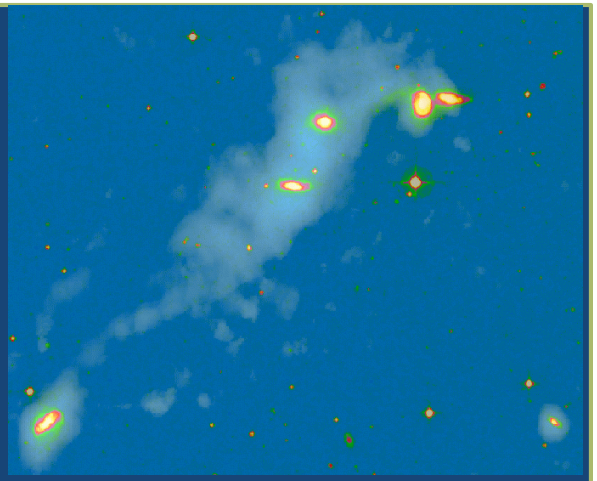

# Cold gas in extremely Deficient Compact Groups

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Instituto de Astrofísica de Andalucía (IAA - CSIC)

Compact Groups' Group:

S. Borthakur, T. Ponman, J. Ramussen, M. S. Yun, D. Espada,

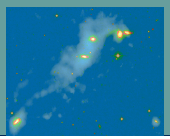
U. Lisenfeld

Malaysia09:Galaxy evolution and Environment

# OUTLINE

- WHAT DO WE KNOW ABOUT HI IN COMPACT GROUPS
- THE QUEST FOR THE MISSING GAS
- HI OBSERVATIONS, SAMPLE
  - HI (VLA,GBT DATA)  FIR,  MH2
  - SLIGHTLY AND HIGHLY DEF EXAMPLES
- CONCLUSIONS ON THE NEW COLD COMPONENT





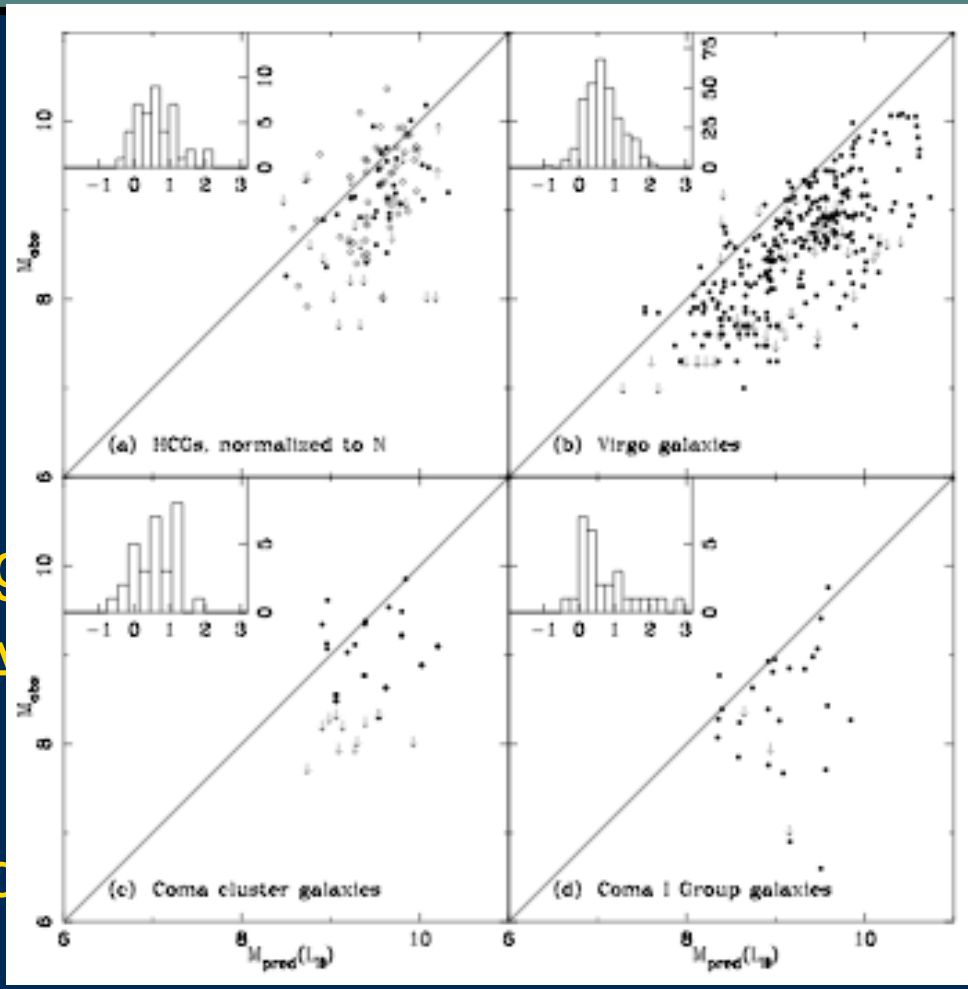
# HI IN HCGs: Previous results

Single dish 72 HCGs:

- 60% HI missing
- Similar to Virgo, Coma cluste
- VLA 16 HCGs:
- 76% HI missing in individual g
- tidal stripping visible with VLA

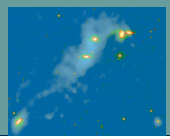
X-rays bibliography

- 45% of HI deficient systems c
- (Ponman et al 1996)
- 18% of HI-normal groups




Verdes-Montenegro et al '01



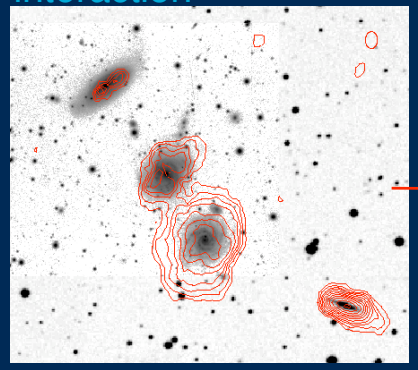


# HI IN HCGs: Previous results

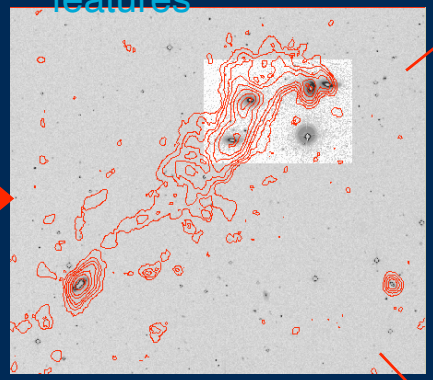
V-M et al '01

## Evolutionary model proposed

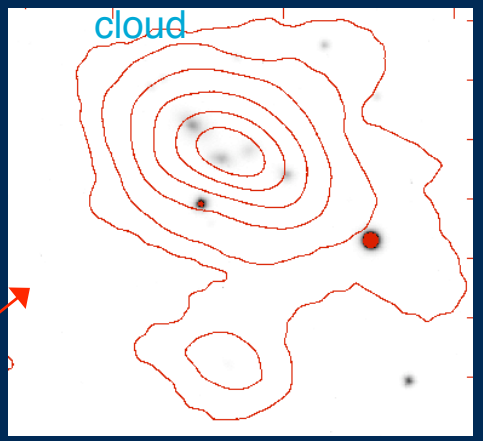
Phase 1: Low level of interaction



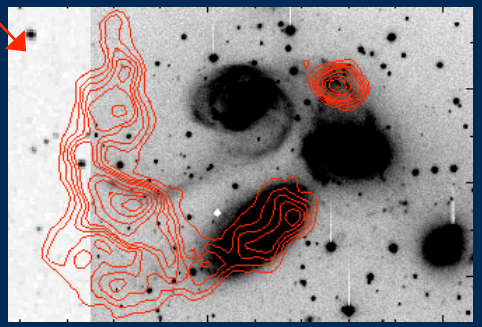
Phase 2: Gas in tidal features



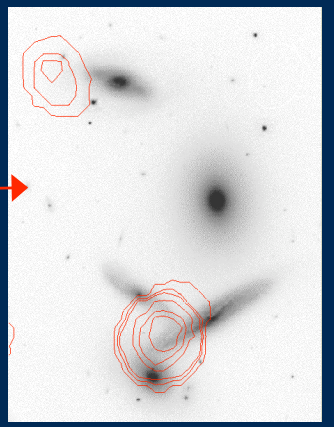
Phase 3b: Gas in a cloud



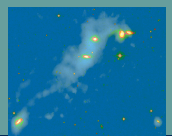
Phase 3a. No HI in the galaxies



¿?







# WHERE IS THE MISSING GAS?

**To look for Intragroup medium** (IGM)

a) Hot gas: Cold gas stripped from galaxies + phase transition

b) ISM stripped from the member galaxies could remain neutral

(reports of HI clouds within Virgo cluster, e.g. this conference)

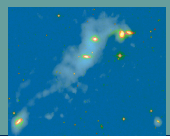
Full accounting of IGM: hot (X-ray) and cold (HI)

Ram pressure stripping insufficient to explain observed

HI deficiencies (Rasmussen et al 08)

**Star formation:** Could contribute to exhausting the gas supply

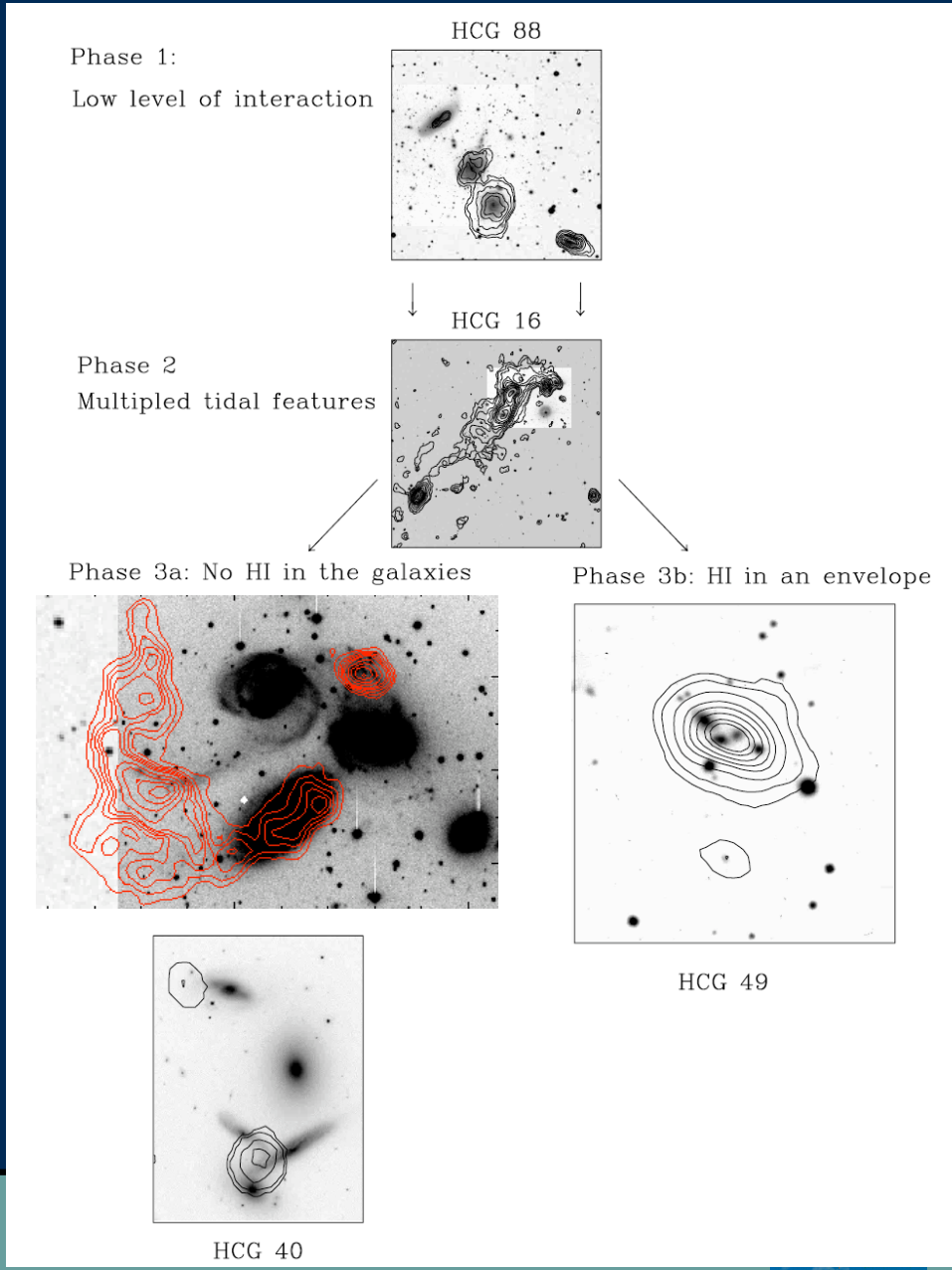




# WHERE IS THE MISSING GAS?

**Is there more gas in these systems that is hiding in the VLA maps?**

**Does the cold gas survive in the Intra-group Medium?**



# HI OBSERVATIONS: SAMPLE

Normal/slightly/highly deficient in HI (2/3 - 1/3 or < of std), D < 100 Mpc

HCG 23, 25, 79, 68

HCG 10, 15 16, 31 37, 40, 58, 88, 91, 92, 97,100

HCG 7, 30,44,67,90,93

a) HI distribution: VLA

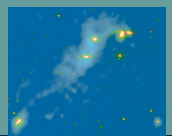
b) Diffuse HI in IGM: may be too faint/extended/broad in v ($\Delta V \sim 1000$ km/s) to be detected by the VLA.

GBT observations: high sensitivity rms/1h = 0.7 mJy (2-20 improvement)

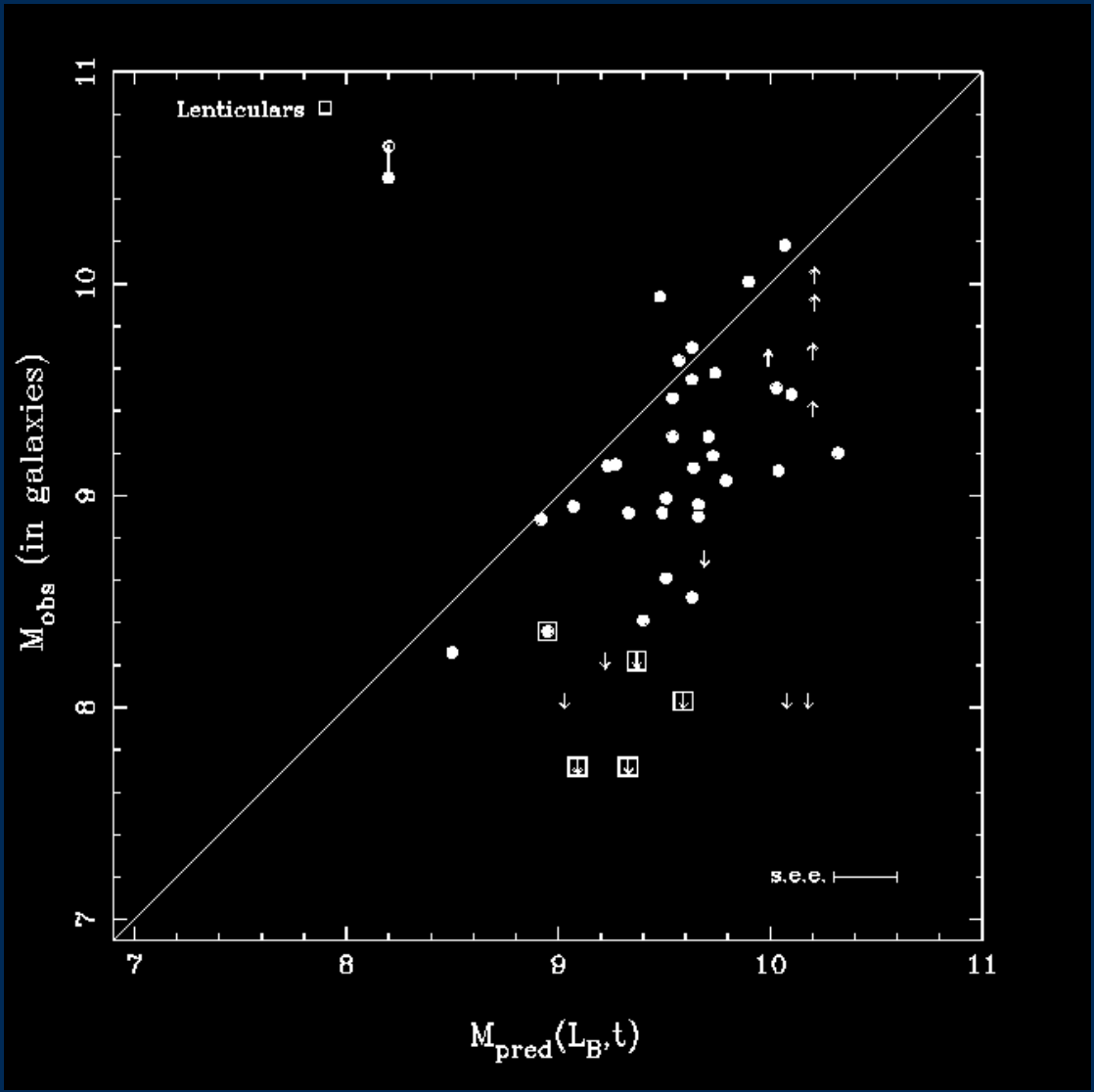
improved baseline stability + careful calibration, $\Delta v = 2500$ km/s

d) CO and FIR data (30m, IRAS) Halpha (Vilchez et al 1998)

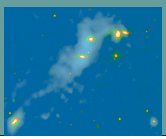




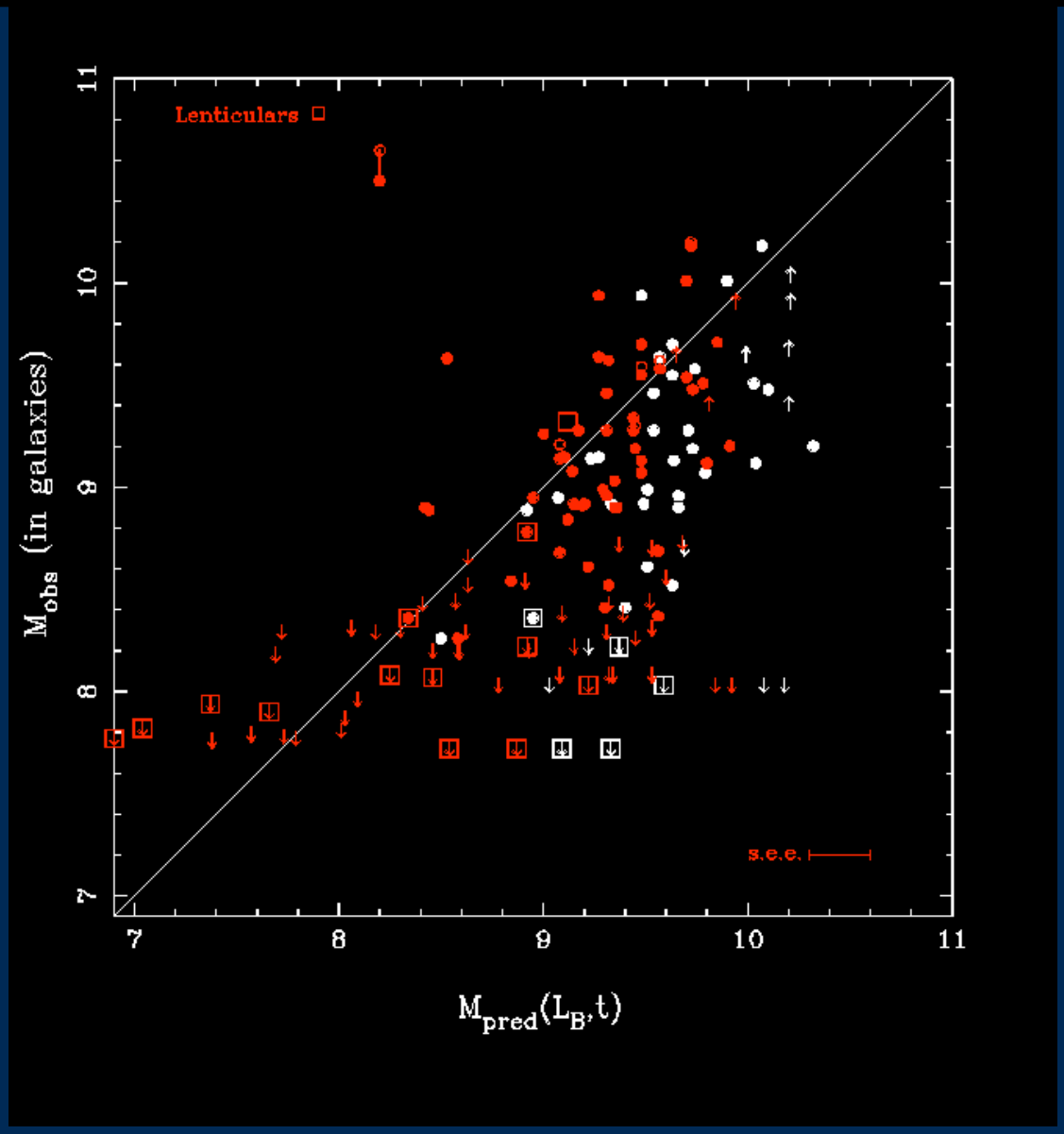
# HI IN INDIVIDUAL GALAXIES: PREVIOUS DATA



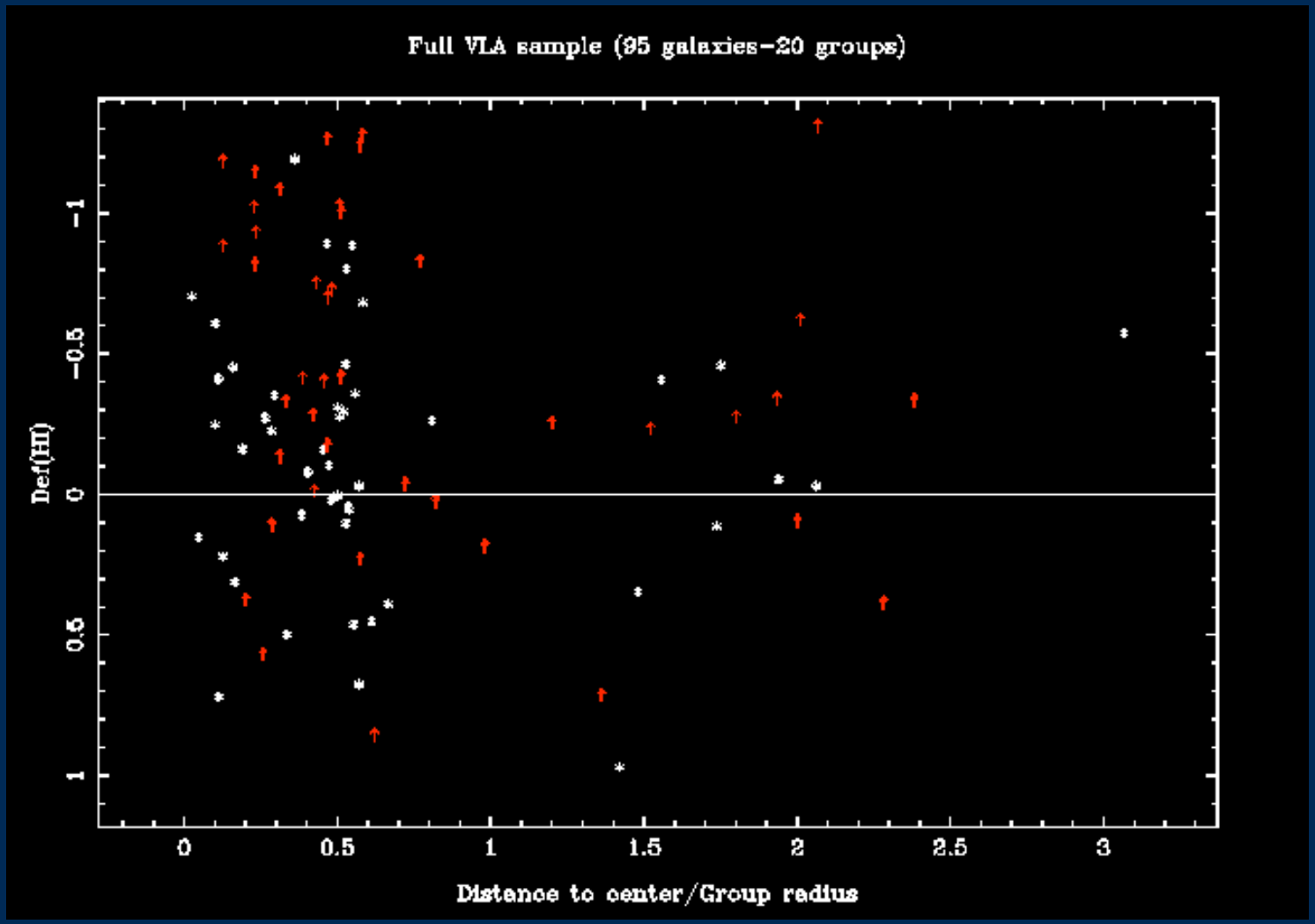


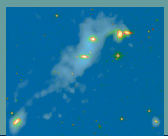
# HI IN INDIVIDUAL GALAXIES: NEW VLA DATA



# HI Deficiency: higher at the center

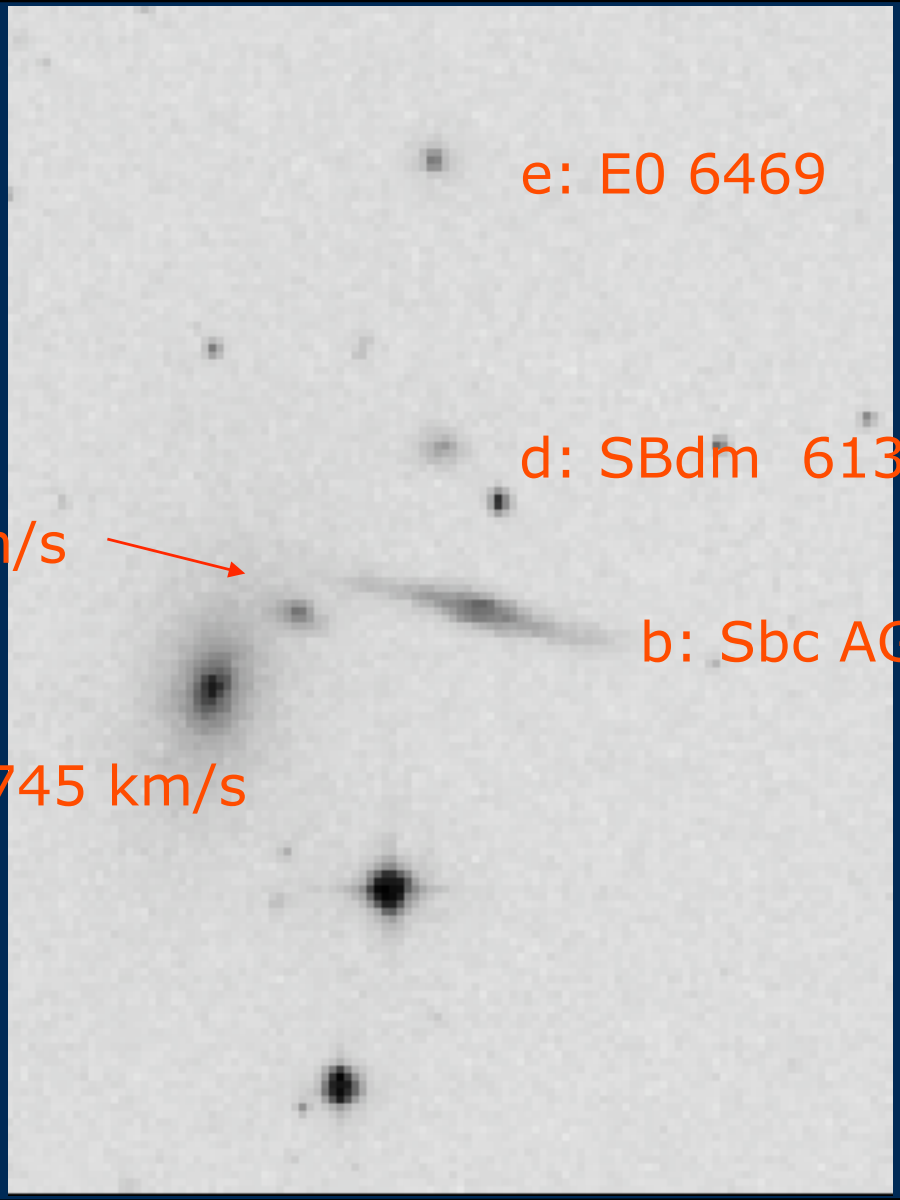




# HCG 37

## dv = 398 km/s



e: E0 6469

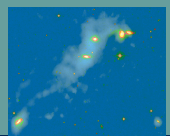
d: SBdm 6131 km/s

c: S0a 7356 km/s

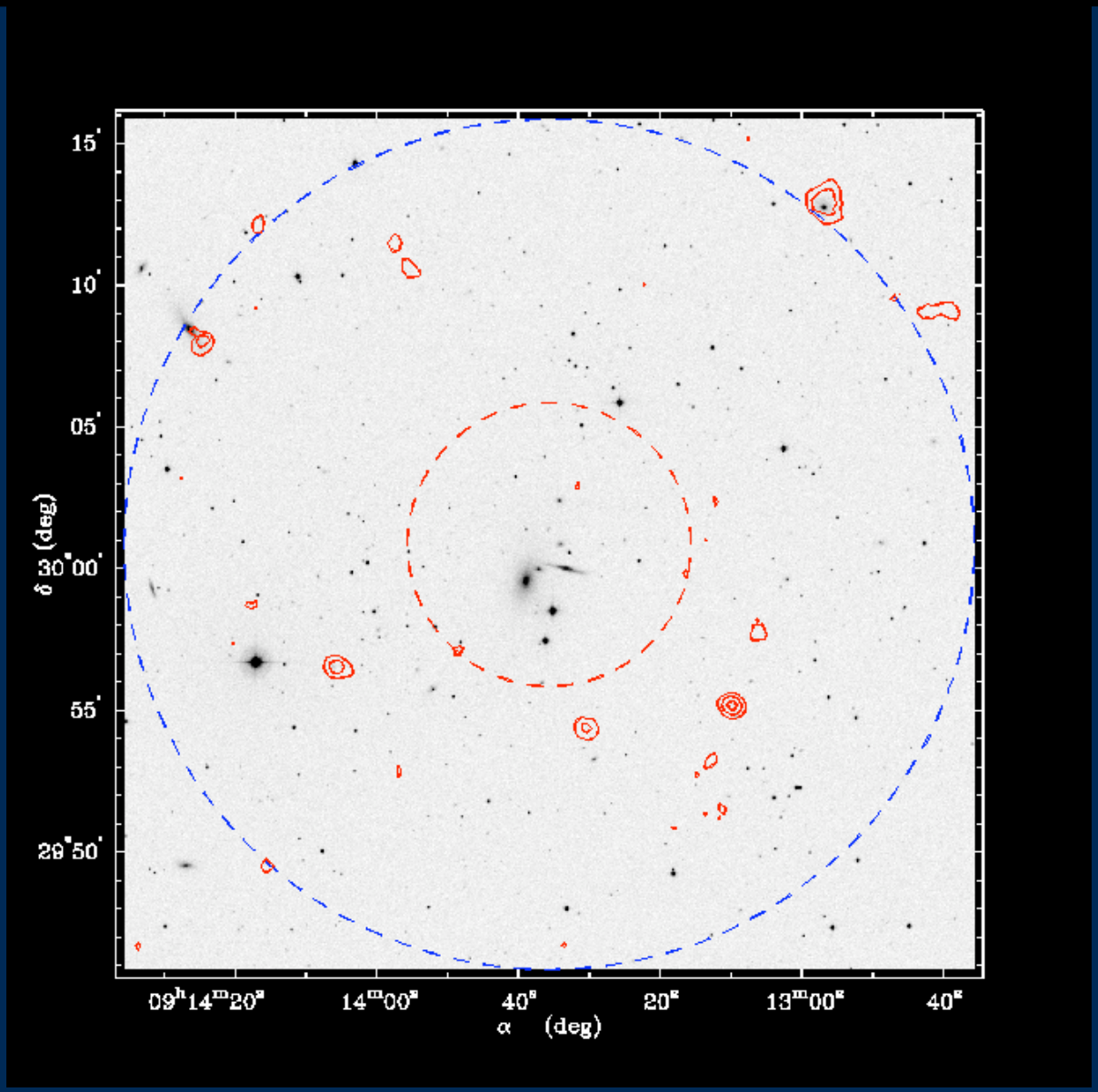
b: Sbc AGN 6758 km/s

a: S0 AGN 6745 km/s

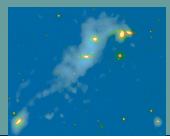




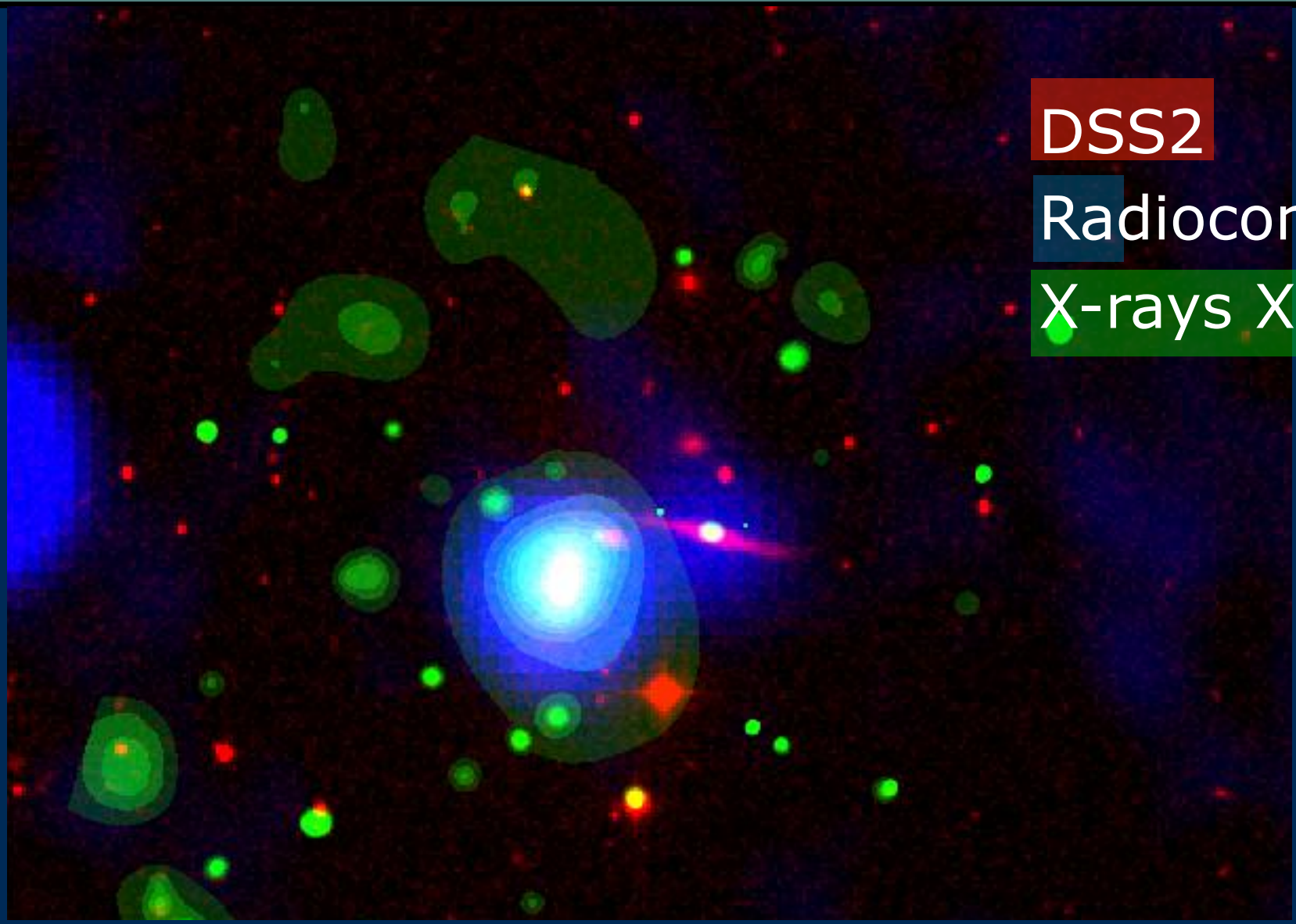
# HCG 37 Atomic gas content





# HCG 37



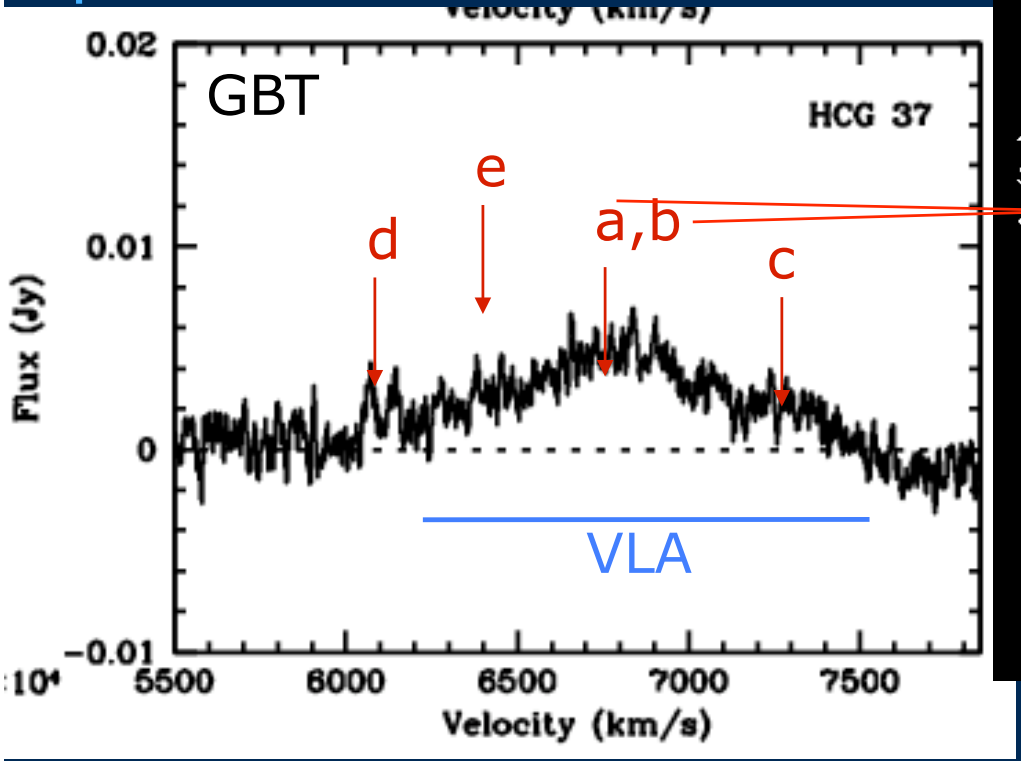
# HCG 37 Atomic gas content

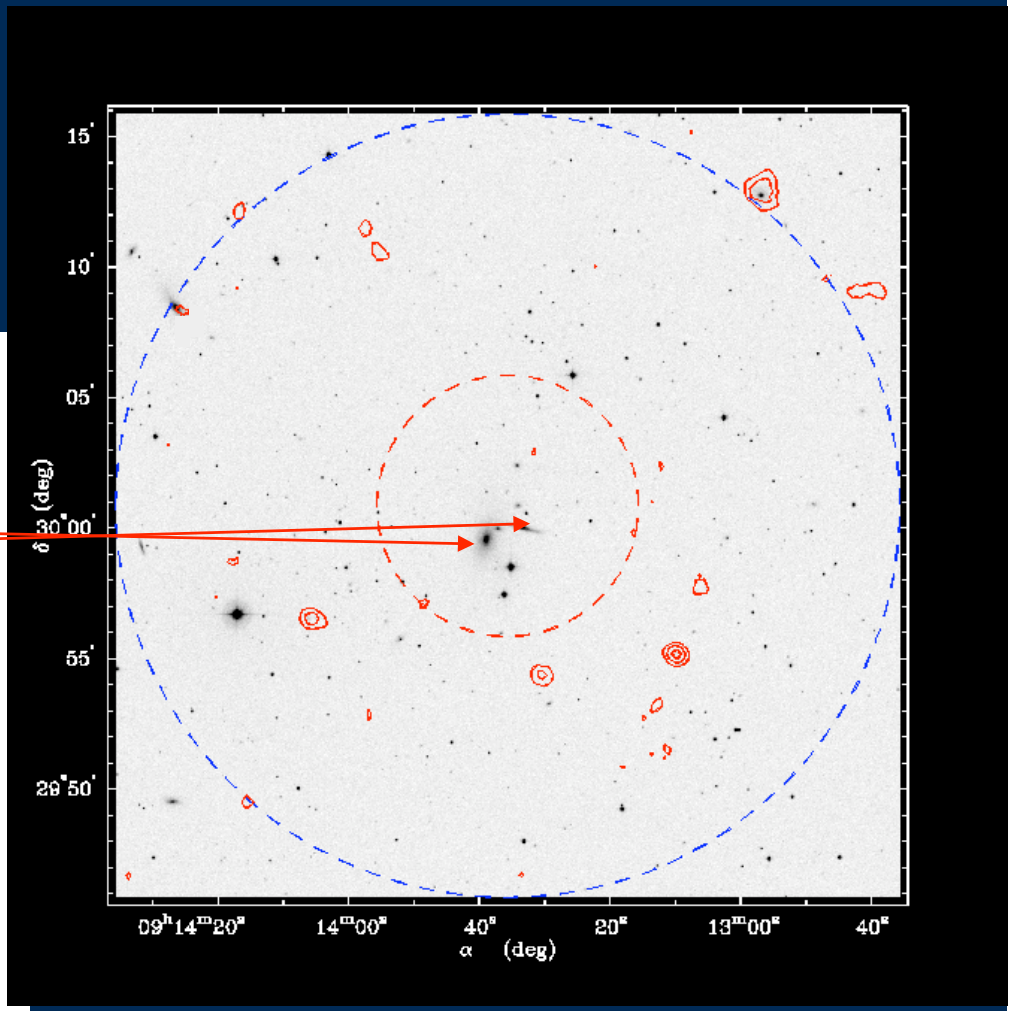
Log(MHI/Msol)

Predicted: 10.1

GBT: 9.8

Spread in v



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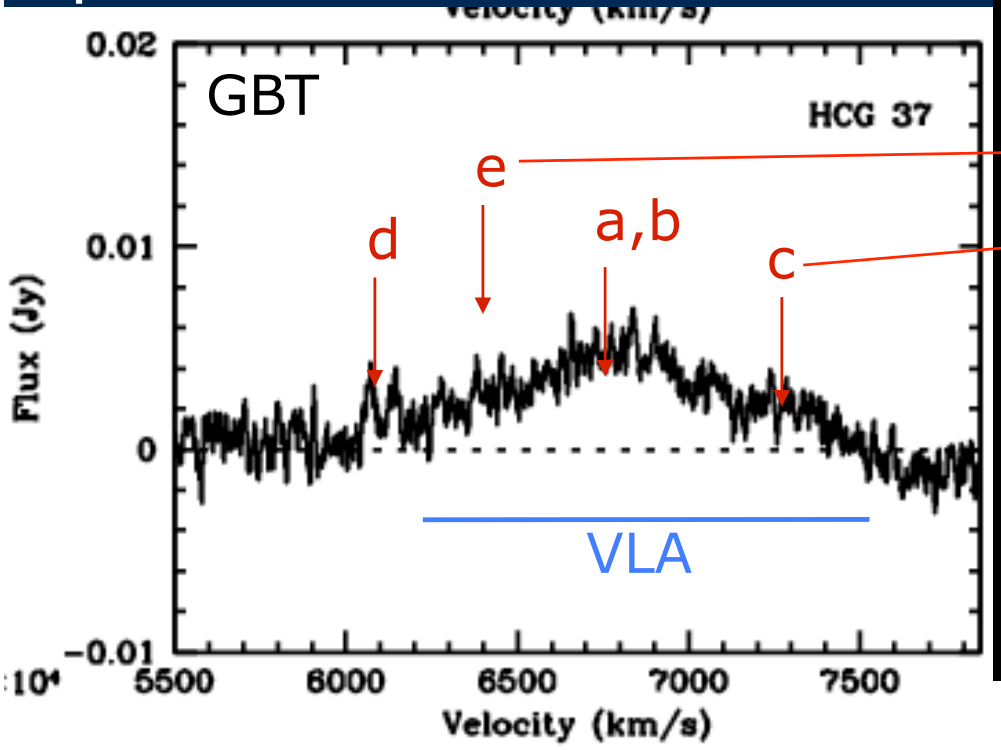


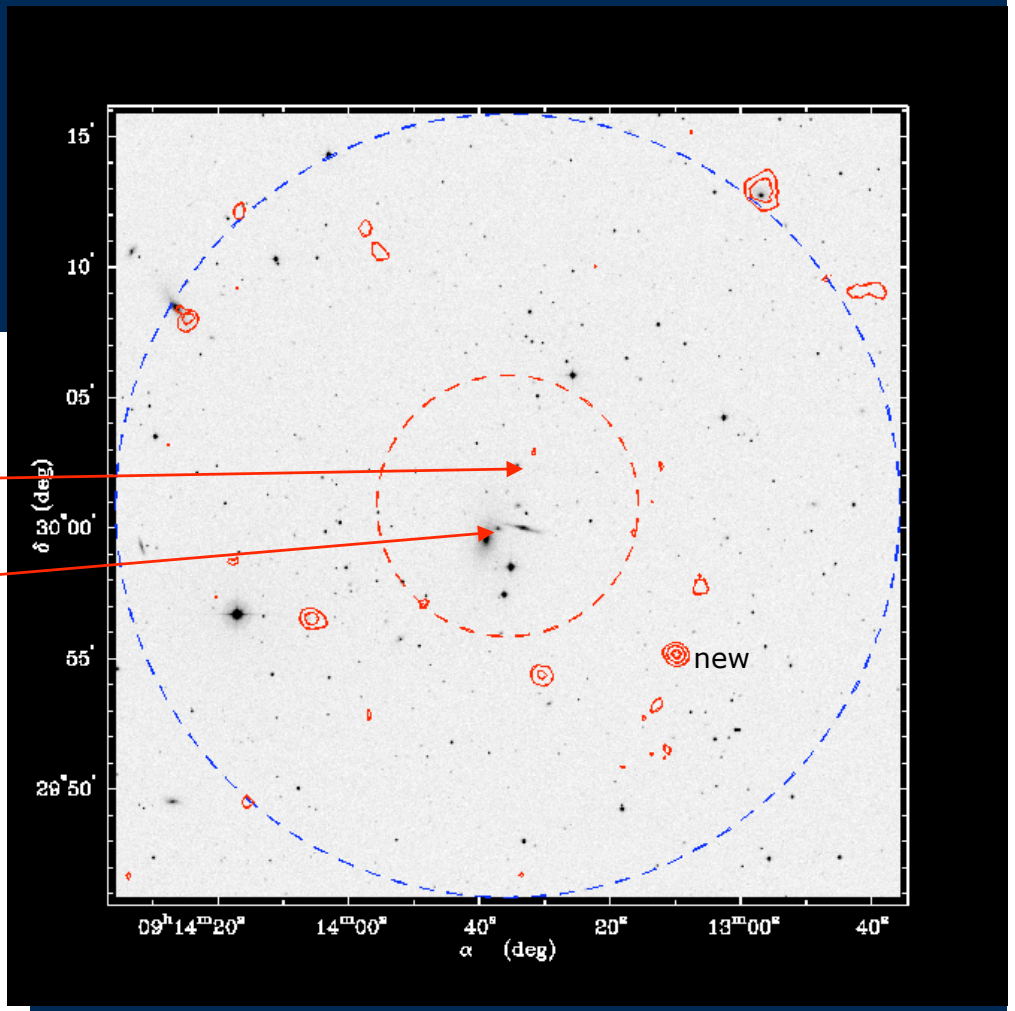




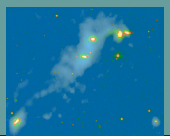

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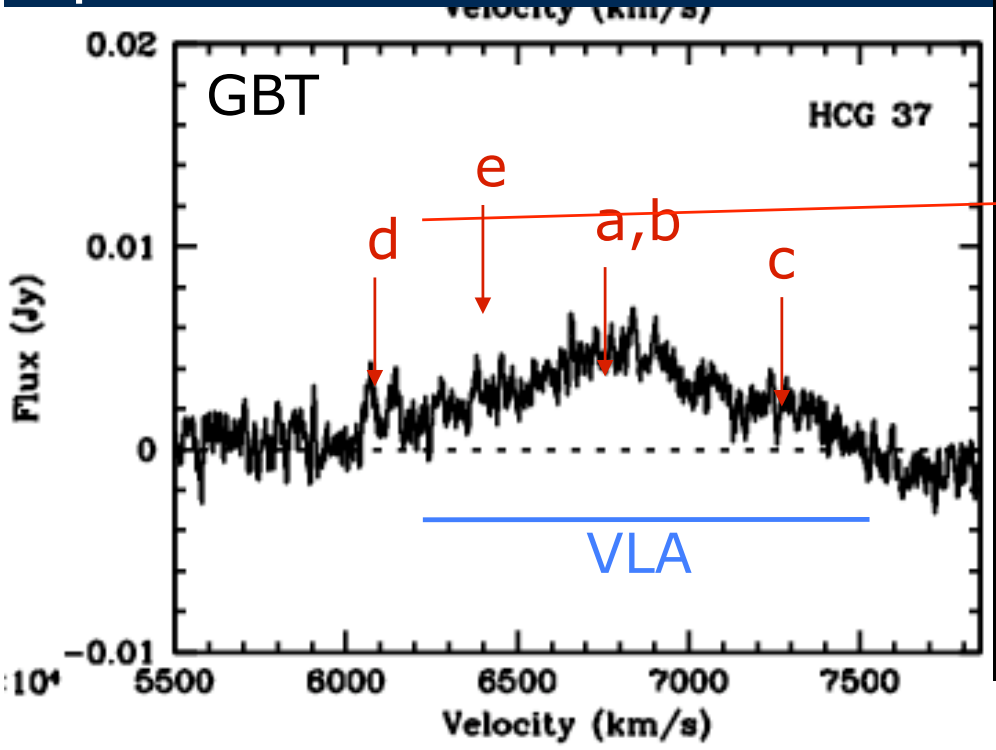
Log(MHI/Msol)

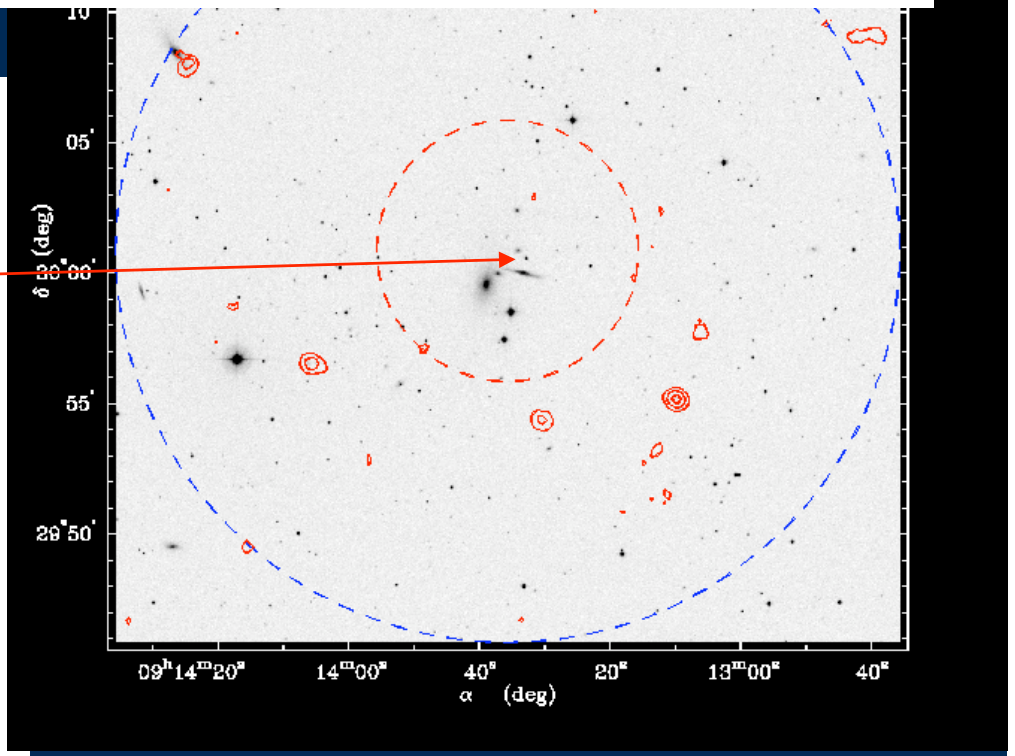
Predicted: 10.1

GBT: 9.

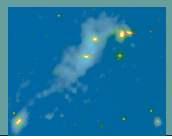
Spread in v

What about the molecular gas, FIR emission?






PUB
TIME!!!

# AMIGA PROJECT

## Analysis of the Interstellar Medium of Isolated GAlaxies

### AMIGA Compact group in Granada

Postdocs: U. Lisenfeld, S. Leon, G. Bergond, S. Verley, D. Espada

PhD's: J. Sabater, V. Martínez

Soft: J. D. Santander, J. E. Ruiz, V. Espigares

### AMIGA Close environment

L. Athanassoula, A. Bosma, F. Combes, W.Huchtmeier, S. Odewahn, T. Ponman, J. Rasmussen, J. Sulentic, M. S. Yun **(accreting companions)**

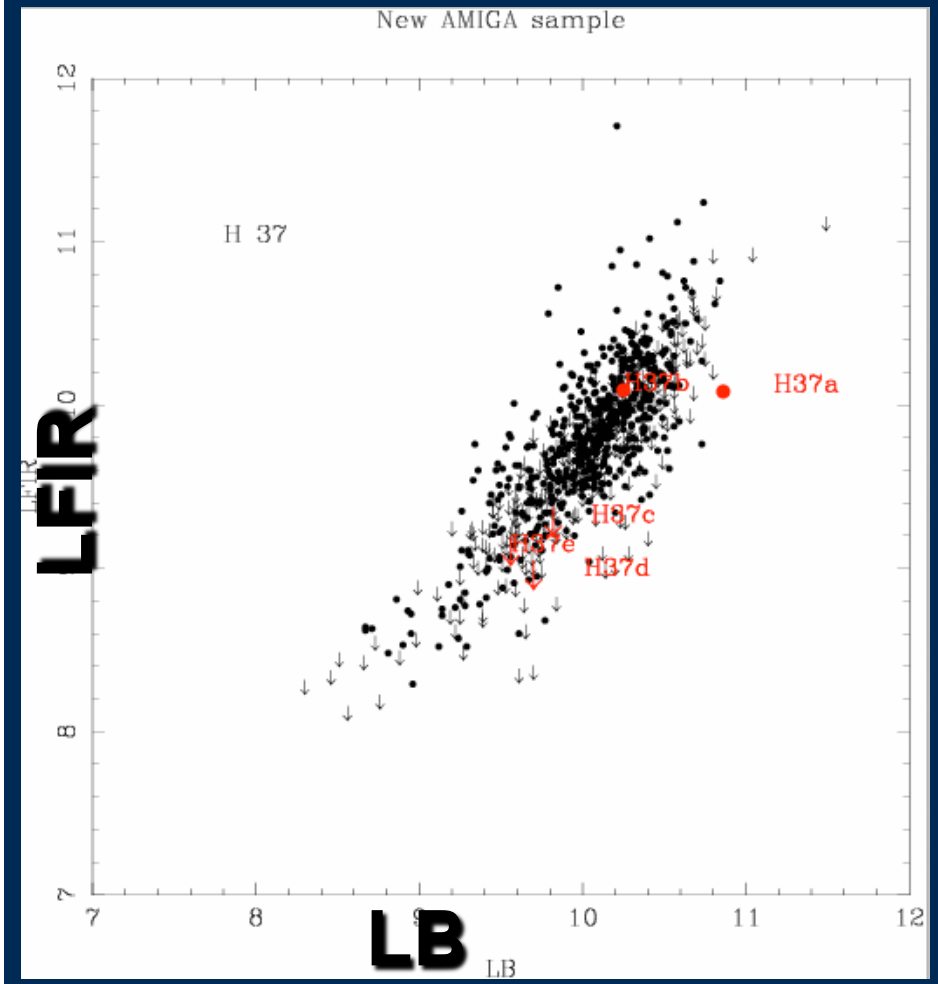
# AMIGA

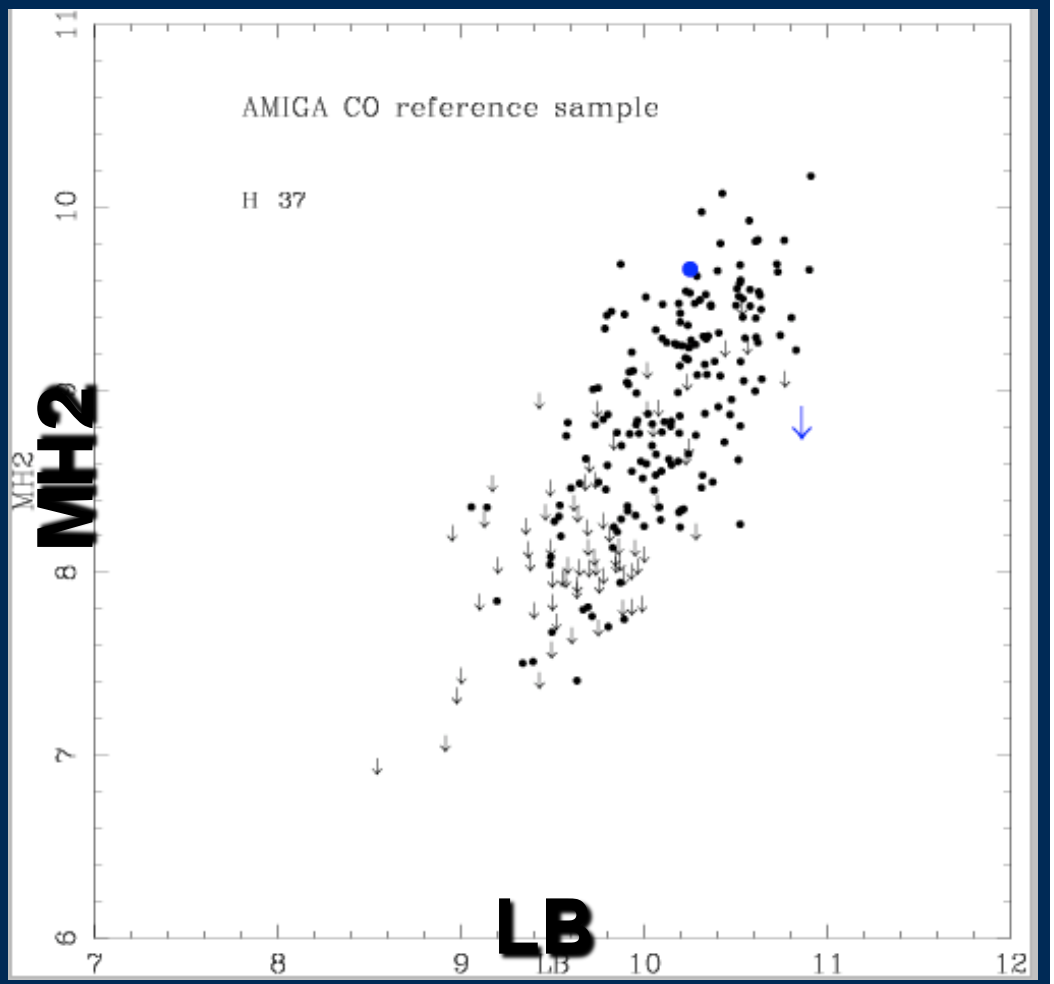
- Provides a catalogue of isolated galaxies with multiλ information (~ 1000 galaxies) www.iaa.es/AMIGA.html
  - Optical (B)
  - Atomic gas.
  - Radiocontinuum & FIR emission.
  - CO & Halpha emission.
- Study of the interplay ISM - SF - nuclear activity
- Performed refinements

  Isolation, morphologies, positions, v and distances, optical characterization (completeness, OLF)

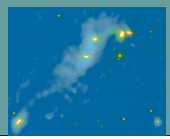

AMIGA
http://amiga.iaa.es

# HCG 37: CO and FIR



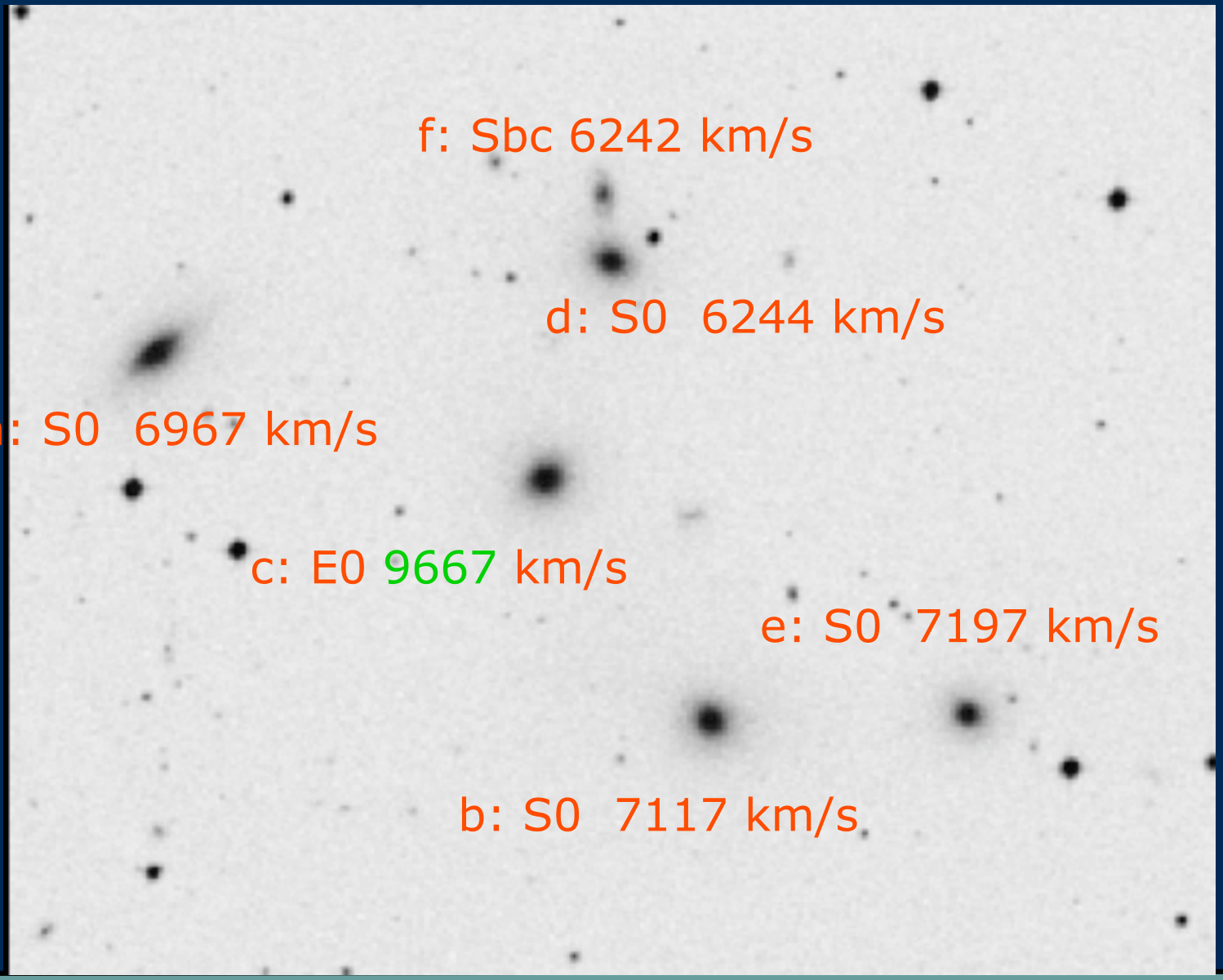





# HCG 15

**dv = 426 km/s**



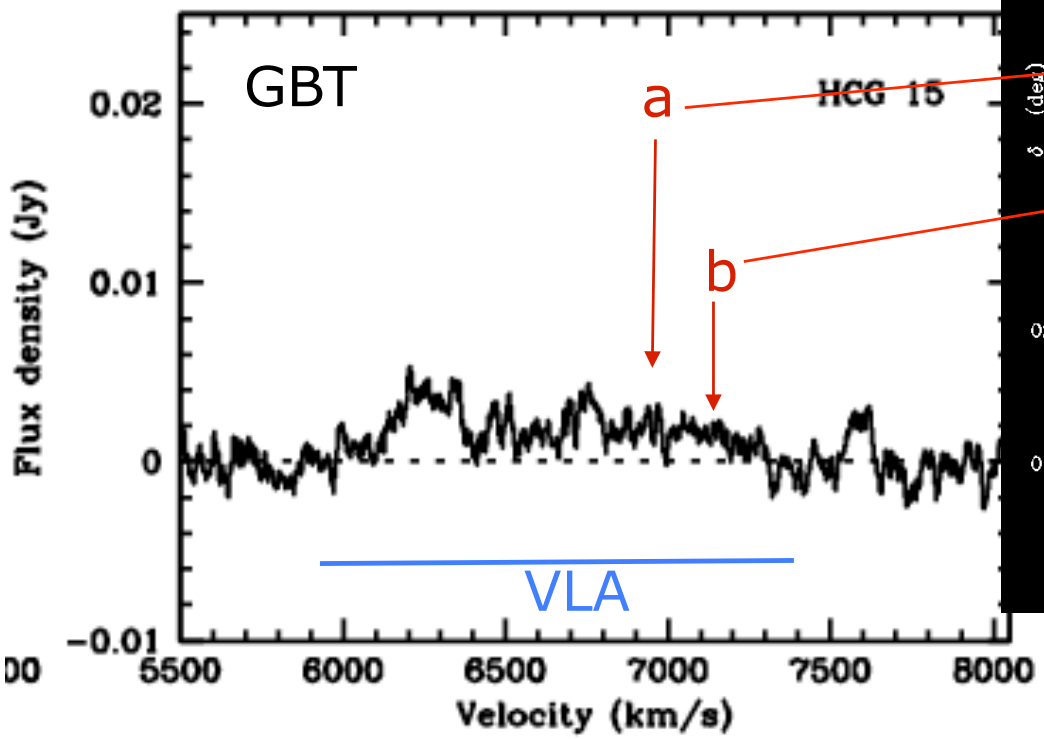
# HCG 15 Atomic gas content

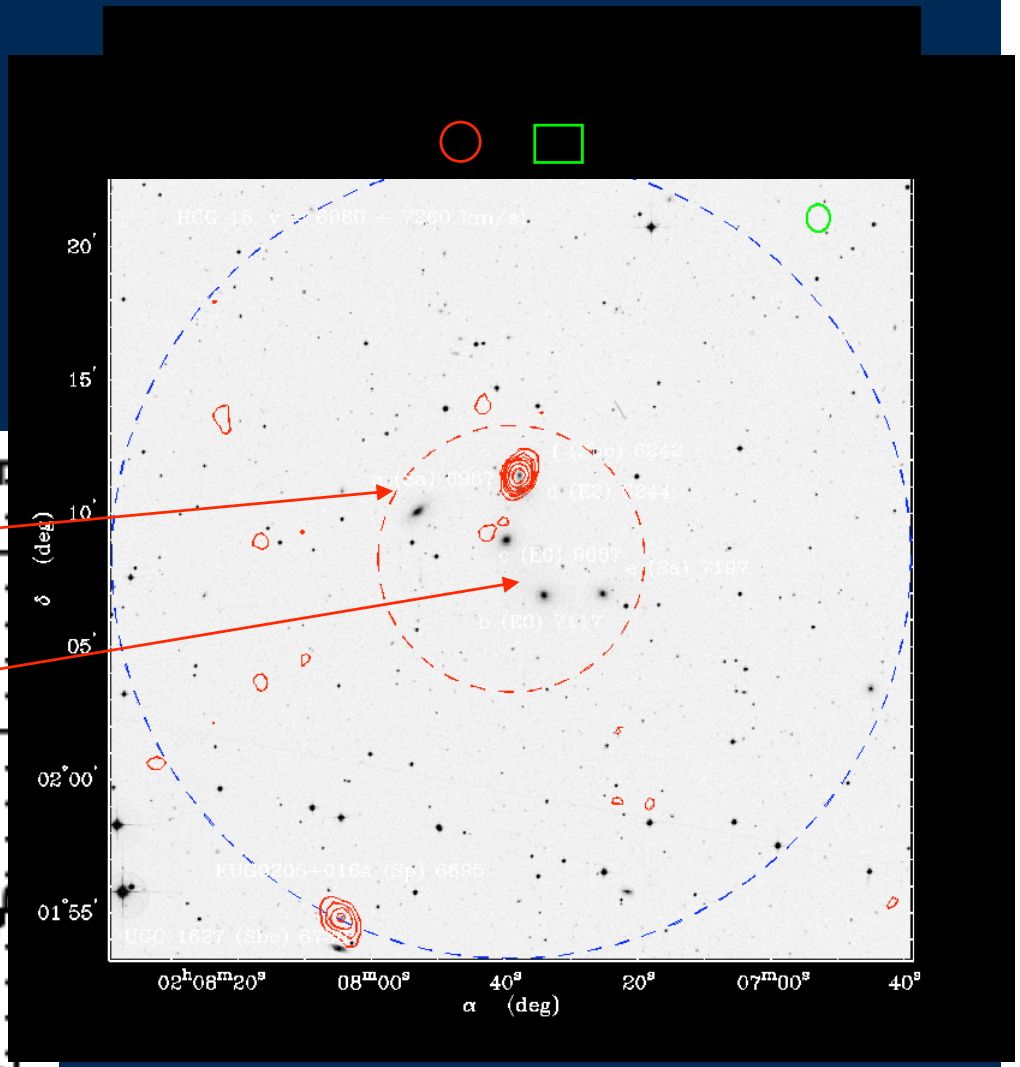
Log(MHI/Msol)

Predicted: 10.0

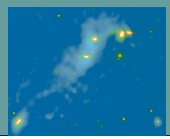
GBT: 9.6

Spread in v





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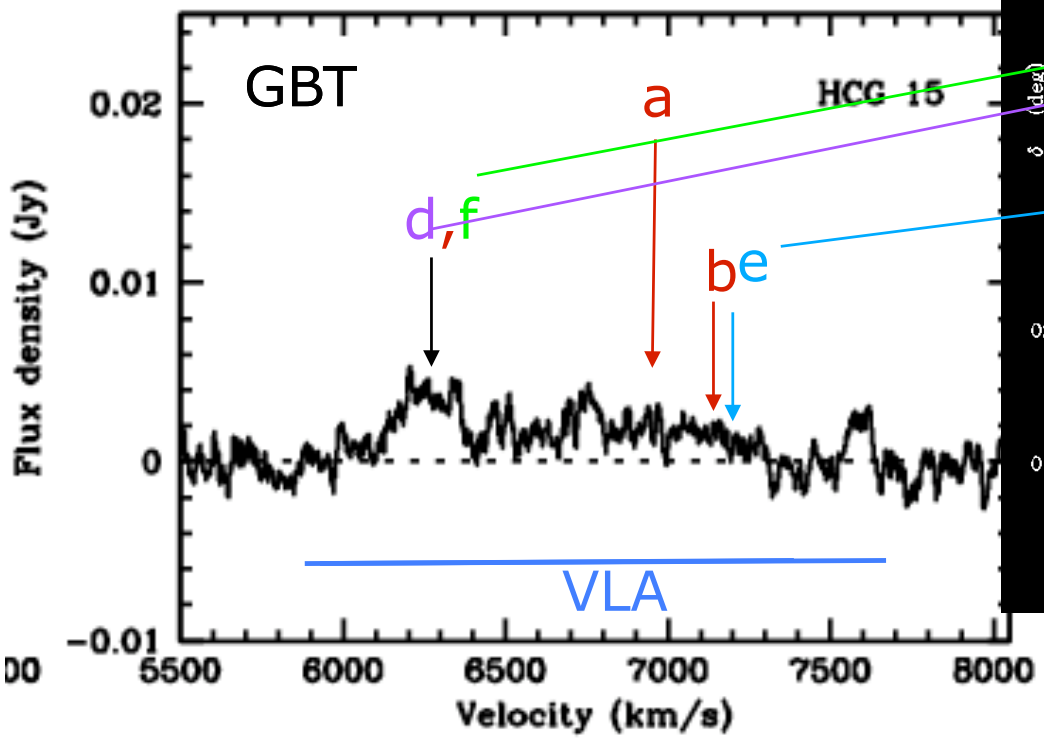
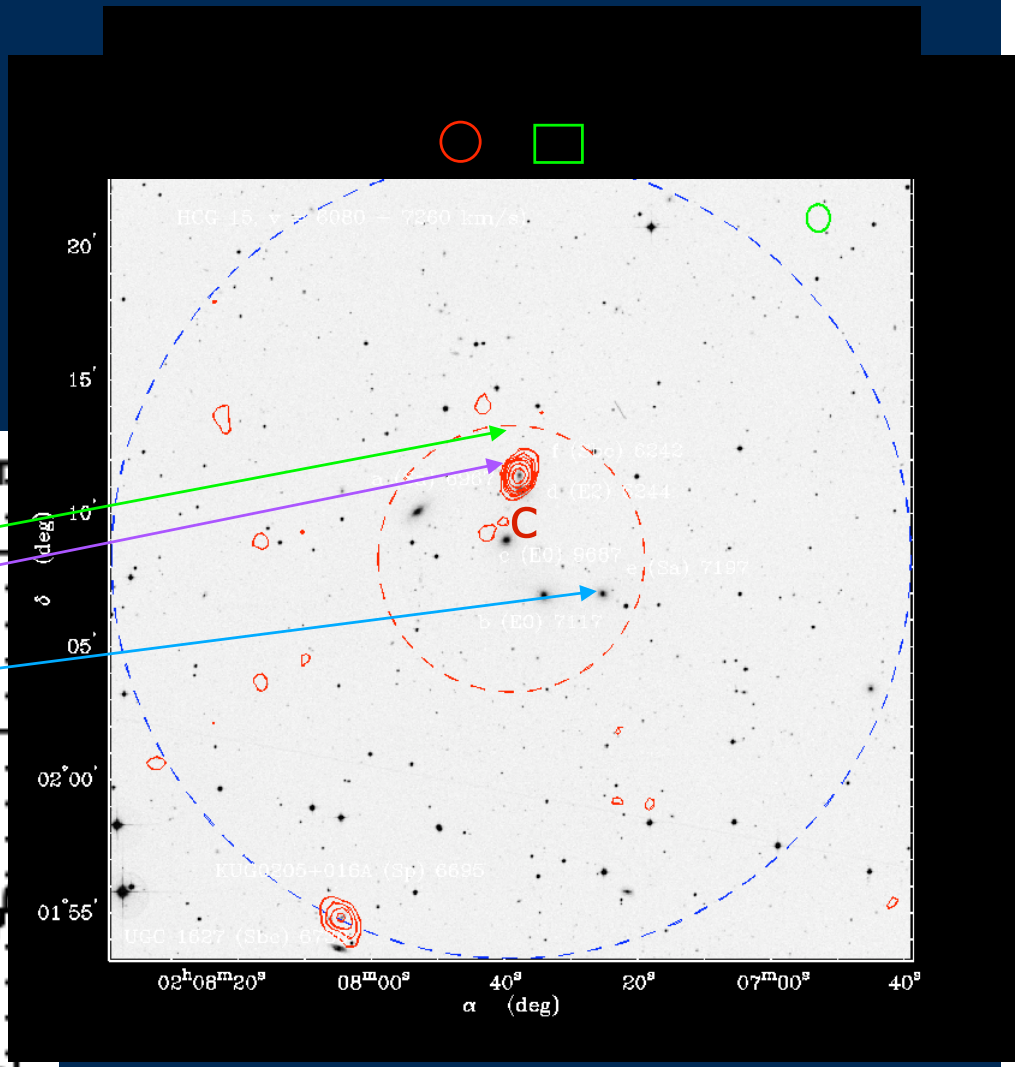
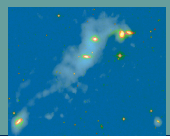
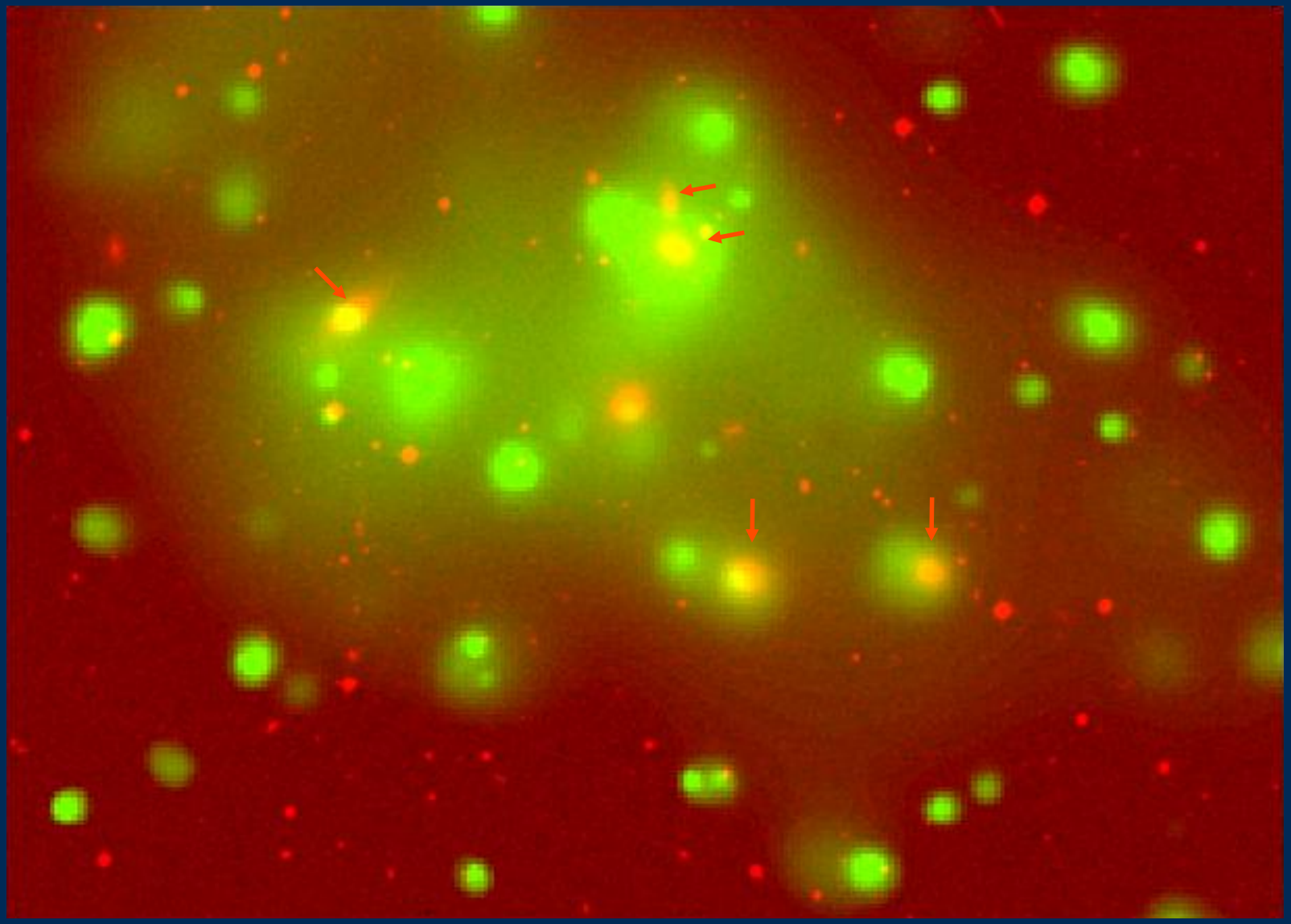




# HCG 15 Hot and cold dv = 426 km/s



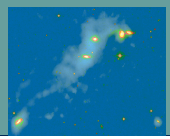
DSS2

X-rays

XMM

Hot IGM





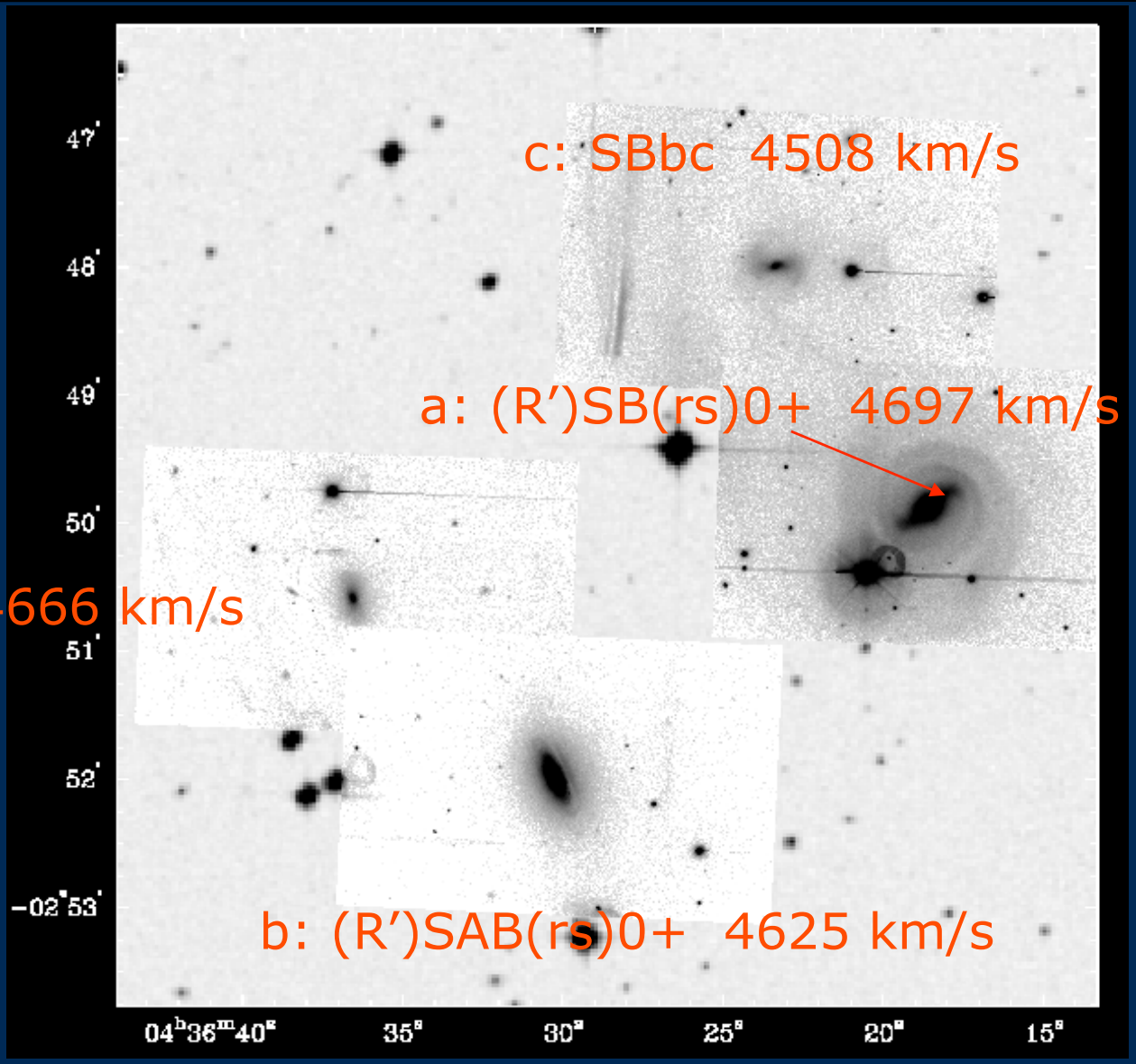
# HCG 30

## dv = 72 km/s

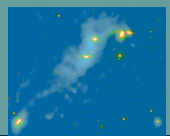
H30a:

Large HI bulge, faint spirals:

old interaction?





# HCG 30

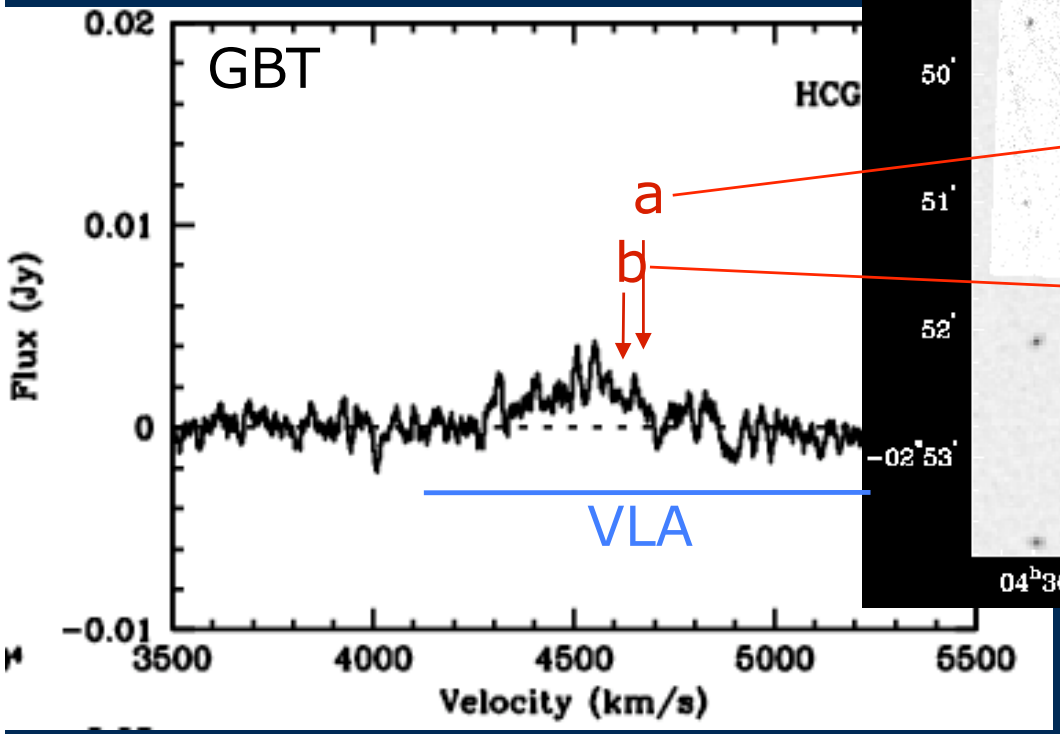
# Atomic gas content

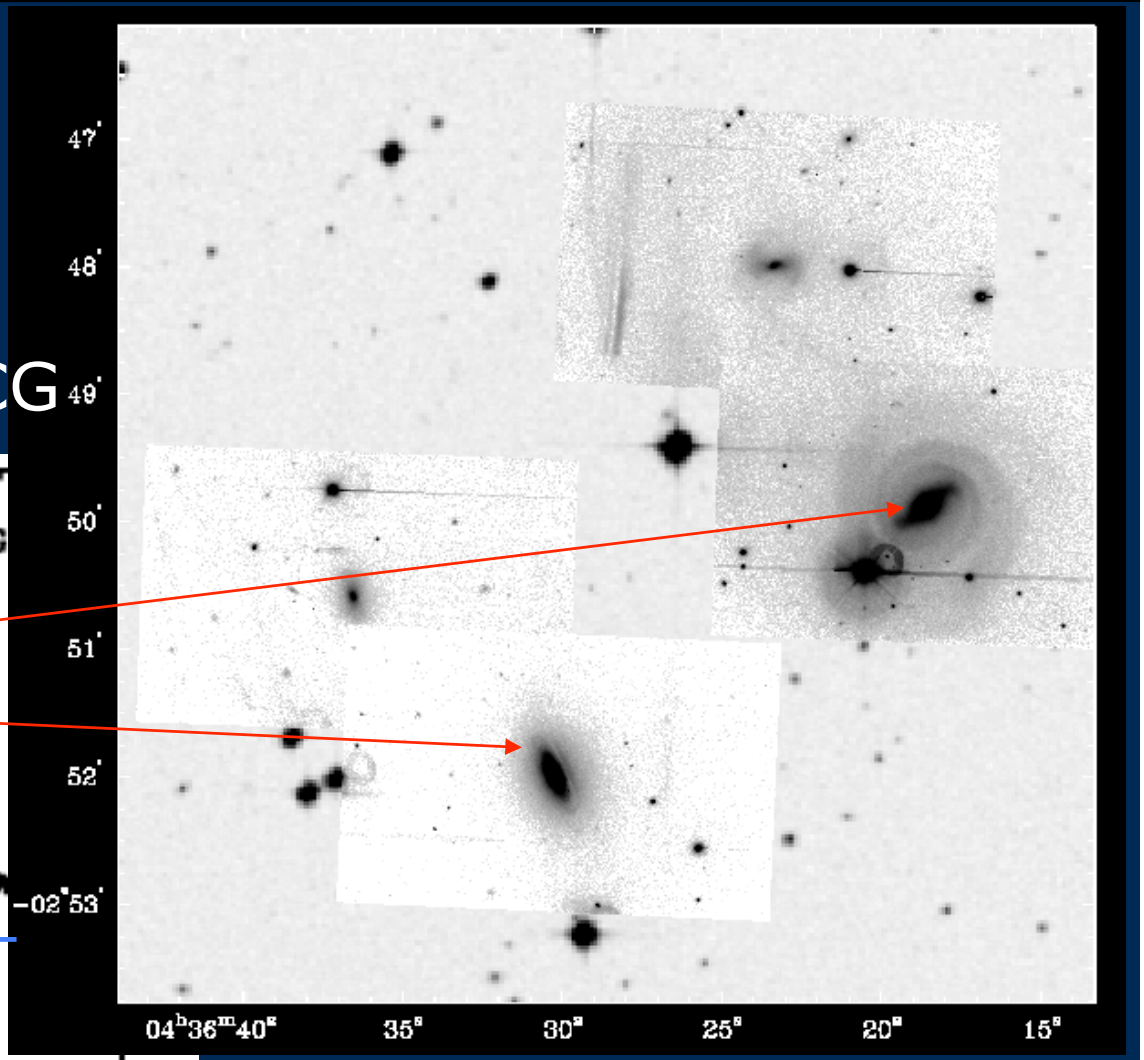
Log(MHI/Msol)

Predicted: 10.2

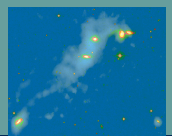
GBT: 8.8: Spread in v

The most HI deficient HCG





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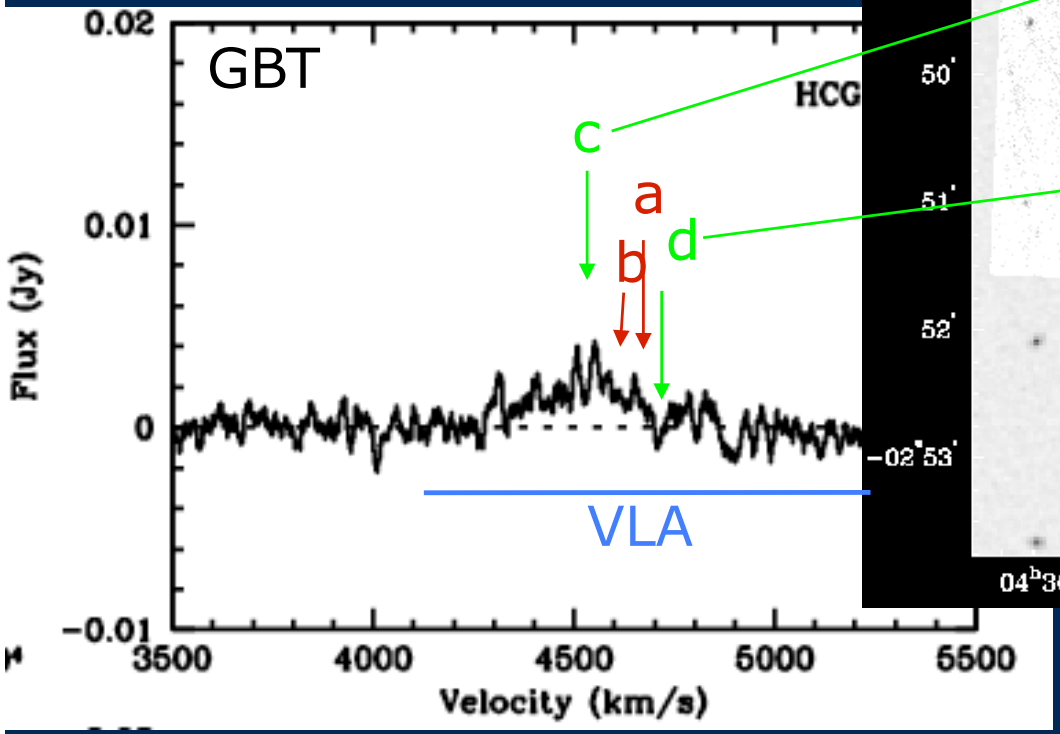
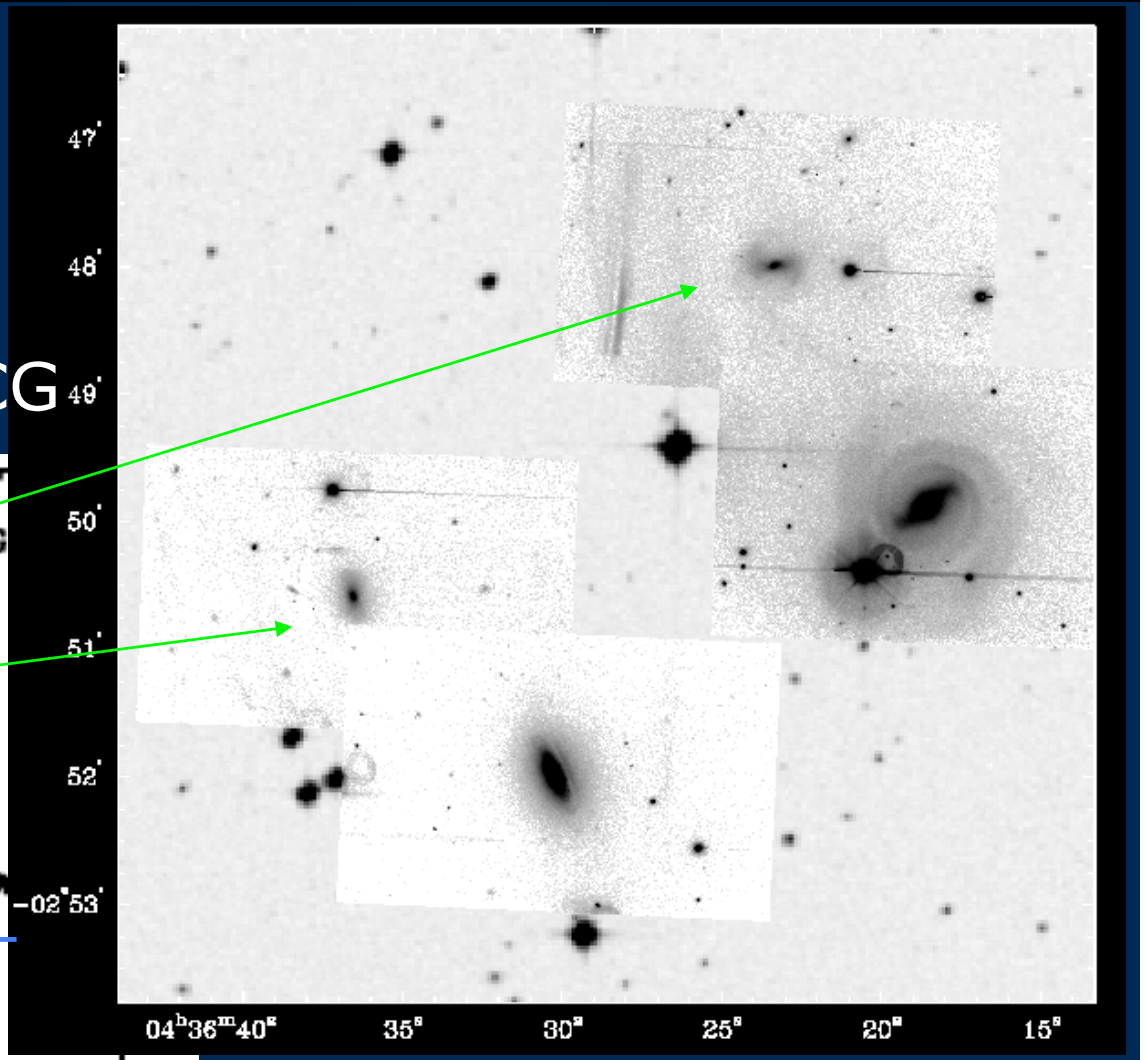
Log(MHI/Msol)

Predicted: 10.2

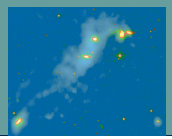
GBT: 8.8: Spread in v

The most HI deficient HCG



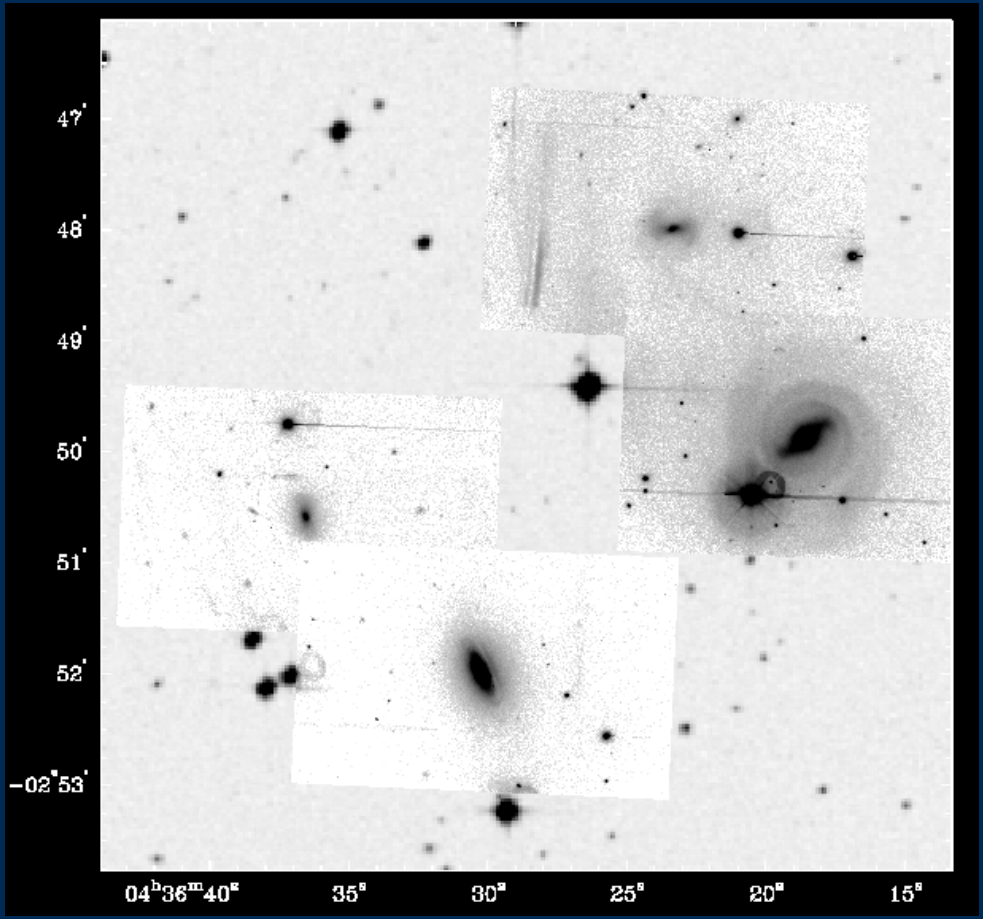





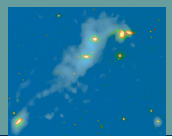
# HCG 30: HI

# Halfa

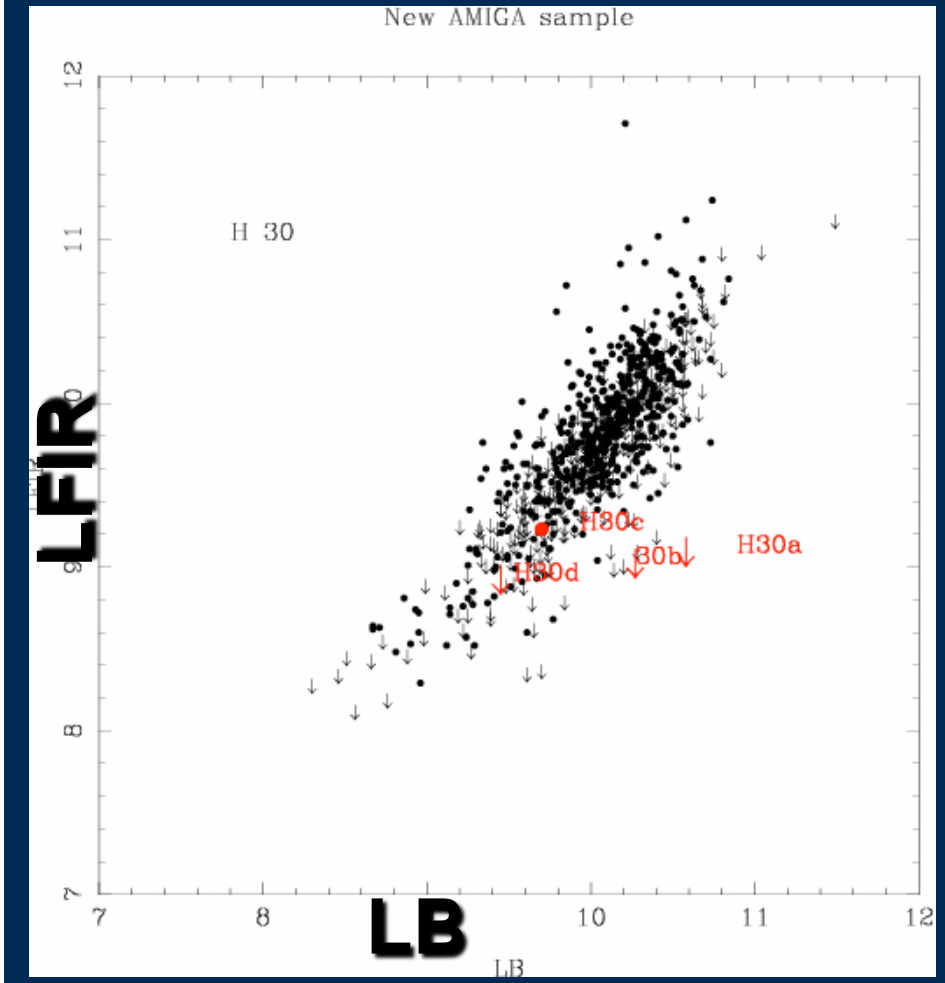


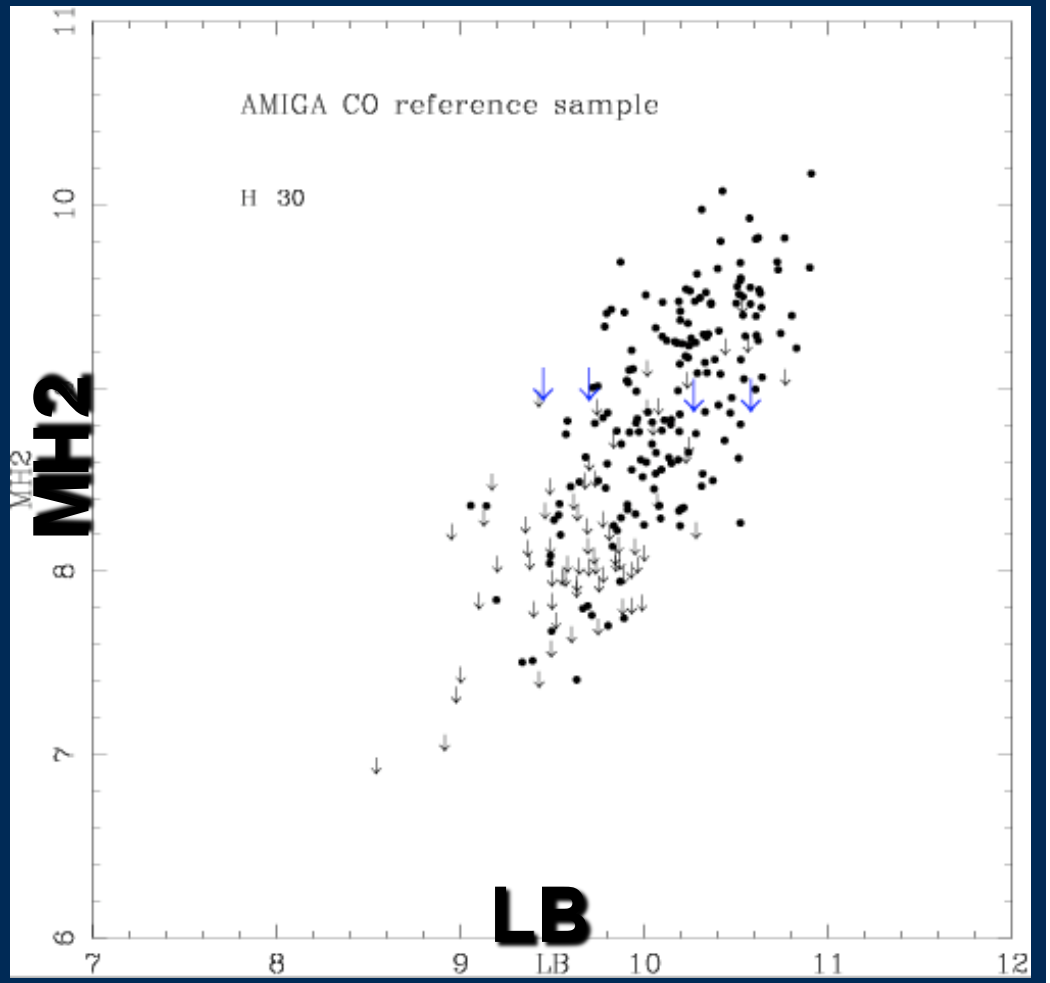






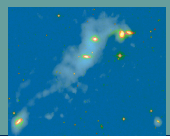
# HCG 30: MH2,LFIR



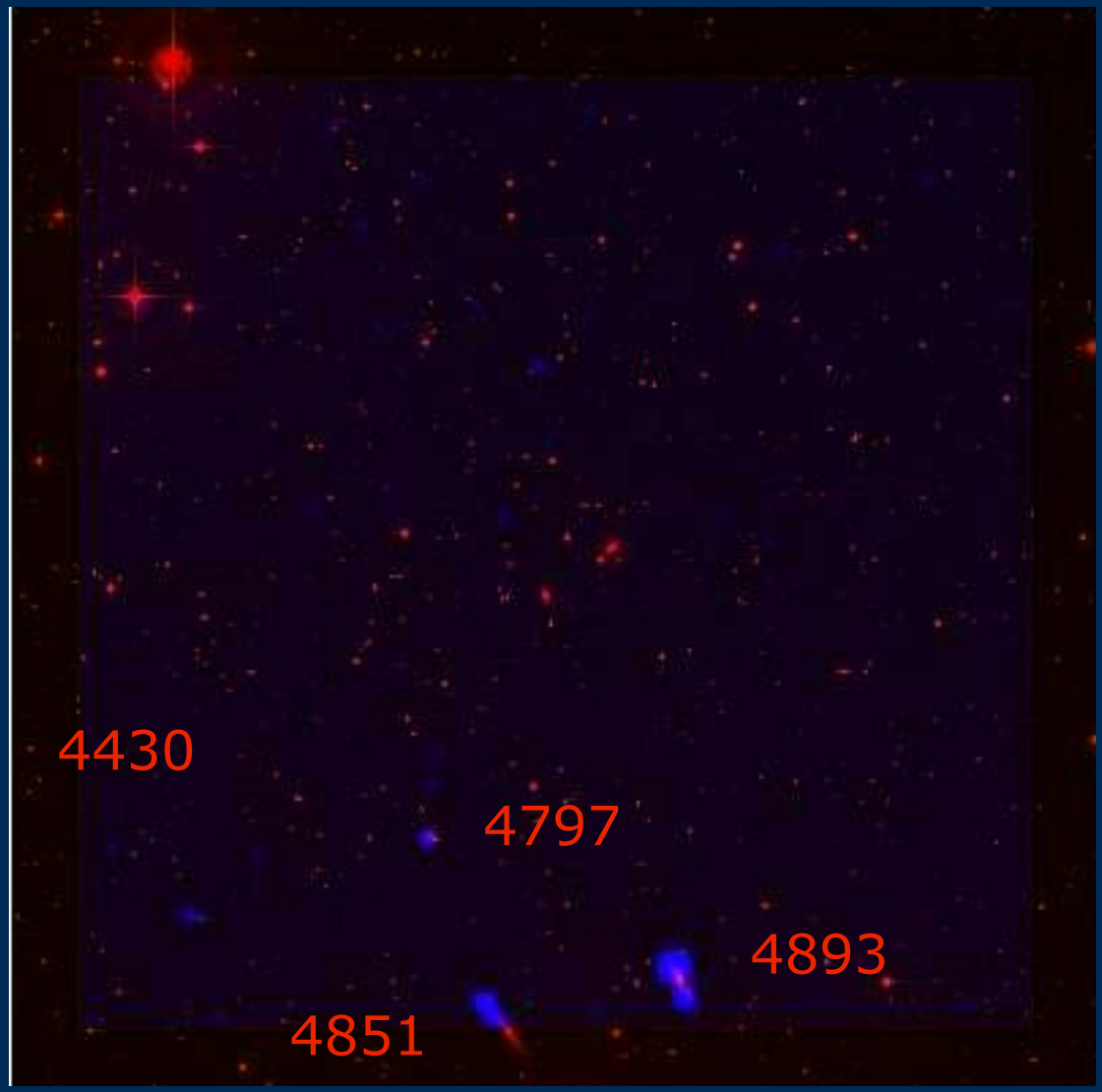




No hot IGM, possible post SB system?





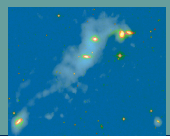
# HCG 30: HI, OPTICAL



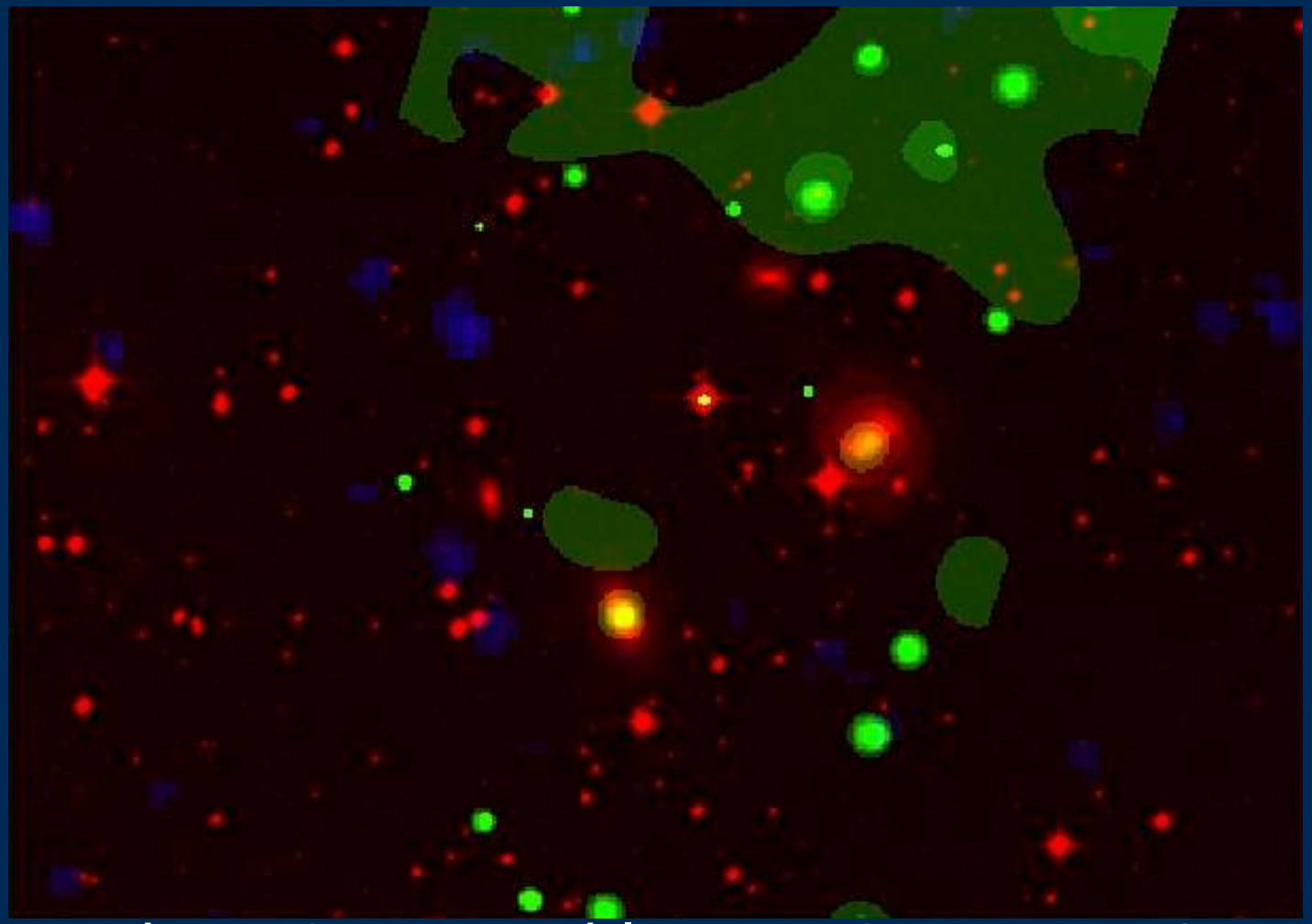

DSS2

HI





# HCG 30: optical



DSS2

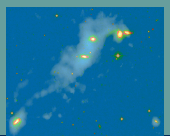
HI

X-rays XMM

CHandra

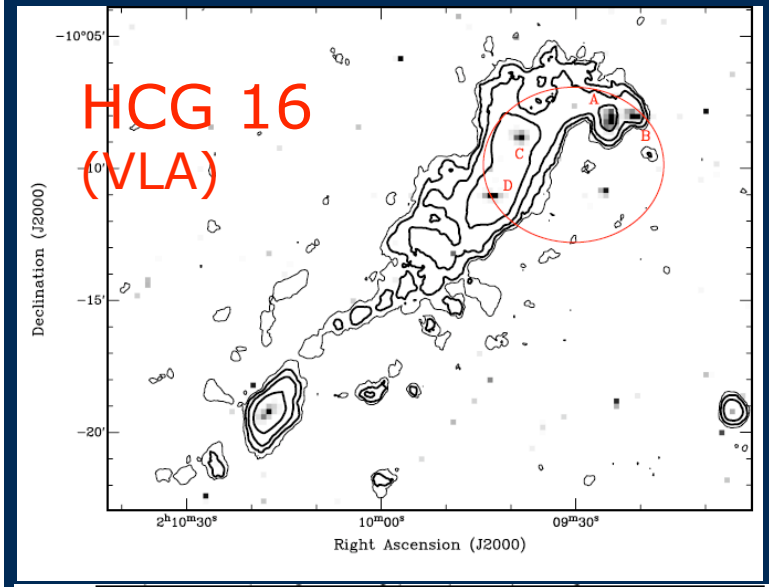
No hot IGM, possible post SB system?

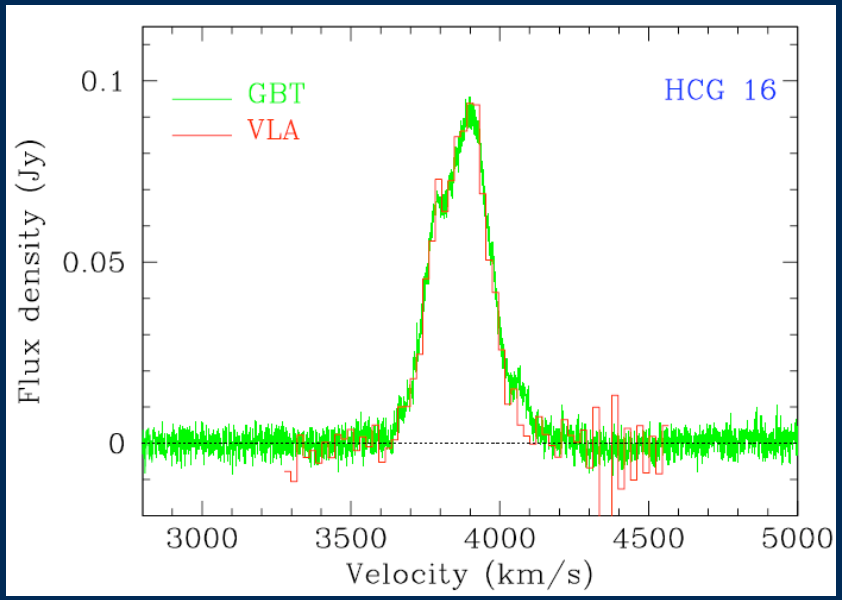


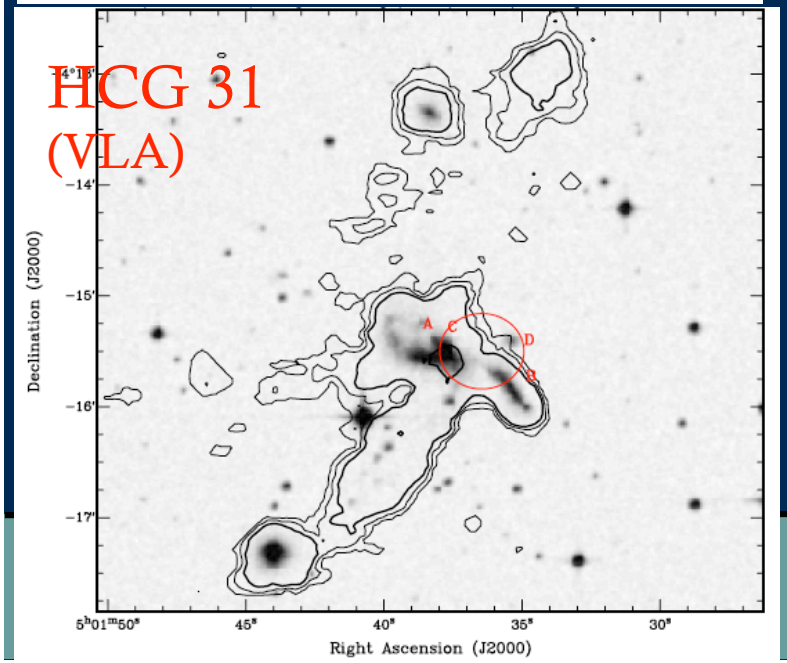


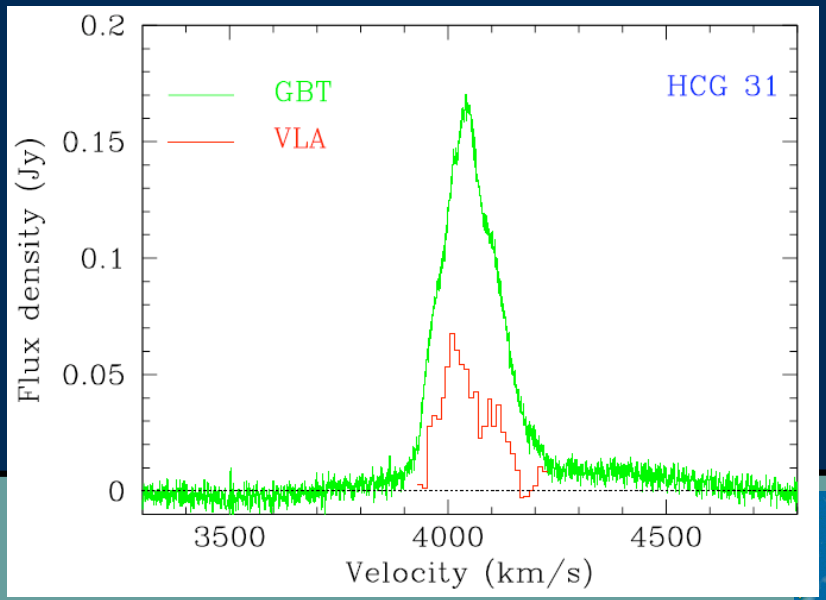
# SLIGHTLY DEFICIENT

## DO THEY ALSO SHOW EXTENDED EMISSION?



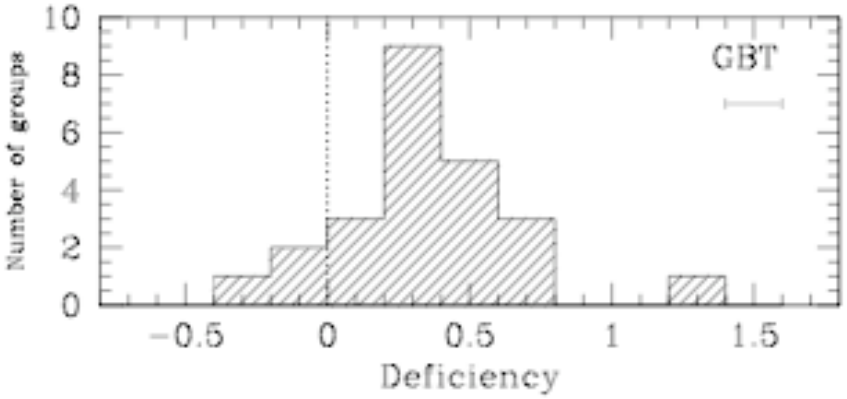



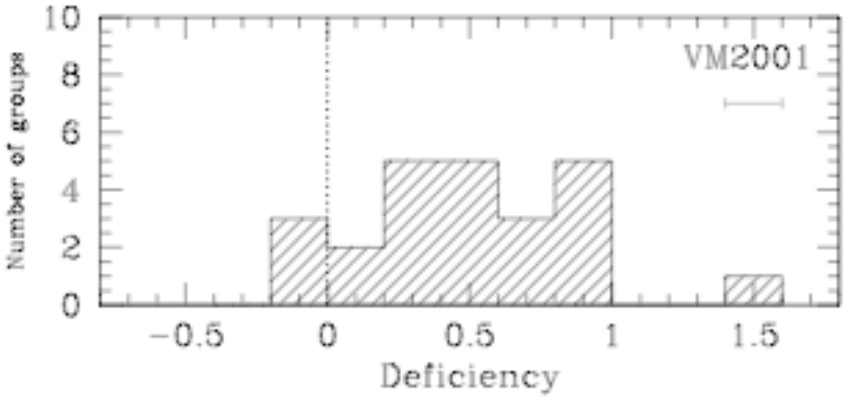



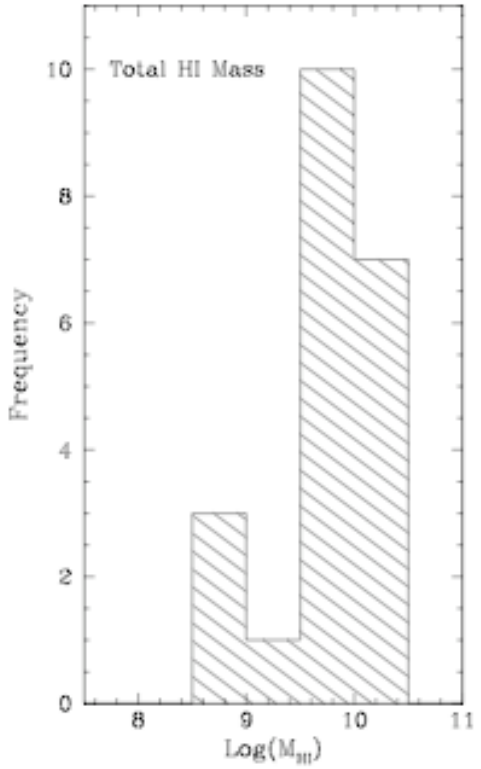



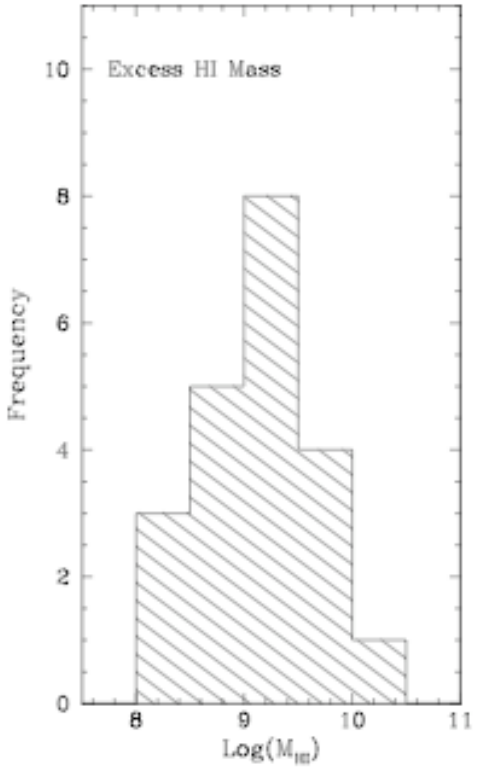
# Evaluating HI deficiencies with new GBT data

Reduction in HI deficiency primarily for HI def. groups: from 66% to 0.46%



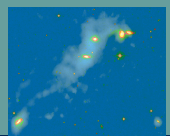




HI (GBT)

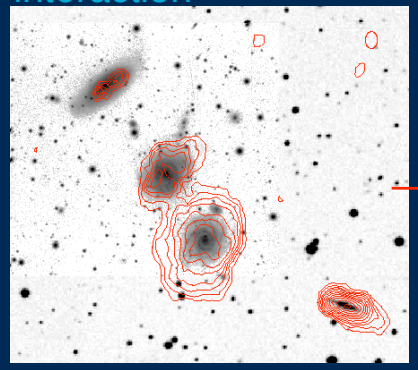
HI (GBT-VLA)



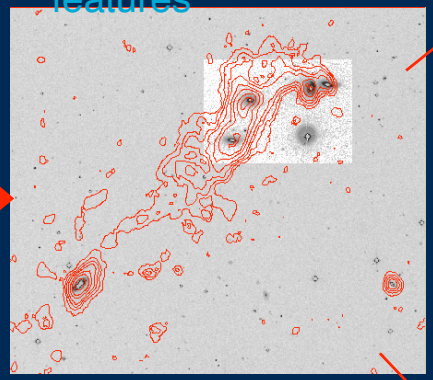
# Evaluating HI deficiencies with new GBT data

## Evolutionary model proposed

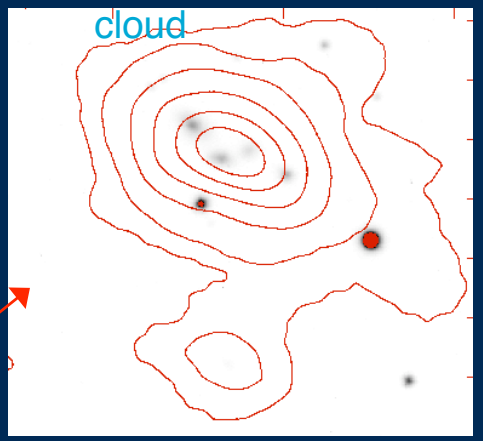
Phase 1: Low level of interaction



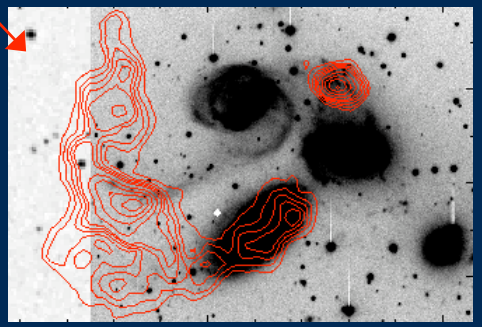
Phase 2: Gas in tidal features



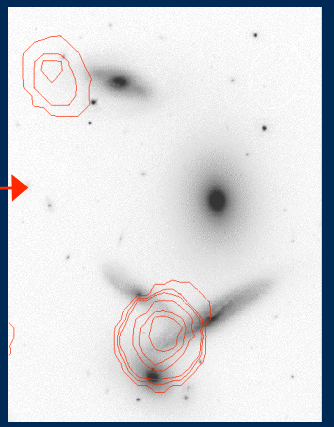
Phase 3b: Gas in a cloud



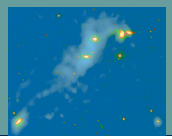
Phase 3a. No HI in the galaxies



¿?







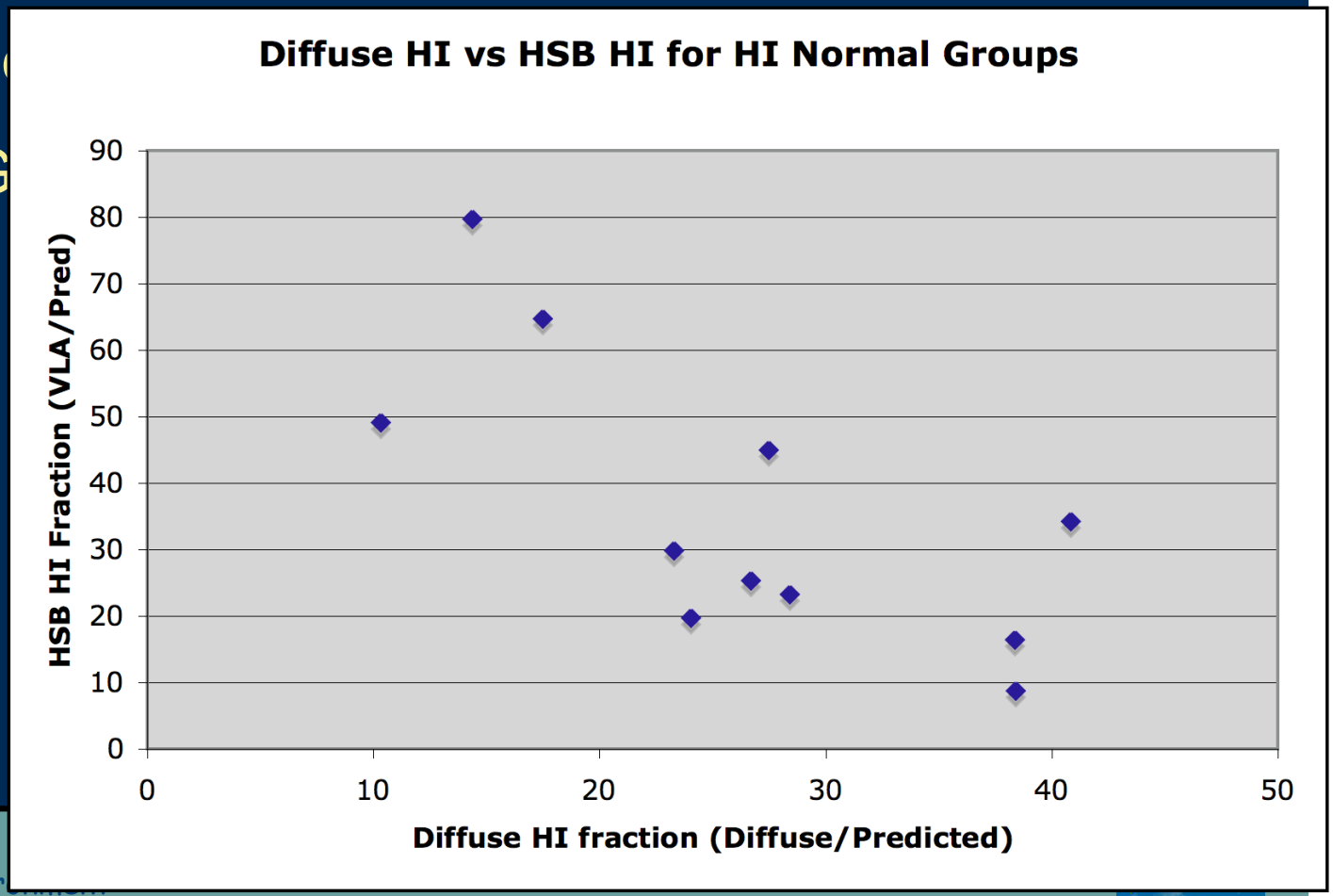
# Evaluating HI deficiencies with new GBT data

| Phase 1 | | Phase 2 | | Phase 3 | |
|---|---|---|---|---|---|
| Source | % detection $M_{excess}/M_{VLA}$ | Source | % detection $M_{excess}/M_{VLA}$ | Source | % detection $M_{excess}/M_{VLA}$ |
| HCG 67 | 17 % | HCG 16 | 5 % | HCG 93 | 9 % |
| HCG 7 | 19 % | HCG 58 | 15 % | HCG 30 | 30 % |
| HCG 88 | 26 % | HCG 25 | 18 % | HCG 90 | 78 % |
| HCG 79 | 27 % | HCG 10 | 21 % | HCG 92 | 105 % |
| HCG 23[b] | 43 % | HCG 91 | 61 % | HCG 68 | 119 % |
| | | HCG 100 | 122 % | HCG 97 | 122 % |
| | | HCG 31 | 233 % | HCG 15 | 125 % |
| | | | | HCG 44 | 151 % |
| | | | | HCG 37 | 859 % |
| Average | 26 % | Average | 68 % | Average | 178 % |

Origin : Tidally stripped HI from the ISM of the member galaxies

# CONCLUSIONS/SUMMARY

- Low surface brightness extended cold gas in groups
- Larger ratio of diffuse gas in HI deficient groups, consistent with evolutionary picture
- Still HI deficien
  recovered by G

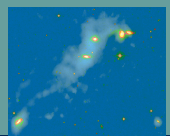


# CONCLUSIONS/SUMMARY

- The 3 groups with diffuse Xrays show high $\Delta v$ (~400 km/s) and are not the most HI deficient !
- Absence of significant hot IGM in most of these systems: RAM pressures stripping is not the main mechanism producing HI deficiency.
- Star formation: could it have exhausted HI as proposed?
- Little signs of current SB activity or tidal stripping in the most deficient, + diffusse HI emission suggest THE OTHER WAY ROUND:

HI stripping into a diffuse medium inhibited SF





# LAST MINUTE (NIGHT) RESULTS:

More deficient groups redder B-I colours: inhibiting SF

Size of galaxies decrease from more isolated, to less isolated to groups