

**The physical fate and  
observable properties of  
fossil radio electrons in  
large-scale structures**

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*D. Wittor G. Brunetti, M. Bruggen, T.  
Hodgson, E. Vardoulaki, L. Di  
Federico, M. Brienza*

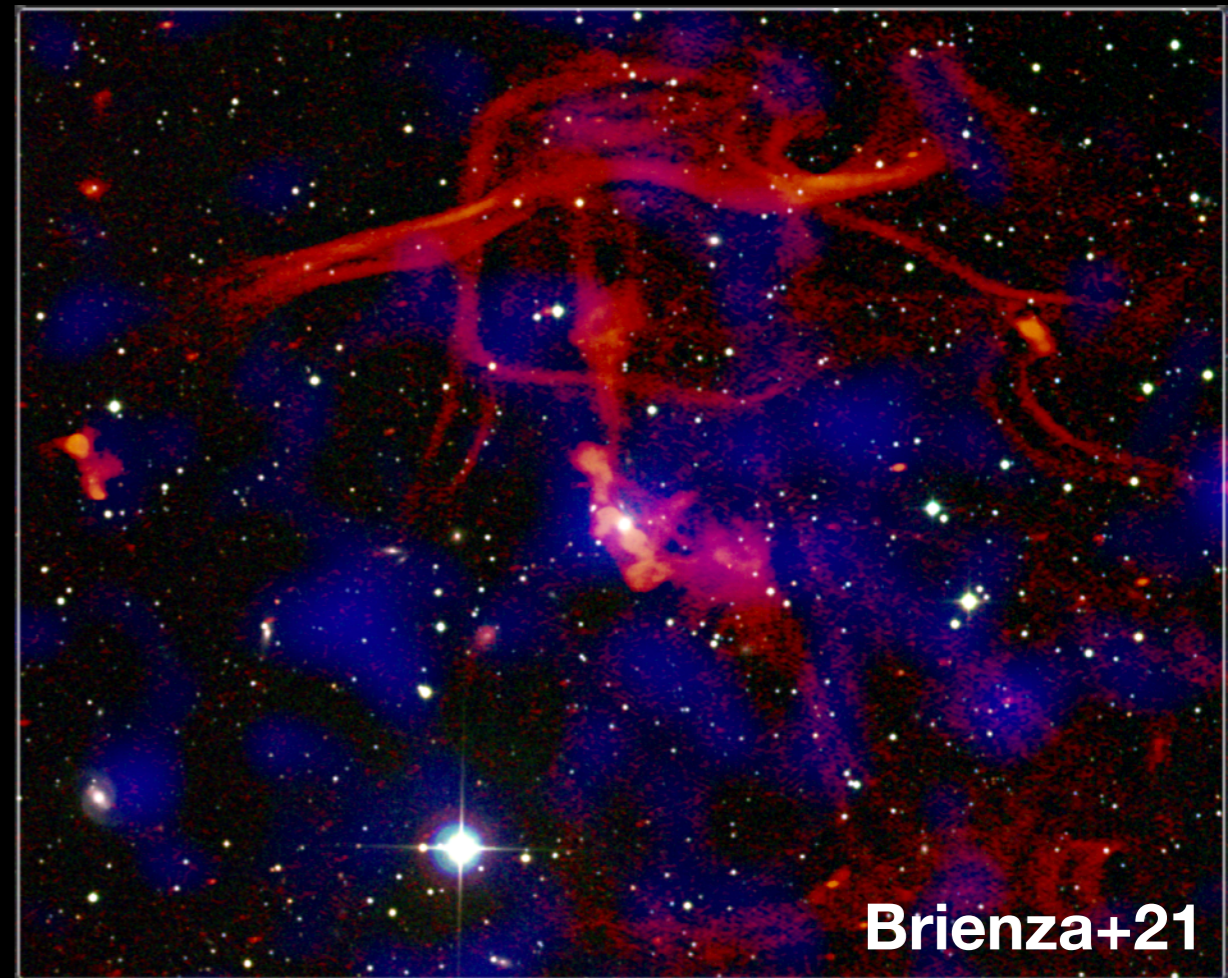


*The Italian Route to the SKAO Revolution*

# RADIOGALAXIES: “NEW” AND “OLD” ASPECTS

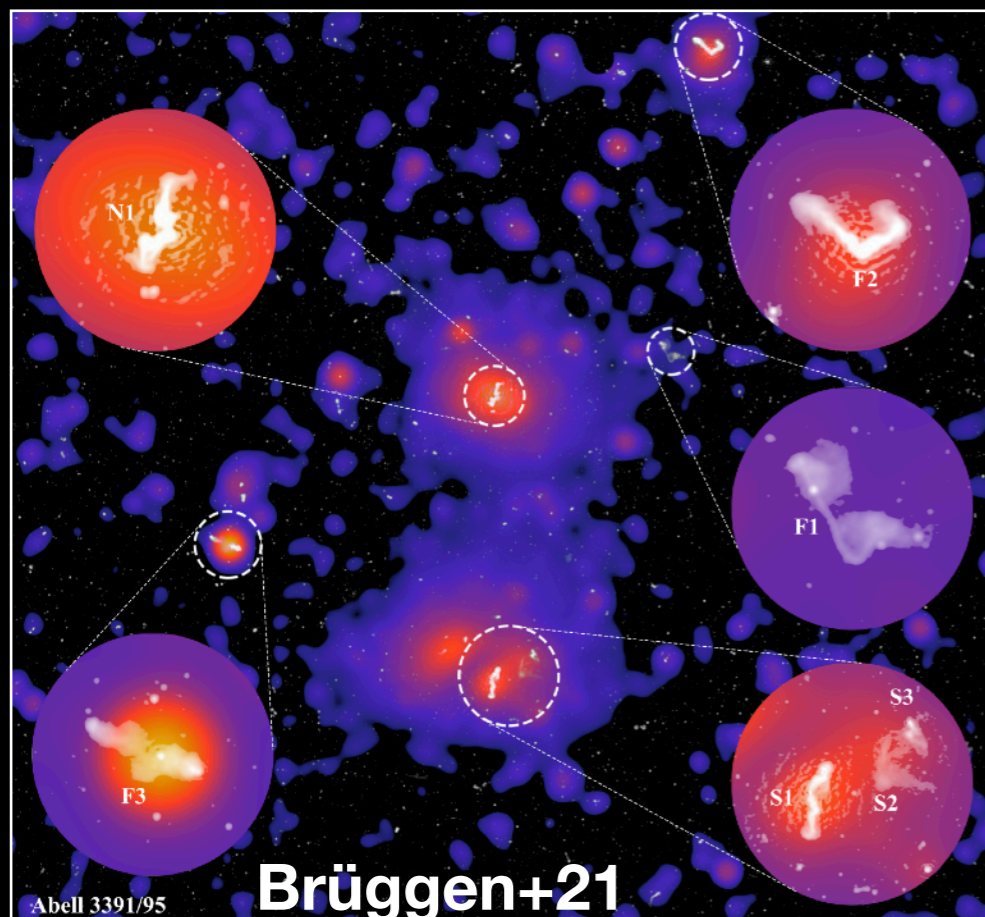
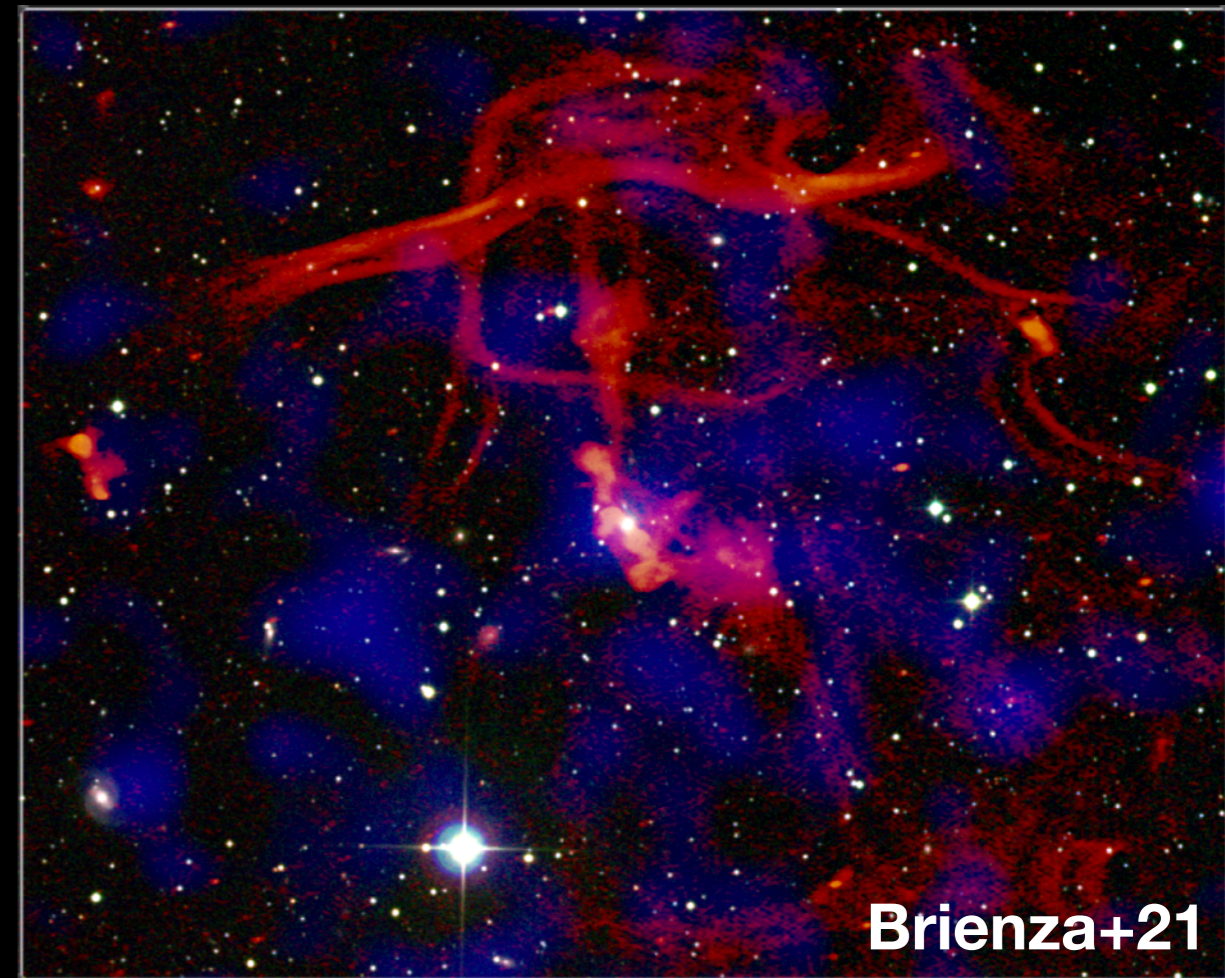
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- ▶ **Complex morphologies of lobe remnants**
- ▶ Injection of magnetic fields
- ▶ Seeding diffuse radio emission (relics/halos)



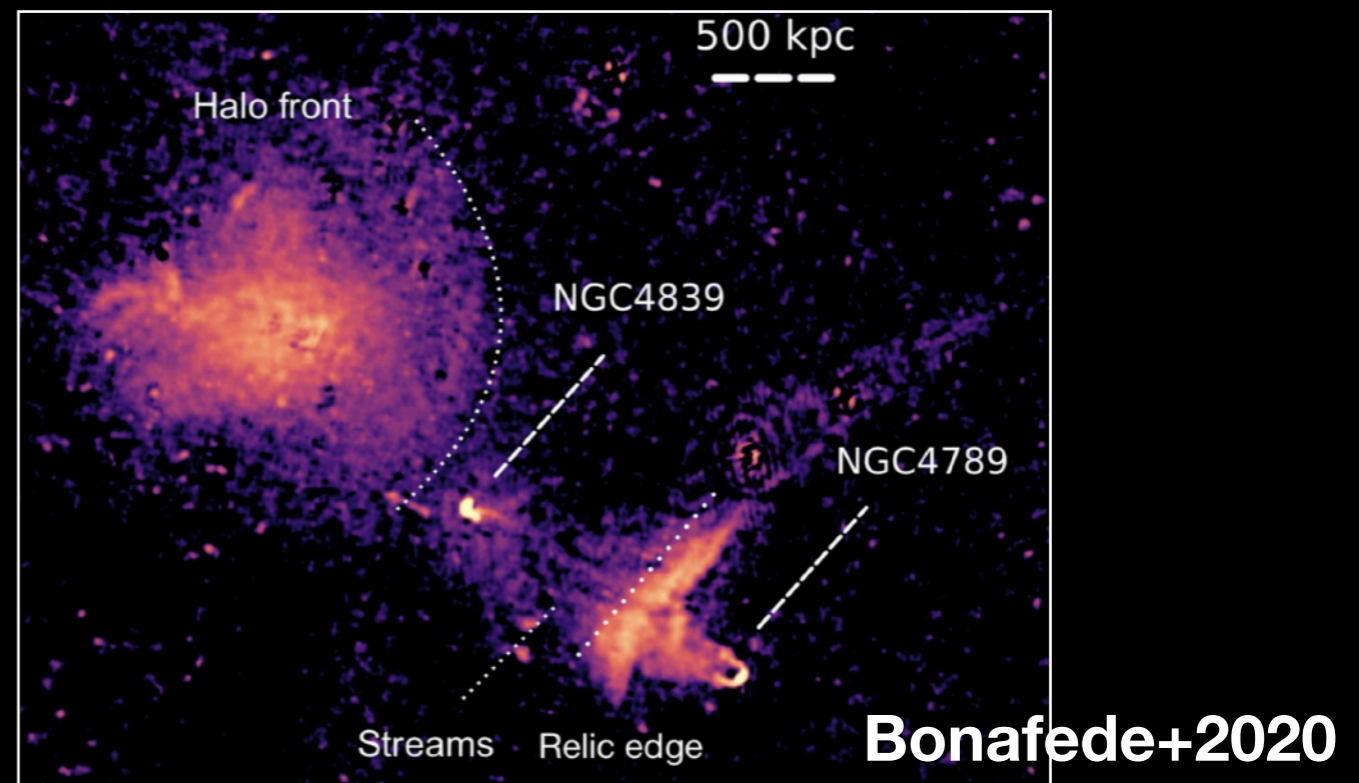
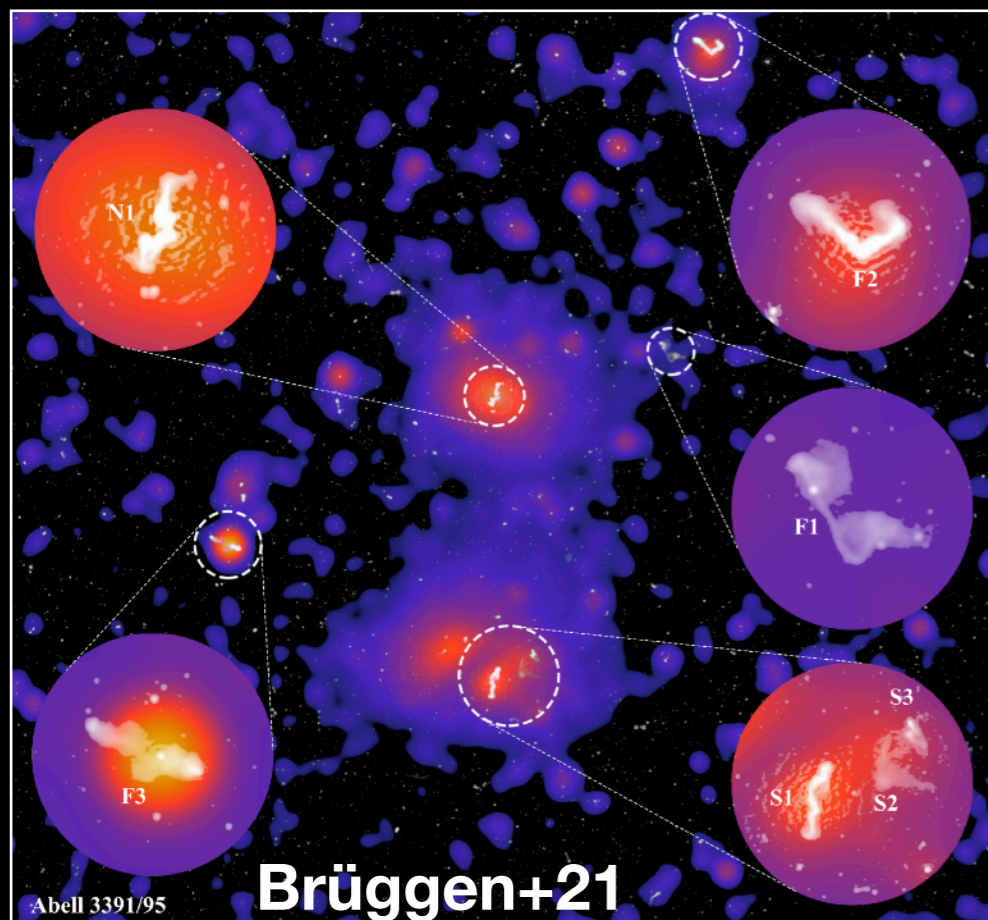
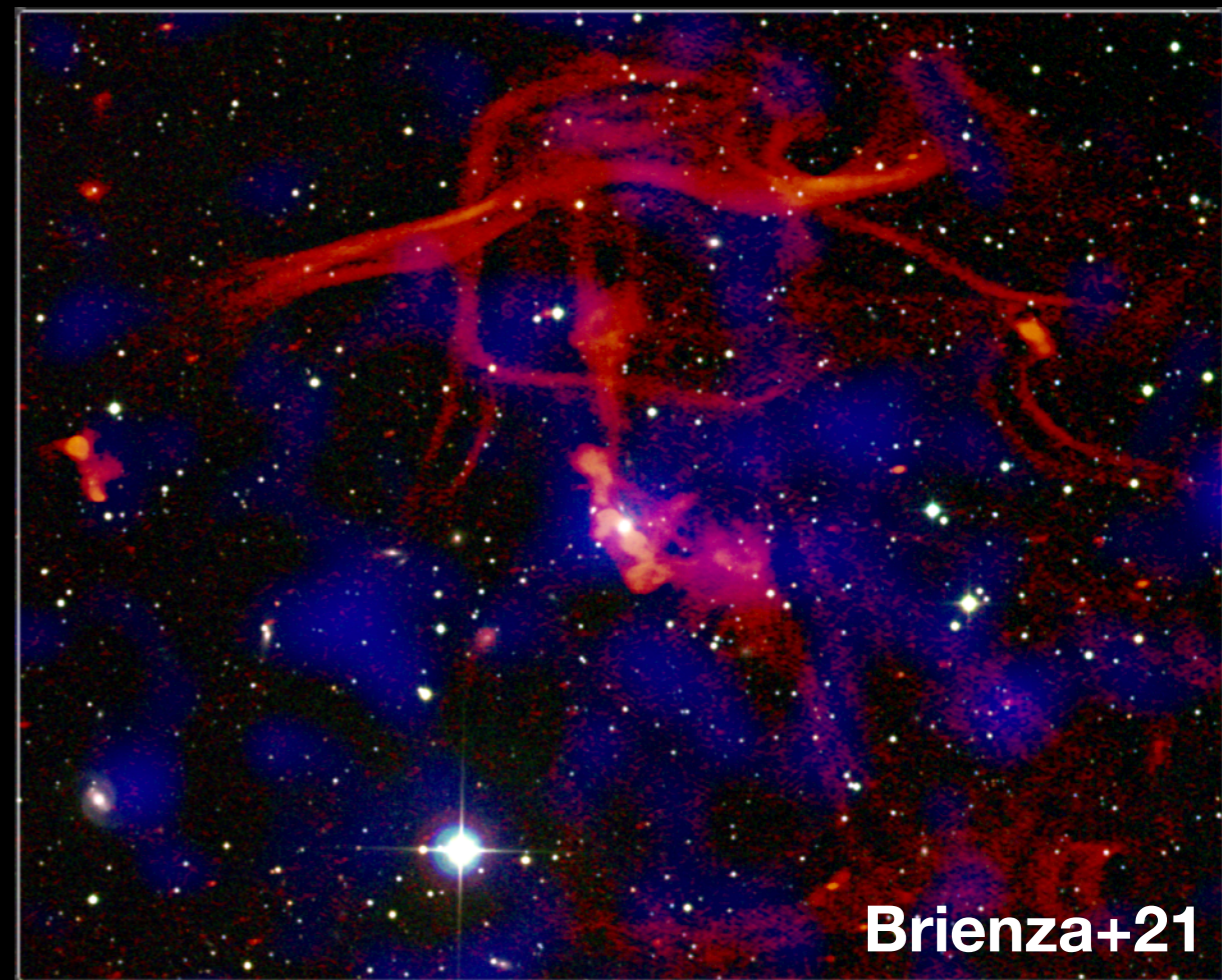
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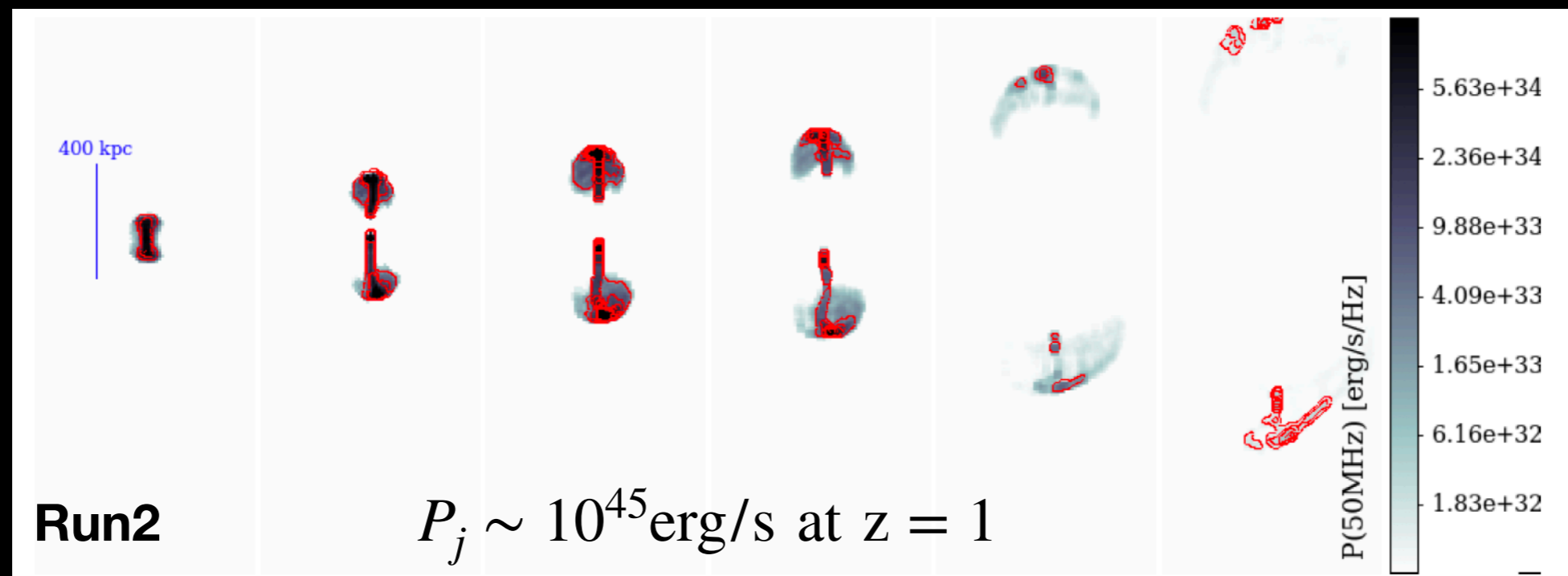
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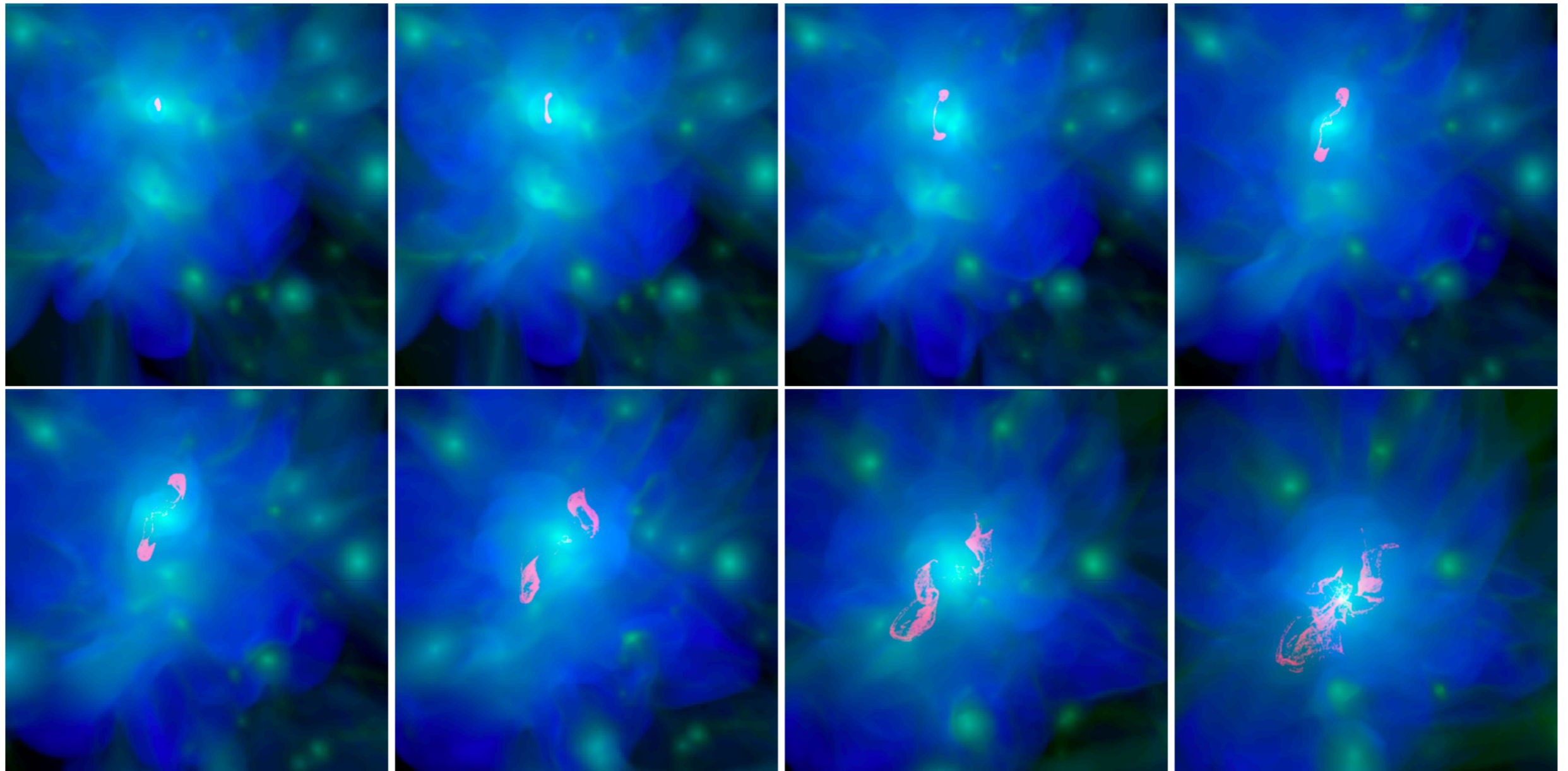
# NEW SIMULATIONS OF RADIO JETS IN COSMOLOGY

- ▶ **Cosmological MHD simulations** of magnetised jets filled with (passive) electrons,  $\Delta x \sim 8 \text{kpc}$
- ▶ Impact of jets on the ICM, and viceversa



# NEW SIMULATIONS OF RADIO JETS IN COSMOLOGY

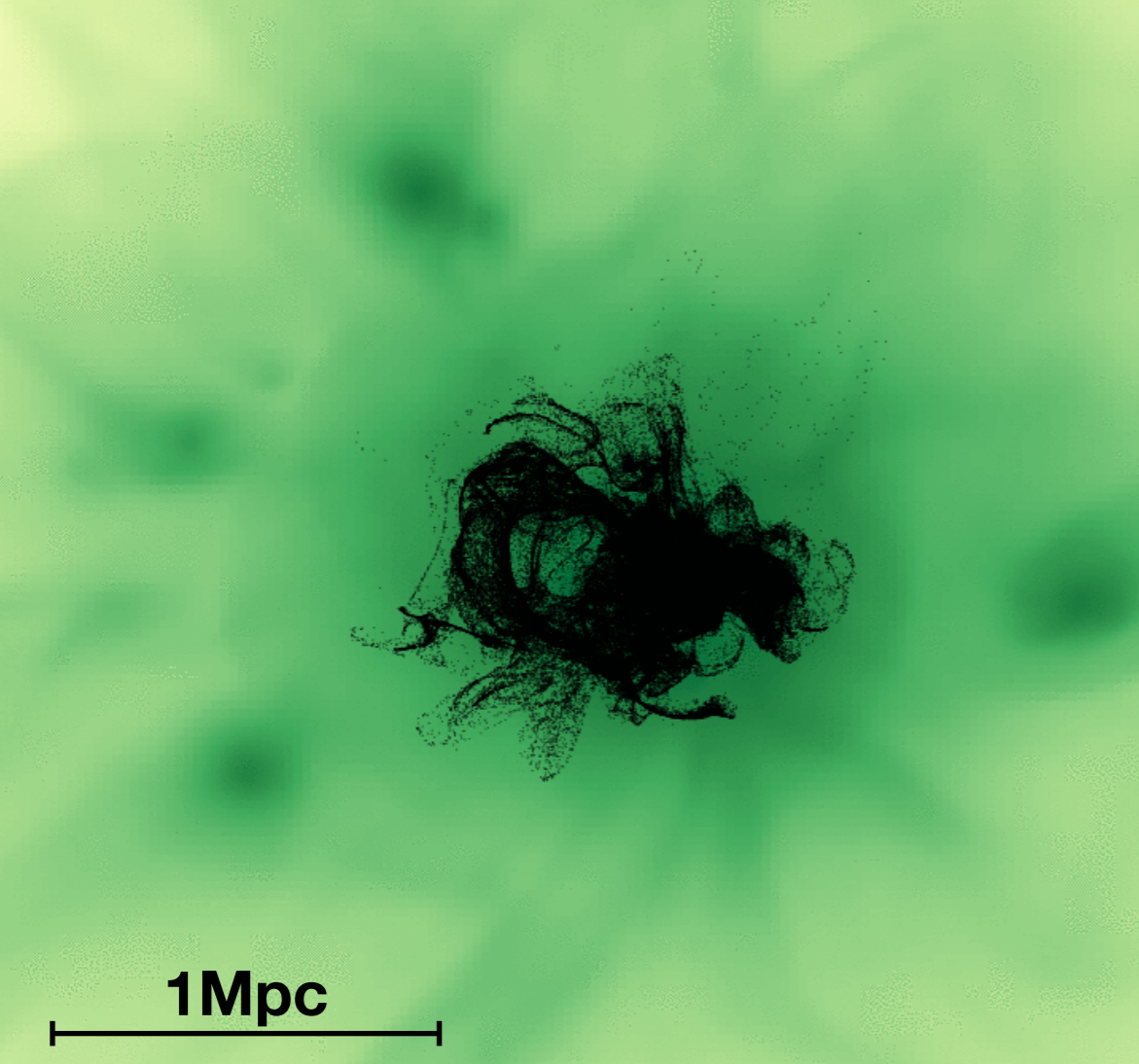
- ▶ Cosmological (matter accretions), jets with magnetic fields and (passive) electrons,  $\Delta x \sim 8\text{kpc}$
- ▶ Impact of jets on the ICM, and viceversa



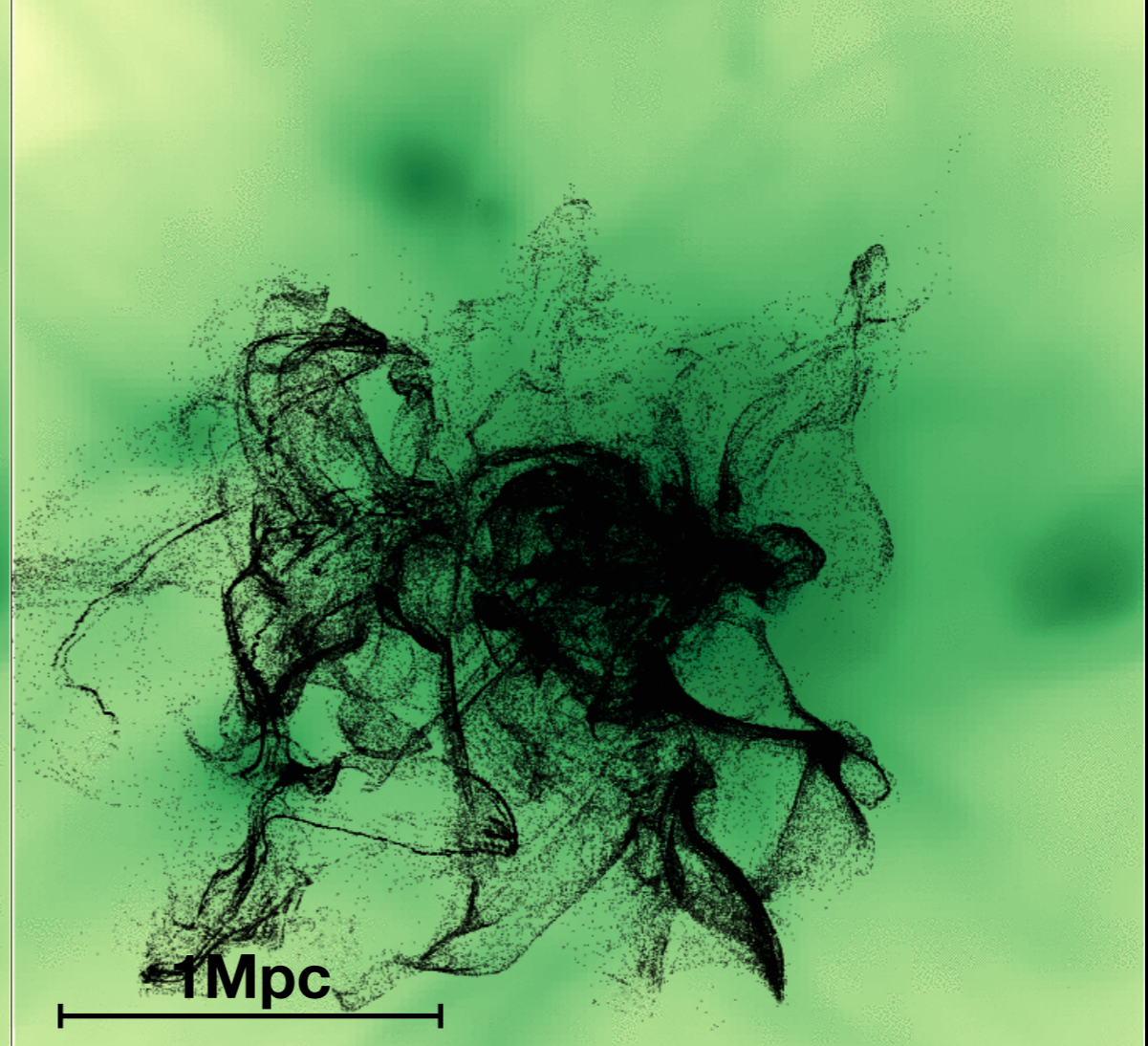
# NEW SIMULATIONS OF RADIO JETS IN COSMOLOGY

- ▶ Cosmological MHD simulations of magnetised jets filled with (passive) electrons,  $\Delta x \sim 8 \text{ kpc}$
- ▶ Impact of jets on the ICM, and viceversa
- ▶ Jets promote **enhance turbulent mixing** out to  $\sim 2 \text{ Mpc}$  from the host galaxy

Run0 (no jet)

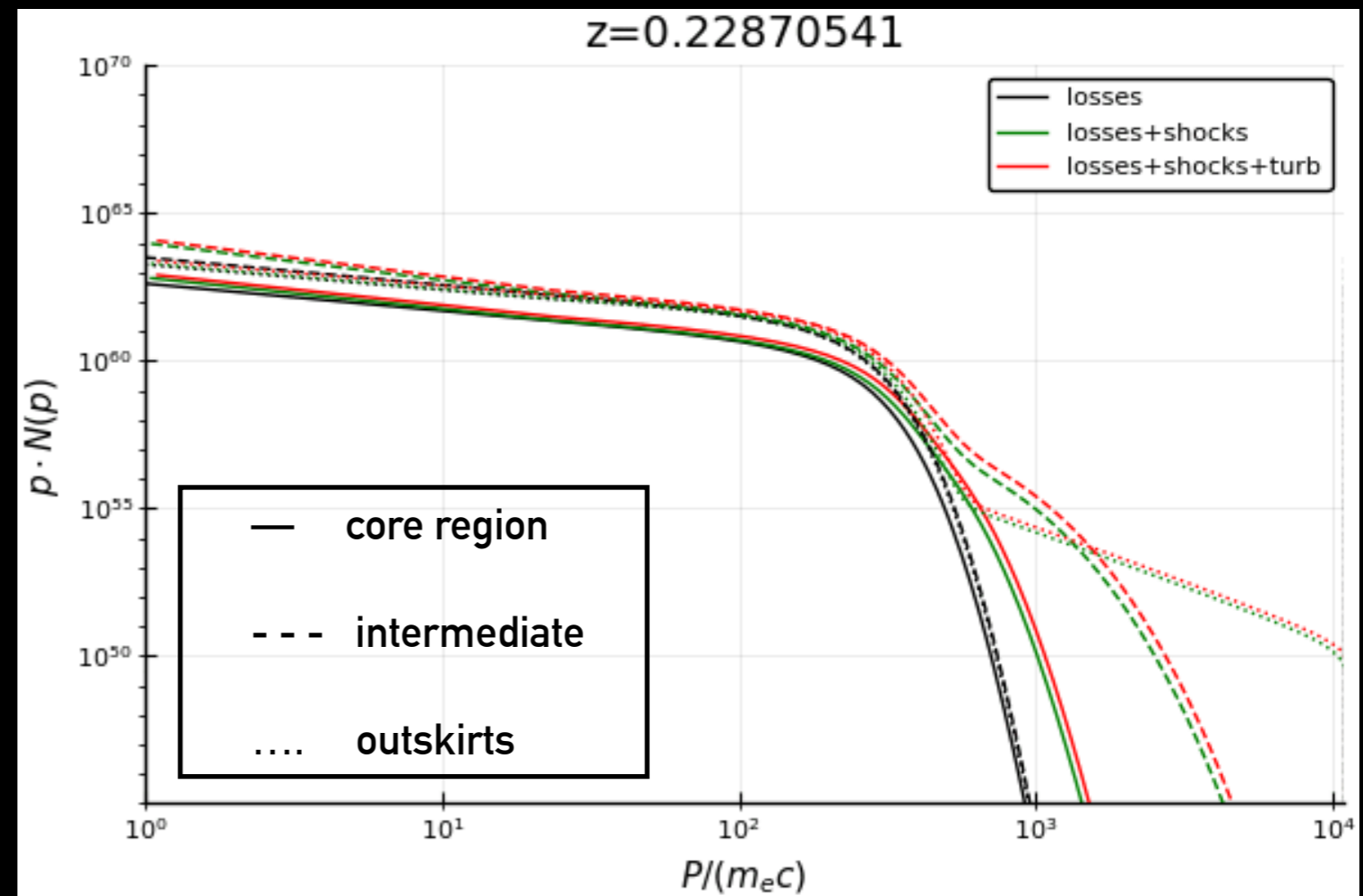
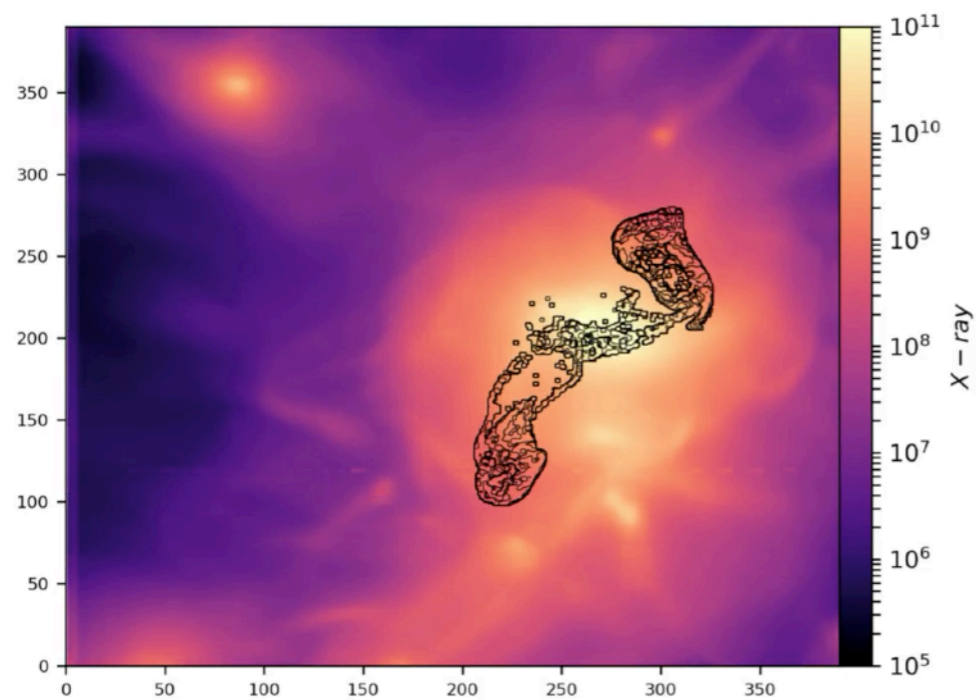


Run1 (jet at  $z=1$ )



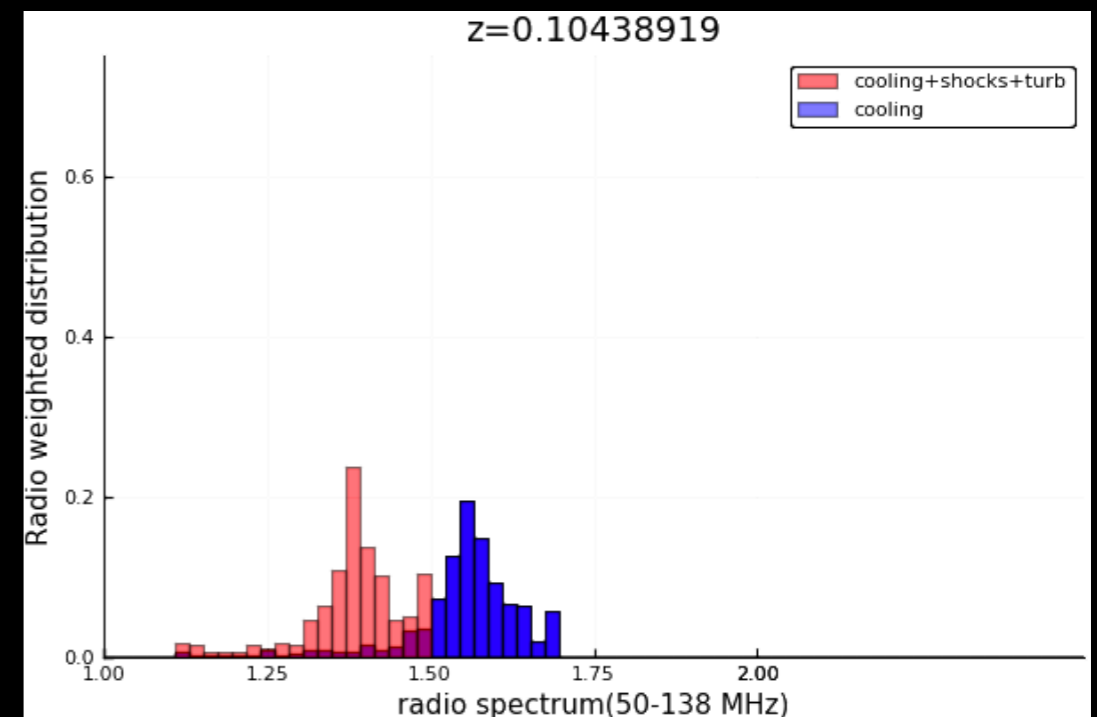
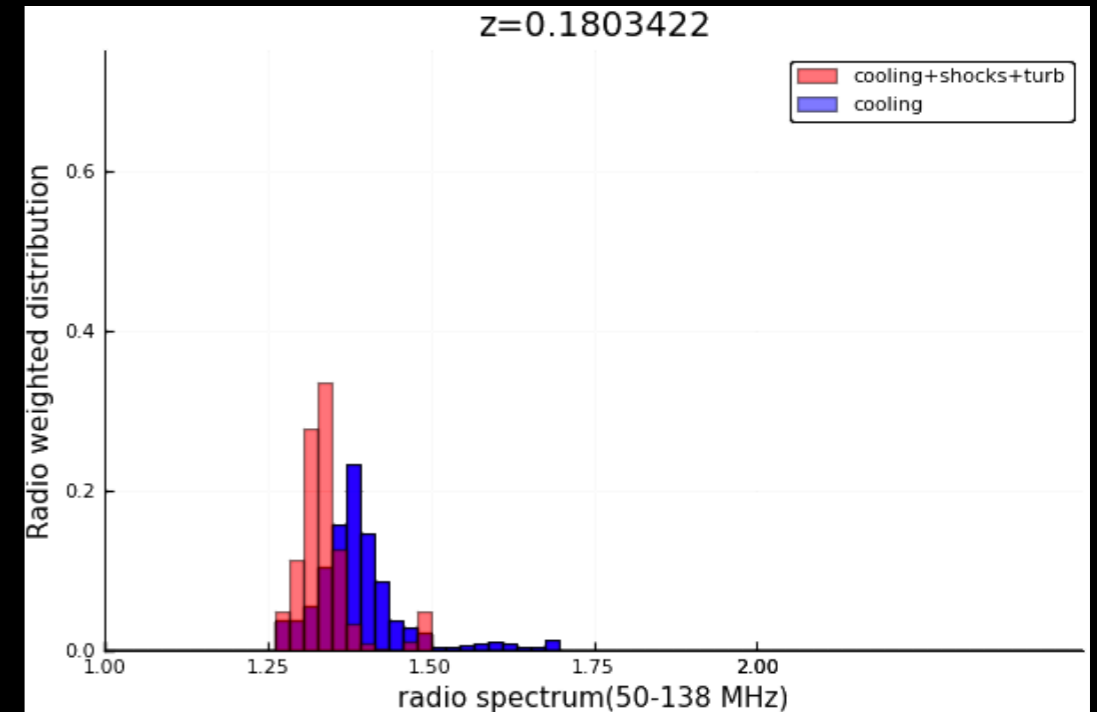
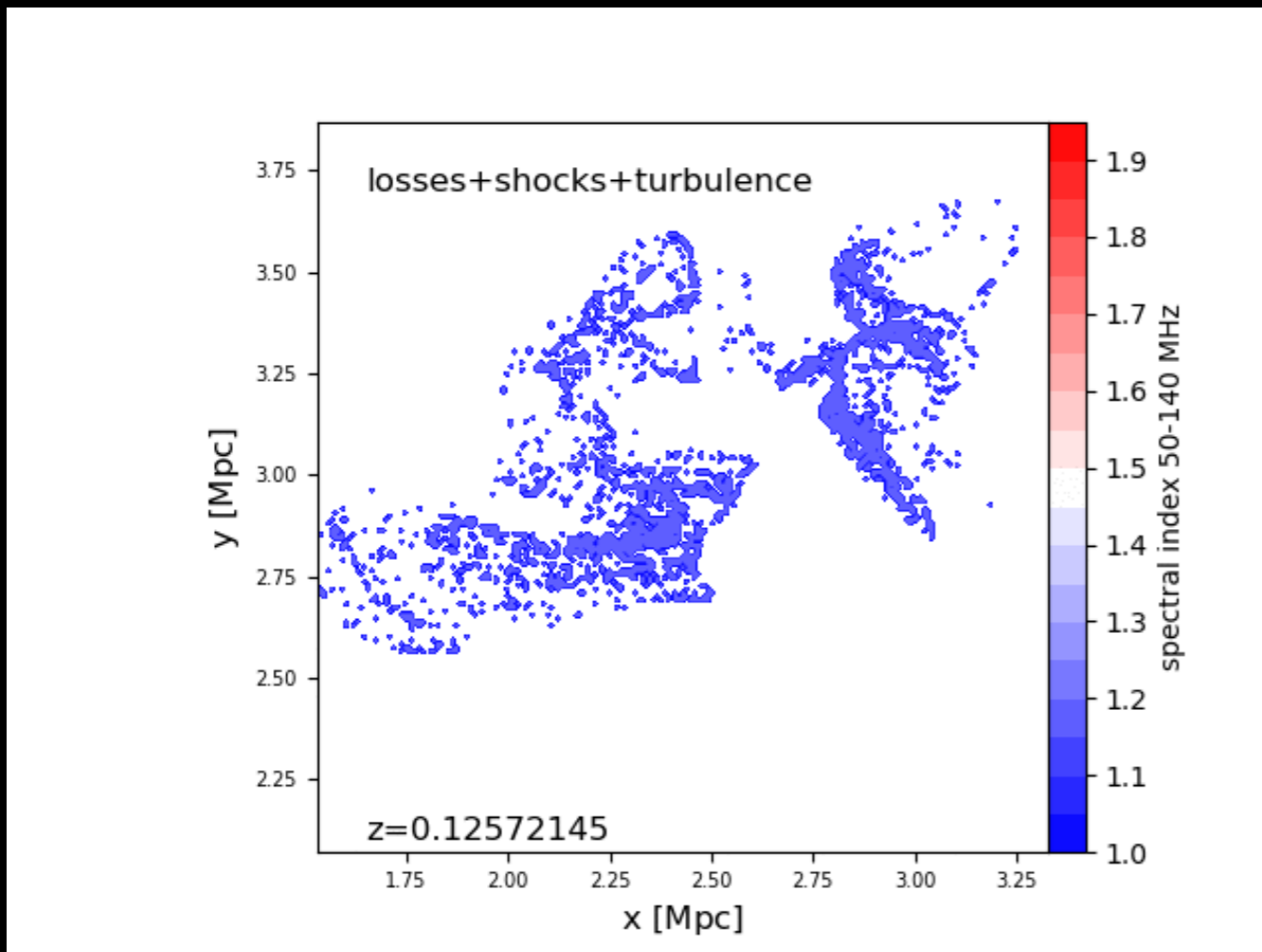
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- ▶ Impact of jets on the ICM, and viceversa
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- ▶ Evolution of electron energy spectra under **cooling** and **(re)acceleration processes**



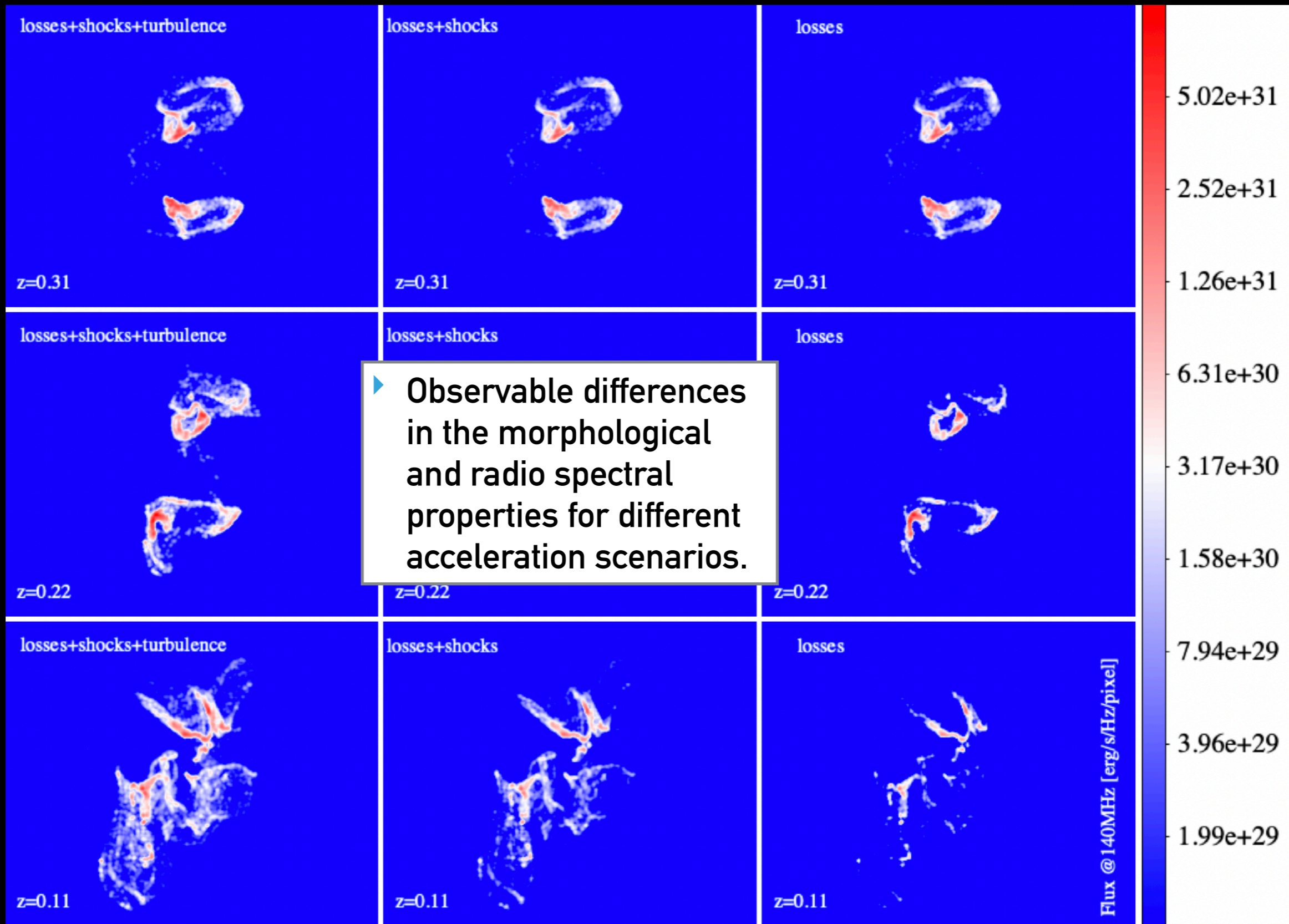


# NEW SIMULATIONS OF RADIO JETS IN COSMOLOGY



- ▶ Different balances of losses and reaccelerations produces large spectral differences visible  $\sim 1$ Gyr after jet release

# NEW SIMULATIONS OF RADIO JETS IN COSMOLOGY



LOFAR HBA

$\theta \sim 30''$ , 8hr

# NEW SIMS

- ▶ 5 different runs with increasing jet power

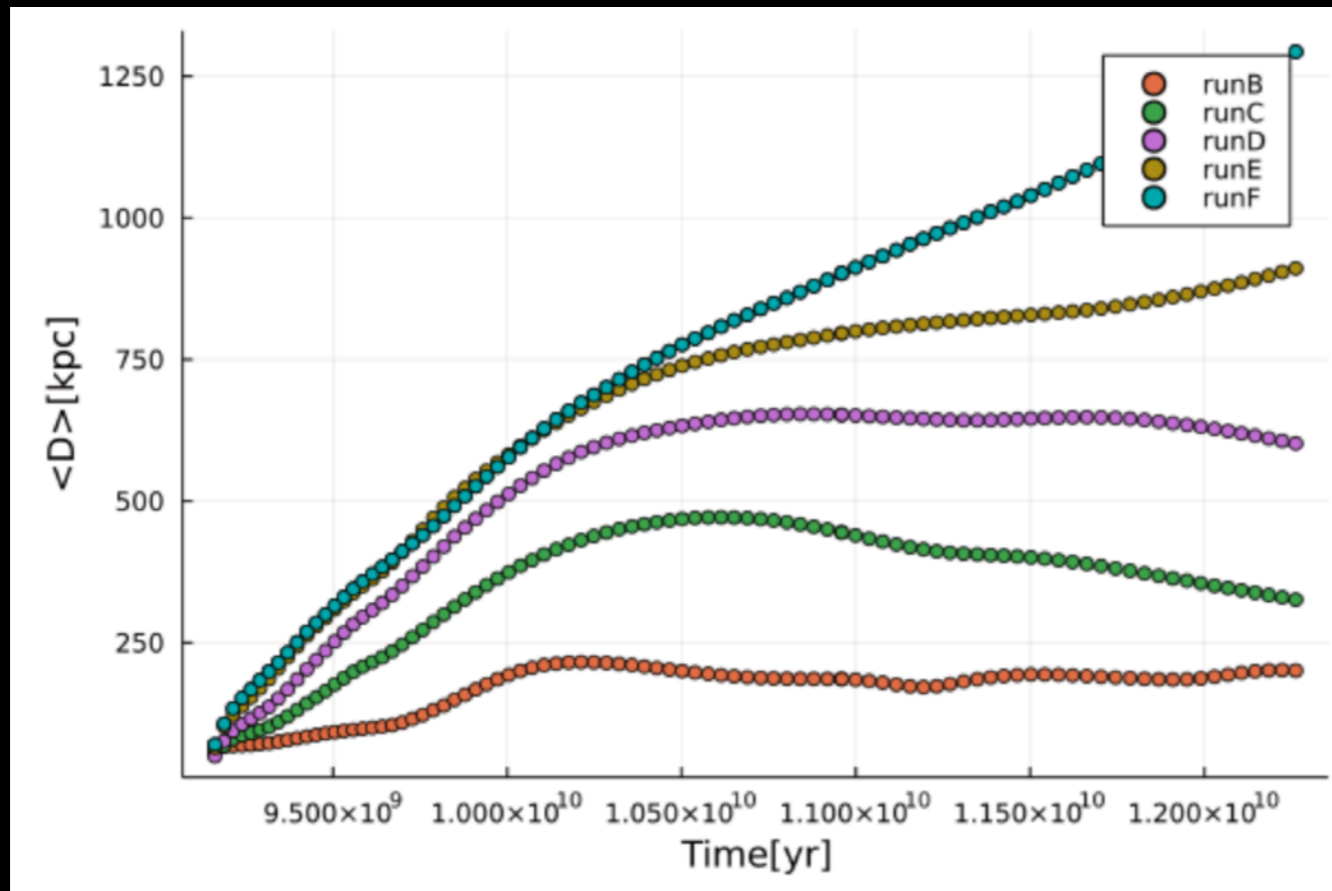
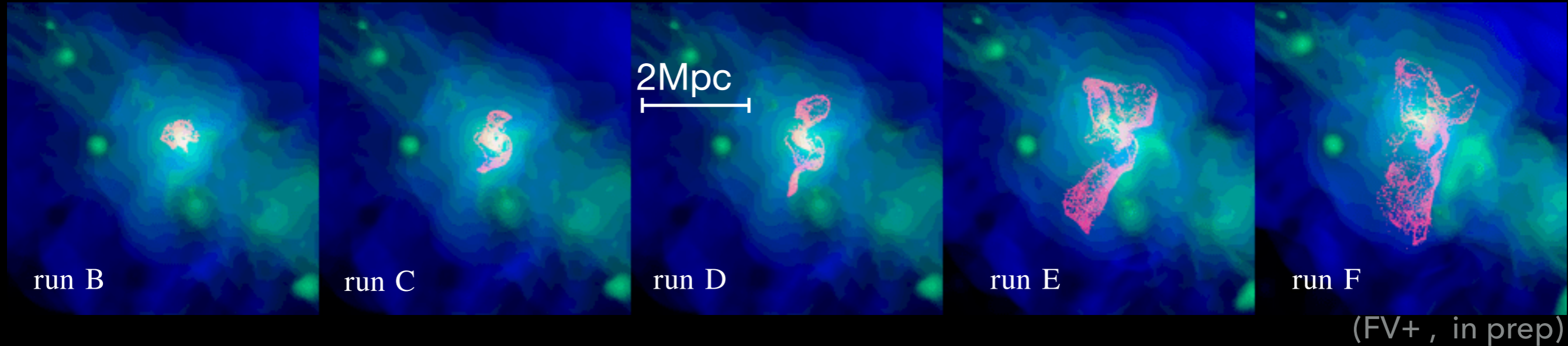
$$P_J = 3 \cdot 10^{42} \text{erg/s}$$

$$P_J = 1 \cdot 10^{43} \text{erg/s}$$

$$P_J = 3 \cdot 10^{43} \text{erg/s}$$

$$P_J = 9 \cdot 10^{43} \text{erg/s}$$

$$P_J = 1.5 \cdot 10^{44} \text{erg/s}$$

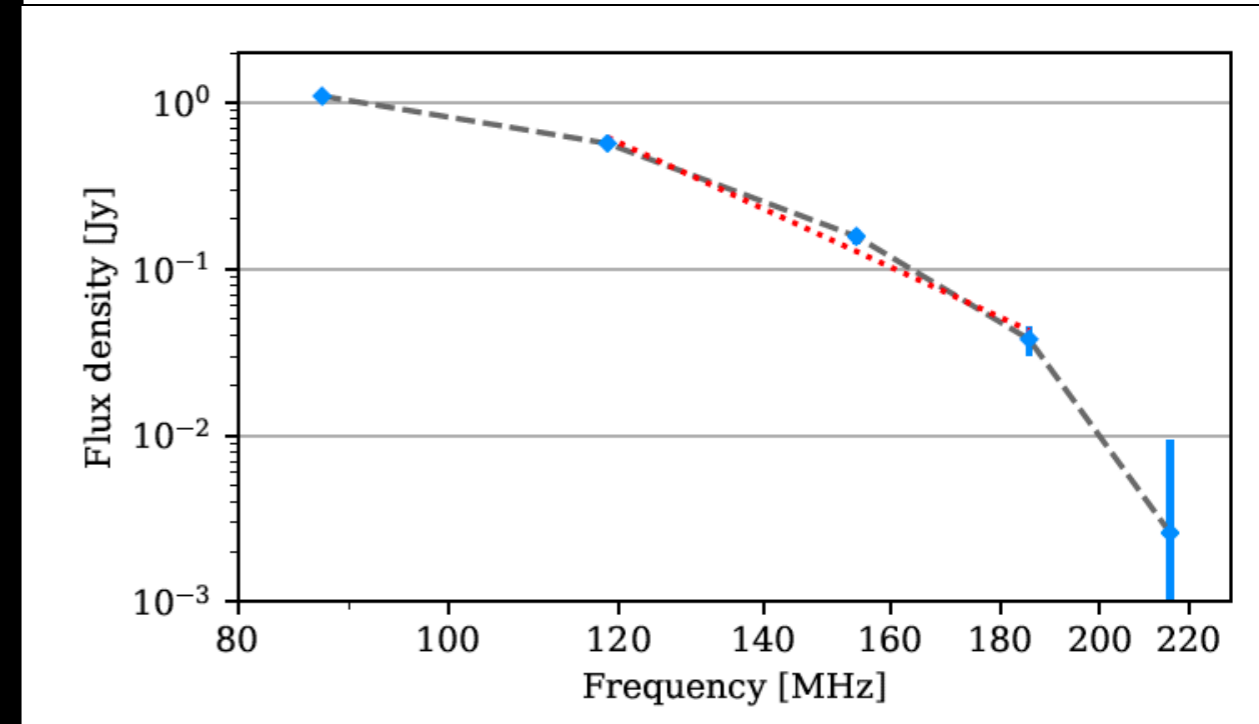
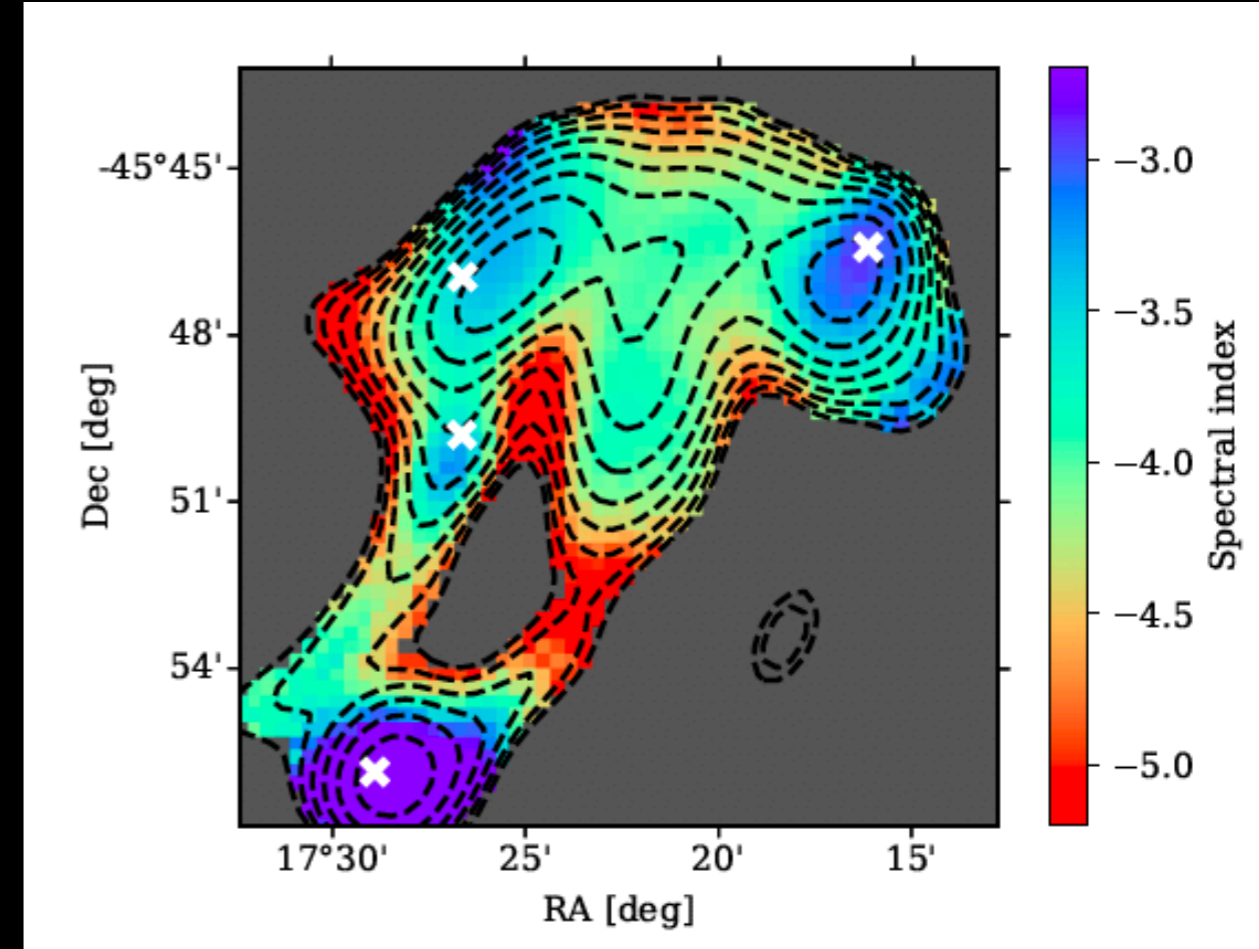
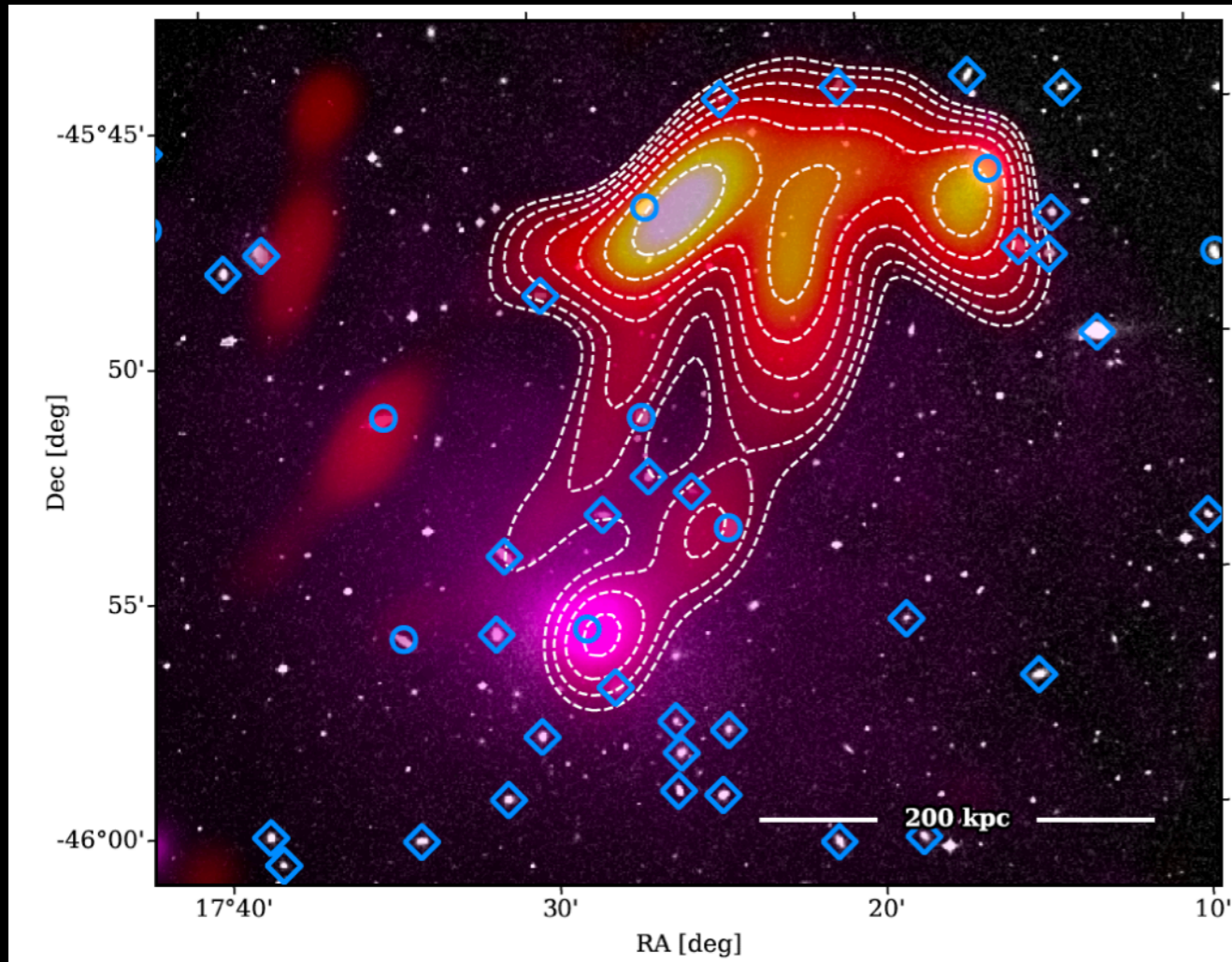


- ▶ What's the link between the diffusion of electrons and the jet power?

(L. Di Federico, FV+, in prep. )

# APPLICATION: A SUPER STEEP RADIO GALAXY

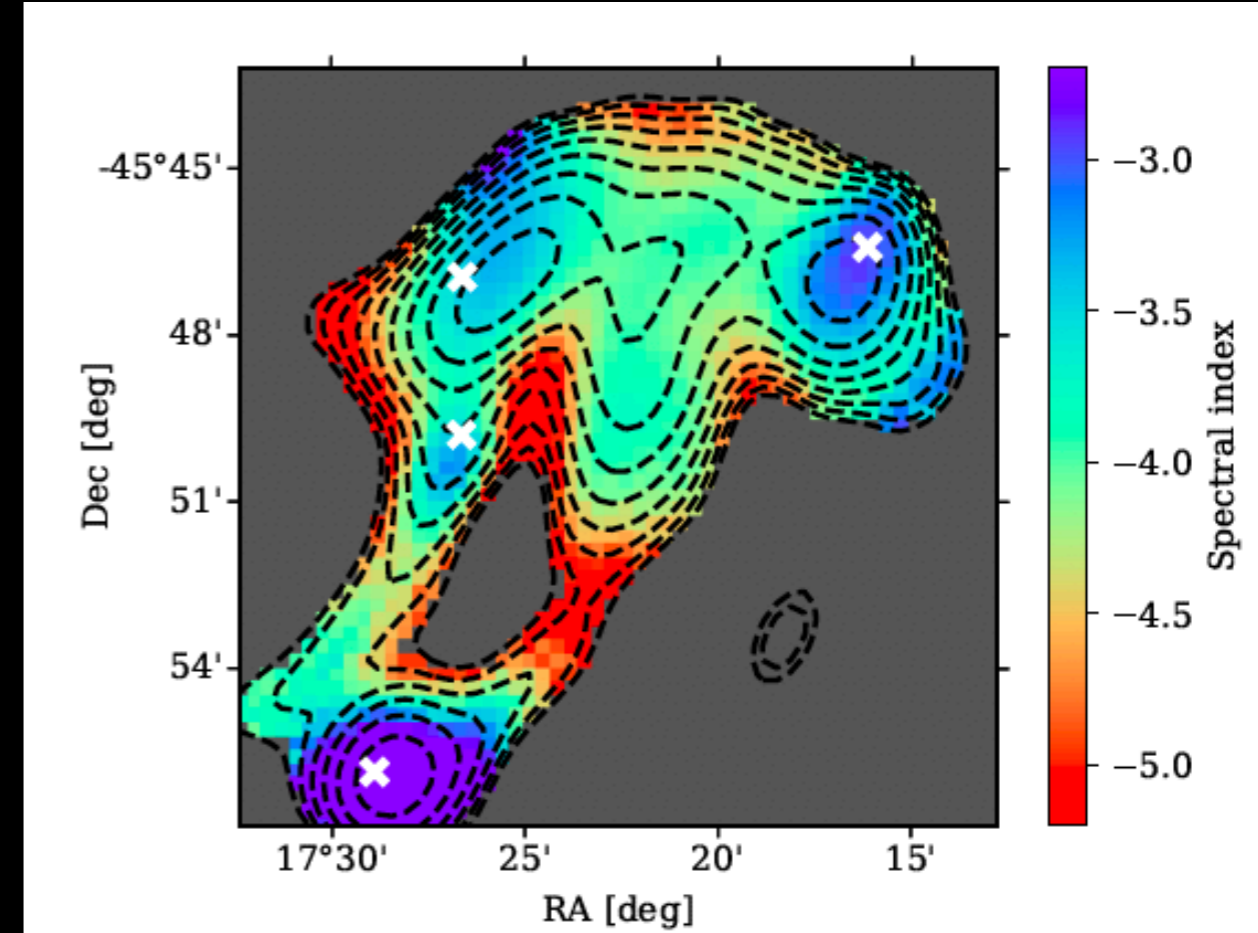
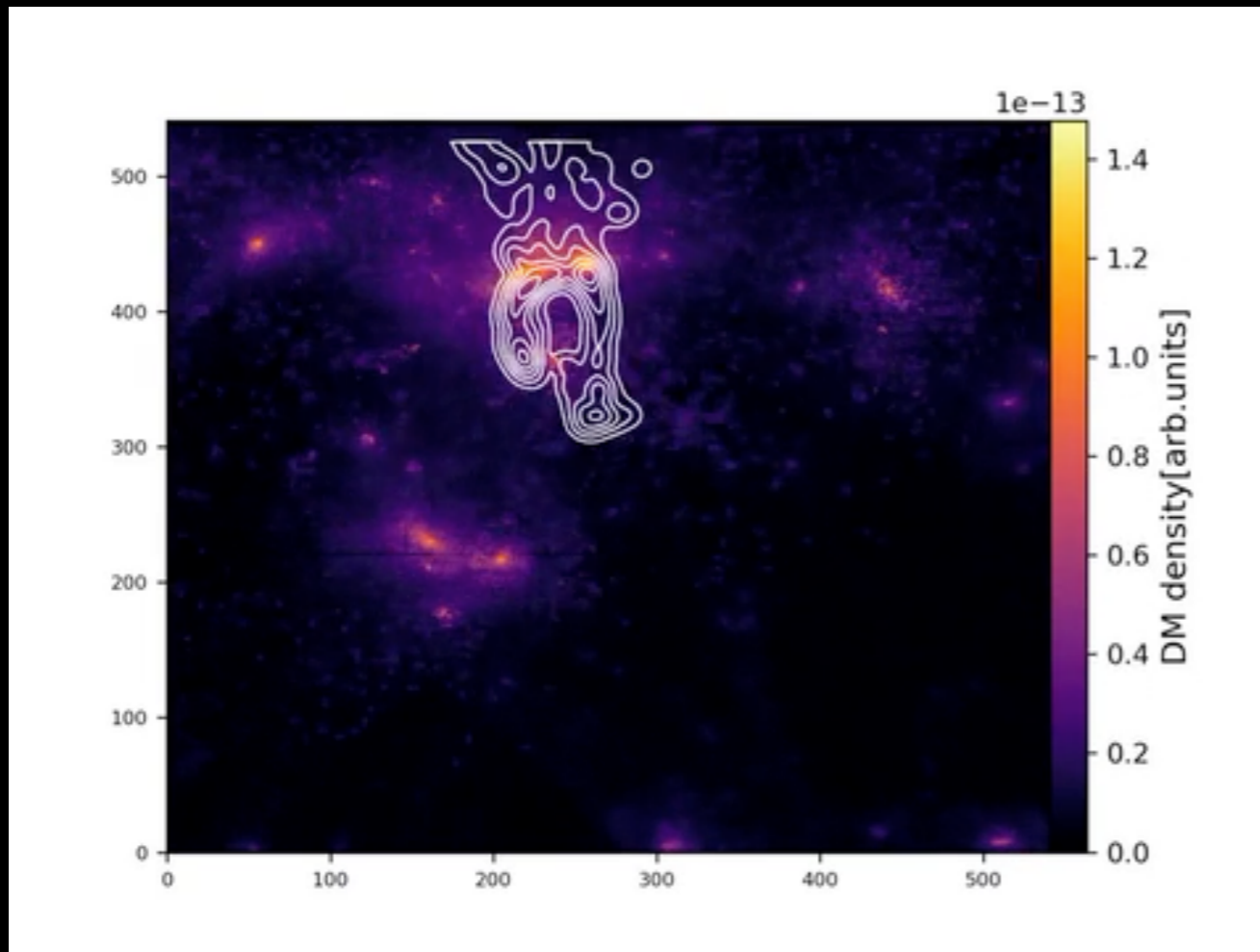
- ▶ “Jellyfish” in A2877 with MWA:  
 $\alpha \sim -5$  from 78 to 231 MHz



(Hodgson et al. 2021 ApJ)

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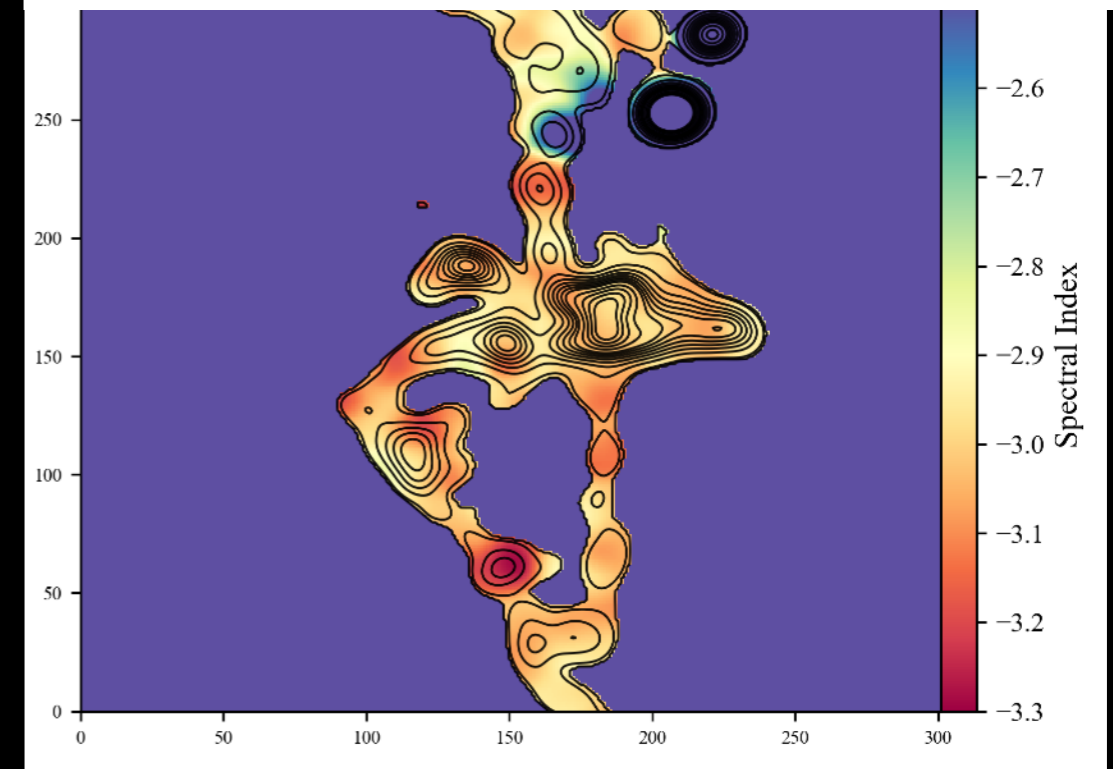
- ▶ “Jellyfish” in A2877 with MWA:  
 $\alpha \sim -5$  from 78 to 231 MHz



- ▶ Compatible with a transient ( $\leq 10^2$  Myr)  
blending of multiple lobes, compressed by  
weak shocks

MWA, 118MHz

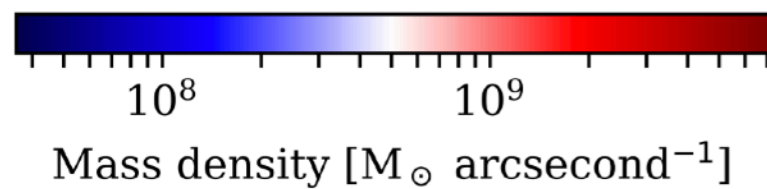
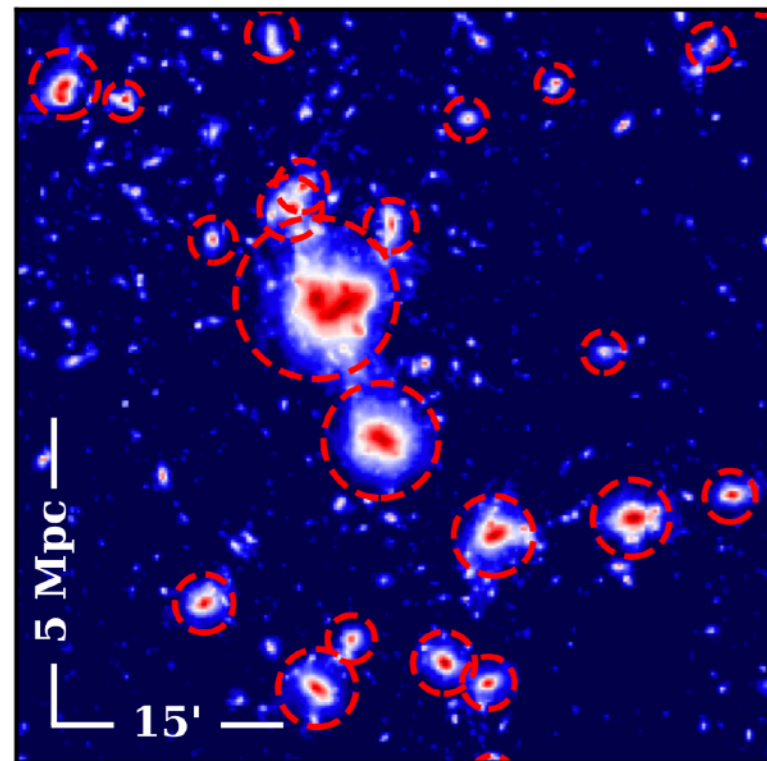
$\theta \sim 100''$



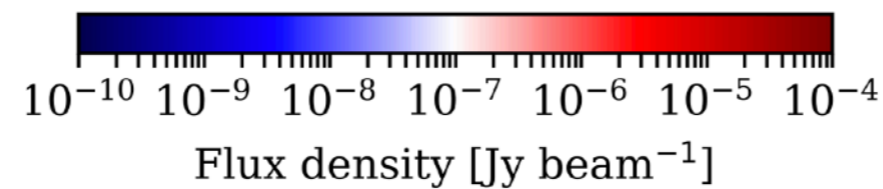
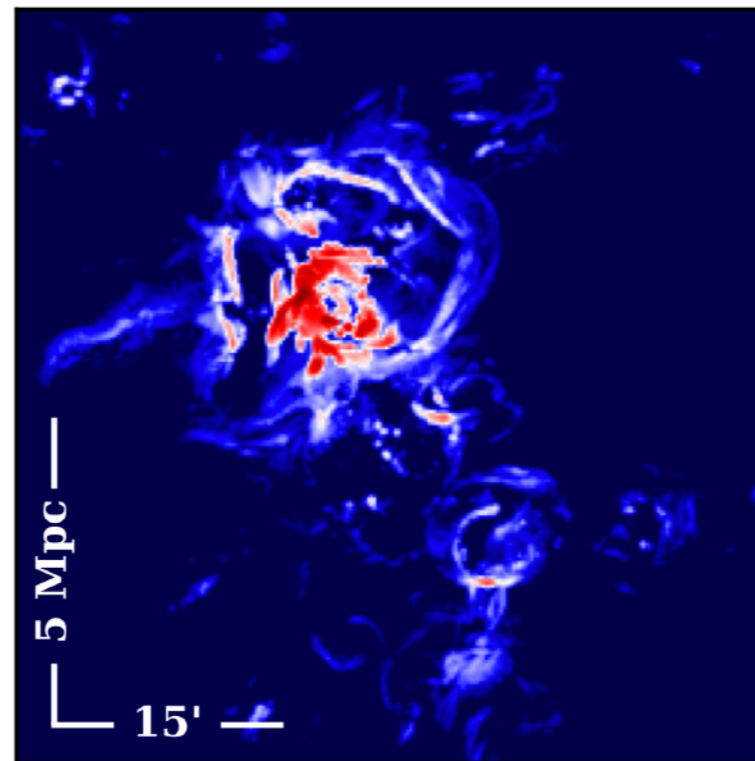
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# THE RADIO COSMIC WEB : INCLUDING SHOCK ACCELERATION AND RADIO GALAXIES

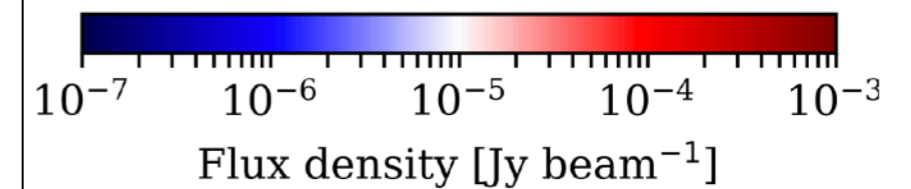
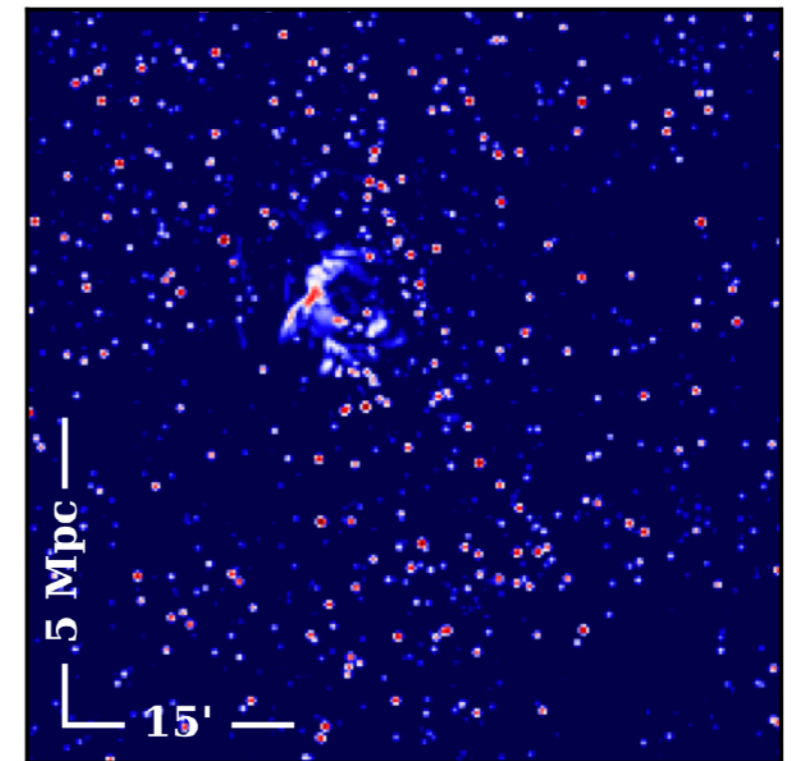
matter distribution (50x50',  $z < 0.2$ )



shocked cosmic web



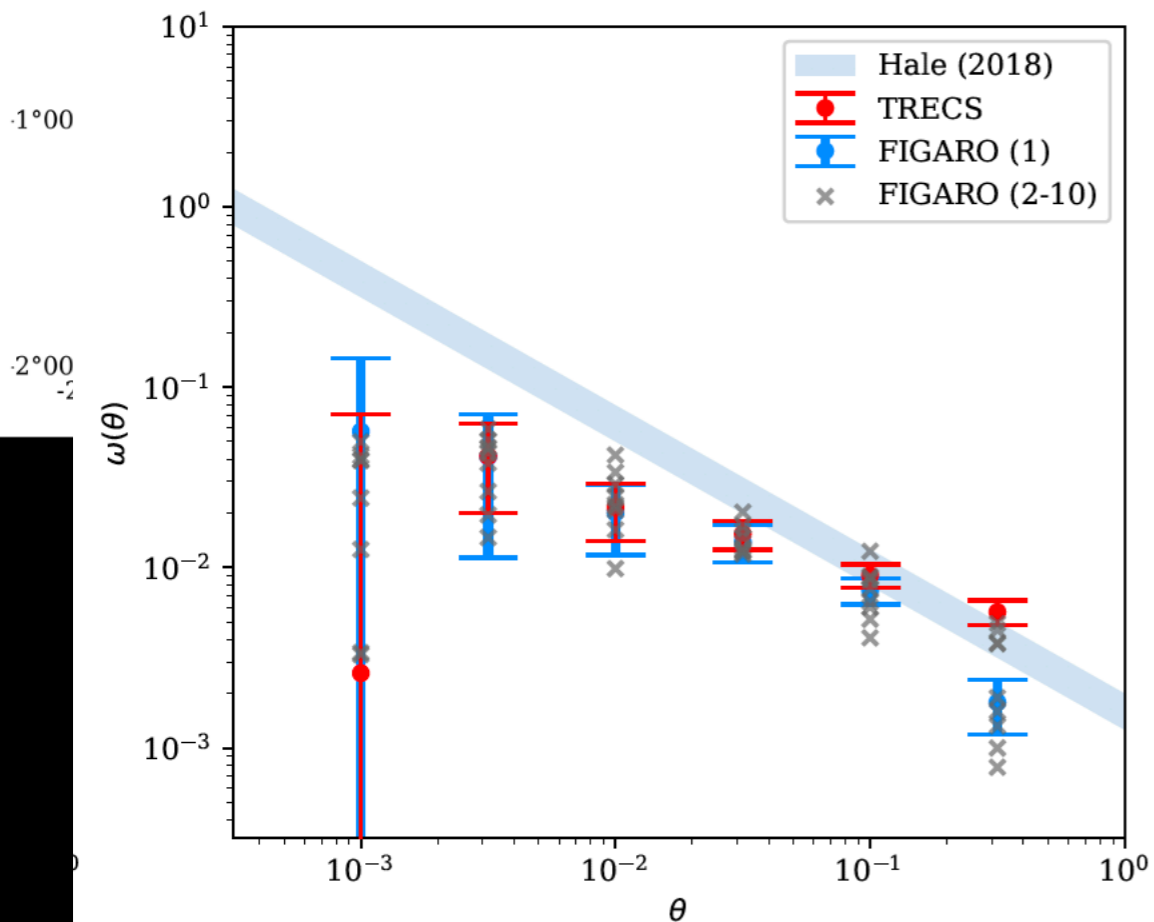
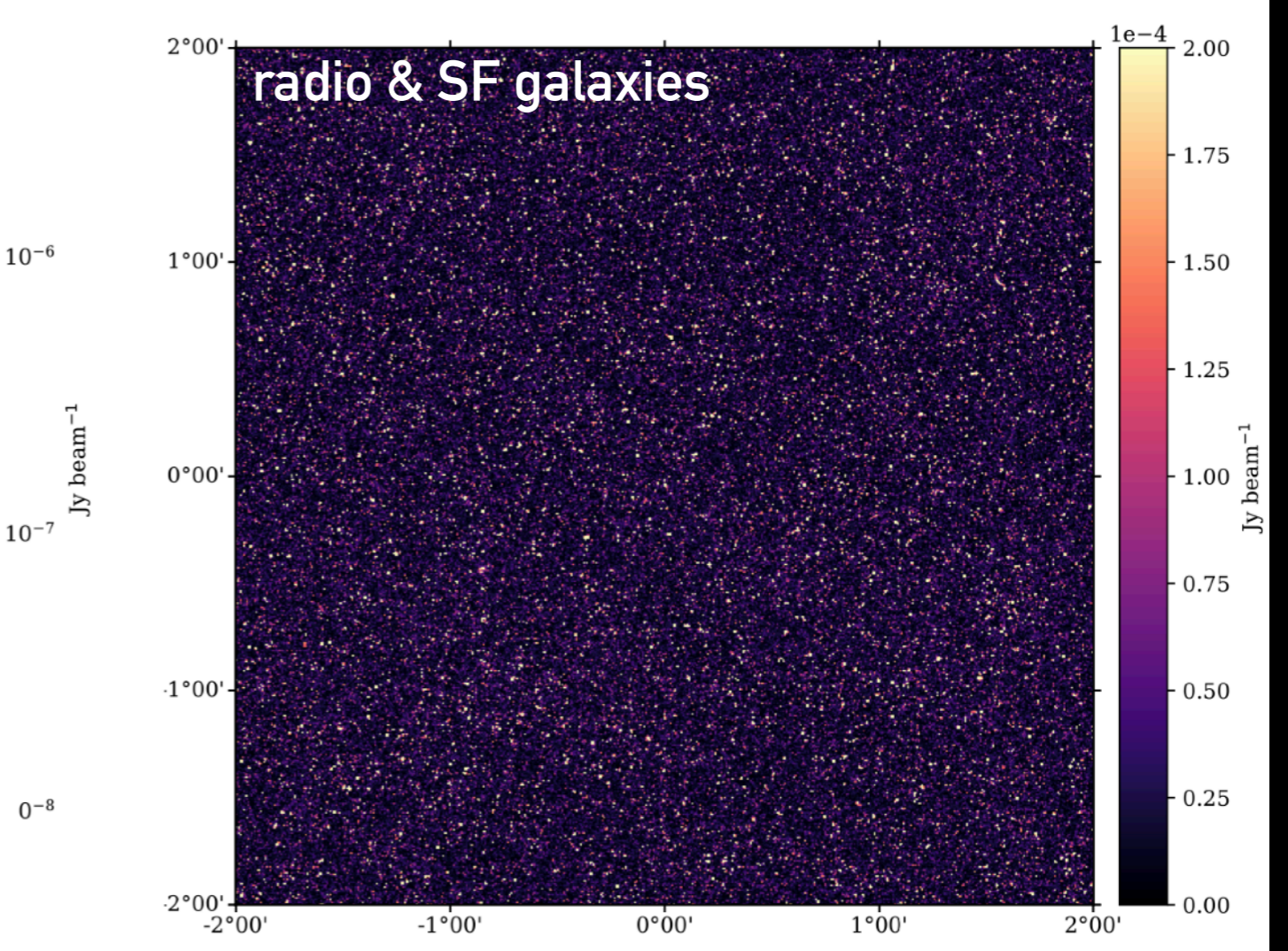
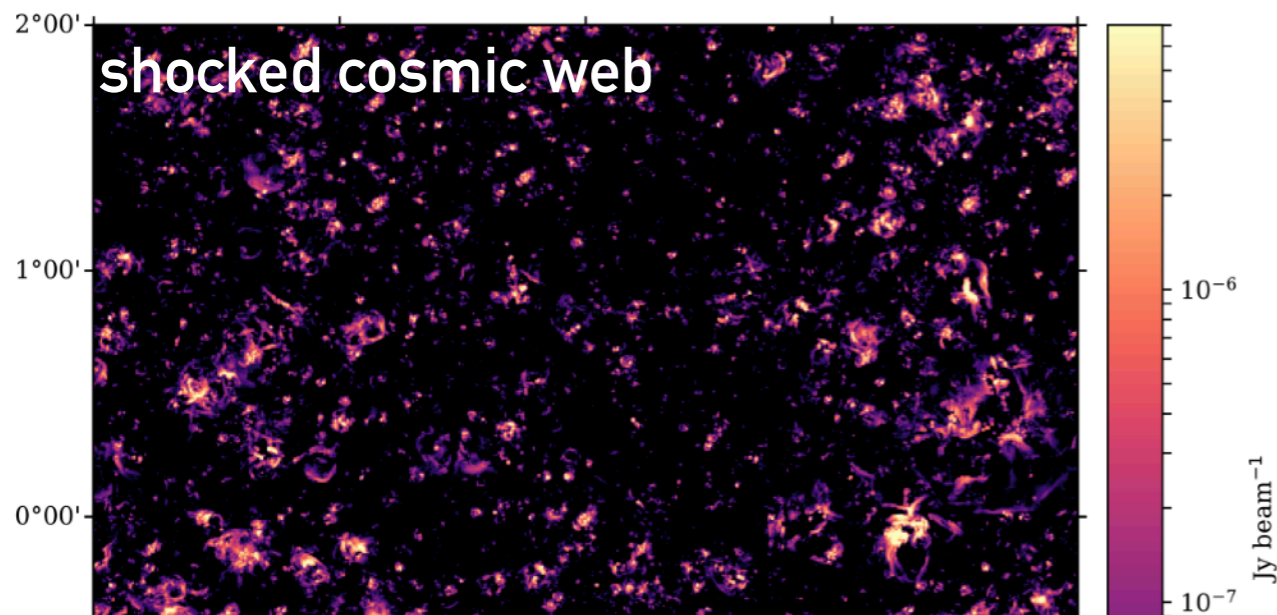
detectable web + radiogalaxies



ASKAP, 900MHz  $\theta \sim 20''$

- ▶ Simulated realistic sky models for MWA, ASKAP and SKA-LOW including cosmic web (our sims) and radio galaxies (from TRECS, Bonaldi+)

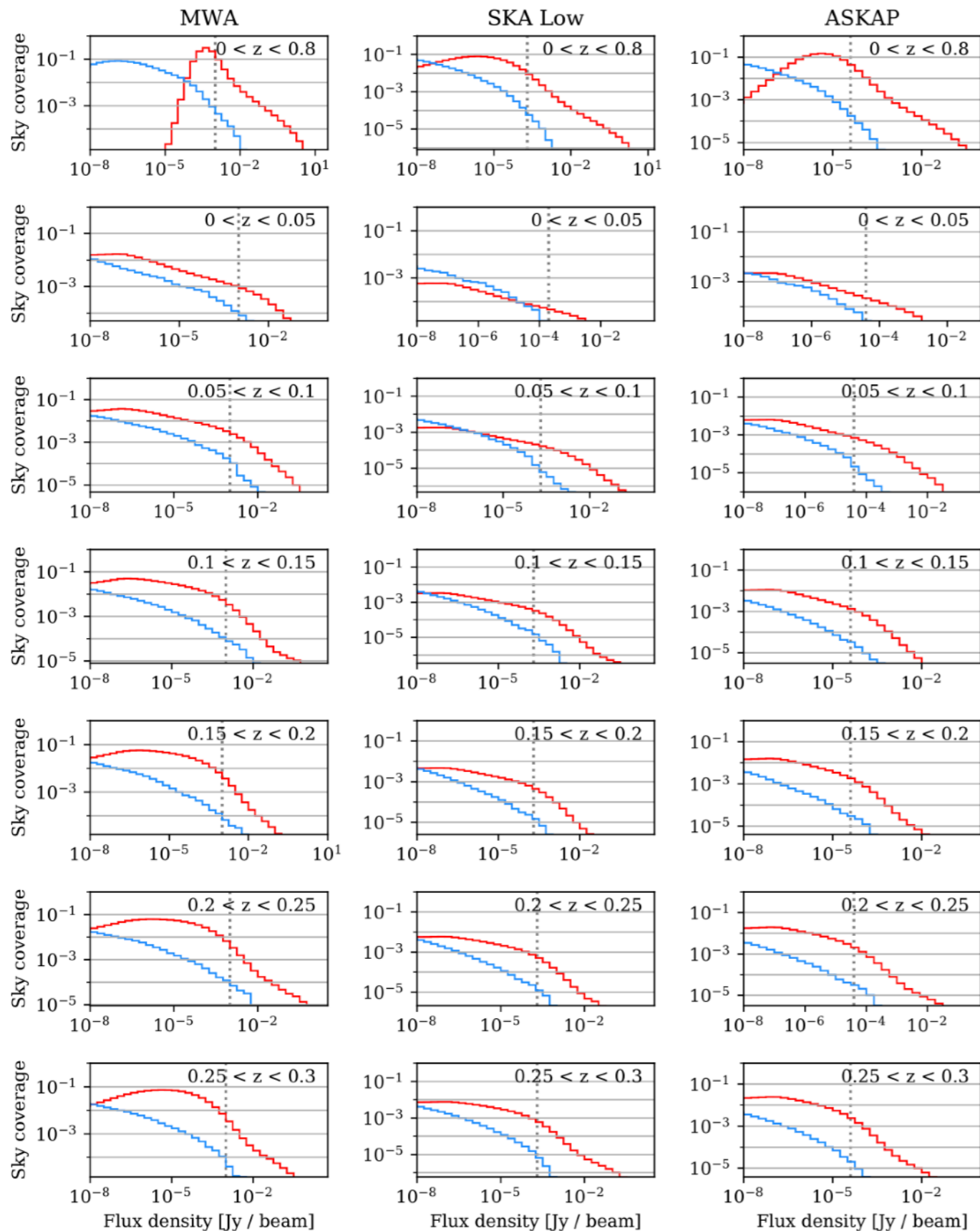
# THE RADIO COSMIC WEB : INCLUDING SHOCK ACCELERATION AND RADIO GALAXIES



4° x 4° ASKAP, 900MHz  $\theta \sim 20''$

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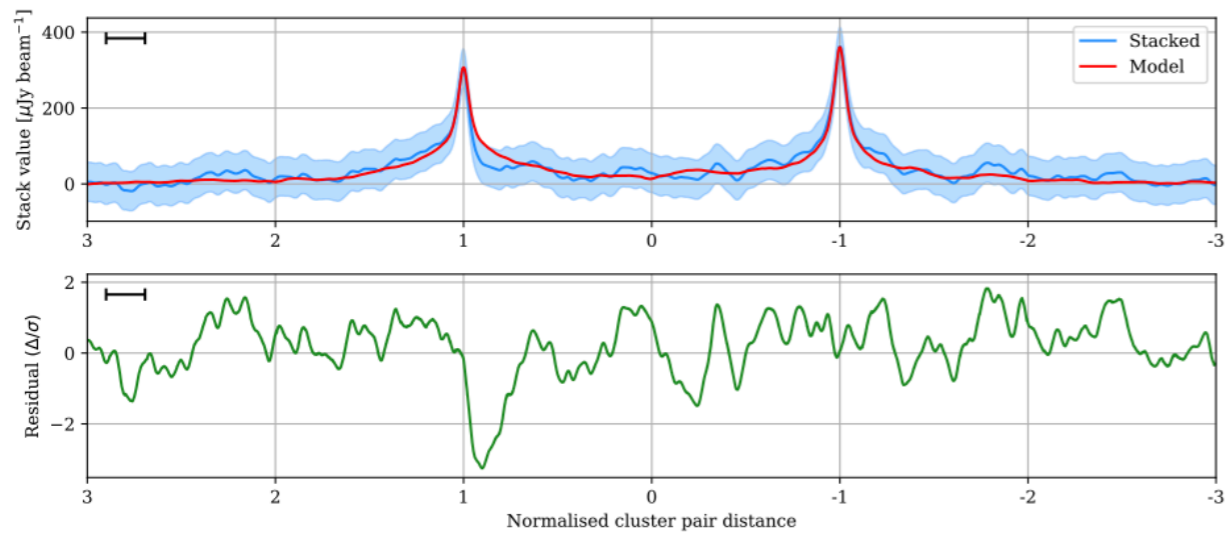


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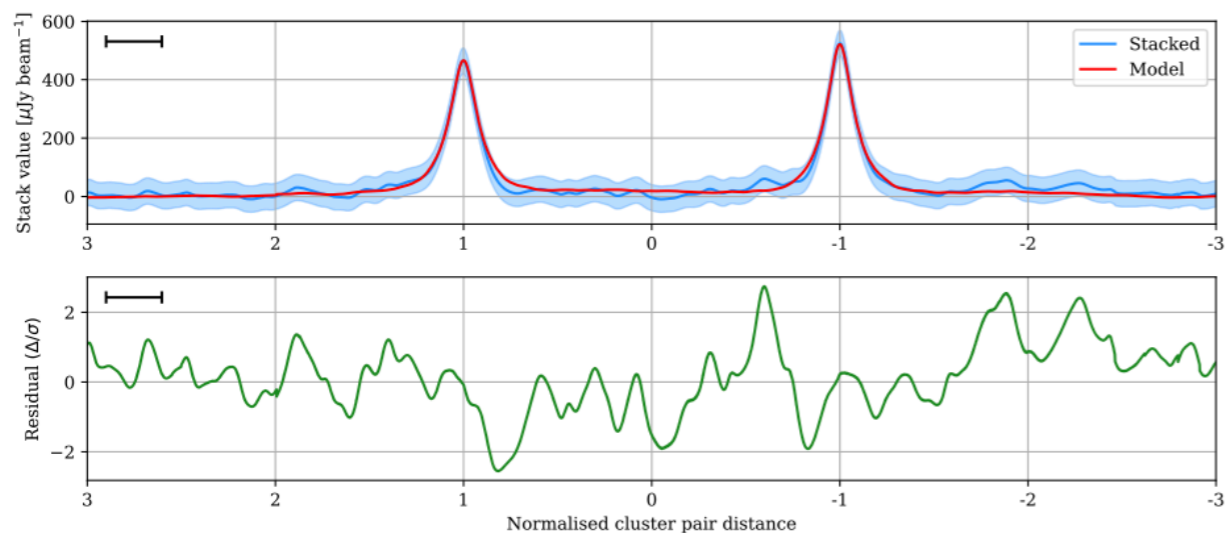
(Hodgson, FV et al. 2021 PASA)



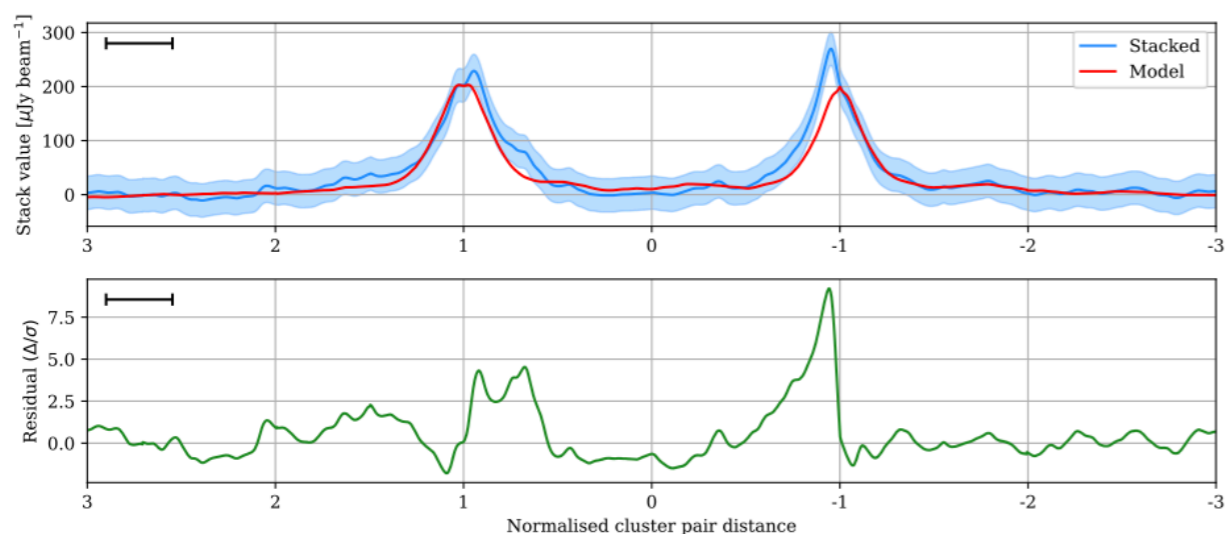
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(a) AGNs & SFGs, cleaned to 5 mJy threshold



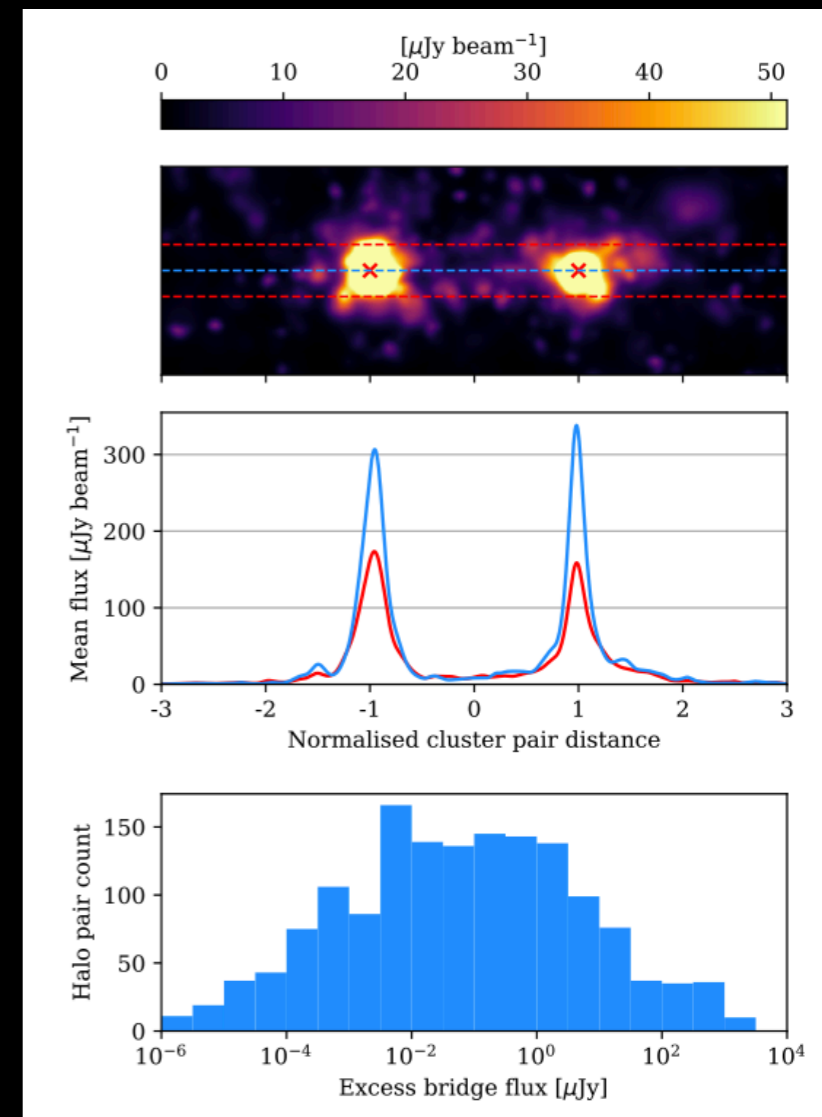
(b) Radio halos



(c) Cosmic web

- ▶ application to the interpretation of the  $\sim 5\sigma$  detected excess emission in the radio stacking of filaments in pairs (Vernstrom+21)
- ▶ contamination by AGN, star forming galaxies, radio halos, radio relics + MWA beam convolution

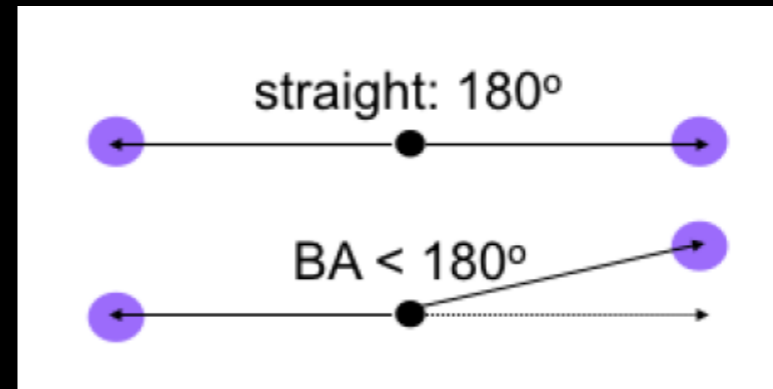
MWA, 154MHz  
 $\theta \sim 200''$



(Hodgson, FV et al. 2021 submitted)

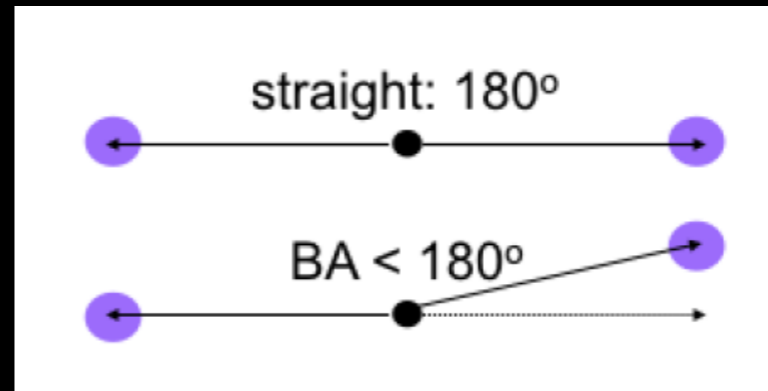
# SIMULATED VS OBSERVED RADIO GALAXIES

- ▶ Bent angle statistics in  $\sim 100$  COSMOS radio galaxies (3 GHz)



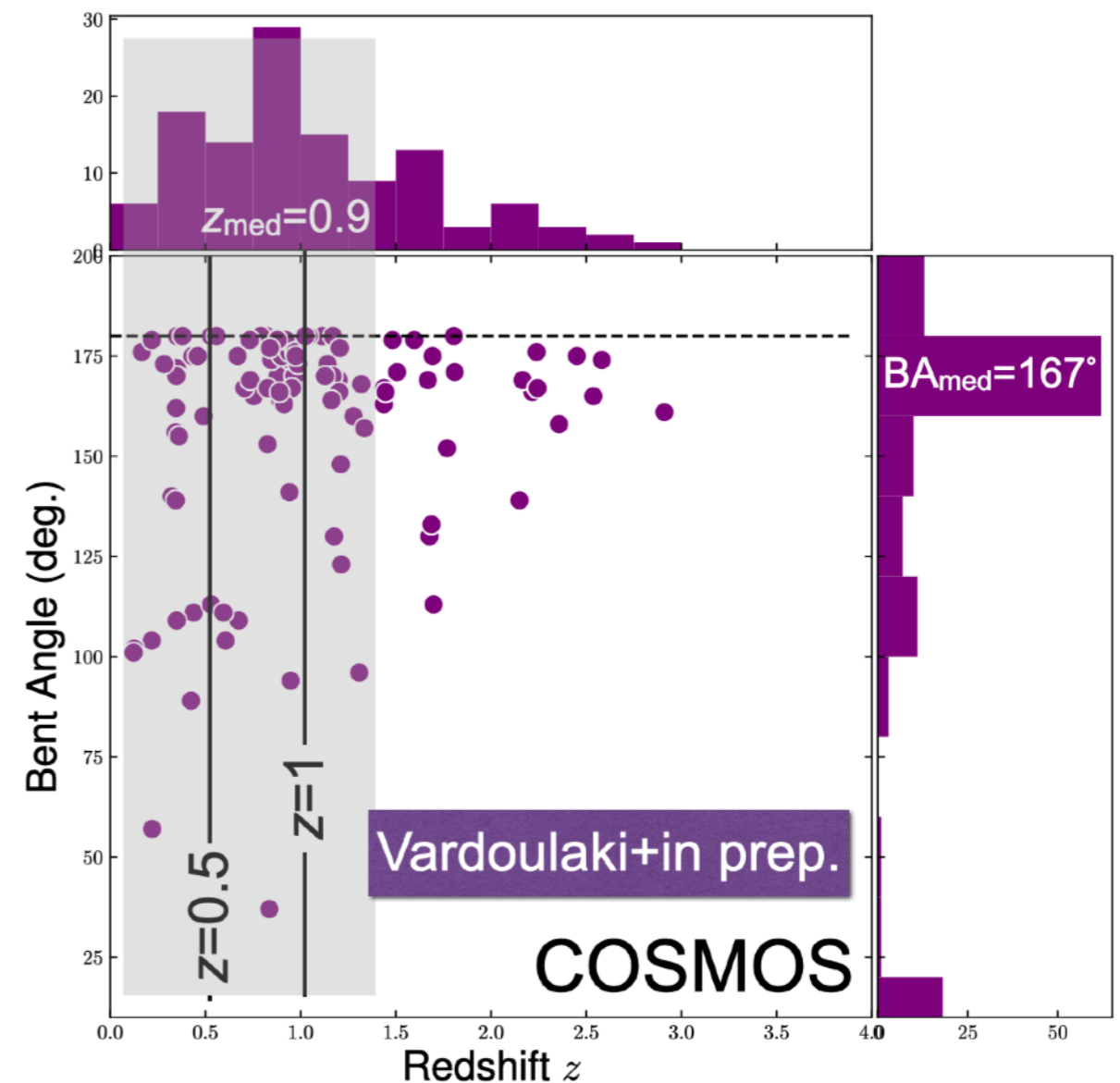
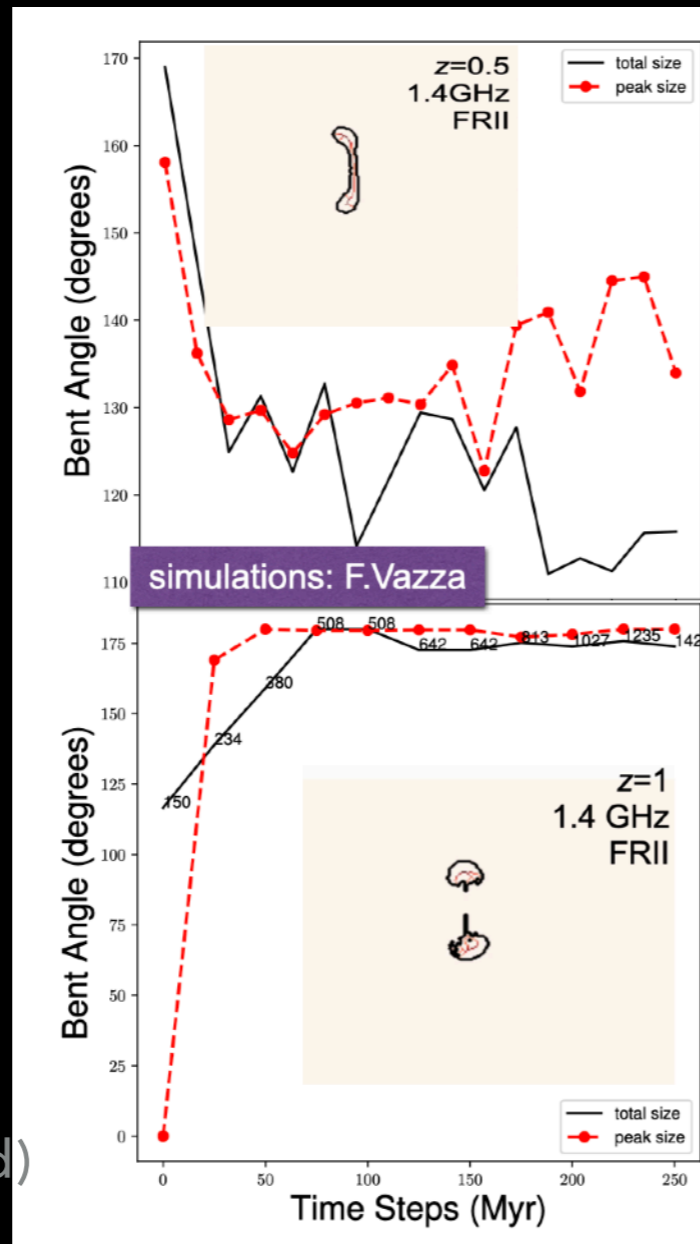
# SIMULATED VS OBSERVED RADIO GALAXIES

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- Evolution of BA as a function of  $z$ : compatible with our simulations.

- Little/no role of environment, host galaxy, host cluster



# THE RADIO COSMIC WEB : INCLUDING SHOCK ACCELERATION AND RADIOLOBES

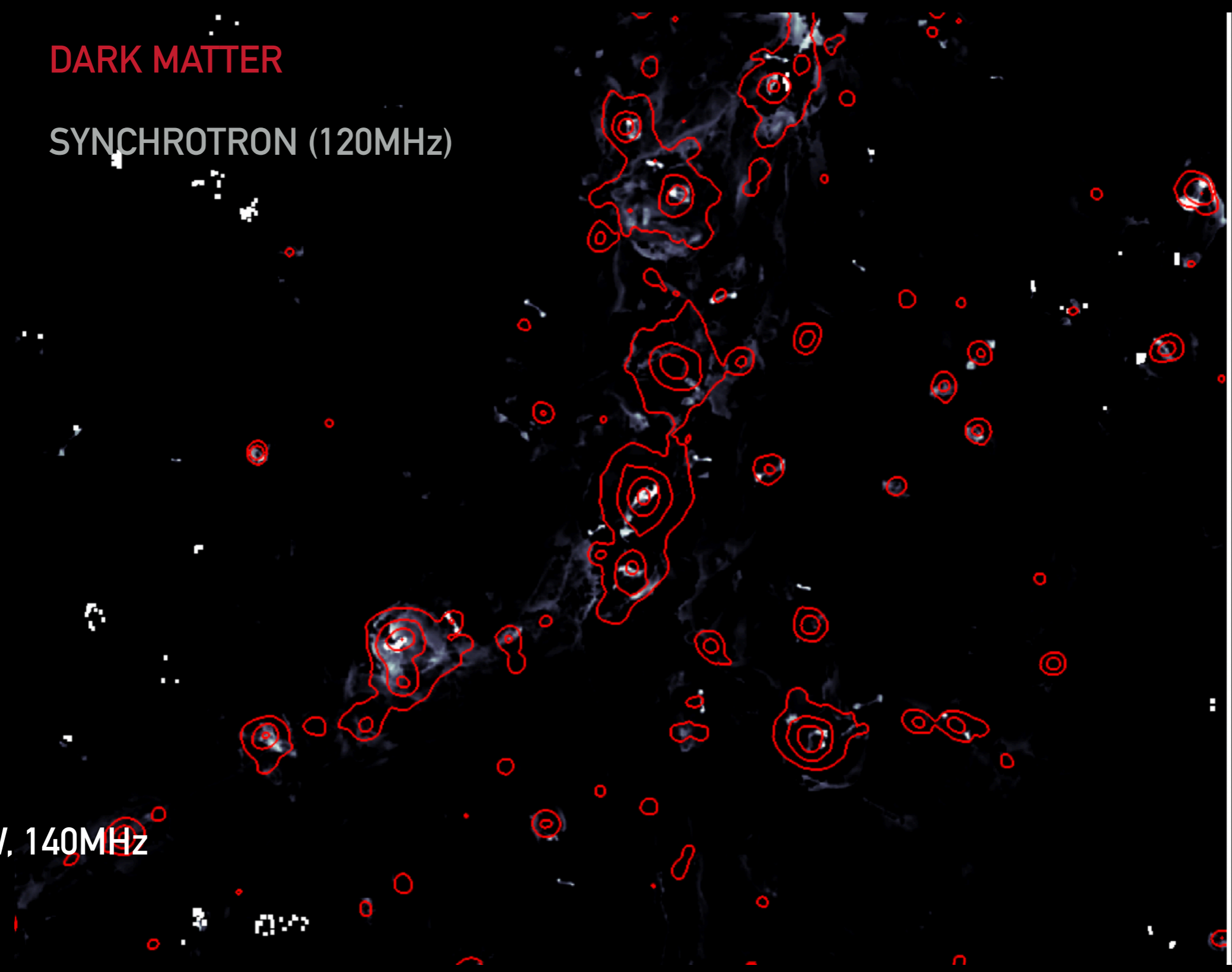
DARK MATTER

SYNCHROTRON (120MHz)

SKA-LOW, 140MHz

$\theta \sim 10''$

$\sigma = 0.17 \mu\text{Jy}/\text{arcsec}^2$



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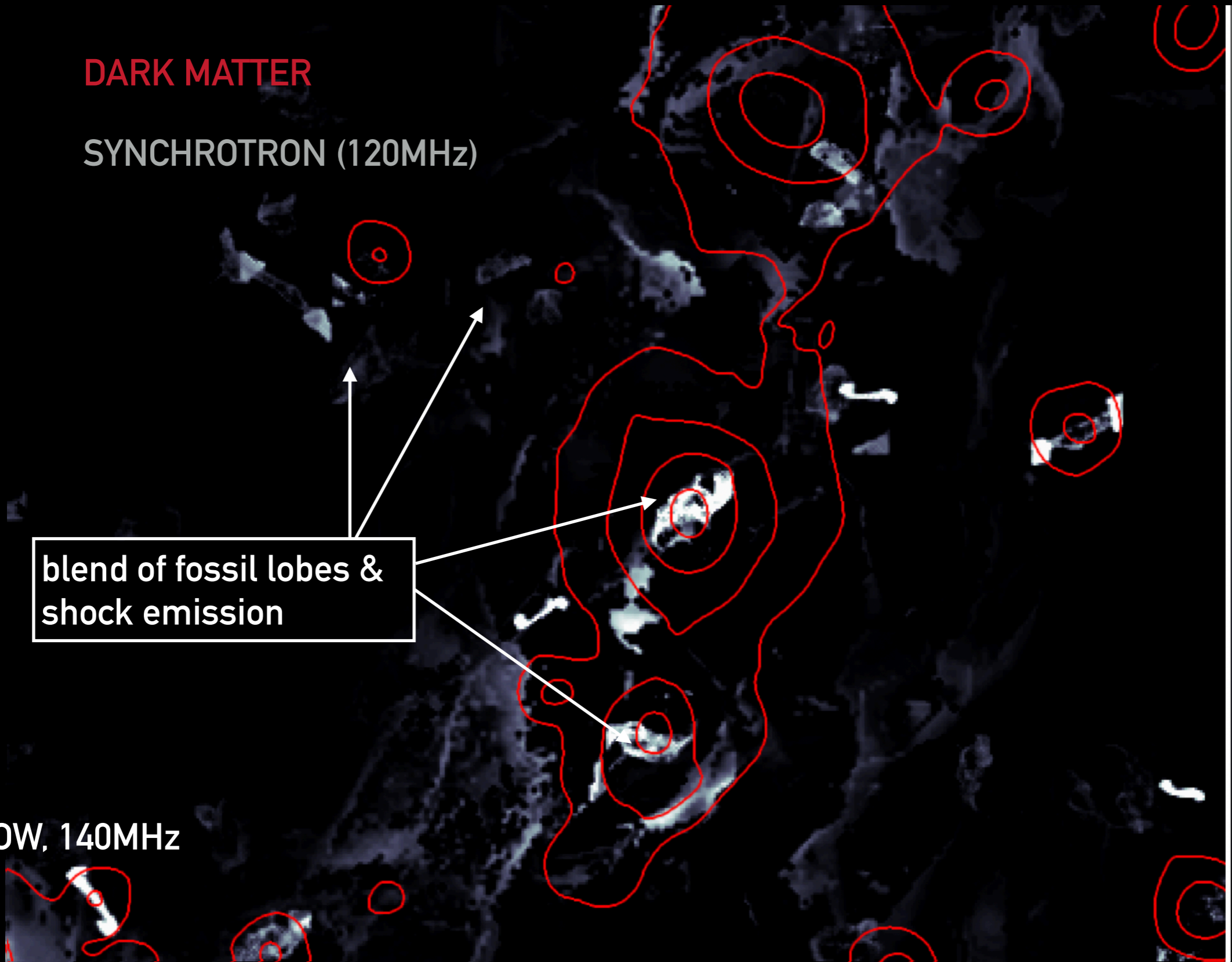
SYNCHROTRON (120MHz)

blend of fossil lobes & shock emission

SKA-LOW, 140MHz

$\theta \sim 10''$

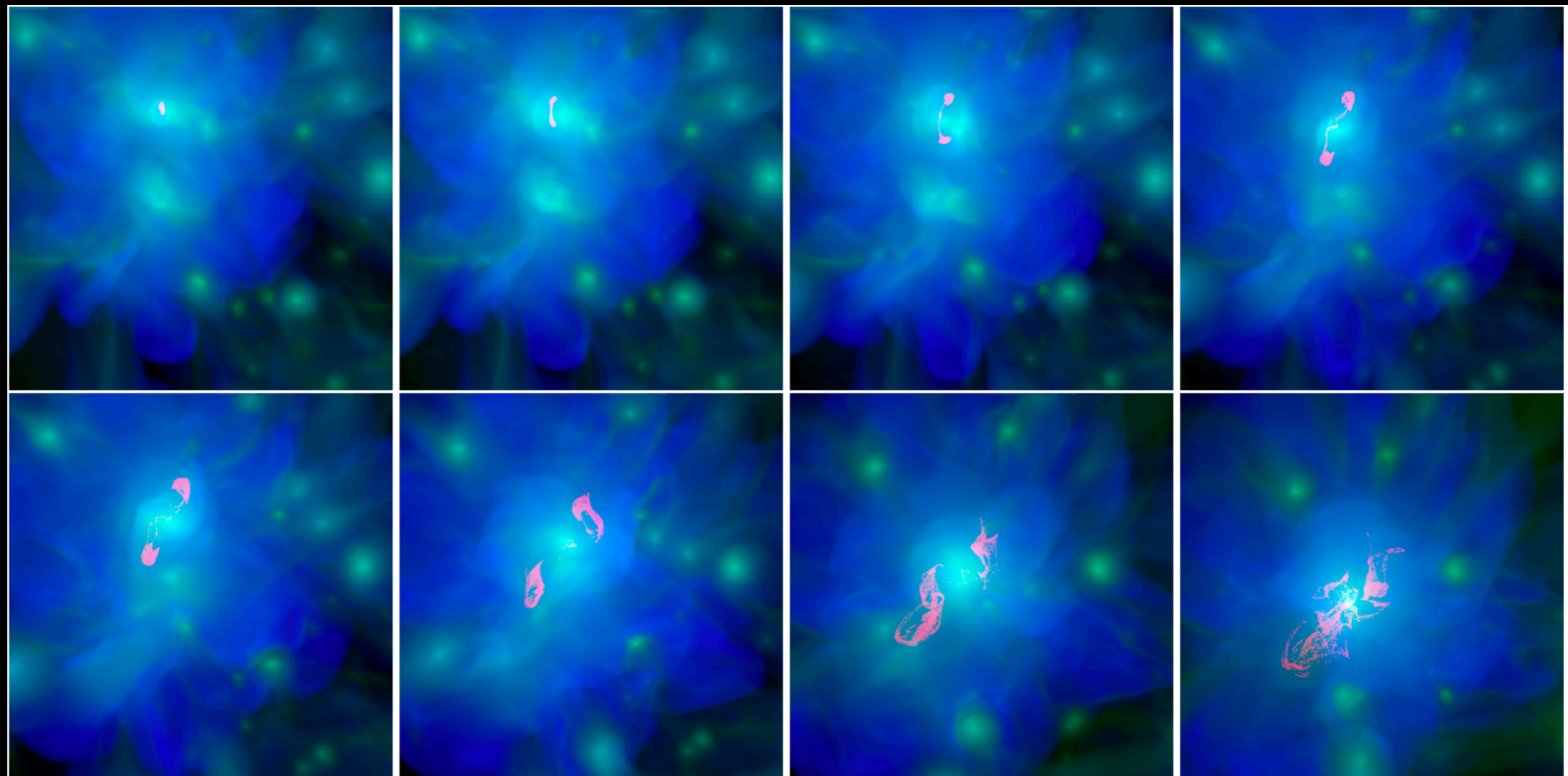
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## SUMMARY AND OVERVIEW OF SKA-RELATED INVOLVEMENT

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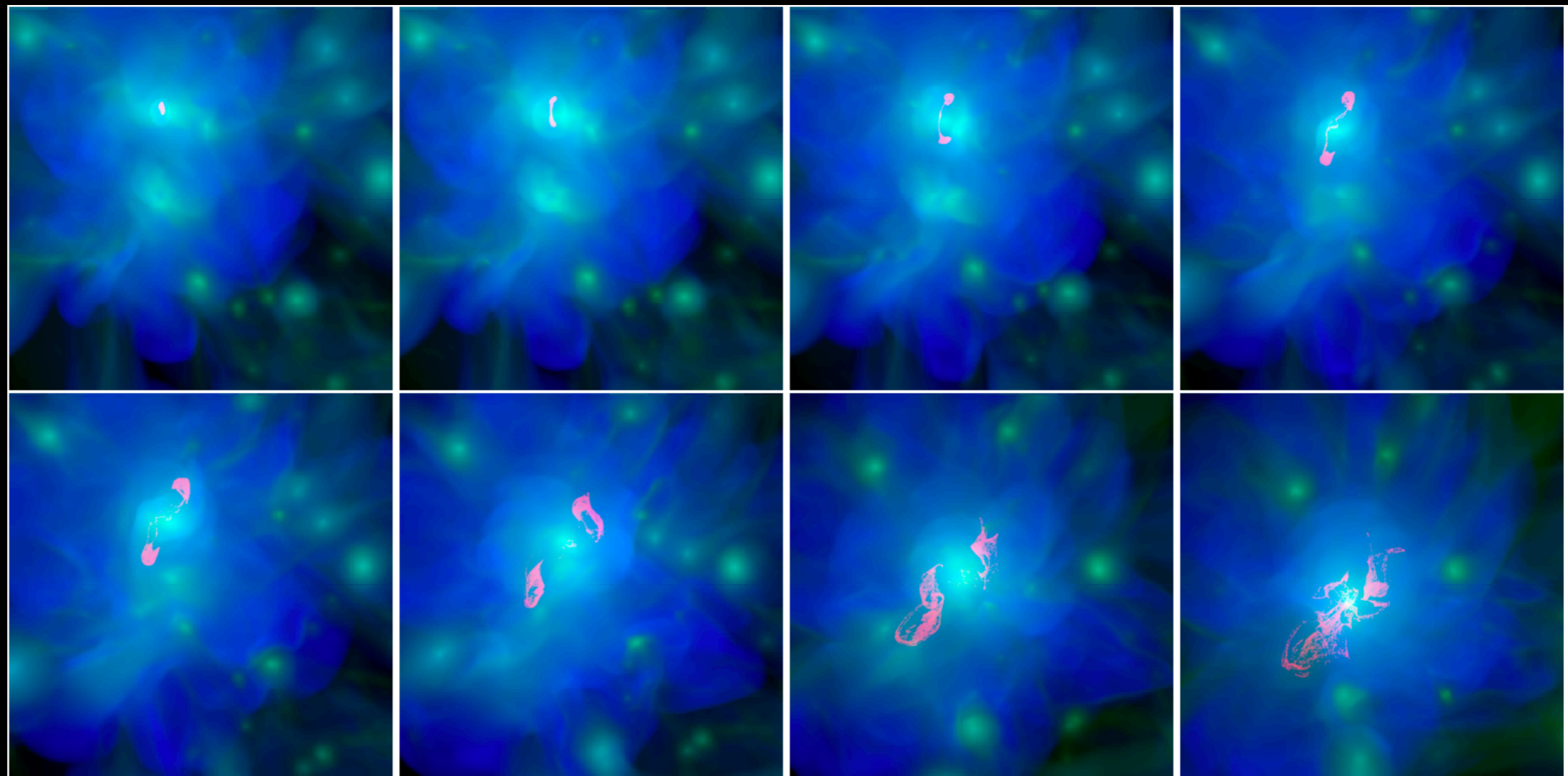
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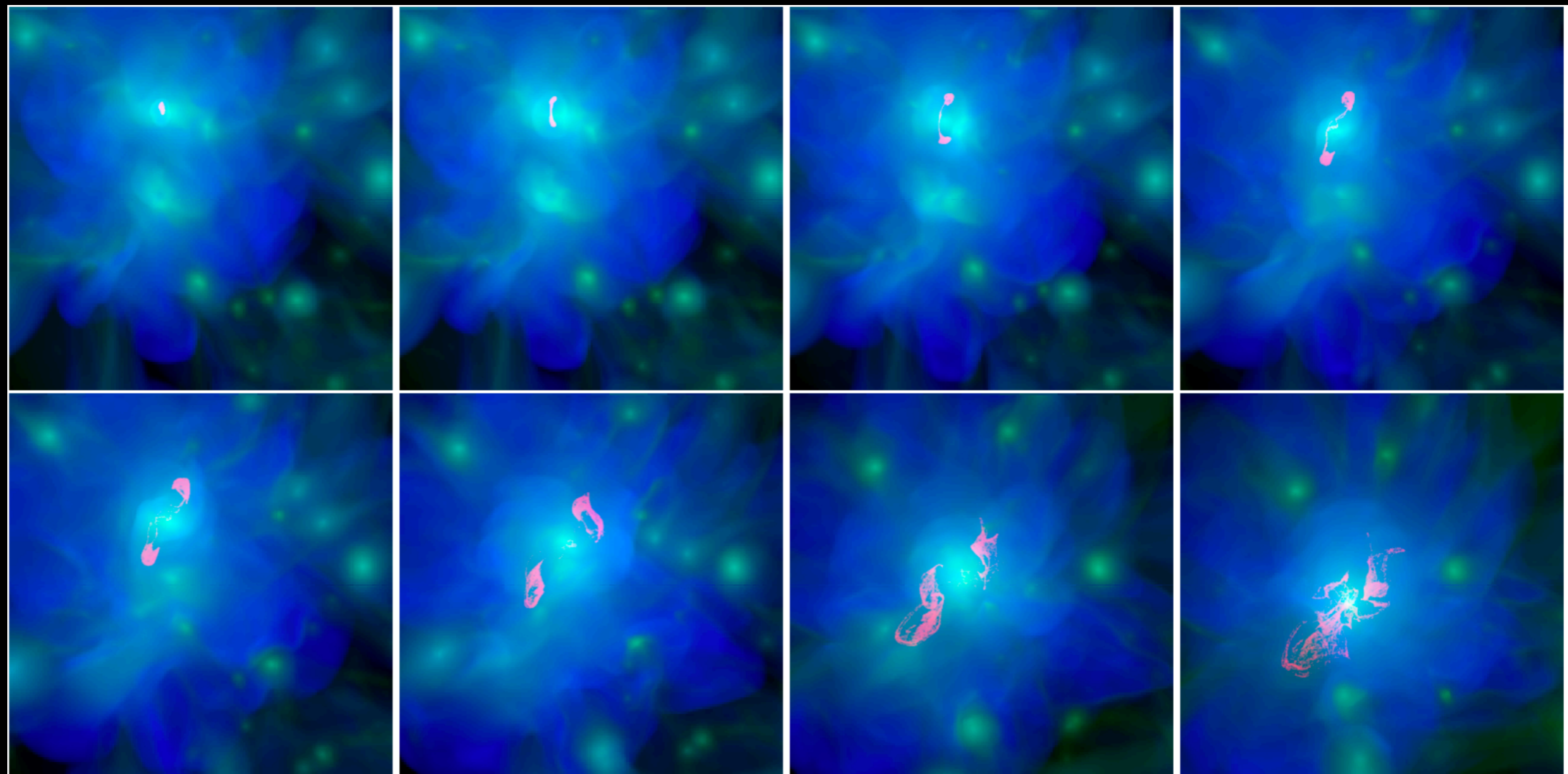
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- ▶ **Training of source finding and imaging techniques (see C. Gheller's talk)**



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- ▶ Simulated sky models: used for the modelling of observations, proposals & feasibility studies
- ▶ Training of source finding and imaging techniques (see C. Gheller's talk)
- ▶ **Heavy usage of CINECA for computing (+Julich and CSCS)**
- ▶ **Heavy usage of INAF OWN CLOUD for data storage**



THANKS