LOFAR2.0

Large Programmes

Jason Hessels - LOFAR2.0 Project Scientist

LOFAR Family Meeting - Olsztyn, Poland - June 12th, 2023

Scope of LOFAR2.0 Large Programmes

- 5-year programme running from about 2025-2030 (early, shared-risk + first 4 years of operation).
- 70% observing efficiency means ~30,000hrs available in ~5 years (best case scenario).
- 70% for Large Programmes would mean ~21,000hrs available.
- The EoIs requested ~42,000hrs, so commensality (or not accommodating all requests) is critical.
- Allocations are possibly 1+2+2 years.
- Calls for more limited-scope proposals will continue.

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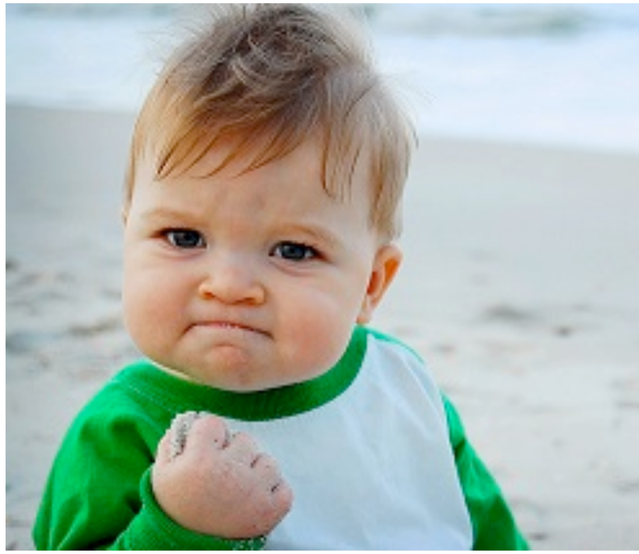
LOFAR2.0 Large Programmes

Success Criteria

- **Scientific impact**
  - Publications, citations, theses, prizes, grants
- **Technical impact**
  - Techniques, software
- **Community impact**
  - Partner countries & institutes, support ECRs, develop SKA leadership roles
- **Accessibility & legacy**
  - Data reuse, distilled data products
- **Visibility**
  - Make LOFAR better known to other astronomers, policy makers, the public



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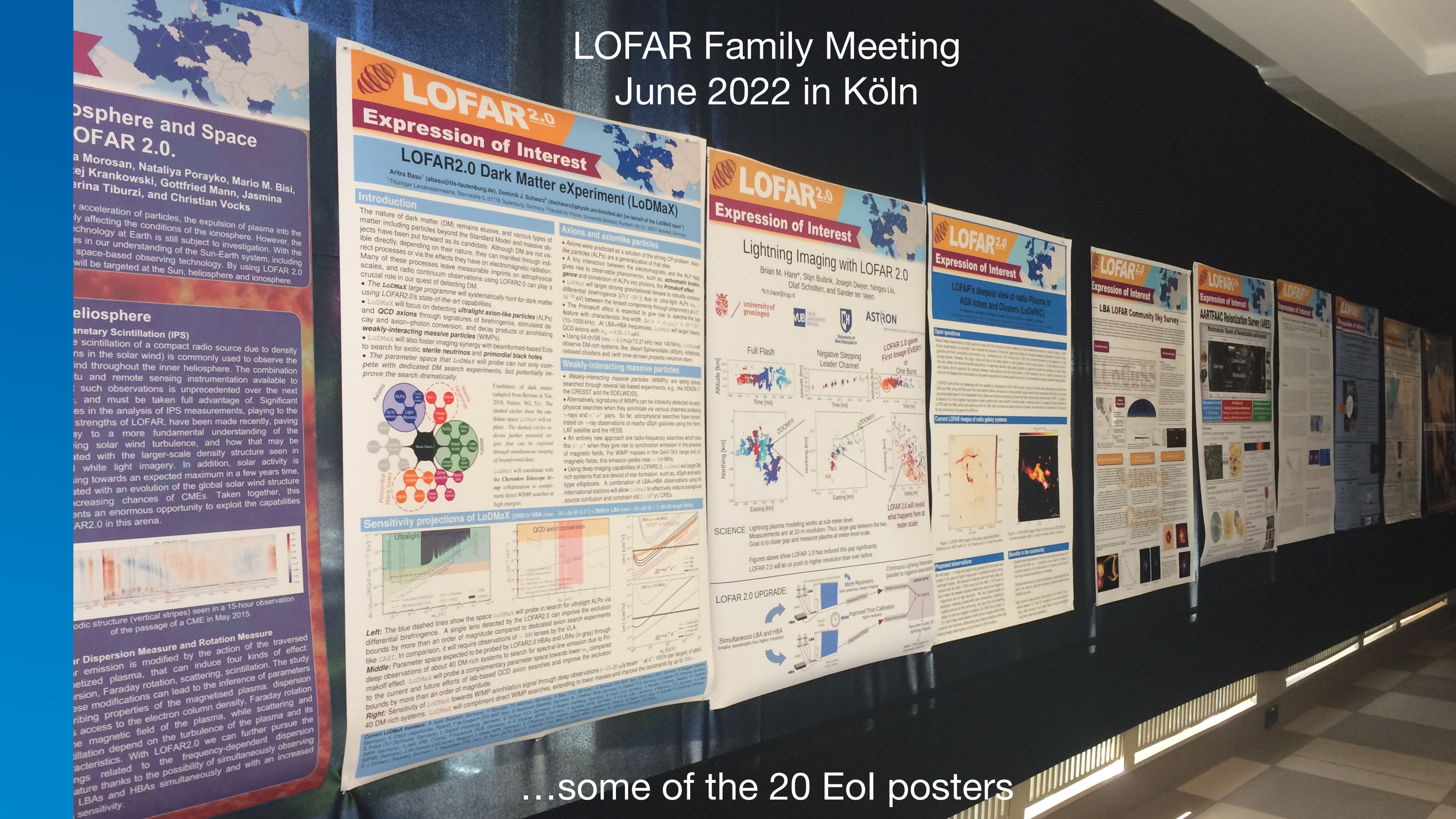
LOFAR Family Meeting
June 2022 in Köln

…some of the 20 EoI posters



LOFAR2.0 Large Programmes

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Deadline: October 12th, 2023 at 12:00 UTC

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L2LPs: proposal template

- Deadline: October 12th, 2023.
- Workshops in the coming 4 months.
- EoI submission is *not* a pre-requisite.
- Find materials via **www.lofar.eu**
- Use this detailed template.
- Submit PDF via email:
  lofar2-proposals@astron.nl
  (also for questions).

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Submission: LOFAR2.0 Large Programmes — Full proposal

(v230515) Template for LOFAR2.0 Large Programme proposals (replace with real title)

Jason W. T. Hessels[1,2], Anne Otherperson[3]

[1]*ASTRON — Netherlands Institute for Radio Astronomy*
[2]*Anton Pannekoek Institute for Astronomy, University of Amsterdam*
[3]*Advanced Institute*

Abstract
In the Abstract, summarise your LOFAR2.0 Large Programme, its scientific goals and required observations.
Please use this LaTeX template to prepare your LOFAR2.0 Large Programme proposal. In the final version, please remove the instructions and other extraneous text included in the template.
PAGE LIMIT: 20 pages total, including 1 page for the title and Abstract, also following the per-section limits. This limit does not include the reference list and you may also place full author lists at the end of the document. Please do not change the font-size, margins, or other aspects of the formatting in the LaTeX template (but do remove the instruction text).
FIRST ANNOUNCEMENT: May, 2023.
WORKSHOP: during the LOFAR Family meeting in Olstyn in June 12-16, 2023.
See http://lfm2023.uwm.edu.pl/program.
DEADLINE: October 12th, 2023.
SUBMISSION: Email a PDF, based on this template, to lofar2-proposals@astron.nl with title "LOFAR2.0 Proposal submission".
QUESTIONS?: Email lofar2-proposals@astron.nl with title "LOFAR2.0 Proposal question".

Keywords
Keyword 1, Keyword 2, Keyword 3, Keyword 4

Announcement (remove this section from final proposal)

LOFAR2.0 is a major upgrade to the Low-Frequency Array, offering simultaneous low- and high-band observing, increased field-of-view, and various other improvements to the sensitivity and operation of the telescope. A set of staged LOFAR2.0 test stations are helping to commission the new hardware and software, with a full system roll-out expected in 2024-2025, followed by early shared-risk observations and full operations thereafter.

Following an earlier call for Expressions of Interest (EoIs), the International LOFAR Telescope (ILT) now solicits full proposals for LOFAR2.0 Large Programmes (L2LPs). Submission of a

hessels@astron.nl (J. W. T. Hessels); anne.otherperson@aol.com (A. Otherperson)
0000-0003-2317-1446 (J. W. T. Hessels); 0000-0000-000-1234 (A. Otherperson)

LOFAR International LOFAR Telescope

LOFAR2.0 Large Programmes

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L2LPs: evaluation

- Reviewed by experts, who consider:
  - Scientific merit & impact
  - Feasibility of observations & analysis
  - Strength & inclusiveness of team
  - Publication & dissemination plan
  - Useful open data products
- Final L2LP portfolio decided by ILT Board (considering the various Success Criteria).

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LOFAR International LOFAR Telescope

L2LPs: background

- Short document summarising main changes between LOFAR and LOFAR2.0.
- See also van Haarlem et al. 2013 and Stappers et al. 2011 for basic system description.

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LOFAR2.0 Large Programme Proposals

LOFAR2.0 compared to LOFAR: a short summary

2023-05-30

LOFAR2.0, see also the LOFAR2.0 White Paper, is a major upgrade to the LOw-Frequency ARray (LOFAR), offering simultaneous low- and high-band observing, increased field-of-view, and various other improvements to the sensitivity and operation of the telescope. A set of staged LOFAR2.0 test stations are helping to commission the new hardware and software, with a full system roll-out expected in 2024 – 2025, followed by early shared-risk observations and full operations thereafter. LOFAR2.0 will continue to be unique and world-leading, with an angular resolution > 10× higher than that of the planned Square Kilometre Array low-frequency component (SKA-Low), and also accessing the largely unexplored spectral window below 50 MHz.

Figure 1: International LOFAR Telescope.

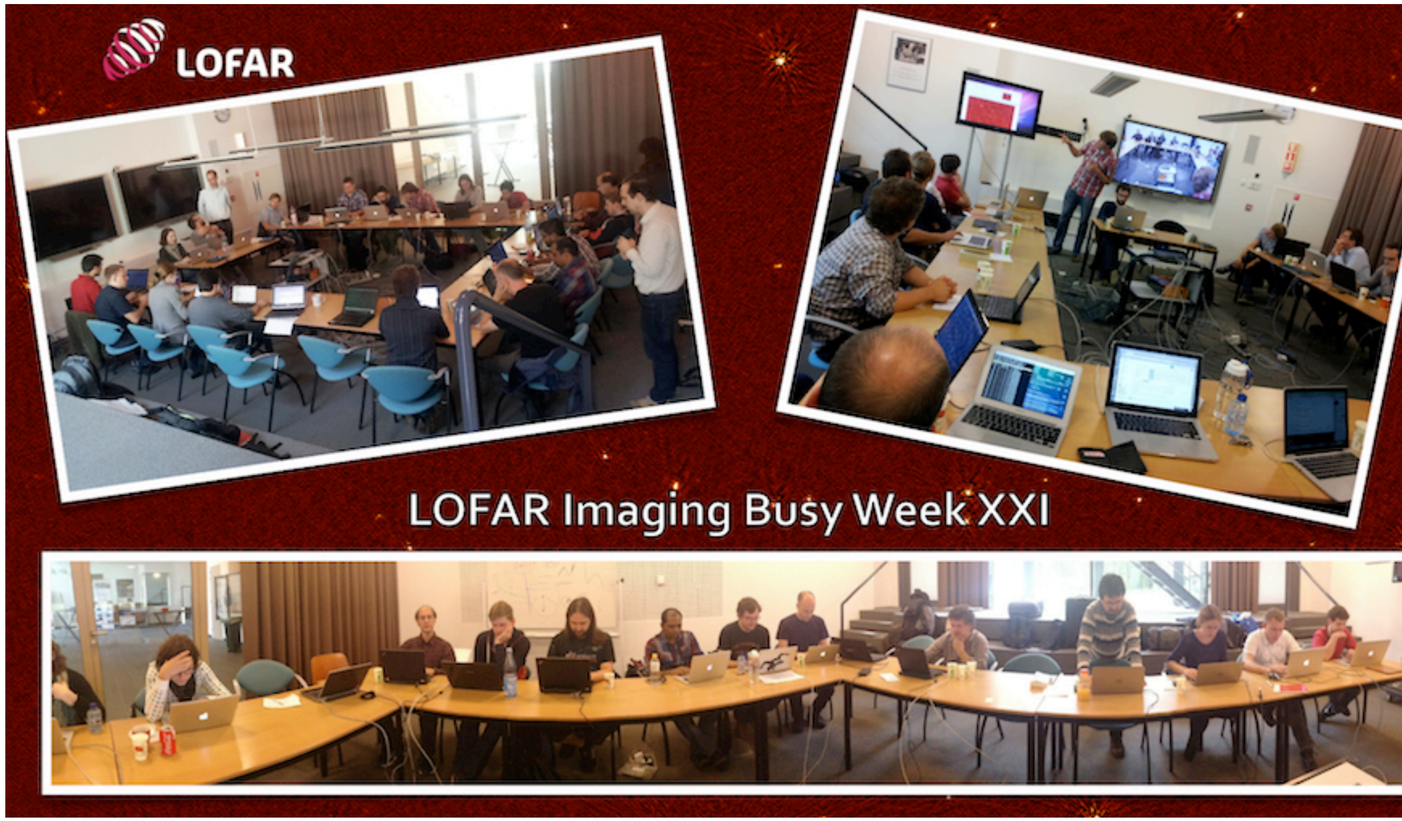
The International LOFAR Telescope (ILT), see Figure 1, has previously been described in a general overview paper[1] and a paper specifically presenting beam-formed modes[2]. The goal of this short document is to summarise what new capabilities and improvements are offered by LOFAR2.0 compared to the previous system.

Telescope array

LOFAR is the world's largest and most sensitive low-frequency radio telescope (Figure 1). It stretches across Europe, from Ireland to Latvia, with a dense 'Core' and 38 stations distributed

Putting the puzzle together

- Commensality in practice
- LTA and processing resources
- Running the observations
- Commissioning LOFAR2.0



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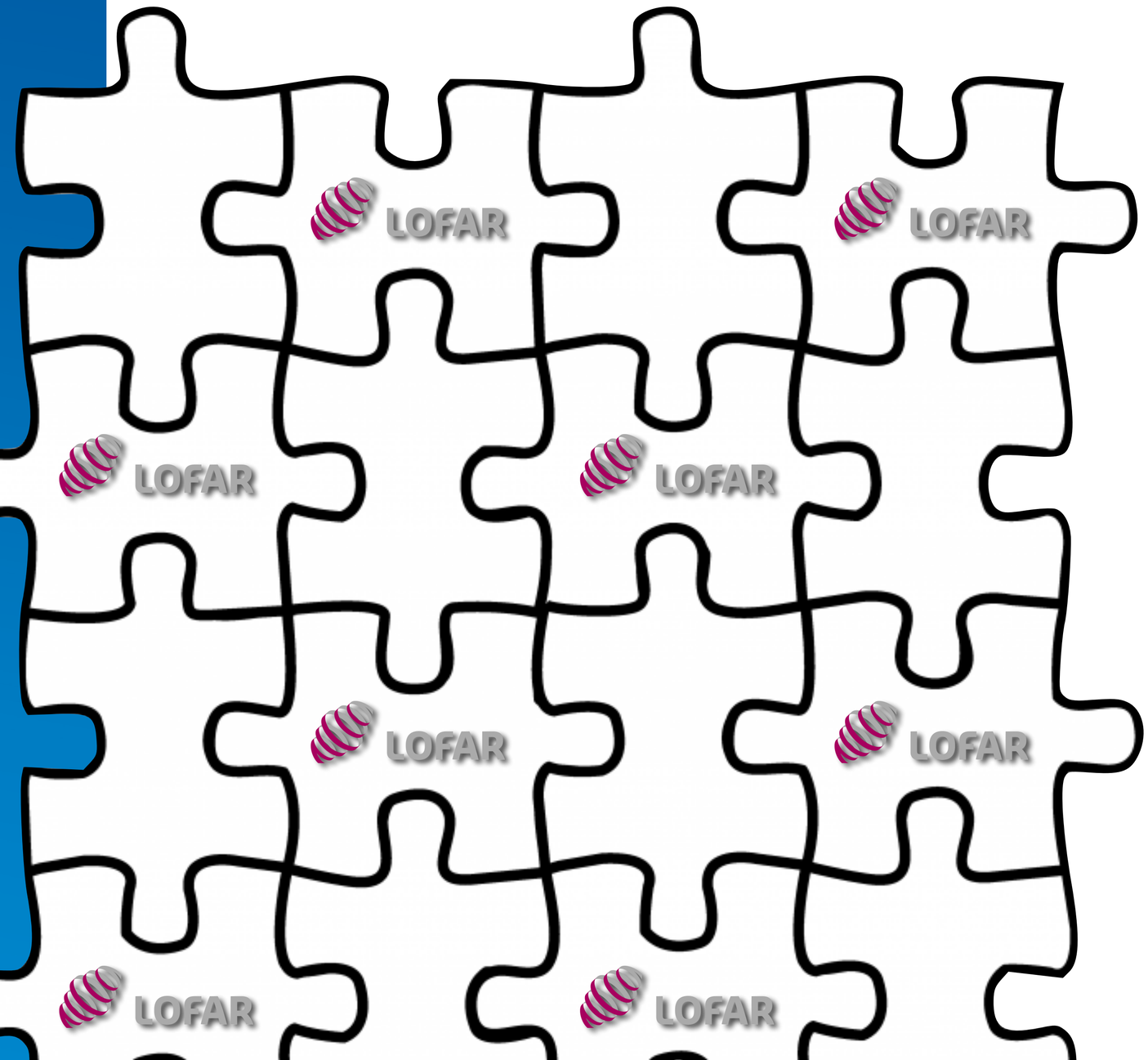
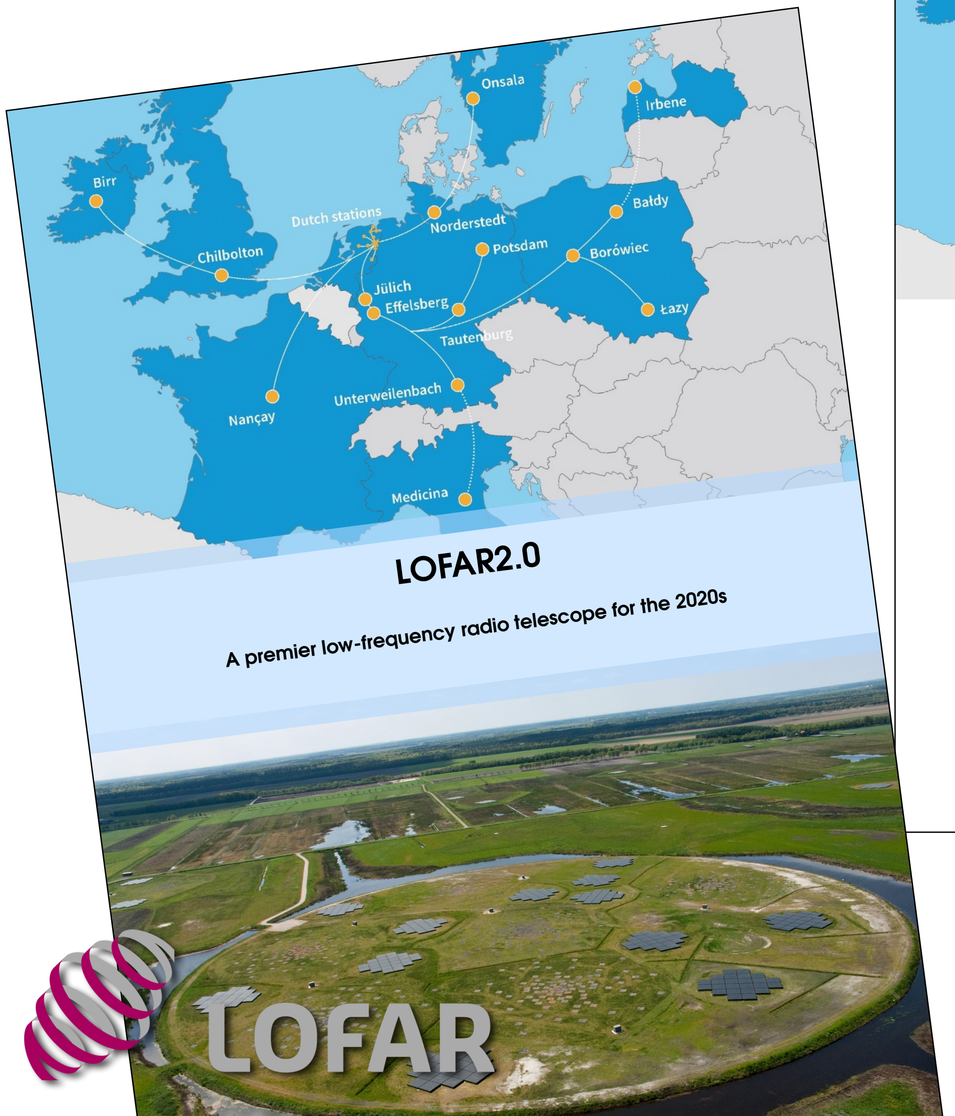
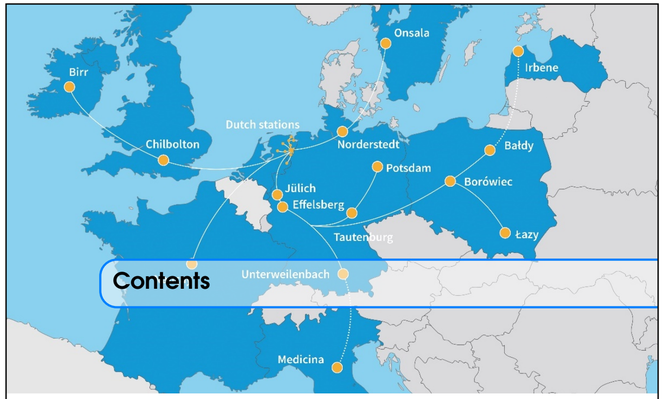


Synergies bases on:

- **LBA + HBA simultaneous**
- **Simultaneous long baselines**
- **Commensal beam-formed observing (+ fast imaging)**
- **Commensal CRs, lightning**
- **Multiple science goals per survey field**

LOFAR2.0 Science White Paper





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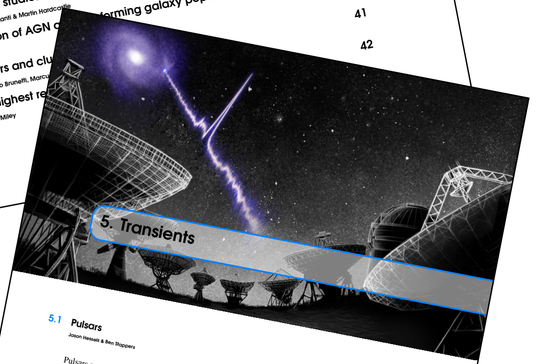

5.1 **Pulsars**
Jason Hessels & Ben Stappers

Pulsars are highly magnetised neutron stars that produce beams of radio waves that sweep across the sky like a cosmic lighthouse. These radio pulsations allow us to study the properties and evolution of neutron stars, which are some of the most extreme objects in the Universe. Using the technique of pulsar 'timing', we can detect gravitational waves, constrain the neutron star equation of state and test Einstein's theory of gravity. Pulsars are exceptionally steep-spectrum radio sources. LOFAR is a unique pulsar telescope because of its high sensitivity across the lowest 4 octaves of the radio band, and its ability to provide voltage tied-array data for multiple sources at once. LOFAR has discovered close to 100 radio pulsars to date[**sanidas2019**]. LOFAR pulsar discoveries include a record-breaking slow 23.5-sec pulsar, which may be a magnetar descendent[**tan2018**], and a 1.41-ms pulsar that is the fastest-spinner in the Galactic field[**bassa2017**]. We have also used LOFAR in tandem with the X-ray telescope *XMM-Newton* to demonstrate broadband modeling, in which a pulsar rapidly changes between two distinct and characteristic emission modes[**hermsen2013**].

Highlight 12 LOFAR has discovered both the fastest- and slowest-spinning radio pulsars in the Galactic field.

With LOFAR2.0 we will perform an ultra-deep pulsar survey by targeting compact, highly polarised sources found in LOFAR imaging surveys like LoTSS. We aim to find the most exotic radio pulsars, and to use them as probes of gravity and dense matter physics. The NL single clock will provide higher-quality and higher-sensitivity tied-array observations. COBALT2.0 allows the parallel observing modes that are needed to conduct such observations. COBALT2.0 allows the imaging surveys. The LOFAR stations, especially the large International stations, are sensitive telescopes in their own right. By using sub-arrays, we can also monitor dozens of pulsars in parallel and use these pulsar timing data to measure neutron star orbits, probe the interstellar medium, and measure the density and magnetization of the solar wind (see also §3.2).

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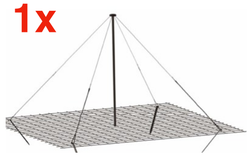
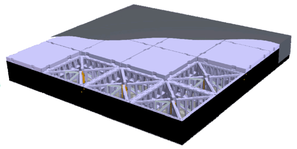
Timeline

2018 2020 2022 2024 2026 2028 2030 2032

1x  or 

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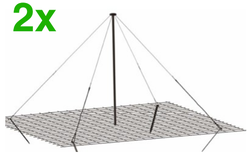
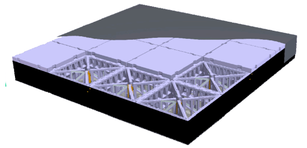
DUPLLO Project

2x  and  and 

LOFAR2.0

Scientific & technical synergy

Square Kilometre Array

LOFAR