LOFAR discovery of new radio emission in the cluster MACSJ0717+3745

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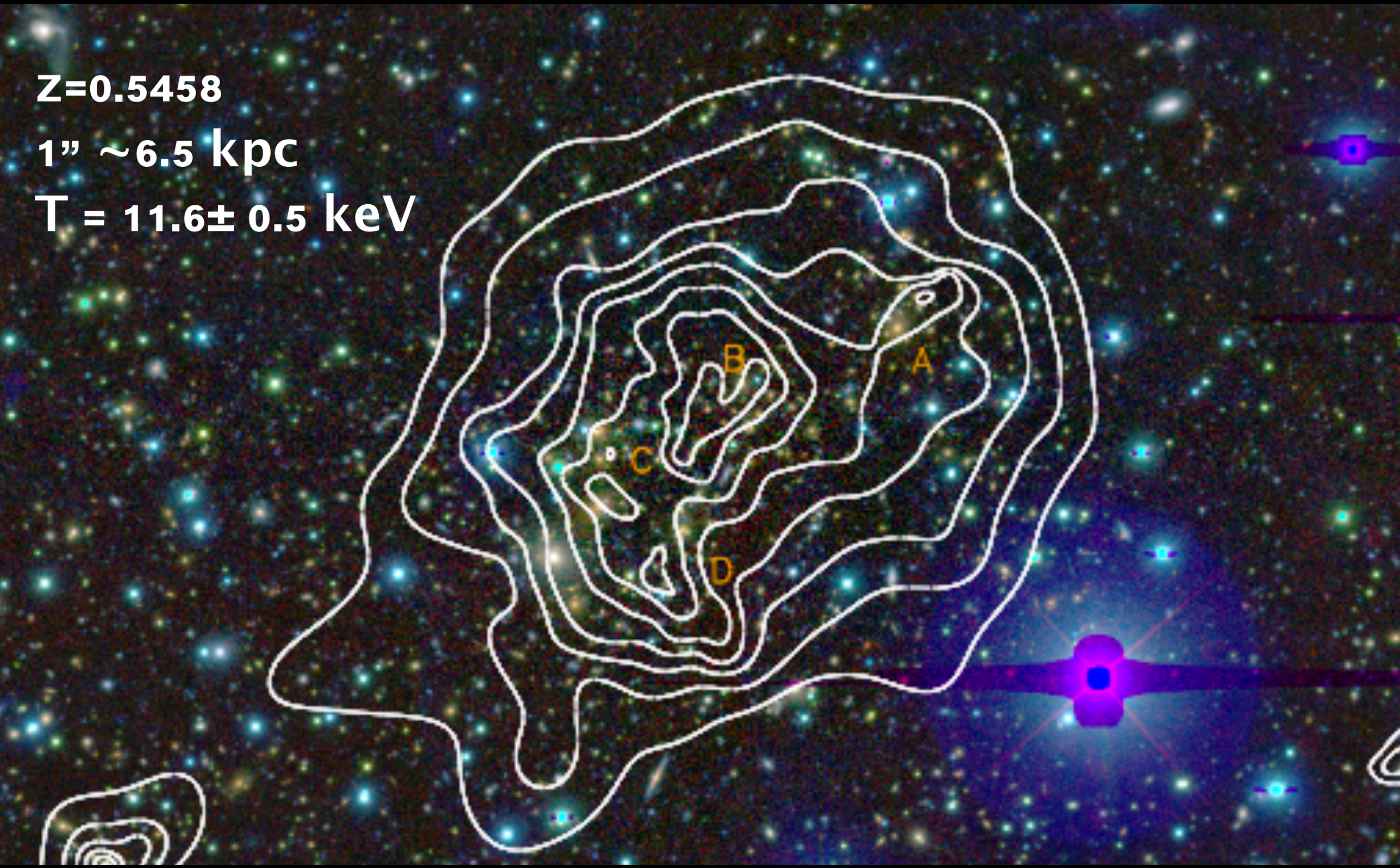
C. Riseley, I. Zhuravleva, J. Farnes, D. Rafferty, F. Savini, A. Wilber
A. Offringa (WSclean), H Intema (SPAM)
& the LOFAR galaxy cluster group

A Textbook example of extreme merging cluster



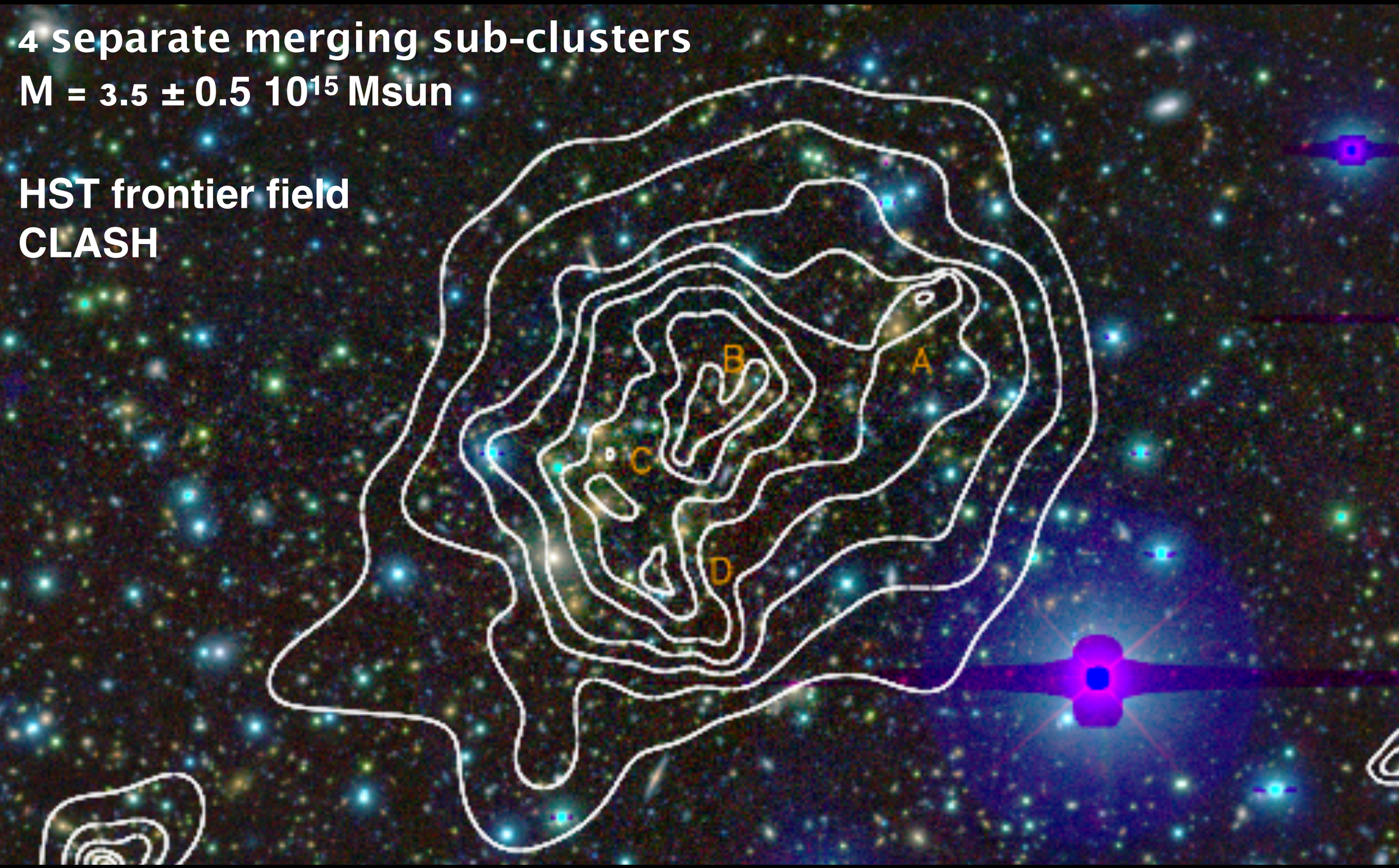
Colors: Subaru B I and CFHT Ks band (Medezinsky et al 2013, Umetsu et al 2014)
Contours: Chandra 0.5 - 4 keV (Ebeling et al 2006)

A Textbook example of extreme merging cluster

4 separate merging sub-clusters

M = 3.5 ± 0.5 10^{15} Msun

HST frontier field
CLASH



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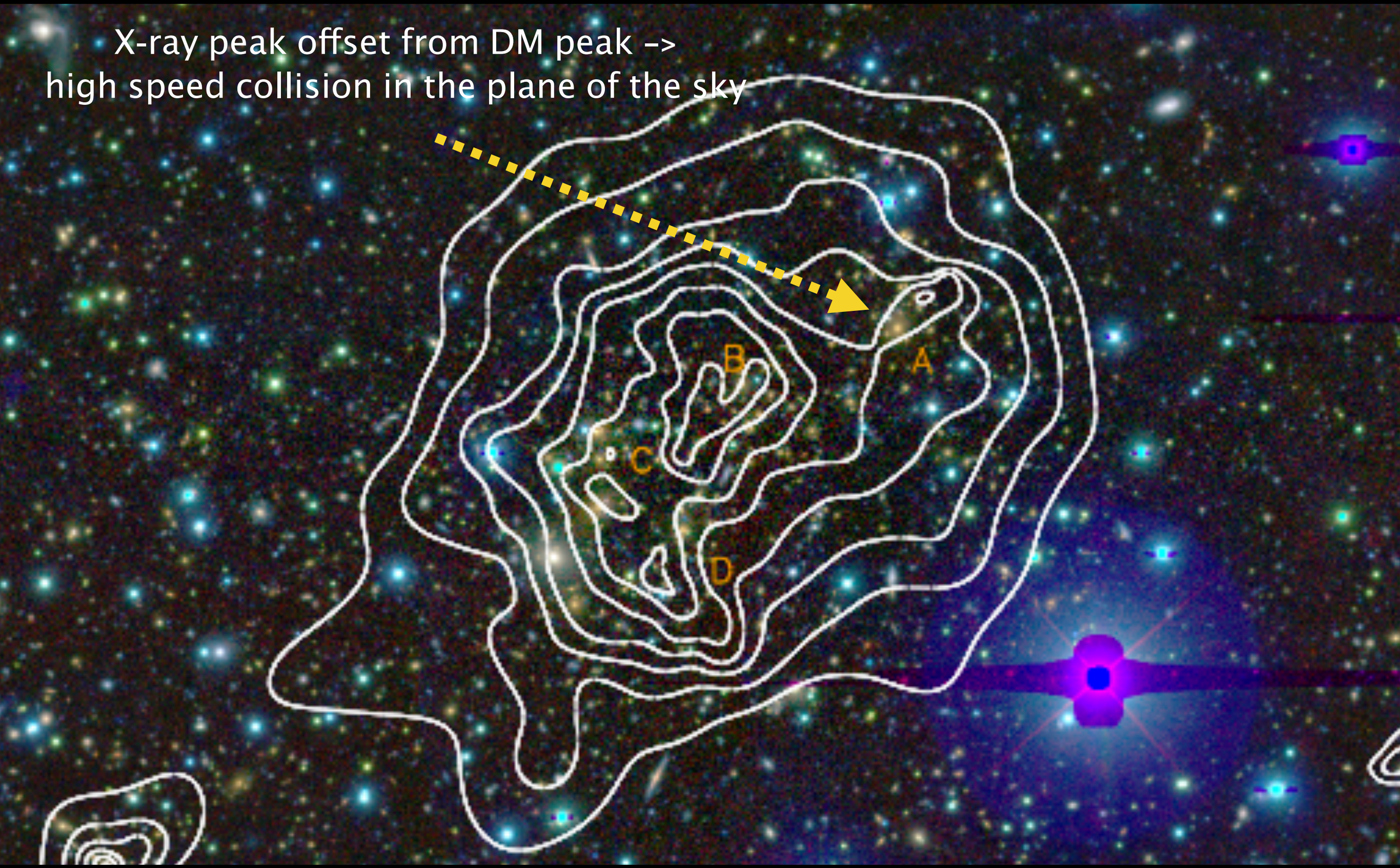
A Textbook example of extreme merging cluster



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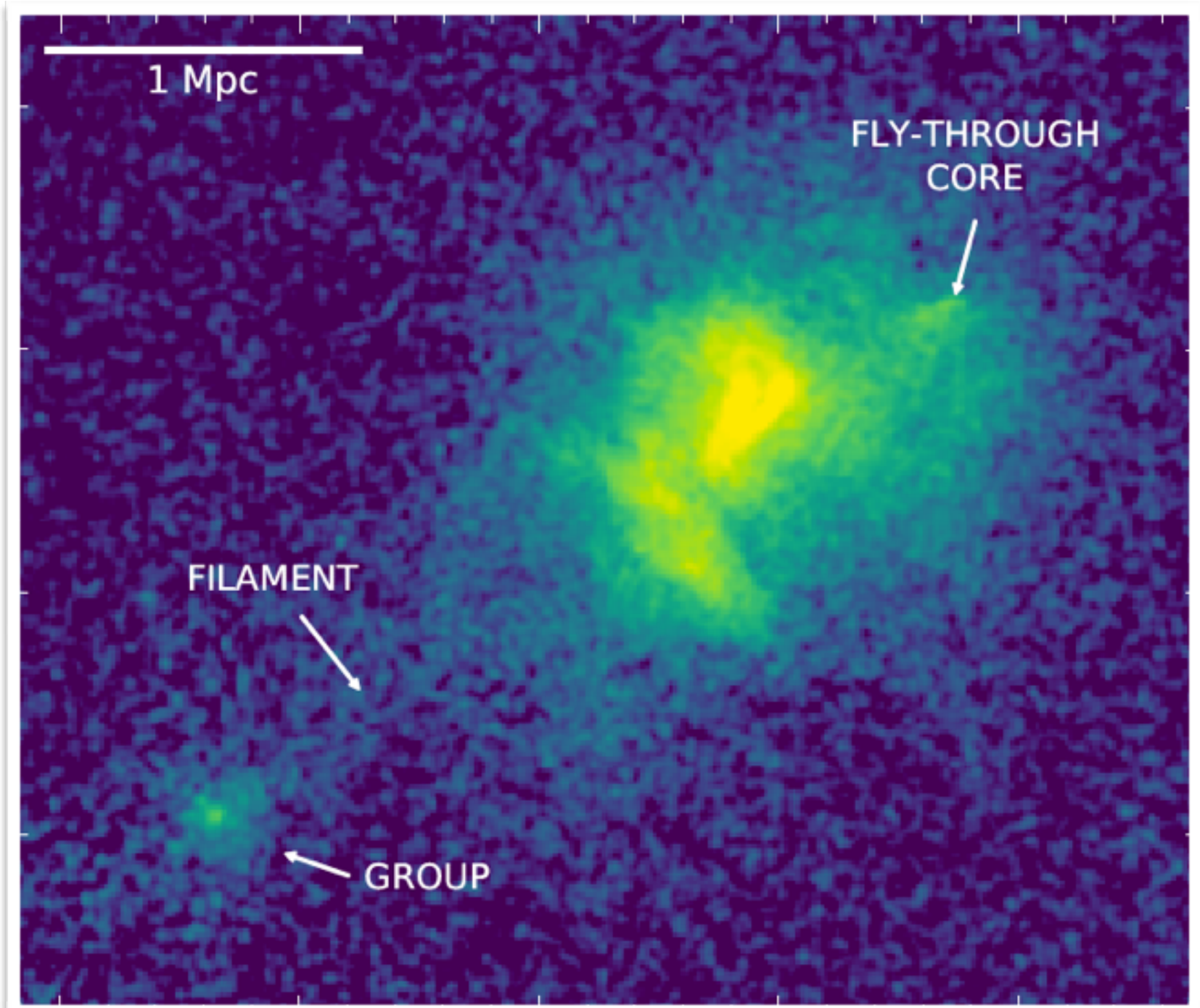
A large scale filament

Deep Chandra (243 ks) observations

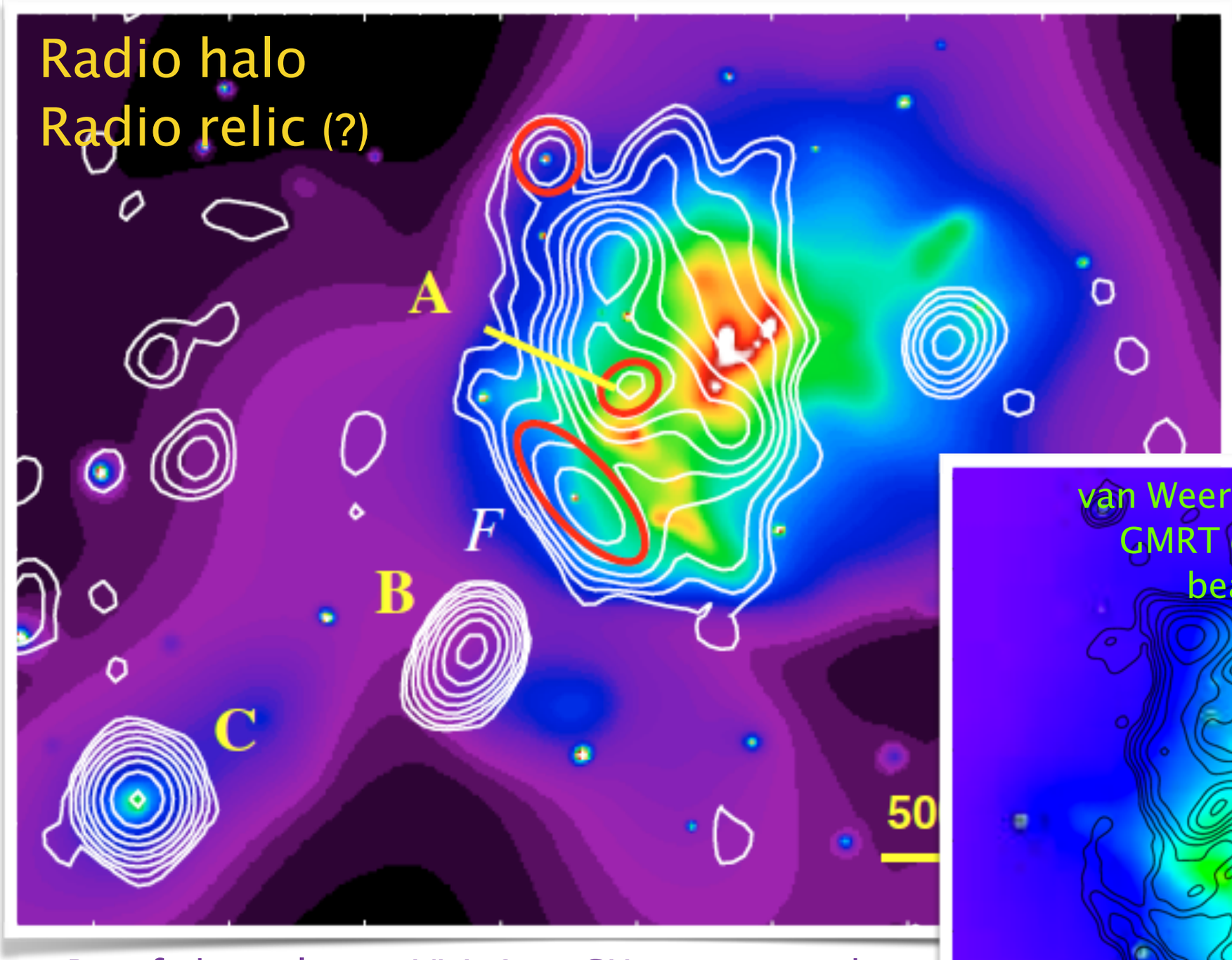
Filament
19 Mpc long
(Jauzac et al 2012)

T ~2 keV
n ~ 10^{-4} cm^{-3}

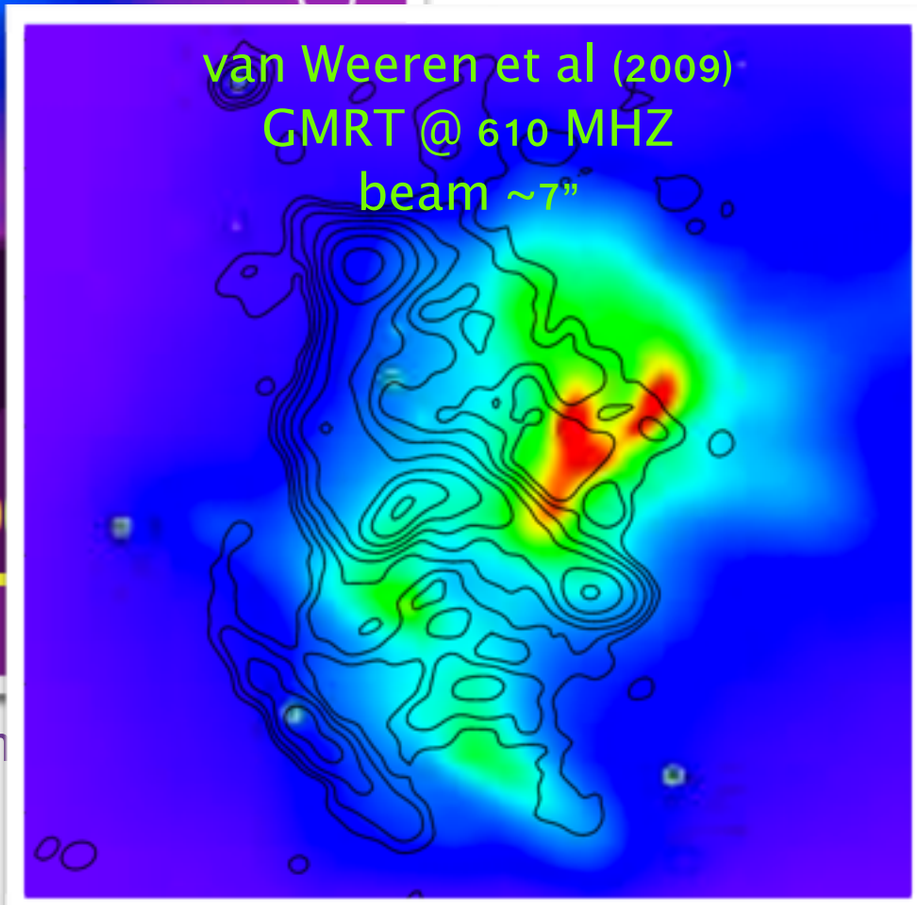


Ogrean et al (submitted)

Radio emission from the ICM



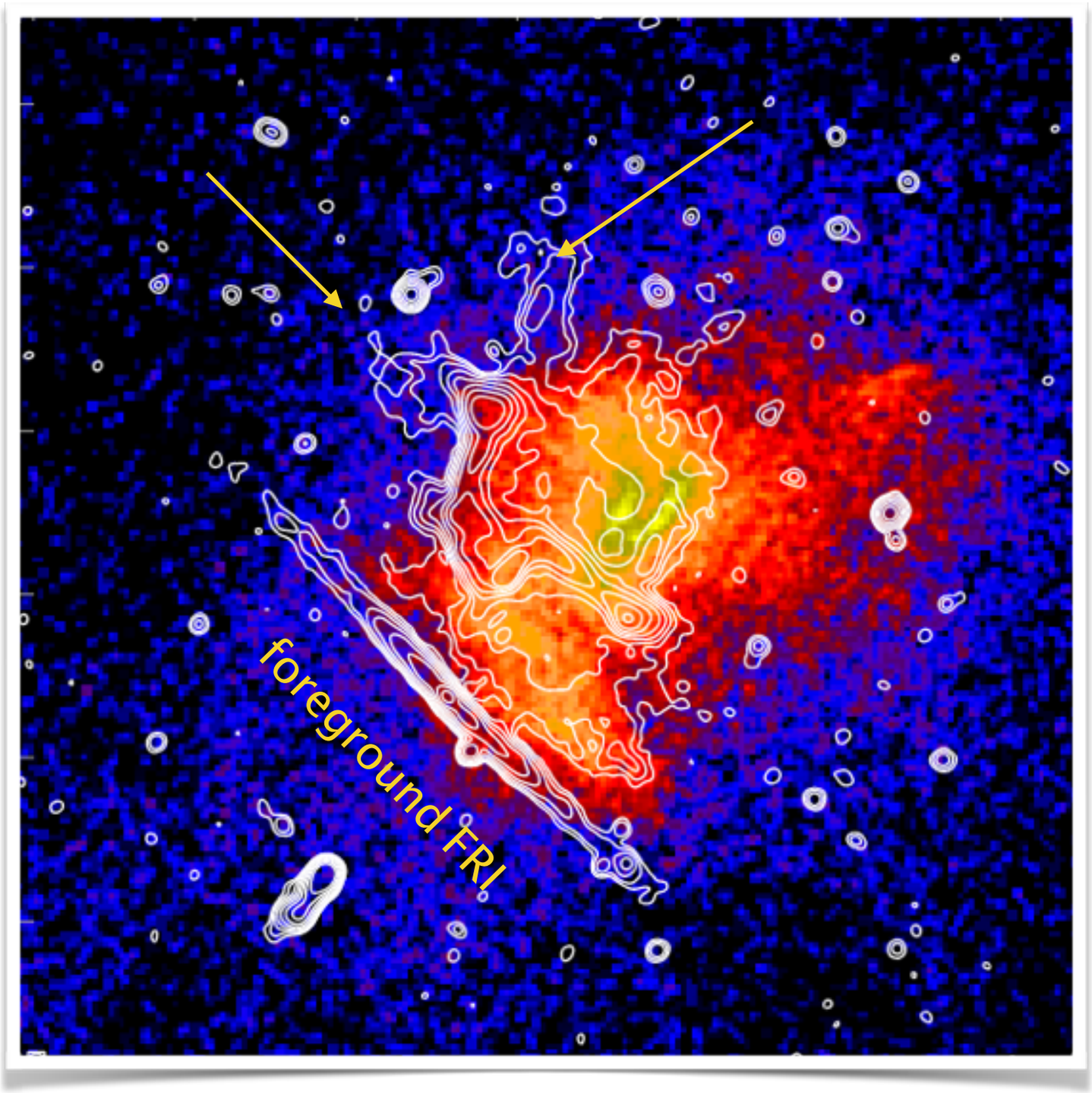
Bonafede et al (2009) VLA @ 1.4 GHz (contours) beam
Chandra 0.5 - 7 KeV (colors)



New JVLA observations

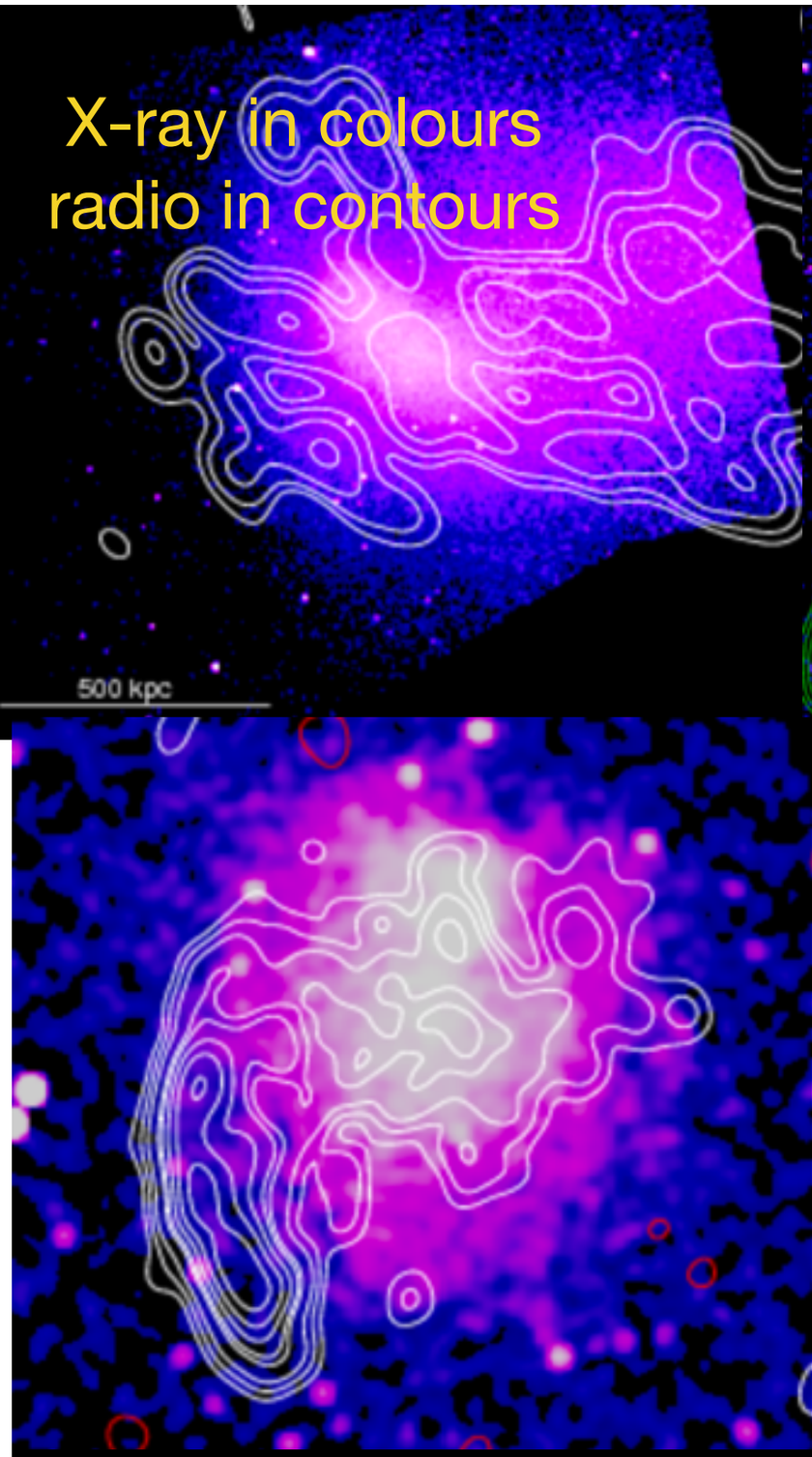
New Jansky VLA (L-S-C band) observations

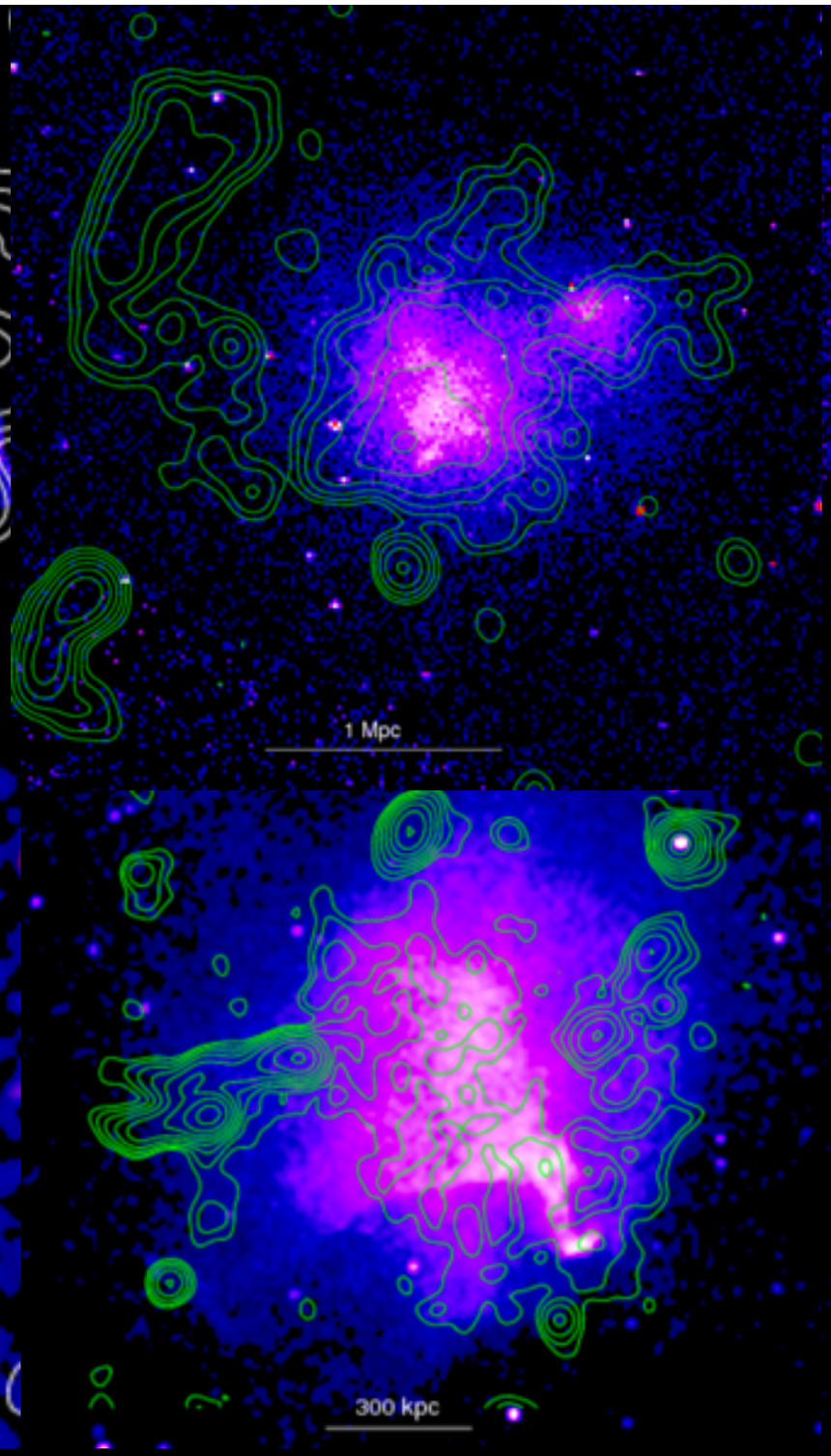
rms ~7 μJy/beam
5” beam

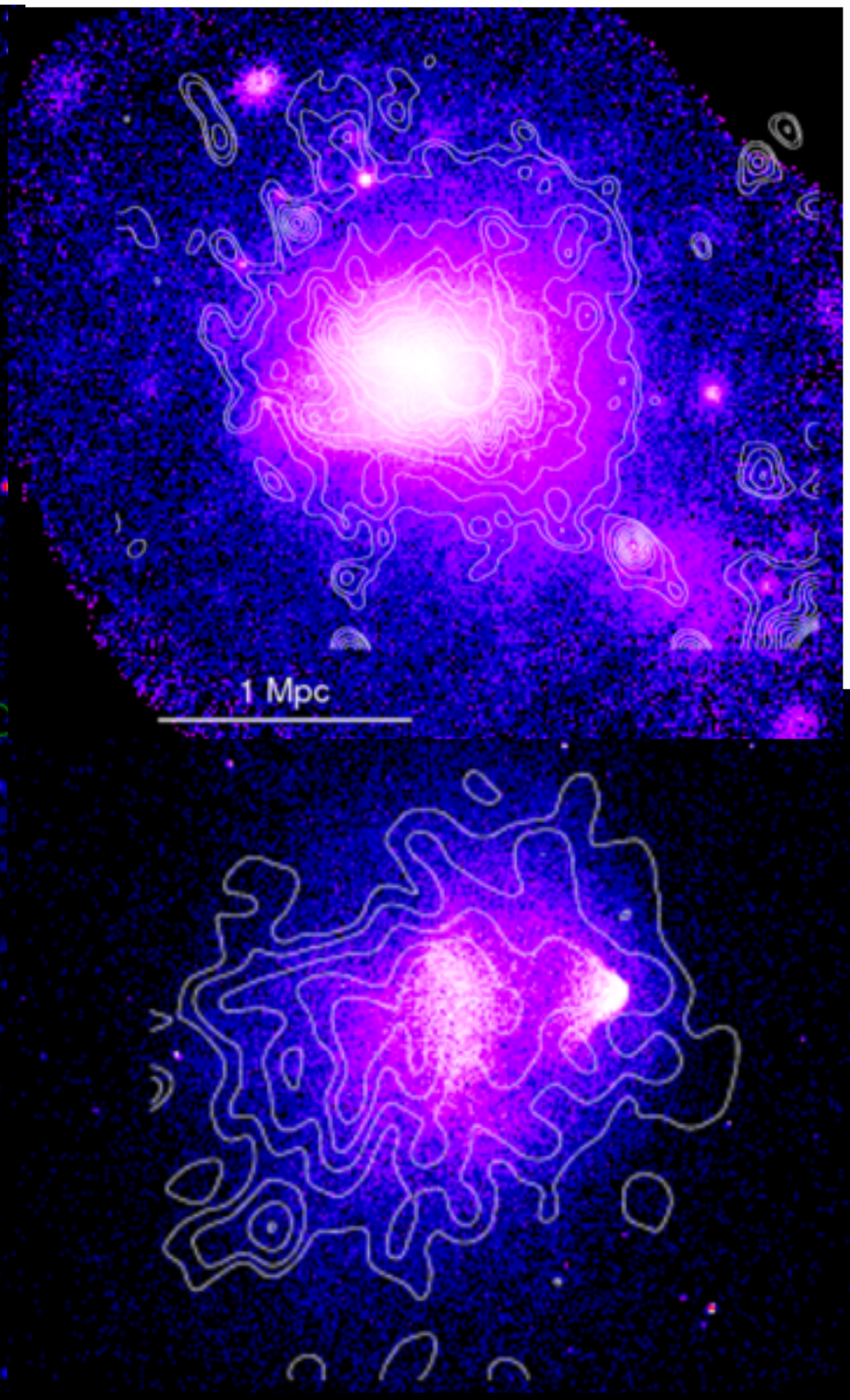


van Weeren et al (2017)

Radio emission and X-ray emission







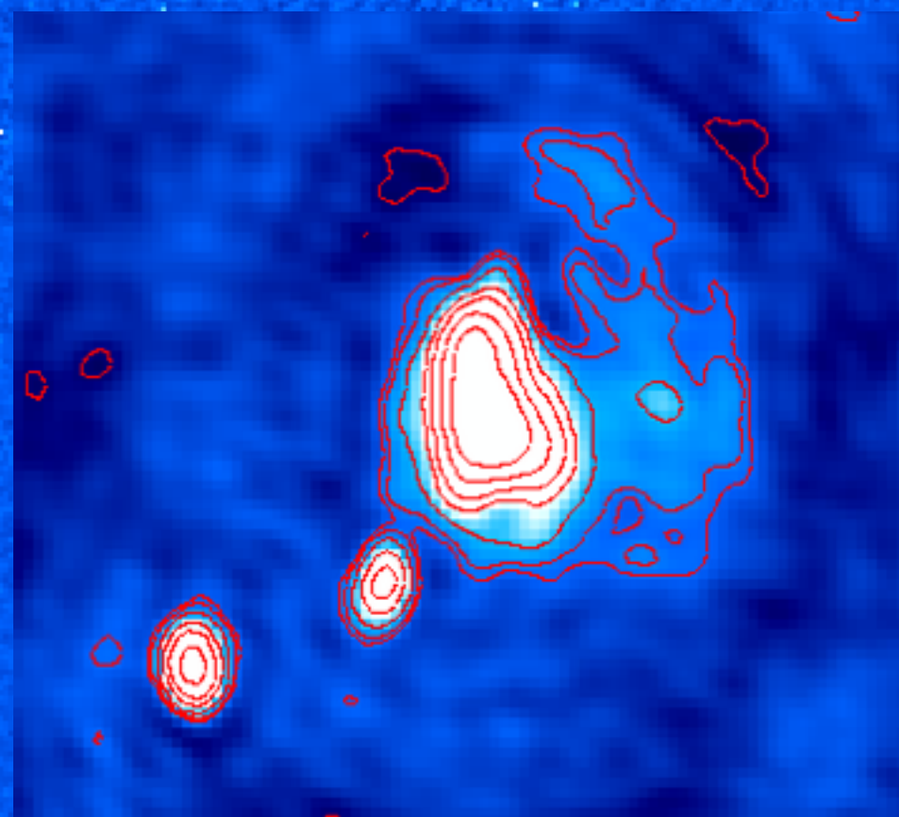
Credits: Liang, Markevitch, Govoni, Venturi, Macario, Brown&Rudnick, Brunetti

LOFAR HBA observations

1 degree

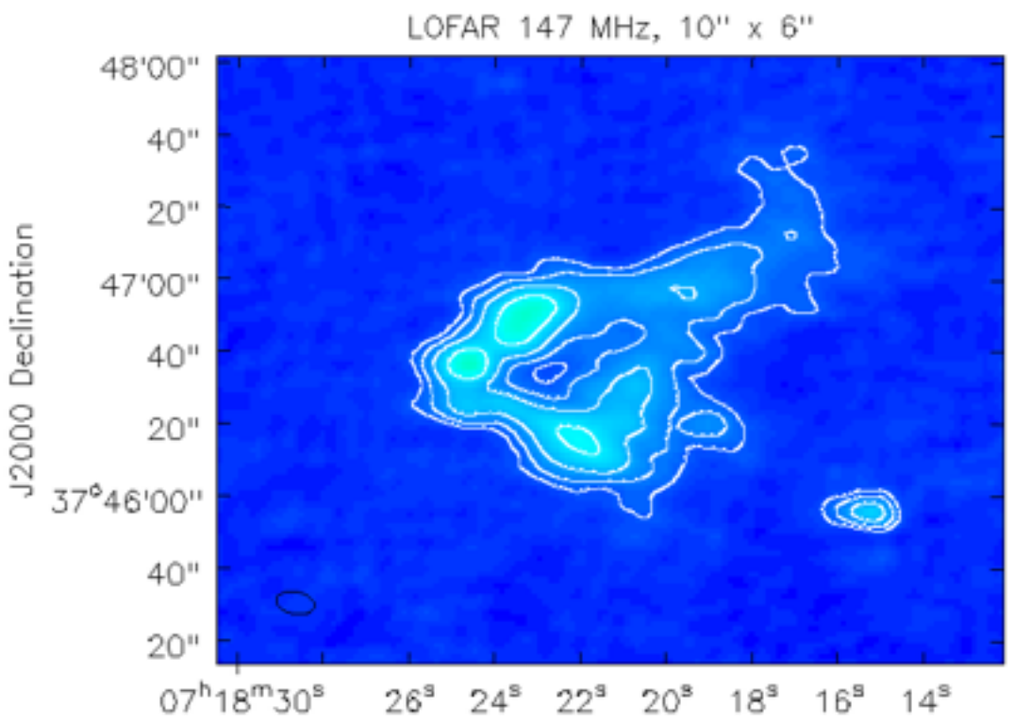
- 2 x 5h observation
  only last 5h used

Processed with
pre-factor
and factor pipeline



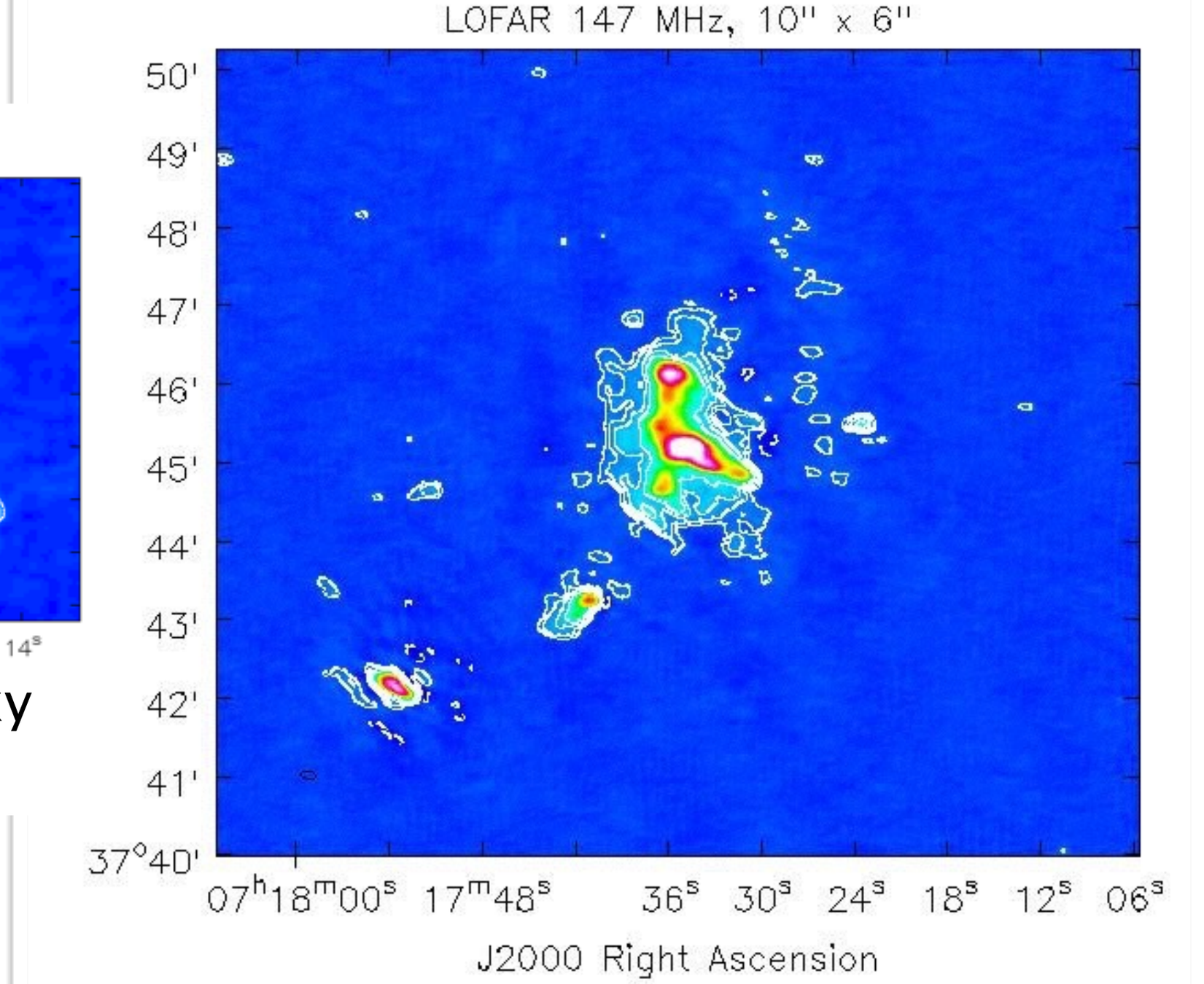
LOFAR images at 147 MHz

freq ~110 - 180 MHz
rms~100 μJy/beam

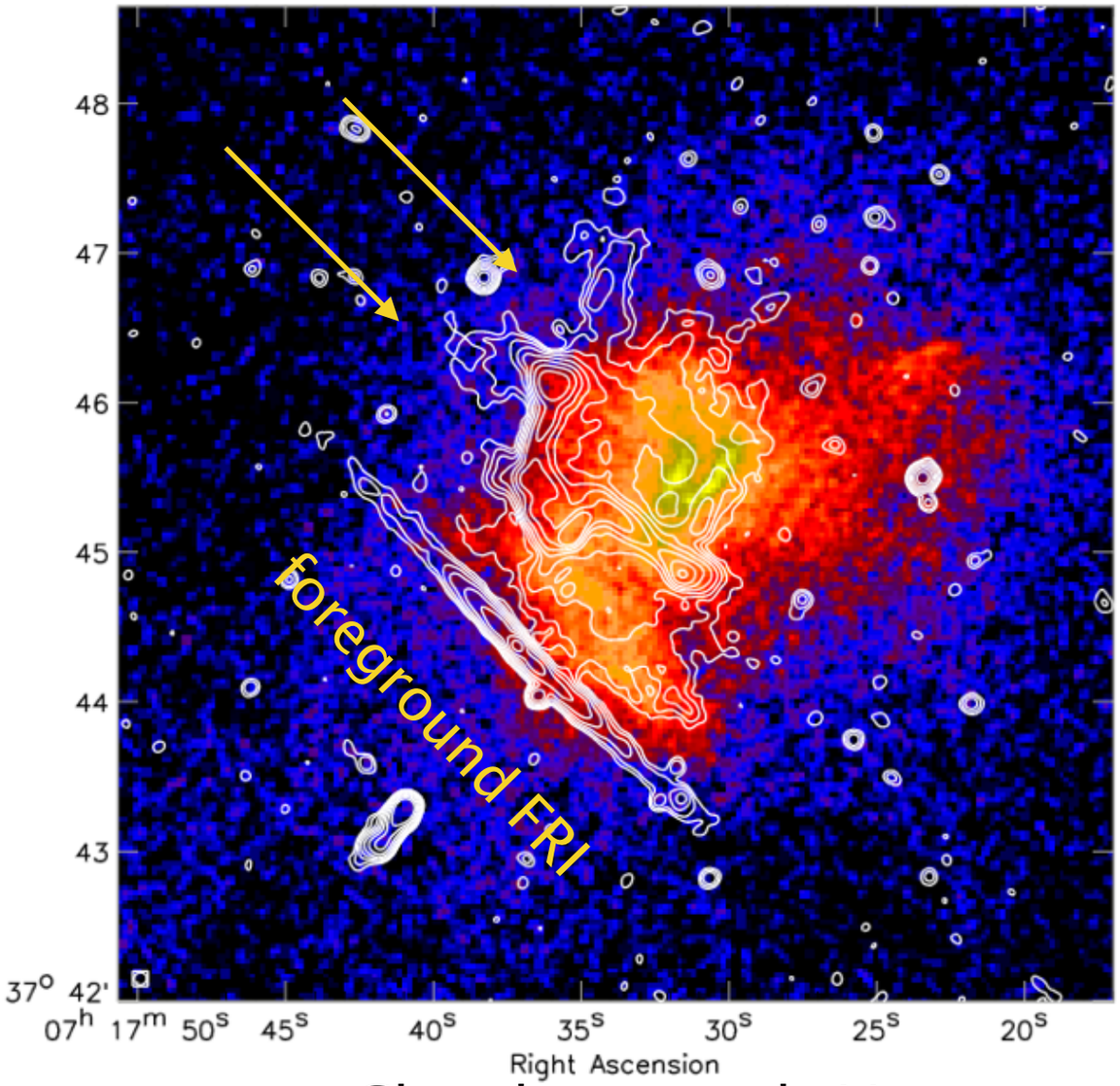


WAT radio galaxy

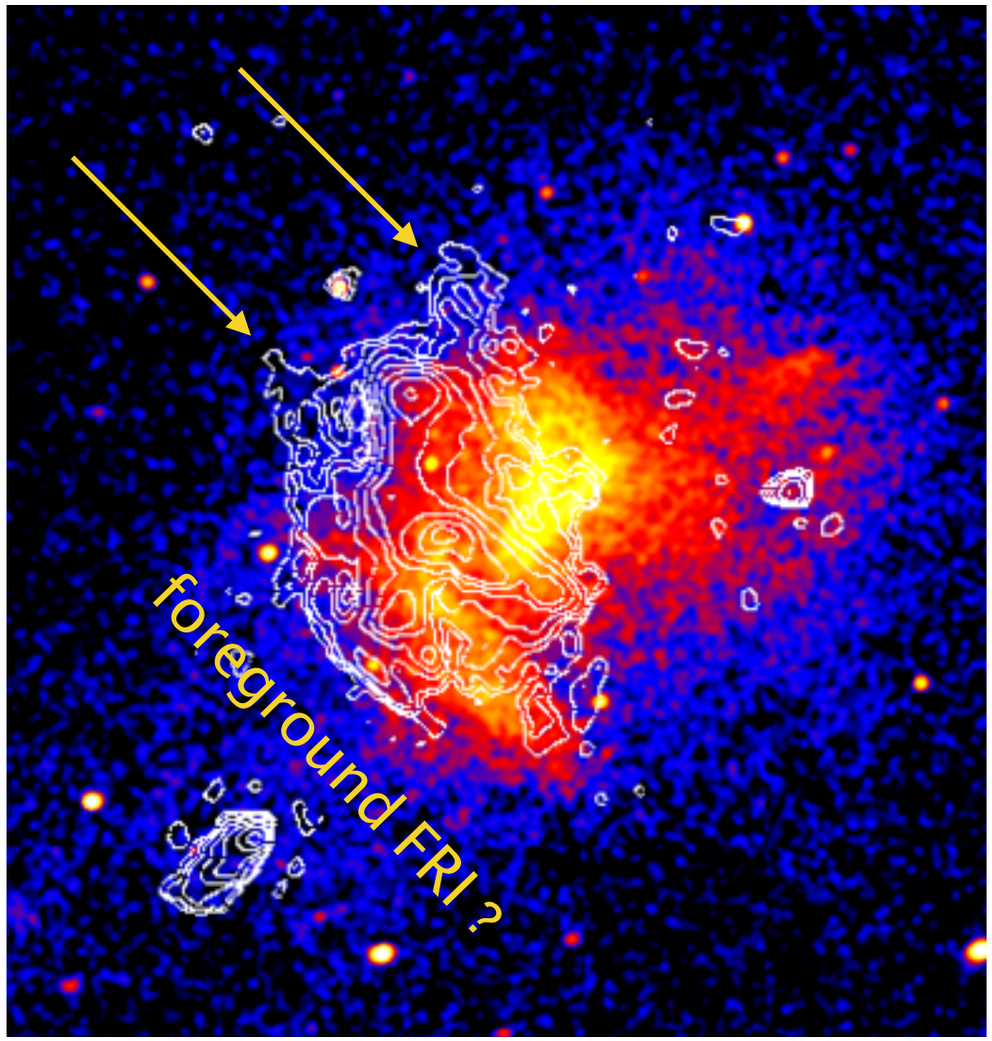
z ~ 0.239



Comparison with Jansky VLA observations

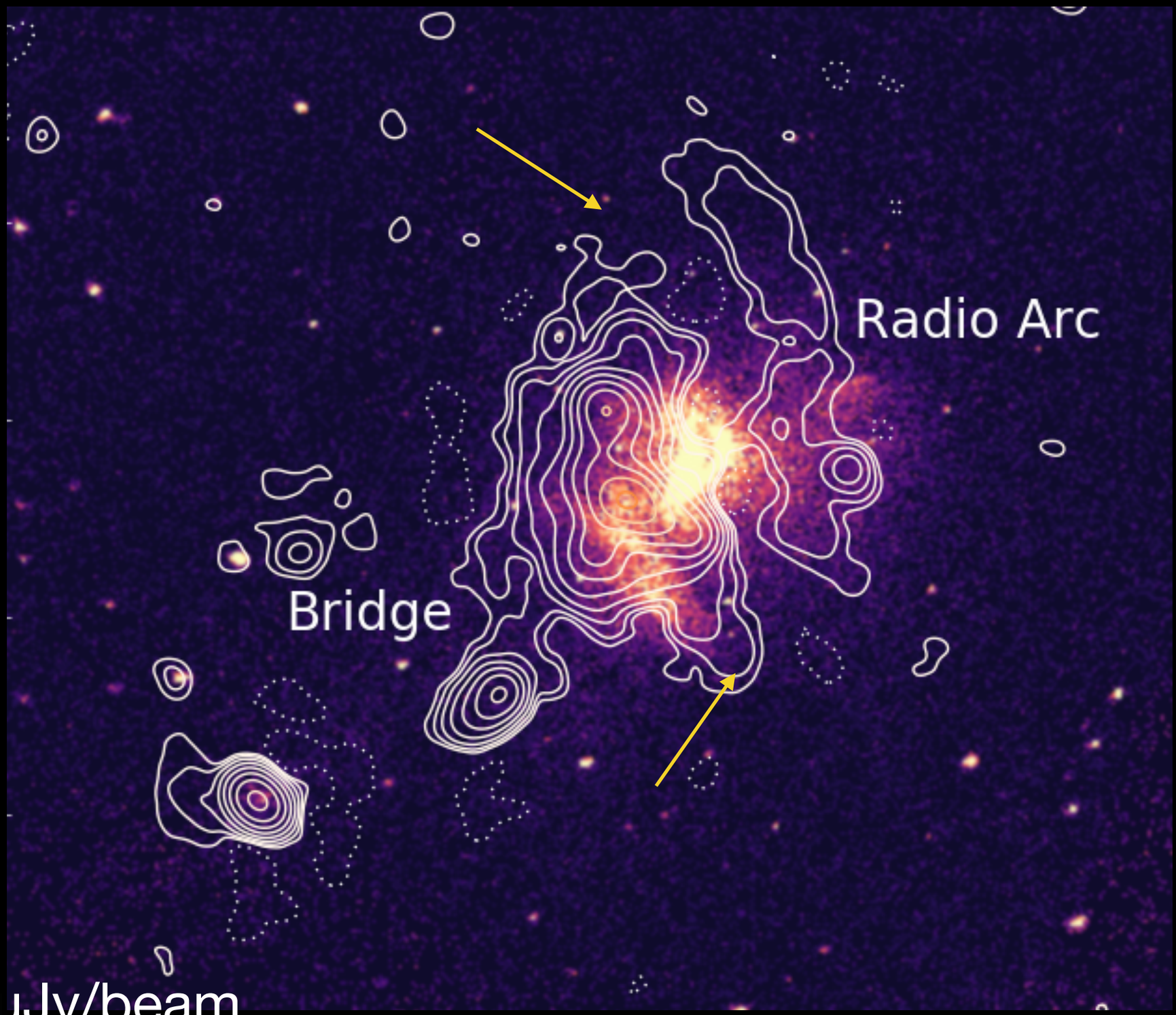


Chandra [0.5 - 4 keV]
Jansky VLA L band - 5”
(van Weeren et al. 2017)



Chandra [0.5 - 4 keV]
LOFAR HBA 4”x6”
first contour at 0.4 mJy/beam

New extended emission

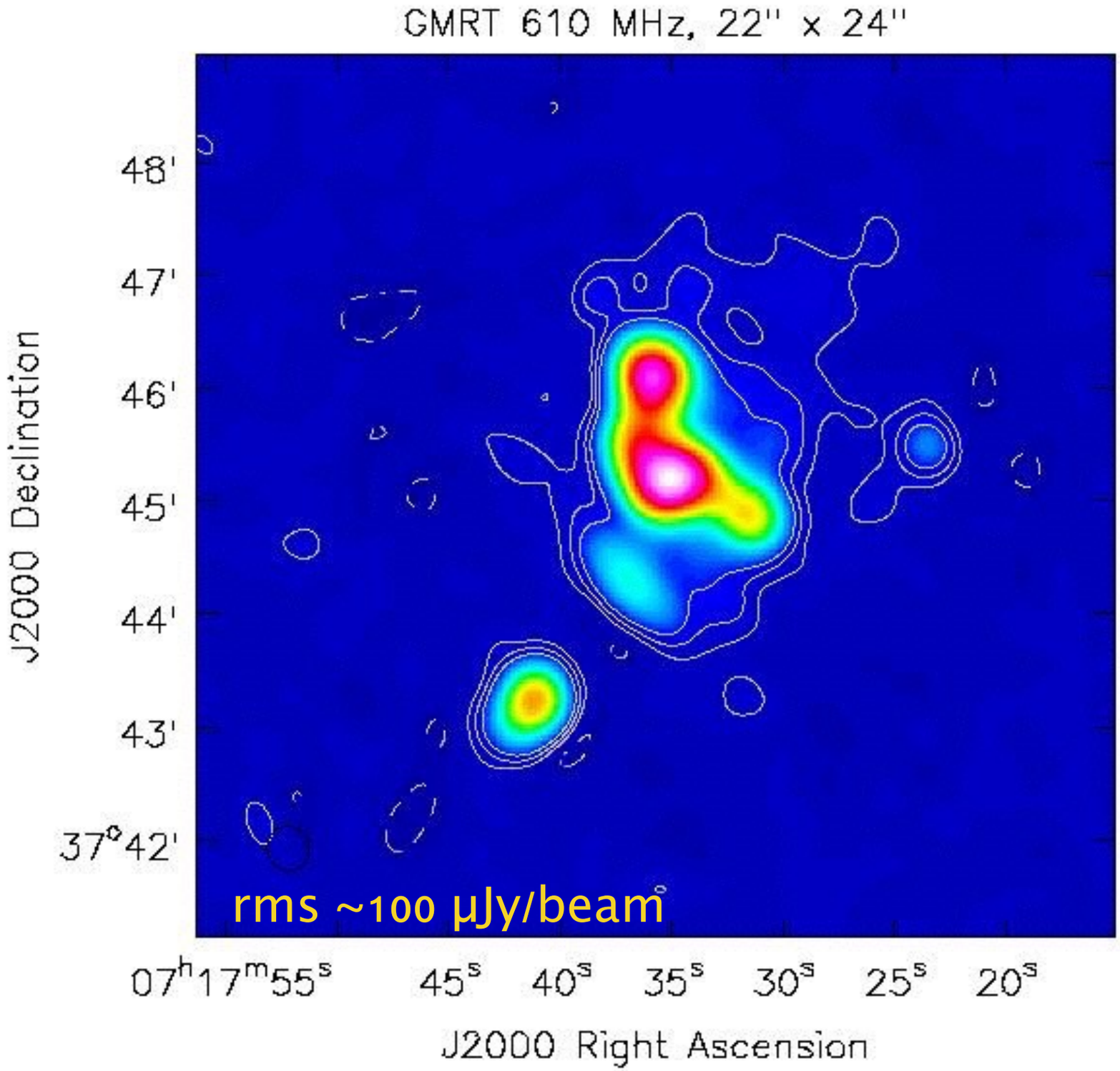


rms ~200 μJy/beam
resolution 25”x 22”

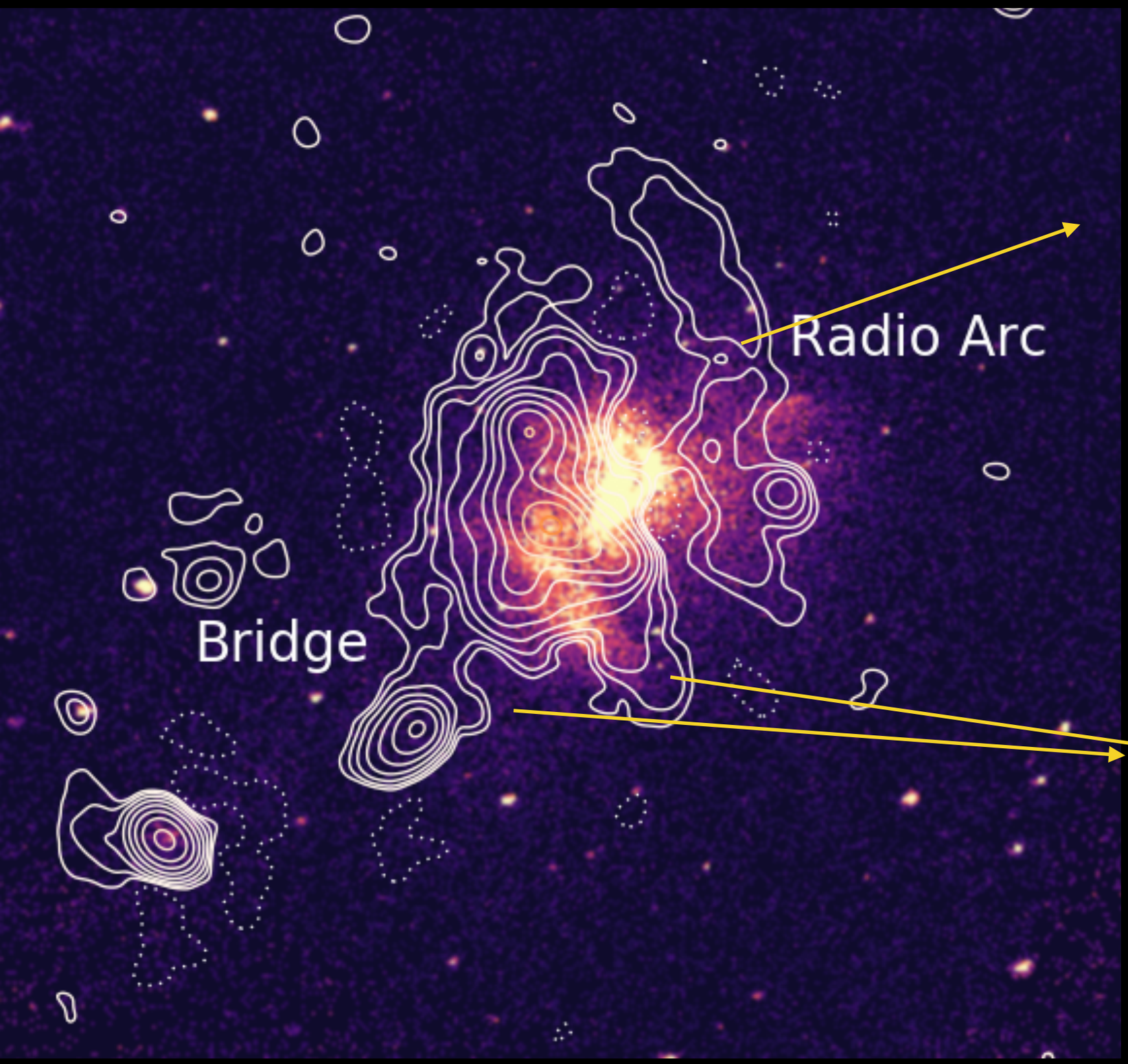
GMRT archive observations

ν ~607 MHz
12 h on target

PI J.Farnes



Spectral estimates



"Radio Arc"

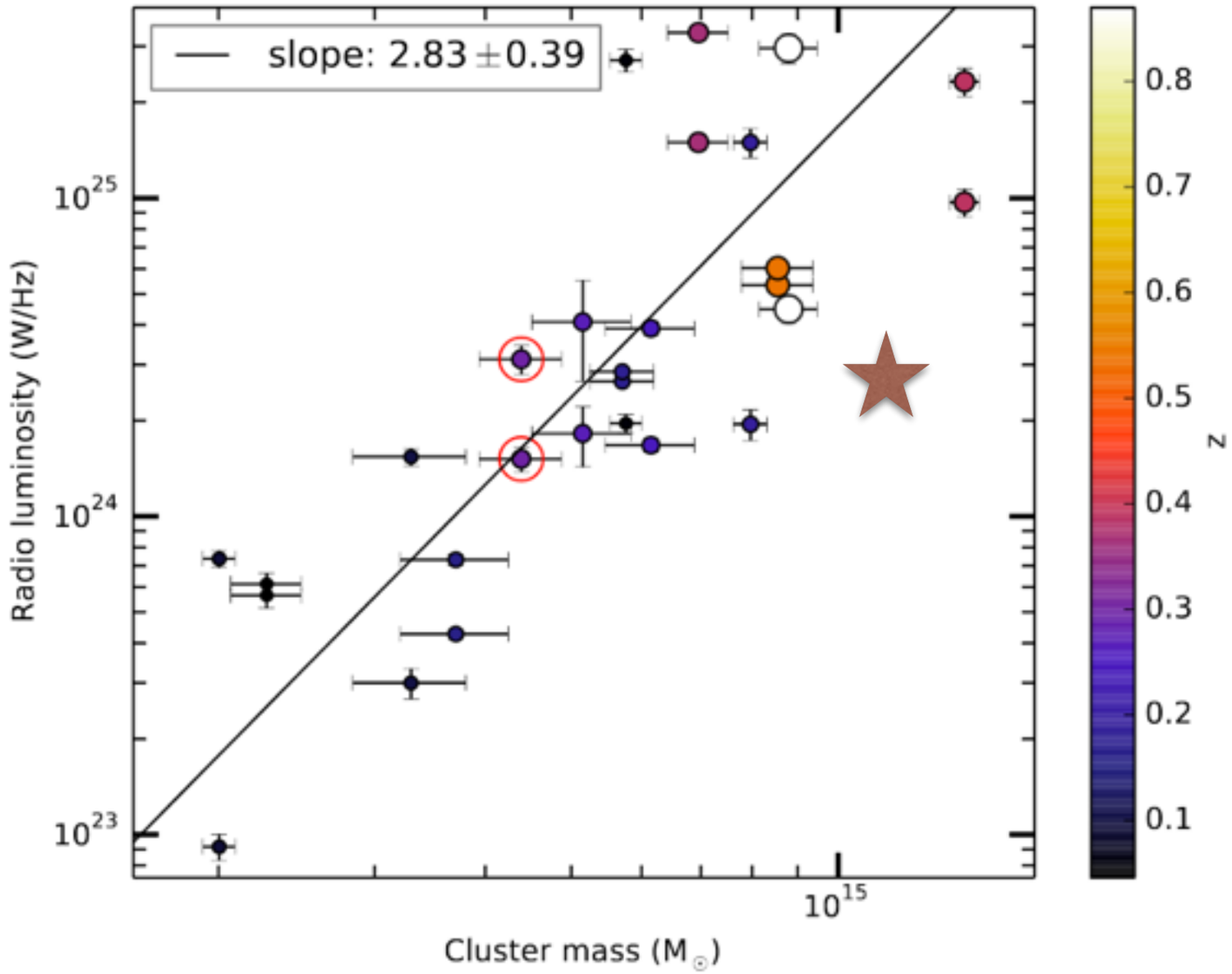
$\alpha_{[147\text{MHz} - 607\text{ MHz}]} > 0.8$

not extremely steep

$\alpha_{[147\text{MHz} - 607\text{ MHz}]} > 1.3$

Relic?

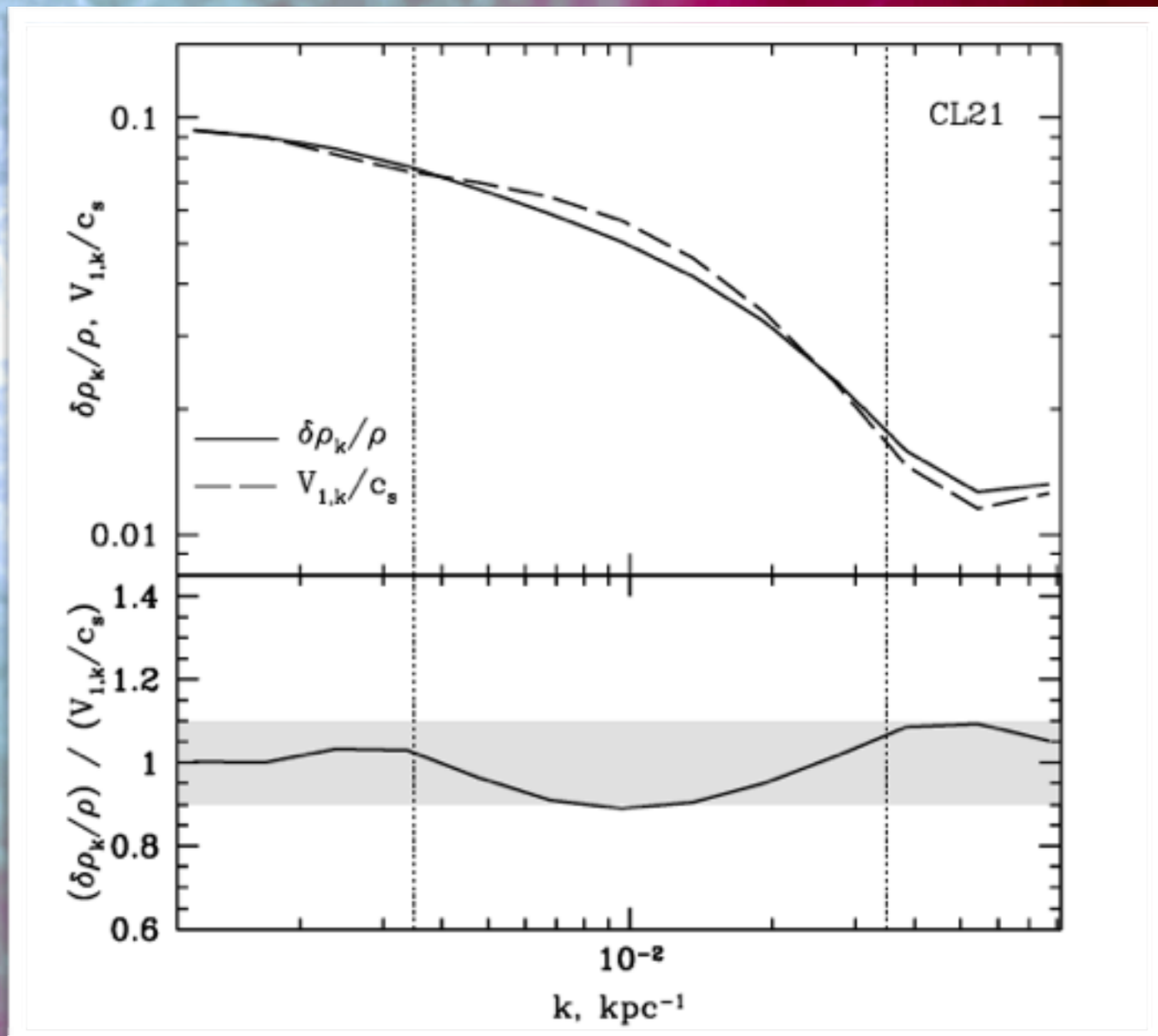
Flux density ~48 mJy
Luminosity at 1.4 GHz ~2.5 10^{24} W/Hz
(assuming α=1.5)



De Gasperin et al (2015)

V fluctuations from gas fluctuations

$$\left(\frac{\delta\rho_k}{\rho}\right)^2 = \eta^2 \left(\frac{V_k}{c_s}\right)^2,$$



Zhuravleva et al. (2014)

Image credits: Vazza et al (2017)

$$\left(\frac{\delta\rho_k}{\rho}\right)^2 = \eta^2 \left(\frac{V_k}{c_s}\right)^2,$$

Radio Arc

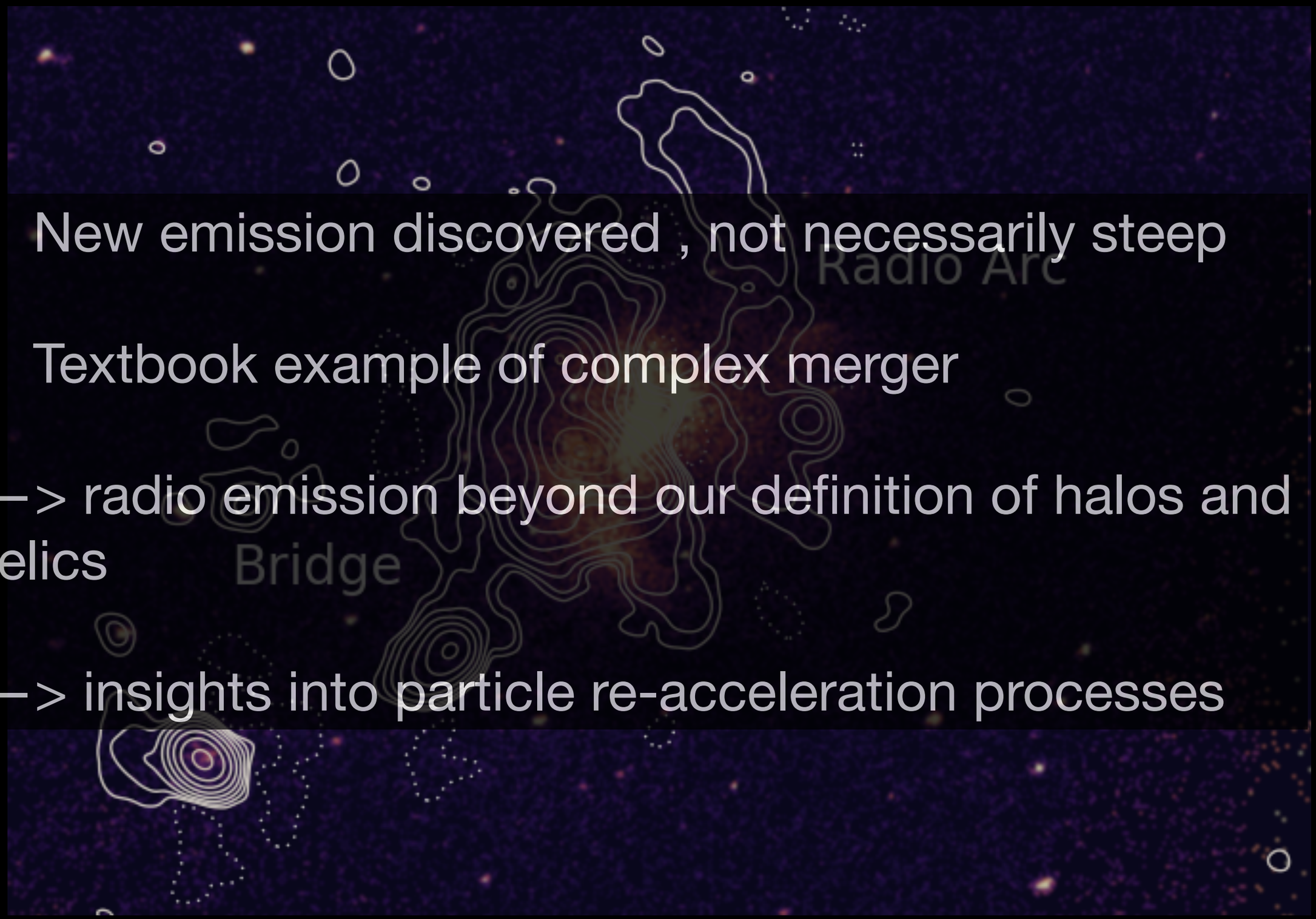
Bridge

Preliminary

E_kin/E_therm twice larger in the left region

Using the method by Zhuravleva et al. (2014)

Conclusions



- New emission discovered , not necessarily steep

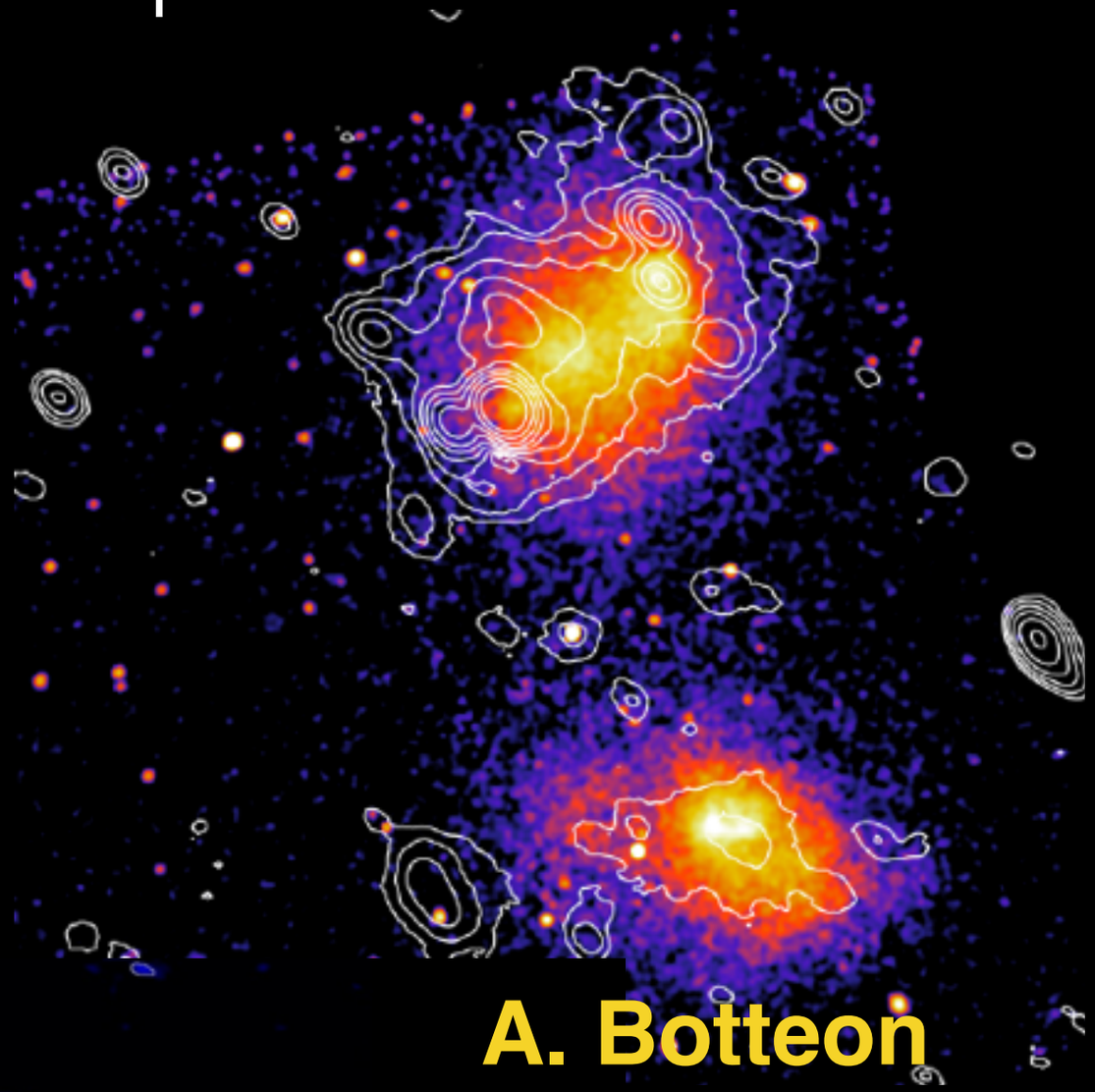
- Textbook example of complex merger

—> radio emission beyond our definition of halos and relics

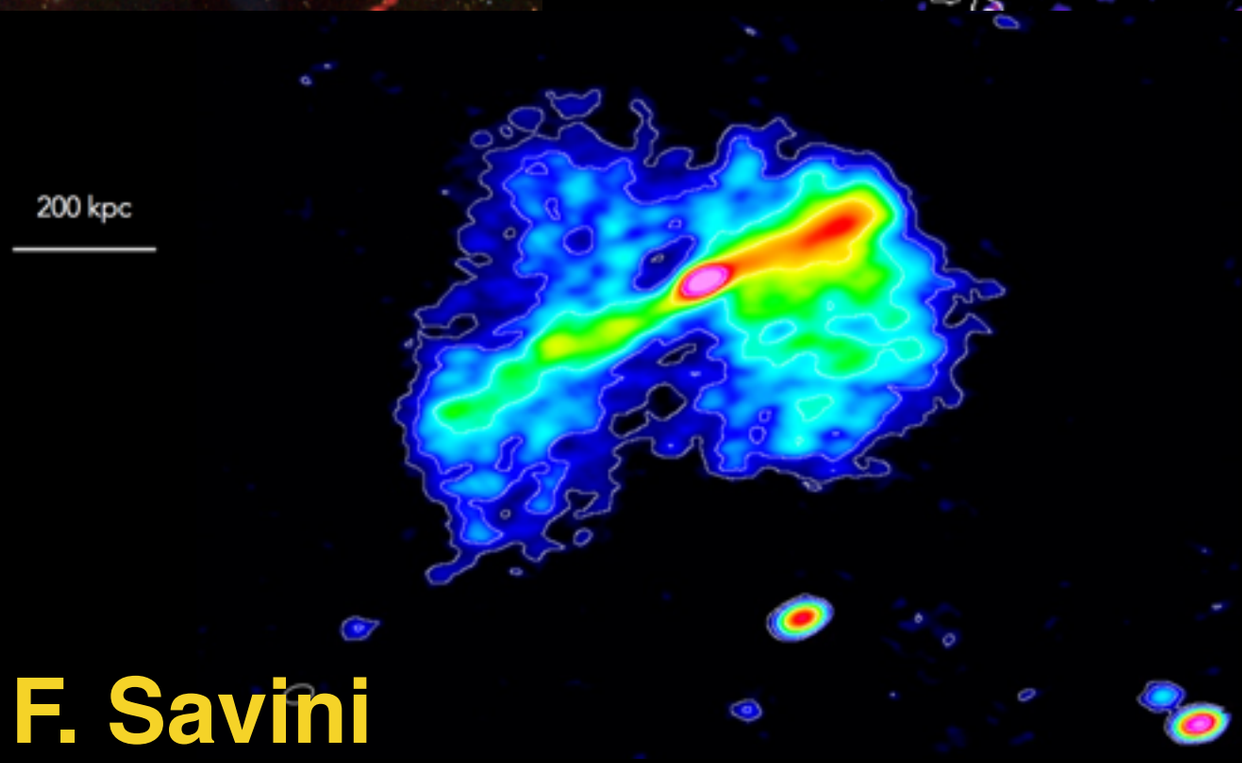
—> insights into particle re-acceleration processes

More LOFAR results - see posters outside!

A. Wilber



A. Botteon



F. Savini

Save the date:
2018 May 14-18, Noto (I)

- **IAUS 342: Perseus in Sicily: from black hole to cluster outskirts**
- https://www.iau.org/science/meetings/future/symposia/1316/
- SOC: Asada, Blandford, Bower, de Gouveia dal Pino, Doeleman, Fabian, Giroletti, Grandi, Jones, Ma, Nagai, Nemmen, Rudnick, Siemiginowska, Stawarz, Yuan
- Topics include
  - Approaching the Schwarzschild radius
  - MHD processes in disks and jets
  - Jet production, collimation, and acceleration mechanisms; particle acceleration mechanisms
  - jet-medium interaction on galactic and cluster scales
  - gas heating and cooling
  - BH-galaxy coevolution and radio source evolution