HI as a probe for dwarf galaxy evolution in different environments: Voids to clusters

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Plan of the talk

- Introduction
- Dwarf galaxies in voids
  - Motivation
  - Sample
  - Results
- Dwarf galaxies in high density environments
  - Environmental processes
  - Preliminary results from Virgo
- Summary

Introduction

- Cosmic web consists of voids, filaments and clusters.
- Environment plays a role in galaxy formation & evolution;
  e.g. Density-morphology relation. (Dressler 1980)
- Smaller galaxies are more sensitive to environment.
- HI is fragile, ideal tracer of various environmental processes.
- High resolution HI observations reveal interactions & gas accretion.

HI to probe different environments

- Our sample consists of low mass galaxies from
  - Virgo cluster
  - Ursa Major super-group
  - Field galaxies (from FIGGS Survey)
  - Void galaxies

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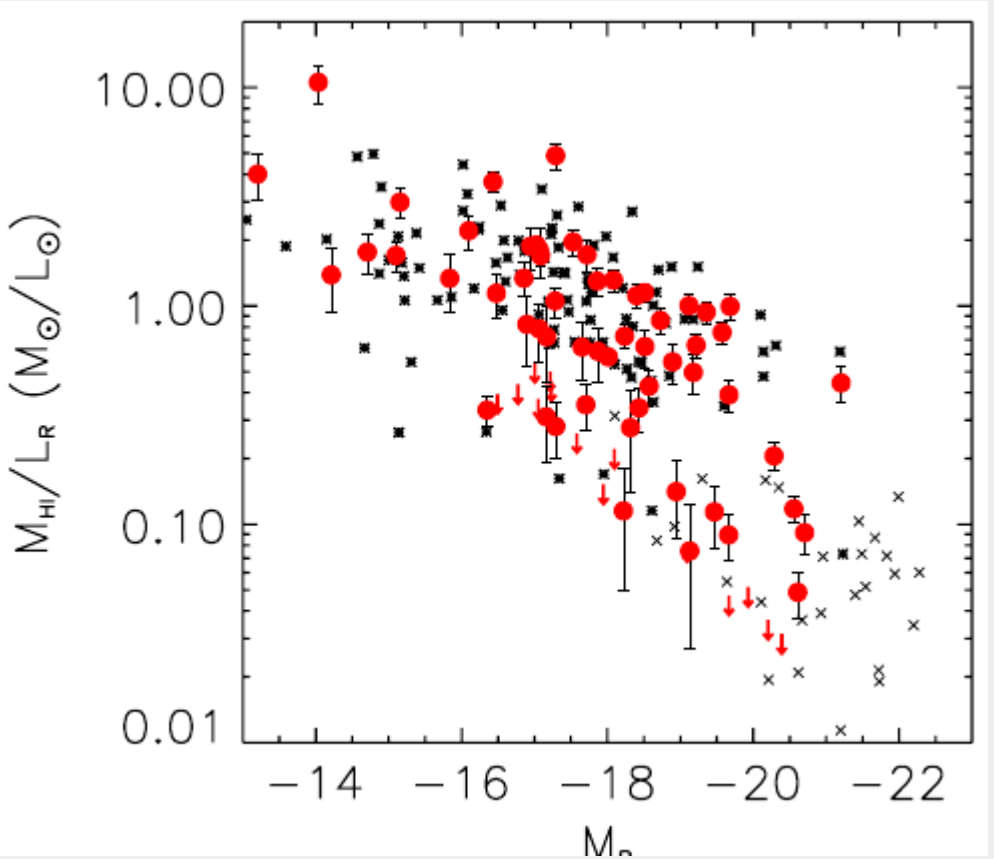
Void galaxies

- Galaxies can be studied at earlier stage of their evolution.
- Gas-rich, low luminosity and blue disks (Rojas et al. 2004, 2005)
- This can be due to morphology-density relation. (Park et al. 2007)
- Brighter galaxies (M_R<-18) in voids have usual optical, HI properties.



Kreckel et al. 2012

Why faint galaxies in voids ?

- Simulations predict
  - Fainter dwarfs (M_r>-16) are significantly bluer.

    (Moorman et al.2016; Kreckel et al. 2011)
  - Trend for low-mass void galaxies to be less evolved

    (Hoeft & Gottloeber 2010; Kreckel, Young, Cen, 2012)
- Dwarf galaxies tend to dominate towards the void center

  (Hayle et al. 2012)

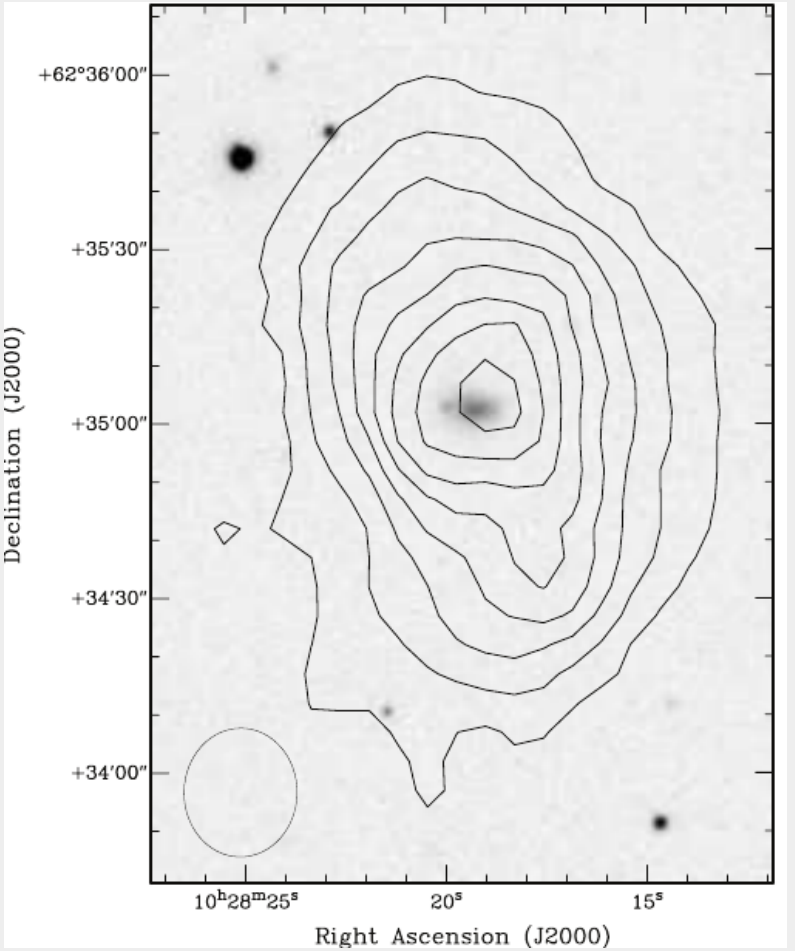
Why voids?

- Different evolutionary histories of void dwarfs may lead to different dark matter distribution.

  (Governato et al. 2012)

- Voids are ideal targets to search for cold accretion. (Keres et al. 2005)

Stanionik et al. 2009

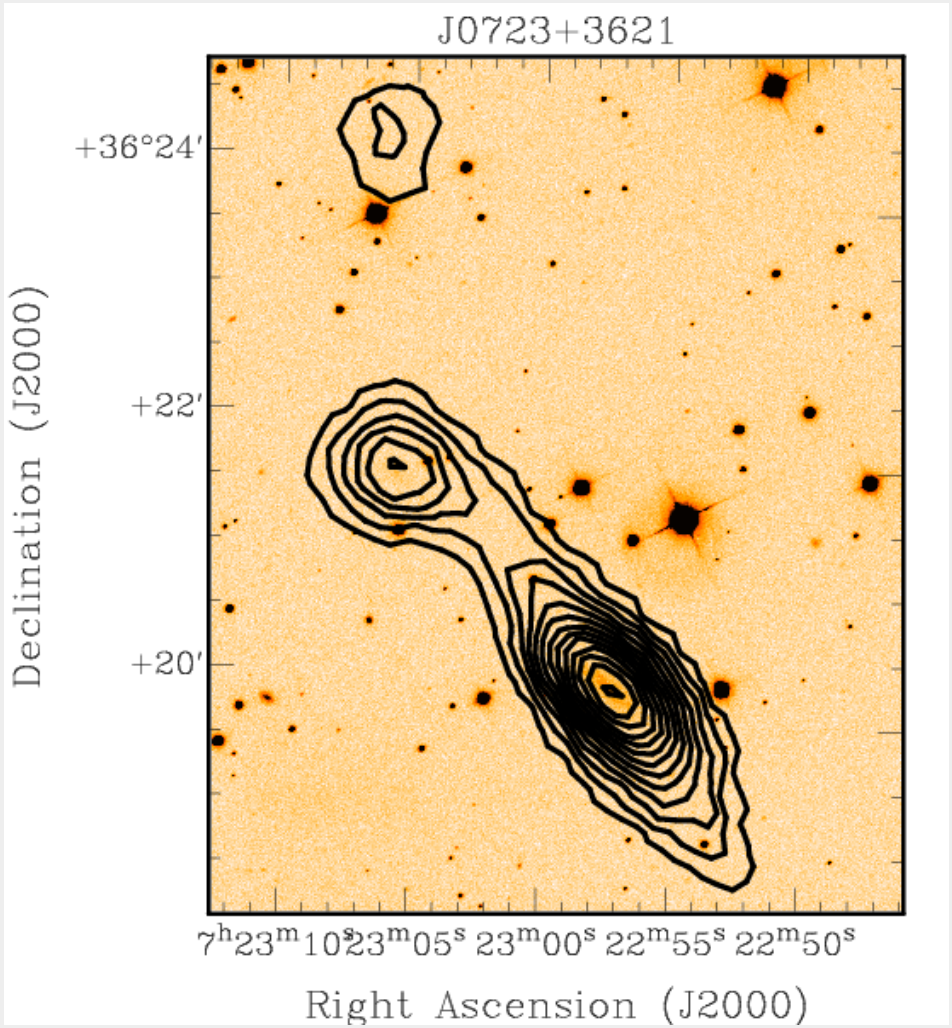


HI polar disk without stellar companion; possible evidence for cold gas accretion (Stanionik et al. 2009)

Sample

- Lynx-Cancer void is at D~ 18 Mpc.
- Consists of 103 faint galaxies (M_B: [-9.7, -18.4]) (Pustilnik et al. 2011)
- 25 gas-rich galaxies($M_{HI}/L_B > 1.9$, $M_B > -16$) were selected.
- This allows us
  - To do statistical analysis of the gas distribution, kinematics, star formation efficiency & dark matter distribution.
  - To explore the details of dynamical properties (e.g. signs of mergers, nearby companions etc).
- Data reduction was done in AIPS.

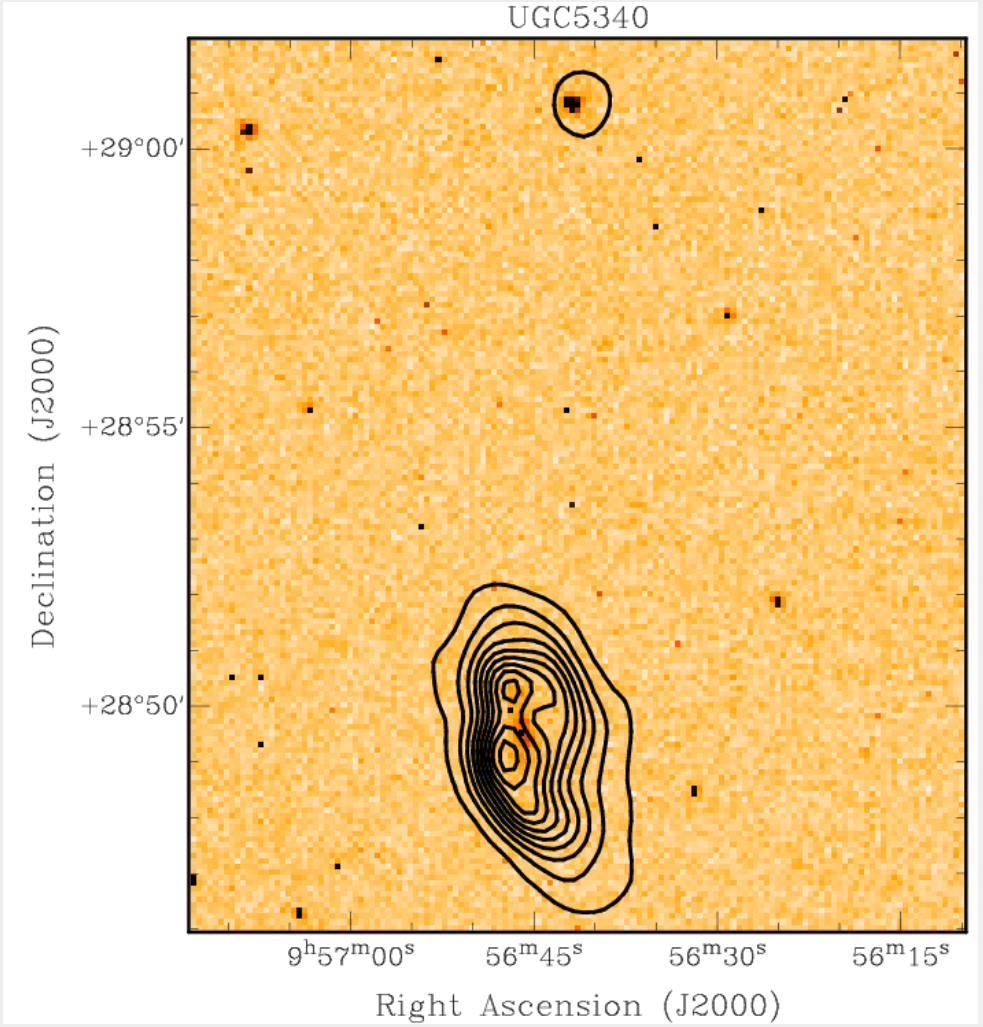
Extremely gas-rich triplet



Chengalur et al. 2012

- $M_{HI}/L_B \sim 3$, 10 and 25.
- $M_B \sim$ -14.2, -12 and -9.7

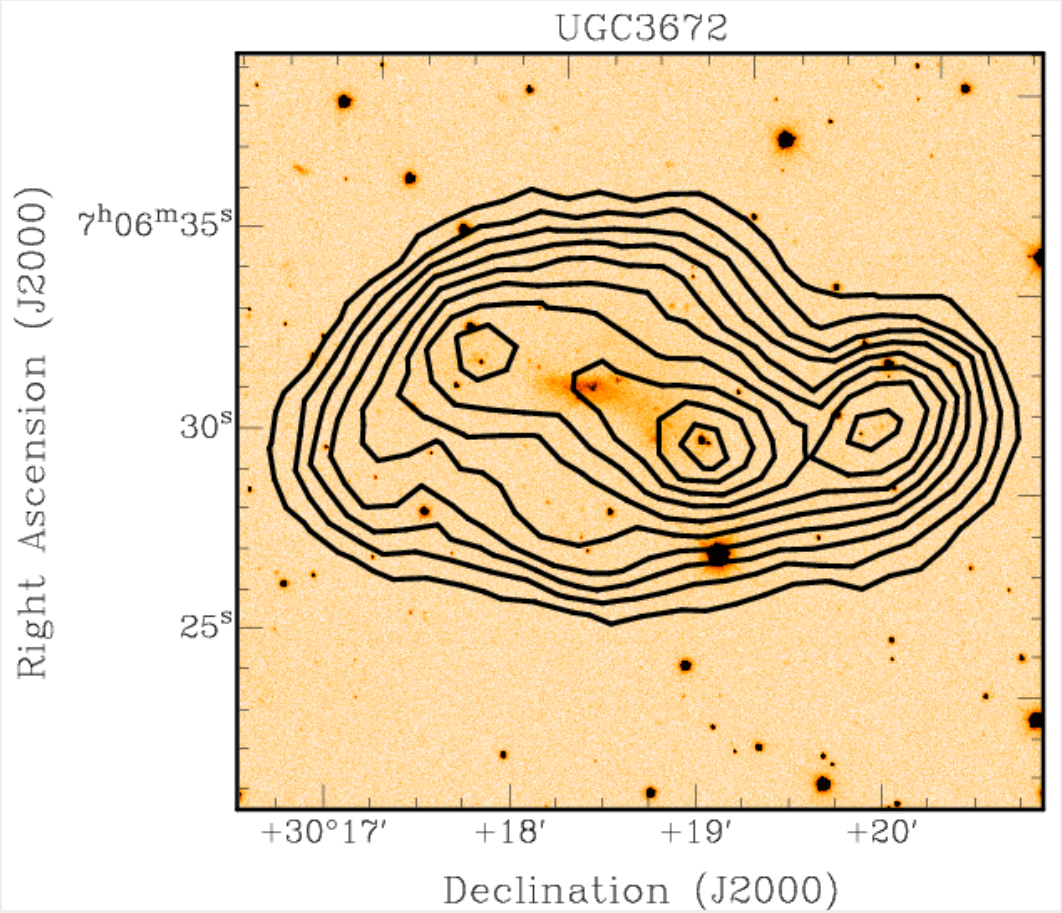
Merger remnant



Ekta et al. 2008

- Extremely metal deficient galaxy
- 12+log(O/H) ~7.12

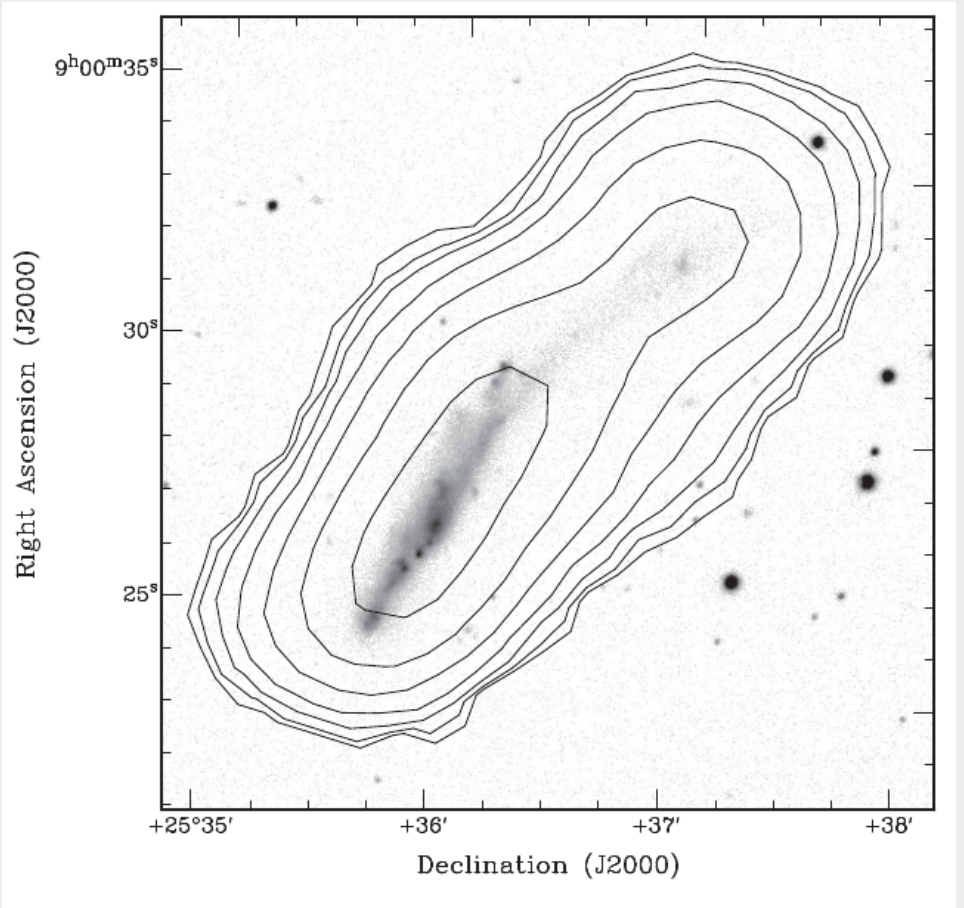
U3672-Merging triplet.



Chengalur et al. 2016

- Faintest component is
- Gas rich M_{HI}/L_B ~17
- 12+log(O/H)~7, metal deficient

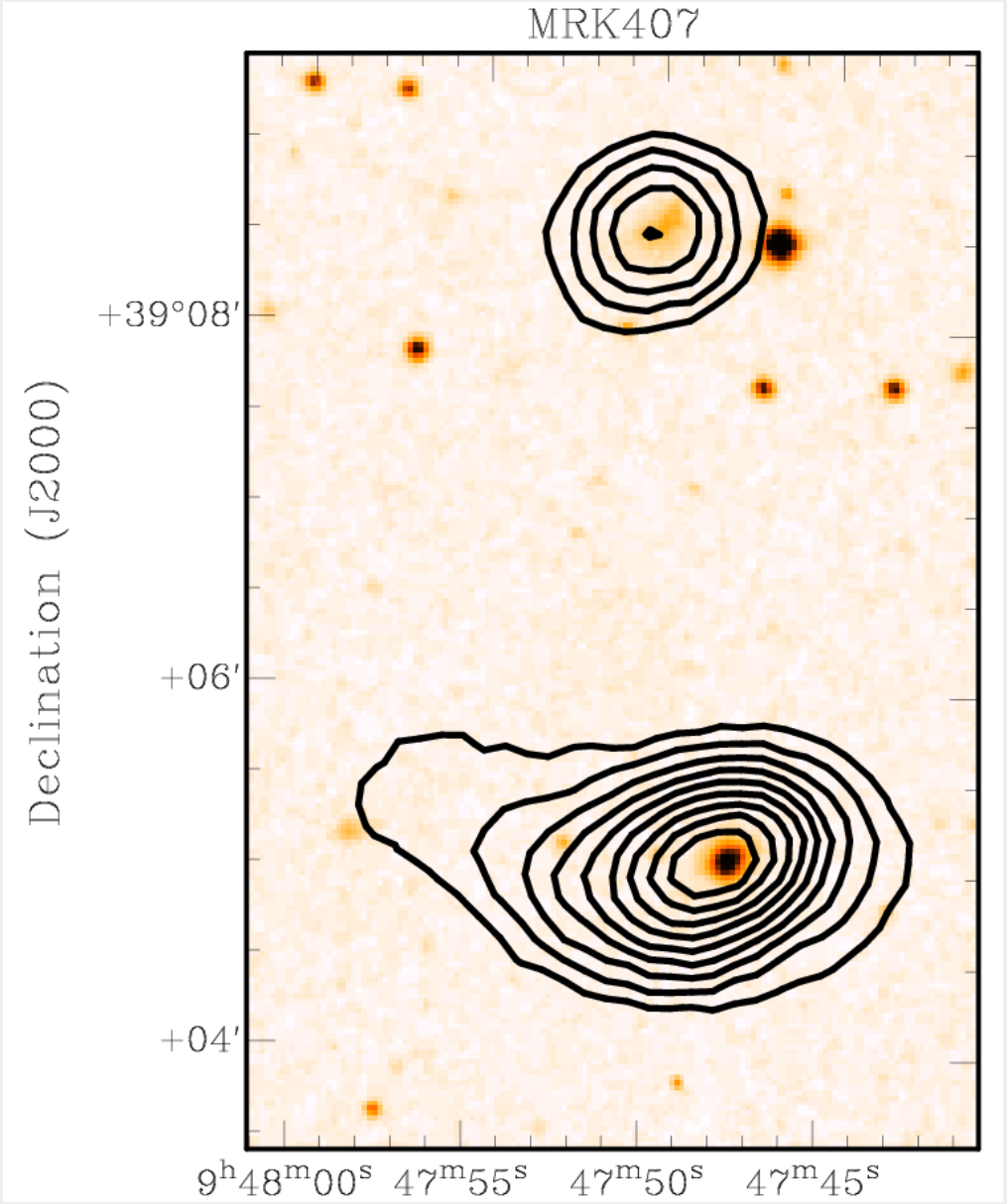
U4722-Merger remnant.



Chengalur et al. 2014

- Minor merger with tidal feature
- Metallicities are 2~3 times lower
- 12+log(O/H) ~ 7.5-7.6

Companions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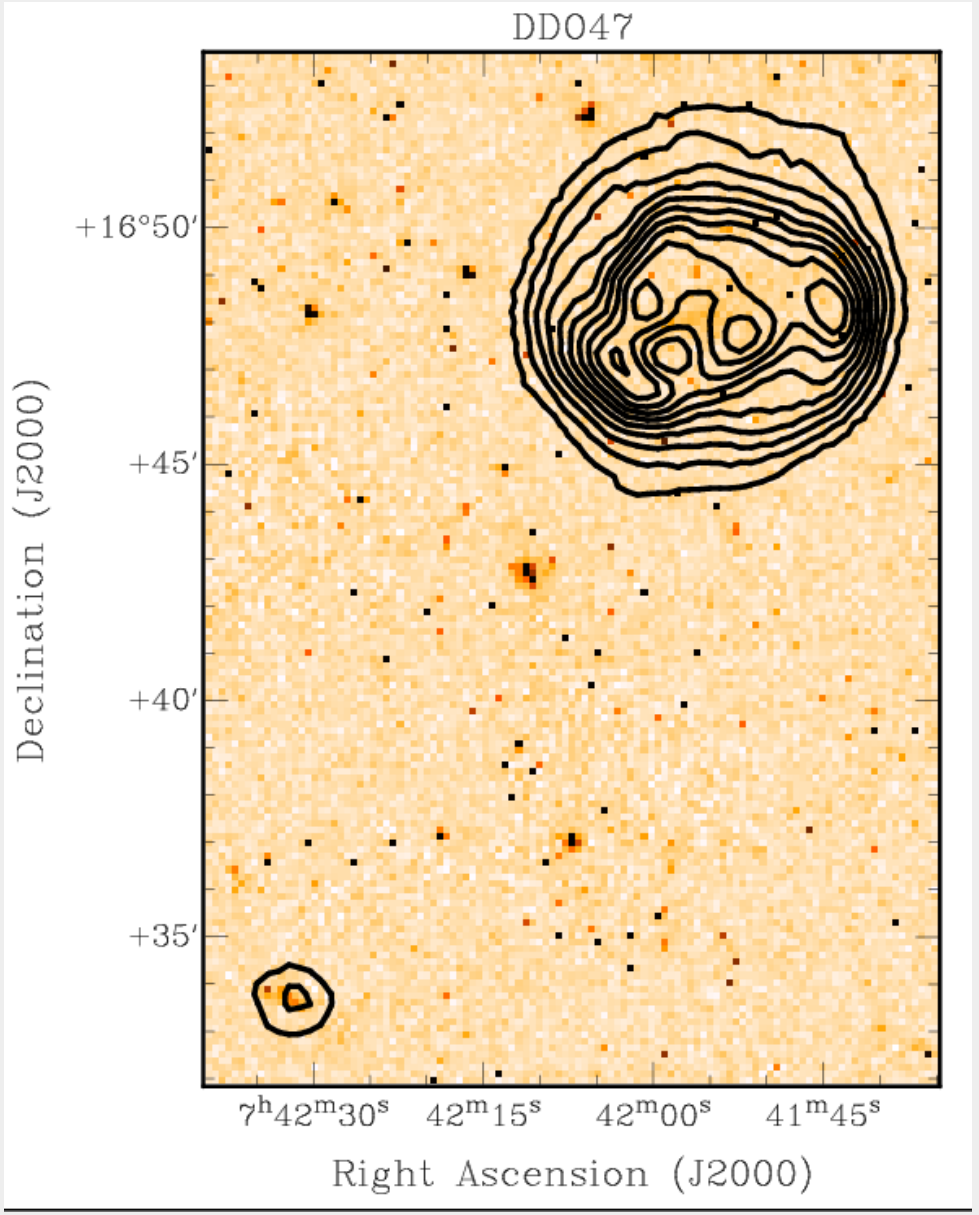
+06′
+04′
Declination (J2000)
9h48m00s
47m55s
47m50s
47m45s


DD047
+16°50′
+45′
+40′
+35′
Declination (J2000)
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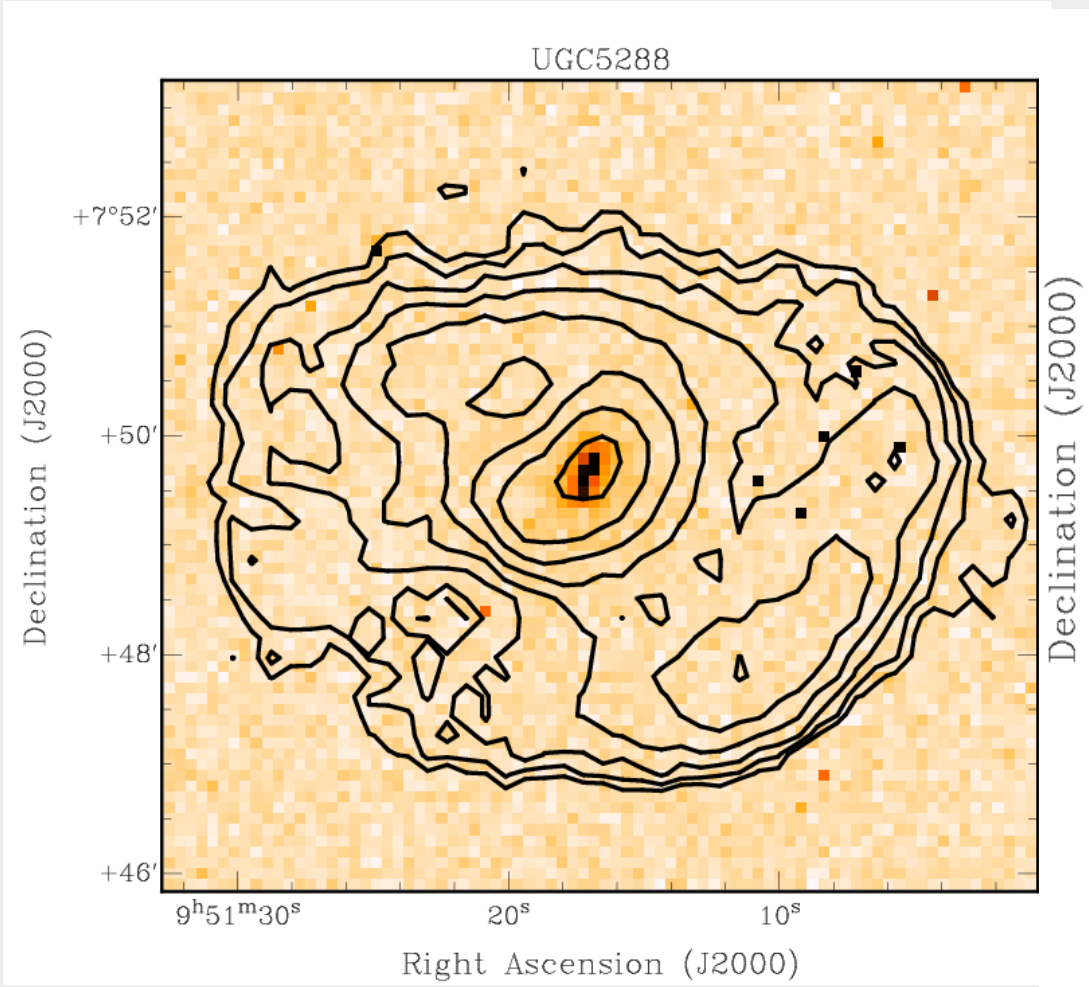
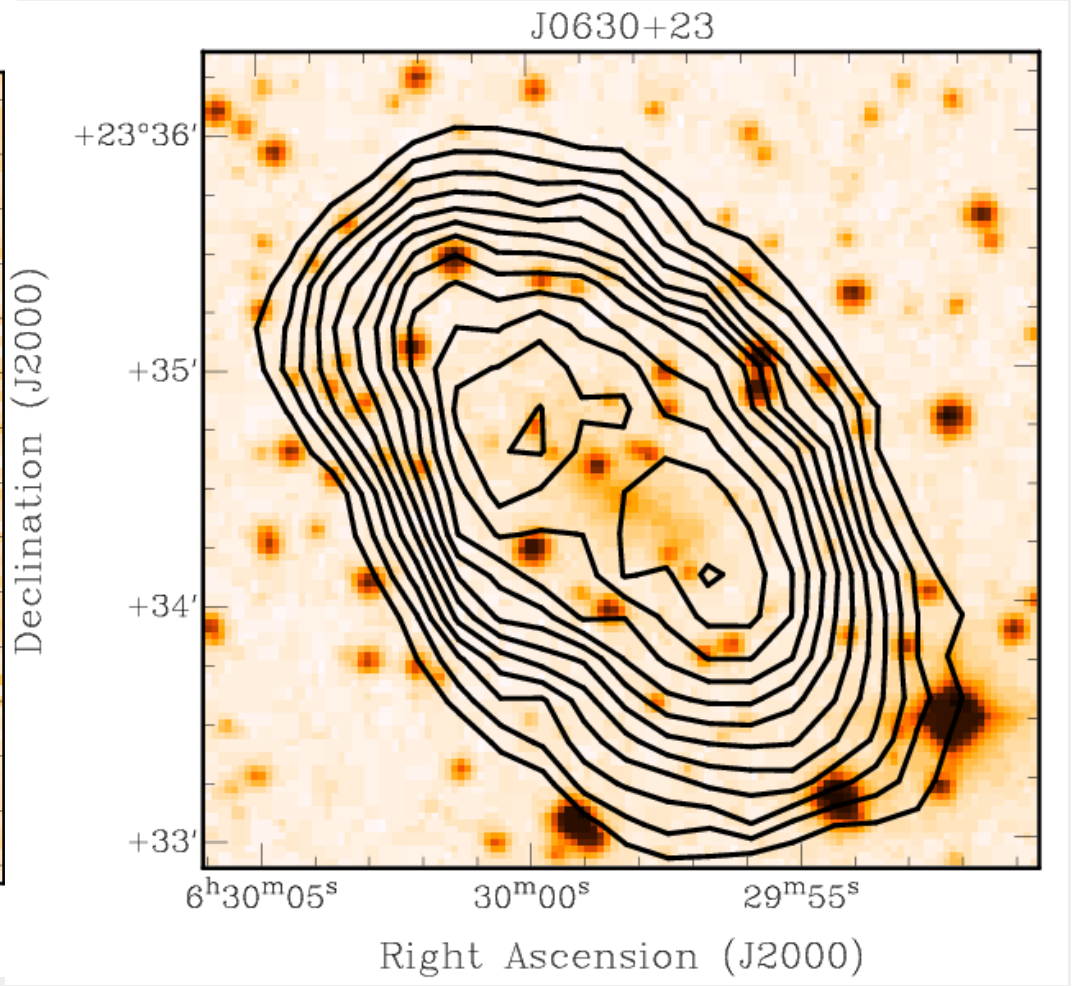
42m00s
41m45s
Right Ascension (J2000)

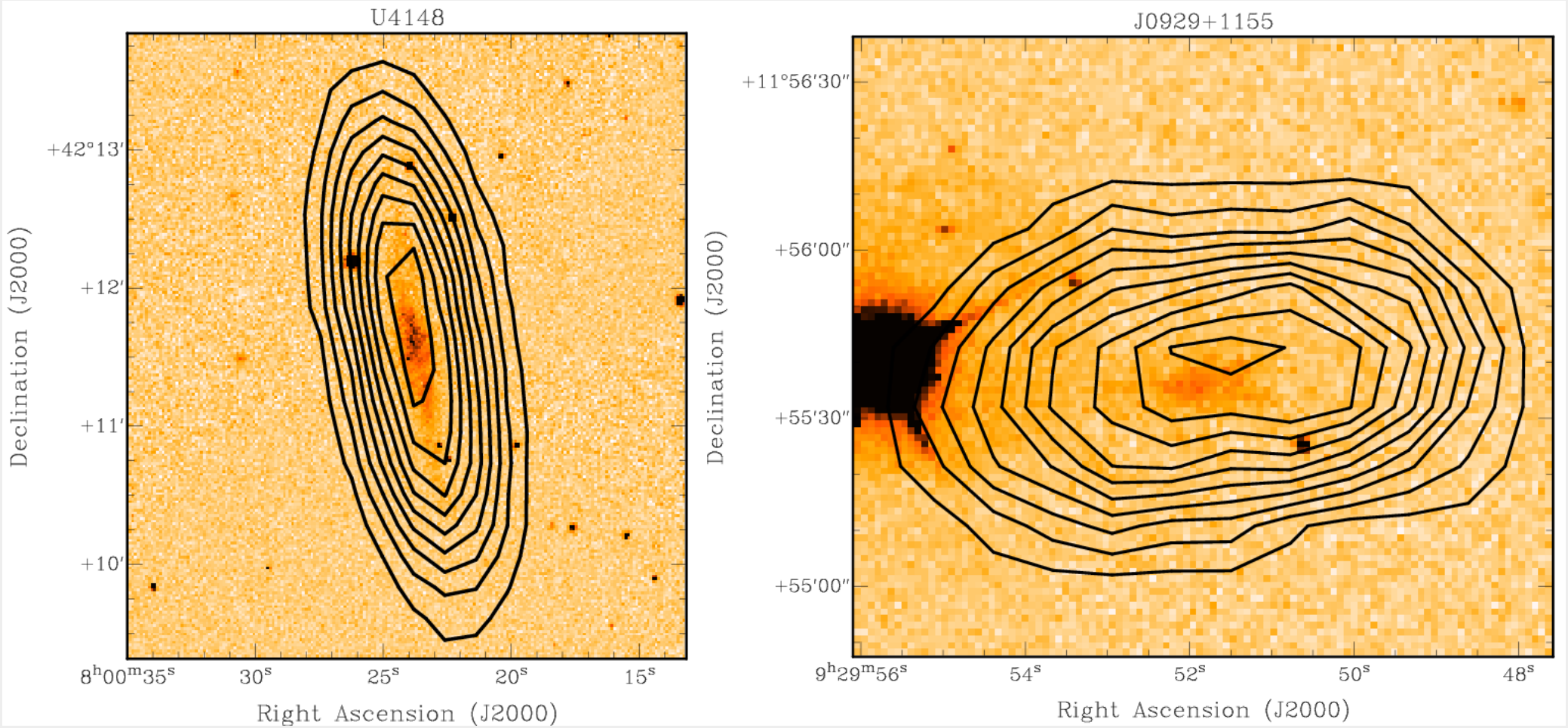
Peculiar morphologies





J0630+23 shows HI ring

Extended HI disks



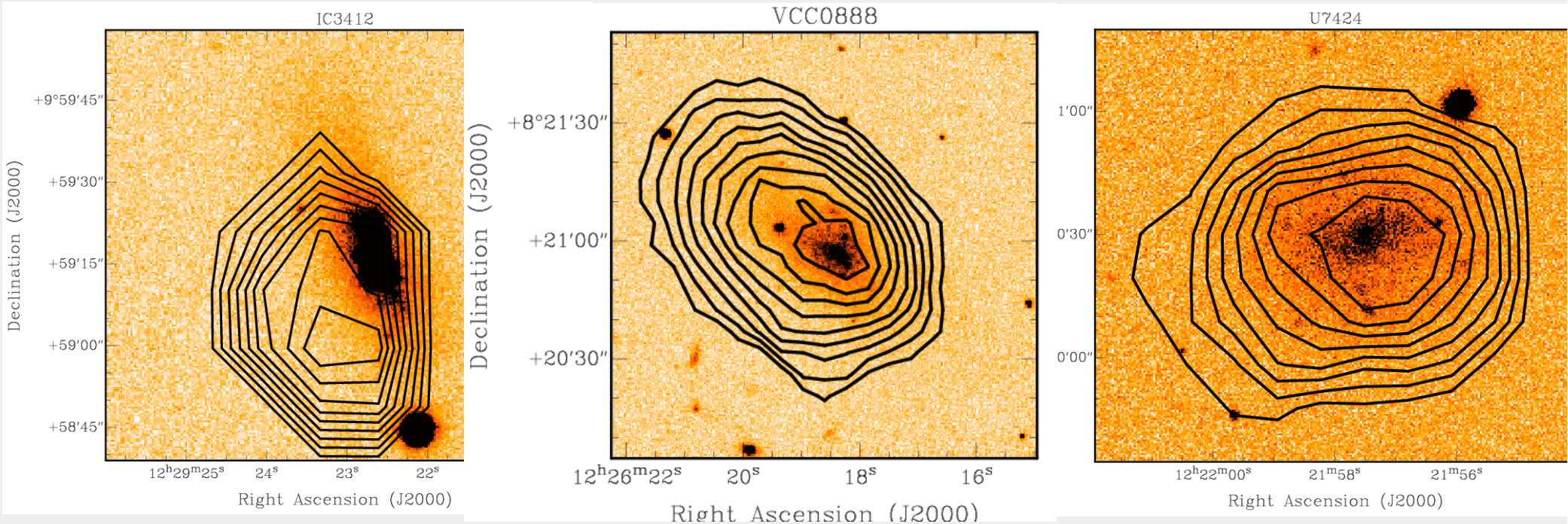
Results

- 3/21 systems are in triplets
- 2/21 systems are merger remnants.
- 4/21 systems have non-interacting companion.
- Some galaxies have HI rings, extended HI disks.
- Clustering in voids can be compared with field galaxies.

Environmental processes in clusters

- Play role in transformation of late-type galaxies to early-type galaxies.
  - Ram-pressure stripping (RPS): dynamic pressure in ICM strips gas (Gunn & Gott 1972)
  - Strangulation: stripping of hot halo (Larson et al. 1980)
  - Tidal interactions between galaxy-galaxy & galaxy-cluster. (Byrd & Valtonen 1990)
  - Harassment: fast, repetitive encounters between galaxies (Moore et al. 1998)
- Efficiency of RPS, strangulation and harassment is high for low mass galaxies (Hester 2006; Bekki 2009; Smith 2015)

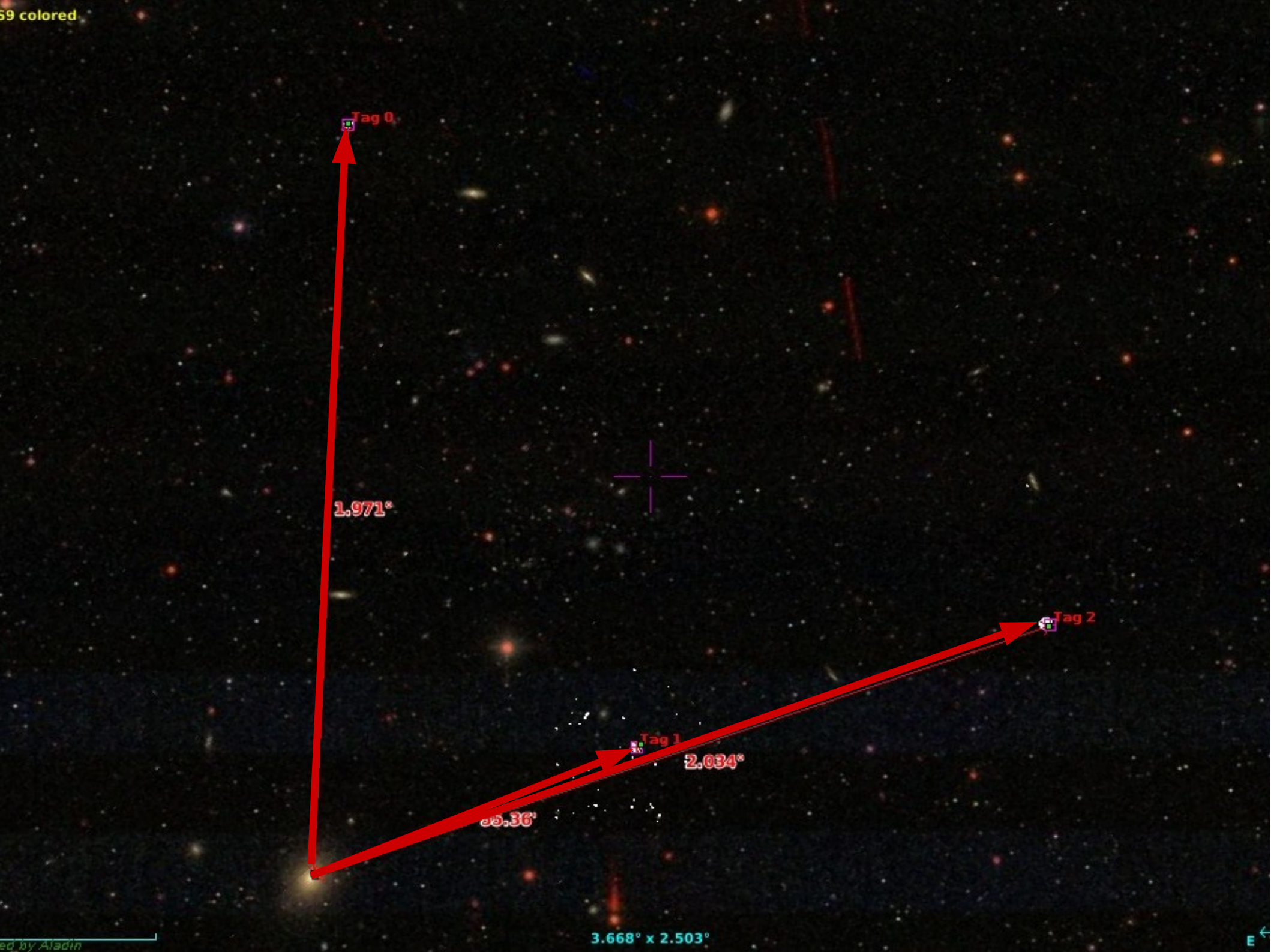
Virgo galaxies- disturbed HI morphologies



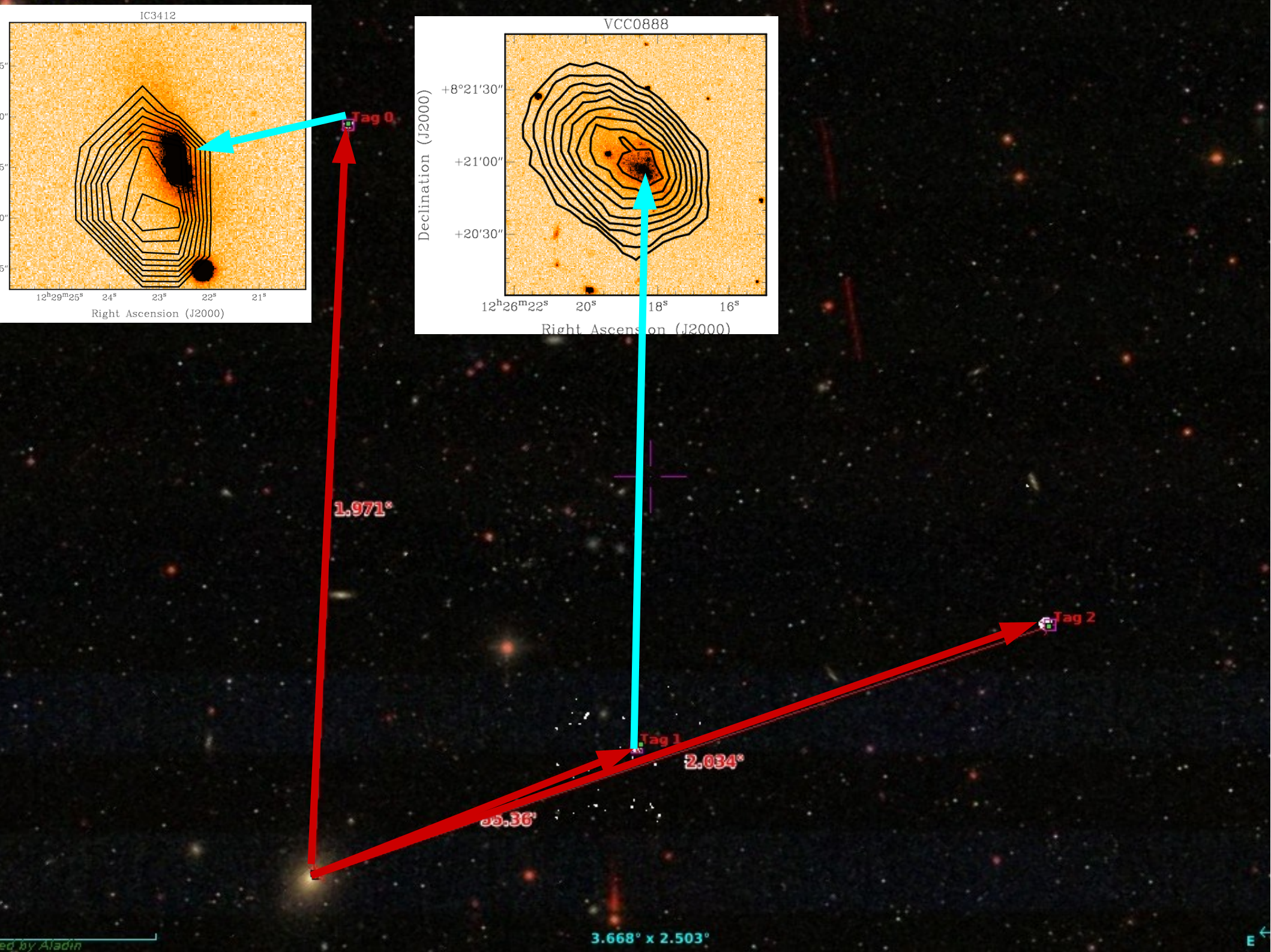
a) IC 3412: HI can be seen to be significantly offset from the stellar counterpart.

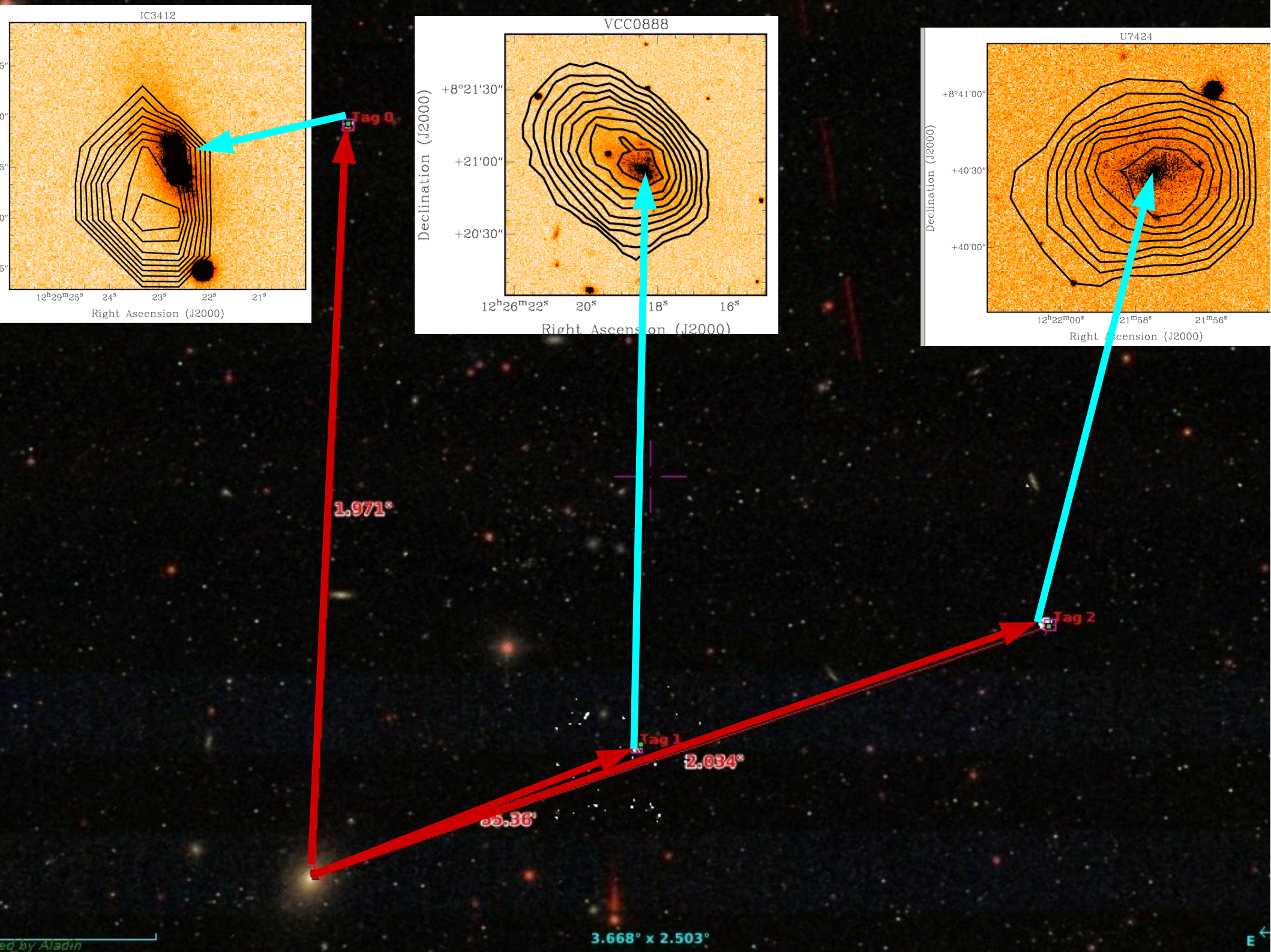
b) VCC0888: The HI and optical emission have a bright knot with a diffuse extension leading away from it.

c) U7424: HI disk is not much larger than the optical disk.


59 colored
Tag 0
1.971°
Tag 2
Tag 1
2.034°
3.668° x 2.503°
E


IC3412
Right Ascension (J2000)
Tag 0
Tag 1
Tag 2
1.971°
2.034°
5.36°
3.668° x 2.503°


IC3412
Right Ascension (J2000)
VCC0888
Declination (J2000)
+8°21′30″
+21′00″
+20′30″
12h26m22s
20s
18s
16s
Right Ascension (J2000)
Tag 0
Tag 1
Tag 2
1.971°
2.034°
3.668° x 2.503°


IC3412
Right Ascension (J2000)
VCC0888
Declination (J2000)
+8°21′30″
+21′00″
+20′30″
12h26m22s
20s
18s
16s
Right Ascension (J2000)
U7424
Declination (J2000)
+8°41′00″
+40′30″
+40′00″
12h22m00s
21m58s
21m56s
Right Ascension (J2000)
Tag 0
Tag 1
Tag 2
1.971°
2.034°
3.668° x 2.503°

Summary

- Dwarfs are more sensitive to environment; ideal targets.
- Sample has galaxies from the Virgo, Ursa Major, field and Lynx-Cancer void.
- Virgo galaxies show disturbed HI morphologies.
- In voids, 3/21 systems are in triplets, 2/21 systems are merger remnants and 4/21 have non interacting companions.
- We plan to
  - compare clustering in void galaxies to field galaxies.
  - compare global statistical properties of void galaxies with their counterparts in average & high density regions.