Multiwavelength study of the most isolated galaxies of the Local Universe

AMIGA

Analysis of the interstellar Medium of Isolated GAlaxies

L. Verdes-Montenegro on behalf of AMIGA team
Instituto de Astrofísica de Andalucía (IAA - CSIC)

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Motivation

Goal: Effects of Environment on interstellar medium, star formation and nuclear activity of Galaxies

- some processes driven by interaction not well quantified/ understood

- E.g groups vs pairs:
  - HCGs: Evidence for morphology changes and HI depletion, excess SF not observed

    (e.g. VM et al ´01, Iglesias-Páramo &Vílchez ´99)
  - Pairs: SF excess but no HI deficit

    (Xu & Sulentic ´91, Zasov & Sulentic ´94)

- E.g. AGN activity frequence

  (e.g De Robertis et al ´98, Krongold et al ´03)

Motivation

- Either no real isolation definition:

  FIELD galaxies (e.g. Kennicut & Kent ´83)

  “NORMAL” galaxias (e.g. Boselli et al ´01)

  Galaxies with no v-data not considered companions

  (Kelm & Focardi ´04: isolated w.r.t. companions brighter than 15.5mag)

- Or if well defined:

  Monochromatic observations of large samples/

  multiwavelength observations of small samples

  10 – 100/200 members

  (Huchra & Thuan ’77, Vettolani et al ’86,, Márquez & Moles ’99, ’00, Colbert et al ’01, Pisano et al ´02, Varela et al ´04)

Members

Starts in 2003 @IAA (PI: L. Verdes-M)

Core team in Granada:

Staff: Jack Sulentic (IAA), Ute Lisenfeld (Univ. Granada)

Postdocs: Daniel Espada(IAA), Jose Sabater (IAA), Simon Verley (Univ. Granada), Gilles Bergond (CAHA), Chandreyee Sengupta (CAHA)

PhDs:Vicent Martínez, Carmen Argudo

Software development (radio-VO, archives, exploitation tools for 3D data): Pique Ruiz del Mazo, Susana Sánchez

Since 2006 Coordinated project IAA-group + IRAM-30m @ Granada

+ International collaboration:

ESO (Chile), Obs. Marseille, Obs. Paris, CfA, ASIAA-Taiwan, MPIfA (Bonn), UMASS, Mc Donald Obs., Arcetri, UNAM, IAC, Kapteyn Institute, ATNF

International conference

NEWSFOCUS

ASTRONOMY

The Tales Told by Lonely Galaxies

To what extent is a galaxy shaped by its surroundings? To find out, astronomers are seeking the rare ones that appear to be isolated

Unblemished beauty. Isolated galaxies like NGC 7217 may have evolved undisturbed for billions of years.

in Ukraine, working with her husband, Igor Karachentsev of the Special Astrophysical Observatory in Nizhnij Arkhyz, Russia. "We divided our work," she says. "Igor worked with the pairs, and I work on the isolated galaxies."

Karachentseva analyzed photos taken in the 1950s with a 1.2-meter telescope in the famed Palomar Observatory Sky Survey. She declared a galaxy isolated if no neighboring galaxy lay closer than 20 times the neighbor's radius or was more than four times as big in diameter as the galaxy in question. Those rules selected galaxies that had not suffered an interaction in roughly 3 billion years. The Karachentseva catalog of 1051 galaxies is "still the best game in town," say Sulentic, who works on the Analysis of the Interstellar Medium of Isolated Galaxies (AMIGA) project at IAA

.org on June 7, 2009

GRANADA, SPAIN—Laden wi
stars, countless planets, and v
gas, our Milky Way galaxy
through the void. Its spiral
50,000 light-years and revolv
220 million years, as we plung
kilometers per hour toward the

Galaxies in Isolation: Exploring Nature vs. Nurture

May 12th-15th, 2009 · Granada (Spain)

Starting sample

AMIGA is a refinement of CIG:

Catalogue of Isolated Galaxies (Karachensetva 1973)

Selected from CGCG (Zwicky) with mpg < 15.7 $\delta > -3$

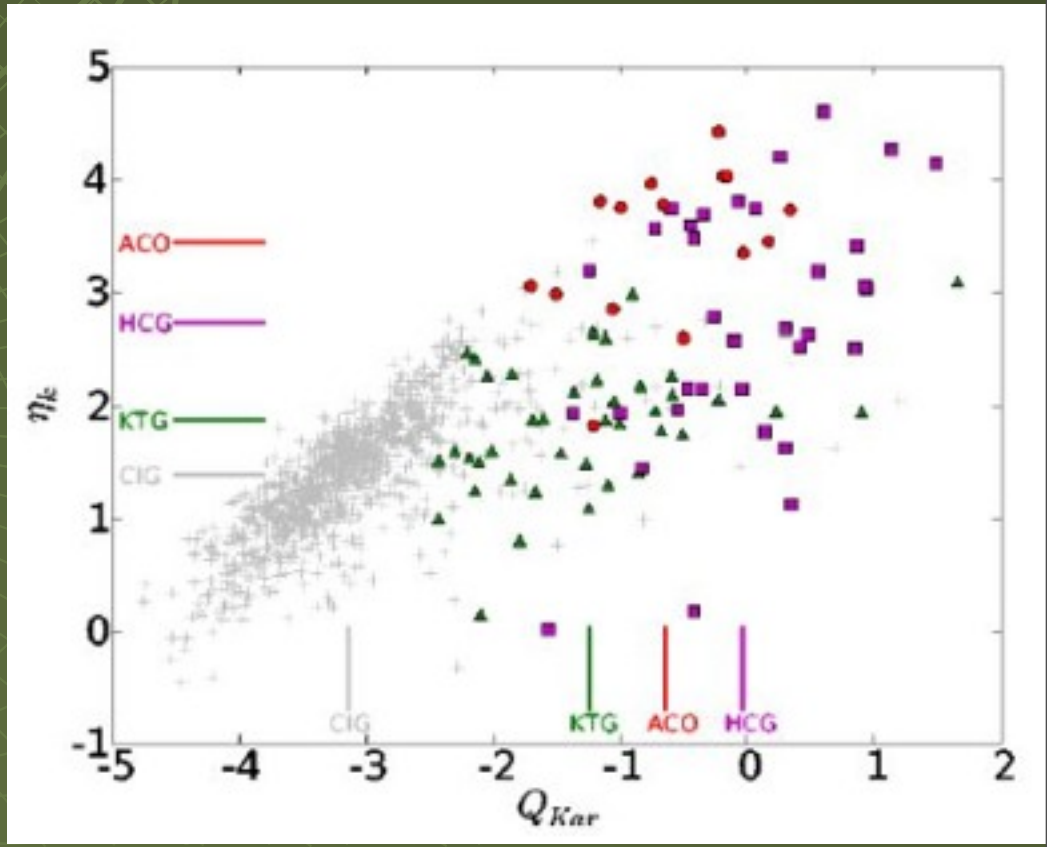
- 1050 galaxies with no similar sized galaxies (factor 4) within 40*R(companion) -> last interaction several Gyrs ago

- Positions
- Redshifts/distances
- Morphologies
- Isolation

Isolation

(Verley PhD; Verley et al 2007ab, A&A)

- Karachentseva (1986): visual examination of plates
- Our revision: POSS-I & II, R >=0.5 Mpc, m_B<17.5
  - Catalog of all potential companions: 54.000
- Quantification: CIG, 41 triplets, 34 groups, 15 clusters :
  - Local number density η_K
  - Tidal force estimation Q



Characterization of neighborhood using SDSS-DR7

PhD thesis (M. Argudo)

Main goals:

- Using the final release of the SDSS to perform a 3D revision of the environment taking into account small size satellites

- Re-evaluation of tidal force exerted on each CIG by its satellites, previously calculated using 2D data, and hence the minimum level of interaction to produce nurture effects

Preliminary results in a selection of 24 CIG galaxies:

608 galaxies in the catalog of neighbours galaxies (Verley et al. 2007)
69 were classified as stars (11.35%).
Our direct inspection: 57 correct, 12 found to be galaxies

CIG 233: 2 candidates to be neighbours previously undetected

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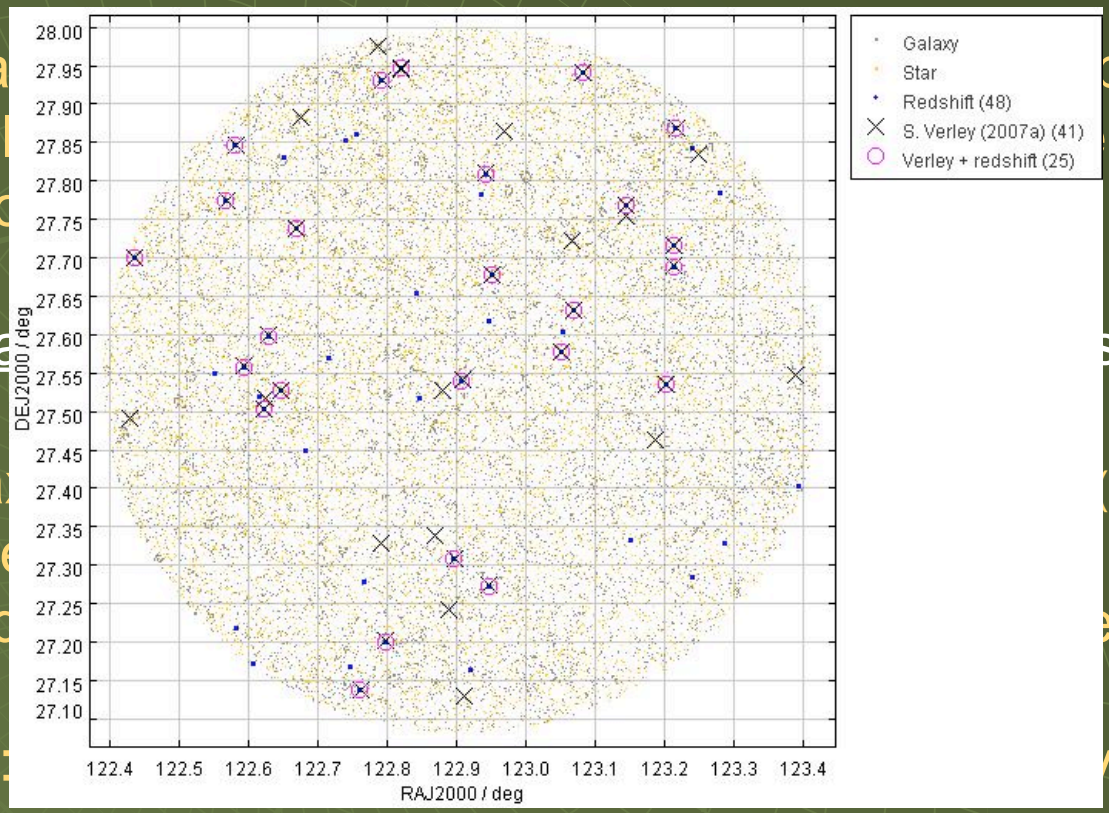
69 we…

Our c… galaxies

CIG 233… undetected



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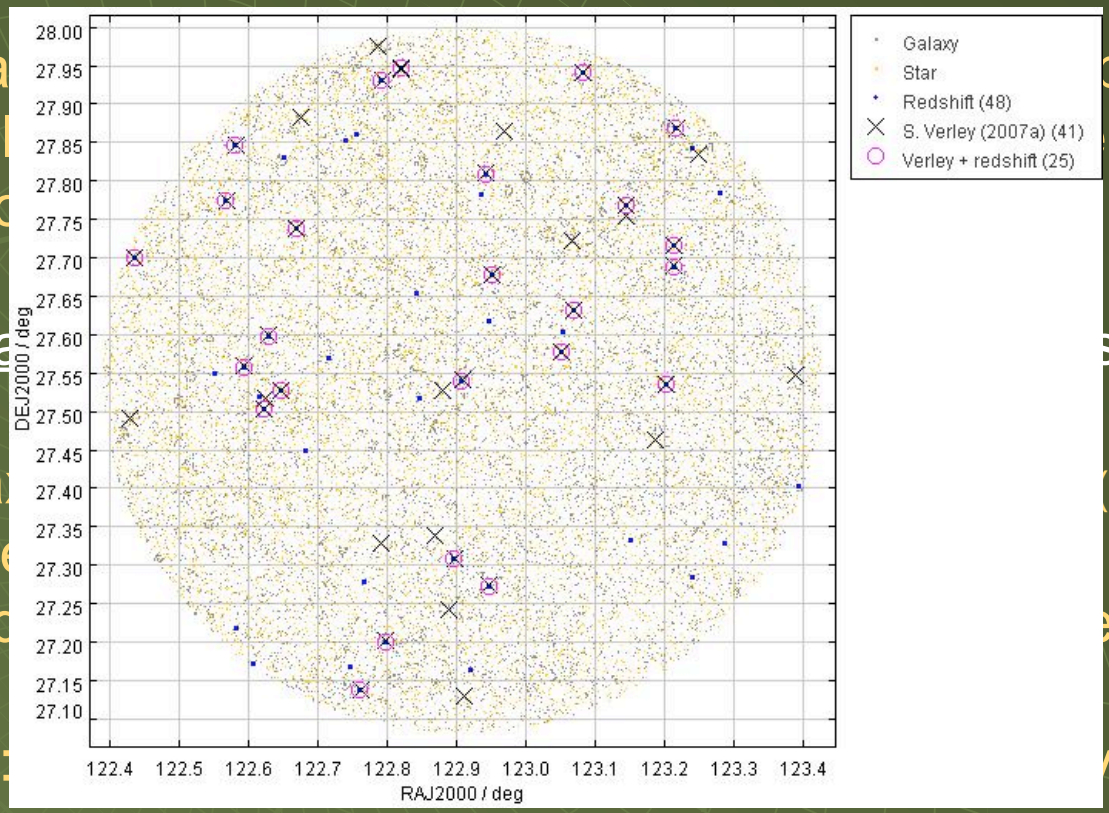


First presentation of this work:
See poster M. Argudo

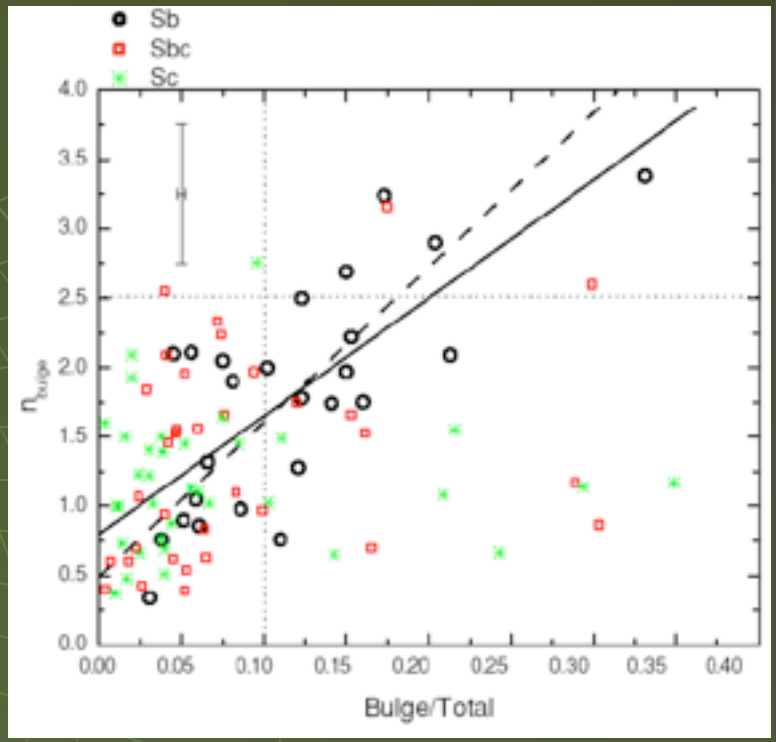
MULTIλ RESULTS

- Sb-Sc dominant population
- **LOWEST VALUES** relative to any other samples of:
  - LB of both late and early types (Sulentic et al 2006)
  - Sersic index of late types

=> **pseudobulges**

  - Optical asymmetry, clumpiness, concentration

(Durbala et al 2008, 2009)



100 Sb-Sc Fourier decomposition and CAS parameter SDSS-i

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  - Optical asymmetry, clumpiness, concentration
  - LFIR

    · $\log(L_{FIR})$: only 2% >10.5 L_{sol}

    · Comparison with 2445 galaxies of CfA sample:

    $\langle \log(LFIR)_{CfA} \rangle =$

    $\langle \log(LFIR)_{AMIGA} \rangle + 0.26$

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  - Radiocontinuum (**disk dominated**)
  - Nuclear activity

Multiwavelength study of nuclear activity

Four methods:

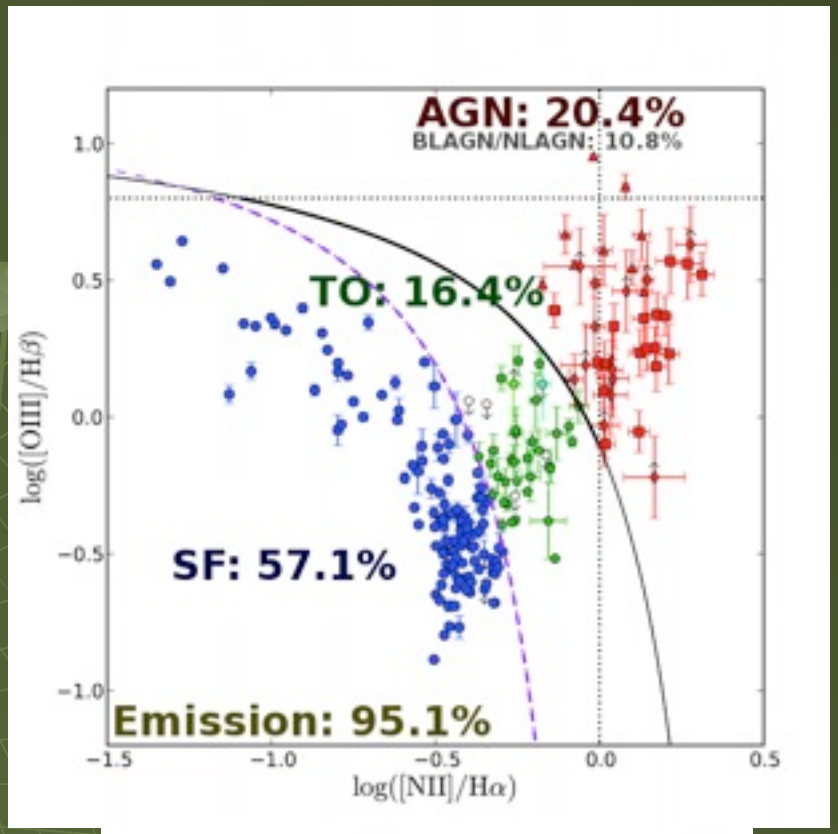
1 - Search in the literature
- NED and Véron & Véron-Cetty catalogue.

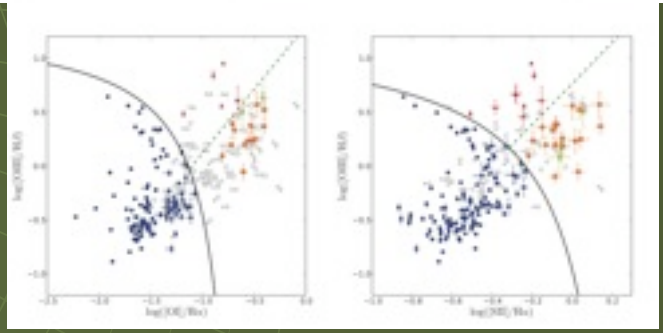
2 - Radio excess in the radio – FIR correlation
- 0.4% radio-excess galaxies
- VLA high resolution study => all background sources
- **<u>0% radio-excess galaxies</u>**

3 - FIR colours
- 7% - 28% of obscured AGN candidates

4 - Diagnostic based on optical spectra
- 353 SDSS DR6 spectra
- Subtraction of stellar populations
- Classification taken into account upper limits in the lines (5% more galaxies class.)
- **<u>20% optical AGN</u>**

Final catalogue of AGN in isolated galaxies.



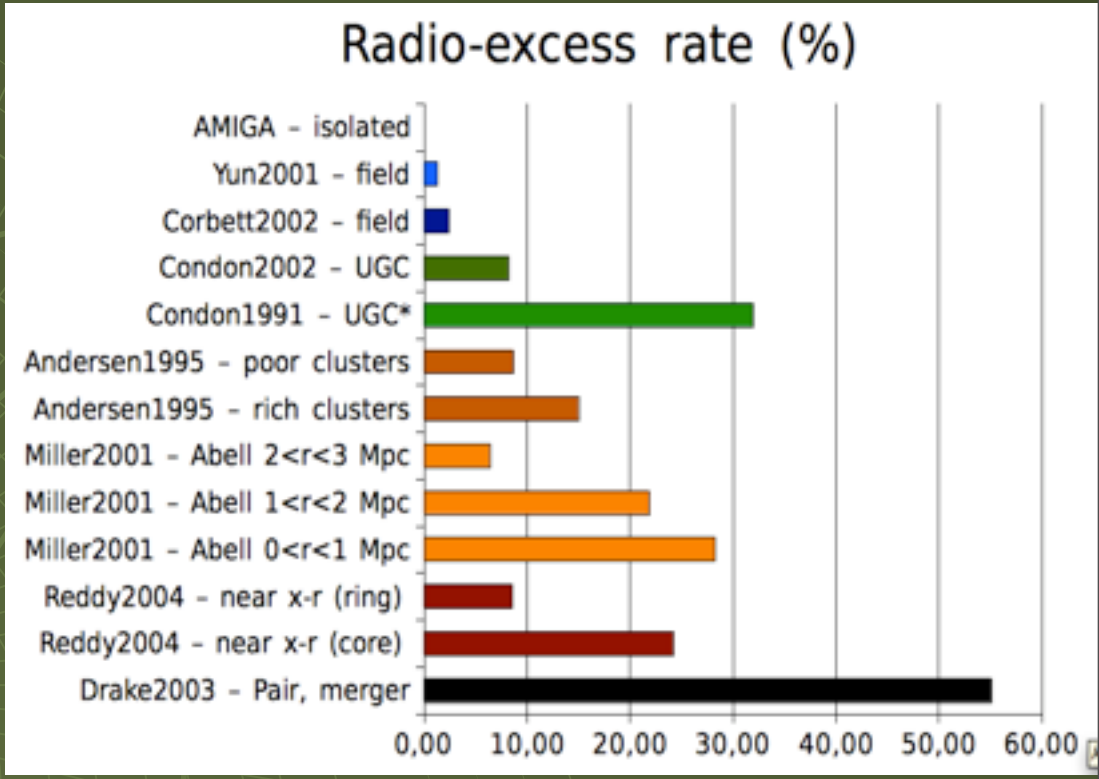


Multiwavelength study of nuclear activity

Comparison with denser environments

AMIGA: Lowest rate of radio excess galaxies

- Increase with the level of interaction (group, distance to the centre of cluster, interacting pairs and mergers)
- Observed independently for each different morphology and luminosity range



Poster: “Efectos del entorno en la actividad nuclear”

Conclusion

Environment plays a crucial direct role in triggering radio nuclear activity and not only via density-morphology or density-luminosity relations

(Sabater et al. 2008; Sabater PhD thesis; Sabater et al. 2010 submited to A&A)

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  - Nuclear activity
  - HI asymmetry

HI asymmetry amplitude and rate

- High percentage rate >50%! of lopsided HI profiles in “field/ isolated” galaxies (e.g. Richter & Sancisi 1994, Haynes et al. 1998)

- Most of previous studies do not use a strict isolation criterion

- Characterizing the asymmetry distribution in CIG (Espada et al. 2010)

  CIG 30% > 1.13

  Other samples in bibliography 50%

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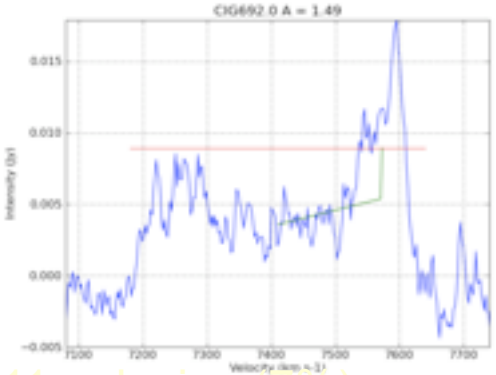
Strongly asymmetric

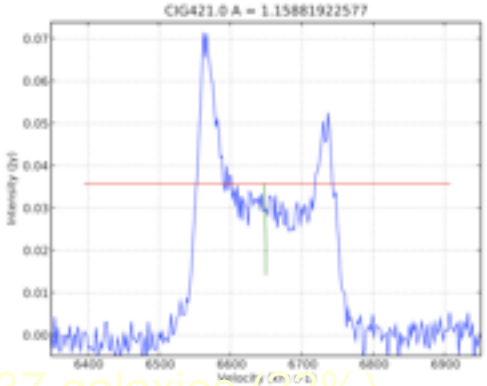
Aflux ratio > 1.3



11 galaxies (7%)

Slightly asymmetric

1.15 < A < 1.3



37 galaxies (22%)

Symmetric

A < 1.15

115 galaxies (71%)

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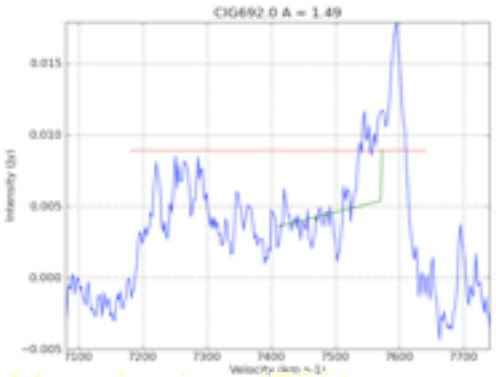

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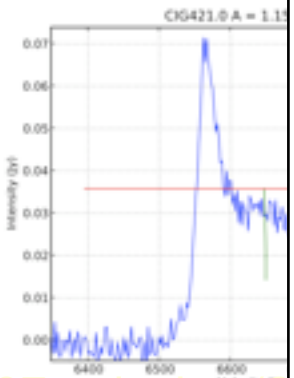
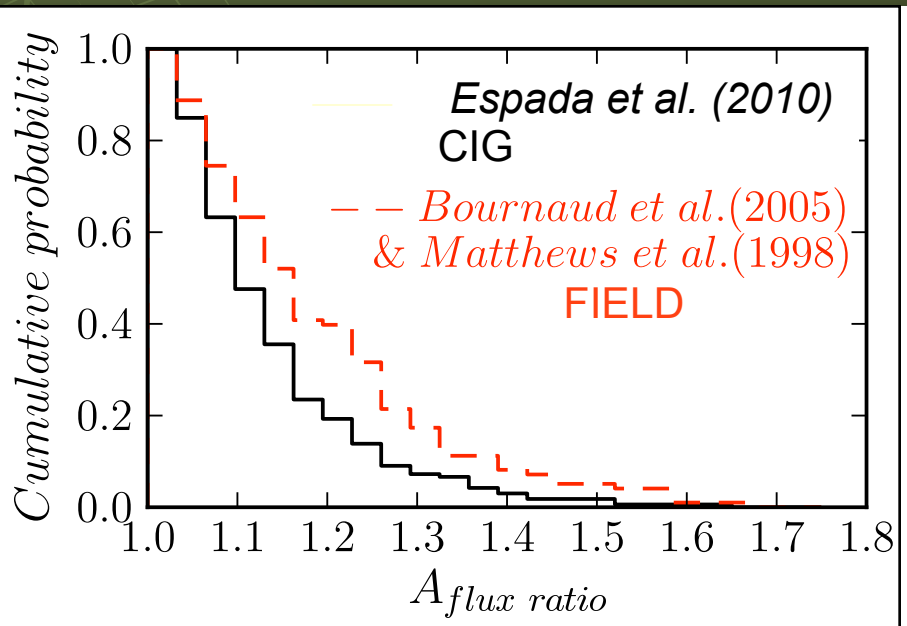


37 galaxies (2



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  - Molecular gas content

Molecular gas content

CO single dish

205 (276) AMIGAs

1500 < v < 5000 km/s

Major axis maps for ~ 20

IRAM 30M, FCRAO, Nobeyama

470h

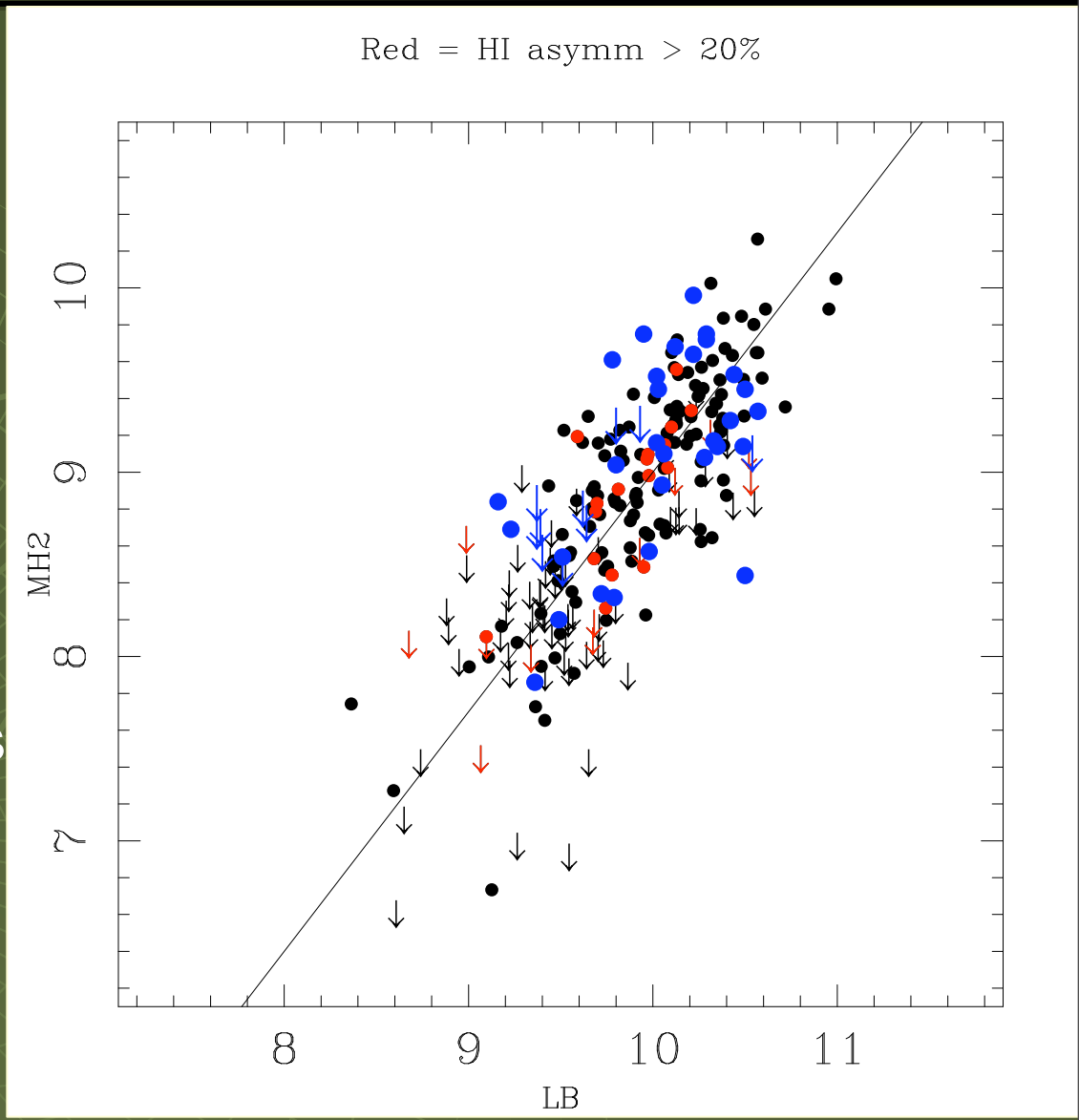
HI ASYMMETRIES >20%

Hickson Compact Groups

CO @ 30m

83gal@20HCGs

(PhD V. Martínez)



Molecular gas content

CO single dish

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Major axis maps for ~ 20

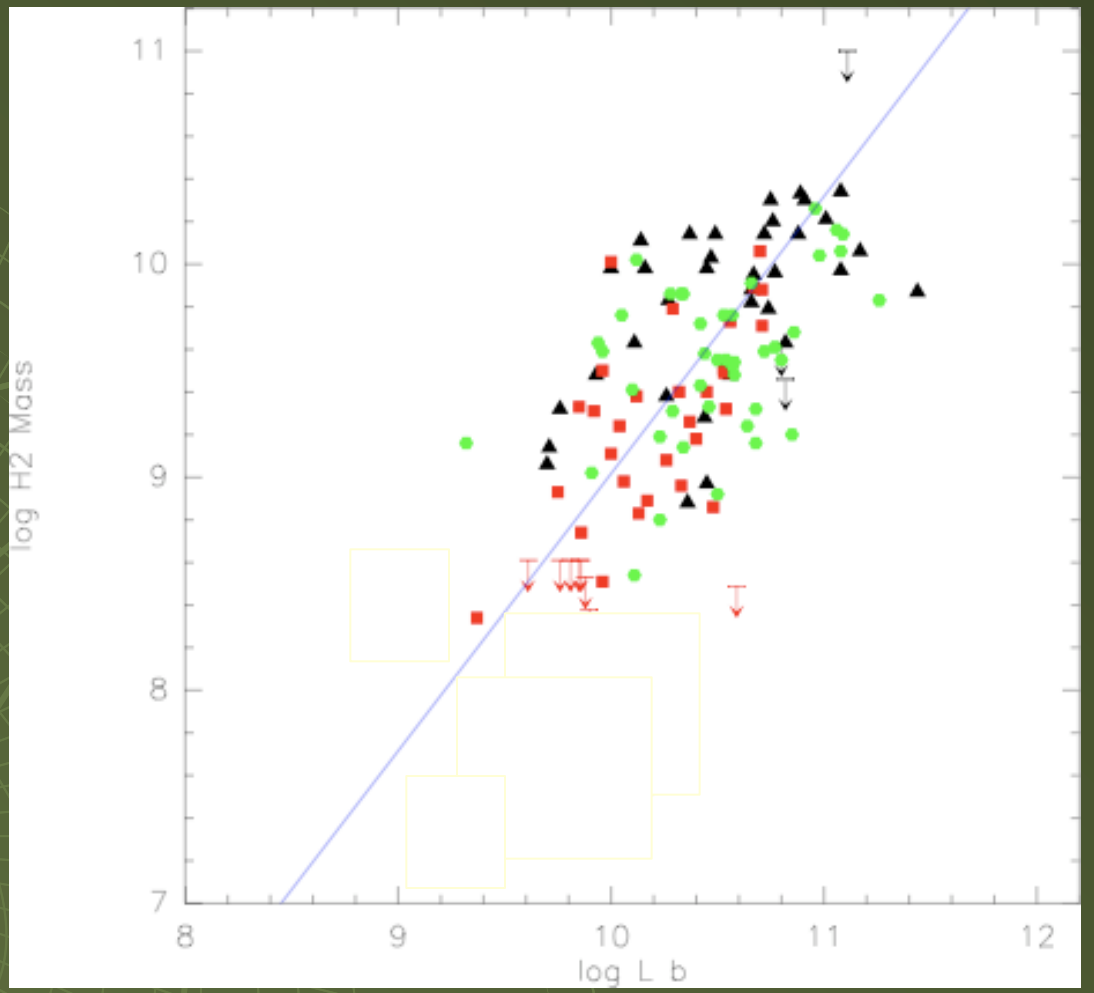
IRAM 30M, FCRAO, Nobeyama 470h

No enhancement in

- Weakly interacting pairs (Solomon & Sage 1988)
- Virgo galaxies (K&Y 88, Bosselli et al 1995)

Slight enhancement in

- strongly interacting pairs (Sanders et al 1991)



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AMIGA:

Lowest possible values

Nurture-free zero point