The environment of low-redshift quasar pairs

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OUTLINE

The program:

- **ENVIRONMETAL PROPERTIES of QSOs and QSO PAIRS**

Large (~400) and homogeneous sample of low redshift (z<0.5) QSOs from SDSS stripe82 dataset

- HOST GALAXIES PROPERTIES (Falomo+2014, MNRAS)
- GALAXY ENVIRONMENT (Karhunen+2014, MNRAS)
- HOST MORPHOLOGY AND COULORS (Bettoni+2014, in preparation, see POSTER)

QSO pairs (z<1) from SDSS

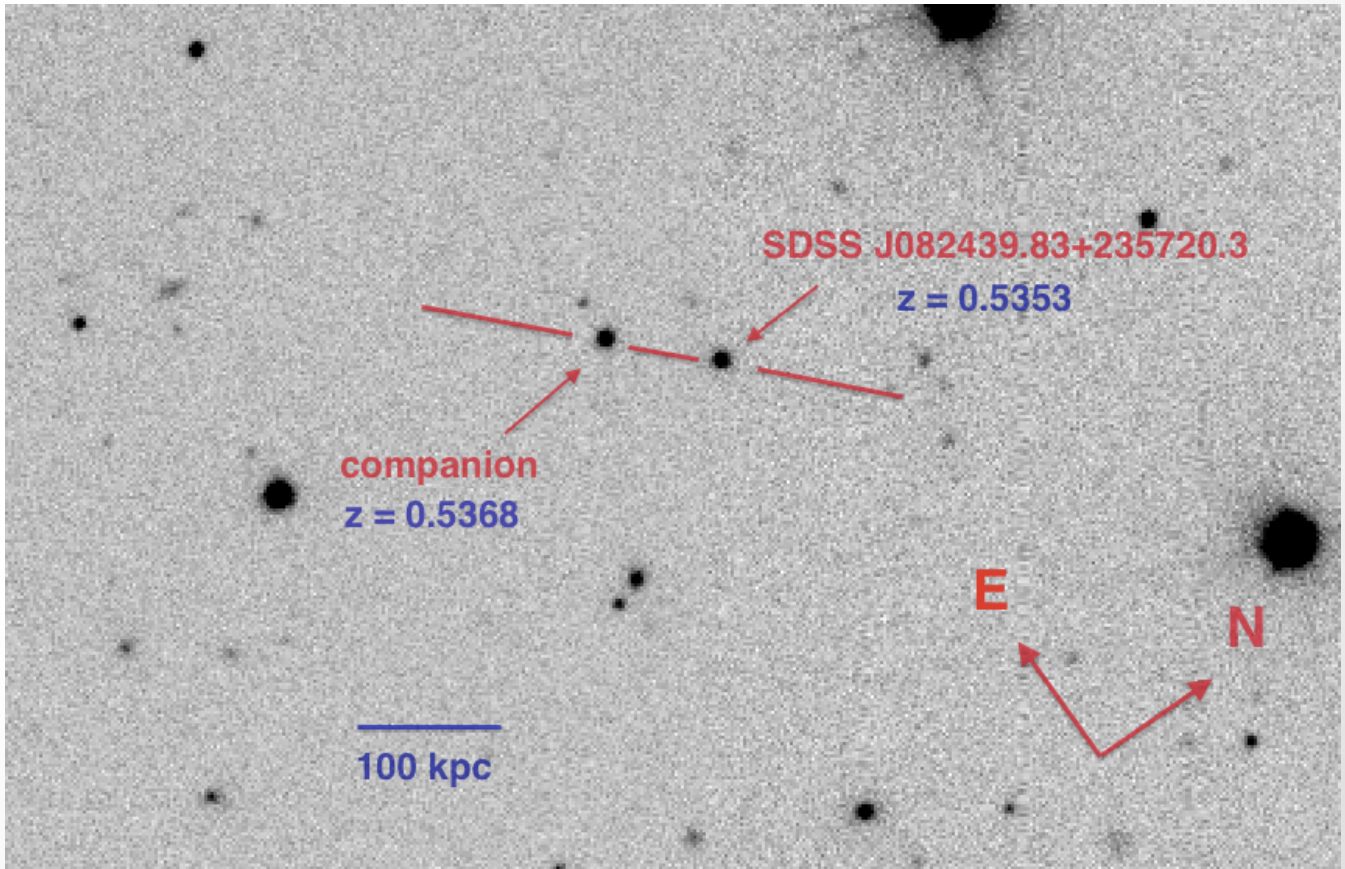
- **GALAXY ENVIRONMENT** (Sandrinelli+2014, MNRAS)
- MORPHOLOGHY OF HOST GALAXIES (NOT observations and analysis in progress)

OUTLINE

QSO pairs (z<1) from SDSS : close redshifts, bound

GALAXY ENVIRONMENT (Sandrinelli+2014, MNRAS)

- Search for low-redshift QSO physical pairs
- Host galaxies and Environment
- Comparison with isolated QSOs



WHY QSO PAIRS?

If mergers place an important role in nuclear activity
QSO pairs are expected to be located in extraordinary environment of galaxies .

A number of QSO pairs have been discovered at tens – hundreds kpc scale

QSO pairs are rare systems , poorly investigated:

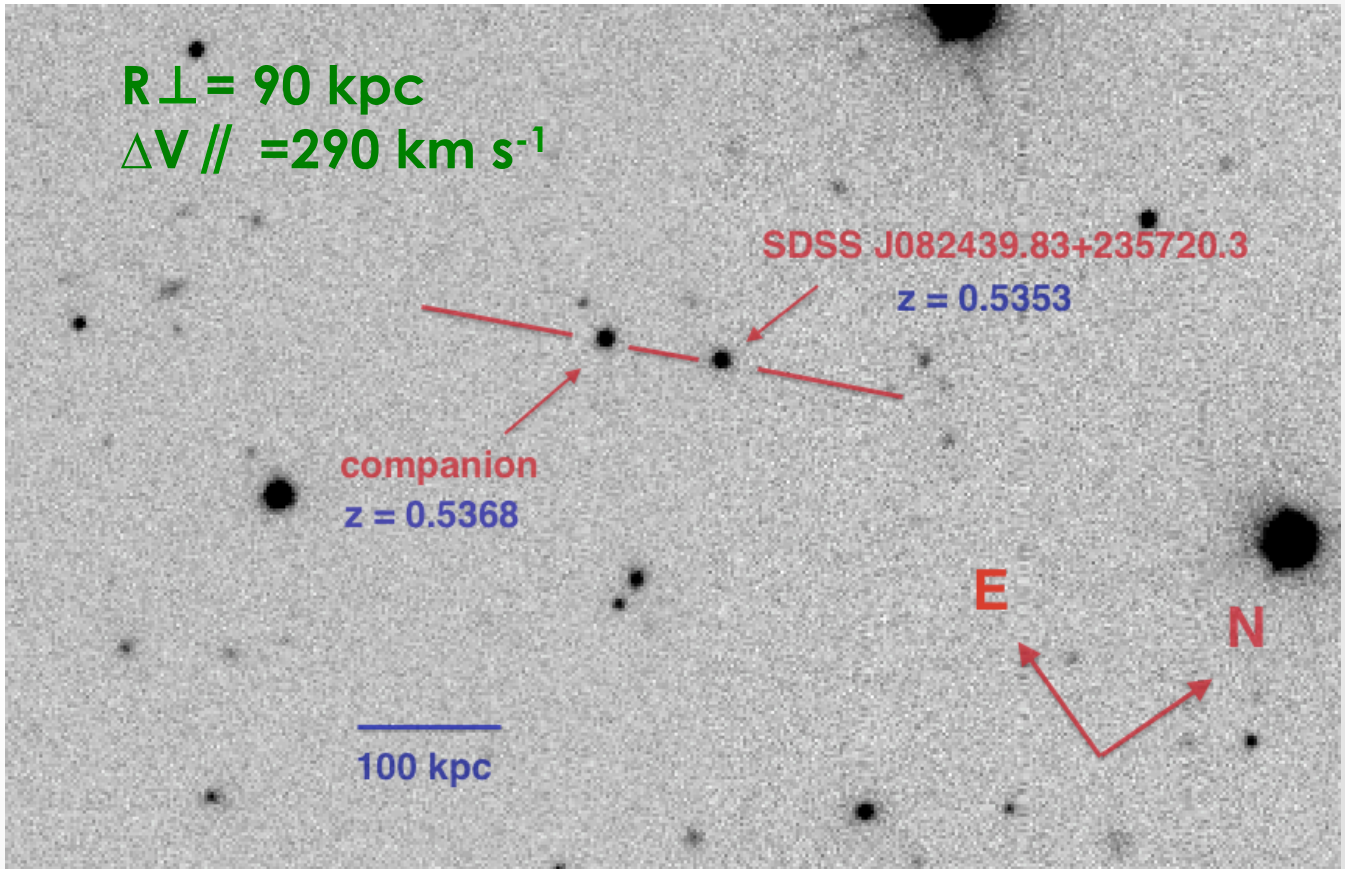
Boris+2007 environment of 4 QSO pairs, z~1,
Hennawi+2006 large sample ,
no study on environment

SEARCH FOR PHYSICAL QSO PAIRS.

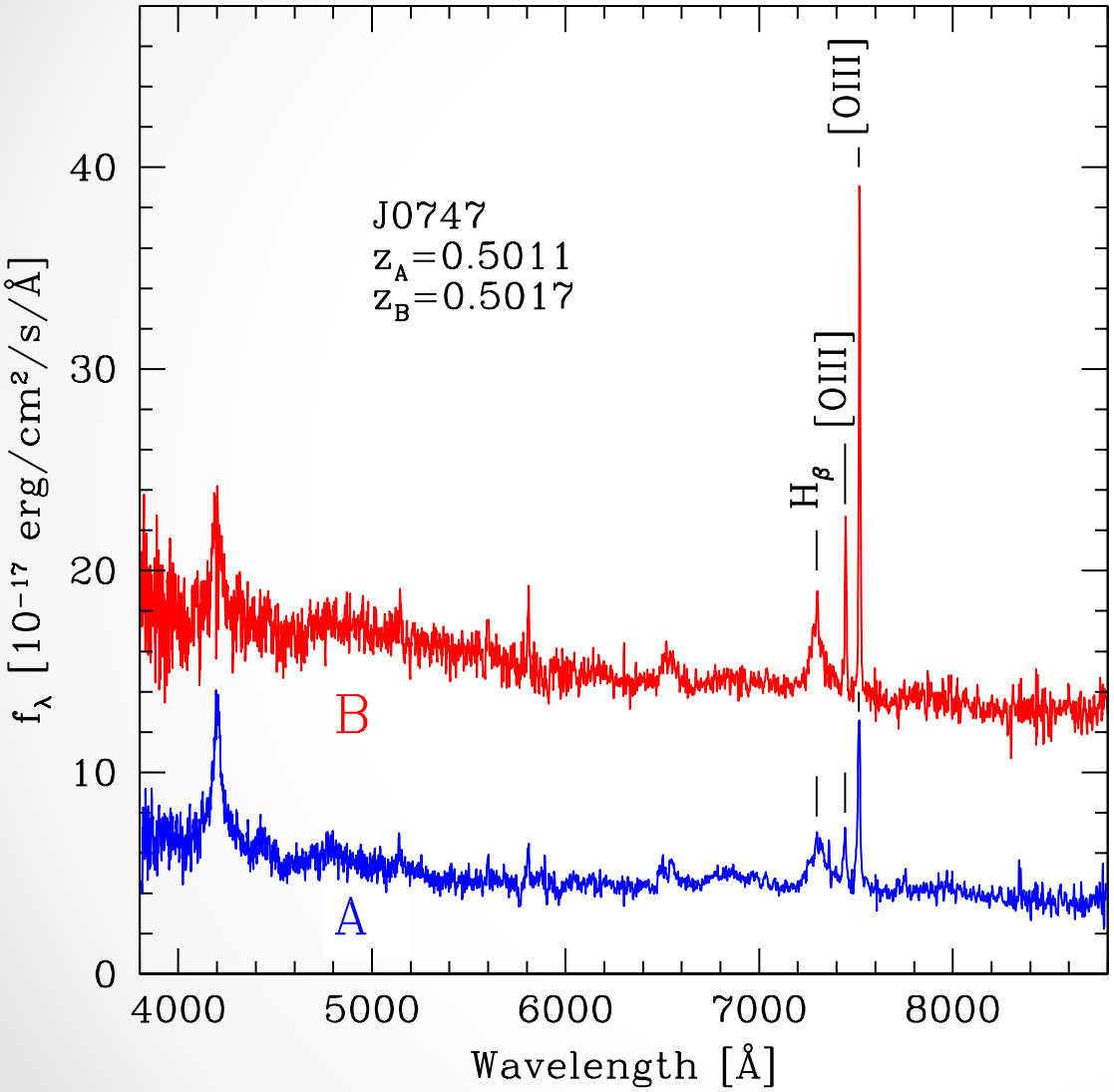
from ~ 260,000 SDSS QSOs (Schneider+2010,Paris+2014)

QSO pairs characterized by

- the **projected separation <600 kpc**
- the **difference of their radial velocities <600 km/s**



SEARCH FOR PHYSICAL QSO PAIRS.

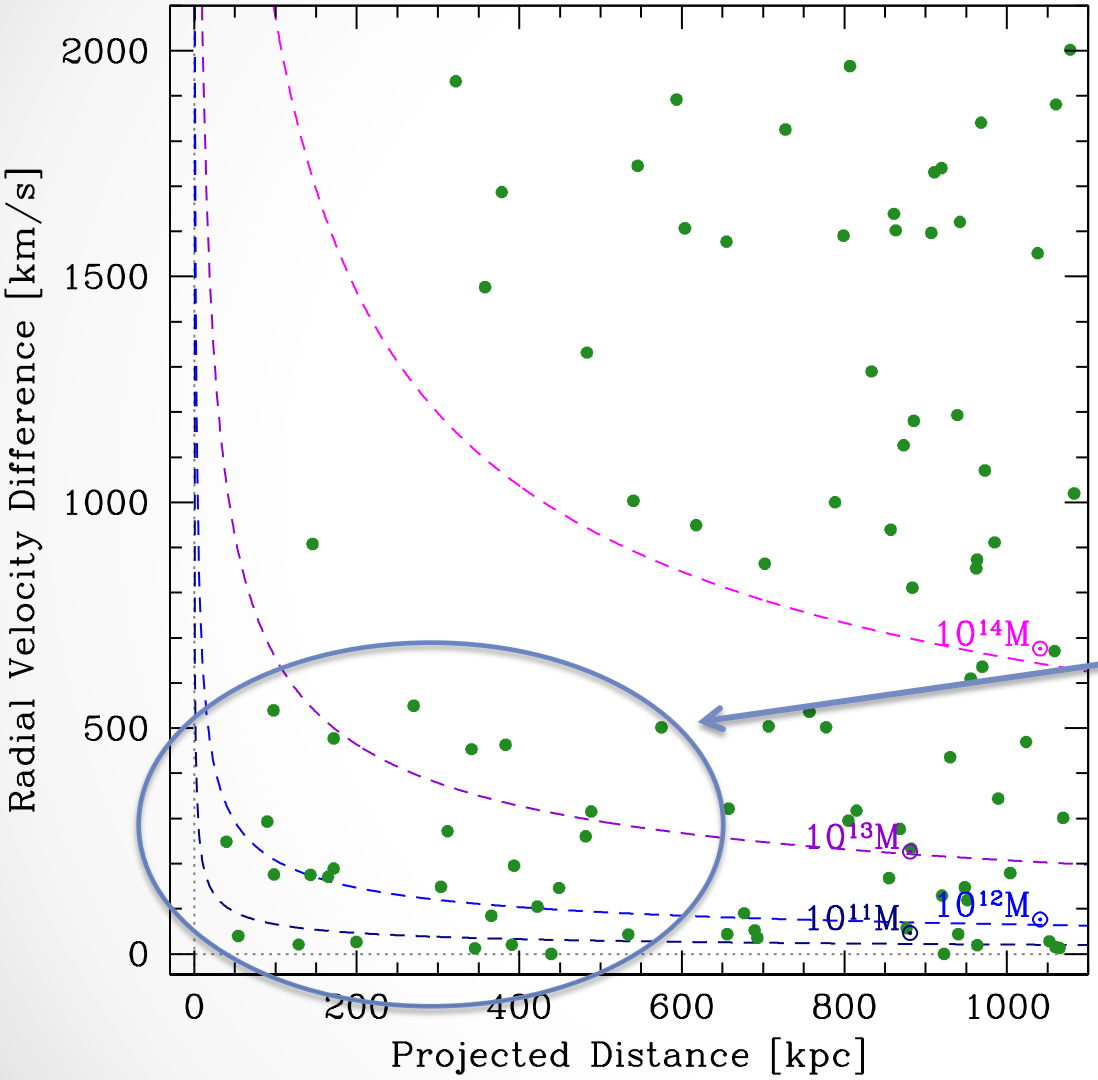


ΔV // determination is crucial:

Estimation of **systemic radial velocity V //** from **forbidden [OIII]5007 Å narrow line**

➔low redshift **z< 0.85**

SEARCH FOR PHYSICAL QSO PAIRS.



better choice for
$N_{OBSERVED}/N_{RANDON}$:

➔ $R\perp$ < 600 kpc
➔ ΔV // < 600 km/s

➔low redshift **z< 0.85**

➔ **spectra visual inspection**

14 QSO pairs from SDSS

ANALYSIS

- **Host galaxies luminosity**
- **Galaxy overdensity**

QSOs in PAIRS vs ISOLATED QSOs

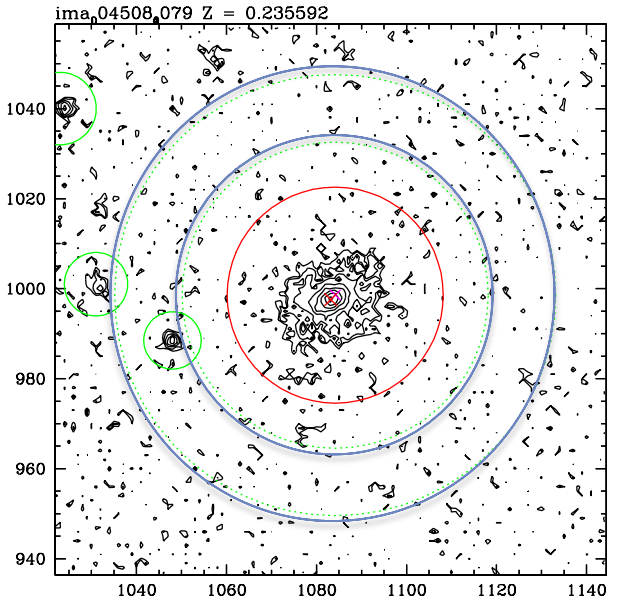
We compared the QSO pair sample with parallel works related to isolated QSOs

Falomo+, 2014, MNRAS, 440, 476,	**416 QSO, z<0.5**
Karhunen+, 2014, MNRAS, 441, 1802,	**308 QSO, z<0.5**
Decarli+, 2010, MNRAS, 402, 2441,	**58 QSOs, z<0.85**

ANALYSIS: HOST GALAXIES of QSO PAIRS

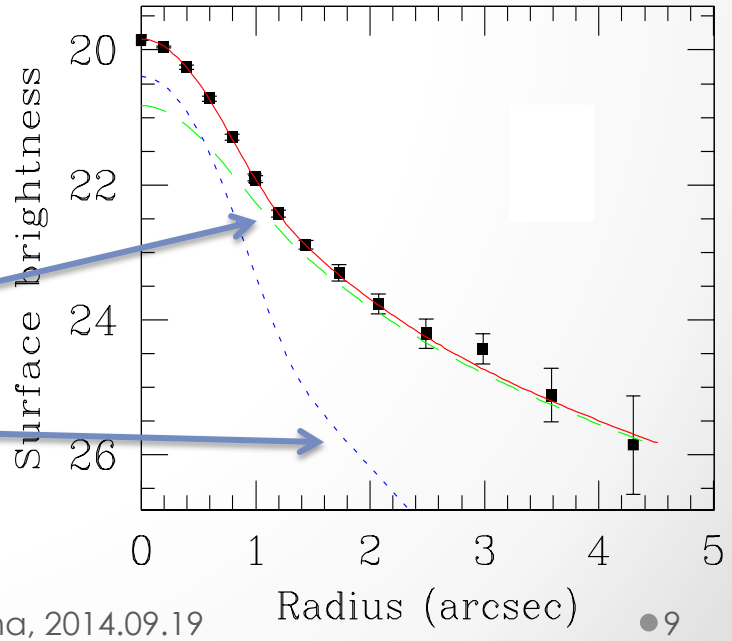
- **Photometrical and morphological study of I images** (**i < 22** mag = 50% completeness, Capak+2007)

➔ **HOST and NUCLEUS LUMINOSITIES**
(for resolved galaxies)



Astronomical Image Decomposition and Analysis **AIDA** (Uslenghi+2008) software

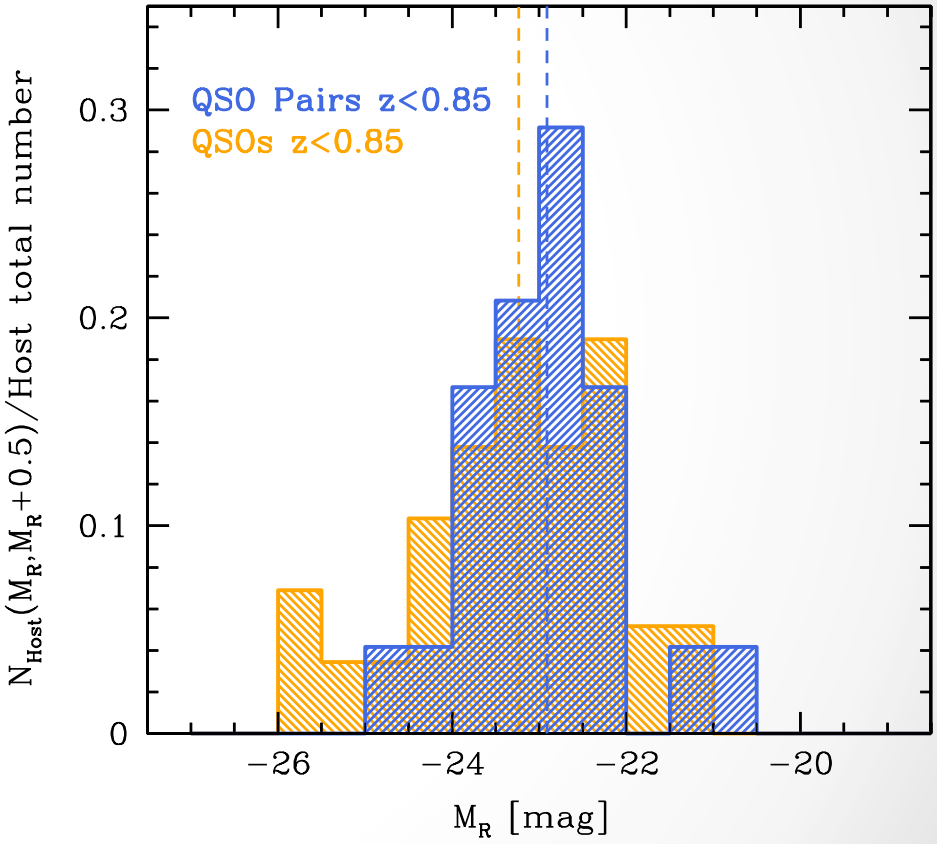
PSF from isolated stars in the field + **galaxy model** (Sersic1963)



RESULTS:
HOST GALAXIES

- **24/28** resolved hosts
- **host typical luminosity:**
  M* < M < M*-3

NO HOST LUMINOSITY DIFFERENCES between QSOs in pairs and isolated QSOs

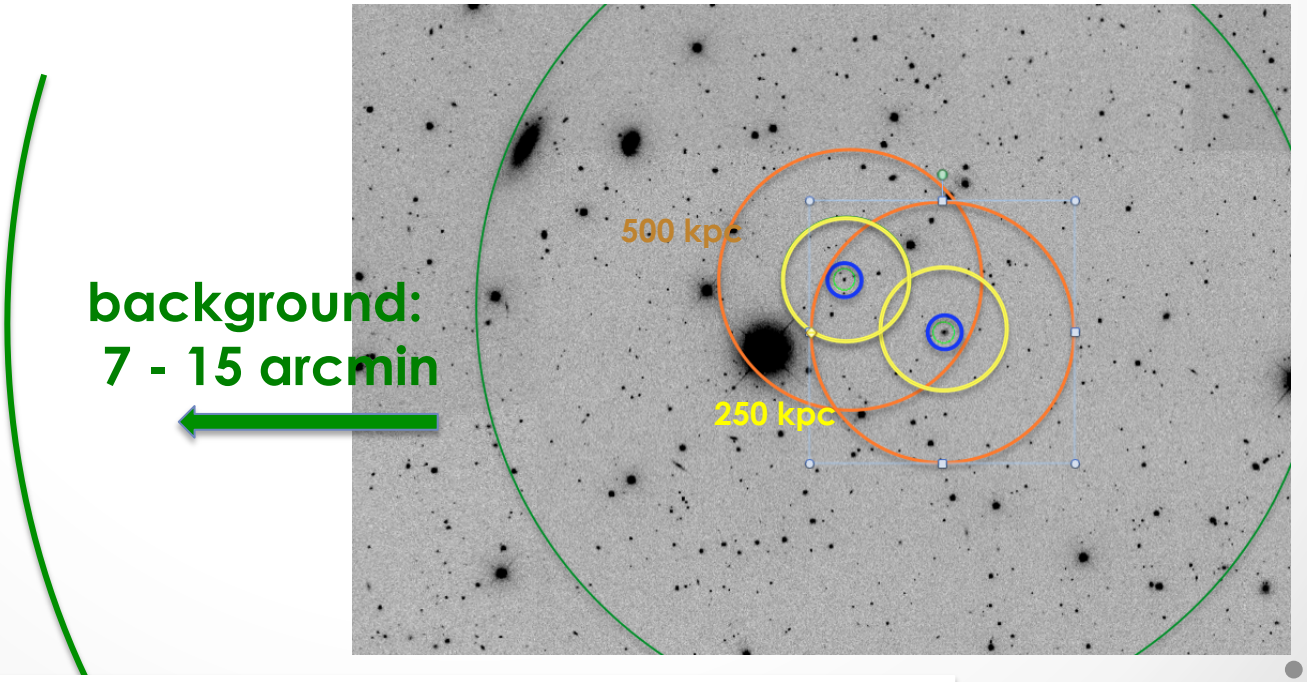


ANALISYS: GALAXY ENVIRONMENT of QSO PAIRS

- i < 22 mag = 50% completeness (Capak+2007)

Galaxy positions and photometry of all primary objects photometrically classified as galaxies in SDSS DR10 catalogue

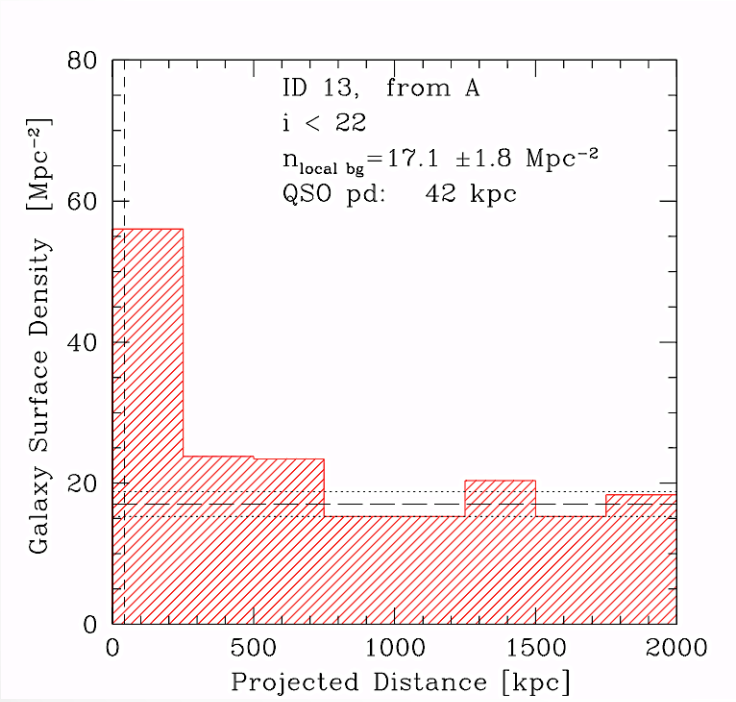
Surface galaxy distributions from the positions of the two QSOs or from their midpoint?

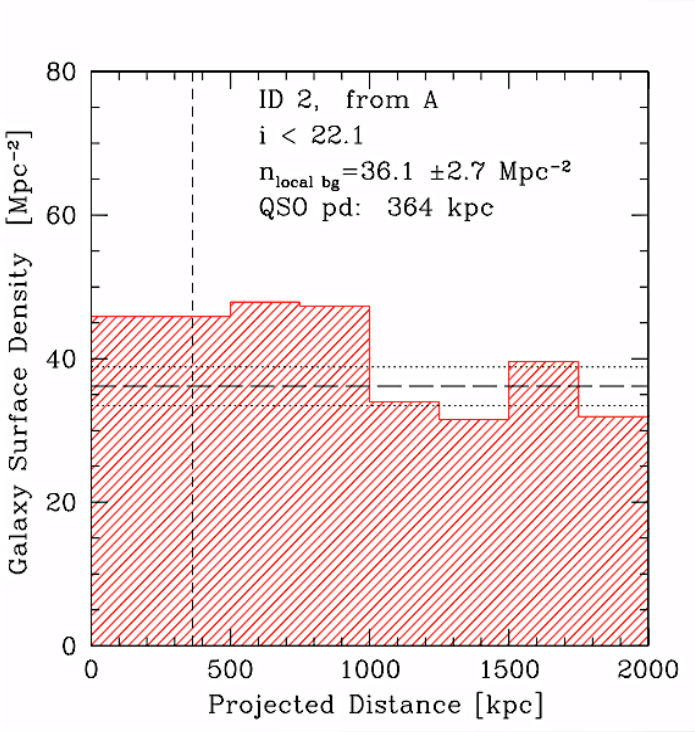


RESULTS: GALAXY ENVIRONMENT of QSO PAIRS

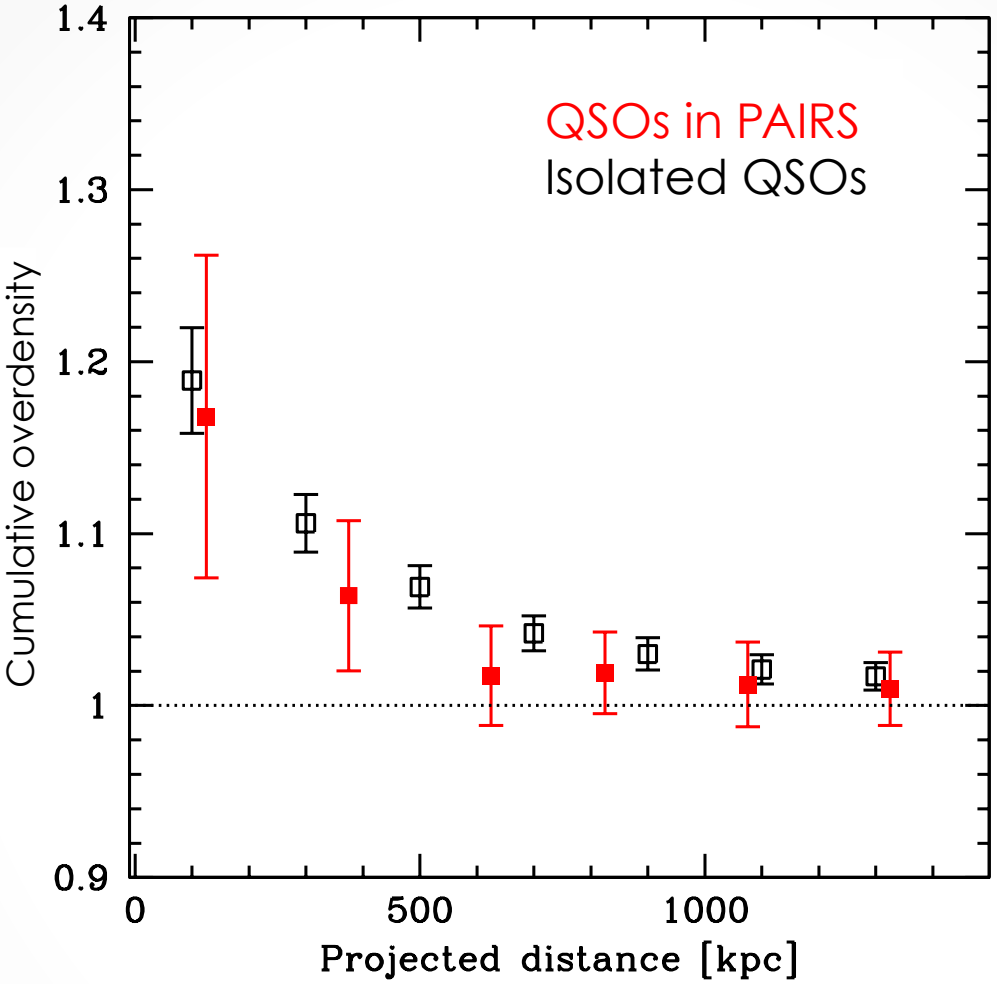
- i < 22 mag = 50% completeness (Capak+2007)

Modest overdensity up to ~500 - 750 kpc





RESULTS: GALAXY ENVIRONMENT of QSO PAIRS



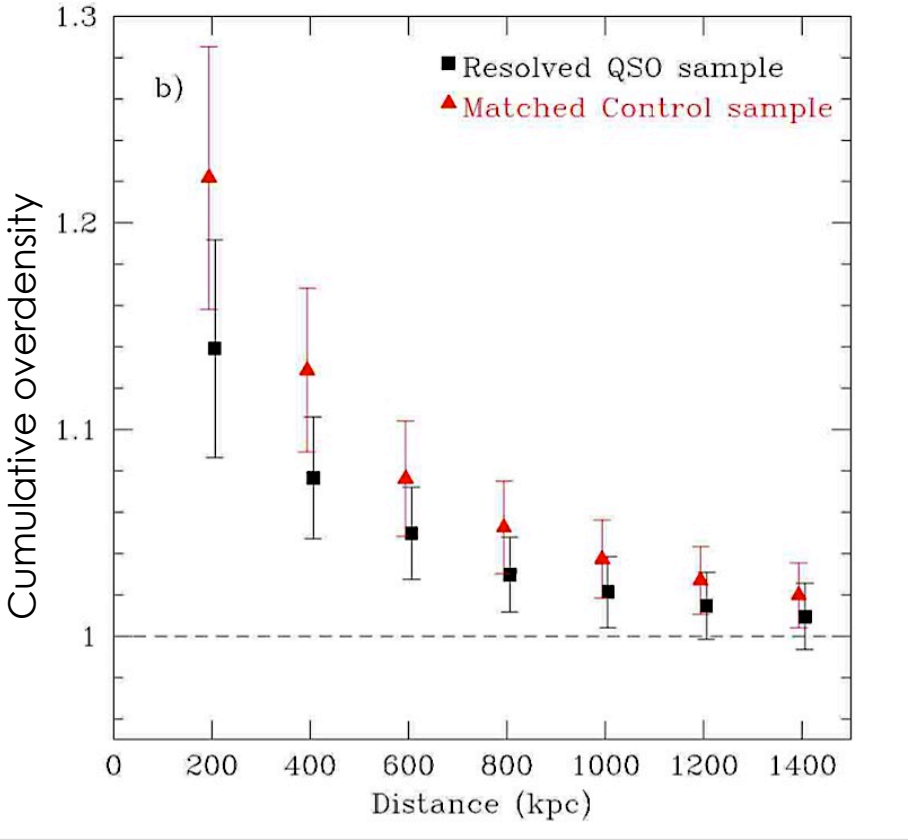
(Sandrinelli+2014, MNRAS, 444, 1835)

on average the galaxy overdensity around quasars in pair is indistinguishable from that of isolated quasars

ENVIRONMENT: ISOLATED QSOS vs INACTIVE GALAXIES

Karhunen+2014:
SDSS Stripe82 , z<0.5
QSO sample
~ 400 QSOs from Schneider+2010 catalog
~ 300 QSOs with **resolved host galaxies**
(Falomo+2014)

Inactive galaxy control sample
~ **300 galaxies** with z and luminosity close to QSO hosts (M(i)<~23)



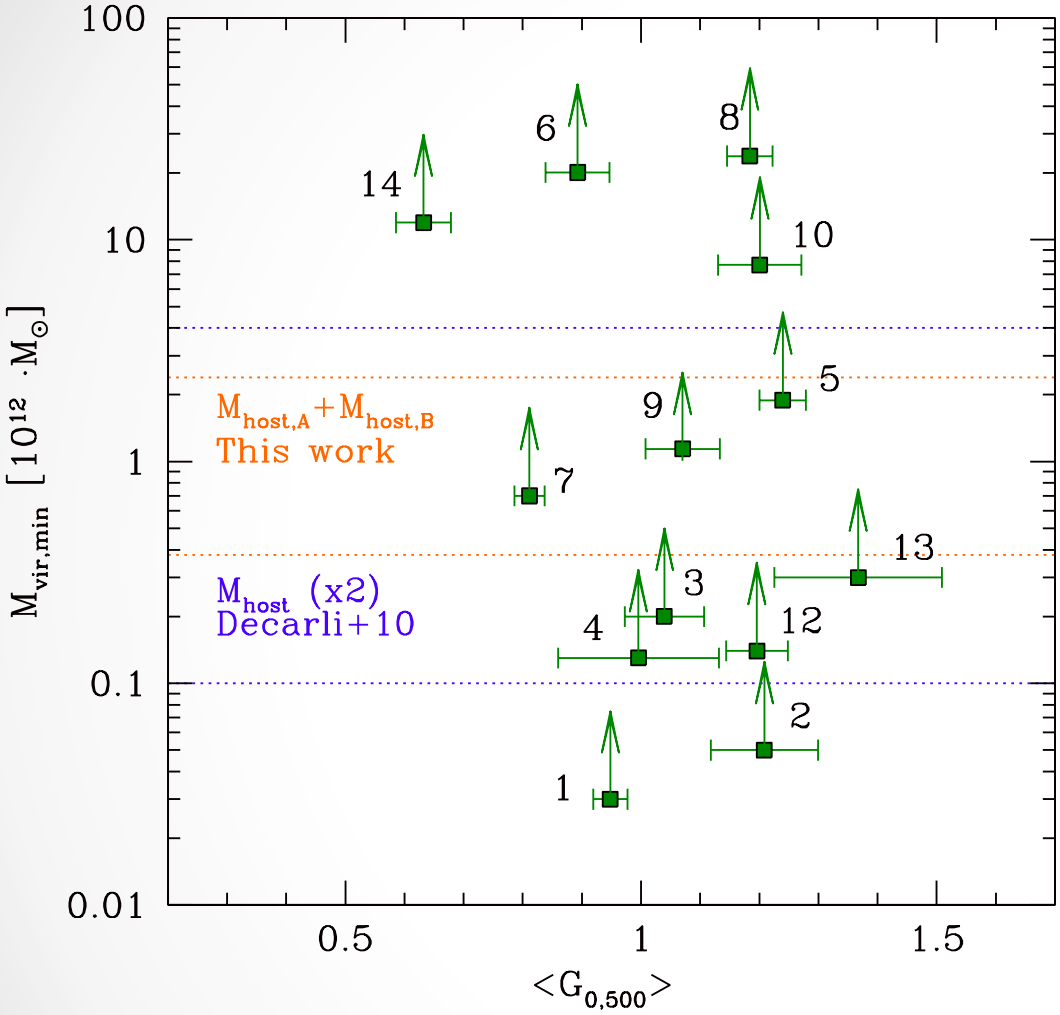
The ENVIRONMENTS around QSO and inactive galaxies do not significantly differ (QSOs not in richer environments)

the inference is therefore that the environment of QSO pairs is similar to that of luminous galaxies

MAIN RESULT

the indication is therefore that at the scale of our investigation (< 1 Mpc) the activation of two QSOs does not require any extraordinary galaxy environment

VIRIAL MASS OF THE SYSTEMS of QSO PAIRS



$$M_{vir} = C \frac{\Delta V_{\parallel}^2 \, R_{\perp}}{G}$$

C : orbit-plane orientation param.
<C> = 3.4, **minimum C_{min}=1**
(Farina+2001)

in at least 3 cases $M_{vir,min}$ **exceeds** the sum of the masses of the hosts by a **factor of ~ 10** and **no** extraordinary overdensity

This is suggestive of a **huge dark matter contribution**
(see also Farina+2011)

ONGOING PROGRAMS and FUTURE GOALS

larger and homogeneous samples ARE REQUIRED

ongoing observational programs on selected samples of QSO pairs:

- spectra and R and I band imaging from **GTC** : **18 pairs,** z<1
- J deep images from **NOT** : **33 pairs,** 0.7 < z < 1.6
- U, B, R, I multicolor imaging from **BUSCA-CAHA**: **20 pairs**, z<1

future goals

- HOST COLOR AND MORPHOLOGY
- DEPENDENCE OF ENVIROMENTAL PROPERTIES ON QSO PAIR SEPARATION
- COSMOLOGICAL EVOLUTION (EXPLORING LARGER REDSHIFTS)