IRAM NOEMA interferometer

Observing Capabilities and Current Status

Jan Martin Winters

February 13, 2017

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 previous versions 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

1.1 Antenna construction

The commissioning and science verification campaign of antenna 9 is planned to start in March and the antenna will be integrated in the array for the commissioning of the new NOEMA correlator.
Construction of antenna 10 started at the end of July 2016 and is foreseen to be commissioned around end of 2017.

1.2 Receiver upgrades

All NOEMA antennas will be 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 are 70.9 GHz to 121.6 GHz for band 1, 124.4 GHz to 183.6 GHz for band 2, and 196.4 GHz to 279.6 GHz for band 3, but the receiver performance assessment, in particular in the upper half of the IF bands, is conditional on the installation of PolyFix. Details on the receiver characteristics are given in Table 2.
Receiver tuning will preferentially be done on a fixed LO frequency grid of 500 MHz step width, four times denser than before, on which the receiver performance is optimized.

1.3 New correlator PolyFix

The new NOEMA correlator *PolyFix* is scheduled to be installed around end of April. The installation and commissioning of PolyFix representing a major and complex task, **science operations will be shut down during the 1st half of the semester**. **Because of the complexity of the upgrades, observations will be offered on a shared-risk basis in the summer semester and no DDT proposals will be accepted in this period**.
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 3.5. The Gildas software ASTRO has been upgraded to help users configure the PolyFix spectral setups (see Section ASTRO below). The use of the `feb17` version (or later) of Gildas is mandatory to prepare your proposals.

2 Weather conditions and observing during the winter semester

The interferometer entered into the current winter semester with the antennas arranged in the eight-antenna C configuration. Weather conditions became very good to excellent at the beginning of December. The interferometer was moved to A configuration already around mid December, well ahead of the original configuration planning, and after virtually all A-rated projects asking for C configuration had been worked off. All A-rated and even most B-rated proposals requesting the A configuration could be successfully observed and obtained on average data of excellent quality. On January 20, the interferometer was finally arranged in its most compact (D) configuration.

As far as A-rated projects are concerned, we strive

to bring most of them to completion before the arrival of PolyFix, when regular science observations will be stopped in favor of the installation and the commissioning of the new correlator.
B-rated projects are likely to be observed only if they fall in a favorable LST range. We remind users of the interferometer that B-rated projects and time-filler projects which are not started before the proposal deadline have to be resubmitted.
Investigators, who wish to check the status of their project may consult the `interferometer schedule` on the Web. This page is updated daily.

3 Conditions for the next summer period

During the summer we plan to schedule essentially the 8-antenna D configuration (see Tab. 1), and the 9 antenna C configuration should be available toward the end of the semester.
Due to the large investment in technical time necessary in the current extension phase of the NOEMA project, *Large Programs* will not be accepted for the interferometer under the current *Call for Proposals*.

We strongly encourage observers to submit proposals that can be executed during summer operating conditions. To keep the procedure as simple as possible, we ask you to put emphasis on:

- observations requesting the use of the 3 mm and 2 mm receivers,
- circumpolar sources or sources transiting at night between June and September,
- observations that qualify for the 8D and 9C configurations (see Tab. 1 and Sect. 3.3 below).

3.1 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 NOEMA time is needed.
Don't hesitate to contact the NOEMA Science Operations Group (sog@iram.fr) in case of doubts and for questions related to the preparation of a proposal.

3.2 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 proposers.

Within each of these categories, observations in one or several of the following frequency bands can be requested:

BAND 1: Proposals that ask for 3 mm data.

BAND 2: Proposals that ask for 2 mm data. Band 1 receivers may be used for pointing and calibration purposes, but cannot provide any imaging in parallel.

BAND 3: Proposals that ask for 1.3 mm data. Band 1 receivers may be used for pointing and calibration purposes, but cannot provide any imaging in parallel.

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

Table 1: Summer semester configurations of the eight- and nine-antenna array

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

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]	$\leq$102	$\leq$164	$\leq$260
RF USB/[GHz]	$\geq$92	$\geq$144	$\geq$216

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

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.

3.3 Configurations of the eight- and nine-antenna array

New configurations have been designed for the eight- and nine-antenna array, they are given in Table 1.

Part of the projects will be scheduled at the end of the summer period when all nine antennas should be available. Projects observed with a subset of the regular array will be adjusted in uv-coverage and observing time.

The following configuration sets are available:

- `D` is best suited for deep integration and coarse mapping experiments (resolution $\sim$ 3.6″ at 100 GHz). This configuration provides both the highest sensitivity and the lowest atmospheric phase noise.
- `CD` (i.e. the combination of C **and** D configuration) is well adapted for low angular resolution studies ($\sim$2.4″ at 100 GHz).
- `C` is appropriate for mapping, snapshot, and size measurements and for detection experiments at low declination. It provides a spatial resolution of $\sim$ 2″ at 100 GHz.

The above numbers refer to a source at 20° declination.

Finally, enter ANY in the proposal form if your project is flexible for scheduling in either of these configurations.

3.4 Sensitivity

Investigators have to specify in the "technical justification" and on the Technical Sheet the 1 sigma point source sensitivity which is necessary to achieve each individual goal of a proposal, and particularly for projects aiming at deep integrations. Please verify that your numbers match throughout the proposal. `PMS` asks for the telescope time requested and calculates the resulting point-source sensitivities. The sensitivity estimate implemented in `PMS` has been updated for the NOEMA performance at the time of publication of this document. The same implementation for the sensitivity calculation is available in ASTRO (starting with Gildas version `feb17`) through the *NOEMA Proposal Sensitivity estimator*. Only for low-declination sources ($\delta < -10°$) that result in higher system temperatures than implemented in `PMS`, the *NOEMA Detailed Sensitivity estimator* must be used to estimate realistic on-source times for a given sensitivity. In these cases, please request in the `PMS` form the needed telescope time, even if it results in the PMS estimate in a better sensitivity than actually needed. An explanatory sentence should then be added in the "technical justification".

3.5 PolyFix

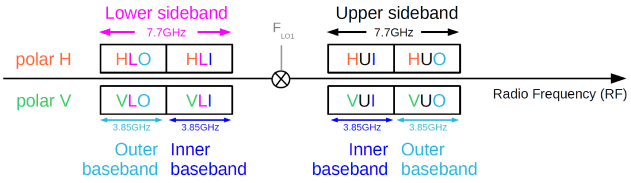

Figure 1: Basebands fed to the correlator

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*.

3.5.1 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. 33 ff).
This new functionality is distributed starting with the `feb17` version of Gildas.

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 now 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 line-of-sight velocity is needed. All this is taken into account in the latest ASTRO version (`feb17`). 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.

3.6 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.

3.7 Sun Avoidance

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

3.8 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.

3.9 Non-standard observations

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

3.10 Documentation

Documentation for the IRAM Interferometer can be retrieved from the `NOEMA Documentation web pages`. Detailed up-to-date information is currently only available in the description of the `Current NOEMA capabilities` (this document).

3.11 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.

3.12 Data reduction

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

- As far as projects observed with PolyFix are concerned, we request that proposers reduce their data in Grenoble. Remote data reduction is not offered during the initial phase of PolyFix.
- We keep the data reduction schedule very flexible, but wish to avoid the presence of more than 2 groups at the same time in Grenoble. Data reduction will be carried out on dedicated computers at IRAM. Please contact us in advance. Only very limited support will be available during this summer semester for calibrating data obtained previously with WideX and the NB correlator.
- 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.
- 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. This is of particular importance during the initial phase of PolyFix. The newer versions are downward compatible with the previous releases.