



Analyzing the Interstellar Medium of Isolated GALaxies



Isolated galaxies - Part I -

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Vatican Observatory Summer School 2003

Team

Instituto de Astrofísica de Andalucía

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- Emilio García (*System Manager*)
- Stéphane Leon (*PostDoc*)
- Ute Lisenfeld (*PostDoc*)
- Lourdes Verdes-Montenegro (*Staff, P.I.*)
- Simon Verley (*Student IAA – Obs. Paris*)

International collaboration

- Jack Sulentic – *University of Alabama*
- Steven Odewahn – *Arizona State University*
- Walter Huchtmeier – *Max Planck Institute of Bonn*
- Min S. Yun – *FCRAO*
- Soledad del Rio – *INAOE*
- Françoise Combes – *Paris Observatory*
- Margarita Rosado – *UNAM*
- Isaura Fuentes – *UNAM*

Introduction

- Role of the environment in the formation and evolution of galaxies;
- reference sample with minimum influence from the environment;
- properties of ISM as a function of isolation, and its relation to star formation, morphology, luminosities, nuclear activity.

Statistically significant sample of isolated galaxies

A- The sample of isolated galaxies

B- Complete multiwavelength information concerning the ISM:

1. Optical
2. H α
3. Infrared
4. Radiocontinuum emission
5. Molecular gas content
6. Atomic gas content

C- Public database

The Catalogue of Isolated Galaxies: CIG.

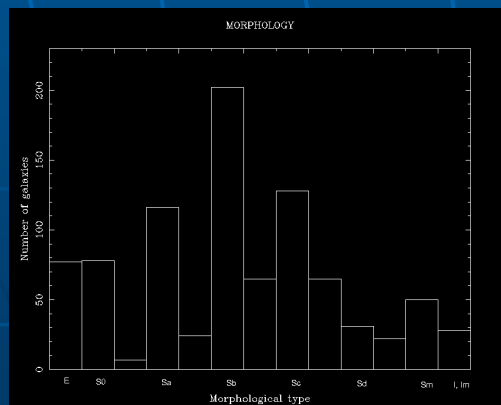
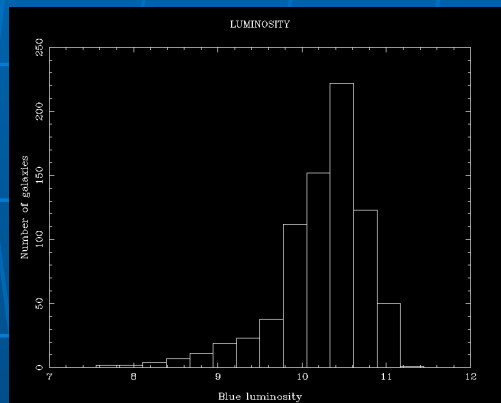
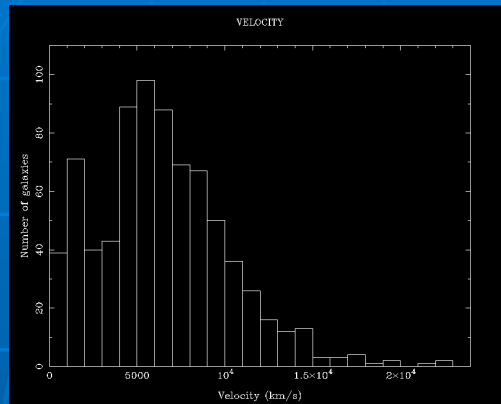
Isolation criterion (Karachentseva, 1973):

- No other galaxy within a distance of 20 times the galaxy diameter d
- $\frac{1}{4} d < d' < 4 d$

- POSS-I plates
- Northern hemisphere: $\text{dec} > -3^\circ$
- Optical magnitude: down to 15.7 (B band)

- 1051 isolated galaxies
- Revision (1980):
 - 0 – Isolated (893)
 - 1 – Marginally isolated (85)
 - 2 – Member of a group or a cluster (64)

The Catalogue of Isolated Galaxies: description of the sample.



a) **Velocity:** the CIG samples a deep enough volume of space to measure the radio, IR and optical luminosity functions;

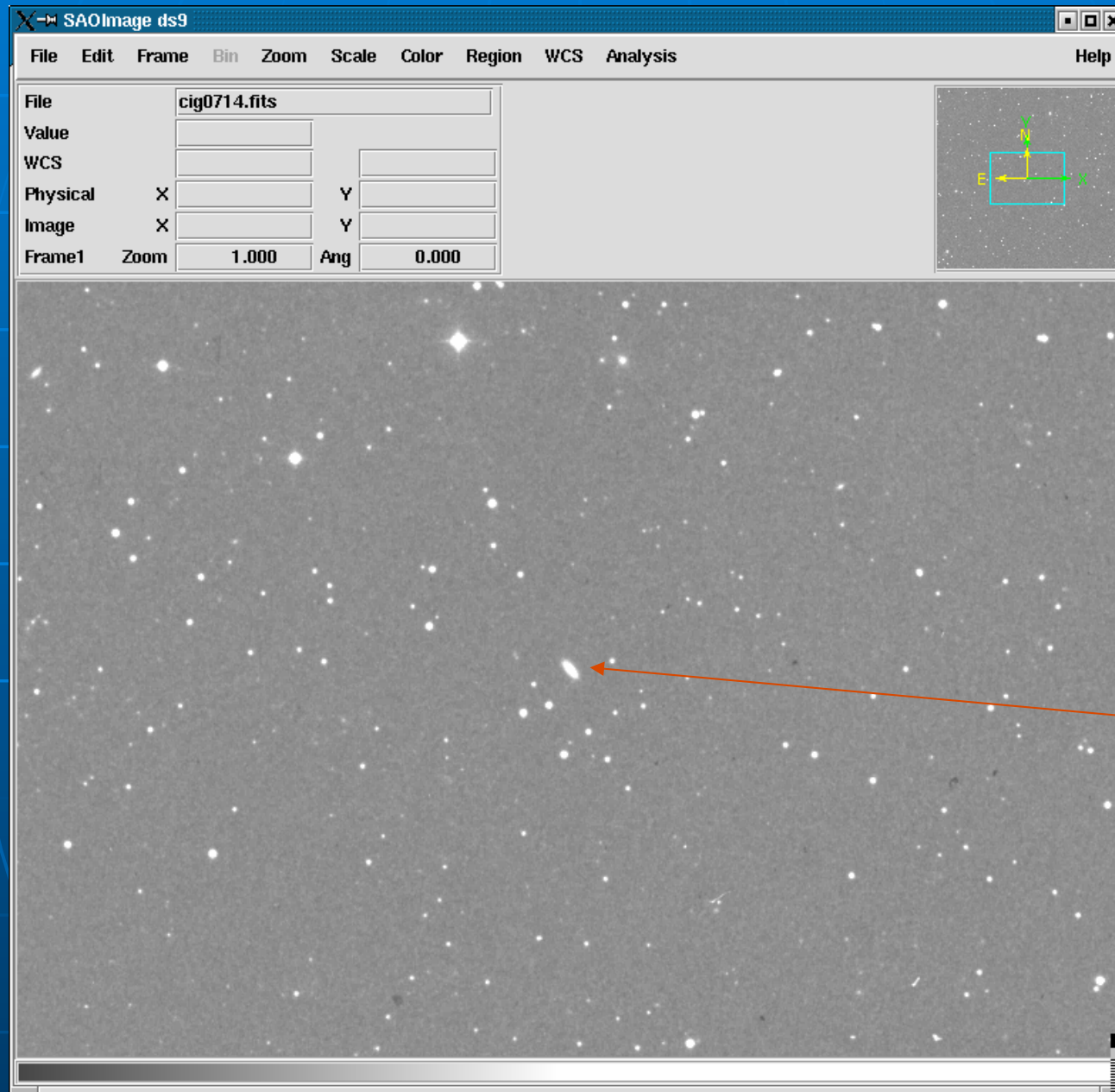
b) **Blue luminosity:** large range of luminosities;

c) **Morphology:** the CIG is morphologically diverse to permit statistical studies correlated with Hubble type.

Checking the isolation criterion: our method.

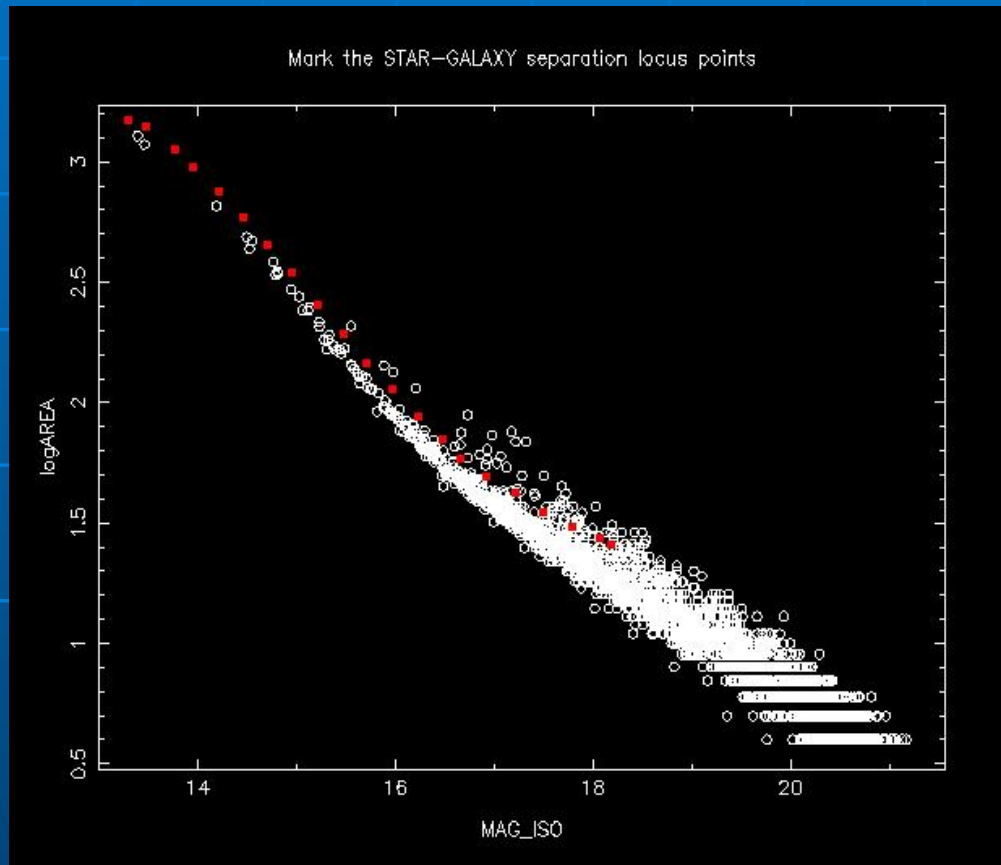
- Local objects are excluded due to uncertain isolation determination (101 gal with $v < 1500$ km/s);
- 950 galaxies: our whole basic sample;
- DSS – POSSI;
- Star/Galaxy separation in each field around the isolated galaxy.

Checking the isolation criterion: the field.



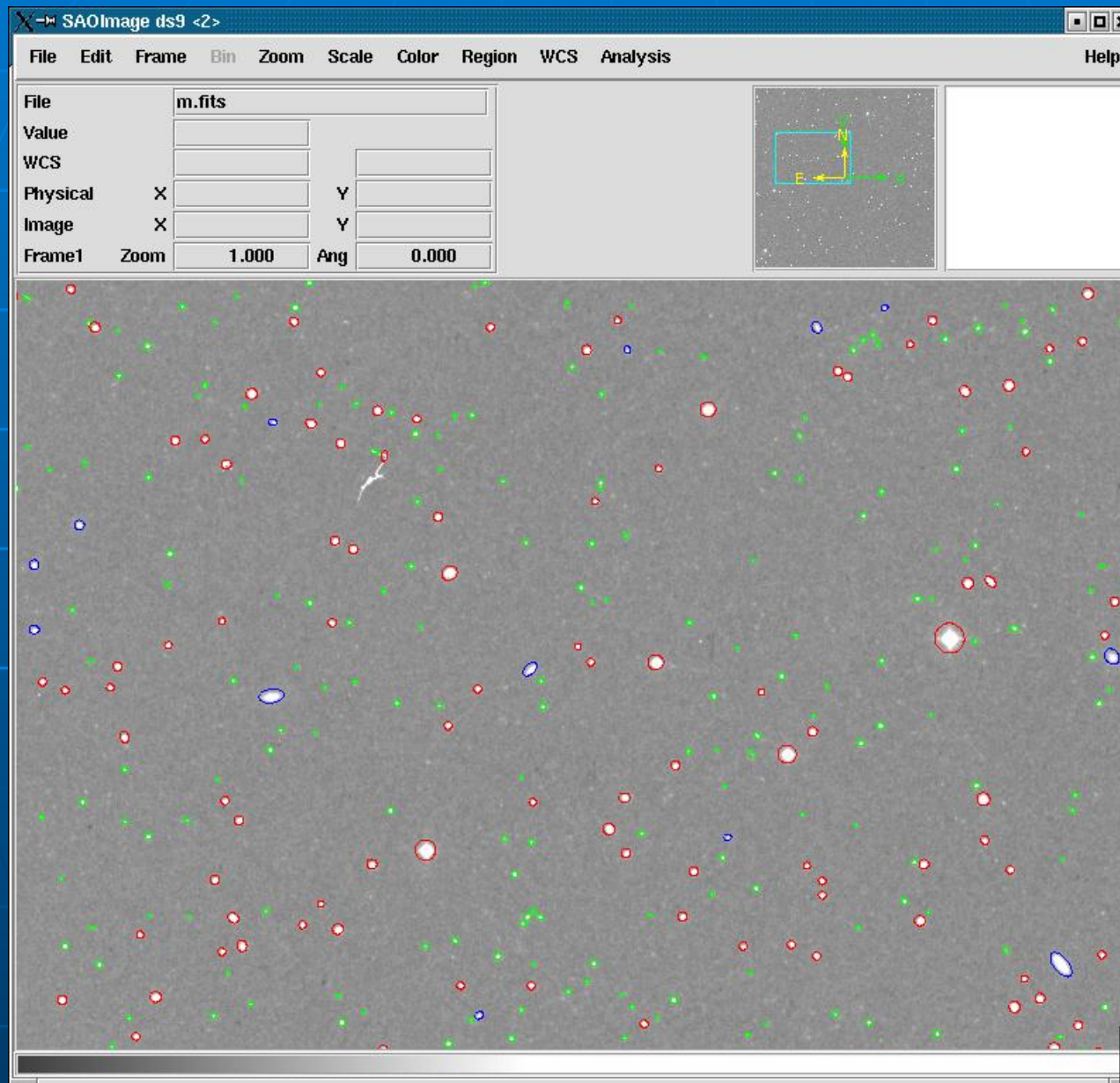
CIG 0714

Checking the isolation criterion: star/galaxy separation



- Example CIG0714
- Extraction of sources: SExtractor
- Star/Galaxy separation: Line of demarcation
- Assigned type:
 - Blue = galaxy
 - Red = star
 - Green = unknown

Checking the isolation criterion: other galaxies ?



Advantages of our method:

- extraction and S/G separation done with computer
- mag = 18
- redshift criterion
- isolation degree

Statistically significant sample of isolated galaxies

A- The sample of isolated galaxies

B- Complete multiwavelength information concerning the ISM:

1. Optical
2. H α
3. Infrared
4. Radiocontinuum emission
5. Molecular gas content
6. Atomic gas content

C- Public database

1. Optical

- Optical emission: L_B -Blue band- to account for the stellar content;
- sample: the 950 galaxies from CIG;
- data: blue luminosity from the Zwicky Catalogue.

Statistically significant sample of isolated galaxies

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B- Complete multiwavelength information concerning the ISM:

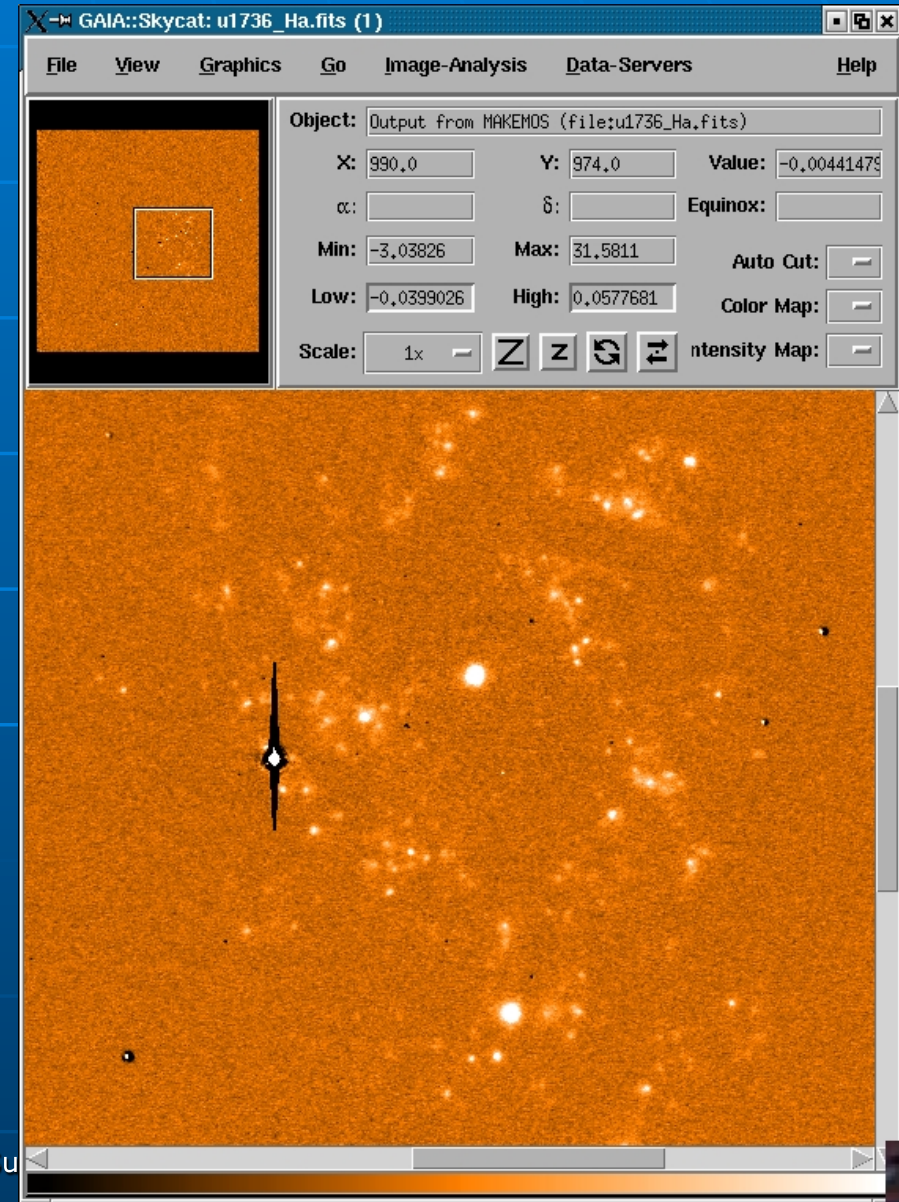
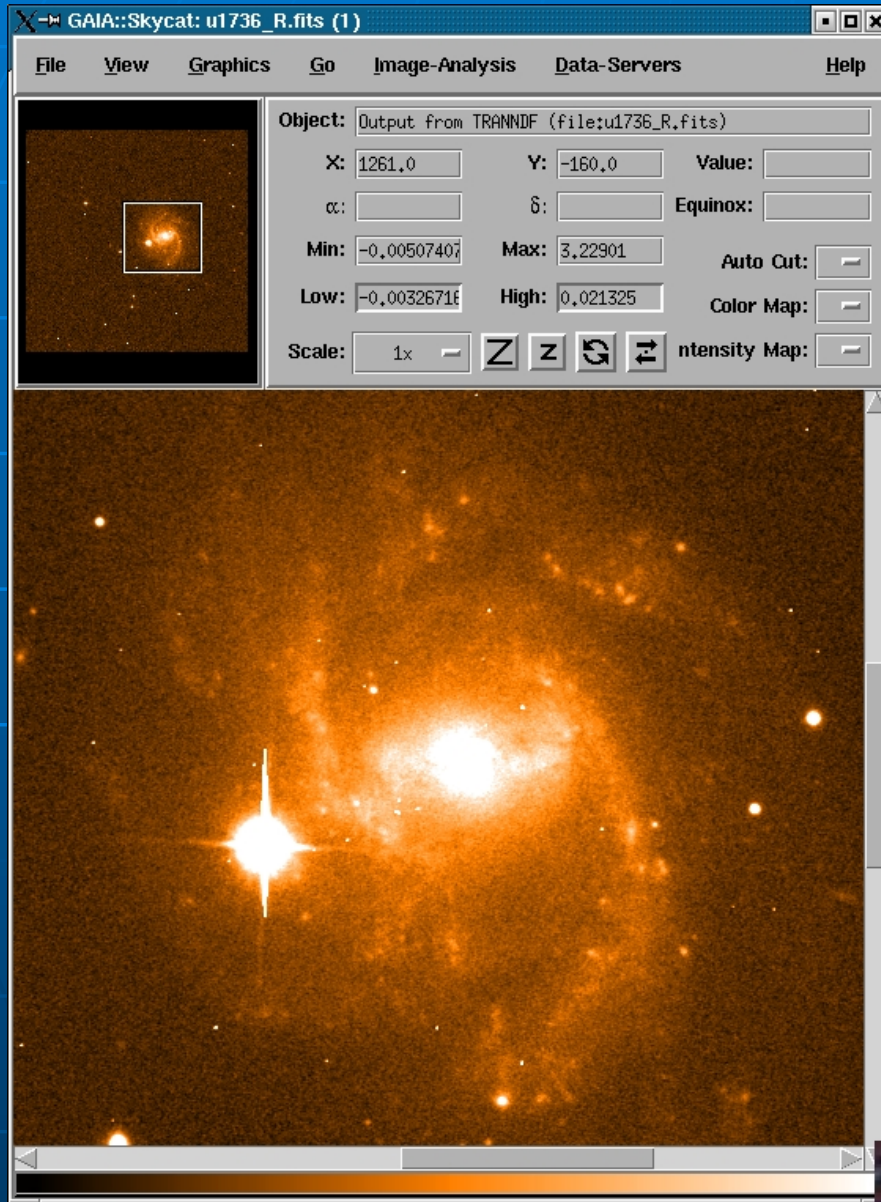
1. Optical
2. H α
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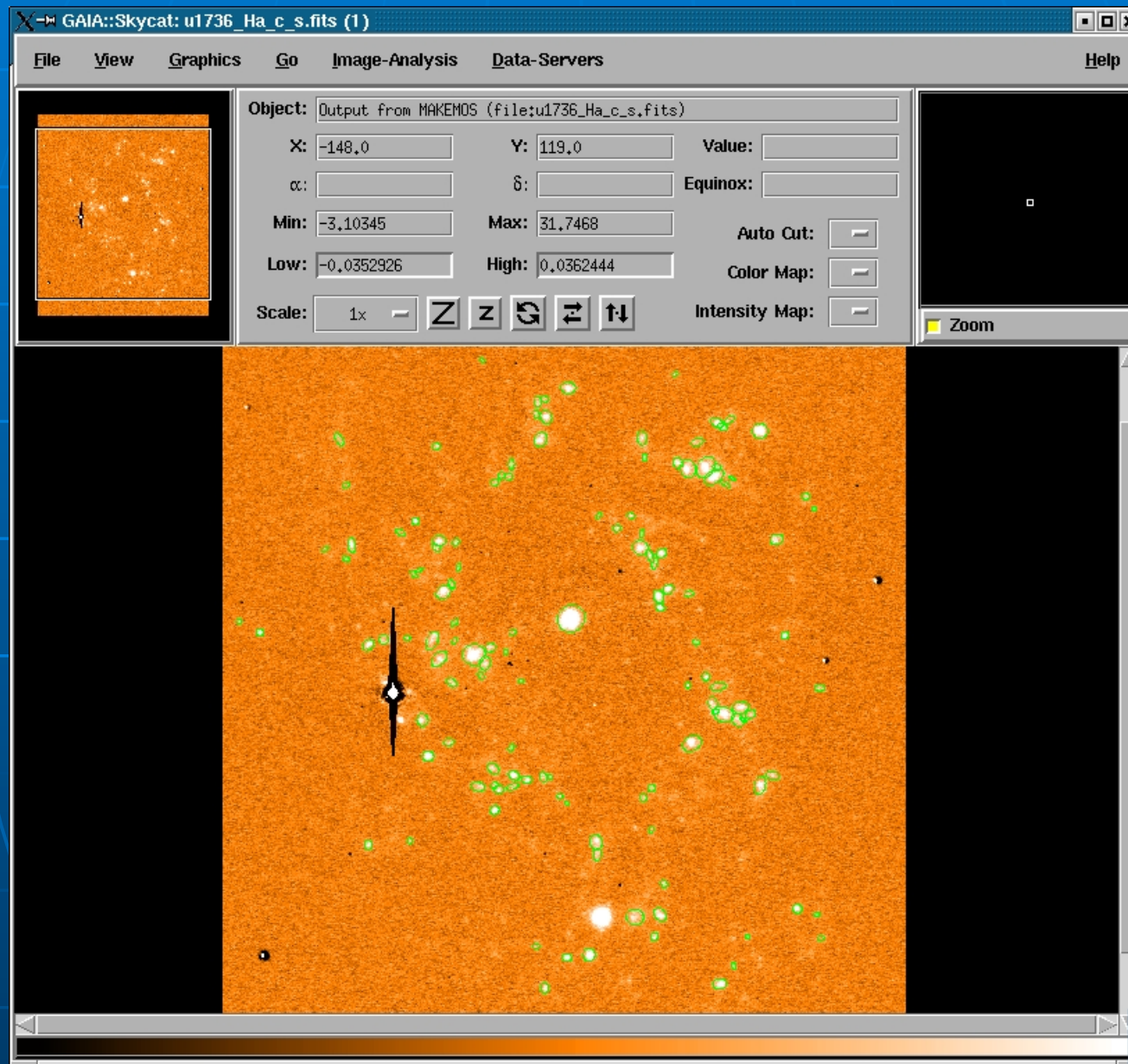
2. $H\alpha$

- $H\alpha$: recent star formation history tracer last 10^{10} years, $M > 20 M_{\text{sun}}$;
- sample: redshift limited subsample, i.e. 206 galaxies with $1500 \text{ km/s} < V < 5000 \text{ km/s}$;
- data: CCD photometry;
- telescopes:
 - Sierra Nevada Obs.: 1.5m;
 - Calar Alto Obs.: 2.2m & 1.52m;
 - Jacobus Kapteyn Telescope: 1.5m;
 - San Pedro Martir: 1.5m.

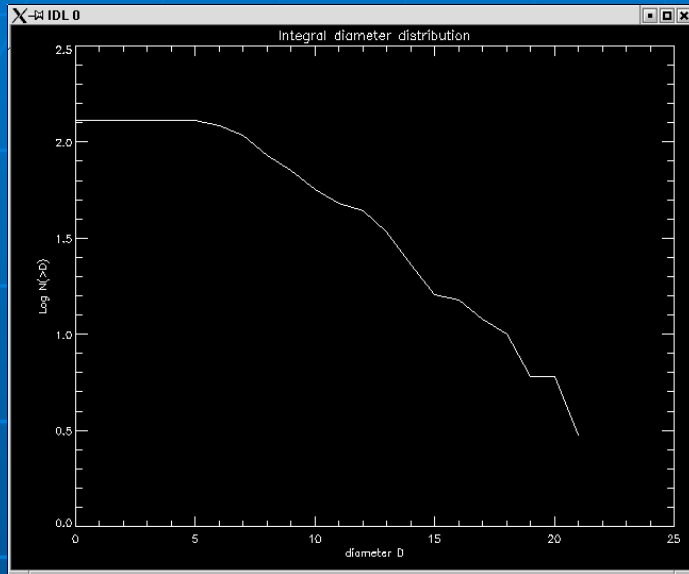
HII regions: example with CIG0096



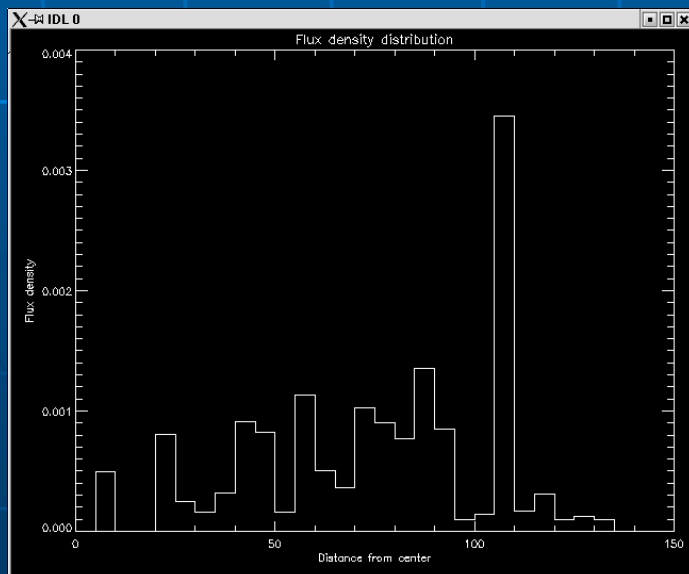
Extraction of HII regions: example with CIG0096



Features of HII regions: example with CIG0096

Integral diameter distribution:

- fitted by an exponential of form $N(>D) = N_0 \exp(-D/D_0)$
- characteristic diameter: 63 pc

Flux density distribution

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3. Infrared

- Far infrared: which corresponds to the thermal dust emission, warmed by young stars, $5 M_{\text{sun}} \rightarrow 100 \text{ Myrs}$;
- sample: the whole 950 galaxies CIG;
- data: IRAS data re-processed.



Analysing the Interstellar Medium of Isolated GALaxies



Isolated Galaxies - Part II -

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Vatican Observatory Summer School 2003

Statistically significant sample of isolated galaxies

A. The sample of isolated galaxies

B. Complete multiwavelength information concerning the ISM:

1. Optical
2. $H\alpha$
3. Infrared
4. Radiocontinuum emission
5. Molecular gas (CO line)
6. Atomic gas (HI line)

C. Public database

4.Radiocontinuum emission

- RADIOCONTINUUM EMISSION: A tracer of the current SFR and the nuclear activity (AGN)
- SAMPLE: Whole sample.
Radiocontinuum surveys considered:

Survey	Frequency	resolution	Isolated galaxies of our sample found
WENSS	320 MHz	55''	139
NVSS	1.4 GHz	50''	622
GB6	4.8 GHz	7'	240

non thermal
(synchrotron radiation)

both thermal (free-free emission) and non thermal radiation

- GOALS: -Correlations with other wavelengths (FIR-Radiocontinuum, for example)

Statistically significant sample of isolated galaxies

A. The sample of isolated galaxies

B. Complete multiwavelength information concerning the ISM:

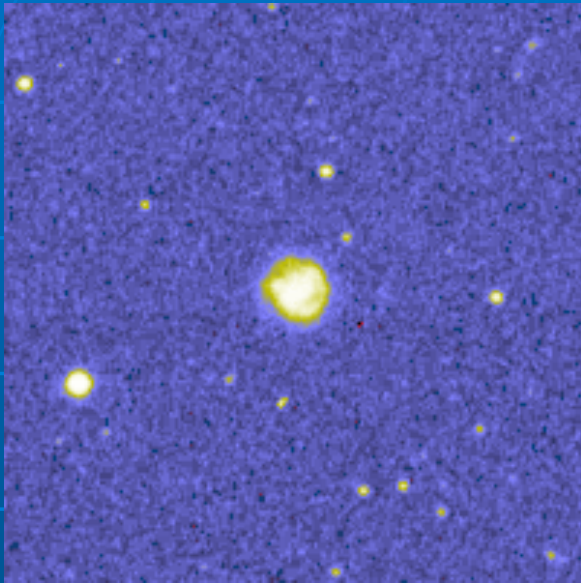
1. Optical
2. $H\alpha$
3. Infrared
4. Radiocontinuum emission
5. Molecular gas (CO line)
6. Atomic gas (HI line)

C. Public database

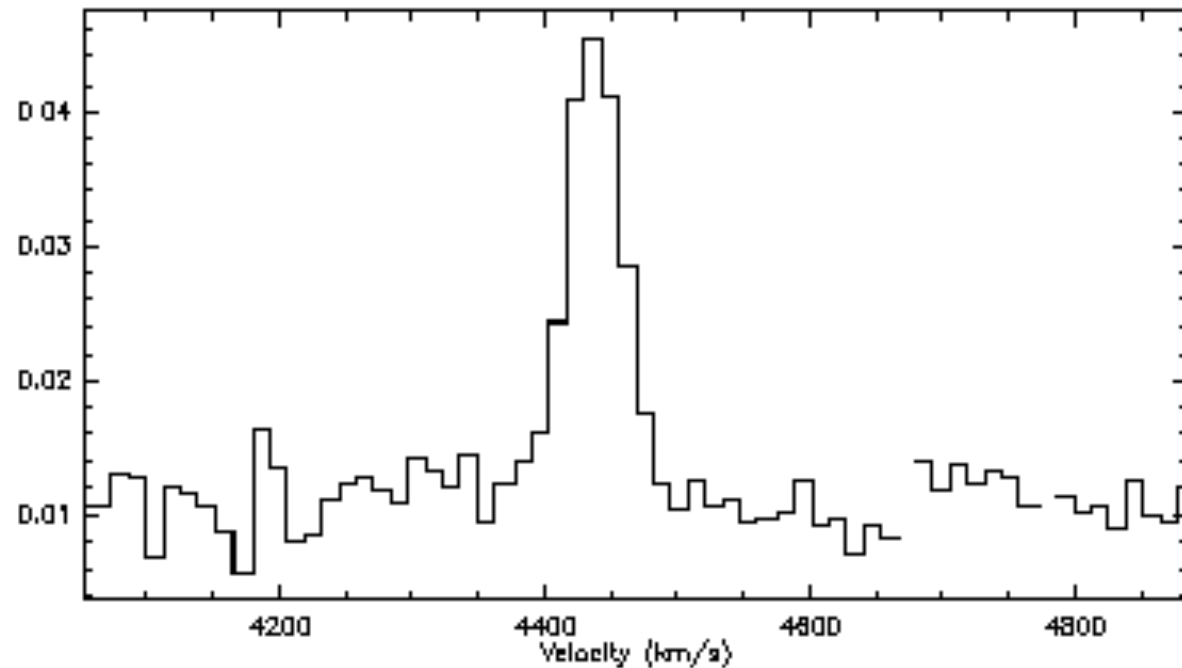
5.Molecular gas

- CO: Tracer of H_2 , which is the material for the SF.
- SAMPLE: Redshift limited subsample. 206 galaxies
- DATA:
 - Search in the literature.
 - Single dish observations .
 - Radiotelescopes: FCRAO 14m
(Massachusetts, USA) , IRAM 30m
(Granada, Spain), Nobeyama (Japan).
- GOALS: Compare with SF in denser environments

CO profile example: CIG 444



POSSI



Radial velocity : 4469 +/- 9 km/s

Diameters (arcmin) : 0.8 x 0.8

Magnitude : 13.43

Type : SB(s)m

FCRAO 14m

Flux CO = 1.85 +/- 0.11 K km/s

W = 170 km/s

velocity CO = 4435 +/- 20 km/s

Statistically significant sample of isolated galaxies

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B. Complete multiwavelength information concerning the ISM:

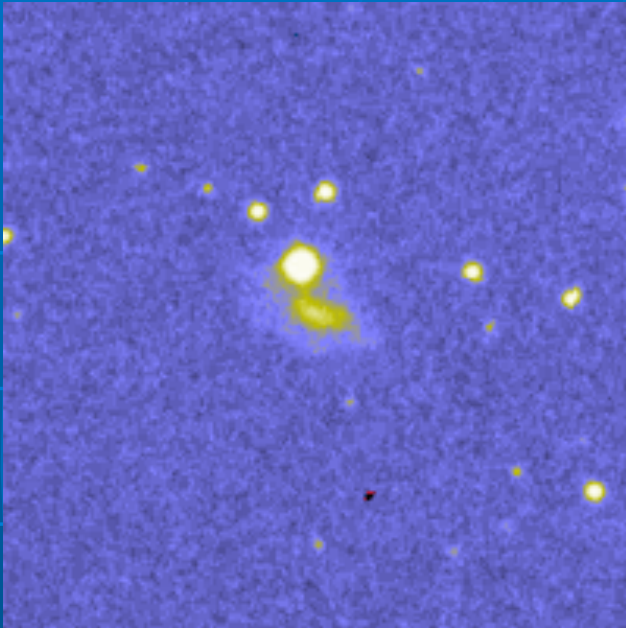
1. Optical
2. H α
3. Infrared
4. Radiocontinuum emission
5. Molecular gas (CO line)
6. Atomic gas (HI line)

C. Public database

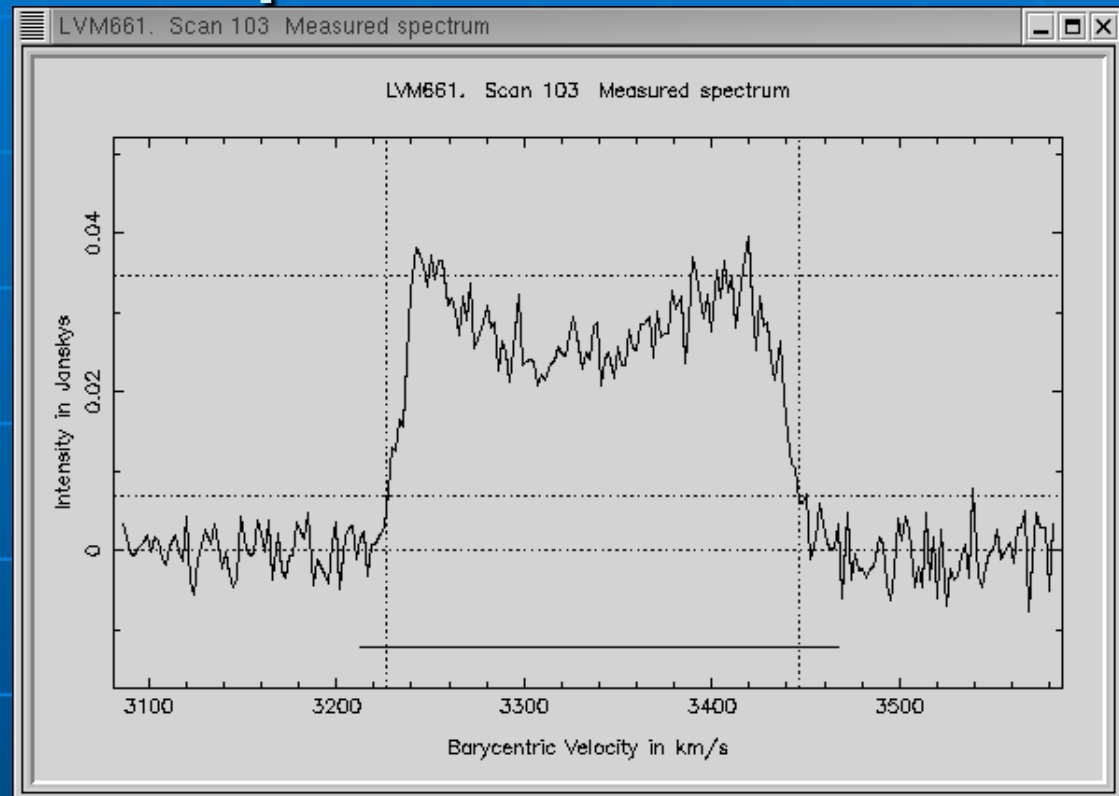
6.Atomic gas

- HI: Extent is larger than optical. A very sensible tracer of interaction (and fundamental ingredient of ISM) .
- SAMPLE:
 - Whole sample.
 - Search in the bibliography.
 - Single dish observations at several radiotelescopes: Arecibo 304m, Effelsberg 100m, Nançay, NRAO 91m.
- GOALS:
 - HI content
 - Symmetry of the profiles

HI profile example: CIG 661



POSSI



NRAO 91m

Radial velocity : 3341 ± 9 km/s

Diameters: 1.3×0.9 arcmin

Magnitude : 15.1

Type: Sm

Flux HI = 6.05 ± 0.11 Jy km/s

$W=220$ km/s

velocity HI = 3336 ± 10 km/s

6.1.HI content

- REFERENCE OF ISOLATED GALAXIES

Until now the best reference was Haynes et al 1984 = 324 isolated galaxies observed in HI; or field galaxies.

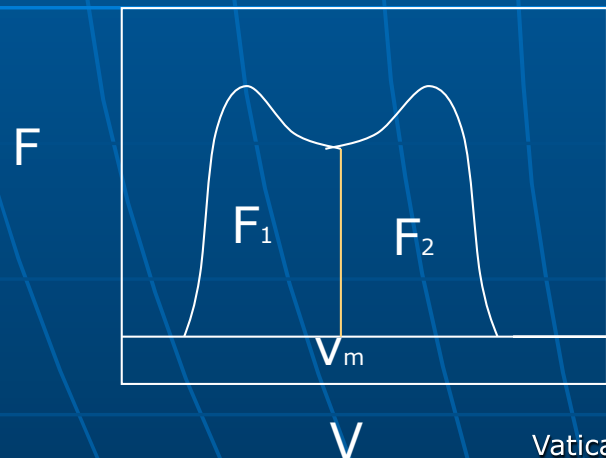
- DENSER ENVIROMENTS

For example, spirals in clusters are HI deficient (Van Gorkom et al 1996) and some of them are stripped until 90 % of their atomic gas (Haynes et al 1990).

-> DEFICIENCY CAUSED BY INTERACTION

6.2. HI-profile asymmetry

- EXPLANATION OF LOPSIDENESS:
 - 1) Pointing offsets of the radiotelescope.
 - 2) Confusion with companions within the radiotelescope beam.
 - 3) Noncircular motions.
 - 4) True distortions in the HI mass distribution.



$$a = \frac{F_1}{F_2}$$

6.2. HI-profile asymmetry

1. OTHER SAMPLES OF ISOLATED GALAXIES

N=104 Haynes et al 1998

N=30 Matthews et al 1998

50 % of them have
asymmetric profiles!

2. OTHER ENVIRONMENTS

-Clusters

N=30 Sp Van Driel et al 1998

77%

N=1700 Richter & Sancisi 1994

50 %

(Visual examination)

-Groups

N=100 Sulentic & Arp 1983 most of asymmetric prof. are
not isolated galaxies

3. OUR SAMPLE OF ISOLATED GALAXIES

coming soon

Statistically significant sample of isolated galaxies

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2. $H\alpha$
3. Infrared
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5. Molecular gas content (CO line)
6. Atomic gas content (HI line)

C. Public database

C.Public database

The screenshot shows a Netscape browser window displaying the AMIGA database website. The browser's address bar shows the URL `http://www.iaa.csic.es/~amiga`. The website header features the CSIC logo, the AMIGA logo, and the text "Analysing the Interstellar Medium of Isolated Galaxies". A navigation menu includes "The Project", "The Group", "The Database", "Publications", and "Links". The "Database" section is active, showing a list of links under "General Documentation" and "Menu". A central image displays a B-band image of a galaxy with a coordinate system.

Untitled Document - Netscape

Mail Home Radio My Netscape Search Bookmarks Google Support Shop Products Tr...

Untitled Document Your NED Search Results CIG.IMOPTICO_CIG running on loc...

AMIGA
Analysing the Interstellar Medium of Isolated Galaxies

The Project The Group The Database Publications Links

Database

General Documentation

- [What's AMIGA Database?](#)
- [How can I search in AMIGA Database](#)
- [How can I retrieve the information?](#)

Menu

- [Fundamental Physics Parameters](#)
- [Photometry & SED](#)
- [Images & Maps](#)
- [Wavelengths](#)
- [Batch Jobs](#)

BIG 1001 (J20 74 79) B band

offset (arcmin)

offset (arcmin)

Transferring data from ux2.iaa.csic.es...

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Mail Home Radio My Netscape Search Bookmarks Google Support Shop Products Tr

Untitled Document Your NED Search Results CIG.IMOPTICO_CIG running on loc...

Search by Parameters

Input Parameters

Coordinates

Choose epoch

Equinox J2000

Define a center

Coord.	Format	Value
RA	<input checked="" type="radio"/> (h,m,s)	12 h. 00 m. 00.00 s.
	<input type="radio"/> decimal (degrees)	000.000000
DEC	<input checked="" type="radio"/> (d,m,s)	+30 d. 00 m. 00.00 s.
	<input type="radio"/> decimal (degrees)	000.000000

Choose a field type

Circular Radius 10 deg

Rectangular RA 00 arc min DEC 00 arc min

Velocity

Between : 1500 <= Km/sec <= 99999

Morfology

Include all types

Sending request to ux2.iaa.csic.es...

Untitled Document - Netscape

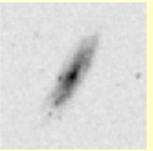
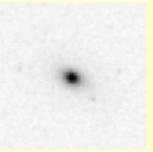
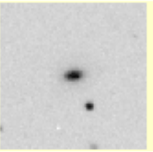
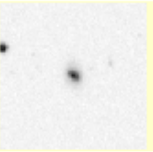
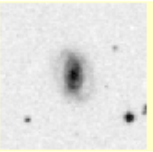
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Database

AMIGA Fundamental Parameters Search Results

5 objets found.

Name	Equatorial J2000		Morf	Dia.(pc)	P.A.	Incl.	mag.	Vel. (Km/sec)	Ref.	Images
	RA.	DEC.								
CIG S07	11h 52m 37.956s	24d 18' 28.280"	Sbc	1.5	151	79.250	13.69	4942.0±7.0	2	
CIG S17	12h 2m 52.092s	26d 15' 11.410"	SO	0.4	64	57.665	15.46	9633.0±30.0	2	
CIG S29	12h 24m 57.736s	24d 22' 58.990"	E-SO	0.4	0	51.916	15.35	99999.0±99.0	2	
CIG S37	12h 35m 1.256s	25d 46' 47.210"	S?	0.3	6	49.364	15.98	8843.0±0.0	2	
CIG S44	12h 41m 20.061s	30d 7' 19.360"	SBab	0.8	11	52.970	14.57	8184.0±32.0	2	

You can retrieve all these data in the formatted ASCII file [file.tar.gz](#) (*)

*This file no include images.
Include a fortran and a perl script to read the table.*

Sending request to ux2.laa.csic.es...

Status of the project

- Isolation criteria: 77 % of the POSS fields checked
- L_B y L_{FIR} for the whole sample
- 36 % $H\alpha$ of the subsample observed
- 67 % CO of the subsample observed or compiled
- 85 % HI data has been observed or compiled
- 80 % radio continuum reprocessed



IAA-CSIC, Granada



Effelsberg
100m, Bonn, Germ.



Arecibo 304m, Puerto
Rico



FCRAO 14m,
Mass., USA



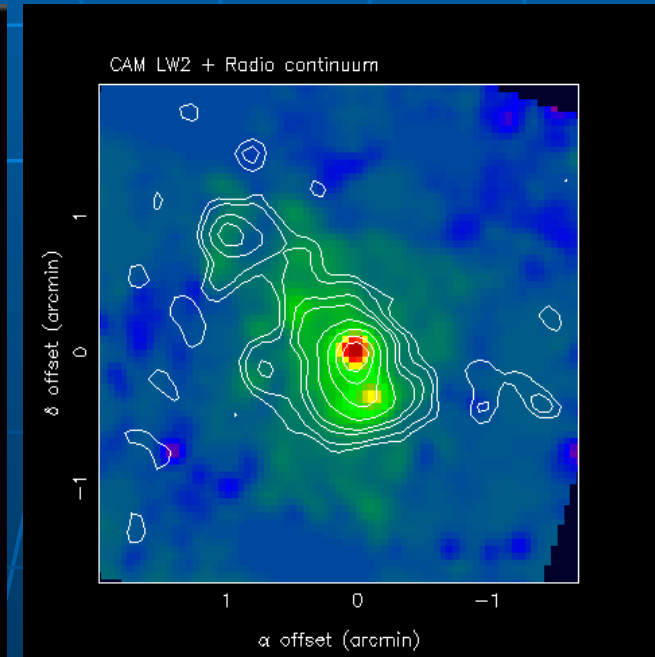
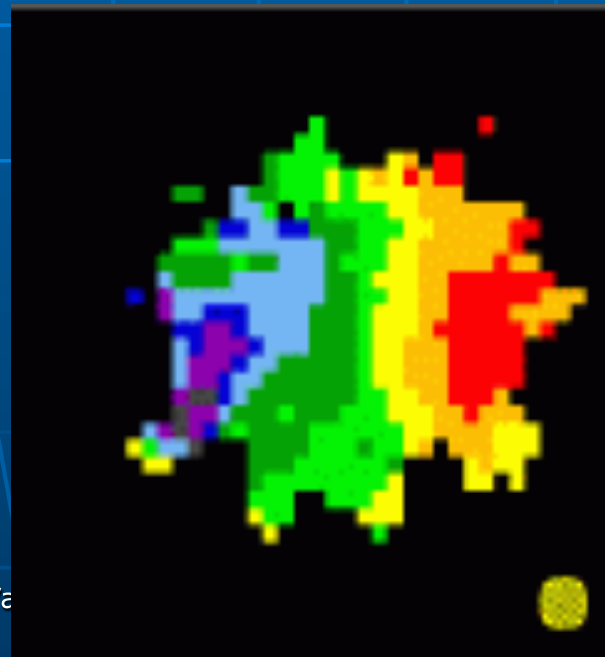
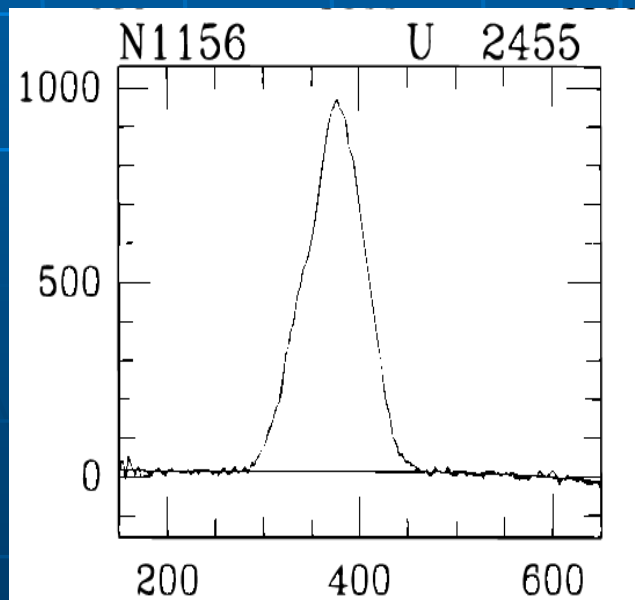
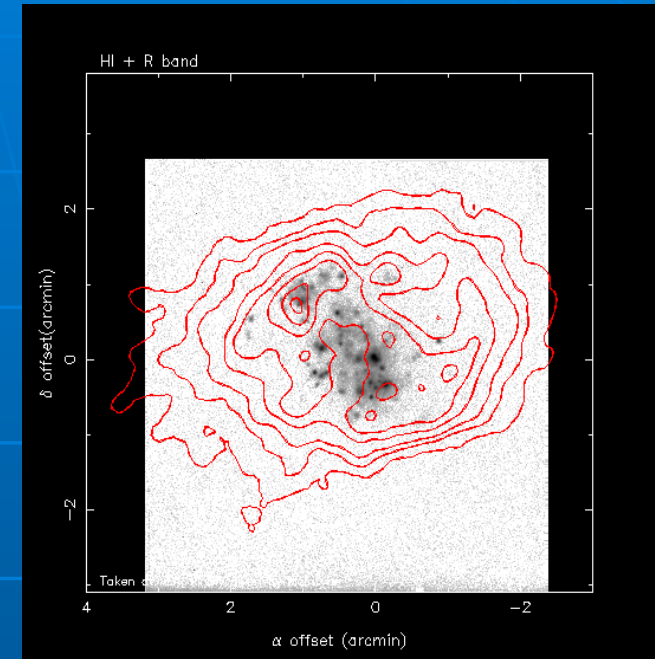
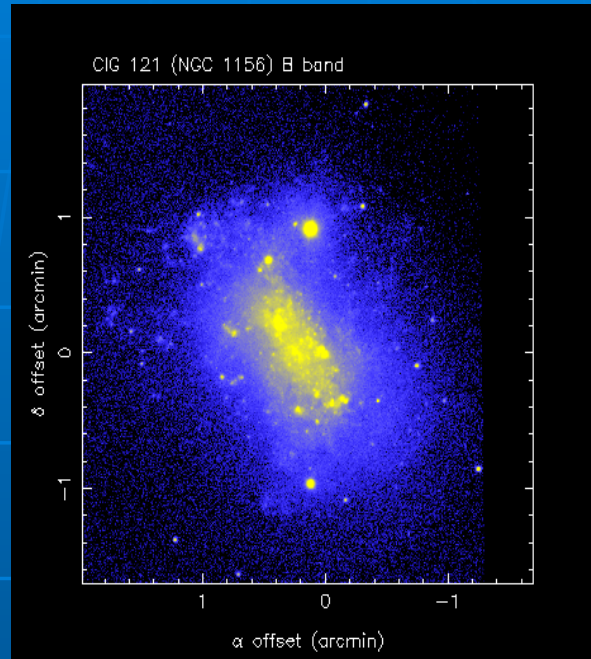
IRAM 30m, Granada
Spain



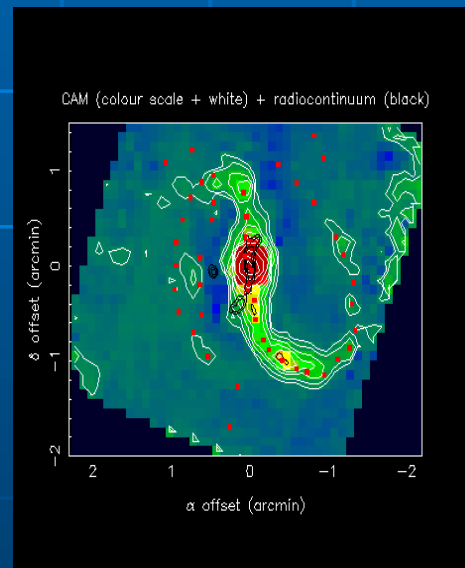
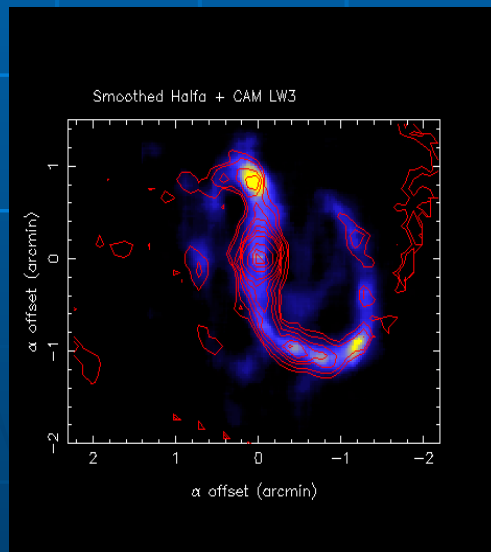
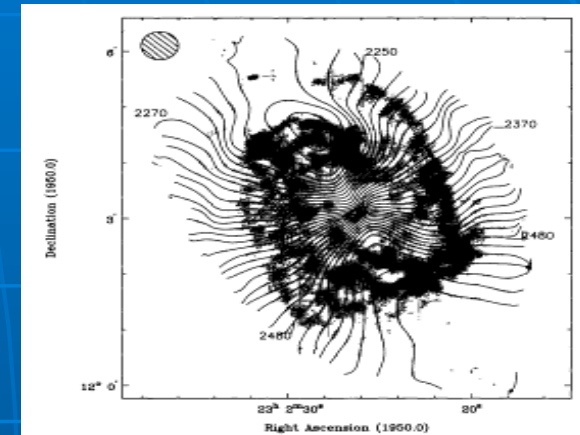
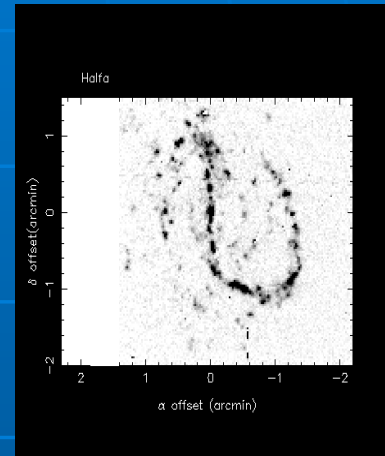
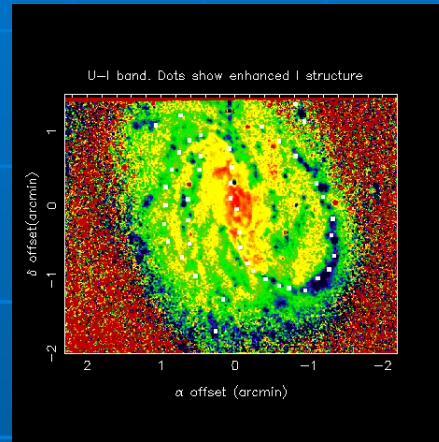
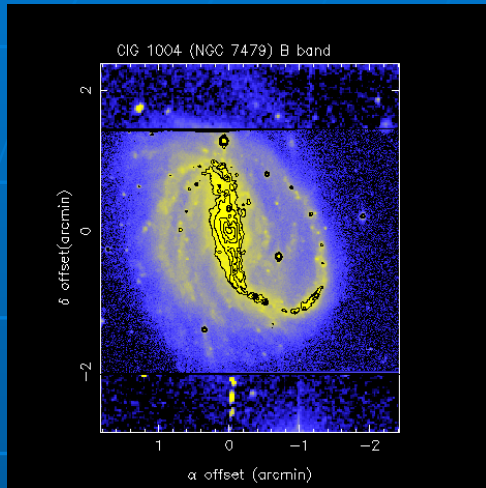
Nançay, France

CIG 121

- $v = 382$ km/s
- $D = 7.8$ Mpc
- $\log(L_B/L_{sol}) = 9.31$
- $\log(L_{FIR}/L_{sol}) = 8.73$
- $\log[M(HI)/M_{sol}] = 8.6$
- $\log(LH\alpha/erg\ cm^{-2}) = 40.8$
- $\log(SFR/area) = -1.99$
- $1\ kpc = 26''$



CIG 1004



$$v = 2376 \text{ km/s}$$

$$D = 31.7 \text{ Mpc}$$

$$\log(L_B/L_{\text{sol}}) = 10.73$$

$$\log(L_{\text{FIR}}/L_{\text{sol}}) = 10.35$$

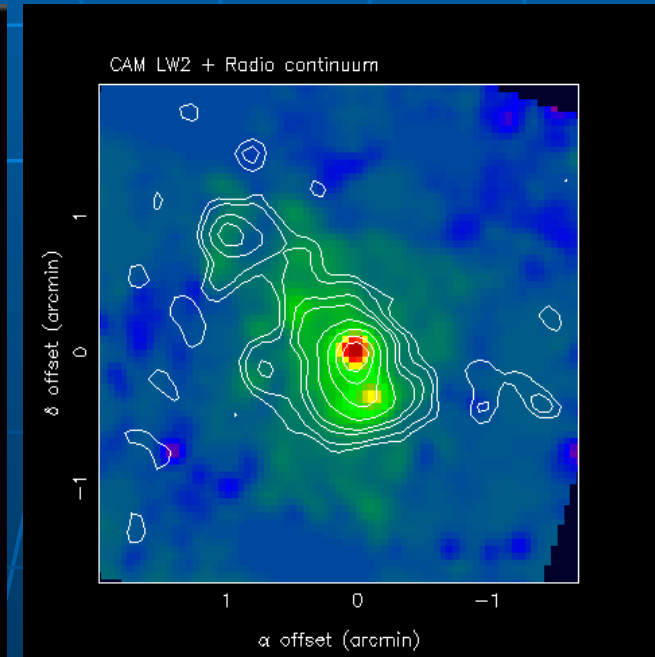
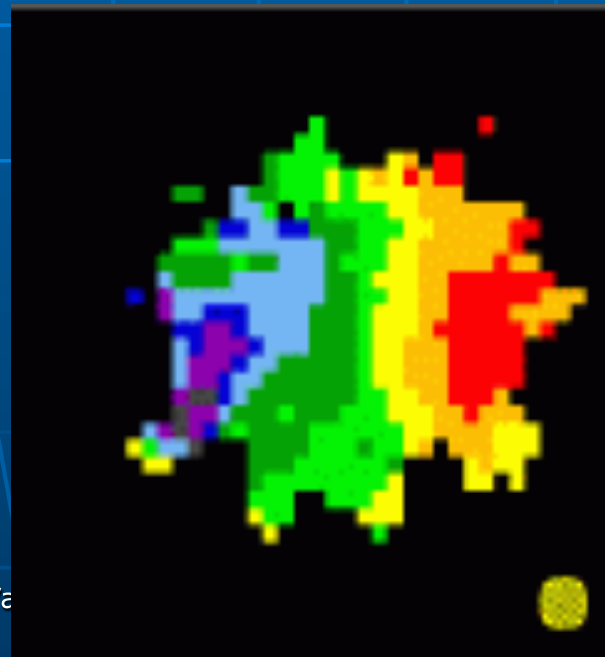
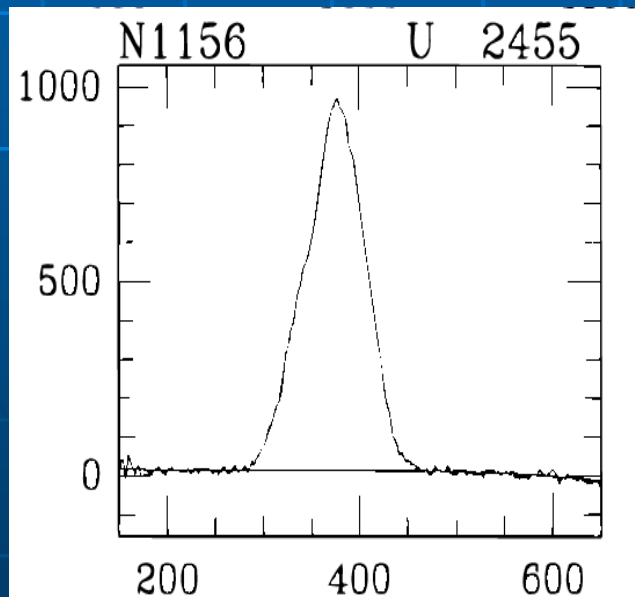
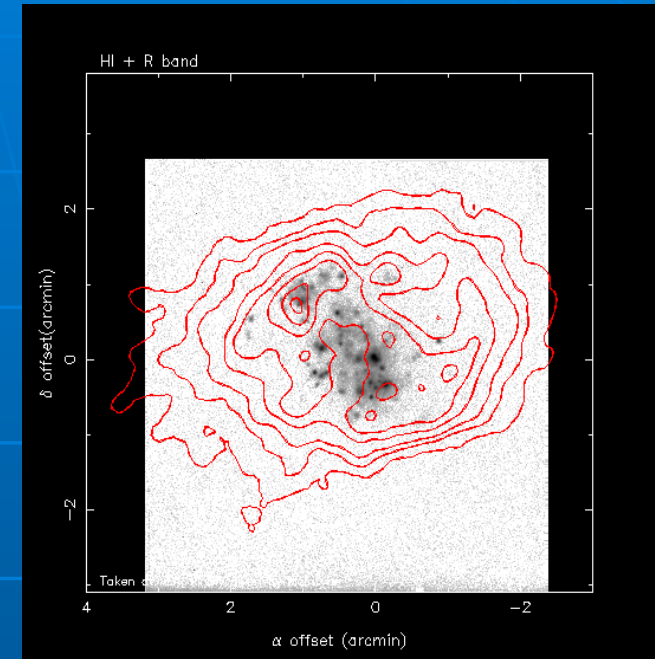
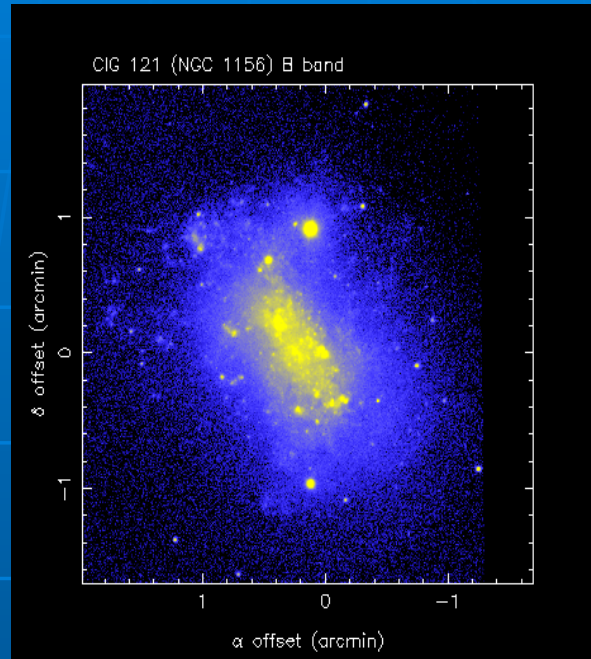
$$\log[M(\text{HI})/M_{\text{sol}}] = 9.9$$

$$\log(L\text{H}\alpha/\text{erg cm}^{-2}) = 42.1$$

$$1\text{kpc} = 6''$$

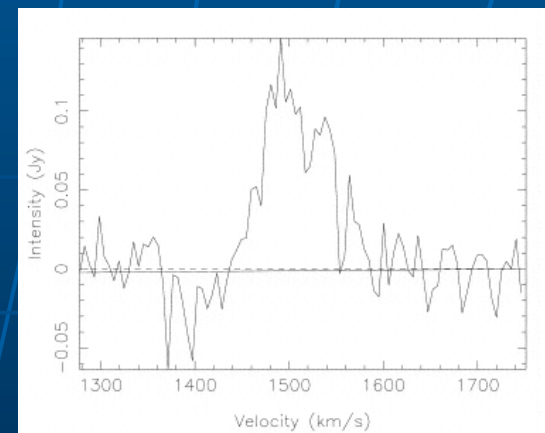
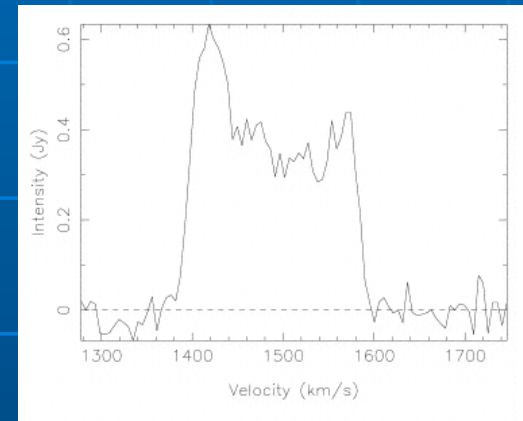
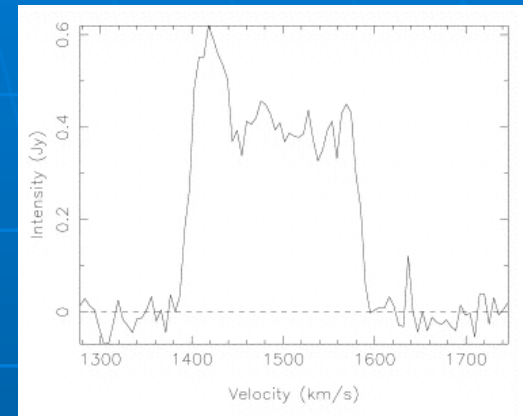
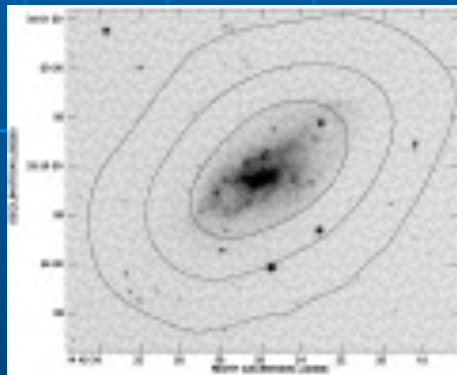
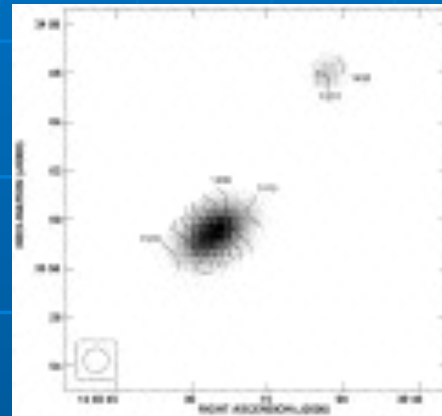
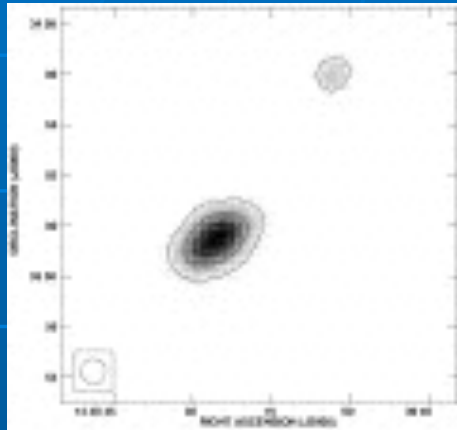
CIG 121

- Optical: Larsen, NOT tel.
- Ha: Hunter, Perkins tel.
- HI data:
 - imaging: Van der Hulst, WST-WHISP
 - single dish: Haynes et al (1998), NRAO 43m
- Radiocontinuum: Condon et al (1996), VLA .



Example of isolated galaxy with dwarf companion

CIG 642



(D. Pisano et al 2000, VLA)