

Science Ready Data Products and Other NRAO Initiatives

John Tobin (slides mostly from Mark Lacy)



Talk overview

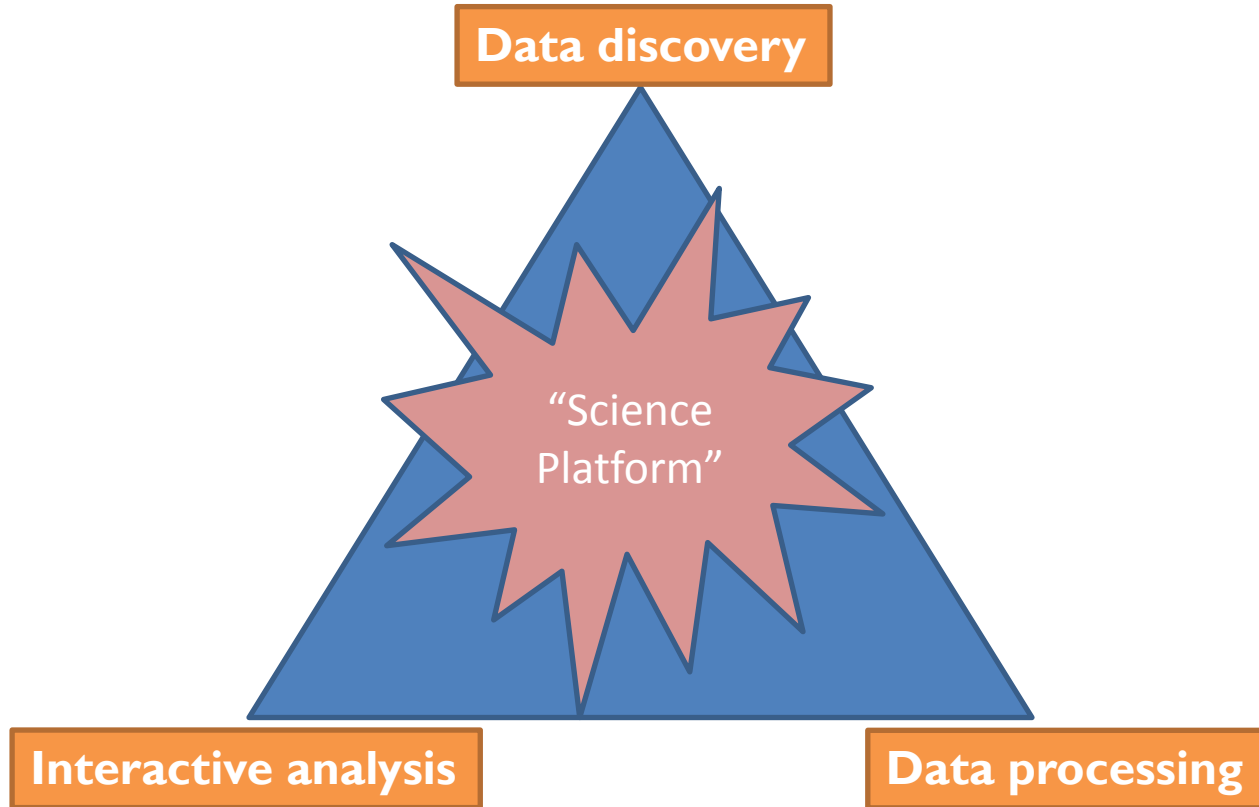
- The data challenge in radio astronomy.
- User interaction with large datasets via “Science Platforms”, NRAO’s Science Ready Data Products (SRDP).
- The NRAO Archive Access Tool (AAT)
 - CARTA visualization
 - Restoration of calibration
 - ALMA user-driven reimaging (AUDI; with self-calibration)
 - Radio astronomy in the Virtual Observatory
- CASA-based data processing pipelines for ALMA and the VLA.
- The future
 - TTA tools, user-driven imaging for VLA, user-driven calibration, large data collections.
- The VLA Sky Survey (VLASS)
- The far future (ALMA WSU, ngVLA, SKA, DSA-2000....)

How can we deal with the massive datasets coming from modern interferometers?

- The commissioning of the WIDAR correlator on the VLA in ~2010 and ALMA shortly afterwards presented a huge challenge to data processing.
- Data volumes went from ~100 MB to ~100 GB per observation in a few years.
- Large bandwidths are challenging both in terms of data manipulation and algorithmic complexity.
- Needs more support from the Observatory in terms of processing pipelines, analysis tools and available computing.
 - ***NRAO's Science Ready Data Products (SRDP) initiative.***
- The future will see another ~10-1000x increase with the ALMA WSU, ngVLA, SKA, DSA-2000.....

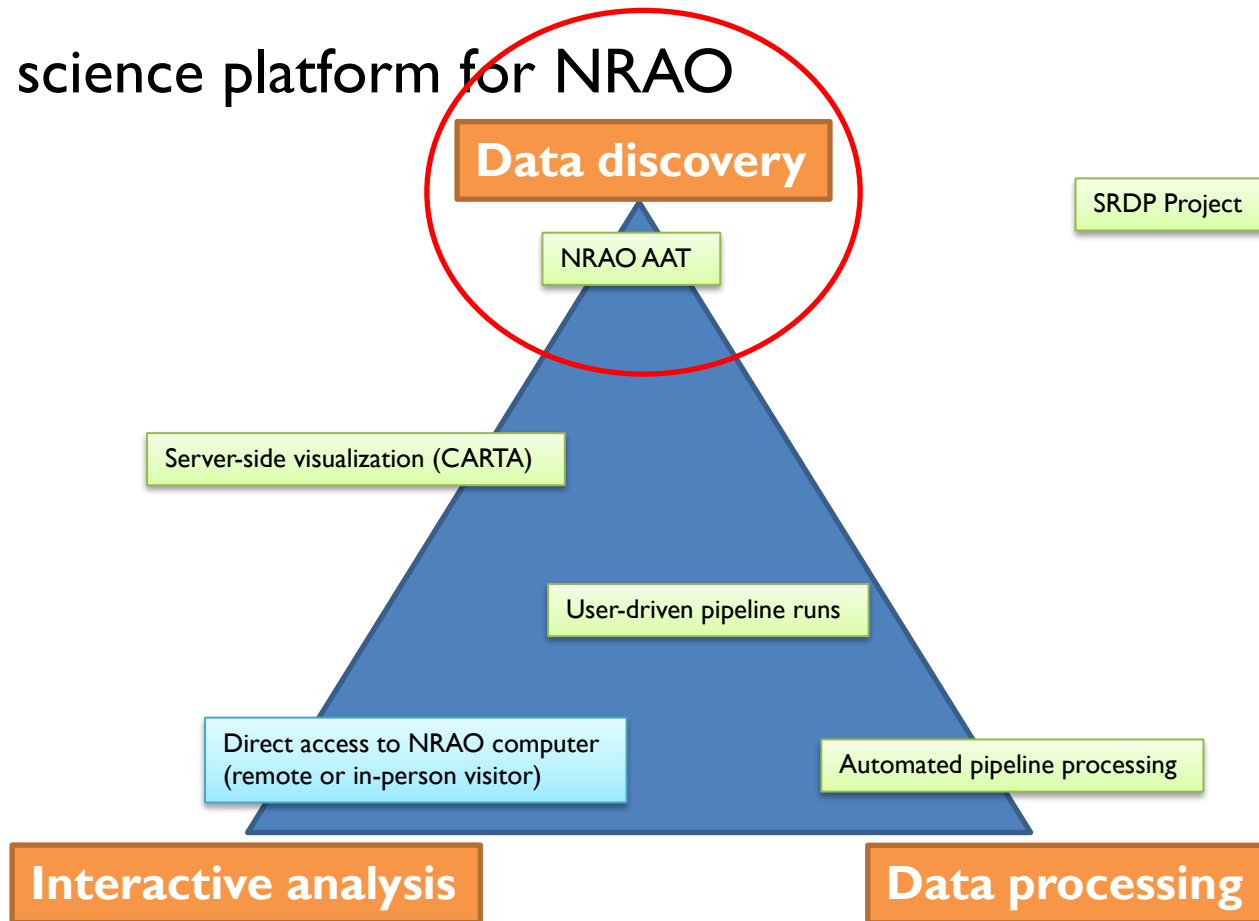


User interaction with large datasets



Courtesy E. Ryan

SRDP as a science platform for NRAO



The NRAO archives

- NRAO current primary archive is the Archive Access Tool (AAT) (<https://data.nrao.edu>)
- NRAO also separately hosts a mirror of the ALMA archive (<https://almascience.nrao.edu/aq>)
- (NRAO's legacy archive (archive.nrao.edu) is for internal use only and will be fully retired soon)
- The AAT supports both interactive use, and scripted queries via a Virtual Observatory TAP interface (more later).

Simple text search

Click for advanced interface

National Radio Astronomy Observatory
Enabling forefront research into the Universe at radio wavelengths

Archive Access Tool Back

Search

Show Search Inputs

View Projects View Observations View Images

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Show 25 of 26405 Projects

Project	Instrument	Title	First Obs	Last Obs	Execution Blocks
VLASS3.1	EVLA	The Very Large Array Sky Survey	2023-01-13 07:43	2023-06-13 15:27	153 execution blocks
Operations	EVLA	No title found	2009-10-14 21:18	2023-06-13 12:56	59763 execution blocks
23A-009	EVLA	Synergistic observations of repeating fast radio bursts with FAST and VLA	2023-05-09 13:28	2023-06-13 11:34	6 execution blocks
2022.1.01204.S	ALMA	Forming hub-filament systems: An unbiased study of the gas kinematics of increasingly complex filamentary structures	2022-10-15 00:10	2023-06-13 03:12	330 execution blocks
2022.1.00131.S	ALMA	Outflows in Class 0/I Protostars with ALMA: A multi-scale approach	2022-10-23 00:26	2023-06-13 02:42	148 execution blocks
23A-162	EVLA	Completing the Radio Continuum Survey of the Low-z Lyman Continuum Leakers	2023-02-07 15:22	2023-06-12 23:43	79 execution blocks
3740_4	EVLA	No title found	2022-11-18 21:36	2023-06-12 22:29	6 execution blocks
2022.1.00477.S	ALMA	Constraining the water evolution in an embedded disk around HH100	2023-06-12 07:32	2023-06-12 07:52	1 execution blocks
2022.1.01163.S	ALMA	Simultaneous Monitoring of Stellar Flares with ALMA and TESS to Discover Space Weather Environments of Exoplanets	2023-01-22 06:13	2023-06-12 02:05	37 execution blocks

Dates From: **Dates To:**

Start Frequency: GHz ▾ **End Frequency:** GHz ▾

Coordinate Frame: **Equinox:** **Right Ascension:** **Declination:**

Radius: " ▾ **Source Name:**

Telescope: **Array Configuration:** **Receivers:** **Polarizations:**

Project Code: **Archive Filename:** **PI Name:** **Title Text:**

Abstract Text:

Show only CMS data
 Show only data flagged public

▲ Hide Search Inputs ▲

	⇅ Project	⇅ Instrument	Title	⇅ First Obs	⇅ Last Obs	
<input type="button" value="⊕"/>	21A-017	EVLA	A 3GHz survey of the Expanded Chandra Deep Field South	2021-07-24 14:16	2021-09-15 10:03	<input type="button" value="31 execution blocks"/>
<input type="button" value="⊕"/>	20A-156	EVLA	Studying the formation of galactic-scale magnetic fields in ELAIS-N1	2020-01-29 13:16	2020-09-10 03:13	<input type="button" value="26 execution blocks"/>
<input type="button" value="⊕"/>	20A-274	EVLA	Imaging the Sunyaev-Zeldovich Effect from a strong wind in a stormy teacup	2020-01-31 12:41	2020-04-07 08:31	<input type="button" value="14 execution blocks"/>
<input type="button" value="⊕"/>	19A-306	EVLA	Feedback mechanisms in the hyperluminous quasar HE 0515-4414	2019-08-11 14:21	2019-08-23 15:30	<input type="button" value="2 execution blocks"/>
<input type="button" value="⊕"/>	17A-109	EVLA	A detailed study of the jet-galaxy interaction in Minkowski's Object	2017-02-11 20:10	2017-05-19 18:49	<input type="button" value="2 execution blocks"/>
<input type="button" value="⊕"/>	2019-1-00000-0	EVLA	Directed detection of the Sunyaev-Zeldovich Effect in the ...	2019-11-27 04:55	2019-03-20 04:14	

Launch Workflow Task on: 21A-017

User Email (required):

Request Description:

Destination Directory: Specify directory (must be logged in)

Create tar file: Return results as a tar file

Choose download data format:

- SDM tables only (metadata only)
- SDM-BDF dataset (metadata + visibilities)
- Basic Measurement Set (uncalibrated)
- Calibrated Measurement Set

Apply telescope flags: Apply flags generated during observing

CASA|Pipeline Version:

Restore previous CMS

Estimated Processing Time: an hour

[View Projects](#) [View Observations](#) [View Images](#)

Project	Instrument	Title
21A-017	EVLA	A 3GHz survey of the Exp

Title: A 3GHz survey of the Expanded Chandra Deep Field South
Abstract: We propose a survey of 10 square degrees in the Extended Chandra Deep ECDFS already has good optical, near-infrared (ground-based and Spitzer) and mid-to deep field on a scale ~ 10 deg^2 to study the evolution of active and normal galaxies enhance time domain studies in this field. This survey will complement proposed observations.
PI: Mark Lacy
Legacy ID: AL1175
Co-Authors: Casey Law, Nicholas Seymour, Hugo Messias, Steven Myers, Amy Kirshner, Hatziminaoglou, Anna D. Kapinska, Richard White
Proposal: Click to search

[Observations](#) [Images](#)

« < Page 1 > »

Show 25 of 31 Observations

1 selected (17.5 GB/10.0 TB)

[View Selection\(s\)](#) [Select All](#) [Clear All](#) [Download](#)

Archive File	Project	Instrument	Observation Start	Observation Stop	File Size	Array Config	Bands	Type	Cals	Scans
<input checked="" type="checkbox"/> 21A-017.sb39671704.eb40150960.59472.3358566088	21A-017	EVLA	2021-09-15 08:03:38	2021-09-15 10:03:04	17.495 GB	C->B	C, S	visibility	1	49
<input type="checkbox"/> 21A-017.sb39605303.eb40145692.59471.379705810185	21A-017	EVLA	2021-09-14 09:06:47	2021-09-14 11:06:12	16.248 GB	C->B	C, S	visibility	1	49
<input type="checkbox"/> 21A-017.sb39653904.eb40142133.59470.43886270833	21A-017	EVLA	2021-09-13 10:31:58	2021-09-13 12:31:25	16.260 GB	C	C, S	visibility	1	49

Coordinate Frame: **Equinox:** **Right Ascension:** **Declination:**

Radius: " **Source Name:**

Include name text in search

Telescope: **Array Configuration:** **Receivers:** **Polarizations:**

Project Code: **Archive Filename:** **PI Name:** **Title Text:**

Abstract Text:

Show only CMS data
 Show only data flagged public

▲ Hide Search Inputs ▲

↕ Project	↕ Instrument	Title	↕ First Obs	↕ Last Obs	
<input type="checkbox"/> 2019.1.00847.S	ALMA	A Complete Survey of Protostellar Disk Gas and Dust Structure in Taurus	2019-10-07 06:28	2022-08-05 12:12	<input type="button" value="35 execution blocks"/>
<input type="checkbox"/> 2019.1.00458.S	ALMA	What is Carving the Gaps in Young, Embedded Disks?	2021-05-12 19:57	2022-07-31 00:07	<input type="button" value="14 execution blocks"/>
<input type="checkbox"/> 2021.1.00486.S	ALMA	What is Carving the Gaps in Young, Embedded Disks?	2021-10-30 10:16	2022-05-22 19:07	<input type="button" value="3 execution blocks"/>
<input type="checkbox"/> 2019.1.00493.S	ALMA	Direct Mass Measurements of Pre-Main Sequence Stars in Upper Sco	2020-02-27 07:47	2022-05-20 06:51	<input type="button" value="10 execution blocks"/>



Show only CMS data

Show only data flagged public

▲ Hide Search Inputs ▲

View Projects View Observations View Images

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Show 25 of 8 Projects

↕ Project

↕ Instrument

Title

↕ First Obs

↕ Last Obs

2019.1.00847.S	ALMA	A Complete Survey of Protostellar Disk Gas and Dust Structure in Taurus	2019-10-07 06:28	2022-08-05 12:12	35 execution blocks
----------------	------	---	------------------	------------------	---------------------

Title: A Complete Survey of Protostellar Disk Gas and Dust Structure in Taurus

Abstract: Recent findings of substructures in the protoplanetary disks of nearly every 1-5 Myr old pre-main sequence star observed with high enough spatial resolution suggest that these disks may already have undergone a significant amount of planet/planetesimal formation. If so, then younger, <1 Myr, protostellar disks likely better represent the initial disk conditions before significant dust processing or planet formation has occurred. To date, however, there have been few large samples of protostellar disks observed with high resolution (<0.5") in both gas and dust to study their structure. Here we propose to observe every embedded protostar in Taurus. We will map their disks with 870 micron continuum and spectral line observations at ~0.3" resolution to determine the geometry of the circumstellar material, and couple our observations with existing VLA 9 mm observations of similar resolution to constrain the maximum dust grain sizes in the disks and search for evidence of the onset of planet formation at early times. The proposed observations will allow us to put together a comprehensive picture of the initial conditions in disks, from which all subsequent planet formation will proceed.

PI: Patrick Sheehan

Co-Authors: Josh Eisner, John Tobin, Nicholas Ballering, Zhi-Yun Li, Ryan Loomis, Hauyu Baobab Liu, Tyler Bourke

MOUSes

Images

« < Page 1 > »

Show 25 of 7 MOUSes

MOUS	↕ Observation Start	↕ Observation Stop	File Size	Array Config	Ang Res	Bands	EBs		
04016+26_a_07_TM1	2022-08-05 10:48	2022-08-05 12:12	199.010 GB	12M	0.208"	07	6	Download Restored MS	Re-imaging
04016+26_a_07_7M	2021-08-18 09:47	2021-08-18 11:45	40.789 GB	7M	3.365"	07	18	Download Restored MS	Re-imaging
04489+30_a_07_TM2	2019-11-28 04:57	2019-11-28 05:23	10.039 GB	12M	0.875"	07	1	Download Restored MS	Re-imaging
04489+30_a_07_7M	2019-10-22 08:01	2019-10-22 09:12	4.446 GB	7M	4.077"	07	3	Download Restored MS	Re-imaging
04191+15_a_07_7M	2019-10-21 06:28	2019-10-21 08:16	7.346 GB	7M	3.571"	07	4	Download Restored MS	Re-imaging
04489+30_a_07_TM1	2019-10-07 08:47	2019-10-07 09:32	19.431 GB	12M	0.309"	07	1	Download Restored MS	Re-imaging
04191+15_a_07_TM1	2019-10-07 07:39	2019-10-07 08:46	58.661 GB	12M	0.265"	07	2	Download Restored MS	Re-imaging

2019.1.00458.S	ALMA	What is Carving the Gaps in Young, Embedded Disks?	2021-05-12 19:57	2022-07-31 00:07	14 execution blocks
----------------	------	--	------------------	------------------	---------------------

Show only CMS data

Launch Workflow Task on: 2019.1.00847.S

User Email (required):

Request Description:

ALMA Processing Request

Destination Directory:

Specify directory (must be logged in)

/lustre/

Create tar file:

Return results as a tar file

Choose download data

format:

SDM tables only (metadata only)

ALMA SDM+BDF (metadata + visibilities)

Calibrated Measurement Set

Apply telescope flags:

Apply flags generated during observing

CASA/Pipeline Version:

6.6.6-18 | 2025.1.0.36 (recommended) ▾

Restore previous CMS

uid://A001/X1467/X26e ▾

Estimated Processing Time: 3 hours

Cancel

Submit Request

Data Acknowledgements:



This paper makes use of the following ALMA data: ADS/JAO.ALMA#2019.1.00847.S. 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 and Green Bank Observatory are facilities of the U.S. National Science Foundation operated under cooperative agreement by Associated Universities, Inc.

View Projects View Observations View Images

Project Instrument Title

2019.1.00847.S ALMA A Complete Survey of

Title: A Complete Survey of Protostellar Disk Gas and Dust Structure in Taurus

Abstract: Recent findings of substructures in the protoplanetary disks of nearby planetesimal formation. If so, then younger, <1 Myr, protostellar disks likely better disks observed with high resolution (<0.5") in both gas and dust to study their resolution to determine the geometry of the circumstellar material, and couple planet formation at early times. The proposed observations will allow us to put **PI:** Patrick Sheehan

Co-Authors: Josh Eisner, John Tobin, Nicholas Ballering, Zhi-Yun Li, Ryan Lo

MOUSEs Images

Page 1

MOUS

Observation Start

04016+26_a_07_TM1	2022-08-05 10:48
04016+26_a_07_7M	2021-08-18 09:47
04489+30_a_07_TM2	2019-11-28 04:57
04489+30_a_07_7M	2019-10-22 08:01
04191+15_a_07_7M	2019-10-21 06:28
04489+30_a_07_TM1	2019-10-07 08:47
04191+15_a_07_TM1	2019-10-07 07:39

Show 25 of 8 Projects

Last Obs

2022-08-05 12:12 35 execution blocks

that these disks may already have undergone a significant amount of planet/ occurred. To date, however, there have been few large samples of protostellar disks with 870 micron continuum and spectral line observations at ~0.3" minimum dust grain sizes in the disks and search for evidence of the onset of planet formation will proceed.

Show 25 of 7 MOUSEs

Bands EBs

07	6	Download Restored MS	Re-Imaging
07	18	Download Restored MS	Re-Imaging
07	1	Download Restored MS	Re-Imaging
07	3	Download Restored MS	Re-Imaging
07	4	Download Restored MS	Re-Imaging
07	1	Download Restored MS	Re-Imaging
07	2	Download Restored MS	Re-Imaging

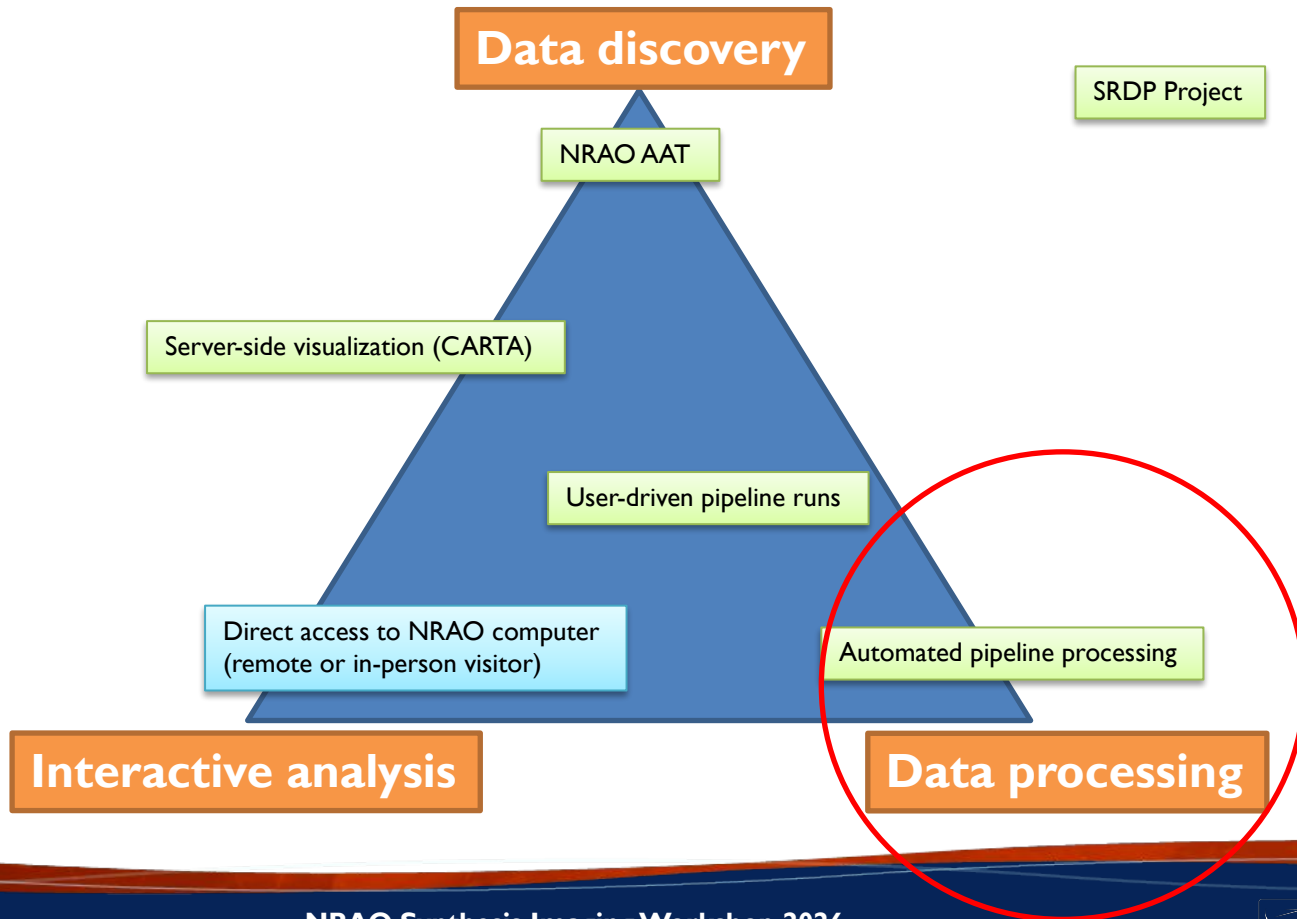
Radio astronomy in the Virtual Observatory

- NRAO TAP (Table Access Protocol) service (<https://data-query.nrao.edu/tap>)
 - See <https://science.nrao.edu/facilities/vla/archive/scripted-access-to-the-nrao-archive> for details
 - Allows e.g. access to archive metadata via Topcat
 - Example notebook for a pyvo scripted query available
 - Astroquery integration coming soon!
- CADC access to VLASS
 - Scripted downloads of images and cutouts.
 - See example notebooks at <https://gitlab.nrao.edu/mlacy/vlass-vo>
- VLASS in Aladin (HIPS)
 - http://archive-new.nrao.edu/vlass/HiPS/All_VLASS/Quicklook/
- Other radio telescopes and databases with VO
 - CASDA (ASKAP and ATCA)
 - ASTRON (LOFAR and APERTIF)



Name	Type	Unit	Indexed	Description
obs_publisher_did	char(255)		<input type="checkbox"/>	Dataset identifier
o_ugd	char(255)		<input type="checkbox"/>	UCD of observation
pol_states	char(255)		<input type="checkbox"/>	List of polarization states
s_dec	double		<input type="checkbox"/>	Central declination
s_fov	double		<input type="checkbox"/>	Diameter (beam size)
s_ra	double		<input type="checkbox"/>	Central right ascension
s_region	char(255)		<input type="checkbox"/>	Region covered
s_resolution	double		<input type="checkbox"/>	Spatial resolution
target_name	char(255)		<input type="checkbox"/>	Astronomical object name
t_exptime	double		<input type="checkbox"/>	Total exposure time
t_max	double		<input type="checkbox"/>	Stop time in MJD
t_min	double		<input type="checkbox"/>	Start time in MJD
t_resolution	double		<input type="checkbox"/>	Temporal resolution

SRDP as a science platform for NRAO

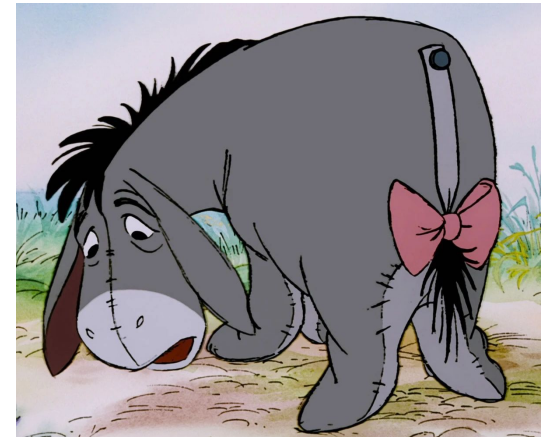


The pipelines

- Why use the pipeline?
 - Data processing algorithms very complex, easy to miss a step or set a parameter wrong. ALMA/VLA pipelines have been very well tested and are suitable for most common observations (**notable exceptions: VLA wide-band/mosaic imaging**).
 - Gain compression correction for VLA observations is currently only possible via the pipeline.
 - Automated self-calibration is now also available.
 - Results are reproducible (data provenance, “Open Science” initiatives).
 - Even if you don’t use the pipeline products for your final analysis, they are a good check on your processing, and can tell you (and/or us) quickly if there was a problem with the observation.



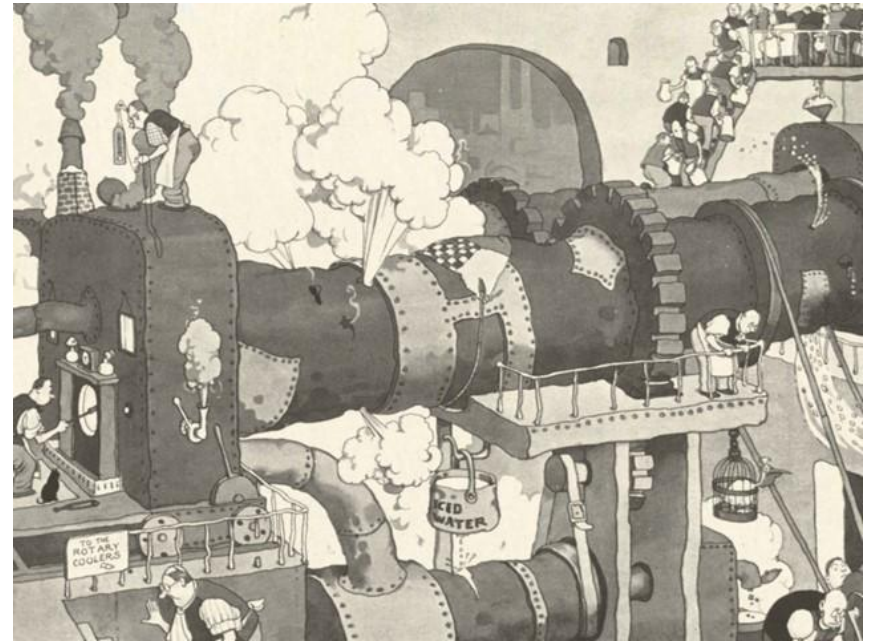
The pipeline takes the misery out of making radio images, what do you think?



Maybe I like the misery....

Pipeline structure

- The pipeline is structured like an recipe for data processing.
 - Similar steps to calibration tutorials
 - Delay (VLA), T_{sys} (ALMA), bandpass, flux calibration, gain calibration, etc.
- One of the pipeline products is a script that allows you to rerun the commands inside CASA.
- Another product is the weblog – a log of tasks with graphical output that allows you to assess how successful a pipeline run was, and exactly what it did.



Navigating your weblog

- Detailed information on the calibration of your EB (VLA) or MOUS (ALMA) can be found in the weblog that is produced by the pipeline.
- Go to the archive, observations tab and click on the “cals” icon to retrieve the tarred up calibration files and weblog.

Title: Is There a Delayed 5 cm Response to Accretion Variability? The Case of HOPS-373

Abstract: The protostar HOPS-373 was discovered by the JCMT transient survey to have undergone a 25% increase in 0.85mm continuum in 2021, corresponding to a ~4x increase in accretion luminosity (5.3 to ~21Lsun total luminosity) and is expected to result in a 2.7x increase in 5cm flux density. Thus far, VLA monitoring from 2021-2023 at 5cm has not shown a flux density increase, but the 1.3cm water masers are highly variable and potentially show propagation of the maser spots away from the protostar. We propose an additional observation of C-band continuum in each of A and D-configurations and water maser observations in A-configuration, as a bookend to our previous monitoring program. These data will enable us to determine if the free-free emission has responded to the change in luminosity (and by inference accretion rate), but on a timescale that is delayed relative to the thermal dust emission. Moreover, the water maser observations will help determine if the maser spots are tracing an outward propagating shockwave. Changes in C-band flux density and water maser positions may be linked to the outburst event and can demonstrate the link between increased outflow activity and increased accretion that has yet to be observationally confirmed.

PI: John Tobin

Legacy ID: AT672

Co-Authors: Doug Johnstone, Carlos Contreras Pena, Watson Varricatt, Sung-Yong Yoon, Ho-Gyu Lee, Gregory Herczeg, Jeong-Eun Lee, Ross Burns, Steve Mairs

Proposal: [Click to search](#)

Observations Images

Page 1

Show 25 of 2 Observations

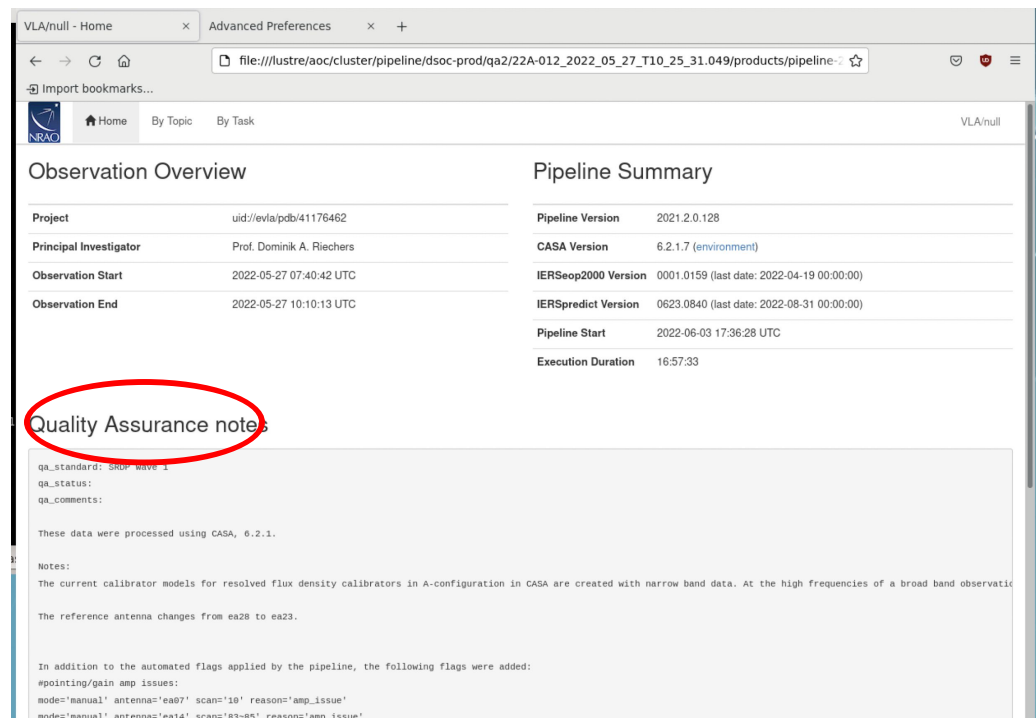
0 selected (0/10.0 TB)

View Selection(s) Select All Clear All Download

Archive File	Project	Instrument	Observation Start	Observation Stop	File Size	Array Config	Bands	Number of Antennas	Type	Cals	Scans
26A-268.sb49991704.eb50366892.61092.96357847222	26A-268	EVLA	2026-02-21 23:08:00	2026-02-22 01:49:33	121.038 GB	BnA->A	C	26	visibility	QA Notes	43
26A-268.sb49972628.eb50096941.61073.27670287037	26A-268	EVLA	2026-02-02 06:40:36	2026-02-02 07:50:25	41.445 GB	BnA	K	26	visibility	QA Notes	29

Navigating your weblog

- The VLA CASA Pipeline Guide (https://casaguides.nrao.edu/index.php/VLA_CASA_Pipeline) or the ALMA equivalent (<https://almascience.nrao.edu/processing/science-pipeline>) contains a detailed description of the weblog.
 - You may also need to change the security settings in your browser to view some of the pages as described in the Guide.
- First, look at the index page of the weblog, where QA notes from the DAs appear.
- Most VLA pipeline data are run through a combined calibration and imaging pipeline



The screenshot shows a web browser window displaying a VLA pipeline weblog page. The page is titled "VLA/null - Home" and "Advanced Preferences". The URL in the address bar is "file:///lustre/aoc/cluster/pipeline/dsoc-prod/qa2/22A-012_2022_05_27_T10_25_31.049/products/pipeline-". The page content is divided into two main sections: "Observation Overview" and "Pipeline Summary".

Observation Overview

Project	uid://evla/pdb/41176462
Principal Investigator	Prof. Dominik A. Riechers
Observation Start	2022-05-27 07:40:42 UTC
Observation End	2022-05-27 10:10:13 UTC

Pipeline Summary

Pipeline Version	2021.2.0.128
CASA Version	6.2.1.7 (environment)
IERSeop2000 Version	0001.0159 (last date: 2022-04-19 00:00:00)
IERSpredict Version	0623.0840 (last date: 2022-08-31 00:00:00)
Pipeline Start	2022-06-03 17:36:28 UTC
Execution Duration	16:57:33

Quality Assurance notes:

```
qa_standard: SRDP Wave 1
qa_status:
qa_comments:

These data were processed using CASA, 6.2.1.

Notes:
The current calibrator models for resolved flux density calibrators in A-configuration in CASA are created with narrow band data. At the high frequencies of a broad band observation the reference antenna changes from ea28 to ea23.

In addition to the automated flags applied by the pipeline, the following flags were added:
#pointing/gain amp issues:
mode='manual' antenna='ea07' scan='19' reason='amp_issue'
mode='manual' antenna='ea14' scan='83-85' reason='amp_issue'
```

Task	QA Score	Duration
1. hifv_importdata : Register VLA measurement sets with the pipeline MS dates not fully covered by IERSep2000. CASA will use IERSpredict.	0.90	0:12:28
2. hifv_hanning : VLA Hanning Smoothing	1.00	0:01:46
3. hifv_flagdata : VLA Deterministic flagging Clipping 1.33% in spectral line spw 13.	0.30	0:12:51
4. hifv_vlasetjy : Set calibrator model visibilities	1.00	0:27:01
5. hifv_priorcals : Priorcals (gaincurves, opacities, antenna positions corrections, rq gains, and switched power)	No QA N/A	0:14:21
6. hifv_syspower : Syspower (modified rq gains)	1.00	0:03:31
7. hifv_testBPDcals : Initial test calibrations	1.00	0:22:21
8. hifv_checkflag : Checkflag summary	1.00	0:24:05
9. hifv_semiFinalBPDcals : Semi-final delay and bandpass calibrations	1.00	0:27:36
10. hifv_checkflag : Checkflag summary	1.00	0:38:51
11. hifv_solint : Determine solint and Test gain calibrations	1.00	0:07:50
12. hifv_fluxboot : Gain table for flux density bootstrapping	0.98	0:42:14
13. hifv_finalcals : Final Calibration Tables	1.00	1:05:31
14. hifv_applycals : Apply calibrations from context	1.00	0:17:33
15. hifv_checkflag : Checkflag summary	1.00	1:21:03
16. hifv_statwt : Reweight visibilities	0.96	0:30:05
17. hifv_plotsummary : VLA Plot Summary	1.00	0:21:18
18. hif_makeimlist : Set-up parameters for phase calibrator & bandpass calibrator imaging	1.00	0:03:13
19. hif_makeimages : Make calibrator images	1.00	1:08:15
20. hifv_exportdata : Prepare pipeline data products for export	1.00	0:10:07
21. hifv_mstransform : Create science target MS	1.00	0:06:53
22. hifv_flagtargetsdata : VLA Flagtargetsdata	No QA N/A	0:01:54
23. hif_checkproductsizes : Check product size Size was mitigated	0.85	0:08:11

23. hif_checkproductsize : Check product size	Size was mitigated		0.85	0:08:11
24. hif_makeimlist : Set-up parameters for target per-spw continuum imaging			1.00	0:02:21
25. hif_findcont : Detect continuum frequency ranges			1.00	10:58:10
26. hif_uvcontsub : UV continuum fit and subtraction			1.00	0:08:48
27. hif_checkproductsize : Check product size			1.00	0:03:52
28. hif_makeimlist : Set-up parameters for target aggregate continuum imaging			1.00	0:03:29
29. hif_makeimages : Make target aggregate continuum images	snr = 14.78		0.10	1:07:24
30. hif_checkproductsize : Check product size	Size was mitigated		0.85	0:08:29
31. hif_makeimlist : Set-up parameters for target cube imaging			1.00	0:01:50
32. hif_makeimages : Make target cubes			1.00	20:50:02
33. hif_checkproductsize : Check product size			1.00	0:04:55
34. hif_selfcal : Selfcal			1.00	0:25:02
35. hif_makeimlist : Set-up parameters for target aggregate continuum imaging	No clean targets expected		N/A	0:00:32
36. hif_makeimages : Make target aggregate continuum images	Nothing to image		N/A	0:00:01
37. hif_checkproductsize : Check product size	Size was mitigated		0.85	0:08:51
38. hif_makeimlist : Set-up parameters for target cube imaging	No clean targets expected		N/A	0:00:16
39. hif_makeimages : Make target cubes	Nothing to image		N/A	0:00:01

CASA logs and scripts

- [View](#), [view in new tab](#) or [download casa-20260203-145540.log](#) (40.9 MiB)
- [View](#), [view in new tab](#) or [download casa_commands.log](#) (211.3 KiB)
- [View](#), [view in new tab](#) or [download casa_pipescript.py](#) (2.1 KiB)
- [View](#), [view in new tab](#) or [download casa_piperestorescript.py](#) (211 bytes)
- [View](#), [view in new tab](#) or [download PPR.xml](#) (11.8 KiB)
- [View](#), [view in new tab](#) or [download pipeline_aquareport.xml](#) (55.4 KiB)

Plot Summary (VLA only)

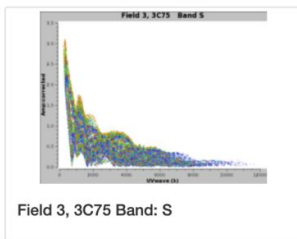
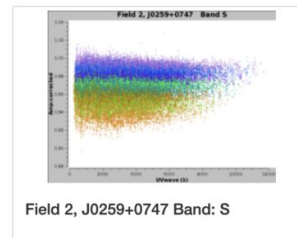
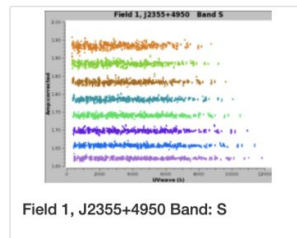
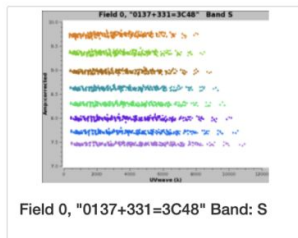
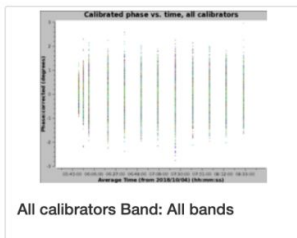
17. Plot Summary

BACK

VLA Pipeline Summary Plots

Phase vs. time for all calibrators, Amp vs. UVwave for all calibrators, as well as a representative selection of fields with intent='TARGET' with Amp vs. UVwave plots.

TDRW0001.sb35624494.eb35628826.58395.23719237269.ms



Similar plots for
ALMA may be found
in the
hifa_timegaincal
step.

ALMA weblog

- Similar to VLA weblog in overall structure, some detailed differences in how the steps are broken down, and some additional steps (e.g. Tsys calibration).
- Most ALMA datasets are run through a combined calibration and imaging.
- Note that both ALMA and VLA imaging pipelines have “image mitigation” – if the total image size calculated by the pipeline is too large, the image will be made smaller and/or the image downsampled.

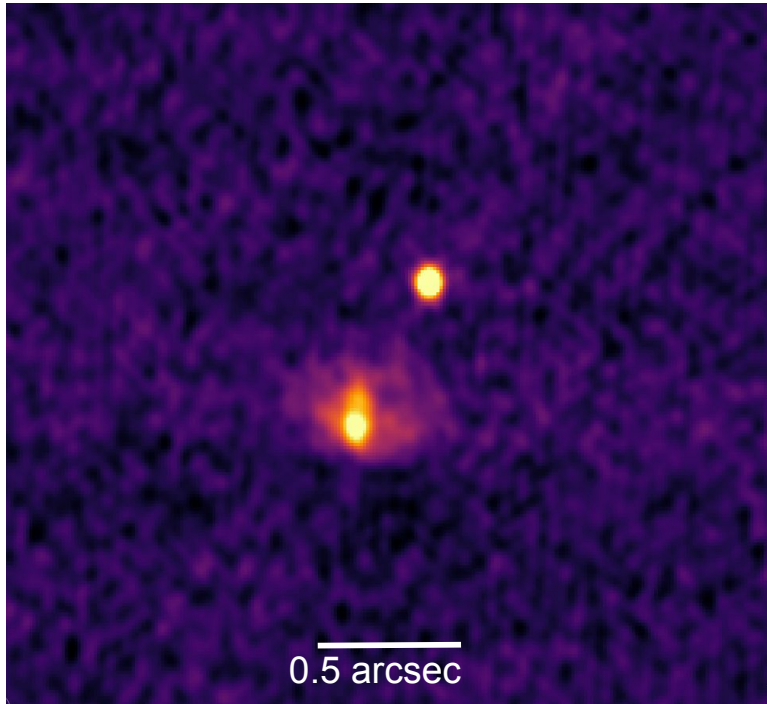


Science Ready Data Products (SRDP)

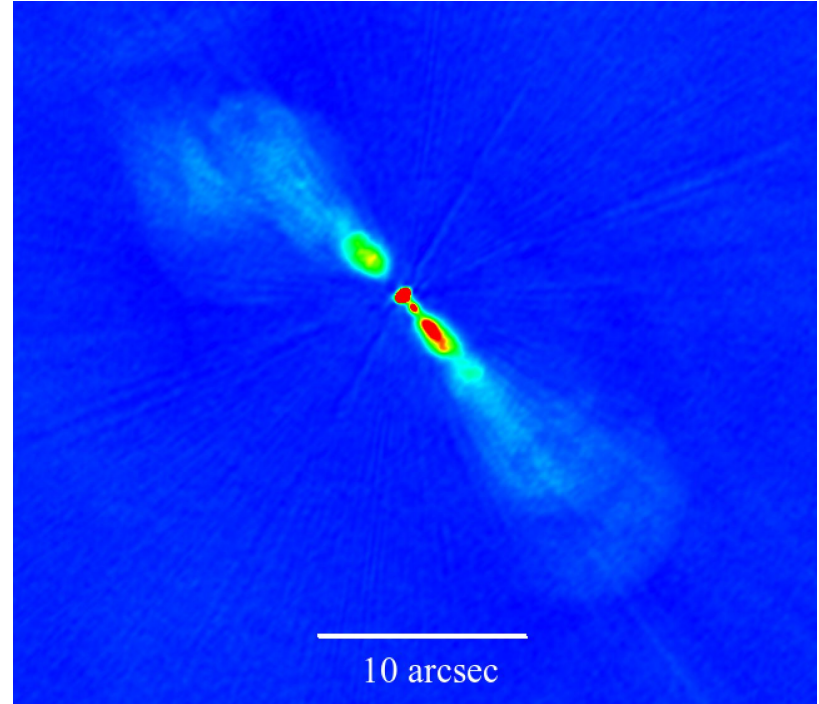
- ALMA standard pipeline and VLA pipelined data are classed as “science ready”.
- We define science ready products as being processed and quality assured to a uniform standard, with known provenance – “publishable as is”, but also a basis for more advanced processing.
 - For simple Stokes I continuum science cases, SRDP calibration will be good to go.
 - Polarization calibration not yet fully supported, see later.
 - The standard VLA imaging pipeline imaging uses a fixed $\text{robust}=0.5$ and happens only on a per-EB basis. Combining data from different EBs is left to the user.
 - Images should be useful as a reference, many users will want to reimage.
 - User-driven imaging, with options for tuning beamsize and combining EBs from either a single or multiple configurations is planned.
 - Imaging pipeline can take multiple calibrated EBs and image together

Example pipeline images

HOPS-400 (Ka-band, A-config)



Field FRI C-band, A-config



VLA Spectral line calibration and imaging

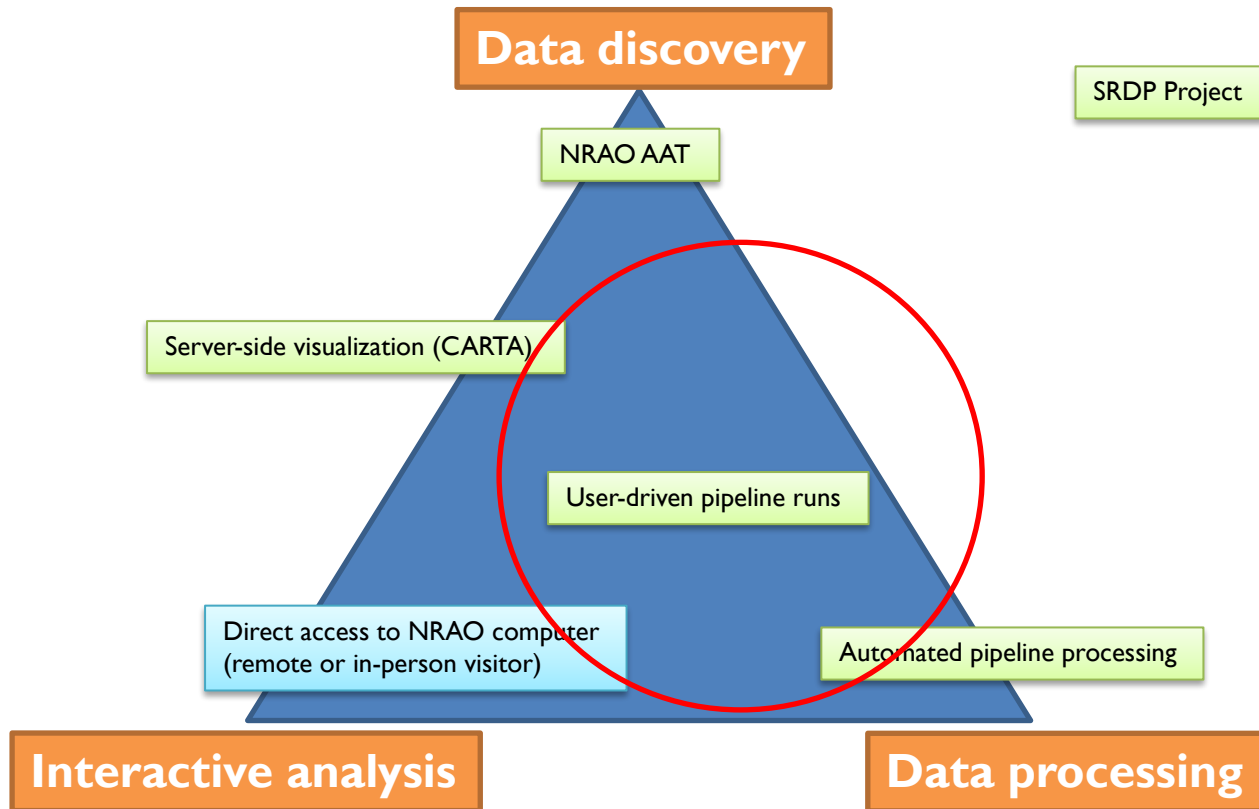
- The current VLA pipeline can do both continuum and spectral lines
 - VLA A and B configurations will have extensive product mitigation
 - Cannot feasibly make all cubes for all targets for the full primary beam
 - continuum subtraction and imaging of some fields/spws may be left to users

QA review and flagging

- Data are reviewed in detail by a data analyst (DA).
- Extra flags are applied for bad data missed by the pipeline (if necessary).
 - Typically minor issues related to RFI missed by the pipeline, poor pointing (at high frequencies), weather, data transfer problems, low-level (<20%) gain compression on a few antennas.
- Data are rerun with the extra flagging.
- Flagging is iterated if necessary and data rerun
- Results are inspected by a scientist or senior DA before being archived.

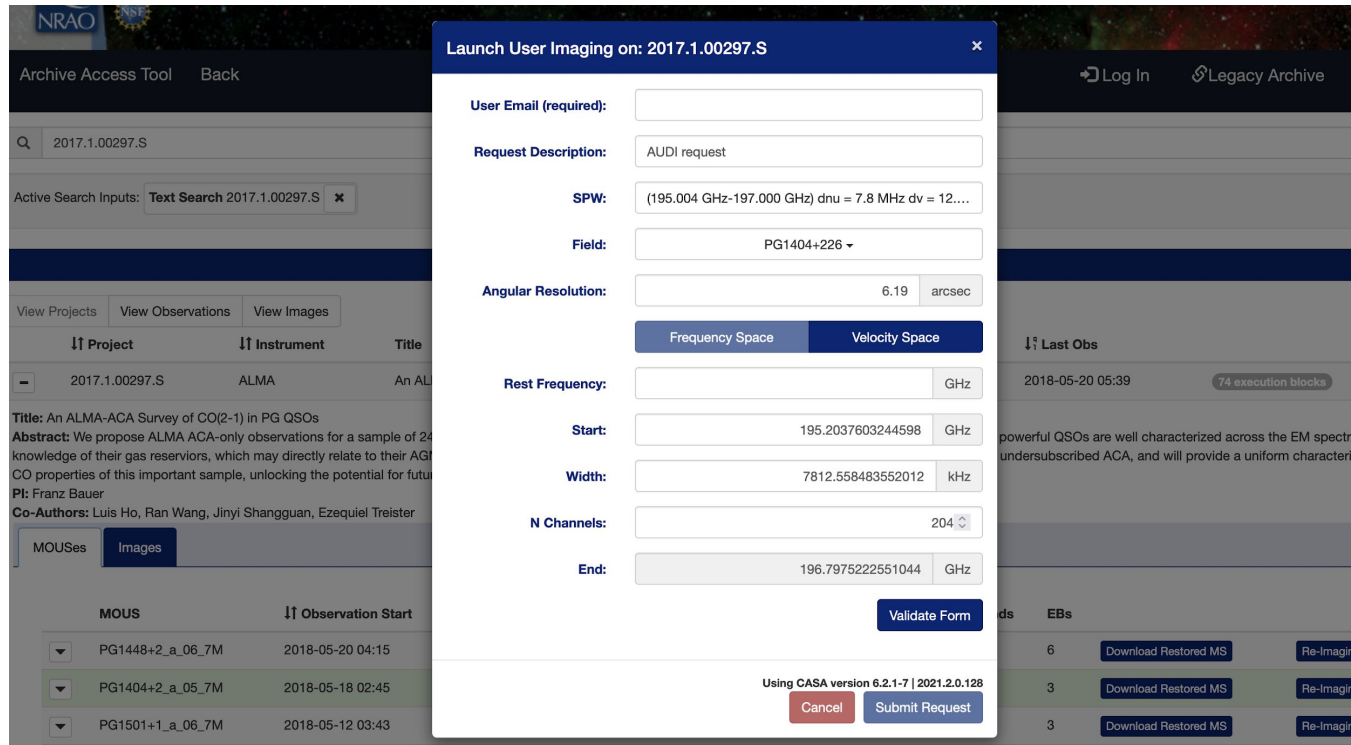


SRDP as a science platform for NRAO



ALMA User-Driven Imaging (AUDI)

- In some cases, a user may wish to recalibrate or reimage data. Reimaging is likely to be the most common use case.
- So far only working for ALMA (AUDI)



The screenshot displays the NRAO Archive Access Tool interface. A search for project 2017.1.00297.S is active. The main content area shows project details for 2017.1.00297.S, including the instrument ALMA and a table of MOUS (Measurement Units) with observation start times.

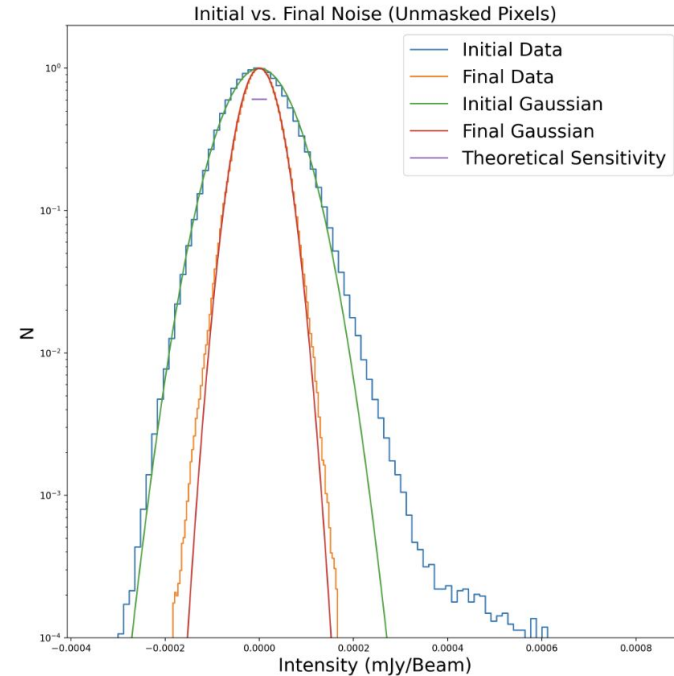
Overlaid on the interface is a modal window titled "Launch User Imaging on: 2017.1.00297.S". The form contains the following fields:

- User Email (required):** [Empty text input]
- Request Description:** [AUDI request]
- SPW:** [195.004 GHz-197.000 GHz] dnu = 7.8 MHz dv = 12....
- Field:** [PG1404+226]
- Angular Resolution:** [6.19] arcsec
- Rest Frequency:** [Empty] GHz
- Start:** [195.2037603244598] GHz
- Width:** [7812.558483552012] kHz
- N Channels:** [204]
- End:** [196.7975222551044] GHz

Buttons include "Validate Form", "Cancel", and "Submit Request". The modal also indicates "Using CASA version 6.2.1-7 | 2021.2.0.128".

Imaging: Self-calibration

- Self-calibration takes advantage of the fact that the complex gain solutions from any given antenna are over-determined (because many baselines are sampled by an interferometer for a given antenna.).
- The imaging pipelines self-calibrate in phase only, iteratively choosing a solution interval to obtain the highest dynamic range image.



Tobin & Sheehan in prep

User-driven VLA recalibration and imaging

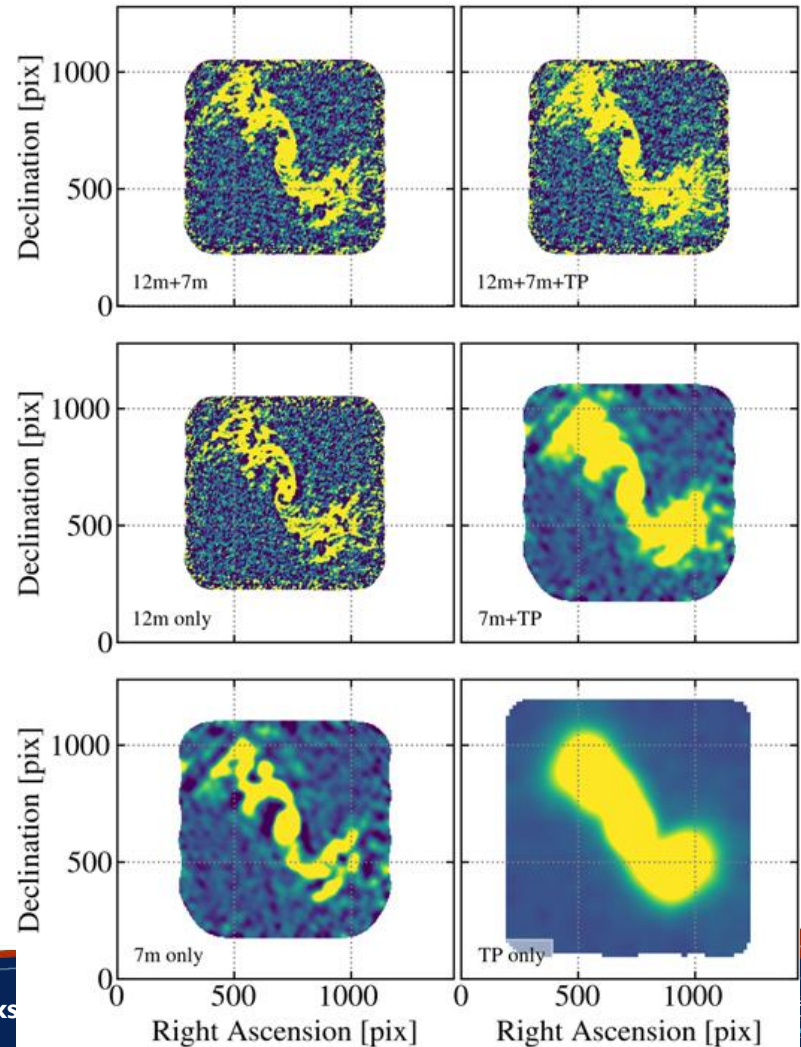
- A small number of pipeline parameters will be made available to tweak calibrations and images.
- For calibrations, spectral line avoidance (cont.dat) and RFI flagging, and optional calibration steps (TEC map and compression fix application) would be examples of things that could be changed.
- For imaging, the robust parameter/target resolution, frequency/velocity range and continuum ranges for spectra, and whether or not to attempt self-calibration.



Imaging from combined EBs

- Future work will run pipelines to combined ALMA configurations and configurations, and allow users to combine data from VLA configurations.
- Combined imaging (array not TP) is planned for ALMA WSU
- VLA combined imaging is a planned feature for VLA User-Defined Imaging

Leroy+21

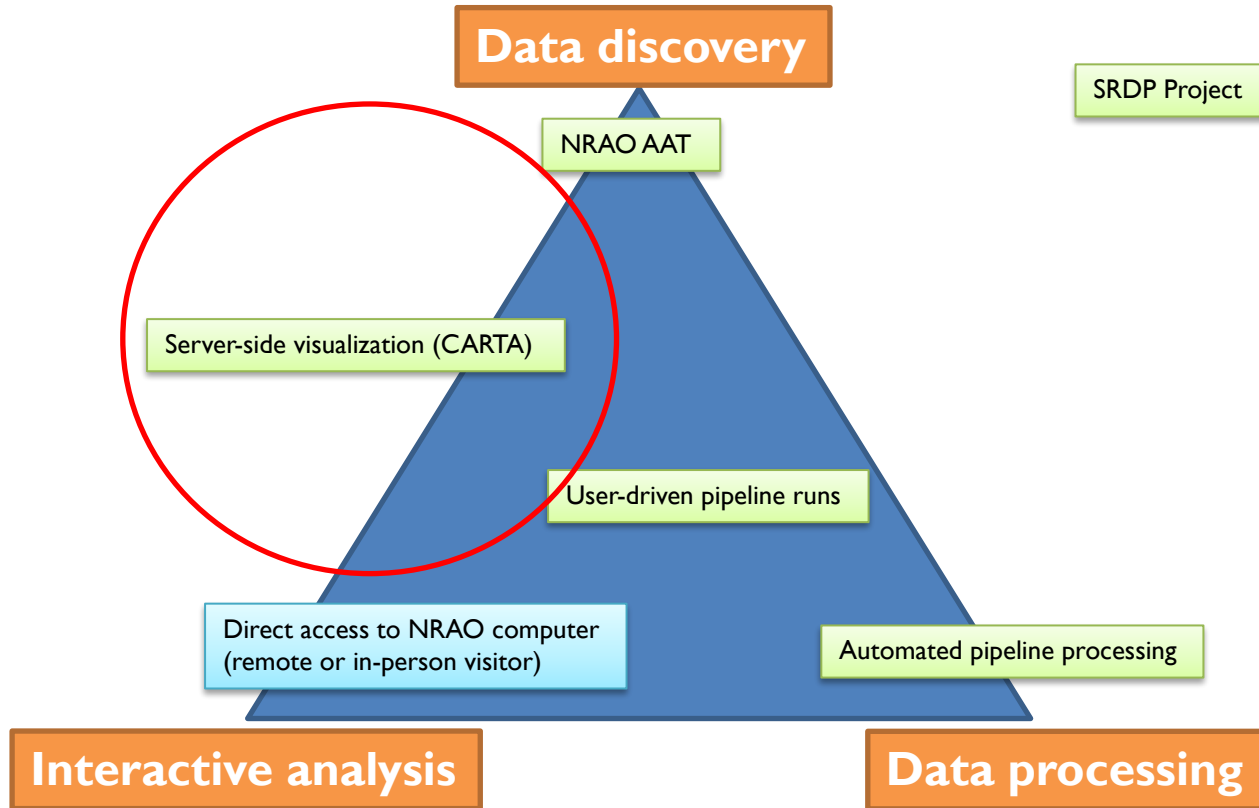


TTA tools

- A new suite of proposal, observing-block generation and scheduling tools is being developed.
 - New proposal system coming soon!
 - Aug. 2027 for NRAO DDT submission
 - Jan 2028 for 2028B proposal call
- This could allow us to improve our SRDPs, for example:
 - Associate EBs that should be combined for imaging
 - Specify frequencies where strong spectral lines are likely to feed into the spectral line pipeline.
 - Specify the polarization calibration method (Df, Df+QU) so we can include polarization in SRDP.



SRDP as a science platform for NRAO



CARTA visualization



 **National Radio Astronomy Observatory**
Enabling forefront research into the Universe at radio wavelengths

version: 4.2.3

Archive Access Tool Back

Log In About

Q VLASS2.2


Active Search Inputs: **Text Search VLASS2.2** ✕






▼ Show Search Inputs ▼







View Projects View Observations View Images

« < Page 1 > »

Show **25** of 17802 Images

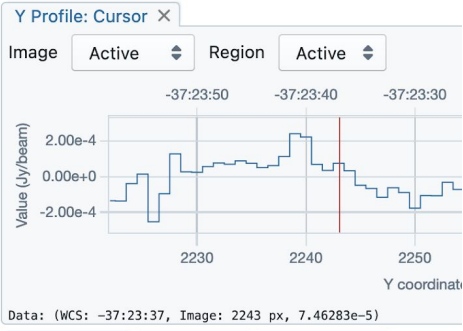
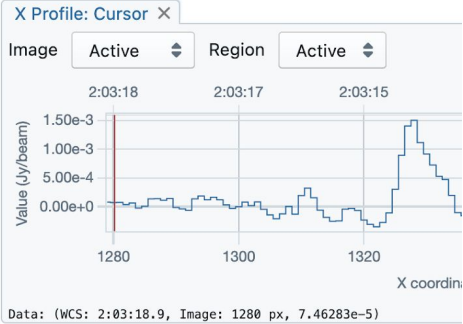
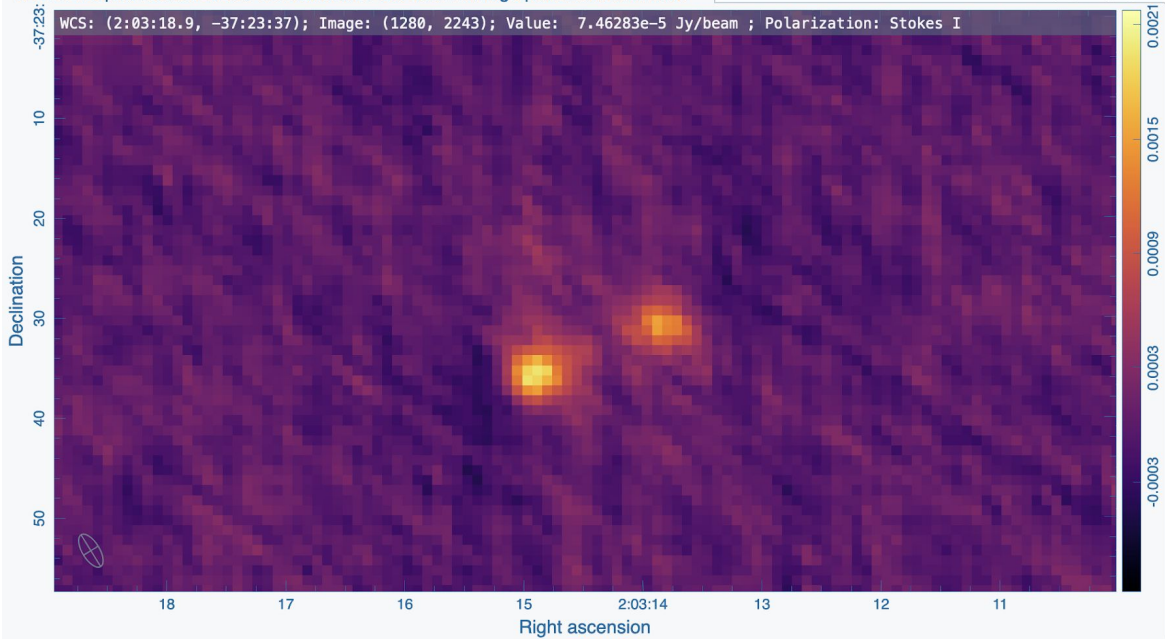
 **0 selected (0/10.0 TB)**

 View Selection(s)  Select All  Clear All  Download  View In Carta

	↕ Project	↕ Longitude	↕ Latitude	↕ Band	Sp Resolution	Beam Axis Ratio	↕ File Name
 	VLASS2.2	2h2m28.308s	-36°30'0.771"	S	2.573	2.776	VLASS2.2.q1.T01t05.J020228-363000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS2.2	2h2m30.243s	-37°30'0.773"	S	2.535	2.166	VLASS2.2.q1.T01t05.J020230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits
 	VLASS2.2	2h2m32.277s	-38°30'0.794"	S	2.641	1.825	VLASS2.2.q1.T01t05.J020232-383000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits

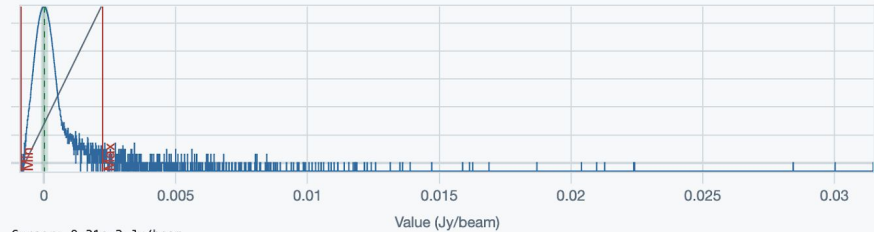


VLASS2.2.q1.T01t05.J020230-373000.10.2048.v1.l.iter1.image.pbcor.tt0.subim.fits



Render Configuration X

- 90%
- 95%
- 99%
- 99.5%
- 99.9%
- 99.95%
- 99.99%
- 100%
- Custom



Clip Min: -0.0008762884

Clip Max: 0.002177886951

Scaling: Linear

Color map: [Color bar]

Invert color map:

Bias / Contrast: [Dropdown]

Image List X Animator X Region List X

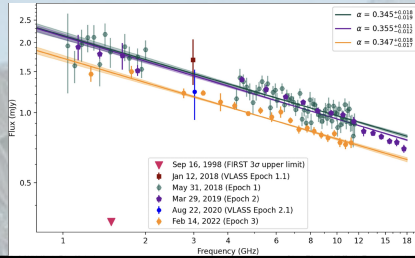
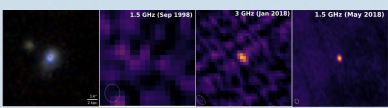
Image	Layers	Matching
0 VLASS2.2.q1.T01t0	R	XY R

Other science platforms

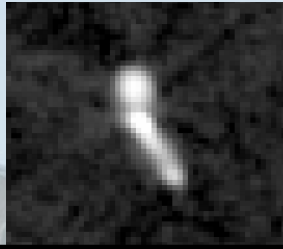
- CANFAR (Canadian Advanced Network for Astronomical Research)
 - Allows upload of software containers so you can run anything you like.
- NOIRLab (<https://datalab.noirlab.edu>)
 - Based on Jupyter notebooks, mostly for large catalog manipulation.
- Science platforms under development by ESA and NASA.

The screenshot shows the Astro Data Lab website. At the top, the title "Astro Data Lab" is centered. To the right, there are links for "Login" and "Sign up", and a "Service Status" section with five green checkmarks. Below the title is a navigation menu with links for "About", "Quick Start", "Tools", "Survey Data", "Docs/Help", and "News/Events". A central banner features the "ASTRO DATA LAB" logo and a blue arrow pointing to the "About" link. Below the navigation is a pink banner with the text: "DESI Early Data Release now [available at Data Lab](#)." Below that is a red banner with the text: "The Legacy Surveys DR3 through DR7 catalogs are now deprecated, and will be removed from Data Lab on or after Sept 1, 2023. Please use DR8 through DR10, which supersede the older versions." The main content area displays a large, colorful astronomical map of the sky, showing a distribution of objects with a color scale from blue to red. The map is overlaid with a grid of latitude and longitude lines. Below the map, the text reads: "All-sky NOIRLab Source Catalog DR2 (3.9 billion objects, 68 billion measurements)". At the bottom, there is a row of buttons: "About", "Launch a Jupyter notebook", "Table Browser", "Query Interface", "Image Cutout", and "X-match Service".

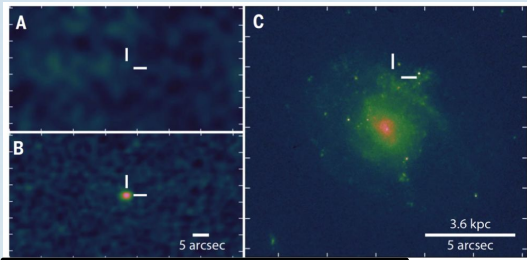
- What is VLASS?
 - All the sky north of dec -40 deg, imaged in three (3.5) epochs ~32 months apart. “On-the-fly” raster mode observing.
 - S-band (2-4 GHz); 2.5” resolution; RMS~120-170 μ Jy (RFI dependent).
 - IQU polarization (will also store some Stokes V information).
 - Radio astronomy community heavily involved in the survey from the design stage onwards.
 - All products are public following QA and archiving.
 - All epochs now complete! A half fourth epoch was conducted to replace difficult to process data from the first half epoch.



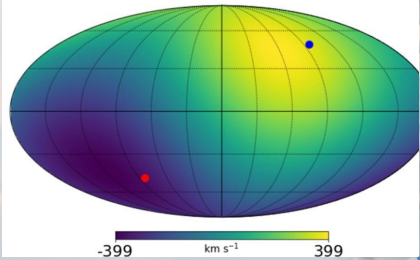
Emergent pulsar wind nebula, Dong+23



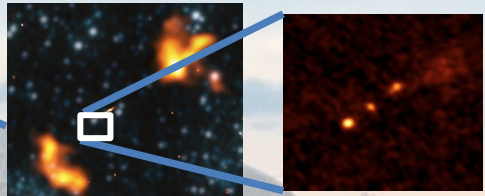
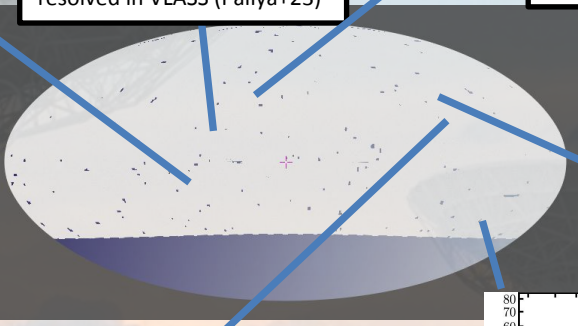
TXS 1433+205, the most distant gamma-ray AGN, resolved in VLASS (Paliya+23)



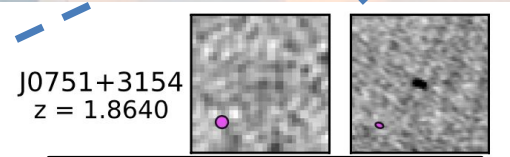
VT1210+4956: merger-driven supernova; Dong+21



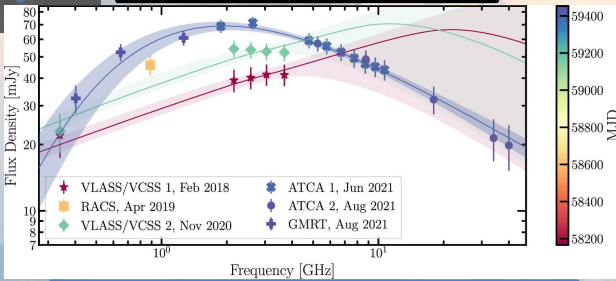
The cosmic dipole signal from VLASS matches the Planck signal (Darling+22)



Inner jet of a 5-Mpc giant (Oei+22)

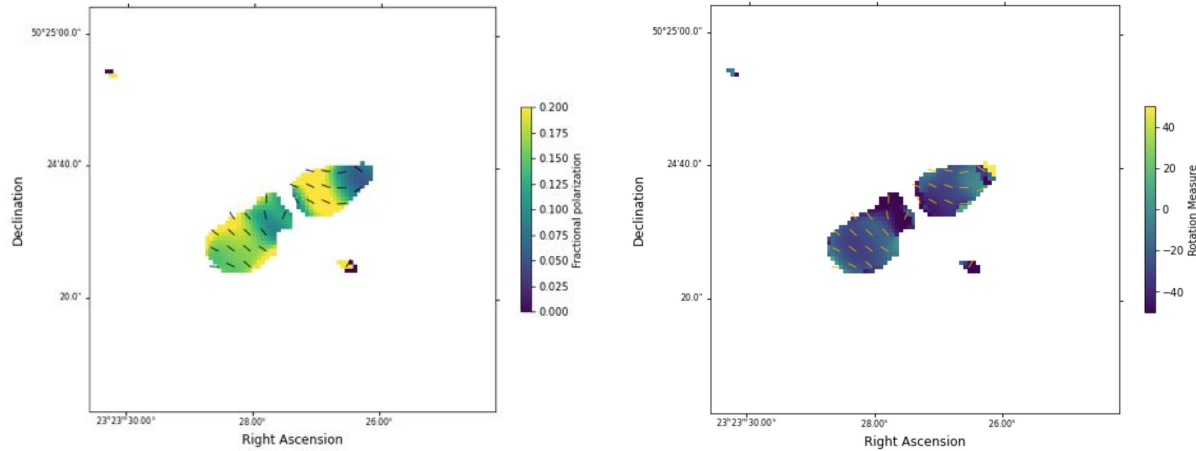


J0751+3154 $z = 1.8640$
Quasars changing from radio-quiet to radio-loud; Nyland+20



VT0243-2840 radio TDE candidate (Somalwar+22)

VLASS data products



- “Quick Look” images are available for all epochs.
- More refined “Single Epoch” images (including self-calibration, spectral index and polarization information) are available for parts of 2nd and 3rd epochs (areas of sky observed at low zenith angles and can be imaged with mosaic gridded).
- At the end of the survey, a combined image will be made from all three epochs of data.

VCLASS data products access

- VCLASS raw data, calibrations and weblogs are available in the archive (data.nrao.edu) (images are available too, but not the final position corrected versions for Epoch I).
- The latest VCLASS images are available from archive-new.nrao.edu/vlass, and from CADC (<https://www.cadc-ccda.hia-ihp.nrc-cnrc.gc.ca/en/vlass/>). CADC services include Virtual Observatory SIA and TAP, and data can be accessed via astroquery or pyvo.
- Our Canadian colleagues have also made a handy cutout server at <http://cutouts.cirada.ca/>
 - Makes cutouts of VCLASS images, also NVSS/FIRST/GLEAM/RACS radio surveys, WISE infrared and SDSS/PanSTARSS optical.

Version 2.0 Cutout Server

Enter Cutout Query Input Below

Source Name:

Coordinates:

Batch .csv File: No file selected.

Surveys:

- VLASS-QL
 - Epoch 1.1 Epoch 1.2 Epoch 2.1 Epoch 2.2
- GLEAM
- FIRST
- NVSS
- WISE
- PanSTARRS
 - g r i z y
- SDSS-I/II

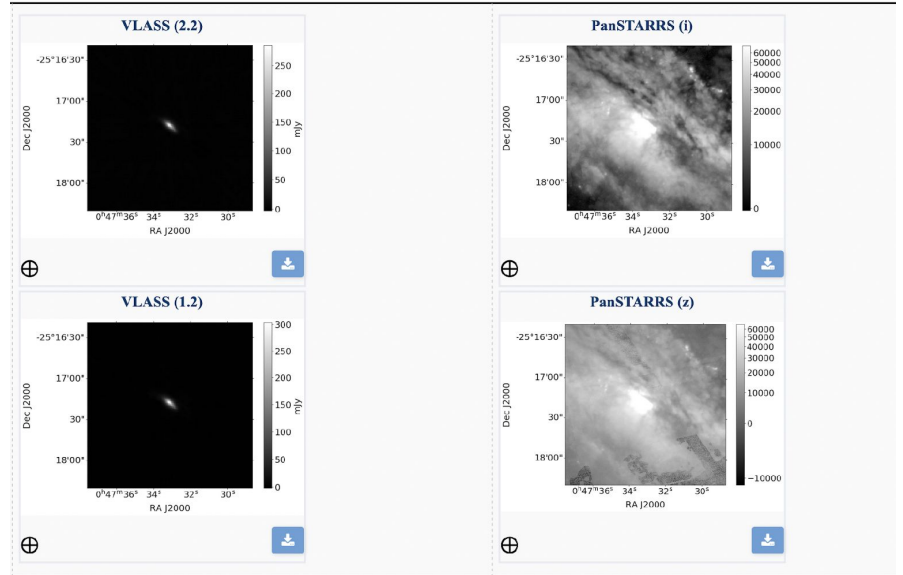
Radius: Arcminutes

Image Size / 2:

Group By:

VLASS

PanSTARRS



Download Batch 0 Selected

Rubin Alert Observations

- The VLA will be observing some Rubin Alerts in service mode
 - 10 minute X-band observation (20 minute EBs)
 - flux calibrated using VLA switched power system
 - rapidly processed with abbreviated VLA pipeline recipe
 - abbreviated for speed, no selfcal
- Archived and products available to community as quickly as possible
- Details are still being worked out, but expect something within the next few months.

Large-scale processing of radio data

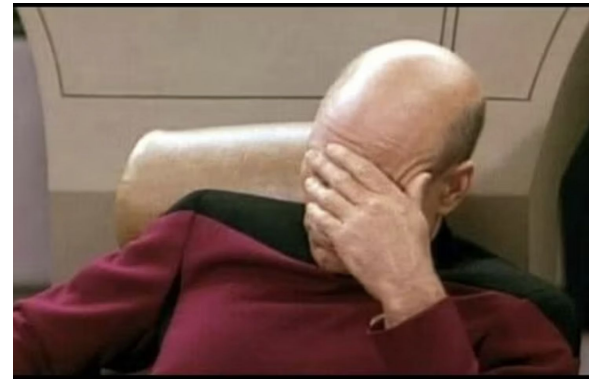
- Unique challenges:
 - Large memory requirement per processing core compared to most other jobs run on high performance computers.
 - Large disk space needed and i/o heavy (needs either a centralized fast disk system like Lustre, or have a large amount (several TB) of fast read/write storage on each node).
 - Job profiling difficult
- Solutions:
 - High Throughput Computing – focus on maximizing the throughput as a whole rather than the speed of an individual job.
 - GPUs for some especially intensive steps (e.g. gridding)
 - Try splitting jobs into smaller chunks.



The far future

- How will we deal with the needs of ngVLA, SKA, and ALMA WSU with ~ 10 - $1000\times$ the current data volume?
- One key will be to distribute and parallelize the processing.
 - Needs new algorithms to split large datasets into manageable chunks and send $\sim 10^3$ - 10^6 concurrent jobs to compute clusters.
 - VLASS has already demonstrated the ability to run >1000 jobs at once.
- On the users' side, interoperability of archives and processing centers/science platforms will be essential – can't store all the data in one place.
 - Virtual Observatory (VO) protocols will play a key role in this.
- But also need to maintain the knowledge of how to process radio data when astronomers mostly get the output of pipelines.

RADPS...



Summary

- We are already at the point where users are having trouble dealing with the volume of data from the VLA and ALMA, and the complicated algorithms needed to correctly process it.
 - With ngVLA and ALMA WSU on the horizon, it will just get worse.
- SRDP delivers standard pipelined VLA data products that users can either use “off the shelf” or as a basis for more refined processing.
- Still much to be done (user-driven processing options, combined EB & combined array imaging, full resolution/FOV cubes, fixes for flux calibrator variability etc).
- What you can get now:
 - Standard pipeline calibrations (all data), images (all ALMA, most VLA continuum)
 - Calibrated MS for ALMA or VLA
 - Rerun imaging pipeline for ALMA (with self-cal)
 - Visualization in CARTA for recent VLA continuum/spectral line and VLASS, ALMA images
 - ALMA (via ALMA archive)
- Coming soon (next 1-2 yr): Reimaging for VLA, Rubin Alert Data



www.nrao.edu
science.nrao.edu

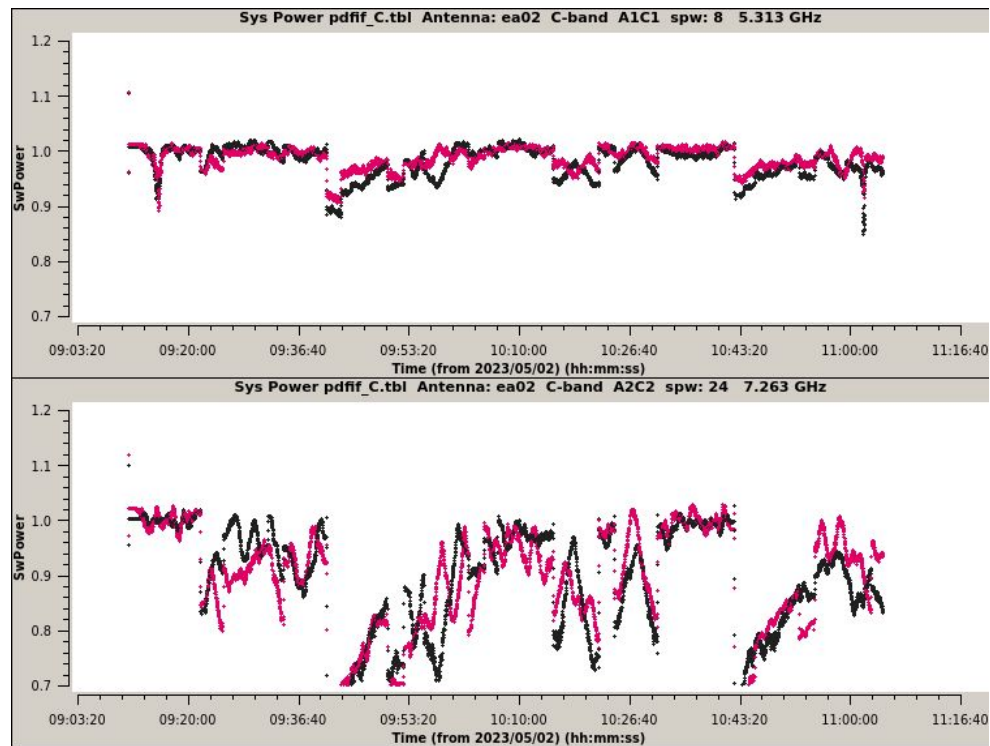
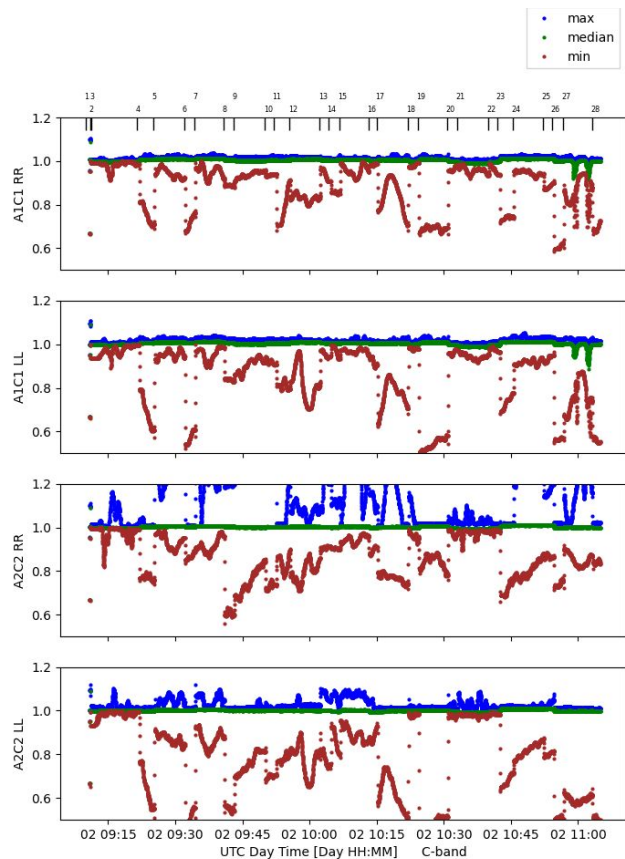
*The National Radio Astronomy Observatory is a facility of the National Science Foundation
operated under cooperative agreement by Associated Universities, Inc.*

Gain compression (VLA only)

- Happens when severe RFI is detected to the extent that it changes the apparent brightness of the sky as seen by the telescope and thus changes the system gains.
 - Effect is per baseband, so most of baseband can be unaffected by RFI, but still get affected by gain compression.
 - Recognize by seeing calibration amplitude variations that affect an entire baseband.
 - Can also be seen in the switched power plots (hifv_priorcals)
 - Mostly affects L- and S-bands, but now being seen at higher frequencies (especially C-band)
- Fix is to use the switched power data to correct for the change in amplifier gains.
 - Correction is best for 8-bit (so if you want high flux density accuracy best to use 8-bit), but works reasonably well for 3-bit data too.

Gain compression (Stage 6 (syspower))

ea02



Lessons learned from SRDP

- Closely examining the data coming off the VLA has many benefits
 - Improved feedback to engineering/technical teams on issues with the telescope.
 - Detection of a flare in one of the “big four” calibrators, 3C138 in December 2020.
 - Identification of some issues with the calibrator models in CASA.
- In addition, the combination of VLASS and SRDP has pushed software development:
 - Fix for gain compression using the switched power data.
 - Improved workflows for calibration and imaging, ability to run these workflows on external clusters if necessary.
 - GPU-based gridder for fast processing of wide-field images.