

Toward Aperture Arrays for the SKA

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- Introduction
- Aperture Arrays
- What comes next
- Summary

“Nothing is so firmly believed as what we least know”

Michel de Montaigne (1533-1592)



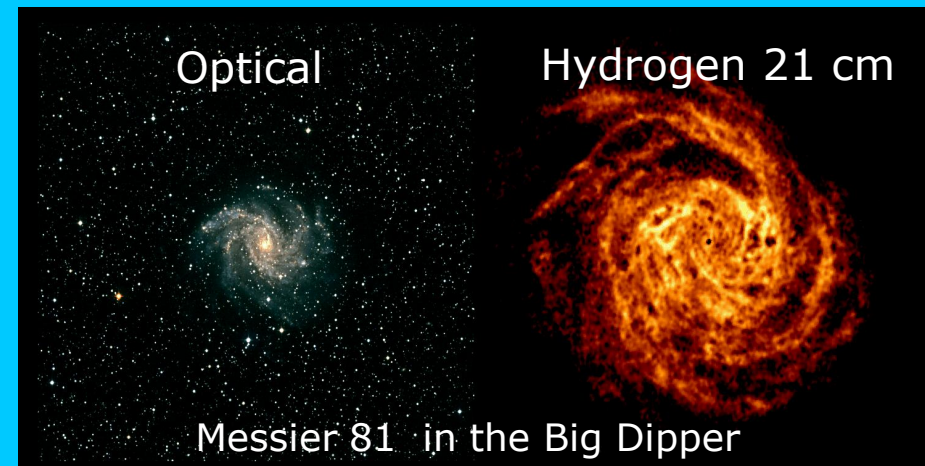
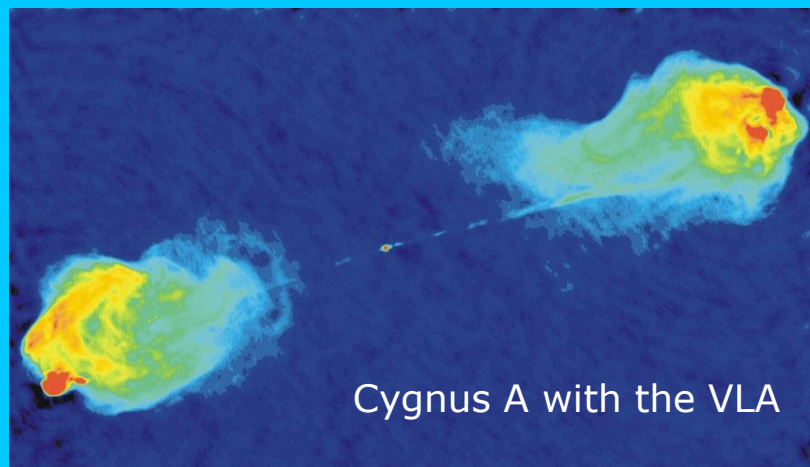
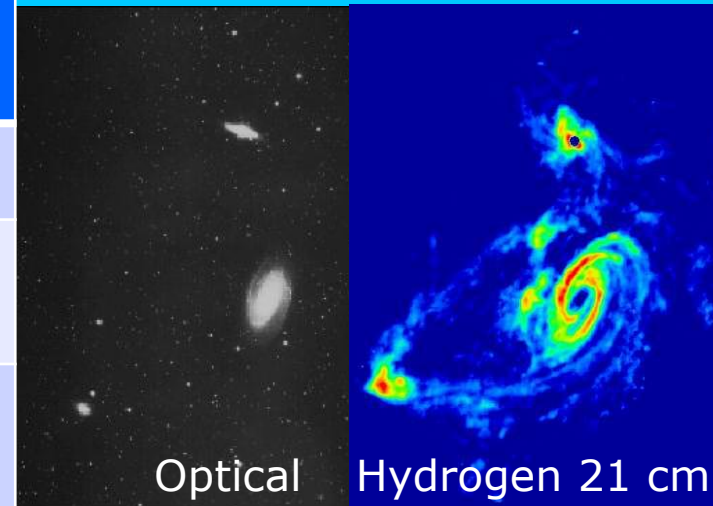
Courtesy: ASTRON/MikeGarrett, LOFAR and SKA collaborators



Courtesy: LOFAR & SKADS/AAVP teams

Advances in Radio Astronomy ASTRON

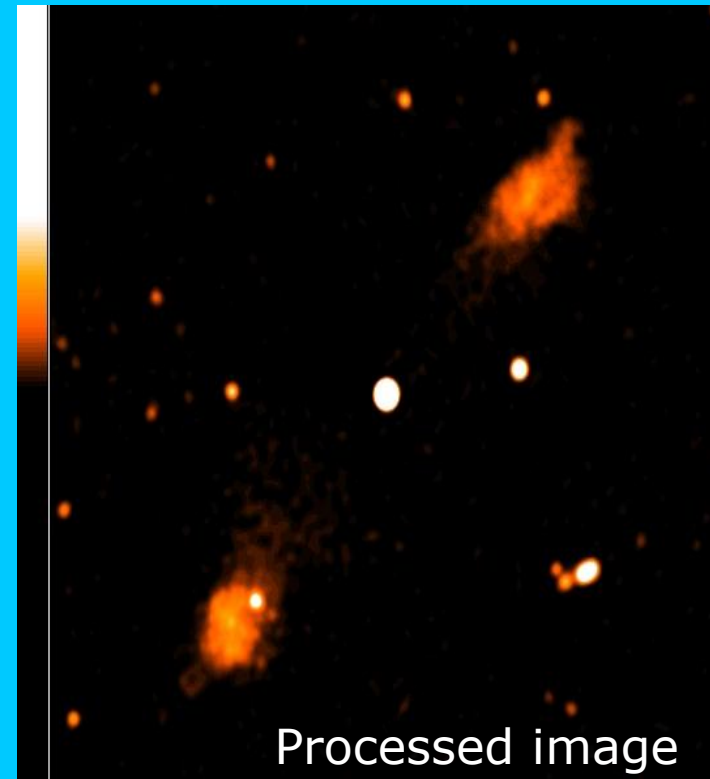
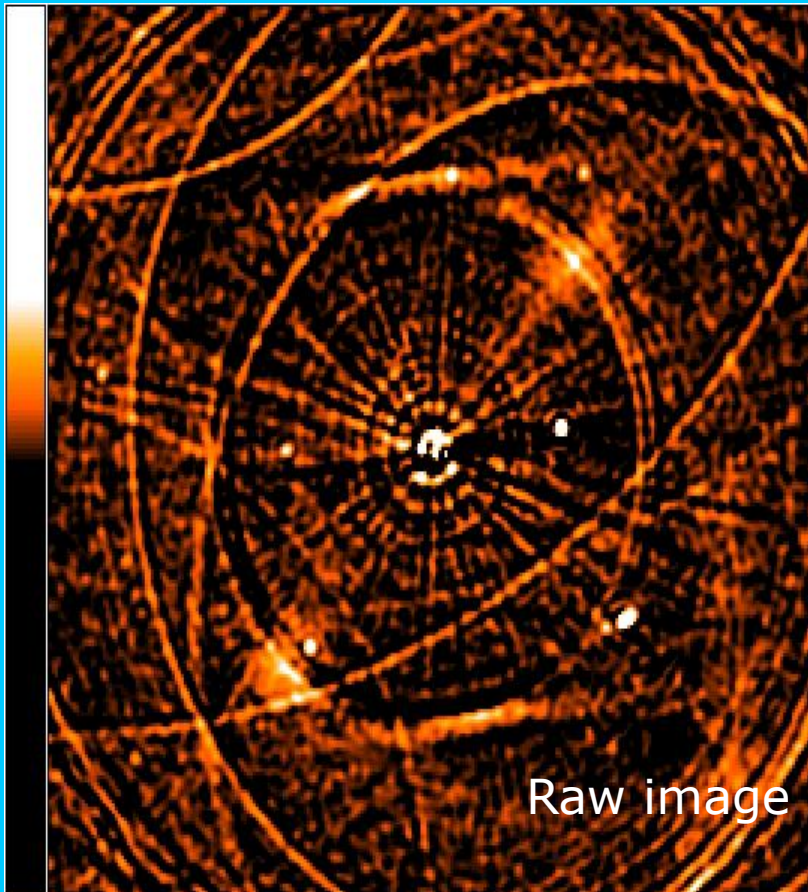
Key Improvement areas in R.A.	Facts and Figures	Enabling key technologies
Sensitivity	$\sim 10^5 \times$ in 50 years SKA: 50-$\rightarrow$ 100x	Collecting Area, Receivers and SW
Angular resolution ("detail")	$\sim 10^7 \times$ in 50 years SKA: same	Baseline extension ("VLBI"), clocks and network-technologies
Field of View (all resolution pixels)	$> \sim 10^5 \times$ in 50 years SKA: 100-$10^4 \times$ (computing power measure using AA's)	Array techniques, SW and computing power



NGC 6946: deepest WSRT H I map ever
(16x12h)

Synthesis imaging; substantial postprocessing

- Deep imaging requires (complicated) calibration schemes on the correlated data
- Massive data (such as LOFAR) require on the fly calibration and imaging algorithms

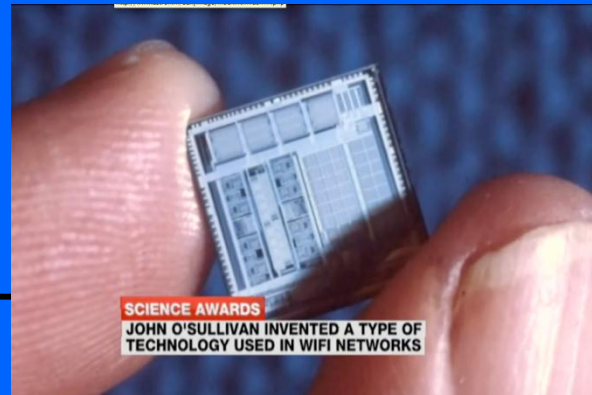


Radio Astronomy –valorization of fundamental research

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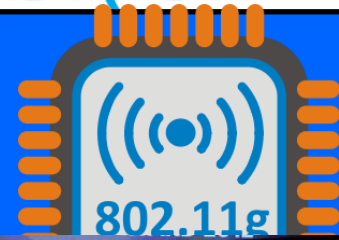


IEEE 802.11 standard - an example!



Radio Astronomy –valorization of fundamental research

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IEEE 802.11 standard - an example!



20+ years!



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1.E+16 Vacuum-tube Era Transistor Era Microprocessor Era

1.E+15

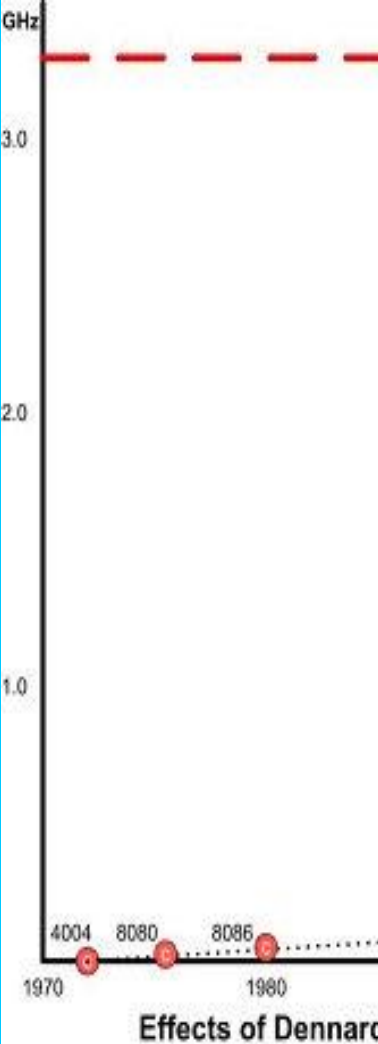
CURRENT LAPTOPS

SICORTEX SC5832

DELL DIMENSION 2400

GATEWAY P3 (733 MHz)

Blue
Gene/Q



en

Together with Dome partner in S.A.

The complete study
from the Intel Web
download.intel.com
pdf/computertrend

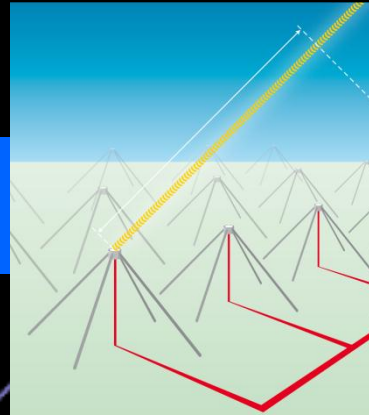
2010

Radio Astronomy Transformed

New antenna technologies:

- Next Generation Aperture Array “Software Telescopes”

Cheap & cheerful dipoles married to the new technologies:



Aperture Array concept firmly established as technology of choice at frequencies < 500 MHz:

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International Lofar Stations



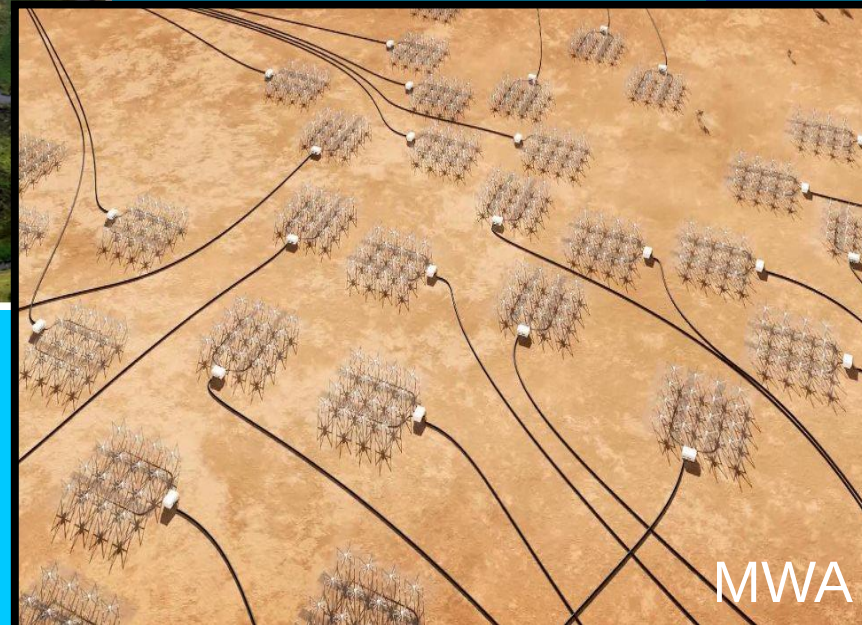
LOFAR



LWA



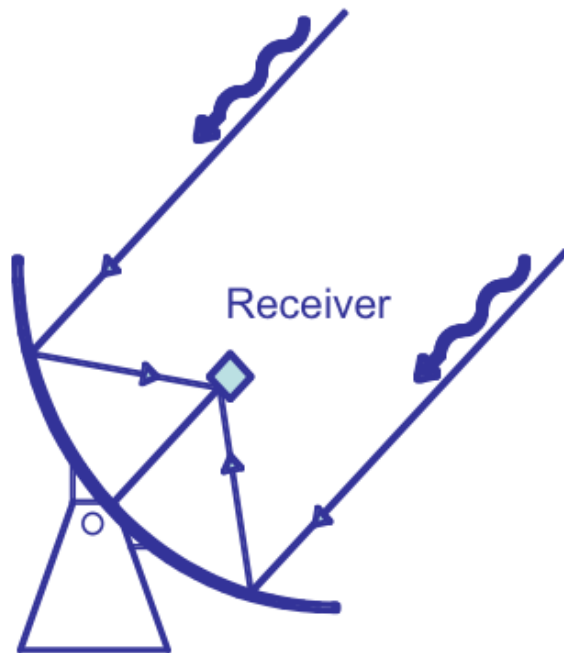
PAPER



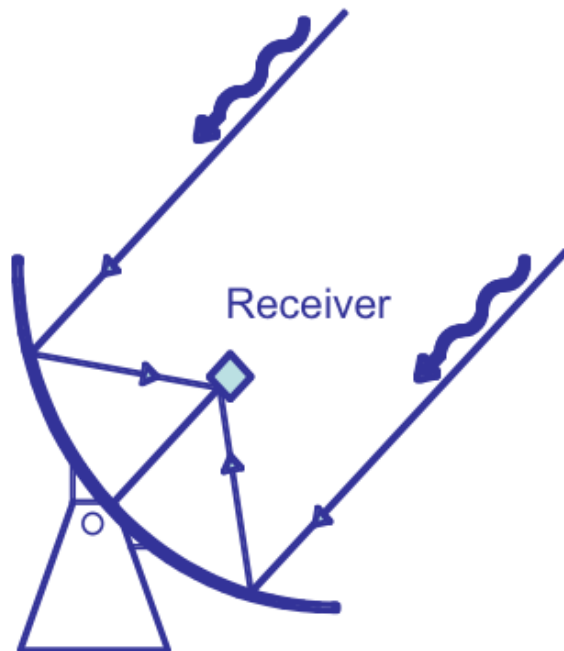
MWA



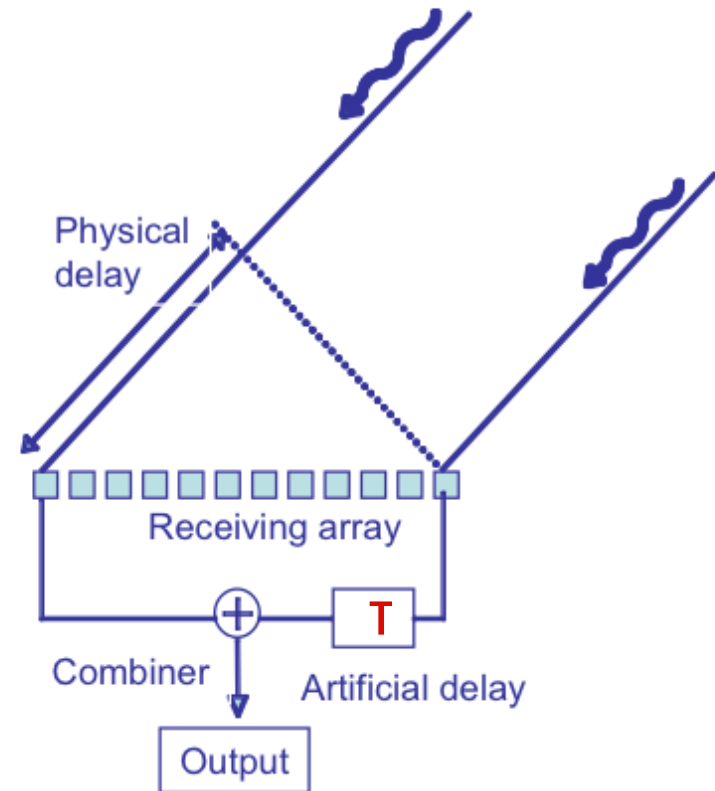
Internat. LOFAR Telescope: LOFAR Stations Across Europe



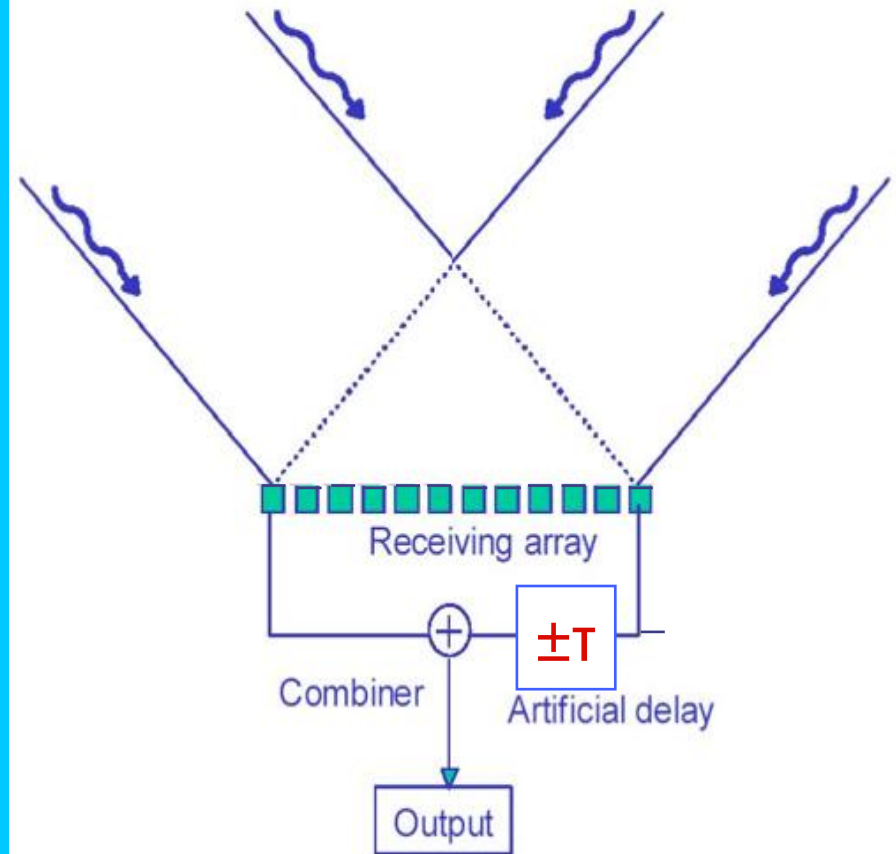
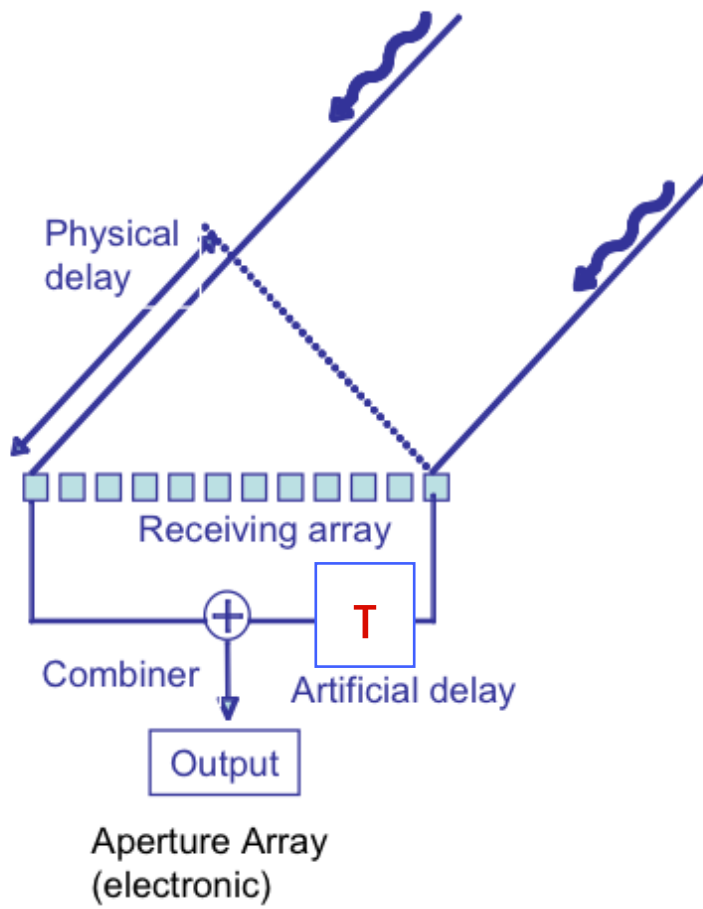
Parabolic reflector
(mechanical)



Parabolic reflector
(mechanical)



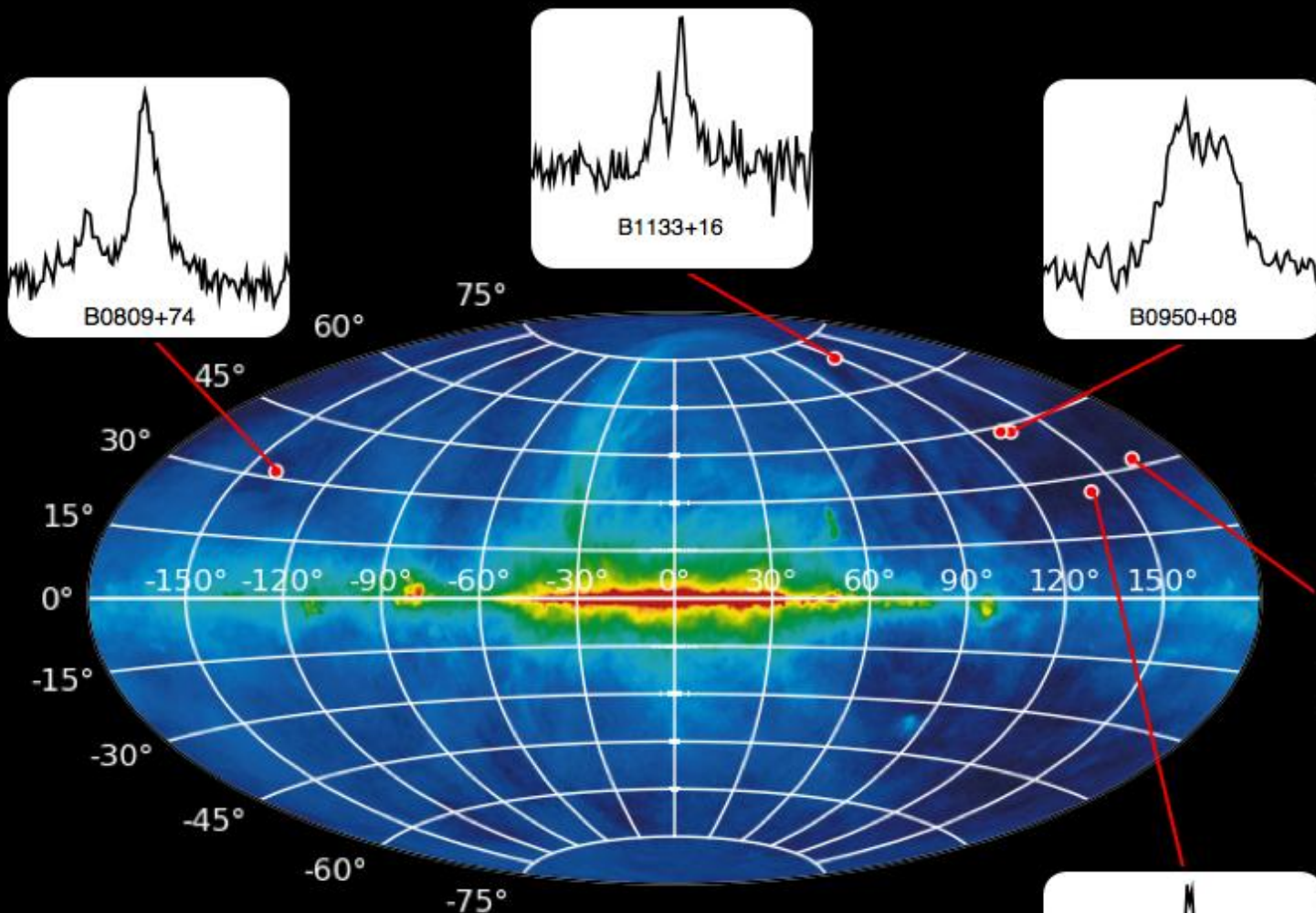
Aperture Array
(electronic)



Advantages of Aperture Arrays

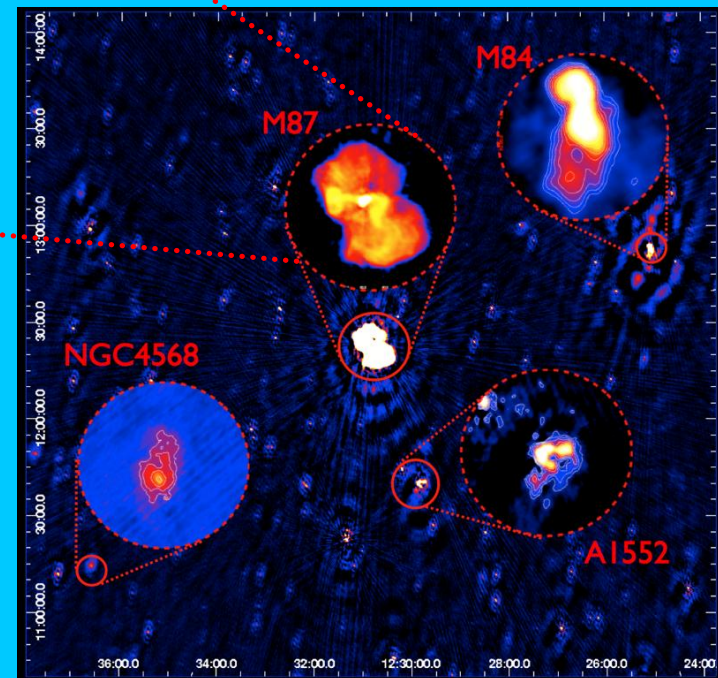
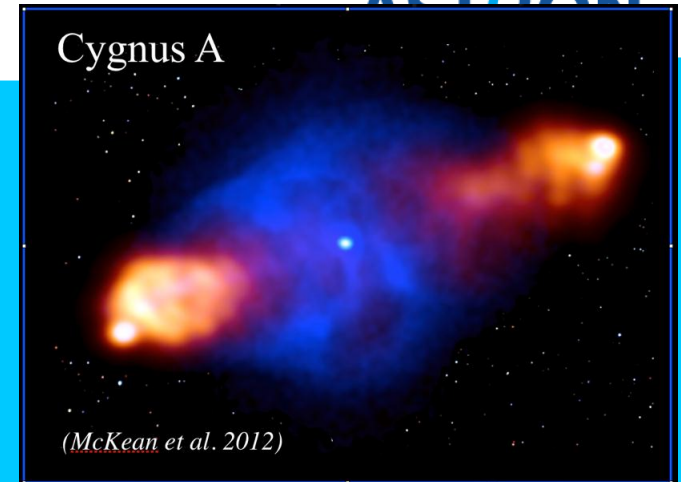
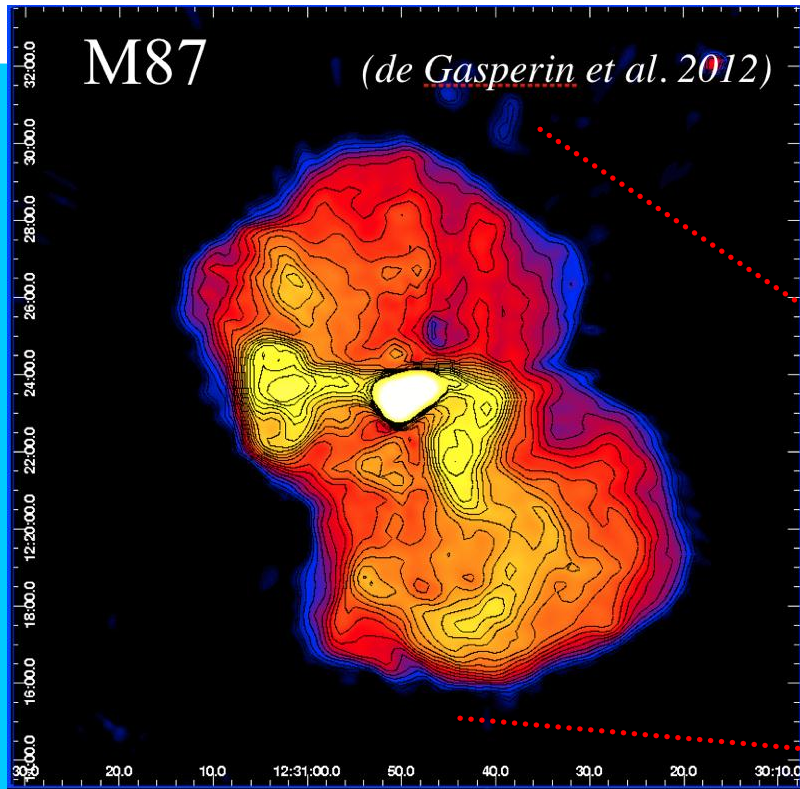


- Unblocked aperture with full view of the entire sky!
- Ultimate flexibility and reliability - no moving parts!
- Beams are formed and controlled electronically at element level
- Multiple beams (or fields of view) permits concurrent, independent (or associated) observations => huge field of view.
- Data from individual dipoles can be buffered, permitting “playback” of any part of the sky as it appeared in the past.



**simultaneous multi-beam
observations in the LOFAR low
band**

LOFAR - commissioning images



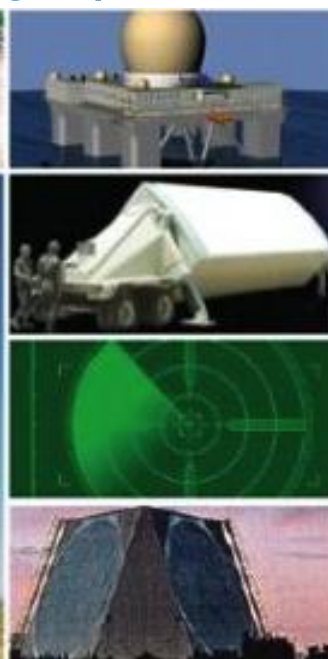
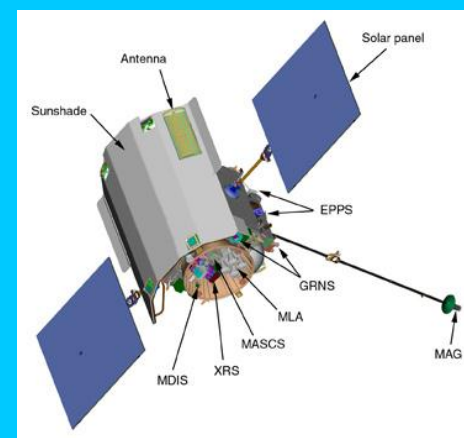
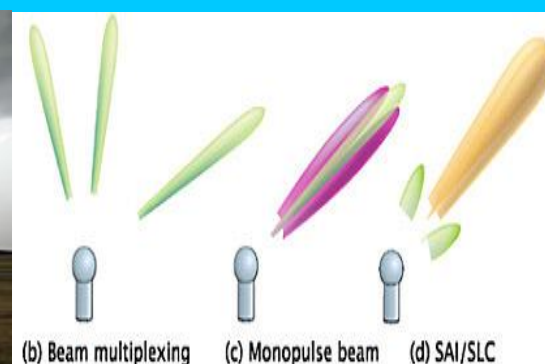
First "Official" observing program
to be launched soon

Parallel steps

Aperture arrays for higher frequencies
From ~ 1420 MHz (neutral hydrogen) to lower

Explosion of civilian and military applications using Aperture Arrays

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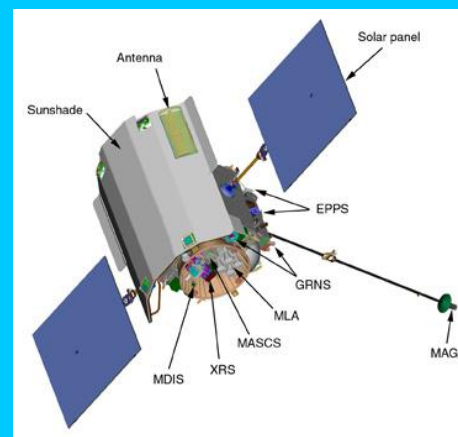
Explosion of civilian and military applications using Aperture Arrays

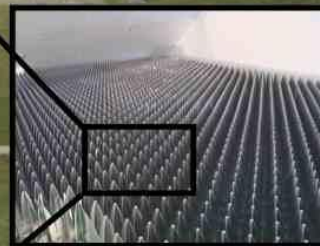
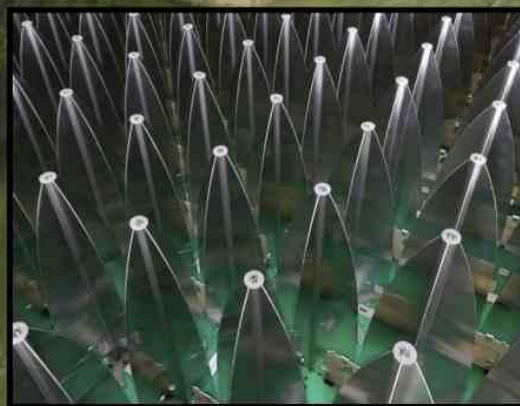
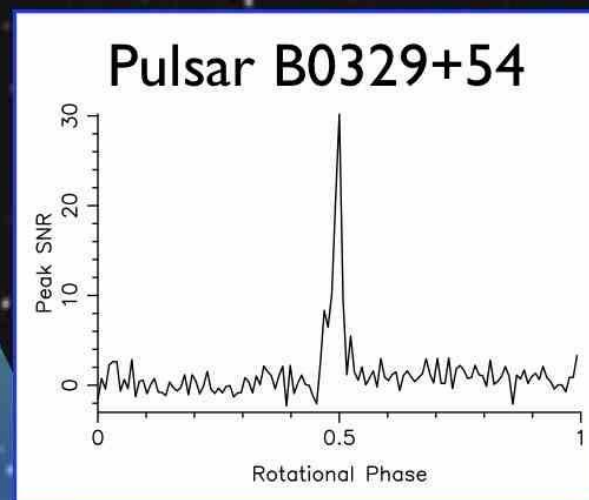
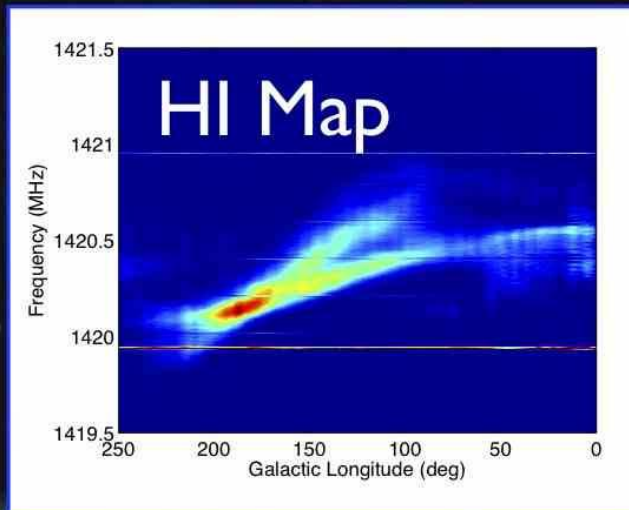
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Challenge facing Astronomy is how to reduce manufacturing and operating costs while maintaining performance and reliability.

(b) Beam multiplexing (c) Monopulse beam (d) SAI/SLC





EMBRACE Dual Beam

EMMA; SKA station-level high frequency science capable array demonstrator

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■ *Synergies*

- Science capable demonstrator
- ICT enabled
- Green Energy
 - Technically feasible
(energy WS last September))

- Cradle
(Appr



Participants MID-AA

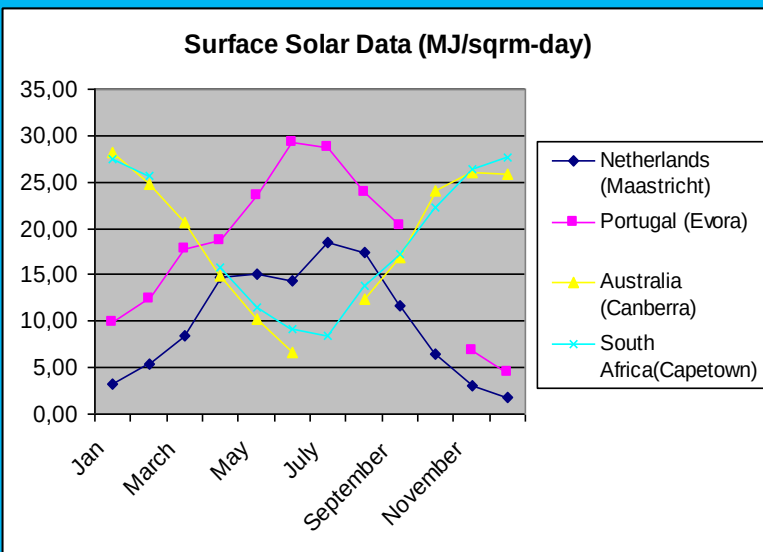
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- Universities, Institutes in
 - NI, NWO/ASTRON
 - Fr., Observatoire de Paris/ Nancay Obs.
 - It, INAF/IRA
 - UK
 - Spain, Portugal science, ICT, power, testsite
 - S.A., W.Aus.
- Industry and other engagement
 - In NI: Dutch SKA Industry Alliance
 - IBM(nl), Siemens(nl), NXP, TE etc.
 - Others e.g. Iberia, Germ.(e.g. MPI), NI, Sw.
 - EC funded BIOSTIRLING energy project
- Preparing for SKA (RfP etc.)
- EC funding opportunities being explored
 - H2020,



Where?

- Aim: S.A. Site
- Site in Moura for verification



Lisboa



- Major developments for Aperture Arrays developing
- Great interest in Europe growing e.g. through ILT
- Next step for higher frequency underway with major industry interest
 - Synergies between Science, Energy, ICT and Materials
 - Collaborations with Portugal, Spain in these areas growing
- Enables SKA widest field of view approach
- Excellent opportunities between EU-Africa
 - Demonstrators, Energy, policies etc.
- Collaborative schemes i.e. EU partners, EC/H2020 etc. to be investigated