

The AMIGA project – Asymmetries in isolated galaxies



Pablo Ramírez Moreta

Ph.D. student at IAA-CSIC

Thesis advisors:

Lourdes Verdes-Montenegro (IAA-CSIC, Spain)
Stephane Leon (ESO, Chile)



AMIGA project



Analysis of the interstellar **M**edium of **I**solated **G**Aaxies



<http://amiga.iaa.es>

AMIGA project



Analysis of the interstellar **M**edium of **I**solated **G**Aaxies



<http://amiga.iaa.es>

identification and multiwavelength study

of a

statistically significant sample

of the

most isolated galaxies in the Local Universe

AMIGA project



Analysis of the interstellar **M**edium of **I**solated **G**Aaxies



<http://amiga.iaa.es>

identification and multiwavelength study

of a

statistically significant sample

of the

most isolated galaxies in the Local Universe

identification

sample

isolated

AMIGA project



AMIGA project:

MULTIWAVELENGTH observations of a **LARGE** sample

CIG

size:

1051 galaxies

isolation:

no similar galaxies (1/4 – 4x SIZE) within $40 * R_{\text{companion}}$

depth:

large volume , OLF sampling up to ~ 15.000 km/s

what is ‘isolated’ ?



In the last 40 years...

Turner & Gott (1975)

Balkowski & Chamaraux (1981)

Vettolani et al. (1986)

Zaritsky et al. (1993)

Aars et al. (2001)

Colbert et al. (2001)

Pisano et al. (2002)

Prada et al. (2003)

Márquez & Moles (1996, 1999)

Márquez et al. (2002, 2003)

Varela et al. (2004)

...

identification: first steps



V. Karachentseva 1973
(POSS1)

isolation:

no similar galaxies (1/4 – 4x SIZE) within $40 * R_{\text{companion}}$

sample: CIG



V. Karachentseva 1973: Catalogue of Isolated Galaxies
(POSS1)

CIG

size:

1051 galaxies

isolation:

no similar galaxies ($1/4 - 4 \times \text{SIZE}$) within $40 * R_{\text{companion}}$

depth:

large volume , OLF sampling up to $\sim 15.000 \text{ km/s}$

sample: CIG



Classic samples:

MONOCHROMATIC observations of **LARGE** samples

MULTI WAVELENGTH observations of samples

of small samples

sample: CIG



Classic samples:

MONOCHROMATIC observations of **LARGE** samples

MULTI WAVELENGTH observations of small samples

of small samples

AMIGA project:

MULTIWAVELENGTH observations of a **LARGE** sample

identification... criteria ?



let's push this a bit further...

isolation criteria revision



POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

Verley PhD

Verley+ 2007ab

$V > 1500 \text{ km/s}$ for proper isolation evaluation

isolation criteria revision



Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_K

isolation criteria revision

Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_K



isolation criteria revision



Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_K

Tidal force estimation: Q_{Kar}

isolation criteria revision

Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation
Local number density: η_K

Tidal force estimation: Q_{Kar}



isolation criteria revision

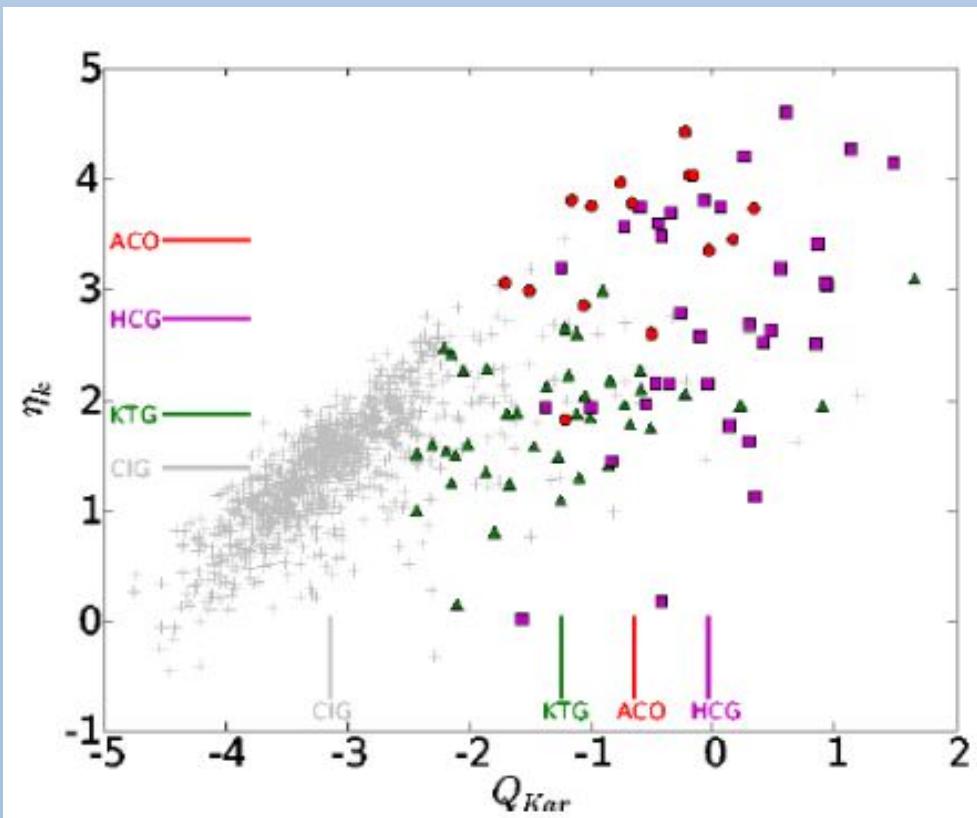
Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_k

Tidal force estimation: Q_{Kar}



isolation criteria revision



Verley PhD
Verley+ 2007ab

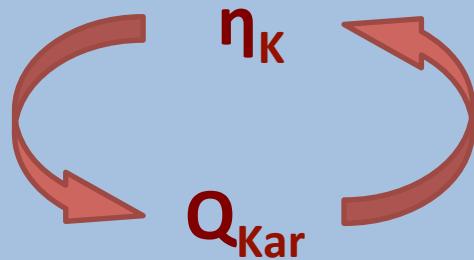
POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_K \rightarrow minor companions

Tidal force estimation: Q_{Kar}

- complementary parameters



- velocities $< 1500 \text{ km/s}$: 100 CIGs X

- perturbations $\Leftrightarrow 1\%$ ($\eta_K = 2.4$) Athanassoula 1984
Varela et al. 2004

159 CIGs Q_{kar} X
 η_K X

isolation criteria revision



Verley PhD
Verley+ 2007ab

POSS-I+II $R \geq 0.5 \text{ Mpc}$ $m_B < 17.5$

$V > 1500 \text{ km/s}$ for proper isolation evaluation

Local number density: η_K \rightarrow minor companions

Tidal force estimation: Q_{Kar}

CIG

1051 \rightarrow **792 galaxies**

- complete up to $BT = 15.3 \text{ mag}$
(test V/V_m Schmidt 1968)

Morphologies:

- E, E/S0 = 6%
- S0, S0a = 9%
- Sa – Sab = 4%
- Sb – Sc = 65%
- Scd – Im = 16%

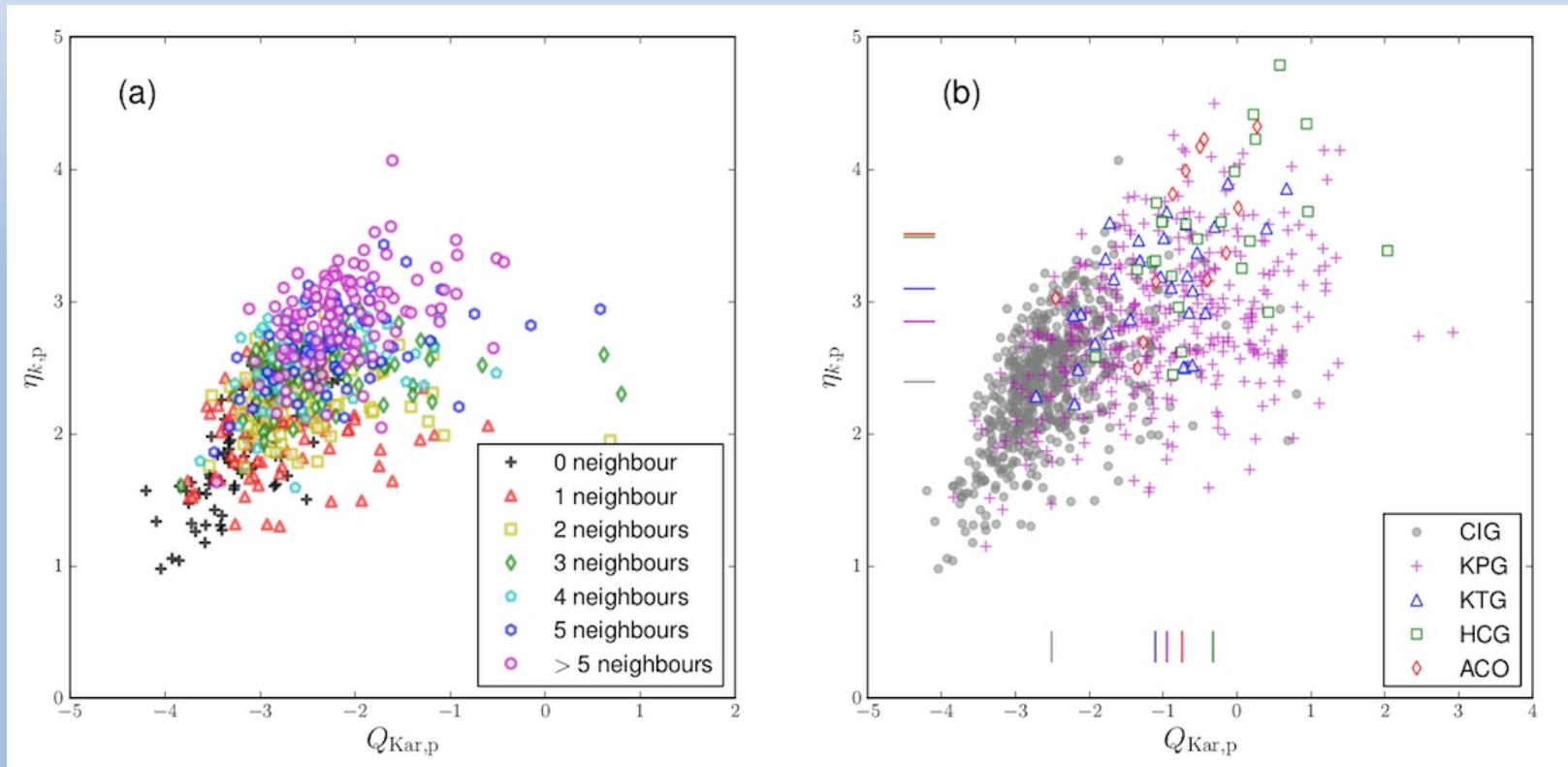
Sulentic+ 2006

Fernandez-Lorenzo+ 2012

isolation criteria revision: SDSS

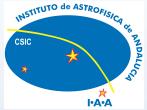
Fernandez-Argudo+2013 and Ph.D

freshly baked!



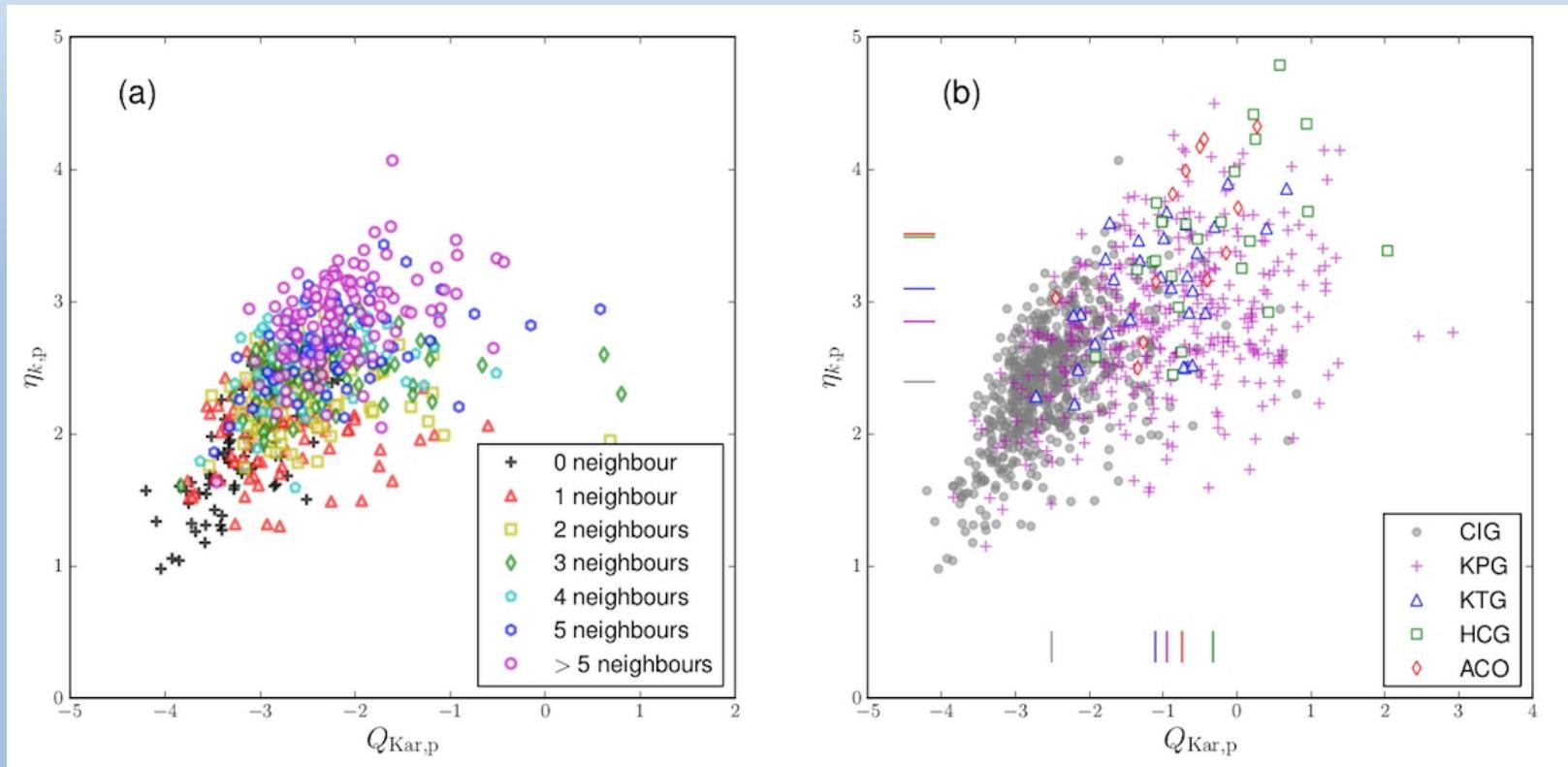
Photometric isolation parameters: approx. 1/3 comp. have $\Delta(V) < 250$ km/s

isolation criteria revision: SDSS



Fernandez-Argudo+2013 and Ph.D

freshly baked!



Spectroscopic data: 50% are background objects!

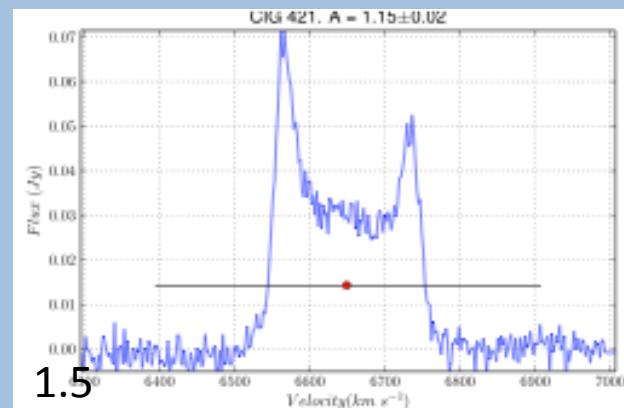
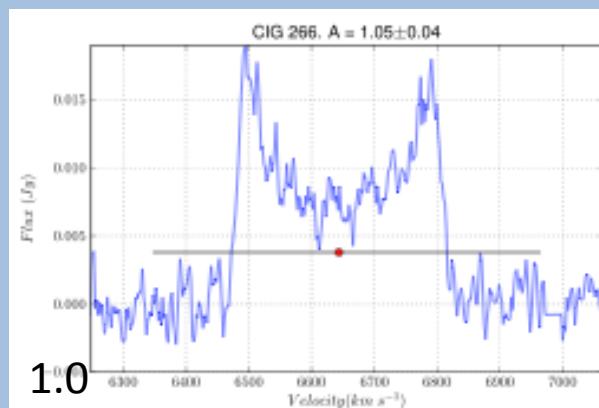
347 CIGs

multiwavelength results

- ✓ **dominant types:** Sb - Sc
- ✓ **lowest values** (VS any other sample) of:
 - L_B (early types):

$M_*(S) \geq M_*(E)$: no "fossil" merger population
modest sample of primordial E/SO?

- L_{FIR}
- atomic gas asymmetry:
only 2% $A_{3\sigma} > 1.39$
- radiocontinuum



Leon+ 08

Espada+ 06, 11

multiwavelength results

✓ ***lowest values*** (VS any other sample) of:

- molecular gas Lisenfeld+ 11
- lower dispersion of (redder) colors:
more passive SF Fernández-Lorenzo+ 12

✓ ***bars***:

- NOT preferentially barred/unbarred Verley+07
- larger bars Durbala+ 08

✓ ***pseudobulges***:

many perspectives!

- present in most Sb-Sc Durbala+ 08,09
- redder colors than the disks Fernández-Lorenzo+ 14



my particular work for AMIGA



Asymmetries in isolated galaxies:
looking for and studying faint structures

the study of faint features



tidal interactions → asymmetries

typical R = 25 kpc CIG → 3 Gy not visited by any other galaxy
(typical field velocity = 150 km/s)

highly isolated galaxies → *no apparent reason for such search*

the study of faint features



tidal interactions → asymmetries

typical R = 25 kpc CIG → 3 Gy not visited by any other galaxy
(typical field velocity = 150 km/s)

highly isolated galaxies → *no apparent reason for such search*

however...

the study of faint features



tidal interactions → asymmetries

typical $R = 25$ kpc CIG → 3 Gy not visited by any other galaxy
(typical field velocity = 150 km/s)

highly isolated galaxies → *no apparent reason for such search*

however...

faint halo substructures may survive several Gy

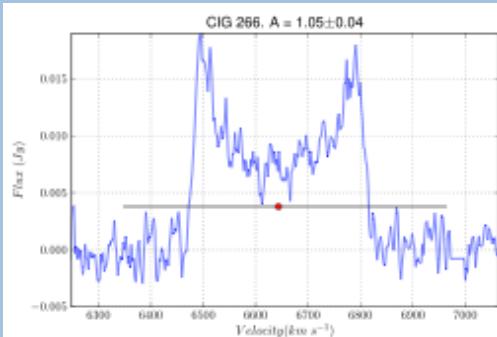
Peñarrubia+ 05

the study of faint features

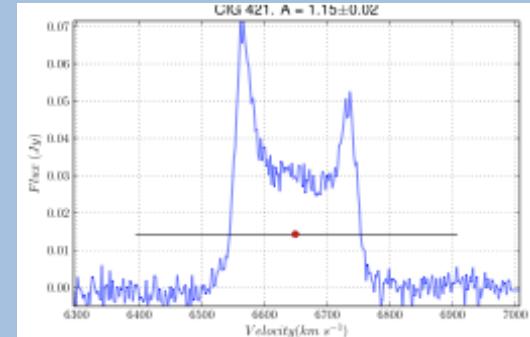
tidal interactions → asymmetries

typical R = 25 kpc CIG → 3 Gy not visited by any other galaxy
(typical field velocity = 150 km/s)

highly isolated galaxies → *no apparent reason for such search*



and we DO see asymmetries in
optical and HI



**DOES THIS IMPLY THAT SECULAR EVOLUTION PROCESSES
CAN LEAD TO ASYMMETRIES?**

Espada+ 06, 11

the study of faint features



open possibilities for the asymmetries in isolated galaxies:

- disrupted (small) companions

Weinberg & Blitz 06

- cold HI clouds accretion

Westmeier+ 08

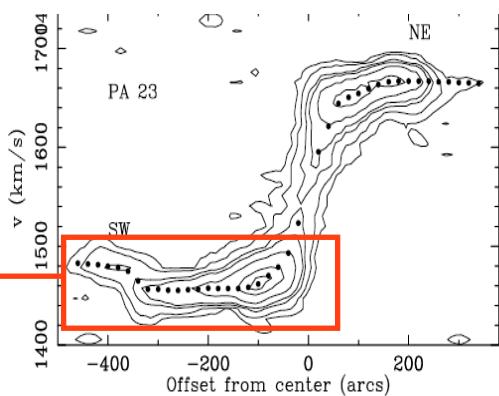
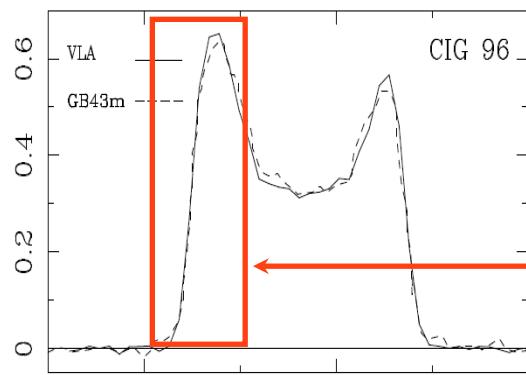
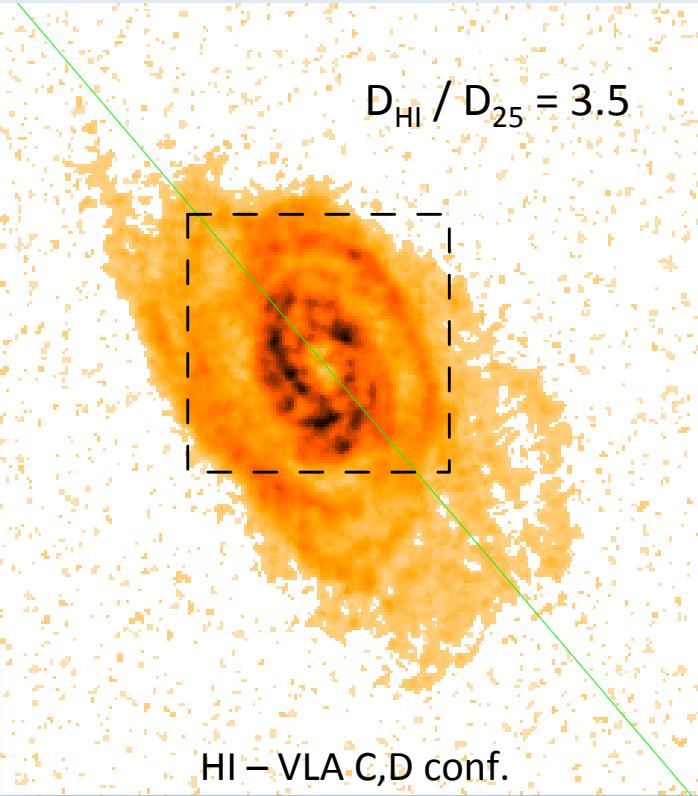
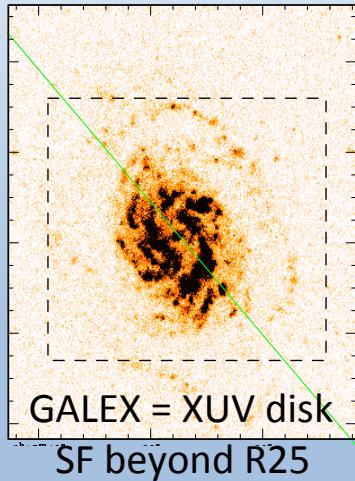
- baryonic disks vs DM halos misalignment

Dubinski & Kuijken 95

the study of faint features



CIG96 - SDSS



Espada+ 06, 11

today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

INT

WHT

NOT

ALMA

soon, hopefully...



today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

INT

WHT

NOT

ALMA

soon, hopefully...



today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

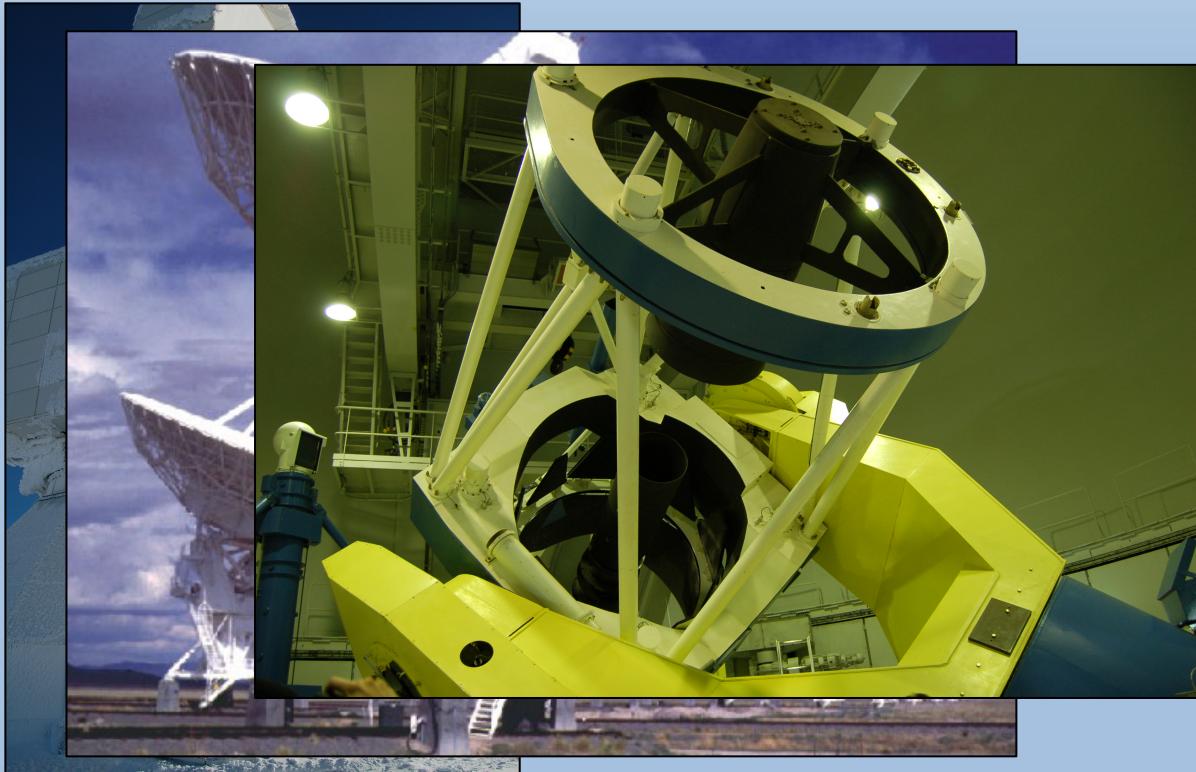
INT

WHT

NOT

ALMA

soon, hopefully...



today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

INT

WHT

NOT

ALMA

soon, hopefully...



today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

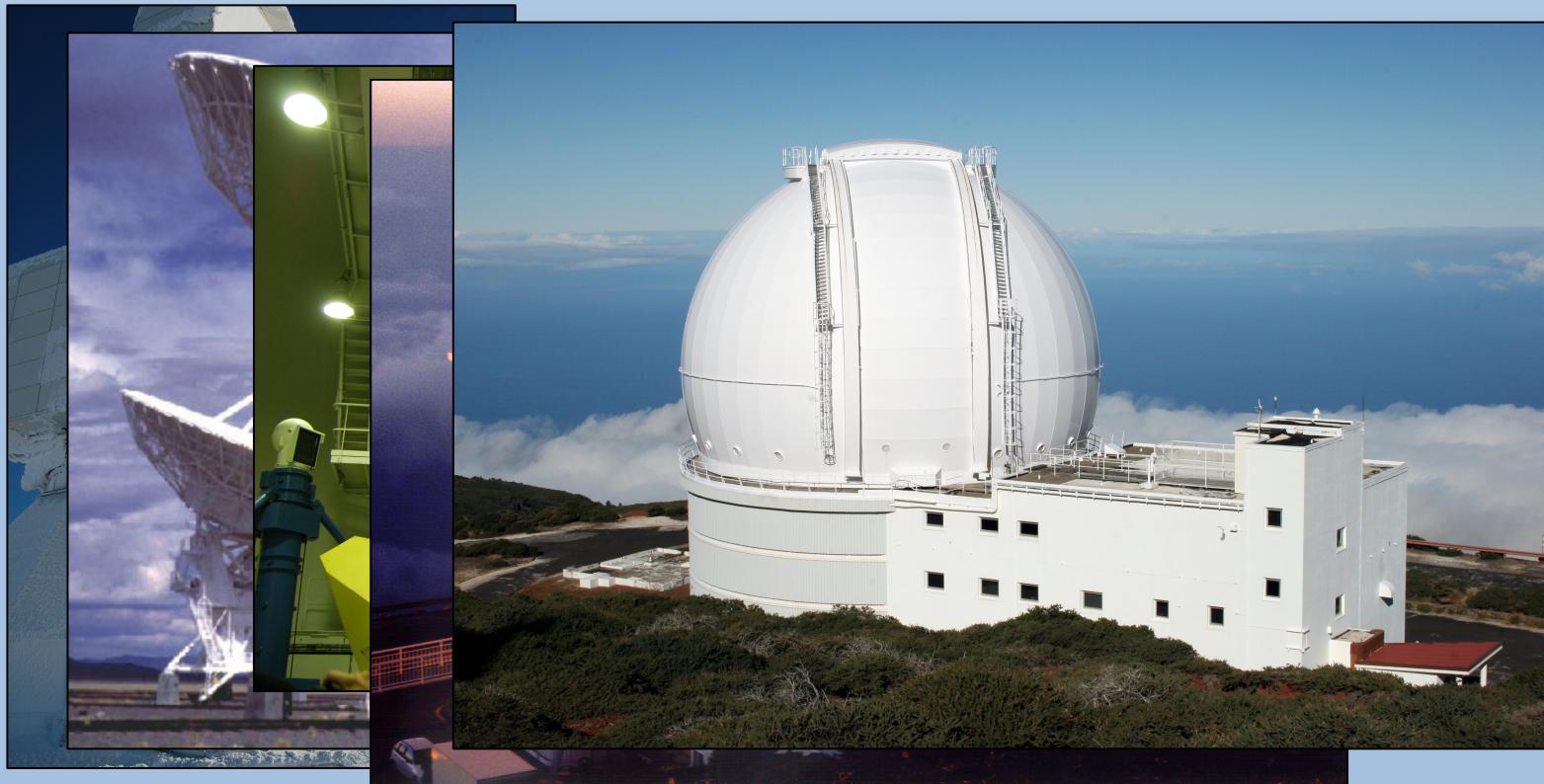
INT

WHT

NOT

ALMA

soon, hopefully...



today...



What I need:

radio observations + optical counterpart

30m

VLA

CAHA

INT

WHT

NOT

ALMA

soon, hopefully...



on-going work...

What I need:

radio observations + optical counterpart

and some
good luck...

30m



VLA

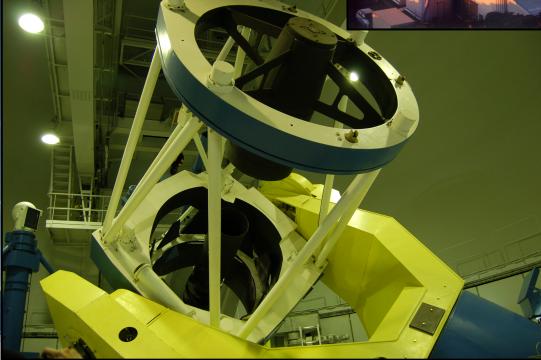
CAHA

INT

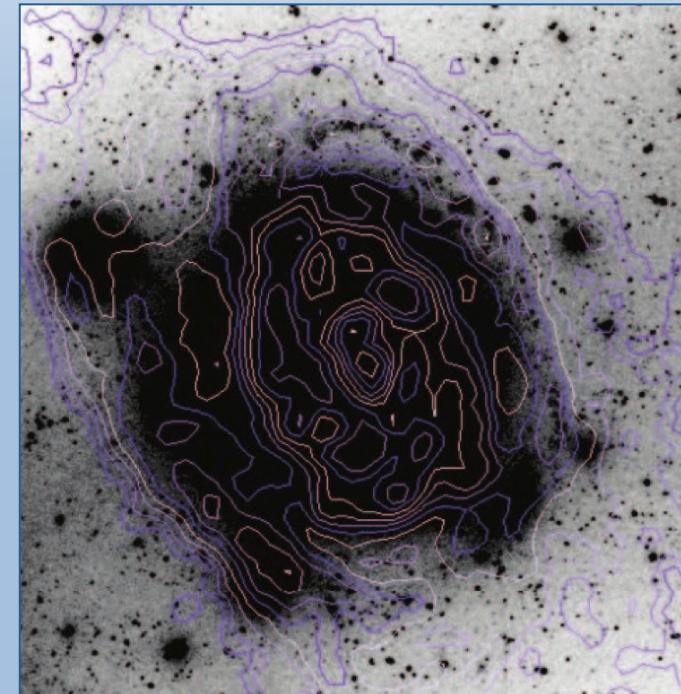
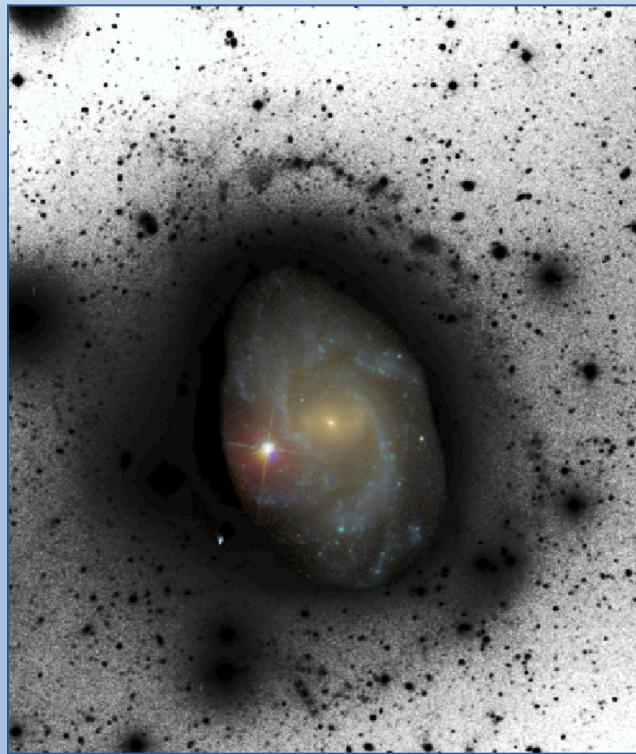
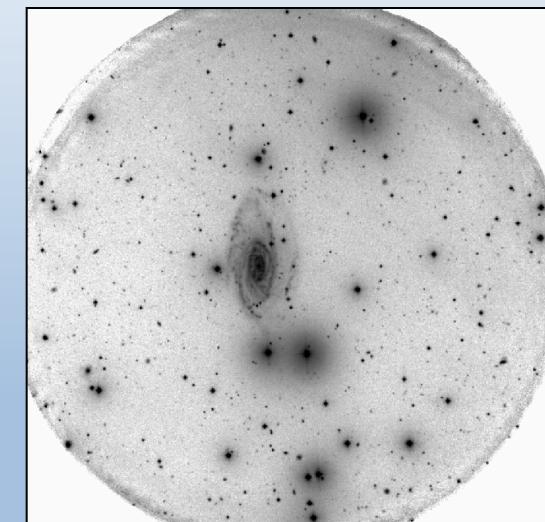
WHT

NOT

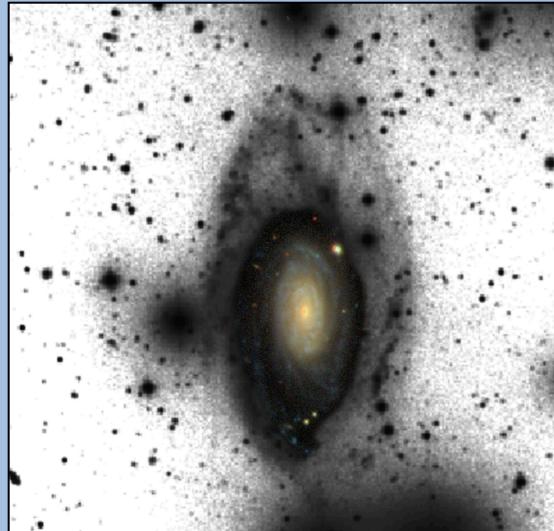
ALMA



on-going work...



NGC 864 - CIG96 – CAHA2.2m + VLA



NGC 7664 - CIG 1019 – CAHA2.2m

on-going work...



radio & mm - VLA , IRAM30m ~ 30h approx. for CIG96 and other galaxies

optical - NOT, INT, CAHA 14+ CIGs observed for at least 4h

DEEP sample

HI spectrum and detection

$nk \leq 2.7 / 2.4$

184 CIGs $V > 1500 \text{ km/s}$

Extinction $< 0.5 \text{ mag}$

$4.57 \text{ arcmin} > \text{angular size} > 1 \text{ arcmin}$

on-going work...

radio & mm - VLA , IRAM30m

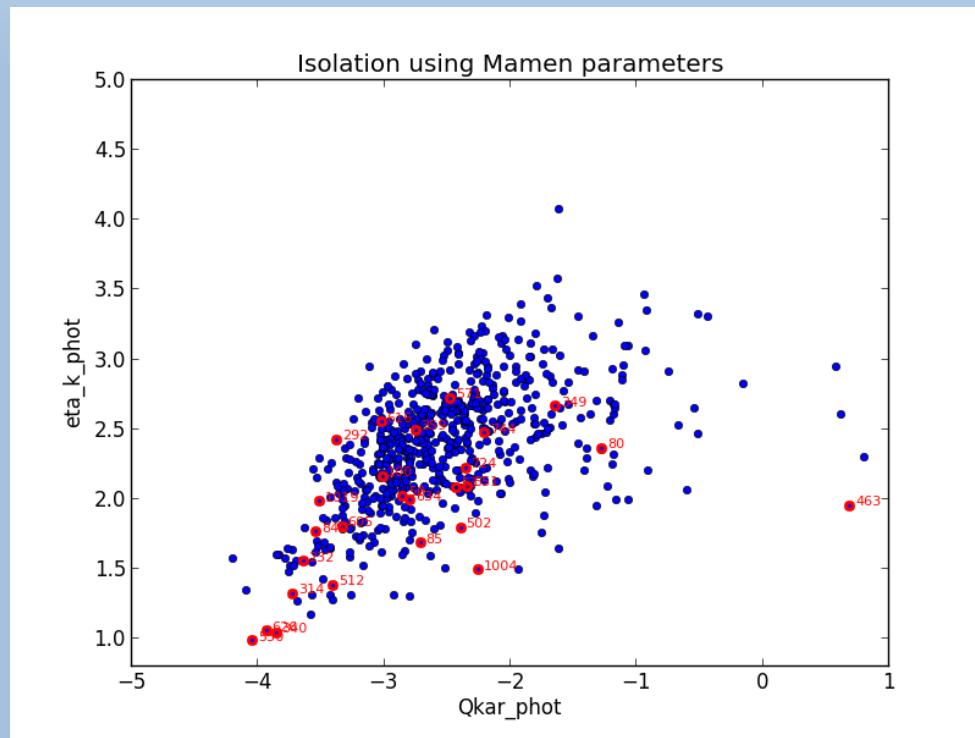
~ 30h approx. for CIG96 and other galaxies

optical - NOT, INT, CAHA

14+ CIGs observed for at least 4h

DEEP sample

184 CIGs



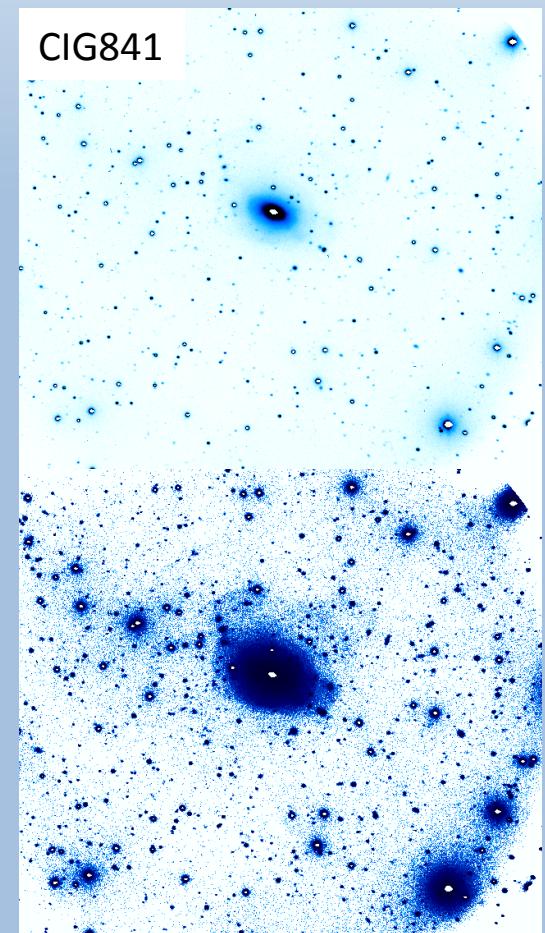
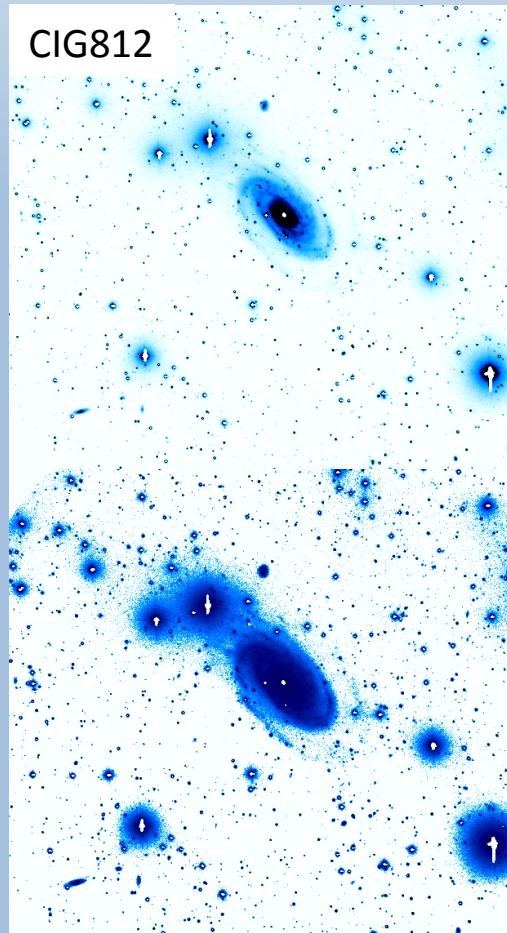
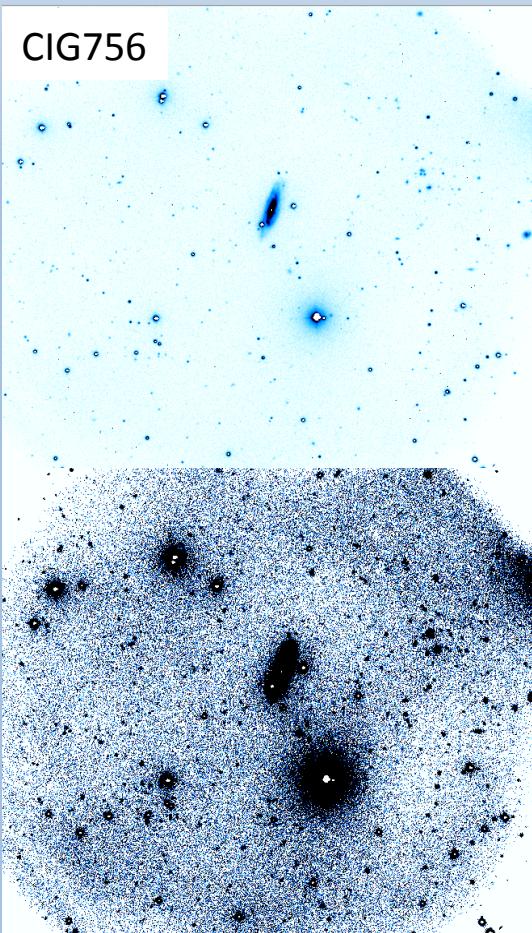
on-going work...

radio & mm - VLA , IRAM30m

~ 30h approx. for CIG96 and other galaxies

optical - NOT, INT, CAHA

14+ CIGs observed for at least 4h



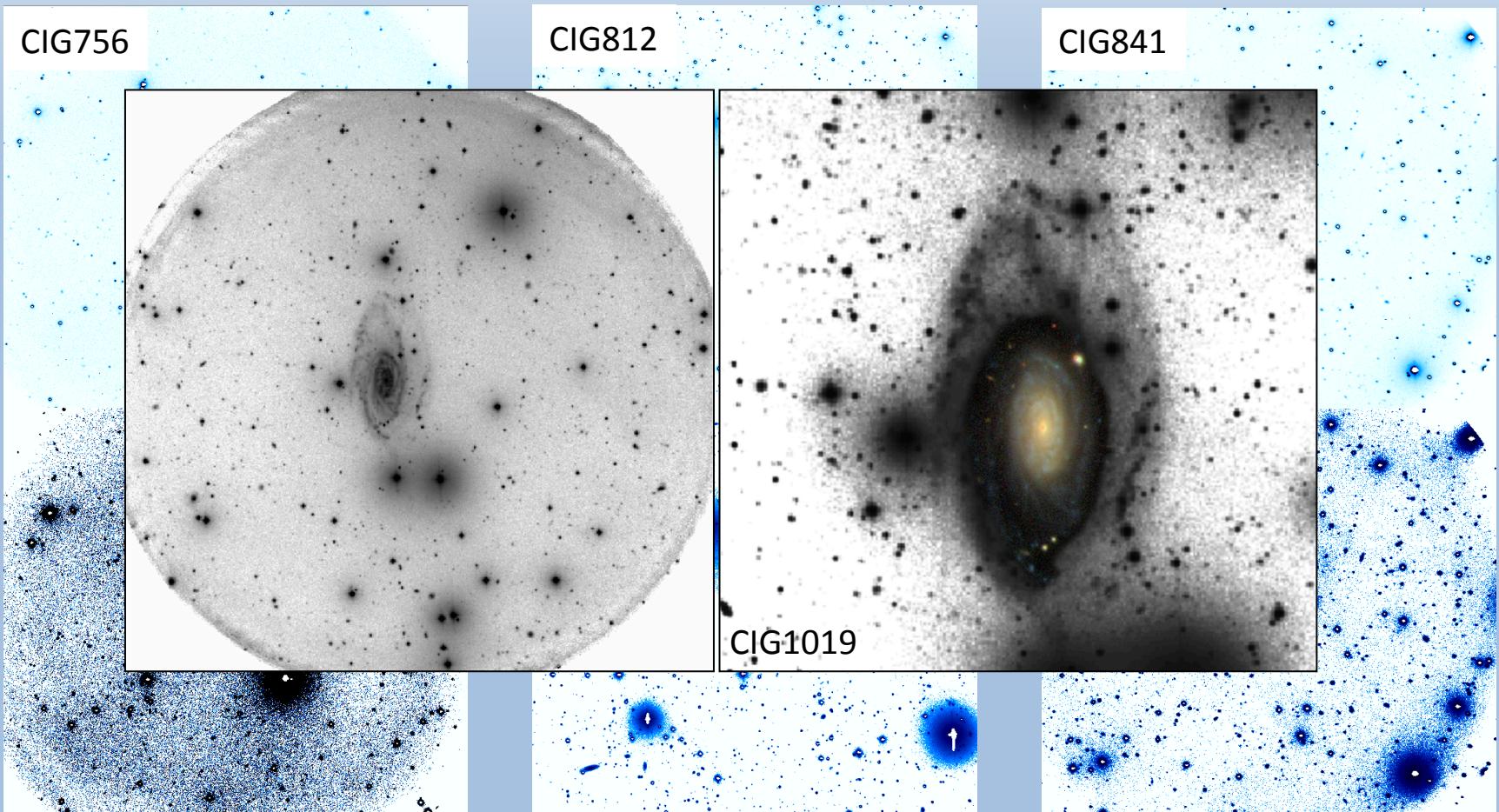
on-going work...

radio & mm - VLA , IRAM30m

~ 30h approx. for CIG96 and other galaxies

optical - NOT, INT, CAHA

14+ CIGs observed for at least 4h



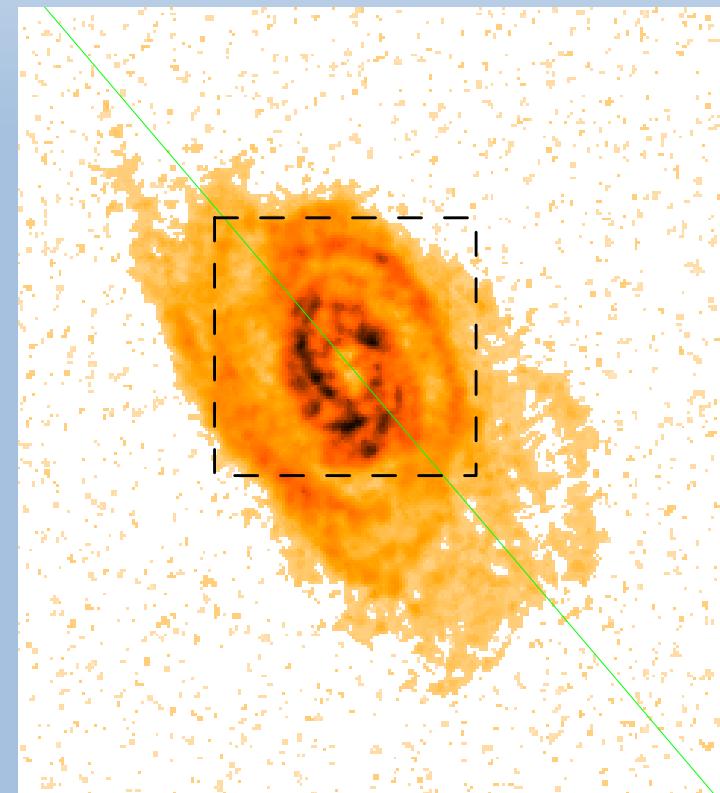
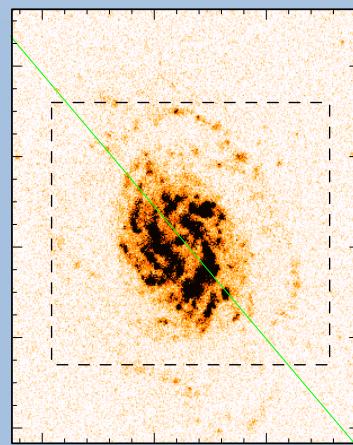
the case of CIG96

EVLA

16 datasets (approx. 10h on target)

CAHA (optical)

4h on target



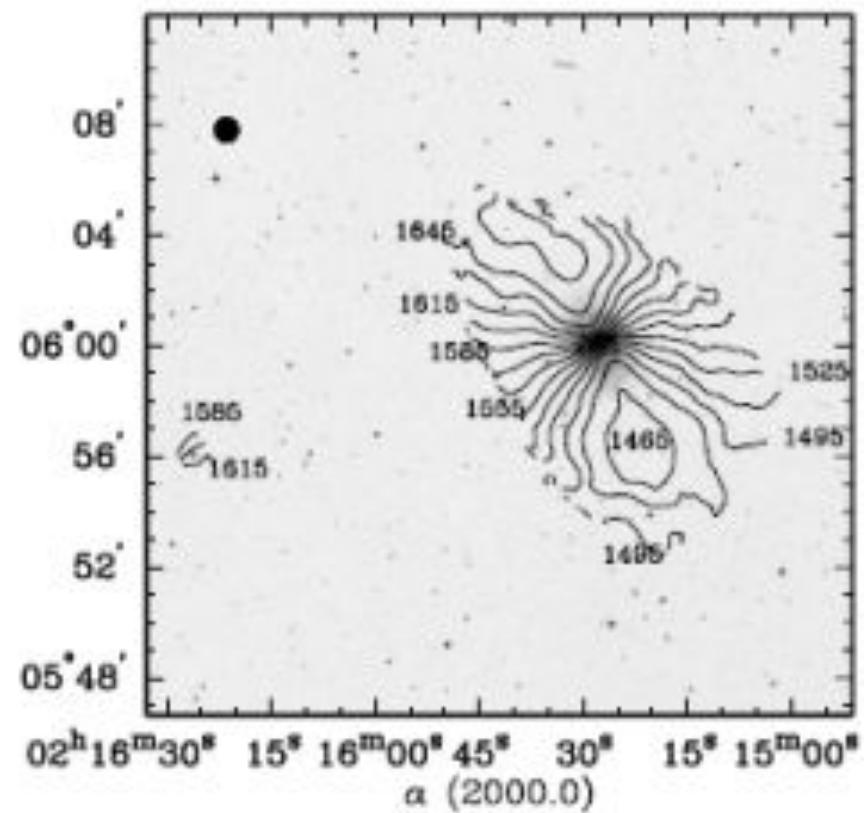
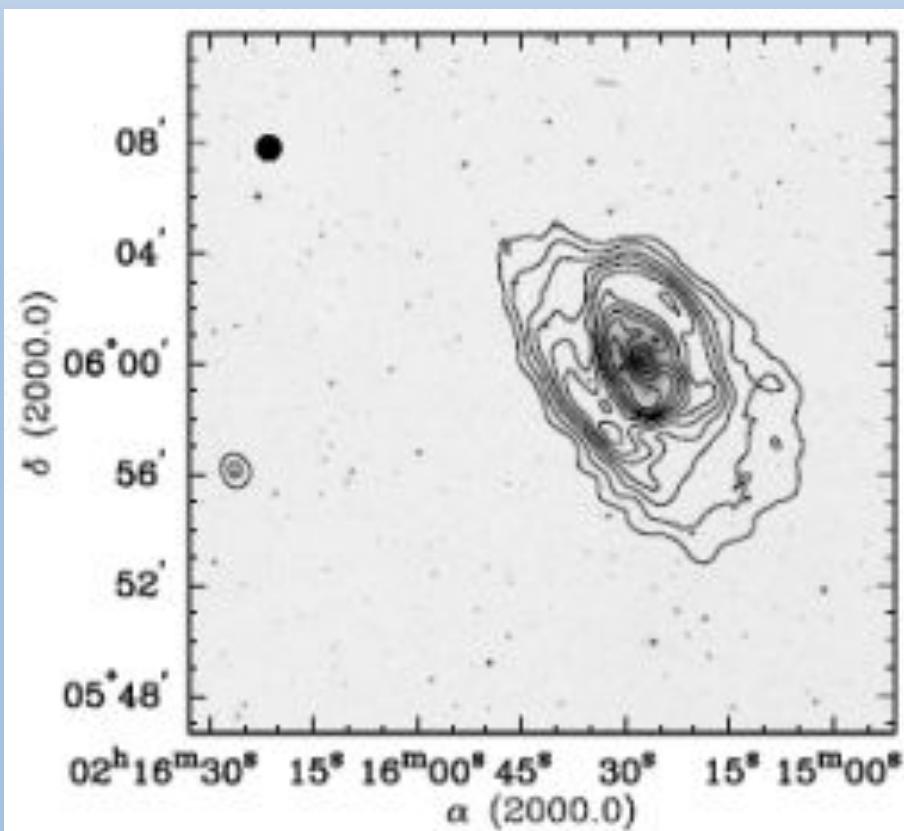
the case of CIG96

EVLA

16 datasets (approx. 10h on target)

CAHA (optical)

4h on target



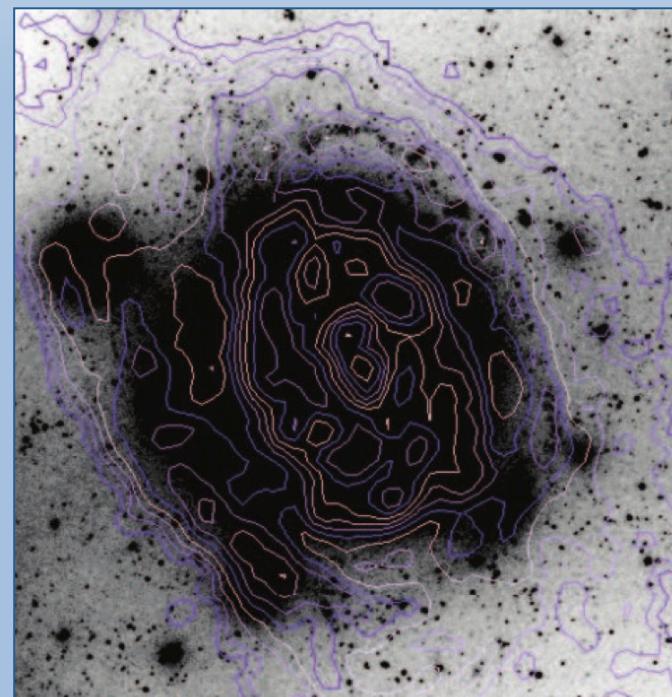
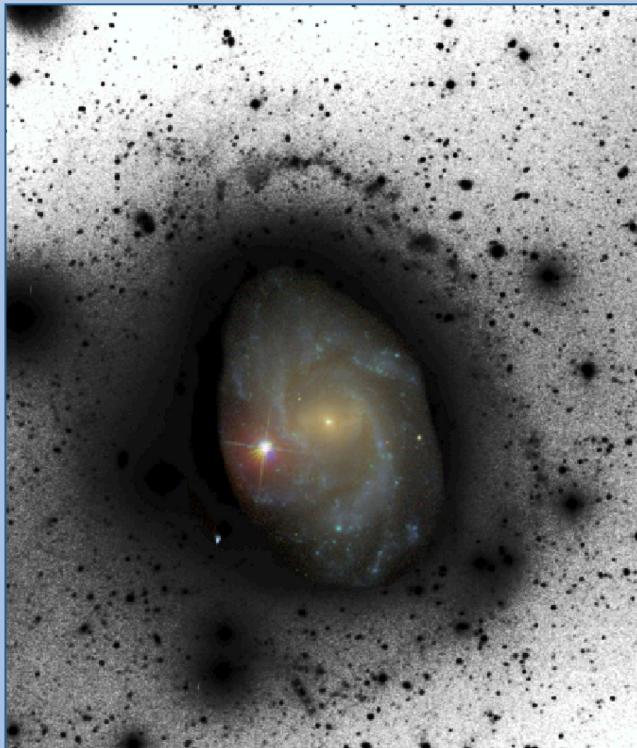
the case of CIG96

EVLA

16 datasets (approx. 10h on target)

CAHA (optical)

4h on target



the case of CIG96

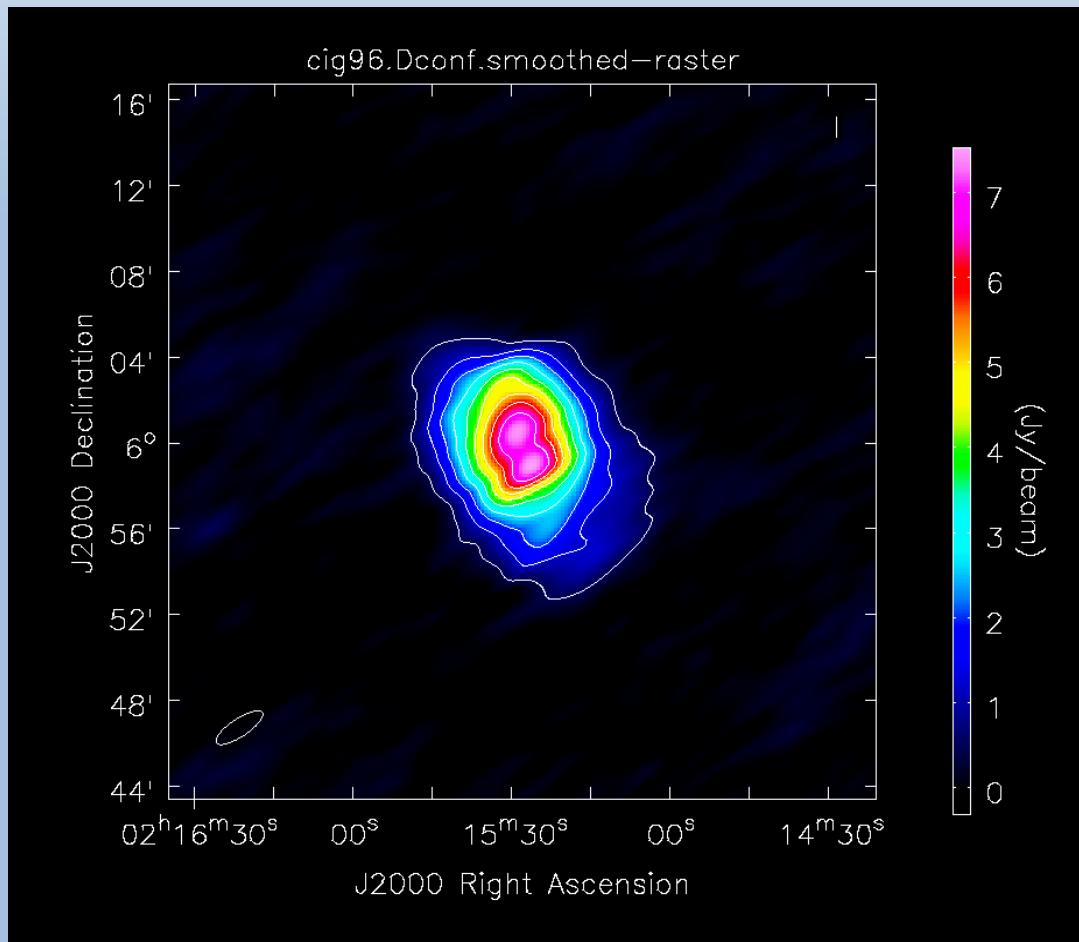


EVLA

16 datasets (approx. 10h on target)

CAHA (optical)

4h on target



2h integration on source

D configuration

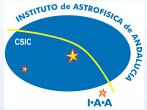
beam size 155x50 arcsec²

rms 0.1 mJy

SNR spans from 8 to 40

Ramirez-Moreta+ in prep.

the case of CIG841



CAHA (optical)

4h+ on target

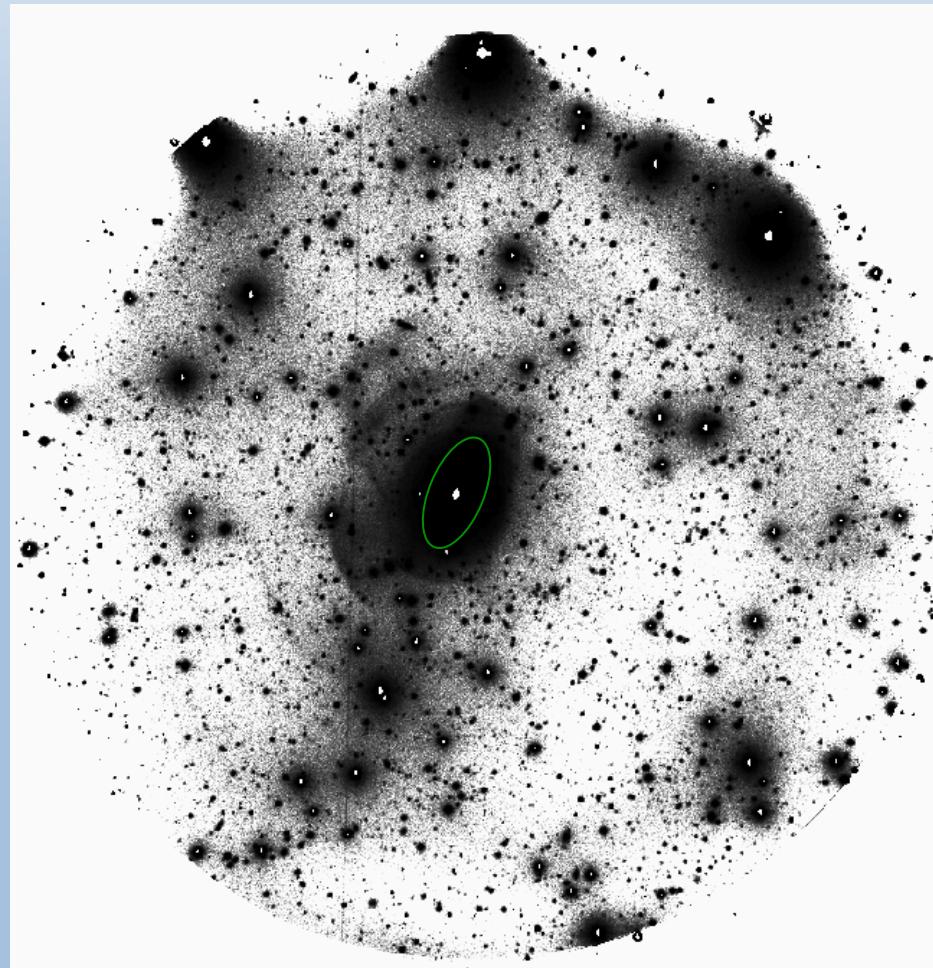


the case of CIG841

CAHA (optical)



4h+ on target



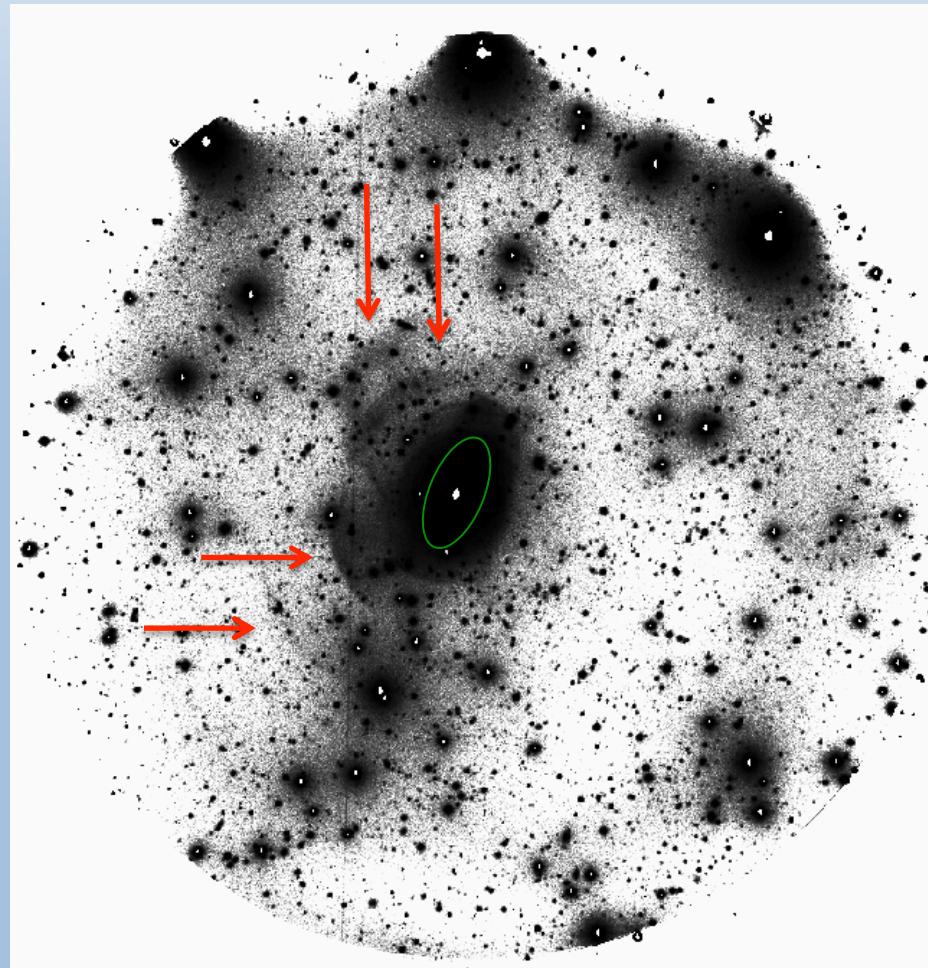
Ramirez-Moreta+ in prep.

the case of CIG841

CAHA (optical)



4h+ on target

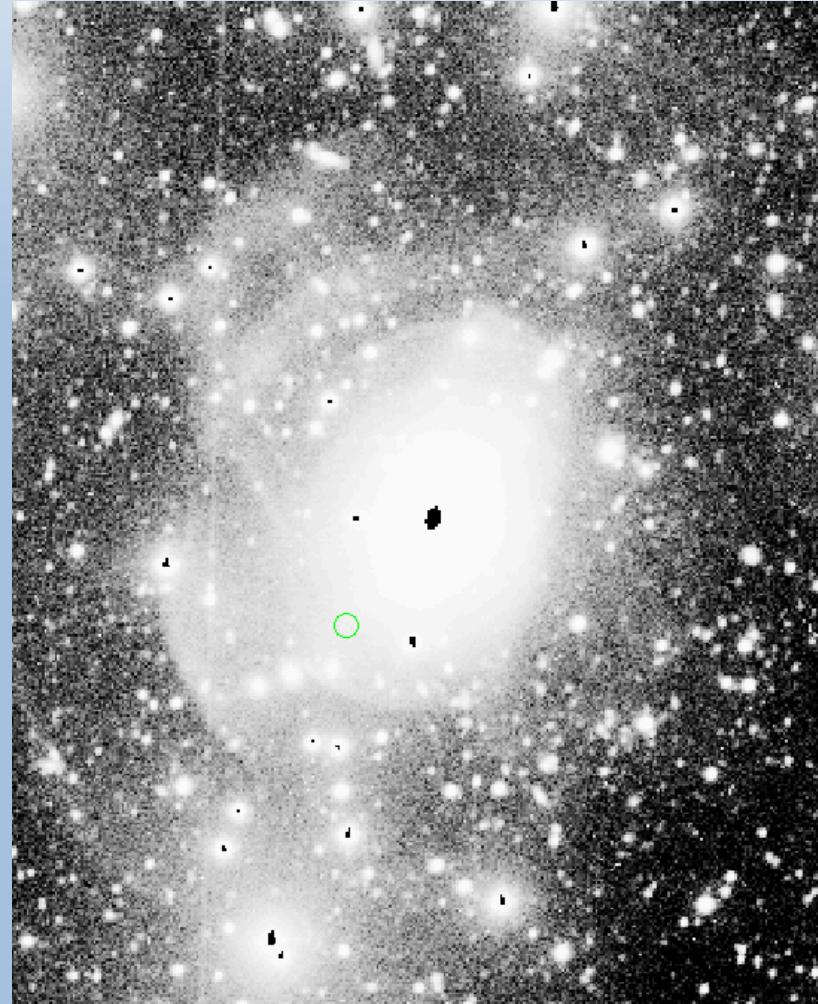


Ramirez-Moreta+ in prep.

the case of CIG841

CAHA (optical)

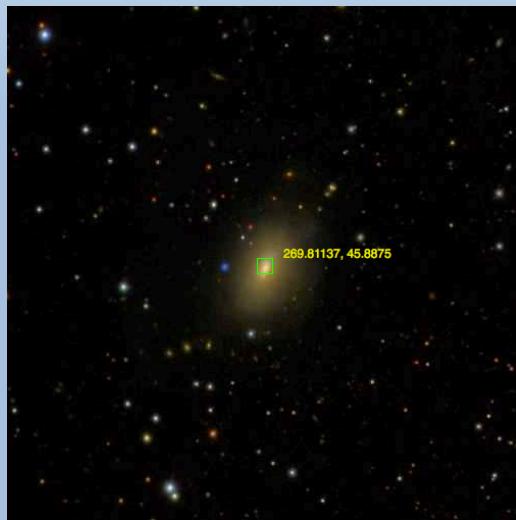
4h+ on target



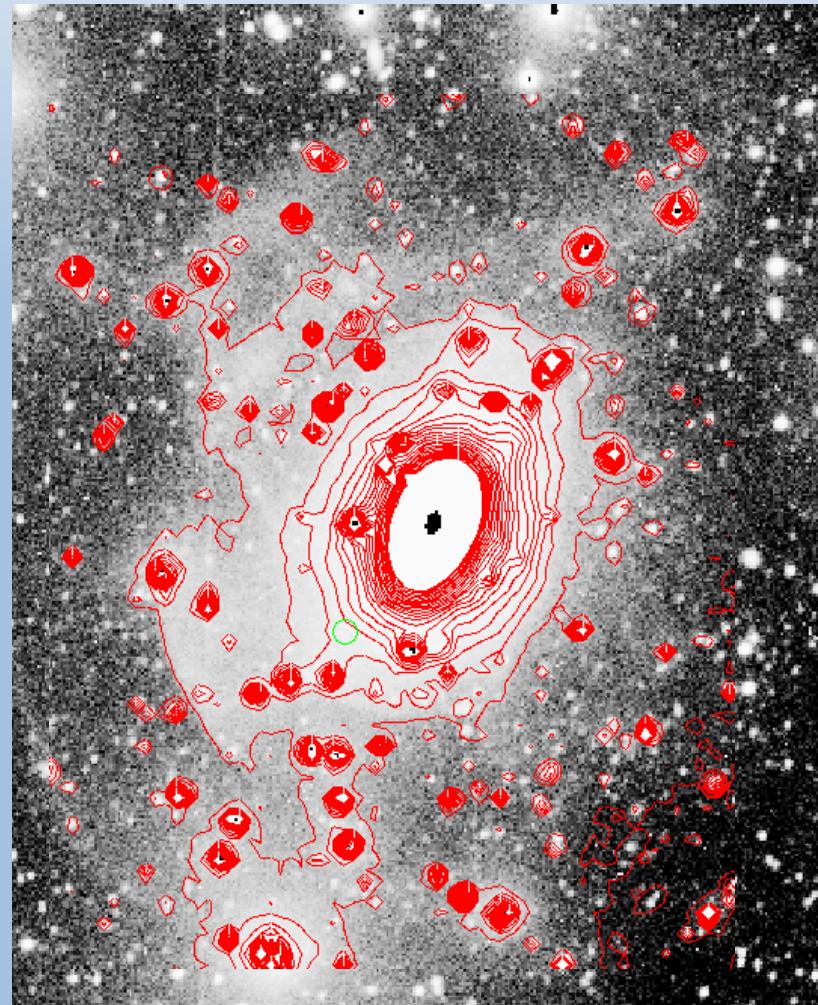
Ramirez-Moreta+ in prep.

the case of CIG841

CAHA (optical)



4h+ on target



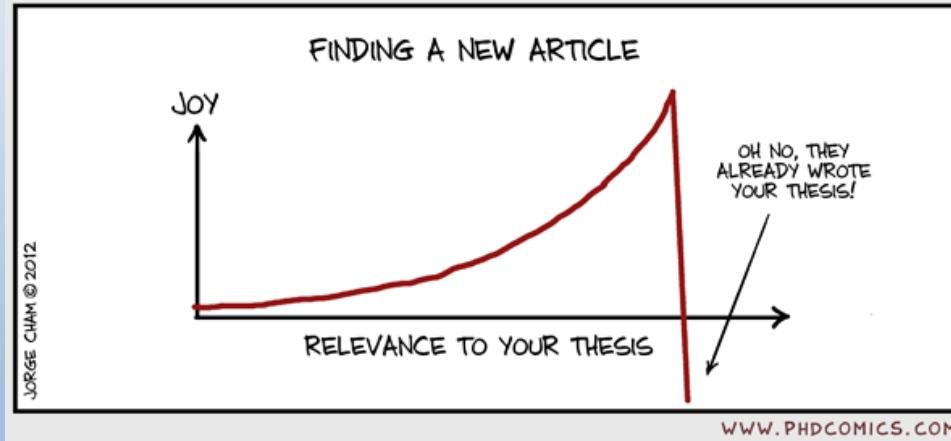
Ramirez-Moreta+ in prep.

references



[http://
amiga.iaa.es](http://amiga.iaa.es)

after the pretty pictures...



THANK YOU!



*how to keep researching
while being in crisis*

The AMIGA project – Asymmetries in isolated galaxies



Pablo Ramírez Moreta

Ph.D. student at IAA-CSIC

Thesis advisors:

Lourdes Verdes-Montenegro (IAA-CSIC, Spain)
Stephane Leon (ESO, Chile)

