

Characterisation of an Isolated Galaxy Sample and the Influence of the Environment

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Stellar Cluster and Galaxy group seminar
September 24th, 2014

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- AMIGA project
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Revision of the isolation of the CIG galaxies

- Photometric study
- Spectroscopic study
- Conclusions

Effects of the environment on the CIG galaxies

- Physical satellites
- Influence of the environment
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- Catalogues
- Relation to the LSS
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- Role of the environment in the formation and evolution of galaxies
- Which properties are due to internal secular evolution and which to external influences
- Reference sample with minimum influence from the environment

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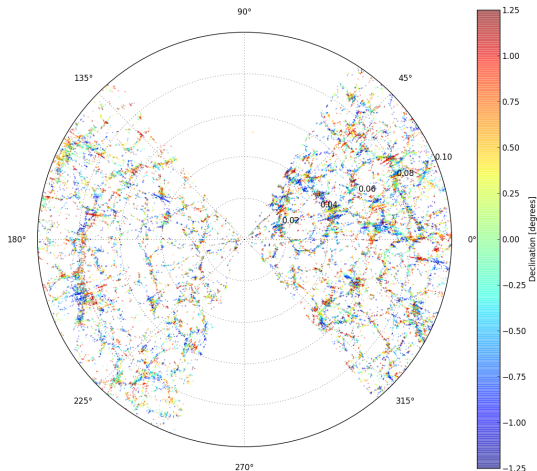
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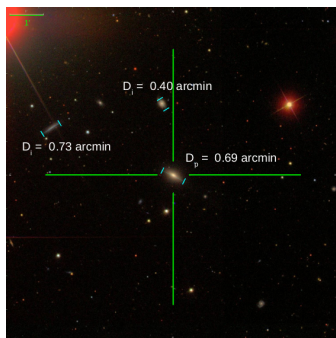
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- Analysis of the interstellar **M**edium of **I**solated **G**Alaxies
- Catalogue of **I**solated **G**alaxies [CIG, Karachentseva 1973]



1050 CIG galaxies
2D isolation criterion:

- $\frac{1}{4} D_P \leq D_i \leq 4 D_P$
- $R_{iP} \leq 20 D_i$

No similar-size galaxies in
their close environments

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1 Refinement of the sample

- Positions [Leon & Verdes-Montenegro 2003]
- Redshift and distances [Verdes-Montenegro et al. 2005]
- Morphologies [Sulentic et al. 2006]
- Isolation degree [Verley et al. 2007b,c, Argudo-Fernandez et al. 2013, 2014a]

2 Multiwavelength characterisation of the ISM

- Optical [Sulentic et al. 2006, Durbala et al. 2008, 2009, Sabater et al. 2008, 2012, Fernández Lorenzo et al. 2012, 2013, 2014]
- H α [Verley et al. 2007a]
- Near & far infrared [Lisenfeld et al. 2007]
- Radiocontinuum [Leon et al. 2008]
- Atomic gas [Espada et al. 2005, 2011]
- Molecular gas [Lisenfeld et al. 2012]

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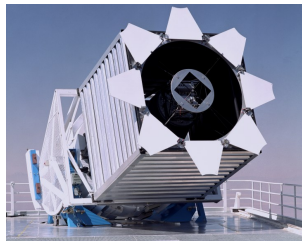
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The SDSS

[York et al. 2000]

<http://www.sdss3.org>



Sloan Digital Sky Survey

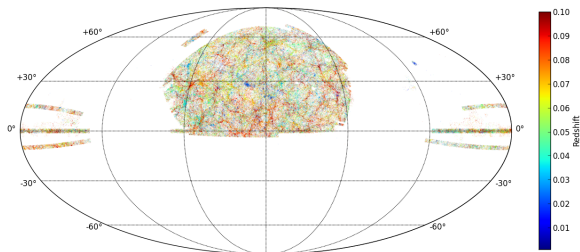
2.5 m Telescope [Gunn et al. 2006]

Apache Point Observatory, New Mexico

SDSS-DR9 [Eisenstein et al. 2011]

Photometry: 208,478,448 galaxies

Spectroscopy: 952,740 galaxies



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- Projected density to the k^{th} nearest neighbour:

$$\eta_k \propto \log\left(\frac{k-1}{V(r_k)}\right)$$

$$V(r_k) = \frac{4}{3}\pi r_k^3$$

- Tidal strength (estimation of gravitational interaction):

$$Q_{iP} \equiv \frac{F_{\text{tidal}}}{F_{\text{bind}}}$$

$$\log Q_{iP} \propto 0.4 (m_r^P - m_r^i) + 3 \log\left(\frac{D_P}{R_{iP}}\right)$$

and $Q = \log(\sum_i Q_{iP})$

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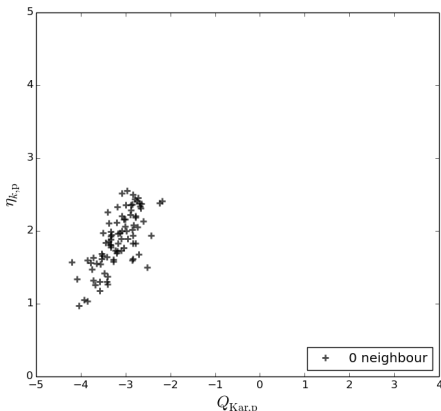
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- 636 CIG galaxies in the photometric SDSS
- 86 CIG galaxies pass the CIG isolation criterion



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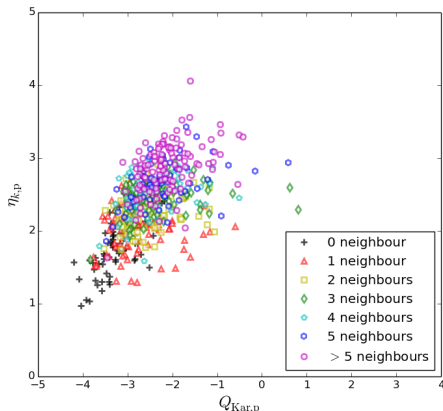
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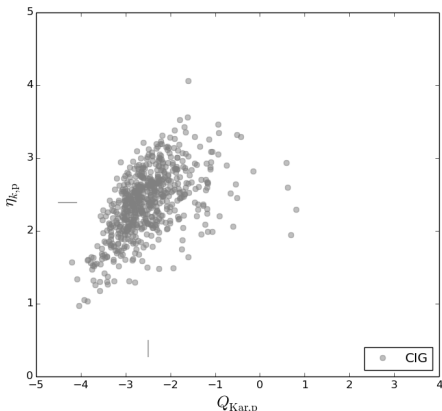
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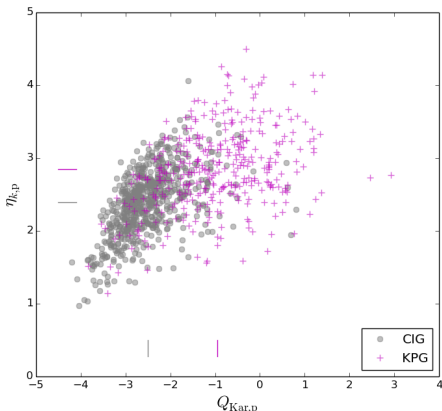
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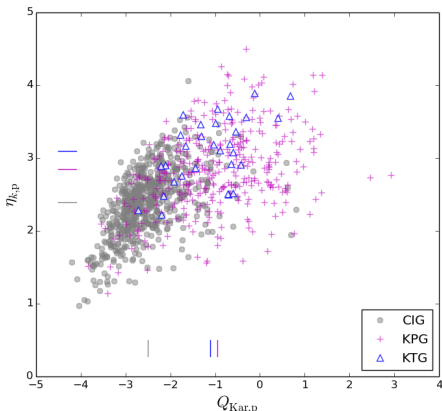
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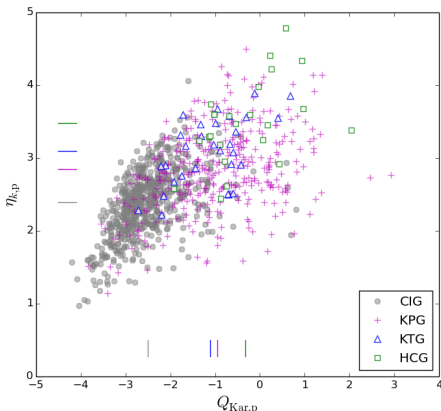
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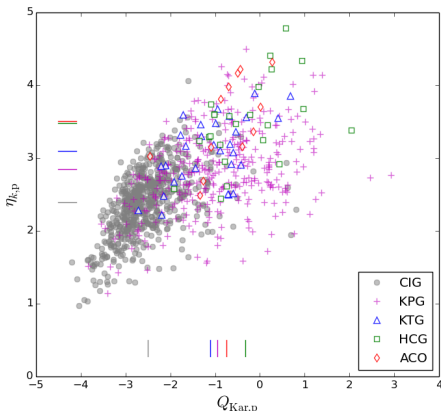
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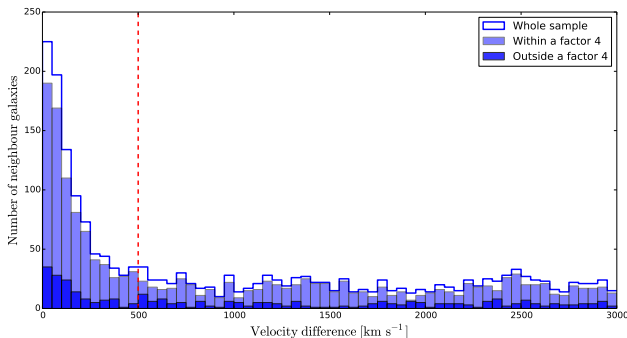
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Spectroscopic isolation criterion

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- 411 CIG galaxies in the spectroscopic SDSS
- 347 CIG galaxies pass the CIG isolation criterion
- 105 CIG galaxies pass $\Delta v \leq 500 \text{ km s}^{-1}$
- 50% of the companions by the CIG isolation criterion show very high Δv
- 92% of similar Δv are not considered as companions



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- **Fainter & smaller neighbours**
- **Nearby dwarf galaxies** not taken into account by the CIG isolation criterion
- **50%** of the companions by the CIG isolation criterion are **background galaxies** showing very high Δv
- **92%** of similar Δv are **not considered as companions**

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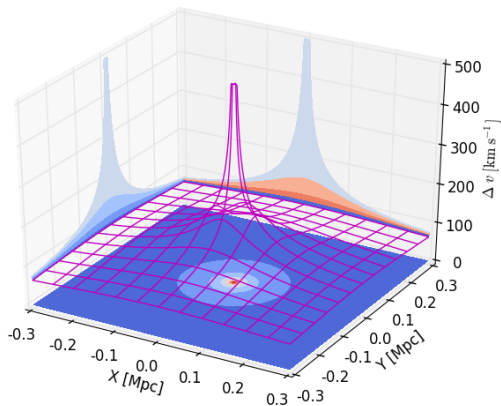
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$$v_{\text{esc}} = \sqrt{\frac{2GM_P}{R_{iP}}}$$



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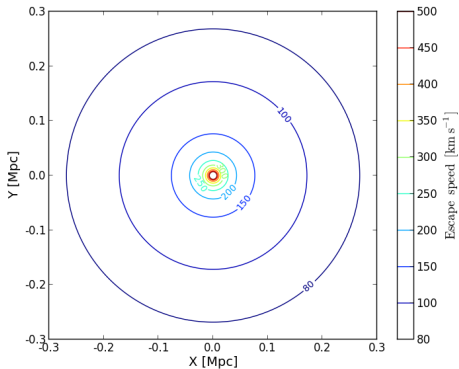
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$$|\Delta v| \leq \sqrt{\frac{2GM_P}{3\frac{\sqrt{3}}{\sqrt{2}}R_{iP}}}$$



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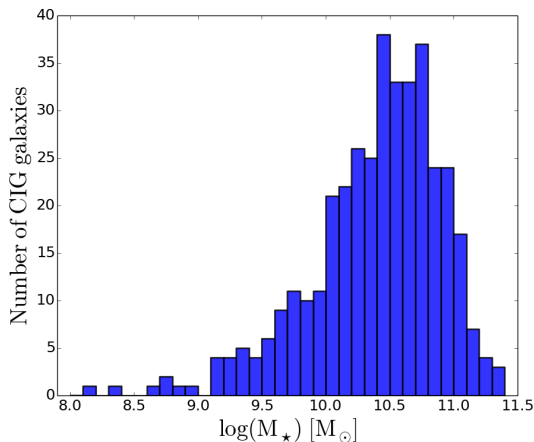
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- SDSS g -, r -, and i -bands
- K correction rest-frame magnitudes and stellar masses
[Blanton et al. 2007]



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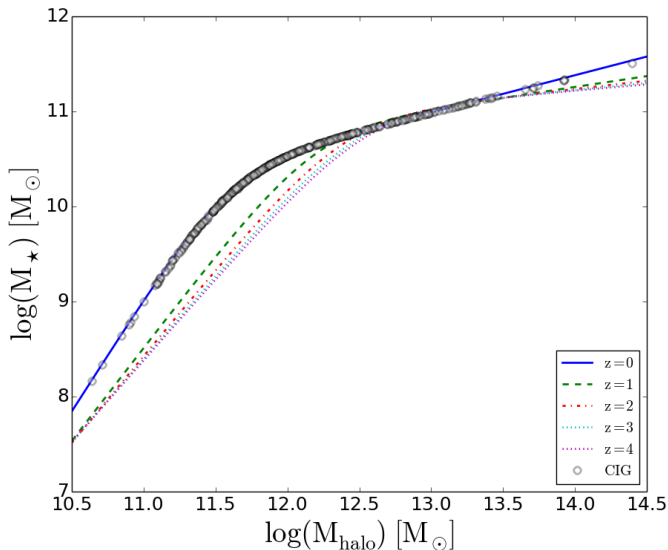
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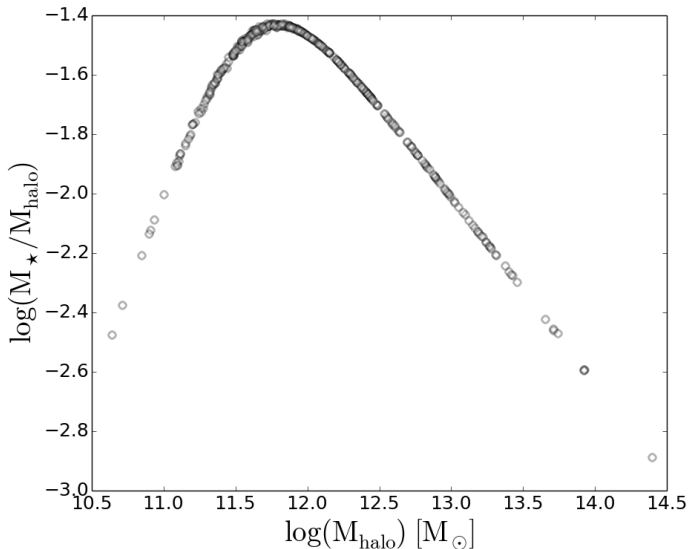
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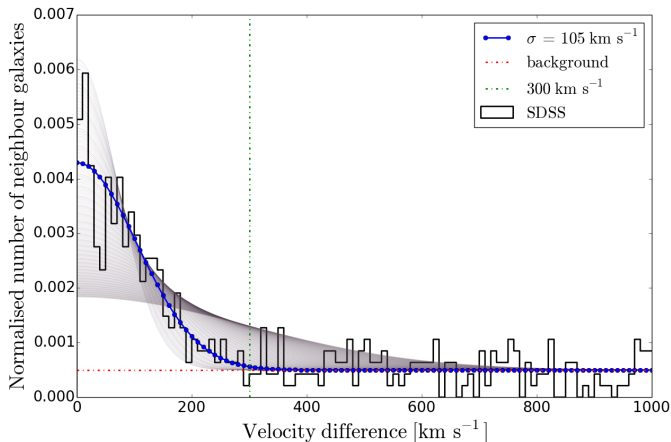
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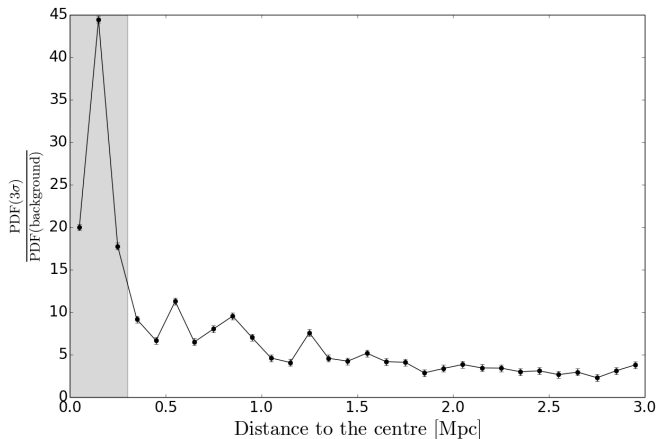
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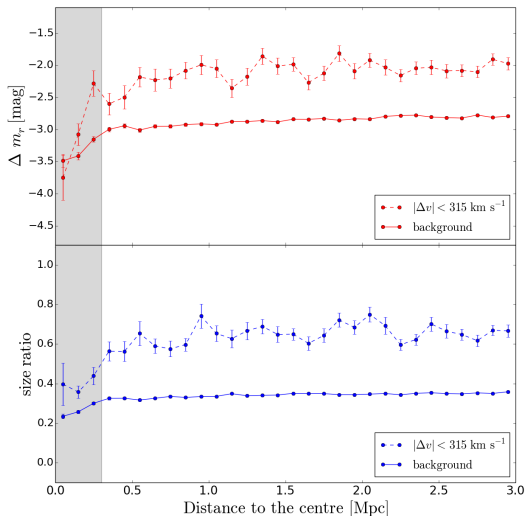
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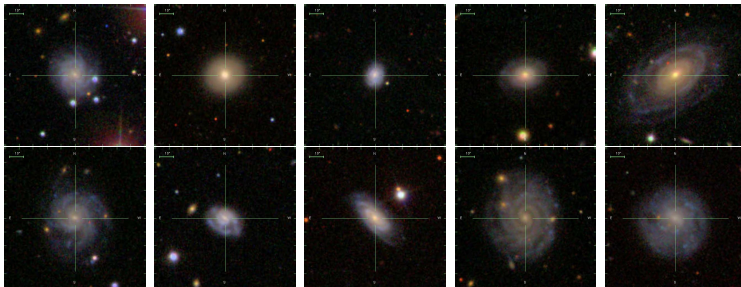
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- 386 CIG galaxies
- 37 CIG galaxies (10% of the sample) with physically bound satellites
- 10 most isolated (no neighbours within 3 Mpc):



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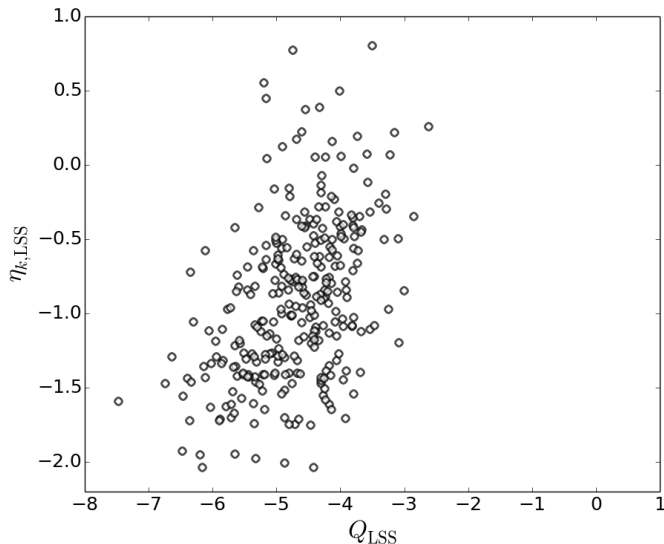
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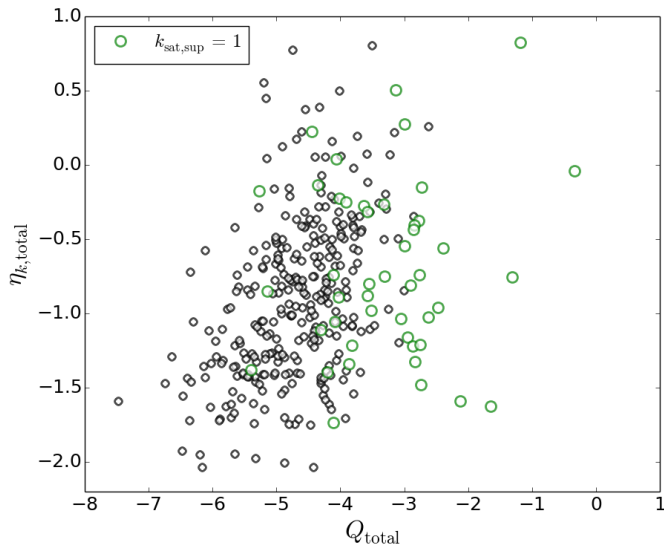
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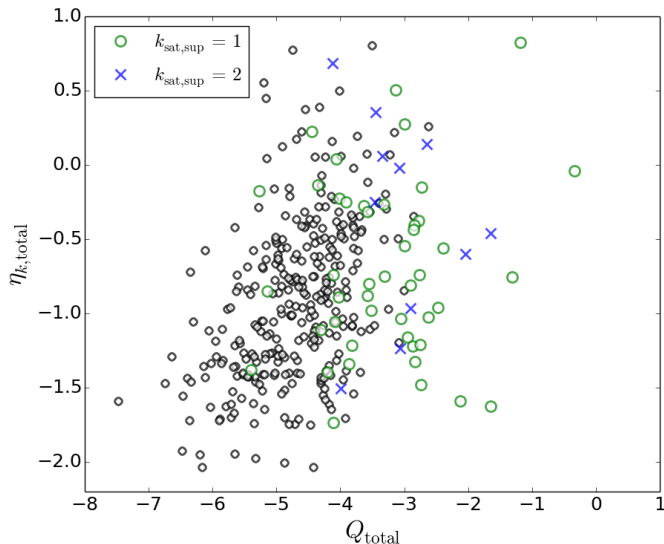
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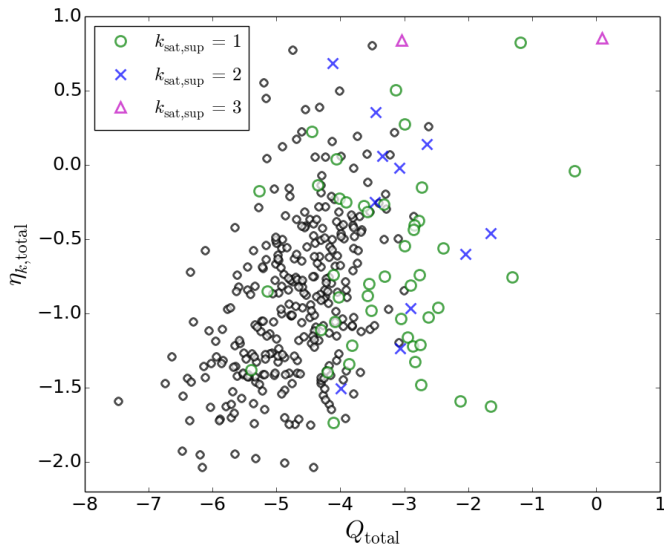
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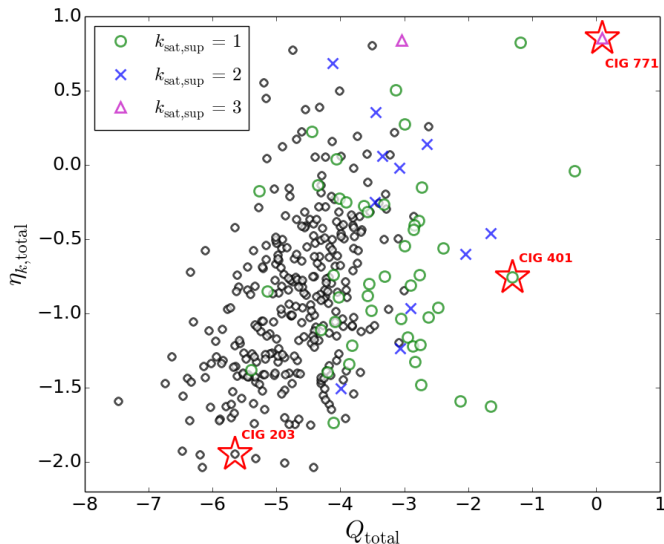
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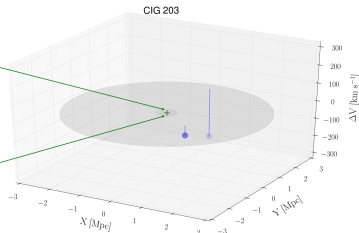
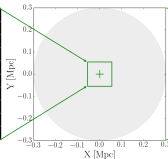
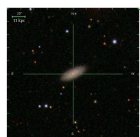
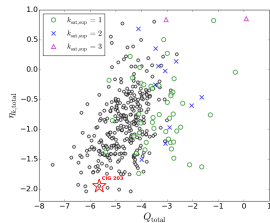
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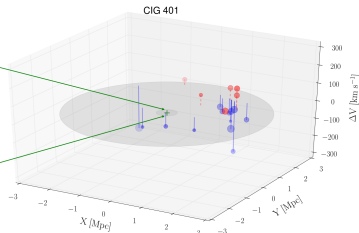
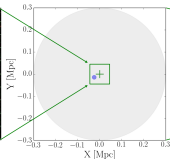
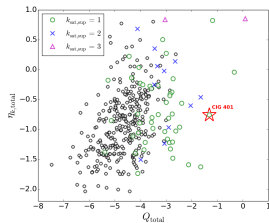
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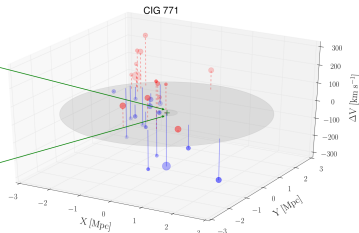
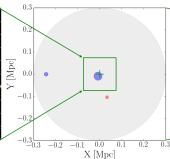
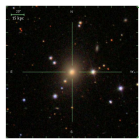
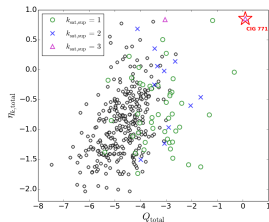
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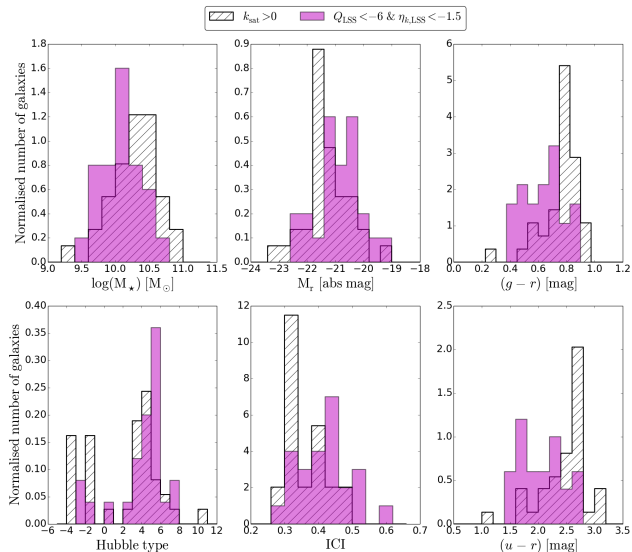
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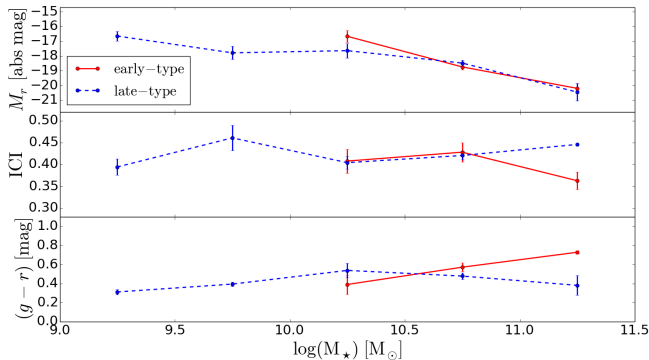
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- **10%** of the sample have **physically bound satellites**
- **90%** of the sample have no physically bound satellites but **may suffer interactions with fly-by galaxies**
- CIG galaxies show **continuous degree of connection with the LSS**
- Clear segregation between **younger and older systems**, confirmed by the nature of the physically associated galaxies

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Primary galaxies

$$11 < m_r < 15.7$$

$$0.005 < z < 0.080$$

80% z completeness

33,081

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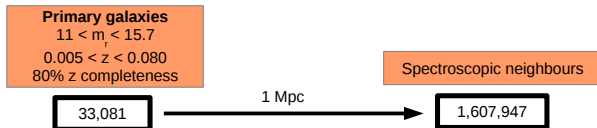
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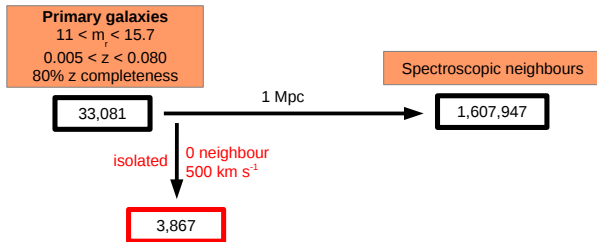
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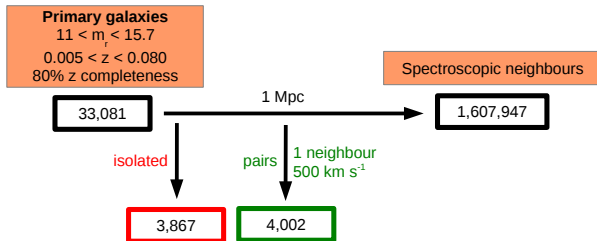
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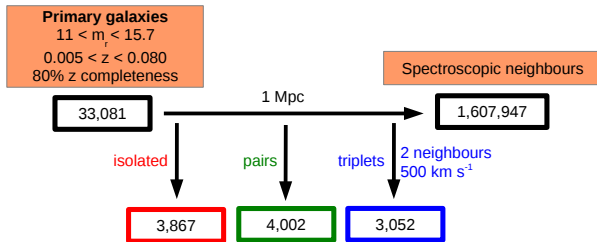
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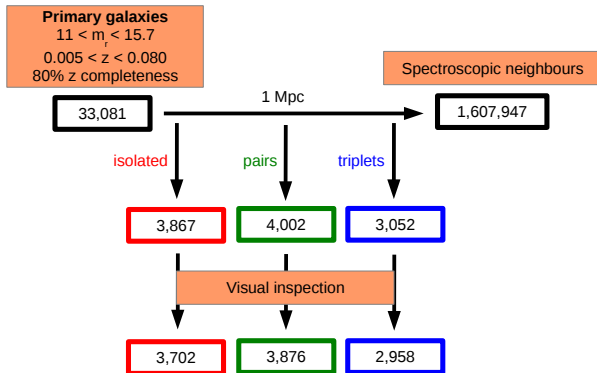
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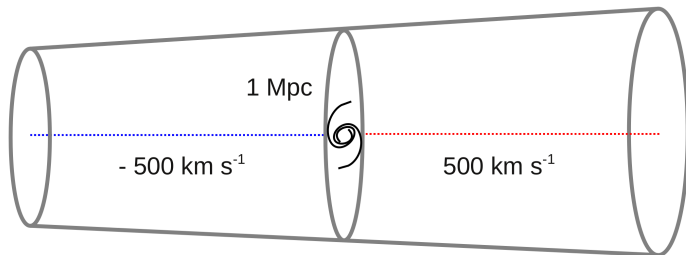
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- Field radius of 1 Mpc: crossing time ~ 5.2 Gyr
- $\Delta v \leq 500 \text{ km s}^{-1}$ to avoid physical associations
- 3,702 isolated galaxies



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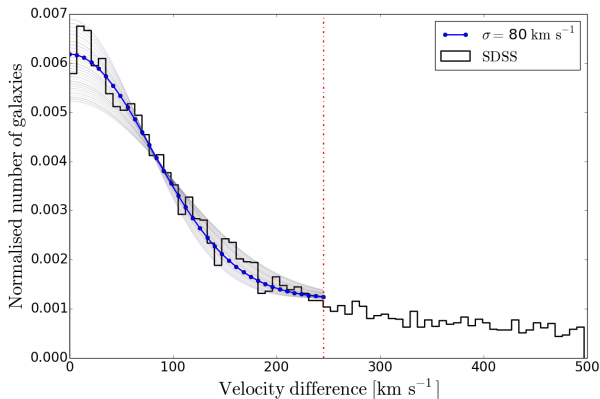
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- Pairs & triplets: $\Delta v \leq 160 \text{ km s}^{-1}$ & $d \leq 450 \text{ kpc}$
- Close pairs & triplets: $\Delta v \leq 160 \text{ km s}^{-1}$ & $d \leq 250 \text{ kpc}$



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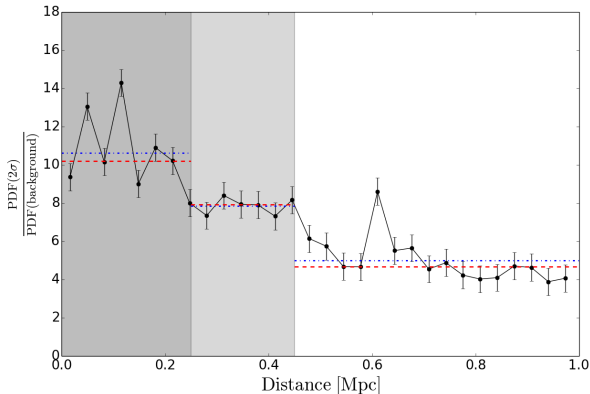
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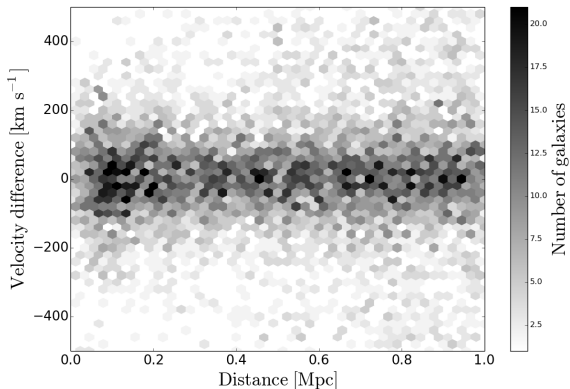
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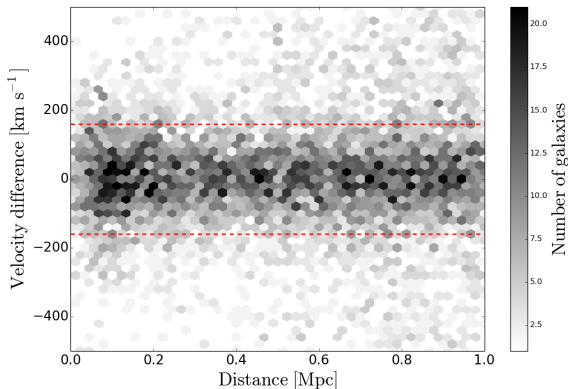
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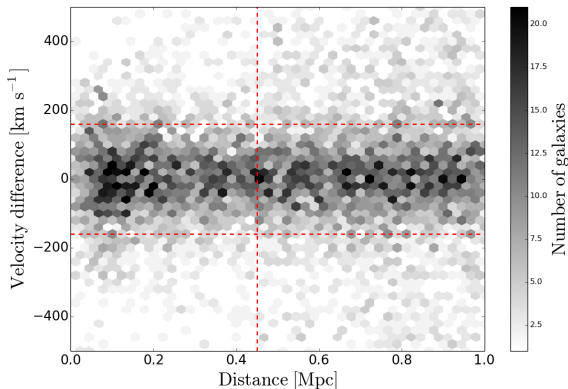
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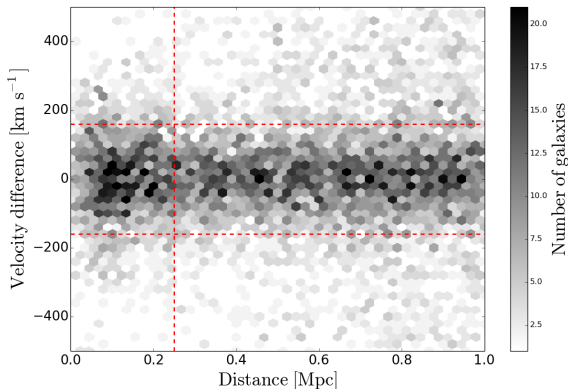
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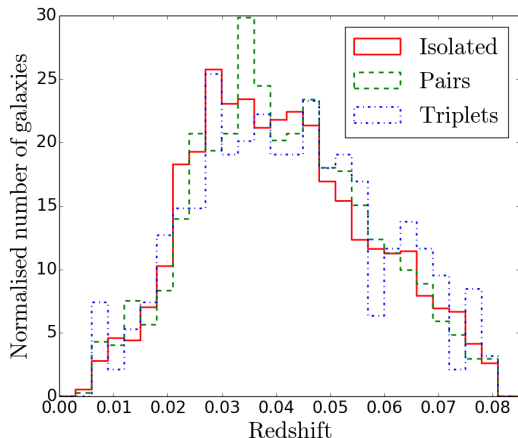
Redshift distributions

- 3,702 isolated galaxies
- 1,240 isolated pairs
- 315 isolated triplets

SDSS-based Isolated Galaxies (SIG)

SDSS-based Isolated Pairs (SIP)

SDSS-based Isolated Triplets (SIT)



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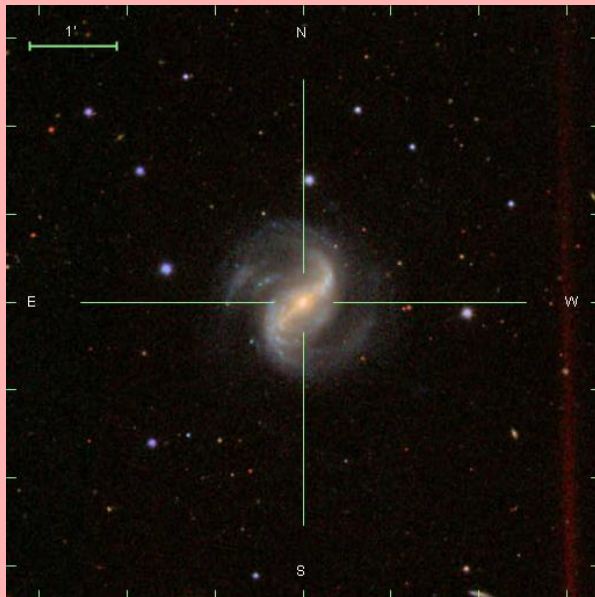
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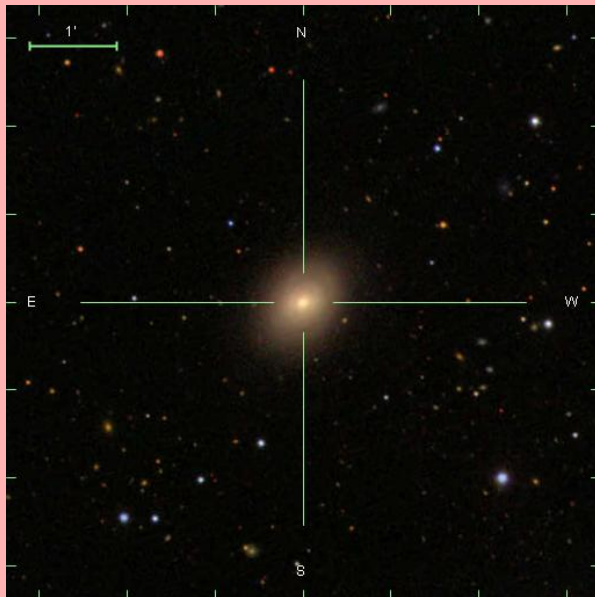
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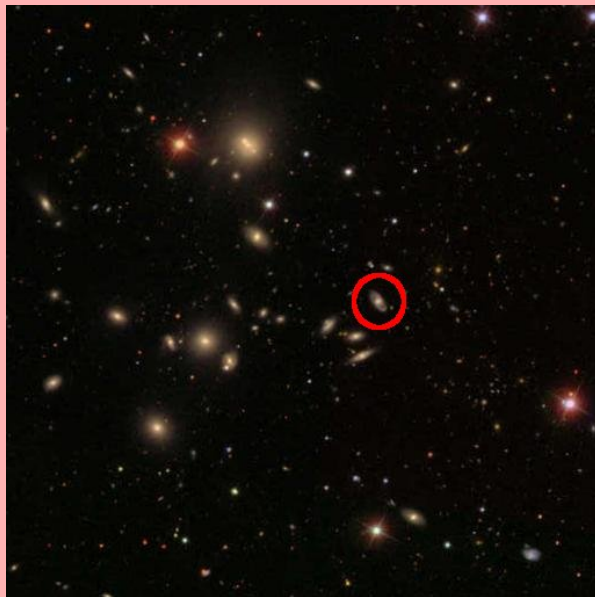
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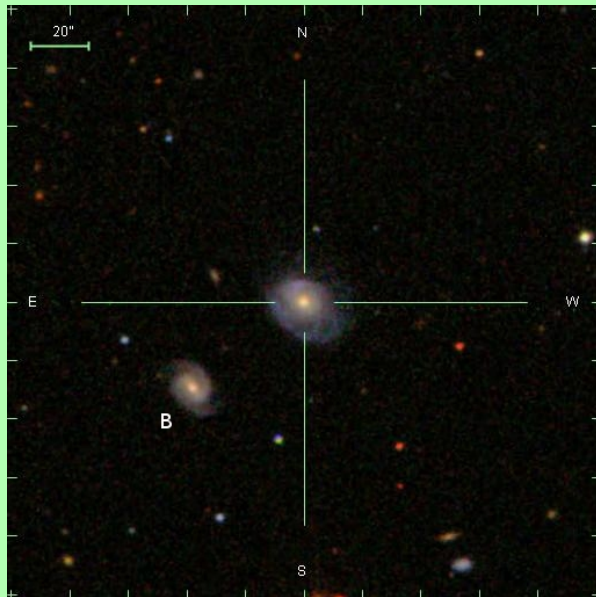
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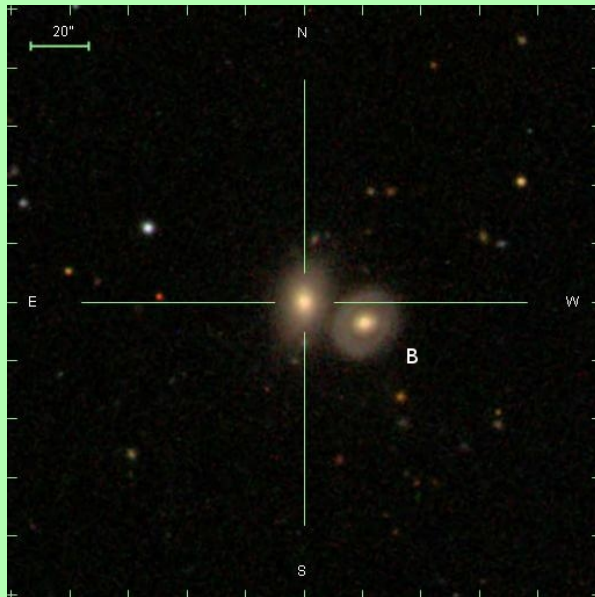
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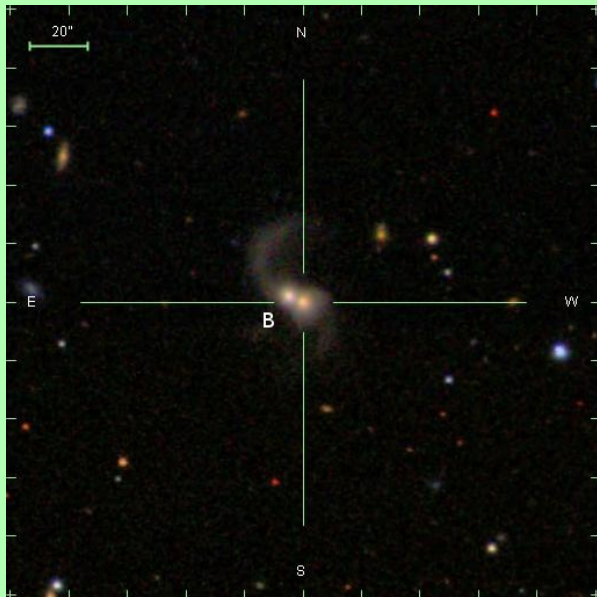
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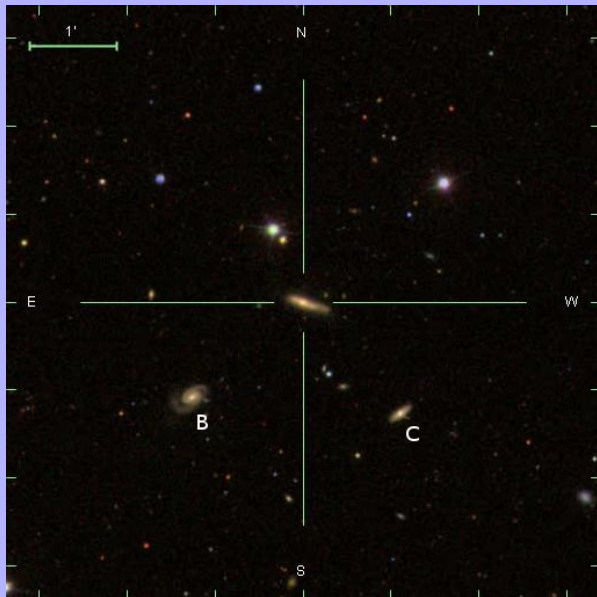
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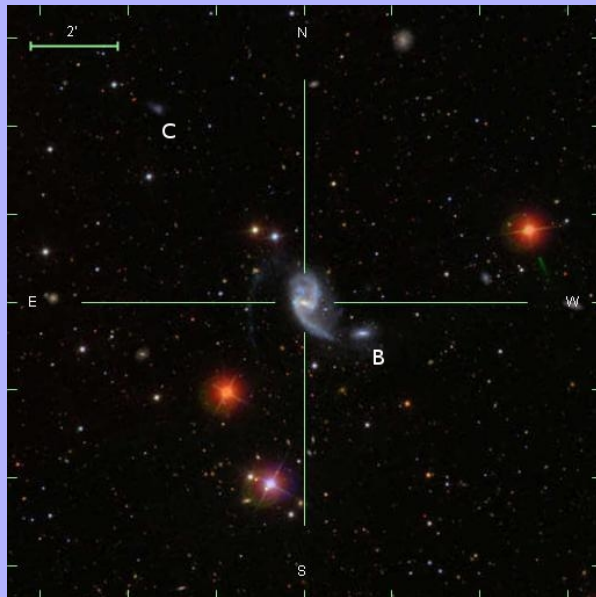
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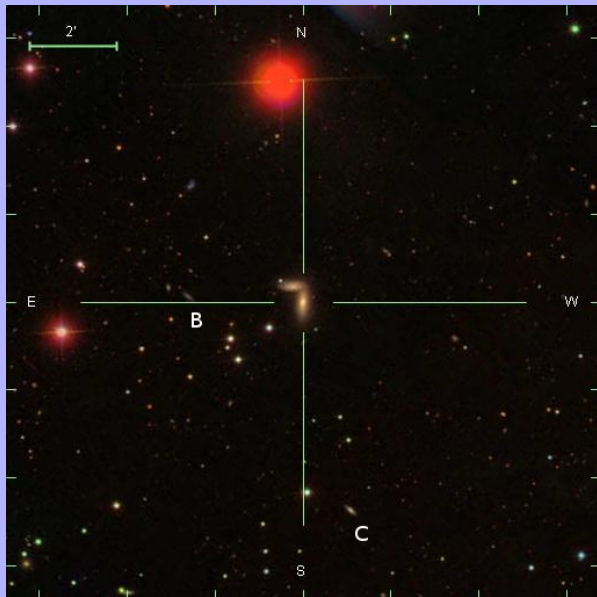
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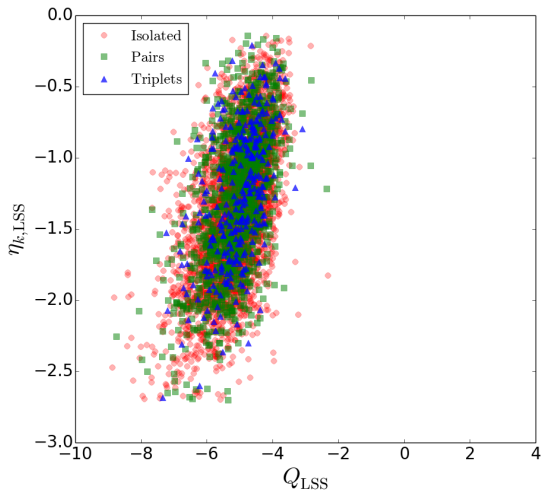
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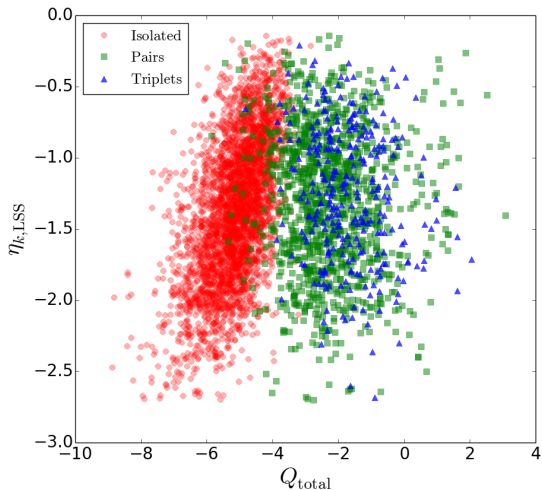
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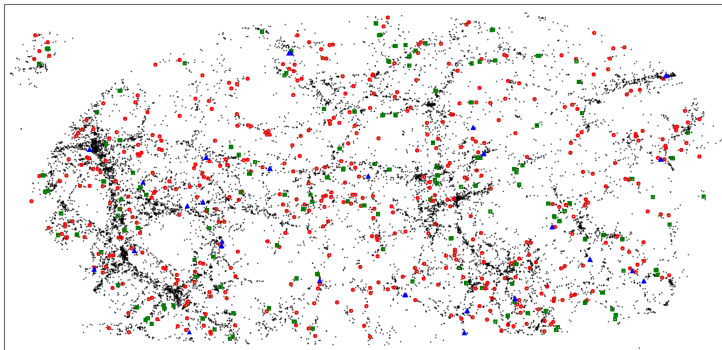
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• Isolated ◻ Pairs ▲ Triplets



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Relation to the LSS

S. Duarte Puertas & E. Ramos Carmona

Mollweide projection

$0.030 < z < 0.035$

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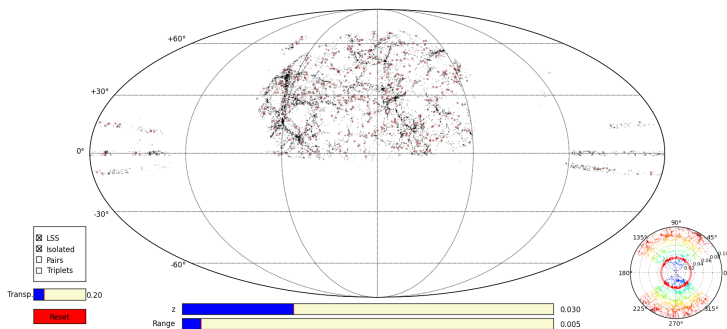
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Relation to the LSS

S. Duarte Puertas & E. Ramos Carmona

Wedge diagram

$$-2^\circ < \delta < 2^\circ$$

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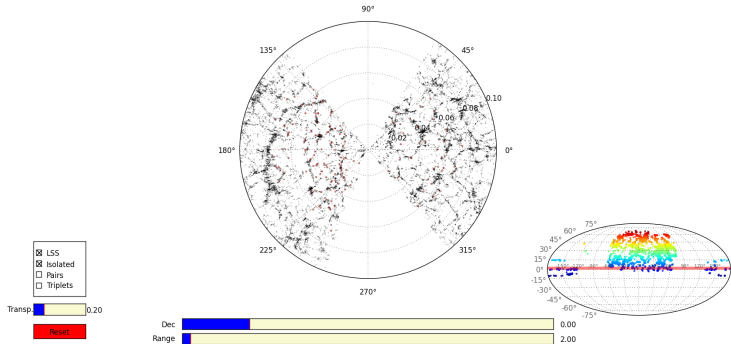
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Minimum Spanning Tree

[Vanderplas et al. 2012, Ivezić et al. 2013]

$-1.25^\circ < \delta < 1.25^\circ$

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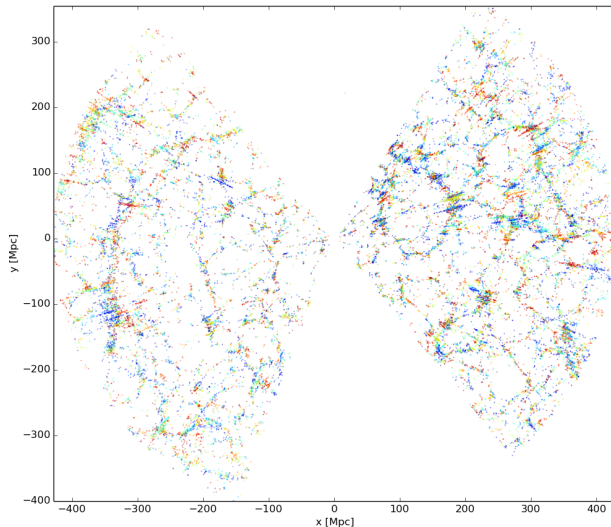
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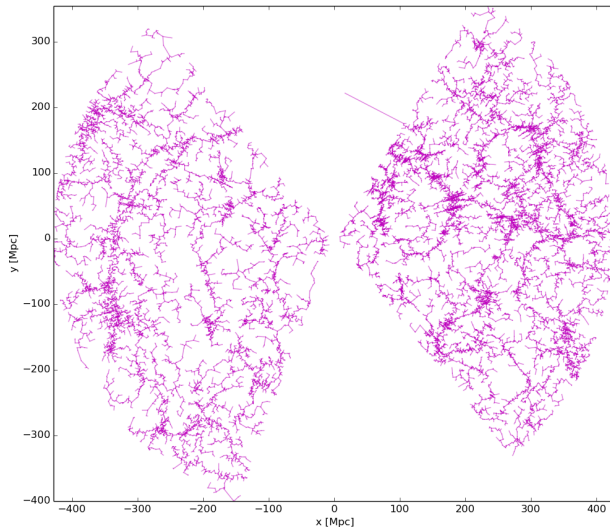
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Minimum Spanning Tree

[Vanderplas et al. 2012, Ivezić et al. 2013]

Threshold 2.9 Mpc

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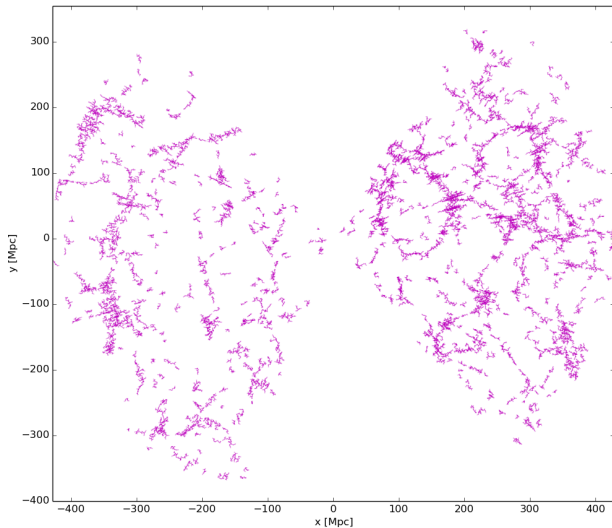
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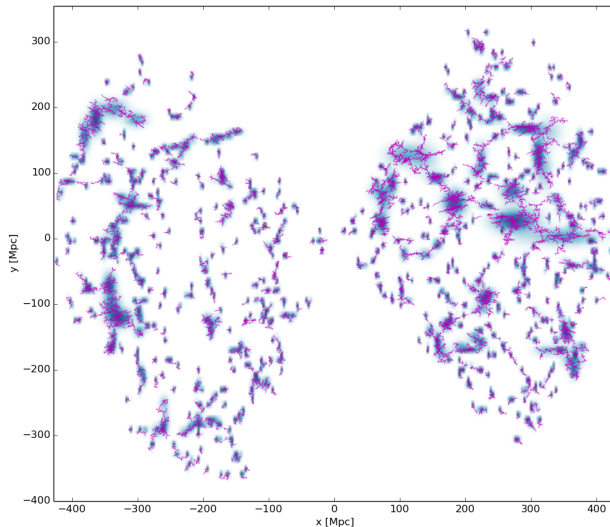
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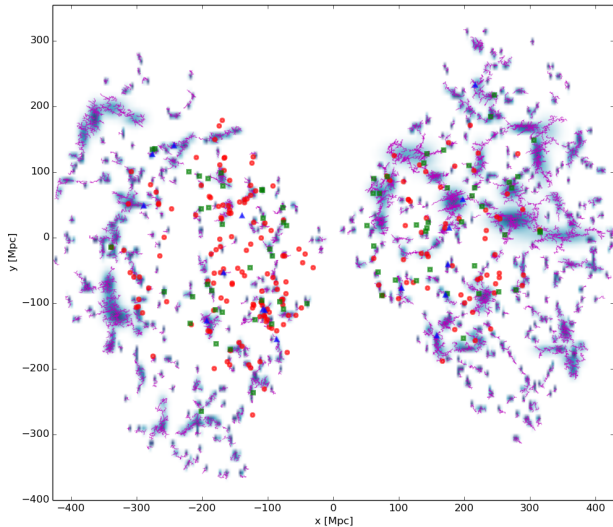
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- **SIG catalogue: 3,702 isolated galaxies** which represent about **11%** of the considered galaxies in the local Universe
- **SIP catalogue: 1,240 isolated pairs** which represent about **7%** of the considered galaxies in the local Universe
- **SIT catalogue: 315 isolated triplets** which represent about **3%** of the considered galaxies in the local Universe
- Generally **differ from the void** population of galaxies
- Most of the isolated galaxies, isolated pairs, and isolated triplets, belong to the **outer parts of filaments, walls, and clusters**

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Multi-wavelength studies of galaxy properties and their relation with local and large-scale environments:

- **morphology** Galaxy Zoo 2 (GZ2) [Willett et al. 2013],
- **star formation (SFR)** [Brinchmann et al. 2004],
- **metallicity** [Tremonti et al. 2004],
- **nuclear activity** BPT diagrams [Baldwin, Phillips & Terlevich 1981, Kauffmann et al. 2003],
- ...

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