EVLA

The Jansky VLA: Transforming the Study of Outflows, Winds, and Jets at Centimeter Wavelengths

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

NRAO

Radio emission from outflows, winds, jets

- Thermal and non-thermal radio emission from outflows, winds, and jets common in a wide range of astrophysical sources
  - Young stellar objects of all masses
  - WR stars, evolved stars, planetary nebulae
  - X-ray binaries (WDs, NSs, BHs…)
  - Microquasars
  - Tidal disruption events
  - Galactic winds
  - AGN (FRI, FRII)
  - GRBs
- The superb combination of resolution, sensitivity, frequency coverage, and rapid scheduling of the VLA means that it has, and will continue, to play a key role in outflow/wind/jet studies
  - Structure, chemistry, dynamics, emission and absorption mechanisms, accretion, jet launch

The Jansky VLA

- Culmination of the decade-long Expanded Very Large Array project funded by the NSF, Canada, Mexico
- Multiplies by orders of magnitude the observational capabilities of the VLA
  - Full frequency coverage from 1 to 50 GHz, provided by 8 receivers
  - Up to 8 GHz/pol instantaneous bandwidth
  - 5 to 10 times better continuum sensitivity
  - New correlator with unprecedented capabilities
  - From 16384 to 4.2e6 channels in up to 64 independent sub-bands
- First fringes with the new correlator March 2010, full operation Jan 2013
- Fully dynamic scheduling (based on scientific priority, weather conditions, scheduling efficiency, time critical observations)
- New data reduction software (CASA)
- Pipeline-calibrated visibility data plus QA images

The Jansky VLA

- 27x25m antennas in an upside-down Y, in one of four configurations, D (most compact) to A (most extended)
- Located on Plains of San Agustin in central New Mexico at 2100m altitude

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Technical capabilities: receivers/bands

- 8 wideband receivers
- Switching receivers can be as fast as 20s

Band	Range
	(GHz)
20 cm (L)	1.0–2.0
13 cm (S)	2.0–4.0
6 cm (C)	4.0–8.0
3 cm (X)	8.0–12.0
2 cm (Ku)	12.0–18.0
1.3 cm (K)	18.0–26.5
1 cm (Ka)	26.5–40.0
0.7 cm (Q)	40.0–50.0

Technical capabilities: spatial resolution

- From the D to A configurations the VLA varies its angular resolution by a factor ~35 (depends on *largest* baseline/telescope separation)
- Reconfiguration every ~4 months

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

Technical capabilities: largest angular scale

- The *shortest* baseline sets the largest angular scale measured
- Compact configurations give less spatial resolution but better surface brightness sensitivity

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
	Largest Angular Scale θ_{LAS}(arcsec)[1,4]			
74 MHz (4 band)	800	2200	20000	20000
1.5 GHz (L)	36	120	970	970
3.0 GHz (S)[6]	18	58	490	490
6.0 GHz (C)	8.9	29	240	240
8.5 GHz (X)[7]	6.3	20	170	170
15 GHz (Ku)[6]	3.6	12	97	97
22 GHz (K)	2.4	7.9	66	66
33 GHz (Ka)	1.6	5.3	44	44
45 GHz (Q)	1.2	3.9	32	32

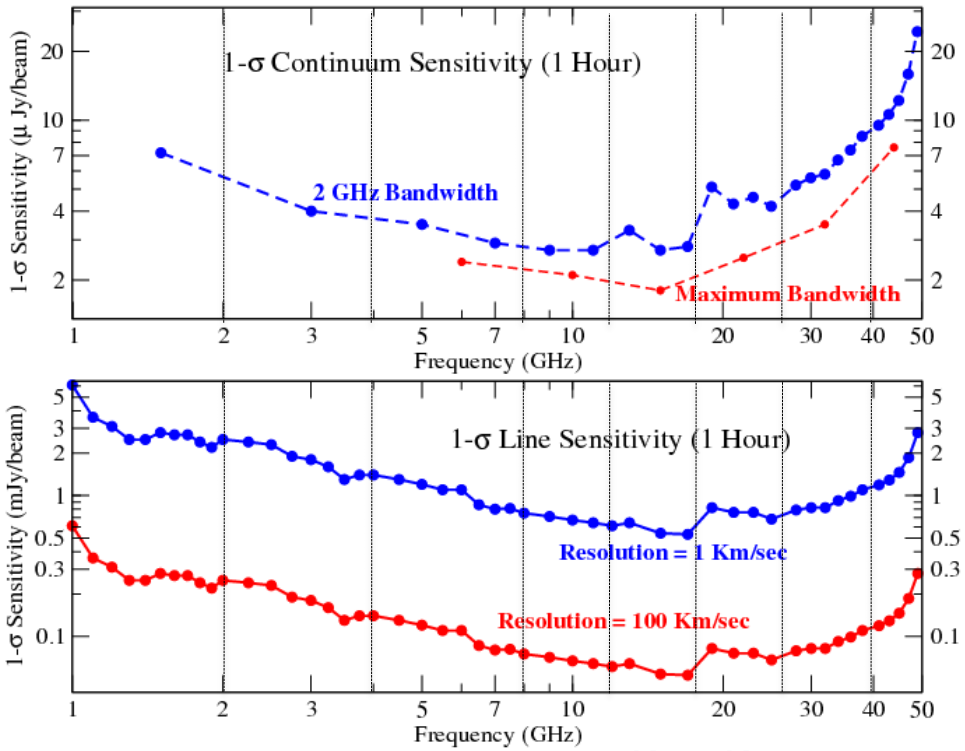
Field of view (depends on diameter of a single antenna)

608’
30’
15’
7.5’
5.3’
3’
2’
1.4’
1’

Technical capabilities: sensitivity

- At 10 GHz: in 1hour, 1σ = 2 μJy continuum
- 0.8 mJy in 1 km s^{-1} channel

1 GHz 10 GHz 50 GHz



L S C X Ku K Ka Q

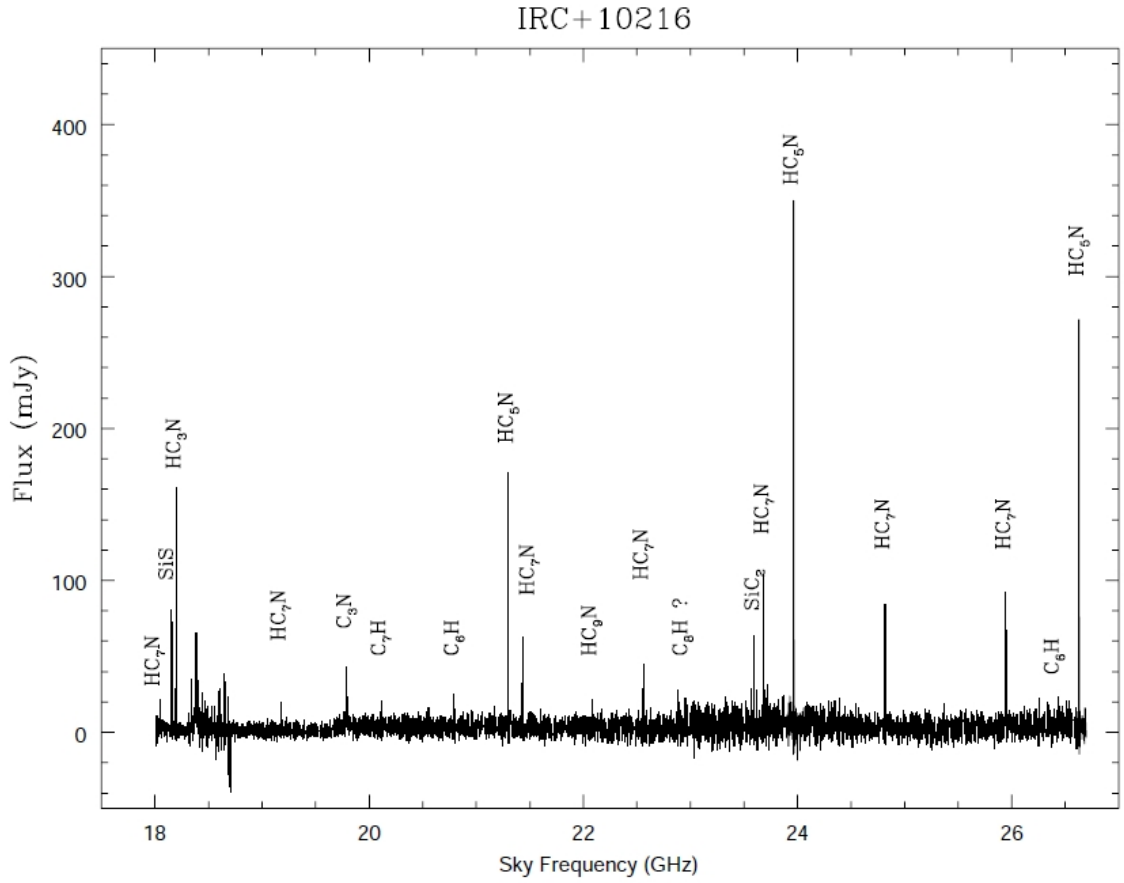
- http://evlaguides.nrao.edu/index.php?title=Observational_Status_Summary

Scientific capabilities

- Wide bandwidths:
  - Continuum sensitivity
  - Spectral index information
  - Rotation measure studies
  - Survey speed for wide-field mosaics
  - Dynamic spectra
- Correlator flexibility:
  - Blind redshift surveys
  - Combined continuum and spectral line observations of star-forming regions and external galaxies
  - Multiple, key diagnostic lines for chemical and physical analyses
  - High spectral resolution
  - Very fast dumps for pulsars and transient searches

JVLA demonstration science: IRC+10216

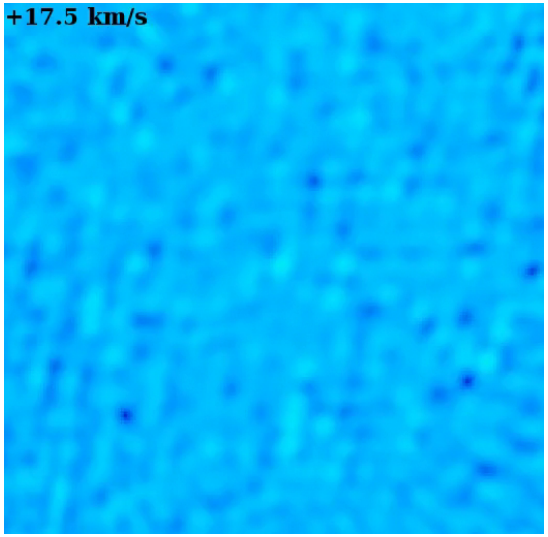
- Spectroscopy and imaging of IRC+10216



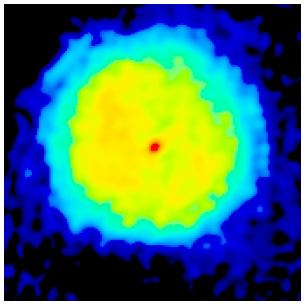
https://science.nrao.edu/facilities/evla/early-science/demoscience

JVLA demonstration science: IRC+10216

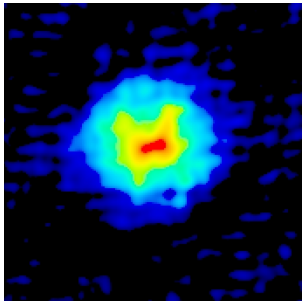
- Spectroscopy and imaging of IRC+10216
- $HC_3N(4-3)$ emission a 36.4 GHz tracing the expanding shell
- Similar movies for $HC_5N(9-8)$, $HC_7N(22-21)$, SiS(2−1), reveal chemical structure of the envelope



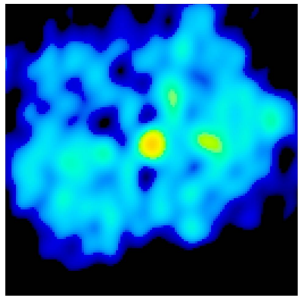
HC_3N



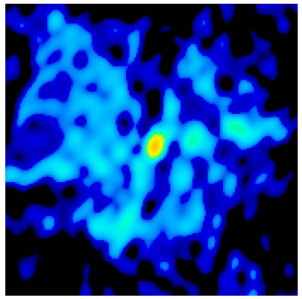
SiS



HC_5N

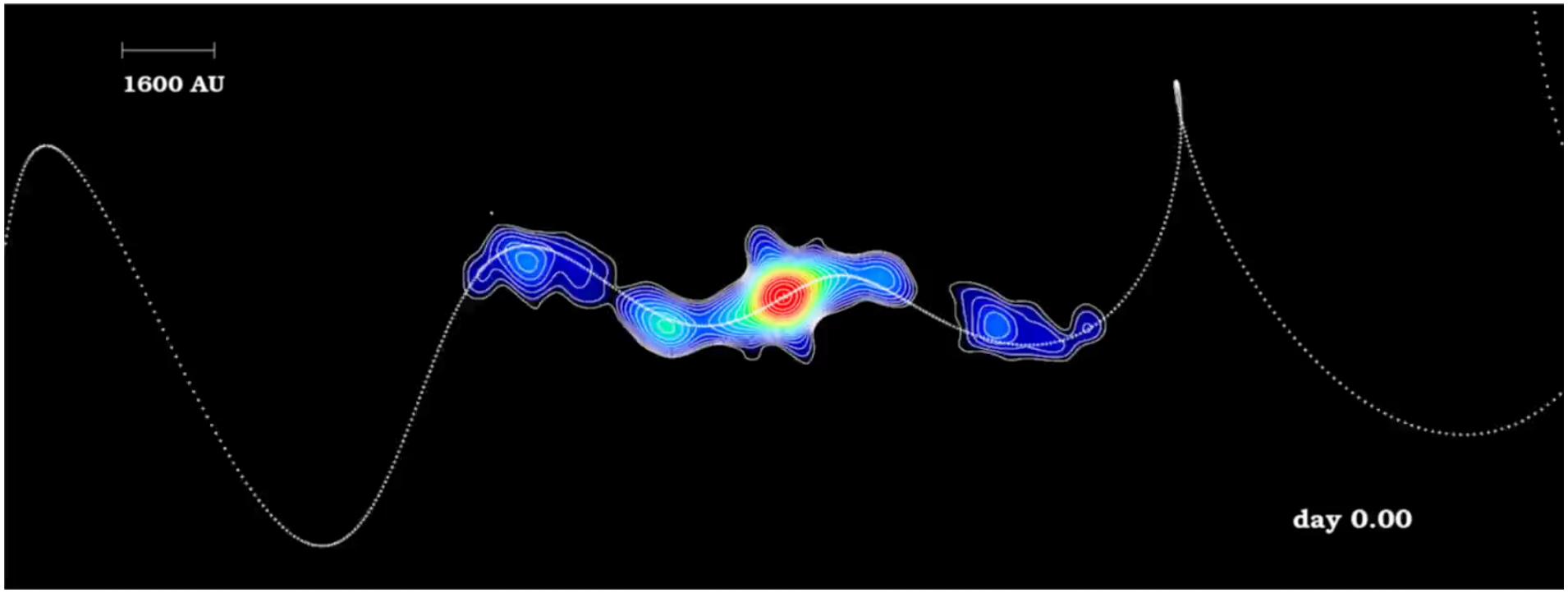


HC_7N

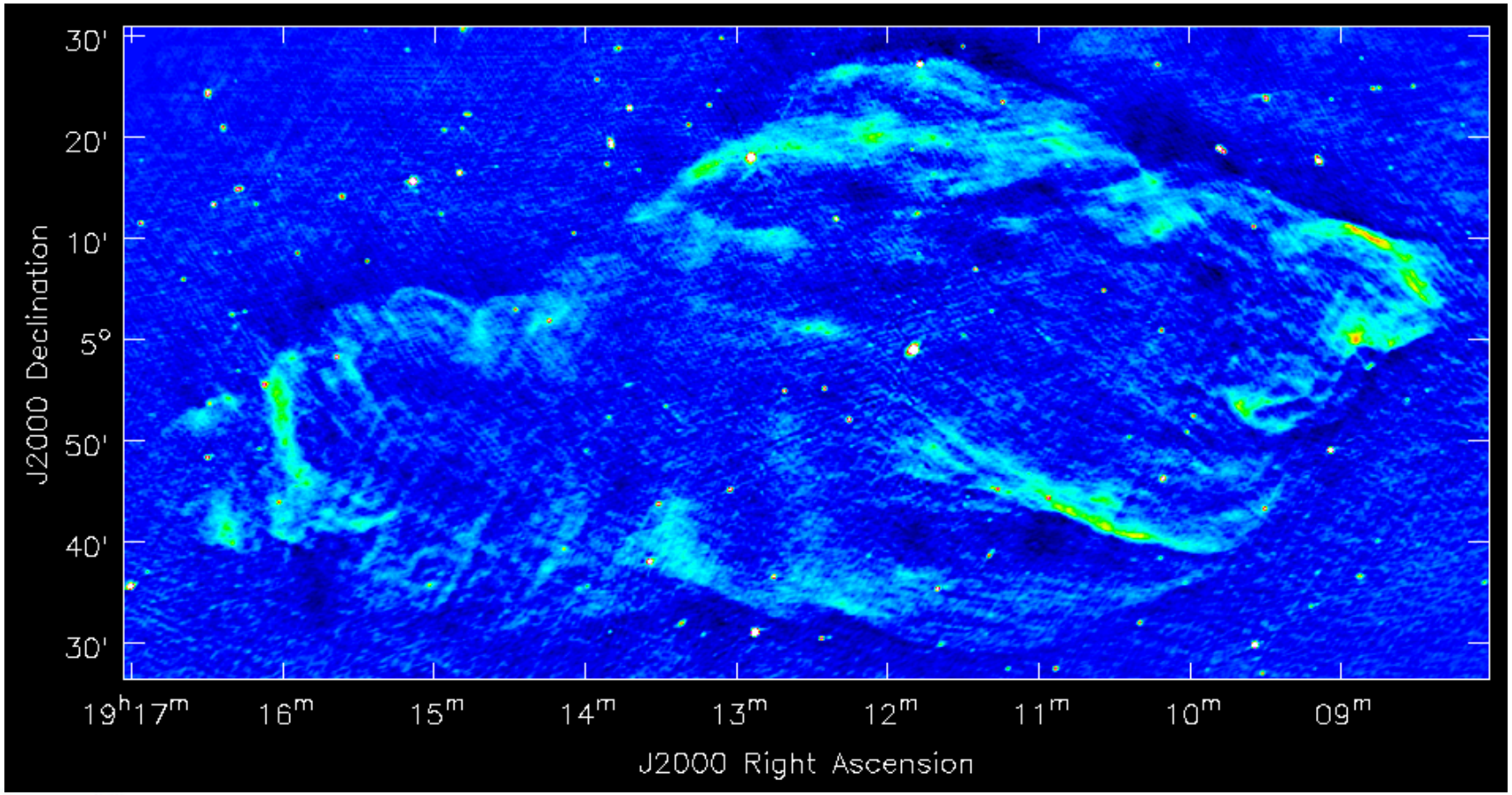


SS433 and the W50 nebula

- 26 GHz emission from SS433, 0.095" (520 AU) resolution



SS433 and the W50 nebula



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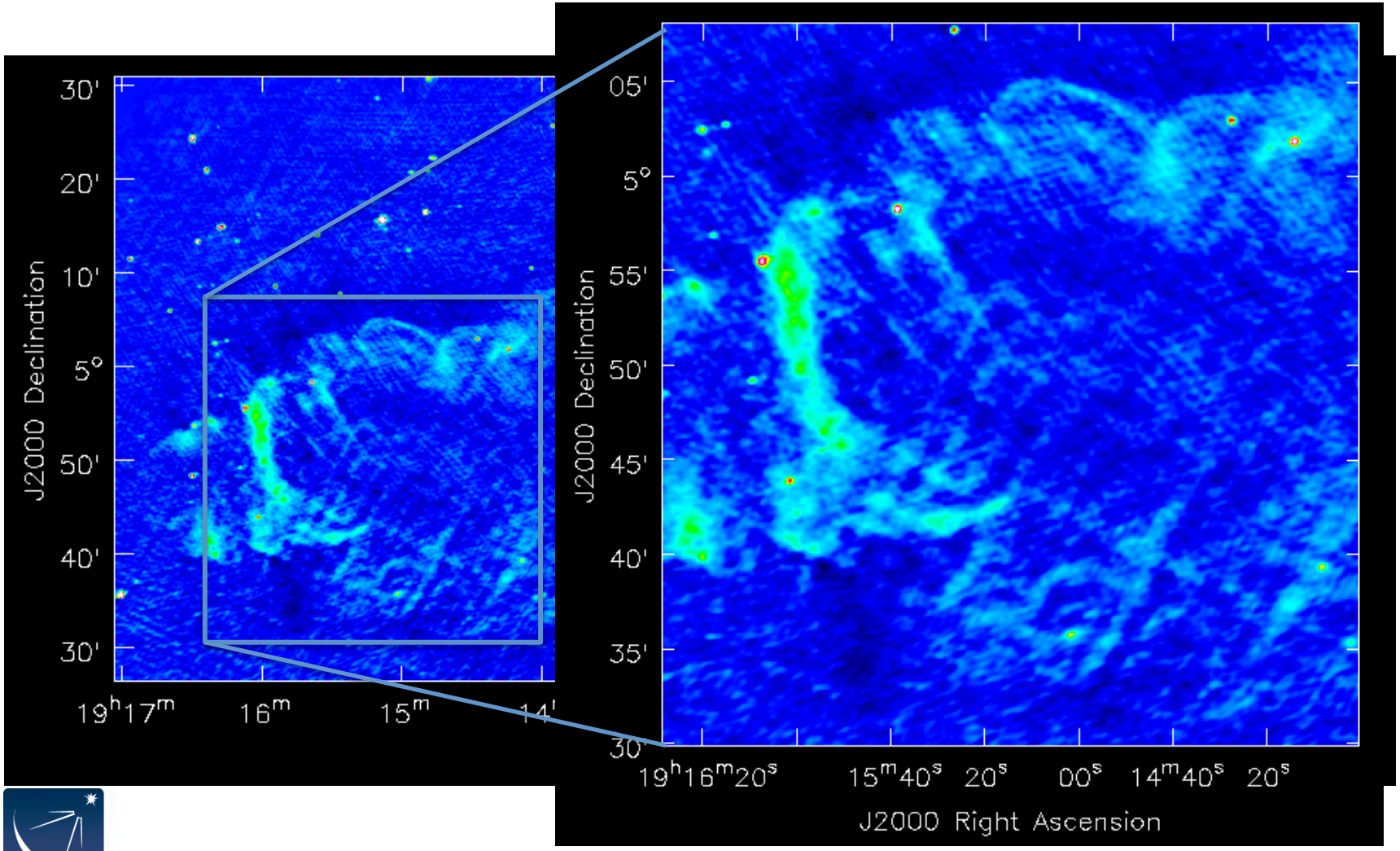
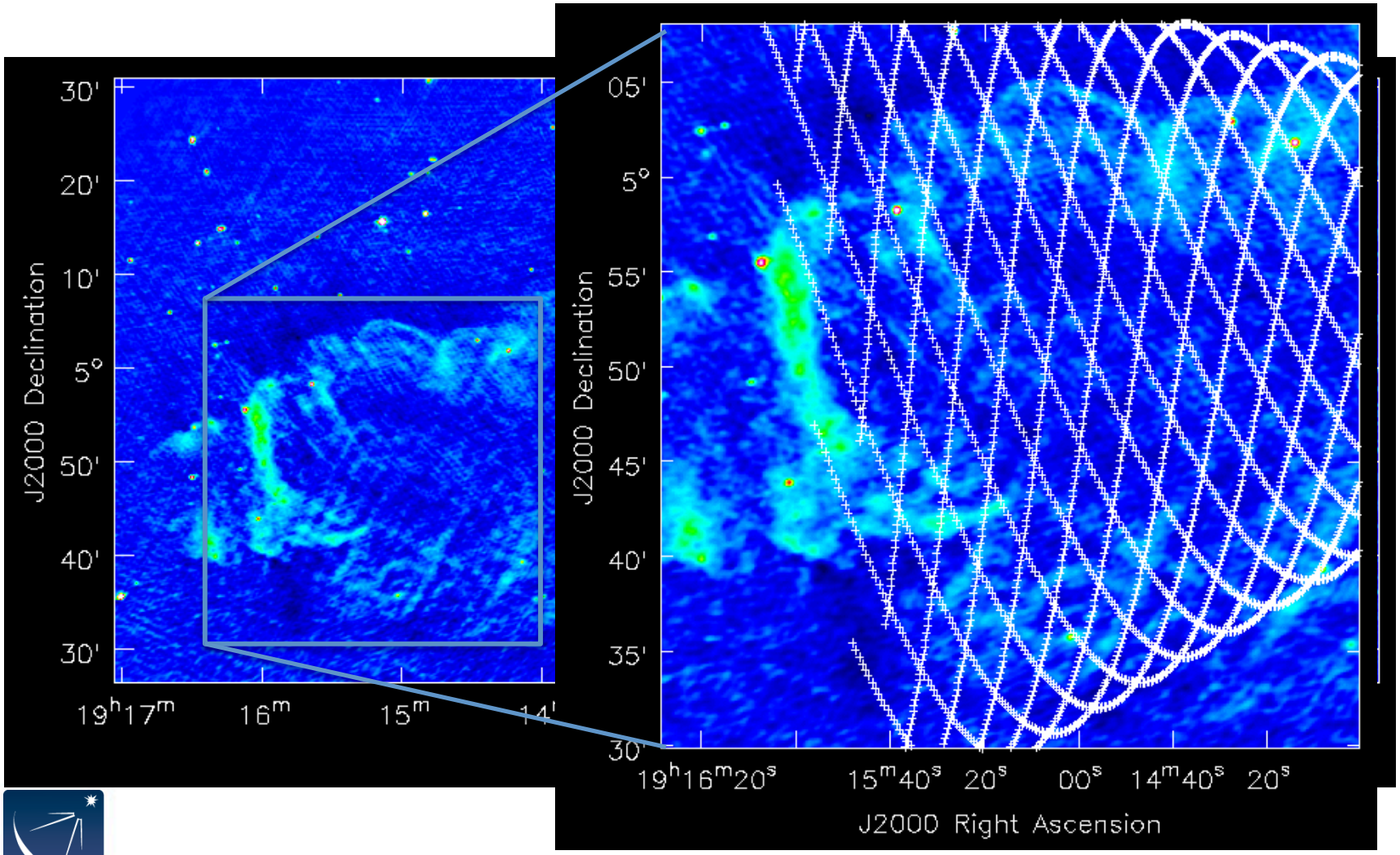


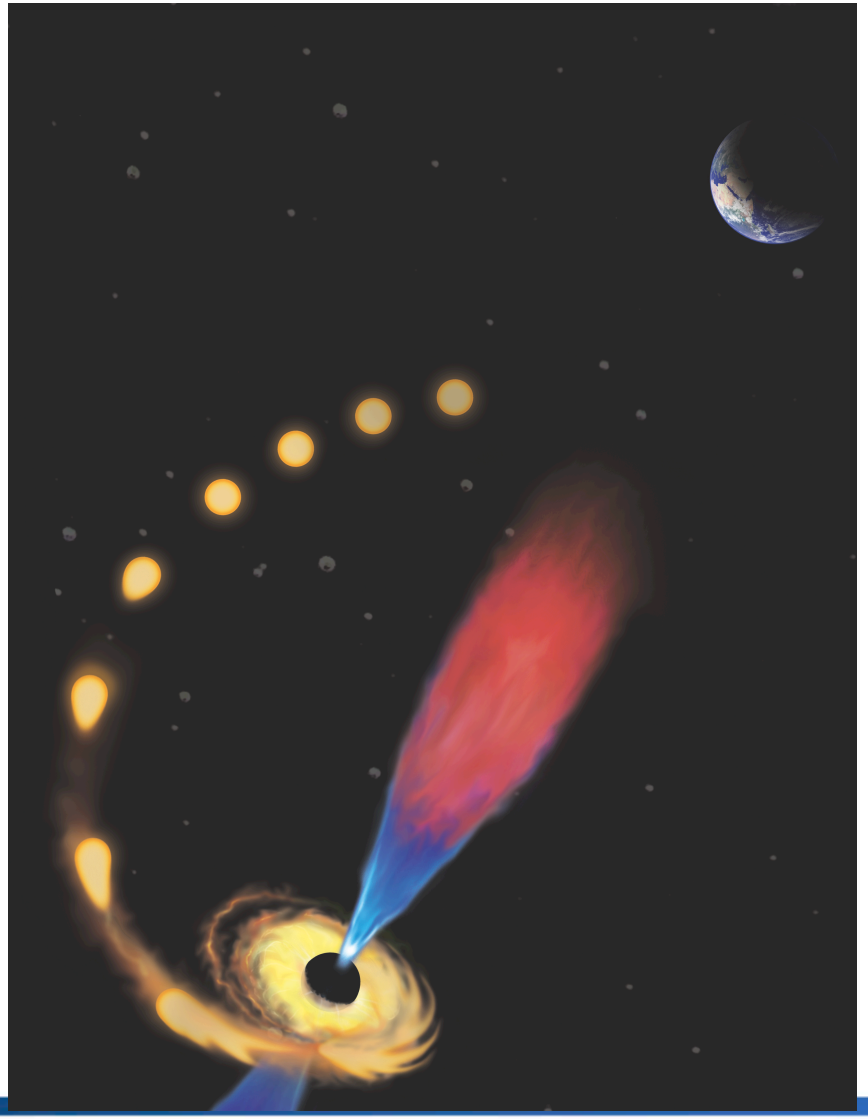
SS433 and the W50 nebula



Tidal disruption events

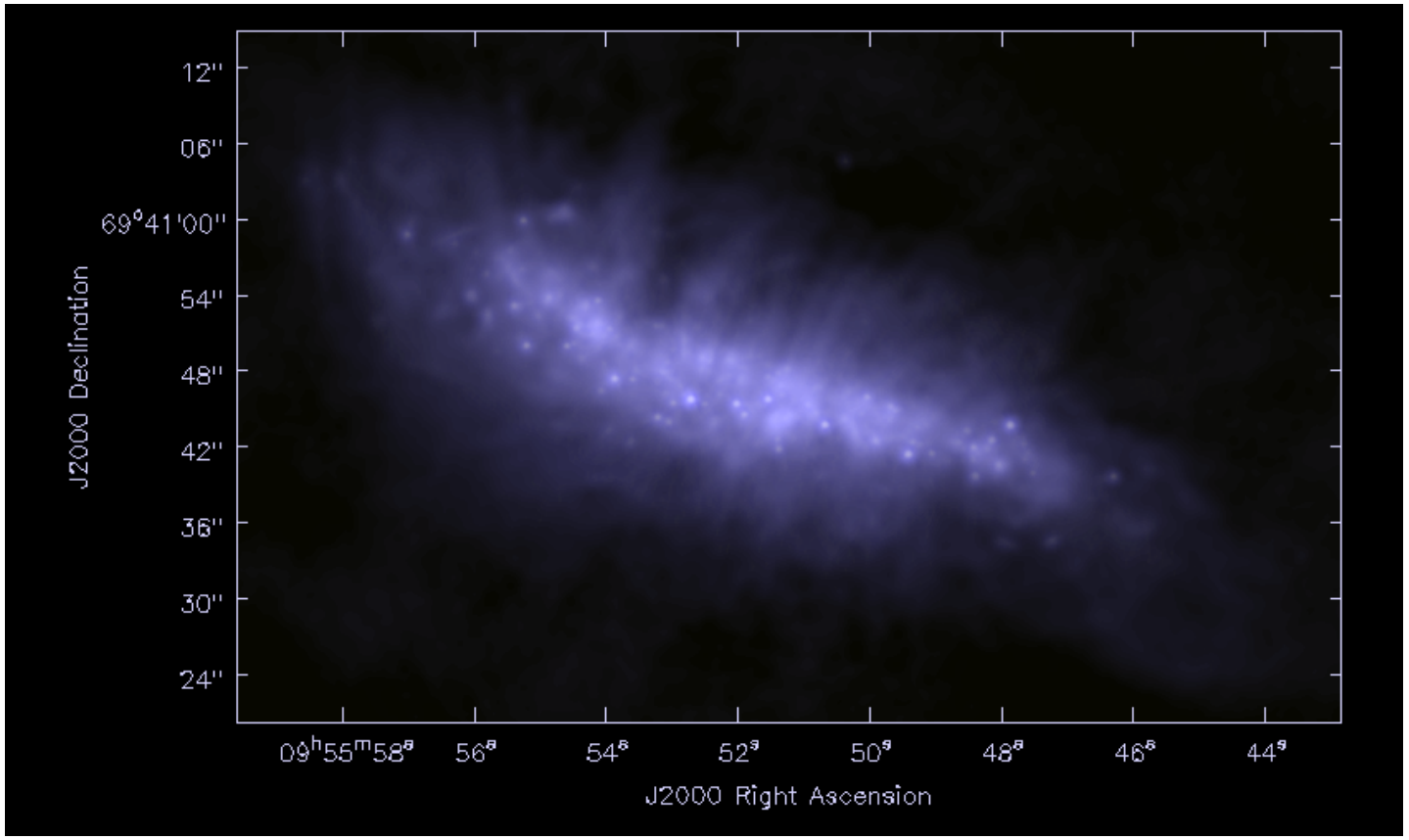
- *Swift* discovered a unique, long duration, luminous event on March 25, 2011
- EVLA able to follow up within a day, discovers a radio transient with optically thick emission, localized to the center of a normal galaxy at $z=0.354$
- Radio emission best explained as a relativistic jet formed as the result of a tidal disruption event

- (See talk by Ashley Zauderer)



Winds, SNRs, HII regions in M82

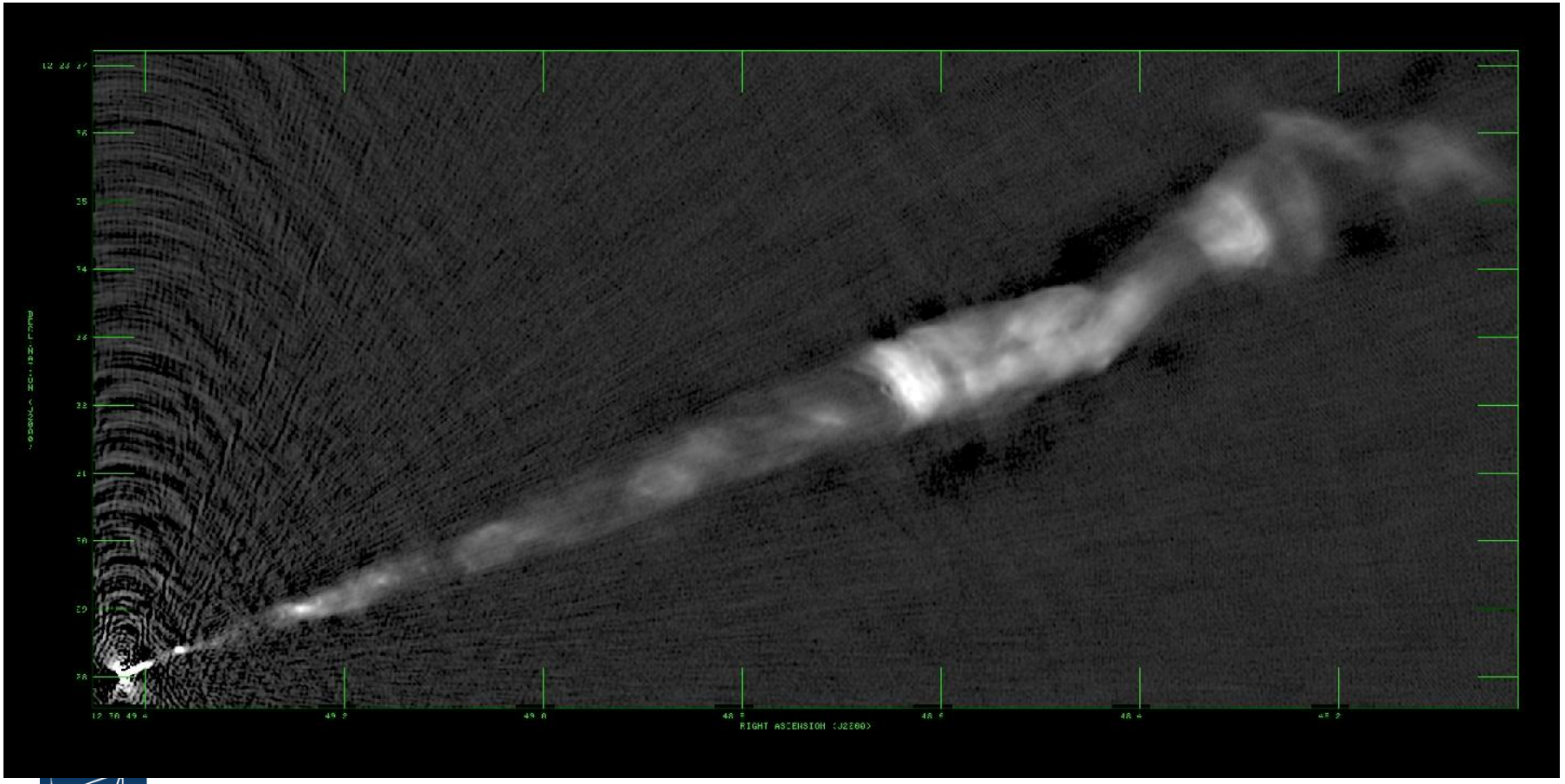
- Non-thermal filaments trace the superwind perpendicular to the plane of the galaxy (Josh Marvil, PhD Thesis, NMT)



EVLA

M87

- Shocks, particle acceleration, and jet physics (EVLA demo science: F. Owen)



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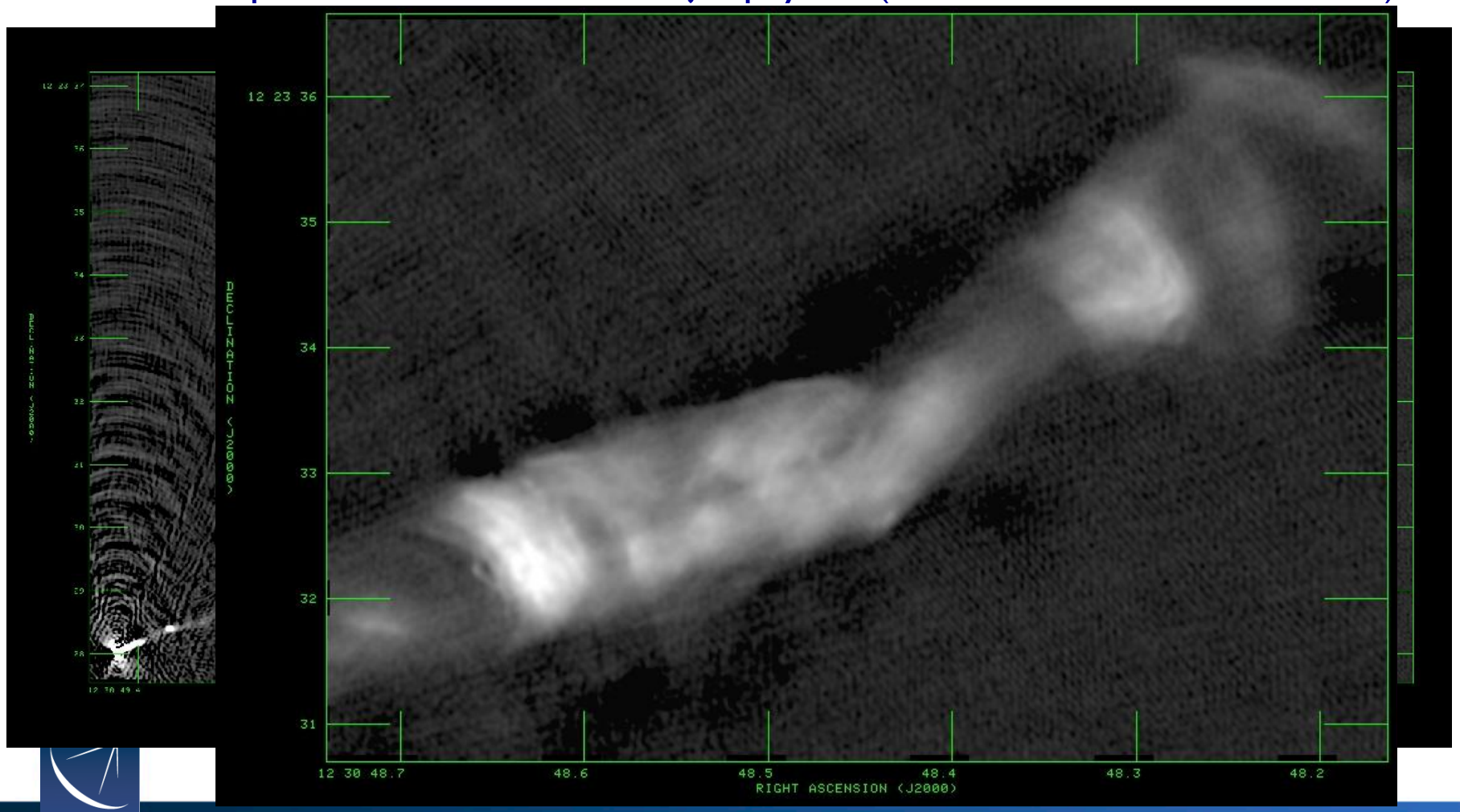

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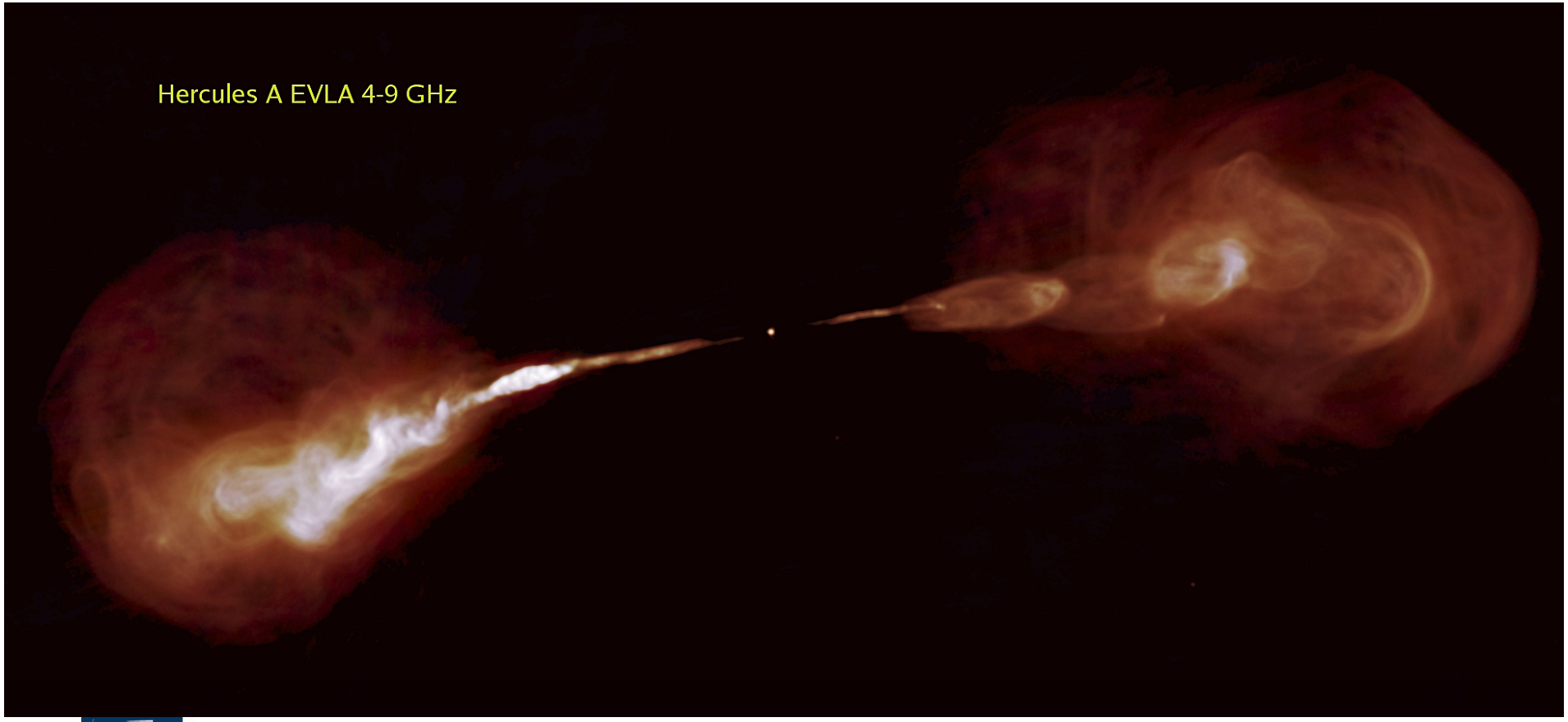
Hercules A

- 4-9 GHz "true radio color"



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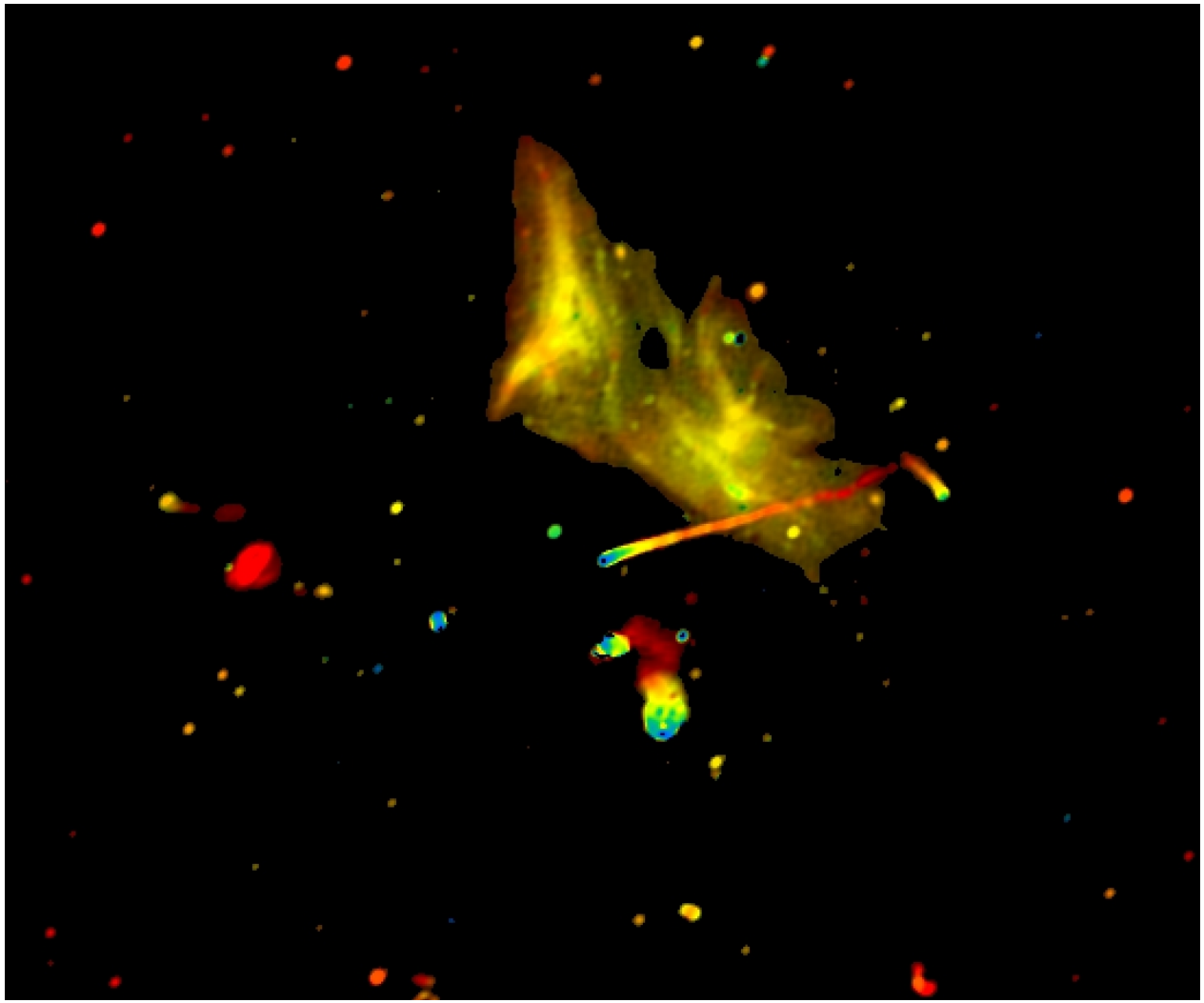
Relics and jets in Abell 2256

- 1–2 GHz, 20-arcmin on a side; color corresponds to spectral index (Owen, Rudnick, Eilek, Rau, Bhatnagar, Kogan)
- Studies of the complex interactions between galaxies, AGN feedback, ICM, magnetic fields, and dark matter content of clusters
- Role of radio galaxies and relics in cluster evolution?



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Using the JVLA

- Next proposal deadline AUGUST 1, 2012
- General capabilities available:
  - Up to 8 GHz bandwidth, full polarization for continuum science
  - Standard spectral set-ups covering key lines plus continuum for each receiver band, for galactic and extragalactic applications
  - Fast dumps (subject to a data rate maximum)
  - Multiple sub-arrays
  - Mosaics
- Advanced capabilities for Resident Shared Risk Observers
  - Complex observing strategies and correlator set-ups
    - E.g., mixing of standard correlator modes and recirculation for phased array using ultra-fast dumps
  - Any other innovative uses of the telescope you can think of!
- Contact us through the NRAO helpdesk, https://science.nrao.edu/observing/helpdesk