LOFAR and the Medicina Northern Cross

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The IRA/INAF Observatory at Medicina

The Northern Cross radio Telescope

E/W arm

Single antenna
560 m x 35 m
(1536 dipoles)

N/S arm

Array of 64 antennas
640 m x 23.5 m
(4096 dipoles)

Collecting area:
30000 m^2

Working bandwidth: 2.7 MHz @ 408 MHz

The Medicina LOFAR SuperStation

Idea:

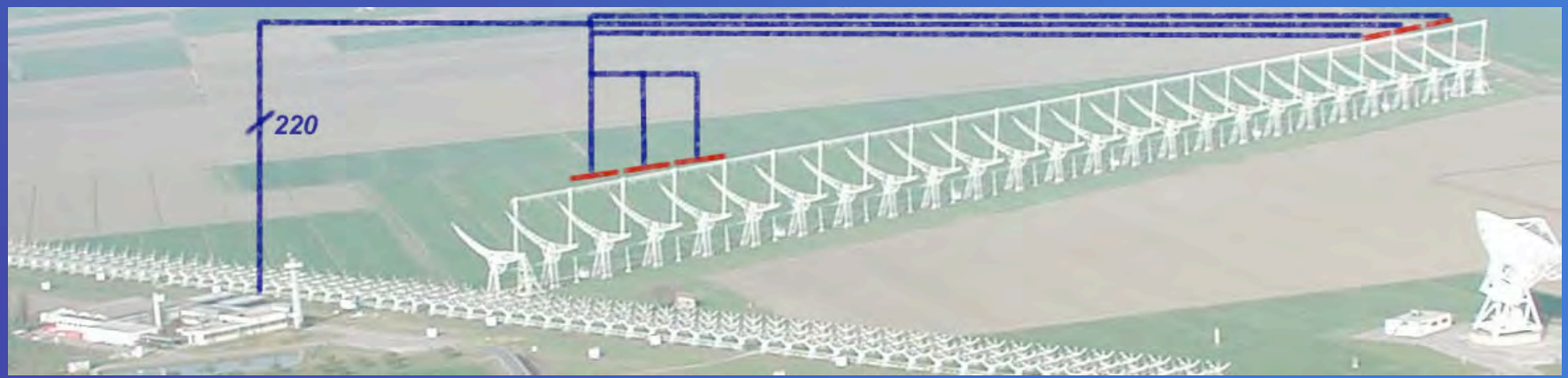
- Enable the East/West arm of the Northern Cross telescope to work in LOFAR frequency range (upper band: 120 – 240 MHz).

Objective:

- To create a LOFAR station with 2000 m^2 effective area.

The Medicina LOFAR SuperStation

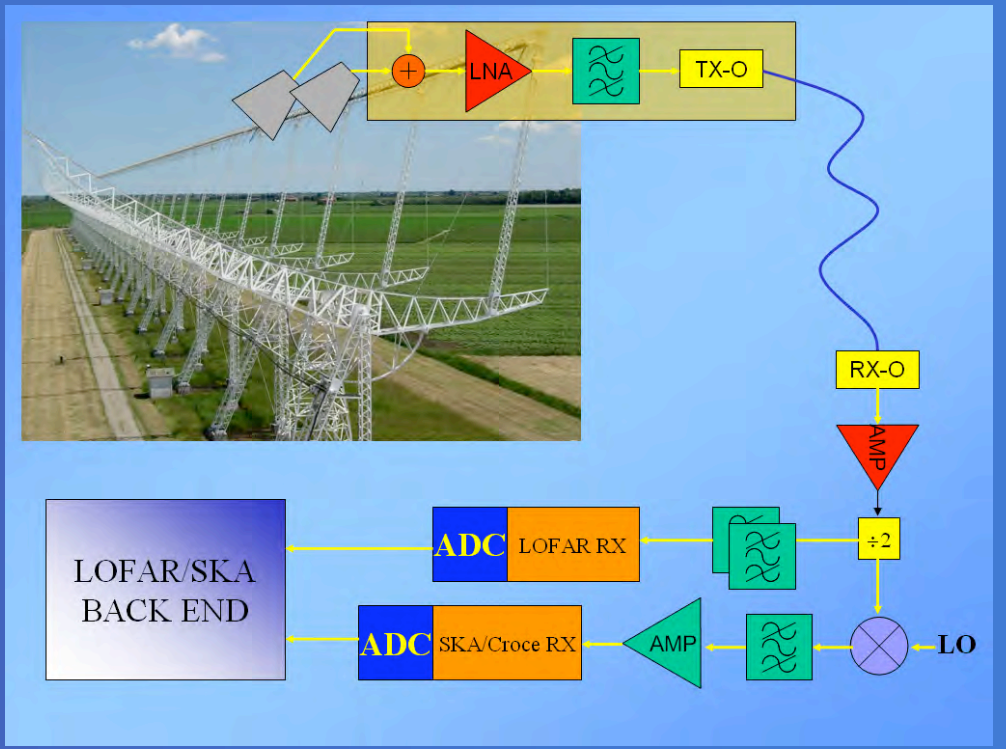
- Design study to upgrade 6 lines (23.5 m each) to the LOFAR upper band
- Simulations and tests in progress in order to obtain the optimum sensor (fat dipoles, branched Vivaldi)
- Electronic devices to be installed on the focal lines (LNAs…) ready
- The LOFAR backend might be used



The Medicina LOFAR SuperStation

Receiving System Scheme

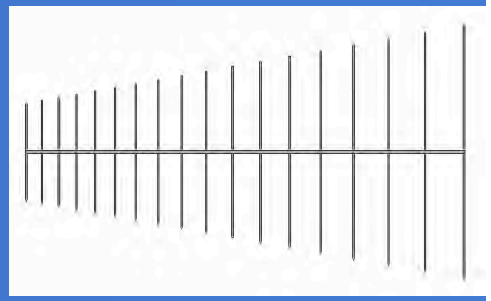
- Up to 220 receiving systems will have to be linked via analogue optical fiber links (700 m long) to the Back Ends
- The requirements are the same of SKA: possibility of sharing the links between the 2 projects



Long Baseline Interferometry Test

Main features (first light):

- 18 log-periodic antennas installed in one section of the E/W arm (~24 m length)
- ~ 400 m^2 of estimated effective area
- *BEE2* (up to 32 receivers) used for data acquisition



Project Status for first light

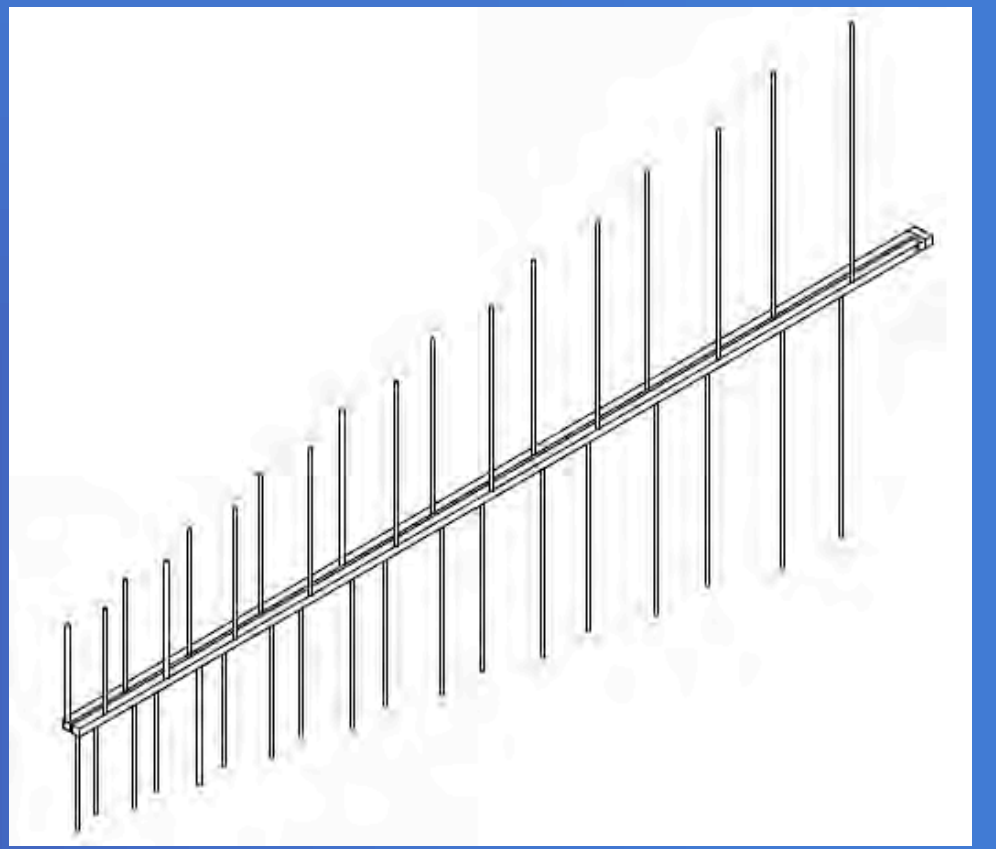
- **Sensors: in production (prototype already designed and tested)**
- **LNA: ready to be used**
- **Data acquisition tool: under test**
- **A/D: ready to be used**

Ready in summer 2008!

Sensor Design (first light)

- **Custom Log-periodic Antenna**
- **Ad hoc for LOFAR 120÷240 MHz band**
- **Designed by:**

  IEIIT-CNR, Torino, Applied Electromagnetics Group



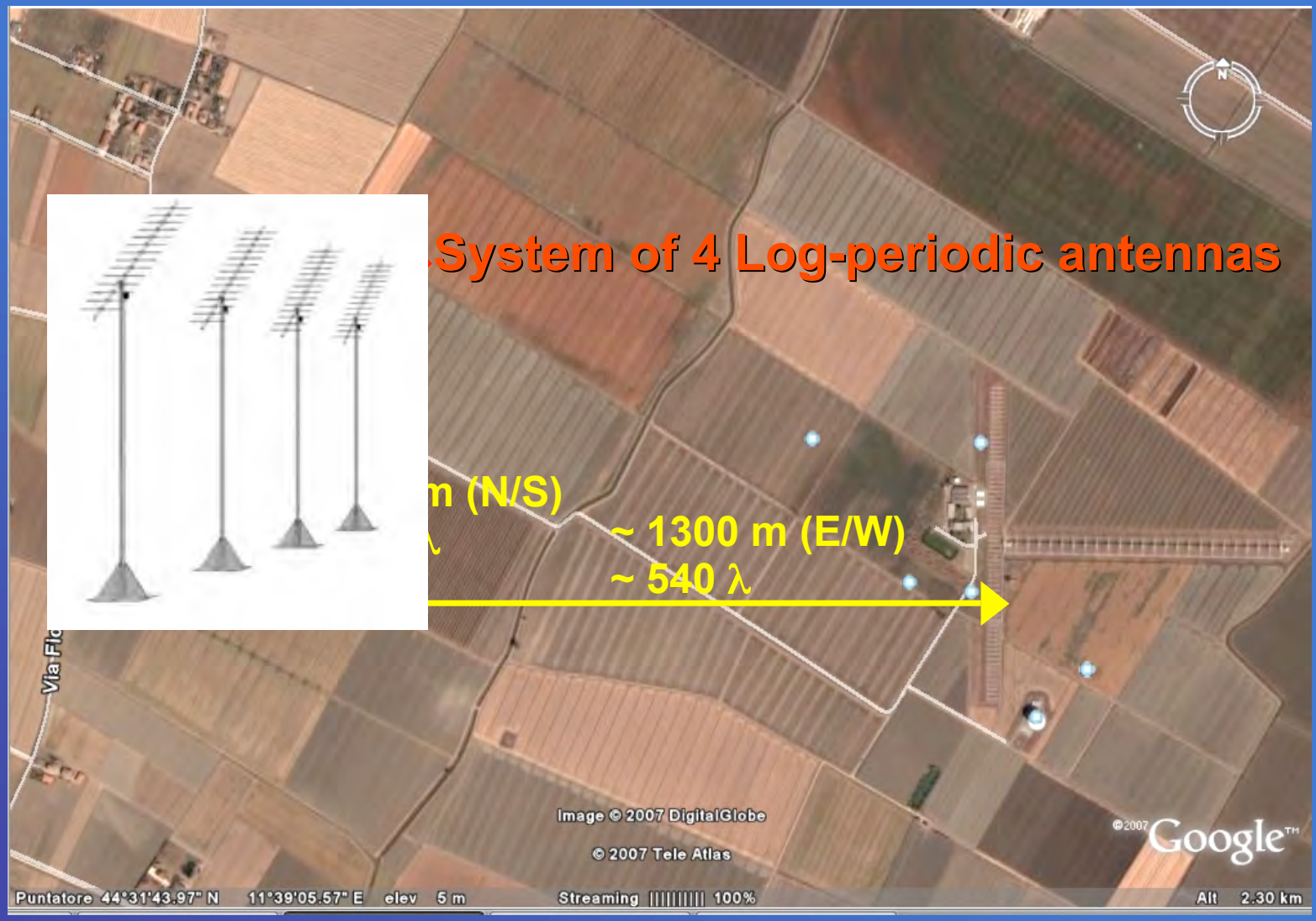
Sensor Design (first light)

- **First prototypes completed…**
- **… and already tested with good results**

Performance E/W array: Summary

Frequency (MHz)	Antenna Width Efficiency η (%)	HPBW (Deg.)	Secondary Lobes (dB)	Spillover Lobes (dB)
120	**75**	**4.5 × 6**	**-13.5**	**-14**
240	**65**	**2.2 × 3**	**-13.5**	**-15.5**

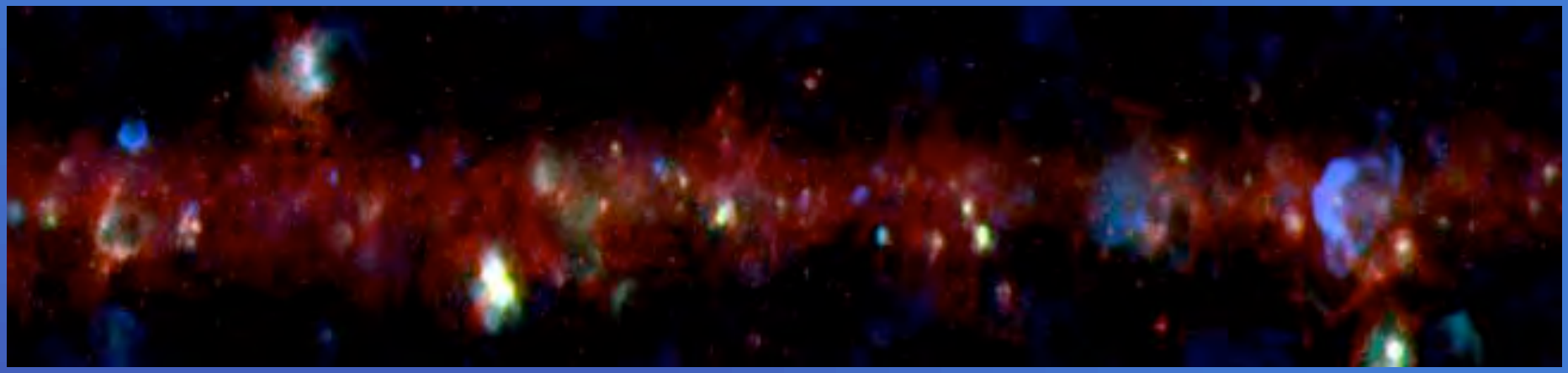
System of calibration: towards the superstation



Main specs of the test station

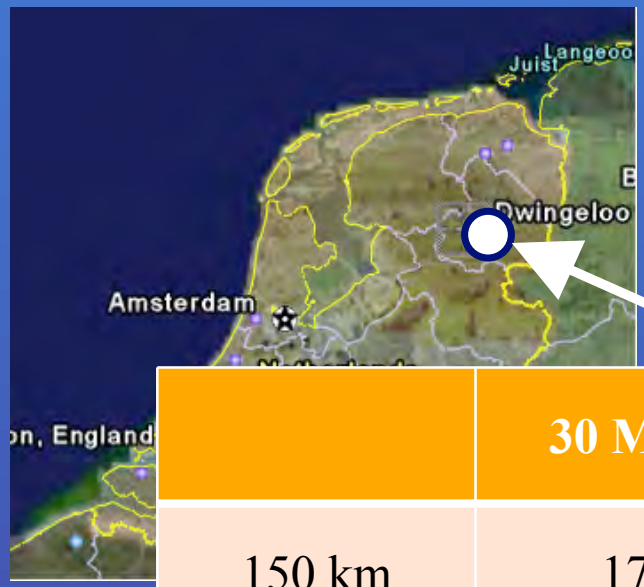
	120 MHz	240 MHz
FOV	4.5° × 60°	2.2° × 30°
Resolution	7.4' × 32'	3.7' × 16'
Sensitivity	≈ 100 Jy	≈ 100 Jy

Search for Supernova Remnants



- ≈ 270 SNRs are known
- Up to 3000 Galactic SNRs predicted
- Typical angular dimension: 10' - 2°
- Non-thermal spectra => search at low frequencies
- Low-frequency spectra => probe shock acceleration
  foreground free-free absorption

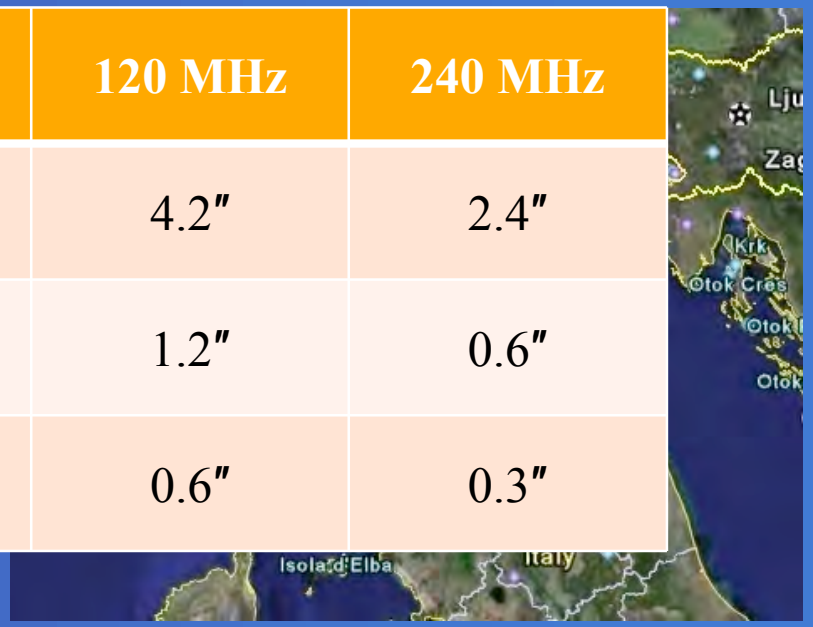
Long Baseline Interferometry Test



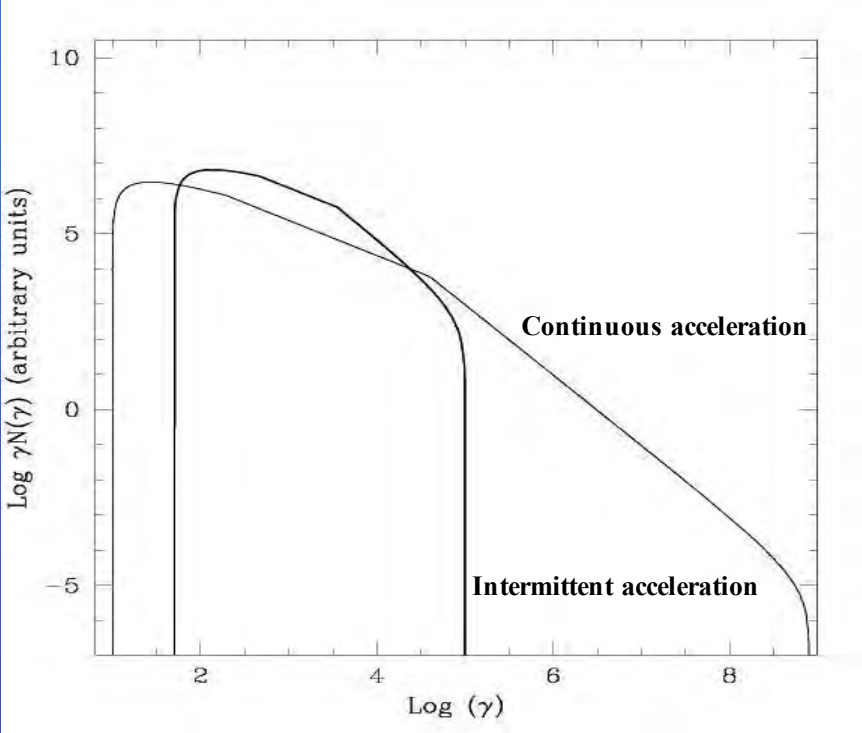
- ~ 1000 km baseline
- Medicina station already connected to EVN (European VLBI Network) through optical fiber link (Géant)

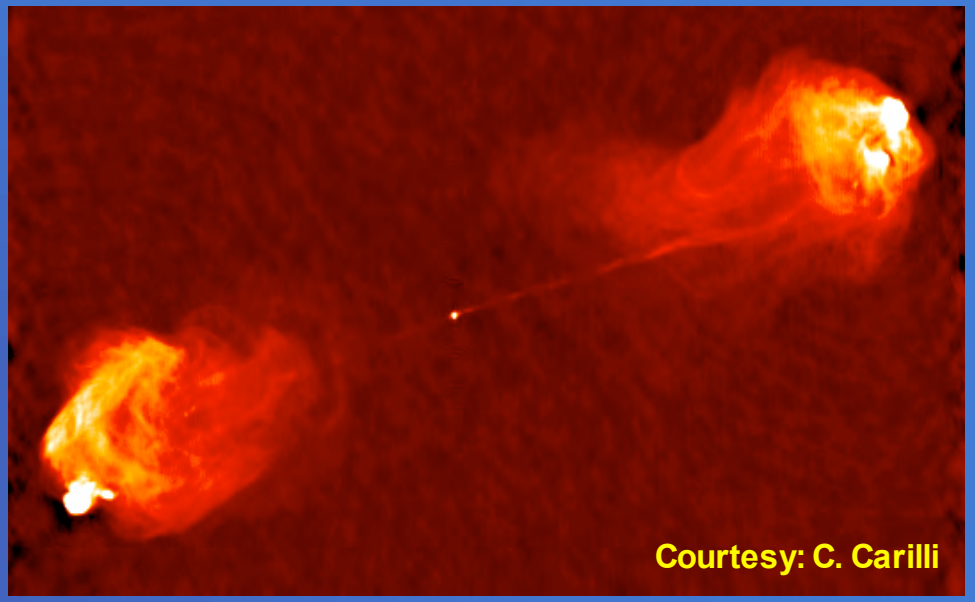
	30 MHz	75 MHz	120 MHz	240 MHz
150 km	17″	6.7″	4.2″	2.4″
500 km	5″	2″	1.2″	0.6″
1000 km	2.4″	1″	0.6″	0.3″

- Onl
  sim
  (November 2005)



Hot spots in radio galaxies: physics of long-baseline calibrators





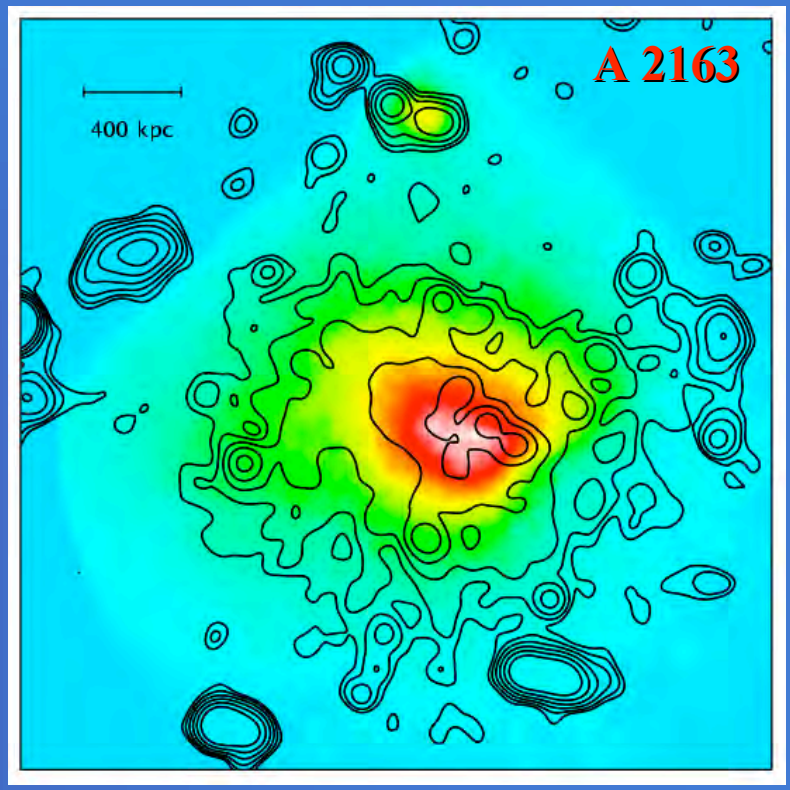
$\gamma \propto (v/B)^{0.5}$

Sub-arcsec resolution!
500 -1500 km baseline

Radio Halos in Clusters of Galaxies

Diffuse synchrotron radio cluster sources:

- Low surface brightness (μJy arcsec^{-2} at 1.4 GHz)
- Not associated with any individual galaxy
- Permeate the cluster volume, similarly to the hot X-ray gas (**~Mpc size**)



Feretti et al. 2001

Promising possibility:

Merger induced particle acceleration

(Turbulent acceleration):

Reacceleration Model (Brunetti et al. 2001, Petrosian et al. 2001)

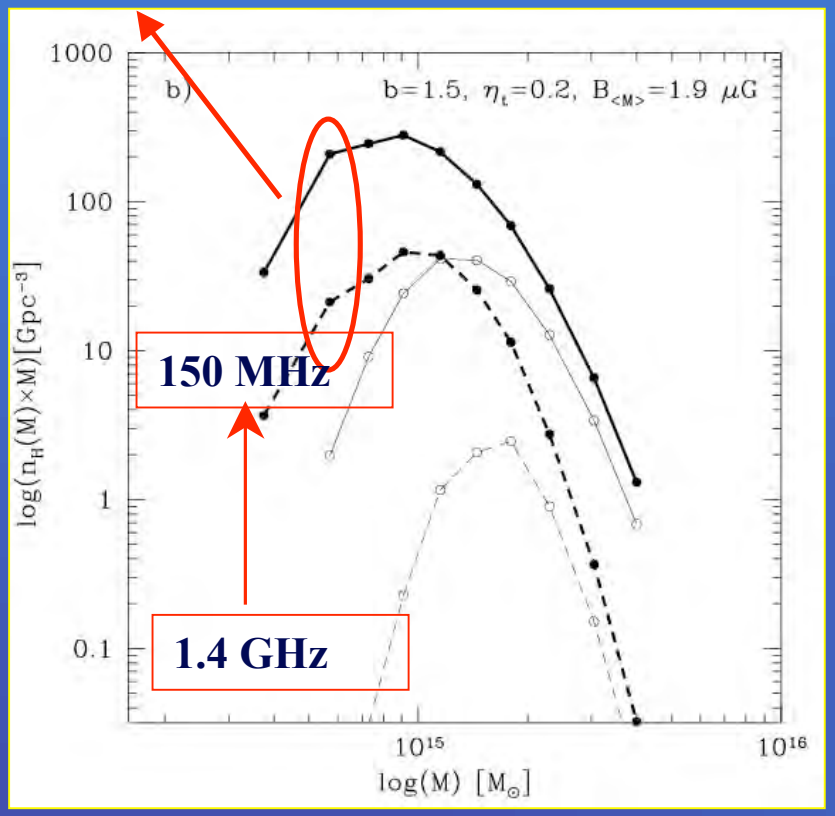
Expectations at 150 MHz

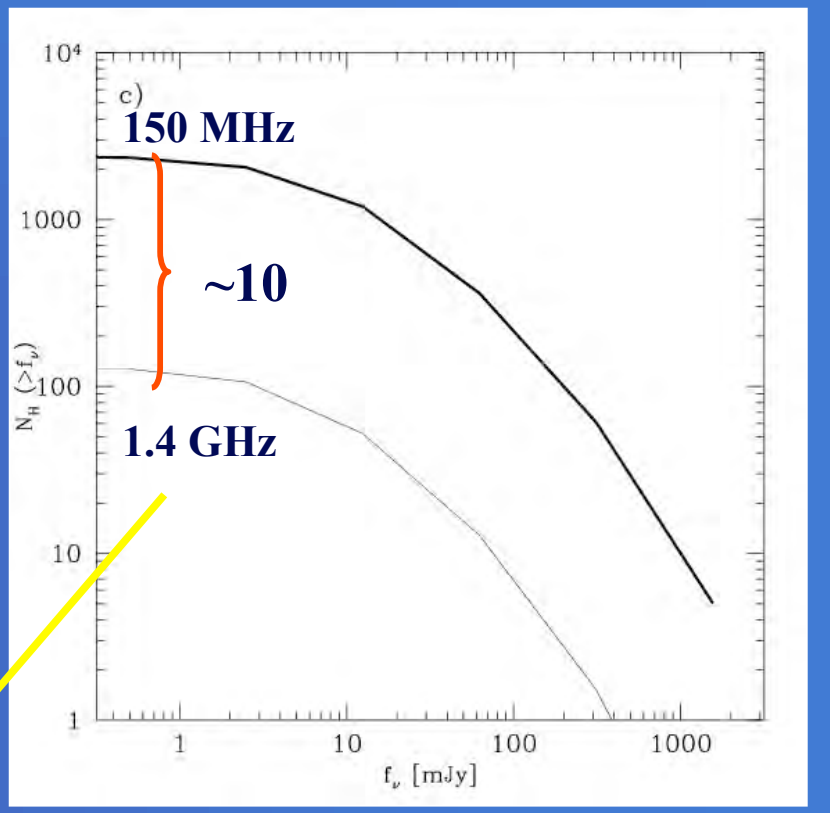
(Cassano et al. 2006; Cassano et al. in prep.)

low-mass cut-off

——— z=0-0.1

-------- z=0.4-0.5





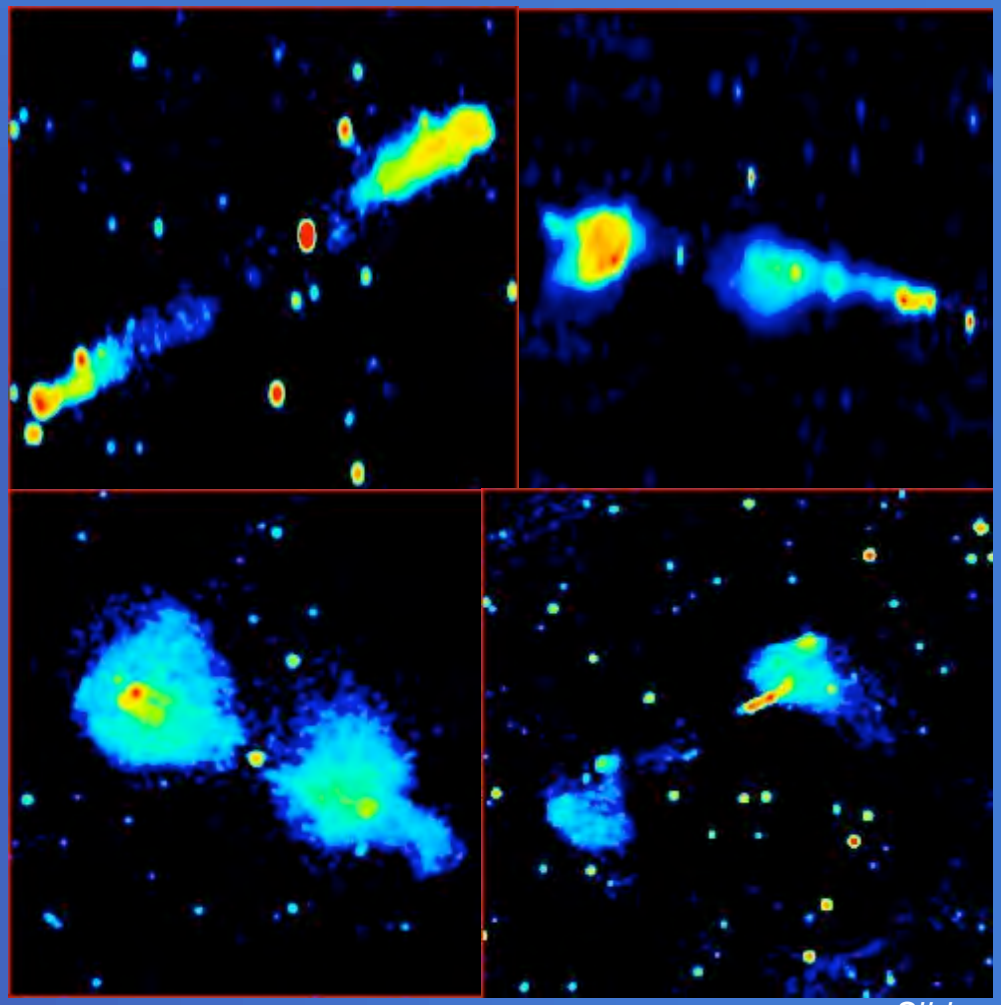
Number density of GRHs increases from 1.4 GHz to 150 MHz!

LOFAR can detect diffuse emission on Mpc scales at 150 MHz down to few mJy. Sufficient to catch the bulk of GRHs

But confusing point sources must be subtracted => arcsecond resolution

Giant Radio Galaxies: Tracing the Density of the Intergalactic Medium (IGM)

- Radio galaxies > 1 Mpc
- Relatively old (~10^8y) AND embedded in very tenuous IGM
- Low surface brightness, in particular at high frequencies
- Mostly known at low z
- Search at higher z to probe cosmological evolution of IGM density



LOFAR in INAF

May-June 2008
LOFAR Medicina Super Station Workshop

- Italian White Paper coming out soon.
- participation in LOFAR highly ranked both in mid-term and long-term plan
- INAF priority to purchase a standard LOFAR station
- University of Bologna has invested in Northern Cross

} Synergy