Abell 399/401

Re-acceleration in radio bridge

Jurjen de Jong

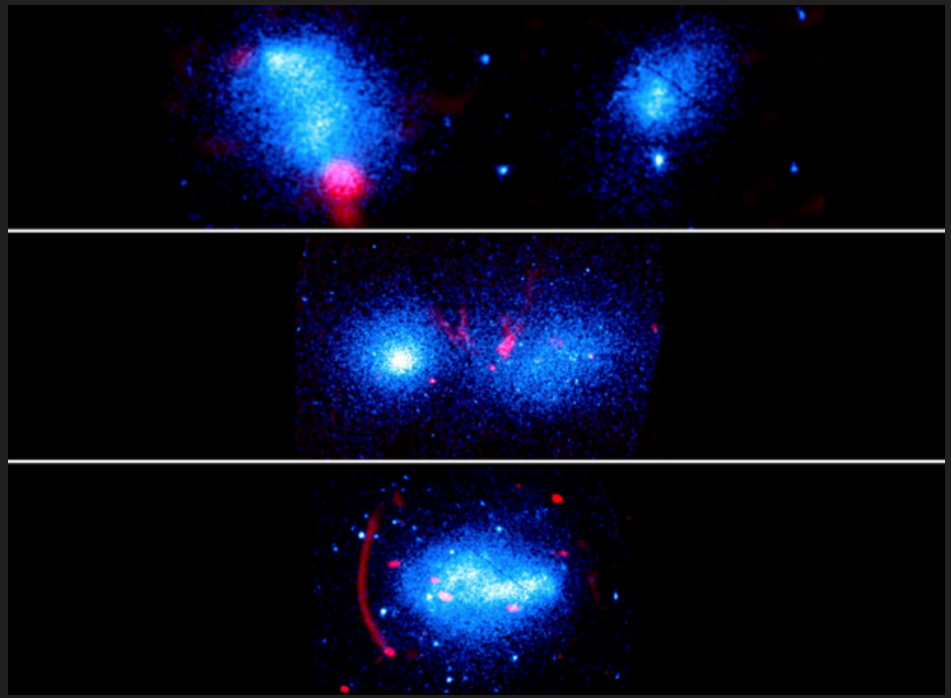
IAUGA 2022 (FM6)

Collaborators:
R. van Weeren, A. Botteon, R. Oonk, G.Brunetti, T. Shimwell, R. Cassano,
H. Röttgering, C. Tasse

Universiteit
Leiden

Galaxy cluster mergers

- Energetic events ~10^{64} erg
- Filaments (bridges) between pre-merging clusters
- Magnetic fields and cosmic rays
- Diffuse synchrotron emission



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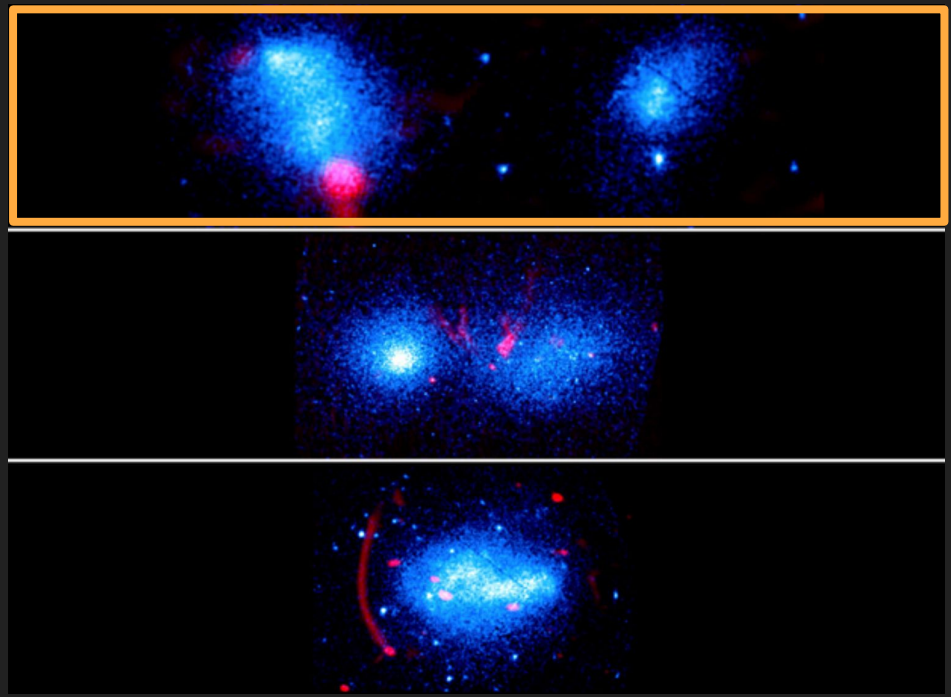
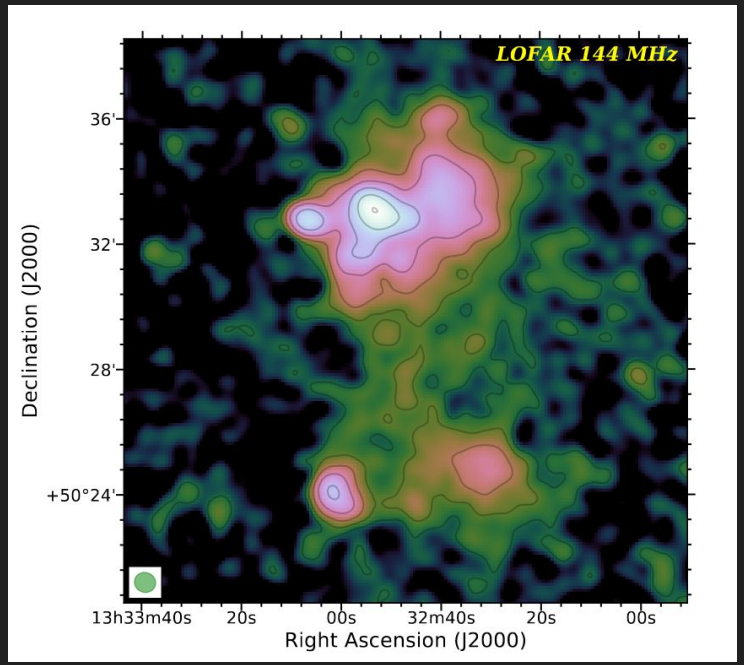


Radio bridges

Botteon et al. 2020:

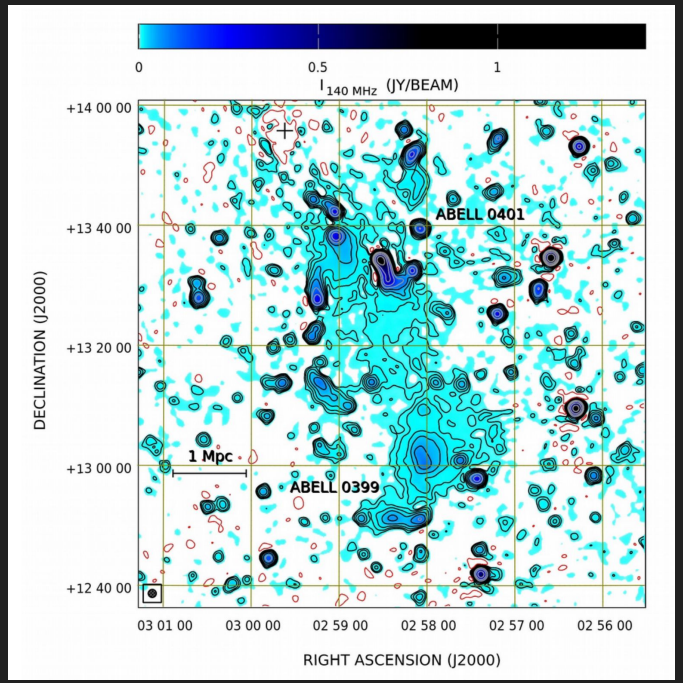
Abell 1758N - Abell 1758S



~2 Mpc at z=0.279

Govoni et al. 2019:

Abell 399 and Abell 401



~3 Mpc at z=0.072

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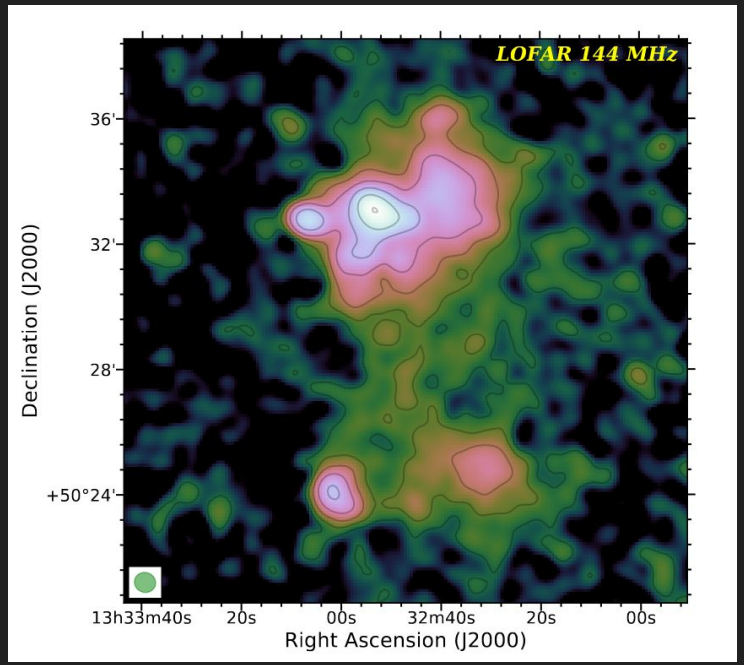

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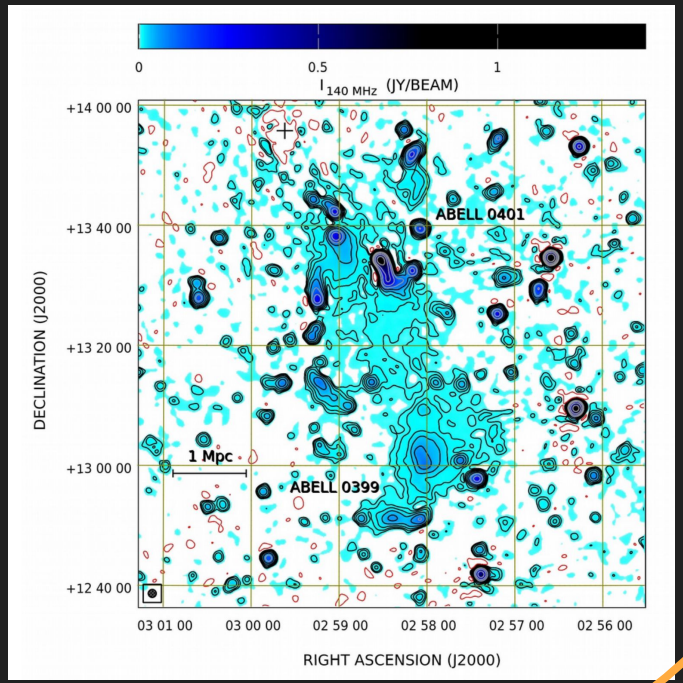

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Radio bridge origin

- Lifetime electrons vs. bridge size →sub-Mpc vs. ~Mpc scale
- In-situ re-acceleration of fossil electrons
- Particle injection by shocks, AGN, Galactic winds, ...

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	Fermi-I (weak shocks) (Govoni et al. 2019)	**Fermi-II (turbulence)** (Brunetti et al. 2020)
Radio distribution	Substructure	Smooth/volume-filling
Radio/X-ray correlation	Weak	Strong

Open questions

1) Origin of cosmic rays in the radio bridge?

2) What is the main (re-)acceleration mechanism in the radio bridge?

LOFAR Data

- Abell 399-401
- 6x8-hour LOFAR observations
- HBA [120-168 MHz]
- Dutch stations

Calibration

Issues	Solutions	Case
Bright sources		

Calibration

Issues	Solutions	Case
Bright sources	Direction-dependent recalibration (van Weeren et al. 2021)	N=1

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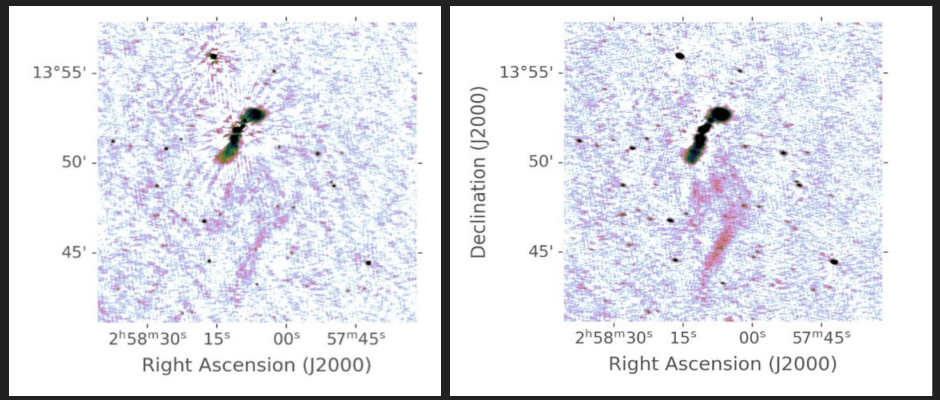
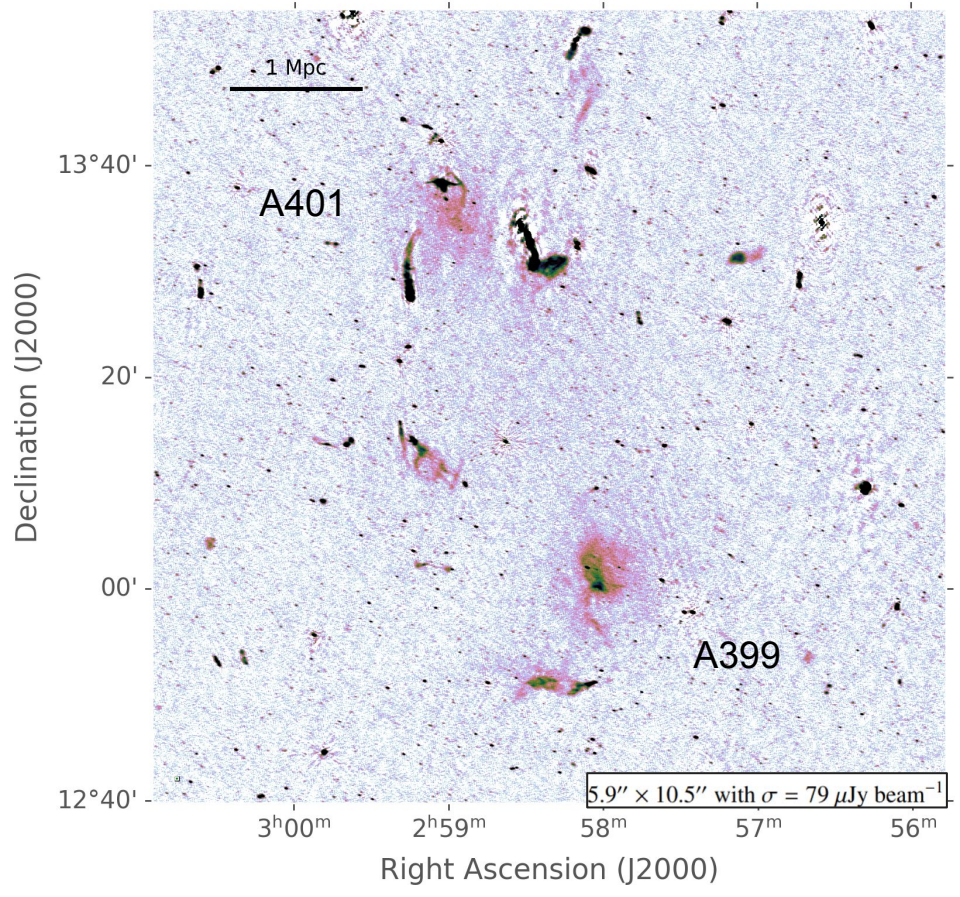
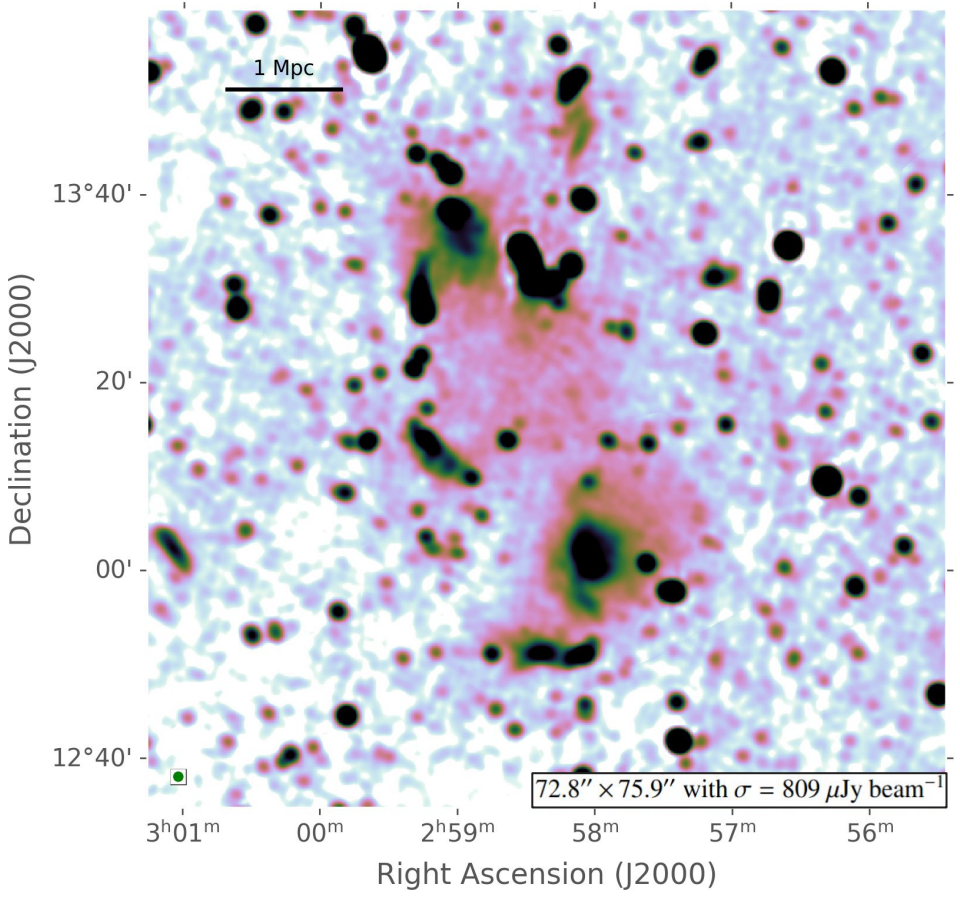
Standard **Recalibration**



Results


1 Mpc
A401
A399
13°40'
20'
00'
12°40'
Declination (J2000)
3h00m
2h59m
58m
57m
56m
Right Ascension (J2000)
5.9″ × 10.5″ with σ = 79 μJy beam−1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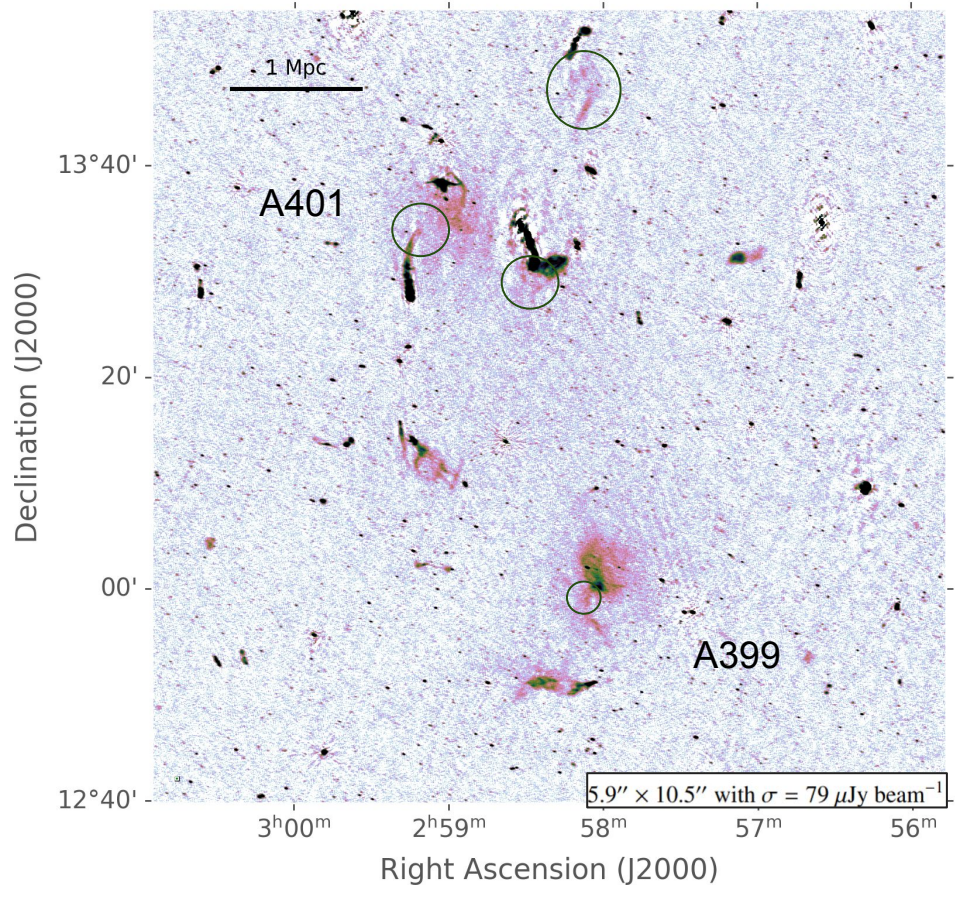
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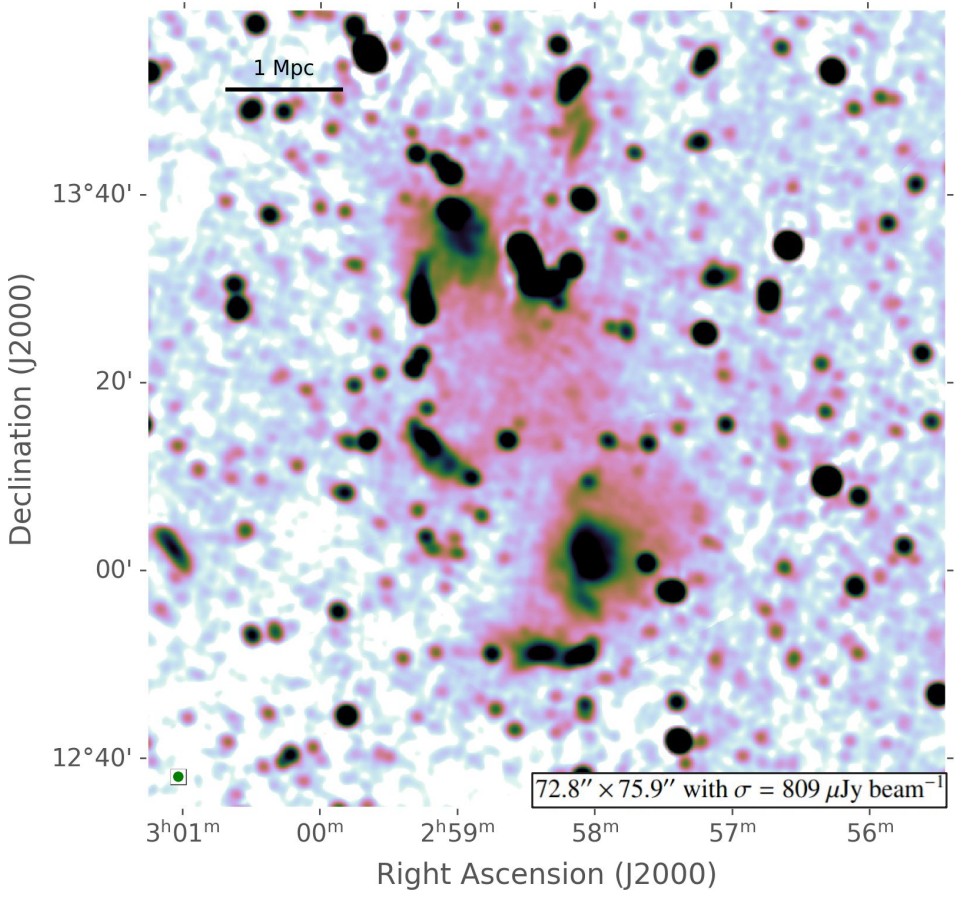
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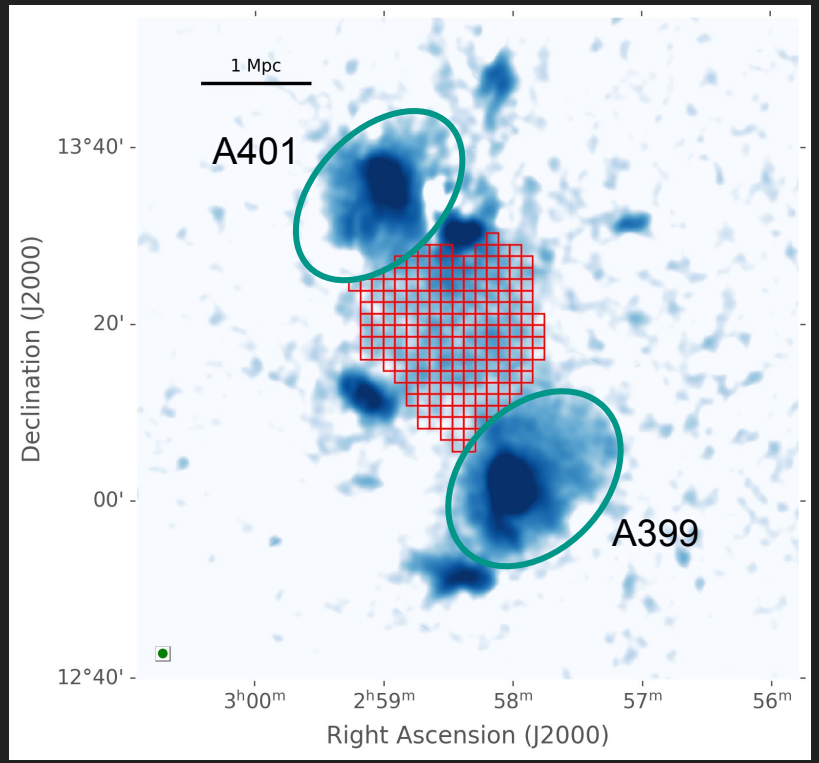
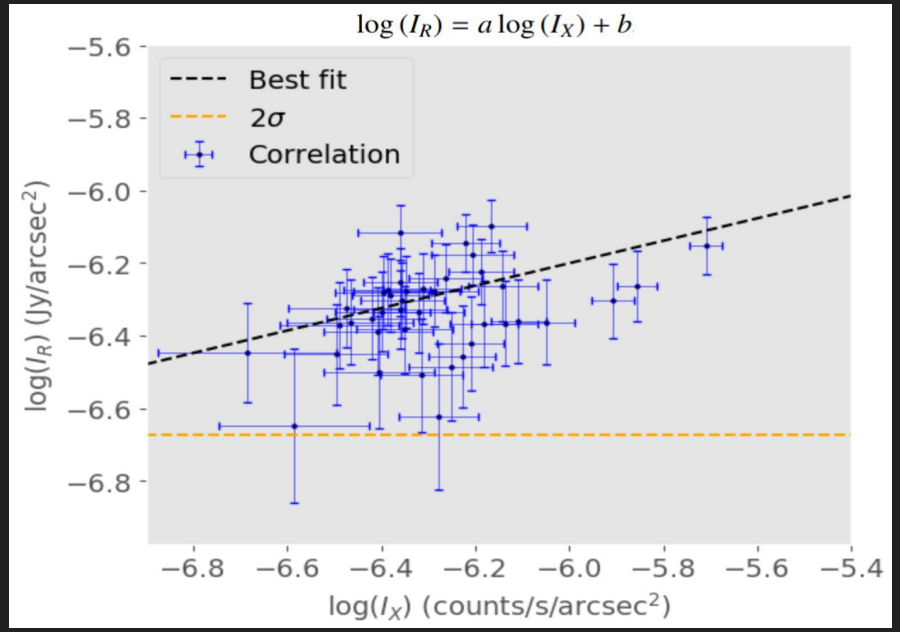
Radio/X-ray trend



LOFAR



XMM-Newton

Ingredients

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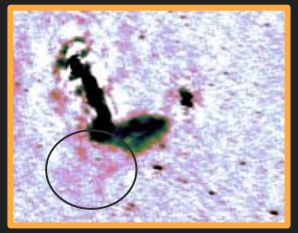

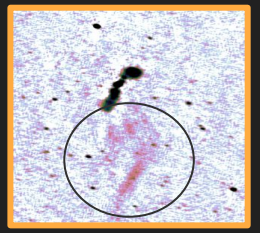

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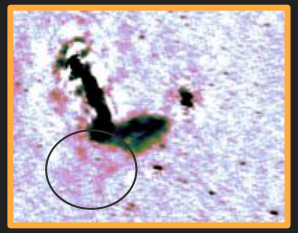
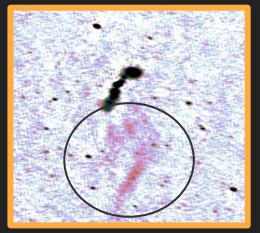
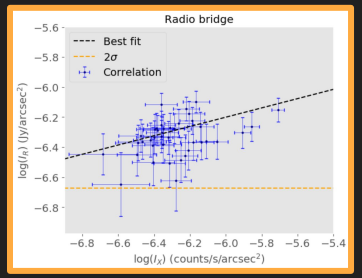




2) Trend between radio and X-ray



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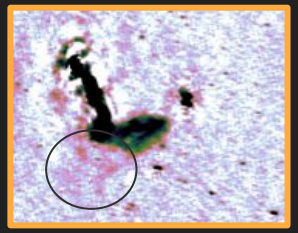

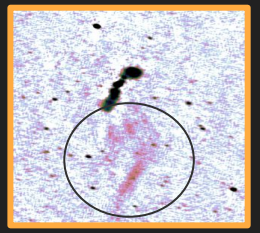

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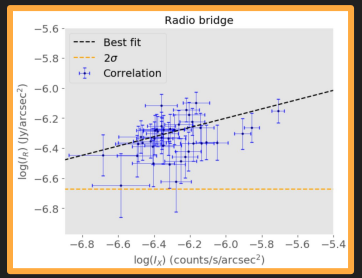

3) Steep spectral index –> **α > 1.5**

(Nunhokee et al. 2021)

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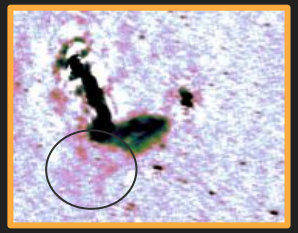

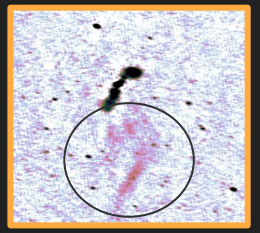

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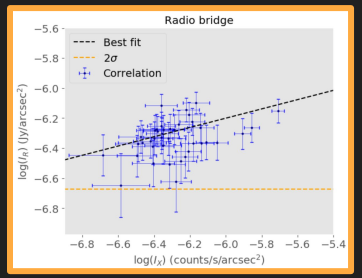

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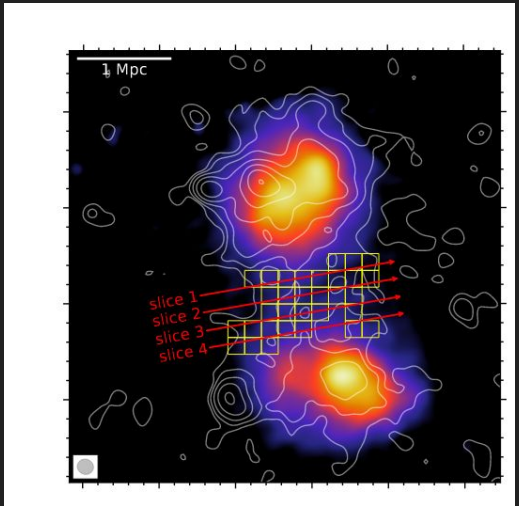
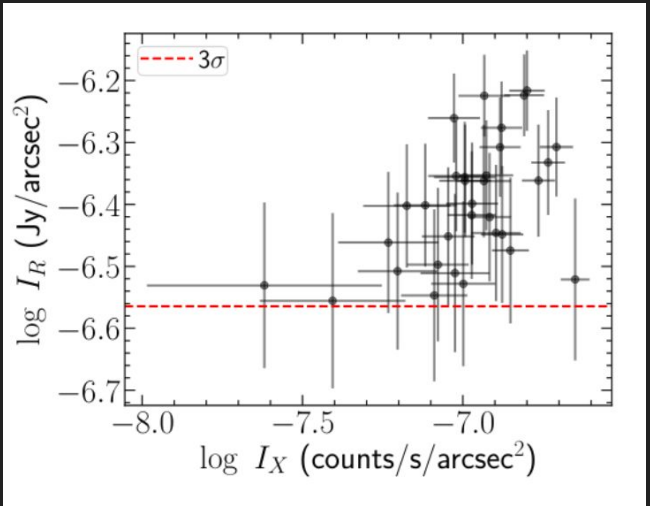
Fermi-II re-acceleration

(Predicted by Brunetti et al. 2020)

Other radio bridge (A1758)

- Radio/X-ray trend is very similar –> similar origin?
- Different radio/X-ray relation than radio halos
- Need N>2





(Botteon et al. 2020)

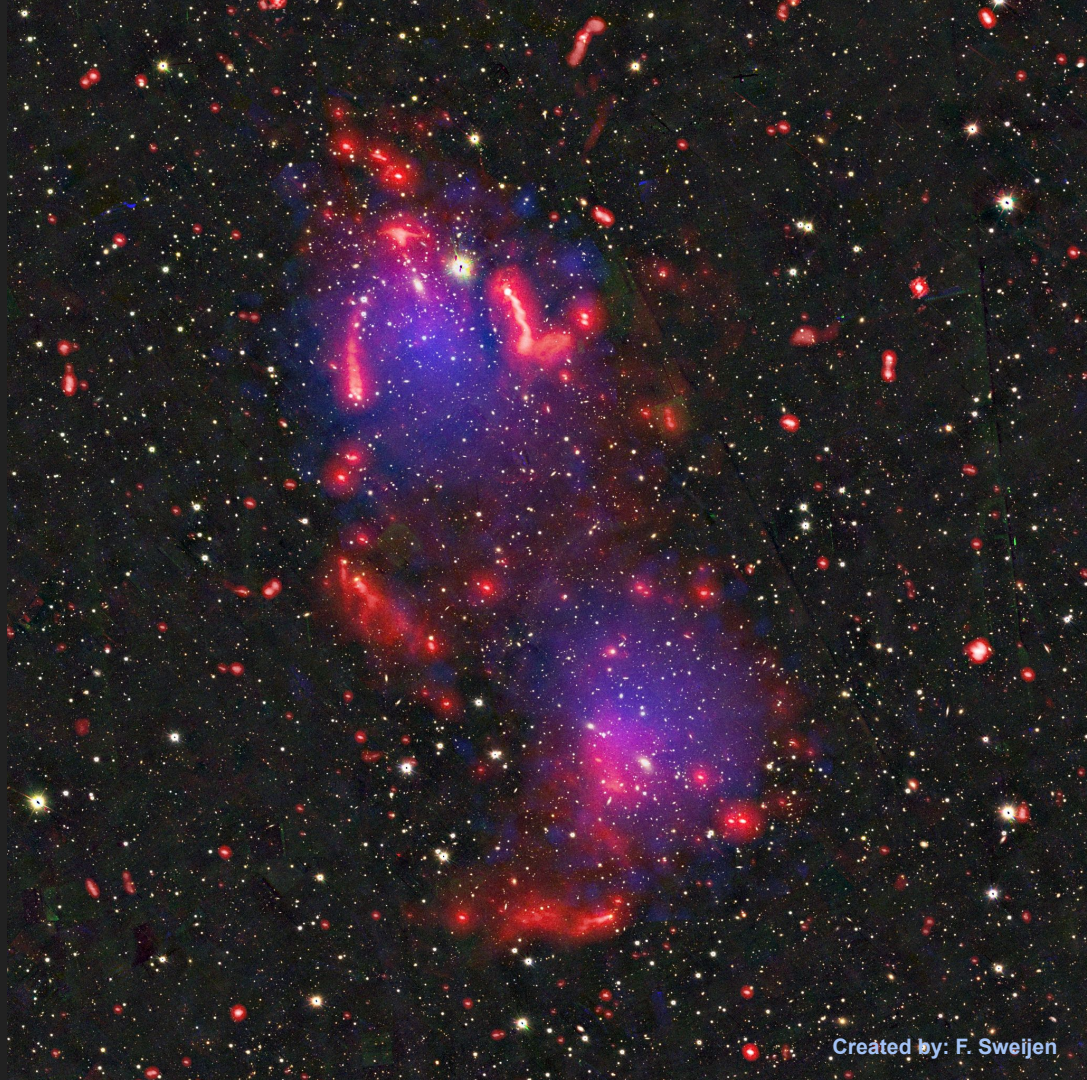
Summary

1. Radio bridge emission likely generated by Fermi-II re-acceleration of fossil plasma.

2. Fossil plasma might originate from past AGN activity.

3. A1758 and A399-401 bridges have a similar radio/X-ray trend.

See: J.M.G.H.J. de Jong et al. submitted



Created by: F. Sweijen

Acknowledgement

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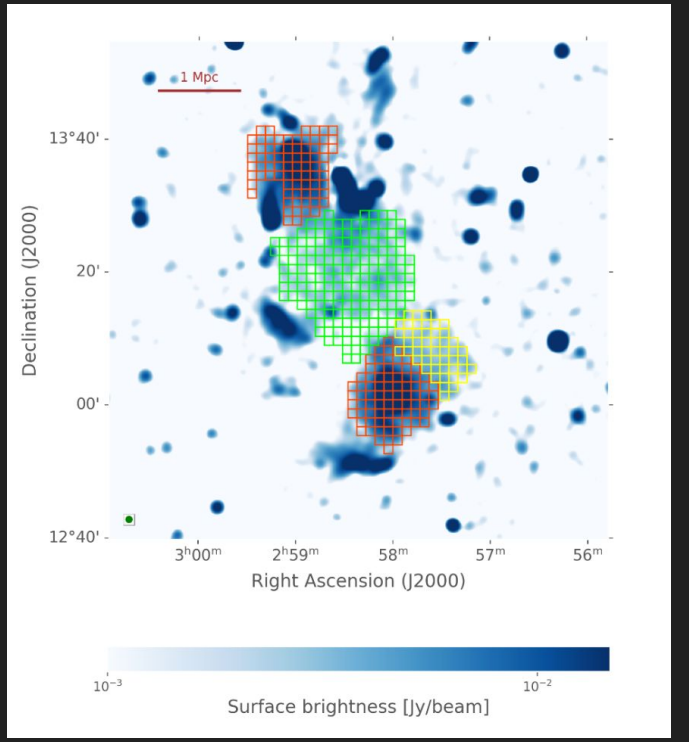
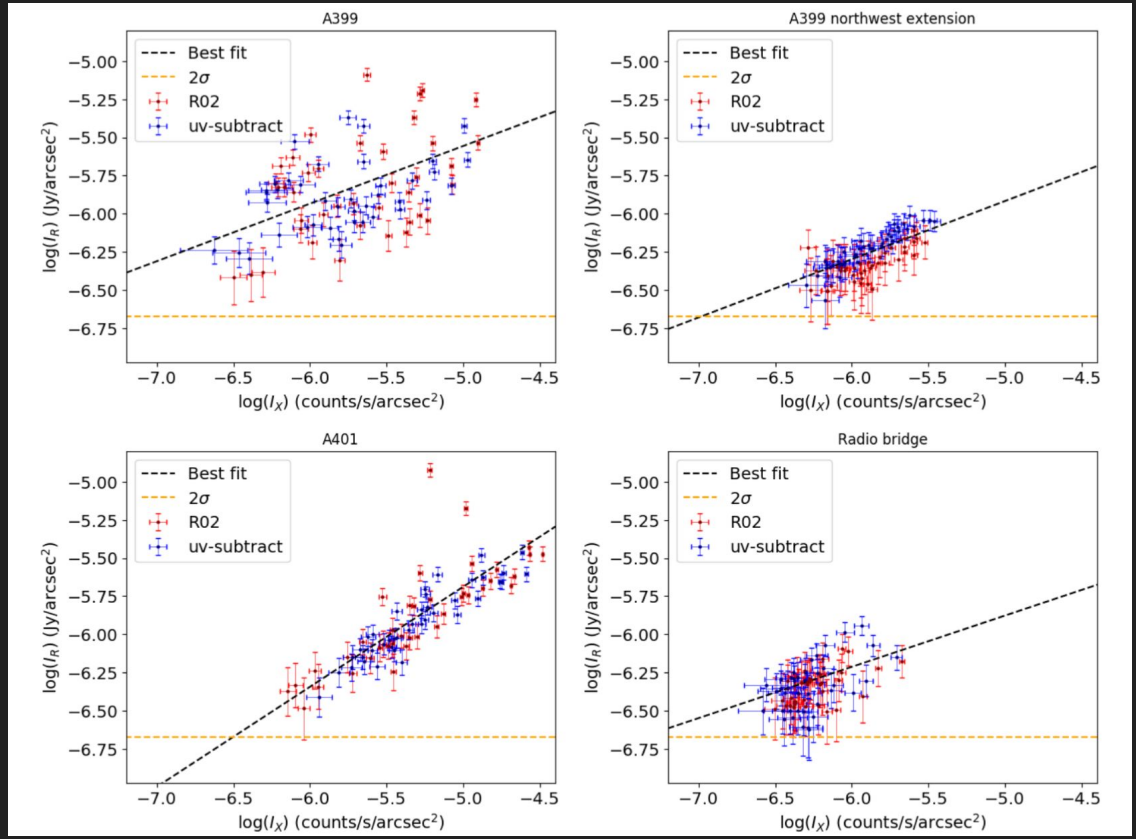
EXTRA SLIDES

Point-to-point analysis

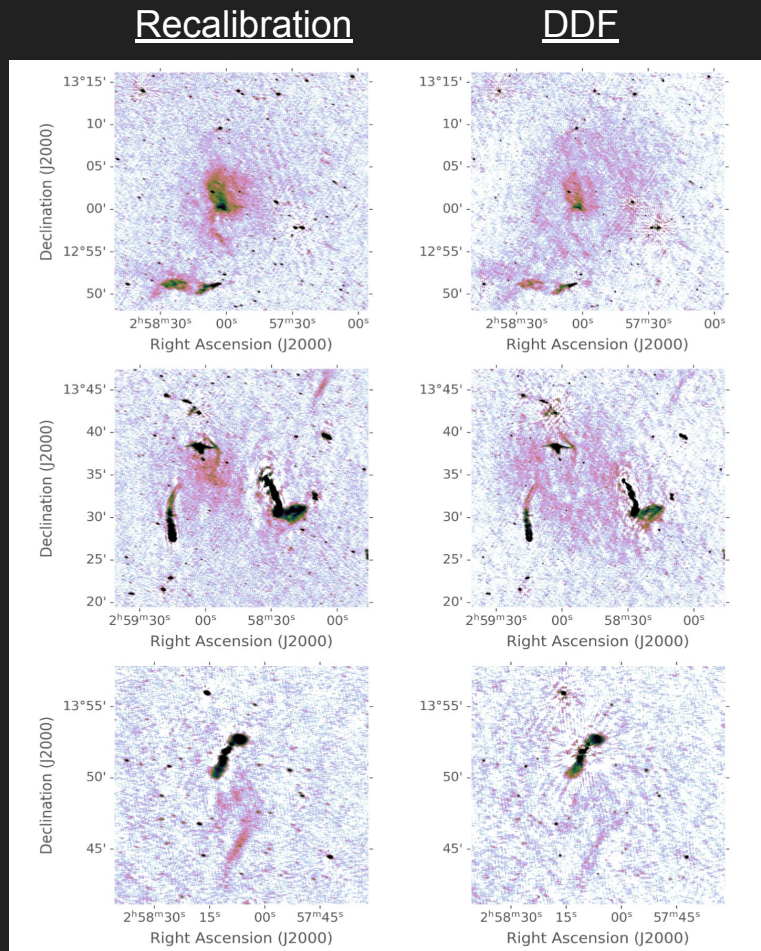


(de Jong et al. subm)

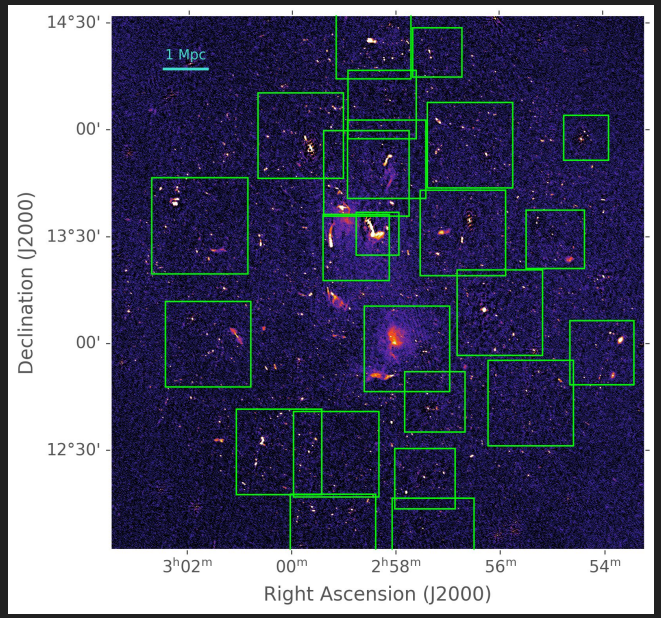


DDF - Recalibration comparison

- Similar sensitivity
- Dynamic range improvement factor ~1.6
- Recalibration costs 16500 extra CPU core hours



1


1 Mpc
14°30'
00'
13°30'
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12°30'
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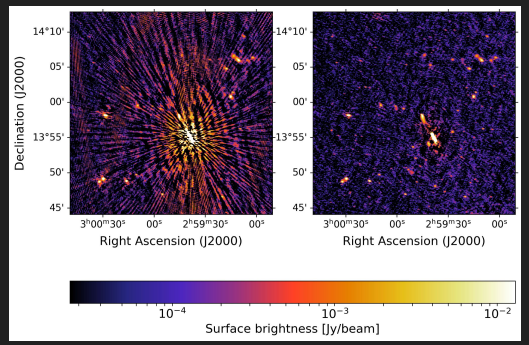
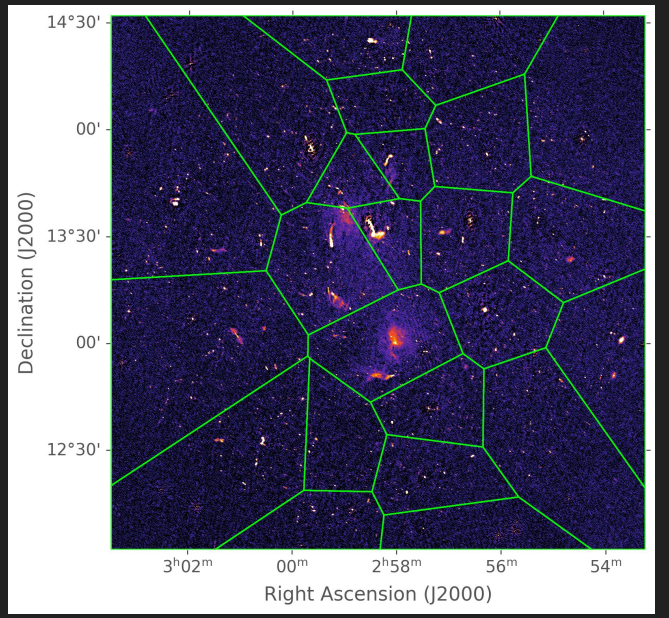
00m
2h58m
56m
54m
Right Ascension (J2000)

2


14°10'
05'
00'
13°55'
50'
45'
Declination (J2000)
3h00m30s
00s
2h59m30s
00s
Right Ascension (J2000)
10−4
10−3
10−2
Surface brightness [Jy/beam]

3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