



Radio Astronomy Transformed

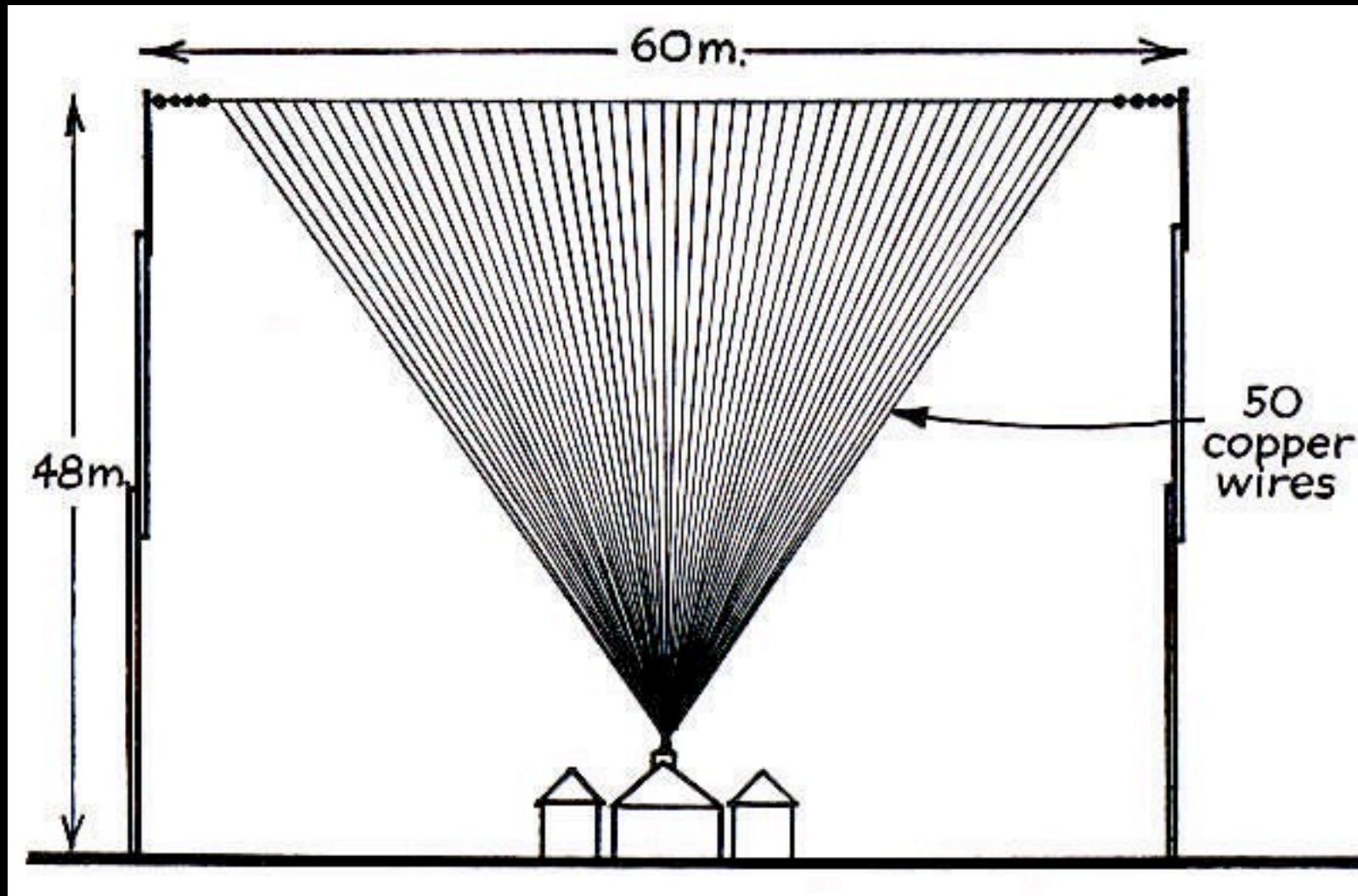
- Aperture Arrays: Past, Present & Future



Prof. Michael Garrett

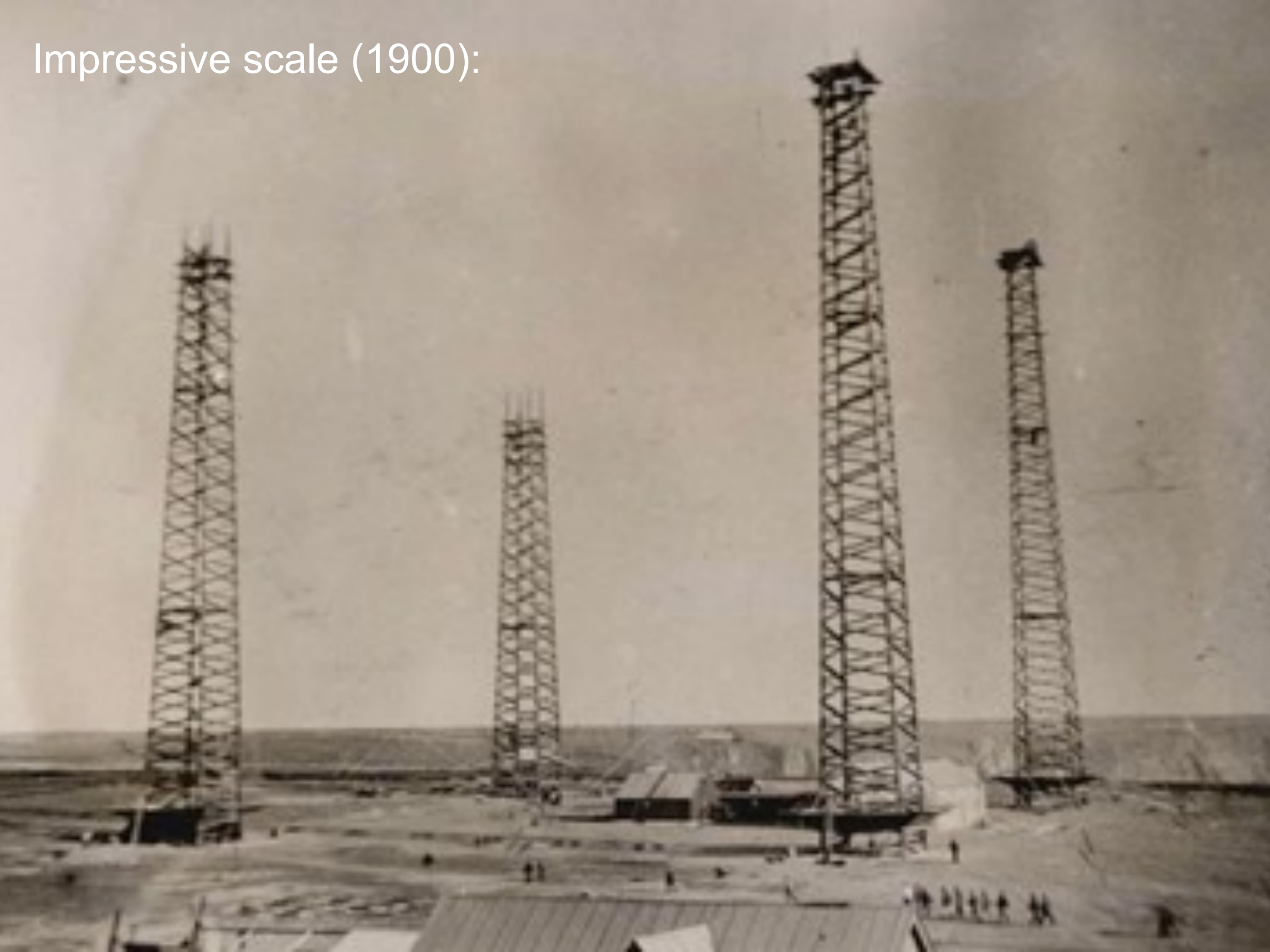
ASTRON, the Netherlands Institute for Radio Astronomy
Leiden University.

Early Antenna Arrays



Centrally fed ground antennas - G. Marconi (1901)

Impressive scale (1900):



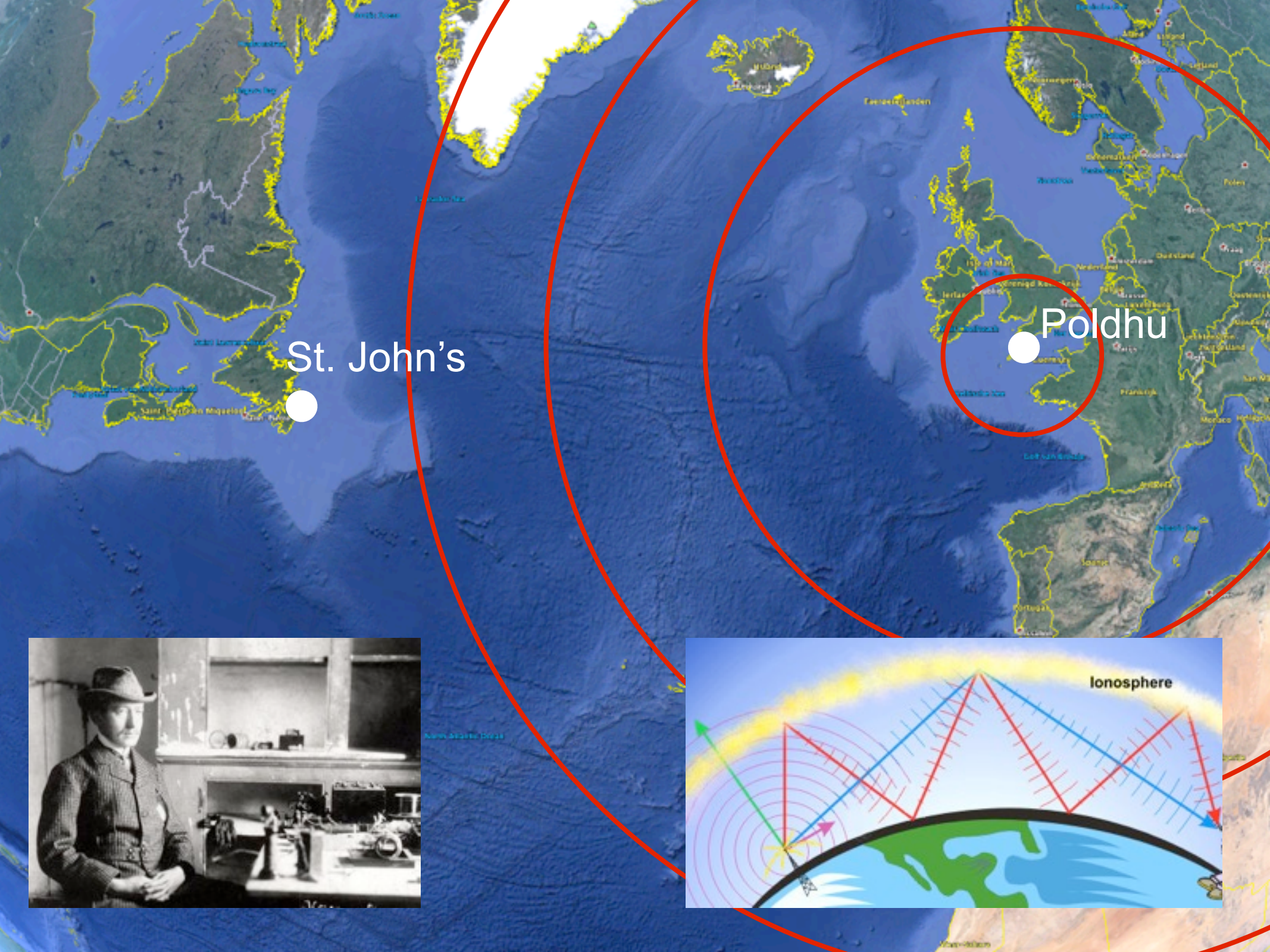
Poldhu, Cornwall, UK 1901:



“My previous tests had convinced me that when endeavouring to extend the distance of communication, it was not merely sufficient to augment the power of the electrical energy of the sender, but that it was also necessary to increase the area or height of the transmitting and receiving elevated conductors” - Marconi.

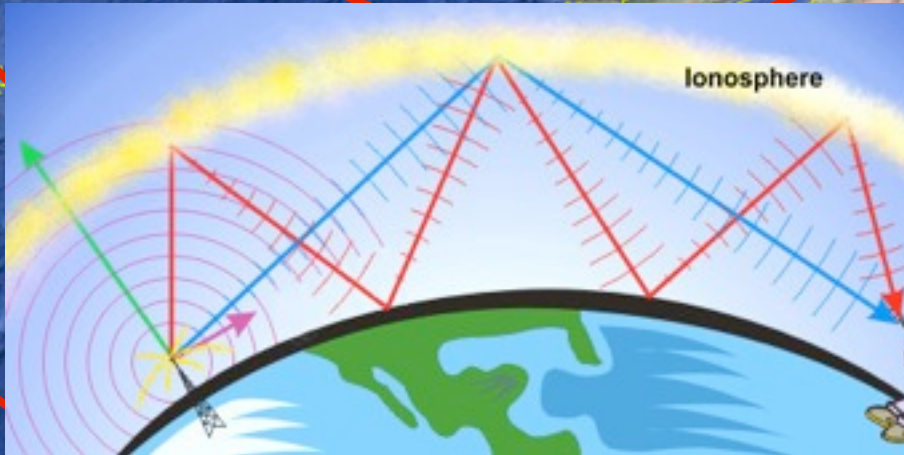
Some problems too...:





St. John's

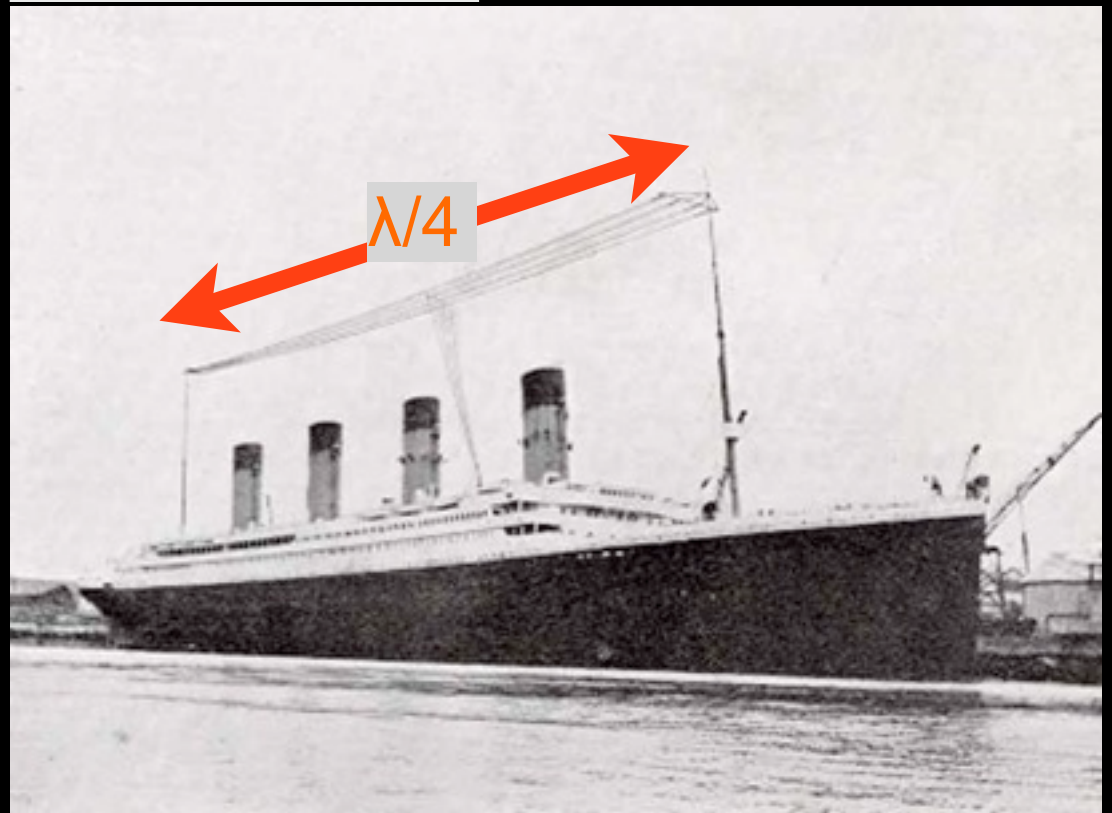
Poldhu



Eventual success despite a sceptical science community:



1912: HMS Titanic



Radio Broadcasting (post WWI)



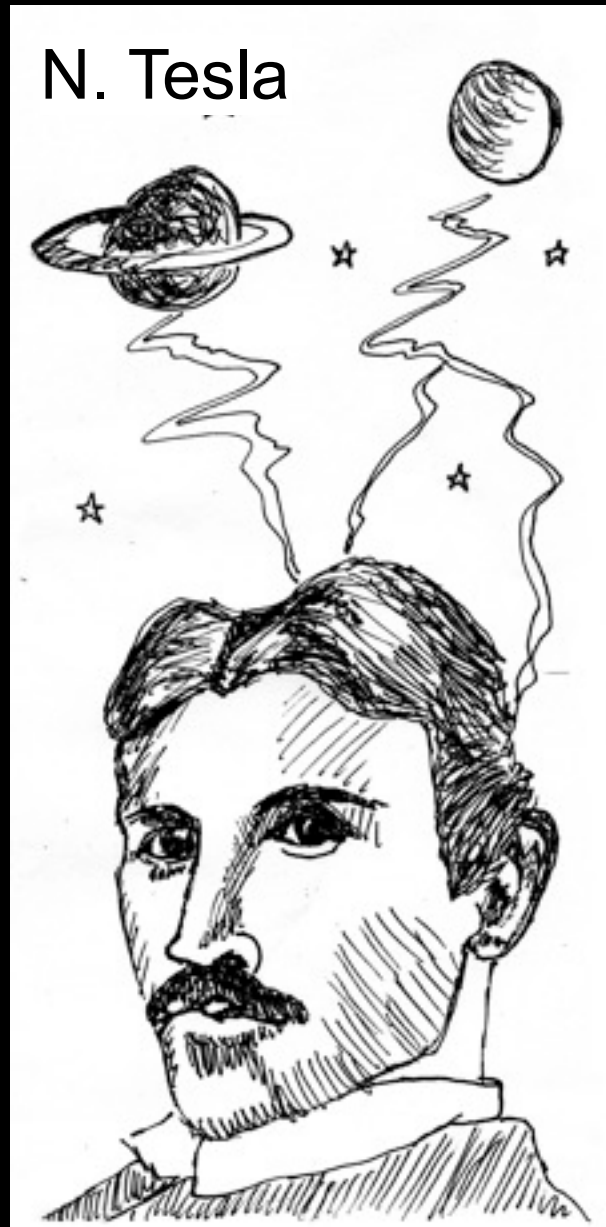
Y-Stations WWI



Radio WWI trenches



Cosmic Radio Emission - first claims...



MARCONI SURE MARS FLASHES MESSAGES

Regularity of Signals, London Expert Says, Eliminates Atmospheric Disturbance Theory.

WAVES TEN TIMES OURS

J. H. C. Macbeth Declares It Would Be Simple Matter to Arrange a Code.

William Marconi is now convinced that he has intercepted wireless messages from Mars, J. H. C. Macbeth, London manager of the Marconi Wireless Telegraph Company, Ltd., said at a Rotary Club luncheon at the McAlpin yesterday. Mr. Macbeth added by way of prediction, that should this prove to be so, it will be only a question of time before inventive genius and ingenuity in deciphering unknown codes will evolve a method of communication between the two planets.

The first “phased arrays”:

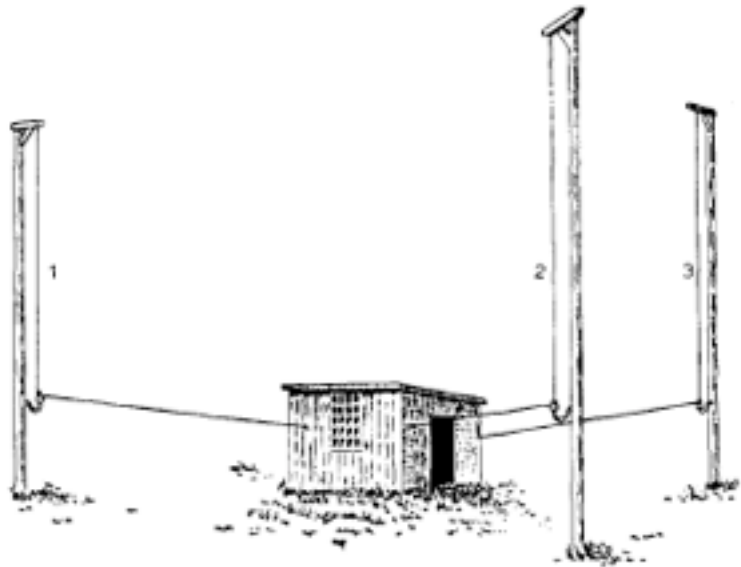
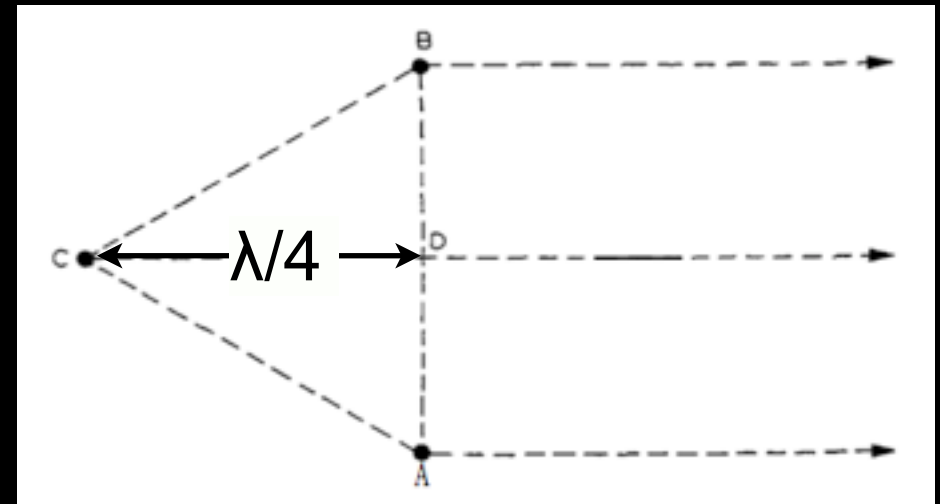
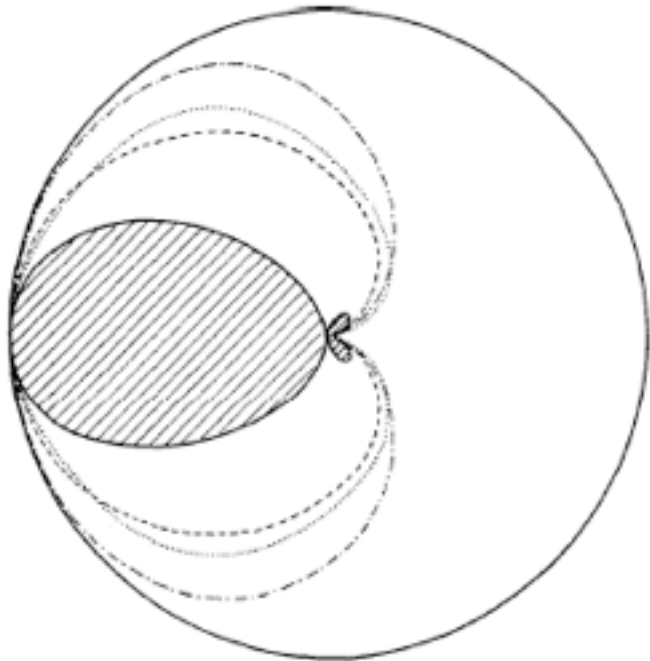


Fig. 13.



Braun et al. 1907

The first "phased arrays":

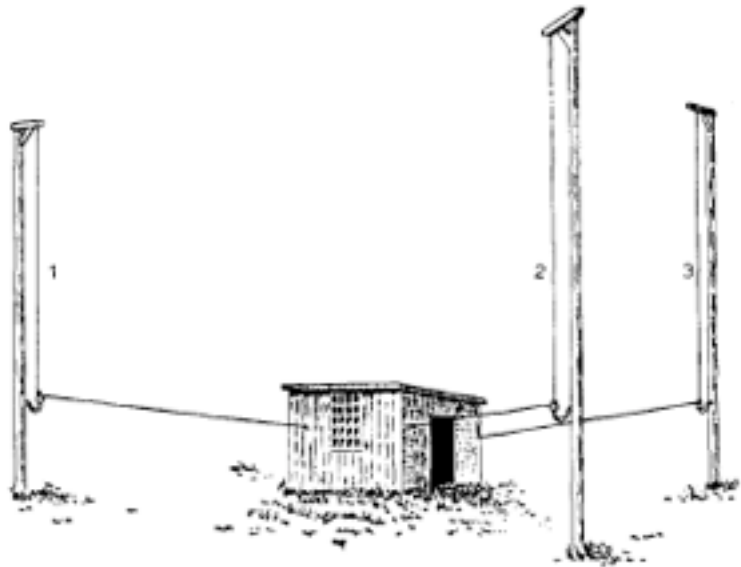
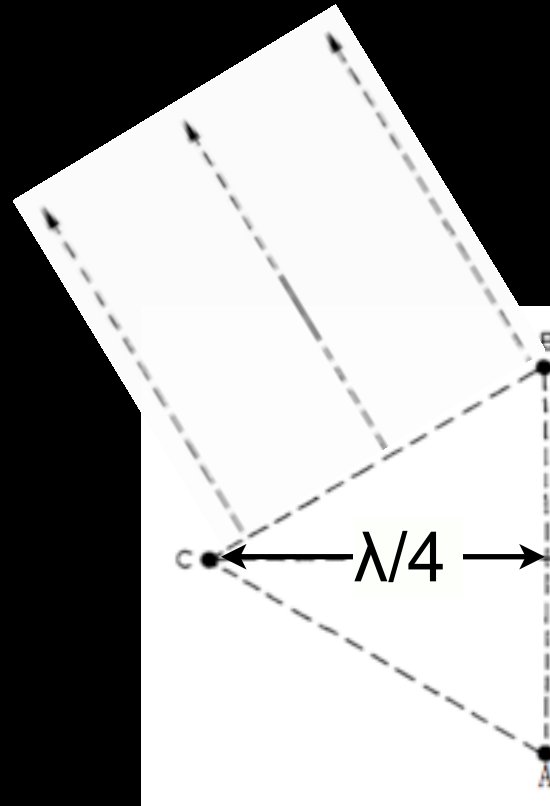
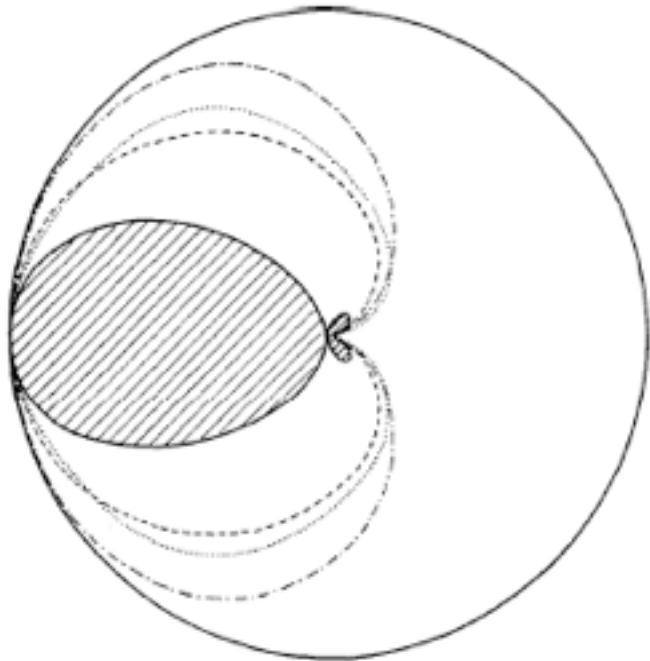


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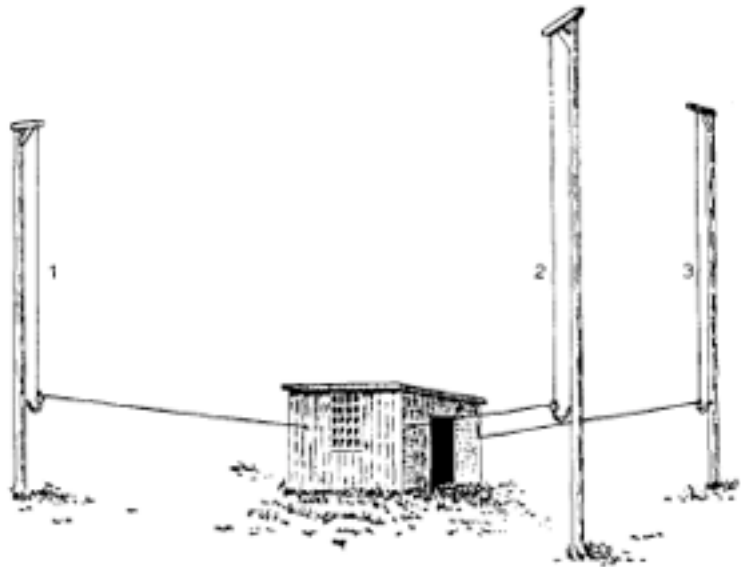
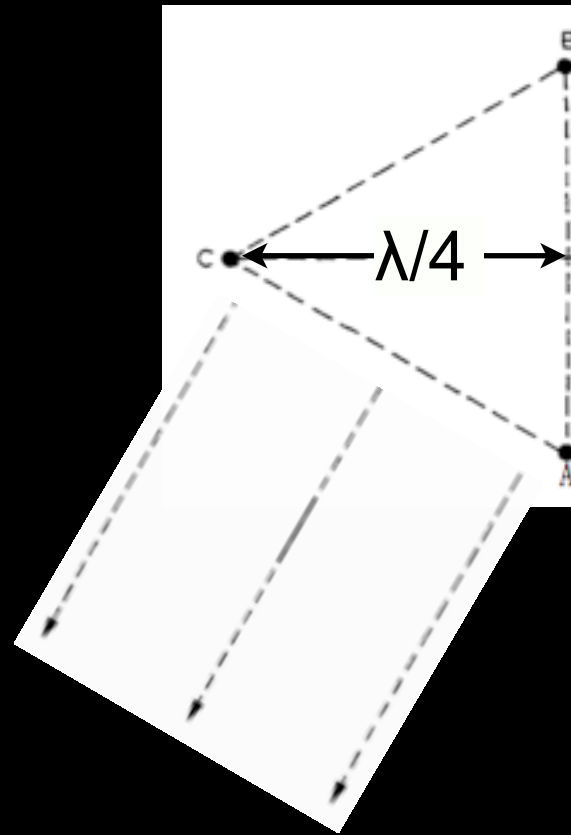
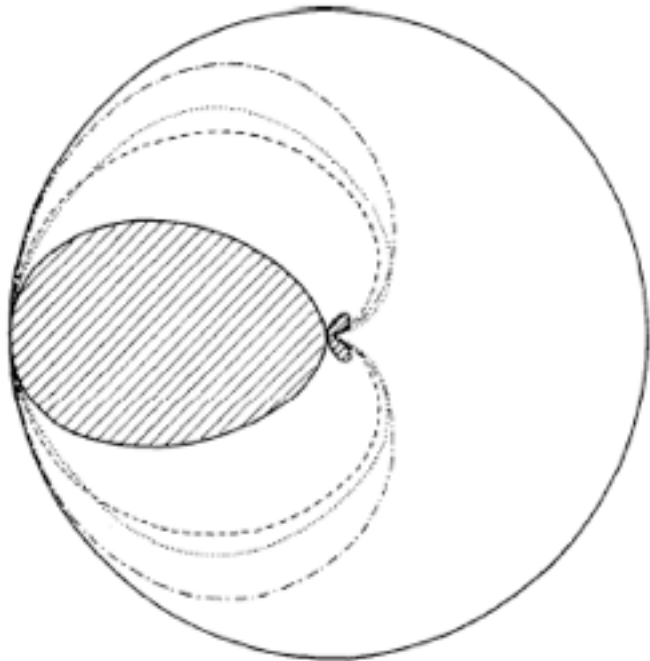


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Braun et al. 1907

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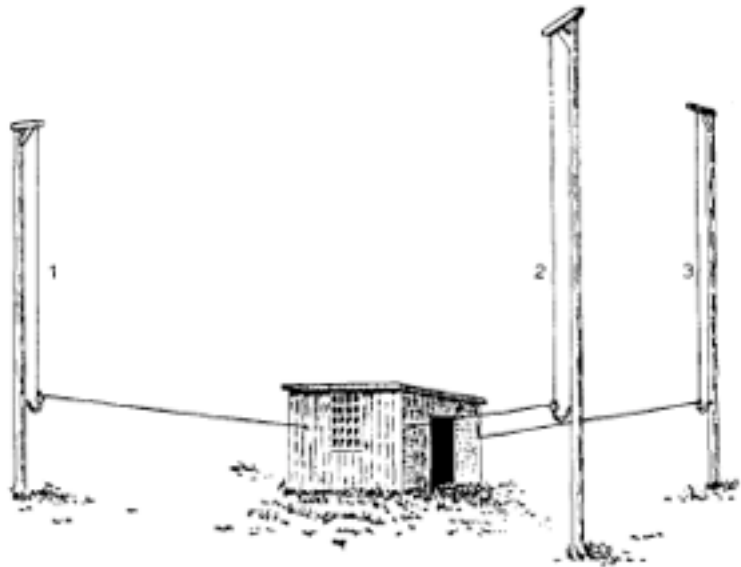
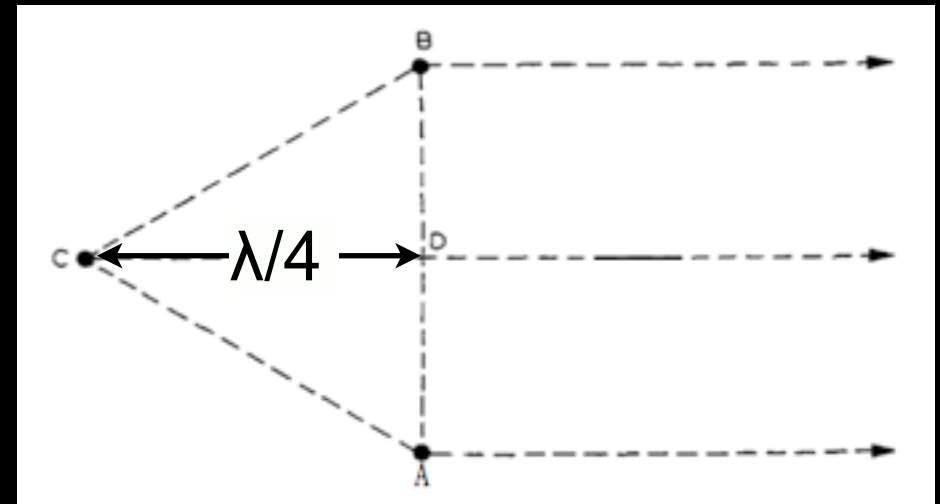
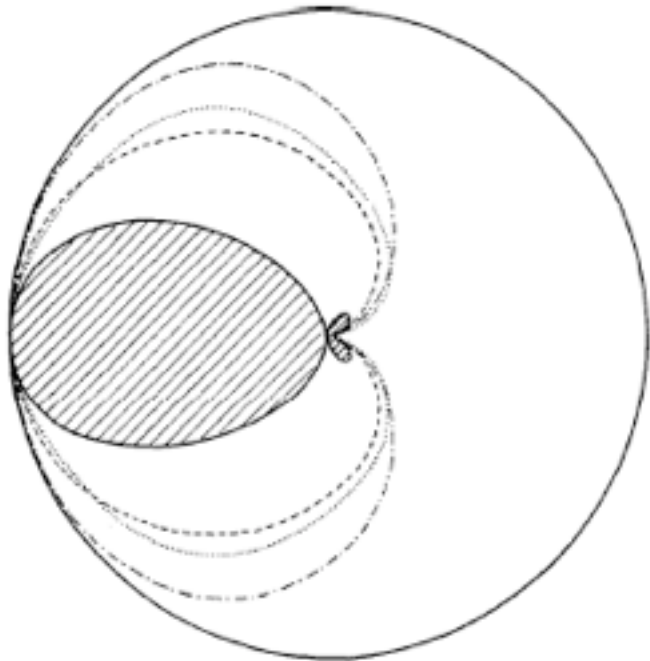


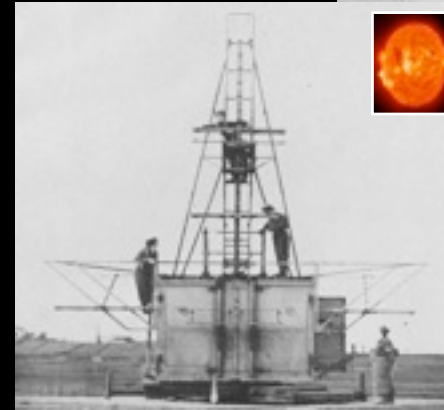
Fig. 13.



Braun et al. 1907

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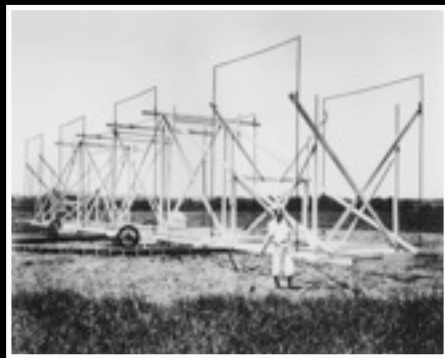
Phased arrays and radio astronomy (1950/60s)



J.S. Hey et al. 1942

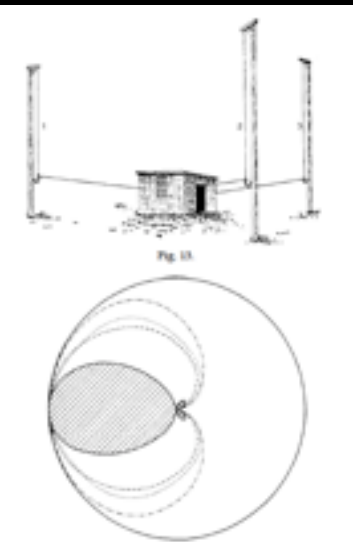


Friis & Feldman
1937 (Bell labs)
- first phase
shifted system.



Jansky 1932, detects
cosmic radio
emission

Braun et al. 1907



Aperture Array “a lost technology”: 1970-2010...?

Google

radio telescope

Advanced search

Search

About 2,170,000 results (0.10 seconds)

Everything

Related searches: [arscibe radio telescope](#) [radio telescope array](#) [self radio telescope](#) [radio telescope diagram](#) [biggest radio telescope](#)

Images

Maps

Videos

News

Shopping

More

Sort by relevance

Sort by subject

Any size

Large

Medium

Icon

Larger than...

Exactly...

Any color

Full color

Black and white

Any type

Face

Photo

Clip art


Line drawing

Standard view

Show sizes

Any time

Past week

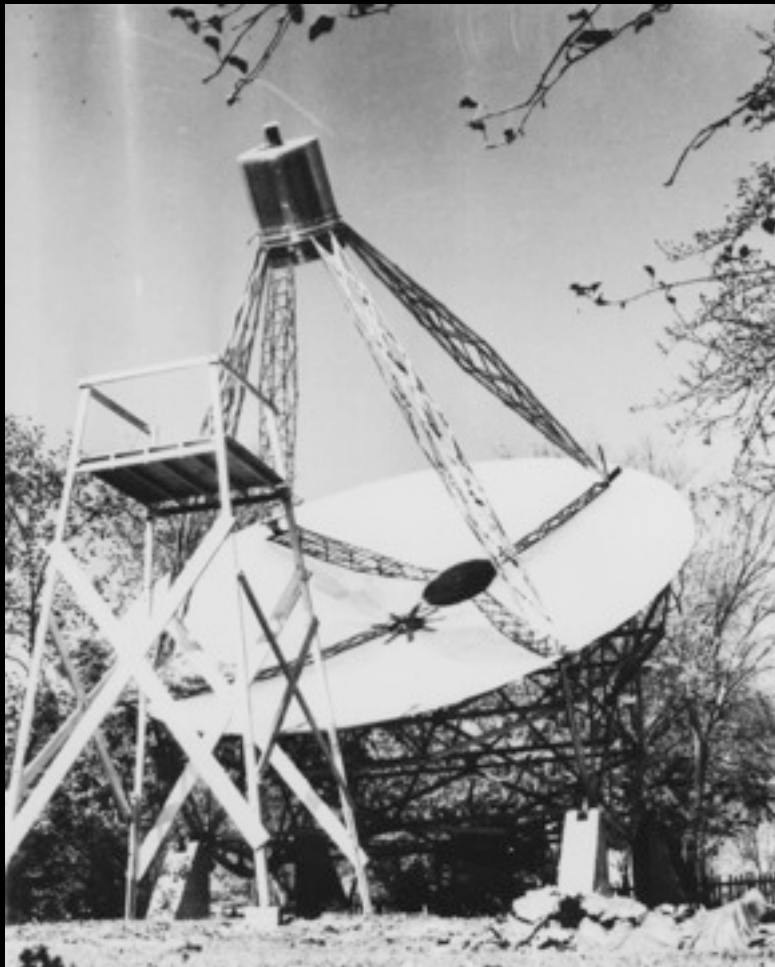


The image displays a Google search results page for the query "radio telescope". The search bar at the top shows the Google logo, the search term "radio telescope", and a search button. Below the search bar, it indicates "About 2,170,000 results (0.10 seconds)". The main content area is a grid of image search results. The first row contains several images, including a large parabolic dish, a diagram of an aperture array, and several other dishes. The second row continues with more dishes and a diagram. The third row shows a variety of dishes, some in arrays, and a diagram. The fourth row features a large dish, a smaller dish, a diagram, and several other dishes. The fifth row shows a large dish, a smaller dish, a diagram, and several other dishes. The sixth row contains a large dish, a smaller dish, a diagram, and several other dishes. The seventh row shows a large dish, a smaller dish, a diagram, and several other dishes. The eighth row features a large dish, a smaller dish, a diagram, and several other dishes. The ninth row shows a large dish, a smaller dish, a diagram, and several other dishes. The tenth row contains a large dish, a smaller dish, a diagram, and several other dishes. The search filters on the left side include "Everything", "Images", "Maps", "Videos", "News", "Shopping", "More", "Sort by relevance", "Sort by subject", "Any size", "Any color", "Any type", "Standard view", and "Any time".

One exception - Reber.. visionary



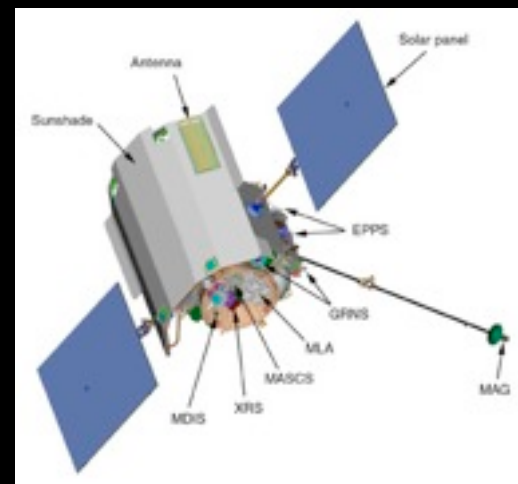
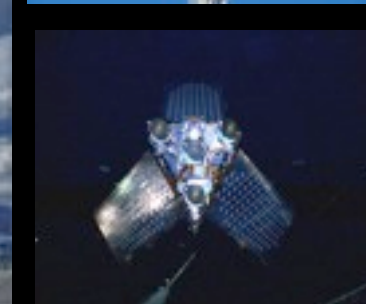
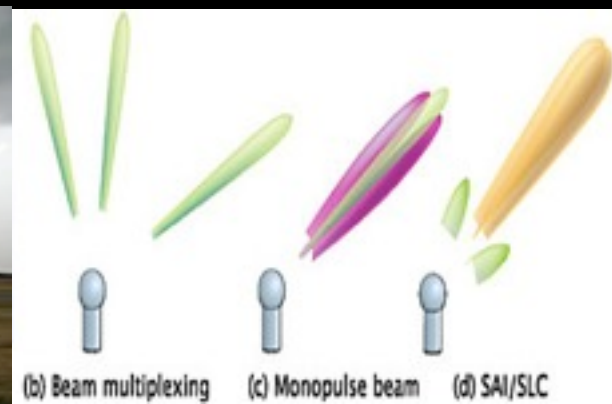
1937:



1970s:



Explosion of civilian and military applications using Aperture Arrays



TracVision A7 - How Does It Work?

Easy to Install
The TracVision A7 mounts to virtually any installation in factory installed vehicles or directly to the roof rack. A single cable connects the antenna to the CD receiver inside the vehicle.

Reliable Connection
The new antenna TracVision A7 is capable of handling up to 100 channels of video (DVR programming, HD digital video, satellite channel selection, live video feeds, etc.) and is designed to be a robust, reliable connection to the receiver (DVR) inside the vehicle.

TracVision A7 Features
The TracVision A7 features a 7" liquid crystal display, high-resolution video, and a built-in camera. It also features a built-in camera, a built-in camera, and a built-in camera.

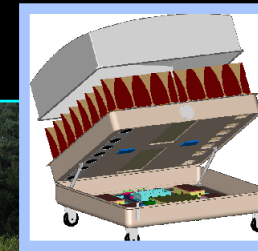
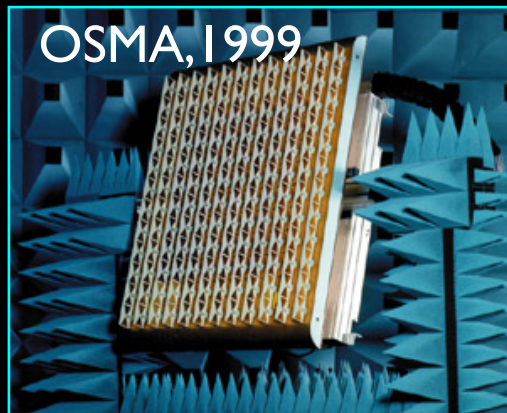
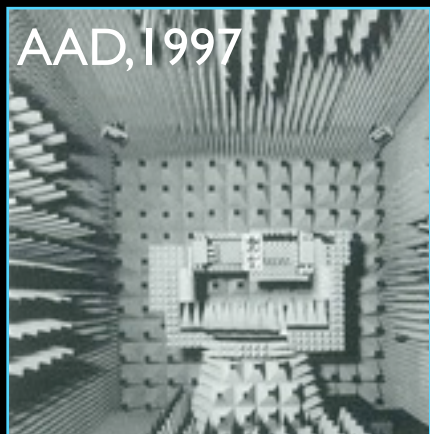
Vehicle Audio/Video System
TracVision A7 is compatible with virtually all factory installed car stereo systems and other systems.

CD Receiver for DVD/TV Services
TracVision A7 is compatible with virtually all factory installed car stereo systems and other systems.

Mid-frequency Aperture Array R&D at ASTRON (1995-2010)

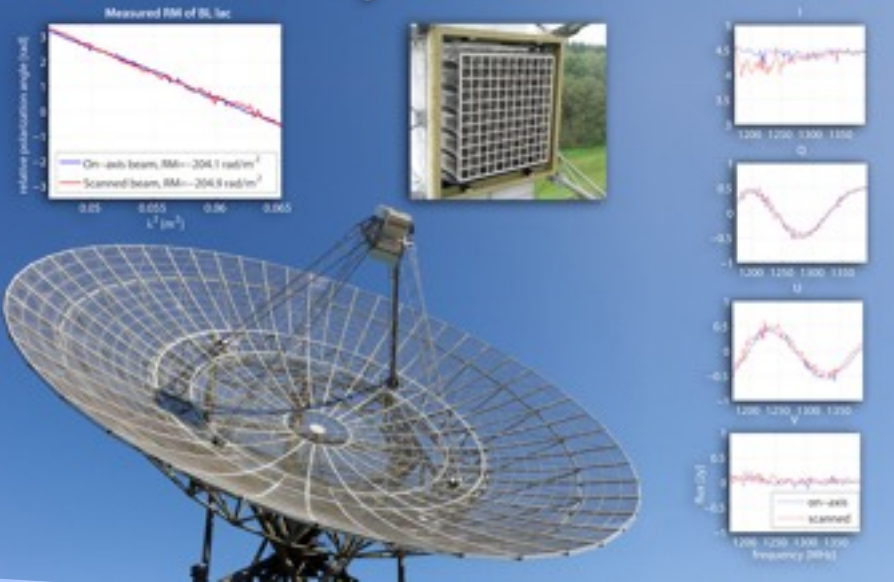
Aperture Arrays R&D focused on:

- concept demonstration,
- integration,
- cost reduction.



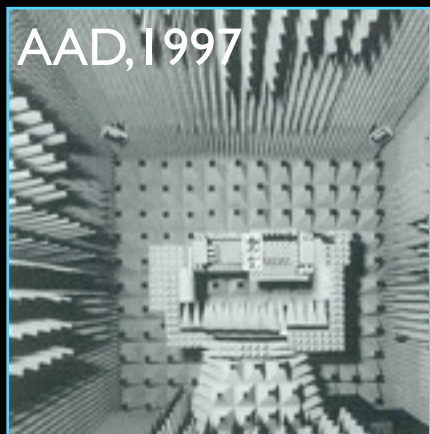
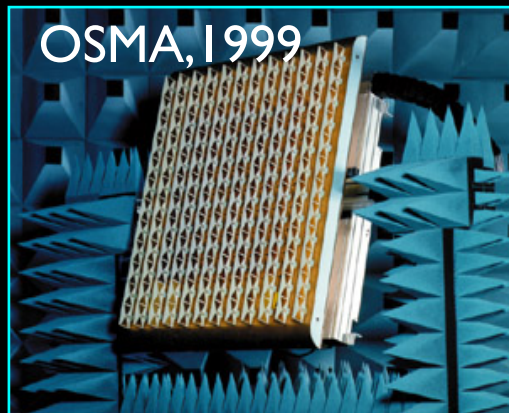
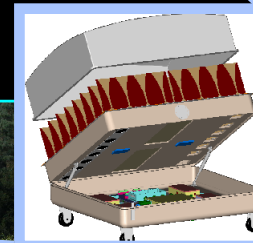
Ardenne et al.

Polarimetry with a Phased Array Feed



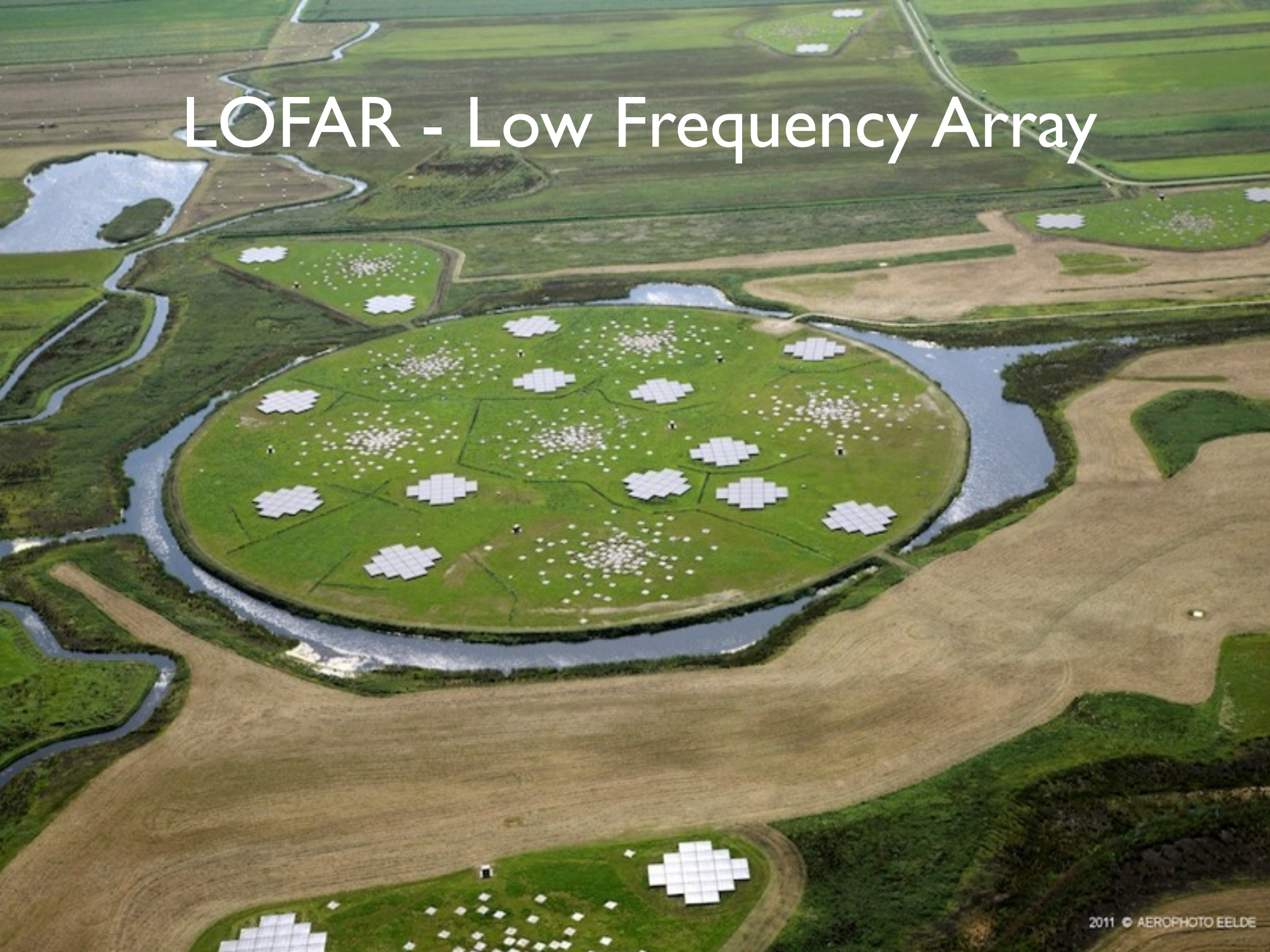
Array R&D at ASTRON (1995-2010)

on:



Ardenne et al.

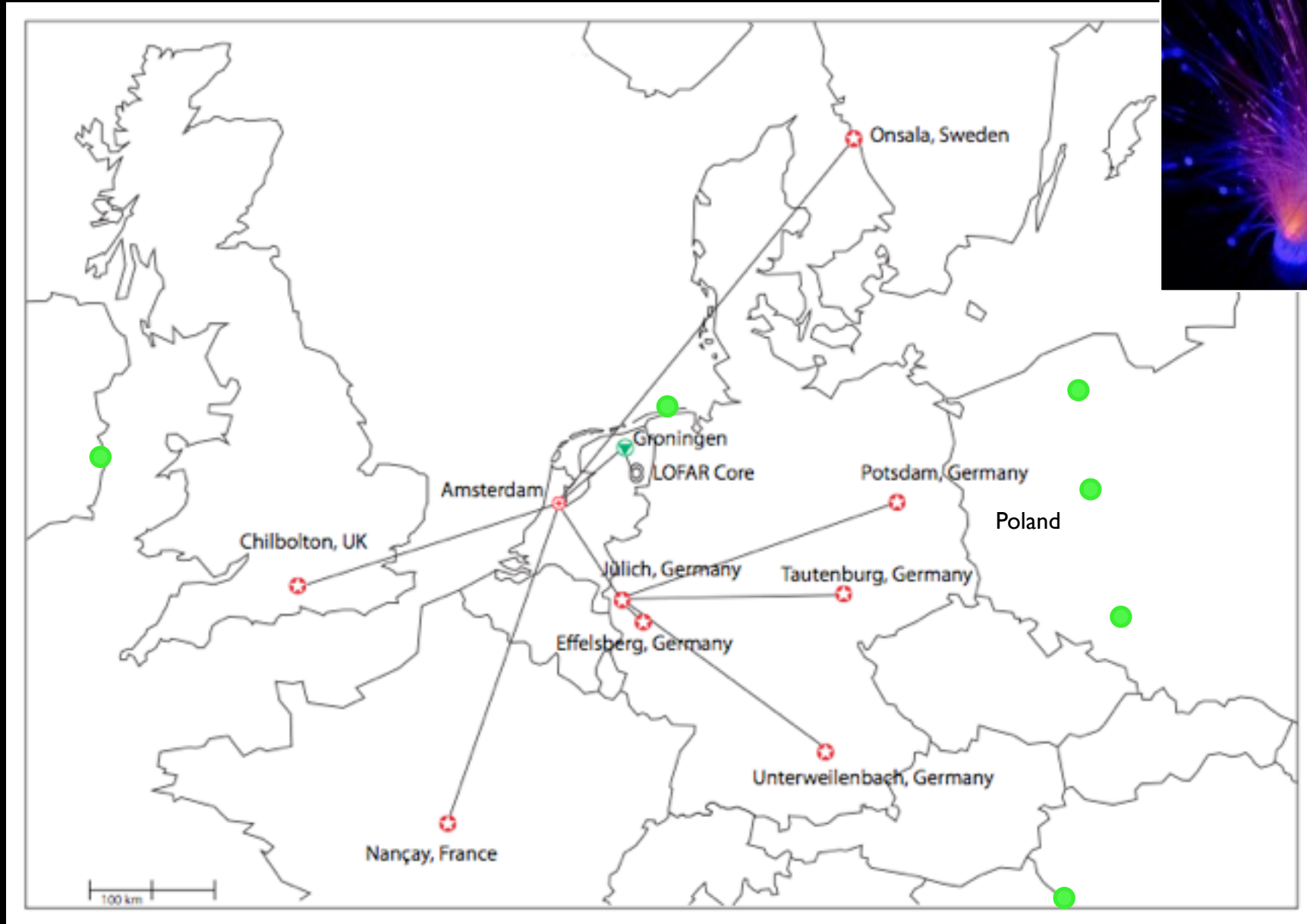
LOFAR - Low Frequency Array



Inner core, near Exloo.



8+ European LOFAR stations:



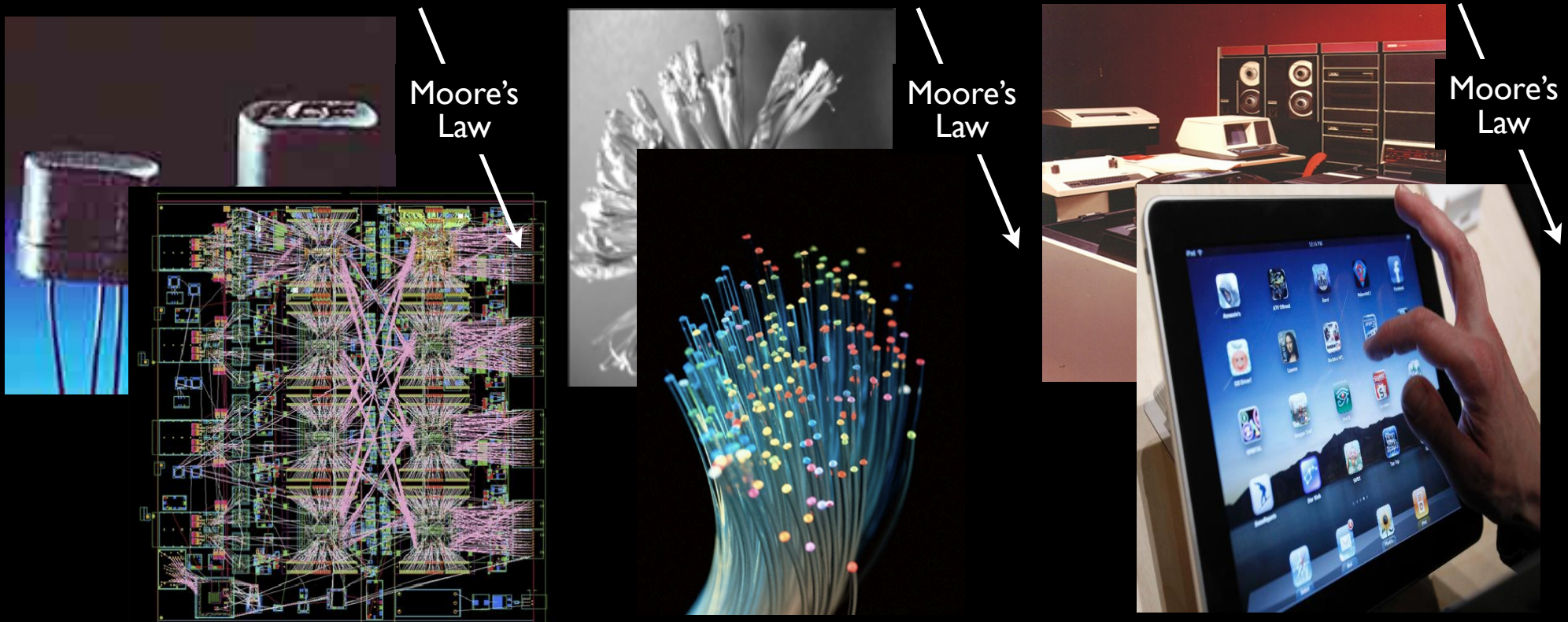
e.g. LOFAR UK station at
Chilbolton, England.



Radio Astronomy Transformed (I)

ICT capability explosion in:

- direct sampling & digitisation
- high speed data transport
- super-computing
- archive capacity
- data mining

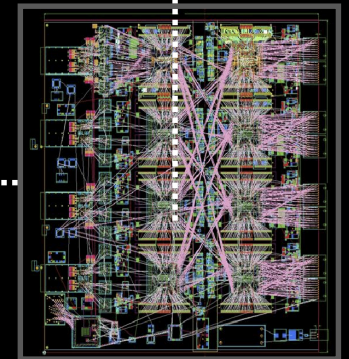


Radio Astronomy Transformed (II)

New antenna technologies:

- Next Generation Aperture Array “Software Telescopes”

Cheap & cheerful dipoles married to the new technologies:



Aperture Array concept now firmly established as technology of choice at frequencies $< \sim 400$ MHz:

International Lofar Stations



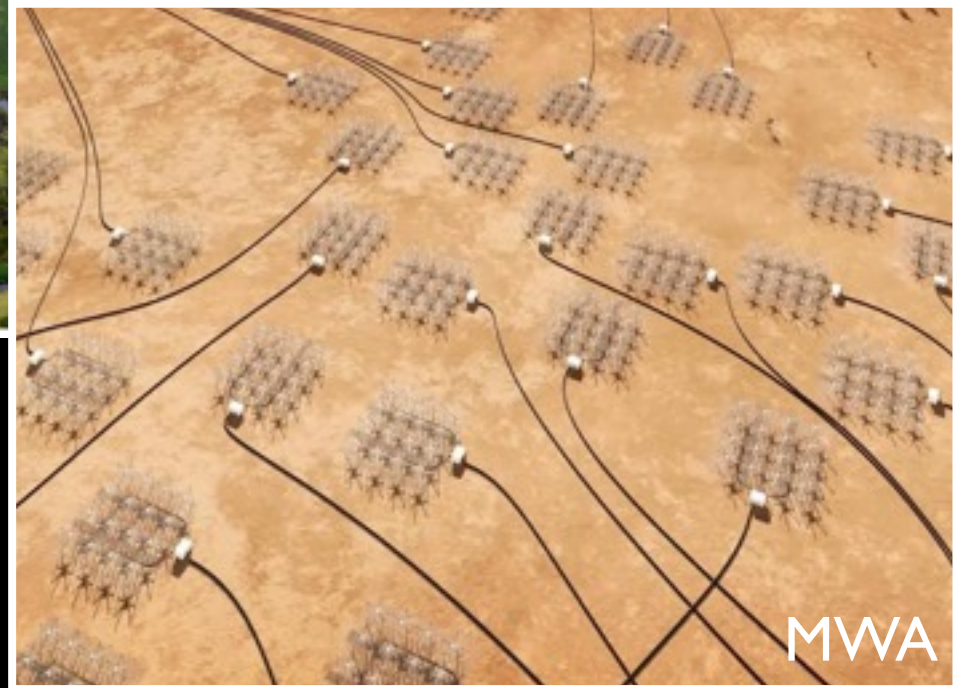
LOFAR



LWA



PAPER



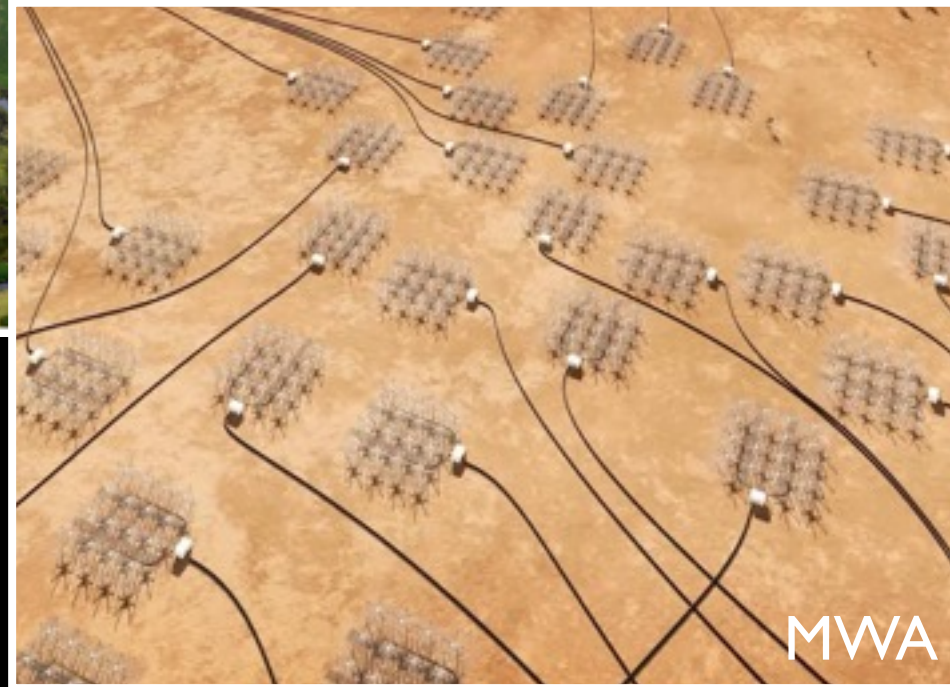
MWA

Aperture Array concept now firmly established as technology of choice at frequencies $< \sim$ 1400 MHz:

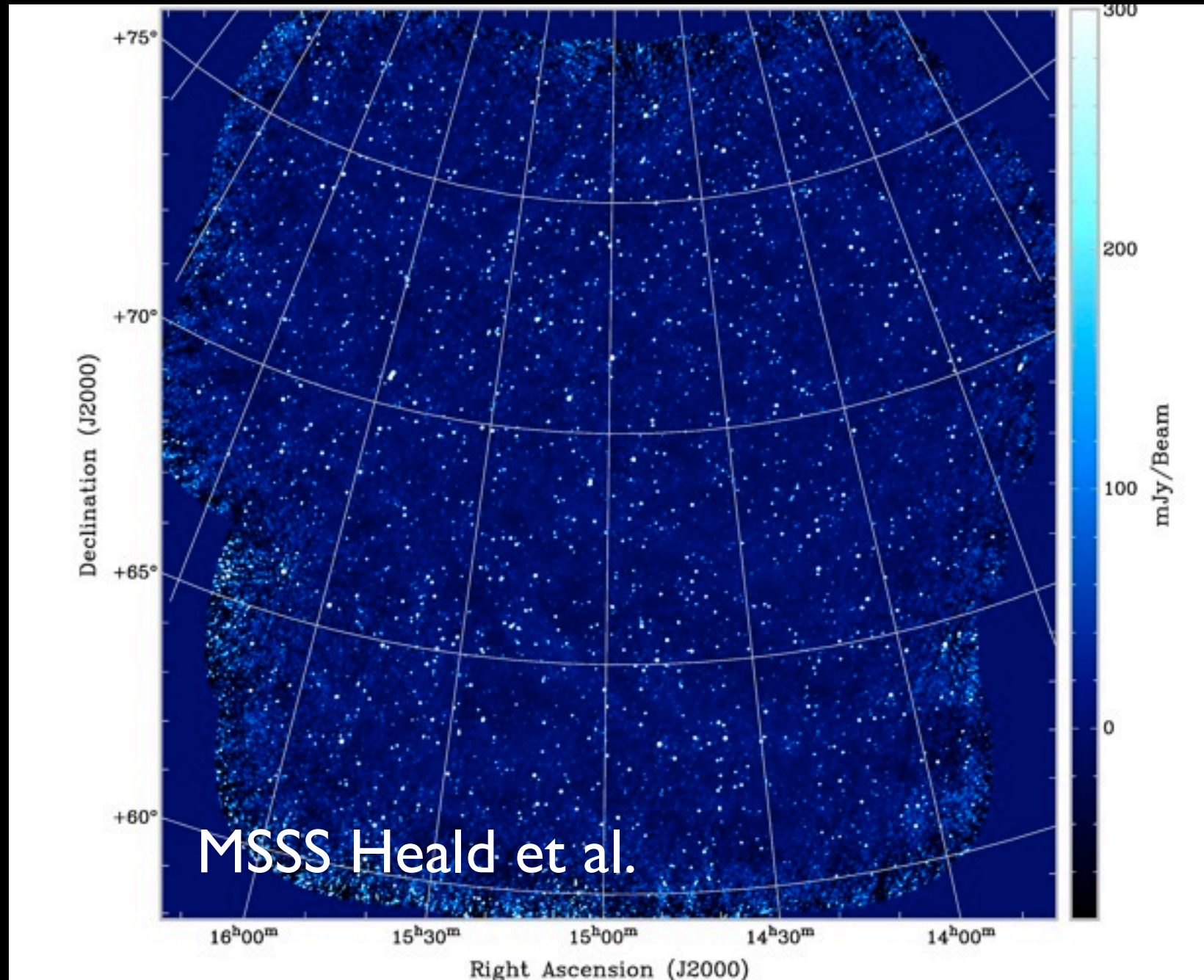
International Lofar Stations

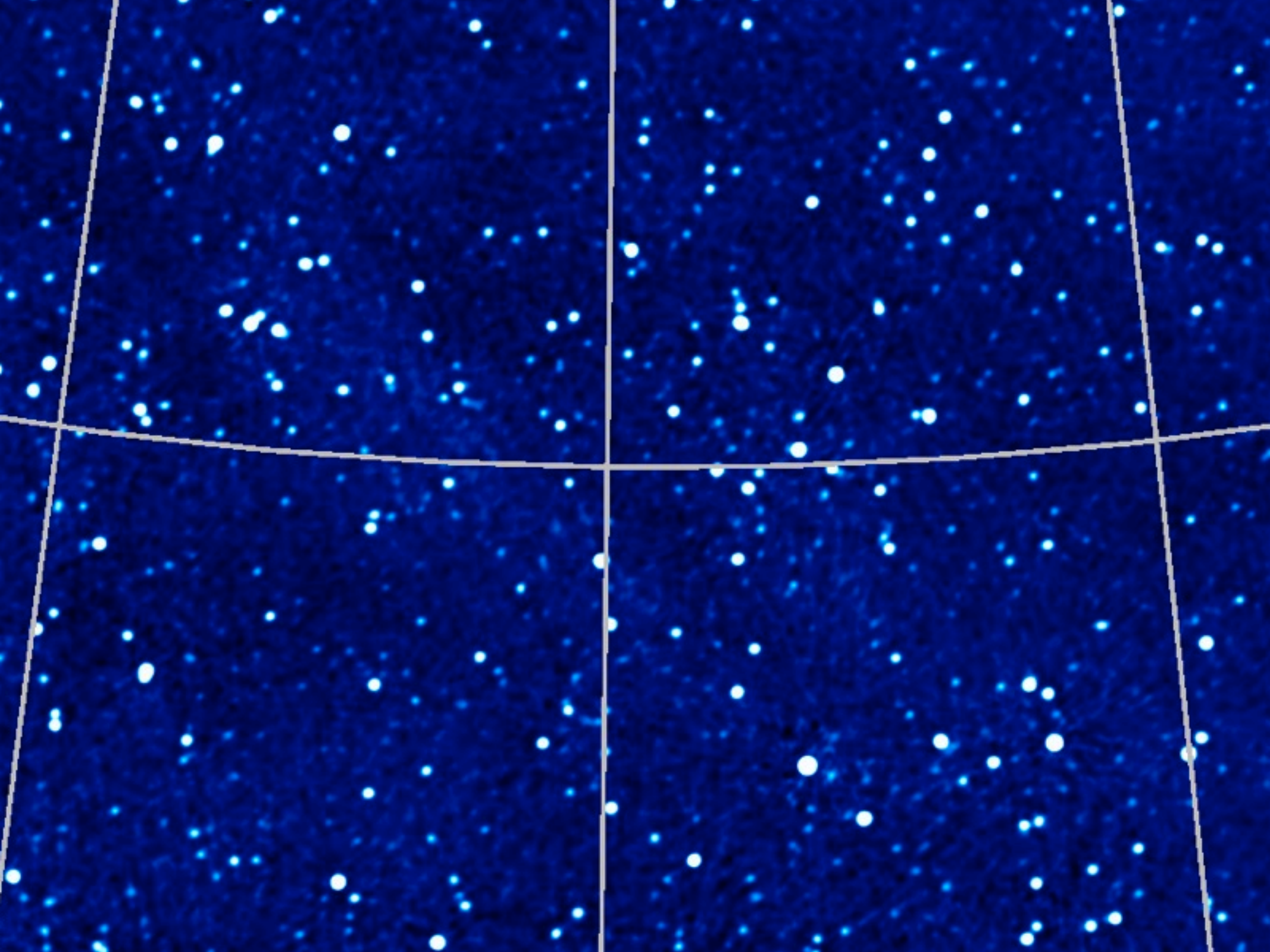


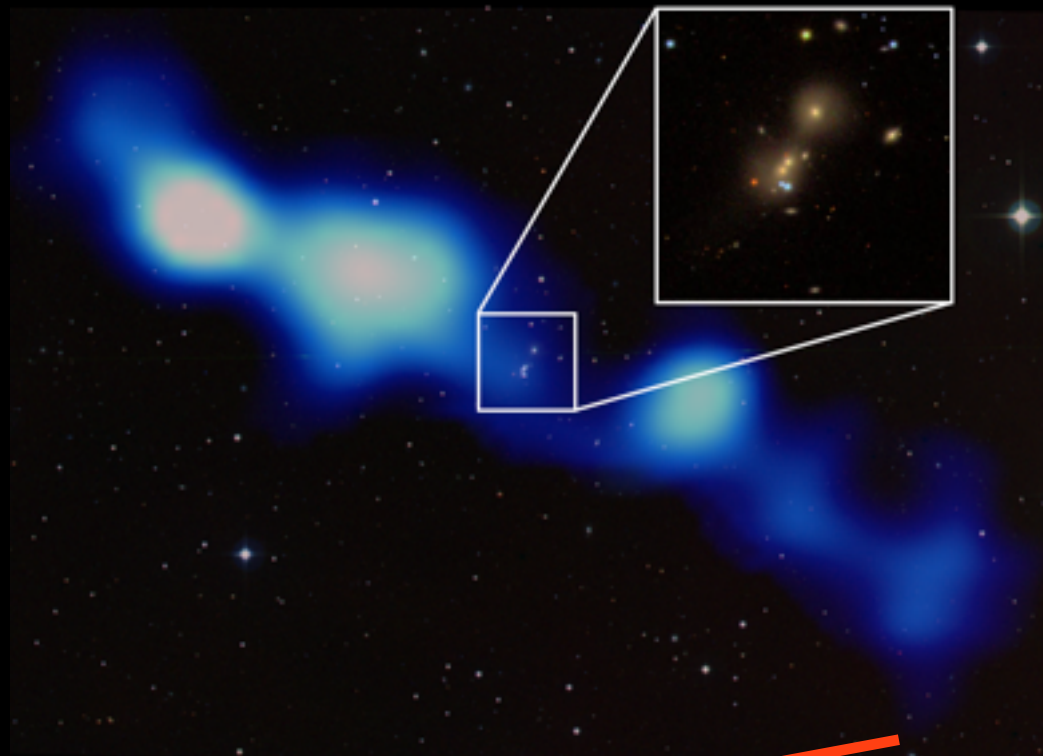
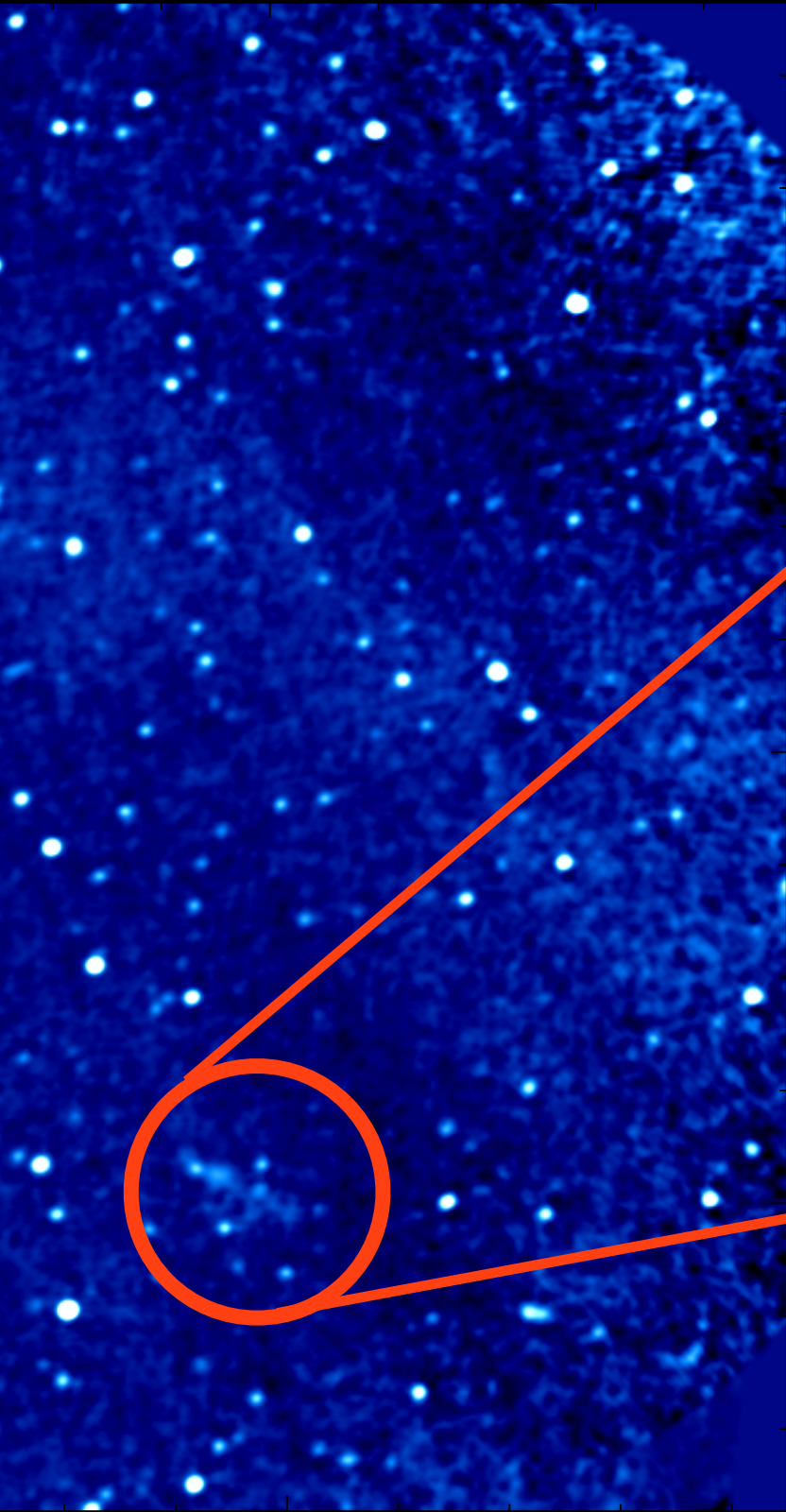
LOFAR



MSSS - LOFAR's first all-sky survey.

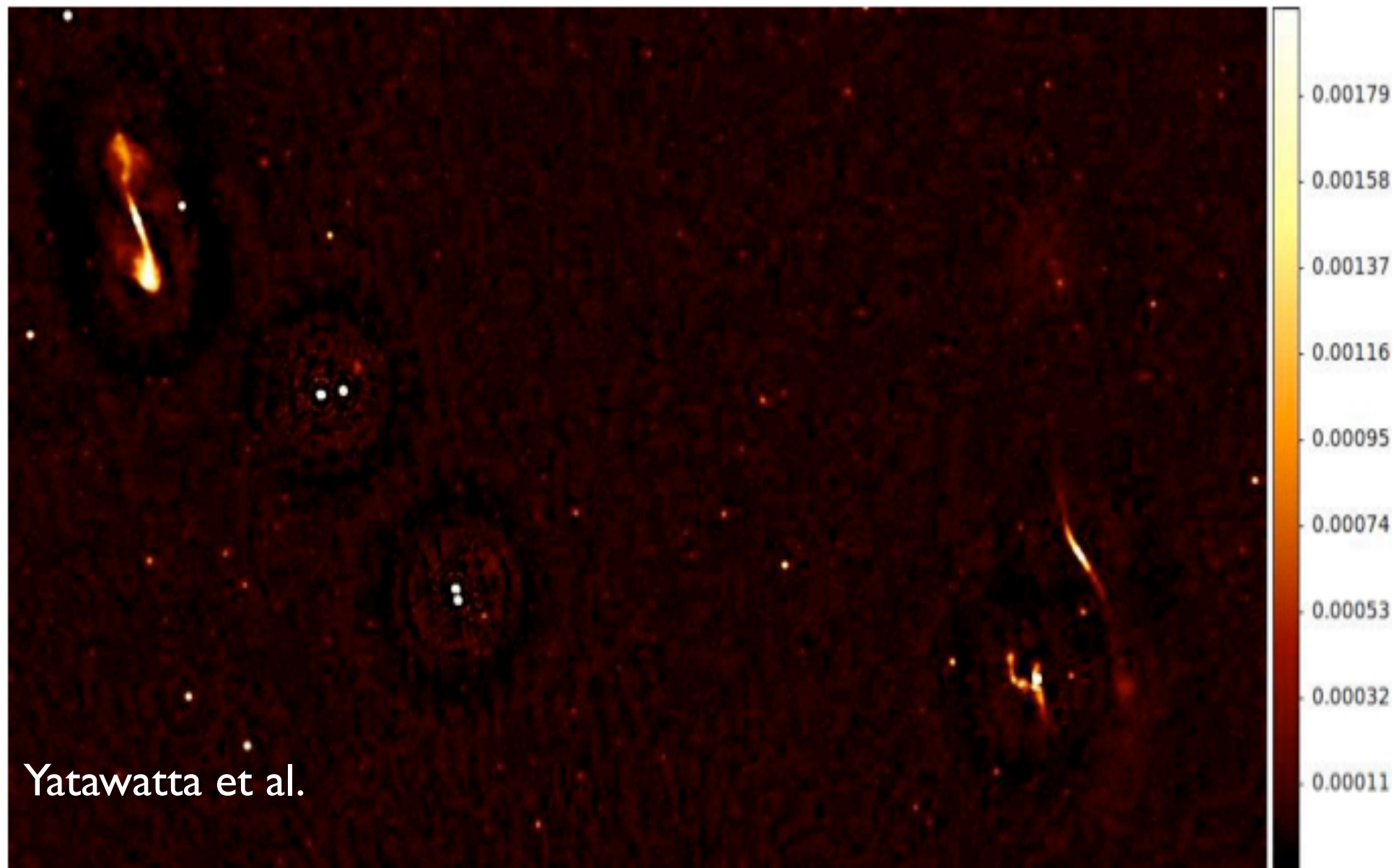






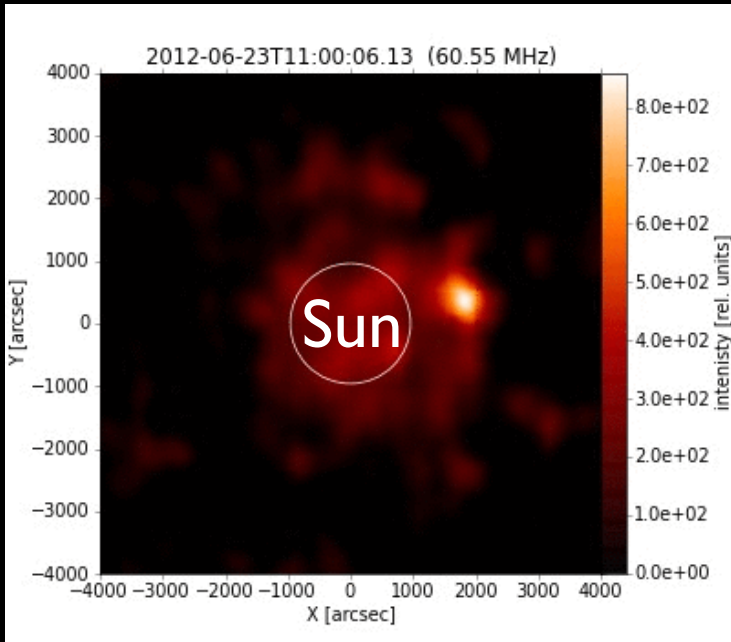
← 2 Mpc →

Deep Field Surveys (EoR)



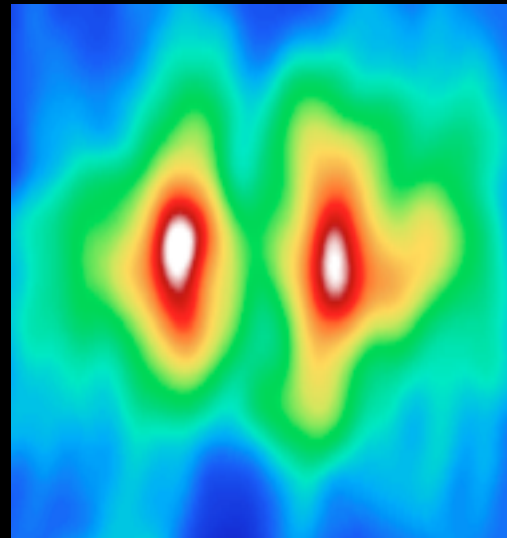
25-30 μJy , 6'' PSF, Dec 2012-Feb 2013, 80 km array, 0.5 \times 0.25 degrees

Solar System Science



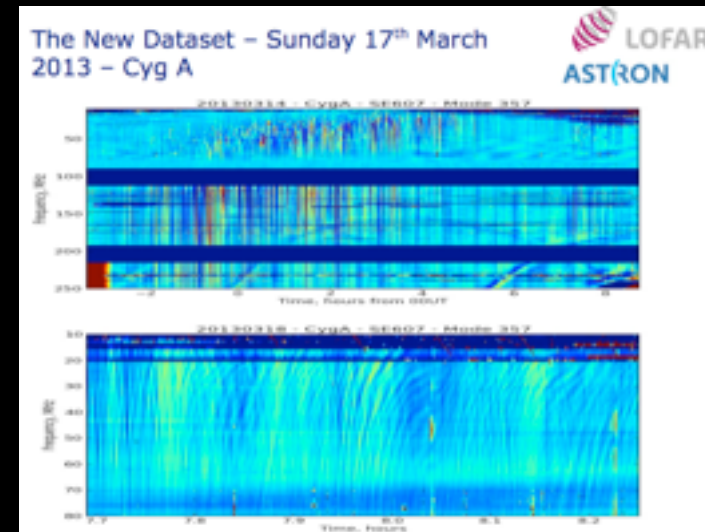
Type III burst
propogating via open
B-field lines - Mann et
al.

Jupiter

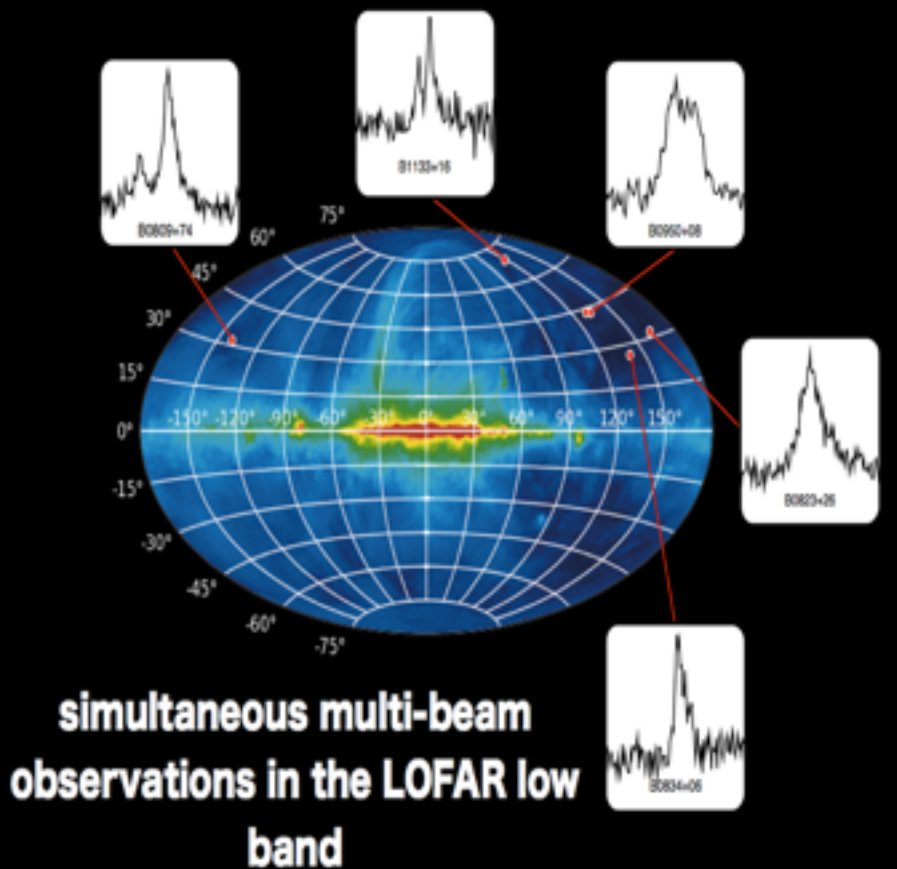


Girard et al.

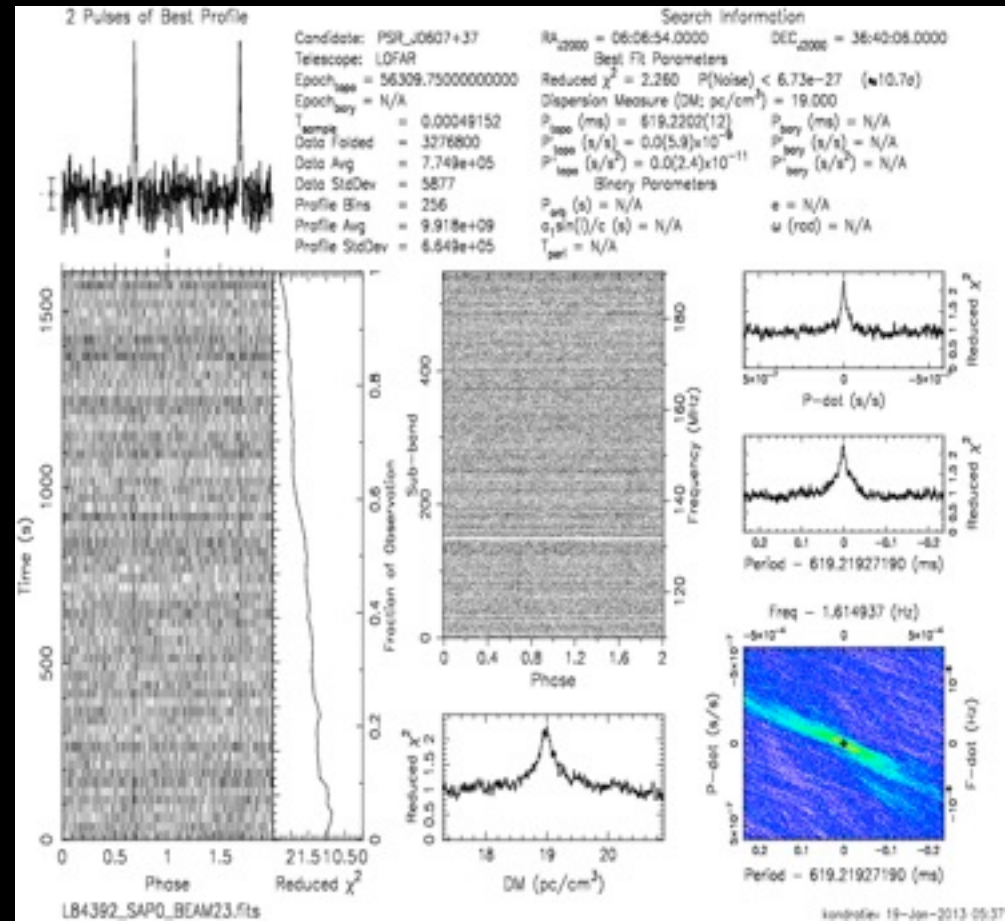
Inter-planetary
Scintillation. Fallows et al.



LOFAR: Pulsar discoveries

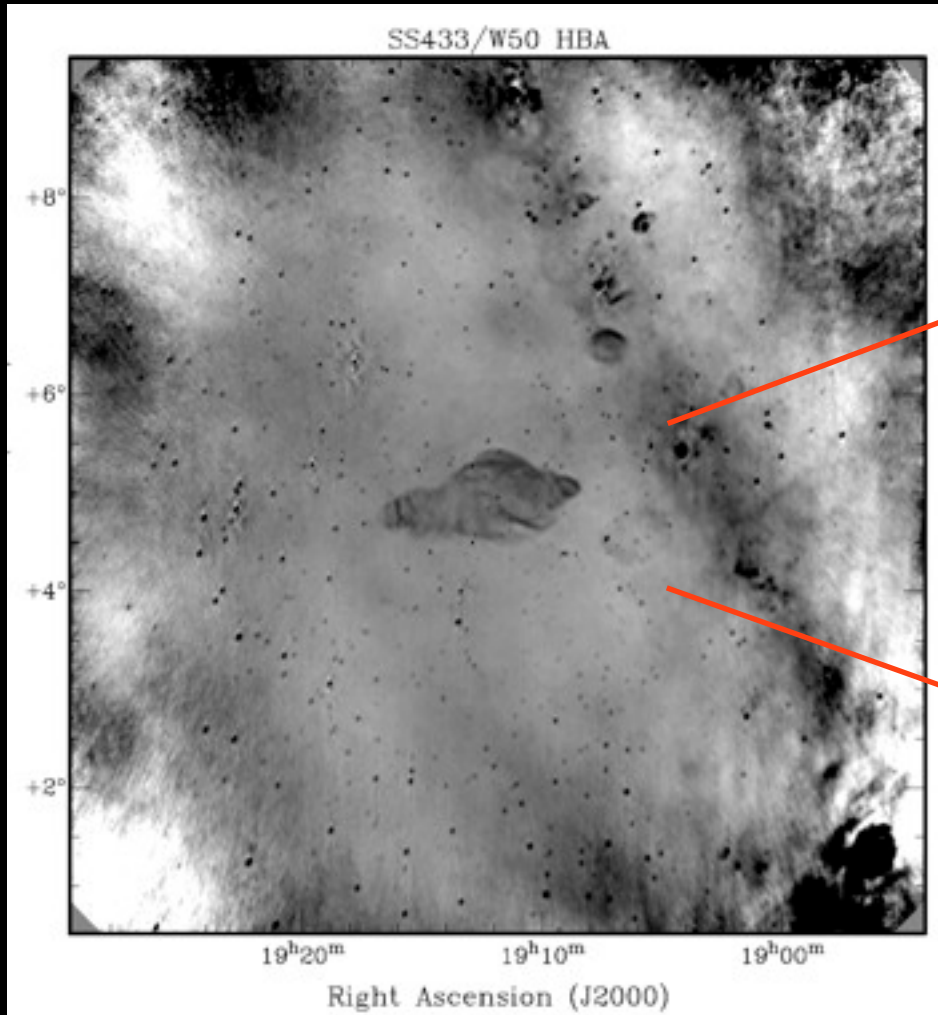


Haslam 408 MHz map courtesy of LAMBDA



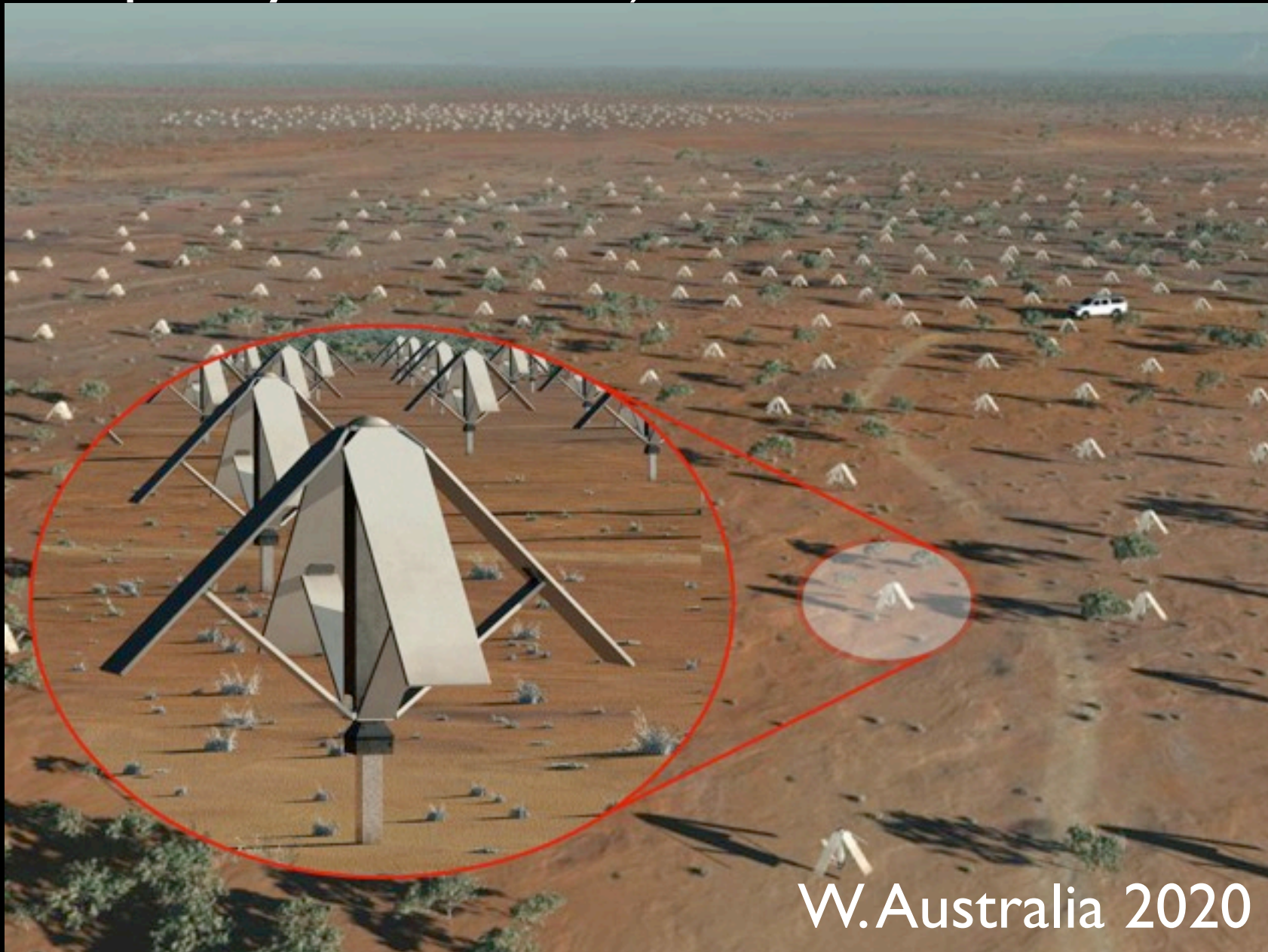
First Pulsars discovered by LOFAR (Dec. 2012 - Hessels et al.)

LOFAR: Galactic Science



First Pulsars discovered by LOFAR (Dec. 2012 - Hessels et al.)

AAs major component of SKA Phase I (Low Frequency < 350 MHz):



W. Australia 2020

AA's major component of SKA Phase 2 in Africa (< 1.4 GHz):



www.skatelescope.org



S. Africa 2024

Aperture Arrays & Africa

Africa will host the SKA-2 mid-freq aperture array...

- *SKA-2 is 2024++*
- *Significant R&D, prototyping & demonstration efforts still required*
- *Major SKA-2 AA-mid Precursor needs to be built & tested soon!!!*
- *EC is interested in funding SKA R&D (not nuts & bolts for SKA-1)*
- *AERAP can be a vehicle to unite R&D efforts in Africa, Europe and beyond, and to realise an SKA2 mid-AA Precursor.*

Current challenges



Extending aperture arrays to higher frequencies
~ 1420 MHz (neutral hydrogen)