NOEMA

The mm-interferometer for the Northern Hemisphere

Ana López Sepulcre

iram
Institut de Radioastronomie Millimétrique

x12
NOEMA
project

ERIS - 21 September 2022

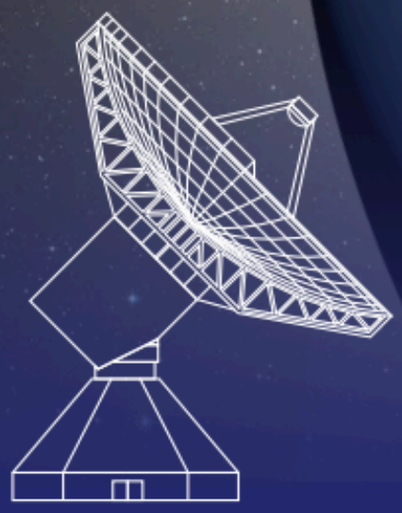
IRAM

Institut de **R**adio **A**stronomie **M**illimétrique

IRAM Headquarters
Grenoble, France

NOEMA
Hautes-Alpes, France

30-meter telescope
Sierra Nevada, Spain



The 30-meter telescope

NOEMA

- International radio astronomy research institute.
- Founded in 1979 by scientific institutions from France, Germany, and Spain.
- Two nodes: **Grenoble** (FR) and **Granada** (ES).
- More than 120 researchers, engineers, technicians, and administrative staff.
- Development and management of two observatories: the **30-m** telescope and the interferometer **NOEMA**.

OUTLINE

1. The NOEMA interferometer
    - Brief history and description
    - Current capabilities
    - Planned upgrades
2. How to use NOEMA
    - Proposing for NOEMA time
    - Observations
    - Data reduction

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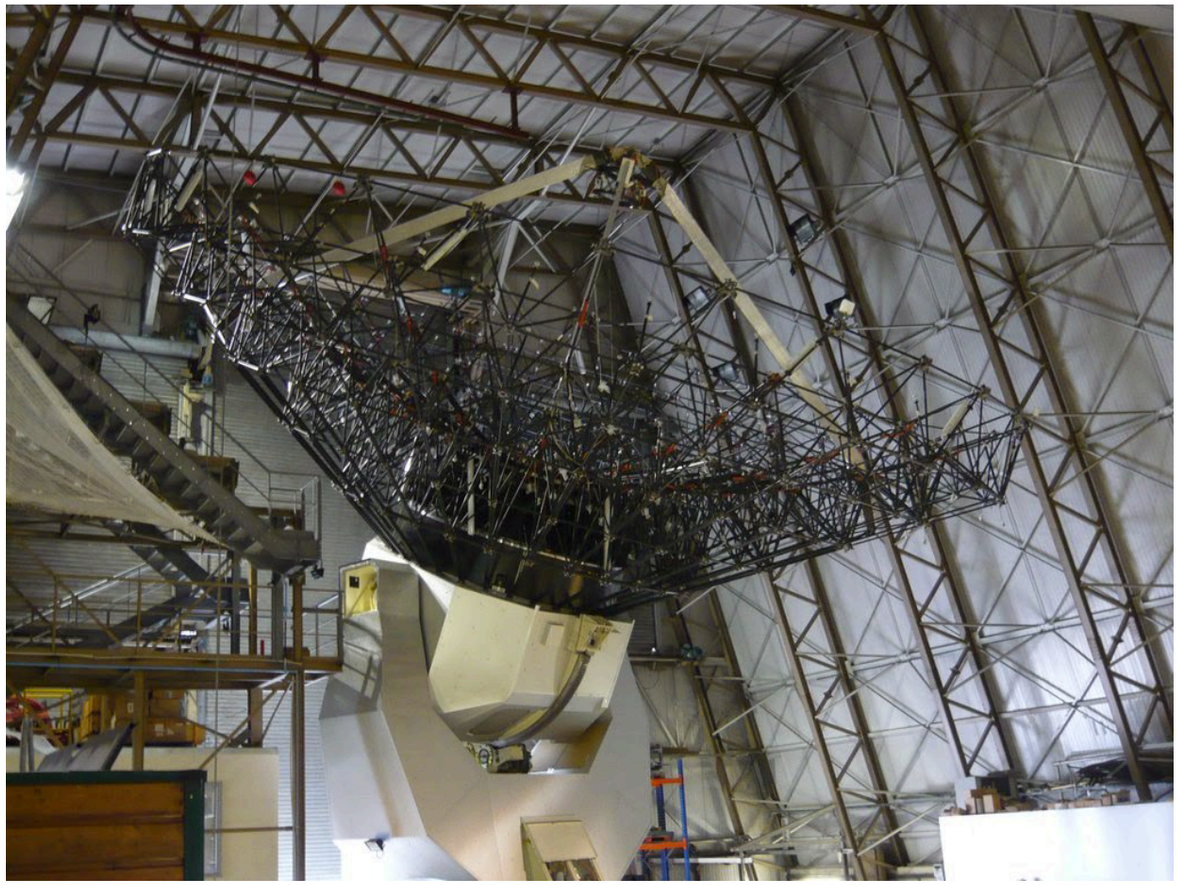
The NOEMA interferometer

NOrthern **E**xtended **M**illimeter **A**rray

- Successor of the Plateau de Bure Interferometer (6 antennas)
- Currently 12 15-m antennas in operation
- Millimetre-wavelength science

Everything is built in-house: antennas, receivers, correlator(s), software

Official inauguration of the 1st NOEMA antenna (from left to right): Bertrand Gautier (PdB station manager), Karl Schuster (IRAM Director), Reinhard Genzel (MPE Director), Richard Bonneville (French Ministry for Research), Martin Stratmann (MPG President), Klaus Ranner (Consul General of the Federal Republic of Germany), David Musial (German Ambassy), Pascale Delecluse (INSU Director), Denis Mourard (INSU Vice Director), Brigitte Indigo (IRAM), Jesus Gomez-Gonzalez (Vice Director Spanish IGN), Markus Schleier (MPG), Linda Tacconi (IRAM SAC Member), Susanne Wasum-Rainer (Ambassadress of the Federal Republic of Germany), Milda Krasauskaite (MPG). © Edyta Tolwinska



176 panels cover the parabola
Surface precision of 40 micron


Feb 2015


May 2016


May 2017

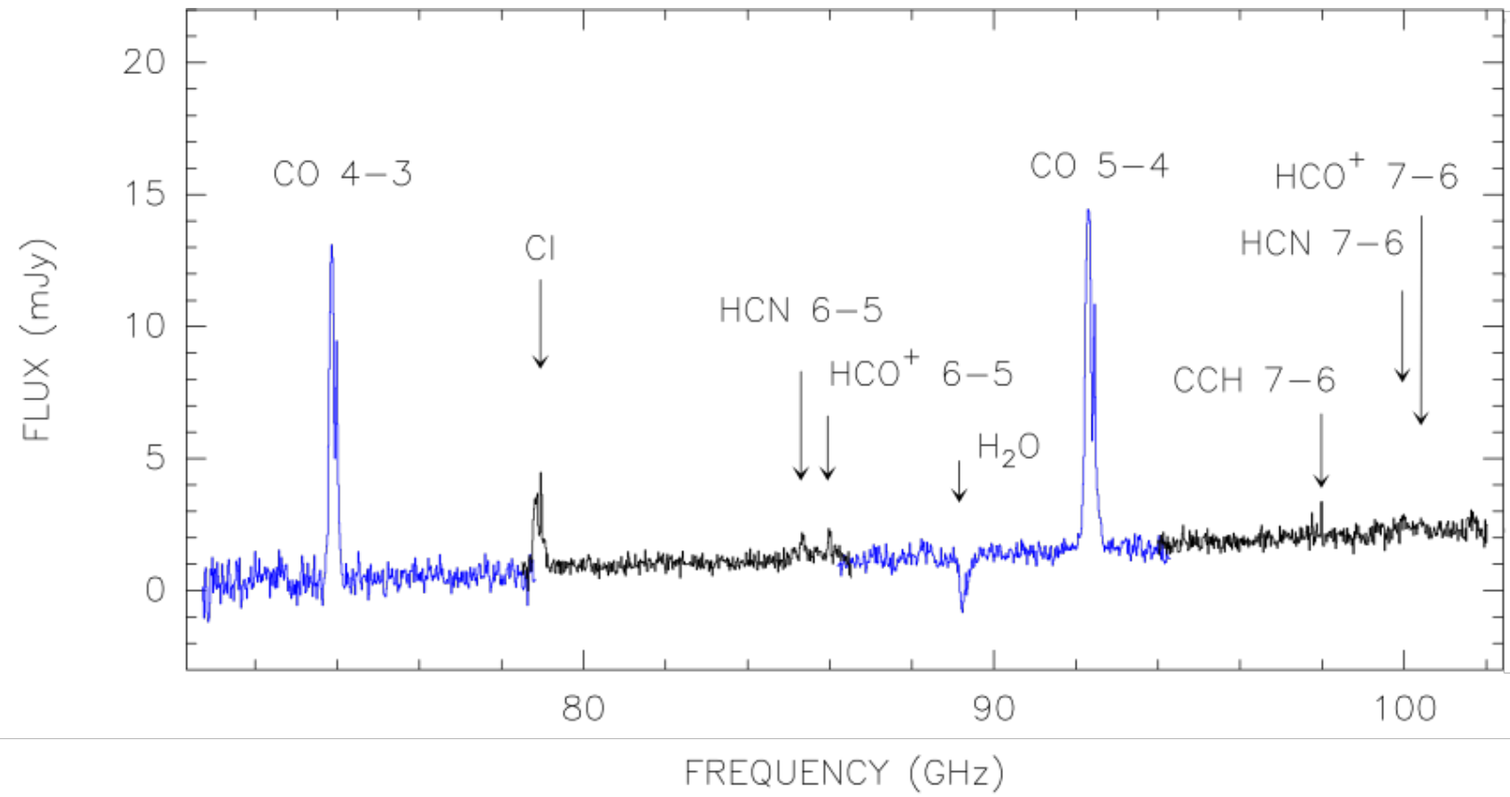

Feb 2018

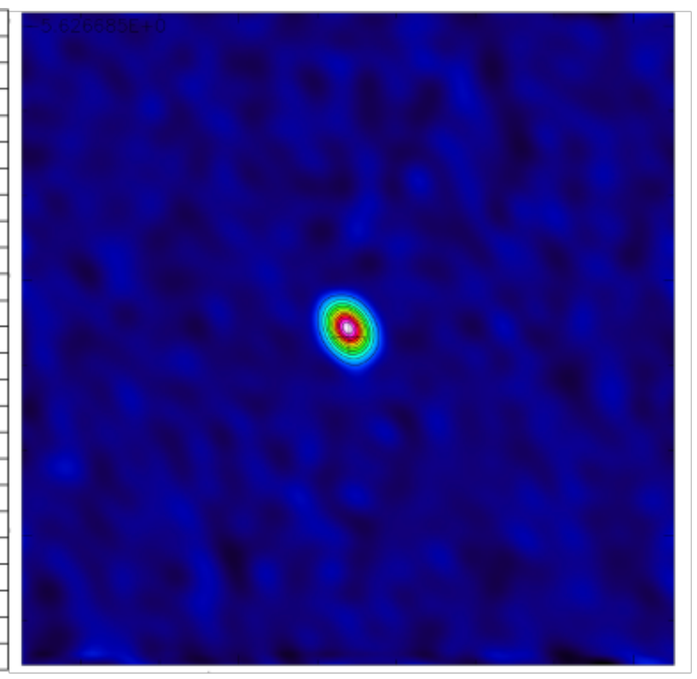

Jan 2021


Jan 2022

NOEMA capabilities

- Collecting area of a 52m telescope
- Three frequency bands: B1 (70-116 GHz), B2 (127-179 GHz), B3 (200-276 GHz)
  —> exclusive band coverage in the 70-84 GHz range
- 2SB receivers with 16GHz in each polarisation
  —> perfect sideband interleaving for spectral surveys





Courtesy of C. Herrera

NOEMA capabilities

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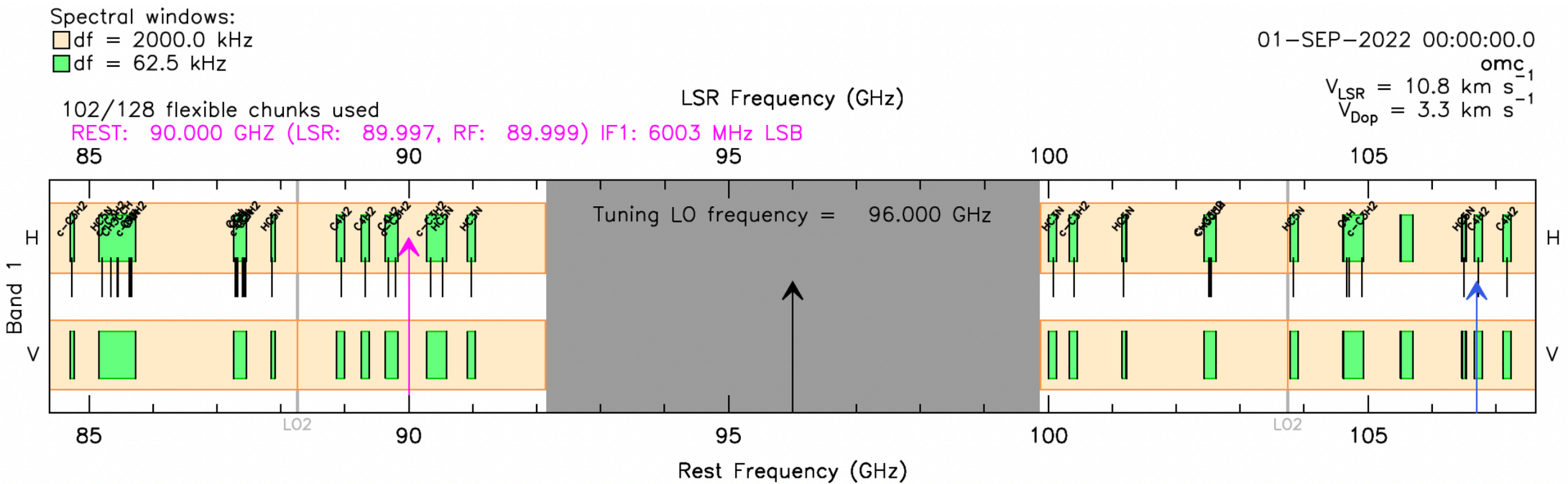
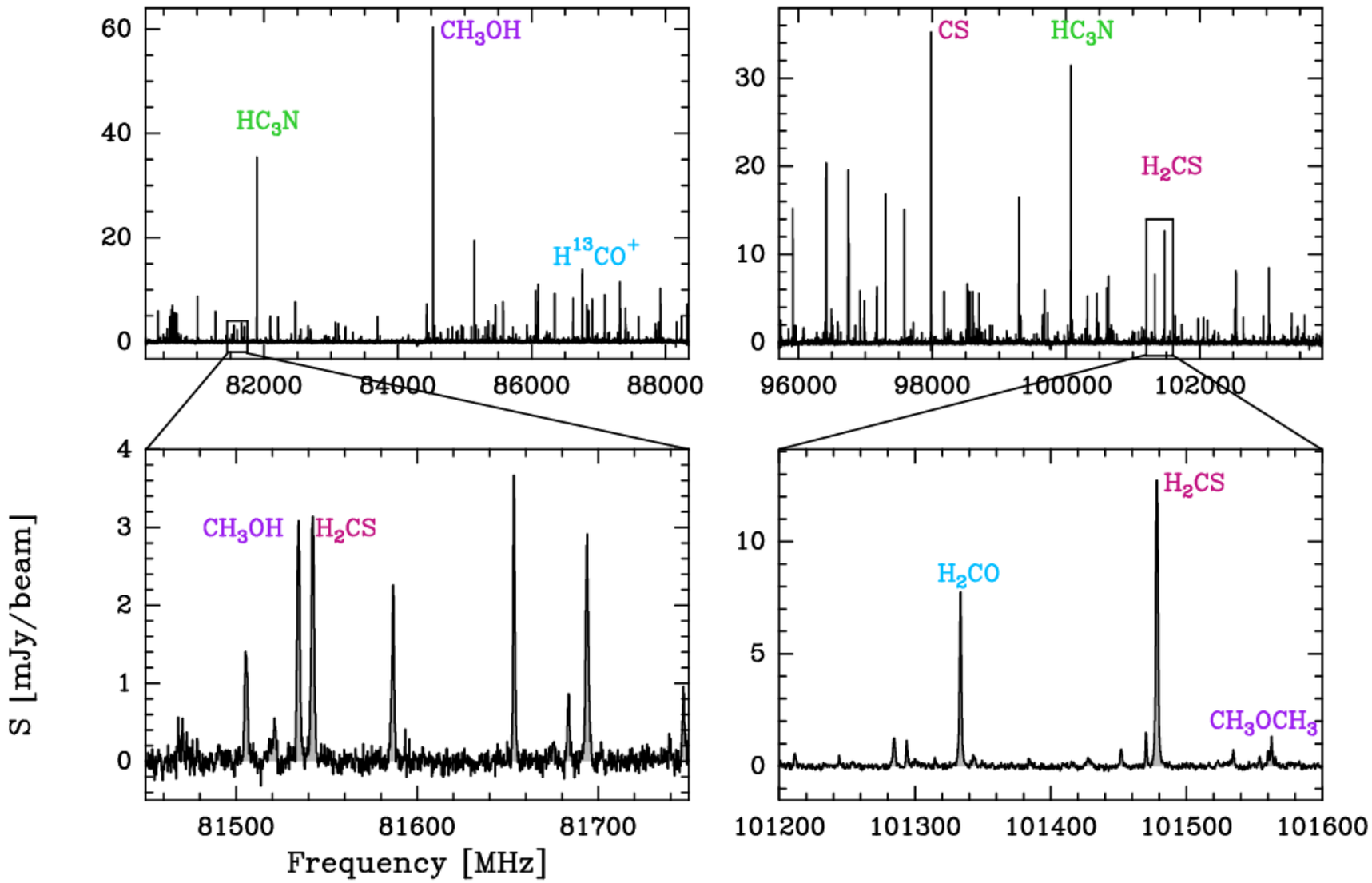
  —> exclusive band coverage in the 70-84 GHz range
- 2SB receivers with 16GHz in each polarisation
  —> perfect sideband interleaving for spectral surveys
- Simultaneous continuum and spectral line imaging
  —> full spectral coverage with 2-MHz channels for continuum
  —> 128 spectral windows of 64 MHz with 62.5-kHz channels

PolyFiX correlator



NOEMA capabilities

- 250 kHz mode offered since 2022:
  —> spectral line surveys with 0.2 km/s @350 GHz, 1 km/s @70 GHz
  —> ALMA-PILS surveys (32 GHz) are possible with 2 tunings instead of 8



PolyFiX correlator

Courtesy of L. Bouscasse

NOEMA capabilities

- 250 kHz mode offered since 2022:
  —> spectral line surveys with 0.2 km/s @350 GHz, 1 km/s @70 GHz
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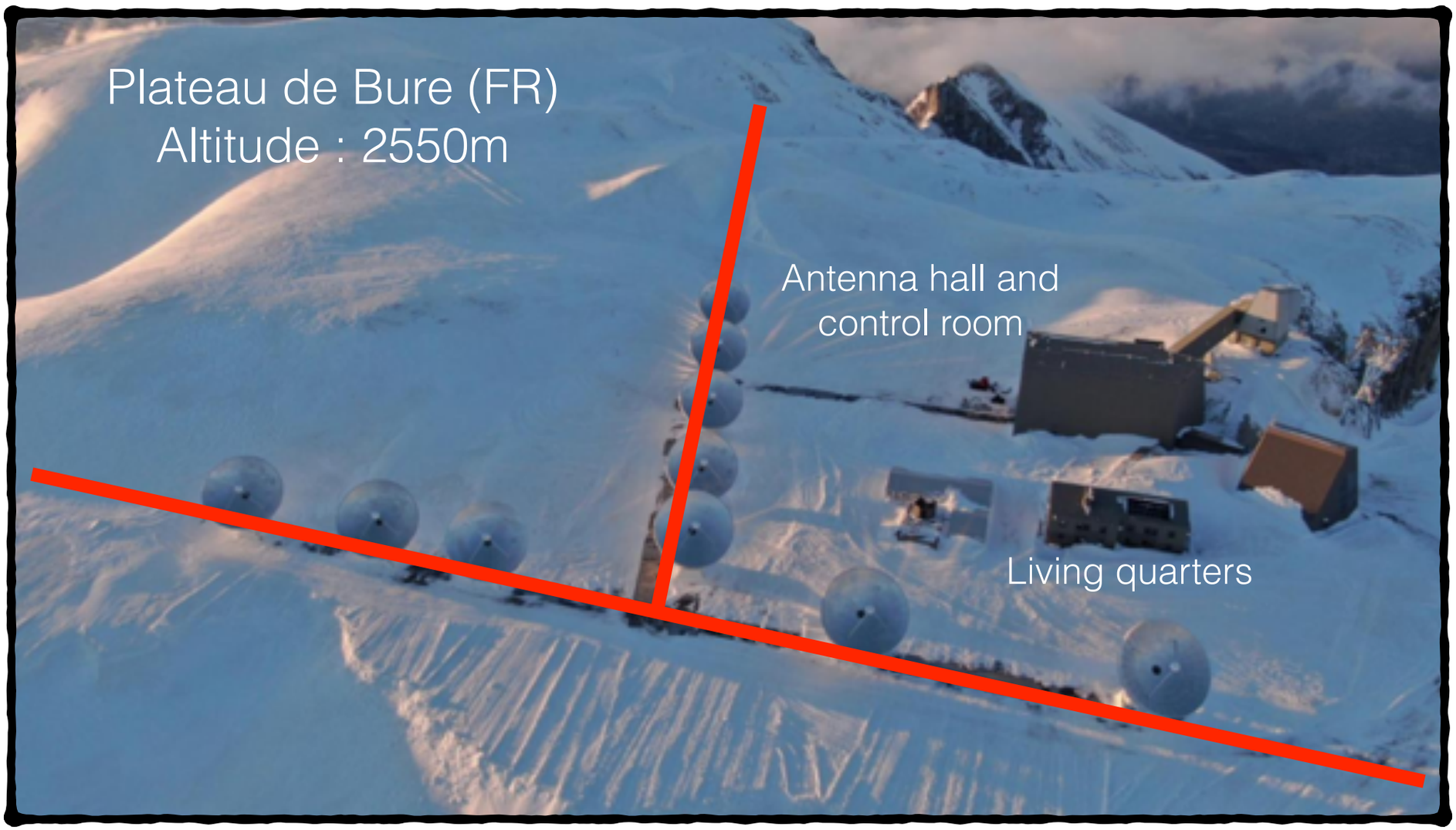
- NOEMA sensitivity:
  —> 65% of ALMA continuum sensitivity / 45% of ALMA single line sensitivity @100GHz
  —> NOEMA has 2x the bandwidth of ALMA: spectral surveys + redshift searches

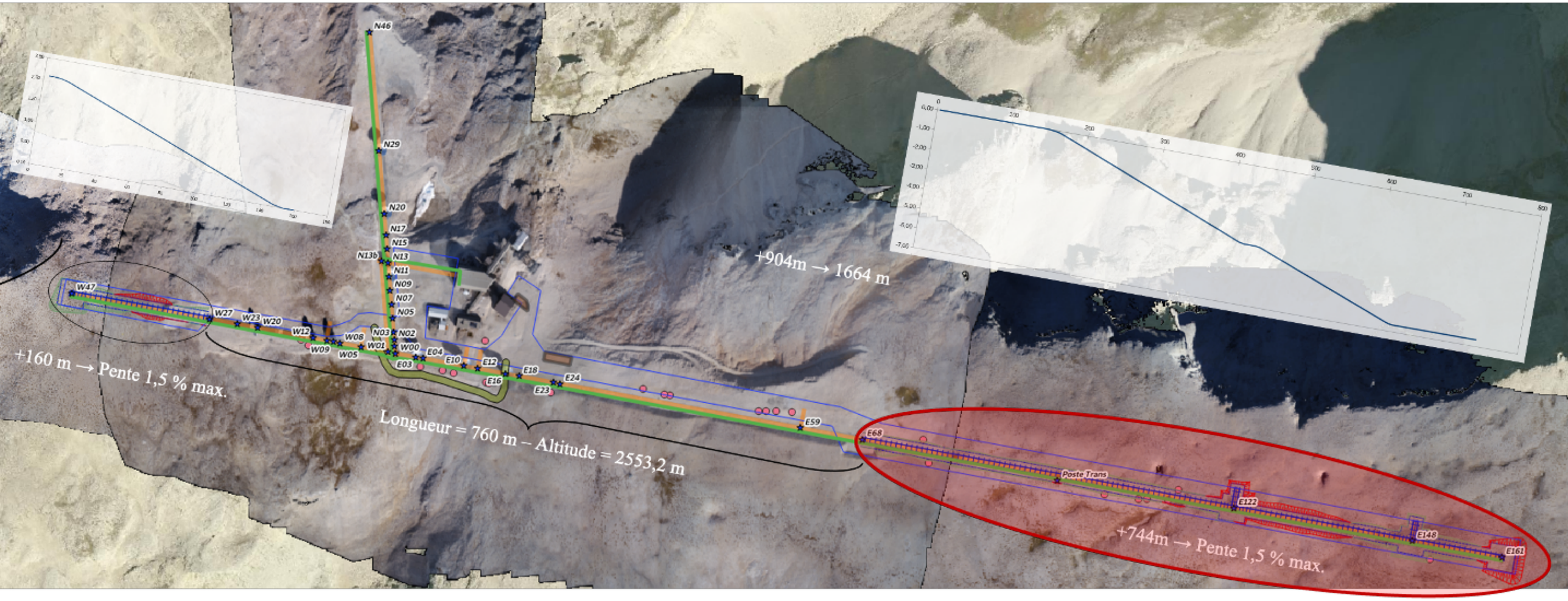
NOEMA capabilities

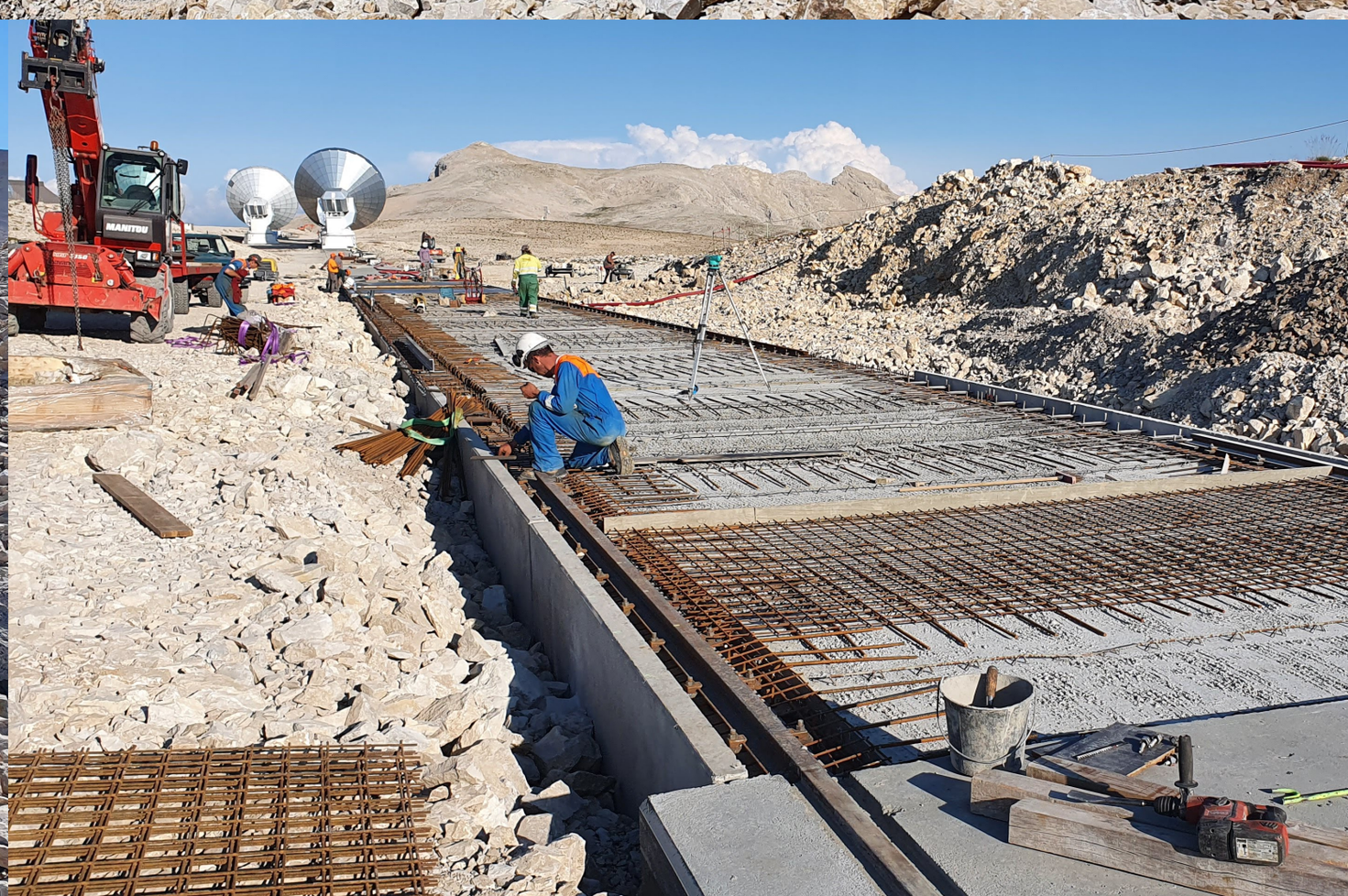
- 4 offered configurations: A (1700m), B, C, D
  —> 0.7” @100 GHz; 0.3” @230 GHz
  —> the antennas can be moved along rails to change the array configuration



Baseline extension finalised

Latest novelty this year: the new A configuration
angular resolution 2x better than last year's A configuration (currently re-named 'B')

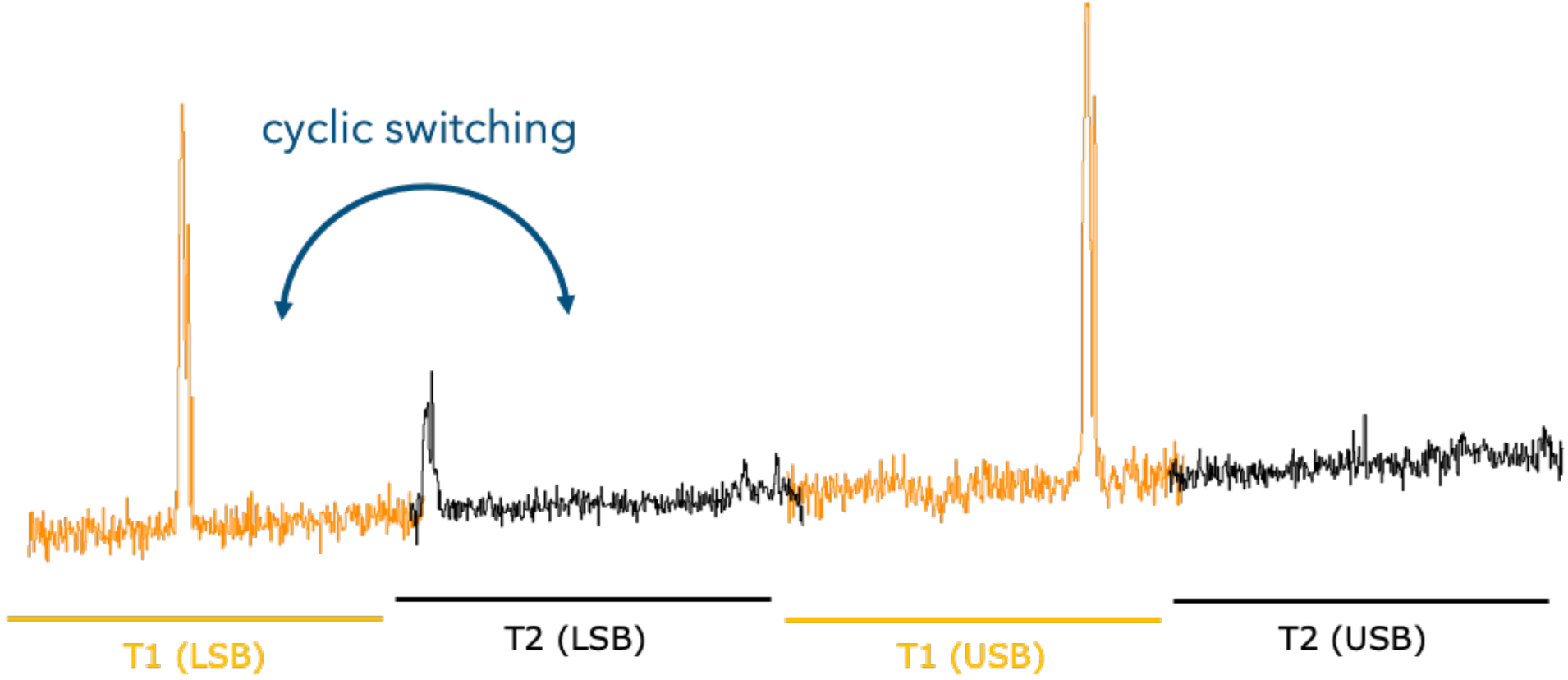



MANITOU

NOEMA: what comes next

- Spectral sweep mode (Q3/2023 @3mm)

—> redshift searches + spectral surveys with uniform noise, uv coverage, and improved calibration/spectral indices



NOEMA: what comes next

- Spectral sweep mode (Q3/2023 @3mm)
  —> redshift searches + spectral surveys with uniform noise, uv coverage, and improved calibration/spectral indices

- Full polarimetry (Q4/2024)
  —> currently undergoing commissioning

- Band 4 (Q4/2024)
  —> Frequency coverage: 275-373 GHz
  —> Angular resolution down to 0.12”

- Dual-band receivers (Q4/2024)
  —> B1 (3mm) + B3 (1mm)
  —> 2nd correlator PolyFix2

STAY TUNED!

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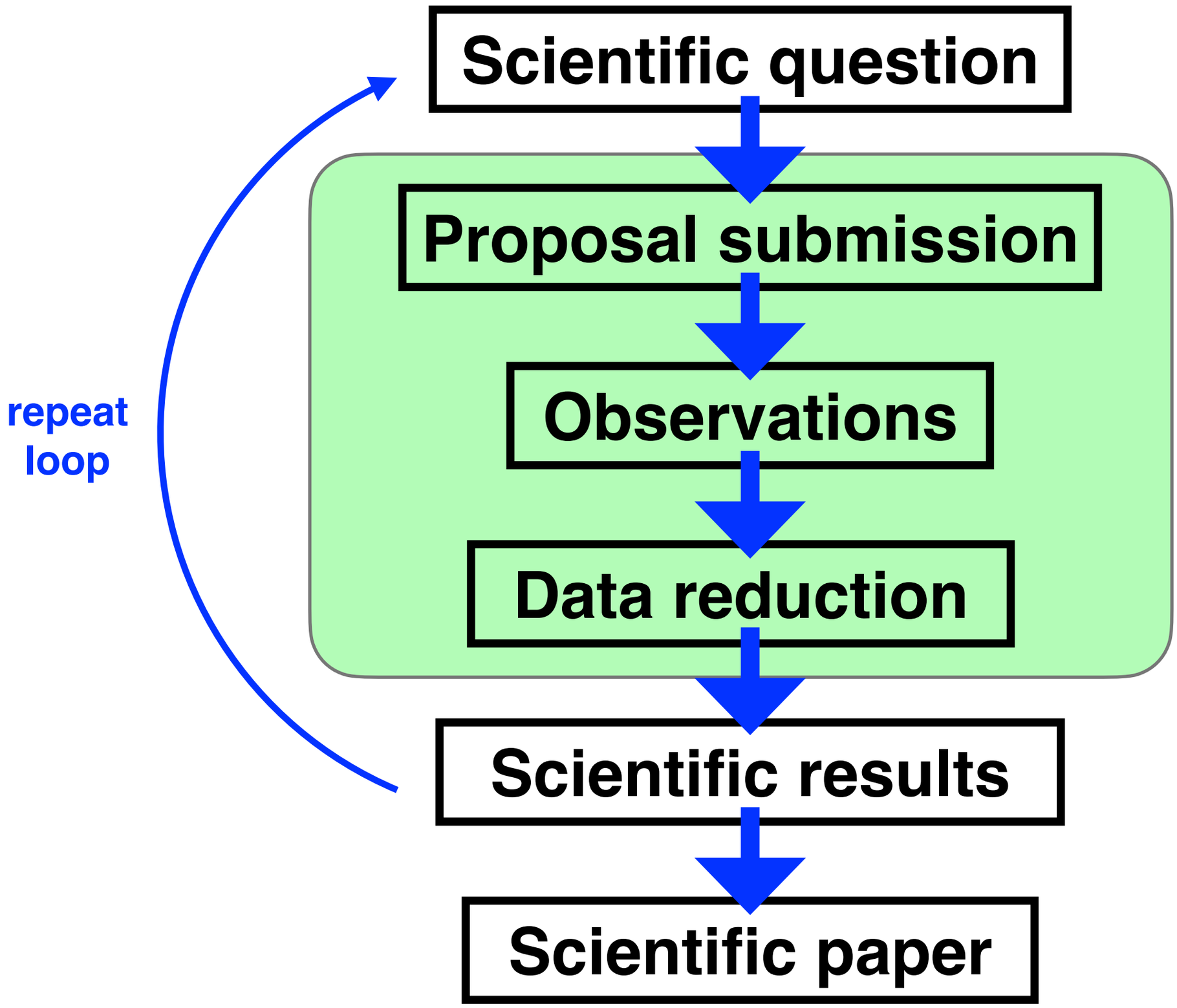
Observer's plan:



IRAM call for proposals

Two annual calls:

- Summer semester deadline in mid-March; observations Jun-Nov
- Winter semester deadline in mid-September; observations Dec-May

https://www.iram-institute.org/

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About us | NOEMA | 30m telescope | Science & technology | International cooperation | Public outreach | Science users

- 30m telescope
- NOEMA interferometer
- ARC NODE
- Proposals
  - Call for proposals
  - Large Programs
  - Director's discretionary time proposals
  - Data policy
  - Preparing proposal submission
  - Guidelines for observing time

Call for proposals

The call for NOEMA and 30-meter proposals for the winter semester 2022/23 (01 December 2022 to 31 May 2023) is online available. The proposal deadline is 15th September 2022.

This document describes the proposal submission procedure. A detailed description of the observing capabilities of the 30m telescope and the current status of the NOEMA interferometer are given in separate documents.

Proposals should be submitted through the Proposal Management System (PMS) at http://oms.iram.fr/pms. More details on the proposal submission procedure with PMS are available in the Call for Proposals and on the IRAM web pages. Note that this tool is straight-forward to handle, yet we urge proposers to start preparing their proposals well before the deadline.

Please also take note of the IRAM data policy.

IRAM call for proposals

Two annual calls:

- Summer semester deadline in mid-March; observations Jun-Nov
- Winter semester deadline in mid-September; observations Dec-May

Types of proposals:

STANDARD: Proposals that ask for a total of less than 100 h of observing time and for the standard capabilities of NOEMA's current status (see the following sections).

TIME FILLER: Proposals that can be considered as backup projects to fill in periods where the atmospheric conditions do not allow mapping, to fill scheduling gaps, or even to fill in periods when only a subset of the standard antenna configurations are available. These proposals will be carried out on a "best effort" basis.

SPECIAL: Exploratory proposals, whose scientific interest justifies the attempt to use the array beyond its guaranteed capabilities. This category includes, for example, non-standard frequencies for which the tuning cannot be guaranteed, non-standard configurations, special needs with respect to calibration and more generally all non-standard observations. These

LARGE PROGRAM: Under the current Call for Proposals, certain restrictions still apply (see the `Large Program Policy` on the IRAM web site for general details). In the frame of NOEMA's construction, more capabilities of the correlator are expected to become available during the "lifetime" of a Large Program, usually spanning over several observing semesters. The requested time and/or observing strategy may

A good observational proposal needs…

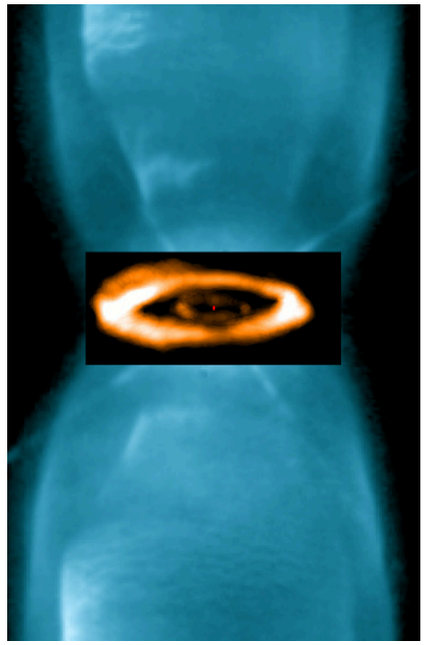
• A good **science case**: the goal should *not* be to observe a certain source, but to address a certain scientific question

Our goal is to observe my favourite source…

Our goal is to address the mystery of….

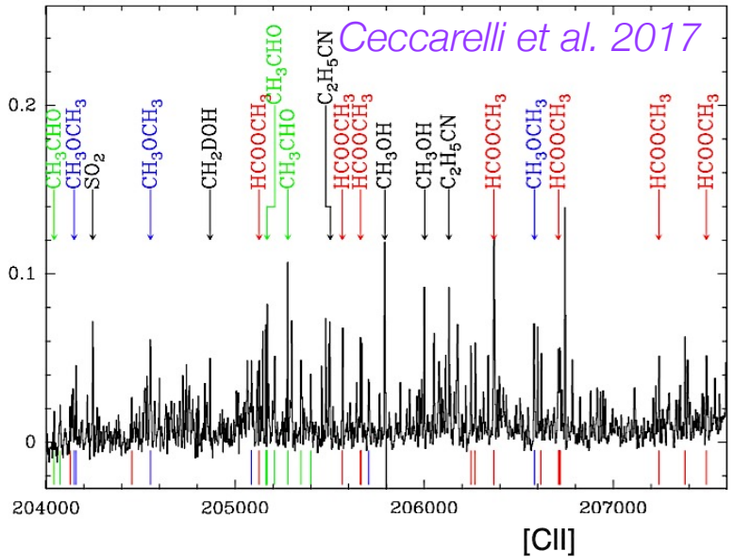
Science with NOEMA

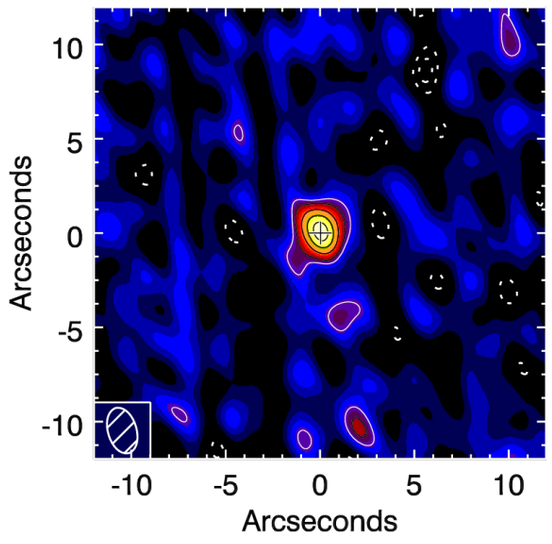
Evolved stars

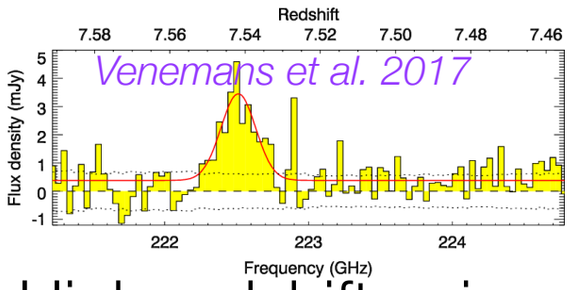


Castro-Carrizo et al. 2012

Astrochemistry, molecular complexity

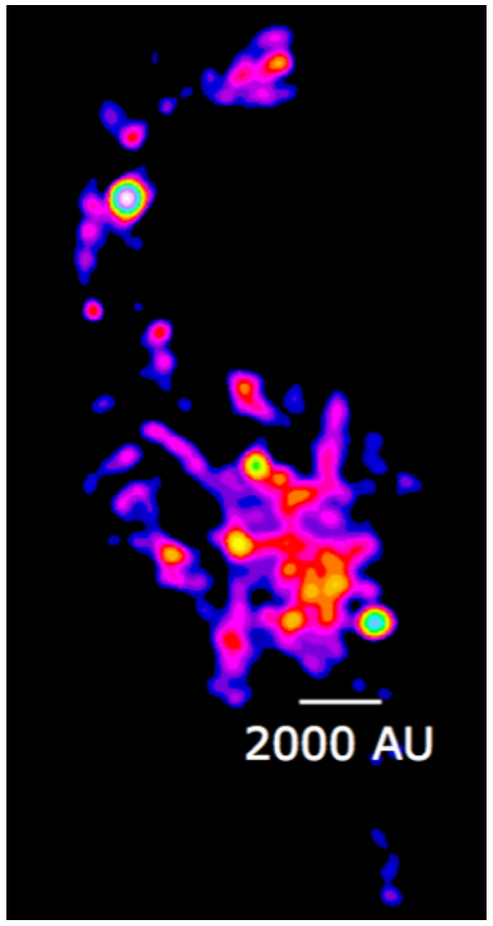






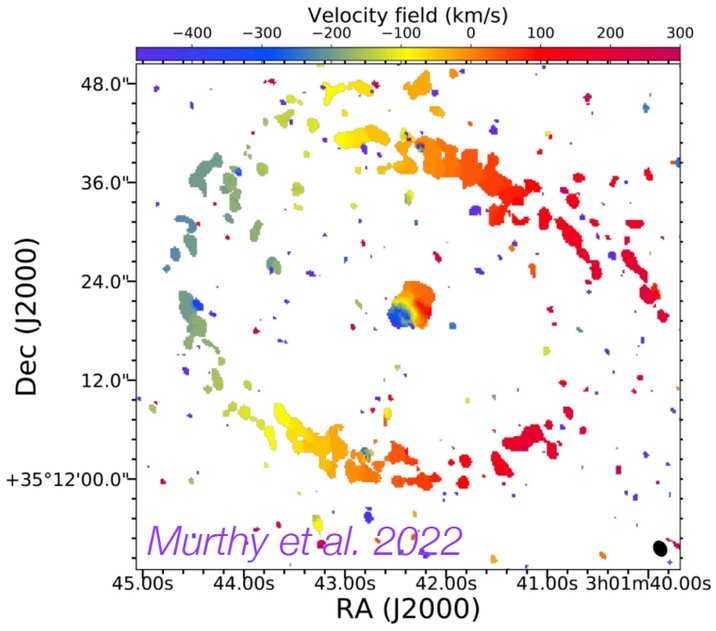
High redshift universe

Star formation



Neri et al. in prep.

Nearby galaxies



…and much more!

A good observational proposal needs…

• A good **science case**: the goal should *not* be to observe a certain source, but to address a certain scientific question

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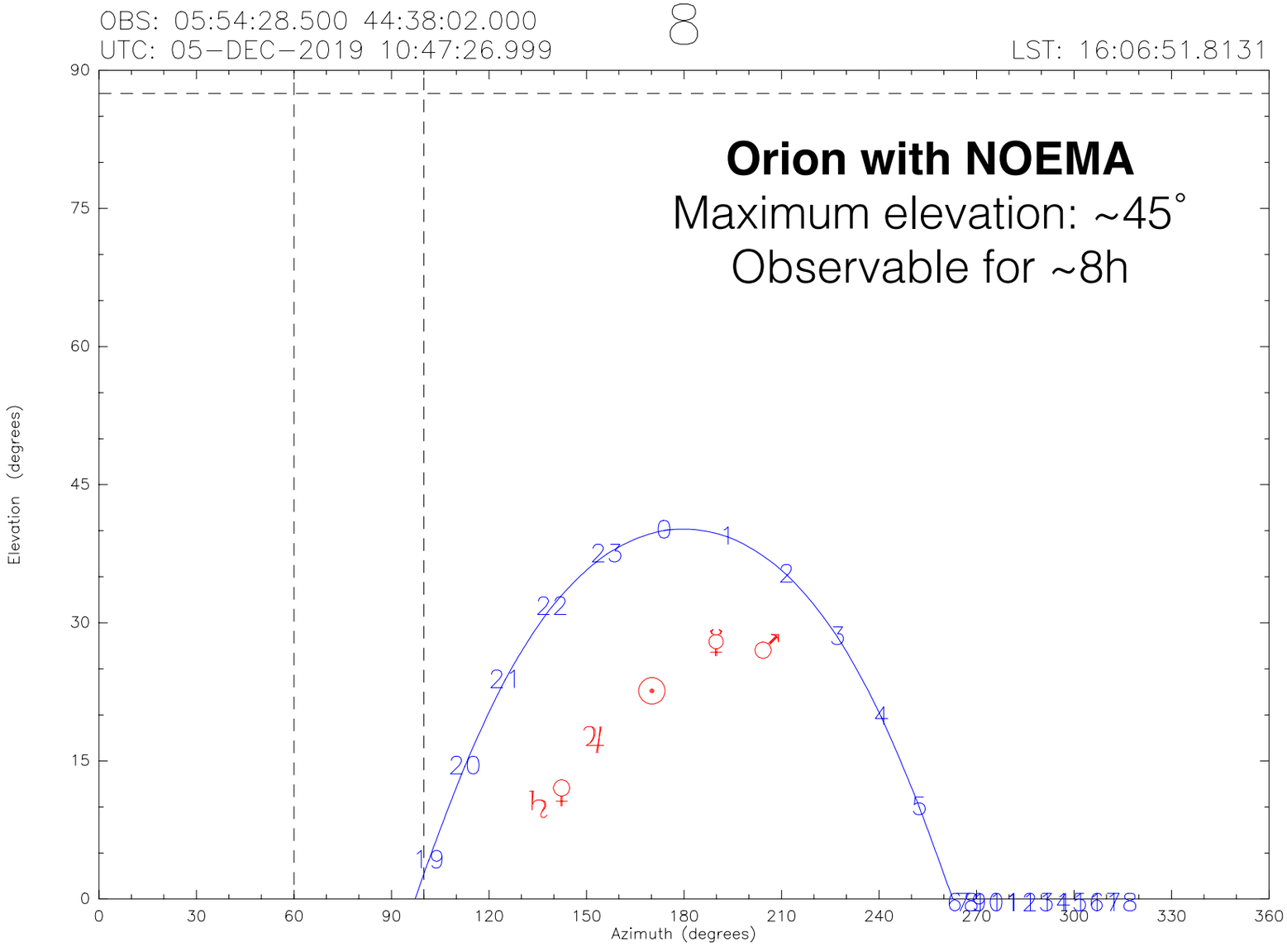
Our goal is to address the mystery of….

• A good **technical part**: designing the observations. How long do I need to observe? What frequencies do I need to observe? What angular resolution? Etc.

1. Target(s)
2. Frequency setup
3. Sensitivity and telescope time
4. Angular resolution and other angular scales
5. Detection or mapping?

Some technical considerations

- Target coordinates: check **elevation** and duplications



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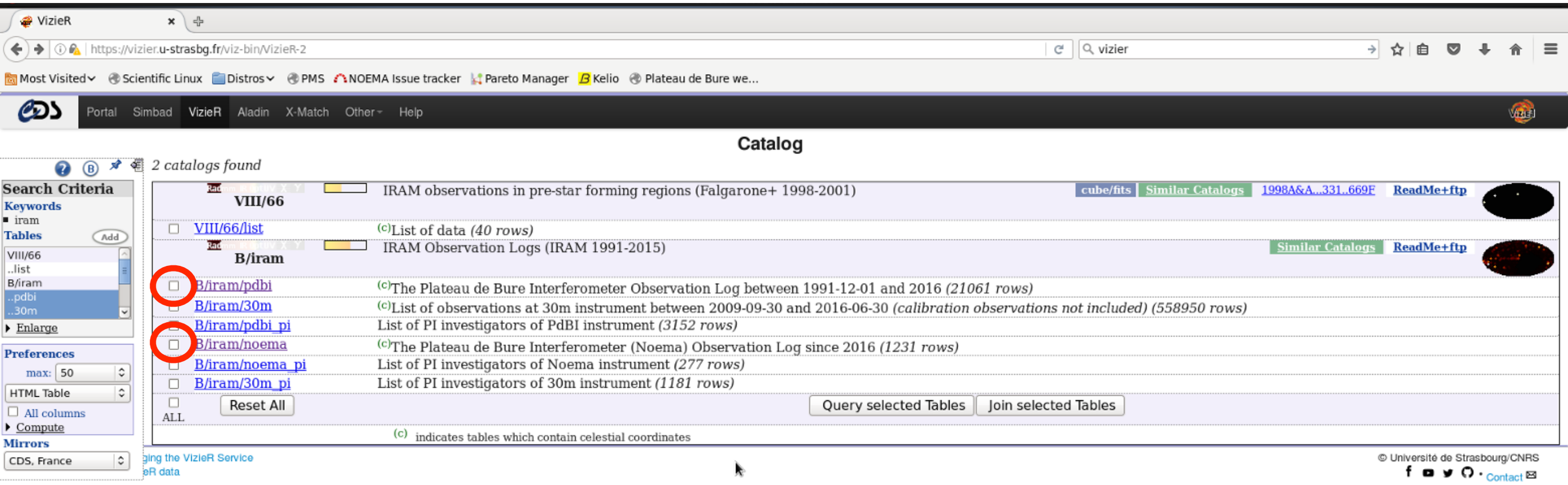
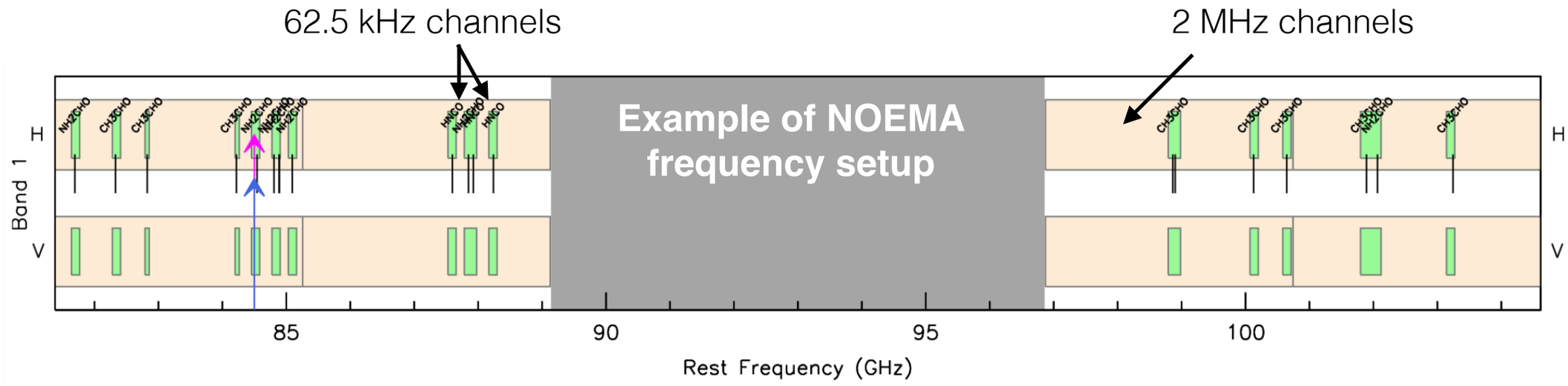


Some technical considerations

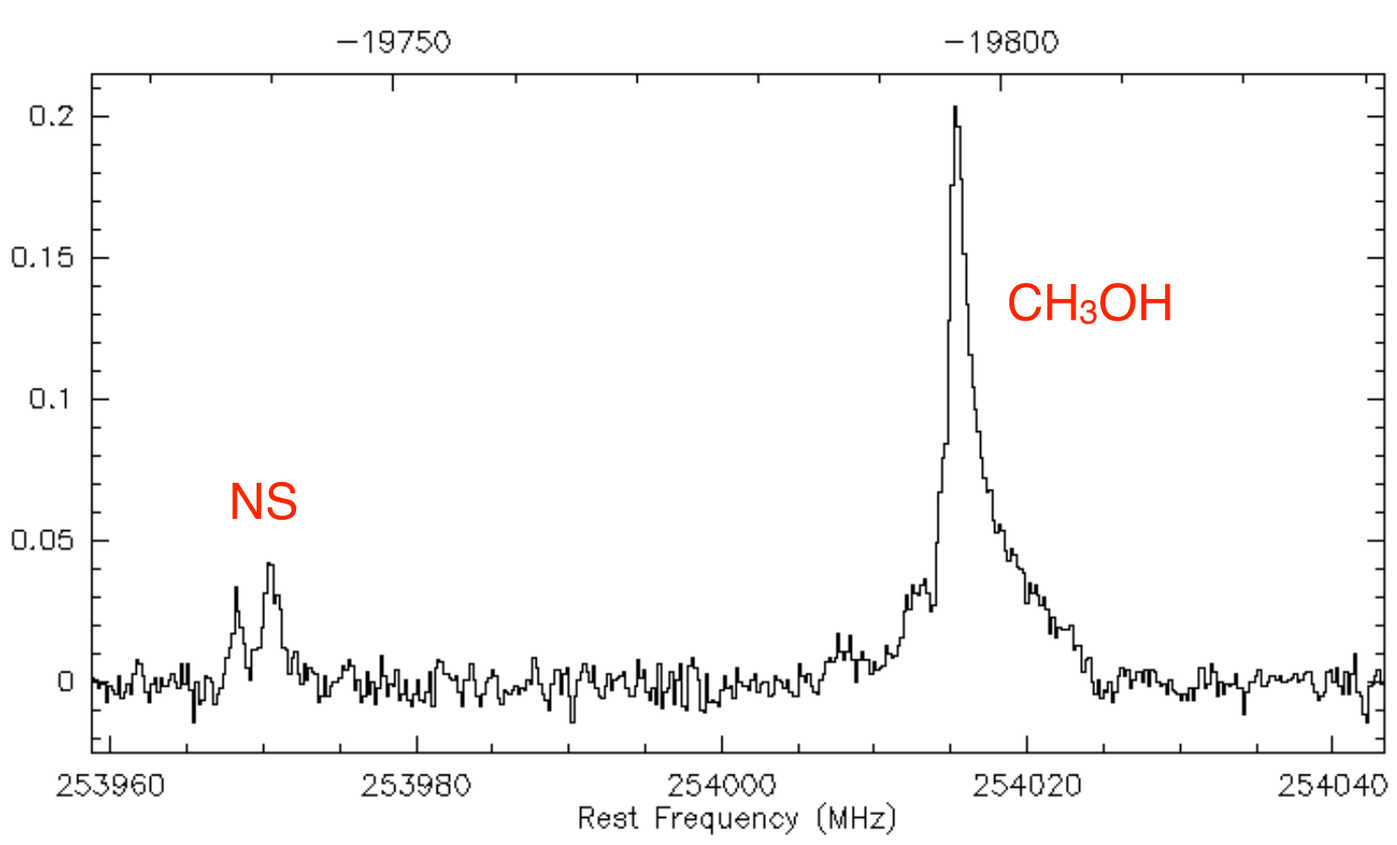
- Target coordinates: check elevation and duplications
- Frequency setup: what frequency band (1, 2, 3mm)? Lines or continuum? What spectral resolution? How many frequency setups do I need?



Some technical considerations

- Target coordinates: check elevation and sun avoidance dates
- Frequency setup: what frequency band (1, 2, 3mm)? Lines or continuum? What spectral resolution?

1;1 IRAS4A ASAI IRAM EMIR 0:01−JAN−1900 R:05−DEC−2019
RA: 16:32:22.75 DEC: −24:28:34.2 Eq 2000.0 Rad. 0.0° Offs: +0.0 +0.0
Unknown tau: 0.000 Tsys: 1. Time: 1.0sec El: 0.0
N: 386625 I0: 193313. V0: 6.800 Dv: −0.2457 Unkn
F0: 238275.781 Df: 0.1953 Fi: 238275.781



Some technical considerations

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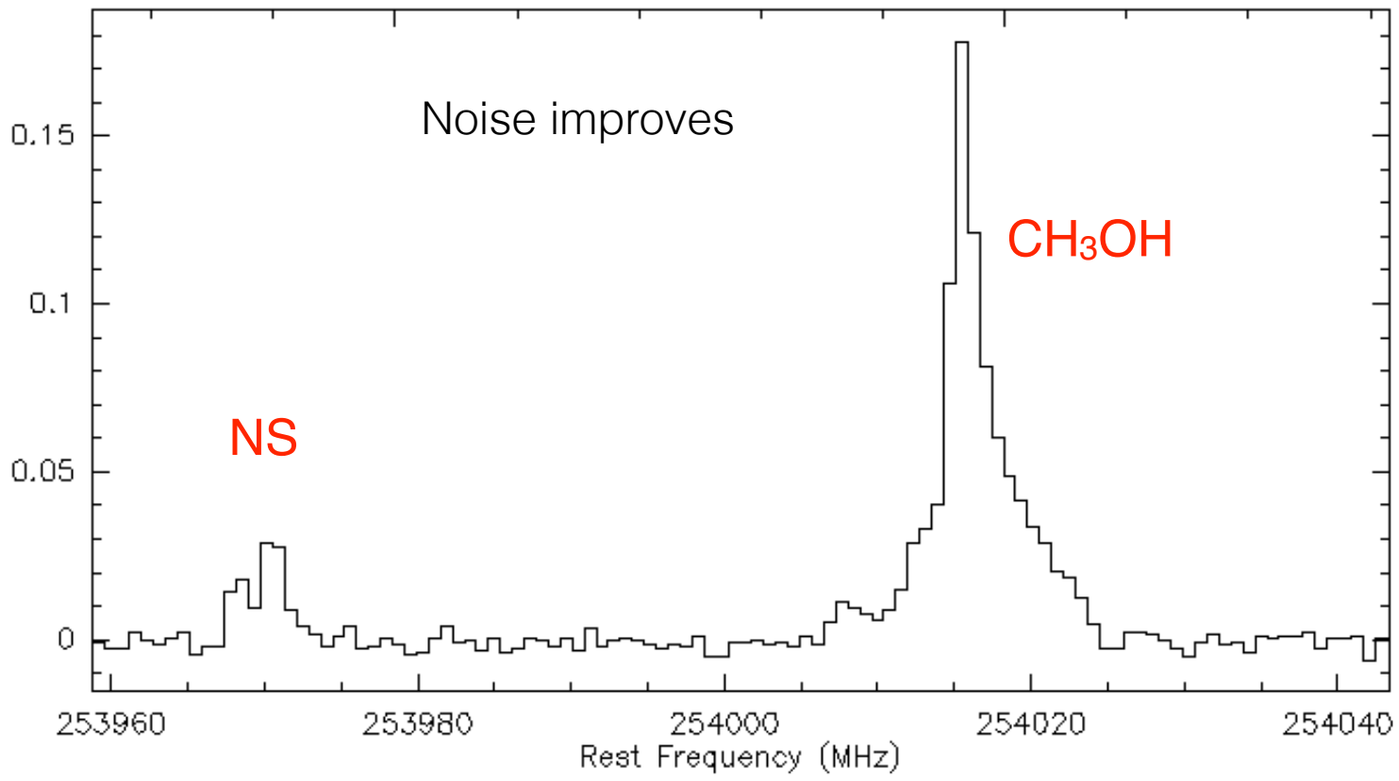
Unknown tau: 0.000 Tsys: 1. Time: 1.0sec El: 0.0
N: 96655 I0: 48328.2 V0: 6.800 Dv: −0.9830 Unkn
F0: 238275.781 Df: 0.7813 Fi: 238275.781

x4



Some technical considerations

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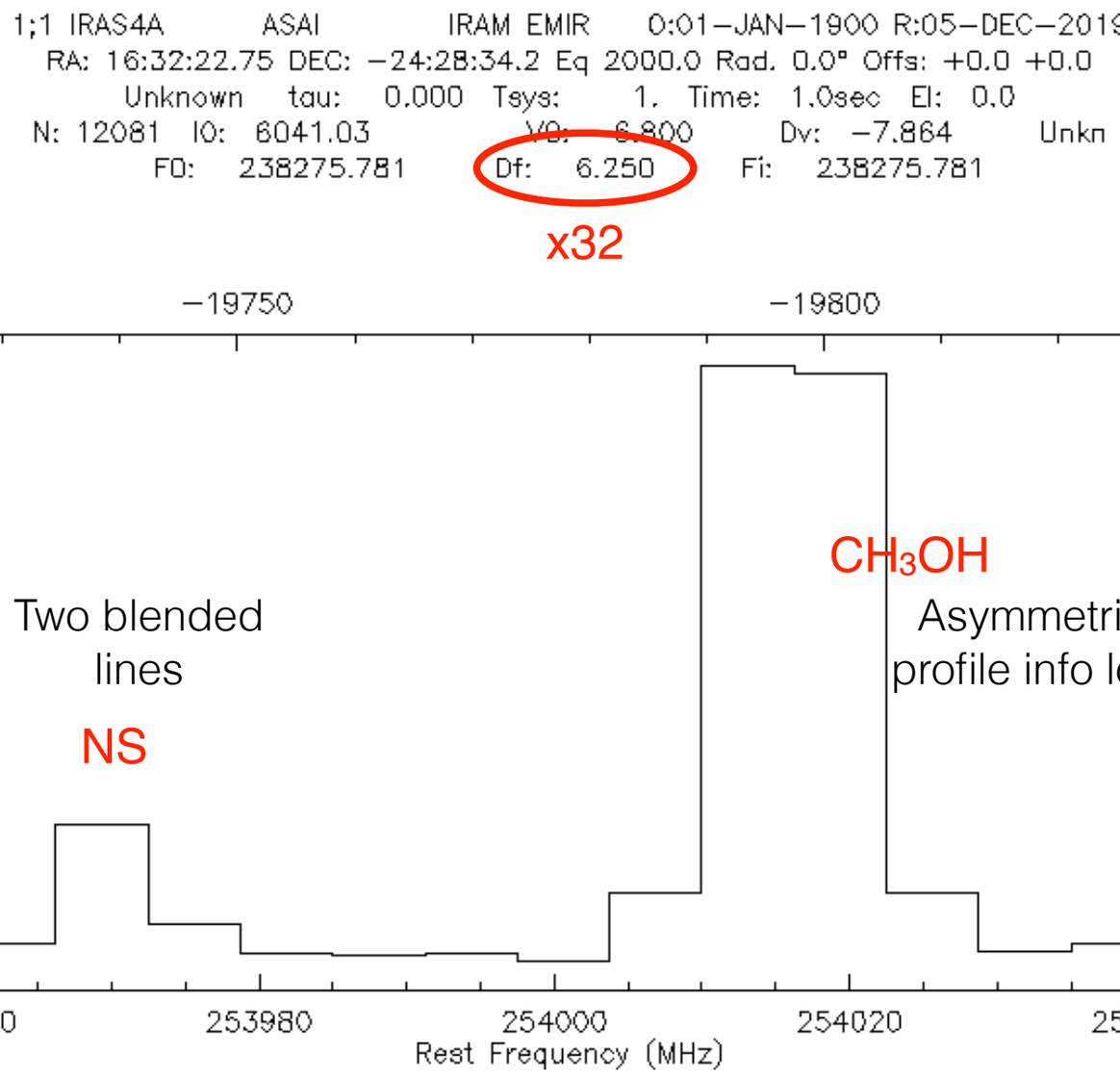


Some technical considerations

- Target coordinates: check elevation and sun avoidance dates
- Frequency setup: what frequency band (1, 2, 3mm)? Lines or continuum? What spectral resolution?
- Sensitivity: how much telescope time do I need to reach the necessary sensitivity? Use the online time estimator

30m-EMIR | 30m-HERA | **NOEMA** https://oms.iram.fr/tse/#noema

NOEMA Sensitivity Estimator for Sep 15, 2022, 5:00:00 PM CEST deadline Help Reset

Options

Sessions	winter summer
Observing mode	single mosaic track-sharing
Verbose output	observing mode tuning overhead
Expert mode	

Parameters

Number of polarizations	1 2		(for line only)
Representative frequency	100.0	GHz	
At intermediate frequency	6000.0	MHz USB	(expert mode)
Configurations	A B C D	Uncheck all	
Targeted angular resolution		arcsec	
Spectral resolution	1.0	MHz	

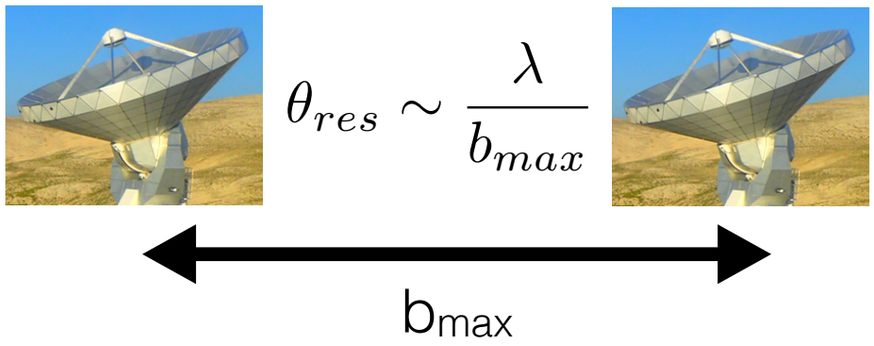
Selected result:

You may select the appropriate sensitivity estimate from the result table, and paste the text below into your proposal.

```
We propose to observe during the winter season using the single-field observing mode. For a typical declination of 20.0 degrees, an observing frequency
of 100.0 GHz, and an angular resolution of 3.90 arcsec, the sensitivity estimator tells us that we will reach a line sensitivity of 1.1 mJy/beam
(spectral resolution of 3.0 km/s, 2 polarizations) and a continuum sensitivity of 8.8 μJy/beam per source in 8.0 hours with 5 mm of pwv (Tsys = 77.6 K
in line and Tsys = 76.9 K in continuum).
```

Some technical considerations

- Angular scales probed:
  —> What angular resolution do I need?
  —> What is the largest angular scale I want to probe?



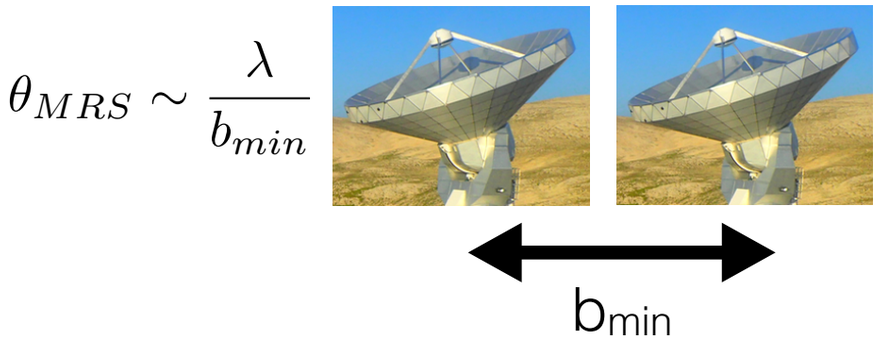


Table 1: Configuration schedule for the winter period

Conf	Scheduling Priority
C	November – December
A	December – February
B	February – March
C	March – April
D	April – May

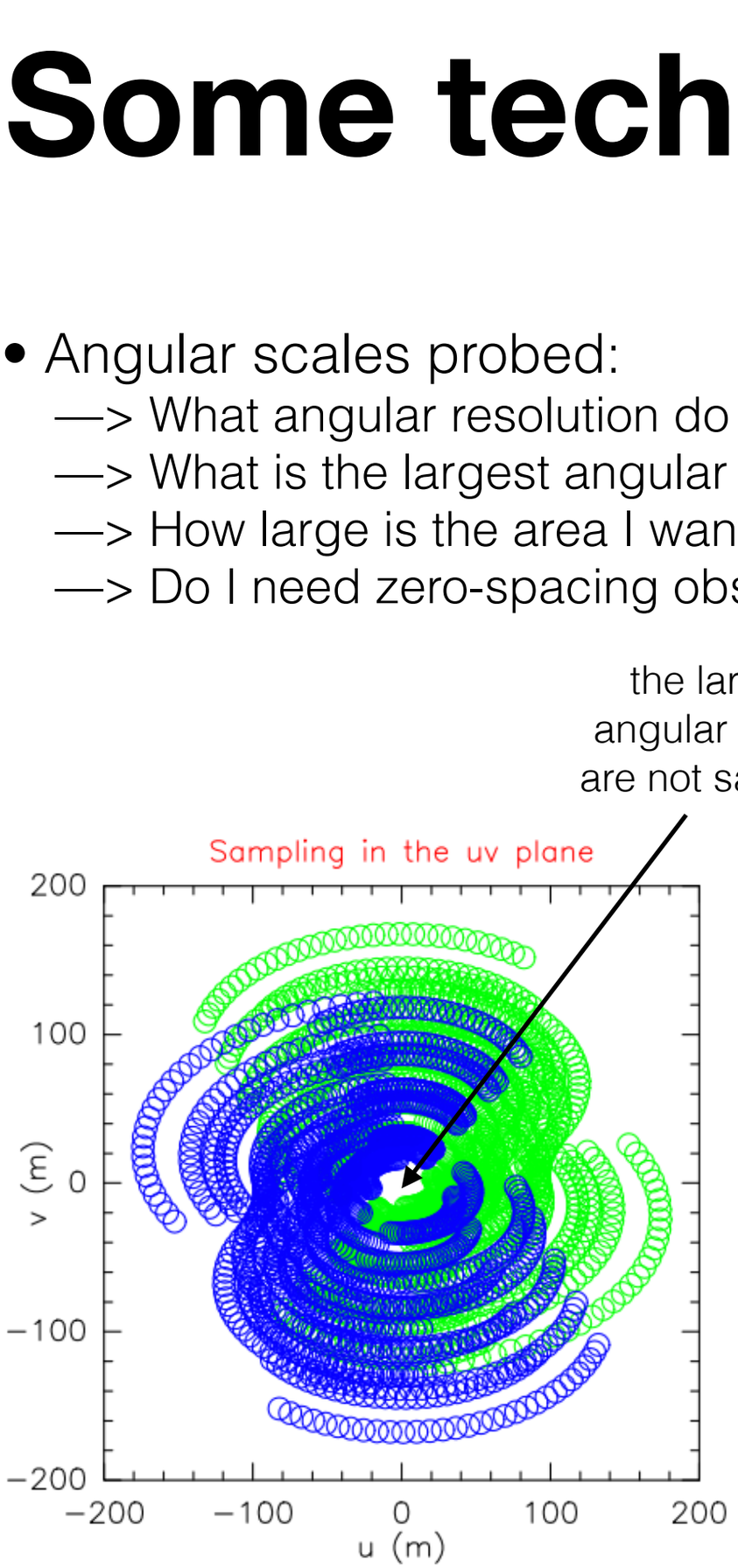
Table 1: Configuration Schedule for the Summer 2022 period

Conf	Scheduling Priority
D	June – September
C	October – November

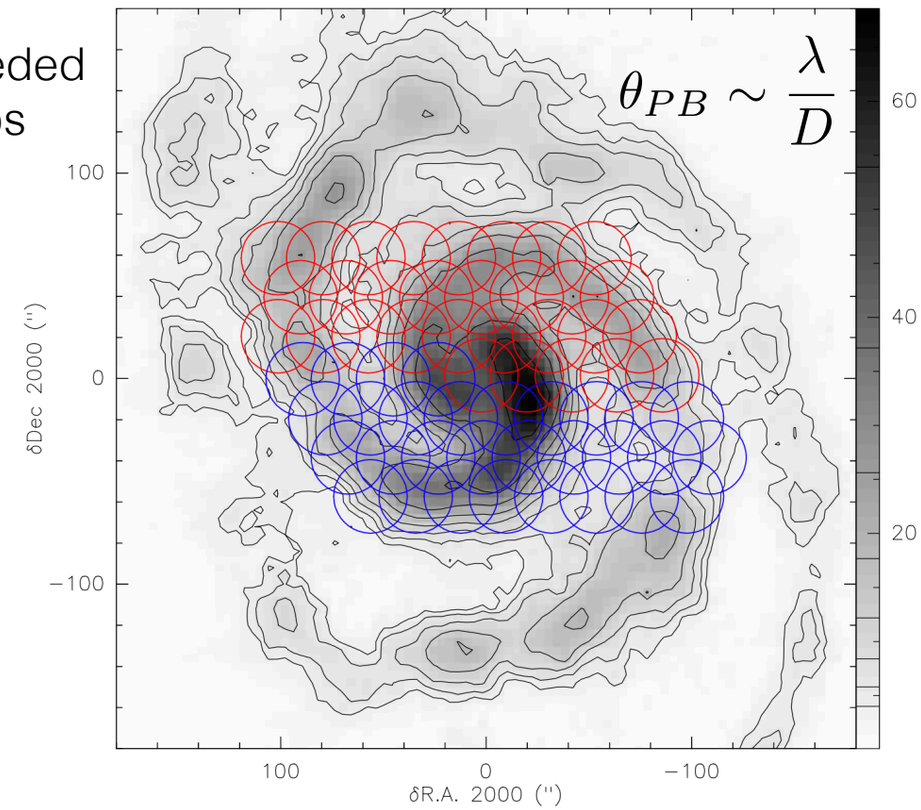
Some technical considerations

- Angular scales probed:
  —> What angular resolution do I need?
  —> What is the largest angular scale I want to probe?
  —> How large is the area I want to map?
  —> Do I need zero-spacing observations?

the largest
angular scales
are not sampled



Mosaics are needed
for large maps



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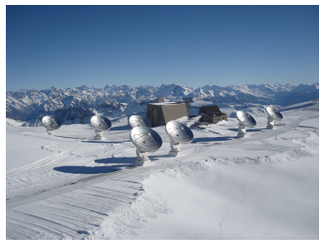
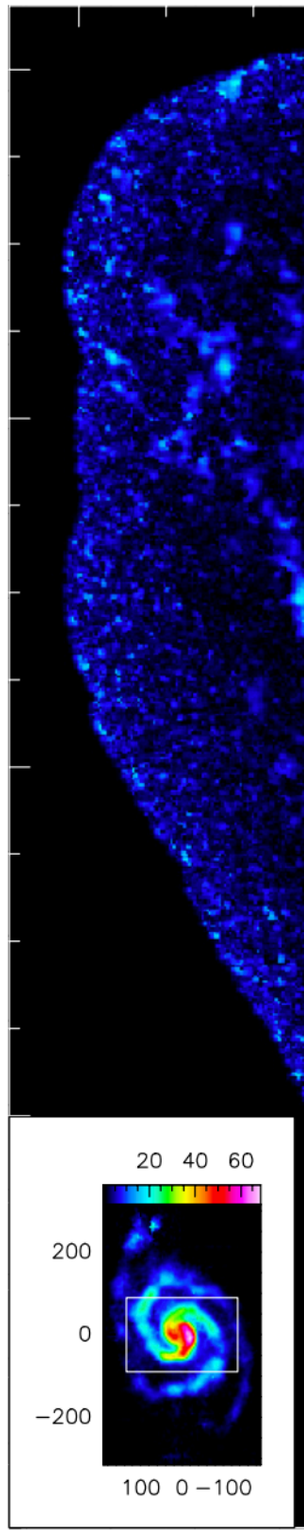


Pety et al. 2013

CO(J=1-0) emission
Interferometric mosaic (60 fields) + single-dish



Single-dish only

δDec. 2000 (")
50
0
−50

δR.A. 2000 (")
100
50
0
−50
−100

400
300
200
100
0

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- Angular scales probed:
  —> What angular resolution do I need?
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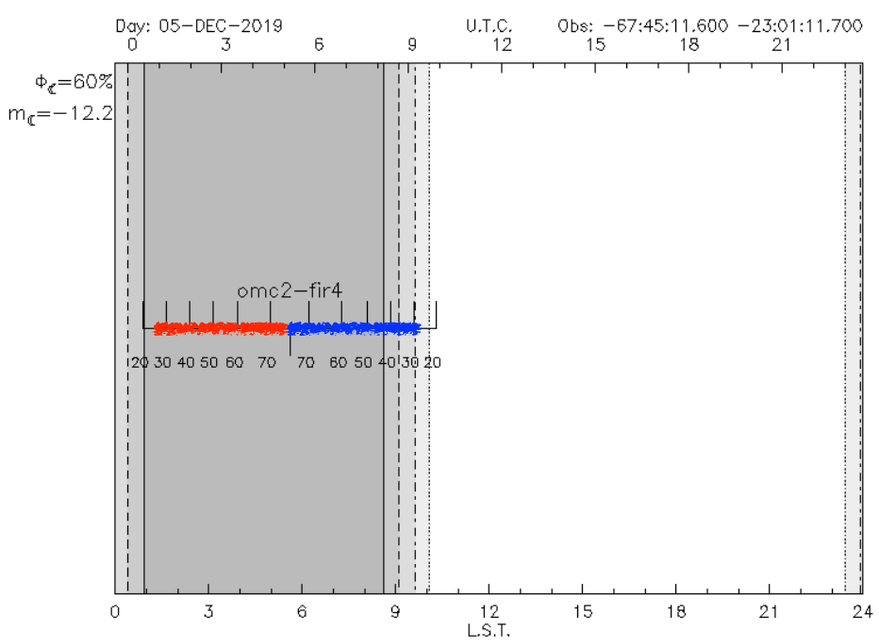
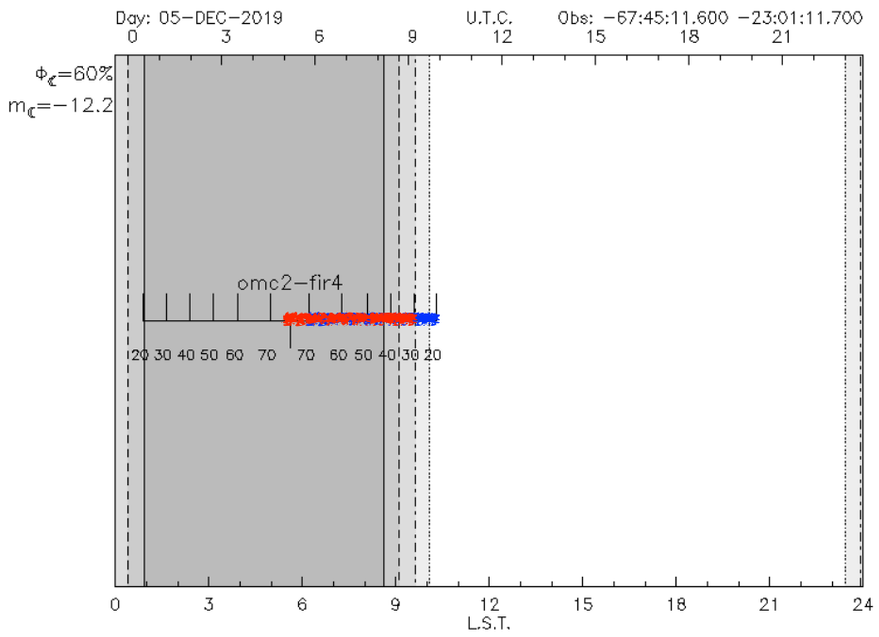
  —> How large is the area I want to map?
  —> Do I need zero-spacing observations?

- Mapping quality:
  —> Mapping project: it needs good uv coverage and often more time than that required to reach the targeted sensitivity
  —> Detection project: sensitivity is the limiting factor and good uv coverage is not required





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Proposals
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Results, Reports and Archives
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Call for proposals

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OPTICON RadioNet Pilot

https://www.iram-institute.org/

Proposal Management System

https://oms.iram.fr/pms/

Title: Cyanopolyynes and hydrocarbons as probes of protostellar energetic particles
PIs: Ana Lopez-Sepulcre
CoIs: Cecile Favre, Cecilia Ceccarelli, Francesco Fontani
Total requested time: 23.5 (PolyFiX)
Abstract:

The protostellar cluster OMC-2 FIR4, in the Orion star forming complex, is to date the only object known to harbour a strong internal source of
Solar System during its early formation history. In order to start exploring how frequent these phenomena are in our Galaxy, and whether this is
that are likely to be undergoing such energetic particle irradiation, with NOEMA in its D configuration. To this end, we propose to map several
for each source. The abundances of these three molecules have recently been found to be very sensitive to the energetic-particle ionisation rate
protostellar energetic particles in our three targeted sources.

Sources and setups

Sources: Download sources

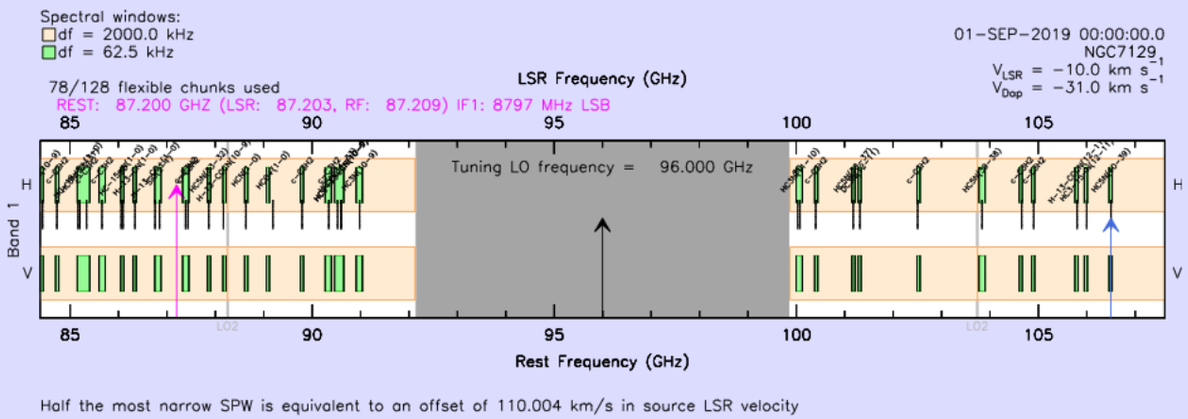
Id [?]	Epoch	RA	DEC	Vlsr (km/s)	Setups
NGC7129	J2000	21:43:01.700	66:03:23.600	-10.0	1
L1641-S3	J2000	05:39:56.100	-07:30:28.000	5.0	2
IRAS2	J2000	03:28:55.400	31:14:35.000	7.45	3

Technical sheets:

Id↑	PolyFiX	Rec. time	Grade	
1	**NGC7129:**	6.0	B	view

Summary
Single field mapping with lines & continuum on 1 source(s).
Total observing time[?]: 6.00 hours
Track fractions: D: 100.0 %

Instrumental tuning



Source properties for lines [?]
Smallest resolved scales: 4.0 arcsec **Largest scales:** 10.0 arcsec
Expected signal: 500.0 mJy/beam **Sensitivity:** 2.9 mJy/beam (0.800 km/s) → **SNR:** 170
Expected line width: 4.000 km/s

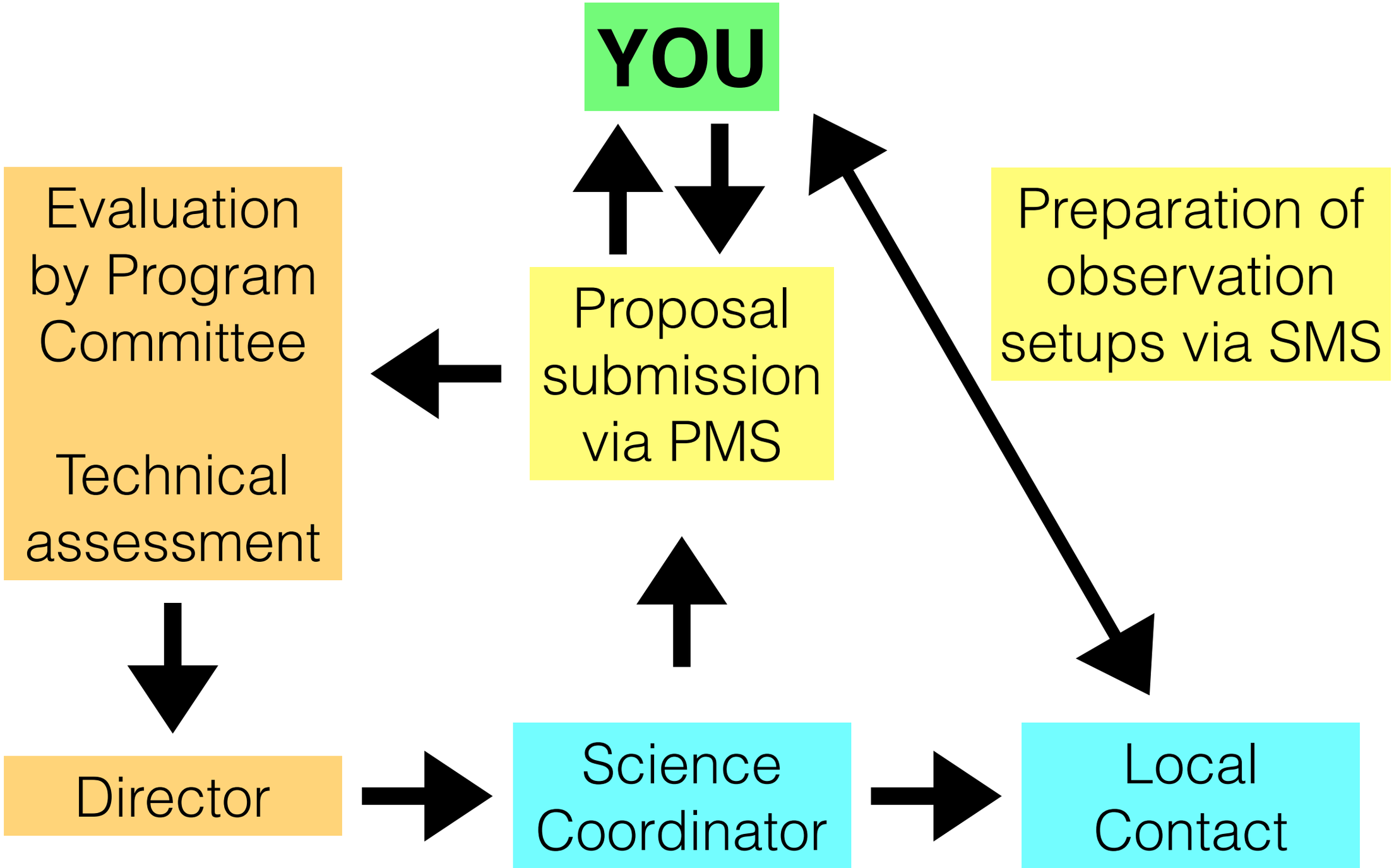
Source properties for continuum [?]
Smallest resolved scales: 4.0 arcsec **Largest scales:** 10.0 arcsec
Expected signal: 10.0 mJy/beam **Sensitivity:** 11.7 microJy/beam (15488.0 MHz x 2 polar) → **SNR:** 857

Proposal grades

A Highest priority. Will be observed.

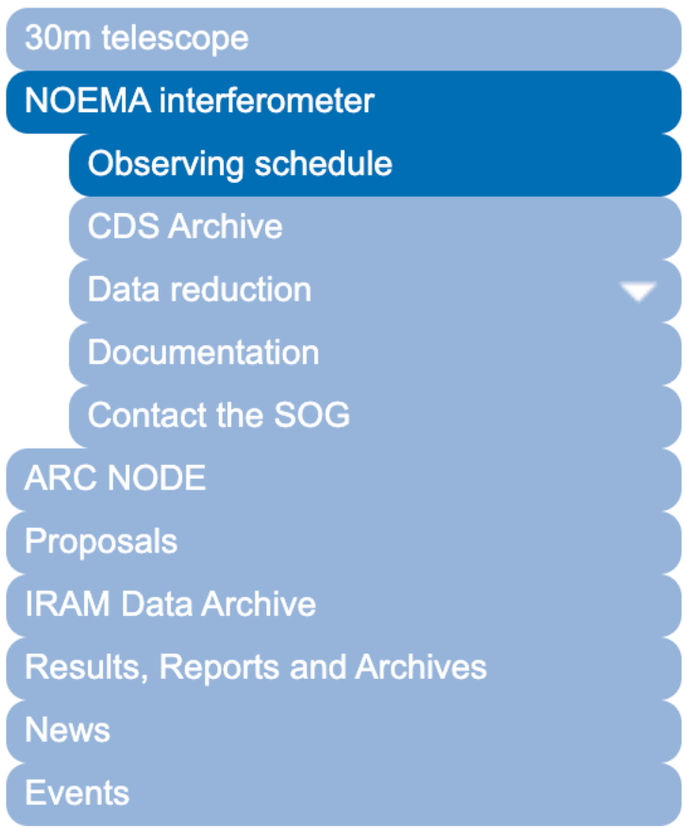
B “Back-up”. Will be observed, if time allows, depending on several factors such as weather, ranking, LST ranges, etc. Once started, a B project will be finished,

C Rejected. Will not be observed.


YOU
Evaluation by Program Committee
Technical assessment
Director
Proposal submission via PMS
Preparation of observation setups via SMS
Science Coordinator
Local Contact

Tracking your project

NOEMA accepted projects are observed in service mode



Observing schedule

List of recently scheduled projects with links to all previous observations, and a complete overview of the status of ongoing projects.

https://www.iram-institute.org/

Tracking your project

Started	Completed	Reduced, Stopped, ...	Sun avoidance period

Current configuration is:
W05-N02-N09-W08-E04-N13-E10-W12-N17-N05-H03-H01 (10D)
Generated automatically by sog@iram.fr on Monday 19-Sep-2022 22:56 CEST
For projects before June 2014 check here

Plateau de Bure Semester SS22

June 2022 - November 2022

Project	*PI*	*LOC/co-I*	*Completed*	*Planned*	*Sun-Avoidance*	*Priority*	*Status*
S22AA001	*Lellouch*	*Boissier*		*Any*	*19-feb / 27-apr*	*A*	
S22AA002	*Lellouch*	*Boissier*		*Any*	*19-feb / 27-apr*	*A*	
S22AC001	*Andre*			*D*		*B*	*No Procedure*
S22AC002	*Andre*			*D*		*B*	*No Procedure*
S22AC003	*Andre*			*D*		*B*	*No Procedure*
S22AD001	*Coutens*	*Winters*		*C*	*30-apr / 28-jun*	*B*	
S22AD002	*Coutens*	*Winters*		*C*	*05-jun / 26-jun*	*B*	
S22AD003	*Coutens*	*Winters*		*C*	*10-jun / 22-jun*	*B*	
S22AD004	*Coutens*	*Winters*		*C*	*17-may / 19-jul*	*B*	
S22AD005	*Coutens*	*Winters*		*C*	*24-may / 13-jul*	*B*	
S22AE001	*Thompson*	*Bouscasse*		*C*	*17-apr / 20-jun*	*B*	
S22AF001	*Qin*	*Winters*	*D*	*CD*	*16-apr / 20-jun*	*B*	*Started*
S22AF002	*Qin*	*Winters*		*CD*	*05-dec / 24-jan*	*B*	
S22AG001	*De Simone*	*Lopez-Sepulcre*		*C*	*17-apr / 20-jun*	*B*	
S22AG002	*De Simone*	*Lopez-Sepulcre*		*C*	*17-apr / 20-jun*	*B*	
S22AH001	*Spezzano*	*Le Gal*	*D*		*05-may / 13-jul*	*A*	*Completed*

Behind the scene: the team

A team of workers climbs to NOEMA every Thursday (1-week shift) :

- 1 cook
- 2 operators: they command the antennas and intervene in case of technical problems
- 1 technician: electrical interventions
- 1 mechanician: mechanical interventions, snow clearance, vehicle/ building maintenance
- 1 nurse
- 1 astronomer: observation plan and data quality verification

There is a dedicated team behind every observational project, without which NOEMA science would not advance

Day: 20-SEP-2022 UTC 05:54:28.500 44:38:02.000

10D 0 3 6 9 12 15 18 21 FLO1

comm	COMM-Go2WIKI	rec1
holo	H-A5-A6-A8	rec1
aflu	aflu auto+SIN	—
s22aa001 d	lo-leading	254.0 U
s22aa002 d	lo-trailing	254.0 U
l19md008 m	G438065	226.5 U
l19mb011 S	Per-emb-29	226.5 L
l19mb012 S	L1448NW	226.5 L
w21ap002 M	05380+2020	225.5 U
w21ap003 M	05380+2020	225.5 U
w21ap004 M	05380+2020	225.5 U
l19md025 m	GN4-32562	155.0 U
l19md024 m	GN4-37399	155.5 U
l19md029 m	GN4-19554	155.5 U
l19md023 m	G4-20371	157.5 U
l19md022 m	G4-39065	157.5 U
s22af001 S	IRAS2A1	138.6 L
s22af002 S	SerpS-MM18a	138.6 L
l19ma014 M	CYGMOS14_1	82.0 U
l19ma009 M	CYGMOS9	82.0 U
l19ma010 M	CYGMOS10	82.0 U
l19ma011 M	CYGMOS11	82.0 U
l19ma012 M	CYGMOS12	82.0 U
l19ma013 M	CYGMOS13	82.0 U
l19ma041 M	CYGMOS41	82.0 U
w21dg002 d	J0209-0005	262.0 U
e21ac001 d	XMM3-3086	162.5 U
w21bc001 d	GGTau	150.0 U
s22dc005 d		88.0 L
s22bu001 m	CLJ1227	82.0 L
s22as001 M		82.0 L
s22bb004 d		104.4 L
s22bb001 d	7838Mon	82.0 L
s22dd001 d	HSCJ1628+43	264.3 U
s22cq001 s	EGS.0009	264.0 U
s22cq002 s	EGS.0073	264.0 U
s22df001 d	J1427+3312	261.0 U
s22av001 d	hd35187	256.3 U

Astronomer at NOEMA

1. Familiarise with the list of scientific projects to be observed
2. Decide and plan which projects to observe when depending on time, weather, priority, and other technical constraints
3. Check the data quality of each observed project after it is observed
4. Decide whether the project is finished or needs more observing time

Communication between team members is critical

Observations run 24/24h and 7/7 days if possible

Bad weather or technical issues/interventions can stop observations

Data reduction

Once your project is completely observed, your Local Contact will guide you through the data calibration steps according to your experience level

30m telescope
NOEMA interferometer
Observing schedule
CDS Archive
Data reduction
Visiting astronomers
Data Reduction Schedule
Travel to Grenoble
Financial support for visiting astronomers
Local contacts

Data reduction

Data reduction is in general carried out by the proposers at IRAM Grenoble. In exceptional cases, however, remote data reduction is possible. In these cases, please contact your local contact **and** the scientific coordinator.

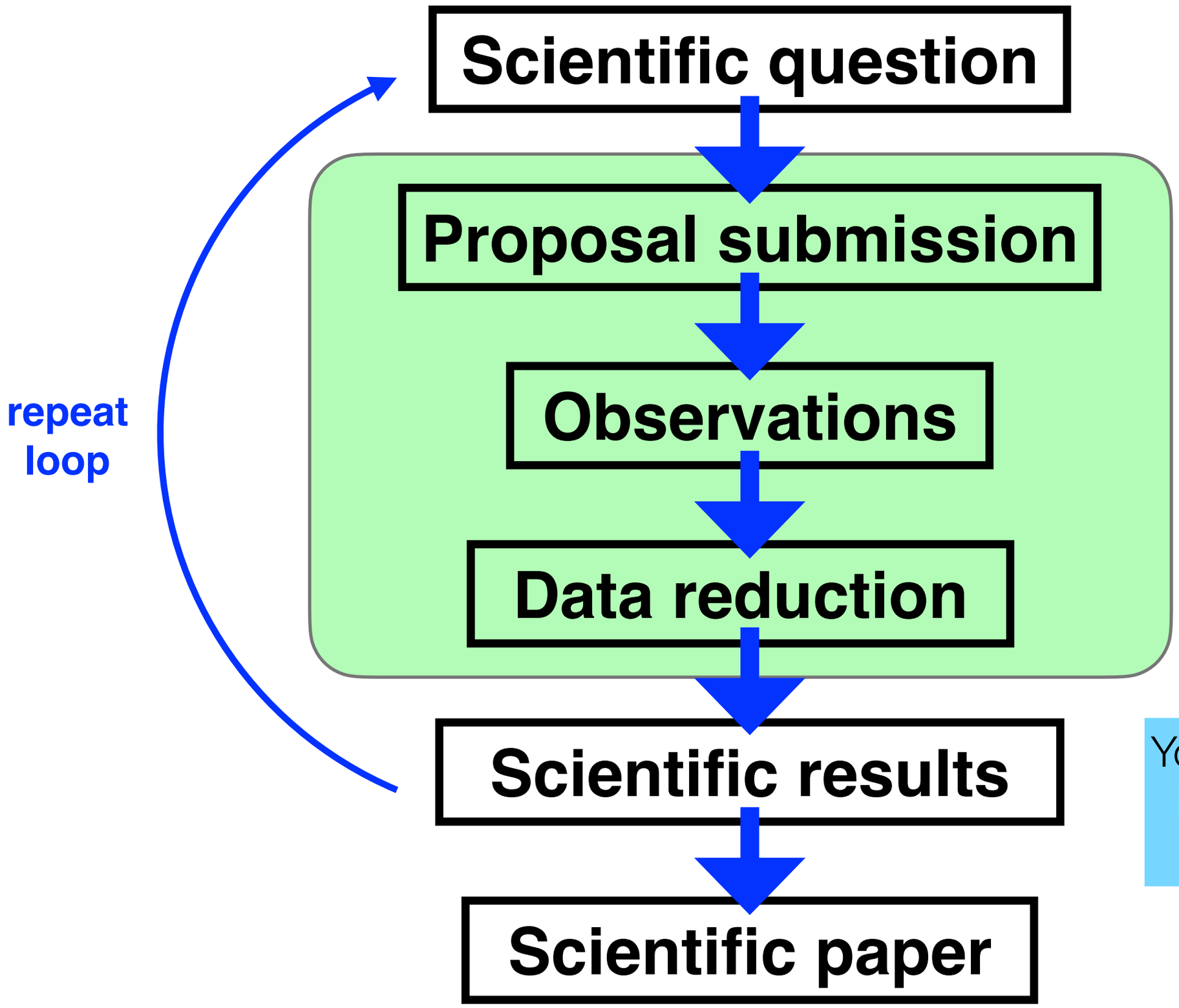
Travel preparation

Visits must be announced at least two weeks in advance. Contact the scientific secretary as soon as possible for your travel dates. Please do consult the conditions for financial support for visiting astronomers.

To avoid overbooking the computer facilities, no more than two groups are accepted simultaneously. Please consult the visitor list before you get in touch with IRAM.

https://www.iram-institute.org/

Observer's plan:



Your data are ready to image and analyse.
ENJOY!

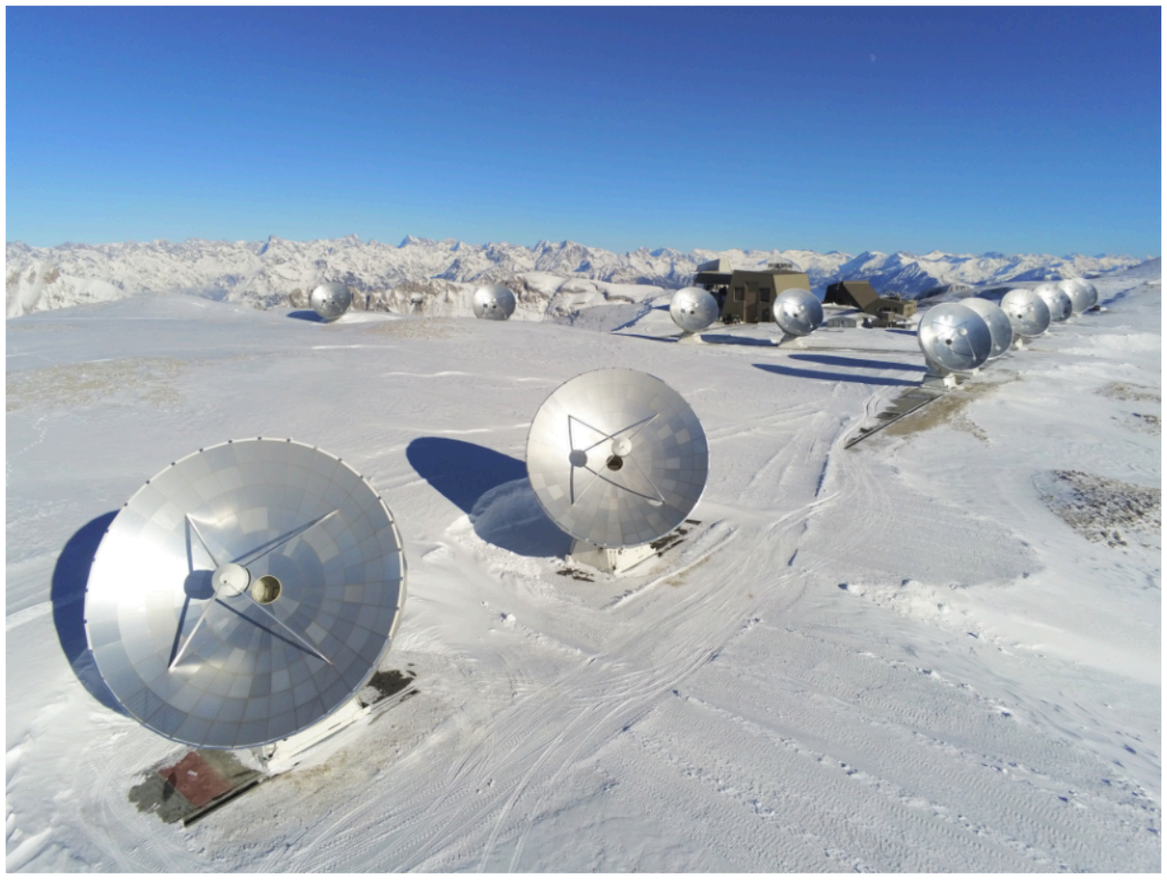
IRAM interferometry school

- 30m telescope
- NOEMA interferometer
- ARC NODE
- Proposals
- IRAM Data Archive
- Results, Reports and Archives
- News
- Events
  - 11th IRAM Interferometry School
    - Practical information
  - 10th IRAM 30-meter School on Millimetre Astronomy
  - 50th YERAC
  - 9th IRAM 30-meter Summerschool
  - 10th IRAM mm Interferometry School
  - 9th IRAM Interferometry School
  - IRAM Science Software User Meeting 2016
  - 8th IRAM 30m Summerschool
  - ALMA Cycle 2 - Proposal Preparation 2013
  - 7th IRAM 30m Summer School 2013
  - 8th IRAM Interferometry School 2012
  - Kryo 2011
  - 6th IRAM 30m Summer School 2011
  - 4th Microresonator Workshop 2011
  - ALMA Early Science - Proposal Preparation 2011
  - Observing with ALMA - Early Science 2010
  - 7th IRAM Interferometry School 2010
  - International conference 30 years of IRAM 2009
  - Previous IRAM Schools

11th IRAM Interferometry School

First Announcement

The 11th IRAM millimeter interferometry school will be held **November 21–25, 2022** at the IRAM headquarters (Grenoble, France). It is intended for students, post-docs and scientists who want to acquire a good knowledge of interferometry and data reduction techniques at millimeter wavelengths, with a special emphasis on the NOEMA interferometer and its new capabilities.



In addition to presentation of the basics of millimeter interferometry observations, data calibration and imaging, the program will also include practical tutorials on interferometric data reduction and imaging techniques. Presentations given during the previous interferometry school can be found here.

School pre-registration form

Useful links & contacts

- IRAM web site: https://www.iram-institute.org/
- IRAM Call for Proposals: http://www.iram.fr/GENERAL/calls/w22/Call_for_proposals.pdf
- NOEMA capabilities: http://www.iram.fr/GENERAL/calls/w22/NOEMACapabilities.pdf
- GILDAS software: https://www.iram.fr/IRAMFR/GILDAS/
- Last IRAM interferometry school (presentation slides): https://www.iram-institute.org/EN/content-page-399-7-67-367-399-0.html

Your question is not answered in any of these links? Contact us directly!

- Technical questions about your proposal/NOEMA: sog@iram.fr
- NOEMA data archive access/question: isda@iram.fr
- GILDAS software team: gildas@iram.fr

THANK YOU