On the discovery of an interaction between a spiral galaxy and a radio jet

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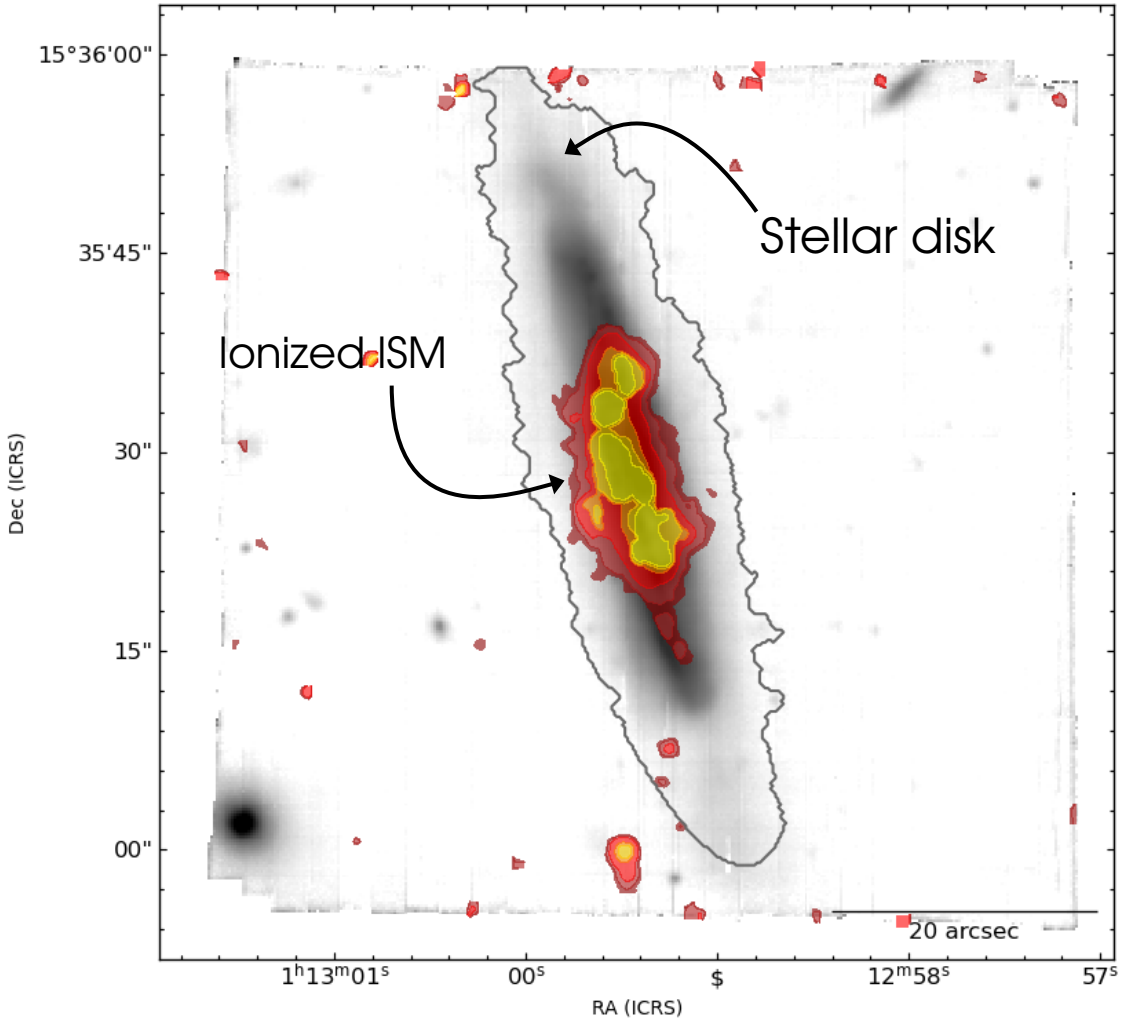
In collaboration with Dr. Marisa Brienza and the GASP team

From Ignesti et al., to be submitted.

European Research Council
Established by the European Commission

JO36

A case-study of ram pressure stripped galaxy



MUSE (total I+Hα)+ stellar disk (Fritz+2017, Gullieuszik+2020)

JO36 (z=0.043)

Hosting cluster: Abell 160 z=0.0407

Ram-pressure stripped galaxy: lost most of the ISM due to ICM ram pressure → **Fast-evolving galaxy!**

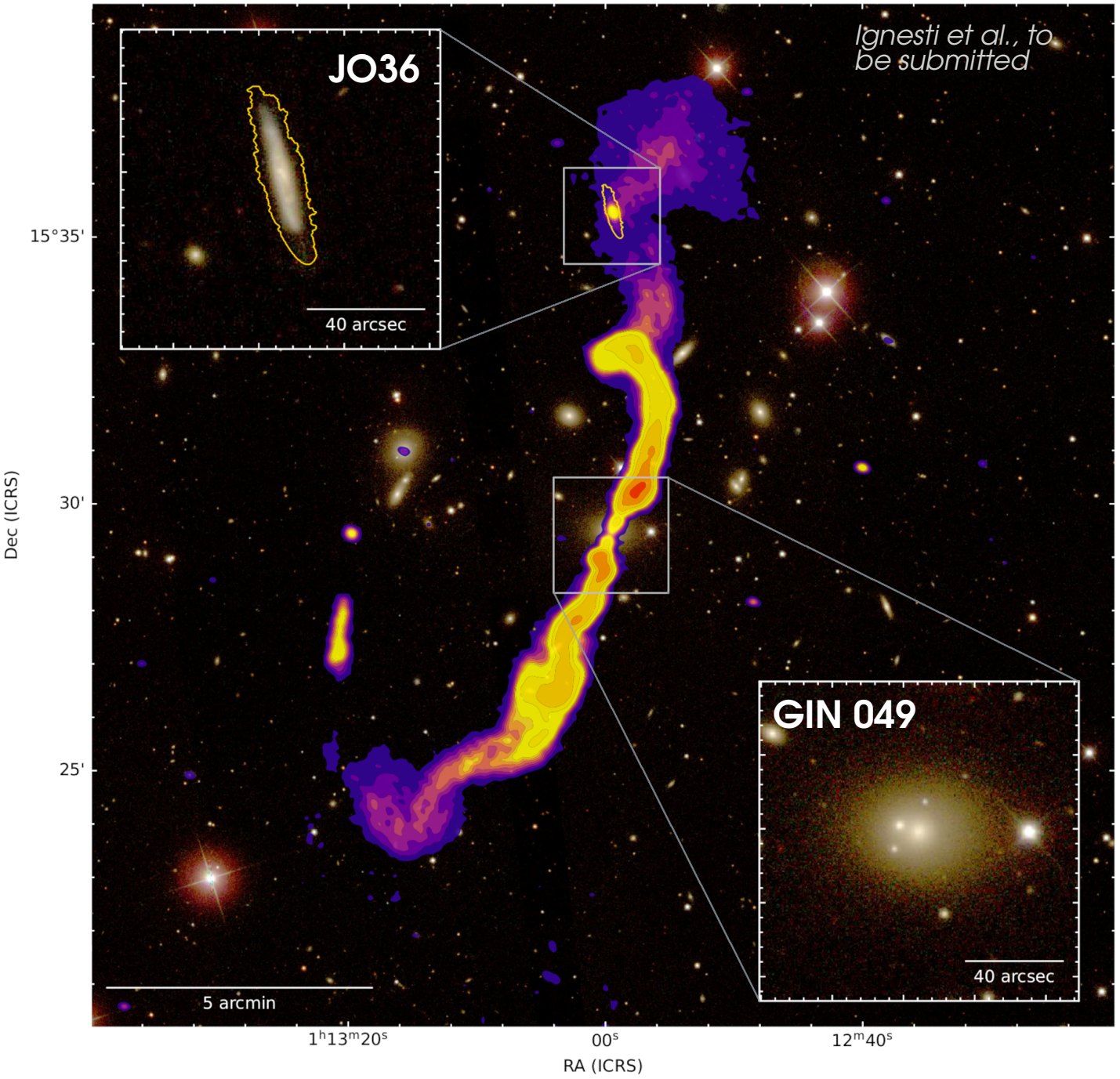
Distinguishing features:

- Truncated Hα emission
- No tail (`post-jellyfish' phase)

[Fritz+2017]

- **Northern sky**
  → Observed by LoTSS in GASP-LOFAR MoU program!

The new LOFAR view



GIN 049 (aka 0110+152)
FRI galaxy, BCG of A160
[e.g., Wirth+1982; Fanti+1983; Giovannini+1987; O'Donoghue+1990; Parma+1991]

1) **Is the interaction real?**

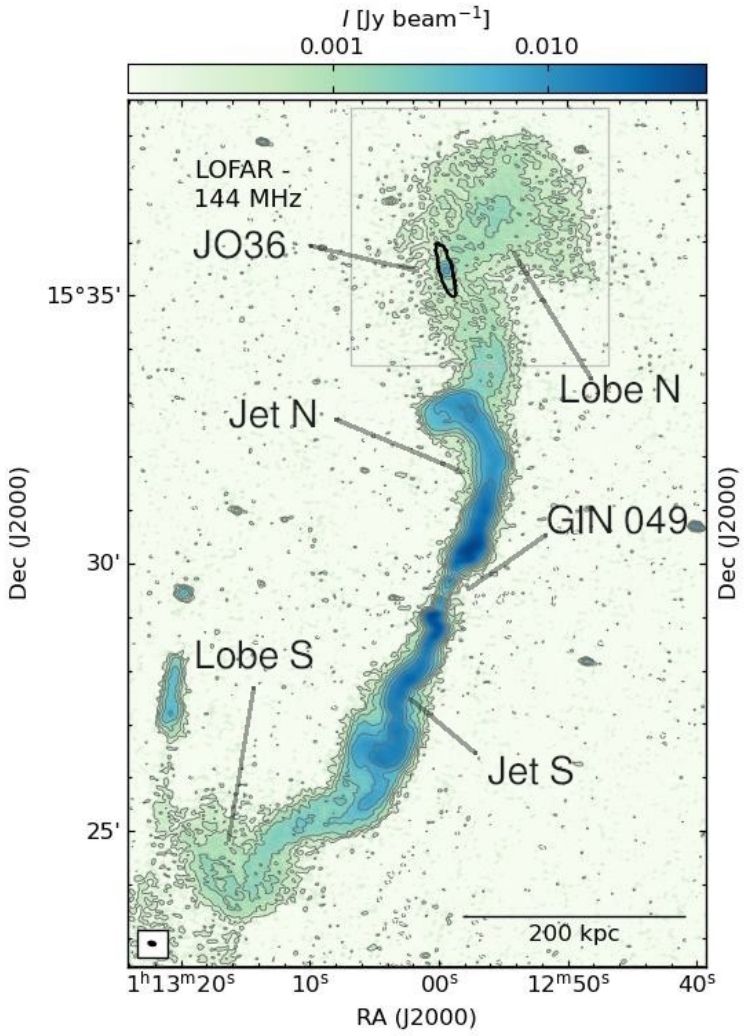
2) **How did it affect JO36?**

3) **How did it affect the radio lobe?**

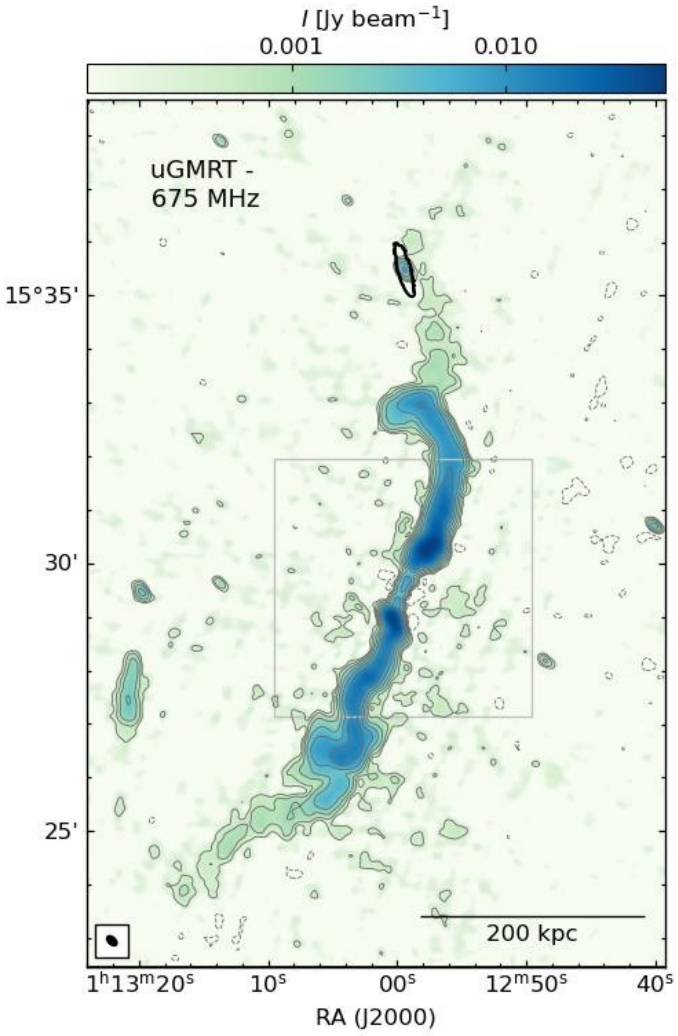
SDSS (rgb) + LOFAR contours @144 MHz (3-500xRMS) from LoTSS

LOFAR & uGMRT

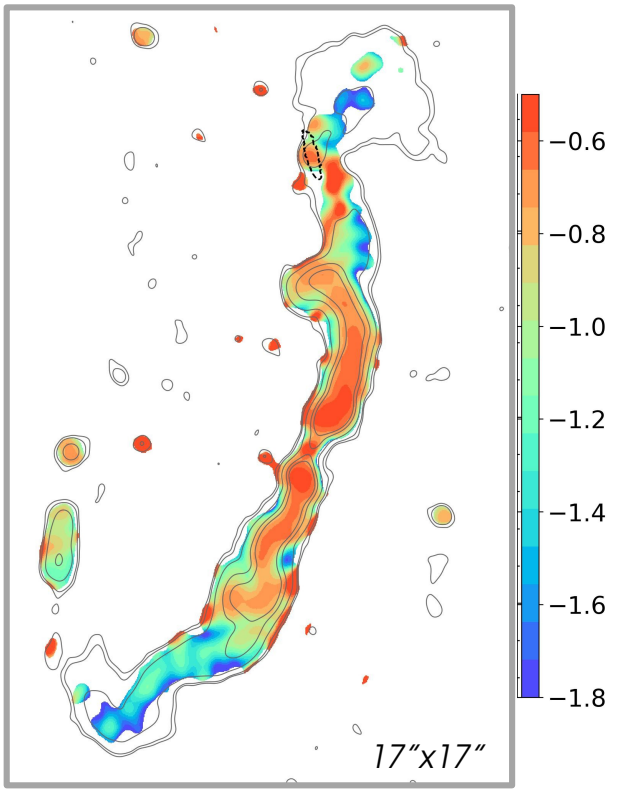
LOFAR @144 MHz



uGMRT @675 MHz



144-675 MHz spectral index map

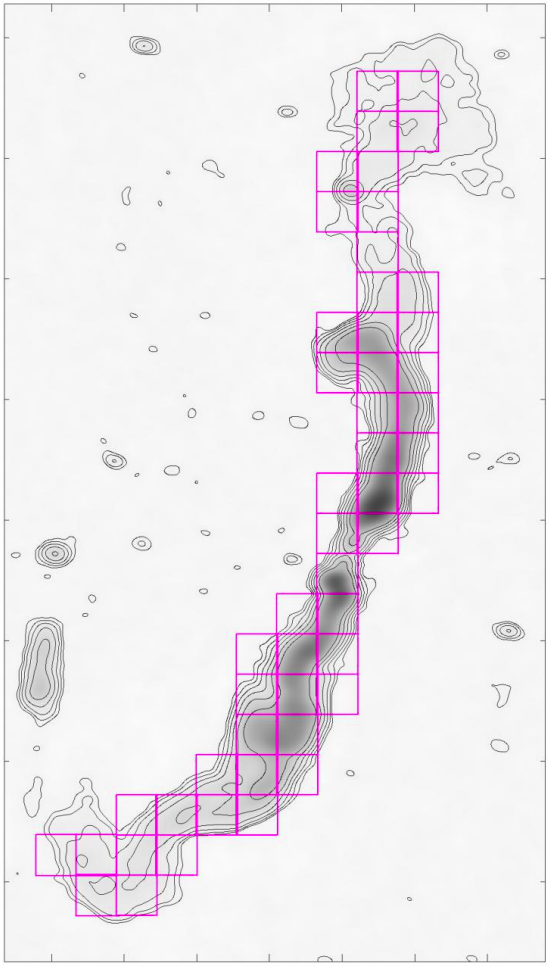


New uGMRT data to map 144-675 MHz spectral index (Obs ID 43_009, ~6hr, PI Ignesti).

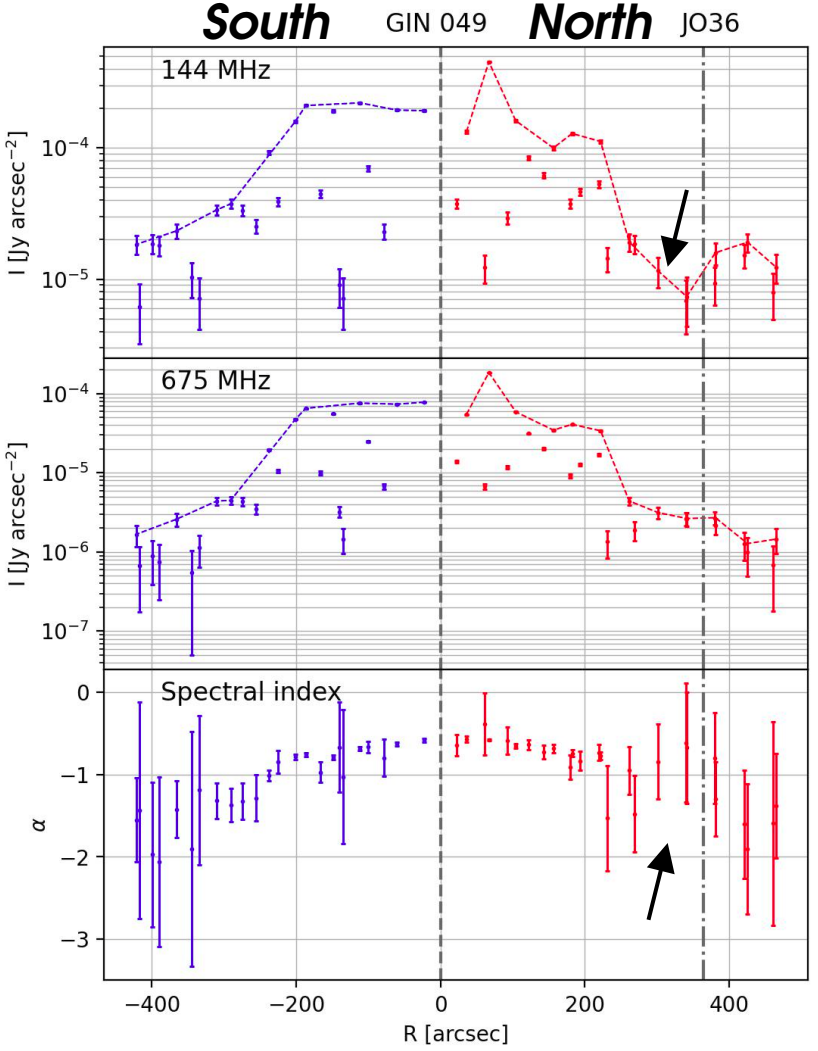
Core and Jets already studied at GHz frequencies,

Lobes discovered thanks to LOFAR, ~740 kpc at 144 MHz

Analysis n. 1: I_R and spectral index profiles



40x40 arcsec^2 cells, Emission above the 2xRMS level



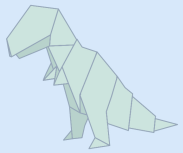
- Symmetric within ~200″ (i.e. the Jets)
- Sharp decline at 144 before JO36

  → ***Sharp spectral flattening***
- Similar properties in the lobes

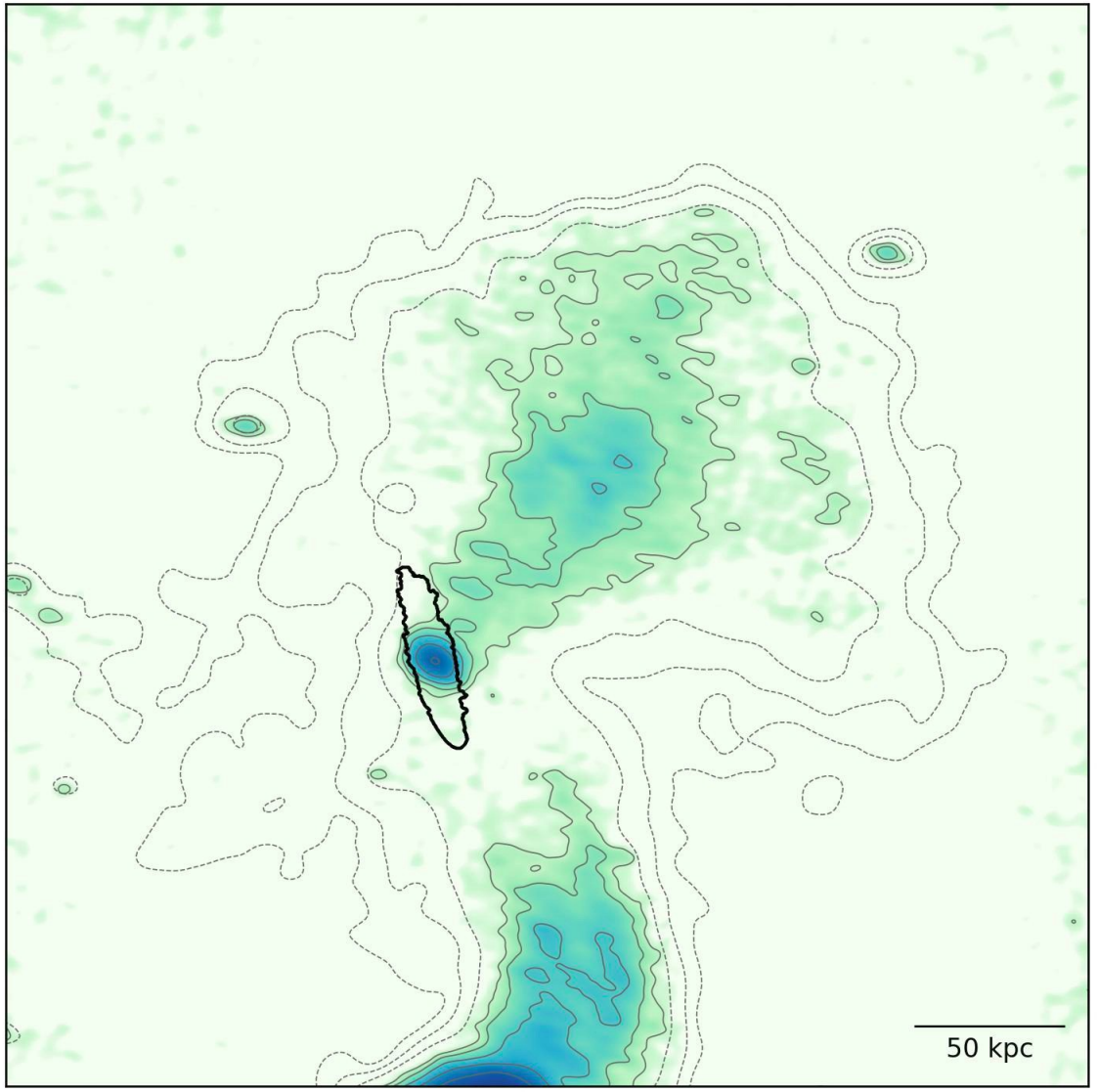
JO36 passage left no signatures in the radio emission, except potential lobe `truncation'

→ No supersonic motion, no re-acceleration?

Analysis powered by the PT-REX code, Ignesti 2022



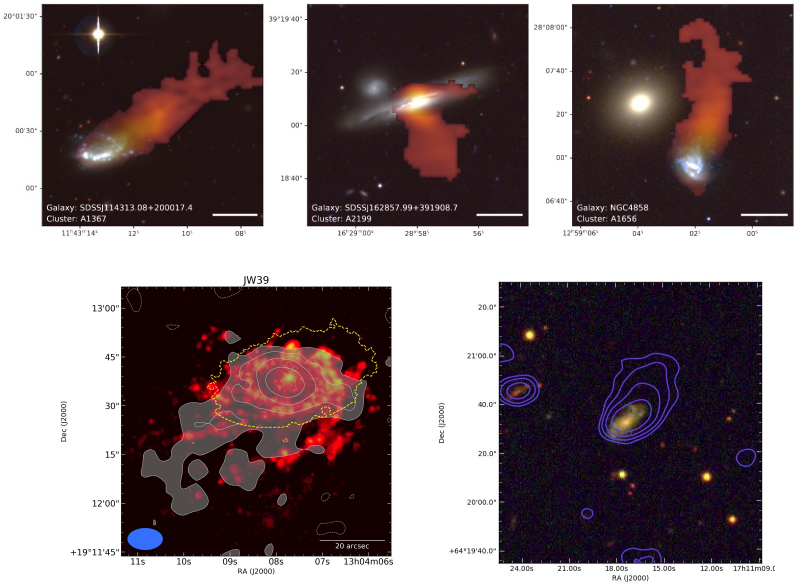
Analysis n. 2: *Morphology*



144 MHz image with UVrange>700 λ to remove emission on ~1′ scale + Original emission (dashed)

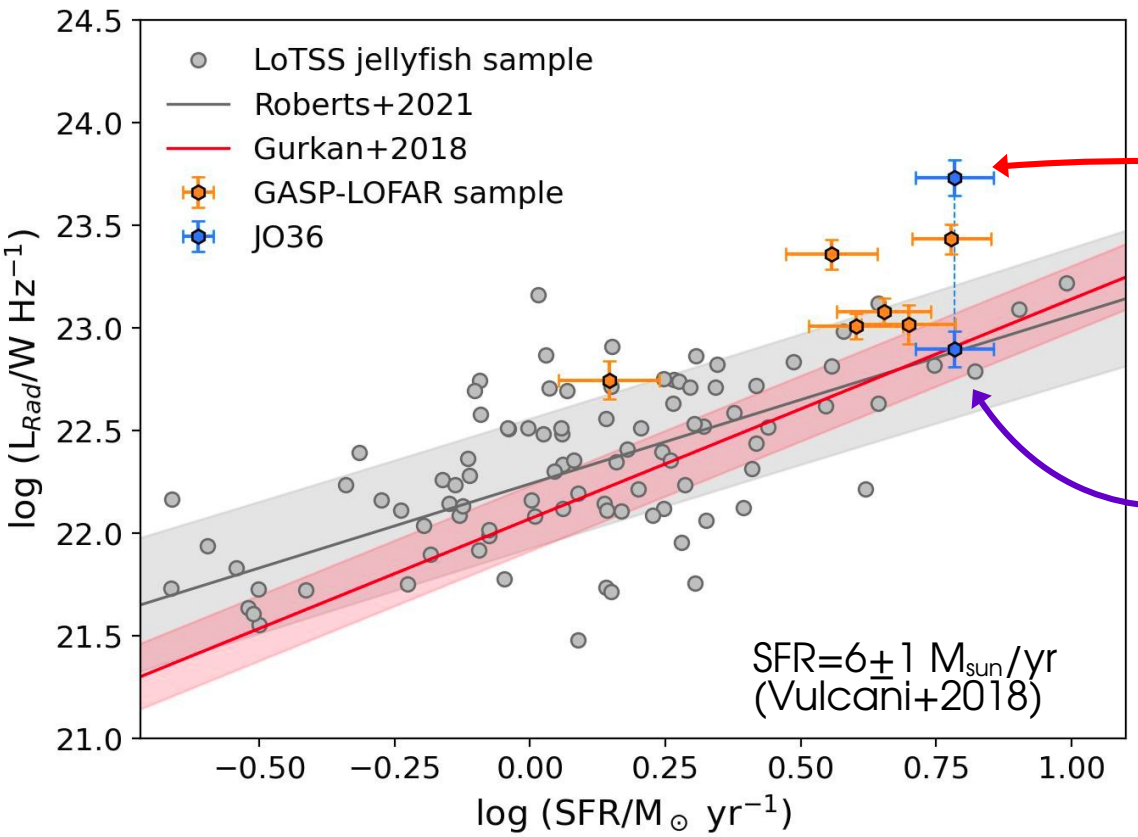
- Giant tail ***L*~150 kpc**
- Anomalous morphology, increasing tail **brightness and width** with the distance

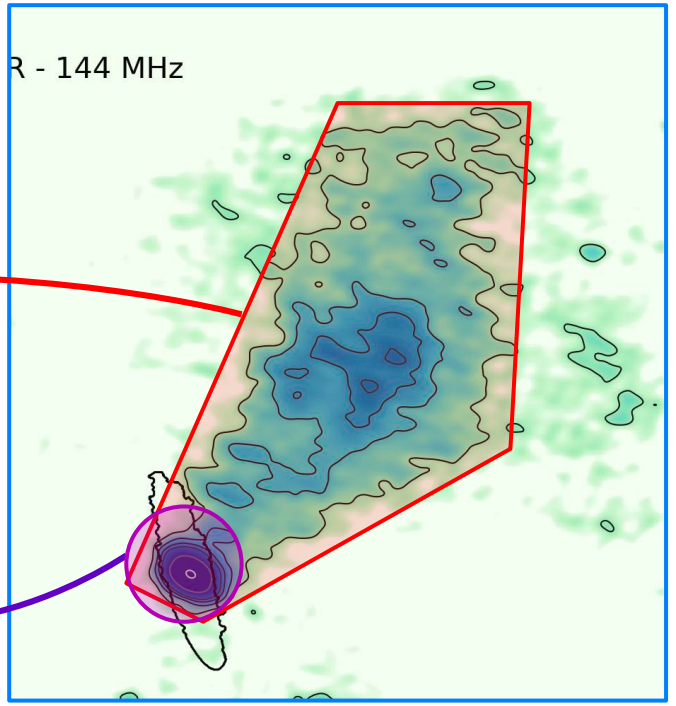
→ **JO36 is not a 'classical' radio jellyfish**



[*From Roberts+2021, Ignesti+2022, 2023*]

Analysis n. 3:
L_{144} vs Star Formation Rate





Two regions:

(A) Stellar disk

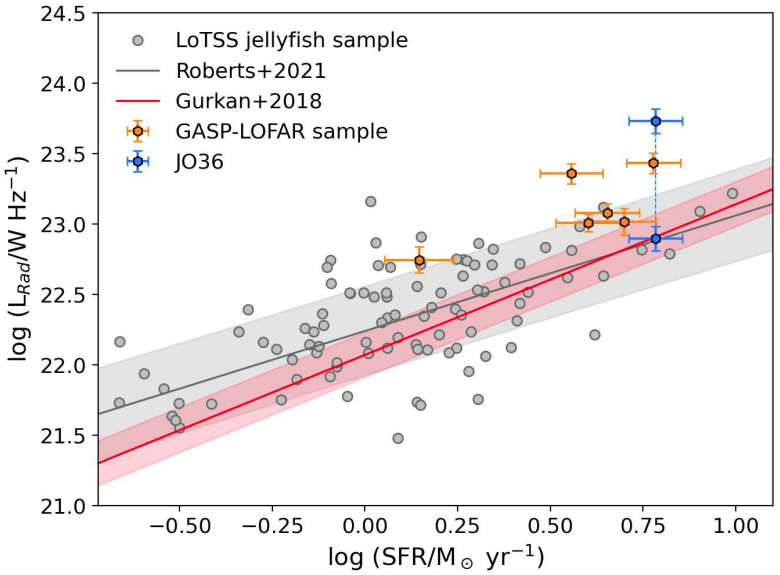
(B) Extended region

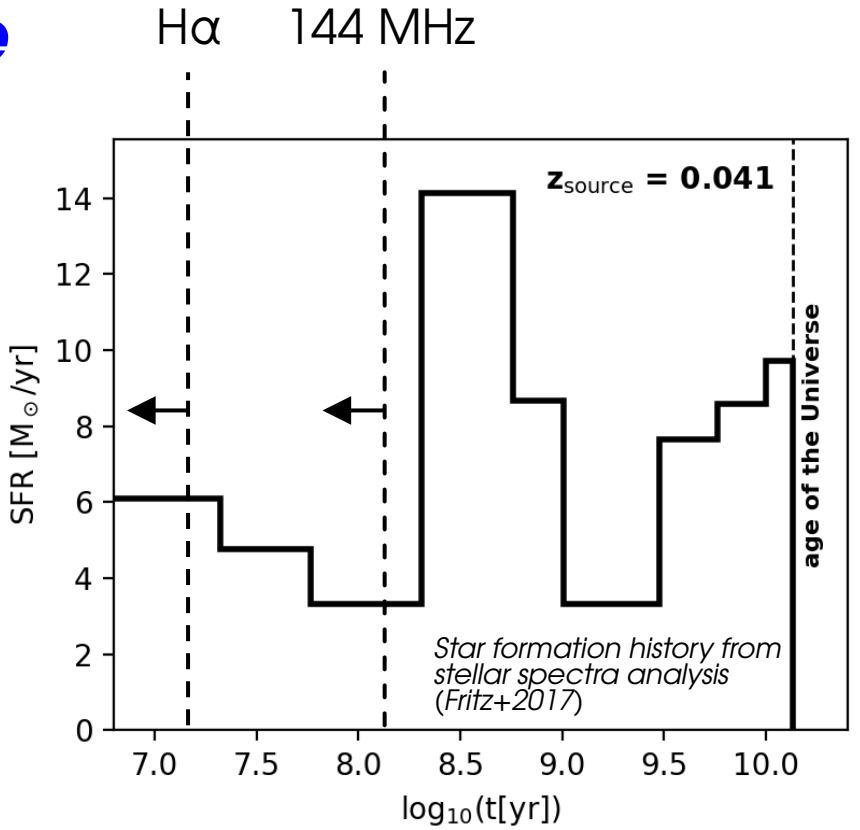
Results:

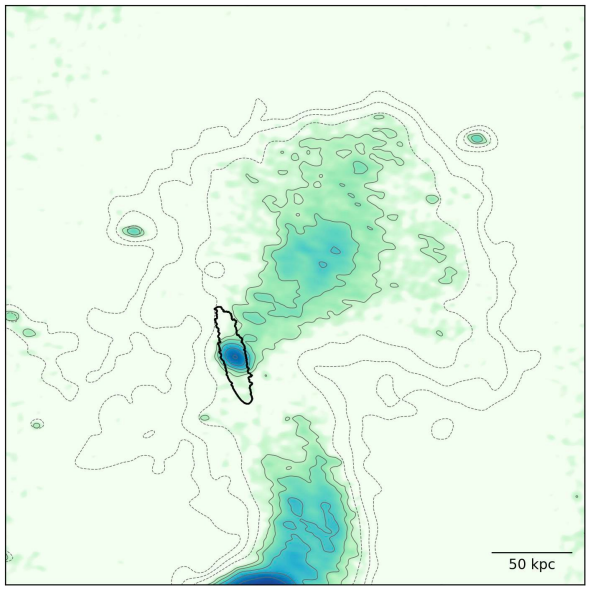
(A) JO36 is consistent with general trend → No radio excess of JF galaxies

(B) Significant excess of a factor ~10x → **Echoes of past star formation?** [Ignesti+2022d]

Analysis n. 4:
L_{144} vs Star Formation Rate







Past SFR burst cannot explain radio excess:

- Too **old** to be traced by radio emission
- Too **weak** (x2) wrt radio excess (x10)

→ Extended radio emission is not consistent with JO36, radio plasma comes from the lobe

Moreover:

$$\tau = \frac{\text{Lobe size}}{\text{Cluster velocity dispersion}} \simeq \frac{200\ \text{kpc}}{738\ \text{km s}^{-1}} = 265\ \text{Myr}$$

→ Positive feedback on SFR after JO36 first impact on radio lobe?

3 questions:

1) Is the interaction real?

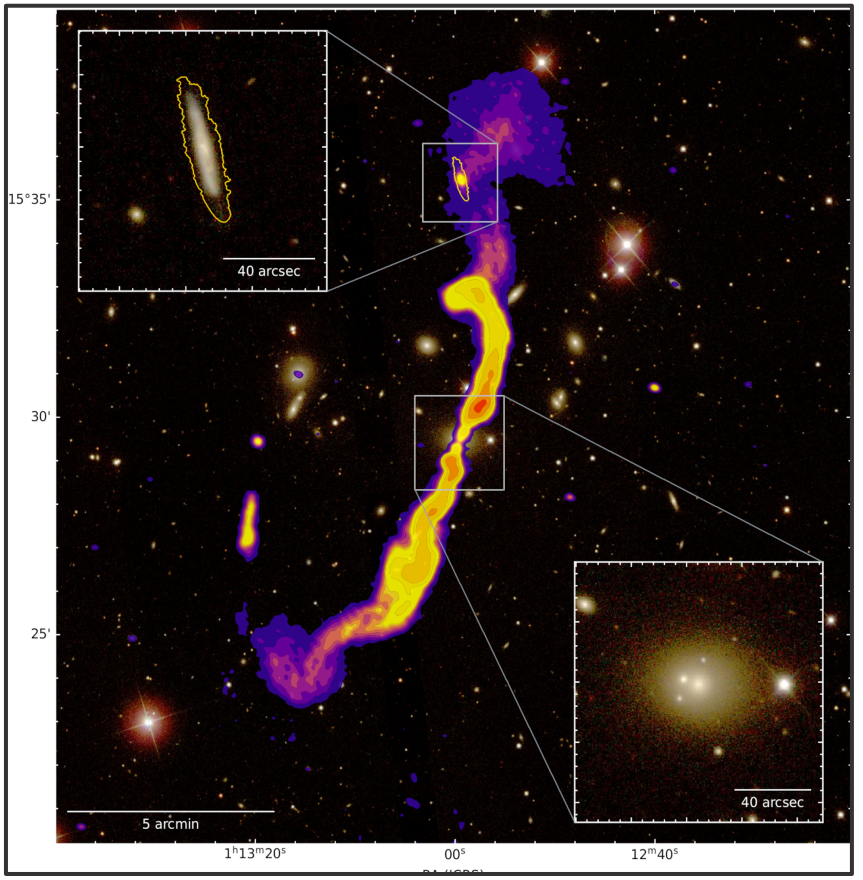
Yes, unique features unusual for both RPS and FRI

2) How did it affect JO36?

Positive feedback on SFR

3) How did it affect the radio lobe?

It re-shaped it, no evident effects on its radio emissivity/luminosity, possible jet truncation



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Positive feedback on SFR

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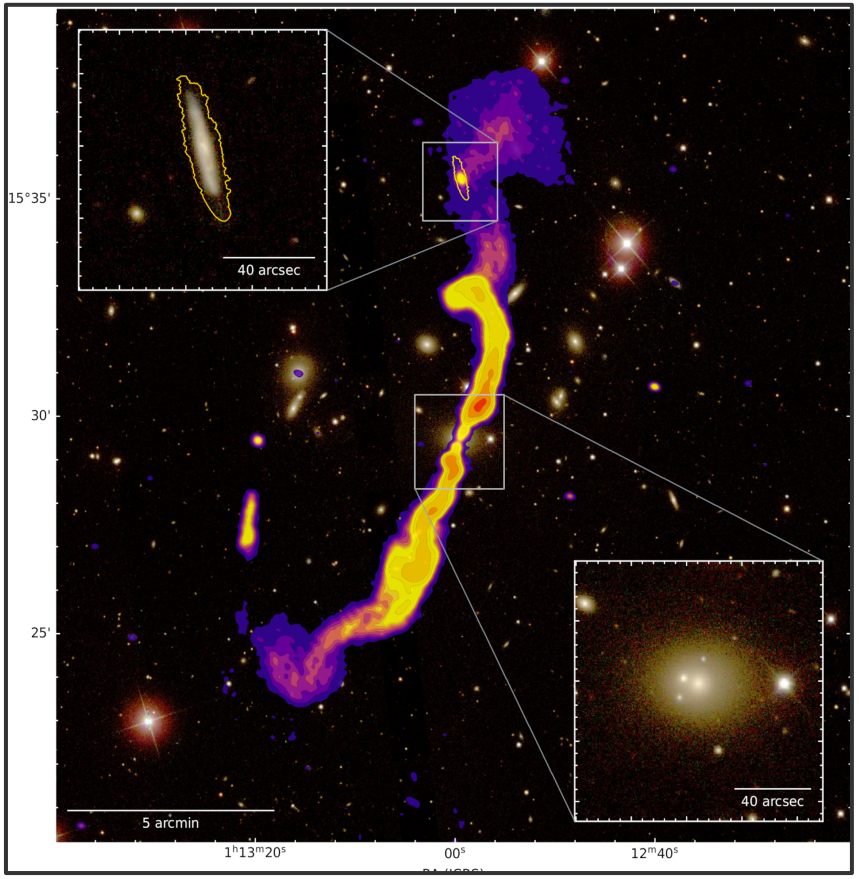
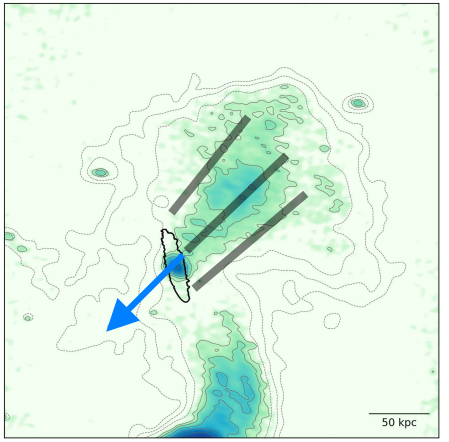
4) How?

JO36 is **transonic** (M=1.2-1.6) and **super-alfvenic** (M_A=3.4-3.8). Passage through the pre-existing lobe bent the magnetic field via magnetic draping without re-accelerating the electrons

→ **Radio emission amplification via compression?**

.....food for theoreticians, and critical prediction on **ordered magnetic field!**

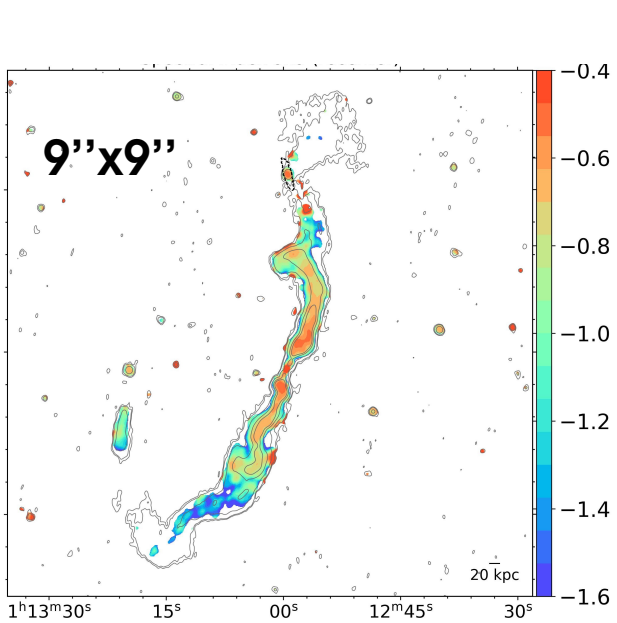


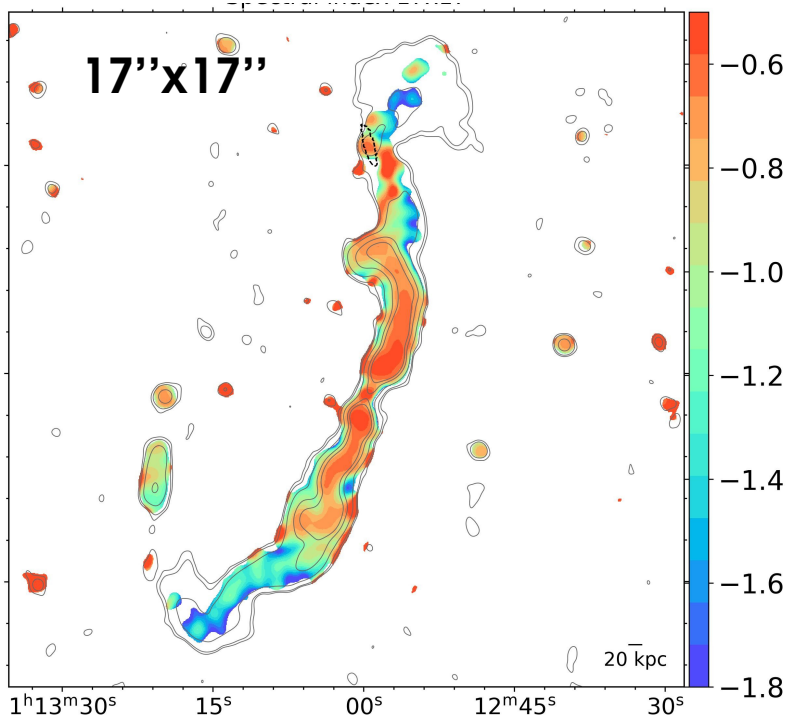


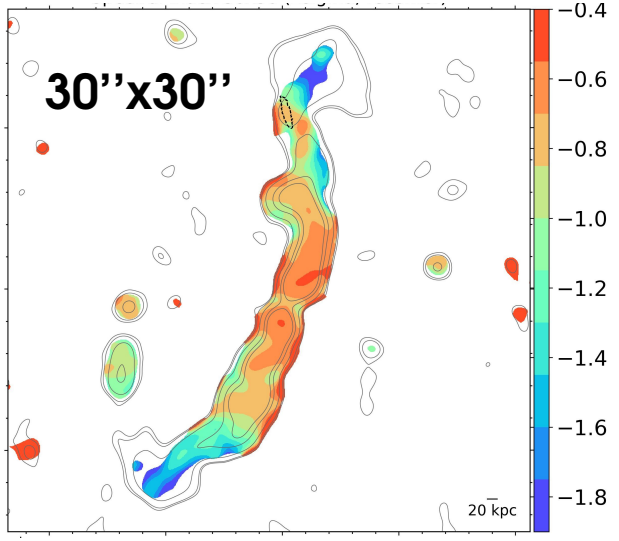
Thank you for your attention

EXTRA SLIDES

Spectral index maps 144-675 MHz







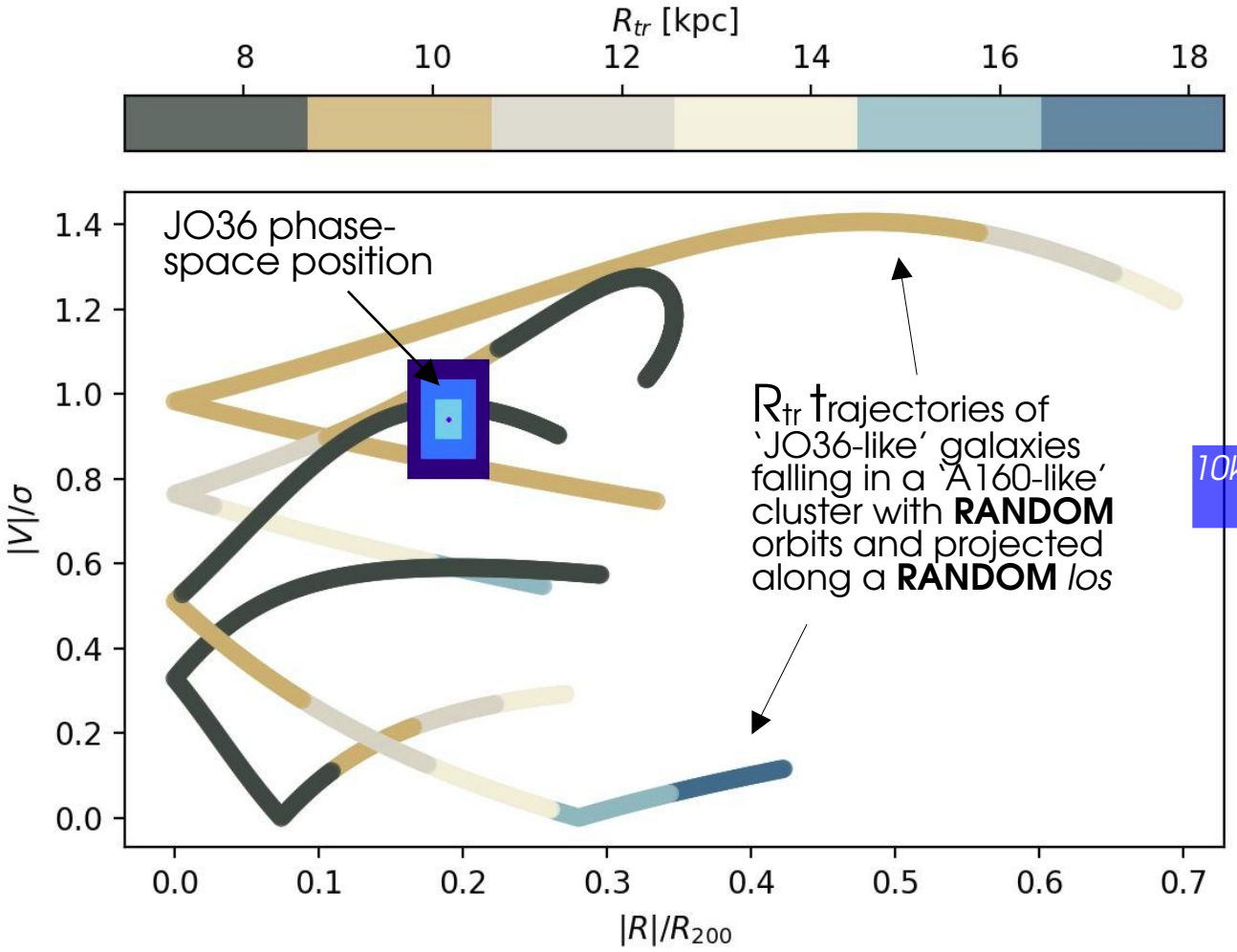
2XRMS threshold, lower UV 300 λ, σ~0.05-0.3

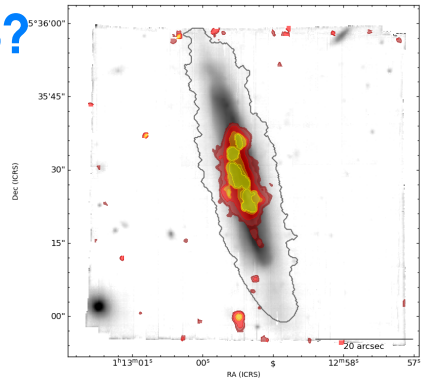
- **Steepening trend with the distance**, expected from FRI galaxies (*e.g., Katz-stone&Rudnick 1997, Heesen+2018*)
  + steepening from the center toward the edges of the Jets
- **Anomalies nearby JO36**, sudden flattening between northern jet and the galaxy

Analysis n. 5: *Truncation radius*

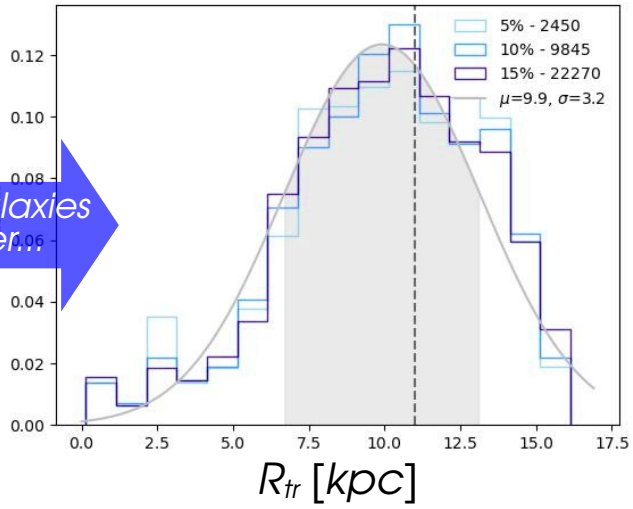
JO36 is truncated (R_{tr}=11 kpc), but is it as truncated as we should expect?

→ **Could the encounter have enhanced/reduced the RPS?**





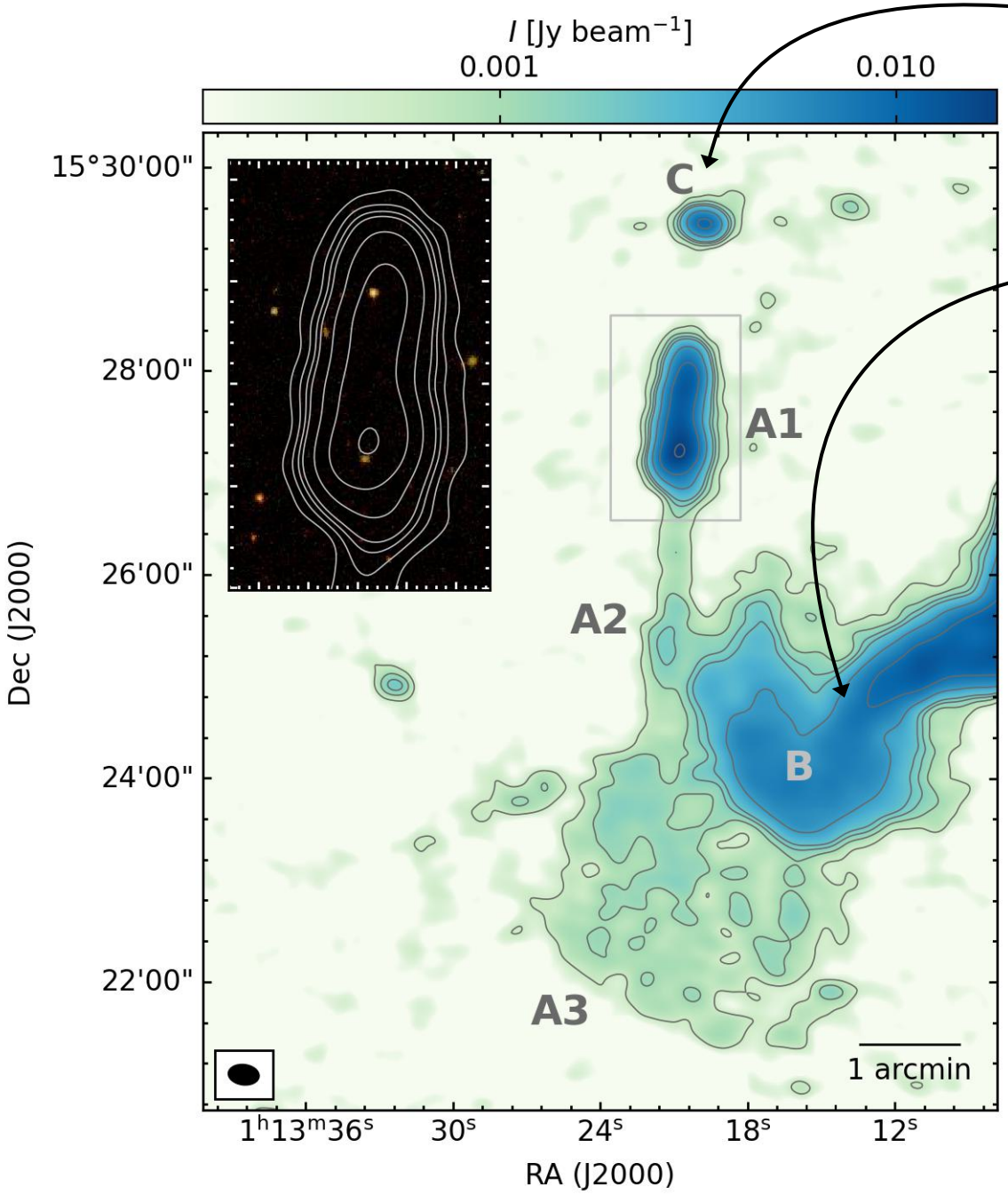
10k galaxies later...



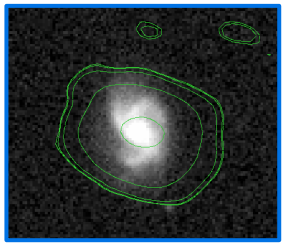
Answer: **probably no**, R_{tr} is consistent with the expectations.

[*Code for single orbit simulation by Dr. Rory Smith & JO36 properties by Dr. Antonino Marasco*]

The *Mandolin*



Cluster spiral galaxy



GIN 049 southern lobe

Main features:

- 3 components:
  1) Headstock (A1)
  2) Neck (A2)
  3) Body (A3)
- No evident optical counterpart
- A1 detected up to 1.4 GHz, curved synchrotron spectrum
- A2, A3 detected only at 144 MHz
- S_{144}= 213 mJy
- ~300 kpc at cluster *z*