HI scaling relations of the most isolated galaxies

Mike Jones

Instituto de Astrofísica de Andalucía (CSIC)

Collaborators: L. Verdes-Montenegro, D. Espada, W. Huchtmeier, S. Leon, U. Lisenfeld, J. Sulentic, E. García, J. Sabater, S. Verley, D. Jones, S. Sanchez, J. Garrido

Background: AMIGA galaxies in SDSS
Compiled from Baillard et al. 2011

Outline

- Motivation – Why scaling relation of isolated galaxies?
- The AMIGA sample.
- HI-scaling relations of isolated galaxies.
- Our HI data set, model, and relations.
- Summary.

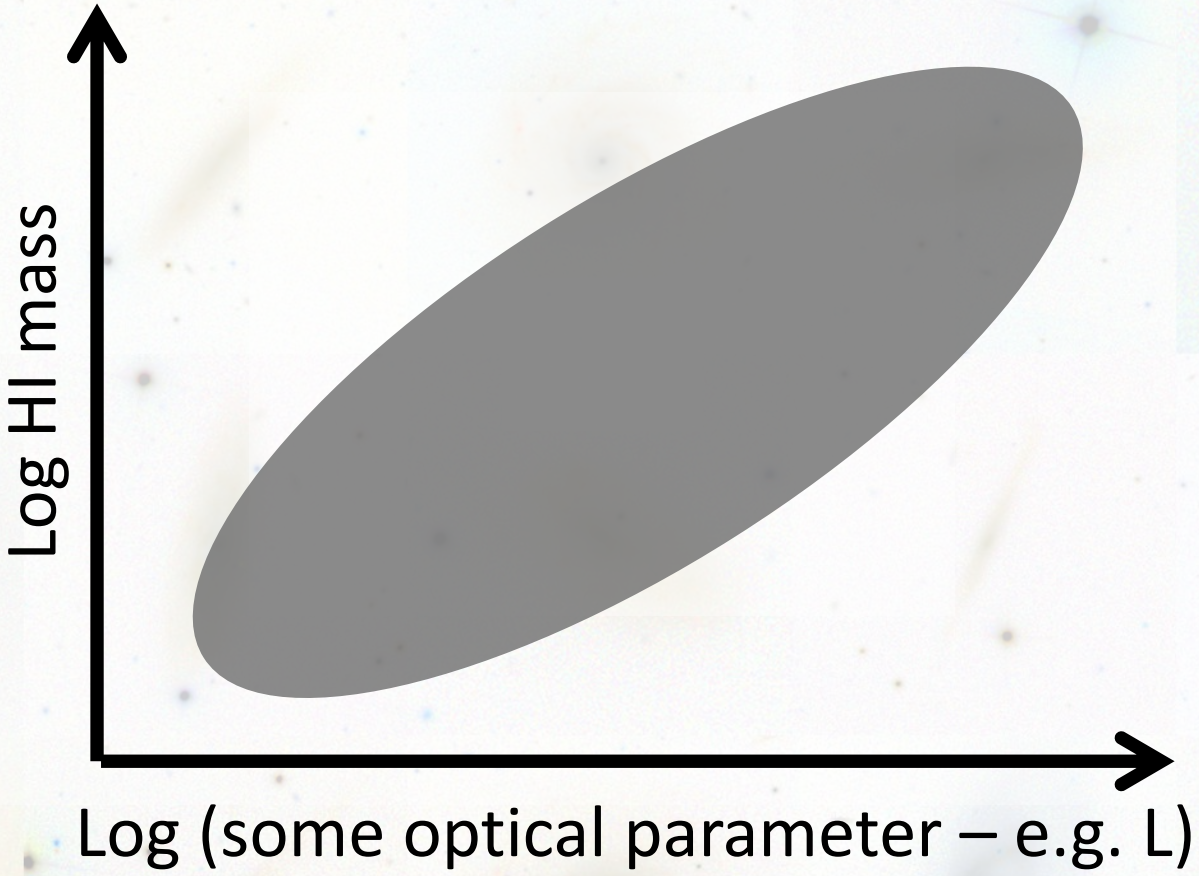
Why isolated galaxies?

- Isolated galaxies represent a “nurture free” population where the properties of galaxies with minimal environmental impact can be studied.

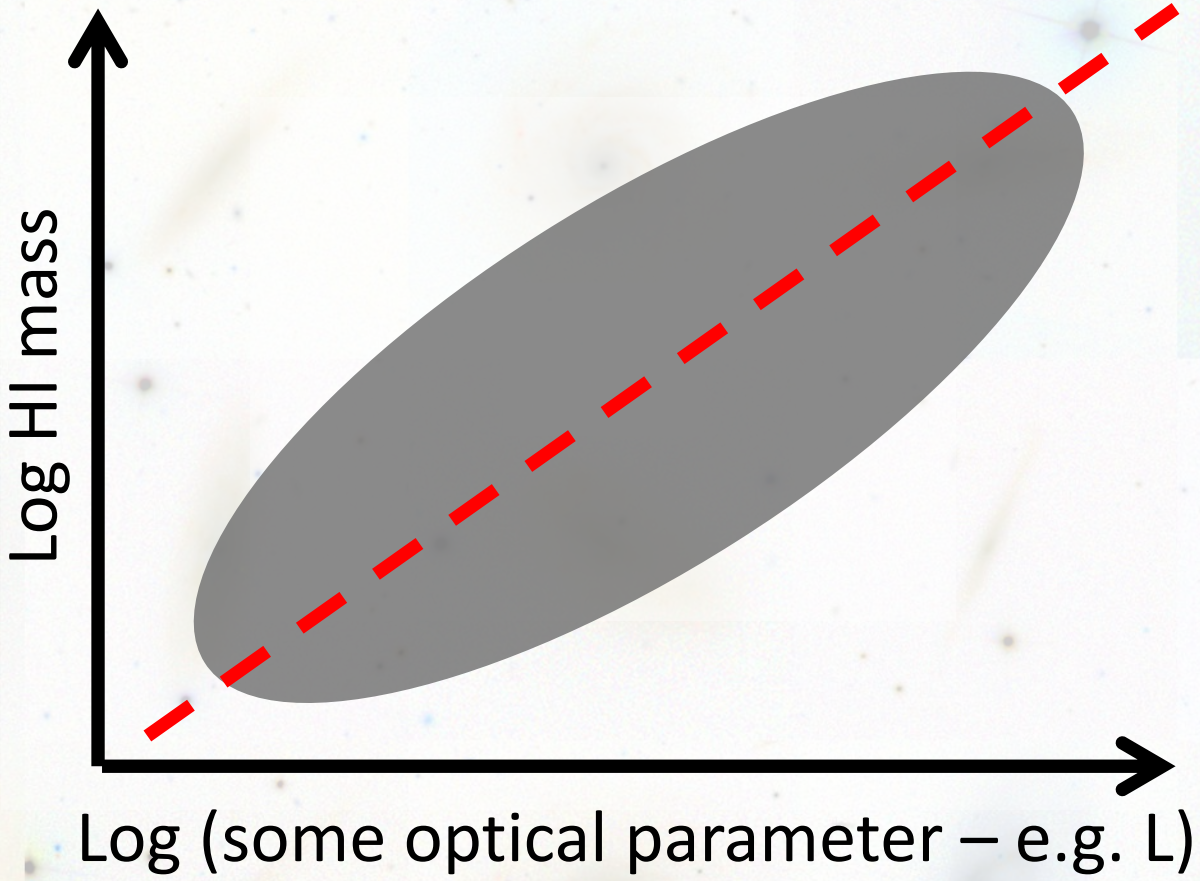
- For HI they represent the baseline of normal HI content.

- For accretion studies they are a sample without neighbours to accrete from, and without enhanced SF driving galactic fountain processes.

HI-scaling relations



HI-scaling relations



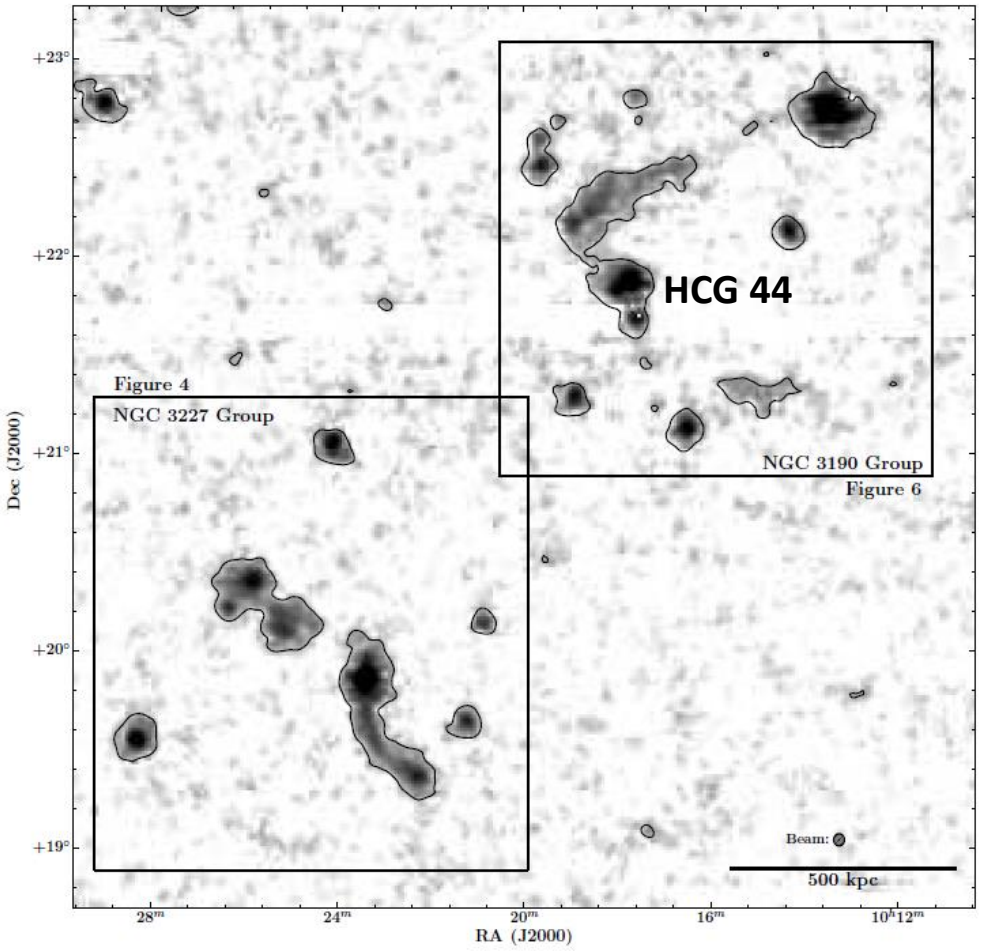
Galaxy and group evolution

- Another focus of the AMIGA team is the evolution of compact group galaxies.

Leisman *et al.* 2016

- CGs are thought to follow an evolutionary track (Verdes-Montenegro et al. 2001).

- However, to be sure we are accounting for all the gas we need to know what was there to begin with.

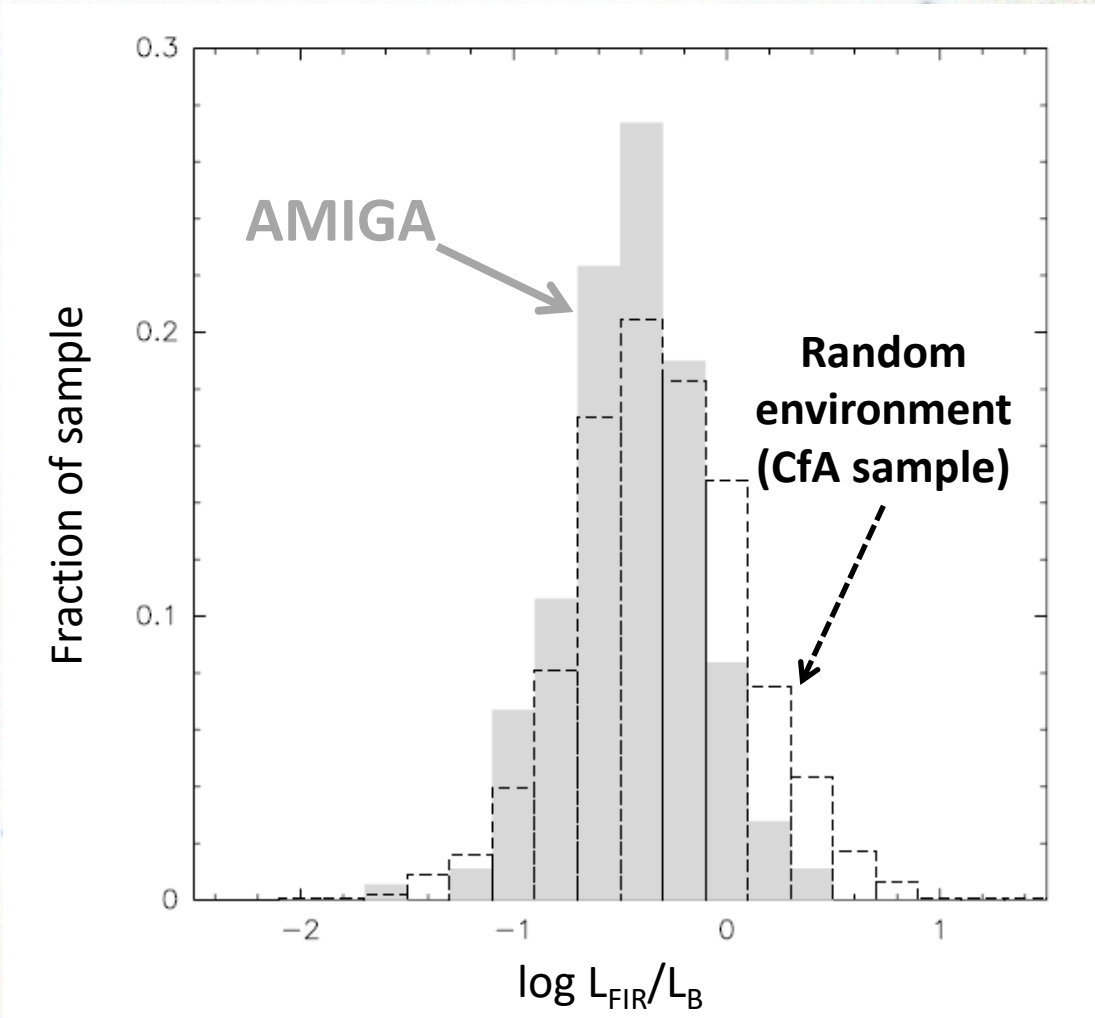


The AMIGA sample

- The AMIGA sample is taken from the Catalogue of Isolated Galaxies (CIG N = 1051, Karachentseva 1973).
- These galaxies are highly isolated, with minimal tidal forces exerted on them, and have very low neighbour density (Verley et al. 2007).
- A multi-wavelength dataset has been collected and analysed - radio continuum, HI, CO, FIR, NIR, optical, and Hα.
- The sample shows the lowest rates of all parameters that are usually enhanced by interaction.

The IR properties of AMIGA

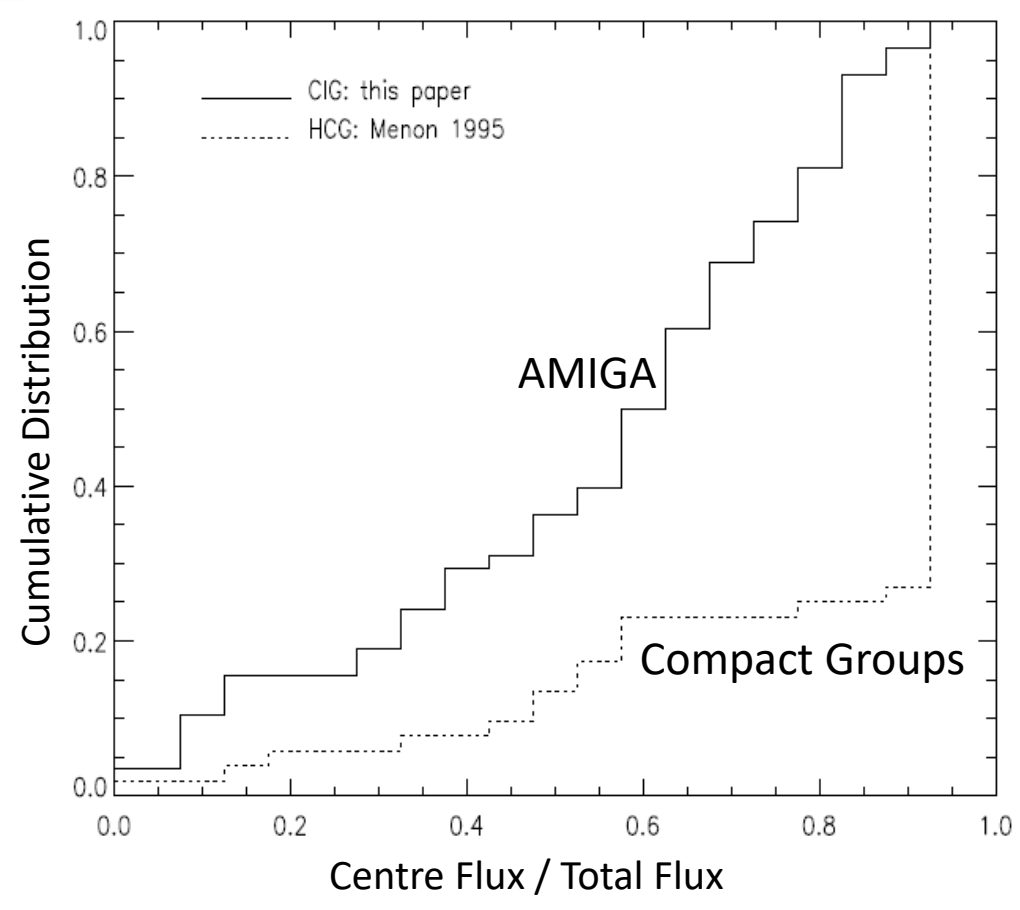
- AMIGA galaxies have low L_{FIR} relative to L_B.
- This likely an indication that their SFRs are not enhanced, due to a lack of interaction.



Lisenfeld *et al.* 2007

The radio continuum in AMIGA

- Less than 1.5% of AMIGA galaxies show excess radio emission above the radio-FIR relation.
- Overall the sample is radio-quiet with most of its continuum emission being consistent with low level SF in the disc.
- The entire sample contains only 89 potential AGN candidates.



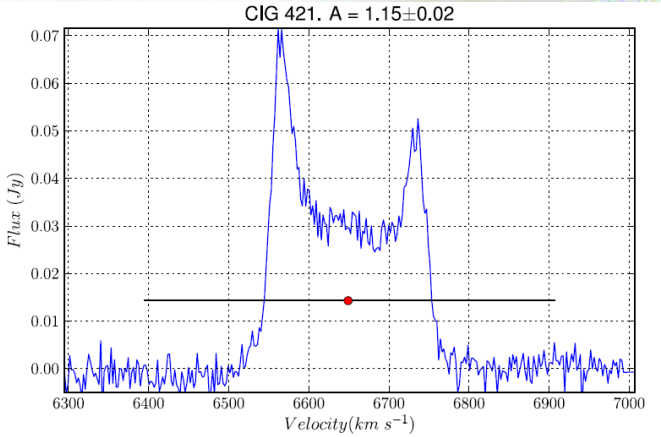
Leon *et al.* 2008
Sabater *et al.* 2008

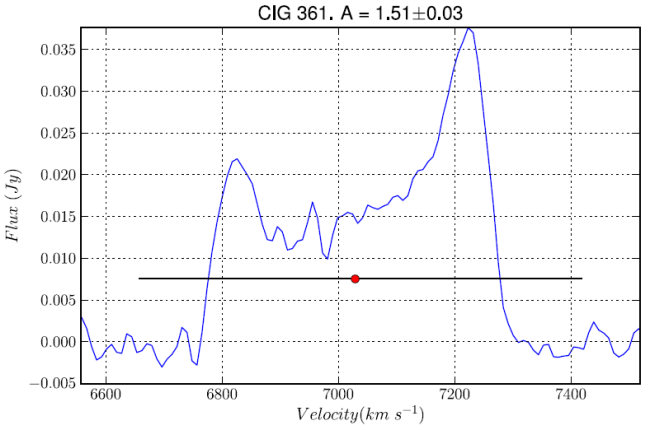
HI asymmetry in AMIGA

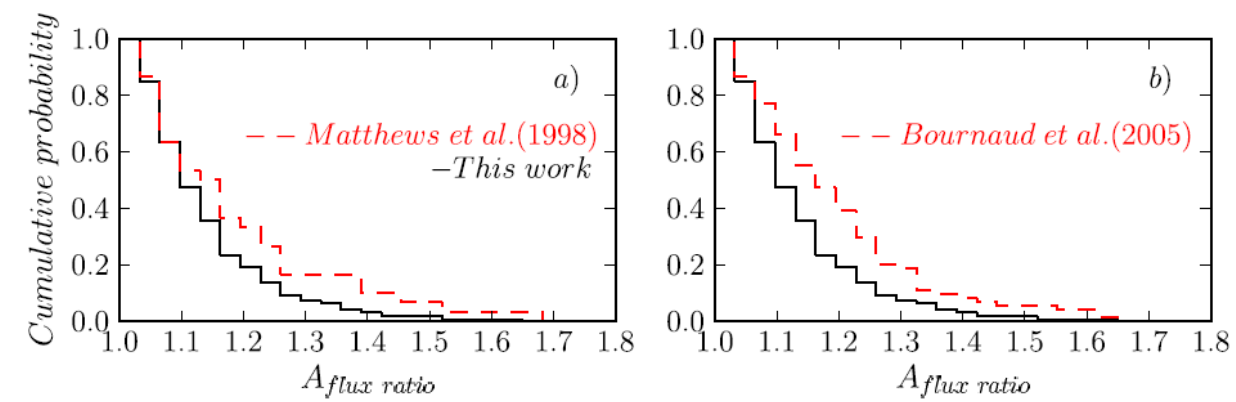
- AMIGA has the lowest level of HI asymmetry in any galaxy sample.

- HI asymmetry measured as the ration of the right and left integrated fluxes.

Espada *et al.* 2011

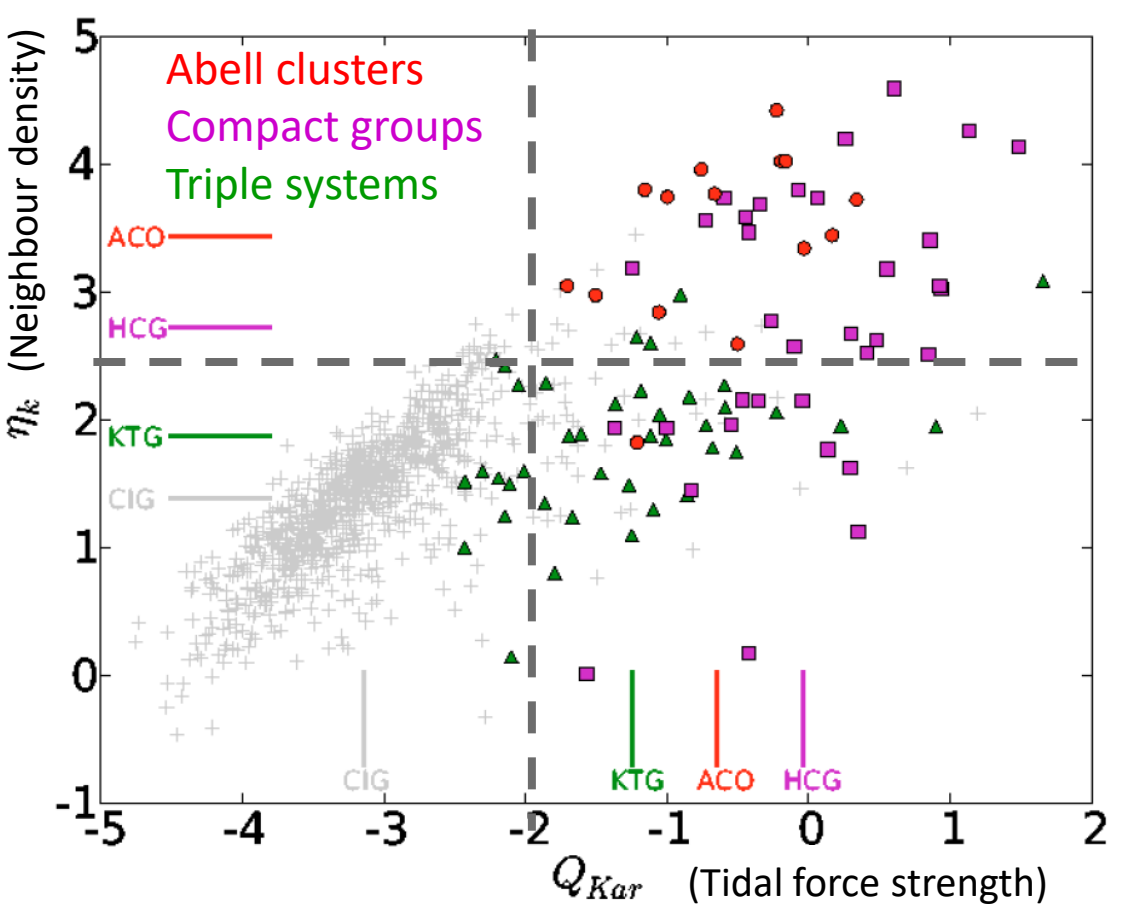






AMIGA is a truly isolated sample

- AMIGA is essentially "nurture-free".
- This is an ideal sample to study the properties of galaxies with minimal impact from their surroundings.
- We use it to establish what is the normal HI content of a galaxy.



Verley *et al.* 2007

HI scaling relations – some history

- Single-dish spectra are ideal as we want the total integrated flux.

- Haynes & Giovanelli 1984 fit linear relations between log L_B, log D, and log M_{HI} for 324 Arecibo spectra of CIGs (N = 288).

- Solanes et al. 1996 made new relations based on isolated field galaxies in Pisces-Perseus (N = 532).

- Toribio et al. 2011 performed PCA between log M_{HI} and a number of optical measures of the ALFALFA 40% sample (N = 1624).

- Dénes et al. 2014 compared field HIPASS sources (N = 1262) HI masses to absolute magnitudes in optical and IR bands.

Our HI data compilation

- HI single dish spectra for 844 of the 1051 CIGs.
- 429 AMIGA spectra from AO, NRT, ERT, GBT, and 415 literature spectra (mostly from Springob et al. 2005 and Haynes & Giovanelli 1984).
- After applying completeness (-10%) and isolation cuts (-25%) there are:
  - 378 detections
  - 44 marginal detections
  - 130 non-detections
- HG84 had 288 detection, however, that is without cuts for completeness and isolation.

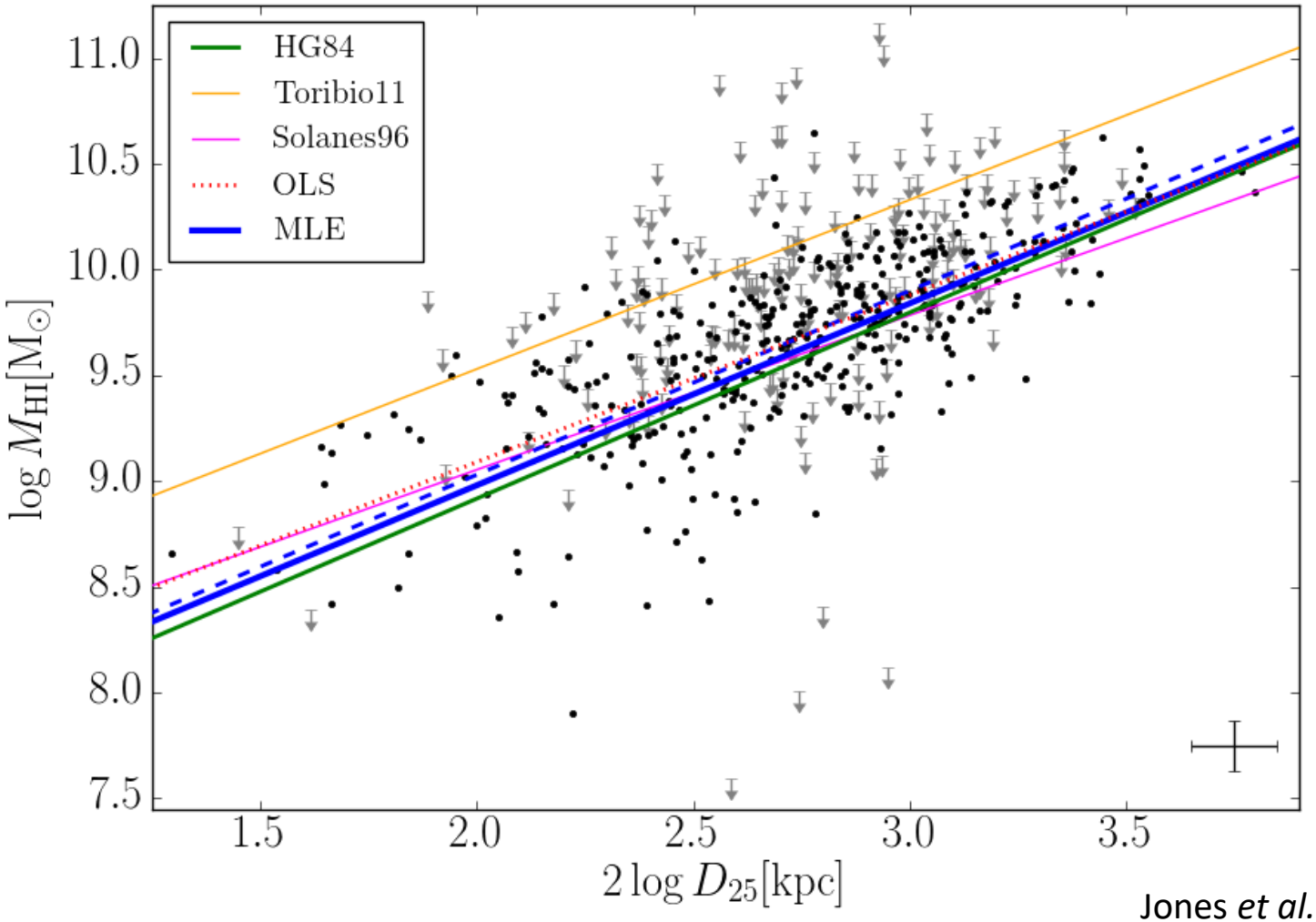
Our regression model

- We find the maximum likelihood parameters for a regression model that assumes:
  - All data follow a linear trend with constant scatter.
  - The measurement uncertainties in both variables is Gaussian.
  - Undetected sources follow the same distribution as those detected.
  - [Equal Gaussian distance errors in both variables.]

- Previous studies have only considered the first two of these, and normally only partially.

The relations – log D_{25}

$$\log M_{\mathrm{HI}} = 0.86 \times 2\log D_{25} + 7.26$$



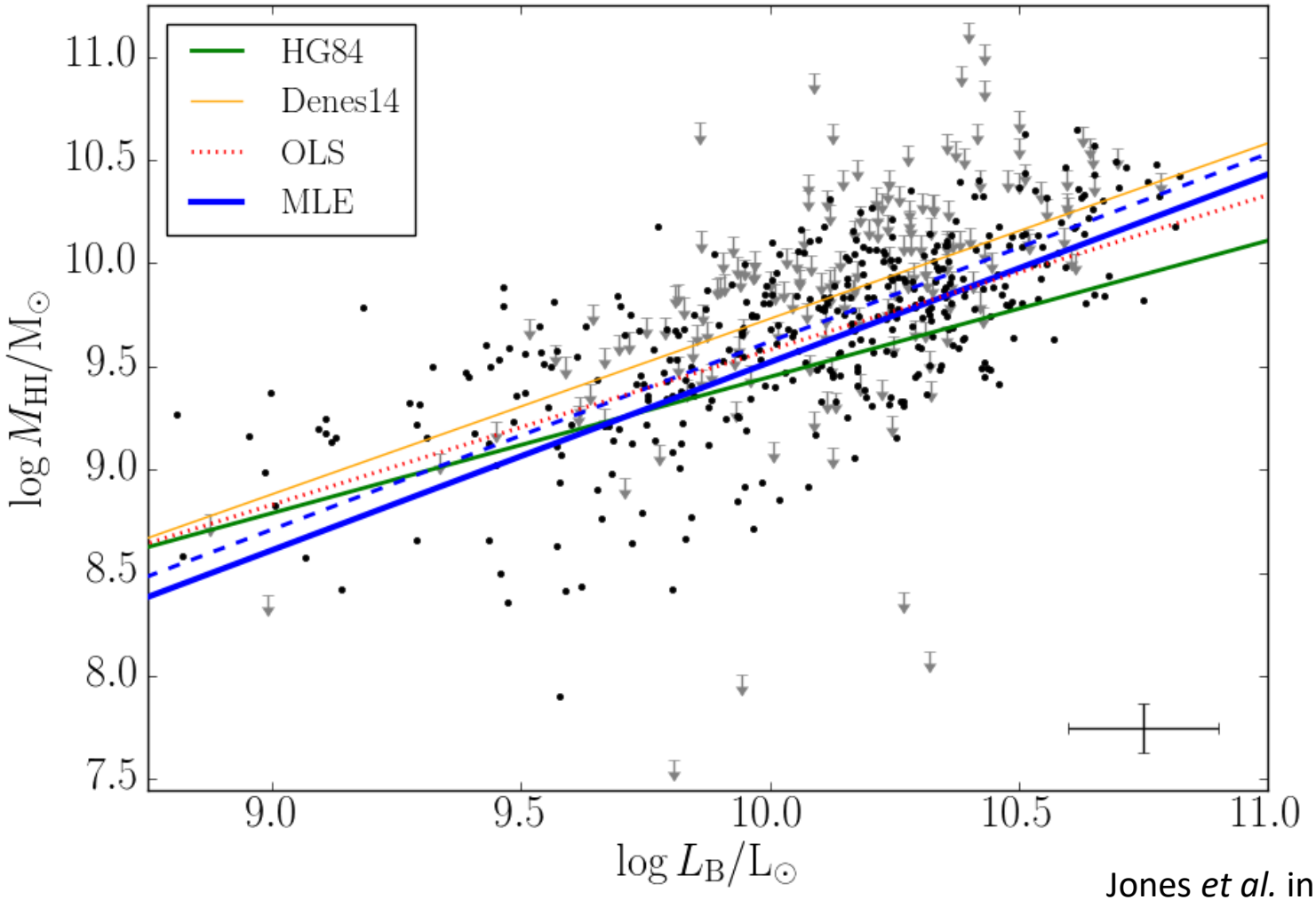
Jones *et al.* in prep

The relations – log D_{25}

- This is the optical parameter most correlated with HI mass (correlation coefficient = 0.73).
- We find a very similar trend to that of HG84, but our sample is marginally more HI-rich.
- The Toribio relation shows that ALFALFA galaxies have almost an about 0.5 dex more HI than AMIGA galaxies.

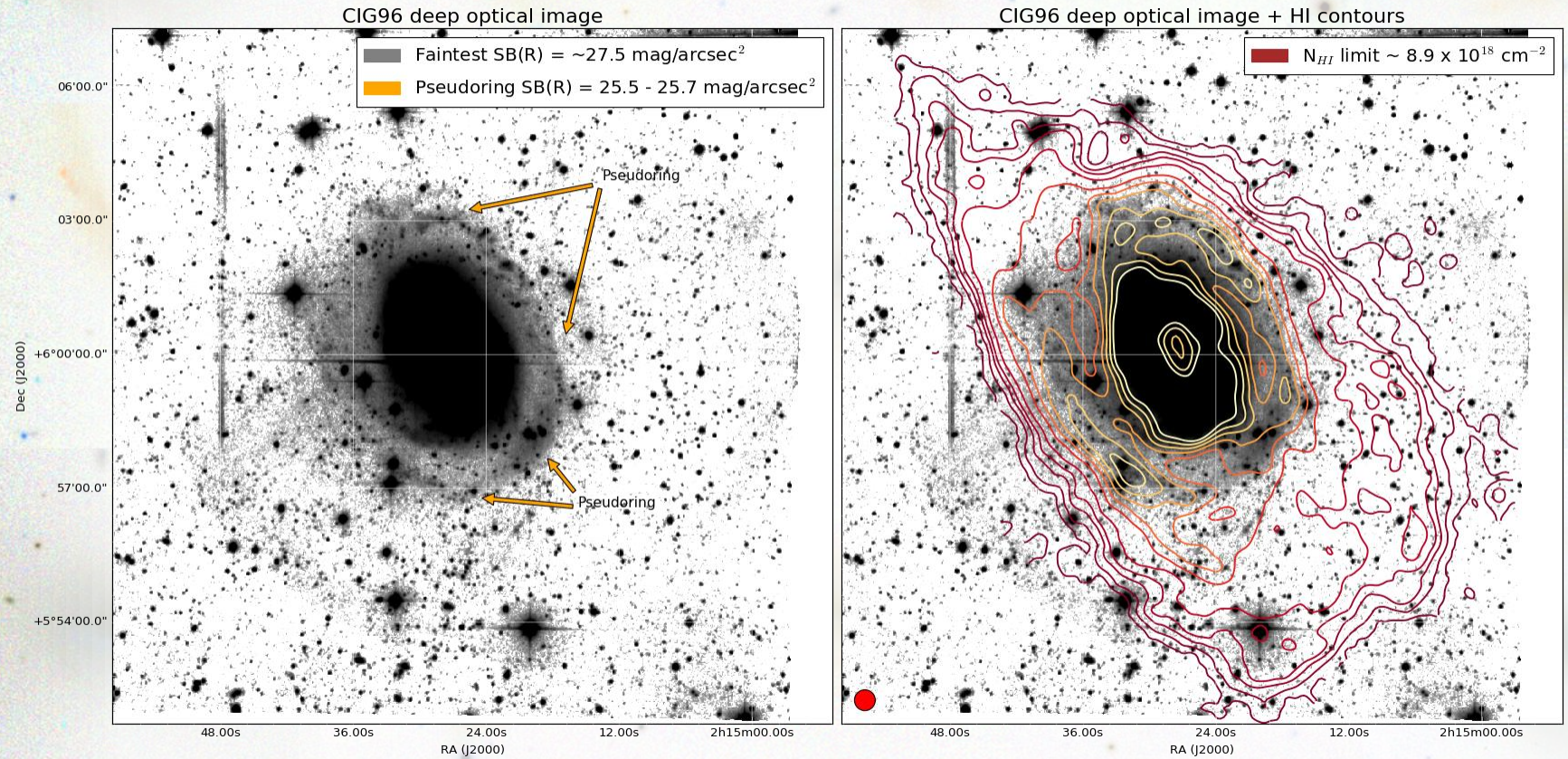
The relations – log L_B

$$\log M_{HI} = 0.91 \log L_B + 0.42$$



Jones *et al.* in prep

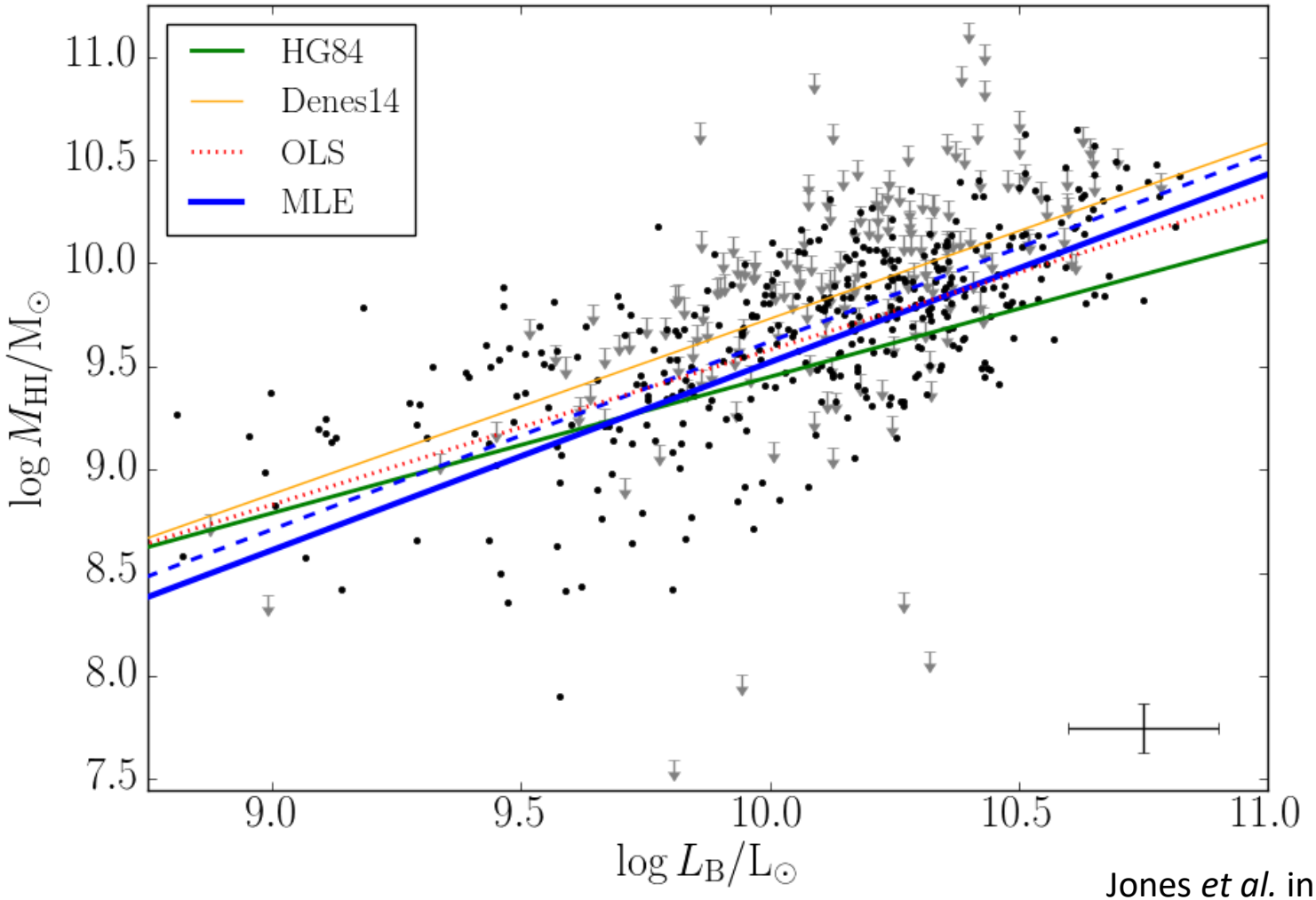
CIG 96 – Pablo Ramirez (AMIGA PhD student)



- A very HI-rich isolated galaxy. With an deep optical and HI image ($N_{HI} < 10^{19}$ cm^{-2}). The galaxy shows a pseudo ring in optical and HI.

The relations – log L_B

$$\log M_{HI} = 0.91 \log L_B + 0.42$$



Jones *et al.* in prep

The relations – log L_B

- A good, but slightly weaker, correlation with HI mass (correlation coefficient = 0.67).
- L-band luminosity is a more conservative proxy than D_{25} for systems that may be interacting.
- Our trend is considerably steeper than HG84, indicating that large isolated galaxies are more HI-rich than found previously.
- Again the Dénes relation shows HI-selected galaxies (HIPASS) are richer in HI.

Where next?

- These scaling relations represent an updated standard of HI-normalcy.

- They can be used in a number of ways:
  - In compact groups to revise how HI-deficient the constituent galaxies are and how much HI might be "missing" in the IGM.
  - For HI stacking experiments – where sources are selected from optical catalogues.
  - Pretty much any application that normally uses a global HI mass-to-light ratio.

- The full HI database will be made public so you can make your own relation if we did not use your optical/IR parameter of choice.

Conclusions

- The AMIGA sample is a highly isolated and “nurture-free” galaxy sample.
- All properties enhanced by interaction are found to be low for AMIGA galaxies.
- We have updated HI scaling relations for highly isolated galaxies (last done in 1984).
- These will be useful tools for quantifying HI-content. In many scenarios.

	Gradient	Intercept	Scatter	Correlation
2 log D_{25}	0.86	7.26	0.23	0.73
log L_B	0.91	0.42	0.23	0.67

PRELIMINARY