

The Very Large Array

Past and Future

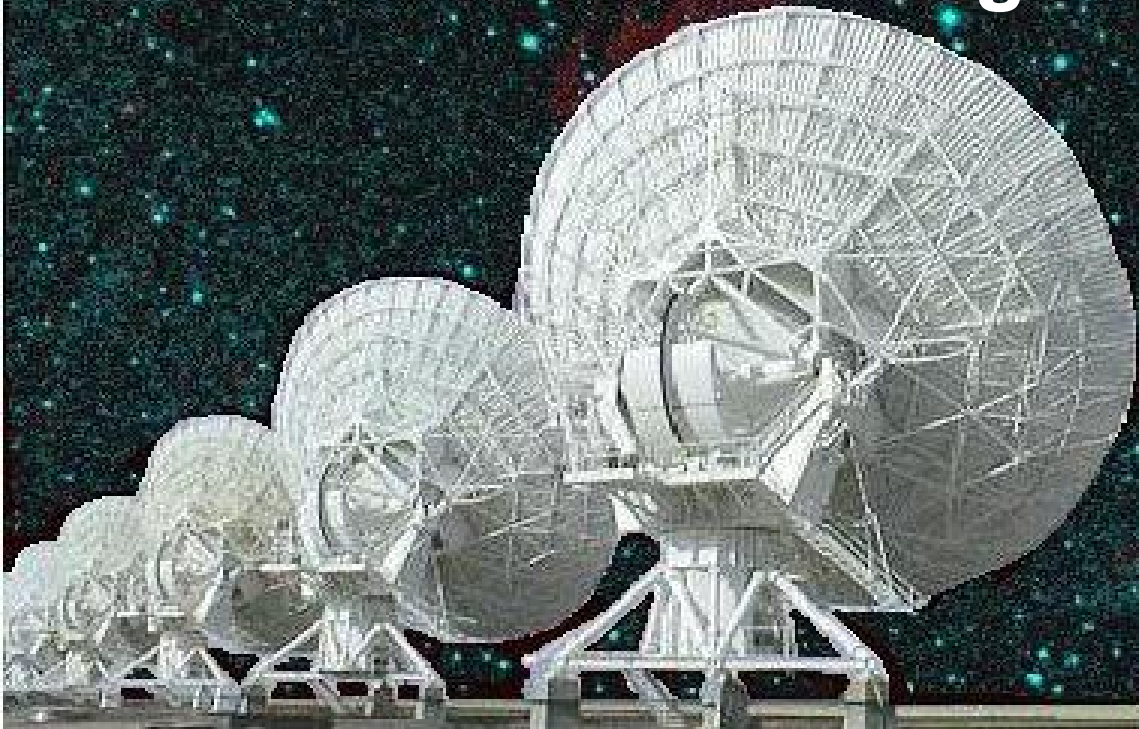


Dave Finley



Outline

Pre-VLA Radio Astronomy
VLA Design & Construction
“Classic” VLA
Expanded VLA
ngVLA – The Future

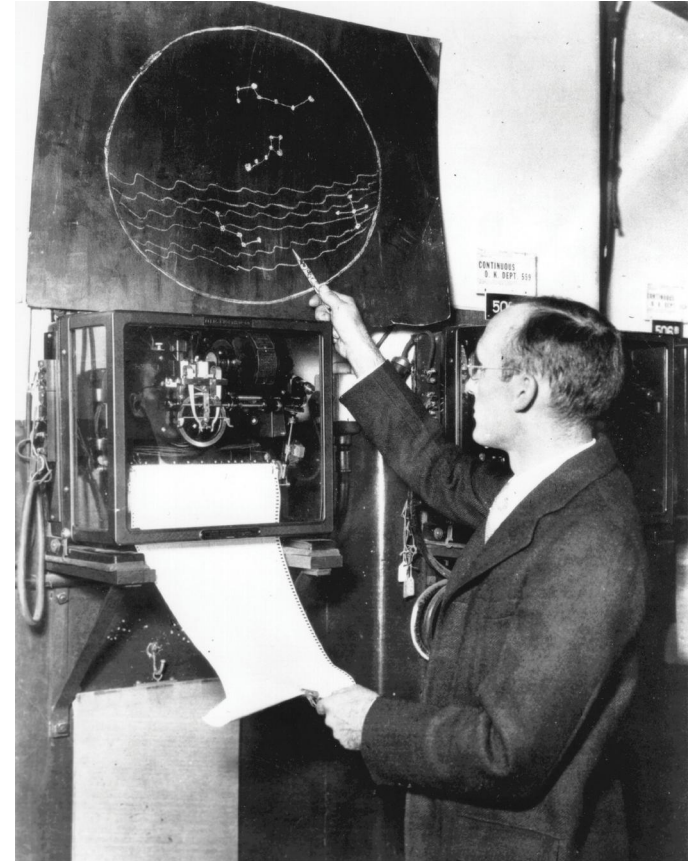
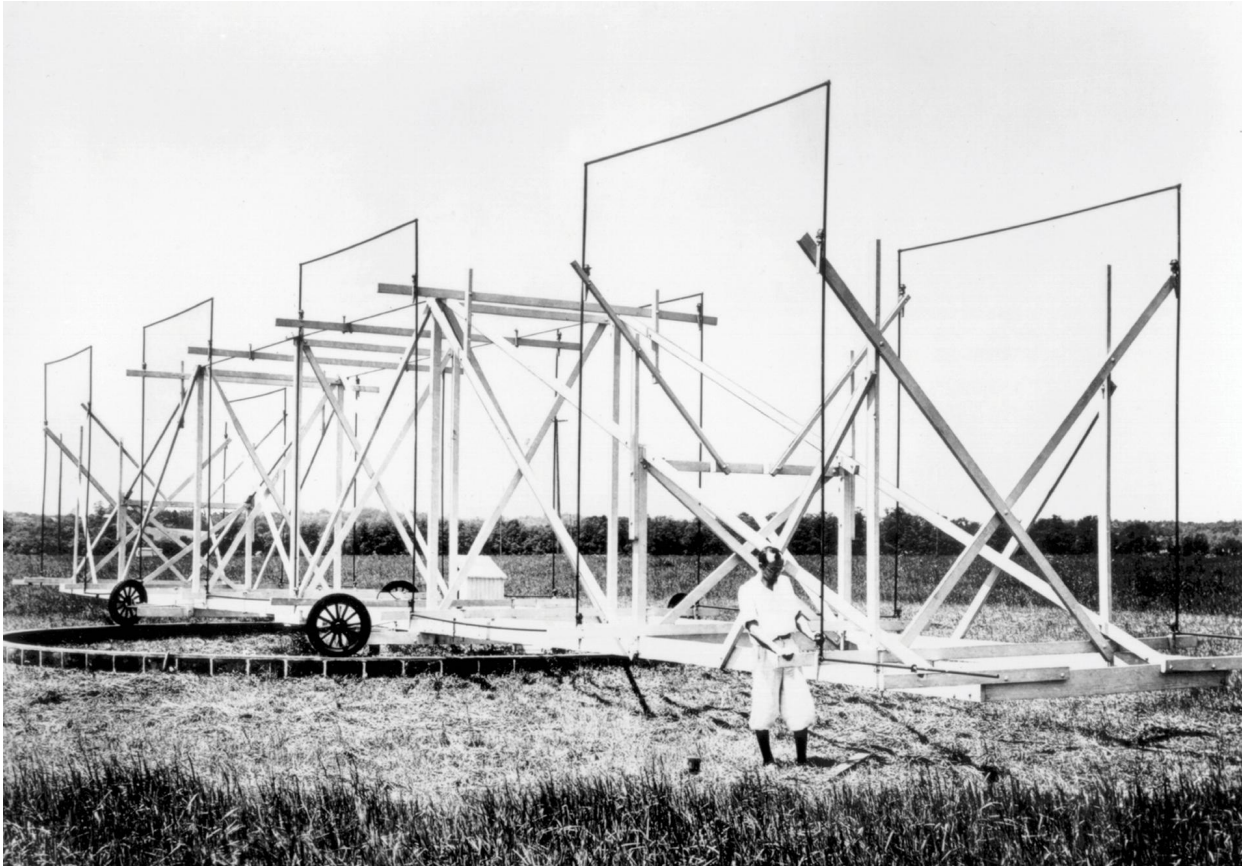


5,000 Astronomers
14,000 Observing Projects
500 Ph.D Dissertations

— ... and counting

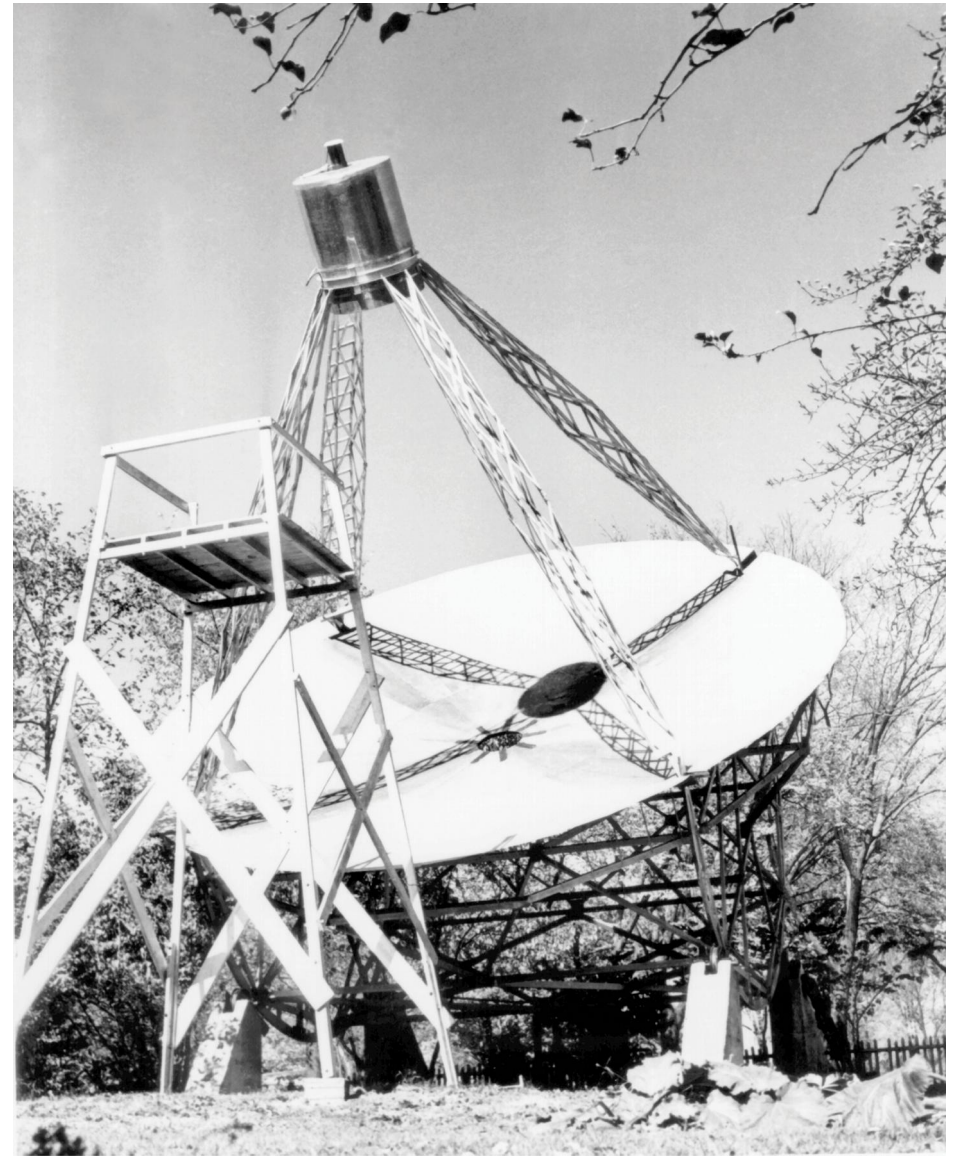


The Beginning: Karl G. Jansky

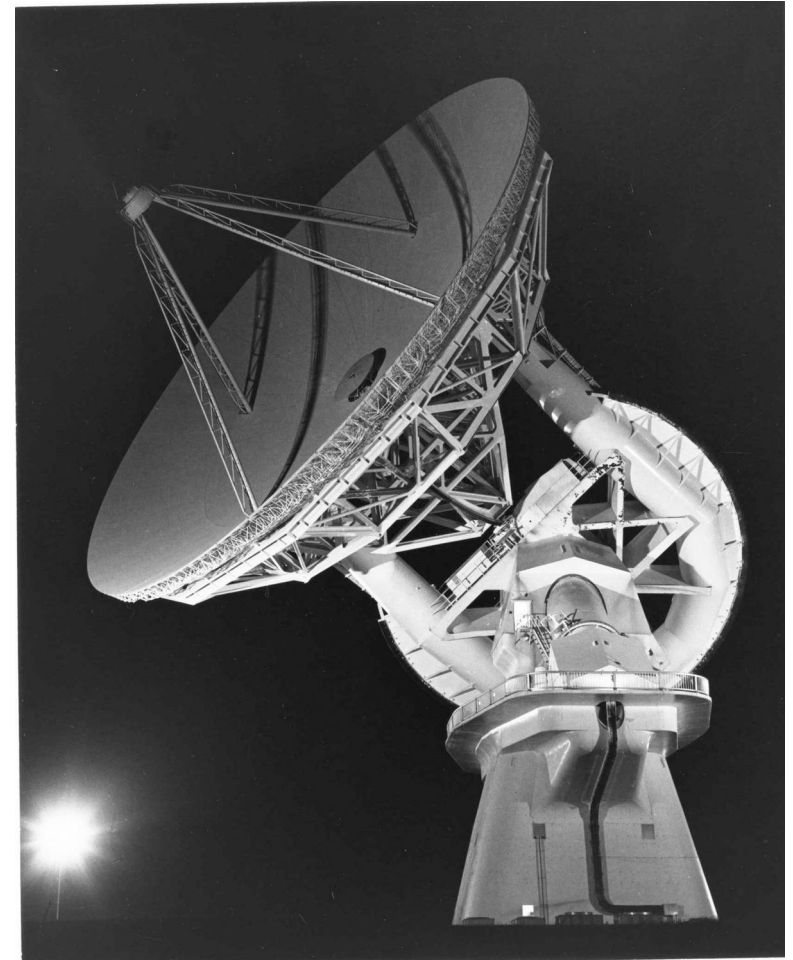


The Pioneer: Grote Reber, W9GFZ

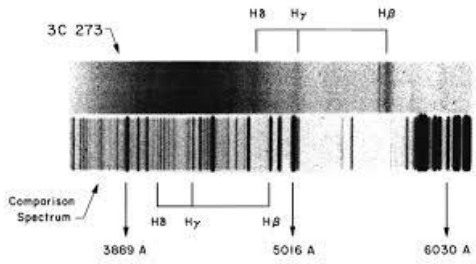
First map of sky
at Radio Wavelengths



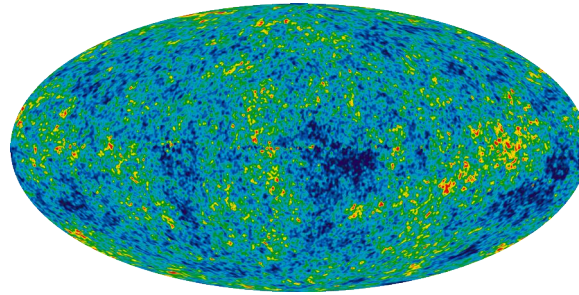
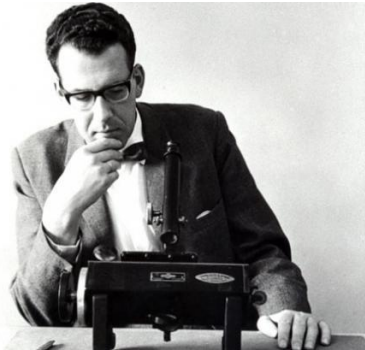
Radio Telescopes of the 1960s



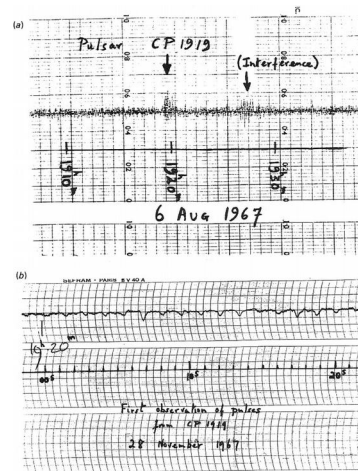
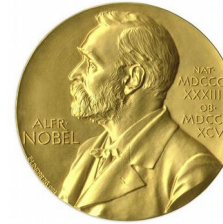
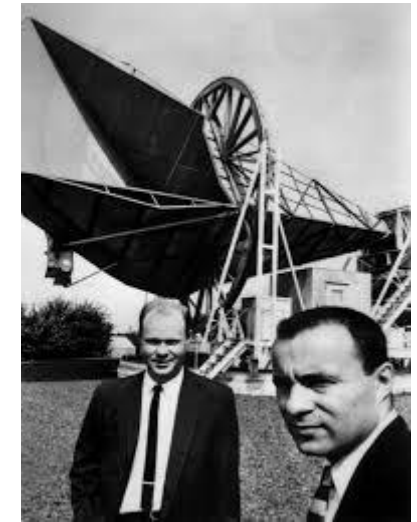
1960s Radio Astronomy Discoveries



Quasars 1963



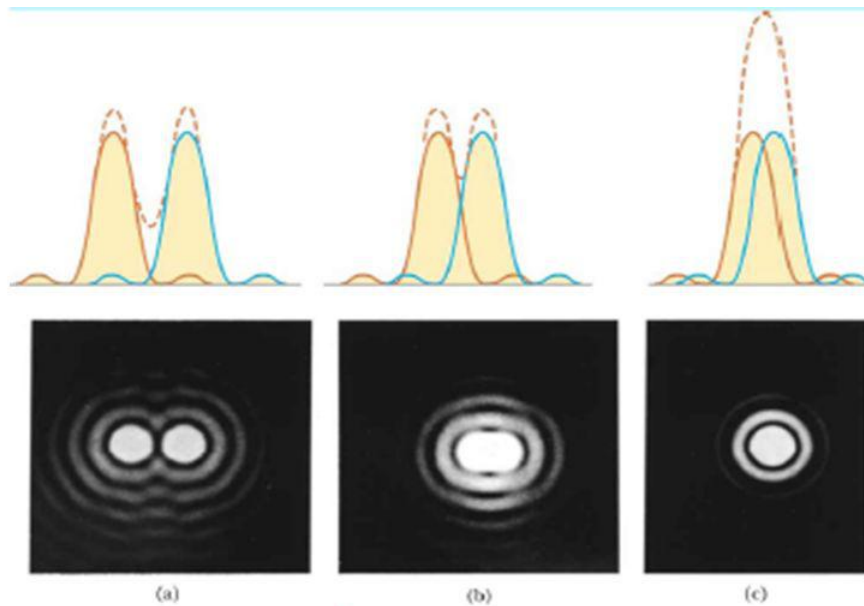
Cosmic Microwave Background 1964



Pulsars 1967



The Big Need: Resolving Power



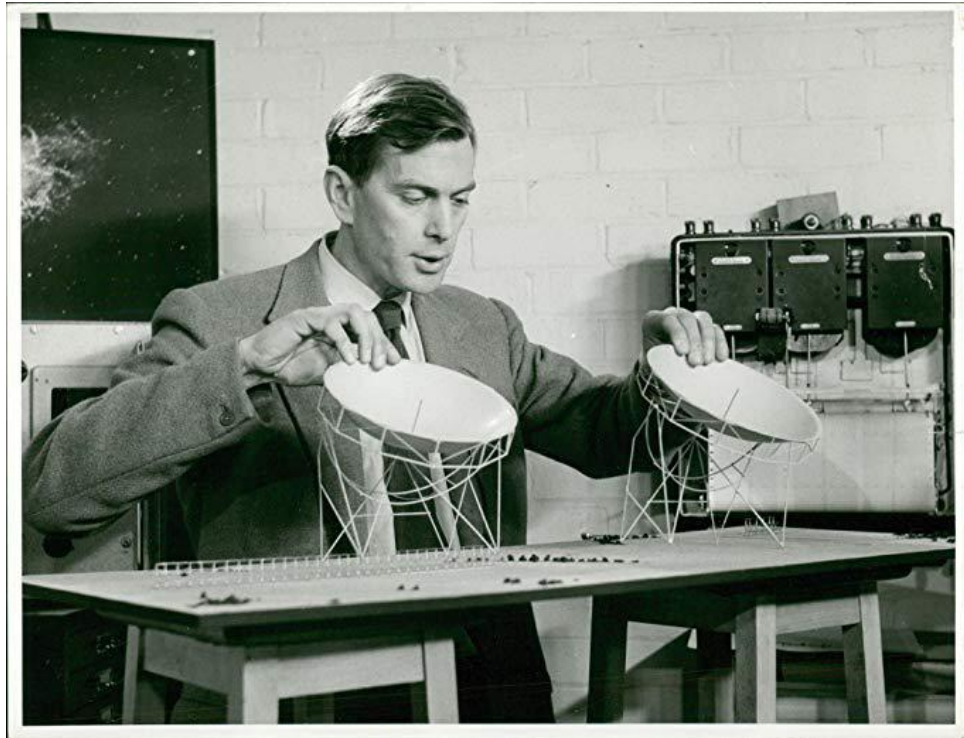
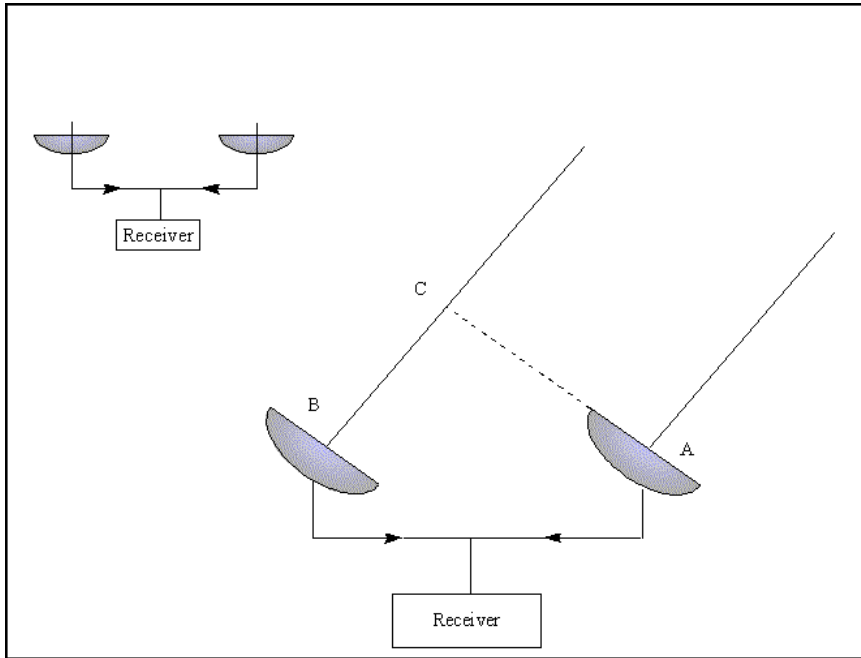
2 sources
far apart

2 sources are
close enough
together that
they are 'just
resolved'

2 sources
so close
that they are
not resolved

$$\text{Resolution} = \frac{\text{Wavelength}(\lambda)}{\text{Diameter}(D)}$$

The Solution: Interferometry



Sir Martin Ryle



NOBEL PRIZE IN PHYSICS 1974:
"... for his observations and inventions, in particular of the aperture synthesis technique..."

NRAO Conceives a Project

NATIONAL RADIO ASTRONOMY OBSERVATORY
Green Bank, West Virginia

March 5, 1962

MEMO TO: JWF, FDD, HH, CMW, DH, MV, NW, FJC

Attached is a draft of a proposed development program for the very large telescope. Some such statement as this will be submitted to NSF this week (probably tomorrow) as justification for our 1964 budget. I would like to have as much comment and discussion on this as possible, before it is submitted. To this end, there will be a meeting at 2:00 PM today - Monday - in the upstairs conference room. Please be there if you can. Anyone who has comments but can't get to the meeting should please give me his comments some time today - preferably before 2:00 PM.

DSH



Recommendation: Build One

Panel on Astronomical Facilities Committee on Science and Public Policy



NATIONAL ACADEMY OF SCIENCES

1964:

- *Large, multi-antenna radio telescope***
- *National Facility***
- *Available to all astronomers***



Looking for a Home

Possible VLA Sites

Inspections 1965-1969

Initial List: 89 Sites

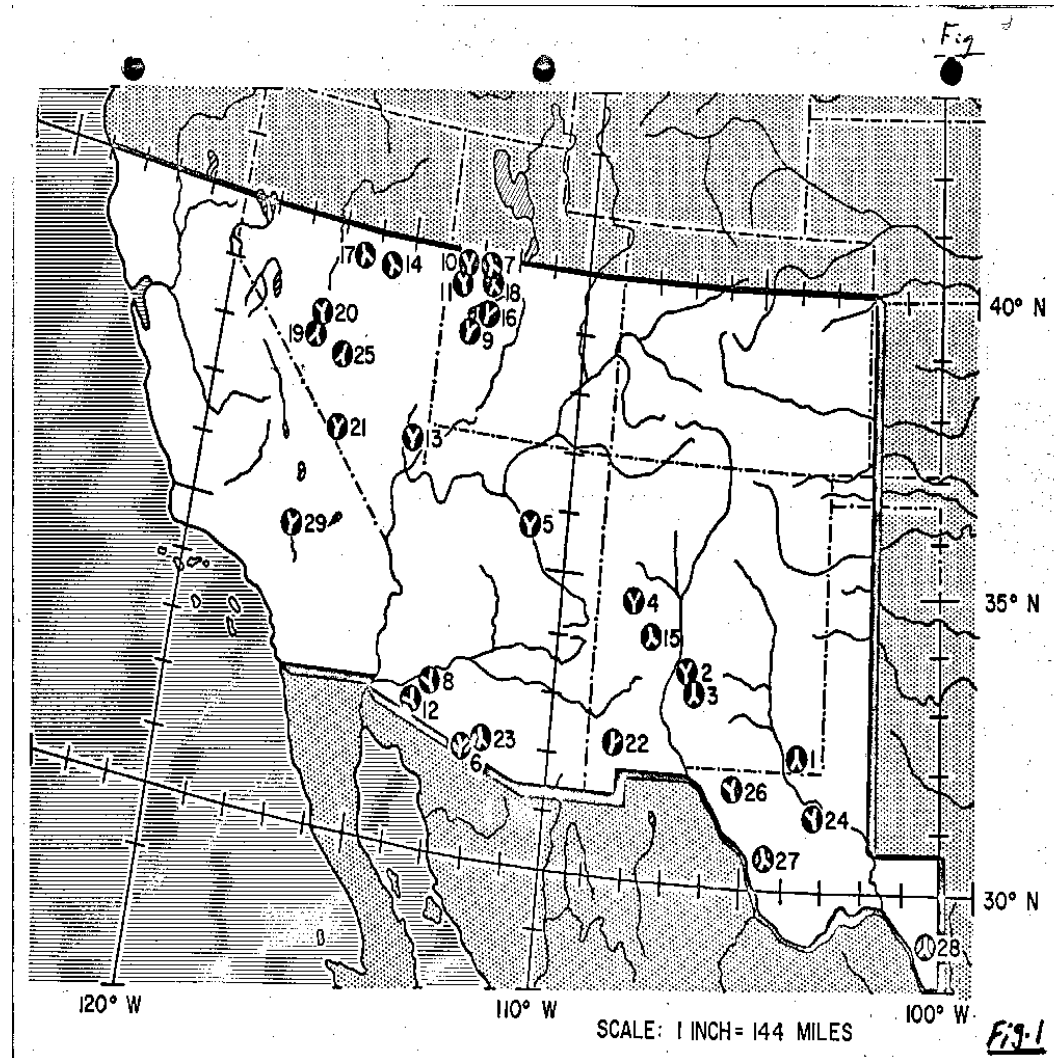
Map Selection: 29 Sites

Air Inspection: 20 Sites

Ground Visits: 12 Sites

Finalists: 4 Sites

- San Agustin, NM
- Van Horn, TX
- Van Horn, TX
- Ft. Sumner, NM



Meanwhile, in Green Bank



Green Bank Interferometer 1967



The Winning Site

Plains of San Agustin, New Mexico

“Appears to be an excellent potential site.”

– Report, May 1966

Final Site Selection
and Approval: 1972



Maxwell Small, Robert Weber, Campbell Wade: 13 February 1966



Early Milestones

August 1972:
Congress Approves VLA Project

November 1972:
NSF Gives Authorization to Proceed



April 1973:
NRAO Office in Magdalena

November 1973:
NRAO Takes Possession of Central Site



VLA Construction: 1974-1980

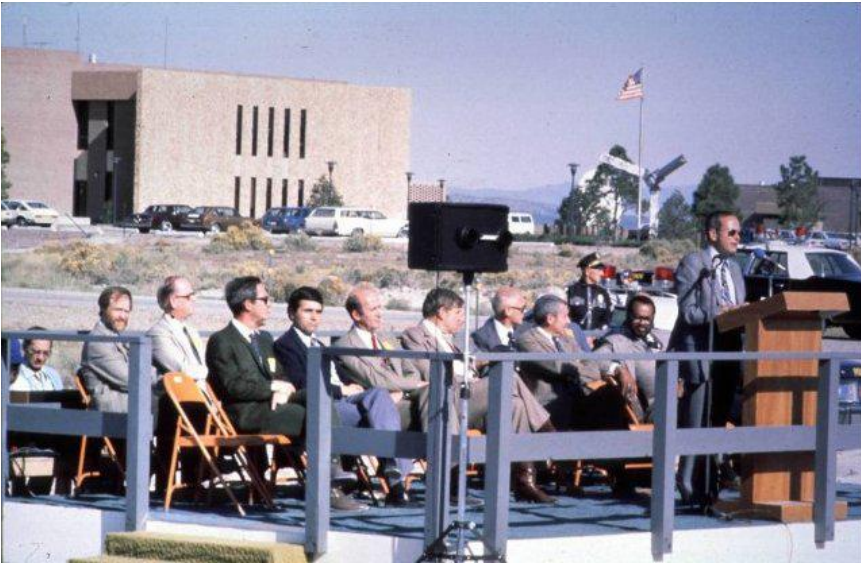


Buildings
Utilities
Tracks
Transporters
Antennas

Staff Moves to NM May 1975
First Observation 24 October 1975
– 3C 274 (M87)
First Fringes 18 February 1976
Open to Science 15 June 1978



VLA Dedication: 10 October 1980



**1 Governor
2 U.S. Senators
1 U.S. Congressman
President's Science Advisor
NSF Acting Director
NSF Director Designate
AUI President (2)
NRAO Director
NRAO Associate Director
VLA Project Manager
+ 600 Guests**

VLA Completed:

On Budget (\$78.6M in 1972 dollars)

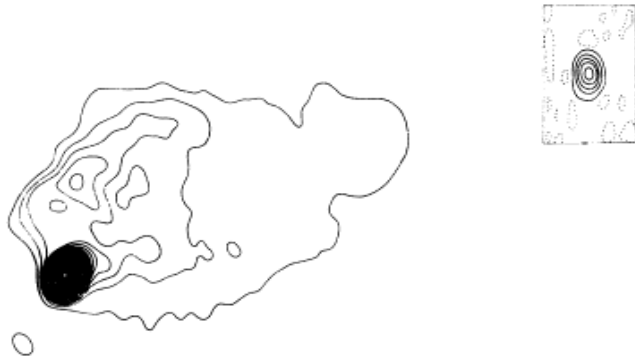
Met Specifications

~ 1 Year Ahead of Schedule

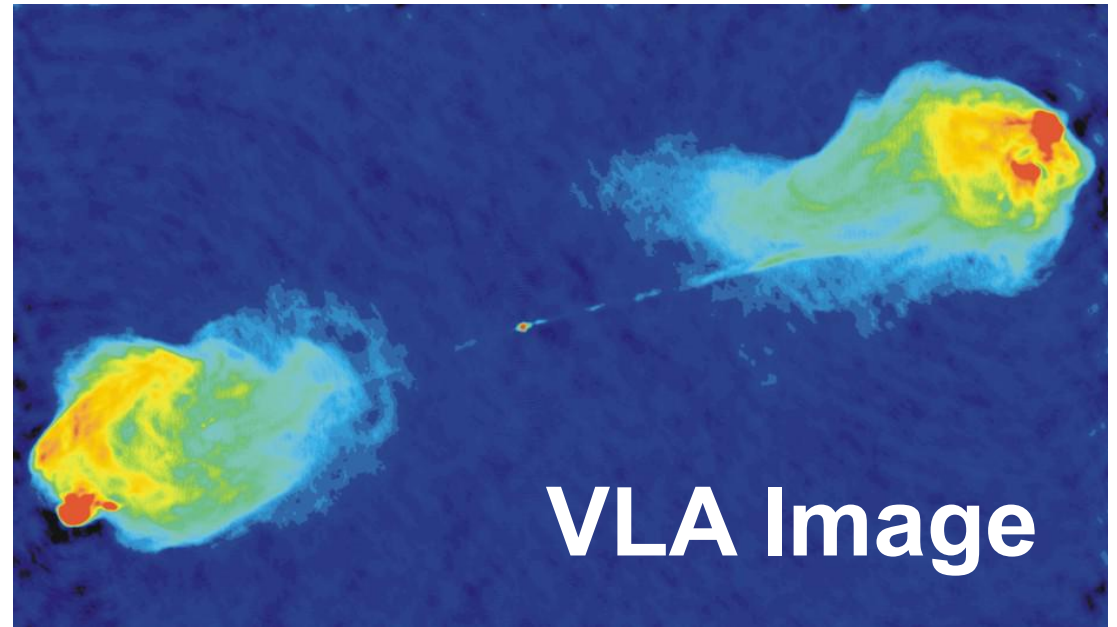


Scientific Impact

Pre-VLA Image



Radio Galaxy Cygnus A



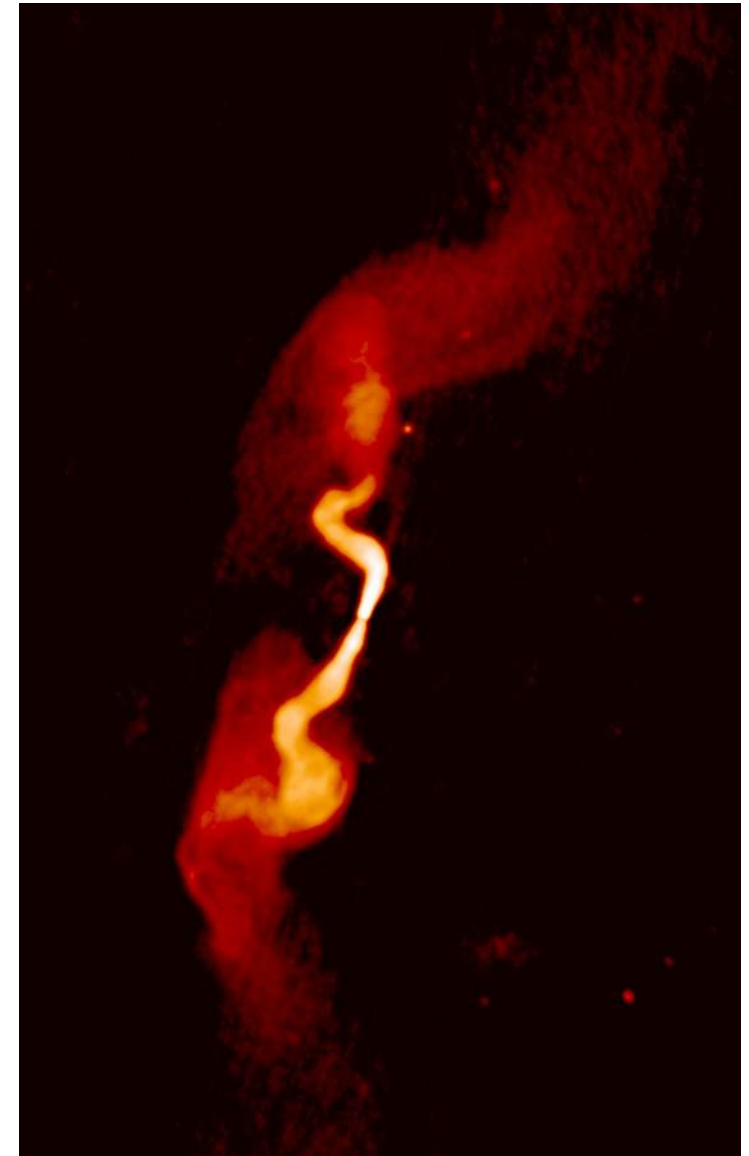
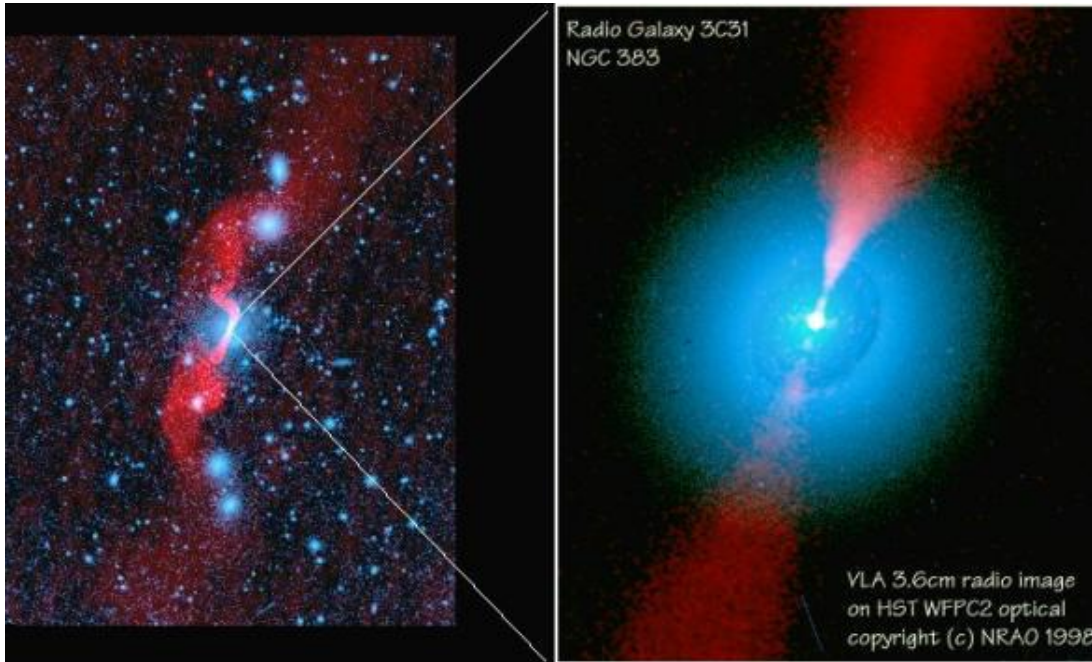
“Suddenly, radio astronomy went from being a science that could only get crude images to being able to get the best images of all.”

– Space.com, 2002



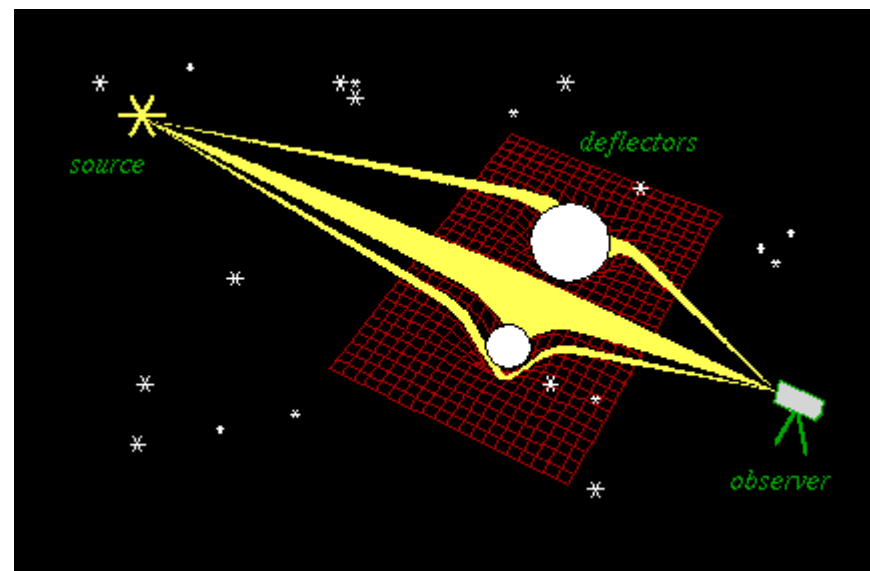
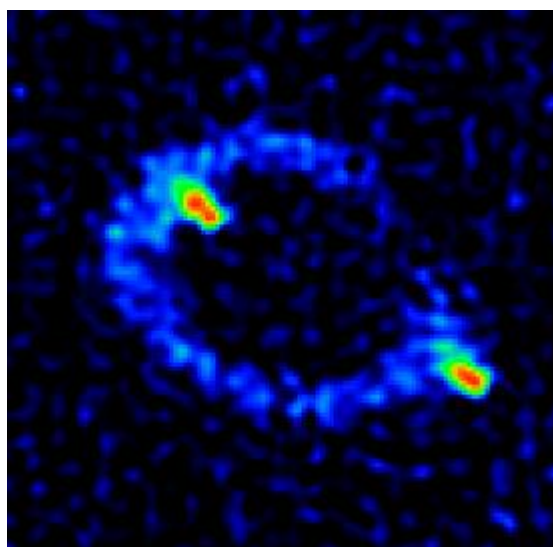
VLA Discoveries

Cosmic Jets



VLA Discoveries

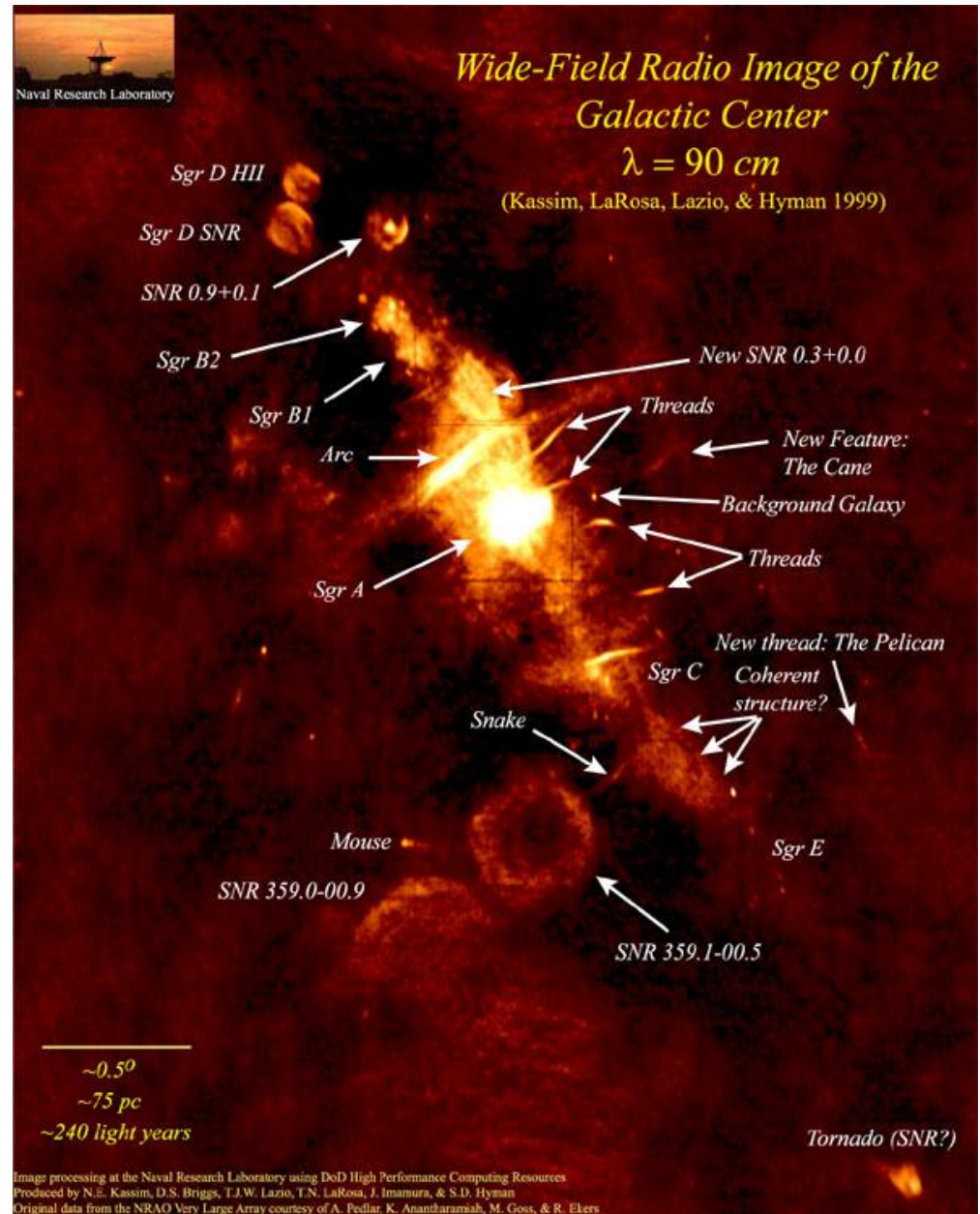
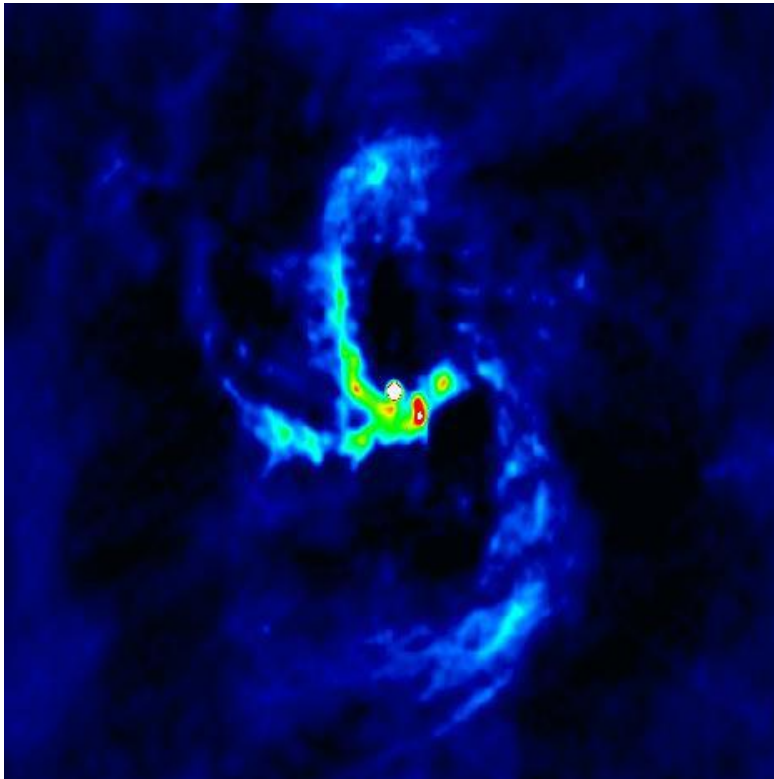
Gravitational Lenses



Einstein Ring, VLA 1987

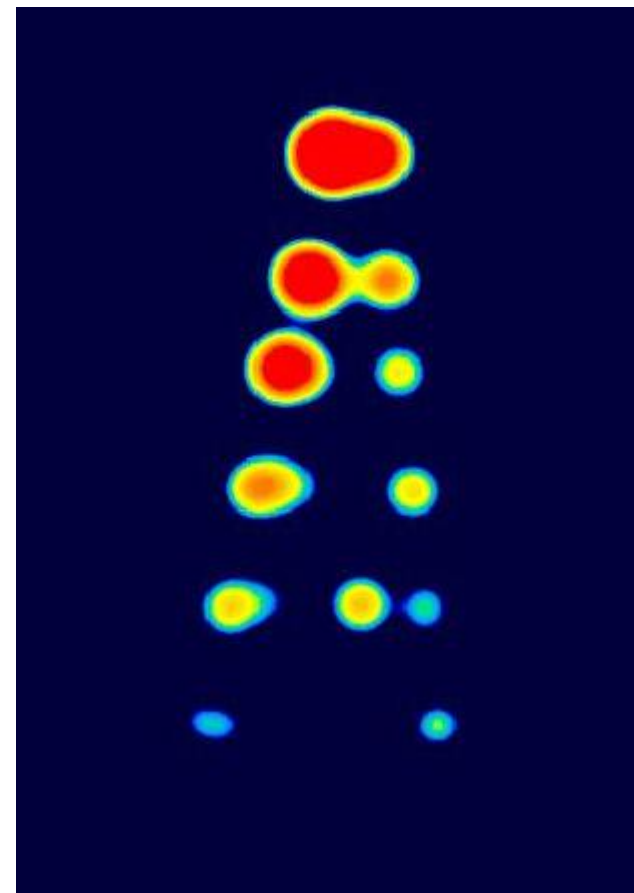
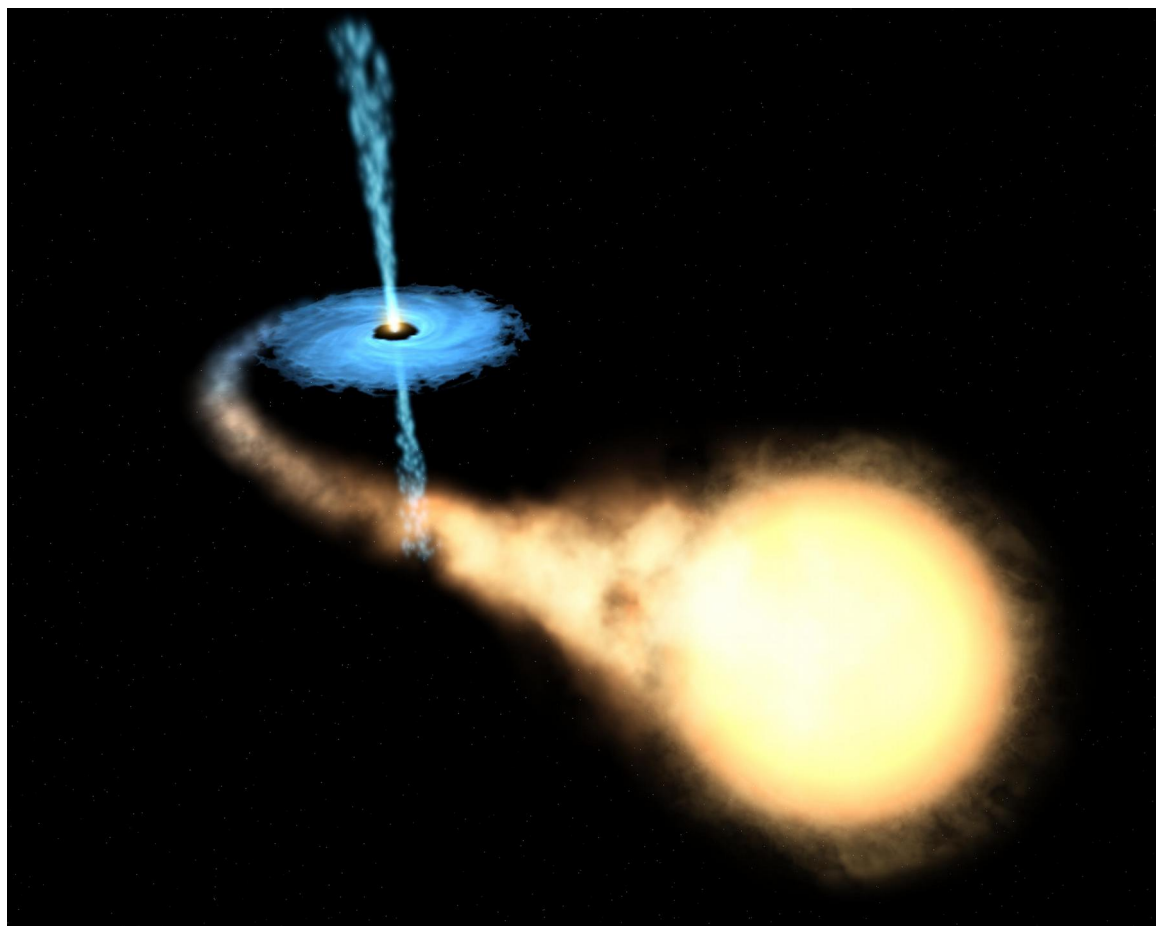
VLA Discoveries

Our Galaxy's Center



VLA Discoveries

“Microquasars” in Milky Way

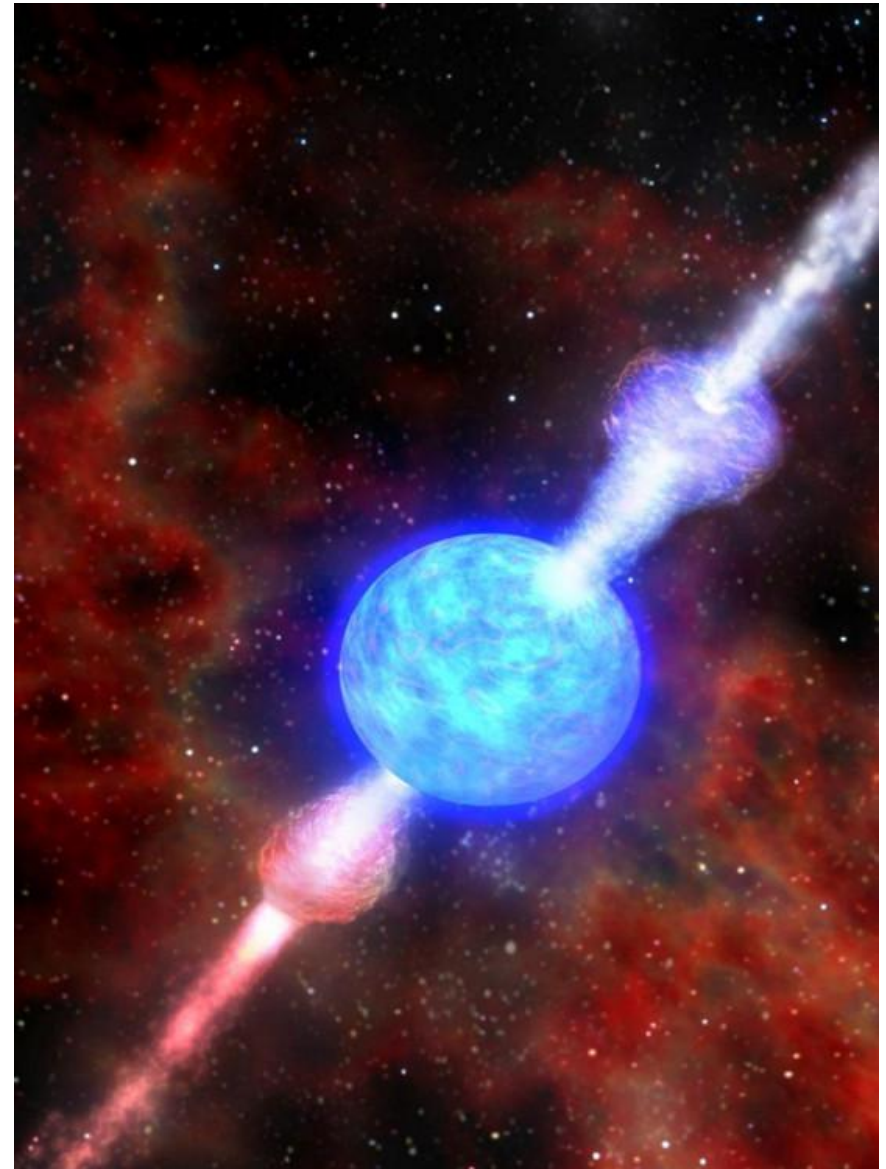


VLA 1994

VLA Discoveries

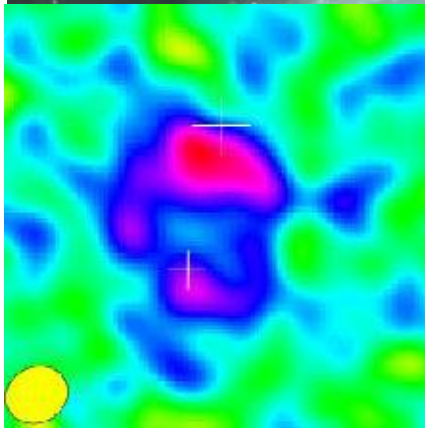
Gamma Ray Bursts

First Radio Detection 1997

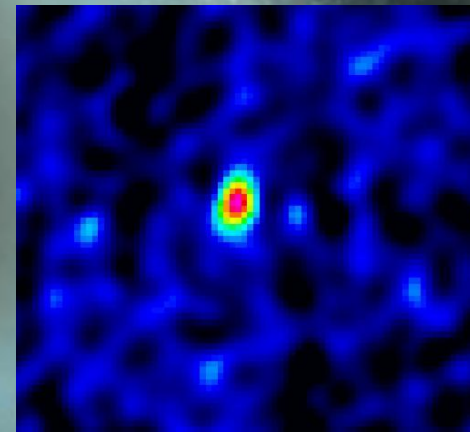


VLA Discoveries

Molecules in Early Universe



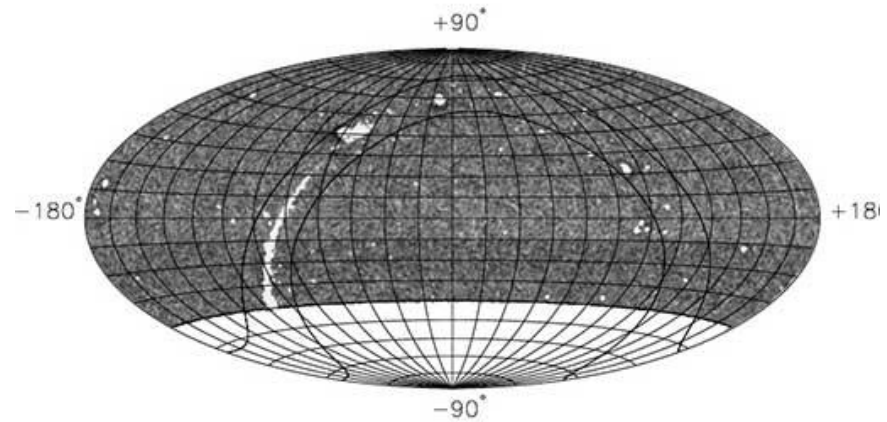
PSS J2322+1944
12 Billion L.Y.



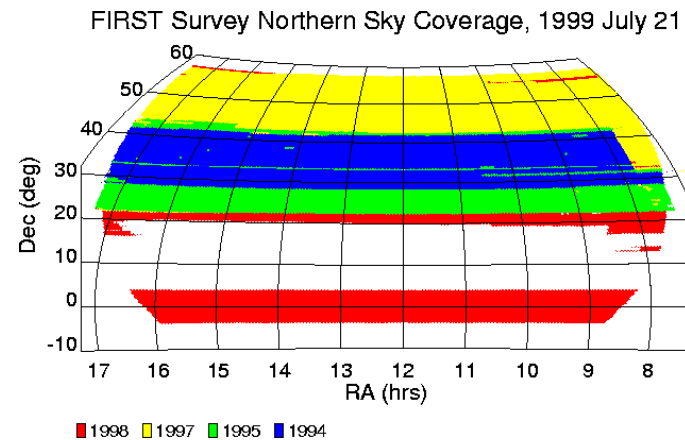
J1148+5251
12.8 Billion L.Y.

Sky Surveys With the VLA

***NRAO VLA Sky Survey
(NVSS)
1993-1996
2932 Observing Hours***



***Faint Images of the
Radio Sky at
Twenty centimeters
(FIRST)
1993-2002
3200 Observing Hours***

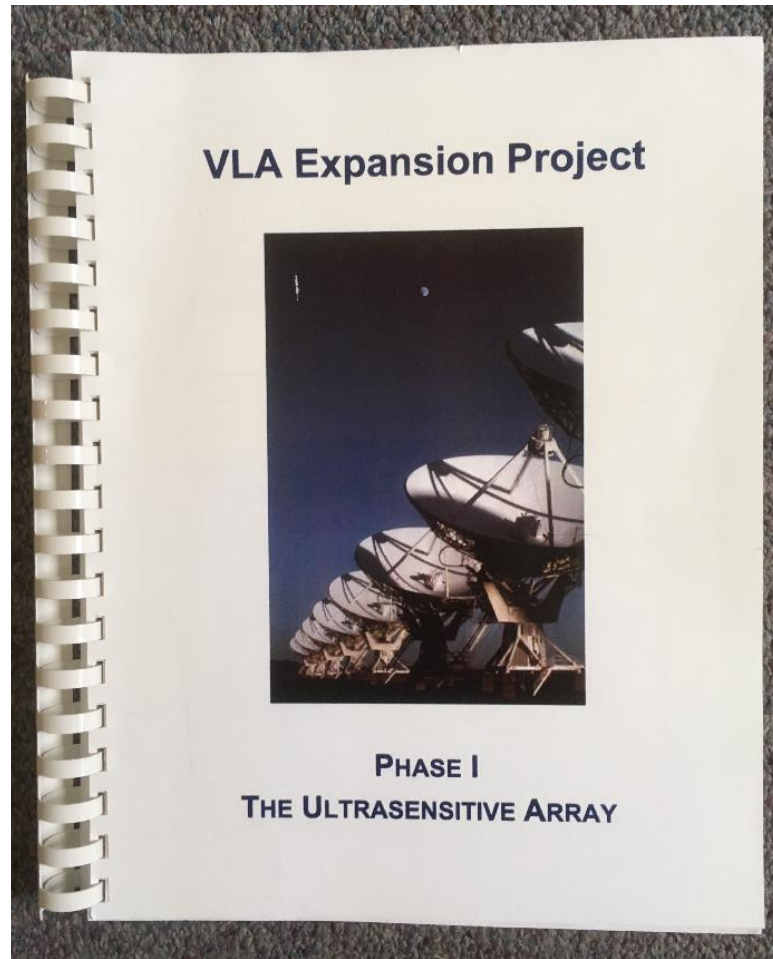


More Than 4,500 Citations in Scientific Papers!



The VLA Expansion Project:

Returning to the State of the Art



Scientific Workshop 1995

Scientific Workshop 1997

Decadal Survey Endorsement 2000

NSF Approval 2001

Funding from:

NSF

Canada

Mexico



VLA Expansion: 2002-2012

New receivers

Antenna modifications

**New data-transmission system
(Digital replaced analog)**

**New central supercomputer
(Correlator)**

New control system



***10 Times the Capability for a Fraction
Of The Replacement Cost!***



VLA Expansion: 2002-2012



Karl G. Jansky Very Large Array



**Rededication Ceremony
31 March 2012**





Post-Expansion VLA Discoveries

Fast Radio Burst – Location of Repeater

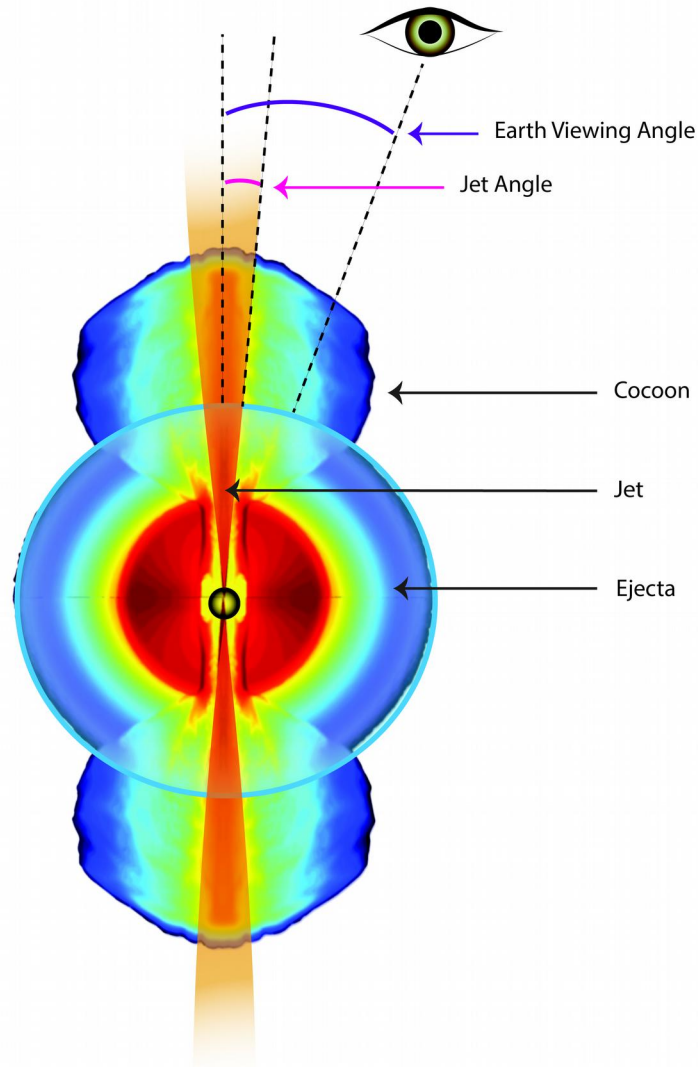
2017



National Radio Astronomy Observatory

Post-Expansion VLA Discoveries

Neutron Star Merger – Nature of Aftermath

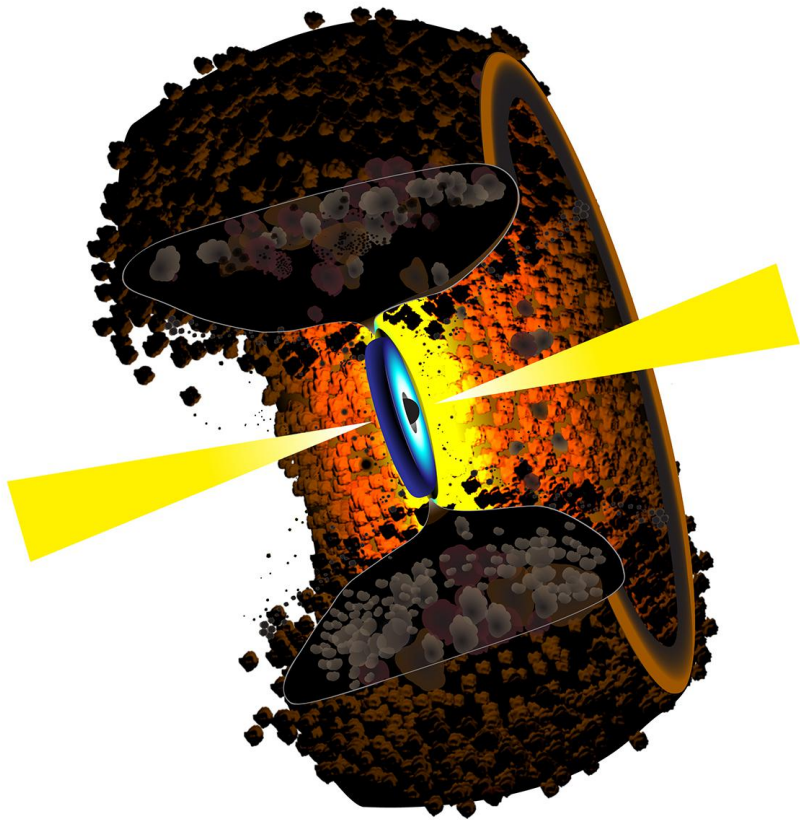


2017 - 2018

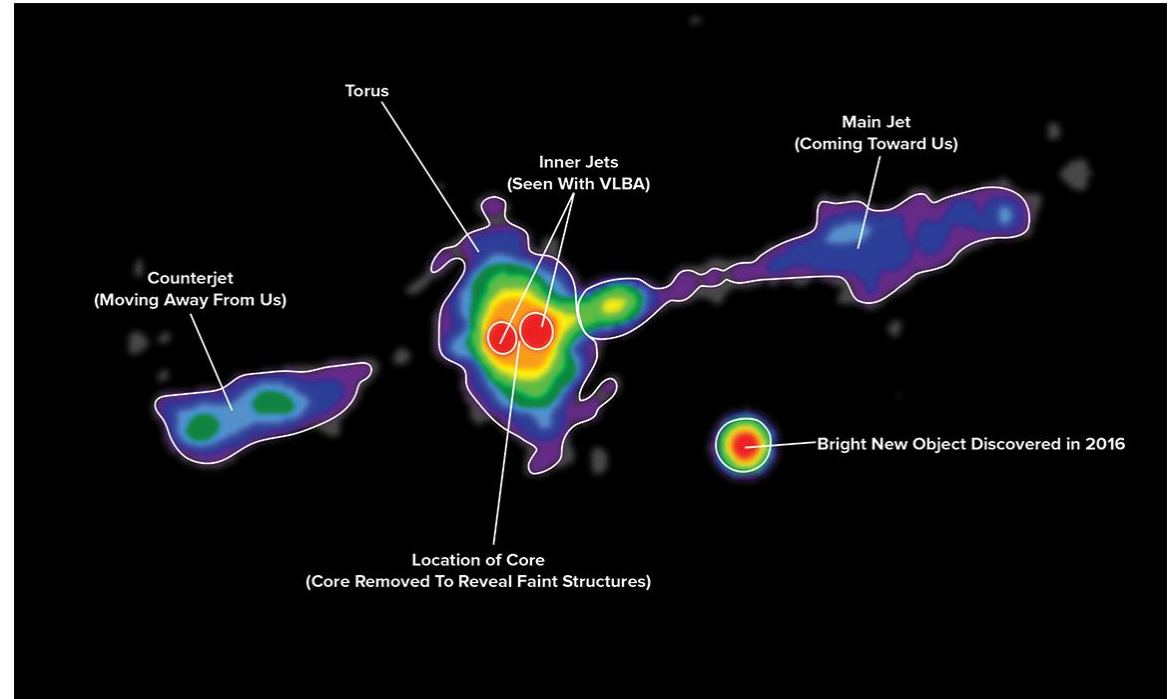
*First event in history
observed with both
gravitational waves
and electromagnetic waves*



Post-Expansion VLA Discoveries



2019



Long-predicted “Torus” of Active Galactic Nucleus



The VLA Sky Survey (VLASS)

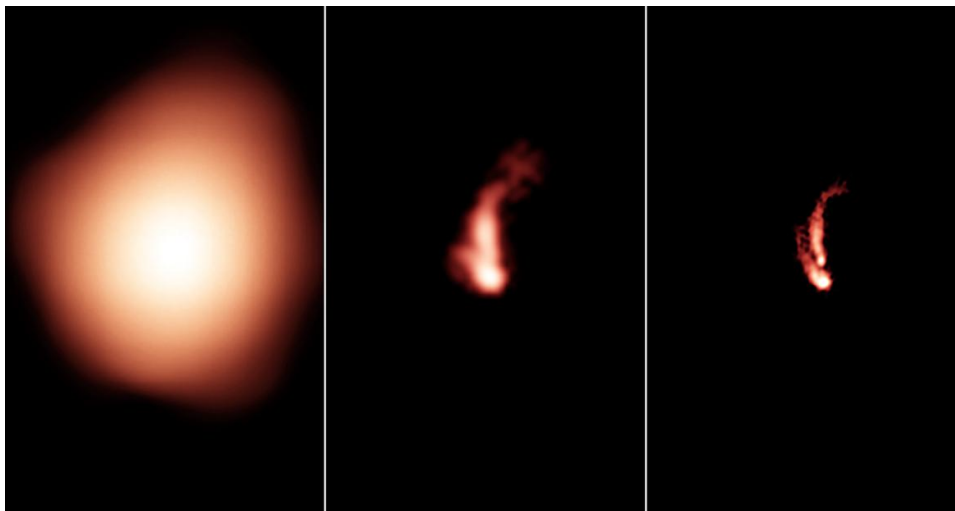
Started 2017

7 Years

3 Epochs

5,500 Observing Hours

10 Million Objects



Same Object:

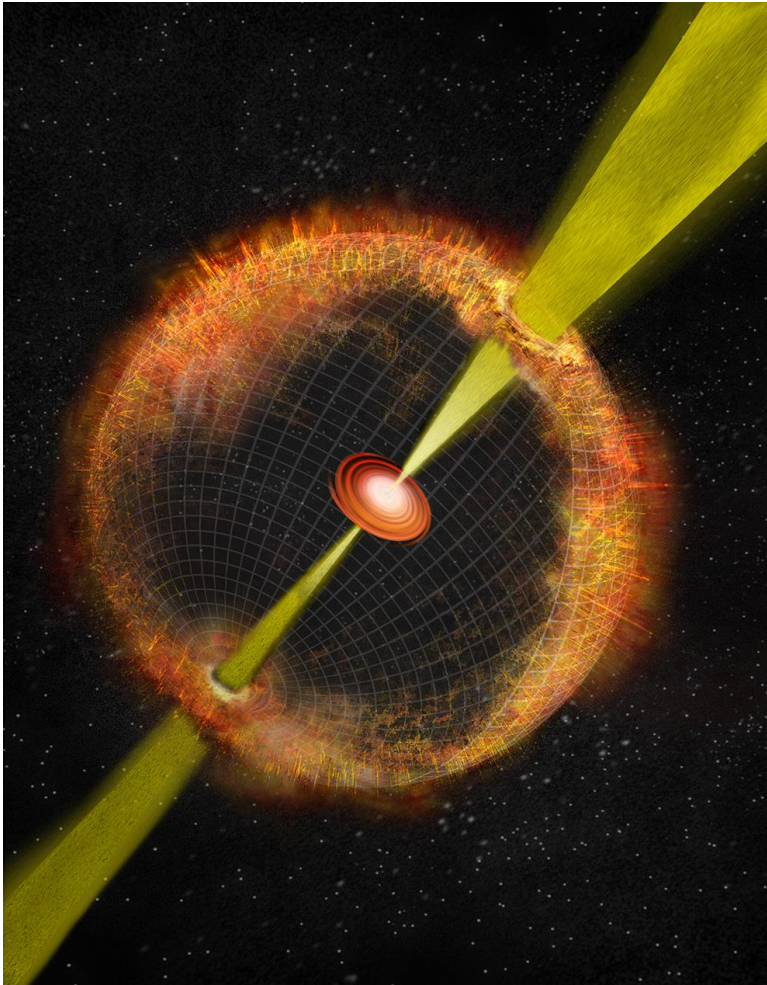
NVSS

FIRST

VLASS



Science From VLASS



“Orphan” Gamma-Ray Burst

2018

Science From VLASS

Young Pulsar in Dwarf Galaxy



2022

Age: 14 – 80 years

Pulsar Wind Nebula

Just Emerged From SN Shell

Not seen in FIRST 1998

Found in VLASS 2018

Energy: 10,000X Crab

The Future



ngvta

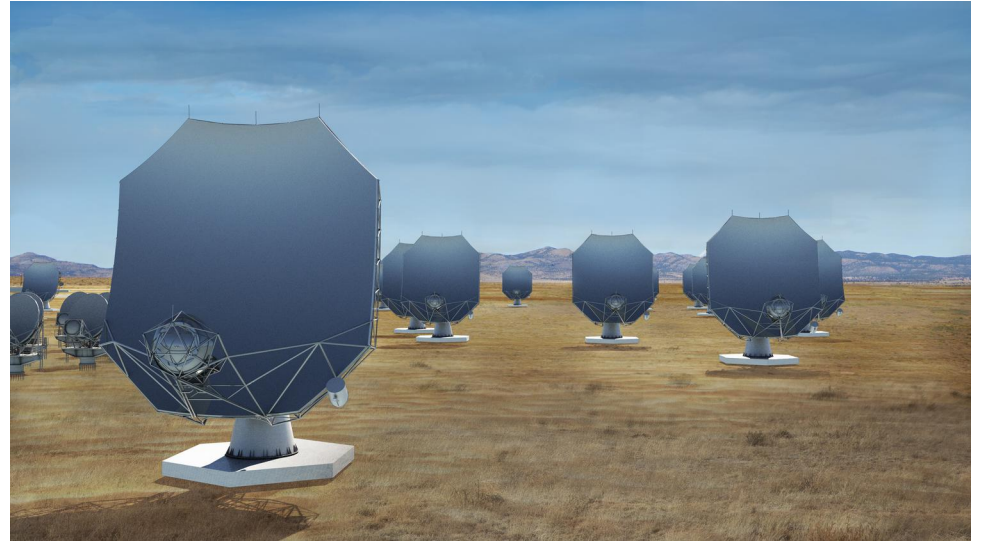
Next Generation Very Large Array



ngVLA: The Forefront of Discovery

Seeing Deeper and Farther
Greatly improved sensitivity
Many more celestial objects

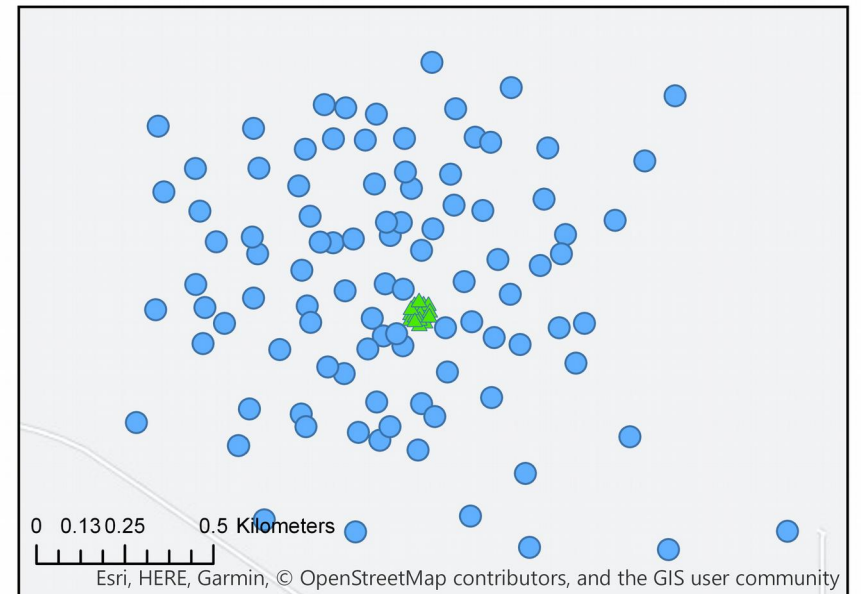
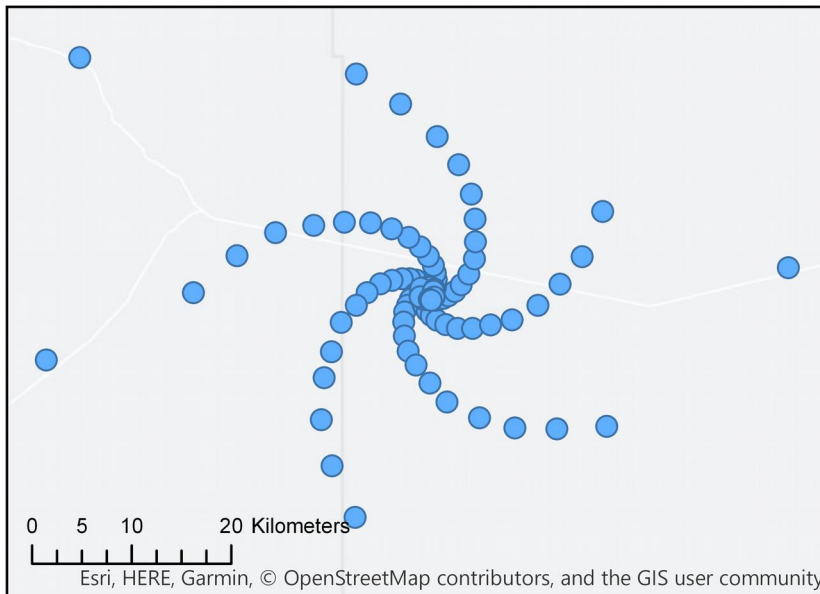
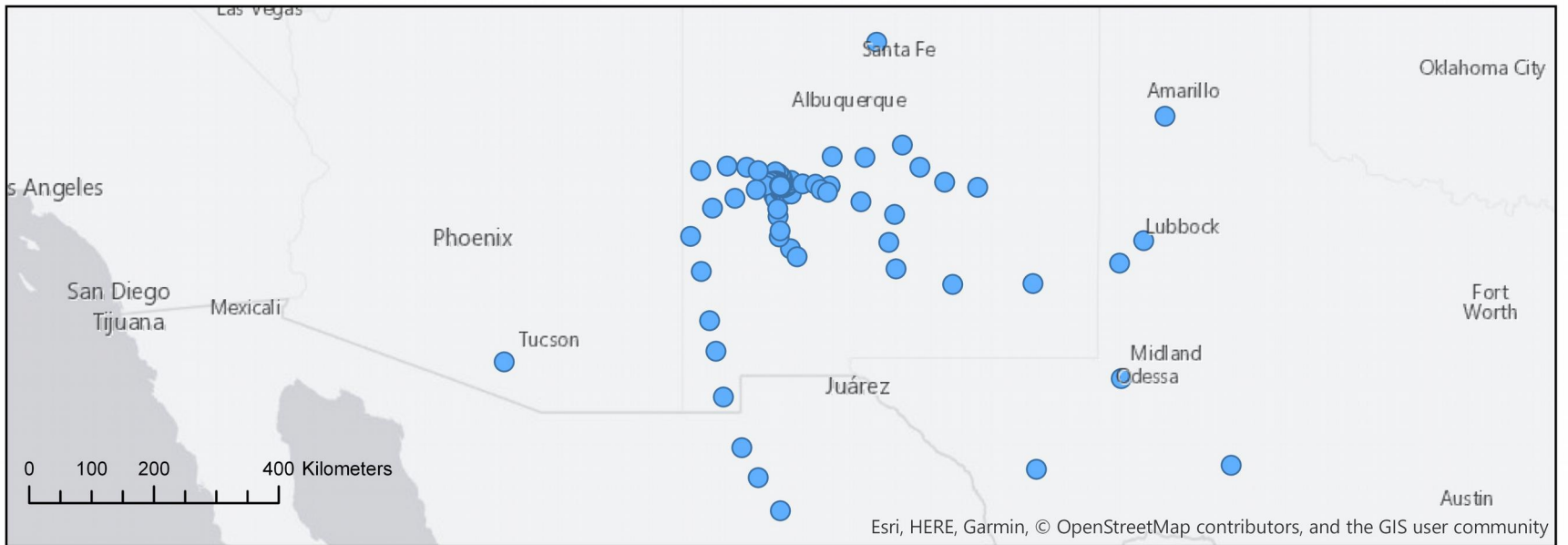
Unveiling Finer Details
> 10x current resolution
Previously unseen details



244 Antennas, 18 Meters in Diameter
+ 19 Antennas, 6 Meters in Diameter
1.2 – 116 GHz Frequency Coverage
Subarray Capability
Pulsar Capability



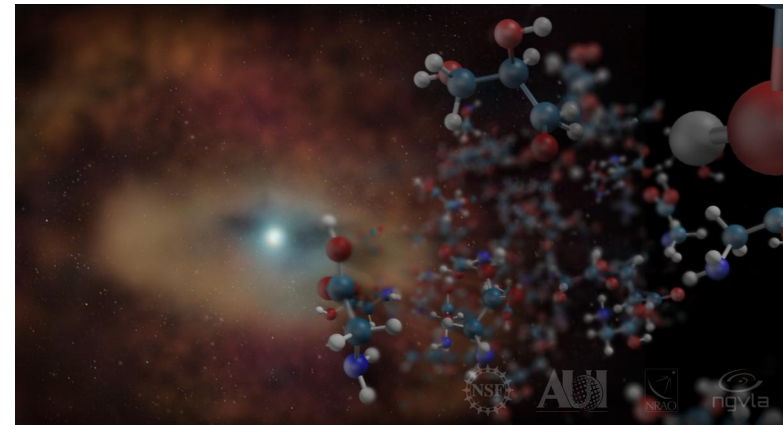
ngVLA Antenna Distribution



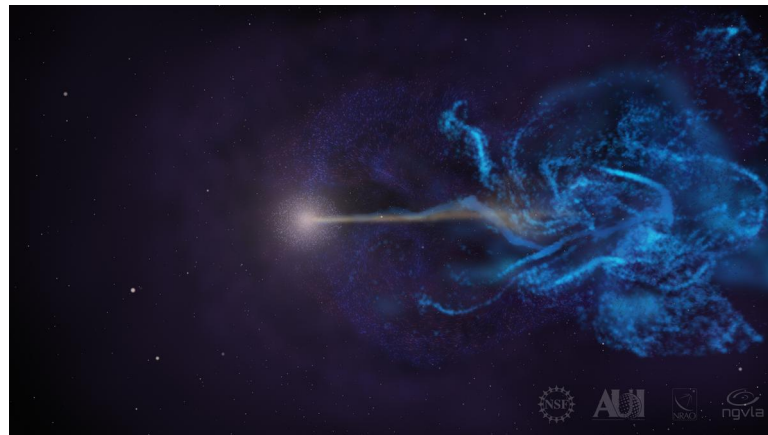
ngVLA Science



Learning how Solar Systems are formed



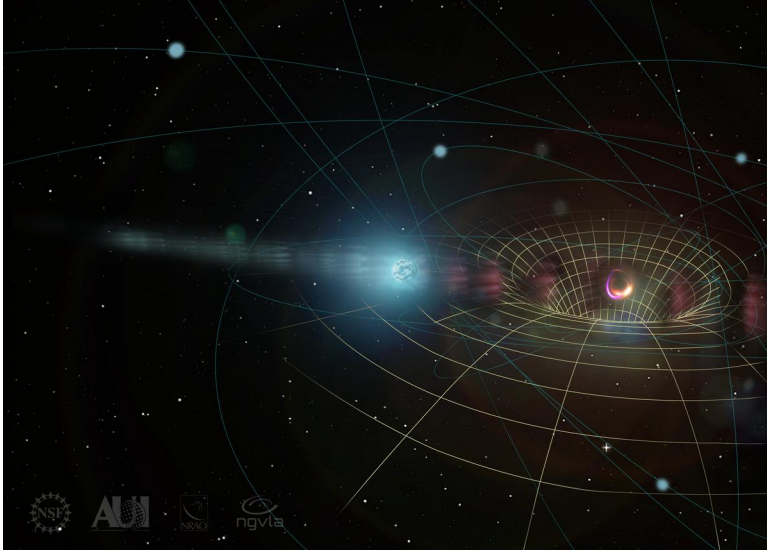
Revealing the chemical foundations of life



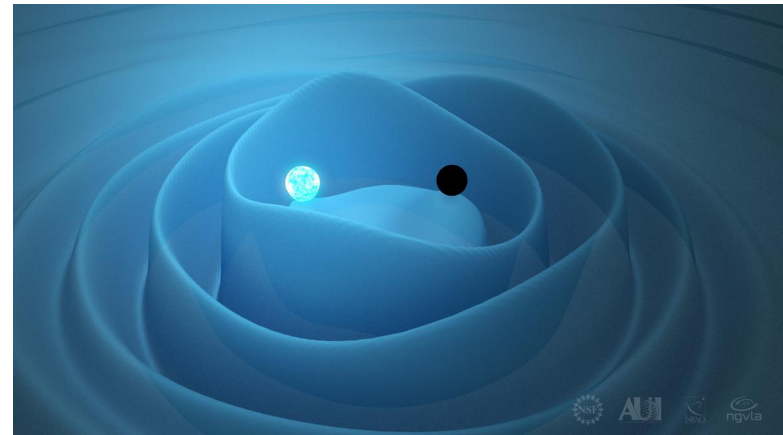
Charting the assembly, structure, and evolution of galaxies



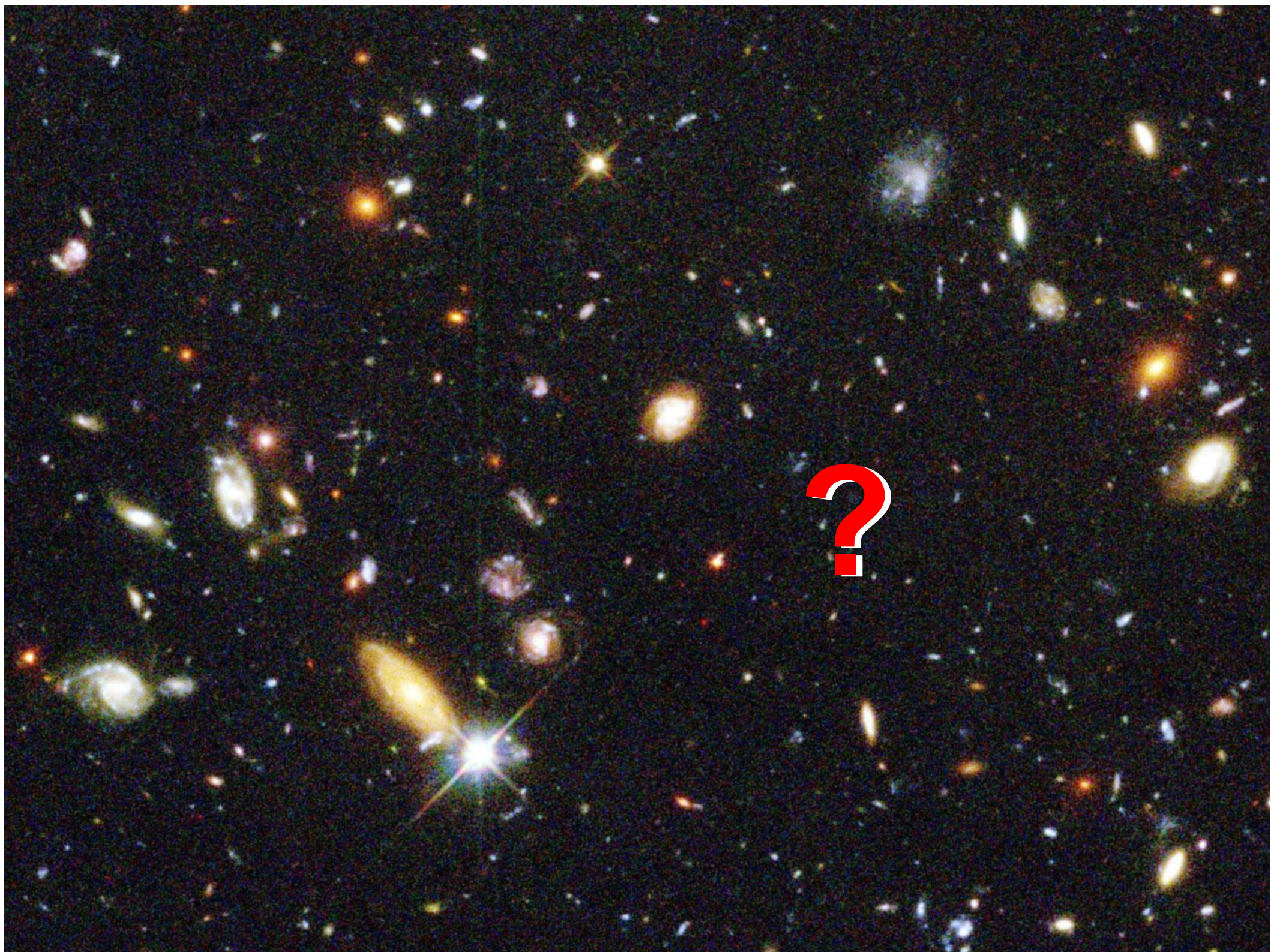
ngVLA Science



**Fundamental tests
of gravity, using pulsars
at the Galactic center**



**Understanding the formation
and evolution of black holes**



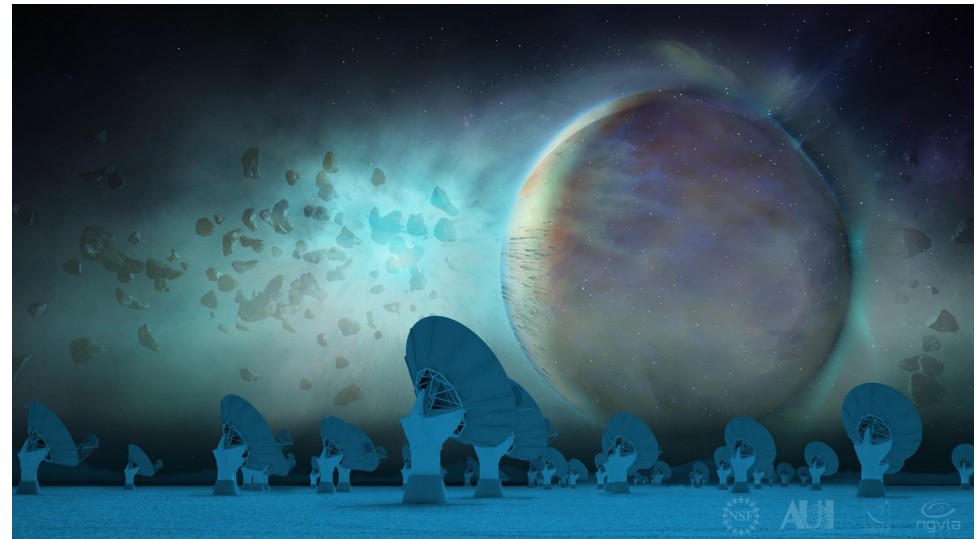
Very Large Array

Karl G. Jansky Very Large Array

ngVLA

More than four decades
of frontier science

*And poised
for a new century!*



Thank You



**Dave Finley
National Radio Astronomy Observatory**