NIR observations of late-stage merger QSOs in the context of ULIRG-to-QSO evolution

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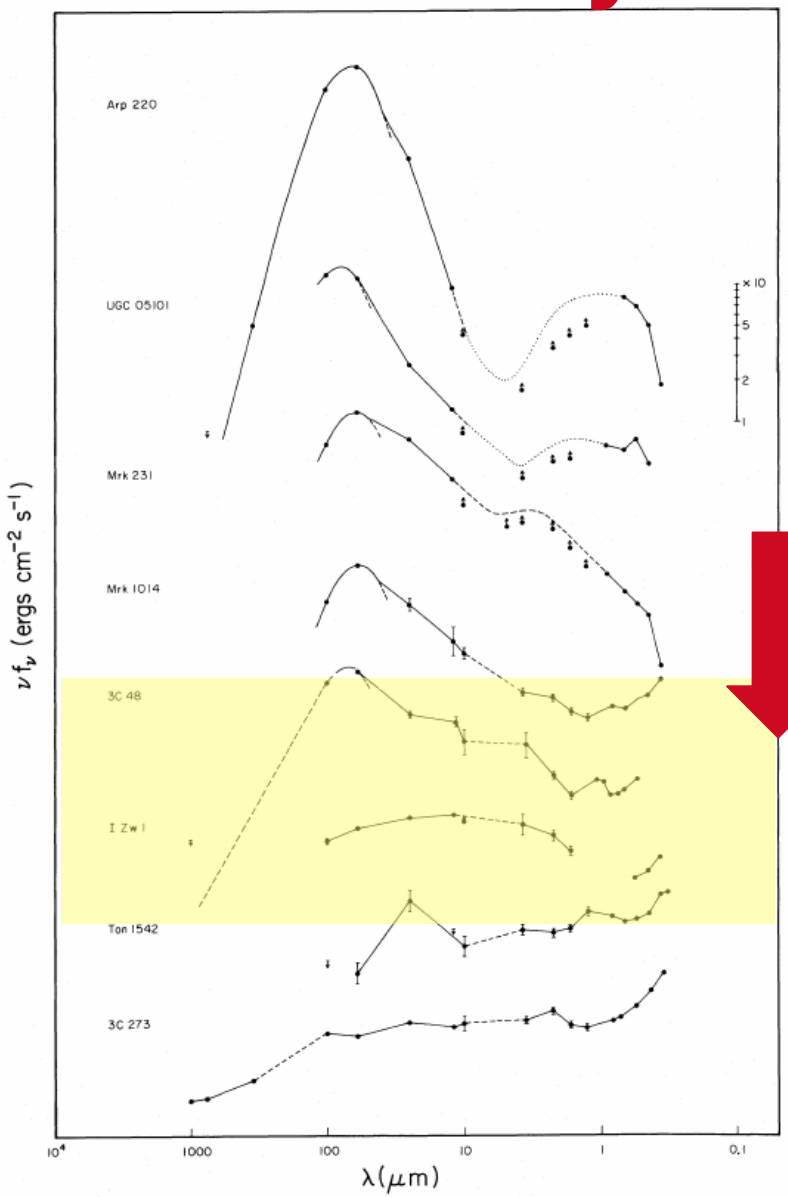
Motivation

- How and when are QSOs born?
- How is nuclear activity (starburst and accretion onto the SMBH) triggered/fuelled?
- How do QSOs and their harboring galaxies evolve?

Evolutionary scenario



- ***ULIRGs***
  - gas & dust rich
  - intense starburst
  - interacting
  - burried AGN?
- ***transition objects***
  - gas & dust rich
  - starburst
  - Seyfert character
- ***QSOs***
  - little/no gas
  - old stellar population
  - bright Seyfert nucleus

(Sanders+ 1988)

Case studies (3C 48, IZw1)

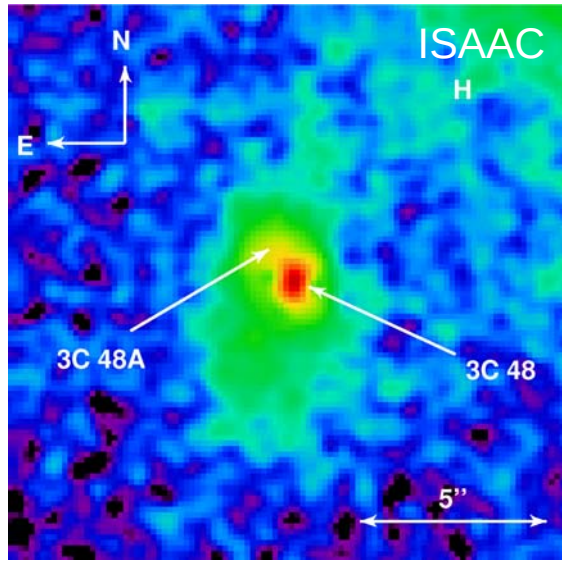
Use

- ***high-resolution***, ***multiwavelength*** **data, and**
- ***multiparticle simulations*** **(stars and gas)**

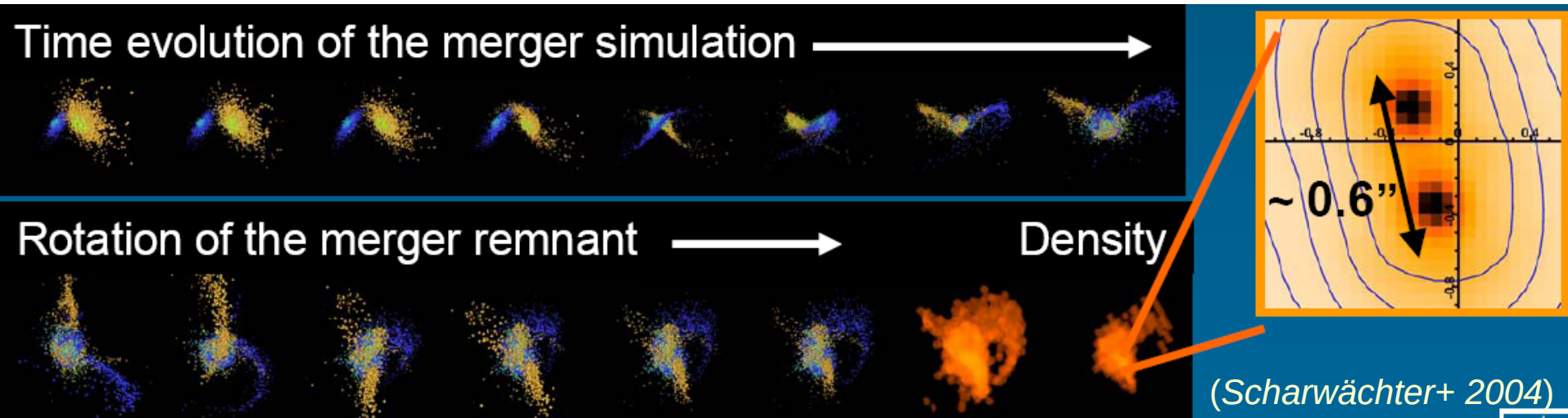
to study the physical properties of transition objects and to search for indications of a recent merger event

The major merger 3C 48

- Radio-loud QSO at z = 0.36
- ULIRG $L_{FIR} \sim 5*10^{12} L_{sun}$
- Signs of a recent major merger
- Young stellar populations close to the nucleus (<100Myr) but
- Older stellar populations in the tidal tail (*Canalizo & Stockton 2000*)
- Missing tidal tail problem just by projection
- Second nucleus constrains the merger stage (cf. PdBI CO obs. by *Krips+ 2005*)



(*Zuther+ 2004*)



(*Scharwächter+ 2004*)

The minor merger IZw1

- **Narrow-line Seyfert 1**
- **One of the closest QSOs at z=0.06**
- **Spiral host with small companion**
- ***Blue tidal bridge* between IZw1 and companion and *blue color concentration* in host region adjacent to companion**
- **Blue shifted high excitation lines -> nuclear outflow -> young QSO stage**
- **NLS1 -> small BH mass and high accretion rate? (*e.g. Mathur 2000*)**

(Scharwächter+ 2007)

Prospects for a systematic multiwavelength study

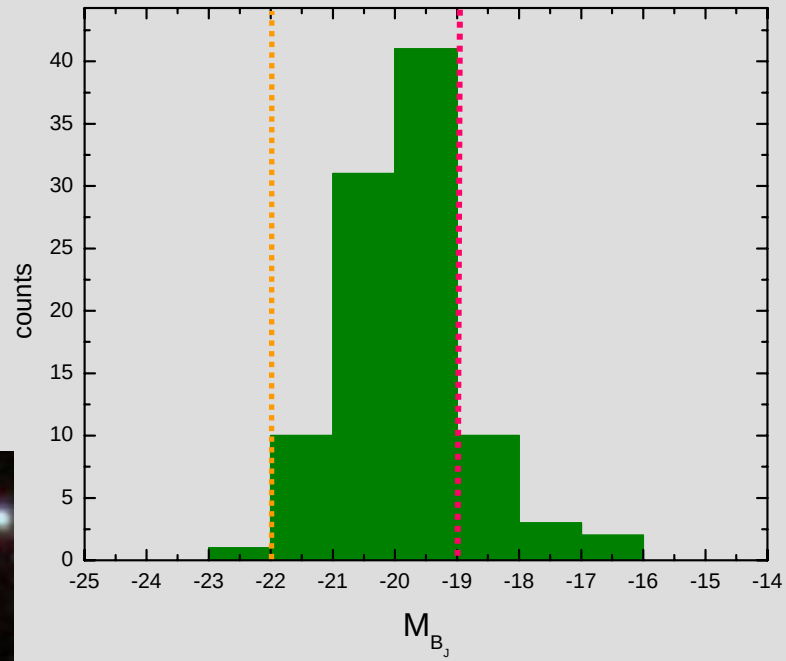
- **NIR is dominated by stellar host**
- **NIR is less influenced by dust extinction**
- **Use *z*<0.06 *low-luminosity type-1 QSOs* based on the Hamburg/ESO survey (Wisotzki+ 2000) for a detailed look**
- **CO(6-3) and CO(2-0) band heads are available for stellar kinematics → BH masses**
- **Star-formation tracers like CO, Mg, Na**

→ Census of host properties of low-redshift, low-luminosity QSOs

A sample of nearby low-luminosity QSOs

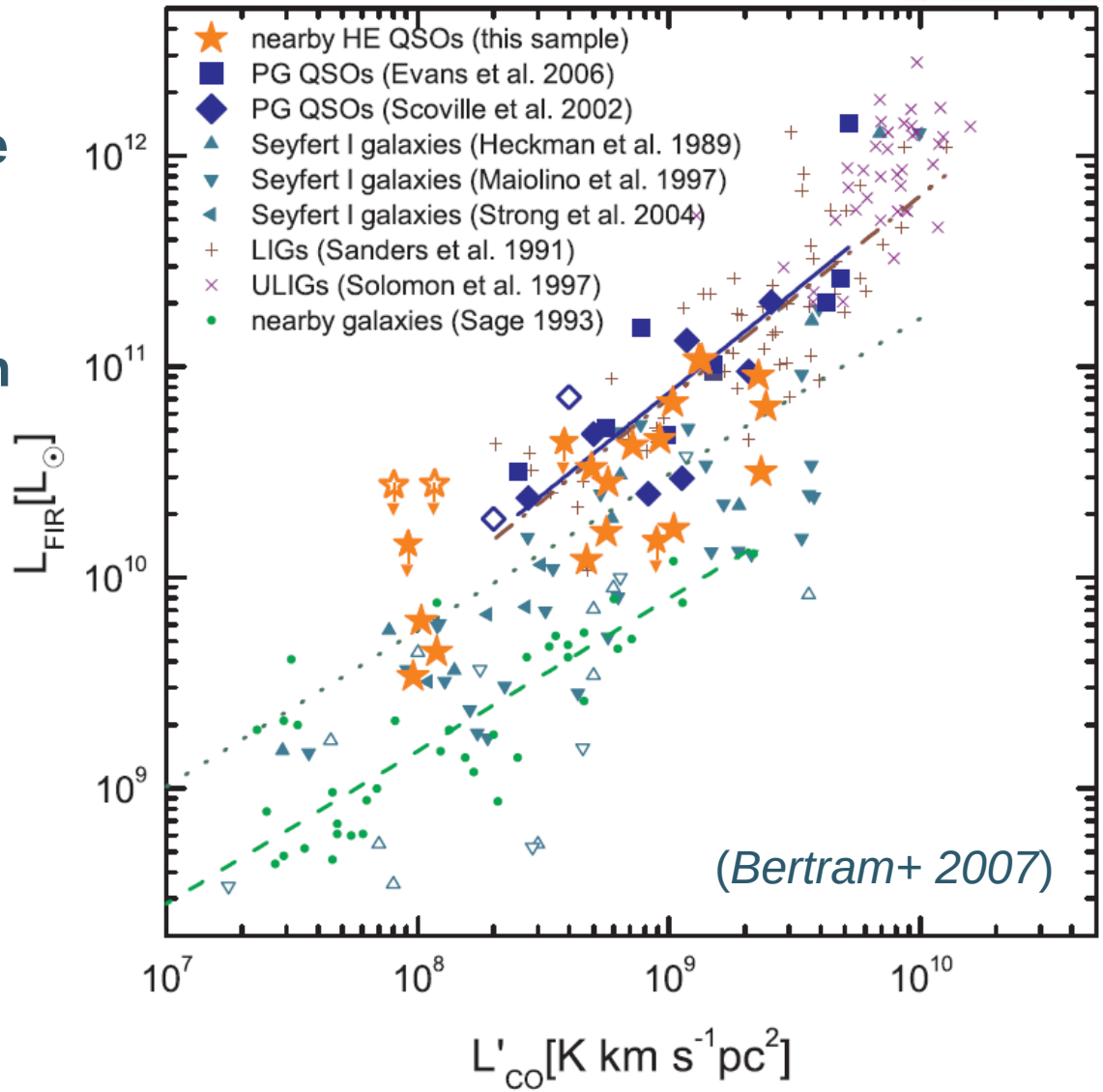
Study host properties of close-to volume limited sample of 99 objects down to a B_J-mag ~17.3:

- **molecular gas content**
- **stellar/gaseous kinematics**

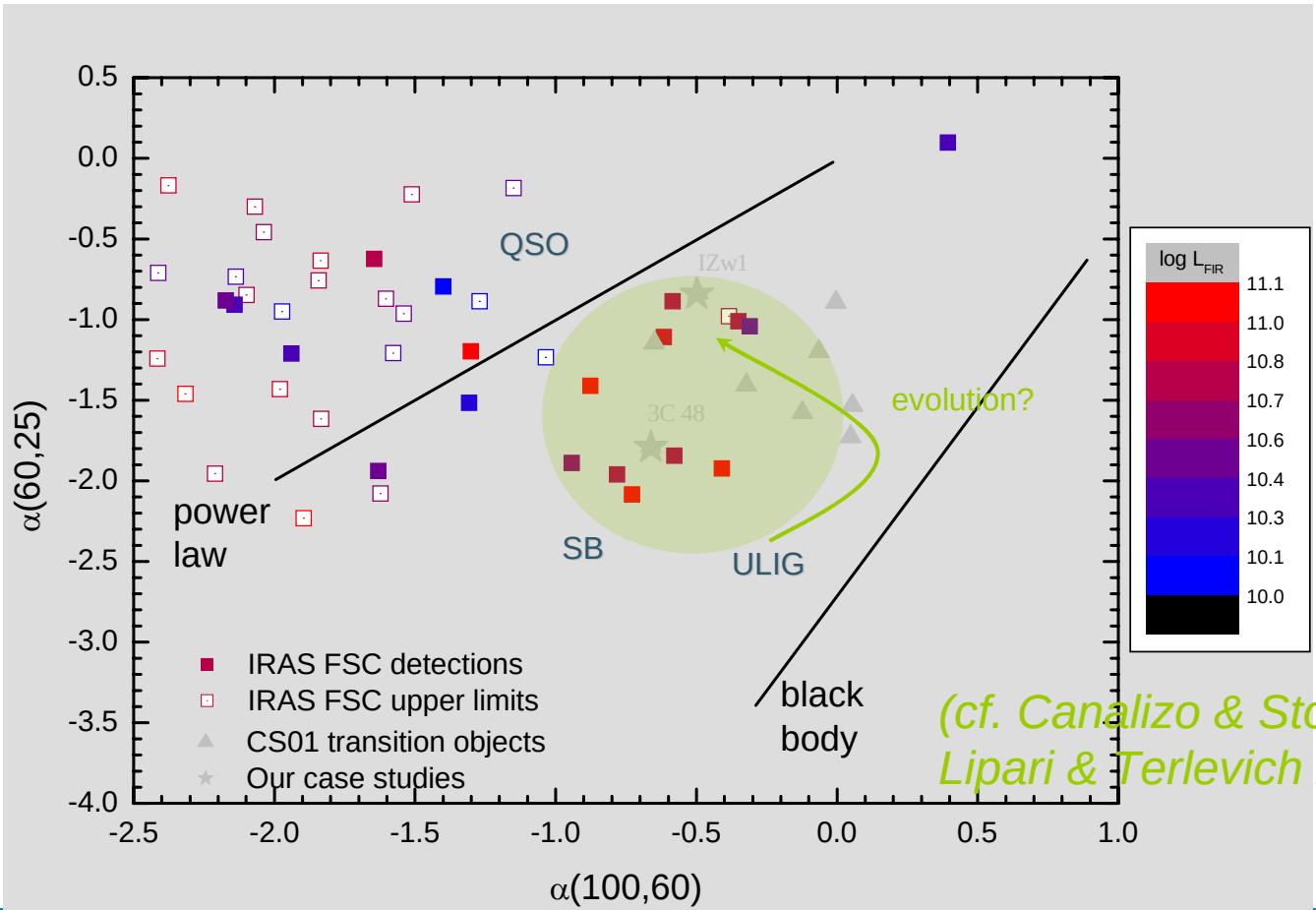


mm-CO observations

- 27 of 39 observed are rich in molecular gas (0.4 – 9.7)*10^9 M_{sun}
- Broader CO-linewidth for brighter objects → M_{BH} ~10^7-10^8 M_{sun} (*Wu, 2007*)
- Avg. radio spectral index (21cm/6cm) of 13 objects: -0.64 → star formation



FIR 2-color diagram
Transition objects

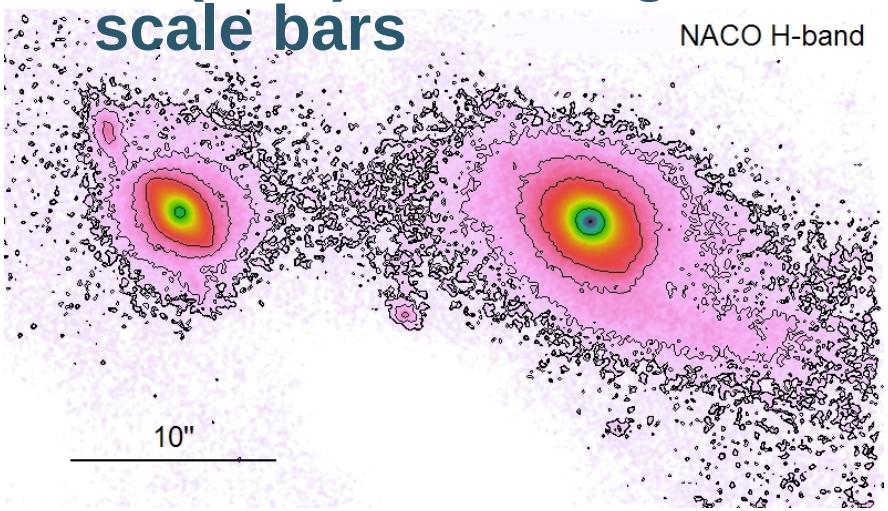


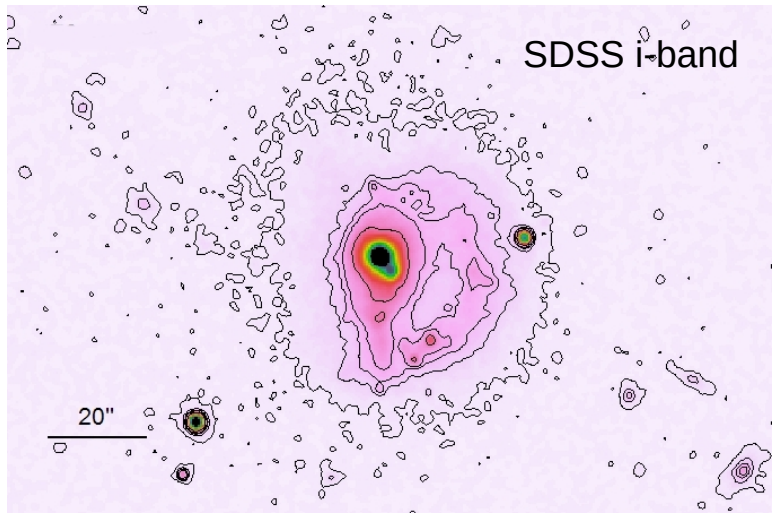
(cf. Canalizo & Stockton 2001; Lipari & Terlevich 2006)

Transition objects

- 26/99 objects with good quality imaging (ISAAC, NACO, SDSS, HST)
- 9 (~35%) show sign of interaction
- 13 (50%) show large scale bars

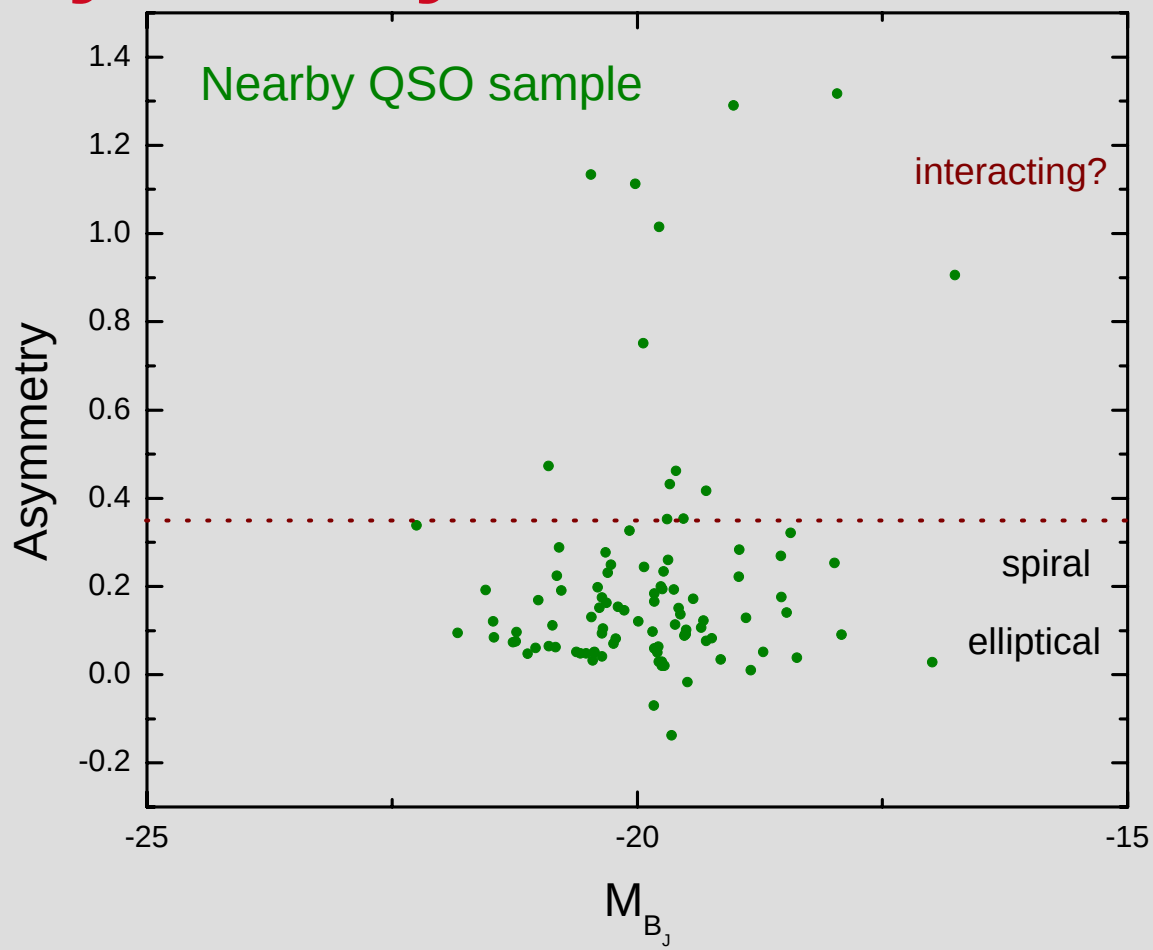
- 11/99 transition objects
- 6 (55%) of which show signs of interaction
- 3 (27%) show large scale bars

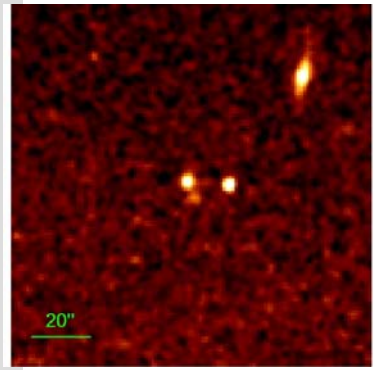


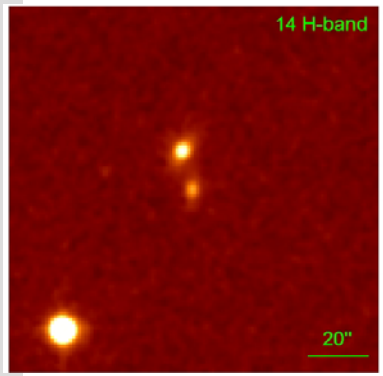


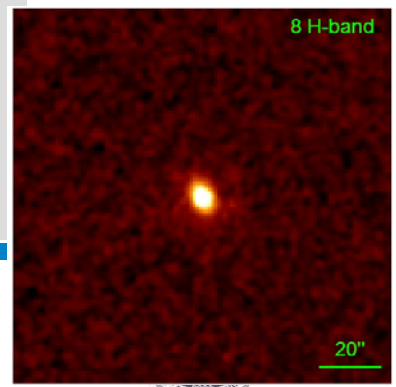
(Fischer+ 2006; *Fischer+ in prep.*)

Asymmetry from 2MASS images





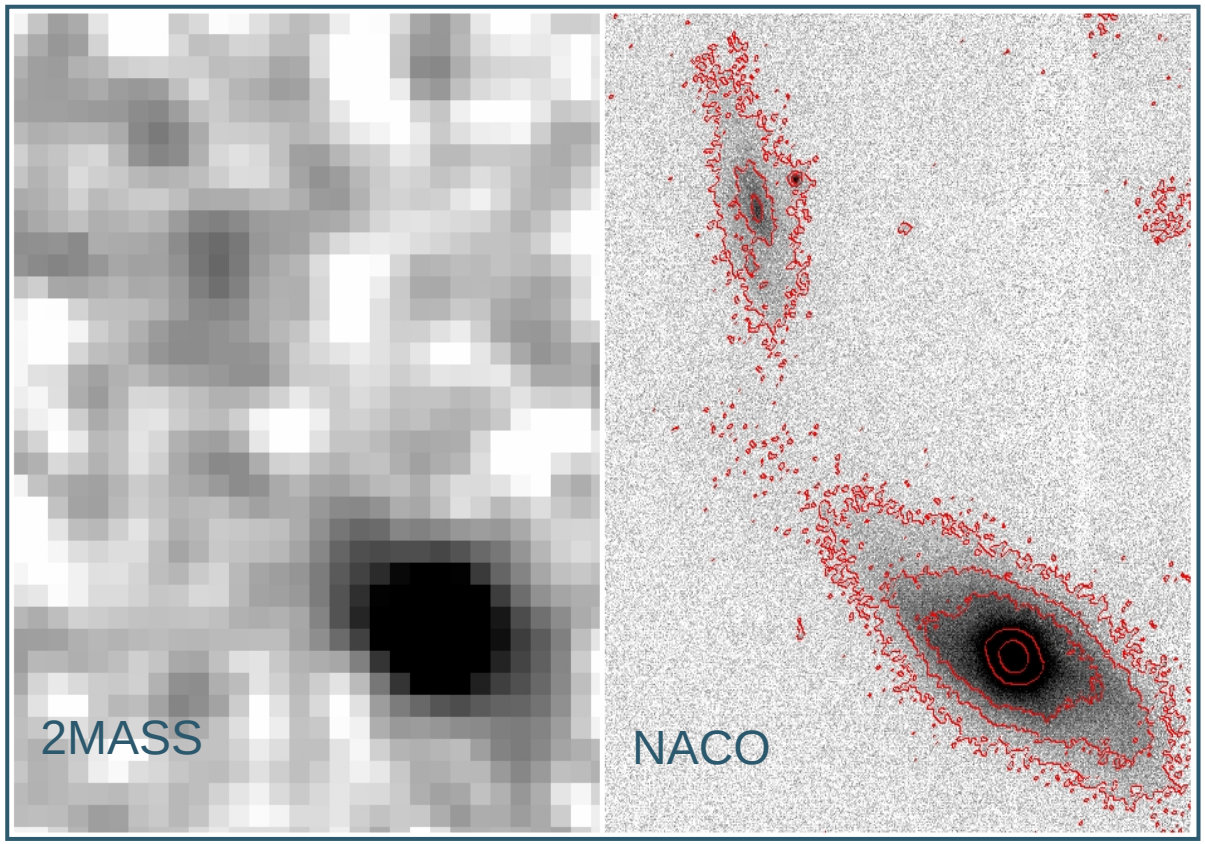




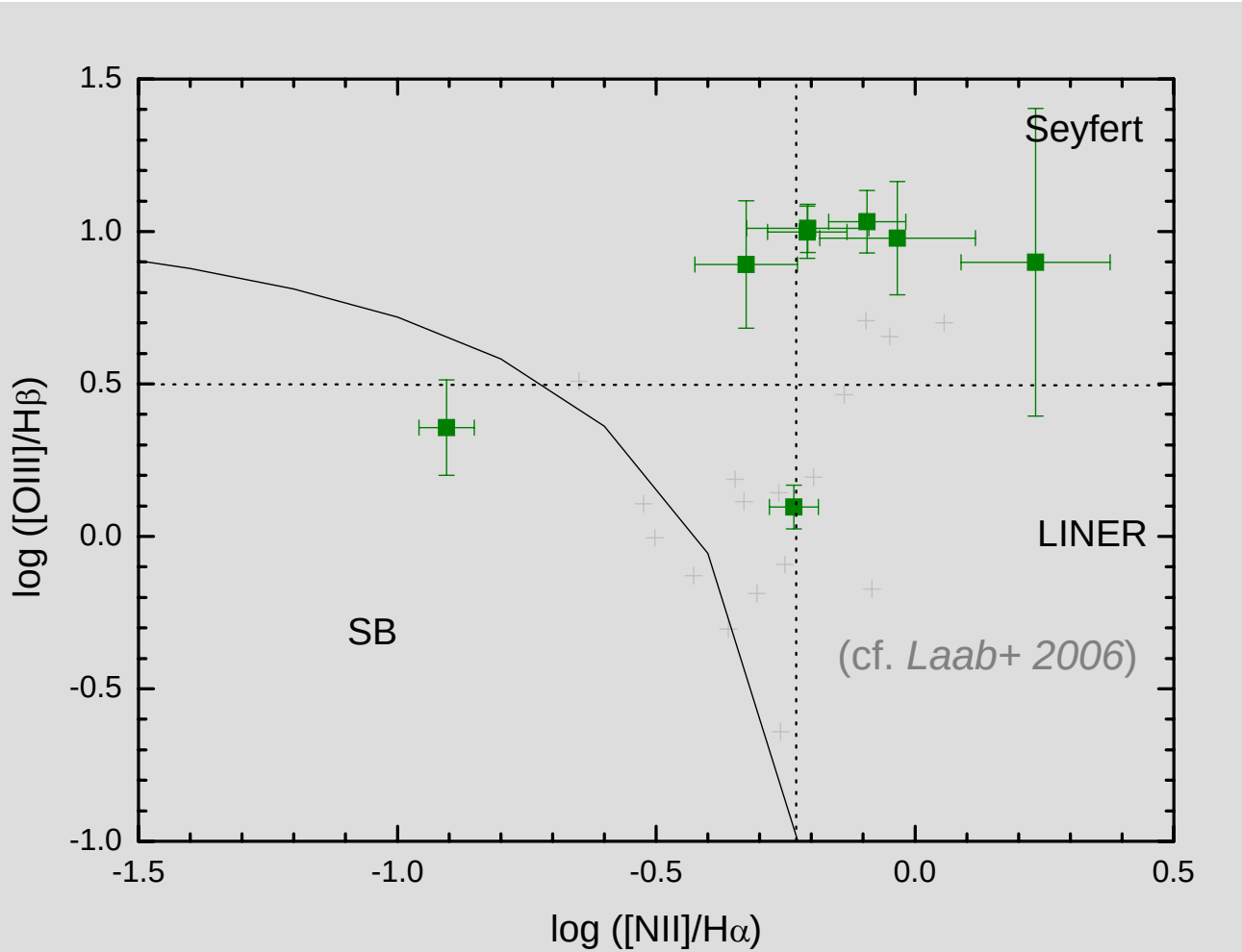
(*Zuther+ in prep.*)

(Asymmetry index cf. *Conselice 2003, ApJS, 147,1)*

2MASS vs NACO



Excitation mechanisms

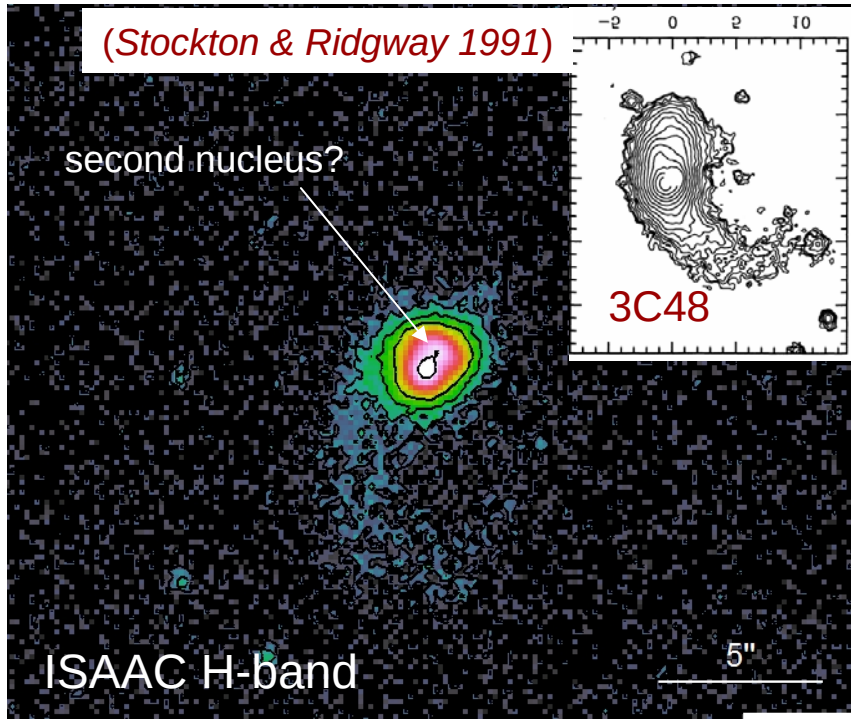


But SDSS fiber is only 3'' in diameter!

Outlook:
SDSS based merger(?)-QSOs

- **Use SDSS imaging and spectroscopic database for homogeneous selection of SDSS quasars as transition objects**
- **Excercise *Asymmetry index* and *Gini coefficient* classifiers**

→ Ongoing imaging study of with ISAAC and NACO (VLT)



Summary

- **Detailed NIR/mm studies of the host galaxies are *necessary* in order to classify**
  - **the morphology**
  - **the merger stage,**
  - **the molecular gas content,**
  - **the stellar/gaseous kinematics,**
  - **the excitation conditions**
- **These observations provide important input parameters for multiparticle simulations of the merger dynamics**
- **And constraints for possible ULIRG(merger)-QSO evolutionary scenarios**

The end

- **Any questions?**

…but

- **not all ULIRGs evolve into bright QSOs and not all QSOs emerge from ULIRGs (*Tacconi+ 2002; Dasyra+ 2007*)**