
Building the Hot Intra-Group Medium in Spiral-Rich Compact Groups
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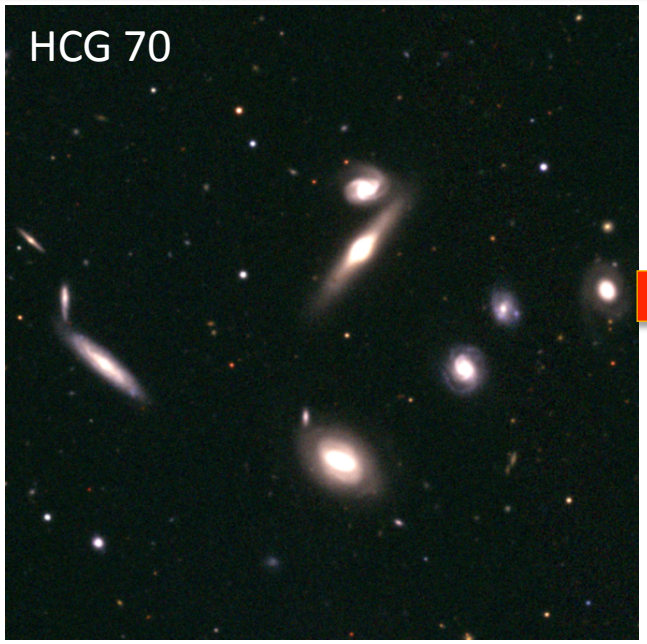
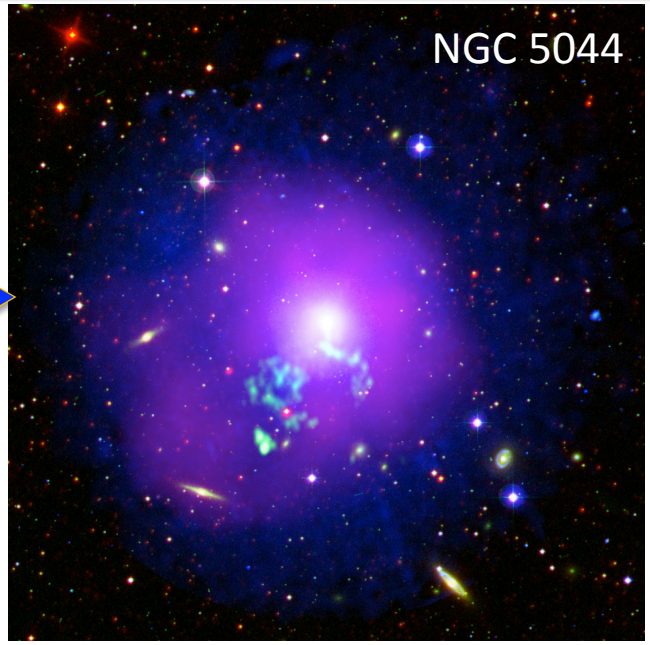
Co-evolution of galaxies and groups: How do we build the IGM?



MASS

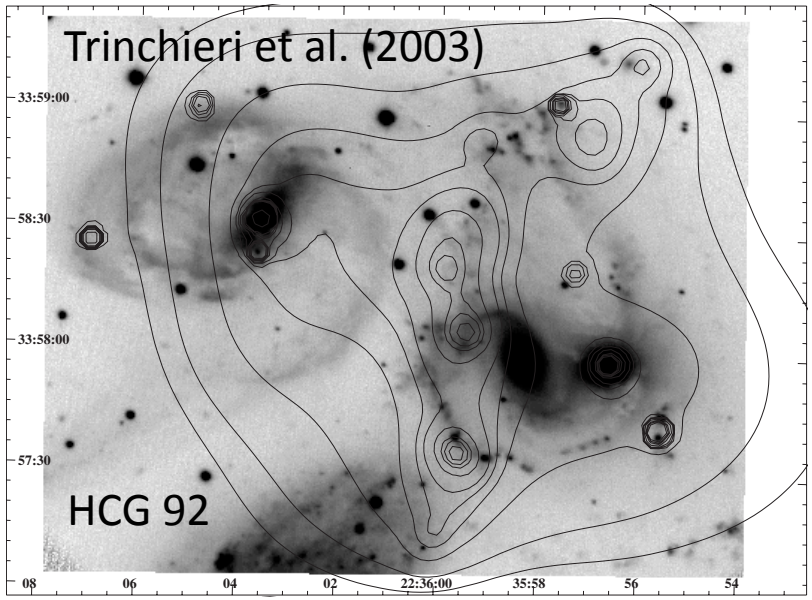


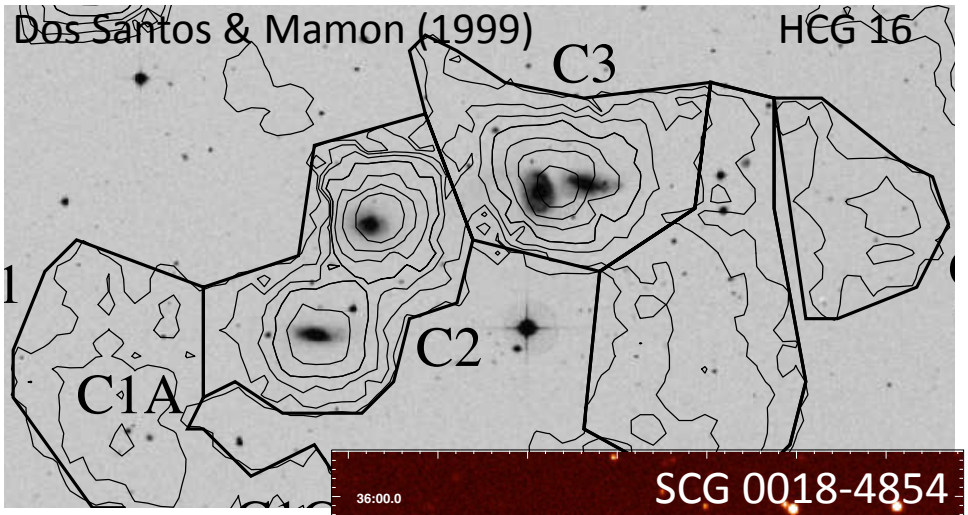
Spiral-rich
HI-rich / X-ray faint

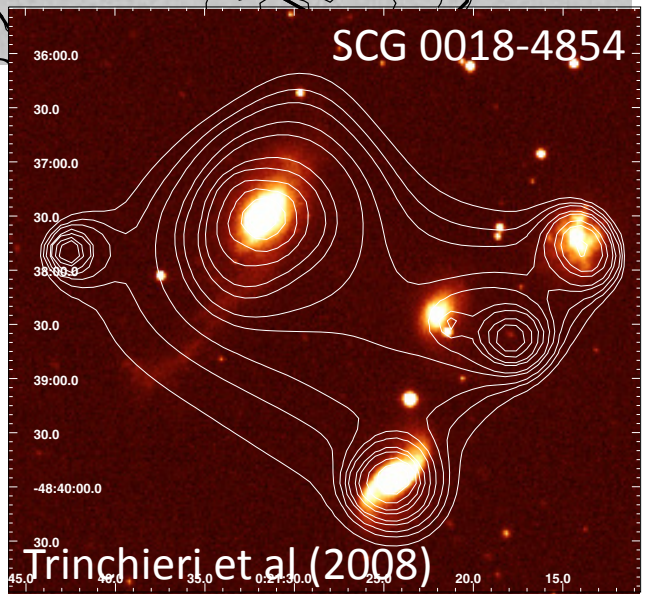
Elliptical-dominated
HI-poor / X-ray luminous

- Transition from spiral-rich to elliptical-dominated through tidal interactions
- Hot does the hot IGM form? Gravitational accretion and heating as in clusters?

Groups in transition: Spiral-rich groups with a hot IGM

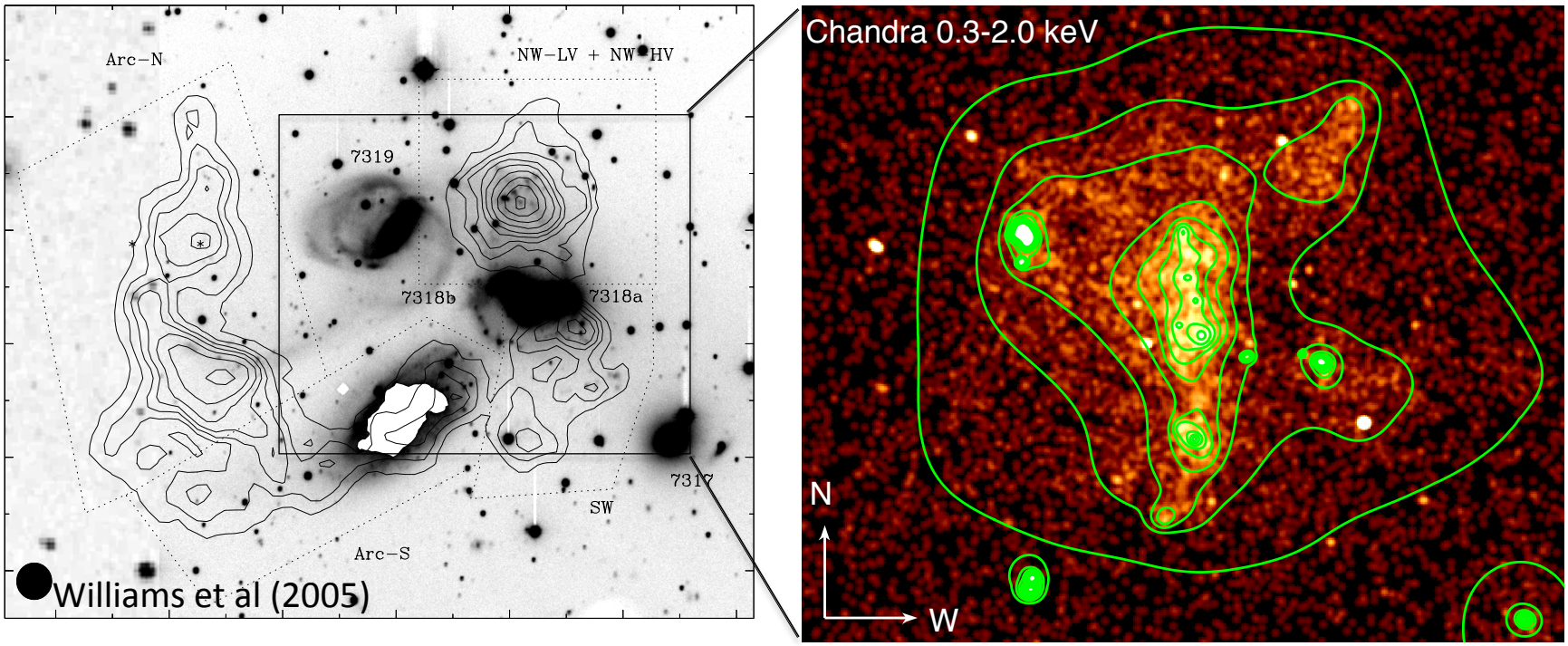






- Only a handful of spiral-rich groups with X-ray emitting intra-group gas are known.
- Typically faint: $L_X \approx$ few x10^{41} erg s^{-1}
- All are disturbed – filamentary structures, gas more closely linked with galaxies than group?
- Is IGM formation linked to galaxy transformation?

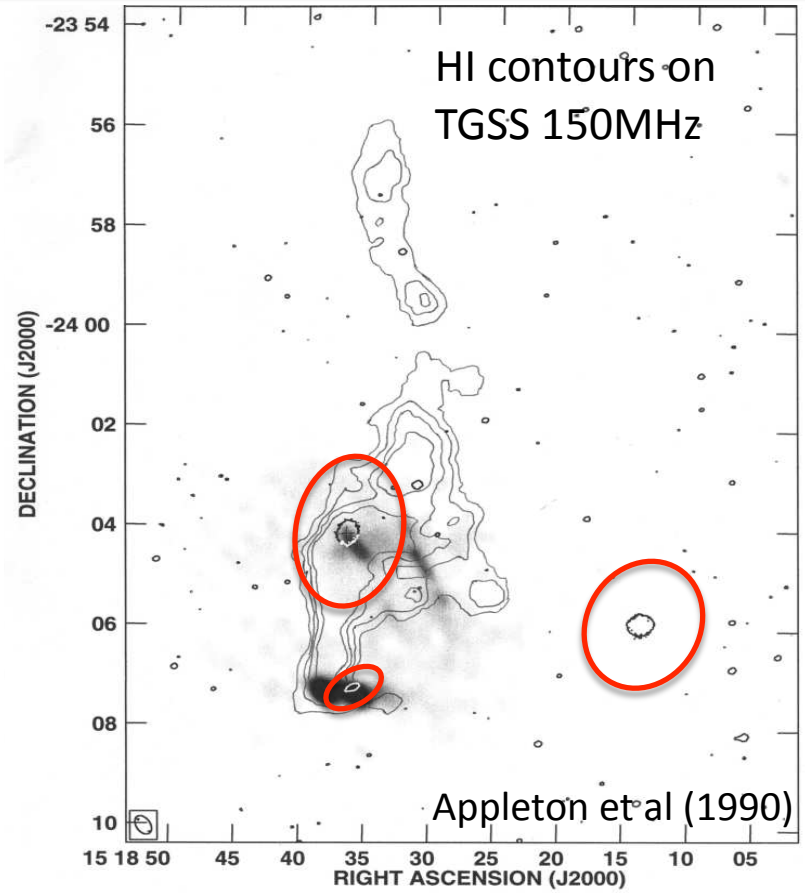
Stephan's Quintet: Heating HI via collision shocks (O'Sullivan et al. 2009)

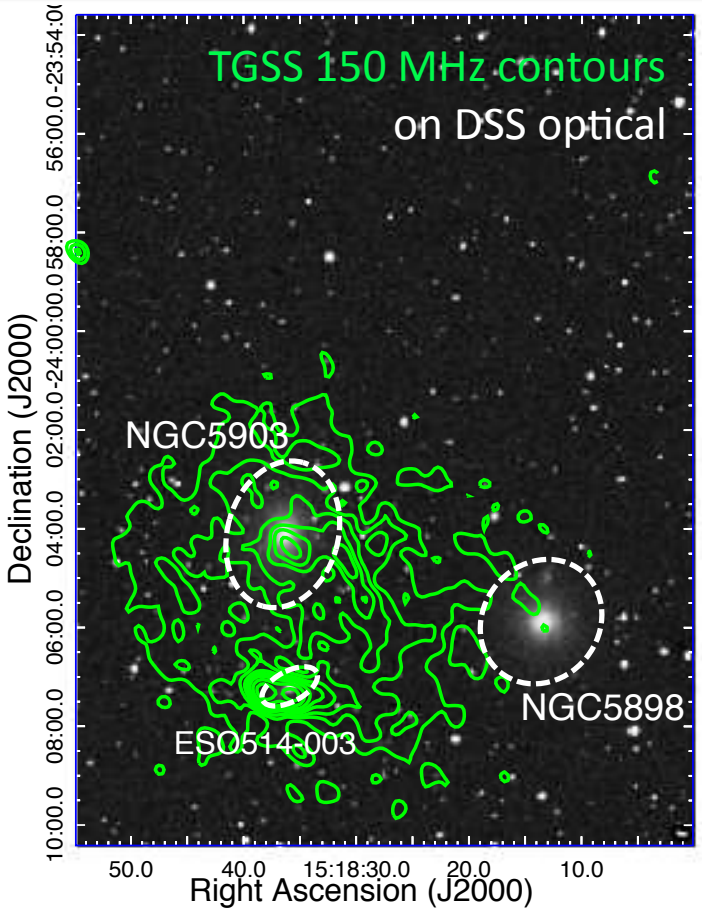


- Tidal tails indicate multiple past interactions
- 900 km/s collision between infalling spiral and HI filament visible in radio, X-ray, IR
- Mass of ~0.7 keV IGM (~3×10^{10} $M_\odot$) ≈ HI deficit (2×10^{10} $M_\odot$)

  ➔ Shocked HI may make up a significant fraction of IGM

NGC 5903
A second Stephan's Quintet?





- $3x10^9$ $M_\odot$ of HI in 100 kpc filament extending across NGC 5903 (Appleton et al. 1990)
- ~60 kpc wide radio structure, ~7 Jy @150 MHz, steep spectral index α=1.5±0.08

NGC 5903: a second Stephan's Quintet? (O'Sullivan et al. in prep.)

- ~40 ks XMM, low-level flaring throughout
- Disturbed 0.7 keV IGM correlated with HI!
- Hot gas mass ≈ HI deficit (3×10^{10} $M_\odot$)

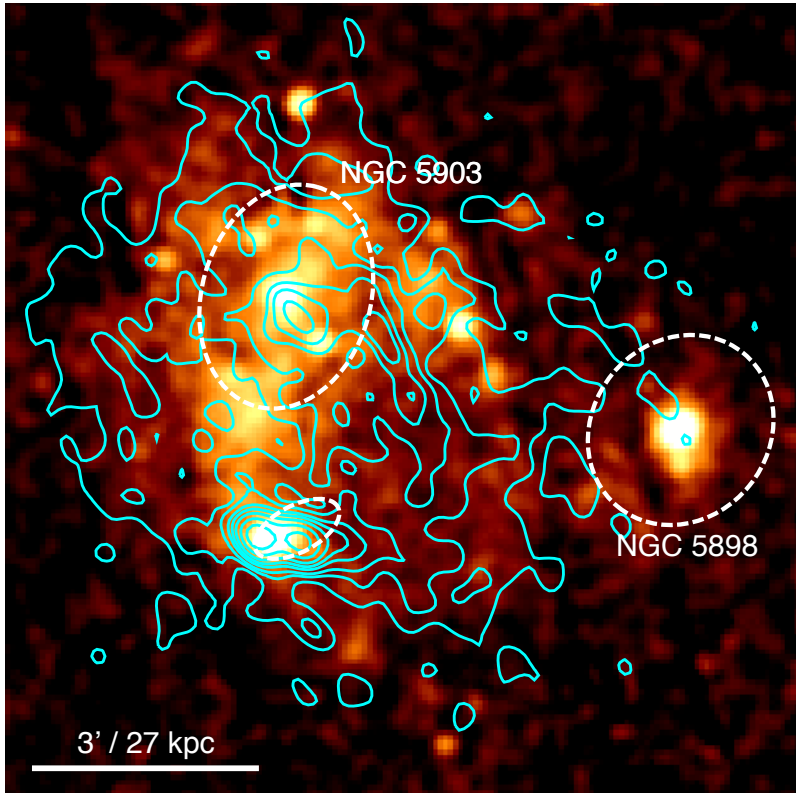
Collision shock as in Stephan's Quintet?

- No clear high-velocity intruder galaxy

➔ collision in plane of sky?

- In SQ radio correlated with HI and X-ray

Only see a hint of this in NW spur ➔ age?



XMM 0.3-3 keV 150 MHz contours

Plans:

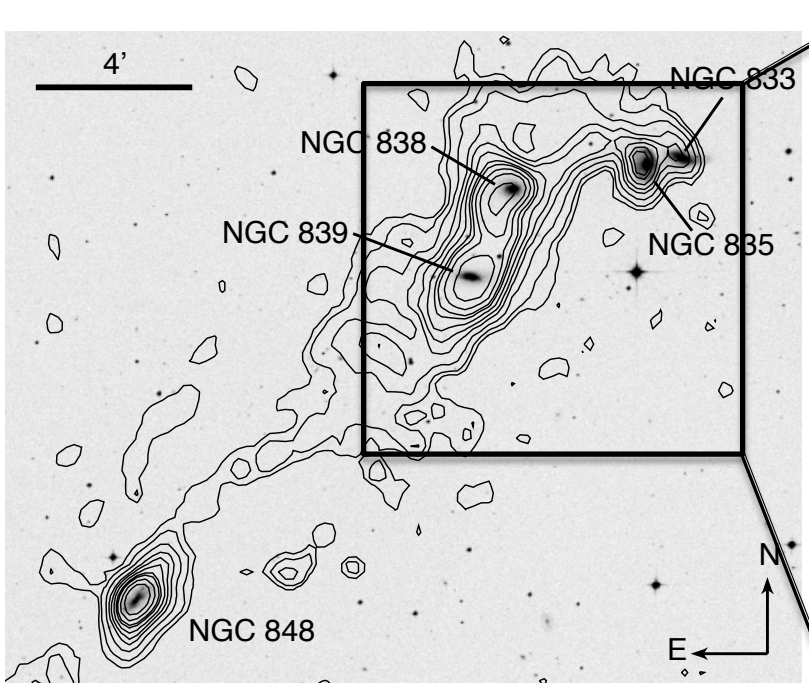
GMRT HI observations (high-resolution maps)

Hα imaging (trace warm gas content)

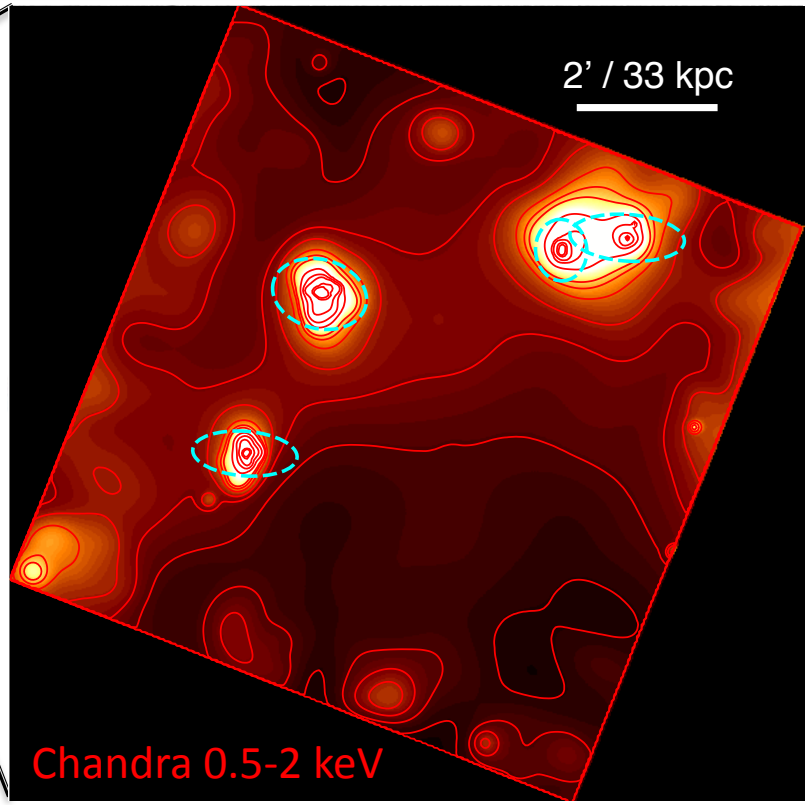
Deep Chandra pointing proposed (155 ks)

HCG 16: A spiral-only group with a hot IGM

(O'Sullivan et al. submitted)



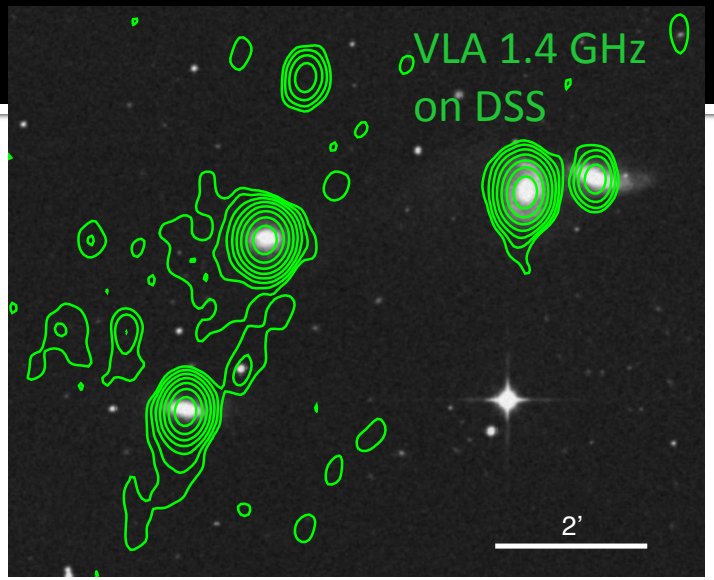
VLA HI on DSS optical



- Hot gas detected by *ROSAT* and *XMM* but morphology uncertain
- 137.5 ks *Chandra* observation ➔ irregular ridge of 0.3 keV gas
- X-ray ridge, HI filament linking galaxies ➔ group not yet relaxed?

HCG 16: Starburst winds

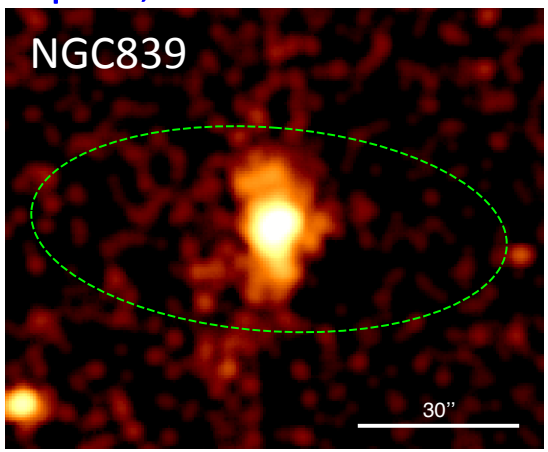
(O'Sullivan et al. submitted)



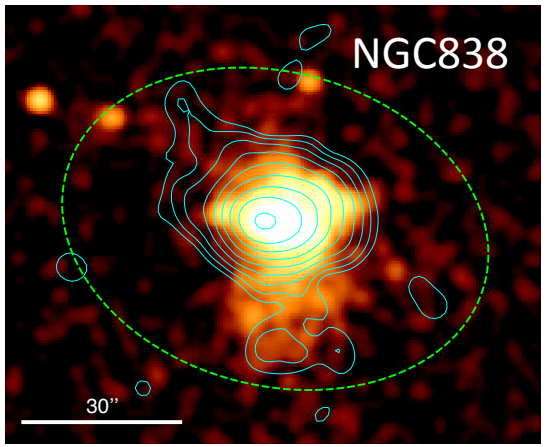
- 2 northern spirals: Seyferts, low SFR
- 3 southern spirals: starbursts
- HI and hot gas in ridge are densest around NGC 838 and NGC 839
- SF has been ongoing for 4-5x10^8 yr
- ~10^{10} $M_\odot$ of hot gas ejected in that period

➔ ~20% of IGM mass

➔ If other group members have ejected gas at a similar rate in the past, ~40% of IGM could have come from starburst galaxies.



GMRT
610 MHz
on Chandra
0.5-2 keV



Summary

1. Only a handful of spiral-rich groups with a hot IGM have been studied with Chandra and/or XMM
2. Stephan's Quintet: demonstrates that collisional shocks can contribute significantly to building IGM by heating HI
3. NGC 5903: shows that SQ is not unique – collisional shocks are short-lived, but can be detected from radio/X-ray data
4. HCG 16: demonstrates that starburst winds can inject significant quantities of hot gas into the IGM in spiral-only groups. Up to ~40% of IGM observed in this unrelaxed group may have been contributed by galaxy winds.
5. Deeper surveys are needed to identify more examples (eROSITA, low frequency radio?) with Chandra follow-up to study interactions in detail.