



THE ALMA SCIENCE ARCHIVE



EUROPEAN ARC
ALMA Regional Centre || Italian

M. MASSARDI & K. RYGL

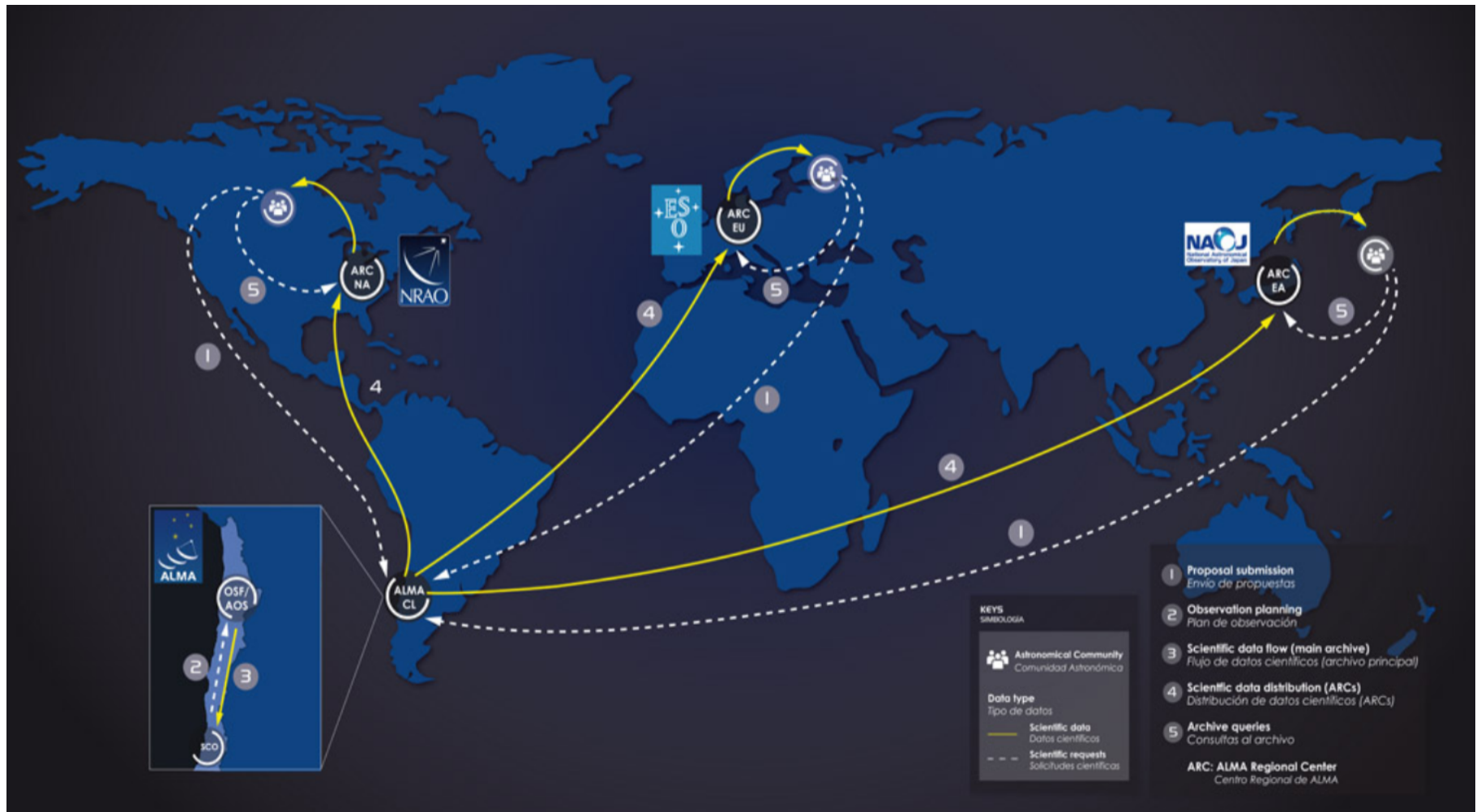


Reasons to use archived data

- Check if data are already available for a target
- Check the feasibility of a project looking for similar targets
- Retrieving information on similar objects (e.g. statistics of populations, ...)
- Retrieving information on a single object but with different configuration (e.g. multifrequency studies) or in different epochs (e.g. variability studies)
- Extracting unpublished information from existing data (e.g. finding additional spectral lines, targets in the same region/time of other observations,)
- **For ALMA in particular avoid the stress of competition and oversubscription**

	Proposal submission	Archive mining
Time to get data	✗	+
Amount of data	✗	+
Data homogeneity	+	✗
Adherence to idea	+	✗

The ALMA archive mirrors



Data is collected, reduced and archived.

Each ARC hosts an archive mirror.

What is in the archive?

For each project the main deliverables are

Raw Data, Calibration Scripts and tables, Images and Quality summary

Users need to run CASA to generate the Calibrated Data.

The resulting calibrated data is considered science-ready.

Some Imaging Products are delivered too, as result of QA processing

(in Early Science provided on a best effort basis, not necessarily science-ready)

a) for Line Observations:

- continuum-subtracted (where needed) image cubes at the requested resolution
- a continuum image for all line-free channels (where possible)

b) for Continuum Observations:

- continuum image combining all SPWs

The main purpose is to measure the rms and verify the achievement of PI requests.

Images in the archive are provided as starting point on the way to obtain the final images and a valuable basis for archive researchers (i.e. they are not considered science-ready!!!)

Data Quality Assessment

The goal of ALMA Quality Assurance (QA) is to deliver to the PI a reliable final data product that has reached the desired control parameters outlined in the science goals, that is calibrated to the desired accuracy and free of calibration or imaging artifacts i.e. ALMA performs **science-goal-oriented service data analysis**

ALMA QA happens on 4 levels:

QA0: near-real time verification of weather and hardware issues carried out on each execution block immediately after the observation.

QA1: verification of longer-term observatory health issues like absolute pointing and flux calibration.

QA2: offline calibration and imaging (using CASA) of a completely observed MOUS. Performed by expert analysts distributed at the JAO and the ARCs with the help of a semi-automatic CASA pipeline. **Results are archived and given to the PI. Only “QA2-passed” or “QA2-semipassed” data sets are archived.**

QA3: (optional) PIs may request rereduction, problem fixes, possibly reobservation

The ALMA Reduction procedures

Manual Calibration

- Always available
- Applied on old cycles and non standard mode observations (at the time of QA2)
- To be restored **requires specific versions of CASA (see the README file!)**
- An **editable script is made available**
- Generates calibrated data and a png-txt Summary

Manual Imaging

- Always available
- Applied on old cycles and non standard mode observations (at the time of QA2)
- An **editable script is made available** as hint
- Typically **only fraction of data are imaged** as it is time consuming for analysts

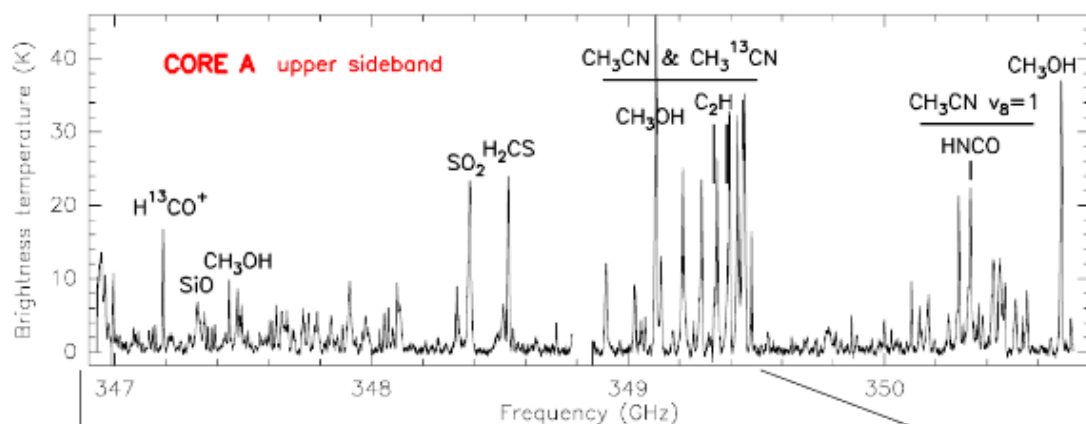
Calibration Pipeline

- Available since Cycle 3
- Applied on standard mode observations (“standard” at the time of QA2)
- To be restored **requires specific versions of CASA (with pipeline!)**
- Can be edited by expert people (usually manual processing is faster!)
- Generates calibrated data and weblog Summary

Imaging Pipeline

- Available since mid Cycle 4 (now more than 75% of the QA2)
- Applied on pipeline calibrated data
- To run requires specific versions of CASA (with pipeline!)
- Can be edited by expert people (manual imaging is faster!)
- Generates full cubes at the native resolution
- **No additional script is made available** as hint for manual reimaging

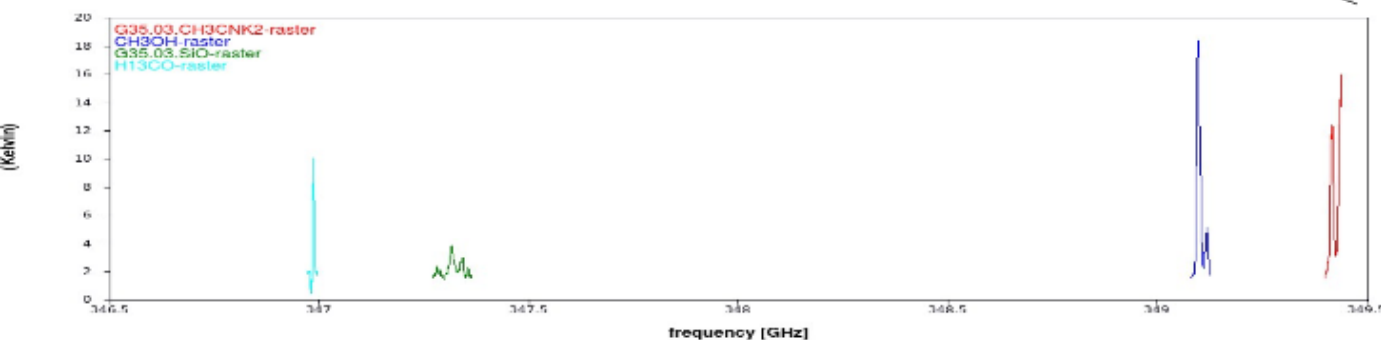
What is in the archive?



Images in the archive might cover only a fraction of the spectrum available

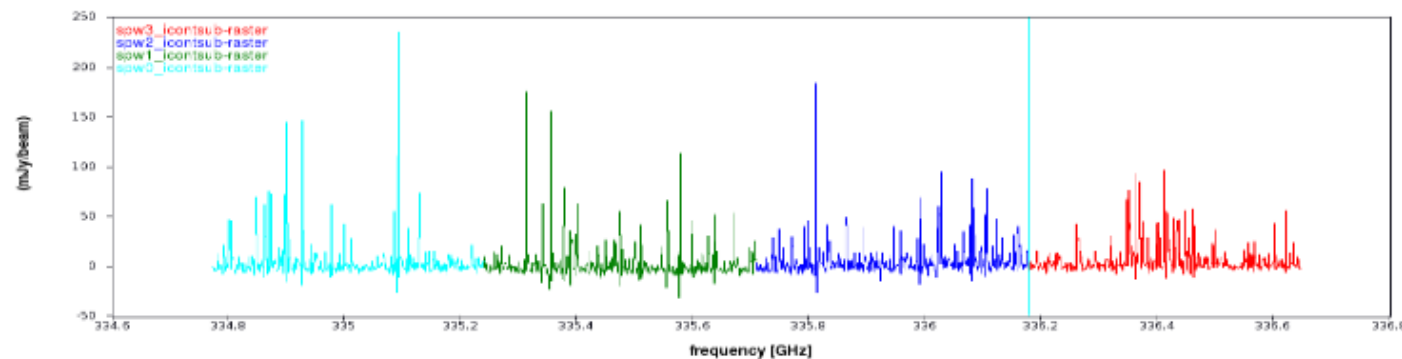
Spectrum observed (and available in the raw data)

Elliptical Region Profile



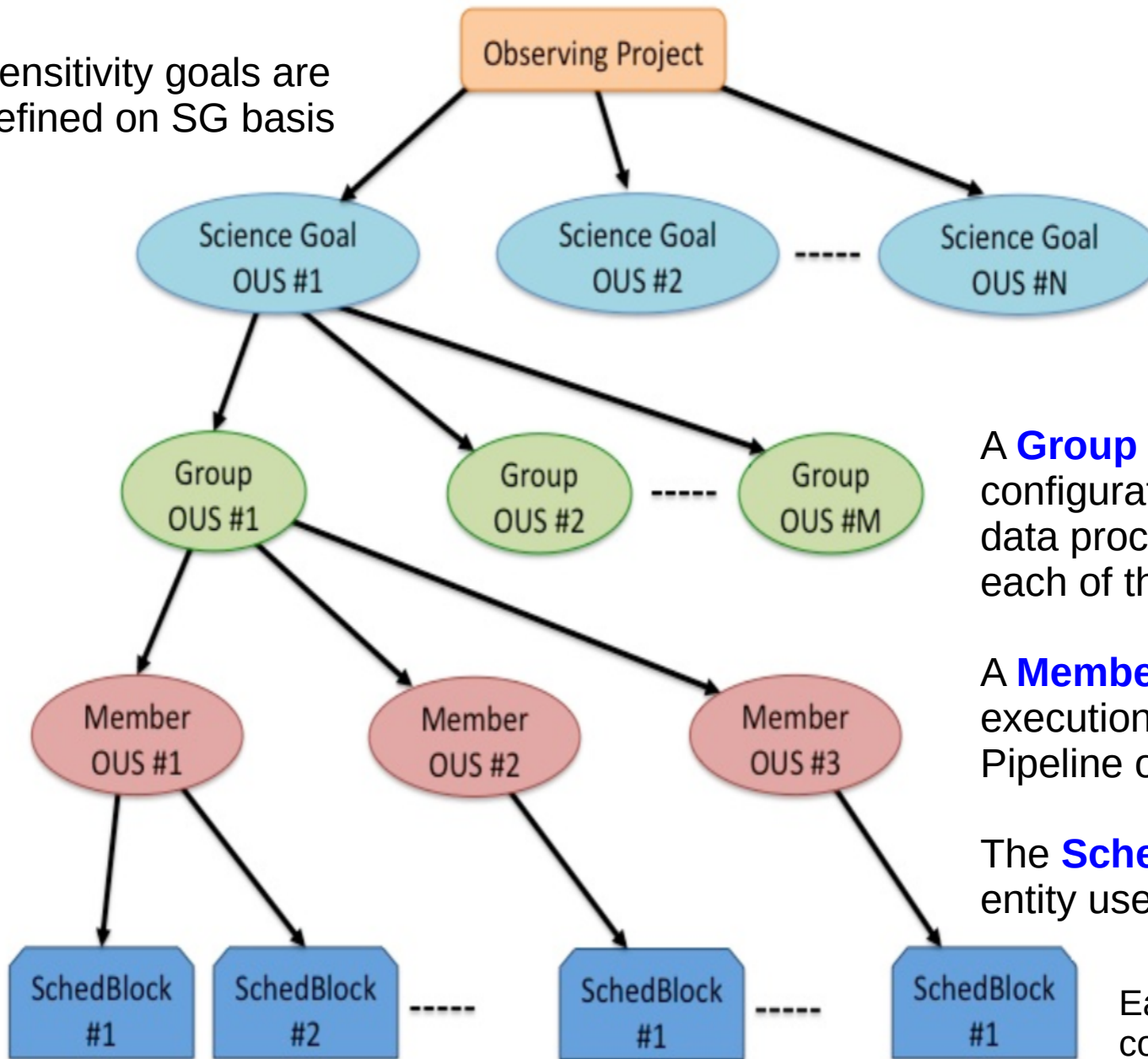
Imaged data for QA2

Elliptical Region Profile



Different data and PI requests on different sources generate different products
In the archived images but raw data contain the full spectral windows

Data structure



Sensitivity goals are defined on SG basis

Science goal:
Group of sources in the same sky region that share the same spectral setup

OUS= Observing Unit Set
Smallest unit for data processing

A **Group** can contain several configurations to be combined in data processing (e.g. several arrays), each of them is a Member.

A **Member** can contain multiple executions of a Scheduling Block. Pipeline operates at this level.

The **Scheduling Block** is the smallest entity used for observing

Each repetition of a Scheduling Block constitutes an **Execution Block**

The ALMA Science Archive

<https://almascience.eso.org/alma-data/archive>

The screenshot shows the ALMA Science Portal at ESO website. The browser address bar displays the URL <https://almascience.eso.org/alma-data/archive>. The page header features the ALMA logo and the text "Atacama Large Millimeter/submillimeter Array In search of our Cosmic Origins". A navigation menu includes "About", "Science", "Proposing", "Observing", "Data", "Processing", "Tools", "Documentation", and "Help". A search bar labeled "Search Site" is present. The main content area is titled "Archive" and contains three links: "Archive Query", "ALMA Science Archive Manual", and "ALMA QA2 Data Products". A yellow arrow points to the "Archive Query" button. Below the navigation is a table with three columns: "What's new", "Did you know ...", and "Known issues".

What's new	Did you know ...	Known issues
<ul style="list-style-type: none">2019 February<ul style="list-style-type: none">Improved footprint calculation for some mosaic footprintsSensitivity calculation improved if 12m antennas area added to 7m arrayImproved frequency display (LSRK)ObsUnitSet README file now better visibleDownload script now offers to unpack the tar files2019 January<ul style="list-style-type: none">SV data can be searched and downloaded through the Archive interface2018 October<ul style="list-style-type: none">The display of the file number and size on the Request Handler was correctedBand 5 observations are now classified correctly as Band 5 even if they are at the very edge of the band	<ul style="list-style-type: none">that you can search for public but not yet published data? Put '0' into the 'Publication count' field and select the 'public data only' checkbox like so.that queries and downloads can be done also from a script with astroquery?Cycle 5+ files can now be downloaded individually?that as a PIs you can give other registered ALMA users access to your proprietary data by logging into the Science Portal and then in the Profile section selecting the 'Project delegation' tab?that in addition to the ALMA Science Archive Manual we provide answers to Frequently Asked Questions?that authors who make use of ALMA data in their publications must place the ALMA acknowledgement statement into their publications?	<ul style="list-style-type: none">the headings for two columns of the frequency_support tooltip are missing (line sensitivities at 10kms and at native resolution)some column headings do not show the column's unitsthe links to the list of the publications related to an observation do not work if a source-name query was performed. Users need to query for the project code instead.The right-click and "Save as ..." from web-browser to download ASDMs does not work. Please use the download script for all downloads. <p>Report a new issue.</p>

At the bottom of the page, there is a footer with links for "Site Map", "Accessibility", "Contact", and "Privacy Statement". The right side of the footer shows "ESO", "NRAO", and "NAOJ". The Windows taskbar at the bottom indicates the time is 16:38 on 15/02/2019.

The ALMA archive: query

The screenshot shows the ALMA Science Archive query interface. At the top, there is a browser window with the URL `almascience.eso.org//aq/`. Below the browser, there is a search bar with a search button and a reset button. The main interface is divided into several sections:

- Position**: Source name (Resolver), Source name (ALMA), RA Dec, Galactic, Target list, Angular resolution, Largest angular scale, Field of view.
- Energy**: Frequency, Bandwidth, Spectral resolution, Band.
- Time**: Observation date, Integration time.
- Polarisation**: Polarisation type.
- Observation**: Line sensitivity (10 km/s), Continuum sensitivity, Water vapour.
- Project**: Project code, Project title, PI name, Proposal authors, Project abstract, Publication count, Science keyword.
- Publication**: Bibcode, Title, First author, Authors, Abstract, Year.
- Options**: View: observation, project, publication; public data only; science observations only.

Annotations with arrows point to specific sections:

- "Search target name or position within a radius" points to the **Position** section.
- "Search the spectral setup" points to the **Energy** section.
- "Search a project" points to the **Project** section.
- "Search data associated to papers" points to the **Publication** section.
- "Visualization options for the result table" points to the **Options** section.

The query display will change after the ALMA deadline!!!

The ALMA archive: help

1) Search with the criteria you need and click Search

The screenshot shows the ALMA Science Archive search interface. At the top right, it says "ALMA Science Archive" and "Query Help". Below this are tabs for "Query Form" and "Results Table". There are "Search" and "Reset" buttons. The main area is divided into several filter panels: "Position", "Energy", "Time", "Polarisation", and "Options". The "Position" panel has a search input field containing "NGC5135" with a green checkmark to its right. A contextual help popup is open over the "Position" panel, providing detailed information about the "Source name (Resolver)" search criteria. The popup includes a description, an example search string, and a list of search results for "NGC 5135".

Source name (Resolver)
Case-insensitive search for source name, to be resolved with Sesame. Wildcard matching is disabled. Search is performed within a radius of 10 arcminutes.

A search radius in degrees can be added to the end separated by a comma.

Description.
Use Sesame (via. NED, Simbad and VizieR) to parse names commonly found throughout literature. A green tick indicates a successful search, otherwise, a red cross is returned.

Example
[Cen A](#)
[NGC3375](#)
[ARP220, 20](#)

Source
NGC 5135

Coordinates (RA Dec)
13:25:44.05 -29:50:01.2

Object type
Sy2 (Seyfert 2 Galaxy)

Morphology Type
Sa

Resolver
Sesame using [Simbad](#)

Contextual help for each tab

The ALMA archive: help

1) Search with the criteria you need and click Search

Query Form Results Table ALMA Science Archive

Search Reset Query Help

Position

- Source name (Resolver)
- Source name (ALMA)
- RA Dec
- Galactic
- Target list
- Angular resolution
- Largest angular scale
- Field of view

Energy

- Frequency
- Bandwidth
- Spectral resolution
- Band

Time

- Observation date
- Integration time

Polarisation

- Polarisation type

Observation

- Line sensitivity (10 km/s)
- Continuum sensitivity
- Water vapour

Project

- Project code
- Project title
- PI name
- Proposal authors
- Project abstract
- Publication count
- Science keyword

Publication

- Bibcode
- Title
- First author
Sabatini, G.
- Authors
- Abstract
- Year

Options

View: observation

First author
First author of the publication.

Description
The first author as provided by telbib.eso.org

Example
[Carpenter, John M.](#)

Contextual help for each tab

The ALMA archive: result table

2) Select the MOUS you need and click
"Submit the download request"

Query Form Results Table

ALMA Science Archive

Submit download request

Close Viewer Results Bookmark Export Table Results Help



More columns Showing 4 of 4 rows. Select the columns to show

<input type="checkbox"/>	Project code	Source name	RA	Dec	Band	Release date	Velocity resolution	Frequency support	Pub	Angular res
<input type="checkbox"/>	2013.1.00243.S	NGC_5135	13:25:44.06	-29:50:01.2	6	2016-01-27	1206.86	226.47..242.55GHz	2	1.16
<input type="checkbox"/>	2013.1.00243.S	NGC_5135	13:25:44.06	-29:50:01.2	6	2016-08-22	1207.26	226.47..242.55GHz	2	0.23
<input type="checkbox"/>	2013.1.00524.S	NGC5135	13:25:43.99	-29:50:01.1	9	2016-10-01	13682.87	677.29..684.77GHz	7	0.16
<input type="checkbox"/>	2018.1.01344.S	NGC5135	13:25:44.06	-29:50:01.2	6	2020-01-03	8842.47	245.67..264.86GHz	0	0.26

Restricted access

Click to see abstract details

Notice multiple MOUS on the same proj (different resolution)

The ALMA archive: download manager

3) Select the data you want: which MOUS products, raw data

ALMA Request Handler

Login

Anonymous User: Request #2146910448196 ✓

Request Title: [Click to edit](#)

Download Selected

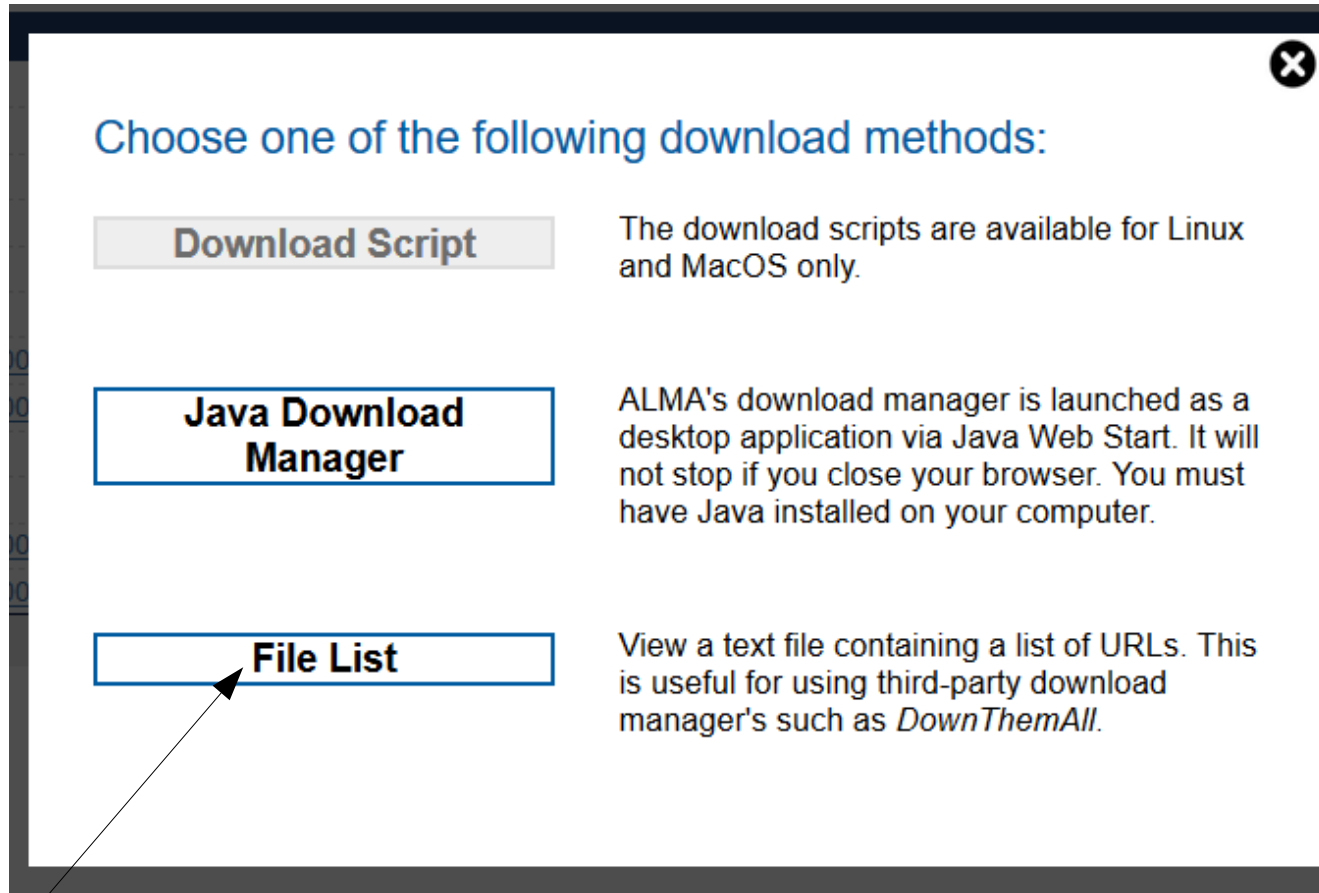
readme product auxiliary raw raw (semipass) external

Project / OUSet / Executionblock	File	Size	Accessible
Request 2146910448196			
Project 2013.1.00243.S			
Science Goal OUS uid://A001/X122/X48a			
Group OUS uid://A001/X122/X48b			
Member OUS uid://A001/X122/X48c			
SB NGC_5135_a_06_TE			
<input checked="" type="checkbox"/> product	2013.1.00243.S uid A001 X122 X48c 001 of 001	977.9MB	✓
<input type="checkbox"/> raw	2013.1.00243.S uid A002 Xa68906 X1bd.asdm.sdm	28.3GB	✓
Member OUS uid://A001/X122/X48e			
SB NGC_5135_a_06_TC			
<input checked="" type="checkbox"/> product	2013.1.00243.S uid A001 X122 X48e 001 of 001	243.5MB	✓
<input type="checkbox"/> raw	2013.1.00243.S uid A002 X9652ea Xbf8.asdm.sdm	12.5GB	✓
		Total: 40.7GB	

Zipped raw data sizes for whole projects are typically >10GB

The ALMA archive: download manager

4) Choose the download method



Choose one of the following download methods:

Download Script	The download scripts are available for Linux and MacOS only.
Java Download Manager	ALMA's download manager is launched as a desktop application via Java Web Start. It will not stop if you close your browser. You must have Java installed on your computer.
File List	View a text file containing a list of URLs. This is useful for using third-party download manager's such as <i>DownThemAll</i> .

Request 2146910448196

total size of files: 1.2GB

This page does not use single-sign on. It uses basic authentication and is intended to be scriptable.

PLEASE do not attempt to chop a single download into pieces to make it faster. This places a significant load on our servers and may result in your downloads being throttled. For example, in the Firefox plugin *DownThemAll*, make sure that the property "Max. Number of Segments Per Downloads" is set to 1. Likewise, it's easy to download more than 5 files in parallel. Please don't.

- https://almascience.eso.org/dataPortal/requests/anonymous/2146910448196/ALMA/2013.1.00243.S_uid_A001_X122_X48c_001_of_001.tar/2013.1.00243.S_uid_A001_X122_X48c_001_of_001.tar
- https://almascience.eso.org/dataPortal/requests/anonymous/2146910448196/ALMA/2013.1.00243.S_uid_A001_X122_X48e_001_of_001.tar/2013.1.00243.S_uid_A001_X122_X48e_001_of_001.tar

What is in the packages?

When untarred, the Product Package standard directory structure contains

Untarred products only	-- project_id/	
	-- sg_ouss_id/	
	-- group_ouss_id/	
	-- member_ouss_id/	
	-- README	important summary of the contents
	-- product/	all the imaging products as result of QA2
	-- calibration/	calibration and flagging tables
	-- qa/	diagnostic plots generated during QA2
-- script/	the scripts necessary to regenerate the products	
-- log/	CASA log files from QA2 calibration and imaging	
Untarred ASDM (raw data)	-- raw/	for calibration move it in the products folder at the right level (follow the README)

**Do not change the folder structure and names if you want to run the scripts!
ALWAYS READ THE README FILE!!!!!!**

Look to QA summary for data quality

Task	QA Score
1. hifa_importdata : Register measurement sets with the pipeline	1.00
2. hifa_flagdata : ALMA deterministic flagging	24.37% data flagged 0.76
3. hifa_fluxcallflag : Flag spectral features in solar system flux calibrators	1.00
4. hif_refant : Select reference antennas	1.00
5. hifa_tsyscal : Calculate Tsys calibration	1.00
6. hifa_tsysflag : Flag Tsys calibration	5.46% data flagged 0.99
7. hifa_wvrgcallflag : Calculate and flag WVR calibration	1.00
8. hif_lowgainflag : Flag antennas with low gain	1.00
9. hif_setjy : Set calibrator model visibilities	1.00
10. hif_bandpass : Bandpass calibration	Phase derivative 0.66
11. hif_bpfalgchans : Flag channels of bandpass calibration	Phase derivative 0.66
12. hifa_gfluxscale : Transfer fluxscale from amplitude calibrator	1.00
13. hifa_timegaincal : Gain calibration	X2-X1 deviation 1.00
14. hif_applycal : Apply calibrations from context	32.90% data flagged 0.69
15. hif_makecleanlist : Compile a list of cleaned images to be calculated	N/A
16. hif_cleanlist : Calculate clean products	N/A

Look to the weblog or to the png summary plots and details in the “qa” folder to verify the quality of the data.

For more info come to the ARC or have a look to

http://www.alma.inaf.it/index.php/ALMA_Data_Handling_Workshop

ALMA 2013.1.00243.S
Home By Topic By Task

Summary of measurement set flagging status after application of (potentially flagged) calibration tables. Each cell gives the amount of data flagged as a fraction of the specified data selection.

TASKS IN EXECUTION ORDER

1. hifa_importdata
2. hifa_flagdata
3. hifa_fluxcallflag
4. hif_refant
5. hifa_tsyscal
6. hifa_tsysflag
7. hifa_wvrgcallflag
8. hif_lowgainflag
9. hif_setjy
10. hif_bandpass
11. hif_bpfalgchans
12. hifa_gfluxscale
13. hifa_timegaincal
14. hif_applycal
15. hif_makecleanlist
16. hif_cleanlist

Plots

Calibrated amplitude vs frequency

uid__A002_X9652ea_Xbf8.ms

Amprcorrected vs. Frequency

Baseband 1

Calibrated amplitude vs frequency for PHASE calibrator J1342-2900, baseband 1, all antennas and correlations, coloured by antenna.

Amprcorrected vs. Frequency

Baseband 2

Calibrated amplitude vs frequency for PHASE calibrator J1342-2900, baseband 2, all antennas and correlations, coloured by antenna.

Amprcorrected vs. Frequency

Baseband 3

Calibrated amplitude vs frequency for PHASE calibrator J1342-2900, baseband 3, all antennas and correlations, coloured by antenna.

Amprcorrected vs. Frequency

Baseband 1

Calibrated amplitude vs frequency for BANDPASS calibrator J1337-1257, baseband 1, all antennas and correlations, coloured by antenna.

Amprcorrected vs. Frequency

Baseband 2

Calibrated amplitude vs frequency for BANDPASS calibrator J1337-1257, baseband 2, all antennas and correlations, coloured by antenna.

Amprcorrected vs. Frequency

Baseband 3

Calibrated amplitude vs frequency for BANDPASS calibrator J1337-1257, baseband 3, all antennas and correlations, coloured by antenna.

Look to products with CASViewer

Activities Casaviewer Fri 18:18 Viewer Display Panel (Ht) (on arcb103.ira.inaf.it)

Data Display Panel Tools View Help

Display

Xbf8_NGC_5135_a_06_TC-CO.clean.image.pbcor.fits-raster

48''

51''

54''

57''

J2000 Declination -29°50'00''

03''

06''

09''

12''

-5175.98 km/s

13^h25^m45^s.0 44^s.4 44^s.0 43^s.6 43^s.2

J2000 Right Ascension

Animators

Channels

Rate: 10 Jump 12 25

0 24

Images

Rate: 10 Jump 1 2

0 1

Regions

Properties	Statistics	Fit	File	Histogram
-Xbf8_NGC_5135_a_06_TC_cont.clean_ap.image.pbcor.fits				
Frequency	Velocity	Stokes	BrightnessUnit	
2.34518e+11Hz	-5175.98km/s	I	Jy/beam	
BeamArea	Npts	Sum	FluxDensity	
53.7831	20	7.476082e-03	1.390043e-04	
Mean	Rms	Std dev	Minimum	
3.738041e-04	3.930662e-04	1.246955e-04	2.157609e-04	
Maximum	region_count			
6.582339e-04	1			

next

Spectral Profile - Xbf8_NGC_5135_a_06_TC-CO.clean.image.pbcor.fits-raster

Elliptical Region Profile

channel

(Jy/beam)

27.0374 20.5354 14.0333 7.53132

227.2 227.3 227.4 227.5

frequency [GHz]

Bottom: frequency [GHz] Top: channel Left: Jy/beam

Data format

ALMA Science Data Model (ASDM) **Final archived product from each observation**

Each has an unique hexadecimal name
(eg uid://A002/X2fed6/X3f).

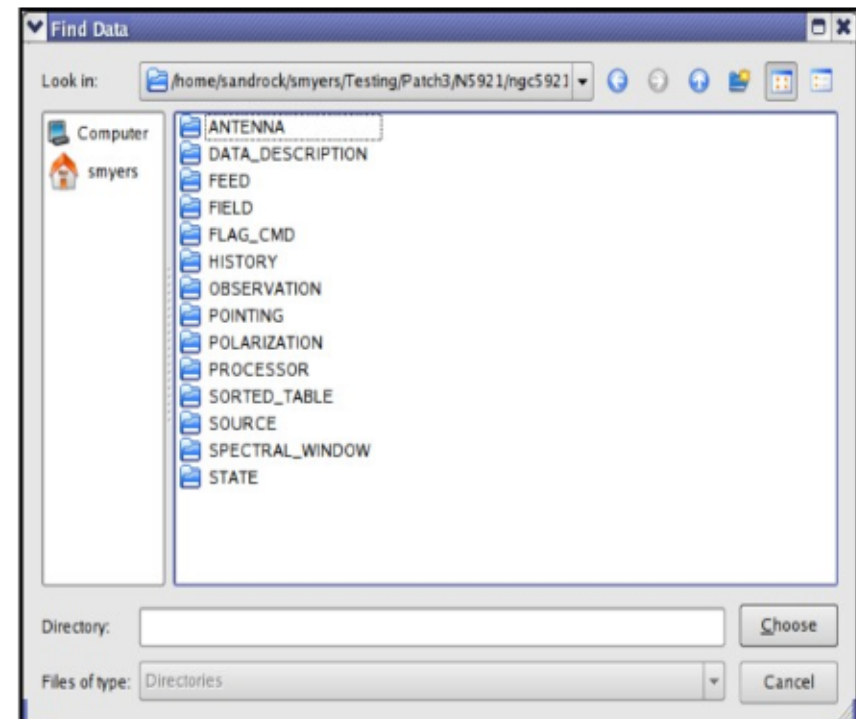
Each contains the meta-data (headers,
descriptions of the observation setup, etc),
and the binary data (the raw data)

The first step of any data processing is importing the ASDM in the format suitable for the software used

Measurement Set (MS)

Data format used in CASA

Constituted by several tables
referring each other and collecting
most (not all!) the information in the ASDM

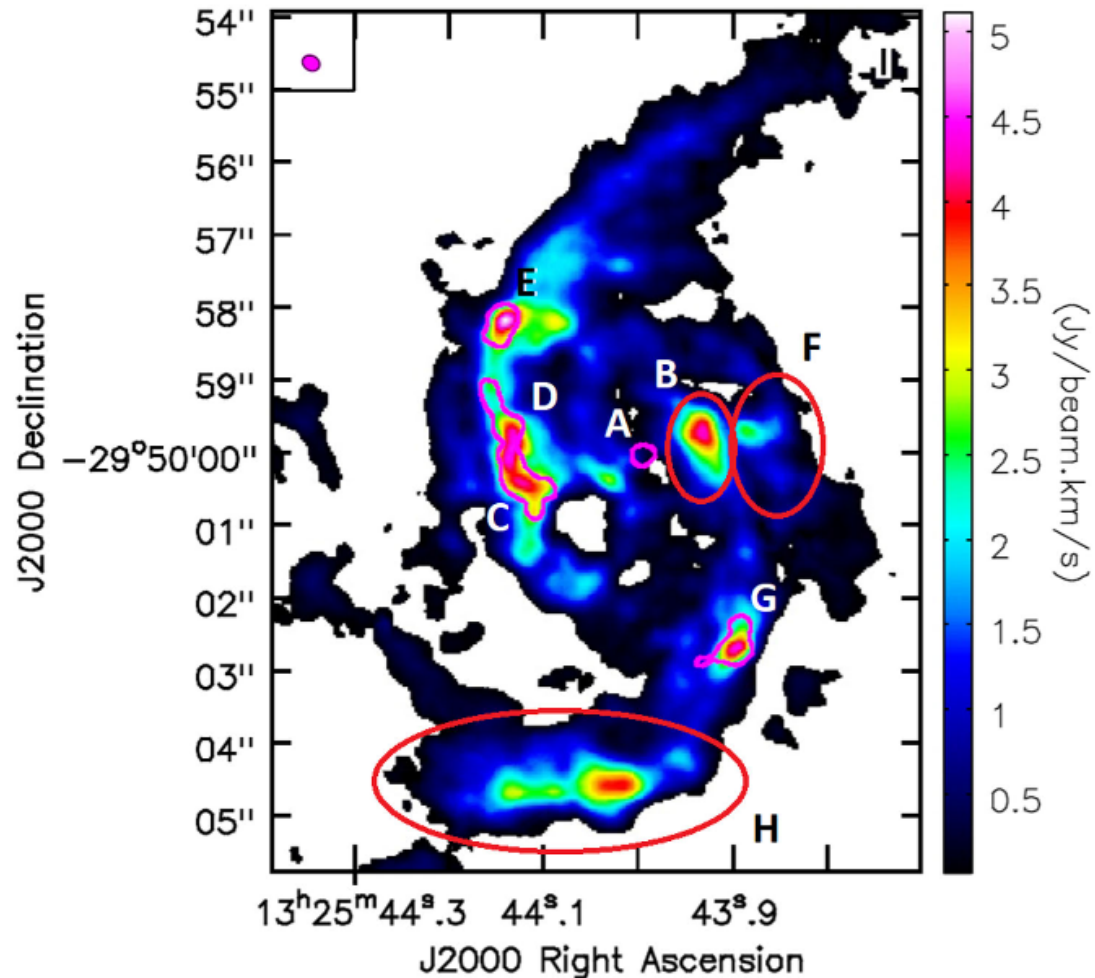


What to do after download?

```
[massardi@arcbl02 member.uid__A001_X120_X102]$ cd script/  
[massardi@arcbl02 script]$ casapy-setup 42.2.30986-pipe-1-64b  
[massardi@arcbl02 script]$ casapy --pipeline  
...  
CASA <2>: execfile('scriptForPI.py')
```

- 1) Untar the packages
- 2) Look at weblog and/or QA reports
- 3) Read the README file and follow the instructions: typically
 - Launch the correct CASA (with pipeline) version in the script folder
 - Run the “Script_for_PI” to generate the calibrated MS
 - Run the “Script_for_Imaging” to regenerate the images
(In case of pipeline imaging there is no Script_for_Imaging)
- 4) Edit the scripts where needed according to your purposes

Sabatini et al. (2018)



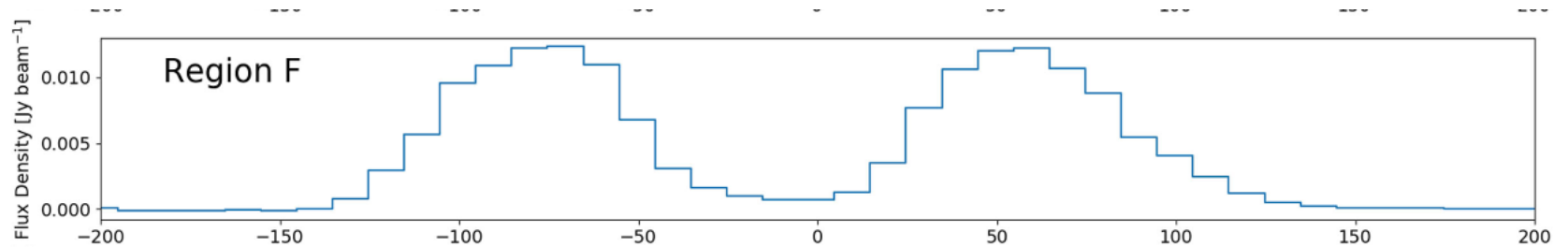
!!!Disclaimer!!!

Images are not supposed to be science ready in the ASA (even if sometimes they are pretty good).

No combination is done for multiple configurations.

Consider to re-image the archive products for science purposes.

Use products only as indication of data content.





The “Additional Representative Images for Legacy (ARI-L) in the ASA” project will produce and ingest into the ASA a set of additional image products representative of the whole data content for more than 70% of the observing projects in cycles 2-4 that can be processed through the ALMA Imaging Pipeline, to complement the QA2-generated images. In addition calibrated MS of the processed dataset will be released too.

The ARI-L images will:

- constitute a complete set of imaging products highly relevant for all science-cases and enhance the possibilities of exploitation of archival data
- facilitate the archive access and the data usage for science purposes also to non-expert data-miners,
- provide a homogeneous view of all data to compare datasets and to do a more conscious download selection,
- allow to more profitably link the archive to several tools of visualization and analysis (e.g. VO, CARTA, ADMIT, KAFE, ...),
- allow to generate previews similar to those planned for the following cycles.

THE ARI-L DEVELOPMENT PROJECT : PRODUCTS IN THE ASA



The ARI-L products will not modify the current deliverables, but will be included as “externally contributed products”. The project will produce a cube and a continuum image for each source (including calibrators) for at least 70% of the 3476 MOUS in cycle 2-4.

ALMA Request Handler

Anonymous User: Request #409589486 ✓
Request Title: [Click to edit](#)

Download Selected

readme product raw raw (semipass) external

Project / OUSet / Executionblock	File	Size	Accessible
Request 409589486			
Project 2016.1.00164.S			
readme	2016.1.00164.S_readme.txt		
Science Goal OUS uid://A001/X87a/X9ee			
Group OUS uid://A001/X87a/X9ef			
Member OUS uid://A001/X87a/X9f0			
SB M83_a_03_TM1			
<input checked="" type="checkbox"/> product	2016.1.00164.S_uid_A001_X87a_X9f0_001_of_001.tar	10.5GB	✓
<input type="checkbox"/> raw	2016.1.00164.S_uid_A002_Xbc0724_X7456.asdm.sdm.tar	59.2GB	✓
<input type="checkbox"/> raw	2016.1.00164.S_uid_A002_Xbc22e9_X1535.asdm.sdm.tar	49.6GB	✓
Member OUS uid://A001/X87a/X9f2			
SB M83_a_03_7M			
<input checked="" type="checkbox"/> product	2016.1.00164.S_uid_A001_X87a_X9f2_001_of_001.tar	419.1MB	✓
<input type="checkbox"/> raw	2016.1.00164.S_uid_A002_Xb91513_X6ea2.asdm.sdm.tar	1.4GB	✓
Externally contributed products			
<input type="checkbox"/> external (ARI-L) ?	2016.1.00164.S_uid_A002_Xb91513_X76eb_ariel_001_of_001.tar	10.9GB	✓

Total: 122.5GB

In publications with ALMA data!

Acknowledgement Statement:


“This paper makes use of the following ALMA data:
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