

Karl G. Jansky Very Large Array (VLA)
Atacama Large Millimeter/ submillimeter Array (ALMA)
European Very Long Baseline Interferometer (EVLBI)
Australian Telescope Compact Array (ATCA)
Data Reduction Results

Plus 9 ft. Dish HI Measurement Results

**DSES Science
Meeting
November 25, 2019**

Dr. Richard A. Russel



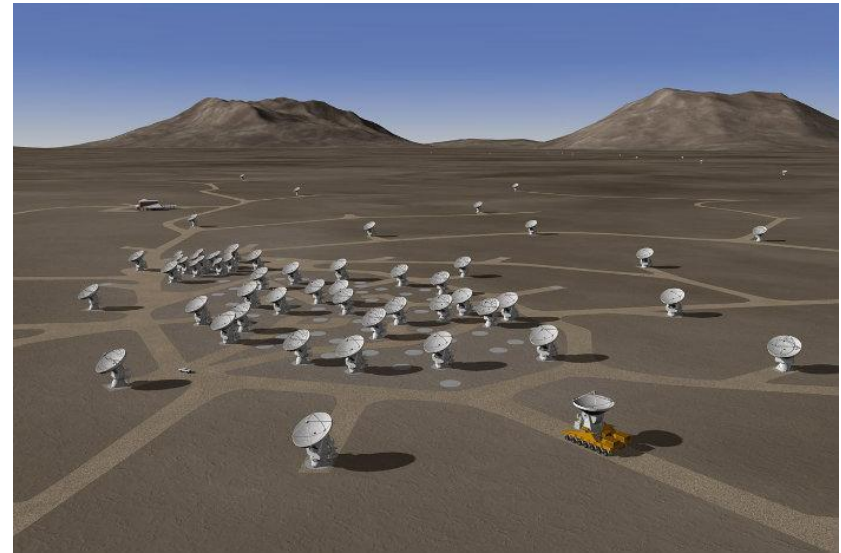
Antenna Systems

VLA



<https://www.atlasobscura.com/places/very-large-array>

ALMA



<http://wikimapia.org/12830127/Atacama-Large-Millimeter-submillimeter-Array-ALMA>

European Very Long Baseline Interferometer (EVLBI)



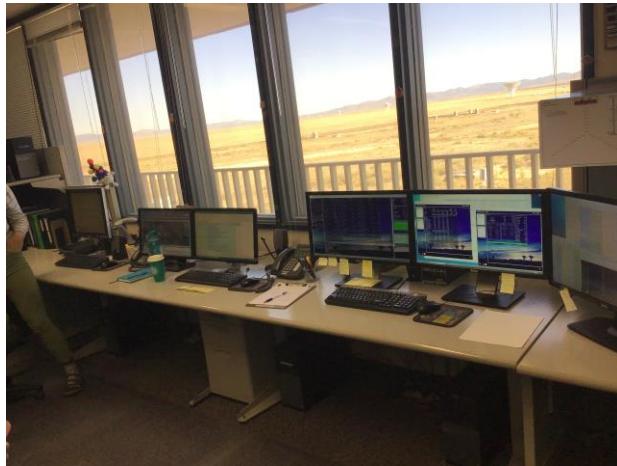
<https://www.evlbi.org/telescopes>

Australian Telescope Compact Array (ATCA)



https://www.narrabri.atnf.csiro.au/observing/users_guide/html/chunked/index.html

VLA Tour



VLA Tour

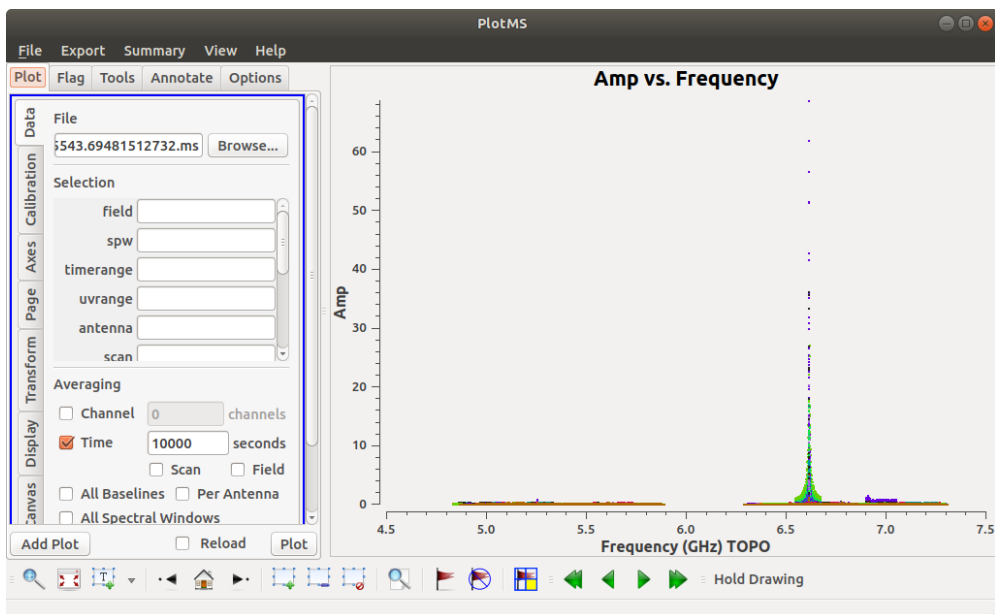


Pulling Data from VLA Archive

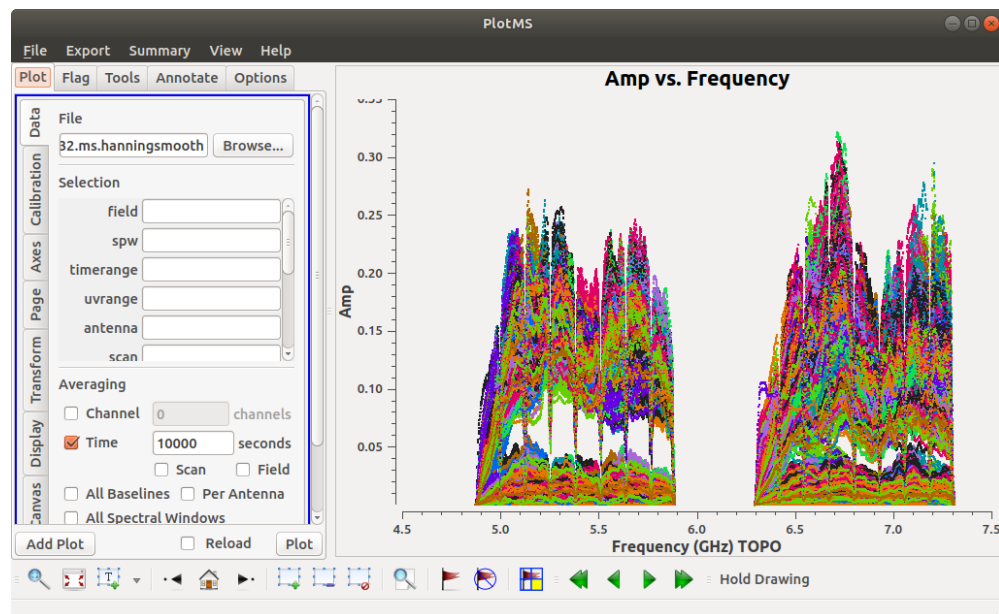
NRAO Science Data Archive : Advanced Search Tool Historical VLA, Jansky VLA, VLBA and GBT Data Products			
<input type="button" value="Submit Query"/>		<input type="button" value="Check Query"/>	
Output Control Parameters :			
<div style="border: 1px solid black; padding: 5px; display: inline-block;"> Choose Query Return Type : <input checked="" type="radio"/> Download Archive Data Files <input type="radio"/> VLA Observations Summary <input type="radio"/> List of Observation Scans <input type="radio"/> List of Projects </div>			
Output Tbl Format <input type="text" value="HTML"/>		Sort Order Column 1 <input type="text" value="Starttime"/> <input type="button" value="Asc"/>	
Max Output Tbl Rows <input type="text" value="NO LIMIT"/>		Sort Order Column 2 <input type="text" value="Starttime"/> <input type="button" value="Asc"/>	
General Search Parameters :			
Telescopes <input checked="" type="checkbox"/> All <input type="checkbox"/> Jansky VLA <input type="checkbox"/> Historical VLA <input type="checkbox"/> VLBA <input type="checkbox"/> GBT			
Project Code <input type="text"/> <small>GBT: AGBT12A_055 JVLA: 12A-256</small>		Project Session <input type="text"/>	
Dates From <input type="text"/>		To <input type="text"/>	
Observer Name <input type="text"/>		Archive File ID <input type="text"/> <small>(partial strings allowed)</small>	
Position Search :			
Target Name <input type="text"/>		Search Type <input type="text" value="SIMBAD or NED"/>	
RA or Longitude <input type="text"/> <small>(04h33m11.1s or 68.29d)</small>		DEC or Latitude <input type="text"/> <small>(05d21'15.5" or 5.352d)</small>	
Search Radius <input type="text" value="1.0"/> <small>(1d00'00" or 0.2d)</small>		Min. Exposure <input type="text"/> (secs)	
- OR - <input type="checkbox"/> Check for automatic VLA field-of-view, freq. dependent.??			
Observing Configurations Search :			
Telescope Config <input checked="" type="checkbox"/> All <input type="checkbox"/> A <input type="checkbox"/> AB <input type="checkbox"/> BnA <input type="checkbox"/> B <input type="checkbox"/> BC <input type="checkbox"/> CnB <input type="checkbox"/> C <input type="checkbox"/> CD <input type="checkbox"/> DnC <input type="checkbox"/> D <input type="checkbox"/> DA		Observing Bands <input checked="" type="checkbox"/> All <input type="checkbox"/> 4 <input type="checkbox"/> P <input type="checkbox"/> L <input type="checkbox"/> S <input type="checkbox"/> C <input type="checkbox"/> X <input type="checkbox"/> U <input type="checkbox"/> K <input type="checkbox"/> Ka <input type="checkbox"/> Q <input type="checkbox"/> W	
Sub_array <input checked="" type="checkbox"/> All <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/> 5		Frequency Range <input type="text"/> <small>(In MHz: 1665.401 - 1720.500)</small>	
Polarization <input type="text" value="ALL"/>		Data Type <input type="text" value="ALL"/>	
Enter Locked Project Access key : <input type="text"/>			
<small>Unique keywords may be used to unlock proprietary data from individual observing projects. Contact the NRAO Data Analysis for project access keys.</small>			
<input type="button" value="Submit Query"/>		<input type="button" value="Check Query"/>	
<input type="button" value="Clear Form"/>		<input type="button" value="Clear Form"/>	
Please direct feedback and/or questions concerning this page and its associated search engine to NRAO DAS contact . Version 5.9.15 (25948)			

Data Before and After Flagging

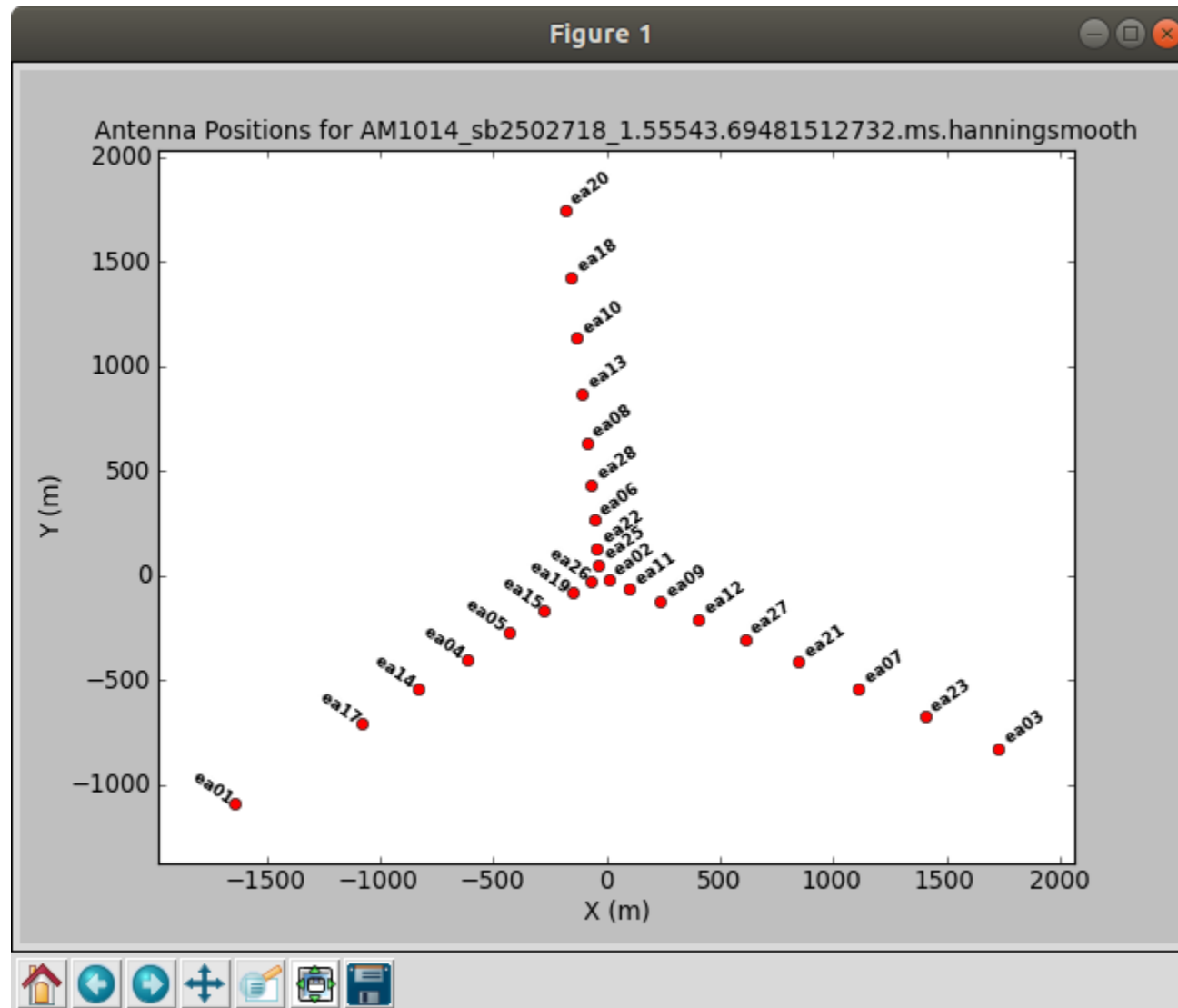
Before Flagging



After Flagging



EVLA Antenna Pattern

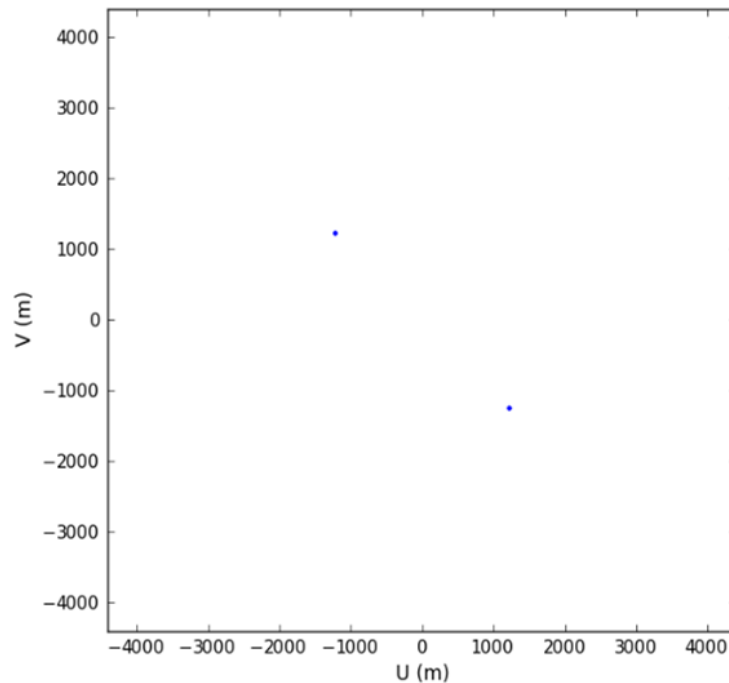
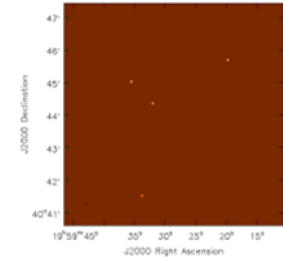


2 Antenna Example

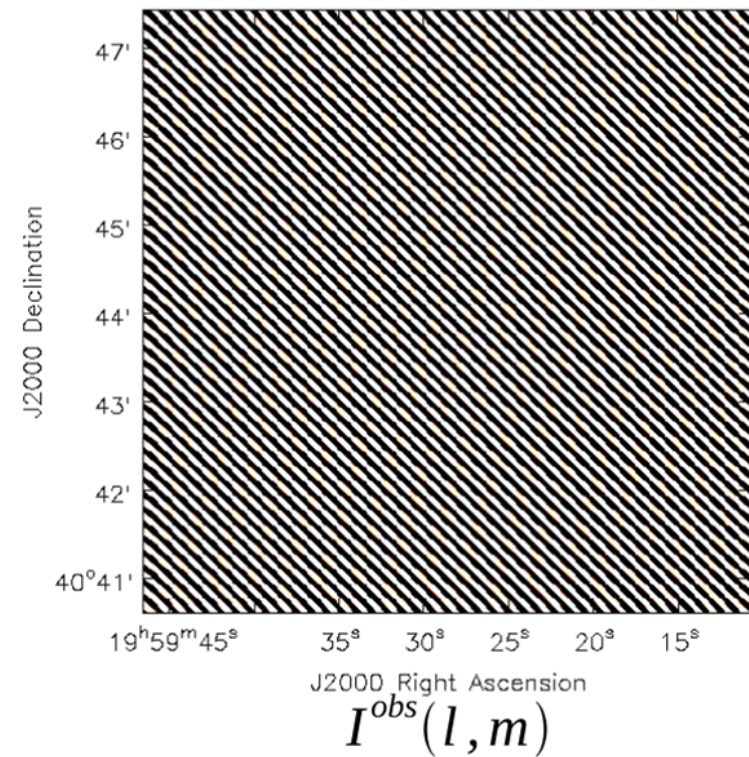
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 2 antennas



$S(u, v)$

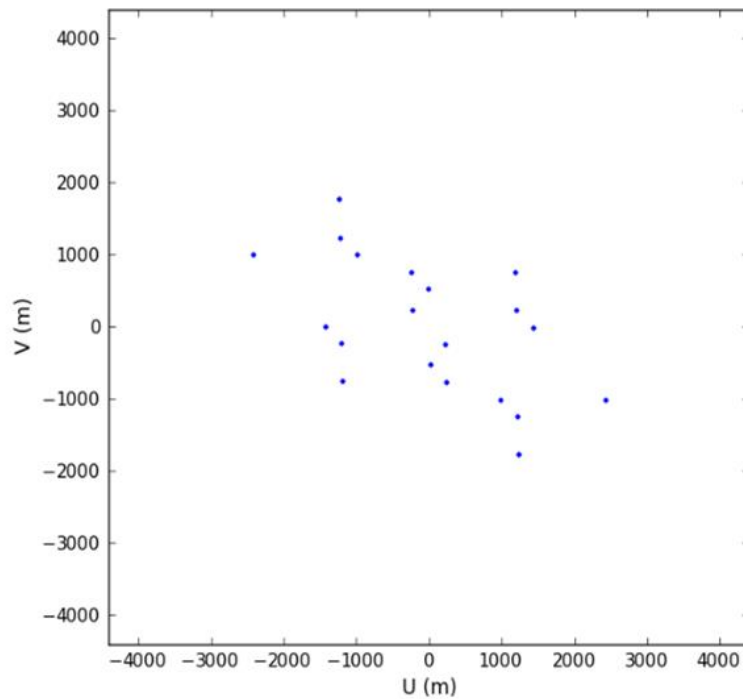


$I^{obs}(l, m)$

5 Antenna Example

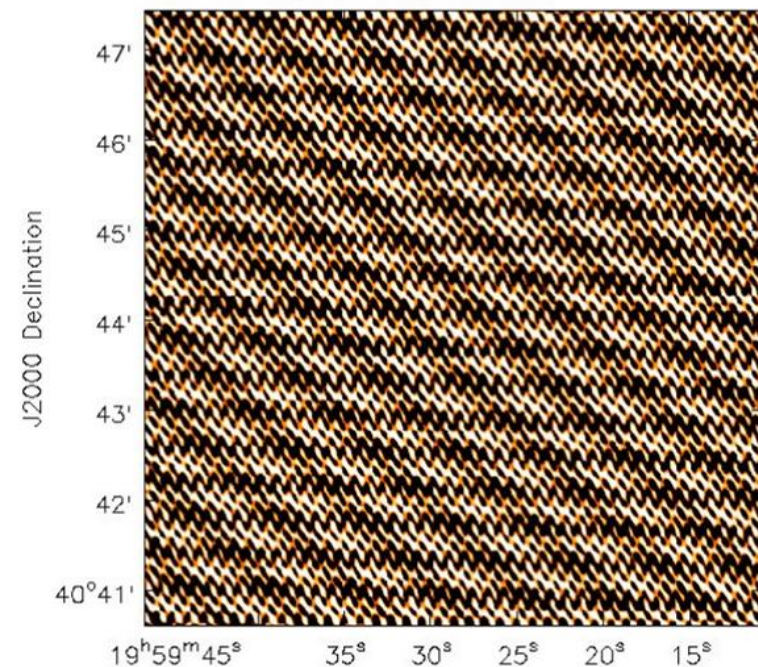
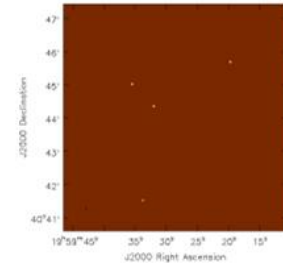
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$



$S(u, v)$

Image of the sky
using 5 antennas



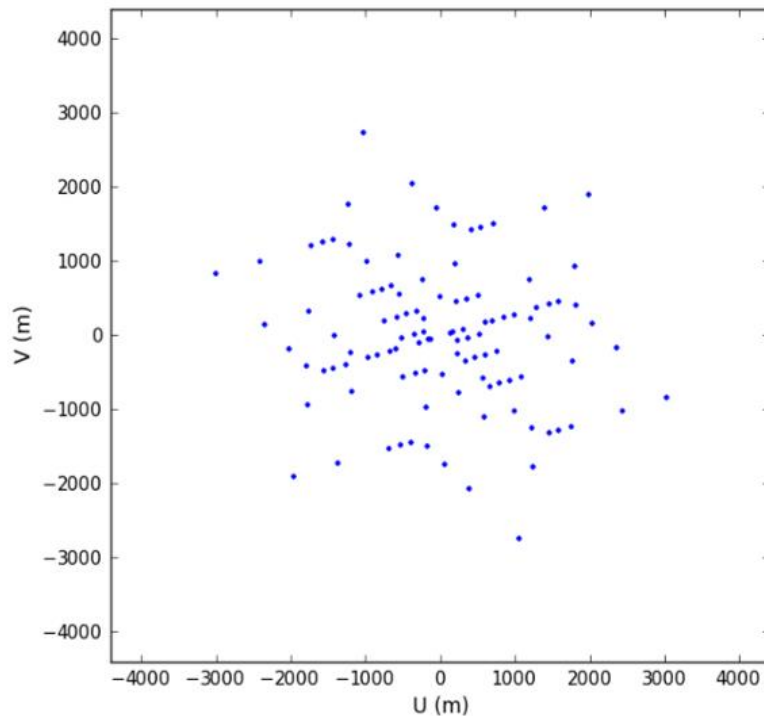
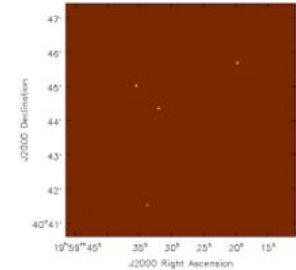
$I^{obs}(l, m)$

11 Antenna Example

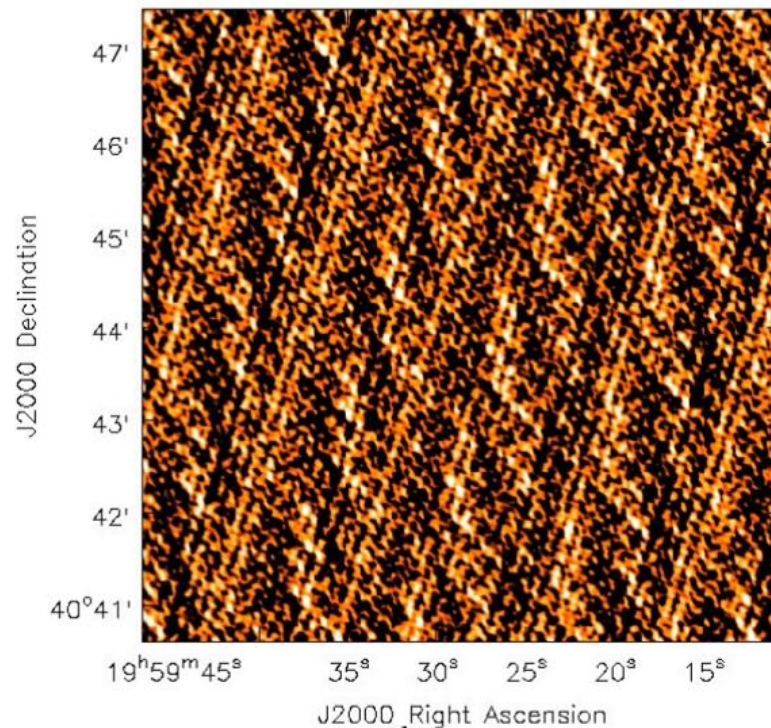
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 11 antennas



$S(u, v)$



J2000 Right Ascension

$I^{obs}(l, m)$

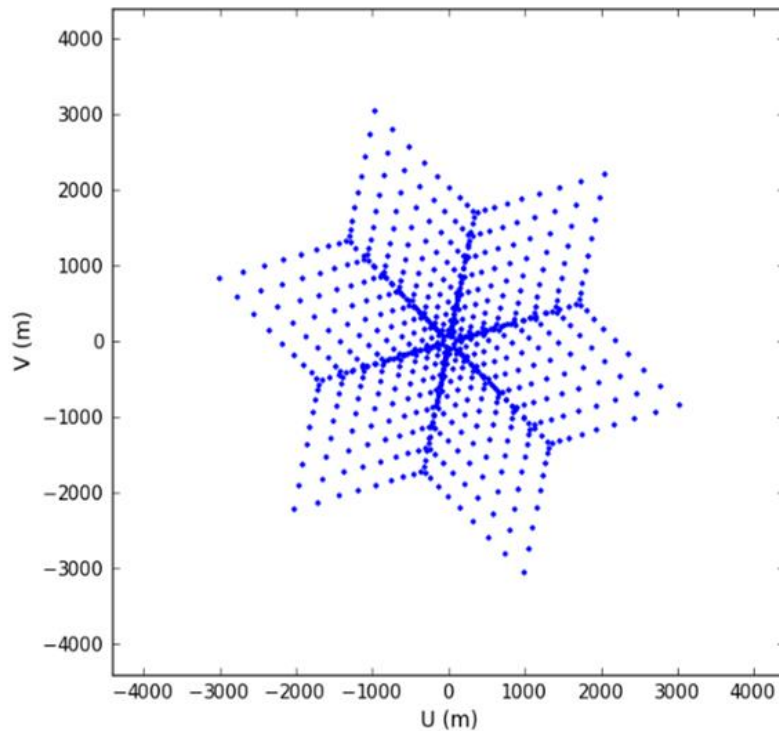
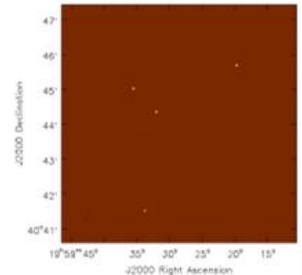
Source: www.NRAO.edu

27 Antenna Example

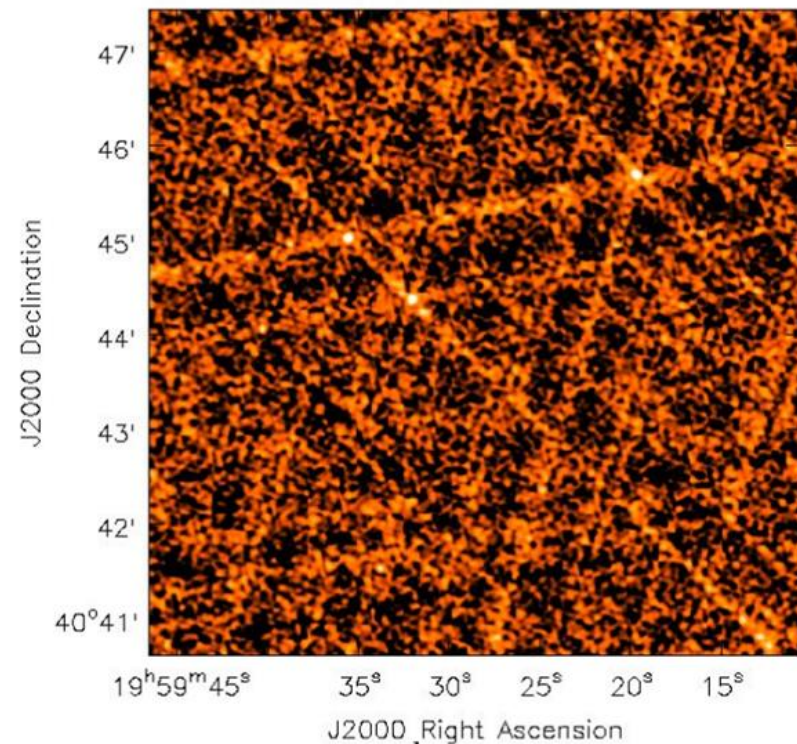
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 27 antennas



$S(u, v)$



J2000 Right Ascension

$I^{obs}(l, m)$

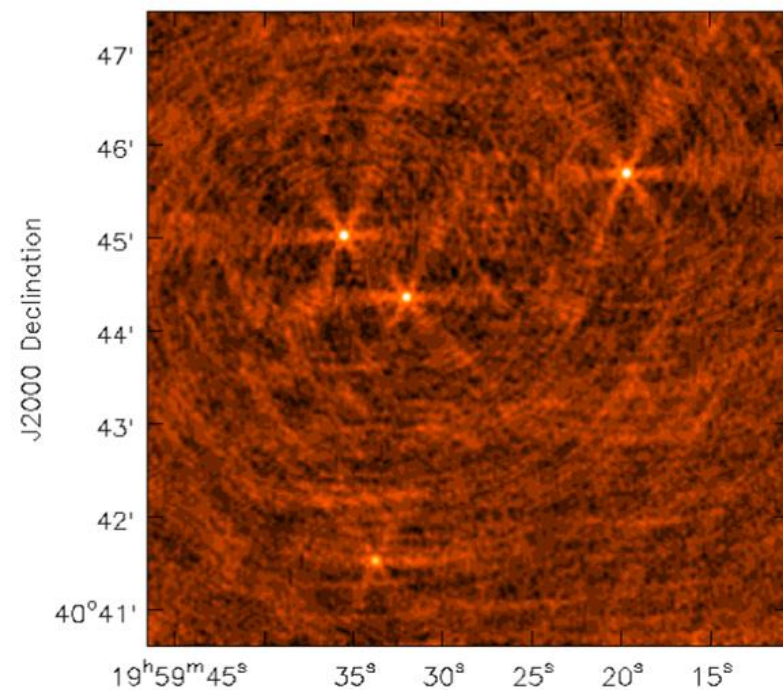
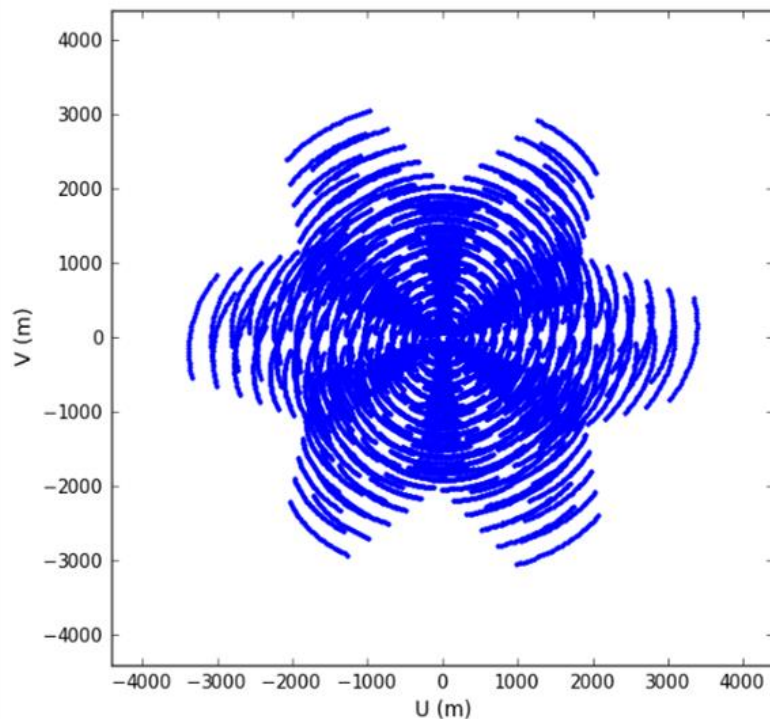
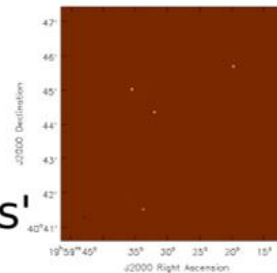
Source: www.NRAO.edu

27 Antennas with 2-hour Rotation

Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} \begin{bmatrix} R(h, \theta) \end{bmatrix} \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 27 antennas
over 2 hours
'Earth Rotation Synthesis'



$S(u, v)$ Source: www.NRAO.edu

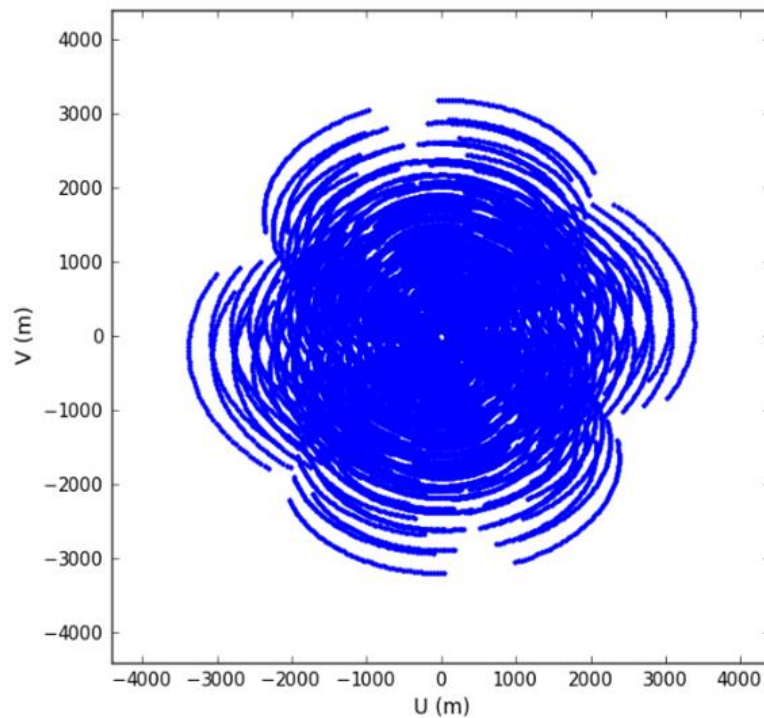
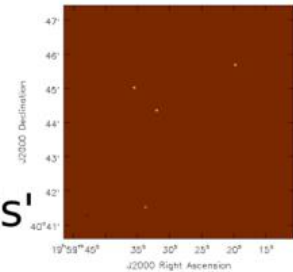
$I^{obs}(l, m)$

27 Antennas with 4-hours Rotation

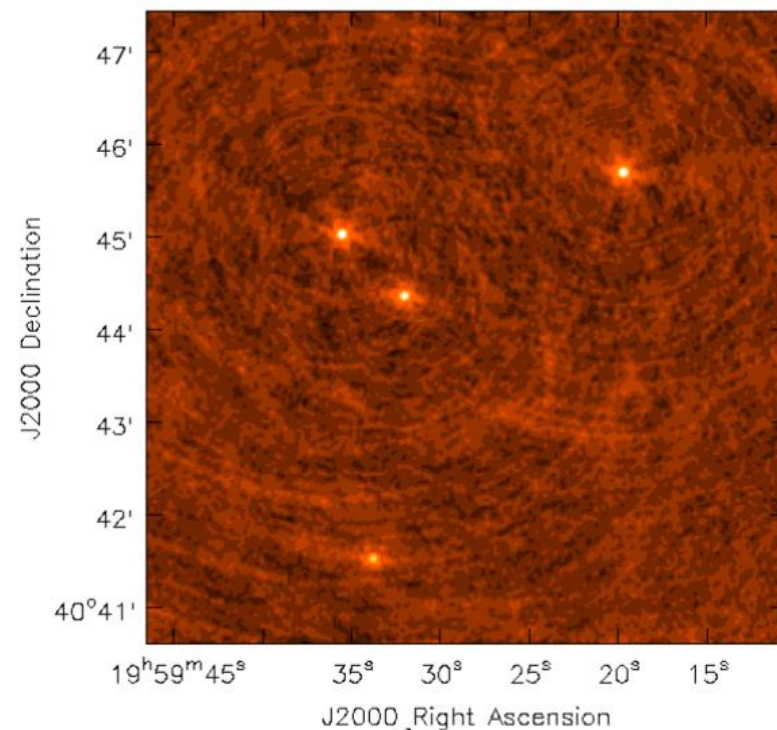
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} \begin{bmatrix} R(h, \theta) \end{bmatrix} \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 27 antennas
over 4 hours
'Earth Rotation Synthesis'



$S(u, v)$



$I^{obs}(l, m)$

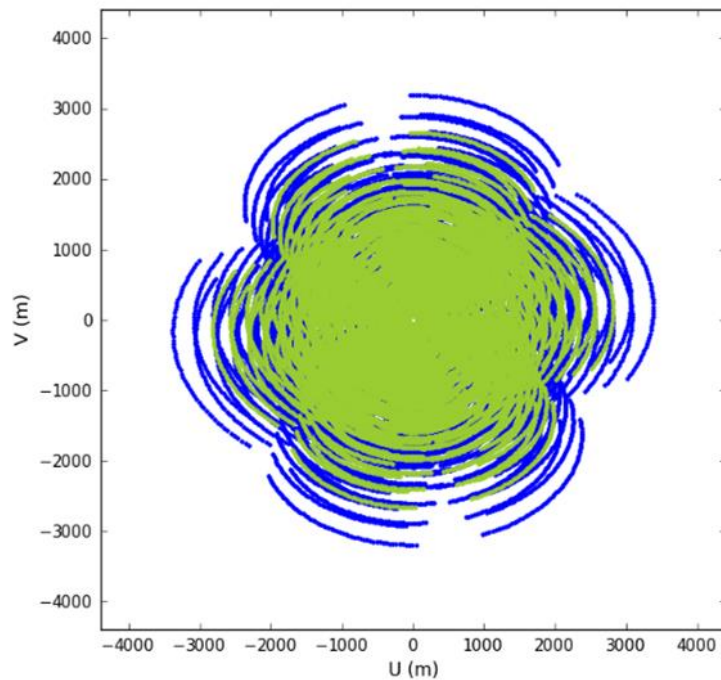
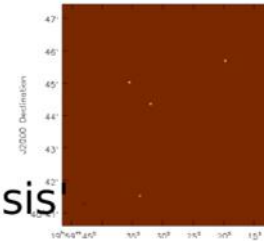
Source: www.NRAO.edu

27 Antennas with 4-hours Rotation and 2 Frequencies

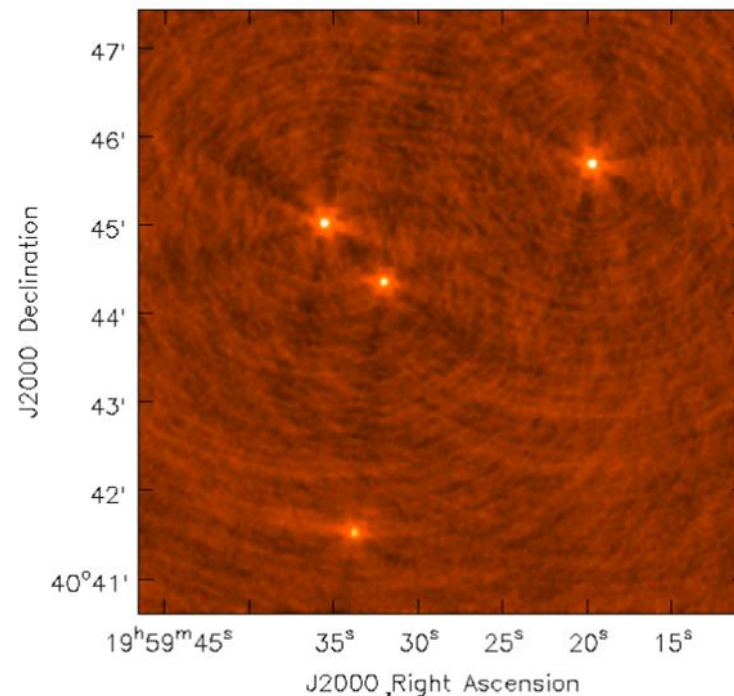
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 27 antennas
over 4 hours, 2 freqs
'Multi-Frequency Synthesis'



$S(u, v)$



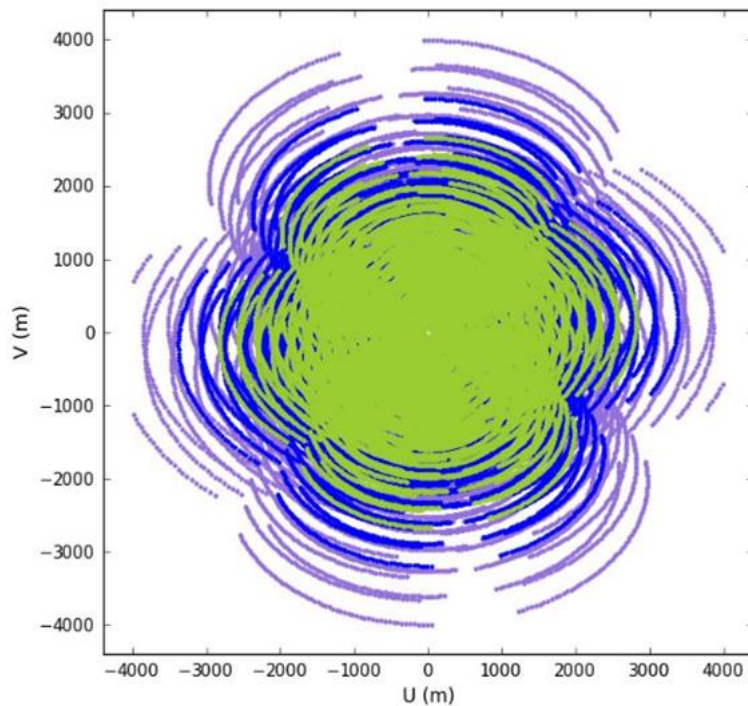
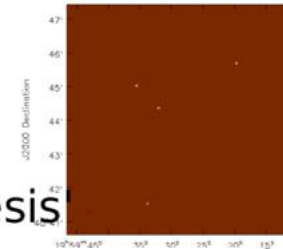
$I^{obs}(l, m)$

27 Antennas with 4-hours Rotation and 3 Frequencies

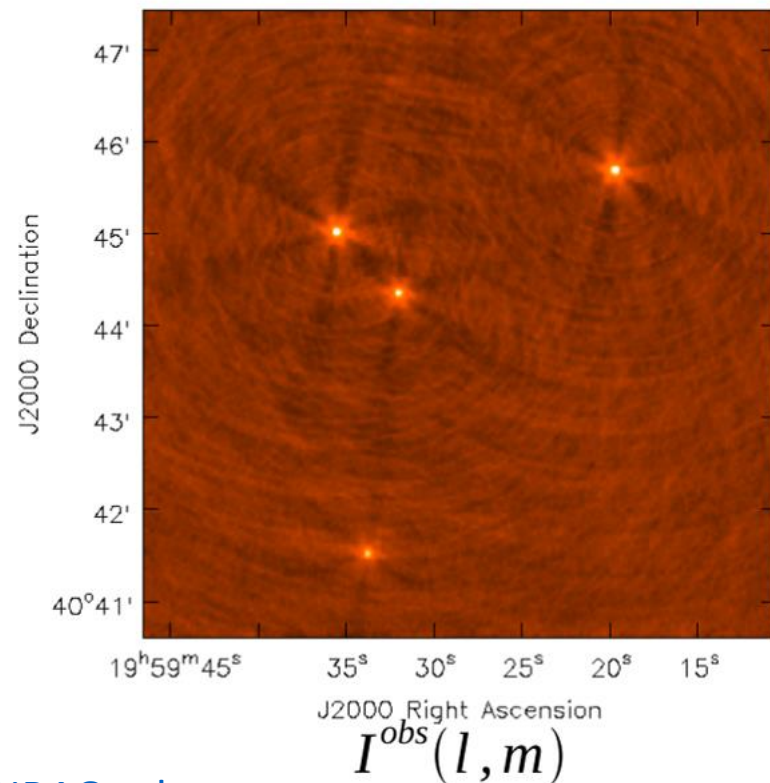
Spatial Frequency (uv) coverage + Observed Image

$$\begin{bmatrix} u \\ v \\ w \end{bmatrix} = \frac{1}{\lambda} R(h, \theta) \begin{bmatrix} \delta x \\ \delta y \\ \delta z \end{bmatrix}$$

Image of the sky
using 27 antennas
over 4 hours, 3 freqs
'Multi-Frequency Synthesis'



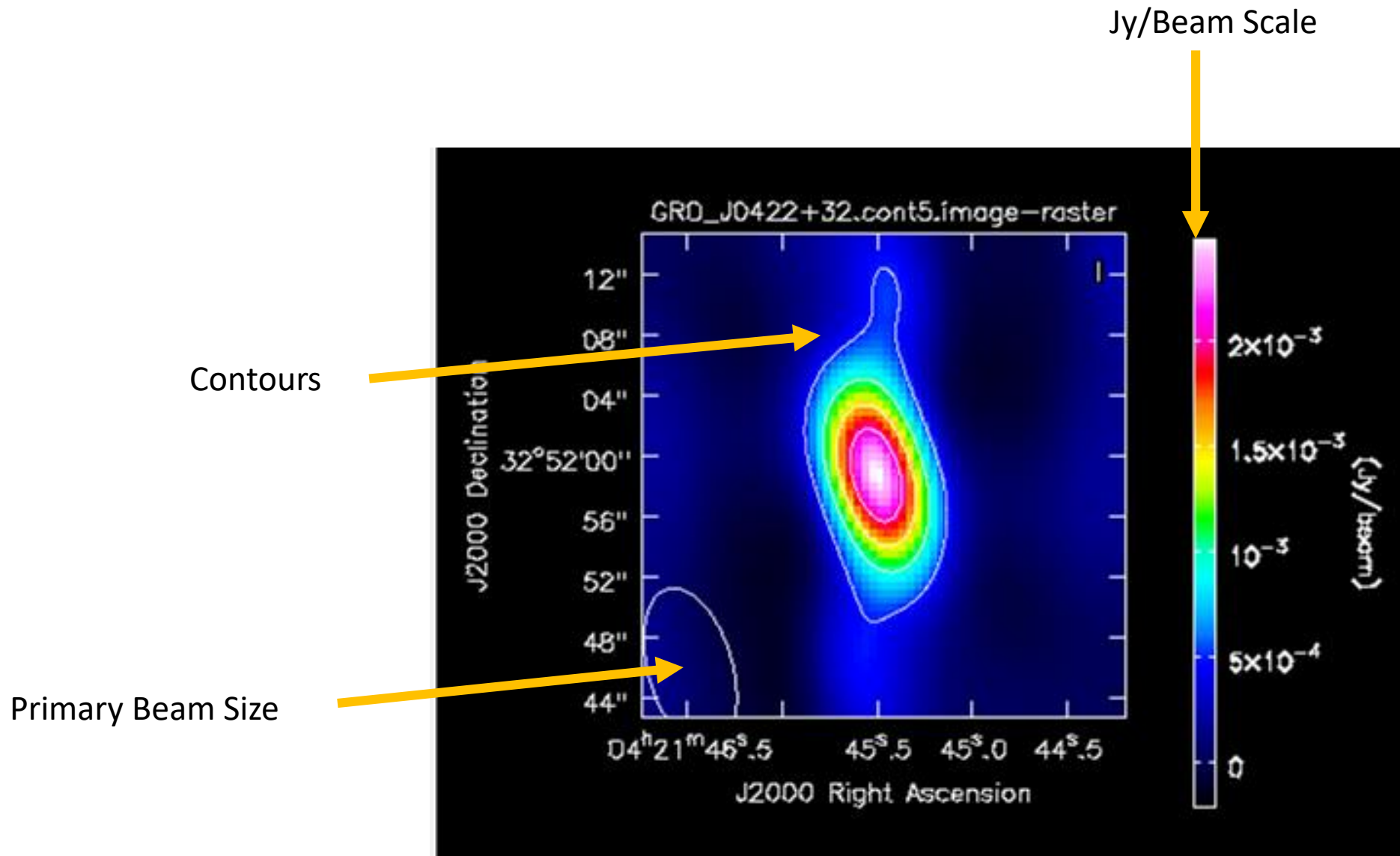
$S(u, v)$



$I^{obs}(l, m)$

Source: www.NRAO.edu

After Clean



3C75 Binary Black Hole System (VLA Archive)

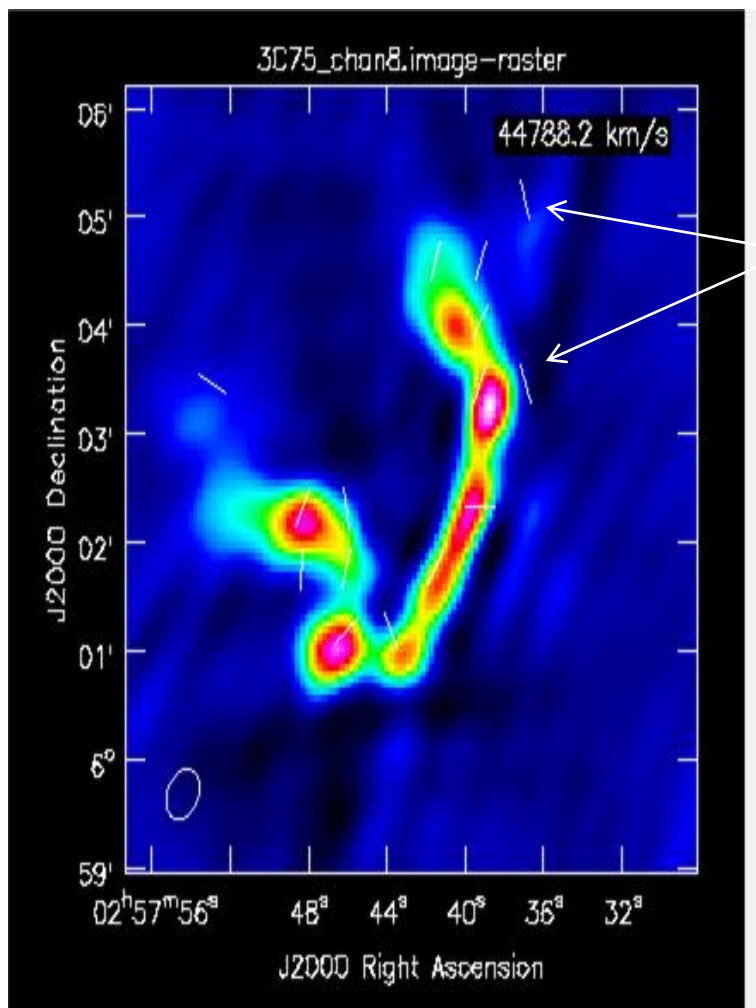
VLA OBSERVING LOG

2018-10-04_0541_TDRW0001

Observing Date: 04-Oct-2018
Configuration: D
Decommissioned: 27

Project:	TDRW0001	# Subarrays:	1	Observation Type:	Test
Observer (PI):	Dr Emmanuel Momjian	Band(s) Used:	C S		
SBID(s):	35624494				
Source File(s):	TDRW0001_sb35624494_1_1				
Observer E-mail:	emomjian@nrao.edu				
Operator(s):	Kenneth Gibson				

Data Reduction Results



Polarization vectors

Background Information Wikipedia

3C75 (a.k.a. 3C 75) is a [binary black hole](#) system in the [Abell 400 cluster of galaxies](#). It has four radio jets (two from each accreting black hole). It is travelling at 1200 kilometers per second through the cluster plasma, causing the jets to be swept back. The binary [supermassive black holes](#) are themselves contained in the dumbbell shaped galaxy [NGC 1128](#). 3C 75 may be X-ray source 2A 0252+060 (1H 0253+058, XRS 02522+060).[\[4\]](#) Wikipedia



Followed tutorial

https://casaguides.nrao.edu/index.php/Polarization_Calibration_based_on_CASA_pipeline_standard_reduction:_The_radio_galaxy_3C75-CASA4.5.2
and produced this image: Dr. Richard A. Russel 10/16/19 (detail in CASA 3C75 Tutorial.odt)

3C391 Supernova Remnant (VLA Archive)

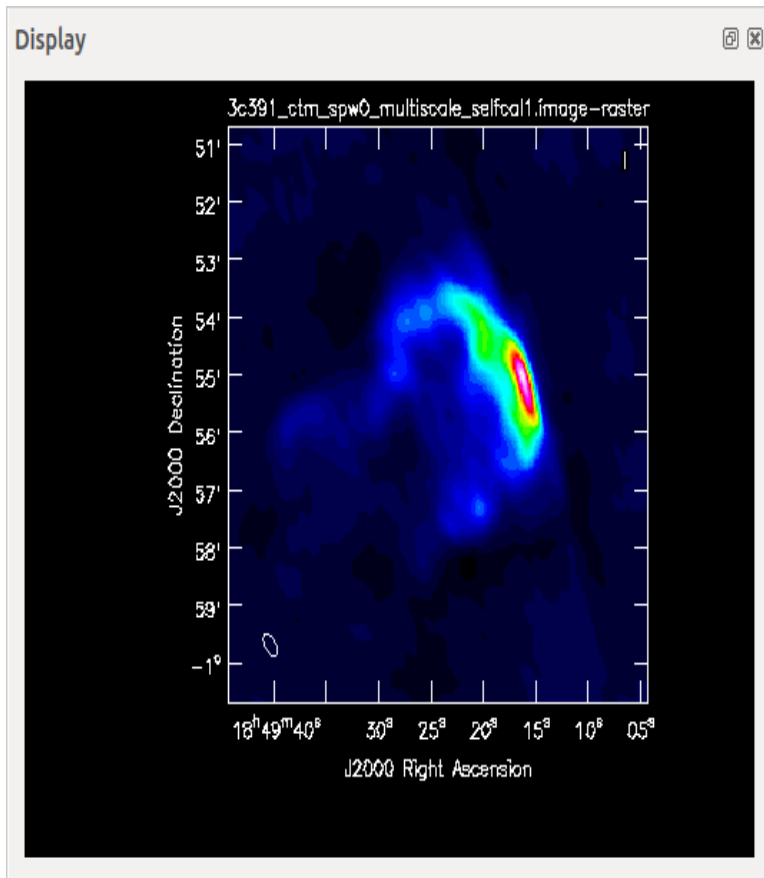
EVLA OBSERVING LOG

2010-04-24_0801_TDEM0001

Observing Date: 24-Apr-2010
Configuration: D
Decommissioned: 10
VLBI Ref Ant:
VLBI Ant Pad:

Program:	TDEM0001	Observing Mode:	Mixed Modes
Observer(s):	James Miller-Jones	Bands Used:	C
User #:	2398	# Subarrays:	1
Observer's E-mail:	j.miller@nrao.edu, m.rupen@ao.nrao.edu	Initial Source:	J1331+3030
Source File(s):	TDEM0001_sb1218006_1.evla		
Operator(s):	Sam Gilmore		

Data Reduction Results



Background Information Astronomy and Astrophysics 78,75-77 (1979)

Observations of the Supernova Remnant 3C391 at 1.4 and 10.7 GHz

W. M. Goss¹, D. J. Skellern², A. Watkinson², and P. A. Shaver^{1*}

¹ Kapteyn Astronomical Institute, University of Groningen, Postbus 800, 9700 AV Groningen, The Netherlands

² School of Electrical Engineering, University of Sydney, Australia

Received August 17, 1978

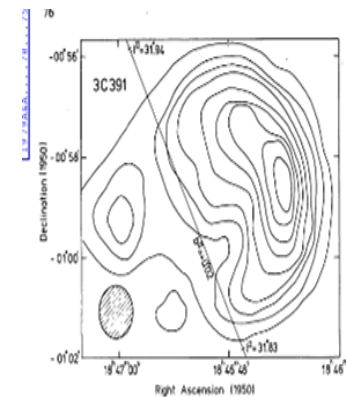


Fig. 1. Map of 3C391 observed with the Fleurs Synthesis Telescope. The HPBW is $54 \times 66''$ arc ($\alpha \times \delta$). The contour levels are 50, 100, 150, 200, 300, ..., 700 K (50 K = 0.27 Jy/beam)

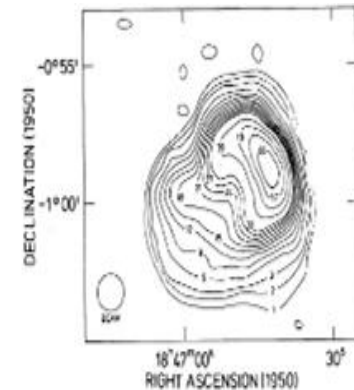


Fig. 2. Map of 3C391 observed at 10.7 GHz with the Effelsberg telescope. The half-power beamwidth is $77''$. The contour unit is 0.02°K in antenna temperature or 0.03°K in brightness temperature

Asymptotic Giant Branch (AGB) Star IRC+10216 (VLA Archive)

Background Information Wikipedia

IRC +10216 or CW Leonis is a well-studied [carbon star](#) that is embedded in a thick dust envelope. It was first discovered in 1969 by a group of astronomers led by [Eric Becklin](#), based upon infrared observations made with the 62 inches (1.6 m) [Caltech Infrared Telescope](#) at [Mount Wilson Observatory](#).

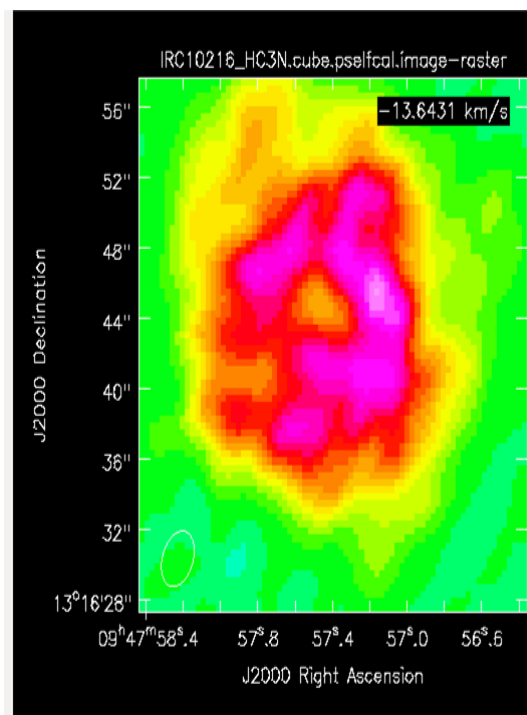
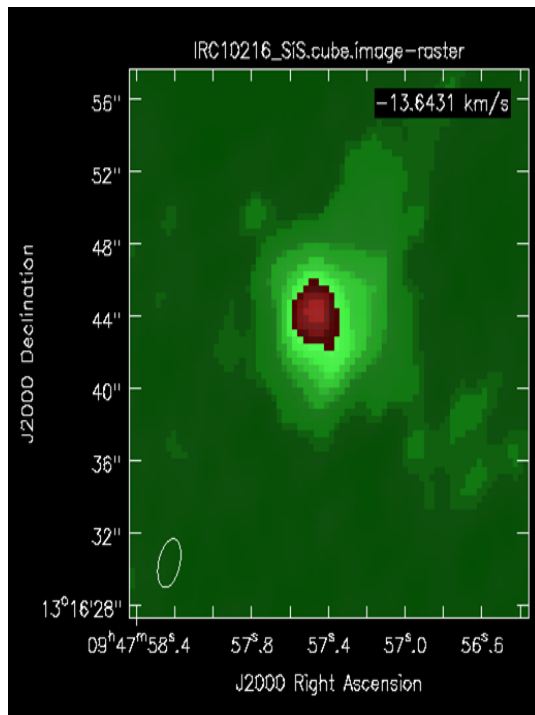
EVLA OBSERVING LOG

2010-04-26_0310_TDEM0003

Observing Date: 26-Apr-2010
Configuration: D
Decommissioned: 10
VLBA Ref Ant:
VLBA Ant Pad:

Program:	TDEM0003	Observing Mode:	Continuum
Observer(s):	Mark Clausen	Bands Used:	C, Ka
User #:	661	# Subarrays:	1
Observer's E-mail:	mclausse@nrao.edu, mrupe@nrao.edu	Initial Source:	J1008+0730
Source File(s):	TDEM0003_sb1345754_1.evla		
Operator(s):	Matt Gardner		

Data Reduction Results



MG0414+0534 Gravitational Lens HI Absorption Line (VLA Archive)

VLA OBSERVING LOG

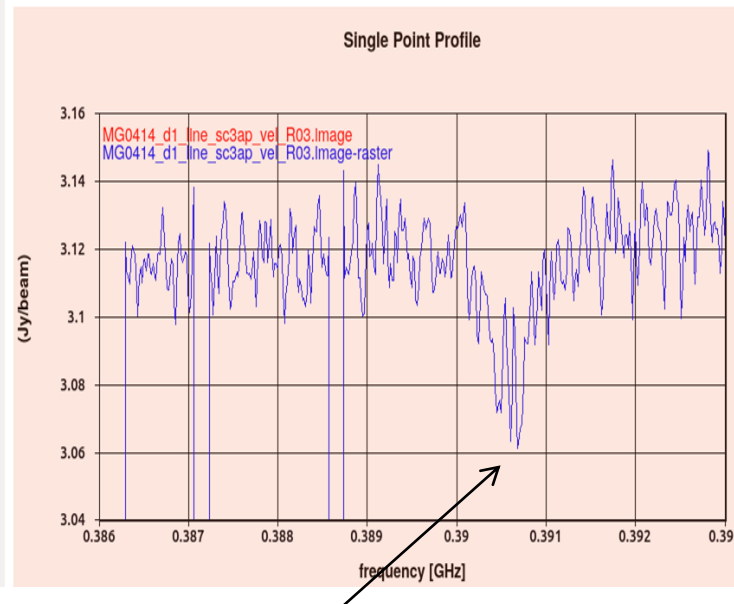
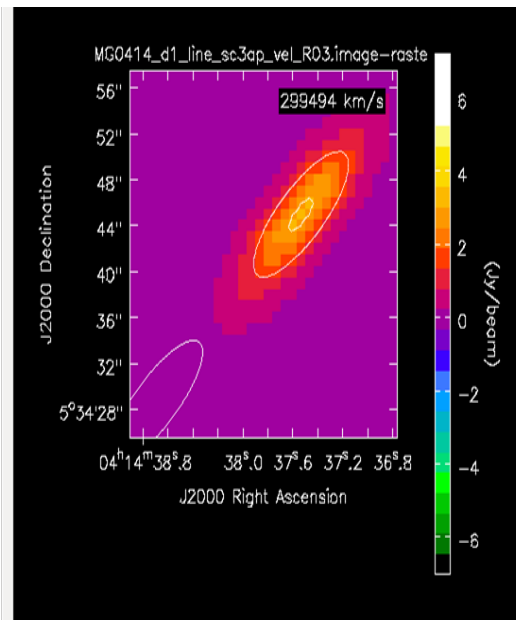
2016-09-14_0620_TSUB0001

Observing Date: 14-Sep-2016
Configuration: B>A
Decommissioned: 11

Project:	TSUB0001	# Subarrays: 1	Observation Type: Test
Observer(PI):	Frazer Owen	Band(s) Used: X P	
SB ID(s):	32720781		
Source File(s):	TSUB0001_sb32720781_1		
Observer E-mail:	fowen@nrao.edu		
Operator(s):	Blythe Guvenen		

Background Information
NRAO.edu

Data Reduction Results



Hydrogen Absorption Feature

Goal was to reduce the spectral-line data in the low-frequency P-band of the VLA (230–470 MHz).

The goal is to make an image cube containing HI 21cm absorption against the strong radio continuum of gravitationally lensed radio galaxy MG0414+0534.

As a result of the high redshift of $z=2.6365$, the HI absorption signal in MG0414+0534 is redshifted to an observed frequency of 390.597 MHz.

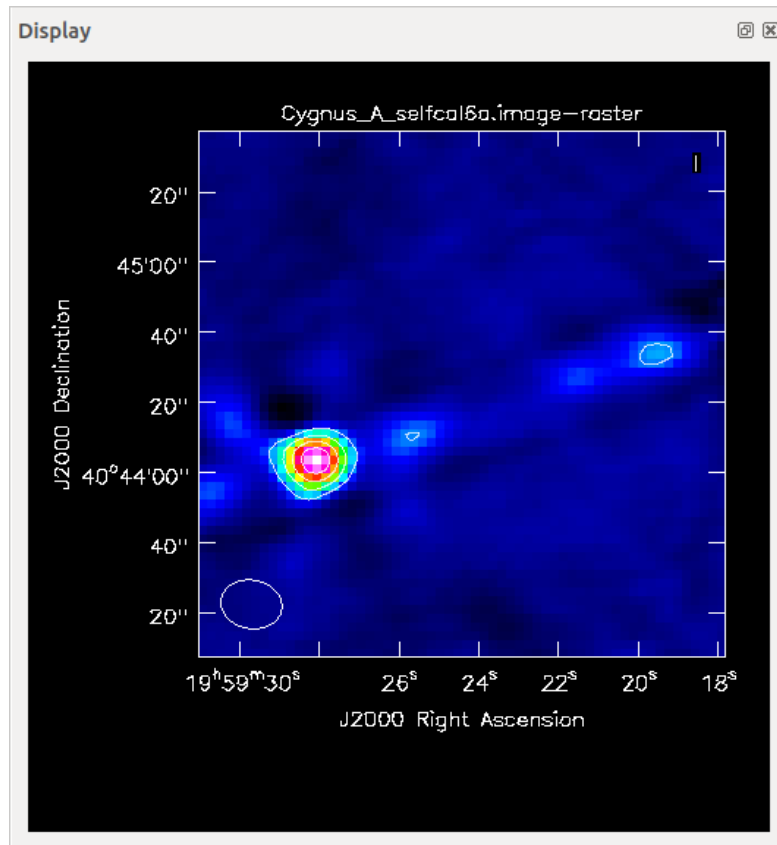
The HI absorption in MG0414+0534 was previously imaged with the VLA by Moore, Carilli & Menten 1999 (ApJ, 510, 87), (at end of this file) before the upgrade to the WIDAR system.

VLA tutorial reduced by Dr. Richard Russel 10/18/19 – full script of reduction in <file://VLA> Image MG0414+0534.odt [https://casaguides.nrao.edu/index.php/MG0414%2B0534_P-band_Spectral_Line_Tutorial - CASA 5.5.0](https://casaguides.nrao.edu/index.php/MG0414%2B0534_P-band_Spectral_Line_Tutorial_-_CASA_5.5.0)

Cygnus A (VLA Archive)

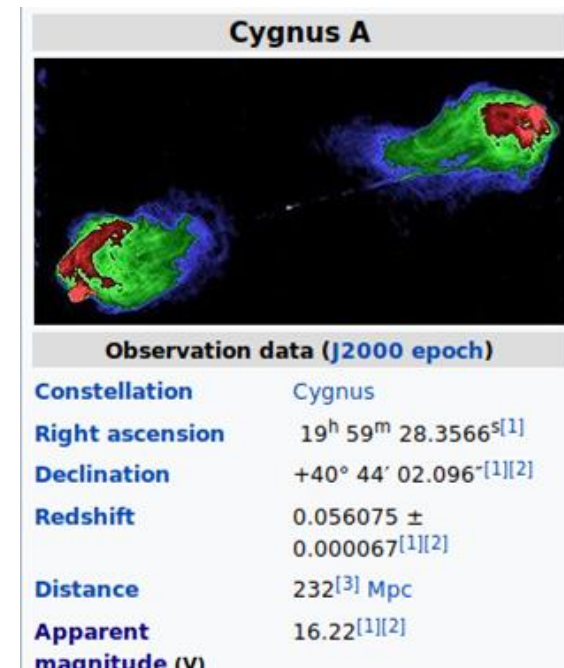
```
=====
Observer: Dr. Frank Schinzel   Project: uid://evla/pdb/1695465
Observation: EVLA
Computing scan and subscan properties...
Data records: 2045736         Total elapsed time = 508 seconds
Observed from 17-Oct-2019/22:34:08.0 to 17-Oct-2019/22:42:36.0 (UTC)
=====
```

Data Reduction Results



Background Information Wikipedia

Cygnus A ([3C 405](#)) is a [radio galaxy](#), and one of the strongest radio sources in the sky. It was discovered by [Grote Reber](#) in 1939. In 1951, Cygnus A, along with [Cassiopeia A](#), and [Puppis A](#) were the first "radio stars" identified with an optical source. Of these, Cygnus A became the first radio galaxy; the other two being [nebulae](#) inside the [Milky Way](#).[\[4\]](#) In 1953 [Roger Jennison](#) and [M K Das Gupta](#) showed it to be a double source.[\[5\]](#) Like all radio galaxies, it contains an [active galactic nucleus](#). The [supermassive black hole](#) at the core has a mass of $(2.5 \pm 0.7) \times 10^9$ [M_☉](#).[\[3\]](#)

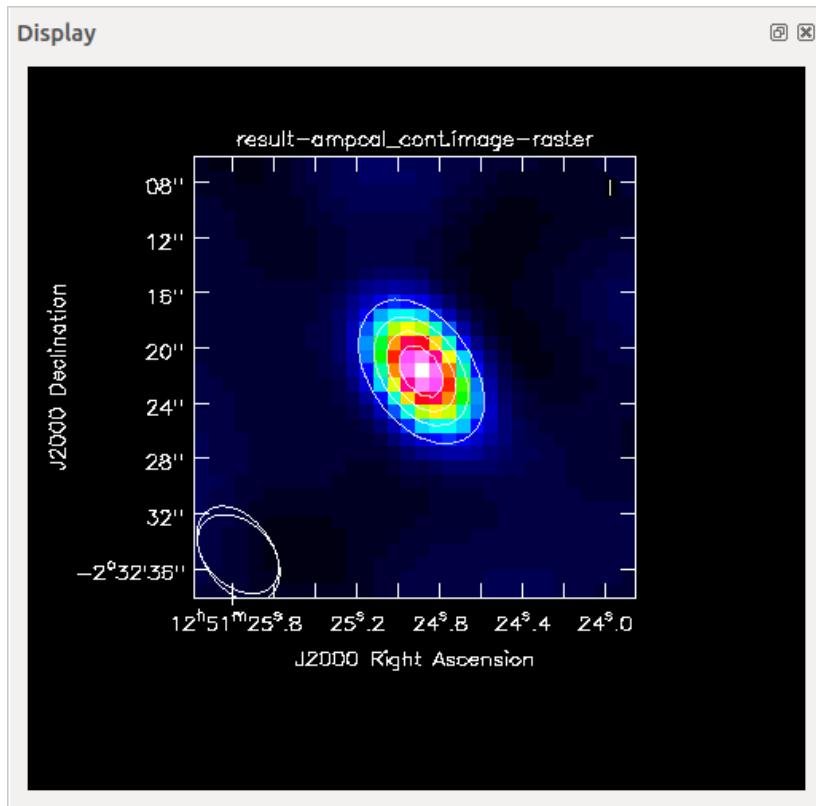


First attempt of a raw data set from archive: Note – no log, or antpos – therefore had to do self calibration to get image. Image reduced by Dr. Richard Russel 10-20-19

Saturn's moon of Titan (ALMA Archive)

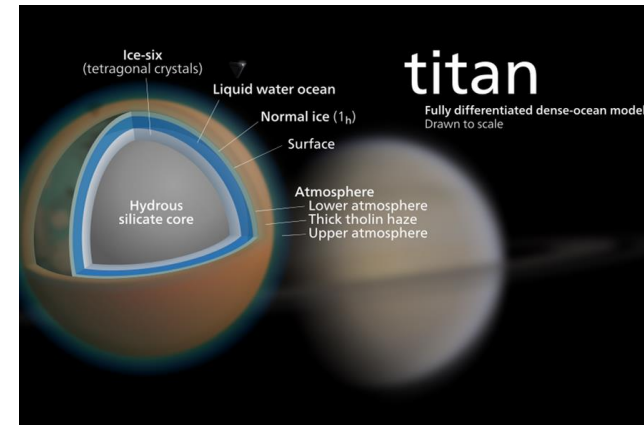
```
Computing scan and subscan properties...
Data records: 326400      Total elapsed time = 90574.4 seconds
  observed from 16-Apr-2011/02:59:18.2 to 17-Apr-2011/04:08:52.6 (UTC)
```

Data Reduction Results



Background Information Wikipedia

Titan is the largest [moon of Saturn](#) and [the second-largest](#) natural satellite in the [Solar System](#). It is the only [moon](#) known to have a dense [atmosphere](#), and the only known body in space, other than Earth, where clear evidence of stable bodies of surface liquid has been found.



Used as calibrator for NGC3256 ImGE

Data reduction conducted by Dr. Richard Russel on 10-22-19 using the ALMA Tutorial located at:
https://casaguides.nrao.edu/index.php/NGC3256_Band3_Imaging_for_CASA_4.2

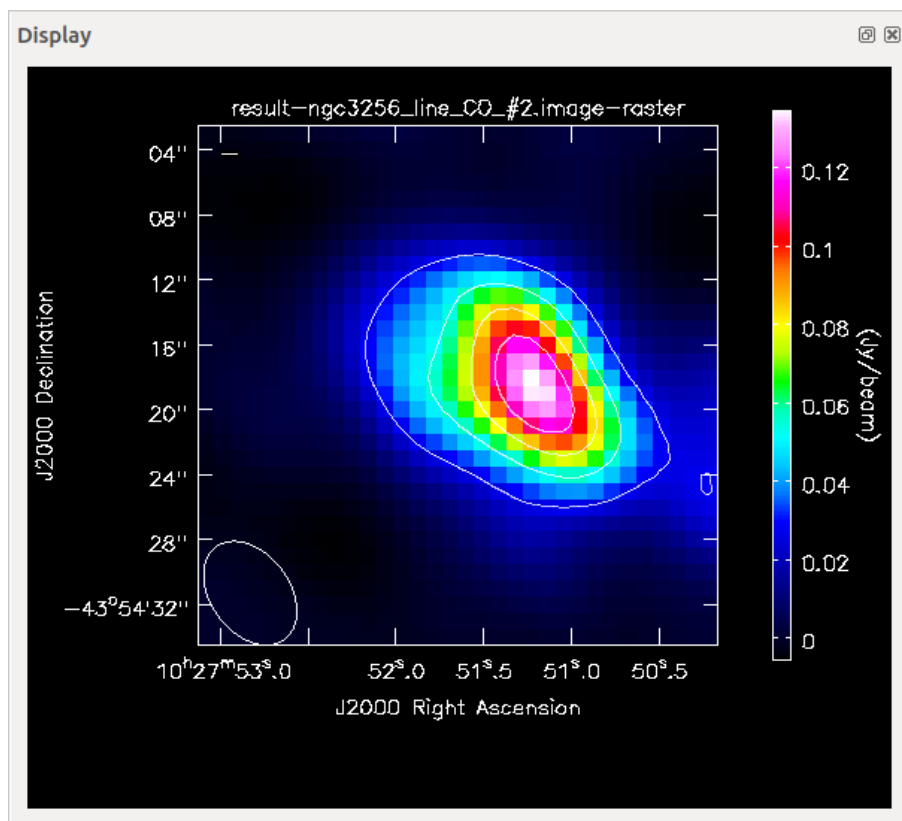
This paper makes use of the following ALMA data: ADS/JAO.ALMA data record: 326400. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

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NGC 3256 (ALMA Archive)

```
Computing scan and subscan properties...  
Data records: 326400      Total elapsed time = 90574.4 seconds  
Observed from 16-Apr-2011/02:59:18.2 to 17-Apr-2011/04:08:52.6 (UTC)
```

Data Reduction Results



Background Information Wikipedia

NGC 3256 is a [peculiar galaxy](#) formed from the [collision of two separate galaxies](#) in the constellation of [Vela](#). NGC 3256 is located about 100 million [light years](#) away and belongs to the [Hydra-Centaurus supercluster](#) complex.



NGC 3256 Hubble Image

Data reduction conducted by Dr. Richard Russel on 10-22-19 using the ALMA Tutorial located at: https://casaguides.nrao.edu/index.php/NGC3256_Band3_Imaging_for_CASA_4.2

This paper makes use of the following ALMA data: ADS/JAO.ALMA data record: 326400. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

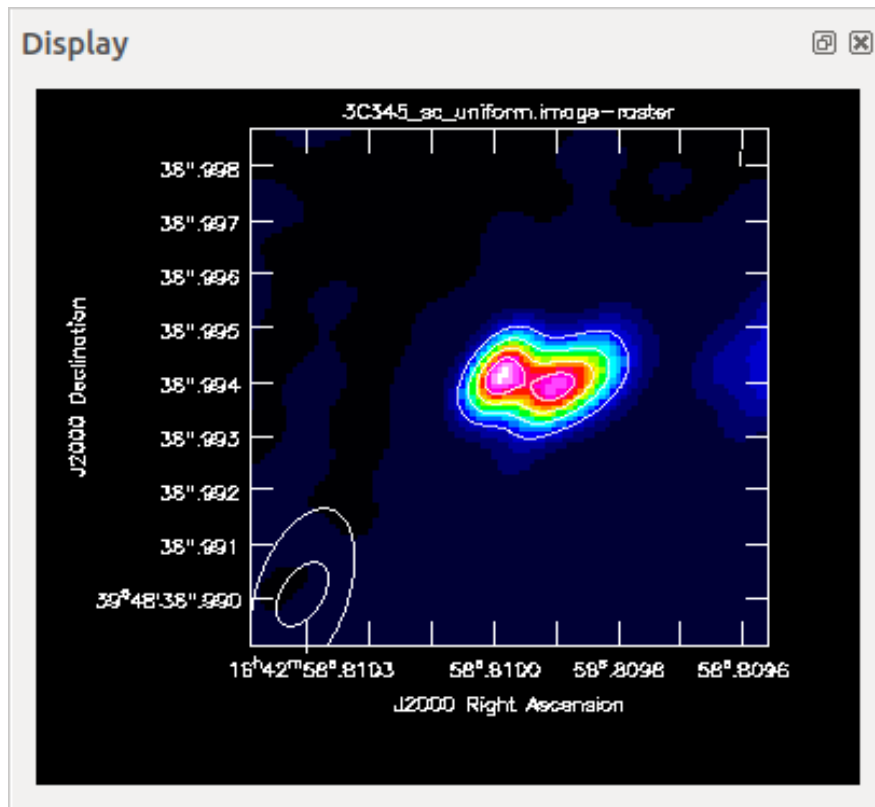
"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

3C345

Binary Supermassive Blackhole Quasar using the European Very Long Baseline Interferometer (EVLBI Archive)

```
Observer: N14C3    Project: N14C3
Observation: EVN
Computing scan and subscan properties...
Data records: 1846080    Total elapsed time = 10800 seconds
Observed from 22-Oct-2014/12:00:00.0 to 22-Oct-2014/15:00:00.0 (UTC)
```

Data Reduction Results



Conducted VLBI Imaging Tutorial at:

http://www.jb.man.ac.uk/DARA/unit4/Workshops/EVN_continuum.html

Data reduction conducted on VLBI archive data by Dr. Richard Russel on 10-25-19

A supermassive binary black hole in the quasar [3C345](#).

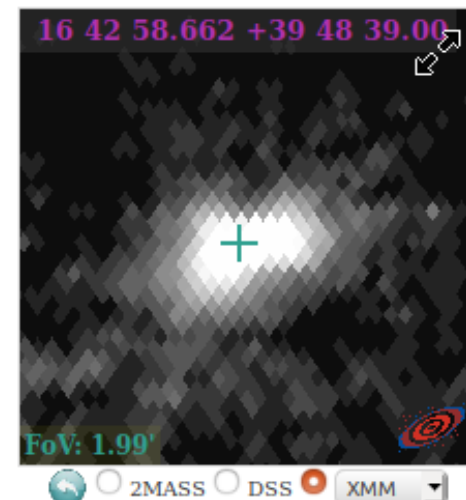
LOBANOV A.P. and ROLAND J.

Abstract (from CDS):

Radio loud active galactic nuclei present a remarkable variety of signs indicating the presence of periodical processes possibly originating in binary systems of supermassive black holes, in which orbital motion and precession are ultimately responsible for the observed broad-band emission variations, as well as for the morphological and kinematic properties of the radio emission on parsec scales. This scenario, applied to the quasar 3C345, explains the observed variations of radio and optical emission from the quasar, and reproduces the structural variations observed in the parsec-scale jet of this object. The binary system in 3C345 is described by two equal-mass black holes with masses of $\approx 7.1 \times 10^8 M_{\odot}$ separated by ≈ 0.33 pc and orbiting with a period ~ 480 yr. The orbital motion induces a precession of the accretion disk around the primary black hole, with a period of ≈ 2570 yr. The jet plasma is described by a magnetized, relativistic electron-positron beam propagating inside a wider and slower electron-proton jet. The combination of Alfvén wave perturbations of the beam, the orbital motion of the binary system and the precession of the accretion disk reproduces the variability of the optical flux and evolution of the radio structure in 3C345. The timescale of quasi-periodic flaring activity in 3C345 is consistent with typical disk instability timescales. The present model cannot rule out a small-mass orbiter crossing the accretion disk and causing quasi-periodic flares.

<http://simbad.u-strasbg.fr/simbad/sim-ref?bibcode=2005A%26A...431..831L>

Interactive AladinLite view



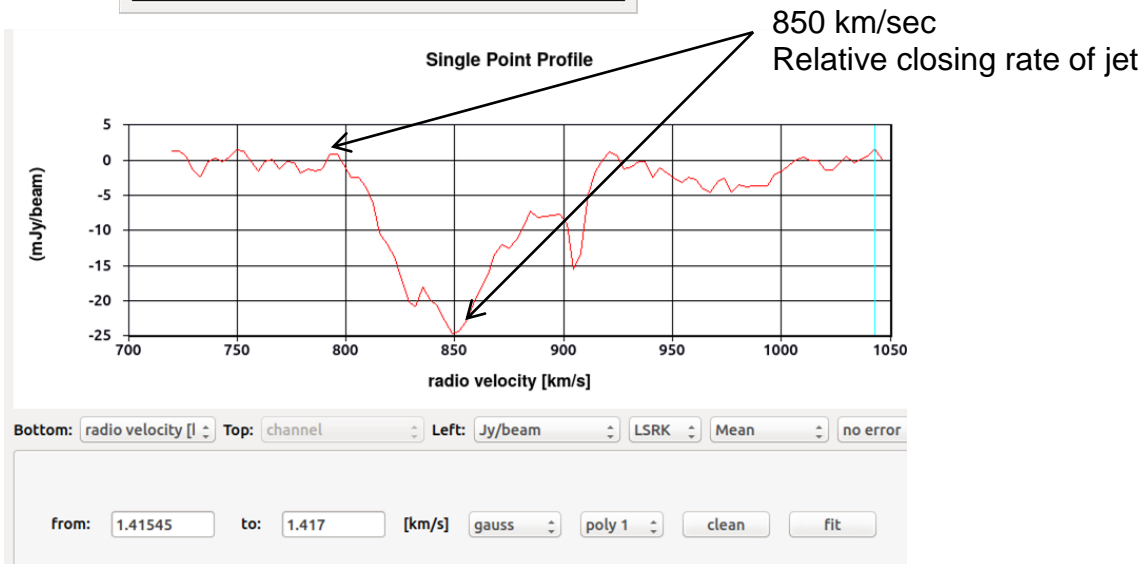
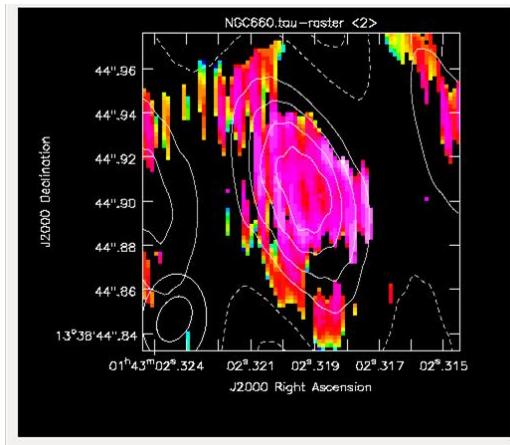
NGC-660 Galaxy

Velocity of Jet Measured using Spectral Line Technique using the European Very Long Baseline Interferometer (EVLBI Archive)

```
=====
Observer: EA054   Project:
Observation: EVN
Computing scan and subscan properties...
Data records: 49159   Total elapsed time = 41950 seconds
Observed from 30-Oct-2013/15:50:40.0 to 31-Oct-2013/03:29:50.0 (UTC)
```

```
ObservationID = 0   ArrayID = 0
Date   Timerange (UTC)   Scan   FlId   FieldName   nRows
30-Oct-2013/15:50:40.0 - 19:16:00.0   1     0   NGC660       16
19:38:42.0 - 23:04:58.0   2     0   NGC660       15
23:26:26.0 - 02:52:38.0   3     0   NGC660       12
31-Oct-2013/03:12:36.0 - 03:29:50.0   4     0   NGC660       12
(nRows = Total number of rows per scan)
```

```
Fields: 1
ID   Code Name   RA   Decl   Epoch   SrcId
0   NGC660       01:43:02.291000 +13:38:44.30000 J2000 0
```



Background Information Wikipedia

NGC 660 is a [peculiar](#) and unique [polar-ring galaxy](#) located approximately 45 million light years from Earth in the [Pisces constellation](#).^[3] It is the only such galaxy having, as its host, a "late-type lenticular galaxy".^[4] It was probably formed when two galaxies collided a billion years ago.^[5] However, it may have first started as a disk galaxy that captured matter from a passing galaxy. This material could have, over time, become "strung out" to form a rotating ring.

Late in 2012, this polar-ring galaxy produced an enormous outburst having a magnitude of approximately ten times brighter than a supernova explosion. The cause is not certain, but this event may have resulted from a tremendous jet being emanating from galaxy's central black hole.

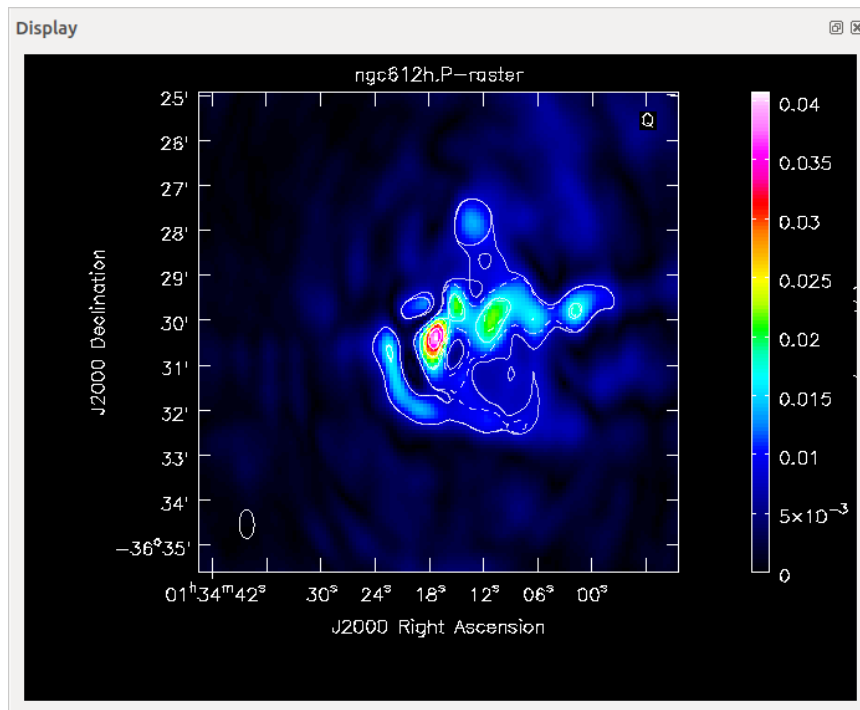


NGC 660 showing Polar-Galaxy Structure

NGC-612 using the Australian Telescope Compact Array (ATCA Archive)

```
-----
MeasurementSet Name: /home/dses/Imaging/NGC612_ATCA/ngc612.ms.0
-----
Observer: obs      Project: C2728
Observation: ATCA
Computing scan and subscan properties...
Data records: 60465      Total elapsed time = 43730 seconds
Observed from 25-Oct-2012/07:07:39.9 to 25-Oct-2012/19:16:29.9 (UTC)
-----
```

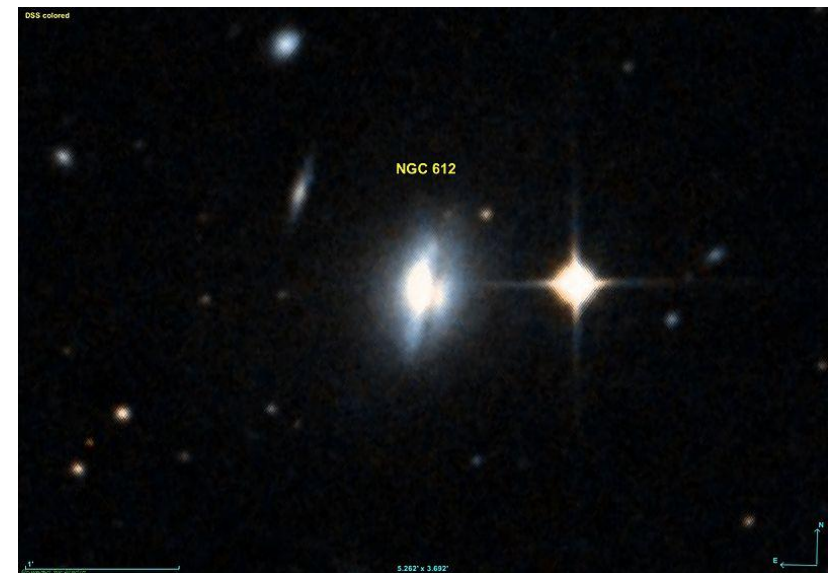
Data Reduction Results



Total polarized flux density: 1.942 Jy
Pol. Angles in western lobe: -57.5 and 23.7 degrees

Background Information Wikipedia

NGC 612 is a [lenticular galaxy](#) in the [constellation](#) of [Sculptor](#) located approximately 388 million [light-years](#) from Earth. It is a type II [Seyfert galaxy](#) and thus has an [active galactic nucleus](#).^{[1][3]} NGC 612 has been identified as an extremely rare example of a non-[elliptical radio galaxy](#), hosting one of the nearest powerful [FR-II](#) radio sources.^[4][Coordinates](#): [01h33m57.74s, -36° 29' 35.7"](#)^[5]

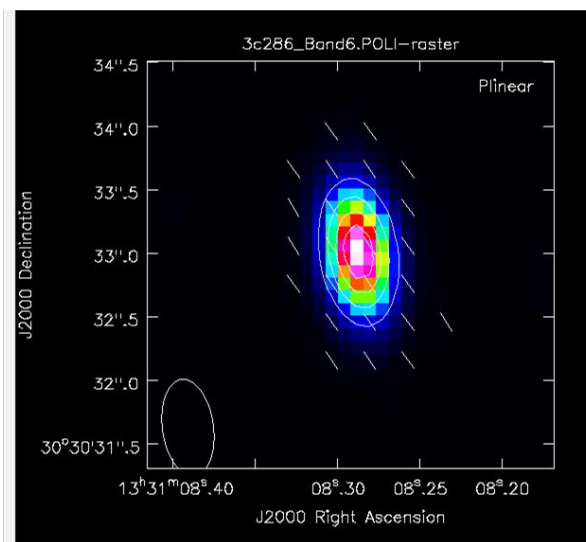


3C286 Quasar Full Polarization (ALMA Archive)

```
=====
Observer: knakanishi   Project: uid://A002/X845868/X11
Observation: ALMA
Data records: 10125065   Total elapsed time = 3858.05 seconds
Observed from 01-Jul-2014/21:18:10.9 to 01-Jul-2014/22:22:29.0 (UTC)
```

Background Information Wikipedia

Data Reduction Results



Measured Statistics

3C286	Flux	Err
I(Jy)	0.369024458019	0.000533920312708
Q(Jy)	0.0120461752389	4.28833878305e-05
U(Jy)	0.0590976963663	0.00010008727778
Pol int (mJy)	60.3129178011	0.0984439608693
P(%)	0.163438808704	0.000356487589209
X (deg)	39.2394747207	0.0221021634448

3C 286, also known by its position as 1328+307 ([B1950](#) coordinates) is a [quasar](#)^[3] at [redshift](#) 0.8493 with a [radial velocity](#) of 164,137 km/s.^[4] It is part of the [Third Cambridge Catalogue of Radio Sources](#).

3C 286 is one of four primary calibrators used by the [Very Large Array](#) (along with [3C 48](#), [3C 138](#), and [3C 147](#)). Visibilities of all other sources are calibrated using observed visibilities of one of these four calibrators.^[5]

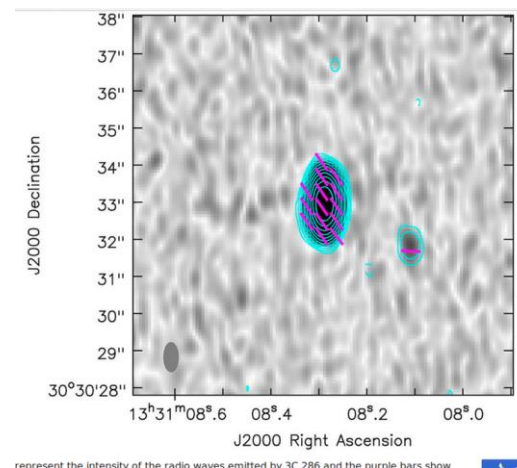


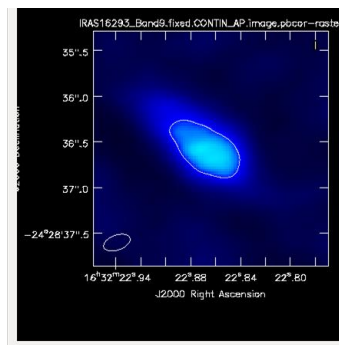
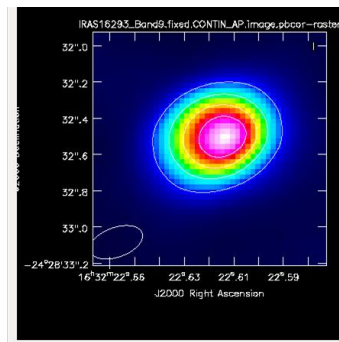
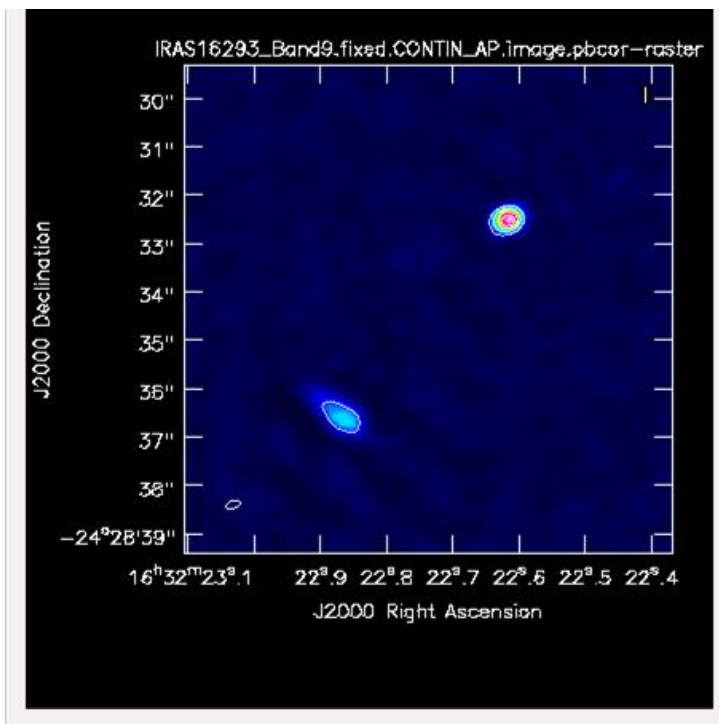
Image and statistics reduced by Dr. Richard A. Russel 10-29-19, using ALMA tutorial located at:
https://casaguides.nrao.edu/index.php/3C286_Polarization

Using the data for publication: The following statement should be included in the acknowledgment of papers using the datasets listed above: "This paper makes use of the following ALMA data: ADS/JAO ALMA#2011.0.00017.SV. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

IRAS16293 Band 9 (ALMA Archive)

Observer: dgarcia	Project: uid://A002/X3cd6b2/X53		
Observation: ALMA			
Telescope	Observation Date	Observer	Project
ALMA	[	4.84128e+09, 4.84129e+09]	dgarcia uid://A002/X3cd6b2/X53
ALMA	[	4.84135e+09, 4.84136e+09]	dgarcia uid://A002/X3cd6b2/X53
ALMA	[	4.84137e+09, 4.84137e+09]	dgarcia uid://A002/X3cd6b2/X53
ALMA	[	4.84137e+09, 4.84138e+09]	dgarcia uid://A002/X3cd6b2/X53
Computing scan and subscan properties...			
Data records: 52996		Total elapsed time = 98524.9 seconds	
Observed from 16-Apr-2012/08:27:40.4 to 17-Apr-2012/11:49:45.3 (UTC)			

Data Reduction Results



Background Information Wikipedia

RAS 16293–2422 is a binary system consisting of at least two forming [protostars](#) A and B, separated by a distance of 700 [astronomical units](#) (au), all having masses similar to that of the [Sun](#).^{[1][2]} It is located in the [Rho Ophiuchi](#) star-forming region, at a distance of 140 [astronomical units](#) (au). Astronomers using the [ALMA array](#) found [glycolaldehyde](#) — a simple form of sugar — in the gas surrounding the star.^{[3][4]} This discovery was the first time sugar has been found in space around a solar-type star on scales corresponding to the distance between Sun and Uranus - i.e., the scales where a planet-forming disk is expected to arise. The discovery shows that the building blocks of [life](#) may in the right place, at the right time, to be included in planets forming around the star.

[Chloromethane](#), also known as methyl chloride, was detected for the first time in the [interstellar medium](#) in IRAS 16293–2422. Chloromethane is an important biomarker but its discovery in a protostellar system showed that it can be formed through abiotic processes in space.^[5]



Data reduction conducted by Dr. Richard Russel on 10-31-19 using the ALMA Tutorial located at: [https://casaguides.nrao.edu/index.php/IRAS16293_Band9 - Imaging for CASA 5.4](https://casaguides.nrao.edu/index.php/IRAS16293_Band9_-_Imaging_for_CASA_5.4)

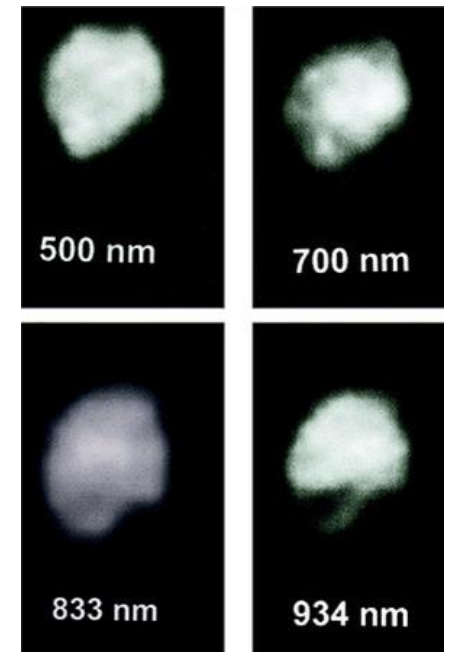
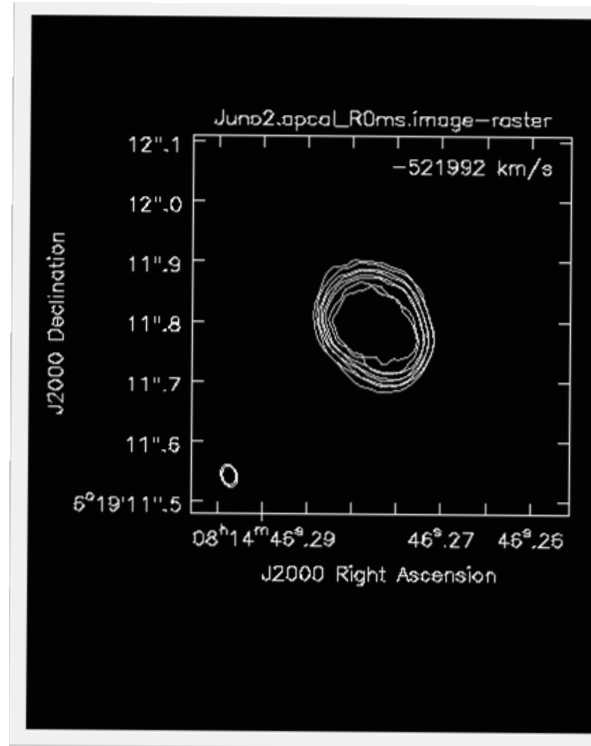
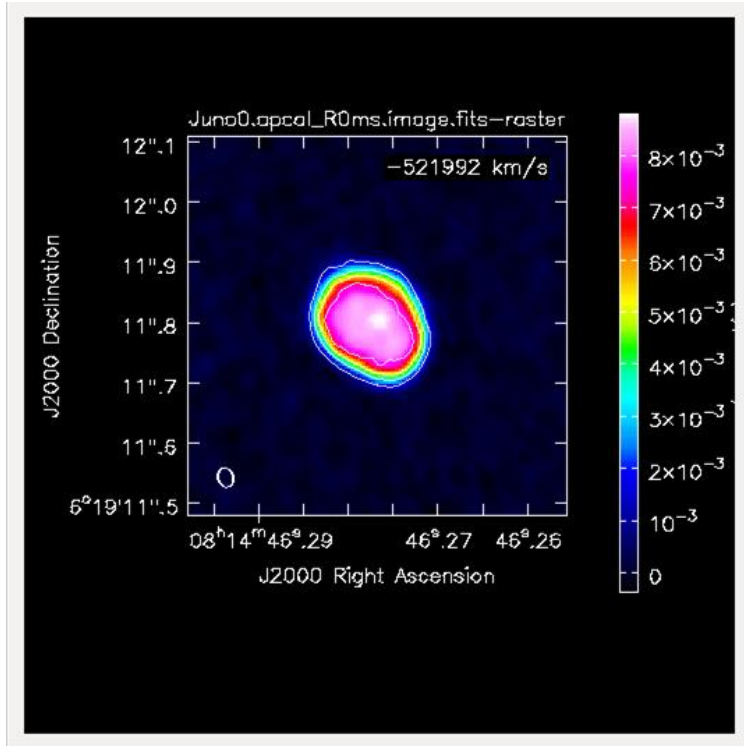
This paper makes use of the following ALMA data: ADS/JAO.ALMA data record: 52996. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

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Juno Asteroid (ALMA Archive)

```
=====
Observer: hirotaaak   Project: uid://A002/X8d0549/X17
Observation: ALMA
Computing scan and subscan properties...
Data records: 830280   Total elapsed time = 1162.32 seconds
Observed from 19-Oct-2014/09:32:23.0 to 19-Oct-2014/09:51:45.4 (UTC)
=====
```

Data Reduction Results



Background Information Wikipedia

Juno is one of the larger asteroids, perhaps tenth by size and containing approximately 1% the mass of the entire [asteroid belt](#).^[17] It is the second-most-massive S-type asteroid after 15 Eunomia.^[4] Even so, Juno has only 3% the mass of [Ceres](#).^[4]

Data reduction conducted by Dr. Richard Russel on 11-1-19 using the ALMA Tutorial located at:

https://casaguides.nrao.edu/index.php/ALMA2014_LBC_SVDATA

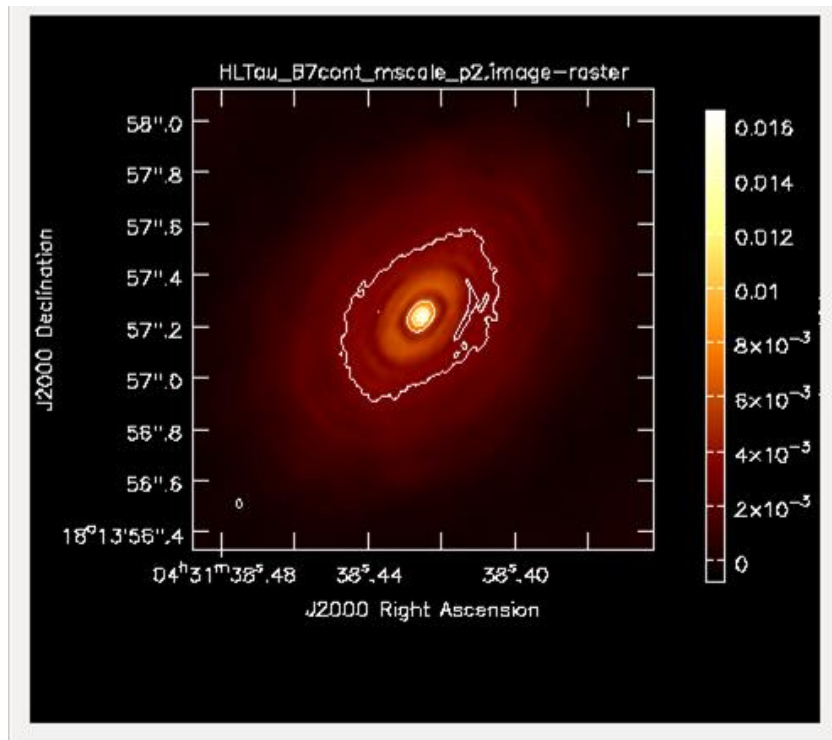
"This paper makes use of the following ALMA data: ADS/JAO.ALMA data record 830280 ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

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HL Tauri Protoplanetary System (ALMA Archive)

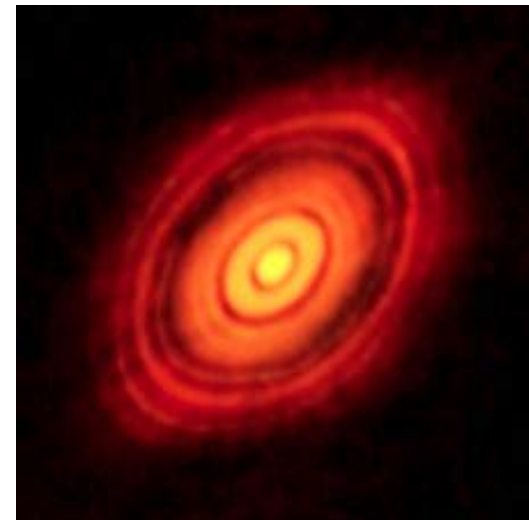
Observer: violette	Project: uid://A002/X8d0549/X5f			
Observation: ALMA				
Telescope	Observation Date	Observer	Project	
ALMA	[	4.92136e+09,	4.92136e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92136e+09,	4.92137e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92137e+09,	4.92137e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92154e+09,	4.92154e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92154e+09,	4.92154e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92155e+09,	4.92155e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92179e+09,	4.92179e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92179e+09,	4.9218e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92196e+09,	4.92197e+09]	violette uid://A002/X8d0549/X5f
ALMA	[	4.92197e+09,	4.92197e+09]	violette uid://A002/X8d0549/X5f
Computing scan and subscan properties...				
Data records: 25005708 Total elapsed time = 609437 seconds				
Observed from 30-Oct-2014/04:24:27.5 to 06-Nov-2014/05:41:44.1 (UTC)				

Data Reduction Results



Background Information Wikipedia

HL Tauri (abbreviated HL Tau) is a very young [T Tauri star](#)^[5] in the constellation [Taurus](#), approximately 450 light-years (140 pc) from Earth^[1] in the [Taurus Molecular Cloud](#).^[6] The luminosity and effective temperature of HL Tauri imply that its age is less than 100,000 years.^[7] At [apparent magnitude](#) 15.1,^[3] it is too faint to be seen with the unaided eye. It is surrounded by a [protoplanetary disk](#) marked by dark bands visible in [submillimeter radiation](#) that may indicate a number of planets in the process of formation.^[2] It is accompanied by the [Herbig–Haro object](#) HH 150, a jet of gas emitted along the rotational axis of the disk that is colliding with nearby interstellar dust and gas.^[8]



Data reduction conducted by Dr. Richard Russel on 11-1-19 using the ALMA Tutorial located at:

https://casaguides.nrao.edu/index.php/ALMA2014_LBC_SVDATA

"This paper makes use of the following ALMA data: ADS/JAO.ALMA data record 25005708 ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

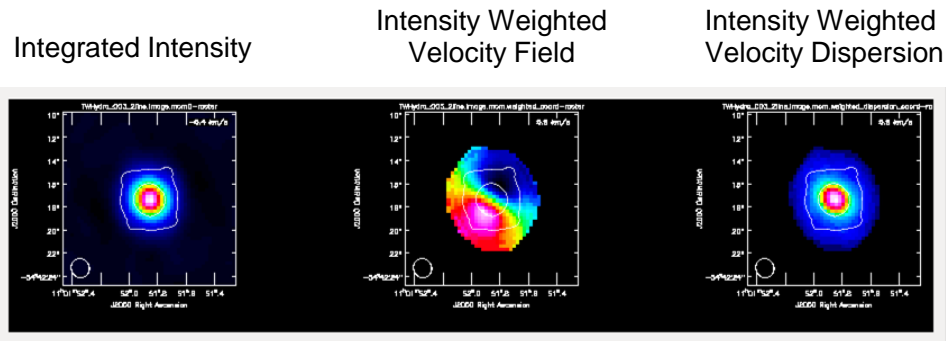
TW Hydrae Band 7 (ALMA Archive)

Observer:	Unknown	Project:	T.B.D.
Observation:	ALMA		
Telescope	Observation Date	Observer	Project
ALMA	[	4.81015e+09, 4.81015e+09]	Unknown T.B.D.
ALMA	[	4.81015e+09, 4.81016e+09]	Unknown T.B.D.
ALMA	[	4.81016e+09, 4.81017e+09]	Unknown T.B.D.
Computing scan and subscan properties...			
Data records:	126900	Total elapsed time =	16902.1 seconds
observed from 22-Apr-2011/00:15:36.7 to 22-Apr-2011/04:57:18.8 (UTC)			

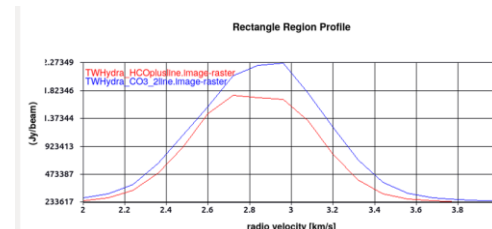
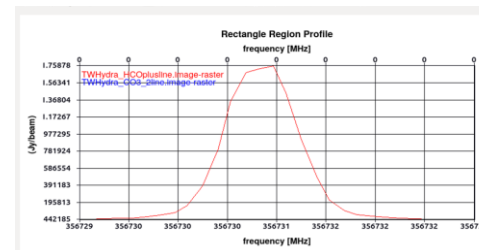
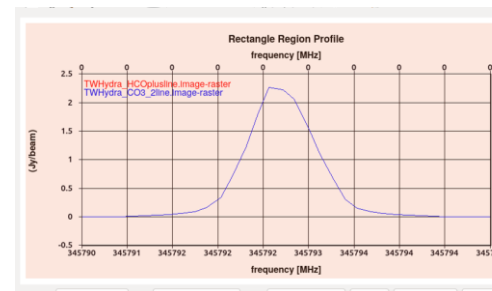
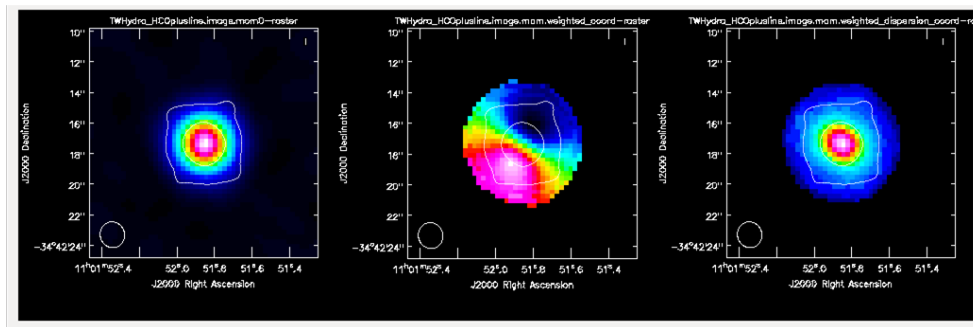
Background Information
Wikipedia

Data Reduction Results

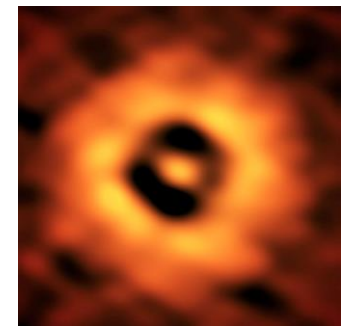
CO(3-2) moment maps



HCO+(4-3) moment maps



TW Hydrae is a [T Tauri star](#) approximately 196 [light-years](#) away[1] in the [constellation](#) of [Hydra](#) (the [Sea Serpent](#)). The star is the closest such star to the [Solar System](#). TW Hydrae is about 80% of the [mass](#) of the Sun, but is only about 5-10 million years old. The star appears to be accreting from a face-on [protoplanetary disk](#) of dust and gas, which has been resolved in images from the [ALMA observatory](#).



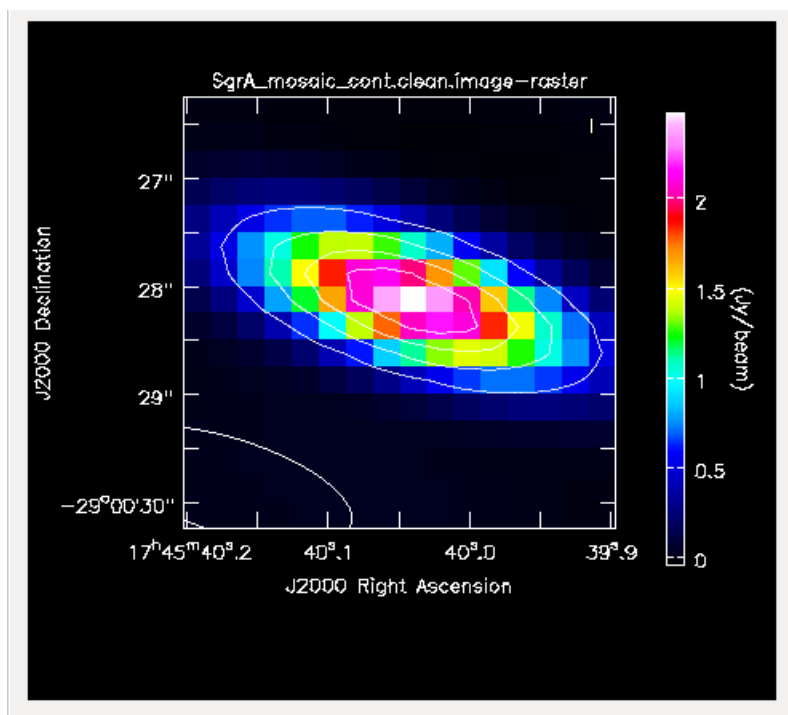
Data reduction conducted by Dr. Richard Russel on 11-2-19 using the ALMA Tutorial located at: <https://casaguides.nrao.edu/index.php?title=TWHydraBand7>

This paper makes use of the following ALMA data: ADS/JAO.ALMA data record 126900 ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ." "The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

SGR A* Band 6 (ALMA Archive)

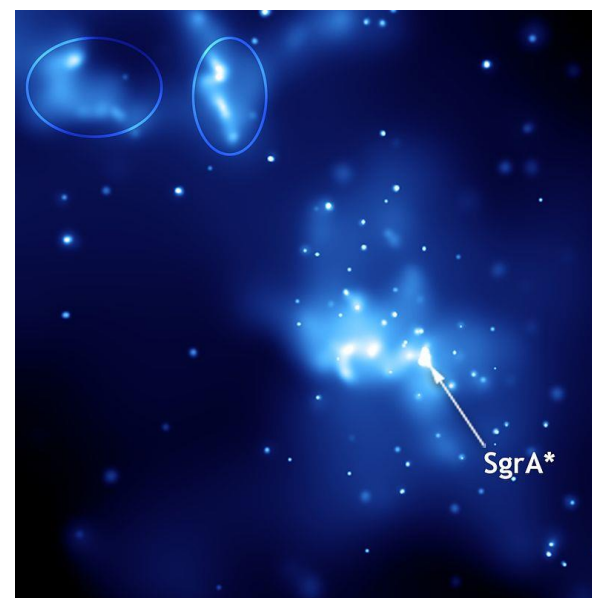
=====				
Observer: Unknown		Project: T.B.D.		
Observation: ALMA				
=====				
Telescope	Observation Date	Observer	Project	
ALMA	[	4.81578e+09, 4.81578e+09]	Unknown	
			T.B.D.	
ALMA	[	4.81577e+09, 4.81578e+09]	Unknown	
			T.B.D.	
ALMA	[	4.81578e+09, 4.81578e+09]	Unknown	
			T.B.D.	
Computing scan and subscan properties...				
Data records: 32400		Total elapsed time = 11328.9 seconds		
observed from 26-Jun-2011/02:40:52.7 to 26-Jun-2011/05:49:41.6 (UTC)				

Data Reduction Results



Background Information Wikipedia

Sagittarius A* (pronounced "Sagittarius A-Star", abbreviated Sgr A*) is a bright and very compact [astronomical radio source](#) at the [center](#) of the [Milky Way](#), near the border of the constellations [Sagittarius](#) and [Scorpius](#) about 5.6° south of the [ecliptic](#).^[6] It is likely the location of a [supermassive black hole](#).^{[7][8][9]} similar to those generally accepted to be at the centers of most if not all [spiral](#) and [elliptical galaxies](#).



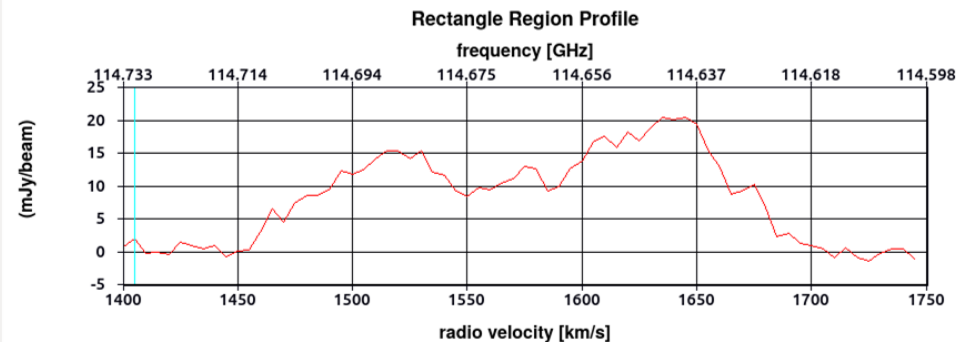
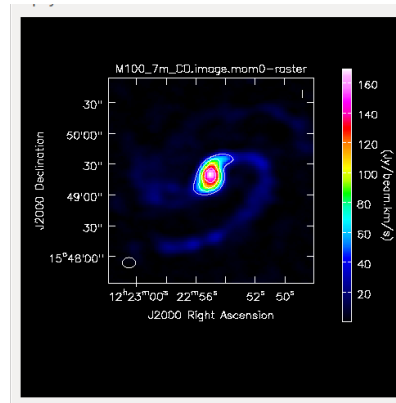
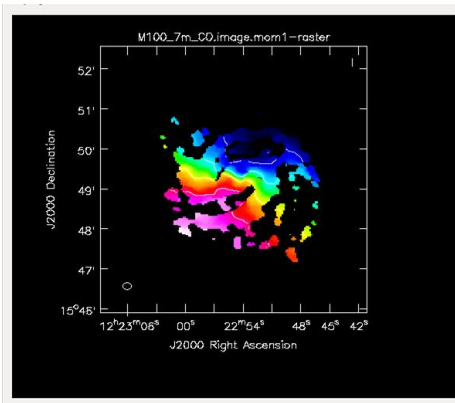
Data reduction conducted by Dr. Richard Russel on 11-3-19 using the ALMA Tutorial located at:
<https://almascience.nrao.edu/alma-data/science-verification/overview>

This paper makes use of the following ALMA data: ADS/JAO.ALMA data record 32400 ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), MOST and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

M100 Spiral Galaxy (ALMA Archive)

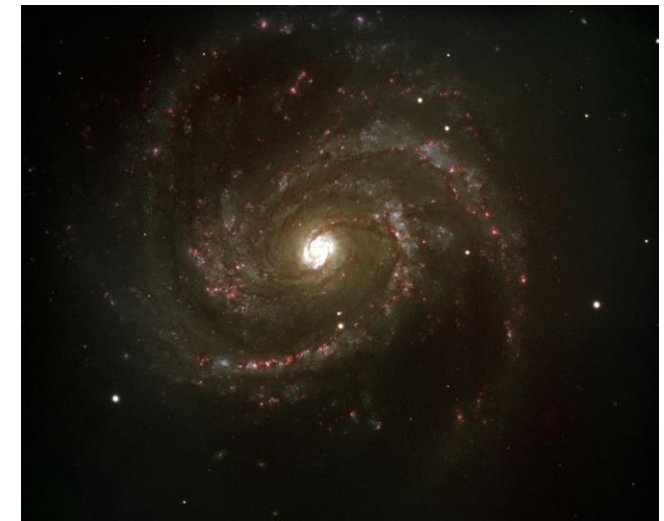
Observer: cvlahakis Project: uid://A002/X5d9e5c/X5d				
Observation: ALMA				
Telescope	Observation Date	Observer	Project	
ALMA	[	4.87021e+09, 4.87022e+09]	cvlahakis	uid://A002/X5d9e5c/X5d
ALMA	[	4.87022e+09, 4.87022e+09]	cvlahakis	uid://A002/X5d9e5c/X5d
ALMA	[	4.8703e+09, 4.87031e+09]	cvlahakis	uid://A002/X5d9e5c/Xb1
ALMA	[	4.87031e+09, 4.87031e+09]	cvlahakis	uid://A002/X5d9e5c/Xb1
ALMA	[	4.87263e+09, 4.87263e+09]	cvlahakis	uid://A002/X5d9e5c/X3e5
ALMA	[	4.87496e+09, 4.87496e+09]	cvlahakis	uid://A002/X5d9e5c/X5d
Computing scan and subscan properties...				
Data records: 177120 Total elapsed time = 4.74969e+06 seconds				
observed from 17-Mar-2013/04:44:04.3 to 11-May-2013/04:05:39.2 (UTC)				

Data Reduction Results



Background Information Wikipedia

Messier 100 (also known as [NGC 4321](#)) is an example of a [grand design\[4\] intermediate spiral galaxy](#) located within the southern part of [constellation Coma Berenices](#). It is one of the brightest and largest galaxies in the [Virgo Cluster](#), located approximately 55 million [light-years\[3\]](#) distant from [Earth](#) and has a diameter of 107,000 light years, roughly 60% the size of the [Milky Way](#). It was discovered by [Pierre Méchain](#) on March 15, 1781 and was subsequently entered in [Messier's catalogue](#) of nebulae and star clusters[5] after [Charles Messier\[6\]](#) made observations of his own on April 13, 1781. The galaxy was one of the first spiral galaxies[6] to be discovered, and was listed as one of fourteen [spiral nebulae](#) by [Lord William Parsons of Rosse](#) in 1850.



Data reduction conducted by Dr. Richard Russel on 11-3-19 using the ALMA Tutorial located at: <https://almascience.nrao.edu/alma-data/science-verification/overview>

"This paper makes use of the following ALMA data: ADS/JAO.ALMA#2011.0.00004.SV. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

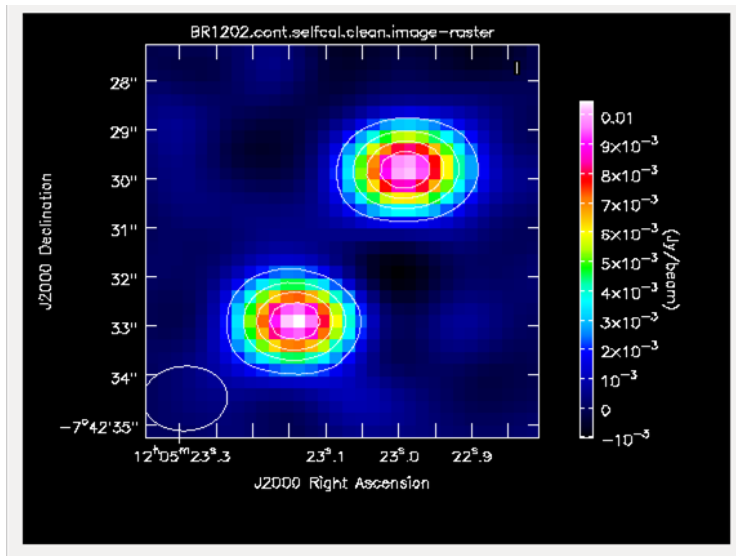
"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

BR1202-0725 Quasar at $z=4.69$ (ALMA Archive)

Observer: Unknown Project: T.B.D.
Observation: ALMA
Data records: 53516 Total elapsed time = 2507.23 seconds
Observed from 14-Jan-2012/12:39:19.7 to 14-Jan-2012/13:21:07.0 (UTC)

Background Information

Data Reduction Results

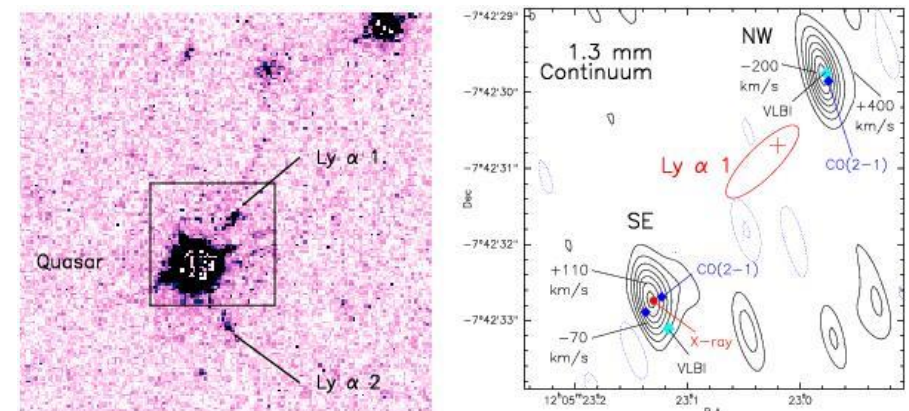
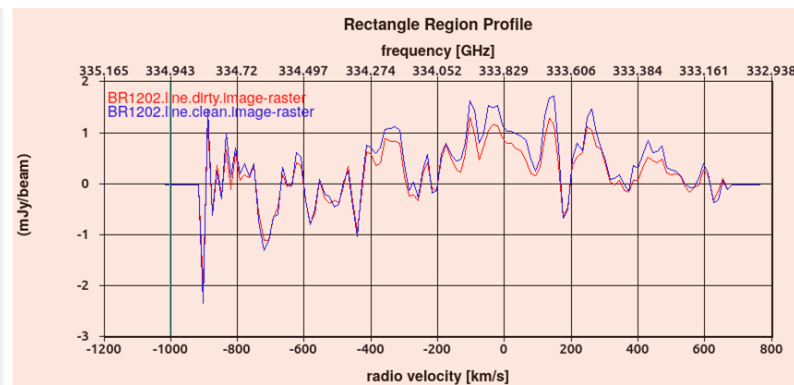


BR1202-0725: an extreme multiple merger at $z = 4.7$ ★

P. Salomé¹, M. Guélin², D. Downes², P. Cox², S. Guilloteau³, A. Omont⁴, R. Gavazzi⁴ and R. Neri²

Received: 5 July 2012 Accepted: 27 July 2012

Abstract: <excerpt>The radio-quiet quasar BR1202-0725 ($z = 4.695$) is a remarkable source with a bright northwest (NW) companion detected at submillimeter and radio wavelengths but invisible in the optical.



https://www.aanda.org/articles/aa/full_html/2012/09/aa19955-12/aa19955-12.html

Data reduction conducted by Dr. Richard Russel on 11-4-19 using the ALMA Tutorial located at: <https://almascience.nrao.edu/alma-data/science-verification/overview>

"This paper makes use of the following ALMA data record 53516. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

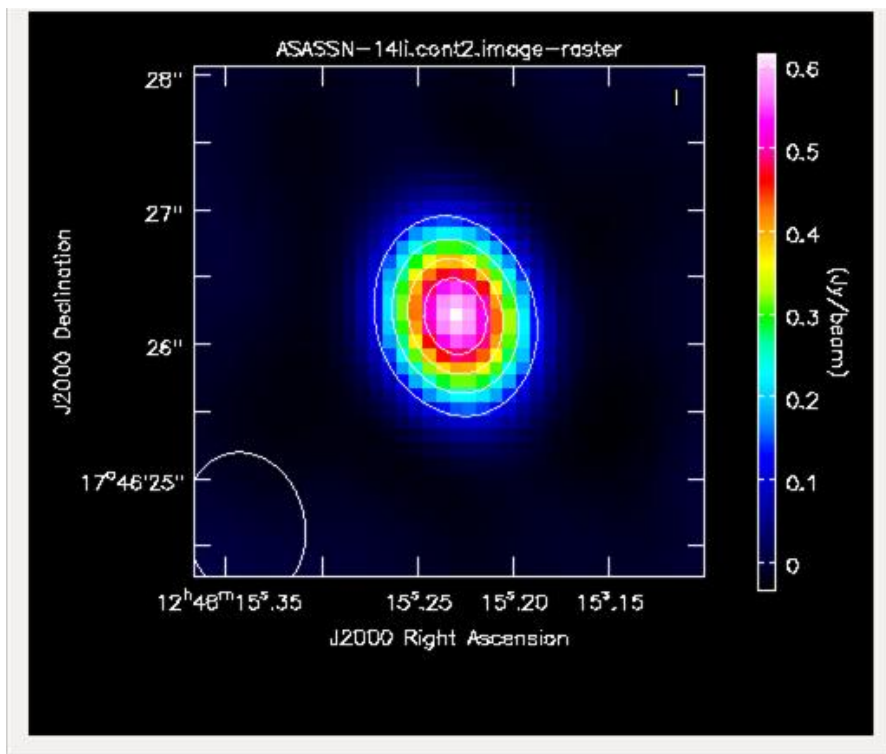
ASASSN-14li

Tidal disruption event

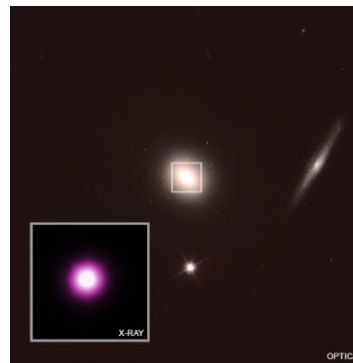
A star is torn apart by a black hole (VLA Archive)

```
Observer: Prof. Edo Berger    Project: uid://evla/pdb/30597145
Observation: EVLA
Computing scan and subscan properties...
Data records: 4585464        Total elapsed time = 3579 seconds
Observed from 21-Apr-2015/05:29:45.0 to 21-Apr-2015/06:29:24.0 (UTC)
```

Data Reduction Results



Background Information



Chandra X-ray
Observatory Center

Harvard-Smithsonian Center for Astrophysics
60 Garden St. Cambridge, MA 02138 USA
<http://chandra.harvard.edu>

ASASSN-14li: A tidal disruption event in a galaxy about 290 million light years from Earth.
(Credit: Illustration: NASA/CXC/M.Weiss; X-ray: NASA/CXC/MIT/D. Pasham et al; Optical: HST/STScI./Arcavi)

Caption: This artist's illustration shows the region around a supermassive black hole after a star wandered too close and was ripped apart by extreme gravitational forces in a source called ASASSN-14li. Some of the remains of the star are pulled into an X-ray-bright disk where they circle the black hole before passing over the "event horizon," the boundary beyond which nothing, including light, can escape. Scientists used Chandra and other telescopes to study this event and determine the spin rate of the black hole, a fundamental property that has been difficult for astronomers to measure.

Chandra X-ray Observatory ACIS Image

CXC operated for NASA by the Smithsonian Astrophysical Observatory

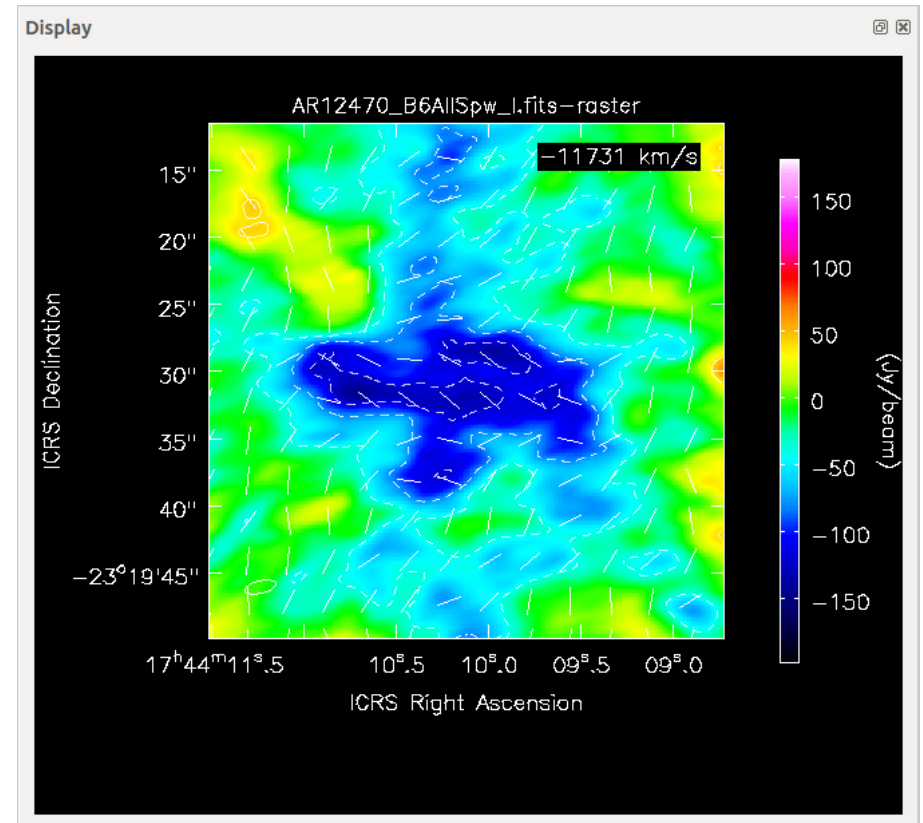
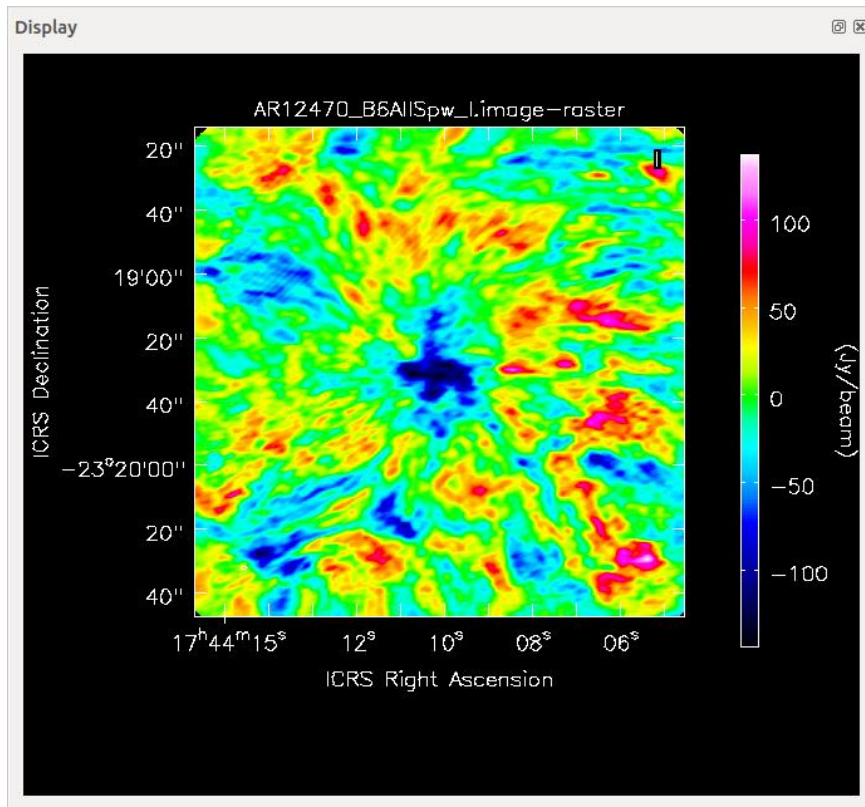
<https://chandra.harvard.edu/photo/2019/bhspin/>

Data reduction completed by Dr. Richard Russel 11-6-2019 using download from VLA database.

Sunspot Band 6 ALMA Archive

```
Observer: shimojo      Project: uid://A002/Xac494e/X3
Observation: ALMA
Computing scan and subscan properties...
Data records: 20923884      Total elapsed time = 3184.8 seconds
Observed from 18-Dec-2015/19:15:42.3 to 18-Dec-2015/20:08:47.1 (UTC)
```

Data Reduction Results



Data reduction conducted by Dr. Richard Russel 11/16/19 based on the NRAO tutorial https://casaguides.nrao.edu/index.php/Sunspot_Band6

"This paper makes use of the following ALMA data: ADS/JAO.ALMA#2011.0.00020.SV. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada) and NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

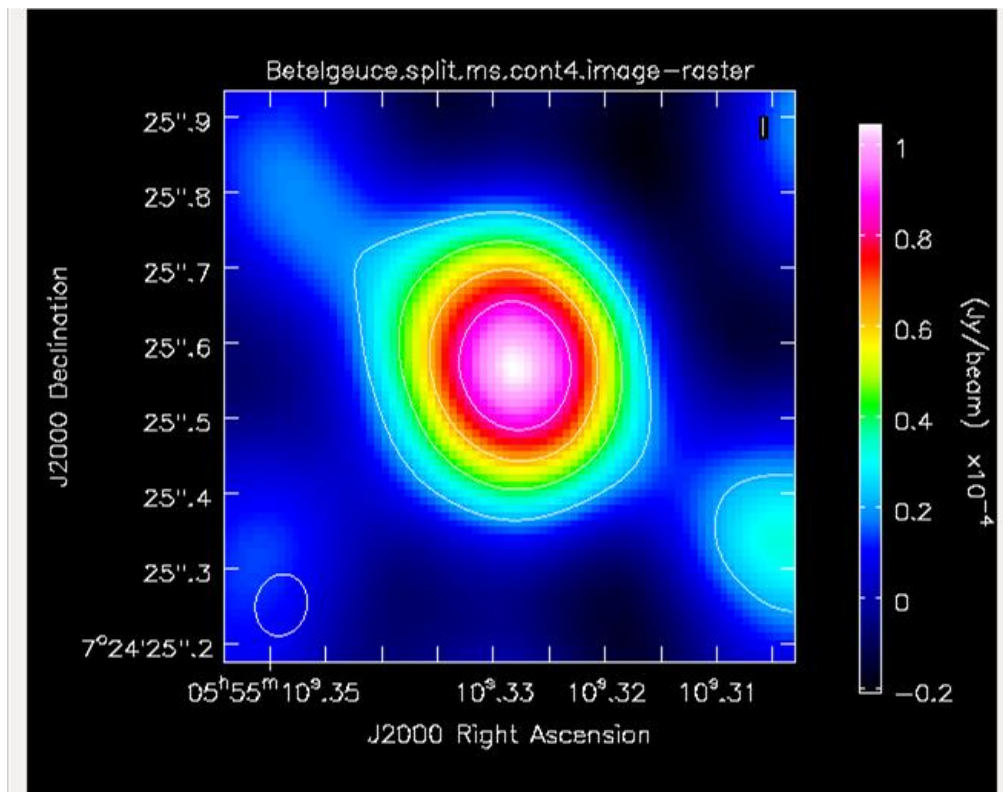
Betelgeuse (Alpha Orionis)

VLA Archive

```

Observer: Prof. Ian T. Durham    Project: uid://evla/pdb/28661765
Observation: EVLA
Computing scan and subscan properties...
Data records: 12524382          Total elapsed time = 4004 seconds
Observed from 27-Feb-2014/01:08:21.0 to 27-Feb-2014/02:15:05.0 (UTC)
  
```

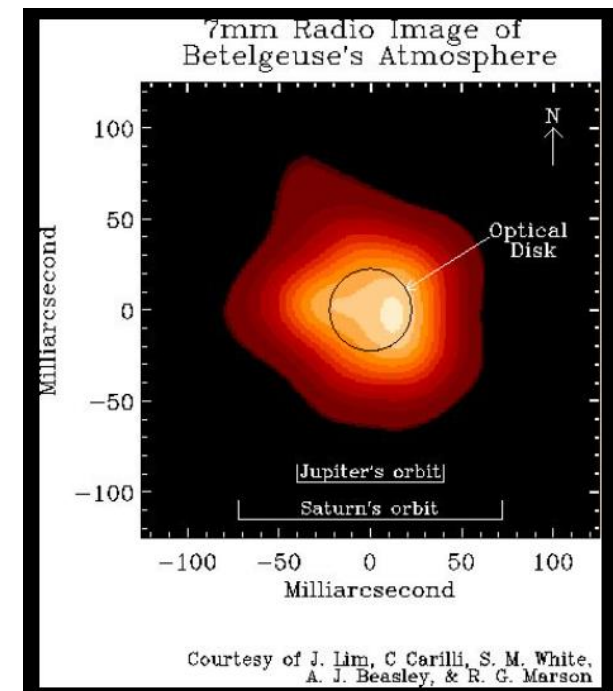
Data Reduction Results



Background Information

Wikipedia

Betelgeuse is generally the [ninth-brightest star](#) in the [night sky](#) and second-brightest in the [constellation](#) of [Orion](#) (after [Rigel](#)). It is a distinctly reddish, [semiregular variable star](#) whose [apparent magnitude](#) varies between +0.0 and +1.3, the widest range of any [first-magnitude star](#). At [near-infrared wavelengths](#), Betelgeuse is the brightest star in the night sky. It has the [Bayer designation](#) α **Orionis**, which is [Latinised](#) to **Alpha Orionis** and abbreviated Alpha Ori or α Ori.

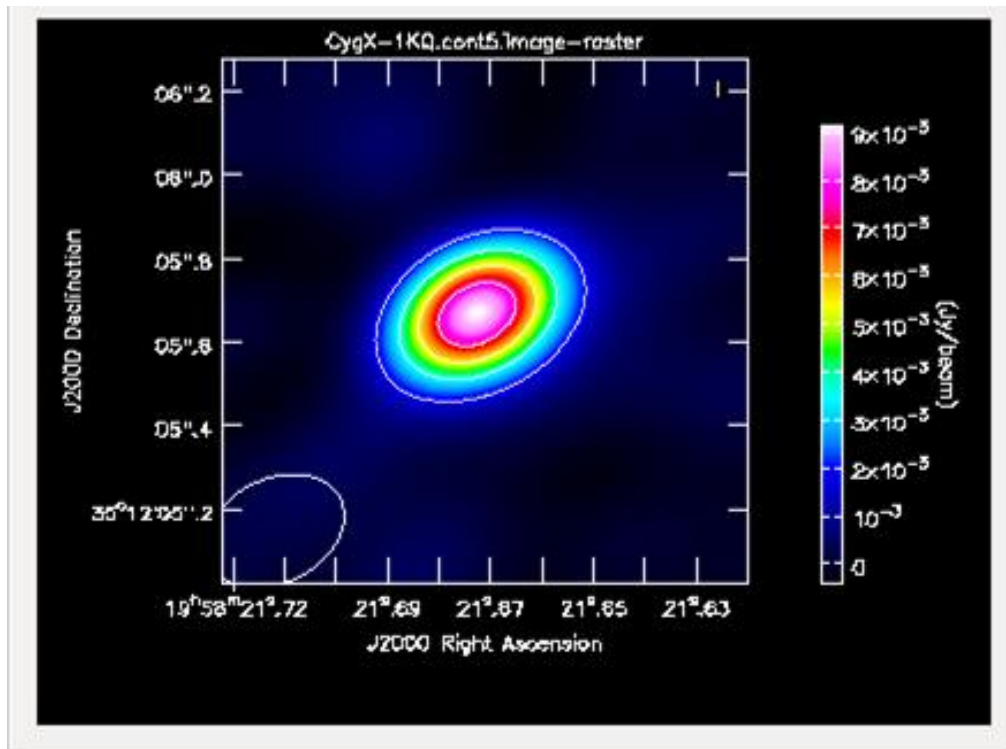


Data reduction completed by Dr. Richard Russel 11-18-2019 using download from NRAO VLA archive.

Cygnus X-1 (Black Hole) VLA Archive

```
=====
Observer: Dr. James Miller-Jones      Project: uid://evla/pdb/31100250
Observation: EVLA(27 antennas)
Computing scan and subscan properties...
Data records: 1858896      Total elapsed time = 675 seconds
Observed from 08-Jun-2016/06:05:09.0 to 08-Jun-2016/06:16:24.0 (UTC)
=====
```

Data Reduction Results



Background Information NASA



www.nasa.gov

Data reduction completed by Dr. Richard Russel 11-20-2019 using download from VLA database.

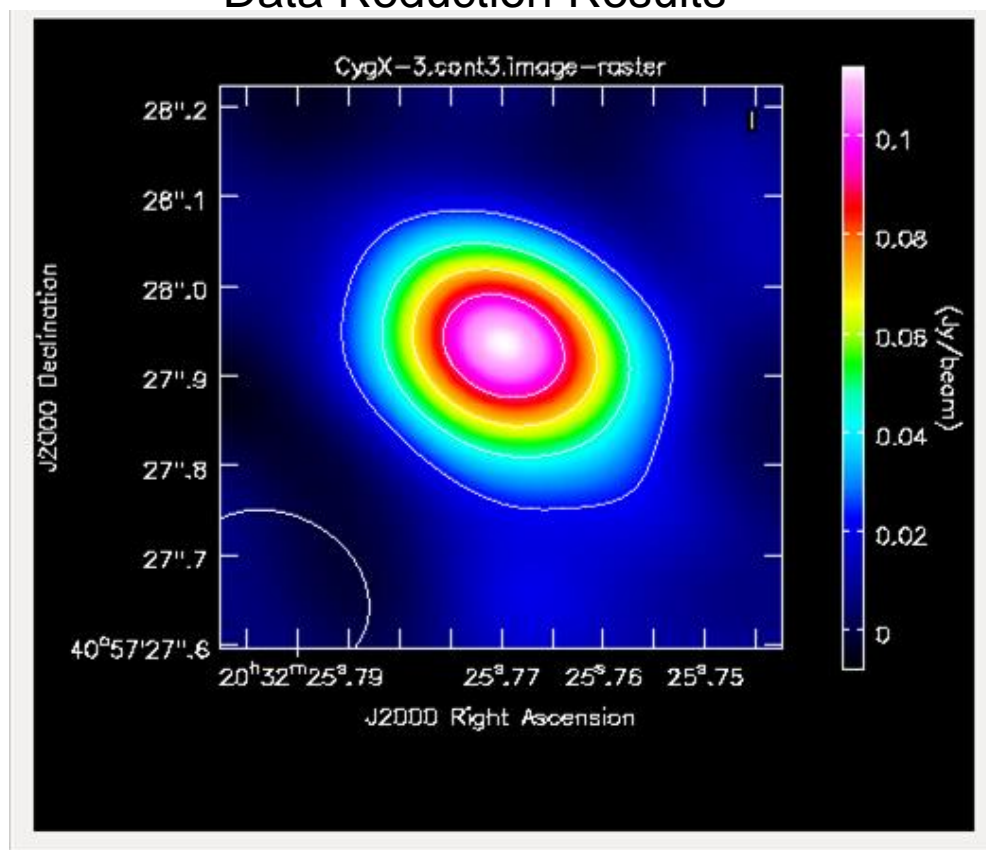
"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc."

Cygnus X-3 (Black Hole or Neutron Star) VLA Archive

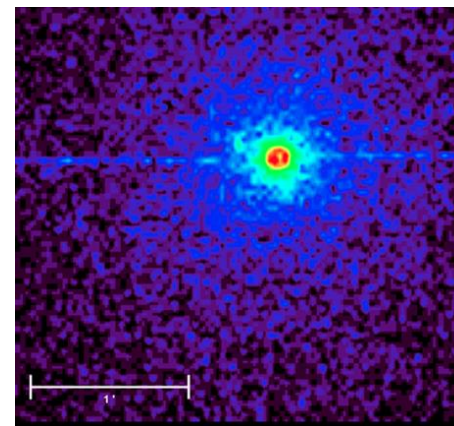
```
-----
Observer: Dr. James Miller-Jones      Project: uid://evla/pdb/1521136
Observation: EVLA
Computing scan and subscan properties...
Data records: 213948      Total elapsed time = 1686.85 seconds
Observed from 08-Apr-2011/13:05:37.5 to 08-Apr-2011/13:33:44.3 (UTC)
-----
```

Background Information Wikipedia

Data Reduction Results



Cygnus X-3 is a [high-mass X-ray binary](#) (HMXB), one of the stronger [binary X-ray sources](#) in the sky. It is often considered to be a [microquasar](#), and it is believed to be a [compact object](#) in a [binary system](#) which is pulling in a stream of gas from an ordinary [star](#) companion. It is the only known HMXB containing a [Wolf-Rayet star](#). It is invisible visually, but can be observed at [radio](#), [infrared](#), [X-ray](#), and [gamma-ray](#) wavelengths.



https://en.wikipedia.org/wiki/Cygnus_X-3

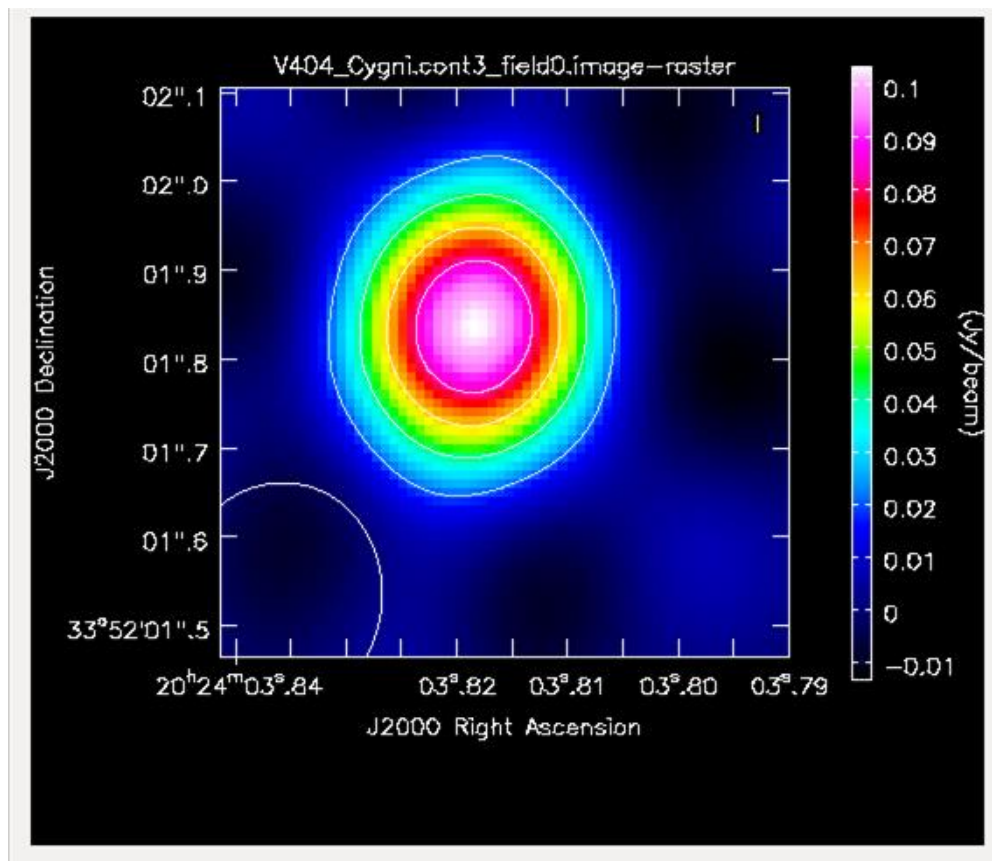
Data reduction completed by Dr. Richard Russel 11-21-2019 using download from VLA database.

V404 Cygni (Black Hole & Q-type Star Binary)

VLA Archive

```
Observer: Dr. James Miller-Jones      Project: uid://evla/pdb/30107161
Observation: EVLA
Computing scan and subscan properties...
Data records: 5479812      Total elapsed time = 1195 seconds
Observed from 17-Jun-2015/10:34:01.0 to 17-Jun-2015/10:53:56.0 (UTC)
```

Data Reduction Results



Background Information

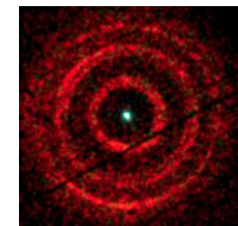
Wikipedia

V404 Cygni is a [microquasar](#) and a [binary](#) system in the constellation of [Cygnus](#). It contains a [black hole](#) with a mass of about 9 [M_☉](#) and an [early K giant star](#) companion with a mass slightly smaller than the [Sun](#). The star and the black hole [orbit](#) each other every 6.47129 days at fairly close range. Due to their proximity and the intense gravity of the black hole, the companion star loses mass to an accretion disk around the black hole and ultimately to the black hole itself.^[9] The "V" in the name indicates that it is a [variable star](#), which repeatedly gets brighter and fainter over time. It is also considered a [nova](#), because at least three times in the 20th century it produced a bright outburst of energy. Finally, it is a [soft X-ray transient](#) because it periodically emits short bursts of X-rays.

In 2009, the black hole in the V404 Cygni system became the first black hole to have an accurate [parallax](#) measurement for its distance from the [Solar System](#). Measured by [very-long-baseline interferometry](#) using the [High Sensitivity Array](#), the distance is 2.39 ± 0.14 [kiloparsecs](#),^[10] or 7800 ± 460 [light-years](#).

In April 2019, astronomers announced that jets of particles shooting from the black hole were wobbling back and forth on the order of a few minutes, something that had never before been seen in the particle jets streaming from a black hole. Astronomers believe that the wobble is caused by the warping of space/time by the huge gravitational field in the vicinity of the black hole.^[11]

The black hole companion has been proposed as a [Q star](#) candidate.^[12]



Data reduction completed by Dr. Richard Russel 11-23-2019 using download from VLA database.

GRO J0422+32

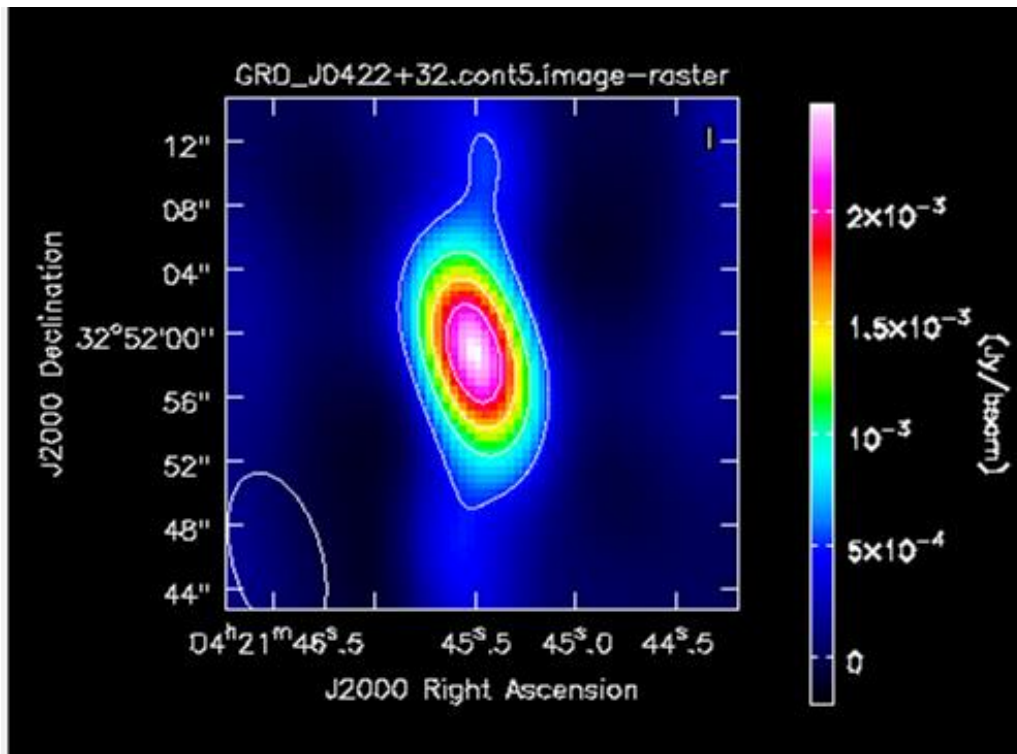
Possible Black Hole or Neutron Star Binary with a M4.5 Star

VLA Archive

```
=====
Observer: Dr. James Miller-Jones      Project: uid://evla/pdb/1072557
Observation: EVLA
Computing scan and subscan properties...
Data records: 13882050      Total elapsed time = 12564.8 seconds
Observed from 15-Nov-2010/01:34:01.4 to 15-Nov-2010/05:03:26.2 (UTC)
Fields: 3
=====
```

ID	Code Name	RA	Decl	Epoch	SrcId	nRows
0	K J0137+3309	01:37:41.299431	+33.09.35.13299	J2000	0	1144962
1	D J0414+3418	04:14:37.255748	+34.18.51.20738	J2000	1	2364336
2	NONE GRO J0422+32	04:21:42.746000	+32.54.26.97999	J2000	2	10372752

Data Reduction Results



Background Information

Wikipedia

GRO J0422+32^[1] is an [X-ray nova](#) and [black hole](#) candidate that was discovered by the [BATSE](#) instrument on the [CGRO](#) satellite on 5 August 1992.^{[3][4]} During outburst, it was observed to be stronger than the [Crab Nebula](#) gamma-ray source out to photon energies of about 500 [keV](#).^[2]

The mass of the black hole in GRO J0422+32 falls in the range 3.66 to 4.97 [solar masses](#).^[5] This is the smallest yet found for any [stellar black hole](#), and near the theoretical upper mass limit (~2.7 [M_⊙](#)) for a [neutron star](#). Further analysis in 2012 calculated a mass of 2.1 [M_⊙](#), which raises questions as to what the object actually is.^[6]

It is also known to have a companion [M-type main-sequence star](#), V518 Per,^[7] in the constellation [Perseus](#). It has a magnitude of 13.5 in the B spectral band, and 13.2 in the visible band.

Data reduction completed by Dr. Richard Russel 11-24-2019 using download from VLA database.

GRO J1635-40 Black Hole Binary with V1030 Sco

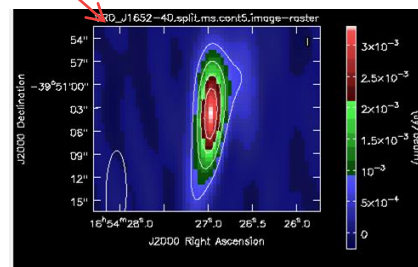
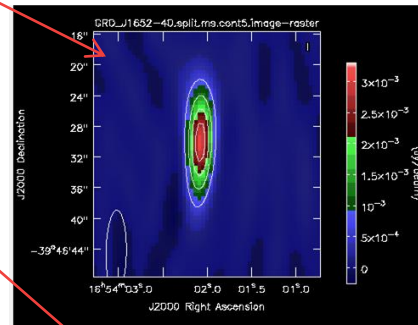
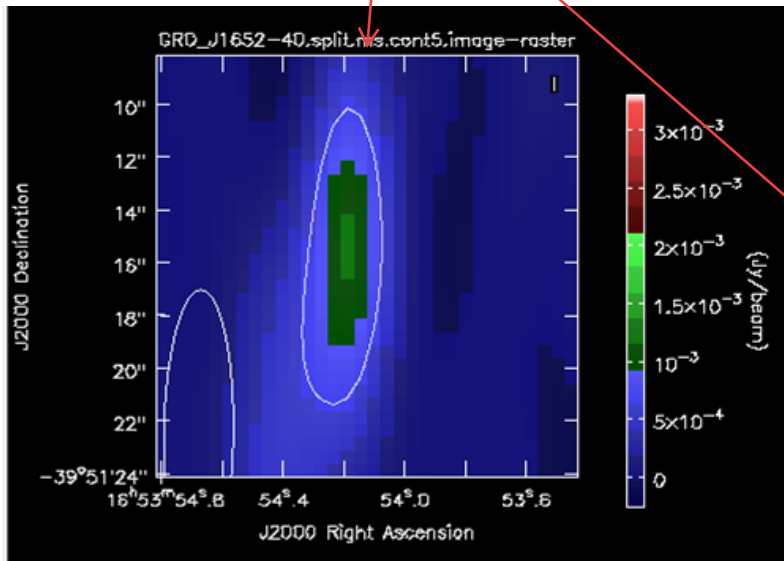
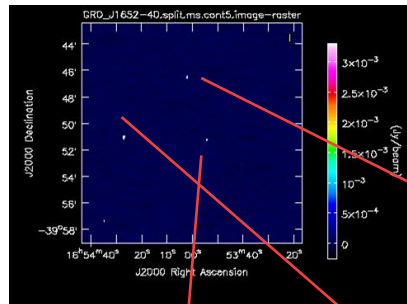
VLA Archive

Three objects in close proximity- Bottom left is closest to expected position of J1635-40

```
=====
Observer: Dr. James Miller-Jones      Project: uid://evla/pdb/1072557
Observation: EVLA
Computing scan and subscan properties...
Data records: 12849200      Total elapsed time = 12564.6 seconds
Observed from 13-Dec-2010/16:40:33.4 to 13-Dec-2010/20:09:58.1 (UTC)
=====
```

ID	Code Name	RA	Decl	Epoch	SrcId	nRows
0	K J1331+3030	13:31:08.287984	+30.30.32.95886	J2000	0	904800
1	D J1607-3331	16:07:34.762344	-33.31.08.91313	J2000	1	2251600
2	NONE GRO J1655-40	16:54:00.137000	-39.50.44.90001	J2000	2	9692800

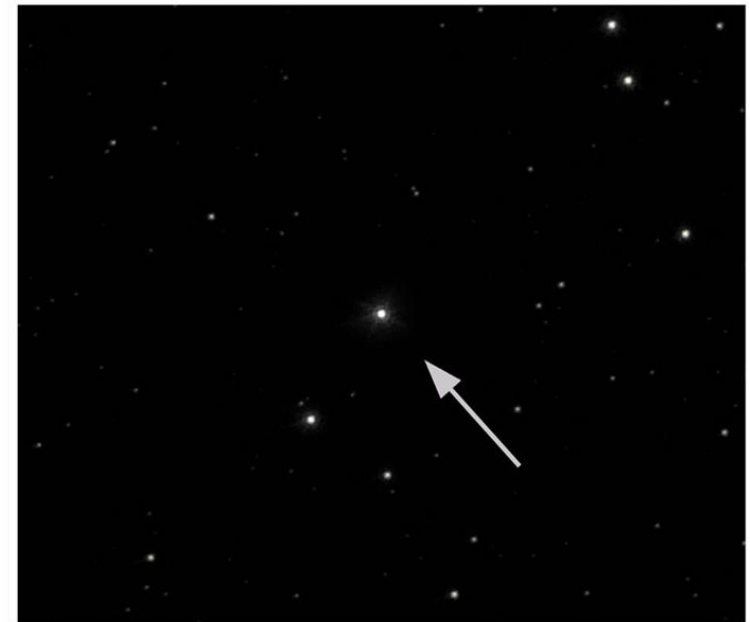
Data Reduction Results



Background Information

Hubble Website

Black-hole system GRO J1655-40 in Scorpius



NASA/ESA Hubble Space Telescope image shows the Year 2001 observation of the black hole system GRO J1655-40 in the constellation of Scorpius. Hubble's high resolution has allowed astronomers to measure the motion of this black-hole system across the sky using this image and an image taken in 1996. Scientists combined the Hubble data with those obtained from ground-based telescopes and found that the black hole is moving through space with a velocity of 400 000 kilometres per hour. This has provided possibly the best evidence yet that stellar-mass black holes are made in supernova explosions. The 720-second exposure was taken through a red filter.

<https://www.spacetelescope.org/images/heic0211c/>

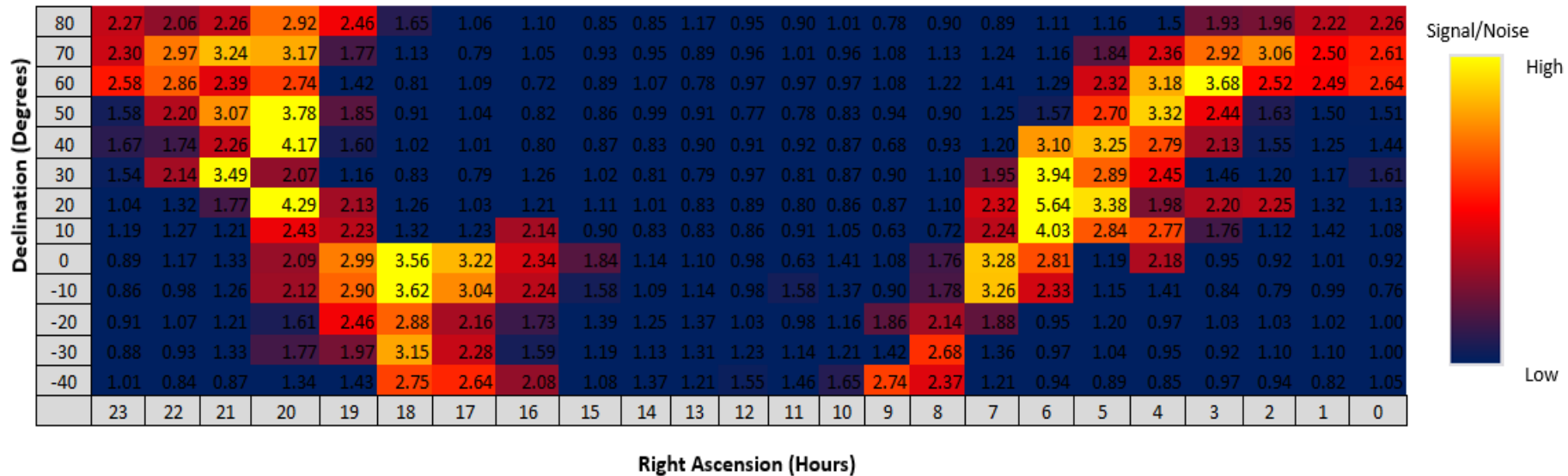
Data reduction completed by Dr. Richard Russel 11-25-2019 using download from VLA database.

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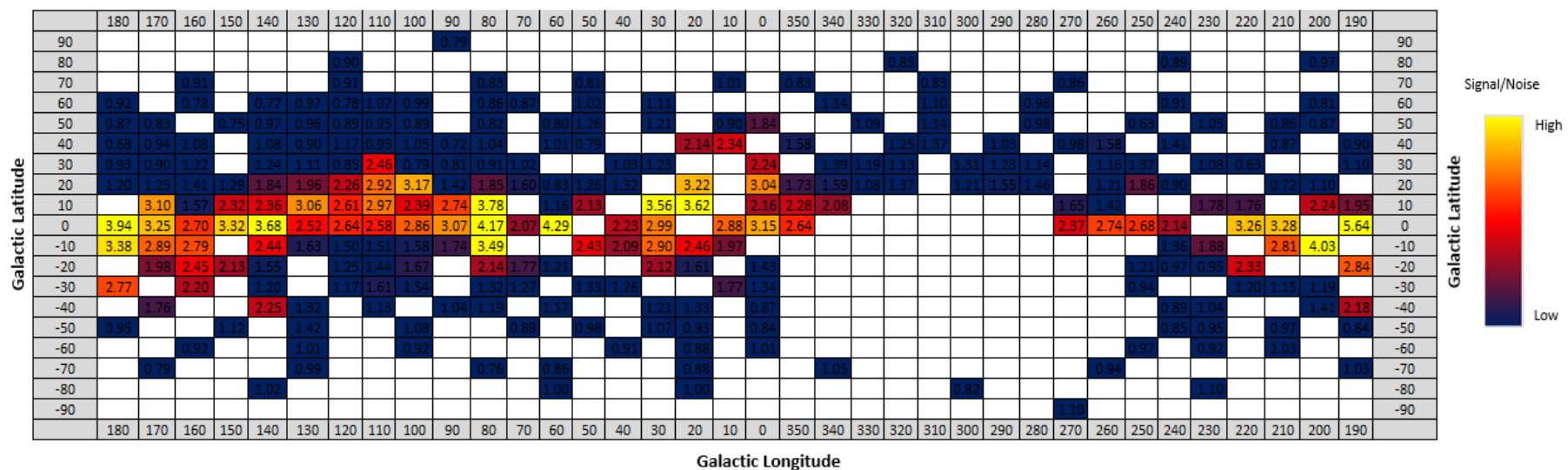
HI Drift Scan using 9-ft Dish at Russel Observatory

September 2019

Russel Observatory HI Spectrum Peak Map Survey



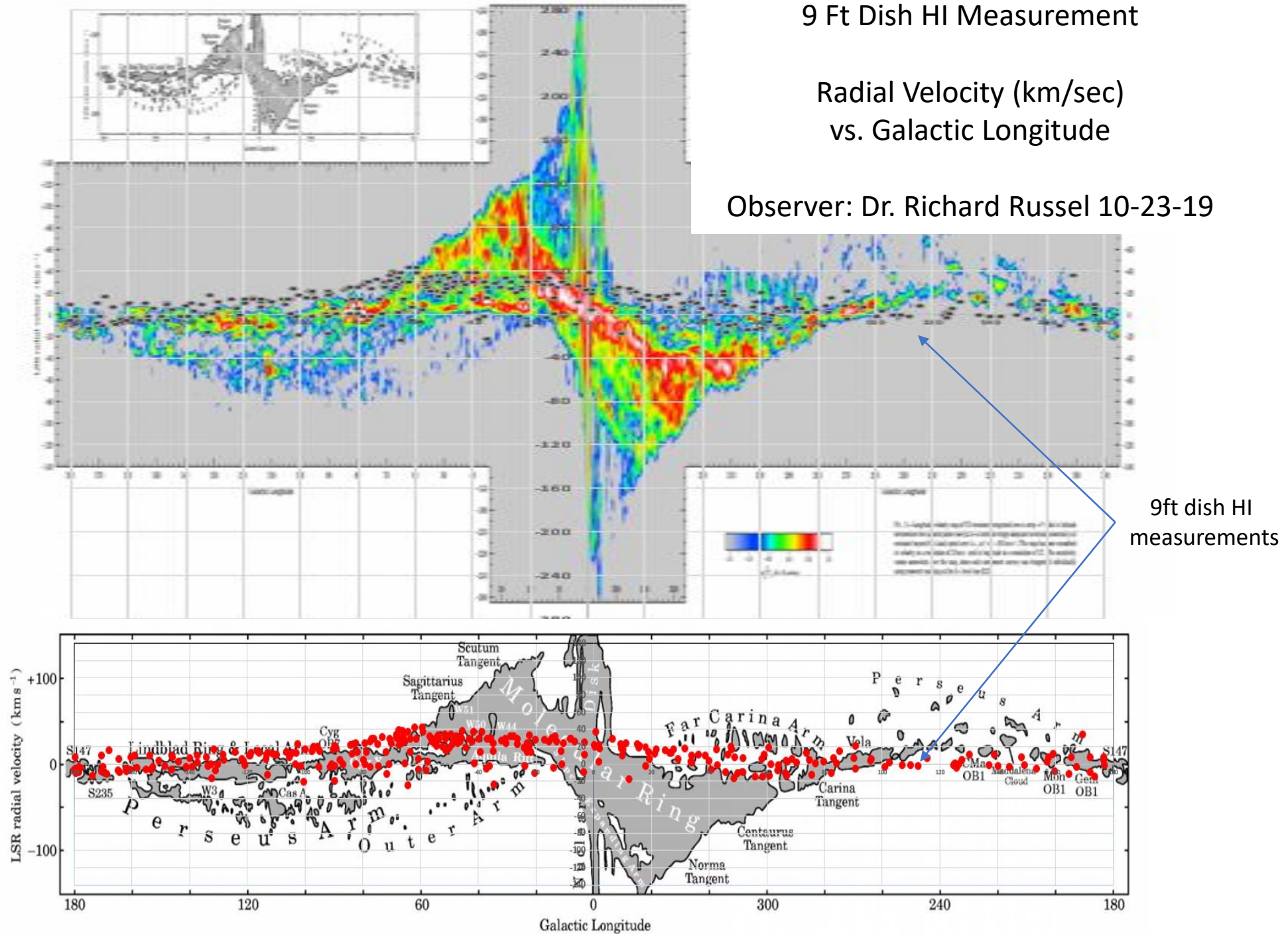
Russel Observatory HI Spectrum Peak Map Survey



9 Ft Dish HI Measurement

Radial Velocity (km/sec)
vs. Galactic Longitude

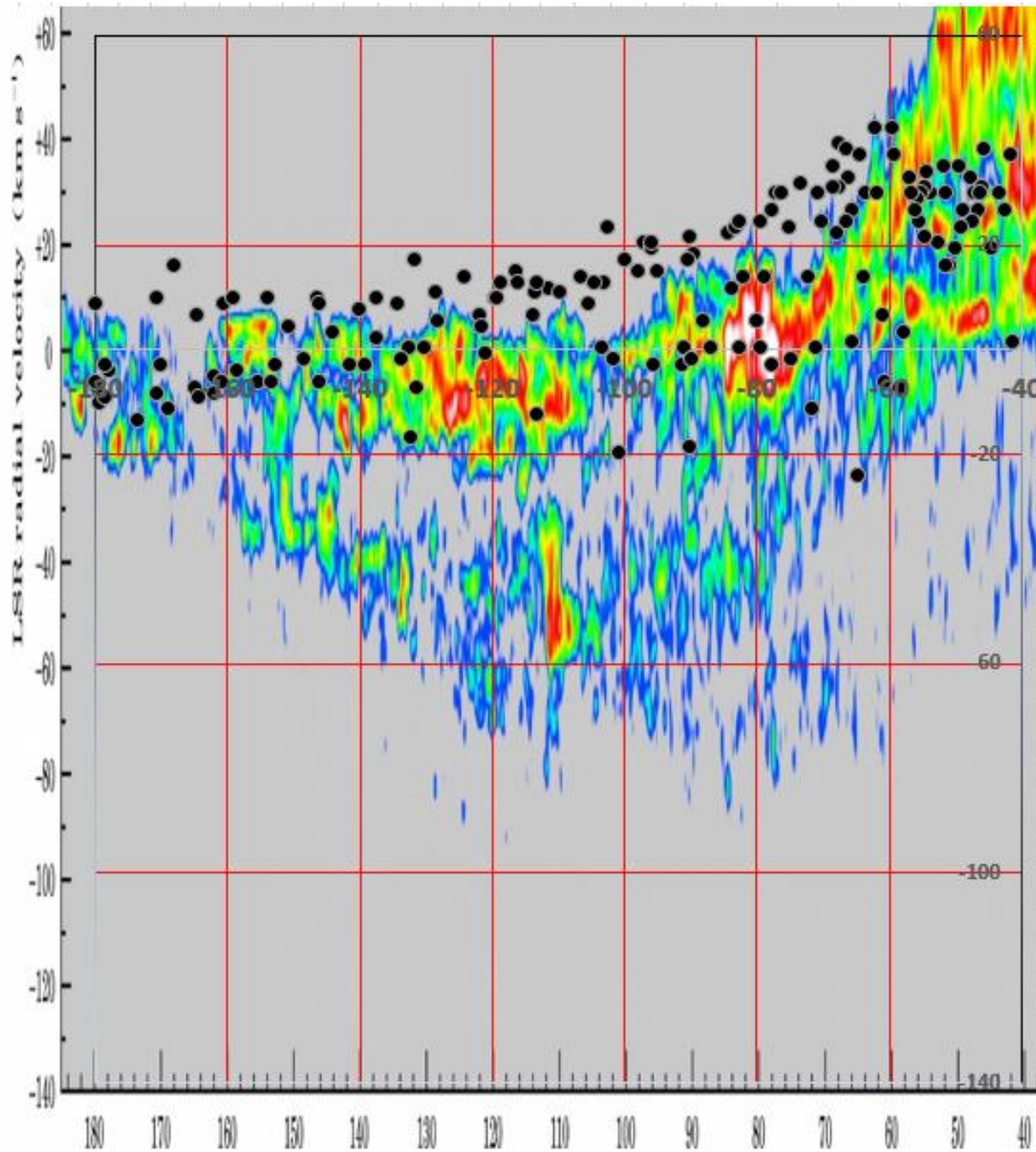
Observer: Dr. Richard Russel 10-23-19



Background images obtained at:

<https://www.britannica.com/place/Milky-Way-Galaxy/The-structure-and-dynamics-of-the-Milky-Way-Galaxy>

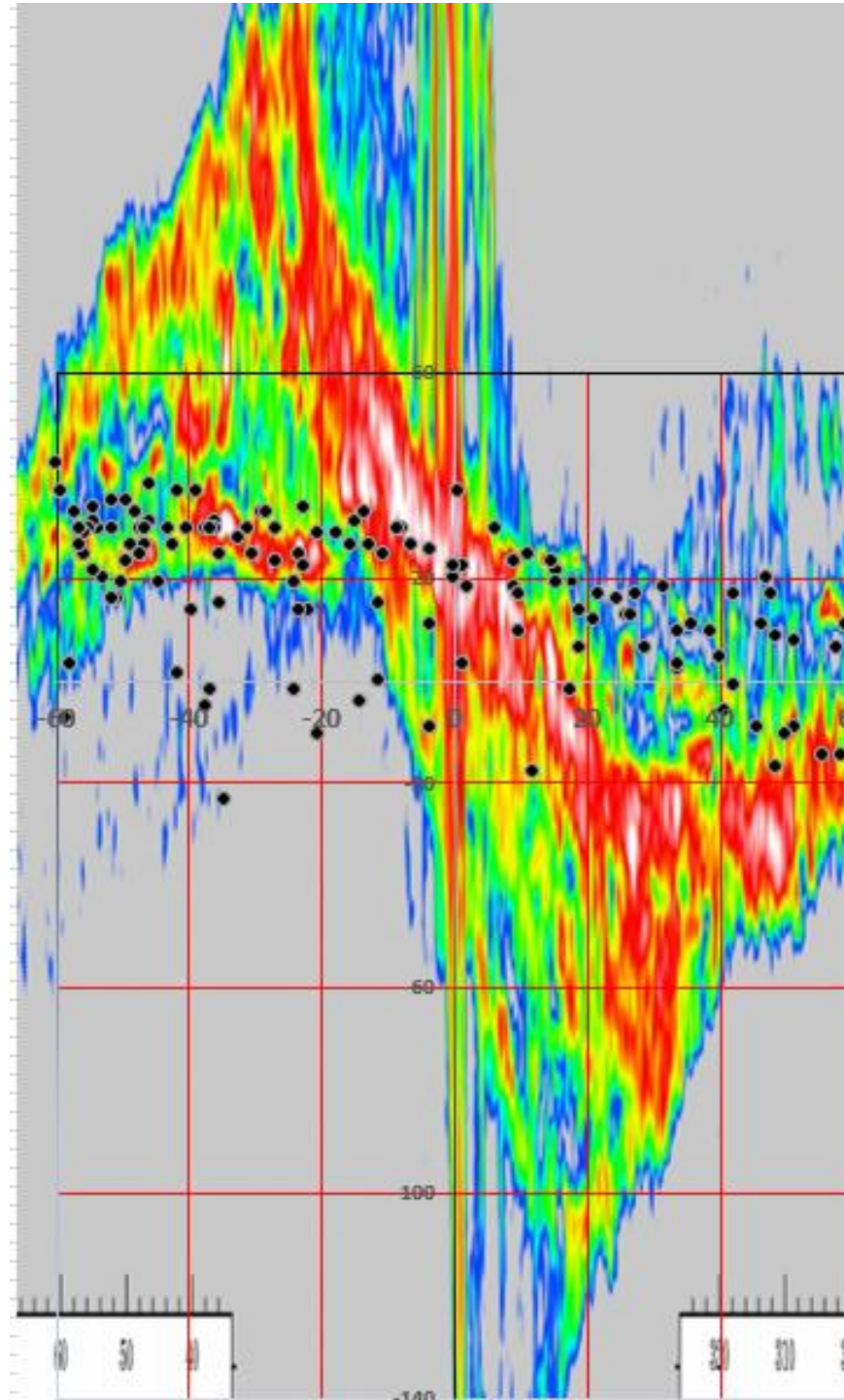
Perseus Arm (Left)



Russell
Observatory
9 ft dish data
(black dots)
overlaid on
the following
image

<https://www.britannica.com/place/Milky-Way-Galaxy/The-structure-and-dynamics-of-the-Milky-Way-Galaxy>

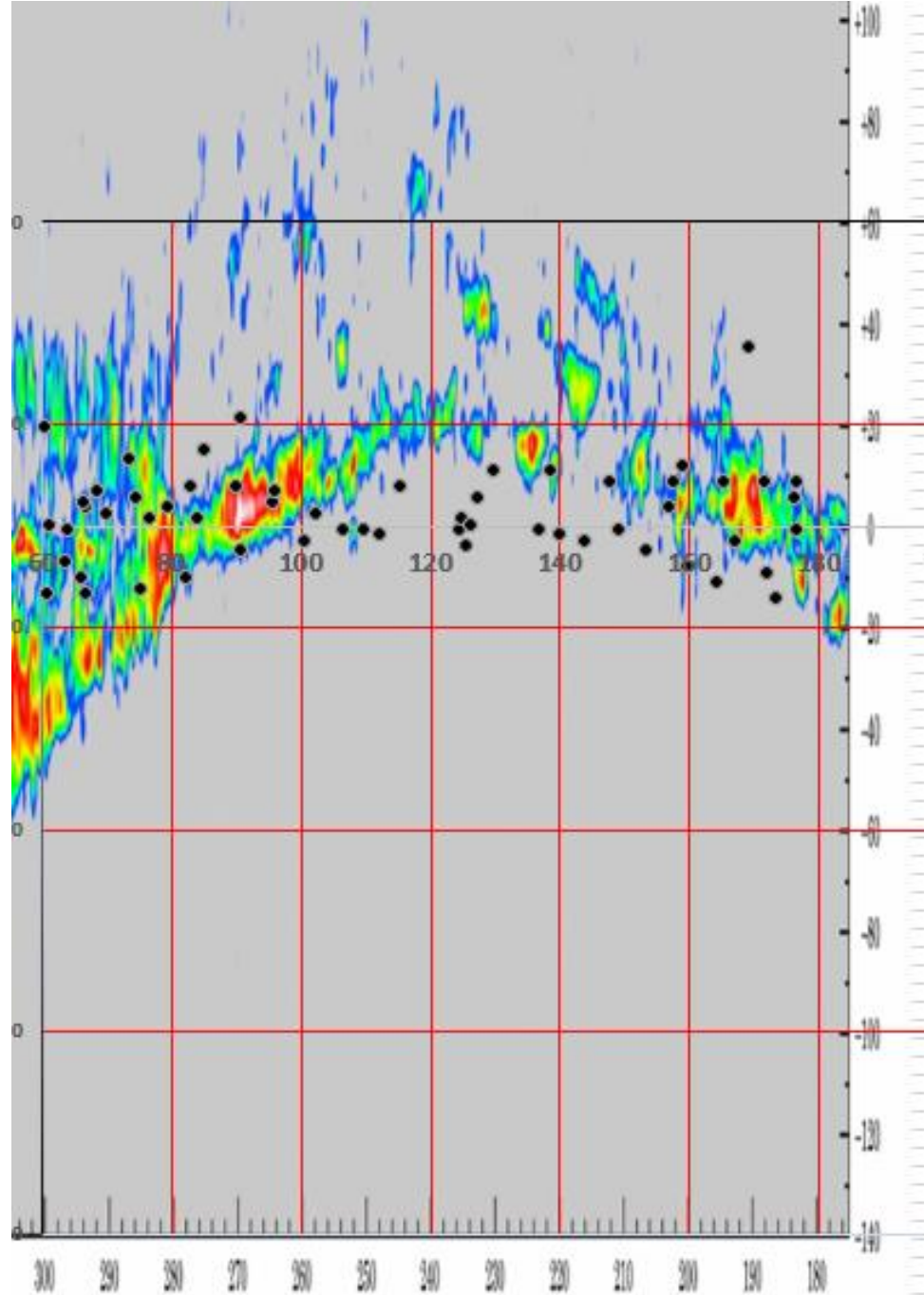
Molecular Ring



Russel Observatory
9 ft dish data (black
dots) overlaid on the
following image

[https://www.britannica.com/plac
e/Milky-Way-Galaxy/The-
structure-and-dynamics-of-the-
Milky-Way-Galaxy](https://www.britannica.com/place/Milky-Way-Galaxy/The-structure-and-dynamics-of-the-Milky-Way-Galaxy)

Perseus Arm (Right)



Russel Observatory
9 ft dish data (black
dots) overlaid on the
following image

<https://www.britannica.com/place/Milky-Way-Galaxy/The-structure-and-dynamics-of-the-Milky-Way-Galaxy>

Publication Acknowledgements

This paper makes use of the following ALMA data: ADS/JAO.ALMA#2011.0.00002.SV. ALMA is a partnership of ESO (representing its member states), NSF (USA) and NINS (Japan), together with NRC (Canada), NSC and ASIAA (Taiwan), and KASI (Republic of Korea), in cooperation with the Republic of Chile. The Joint ALMA Observatory is operated by ESO, AUI/NRAO and NAOJ."

"The National Radio Astronomy Observatory is a facility of the National Science Foundation operated under cooperative agreement by Associated Universities, Inc." .

Reference if you use CASA: McMullin, J. P., Waters, B., Schiebel, D., Young, W., & Golap, K. 2007, Astronomical Data Analysis Software and Systems XVI (ASP Conf. Ser. 376), ed. R. A. Shaw, F. Hill, & D. J. Bell (San Francisco, CA: ASP), 127