LOFAR 2.0

Overview, status and the Italian involvement

Francesco De Gasperin

SKA Italian Meeting - Bologna 28/11/25

INAF
ISTITUTO NAZIONALE
DI ASTROFISICA

LOFAR
ERIC

erc
European Research Council
Established by the European Commission

LOFAR 2.0

SKA Low takeaway messages!

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The LOFAR 2.0 idea

- Leverage existing investments
  - hardware (stations, networks, data centres)
  - algorithms, software, pipelines
- Financially, technically feasible on a few years timescale
- Remain unique and scientifically impactful (in SKA era)

Comparison with SKA-Low

LOFAR 2.0 - sub projects

- LOFAR Mega Mode / COBALT 2

  New "Correlator and Beam-former for the LOFAR Telescope" - receive more than 1 Tb/s i.e. more than 30 billion samples per second from the LOFAR stations

- DUPPLO

  "Digital Upgrade for Premier LOFAR Low-band Observing" - triple the computational capacity of the Dutch LOFAR stations and distributed clock
  (and new RFI filters, thermal design, 12 to 14 bits ADC, new firmware...)

- TMSS

  New "Telescope Manager Specification System" - proposal, administration, and scheduling of LOFAR observations

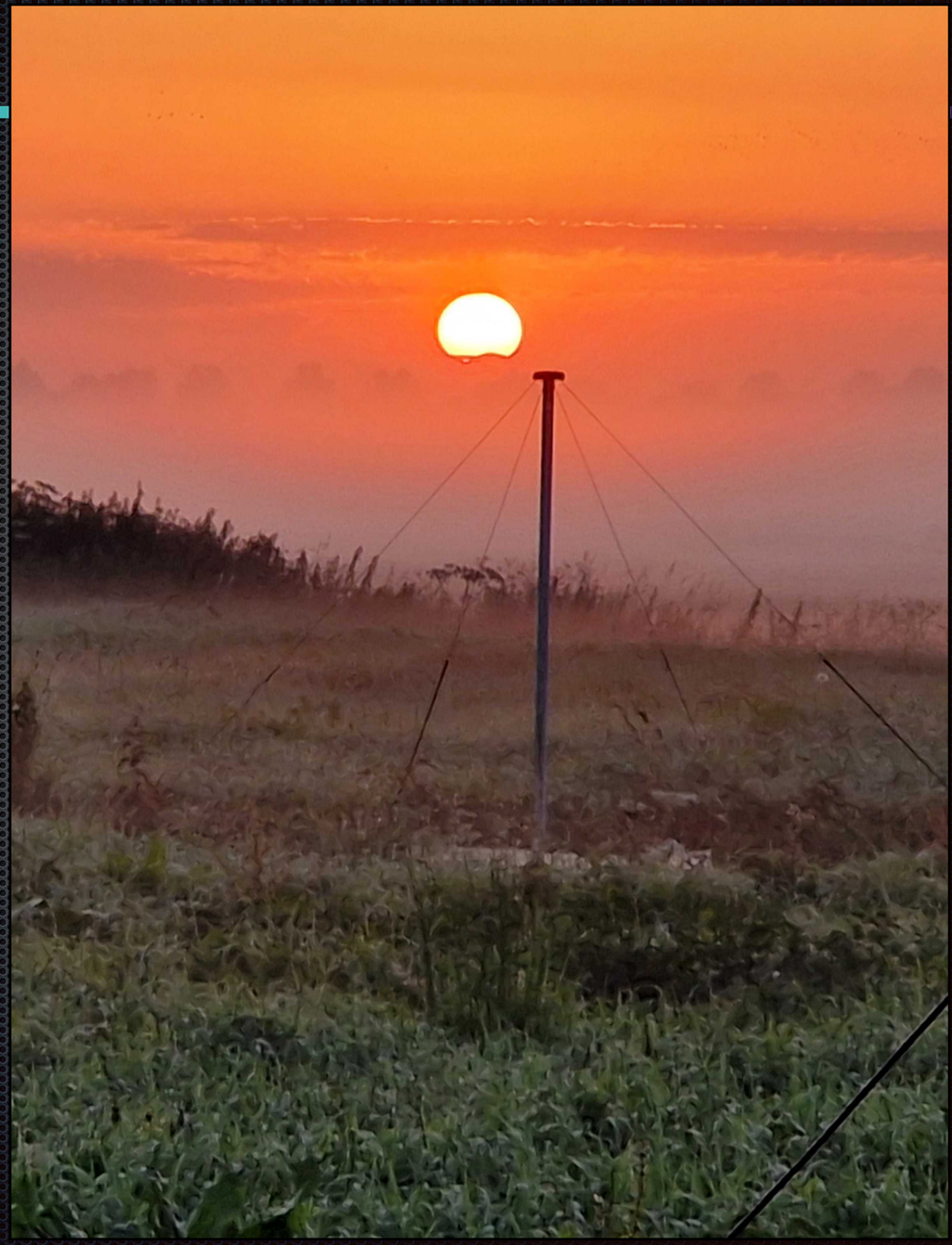
- LOFAR4SW

  "LOFAR for Space Weather" - Use the existing LOFAR hardware for space weather purposes - DANTE (second analogue beam for the HBA tiles)

- PIPELINES

LOFAR 2.0

- Dutch stations 48 → 96 LBA dipoles: more sensitivity!
- Receiver upgrade: parallel observations in LBA and HBA
  → for VLBI 50 MHz calibration this might be essential!
- Dual band: from 96 MHz to 192 MHz (multi-beam)
- Clock distribution - white rabbit
- Ionospheric-based scheduling to improve telescope efficiency
- New beam model



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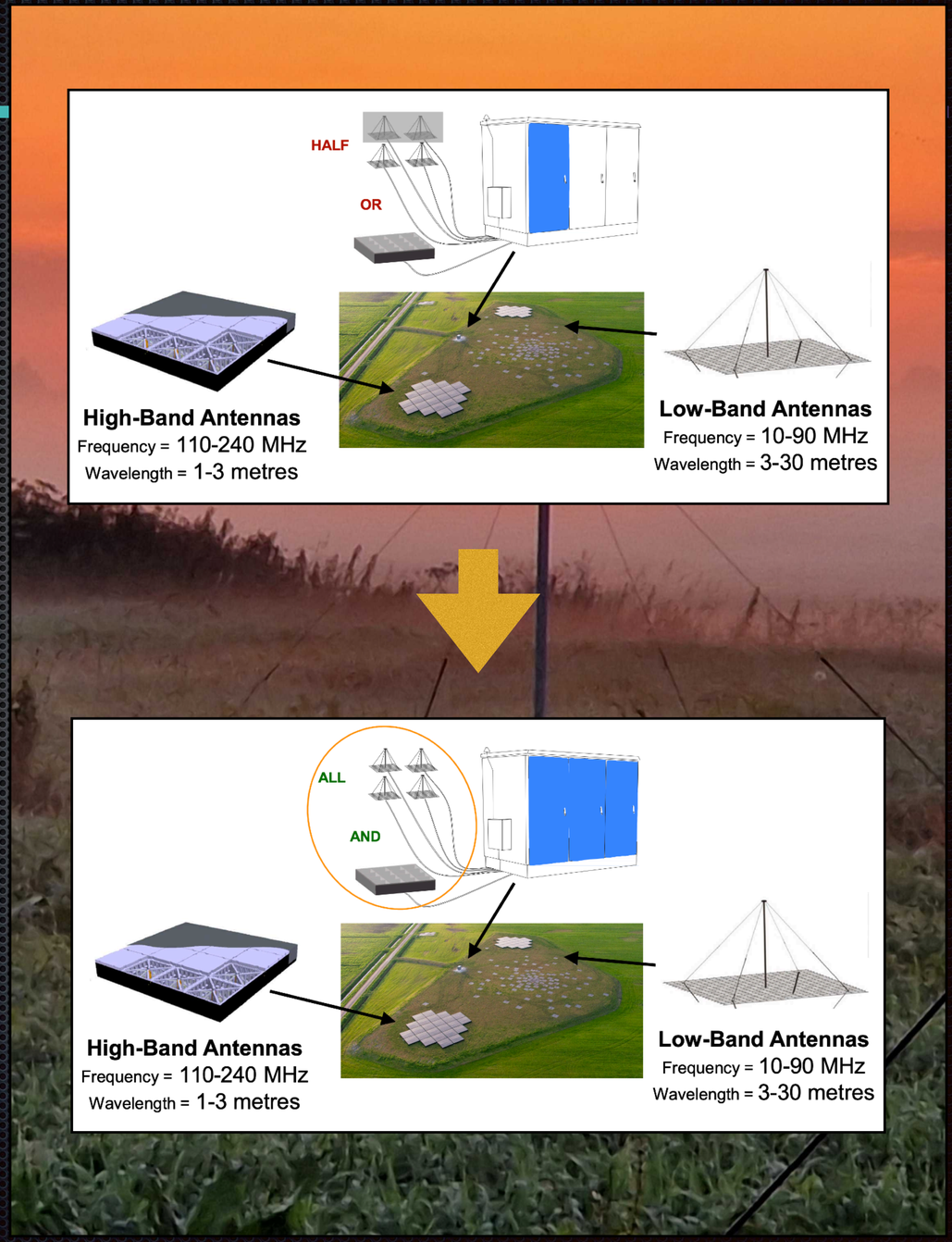

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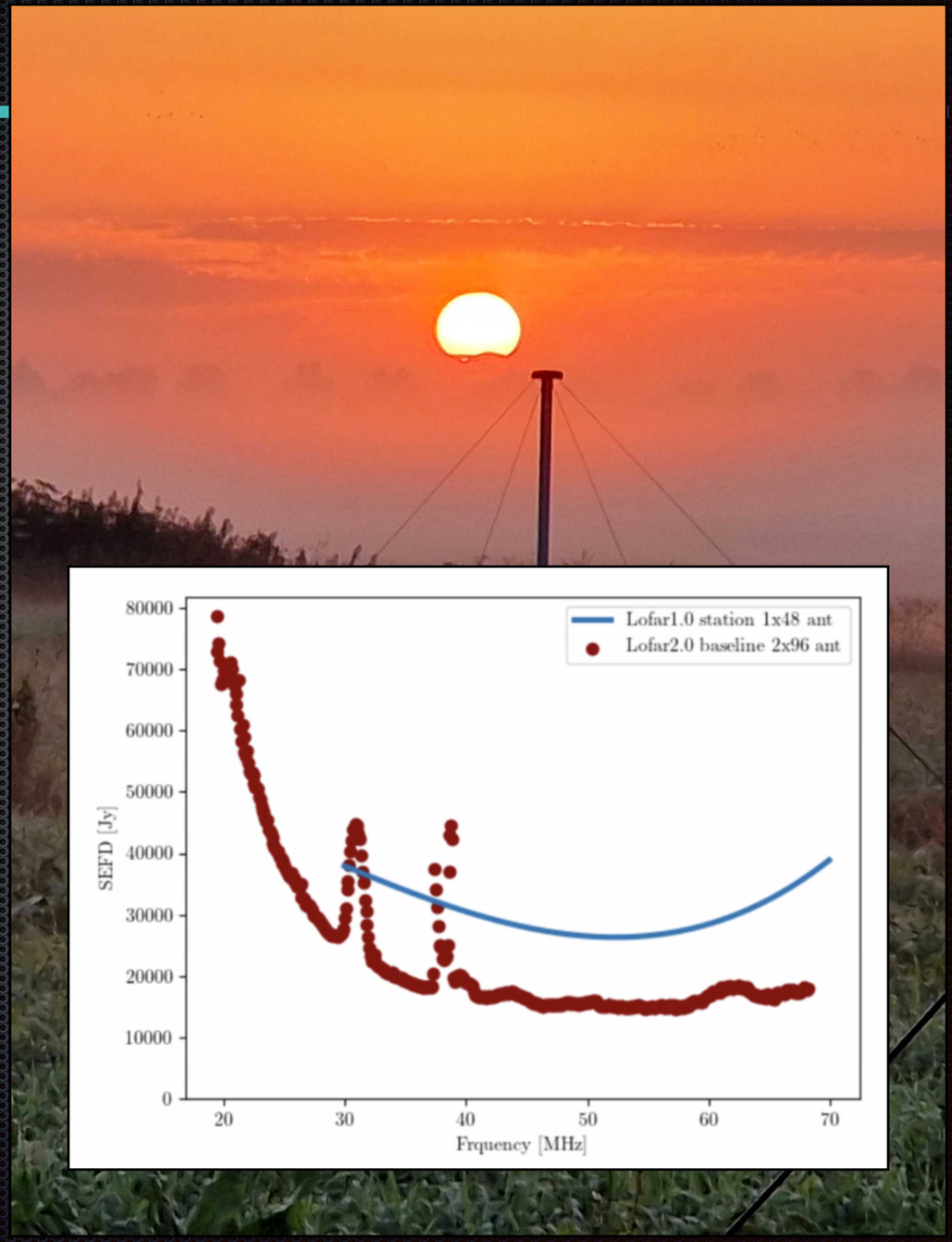

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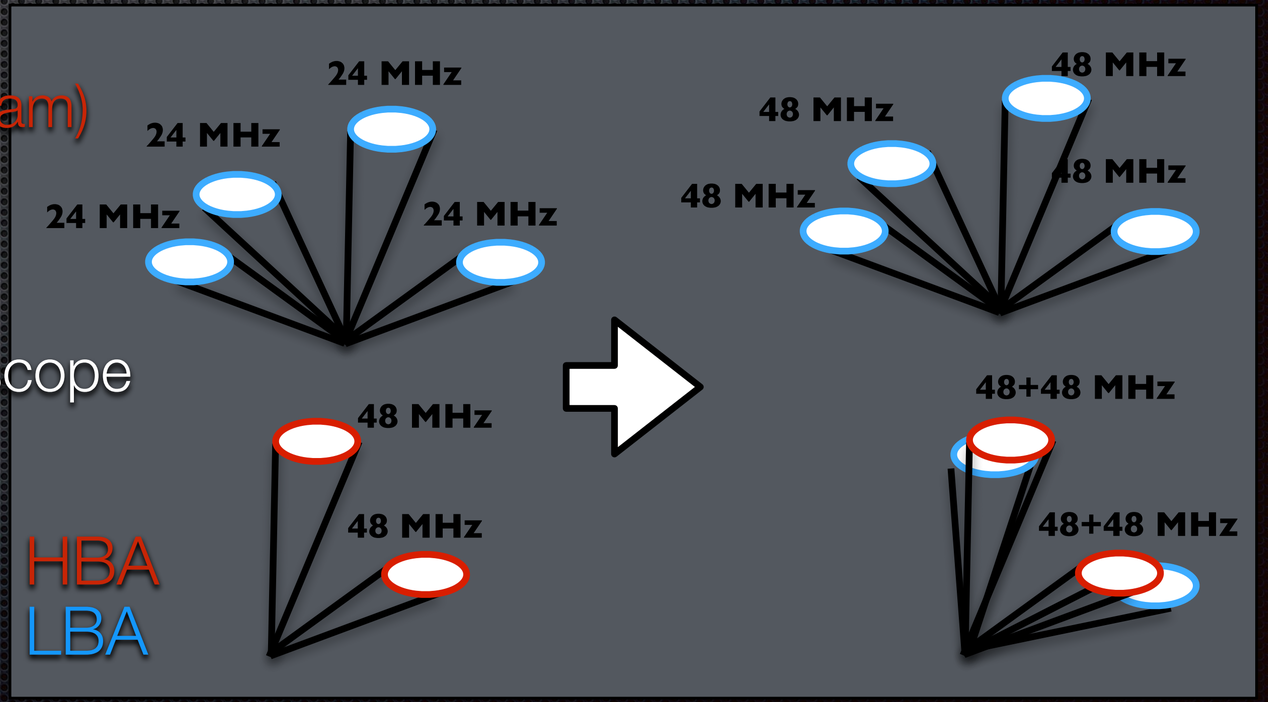

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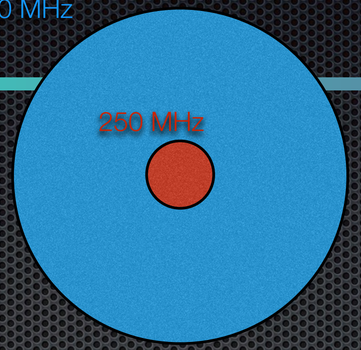

SKA Low: creative multi-beam strategies

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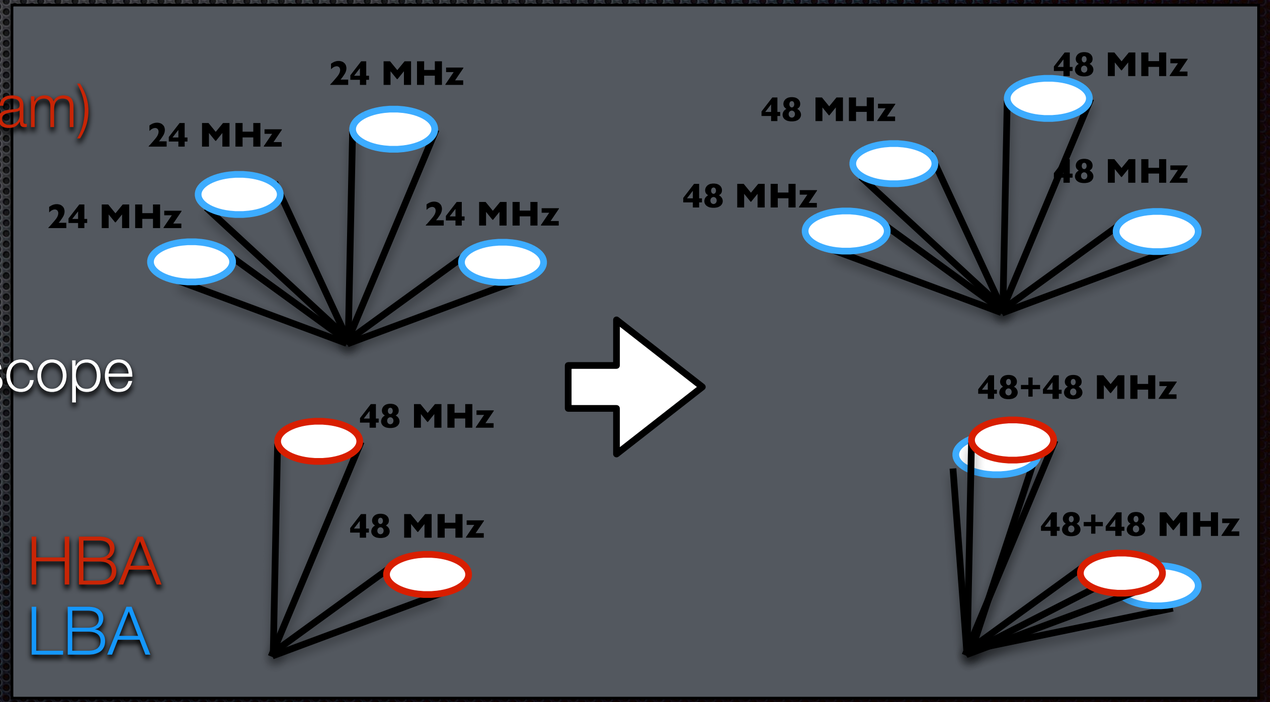

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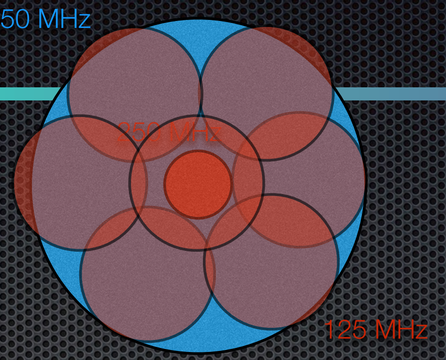

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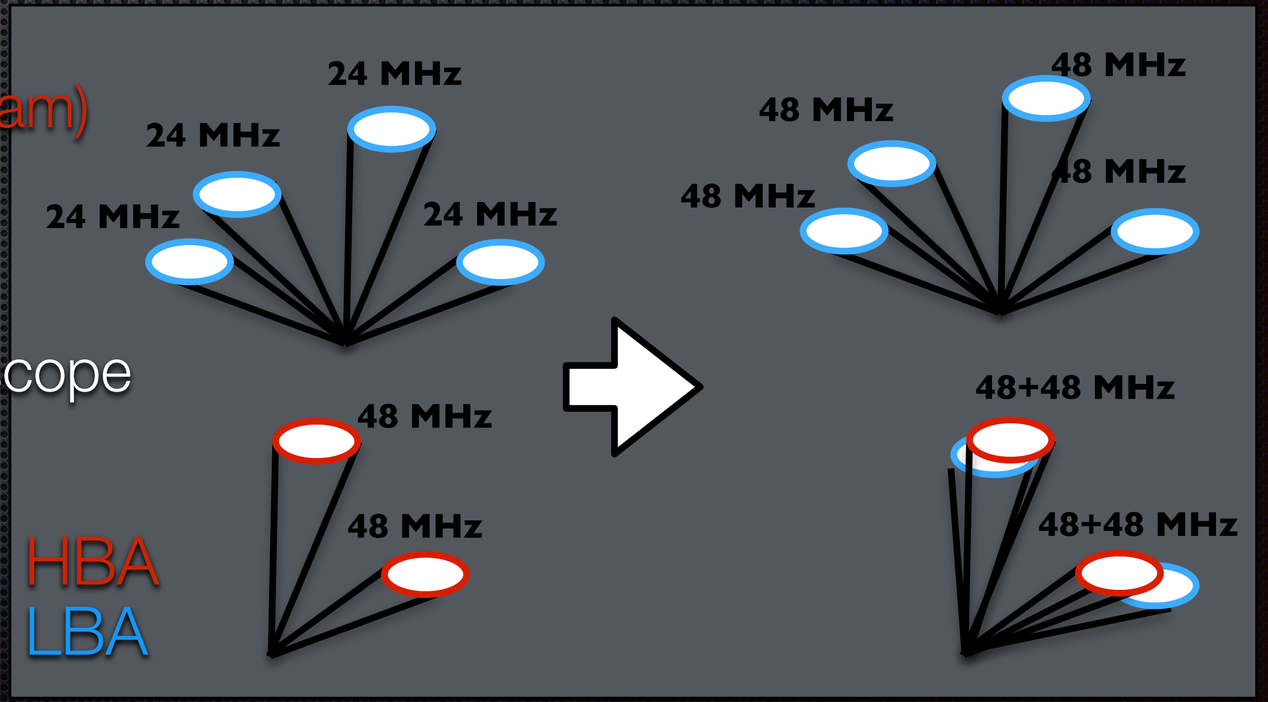

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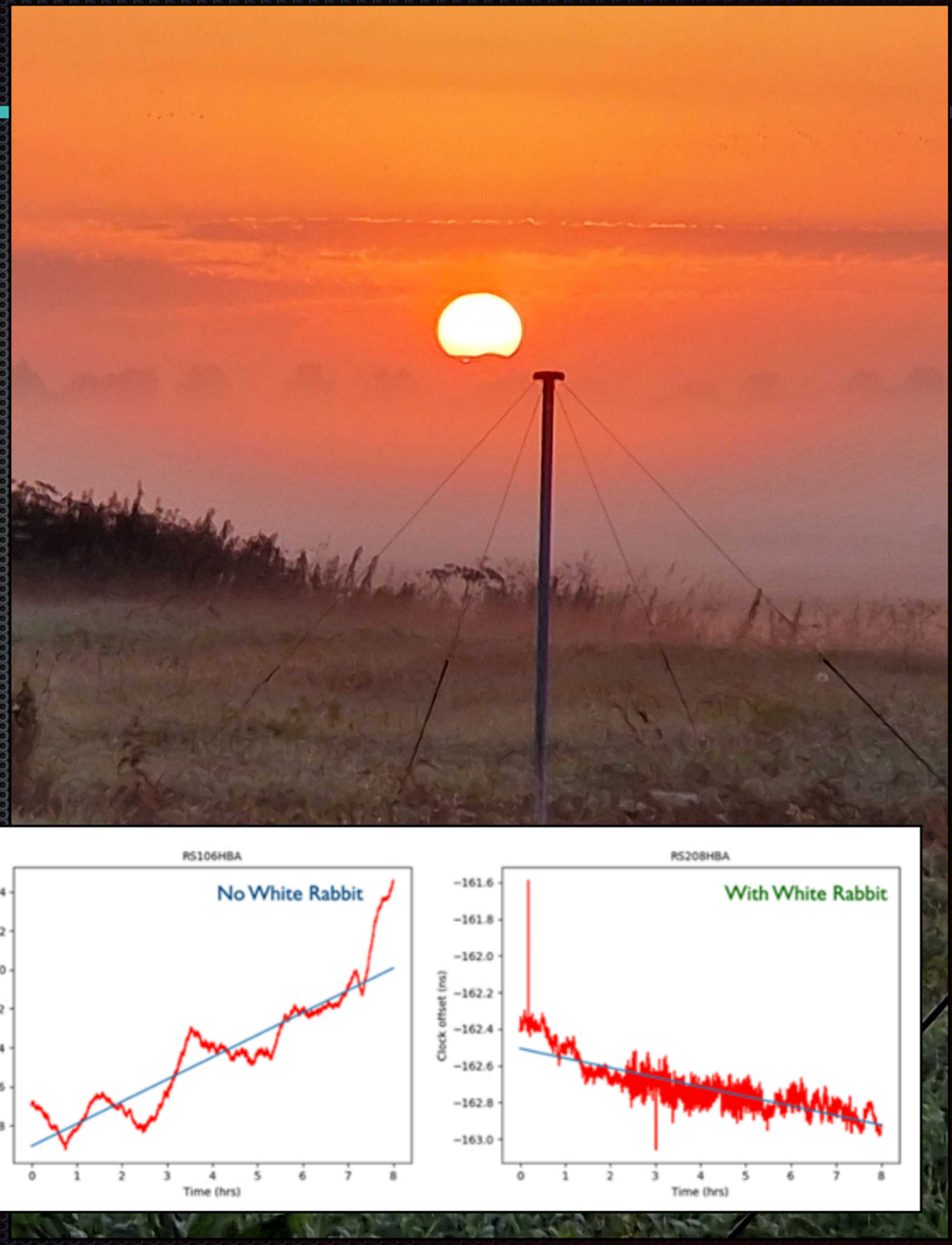

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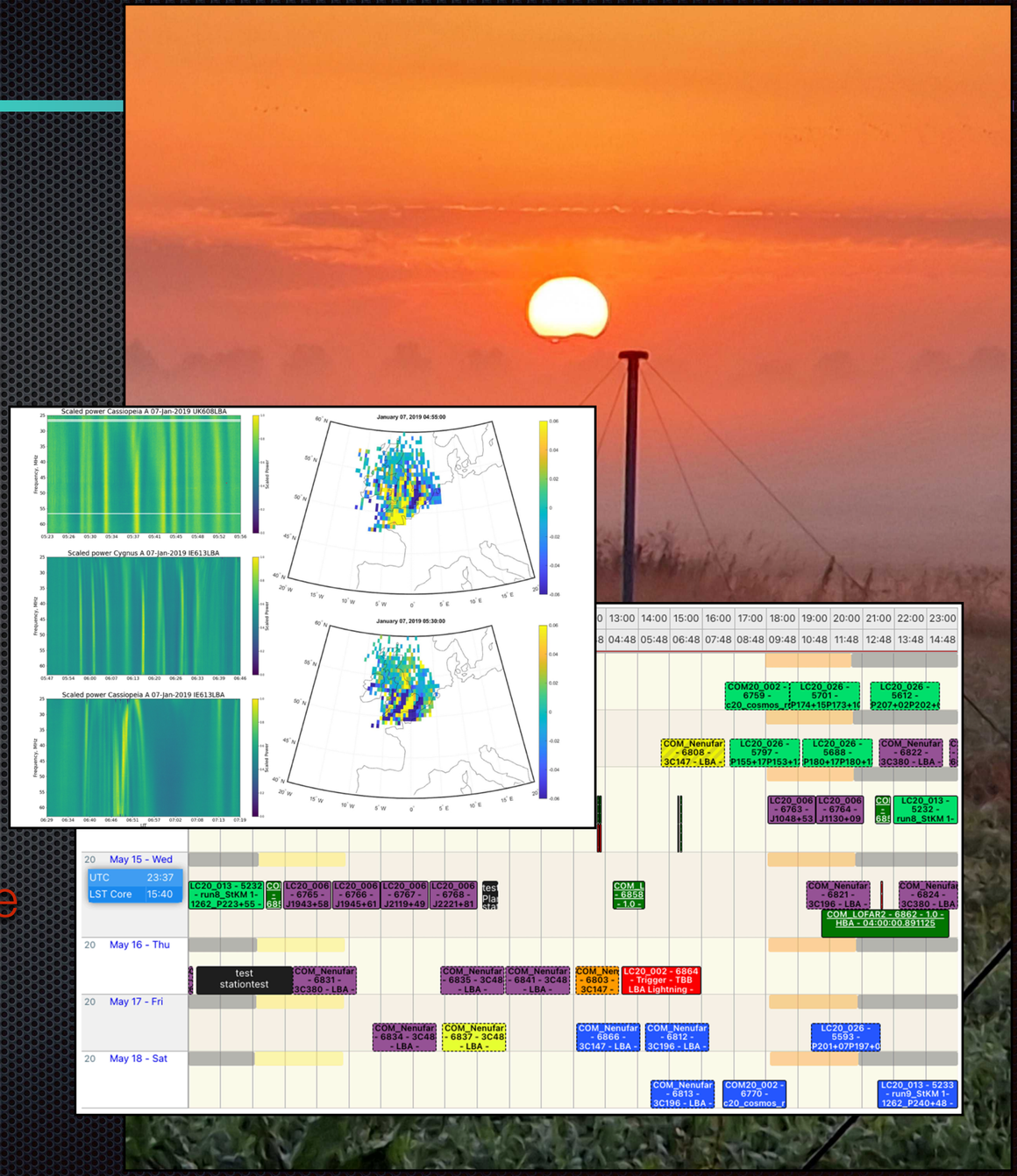

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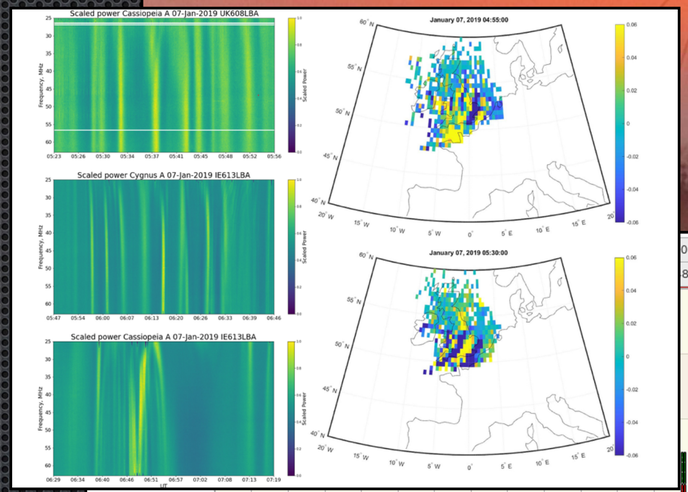
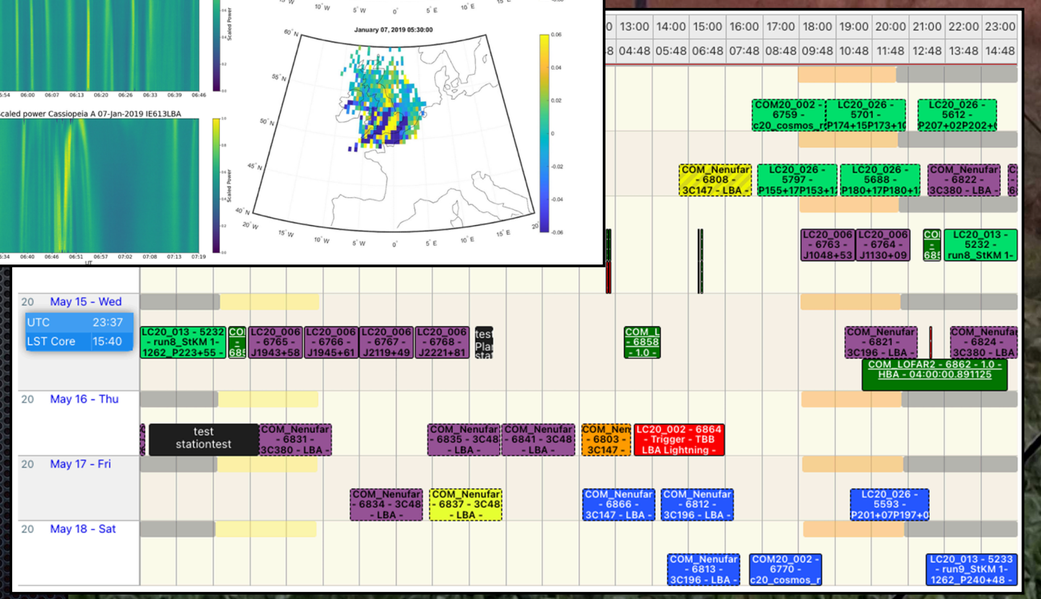
SKA Low: iono-based scheduling





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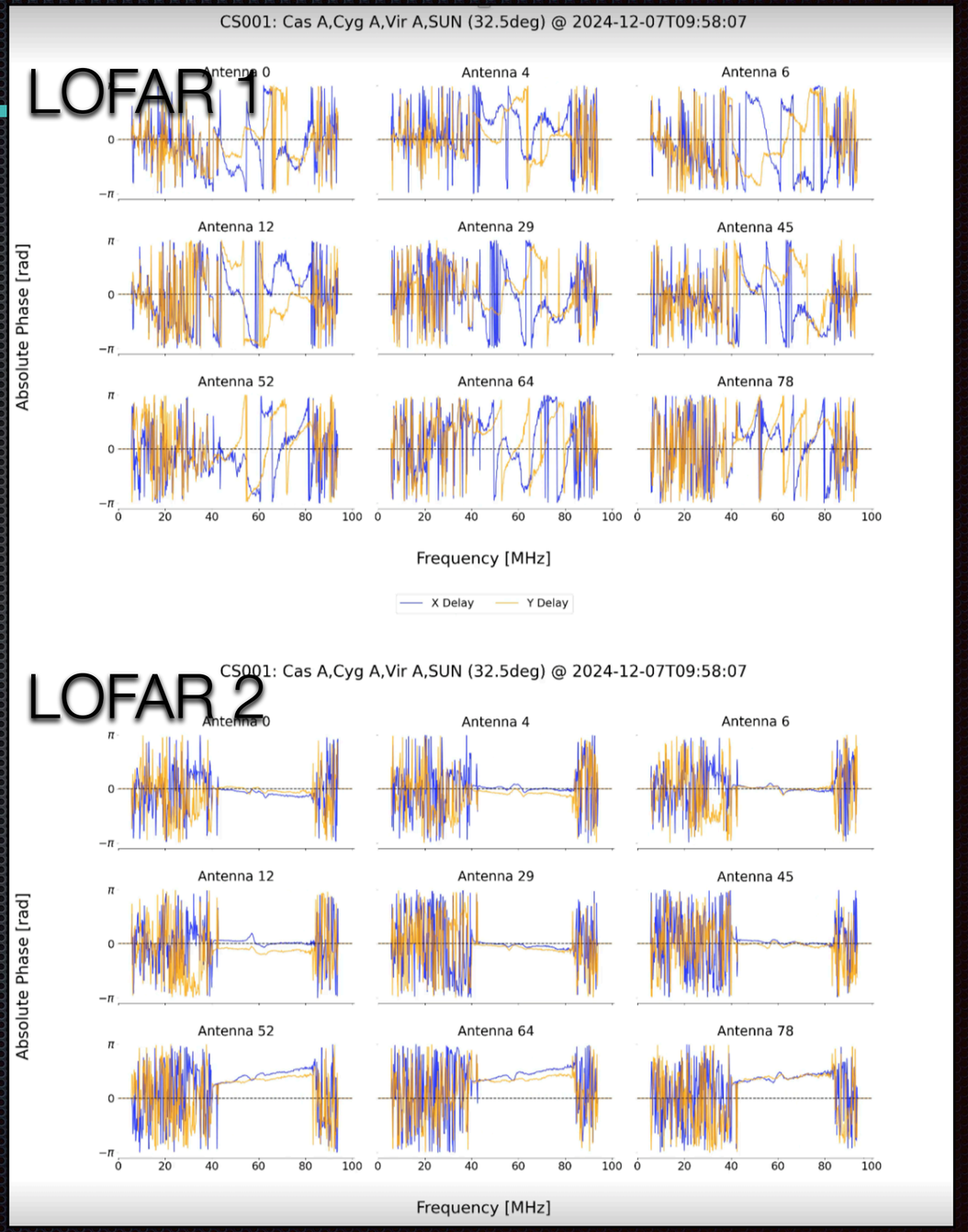

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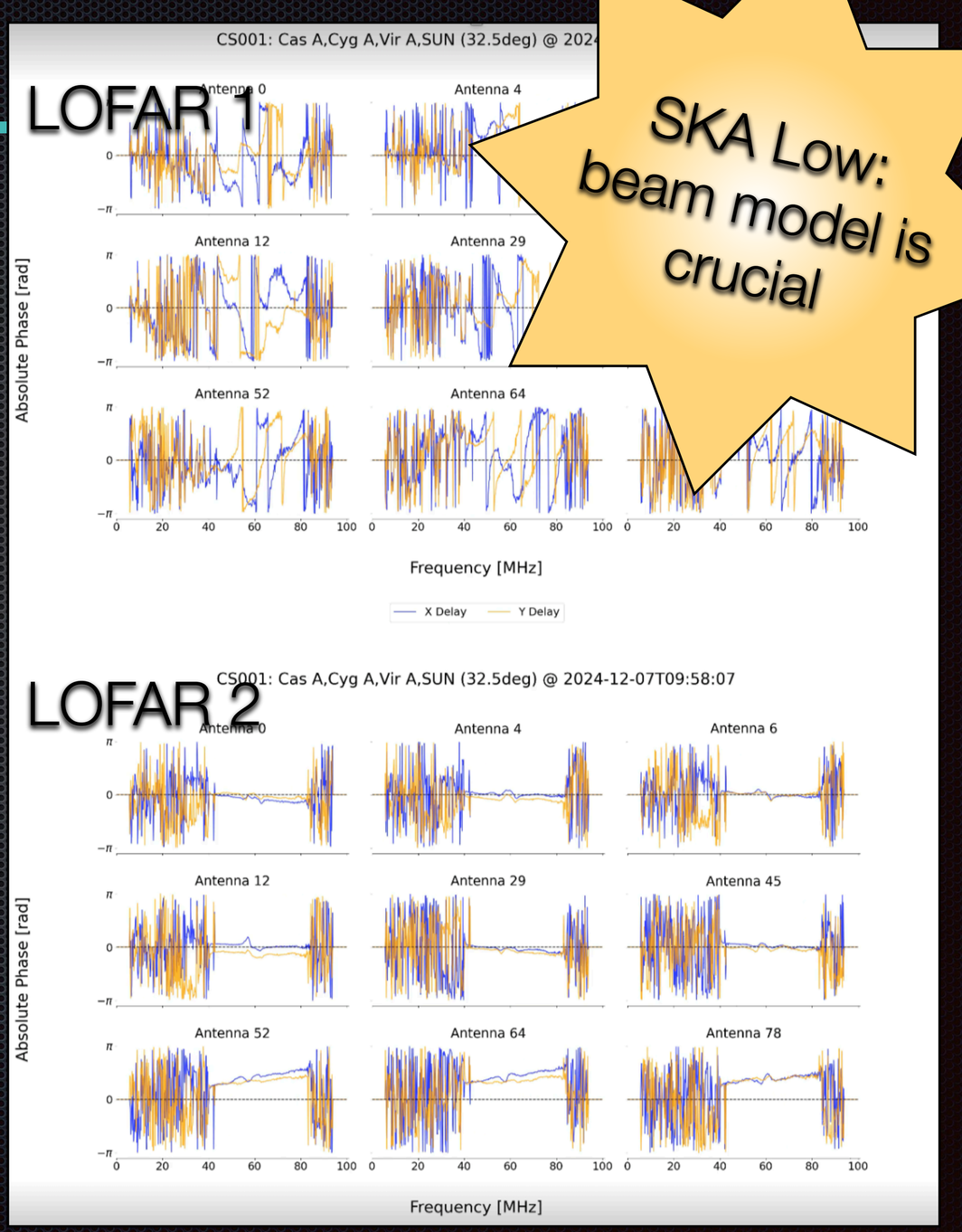


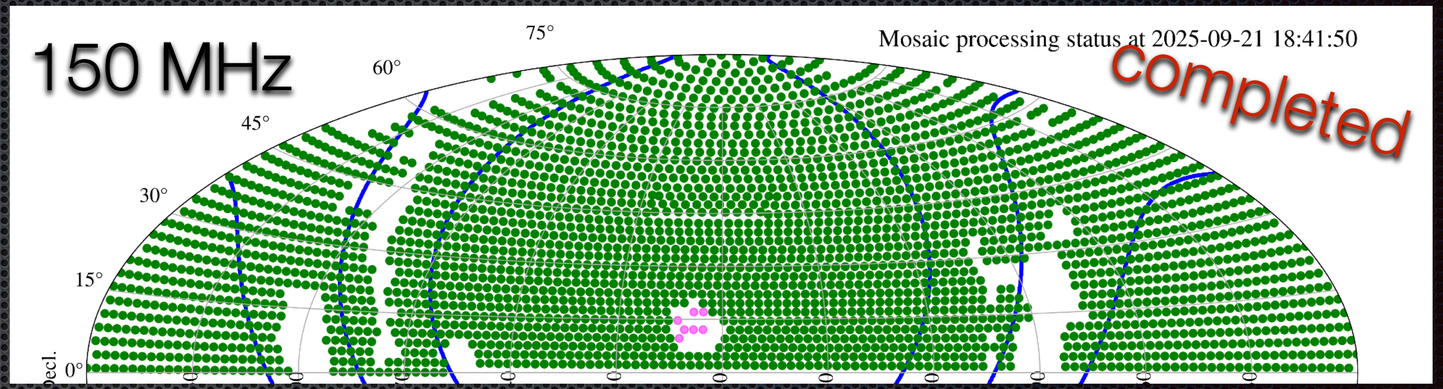
What are we going to do with LOFAR 2.0?

The LOFAR surveys

Surveys are a very efficient way to collect + reduce lage quantities of data

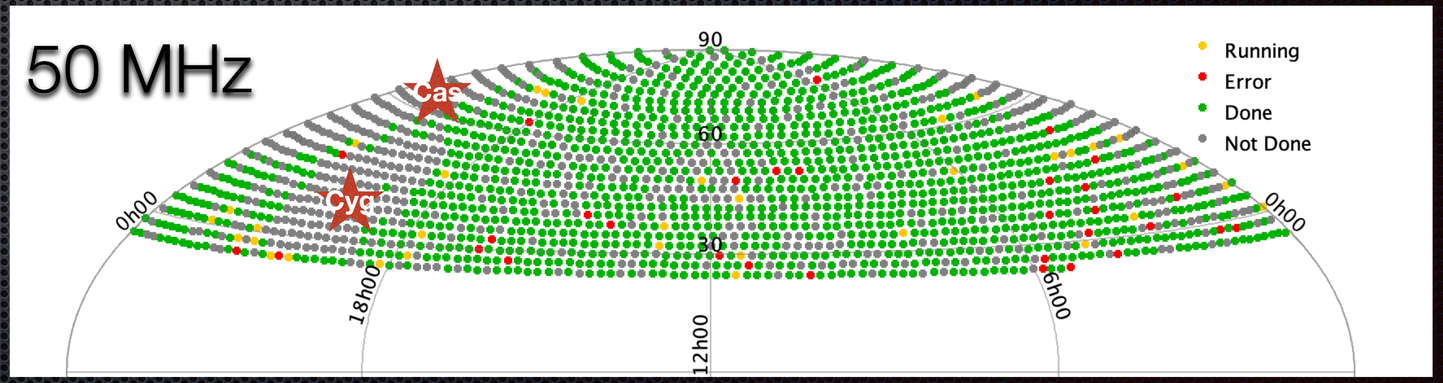
LoTSS survey (150 MHz):

- 2913 fields (about 12k hrs)
- 13,664,379 sources



LoLSS survey (50 MHz)

- 1973 fields (about 2.4k hrs)



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Surveys are a very efficient way to collect + reduce lage quantities

SKA Low: co-obs for large surveys

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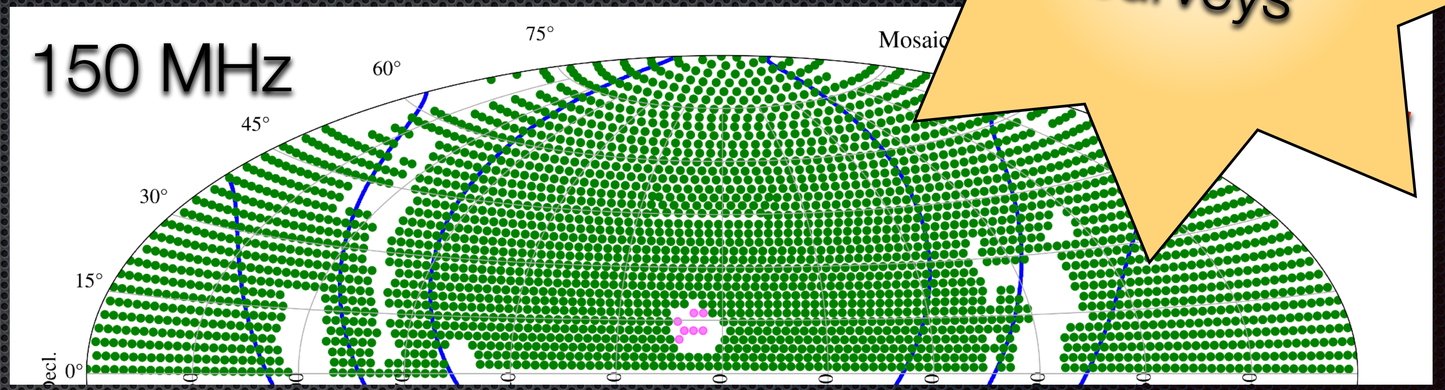

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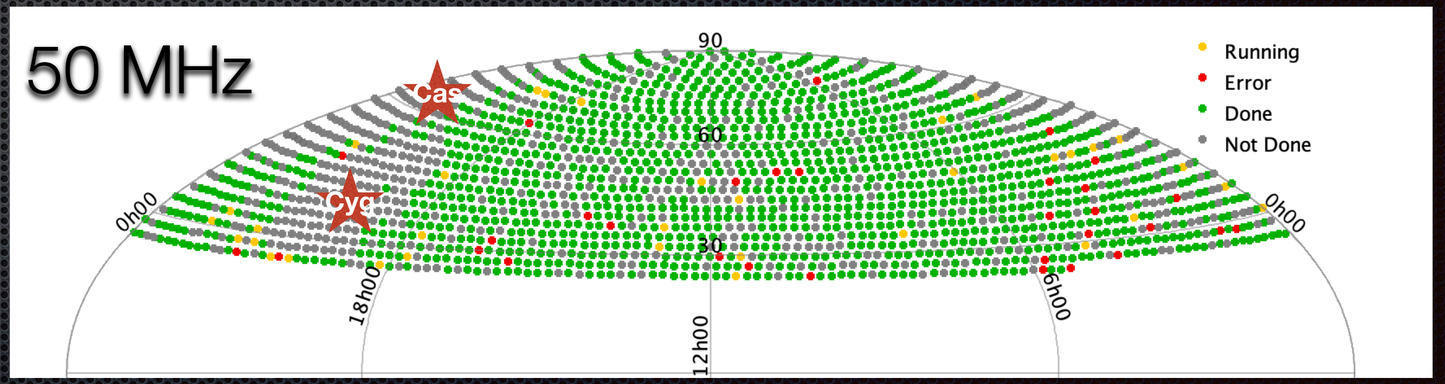
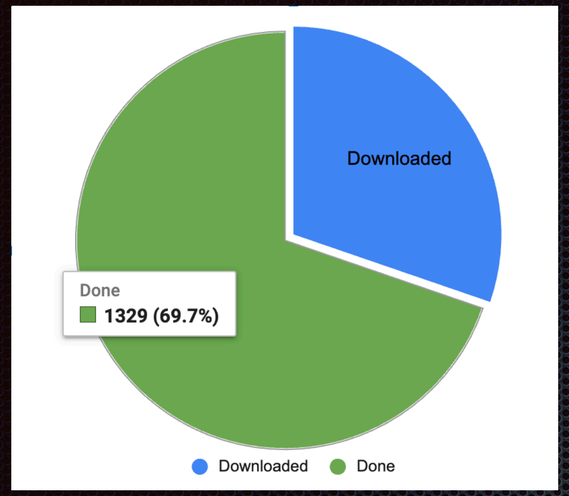
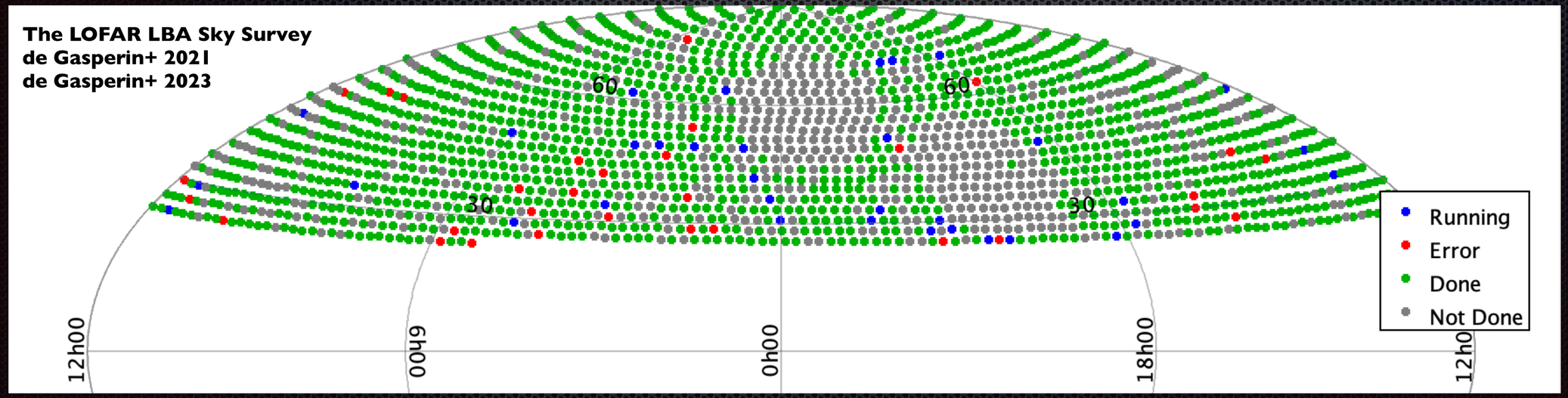


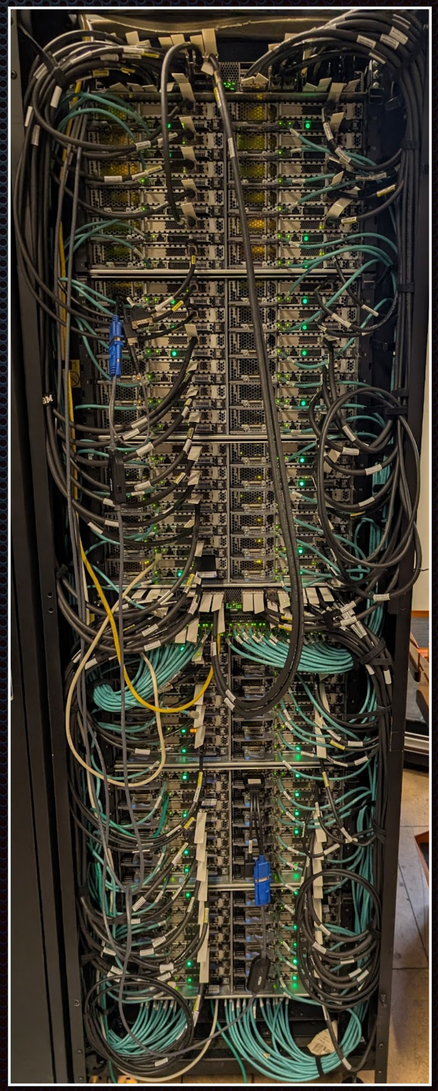
The LOFAR LBA Sky Survey: status



- Completed: 1336 fields (70.3 %)
- Rate: 13 fields/day → 36 nodes @ Pleiadi supercomputer →
- <2% processing error

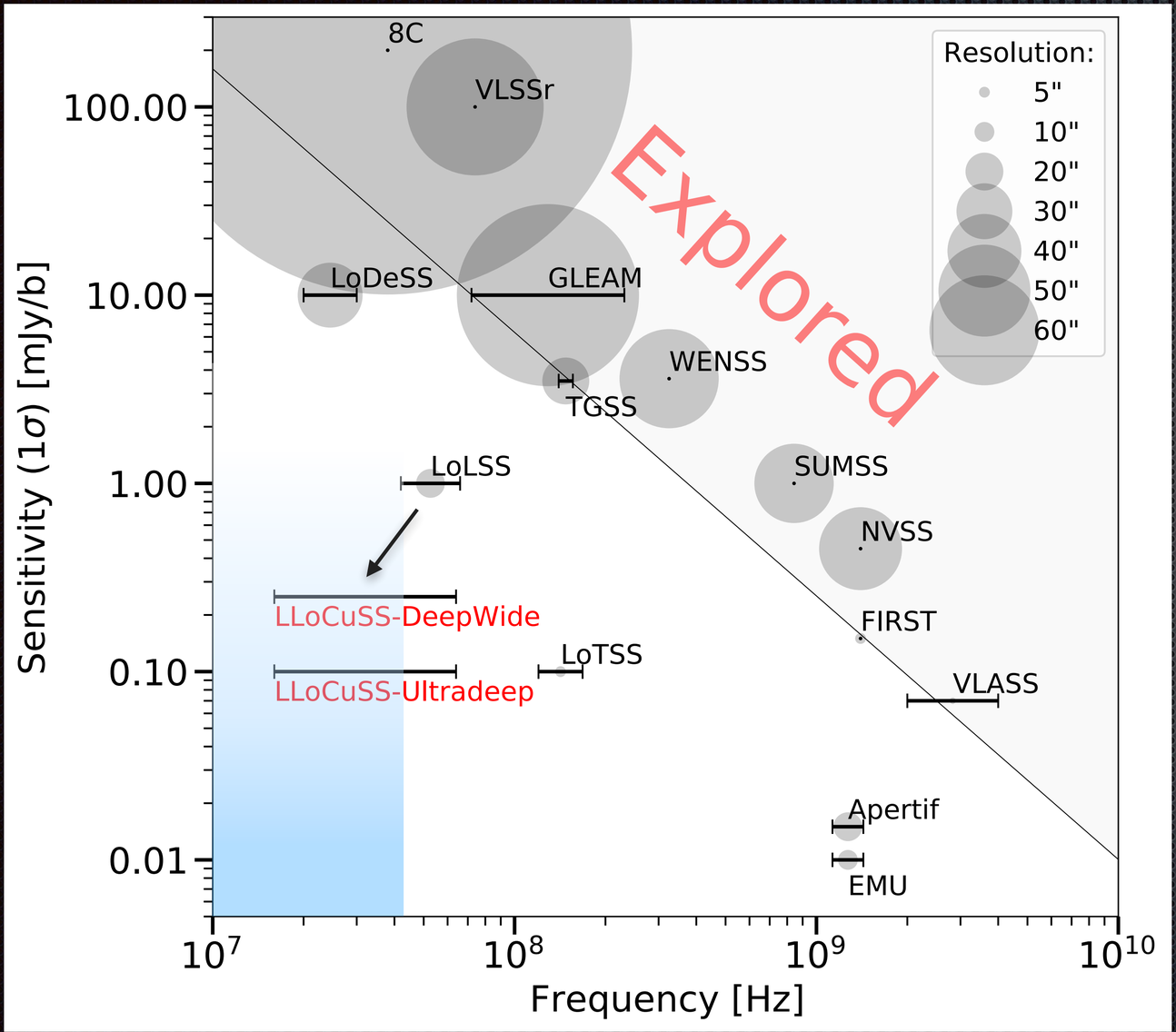
sky survey

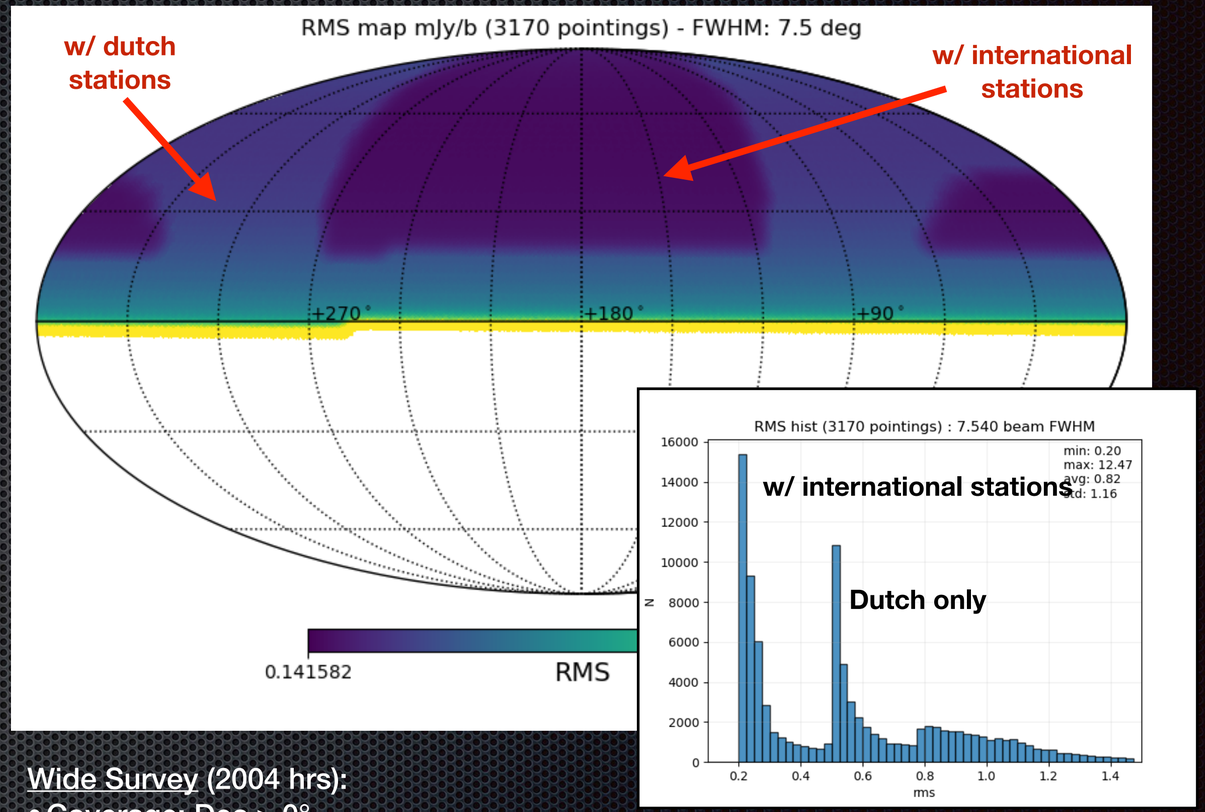




Pleiadi @ IRA

LBA LOFAR Community Sky Survey (LLoCuSS)





Wide Survey (2004 hrs):
- Coverage: Dec > 0°
- Sensitivity: 500–800 μJy beam^{-1}

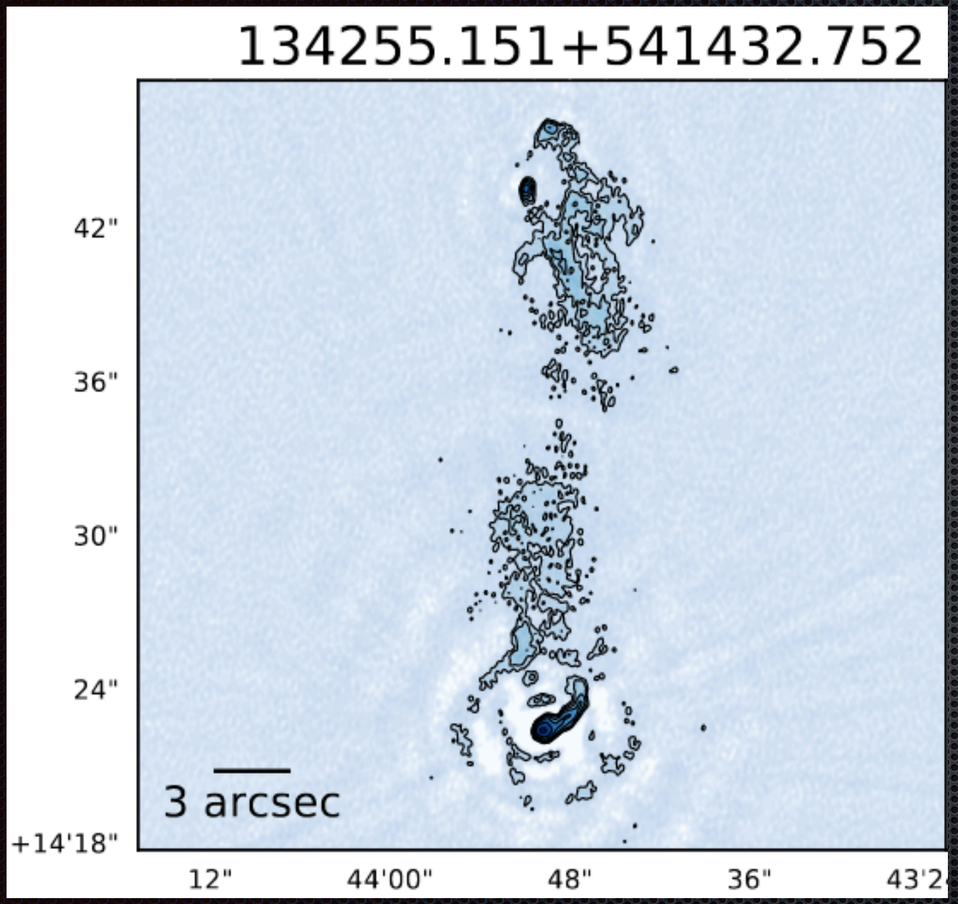
Deep-Wide Survey (5830 hrs):
- Coverage: Dec > 20°, $|b|$ > 23°
- Sensitivity: 350 μJy beam^{-1}

Ultra-deep Fields (100 hrs per field):
- Sensitivity: 130 μJy beam^{-1}

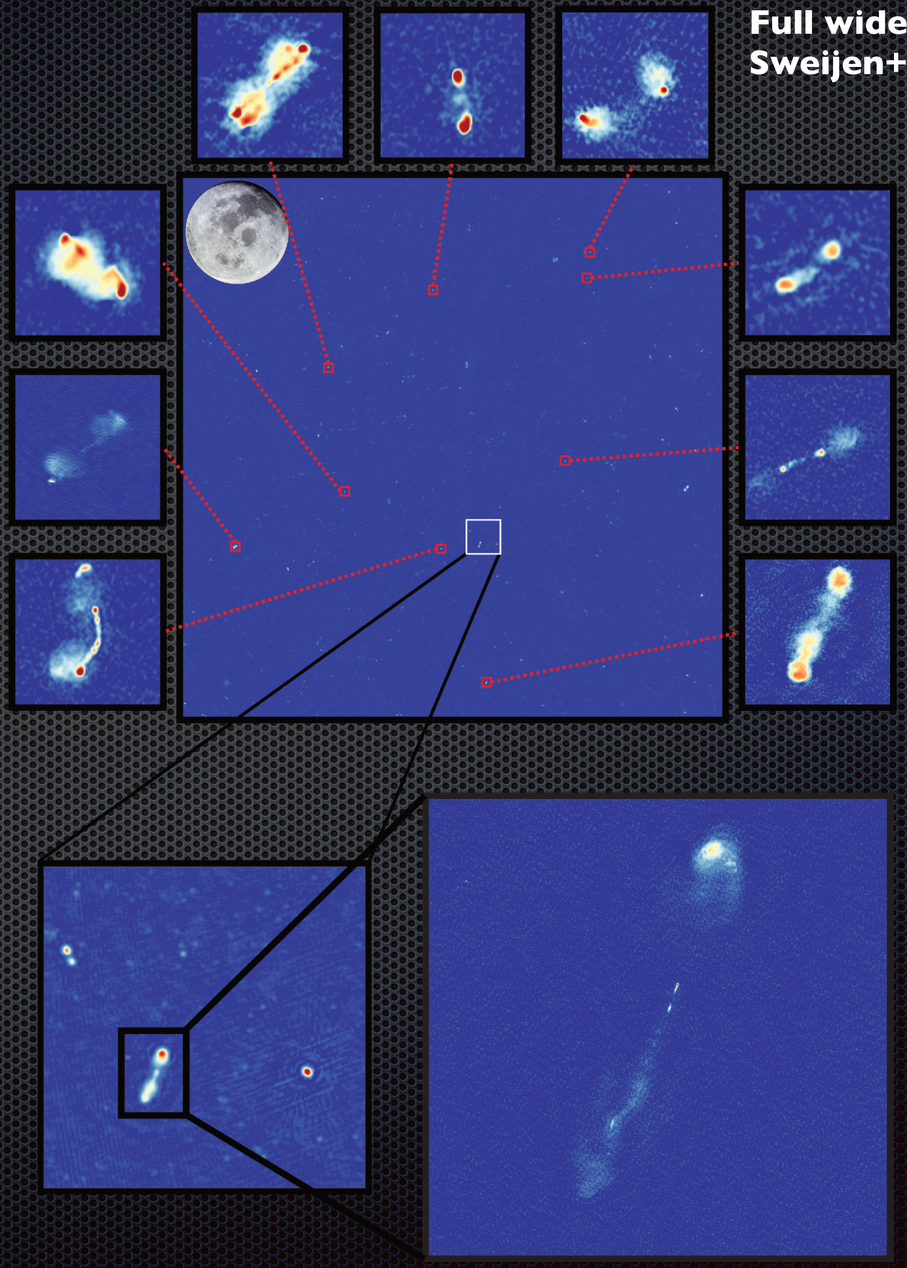
- **Band:** 16 – 64 MHz
- **Resolution:**
  1” (upper half of the band)
  15” (lower half of the band)

International LOFAR Telescope

Almost all LoTSS data contains the LOFAR international stations
(up to 1600km)

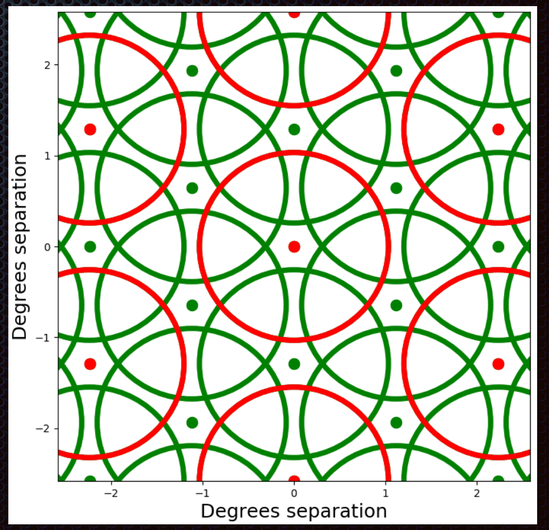


Selected source imagining: Morabito+ 2021

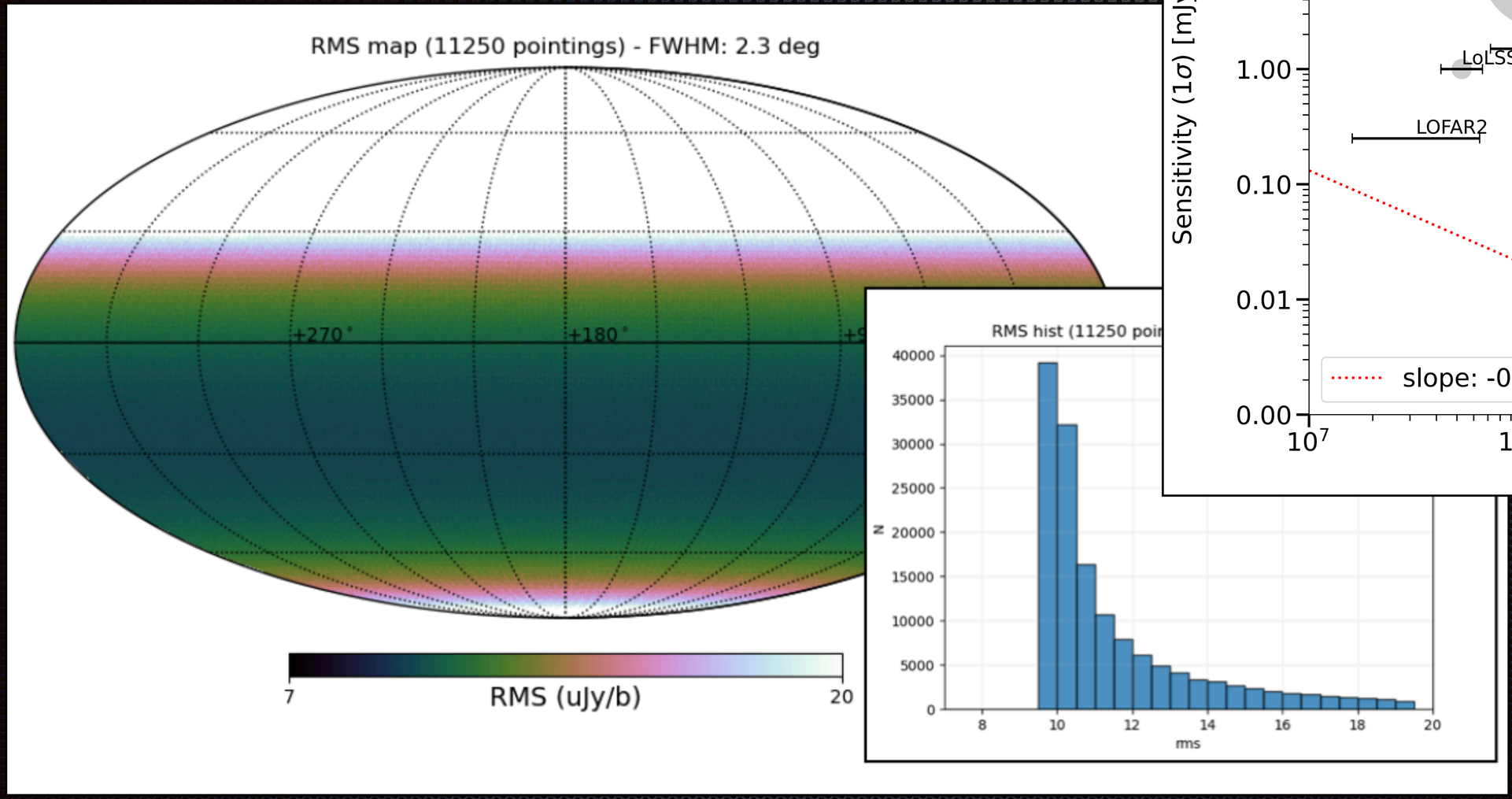


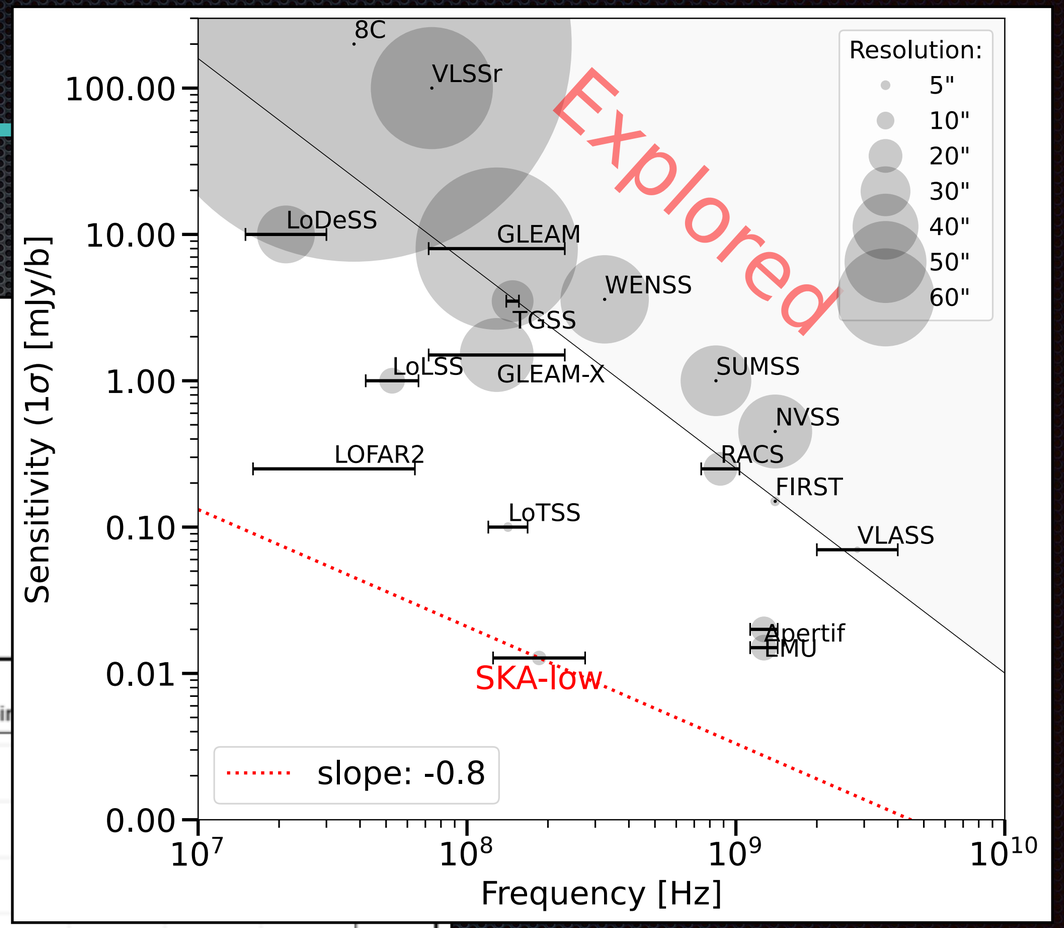
Full wide area imaging: Sweijen+ 2022

LOFAR 2.0: complete LoTSS-IS survey grid doubling the pointings
Aim: entire extragalactic northern sky at 0.3"



A SKA-Low sky survey





Assumptions:

- 5625 hrs (1 hr per pointing)
- 2 simultaneous beams
- 125-275 MHz (band: 150 MHz)
- coverage: dec < +30°
- resolution: 8"
- confusion noise included

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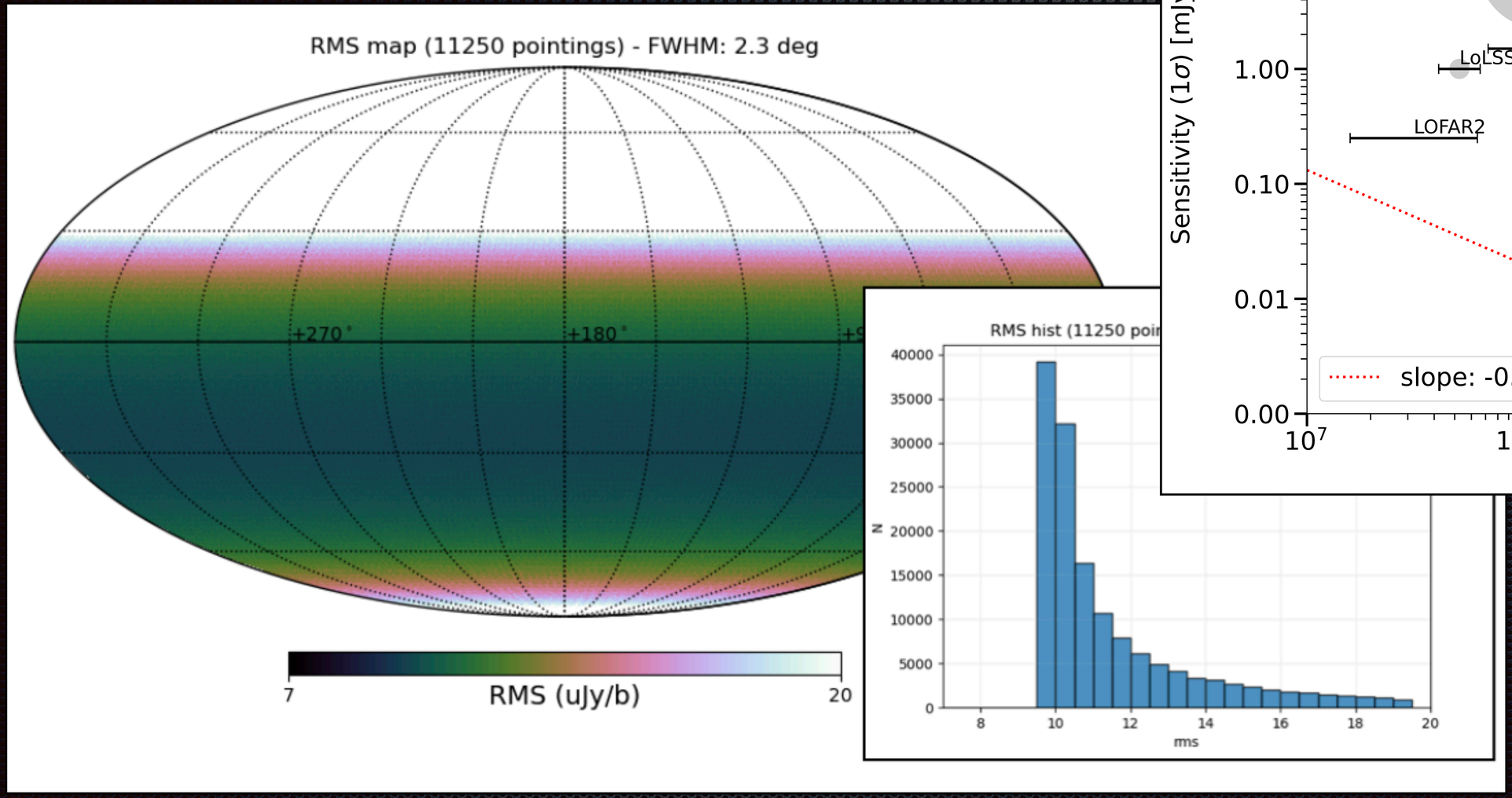

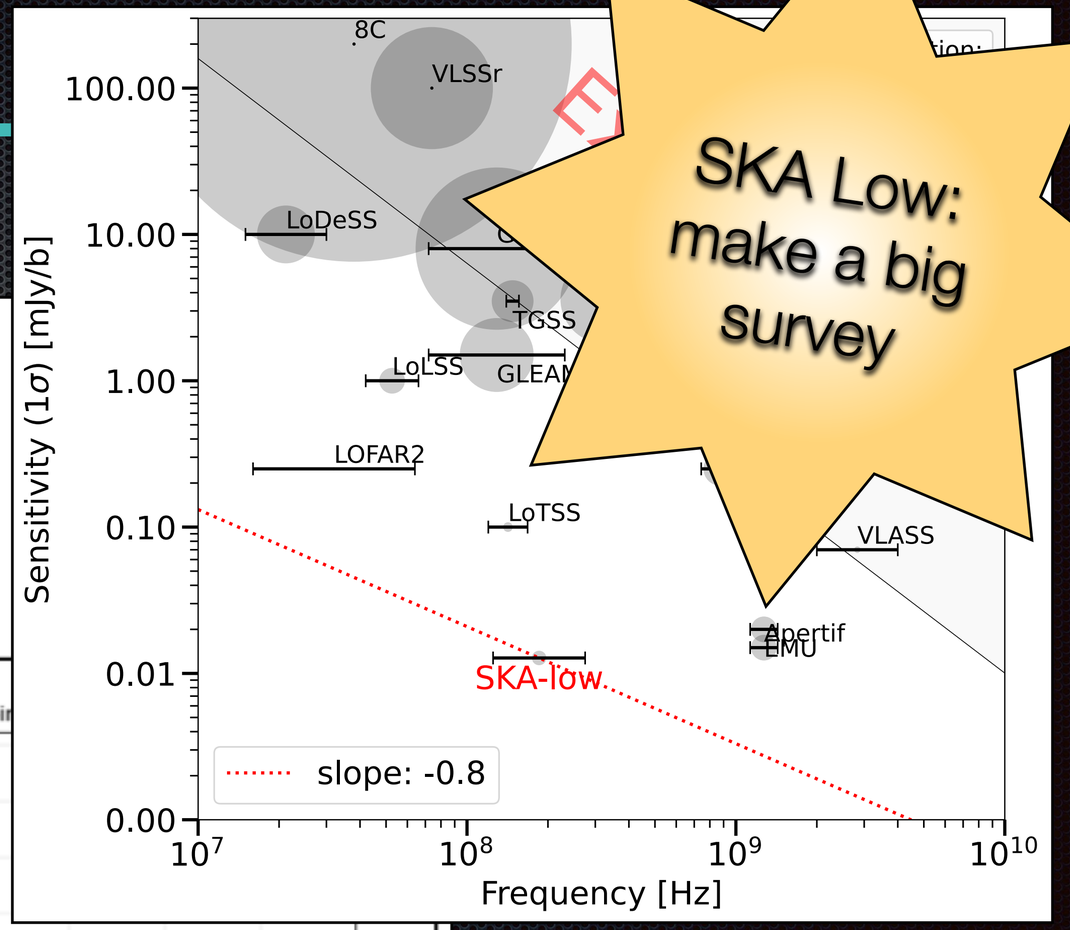

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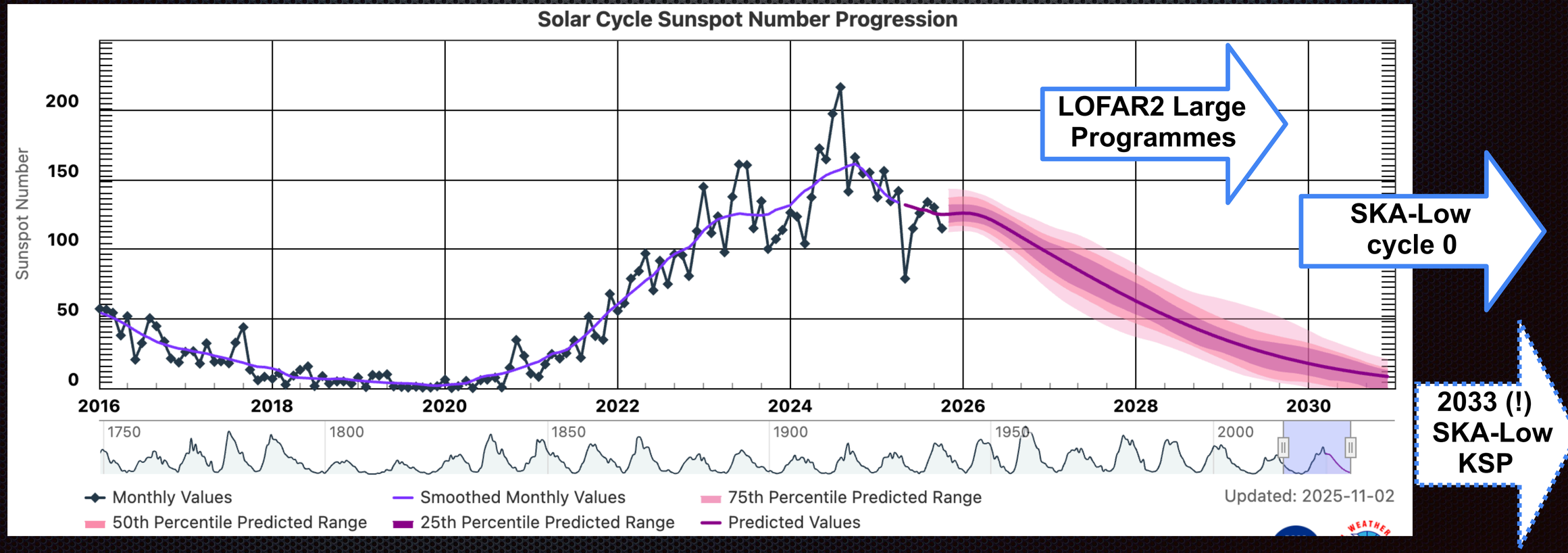
Timeline

LOFAR 2.0 upgrade:

- 2023: 1 LOFAR 2.0 station (L2TS) fully working
- 2024-1q: 3 LOFAR 2.0 stations
- 2025-2q → 2025-4q: roll out of Dutch stations
- 2026-2q → 2026-3q: roll out of Eur stations

Science programmes:

- 2025 - commissioning
- 2026 - science verification
- 2026 → 2030+ LP observations
- 2026 → 2030+ 30% open time



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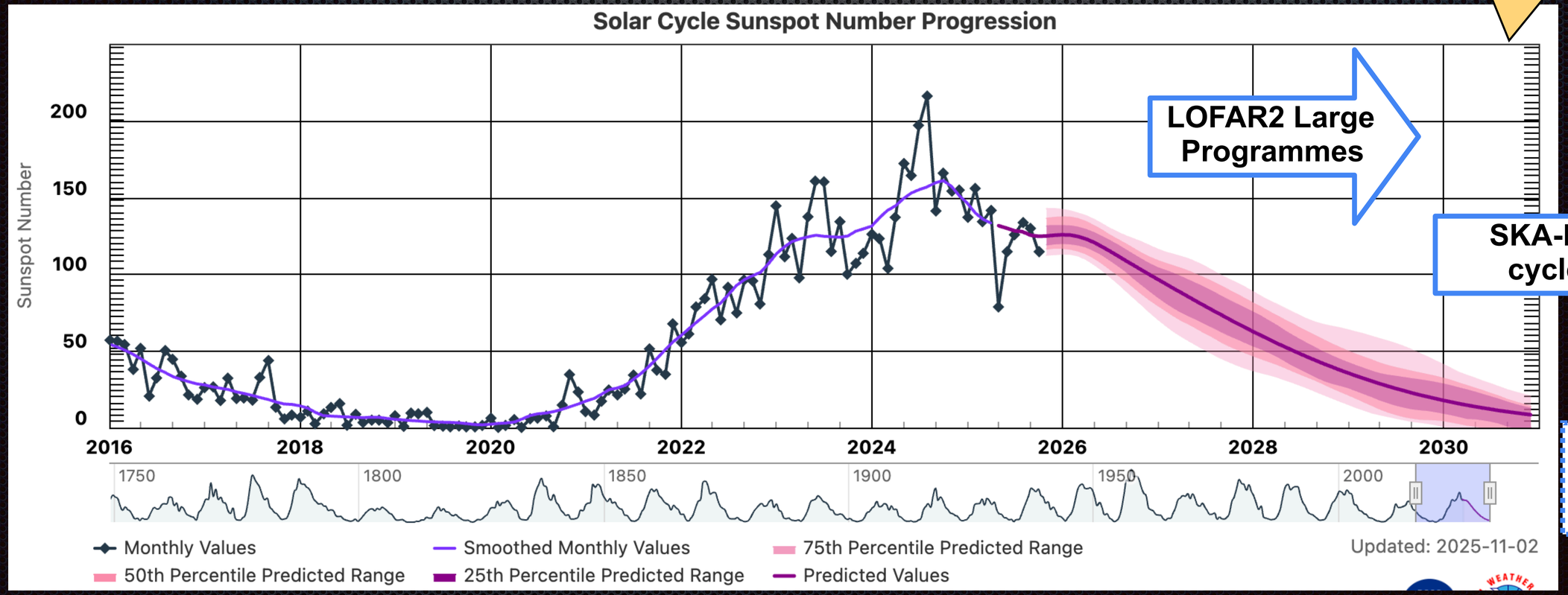
SKA Low: solar cycle defines efficiency



Take away messages

LOFAR 1 → HBA revolution

LOFAR 2 → LBA revolution

(no competitors even with SKA)