

VERY
PRELIMINARY

POSSIBLE RELICS OF FERMI BUBBLES IN ANDROMEDA

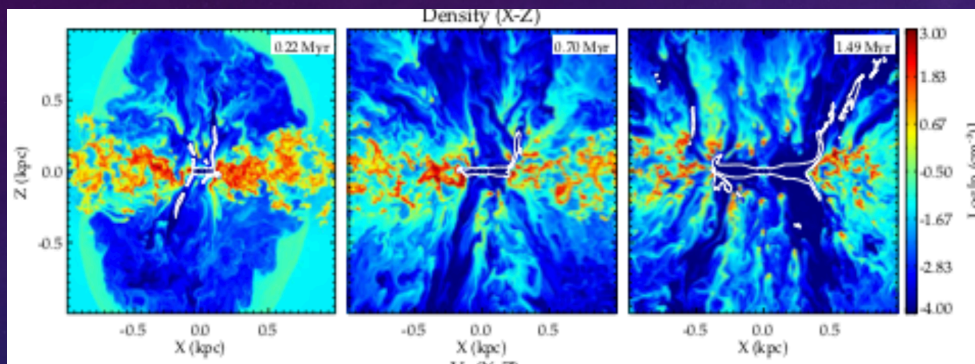
ANNE-LAURE MELCHIOR,
FRANÇOISE COMBES, CYRIL TASSE, AMR EL ZANT,

- Introduction : tracing the past activity of the black hole
- Detection of synchrotron emission at 150MHz (LOFAR):
 - no large scale Fermi bubble
 - synchrotron observations of the bulge
- Multiscale and perturbed kinematics
- Outflows, relics?

Co-evolution of SFR and SMBH

(Kormendy & Ho 2013)

AGN feedback: episodic nuclear activity
→ expulse the gas from central parts



Mukherjee et al. 2018

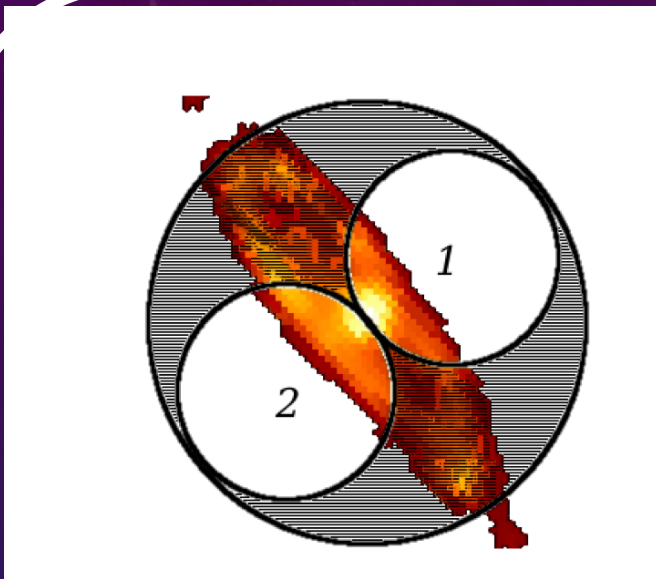
See also Williamson et al. 2019

ANDROMEDA central kpc:

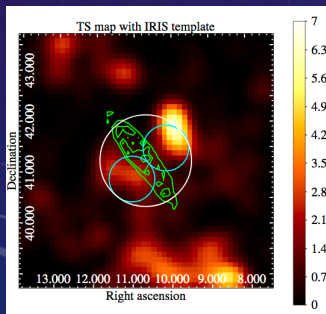
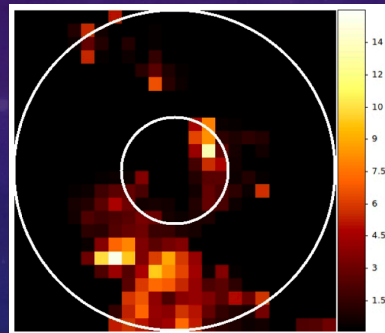
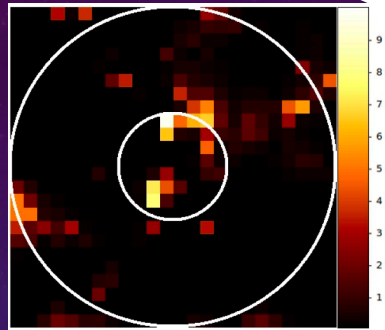
- SMBH $\sim 1.4 \cdot 10^8 M_{\text{SOL}}$ (Bender et al. 2015)
- Very quiet: $10^{-10} L_{\text{Edd}}$ (Li et al. 2011)
- No activity $> 10^{-4} L_{\text{edd}}$ $\tau > 1000\text{yr}$ in the past 100 Myr (Clavel et al. 2017)
- LLAGN (Yang et al. 2017)
- Very close 1 arcsec = 3.8 pc
- Multiwavelength data
- Evidences of **no star formation**
- LIER (Belfiore et al. 2016)
- Small amount of very clumpy cold gas Melchior & Combes 2011, 2016, 2017
- Synchrotron emission
- Presence of shocks

→ What's next?

GAMMA DATA : FERMI BUBBLES IN M31?



Pshirkov et al. 2016

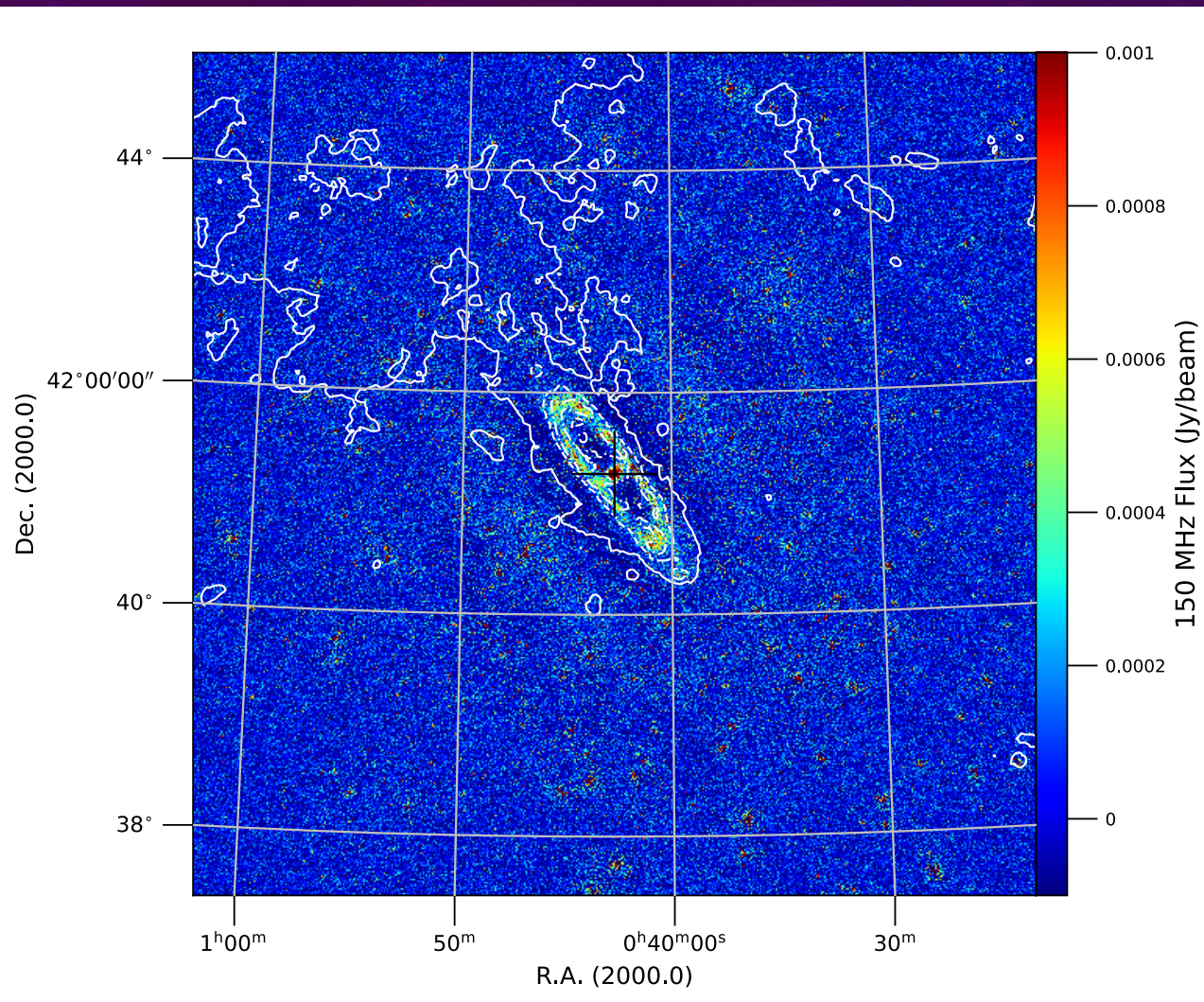


Li et al. 2016

→ Excess of milli-second pulsars?
Ackermann et al 2017, Eckner et al. 2018
See also Feng et al. 2018, Karwin et al.
2019, Fragione et al. 2019

Gamma detections:
M31's disc/bulge : 10σ
Excess along the minor
axis: 4σ
(Ackerman et al. 2017)

- No clear Fermi Bubbles
- Alternatives not satisfactory
e.g. McDaniel et al. (2019) :
dark matter + MSP + SNR



IRAS 100um contours

LOFAR (150 MHz) OBSERVATIONS OF M31

8deg x 8 deg map

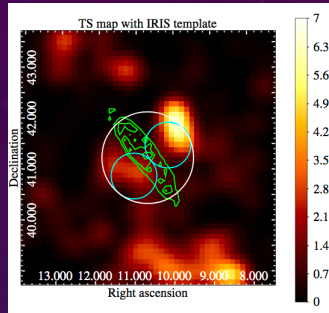
(1.4 arcmin, 20arcsec
and 5 arcsec resolution)

Good correlation with SF
in the 10 kpc ring

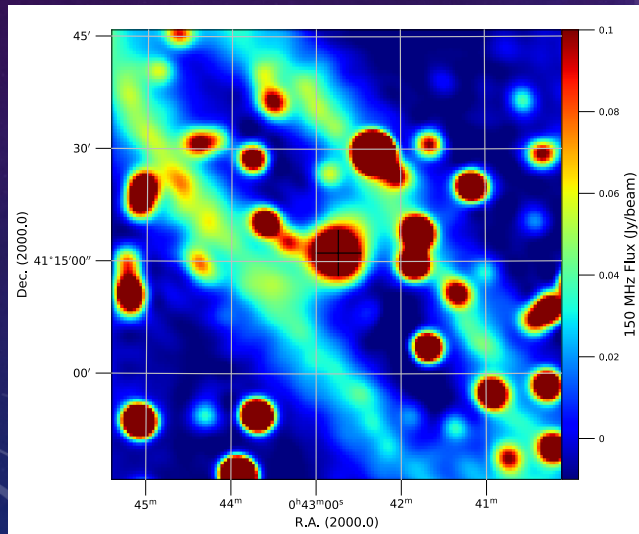
Primary beam // disc

No 150 MHz counter-part to the FERMI excess

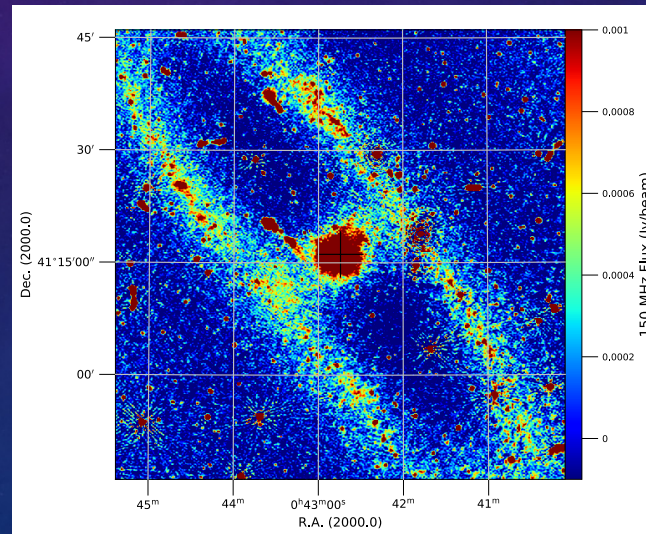
Li et al. 2016



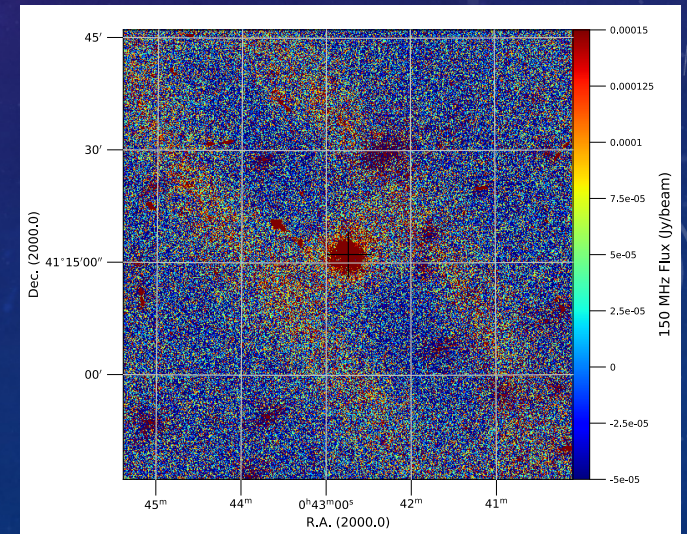
Very low resolution (1.4 arcmin)



Low resolution (20 arcsec)



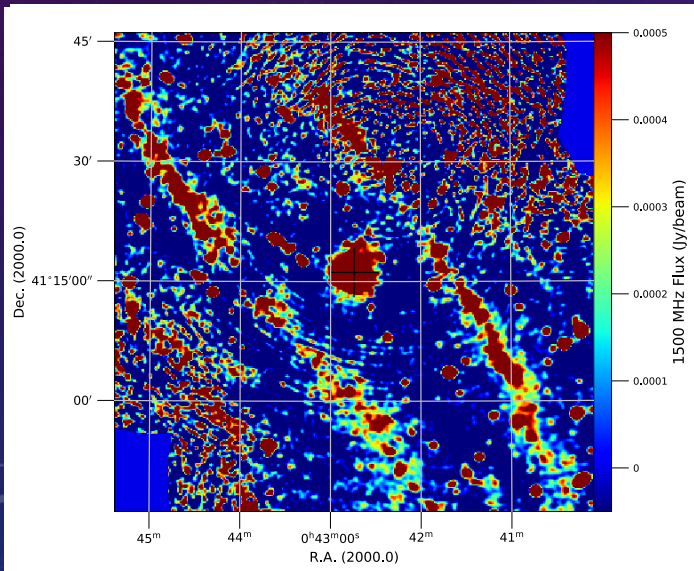
High resolution (5 arcsec)



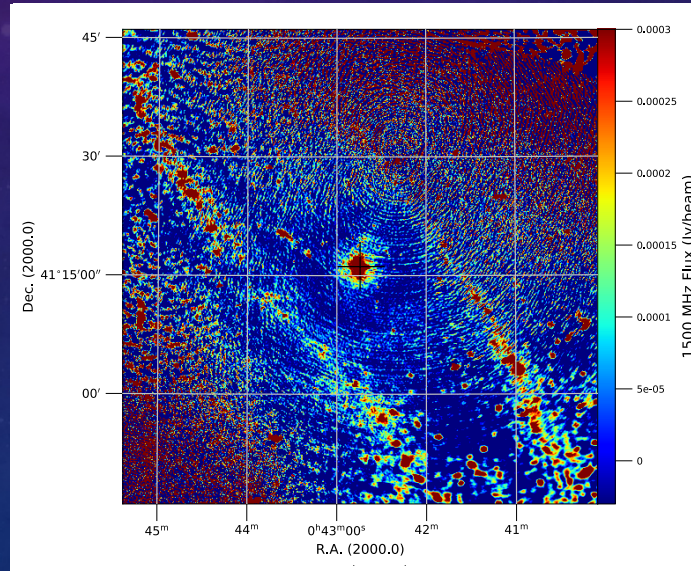
Radio continuum at 1500 MHz

Galvin et al. 2012

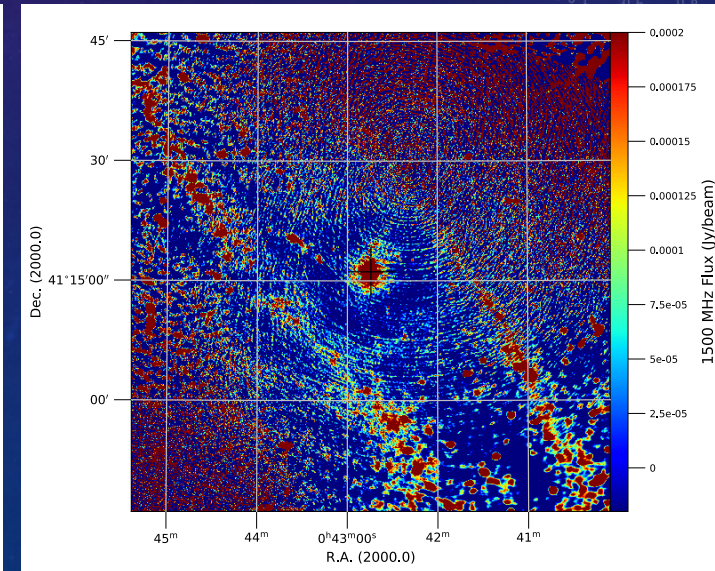
Resolution: 30 arcsec



10 arcsec



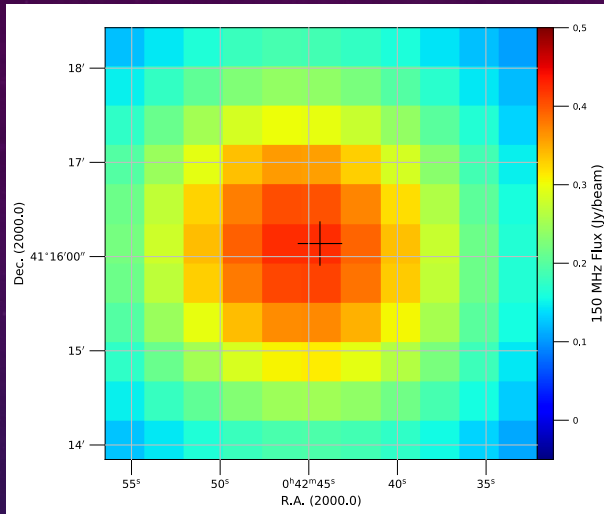
2 arcsec



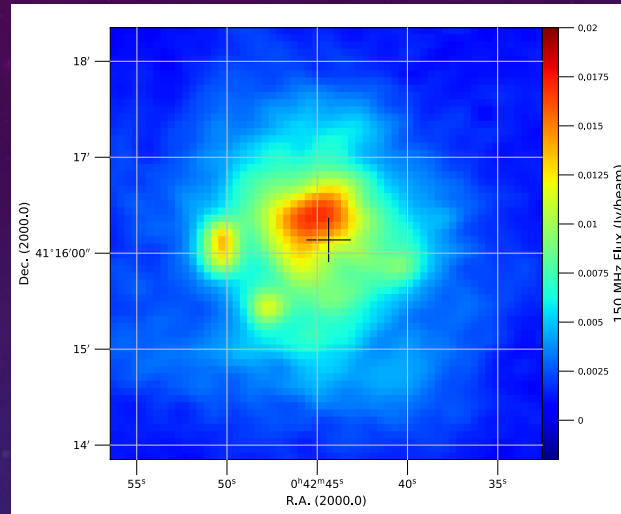
CHARACTERISTICS OF SYNCHROTRON EMISSION

- Detection of the 10 kpc star-forming ring
- The bulge (with no SF) is much stronger than the ring
- Different mechanisms are heating both regions.

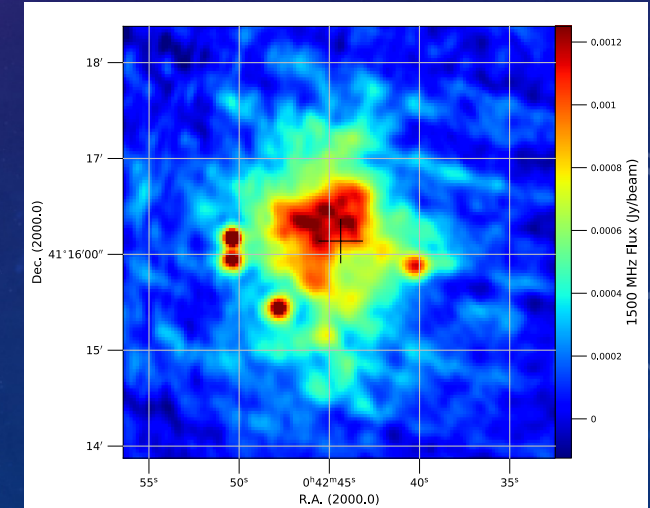
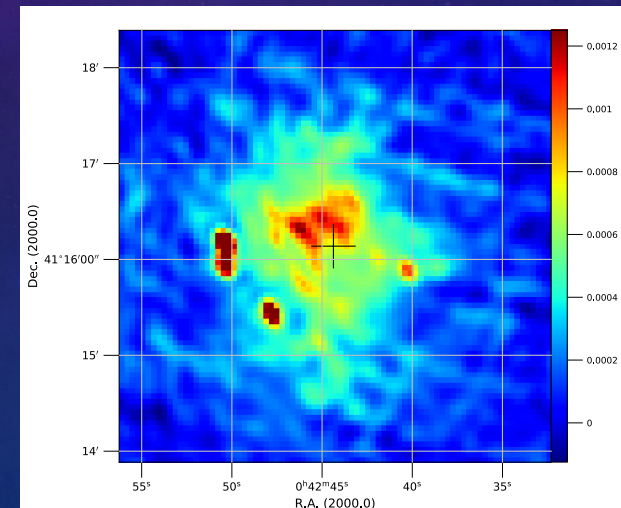
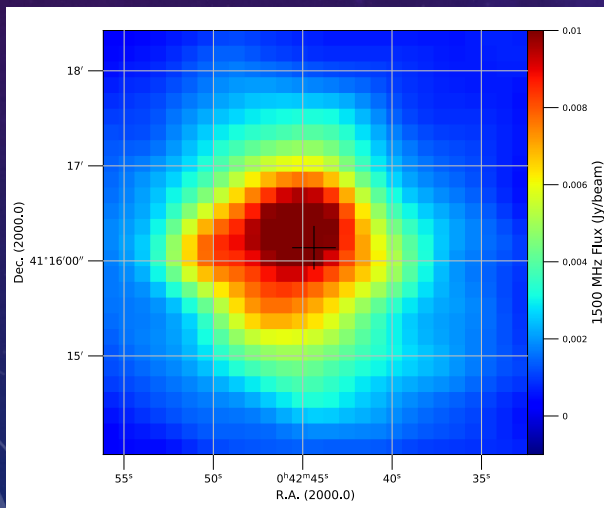
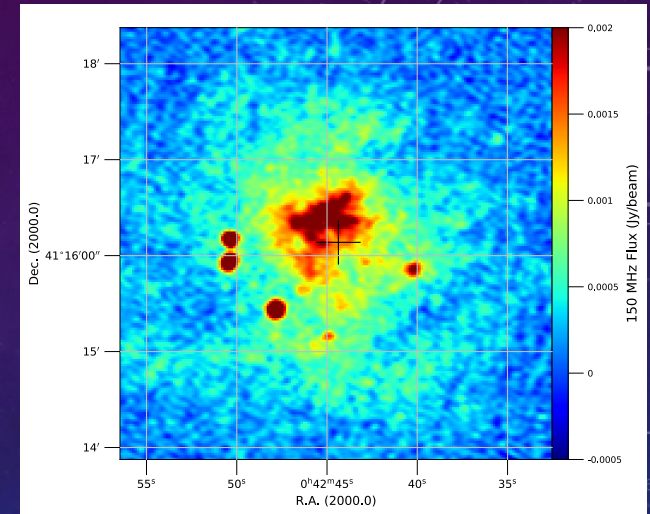
Resolution: 1.4 arcmin



20 arcsec



5 arcsec

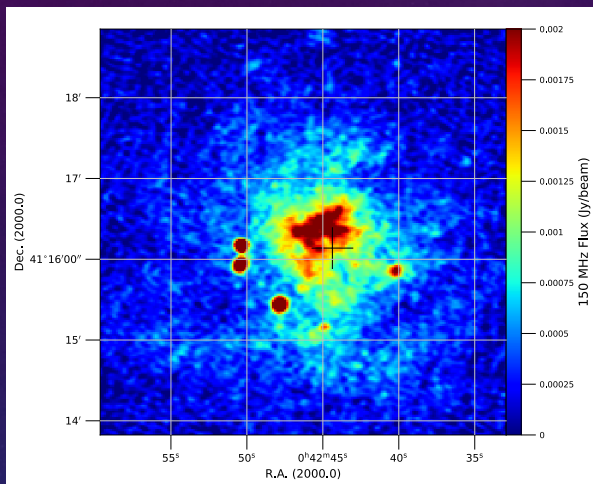


Resolution: 30 arcsec

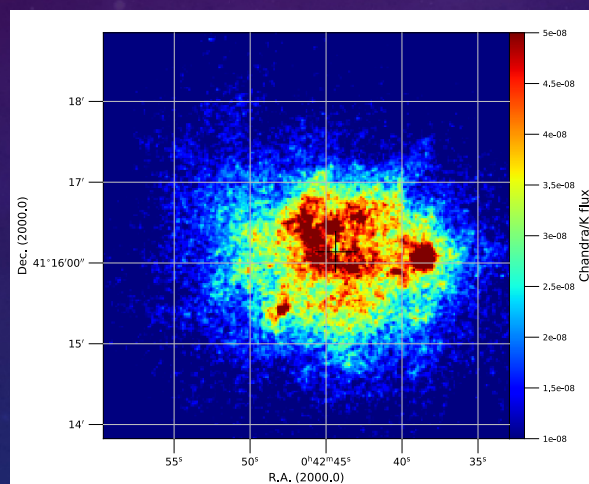
10 arcsec

2 arcsec

RADIO CONTINUUM EMISSION OF THE CENTRAL KPC

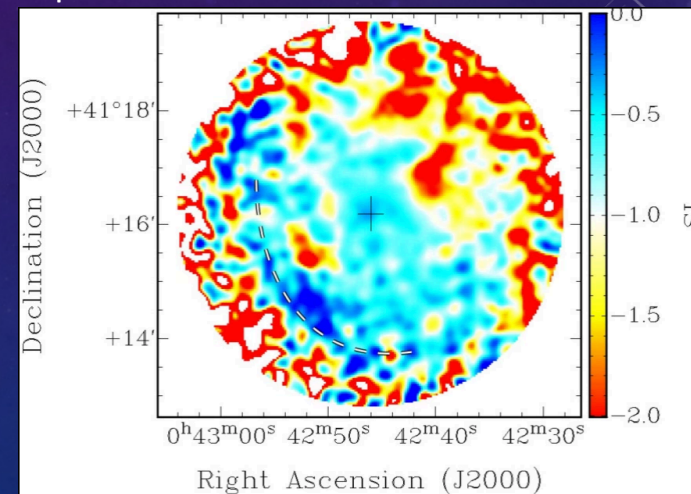


LOFAR 150 MHz



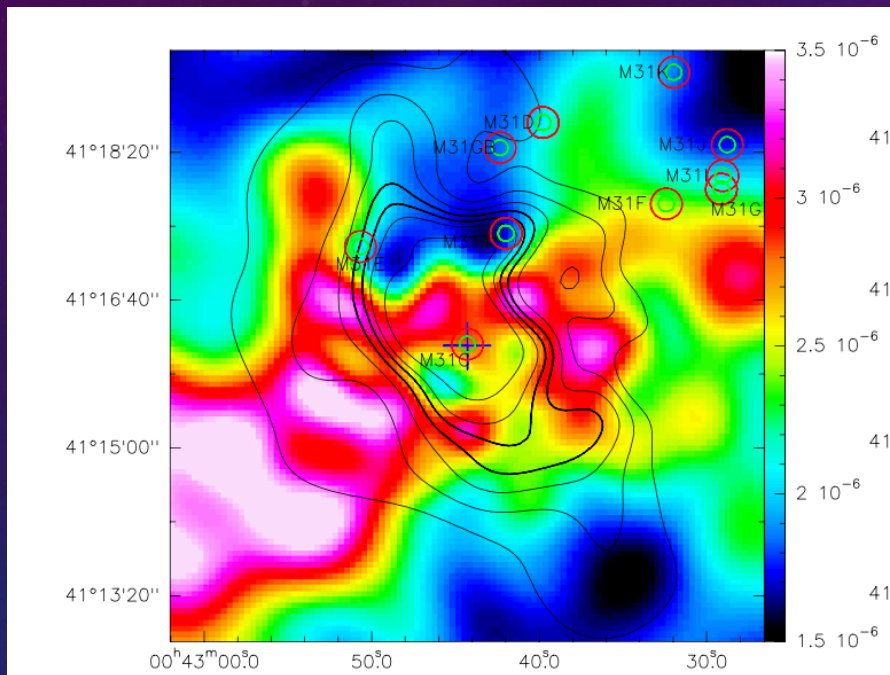
0.5-2keV map– 2MASS K
Xu & Li (2018)

Spectral index



Gießübel & Beck (2014)

X-RAY OUTFLOW



Bogdan & Gilfanov (2008)

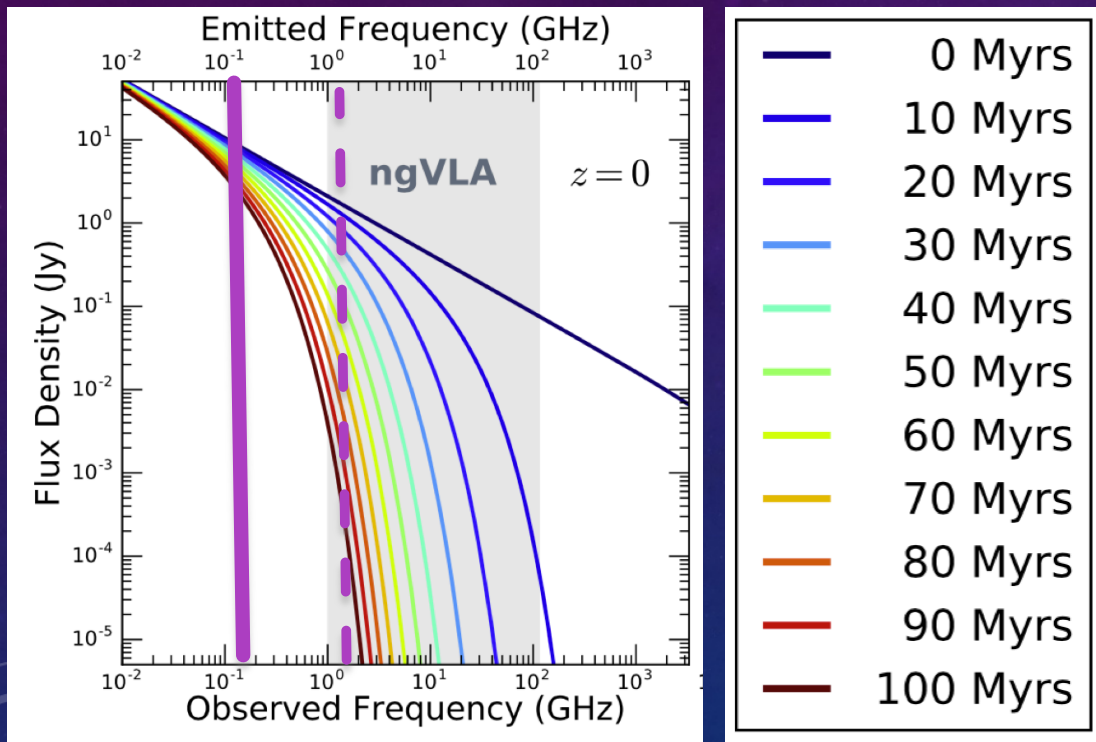
See also Li & Wang 2007

IONISED GAS OUTFLOW

- Kinematic signature in optical ionised gas (Melchior & Combes)
- Gas outflowing from the centre from ionised gas line ratio: low density of electrons in the central arcmin (2 orders of magnitude) Ciardullo et al 1988

PAST AGN?

--- 1.5 GHz/20cm
— 150 MHz/2m



Nyland et al. (2018)

Evidences from XMM-Newton

- X-ray lines ratios compatible with AGN excitation 0.5 Myr ago Wang et al. (2019)
- Evidence of past AGN in radio



THANK YOU!

Comments welcome