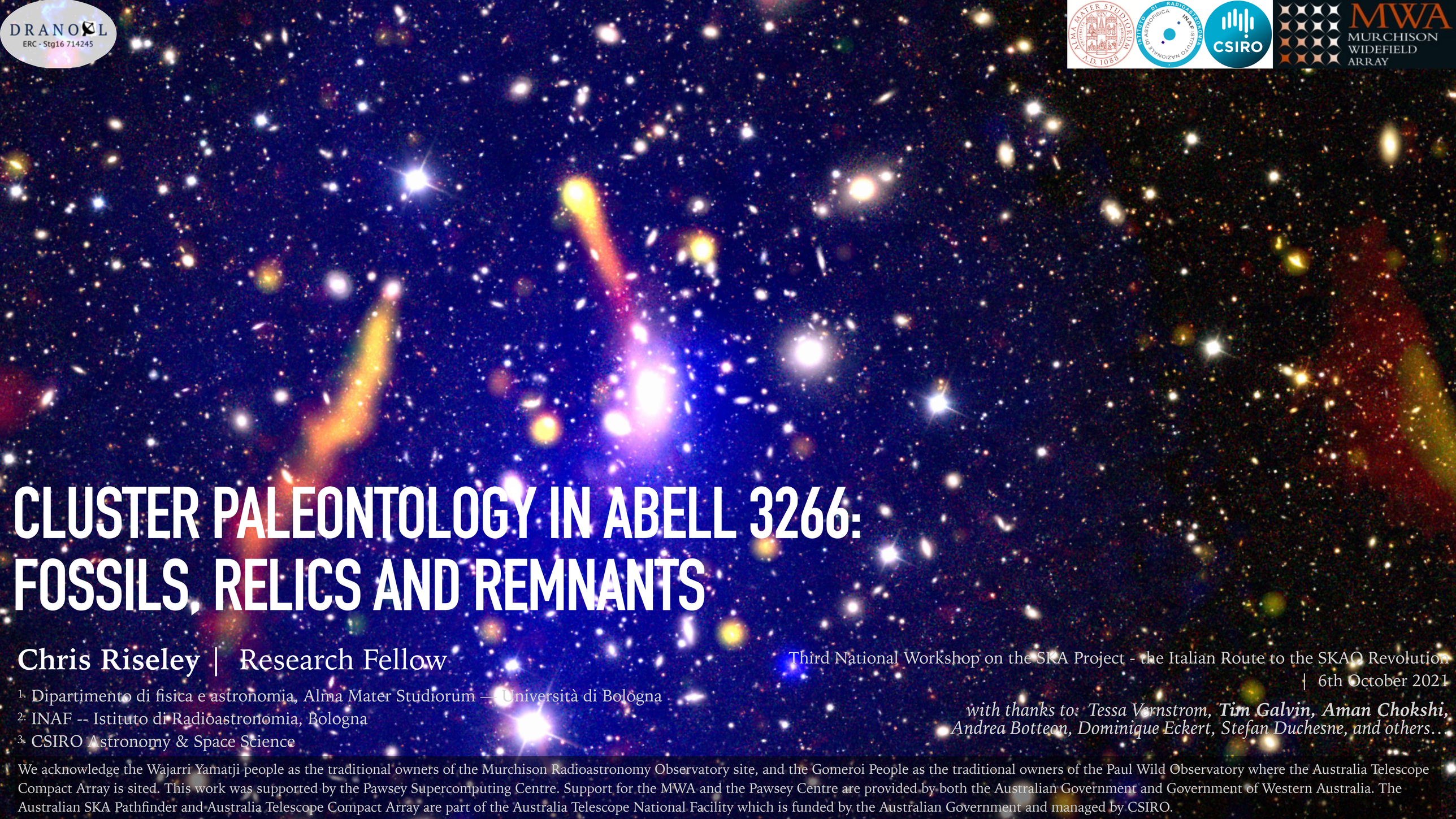

CLUSTER PALEONTOLOGY IN ABELL 3266: FOSSILS, RELICS AND REMNANTS

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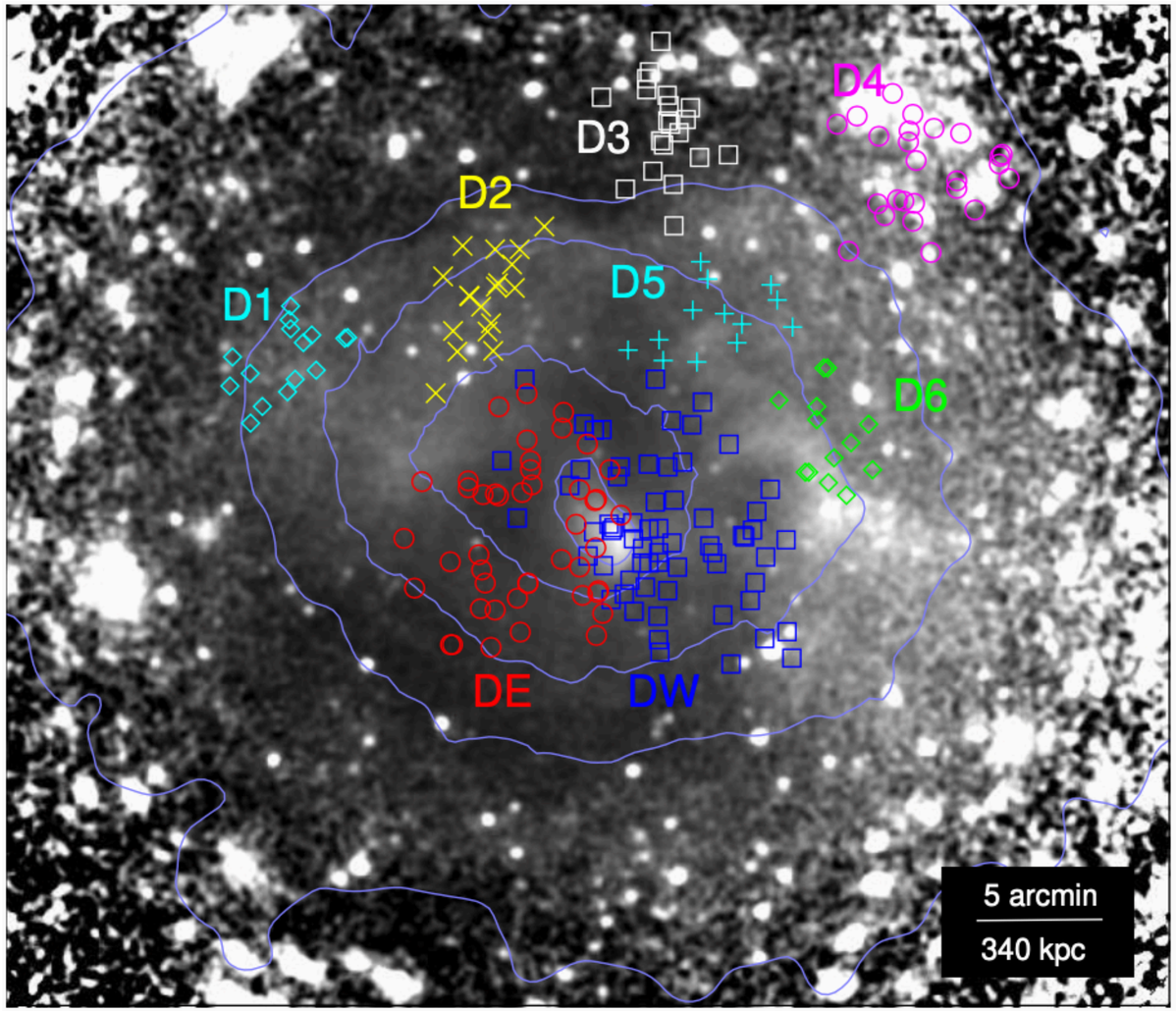
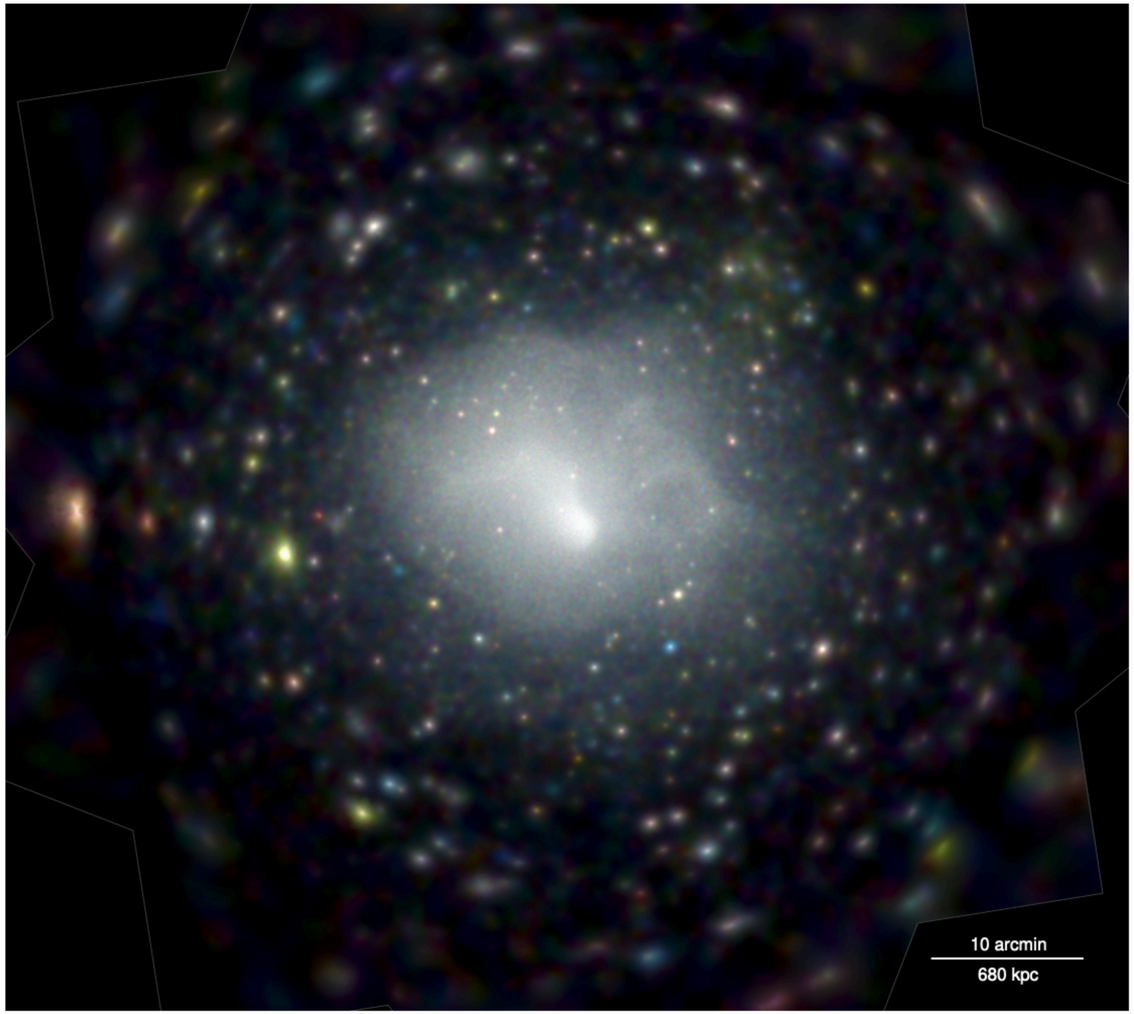
ABELL 3266



Sanders et al. (2021)



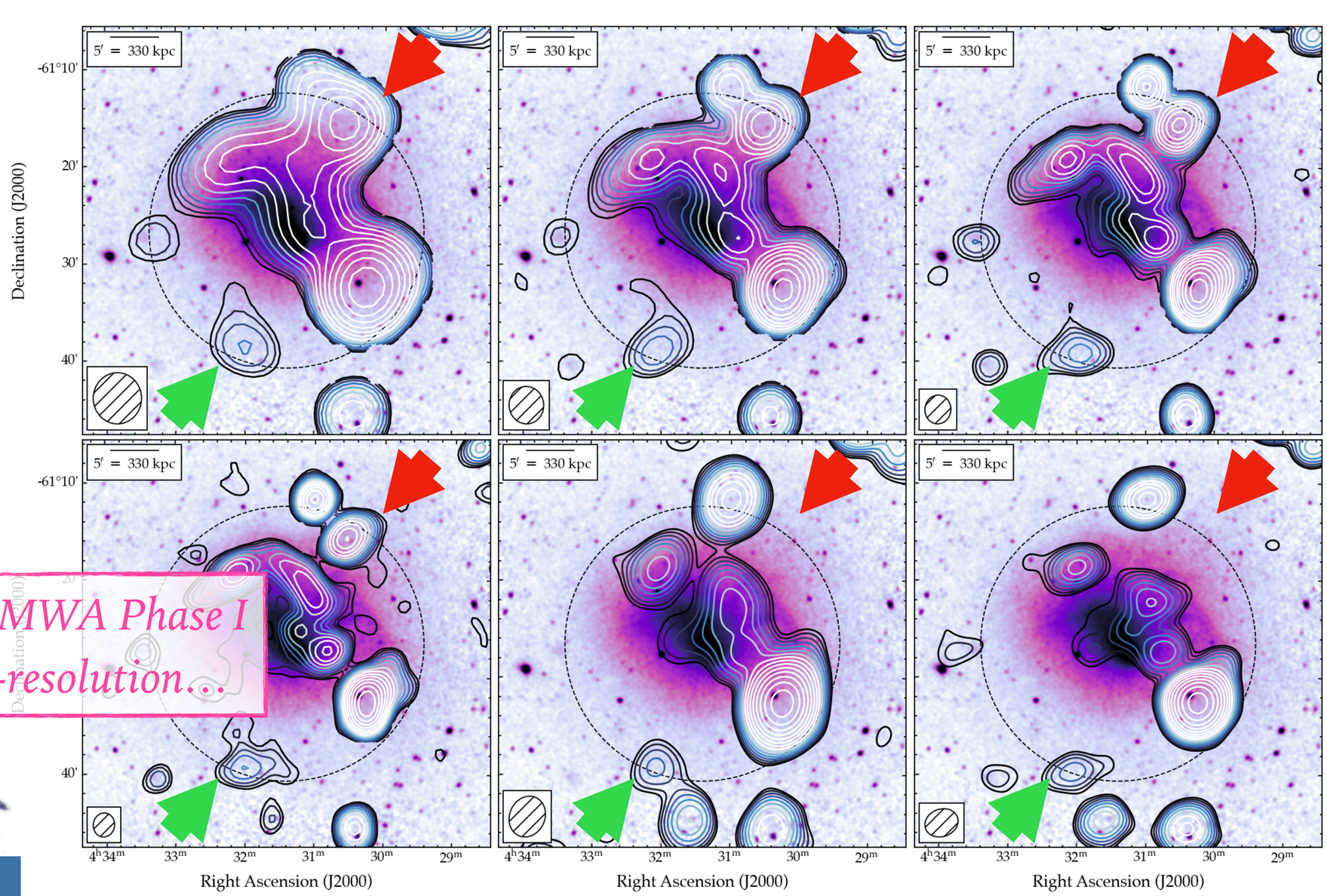
Sanders et al. (2021)

- Complex, low-redshift merging cluster:
  - $z = 0.0385$
  - Significant X-ray substructure (XMM-*Newton*, *Chandra*, *eROSITA*).
  - Significant optical substructure (Dehghan et al. 2017)
  - Poorly-explored in the radio (only shallow and/or low-resolution).

Abell 3266 in the Radio

- Significant emission:
  - *Blended sources or something more?*
  - Inconclusive in 2016
- Interesting sources:
  - *Bright, ultra-steep spectrum source (NW; red)*
  - *Peripheral arc-like source (SE; green)*

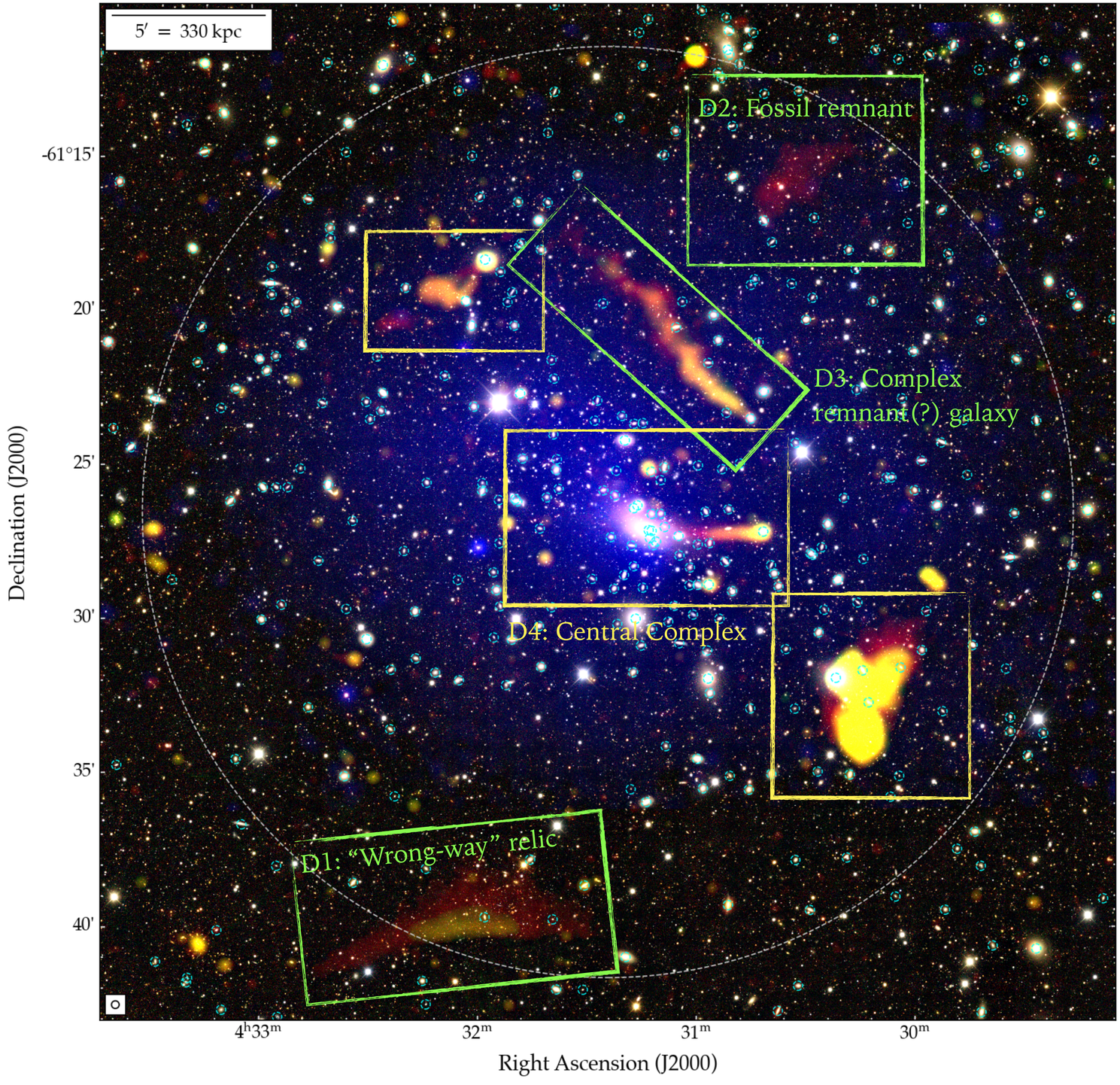
Intriguing radio emission but MWA Phase I (GLEAM) & KAT-7 too low-resolution…



EMU
Evolutionary Map of the Universe

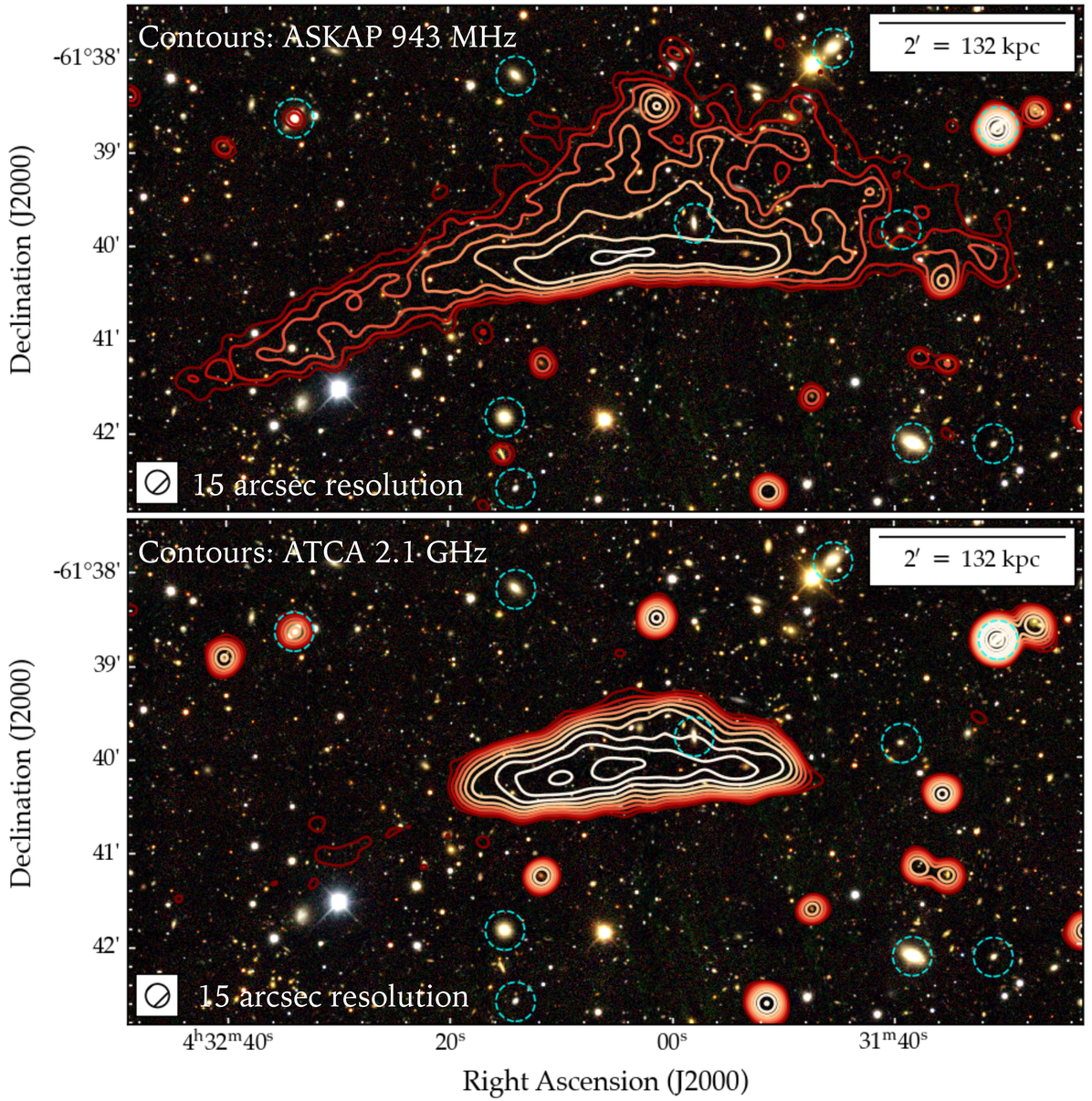
ABELL 3266

- Background map:
  - RGB Dark Energy Survey (DES) *i*-, *r*-, *g*-band.
  - Cyan circles: cluster-member galaxies
- Overlays:
  - X-ray data from XMM-*Newton* (blue channel)
    - Bremsstrahlung: hot plasma (10^7 K)
  - 943 MHz ASKAP data from EMU Early Science (red channel)
  - 2.1 GHz ATCA data (green channel)
    - Synchrotron: CRe & magnetic fields.
- Interpretation:
  - Yellow = typical "active galaxy" steep spectrum ($\alpha \sim -0.8$ to -1)
  - Red = old, (ultra) steep spectrum ($\alpha \ll -1.5$)
  - Green = inverted spectrum ($\alpha > 0$)



D1: The "Wrong-Way" Relic

- Properties:
  - Arc-like morphology (linear size $\sim$ 580 kpc), located in cluster outskirts.
  - Ultra steep spectrum ($\alpha_{\rm int} = -1.83 \pm 0.21$), clear spectral gradient, *possibly curved*.
  - Co-located with X-ray shock (eROSITA; Sanders et al. 2021).
  - *Only a handful of clusters with shocks in radio AND X-ray!*



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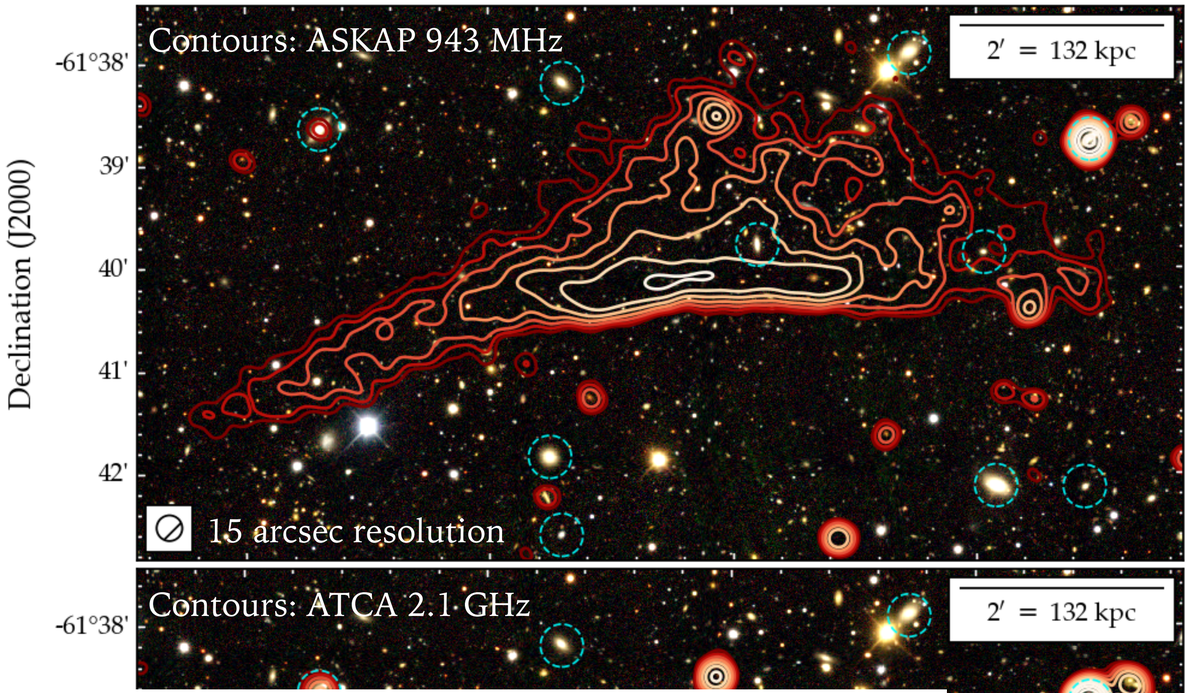
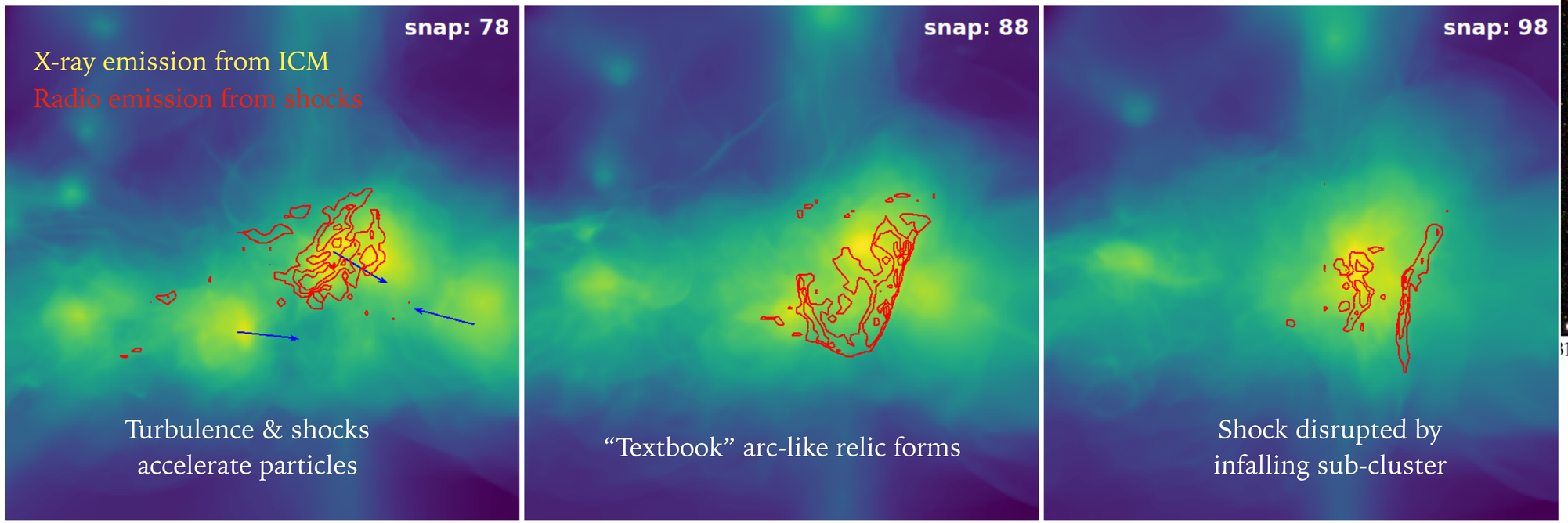
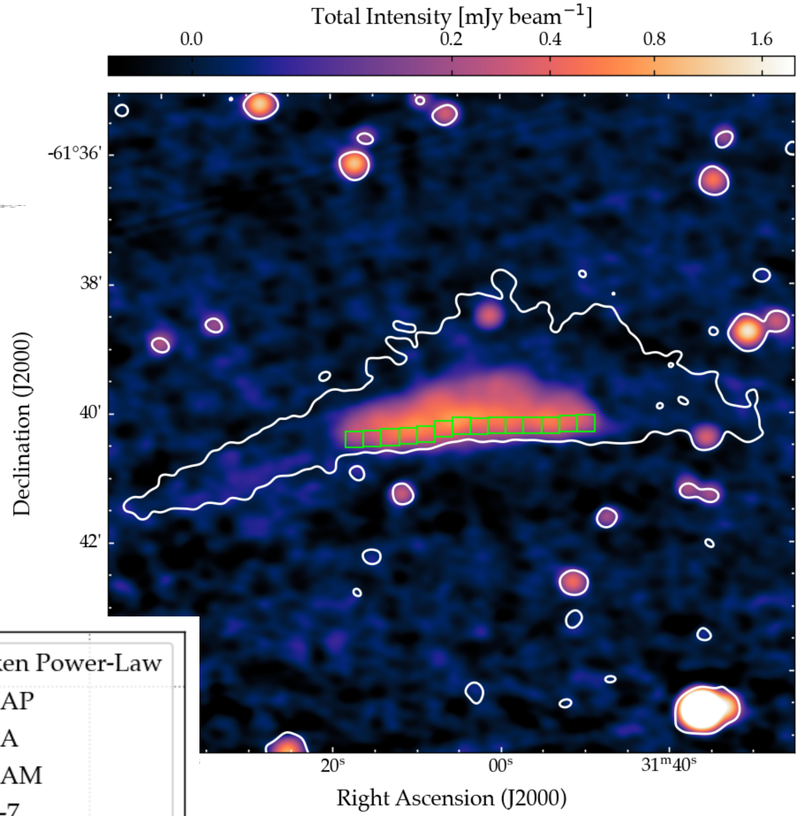


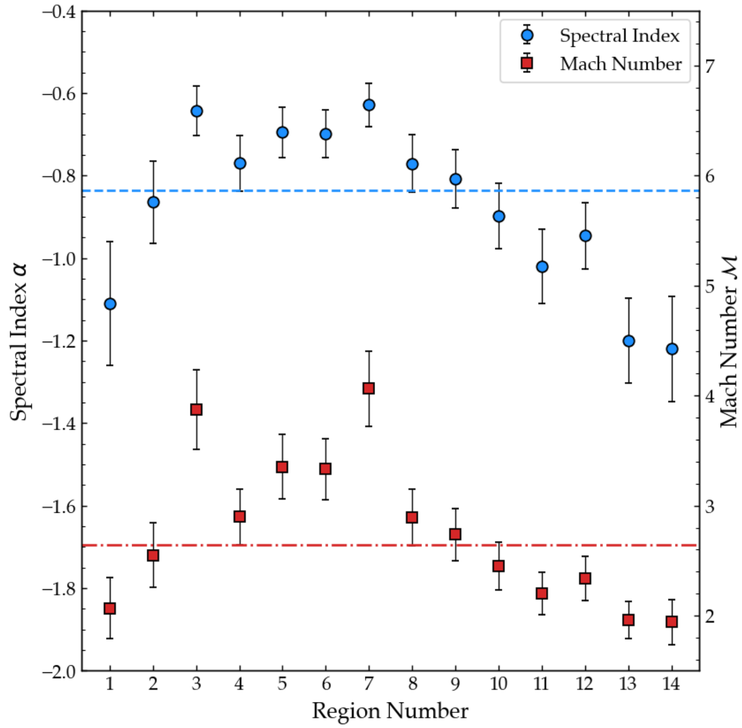


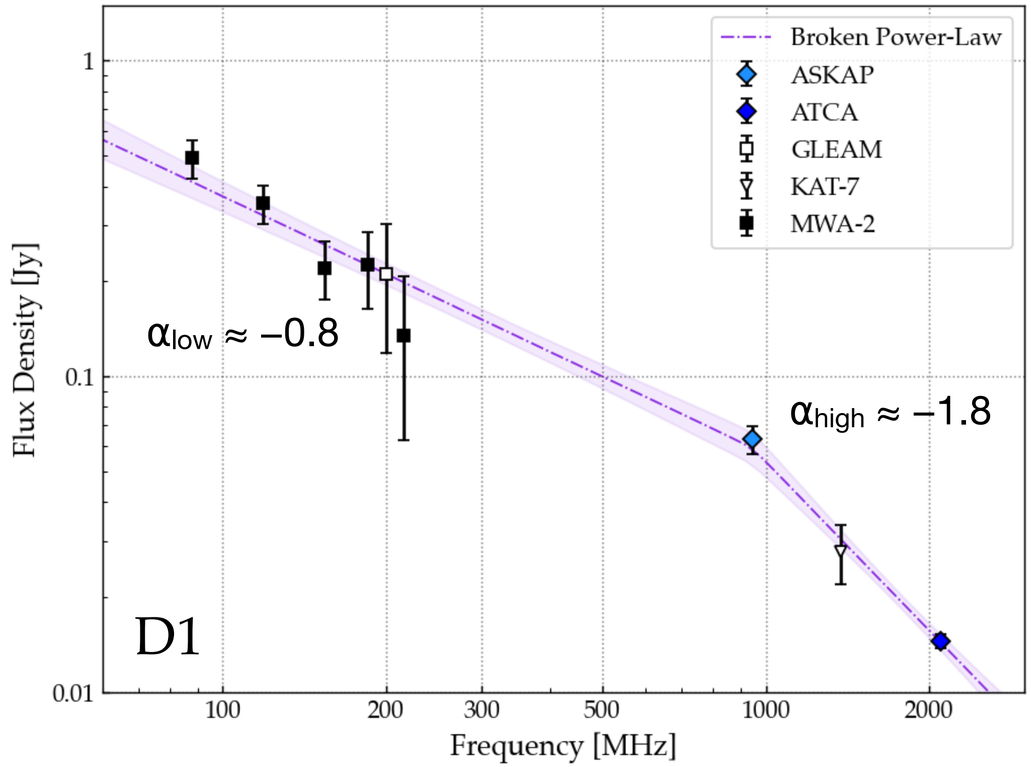
Credit: Denis Wittor

D1: The "Wrong-Way" Relic

- Diffusive Shock Acceleration
  - $\mathcal{M}_{\rm radio} = 4.06 \pm 0.34$; $\mathcal{M}_{\rm X\text{-}ray} = 1.54 \,/\, 1.71$
  - Mach number discrepancy — not unusual.
  - *Moderate/strong shock.*







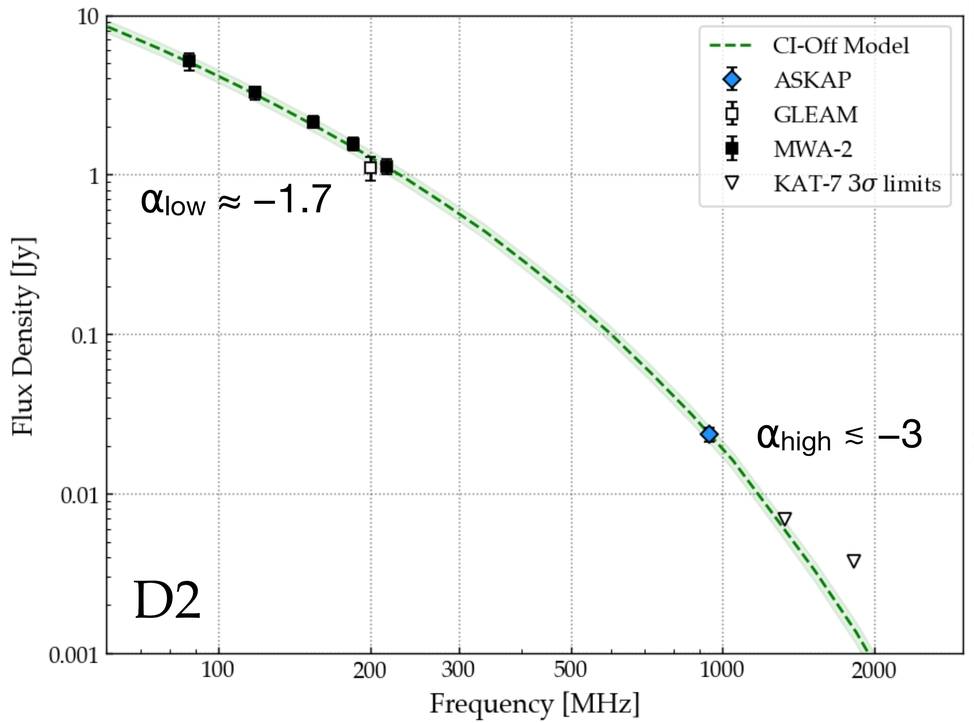
Low $B \sim 1\mu$G : $\xi \sim 2\times10^{-2}$

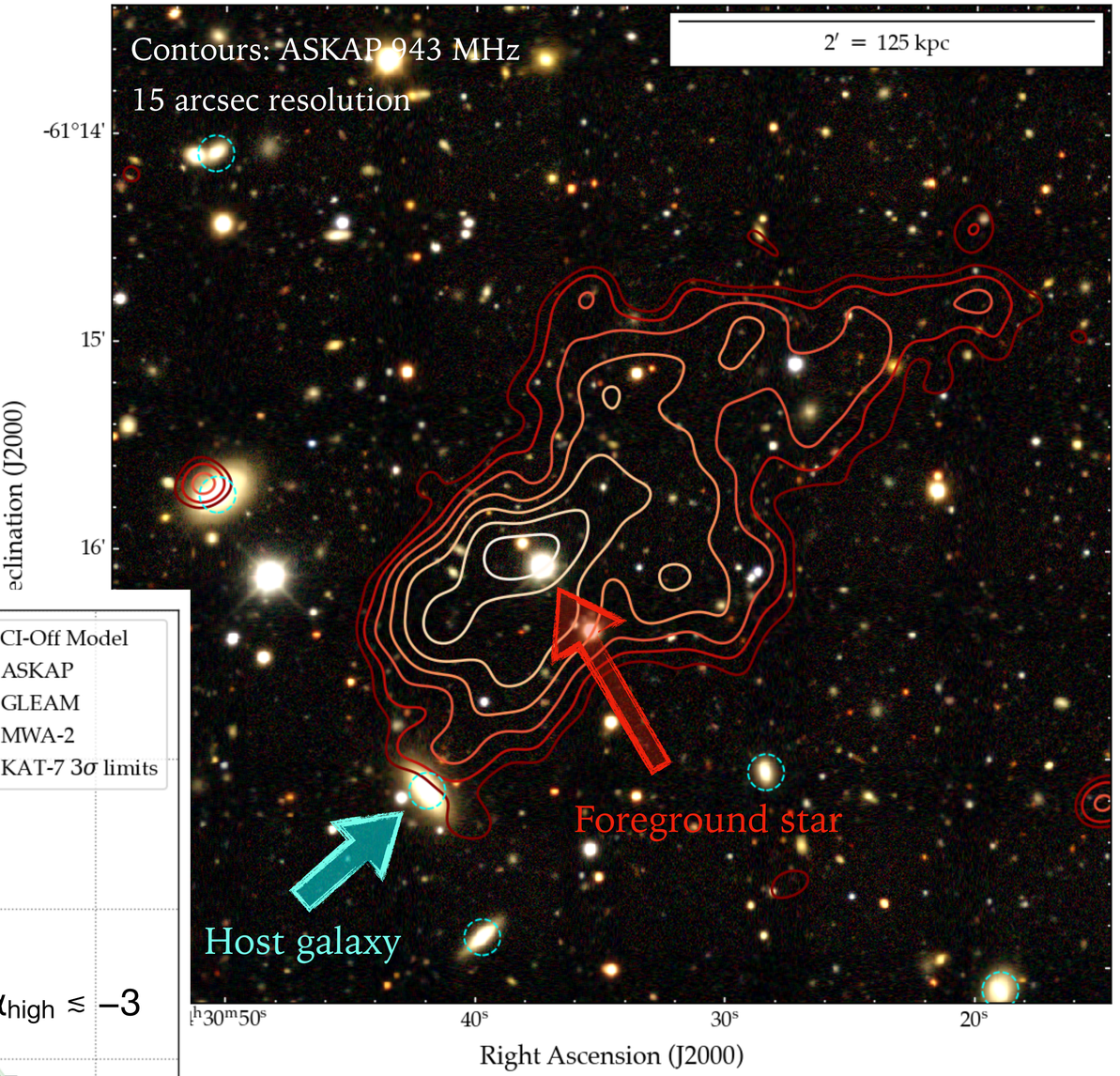
High $B \sim 8\mu$G : $\xi \sim 2\times10^{-3}$

Efficiency is reasonable within DSA framework
BUT… broken spectrum => re-acceleration.

D2: The Fossil Remnant

- Properties:
  - Diffuse, complex morphology => most likely in cluster.
  - *Undetected at 2.1 GHz despite 9 μJy rms => $\alpha \lesssim -4.9$*
- Host galaxy:
  - Cluster member at south-east tip, $z = 0.0559$
  - LLS ~ 223 kpc
- Core prominence:
  - Total flux: 23.6 mJy
  - No core < 0.25 mJy
  - CP ~ 0.01
- Consistent with e.g. Brienza et al. (2017); Quici et al. (2021)

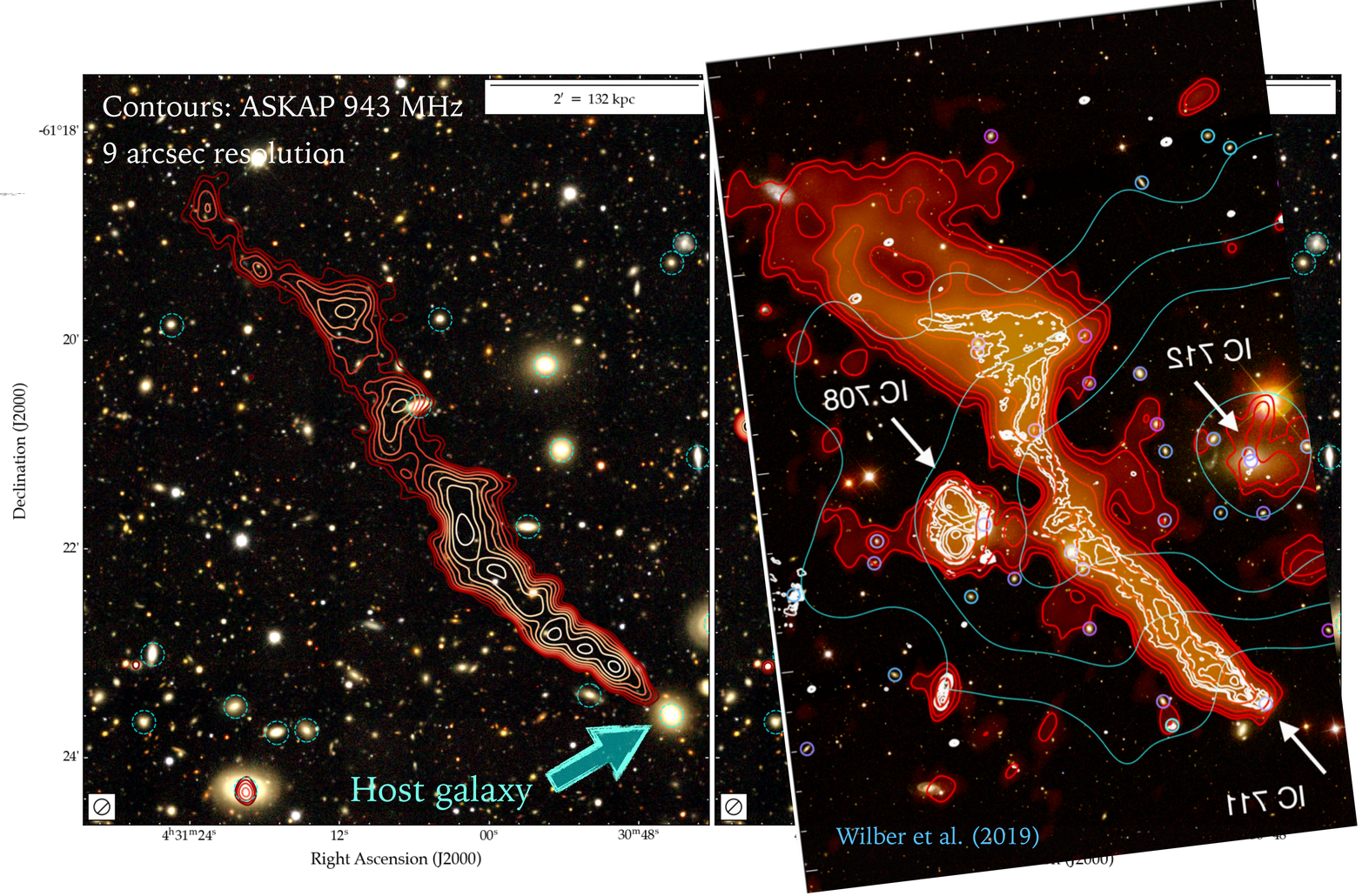




Morphology, USS, curved spectrum…
Diagnosis: fossil AGN remnant

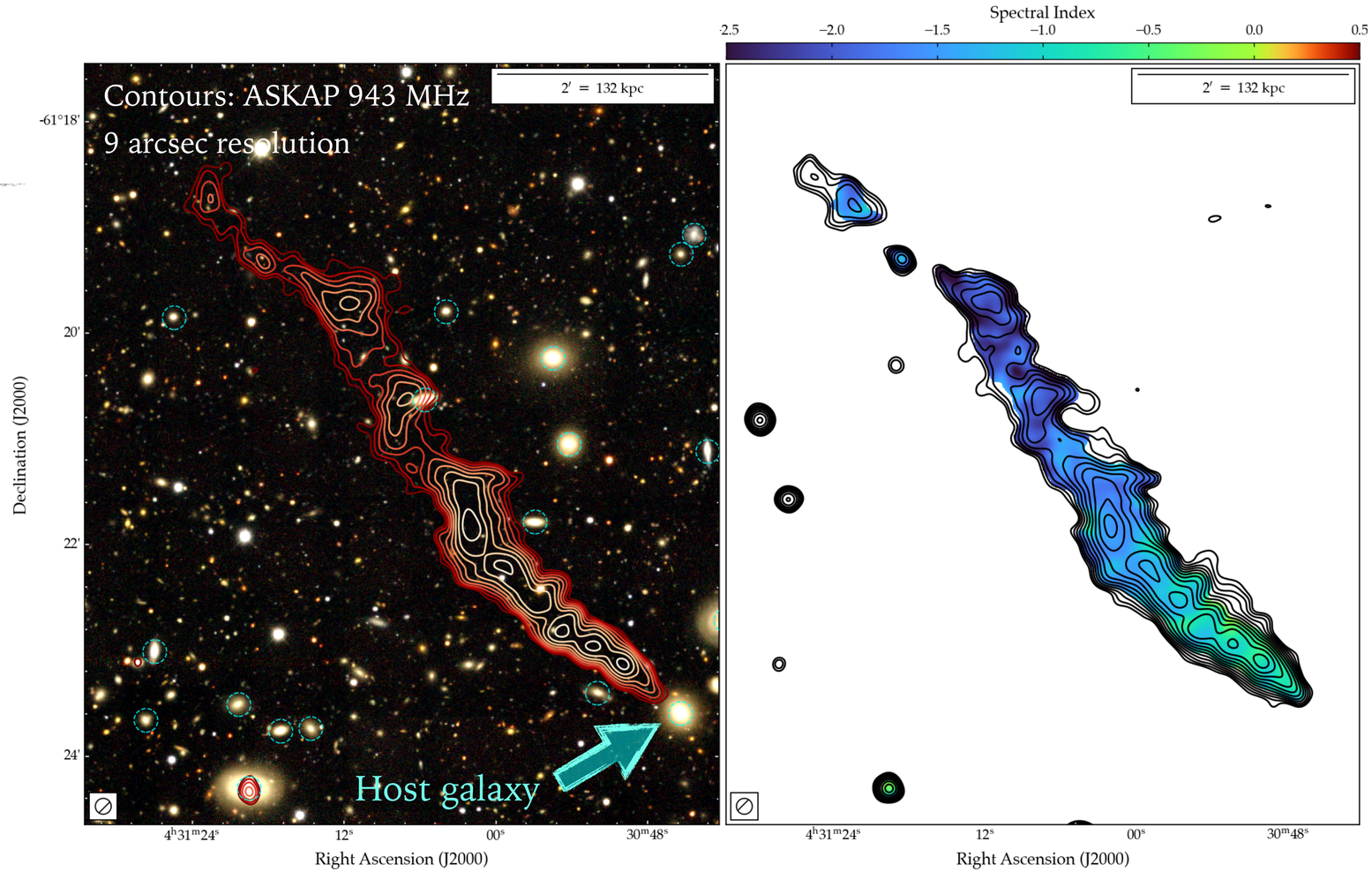
D3: The Complex Remnant(?)

- Properties:
  - Complex, knotty morphology.
  - *Single source or multiple components?*
  - LAS ~ 7.3 arcmin ; LLS ~ 508 kpc.



D3: The Complex Remnant(?)

- Properties:
  - Complex, knotty morphology.
  - *Single source or multiple components?*
  - LAS ∼ 7.3 arcmin ; LLS ∼ 508 kpc.
- Spectrum:
  - Strong spectral gradient following spine.
  - Near host: $\alpha \sim -0.8$; Tail: $\alpha < -2.5$.
  - Integrated: $\alpha \sim -1.4$
- No core detected:
  - Core prominence CP ∼ 10^{-3} to 10^{-4}.



Another remnant?

Why the clumpy morphology?

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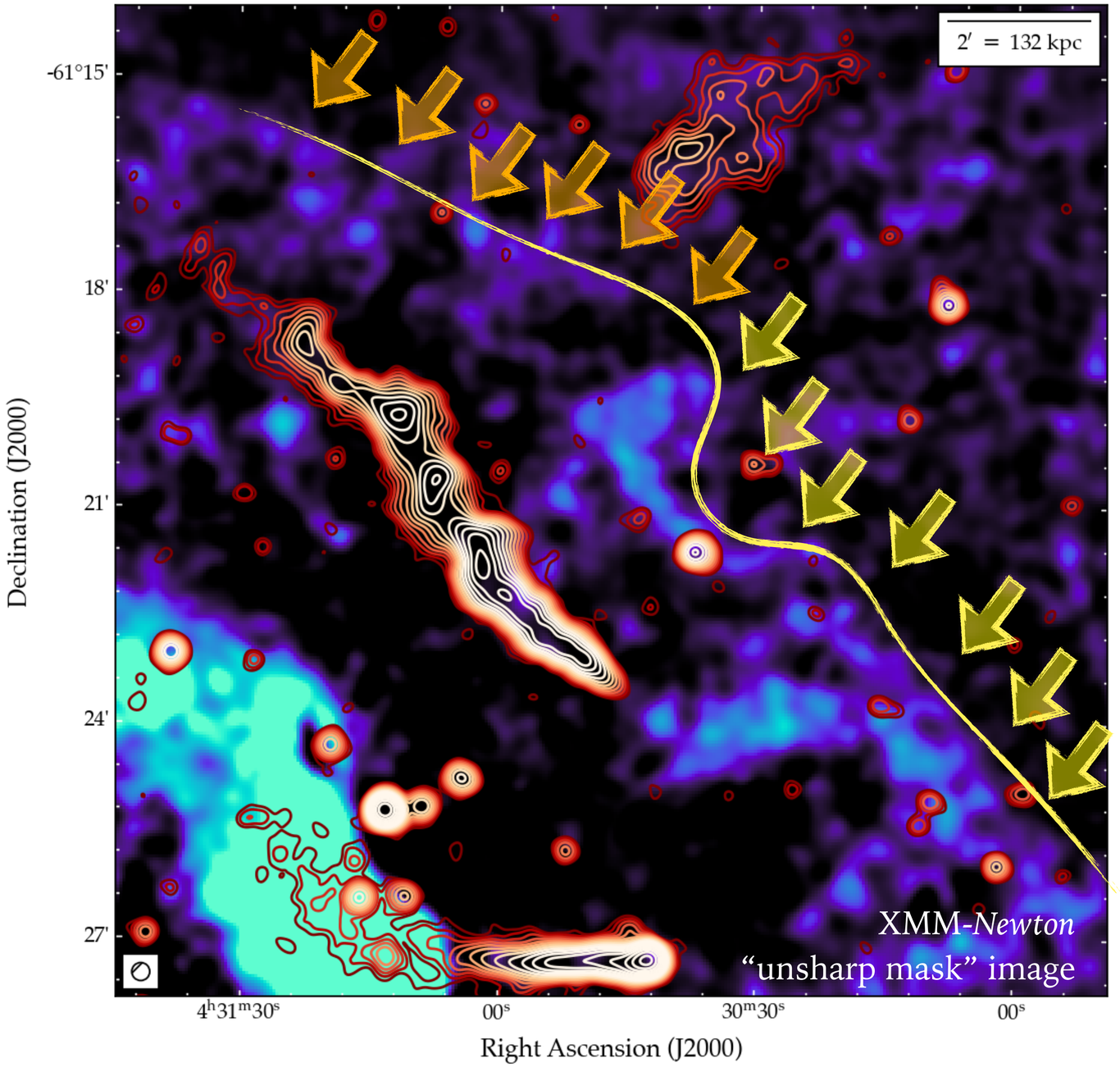
Inhomogeneous re-acceleration by historic shock!



Conclusions

- Abell 3266 is a highly-complex system:
  - Rich sub-structure, rich merger history.
  - Plethora of fossil radio galaxies & bent-tails.
    - *Clear evidence of complex interactions with thermal plasma of the ICM.*
  - New radio relic tracing shock *re*-acceleration.
    - *Thermal pool DSA conclusively ruled out.*
- More to come:
  - Many active galaxies ; other remnants.
  - Other diffuse radio sources
  - *3D magnetic field reconstruction via spectropolarimetry!*

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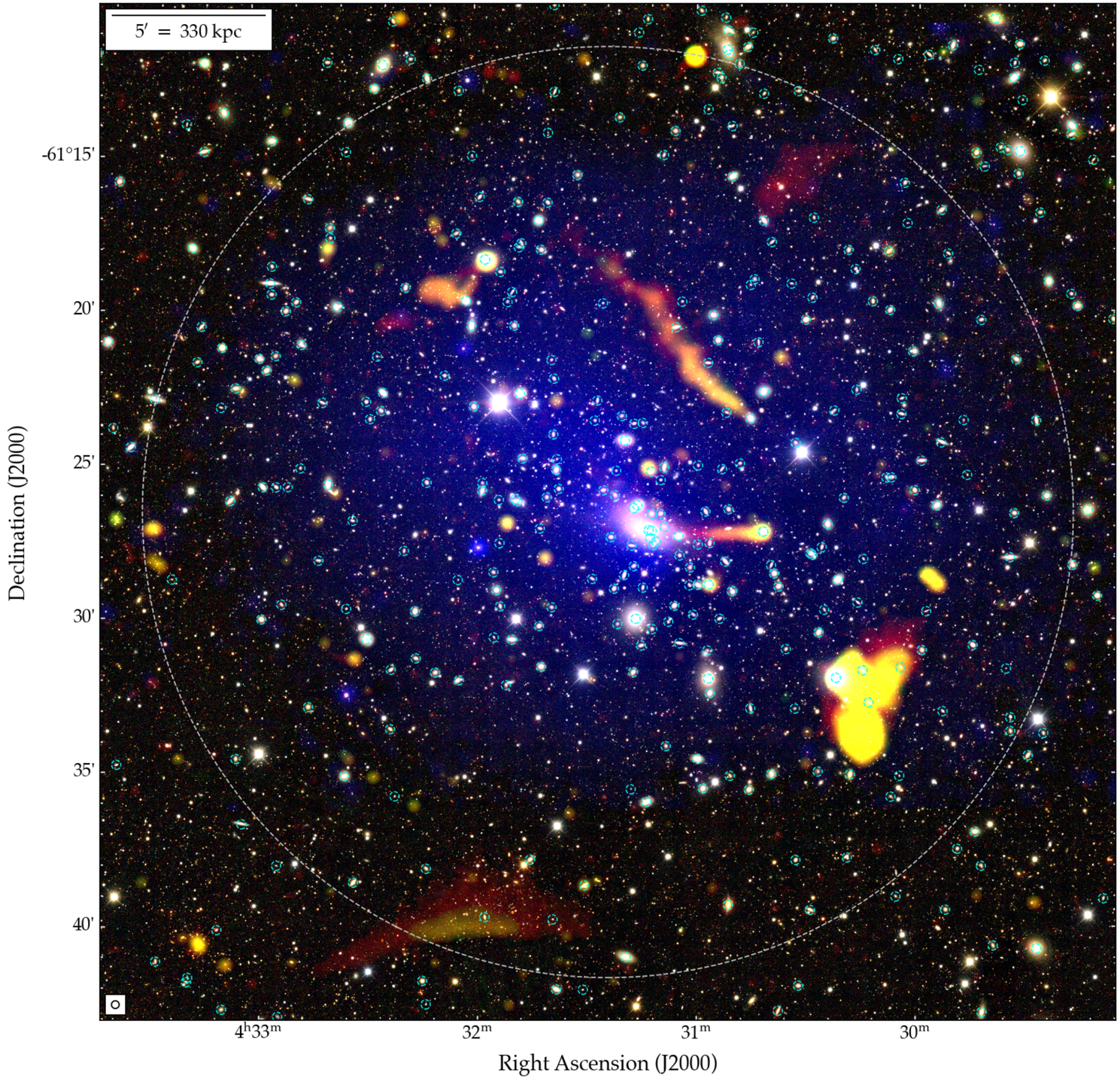
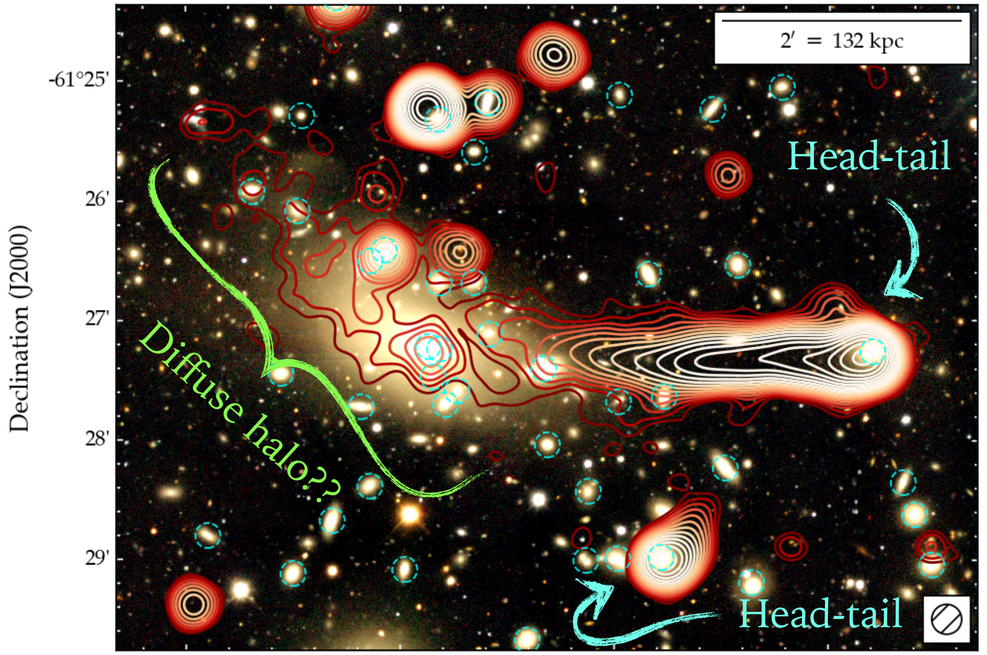
Thanks for listening… Questions?

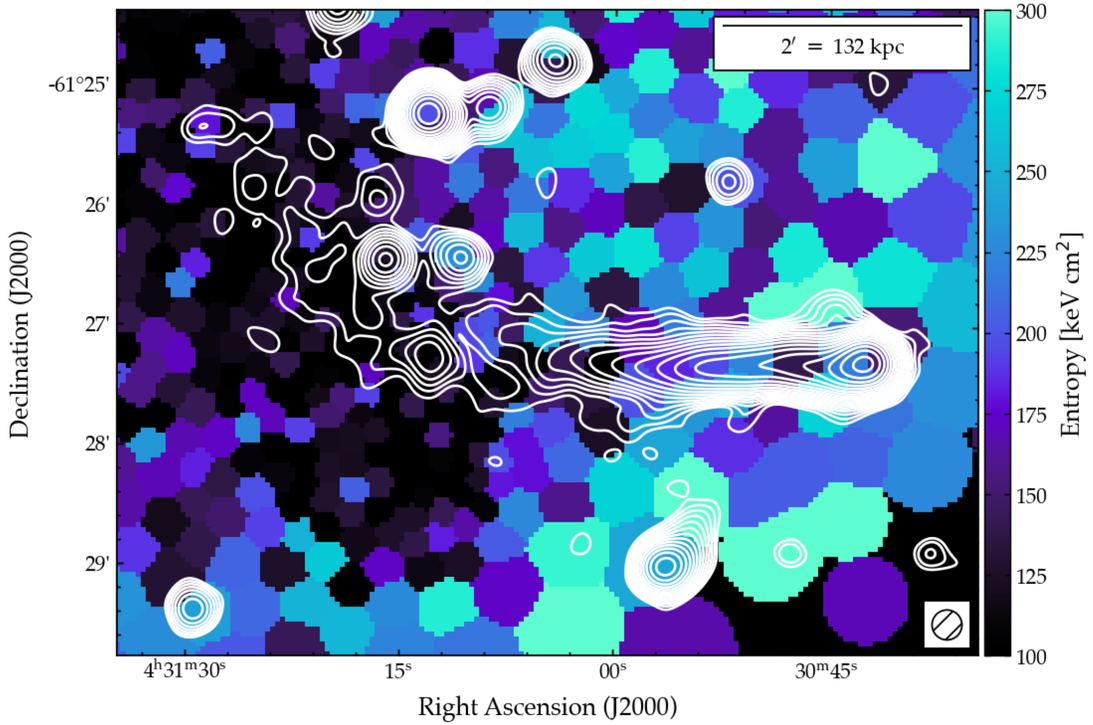


D4: Central Complex

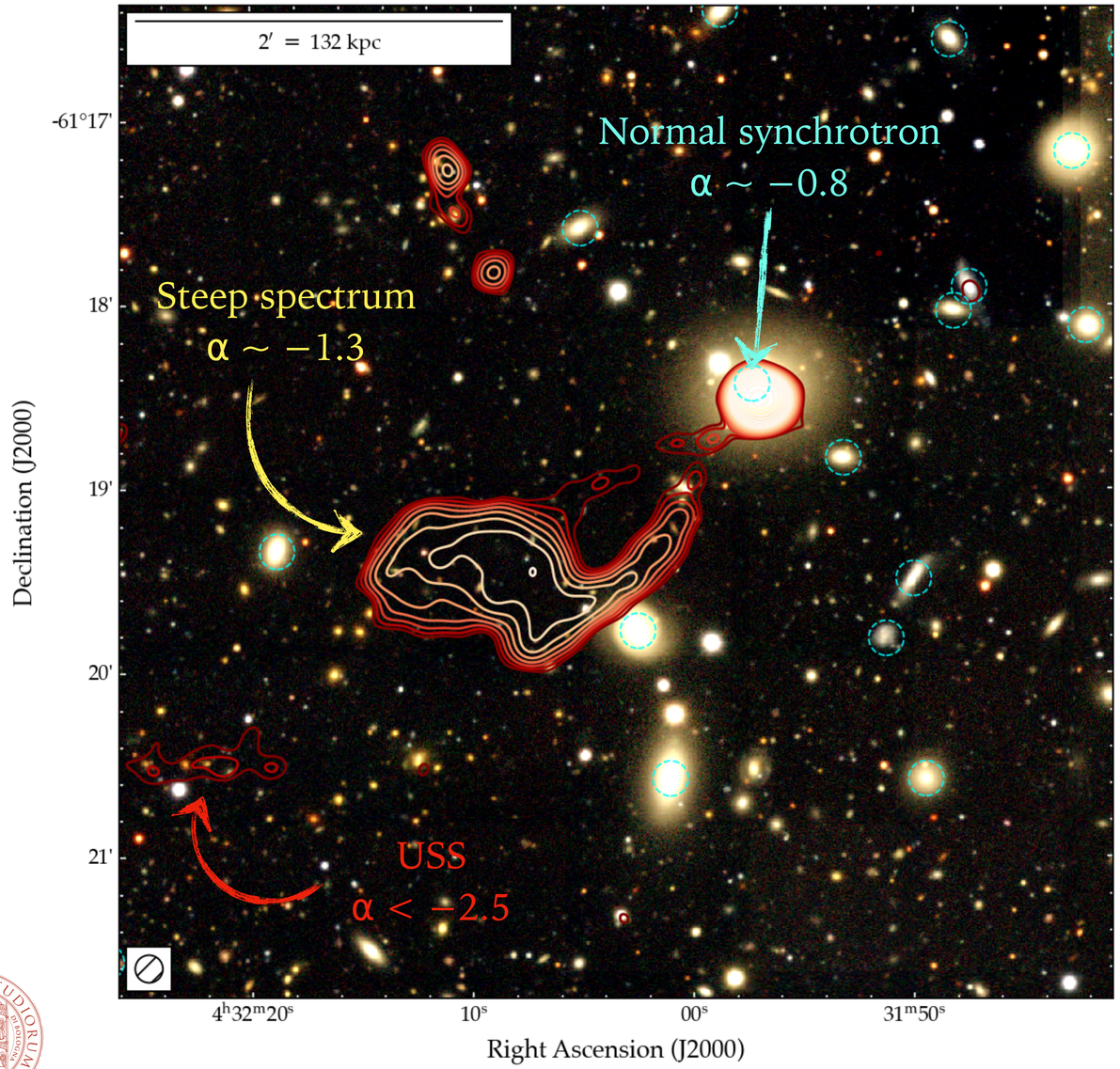
- Properties:
  - Diffuse: ~240 kpc
  - Faint: 0.8 μJy arcsec^{-2}
  - *Ultra-steep spectrum*: $\alpha < -2.54$
- A mini-halo?
  - $P_{1.4\,\mathrm{GHz}} = 2.04 \times 10^{22}$ W Hz^{-1}
  - *Consistent with mini-halo candidate in EMU Pilot Survey* (Norris et al. 2021)
  - No cool core…
- Fossil tail(s)?
  - Traces low-entropy spine.
  - Head-tail: Fossil plasma re-accelerated by merger turbulence?
  - BCG: dumbbell morphology (disturbed), diffuse optical emission traces diffuse radio emission. Stripped material?

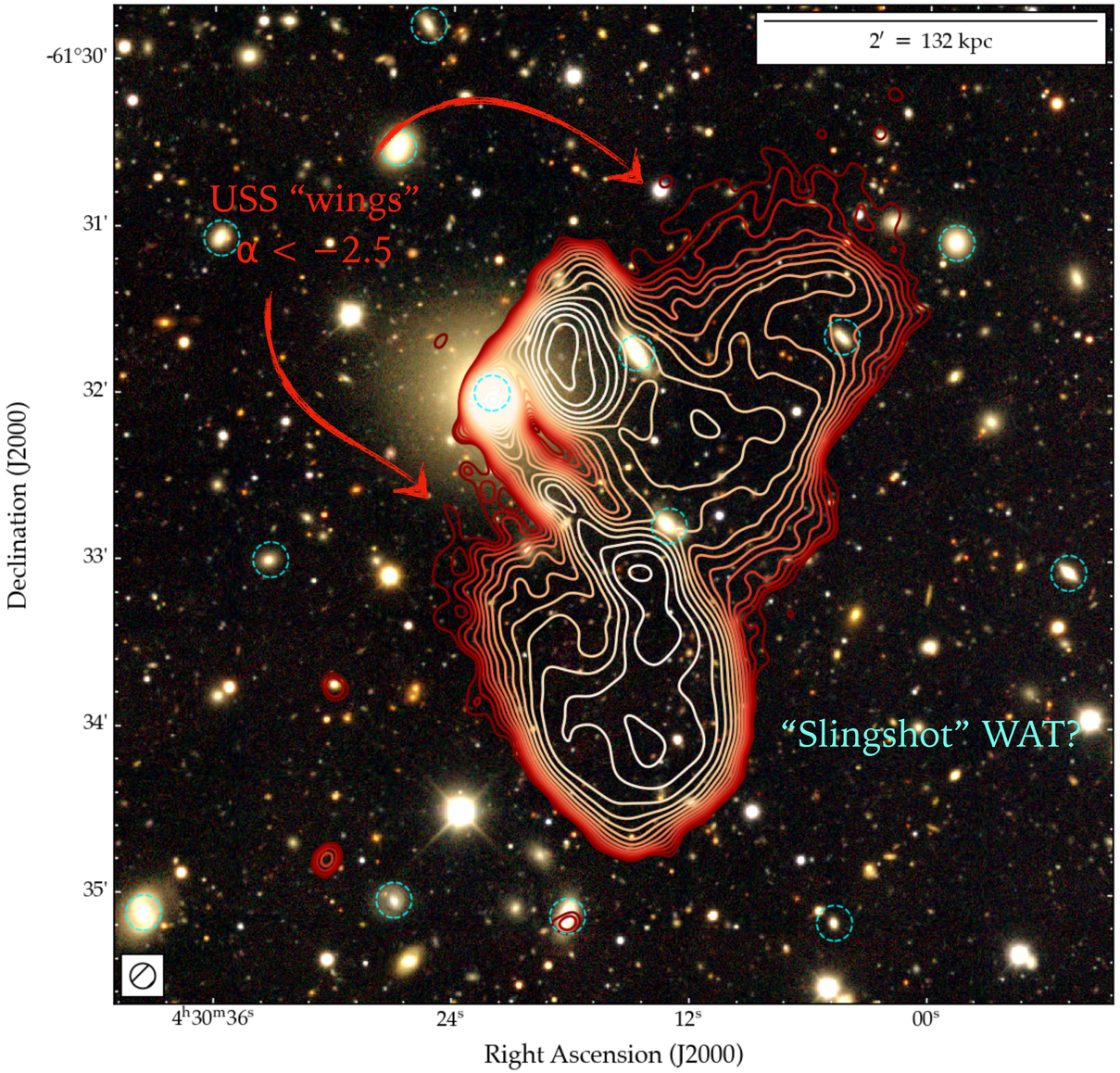
Nature unknown yet. Need a better handle on low-frequency spectrum.





SUPPLEMENTARY





Contours: 943 MHz ASKAP @ 9 arcsec