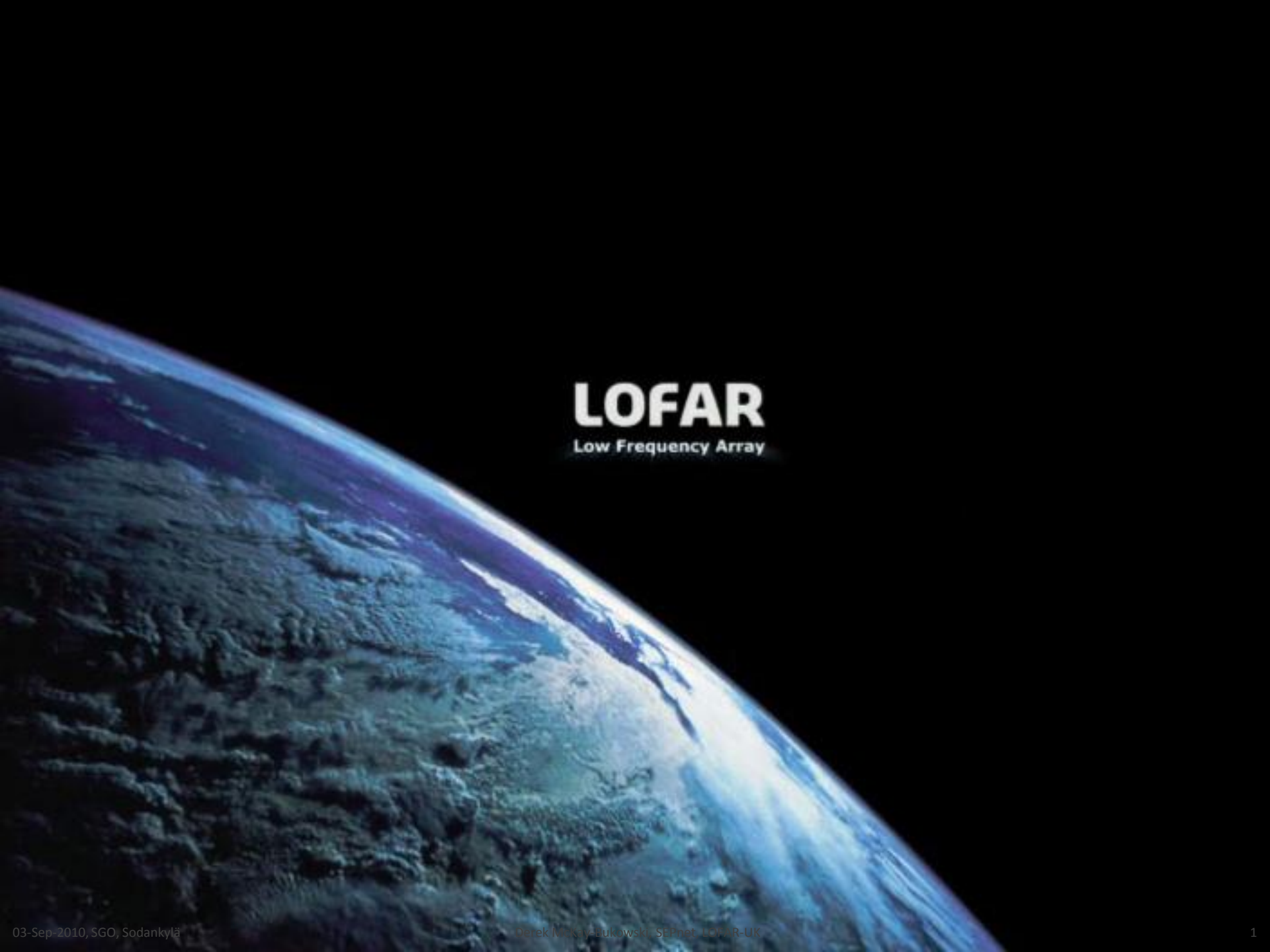
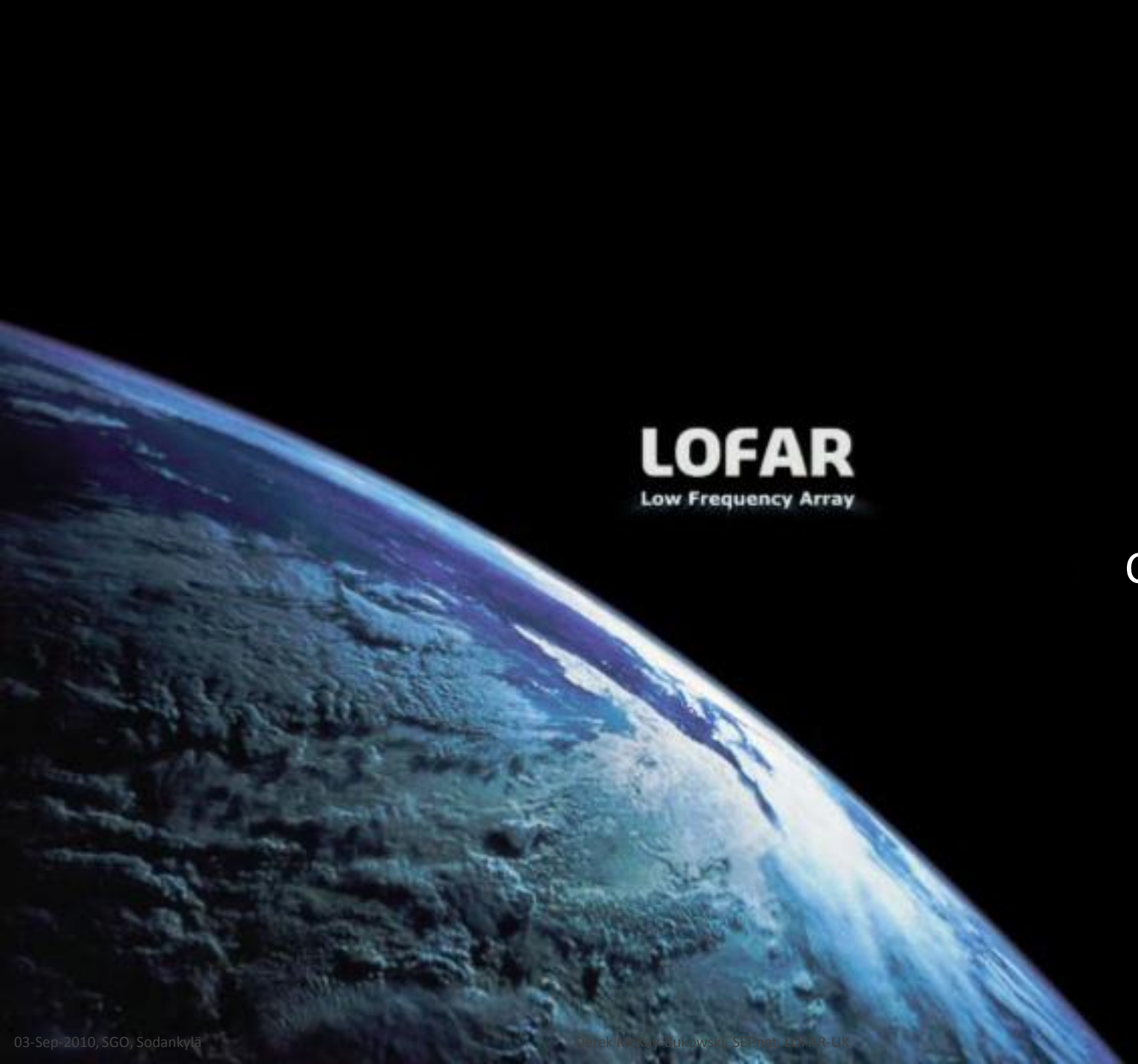

LOFAR
Low Frequency Array



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- ASTRON
  - Netherlands Foundation for Radio Astronomy (!)

- Built during the 50's
  - The largest radio telescope in the world at the time!

- Westerbork Synthesis Radio Telescope
  - 14 × 25m dish interferometer completed during the 60's

- Operations centre in Dwingeloo
  - ILT + Single-station scheduling and observations

- LOFAR
  - VHF, multi-beam, multi-frequency, phased array

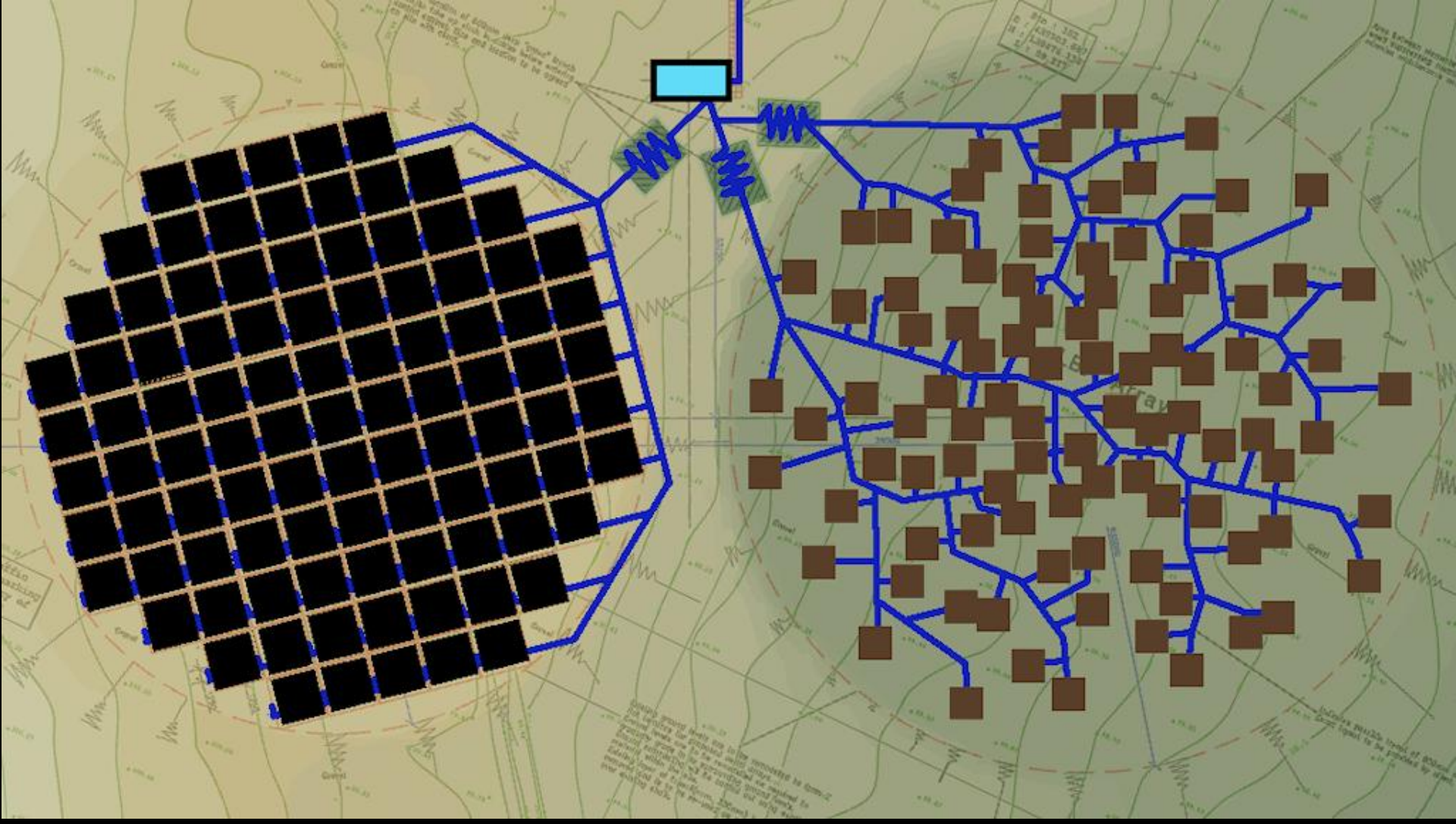
- Core station
  - 96 LBA + 2×24 HBA

- LBA aerial
  - Angled dipole, ground plane, LNAs

- Superterp
  - Equivalent of 6 core stations

- Core and remote cabinets
  - 3 × 19-inch all-weather racks

- LOFAR Netherlands
  - Superterp, core, remote stations, OPS and CEP



- International sites
  - 96 × HBA + 96 × LBA

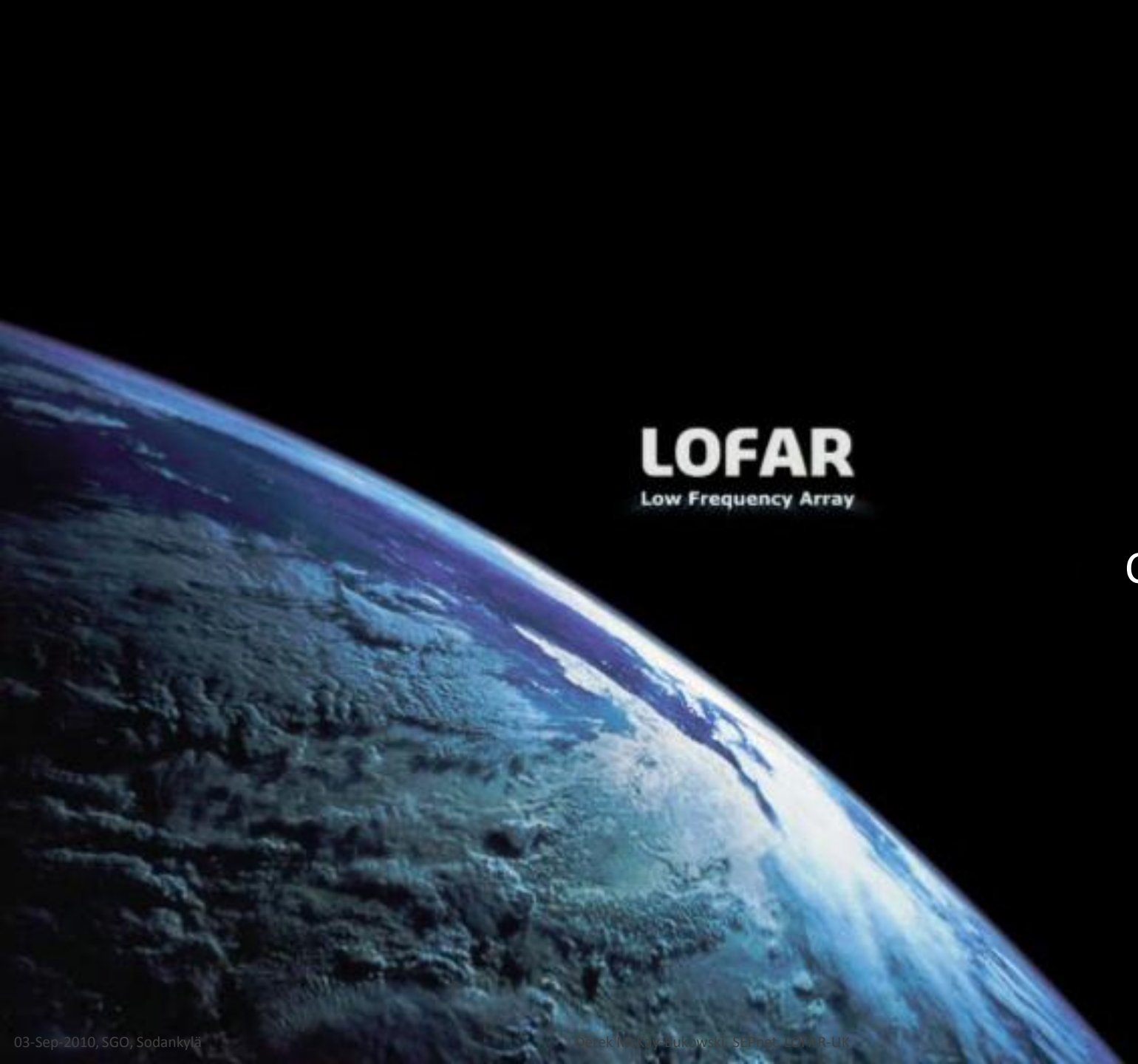
- LOFAR across Europe
  - Netherlands, Germany, France, UK... with more planed!

- Zernike Supercomputing Centre
  - Groningen, Netherlands

- Data ingest and storage
  - Decent broadband and initial storage for processing

- Blue Gene/P
  - Currently 40th largest supercomputer in the world

- Long-term archive
  - Groningen (Netherlands) and Jülich (Germany)



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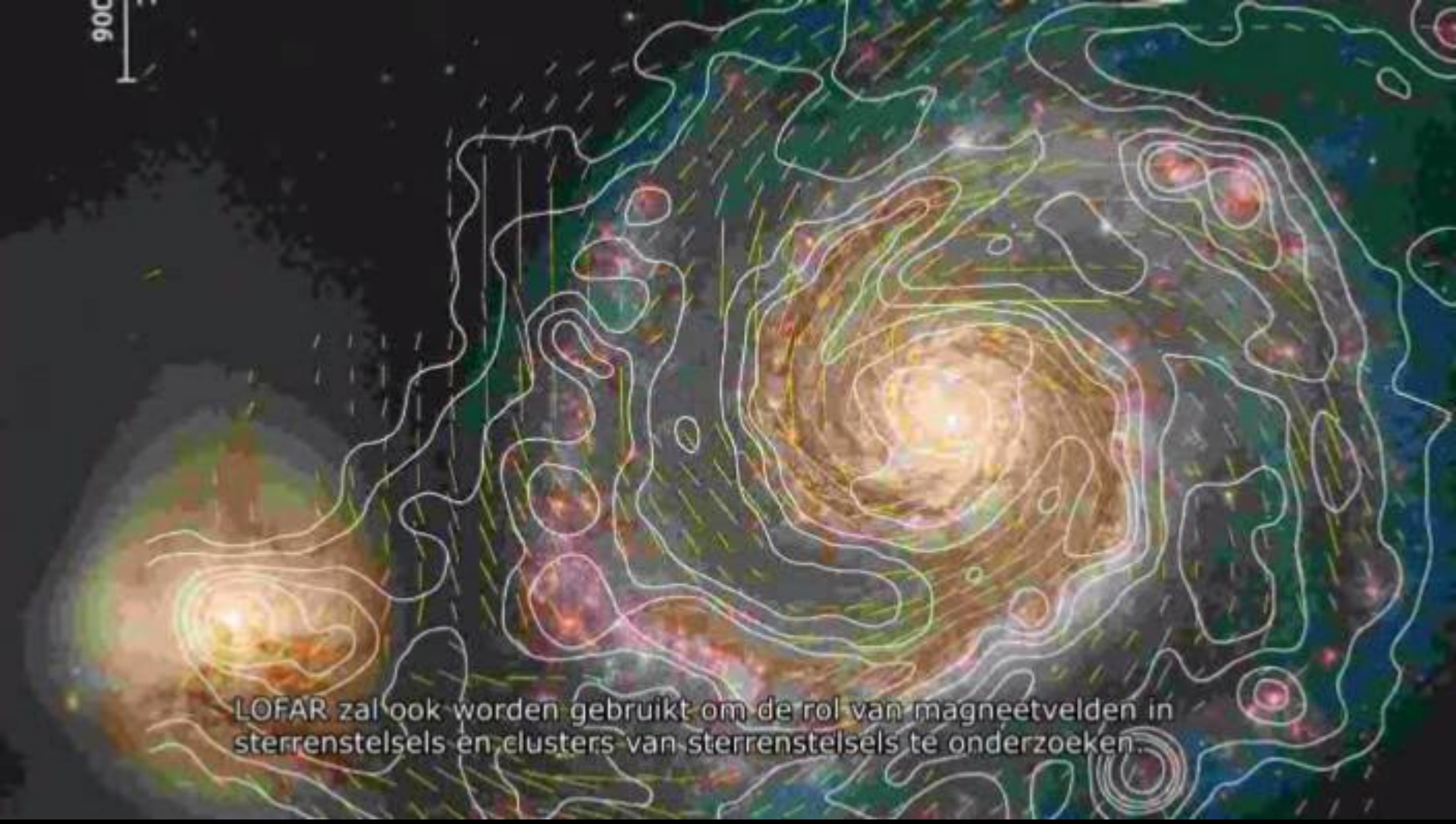


- Conventional radio astronomy
  - Galaxy dynamics, magnetism, clusters, AGNs, etc.

- Cosmology (Epoch of Re-ionisation)
  - Possible at VHF, with huge collecting area

- High time-resolution
  - Radio transients, pulsars, (radar pulses, SETI, etc.)

- Solar physics
  - High-time and spatial resolution studies

- Cosmic rays
  - Trigger-mode and post-observation beam forming

- Ionospheric studies
  - Also radar, space situational awareness, etc.

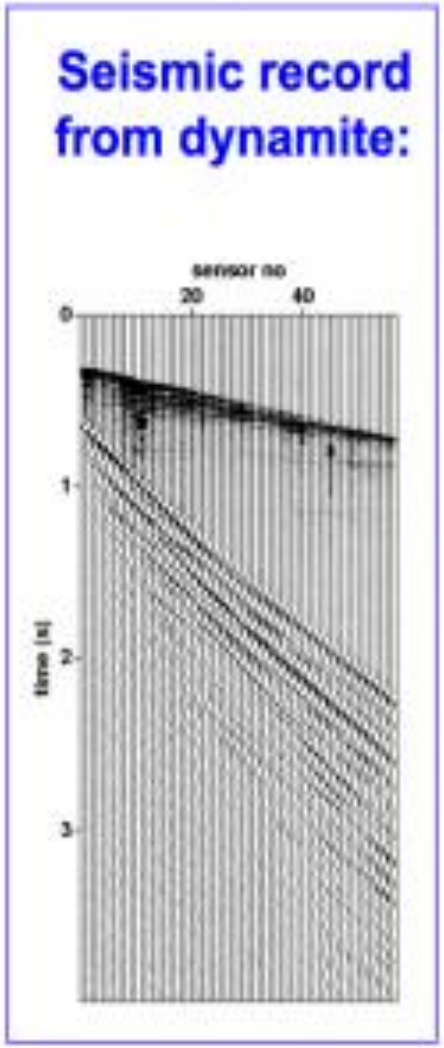
- Lightning
  - Event trigger statistics, direction and time resolution

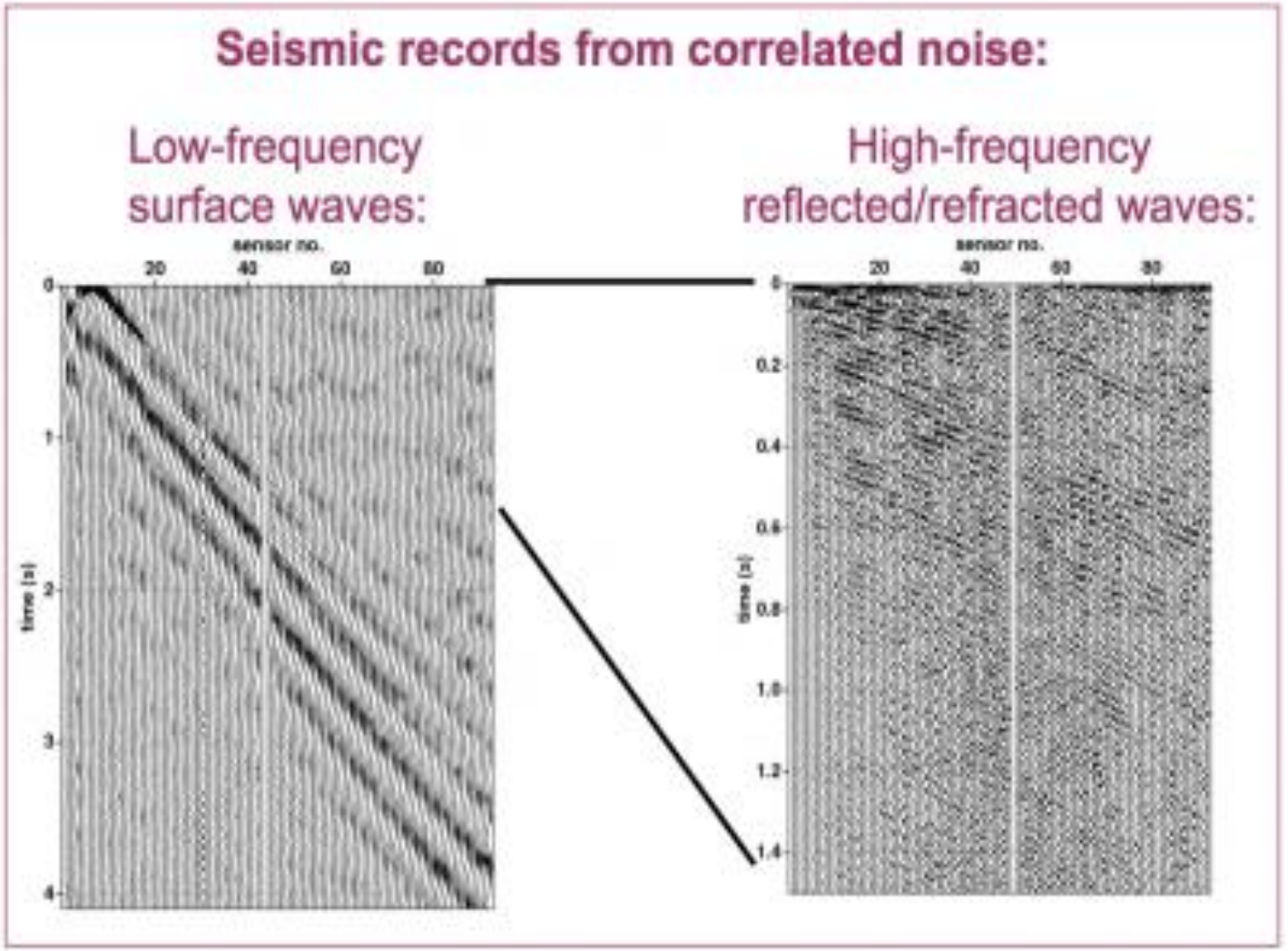
- Agriculture
  - Thermistors, distrometers, tracking, etc.


Geofoons en infrageluidsensoren zijn op veel LOFAR stations in Nederland te vinden.

- Geophones

- Geophones, precision seismography

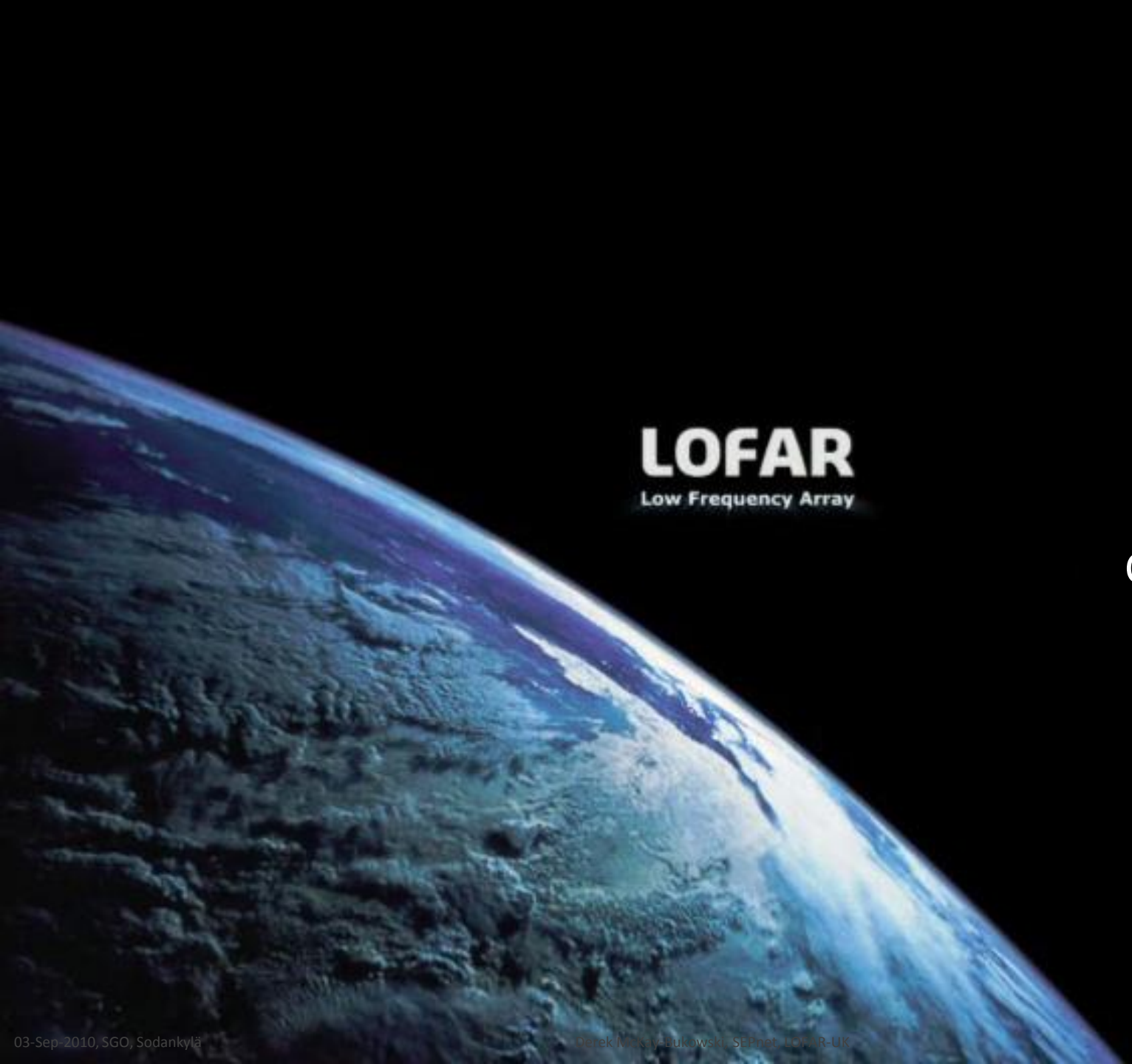




- First LOFAR seismic results
  - Dutch geological and petrochemical research

- Infrasound arrays
  - Supersonic monitoring, NTBT.

- Combined geo-sensors
  - Traditional geophysics: seismology, vulcanology



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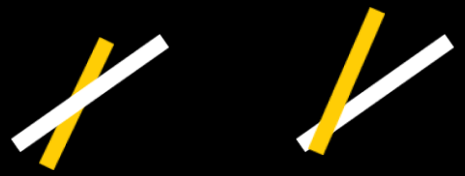
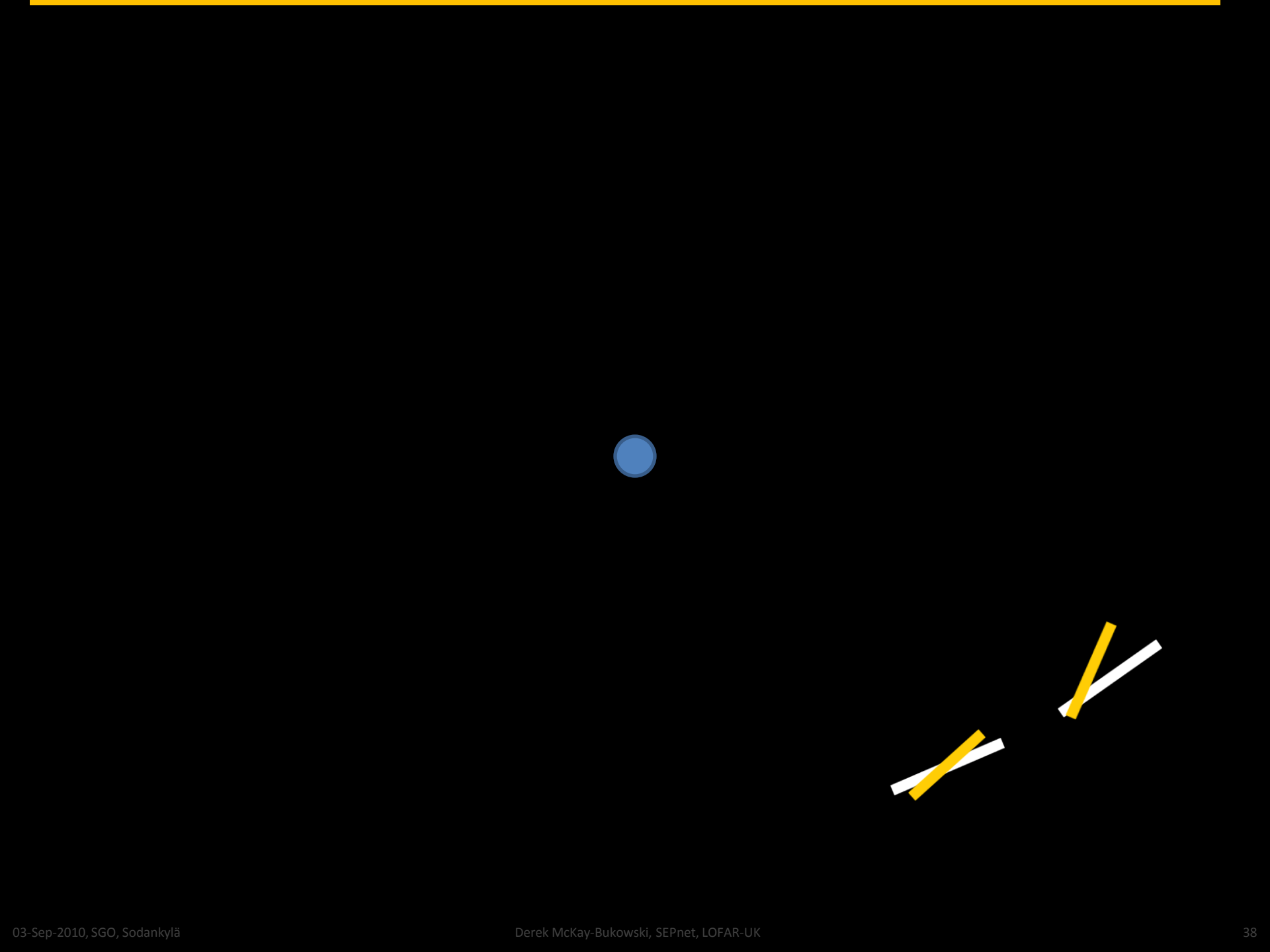
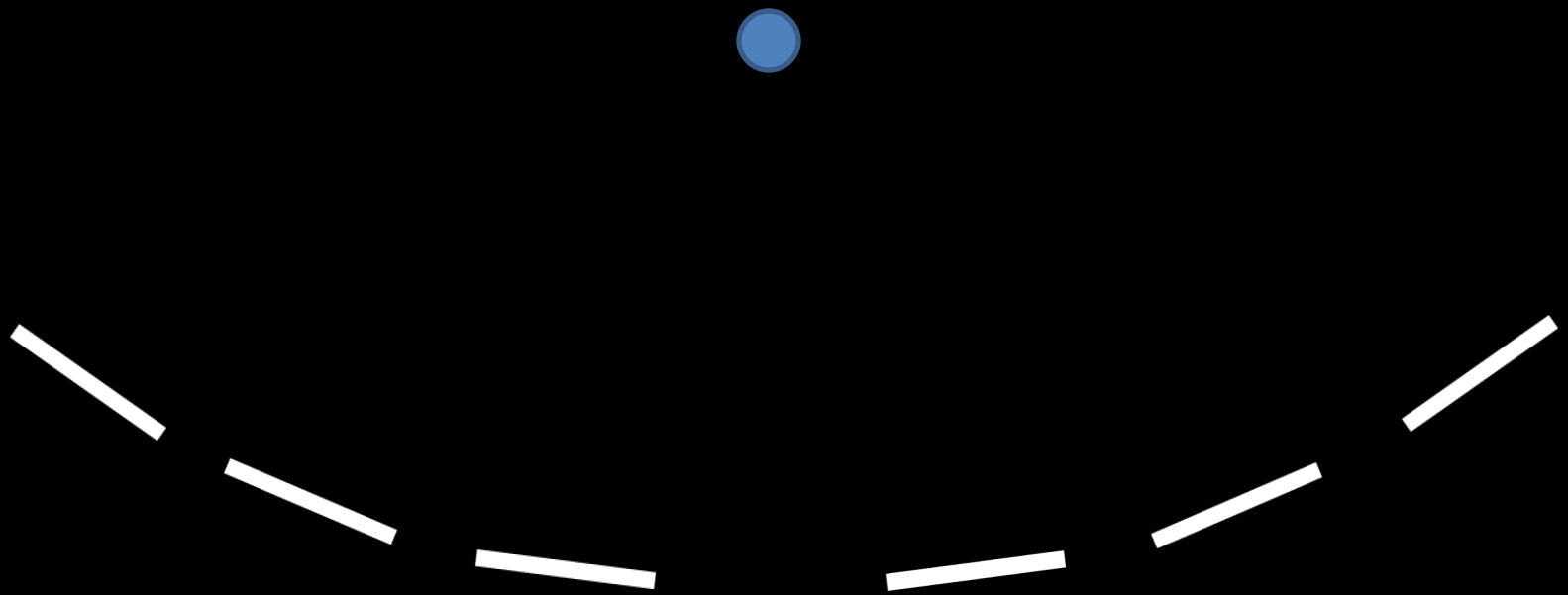
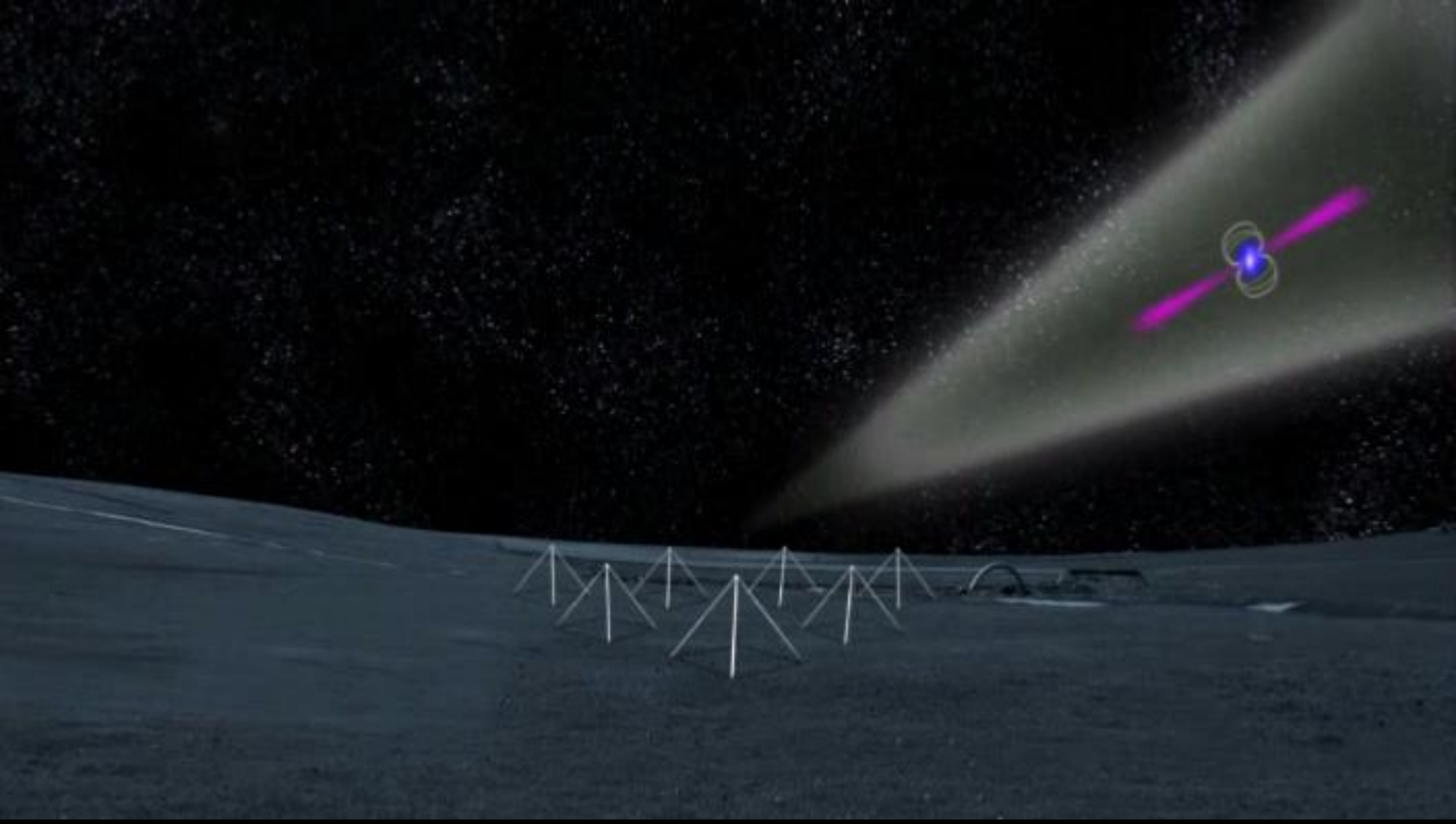


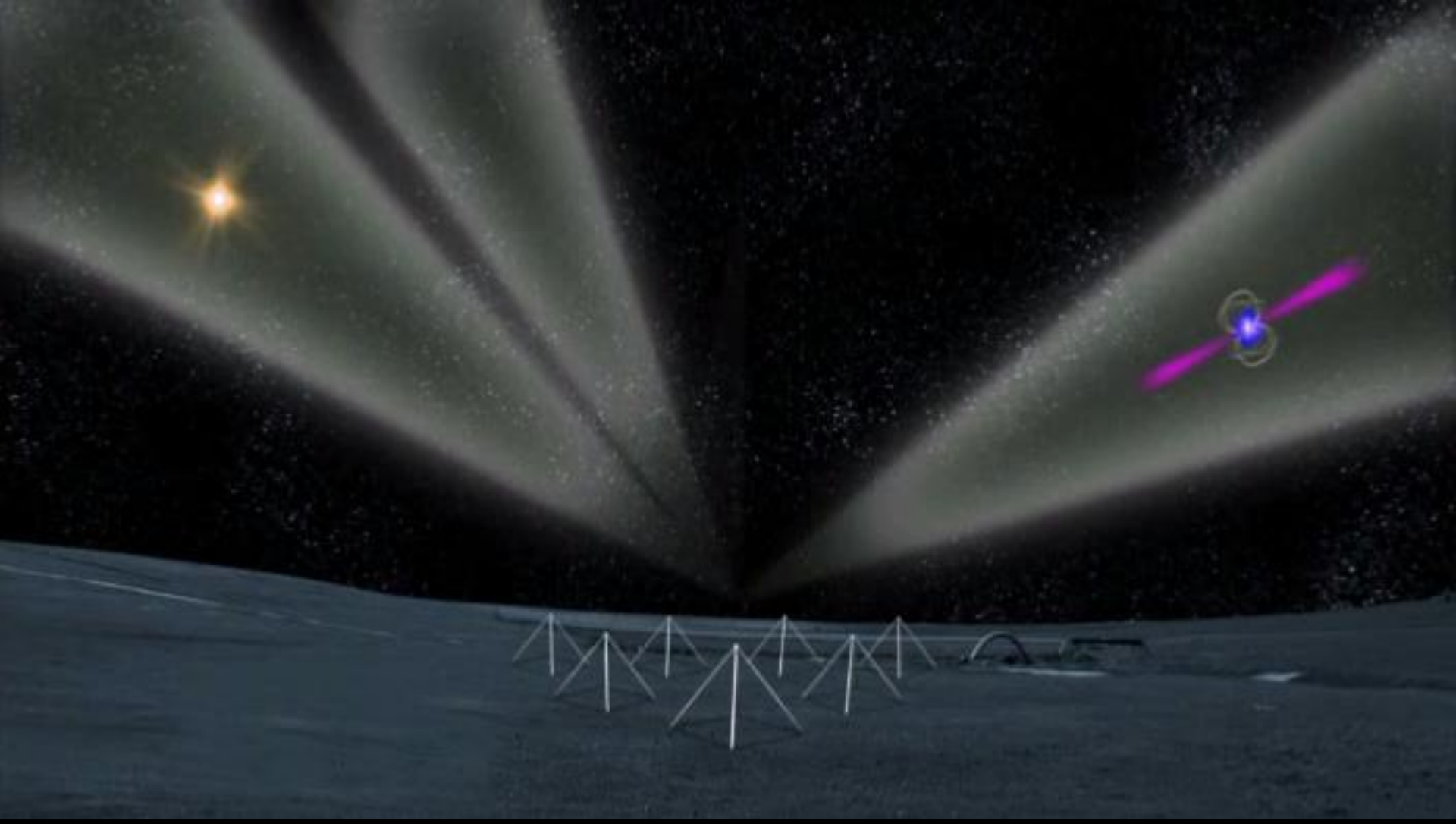




- Phased array alternative
  - Control the delay = control the direction

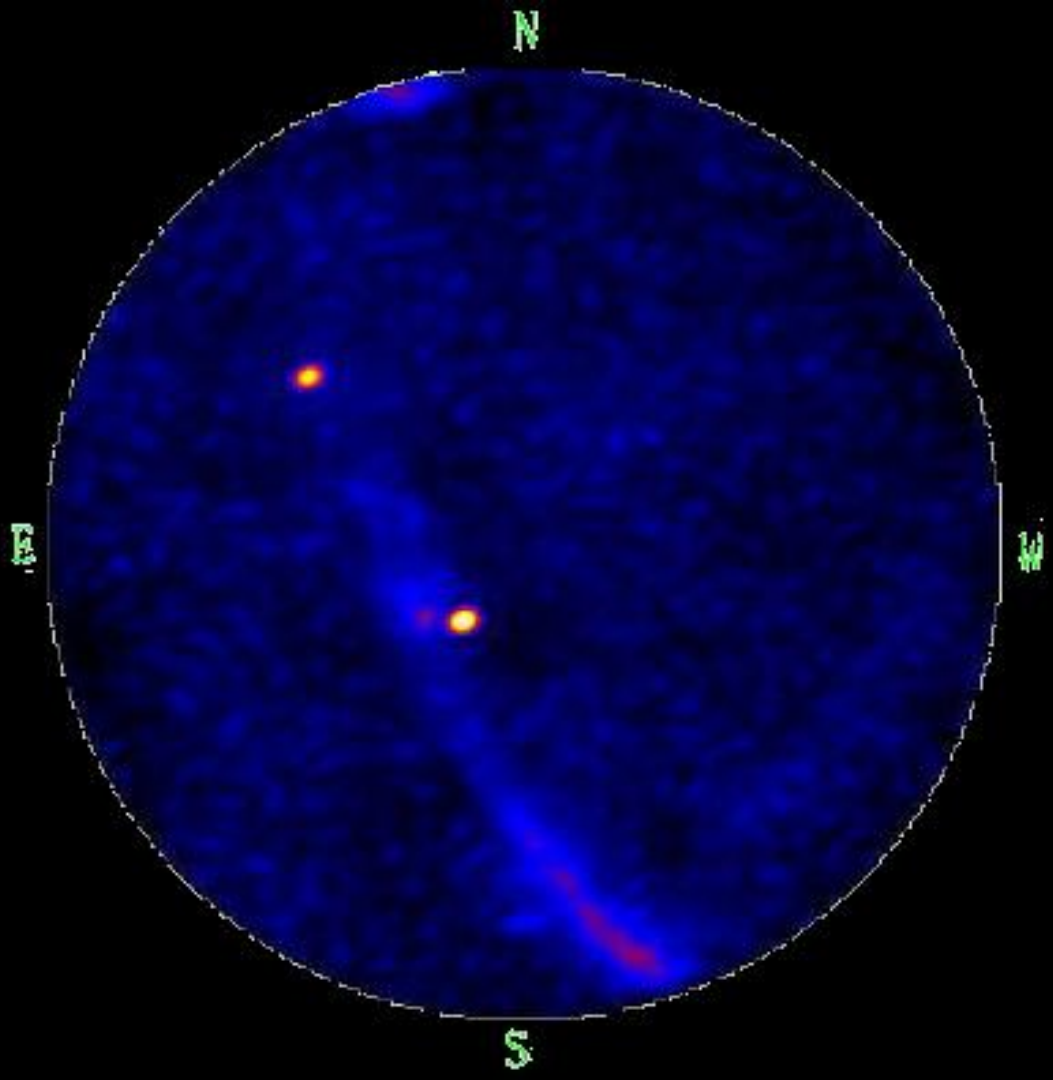


- Single-beam
  - Formed by controlling the delays

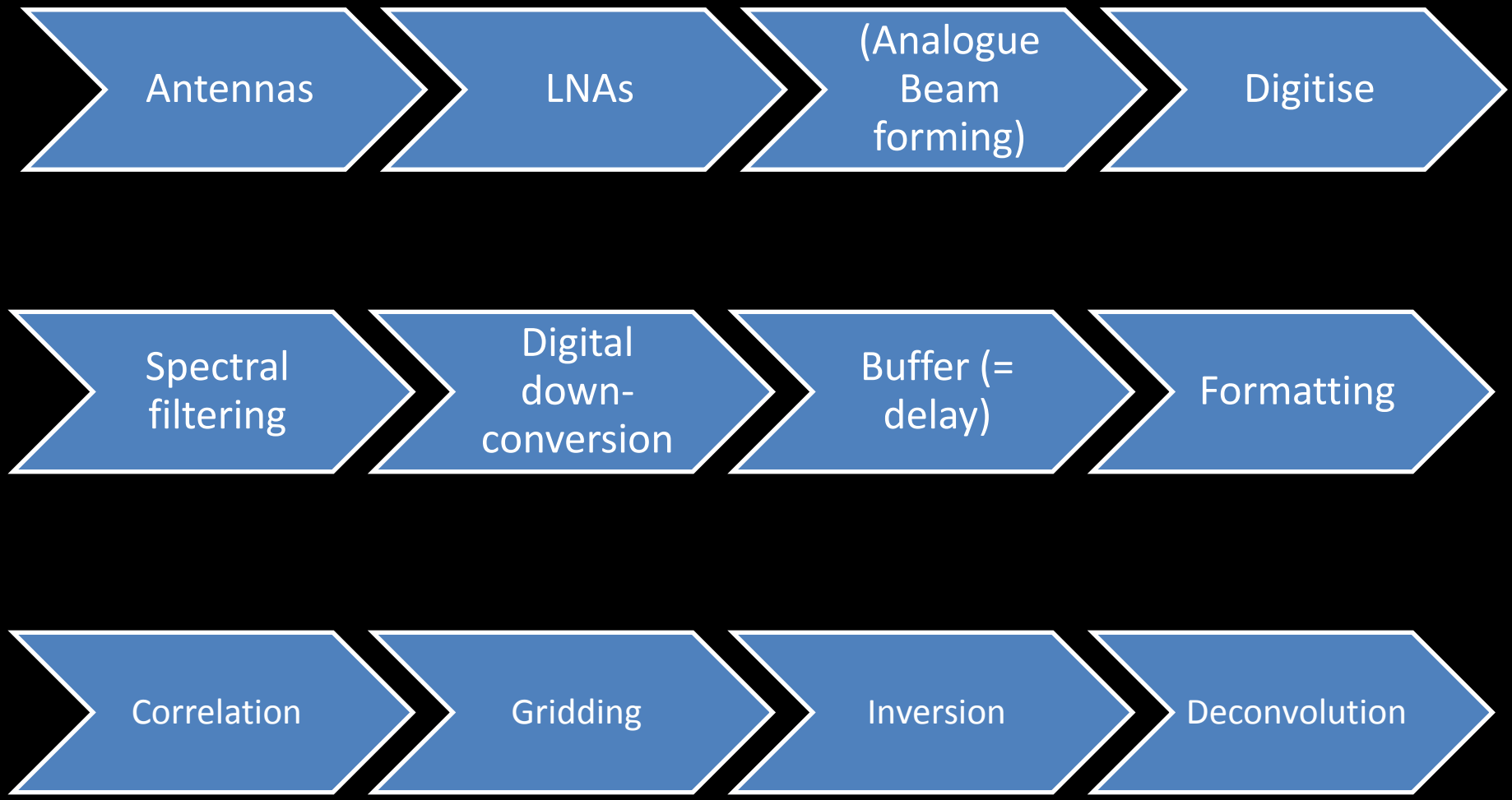


- Multi-beam
  - Up to 8 beams, of 4 MHz each

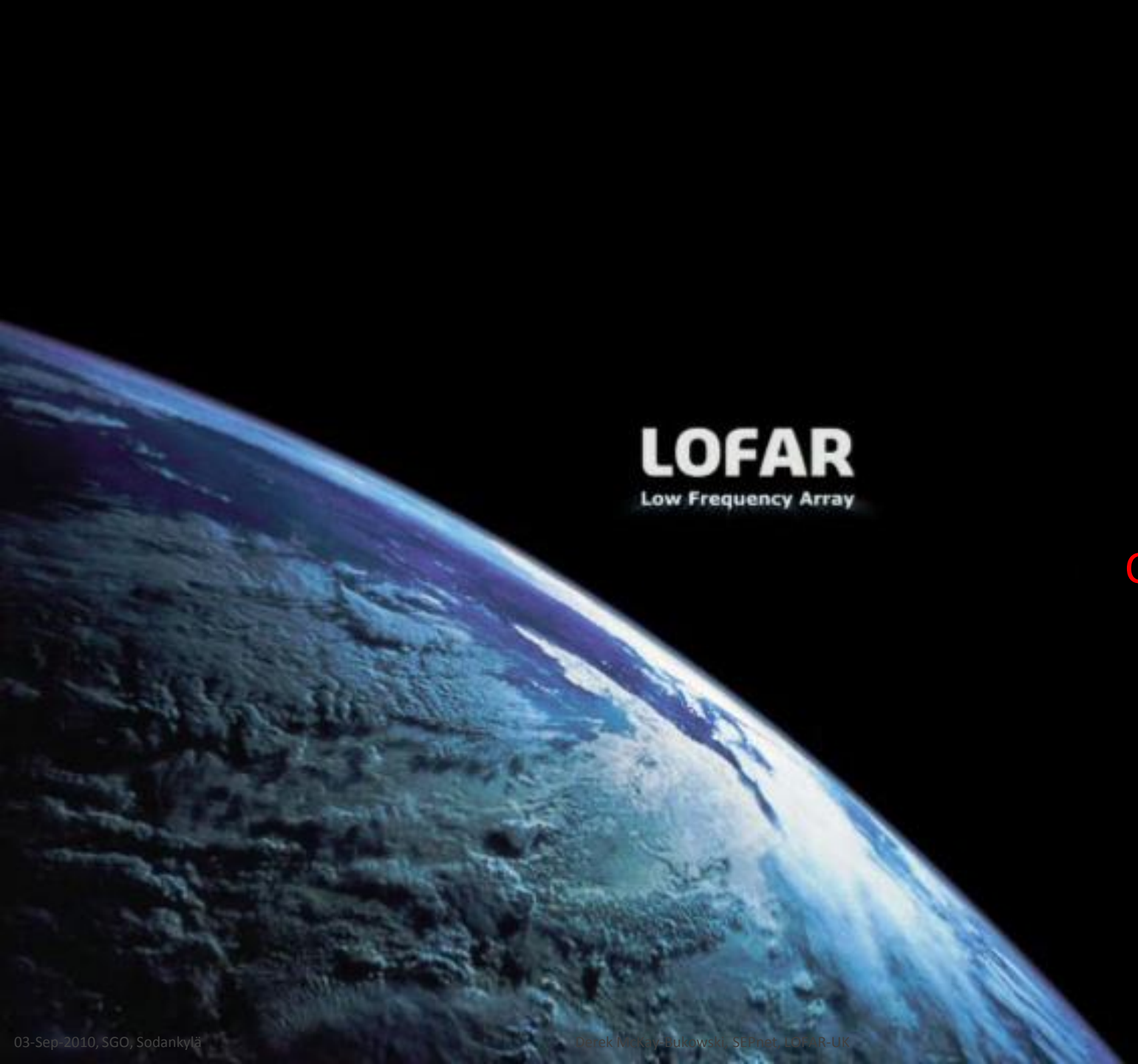
- Full sky coverage
  - SEPcam, Fly's-eye mode, etc.



- LOFAR all-sky image
  - Effelsberg station, Nov’2009, 60 second exposure



- Signal processing
  - Hierarchical phased array / interferometer



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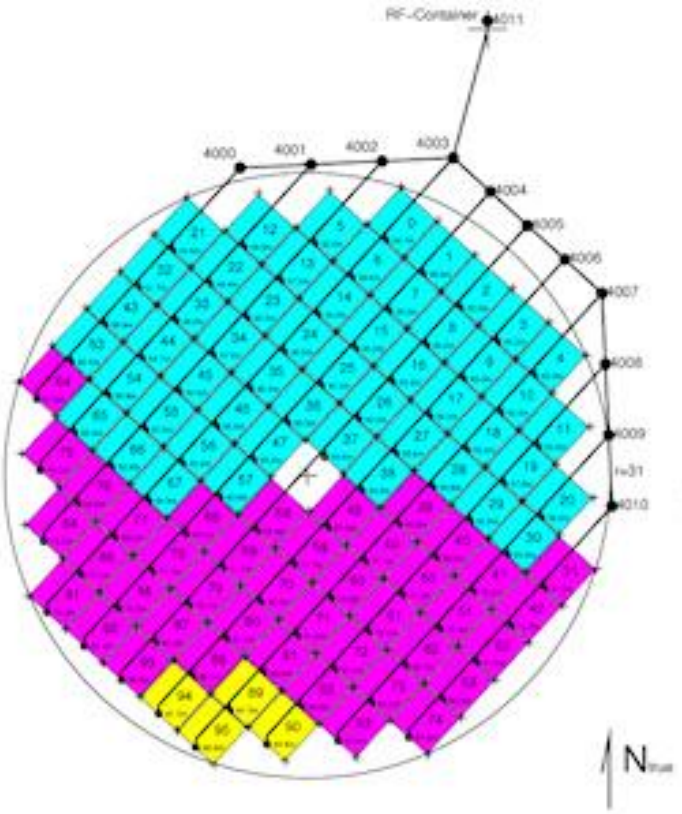
- Chilbolton Observatory
  - LOFAR-UK funded station in Hampshire, UK

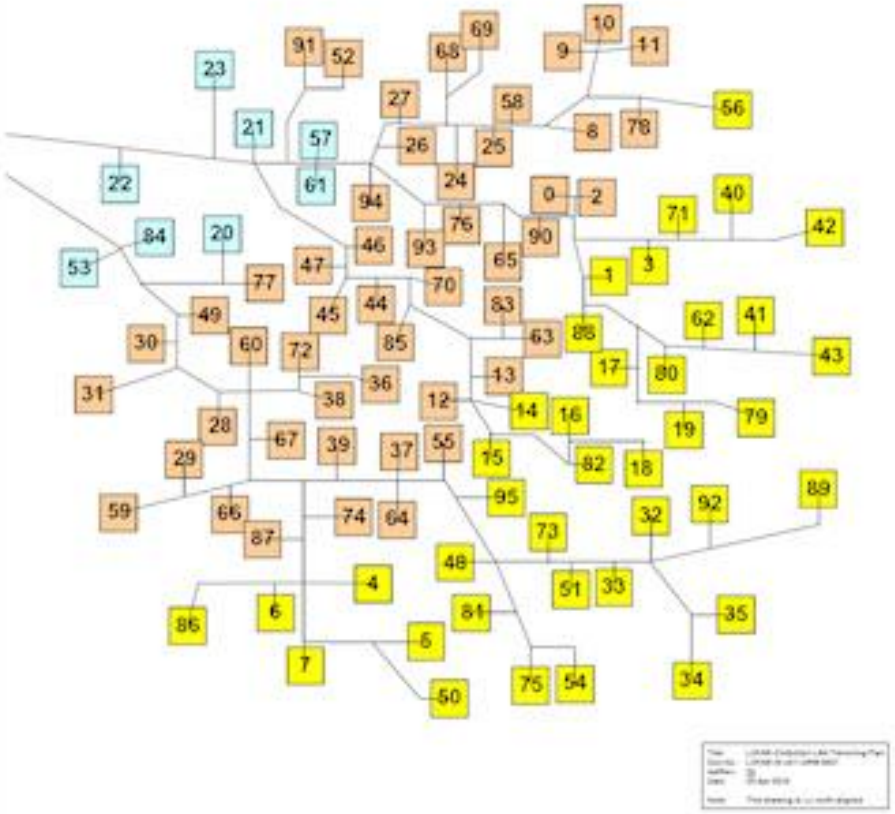
- Chilbolton site
  - 1:55 slope, good buffer zone, 200×100m site

- First delivery
  - RF-container, ground planes, sheets

- Ground works
  - Levelling, trenching and landscaping

- Level the fields (1-in-55 original slope)
  - Level is easier, but the requirement is planar



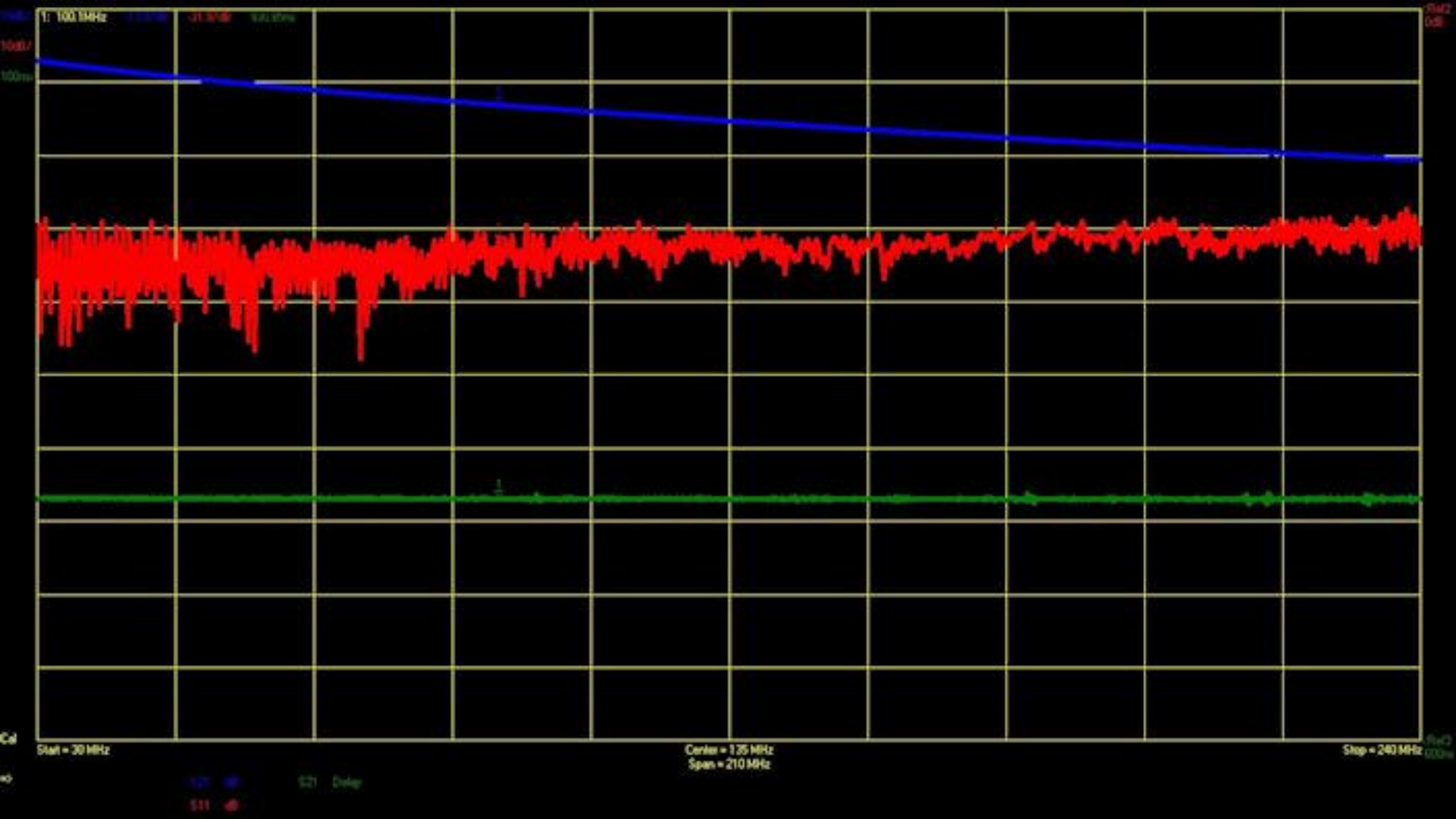


- Array layouts
  - 1536 × HBA elements

- LBA field with trenches dug

- Cable graves
  - A compromise between efficiency and cost

- Cable testing
  - Lab testing, loopback testing, troubleshooting



- Loopback tests
  - Check for cable damage (flint, connectors, etc.)

- LBA (Low Band Array) 30-80 MHz
  - Angled dipole, ground plane, LNAs

- Student build crews
  - LBAs ideally suited to a 3 day field trip for 20 students

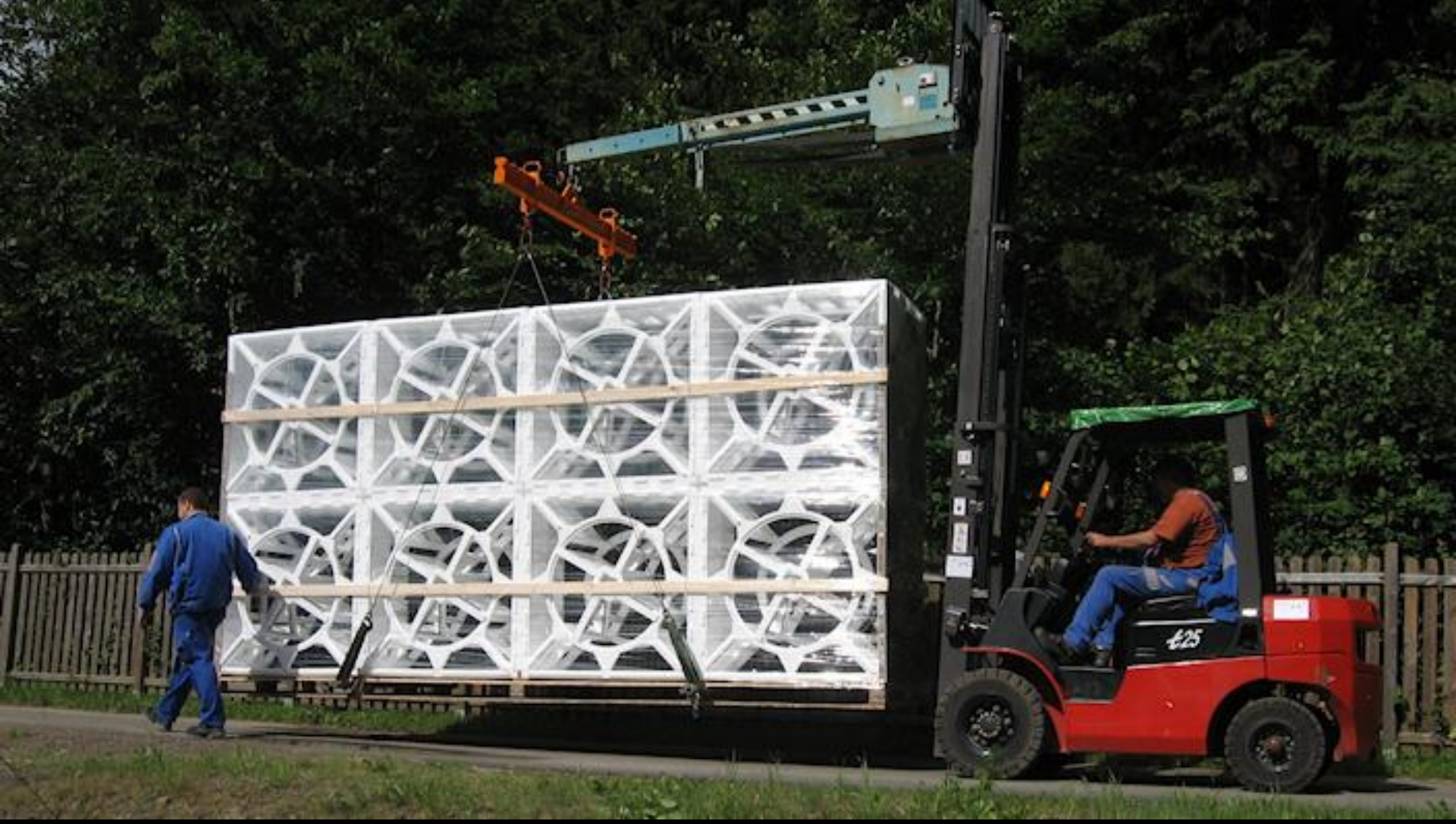
- LBA anchors
  - Different sites, different geology, different pegs

- Project management
  - H&S, training, PPE, First-Aid, budgets and schedules

- HBA (High Band Array) 120-240 MHz Tiles
  - Partially pre-assembled, production engineering

- Flat-pack, mass production line
  - 5000+ tiles, so it needs to be streamlined!

- HBA tiles being delivered “flat-pack”
  - 4 tiles total, plus ancillary deliveries



- Transporting the tiles
  - Effelsberg, standard forklift

- All-terrain forklift
  - Manoeuvrability and access, but a rougher ride

- Placing the tiles
  - Effelsberg, with a long-reach trailer crane

- The unfolding process
  - Using a mobile lifter, as an alternative to a crane

- Geo-textile
  - Placed between tiles to prevent weeds and erosion

- Moving the tiles onto the field
  - Note the strength of the tiles

- Placing the tiles in the final location
  - Note the use of the 18t digger, instead of a crane

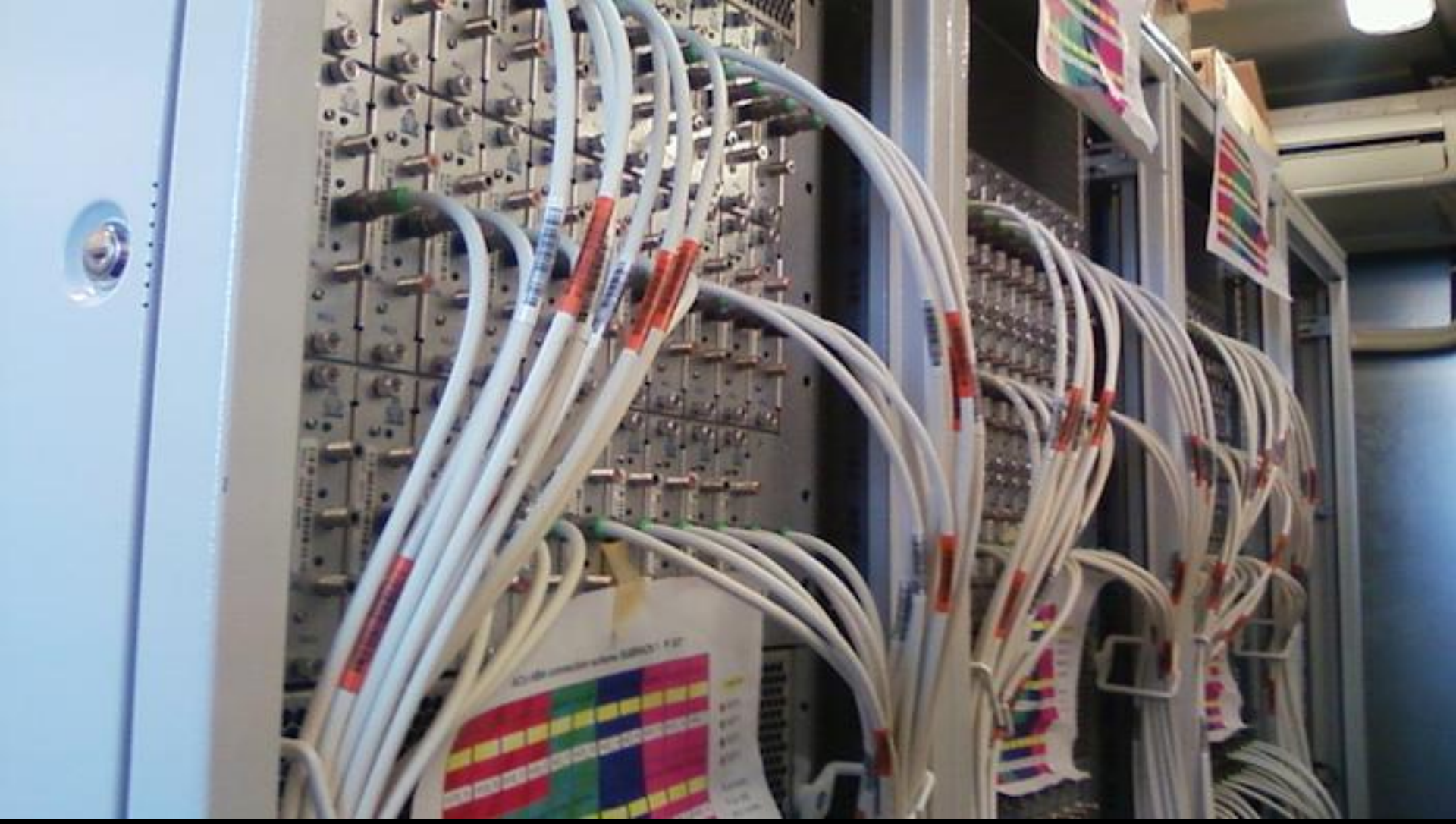
- Preparing an HBA anchor point
  - Fix the cover to the anchor points

- HBA anchor point
  - Ready to be attached

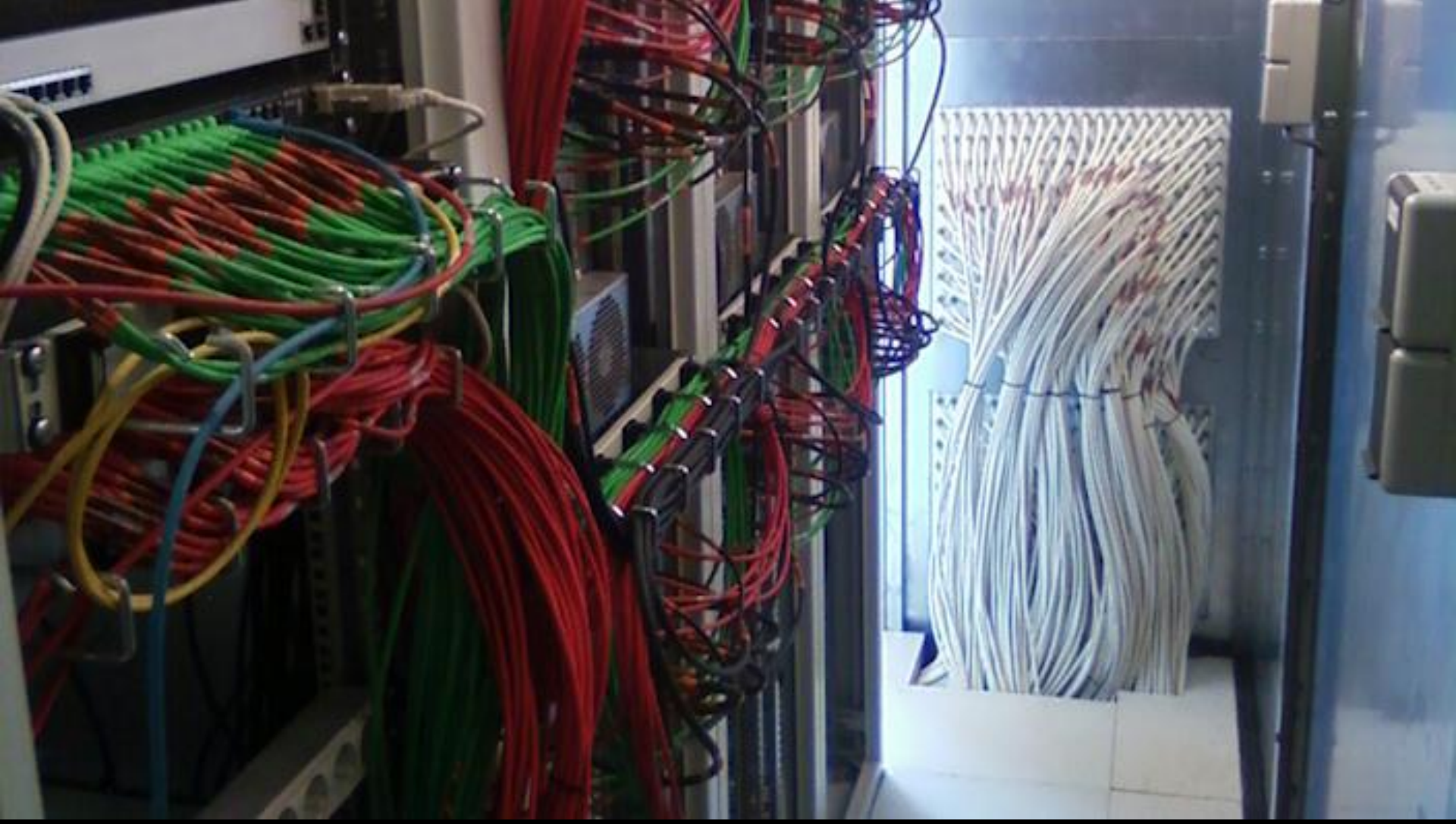
- HBA anchor
  - 2kN breaking load

- Non-metal perimeter fence
  - Wildlife issues

- LOFAR-Chilbolton



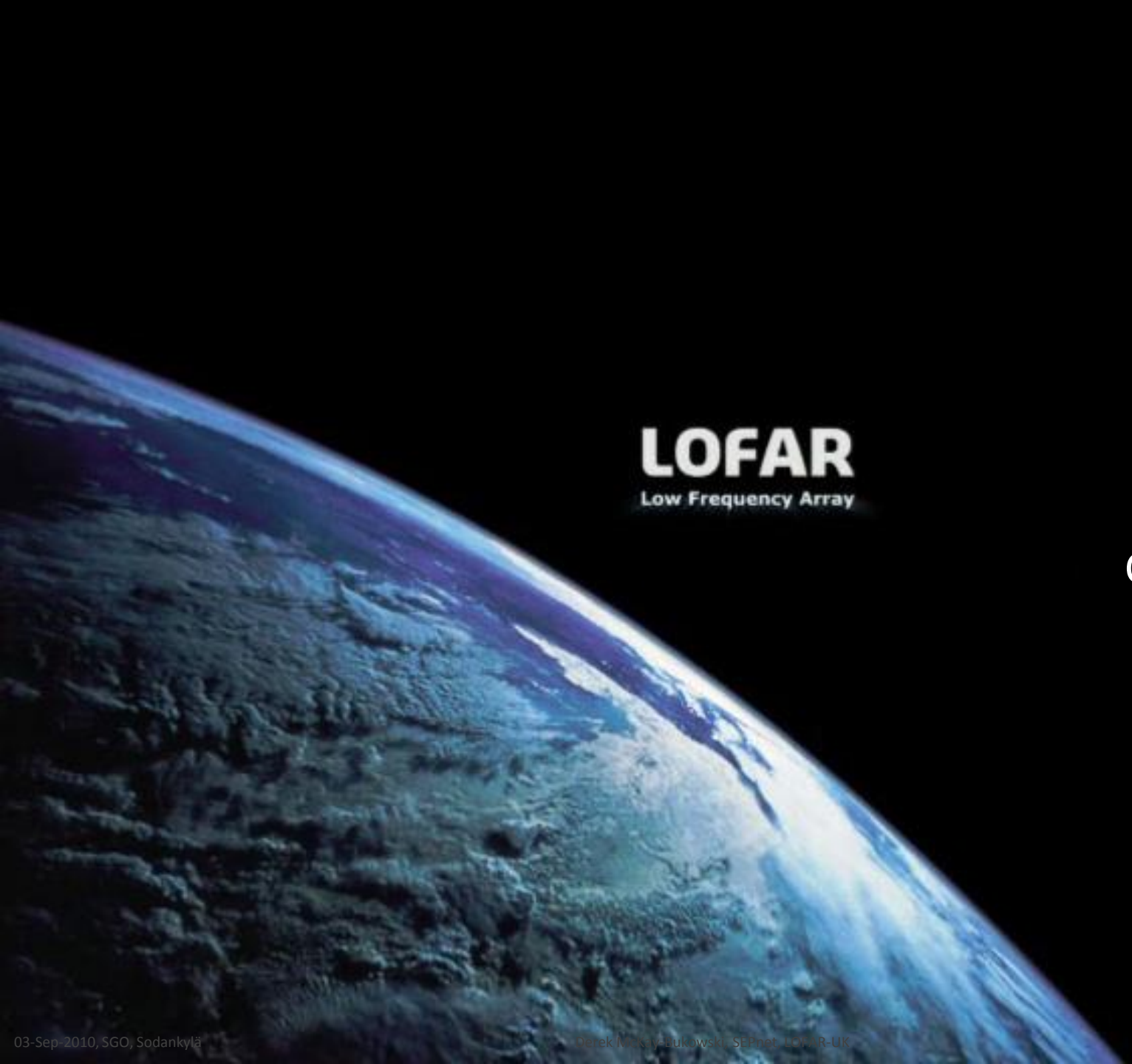
- RF input into the signal processing
  - 384 cables



- Infrastructure
  - Faraday cage, patch panel, infiniband, ethernet

- LBA (Low Band Array) and RF container
  - Array complete, RF installation work in progress

- HBA (High Band Array)
  - Last tile about to be placed



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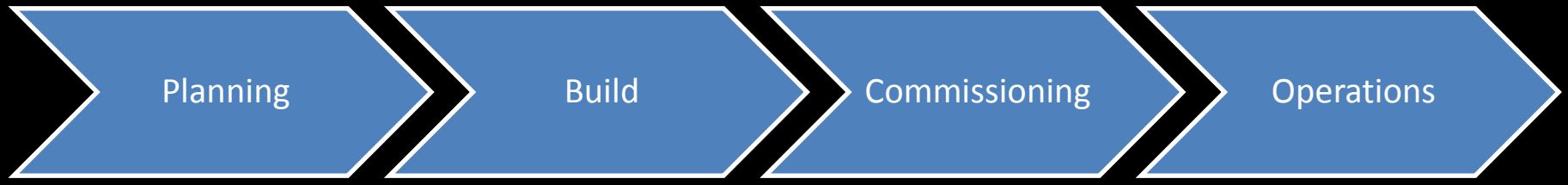
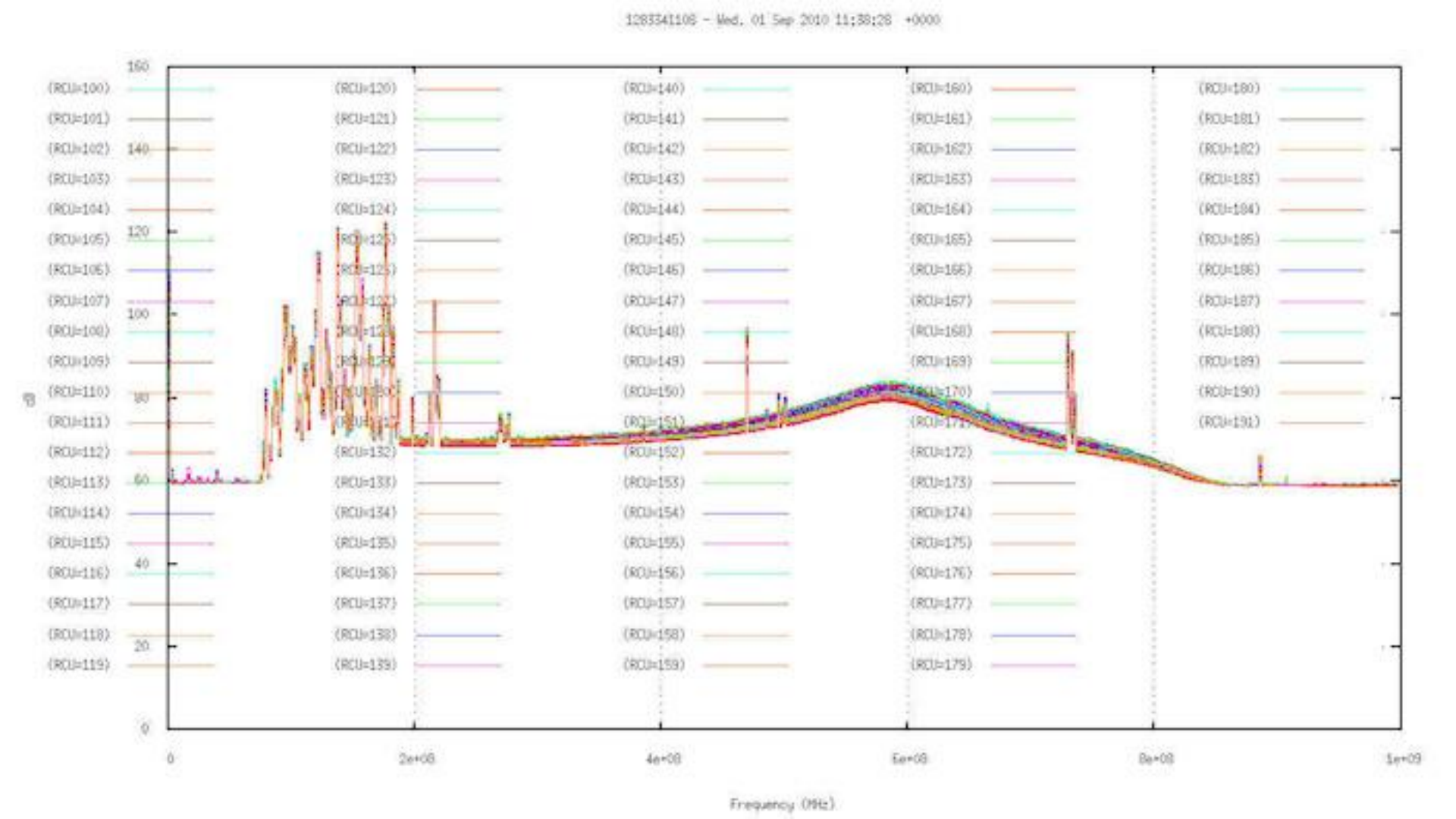


- Schedule
  - 4-month physical build... when vulnerable to weather

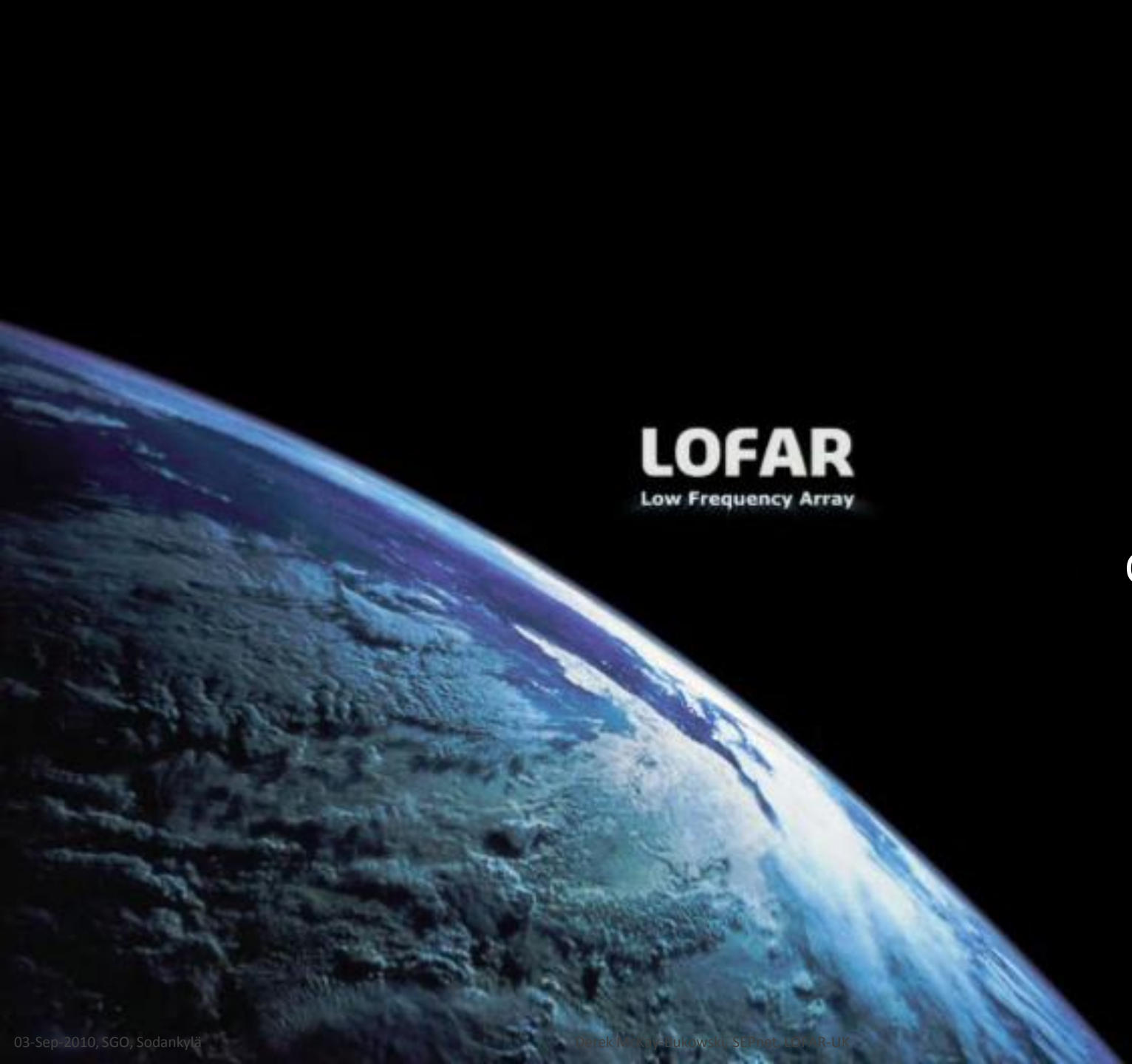
- 17 March 2010
  - Work commences

- 14 July 2010
  - All physical works complete. Site is weather safe.



- “First light”... 01-Sep-2010
  - Full LBA, bandpass and DSP chain to UDP Tx

- Schedule
  - Planning permission Aug’09
  - ASTRON order placed Sep’09
  - Contract placed Jan’10
  - Start of works Mar’10
  - Works complete Jul’10
  - RF commissioning Aug’10
  - First-light and opening Sep’10
  - Data link Oct’10
  - Regular LOFAR operations Nov’11
- Cost



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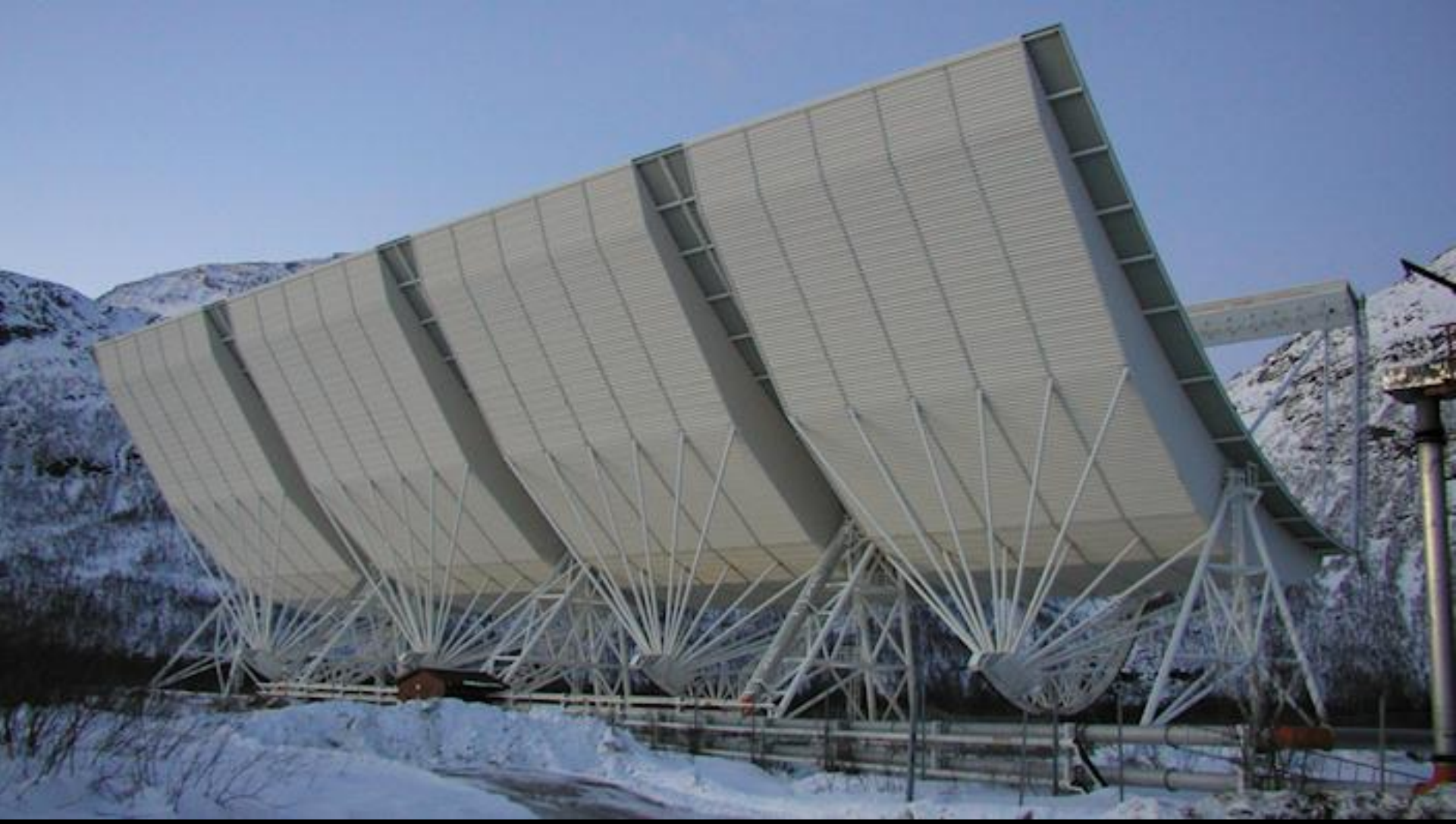
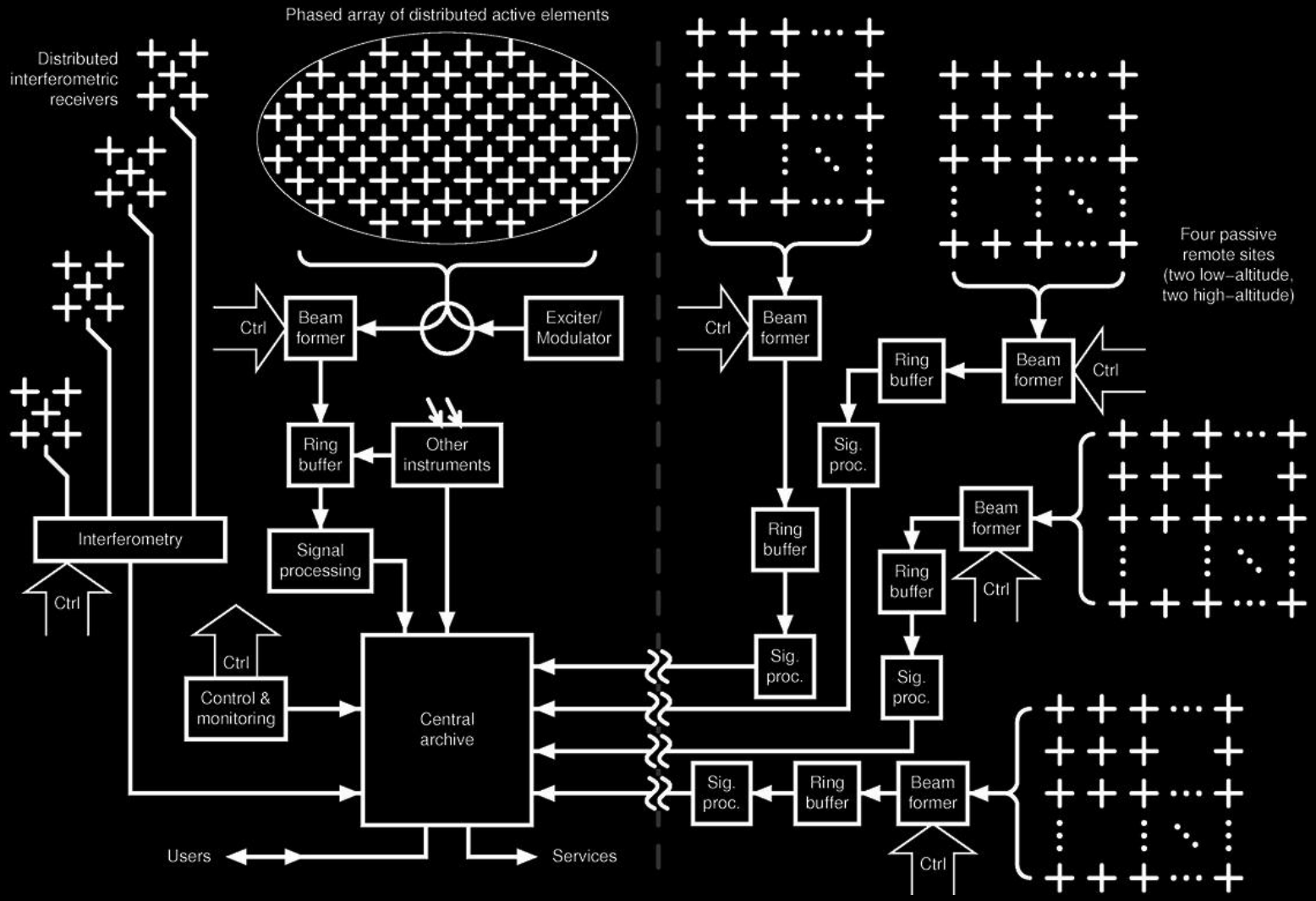
- EISCAT UHF



- EISCAT VHF
  - LOFAR HBA tiles are sensitive to this frequency

- EASI
  - EISCAT Aperture Synthesis Imaging



- EISCAT-3D
  - A large phased array system

- Site of a LOFAR/EISCAT-3D station?
  - Kilpisjärvi

- LOFAR Finland
  - Successful bid for a remote station! More to come?

with thanks to...

Rutherford Appleton Laboratory, STFC, UK,
Thüringer Landessternwarte Tautenburg,
Sodankylä Geophysical Observatory,
Max-Planck Institut für Astrophysik,
South-East Physics Network, UK,
EISCAT Scientific Association,
Chilbolton Observatory,
LOFAR-UK Consortium,
University of Oulu,
Stiching ASTRON,
and Izabela!