Magnetic field and particle acceleration processes in the Coma cluster: a joint VLA/LOFAR view and SKA perspectives

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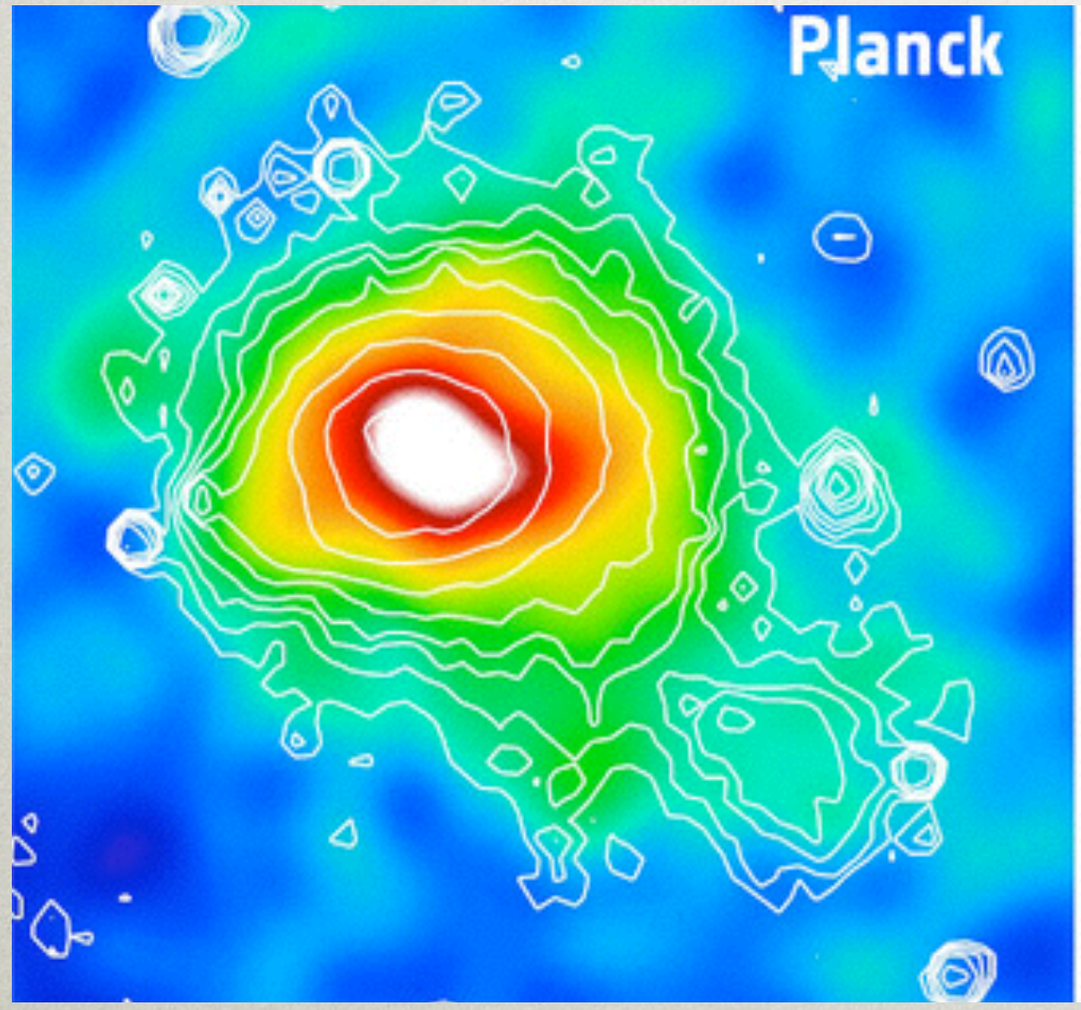
Outline

- Non-thermal emission is the Coma cluster
- State of the art: magnetic field and continuum emission
- LOFAR preliminary data
- SKA perspectives

The Coma cluster

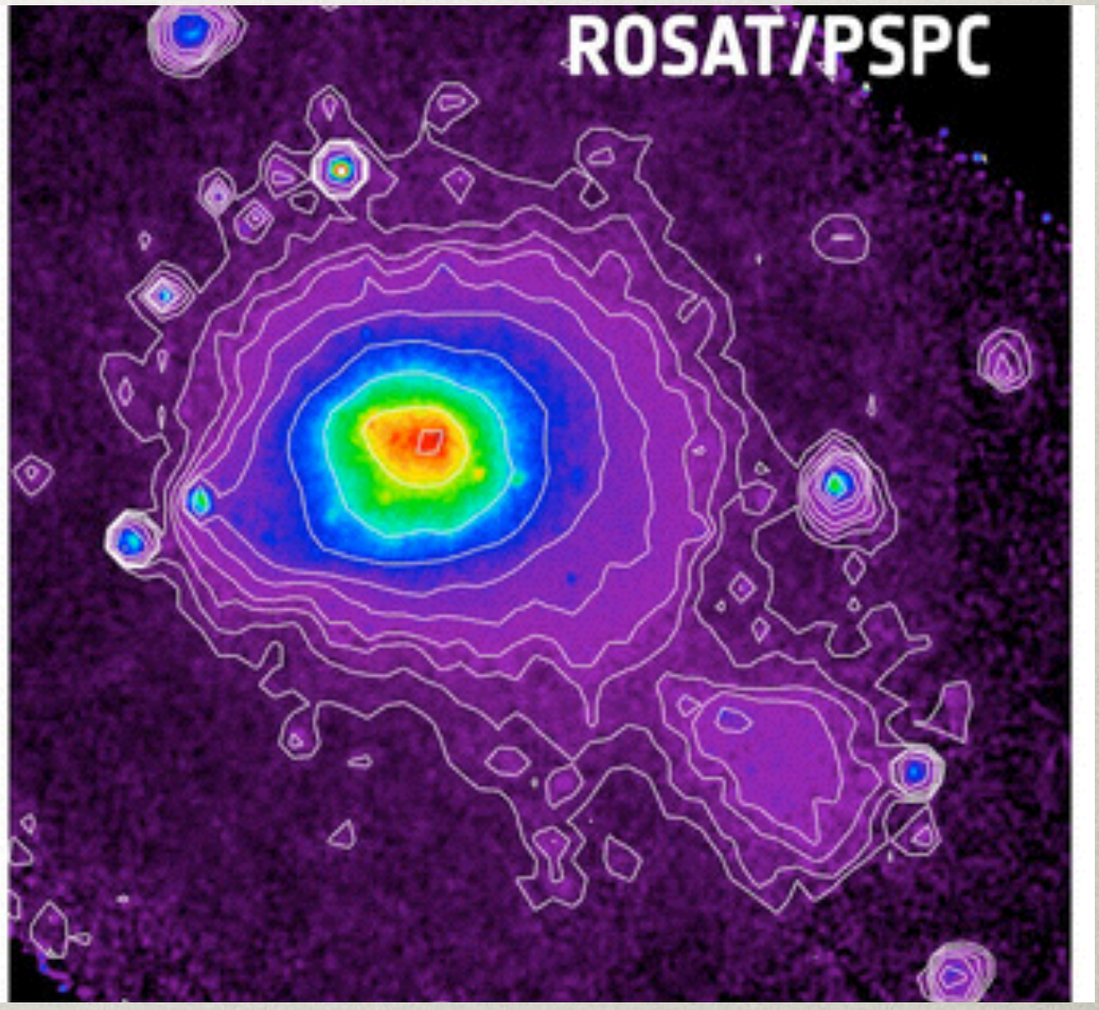
The thermal component

Pressure from *Sunyaev–Zel'dovich* + *X-ray contours*



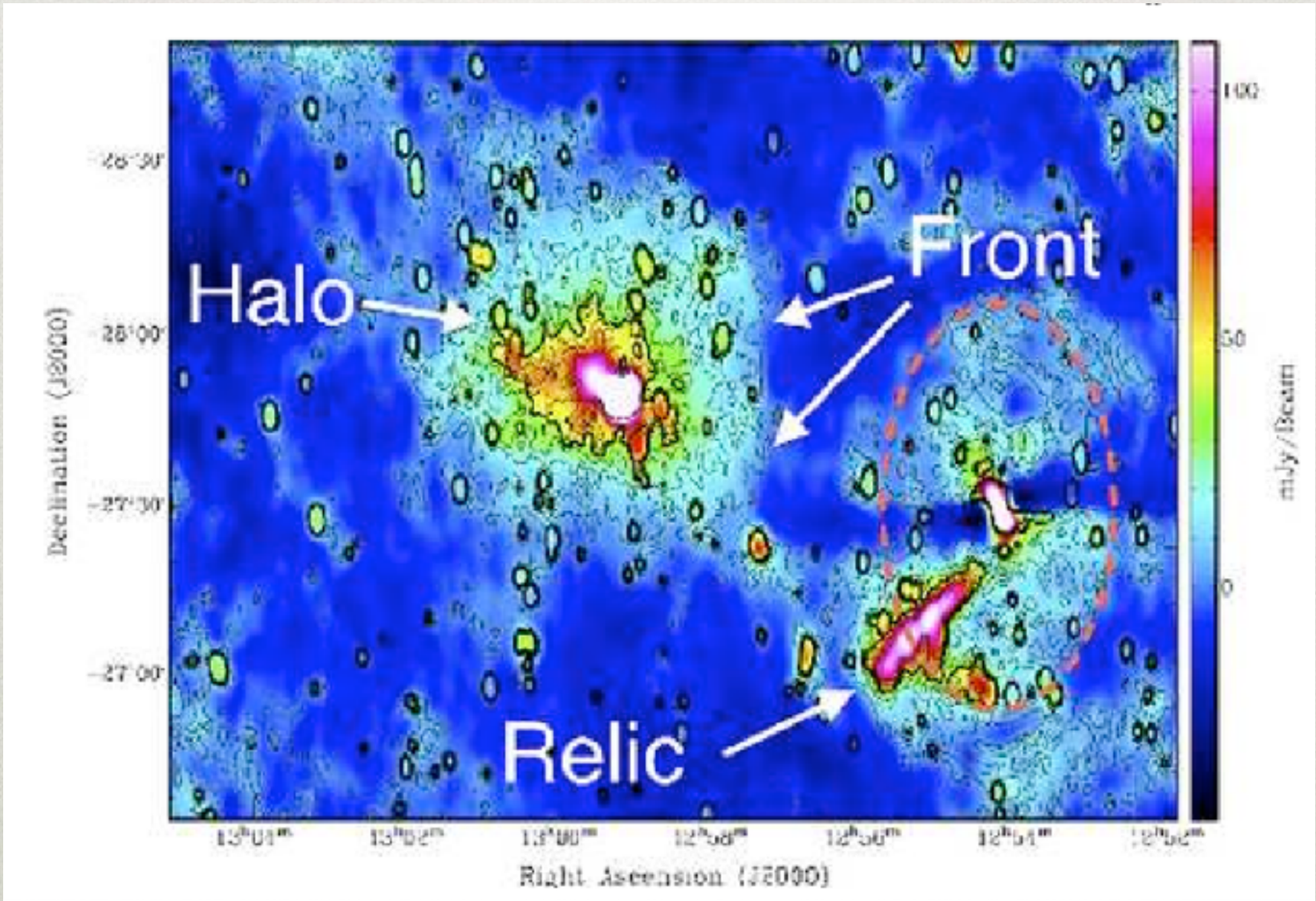
Planck collaboration 2012

Thermal Brehemsstrahlung



ROSAT image (Briel et al 1992)

The Coma cluster



Brown & Rudnick 2011, Westerbork 350 MHz, 1'x 2'

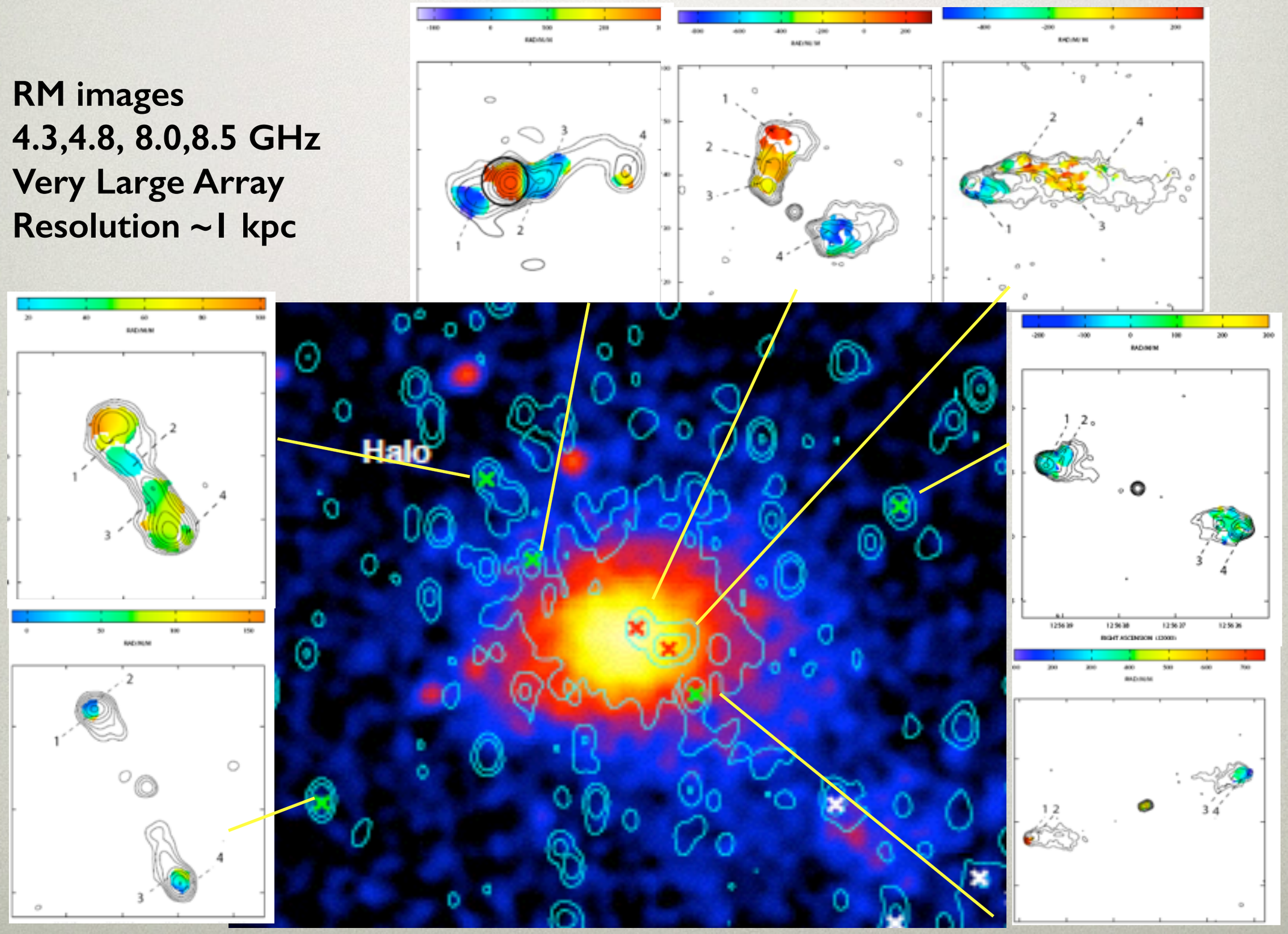
WHAT DO WE NEED?

1) MAGNETIC FIELD

2) LOW FREQUENCY OBSERVATIONS ⇒ SPECTRUM

The Coma cluster magnetic field

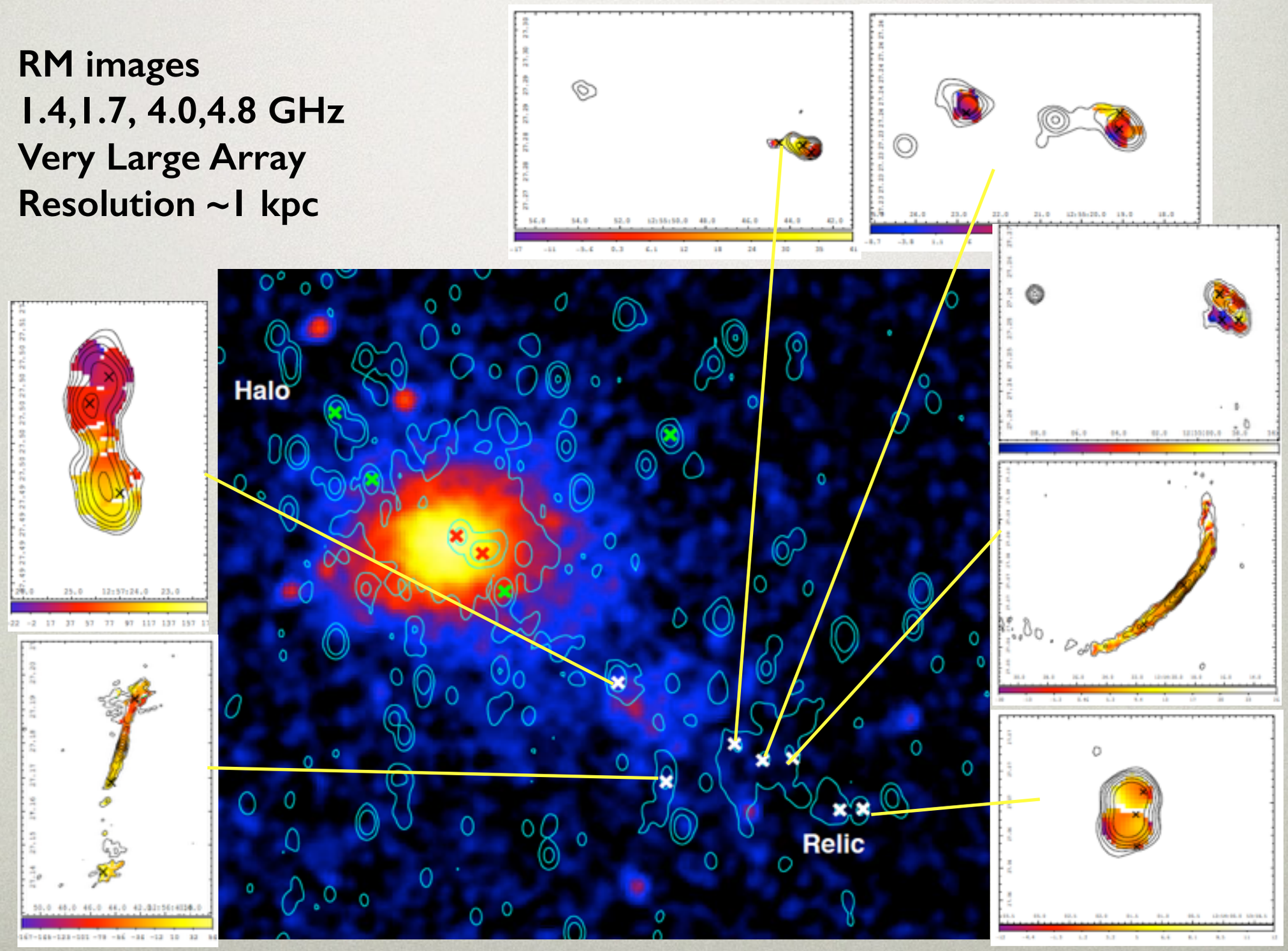
RM images
4.3,4.8, 8.0,8.5 GHz
Very Large Array
Resolution ~1 kpc



Bonafede et al. (2010)

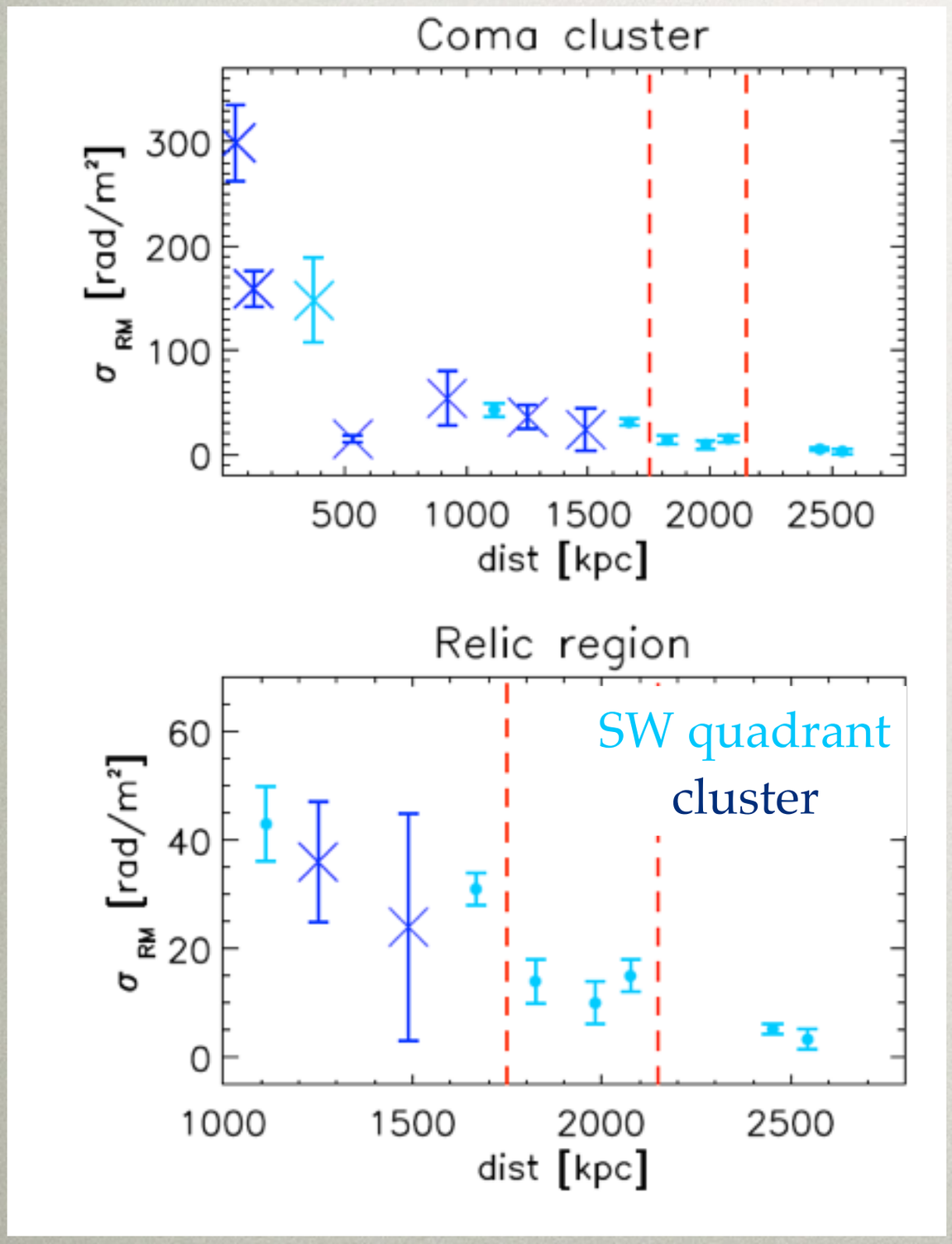
The Coma cluster magnetic field

RM images
1.4,1.7, 4.0,4.8 GHz
Very Large Array
Resolution ~1 kpc



Bonafede et al. (2013)

The Coma cluster magnetic field



$$B \propto B_0 n_{gas}^{\eta}$$

-$B_0 \sim 4.7\ \mu G$

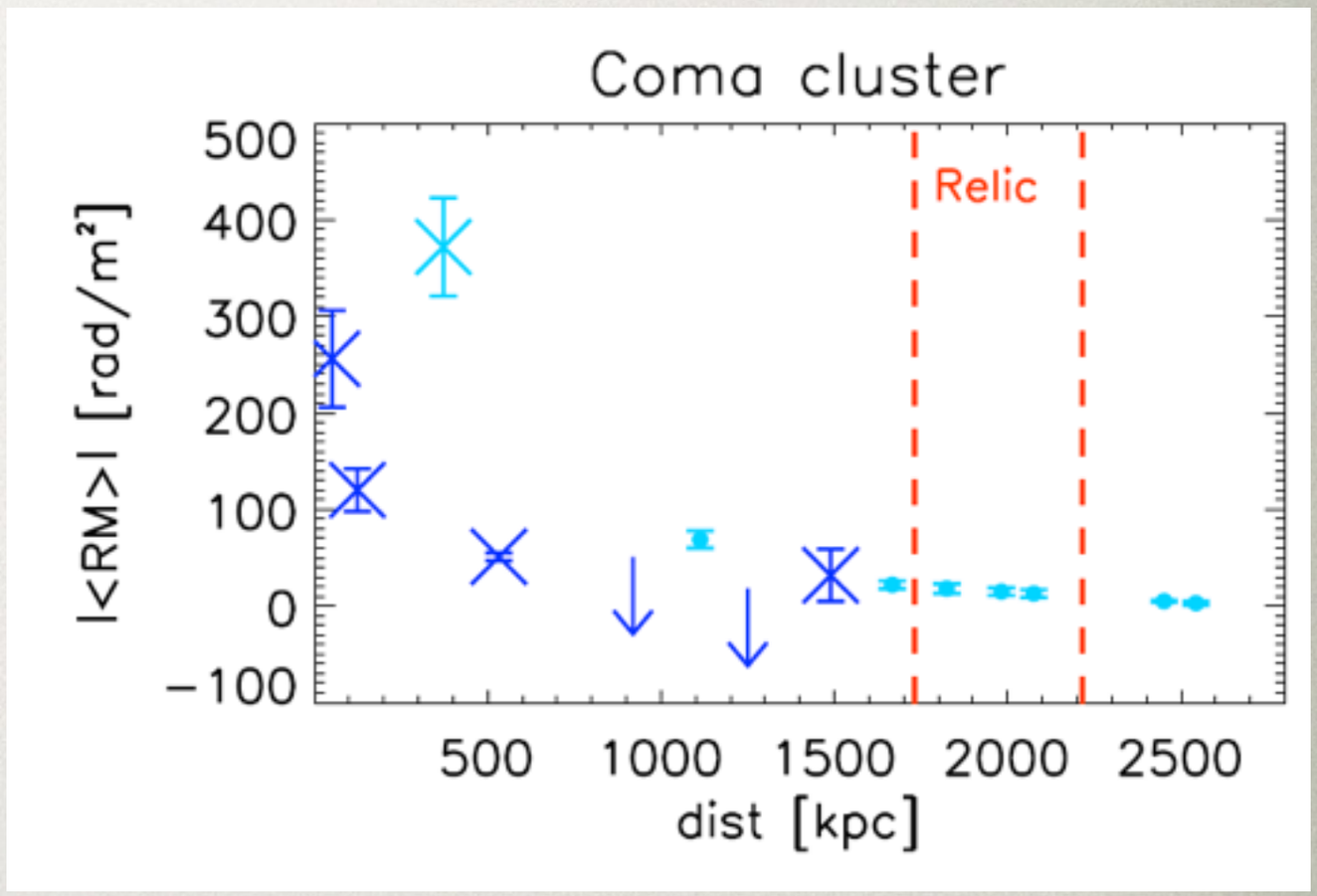
$\eta \sim 0.5$

-No jump at the relics

-Boost across the SW quadrant

LIMITS ON MAGNETIC FIELD STUDIES

1)Number of sources through the cluster



14 sources

~150h observing time

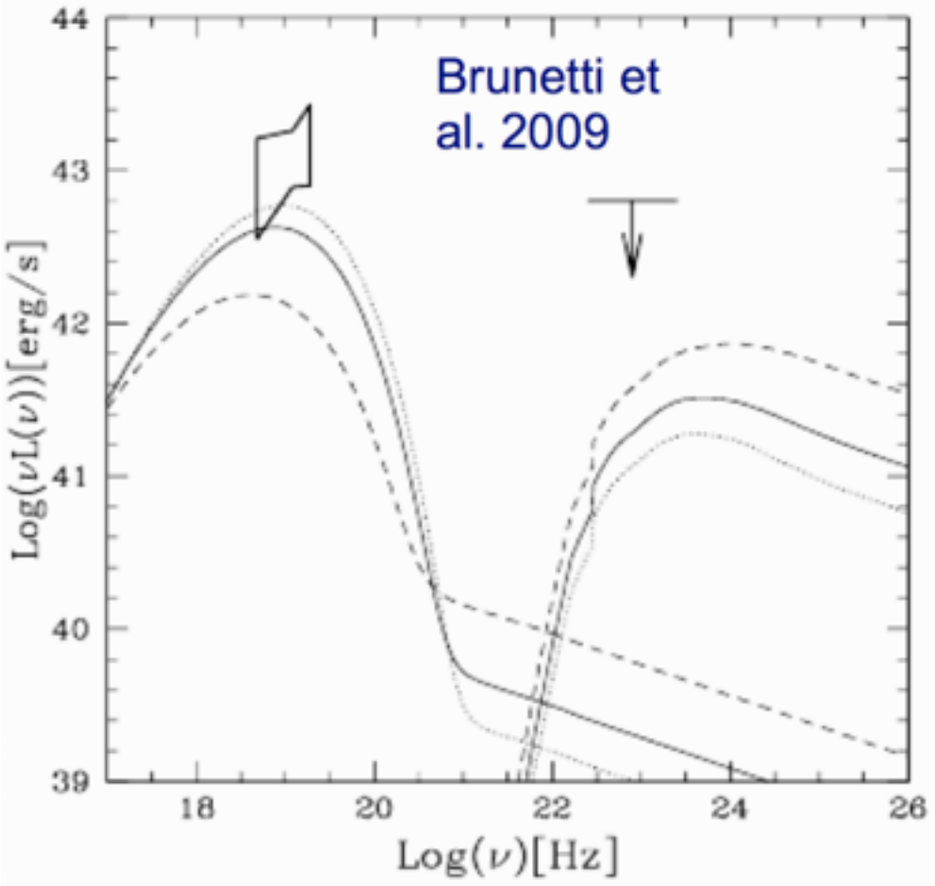
2) Cluster members: local effect?

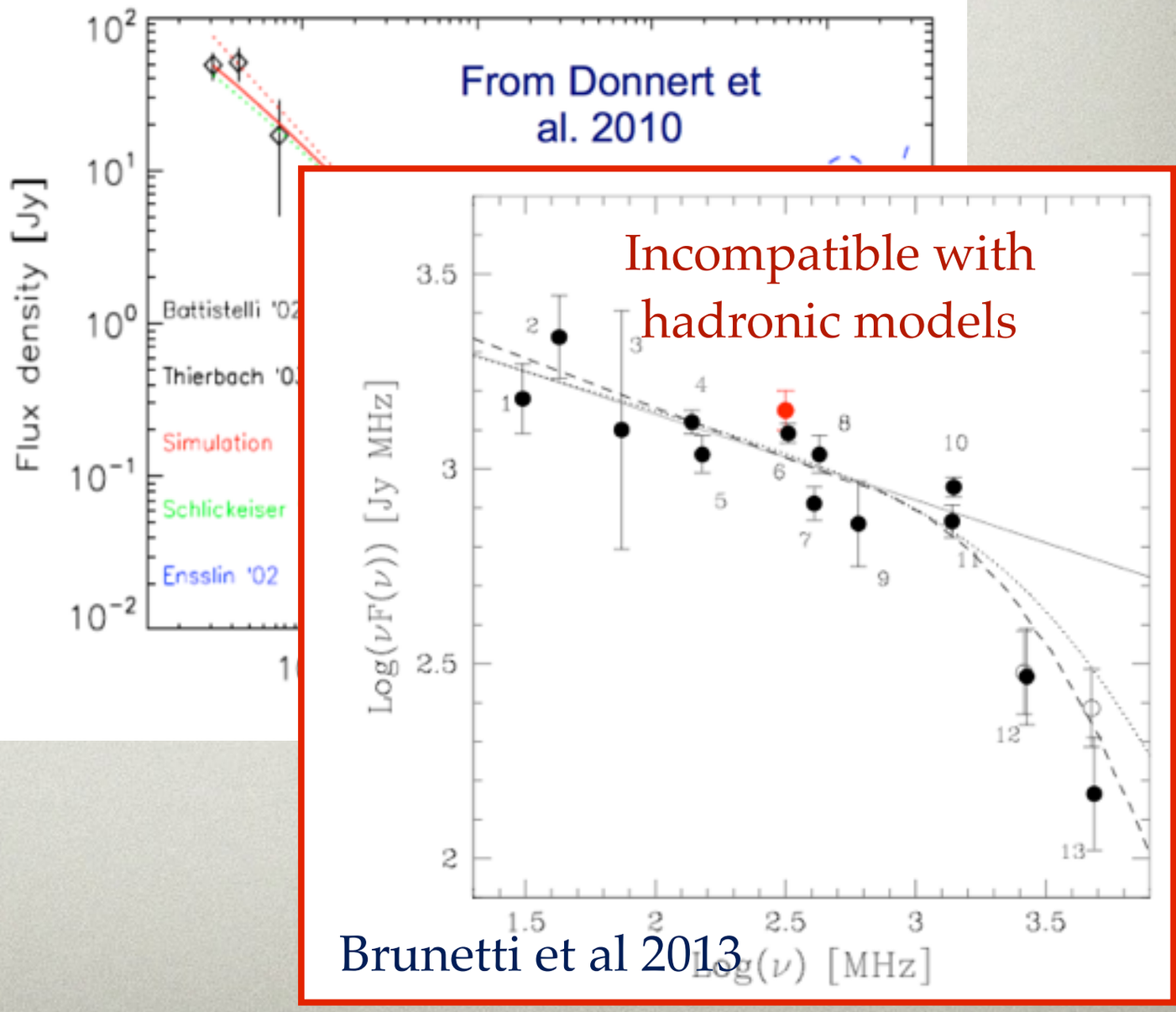
Origin of the radio halo?

Re-acceleration models

Hadronic models

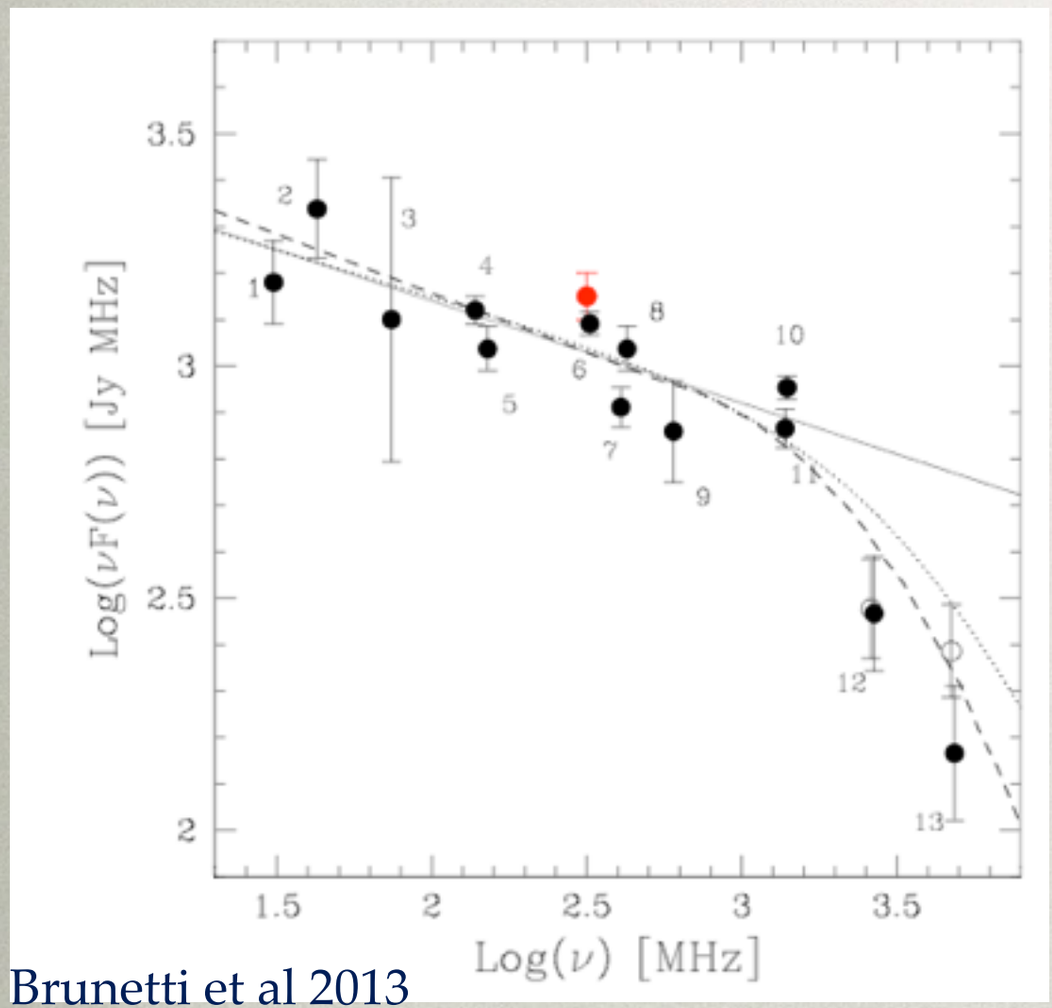
A Coma-like cluster





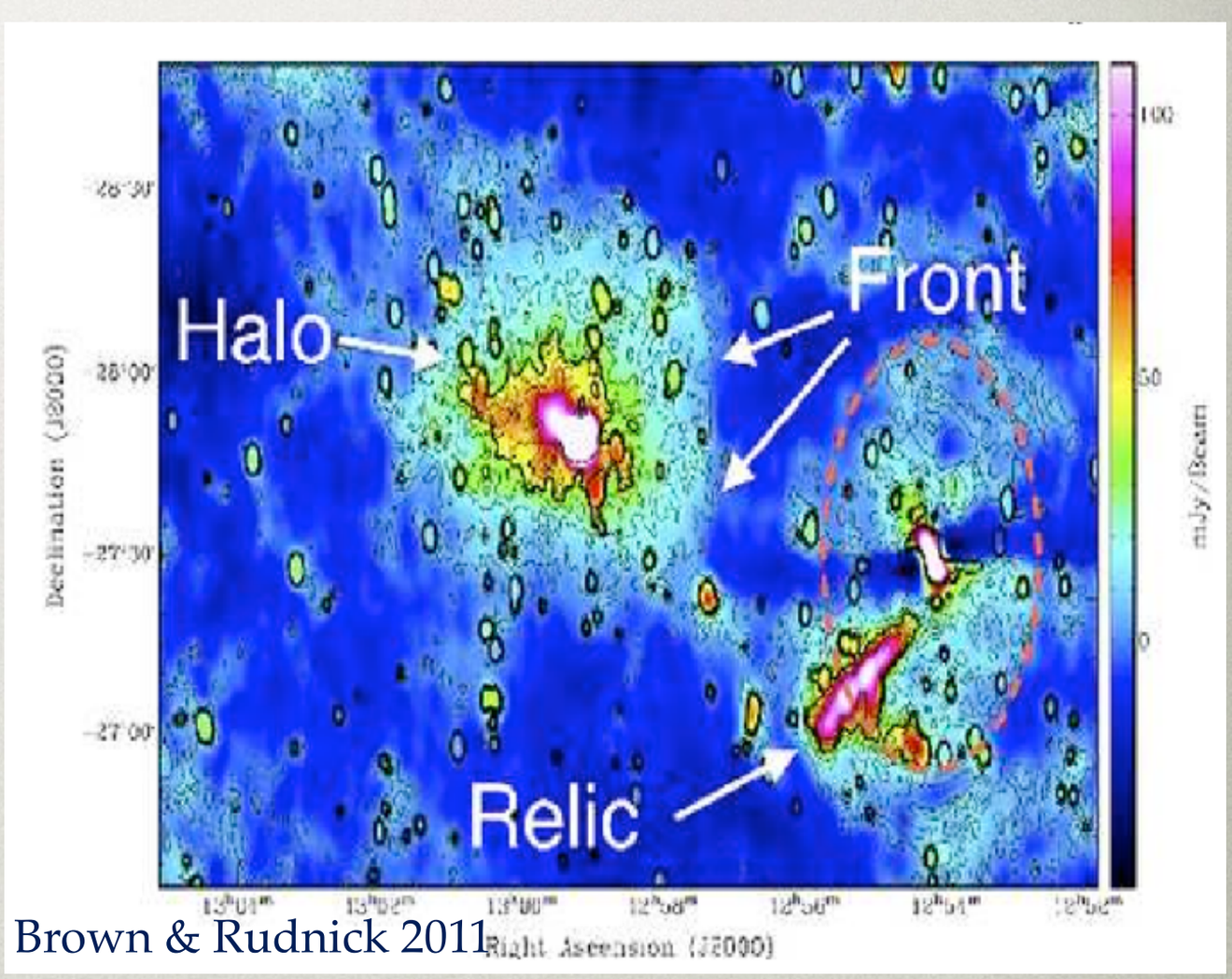
Origin of the radio halo?

There is much more to learn



Brunetti et al 2013

Spectrum of the central halo emission (0.48 R_{500} ~ 23′)



Brown & Rudnick 2011

Most of the flux emitted at r> 25′

1) LOW FREQUENCY RADIO EMISSION

The Coma cluster: LOFAR view

Bonafede & LOFAR survey collaboration

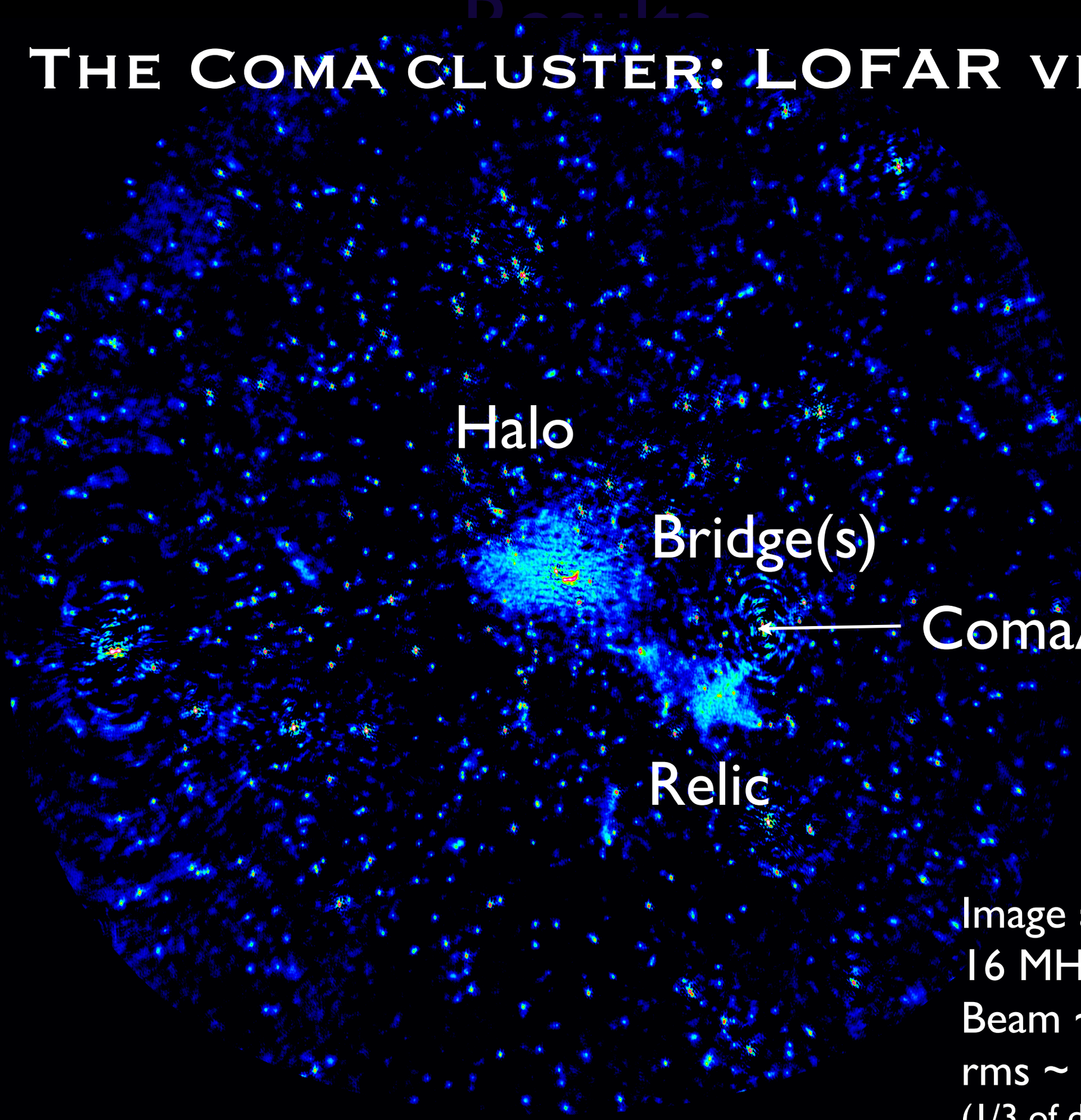
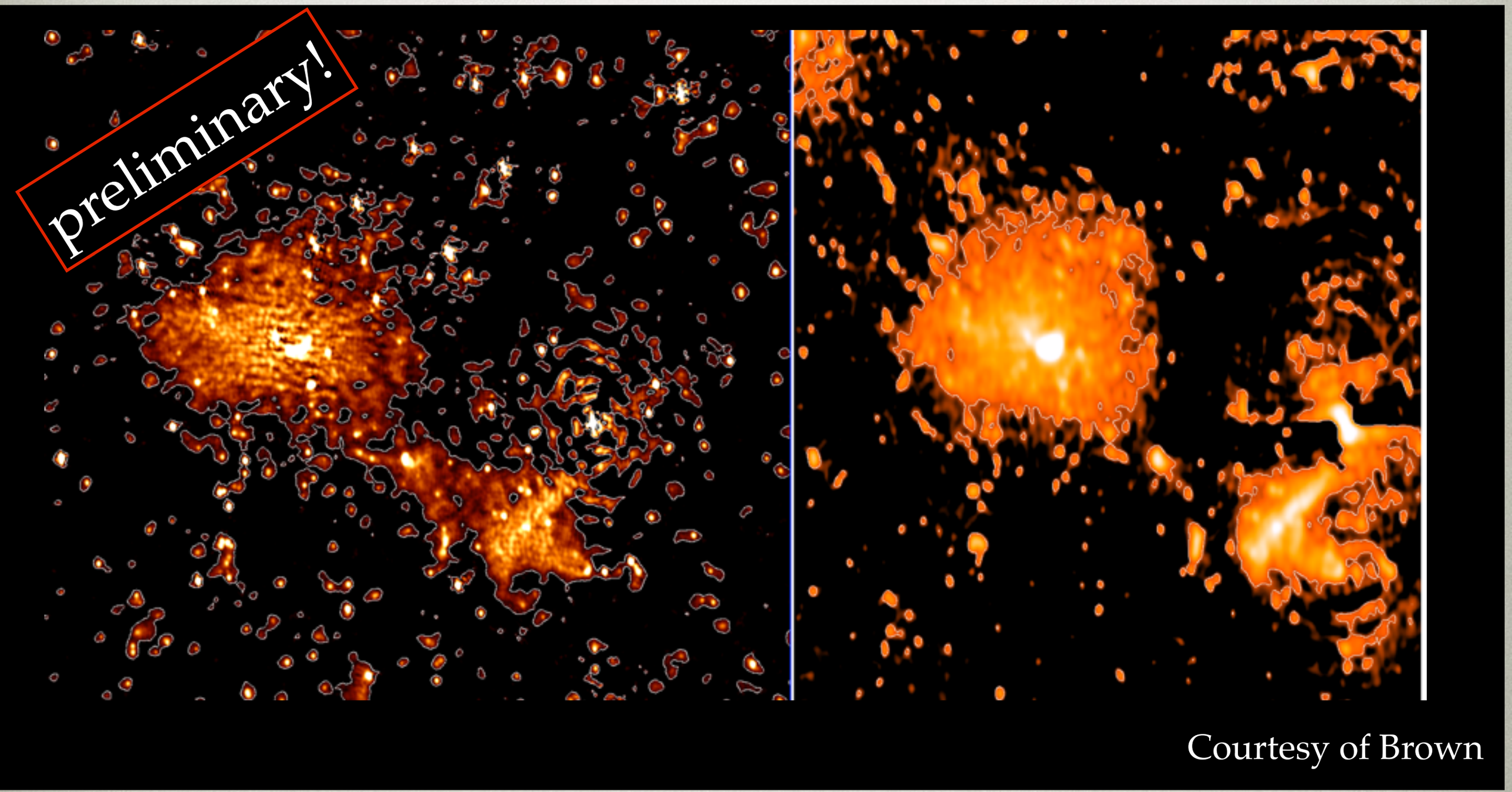


Image at 140 MHz
16 MHz bandwidth
Beam ~ 25”
rms ~ 0.6 mJy/beam
(1/3 of data processed)

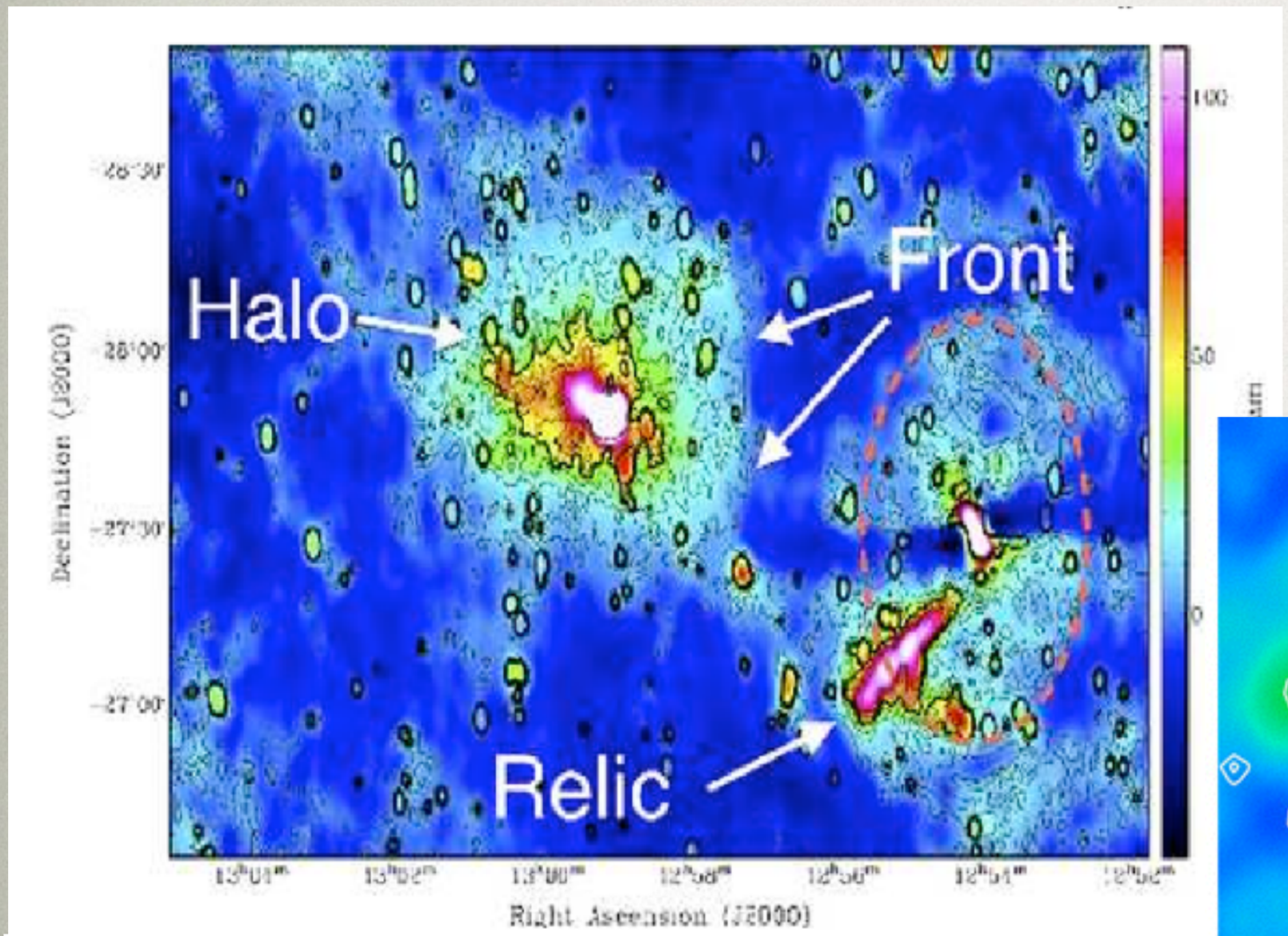
Comparison with 350 MHz map



LOFAR 140 MHz
25″

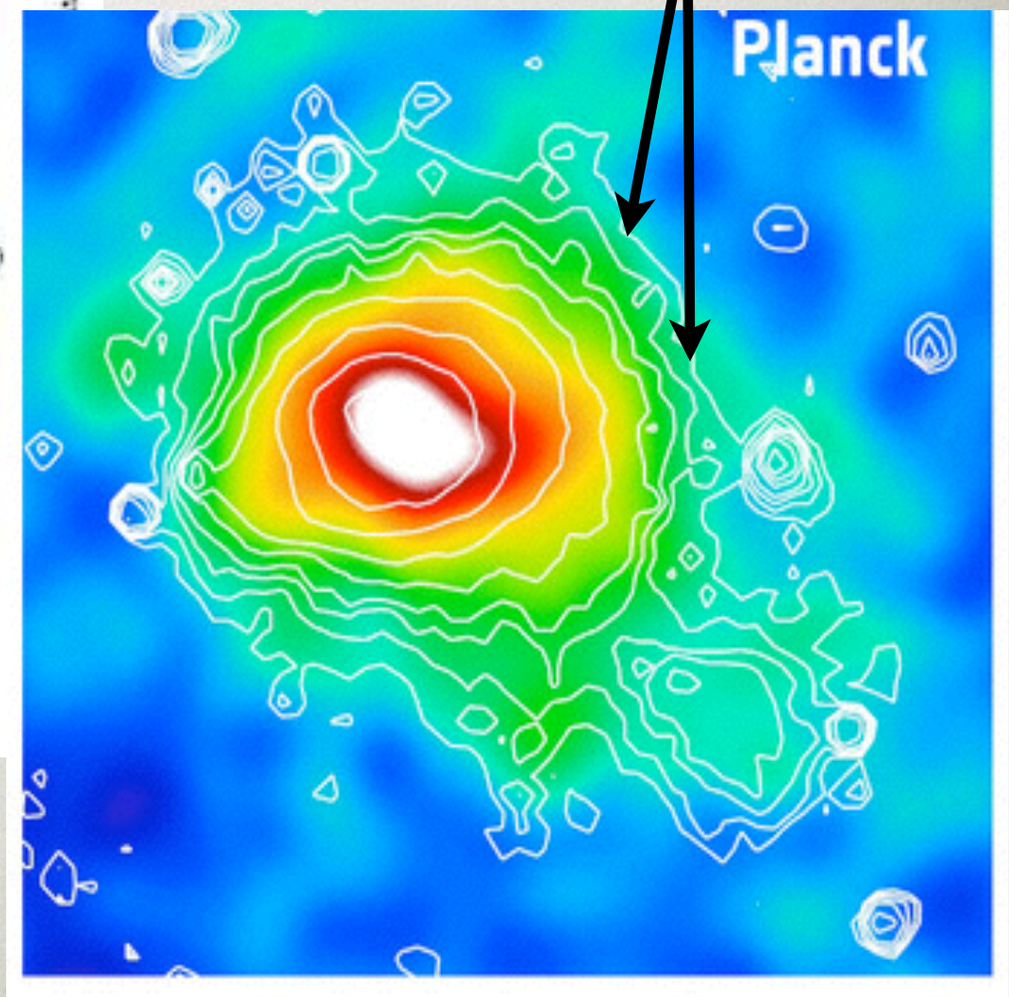
WSRT 350 MHz
1′ x 2′

Halo - Shock front?

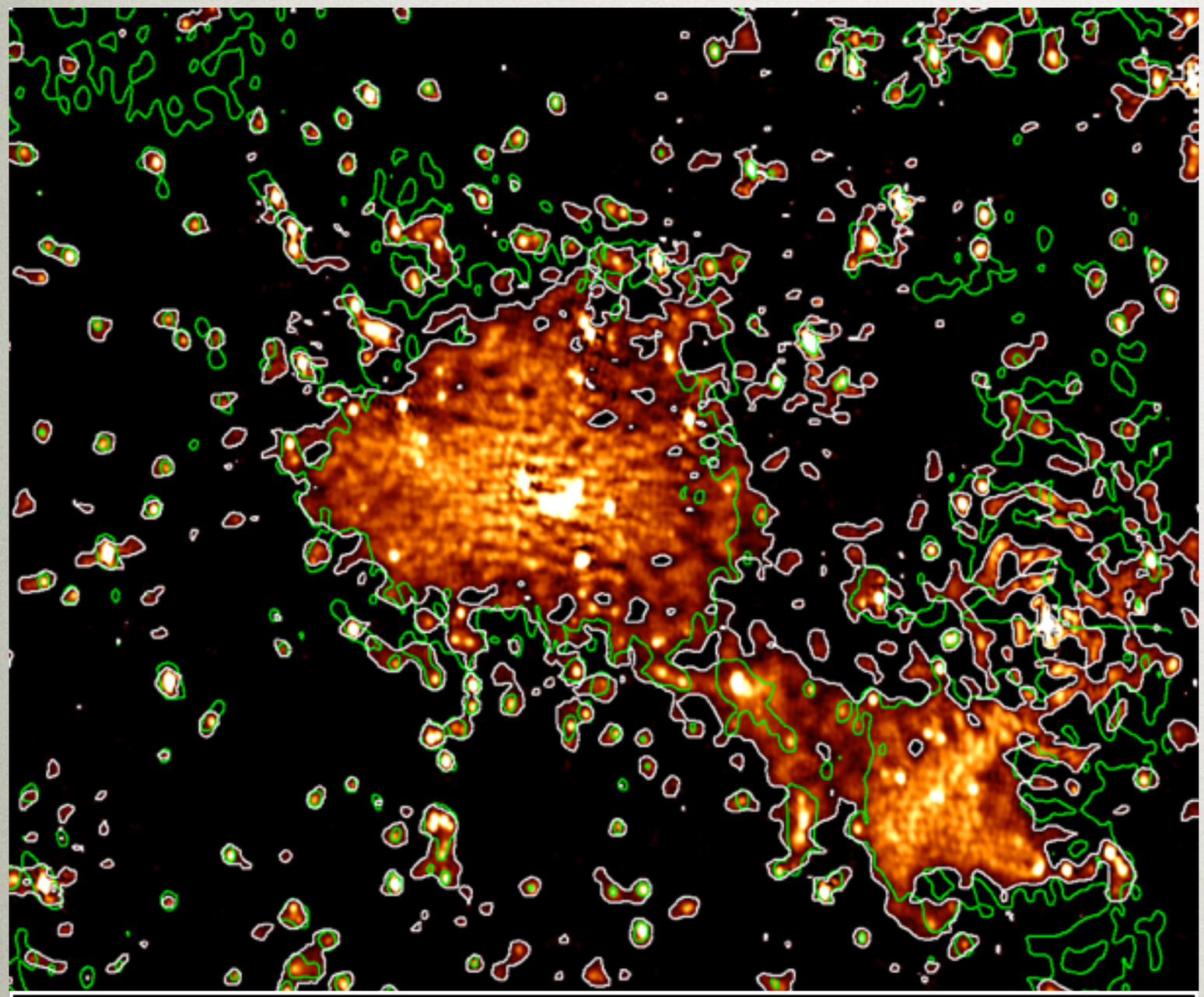


(Brown & Rudnick 2011)

SZ discontinuity



Comparison with 350 MHz map



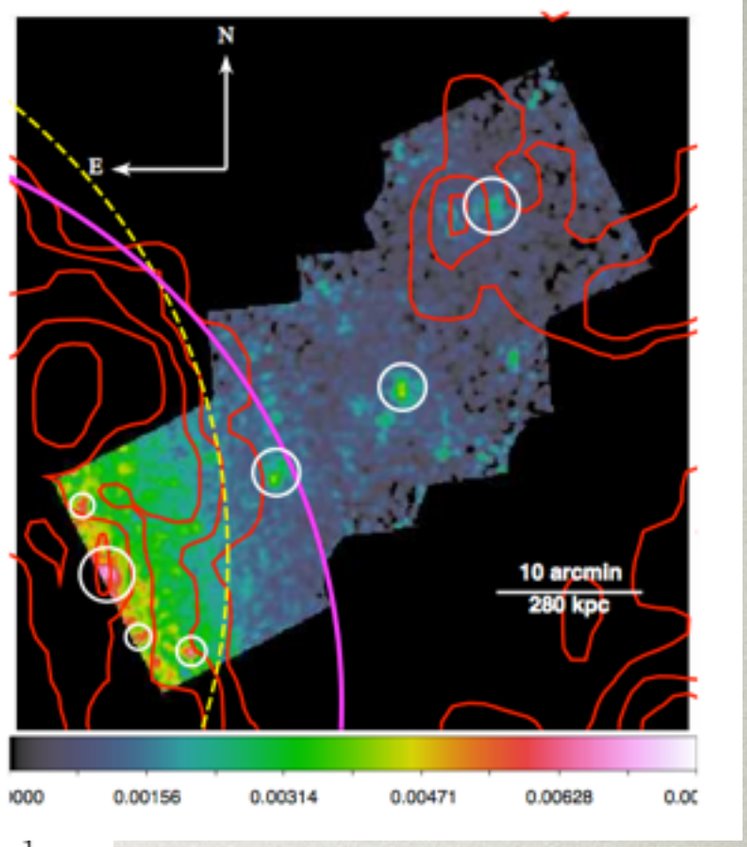
LOFAR 140 MHz

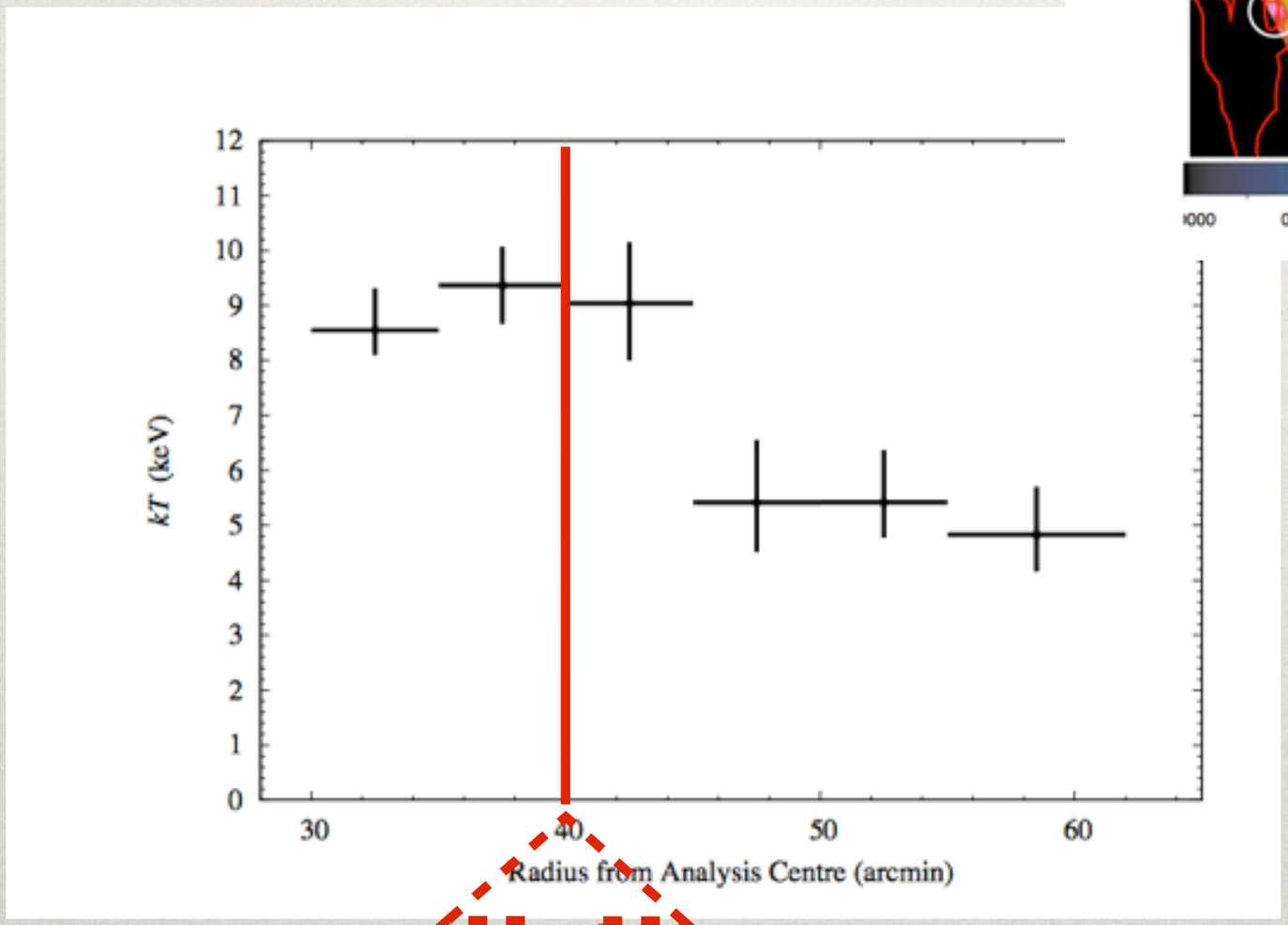
WSRT 350 MHZ (Brown & Rudnick 2011)

- No Front detected

Suzaku observations of a shock front tracing the western edge of the giant radio halo in the Coma Cluster

Yuusuke UCHIDA[1,2], Aurora SIMIONESCU[1], Tadayuki TAKAHASHI[1,2], Norbert WERNER[3,4], Yuto ICHINOHE[1,2], Steven W. ALLEN[3,4,5], Ondrej URBAN[3,4,5] and Kyoko MATSUSHITA[6]

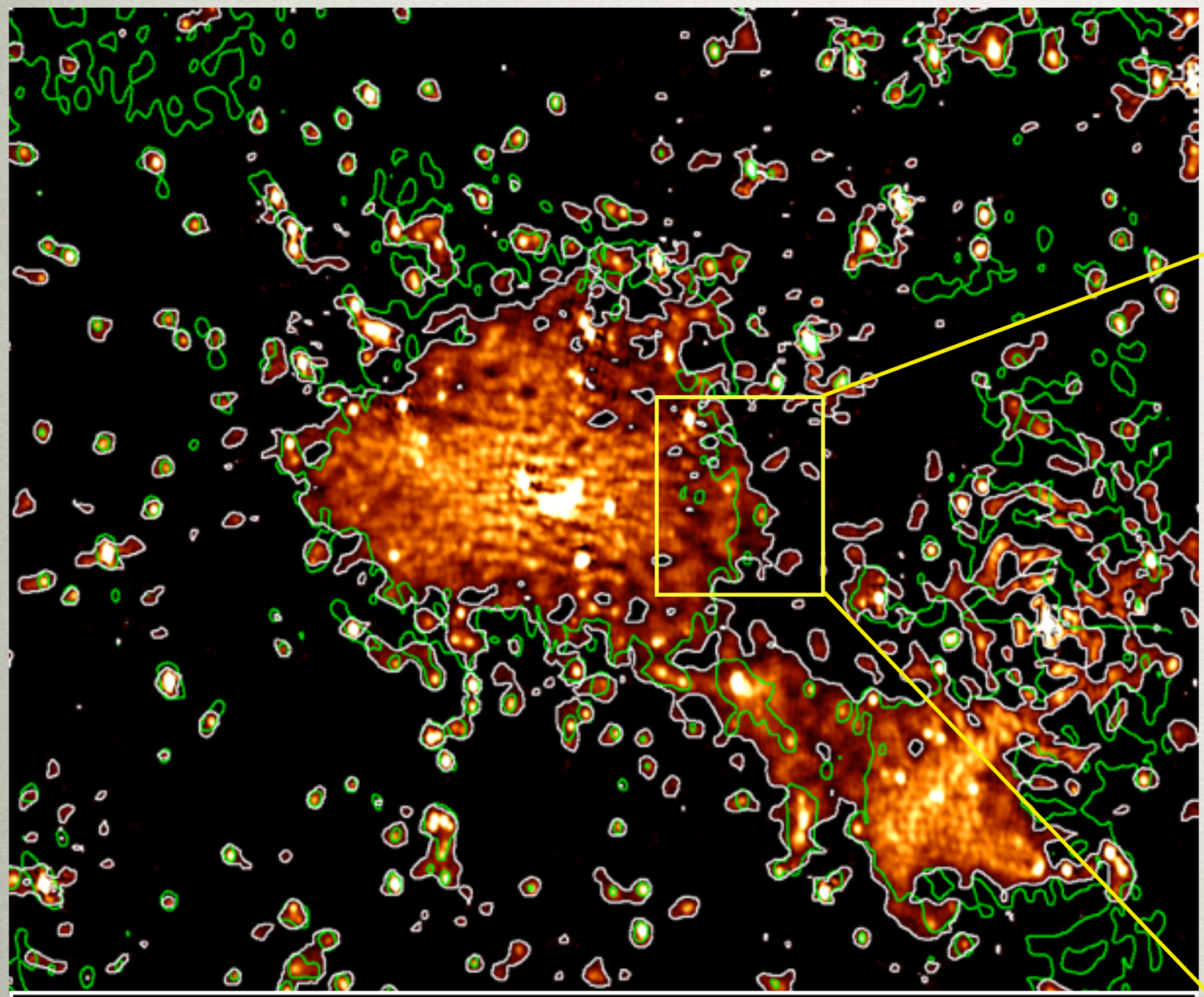




Edge of the radio emission at 350 MHZ

T jump is 4.6 - 6.6 arcmin further out

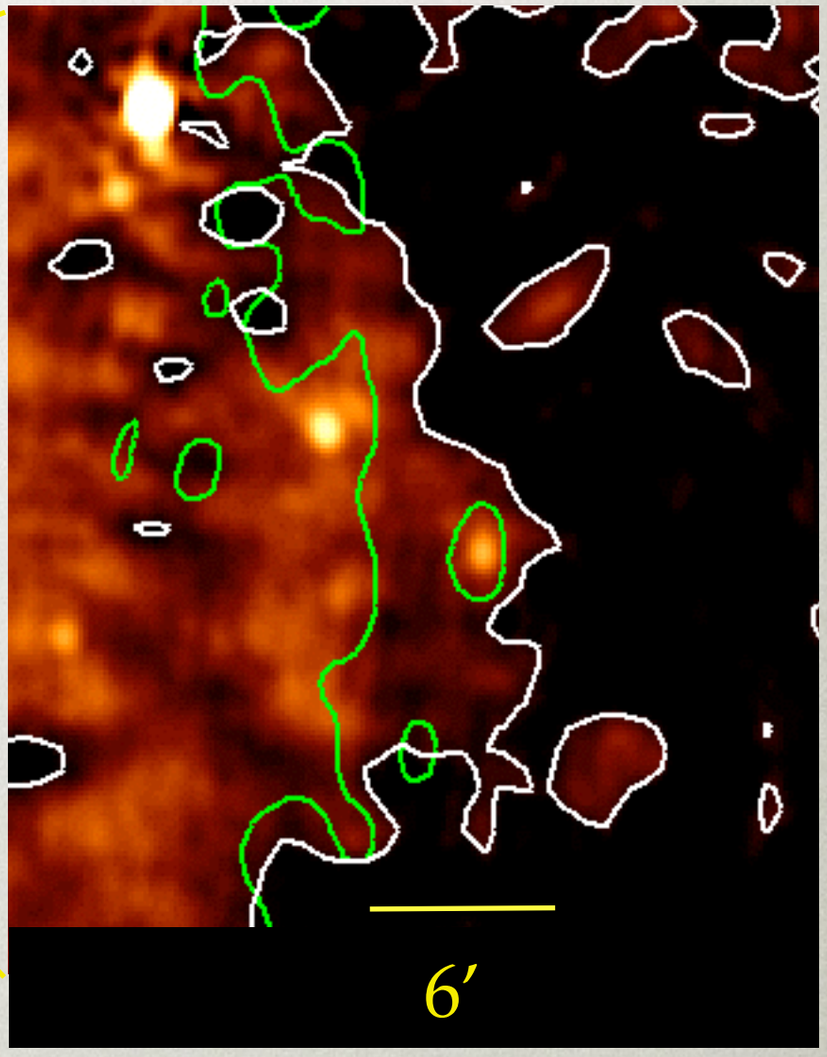
Comparison with 350 MHz map



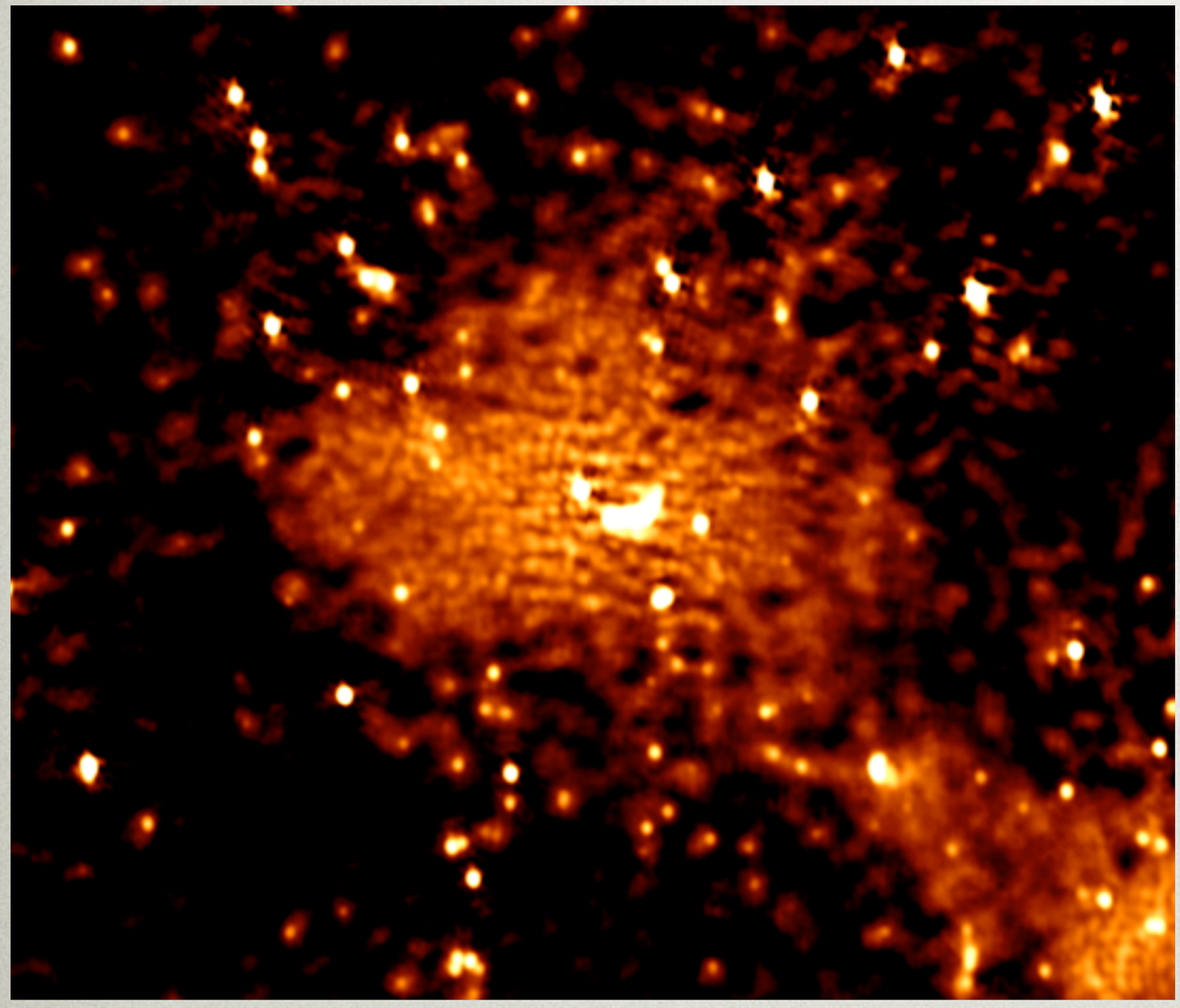
LOFAR 140 MHz

WSRT 350 MHZ (Brown & Rudnick 2011)

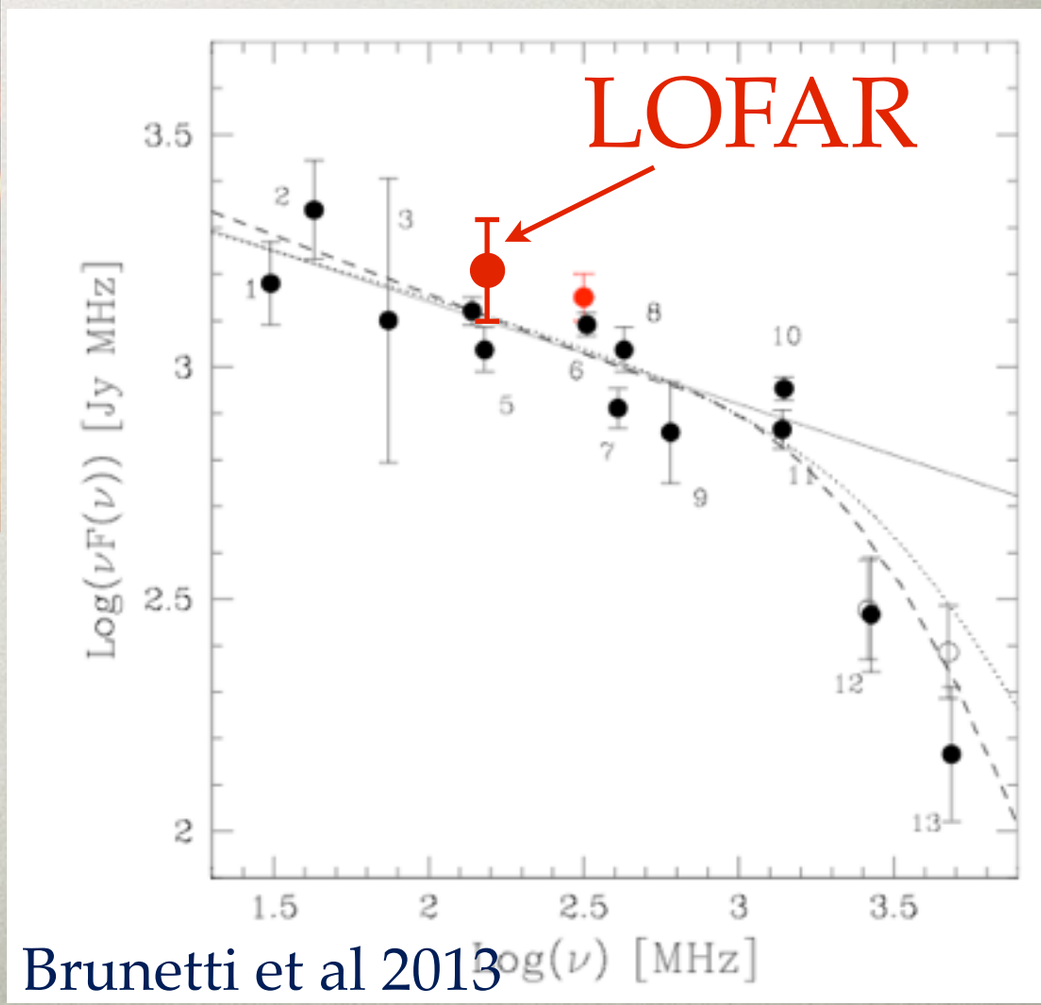
- No Front



The halo

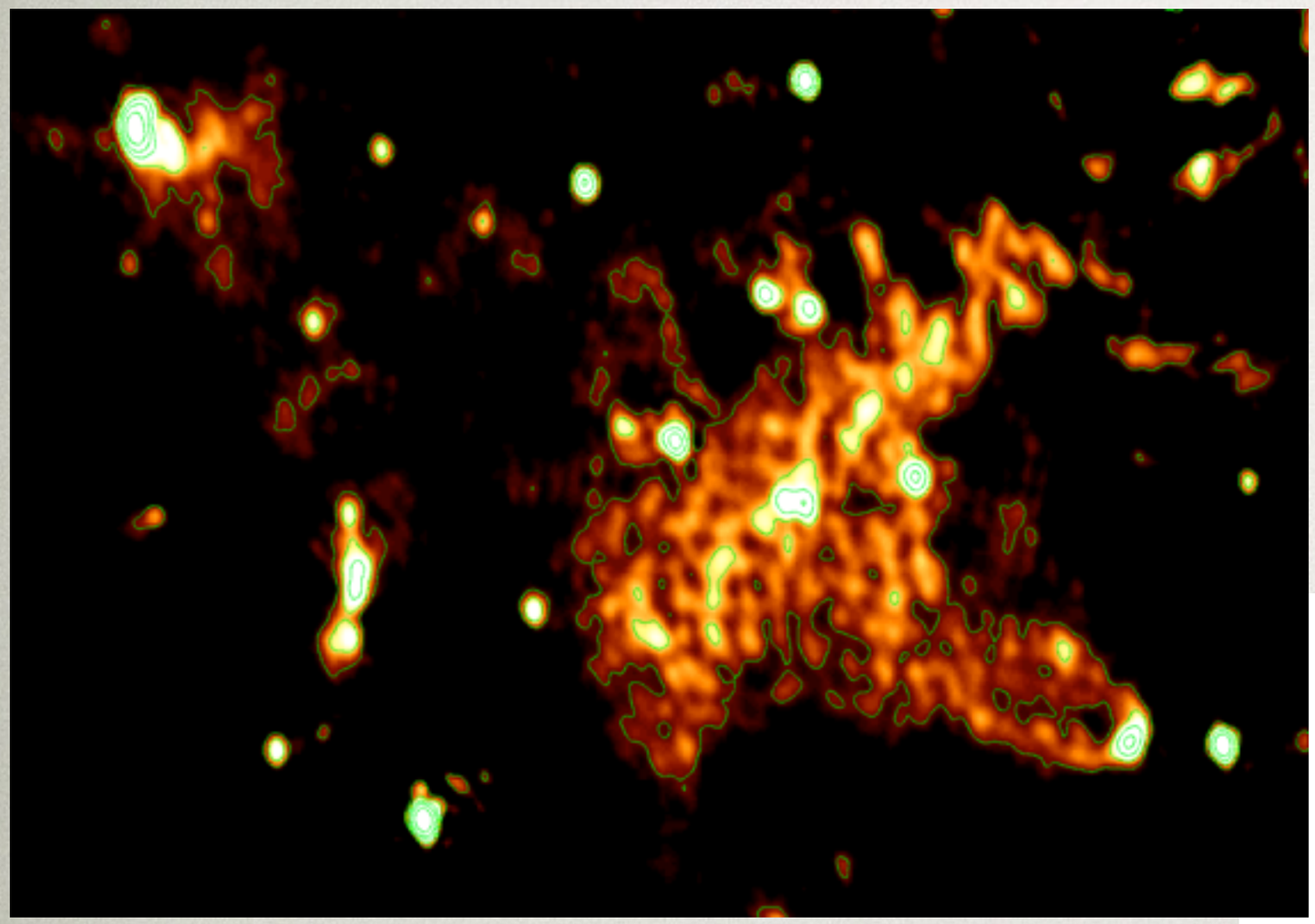


- LLS ~1.8 Mpc ! (~1.1 deg)



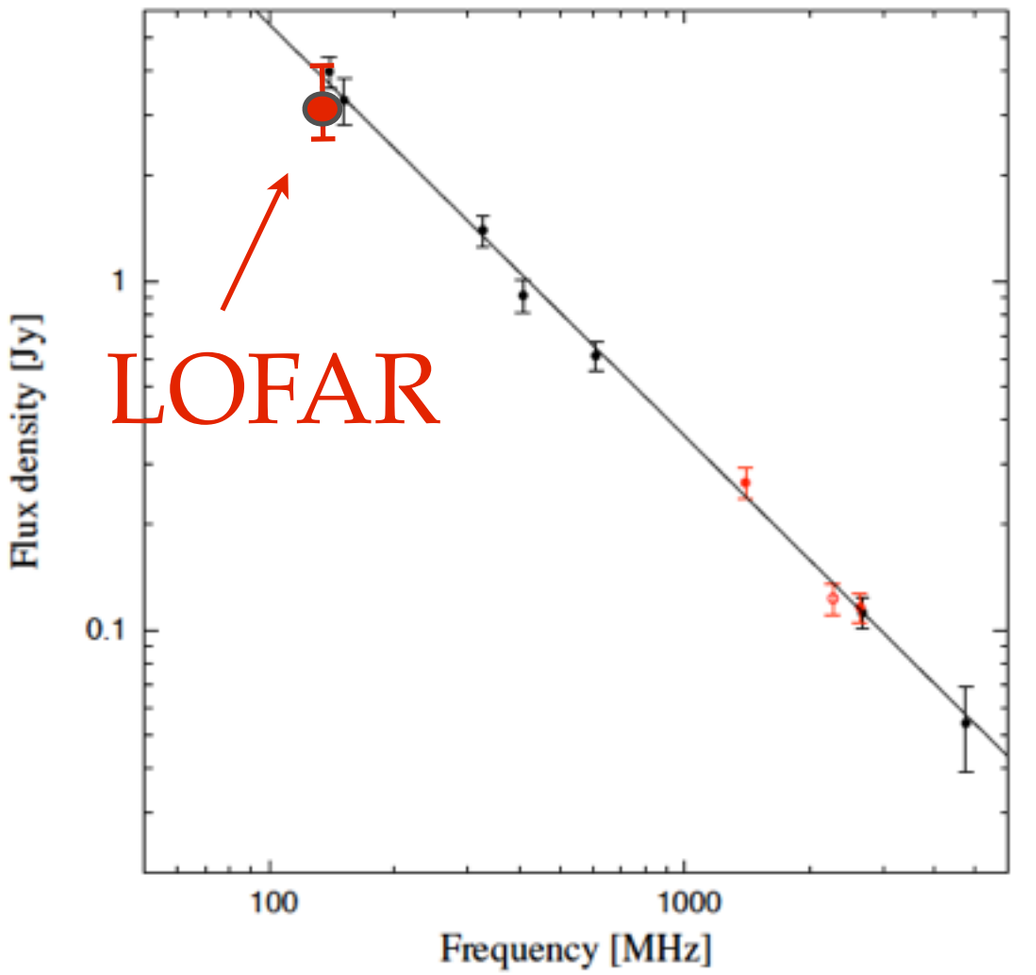
Brunetti et al 2013

The Relic

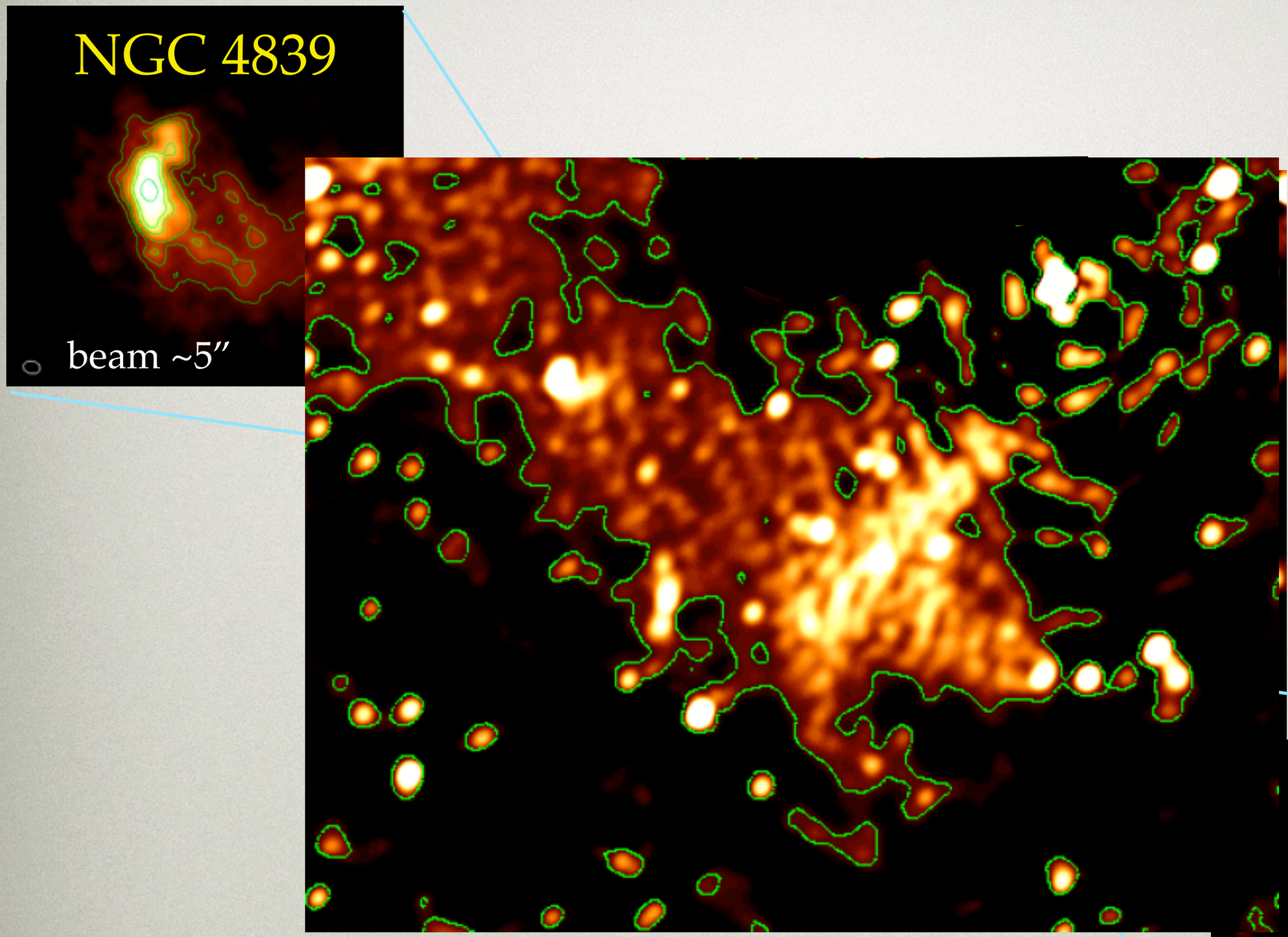


Trasatti et al, submitted
(see Poster!)

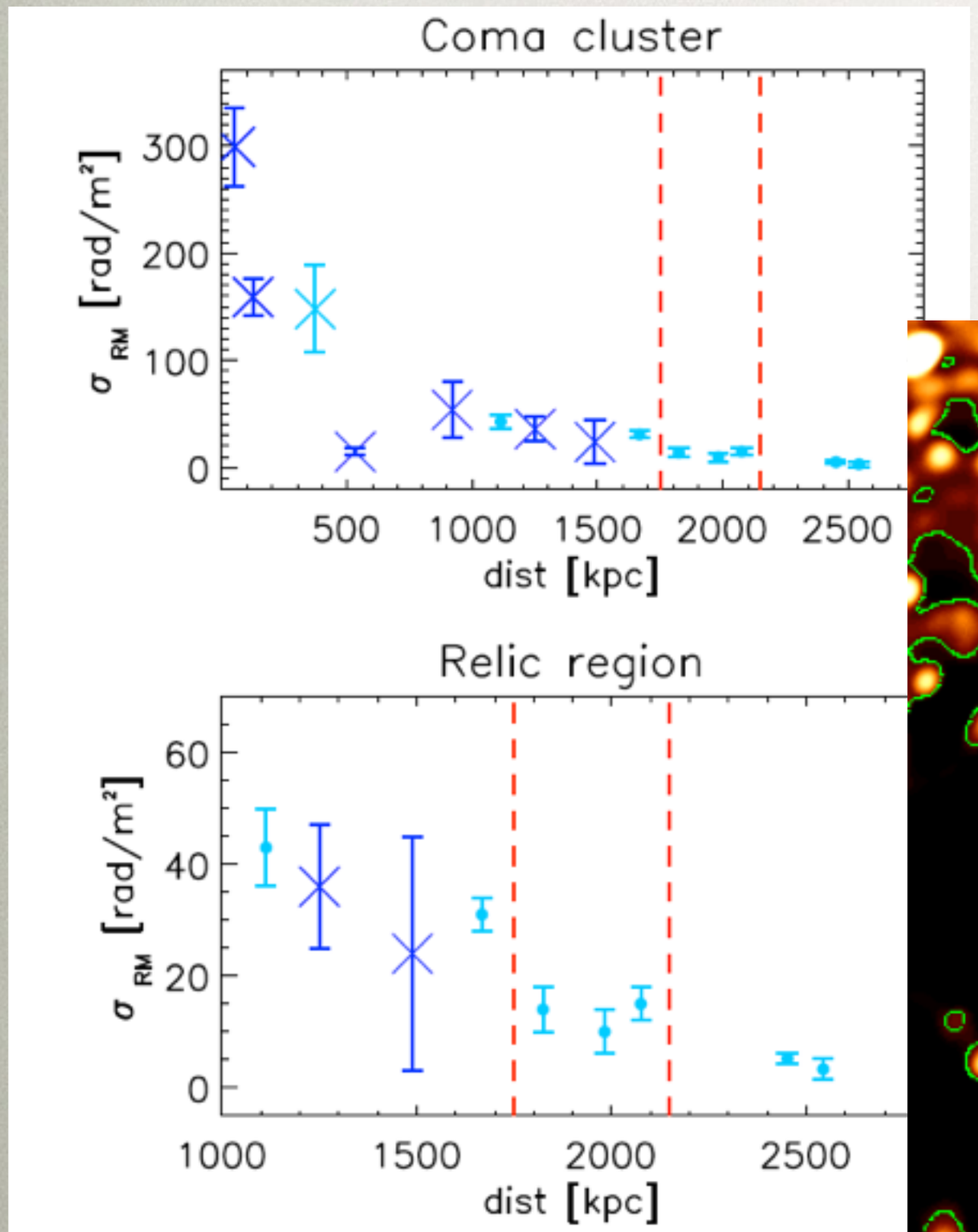
- LLS ~800 kpc
- no sharp edges
- infall shock?



The Bridges

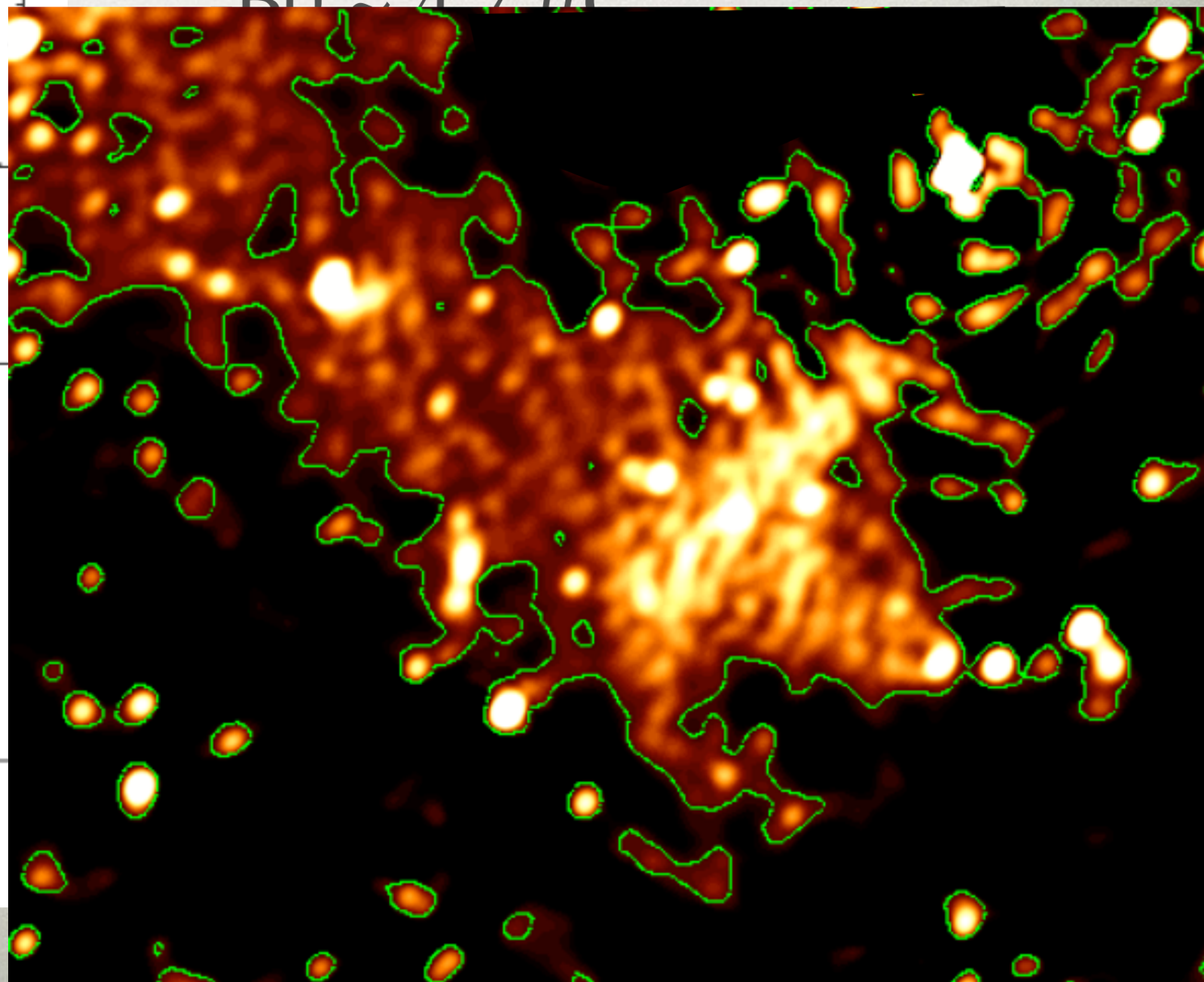


The Bridges

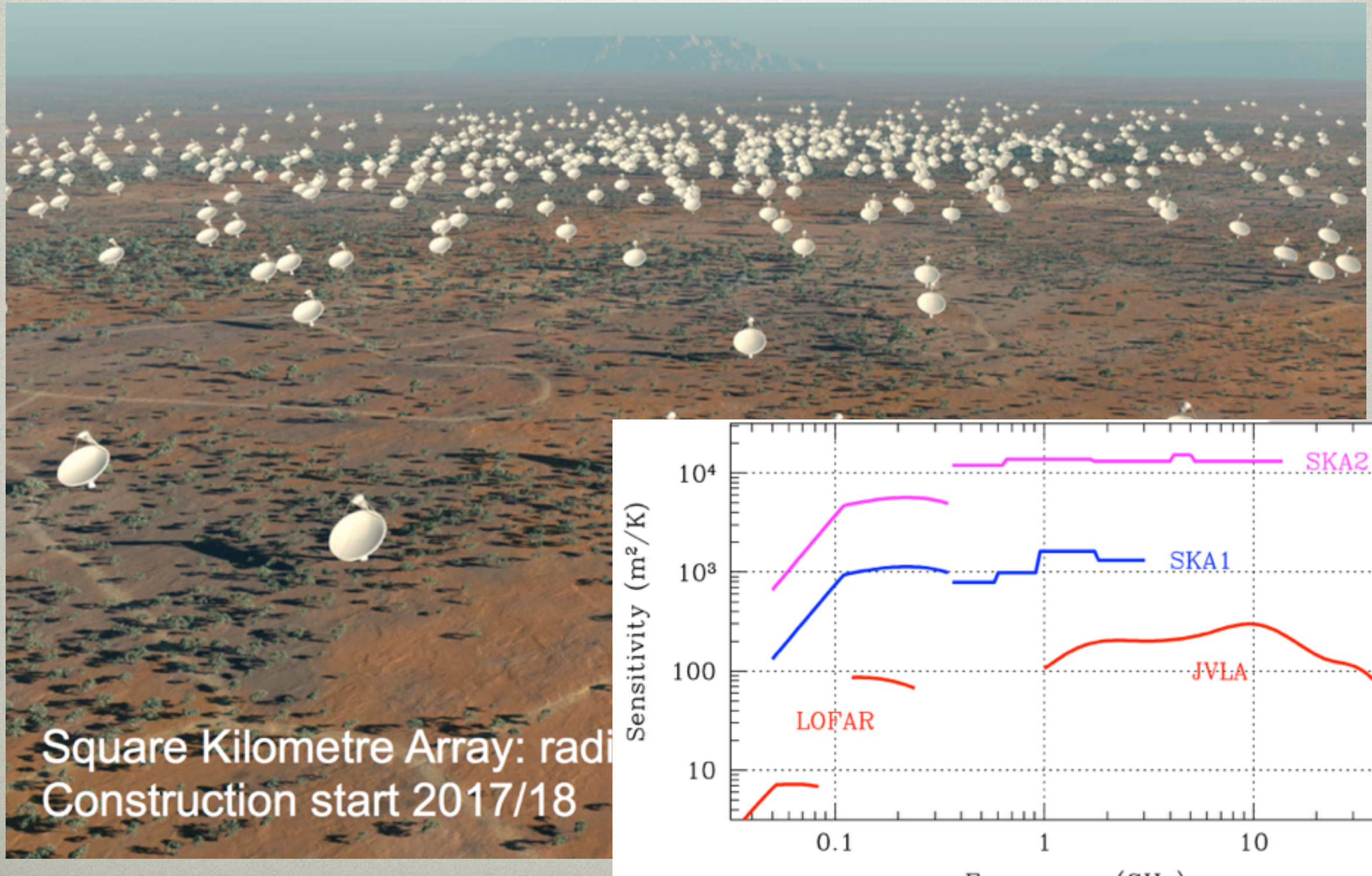


$$B \propto B_0 n_{gas}^{\eta}$$

$B0 \sim 4.7\,\mu G$



FUTURE PROSPECTS
THE SQUARE KILOMETER ARRAY

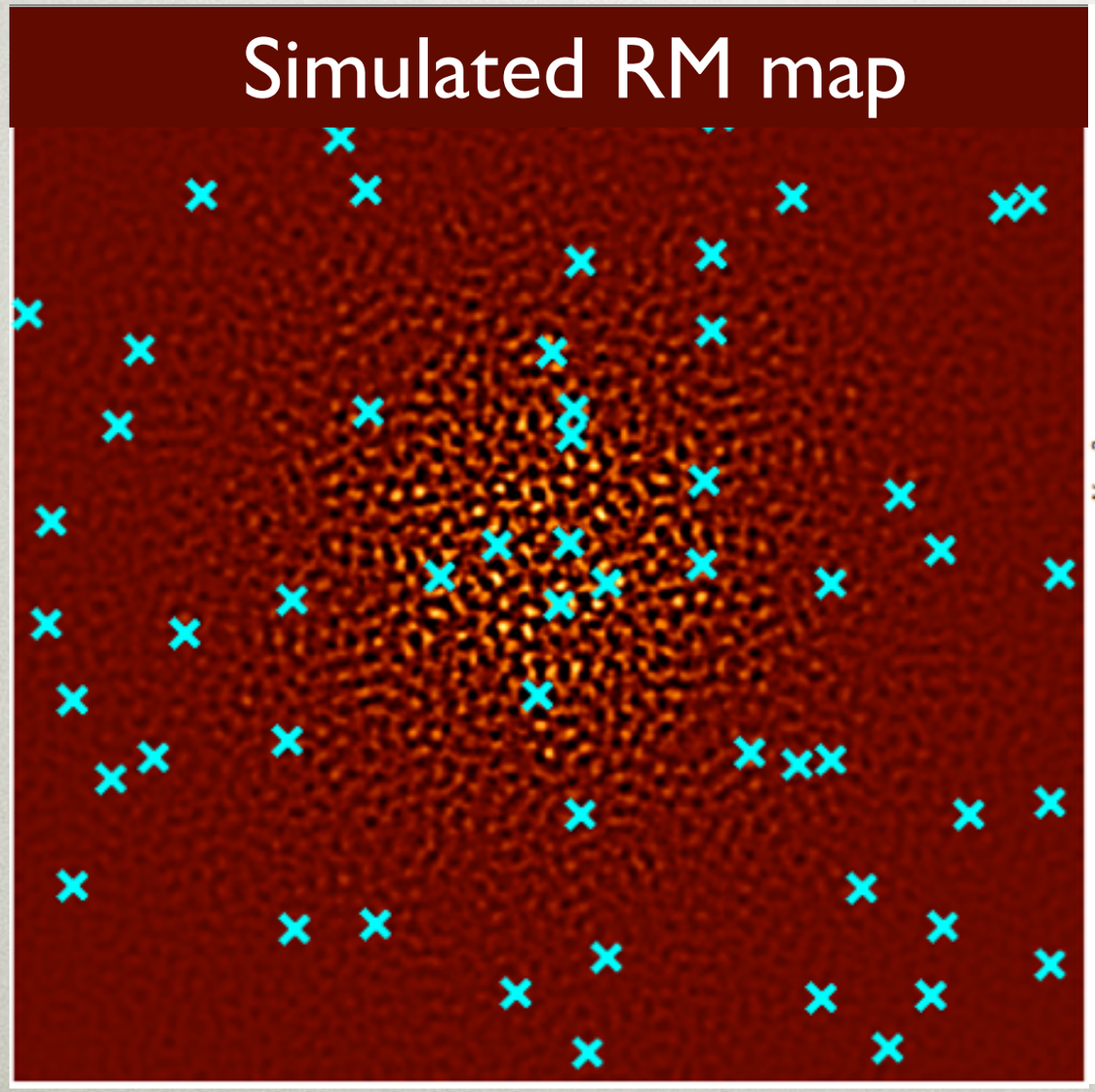


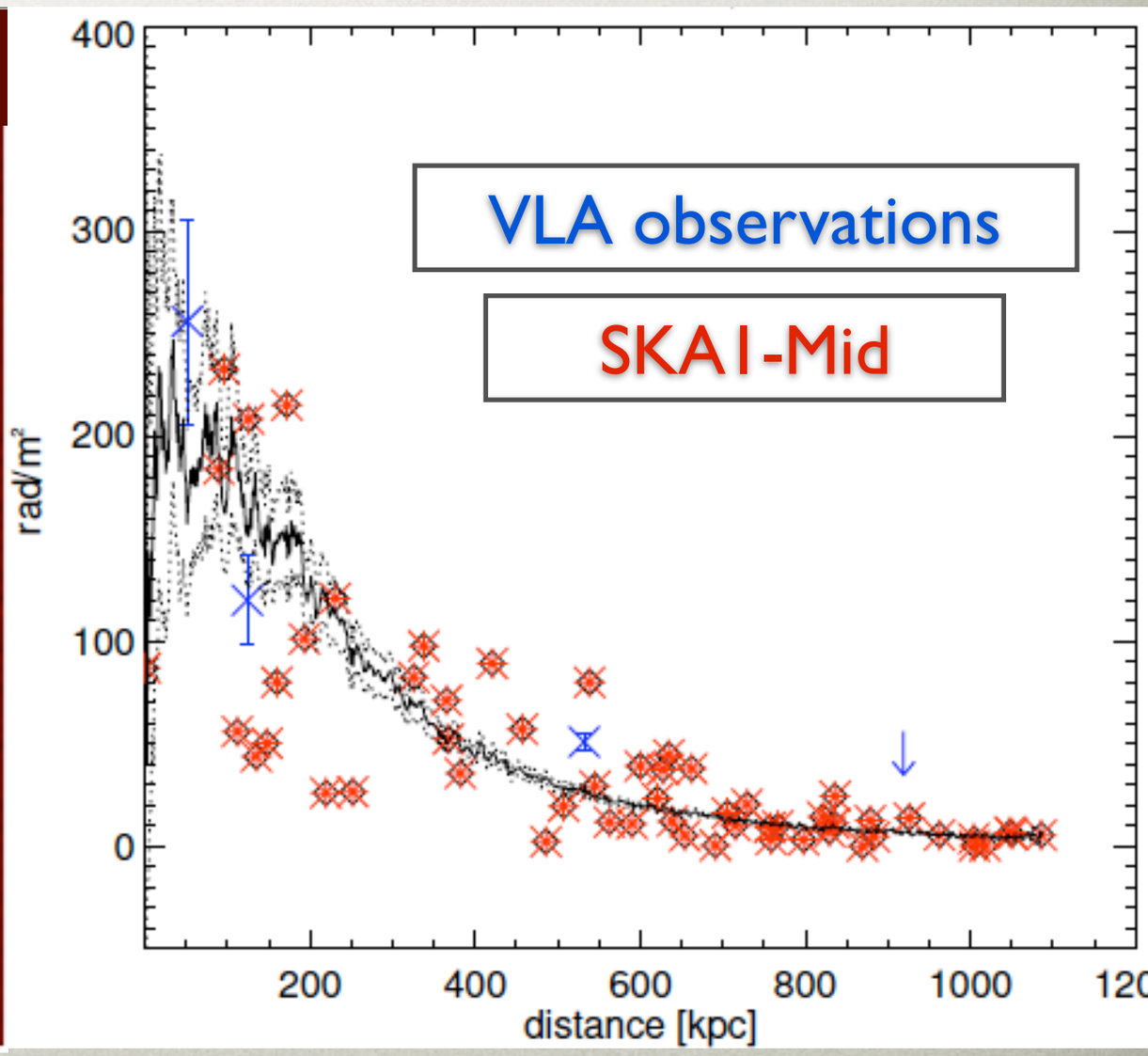
SKA1 A COMA-LIKE CLUSTER

315 polarised
sources / sq deegree

$$B \propto B_0 n_{gas}^{\eta}$$

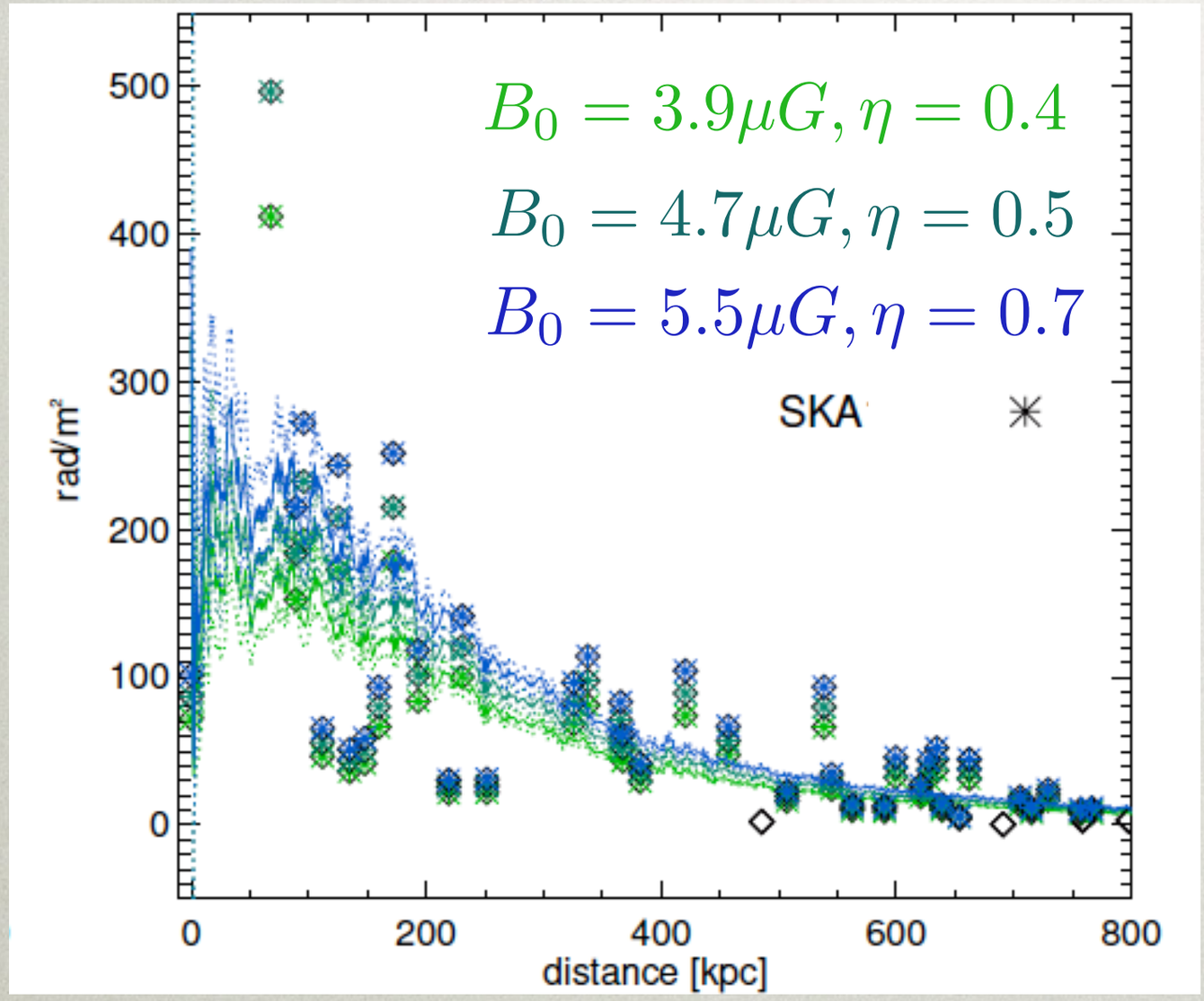
Bonafede et al. (2015)





SKA1: A "Coma-like" cluster

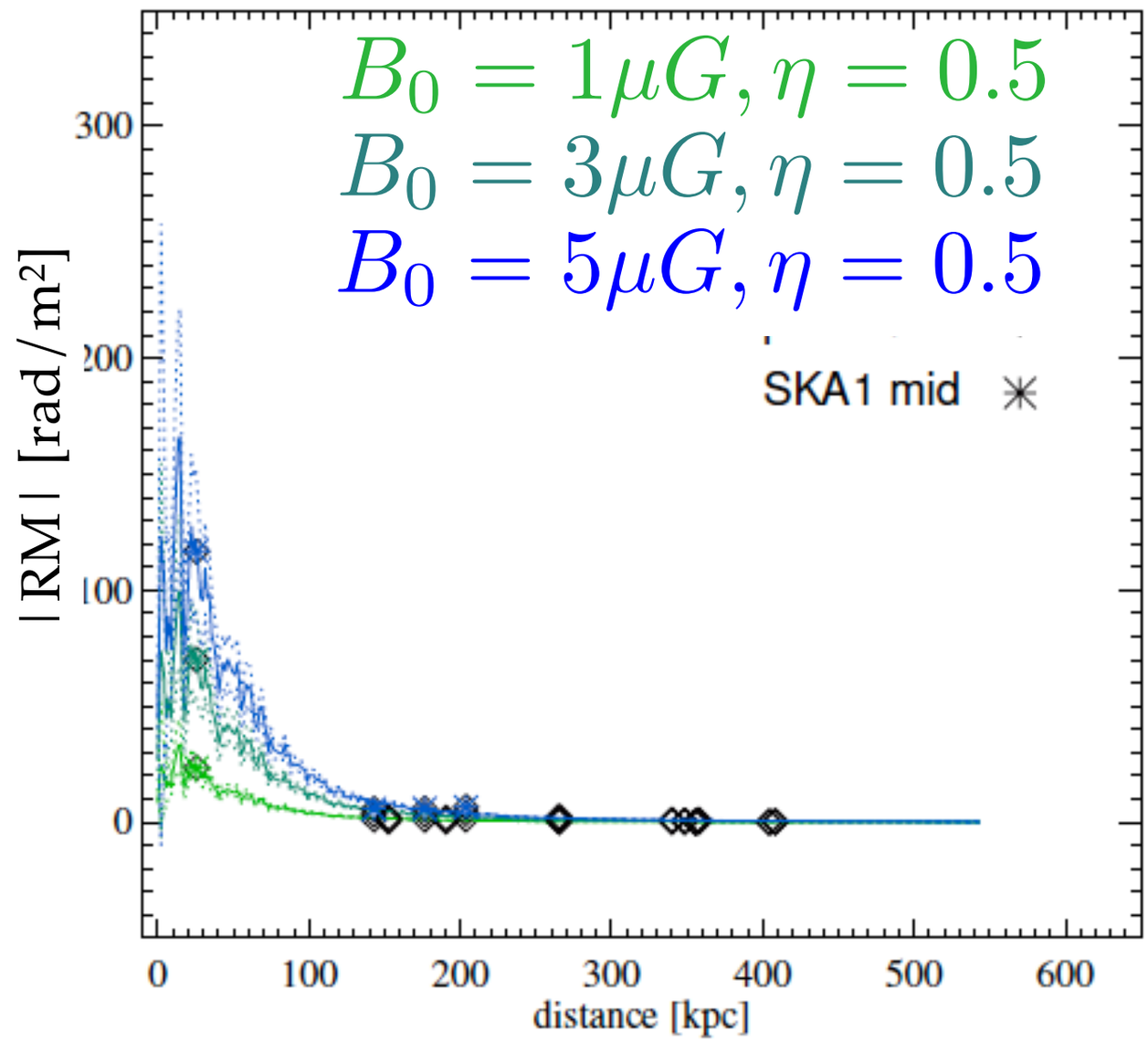
$$M \sim 10^{15} M_{\odot}$$



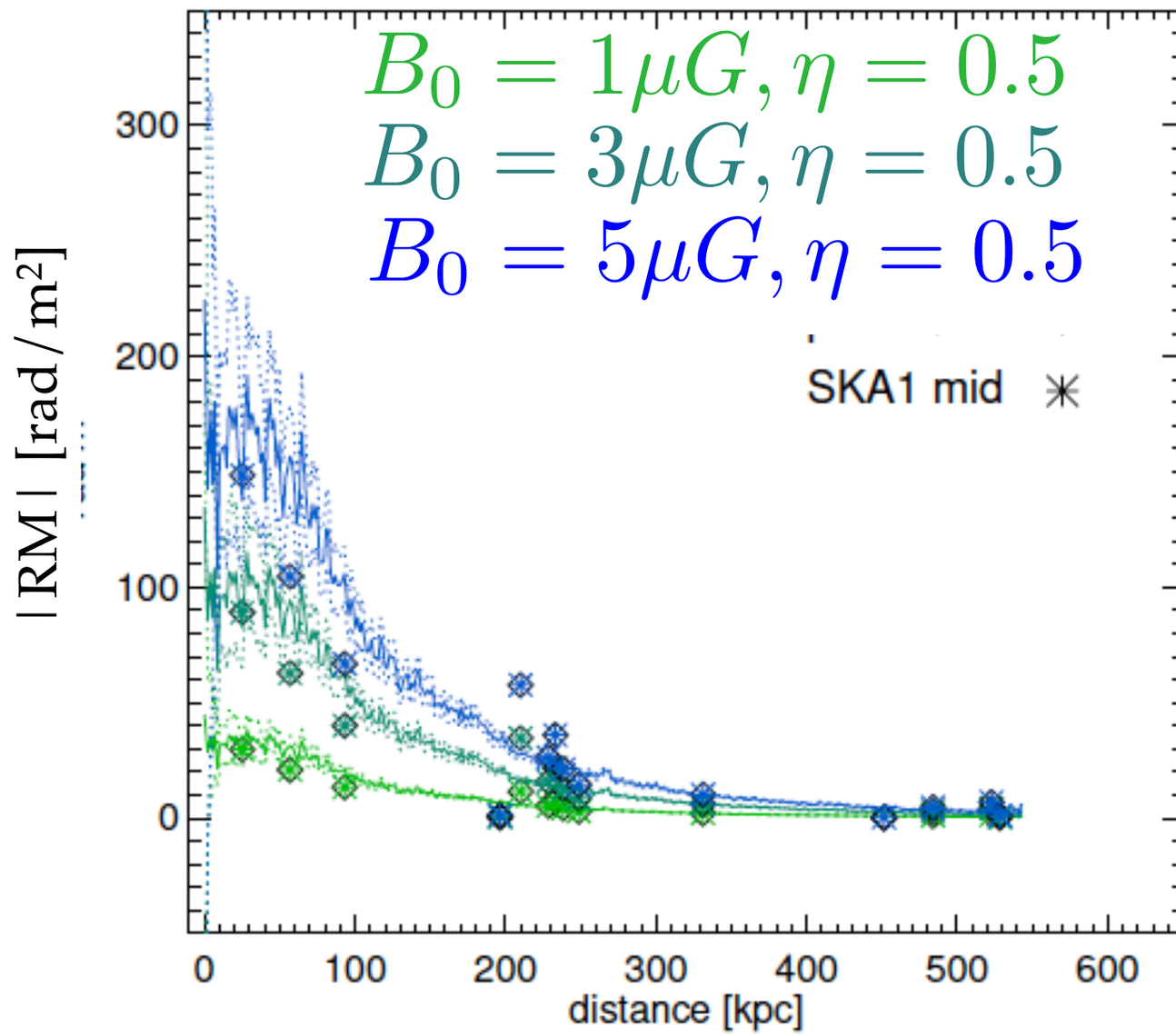
$$B \propto B_0 n_{gas}^{\eta}$$

SKA1: Lower Mass clusters and groups

$M \sim 10^{13} M_\odot$



$M \sim 10^{14} M_\odot$

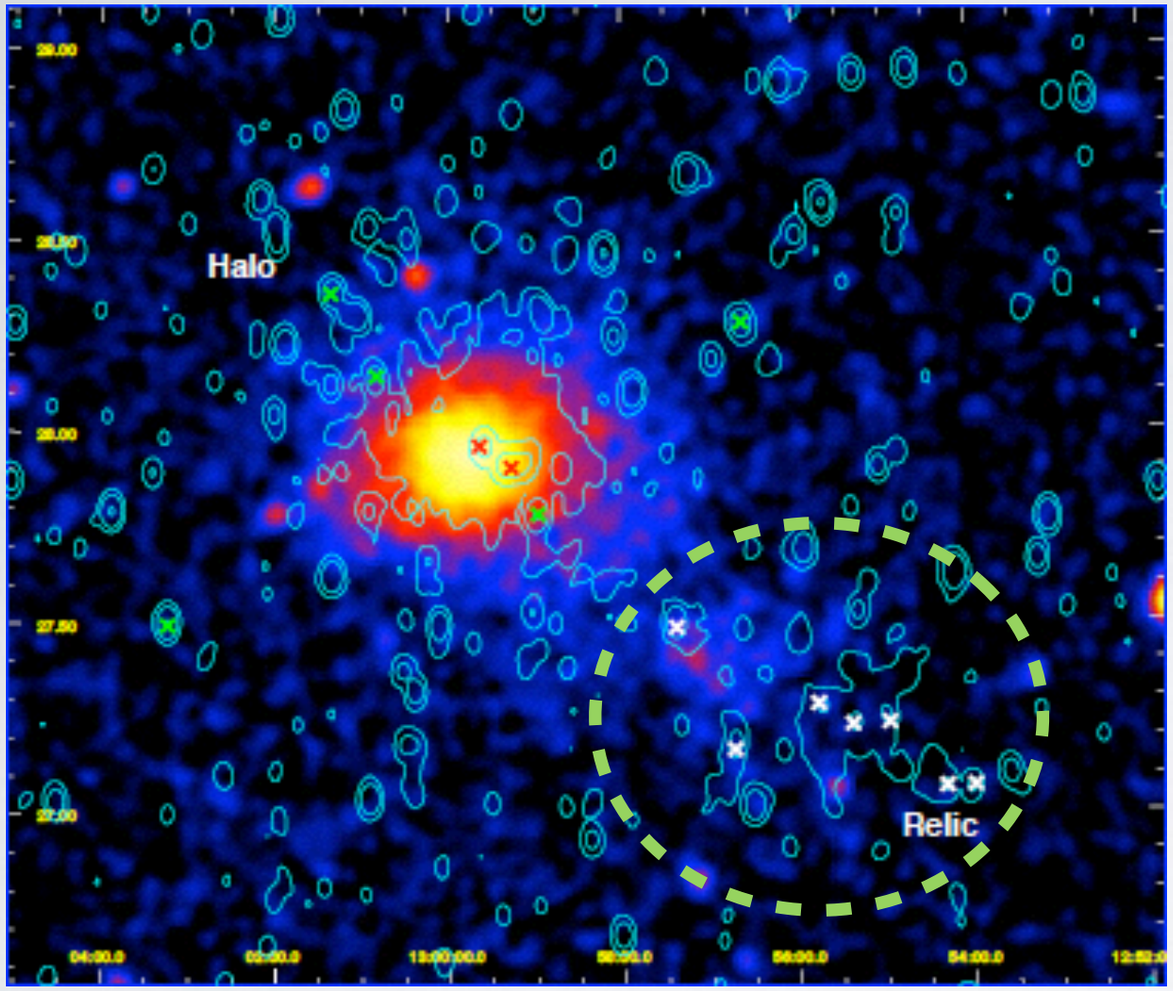


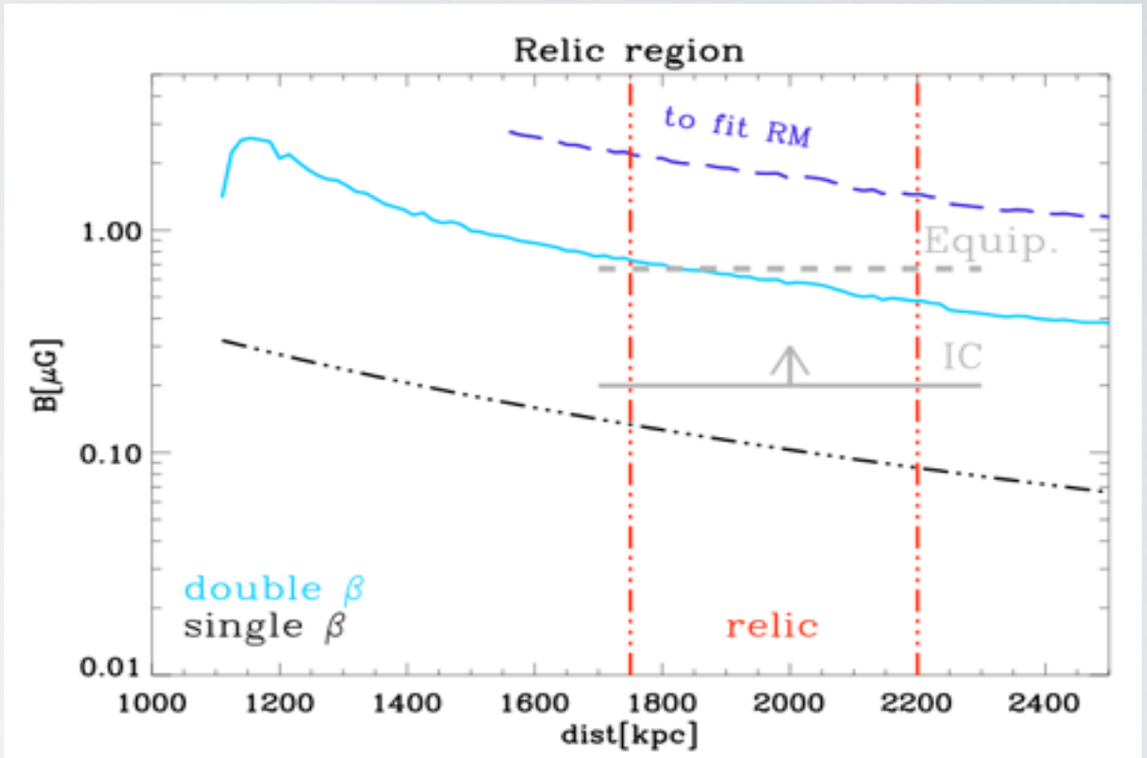
Summary

-Coma cluster: insights on different particle acceleration processes

- LOFAR + VLA and SKA survey prospectives

B AMPLIFICATION IN THE RELIC?





- Magnetic field amplified by a factor 3 in the relic region
- no Jump at the relic (shock)
- filament?

Bonafede et al. 2013