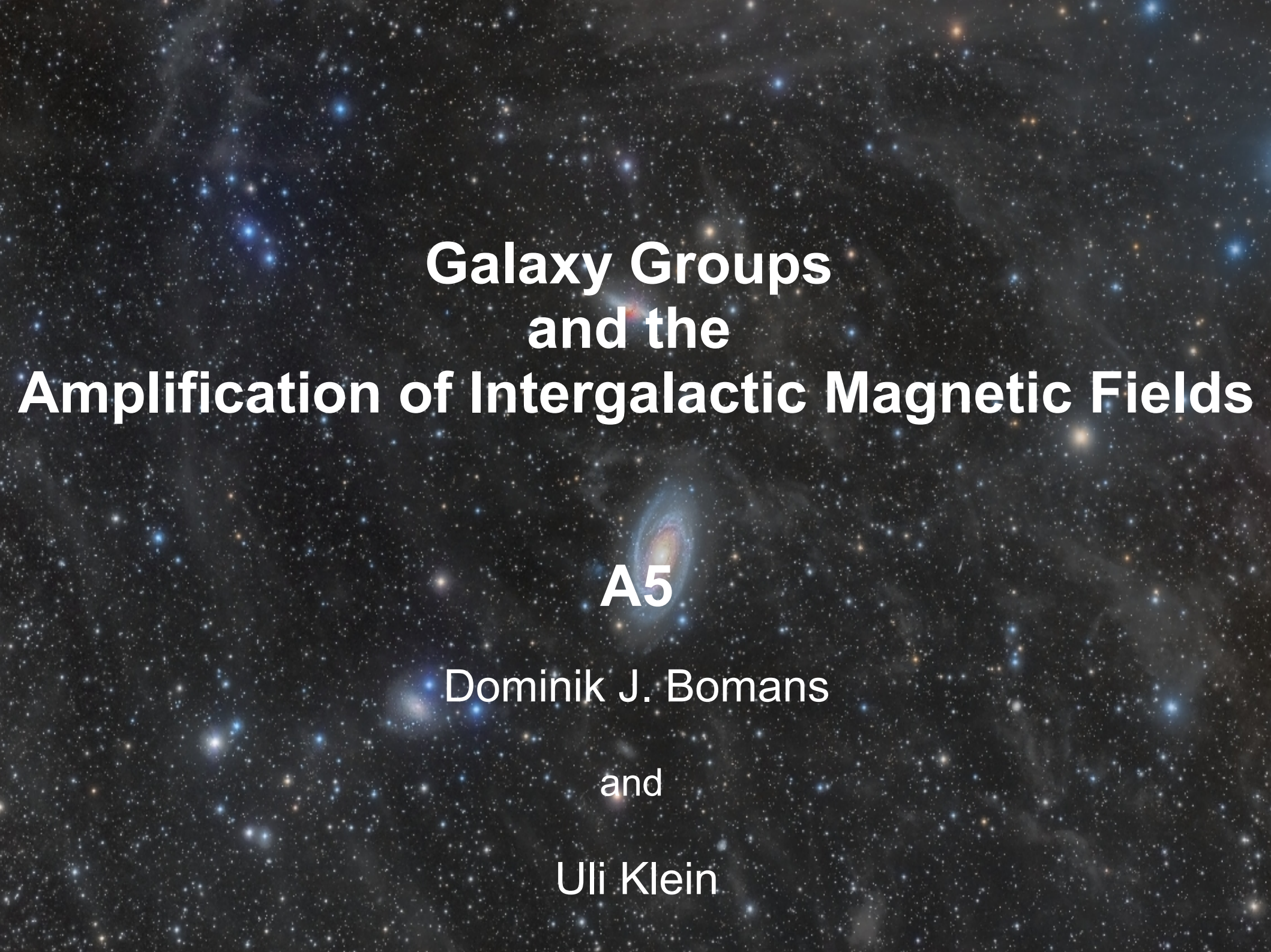

Galaxy Groups and the Amplification of Intergalactic Magnetic Fields

A5

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and

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with

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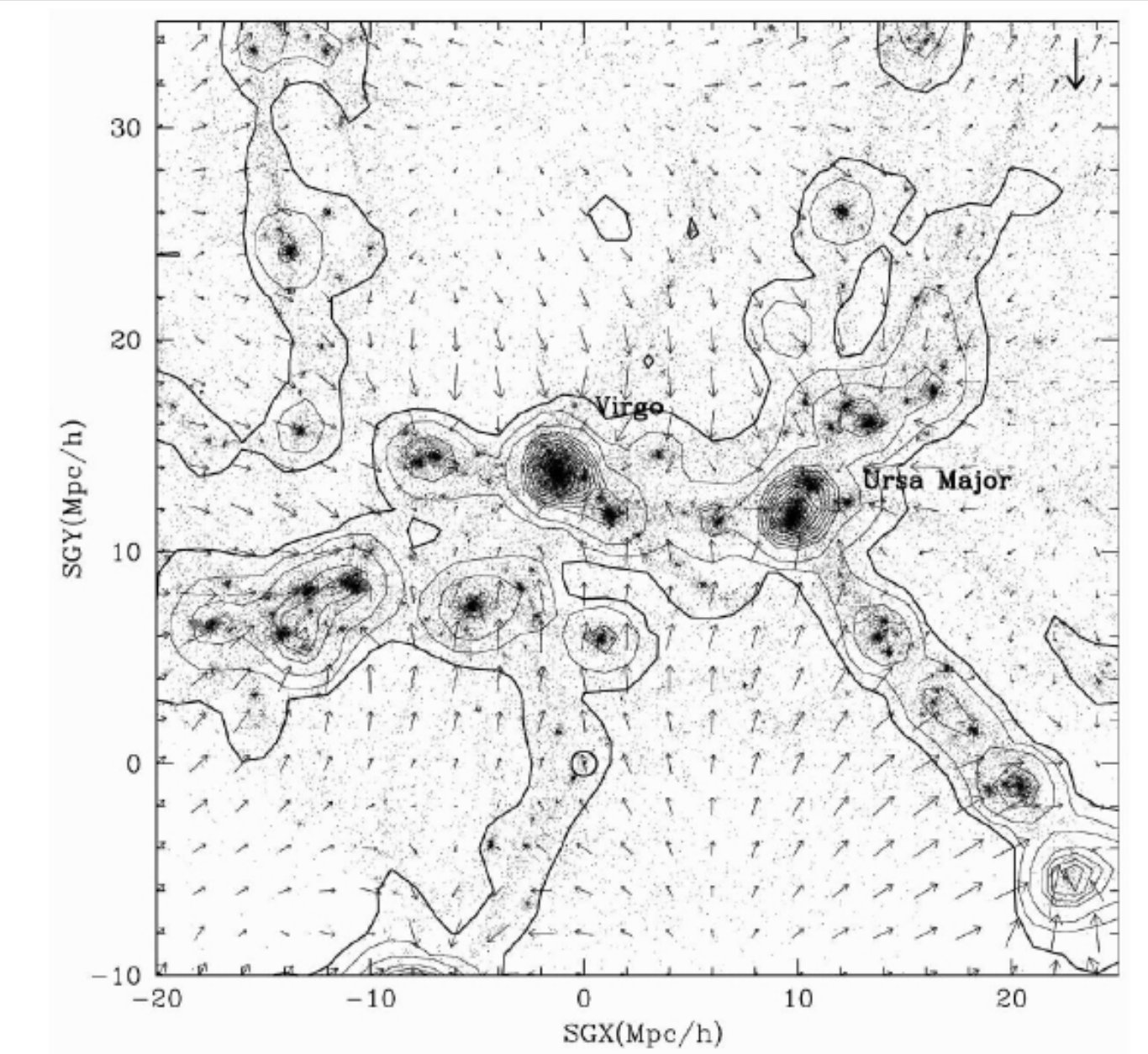
Ginevra Trinchieri, Philippe Amram

Marek Urbanik, Kris Chyzy,

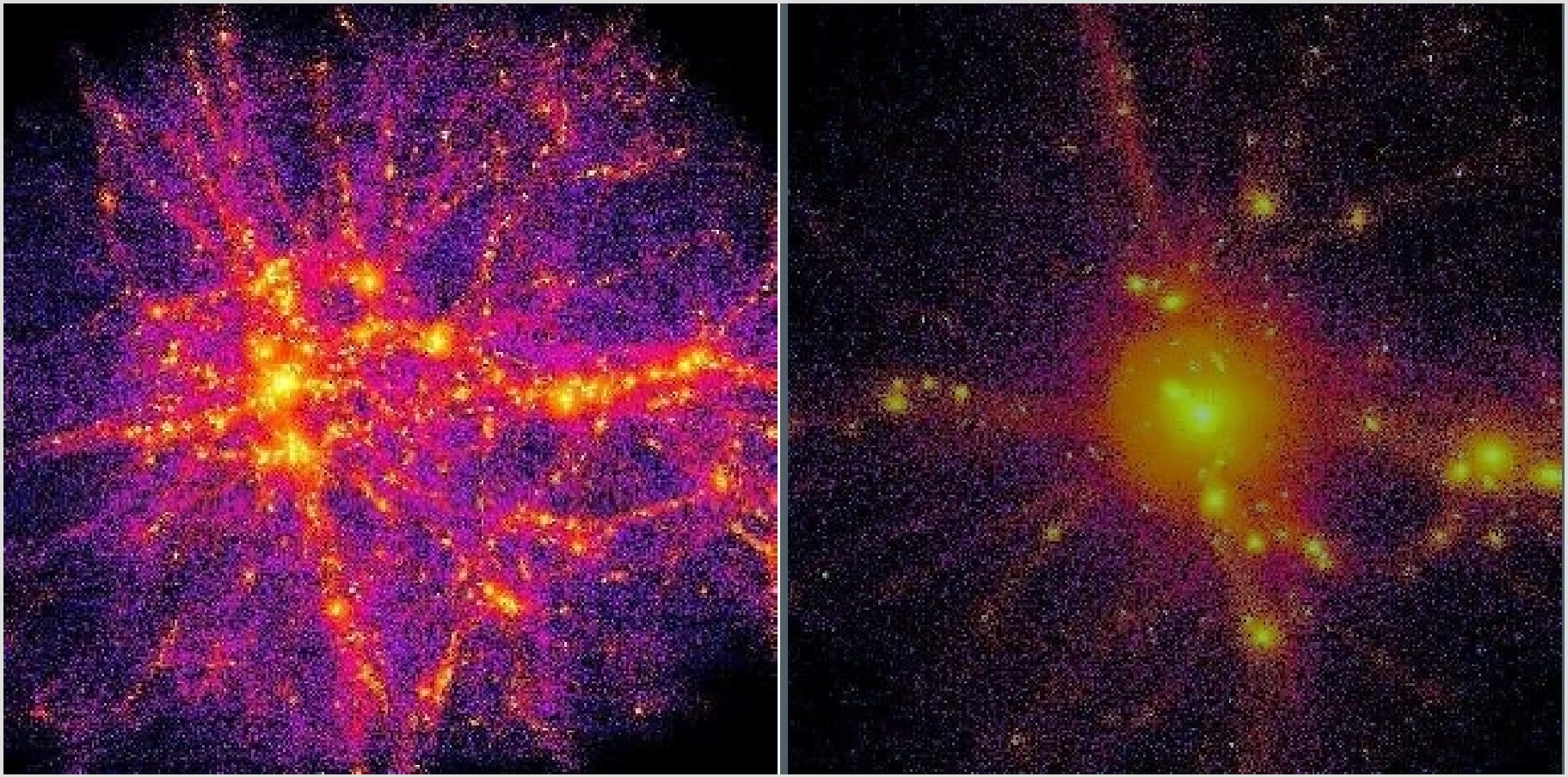
Hubert Siejkowski, Marian Sojda, Katarzyna Otmianowska-Masur

Gas streaming into Large Scale Structure



Klypin et al. 2003

Gas in the large scale structure



Gas density at z=2 and z=0 for a group/cluster (including radiative cooling)

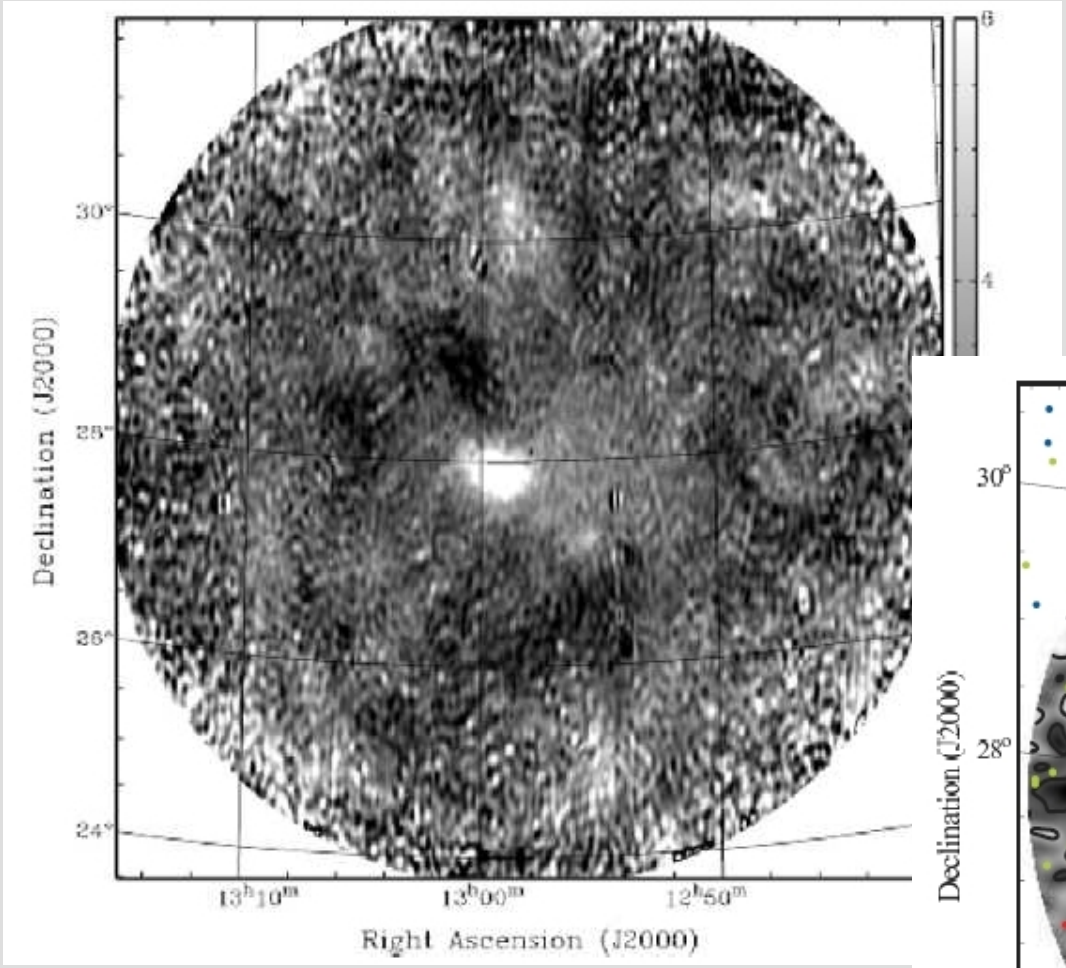
Borgani et al. 2005

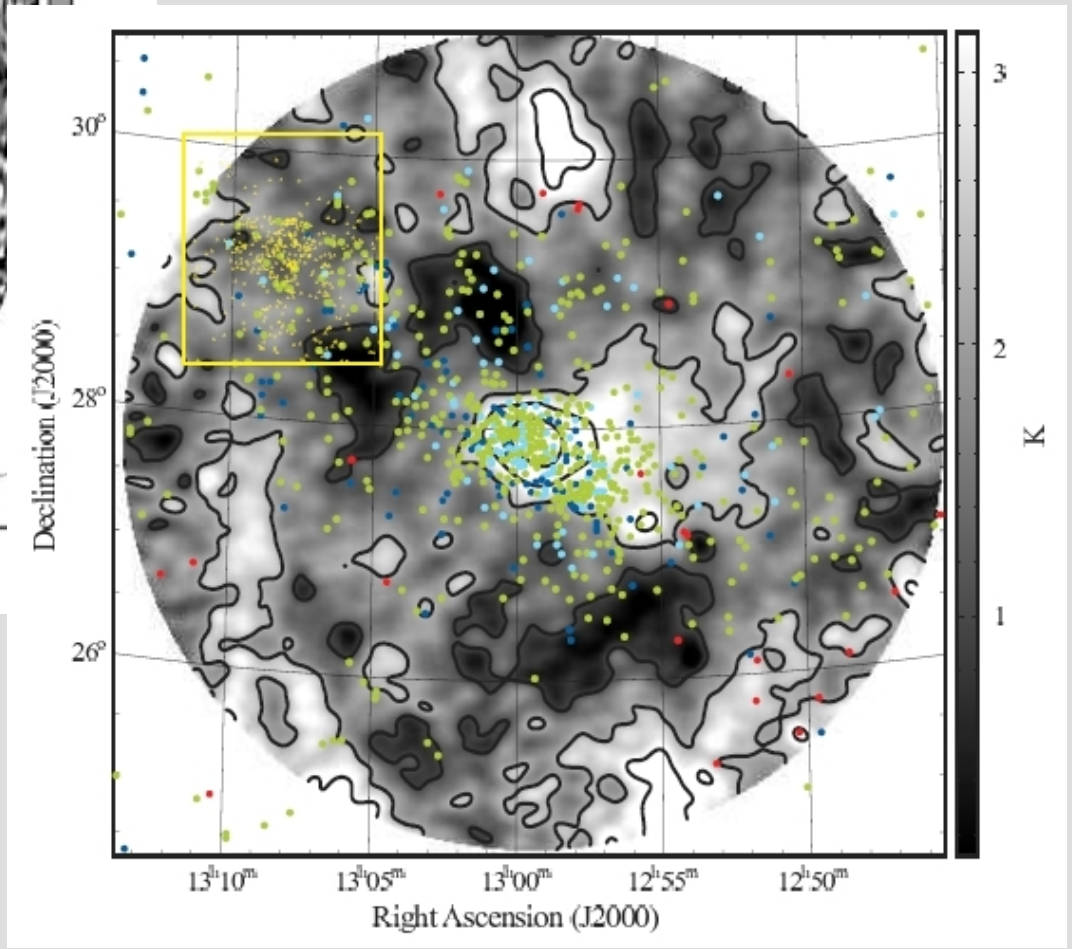
Magnetized diffuse intergalactic medium

Kronberg et al. (2007) observations at 400 MHz

- detected several intergalactic structures
- anti-correlation of the radio continuum emission and the galaxy distribution
- consistent with magnetic field amplification due to galactic winds

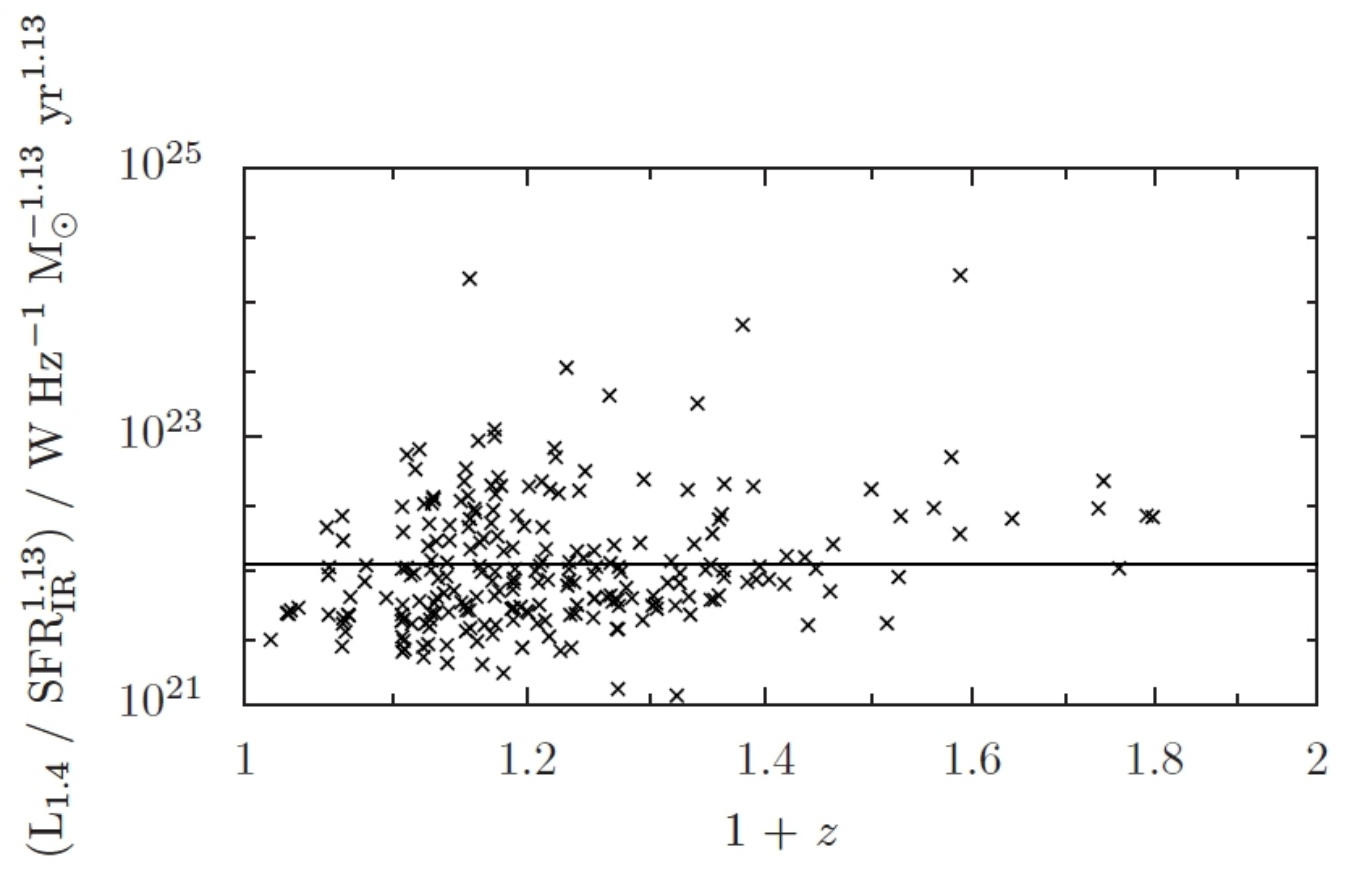
Magnetized diffuse intergalactic medium





Magnetised diffuse intergalactic medium

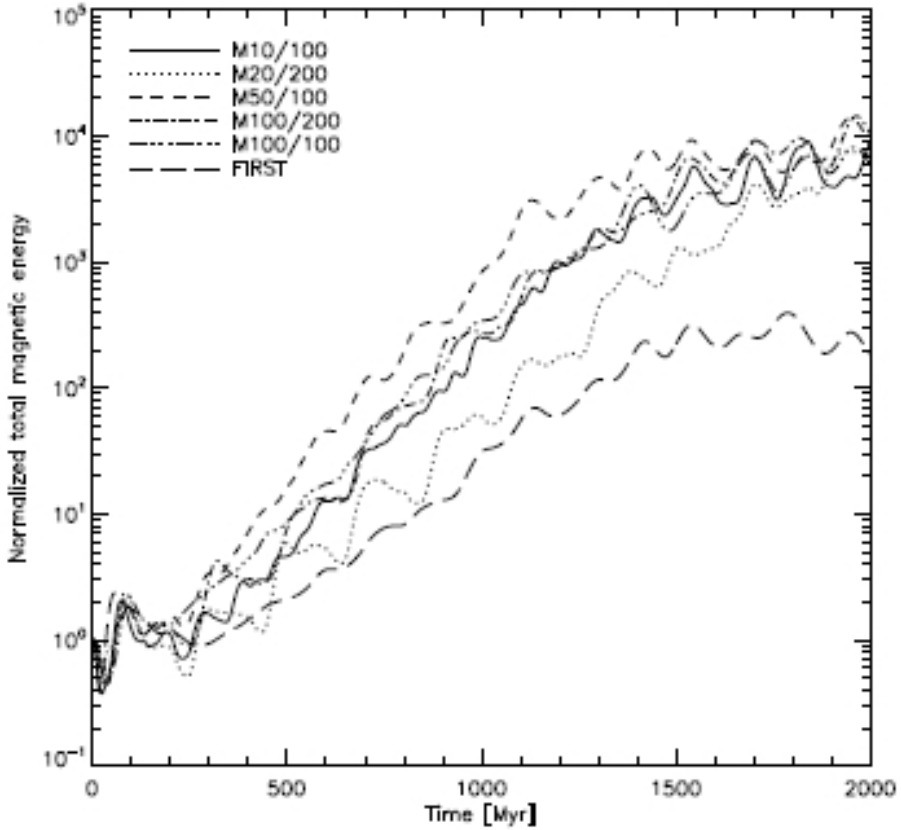
Garn et al. (2008) observations may imply a build-up of magnetic fields around starforming galaxies

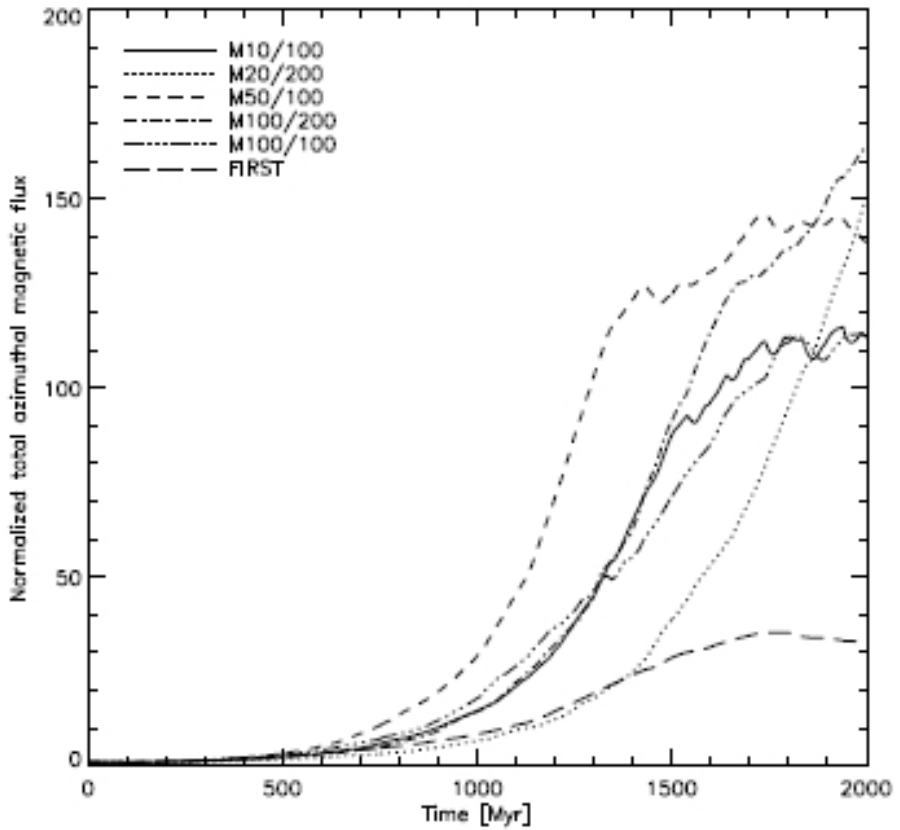


Roughly consistent with the RM results of Kronberg et al. 2007b

Magnetized diffuse intergalactic medium

Siejkowski et al. (2010) shows amplification and transport of magnetic fields away from dwarf galaxies

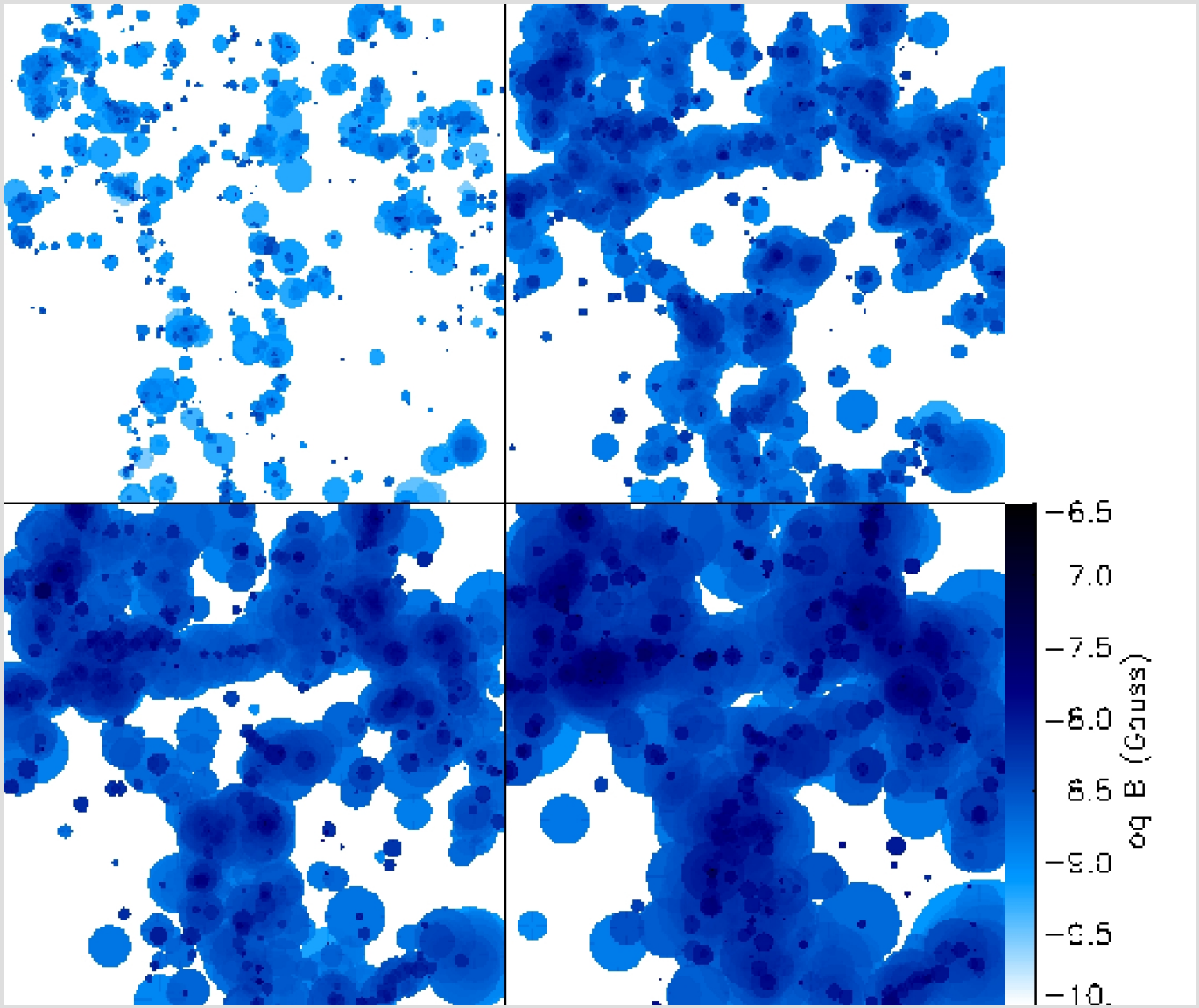




Total magnetic energy
Both for models with different SN modulation

total azimutal fluxmagnetic flux

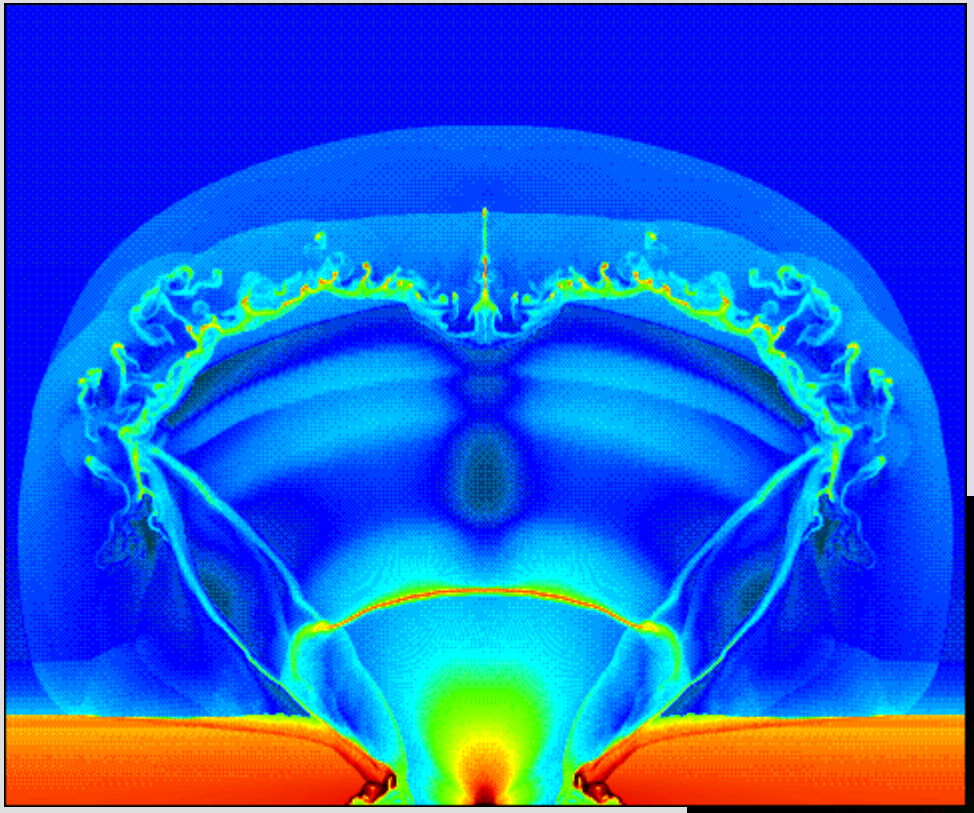
Magnetization of the IGM by galactic winds



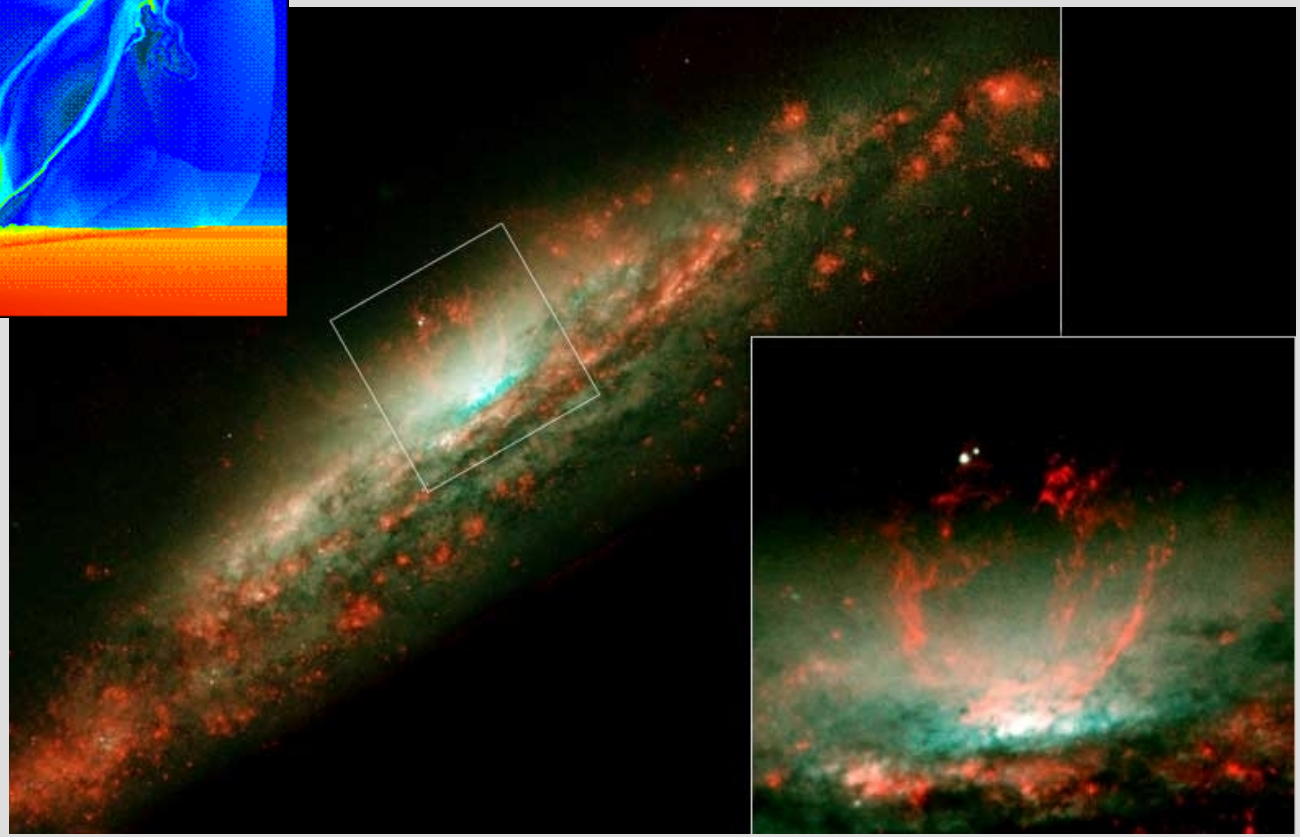
Bertone et al. 2005

See talk by Uli Klein

Galactic outflows and winds



2D hydro simulation of galactic outflow
Strickland et al.



HST imaging of NGC 3079
Cecil et al.

Compression of B field lines

Sensitive observations at low frequencies, especially with *LOFAR*, will allow the detection of magnetic fields out into the intergalactic space, especially where magnetic fields are amplified by compression of field lines.

Large-scale low frequency radio continuum emission:
- magnetization of the IGM
- the late evolution of galactic winds

provided one can define an environment in which the effects of AGN and mixing can be controlled and/or kept at a minimum.

Where to search: galaxy groups

- regions with multiple starbursts
- free of strong AGN
- closed environment
- without strong ram-pressure stripping

→ Galaxy groups

Since groups of spiral and irregular galaxies selected in the past are not fully virialised as discussed by Mamon (2007), they are similar to the filaments of the large-scale structure, but better controlled and more well-defined structures.

Where to search: starbursts

- low frequency radio continuum and polarization
  - detect emission from particles travelling > 500 Myr
  - follow individual winds out to > 50 kpc

- starbursts are not instantaneous but staggered (e.g. Vallenari & Bomans 1996, Tosi et al. 2005)

- lengthy periods of strong star formation activity (of order 10^8 yr)

- gravitational interaction between galaxies lead to multiple triggers for strong star formation
  - temporally and spatially correlated starburst event,

- not only large galaxies transport magnetic field into the halo, but also dwarf galaxies
- ordered magnetic fields transported into their halos (Siejkowski et al. 2010)

B field enhancement processes

Magnetic field lines compression and in situ star formation

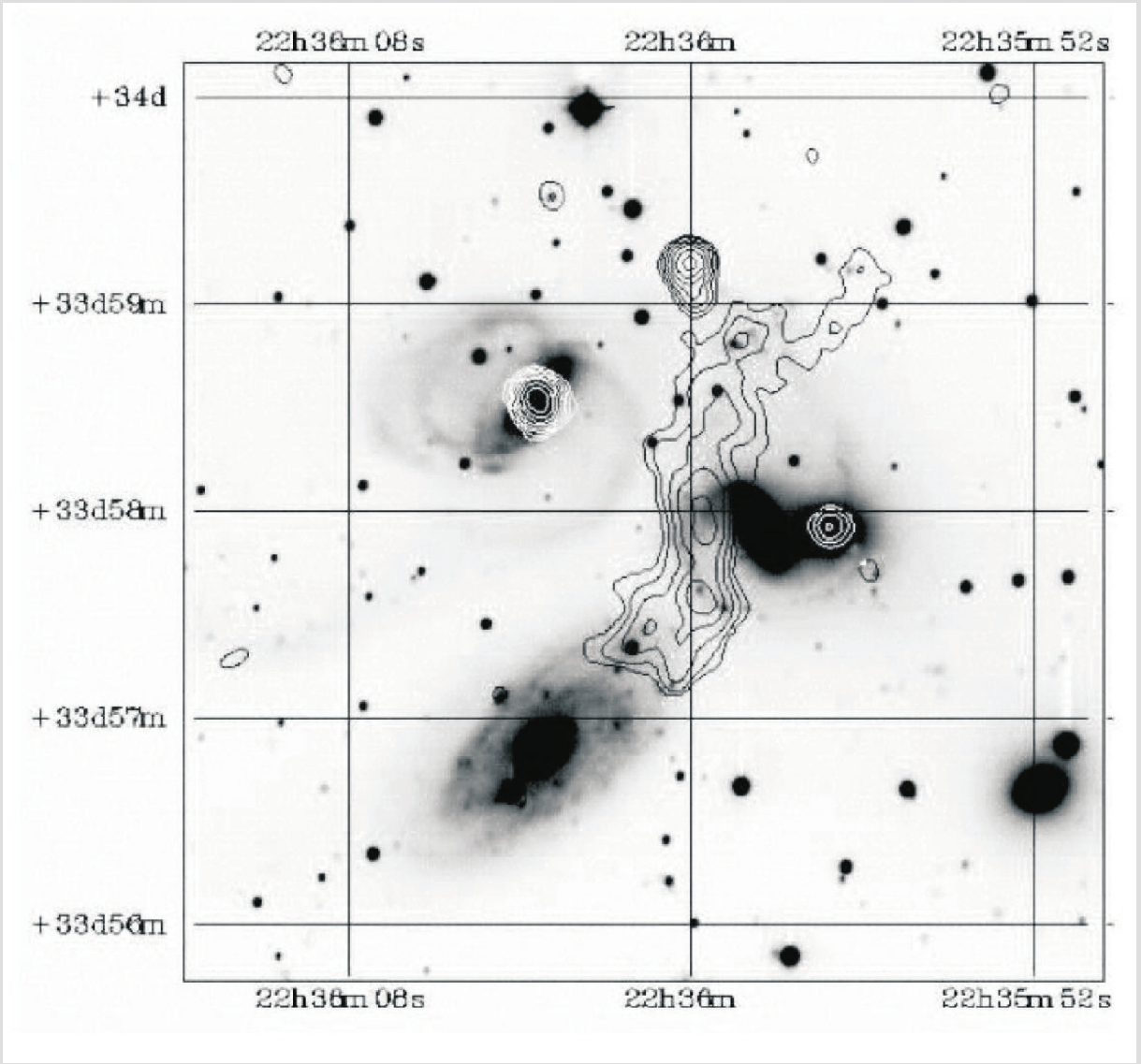
1) ***Fast motion of a galaxy through the central region of a group***
   Stephan's Quintett (HCG 92)
   clearest detection of intra-group magnetic fields up to now.

2) ***Colliding galactic outflows or winds***
   New idea: see Ho 124 and HCG 31

3) ***Interaction of the galactic wind or outflow with preexisting dense clouds***
   A cloud in the intra group medium can be either primordial or remnants of past or current gravitational interaction.
   See "cap" in M82

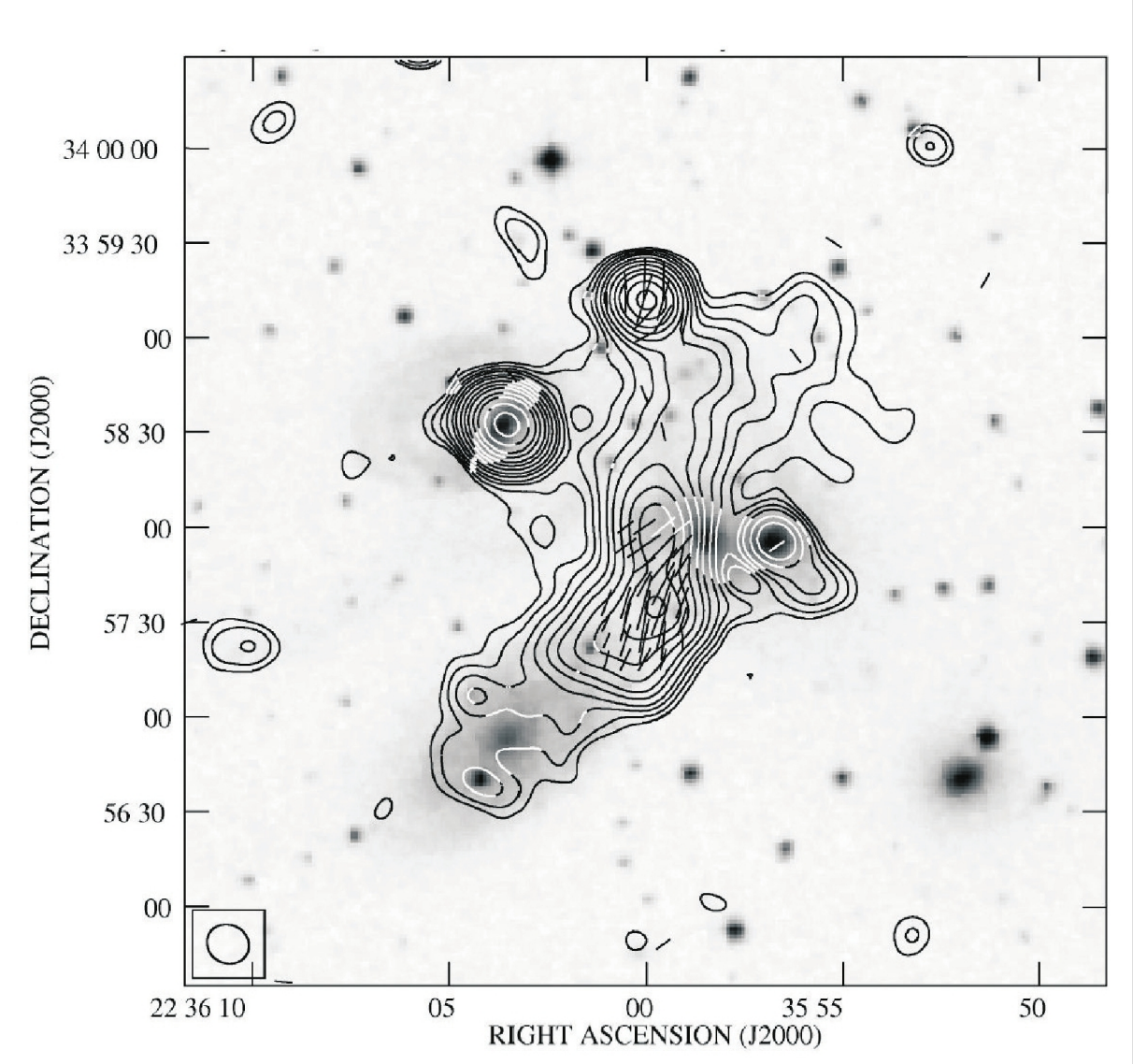
4) ***Star formation knots in the intragroup medium***
   See M81/M82 group,
   and new detections from our survey

Case 1: HCG 92 plus 1420 Mhz radio cont.



Soida et al., in prep

HGC 92 plus 4850 Mhz radio cont. and B vectors



Soida et al., in prep

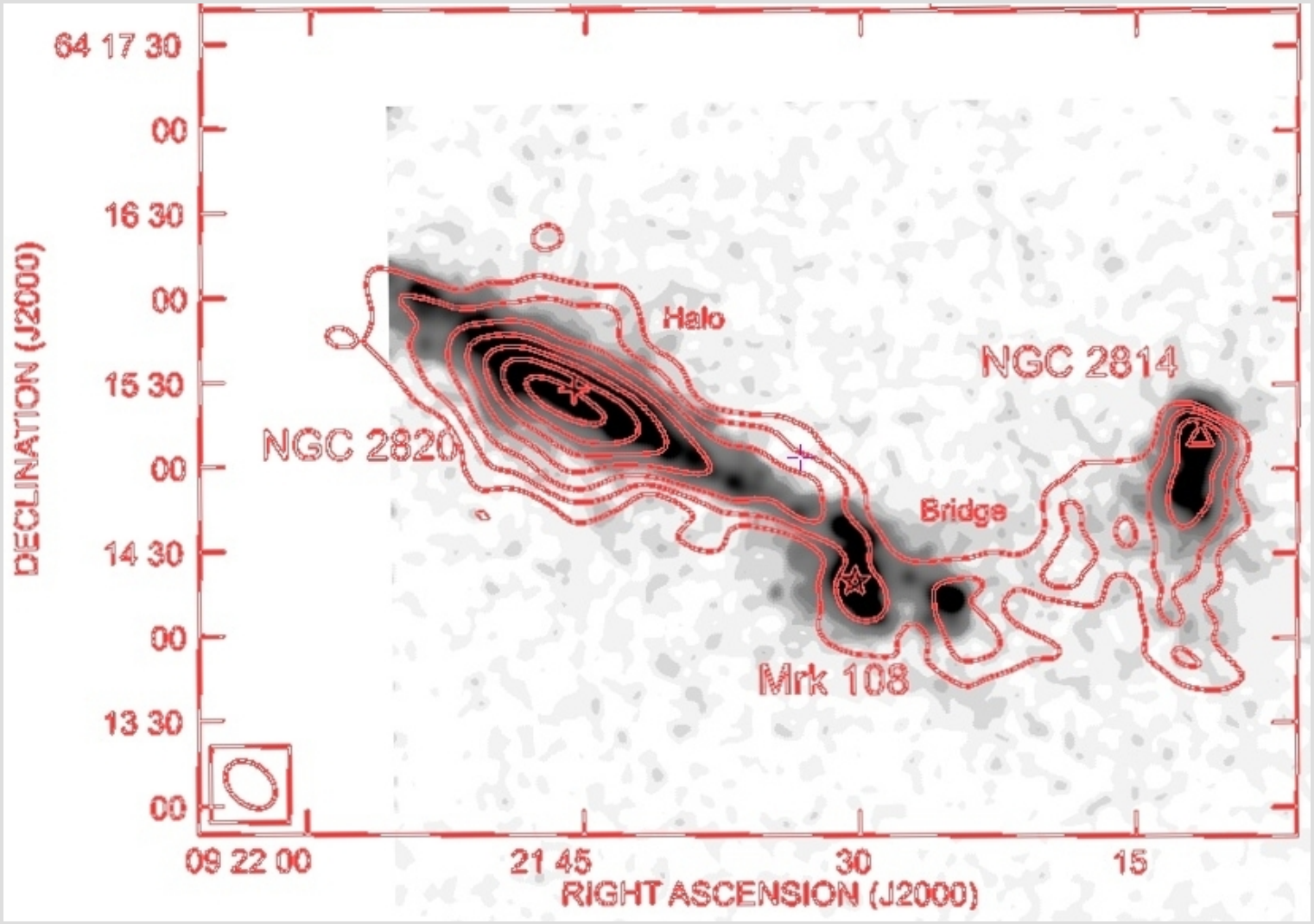
HCG 92

Bright radio continuum filament in HCG 92 (= Stefan's Quintett)

- strong intergalacitc shock
- due to high speed motion of intruder galaxy through galaxy group core
- compression of gas
- compression of magnetic field lines

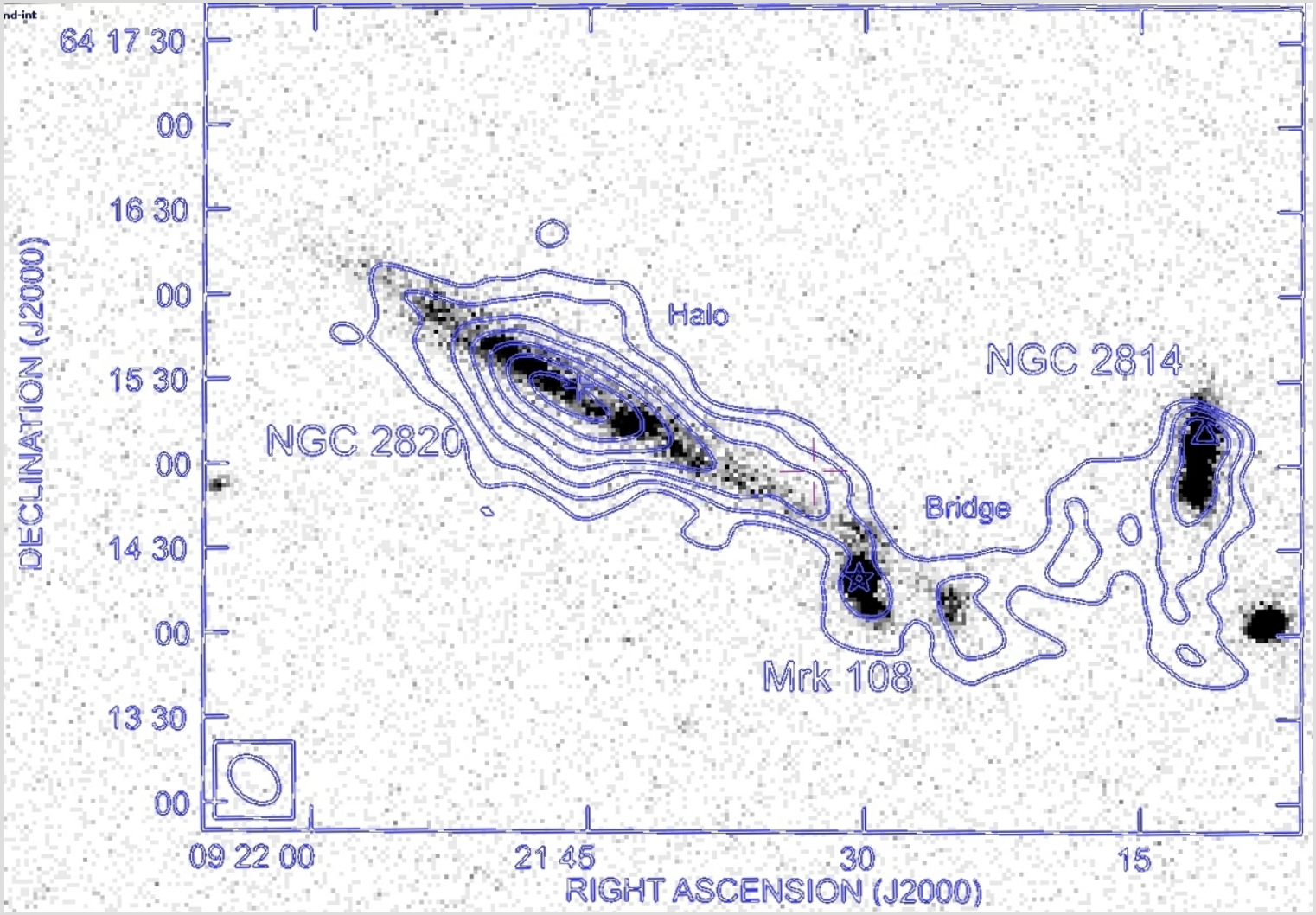
→ bright radio continuum emission and emission of Hα and molecular gas

Case 2: Ho 124 Hα plus 300 Mhz radio cont.



Kantharia et al. 2005; Bomans et al. in prep.

Ho 124 NUV plus 300 Mhz radio cont.



Kantharia et al. 2005; Bomans et al., in prep.

Ho 124

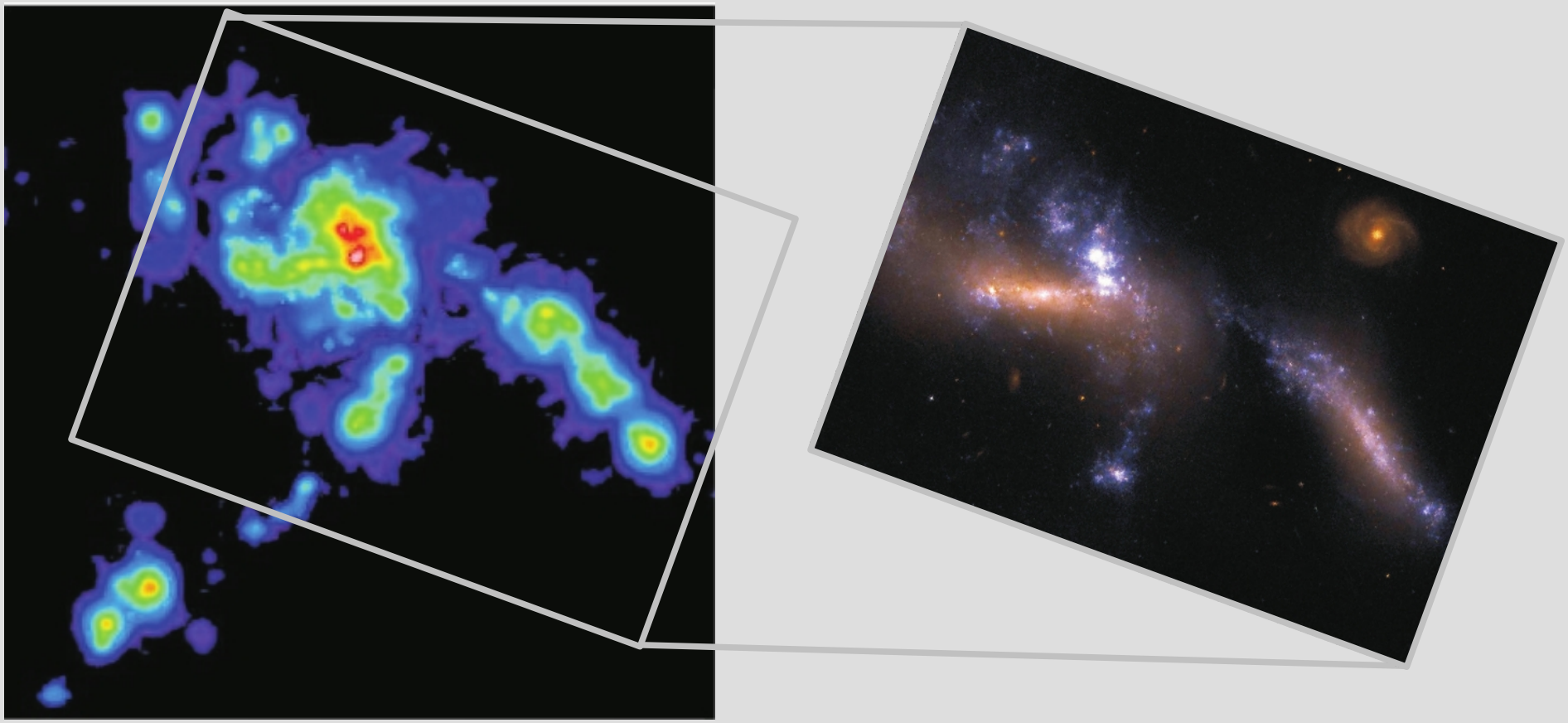
Radio continuum bridges in Ho 124 group:

- correlate with Hα
- do not correlate with NUV emission

→ not tidal bridge with star formation but radio emission of galactic winds

Probably enhanced by collision and therefore field line compression

HCG 31



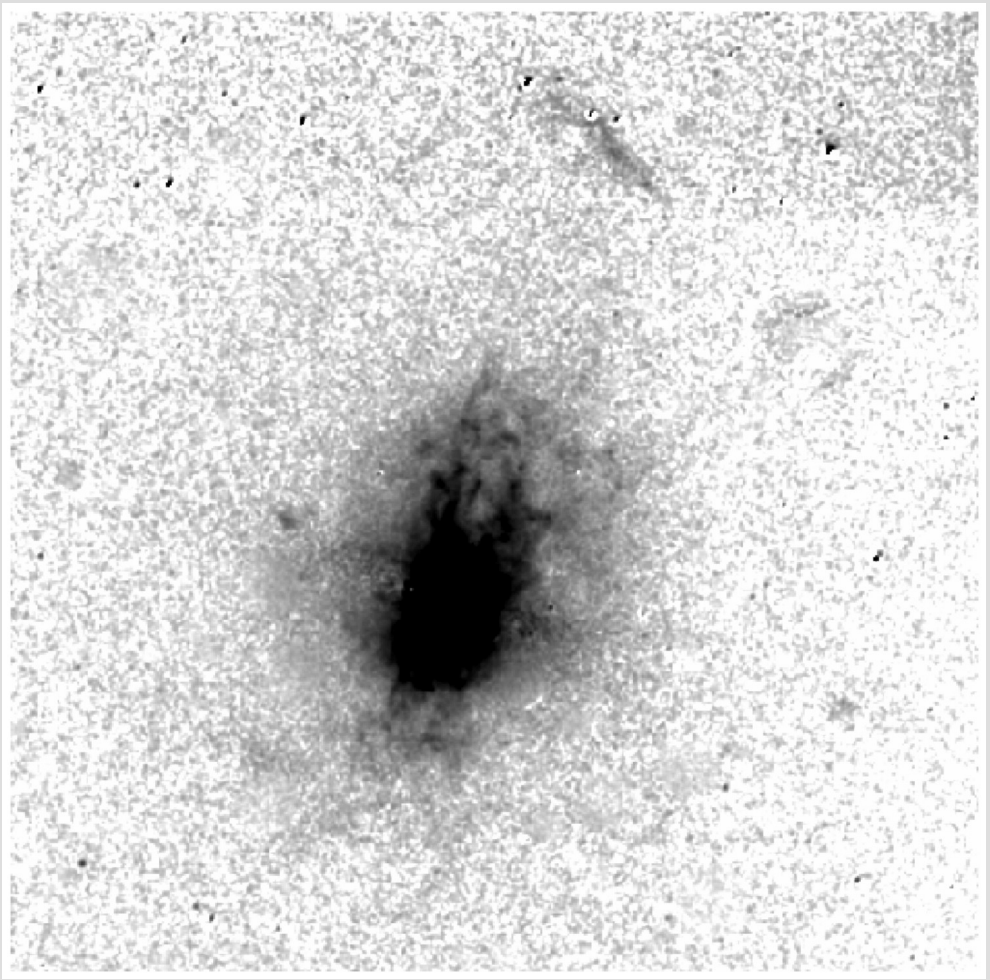
Hα (Amram et al. 2004) HST ACS

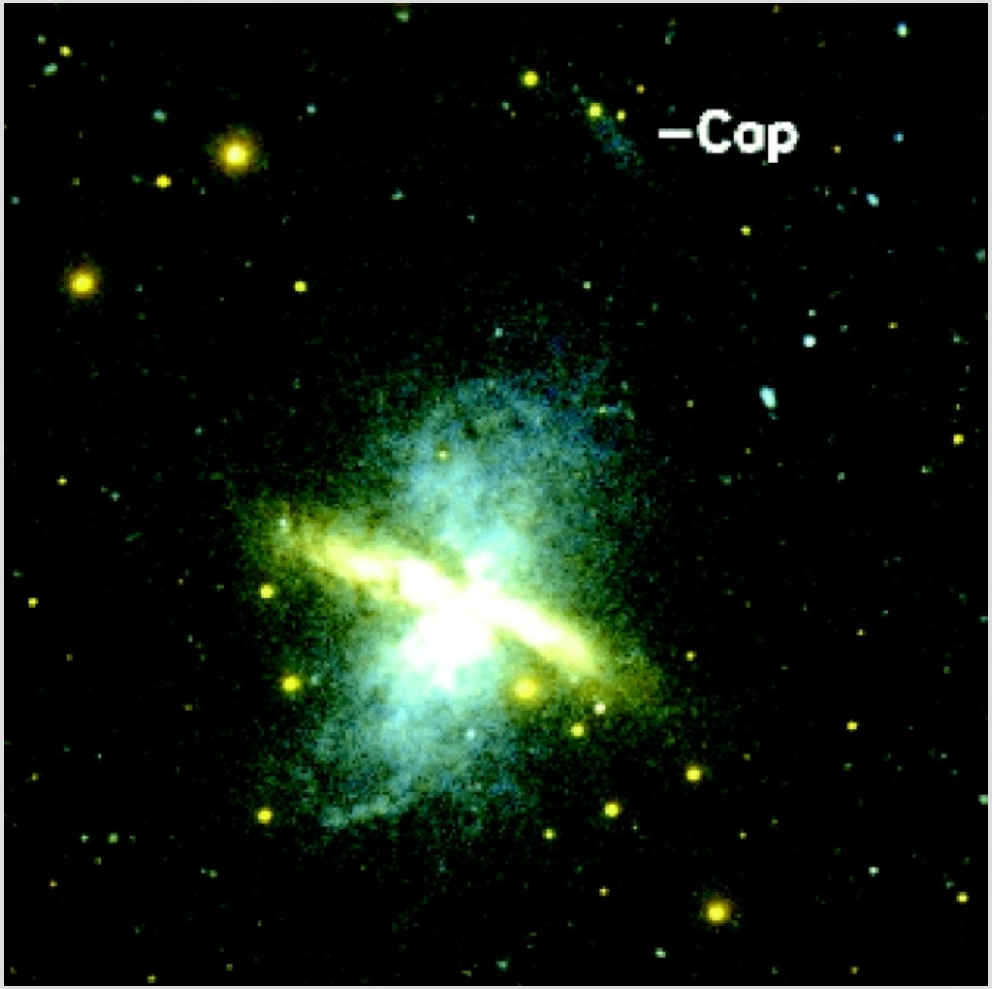
Another case for multiple time correletated starbursts in a group
And therefore potential for colliding galactic winds

Case 3: M82 cap

M82 galacting wind Westmoquette et al. 2005

M82 cap

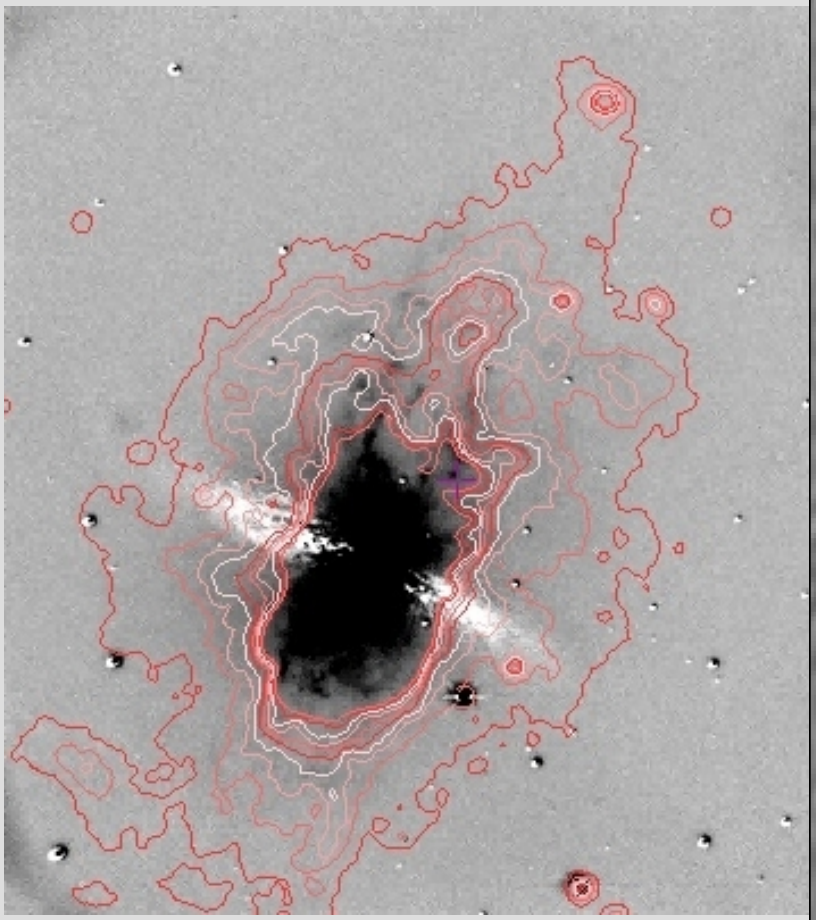


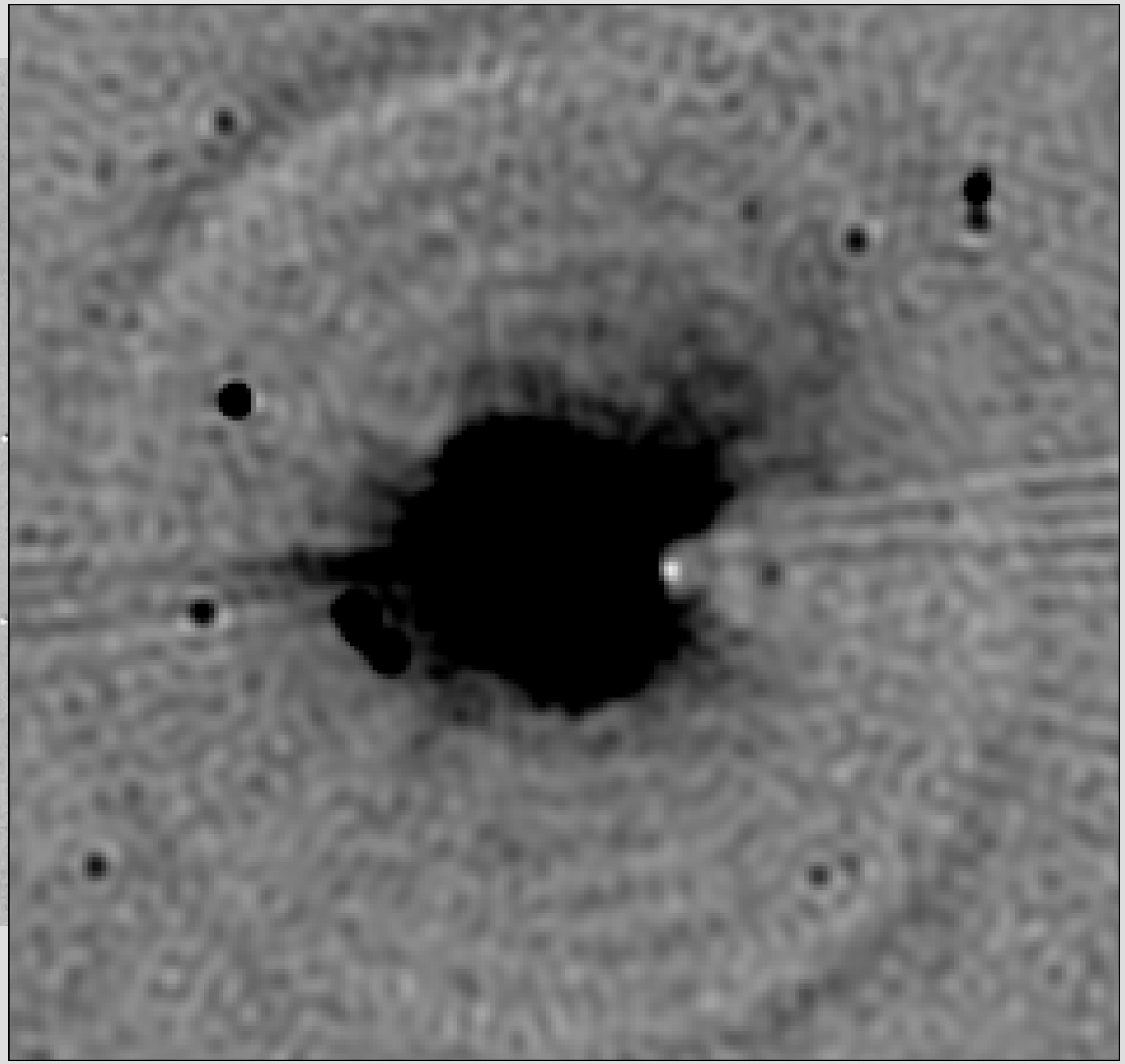


Hα

UV Hoopes et al. 2007

M82 Hα, X-ray, plus radio cont.

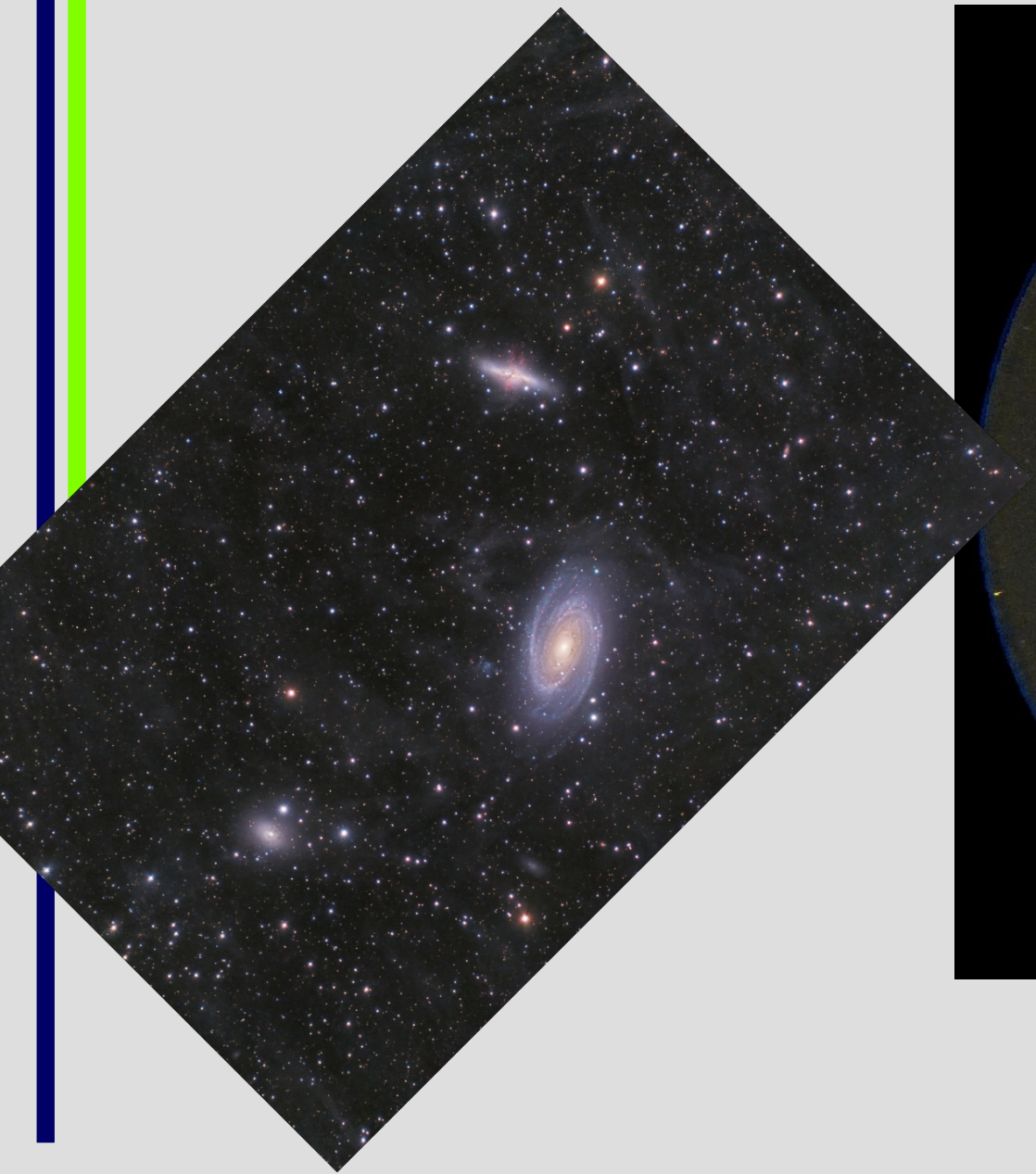


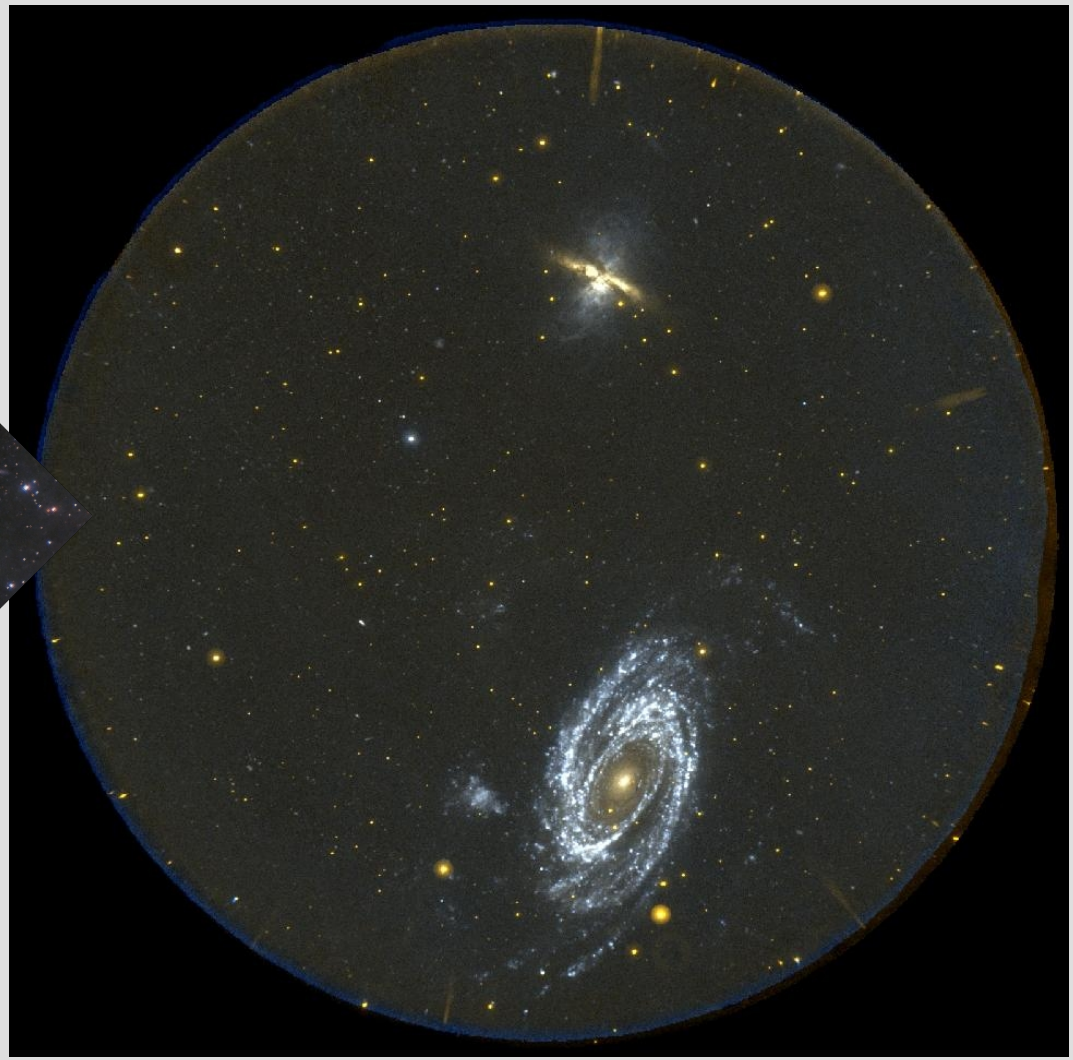


Hα plus X-ray (Wezgoviec, Bomans et al.)

1420 Mhz (Adebahr et al.)

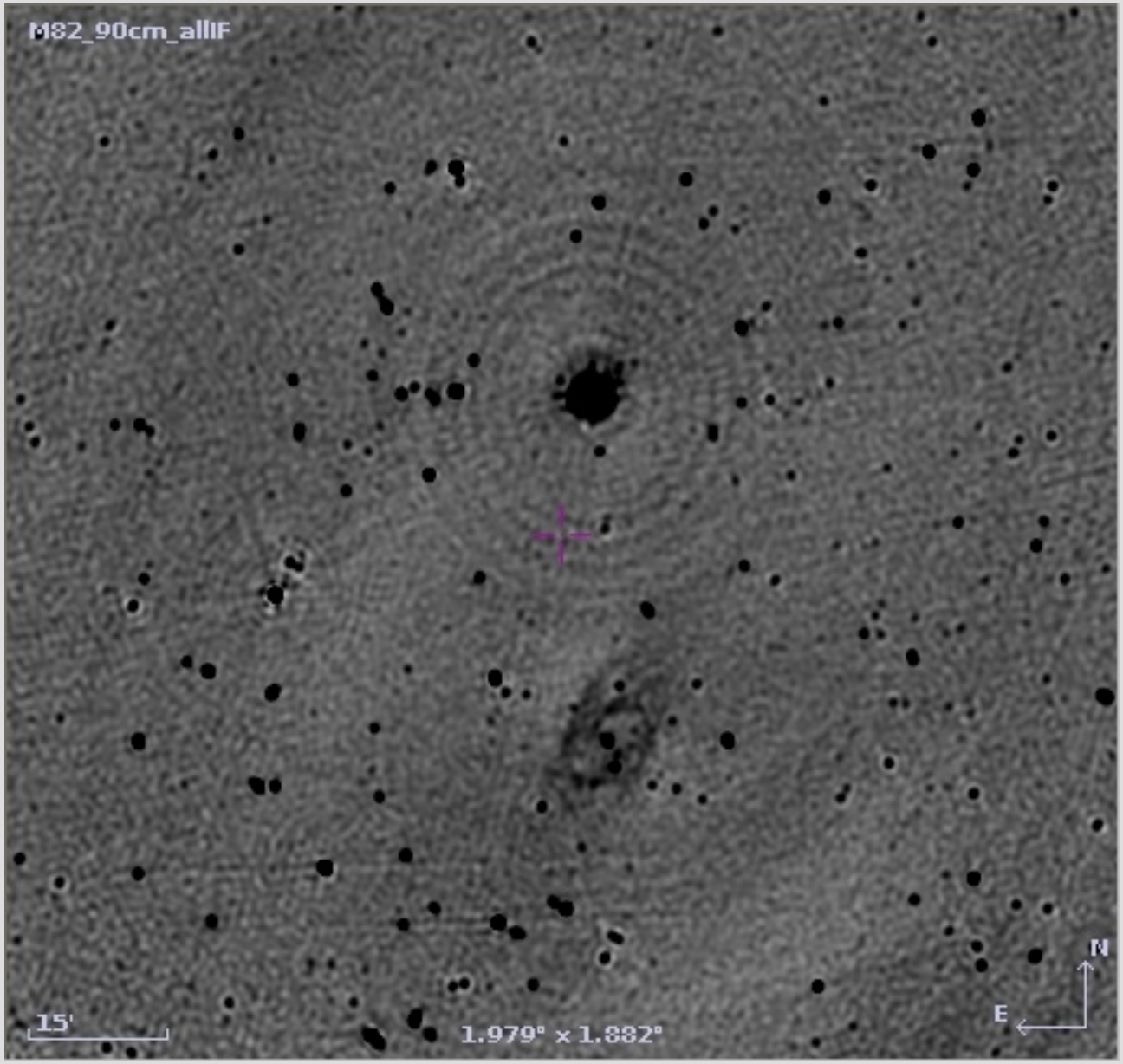
Case 4: M81/M82 group with knots of intragroup SF





GALEX FUV+NUV

M81/M82 group core in radio cont. at 327 Mhz

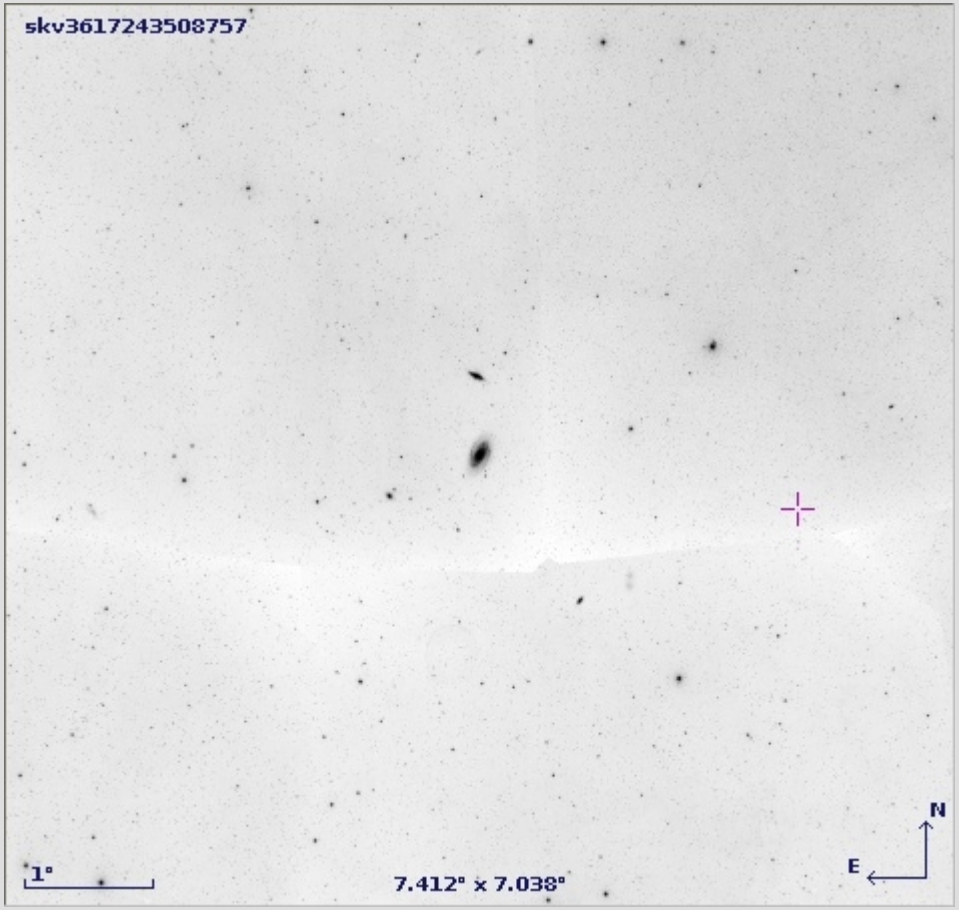


WSRT archival data

Proposal for
600 Mhz submitted

Adebahr et al.

RM from background sources



7d x7d field centered on M81

~50 background sources
From Taylor et al. 2007 catalog

First hint: central 10 background
Sources all negative RM,
Farther out more positive

Bomans et al., in prep

LOFAR !

More interesting groups

Intra-group starforming knots similar to the M81/M82 group core

Becker & Bomans, 2010

Conclusions

- Groups are the best laboratories for study of large scale shocks

- field line compression and in situ star formation activity enhance B fields

- first observational examples are being analysed

- low frequency observations with LOFAR will probe large parts of starbursting galaxy groups

- observational contraints of magnetic field amplification and distribution in the IGM

Prediction: topology of B fields are clumped along the filaments of the LSS


Thank you for your attention !