EUROPEAN ARC
ALMA Regional Centre || IRAM

ALMA
and how to use it

Edwige Chapillon

On behalf of the IRAM ARC node

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ALMA
and how to use it

I- The ALMA observatory

II- The ARC nodes

III- The PI experience

ALMA

Atacama Large Millimeter/Submillimeter Array

World-wide collaboration

- Europe (**ESO**)
- North America (USA, Canada, Taiwan)
- Eastern Asia (Japan, Taiwan, South Korea)
- Chile

- Main array: 50 x 12 m antennas
- ALMA Compact Array (ACA): 4 x 12m + 12 x 7m
- Frequency range: 30—900 GHz (0.3—10 mm)
- 16 km max. baseline

ALMA

Requirement :

- Detect spectral line emission of CO or CI from a normal galaxy (like the Milky-way) at a **redshift 3** in less than 24h of observations

- Image the **gas kinematic in protostars and protoplanetary disks** around young Sun-like stars at a distance of 150pc

- Provide precise image at **0.1 arcsec** resolution

ALMA

- JAO
  - Main operations
- ARC
  - Interface with user
- ARC node
  - Additional user support

OSF

San Pedro de Atacama

AOS

Morita array (ACA)

Morita-array (compact array)

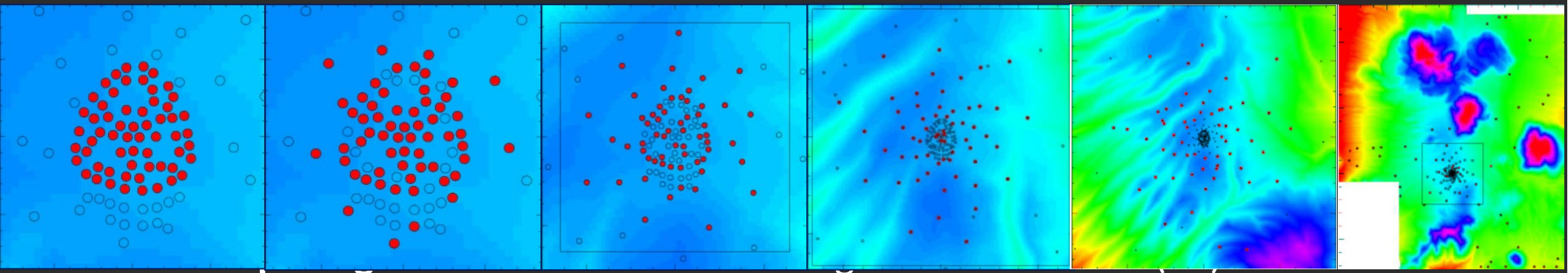
- 12 7-m antennas to observe the short spacings
- offered in stand-alone mode starting cycle 4

Single-dish antennas

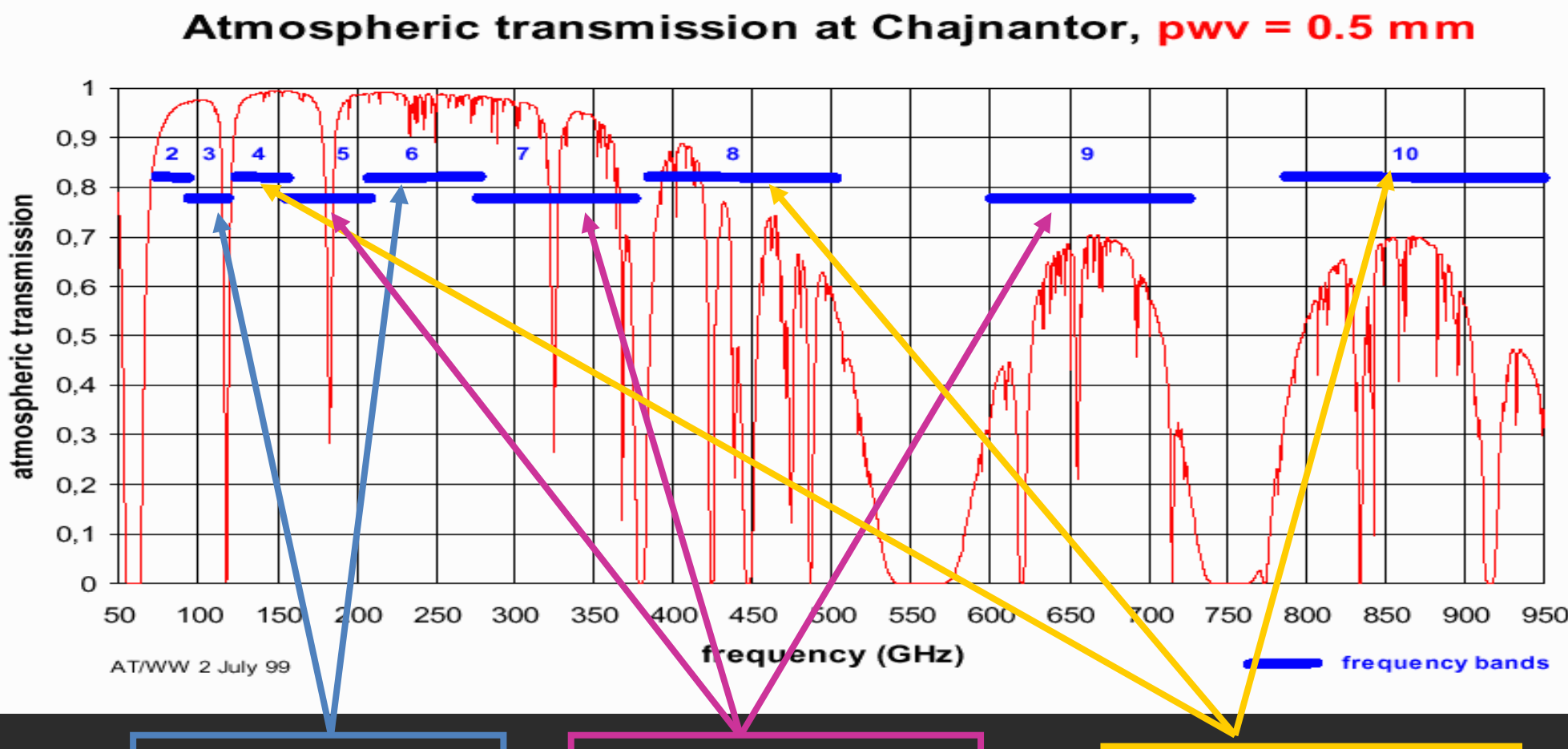
- 4 12-m antennas used in single-dish mode to observe the zero-spacings

Morita array (ACA)

- 50 antennas, 1225 baselines (**Goal = 45 antennas used**)
- Angular resolution λ/B down to 40 mas (100 GHz), 5 mas (900 GHz)
- 28 (TBC) different antenna configurations, from compact to ~16 km



- **Caution: not all projects can have ACA data**!
- ALMA imaging simulator



North America

Band 3 (84-116 GHz)
Band 6 (211-275 GHz)

Europe

Band 7 (275-373 GHz)
Band 9 (602-720 GHz)
Band 5 (158-211 GHz)

Japan

Band 4 (125-163 GHz)
Band 8 (385-500 GHz)
Band 10 (787-950 GHz)

Freq. coverage: **30—900 GHz**
Bandwidth: **8 GHz x 2 polarizations**

Band 1 (35-50 GHz): Taiwan +NRAO
Band 2+3 on study

Receivers

- Receiver Bands currently installed on all antennas:
  - Band 3: 3 mm (84-116 GHz)
  - Band 4: 2 mm (125-163 GHz)
  - Band 5: 1.6mm (158-211 GHz)
  - Band 6: 1 mm (211-275 GHz)
  - Band 7: 850 µm (275-370 GHz)
  - Band 8: 650 µm (385-500 GHz)
  - Band 9: 450 µm (602-720 GHz)
  - Band 10: 350 µm band (787-950 GHz)

- Receiver Bands in development

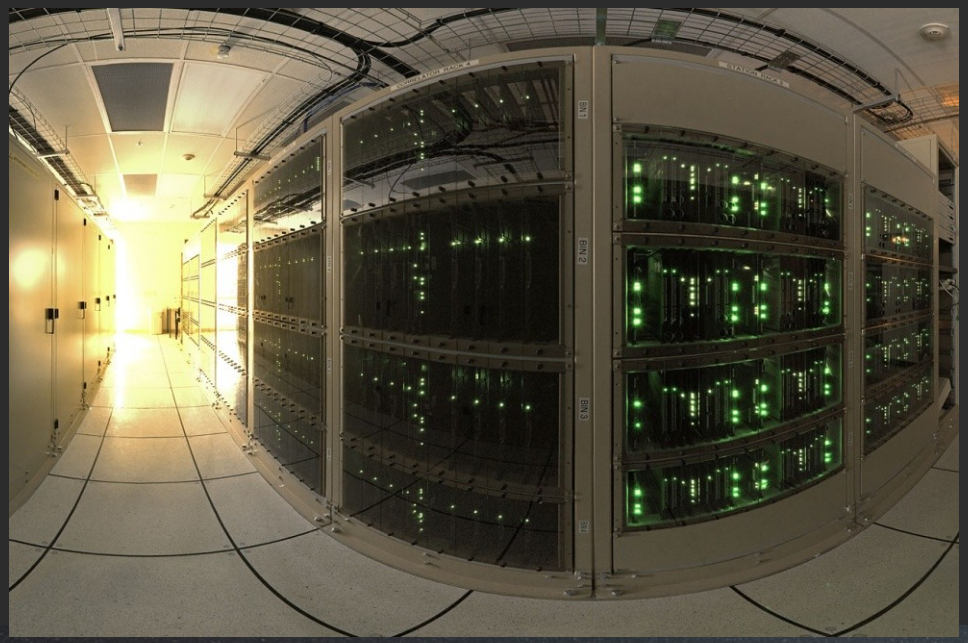
  Band 1: 7mm (35-50 GHz)
- Receiver Bands in study

  Band 2 (2+3)

  Band 11

- All receivers **8 GHz bandwidth x 2 polar**.

Correlator



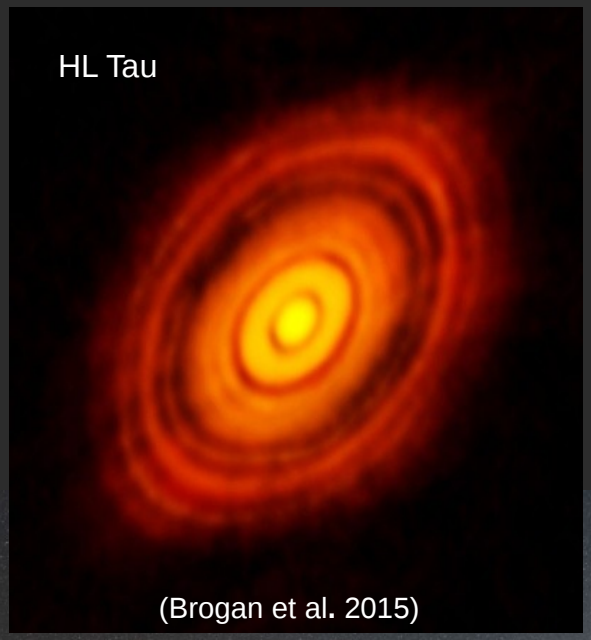
- 4 units of 2 GHz = baseband
- 4 spectral windows per baseband with compromise bandwidth/resolution
- 1/2/4 polarization products (total number of channels = constant)

- Caution: data rate limitations! Partially released in C6

Some results

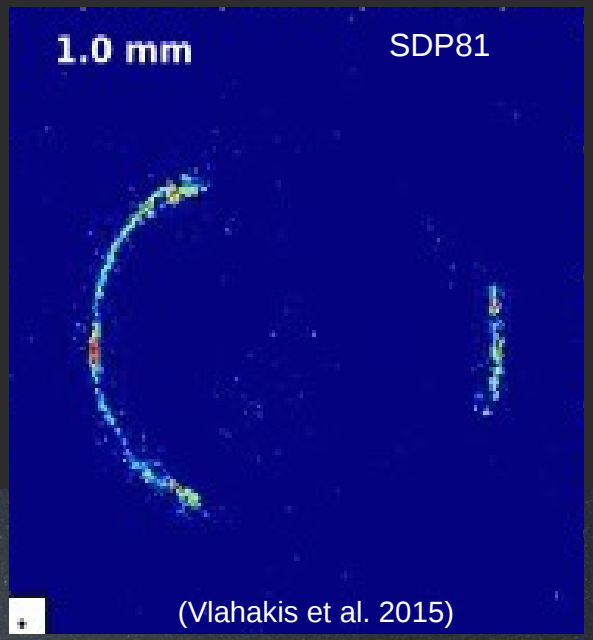
Long baseline campaign (cycle 3)

Protoplanetary disks



(Brogan et al. 2015)

Gravitational lenses

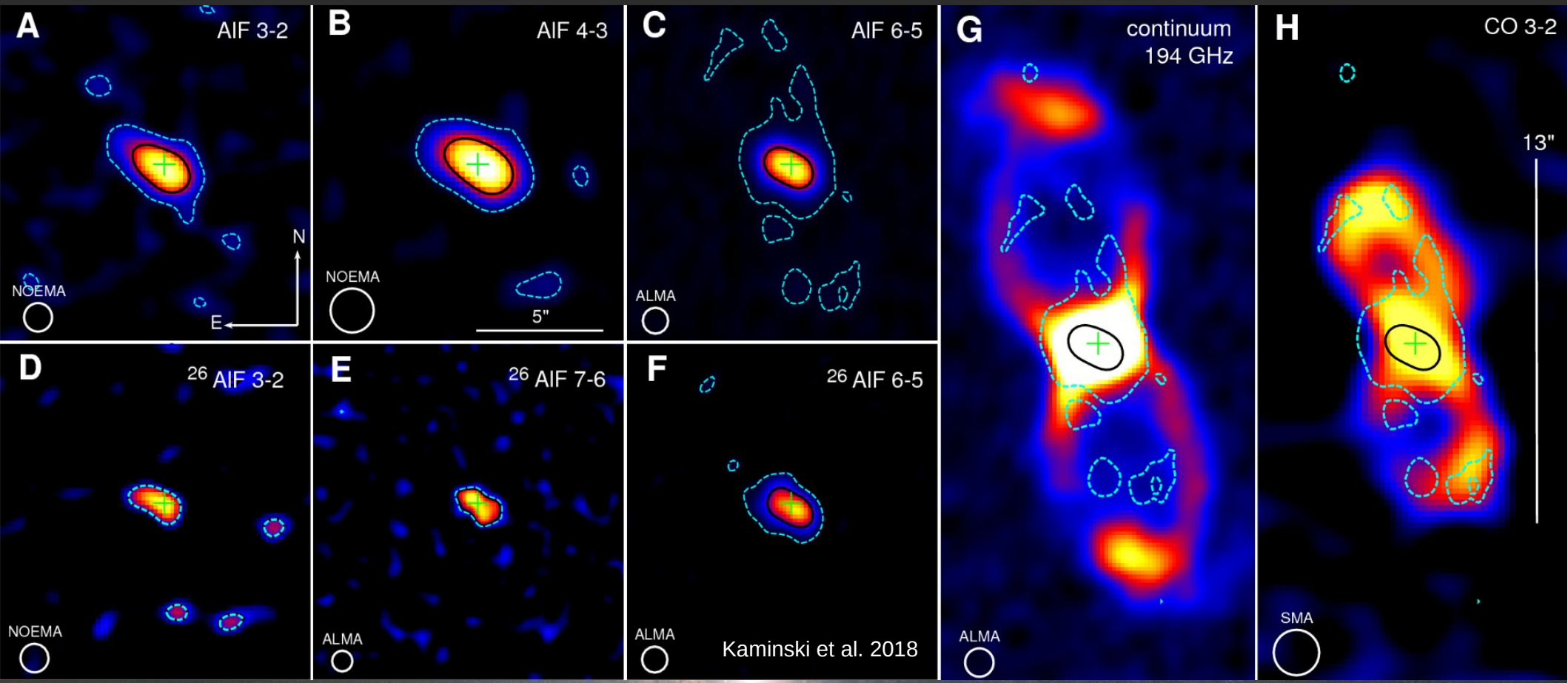


(Vlahakis et al. 2015)

Some results

Detection of ^{26}AlF (ALMA + NOEMA + 30m)

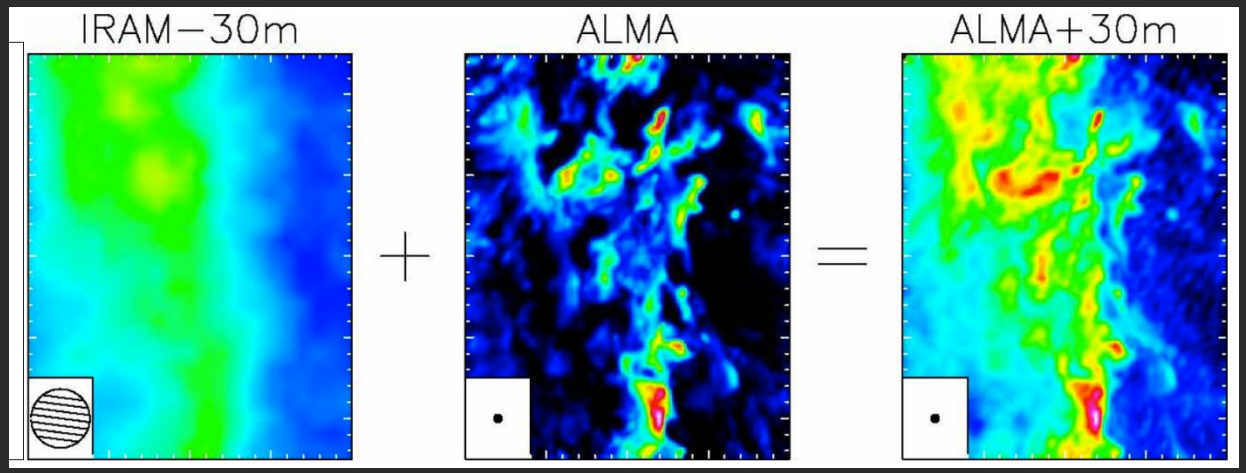
Evolved stars



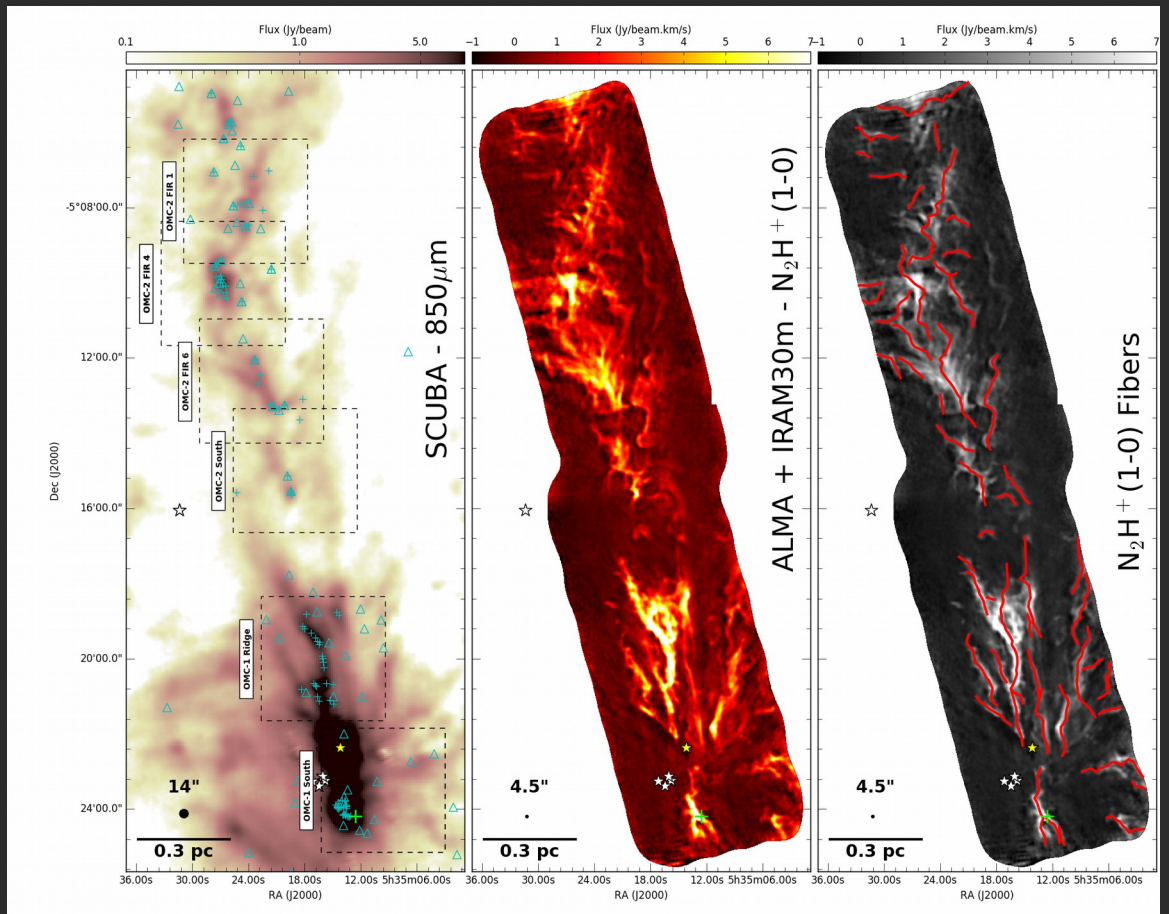
Some results

Orion

Combination with 30m



Goicoechea et al. 2016



Compression and ablation of the photo-irradiated molecular cloud of the Orion Bar

Multiple fibers in the heart of the Orion star-forming region

Hacar et al. 2018

ALMA
and how to use it

I- The ALMA observatory

II- The ARC nodes

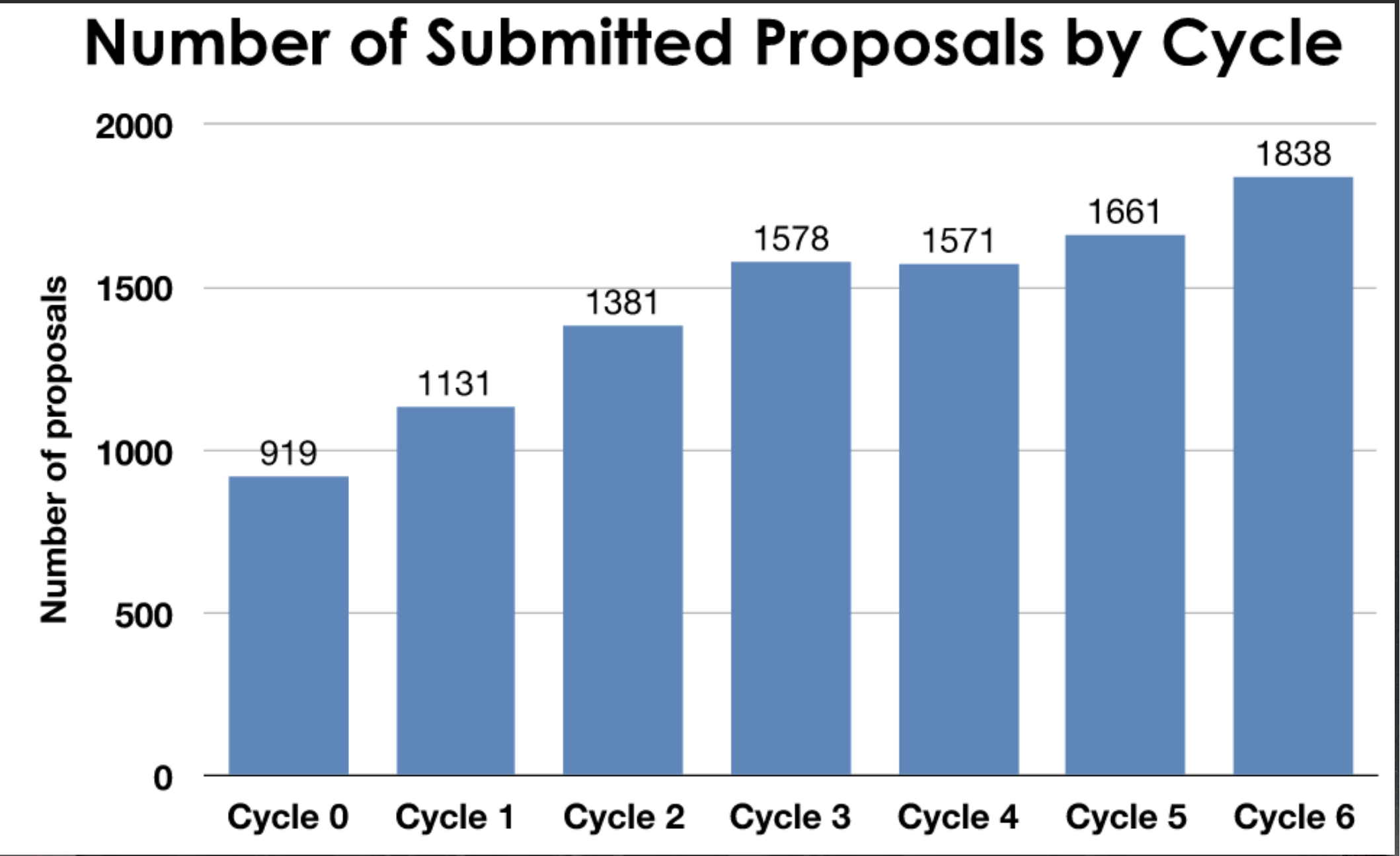
III- The PI experience

ALMA Operations

- Service observing operated by JAO with the help of the ARCs
- Proprietary period = 12 months
- One single Time Allocation Committee for NA+EU+EA+CL
  - No guaranteed time
  - EU 33.75%, NA 33.75%, EA 22.5%, Chile 10%

- In full operations:
  - One call for proposals per year (deadline ~ April) started in Cycle 3
  - Dynamic scheduling: best project determined every SB (hour scale) (goal for Cycle 7)
  - Calibration & imaging pipeline (calibration and imaging for standard projects)
  - Polarimetry (partially open since Cycle 3)
  - Large programs (opened in Cycle 4)
  - ACA stand alone (opened in Cycle 4)
  - Solar observation (opened in Cycle 4, still in progress)
  - VLBI (open in Cycle 4)

ALMA Early Science

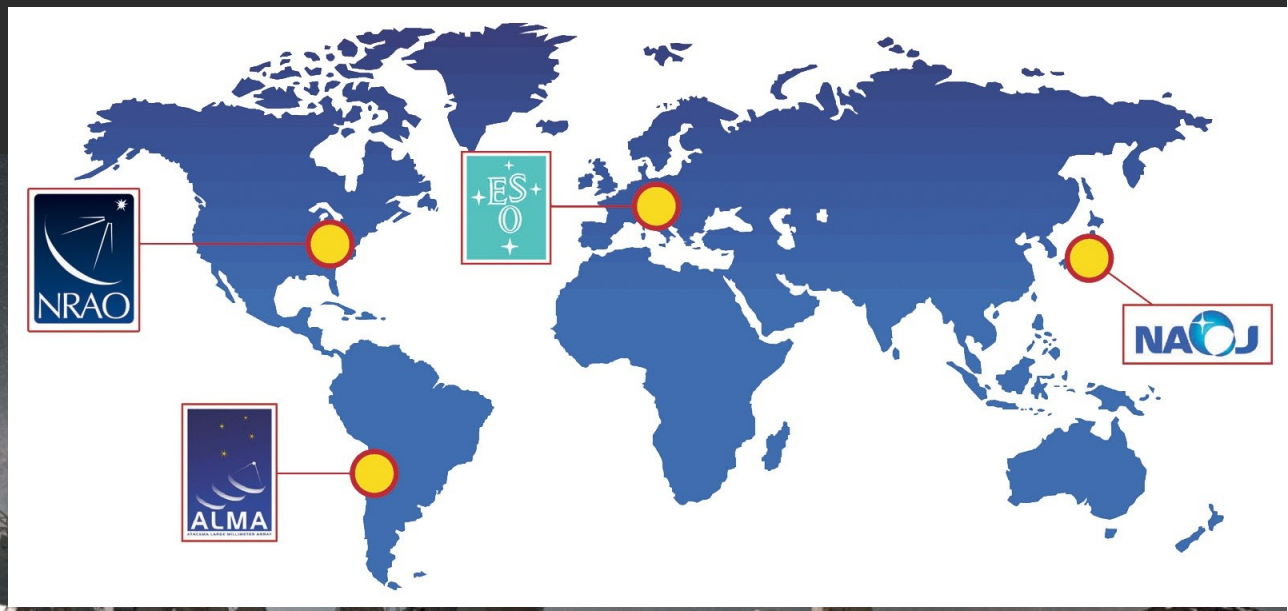


ALMA Regional Centers

Scientific operations & user support outside Chile

- Contact point between users and ALMA
- Call for proposals
- ALMA Helpdesk
- Data product support = delivering data and software
- ALMA archive operations

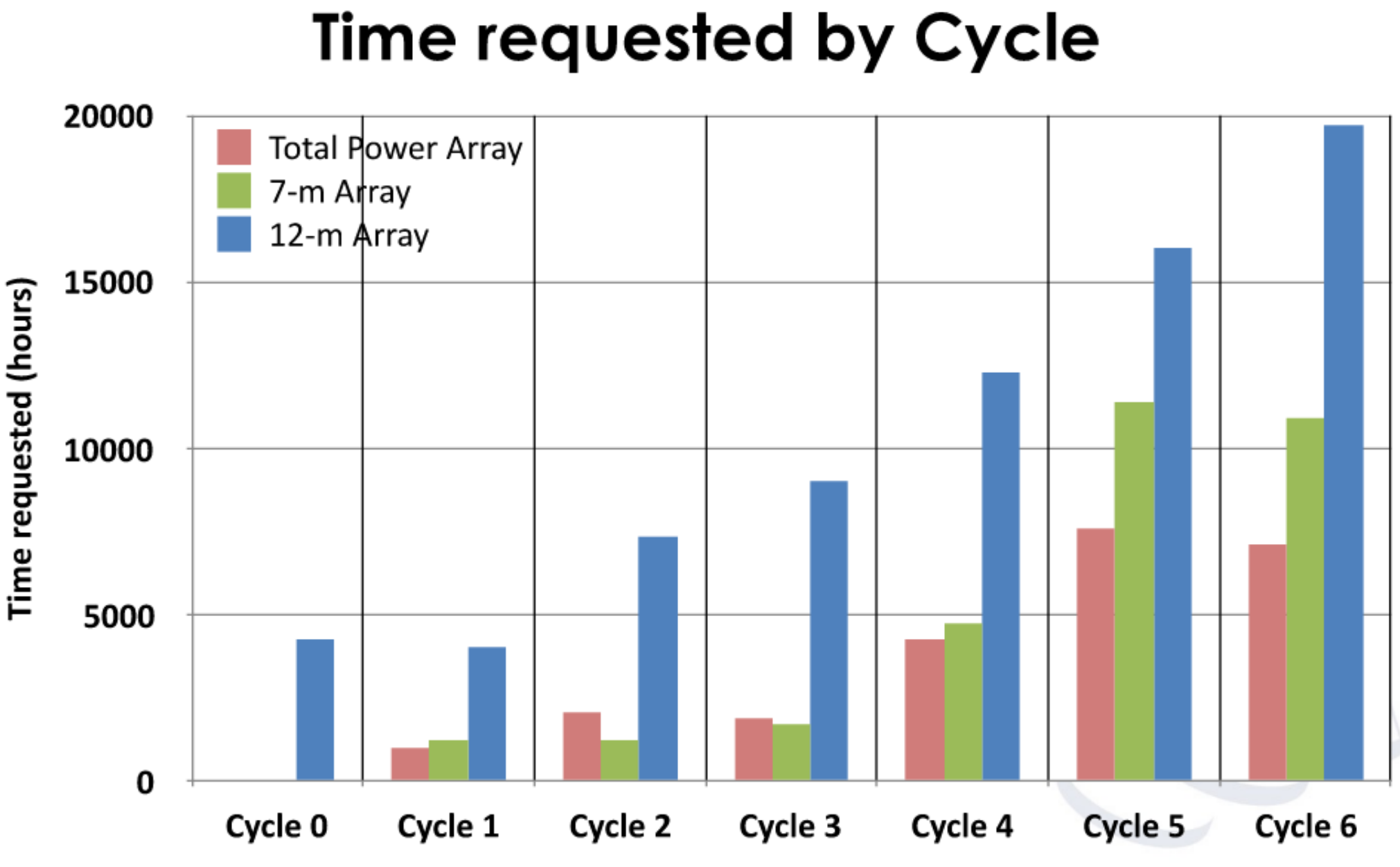
Three ARCs + JAO



ARCs:

- EU : ESO Garching (D)
- NA: NRAO Charlottesville (USA)
- EA: NAOJ Mitaka (J)

ALMA Early Science



ALMA Early Science

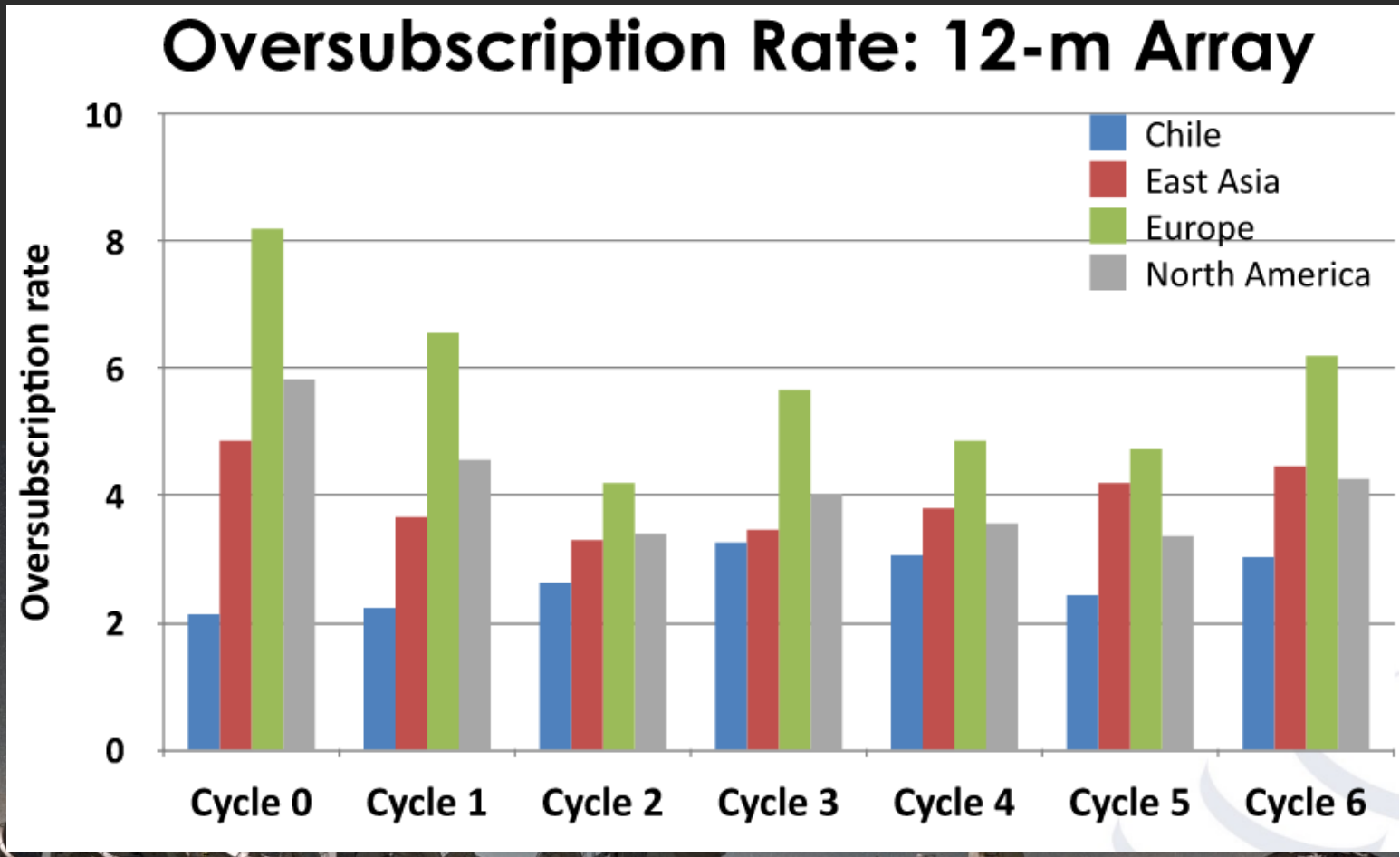
ALMA capabilities deployment

Now distinguish between standard and non-standard modes

- VLBI,
- polarimetry,
- long baselines

Pressure factor

~ **5—10**



European ARC network

Additional tasks : ARC nodes

- User formation & community development
- Phase II support
- **Face-to-face support** for data reduction
- New developments

- All nodes open to all European scientists but target own community
- IRAM = French, German, and Spanish communities

Seven ARC nodes in Europe

- INAF Bologna (I)
- Univ. Bonn (D)
- IRAM (F,D,E)
- Leiden Obs. (NL)
- Manchester Obs. (UK)
- Onsala Obs. (S,DK,SF)
- Prague (CZ)

+ Lisbone (P) Center of Expertise

IRAM ARC node

- Phase II and f2f support to ALMA
  - Local contact assigned to each project
  - Use existing infrastructures and procedures
  - Travels to Grenoble funded by IRAM (same rules as NOEMA)
    Radionet Marcus funding
  - Limited staff (<2 FTE)
  - ~ 33% of European projects

ARC node representative: Frédéric Gueth

Name	Status	FTE	Expertise/task
Edwige Chapillon	Staff	0.5	CS, f2f (QA2)
Ana Lopez Sepulcre	Staff	0.5	CS, f2f (QA2)
Ka Tat Wong	Post-doc	0.5	CS, f2f (QA2)
Cinthya Herrera Contreras	Post-doc	0.2	CS, (QA2)
Arancha Castro-Carrizo	Staff	0.1	CS, f2f

User support

- **Contact Scientists**
  - SB support for all accepted + fillers projects (> observed projects)
  - Interface between PI and ESO & ALMA
  - Also: check projects status during Cycle
  - helpdesk
- **f2f support for data reduction**
  - Main task
  - Re-calibration
  - Re-imaging
  - Covers most bands & observing modes
  - Travel funding available (for PI affiliated to IRAM funding agencies), limited Marcus funding
  - No funding for specific computing equipment.
- Schools, workshops

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iram
Institut de Radioastronomie Millimétrique

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The PI experience

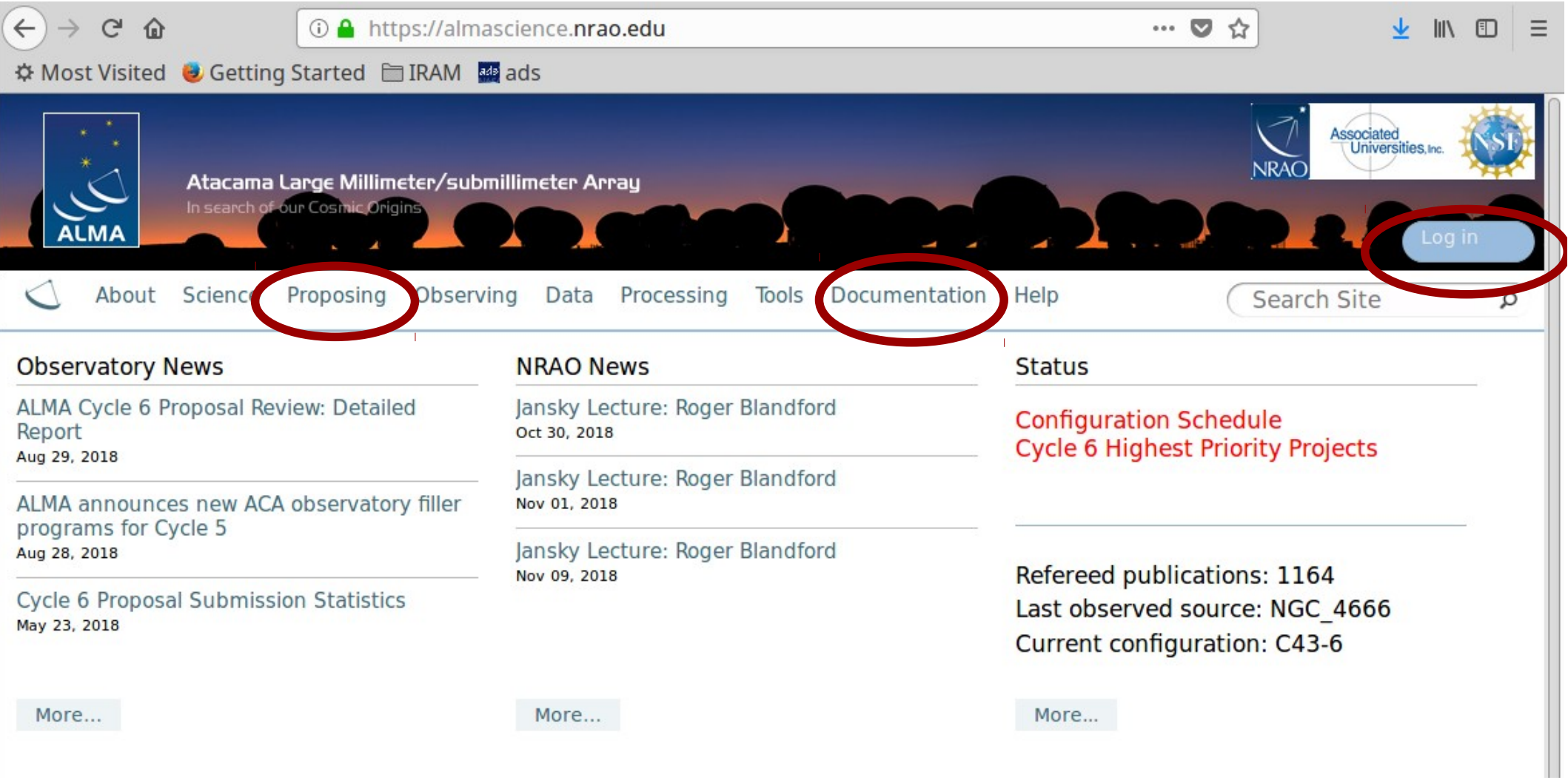
- Phase I : Proposal preparation and submission
- Phase II : Science Block preparation
- Observation
- Quality assessment (QA0 & QA2)
- Data delivery
- Check (QA3)
- Analysis and publication :-)

Phase 1 : Proposal

Call for proposal issued by JAO and the ARC
1 /year, in April

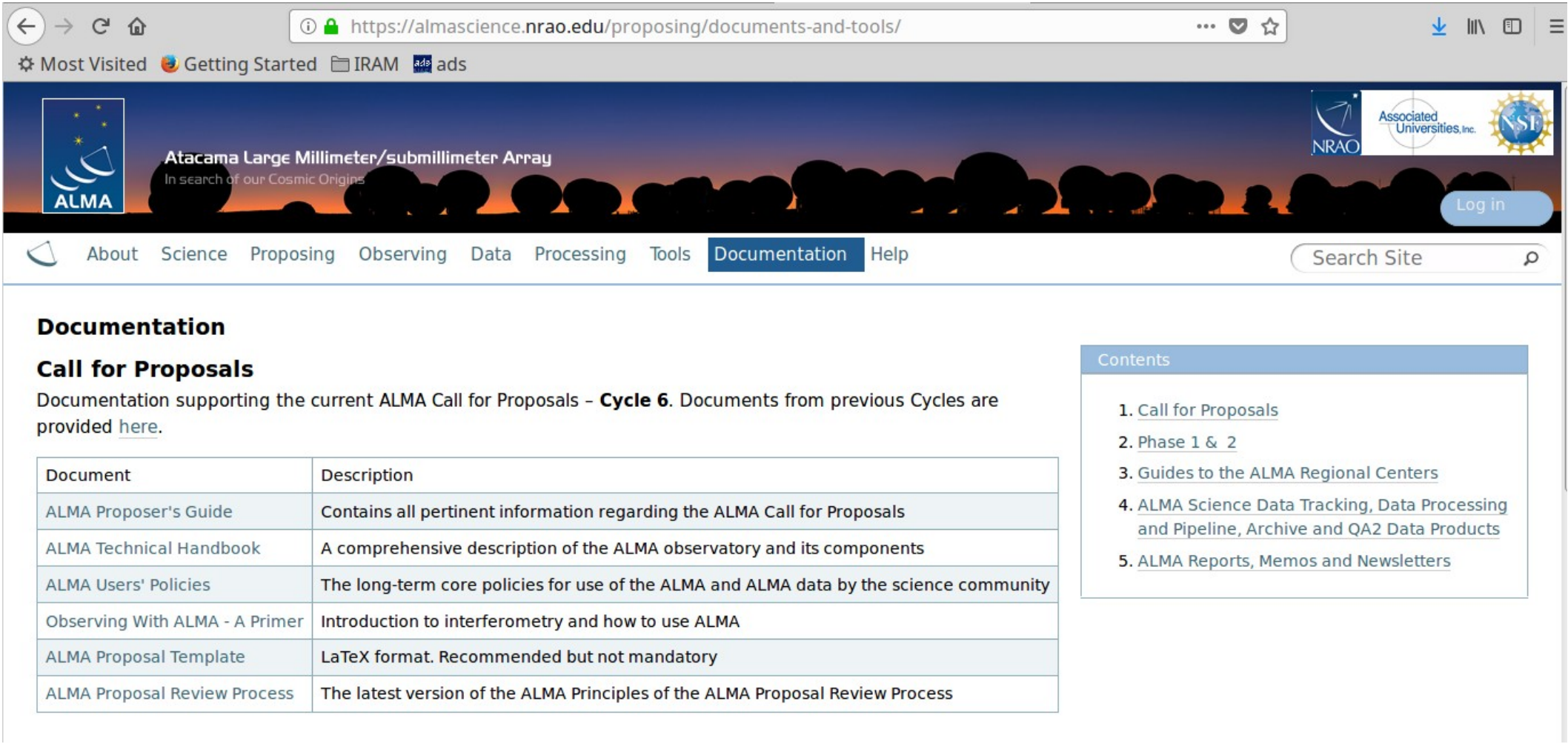
- Proposal preparation
  - Documentation
  - Science portal (almascience.eso.org)
- Duplication check
  - Alma archive
  - Accepted proposal list
- Proposal submission
  - Observing tool

Phase 1 : Science portal



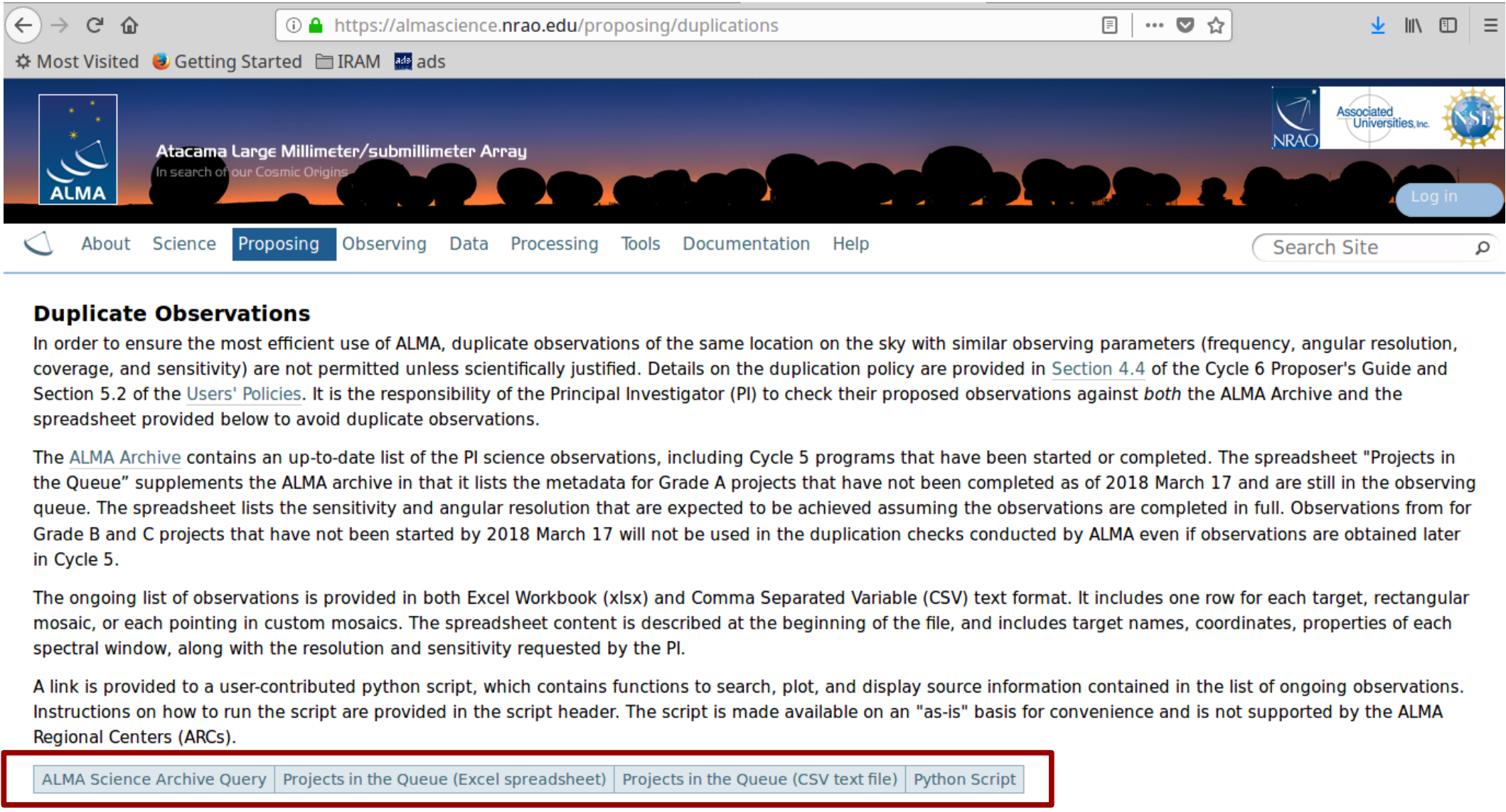
- 3 mirrors : ESO/NRAO/NAOJ
- Documentation
- User account

Phase 1 : Science portal

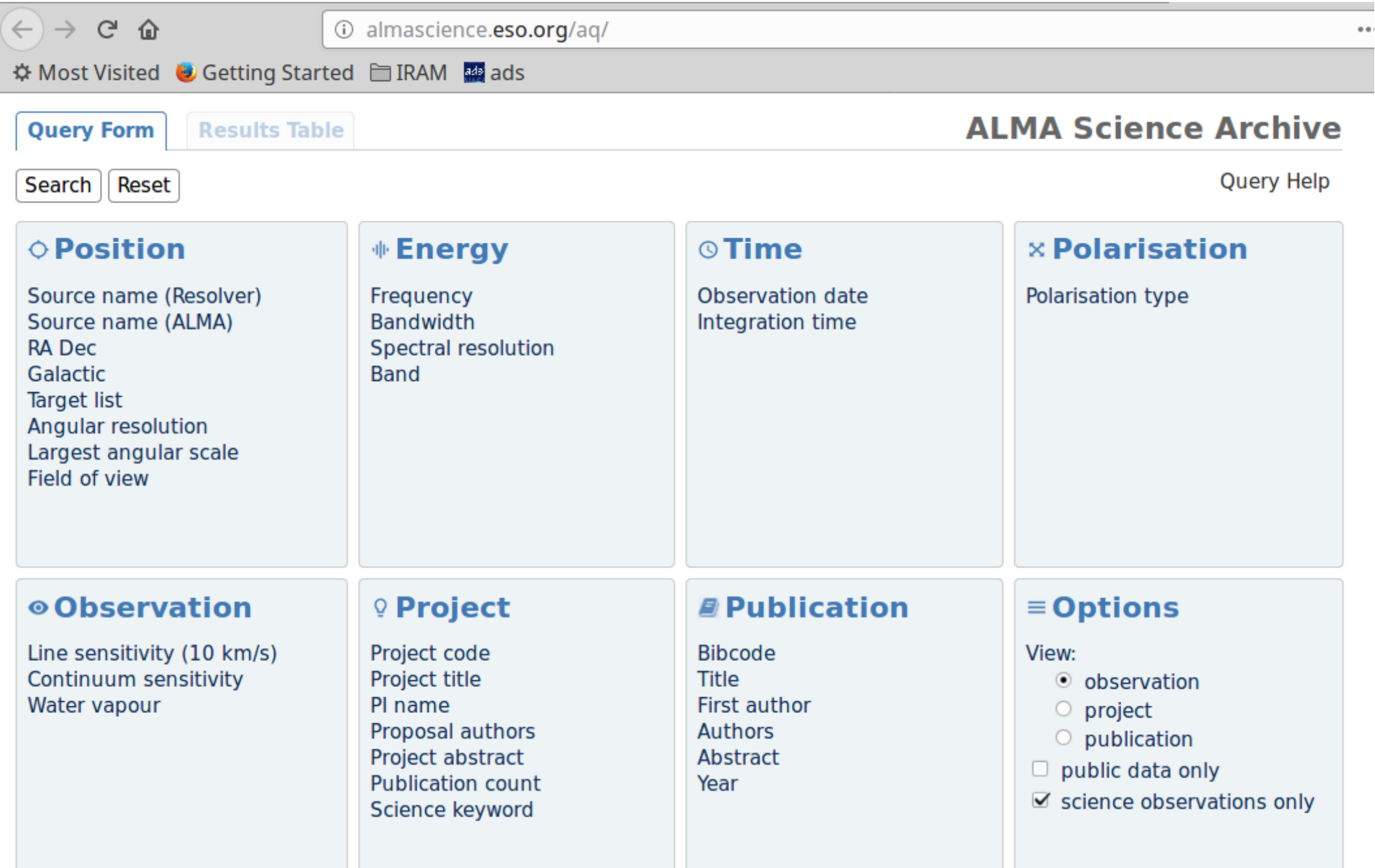


- 3 mirrors : ESO/NRAO/NAOJ
- Documentation (copy on the IRAM ARC node website)
- User account

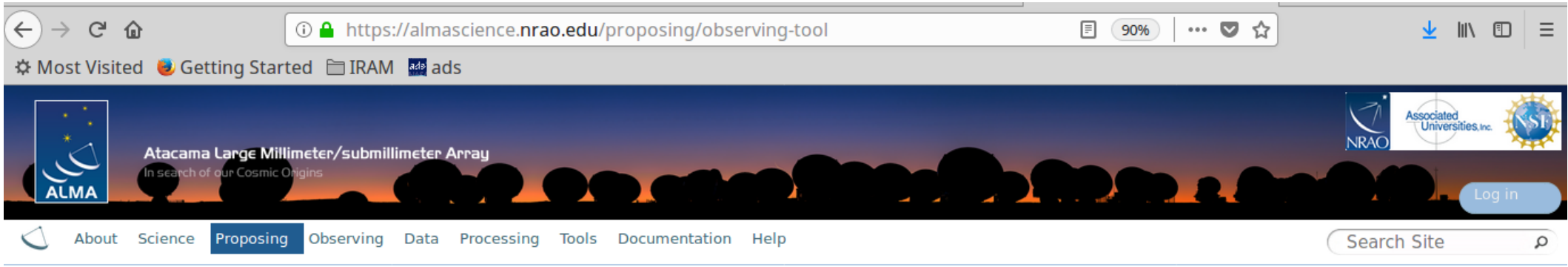
Phase 1 : Science portal



Phase 1 : Archive



Phase 1 : Observing tool



Observing Tool

The ALMA Observing Tool (OT) is a Java application used for the preparation and submission of ALMA Phase 1 (observing proposal) and Phase 2 (telescope runfiles for accepted proposals) materials. It is also used for preparing and submitting Director's Discretionary Time (DDT) proposals. The current *Cycle 6* release of the OT is configured for the present capabilities of ALMA as described in the Cycle 6 Call For Proposals. Note that in order to submit proposals you will have to register with the ALMA Science Portal beforehand.

Download & Installation

The OT will run on most common operating systems, as long as a **64-bit version of Java 8** is installed (see the troubleshooting page if you are experiencing Java problems). The ALMA OT is available in two flavours: Web Start and tarball.

The **Web Start** application is the recommended way of using the OT. It has the advantage that the OT is automatically downloaded and installed on your computer and it will also automatically detect and install updates. There are some issues with Web Start, particularly that it does not work with the Open JDK versions of Java such as the "Iced Tea" flavour common on many modern Linux installations. The Oracle variant of Java should therefore be installed instead. If this is not possible, then the tarball installation of the OT is available.

The **tarball** version must be installed manually and will not automatically update itself, however there should be no installation issues.

Webstart Tarball

Documentation

Extensive documentation is available to help you work with the OT and optimally prepare your proposal:

- If you are a novice OT user you should start with the **OT Quickstart Guide**, which takes you through the basic steps of ALMA proposal preparation.
- Audio-visual illustrations of different aspects of the OT can be found in the **OT video tutorials**. These are recommended for novices and advanced users alike.
- More in-depth information on the OT can be found in the **User Manual**, while concise explanations of all fields and menu items in the OT are given in the **Reference Manual**. These two documents are also available within the OT under the Help menu.

Troubleshooting

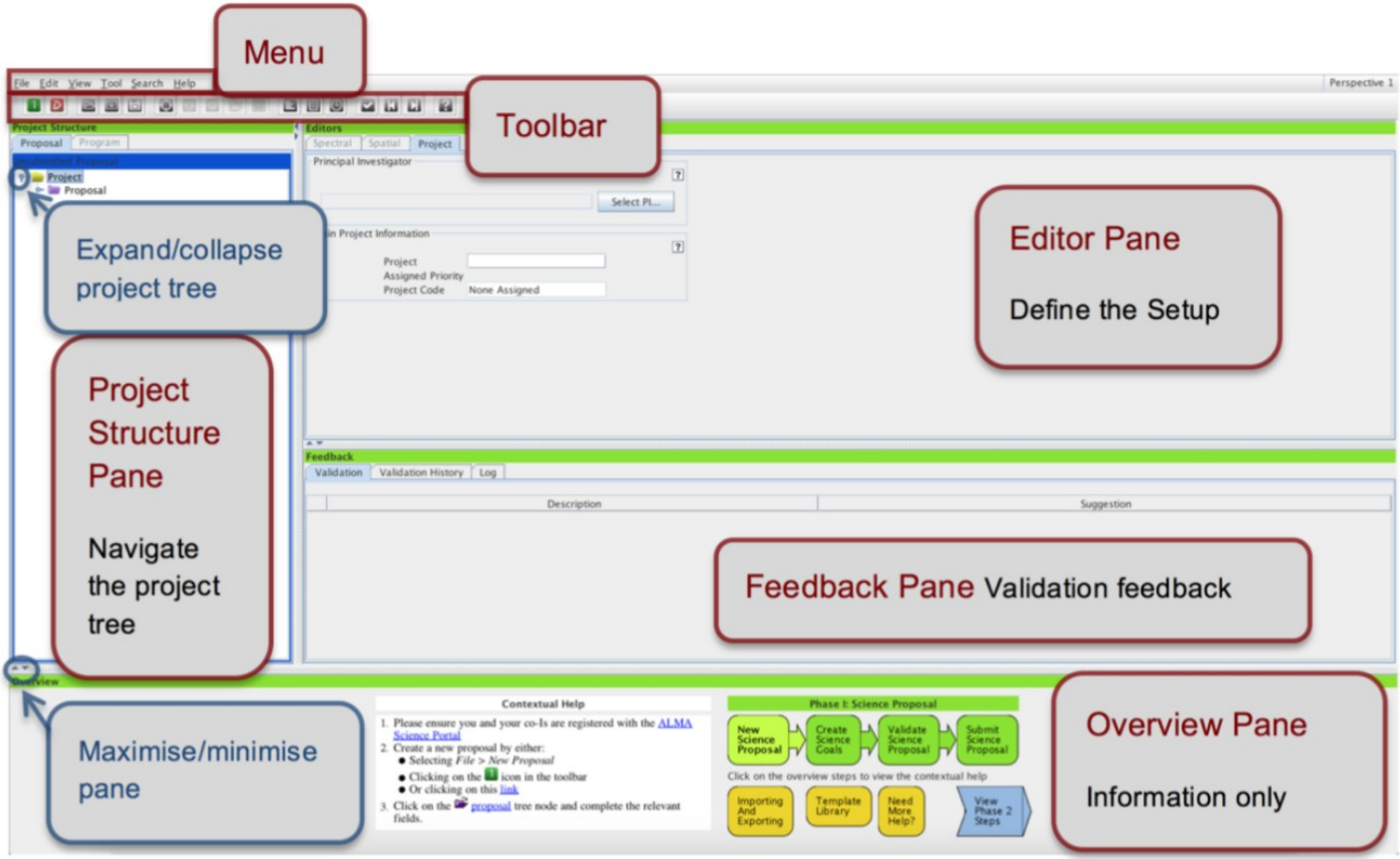
If you have problems with the installation and/or startup of the OT, please see the troubleshooting page. A list of currently known bugs, their status and possible workarounds can be found on the regularly updated **known OT Issues** page. A further source of information is the OT section of the ALMA Helpdesk Knowledgebase - this contains a number of articles that deal with frequently-asked questions. After exploring these resources, if confusion over some aspect of the OT remains, or if a previously unidentified bug has been uncovered, please file a Helpdesk ticket.

Phase 1 : Observing tool

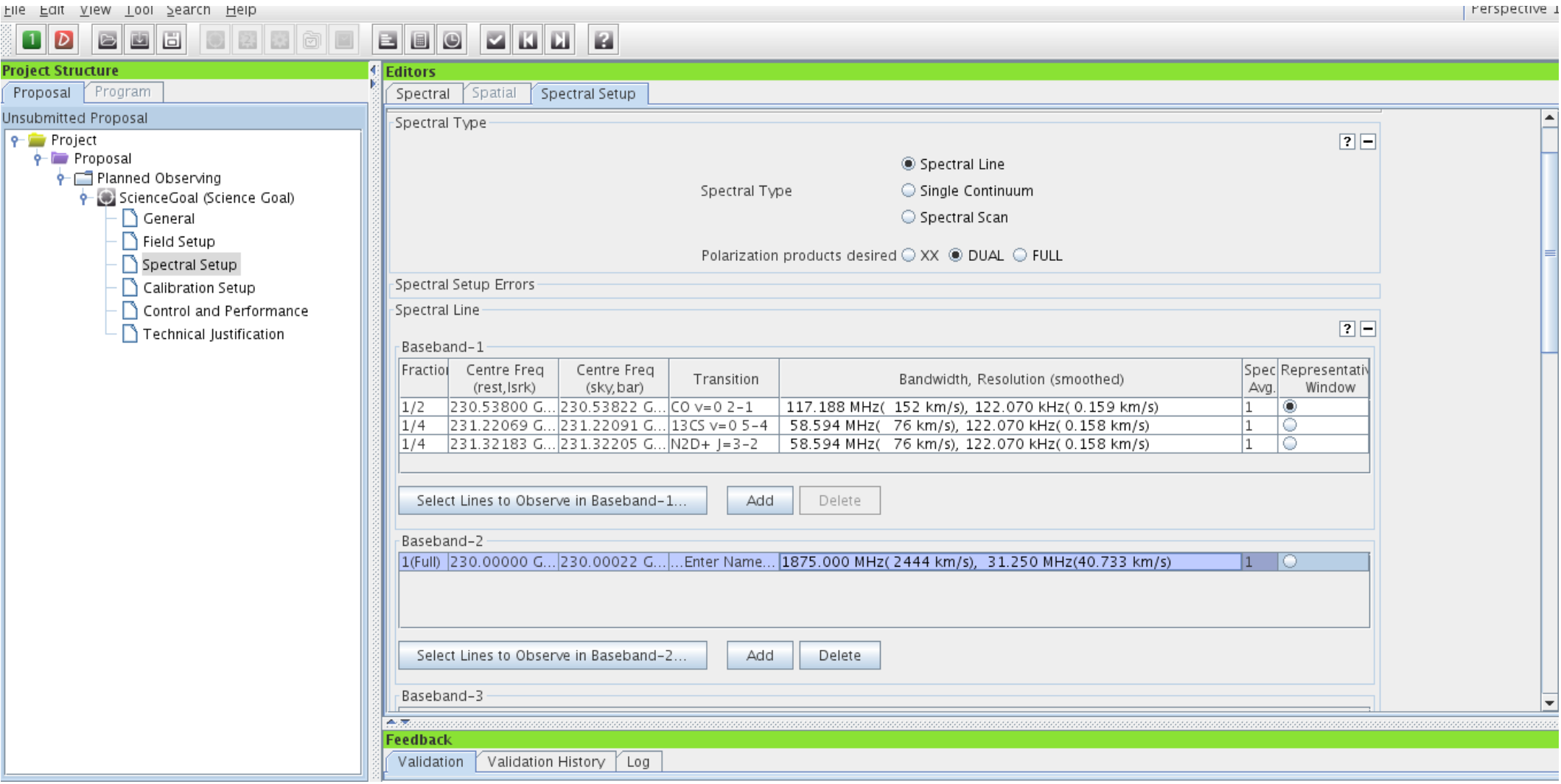
- Java too mandatory to prepare and submit the proposal
- Need the **right java version** (not always the latest, check the documentation!)
- **DO NOT START AT THE LATEST MOMENT**

- Doc : Alma Observing Tool Quickstart Guide
- Troubleshooting page

Phase 1 : Observing tool



Phase 1 : Observing tool



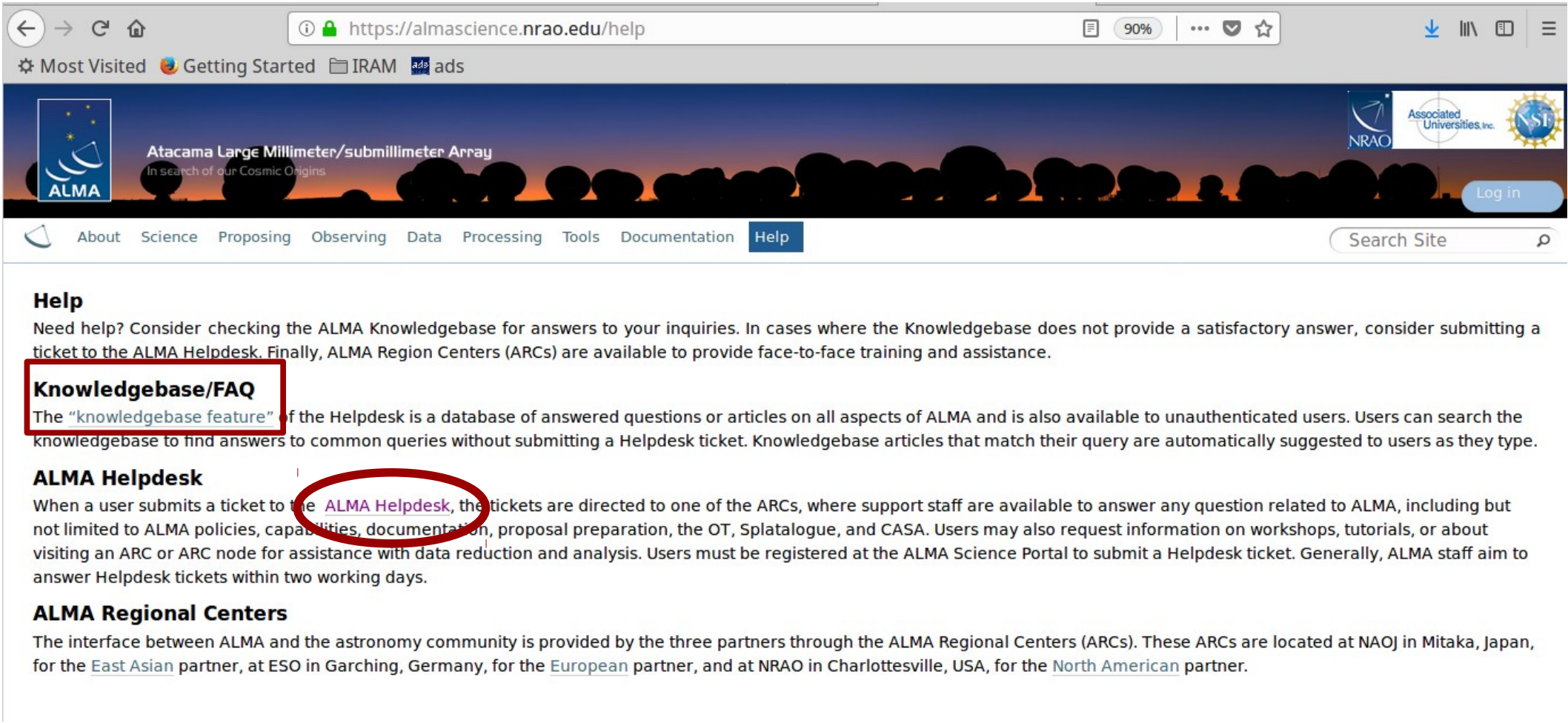
Phase 1 : Observing tool

In case of any problem, do not hesitate to

- Write to the **helpdesk** (recommended)
  Access through the science portal
- **Write to the ARC node**

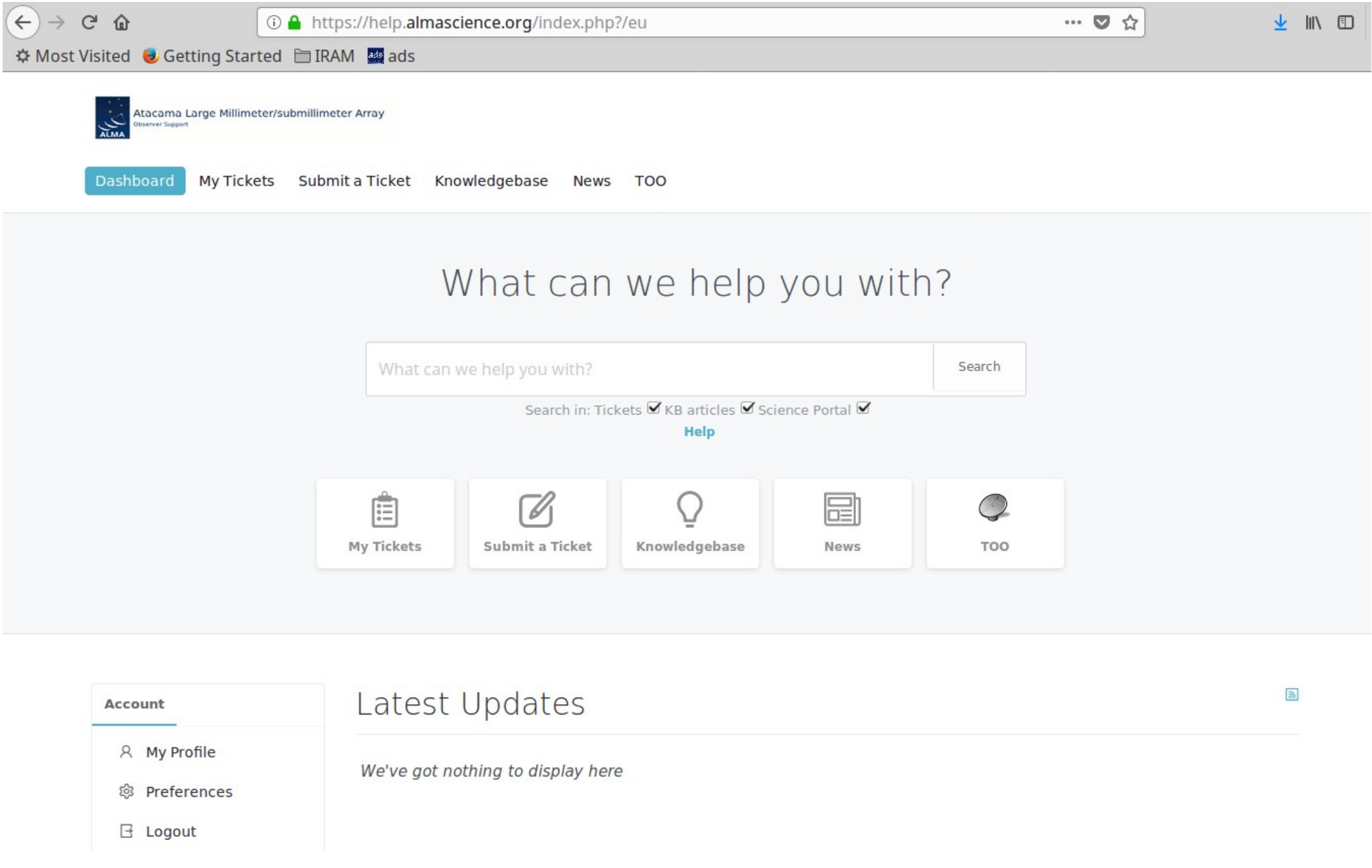
DO NOT WAIT FOR THE LAST MOMENT!

Phase 1 : Helpdesk



Need the science portal user account

Phase 1 : Helpdesk



Phase 2 : You get time !

Result of the APRC by end of July

Goal of Phase 2 : generate the observation scripts

Has evolved from cycle to cycle

- By batch along the years prior to cycle 3
- Hard deadline around Sept 6 since cycle 4
- PI generate the SB up to cycle 4
- PI review the phase1 material since cycle 5

SB are generated by ARC (P2G members)

Check the documentation / helpdesk

Phase 2 : in practice

- You will receive the result of APRC by mail by end of July
- A CS will be assigned to each of your projects
- An helpdesk ticket will be created for each of your projects → email
- **OT version for phase 2** should be ready in the following days
- “Open from archive” your project → under the “Program” tab
- Review your material (source coordinates, mosaic, spectral setup) and submit by the deadline

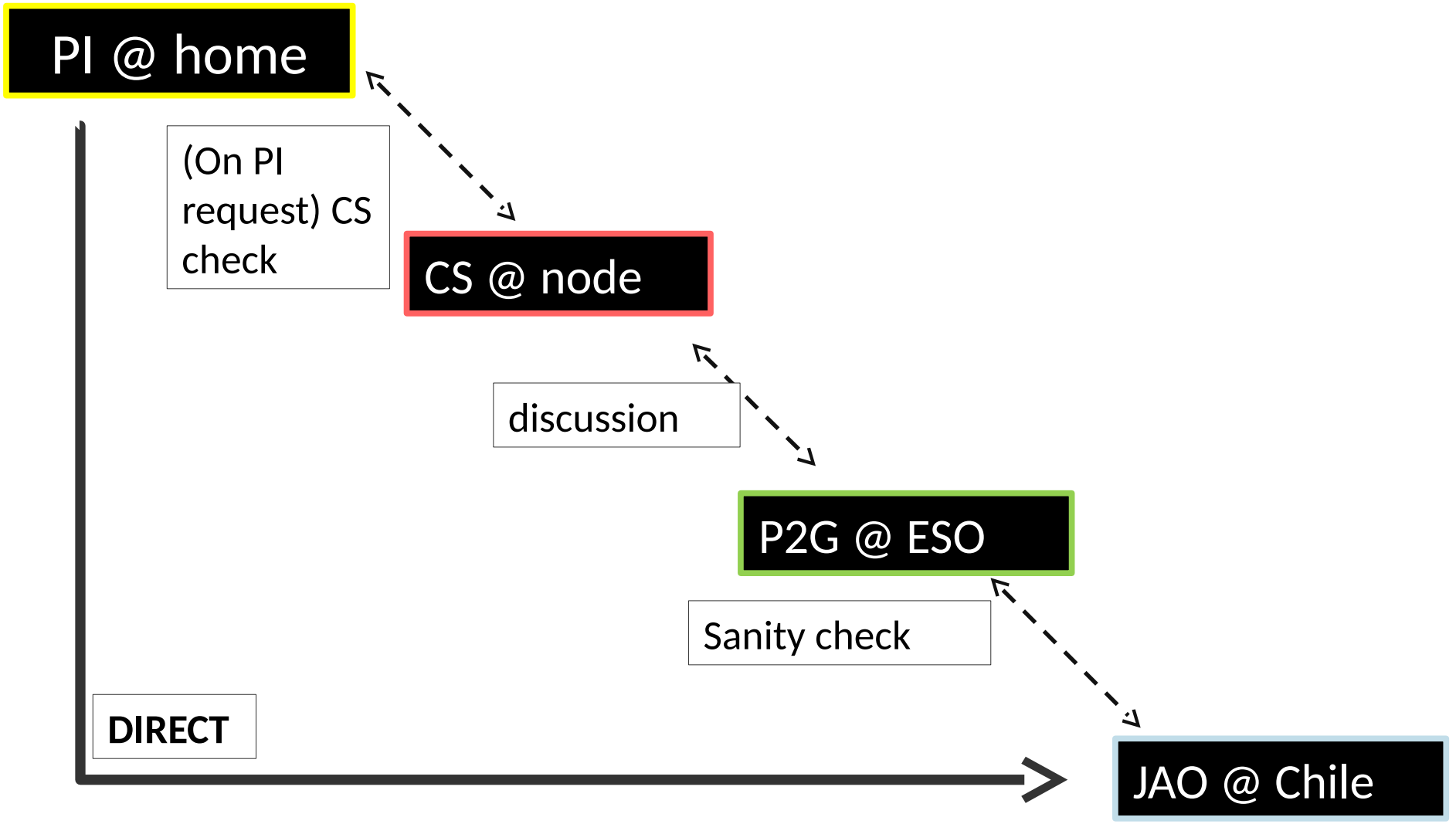
Phase 2 : in practice

- Inform your CS via the helpdesk of any peculiar need (e.g. new time constraint)
- For TP observation, give OFF positions

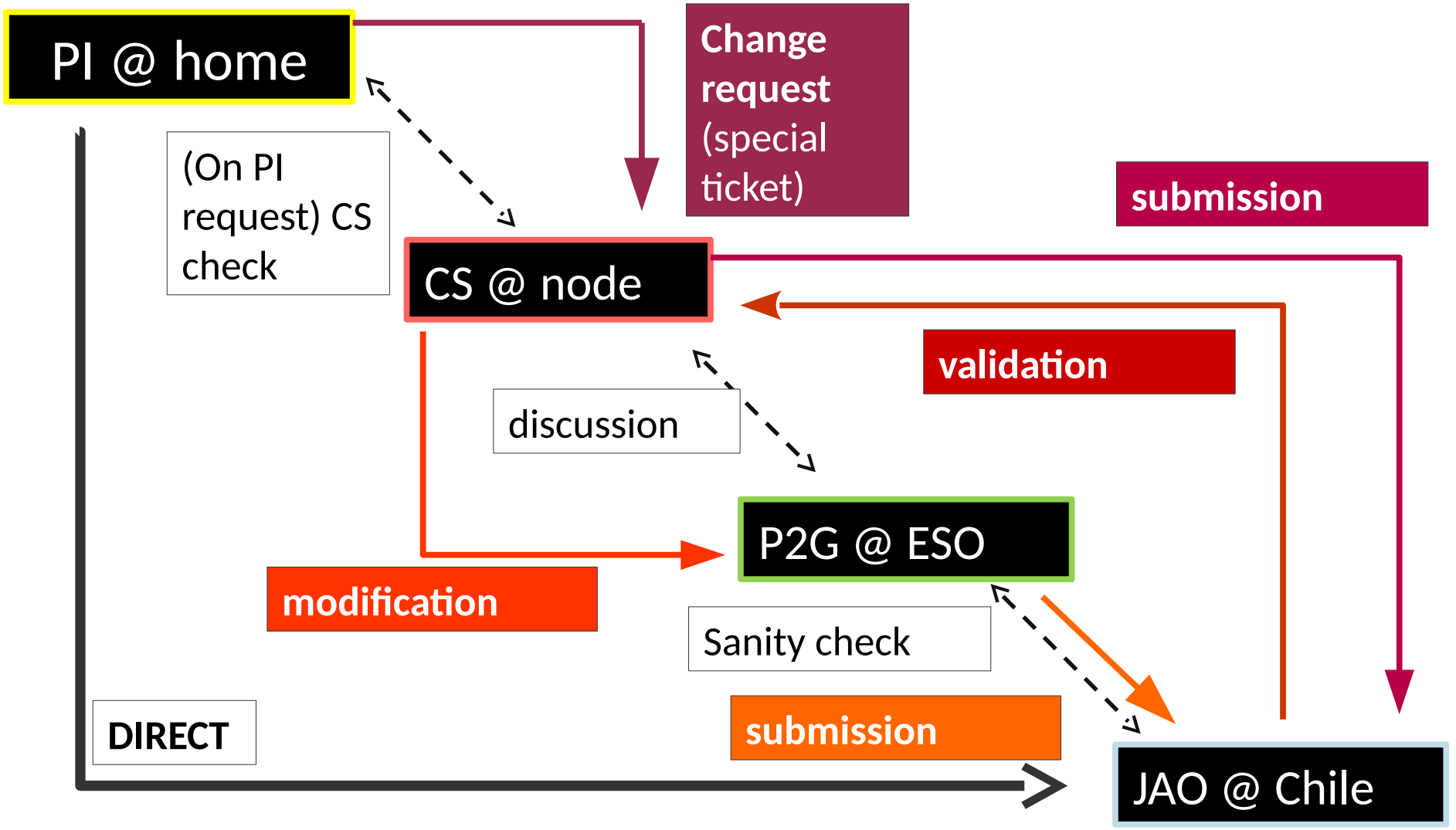
- Possibility to delegate
- Doc : Phase 2 Quickstart Guide
  Video tutorial

- Submission with the OT by the deadline
  HARD DEADLINE, PROJECT COULD BE DOWNGRADED

Phase 2 : in practice



Phase 2 : in practice



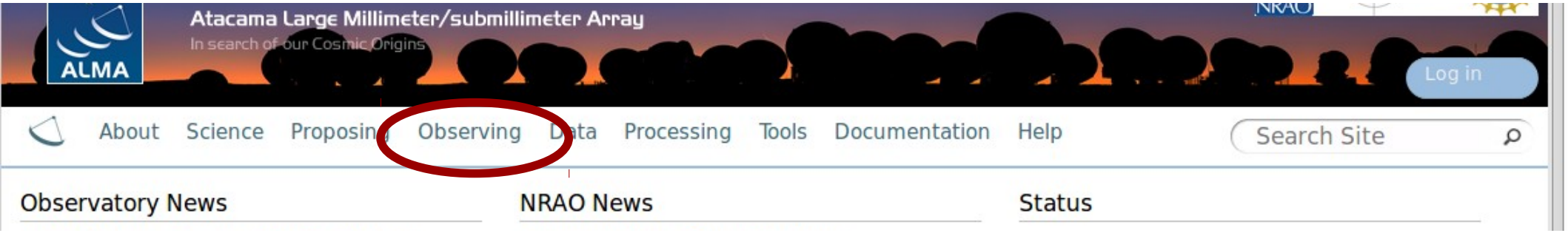
Phase 2 : in practice

If you have question, do not hesitate to

- **Consult**
  - Troubleshooting page
  - Known OT issue
- Write to the **helpdesk** (recommended)
- **Contact an arc node**

Project status

- Antennas configuration spread along the year
- Informations under the “Observing” tab on the Science Portal
  - ALMA status page
  - Configuration schedule
  - SnooPI



Project status : Project tree

Science Goal (SG)
- Group Observing Unit set (GOUS)
  - Member OUS (MOUS)
    - Science Block (SB)
      - Execution Block (EB)

SG : [source(s) + freq. setup]
GOUS : include several ant.conf.
MOUS : [source(s) + freq. setup + 1 ant.conf.]
SB : smallest unit for observing
EB : actual observation of 1 SB

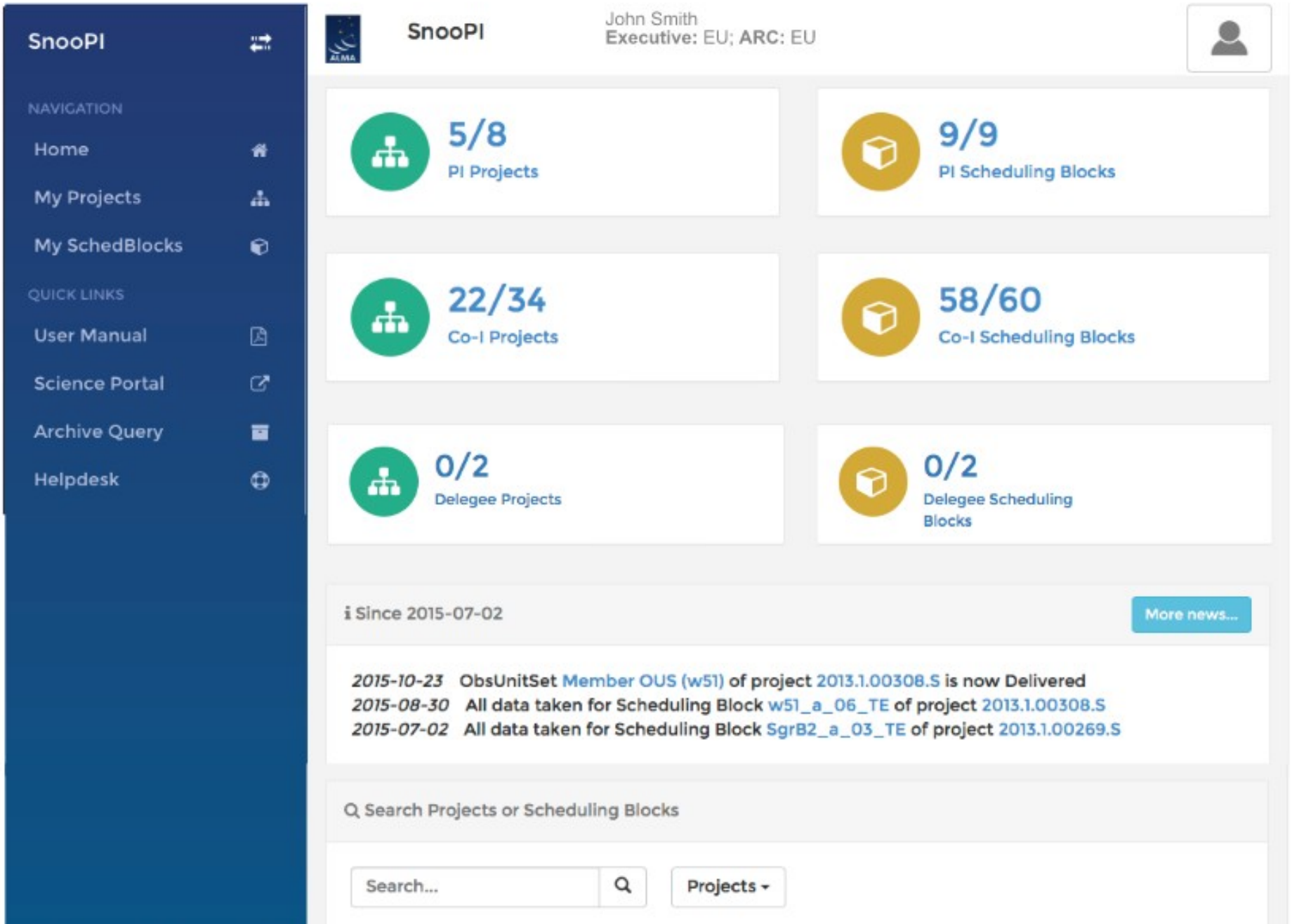
EB are limited to 2h long → several EB / SB

Project status : observation life

For each SB (i.e. 1 freq /source/ant.conf),

- 1 observation = 1 EB, first status = “READY”
- After each EB : **QA0** (sanity check)
- When the requested # of QA0 EB is reached → “fullyObserved”
- Then go to **QA2**
  - Standard projects calibration with the pipeline at JAO
  - Others calibrated “by hand” mainly at ARC (nodes)
  - Images done by pipeline in most of the case
  - DRM (Data Reduction Manager) at ARC decides if it is PASS or FAIL
- If FAIL go back to the observation queue
- If PASS delivered to PI status “delivered”

Project status : SnooPI



Project status : SnooPI

Click on a SB → details of the EB

access to the QA0 report / EB

QA2 report for the SB

After observation

One of your SB is delivered (i.e. not necessary all your project!)

Proprietary period start the day of delivery, i.e. it is **different for each SB**

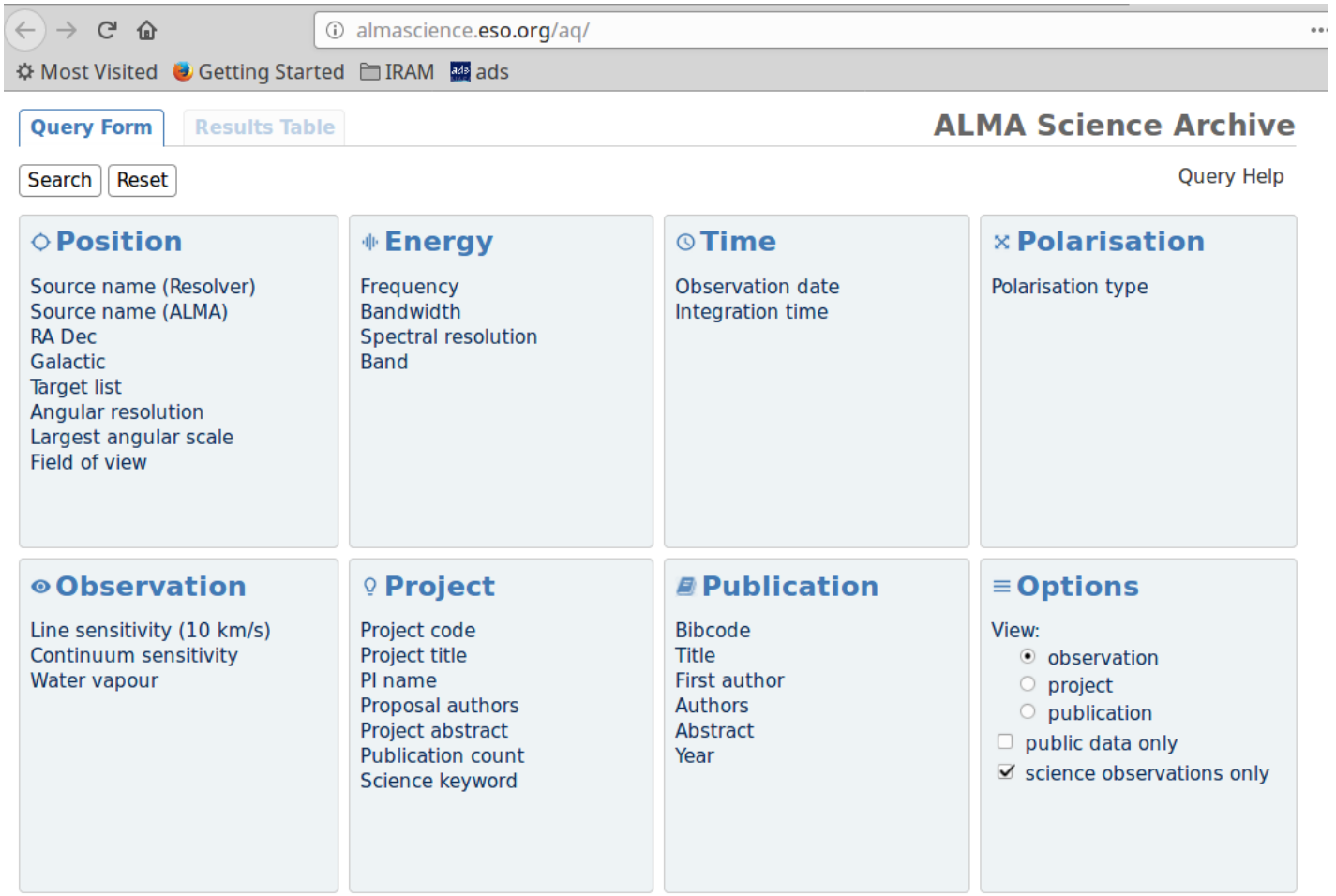
Delivered data consist of :

- Raw data (asdm format)
- Calibration and imaging “scripts” used for the QA2
- Weblog / plots made during the manual QA2
- Images
- Calibration tables

Your data

Need to go to the archive

- Link in the delivery email
- Search in the archive “download request”



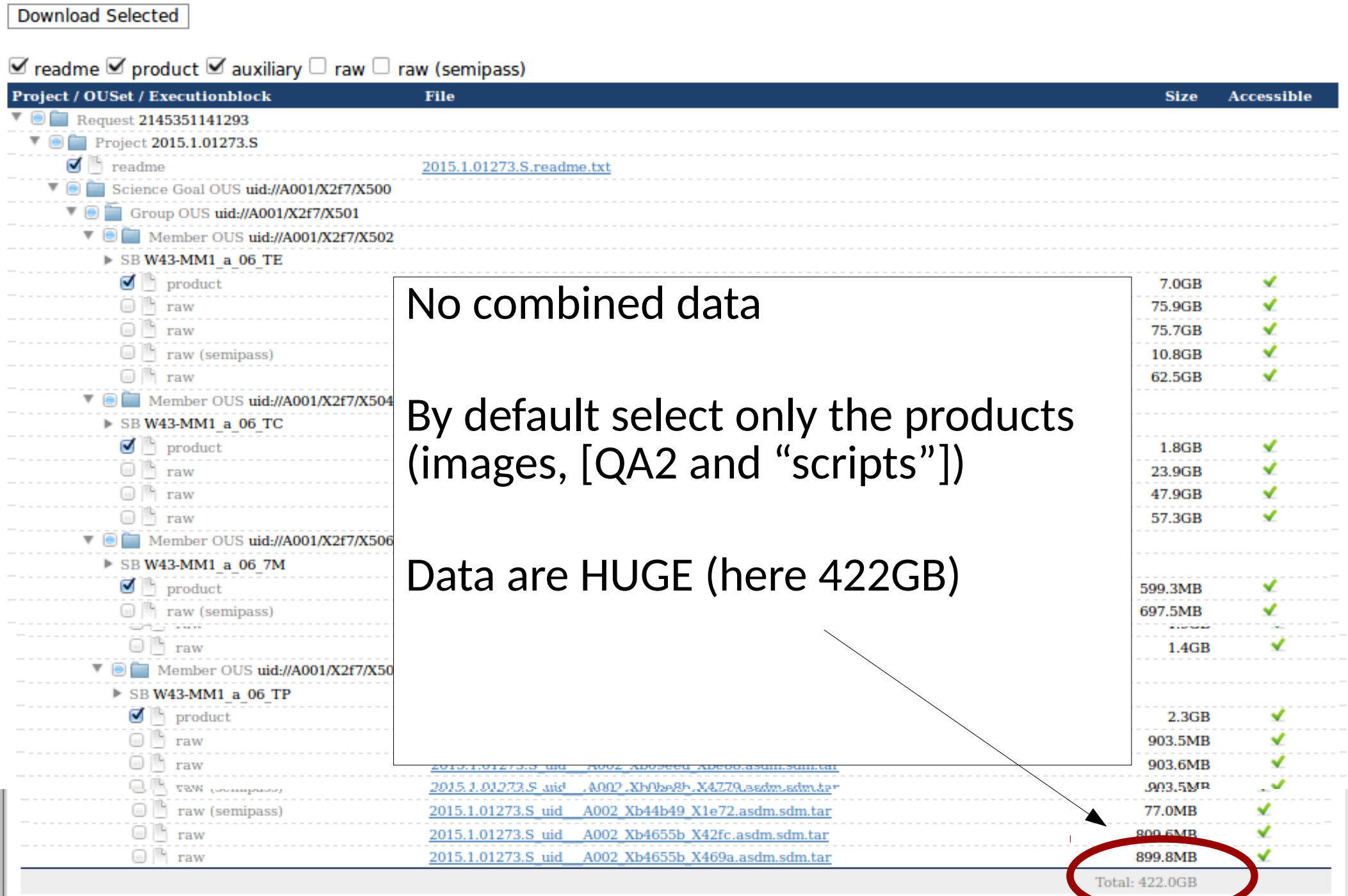
Your data

Download Selected

☑ readme ☑ product ☑ auxiliary ☐ raw ☐ raw (semipass)

Project / OUSet / Executionblock	File	Size	Accessible
Request 2145351141293			
Project 2015.1.01273.S			
☑ readme	2015.1.01273.S.readme.txt		
Science Goal OUS uid://A001/X2f7/X500			
Group OUS uid://A001/X2f7/X501			
Member OUS uid://A001/X2f7/X502			
SB W43-MM1_a_06_TE			
☑ product	2015.1.01273.S_uid___A001_X2f7_X502_001_of_001.tar	7.0GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb372db_X237e.asdm.sdm.tar	75.9GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb3c4ab_X124d.asdm.sdm.tar	75.7GB	✓
☐ raw (semipass)	2015.1.01273.S_uid___A002_Xb3cc45_X1265.asdm.sdm.tar	10.8GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb3cc45_X1353.asdm.sdm.tar	62.5GB	✓
Member OUS uid://A001/X2f7/X504			
SB W43-MM1_a_06_TC			
☑ product	2015.1.01273.S_uid___A001_X2f7_X504_001_of_001.tar	1.8GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xae5b1d_X2ae0.asdm.sdm.tar	23.9GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xae5b1d_X2d2c.asdm.sdm.tar	47.9GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xae6c13_X1768.asdm.sdm.tar	57.3GB	✓
Member OUS uid://A001/X2f7/X506			
SB W43-MM1_a_06_7M			
☑ product	2015.1.01273.S_uid___A001_X2f7_X506_001_of_001.tar	599.3MB	✓
☐ raw (semipass)	2015.1.01273.S_uid___A002_Xb10f33_Xdb49.asdm.sdm.tar	697.5MB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb51110_Xa38.asdm.sdm.tar	1.4GB	✓
Member OUS uid://A001/X2f7/X50a			
SB W43-MM1_a_06_TP			
☑ product	2015.1.01273.S_uid___A001_X2f7_X50a_001_of_001.tar	2.3GB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb09eed_Xba2a.asdm.sdm.tar	903.5MB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb09eed_Xbe88.asdm.sdm.tar	903.6MB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb0be8b_X4779.asdm.sdm.tar	903.5MB	✓
☐ raw (semipass)	2015.1.01273.S_uid___A002_Xb44b49_X1e72.asdm.sdm.tar	77.0MB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb4655b_X42fc.asdm.sdm.tar	809.6MB	✓
☐ raw	2015.1.01273.S_uid___A002_Xb4655b_X469a.asdm.sdm.tar	899.8MB	✓
		Total: 422.0GB	

Your data



No combined data

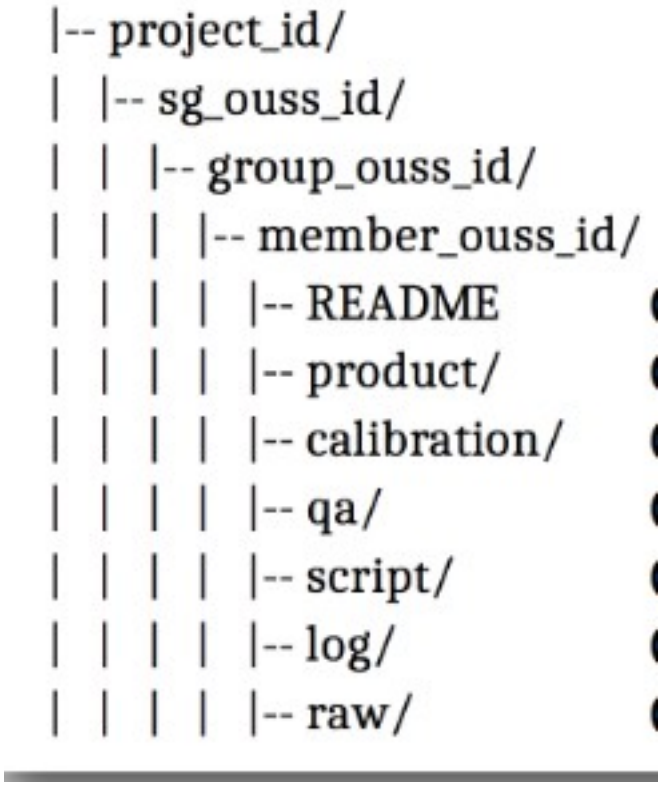
By default select only the products (images, [QA2 and “scripts”])

Data are HUGE (here 422GB)

Your data

“packaging” slightly change from one cycle to other (README content, “auxiliary” files...)

Structure of the delivery data :



Your data

- **Recommended** : **to check the calibration** (QA2 report / weblog), and/or redo imaging

- You need to rerun the calibration scripts to have the calibrated visibilities, using the **SAME CASA version** used by the QA2 (not always the same for all SB)
  The script “scriptForPI.py” call all others and hide details

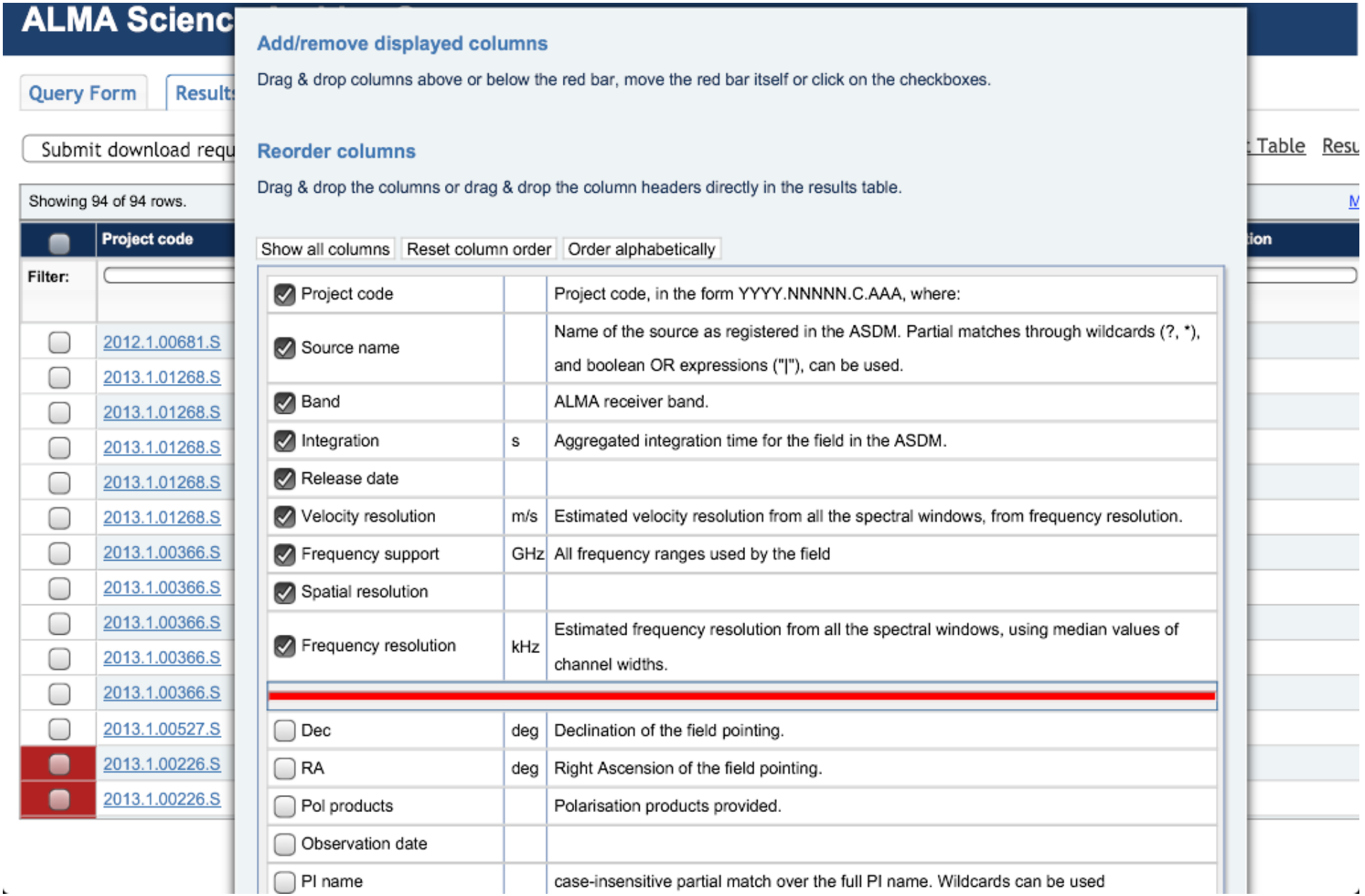
- DISK SPACE : rule of thumb **10-20 times** the raw data

Your data

To got some help :

- CASA guides casaguides.nrao.edu
- Question via the **helpdesk** (ticket directed to CS or ARC/JAO people)
- Do a **F2F visit in an ARC node** (you can chose a different node from your CS or “standard” affiliation)
- In case of problem, ask for re-reduction and/or re-observation via the helpdesk = **QA3**

Your data / data-mining



Your data / data-mining

- Exactly the same data as the PI
  (same structure, same scripts)

- **Do not believe blindly the data delivery !**
  - Calibration problem
  - Too much flagging
  - Quick and dirty imaging (if human processed)
  - …

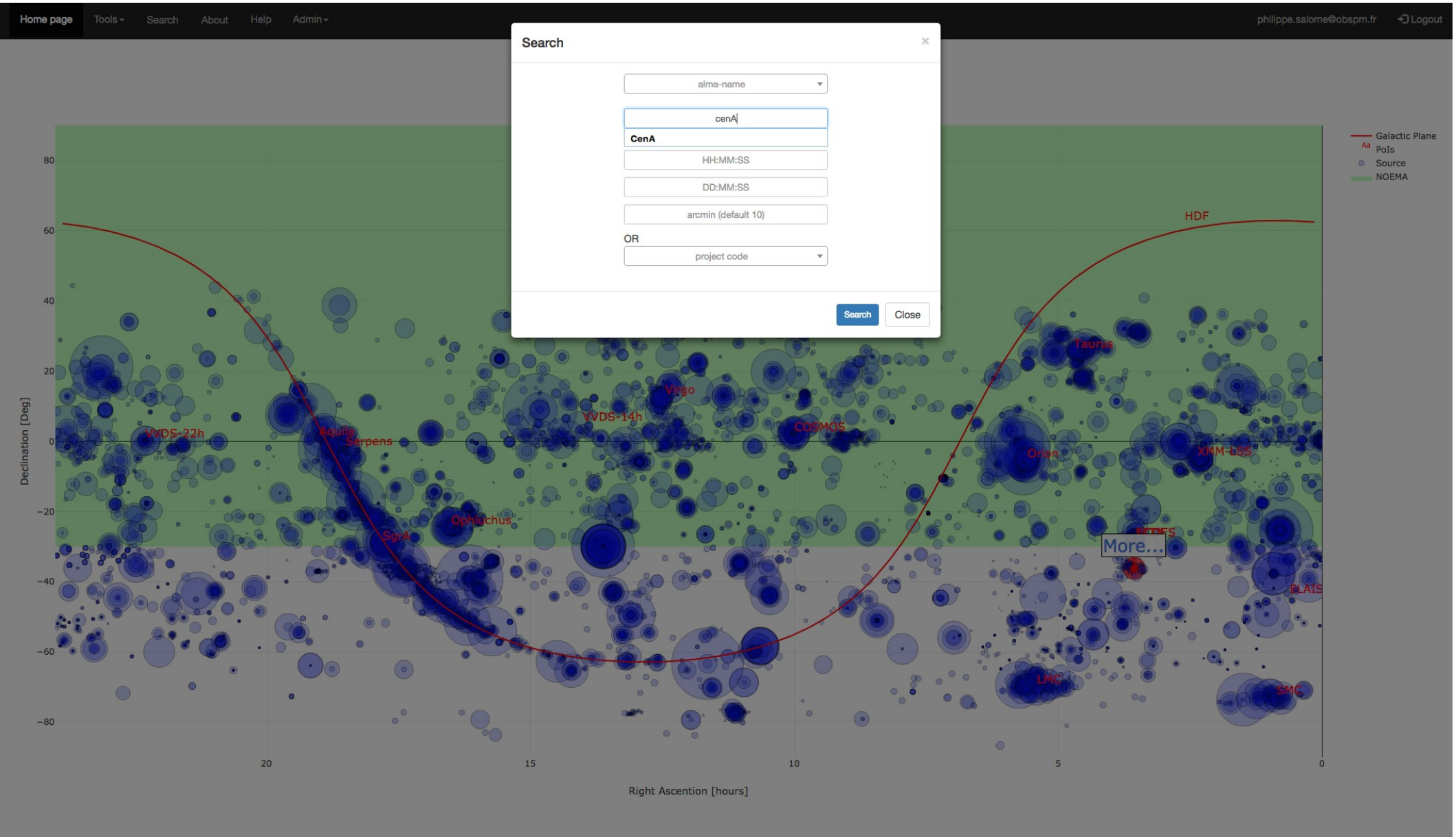
Artemix

an ALMA data mining
experiment prototype

Artemix

- Explore the public data of the ALMA archive
- Goal :
  - Search by product (not instrument configuration)
  - Provide trans-project queries
  - Rapid idea of the data content (fits file)
- Means :
  - ALMA meta data (observing configuration preview)
  - ALMA cube preview (QA2 products)
- Developed by P. Salome, M. Caillat, L. Loria & N. Kasradze (Obs. Paris LERMA)
- Similar tools : CARTA (PI: Erik Rosolowsky)
  Japanese Virtual Observatory

Artemix


Home page
Tools
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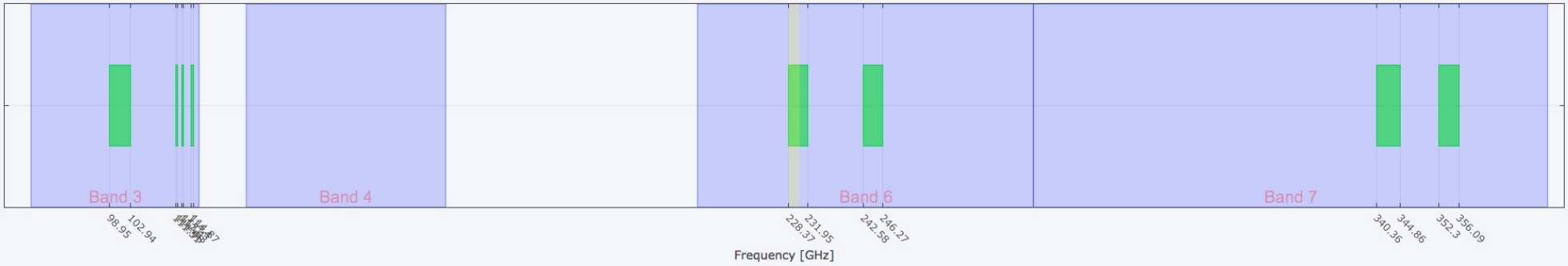
Admin
philippe.salome@obspm.fr
Logout
Search
alma-name
cenA
CenA
HH:MM:SS
DD:MM:SS
arcmin (default 10)
OR
project code
Search
Close
Galactic Plane
PoIs
Source
NOEMA
HDF
Taurus
Virgo
VVDS-14h
VVDS-22h
Aquila
Serpens
COSMOS
Orion
XMM-LSS
Ophiuchus
SgrA
More...
ELAIS
LMC
SMC
Declination [Deg]
Right Ascention [hours]
80
60
40
20
0
−20
−40
−60
−80
20
15
10
5
0

Artemix

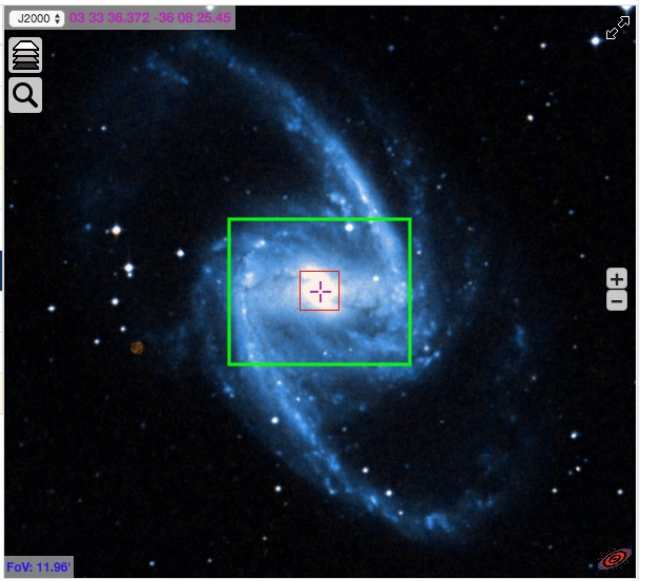
Home page | Tools | About | Help | Admin | philippe.salome@obspm.fr | Logout



Redshift | Velocity (km/s) | All Info

Show all data. Initially shown are the data of which the filename ends with ".pbcor.fits", ".pbcorr.fits", ".image.fits", "line.fits", "cont.fits" or "clean.fits"

#	Fits file	Target	RA	DEC	Cube size	Freq. range	Proj. code	uid
1	Info	NGC1365	03:33:36.38	-36:08:25.70	2916x2560x10	246.011 --- 245.864	2013.1.01161.S	uid://A001/X12f/X321
2	Info	NGC1365	03:33:36.38	-36:08:25.70	2916x2560x30	229.066 --- 229.506	2013.1.01161.S	uid://A001/X12f/X321
3	Info	NGC1365	03:33:36.38	-36:08:25.70	2916x2560x1	228.458 --- 246.218	2013.1.01161.S	uid://A001/X12f/X321
4	Info	NGC1365	03:33:36.38	-36:08:25.70	2916x2560x10	230.572 --- 230.718	2013.1.01161.S	uid://A001/X12f/X321
5	Info	NGC1365	03:33:36.38	-36:08:25.70	2916x2560x11	243.714 --- 243.553	2013.1.01161.S	uid://A001/X12f/X321
6	**Info**	**NGC1365**	**03:33:36.38**	**-36:08:25.70**	**1344x864x500**	**228.4 --- 230.323**	**2013.1.01161.S**	**uid://A001/X12f/X319**
7	Info	NGC1365	03:33:36.38	-36:08:25.70	216x216x497	228.444 --- 230.355	2013.1.01161.S	uid://A001/X12f/X31b
8	Info	NGC1365	03:33:36.99	-36:08:36.33	2048x1500x121	229.064 --- 229.523	2013.1.01161.S	uid://A001/X12f/X317
9	Info	NGC1365	03:33:36.99	-36:08:36.33	2048x1296x1	229.837 --- 246.192	2013.1.01161.S	uid://A001/X12f/X317



Artemix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Tools
0-10000
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Admin
philippe.salome@obspm.fr
Logout
uid___A002_Xa16f89_X2a8c.ms.split.cal.image.spw0.co21.image.pbcor.fits - OBJECT = NGC1365 - NAXIS = 4 - NAXIS1 = 2048 - NAXIS2 = 1500 - NAXIS3 = 121 - NAXIS4 = 1 etc.
Channel 0 (Jy/beam) -300 km/s 229.5232 GHz
B: 0.8x0.6 PA -88°
Flux density(Jy/beam)
Brightness temperature (K)
Frequency (GHz) LSRK
Averaged Spectrum
1252.4141 (Jy . km / s)
Area(Jy / beam . km / s)
Absolute coordinates
Integrated Flux (Jy)
Velocity (km/s) LSRK

Artemix

- Prototype, under development
- Need to create an user account
- Web-based tool, no local download
  - Rapid check of the archive
- No reprocessing :
  - Only the images done in QA2 (not all spw in early science)
  - Could be affected by errors (e.g. wrong frame for the oldest images)
    → do not hesitate to give feedback

http://artemix.obspm.fr/

CASA-GILDAS filler

CASA-GILDAS filler

To have a gateway to be able to :

- **View and analyze** images
  - from CASA into GILDAS
  - from GILDAS into CASA
- Make operations on **visibilities**
  - from CASA with GILDAS (not straightforward)
  - From GILDAS with CASA
- Thanks to (UV)FITS
- Calibration is done in the corresponding software (CASA for ALMA, GILDAS/CLIC for NOEMA)

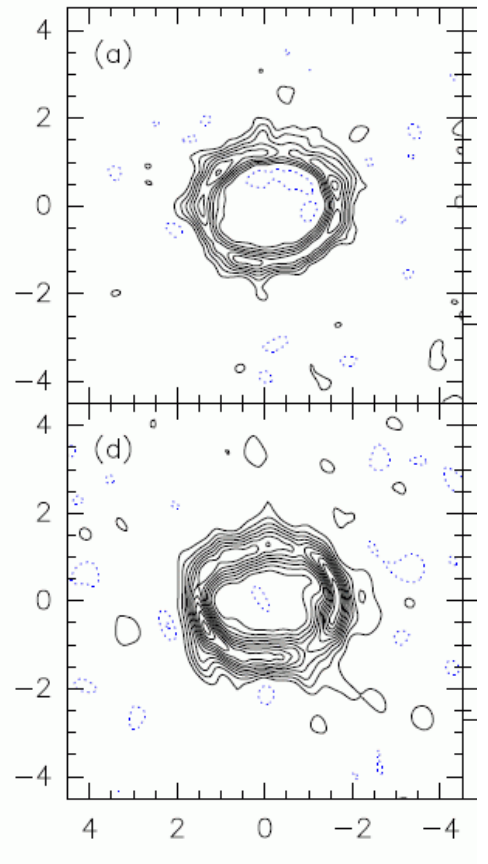
CASA-GILDAS filler

Import/export images

Import/export calibrated uv-data for imaging

Why in GILDAS?

- Analysis of data coming from different instruments
- Imaging faster (and better in some cases)
- Access to specific data reduction and analysis tools
- Short-spacing inclusion: 30m+ALMA
- Publication-quality plots



GG Tau
0.45 mm ALMA, 1.3 mm PdBI
Dutrey et al. Nature, 2015

CASA-GILDAS filler

IRAM Memo 2014-?

From CASA to GILDAS
I - GILDAS Data Format Version 2

S. Guilloteau[1], E. Chapillon[1,2], F. Gueth[2], G. Dumas[2],
A. Lopez Sepulcre[2], K.T. Wong[2]
1. LAB (Bordeaux) 2. IRAM (Grenoble)

January 5, 2018– version 2.2

Abstract

With the advent of ALMA, IRAM users may prefer at some point to handle their ALMA data in GILDAS rather than in CASA[1], vice versa to handle IRAM data into CASA. This document describes the different ways to do so, and what are the benefits and limitations of

CASA-GILDAS filler

- Documentation:

IRAM ARC node website :
www.iram.fr/IRAMFR/ARC
www.iram.fr/IRAMFR/ARC/documents/filler/casa-gildas.pdf

- Contact : **arc@iram.fr**

Do not hesitate to contact us