

NENUFAR AND THE LARGE-SCALE STRUCTURE IN THE UNIVERSE

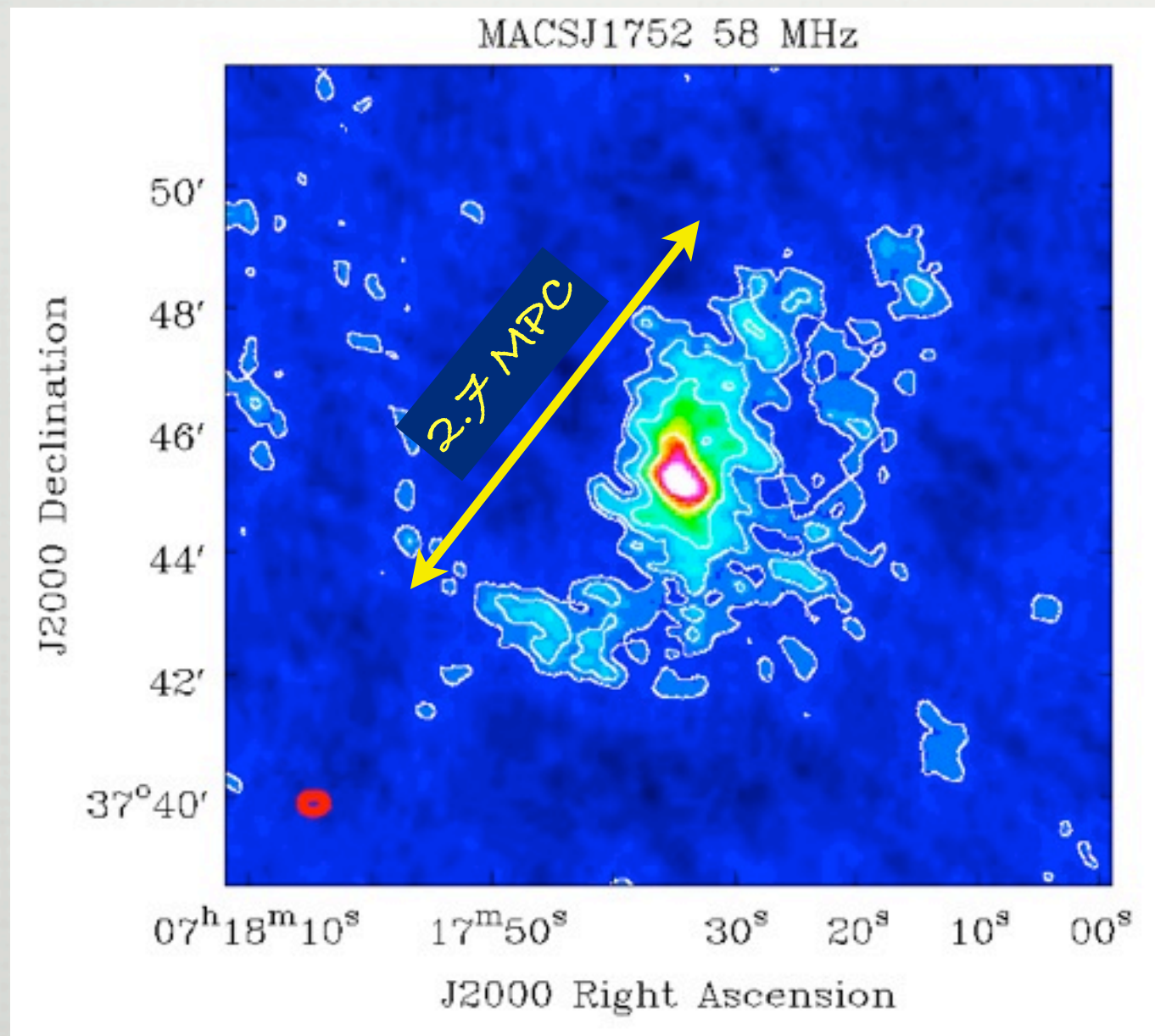
ANNALISA BONAFEDE
HAMBURG UNIVERSITY

C. FERRARI, F. VAZZA, M. BRÜGGEN

OUTLINE

- ☐ LOFAR CAPABILITIES NOW
- ☐ NENUFAR + LOFAR:
 - ☐ IONOSPHERIC CALIBRATION
 - ☐ HIGH-Z CLUSTERS
- ☐ NENUFAR STANDALONE:
 - ☐ INTERGALACTIC FILAMENTS
 - ☐ INITIAL SURVEY

DISTANT GALAXY CLUSTERS

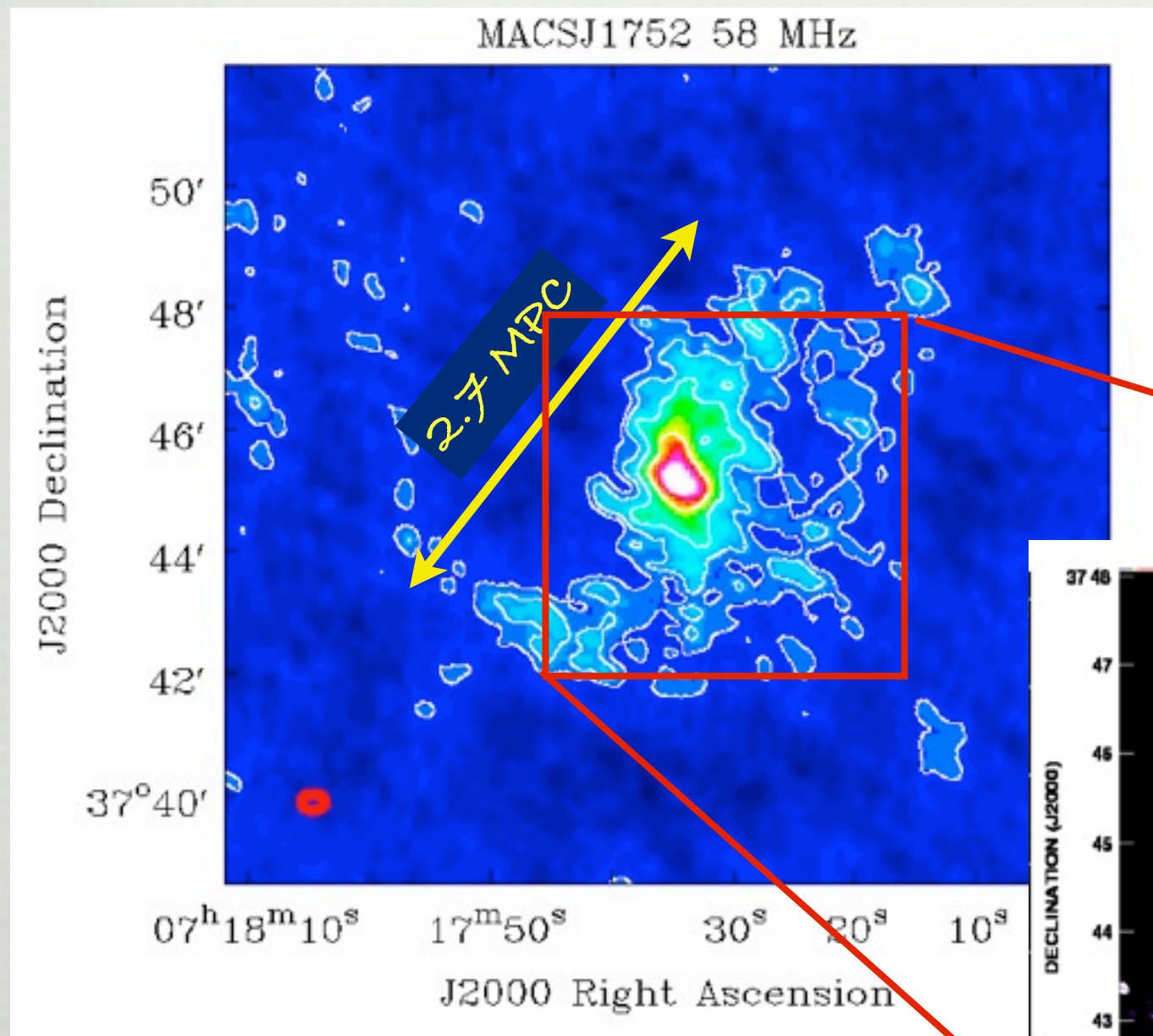


Bonafede & LOFAR survey group (in prep)

MACSJ1752
the most powerful radio halo
 $z=0.55$

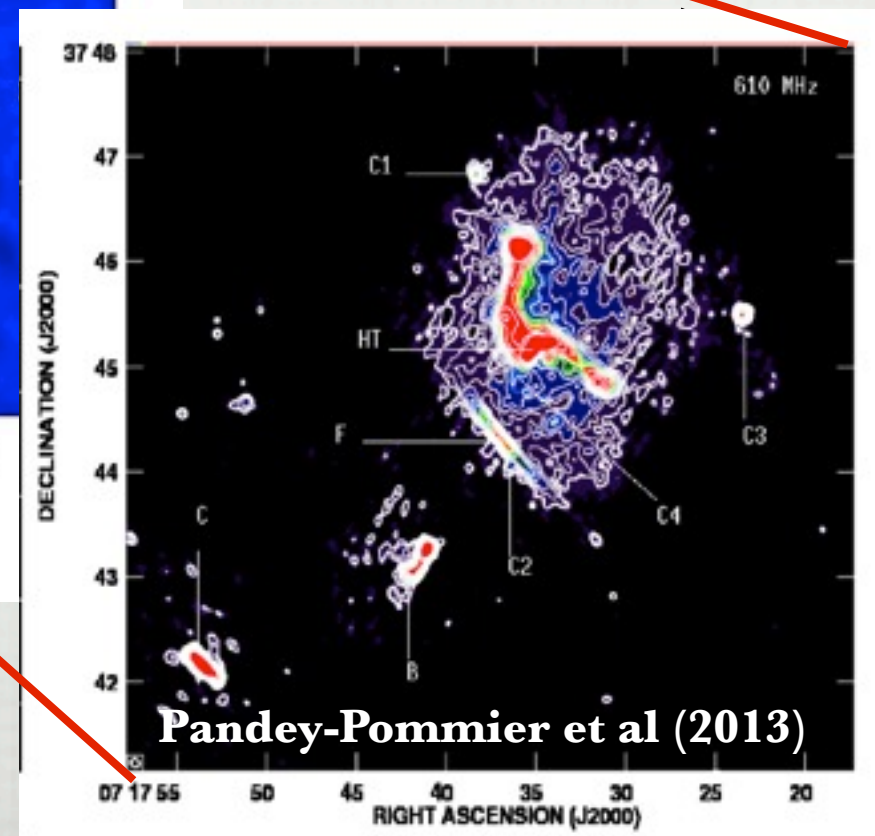
Largest sites of particle
(re)acceleration
by turbulence/shocks

DISTANT GALAXY CLUSTERS



Bonafede & LOFAR survey group (in prep)

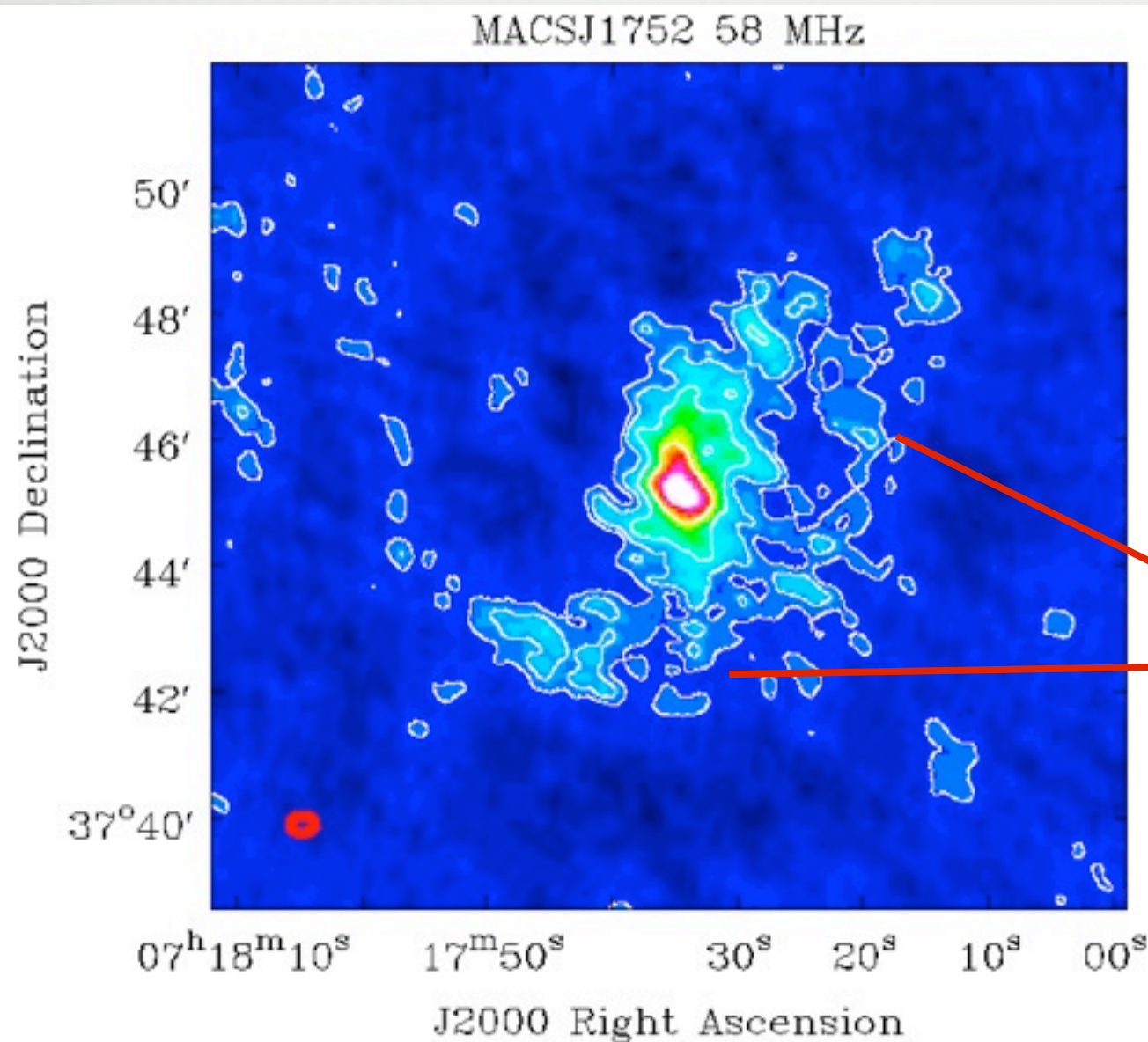
MACSJ1752
the most powerful radio halo
 $z=0.55$



Pandey-Pommier et al (2013)

particle
ion
shocks

DISTANT GALAXY CLUSTERS



Bonafede & LOFAR survey group (in prep)

LOFAR LBA

58 MHz

4 MHz bandwidth

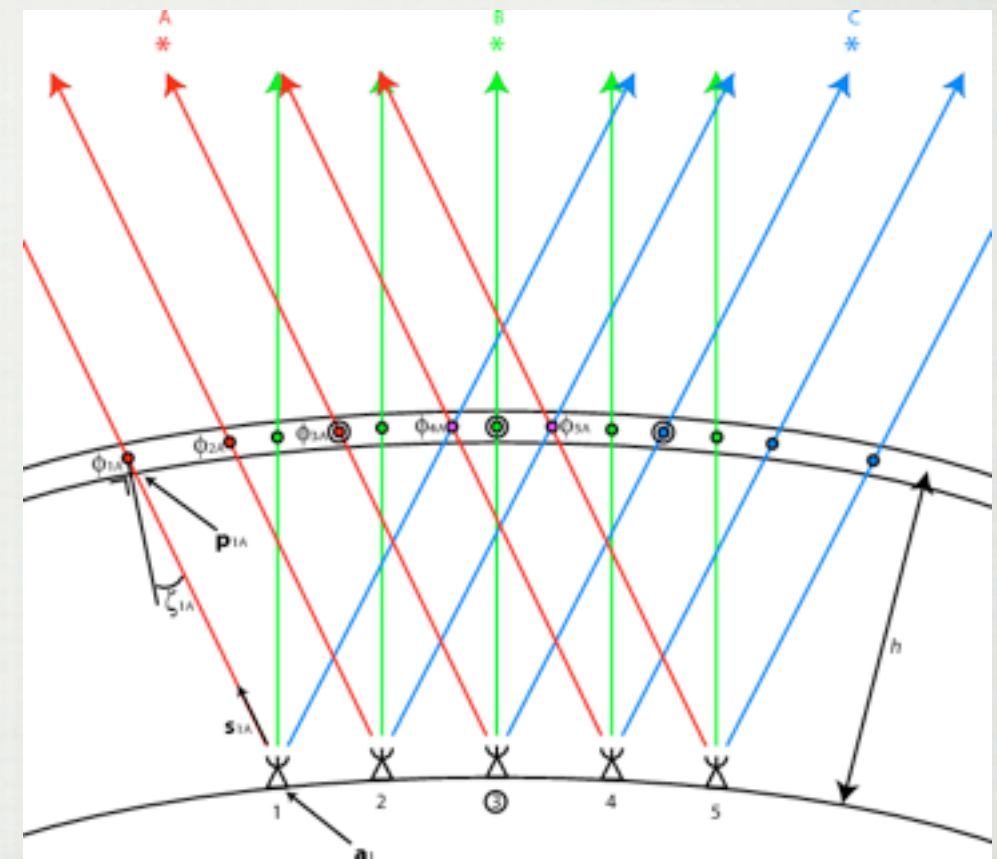
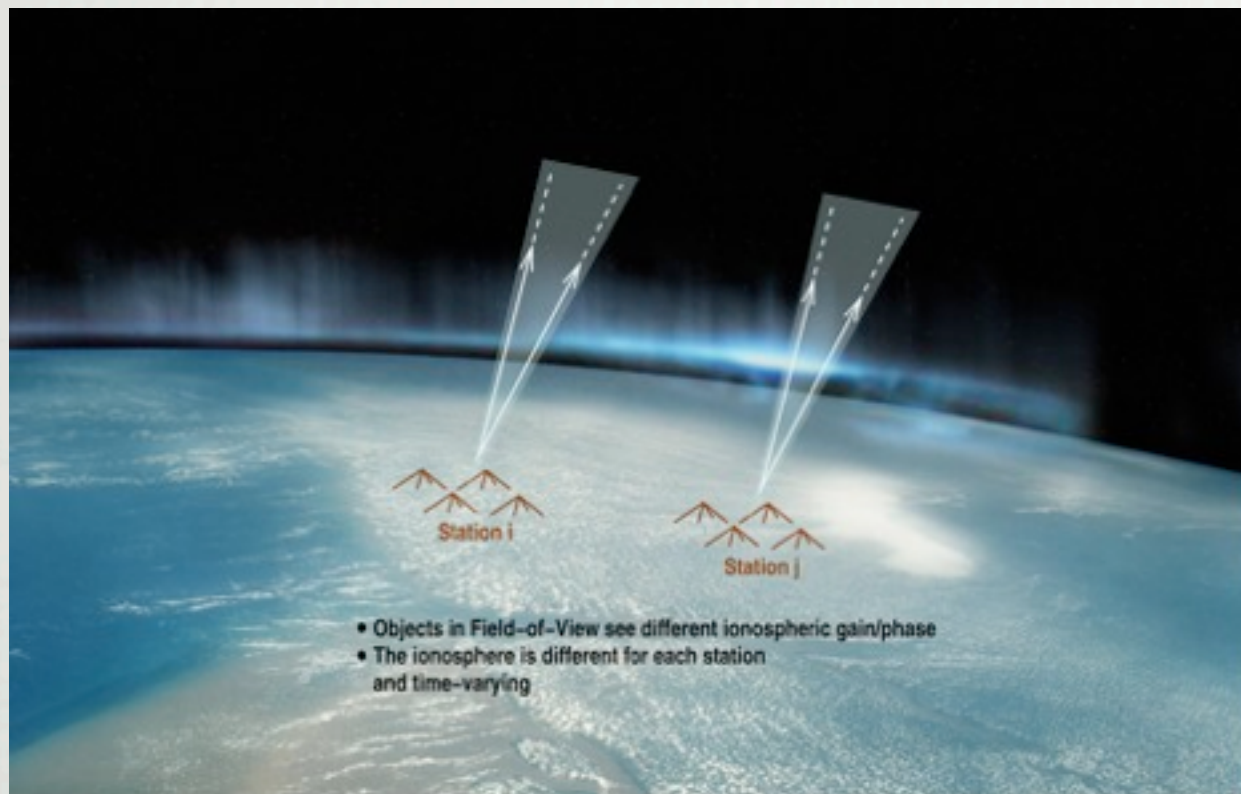
noise 10 mJy/beam

beam 23"x16"

NEW EMISSION
(?)

IONOSPHERIC
ERRORS

IONOSPHERIC CALIBRATION



credits: H. Intema

Ionospheric screen: add varying phase to the geometric delays

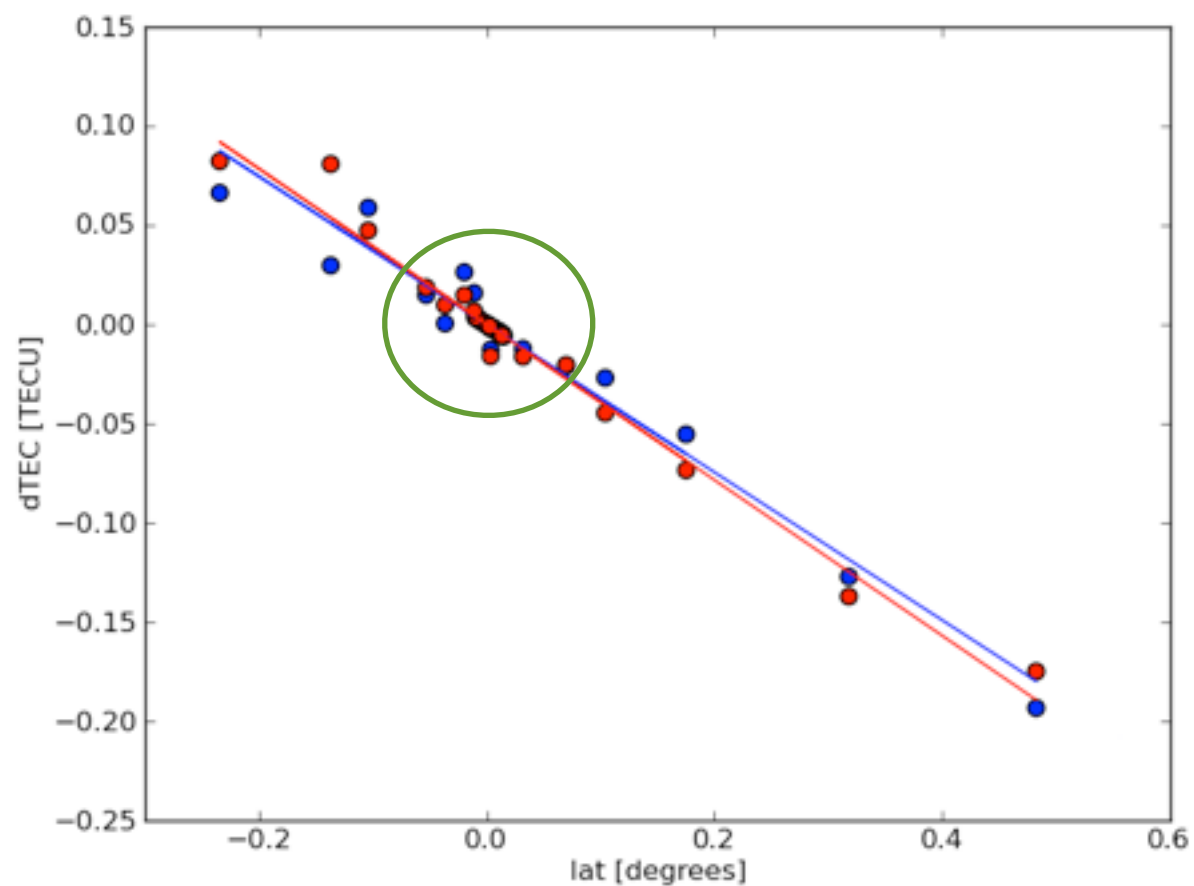
- 1) source appears to have shifted position
- 2) "blurred"

Corrections depend on time, viewing direction, antenna location

CALIBRATING IONOSPHERE

Total Electron Content (\sim ionospheric depth) vs station's latitude

Core stations

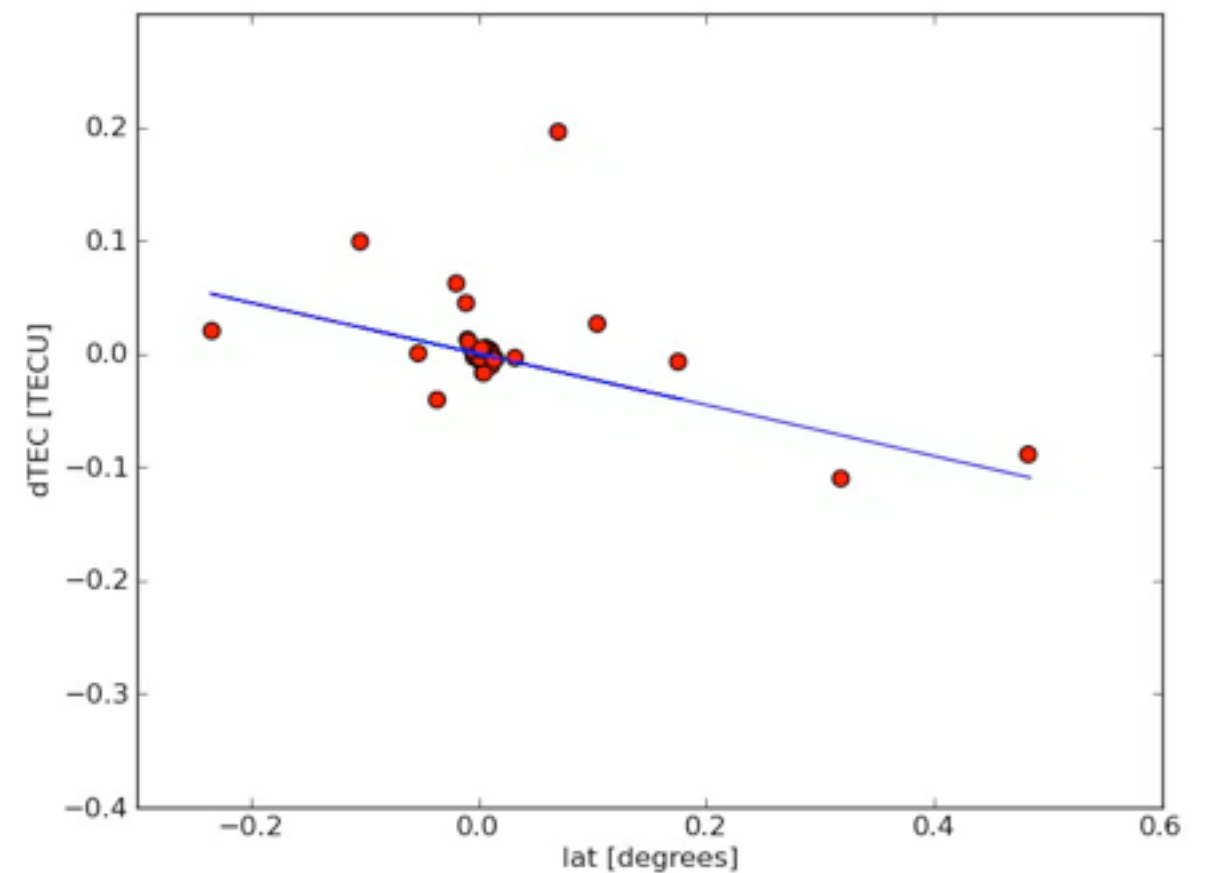
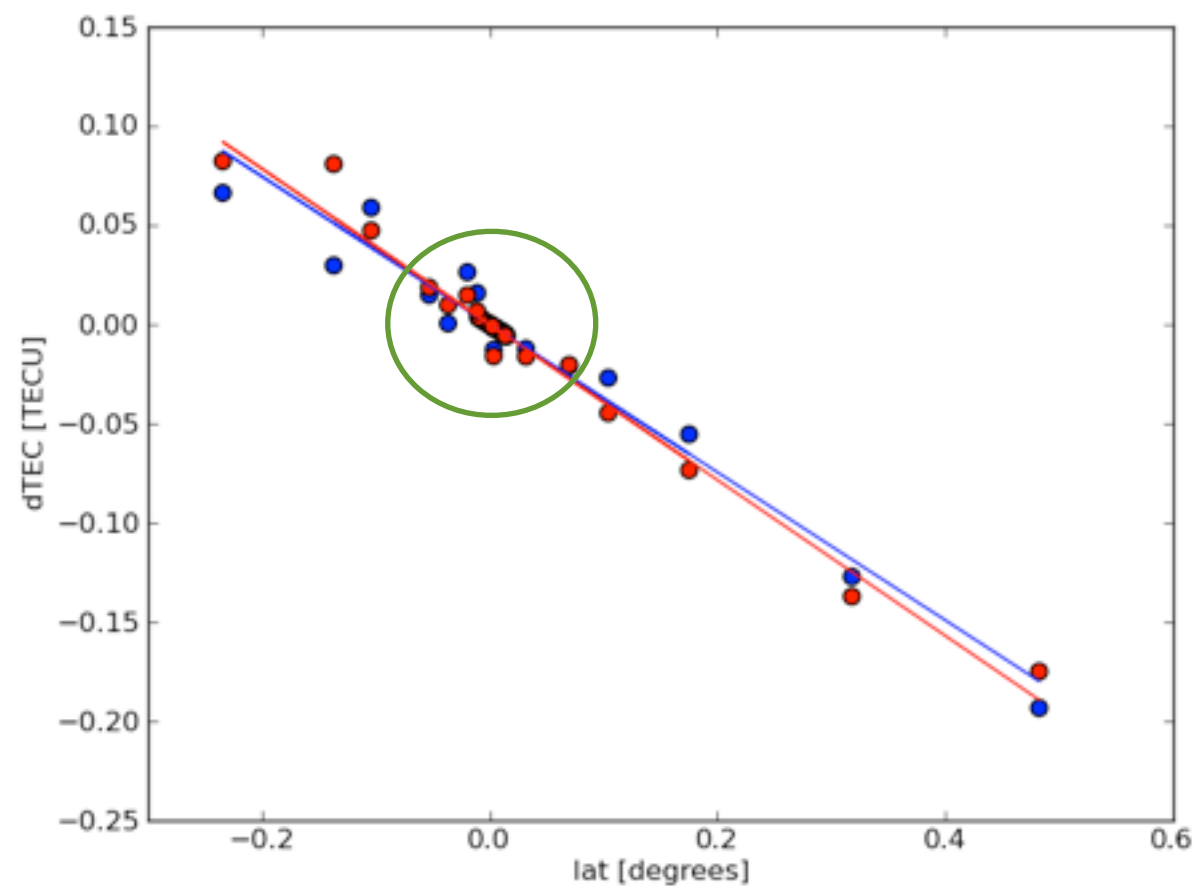


**A. Bonafede & M. Mevius,
LOFAR report**

CALIBRATING IONOSPHERE

Total Electron Content (\sim ionospheric depth) vs station's latitude

Core stations



**A. Bonafede & M. Mevius,
LOFAR report**

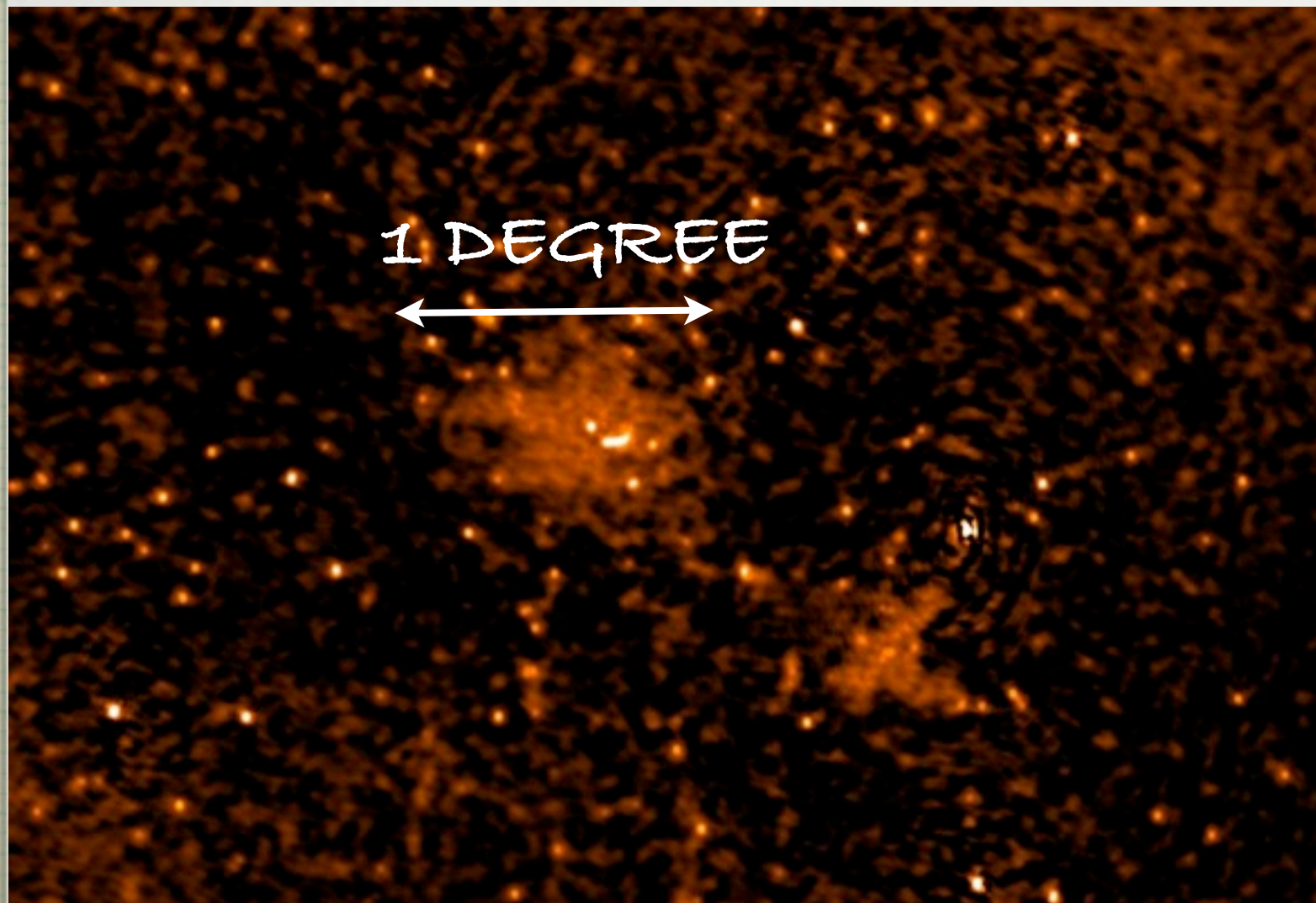
LOFAR + NENUFAR

Name	Antennas	Eff. area	Freq. range	Ang. Res.	N beams	Polar.
LOFAR-LBA	2688 X dipoles	72000 m ² (*)	30-80 MHz	2" (*)	8+beams ×4 MHz	4 Stokes
NenuFAR standalone	1824 X dipoles	62000 m² (*)	15-80 MHz	1.5° (*)	4 beams ×65 MHz	4 Stokes
NenuFAR +LOFAR- LBA	4512 X dipoles	134000 m² (*)	30-80 MHz	2" (*)	8+beams ×4 MHz	4 Stokes

1) Long sensitive Baselines

- Sensitive imaging at high resolution: high z clusters
ionospheric fitting

NEARBY GALAXY CLUSTERS



Bonafede & LOFAR survey group (in prep)

COMA cluster
 $z=0.023$

LOFAR HBA

137 MHz

6 MHz bandwidth

noise 5 mJy/beam

beam 25"x30"

Large-scale emission
which is filtered-out by interferometers as
VLA, GMRT, ...

LOFAR + NENUFAR

Name	Antennas	Eff. area	Freq. range	Ang. Res.	N beams	Polar.
LOFAR-LBA	2688 X dipoles	72000 m ² (*)	30-80 MHz	2" (*)	8+beams ×4 MHz	4 Stokes
NenuFAR standalone	1824 X dipoles	62000 m² (*)	15-80 MHz	1.5° (*)	4 beams ×65 MHz	4 Stokes
NenuFAR +LOFAR- LBA	4512 X dipoles	134000 m² (*)	30-80 MHz	2" (*)	8+beams ×4 MHz	4 Stokes

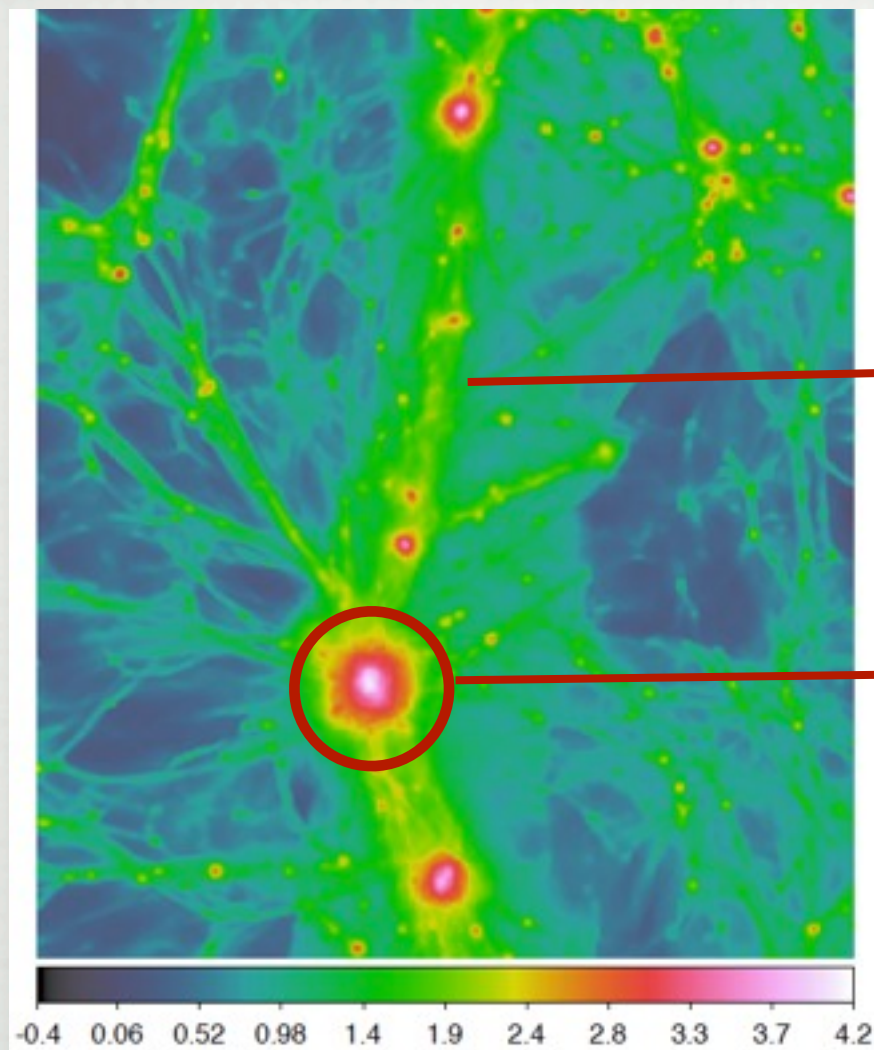
Long sensitive Baselines

- Sensitive imaging at high resolution: high z clusters
ionospheric fitting

Sensitive Short baselines (2x sensitive than LOFAR core)

- Imaging of large-scales (degrees) with 2" resolution
 - subtraction of sources
- small-scale brightness variation of large scale emission

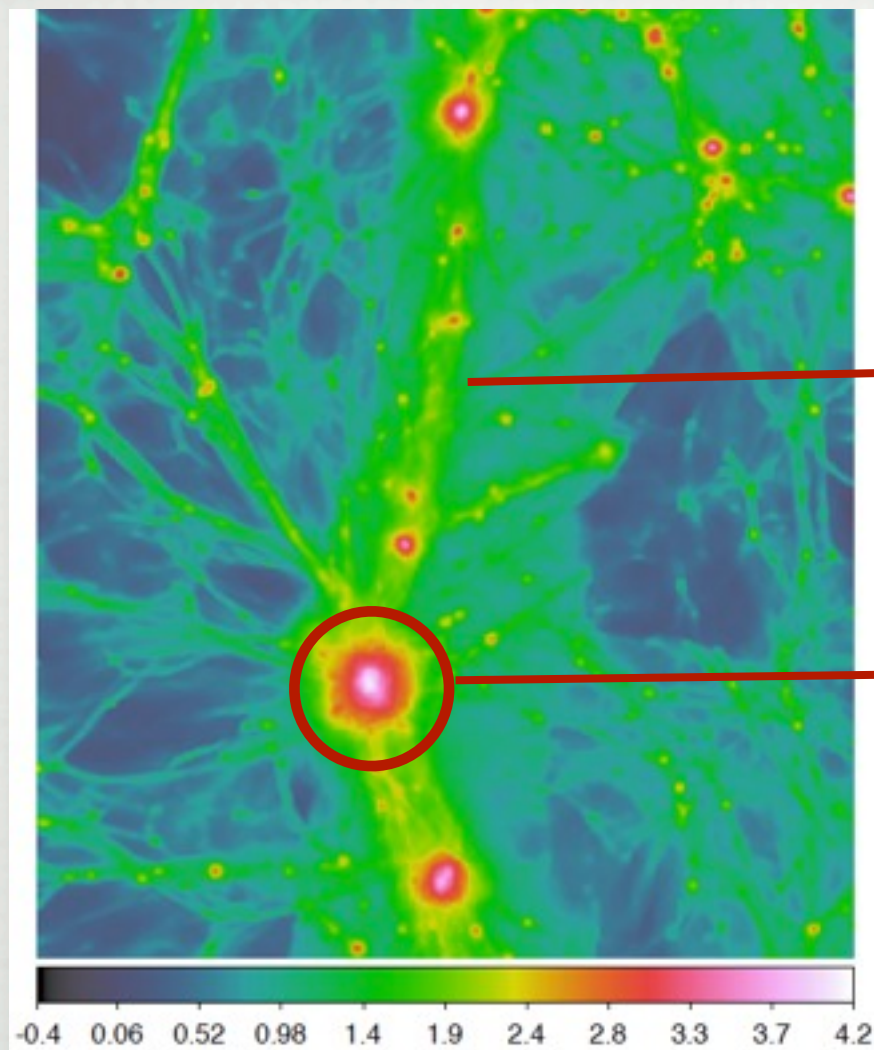
NENUFAR ALONE?



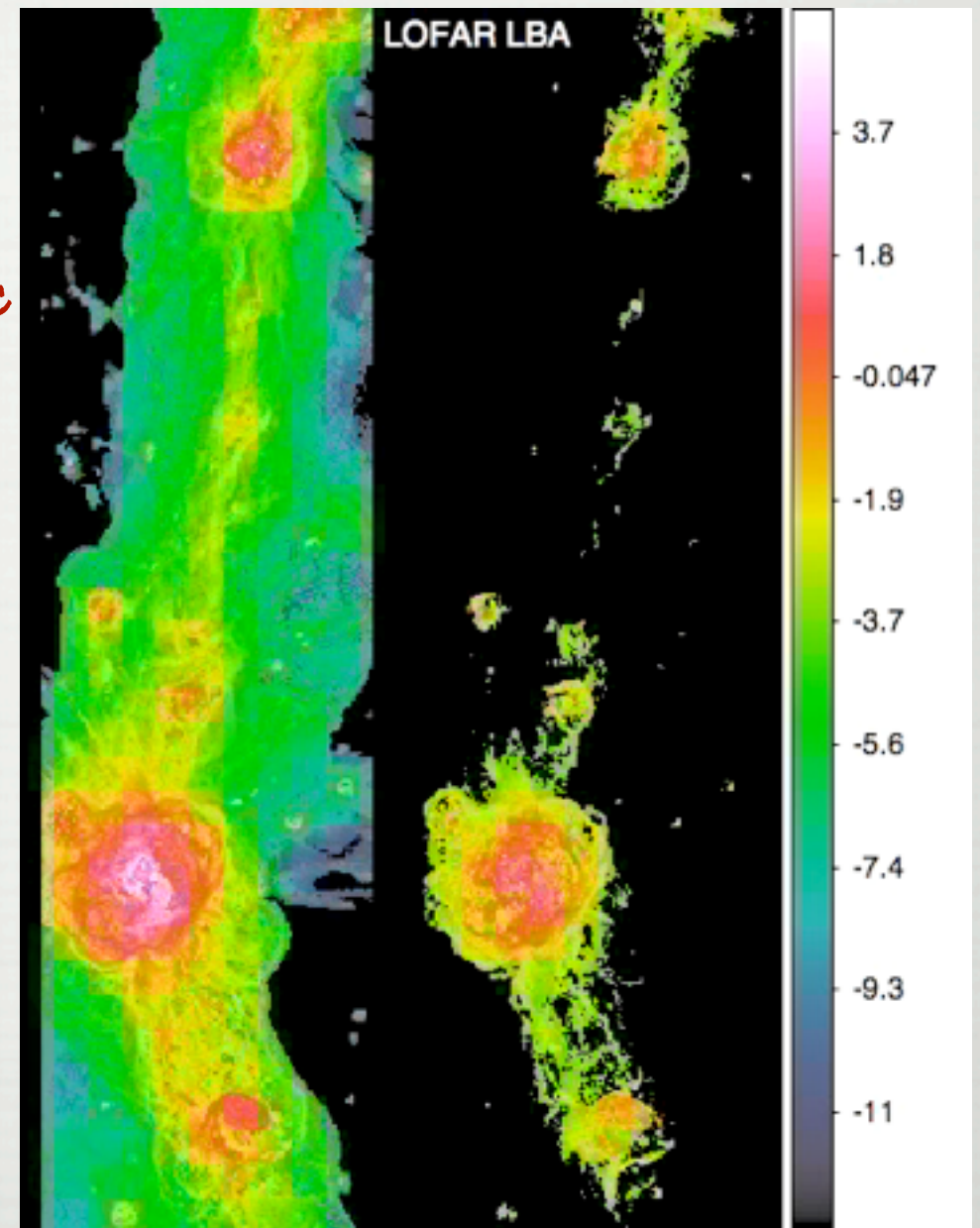
credits: Vazza, Ferrari et al, in
prep.

credits: Franco Vazza

NENUFAR ALONE?



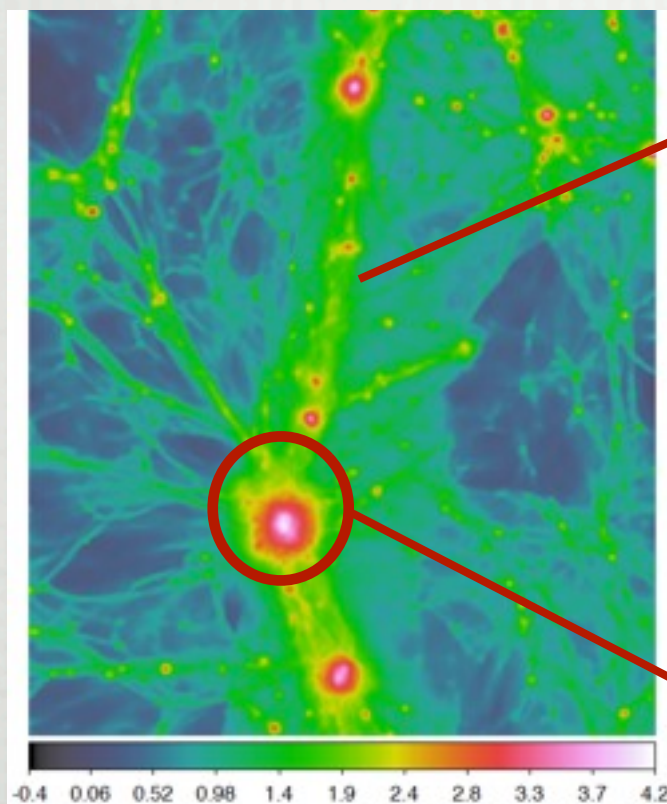
credits: Vazza, Ferrari et al, in prep.



credits: Franco Vazza

NENUFAR ALONE?

Name	Antennas	Eff. area	Freq. range	Ang. Res.	N beams	Polar.
LOFAR-LBA	2688 X dipoles	72000 m ² (*)	30-80 MHz	2" (*)	8+beams x4 MHz	4 Stokes
NenuFAR standalone	1824 X dipoles	62000 m² (*)	15-80 MHz	1.5" (*)	4 beams x65 MHz	4 Stokes



Intergalactic
Filament

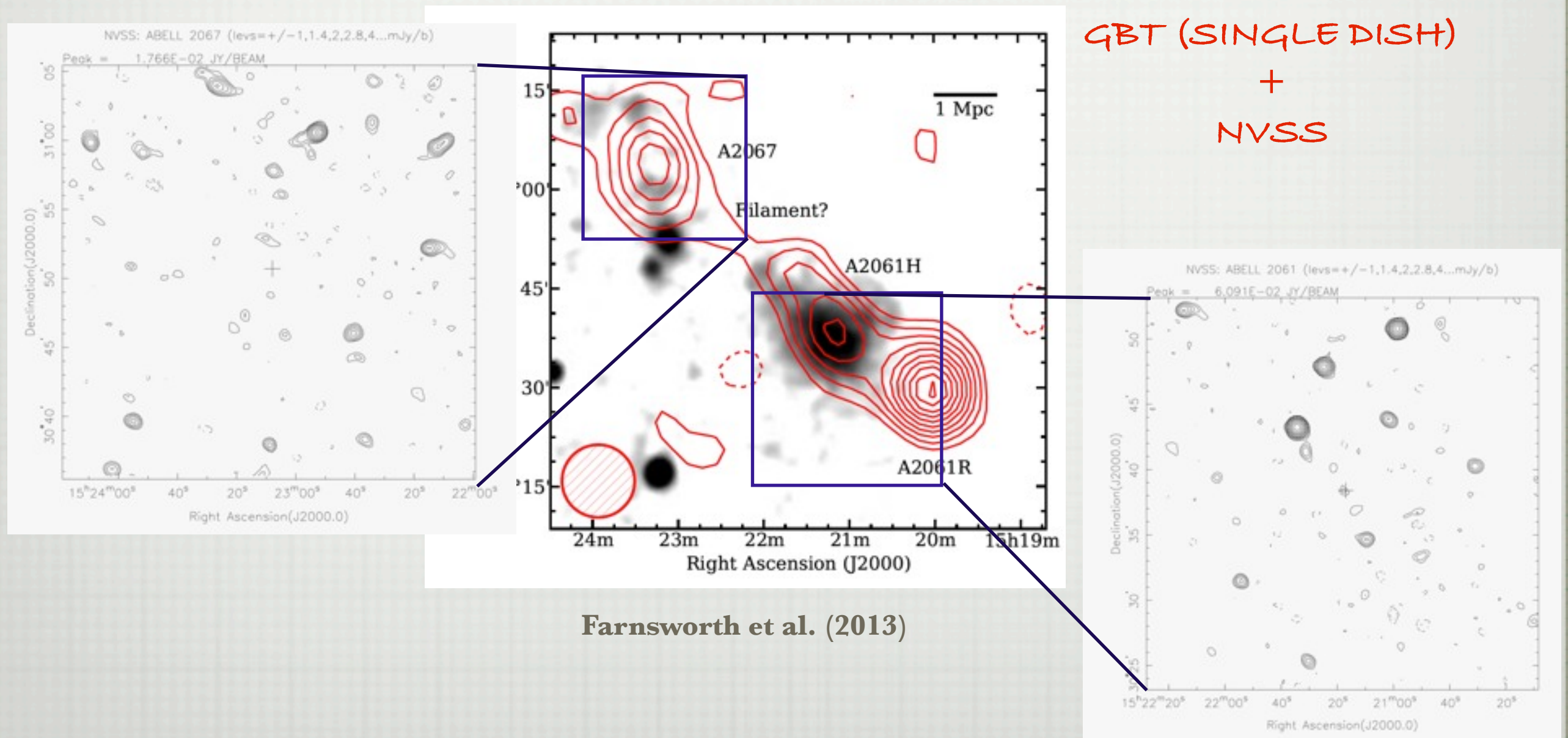
Large Field of view
 - detection of filaments?
 - limits on B and particle acceleration

Galaxy
Cluster

credits: Vazza, Ferrari et al,
in prep.

NENUFAR STANDALONE

- Discovery potentials: single dish + interferometric observations



Farnsworth et al. (2013)

SUMMARY

NenuFAR standalone and combined with the full LOFAR array:

- help in technical aspects (ionosphere)
- reveal large scale emission on clusters and filaments