

Unmasking the history of **3C293** with LOFAR sub-arcsecond imaging

Pranav Kukreti^{1,2} - 2nd year PhD student

Raffaella Morganti^{2,1}, Timothy Shimwell^{2,3} and others (Kukreti et al. 2021, submitted)

- 1. Kapteyn Astronomical Institute, University of Groningen
- 2. ASTRON, the Netherlands Institute for Radio Astronomy
- 3. Leiden Observatory, Leiden University



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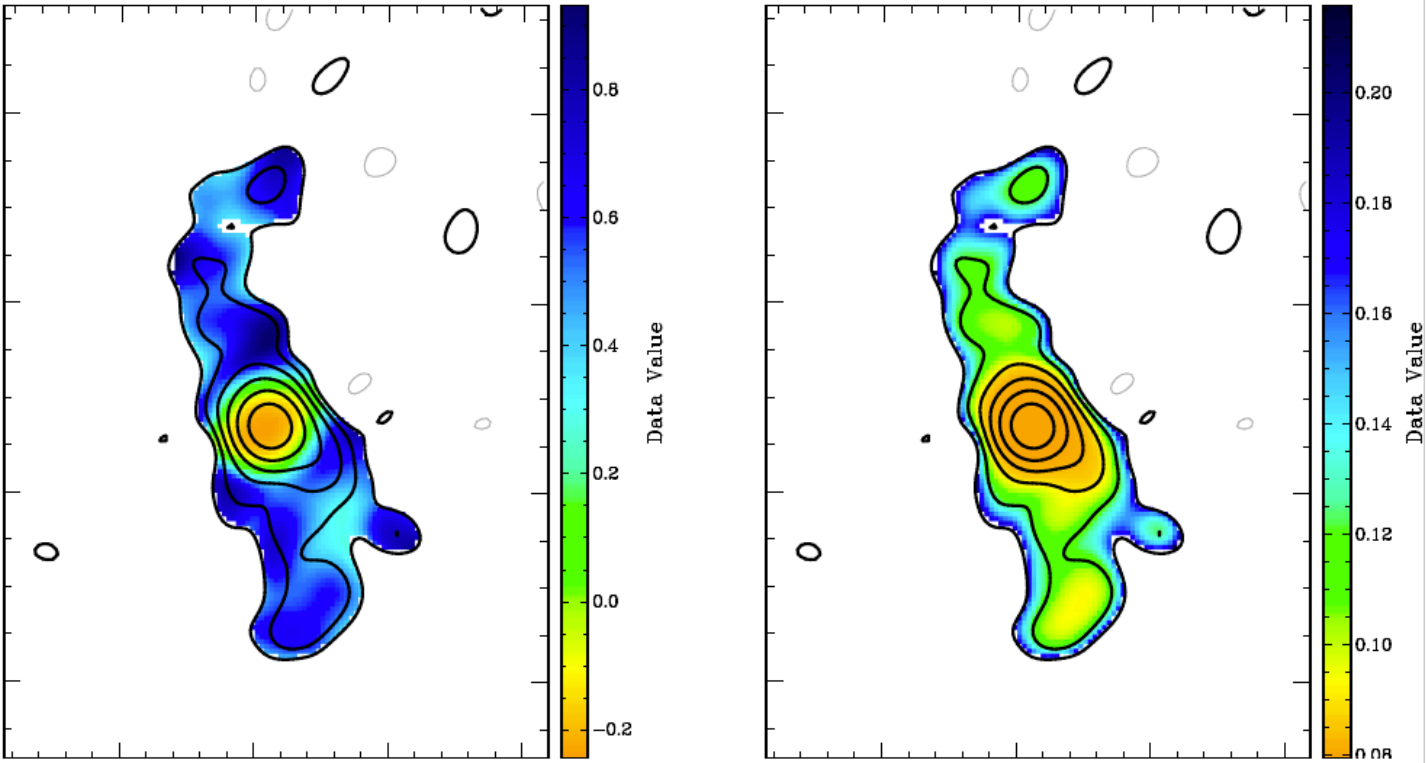
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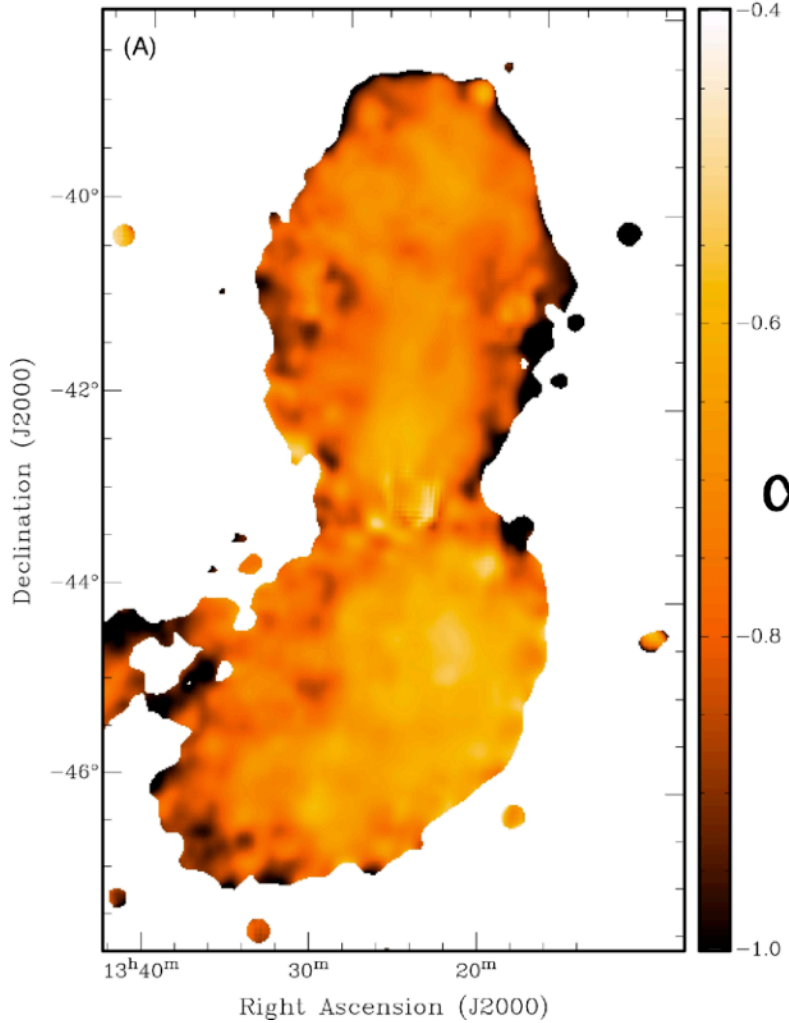
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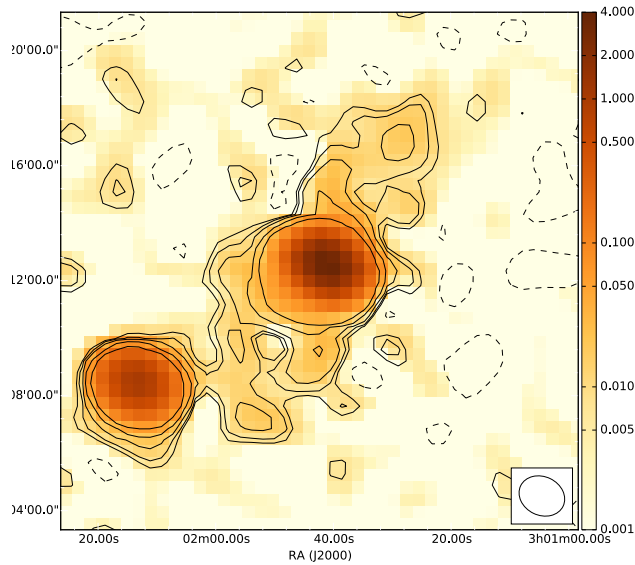
NGC 3998 - Sridhar et al. 2020



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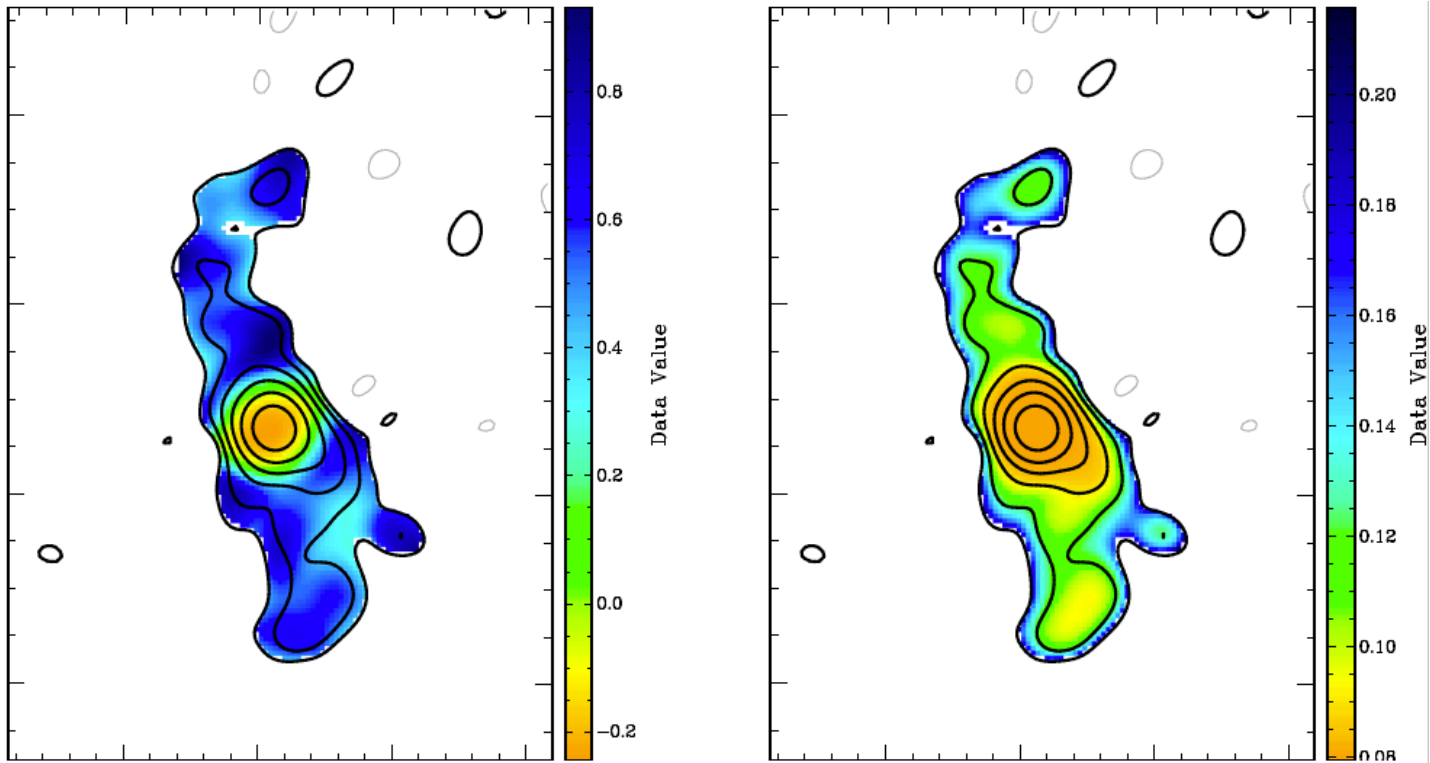
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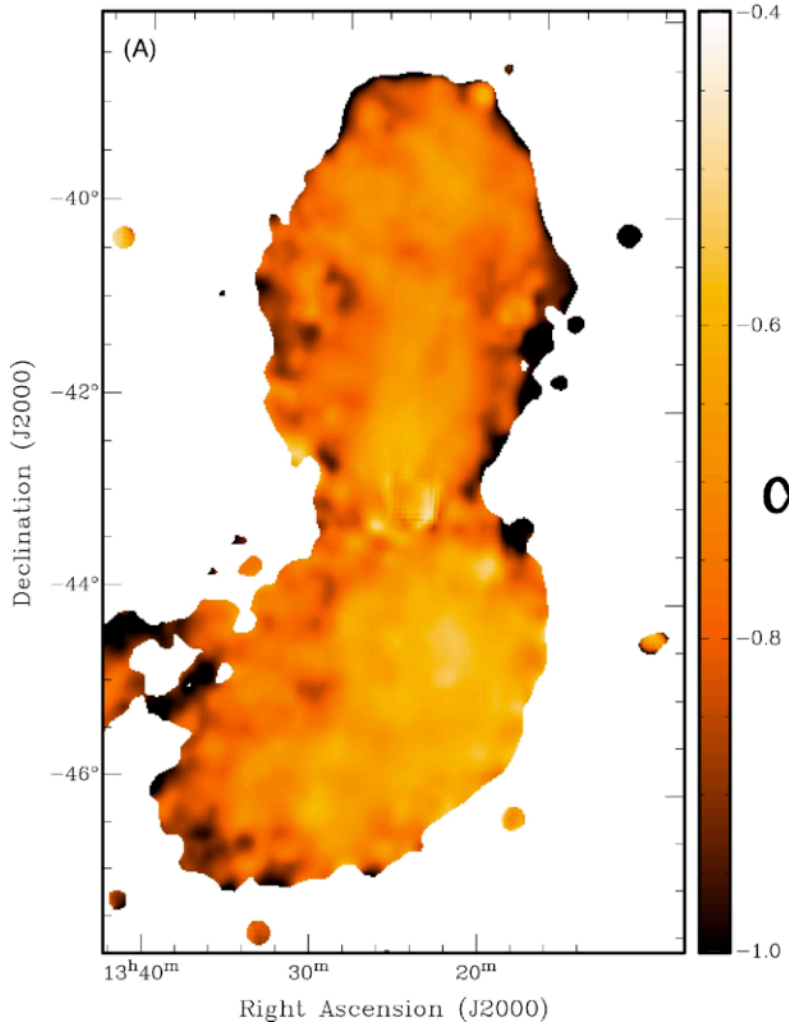
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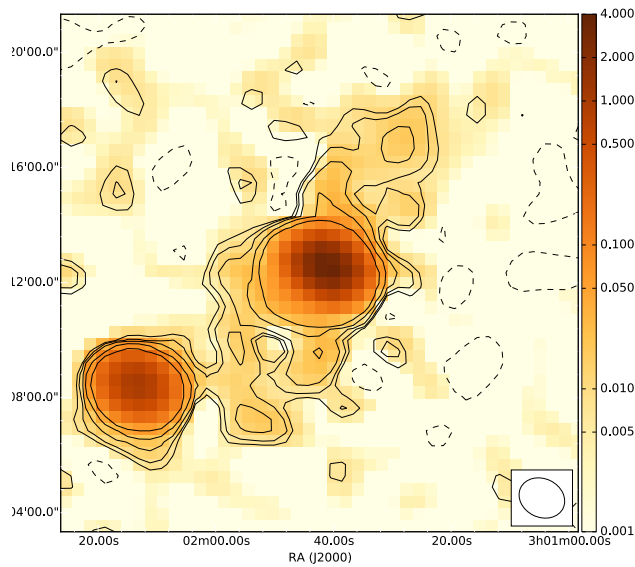
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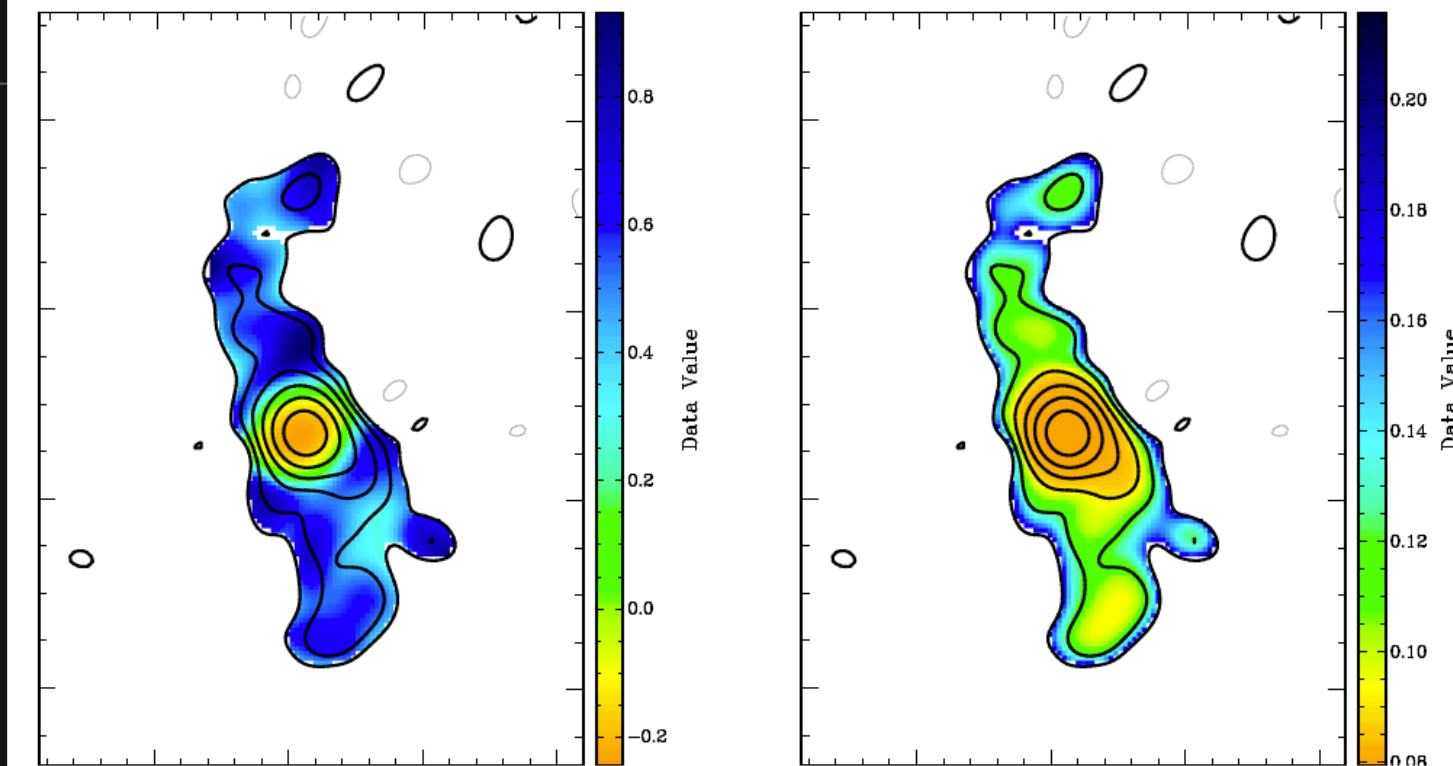


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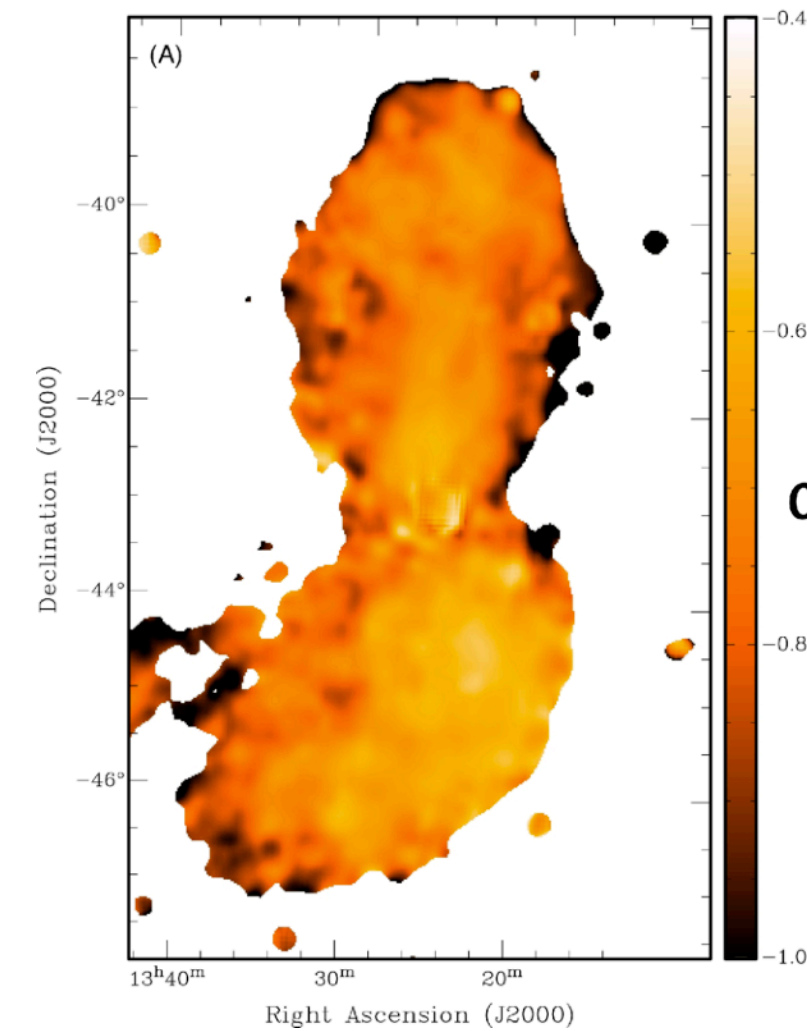
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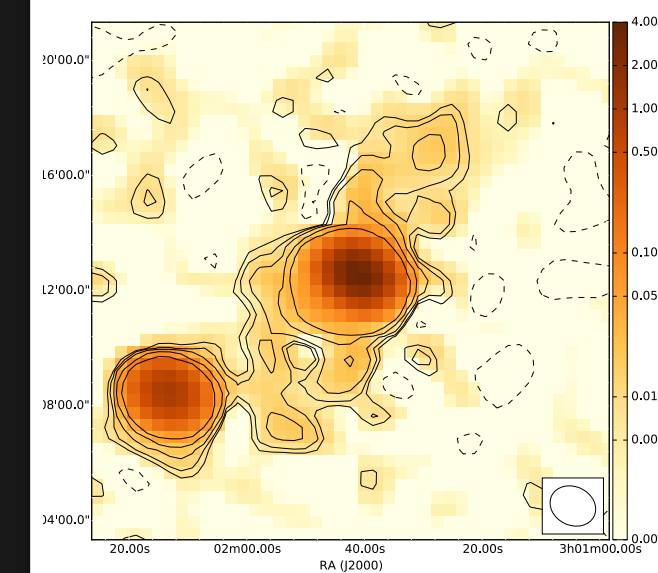
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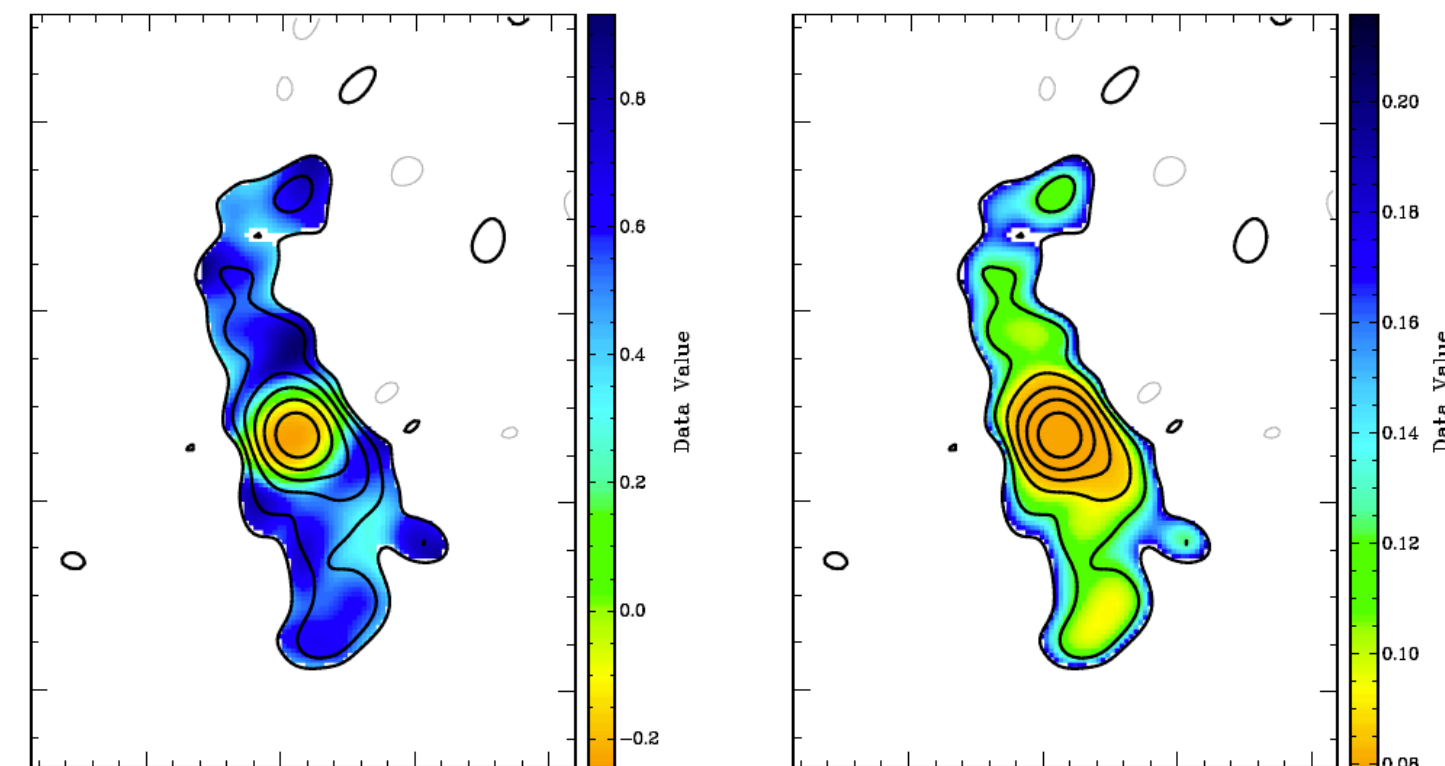
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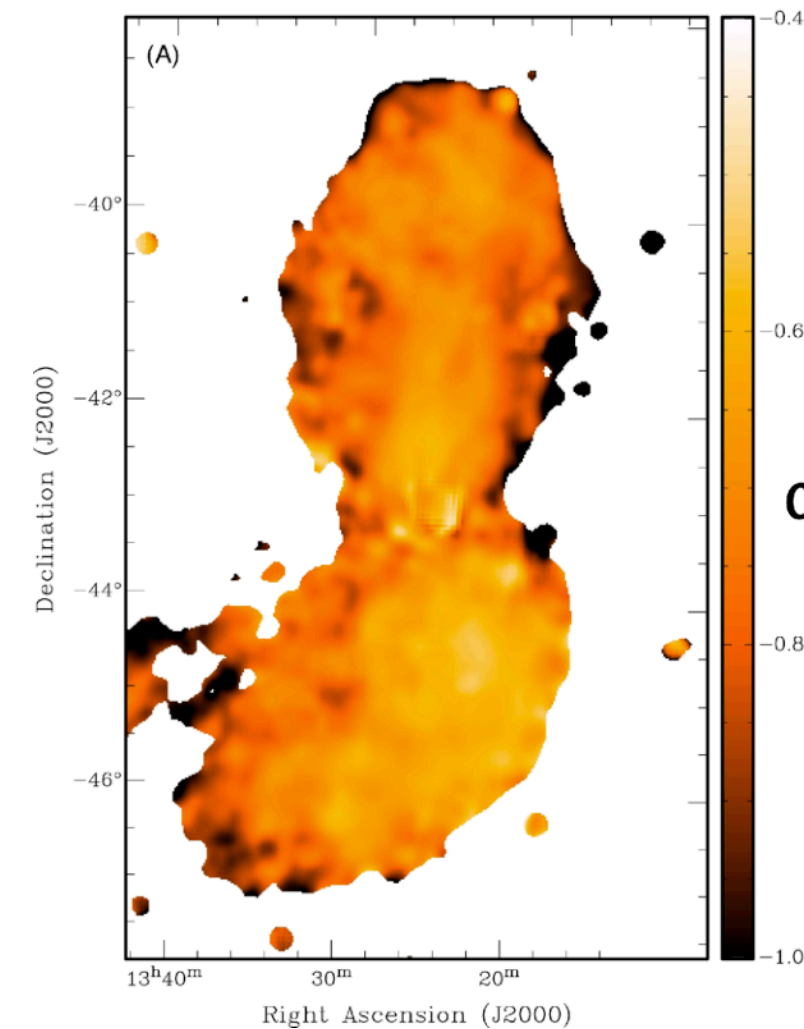
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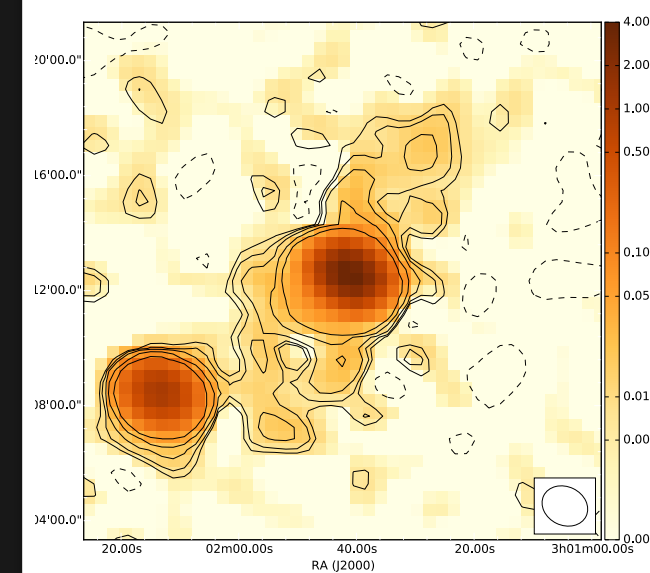
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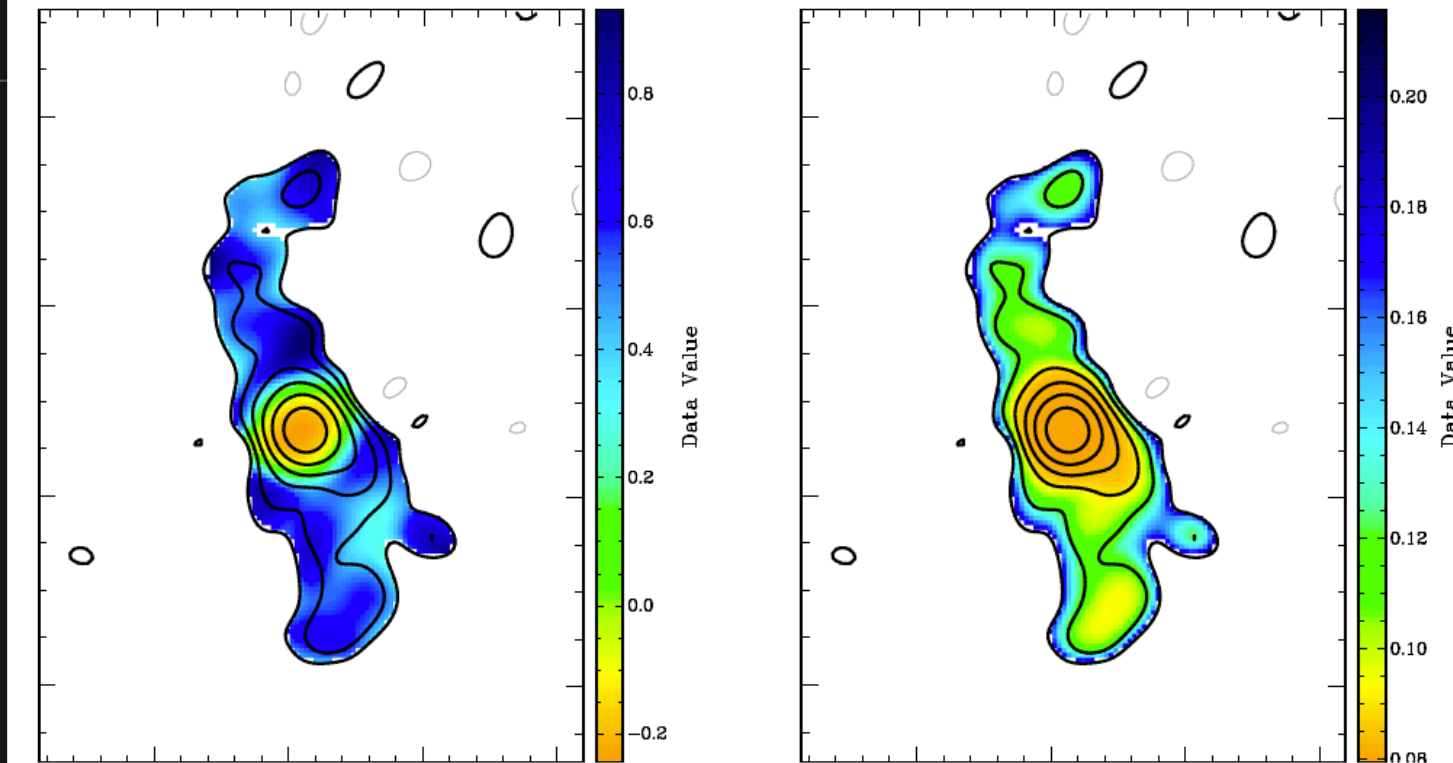
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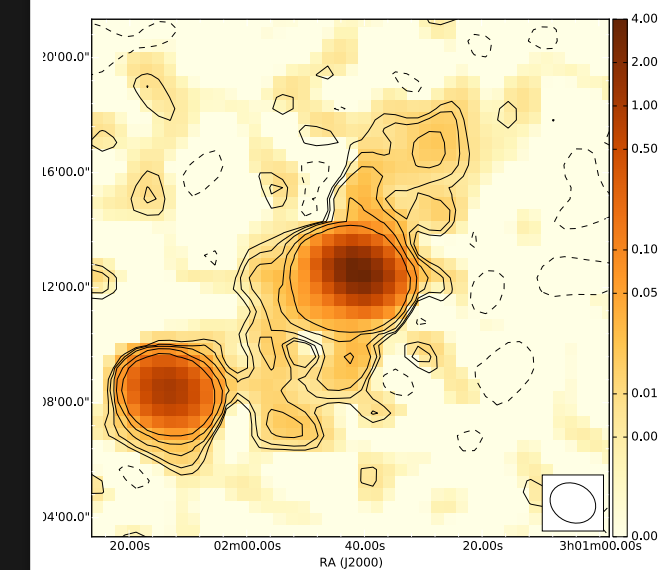
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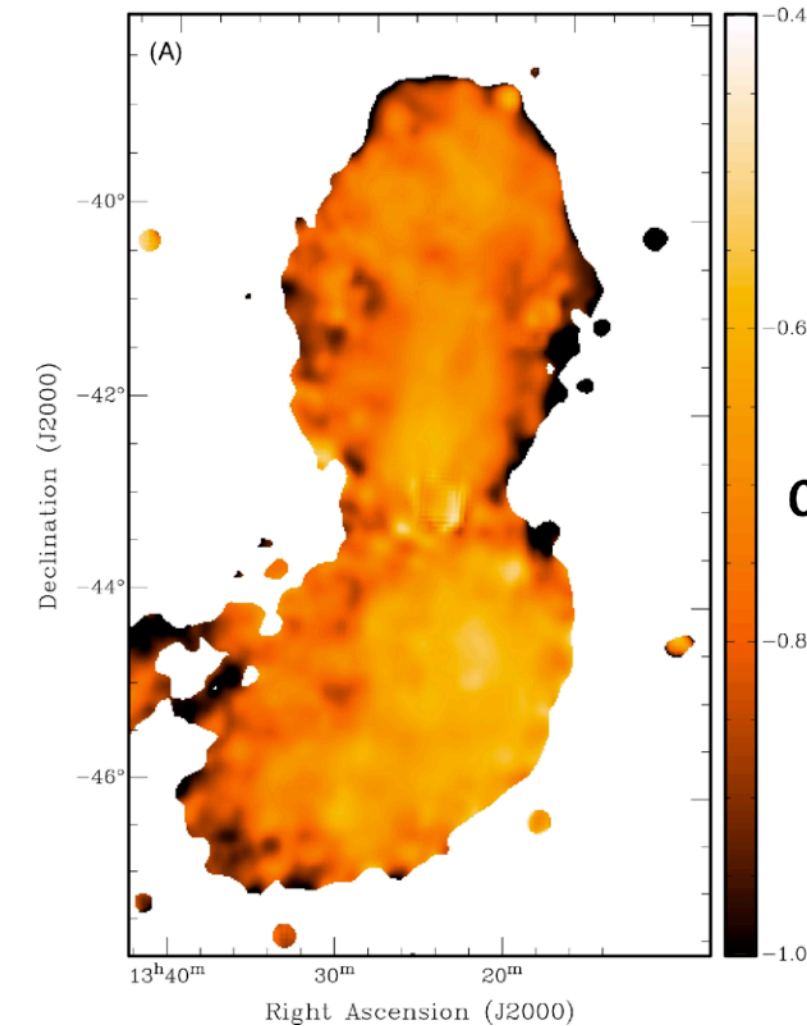
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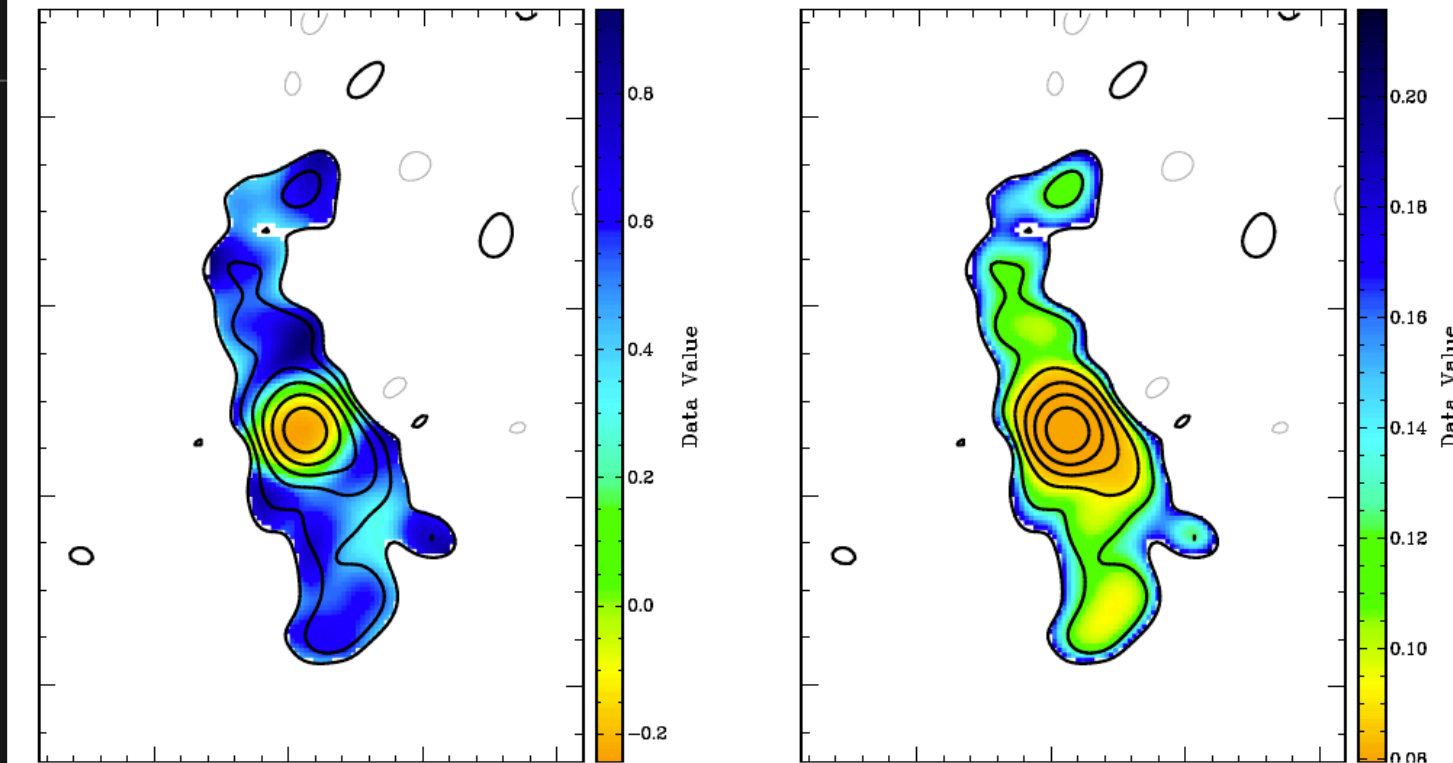


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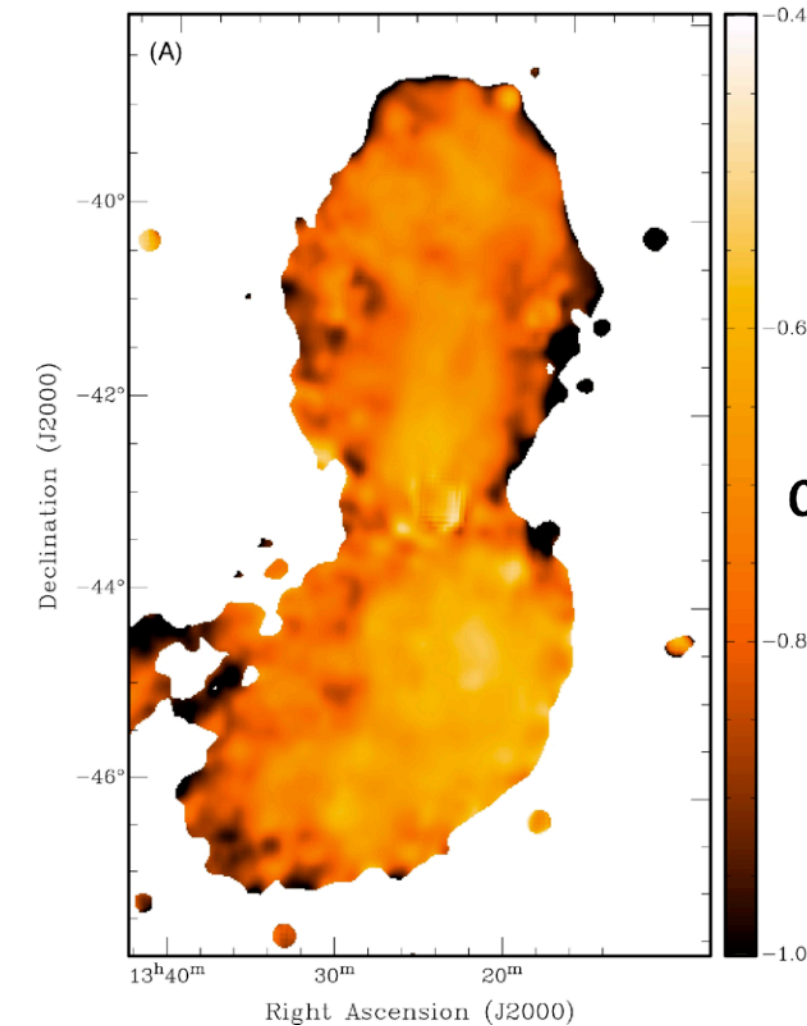
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Jurlin et al. 2020

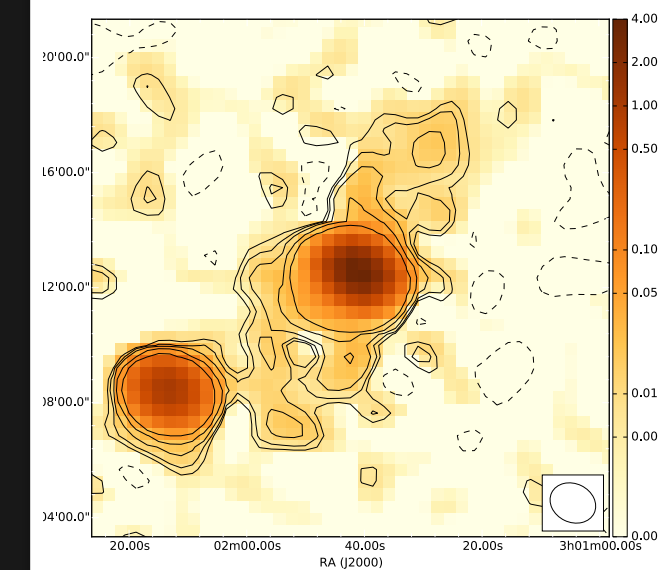
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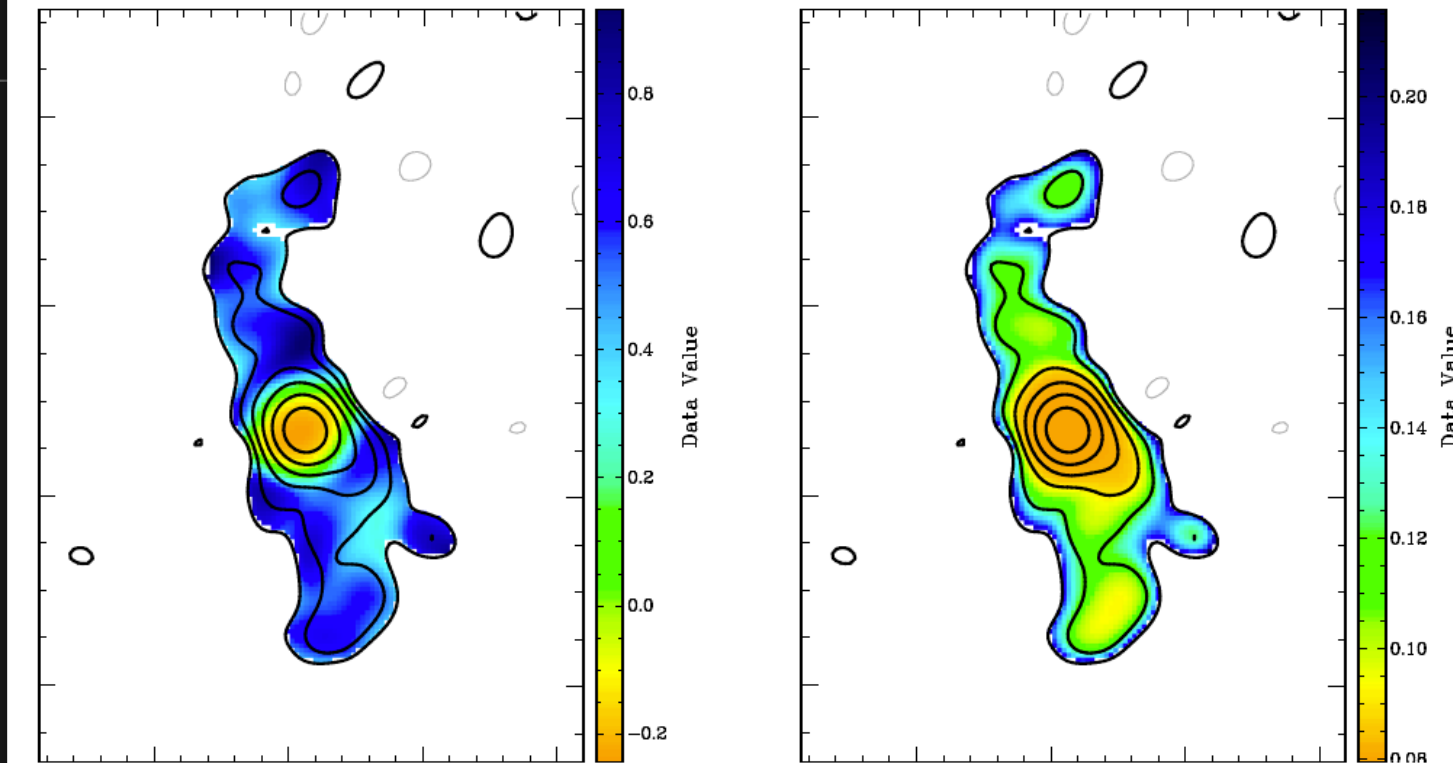
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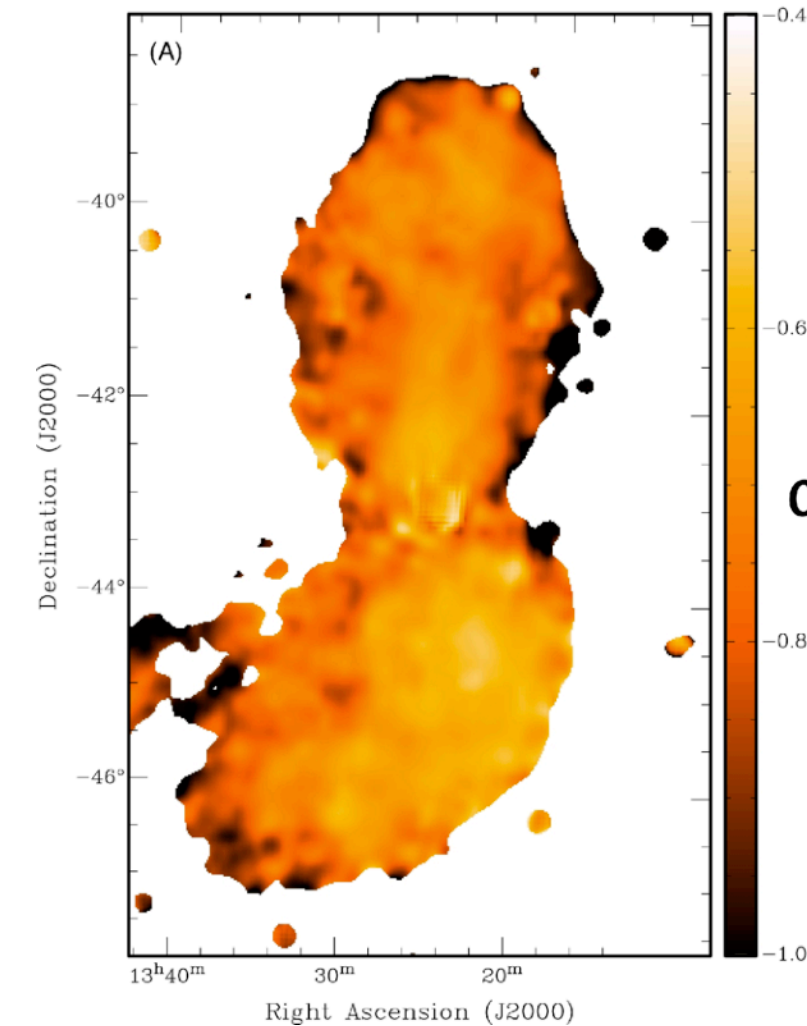
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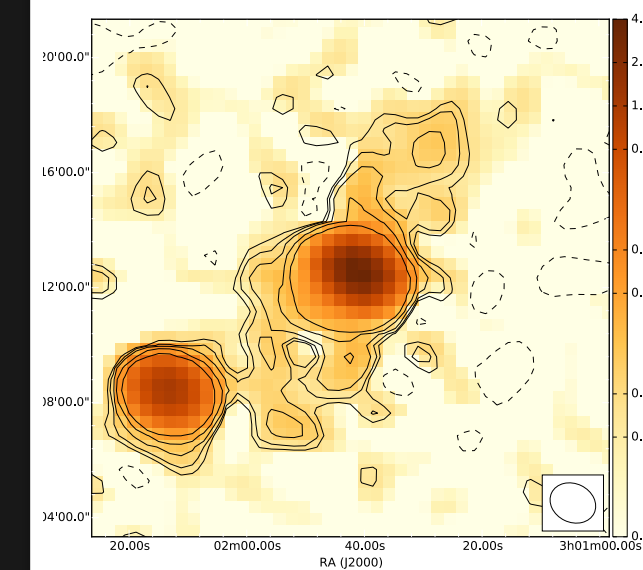
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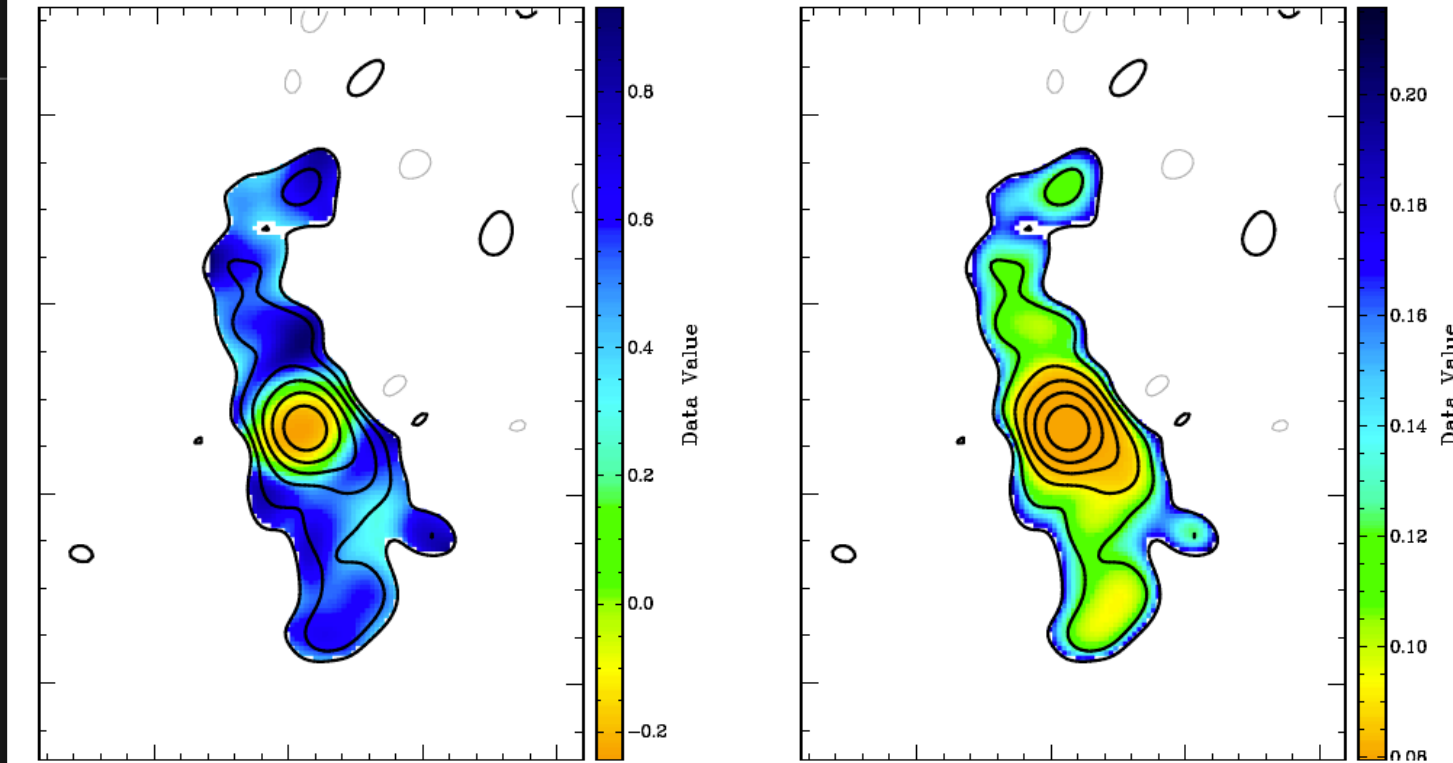
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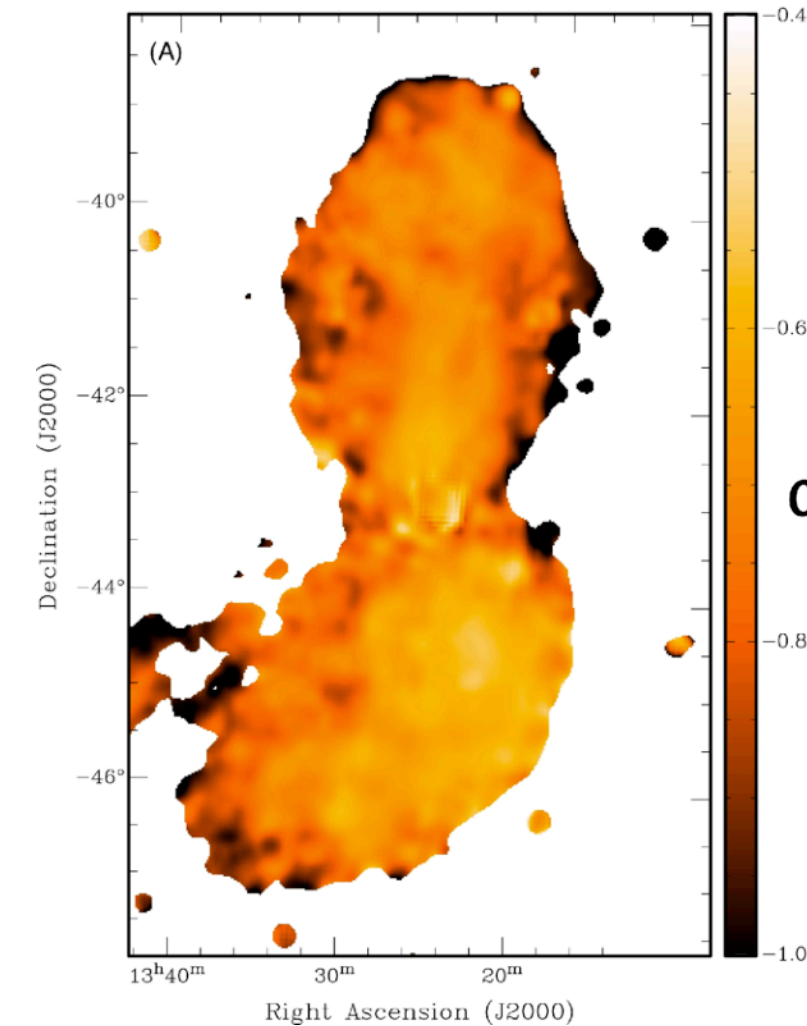
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- Spatially resolved spectral properties need to be investigated to identify more such galaxies.

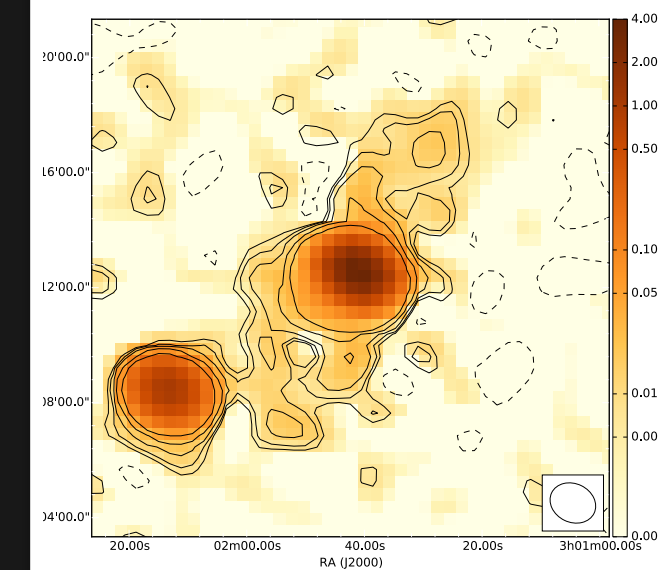
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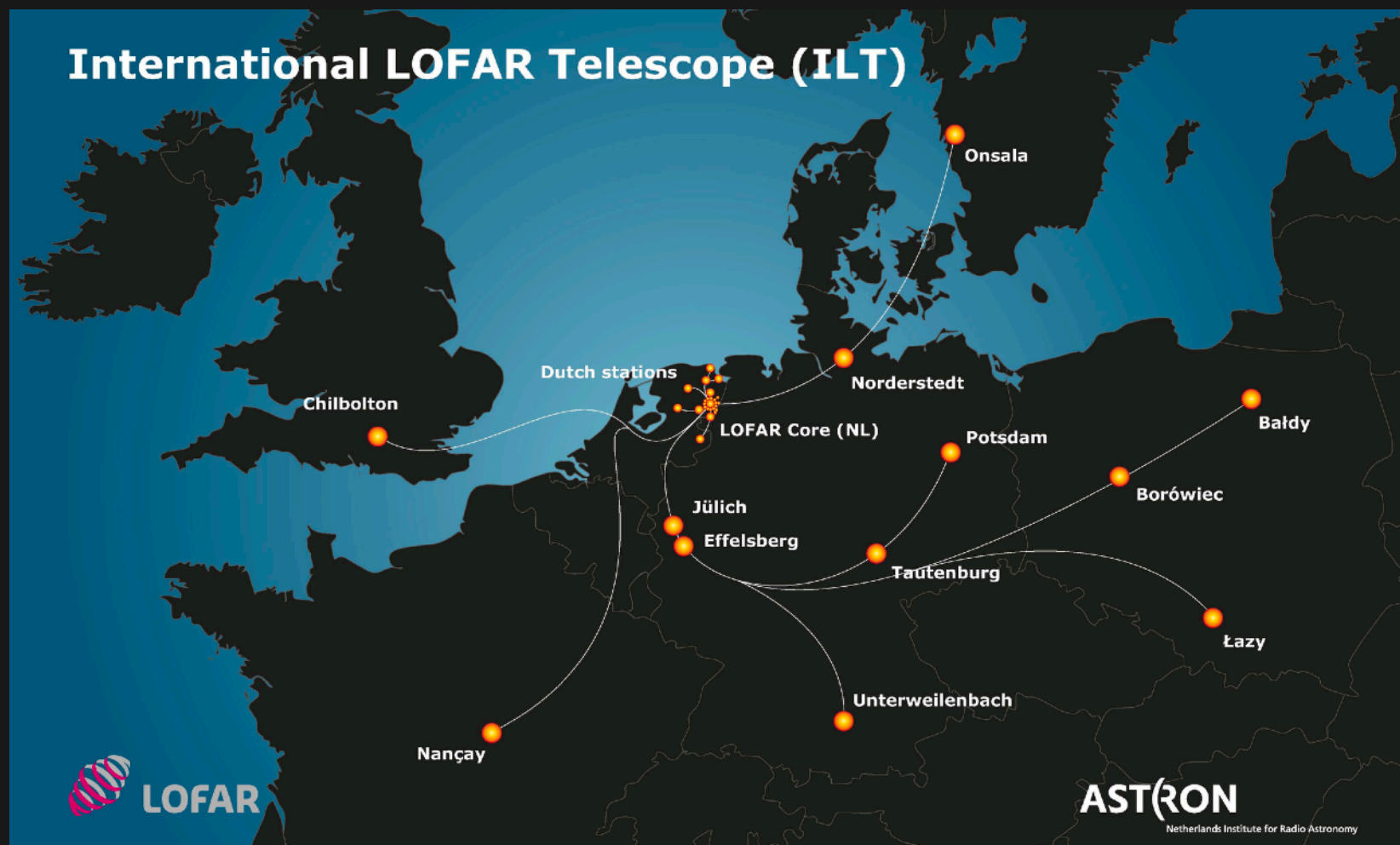
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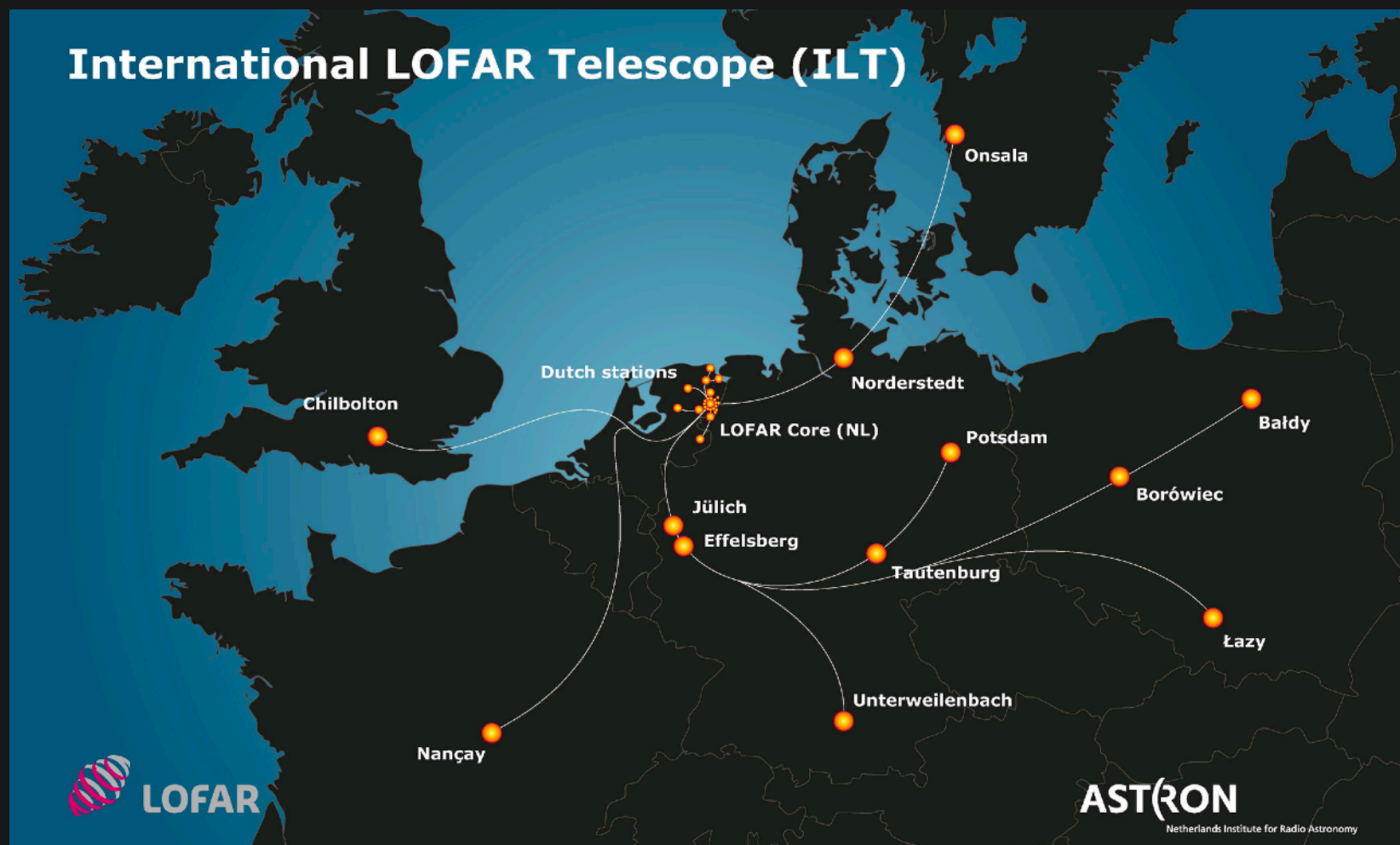
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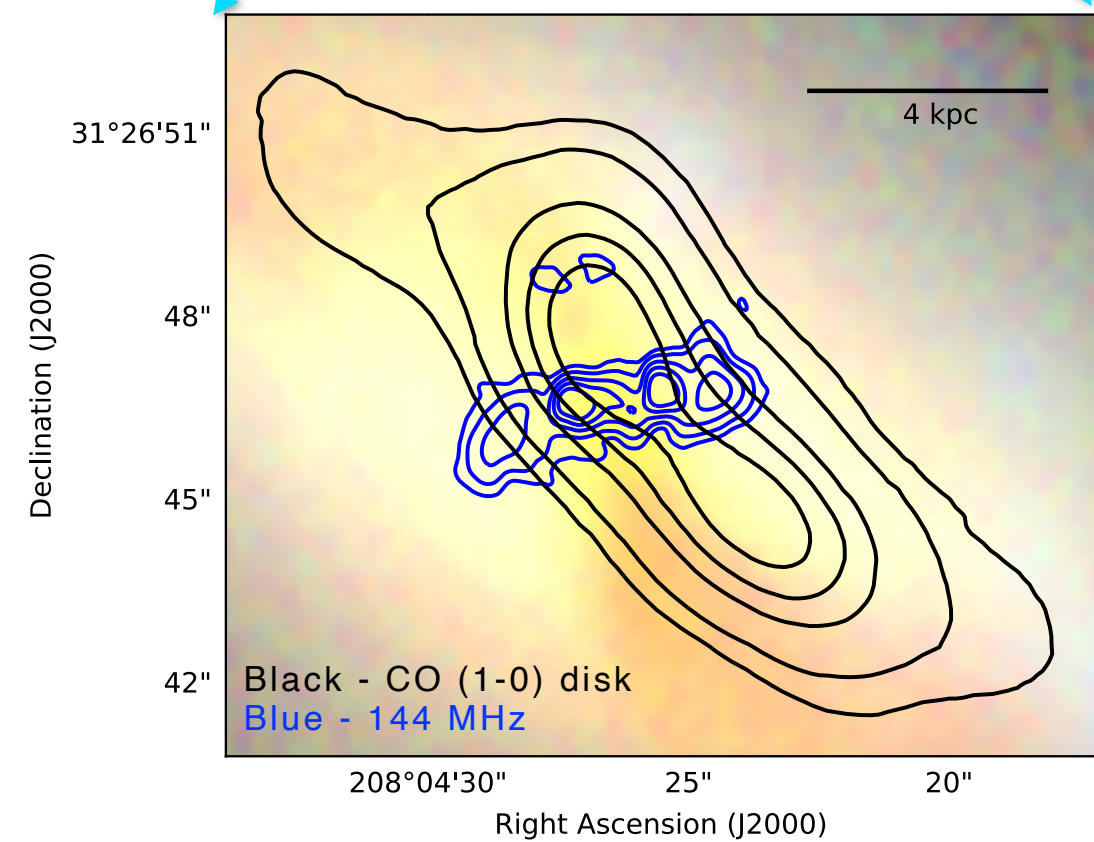
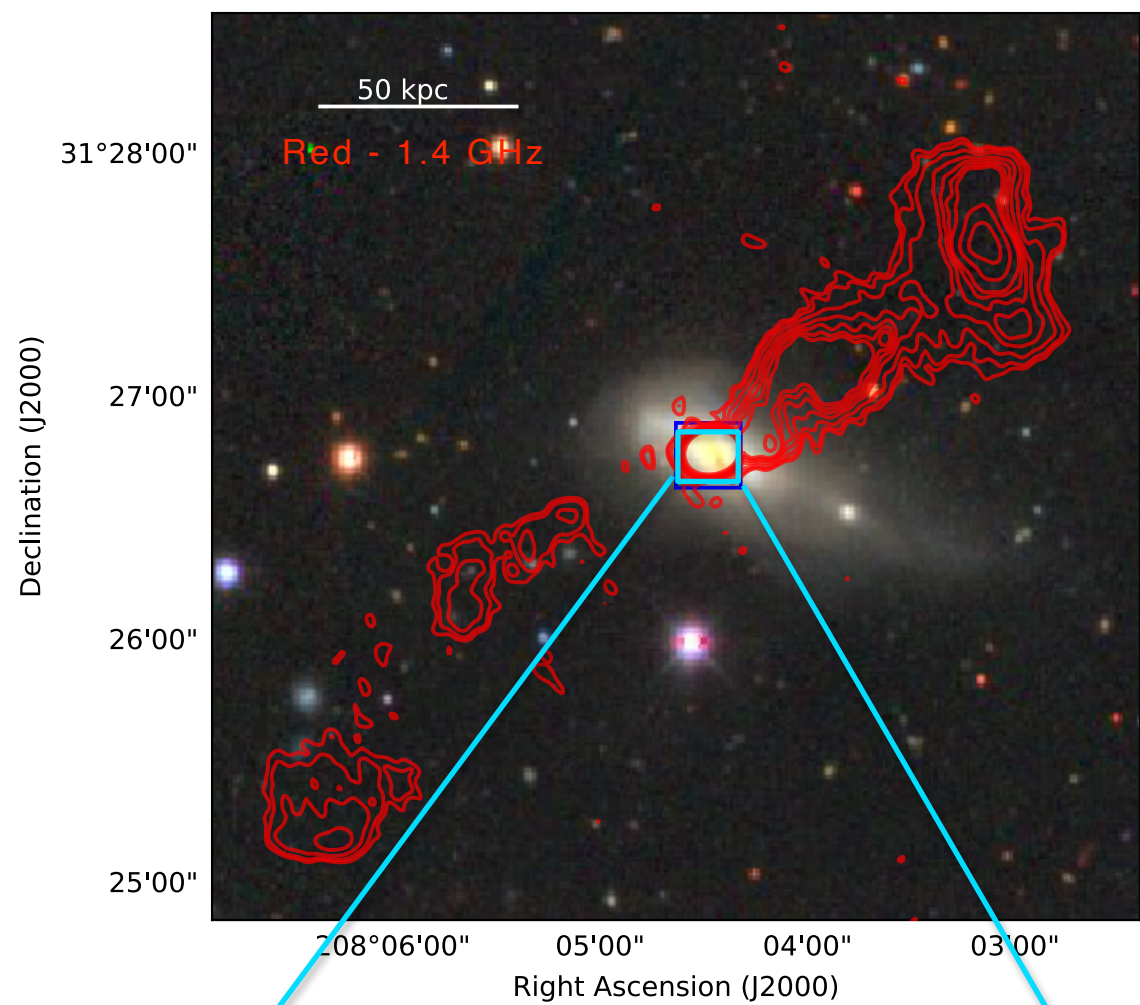


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- 13 international stations - max baseline 1989 km - 0.27" at 150 MHz.



3C293

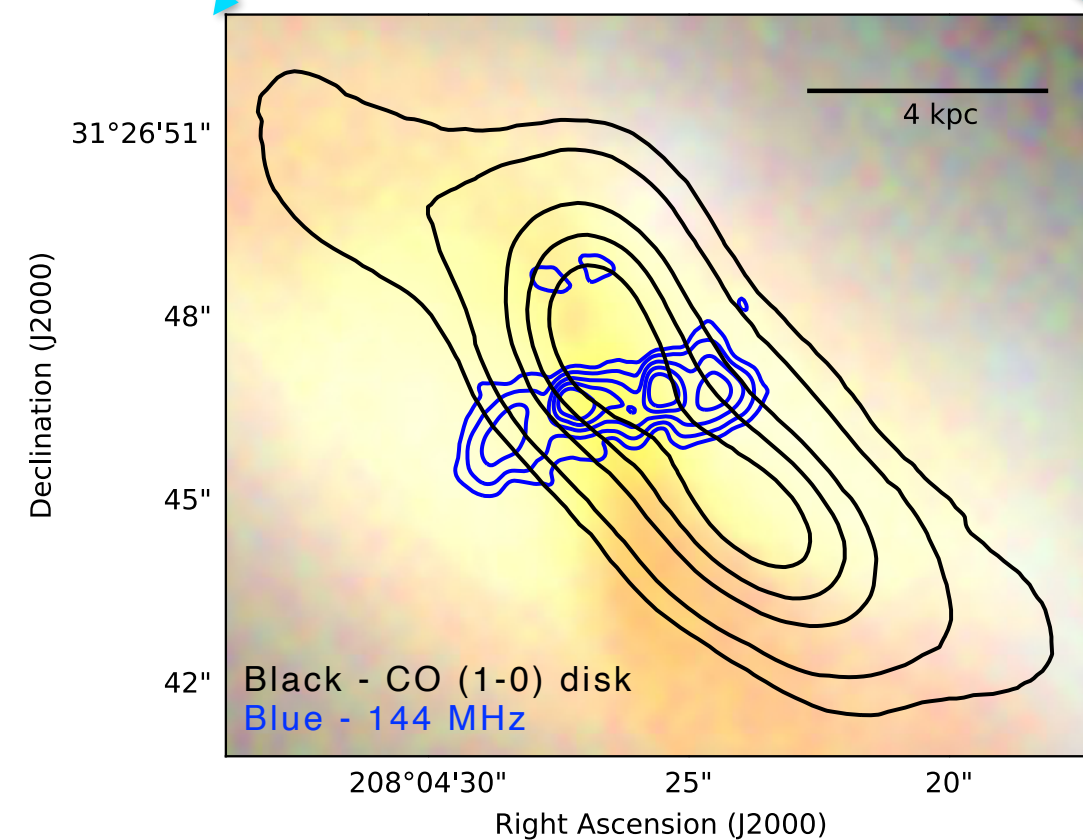
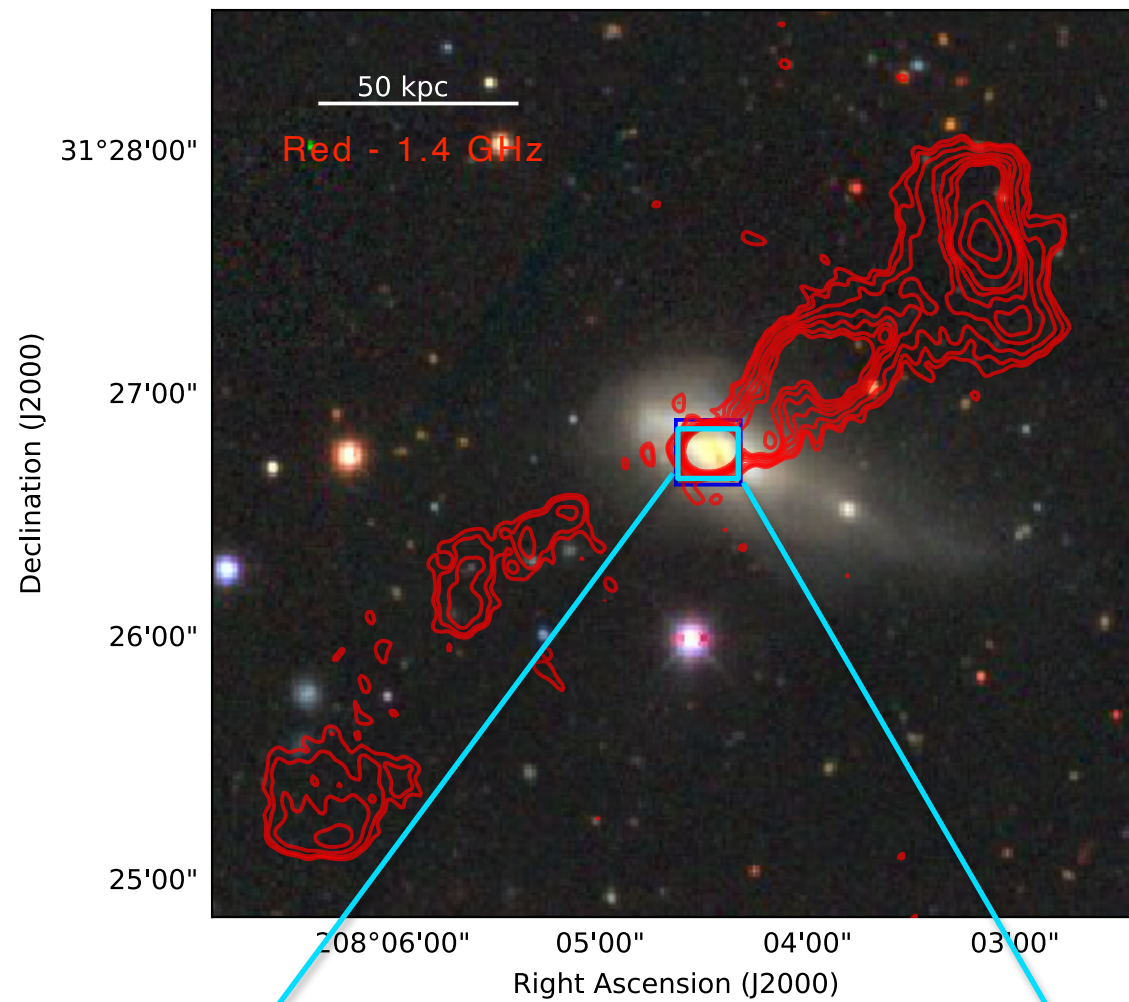


RGB colour image from DECaLS (Dey et al. 2019)

CO (1-0) image from Labiano et al. 2014

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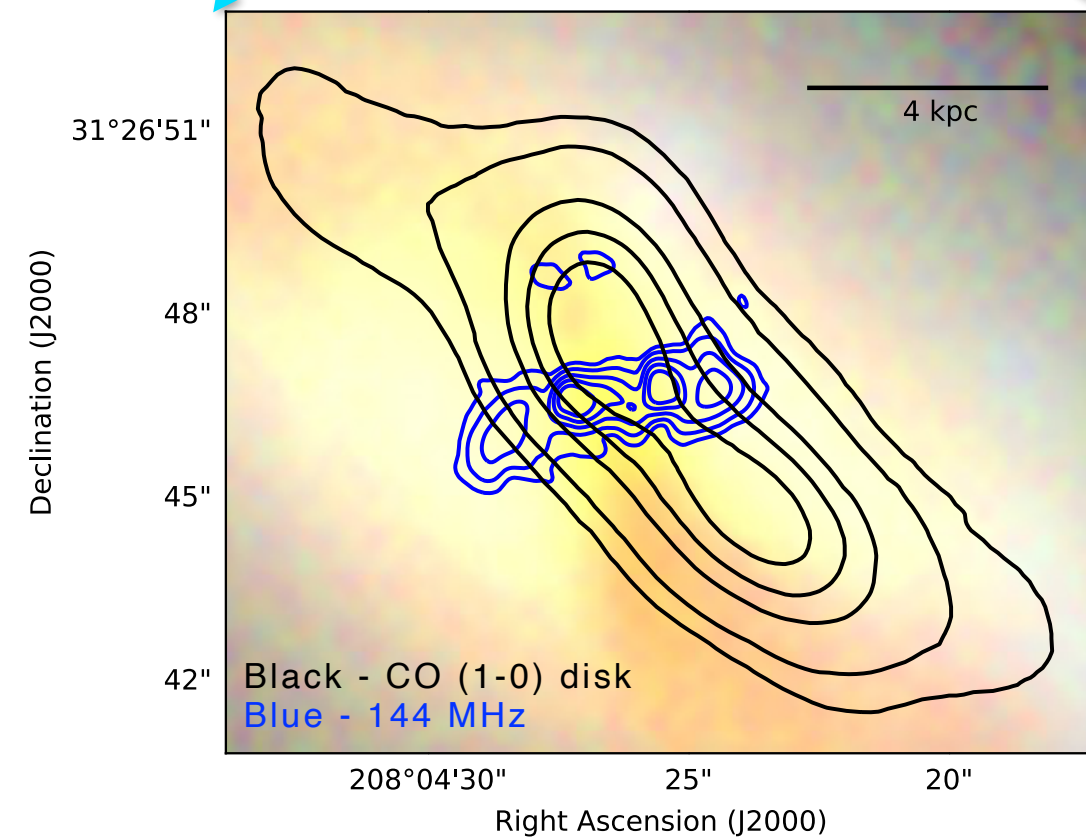
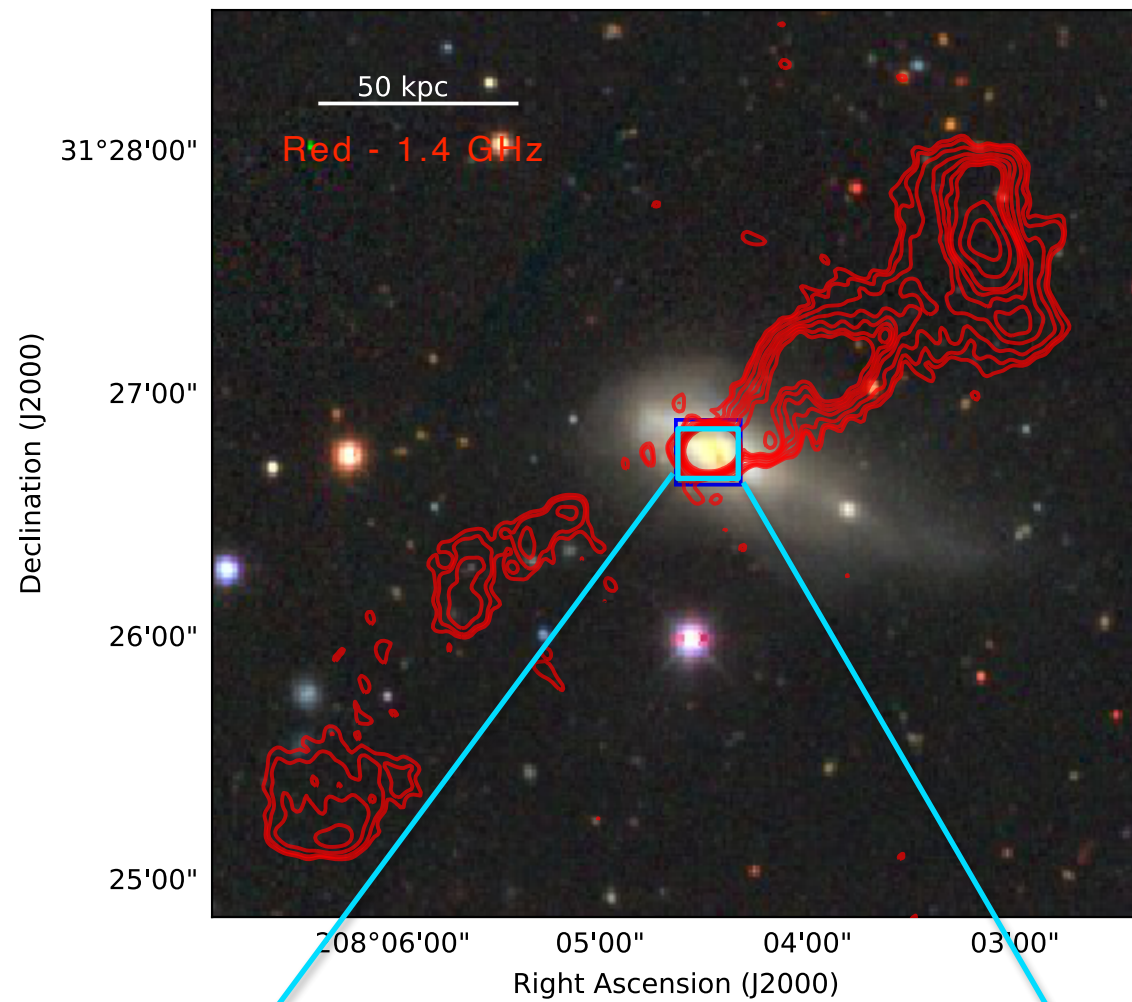


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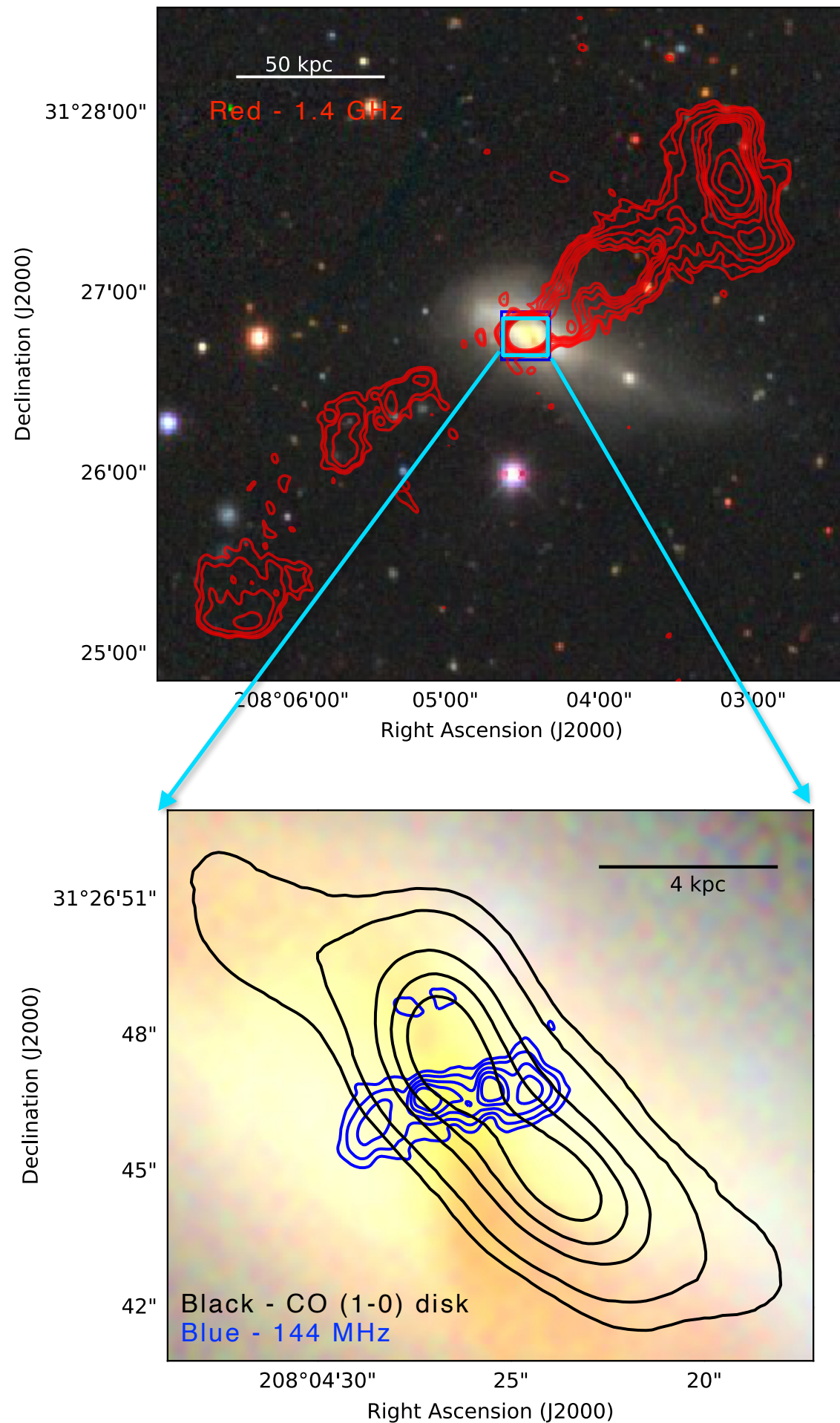


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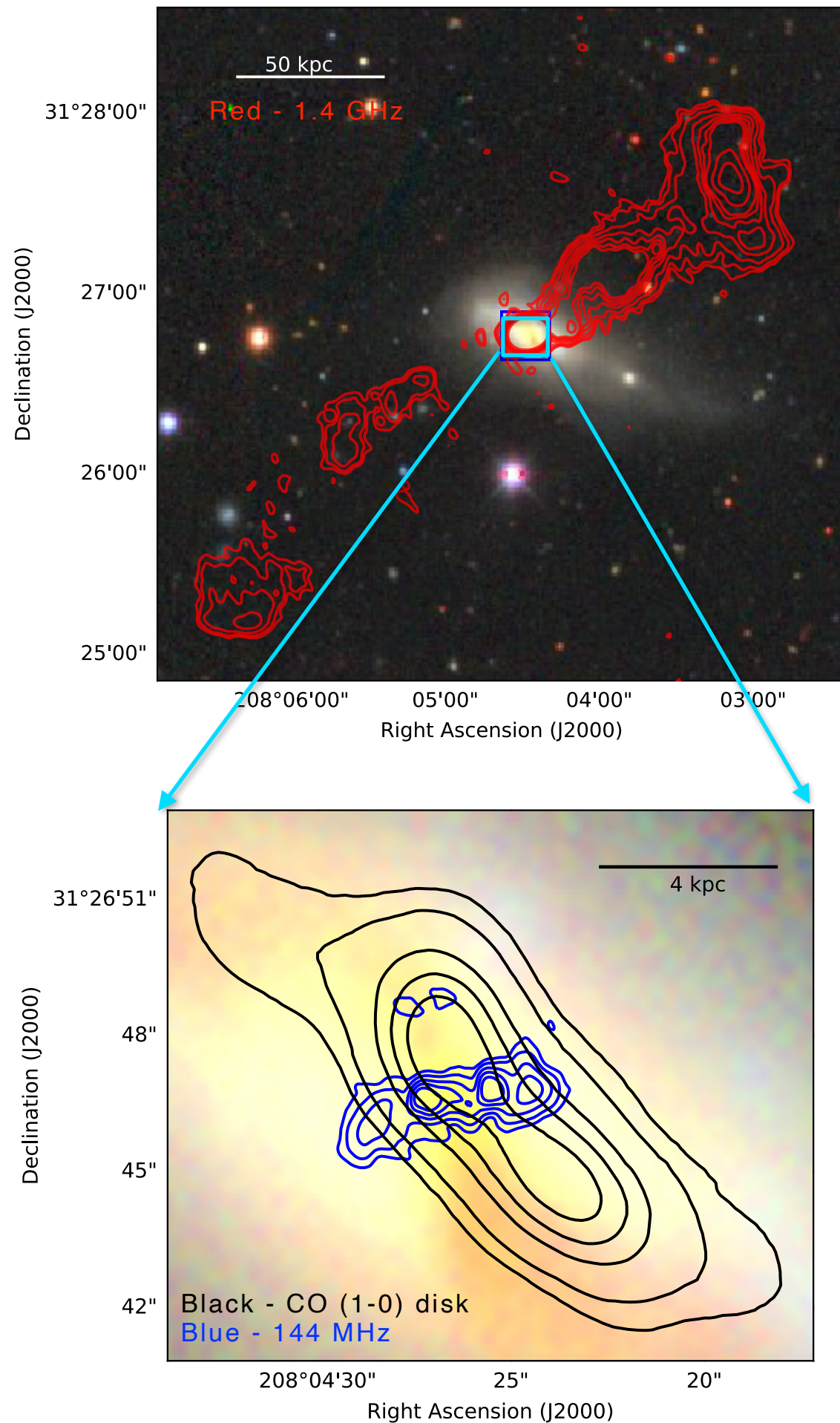


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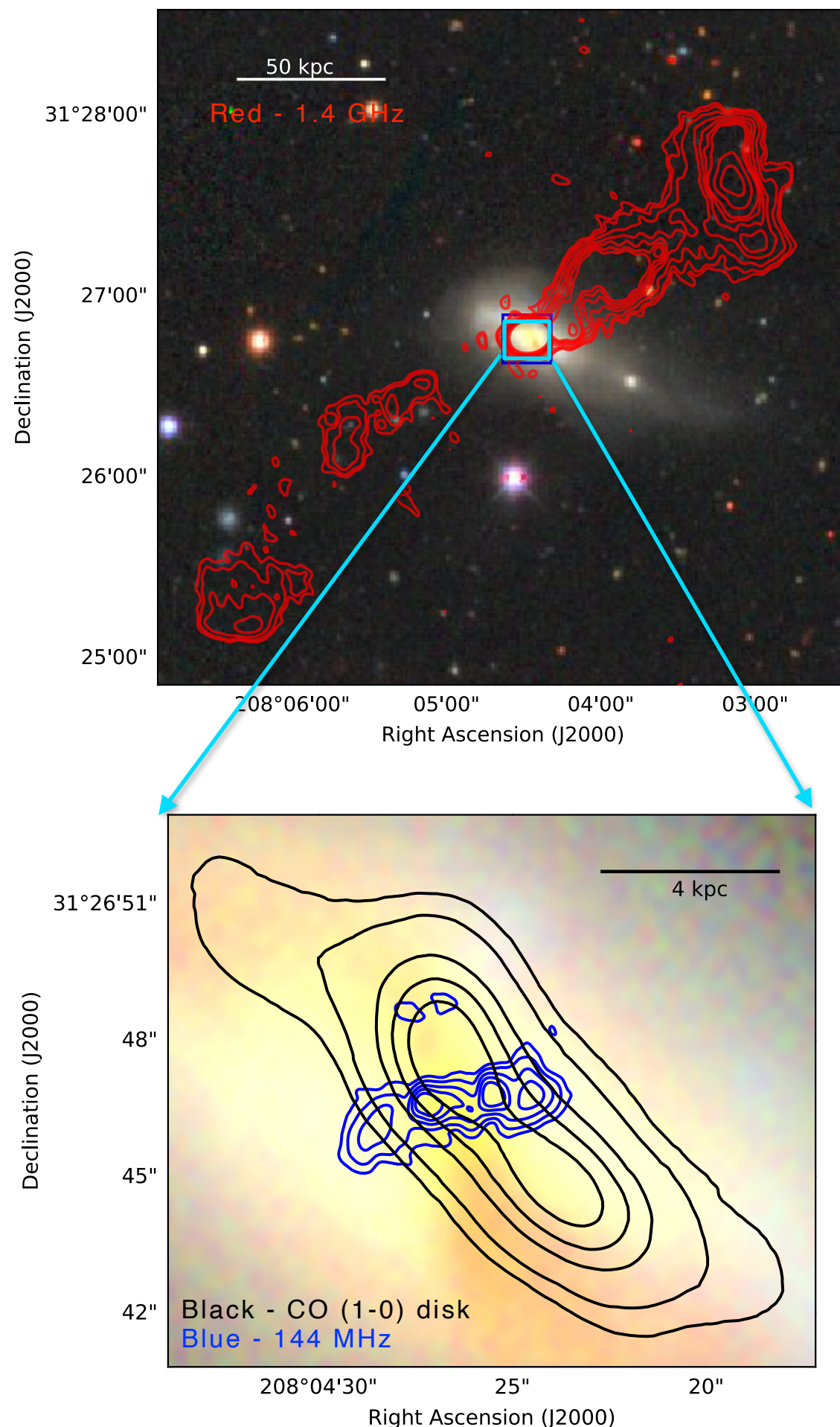
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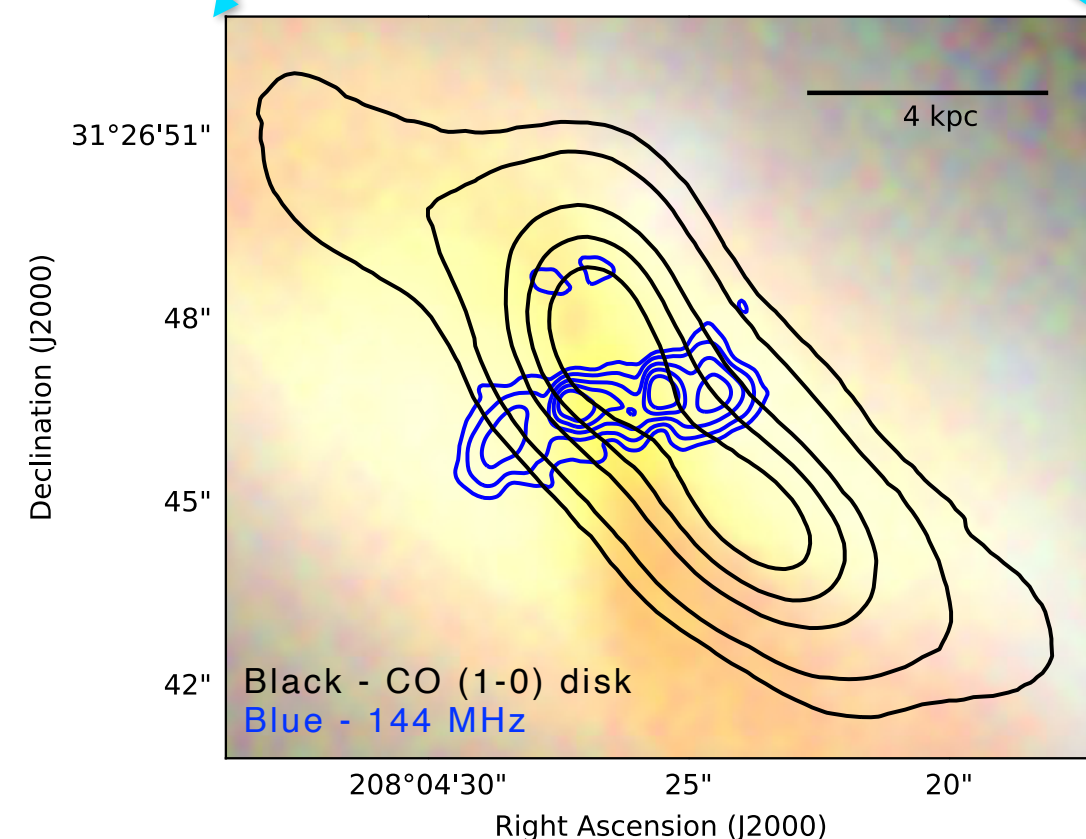
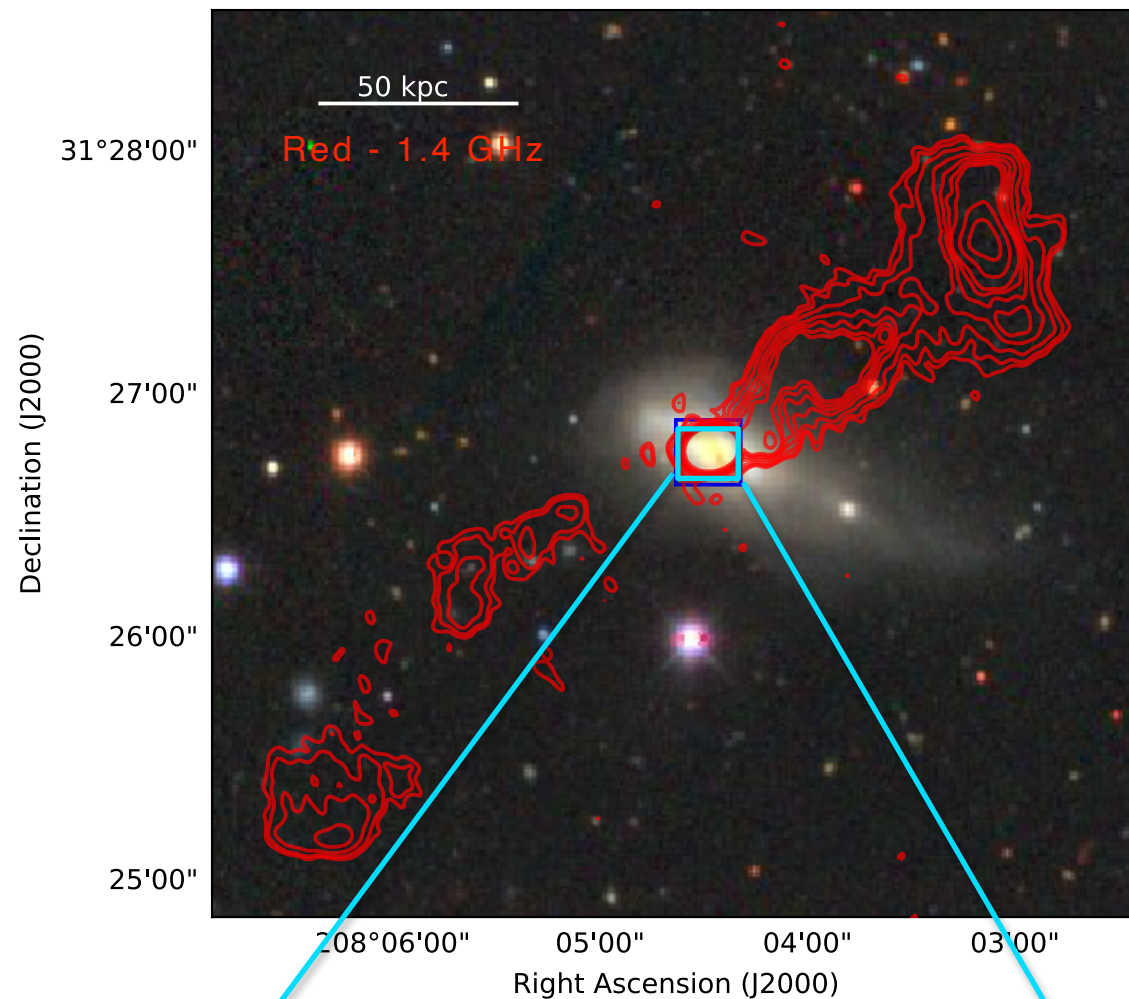
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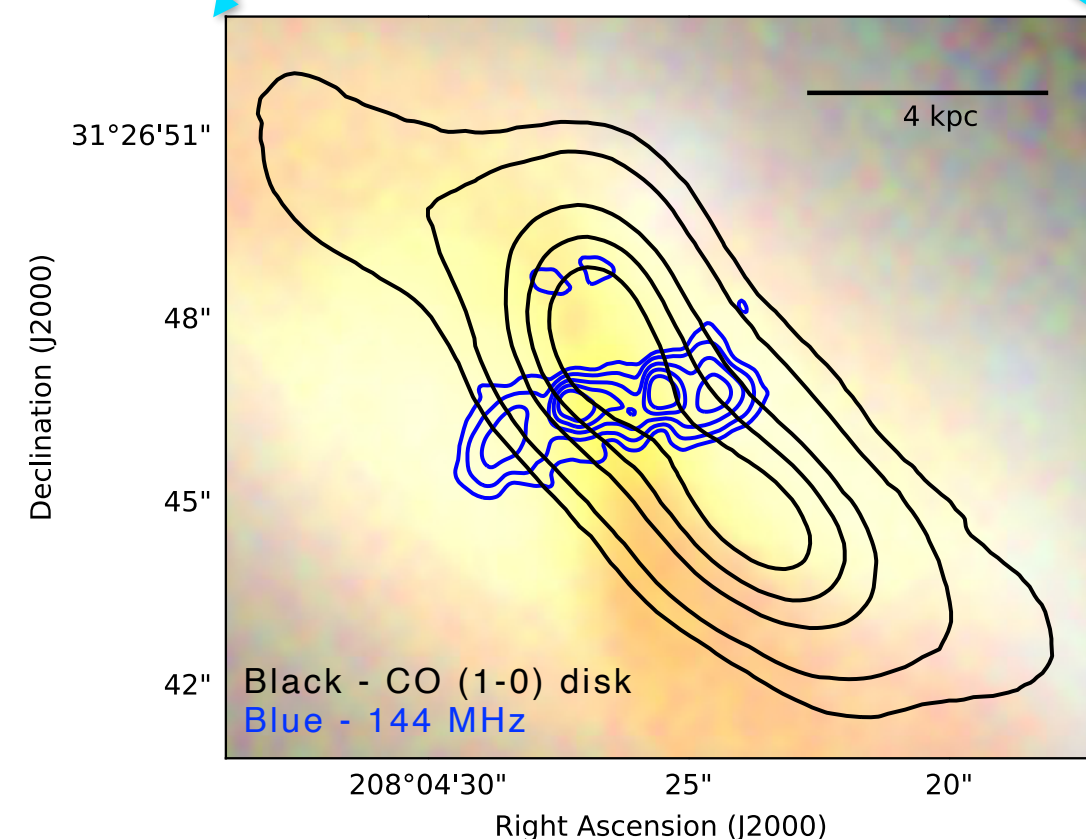
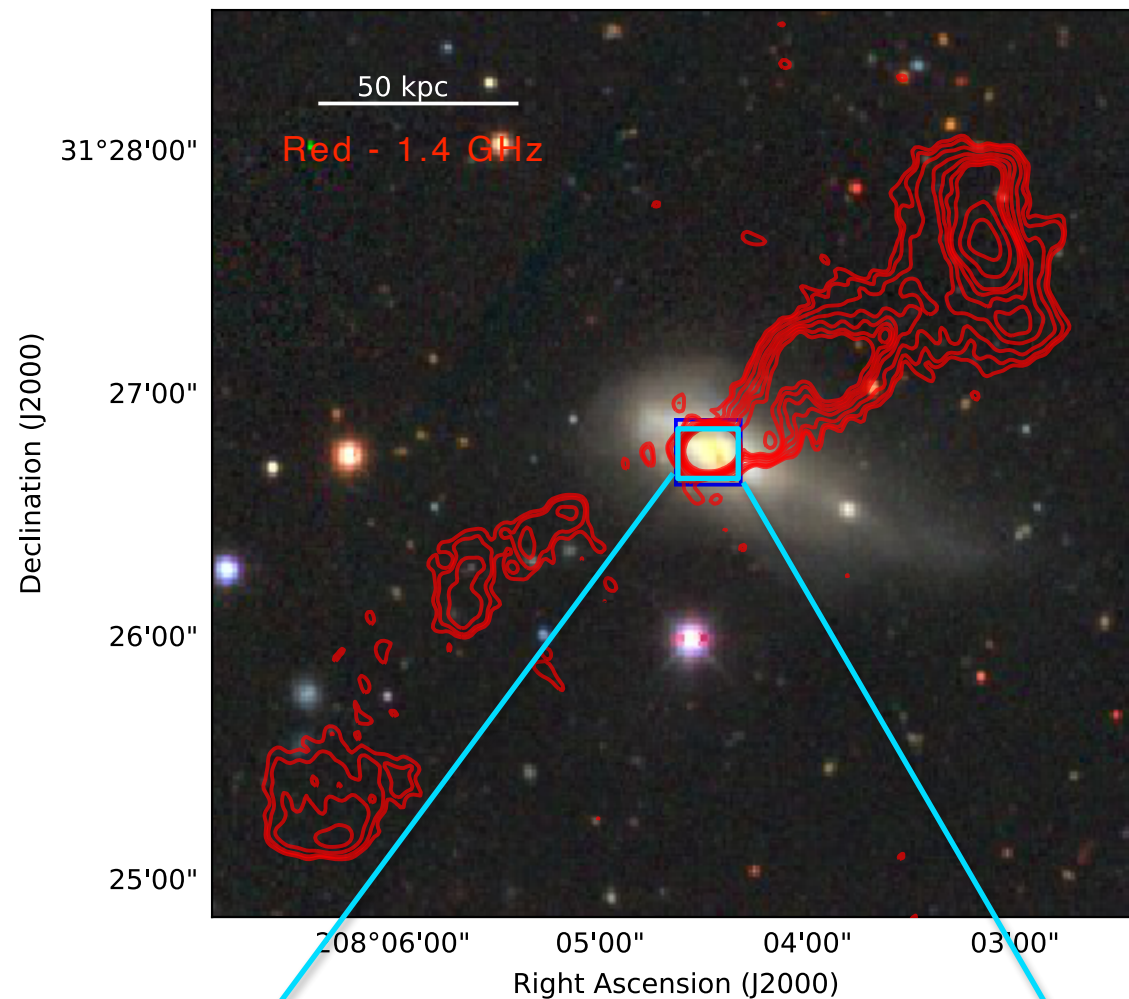
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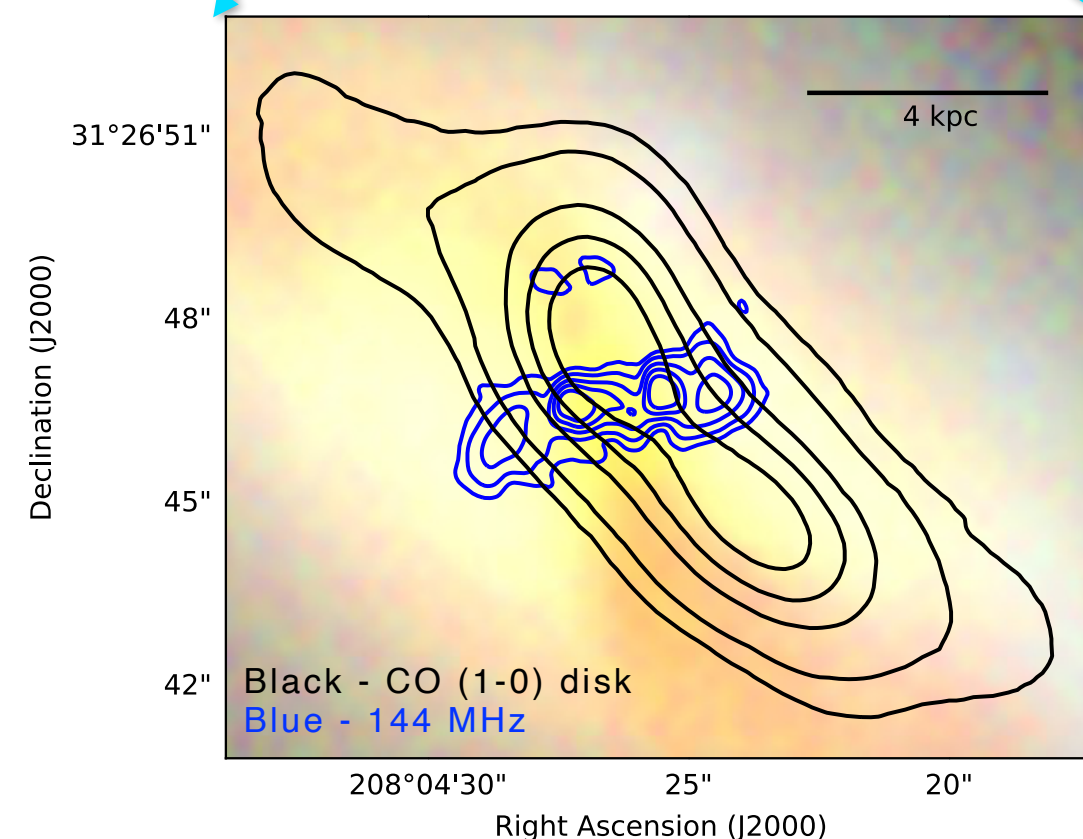
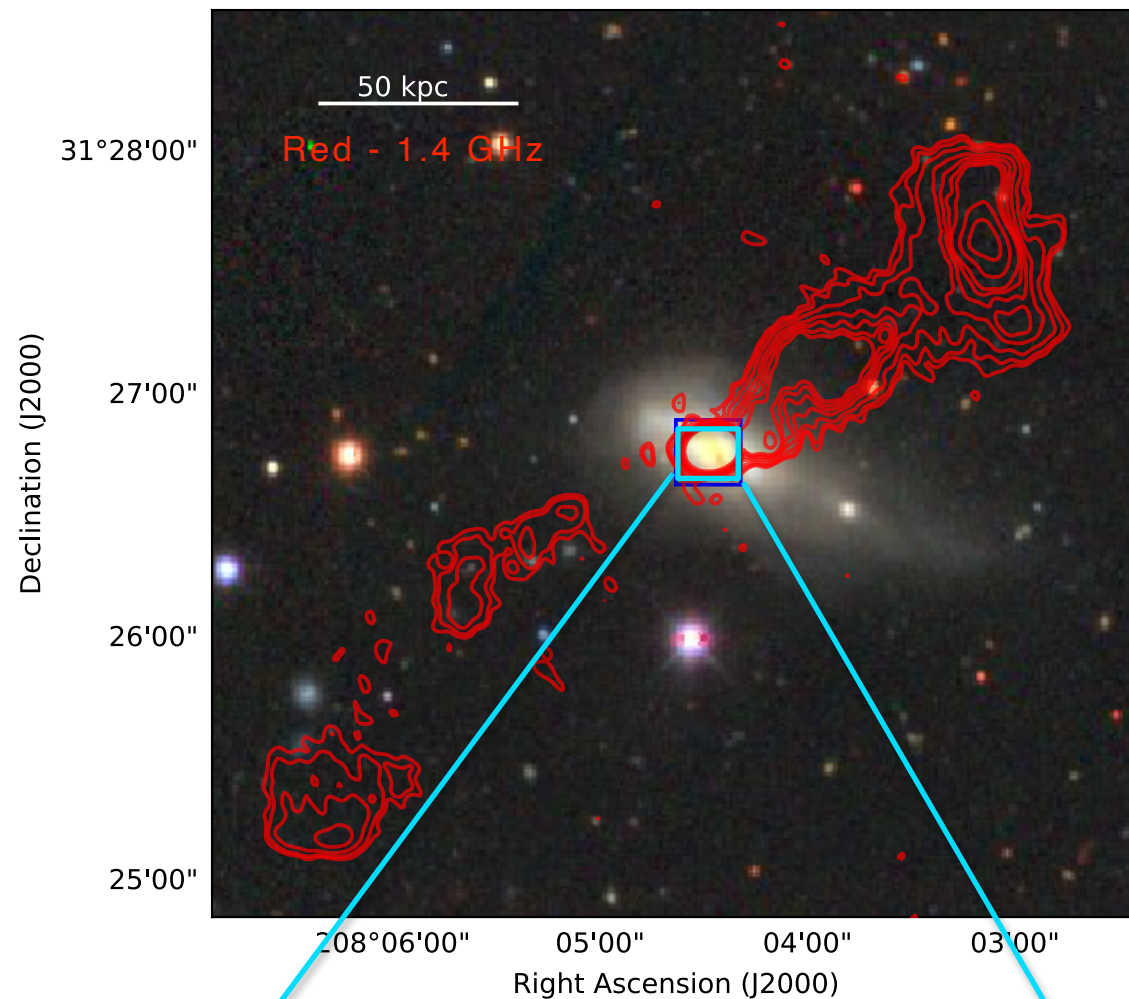
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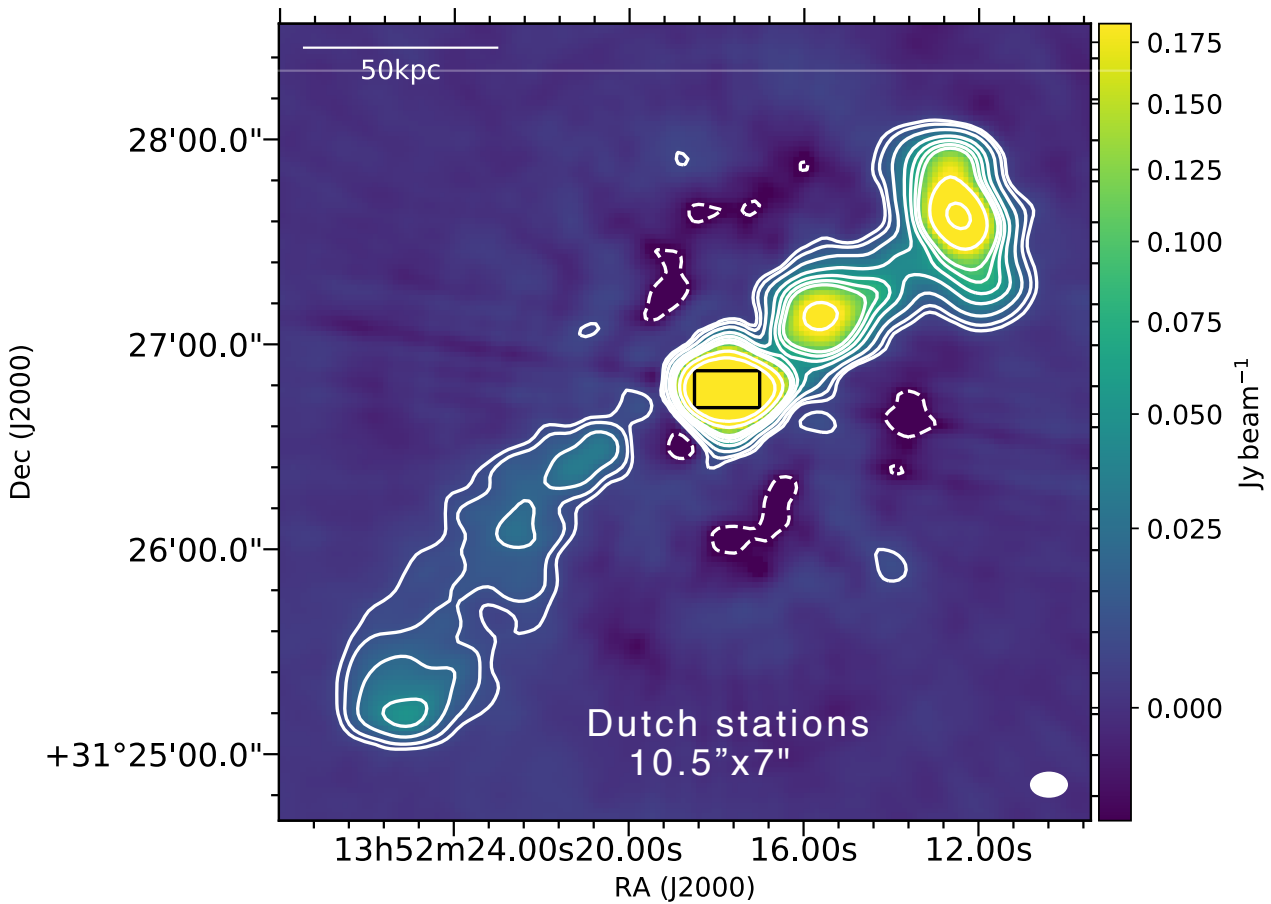
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Spatially resolved spectral study required! (for spectral properties with distance from centre)

LOFAR observations

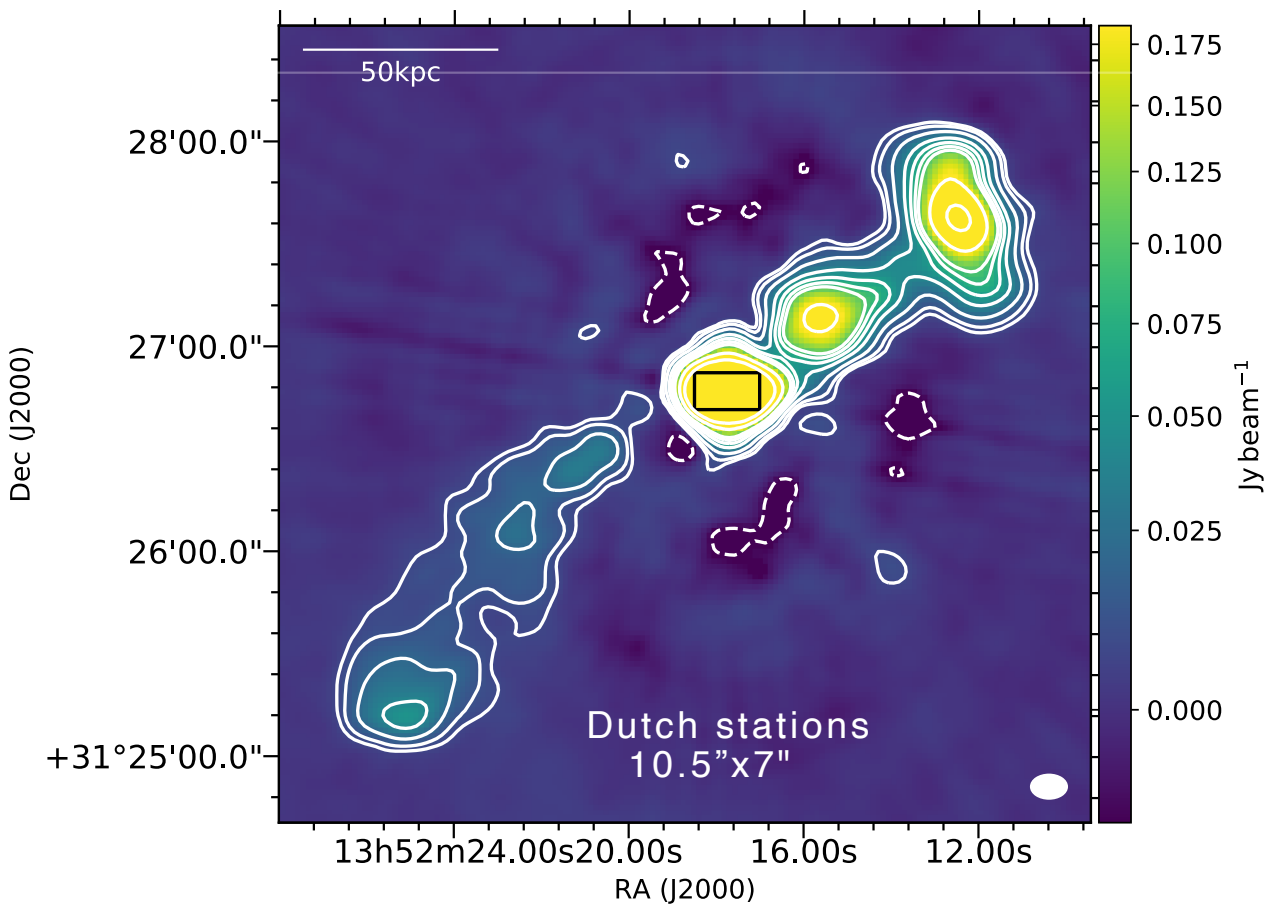
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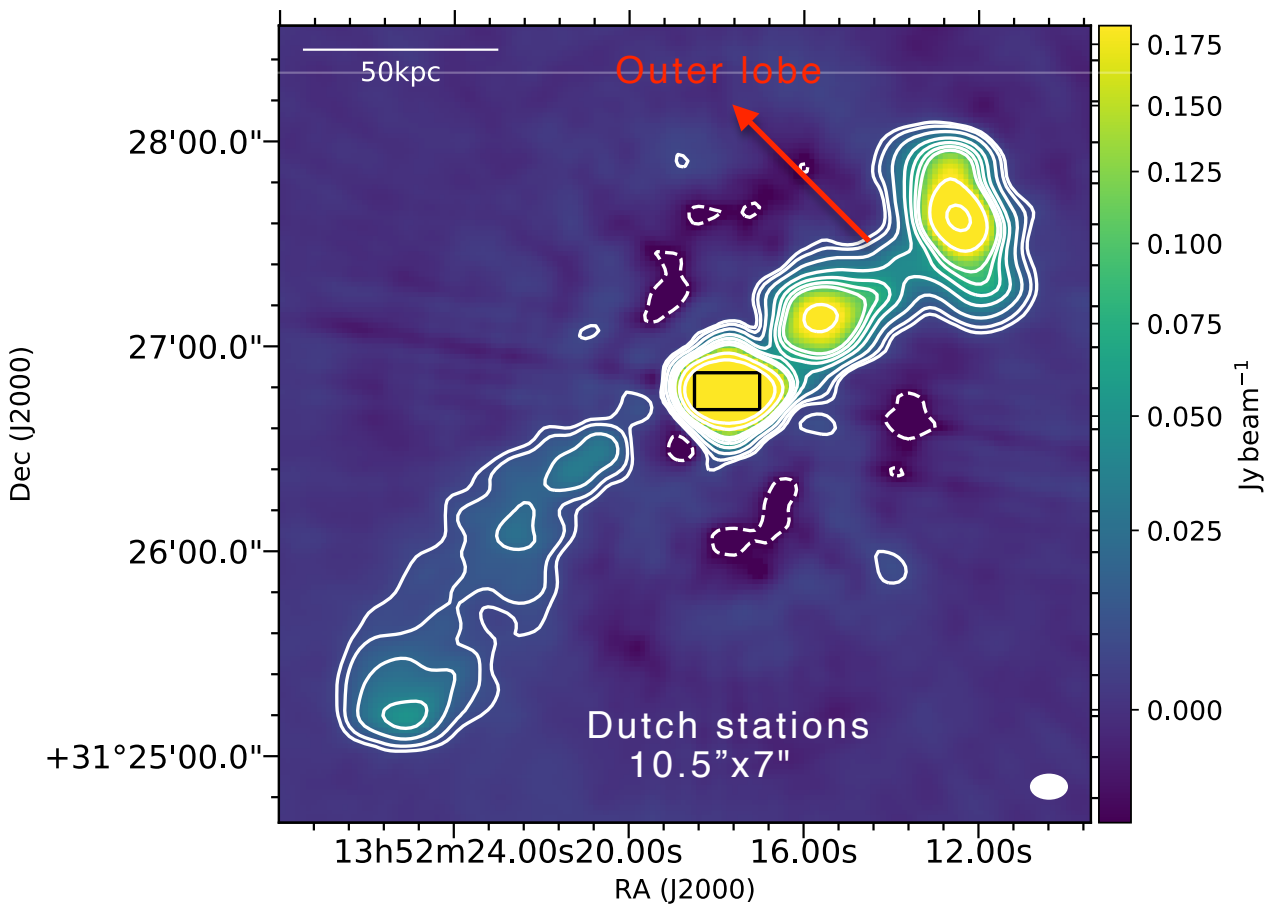
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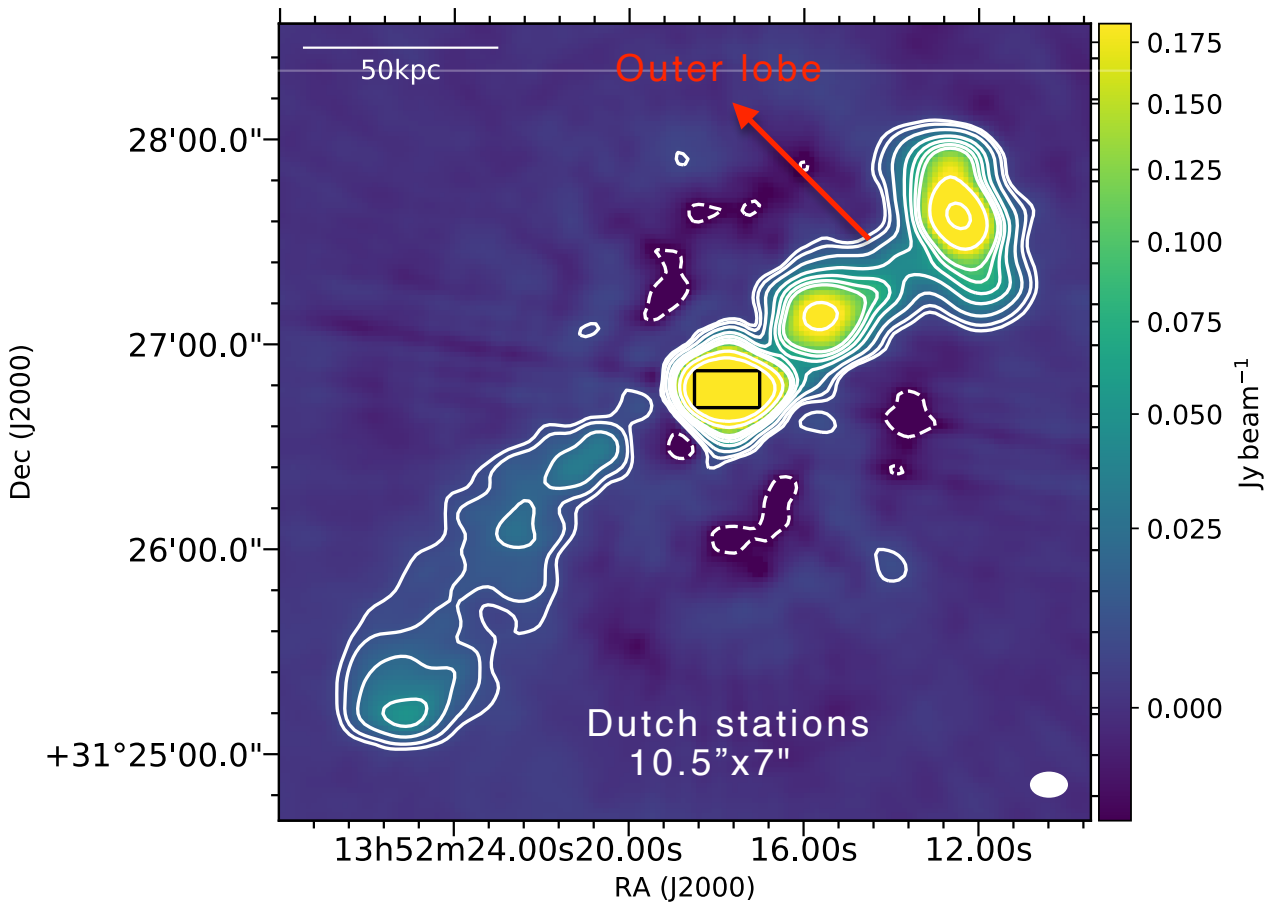
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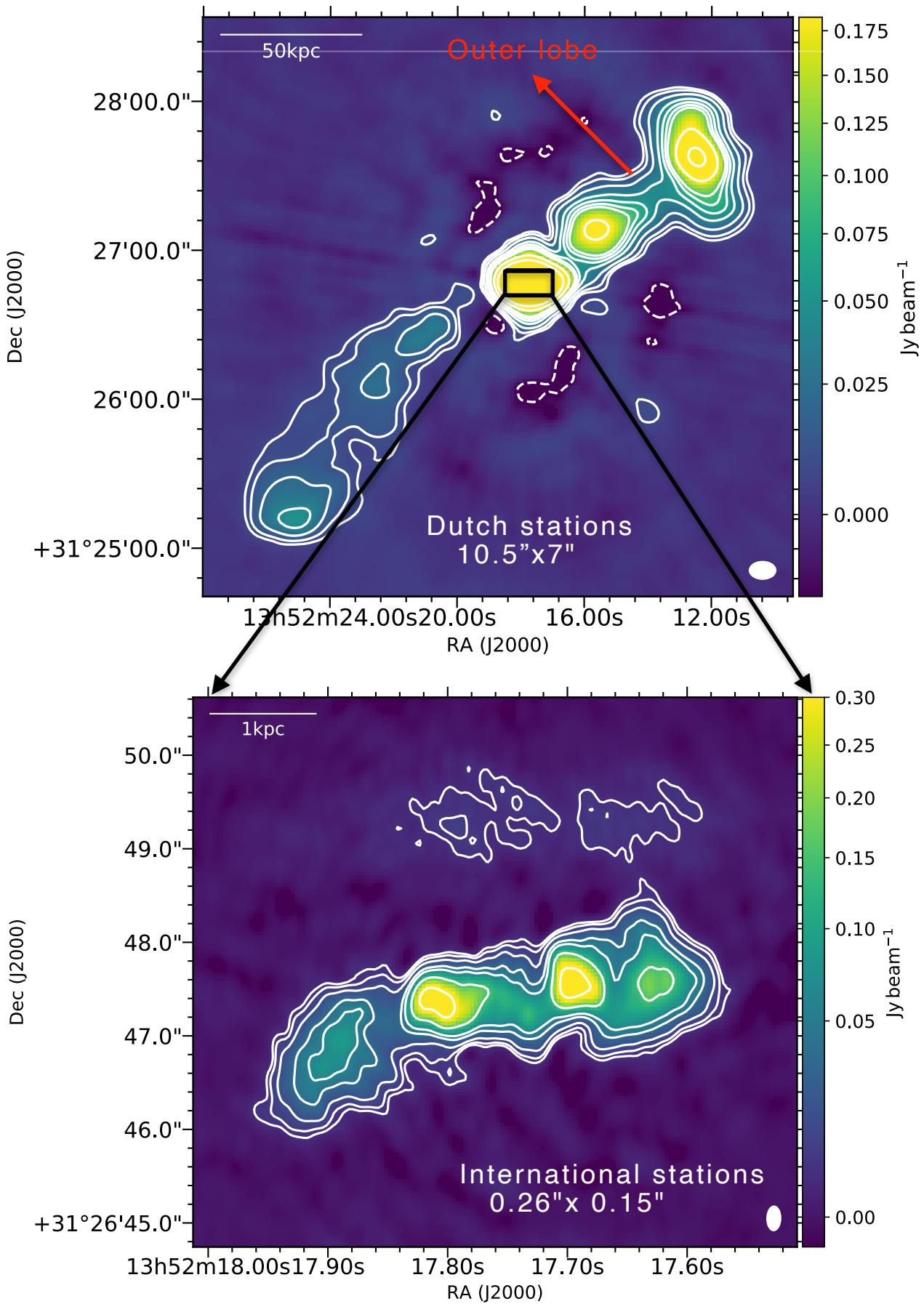
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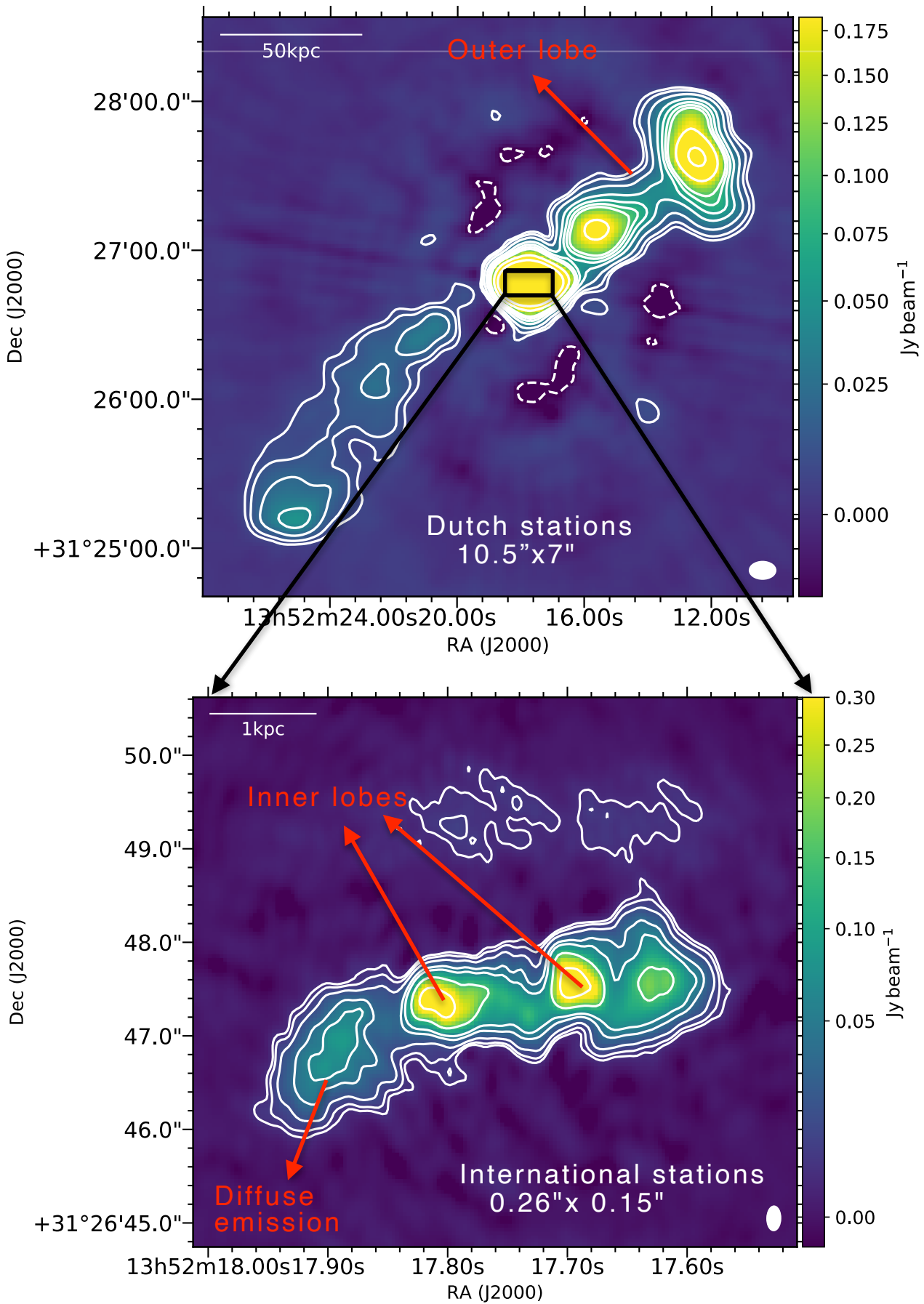
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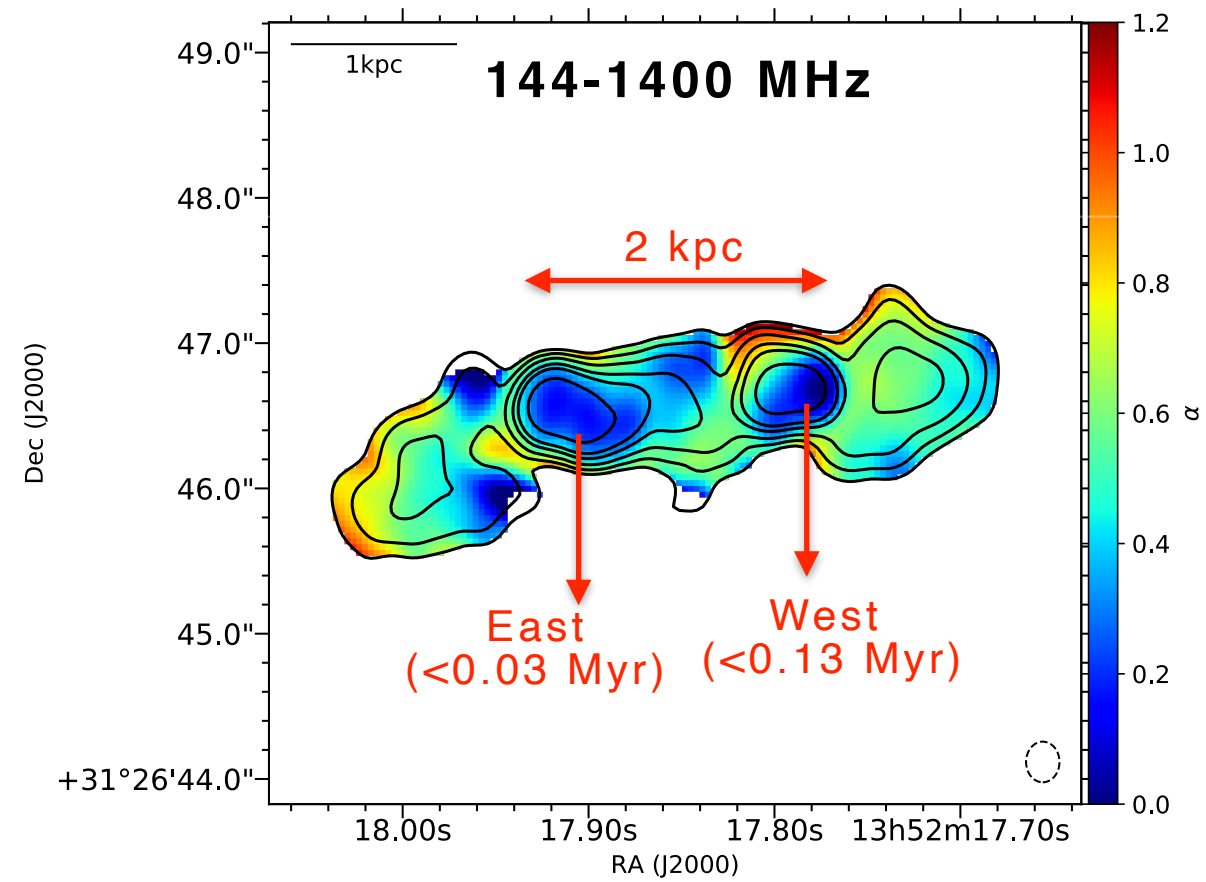
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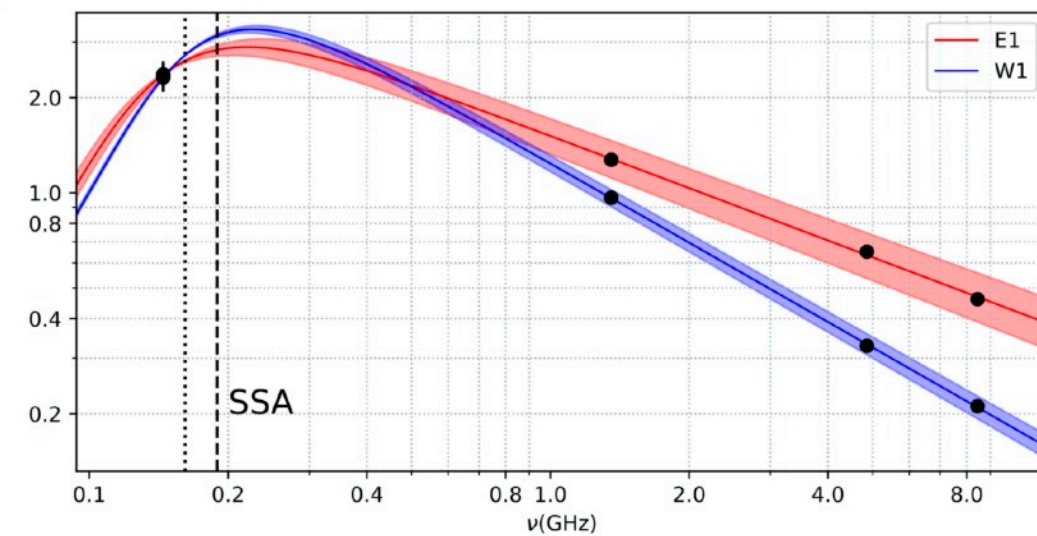
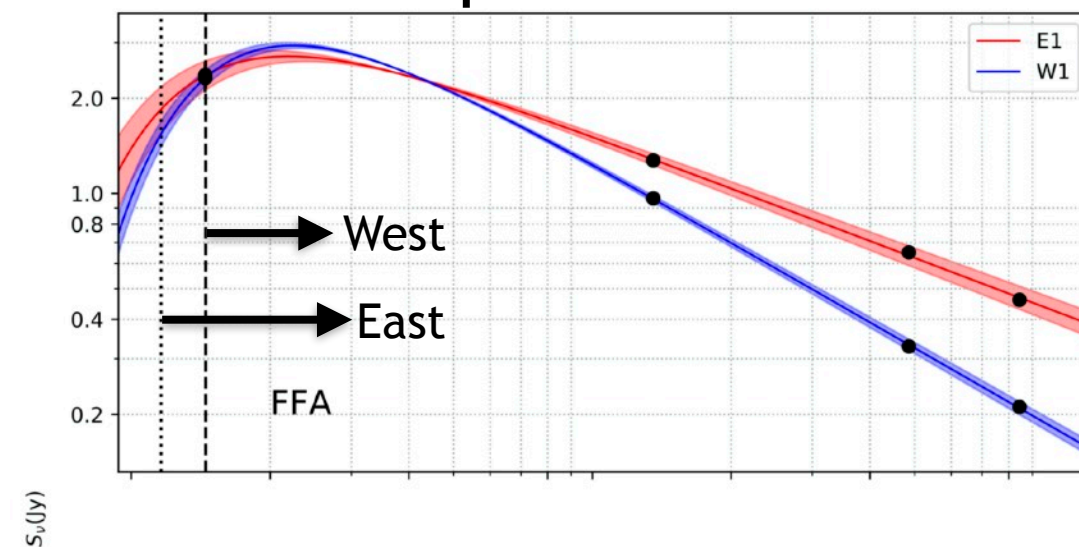
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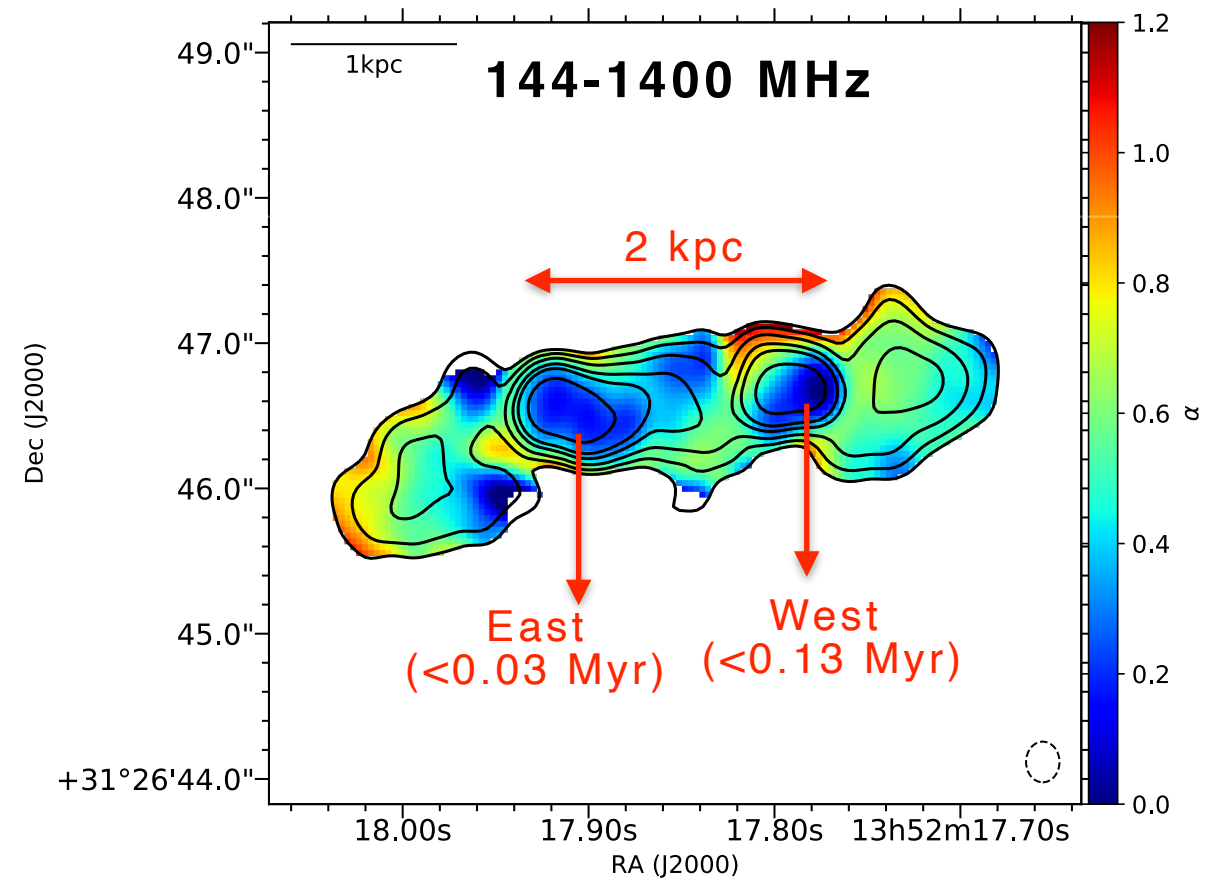


Absorption model fits

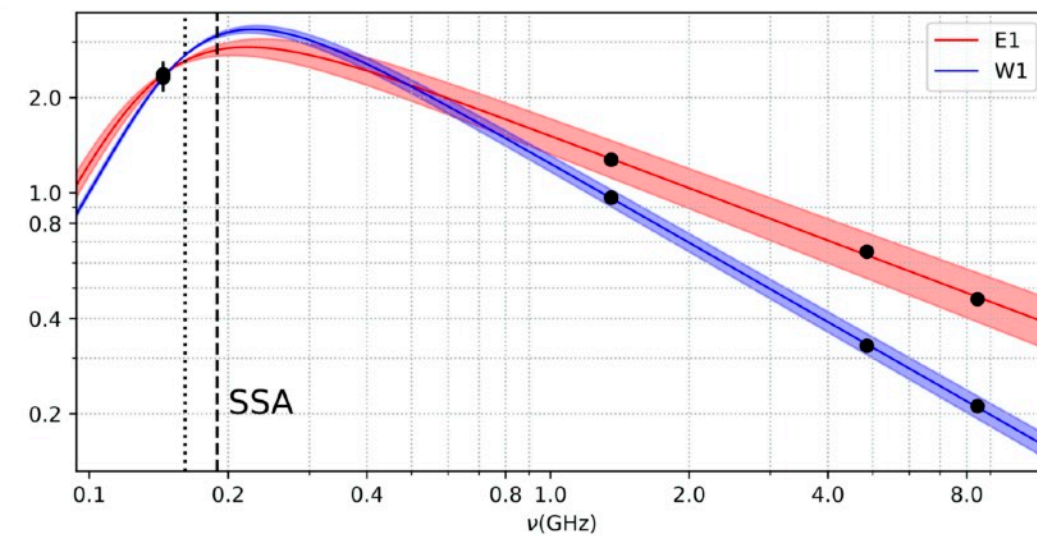
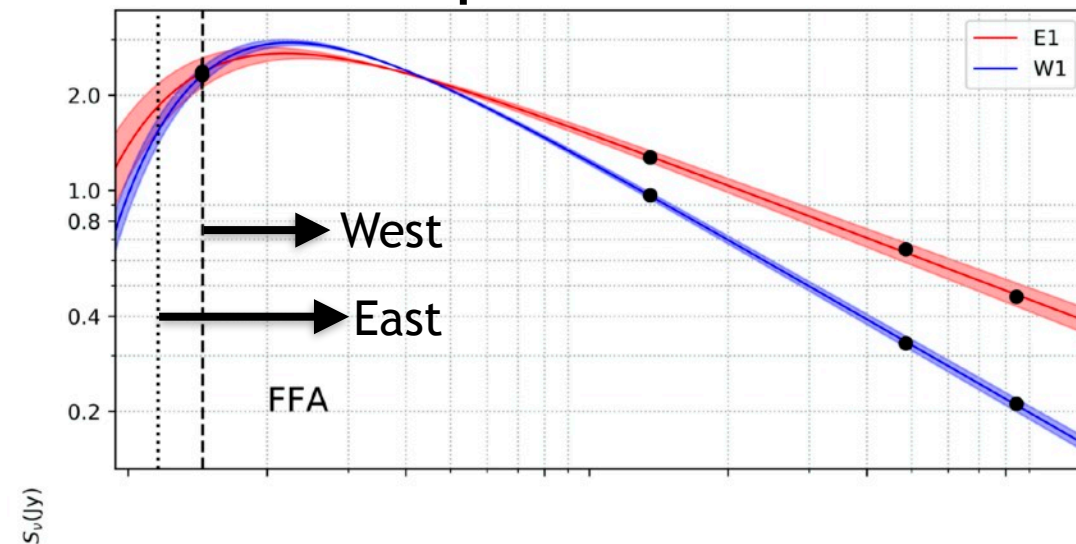


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- Synchrotron Self-Absorption (SSA) gives unrealistically high magnetic field strengths ($\sim 10^2$ G !)



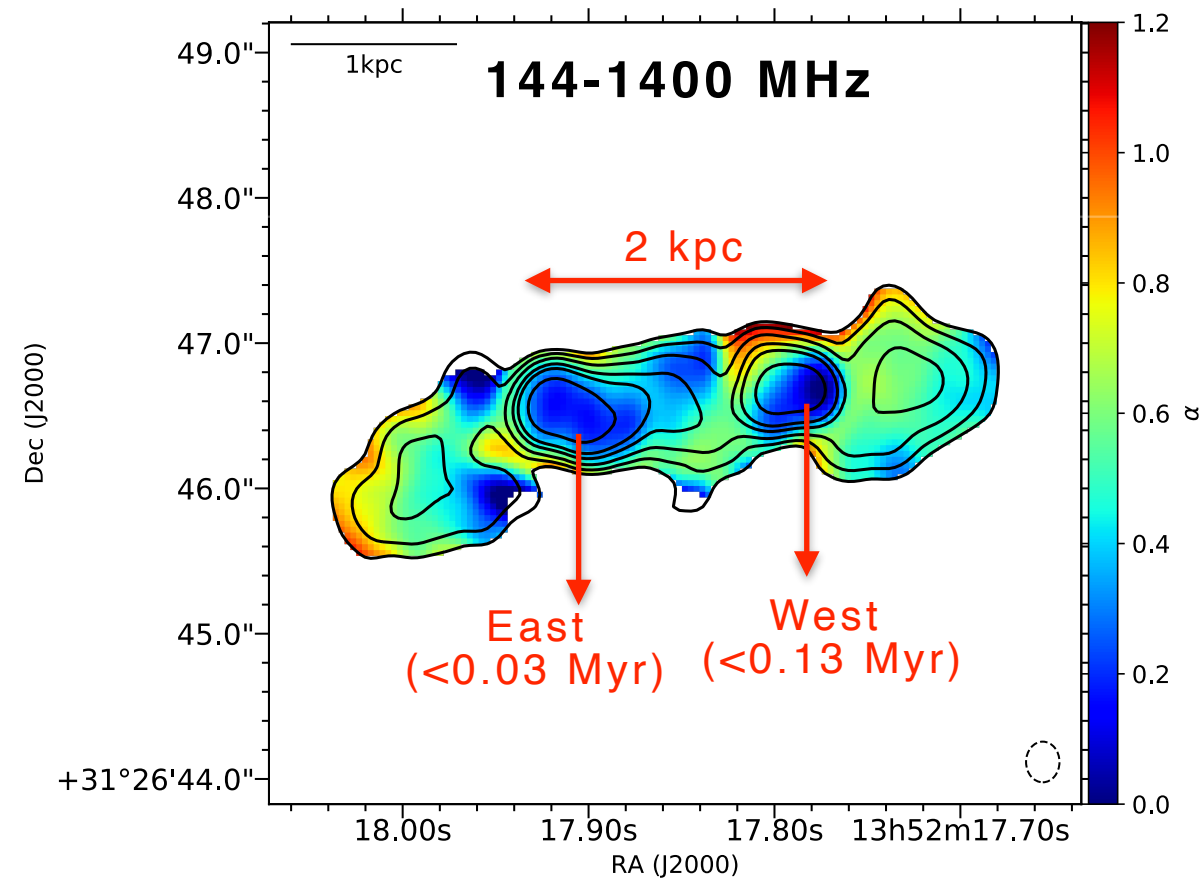
Absorption model fits



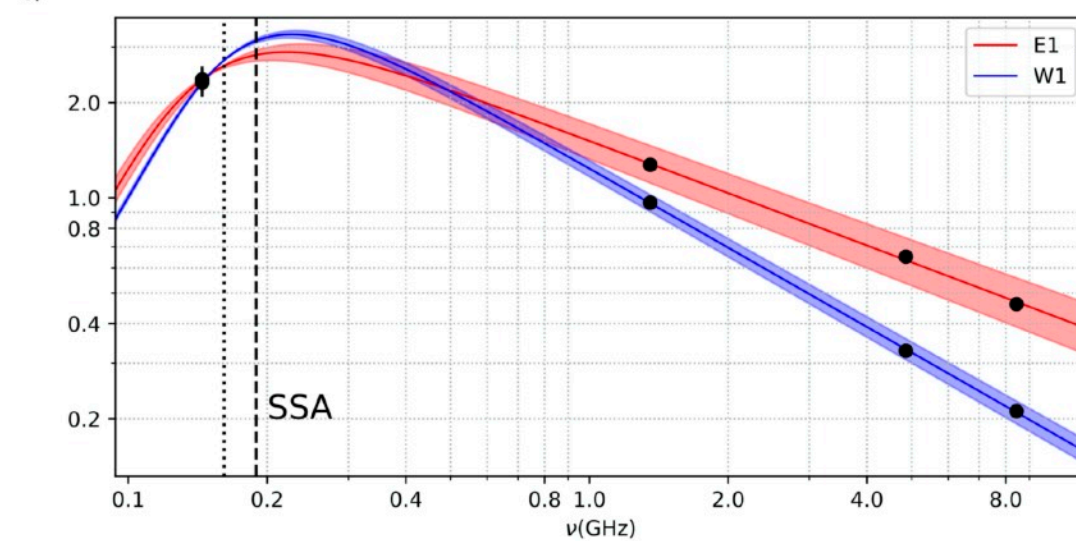
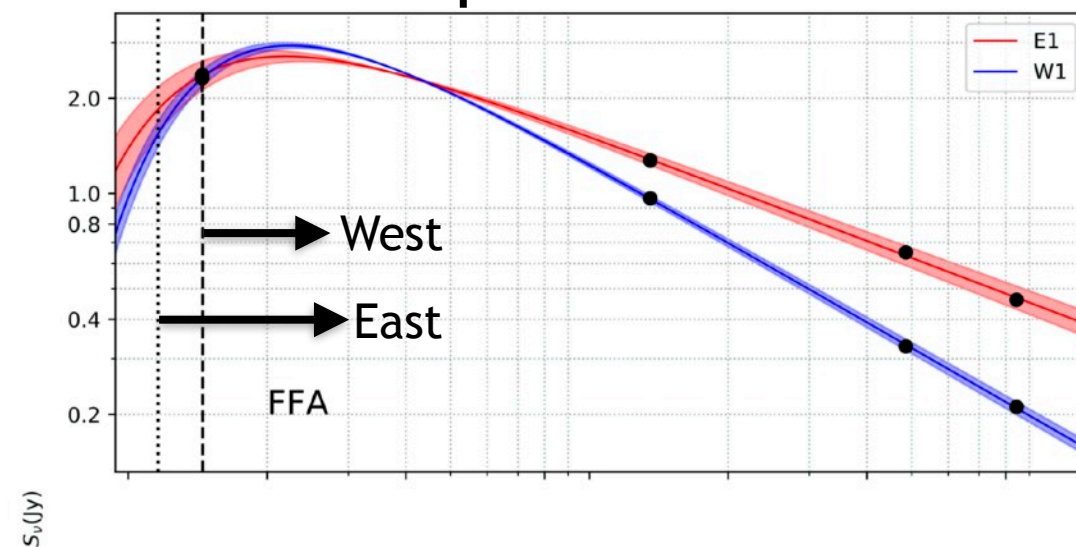
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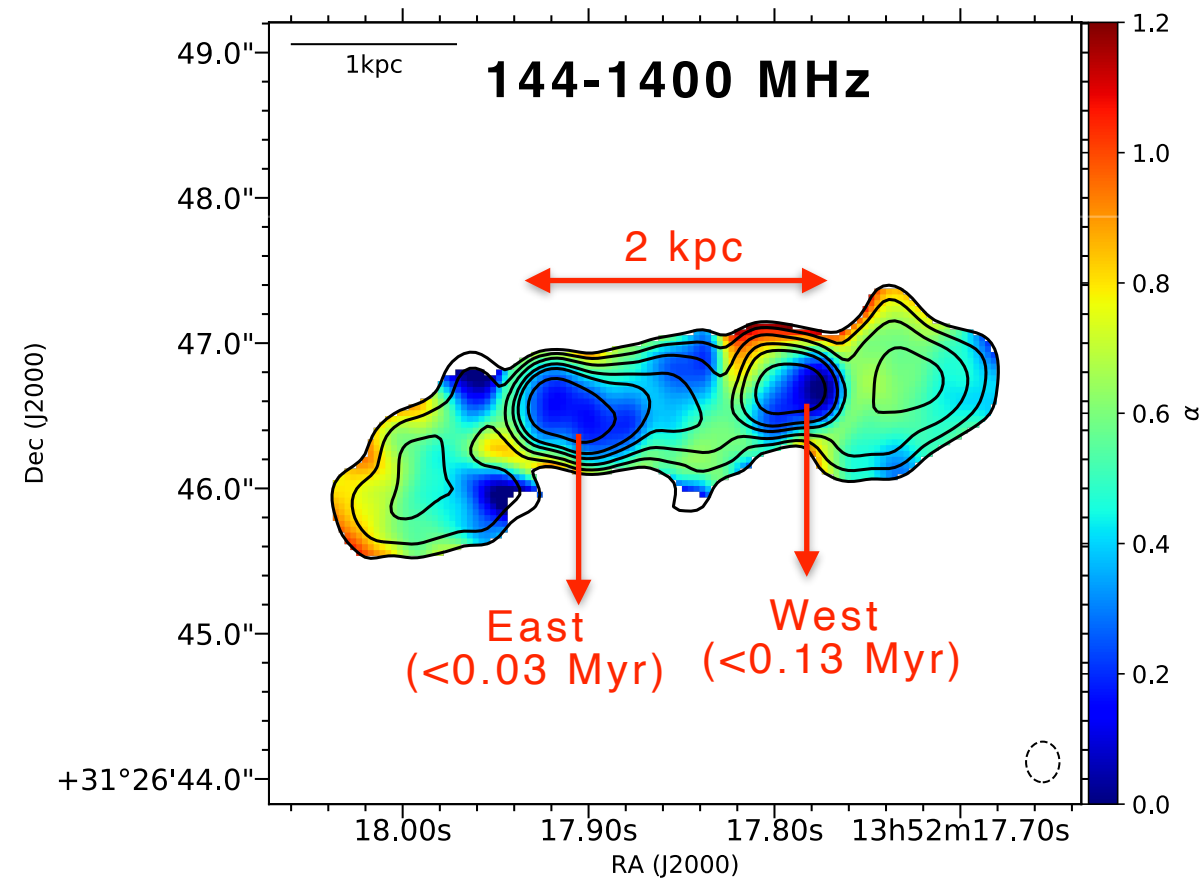
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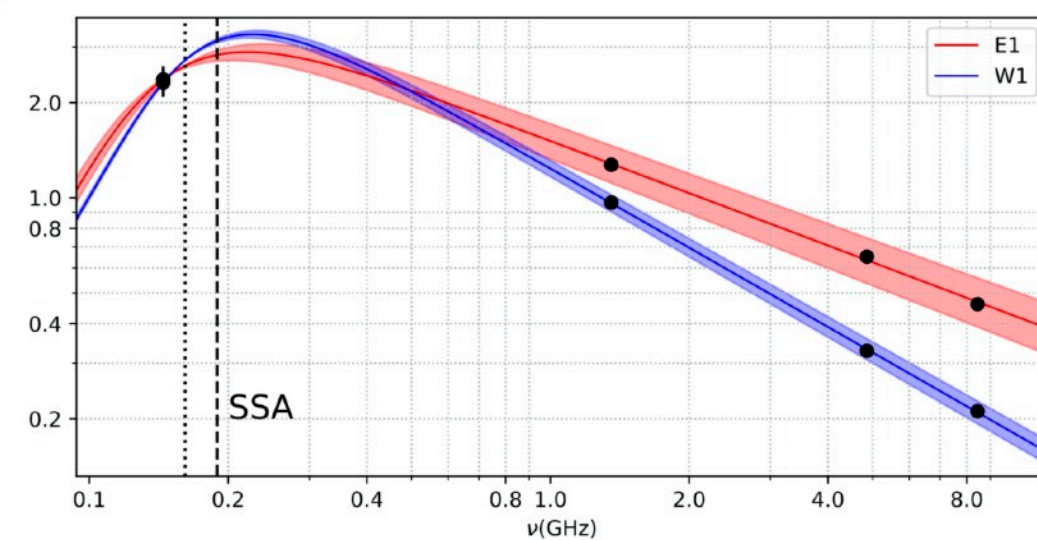
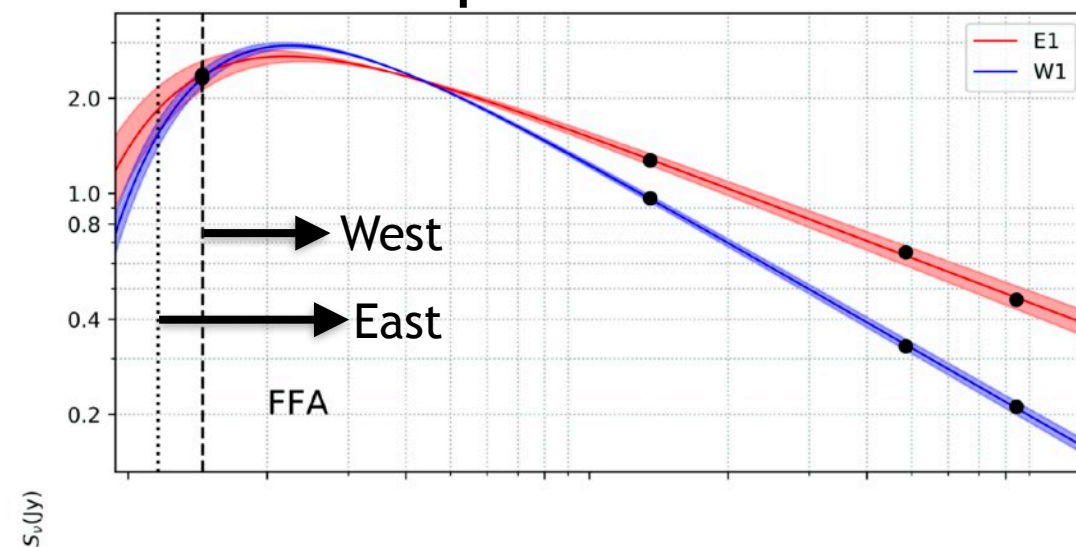


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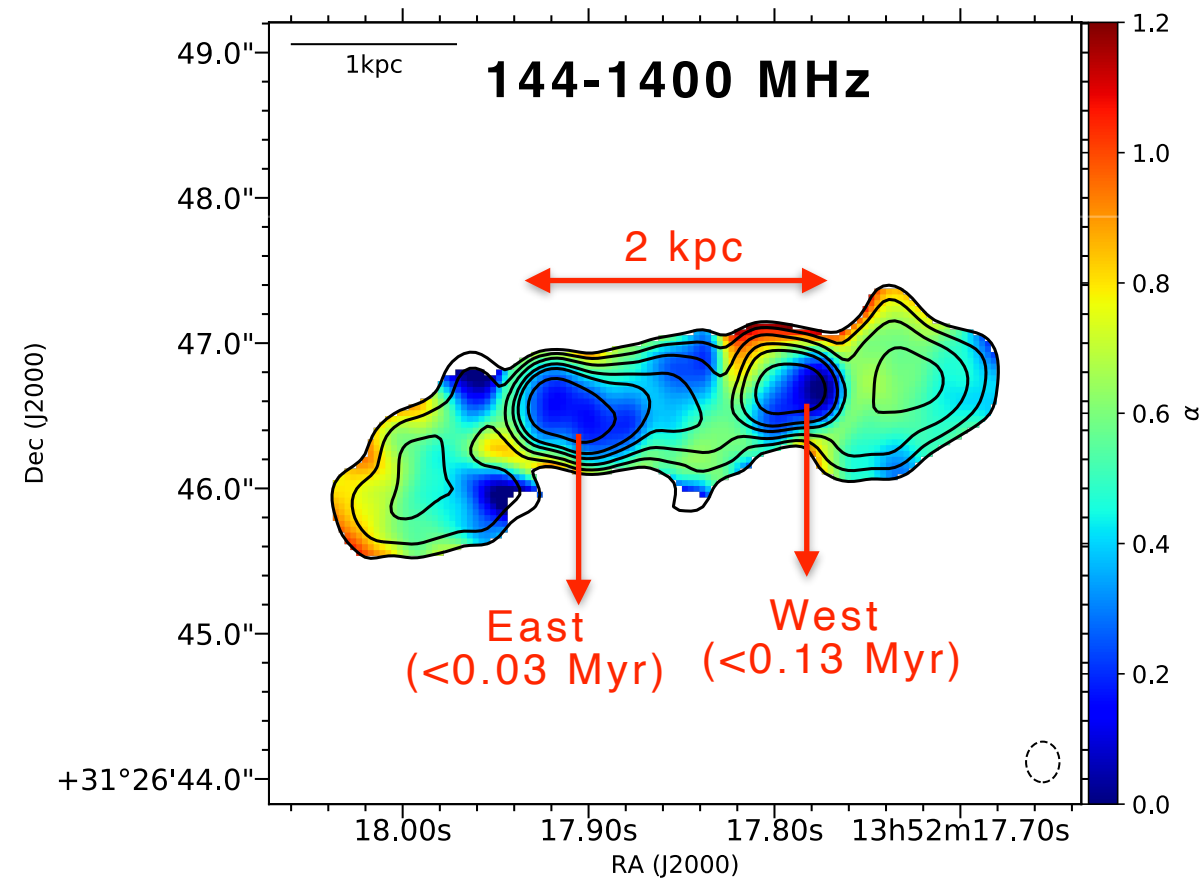


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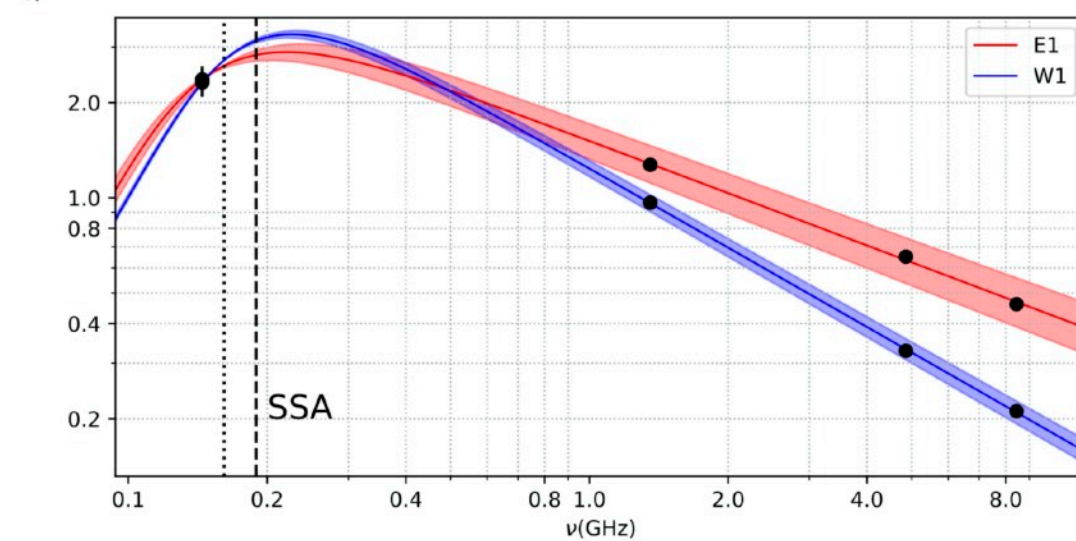
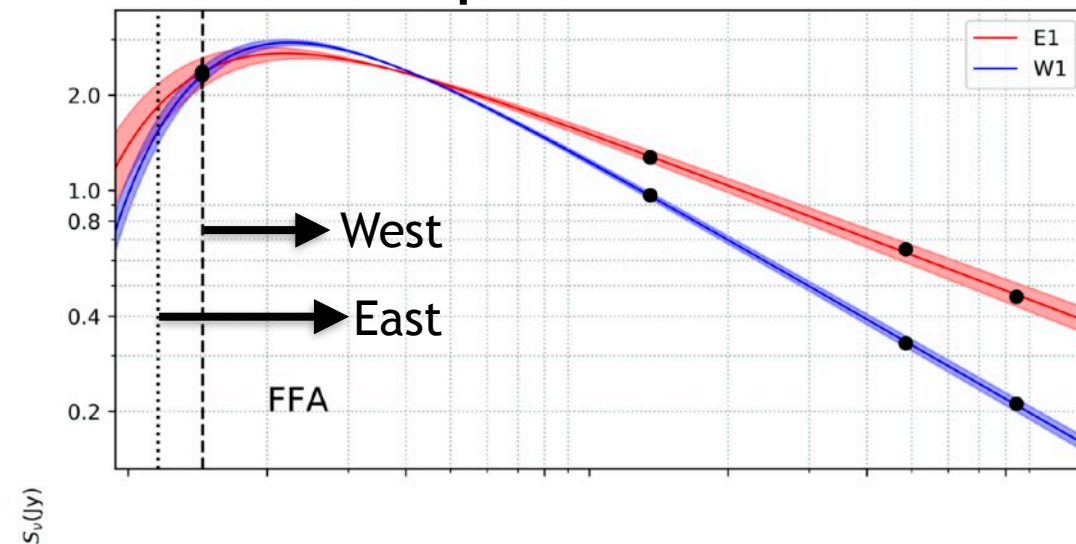
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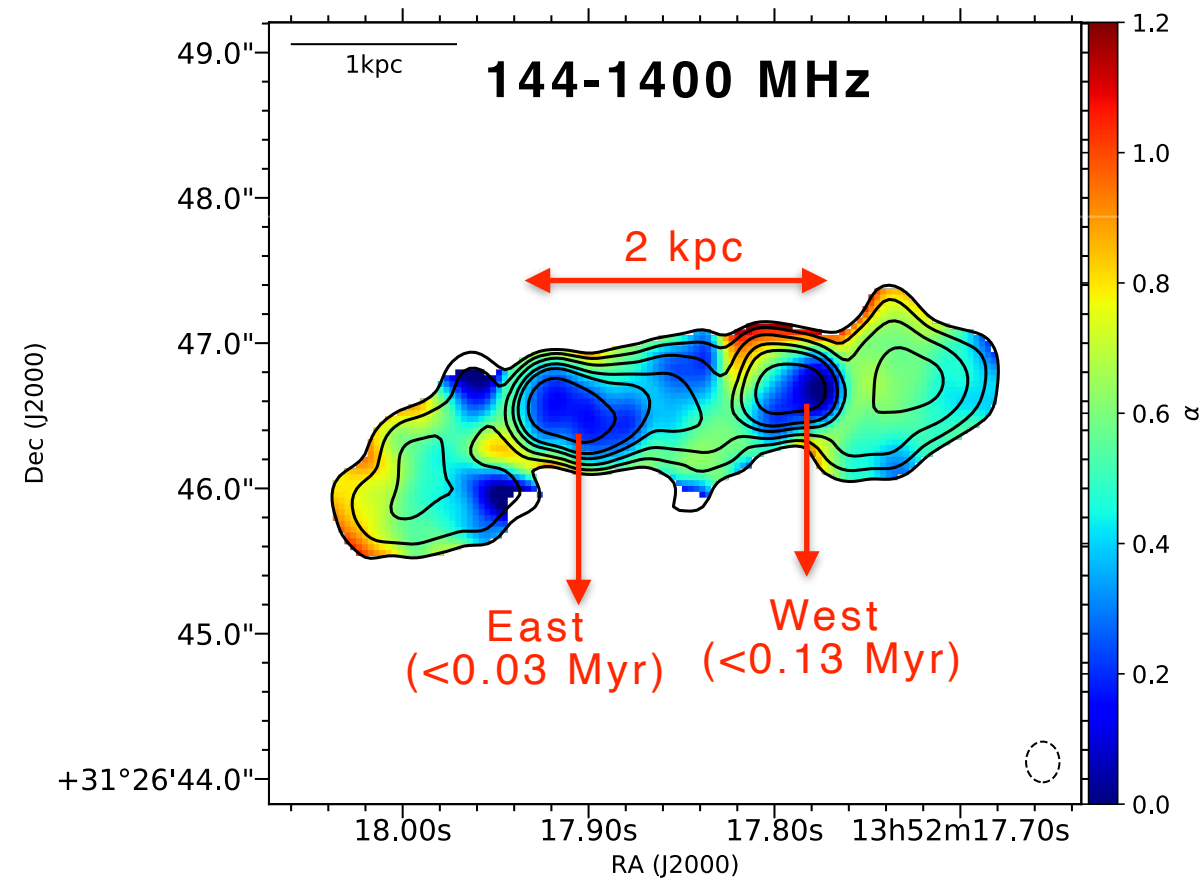


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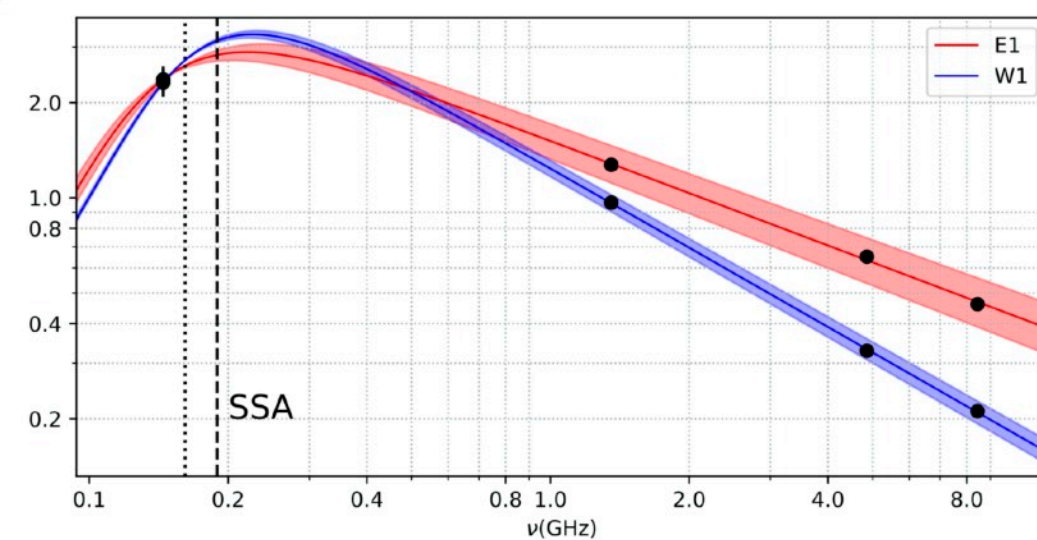
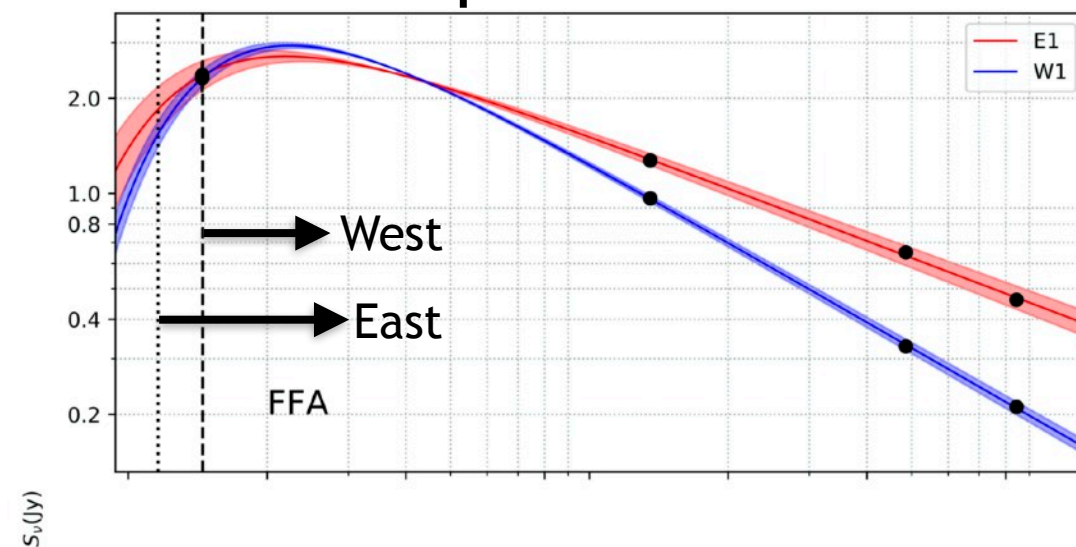


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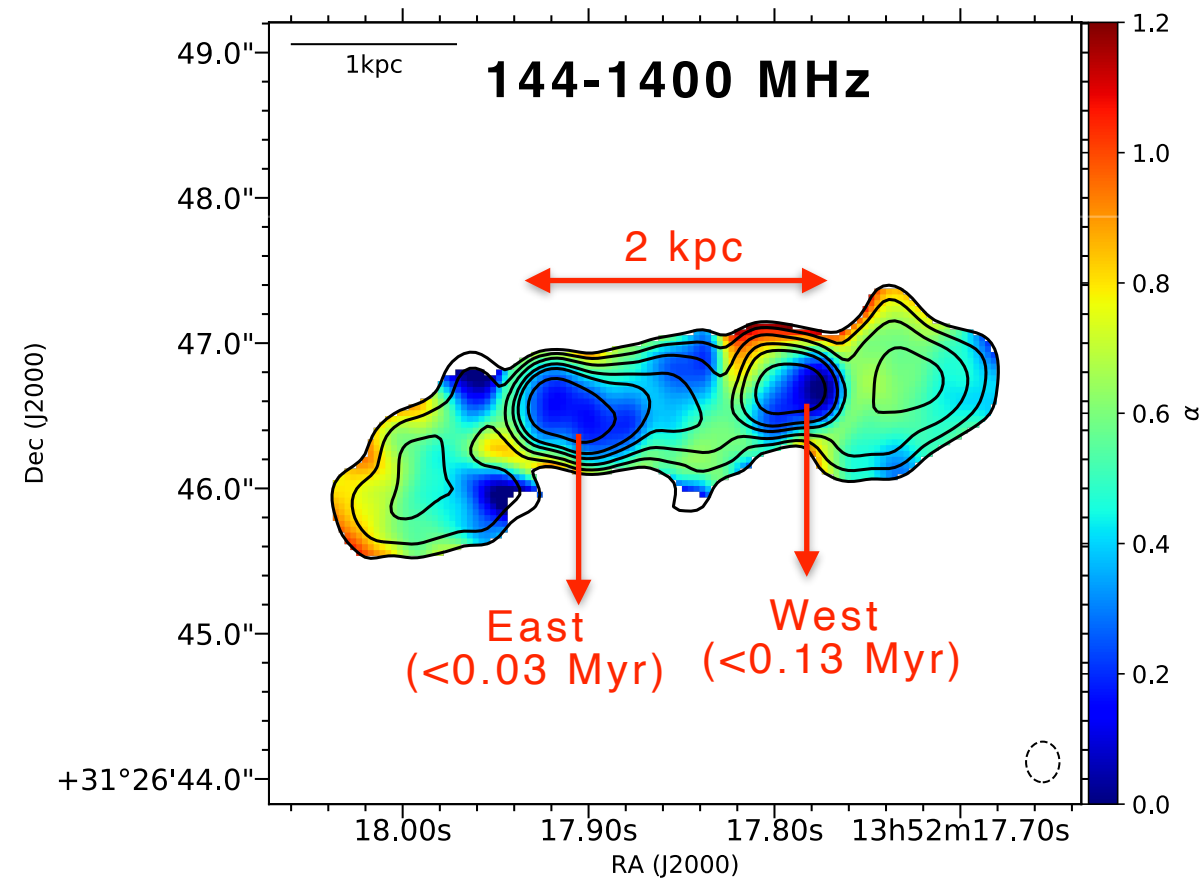
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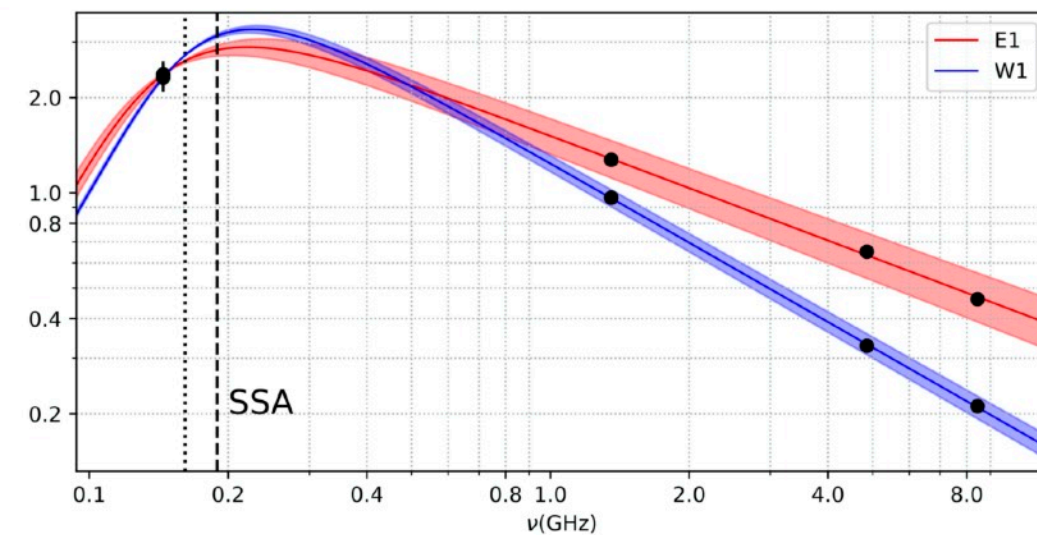
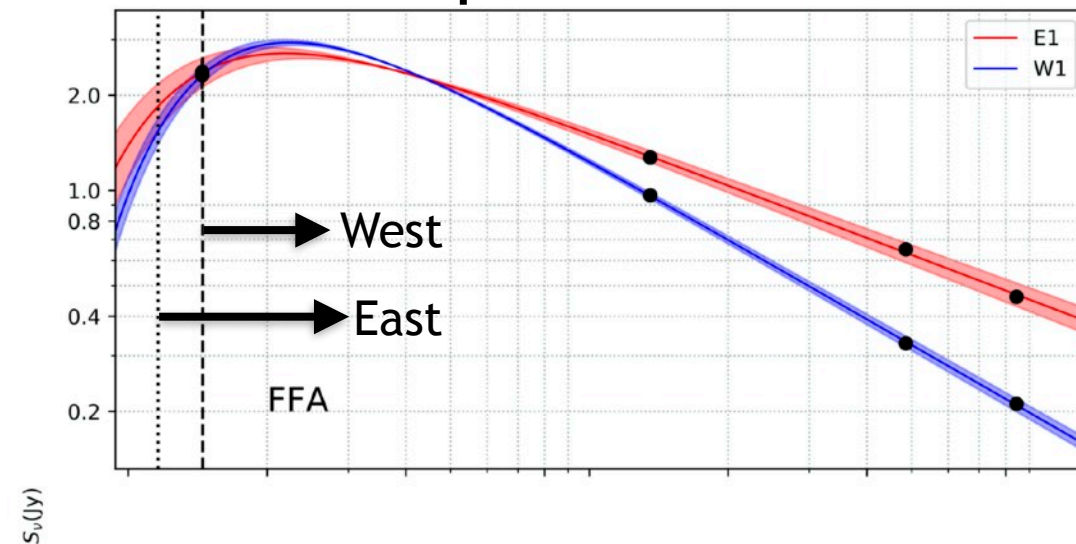
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Inner lobes a young CSS with FFA the most plausible dominant mechanism!

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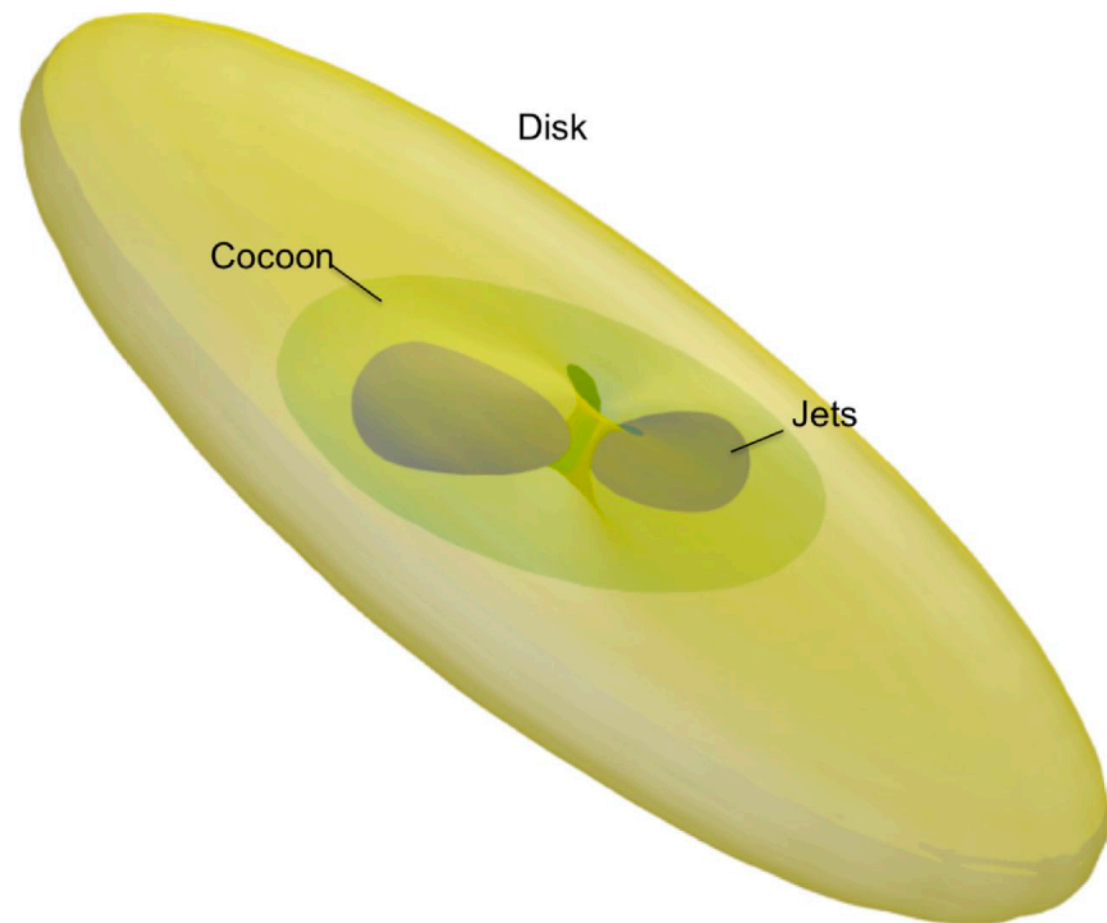
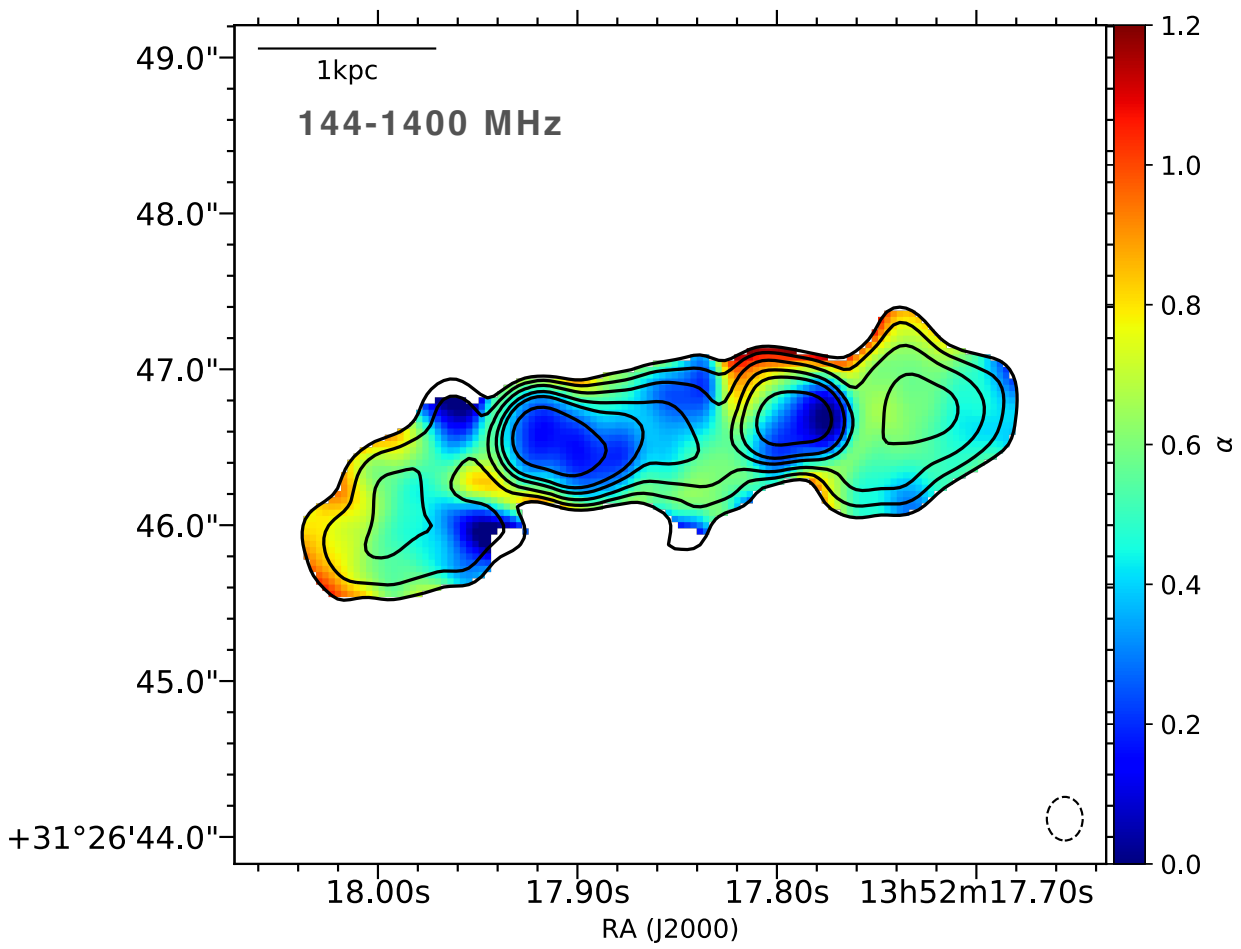


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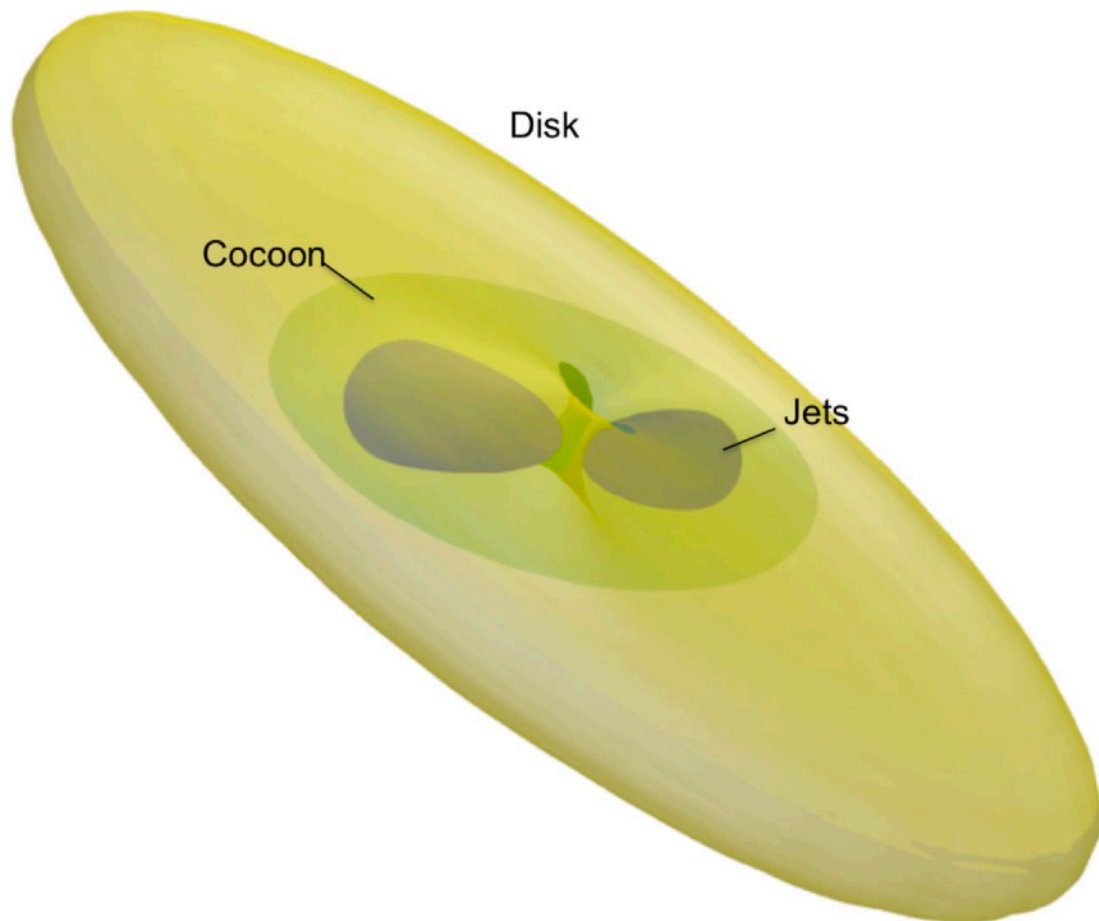
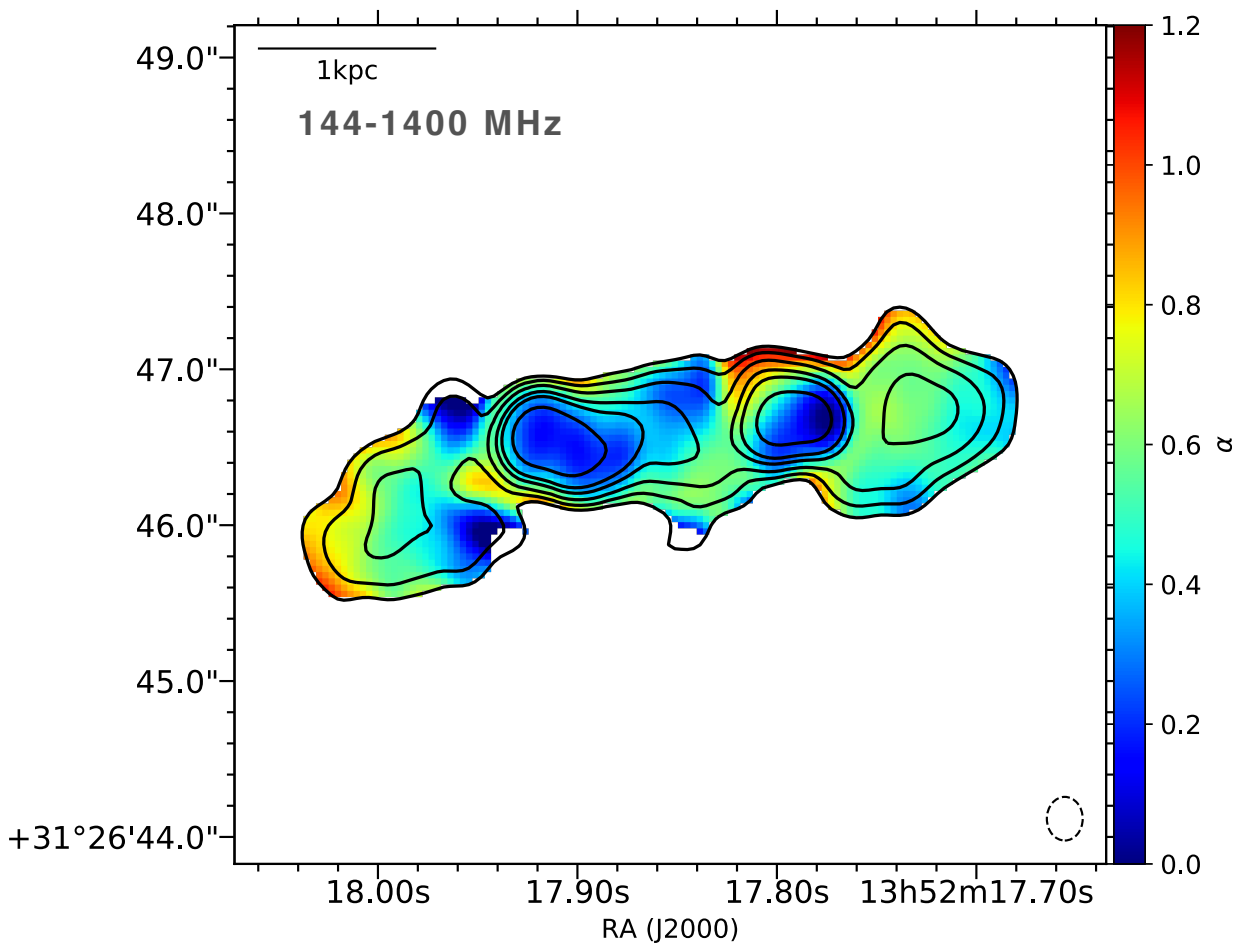
- Inner lobes interacting with surrounding medium, confined by dense ISM - “frustration”?. Morganti et al. 2003, Mahony et al. 2016, Emonts et al. 2005, Labiano et al. 2014

What is the origin of the diffuse emission around inner lobes?

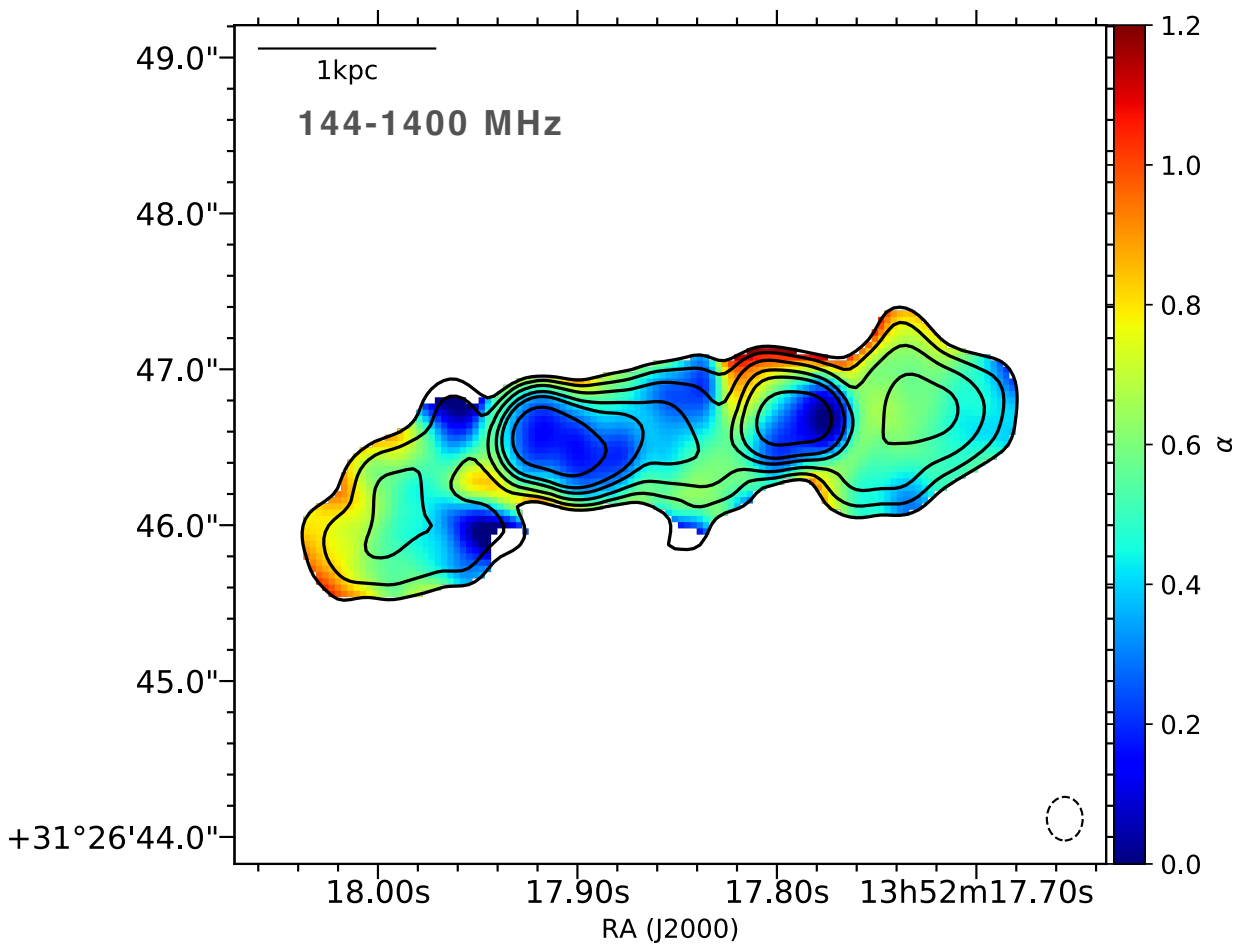


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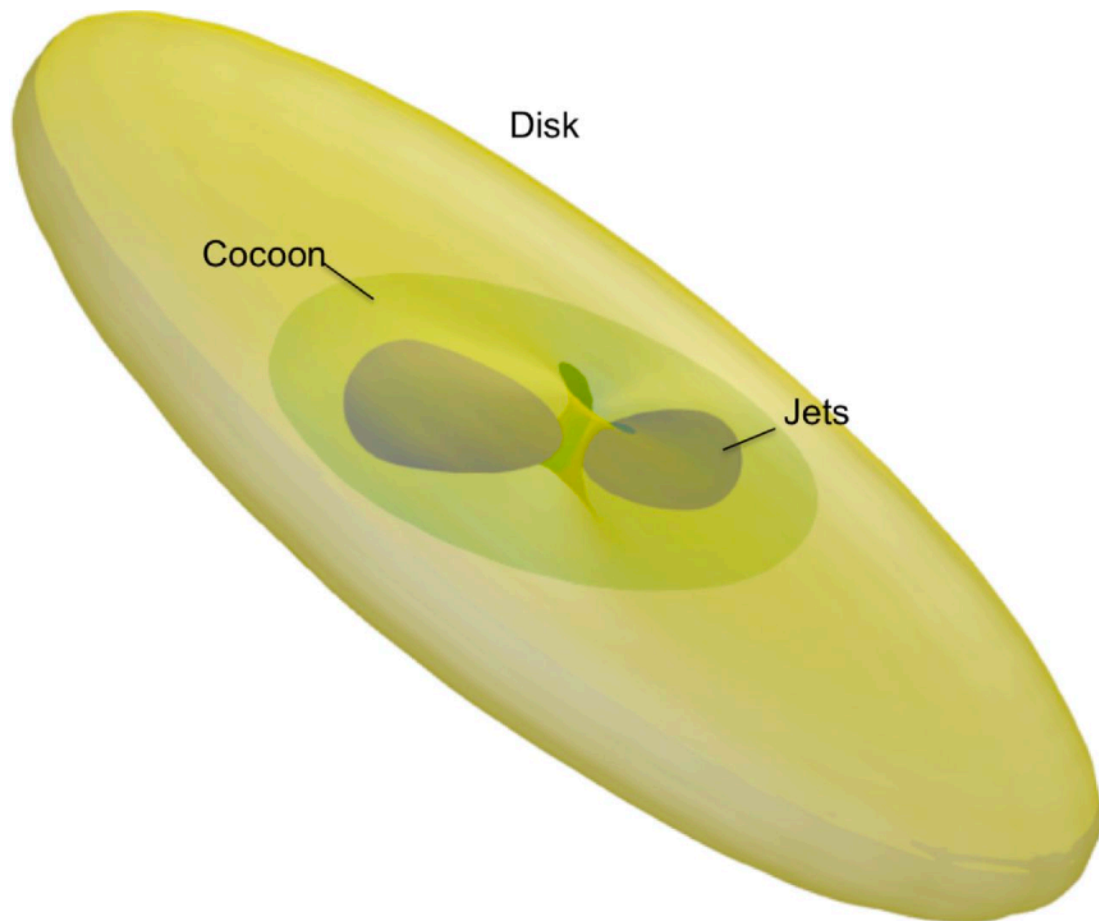


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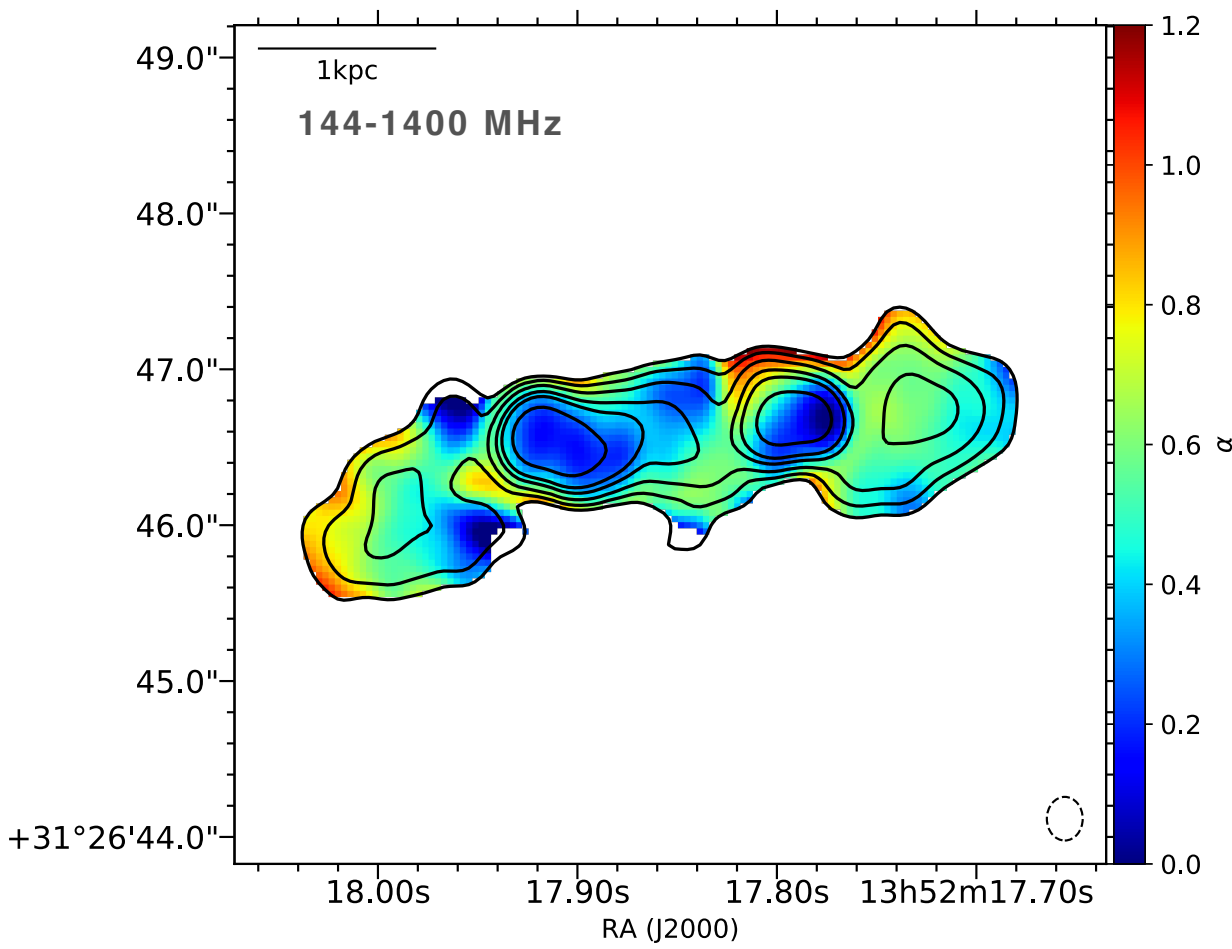
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Cartoon representation of 3C293 by Mahony et al. 2016

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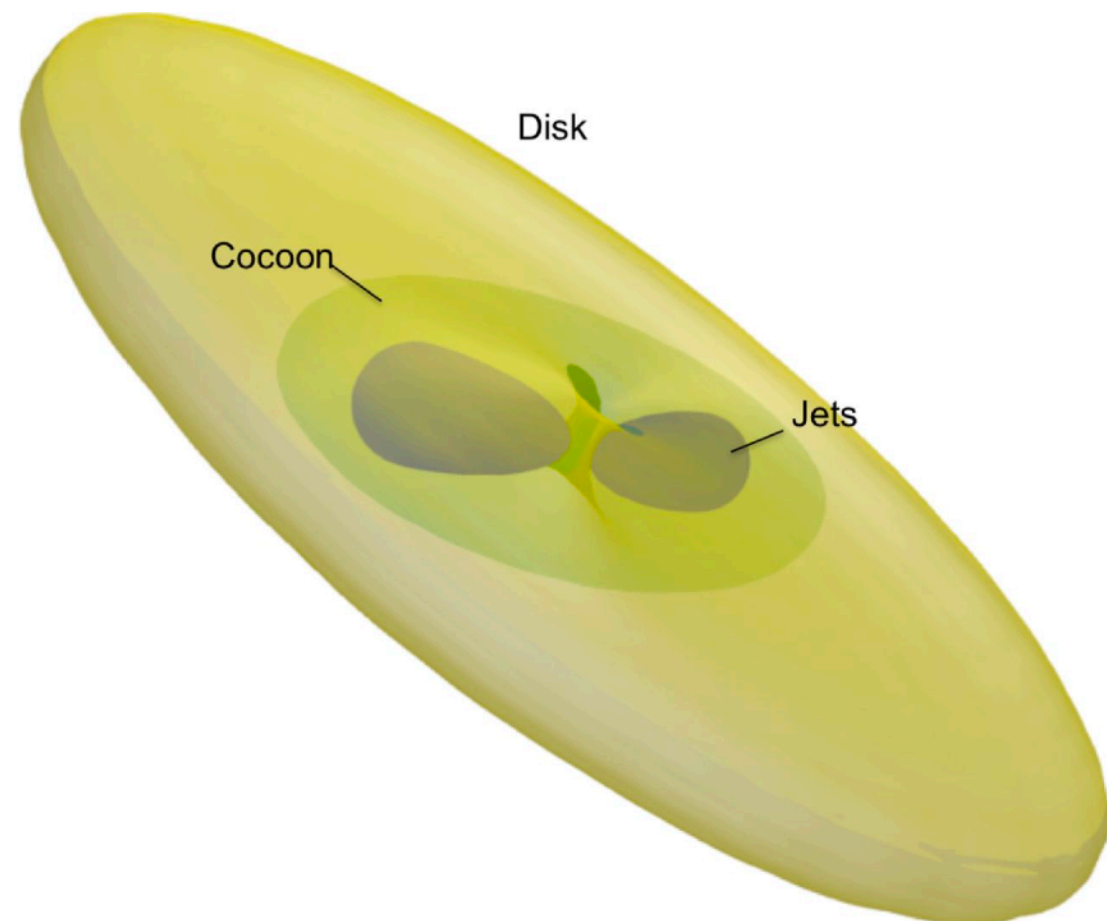
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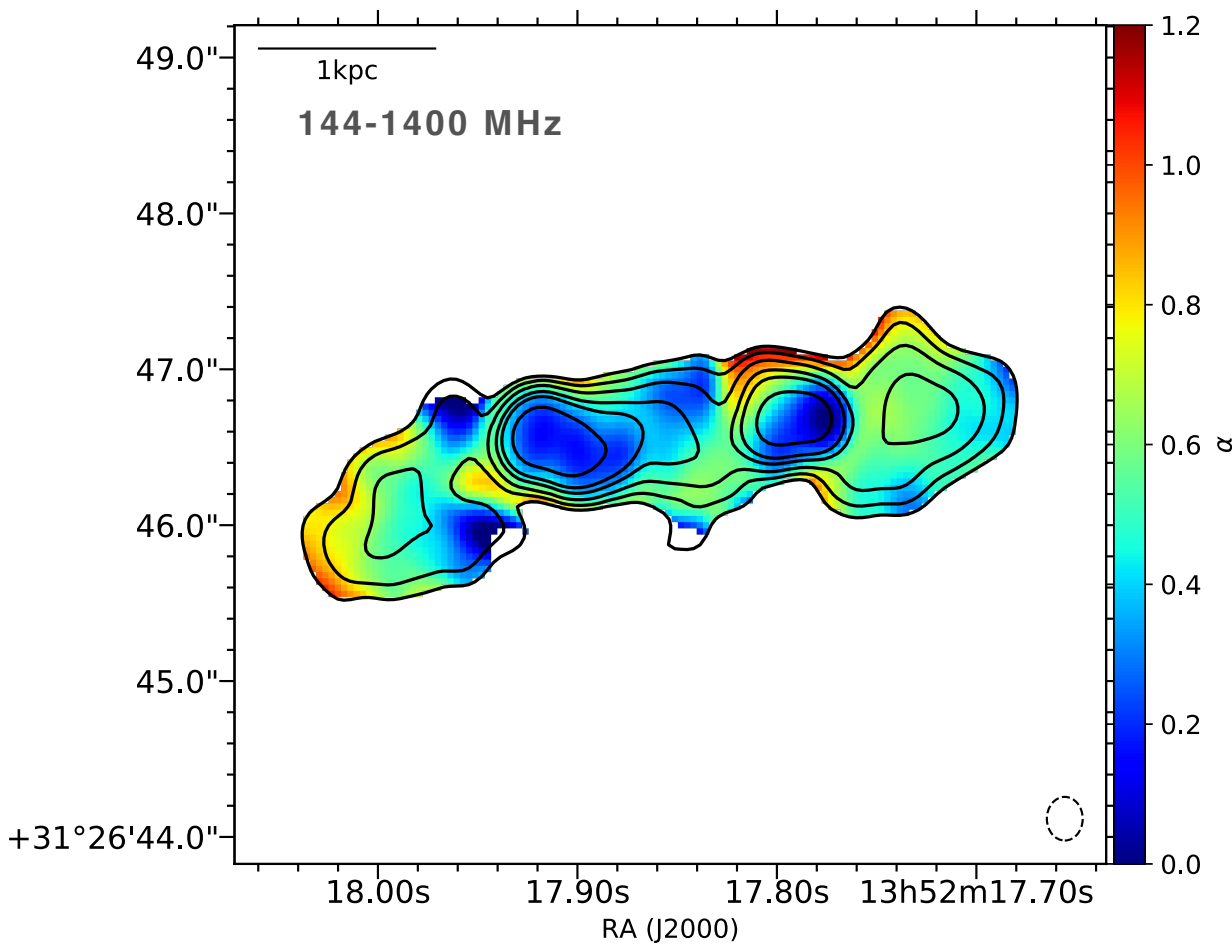
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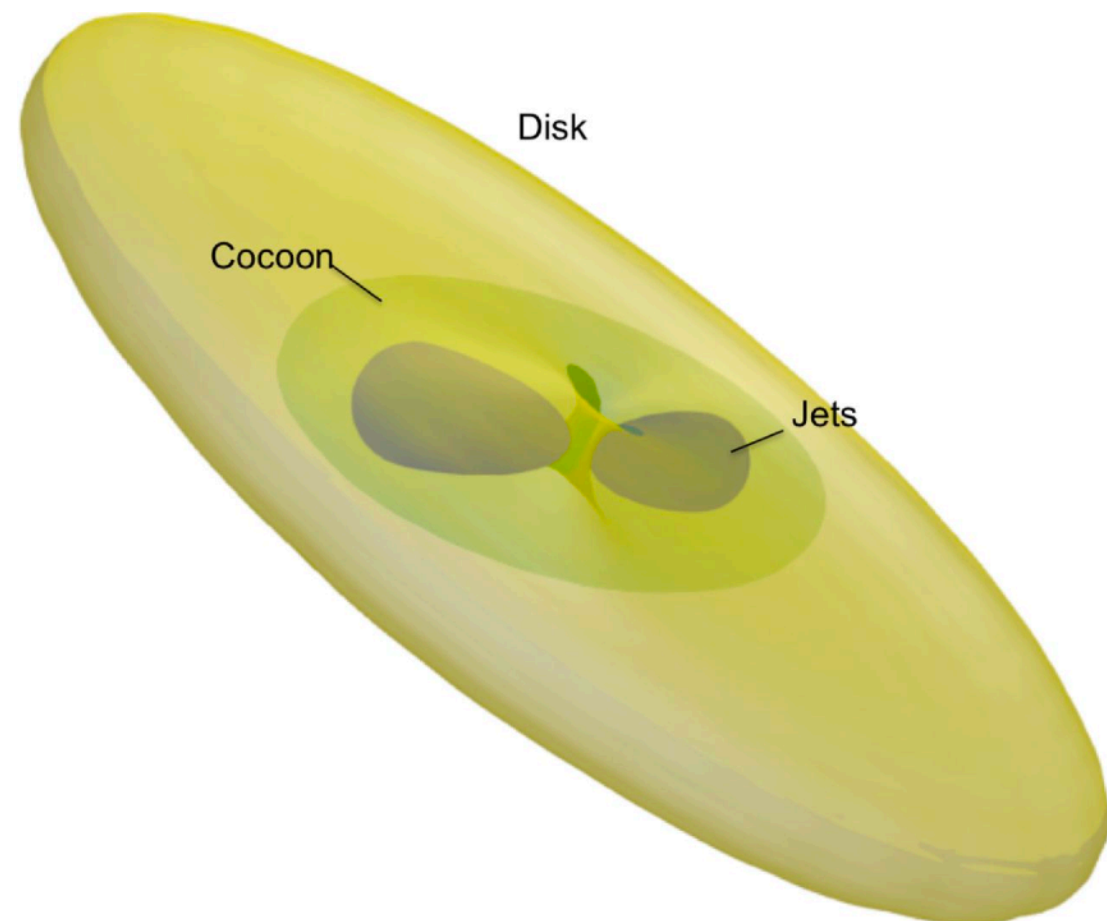
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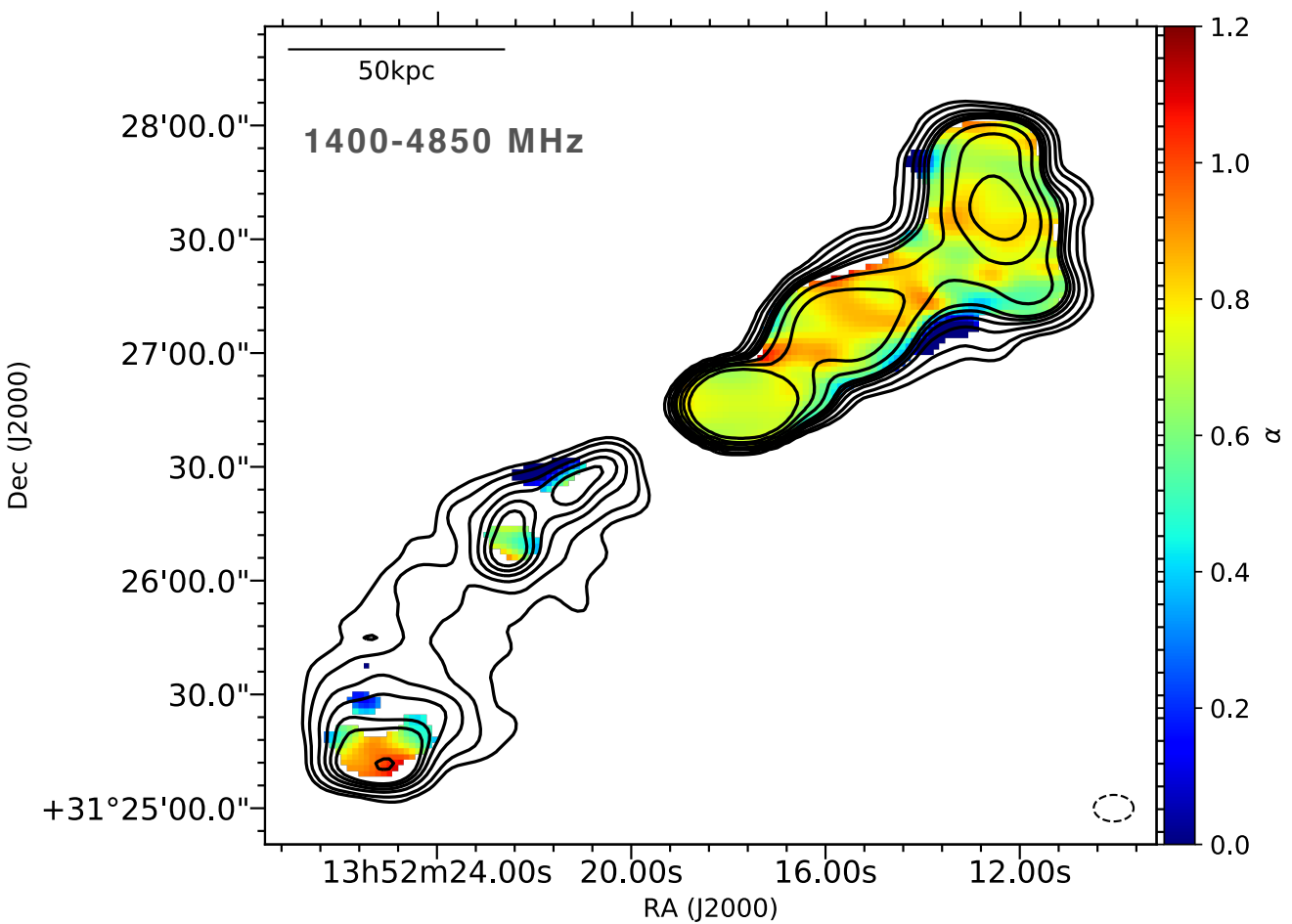
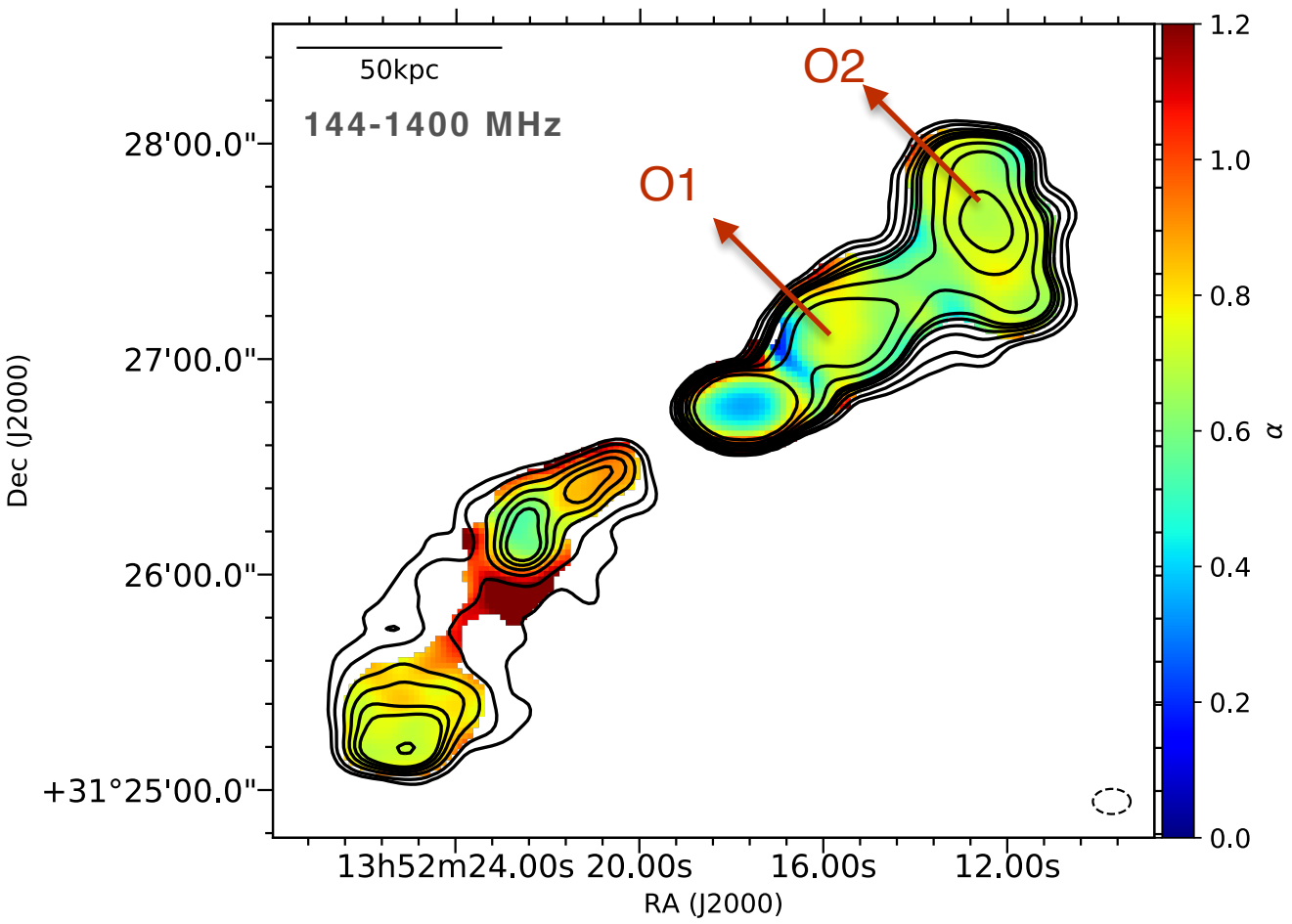
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- Leakage from decelerated plasma could form the low surface brightness diffuse emission.

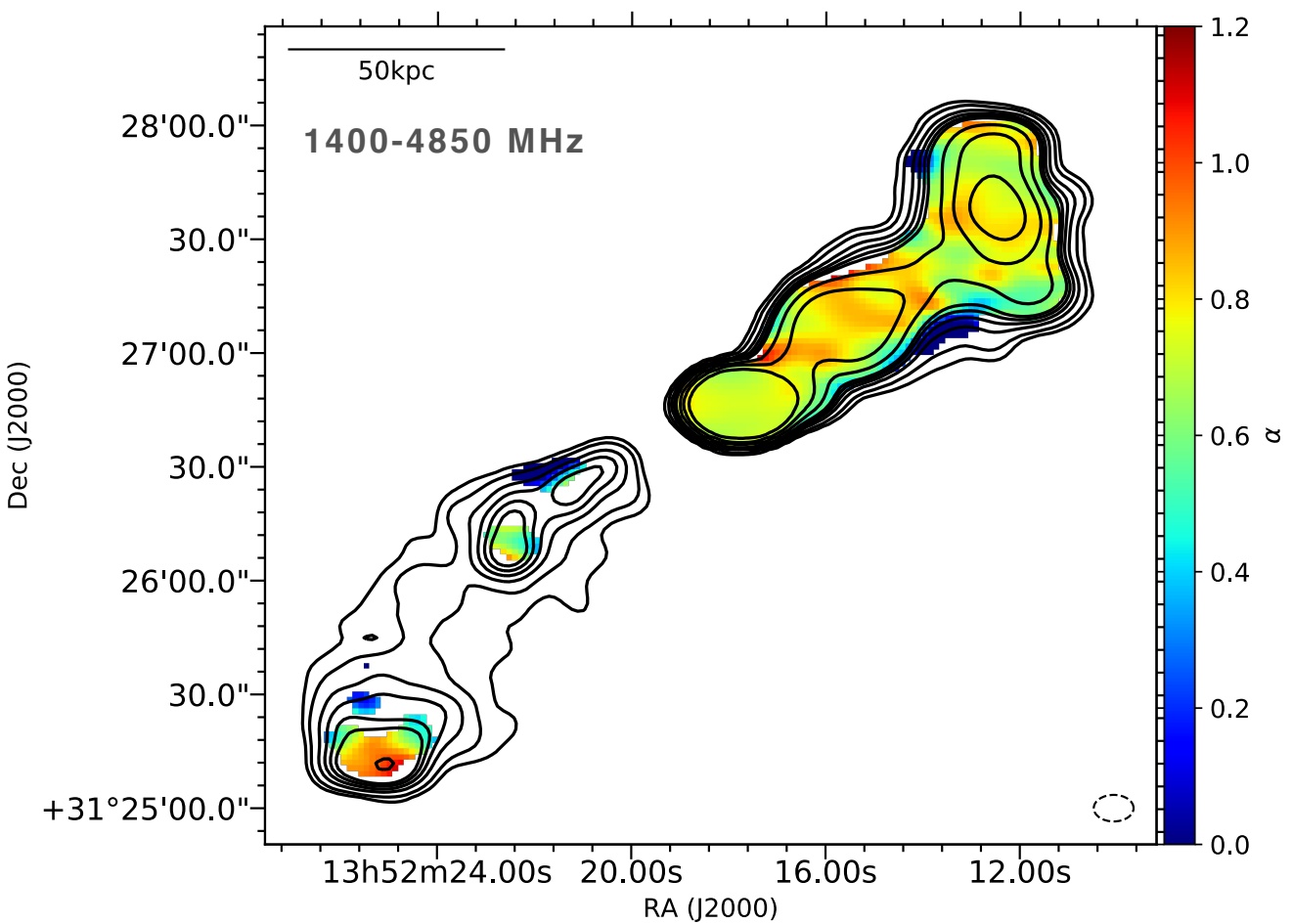
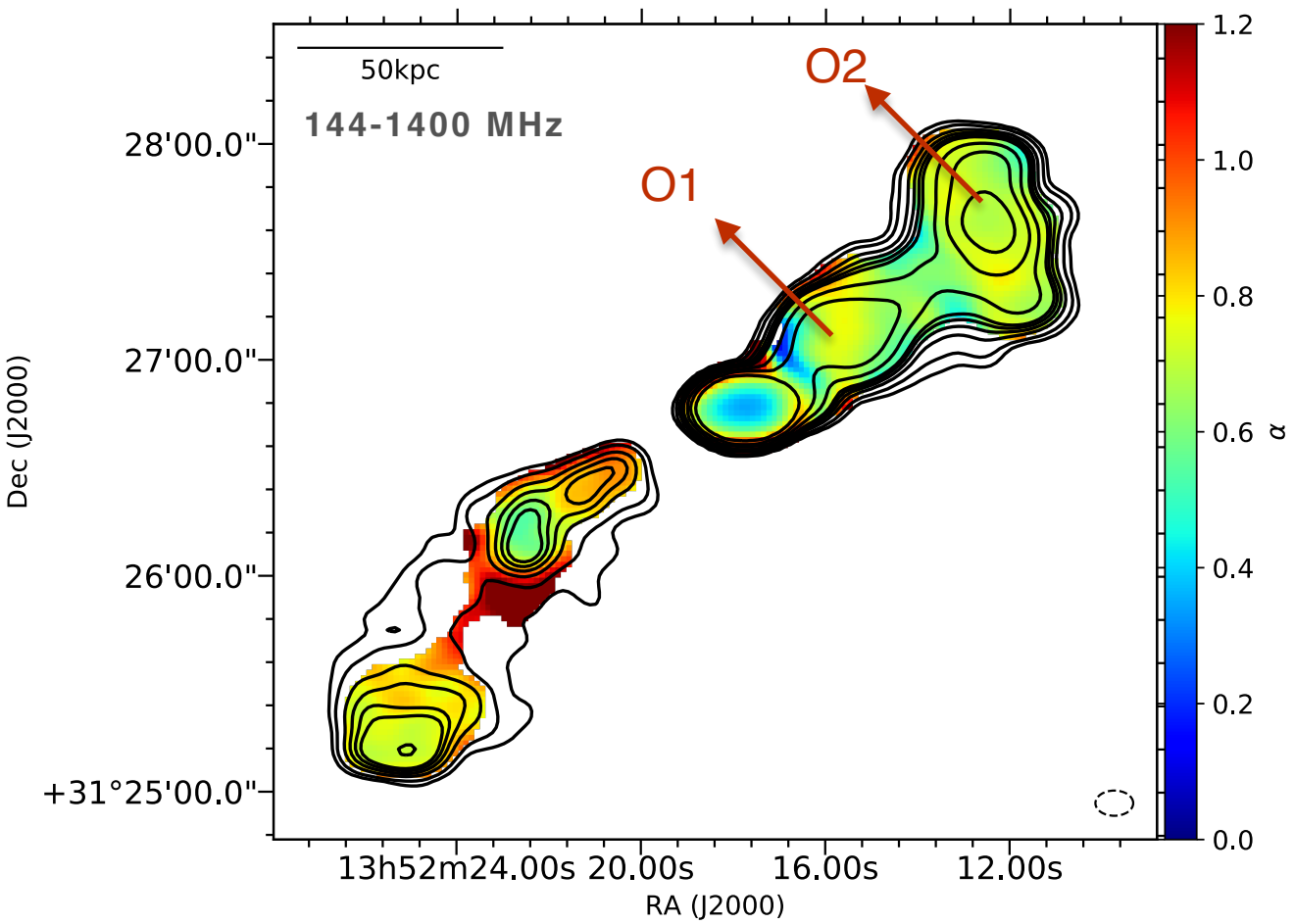


Are the outer lobes still alive?



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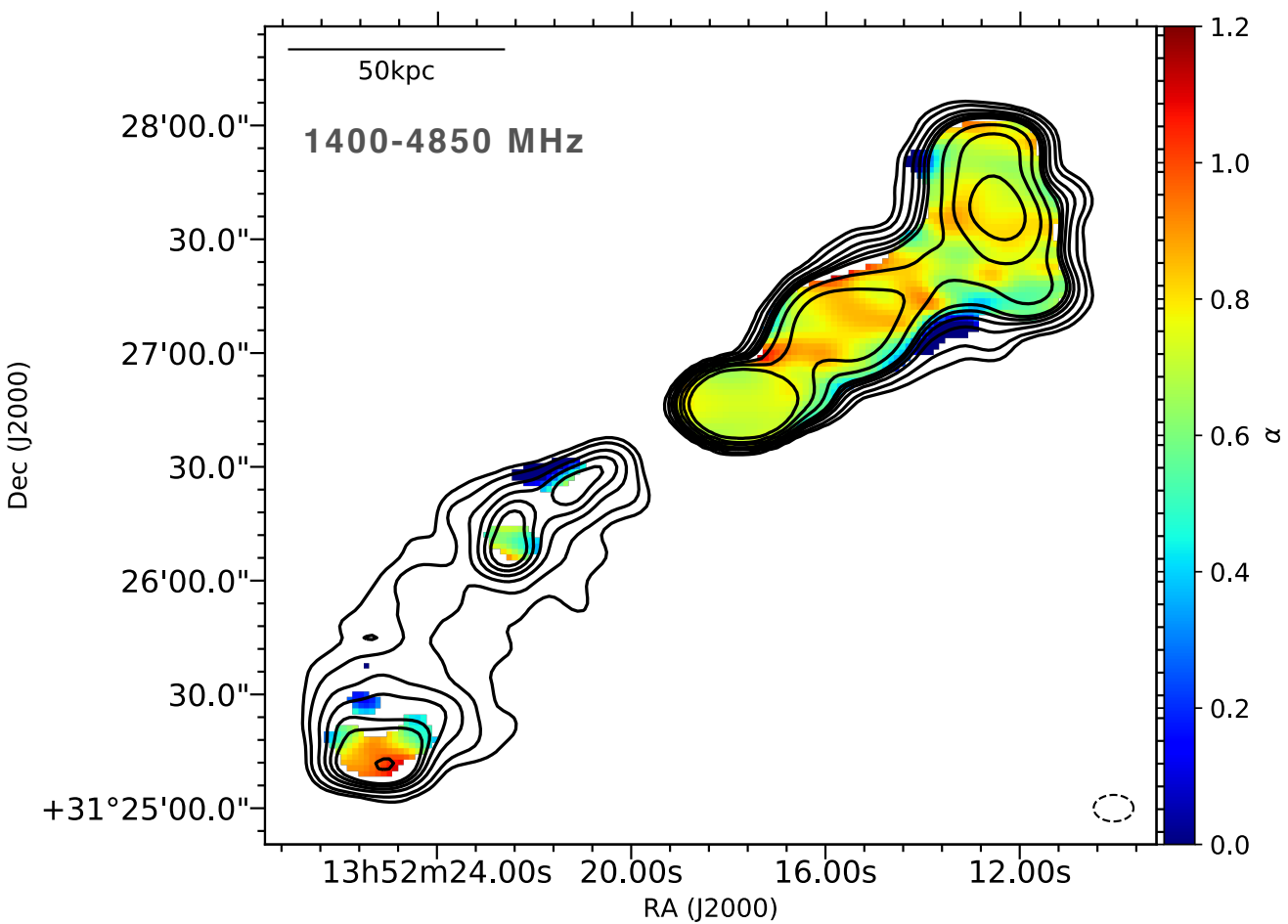
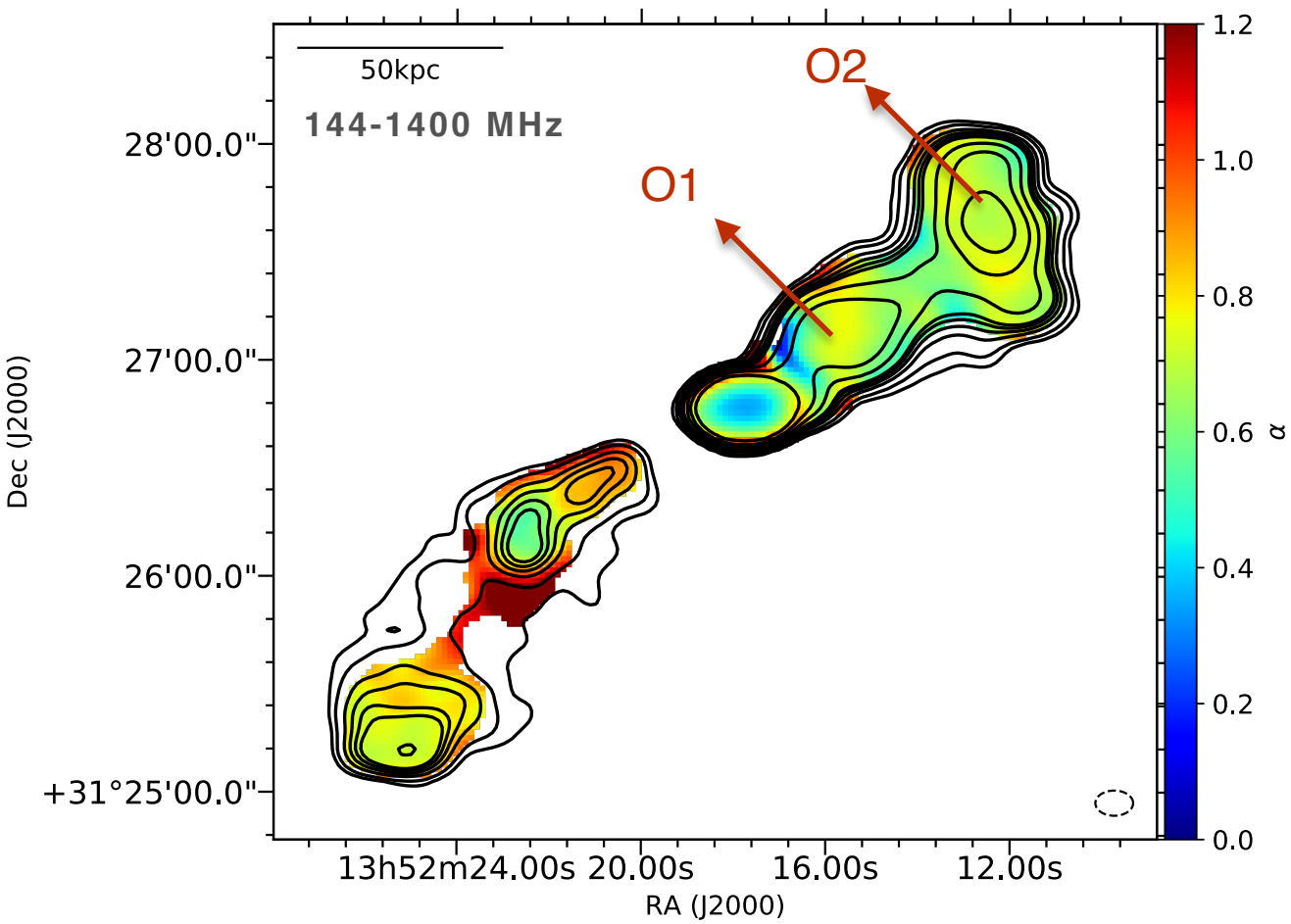
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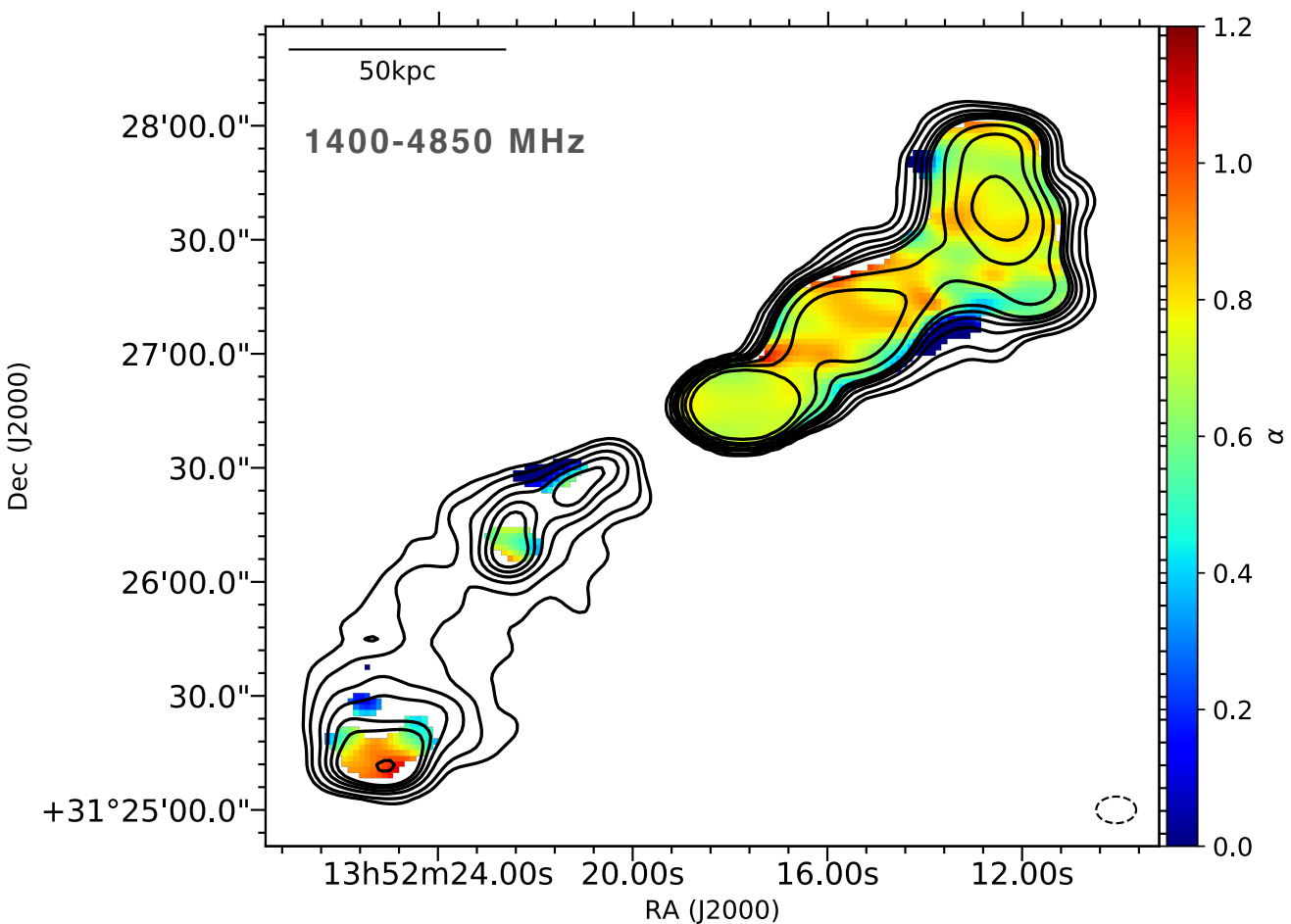
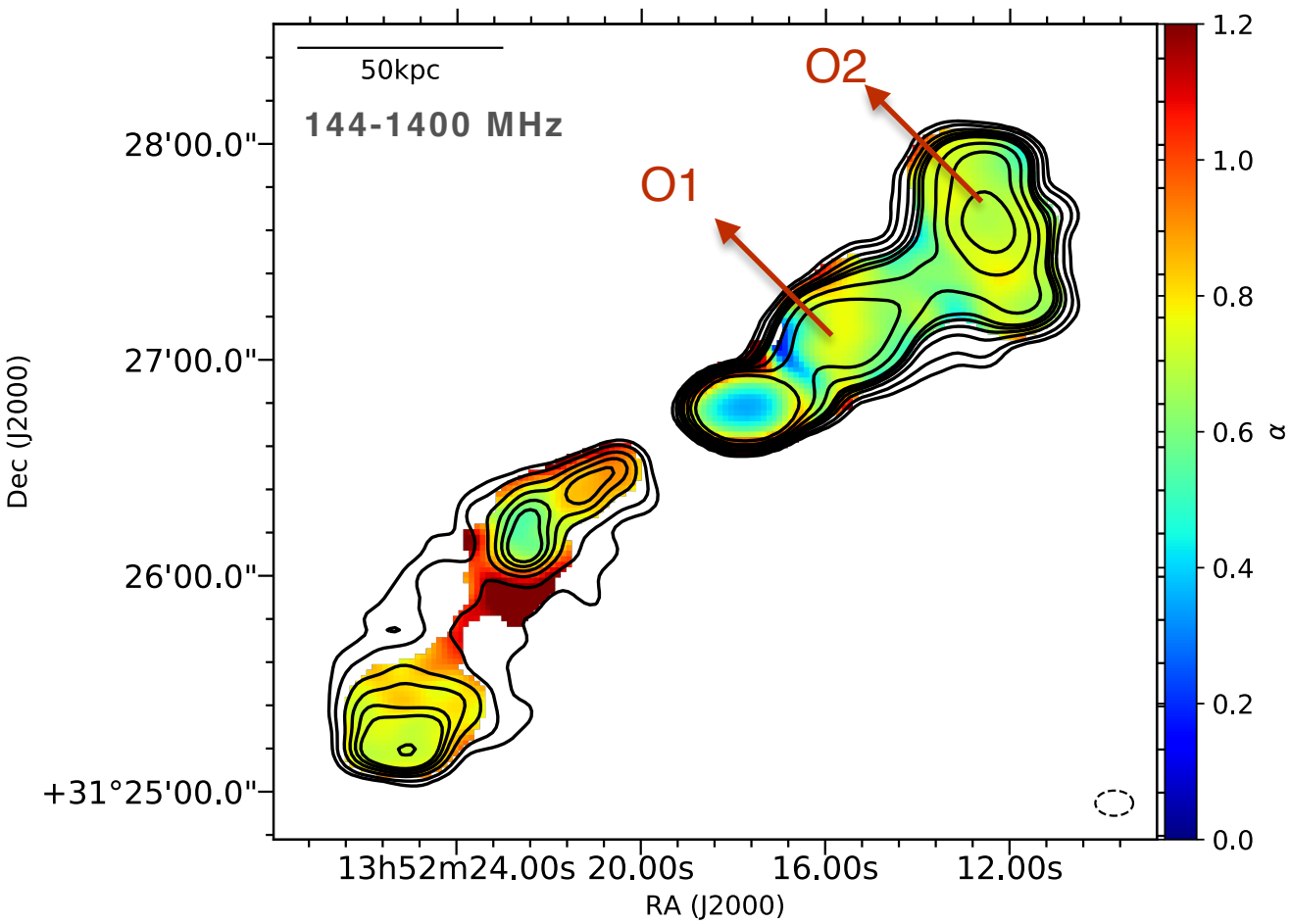


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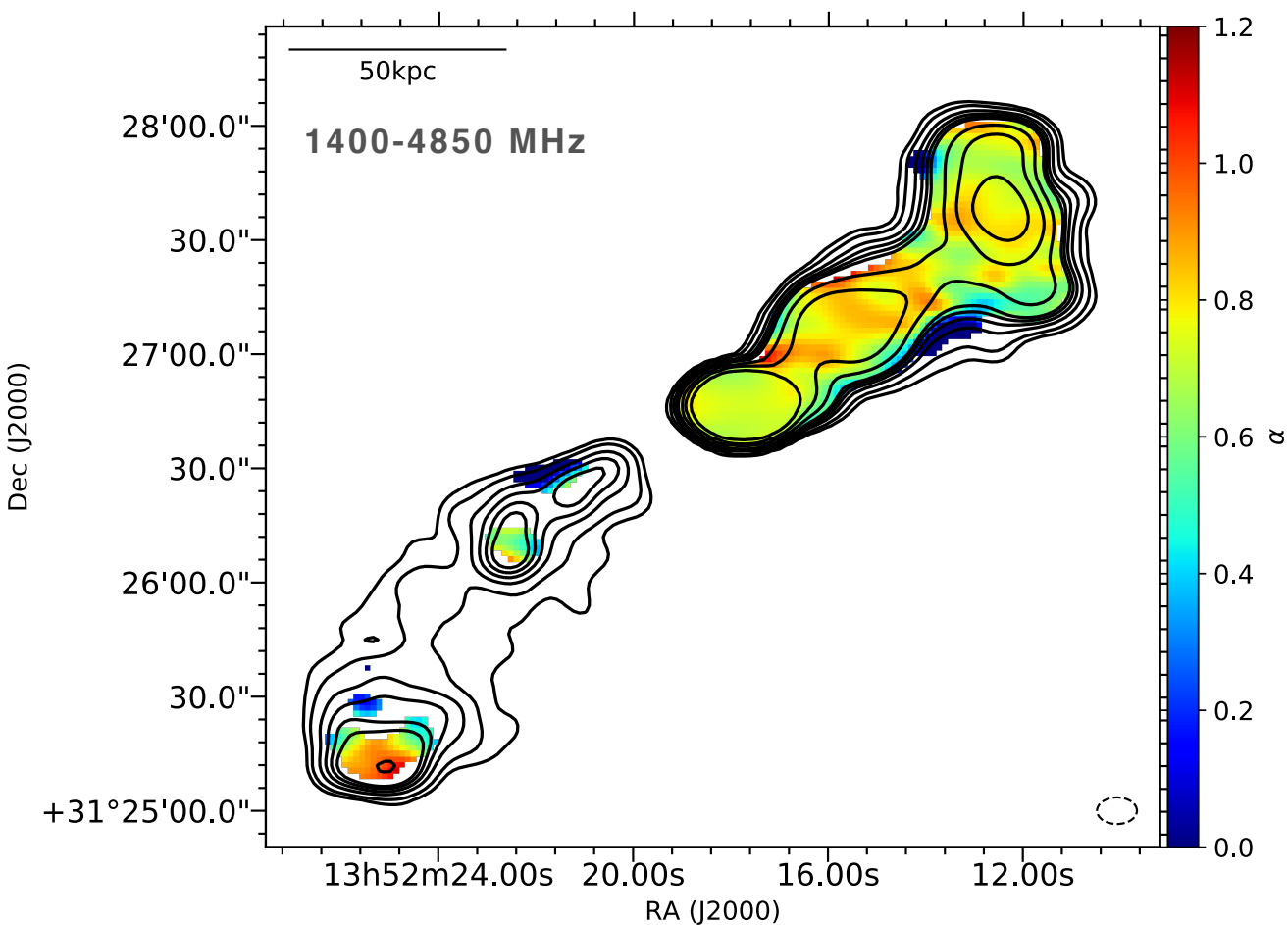
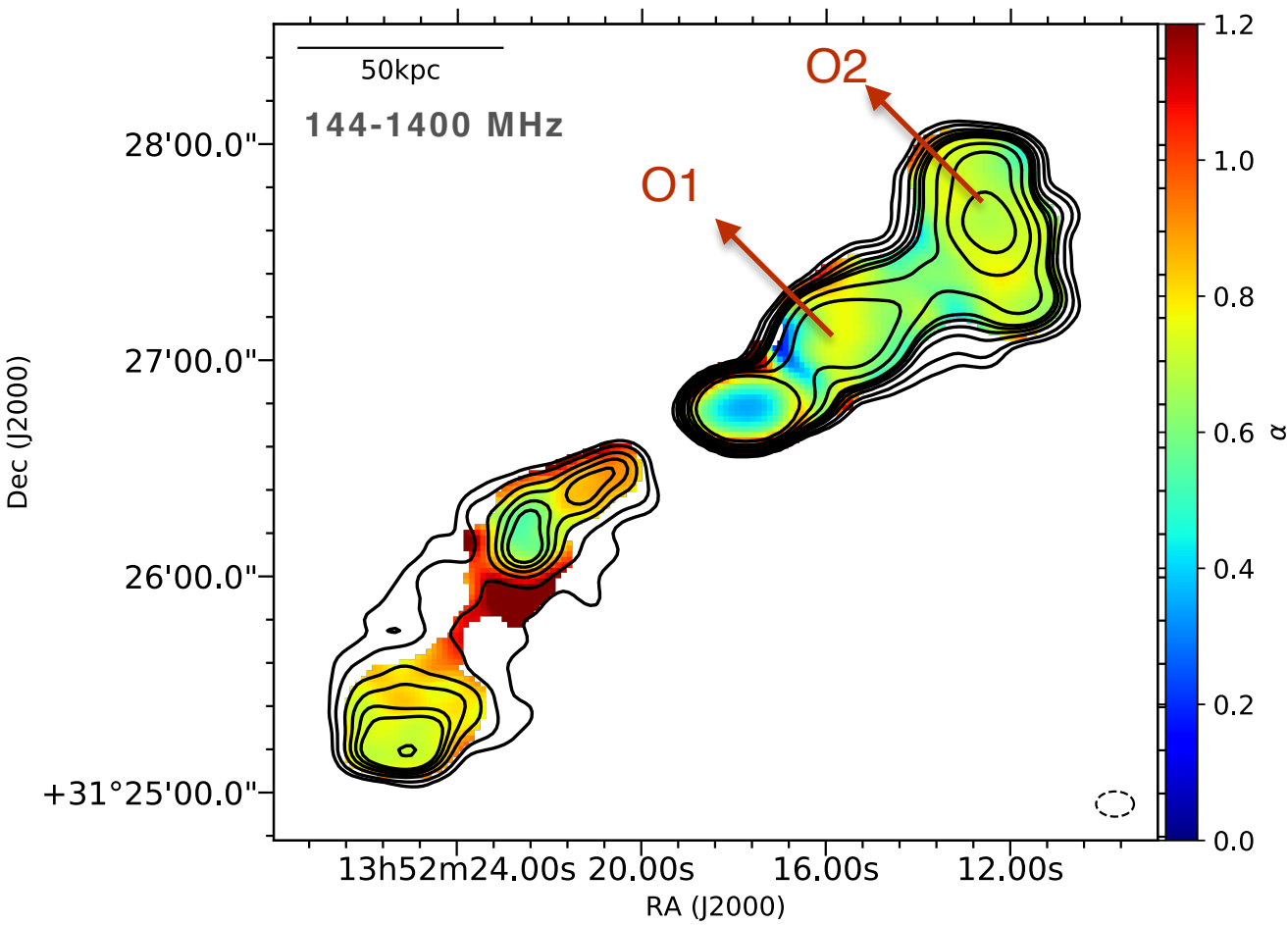


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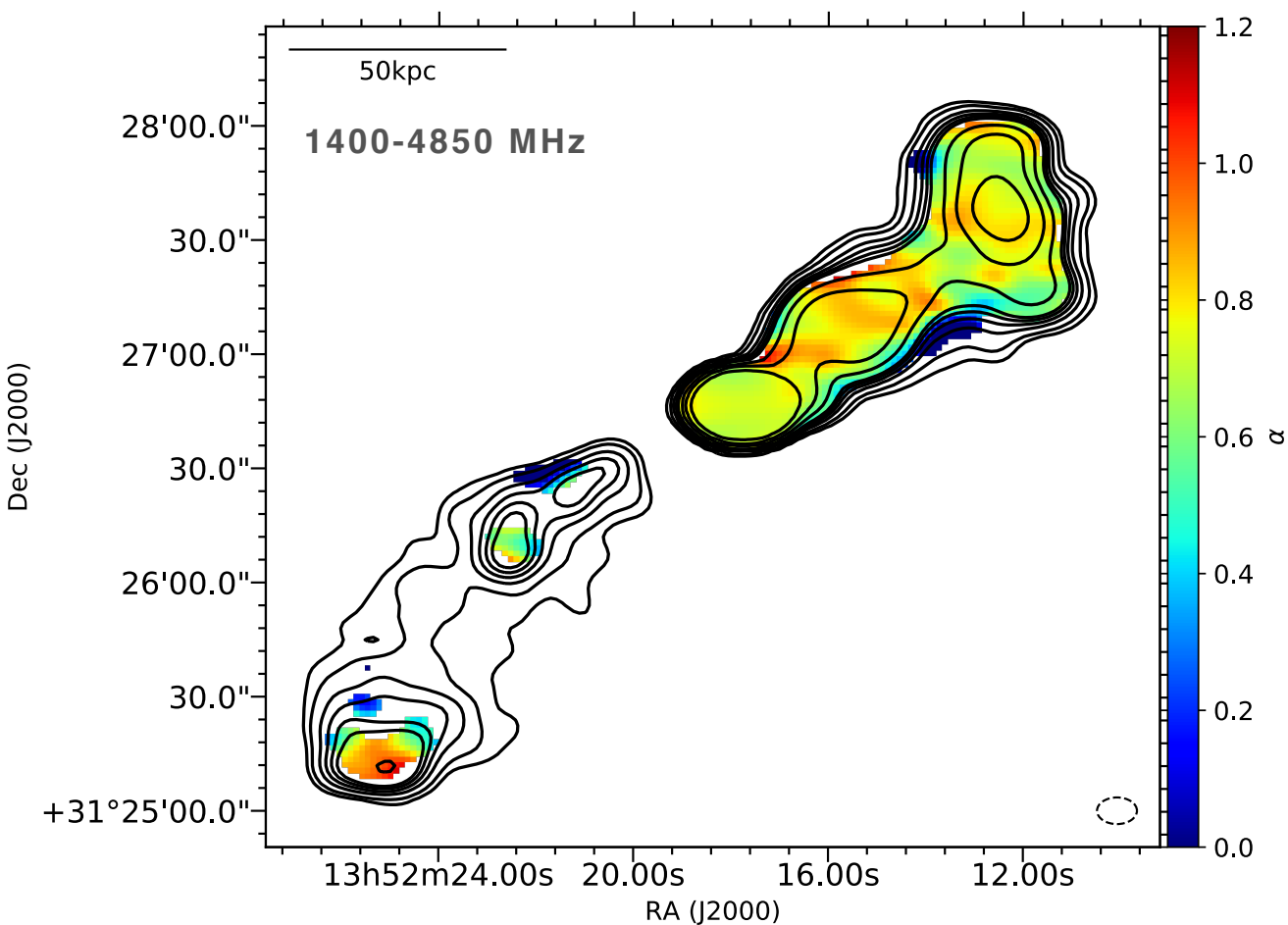
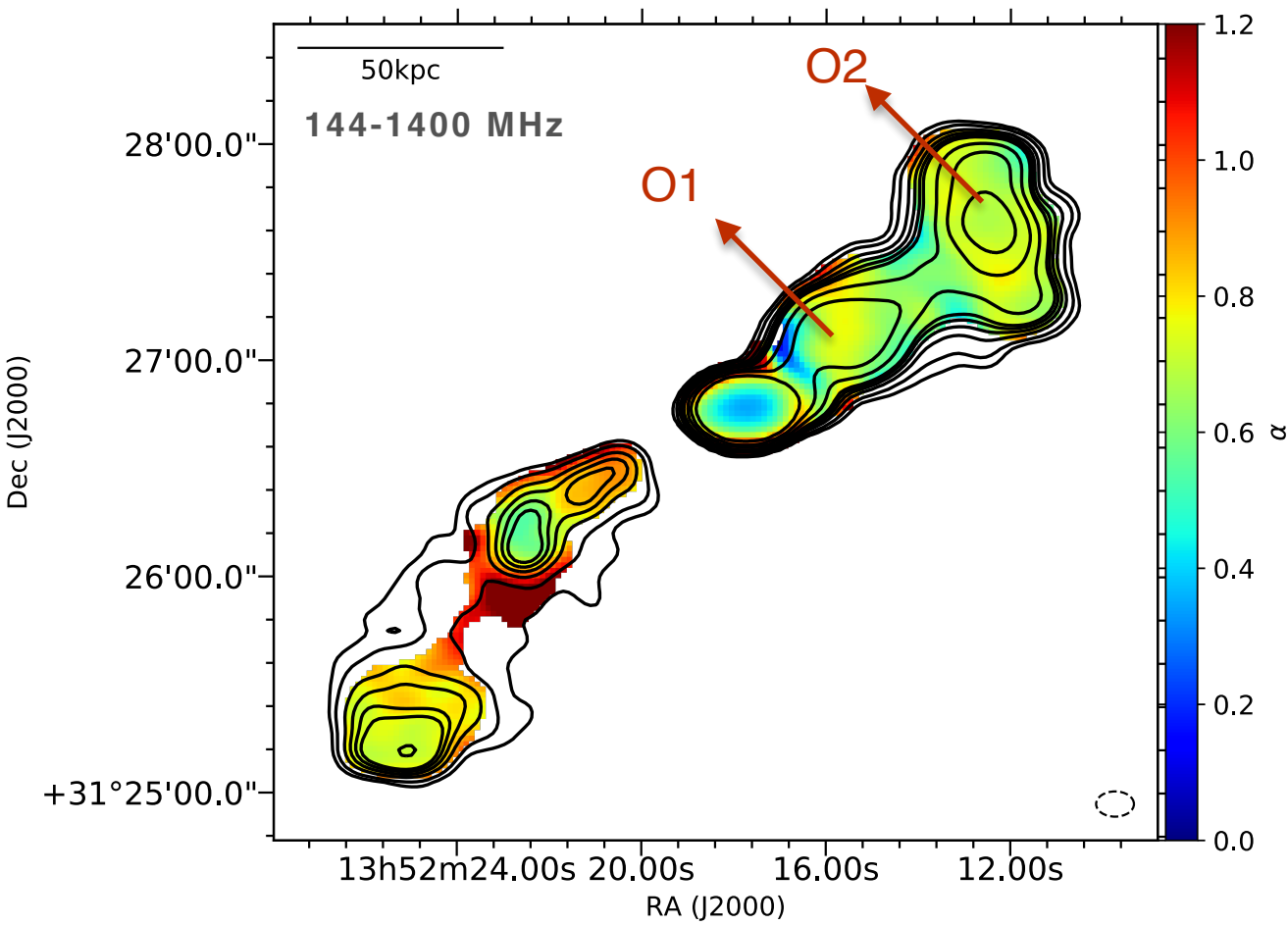


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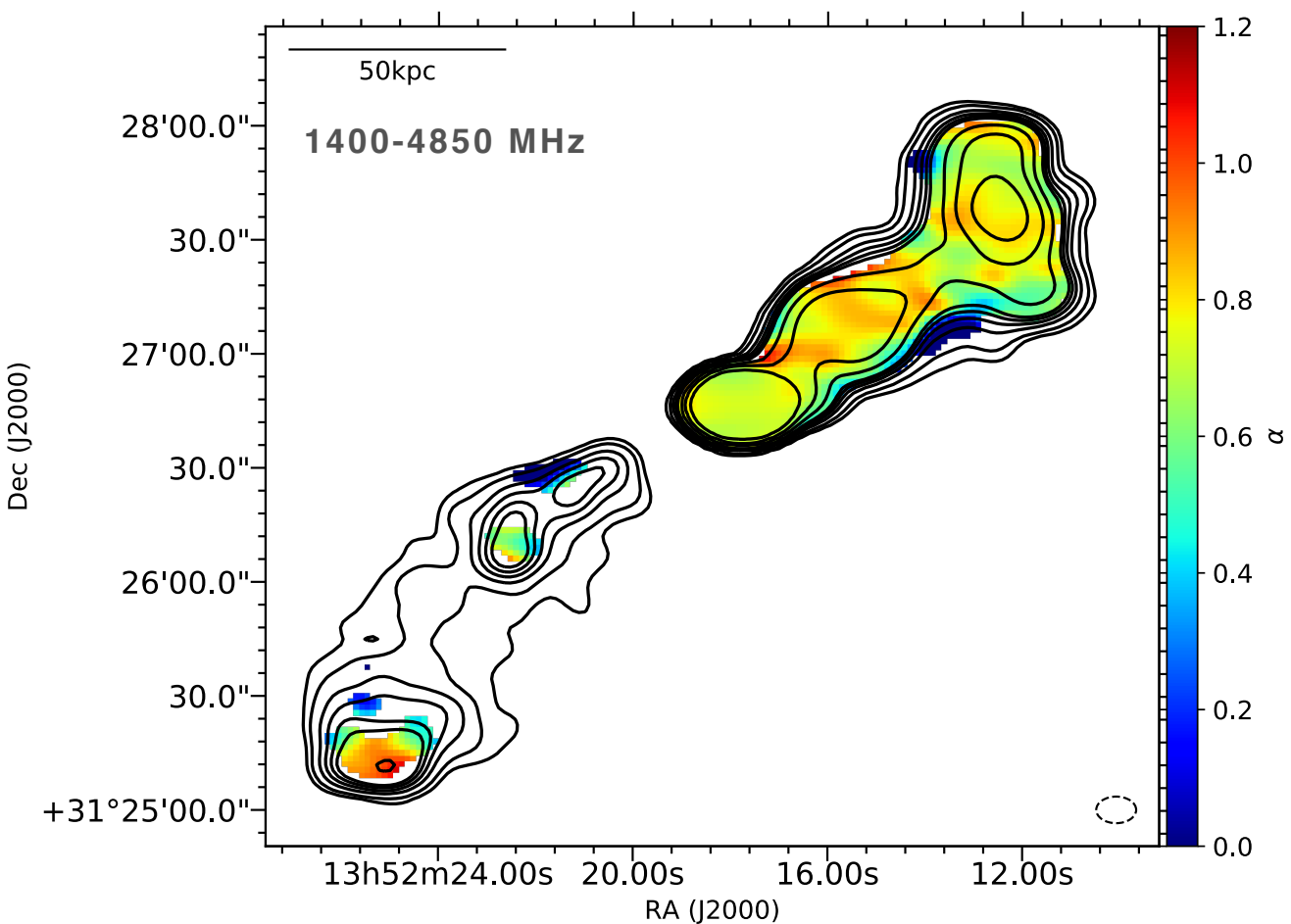
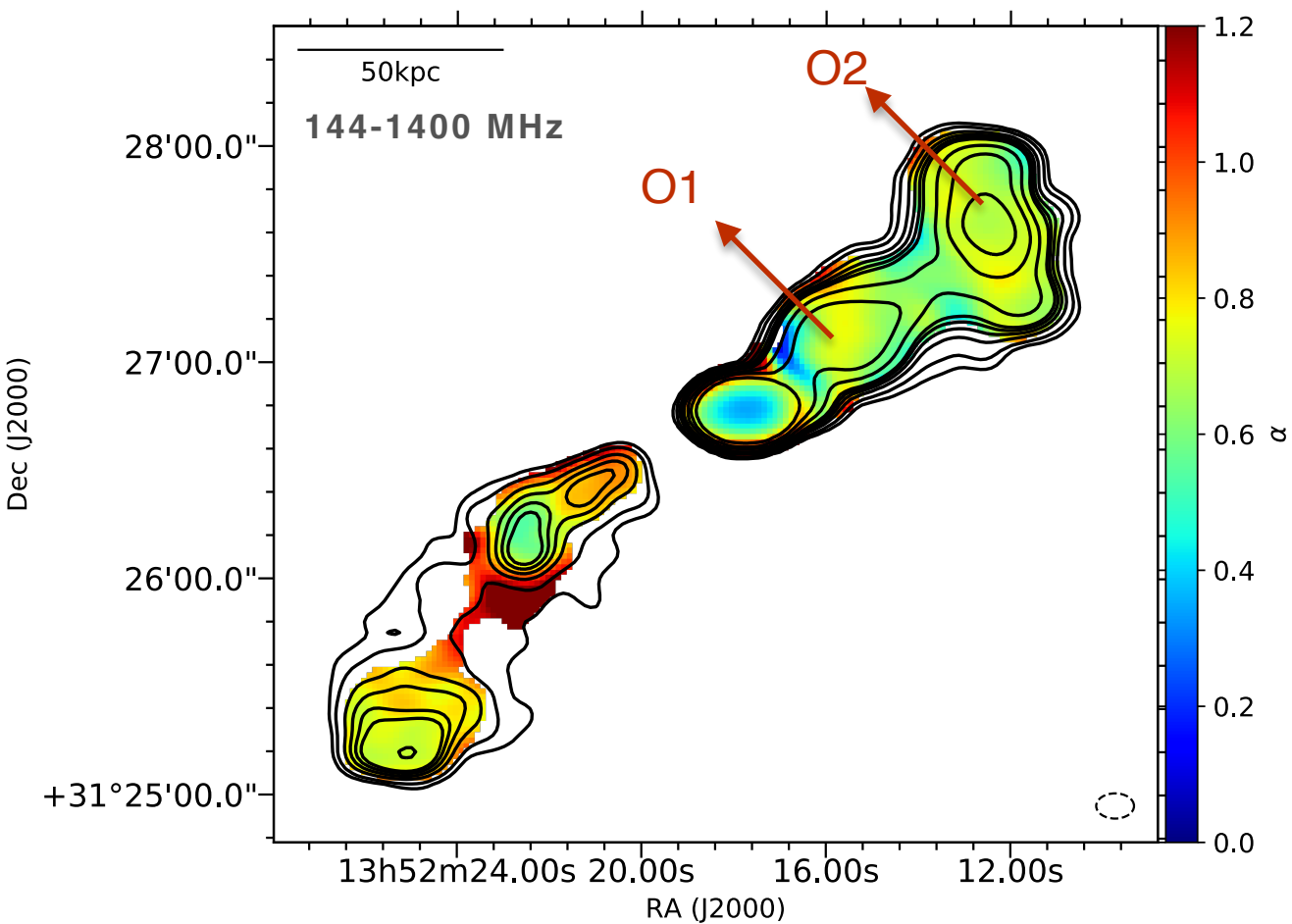
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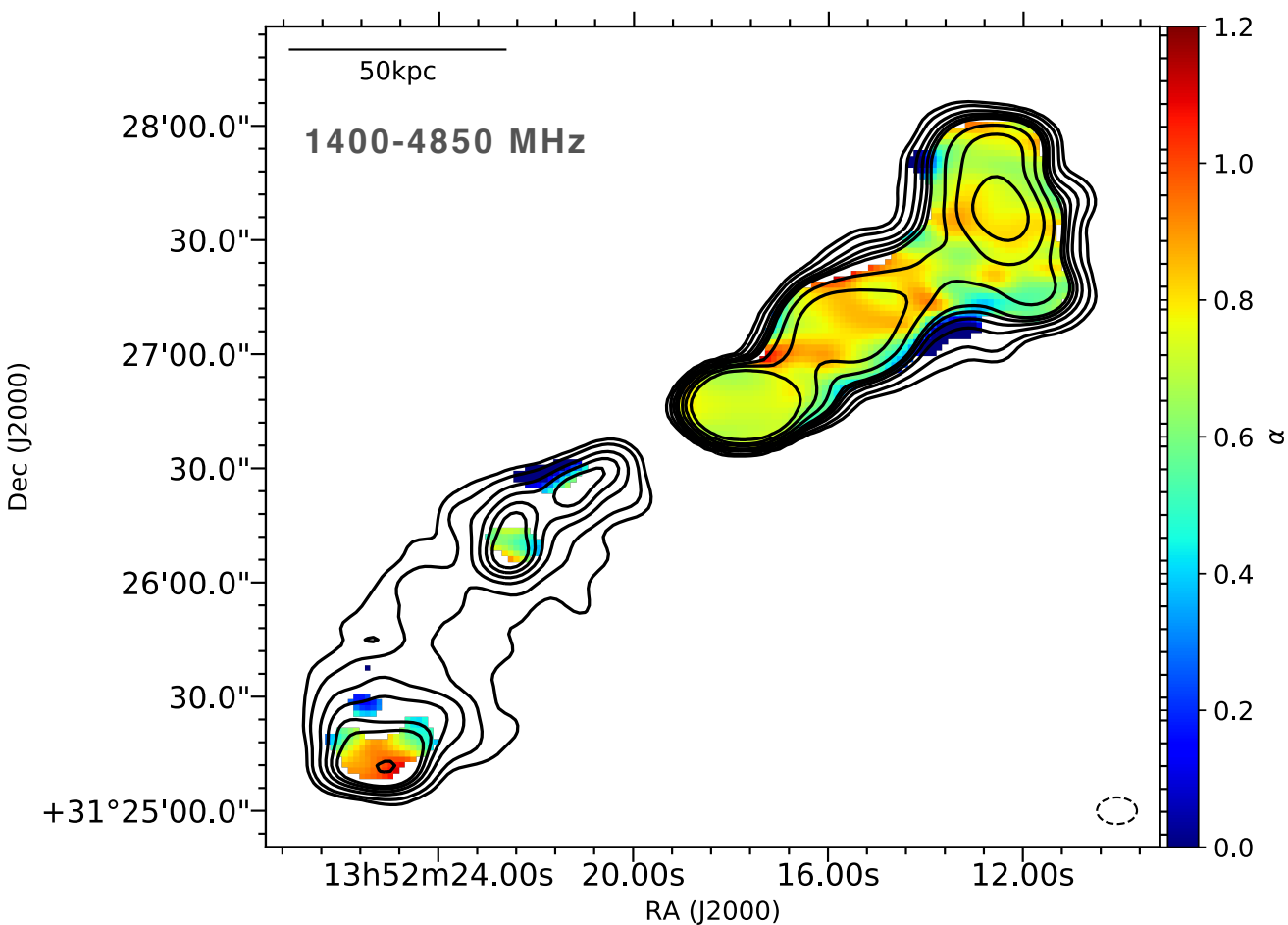
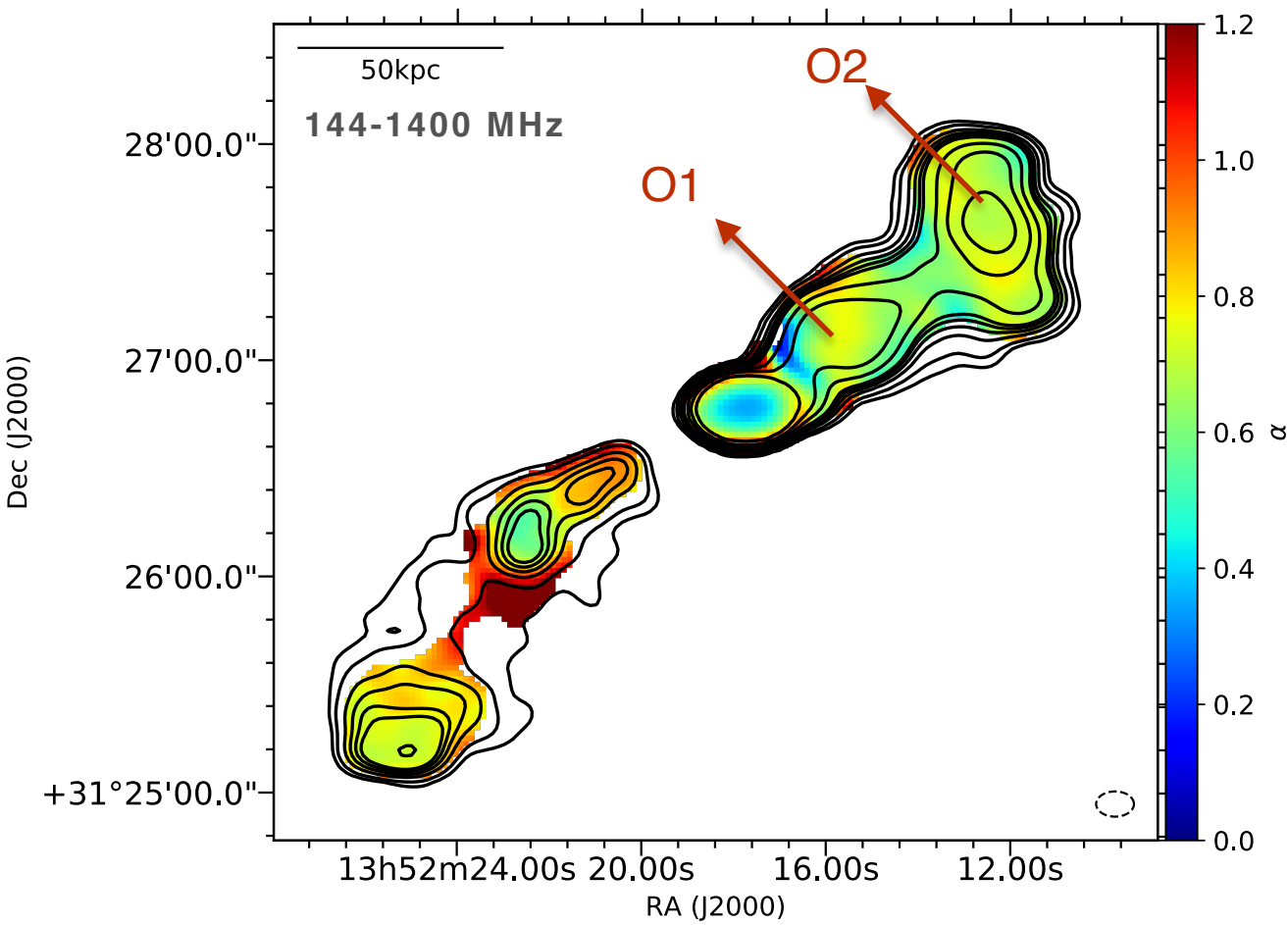
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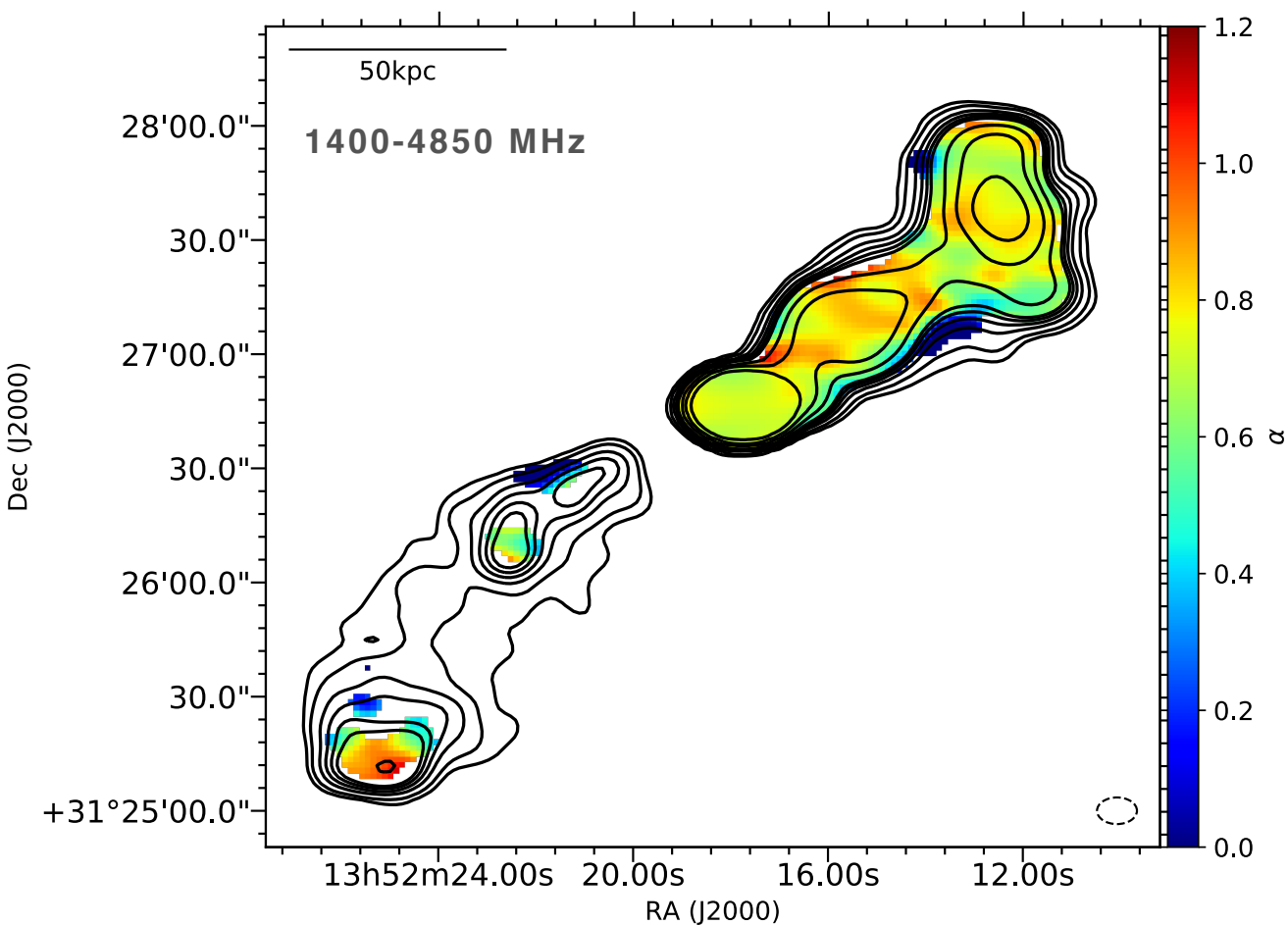
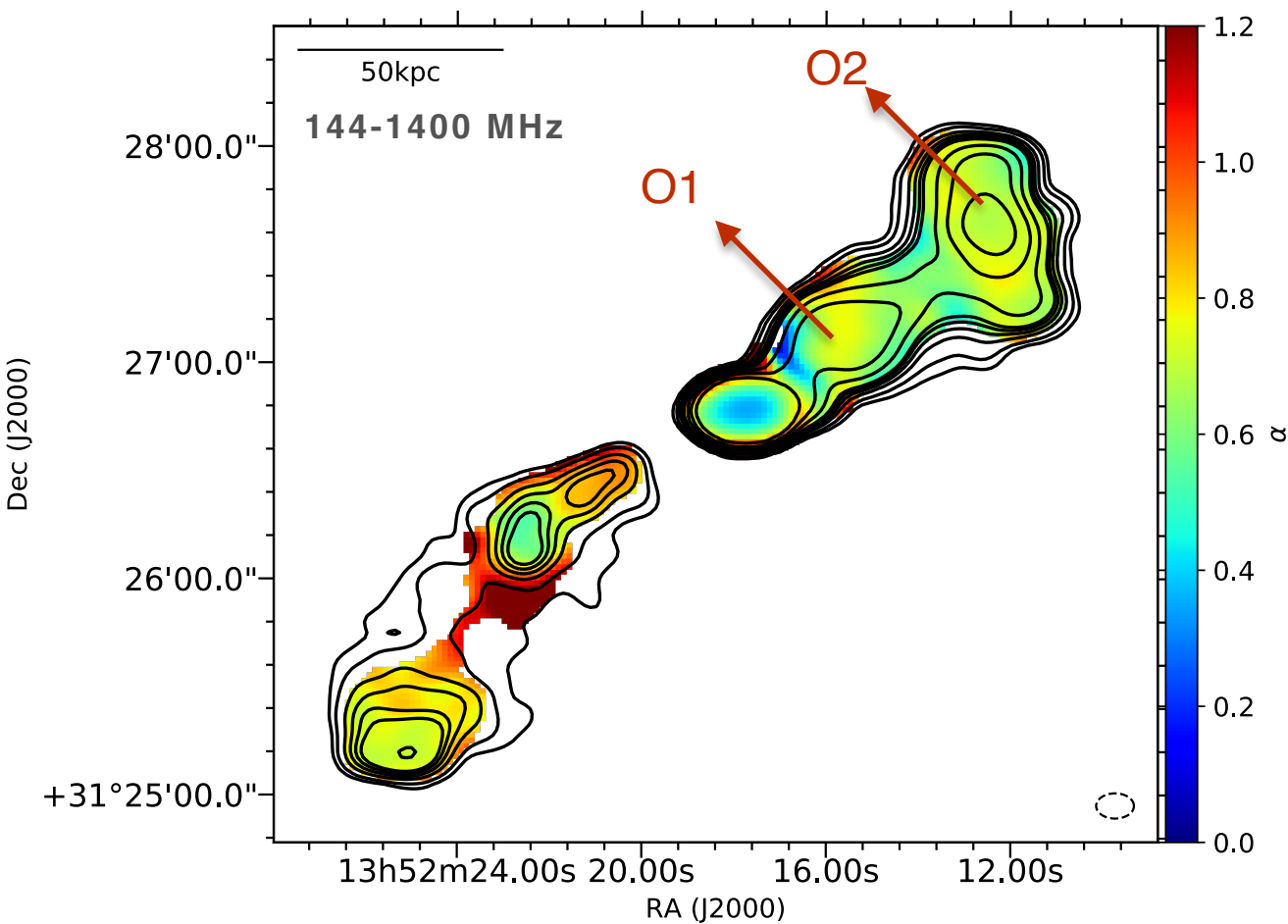
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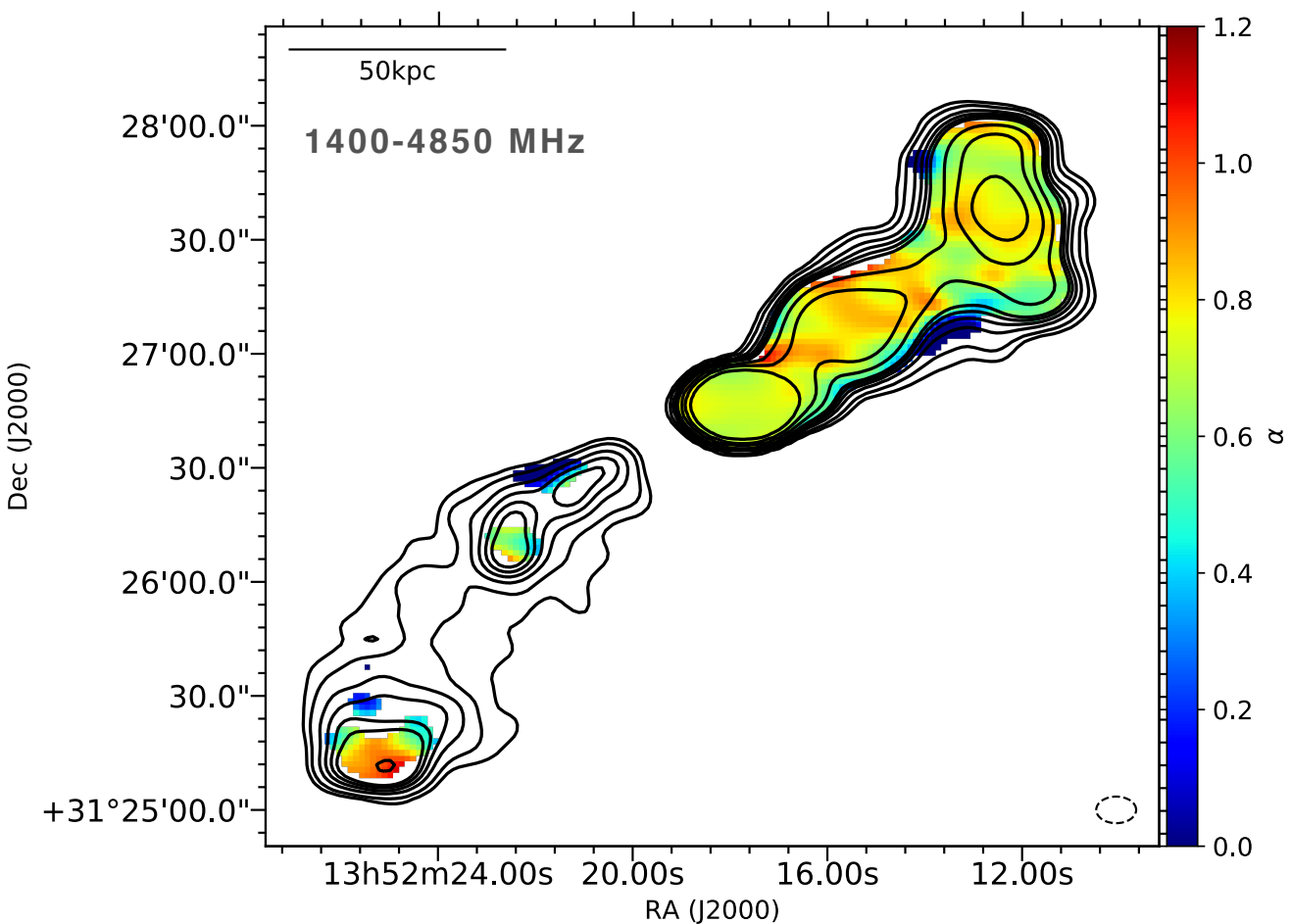
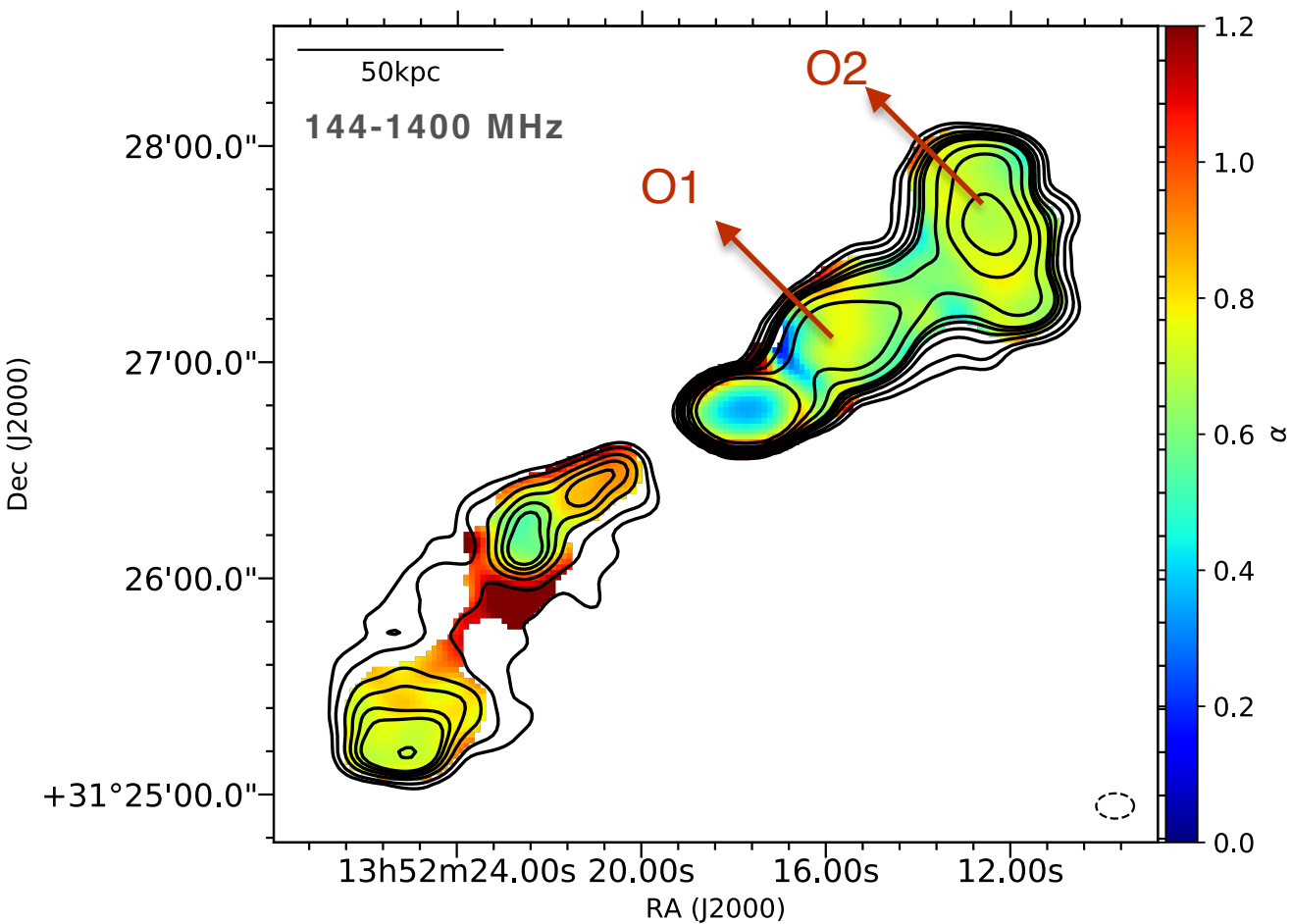
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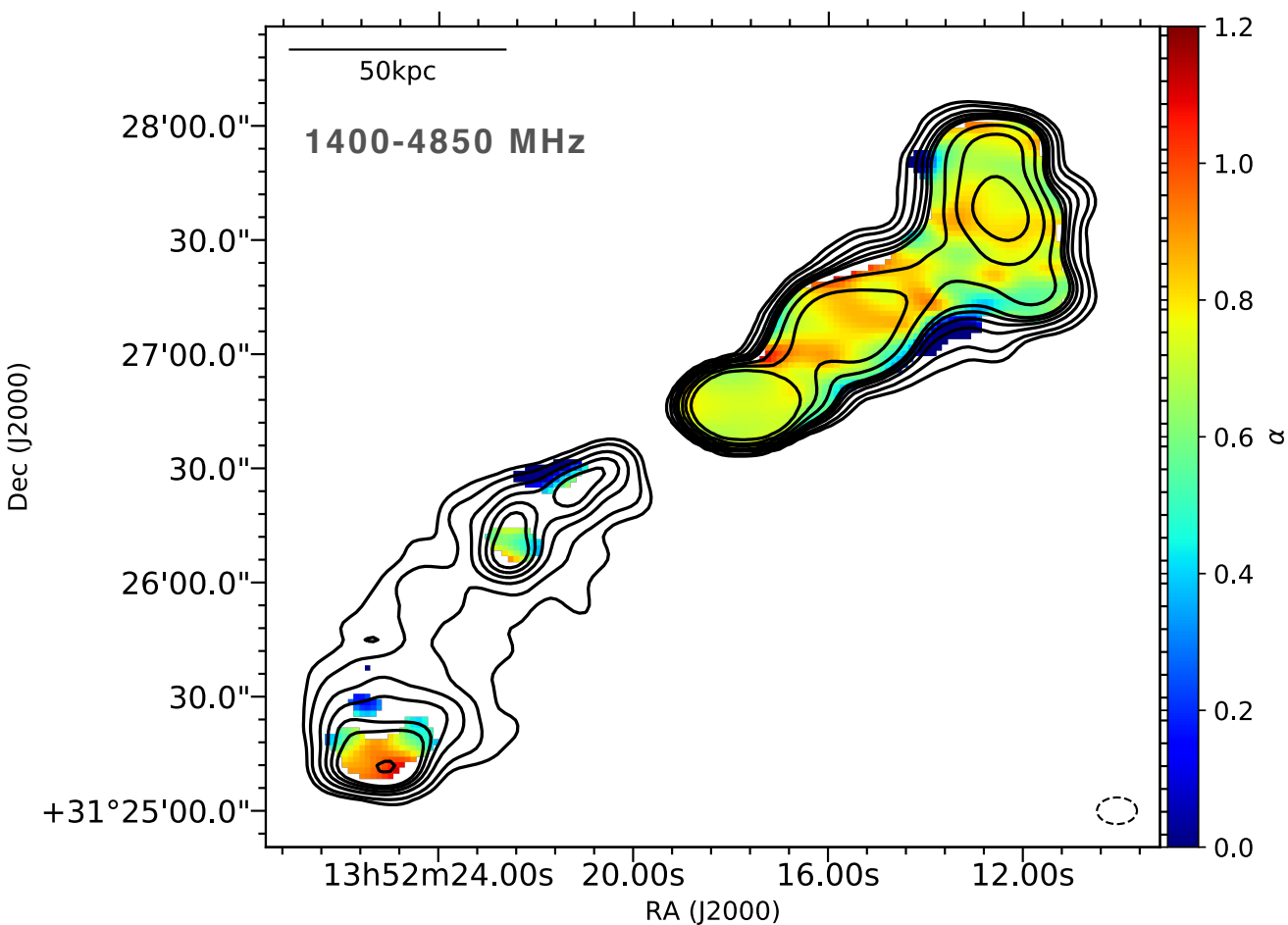
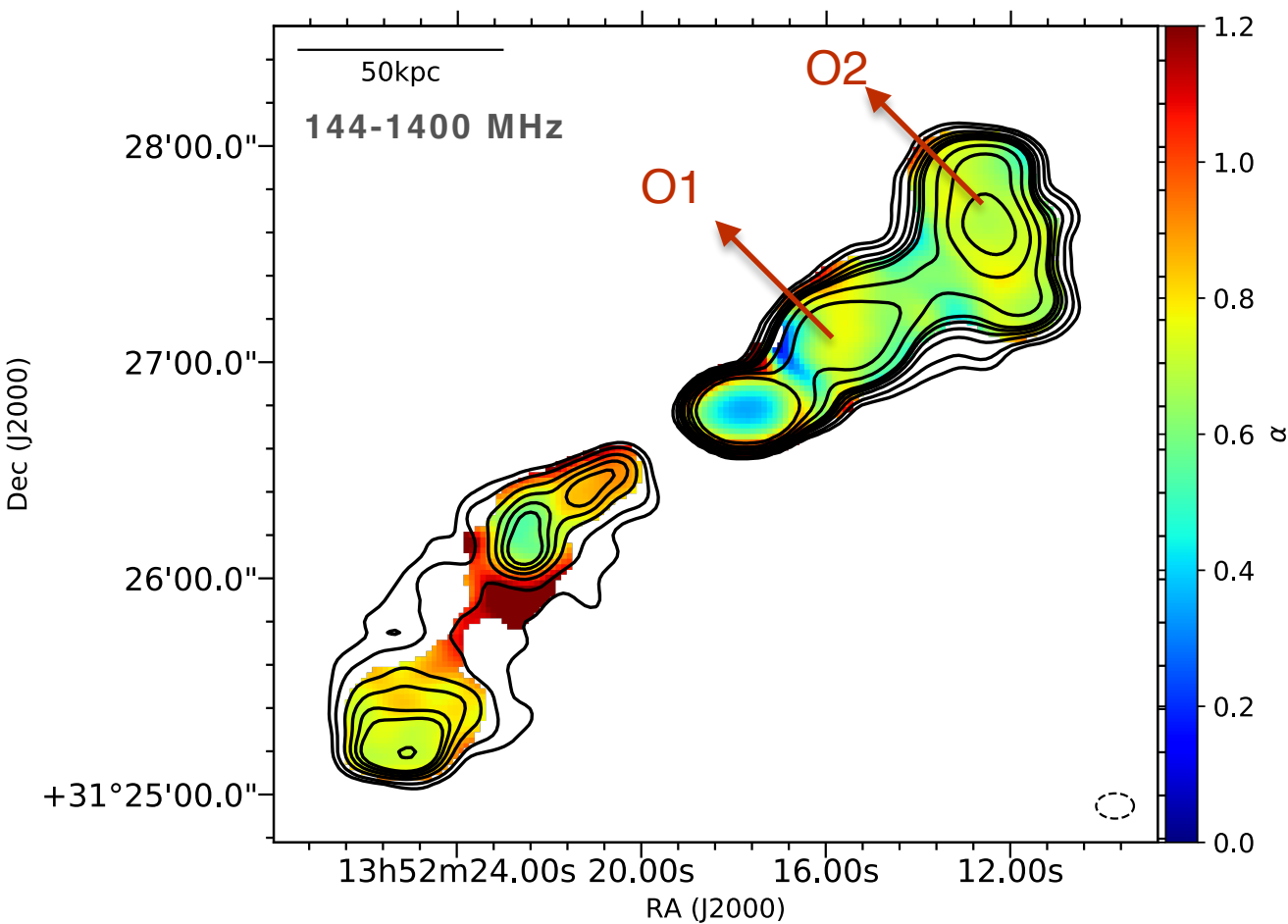
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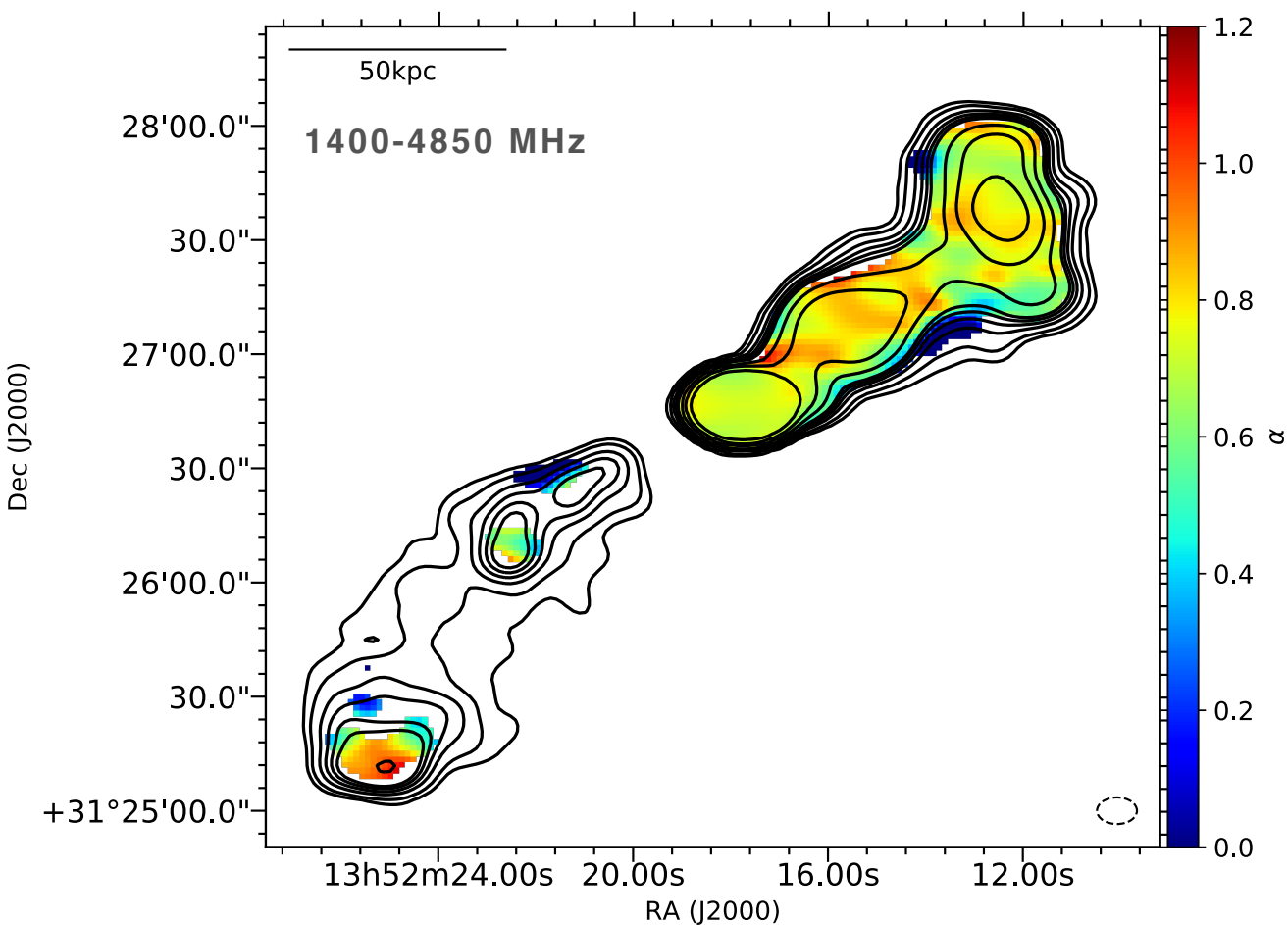
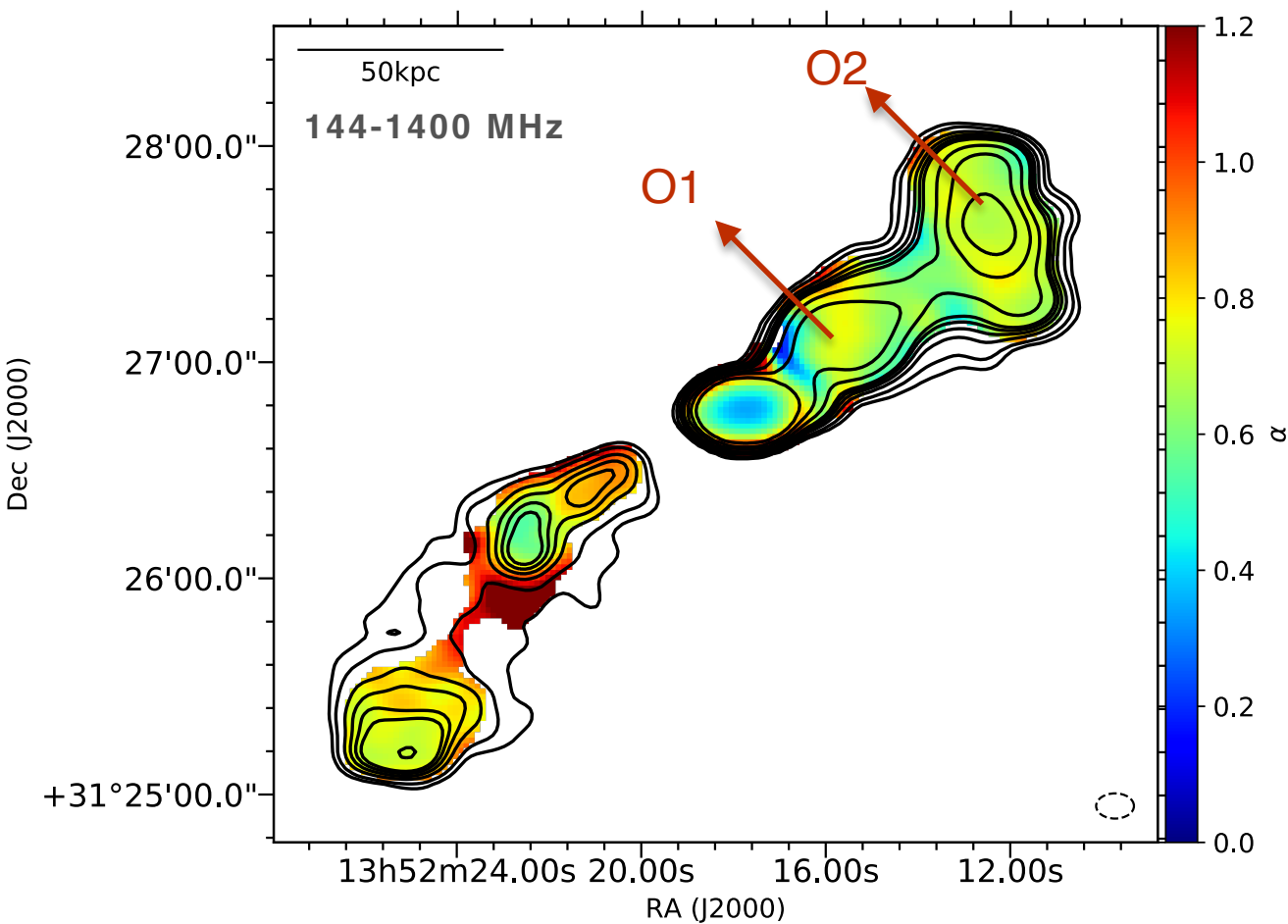
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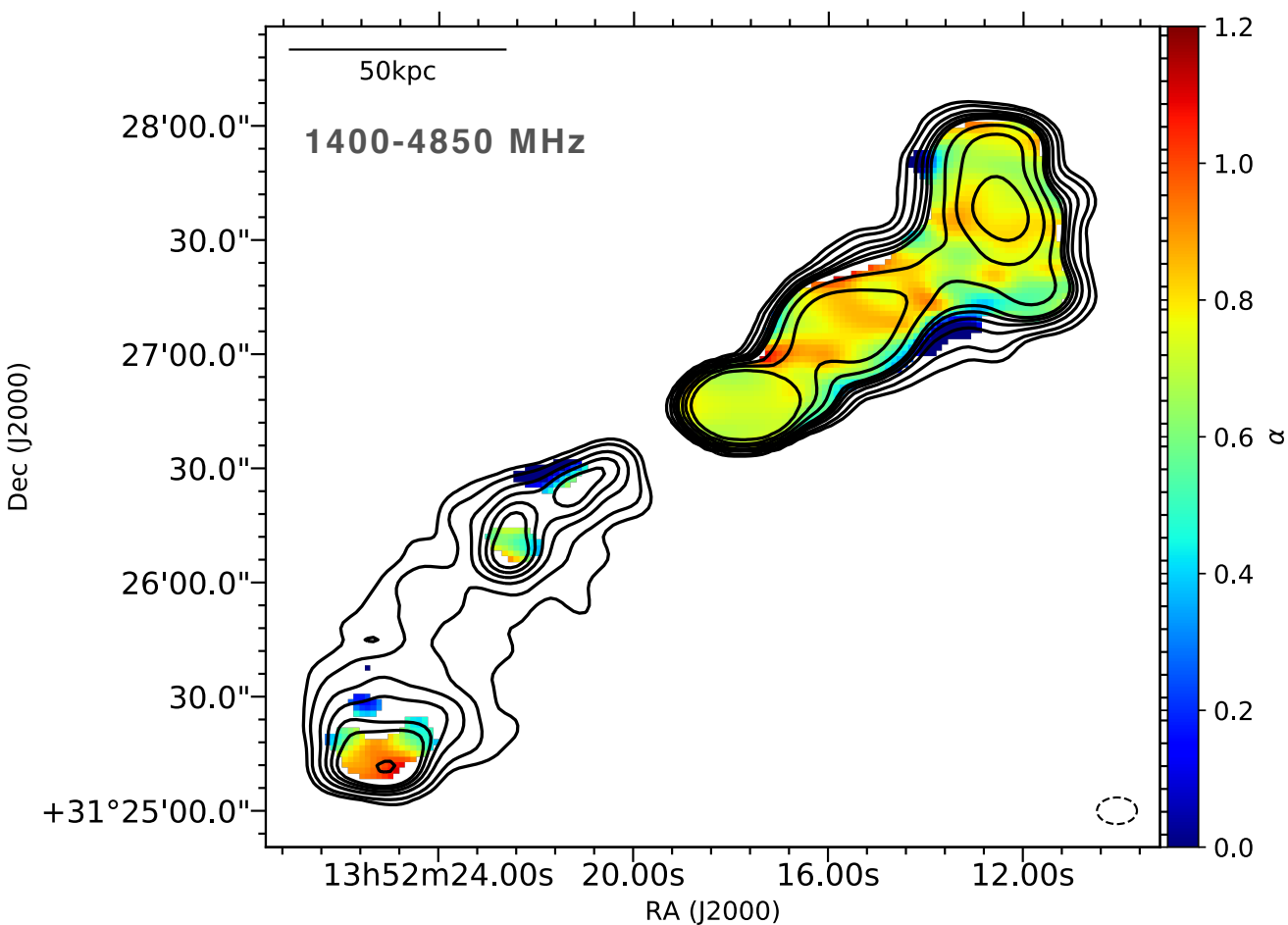
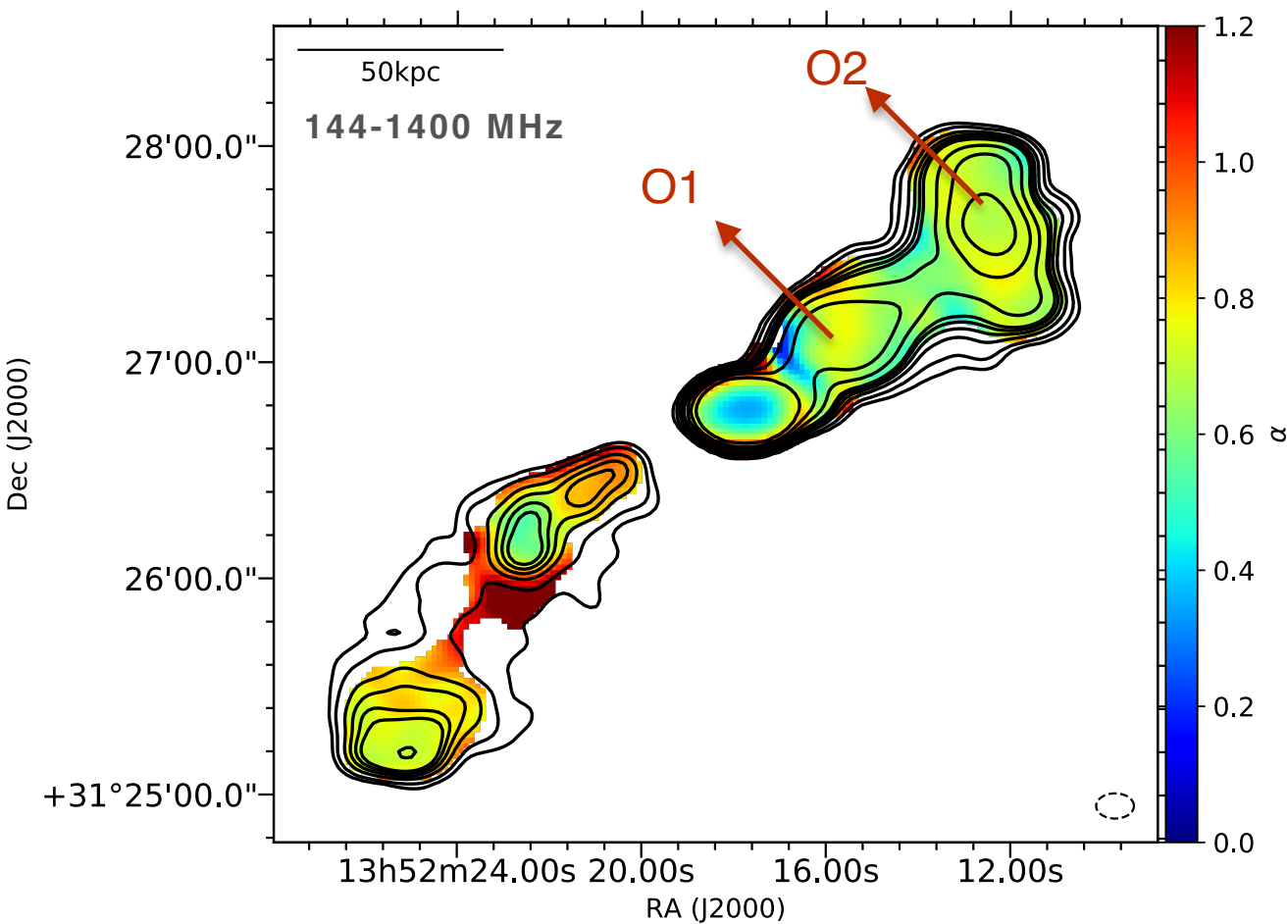
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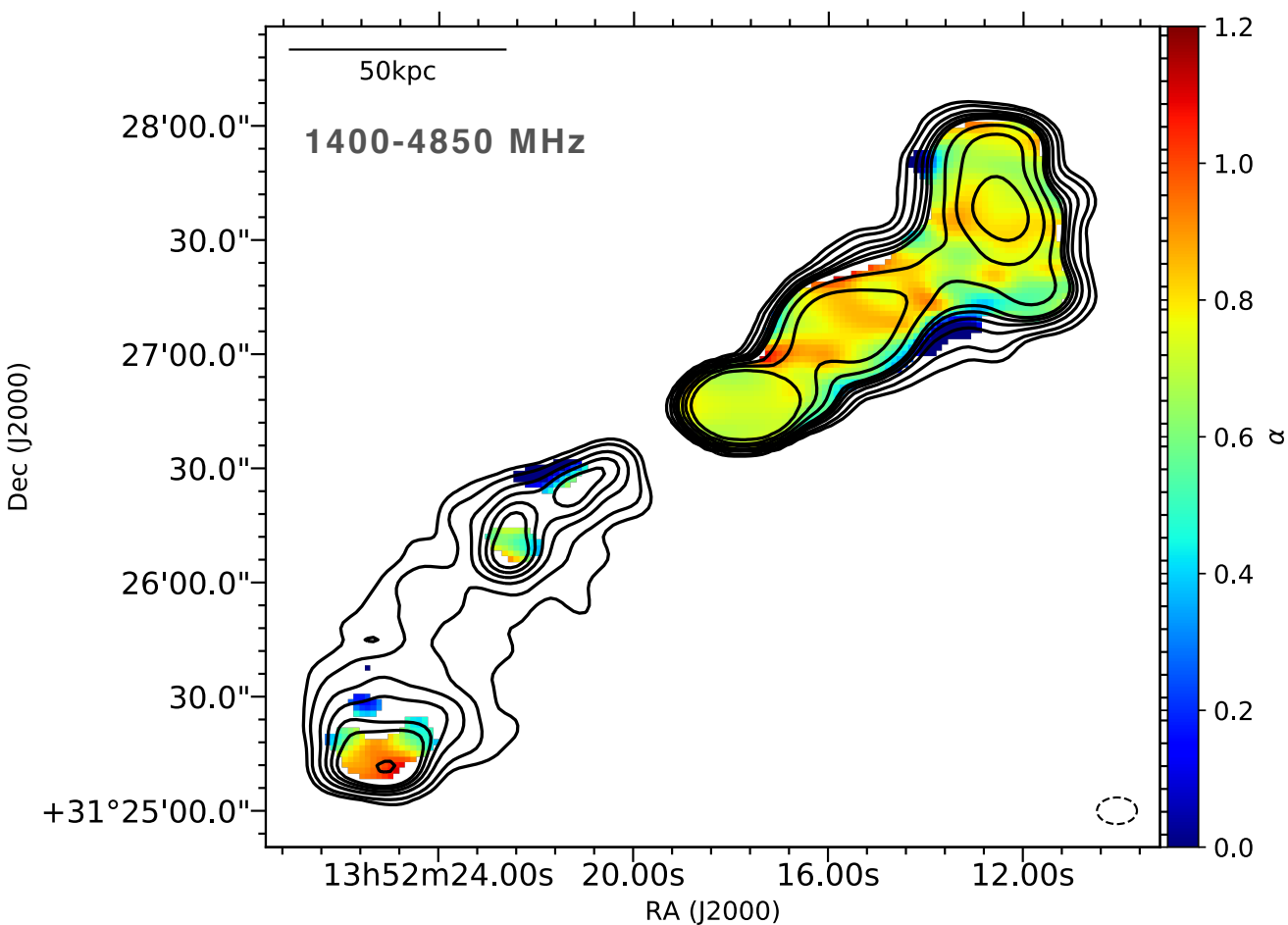
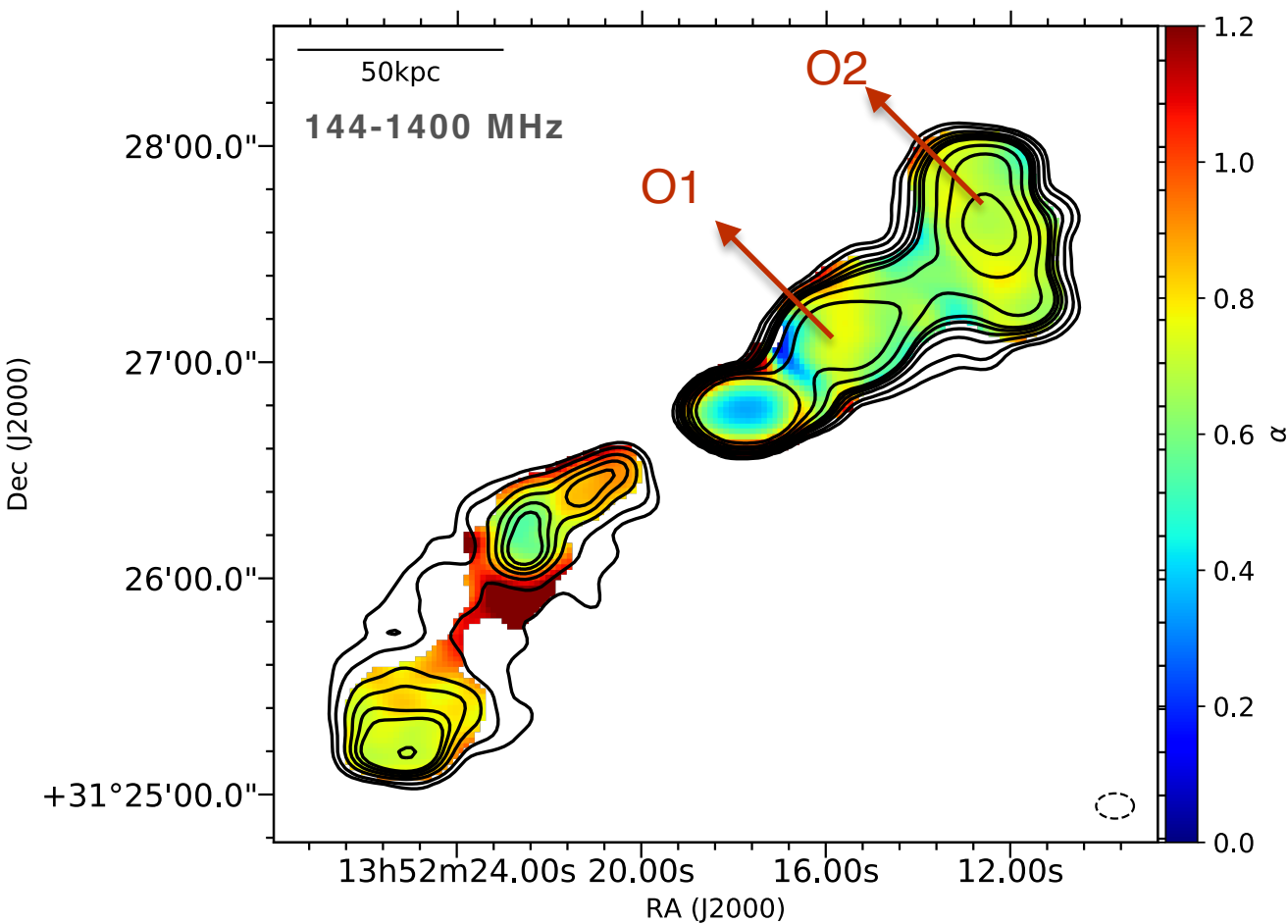
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- This adds 3C293 to a new sub group of galaxies with a life cycle different from model of typical restarted galaxies - short interruption or activity doesn't really stop. Possible link to them being gas rich and sometimes a merger?

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- Age, size and presence of turnover concludes inner lobes are a young CSS source whose growth is affected by the surrounding medium.
- Diffuse emission possibly formed by leakage of radio plasma from the jet, deflected and decelerated by interaction with the disc.
- Spectral properties of outer lobes suggest multiple phases of jet activity with short interruption phase (in agreement with Jurlin et al. 2020) or (and) the activity never really stops (low level fuelling). Outer lobes are still alive!
- This adds 3C293 to a new sub group of galaxies with a life cycle different from model of typical restarted galaxies - short interruption or activity doesn't really stop. Possible link to them being gas rich and sometimes a merger?
- ILT allows studying the small scale CSS emission and large scale lobe emission simultaneously! Synergy with APERTIF and WEAVE will be useful to explore the link between their life-cycle and gas properties!