanagan Falls, where unloading is scheduled to begin tomorrow.

From Okanagan Falls the $250,000 listening post will be trucked three miles into White Lake, where construction on several buildings has already begun.

$500,000 Radio Telescope Project Taking Shape at White Lake Site

AUG. 21, 1959

PENTICTON'S RADIOTELESCOPE:

VANCOUVER SUN OCT 16, 1959

$700,000 Worth of Curiosity Sits in a Dish in the Hills

Paul St. Pierre continues his voyage of rediscovery around B.C.

By PAUL ST. PIERRE
Sun Staff Reporter

PENTICTON—The things we call stars, planets and so forth are actually holes in the big wool blanket that covers the earth.

Some day a large hand is going to pull away the blanket and a voice will say: "The show is over now and you must all go home."

However, it must be admitted that there are other theories about the true construction of the universe.

So the Staff Sweats It Out

"Jack," said one of the men in the main building, "Did you realize your office is over the furnace room? You'll get a rumble. And it'll be hot."

"There are only three rooms air-conditioned in the building," Locke explained to me. "Those are rooms with equipment in them. Civil Service regulations. You can air condition equipment rooms but you are not allowed to spend money air conditioning staff rooms."

WHITE LAKE WILL LISTEN

Feb 27, 1960

When the Heavens Declare Their Glory

By NORMAN GOTRO
Herald Staff Writer

"White Lake is ready."

made great strides in opening up hitherto unknown sources of knowledge is no reason for man to stand still. Were he to do so

Since White Lake Observatory has been established with $750,000 of taxpayers' money and is the outcome of four year's hard work by federal civil servants, one might ask what practical value these far-distant studies have.

BANK OF CANADA
BANQUE DU CANADA

...that cost:	$	750,000.00	in	1960
...would cost:	$	6,411,290.32	in	2018

FOUR THOUSAND YEARS: ONLY ONE-FIFTH OF THE WAY

B.C. Expert Evaluates Astronomy

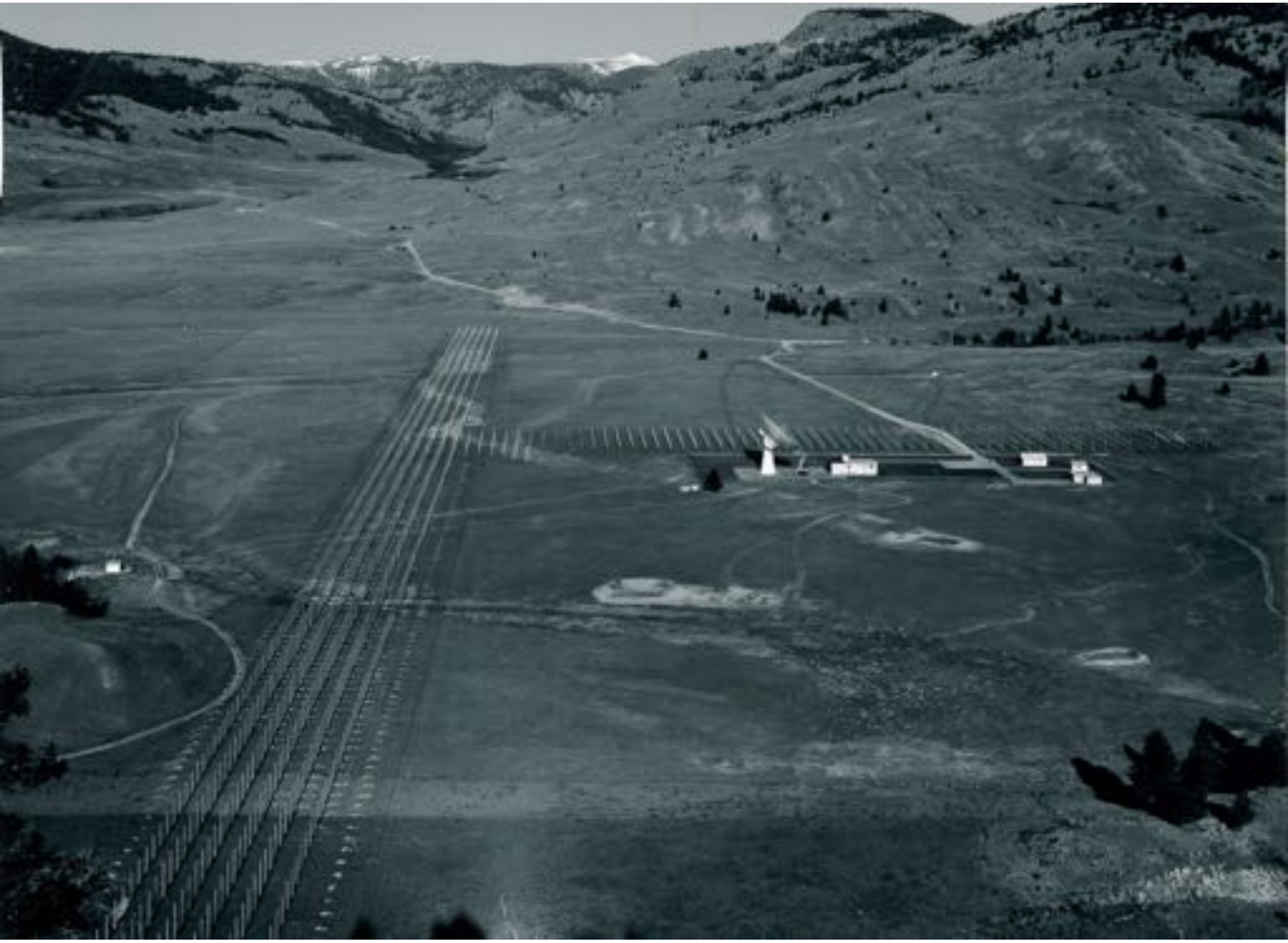
THE PENTICTON HERALD 2
Thursday, June 23, 1960

Four thousands years of research have brought explorers general information of only one-fifth of the Milky Way.

But radio-astronomy is expected to spur considerable advance in space research and Canada's "big ear" — the new 84-foot, $750,000 radio-telescope at nearby White Lake — will make a major contribution in man's

CHIME:
$17M CAD

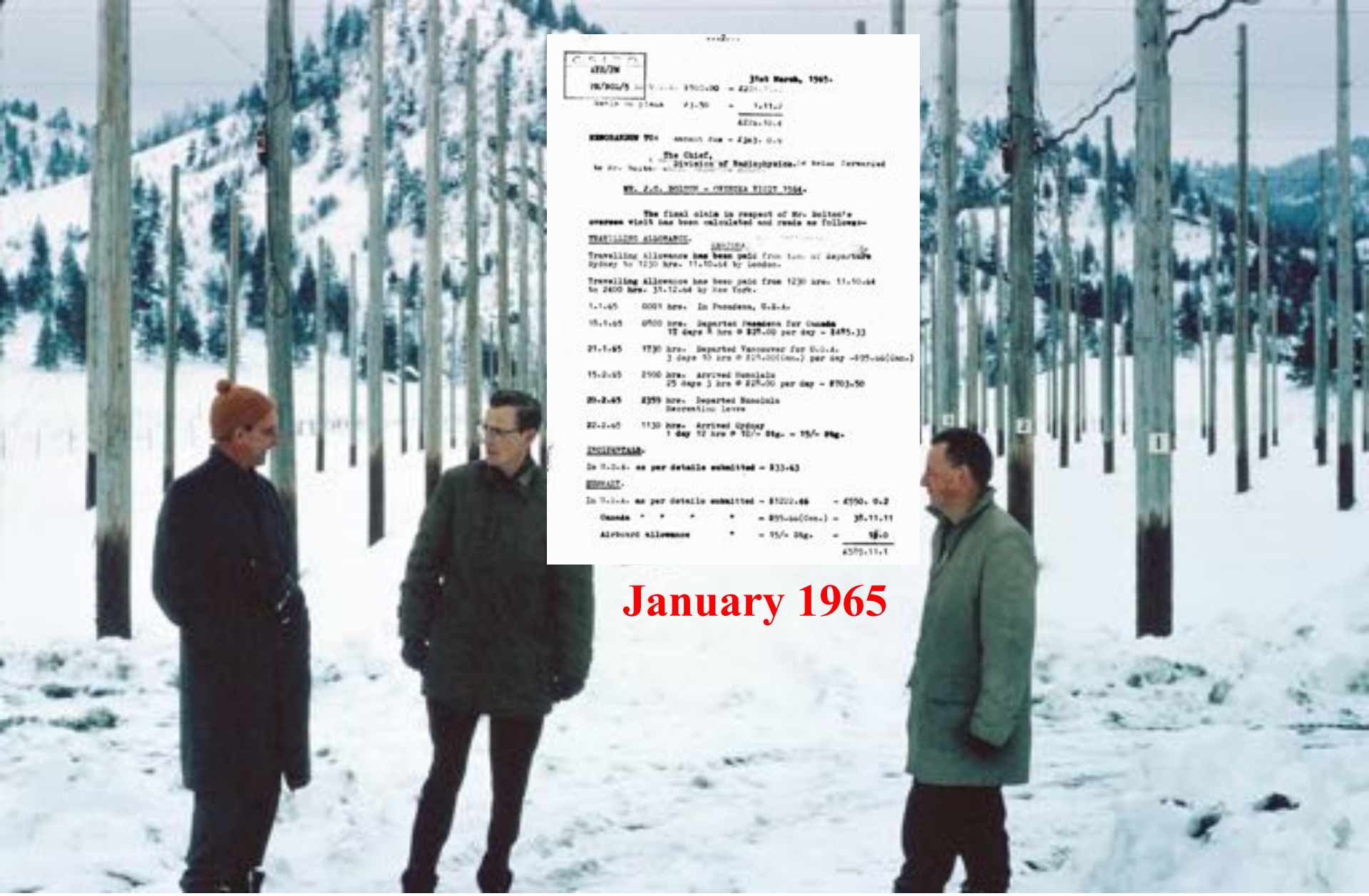
The 22.5 MHz Array



Carman Costain: 1st Canadian to earn Ph.D. in Radio Astronomy

Credit: John Shakeshaft


September 1965
Carman Costain
Martin Ryle



...2...

ATS/TW
PR/BOL/5

31st March, 1965.

The Chief,
Division of Radiophysics.

MR. J.C. BOLTON - OVERSEAS FLIGHT 7564.

The final claim in respect of Mr. Bolton's overseas visit has been calculated and reads as follows:-

TRAVELLING ALLOWANCE.

Travelling allowance has been paid from [illegible] departure Sydney to 1230 hrs. 11.10.64 by London.

Travelling allowance has been paid from 1230 hrs. 11.10.64 to 2400 hrs. 31.12.64 by New York.

1.1.65 0001 hrs. In Pasadena, U.S.A.

15.1.65 0900 hrs. Departed Pasadena for Canada
12 days 8 hrs @ $25.00 per day - $495.33

21.1.65 1730 hrs. Departed Vancouver for U.S.A.
3 days 10 hrs @ $25.00(Can.) per day - $95.00(Can.)

15.2.65 2100 hrs. Arrived Honolulu
25 days 3 hrs @ $25.00 per day - $703.50

20.2.65 2359 hrs. Departed Honolulu
Recreation leave

22.2.65 1130 hrs. Arrived Sydney
1 day 12 hrs @ 70/- Stg. - 75/- Stg.

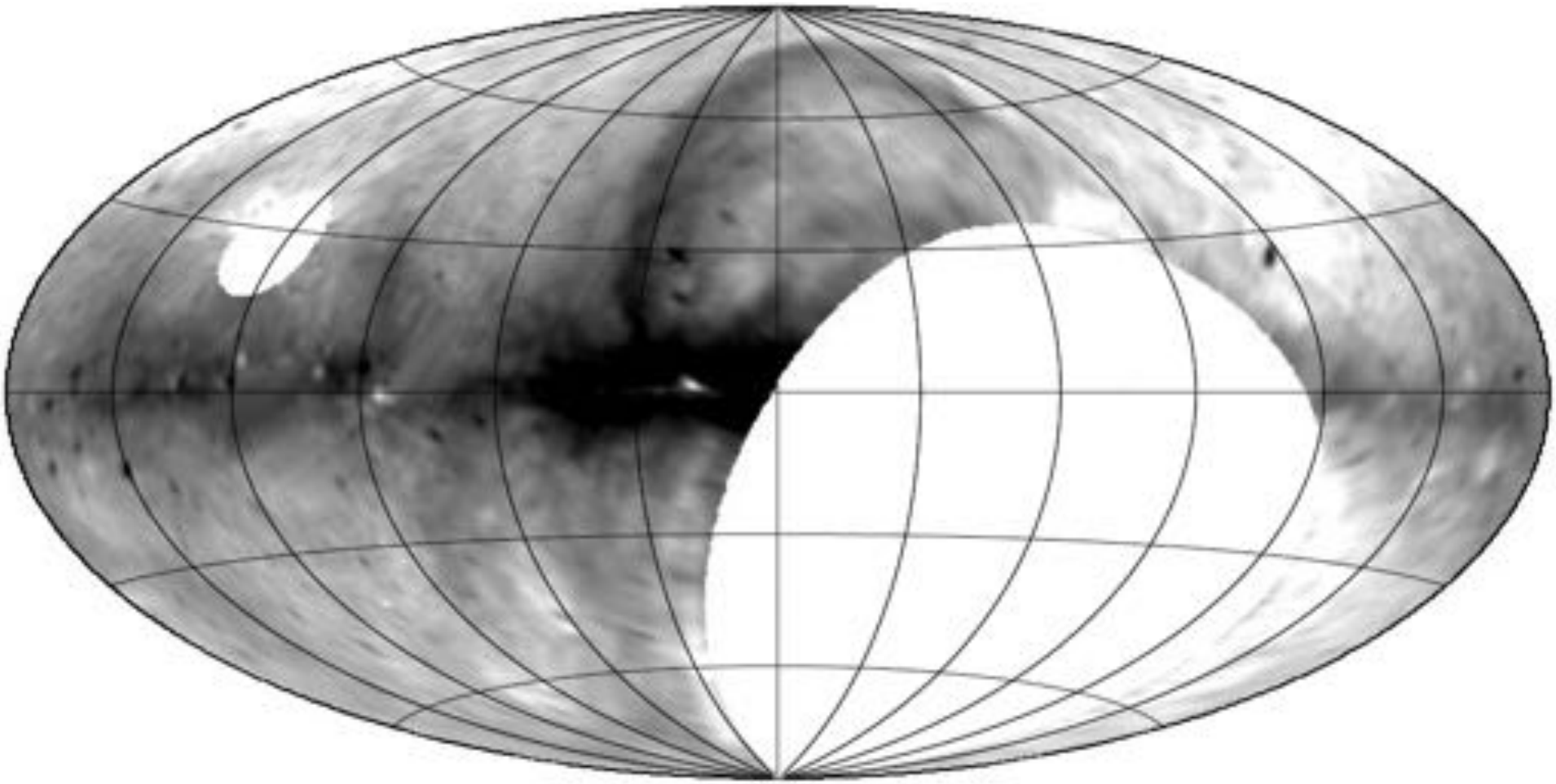
INCIDENTALS.

In U.S.A. as per details submitted - $33.63

SUMMARY.

In U.S.A. as per details submitted - $1222.66 - £350. 0.2
Canada " " " " - $95.00(Can.) - 35.11.11
Airboard allowance " - 75/- Stg. - 15.0
£370.11.1

January 1965



Algonquin Radio Observatory

30 Aug 1960

Canada To Build Giant Telescope

PEMBROKE (CP) — A giant new radio telescope that will help astronomers unravel more of the mysteries of outer space is being planned by the National Research Council.

The huge listening post, designed to pick up faint radio waves given off by objects in outer space, will be erected at the NRC radio observatory in Algonquin Park in central Ontario once the project has government approval.

The proposed telescope, costing in excess of $500,000, will be similar in design to one put into operation June 20 by the Dominion observatory near Penticton, B.C. However, it will not duplicate work at the Penticton station.

Biggest In Country

NRC officials at the Algonquin Park observatory, located on the south shore of Lake Traverse, some 120 miles northwest of Ottawa, said the telescope will be the biggest in Canada and among the largest in the world.

A radio telescope has no lens like ordinary optical telescopes. A dish-shaped antenna picks up radio waves from outer space which are fed into complicated recording equipment to be analyzed.

The antenna of the new telescope will be 120 feet in diameter, compared with 84 feet at Penticton.

Many stars, gas clouds and other objects in outer space cannot be detected with optical telescopes. However, their composition can be analyzed through study of the radio waves they shoot out.

The proposed new telescope will be designed to study radio waves of different frequencies than those being examined at the Penticton operation.

A 33-foot radio telescope is under construction at the Algonquin Park site. It will be a forerunner of the larger telescope.

New Site Chosen

NRC decided to establish the Algonquin Park laboratory a year ago after it was agreed that a site at Goth Hill, 14 miles south of Ottawa, no longer was suitable. Equipment in use

NRC telescope tender bid— decision soon

National Research Council officials are now completing a recommendation for Treasury Board approval on the award of a tender for construction of a 150-foot radio telescope for the council's radio observatory near Lake Traverse, Algonquin Park.

This "dish" telescope will be the largest in Canada and one of the largest in the world.

The NRC recently secured the services of Freeman and Fox, consultant engineers, London, to advise on the award of the tender for the telescope.

Construction of the NRC $2,000,000 Lake Traverse radio observatory has been approved as originally planned for completion in 1964 despite the government's current austerity program.

13 Oct 1960

Ottawa Citizen Newspapers

The Construction of the 150-ft Telecope in the Media

$16M CAD 2018

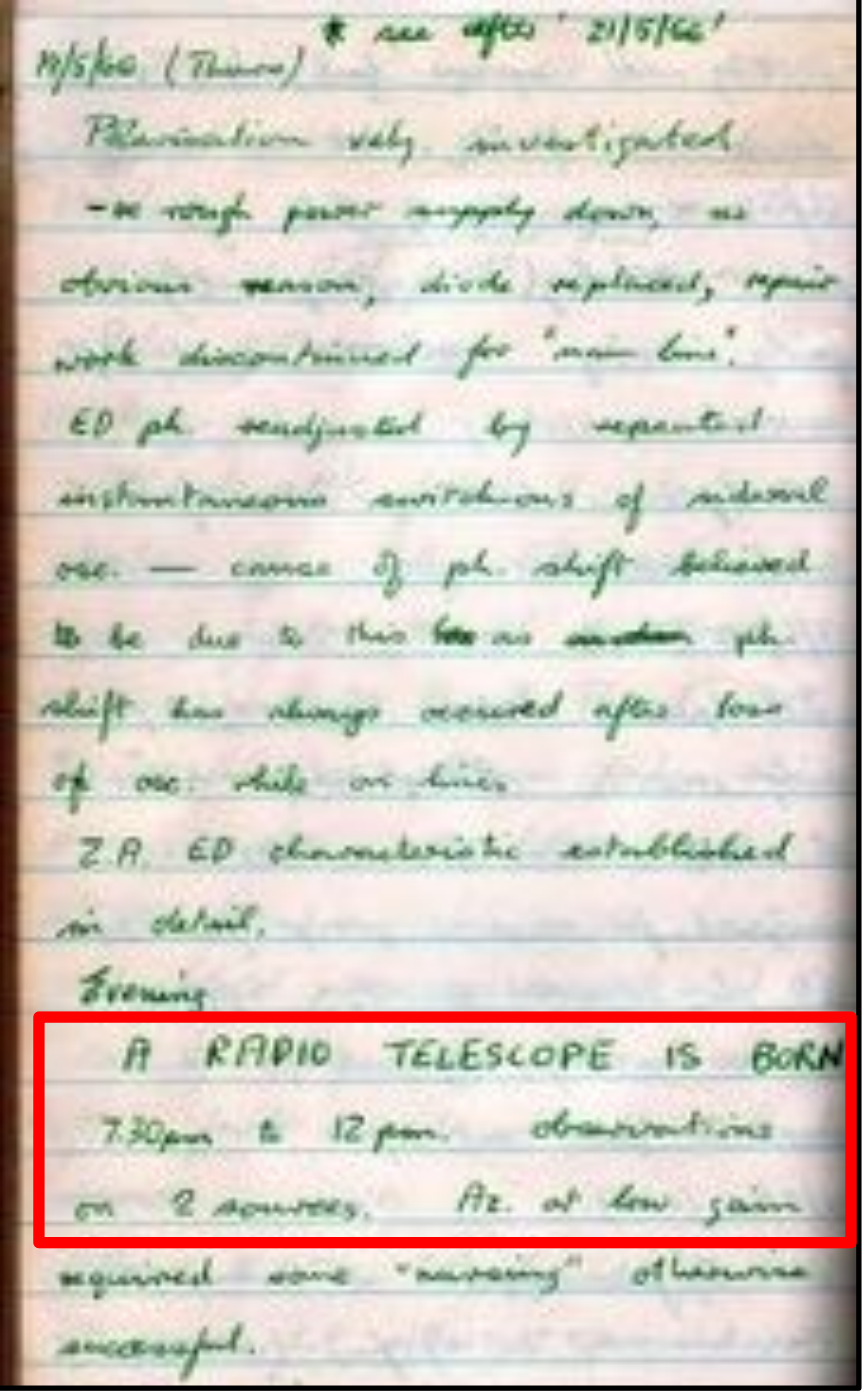
Canada to Build Giant Telescope, Ottawa Citizen, Aug, 30, 1960, p35
NRC Telescope Tender Bid - Decision Soon, Ottawa Citizen, Oct 13, 1962, p38

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

"To the Edge of the Universe"

Construction of Ribs

19 May 1966
ARO 150-ft "First Light"



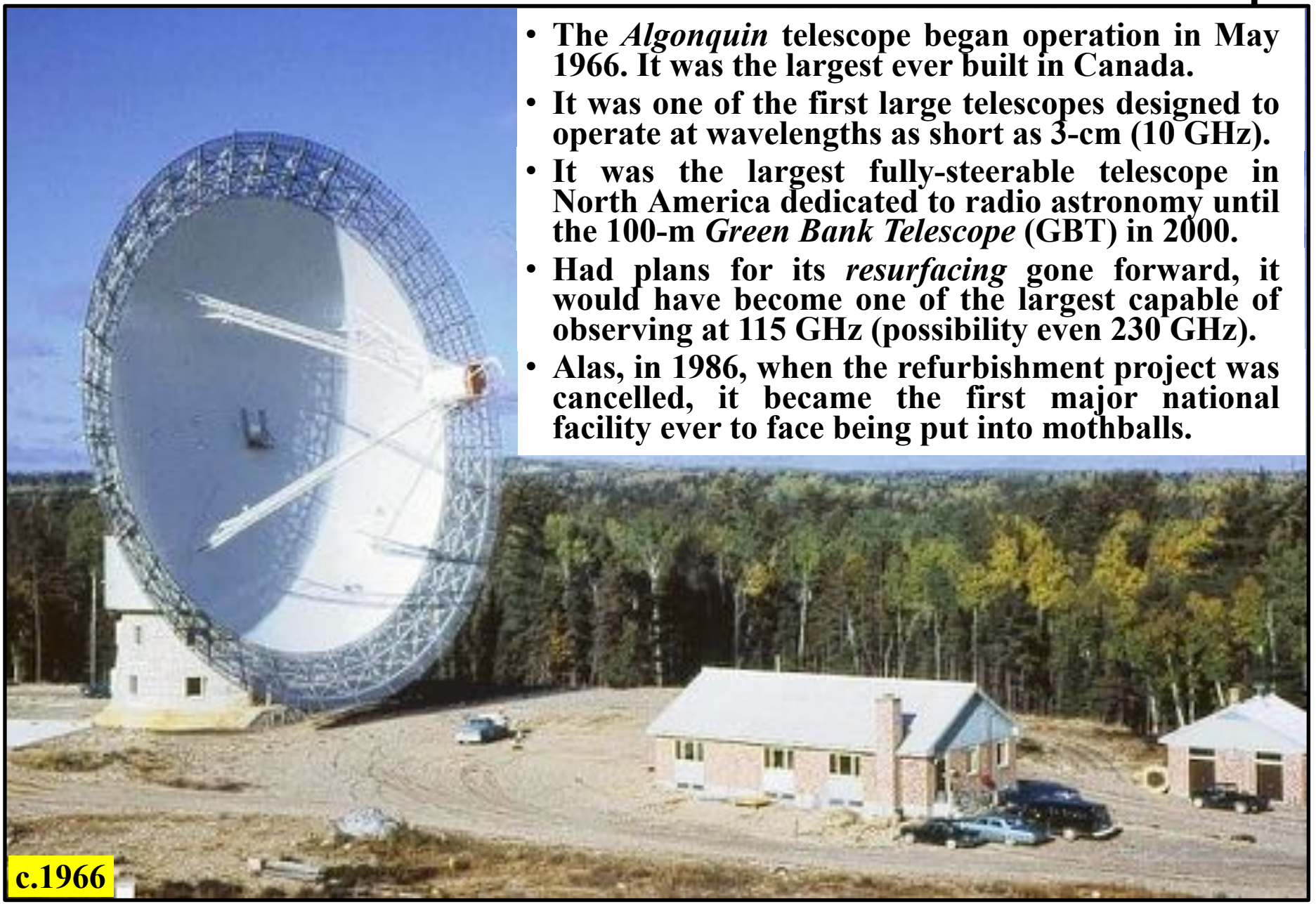
http://www.arocanada.com/ARO/people/John_Kenneth_Ayre.htm

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

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

Introduction : ARO 150-ft / 46-m Telescope

- **The *Algonquin* telescope began operation in May 1966. 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.**
- **Had plans for its *resurfacing* gone forward, it would have become one of the largest capable of observing at 115 GHz (possibility even 230 GHz).**
- **Alas, in 1986, when the refurbishment project was cancelled, it became the first major national facility ever to face being put into mothballs.**



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

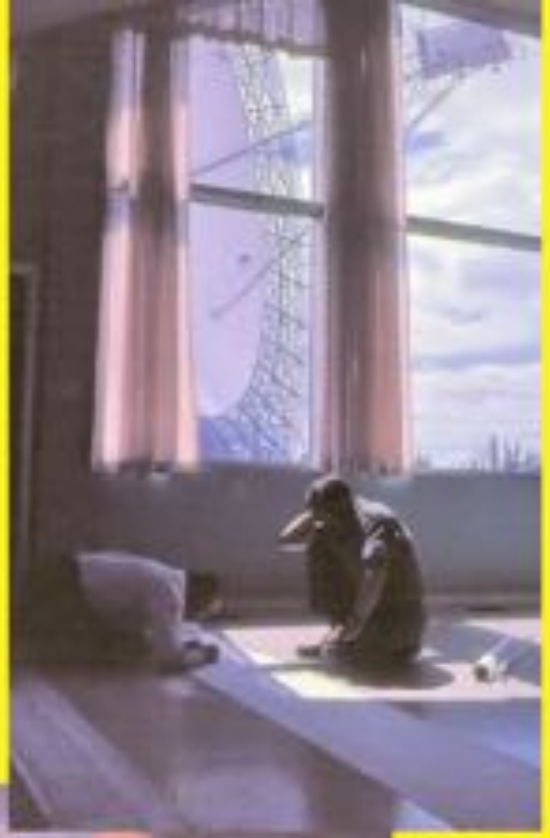
Joseph Fletcher :: "The Canadian Long Baseline Interferometer"

Putting a clock on the train at Chalk River
Joe Fletcher wearing the tie

John Galt and Jack Locke in the DRAO control room

"Fringe Searchers" at work ...

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



Leaving Algonquin at 6 a.m. for Ottawa to describe the discovery at the URSI Congress

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

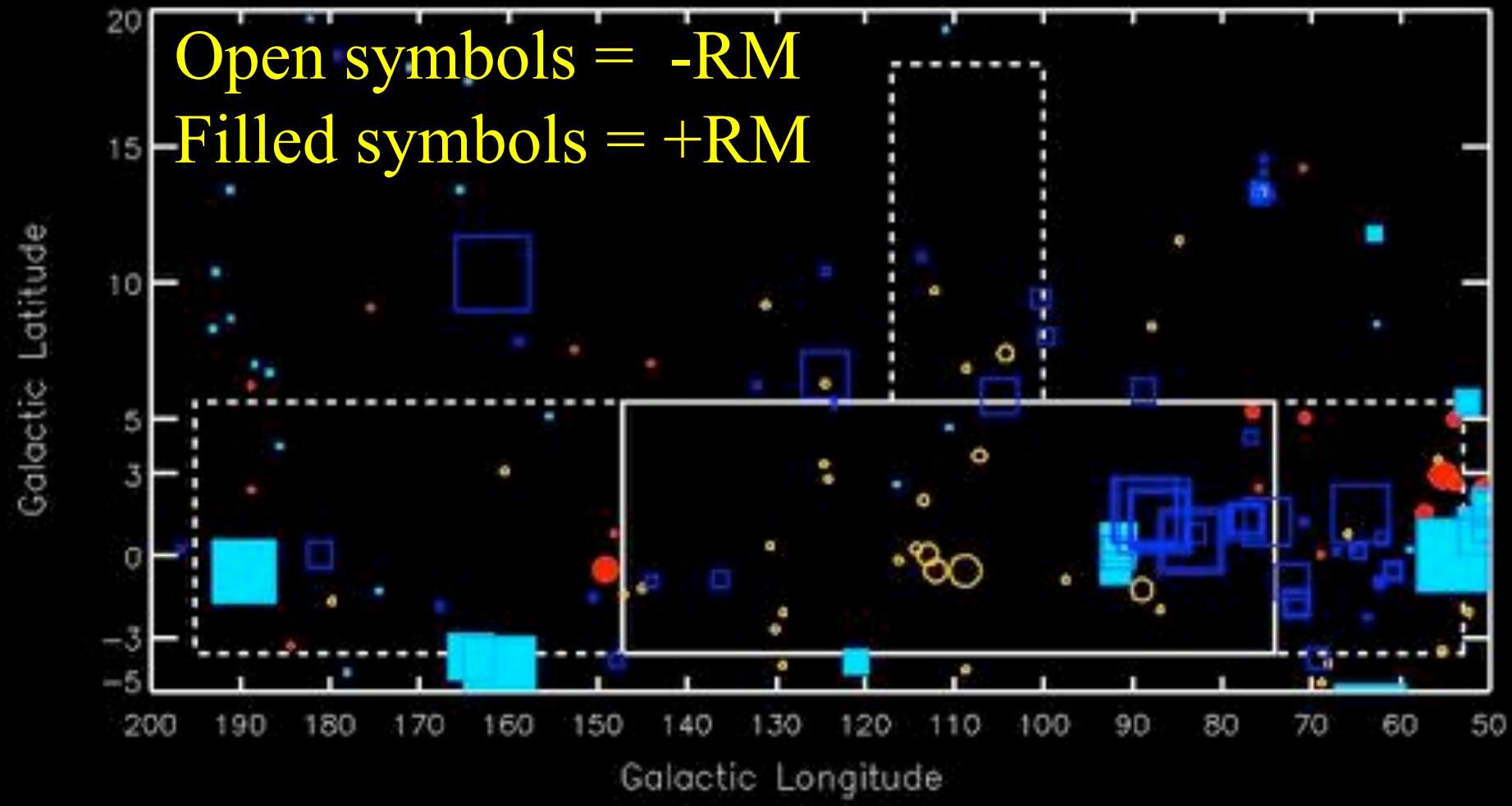
Institute of Electrical and Electronics Engineers
2010 Milestone Award

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

The DRAO Synthesis Telescope

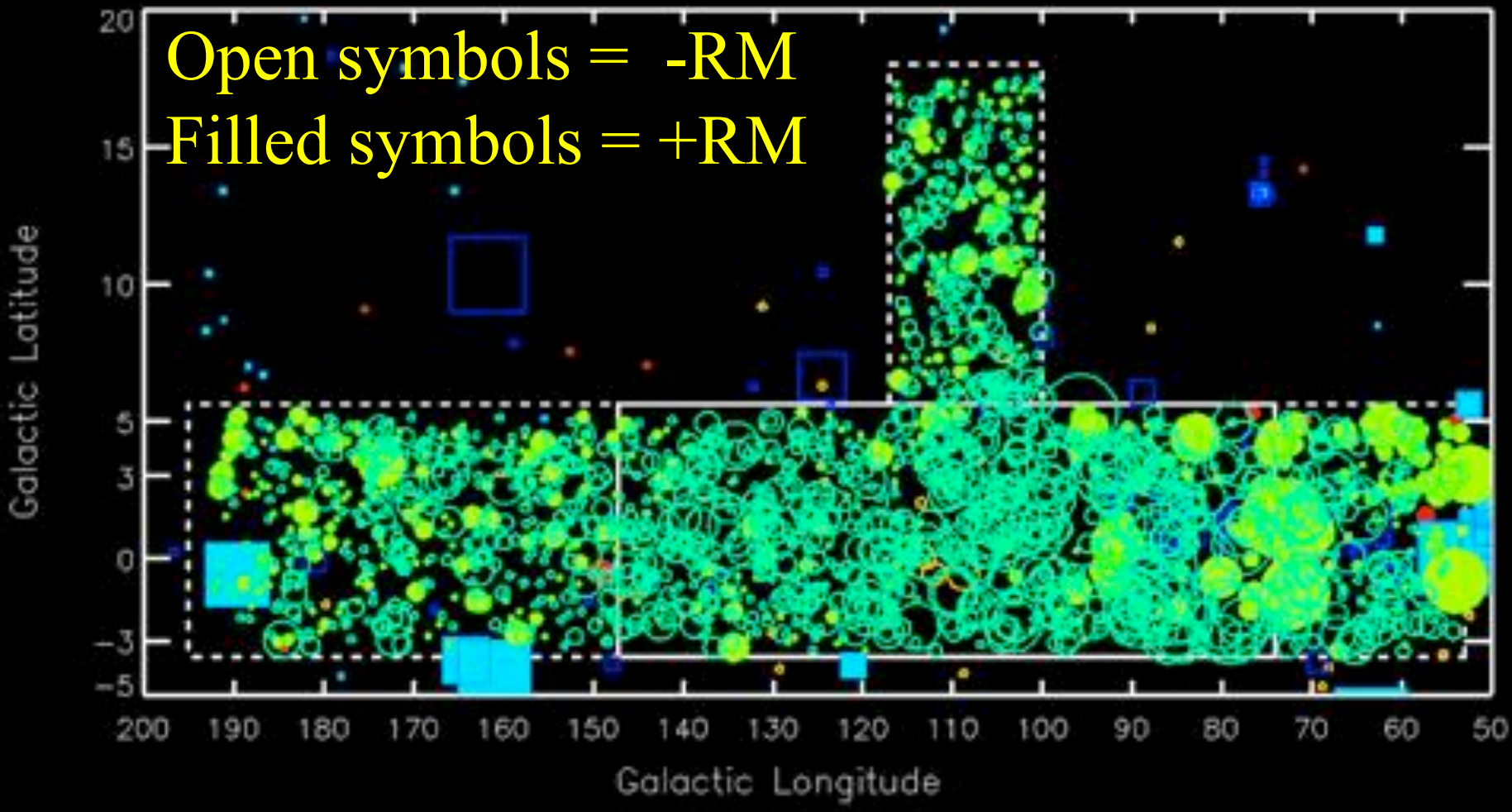

The Canadian
Galactic Plane Survey

RM Sources in the CGPS…

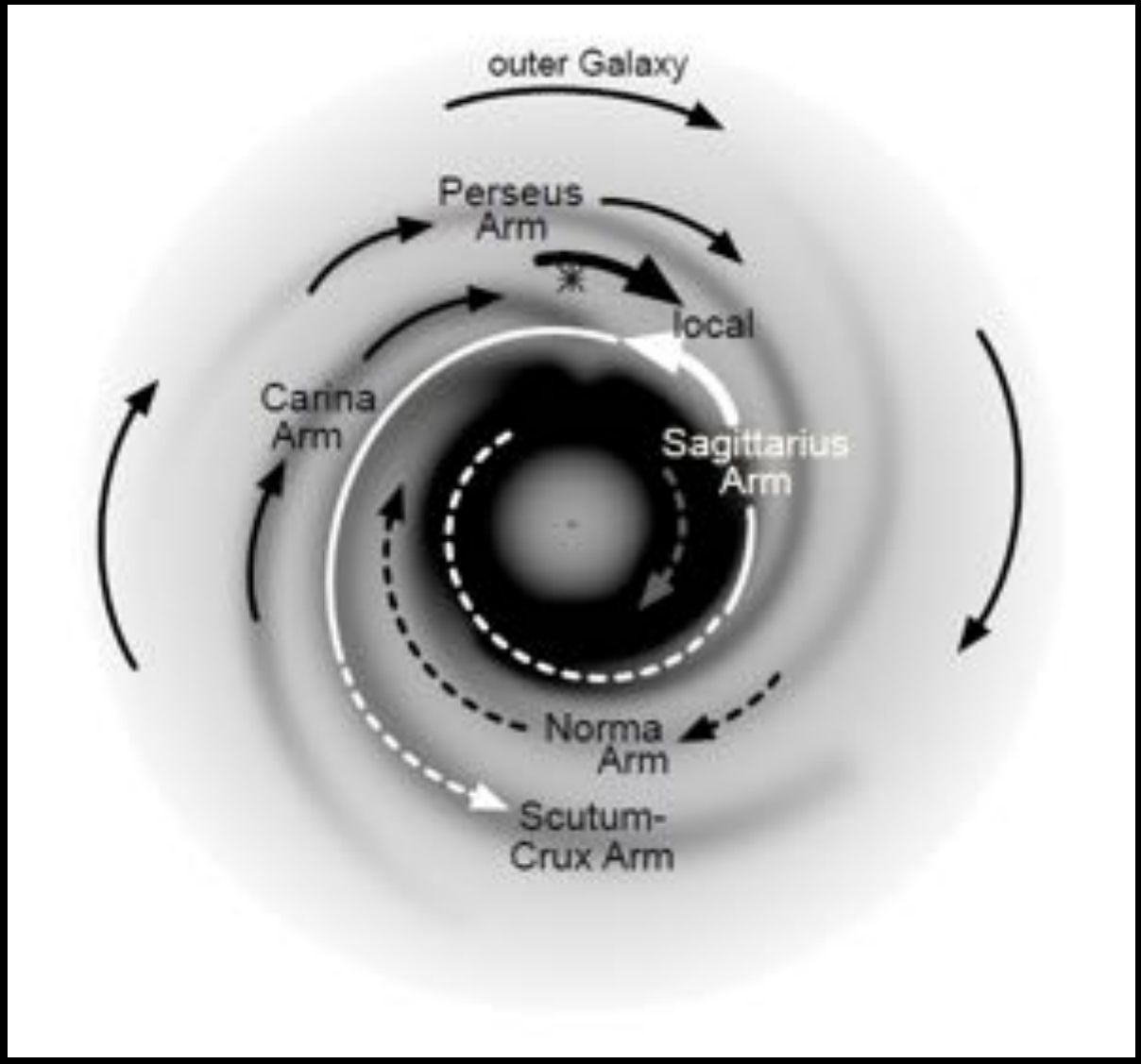


Published as of 2001: 27 pulsars, 40 EGS

…with the latest data (2015).



>1500 new RM sources in the CGPS region!

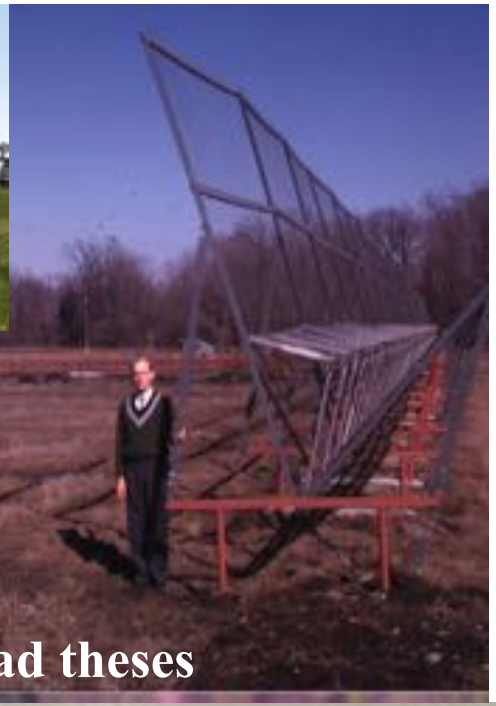


Jo-Anne Brown

Queen's Radio Observatory: A Canadian Training Ground

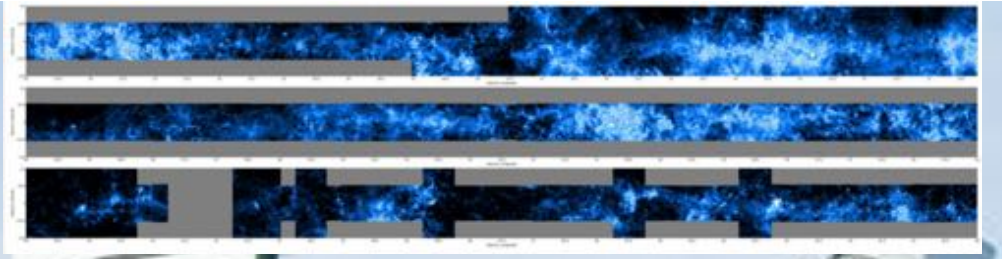
Kronberg

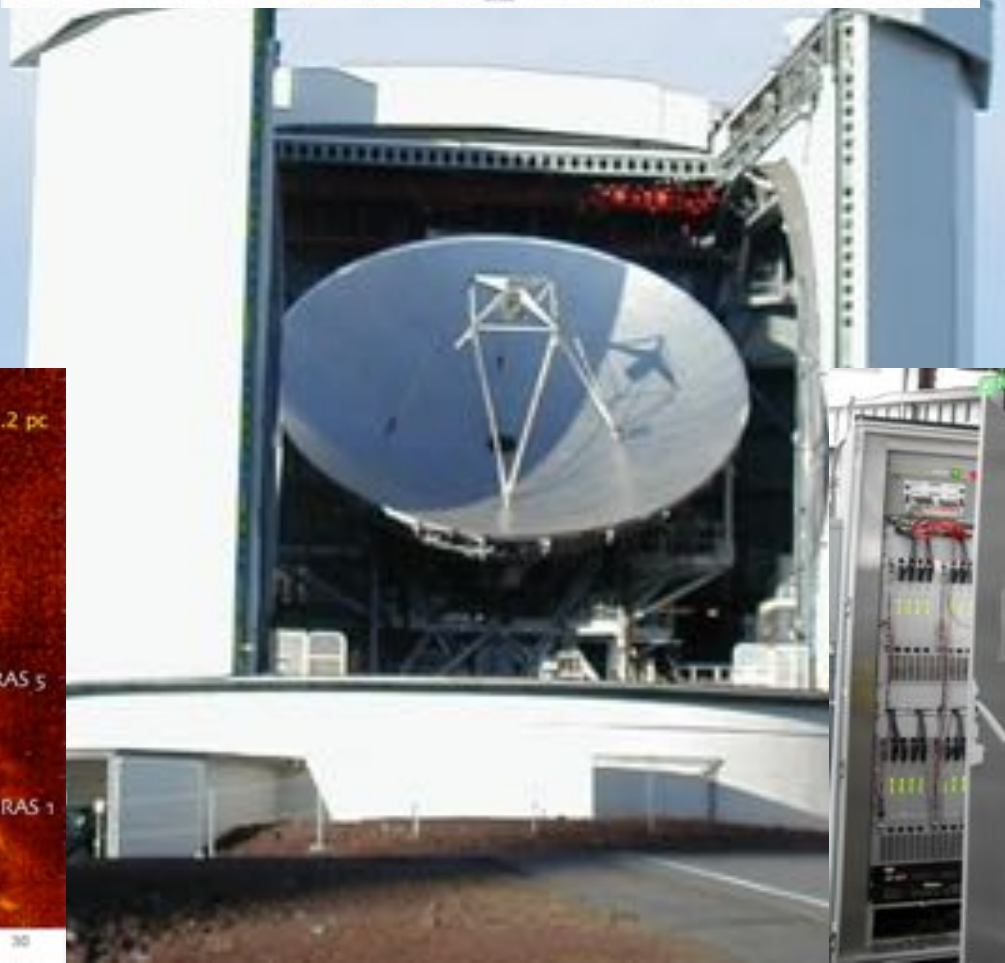
McCutcheon



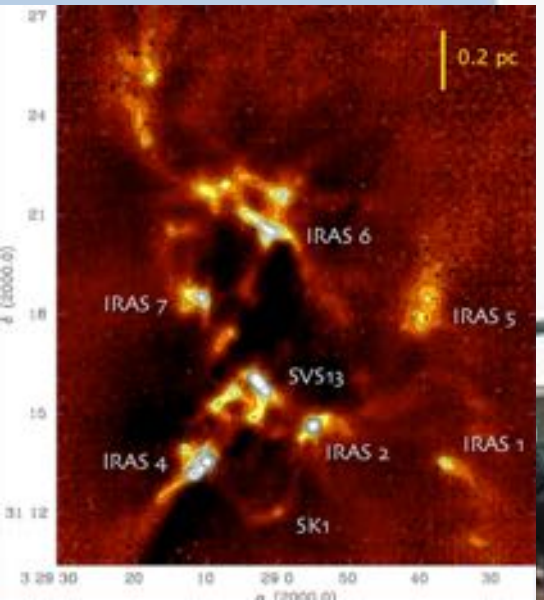
1962-75
Vic Hughes,
George Harrower,
Alan Bridle
supervised 20+ grad theses

JCMT: Canada Gets into Star Formation





ACSIS: Spectral Line Backend

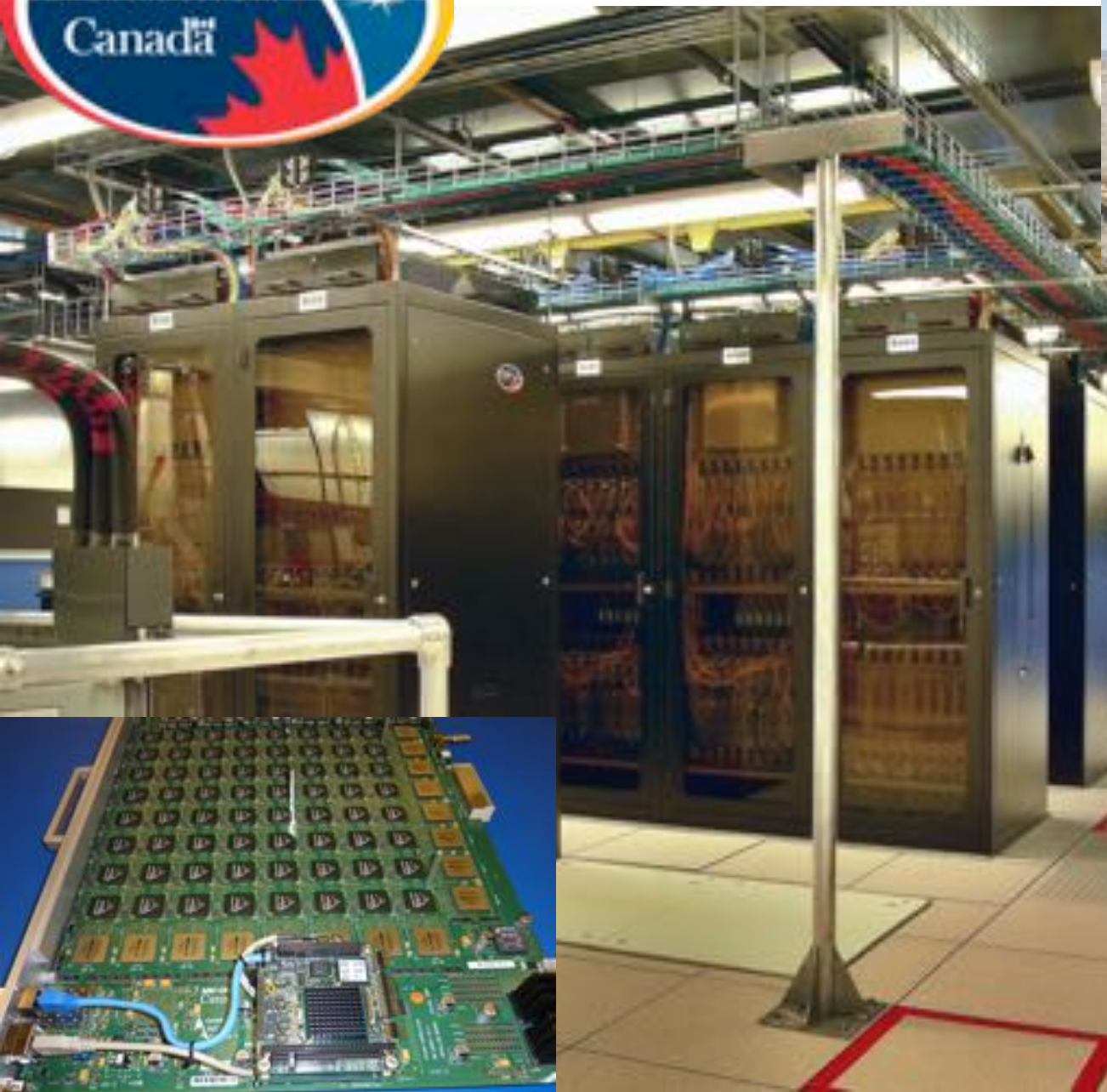


VSOP:

VLBI Space Observatory Program

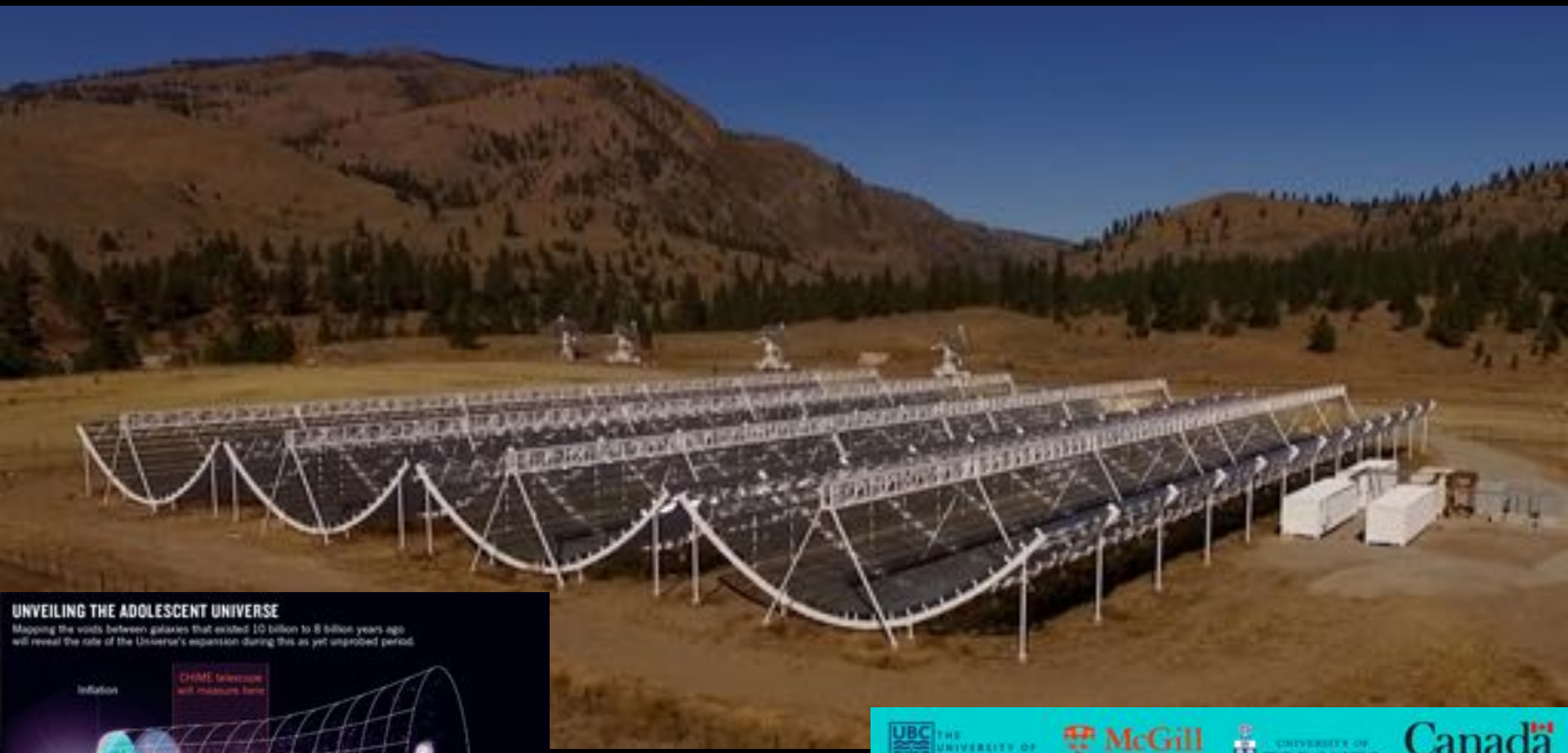
S2 LBI Correlator:
Employed VHS tapes

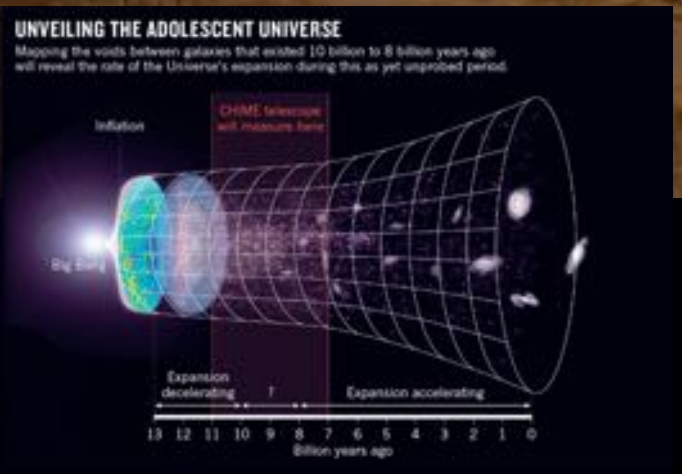
WIDAR



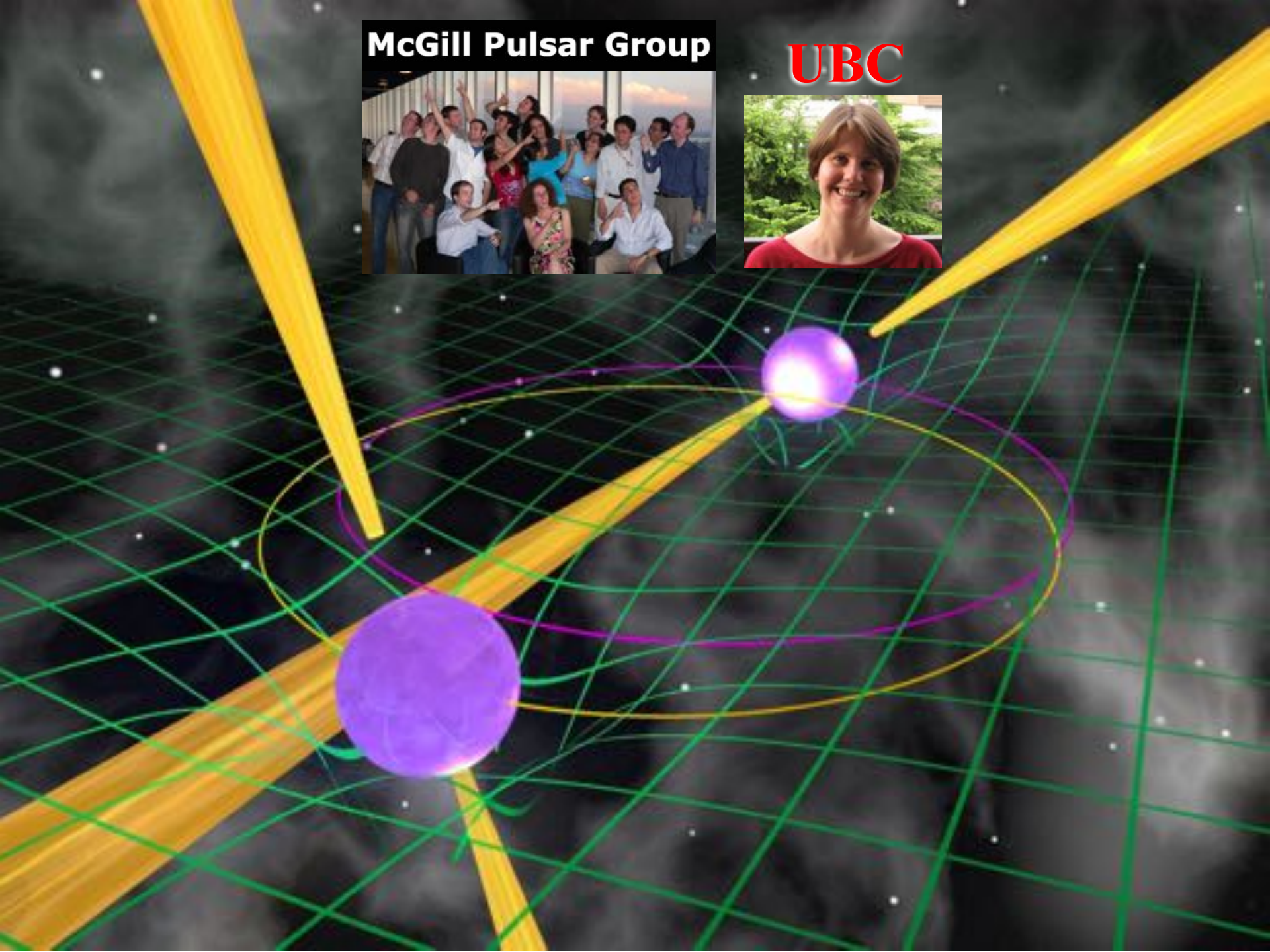
CHIME

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

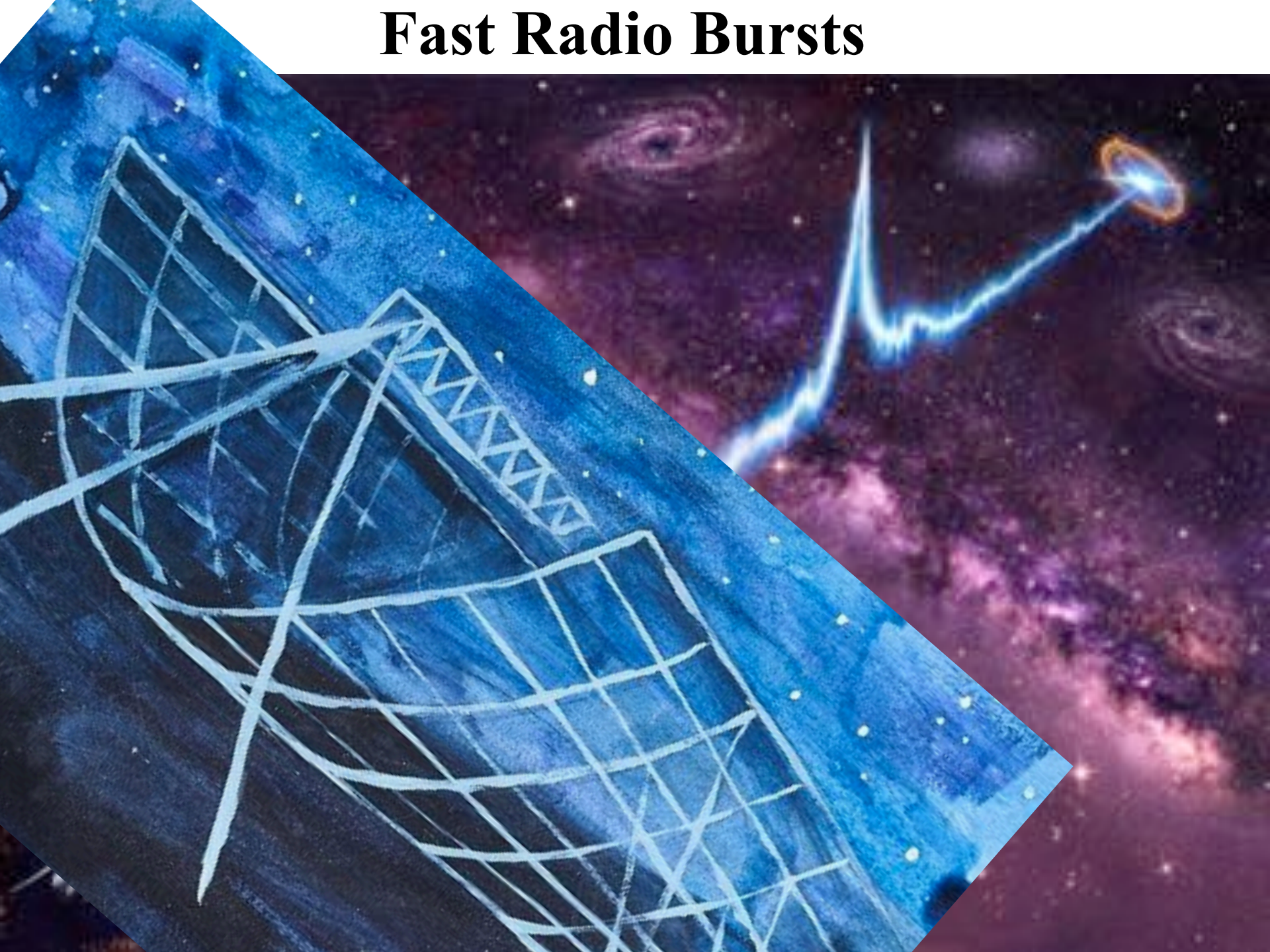




UBC The University of British Columbia · McGill University · University of Toronto · Canada NRC·CNRC · Yale University · West Virginia University · Perimeter Institute · Carnegie Mellon University · NRAO


McGill Pulsar Group
UBC

Fast Radio Bursts



SKA

SQUARE KILOMETRE ARRAY

ngvla

Next Generation Very Large Array


Thanks…
Sheila & Rena Galt
George Aitken
Chris Purton
Jasper Wall
John Locke
Ellen Bouton
Dave Routledge
Richard & Martha Jarrell
Rob Roger
Joseph Fletcher
Woody Sullivan
Mary Ferguson
Tom Landecker
Vic Gaizauskas
Peter Dewdney
Bob Hayward
Brent Carlson
Miller Goss
Ken Tapping