(Pseudo)bulges in isolated galaxies

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Central parts of galaxies

Classical bulge – built through rapid/violent processes (e.g. major mergers)

- Old stellar populations
- Dinamically suported by velocity dispersion
- Follows the same relations than E/S0

Surface brightness profiles: ~ De Vaucouleurs, n>2

Pseudobulge – built through slow/secular processes (e.g. gas infall, star formation; Kormendy & Kennicutt 2004)

- Young stellar populations and SF
- Rotation motions
- Disky structures – memory of their disky origin
- Nuclear bars and rings

Surface brightness profiles: ~ Exponential, n<2

Isolated galaxies – Bulge evolution mainly driven by internal processes

Central parts of galaxies

AMIGA project: Analysis of the interstellar Medium of Isolated Galaxies

Catalogue of Isolated Galaxies (CIG) - 1051 (Karachentseva 1973)

No major tidal interaction within the last ~3 Gyr

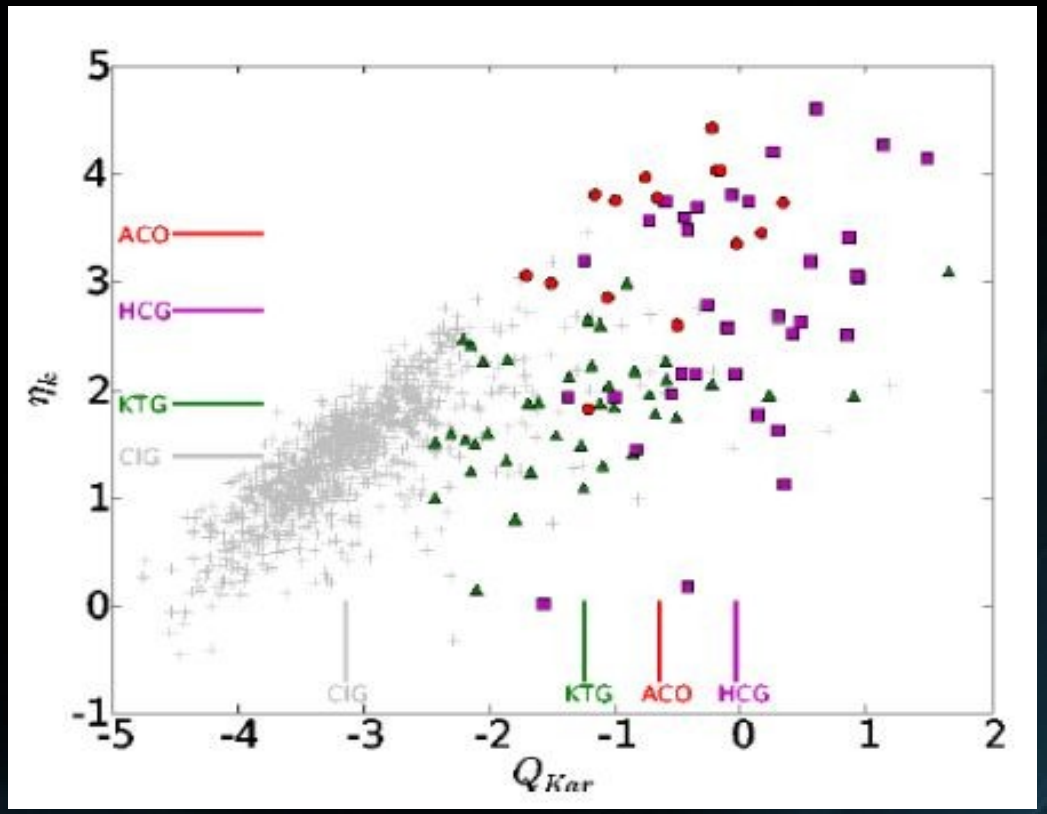
Galaxies present different levels of Isolation

- **Local number density η_K**
- **Tidal force Q**

Revised catalogue, N = 791

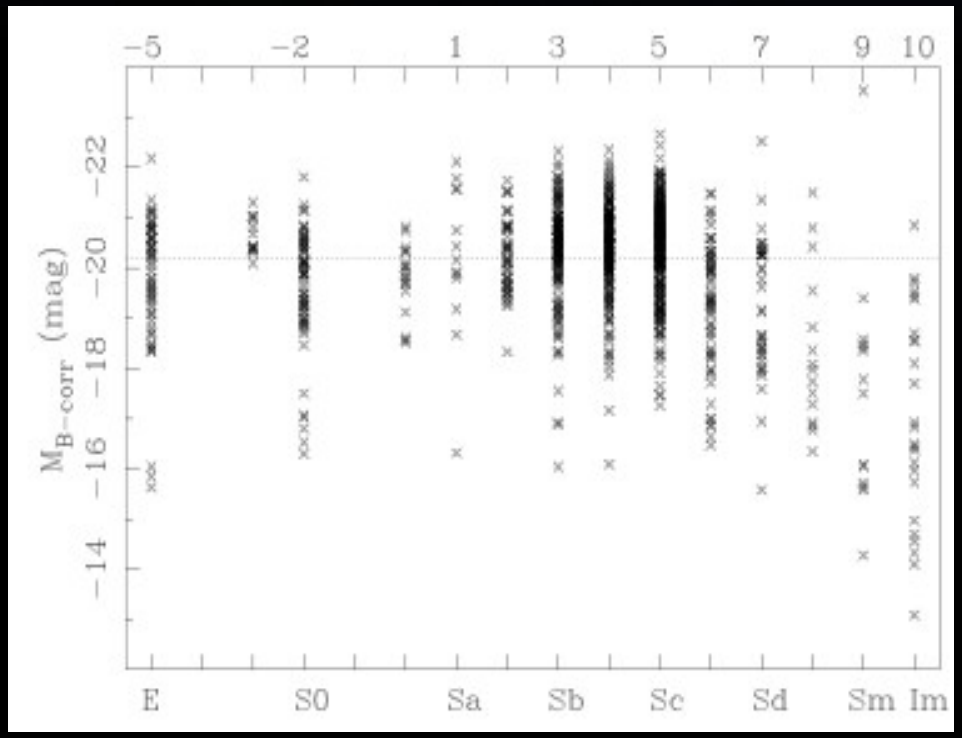
Q < -2 (1% binding forces)
η_K < 2.4

(Verley **PhD**; Verley+ 2007ab)

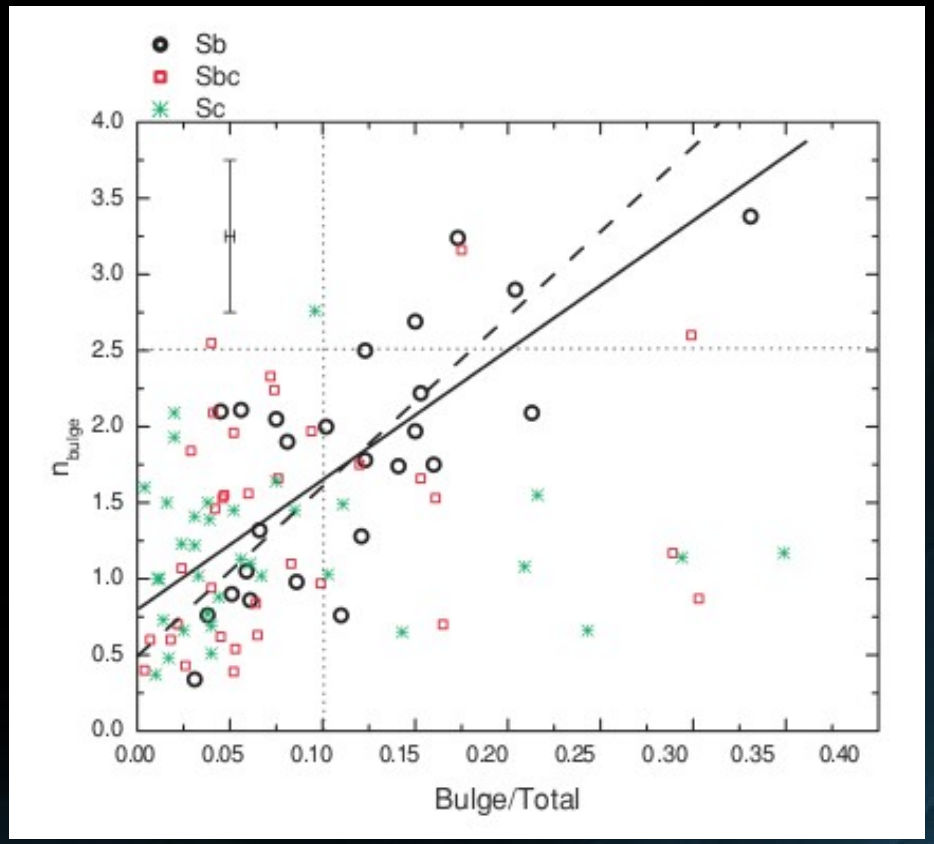


Central parts of galaxies

Some results in the optical:



A higher fraction of spirals
only 15% early-types (Sulentic+ 2006)



Most Sb-Sc spirals present pseudobulges

Durbala+ (2008)

Central parts of isolated galaxies

Bulge classification

(Fernández Lorenzo+ 2014)

Increase the sample (94) in Durbala+ (2008) to all AMIGA spirals in SDSS

Sample selection:

- **Galaxies that follow the isolation criteria of Argudo-Fernández+ (2013)**
- **Completeness criteria: mag B<15.3 (~mag r<14.5)**

⇒ **Final sample: 298 galaxies**

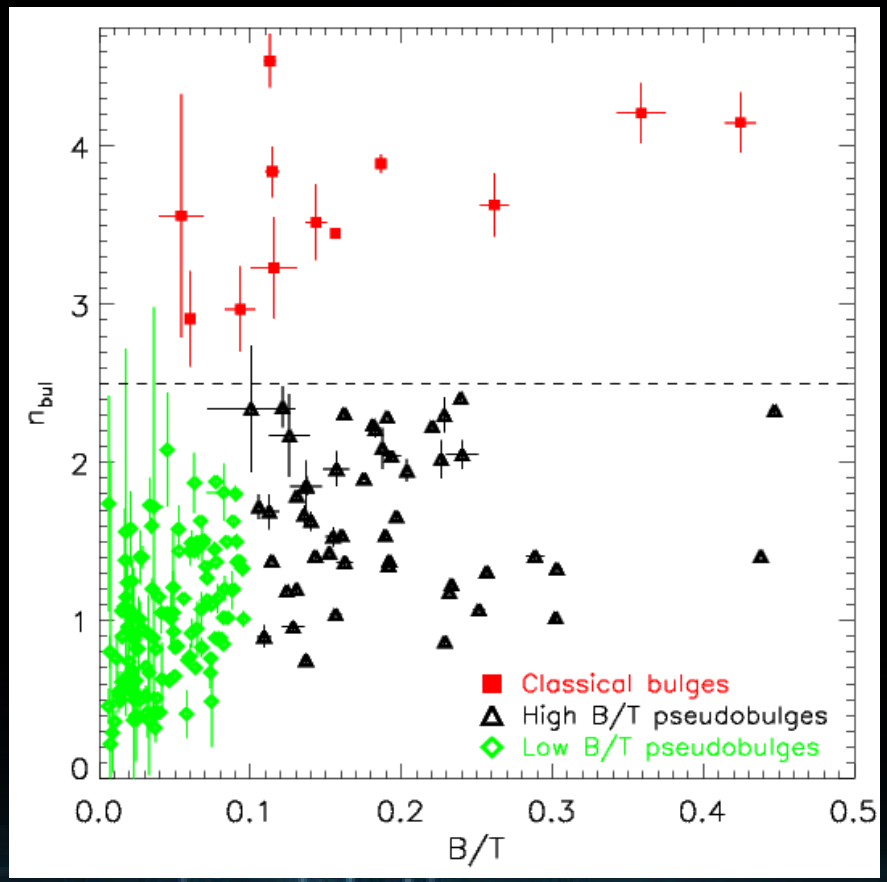
- **Bulge/disk/bar decomposition in the i-band with GALFIT (Peng et al. 2010)**

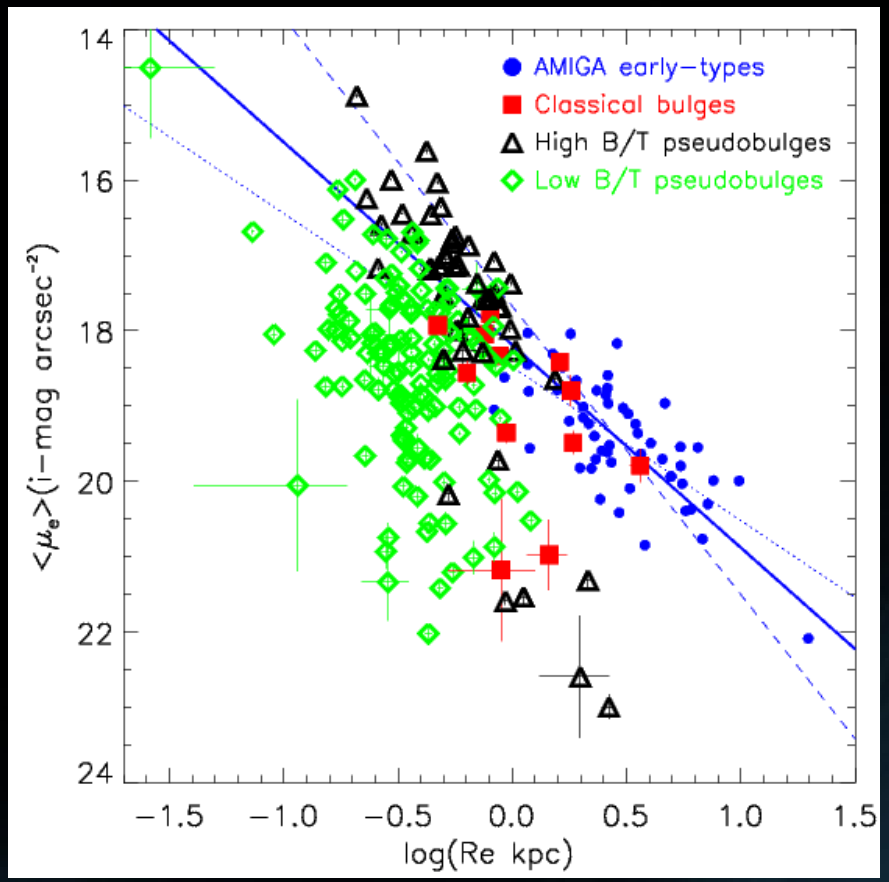
Central parts of isolated galaxies

Bulge classification

(Fernández Lorenzo+ 2014)

Final sample: 189 galaxies (residuals in the center lower than 10%)





Central parts of isolated galaxies

Bulge colors

(Fernández Lorenzo+ 2014)

(g-i) colors as indicative of the stellar populations

- Disk fits in g and i-bands: independent of fixed parameters
- Bulge colors from galfit more than 3σ redder than the red sequence: a change in the disk inside the bulge because the bulge formation and evolution?

(g-i) bulge colors: aperture photometry with ellipse

- Galaxies fitted in the i-band
- Aperture magnitudes in r and g-bands: ellipticity and position angle of isophotal aperture equal to the i-band values.

Central parts of isolated galaxies

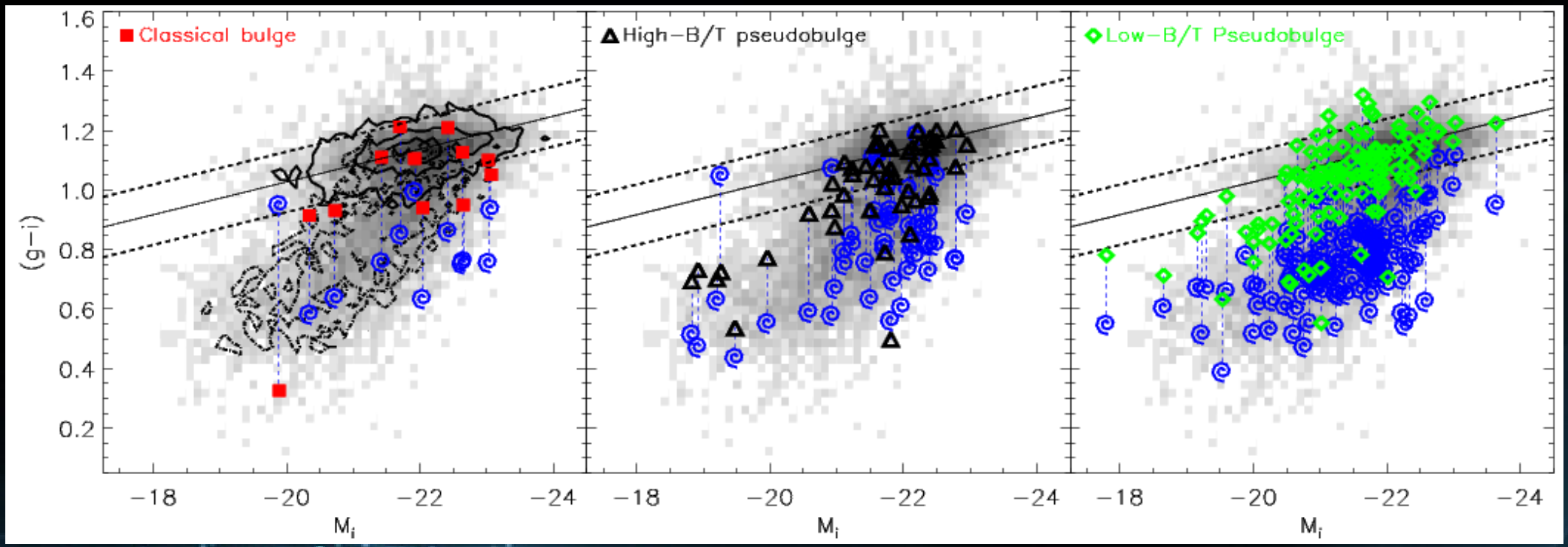
Bulge colors

(Fernández Lorenzo+ 2014)

Color-magnitude relation of galaxies in the Nair & Abraham (2010) sample

63% of bulge in the red sequence

58% of high-BT and 66% of low-BT pseudobulges in the red sequence



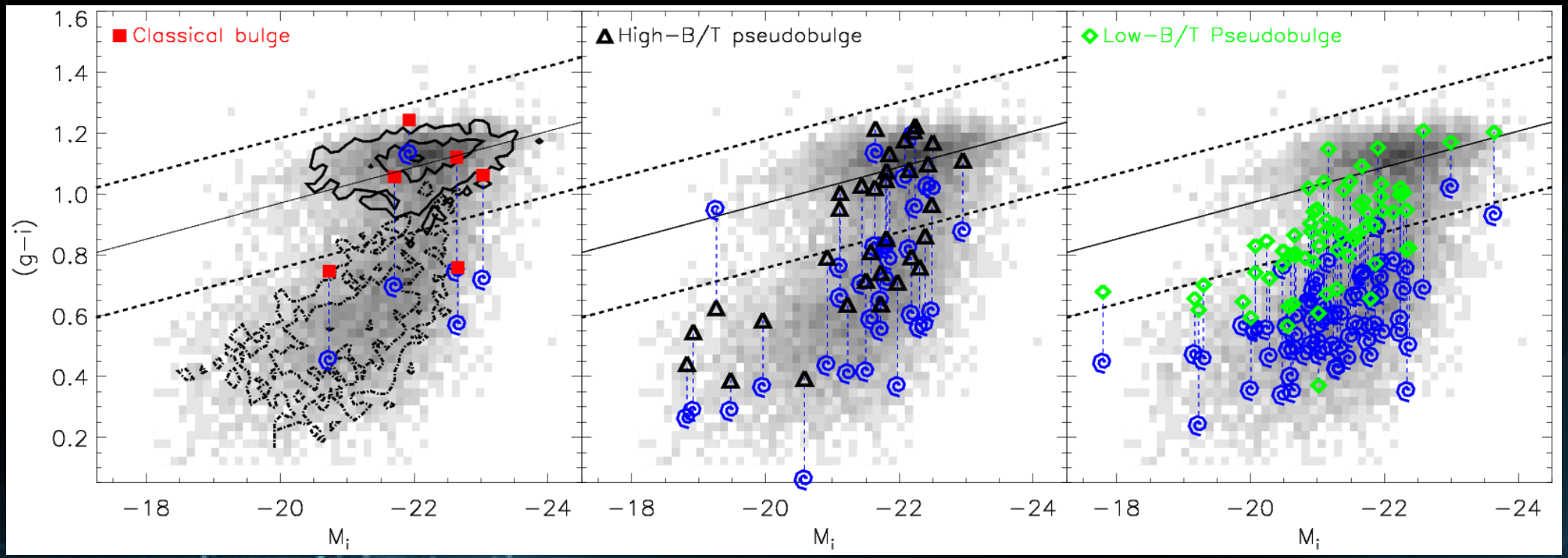
Central parts of isolated galaxies

Bulge colors

(Fernández Lorenzo+ 2014)

- Corrected by Galactic extinction, k-correction and reddening (inclination)
- What about a full reddening correction?
- We used Av from starlight (Cid-Fernandes et al. 2005) for galaxies with spectra

60% of pseudobulges are still in the red sequence



Central parts of isolated galaxies

Bulge colors

(Fernández Lorenzo+ 2014)

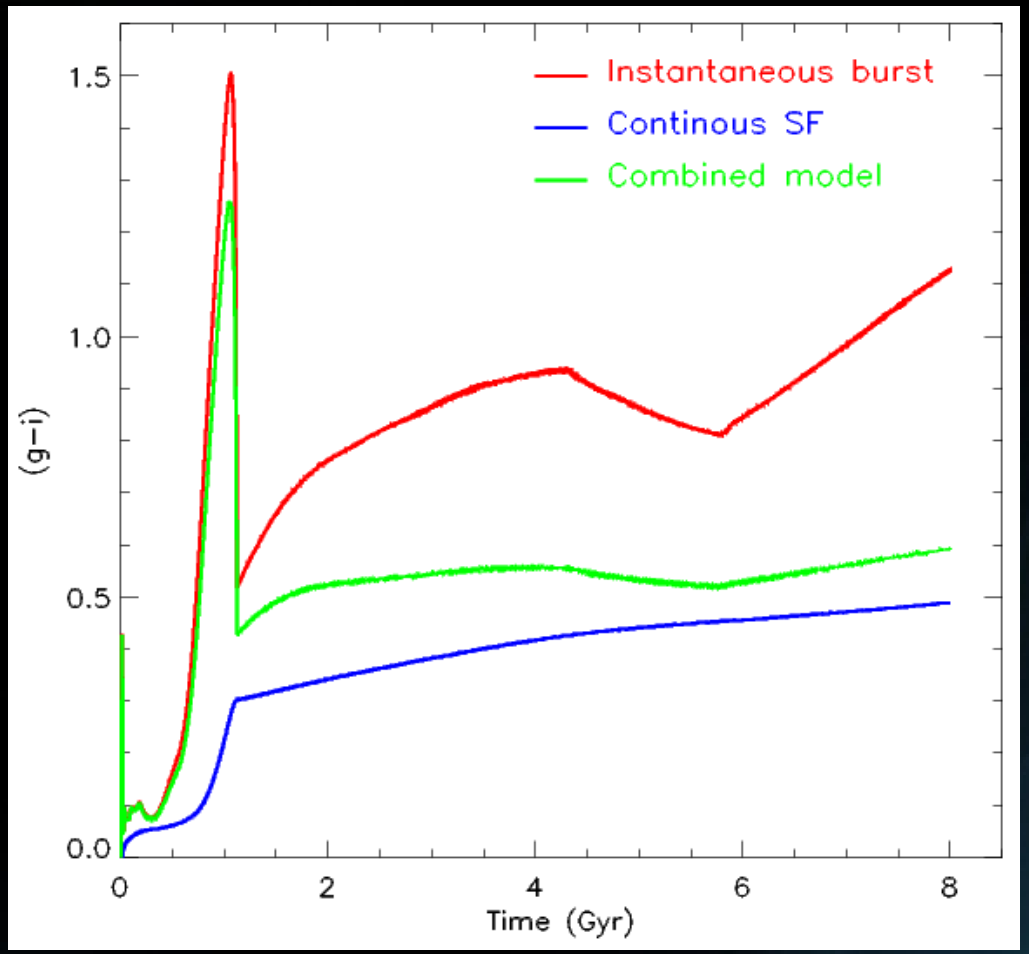
Starburst99 (Leitherer et al. 1999)

Mean bulge stellar mass=3x10^9 M$_\odot$
Two simulations (IMF of Kroupa, Z=0.008):

1) **Instantaneous burst** of 1.5x10^9 M$_\odot$

2) **Continuous SF** of 0.2M$_\odot$ yr^{-1}

After 8Gyr:
- Instantaneous burst: (g-i)=1.13
- Continuous SF: (g-i)=0.49
- Combined model: (g-i)=0.59



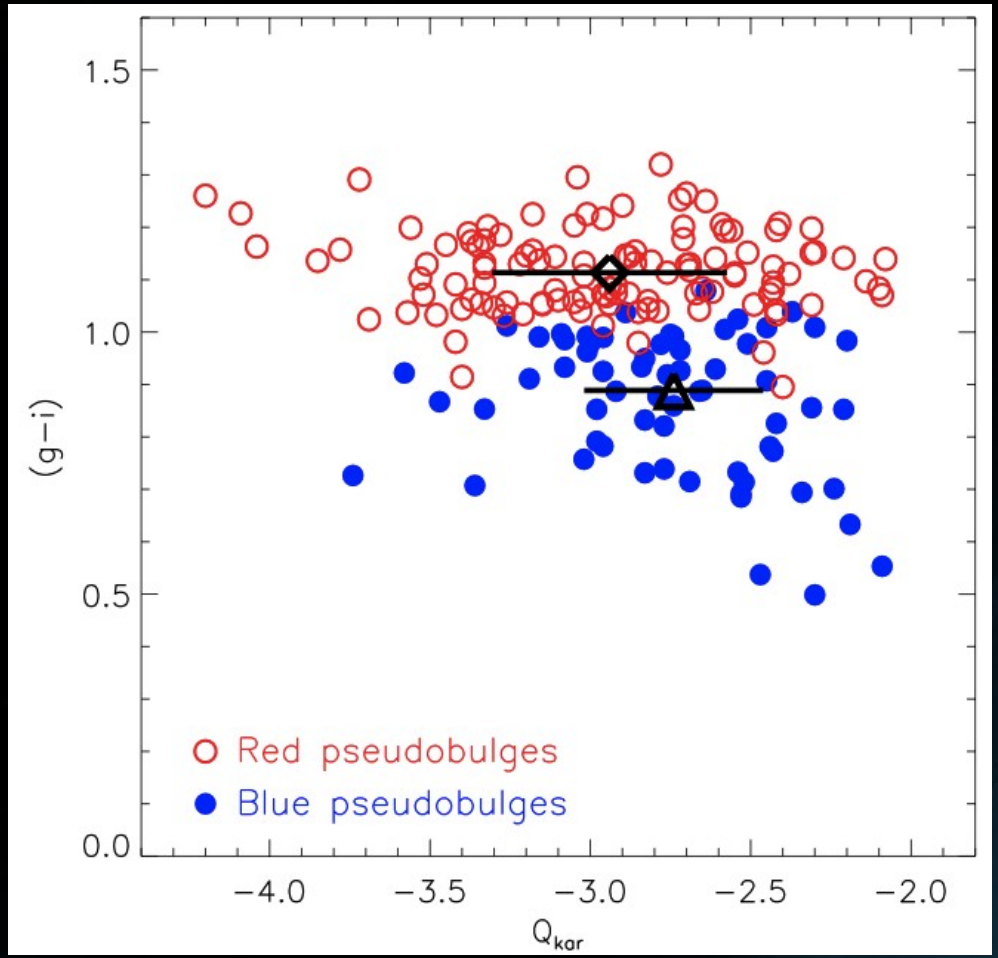
Central parts of isolated galaxies

Dependence with the environment

(Fernández Lorenzo+ 2014)

(g-i) pseudobulge color Vs Qkar

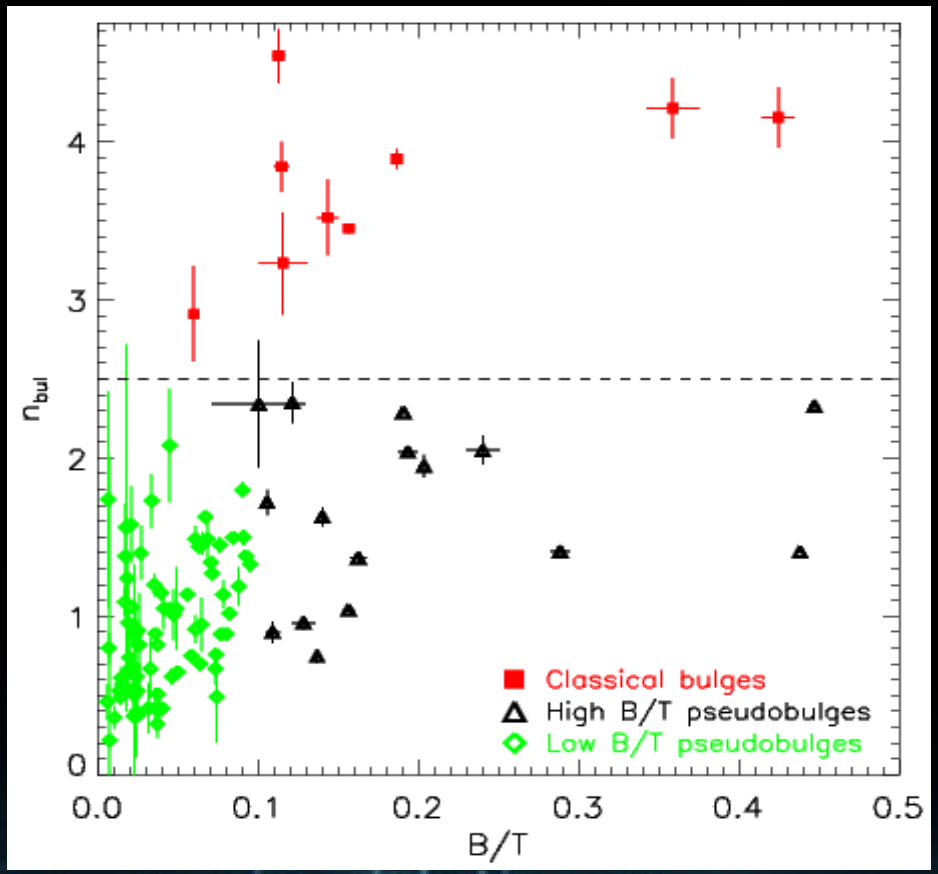
* **Red pseudobulges** distributed in all range
* **Blue pseudobulges** tend to be located at higher values of Qkar



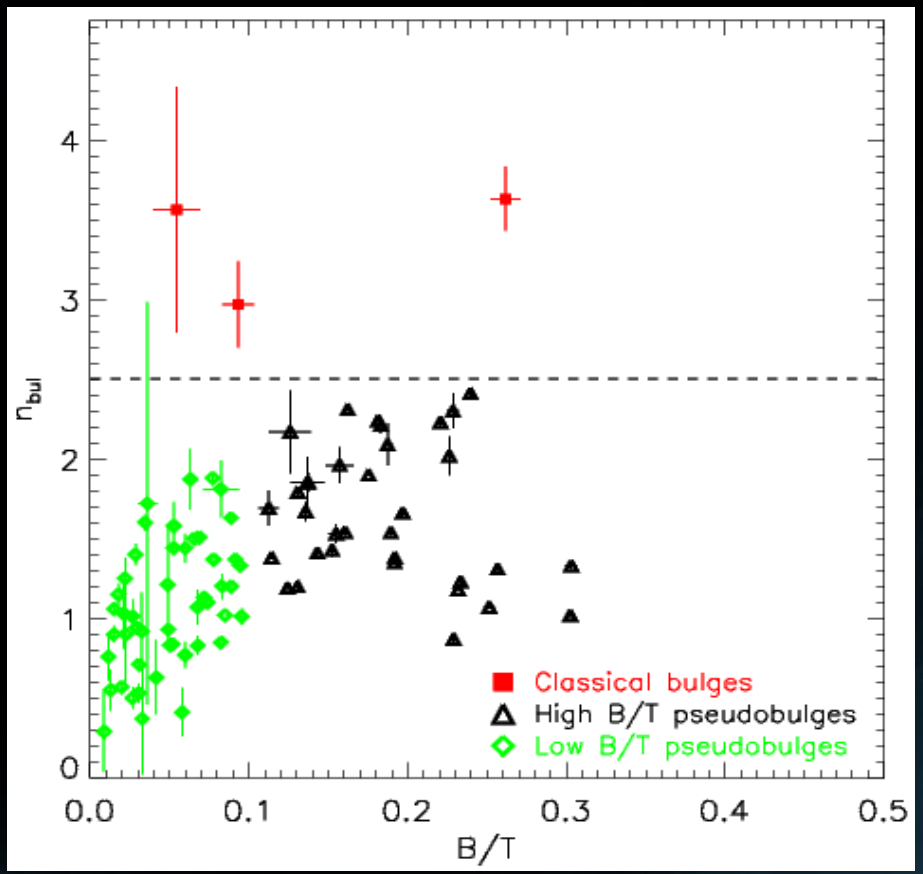
Central parts of isolated galaxies

(Fernández Lorenzo+ in prep.)

Galaxies without bar
⇨ 32% of High-BT pseudobulges
⇨ 62% of Low-BT pseudobulges



Galaxies with bar
⇨ 68% of High-BT pseudobulges
⇨ 38% of Low-BT pseudobulges



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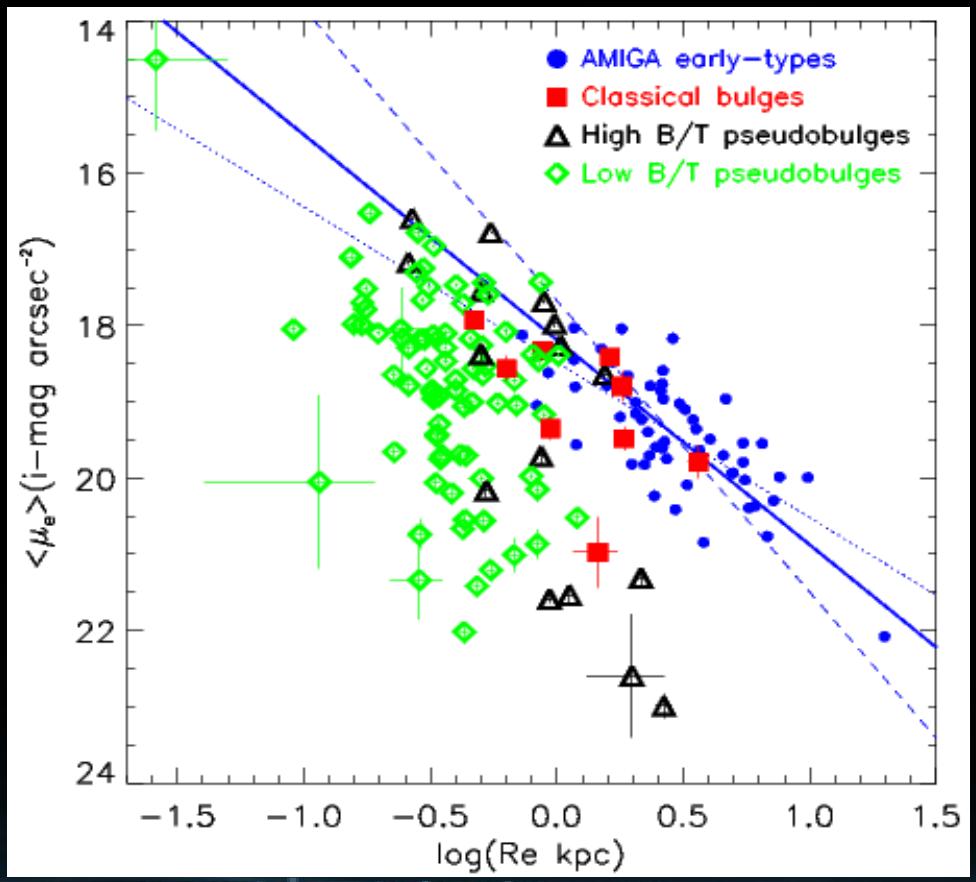

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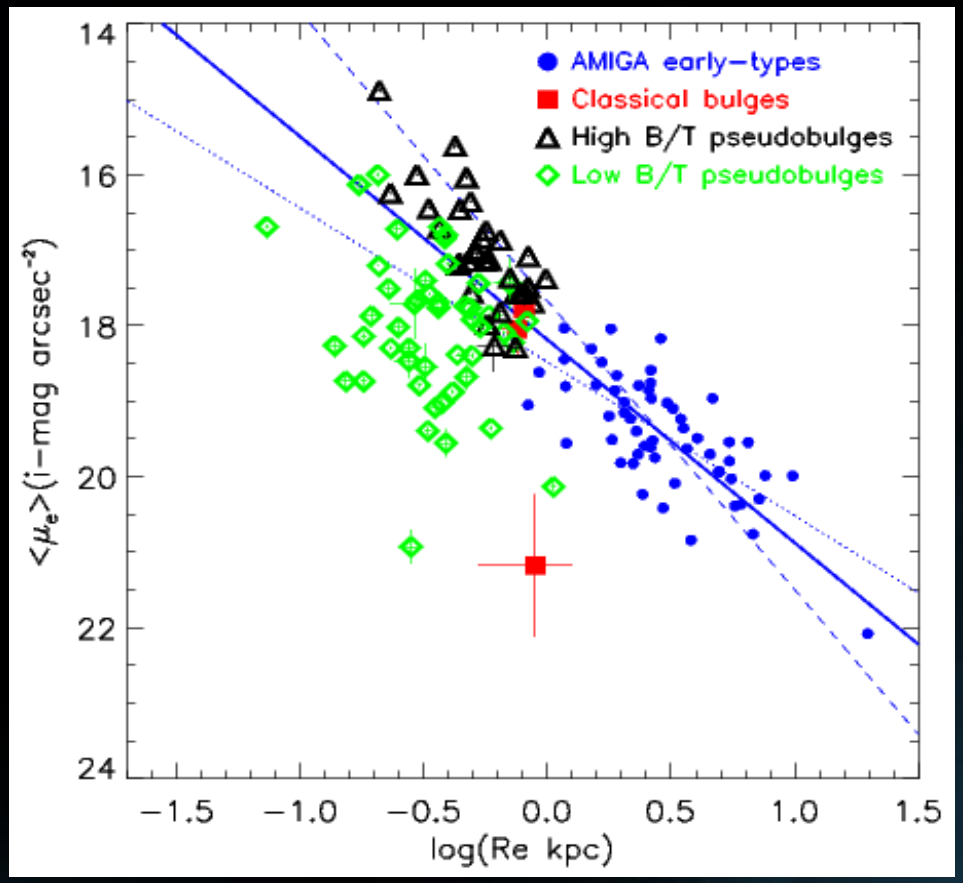

Summary

- 94% of isolated spiral galaxies have pseudobulges
- 63% of pseudobulges are in the red sequence ⇨ old stellar populations
- Continuous star formation cannot form these red pseudobulges

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Are the interactions responsible of rejuvenating the pseudobulges?