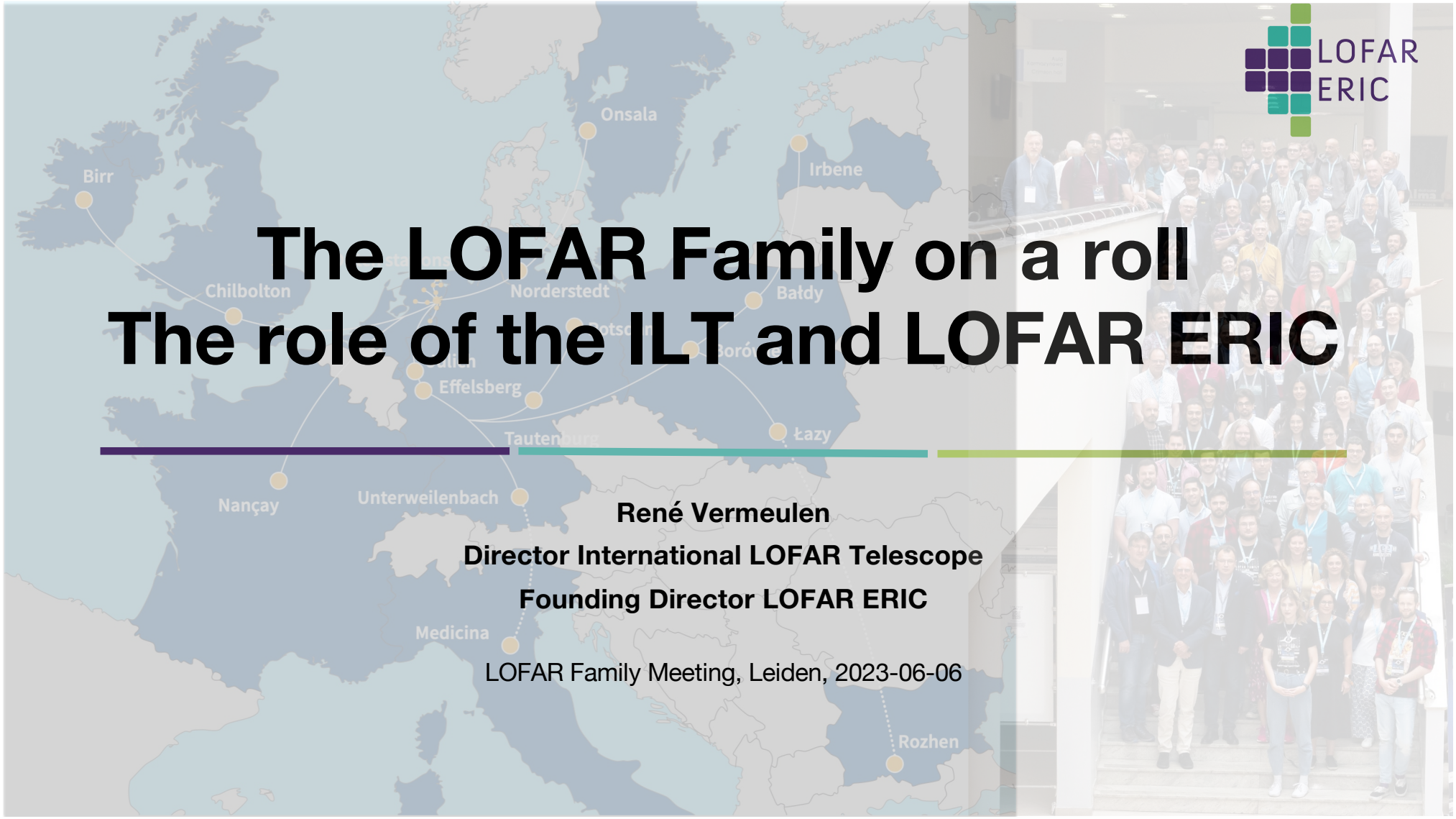


The LOFAR Family on a roll
The role of the ILT and LOFAR ERIC

René Vermeulen

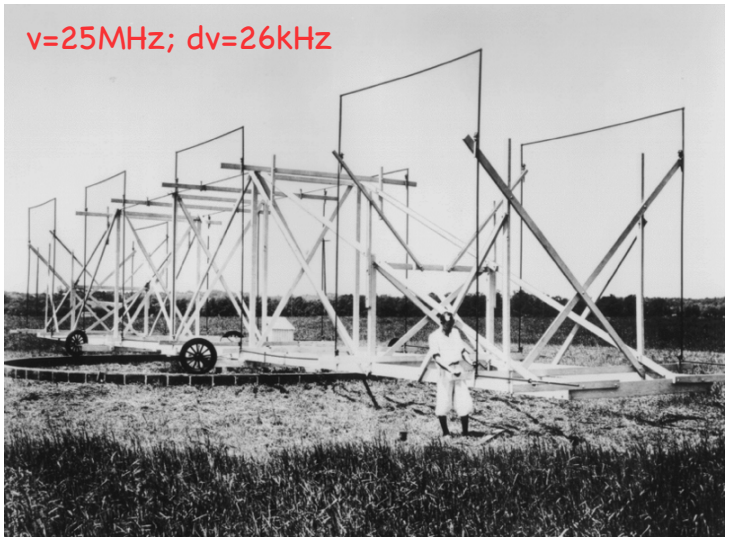
Director International LOFAR Telescope

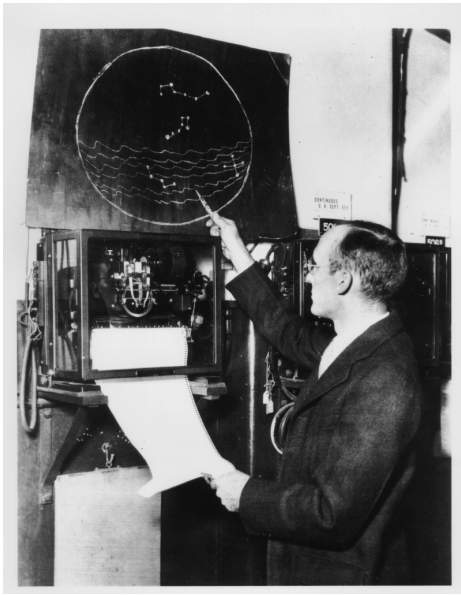
Founding Director LOFAR ERIC

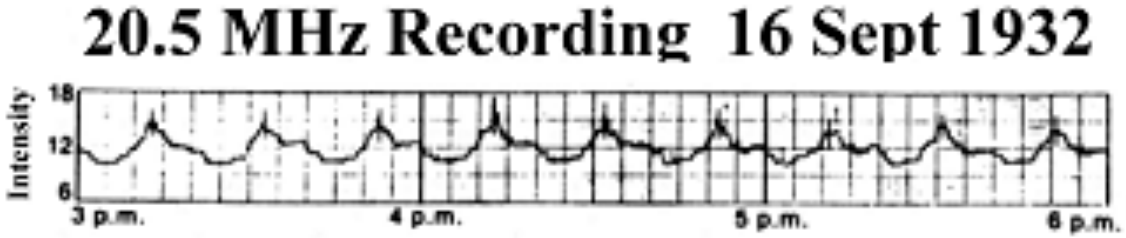
LOFAR Family Meeting, Leiden, 2023-06-06

The start of radio astronomy – at LOFAR frequencies!

- Discovery of cosmic radio waves - Karl Jansky, 1932







The intermediate era of low frequency radio astronomy

Clark Lake (1959 – 1986); USA

UTR-2 (1972 – present currently damaged by war); Ukraine

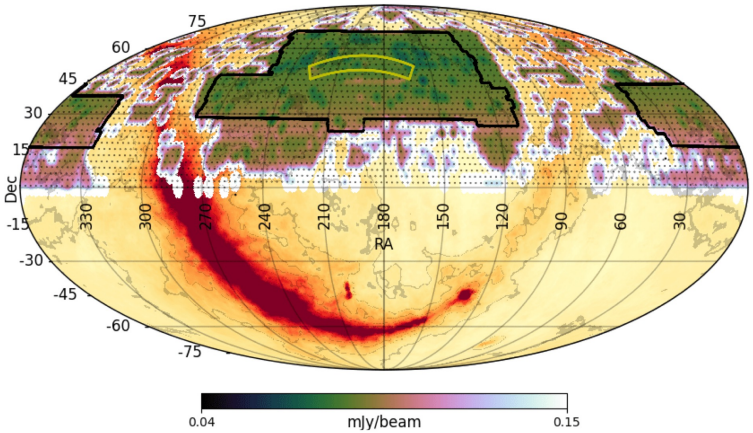
GMRT (1996; now uGMRT); India

VLA 74 MHz (1997 – 2007); USA

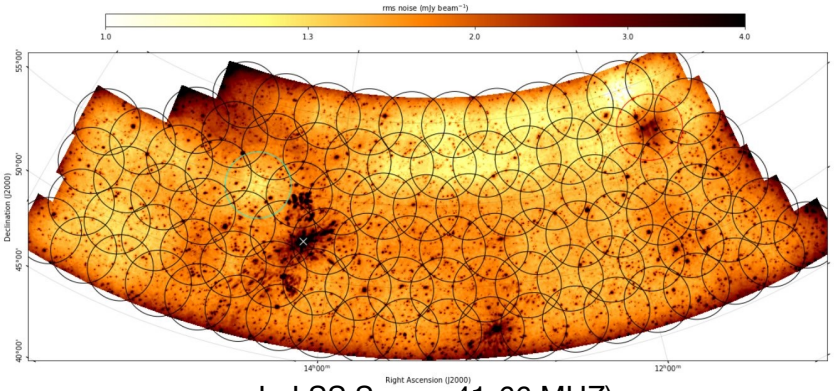
LOFAR concept; late 1990s -> now

Initial science driver (Miley+):
Low-frequency large-area survey to detect/select earliest galaxies

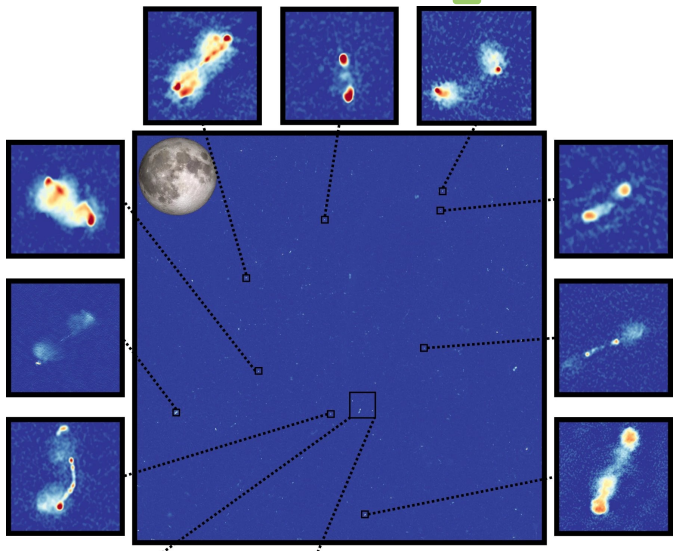
Technical solution (Bregman+):
digital phased-array technologies



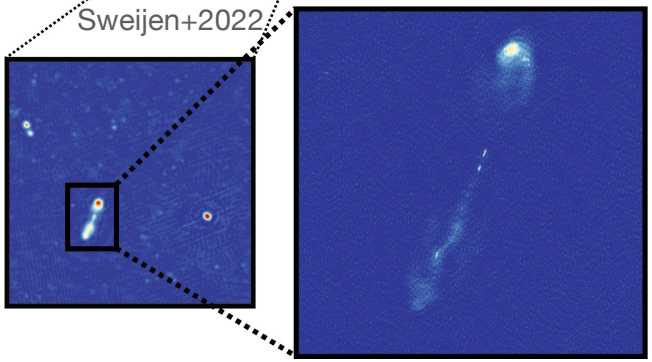
LoTSS Survey (120-168 MHz)
Shiwmwell+2022



LoLSS Survey 41-66 MHZ)
De Gasperin+2023



Sub-arcsec survery 144 MHz
Sweijen+2022



Science with LOFAR

Around 2000: Funding & realization being explored in global & SKA-pathfinder context

First technical concepts sparked scientists' imagination: broadening of science use cases

Around 2003: Funding precipitated NL site choice, technical design by ASTRON

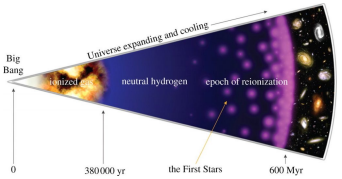
2004-2009 Science groups & institutes in DE, FR, SE, UK attracted

- "affordable" to add a station, for better array resolution & stand-alone use

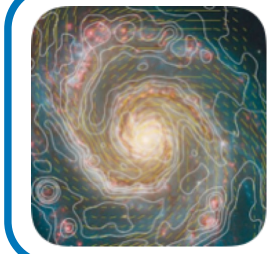
➔ **LOFAR1 design based on 6 diverse Key Science Projects (multinational groups)**

Low frequency sky surveys

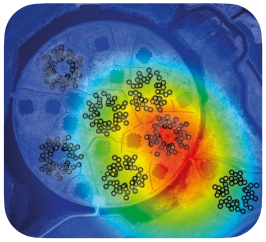
Radio transients and pulsars



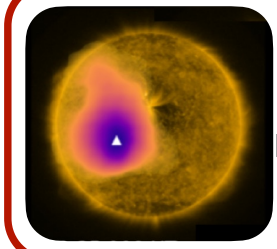
Epoch of reionization



Cosmic magnetism



Ultra-high energy cosmic rays



Solar and heliospheric physics

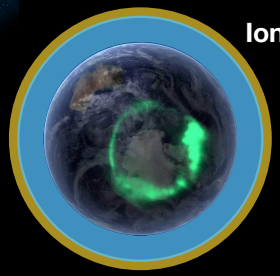
LOFAR's booming science applications in a growing family

LOFAR ERIC

Meteors

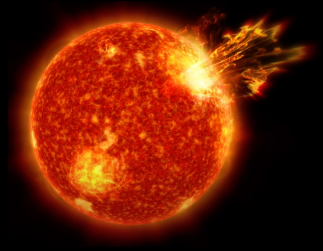
Lightning

Ionosphere

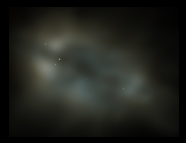


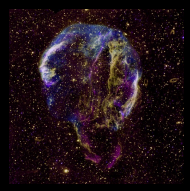
Heliosphere
Space Weather

Sun



Supernova (remnants)
Pulsar Wind Nebulae

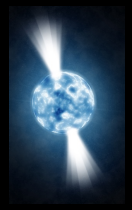




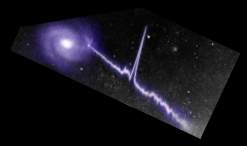
Cosmic
Magnetism

Clusters

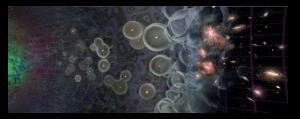
Pulsars



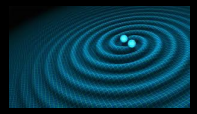
Fast Radio Bursts



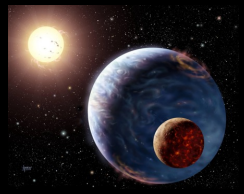
Early Universe
Cosmic Dawn



Gravitational
Wave Events



Exoplanets
Star-Planet Interaction



AGN physics

Cosmic Rays

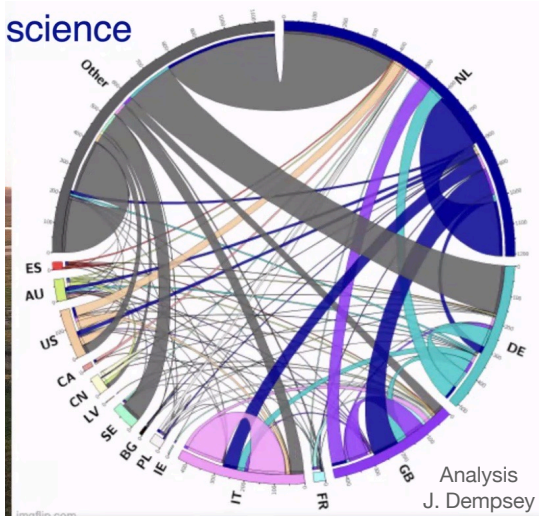
Solar System
Planets

Interstellar
Medium

Nearby Galaxies

The science requires distributed infrastructure, which in turn creates a reinforcement loop: networking, collaboration, capacity building

LOFAR ERIC



The International LOFAR Telescope (ILT) Foundation has structured and fueled the science reinforcement loop

Established in 2010 under Dutch law, after (only) 18 months of preparations (NL, DE, FR, SE, UK)

- Joint exploitation of the committed, distributed facilities: antenna stations, network, data centres
- Participants: ASTRON & quite diverse consortia within European countries

  (universities, research organisations, funding agencies, …)

  - ASTRON provides operational & development organisation

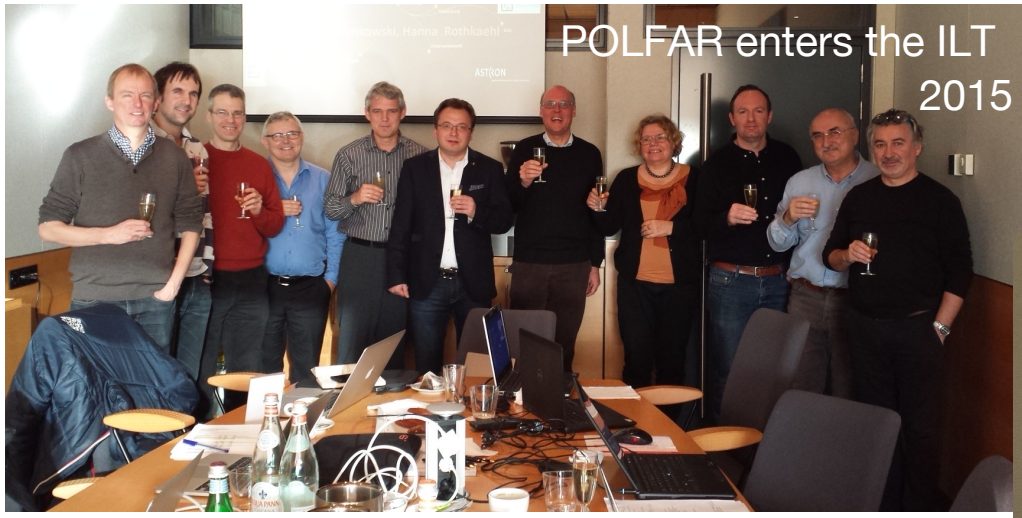
The International LOFAR Telescope (ILT) Foundation has structured and fueled the science reinforcement loop

- ILT policies set by the Board
- ILT allocates its (scarce) resources by peer review: observing, processing, storage, user support
- ILT owns the archived data (currently mostly “CEP output”), strives for FAIR access
- ILT is financed by all participants, plus collective fundraising (great EC Framework track record)

BALTICS

etc.

The International LOFAR Telescope (ILT) Foundation has catalyzed further participation

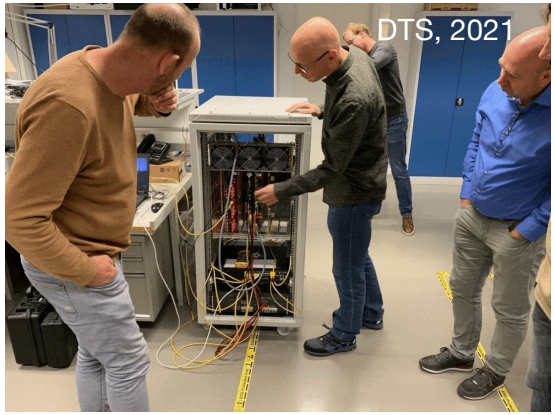


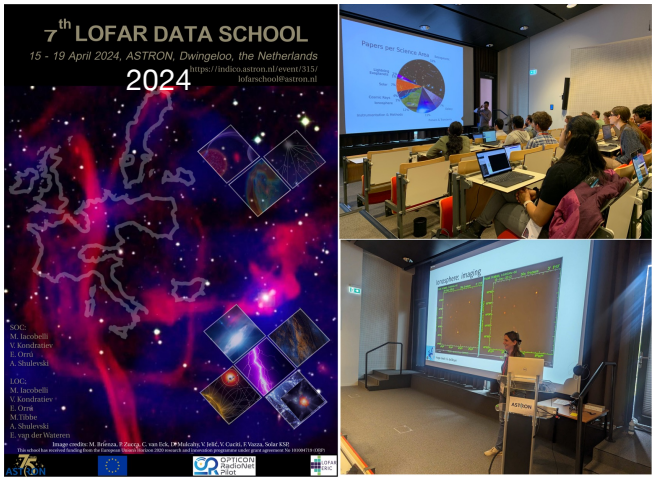
The International LOFAR Telescope (ILT) Foundation has catalyzed further participation

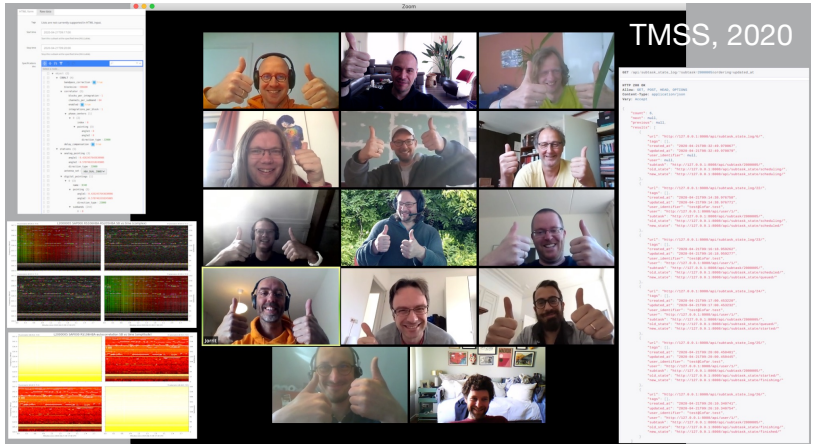
The International LOFAR Telescope (ILT) Foundation

Success ingredients:

World-leading host organisation, highly committed experts





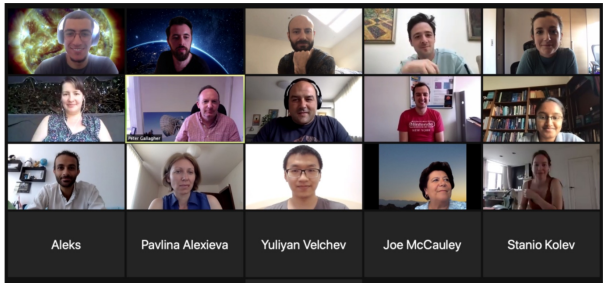


The International LOFAR Telescope (ILT) Foundation

Success ingredients:

Scientific vision & drive

Engaged Community



LOFARBG

LOFAR ERIC

The International LOFAR Telescope (ILT) Foundation

Success ingredients:

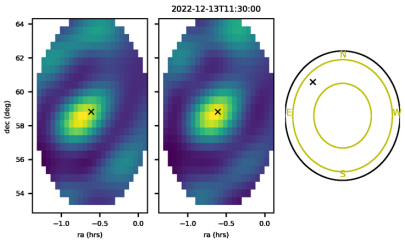
Available real estate & welcoming hosts

Supportive policy and funding bodies

Lobbying with the BG community
2019

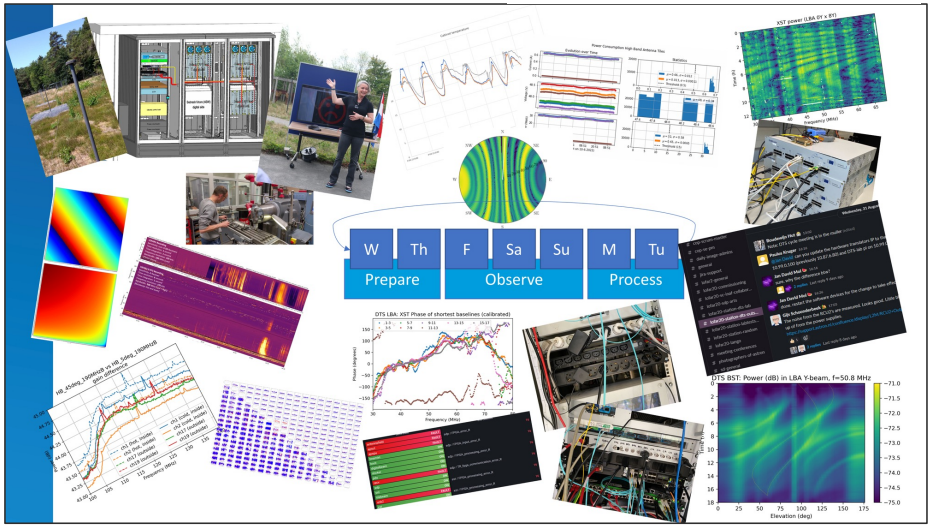
Now: moving LOFAR in the SKA era: LOFAR2.0 funded under ILT in proportion to number of stations

- Major science capability upgrades and expansions to keep LOFAR cutting-edge
  - Priorities/budget set by ILT Board, all ILT partners share development costs, joint hardware procurement
  - Managed and mostly developed by ASTRON, with other partners (incl. INAF) developer contributions
- Driver: 5x more sensitive, well-calibrated high-resolution in LBA (10-90 MHz) + HBA (110-240 MHz)
  - 1 to 5 mJy/beam r.m.s. @ 60 to 30 MHz after 8 hrs with 0.5” resolution over 12 deg^2 FOV
  - 0.03 mJy/beam r.m.s. @ 150 MHz after 8 hrs with 0.2” resolution



- **Ancillary upgrades:**
  - NenuFAR Tied Array as LOFAR Super station
    → Improved sensitivity below 50 MHz
  - Correlator (COBALT), processor (CEP6), network
    → Order of magnitude increase in compute capacity
  - Telescope Management & Scheduling System
    → Dynamic scheduling
  - Standard pipelines for imaging & other use cases
    → Calibration & High-resolution imaging

Credit: A. Schoenmakers

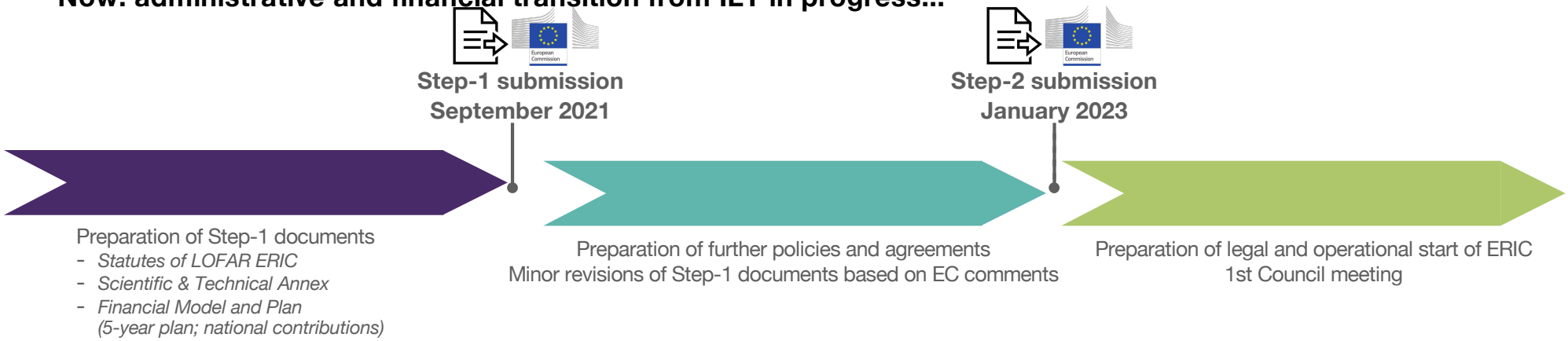


LOFAR ERIC: an even better vehicle to cohere the Family

- Recognition of LOFAR status: world-leading distributed Research Infrastructure
- Members engaged at comparable organisational levels in all partner countries
- Participation including financial commitments aligned to a common 5-year cycle
- Joint policies and operational activities geared to open access, open science
- Joint funding, steering, development, implementation of major development projects
- Joint definition of future science and technological priorities
- Attraction of new partners across Europe, and additional funding (national & EC)
- Partner for policy dialogue with stakeholders at national and EC levels

LOFAR ERIC – Formation time line

- **From at least 2016 thoughts floated within ASTRON and ILT on ERIC perspectives**
- **2018 Sep 26: ILT Board launches study of governance options (part-funded by EC: JumpingJIVE)**
- **2019 Aug 27: Informal exploration with NL ministry (Jeannette Ridder), catalyzed by NWO-I (Job de Kleuver)**
- **2019 Oct 02: ILT Board decision to apply to become LOFAR ERIC, process to be led by NL ministry**
- **2020 Feb 26: First formal LOFAR ERIC Working Group with ministerial representatives (*at Schiphol*)**
- **2021 Sep 21: Submission of Step 1 Application (Statutes, Financial Plan, Science & Technical Description)**
- **2022 May 10: Favourable review by EC**
- **2023 Jan 30: Submission of Step 2 Application (requires formal country commitments)**
- **2023 Dec 21: EC approves, thereby founds LOFAR ERIC as legal entity**
- **Now: administrative and financial transition from ILT in progress...**



LOFAR ERIC, progressing the ILT Family impetus:
My personal vision on the success ingredients & priorities

- Recognition of LOFAR status: world-leading distributed Research Infrastructure
  There are now just 28 ERICs across all disciplines

LOFAR ERIC, progressing the ILT Family impetus:
My personal vision on the success ingredients & priorities

- Joint definition of future science and technological priorities – in era of SKA, ngVLA
  - Engaged community: Nurture next generation of visionaries, afficionados, experts
    Learn from LOFAR2.0 commissioning, pipeline development
    Heed breadth of (trans)national priorities (e.g. Solar, Transients,…)
    Continue mix of expert/targeted and Family meetings
  - Scientific vision & drive: Compose, then maintain a Family Post-LOFAR2.0 White Paper
  - Supportive policy & funding bodies: Lobbying & roadmapping

- Attraction of new partners across Europe, and additional funding (national & EC)
  - Engaged community: Astronomy groups in 4+ countries exploring participation
    Partnering with flanking domains (e.g. Solar & Space Weather)
  - Supportive policy & funding bodies: Lobby & prepare for planned funding lines (FP10,…)

- Partner for policy dialogue with stakeholders at national and EC levels
  - Supportive policy & funding bodies: EC has “preferred” community organization models
  - Engaged community: Align & propose models with partners (RI, scientists)
    Lobby to cater to the needs in “our” field

LOFAR ERIC, progressing the ILT Family impetus:
My personal vision on the success ingredients & priorities

- Joint policies and operational activities geared to open access, open science
- Joint funding, steering, development, implementation of major development projects

Engaged community: Here and now: assign LOFAR2.0 resources
Set priorities for future fundraising & resources, roles

World-leading host organisation: Engender & cohere increasing partner capacity

- Members engaged at comparable organisational levels in the partner countries
- Participation including financial commitments aligned to a common 5-year cycle

Engaged community: Roadmapping suitable to lobby: Supportive policy & funding bodies

The LOFAR Family Meetings
an essential ingredient of the ILT and LOFAR ERIC

LOFAR Family meetings have been held annually since 2012 – except 2020 & 2021 (Covid)

and have always been a very invigorating week for me personally!

Many thanks to you all for jointly being our “Family on a roll”

Keep that excellent, innovative science coming out!