

Abell 399-401 radio bridge study

Using wide-field facet calibration

Jurjen de Jong

SPARCS 2022

Collaborators:

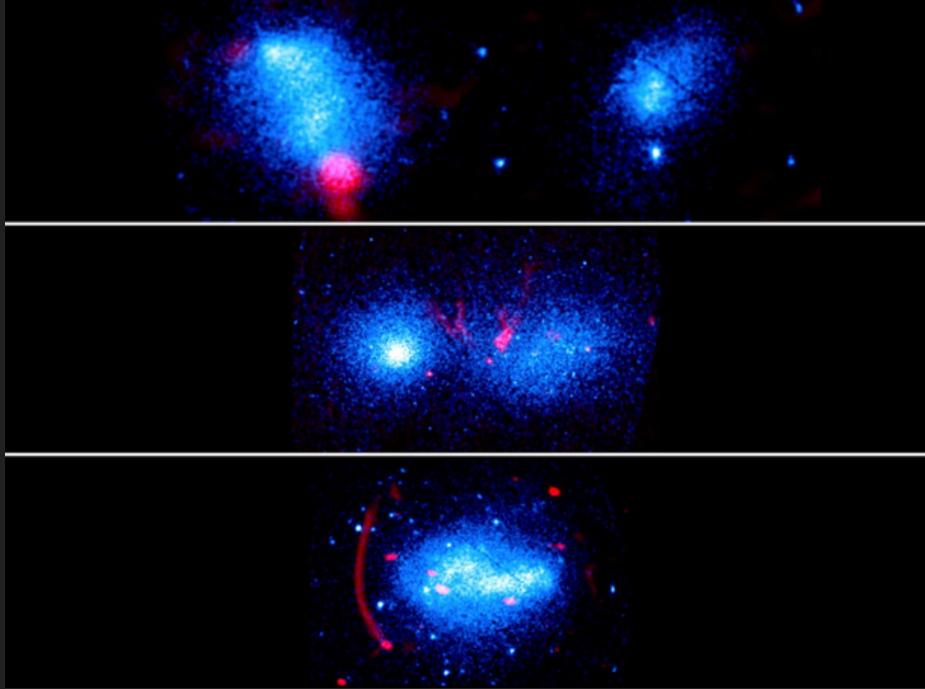
R. van Weeren, A. Botteon, R. Oonk, G.Brunetti, T. Shimwell, R. Cassano,
H. Röttgering, C. Tasse



Universiteit
Leiden

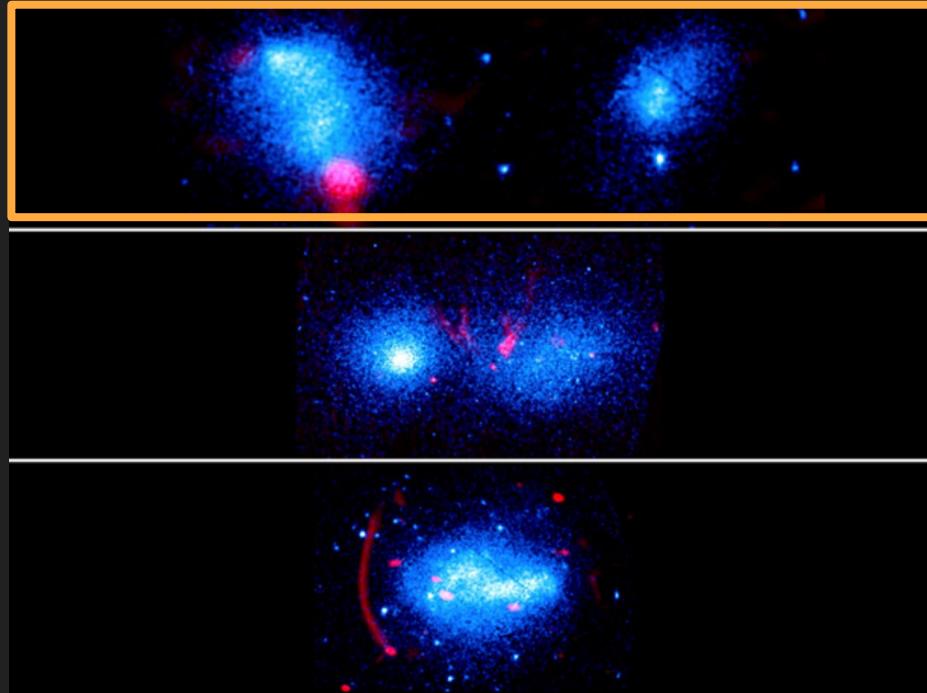


Galaxy cluster merger



Copyright: Abell 1758: ESA/XMM-Newton (X-rays); GMRT/TGSS (radio); 1E2215: NASA/Chandra (X-rays), GMRT (radio); CIZA J2242: ESA/XMM-Newton (X-rays); ASTRON/WSRT (radio)

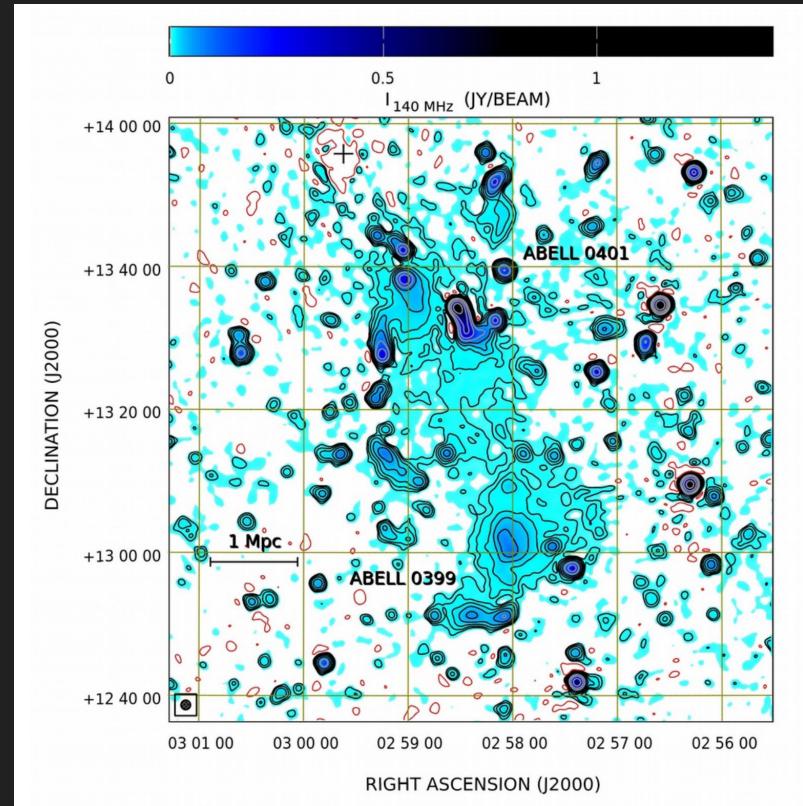
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Radio bridge: Abell 399-401

- Filament between pre-merging clusters
- Magnetic fields and cosmic rays
- Diffuse synchrotron emission
- Abell 399-401: ~3 Mpc at $z=0.072$



Govoni et al. 2019

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?



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

Problem: Radio bridges are diffuse



LOFAR Data

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



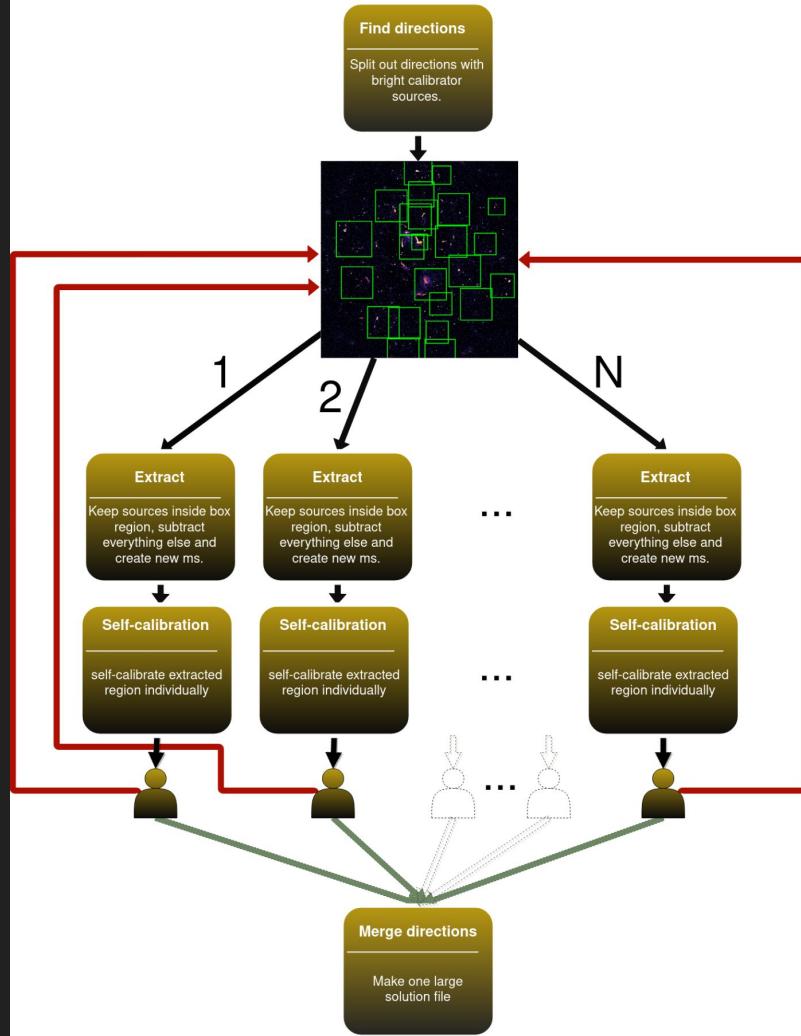
2011 © AEROPHOTO EELDE

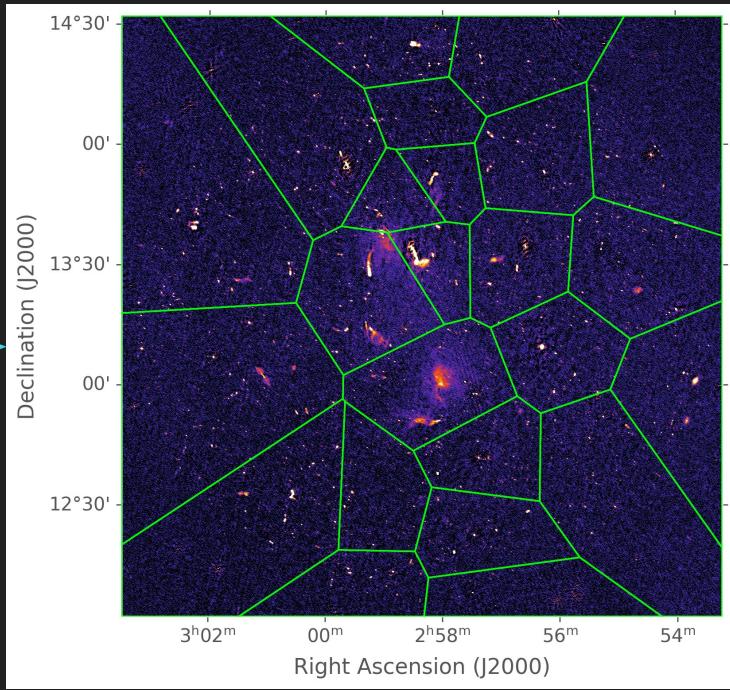
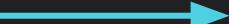
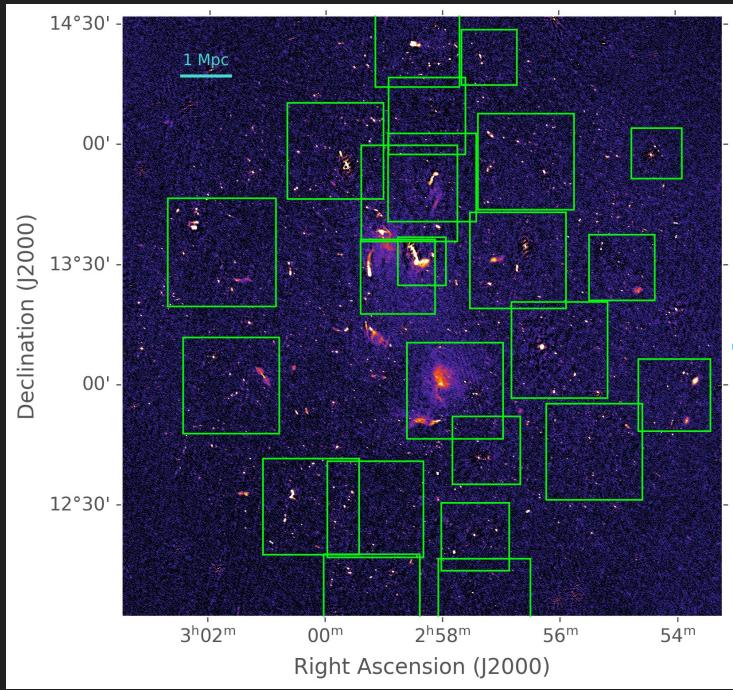
Calibration

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

Calibration

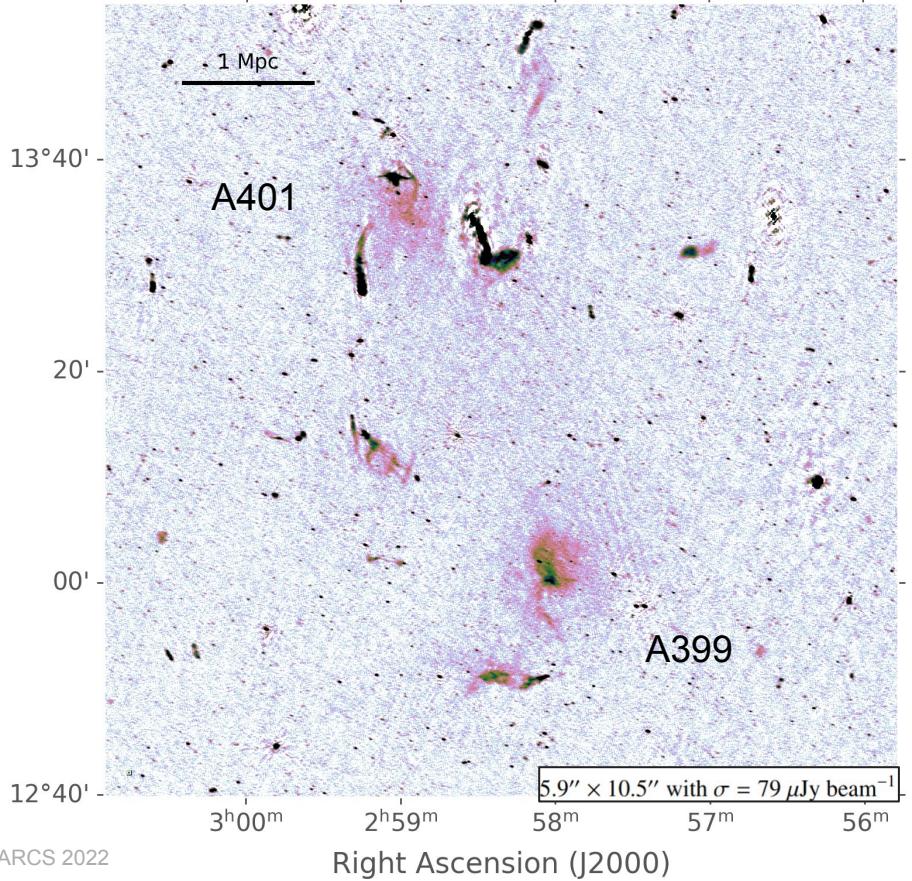
Issues	Solutions	Case
Bright sources	Direction-dependent recalibration (van Weeren et al. 2021)	$N=1$
Large object	Multiple recalibrations (de Jong et al. 2022 accepted)	$N>1$



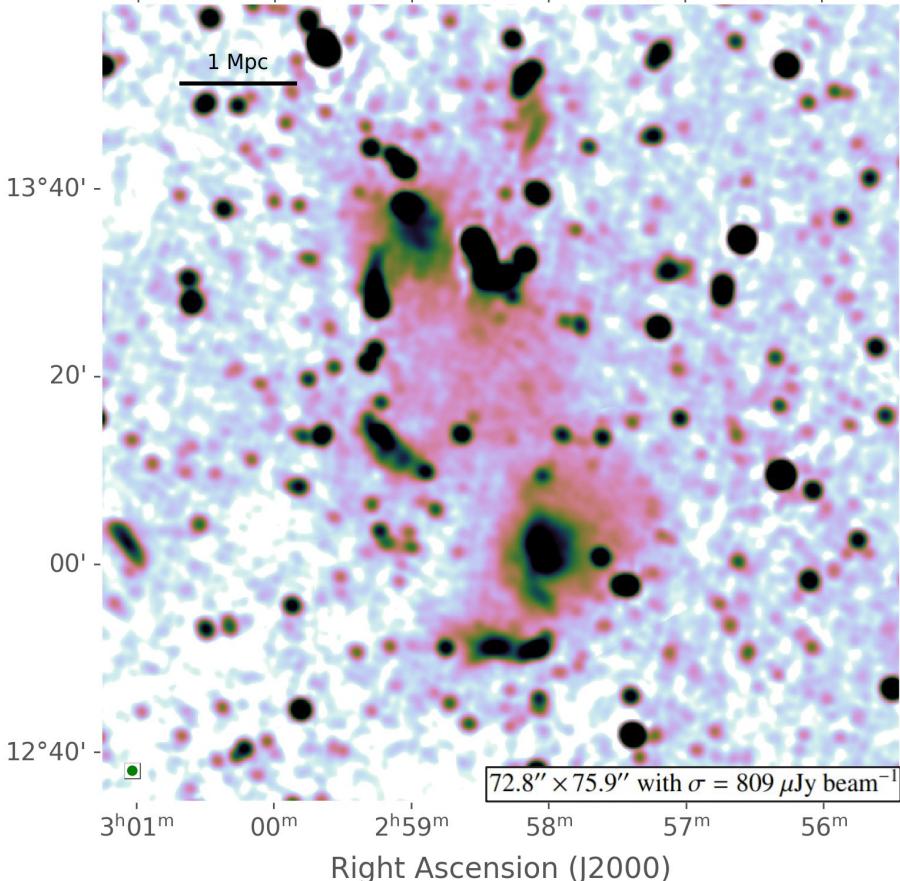


Results

Declination (J2000)



Declination (J2000)

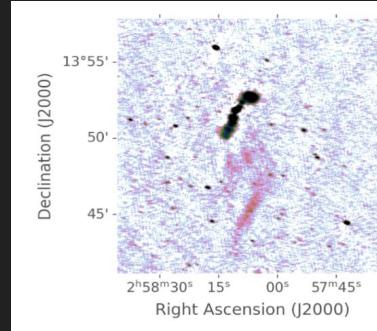


Recalibration vs. Standard (DDF)

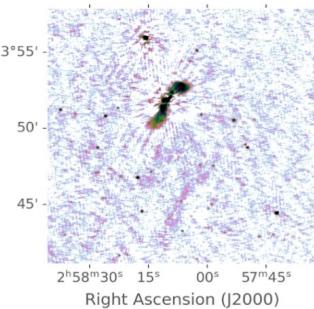


Similar sensitivity

Recalibration



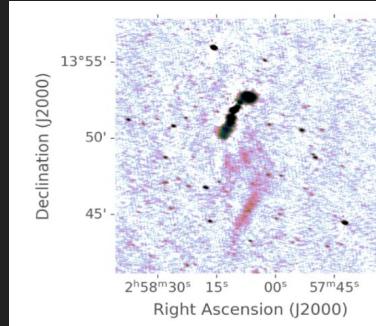
Standard



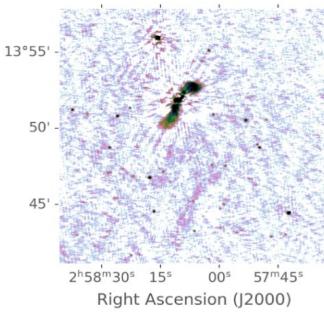
Recalibration vs. Standard (DDF)

- 😊 Similar sensitivity
- 😁 Dynamic range improvement factor ~1.6

Recalibration



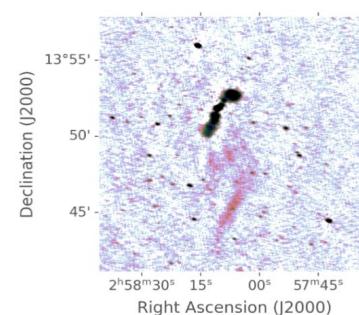
Standard



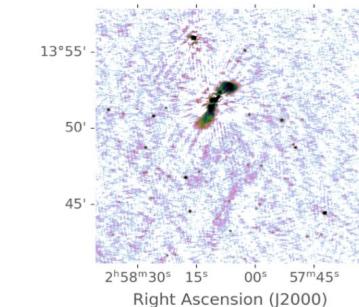
Recalibration vs. Standard (DDF)

- 😊 Similar sensitivity
- 😁 Dynamic range improvement factor ~1.6
- 😢 Recalibration costs 16500 extra CPU core hours (expensive!)

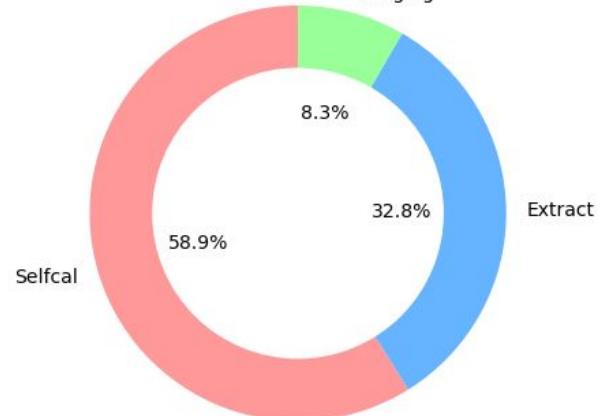
Recalibration



Standard



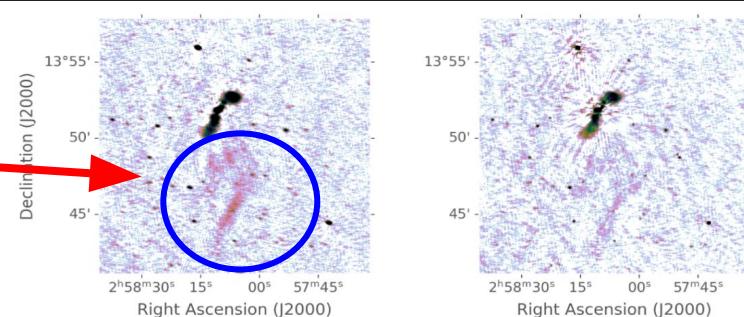
Imaging



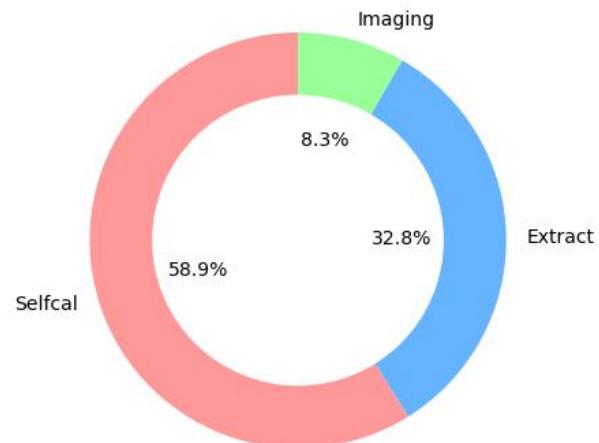
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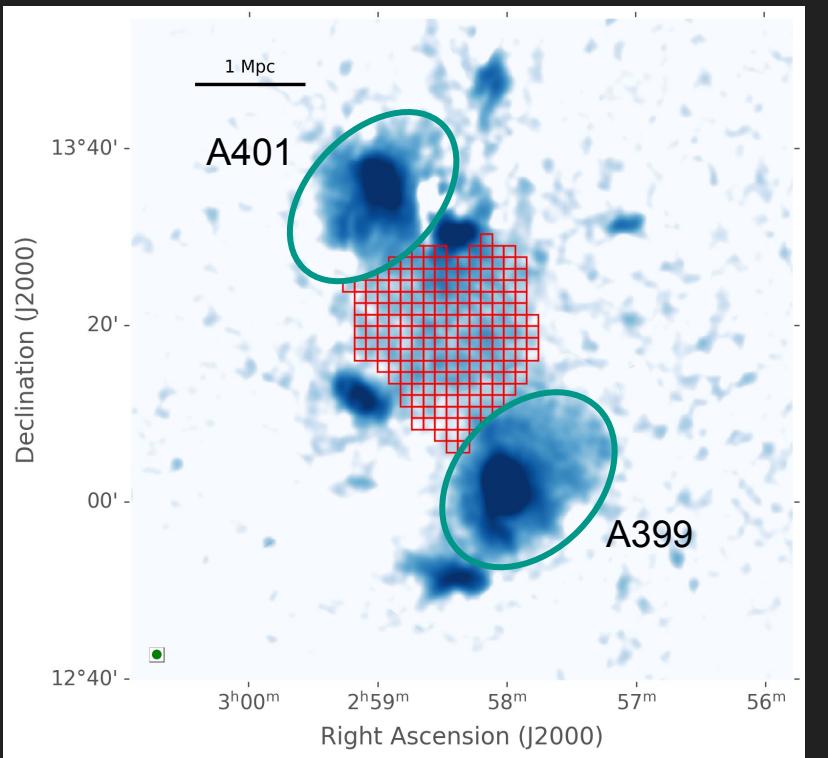
Recalibration



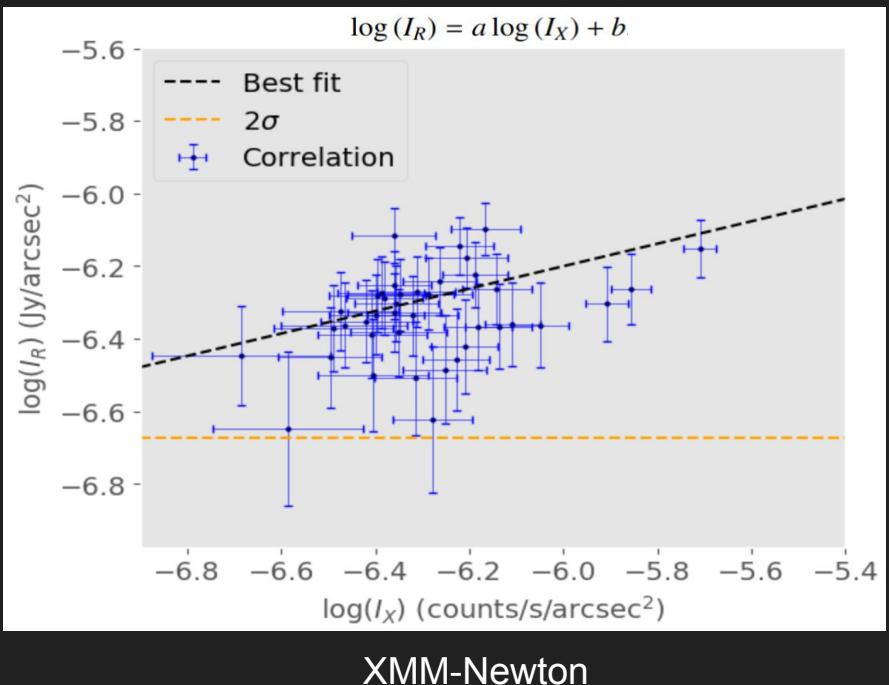
Standard



Radio/X-ray trend

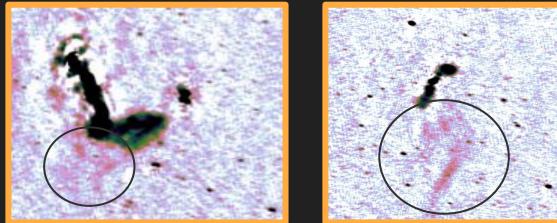


LOFAR



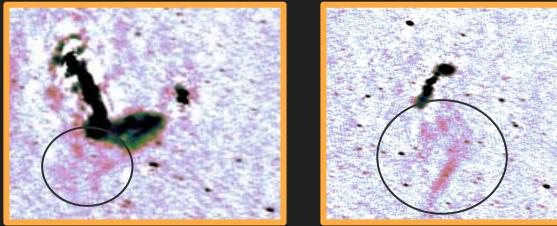
Results

1) Fossil plasma

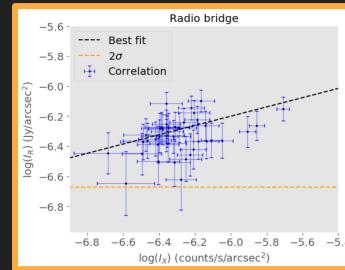


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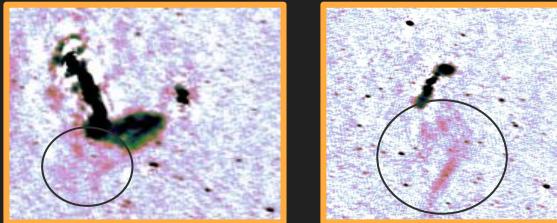


2) Trend between radio and X-ray

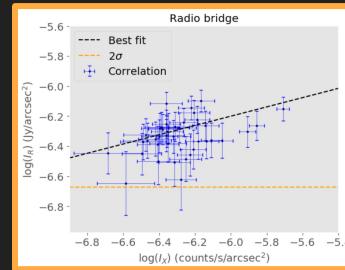


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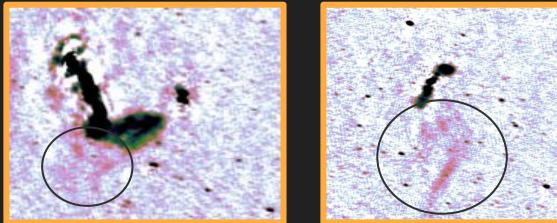


3) Steep spectral index $\rightarrow \alpha > 1.5$

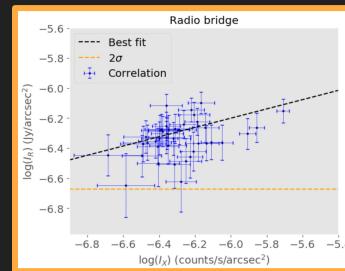
(Nunhokee et al. 2021)

Results

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(Nunhokee et al. 2021)

Fermi-II
re-acceleration

(Predicted by Brunetti et al. 2020)

Summary

Calibration:

1. Recalibration strategy improves calibration of diffuse structures.
2. computationally expensive.

Science:

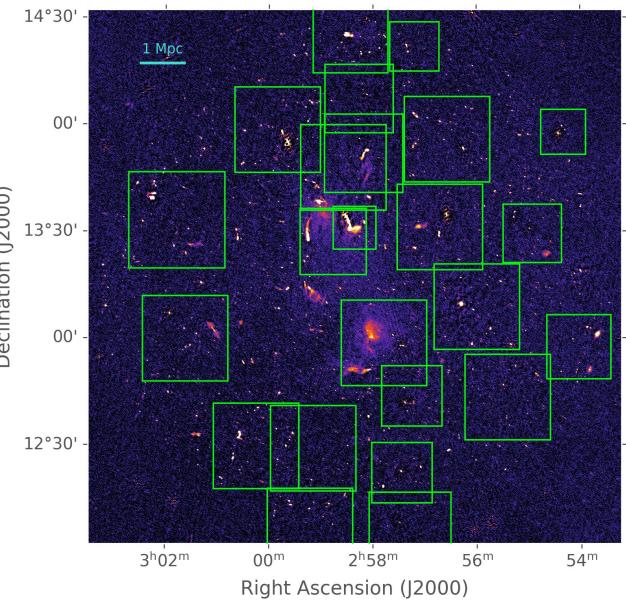
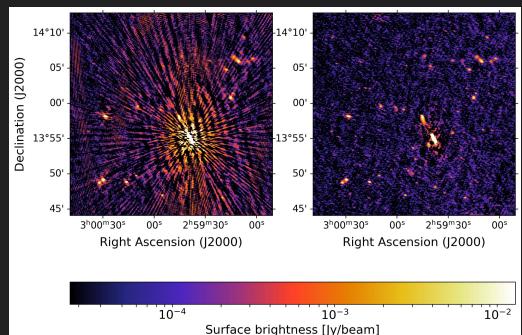
3. Radio bridge emission likely generated by Fermi-II re-acceleration of fossil plasma.
4. Fossil plasma might originate from past AGN activity.

J.M.G.H.J. de Jong et al. 2022 (accepted in A&A)



Created by: F. Sweijen

EXTRA SLIDES

1**2****3**