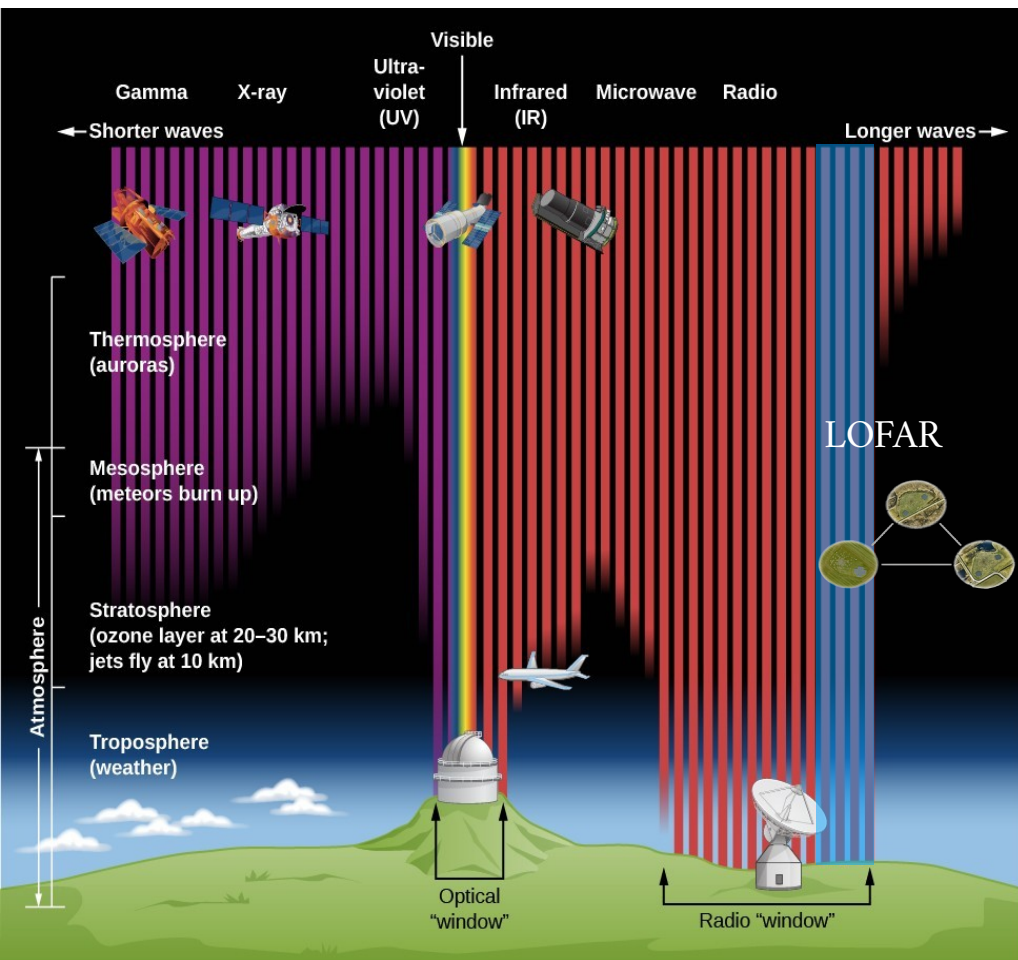




LOFAR 2.0 and Its Prospects in Pulsar Science

LOFAR: LOW Frequency ARray



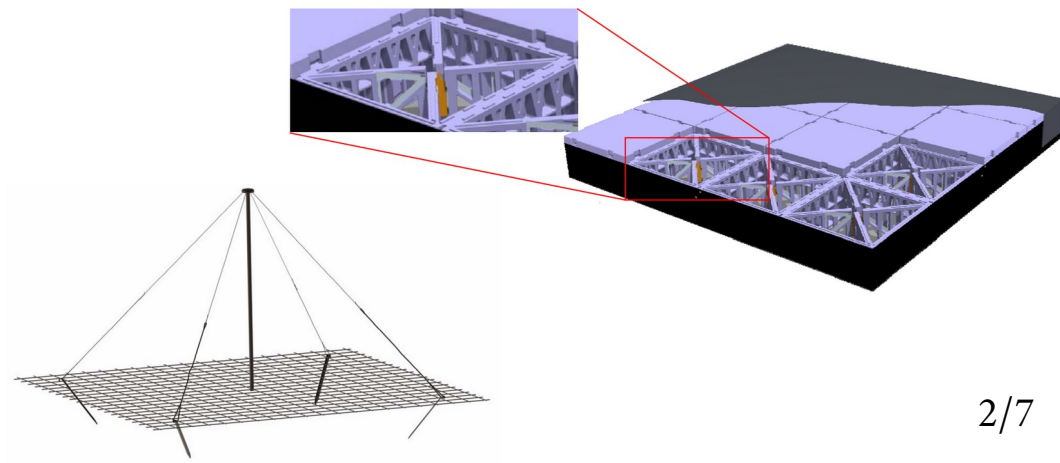
➤ LOFAR is lead by Netherlands Institute for Radio Astronomy, running since 2013.

◆ An interferometric array.

- ~20000 dipole antenna
- Frequency range: 10 MHz to 240 MHz

◆ Two types of antennas:

- Low Band Antenna (**LBA**): 10-90 MHz.
- High Band Antenna (**HBA**): 110-240 MHz.
- **HBA tile**: 4*4 HBA element.

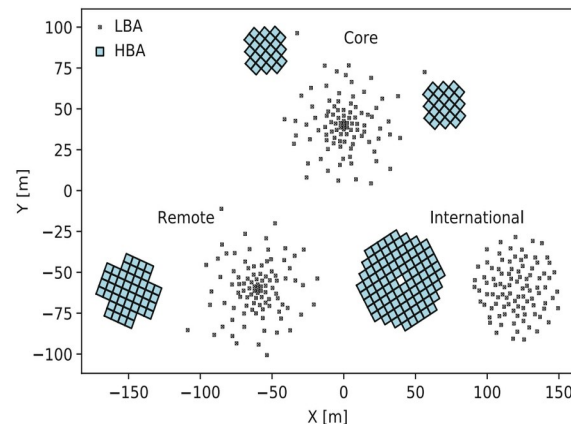


LOFAR: LOw Frequency ARray



➤ Pan-European array (52 stations):

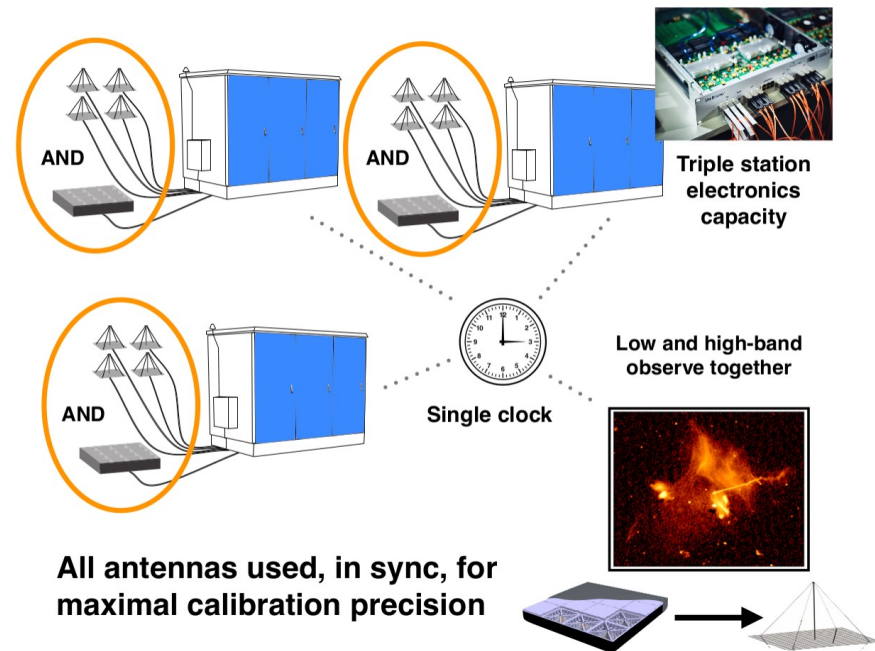
- ◆ **Core Station: (CS, 24 in total)**
 - 96 LBAs and 2 x 24 HBA tiles
- ◆ **Remote Station: (RS, 14 in total)**
 - 96 LBAs and 48 HBA tiles
- ◆ **International Station: (14 + 2)**
 - 6 in Germany (DE601, DE602, DE603, DE604, DE605, DE609)
 - 1 in France (FR606)
 - 1 in Sweden (SE607)
 - 1 in UK (UK608)
 - 3 in Poland (PO610, PO611, PO612)
 - 1 in Ireland (IE613)
 - 1 in Latvia (LV614)
 - 1 in Italy (under construction)
 - 1 in Bulgaria (under construction)



LOFAR 2.0 : An upgrade of LOFAR

➤ LOFAR 2.0

- ◆ **Simultaneous** all LBA & all HBA observing.
- ◆ **COBALT2.0**: correlator and beam-former.
- ◆ **White Rabbit**: single clock to all Dutch stations.
- ◆ **New software system**:
 - **TMSS** : Telescope Manager Specification System.
 - **Station control and monitoring**: Tango, Jupyter lab, Grafana,
- ◆ **New powerful hardware system**:
 - UniBoard2
 - RCU2
- ◆ **Italy & Bulgaria**: new international stations.
- ◆ **NenuFAR**: a low-band (10-90 MHz) **super-station**.



➤ LOFAR 2.0 current status:

- ◆ LOFAR has been turned off for upgrade since September 2024.
- ◆ International stations are still running in single station mode.
- ◆ LOFAR 2.0 full array will come back on early 2026.



LOFAR pulsar studies

➤ Characterize the ionized interstellar medium

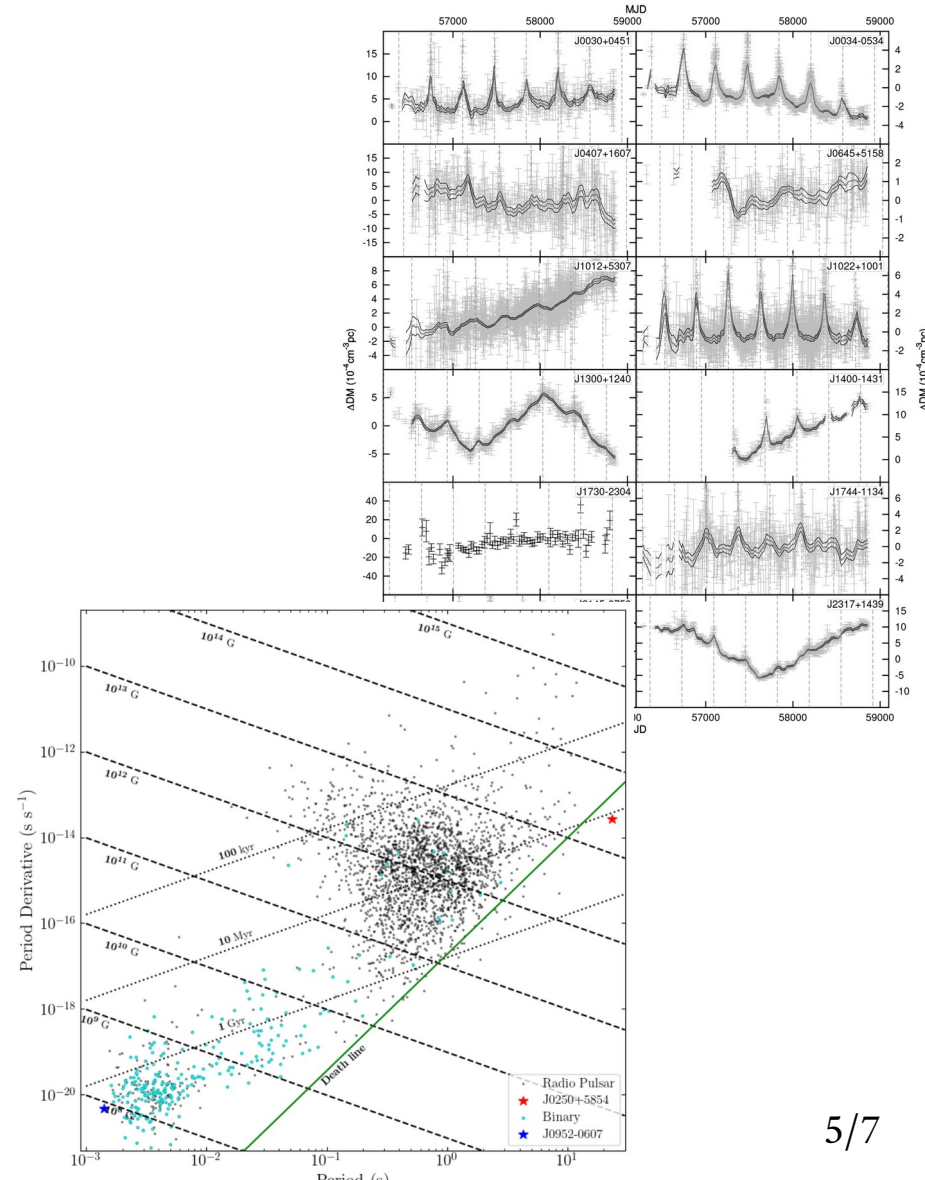
- ◆ Dispersion measure
 - Frequency-dependent, time-variable, Donner et al 2019
 - DM variability for 36 MSPs at 150 MHz, Donner et al 2021
- ◆ Solar wind
 - The impact of solar wind variability on pulsar timing, Tiburzi et al., 2021
 - Solar wind models for pulsar timing corrections, Tiburzi et al., 2021
- ◆ Pulse profiles and single-pulse behavior
 - Single-pulse behavior of 20 LOFAR pulsar, Michilli et al. 2020
 - Pulse profile with LOFAR, Pilia et al. 2016

➤ Pulsar timing at low frequency

- ◆ Timing of LOFAR pulsars: Tan et al. 2020

➤ Pulsar survey

- ◆ Discovered ~100 radio pulsars.
 - Record-breaking slow 23.5 s pulsar PSR J0250+5854, Tan et al. 2018
 - J0952-0607: 1.41 ms pulsar, the fastest-spinner in the Galactic field, Bassa et al. 2017



Jason Shiva LOFAR2.0 Ultra-Deep Observation (LUDO)

- Co-PIs: Philip N. Best¹, Leah K. Morabito^{2,3},
on behalf of >300 people from the LOFAR Surveys and Magnetism KSPs

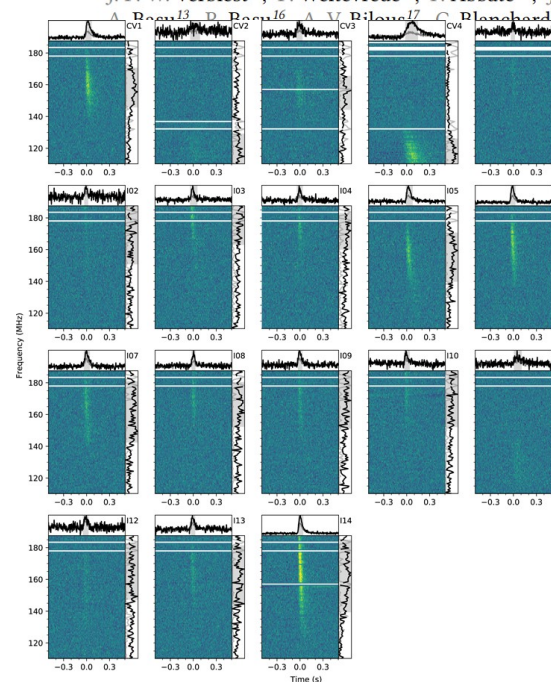
PURR – PULsars and Repeaters Research, a Pulsar and Fast Transient Monitoring Project

[illegible]

117 Selargius (CA), Italy
nsdijk 4, 7991 PD Dwingeloo, The Netherlands

FRB 20180916B

Credit: Pleunis et al. 2021



Summary

- LOFAR is an interferometric array covers from 10 MHz to 240 MHz.
- LOFAR 2.0: LOFAR is under the upgrade to keep ahead.
 - ◆ Officially turned off since September 2024, Will come back on early 2026
 - ◆ Simultaneously LBA & HBA observations enabled with LOFAR 2.0.
 - ◆ All NL stations are now connected with single clock.
- Pulsar studies with LOFAR
 - ◆ LOFAR are excellent tool for pulsar survey and interstellar medium investigation.
 - ◆ Single international station time can also be used.

