

# IRAM NOEMA interferometer

## Observing Capabilities and Current Status

Melanie Krips

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This document is updated twice a year to reflect the capabilities of the interferometer at the time of the *Call for Proposals* publication. Non-trivial changes with respect to the previous version are **marked in red**. Note that this document contains active links marked with a different font for an easy access to documentation, e.g. on the IRAM **web pages**. The full links are also given on the last page of this document.

## 1 Progress of NOEMA

### 1.1 The new correlator PolyFiX

The new NOEMA correlator *PolyFiX* has been installed on Plateau de Bure in September 2017 and its main commissioning and science verification operations have successfully been completed in December 2017. Standard scientific observations have resumed in mid-December 2017, showcasing the immense potential of *PolyFiX* with its instantaneous bandwidth of 31 GHz spread over two sidebands and two polarisations (for more details see Section 2.7). The GILDAS software ASTRO as well as the Proposal Management System PMS have been upgraded to help users configure the *PolyFiX* spectral setups (see Section 2.7.1). The use of the **feb18** version of GILDAS is mandatory to prepare your proposals.

### 1.2 NOEMA's 10th antenna

There has been significant progress in the construction of antenna 10 by the end of last year, when the most massive part of the antenna, the central hub, was successfully carried onto the site. The parabola of the antenna is currently being assembled while this document is being written. The commissioning of antenna 10 is planned to be completed during this summer. We expect antenna 10 to join the array for regular scientific observations before the end of the summer semester.

## 2 Conditions for the next summer session

During the course of the summer semester, we plan to schedule two configurations. The number of antennas is dependent on maintenance work and the availability of antenna ten. A preliminary configuration schedule for the summer period is outlined below. Adjustments to this provisional configuration planning will be made according to commissioning requirements in the frame of NOEMA, proposal pressure, weather conditions, and other contingencies. The configuration schedule given below should be taken as a rough guideline, in particular for astronomical targets that cannot be observed during parts of the summer period because of sun avoidance constraints.

Conf	Scheduling Priority Summer 2018
D	June – August
C	September – November

The summer semester is preferred for low frequency (3 mm) and modest angular resolution observations (see also Section 2.3). Nevertheless, we do not discourage the submission of proposals that ask for observations at higher frequencies (2 mm & 1 mm) as a limited amount of observing time can still be invested. Atmospheric conditions are improving especially toward the end of the semester and sometimes even during summer nights. Circumpolar sources or sources transiting at night are hence the most opportune targets for the summer semester, in particular at high frequencies. Observations in band 4 will not be offered this semester.

We would like to remind you that no program from the current winter semester 2017/2018, including all A-rated programs, will be carried over into the upcoming summer semester. Investigators who wish to check the status of their project may consult the

interferometer schedule on the IRAM website. This page is updated daily.

## 2.1 General Proposal Considerations

Please give high importance to the quality of your proposal. The NOEMA interferometer is a powerful, but complex instrument, and proposal preparation requires special care, especially in light of its new capabilities. In particular, your proposal should not only justify the scientific interest, but also the need for NOEMA. Proposers should note in their application whether the same or a similar proposal was or is intended to be submitted to ALMA, in which case a special justification is required why IRAM interferometer time is needed.

Don't hesitate to contact the NOEMA Science Operations Group ([sog@iram.fr](mailto:sog@iram.fr)) in case of doubts and for questions related to the preparation of a proposal.

## 2.2 Proposal category

Proposals should be submitted through PMS for one of the **four** categories:

**STANDARD:** Proposals that ask for a total of less than 100h 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 and more generally all non-standard observations. These proposals will be carried out on a "best effort" basis.

**LARGE PROGRAM:** This category is re-opened for NOEMA this semester, but with certain restrictions (see the **Large Program Policy** on the IRAM web site for general details). In the frame of NOEMA's construction, additional antennas and more capabilities of the correlator are expected to become available during the

"lifetime" of a Large Program, usually spanning over several observing semesters. For the current Call for Proposals, the observing time request should be based on the availability and performance of a **nine-element array**. We might adjust it and/or review the observing strategy in response to PI needs and enhanced array's capabilities. In addition, and opposed to the general guidelines published on the link given above, less than the standard 50% of the total scheduled observing time will be reserved for *Large Programs* using NOEMA at this point. This restriction is necessary to account for the significant investment of technical time still needed to bring the NOEMA project to its full completion in the upcoming years.

The proposal category will have to be specified on the PMS web form and should be carefully considered by the proposers.

Within each of these categories, observations in Band 1, 2 and 3 can be requested which are described in more detail in Section 2.4 and in Table 2.

**Short spacing observations** on the 30-meter telescope should directly be requested on the interferometer proposal web form through PMS. A separate proposal for the 30-meter telescope is not required. The interferometer proposal form contains a box, labeled "Request for 30-meter short spacings" which should then be checked. The user will automatically be prompted to fill in an additional paragraph in which the need for short spacing data should be justified. It is essential to give here all observational details, including size and type of map, rms noise, spectral resolution, receiver, and time requested. **The following documents may help to prepare your short spacing observations: this Presentation** (especially page 23 for a brief summary) given at the 9th Interferometry School and **this Technical Report**. For further assistance, please contact the Science Operations Group ([sog@iram.fr](mailto:sog@iram.fr)).

## 2.3 Array Configurations

Two main configurations (D and C) will be scheduled providing optimum coverage of the uv-plane (see Table 1).

The general properties of these configurations (numbers refer to a source at 20° declination) are:

Table 1: Configurations of the eight- to ten-antenna array

Name	Stations								
8D	W12	W08	W05	E10	E04	N13	N09	N02	–
9C	W20	W12	W09	E16	E10	E03	N29	N20	N11

Table 2: Receiver characteristics

	Band 1	Band 2	Band 3
$F_{\text{sky}}$ range*/[GHz]	70.4–121.6	124.4–183.6	196.4–279.6
$T_{\text{rec}}$ /[K] LSB	25–35	30–50	30–60
$T_{\text{rec}}$ /[K] USB	25–35	30–50	30–60
$G_{\text{im}}$ /[dB]	-15...-10	-15...-10	-15 ... -10
RF LSB/[GHz]	$\leq 102$	$\leq 164$	$\leq 260$
RF USB/[GHz]	$\geq 92$	$\geq 144$	$\geq 216$

\* The *sky frequency* range  $F_{\text{sky}}$  refers to the limiting sky frequencies that can be covered by using the full receiver bandwidth.

- D alone is best suited for deep integration and coarse mapping experiments (resolution  $\sim 3.8''$  at 100 GHz and  $\sim 1.7''$  at 230 GHz). This configuration provides both the highest sensitivity to extended structures and the lowest atmospheric phase noise.
- C alone ( $\sim 2.0''$  at 100 GHz,  $\sim 0.9''$  at 230 GHz) is especially well suited for projects observing sources at lower declinations, as it reduces shadowing effects between antennas, and provides a higher angular resolution than the D configuration.

The two configurations can be used in combination to achieve complementary sampling of the uv-plane, and to improve on angular resolution and sensitivity. Check the ANY bullet in the proposal form if the scientific goals can be reached with either of the two configurations.

## 2.4 Receivers

All NOEMA antennas are equipped with 2SB receivers, providing low noise performance and excellent long-term stability. The receivers provide two orthogonal linear polarizations in all three bands. Each of the two polarizations delivers a bandwidth of 7.744 GHz in the lower sideband (LSB) and upper sideband (USB). The sky frequency ranges that can be covered in each band and further characteristics are given in Table 2.

Receiver tuning will preferentially be done on a fixed LO frequency grid of 500 MHz step width on which the receiver performance is optimized. However, tunings, that deviate from this tuning grid (see also Section 2.7.1), are still allowed but an explanatory statement should be added to the “technical justification” in the proposal.

## 2.5 Sensitivity

Investigators will be asked in PMS to specify the requested telescope time for each Technical Sheet. Based on the NOEMA performance at the time of publication of this document, PMS then calculates the corresponding 1 sigma point-source sensitivity for one representative frequency. The representative frequency has to be within the frequency range asked for in the respective technical sheet but does not have to be identical to the actual tuning frequency. Please note, that due to the large bandwidth and the dual-sideband mode, the noise can vary significantly with frequency. Especially, if one of the sidebands is close to a receiver band edge, significant differences in the noise can occur within and between the sidebands. This should be taken into consideration when setting the representative frequency for each tuning. Please note also that the *continuum* sensitivity (i.e. for the entire 15.488 GHz bandwidth and both polarisation) is currently calculated based on the *tuning* frequency only and variations of the noise across the band are not yet taken into account.

The same sensitivity calculation as done in PMS is also available in ASTRO through the *NOEMA Proposal Sensitivity estimator* (please use GILDAS version feb18). Contrary to previous semesters, both tools do now also account for the declination of the source. Longer telescope times are needed for sources at low declinations ( $\delta < -10^\circ$ ) than for those at high declinations to achieve the same point-source sensitivity.

Investigators should specify and motivate the telescope times and corresponding point-source sensitivities in the “technical justification” of their proposal. **Please verify that your numbers match throughout the proposal.**

## 2.6 Track-Sharing Mode

Each technical sheet, i.e. frequency tuning, can be connected to several sources in PMS. In case the sources, sharing the same tuning, are reasonably close to each other and need rather short telescope times, PMS now allows to specify a track-sharing mode which will result in a lower overall telescope time due to reduced overheads. Please note that PMS will issue a warning should the maximum distance between the track-shared sources exceed a recommended 15 degrees and/or should the number of track-shared sources be larger than 15. These limitations have been chosen, among other reasons, to allow for gain calibrators that can still be reasonably close to all sources and to reduce observing overheads due to slewing and calibration needs. However, the feasibility of track-sharing is not guaranteed even if no warning is given by PMS. In particular, Doppler tracking will be done by default on the mean LSR velocity of the targets (requests for other tracking modes should be justified). Users should check that the spectral lines of the two targets with the highest velocity difference to the mean velocity will not move out of the defined spectral windows. Therefore, a special care has to be applied when configuring the spectral setup.

## 2.7 PolyFiX

*PolyFiX* can process a total, instantaneous bandwidth of 31 GHz for up to twelve antennas that is split up into two polarisations in each of the two available sidebands (the *upper* and *lower* sideband). The centers of the two 7.744 GHz wide sidebands are separated by 15.488 GHz. Each sideband is composed of two adjacent *basebands* of  $\sim 3.9$  GHz

width that are called *inner* and *outer* basebands (see Fig. 1). In total, there are thus eight basebands which are fed into the correlator. The spectral resolution will be 2 MHz throughout the 15.488 GHz effective bandwidth per polarization. Additionally, up to sixteen high-resolution *chunks* can be placed in each of the eight basebands (i.e. up to 128 chunks in total). Each of these has a width of 64 MHz and, in this first implementation step of *PolyFiX*, a fixed spectral resolution of 62.5 kHz. A number of contiguous chunks defines one *spectral window*.

Please note that there is a “non-exploitable, 20 MHz wide frequency area” ( $\equiv$  LO2 zone) around the center of each sideband, i.e., in between the inner and outer basebands. Due to the filter response of the correlator, the noise level is also increased by up to a factor of two within a width of  $\pm 50$  MHz around the center in each sideband. Thus, important lines should not be placed there (see also pages 19 and 20 in [this PolyFiX tutorial](#)).

### 2.7.1 ASTRO

The software ASTRO should be used to set up the receiver and correlator configuration. A description of the *PolyFiX* correlator and of the commands provided in ASTRO to prepare the correlator configuration can be found in [this PolyFiX tutorial](#). Please use the feb18 version of GILDAS.

The essential ASTRO commands are:

- **TUNING**: receiver tuning
- **BASEBAND**: selection of baseband(s)
- **SPW**: definition of high resolution spectral windows
- **PROPOSAL**: exports a script that needs to be uploaded to PMS

Receiver tuning is done on a fixed grid of LO frequencies, spaced by 500 MHz throughout each receiver band, on which the receiver performance is optimized. For a correct receiver tuning, either the source LSR velocity is needed or the (red)shifted frequencies should be used. In the latter case the LSR velocity (or redshift) have to be set to zero in the source command. For more details see the internal help for the TUNING command.

A typical session in astro would be:

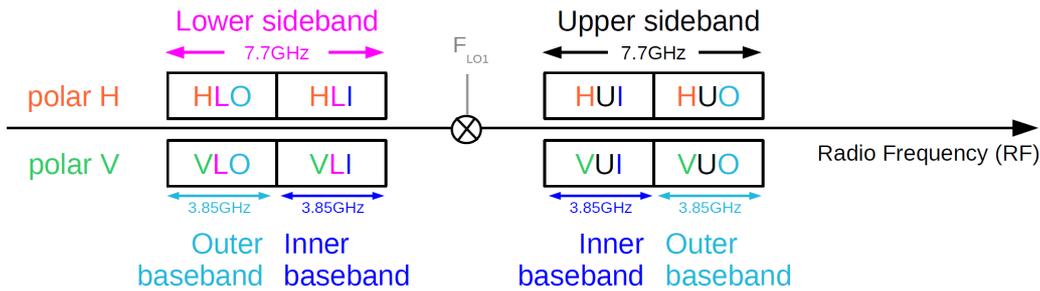


Figure 1: Basebands fed to the correlator

```

! Define a source with LSR velocity
SOURCE TOTO EQ 2000 09:11:39.786 -
          30:53:29.257 LSR 7.0

! choice of receiver tuning
TUNING 232.686 LSB 7500
! ASTRO will shift the IF centering by
! 180.6MHz to match the tuning grid

TUNING 232.686 LSB 7319.4 /ZOOM
! Plots the selected receiver band only

BASEBAND
! select all 8 basebands

! define and display high resolution
! spectral windows (central frequency
! and width specified)
SPW /FREQUENCY 244.9 0.2
SPW /FREQUENCY 245.6 0.2
SPW /FREQUENCY 232.686 0.03
SPW /FREQUENCY 230.538 0.08
SPW /FREQUENCY 231.15 0.3
...

PROPOSAL /FILE MyFile.astro
! write the series of commands
! to set up the instrument
! THE MyFile.astro NEEDS TO BE
! UPLOADED TO PMS

```

The TUNING command produces a plot showing the full 15.488 GHz bandwidth covered in both sidebands. The TUNING command checks that the LO frequency is located on the 500 MHz-spaced tuning grid. If this is not the case, the command moves the tuned frequency to a neighboring IF center frequency that matches the grid. The option /FIXED\_FREQ can be used to ignore the tuning grid (e.g., if using the tuning grid does not cover all

desired lines with the proposed tuning or a contiguous spectral scan is requested).

Compared to the last call, PMS will from now on only accept to load ASTRO scripts created with the NOEMA OFFLINE syntax, i.e., with the PROPOSAL command. This will allow PMS to show spectral coverages in a consistent way for any kind of projects (including line markers at the correct rest frequency for redshifted sources for instance).

In the previous session (W17), PMS was accepting NOEMA ONLINE language scripts, as created by the SETUP command. In case you wish to convert one script produced during the last semester, you should type in astro:

```

OBSERVATORY NOEMA ONLINE
@ MyOnLineScript.astro
PROPOSAL /FILE MyOfflineScript.astro

```

Note that the scripts uploaded to PMS during the W17 session have been automatically converted into OFFLINE syntax. They thus can be directly cut and paste.

## 2.8 Source coordinates and Velocities

The interferometer operates in the equatorial J2000.0 coordinate system. Please do not forget to specify the exact coordinates and either LSR velocities or redshifts for the sources. The source list must contain all the sources (and only those sources) for which observing time is requested. The list must adhere to the standard sexagesimal notation. Source coordinates and velocities must be correct: Wrong or incomplete source coordinates are a potential cause for proposal rejection.

**A later swap of targets is not foreseen for regular projects.**

## 2.9 Sun Avoidance

For safety reasons, a sun avoidance circle is enforced at 32 degrees from the sun.

## 2.10 Technical pre-screening

All proposals will be reviewed for technical feasibility in parallel to being made available to the members of the program committee. Please help in this task by submitting technically precise proposals. Note that your proposal must be complete and exact: the source position and velocity, as well as the requested frequency setup must be correctly given.

### 2.10.1 Duplication Check

In order to ensure the most efficient use of the NOEMA interferometer, proposals will be checked for duplication during the technical pre-screening. Unless scientifically justified, proposals that aim to reach the same goals of programs observed in previous semesters with similar or equivalent observing configurations with respect to target selection, observing frequency, angular resolution and sensitivity will not be accepted. Header information of PdBI/NOEMA observations later than 1991 but before October 2016 (for this Call) can be found in the CDS Vizier catalogue (*Centre de Données astronomiques de Strasbourg*). In the future, PIs will be able to perform a duplication check of their proposals also against programs observed in more recent semesters. However, for this deadline we kindly ask the PIs to contact the NOEMA science operations group at [sog@iram.fr](mailto:sog@iram.fr) in case of doubts concerning duplication of observing programs from the last two years.

## 2.11 Non-standard observations

If you plan to execute a non-standard program, please contact the Interferometer Science Operations Group ([sog@iram.fr](mailto:sog@iram.fr)) to discuss the feasibility.

## 2.12 Documentation

Documentation for the IRAM Interferometer can be retrieved from the following link: [NOEMA Documentation web pages](#). Detailed up-to-date information is currently only available in the description of the [Current NOEMA capabilities](#) (i.e., this document).

## 2.13 Local Contact

A local contact will be assigned to every A and B rated proposal which does not already involve an in-house collaborator. He/she will assist you in the preparation of the observing procedures and provide help to reduce the data.

Assistance (write to [sog@iram.fr](mailto:sog@iram.fr)) is also provided before a deadline to help in the preparation of a proposal. Depending on the program complexity, IRAM may require an in-house collaborator instead of the normal local contact.

## 2.14 Data reduction

Proposers should take the following into account with respect to reduction of their data:

- We recommend that proposers reduce their data in Grenoble. For experienced users, remote data reduction can also be offered. Please contact your local contact if you're interested in this possibility.
- We keep the data reduction schedule very flexible, but wish to avoid the presence of more than two groups at the same time in Grenoble. Data reduction will be carried out on dedicated computers at IRAM. Please contact us in advance.
- In certain cases, proposers can be provided with updates as their observations progress. This service does not replace a careful data reduction after completion of the project. Please contact your local contact or NOEMA's Science Operations Group ([sog@iram.fr](mailto:sog@iram.fr)) if you are interested in observational updates.
- Observers who wish to finish data reduction at their home institute should obtain the most recent version of CLIC. Because differences between CLIC versions may potentially result in errors if new data are reduced with an old package, we advise observers having a copy of CLIC to take special care in maintaining it up-to-date. The newer versions are downward compatible with the previous releases.

## Links to online documentation mentioned in the text:

IRAM Web Pages:

<http://iram-institute.org/EN/content-page-56-7-56-0-0-0.html>

The Proposal Management System PMS:

<http://pms.iram.fr>

Gildas Version feb18:

<http://www.iram.fr/~gildas/dist/index.html>

Interferometer Schedule:

<http://www.iram.fr/IRAMFR/PDB/ongoing-last.html>

Large Program Policy:

<http://www.iram-institute.org/EN/content-page-243-7-158-243-0-0.html>

Interferometry School Presentation on Short-Spacings:

<http://www.iram.fr/IRAMFR/IS/IS2016/presentations/pety-mosaicking.pdf>

Technical Report on Short-Spacings:

[http://www.iram-institute.org/medias/uploads/IRAM\\_memo\\_2008-2-short-spacings.pdf](http://www.iram-institute.org/medias/uploads/IRAM_memo_2008-2-short-spacings.pdf)

*PolyFiX* tutorial:

<http://www.iram.fr/~gildas/demos/astro/demo-astro-noema.pdf>

The CDS VizieR catalogue:

<http://vizier.u-strasbg.fr/viz-bin/VizieR-3?-source=B/iram/pdbi>

NOEMA Documentation web pages:

<http://www.iram-institute.org/EN/content-page-96-7-56-96-0-0.html>

Current NOEMA capabilities:

<http://www.iram.fr/IRAMFR/GENERAL/calls/s18/NOEMACapabilities.pdf>