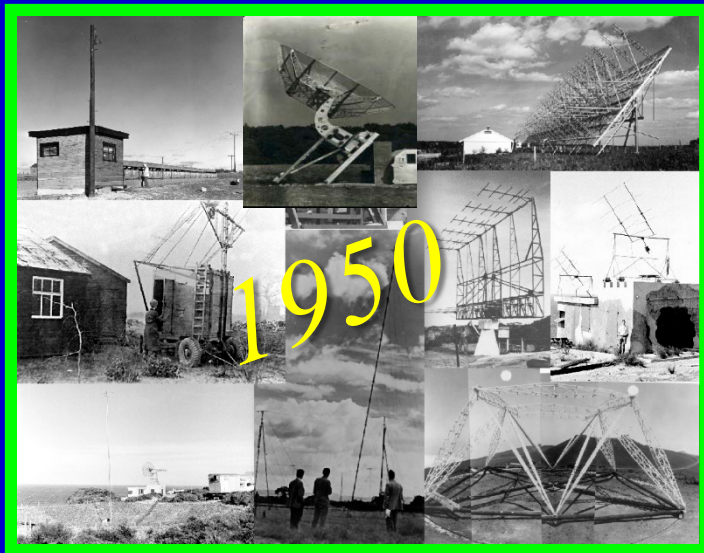
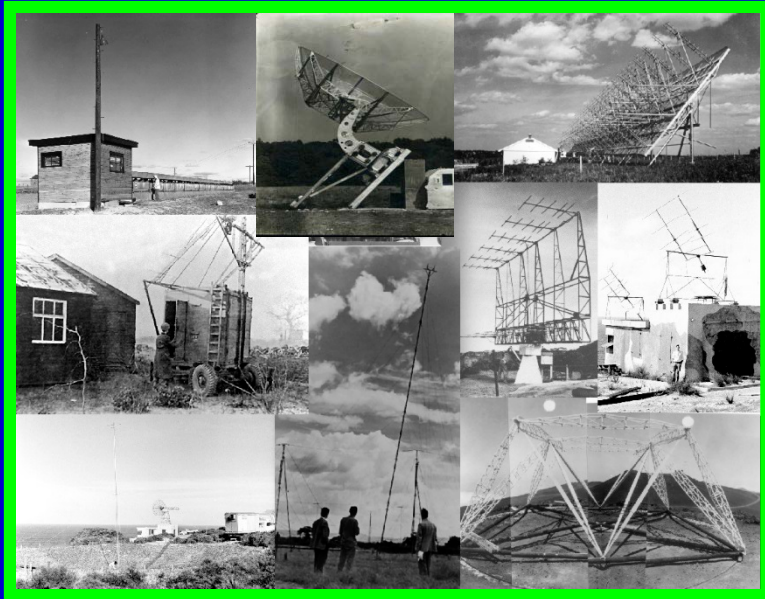


The Beginnings of NRAO and the Transition of Radio Astronomy to Big Science



Ken Kellermann
Socorro, NM
September 25, 2009

Radio Astronomy Scene 1950



UK (Jodrell Bank, Cambridge)

Ryle, Hewish, Graham-Smith

Australia (CSIRO Radiophysics Lab)

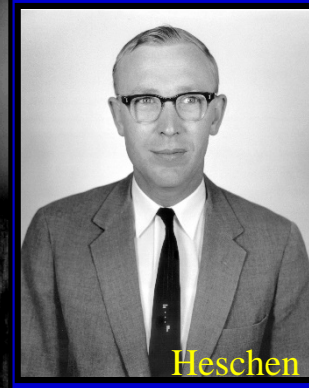
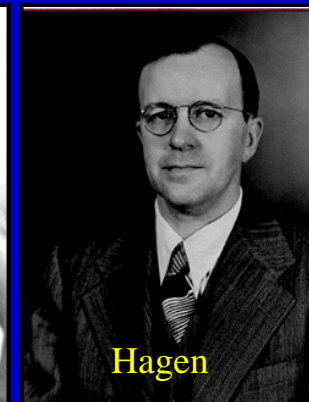
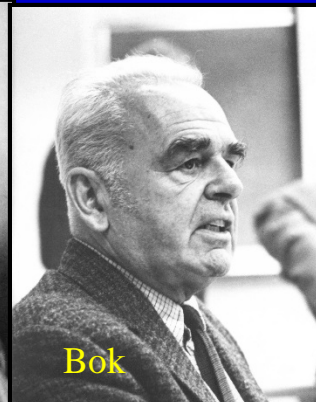
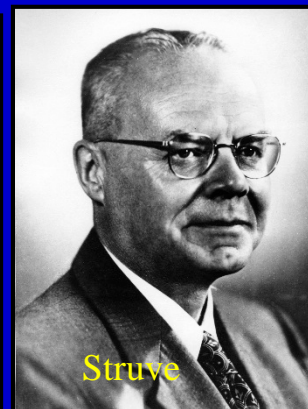
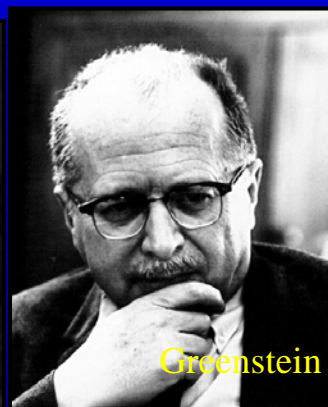
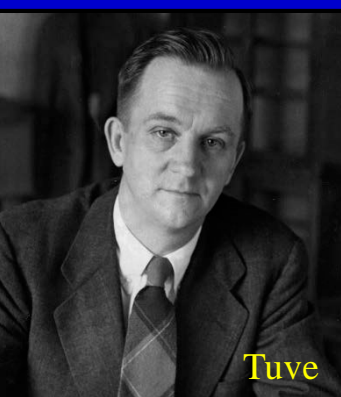
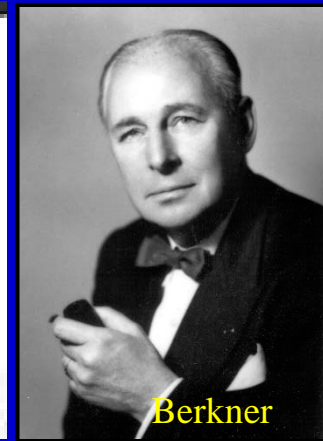
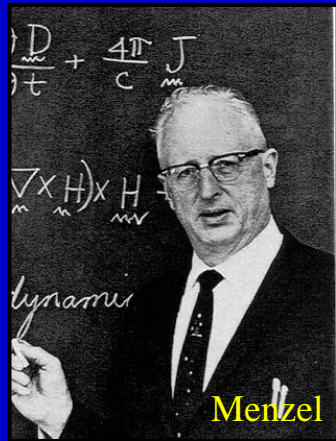
Bowen, Pawsey, Bolton, Mills, Christiansen

- U.S. astronomical community uninterested
- Radio Astronomy perceived as technology, not science, driven

Why did the balance shift from the US to Australia and the UK?

- U.S. scientists preoccupied with nuclear & high energy physics
 - Basic research in the US was largely at universities-little federal support
 - Except for atomic/nuclear research which had military application
- US Radar emphasis on cm wavelengths - not adequate for radio astronomy
- Astronomy, supported by
 - Private philanthropists: Yerkes, Lick, McMath
 - Foundations: Ford, Rockefeller, Carnegie
- Not sympathetic to activities appear to be related to military activities.
- By 1950s U.S. was behind in what was clearly an important emerging field of research
 - scientifically
 - cutting edge technical spin offs
 - military application

The People that Made it Happen





Associated Universities, Inc. (AUI)

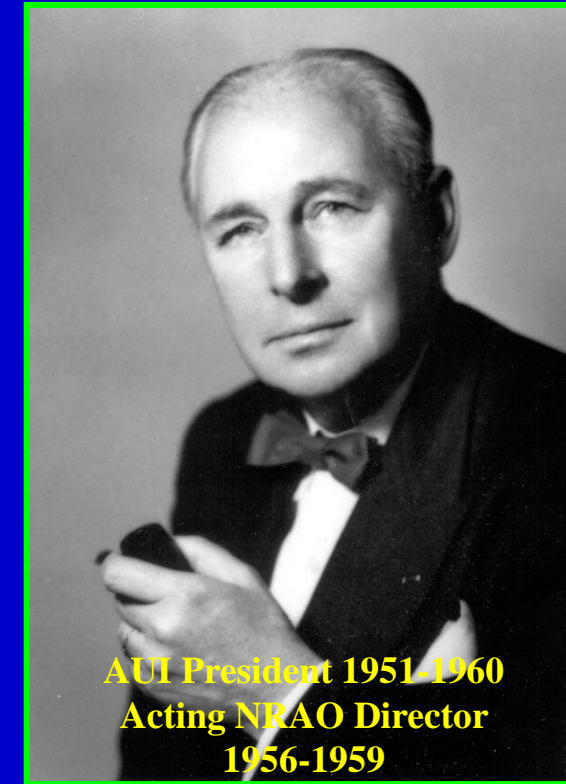
created in 1946 to

"acquire, plan, construct and operate laboratories and other facilities" that would unite the resources of universities, other research organizations and the Federal Government"

- Columbia University,
- Cornell University,
- Harvard University,
- Johns Hopkins University,
- Massachusetts Institute of Technology,
- University of Pennsylvania,
- Princeton University,
- University of Rochester
- Yale University.

- North-East Power was based in AUI
- Founded in 1946 to manage Brookhaven National Laboratory – large accelerators and reactors
- AUI Board $\frac{1}{2}$ scientists and $\frac{1}{2}$ administrators – no astronomers
- Office on 69th floor of Empire State Building in New York
- Radio astronomy obvious field in which to expand.

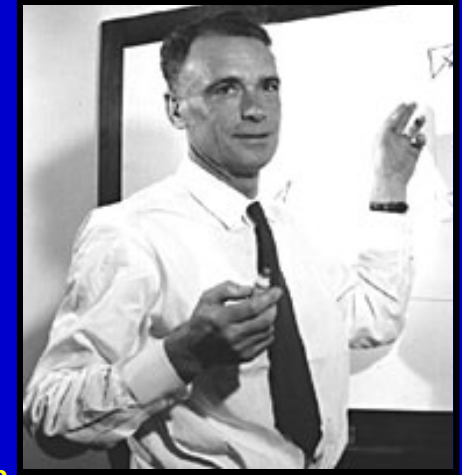
Lloyd Berkner



- 1951 – 1960: 1st President of AUI
- Considered new NSF a good source of funds.
- Science policy “czar” aka “big operator”
- EE Student of Prof. Curtis Jansky at U. Minn.
- Antarctic Explorer (Berkner Island)
- Rear Admiral USN – naval electronics (OBE)
- Amelia Earhart communications support
- Radio astronomy at DTM (under Tuve)
- UFO investigator (Majestic 7)
- Defense advisor (DEW line radar) (NATO)
- PSAC member: Appolo mission planning
- NAS Treasurer
- Advocate for Federal funding of science
 - \$500K for ionosphere studies based on Tuve’s work (1930)
 - 1938 Watheroo, W. Australia
- Driving force in establishing NRAO under AUI (NSF)
- 1956: Acting Director of NRAO
- Chair of IGY (Sputnik, 1957)
- President ICSU /COSPAR (1955); AGU (1959)
- 1960: resigns AUI over 140-ft issues
 - Board TI/Southwest Center for Advanced Studies (Univ. Texas)
 - November 22, 1963, Dallas, Texas



Taffy Bowen



- Key figure in WWII (airborne) radar and in liaison with the U. S.
- Chief of CSIRO Radiophysics where he built radio astronomy team: Pawsey, Bolton, Mills, Christiansen, Wild
- Ambitions to build a big dish
- 1951 visit to US with DuBridge and Bacher at Caltech, Ira Bowen at Mt. Wilson/ Palomar
 - Urged Caltech to set up a radio astronomy facility
 - 200-250 ft antenna
 - Staffed by Australians (Bowen- Director , Bolton, etc.)
- Exchanges with Vannevar Bush, DuBridge, Ira Bowen
 - Plans for a joint facility with MWP
- Bowen received money from Carnegie & Rockefeller Foundations to build 210-ft antenna in Australia
- Planted idea of building a large radio telescope in US
 - John Bolton went alone to start radio astronomy at Caltech
 - Clark, Kellermann, Sramek, Greisen, Wroble, Walker, Ekers, Goss, etc to NRAO

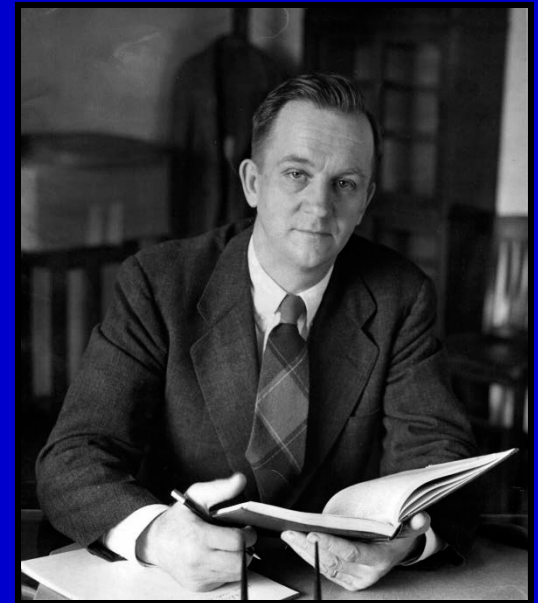
Alan Waterman



- Chief Scientist ONR
- First Director NSF in 1951, two weeks after the discovery of HI
- 1951 NSF budget \$225K
- Saw radio astronomy as an opportunity for the NSF
- 1954 visited Caltech and Mt. Wilson & Palomar
- 1954 appointed NSF Advisory Panel for Radio Astronomy
- Established a separate NSF funding line for large projects
- NRAO was the first big project undertaken by the new NSF



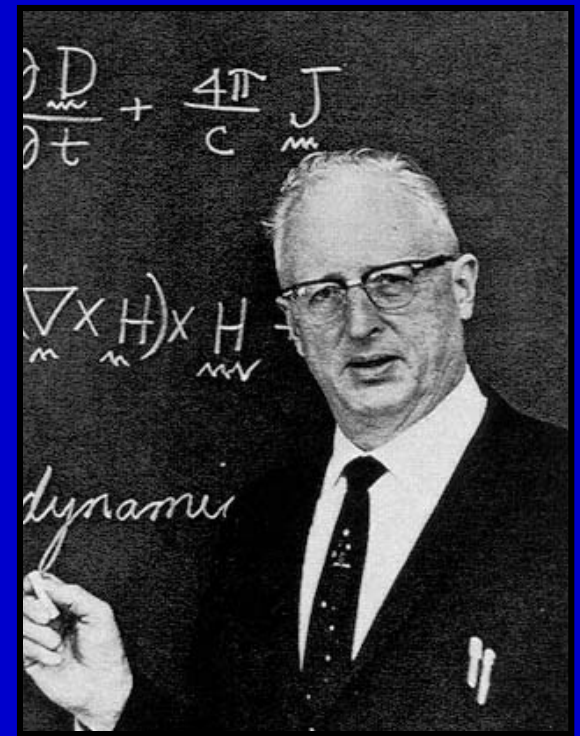
Merle Tuve



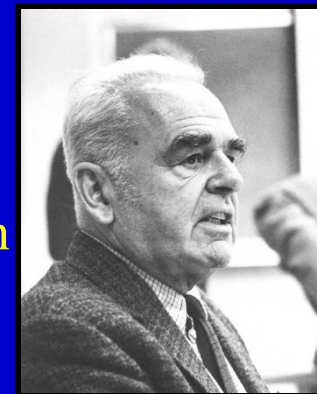
- DTM Director
- Developed ionospheric sounding technique and invented the proximity fuse
- Ran radio astronomy program at DTM (Carnegie)
 - Berkner's boss at DTM
 - Radio ham
 - Idealist concerned about government spending and the growth of big science
 - Berkner and Tuve had a strained relationship
- Offered position of NSF Director
- First chair, NSF Radio Astronomy Panel
- Opposed AUI management of NRAO
 - *“Very high priority, probably ahead of anything else, must be given to the support of existing activities in radio astronomy at universities.”*
 - *“A very large dish (250-600-ft) is a project of uncertain value,”*
 - *“No investigators qualified in radio astronomy are connected with AUI.”*
 - NSF money should go to active research astronomers, not to physicists, engineers, or administrators.
 - University based management instead of AUI

- Director of HCO
- Recognized opportunities for federal support of research
- Background in physics & spectroscopy
- WWII: solar activity and radio propagation
- Radio ham; W1JEX
- Remembered Grote Reber's 1936 letter to Shapley and 1946 proposal for 200-ft dish
- Helped to start the first university radio astronomy program
- April 13, 1954: Survey of the Potentialities of Cooperative Research in Radio Astronomy

Donald Menzel

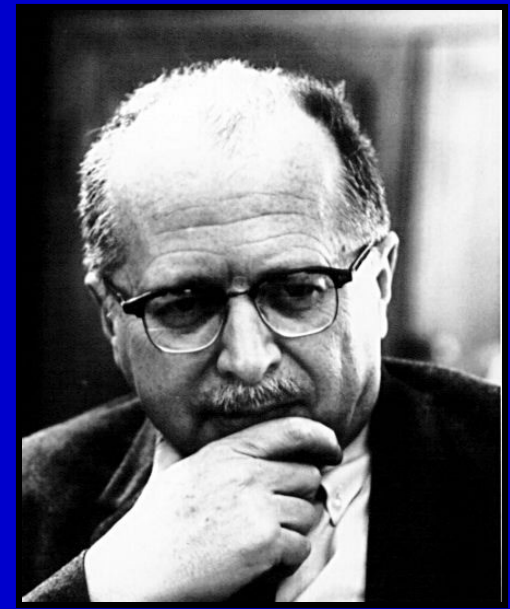


Bart Bok



- Harvard Professor started first academic radio astronomy program in following the 1951 detection of HI.
- All his students had to learn “astronomy.”
- Oct 1951, received first NSF radio astronomy grant for 24-ft antenna.
- 1955, obtained funds for 60-ft radio telescope, the largest in the world.
- Participated in NRAO site search. Dave Heeschen went along.
- Strong advocate of a national radio astronomy facility managed by AUI
- Wanted “his” people to run NRAO
- Dave Heeschen, Frank Drake, Kochu Menon, Cam Wade, Bill Howard, Jack Campbell, Nan Dieter, May Kassim, among first students
- 1956 offered NRAO Directorship
- In 1957 Bok went to Australia to become Director of the Mt. Stromlo Observatory where he established strong ties with CSIRO radio astronomers.
- Many Stromlo students were trained as radio astronomers at CSIRO – e.g., Ron Ekers, Marc Price

Jesse Greenstein



- **First trained astronomer to pay serious attention to radio astronomy**

- Yerkes staff member
- 1937 with Whipple wrote first theoretical paper in radio astronomy
- Made several visits to Wheaton, Ill to see Reber
- 1947 with Reber wrote first review of radio astronomy

- **Started radio astronomy program at Caltech**

- **Very influential in getting U.S. back into radio astronomy**

- But was more concerned about the lack of people than the lack of instruments
- Also concerned funding for radio astronomy would come at the expense of optical astronomy
- East-West balance

- **Organized 1954 Radio Astronomy symposium**

- **Almost discovered quasars**

- **Chair of NAS “Greenstein Committee” (1970 NAS Decade Review)**

- Goal was to fund a 200-inch telescope in Chile
- Recommended the VLA as first priority for astronomy

John Hagen

- Worked at NRL 1935-58 where he began a radio astronomy program
- Chair of US URSI Commission J
- First Chair AUI Radio Astronomy Advisory Panel
- Wanted AUI to build a big (600-ft) telescope and wrote:
 - *“interferometers and arrays are not acceptable at centimeter wavelengths”*
 - *“150-ft would delay the real goal”*
- 1956 Hagen became head of Project Vanguard to launch first U.S. satellite
lost much of his influence at NSF.

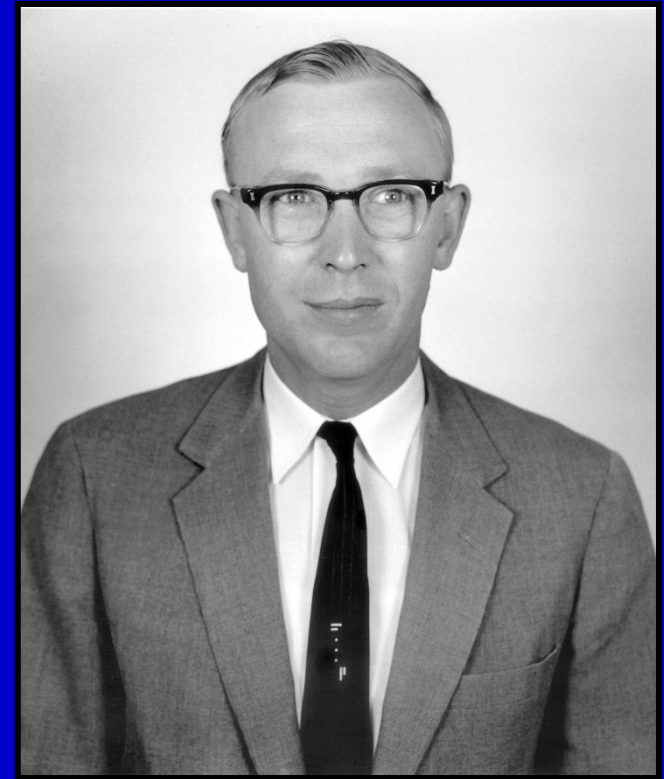


- Background was in optical astronomy – stellar spectroscopy
- WWI Artillery Officer in Turkey
- First involvement with radio astronomy was dealing with Grote Reber
 - 1940 Editor of ApJ
 - Offered Reber a job at Chicago
 - Tried to help Reber get funds to build a 200-ft dish
 - *Small observatories have to search for what they are able to do instead of what is important and interesting*
- Started McDonald Observatory
- Director of Yerkes and McDonald Observatories
 - Workaholic
 - Hired: Kuiper, Stromgren, Chandra, Greenstein,
 - Visitors included: Oort, van de Hulst,
- One of founders of KPNO
- Instrumental in starting radio astronomy at Berkeley
- NRAO Director 1959-1961
- Difficult period for NRAO and Struve

Otto Struve



Dave Heeschen



- Involved with AUI/NRAO from 1955
- NRAO employee #3
- Assistant to Director, Head of Astronomy Department
 - Decided who to hire
 - What programs to pursue
 - What instruments to build
- Heschen appointed NRAO Director 1962-1978 (age 37)
- Became the major force in shaping the nature of NRAO
 - Unique facilities
 - Open skies
 - Emphasized visitor support
 - Strong scientific staff
 - Instrument development

How did NRAO happen?

- 1953: Caltech President DuBridge writes Tuve (DTM) & Bok
- Tuve suggests holding meeting in Washington
- Bok already planning conference
- Two conferences held within 2 weeks of each other
- Dec 26/27 1953 (Sat/Sun): (AAAS)² meeting, Boston
 - First conference on radio astronomy in US
 - Bart Bok – *“Objections have been raised to our original plan of starting ... the morning after Christmas. We ...decided to have the first meeting ... start at 2:15 pm so those coming can travel ... overnight.”*
 - T= -20 F
 - Review papers by Hagen, Ewen, Tuve, Smith, Mills,

Washington Conference on Radio Astronomy Jan 4-7, 1954:

- **Organized by NSF, Caltech, Carnegie Institution (DTM)**
 - NSF funded
 - SOC: Greenstein (Chair), Hagan (sec), SOC-Bok, Weisner, Tuve
 - Attended by about 75 people from universities, government, and industry
 - Alfvén, Mills, Bowen, Hanbury-Brown, Smith, Hoyle, Van der Hulst, Covington, Heeschen, DuBridge
 - Dominated by foreign presentations: See JGR, 59, 149-201 (1954)
- **Provided the catalyst which set the ball rolling to establish a national radio astronomy facility**
- **Initiated serious discussions among the Washington power brokers**
 - Weisner & Stratton (MIT), Menzel & Bok (Harvard), Hagen (NRL), Tuve (DTM)
 - NSF: Helen Sawyer Hogg
- **Important memo written by Donald Menzel**

Survey of Potentialities of Cooperative Research in Radio Astronomy

Donald Menzel , April 13, 1954

- Field of radio astronomy “*encompasses most of astronomy, stars, cosmic evolution, geophysics of the atmosphere, aerodynamics, astroballistics, electronics, radio communication, electromagnetic and hydrodynamic properties of gases, statistical mechanics, thermodynamics, interaction of atoms and radiation, cosmic rays, properties of the atomic nucleus, and the speed of chemical reactions.*”
- Discussed Galactic, solar, and planetary studies, HI, OH, D.
- Included theoretical studies (plasma physics, magnetohydrodynamics, shock waves)
- Suggested AUI consider establishing a national radio astronomy facility
 - Emphasized need to find rfi free site
 - Need to train students
 - Requirements for staff and director
 - Suggested several optical telescopes be included
 - Graciously offered Harvard site and Harvard mirrors
 - Recommended forming advisory committee
- Cover letter: “*I hope this is the beginning of a new important era in radio astronomy*”

NRAO gathers momentum

- **May 20, 1954: New York AUI Conference**
 - 37 participants from 20 institutions including west coast
 - Supported development of national radio facility
 - Berkner sets up AUI Steering Committee for Radio Astronomy-(John Hagan (Chair) to conduct a feasibility study for national radio observatory
 - Boston and Washington meetings discussed “small science.”
By May, they were all discussing “big science.”
- **May 20, 1954 NSB endorses NSF support of large scale scientific facilities**
 - *The NSF should recommend as a national policy the desirability of government support of large-scale basic scientific facilities when the need is clear, and it is in the national interest, when merit is endorsed by panels of experts, and when funds are not readily available from other sources.*
 - *Funds for such large-scale projects should be handled under special budgets.*
- **Jan 13, 1955: Berkner applies for an NSF grant for \$105K to investigate setting up a national radio astronomy facility**
- **NSF Advisory Panel for Radio Astronomy**
 - Tuve (Chair) – referee reports were negative – recommended \$15K
 - Greenstein – referee reports very favorable
- **February, 1955 AUI receives \$85K grant**
- **AUI Advisory Committee for Radio Astronomy**

Radio Astronomy Committees

- **AUI Advisory (Steering) Committee for Radio Astronomy:**
 - Hagen (Chair 1954-55), Bart Bok (Chair 1956), Deutch, Ewen, Goldberg*, Gordon, Haddock, Kraus, Meinel, Tuve, Wells, Weisner (Heeschen-consultant)
 - Discussed site, size, mount, size of staff, etc.
 - 600 –ft design study - largest feasible size - Hagan
- **NSF Advisory Committee (Panel) for Radio Astronomy:**
 - Tuve – Chair, Bart Bok, Greenstein , Hagen, Kraus , Minkowski, Ed Purcell , Peter van de Kamp (NSF Ast)
 - Start with modest size telescope
- **The two committees had overlapping membership sometimes working together, but often in conflict**
 - Wrote to each other and their letters are preserved (10th level carbon copies)
 - Often not clear what hat they were wearing and hard to tell which committee was speaking.
 - Situation complicated by loose definition of committee names
- **NSF Committee on Optical Astronomy working at the same time was concerned about radio astronomers taking funds from real astronomy**
 - *Leo Goldberg was member of both Radio and Optical Committees

Joint meeting of NSF Radio and Optical Panels
Ann Arbor, Michigan
July 23, 1956

I think our position should be that we need them all, and that the country is rich enough to afford them. I have been rather impressed by the timid attitude on the part of astronomers which seems to take it for granted that funds must always be limited.

Leo Goldberg

Shootout in Washington, July 11, 1956

organized by

Raymond Seeger (MPE AD) and Frank Edmondson (PD for Astronomy)

Attendance

- NAS/NSF: Detlev Bronk (Chair),
- NSF: Waterman
- AUI: Berkner, Emberson, Dunbar
- UC: Shane, Struve
- Caltech: DuBridge, Bolton, Minkowski, Bowen
- Harvard, Menzel, Reynolds, Purcell, Bok
- MIT: Weisner, Stratton
- Michigan: Goldberg, Haddock
- Oak Ridge: William Pollard
- Princeton: Spitzer
- (Research Corporation: Reber)
- Vanderbilt: Seyfert
- Univ. Virginia: Darden
- West Va. Univ: Irvin Stewart
- Ohio State: Krauss
- Carnegie: Tuve
- Wisconsin: Whitford

Radio Astronomy Facility Conference

July 11, 1956

am: Scientific and Technical issues (civil)
pm: Organizational Issues (contentious)

- Merle Tuve
 - AUI “*a very small group of self-approving experts*”
 - AUI plan *poisonous and a whitewash*
 - AUI plan for 600-ft: *a power bid by people who love to manage things*
- For AUI: Edward Reynolds (AUI, VP Harvard)
 - *You are going to have to want us enthusiastic. Then we can do a good job for you.*
- Julius Stratton: *Never have so many thought so differently on so few matters*
- July 16: Pre-emptive strike to incorporate AURA :
 - William Pollard, Director, Oak Ridge Inst. for Nuclear Studies & Irvin Steward, President WVU
 - Menzel, Goldberg, Greenstein, etc refused to participate
 - AURA later re-invented for KPNO (1957)

AUI submits Plan for a Radio Astronomy Observatory

August, 1956

IV. ESTIMATED CONSTRUCTION BUDGET (as of March 31, 1956)

The estimated budget for construction follows.

A. Site Development:

Site acquisition	\$ 800,000.
On-site secondary roads	190,000.
Utilities (other than electric power)	
Drainage system	
Water supply (well, pump, etc.)	135,000.
Electric power (on-site generation)	418,000.
Total Site Development\$1,543,000.

B. Buildings:

Diesel generator building (includes cooling tower)	\$ 30,000.
Control buildings (60- & 140-ft. telescopes)	33,000.
Maintenance building (first section)	68,000.
Laboratory and administration building (central section)	441,000.
Housing (remodel existing houses)	20,000.
Total, Building and Housing\$ 592,000.

C. Radio Telescopes and Other Research Equipment:

Design, fabrication & erection of 140-ft. radio telescope	\$1,800,000.	←
Excavation, clearing, foundation etc. for 140-ft. telescope	400,000.	↔
RF components & other electrical equipment	200,000.	
Other observing equipment (including 28-ft. and one 60-ft. telescopes)	350,000.	
Total, Construction & Equipment\$2,750,000.	

D. Service Equipment:*

Library	10,000.	
Machine shop & repair	60,000.	
Electronic test & repair	65,000.	
Furniture & equipment for offices, cafeteria, guest house, etc.	50,000.	
Total\$ 185,000.	
		\$5,070,000.

E. Salaries, Operation, and Maintenance for the first year

.....\$ 100,000. ←

Site Selection

- Parallel discussions about the site started very early
- November, 1954 NSF stipulated site should be with 300 miles of Washington
 - Travel time for north-east radio astronomers? (first 707 - 1957, prototype 1954)
 - Balance optical astronomy largely based in California
 - Control!
- July 1955, AUI receives second grant of \$140K
 - Berkner appoints Site Selection Committee: Bok, Ewen, Kraus, Seyfert, Hagen, Haddock
 - 30 sites in VA, WV, TN evaluated for RFI, latitude, ice and snow, humidity, availability, amenities, distance from Washington, deer hunting
 - RFI testing done by Jansky & Baily Inc.
- Dec 1955, Green Bank site chosen by AUI
- 1956, WV Zoning Act passed – enabled National Radio Quiet Zone
- March 1956, AUI acquires options to purchase 6,200 acres (\$502K)
- July 1956, Congress appropriates \$ 3.5M for land, building, and design and construction of a 140-ft radio telescope
- NSF announces it will acquire land in GB by right of eminent domain.
 - Removes problem of holdouts
 - Neutralizes AUI

Closing the Deal

- August 24, 1956, NSB considered 3 options for the
 - Management by a University
 - West Virginia University : Discussions with President Steward
 - UVA: Discussion between Waterman and President Colgate Darden, Jesse Beams
 - Management by AUI
 - Management by a new organization (e.g., Oak Ridge)
 - Tuve (on “behalf of his NSF committee”)
 - *“no value in a telescope capable of operation at less than 10 cm.”*
 - *“AUI too busy and has no experience”*
 - *“Where will the staff come from: UK, Australia ?”*
 - *“no need to rush”*
 - Hagen, replied that Tuve had misrepresented the Committee and was speaking only for himself
- NSB Decision (Oct 3)
 - It would take too long to form a new corporation
 - They chose AUI with the stipulation that
 - Agree to appoint 3 at-large Trustees
 - Operate facility for *“use of the nation’s scientists”* independent of institutional affiliation.

Completing the deal

November 17, 1956



AUI awarded a 5 Year contract (\$ 4.8 Million) to operate NRAO
To be reconsidered after 5 years
Possible joint operation with national optical observatory

Search for a Director

- **AUI wanted a big name to head NRAO**
- **Berkner appointed a Search Committee for NRAO Director**
 - Menzel (Chair), C. D. Shane, W.W. Morgan, Struve, Ike Bowen, Weisner
- **Selection criteria**
 - Astronomer or radio engineer? “direction of the scientific program ... more important than the ability to design electronics.”
 - Executive experience
 - “primary restriction ... nominee should be U.S. citizen” (Pawsey)
 - Professorship at any AUI university
- **Overwhelming choice – Bart Bok “only qualified astronomer”**
 - Didn’t know enough radio technology
 - Committed to Mt. Stromlo

Director Search Summary

October 30, 1956
Harvard College Observatory

NOMINEE	COMMITTEE VOTES							Aver.	Weight
	Bowen	Menzel	Morgan	Struve	Shane	Wiesner	Aver.		
H. W. Babcock <i>Sept 12</i>	4		3	9	7	17	5.8	4	1.5
G. M. Clemens <i>Aug 28</i>					2	8	2.0	1	2
A. Deuback <i>Jan 15</i>						9	9.0	1	9
F. Edmondson <i>Aug 12</i>	8	9				3	8.5	2	4.3
C. T. Elvey <i>Apr 29</i>	10	8				2	9.0	2	4.5
H. E. Ewen		10			6	8	8.0	3	2.7
W. A. Fowler <i>Aug 11</i>					4	6	4.0	1	4.0
L. Goldberg <i>2</i>	2	1	1	1	5	1	4.9	1.8	6
J. L. Greenstein <i>Oct 29</i>	3	3	5	3		4	3.2	3.6	5
F. Haddock <i>May 19</i>						5	5.0	1	5
J. E. Hagen <i>Jul 28</i>		6		7	3	3	4.7	4	1.2
J. S. Hall <i>Jun 28</i>	9		4			7	6.5	2	3.3
J. D. Kraus <i>Nov 10</i>		13				7	3	10.0	2
G. Kron <i>Apr 13</i>	11							11.0	1
R. Leighton <i>Sept 19</i>		12						12.0	1
N. U. Mayall <i>May 26</i>	7					3	7.0	1	7
A. N. Meinel <i>Nov 22</i>				6	9	5	7.5	2	3.8
R. Minkowski <i>May 25</i>			6	8	8	8	7.3	3	2.4
C. Seyfert <i>Feb 11</i>	13							13.0	1
A. Shapley <i>Mar 19</i>				5		5	5.0	1	5
G. Sherwin <i>Nov 16</i>		11						11.0	1
L. Spitzer <i>June 14</i>	5	7		4		14	5.3	3	1.8
C. Townes <i>Jul 15</i>		4				6	4.0	1	4
H. Weaver <i>Sept 17</i>	12	5				5	8.5	2	4.2
F. L. Whipple <i>Nov 26</i>	6					6	4	6.0	2
A. E. Whitford <i>Apr 25</i>	1	2	4	2	1	2	5.0	1.7	6

NRAO Director

- NRAO Directorship offered to
 - Leo Goldberg, “The only that counts in science is freedom by the individual to pursue any line of activity that he considers personally rewarding.”
 - Greenstein - “Green Bank too isolated.”
 - Whitford, Whipple, Townes, Babcock, Hagen, Haddock
- Lloyd Berkner appointed himself (acting) Director
- May 4, 1959 Otto Struve accepted NRAO Directorship

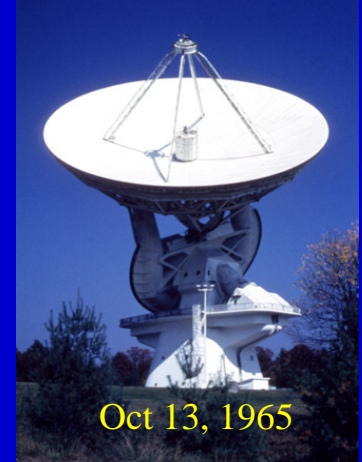
140-ft Saga



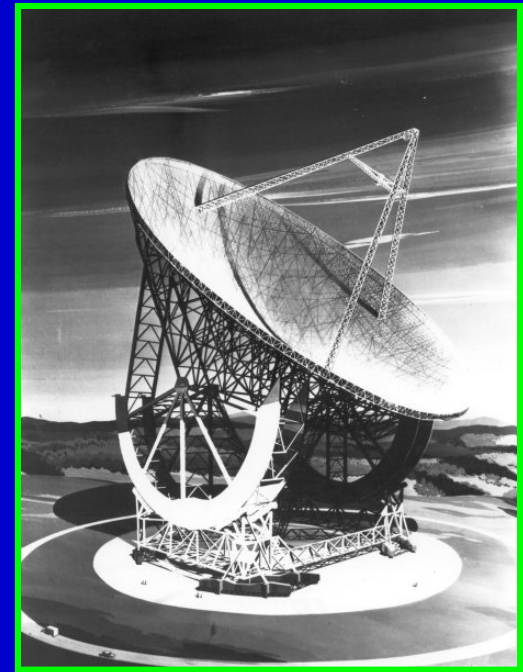
- Initial plans called for a “large radio telescope”
- Sizes of 28, 60, 120-150, 300 and 600 feet were considered
 - NSF (Tuve): start with “moderate size” telescope
 - NSF and AUI committees: alt-az vs, equatorial, 3 or 10cm.
- March, 1955 AUI Steering Committee decided first telescope ~ 150 ft.
 - Hagen: Feasibility study for 600 ft.
- July: AUI Steering Committee -- alt-az mounted 140-ft telescope to operate at 3 cm
- NSF (Tuve) Committee opted for equatorial “conceptual” design by Ned Ashton
 - Full HA required to observe the Sun any time it was up (Menzel)
- 1957, Oct: 9 bids received cost from \$4M to \$12M
 - E. W. Bliss Co. selected as contractor (\$4.75M); NSF did not have \$4.75M
 - Phase 1: \$145 K design
 - Phase 2: construction contingent on appropriation
- August, 1958 Groundbreaking. Begin operating in 1960
- AUI management by Committee in New York
 - Neither AUI nor NSF had experience in managing big contracts
 - Both AUI and NSF were far from Green Bank
 - Strikes at Contractor plant
 - Steel (A-373) too brittle and ended up as shielding at Brookhaven or buried in Green Bank
 - Claims and counterclaims
 - Contract changed from fixed price to cost plus
- 1959-60 Construction suspended
- November 1960 Struve resigns, but given vote of confidence by AUI
- Berkner resigns as AUI President

The Dark Years

- Jan 1961 NSF Review; NRAO threatened with closure
 - Bliss engineering staff inadequate
 - AUI administrative staff inadequate
 - poor communications
- October, 1961 Struve resigns again
 - “too much time in “non scientific meetings”
 - Wants to spend more time in research
- AUI offers Directorship to Joe Pawsey, Heeschen appointed Acting Director
- 1962, Dave Heeschen appointed Director
 - Management shifted to NRAO Director in Green Bank
- 1965, Feb. Construction “complete” at a cost of \$14 million
- 1965, May 1st observations
- 1965, Oct 13, Dedication of 140-ft telescope
 - Jodrell 250-ft, Parkes 210-ft, Haystack 120-ft already in operation
 - “Largest equatorial mounted radio telescope in WV”
- 140-ft had illustrious career primarily due to excellent instrumentation, wise management, and broadly based user community
 - But doubts about NRAO lasted for many years
- July 19, 1999 140-ft closed for astronomical observations due to lack of operating funds



The Big One



- Plans for a large fully steerable dish not forgotten
- NRAO established LFST group
 - Findlay
 - Von Hoerner - Homology concepts
 - $\text{Cost} \propto D^{2.7} f^{0.7}$
- Designs for
 - 600-ft antenna (20 cm)
 - 300-ft (1cm)
 - 64-m (3 mm)
 - 25-m (1 mm)
- ALMA
- 600-ft almost saw a life in secret Navy project at Sugar Grove , WV
 - 50 miles from Green Bank
 - Goal to detect ICBM Russian telemetry off the Moon (1/2 time for radio astronomy)
 - Hagan (and Berkner) aware all along of Sugar Grove project
 - \$78 Million spent before project was abandoned
 - Sugar Grove had a long lasting negative impact on radio astronomy

Broader impact

- NRAO and NSF learned to manage big projects
- Community suspicion of NRAO/big projects
- No equatorial radio telescope ever built again
- No large radio telescope built in US until GBT
 - 85-1 built → GBI → VLA
 - 300 ft built → GBT
- Open skies concept
- Transition to dependence on federal support
- Radio astronomers did not need to be instrumental experts
- Change from “experimenters” to “observers” to “data miners”
- Peer review of proposals, TACs and bandwagon effect for currently fashionable research
- Radio astronomy became part of astronomy

*Radio astronomy is a study of the heavens,
not
just glorified electronics.*

Merle Tuve, May 2, 1955

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- NRAO Archives (special thanks to Ellen Bouton)
 - Papers of John Krauss
 - Records of Harold (Doc) Ewen
 - Papers of Dave Heschen
 - Papers of Grote Reber
 - NRAO/AUI records, minutes, and correspondence
- Carnegie/DTM Archives
- Caltech Archives: Papers of Jesse Greenstein
- Hagen, J. *Washington Conference on Radio Astronomy*, JGR, 59, 149 (March 1954); *Science*, 119, 588 (April 1954)
- Needell, A. Lloyd Berkner, Merle Tuve & the Federal Role in Radio Astronomy, *OSIRIS*, 3 (1987)
- Needell, A. *The Carnegie Institution of Washington , Radio Astronomy: Prelude to an American National Observatory*, Jor. For the History of Astronomy, XXII, 1991
- England, A., *A Patron for Pure Science*, Chapter 14, *Bigger Science*, NSF, 1983

Comments from Miller

- Ruby Payne-Scott
- Watheroo-solar burst correlation; communications between Watheroo and RP (Pawsey's papers)
- Australia also threatened by Germany
- Bowen worked at RadLab under Dubridge and Rabi (AD) and he was invited to leave the UK (Lovell).
- Ike Bowen (Townes) (miller)
- Tuve (knew Lawrence as a child; see Brown book) hired Van allen to work on prox fuse (see van Allen biog) in socorro
- Wade also at RP/Stromlo
- Check on wells