



# Telescopes of the World

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24 September 2012

CSIRO ASTRONOMY & SPACE SCIENCE  
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Space for collaborator logos

[delete instructions before use]

# Overview

Mission Impossible...

Lots of pictures!

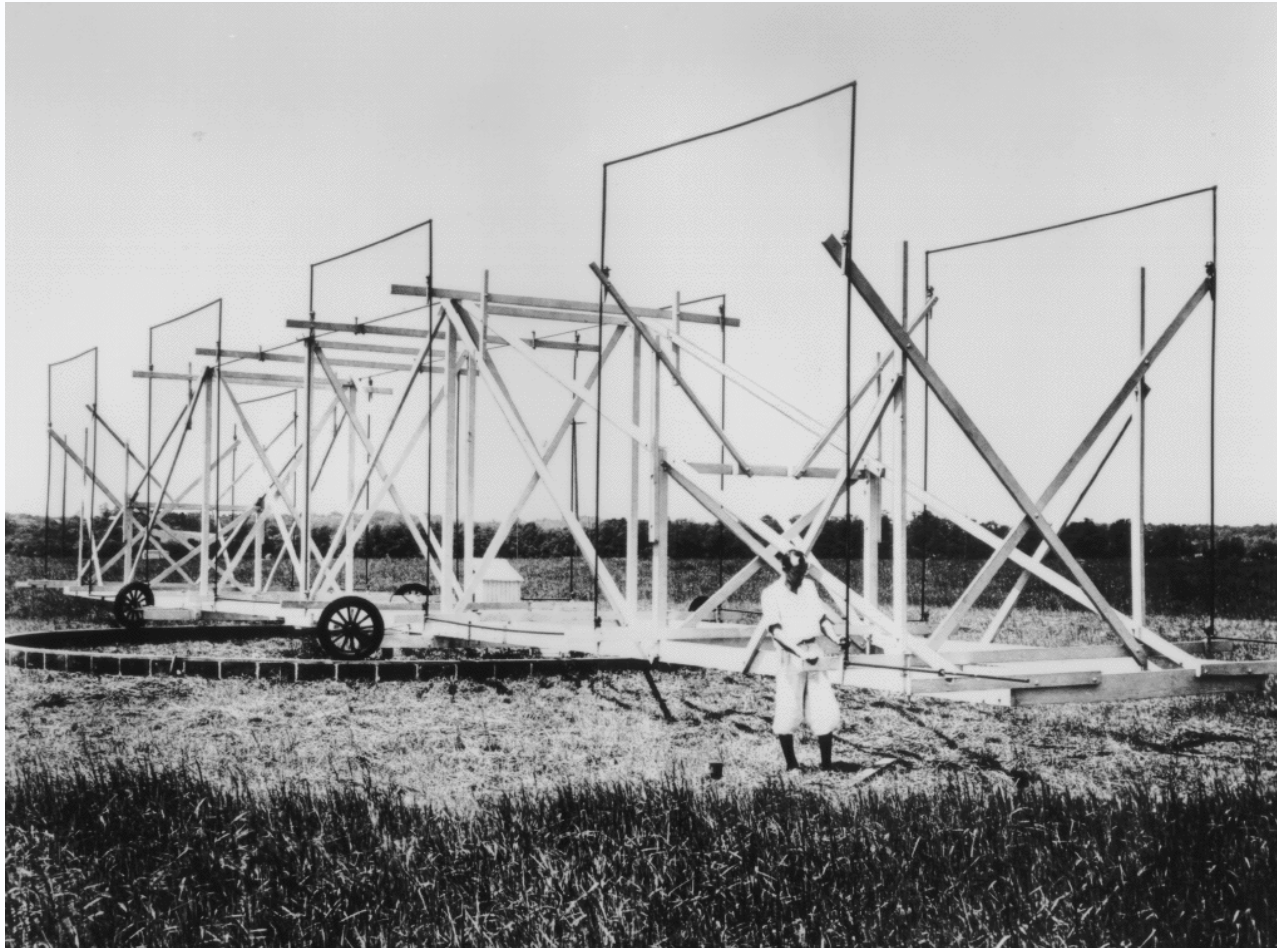
No equations!

Some history

Some telescopes that no longer exist

Some telescopes that don't yet exist

# Karl Jansky, 20MHz (14.6m), looking for RFI



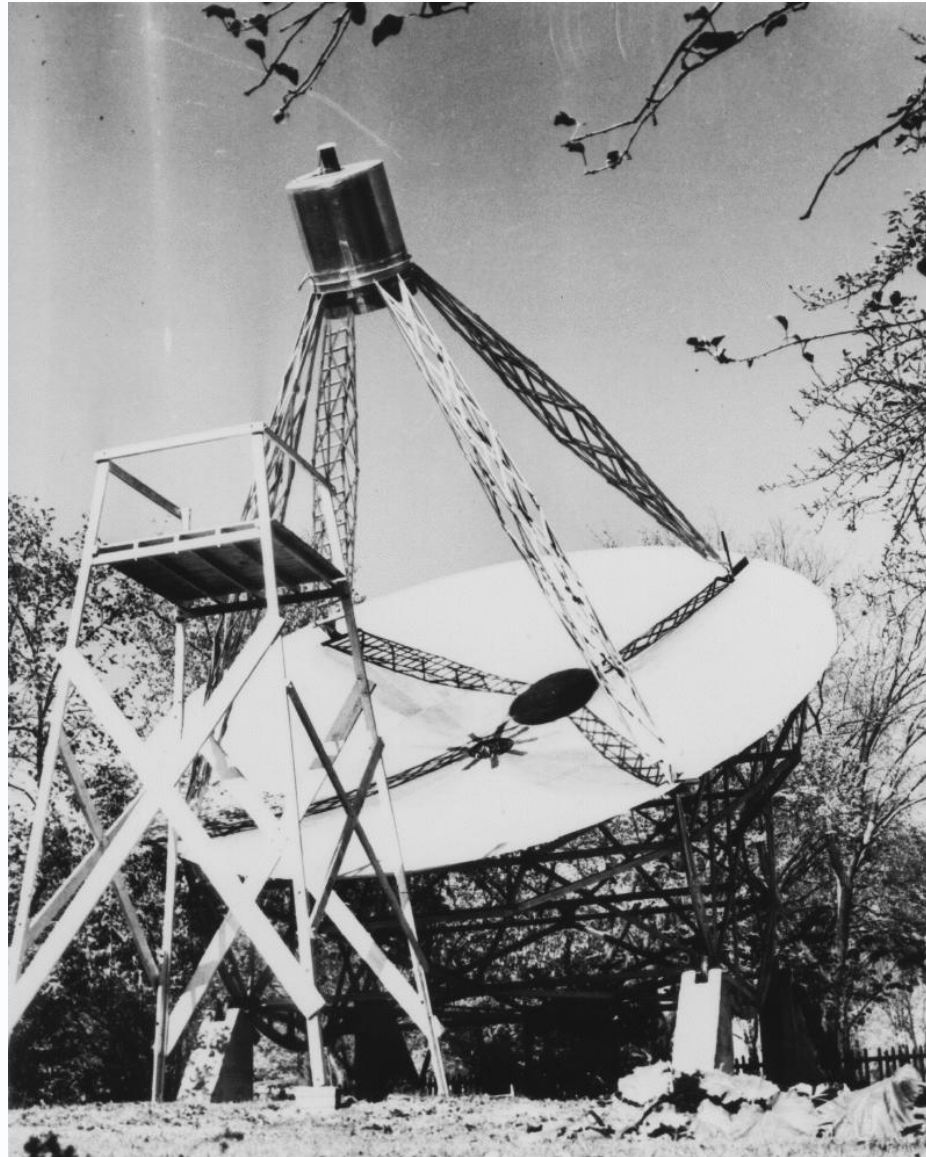
# Grote Reber

3000MHz

900MHz

160MHz

A transit  
telescope



# Reber's telescope today



# Reber later worked for the NBS



# Reber's SKA, operated at 2 MHz



# Dover Heights (1946-1954)

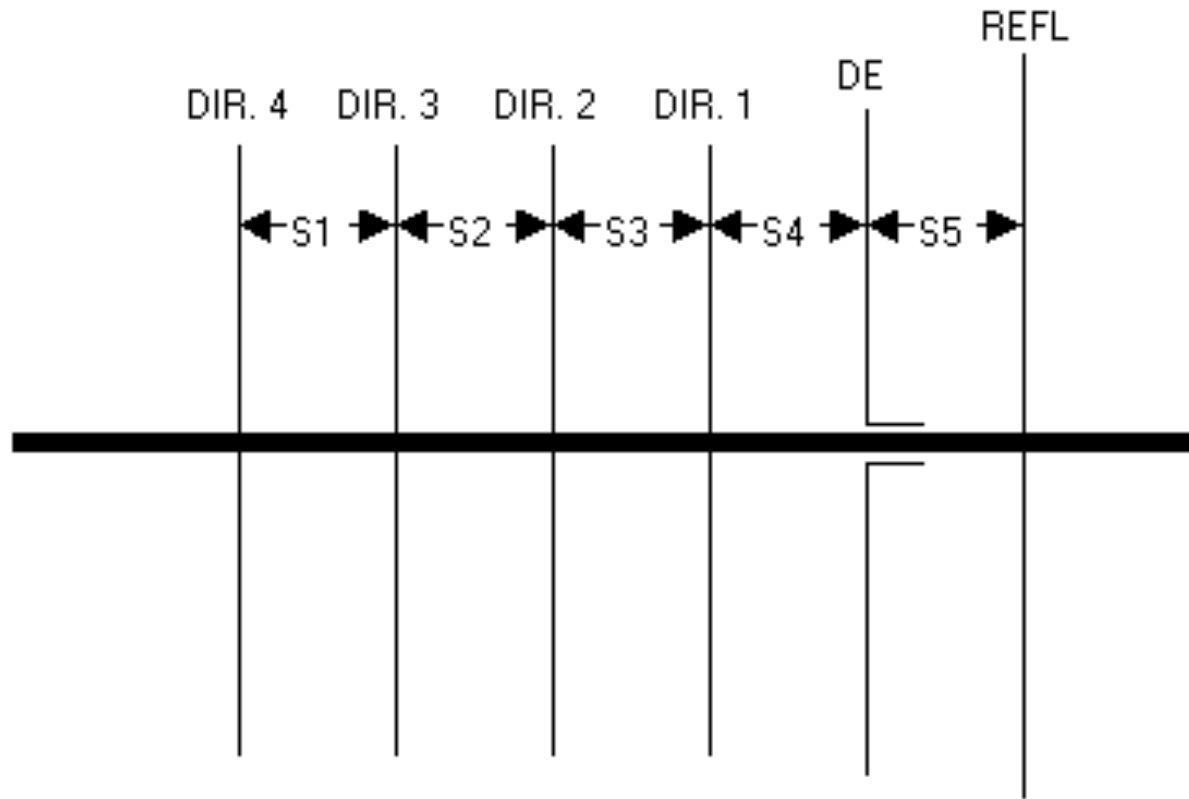


# Yagi antenna



The Yagi Antenna is a directional antenna invented by Dr. Hidetsugu Yagi of Tohoku Imperial University and his assistant, Dr. Shintaro Uta (or Uda). This groundbreaking invention combined a simple structure with high performance. Most ultra short or extremely short wave receiving antennas, such as TV antennas, use this structure. Dr. Yagi's invention was ahead of its time (patented in 1926) and therefore not understood in Japan. Its value was, however, accepted in Europe and North America, where it entered commercial production.

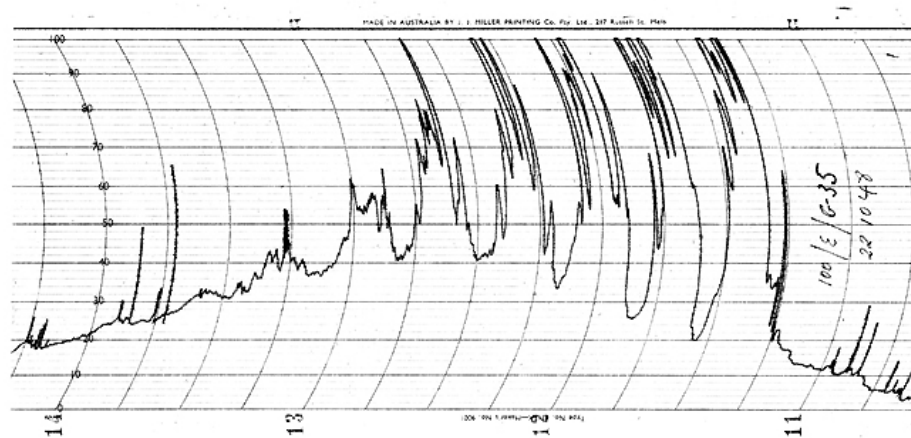
# Yagi antenna



# Log periodic antenna



# Dover Heights



The sea interferometer chart recording of the strong extragalactic radio source, Cygnus A. This was observed at Dover Heights on 22 October 1948 using a four-element Yagi antenna operating at 200 MHz. From the interference fringes it was possible to calculate that the angular size of Cygnus A was less than eight arcminutes. Cygnus A was the first compact extragalactic radio source to be detected at Dover Heights. The observations had a huge impact on radio astronomy. The interference fringes from Cyg A seen here show unusual intensity fluctuations.



# Lovell Telescope 250-ft (76m), from 1957



# Lovell Telescope







# Mk II



In 1964 the second large fully steerable radio telescope was built at Jodrell Bank on the site of the 218ft Transit Telescope. The parabolic reflecting surface had an elliptical outline to increase the collecting area over a circular aperture. It is approximately 25m in diameter. It was the first telescope of any type in the world to be controlled by a digital computer, the Ferranti Argus 100. This was one of the very first computers designed for real time control and built using germanium transistor logic and a ferrite core store. The storage capacity was initially 12 kilobytes! Highly optimised code was used to carry out the co-ordinate transformations required in the control software. In 1971 the Argus 100 was upgraded to an Argus 400 computer which was also capable of carrying out the data acquisition tasks for the telescope's observing. In 1987 new aluminium panels were mounted on the original steel surface.





© J. Sarkissian, CSIRO

THE FIRST STEP ON THE MOON  
NEARLY STUMBLED ON EARTH.

# the Dish

BASED ON A TRUE STORY



WORKING DOGS PRESENTS IN ASSOCIATION WITH DUSTY HORIZON  
"THE DISH" SAM NEILL KEVIN HARRINGTON TOM LONG PATRICK VAUGHAN GENEVIEVE MADY TAYLER KANE WITH BILLY BROUVN OF PRIME TIME LIVE AND ROY BULLING  
ANDREW S. GILBERT LENKA KRIPAC MATTHEW PARSONS ELIZA SZONERT AND JOHN McANULTIN AS DR. AMERASANTO INTRODUCING CARL SNELL AS BOB  
DIRECTED BY EDUARDO CHOI COSTUME DESIGNER JANE KENNEDY EXECUTIVE PRODUCERS PETER HICKS PRODUCED BY KATY STUCKEY EXECUTIVE PRODUCERS BEN MORISON PRODUCED BY CAROL KENNEDY EDITOR GRAHAM WOOD EXECUTIVE PRODUCERS JILL BRIDGEMAN PRODUCED BY DEBRA CHADTE  
PRODUCED BY MICHAEL HIRSH WRITER AND DIRECTOR ANTO CALABRO TOM GLEISNER JANE KENNEDY AND ROB STICH DIRECTOR OF PHOTOGRAPHY ROB STICH

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NOW AVAILABLE ON VIDEOCASSETTE AND DVD VIDEO

**"AN INSPIRED HUMAN COMEDY"**

Byge Elzer-CHICAGO SUN-TIMES

As Neil Armstrong set foot on the moon, our only link  
was a satellite dish in rural Australia with a few bugs

(And a few hundred sheep)

# the Dish

Based on the true story of what we didn't see.

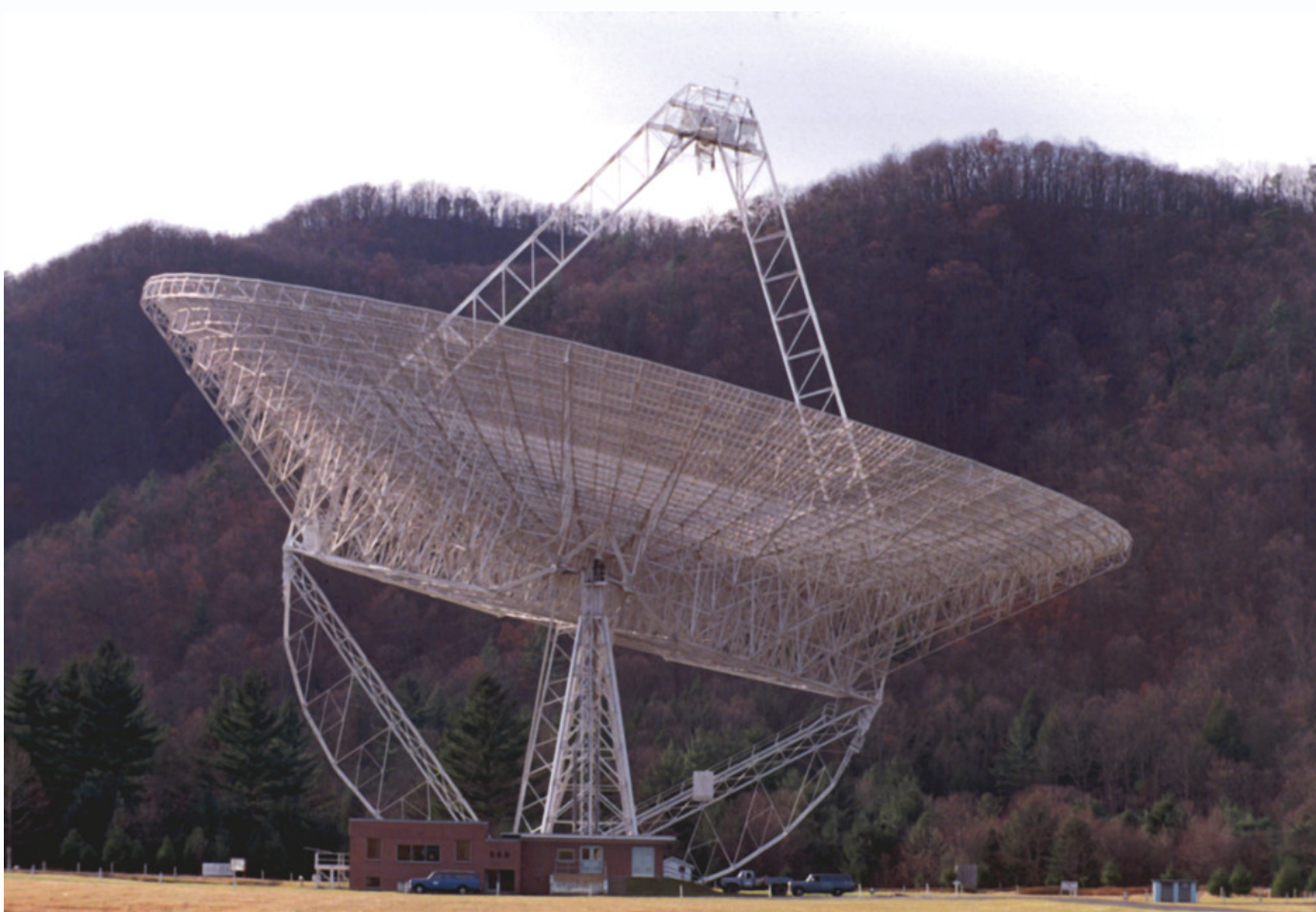


WORKING DOG PRESENTS IN ASSOCIATION WITH DISTANT HORIZON  
"THE DISH" SAM NEILL KEVIN MCGONAGHAN TOM LANS PATRICK HARRINGTON GENYERIE MOORE TAPLER BAILE with COLLE BROWN as THE PRIME MINISTER AND RUBY HOLLING  
ANDREW S GALEBERT KENYA KRIPAC MATTHEW MOORE ELIZA SCORERT and JOHN MAMMATTIN as US AMBASSADOR BROTHROCK CARL SNELL as BOB  
WHIRREPEALING CARL and JANE KENNEDY with YERKEL INKES SUE KITTY STUCKEY with BEN MORNESON with CARRIE KENNEDY with GRAEME WOOD with JILL VOLCKMANN with DEBRA CHASE  
Produced by MICHAEL FIRSH Screenplay by SANTI OLALDO TOM GLEESNER JANE KENNEDY ROB SITCH Music by ROB SITCH  
www.thedishmovie.net AOL Keyword: The Dish





# Green Bank 300-ft (90m), built 1962



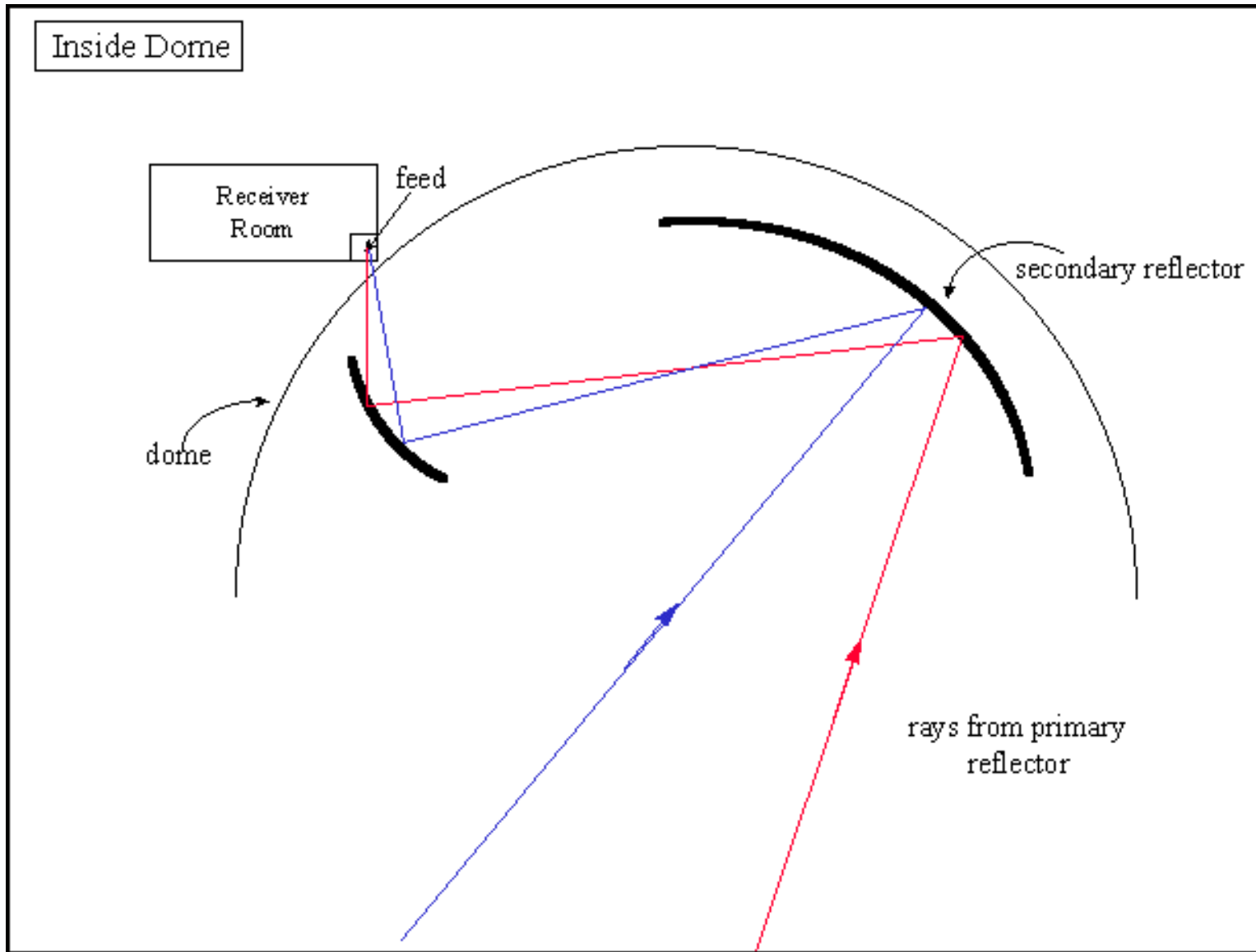


# Arecibo Observatory, built 1960-1963 (NAIC)

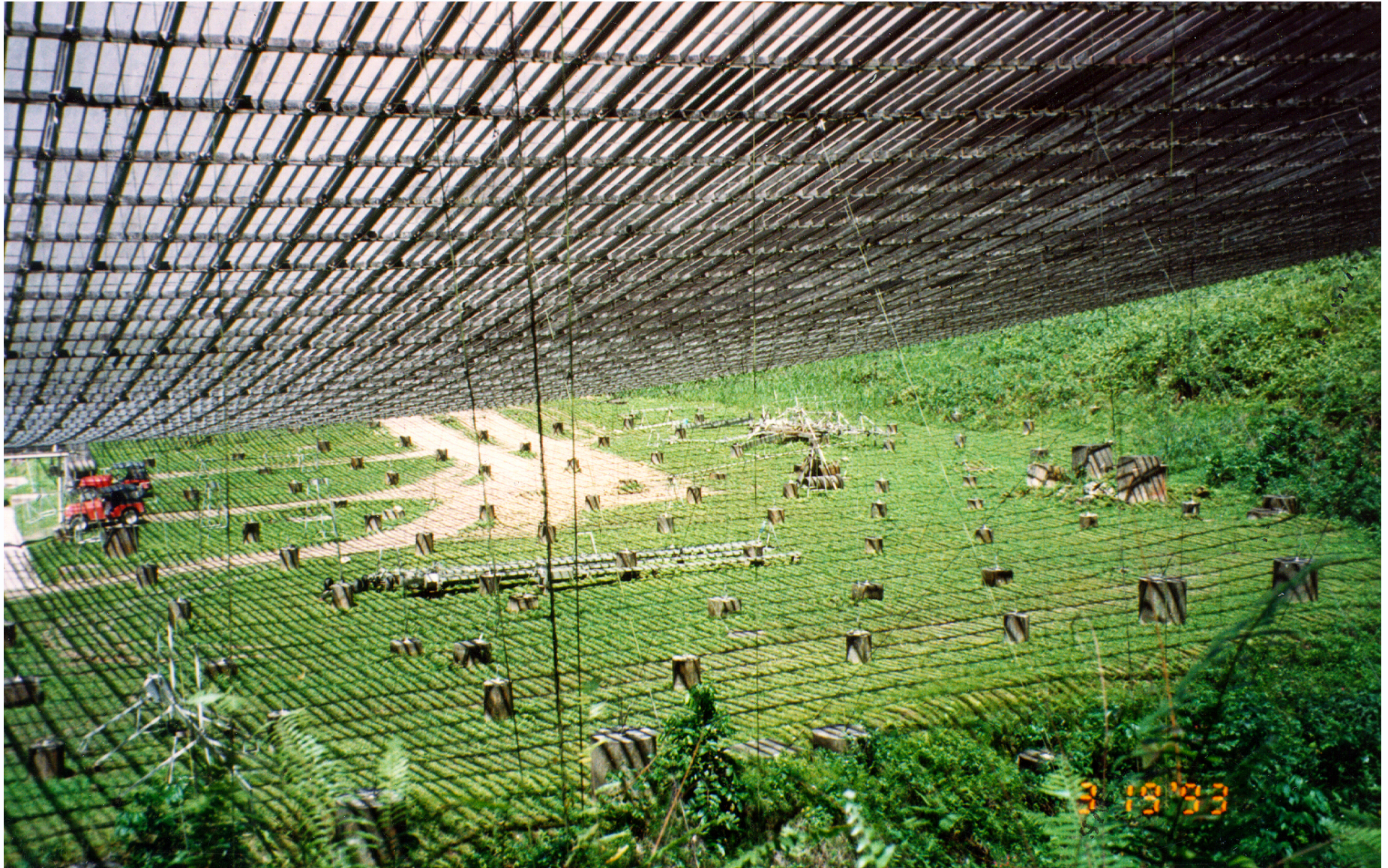














# A BIG EYE ON THE SKY

500-meter aperture spherical radio telescope (FAST)

Surveys neutral hydrogen in the Milky way and other galaxies

Detects new galactic and extragalactic pulsars

Finds and researches the first shining stars

Finds out where extraterrestrial life might exist in space

Detects dark energy and helps us understand the evolution of galaxies

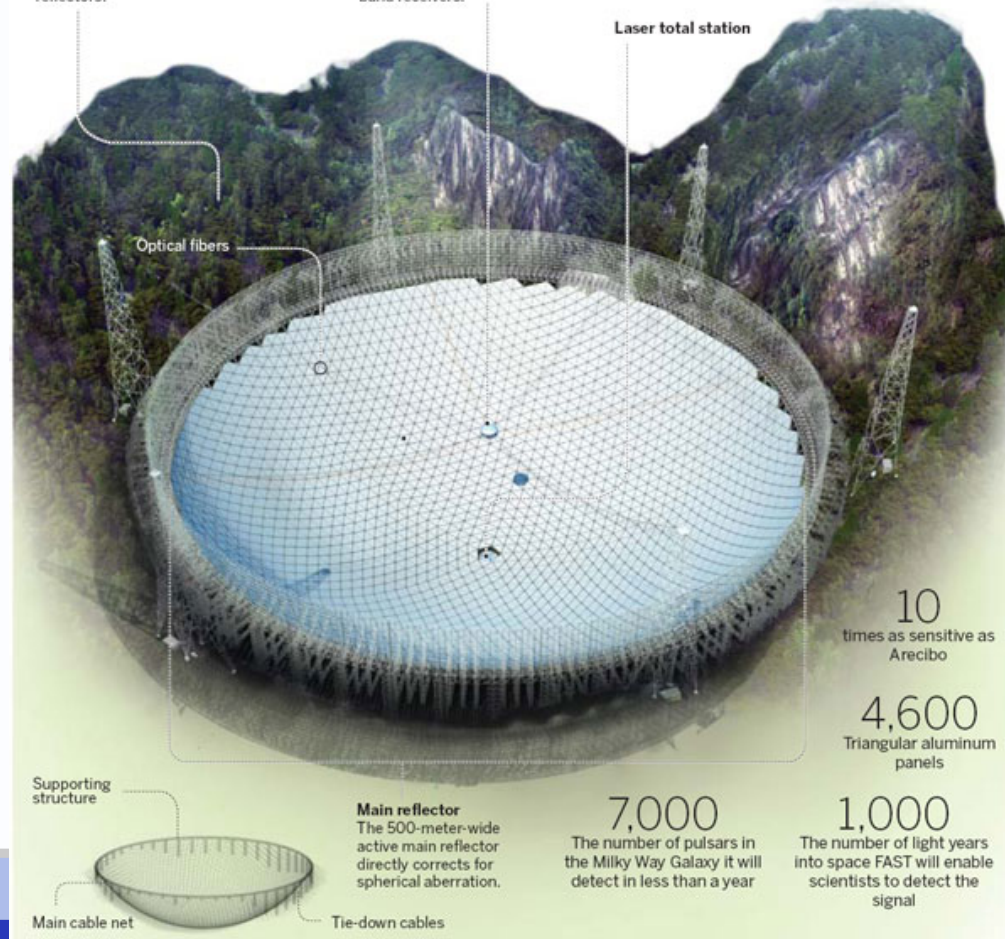
## Karst valley depression

A natural limestone depression in southern Guizhou province creates a cradle for the telescope's main reflectors.

## Receiver Cabin

A lightweight focus cabin is powered by cables and operated by a robot. The cabin contains multiple-beam and multiple-band receivers.

## Laser total station



10  
times as sensitive as  
Arecibo

4,600  
Triangular aluminum  
panels

7,000  
The number of pulsars in  
the Milky Way Galaxy it will  
detect in less than a year

1,000  
The number of light years  
into space FAST will enable  
scientists to detect the  
signal

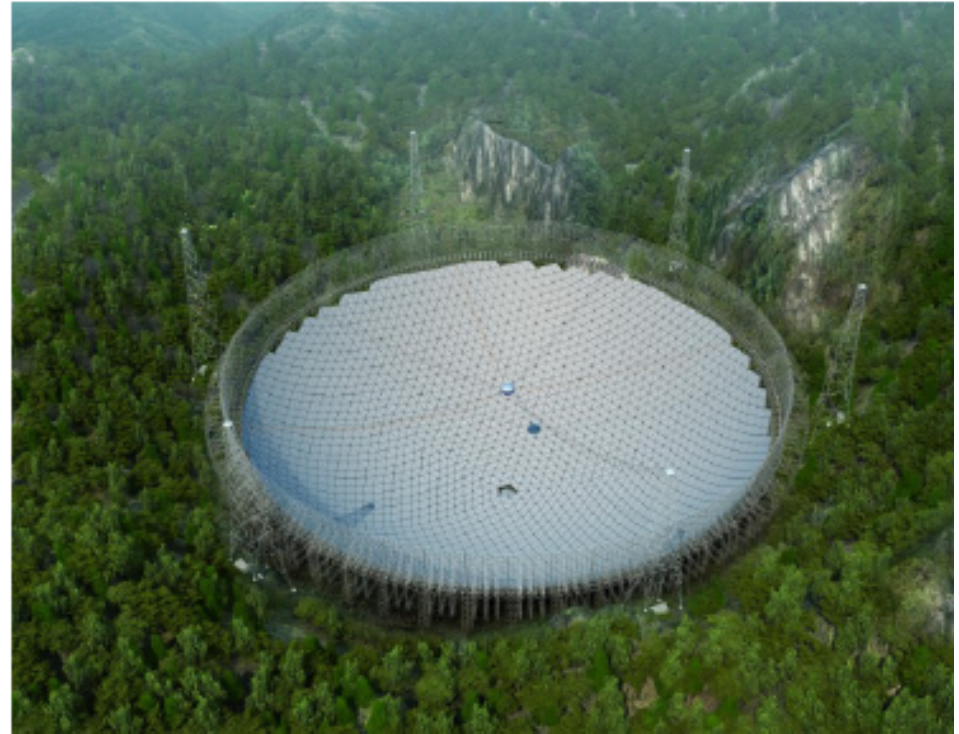
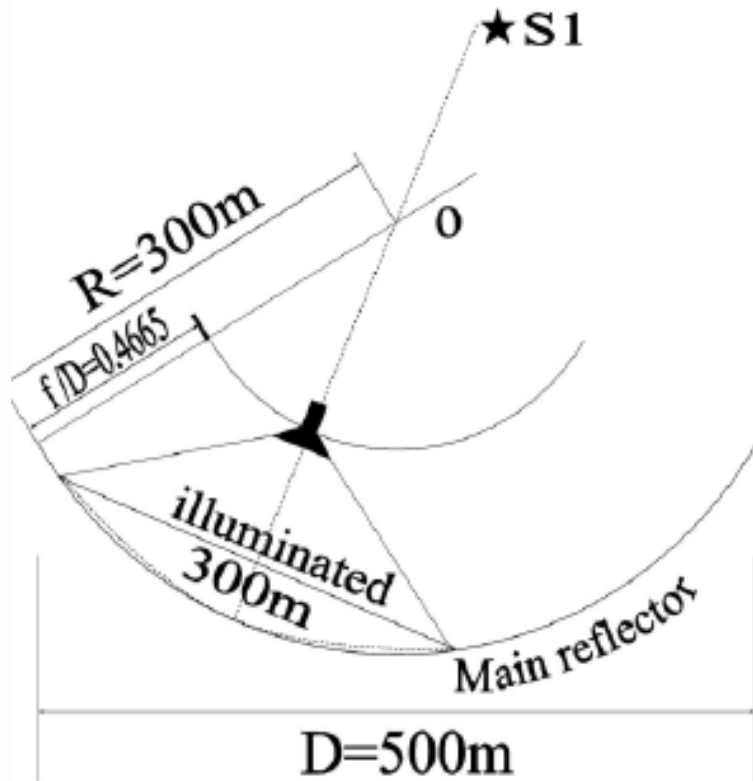


Figure 1: Left: FAST optical geometry, right: FAST 3-D model

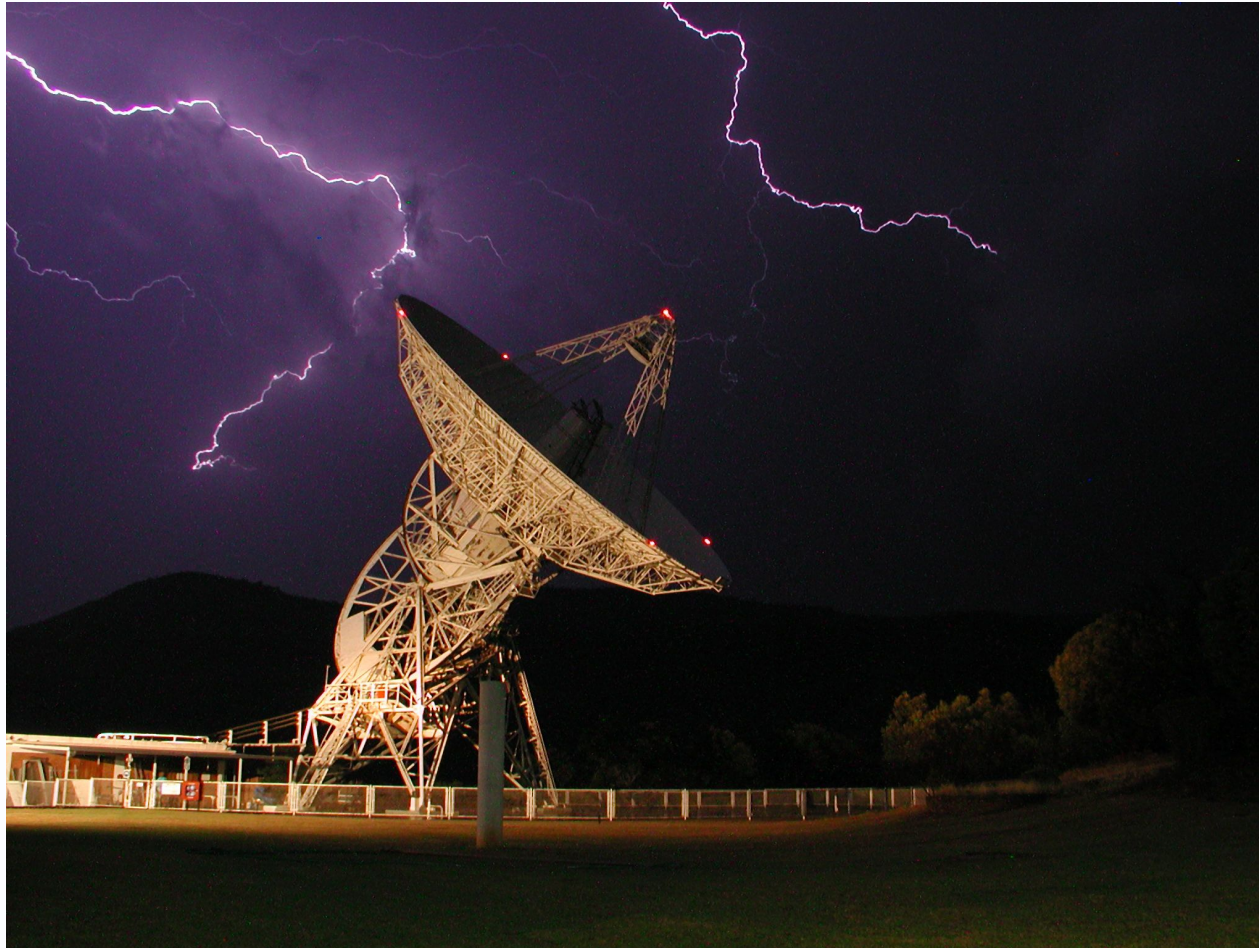
# Green Bank 140-ft, 1965 --







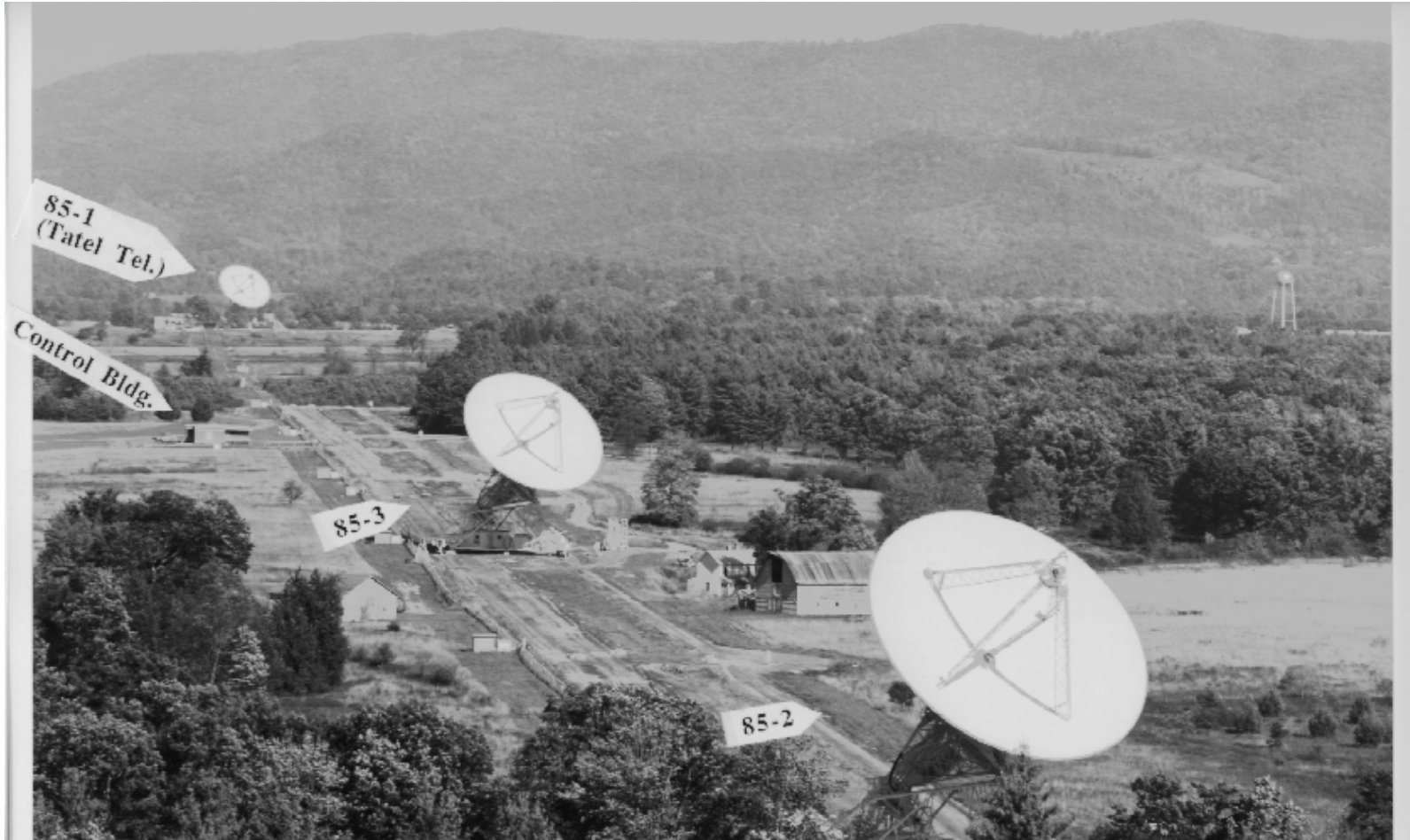
# Hartebeesthoek 26m (1961 – 1975 – now)



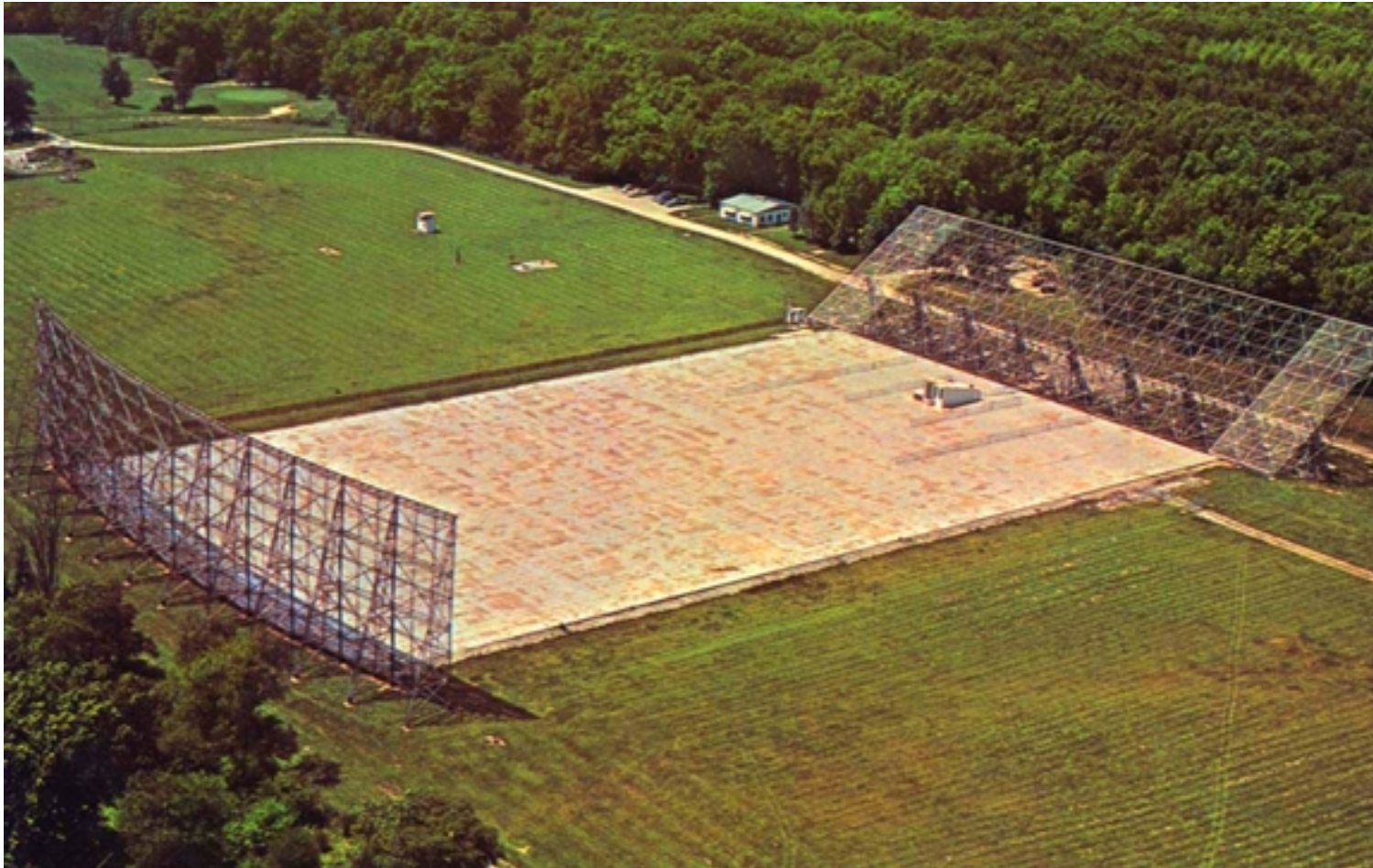
# Hobart 26m (1965—1985 Orroral Valley)



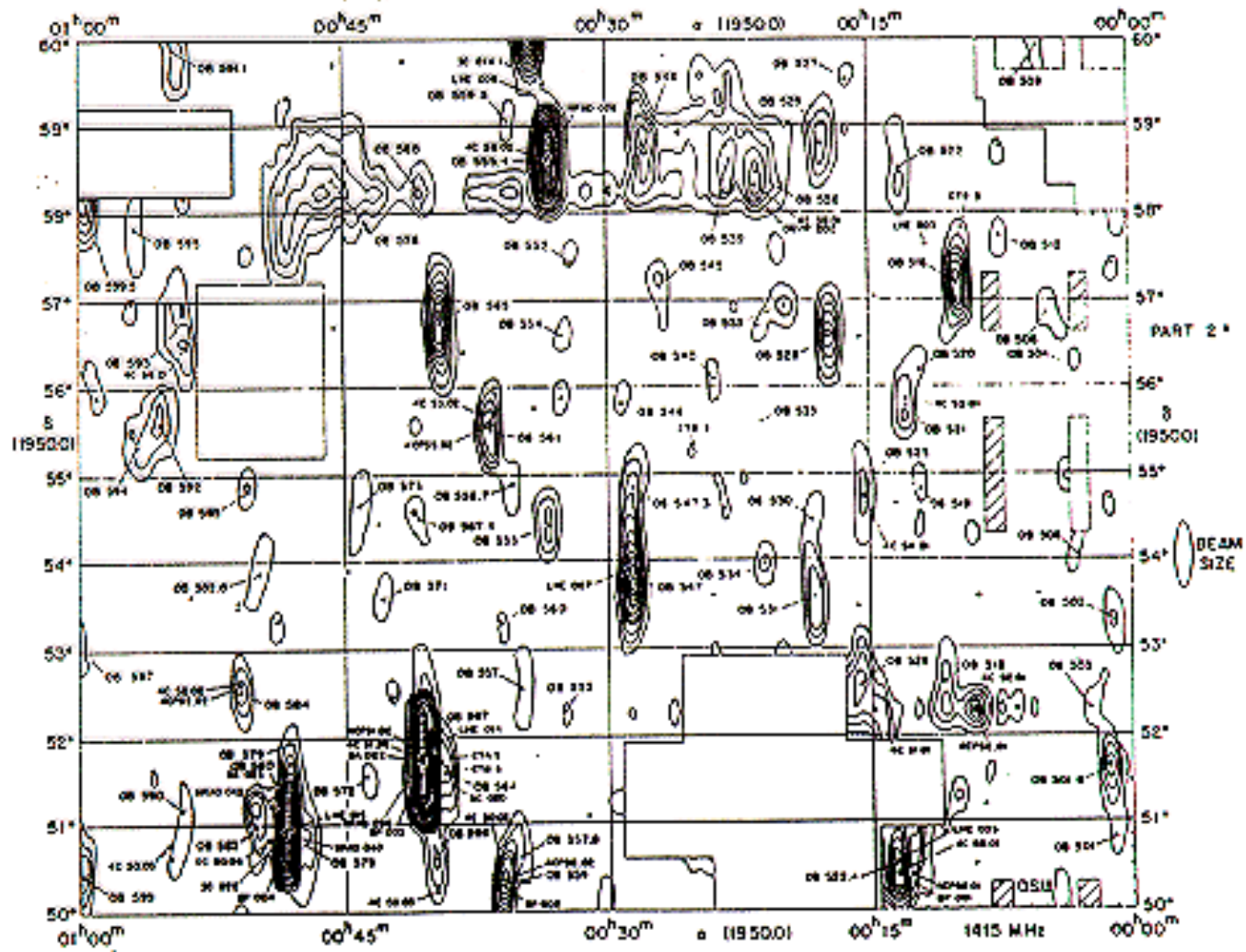
# GBI



# Ohio “Big Ear” 1963-1998



# 1971 Sky Survey



Sources discovered in the course of the survey were assigned names according to a coordinate numbering system consisting of a two-letter prefix followed by three digits. The first letter, O, stood for Ohio, and the second letter, B-Z inclusive (omitting O) indicated the source right ascension in hours (0-23 inclusive). The first digit indicated the declination zone in increments of  $10^\circ$ , while the last two digits give the right ascension to the nearest one-hundredth of an hour.

Wow!

		21	1					121	
1			2				1	4	
1	16		1			1			1
1	11		1		1				11
								3	1
			2					31	
1	24		3		12		1	21	1
1	11		1	6	1	2		1	
1	1		1					3	1
2	31		3	11	1			1	1
1	1							1	
	14		1		113			1	2
1	3		1		1			1	
1	4				1			1	11
	4		1	1	1	11			111
	1					1			2
	1		1					11	1



# WSRT





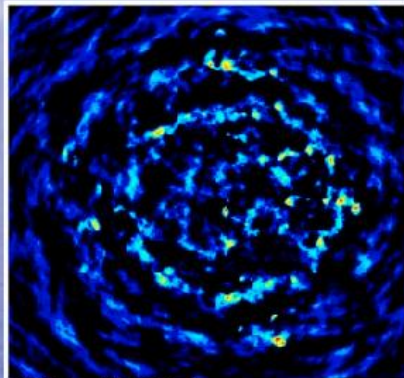
# A real-life example from the VLA



Courtesy Michael Rupen

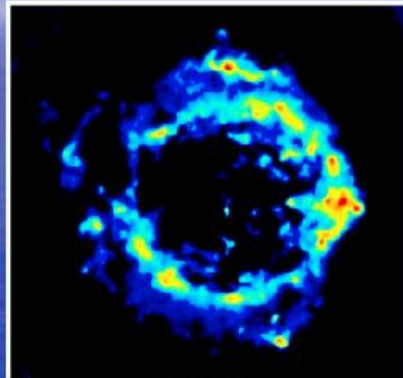
# Cas A: four VLA configurations

A  
0.3''



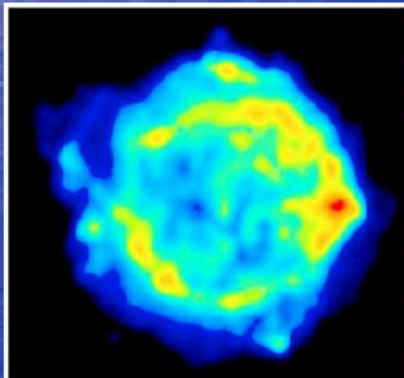
AIPS User 213 CASA: A

B  
1.3''



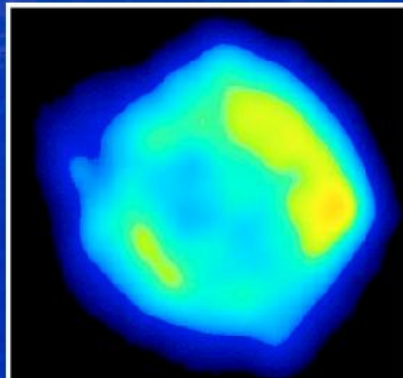
AIPS User 213 CAS A: B CLN

C  
4''



AIPS User 213 CAS A: C CLN

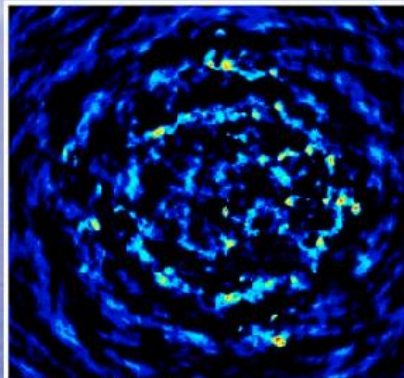
D  
15''



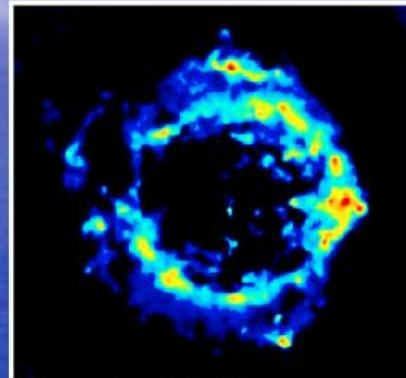
AIPS User 213 CAS A: D CLN

# Cas A: four VLA configurations

A  
0.3''

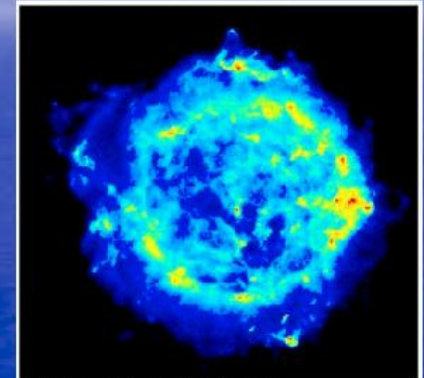


AIPS User 213 CASA: A



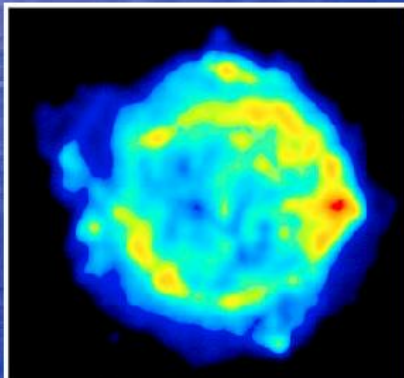
AIPS User 213 CAS A: B CLN

B  
1.3''

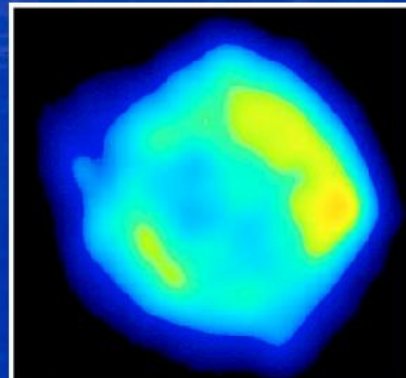


AIPS User 213 CASA: A+B+C+D

C  
4''



AIPS User 213 CAS A: C CLN



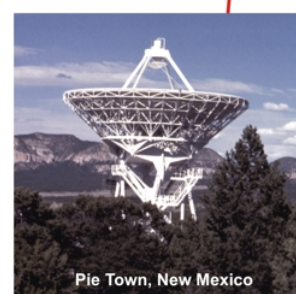
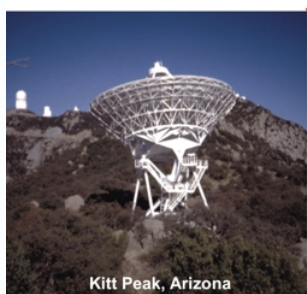
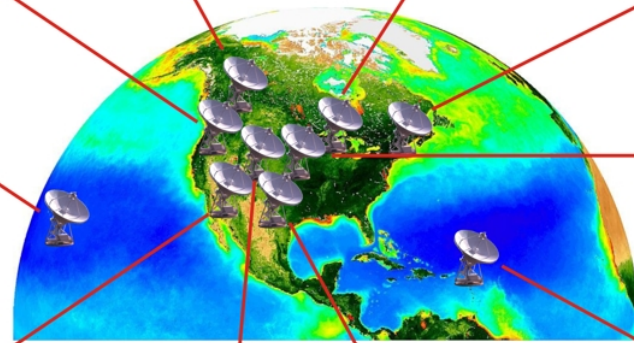
AIPS User 213 CAS A: D CLN

D  
15''

A+ B+ C+ D  
0.3'' +  
total flux



# VLBA



# GMRT

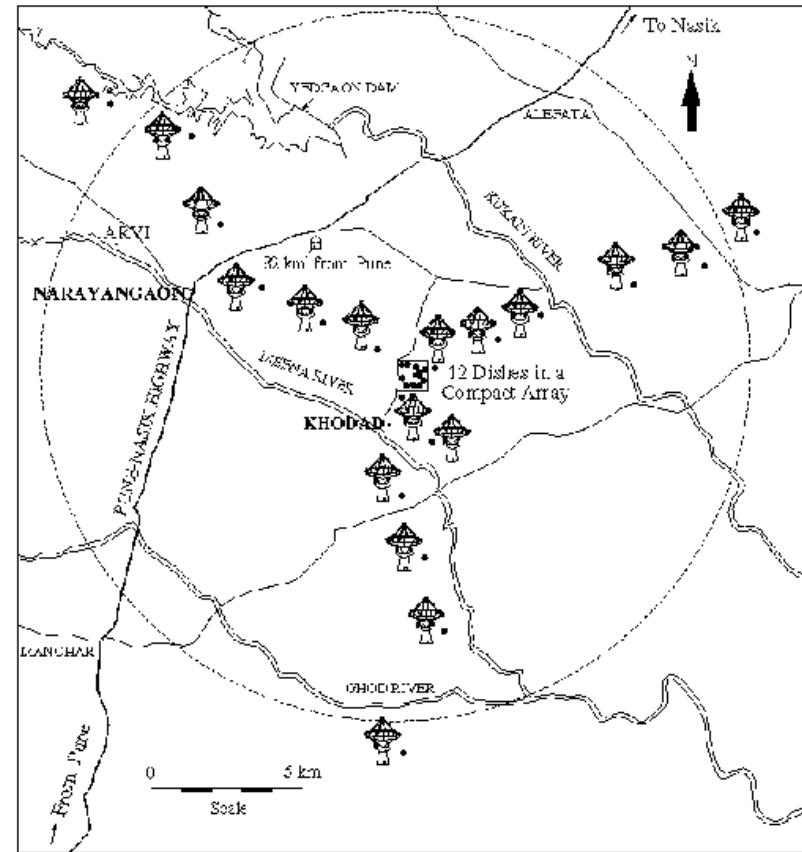


# GMRT

30x45m

38MHz-1.4GHz

LOCATIONS OF GMRT ANTENNAS ( 30 dishes )



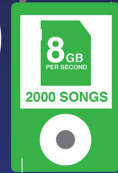


# MWA

## IBM powering the Murchison Widefield Array (MWA).



The IBM Cluster is expected to process the data at a speed of **8 gigabytes per second**, the equivalent to over **2,000 digital songs per second** allowing scientists to study more of the sky faster than ever before, and with greater detail.

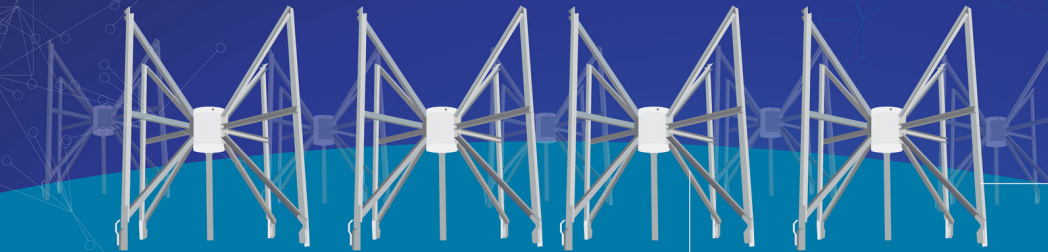


**50**  
TERABYTES  
PER DAY

The cluster is expected to process approximately **50 terabytes** of data per day at full data rate.



The research will help scientists study the early stages in the evolution of the universe some **13 billion years ago**.



MWA is the result of an international collaboration between **13 institutions** from **Australia, New Zealand, the US and India**.



MWA is a new radio telescope designed to capture low frequency radio waves from deep space as well as the volatile atmospheric conditions of the Sun. The signals will be captured by the telescope's **1,198 dipole antennas** positioned in **Western Australia near Svalbard Station** and processed by the IBM technology.

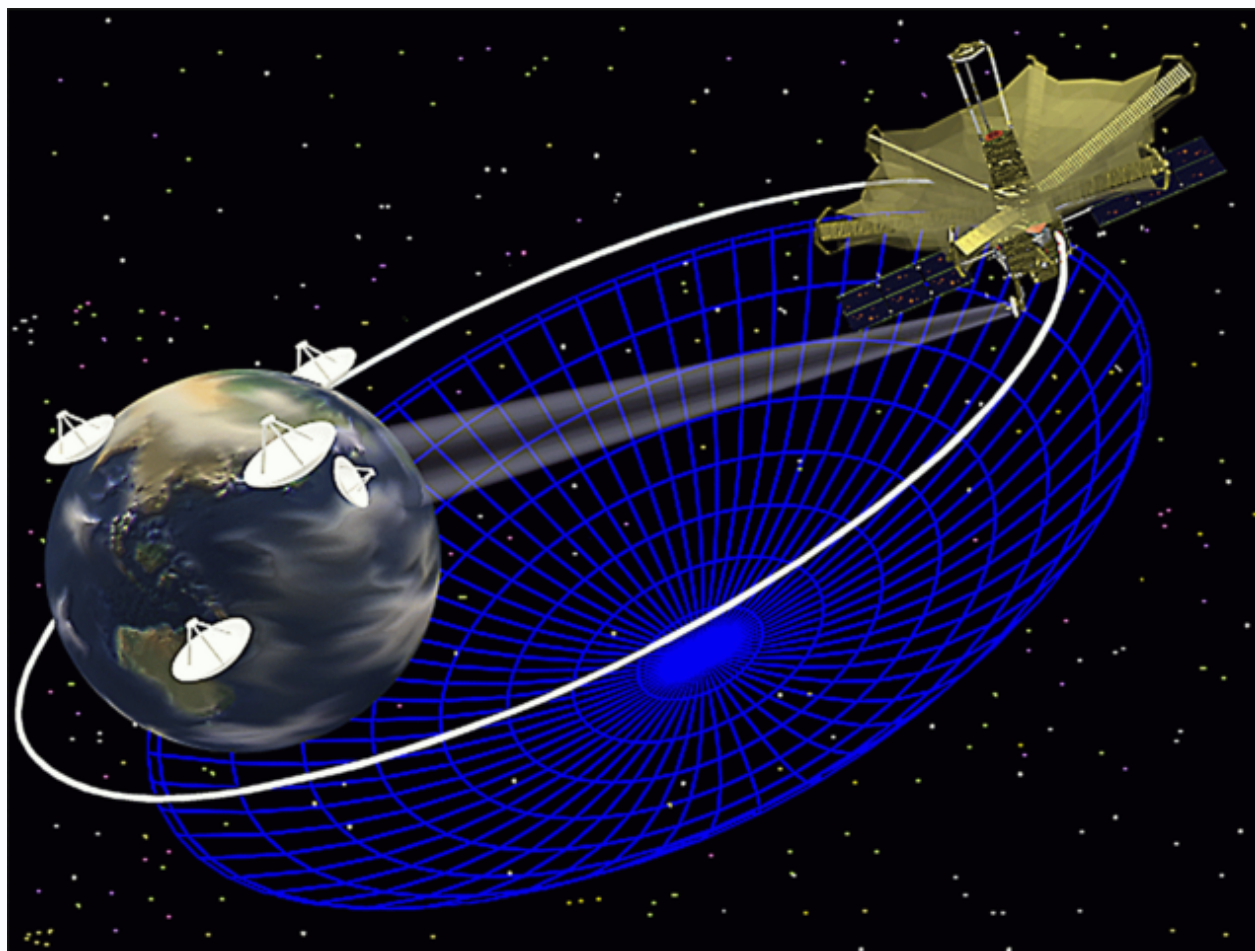


Visit MWA Facebook at: [www.facebook.com/Murchison.Widefield.Array](http://www.facebook.com/Murchison.Widefield.Array)

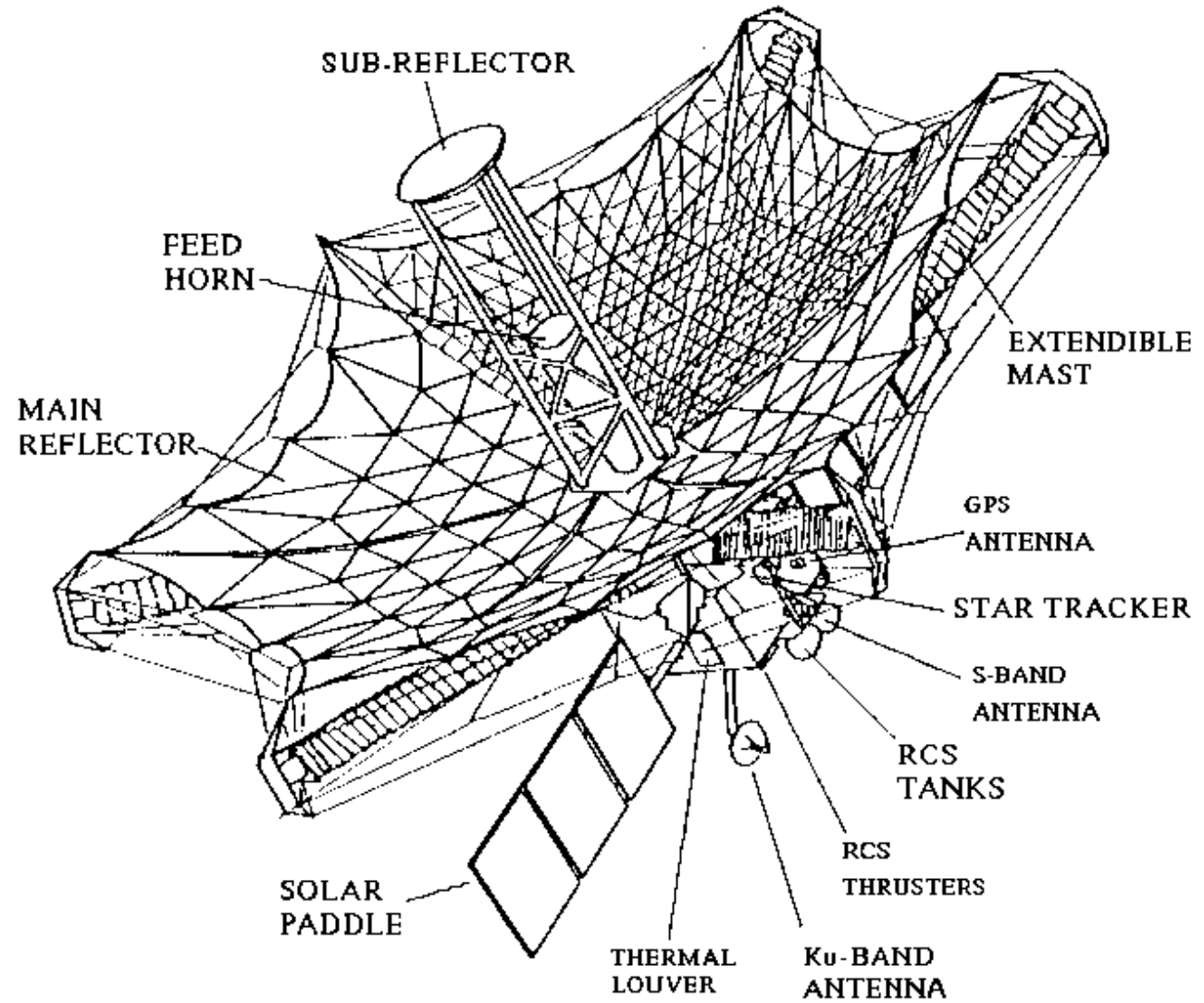




# VSOP, 1997-2003



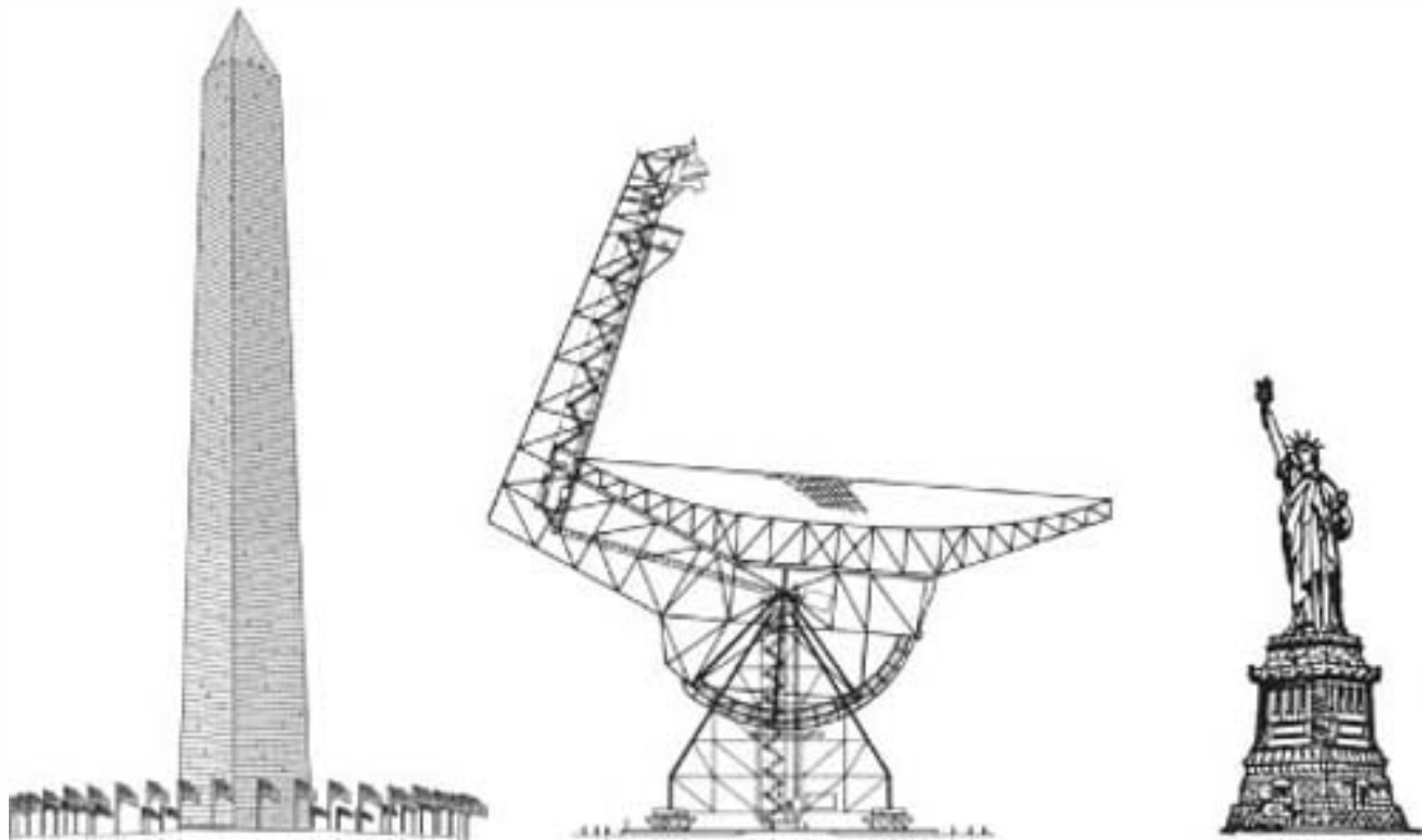
# HALCA

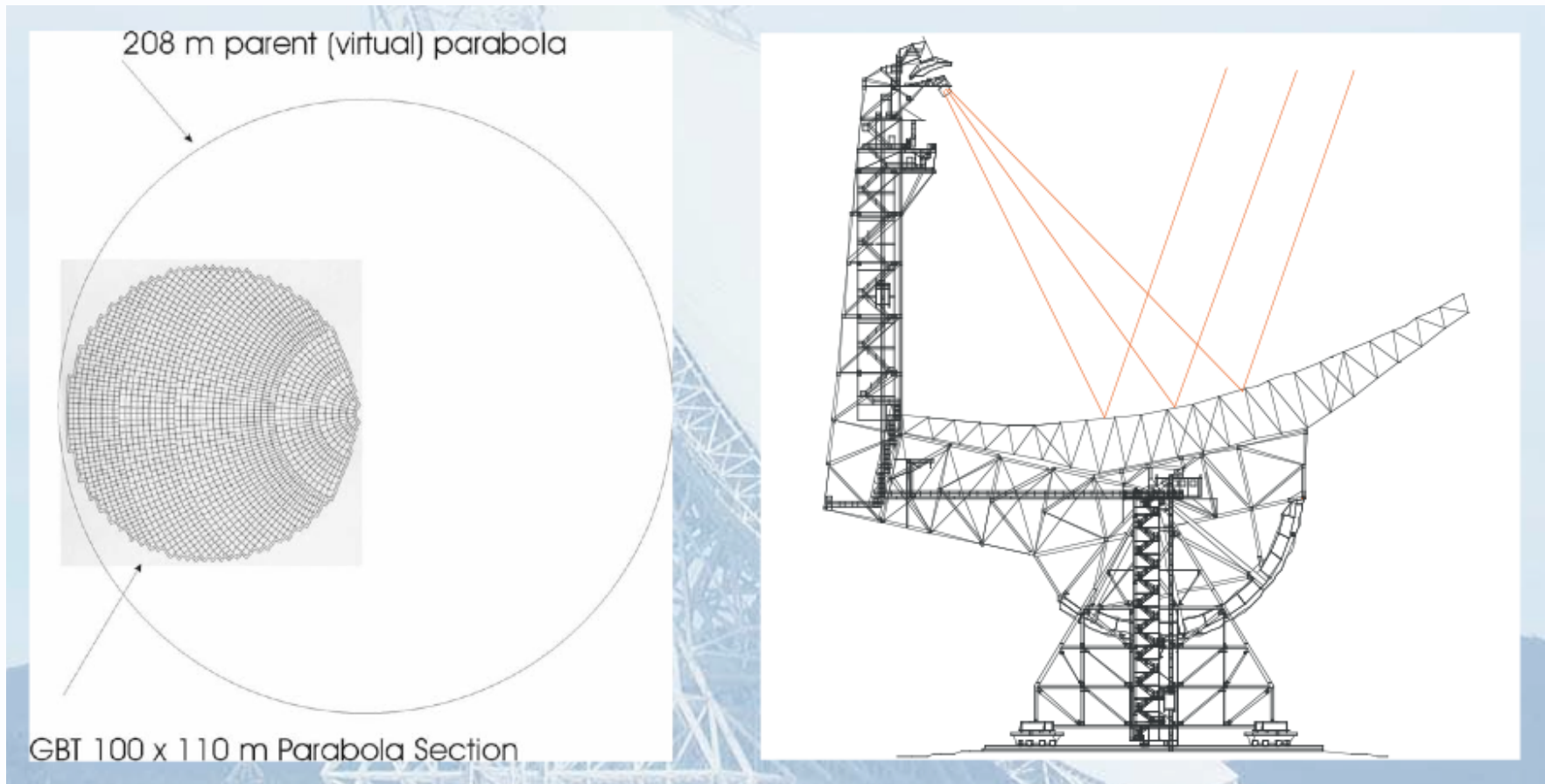


# GBT

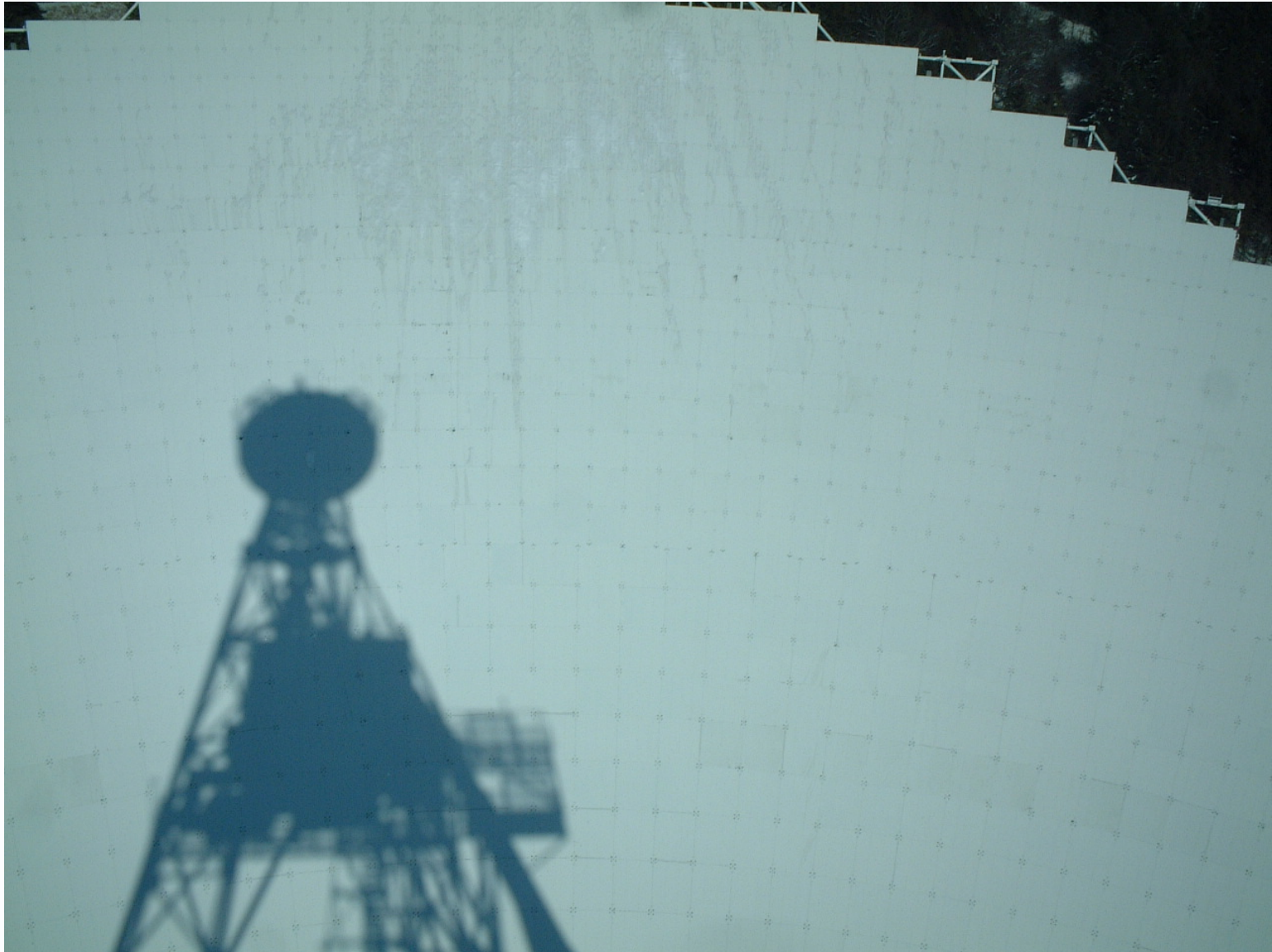




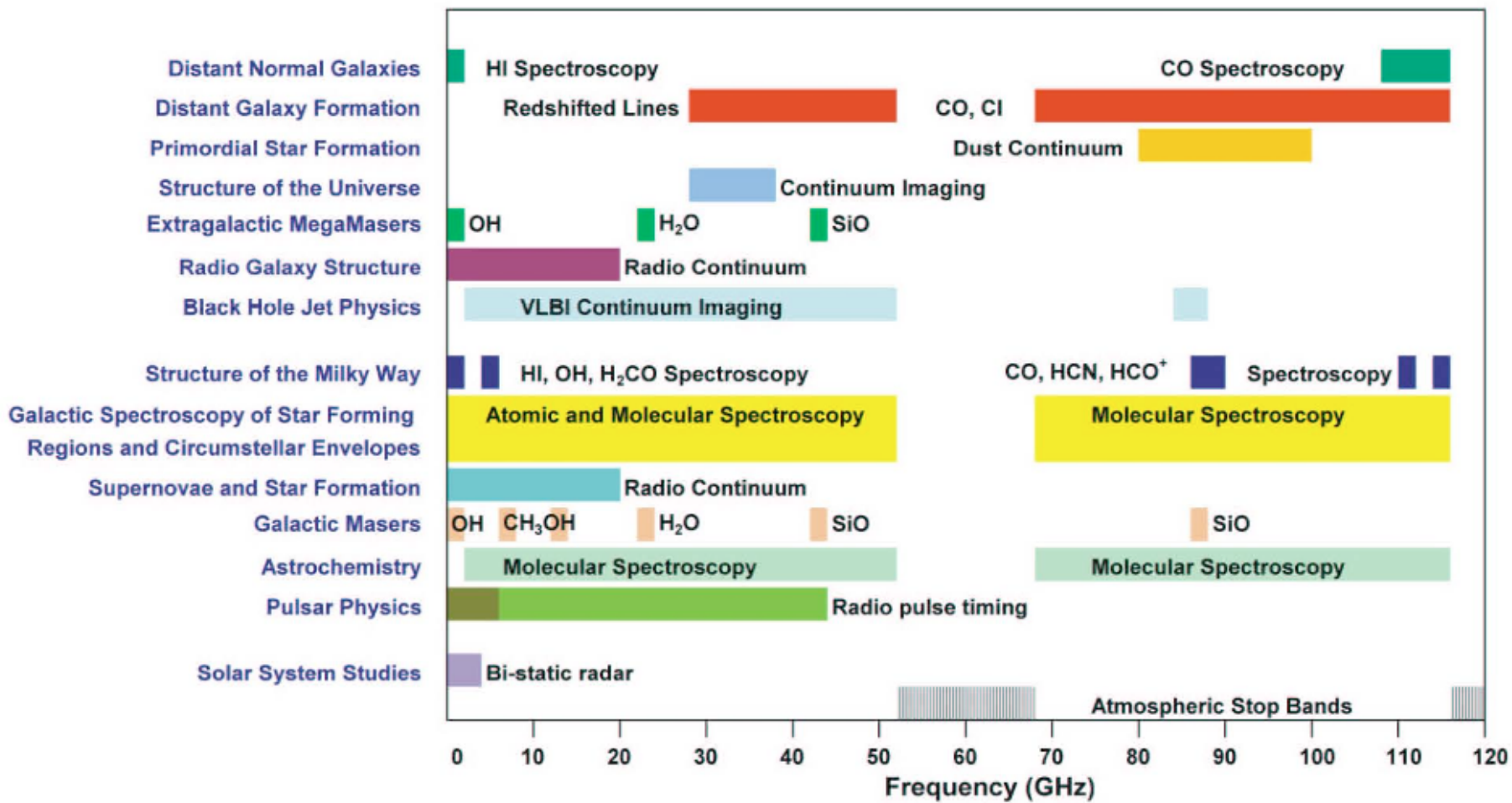




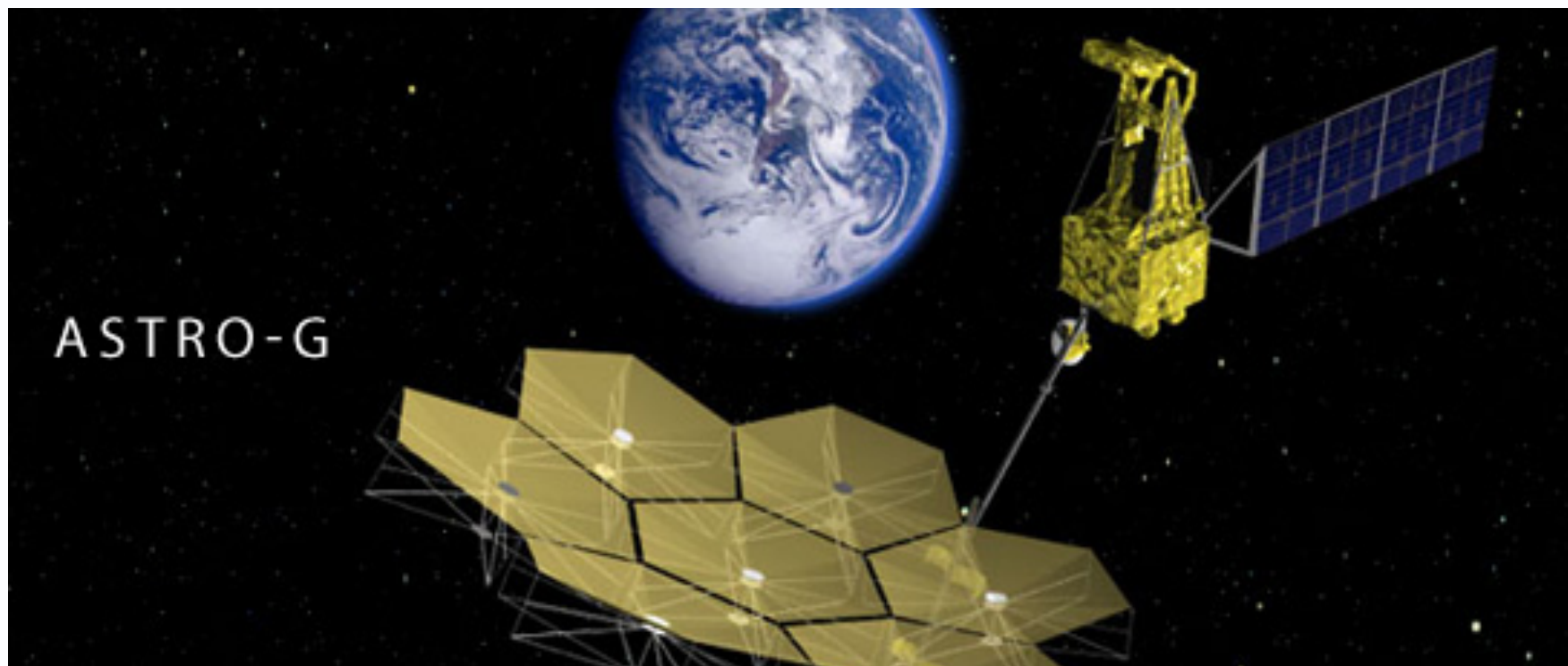


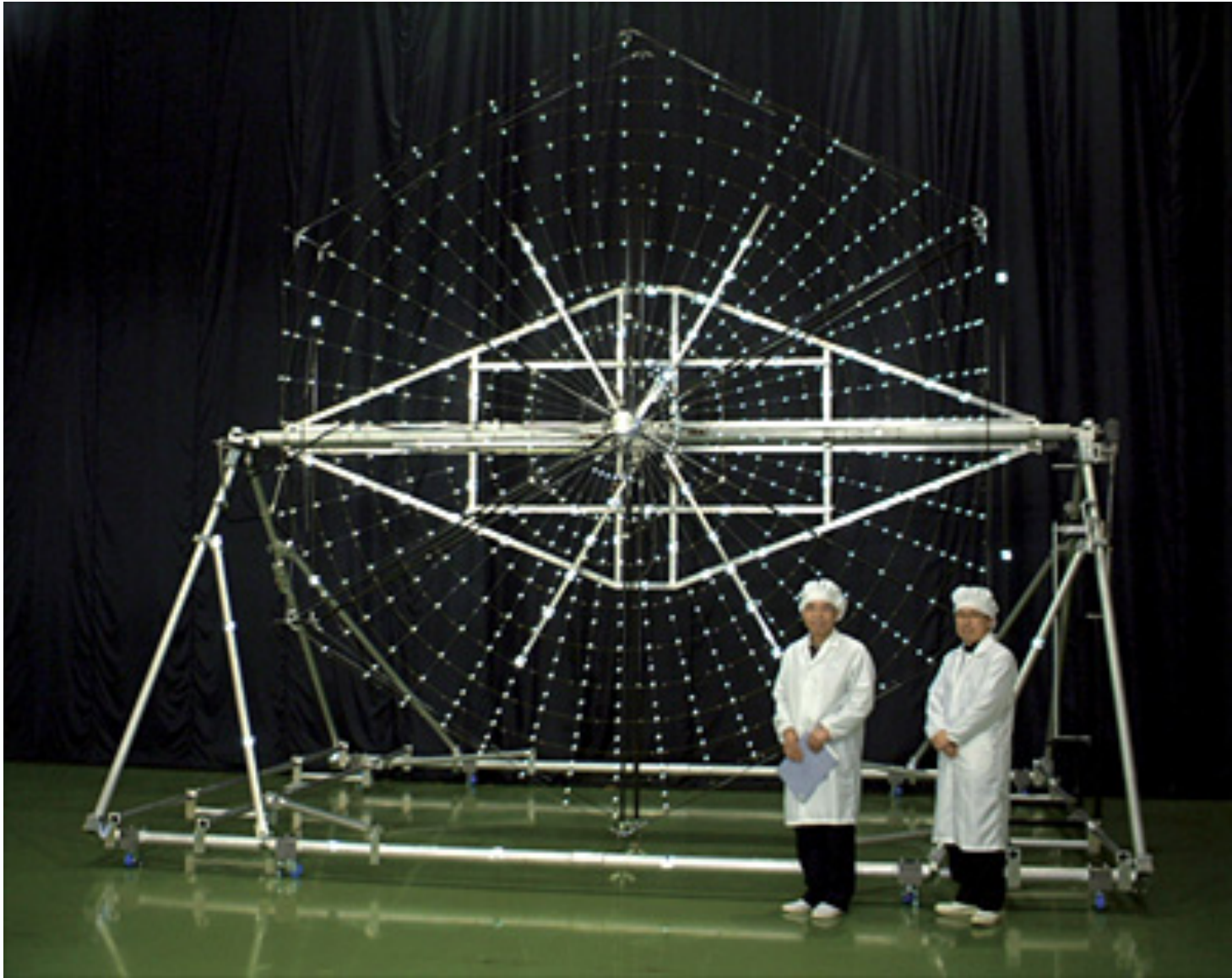




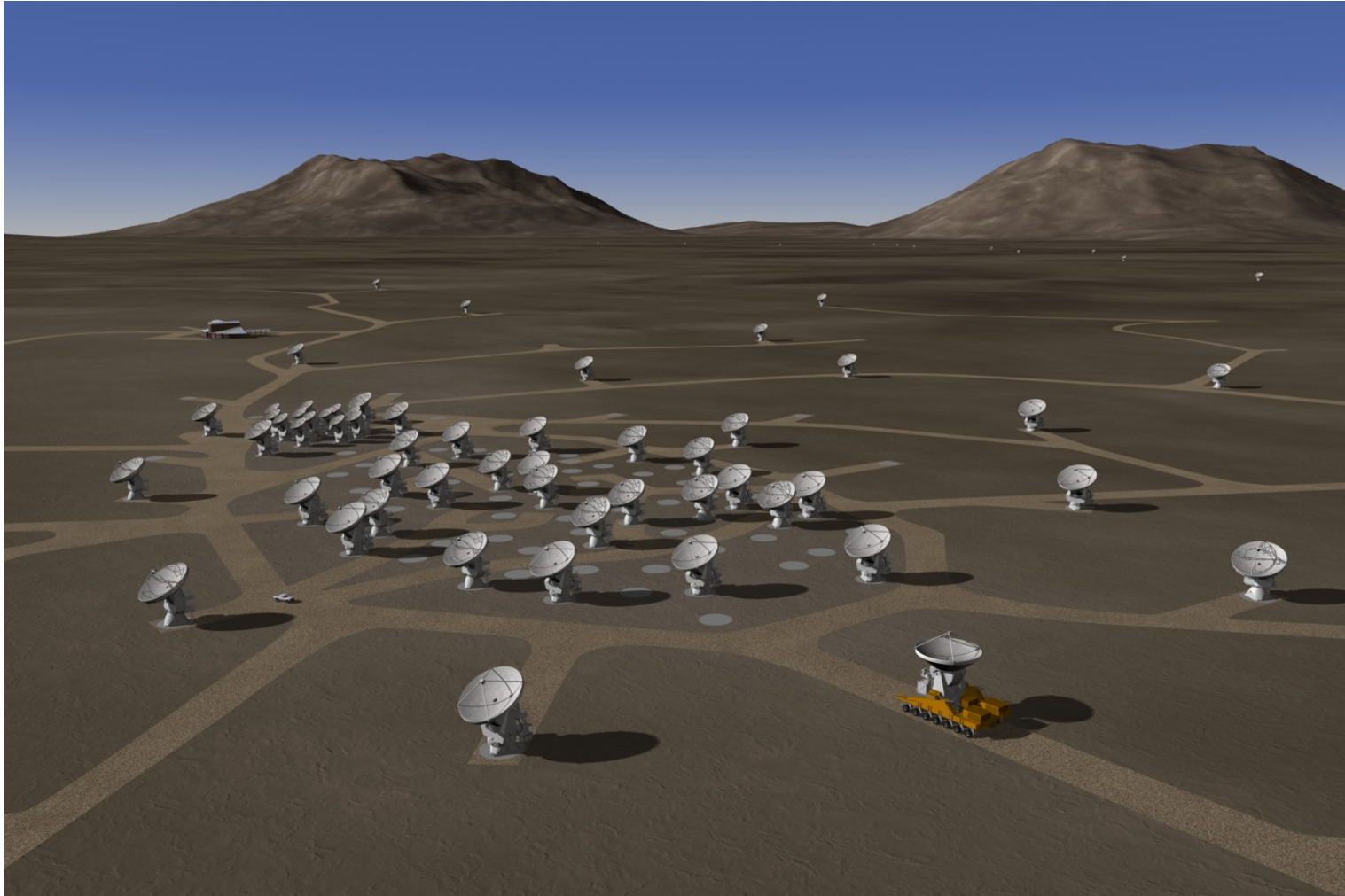


# VSOP-2





# ALMA







The initial ALMA array will be composed of 66 high-precision antennas, and operate at wavelengths of 0.3 to 9.6 mm. The American and European partners have each placed orders for twenty-five 12-metre diameter antennas, that will compose the main array. East Asia is contributing 16 antennas (four 12-metre diameter and twelve 7-metre diameter antennas) in the form of the Atacama Compact Array (ACA) which is also part of the enhanced ALMA.

As of this week, there were 45 of the 66 antennas installed!

Bands 3, 6, 7 and 9 will be the first bands available on all antennas.

Band	Freq. range(GHz)	IF range (GHz)
3	84 – 116	4 – 8
6	211 – 275	5 – 10
7	275 – 373	4 – 8
9	602 – 720	4 – 12

The ALMA 12-m array will cycle from its most compact configuration, with maximum baselines of ~150 m, to its most extended configuration, with maximum baselines of ~16 km (when completed), and back. The Atacama Compact Array (ACA) will have two configurations, one of which is a north-south extension to provide a better beam shape for far-north/far-south targets.



ALMA/ESO/NAOJ/NRAO





# SKA site decision

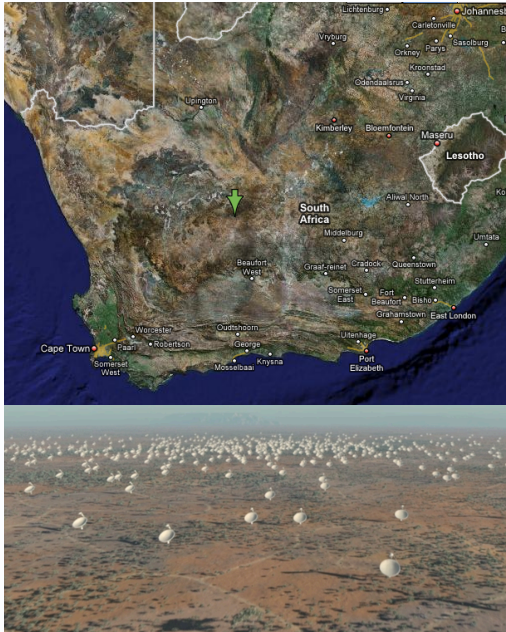
Announced Friday 25 May 2012

**“Site duel ends in dual site”**

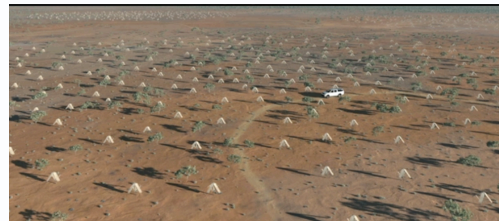
(credit Matthew Colless)



# SKA Phase 1 Dual Site Implementation



SKA1\_Mid + MeerKAT



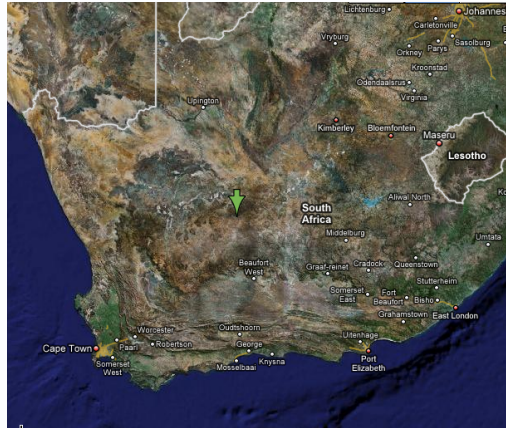
SKA1\_Low



SKA1\_AIP\_Survey + ASKAP

	SKA Element	Location
Dish Array	SKA1_Mid : 190 15m dishes + SPFs	RSA
Low Frequency Aperture Array	SKA1_Low : 280 Aperture array stations	ANZ
Survey Instrument	SKA1_AIP_Survey : 60 15m dishes + PAFs	ANZ

# SKA Phase 2 Dual Site: conditional on delivery of Phase 1



SKA2\_Mid\_Dish



SKA2\_AIP\_AA



SKA2\_Low

	SKA Element	Location
Low Frequency Aperture Array	SKA2_Low	ANZ
Mid Frequency Dish Array	SKA2_Mid_Dish	RSA
Mid Frequency Aperture Array	SKA2_Mid_AA	ANZ or RSA

# SKA Implementation

8 countries: UK, NL, IT, CA, CN, AU, ZA, NZ

3 more to join: IN, SE, DE

More partners welcome

2012 – 2016: pre-construction phase

SKA Observatory to be established

2016 – 2020: €350M Phase 1

2020 – 2025: €1.2B Phase 2

# Your task, if you wish to accept it...

Use as many of these telescopes as possible to maximise your science!

# Thank you

CASS

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Head of Science Operations

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w [www.atnf.csiro.au](http://www.atnf.csiro.au)

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