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LOFAR-BG Current State

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1. Abstract.

LOFAR (LOw Frequency ARray) is the largest radio telescope operating at the lowest frequencies that can be observed from Earth. LOFAR makes observations in the 10 MHz to 240 MHz frequency range with two types of antennas: Low Band Antenna (LBA) and High Band Antenna (HBA), optimized for 10-80 MHz and 120-240 MHz respectively. The electric signals from the LOFAR stations are digitised, transported to a central digital processor, and combined in software in order to map the sky. Now there are LOFAR stations in Netherlands (38 stations), Germany (six stations), Poland (three stations), France, Ireland, Latvia, Sweden, and the United Kingdom (one station each); stations in Italy and Bulgaria are funded to be built.

Keywords: LOFAR; radio; low frequency; astronomy; Rozhen observatory.

2. Introduction

The International LOFAR Telescope (ILT) is one of the foremost radio astronomy observatories in the world, established in 2010, and now undergoing a significant upgrade that will keep it at the cutting edge throughout the next decade and beyond. Highly innovative LOFAR electronic antenna stations are connected by wideband fiber connections to powerful computer clusters. The data are stored in archives encompassing many Petabytes, and processed with advanced algorithms and software involving the very same techniques used for the widely publicized recent M87 black hole image.

The ILT has the ability to transform science projects, probing deeply into the early Universe, allowing major progresses in the understanding of extremely energetic cosmic phenomena, and offering unique tools for studying the Sun, even of the Earth's Ionosphere and Space Weather phenomena. It is also possible to use its advanced technology platform to develop transformational science projects.

The ILT, as a major observatory in its own right, and also a science and technology pathfinder for the planned Square Kilometre Array (SKA), has not only sparked the interest of astronomer groups around the world, but is drawing international attention from commercial high-tech companies. LOFAR scopes out much of "modern" parameter space, with its advanced sensor technology, coupled to cutting-edge ultra-high volume data connectivity over fibre, and state-of-the-art information processing technology to handle the highly complex task of detecting millions upon millions of extremely faint celestial objects in the presence of a host of perturbing influences on the radio signals. To be sure, in the era of the SKA, the ILT will be an important complement, with higher image resolution and longer wavelength coverage, to which a Bulgarian LOFAR station will make important contributions.

3. LOFAR-BG – Part of The National Roadmap for Research Infrastructure 2020-2027

The initiative to establish a LOFAR-BG station of radio antennas is spearheaded by Dr. Kamen Kozarev of the Bulgarian Academy of Sciences.

In May 2020, the infrastructure project LOFAR-BG, coordinated by the Institute of Astronomy and National Astronomical Observatory (IANAO), was approved for inclusion in the updated National Roadmap for Scientific Infrastructure 2020-2027 (NRSI), created and supported by Bulgaria's Ministry of Education and Science. Currently, members of the national consortium for managing the project also include the Dept. of Astronomy of Sofia University, the Dept. of Astronomy of Shumen University, as well as the Dept. of Radio Communication and Video Technologies of the Technical University-Sofia. In the future, we will be adding new partners to the consortium.

The LOFAR-BG station (Figure 1.) will significantly enhance the observing capabilities of the ILT. First, it brings welcome extra sensitivity. A particular strength is the location in southeastern Europe: combining its sensor data with data from stations further north (in Poland) and west (in Italy) will give added "telephoto zoom" capability for more detailed imaging of the sky.

Bulgarian scientists will join in the ILT at the stage where considerable expertise with its novel technical concepts has already accrued. The LOFAR user community (among them more than a dozen ERC grantees already) is rapidly expanding, and an ever-increasing number of publications is emerging in the world's leading peer-reviewed scientific magazines. Joining will mean that the Bulgarian community can be tutored along very steep learning curves, and then can proceed to use the ILT for its research, as well as to contribute to the on-going development of ever more sophisticated electronics, data processing and analysis tools.

Further developments will surely take place in part in the context of existing and continuing national, multinational, and EC funding opportunities.

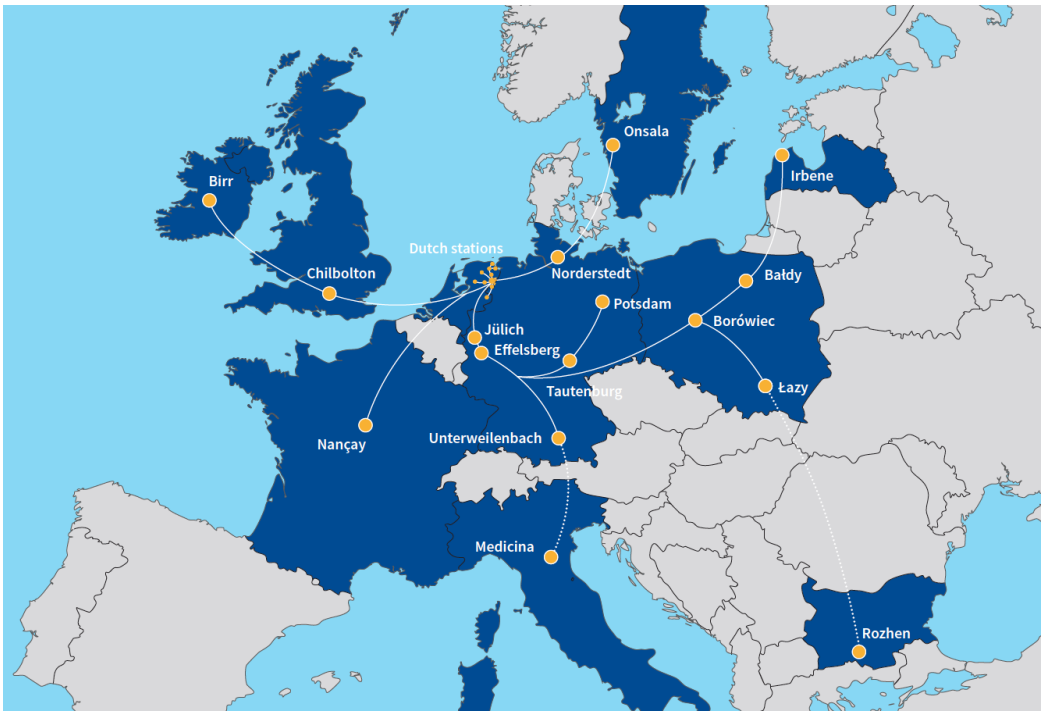

Figure 1. LOFAR Stations across Europe

4. LOFAR-BG – current state

We are currently working on preparing for the station (near NAO Rozhen, see Figures 2, 3):

- LOFAR-BG – part of The National Roadmap for Research Infrastructure 2020-2027
- Building power and communications infrastructure;
- Planning changes to the general municipal layout plan;
- Planning land works for flattening the terrain (2023 - 2024).

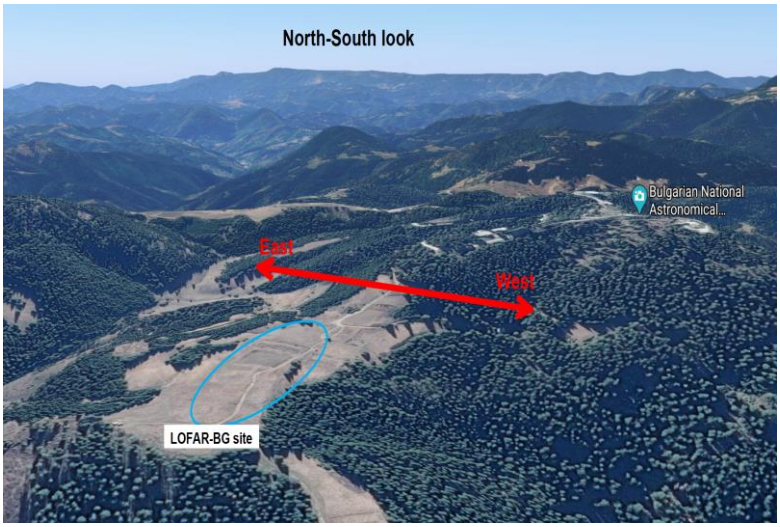

Figure 2. LOFAR -BG site near National Astronomical Observatory

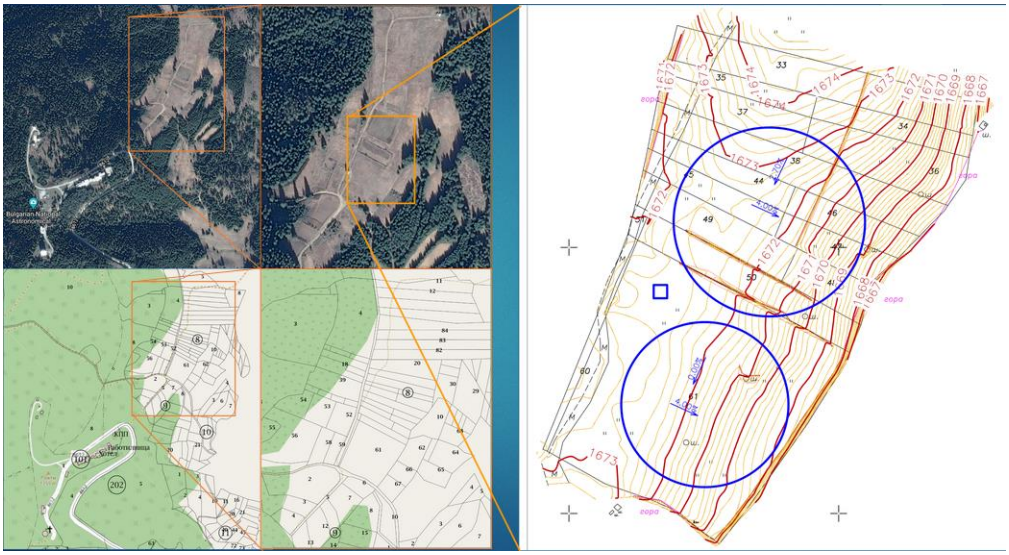

Figure 3. LOFAR-BG site and station plan

The Schedule for LOFAR-BG is shown here below:

Phase/Year	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Design / preparatory													
Building													
Operations													
ILT Participation													

IANAO has obtained the funding covering the purchase and construction of an International LOFAR2.0 station in Bulgaria

● The LOFAR-BG Consortium (through IANAO) contributes to the central operations of the ILT starting 1 January 2023.

● LOFAR-BG will participate in the development of upgrades of LOFAR within the LOFAR2.0 programme, by contributing to the development costs, hardware purchases and rollout.

● IANAO acts as the Representing Entity of Bulgaria in its role as a Founding Member of LOFAR ERIC.

● IANAO will participate in the DANTE development project, designing upgraded LOFAR high-band antenna tile electronics, which it intends to use in the LOFAR-BG station to be constructed.

● LOFAR-BG participates in the Incremental Development of LOFAR for Space weather (IDOLS) project

Closely related to the LOFAR-BG is the STELLAR (Scientific and Technological Excellence by Leveraging LOFAR Advancements in Radio astronomy) Horizon 2020 project. It started on September 1, 2020. with the following objectives:

- To transfer knowledge and capacity from ASTRON and DIAS to IANAO and TUS staff by means of versatile training activities;
- To expand the research potential of the local solar and space weather experts using LOFAR observations;
- To enable IANAO and TUS scientific and engineering personnel to develop expertise for building and operating a Bulgarian LOFAR station;
- To develop local educational curricula for sustainable development of radio astronomy in Bulgaria.

In 2023 we held 3 schools for Bulgarian students, PhD students, and scientists: LOFAR radio technology school; A radio astronomy and LOFAR school and a space weather and LOFAR school. All ectures from the seminars and trainings of schools can be found on the web site: https://www.stellar-h2020.eu.

The LOFAR-BG site is https://lofar.bg.

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