LOFAR

- opening up a new window on the Universe

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This talk:

LOFAR (Low Frequency Array):

- a little bit of history,

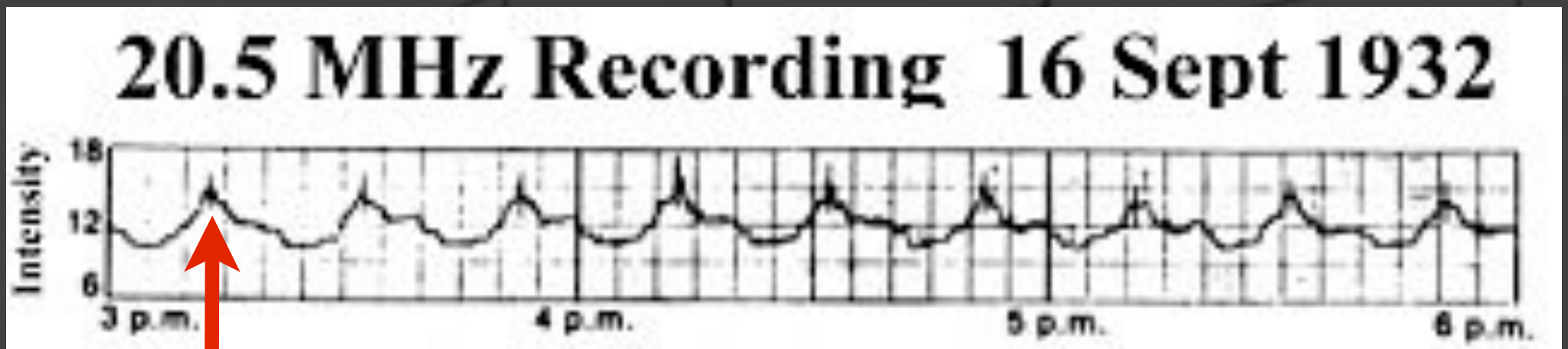
- concept, design, construction, & roll-out

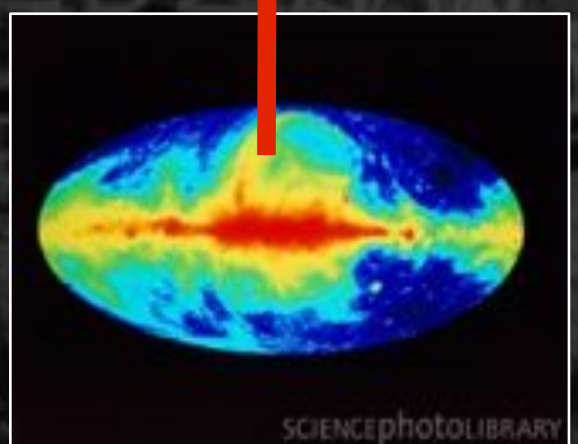
- key astronomy drivers (& other applications),

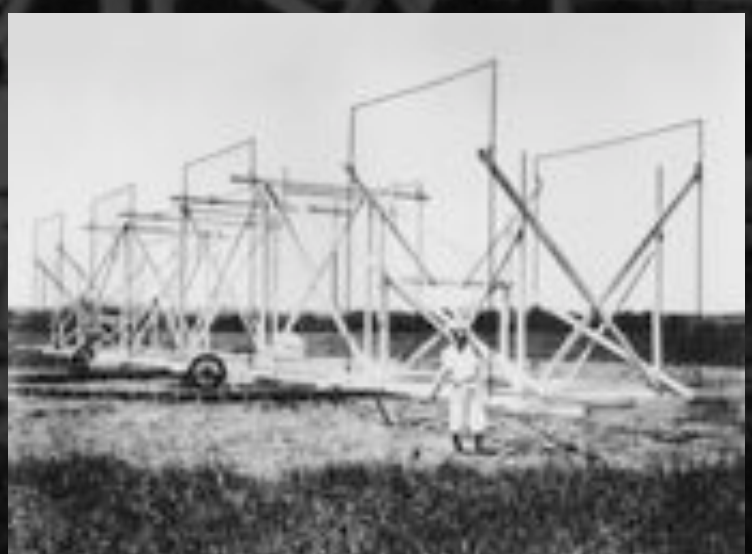
- first commissioning results,

- link to the future & the Square Kilometre Array (SKA).

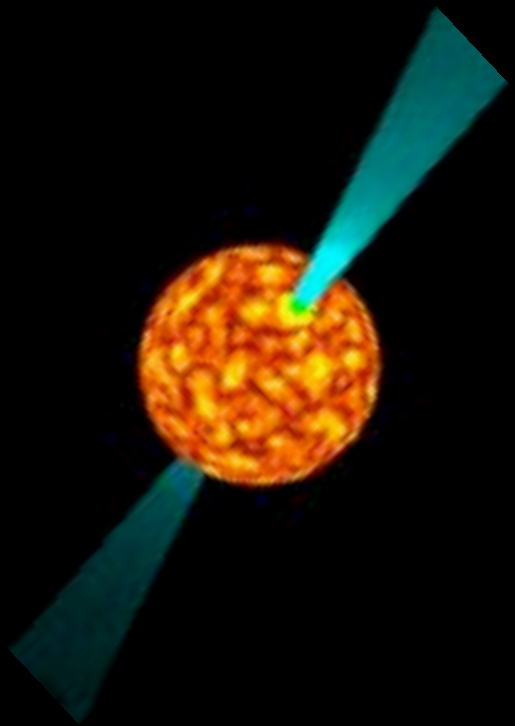
Low frequencies is very much where radio astronomy started - Jansky (1933):

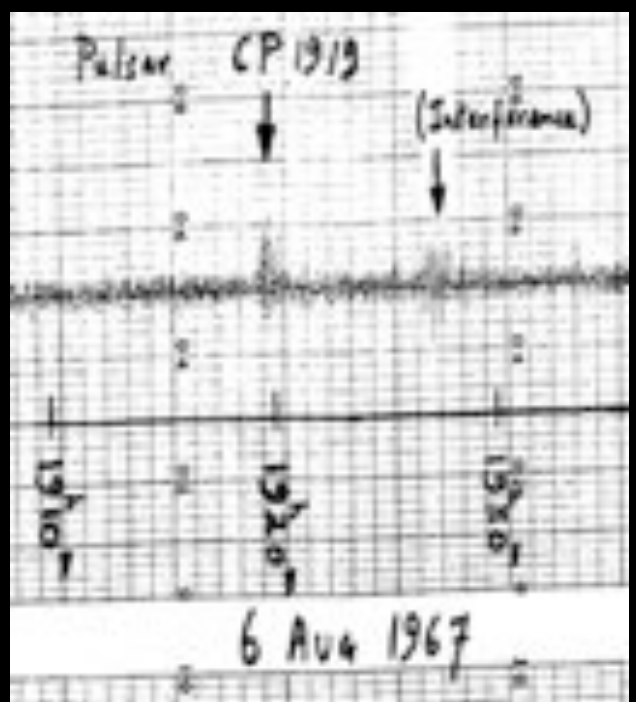






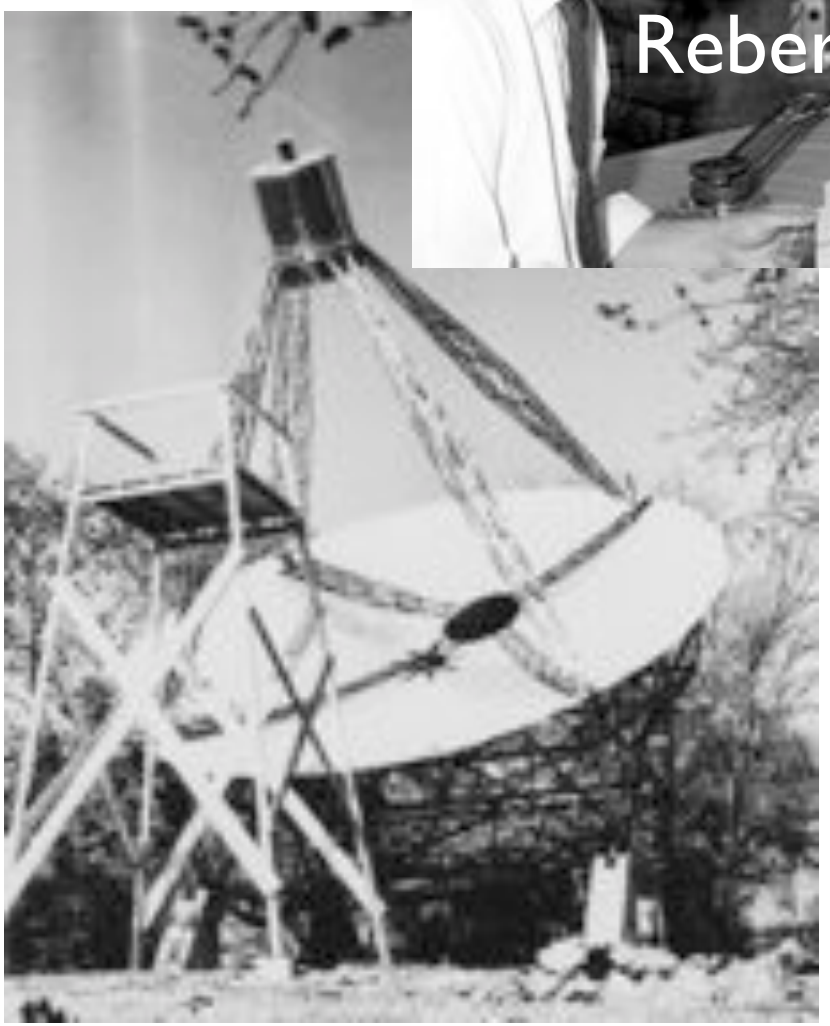
Discovery of pulsars (1967):

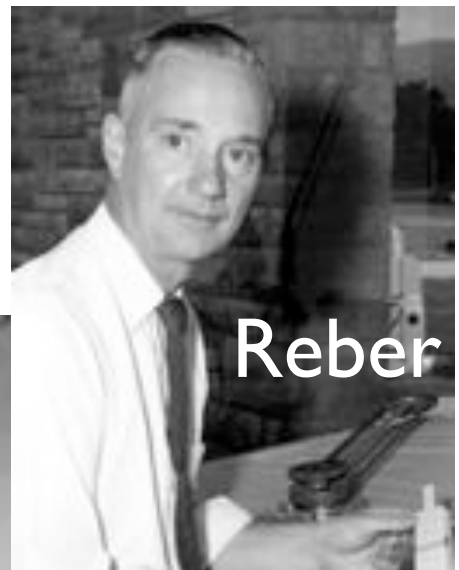




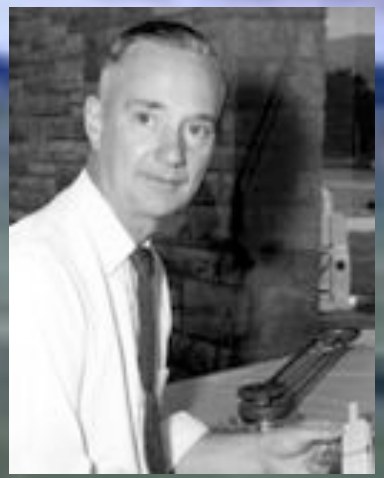
But until recently, radio astronomy gravitated towards cm wavelengths:

- interference less problematic
- atmosphere more stable
- better resolution
- sky noise much lower etc.
- Neutral hydrogen (21cm line)



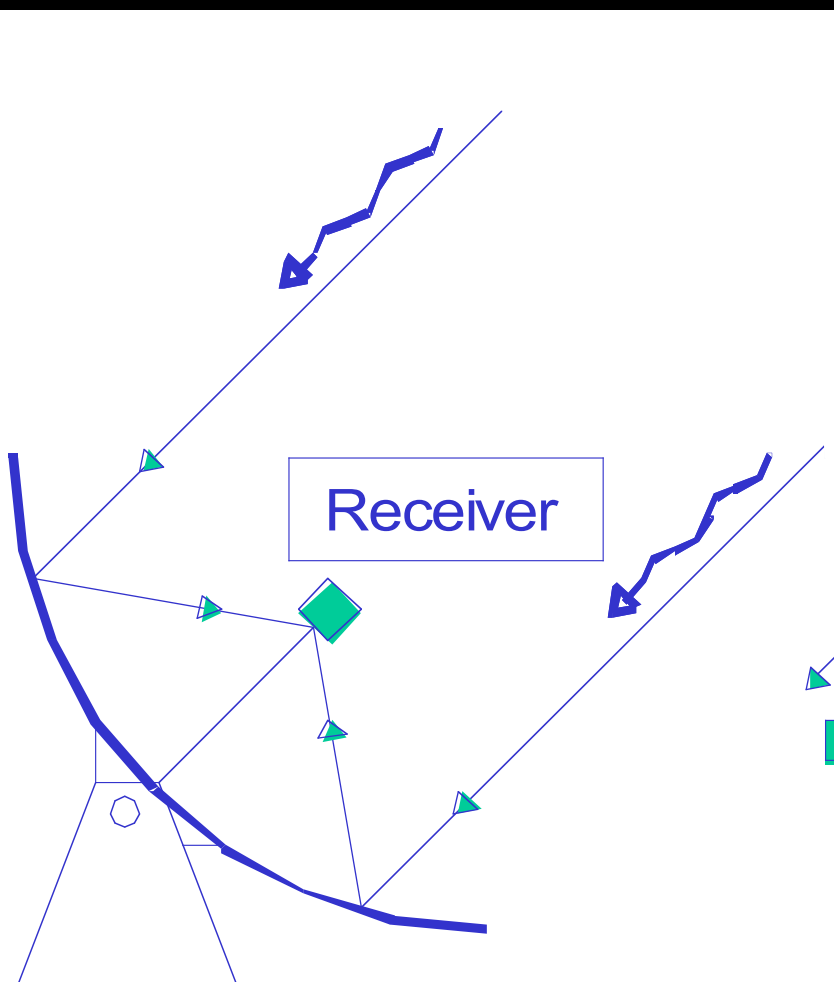


Despite the valiant efforts a few low-frequency pioneers (Grote Reber).

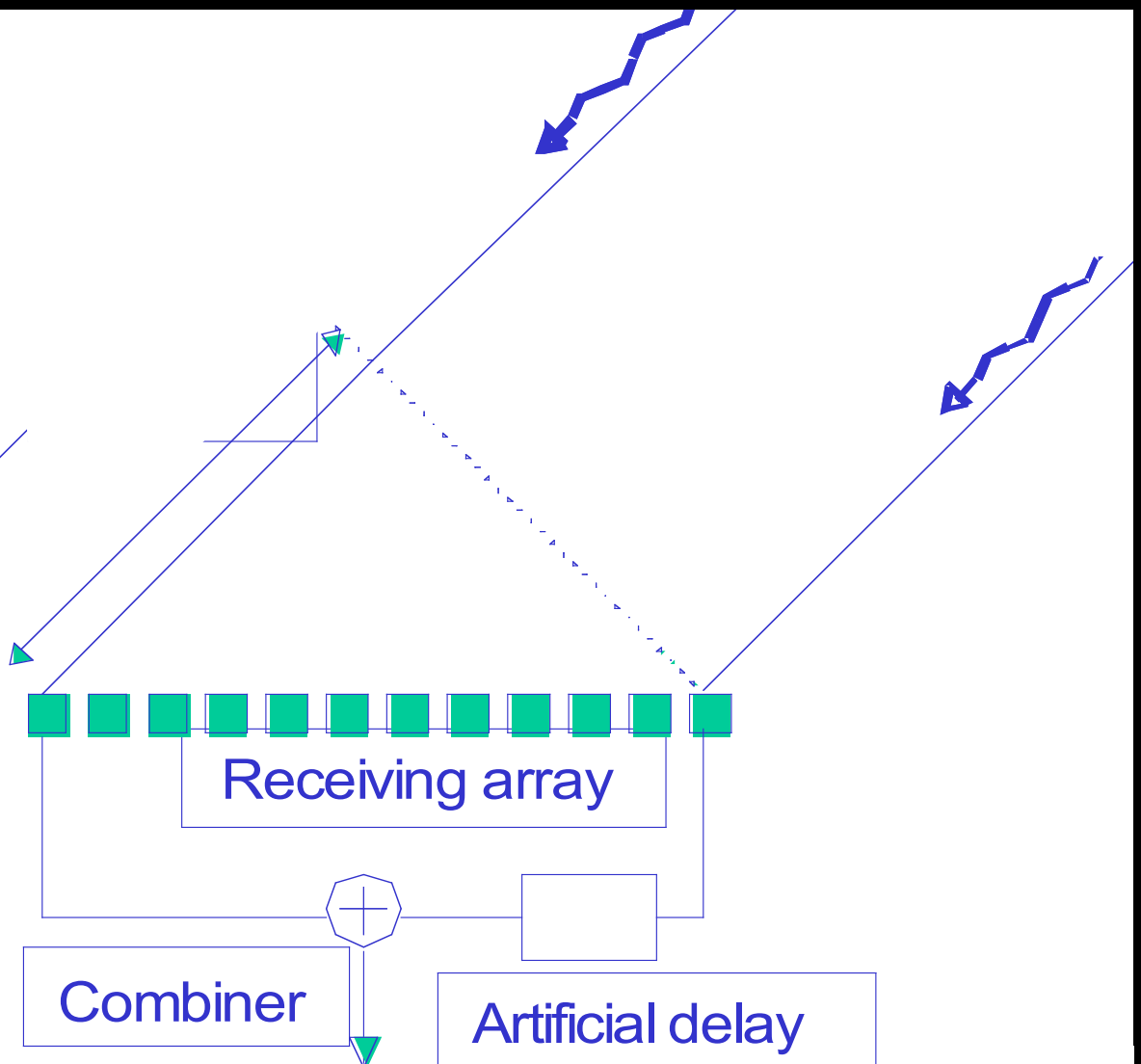


Low-frequency arrays difficult to “steer”.

How low-frequency dipole arrays work:



Parabolic reflector
(mechanical)



Aperture Array
(electronic)

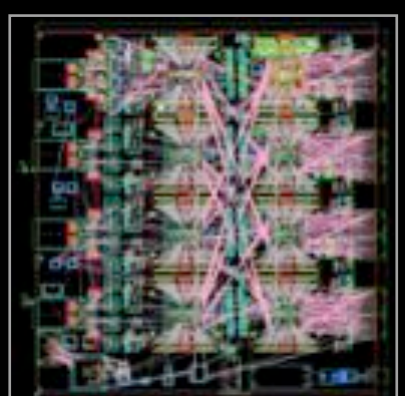
Why LOFAR ?

The time was right! - G. Miley et al.; J. Bregman et al.

- “Software Telescope” concept arose.....

==> *cheap collecting area + ICT & Adv. digital processing.*

x N +



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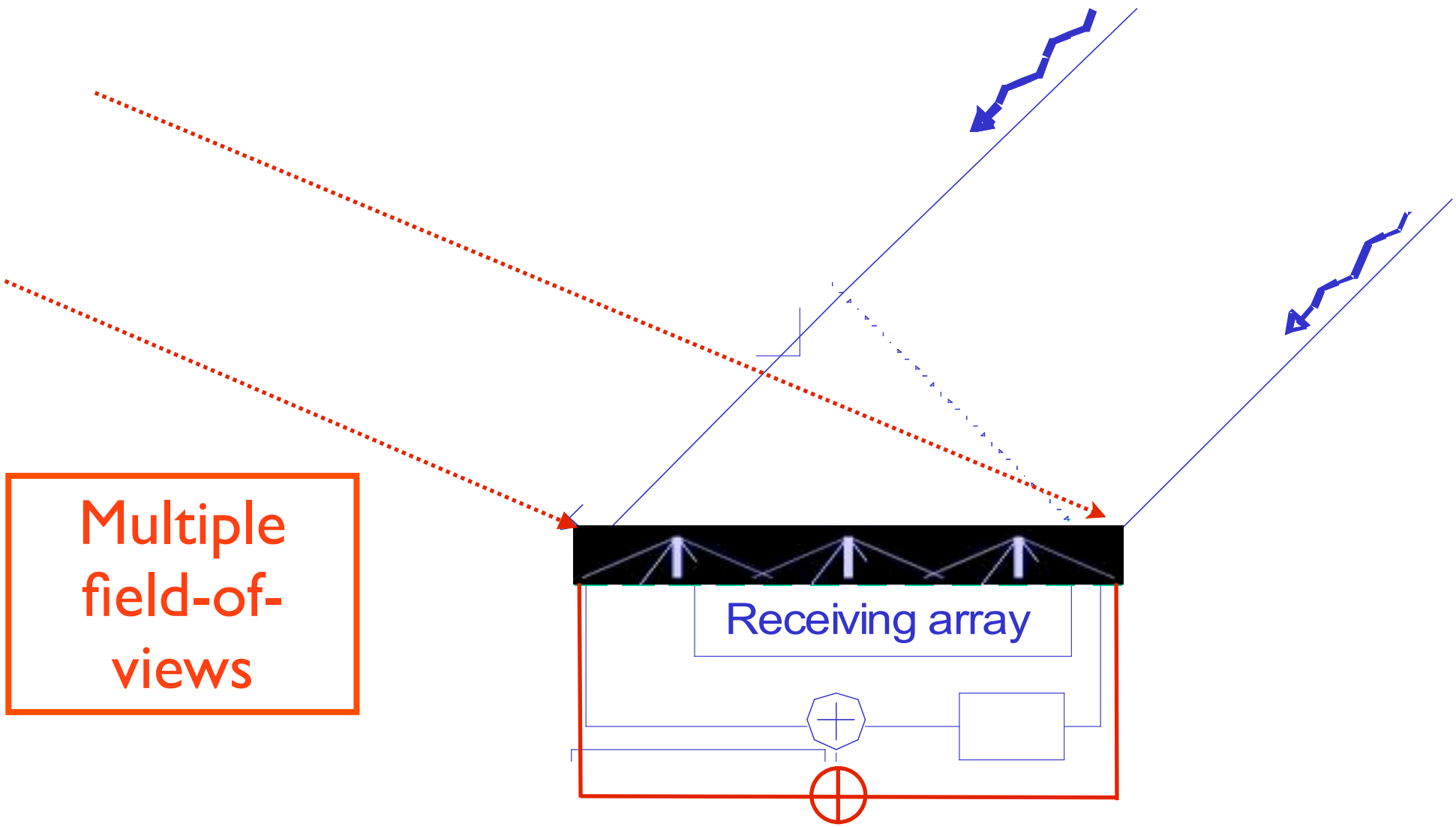
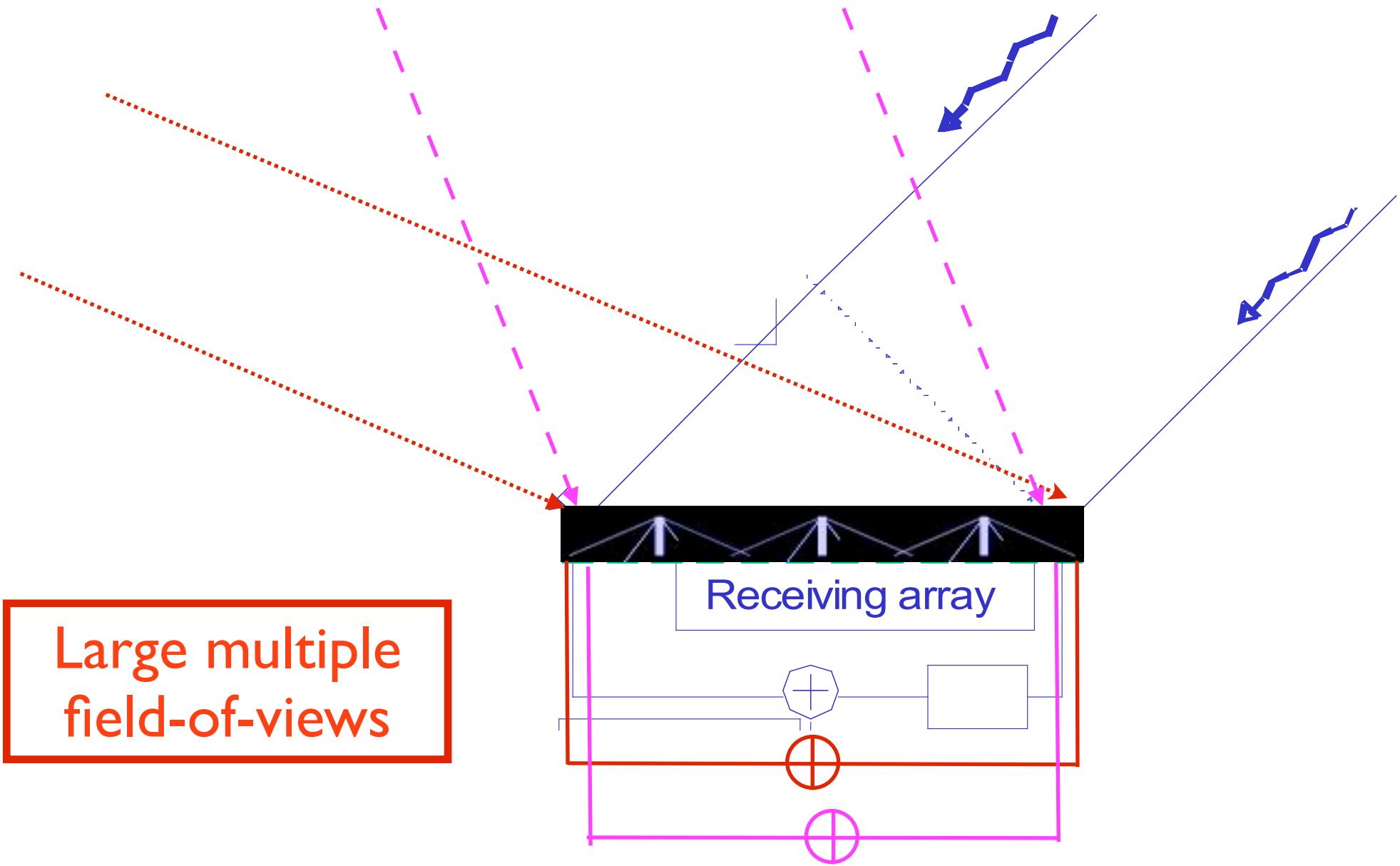
NEW OPPORTUNITIES



Multiple field-of-views

NEW CAPABILITIES



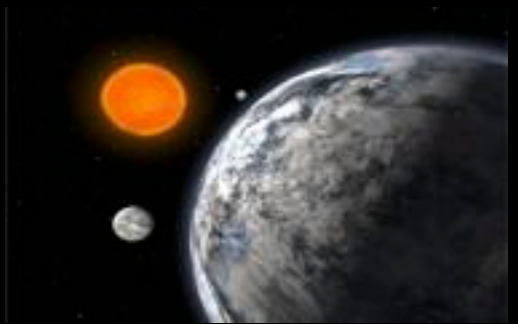
Large multiple field-of-views

woensdag 27 juli 2011

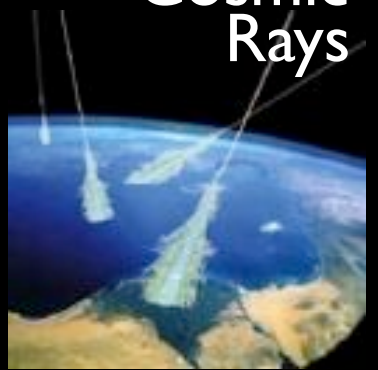
New science [LOFAR examples]

Solar System

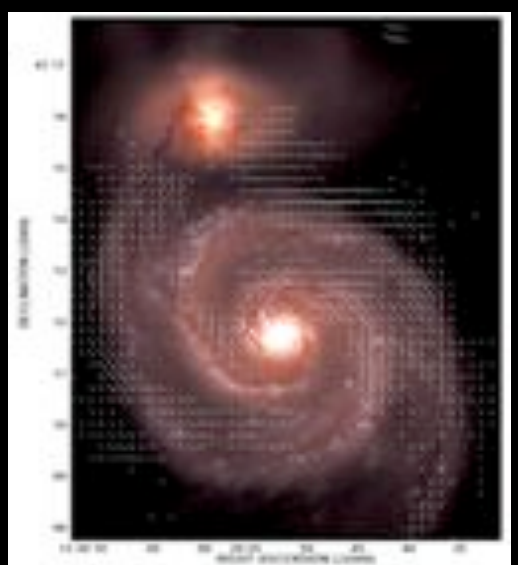
Transient sky



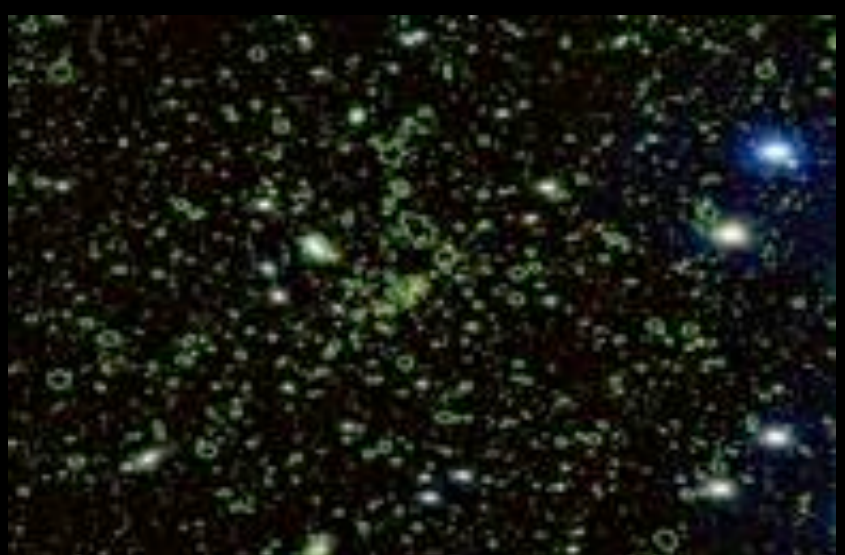
SETI/Exoplanets



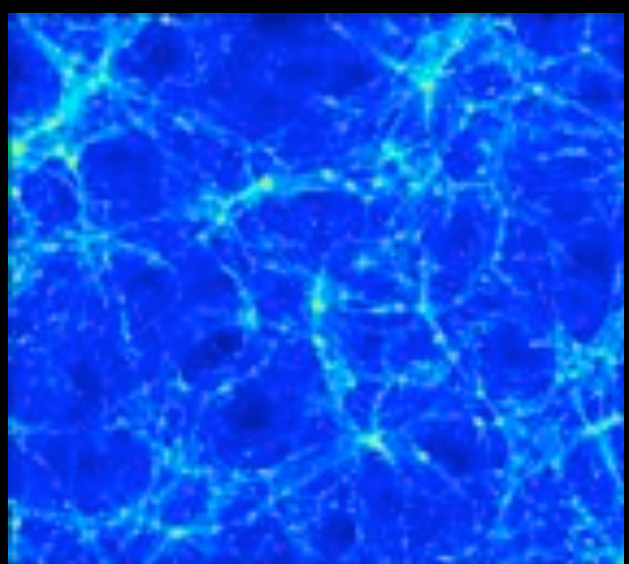
Cosmic Rays



Cosmic Magnetism

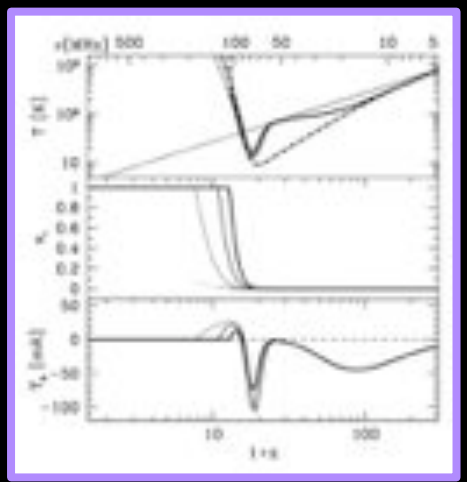


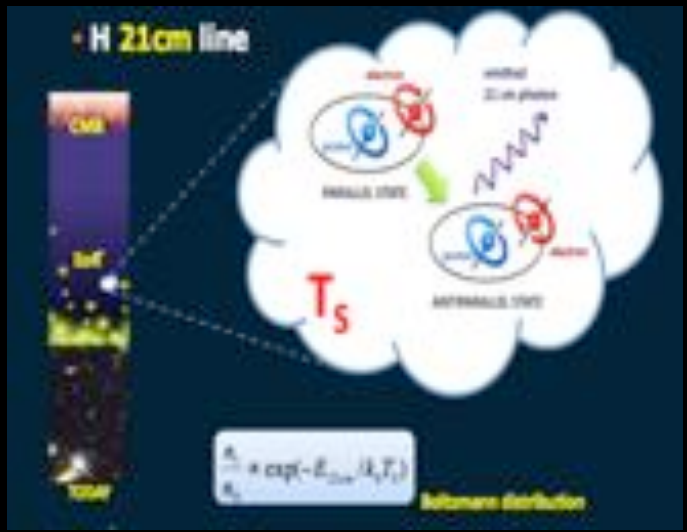
Deep Extragalactic Surveys

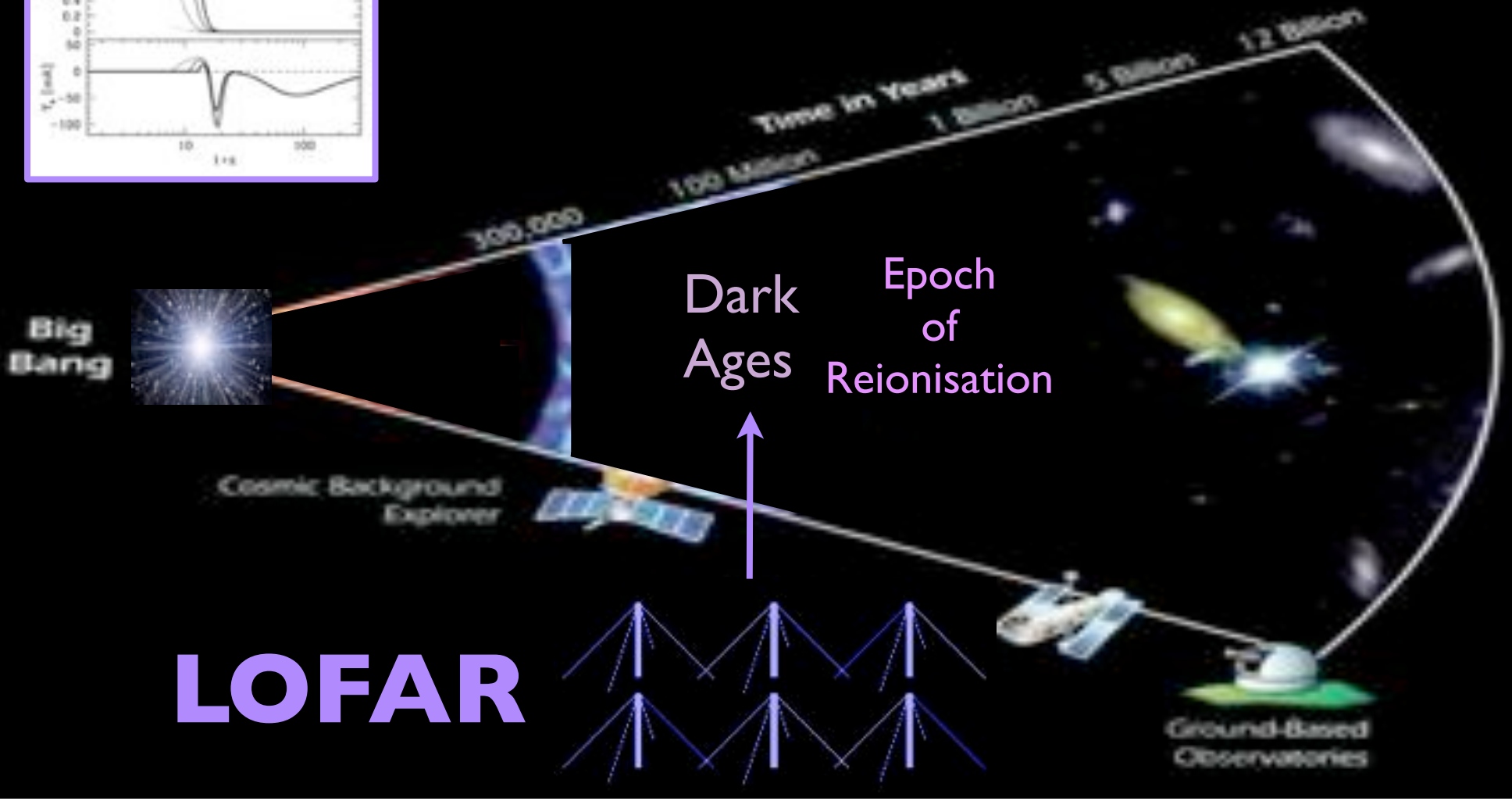


Epoch of Reionisation

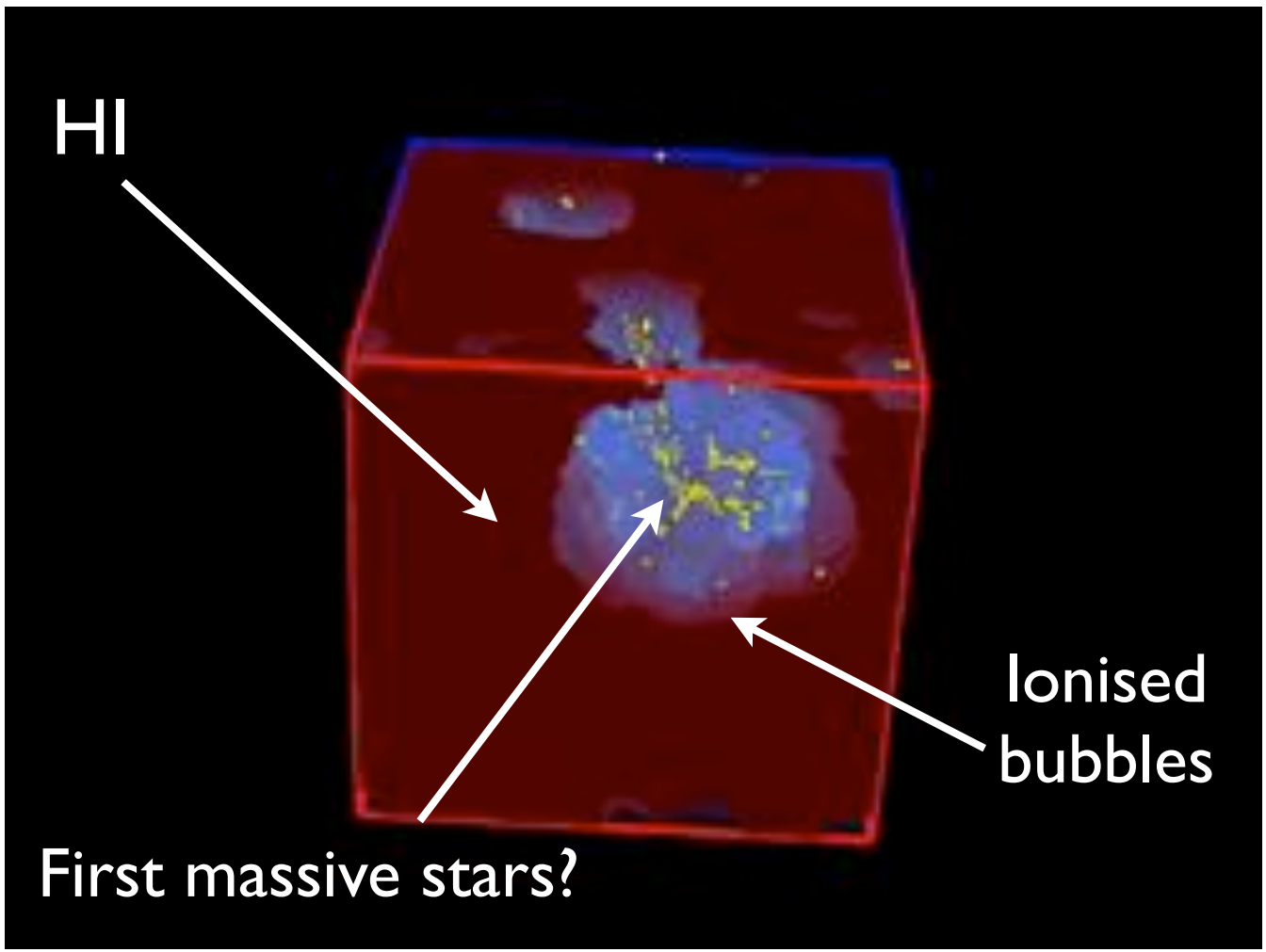
A new window on the Universe







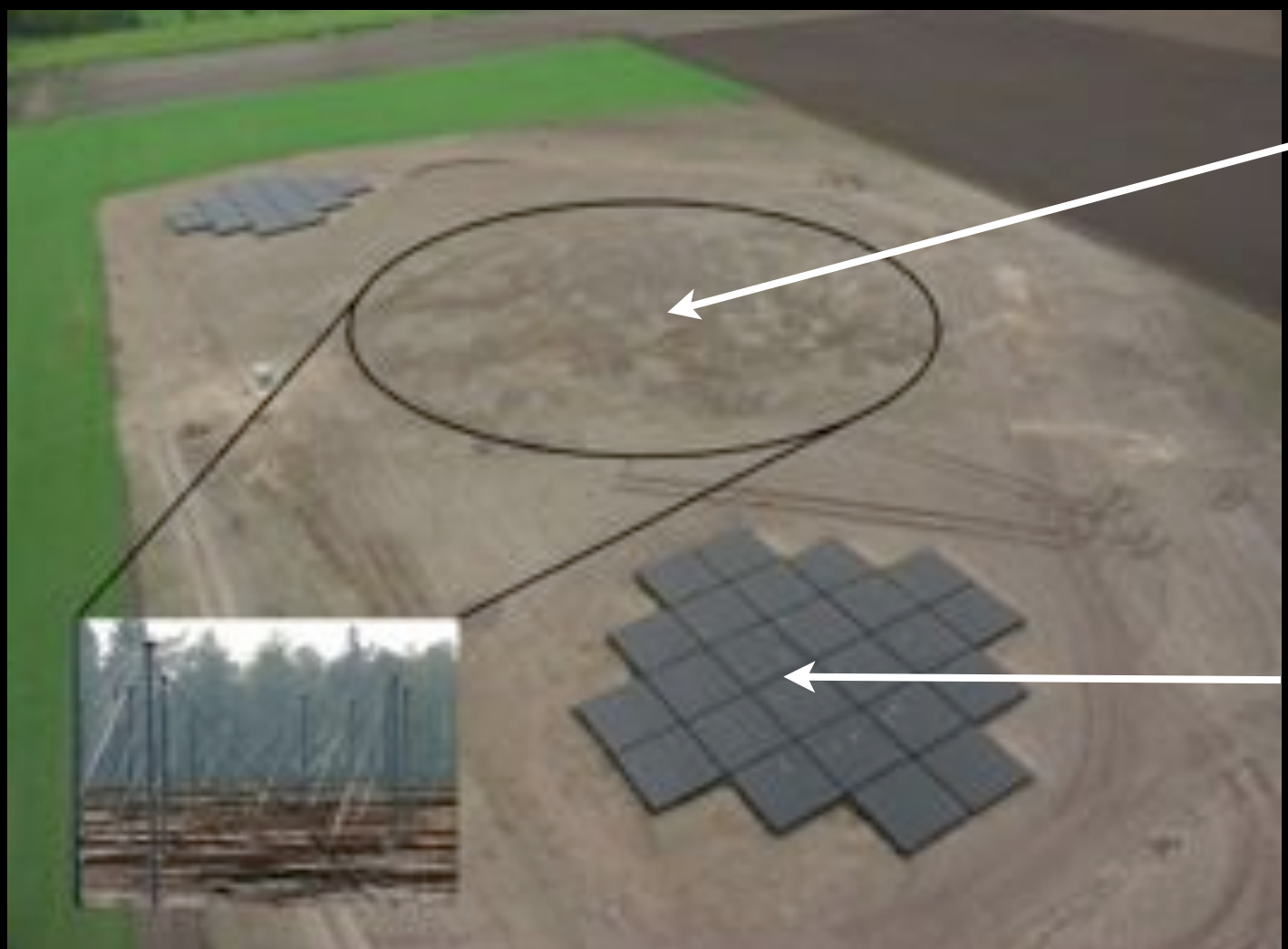
Playing God... looking from the outside in!

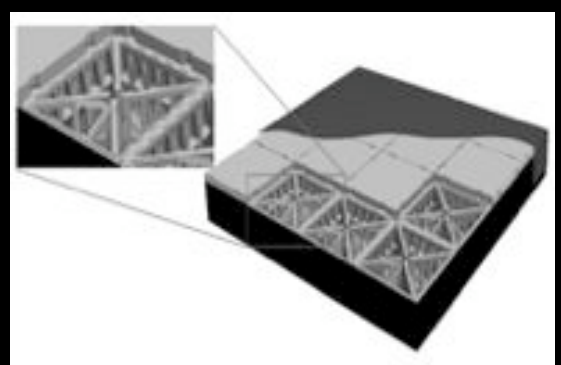


Main elements of LOFAR

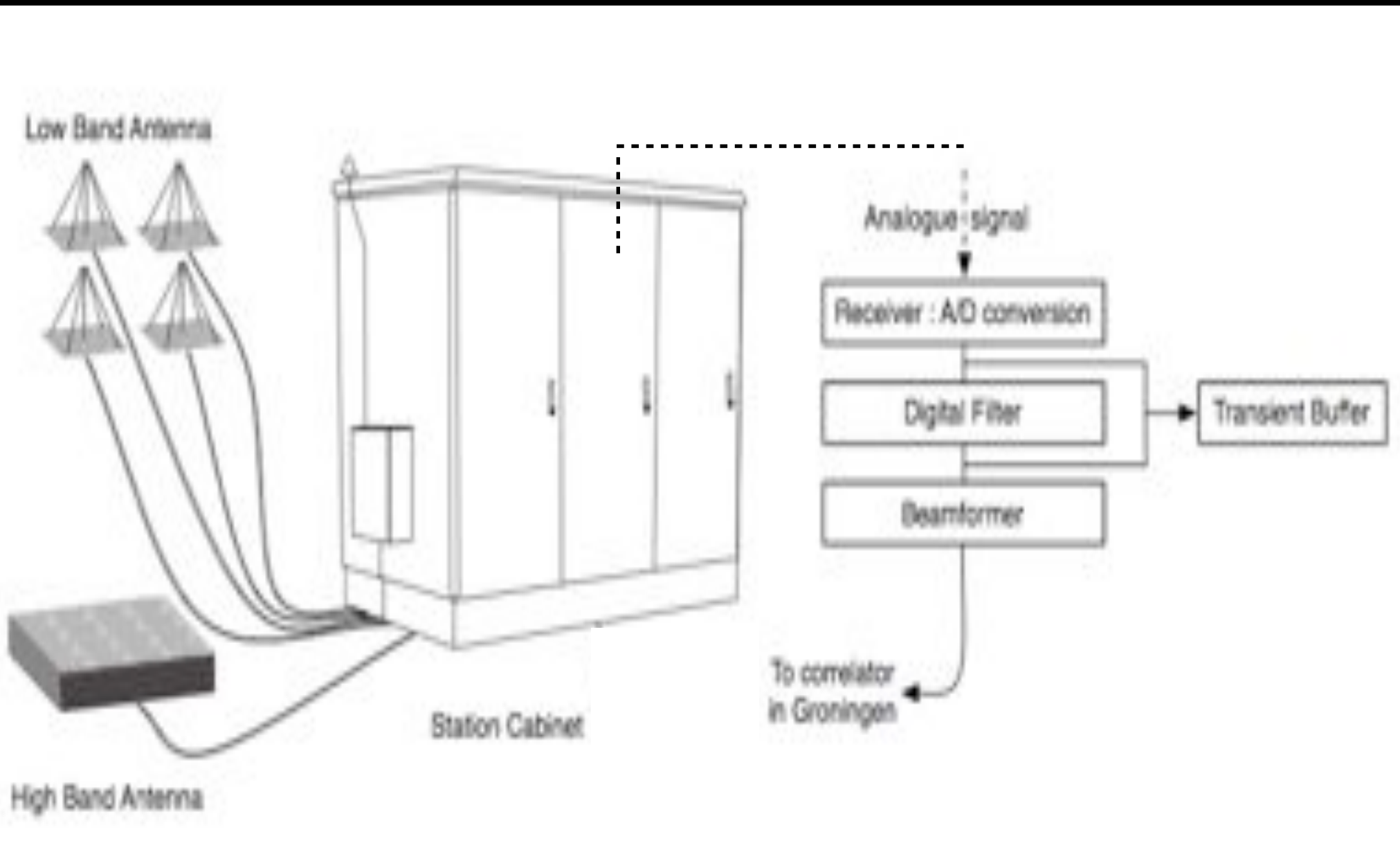
Simple antenna front ends:

96 Low-band antennas (10-90 MHz)

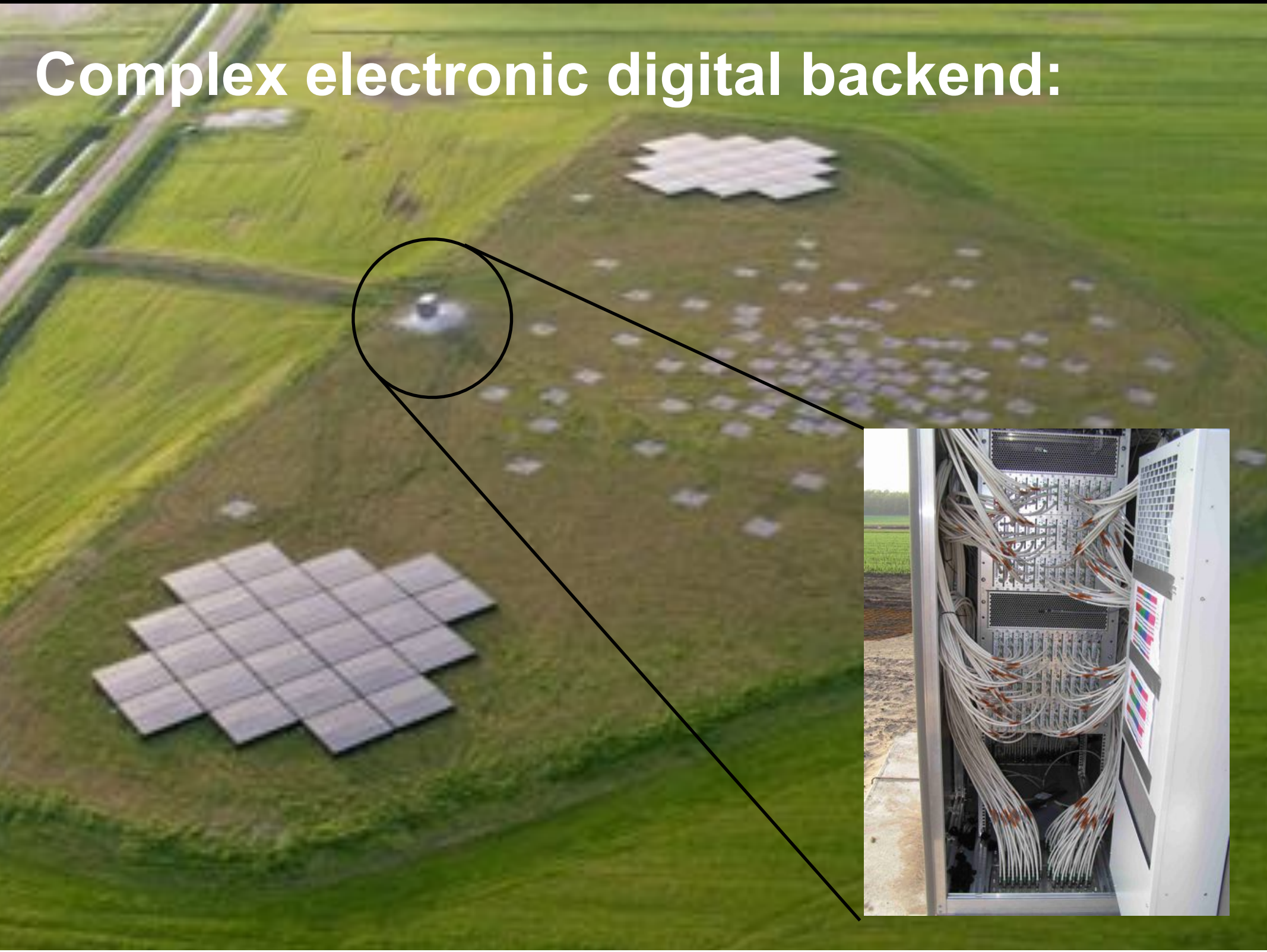




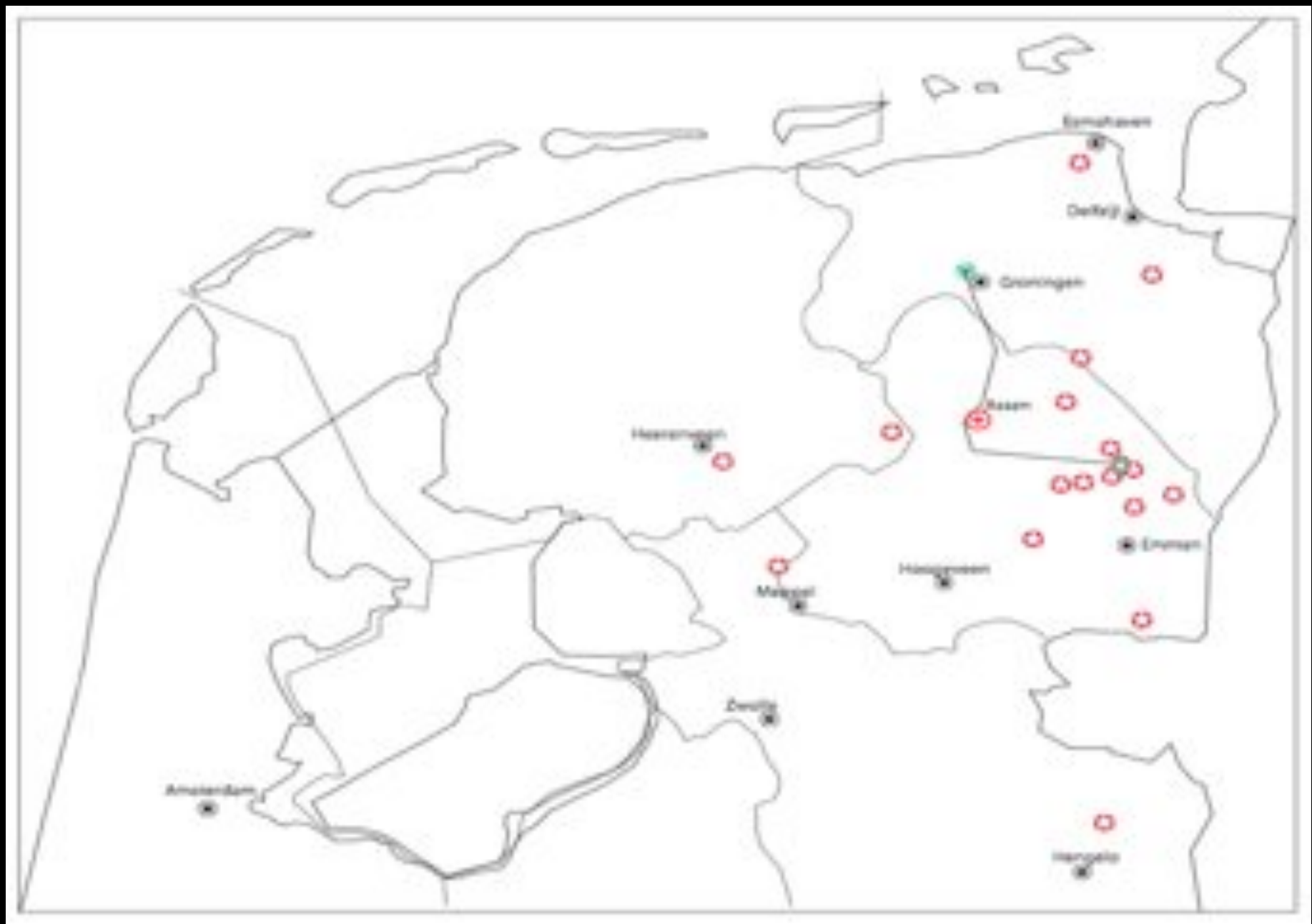
48 High-band antenna tiles (120-240 MHz)


Low Band Antenna
Analogue signal
Receiver : A/D conversion
Digital Filter
Transient Buffer
Beamformer
To correlator
in Groningen
Station Cabinet
High Band Antenna

Complex electronic digital backend:



40 NL stations - 6 remain to be built over next yr.



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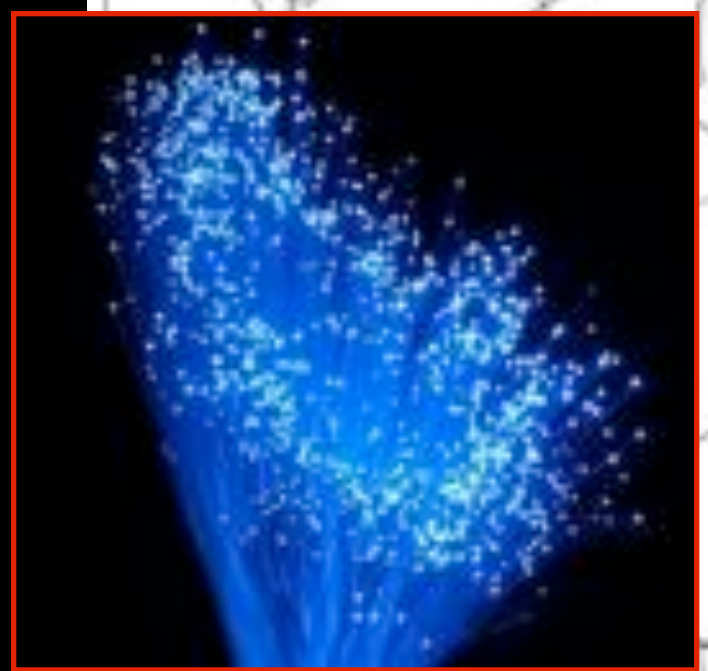
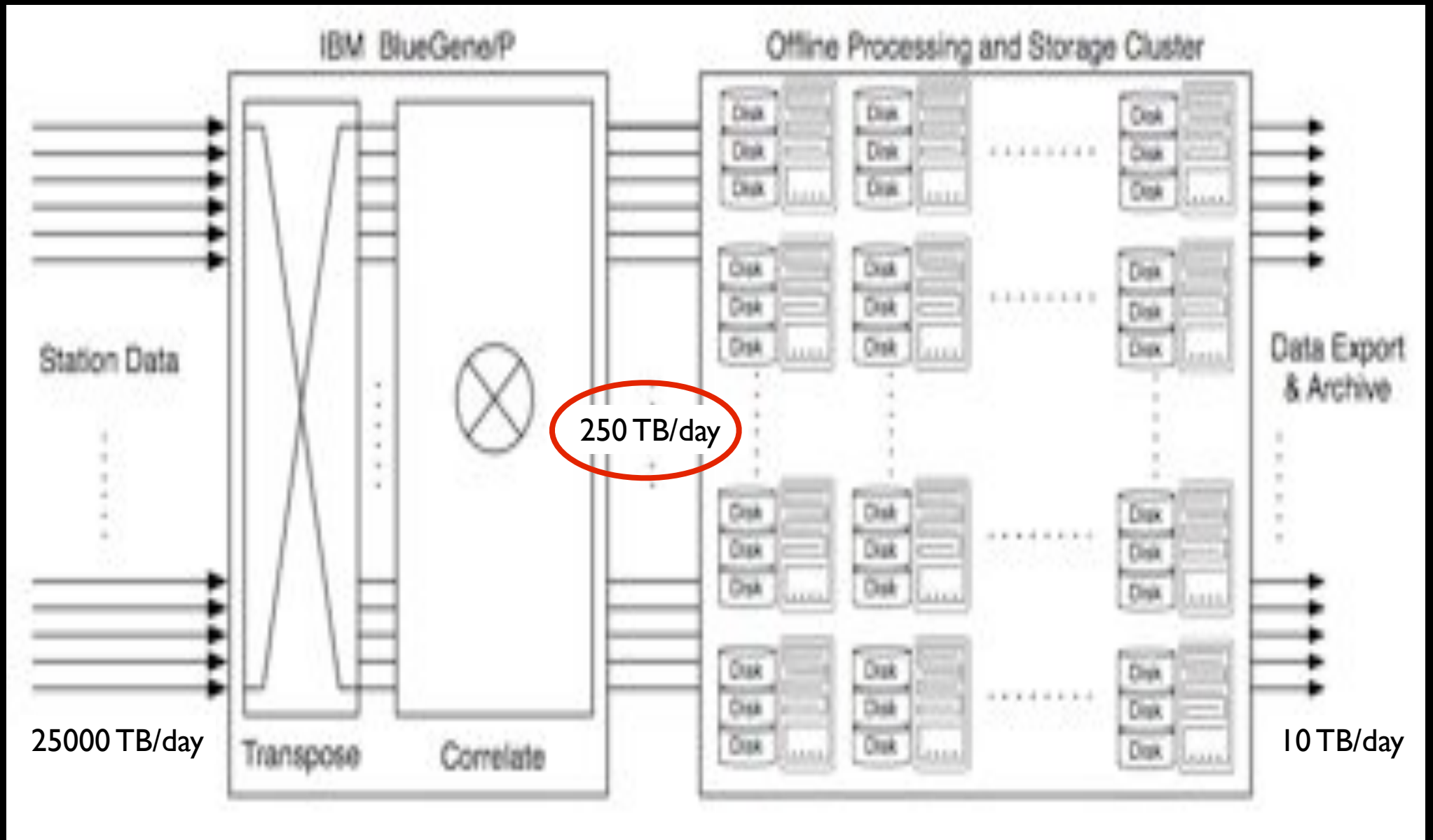




42 TFlops

5 TFlops & 1 PByte storage

6 densely packed LOFAR stations

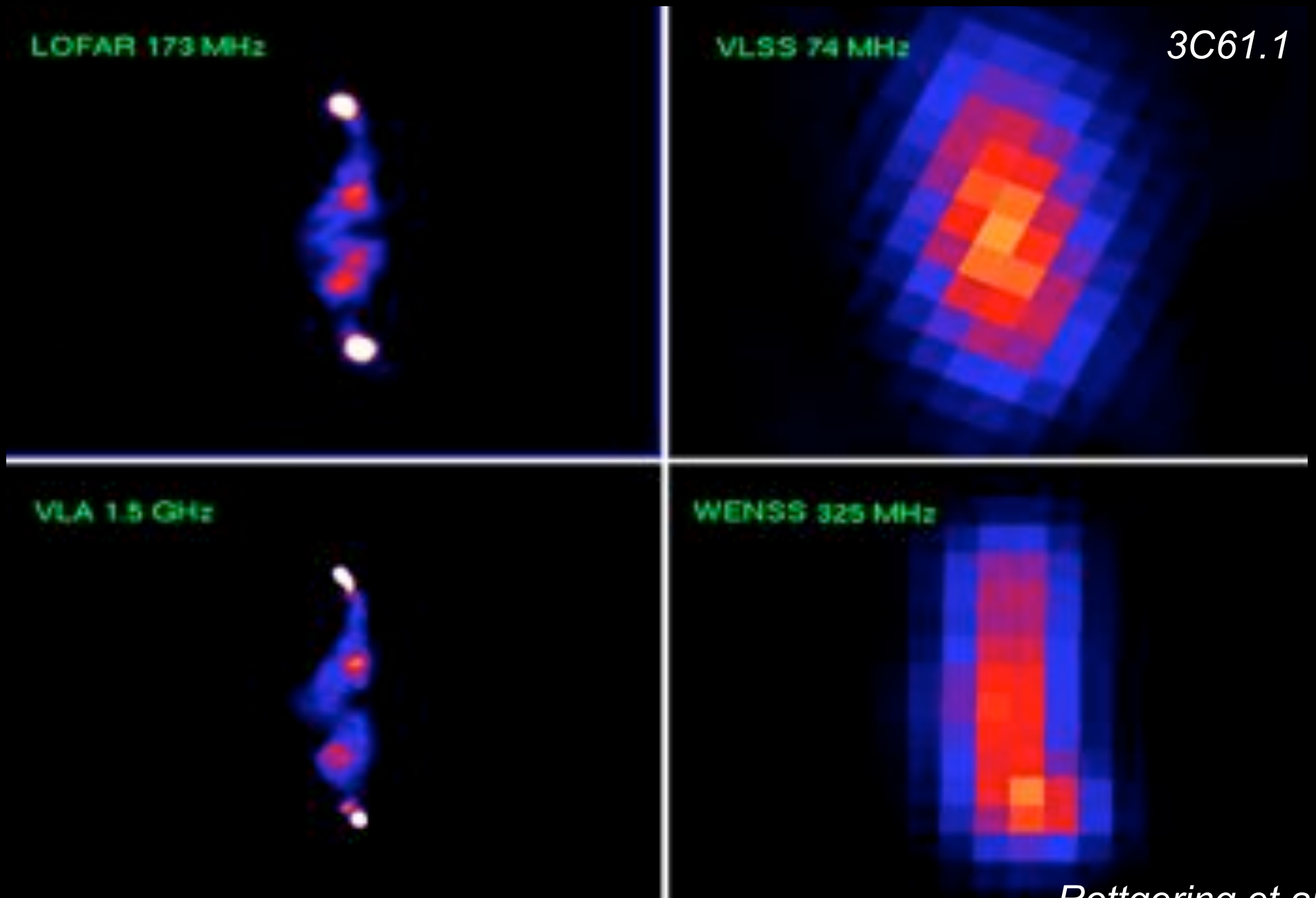
LOFAR inner core and “superterp”

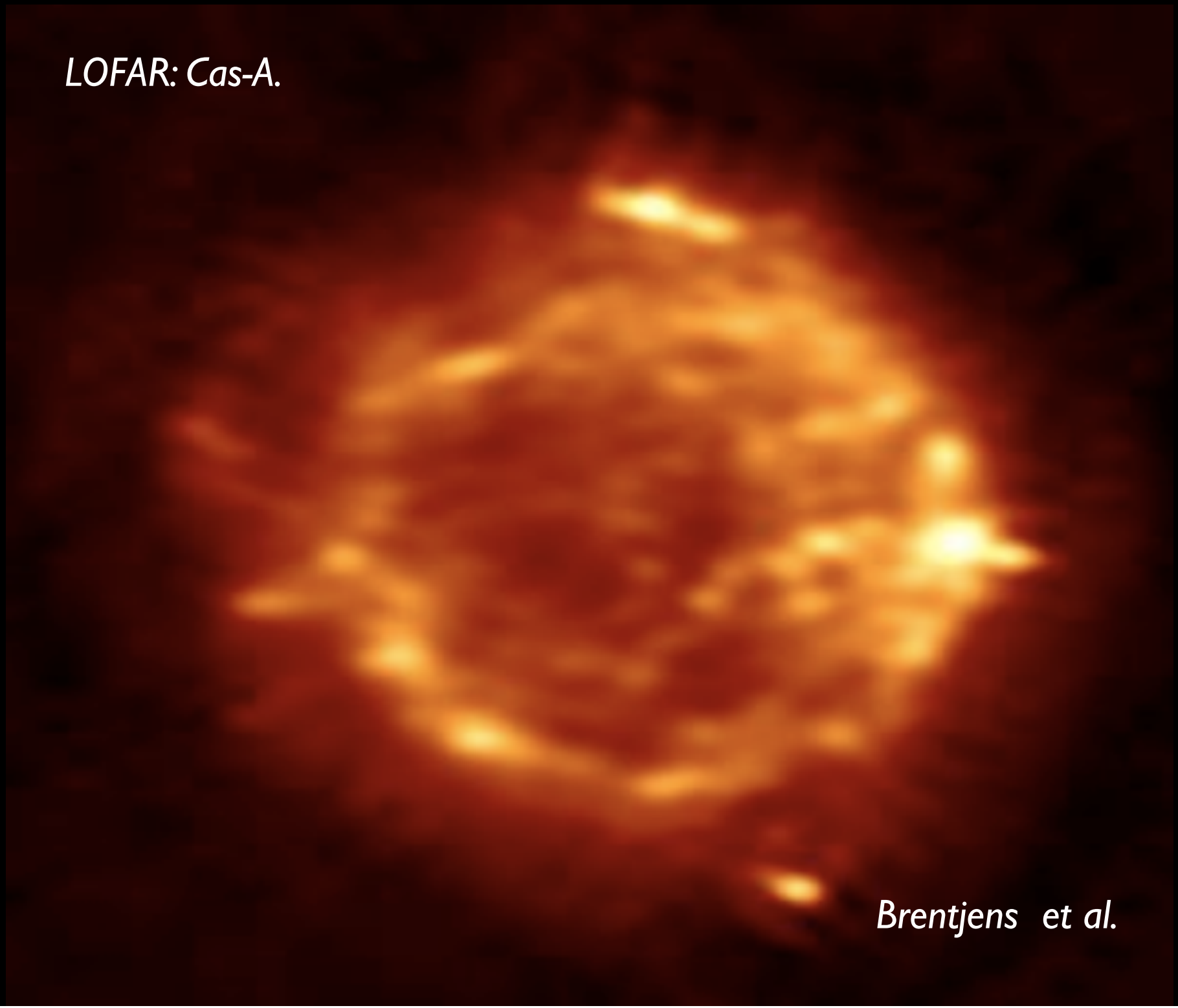

18 core stations (incl. superterp) near Exloo, Drenthe -
all located within an area of 2 km.

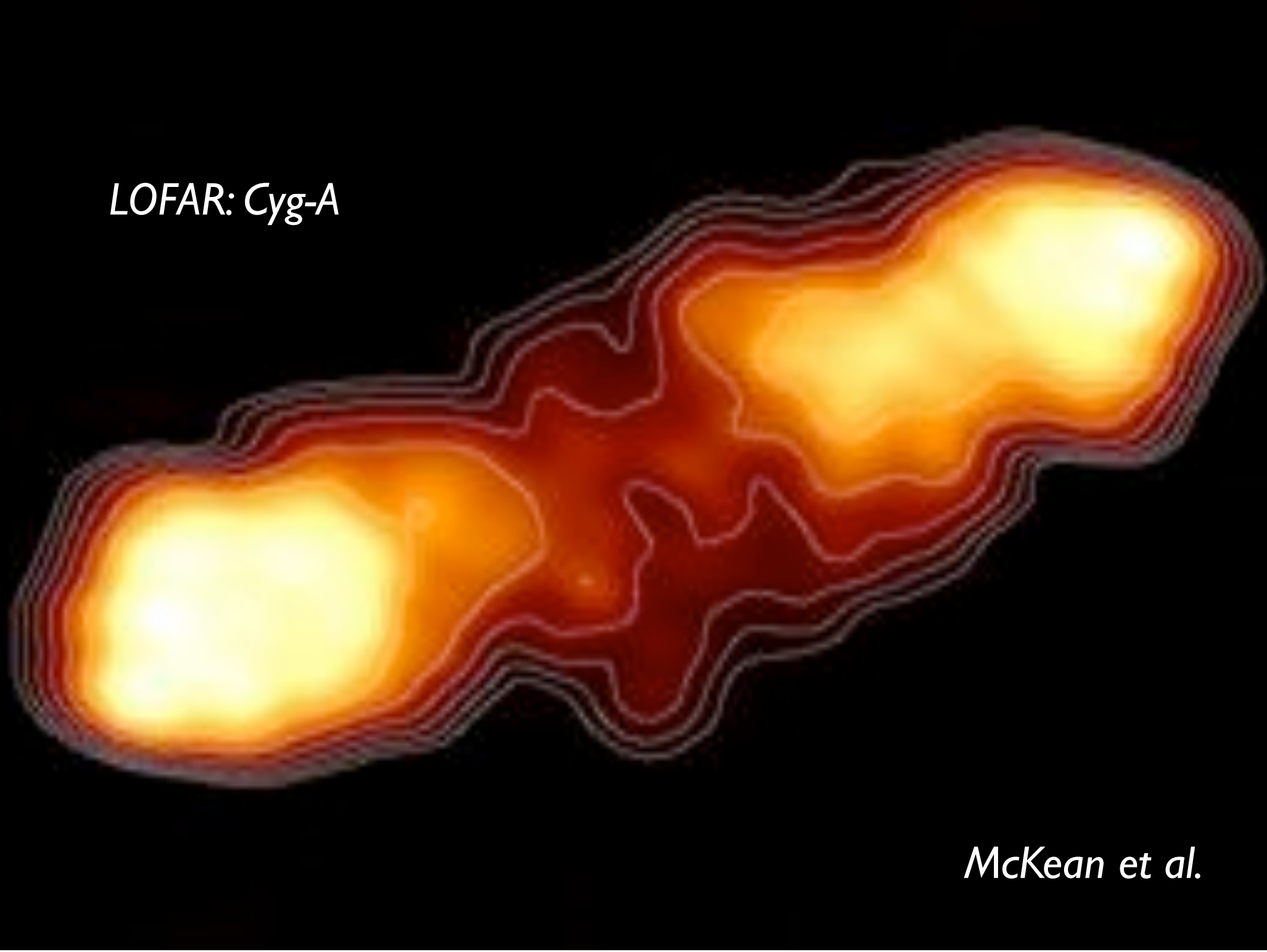
8+ European LOFAR stations:

LOFAR UK station at Chilbolton

LOFAR commissioning results

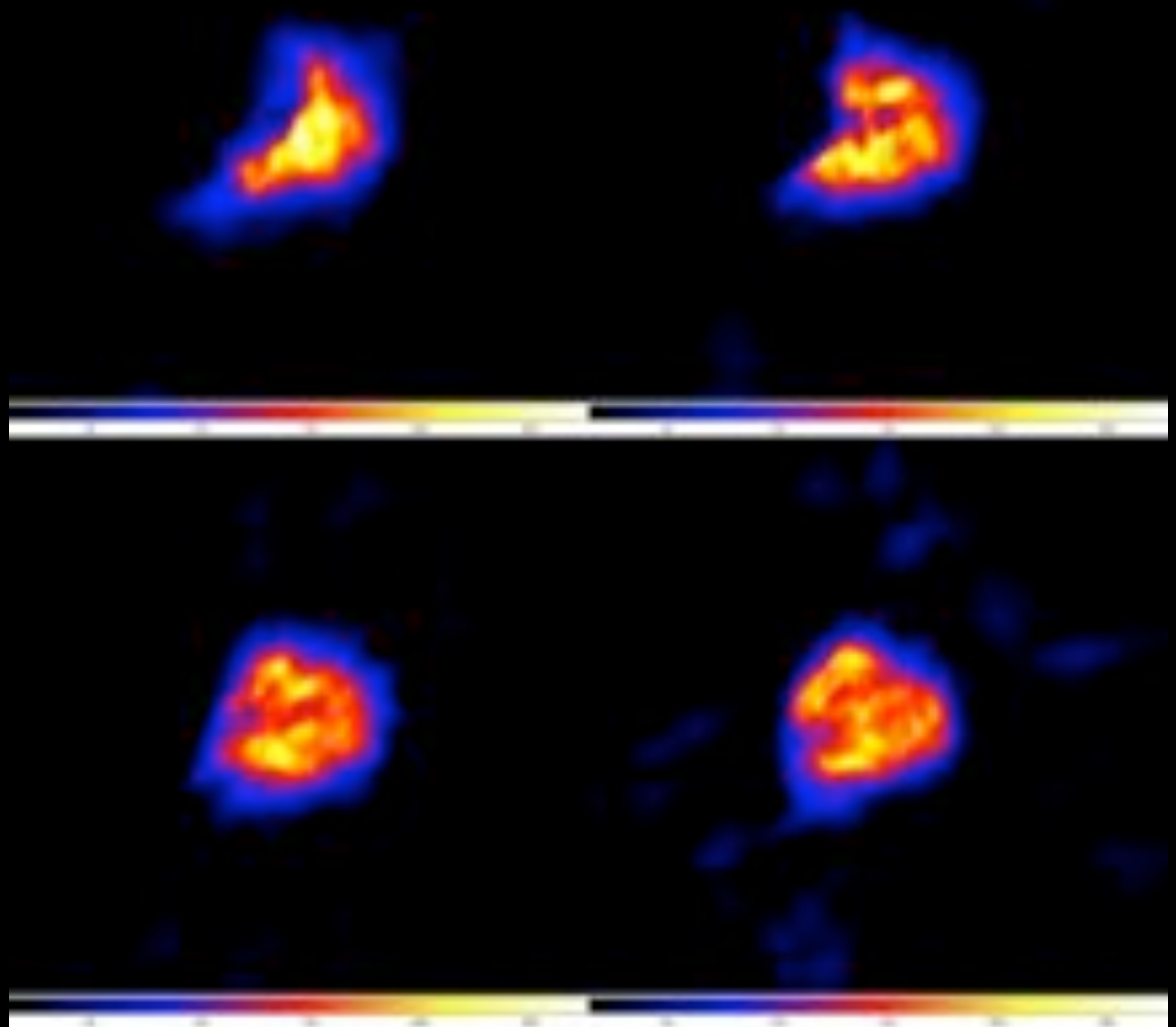



LOFAR: Cas-A.
Brentjens et al.

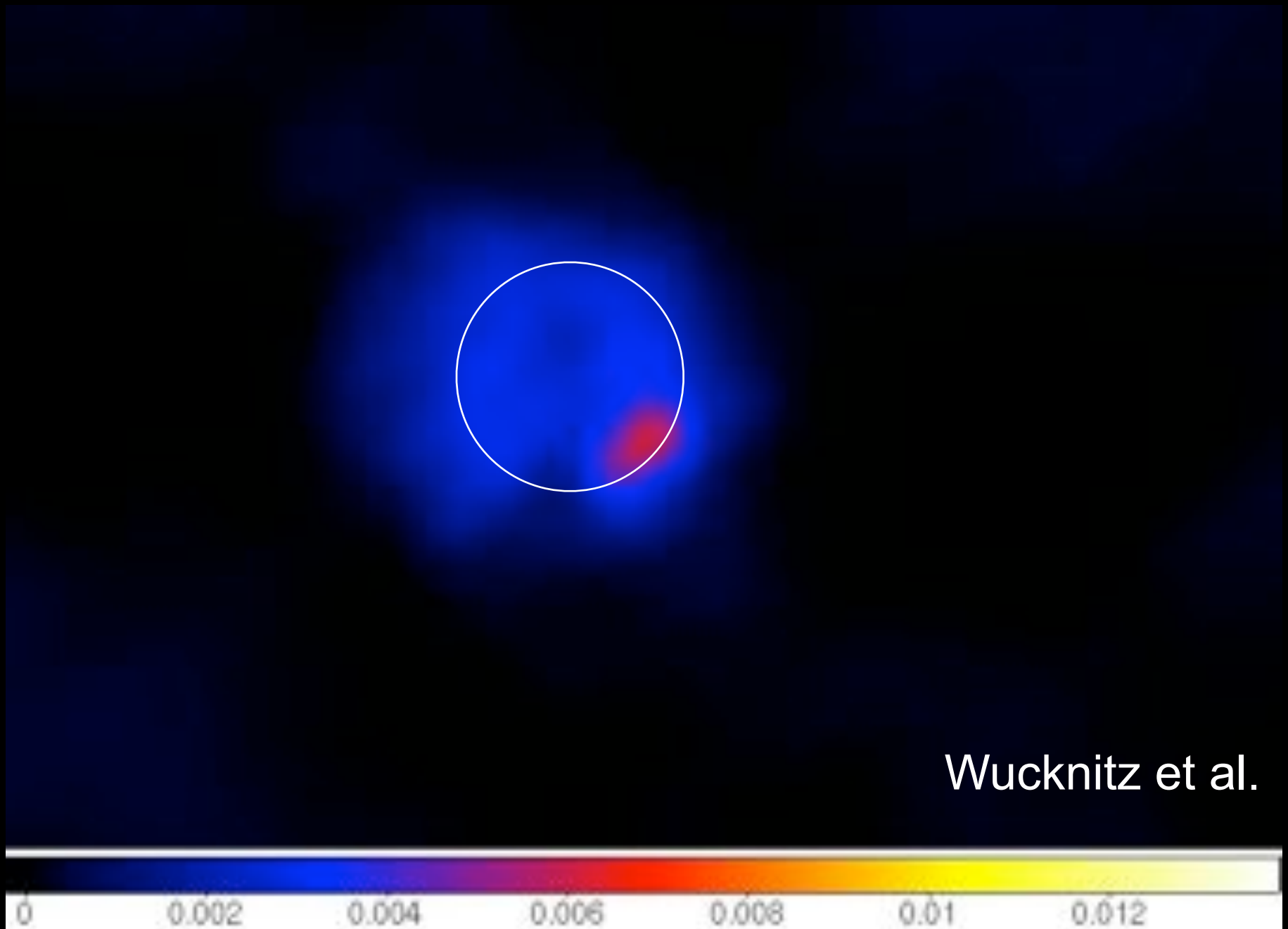

LOFAR: Cyg-A
McKean et al.

LOFAR solar eclipse

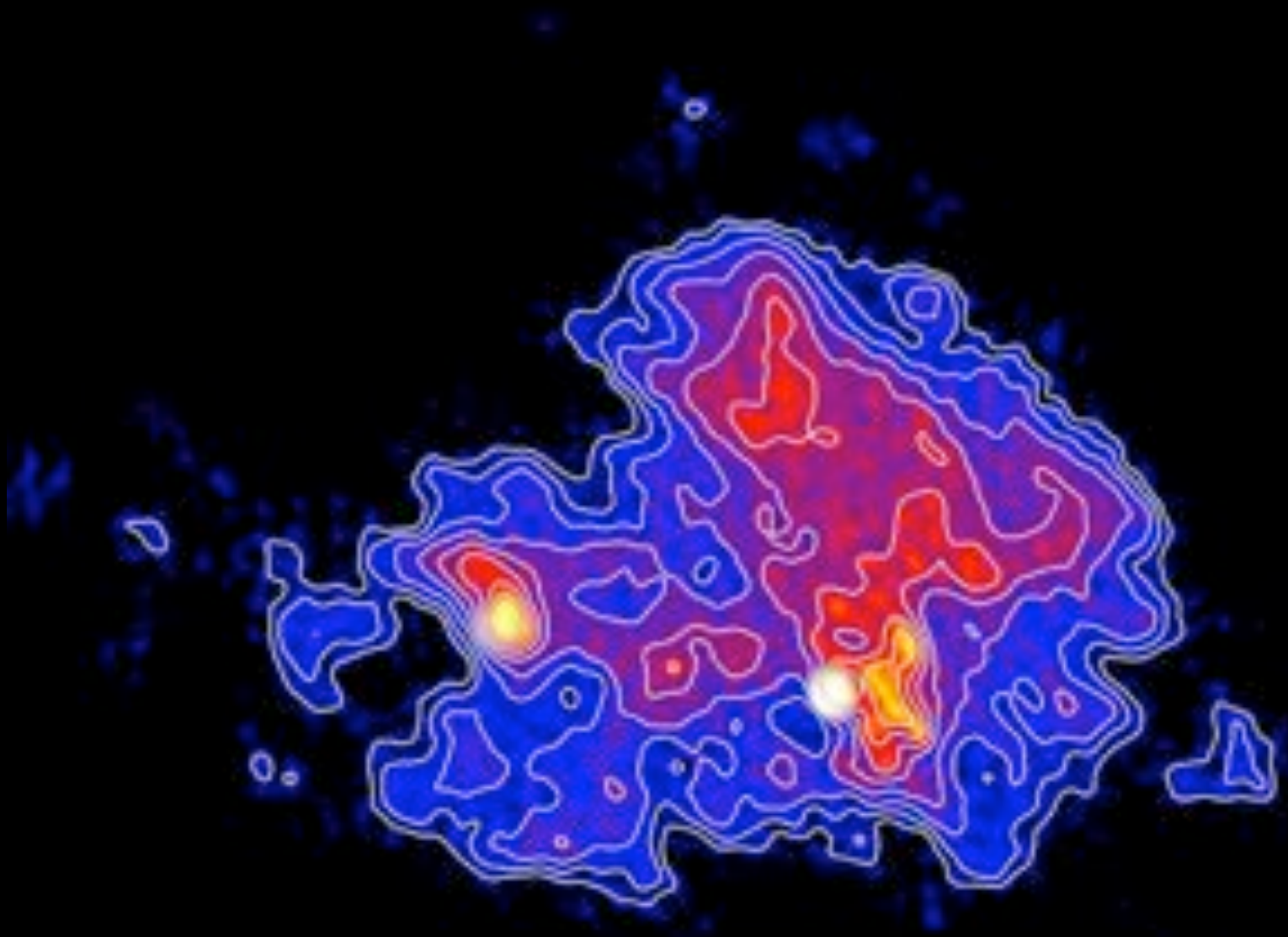
Brentjens et al.



LOFAR solar observations

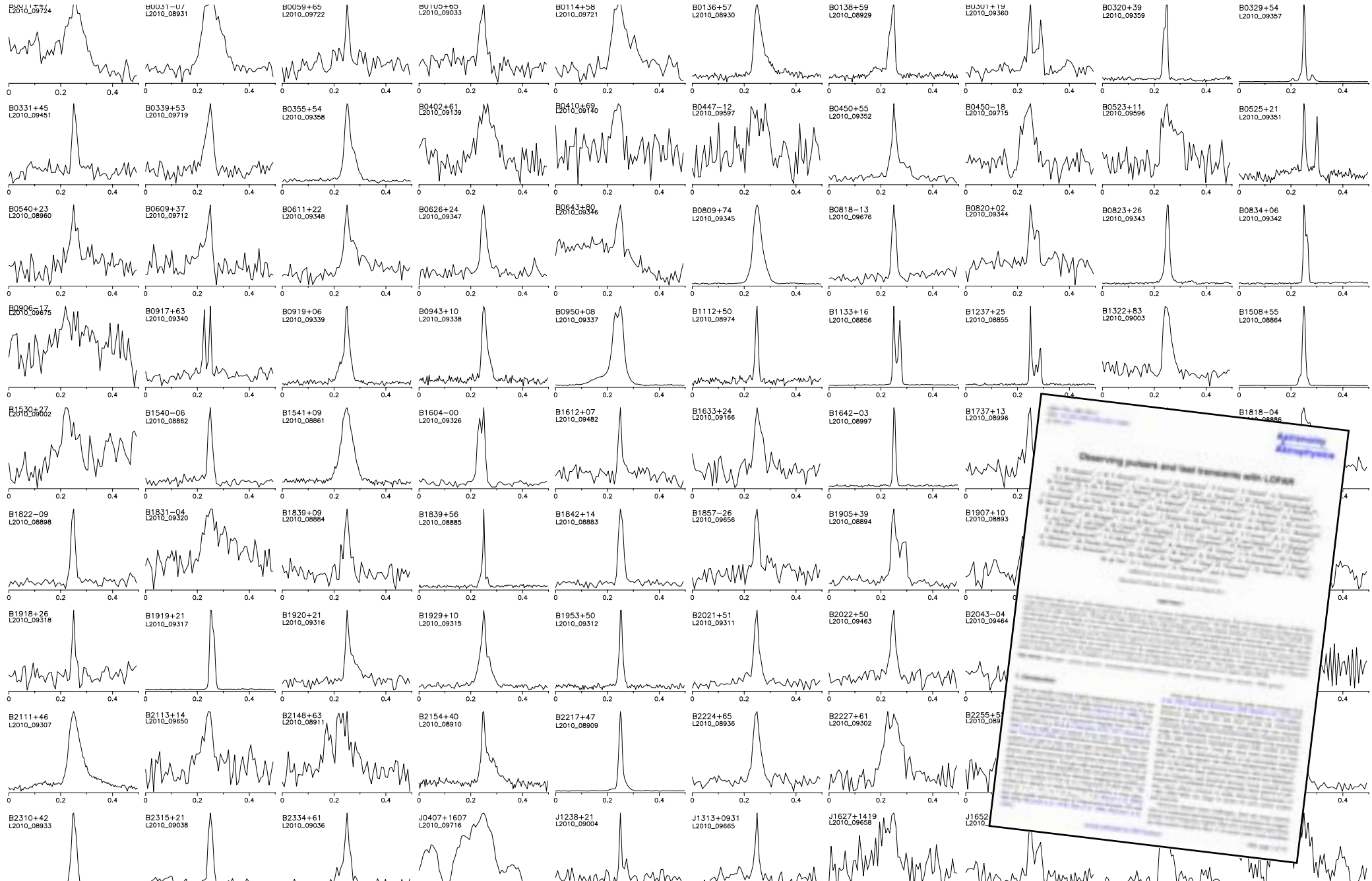


Abell Cluster



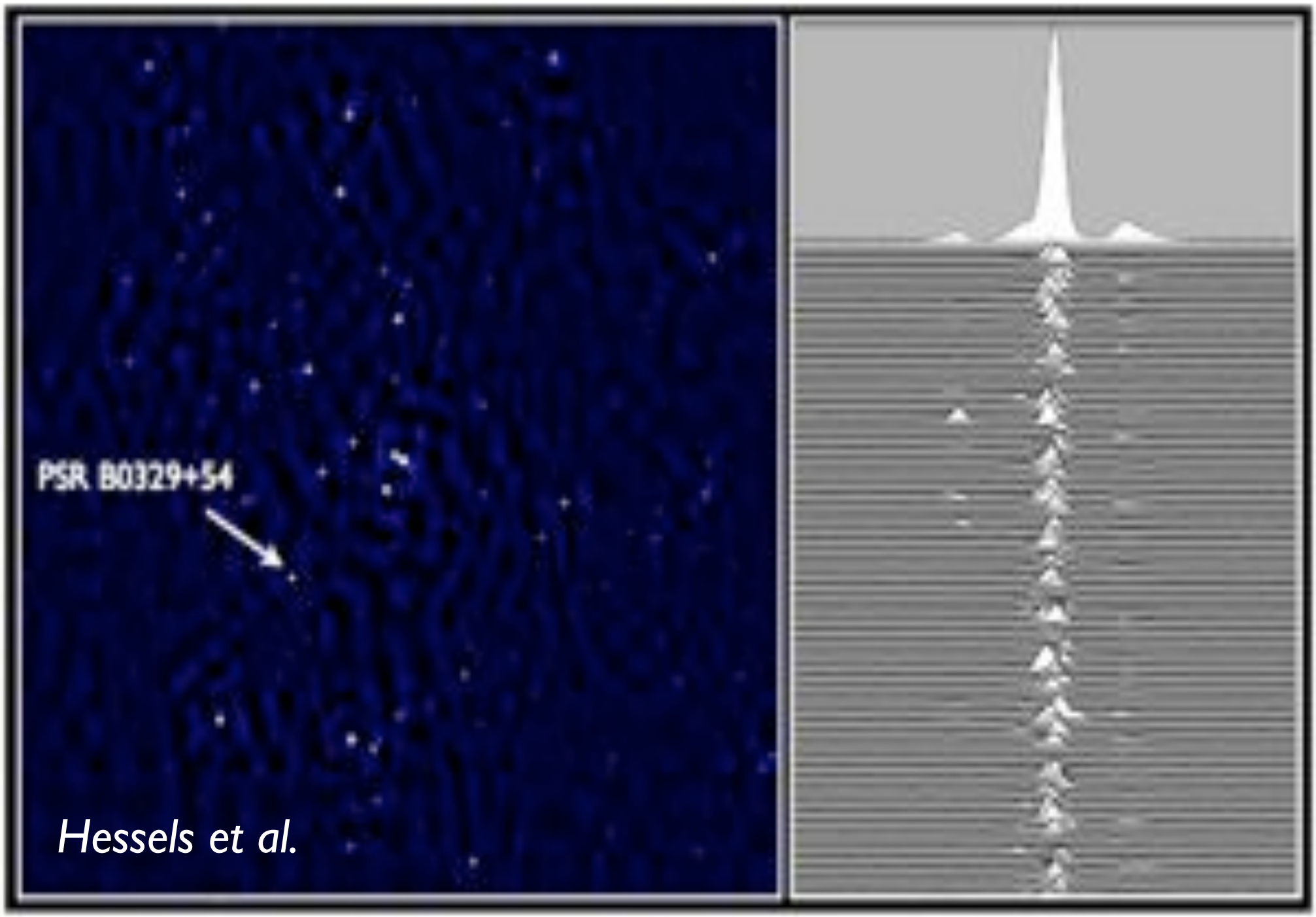
Rottgering et al.

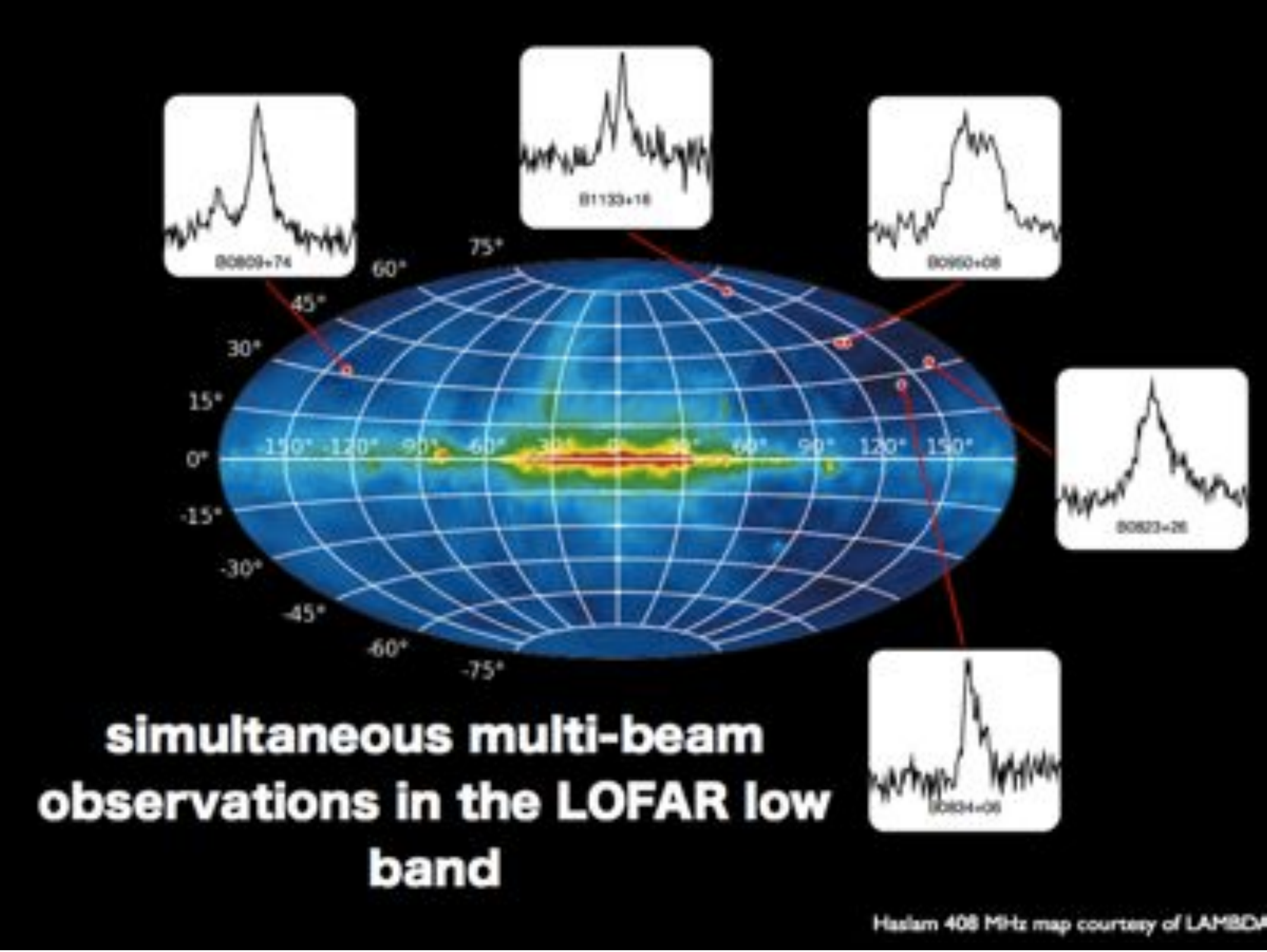
LOFAR - 100 pulsar profiles!



Stappers, Hessels, Alexov et al. 2011

LOFAR - pulsar detection + imaging simultaneously



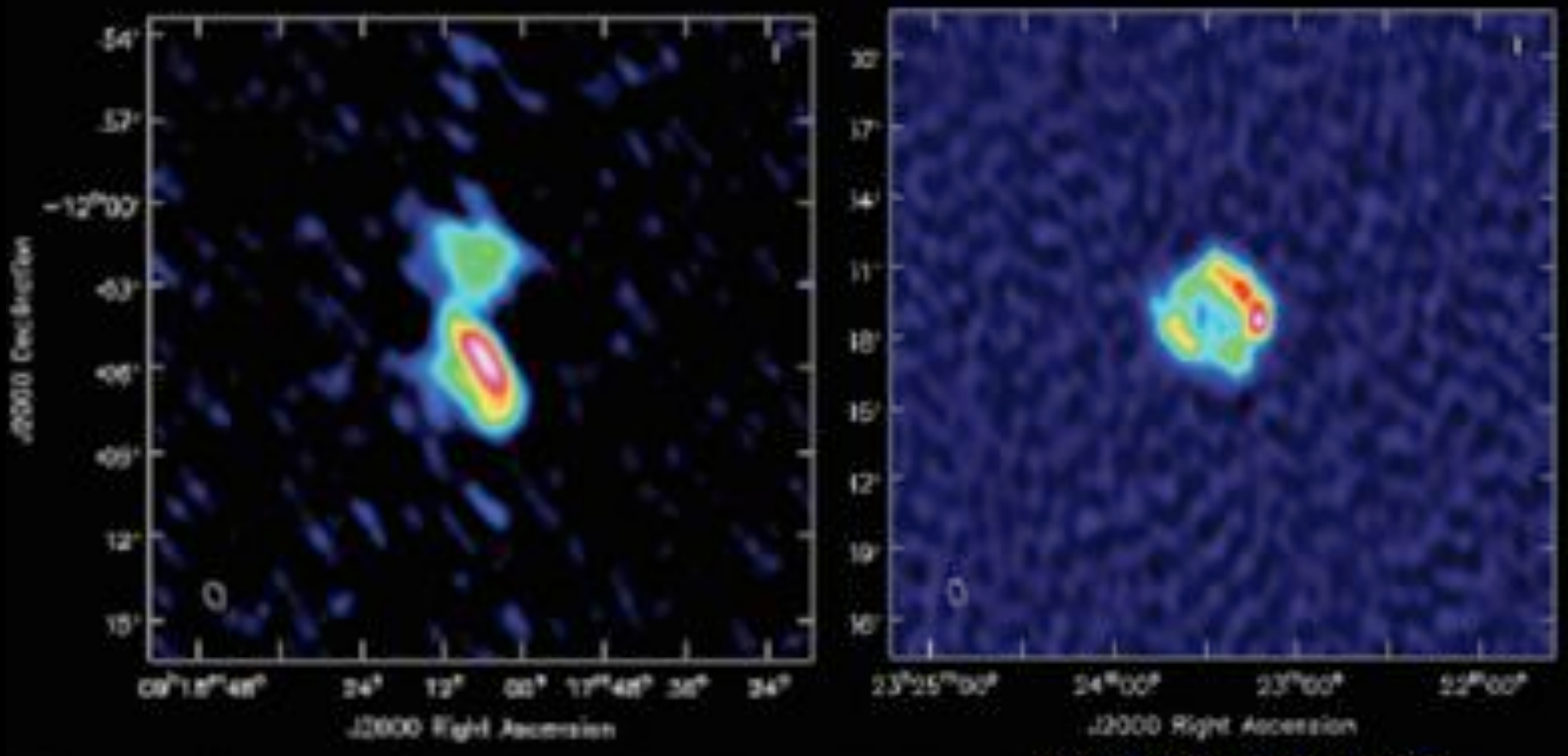

B0809+74
B1133+16
B0950+08
B0823+26
B0834+06
75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
-150°
-120°
-90°
-60°
90°
120°
150°
simultaneous multi-beam observations in the LOFAR low band
Haslam 408 MHz map courtesy of LAMBDA

Aperture Arrays - work - also on long baselines!

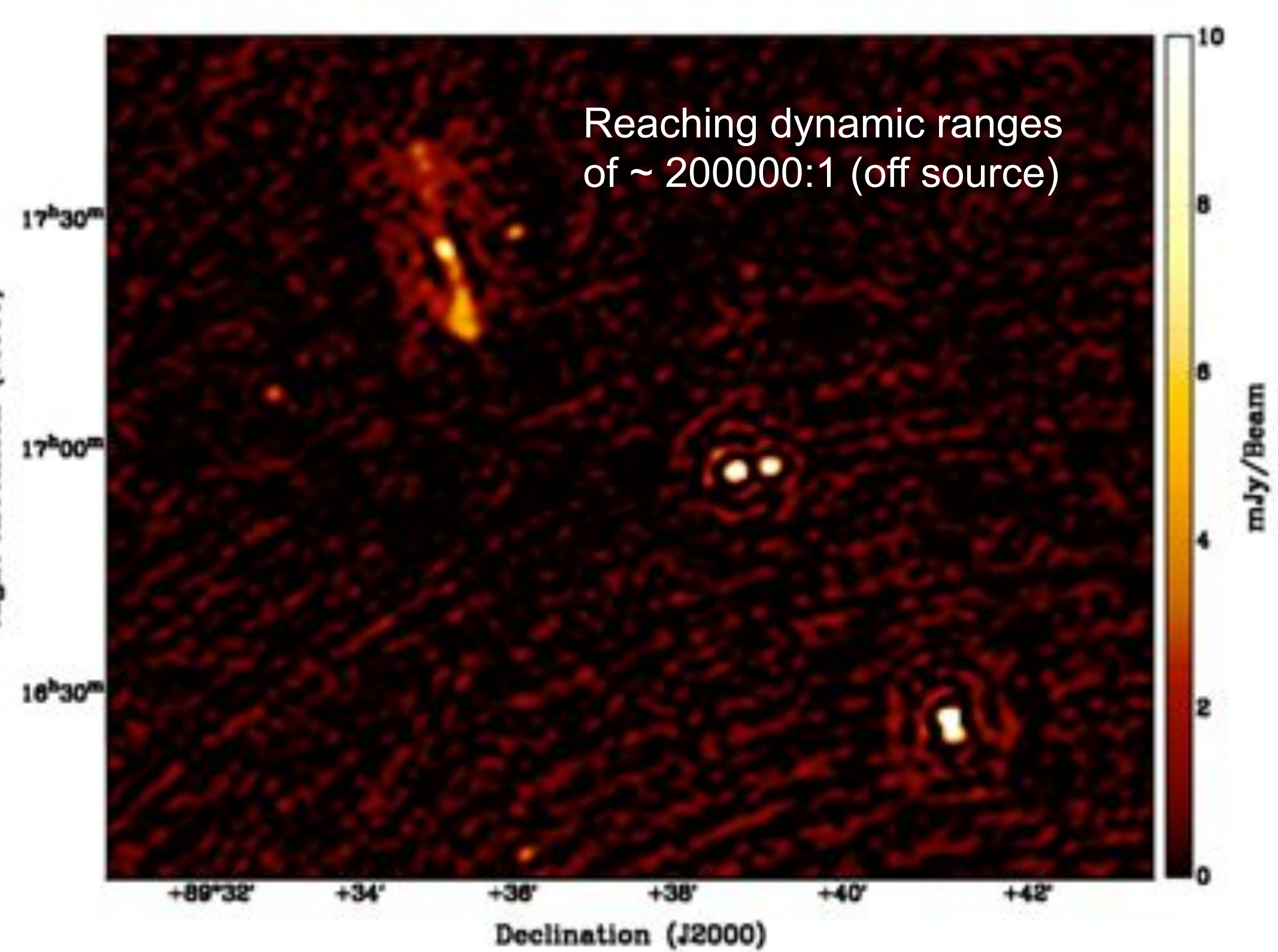
ILT - International LOFAR Telescope

Demixing: Imaging Off-axis Sources

- Hydra A - Cas A distance ~ 127 degrees
- Post-demixing images (target = Hydra A):



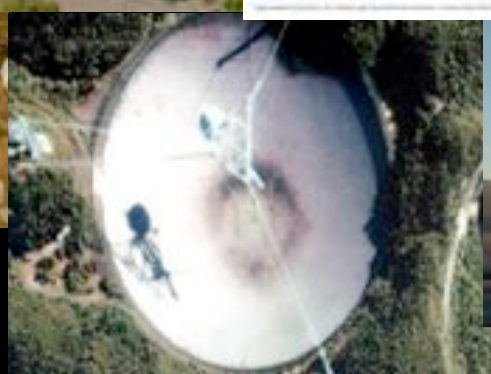
(courtesy: R. van Weeren & D. Rafferty)


Reaching dynamic ranges
of ~ 200000:1 (off source)
17h30m
17h00m
16h30m
+89°32'
+34'
+36'
+38'
+40'
+42'
Declination (J2000)
10
8
6
4
2
0
mJy/Beam

LOFAR just part of a phased radio telescope pathfinders on the road towards the Square Kilometre Array (SKA):










There has never been a better time

to do

radio astronomy!