

Press release

NenuFAR officially becomes a LOFAR super station



Developed and implemented at the Nançay Radio Observatory (Observatoire de Paris - PSL / CNRS / Université d'Orléans), the low-frequency radio telescope NenuFAR will be connected to the international LOFAR telescope, operated by ASTRON, the Netherlands Institute for Radio Astronomy.

NenuFAR¹ is the acronym for "New Extension in Nançay Upgrading LOFAR" and officially becomes a giant "low frequency" station of the International LOFAR Telescope: the LOFAR Super Station (LSS). It thus achieves the objective for which it was originally designed by French radioastronomers: with this connection, its data will now be transmitted to LOFAR, which will significantly increase its observing power: the long baselines linking NenuFAR to the other LOFAR stations will see their sensitivity multiplied by a factor of 4 to 5, or even more below 50 MHz.

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"This is a validation of the scientific and technical vision and ambition that prevailed when this project was created 14 years ago, as well as the result of the efforts of all those who made it possible" says Michel Tagger, CNRS Research Director and scientific co-lead of the project.

As early as 2008, French researchers with expertise in low-frequency radioastronomy noted that the LOFAR instrument was not fully optimised at frequencies between 10 and 85 MHz (outside the 40-70 MHz band), implying limits to its ability to observe faint sources at these frequencies, such as pulsars, exoplanets or the cosmic dawn. One of the goals defined for the creation of NenuFAR in Nançay, around the French LOFAR station installed in 2010, was precisely to improve these performances.

Inaugurated in 2019, NenuFAR, which is still in construction but already in operation, today consists of 1,596 antennas, most of which are gathered in a 'core' 400 m in diameter, and 76 are more distant, up to 3 kilometres from the core. On completion, scheduled for 2023, it will count 1,938 antennas, of which 114 remote.

"We have developed the standalone use of NenuFAR with several observation modes, without ever abandoning the objective of making it a LOFAR super station" explains its scientific lead, Philippe Zarka.

Its official connection with LOFAR follows a recent test campaign that conclusively demonstrated the feasibility of using NenuFAR as a giant LOFAR station, operating at frequencies between 10 and 85 MHz.

¹ <https://nenufar.obs-nancay.fr>

"To carry out these tests, we had to overcome a number of technical and political obstacles, but we persevered and the results fully meet our expectations" says Jean-Mathias Grießmeier, assistant astronomer at LPC2E (CNES / CNRS / Université d'Orléans)², who coordinated these tests.

NenuFAR thus becomes a LOFAR Super Station (LSS), and will thus significantly improve the low-frequency, high-angular resolution images of LOFAR and its upgrade LOFAR 2.0. The first image taken in LSS mode has a resolution better than one arc second at 50 MHz.

"Achieving sub-arcsecond resolution at such low frequencies, was made possible by the baselines between LOFAR stations that extend over more than 2,000 km, and whose sensitivity is enhanced by the contribution of NenuFAR. This resolution gives access to the structure of nearby galaxies or extragalactic jets" says Stéphane Corbel, director of the Nançay Radio Observatory.

"NenuFAR will greatly enhance LOFAR's ability to search for astronomical sources that shine brightest in long-wavelength radio waves. Some of the exciting sources we aim to discover are exoplanets that interact with their parent star, and radio flashes originating at billions of lightyears distance in other galaxies", enthuses Jason Hessels, chief astronomer at ASTRON.

The decision was ratified on 14 December 2021 by the board of the International LOFAR Telescope (ILT), where France is represented by the FLOW consortium.

"This decision was reached following very constructive discussions" notes Michel Tagger.

It states that the connection of NenuFAR in LSS mode is officially integrated into the development of LOFAR 2.0, and defines the conditions under which the connection will be made, namely:

- the hardware and software upgrade of the LOFAR station of Nançay - FR606 to the LOFAR 2.0 standard;
- specific elements dedicated to the LOFAR - NenuFAR dialogue;
- cost and task sharing between ILT and FLOW;
- a fraction of NenuFAR observation time reserved for LSS mode.

A strategy has also been defined to connect the NenuFAR antennas to the French LOFAR station in the near future, without waiting for its upgrade, allowing the LSS mode to be operated with LOFAR as soon as possible, and before the solar maximum of 2025 (which will negatively affect radioastronomical observations due to intense solar radio emissions and perturbations of the Earth's ionosphere caused by solar activity).

This agreement strengthens the international partnership built around LOFAR, operated by the Dutch institute ASTRON, governed by the ILT, and which now

² Laboratoire de physique et chimie de l'environnement et de l'Espace (CNES/CNRS/Université d'Orléans)

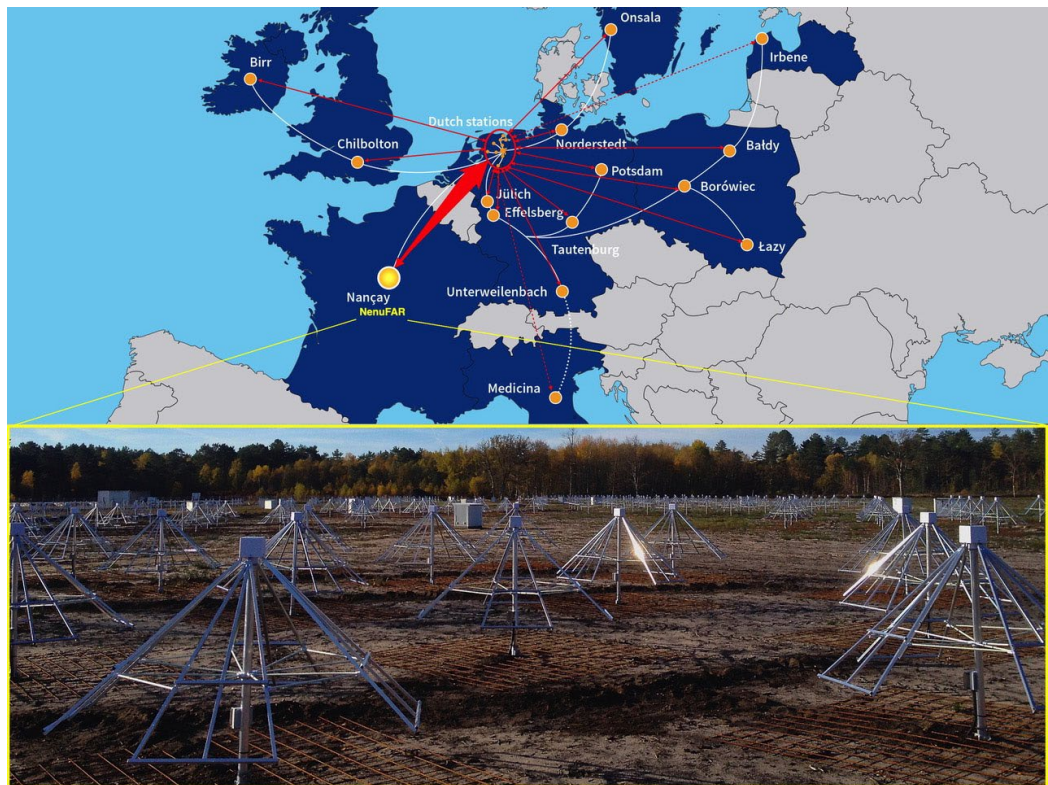
has 52 stations across Europe³.

"The connection of NenuFAR into the pan-European LOFAR antenna network is a great example of international collaboration to enhance a research infrastructure that is unique in the world", adds Rene Vermeulen, director of the ILT. "Astronomers are planning a wide range of sensitive high resolution studies at the lowest radio frequencies observable from Earth."

Since 2014, NenuFAR has been recognised, like LOFAR, as a pathfinder for the future SKA global radio telescope⁴.

"The standalone operation of NenuFAR, which is gaining momentum, will also provide new results in the coming year" promises Philippe Zarka.

Image



Caption: The NenuFAR low-frequency radio telescope (bottom) becomes a LOFAR super station, about 20 times more sensitive than other international stations in the low frequency range. This will greatly improve the quality of LOFAR's high angular resolution images at low frequencies.

Credits: USN / ASTRON

³ <https://www.astron.nl/lofartools/lofarmap.html>

⁴ <https://www.skatelescope.org/precursors-pathfinders-design-studies/>