

# Galaxy clusters in the Decameter Sky

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LOFAR Annual Meeting, Dublin 2026



# Galaxy clusters

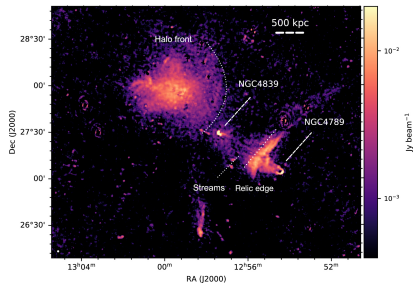
- Most massive virialized objects in the universe
- Majority DM, rest is ICM and galaxies
- Non-thermal component to the ICM



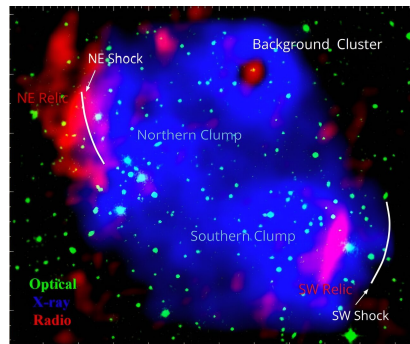
*Perseus, van Weeren+24*

# Diffuse radio emission in galaxy clusters

- Radio halo
- Radio relic
- Phoenix/ Re-energised fossil plasma



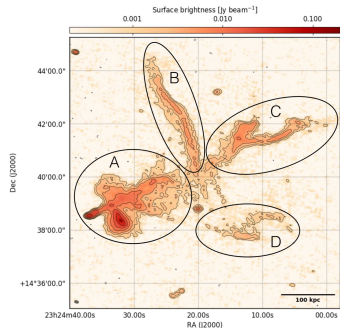
*Coma, Bonafede+21*



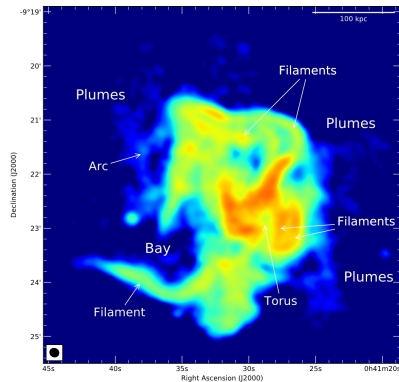
*A2108, Chatterjee+23*

# Diffuse radio emission in galaxy clusters

- Radio halo
- Radio relic
- **Phoenix/ Re-energised fossil plasma**



*A2593, Mandal+20*



*A85, Raja+23*

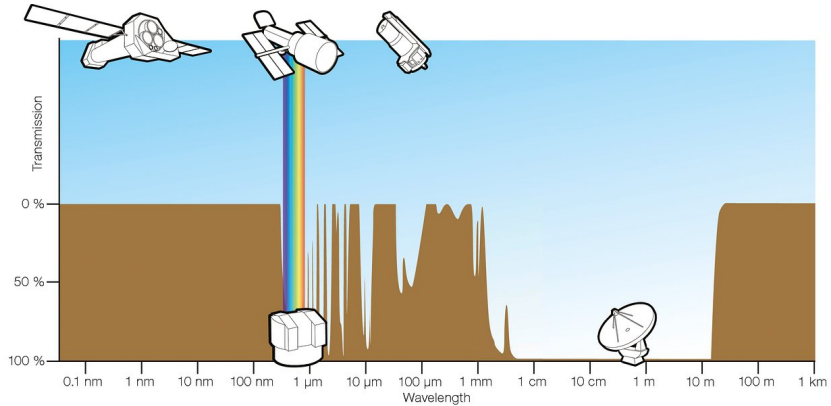
# Particle acceleration in galaxy clusters

- Electrons cool down on timescales  $t < t_{\text{cross}}$
- *In-situ* particle acceleration
  - Diffusive Shock (re-)acceleration (DSA, relics)
  - Turbulent re-acceleration (halos)
  - Adiabatic compression (phenixes?)

# Diffuse radio emission at low frequencies

- Radio halos: Steep and curved spectra
- Re-energised fossil plasma
  - Cluster periphery
  - Irregular morphology
- Only few observations at low frequencies → Poor constraints on spectral behaviour
- Unexplored frequency range: 15 – 30 MHz

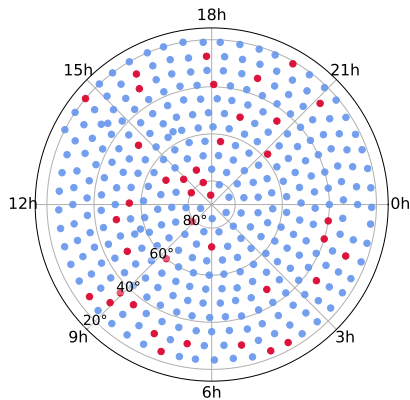
# Decameter band



*Source: ESA/Hubble, F. Granato*

# LOFAR Decameter Sky Survey (LoDeSS)

- Observations done between 2021 - 2023 (reobservations)
- Not performed during the best ionosphere, but partially still doable
- Talk by C. Cordun
- LoDeSS DR1 paper in progress (partial sky, Cordun et al. in prep.)
- LoDeSS DR2 (full sky)

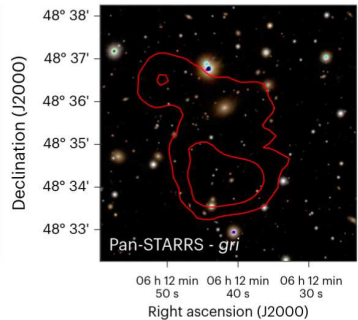
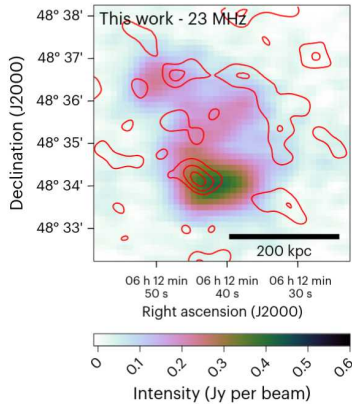
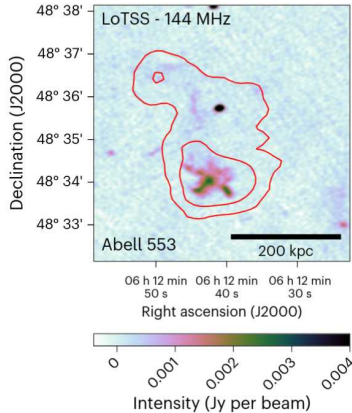


*Cordun et al. in prep.*

- Using modified version of LiLF (pipeline for LoLSS)
- Ran on IRA/Leiden Observatory/ASTRON nodes
- Differences w.r.t. LoLSS:
  - Amplitudes on subfield (DI)
  - Direction finding fine-tuned for decameter
  - Stricter flagging, as amplitude solutions can be more chaotic (ionosphere)
- Some are implemented in LiLF

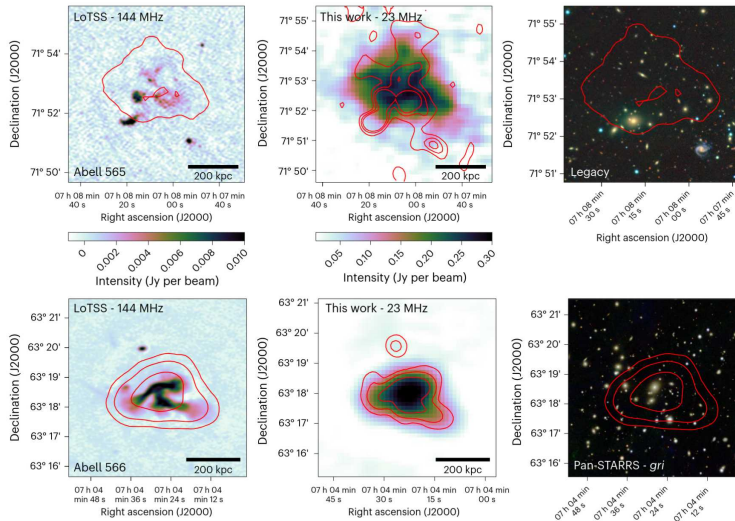
- Decameter band: Large spectral leverage arm
- Primarily: test prediction of turbulent re-acceleration in Giant Radio Halos
- Also expected: re-energised fossil plasma (steep spectrum)
- Earlier work: Groeneveld+24,+25
- DR1 clusters

# Previous Examples - A553

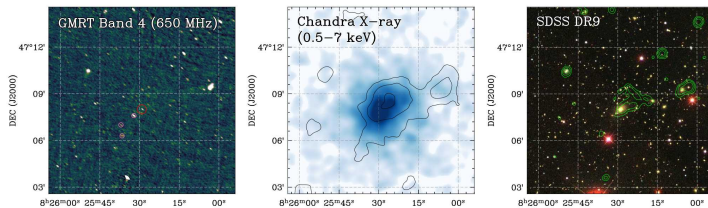
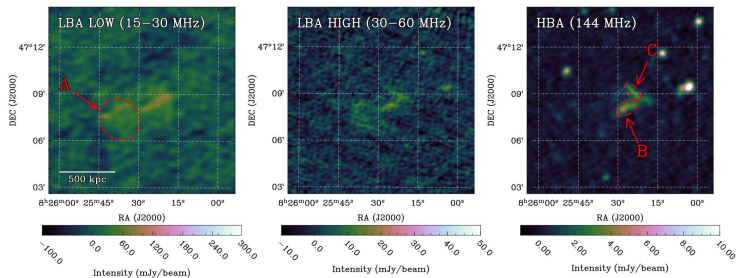


*Groeneveld+24*

# Previous Examples - A565 & A566



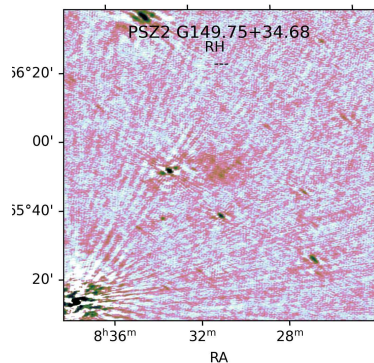
# Previous Examples - A655



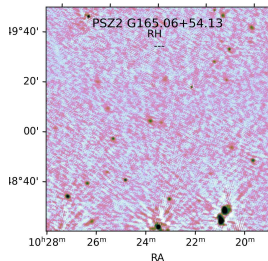
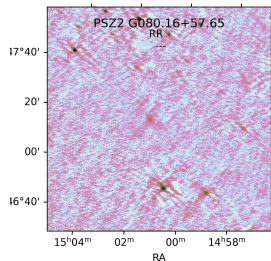
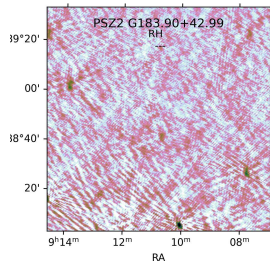
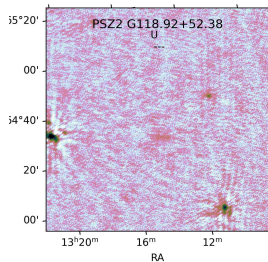
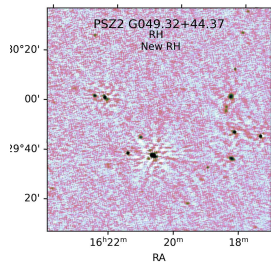
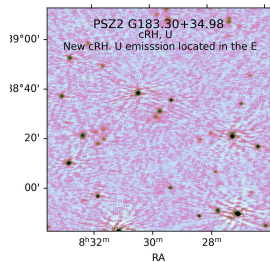
*Groeneveld+25*

# Some Examples from DR1 (1/2)

- Cross-match between Planck-LOFAR catalogue made for LoTSS (*Botteon+22*)
- Diffuse emission: RH/RR,U
- Re-energised fossil plasma between RH/RR/U



# Some Examples from DR1 (2/2)



- Number of fields: ionosphere too disruptive
  - Even non-disruptive ionosphere problematic may cause spikes with bright sources
- Resolution limited (45") → Source subtraction challenging
- Quality of the fields vary
- Future work:
  - DR2
  - LLoCuSS (16-64 MHz)

- Decameter band important for understanding particle acceleration models
- Sub-30 MHz sensitive to radio halos and re-energised fossil plasma
- Future work: extraction and source subtraction (try anyways)
- DR2