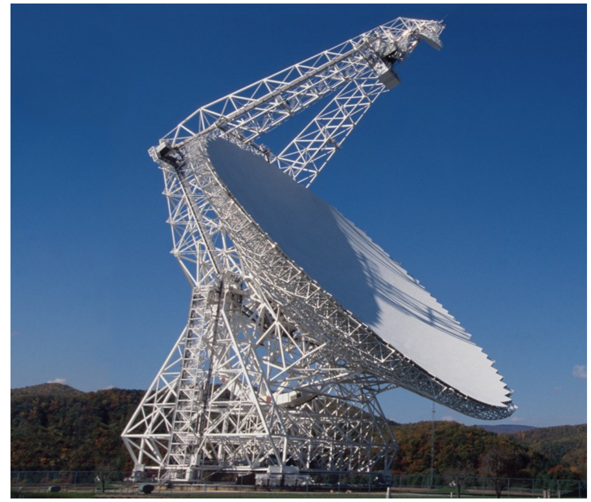
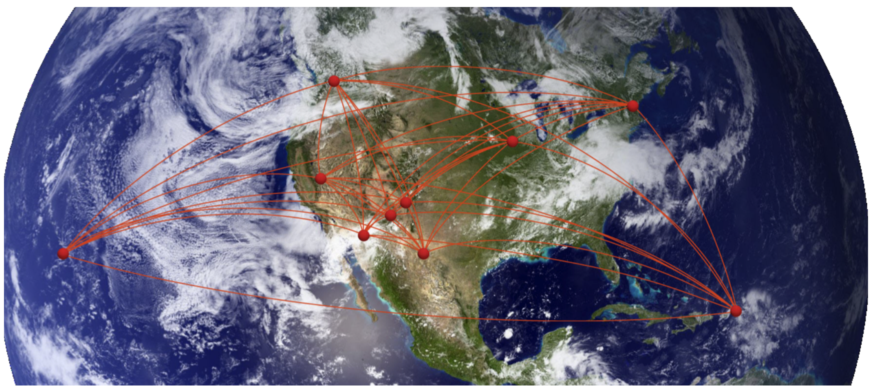
National Radio Astronomy Observatory





Overview of NRAO
Mark Lacy

Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

NRAO:
One Observatory, Four Facilities

NRAO:
One Observatory, Four Facilities

Atacama Large Millimeter/submillimeter Array:
a 66-antenna array in Chile

NRAO

NRAO:
One Observatory, Four Facilities

Jansky Very Large Array:
a 27-antenna array in New Mexico

NRAO

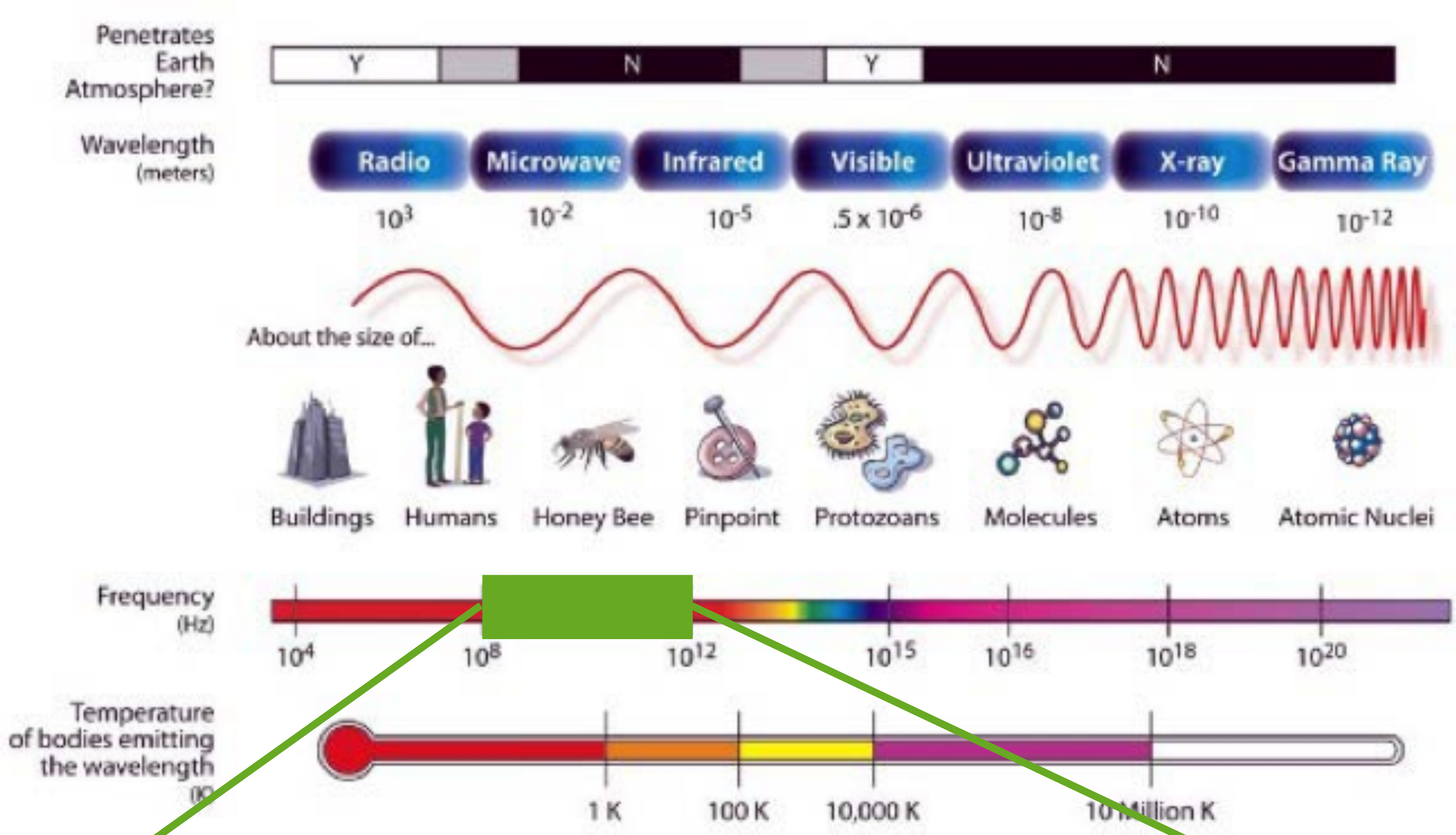
NRAO:
One Observatory, Four Facilities

Robert C. Byrd Green Bank Telescope: world's largest fully steerable radio telescope, in West Virginia

NRAO:
One Observatory, Four Facilities

Very Large Baseline Array:
ten radio antennas spanning 8000 km

NRAO


Penetrates Earth Atmosphere?
Y
N
Y
N
Wavelength (meters)
Radio
Microwave
Infrared
Visible
Ultraviolet
X-ray
Gamma Ray
10^3
10^-2
10^-5
.5 x 10^-6
10^-8
10^-10
10^-12
About the size of...
Buildings
Humans
Honey Bee
Pinpoint
Protozoans
Molecules
Atoms
Atomic Nuclei
Frequency (Hz)
10^4
10^8
10^12
10^15
10^16
10^18
10^20
Temperature of bodies emitting the wavelength (K)
1 K
100 K
10,000 K
10 Million K


GBT
0.1 - 120 GHz
3000 - 3 mm


VLBA
1 - 100 GHz
300 - 3 mm


VLA
1 - 50 GHz
300 - 6 mm

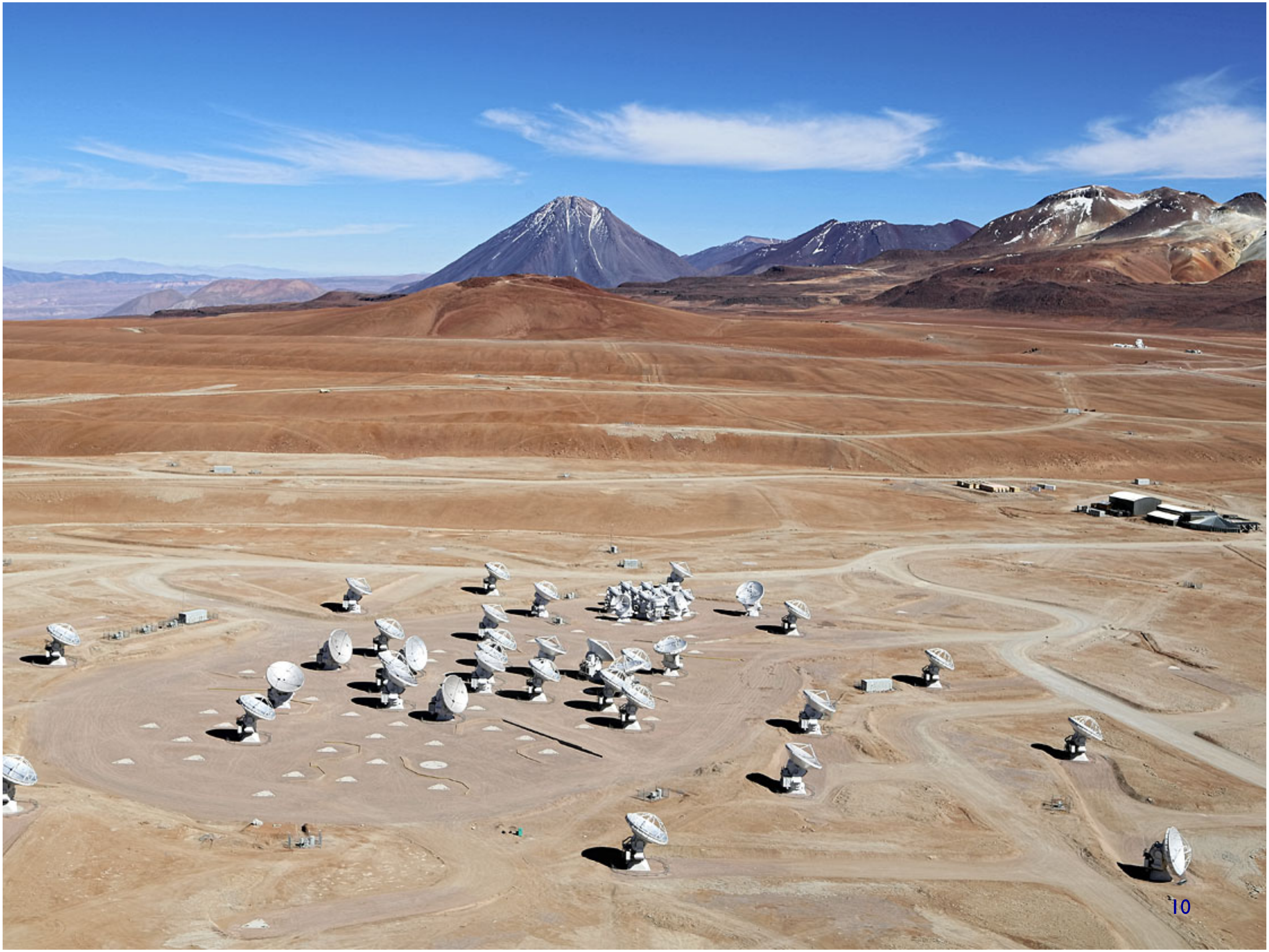

ALMA
80 - 950 GHz
3 - 0.3 mm

Broad Science Topics with NRAO Telescopes

- Sun – coronal mass ejections, magnetic field activity
- Solar system, KBOs – atmospheres, astrometry, composition
- Star-forming regions – dust and gas environment, kinematics (infall, outflows, jets), proto-planetary disks, cores, chemistry, feedback, and natal cloud / star interactions
- Exoplanets – direct imaging, planet formation (gaps in disks), kinematics
- Pulsars – neutron star physics, pulse morphology, gravity, ISM probe
- Galactic structure – spiral arms, bars, global atomic and molecular gas properties
- Nearby galaxies – molecular/atomic gas content and kinematics, dynamics of galaxies at high resolution, star formation, obscured SF, gas flow, astrochemistry
- Galaxy groups and clusters – atomic and molecular gas across systems, star formation efficiency, kinematics, dynamical mass measurements
- Black holes – mass measurements, kinematics
- High redshift galaxies – extragalactic background light, source counts, star formation history and efficiency, evolution of gas content (atomic and molecular)
- Cosmology – H_0 measurement, Sunyaev-Zeldovich Effect

ALMA Overview

- A global partnership to deliver a revolutionary millimeter/submillimeter telescope array
  - North America (US, Canada, Taiwan)
  - Europe (ESO)
  - East Asia (Japan,Taiwan)
  - In collaboration with Chile
- 5000 m (16,500 ft) site in Chilean Atacama desert
- 66 telescopes in full operation
  - Main Array: 50 x 12m antennas
  - Total Power Array: 4 x 12m antennas
  - Atacama Compact Array (ACA): 12 x 7m antennas



ALMA in a Nutshell…

- Angular resolution down to 15mas (at 300 GHz)
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 315 μm)
- State-of-the-art low-noise, wide-band receivers (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities
- Up to 1 TB/day data rate
- All science data archived
- Pipeline processing

ALMA in a Nutshell…

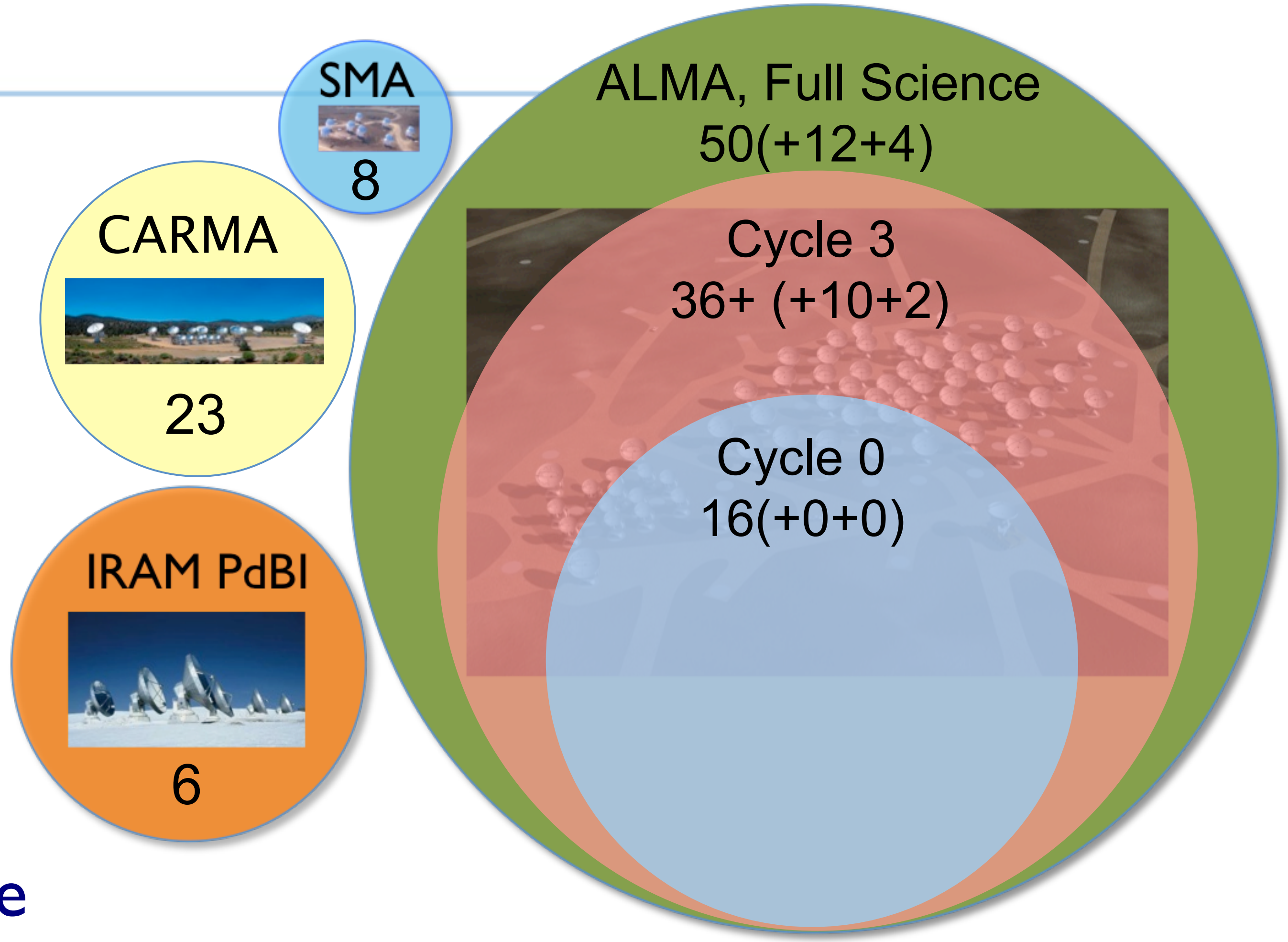
- Angular resolution down to 0.015” (at 300 GHz)
- Sensitive, precision imaging 84 to 950 GHz (3 mm to 315 μm)
- State-of-the-art low-noise, wide-band receivers (8 GHz bandwidth)
- Flexible correlator with high spectral resolution at wide bandwidth
- Full polarization capabilities
- Estimated 1 TB/day data rate
- All science data archived
- Pipeline processing

ALMA is 10-100 times more sensitive and have 10-100 times better angular resolution than previous mm interferometers

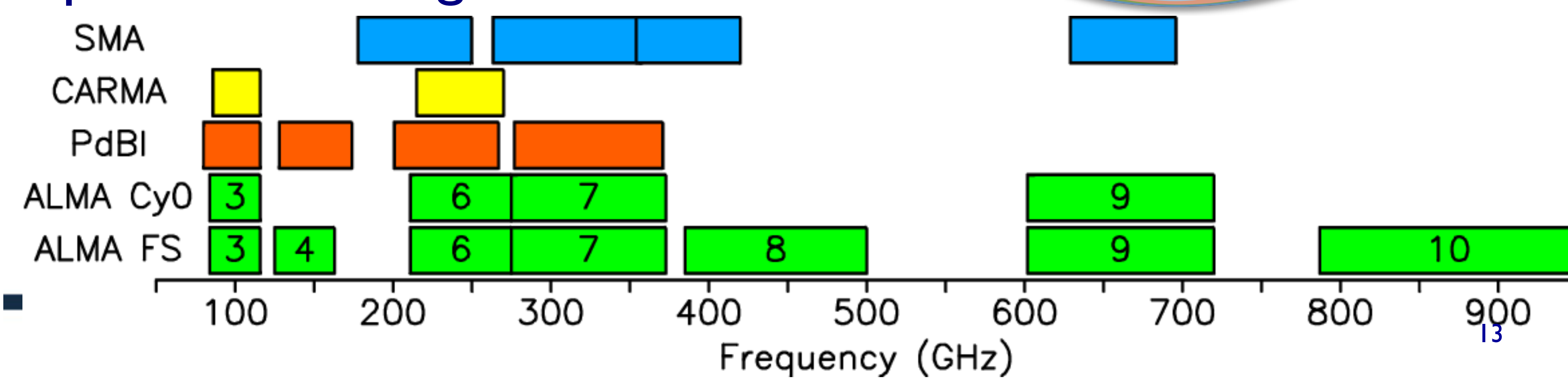
ALMA is a telescope for *all* astronomers

Collecting Area

~ sensitivity

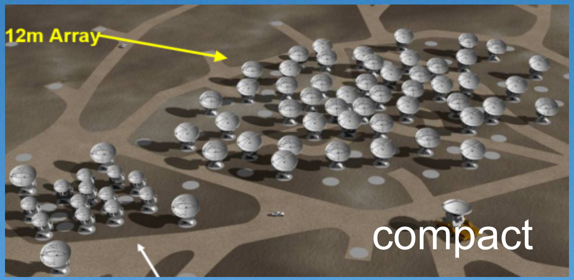


Spectral Coverage



ALMA

An array of **66 antennas,**
using *aperture synthesis* *as a* "zoom lens"
over the *entire accessible mm/submm* wavelength range
up to 1 THz



Built to operate
>30 years

Remotely operated from
OSF Control room

ALMA Current Status

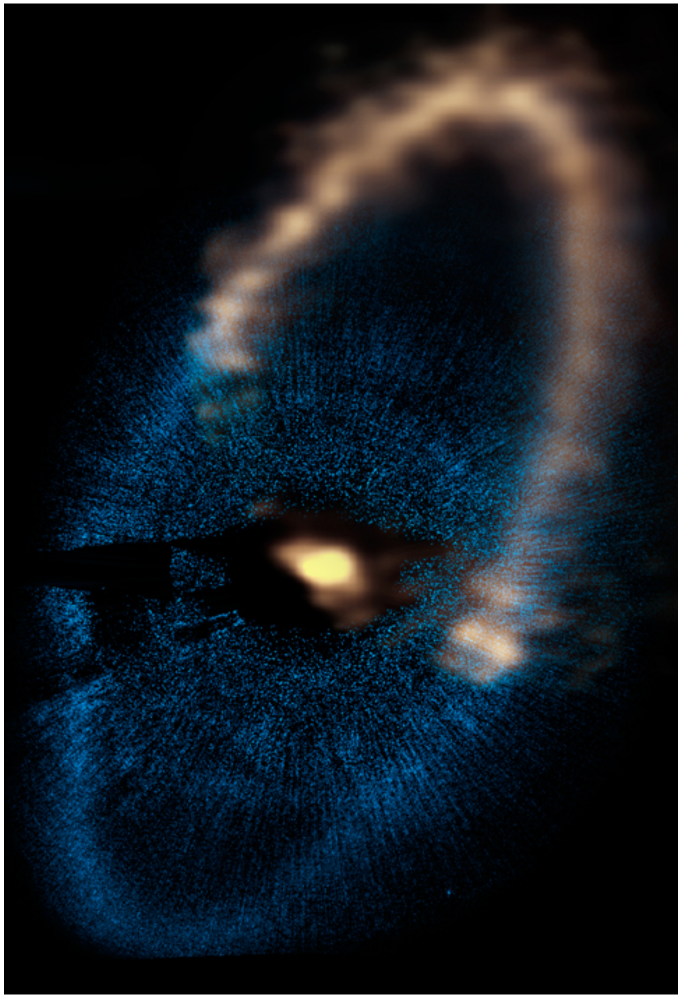
- Construction Project ended in September 2014
- Routine science observing has been limited to 10 km baselines (C36-8), but observations out to 15 km have been proven successful (thanks to the Long Baseline Campaign last year)
- **All 66 antennas accepted**
  - Currently 64 antennas are at the high site (AOS), of which ~47 on average (up to max ~54) are being used for Cycle 3 observations
  - Some construction and verification items remain to be finished (e.g. special observing modes such as OTF and full-field polarization)
- The ACA (Atacama Compact Array) or Morita-san Array – up to 12x7m antennas and 4x12m antennas for TP observations – has been accepted and is routinely used for observations (standalone option in Cycle 4).

ALMA Receivers: Current Status

- Receiver bands currently installed on all antennas
  - Band 3, 3mm (84-116 GHz)
  - Band 4, 2mm (125-163 GHz)
  - Band 6, 1mm (211-275 GHz)
  - Band 7, 850 μm (275-370 GHz)
  - Band 8, 650 μm (385-500 GHz)
  - Band 9, 450 μm (602-720 GHz)
  - Band 10, 350 μm (787-950 GHz)
- Receiver bands partially installed and currently undergoing verification
  - Band 5, 2.5mm (163-211 GHz)

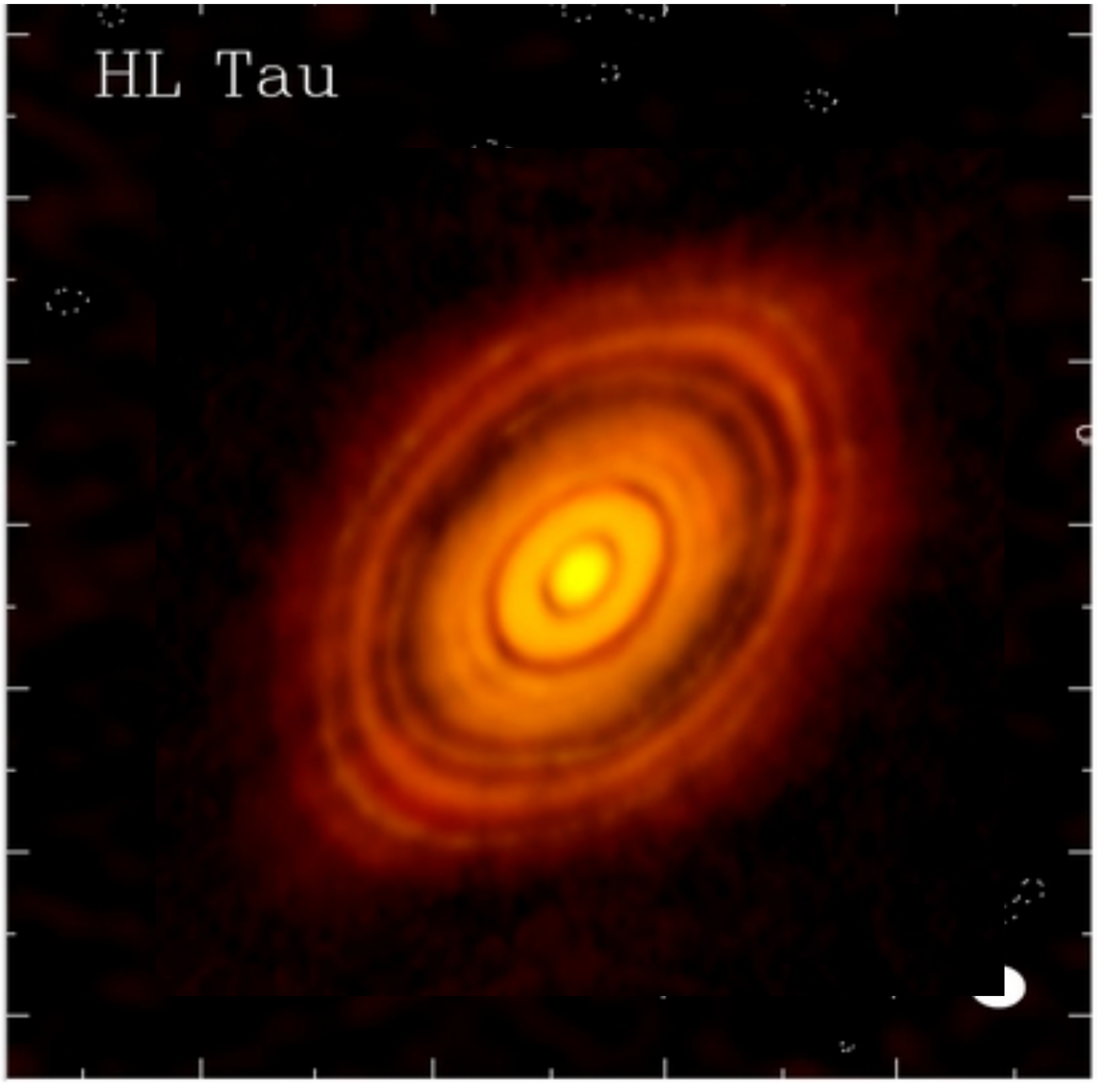
Formation of Planetary Systems

- Remarkably thin, sharp-edged Fomalhaut debris disk: 13-19 AU wide
- Two shepherding planets likely corral the disk on either side
- Each exoplanet < 3 Earth masses
- Data acquired with only 15 ALMA antennas



Boley et al. 2012

ALMA Long Baseline Campaign

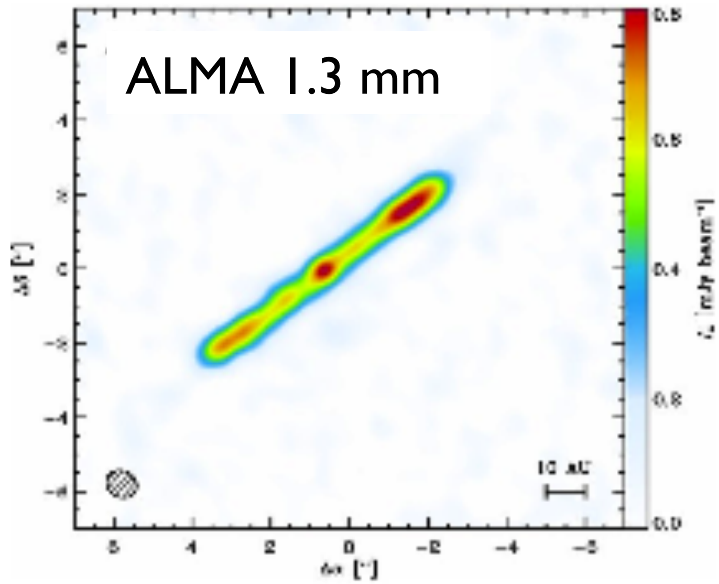


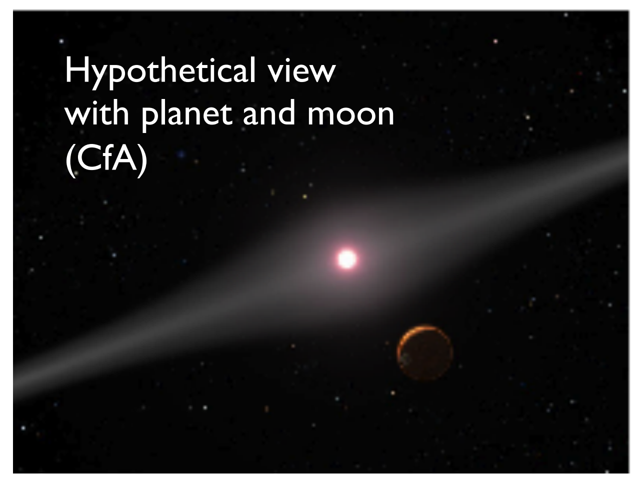
CARMA Observation of HL Tau, resolution of ~25AU

AU Mic: Young Solar System Analog

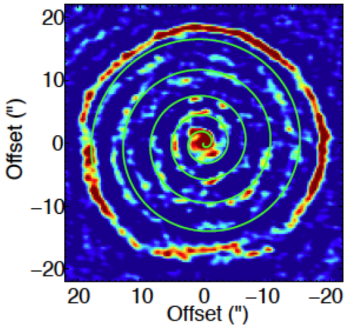
- Two debris emission components
- Central peak: stellar photosphere + asteroid-like belt at a few AU?
- Outer dust belt extends to 40 AU, to break in scattered light profile
  - truncated, reminiscent of classical Kuiper Belt
  - no detectable asymmetries in structure or position: compatible with Uranus-like planet

MacGregor et al. 2013





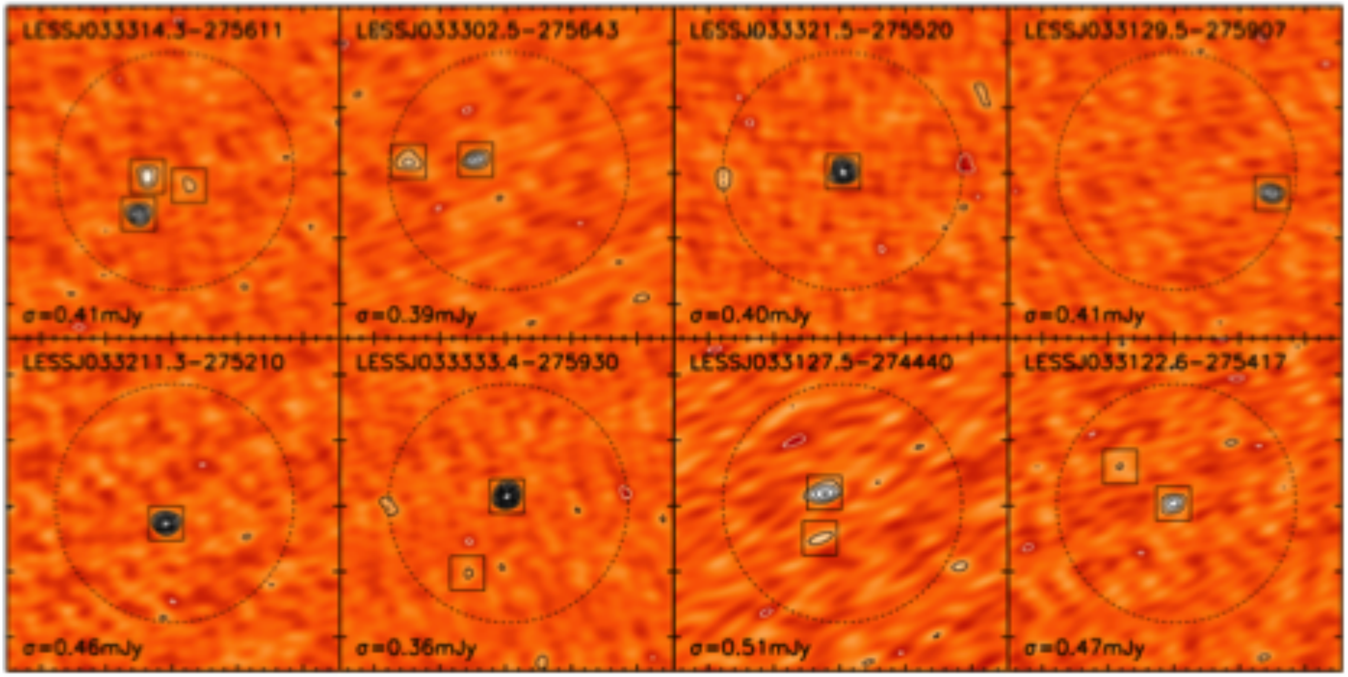
ALMA Measures Stellar Feedback



Maercker et al 2012

- ALMA's high sensitivity high resolution CO image measures the mass (0.003 M_{sun} and timescale (200 years) of feedback to the interstellar medium from the AGB star R Sculptoris and reveals the star to be a binary

Resolving High-z Submm Galaxies



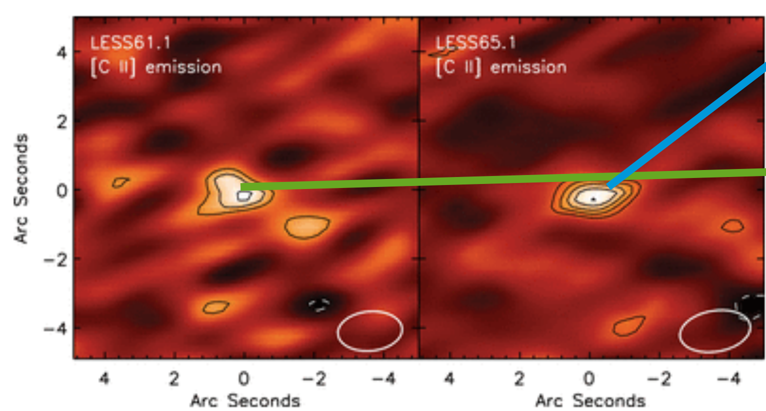
Hodge et al. 2013

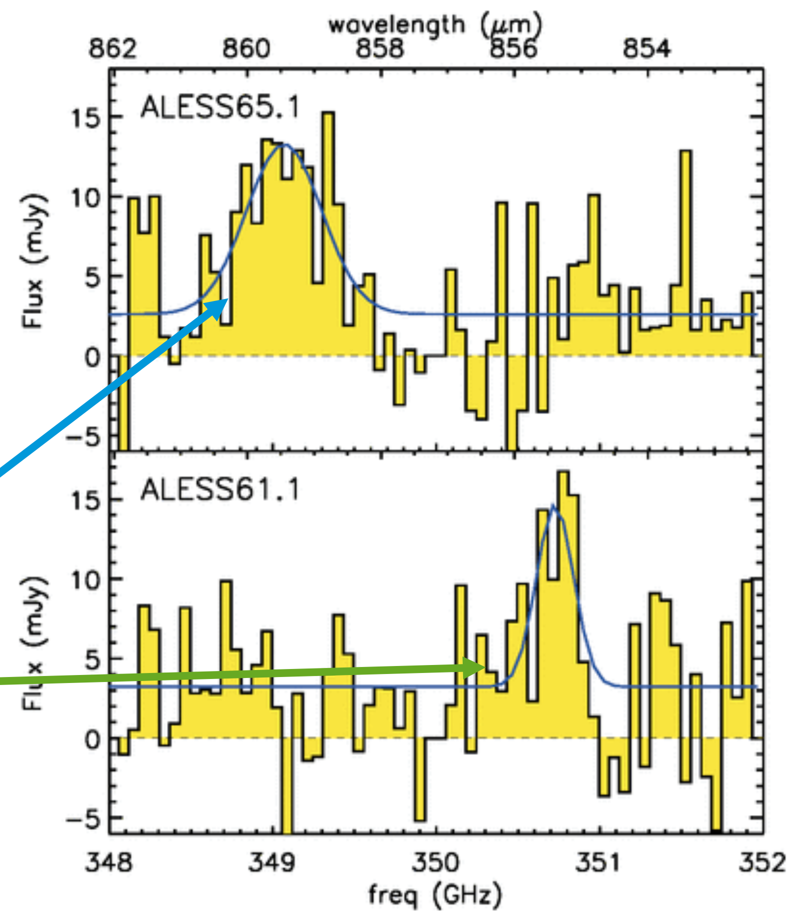
- 126 submm sources observed with ALMA at 870 μm
- 2x deeper, 10x higher angular resolution than previous surveys
- 99 sources detected in 88 fields, integration time ~120 sec
- Significant multiplicity (35-50%) found at 0.2” resolution

Serendipitous [C II] Detection

ALMA 870 μm continuum observations of 100+ submm galaxies resulted in serendipitous detection of [CII] in two galaxies at z ~ 4.4

- Bright end of cooling function evolves strongly between z ~ 0 and 4.4
- Increased interstellar medium cooling at high star formation rates





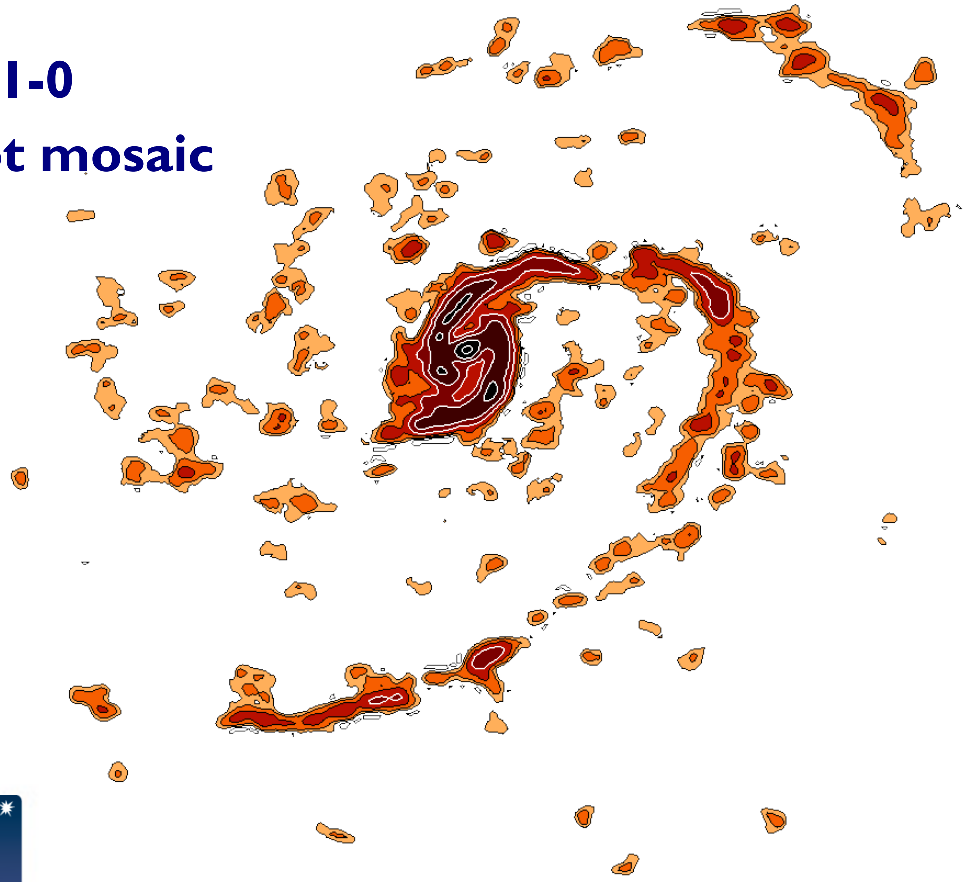
Swinbank et al. 2012

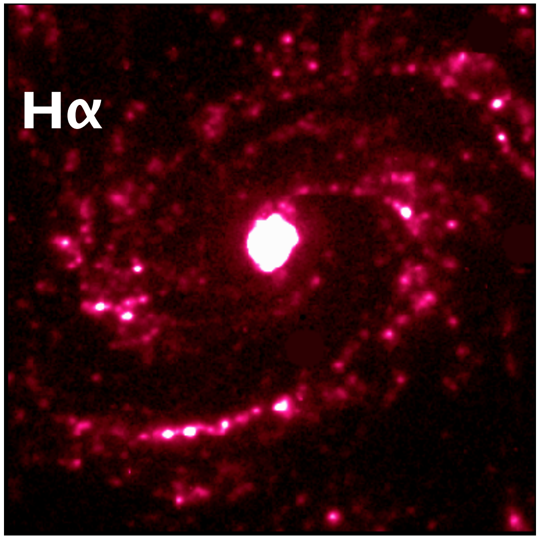
ALMA Images Nearby Galaxies

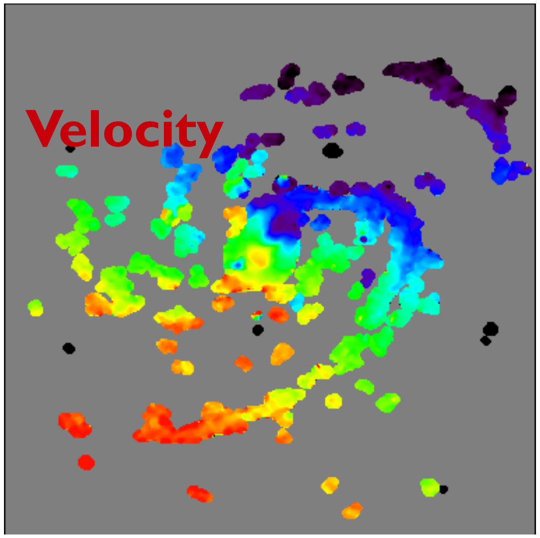
Science verification imaging of M100

CO 1-0

47-pt mosaic







ALMA Development Program

- Goals
  - Incorporate development ideas from the NA ALMA community into the ALMA Development Program
  - Support development of conceptual and detailed designs for new or upgraded ALMA Observatory capabilities
  - Support ALMA-relevant, long-term R&D
- Upgrades progress through three phases:
  1) Conceptual study
  2) Prototype/pre-production
  3) Full production and implementation
- Priorities are science-driven

ALMA Development Program

- Call topics of particular interest are
  - Focal Plane Arrays
  - Phased Array Feeds
  - Increased ALMA bandwidth
- North American ALMA Partners and the North American radio astronomy community at-large are eligible to participate in the Program
- Collaborations are encouraged
- Your participation is welcome and appreciated
- New call for Studies (small scale exploratory proposals): https://science.nrao.edu/facilities/alma/alma-development-cycle4/call-for-proposals-study
- Please direct your questions to Bill Randolph, Program Manager

  (wrandolp@nrao.edu)

The Green Bank Telescope in 2016

Next GBT, VLA, VLBA/HSA/VLBI proposal deadline is

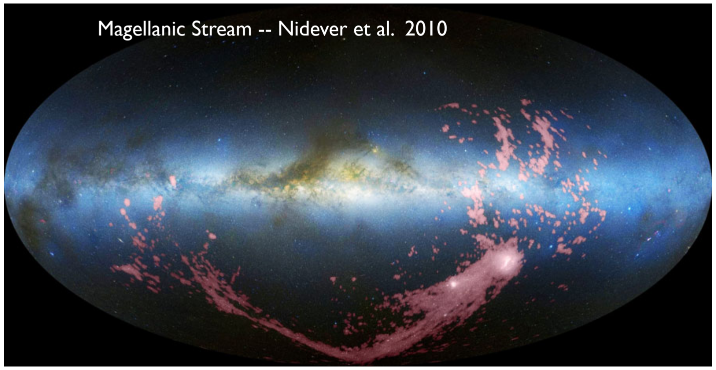
August 01, 2016 at 5pm EST

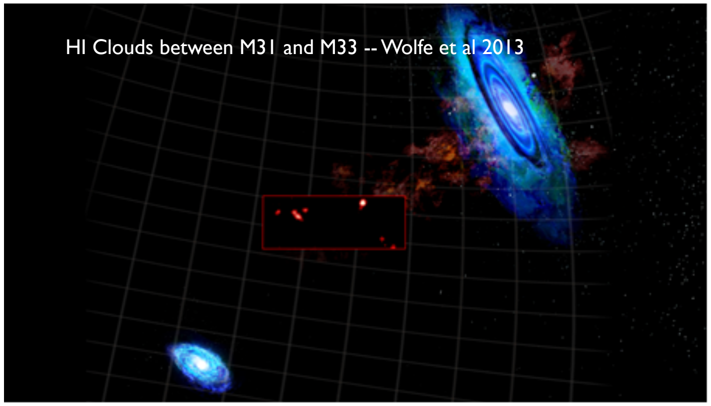
which is for semester "17A" (Feb 2017 – Aug 2017 observations)

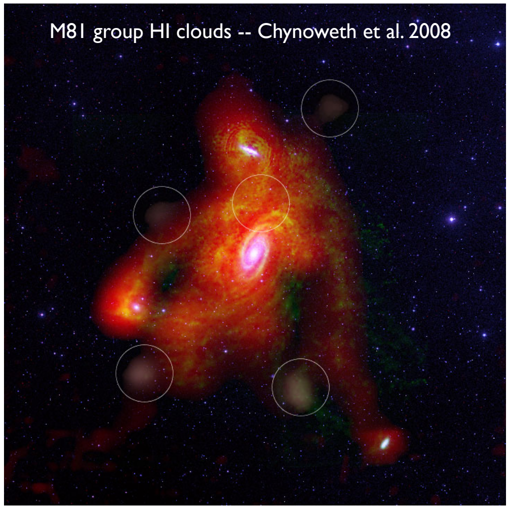
GBT Studies of faint HI -- unequalled sensitivity

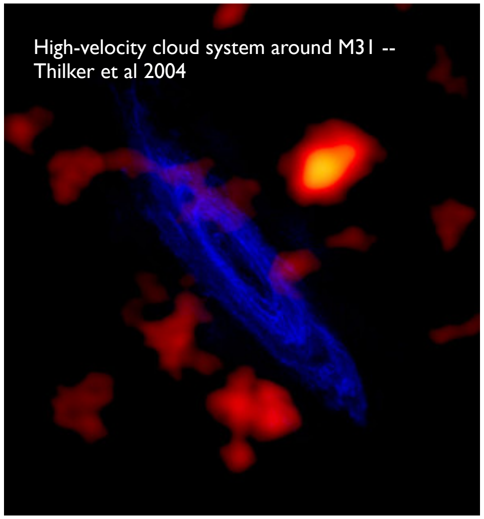
GBT offers ability to detect HI to N_{HI} ~10^{17} cm^{-2}

- Interactions
- Outflows from winds and fountains
- Cool gas accretion







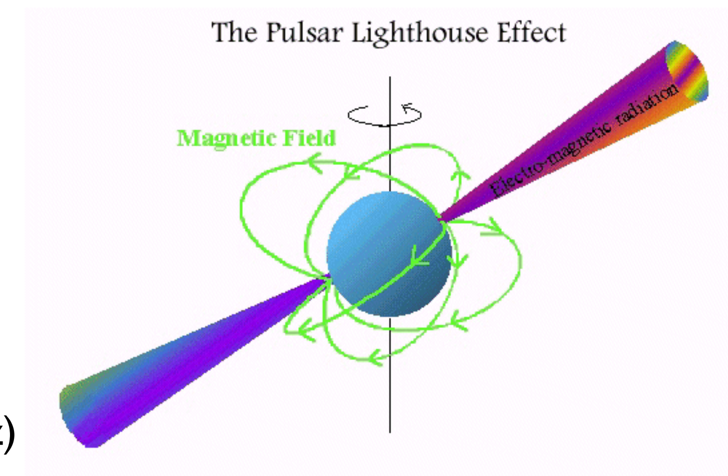


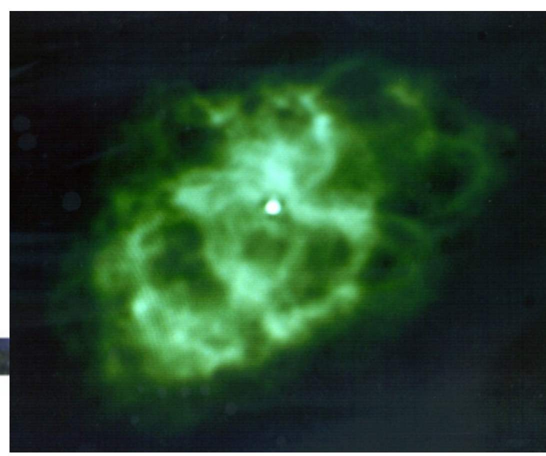
The GBT remains the world's premier pulsar observatory

(Quiet Zone, collecting area, receivers, detectors, sky coverage)

The Pulsar Renaissance:

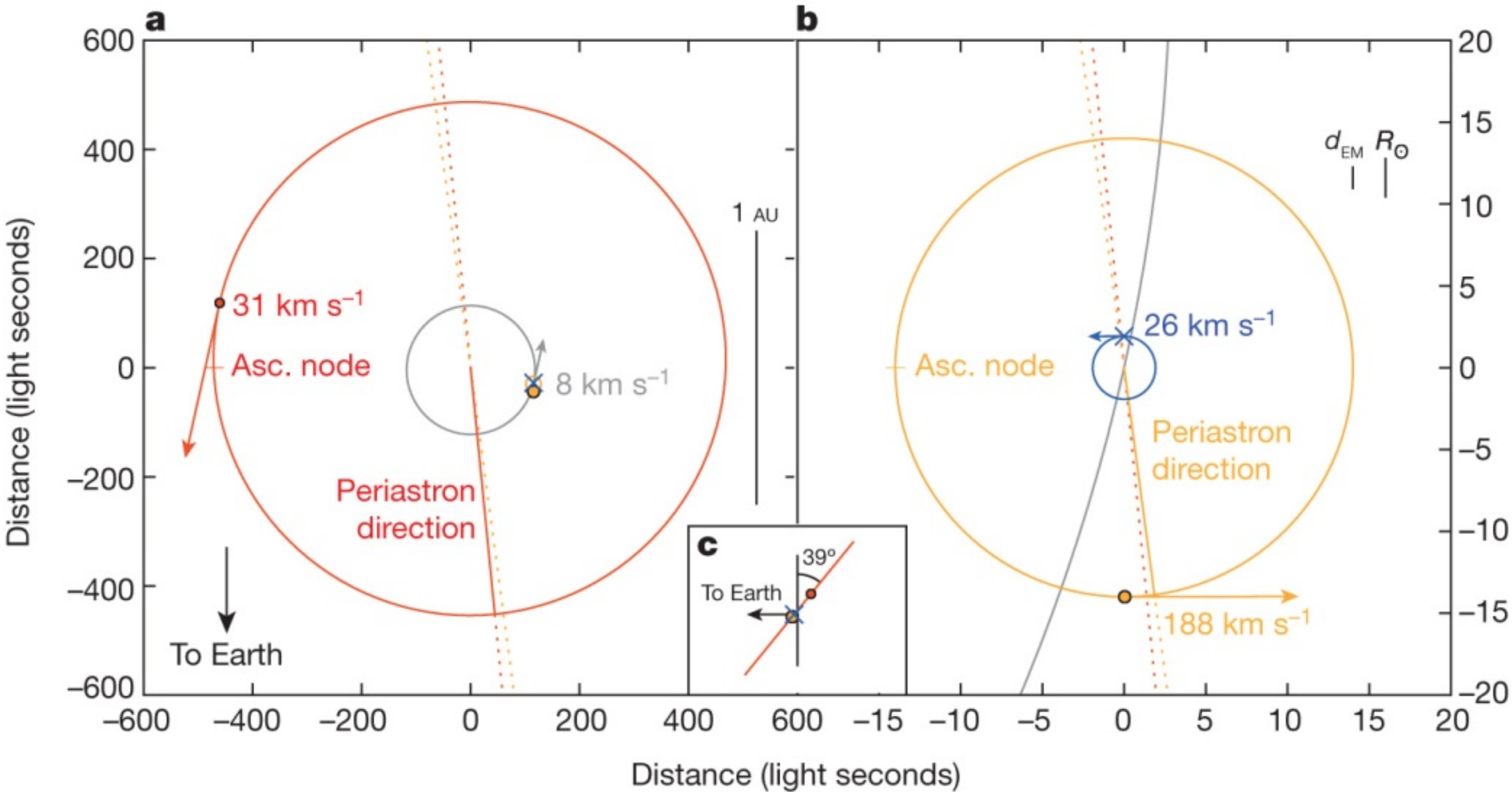
- Fastest Pulsar
- Most Massive Pulsar
- Pulsars in Globular Clusters
- Tests of General Relativity
- Relativistic Spin Precession
- Pulsar in a three-body system
- Coolest white dwarf star (a diamond as big as the Ritz)





GBT Discovery of a Pulsar in a Triple System

Ransom et al. Nature (2014)

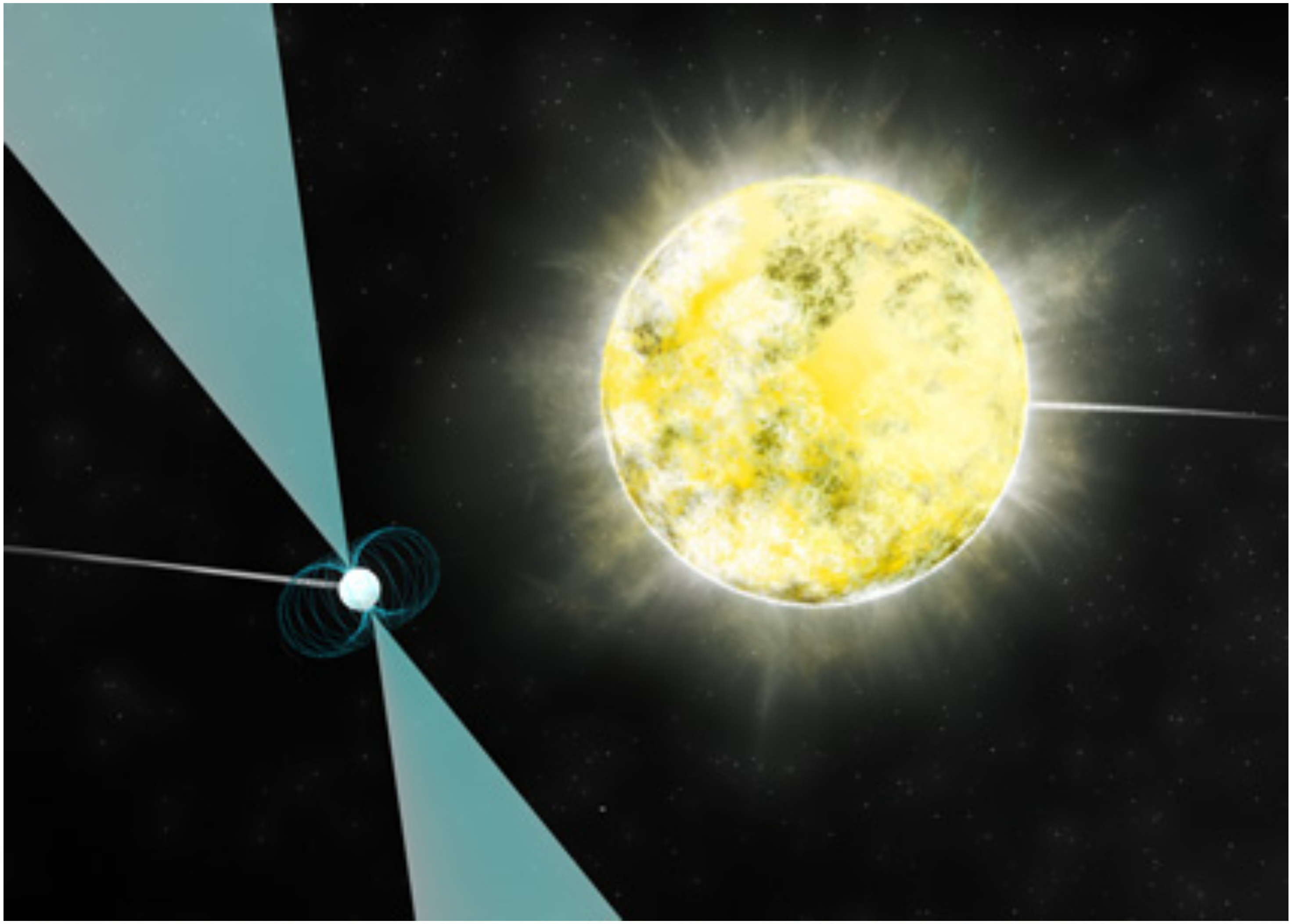


Masses: 1.4378(13), 0.19751(15), 0.4101(3) M$_\odot$
Angle between orbital planes: 1.20(17)x10^{-2} deg

Testing the Equivalence Principle

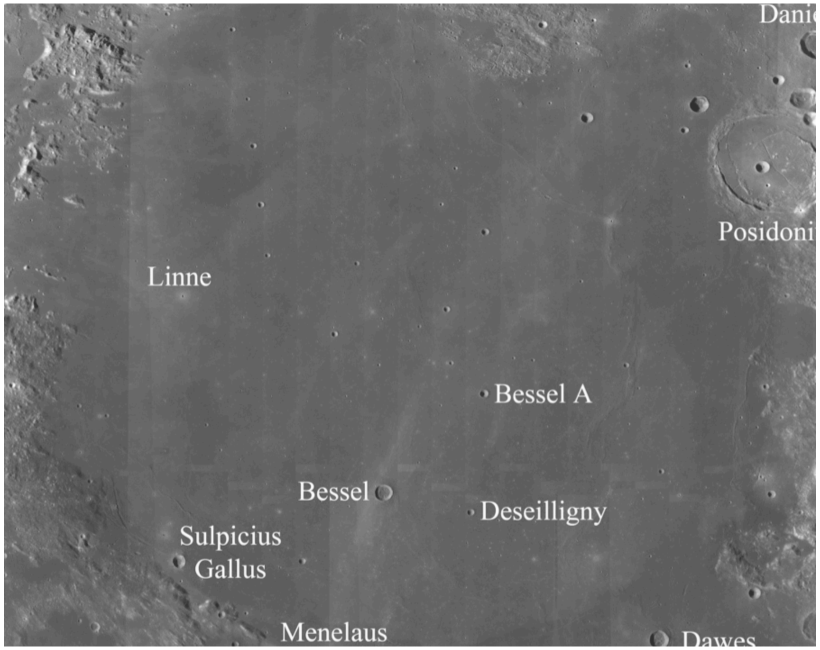
A Solid Carbon "Diamond" Star Orbiting a Pulsar

Kaplan et al. (2014)

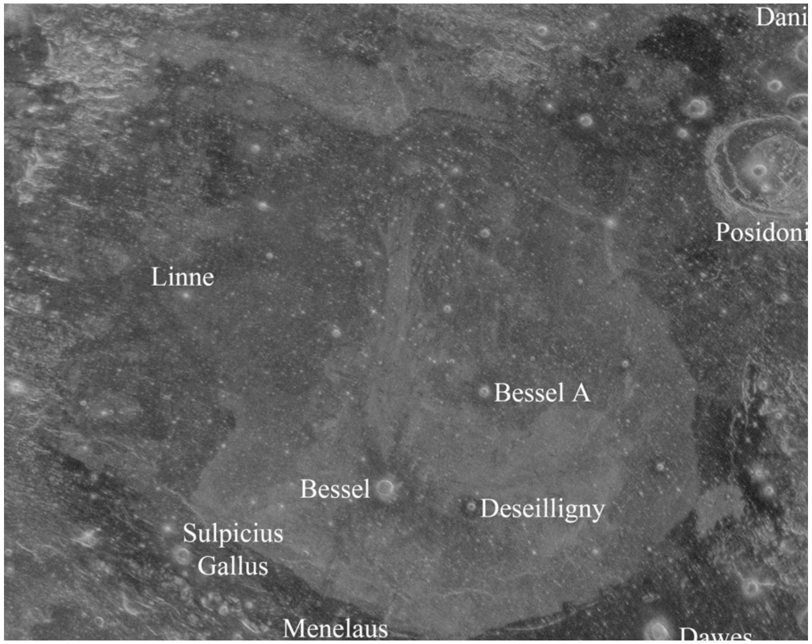


GBT Bi-static radar studies with Arecibo

Campbell, B.A. et al. 2014 JGR-P



Optical



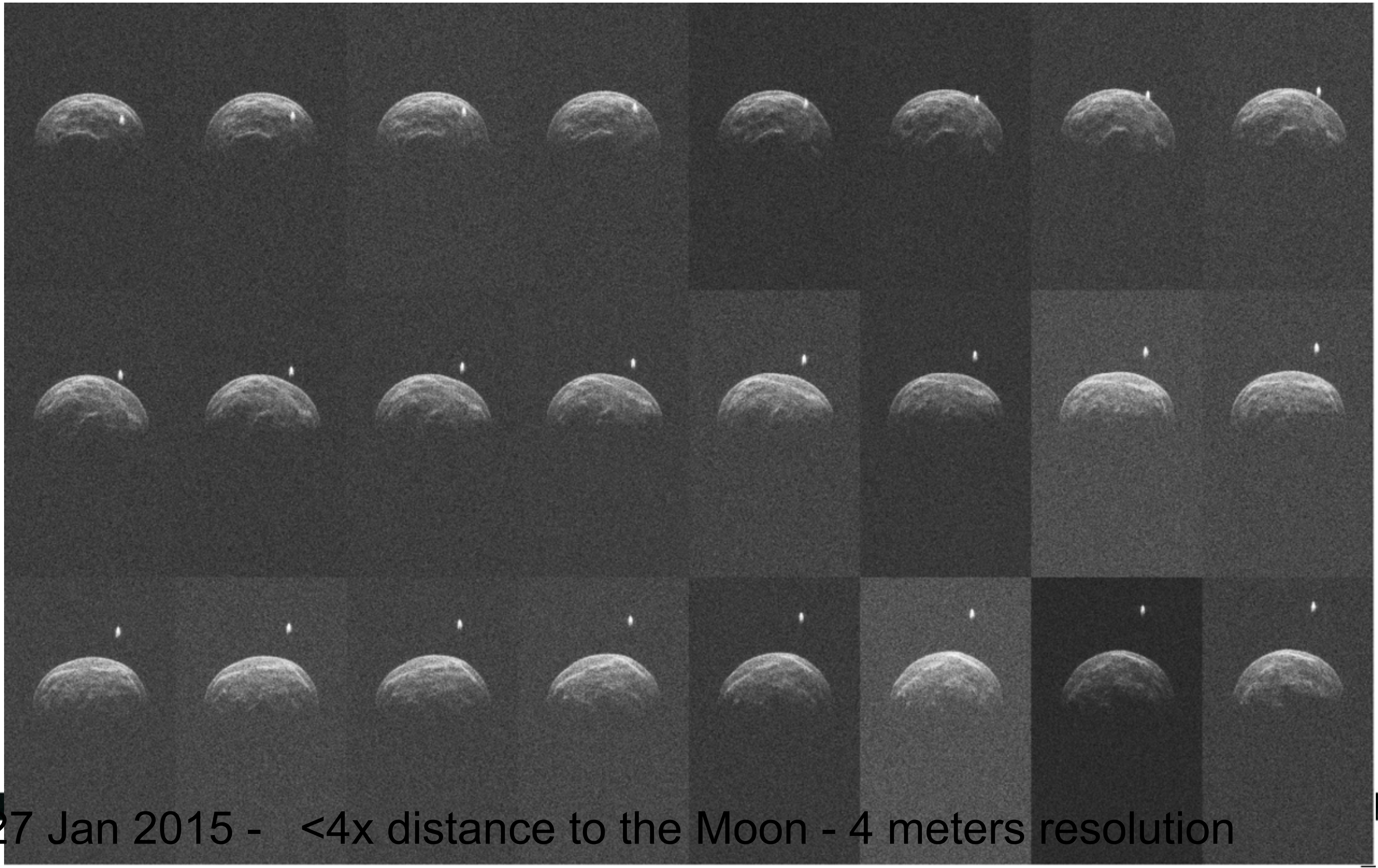
70cm radar

"The 70 cm backscatter differences provide a view of mare flow-unit boundaries, channels, and lobes unseen by other remote sensing methods."
-- Campbell, B.A. et al. JGR-P 2014

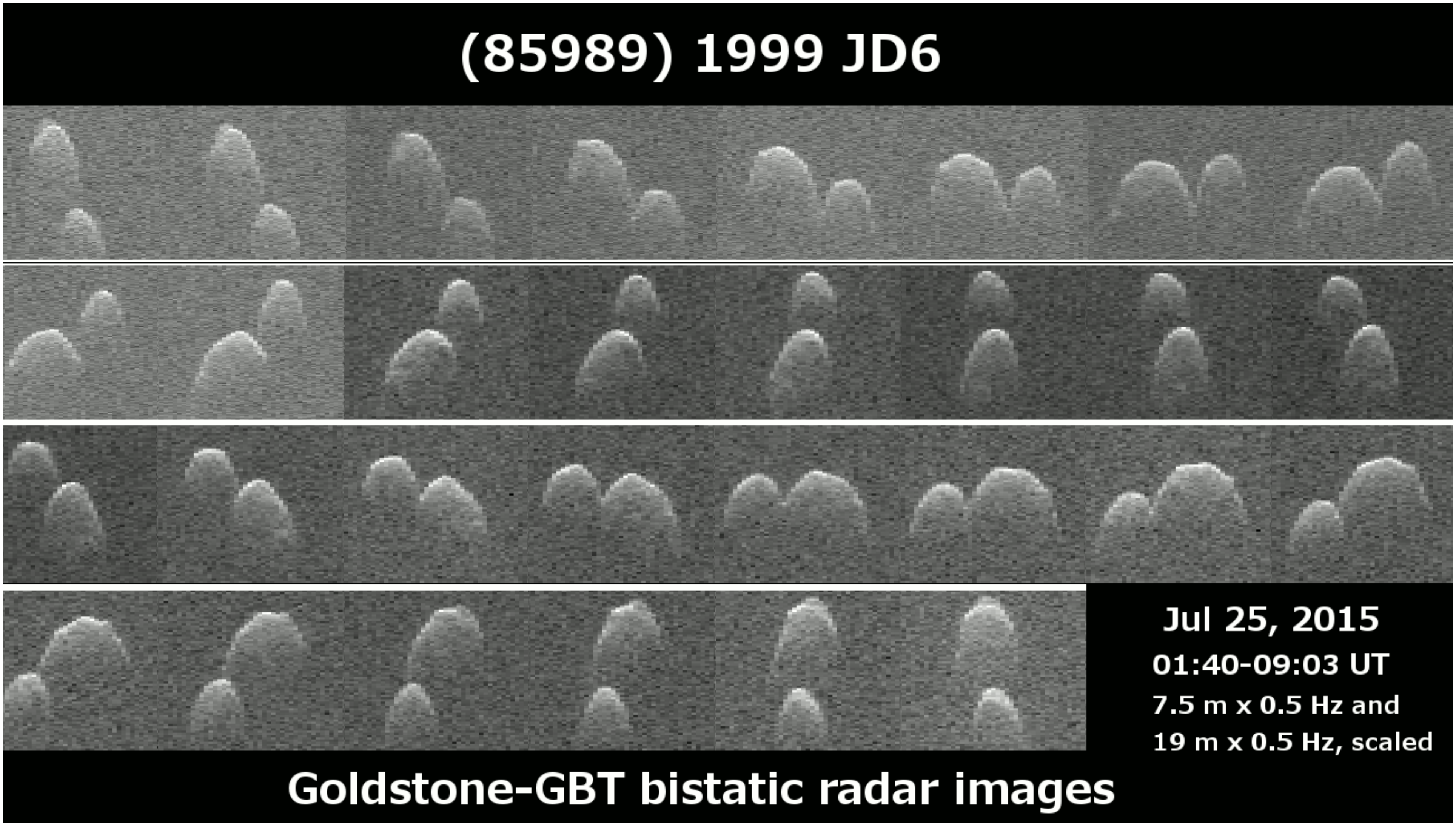
New GBT radar backend in 2014 from JPL

NRAO

Asteroid 2004 BL86
DSS/Goldstone - GBT Radar

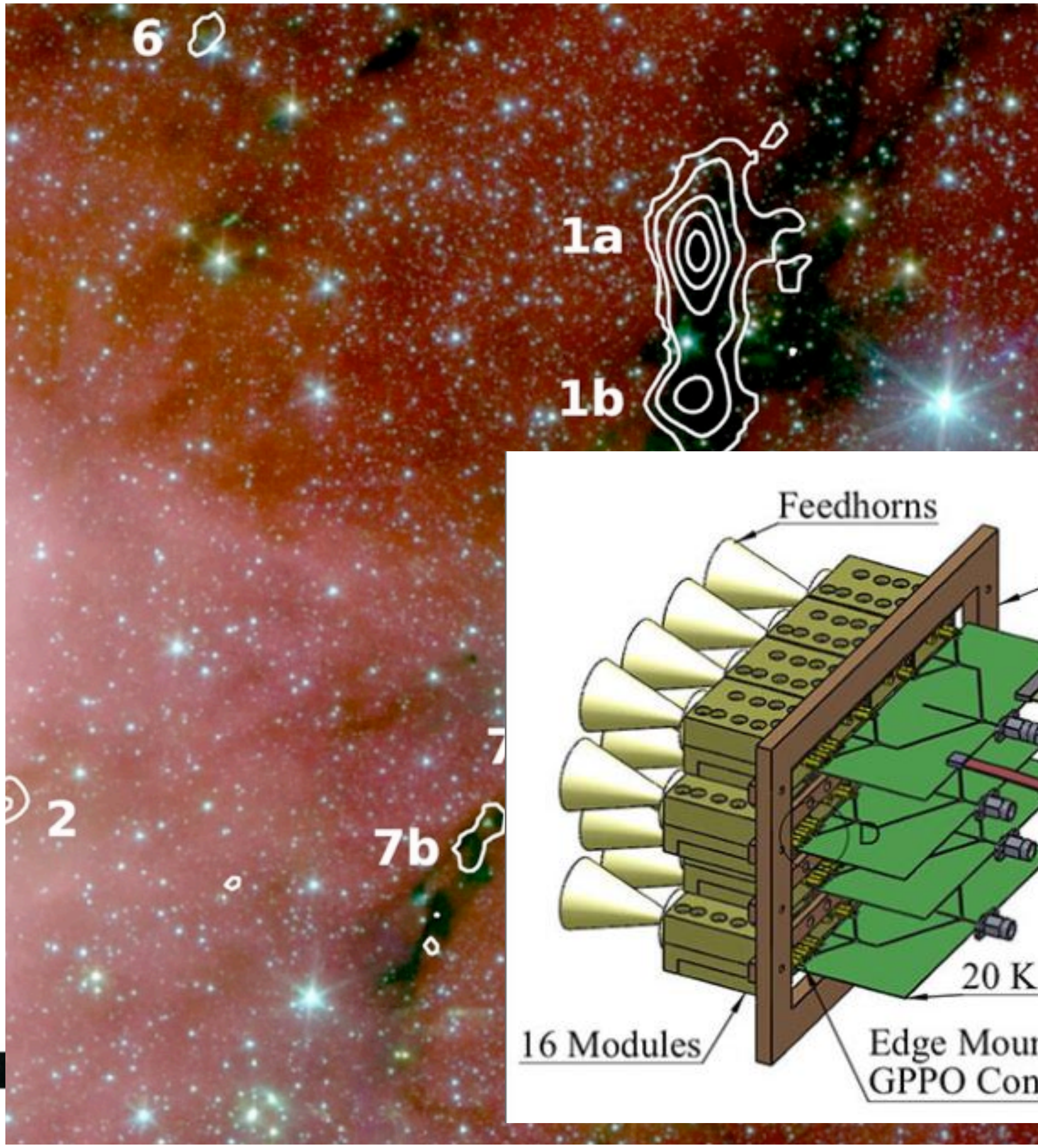


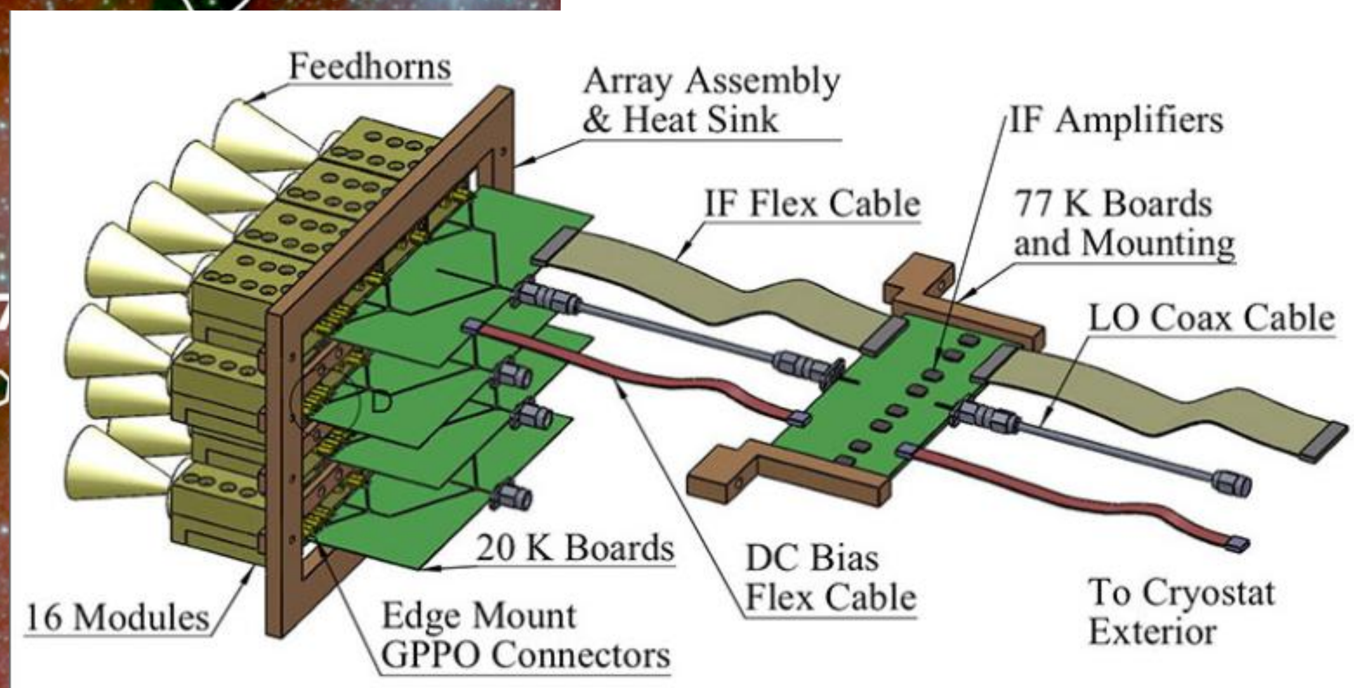
27 Jan 2015 - <4x distance to the Moon - 4 meters resolution



~18x the distance to the Moon

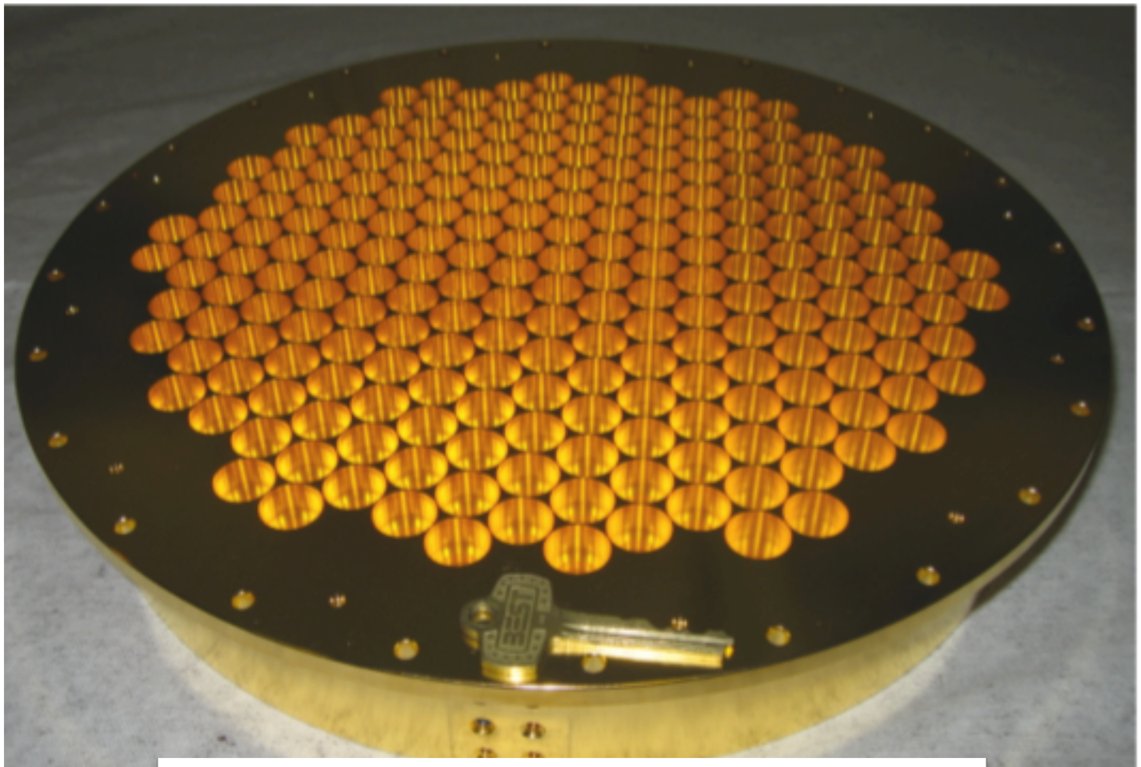
ARGUS – 8” GBT spectroscopy at 3mm





- 16 element scalable 75-115 GHz FPA
- Stanford/CIT-JPL/UMd/ Miami/NRAO
  (NSF grant to Stanford)

GBT MUSTANG - 2 (NSF grant to Univ Penn)

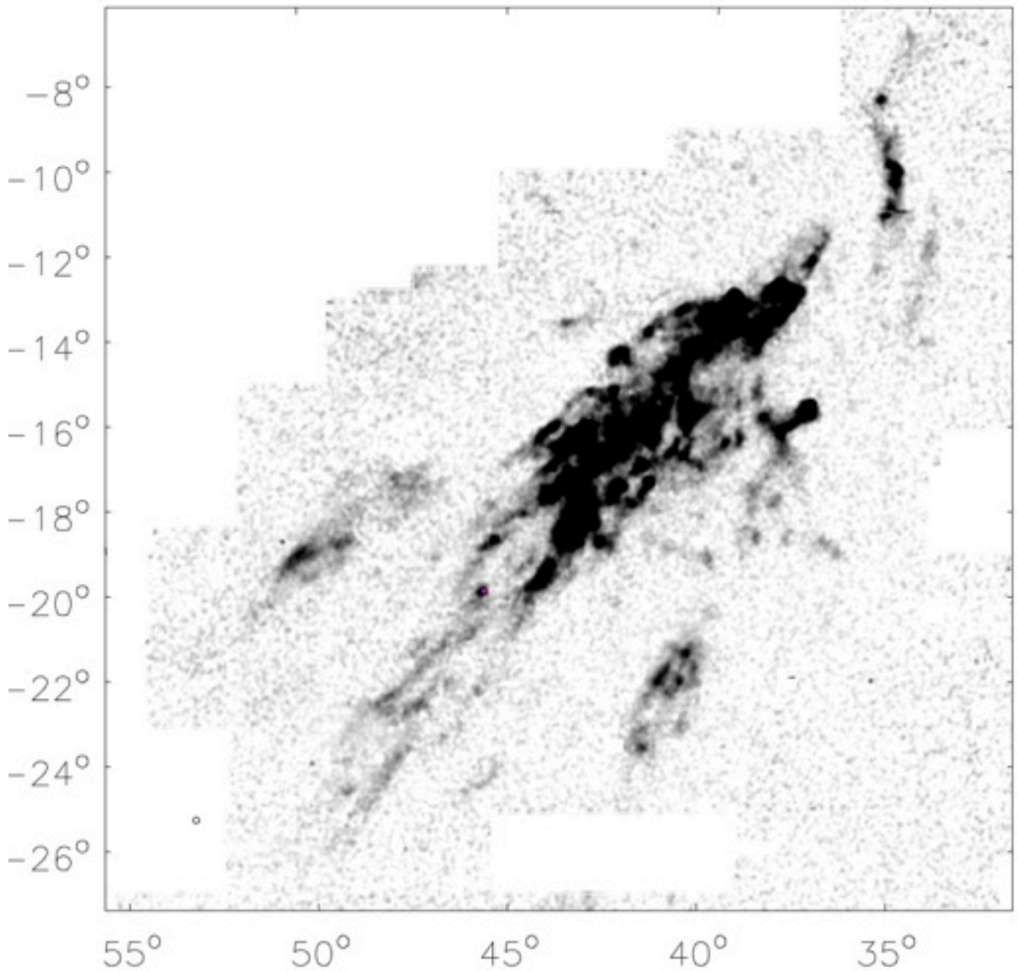


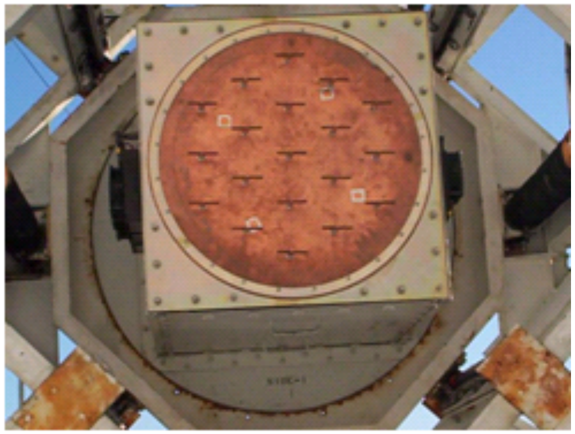
223 pixels
>4’ FOV
35x faster than MUSTANG

NRAO

GBT HI mapping of the Smith Cloud, a "failed" galaxy?

Nichols et al. (2014), Fox et al (2016)





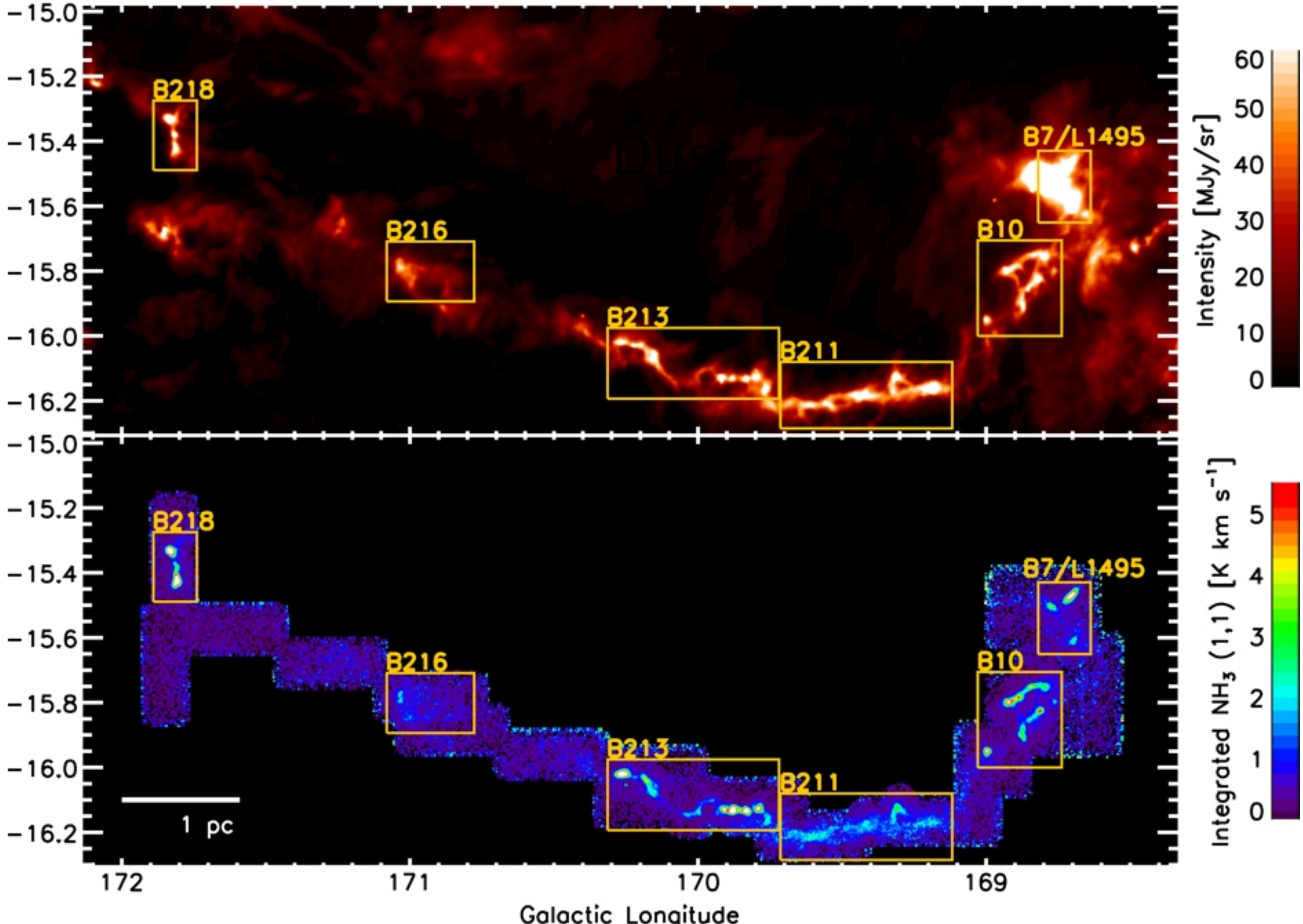
FLAG

19-element phased-array feed [PAF] (7beams) at 21cm

(NSF grant to BYU/WVU)

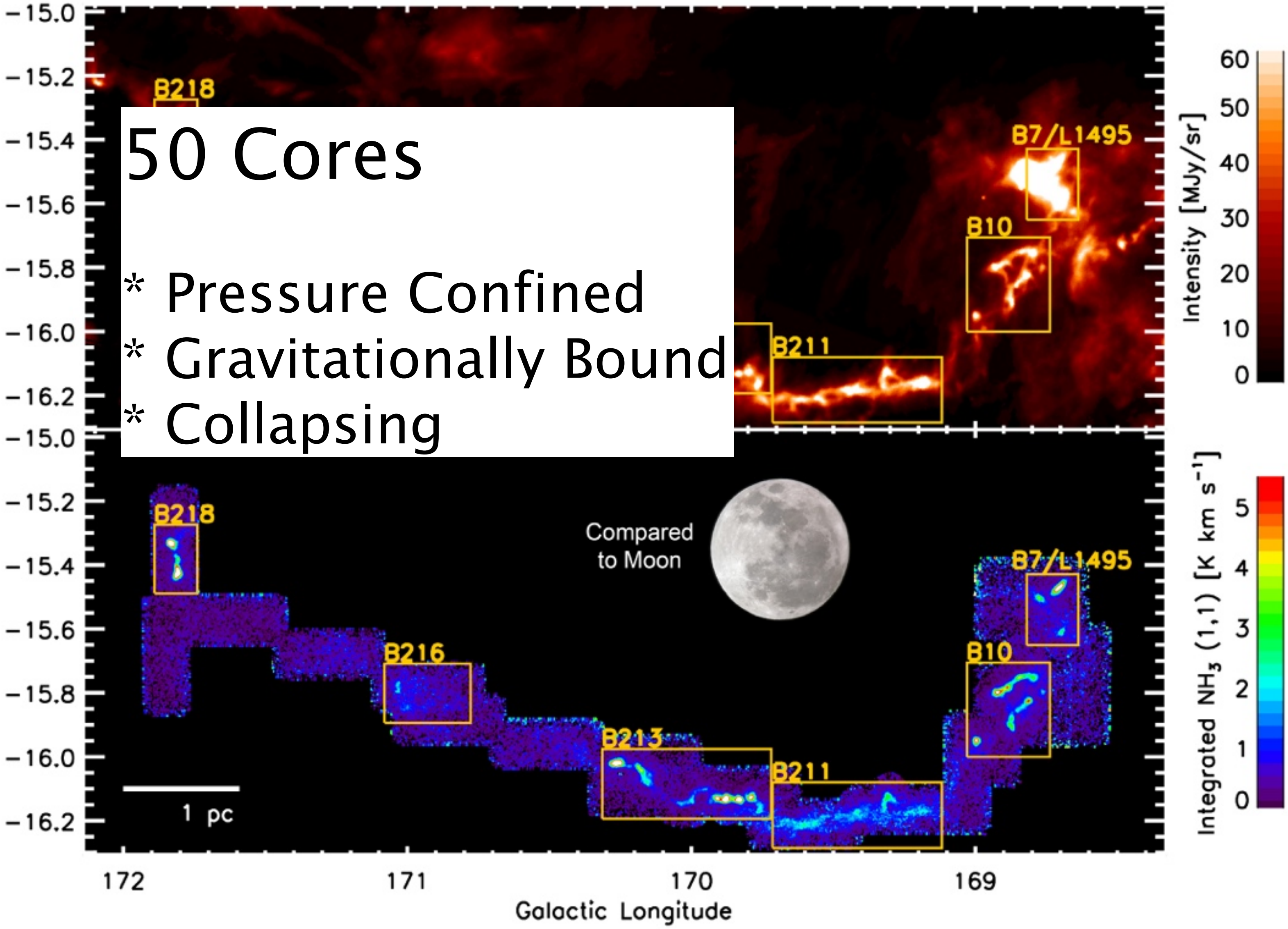
Planned future 20 beam PAF

Star Formation in a Filament in Taurus



Seo et al. 2015 ApJ 805, 185

Star Formation in a Filament in Taurus



50 Cores

* Pressure Confined
* Gravitationally Bound
* Collapsing

Seo et al. 2015 ApJ 805, 185

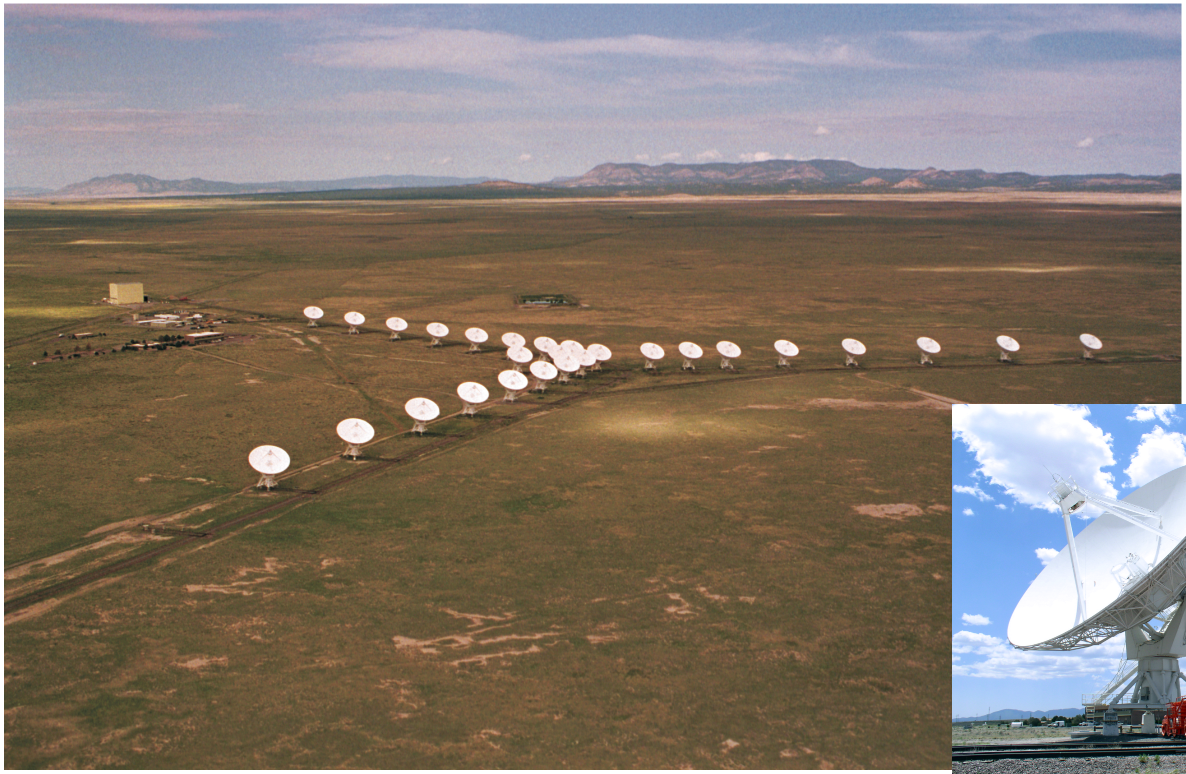
The Karl G. Jansky Very Large Array

Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

NRAO

The (Jansky) VLA

- 27x25m antennas (antennas in the shape of a Y) reconfigurable on baselines 35m to 36km
- located in New Mexico at 2100m altitude



Angular Resolution

- With reconfiguration of the antennas, the array can vary its spatial resolution by a factor of ~40.
- Configuration sequence: D (B_{max}~ 1 km) → C → B → A (B_{max}~ 36 km).
- Reconfiguration every ~4 months.

  The August 1, 2016 deadline is for

  the C and D configurations.

Configuration	A	B	C	D
B_{max} (km[1])	36.4	11.1	3.4	1.03
B_{min} (km[1])	0.68	0.21	0.035[5]	0.035
	Synthesized Beamwidth θ_{HPBW}(arcsec)[1,2,3]			
74 MHz (4 band)	24	80	260	850
1.5 GHz (L)	1.3	4.3	14	46
3.0 GHz (S)[6]	0.65	2.1	7.0	23
6.0 GHz (C)	0.33	1.0	3.5	12
8.5 GHz (X)[7]	0.23	0.73	2.5	8.1
15 GHz (Ku)[6]	0.13	0.42	1.4	4.6
22 GHz (K)	0.089	0.28	0.95	3.1
33 GHz (Ka)	0.059	0.19	0.63	2.1
45 GHz (Q)	0.043	0.14	0.47	1.5

The VLA

- Nine Frequency Bands
  - Eight cryogenic bands, covering 1 – 50 GHz. Utilizes cassegrain subreflector.
  - One uncooled, prime-focus band, covering 50 – 450 MHz.
- Up to 8 GHz instantaneous bandwidth
  - Provided by two independent dual-polarization frequency pairs, each of up to 4 GHz bandwidth per polarization.
  - All digital design to maximize instrumental stability and repeatability.
- Full polarization correlator with 8 GHz instantaneous BW
  - Provides 64 independent 'sub-correlators', and 16384 spectral channels.
  - Many specialized operations modes (burst, pulsar binning, phased arrays …)

Full Frequency Coverage with Outstanding Performance

There are eight cassegrain focus systems, and one prime focus system.

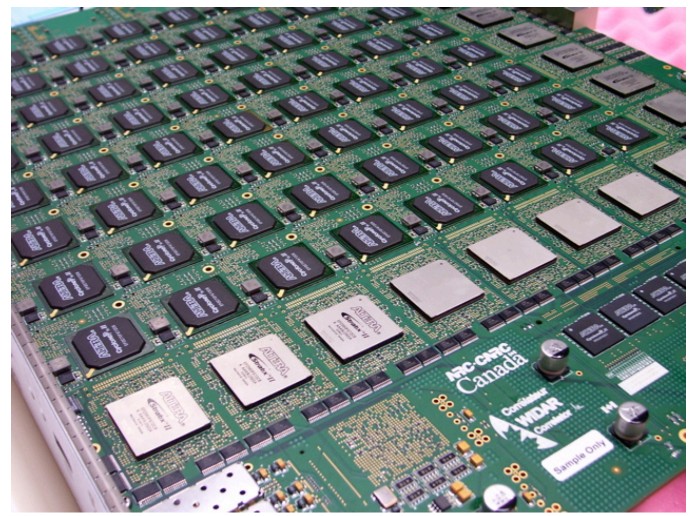
Band (GHz)		SEFD (Jy) (27 antennas)
.05 -- .45	P	~60
1-2	L	13
2-4	S	9.5
4-8	C	8.5
8-12	X	8.1
12-18	Ku	8.1
18-26.5	K	13
26.5-40	Ka	22
40-50	Q	45

Eight feeds around the cassegrain secondary focus ring.

The ‘WIDAR’ Correlator

The VLA’s correlator was built to NRAO’s requirements by the DRAO correlator group, located at the NRC-Herzberg facility near Penticton, BC.

This ‘WIDAR=**W**ideband **I**nterferometric **D**igital **AR**chitecture’ correlator was paid for by the Canadian government, as part of an agreement between NRC and NSF.



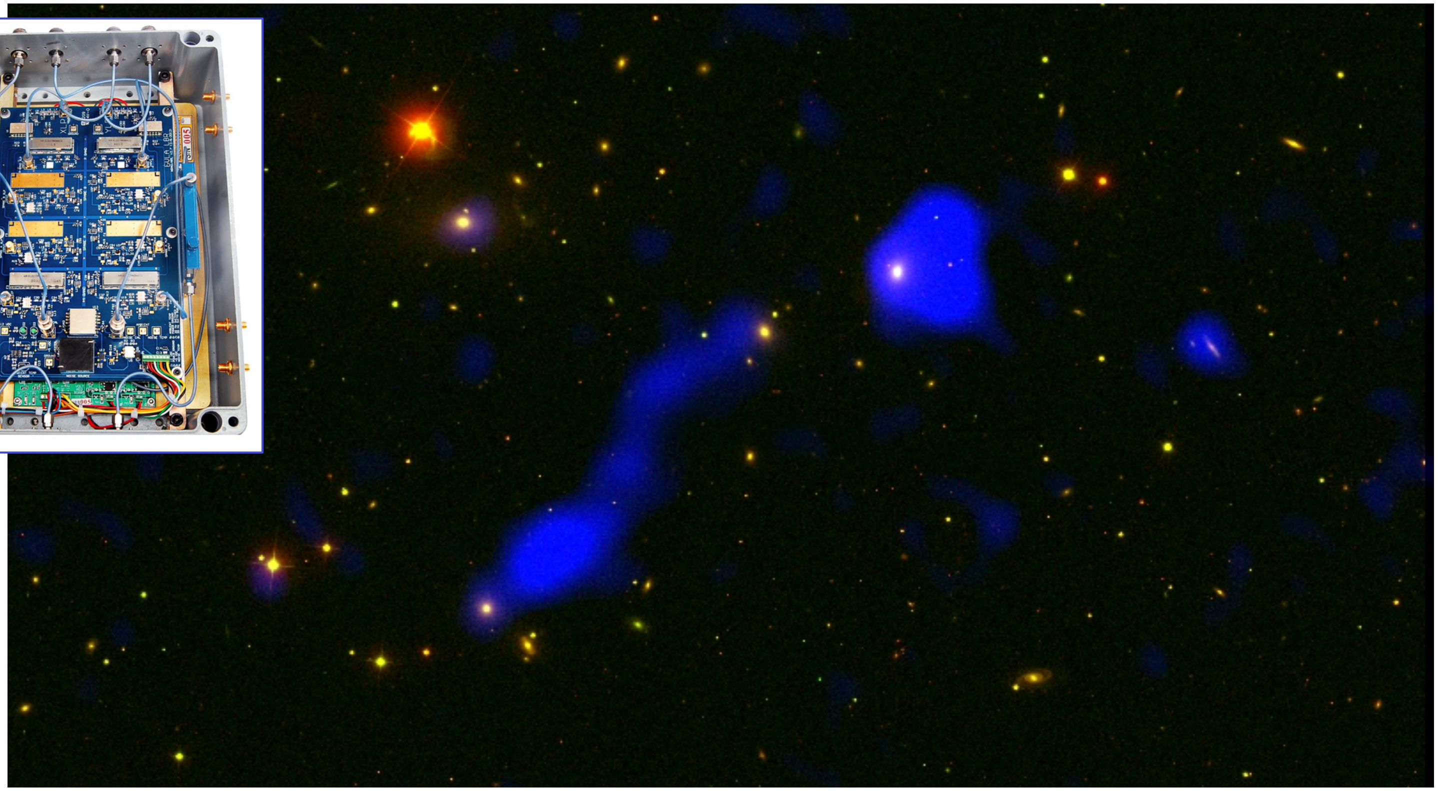
Basic Features of the 'WIDAR' Correlator

The correlator's basic features (not all implemented yet):

- **64 independent full-polarization subbands**
  - Each can be tuned to its own frequency, with its own bandwidth (128 MHz to 31.25 kHz) and spectral resolution (from 2 MHz to .12 Hz)
- **100 msec dump times with 16384 channels and full polarization**
  - Faster if spectral resolution, BW, or number of antennas is decreased.
- **Up to 8 sub-arrays**. Maximum to date is three.
- **Phased array capability** with full bandwidth – for pulsar and VLBI applications. Two different subarrays can be simultaneously phased.
- **Special pulsar modes**: 2 banks of 1000 time bins, and 200 μsec time resolution (all spectral channels), or 15 μsec (64 channels/sp.window). Undergoing testing; See RSRO.

Two Telescopes in One

VLITE (VLA Ionospheric and Transient Experiment)



A VLITE pipeline-processed image of the giant radio galaxy IC 711 in the galaxy cluster Abell 1314

Credit: Radio (blue) from VLITE on the NRAO VLA.
Optical (red and green) from the Sloan Digital Sky Survey.
U.S. Naval Research Laboratory/Dr. Tracy Clarke

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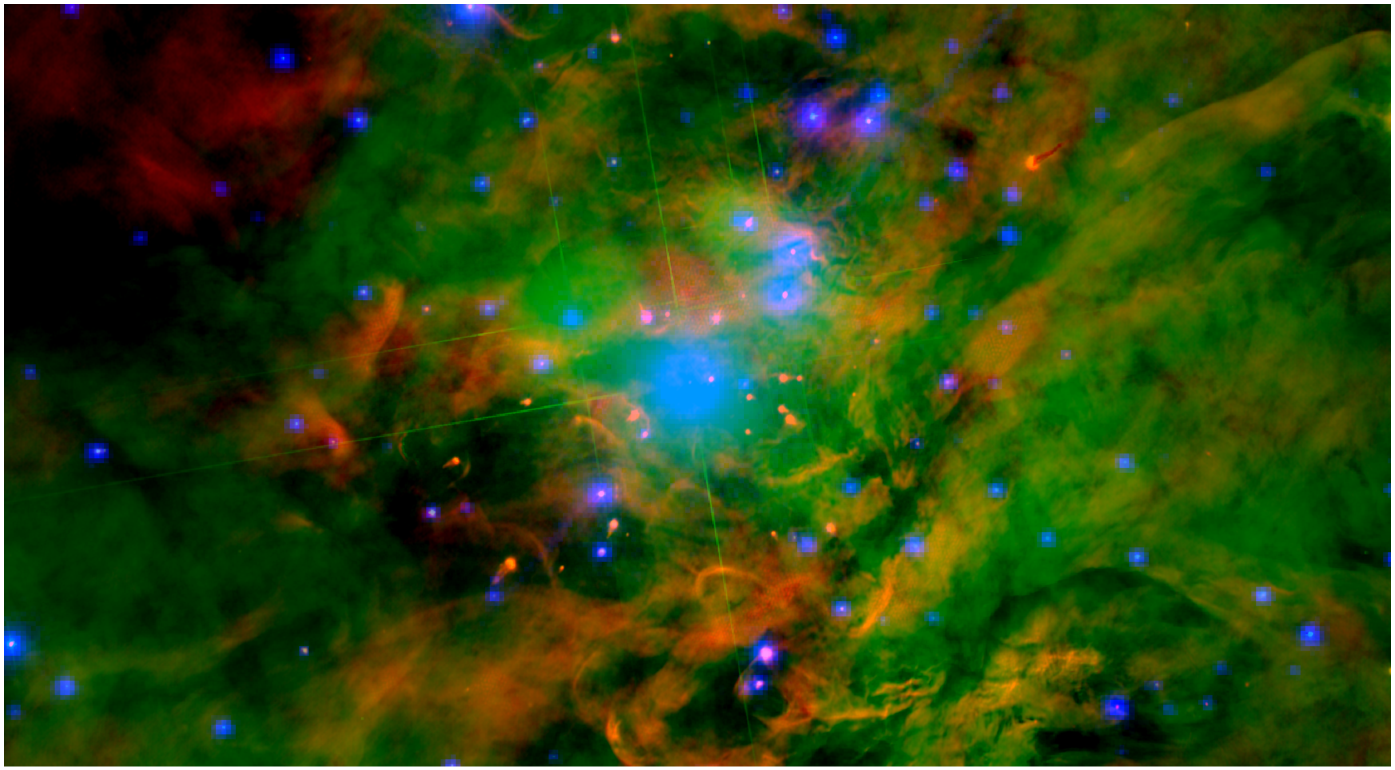
Time-Domain Astronomy

A multiwavelength study of the Orion nebula searches for young stellar variability

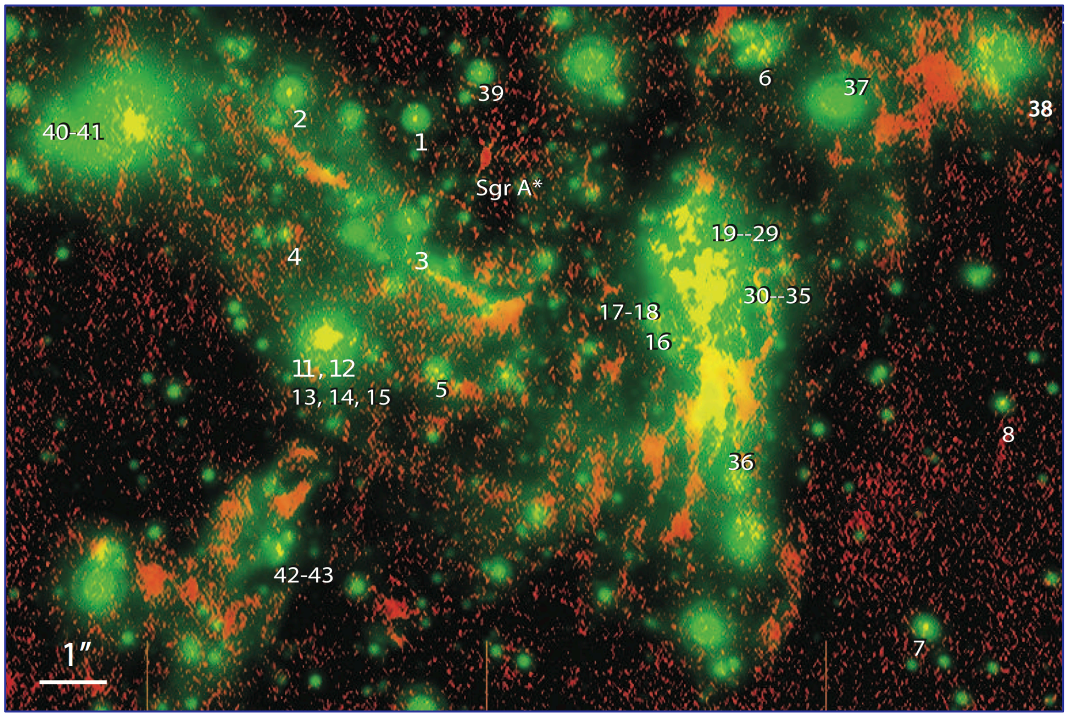


Credit: Red: VLA 6 cm continuum, J. Forbrich et al. Green: Optical data, Hubble Space Telescope, Robberto et al. 2013 Blue: X-rays, Chandra, Getman et al. 2005

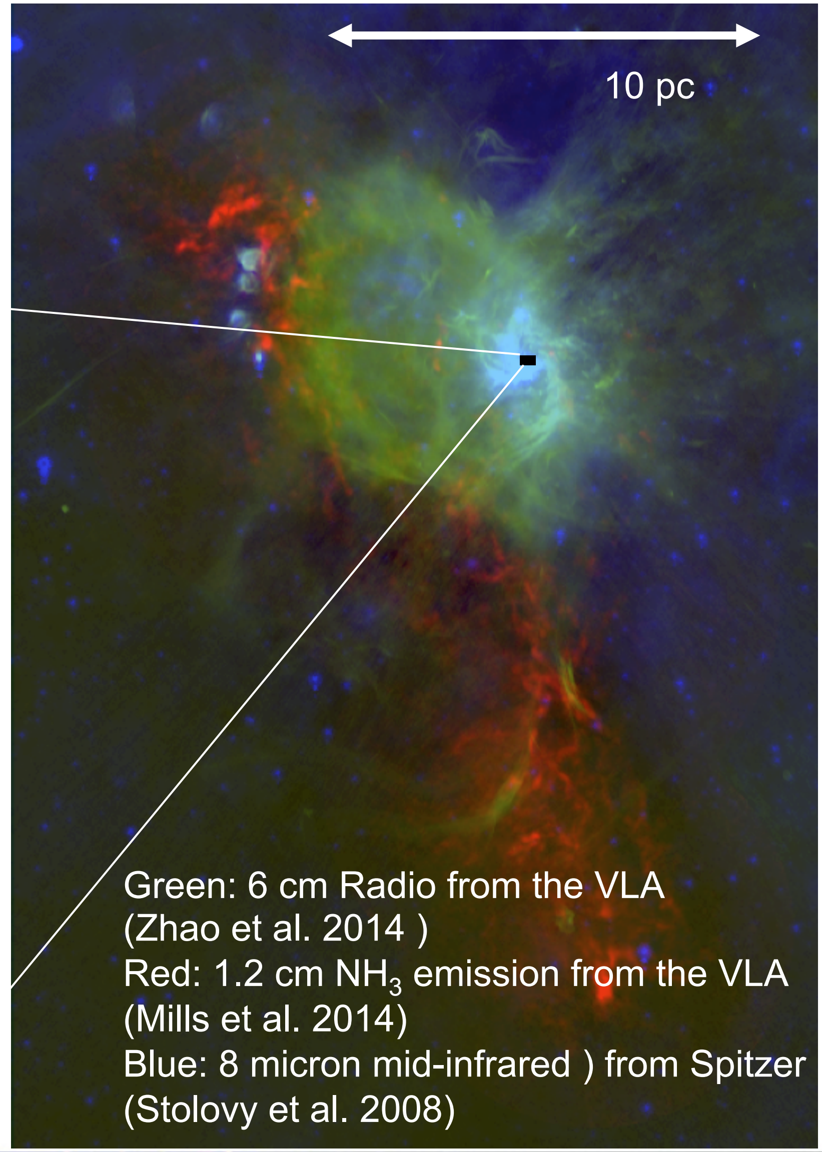
Upcoming VLA Sky Survey will map nearly whole sky in 3 epochs and full polarization at 3GHz.

A Sensitive view of the Invisible Universe

Ionized and molecular gas around the supermassive black hole in the center of our Galaxy



Red: 7mm radio VLA observations
Green: 3.8 um adaptive optics image from the VLT
(Yusef-Zadeh et al. 2014)



Green: 6 cm Radio from the VLA
(Zhao et al. 2014)
Red: 1.2 cm NH_3 emission from the VLA
(Mills et al. 2014)
Blue: 8 micron mid-infrared) from Spitzer
(Stolovy et al. 2008)

Capabilities of Interest (for 2016B)
General Observing (GO)

- Full 8 GHz bandwidth with 16384 spectral channels – 2 MHz spectral resolution (full pol), 1 MHz resolution (Stokes I)
- All 64 subband pairs can be separately tuned, and set to any of 128, 64, 32, 16, … , 0.03125 MHz widths.
- Up to 16384 spectral channels (no recirculation), or up to 1,048,576 (with recirculation)
- Three simultaneous, fully independent subarrays using standard 8-bit continuum setups
- Mix 3-bit and 8-bit modes.
- Phased Array (for VLBI).

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Capabilities of Interest (for 2016B)
Resident Shared Risk Observing (RSRO)

- Access to extended capabilities that require more testing
  - In exchange for a perio
- Correlator dump times <
  - Including as short as 5 r
- Frequency averaging in th
- Data rates above 60 MB/s
- P-band (230-470 MHz) pc
- 4-band (58-84 MHz) com
- Pulsar observations
- More than 3 subarrays wi
- Subarrays with the 3-bit samplers
- Complex VLBI observing modes with the phased array

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Next Generation Very Large Array

Killer Gap: *Thermal imaging on milliarcsecond scales at* $\lambda \sim$ *0.3cm to 3cm*

Notional Specifications

- Collecting area: spec = 5x VLA; goal = 10x VLA
- Frequency range: 1– 50 GHz + 70–115 GHz
- Configuration: 50% to 3km; 40% to 200km; 10%? to 3000km
- Science and technical white papers: http://library.nrao.edu/ngvla.shtml

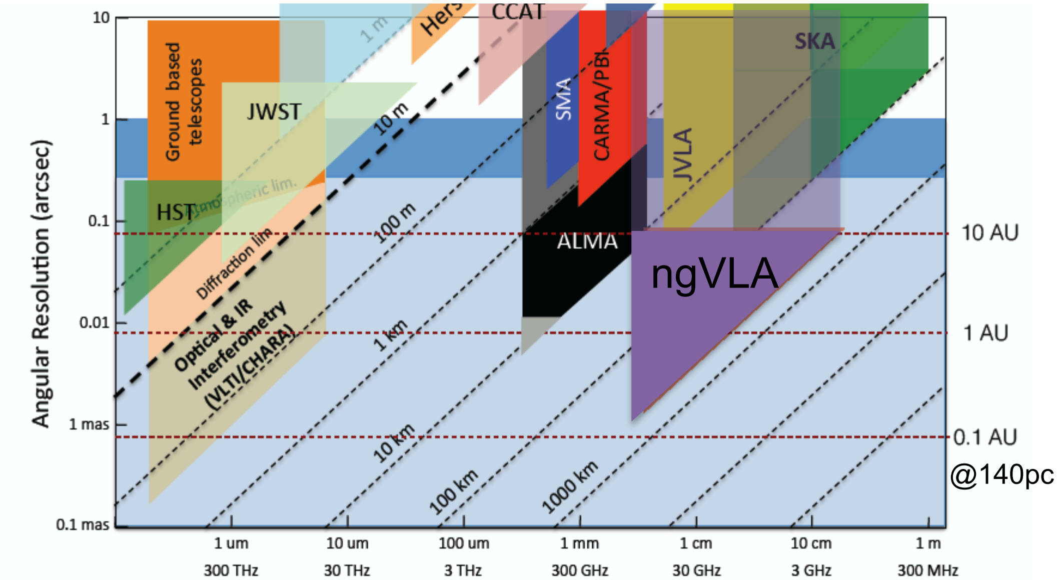
Killer Gap: Opening parameter space

Order of magnitude improvements

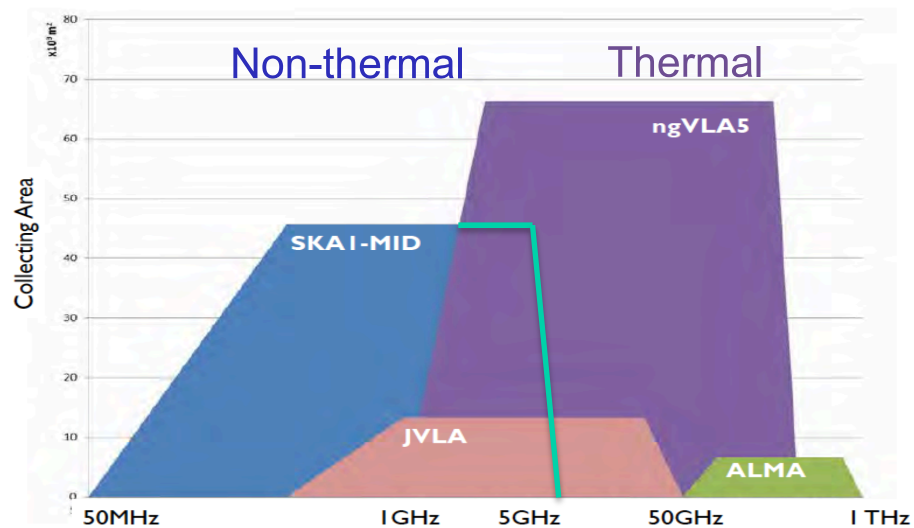
- Resolution ~ 15mas @ 1cm (180km)
- Sensitivity ~ 0.2uJy (1cm, 10hr, 8GHz)
- T_B ~ 1K @ 15mas, 1cm

Science Cases:

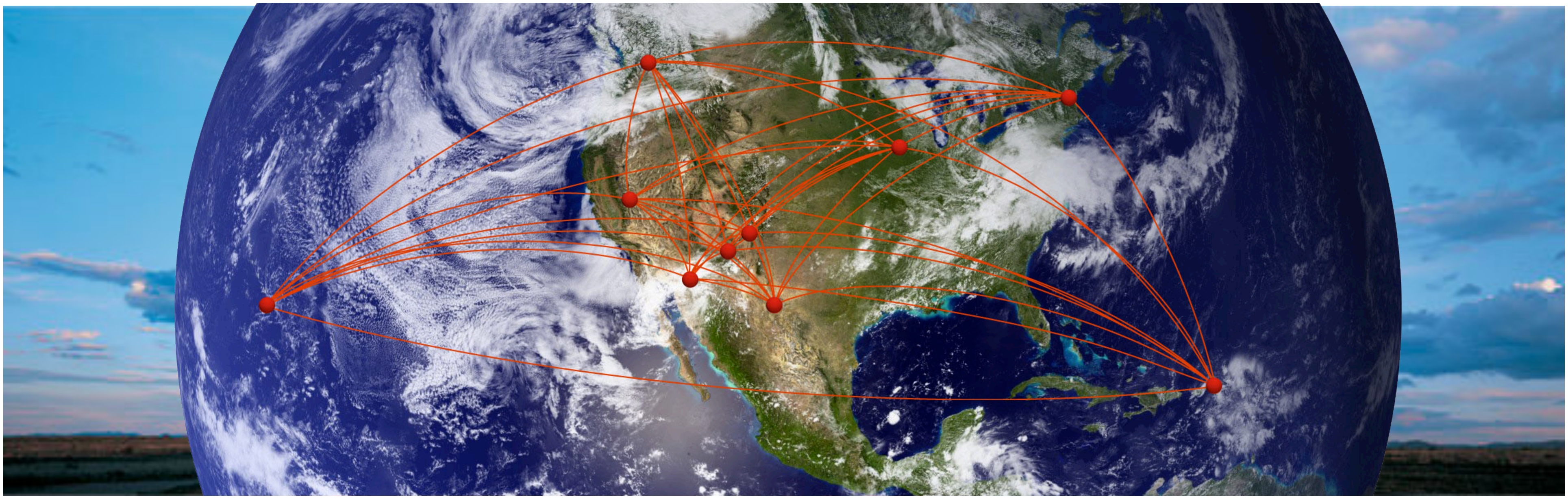
- "Cradle of Life"
- "Galaxy Ecosystems"
- "Galaxy Assembly"
- "Time Domain and cosmology"



Next-generation VLA – x5



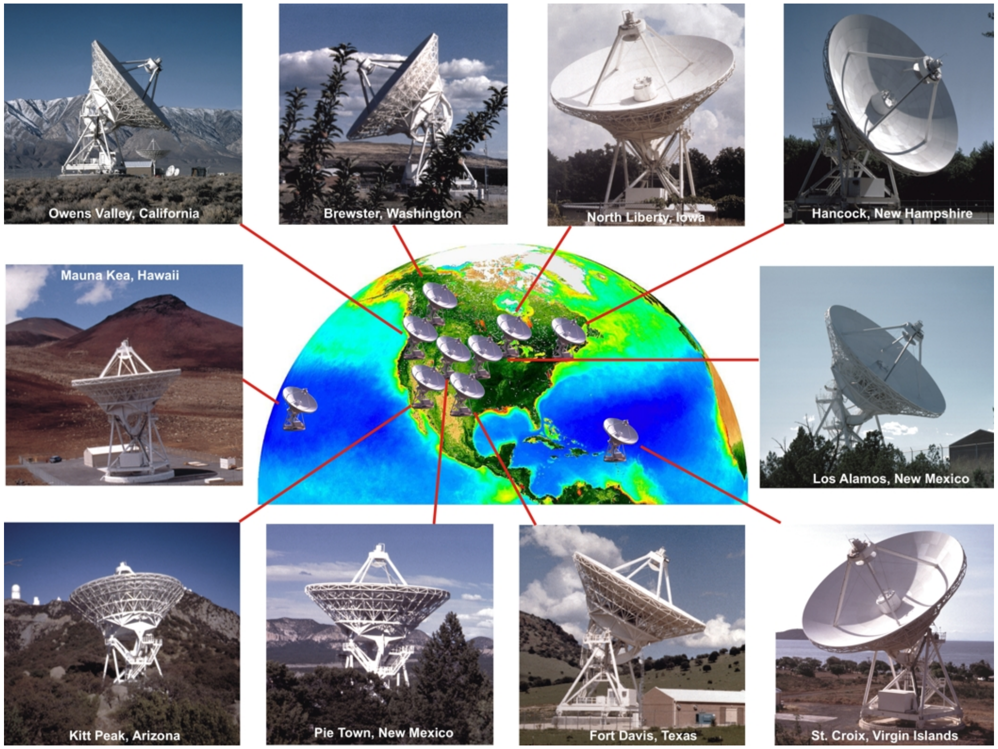
The Very Long Baseline Array



Atacama Large Millimeter/submillimeter Array
Karl G. Jansky Very Large Array
Robert C. Byrd Green Bank Telescope
Very Long Baseline Array

The VLBA

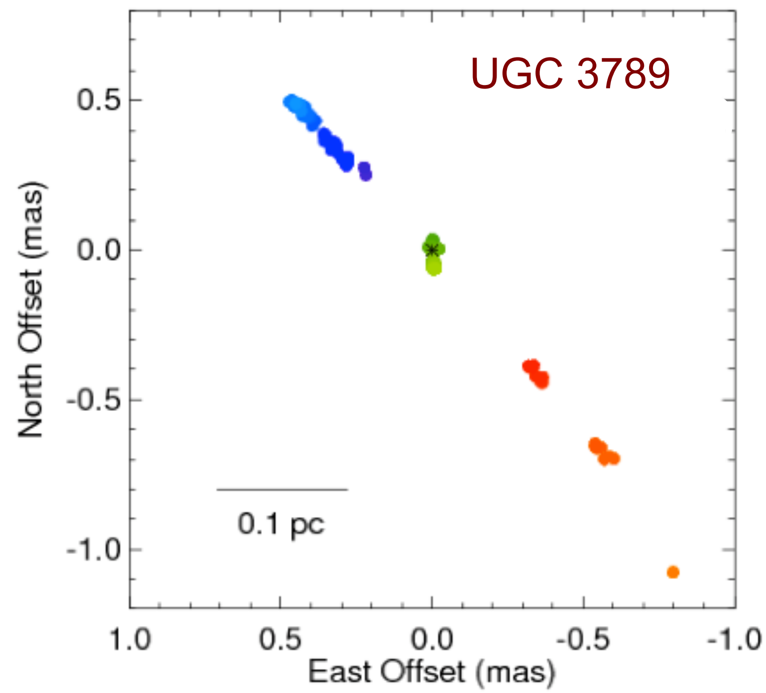
- A dedicated VLBI array
- 10 identical 25-m antennas.
- Spanning Mauna Kea to St. Croix
- Baselines 200 to 8600 km
- Frequencies 310 MHz to 90 GHz
- Sensitive to compact structures with $T_b > 10^5$ K
- Software correlator, DiFX



Resolution!

- 25 *milli* arcsecond at 330 MHz.
- 80 *micro* arcsec at 90 GHz.

- 1 mas is
  - 0.1 AU at 100 pc (Galactic)
  - 10 AU at 10 kpc
  - 1000 AU at 1 Mpc (Extragal)
  - 5 pc at 1 Gpc

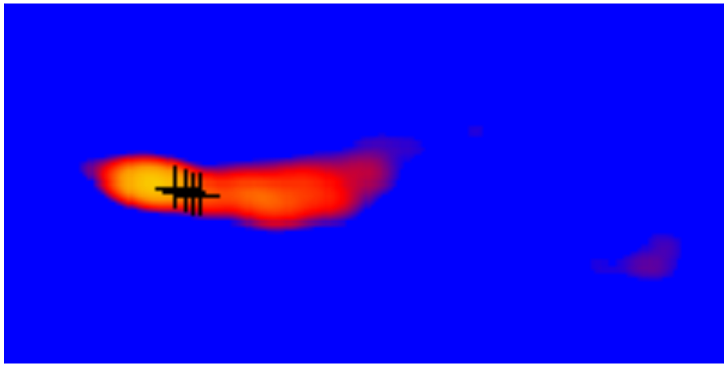


The Megamaser Cosmology Project
(Braatz et al.)

Mapping H_2O maser disks in AGNs
to measure H_0 and determine SMBH masses

Fast Response & Monitoring

- Dedicated array
- Targets of Opportunity
- Monitoring



AGN 1222+216

Example: The MOJAVE project (Lister et al.)

Examining the evolution of AGN jets and their magnetic fields, and the medium into which the jets are expanding

Astrometry

- Astrometry: parallax and proper motions.
  - Instrumental stability with long baselines
  - < 0.1 mas positions are routine
  - 0.01 mas demonstrated in some cases
  - Allows 1% distance measurements at 1 kpc

Example: Distance to Pleiades
(Melis et al. 2014)

d = 136.2 ± 1.2 pc (1%)

Astrometry

- Astrometry: parallax and proper motions.
  - Instrumental stability with long baselines
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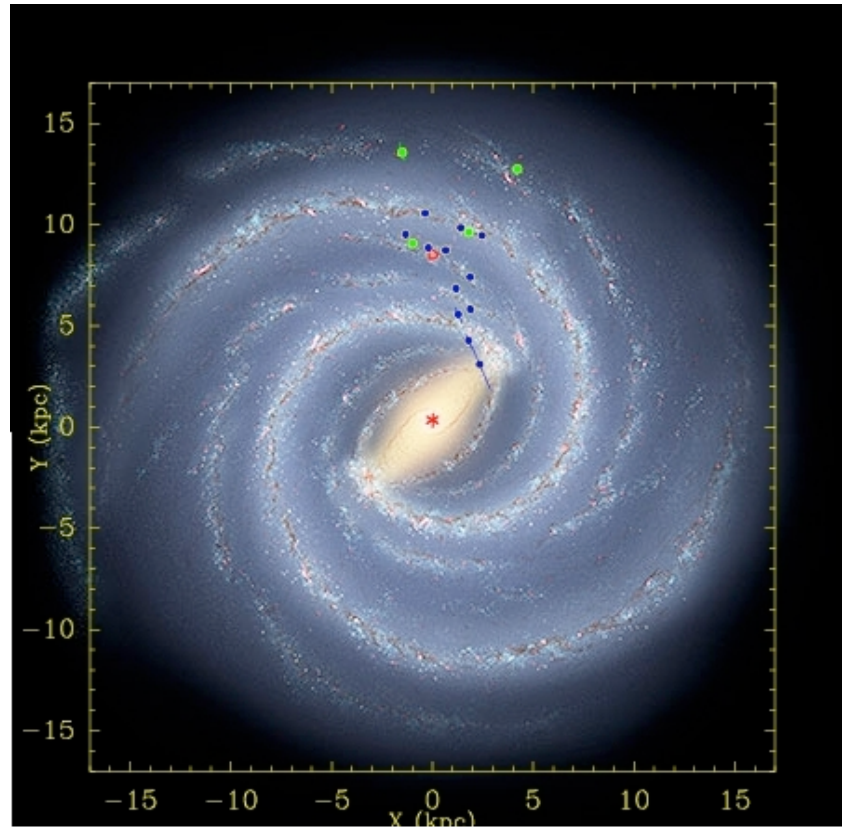

Example: BeSSeL (Reid et al. 2014)

Mapping Galactic structure and measuring fundamental parameters by measuring parallaxes and proper motions of SF regions

R_0 = 8.4 ± 0.6 kpc
Θ_0 = 254 ± 16 km/s

VLBA Frequency bands and Sensitivity

λ(cm)	ν(GHz)	σ(μJy/beam) in 8 hrs at 2Gbps
90 cm	0.312 - 0.342	266*
50 cm	0.596 - 0.626	681*
21 cm	1.35 - 1.75	10-12
13 cm	2.15 - 2.35	12
6 cm (upgrade)	3.9 - 7.9	6-9
4 cm	8.0 - 8.8	11-15
2 cm	12.0 - 15.4	18
1 cm	21.7 - 24.1	18-22
7 mm	41.0 - 45.0	40
3 mm	80.0 - 90.0	180†

- 2 Gbps recording delivers a bandwidth of 256 MHz with two polarizations.
- 90 cm band assumes 32 MHz of bandwidth.
- 50 cm band assumes 4 MHz of bandwidth.

* Narrower bandwidths

† 8 stations

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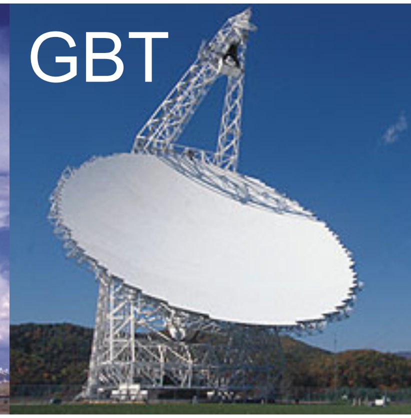
The High Sensitivity Array (HSA):
To boost the sensitivity of the VLBA by an order of magnitude



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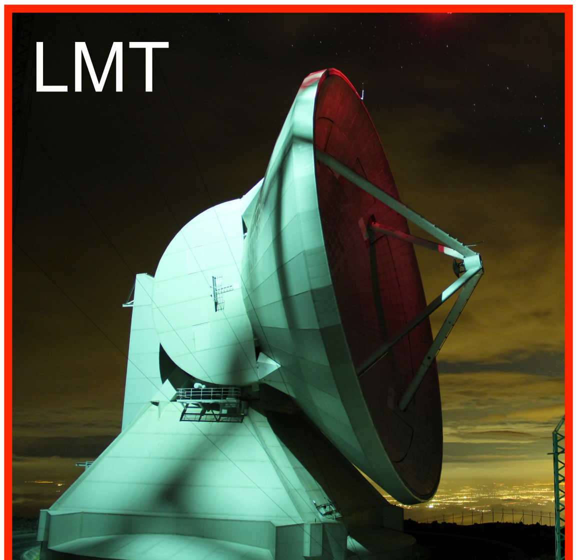
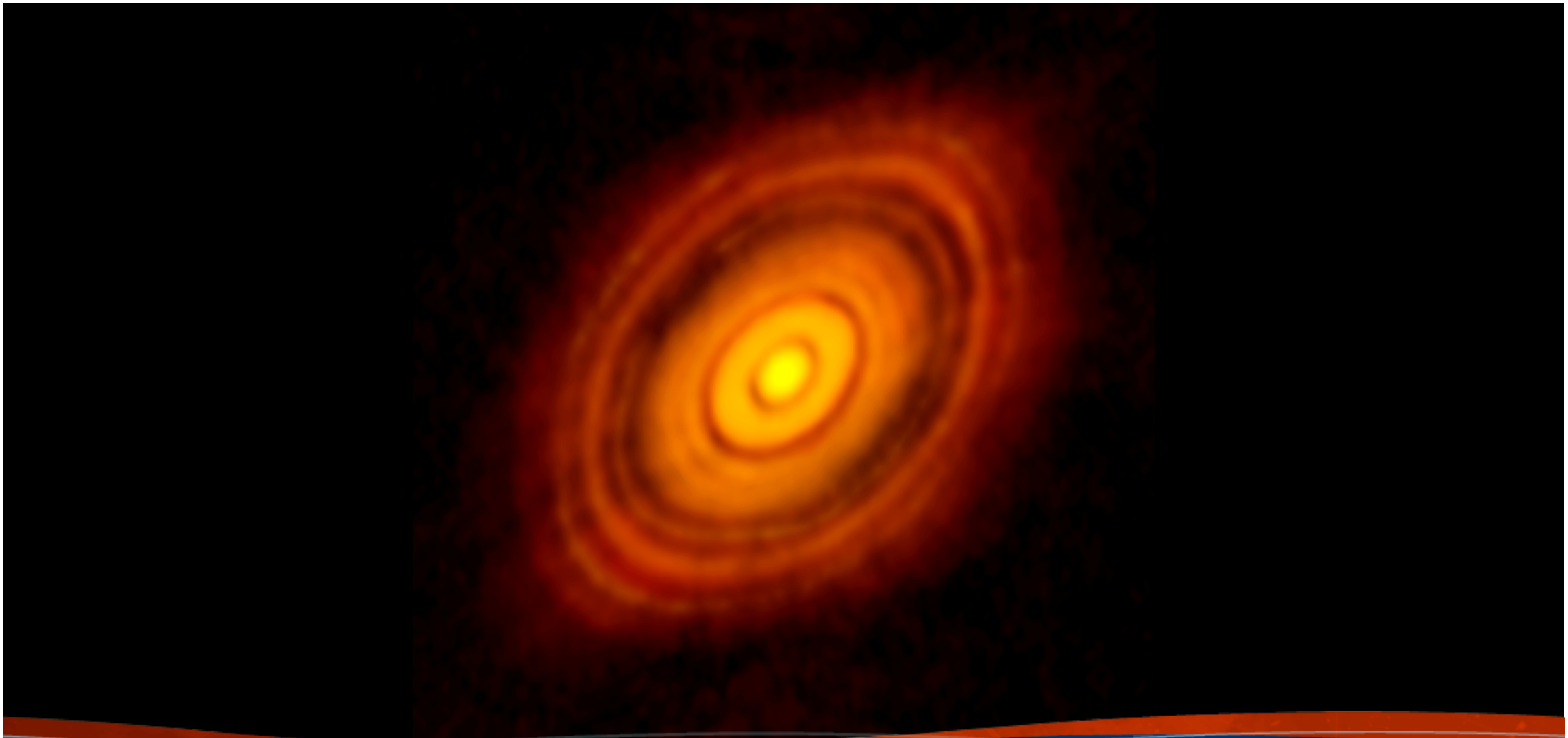
The High Sensitivity Array at 3mm

VLBA+LMT+GBT offered under the VLBA RSRO program





ALMA Cycle 4 Preparations

ALMA Cycle 4 Planning

ALMA Cycle 4 will provide 3000 hours of 12-m array science observations. The remaining time on ALMA will be reserved for engineering, computing and scientific testing to extend and optimize ALMA capabilities.

Dates to remember:

22 March 2016	Call for Proposals
21 April 2016	**Proposal deadline**
August 2016	Review results sent to PIs
October 2016	Start of ALMA Cycle 4 observations
September 2017	End of Cycle 4 observations

Cycle 4 Capabilities

At least forty (40) antennas in the 12-m Array, ten (10) 7-m antennas (for short baselines) and three (3) 12-m antennas (for zero-spacing)

Receiver bands 3, 4, 6, 7, 8, 9, & 10 (wavelengths of about 3.1, 2.1, 1.3, 0.87, 0.74, 0.44, and 0.35 mm, respectively)

Nine 12-m array configurations with maximum baselines from 155 m to 12.6 km

Maximum baselines of 2.7 km for Bands 8, 9 and 10, 5.3 km for Band 7, 12.6 km for Bands 3, 4, & 6

Spectral line, continuum, and mosaic observations

Single pointing, on axis, full (linear) polarization capabilities for continuum and full spectral resolution observations in Band 3, 6 and 7 on the 12-m array

New Capabilities in Cycle 4:

In Cycle 4, the following opportunities will be available to Proposers for the first time.

ACA stand-alone mode

Proposals will be accepted to use the ACA in a stand-alone capacity for spectral line (7m Array plus Total Power Array) or continuum (7m Array) observations.

Large Programs

defined as more than 50 hours of observations with either the 12-m Array or the ACA in stand-alone mode.

Millimeter-wavelength VLBI

Proposals will be accepted for Very Long Baseline Interferometry (VLBI) observations with ALMA in Bands 3 and 6 continuum, in concert with an existing VLBI network: the Global mm-VLBI Array (GMVA) at 3 mm and a new NRAO/Event Horizon Telescope Consortium (EHTC) network at 1.3 mm. In addition to submitting an ALMA proposal, VLBI programs must also submit a proposal to the appropriate VLBI network according to their deadlines. Additional information about proposing with ALMA using these networks will be made available in mid-January 2016.

Solar observations - Bands 3 and 6.

Cycle 4 – standard and non-standard

Cycle 4 observing modes will be classified as standard or non-standard, and up to 20% of the observing time will be allocated to proposals requesting non-standard modes, which include:

- Bands 8, 9 & 10 observations
- Band 7 observations with maximum baselines > 2.7 km
- All polarization observations
- Spectral Scans
- Bandwidth switching projects (less than 1GHz aggregate bandwidth over all spectral windows)
- Solar Observations
- VLBI observations
- User-specified calibrations

Important Links

NRAO Help Desk

https://help.nrao.edu

VLA Observational Status Summary

go.nrao.edu/vla-oss

VLA Exposure Calculator

https://obs.vla.nrao.edu/ect/

Proposal Submission Tool

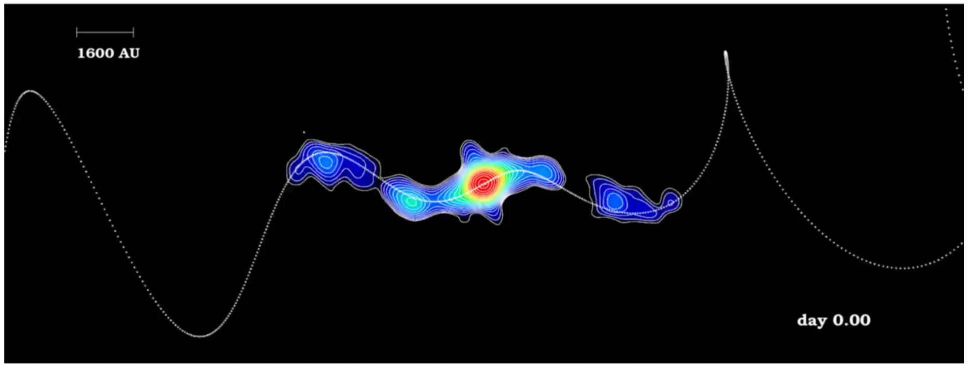
my.nrao.edu

CASA– data reduction software

http://casa.nrao.edu/

VLA Calibration Pipeline

https://science.nrao.edu/facilities/vla/data-processing/pipeline



SS433 at 26 GHz (0.095"; 520 AU resolution)
Credit: Miodusweski & Miller-Jones, EVLA demo science

www.nrao.edu

science.nrao.edu

ALMA

ALMA Development Program

- The Program seeks to enhance capabilities consistent with the ALMA Science Advisory Committee's strategic recommendations (cf. '*A Roadmap for Developing ALMA*'), including new means to:
  - Increase sensitivity
  - Improve angular resolution
  - Enlarge field of view
  - Increase spectral coverage
  - Expand simultaneous frequency coverage
  - Enhance image quality
  - Increase amplitude accuracy
  - Increase phase accuracy
  - Increase polarization accuracy
  - Improve systems flexibility and usability

NRAO

ALMA Development Program

- The Program aims to fund and promote a portfolio of initiatives composed of "Studies" and Projects"
- Studies are typically funded annually and are early-stage in the development process
- Projects are typically funded bi-annually and are mid or late-stage in the development process
- Study awards are typically $200K with a 1-year period of performance, but they may be larger
- Project awards are typically $1M with a 2-year period of performance, but they may be larger

ALMA Development Program

- The next *Call for Proposals* will be released 01 March 2016
- A Proposal Webinar is scheduled for 15 March 2016
- The Proposal deadline is COB 02 May 2016
- The specific details and Call parameters will be available, 01 March, on the NRAO website

https://science.nrao.edu/facilities/alma/alma-development-2017/call for proposals

- Proposal categories are:
  - Advanced techniques
  - Advanced hardware
  - Advanced software
- The Call does not emphasize any particular category