IRAM NOEMA interferometer

Observing Capabilities and Current Status

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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`.

1 Progress of NOEMA

Commissioning of antenna 9 was successfully completed during the last months, and the new antenna joined the array for regular observing in May 2017. For the upcoming winter semester 2017/2018, nine antennas will therefore be available for science observations.

1.1 New correlator PolyFiX

The new NOEMA correlator *PolyFiX* is now scheduled to be installed on Plateau de Bure starting end of August 2017. Commissioning is expected to be finished by the start of the winter semester.

PolyFiX will be able to process an instantaneous bandwidth of 31 GHz, i.e. two times 7.7 GHz delivered by the receivers in each of the two sidebands, and in each polarization (= 4 *IF channels* in total). More details are given in Section 2.6. The GILDAS software ASTRO has been upgraded to help users configure the *PolyFiX* spectral setups (see Section 2.6.1 below). The use of the `jul17` version of GILDAS (or later) is mandatory to prepare your proposals.

1.2 Antenna construction

Construction of NOEMA antenna 10 is progressing according to plans. The antenna mount, its thermal insulation and electronic interfaces have already been completed. The next step will be to assemble the reflector. If the current schedule is maintained, antenna 10 will be delivered for commissioning and science verification end of spring 2018.

2 Conditions for the next winter session

During the course of the winter semester, we plan to schedule all three configurations of the nine antenna array. A preliminary configuration schedule for the winter 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 when the requested astronomical targets cannot be observed during the entire winter period because of sun avoidance constraints.

9-Ant Conf	Scheduling Priority Winter 2017/18
C	December
D	December – January
A	January – February
C	February – March
D	March – May

The winter semester is preferred for high frequency (1.3 mm) observations. Nevertheless, we encourage proposers to submit proposals also for observations at lower frequencies (3 mm & 2 mm) for which a significant amount of observing time can be invested, especially when atmospheric conditions are not good enough at high frequencies.

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

Table 1: Configurations of the nine-antenna array

Name	Stations								
9A	W27	W10	E68	E24	E12	E04	N46	N29	N20
9C	W20	W12	W09	E16	E10	E03	N29	N20	N11
9D	W12	W09	W05	E10	E04	N13	N09	N05	N02

`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. 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 NOEMA's Science Operations Group (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 the `Proposal Management System PMS` for one of the three categories:

STANDARD: Proposals that ask for a total of less than 100 h of observing time and to use the interferometer within its guaranteed capabilities (see the following sections).

TIME FILLER: Proposals that have to be considered as background 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.

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 30m telescope should directly be requested on the interferometer proposal web form through `PMS`. A separate proposal for the 30m telescope is not required. The interferometer proposal form contains a box, labeled "Request for 30m 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: a `Presentation` (especially page 23 for a brief summary) given at the 9th Interferometry School and a `Technical Report`. For further assistance, please contact NOEMA's Science Operations Group (sog@iram.fr).

Due to the large investment in technical time in the current phase of the NOEMA project, Large Programs will not be accepted for the interferometer under the current Call for Proposals.

2.3 Configurations of the nine antenna array

Three new configurations have been designed for the nine-antenna array providing optimum coverage of the uv-plane (see Table 1).

Table 2: Receiver characteristics

	Band 1	Band 2	Band 3
F_{sky} range*/[GHz]	70.9–121.6	124.4–183.6	196.4–279.6
T_{rec}/[K] LSB	25–35	30–50	30–60
T_{rec}/[K] USB	25–35	30–50	30–60
G_{im}/[dB]	-15-...-10	-15...-10	-15 ... -10
RF LSB/[GHz]	≤102	≤164	≤260
RF USB/[GHz]	≥92	≥144	≥216

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

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

- `A` alone is well suited for mapping or size measurements of compact, strong sources. It provides a resolution of 1.0″ at 100 GHz, ∼0.4″ at 230 GHz.
- `C` provides a fairly complete coverage of the uv-plane and is well adapted to combine with D for low angular resolution studies (∼2.6″ at 100 GHz, ∼1.1″ at 230 GHz) and with A for higher resolution (∼1.4″ at 100 GHz, ∼0.6″ at 230 GHz). C alone (∼1.9″ at 100 GHz, ∼0.85″ at 230 GHz) is also well suited for snapshot and size measurements, and for detection experiments at low source declination.
- `D` alone is best suited for deep integration and coarse mapping experiments (resolution ∼ 3.7″ at 100 GHz and ∼ 1.6″ at 230 GHz). This configuration provides both the highest sensitivity to extended structures and the lowest atmospheric phase noise.

The three configurations can be used in different combinations to achieve complementary sampling of the uv-plane, and to improve on angular resolution and sensitivity. Mosaicing is usually done with D or CD, but the combination ACD can also be requested (e.g. for high resolution mosaics). Check the ANY bullet in the proposal form if the scientific goals can be reached with any of the three configurations or their subsets. There is a possibility on the PMS web form to restrict the choice of configurations, e.g., to C or D, if your project qualifies for ANY of the more compact configurations.

2.4 Receivers

All NOEMA antennas are equipped with the new 2SB receivers, providing reduced noise temperatures and excellent long-term stability. The receivers provide two orthogonal linear polarizations in Band 1, 2, and 3. Each of the two polarizations delivers a bandwidth of 7.7 GHz per sideband, LSB and USB. The sky frequency ranges that can be covered in each band and further characteristics are given in Table 2. However, the assessment of the receiver performance, in particular in the upper half of the IF bands, is conditional on the installation of *PolyFiX*.

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, if a tuning is needed that deviates from the tuning grid (see also Section 2.6.1), an explanatory statement should be added to the "technical justification" in the proposal.

2.5 Sensitivity

Investigators will be asked in the Technical Sheet in `PMS` for the requested telescope time. `PMS` then calculates the corresponding 1 sigma point-source sensitivities based on the NOEMA performance at the time of publication of this document. The same sensitivity calculation is also available in ASTRO through the *NOEMA Proposal Sensitivity estimator* (please use GILDAS version `jul17` or later). 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.

Please note that neither the *NOEMA Proposal Sensitivity estimator* in ASTRO nor `PMS` currently account for the declination of the source. For low-declination sources ($\delta < -10°$), however, longer

integration times are needed to achieve the point-source sensitivities estimated by PMS and ASTRO. We hence ask the proposers to increase the telescope times in the technical sheets of their proposal by a factor of 2 for low declination sources, even if it results in a better sensitivity in PMS than actually needed. Please also add an explanatory sentence about the increased telescope times and hence apparently better sensitivities in the "technical justification".

2.6 *PolyFiX*

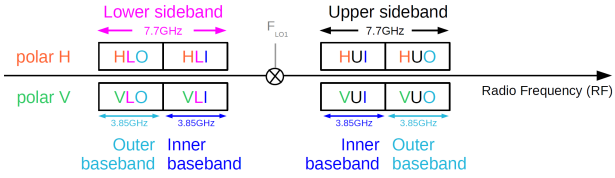

Figure 1: Basebands fed to the correlator

PolyFiX will be able to process the full instantaneous bandwidth of 31 GHz, i.e. 7.7 GHz in each of the two sidebands, and in both polarizations (= 4 *IF channels* in total) for up to 12 antennas. Each IF channel is split into two *basebands* of ∼3.9 GHz width (*inner* and *outer* baseband) that are fed into the correlator (see Fig. 1). In total, there are thus 8 basebands which are processed by the correlator. The spectral resolution will be 2 MHz throughout the 15.4 GHz total bandwidth in both polarizations. Additionally, up to 16 high-resolution so-called *chunks* can be placed in each of the 8 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 channel spacing of 62.5 kHz. A number of contiguous chunks defines a *spectral window*. Please note that the four neighboring chunks stitching the inner and outer basebands together can be contaminated by each other due to the filter response toward the baseband edges (for more details see pages 19 and 20 in the presentation following `this link`). While the continuum signal can be fully recovered in this 256 MHz wide "confusion zone", spectral lines may not be fully recoverable in the affected chunks under certain circumstances. For more information, please contact NOEMA's Science Operations Group (sog@iram.fr).

2.6.1 ASTRO

The software ASTRO can be used to set up the receiver/correlator configuration. A description of the *PolyFiX* correlator and of the commands provided in ASTRO to set up the correlator configuration can be found `here` (see p. 25 ff). Please use the `jul17` version of GILDAS (or later).
The essential new ASTRO commands are:

- `TUNING`: receiver tuning
- `BASEBAND`: selection of baseband(s)
- `SPW`: definition of high resolution spectral windows
- `SETUP`: export 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, the source LSR velocity is needed. All this is taken into account in the latest ASTRO version (`jul17`). For more details see the internal help for the TUNING command.

A typical session would be:

```
! 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
! display 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
...
SETUP /FILE MyFile.astro
! write the series of commands
! to set up the instrument
! This file needs to be uploaded to PMS
```

The TUNING command would produce a plot showing the full 15.4 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 the tuning grid does not cover all desired lines with the proposed tuning).

2.7 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.

2.8 Sun Avoidance

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

2.9 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 tinhat 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 Non-standard observations

If you plan to execute a non-standard program, please contact NOEMA's Science Operations Group (sog@iram.fr) to discuss the feasibility.

2.11 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` (this document).

2.12 Local Contact

A local contact will be assigned to every A or B rated proposal which does not 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) 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.

2.13 Data reduction

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

- All projects that are observed within the first few months after the commissioning of *PolyFiX* are requested to be reduced in Grenoble (i.e., no remote data reduction will be offered). To guarantee the best possible support for these projects, only one data reduction group will be allowed at the same time. Please contact us in advance to help us organise reduction trips in the most efficient way. We will try to keep the schedule on data reduction as flexible as possible.

- 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) if you are interested in observational updates.