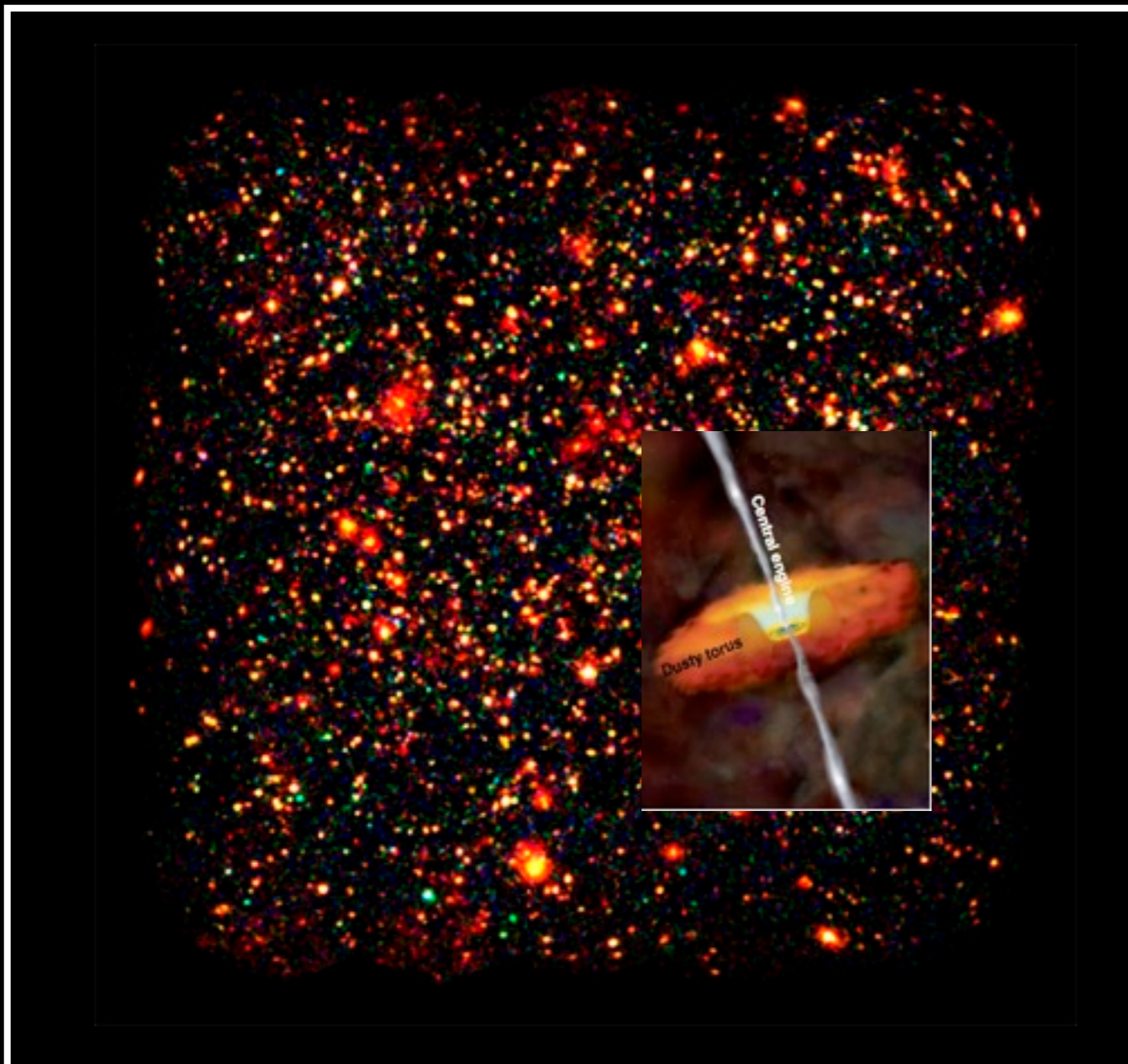# Obscured QSO: placing objects in the merging sequence (with ALMA)

Marcella Brusa

MPE - Garching
[+COSMOS/CDFS collaborations]

XMM view of the COSMOS field

CNR-Bologna / Secondo workshop sull'Astronomia millimetrica e submillimetrica italiana / 2-3 Aprile 2012

Tuesday, April 3, 2012

Obscured QSO: placing objects in the merging sequence (with ALMA)

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XMM view of the COSMOS field

X-ray / mm synergies (space/ground)

Tuesday, April 3, 2012

WHY: the relevance of obscured AGN

- Obscured AGN are needed to:

  - **reconcile the local BH mass function with mass accreted on BH**

  (via Soltan argument, e.g. Fabian & Iwasawa 1999, Marconi+2004, Merloni&Heinz 2008, Shankar+2009)

  - **reproduce the X-ray background peak**

  (Setti & Woltjer 1989, Comastri+1995, Gilli+2007, Treister+2005,2009, Ballantyne+2010)

  - **test AGN-galaxy co-evolutionary models and constrain growth phases**

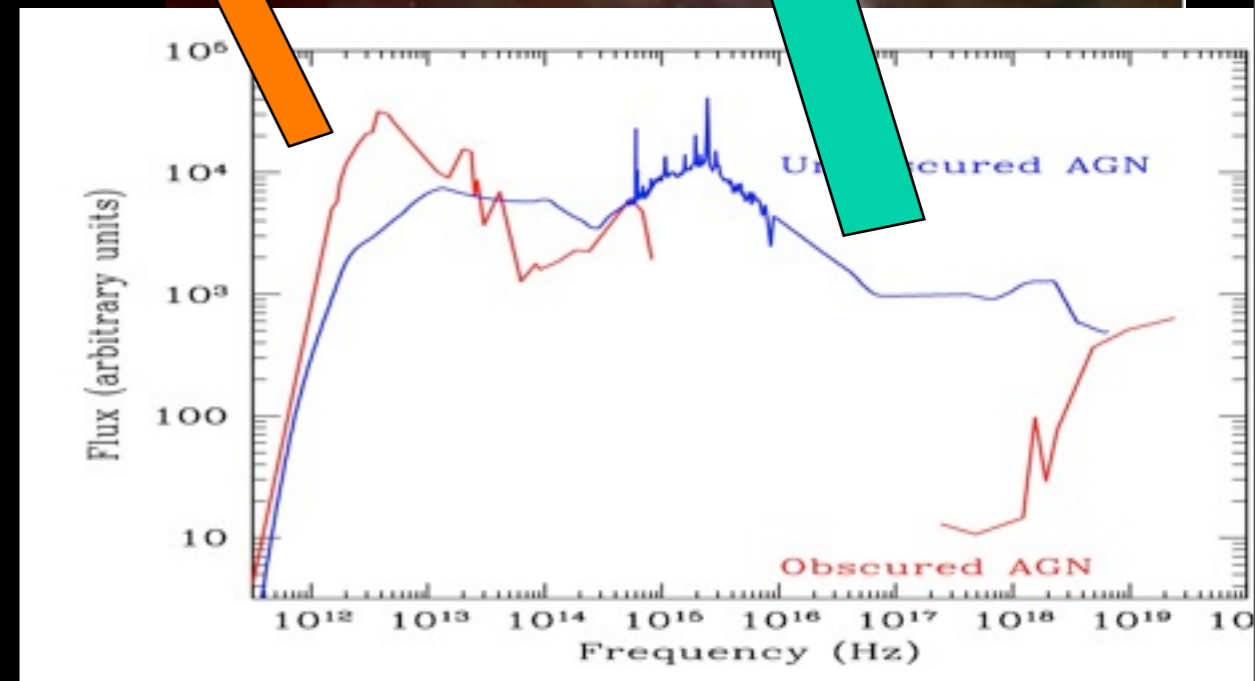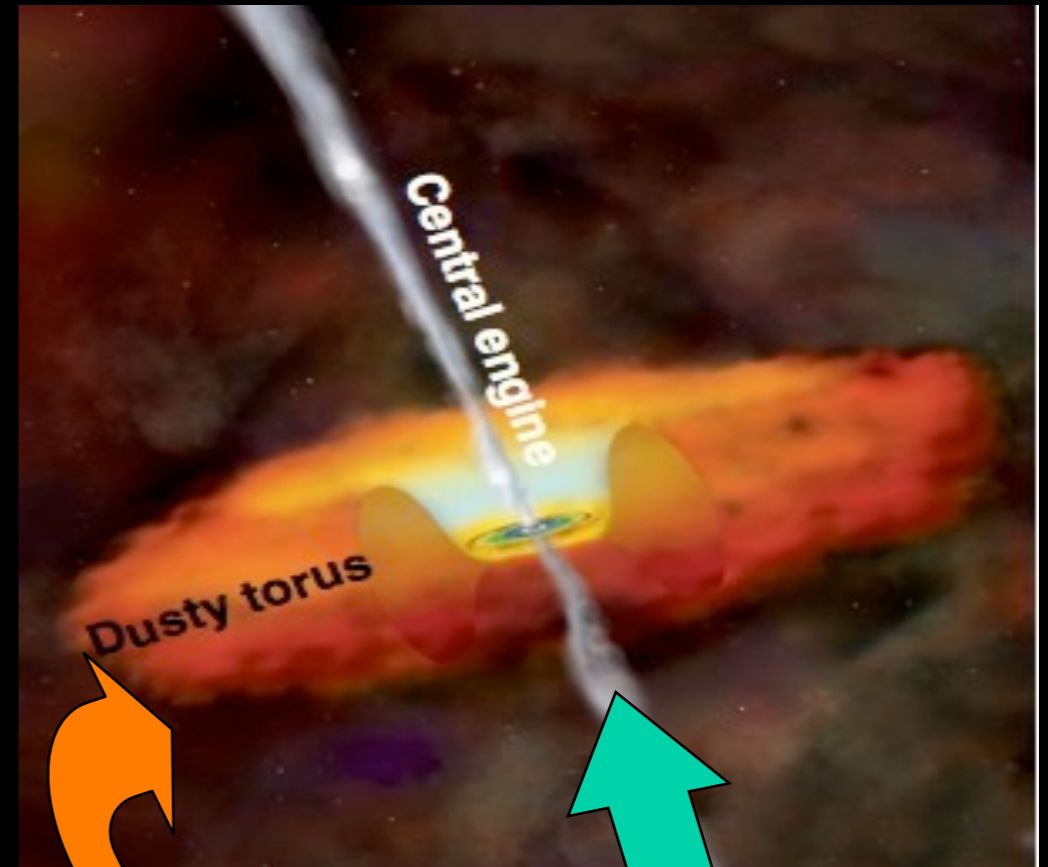 (Hopkins+2008, Hasinger2008, Menci+2008, Narayanan+2009 etc.)

definition of obscured AGN

- **Unified models:**
  - "viewing angle/geometry"
  - AGN emission absorbed by torus
    (or "clumpy" system)
    BL vs. NL classification
    X-ray obscured vs. X-ray unobscured

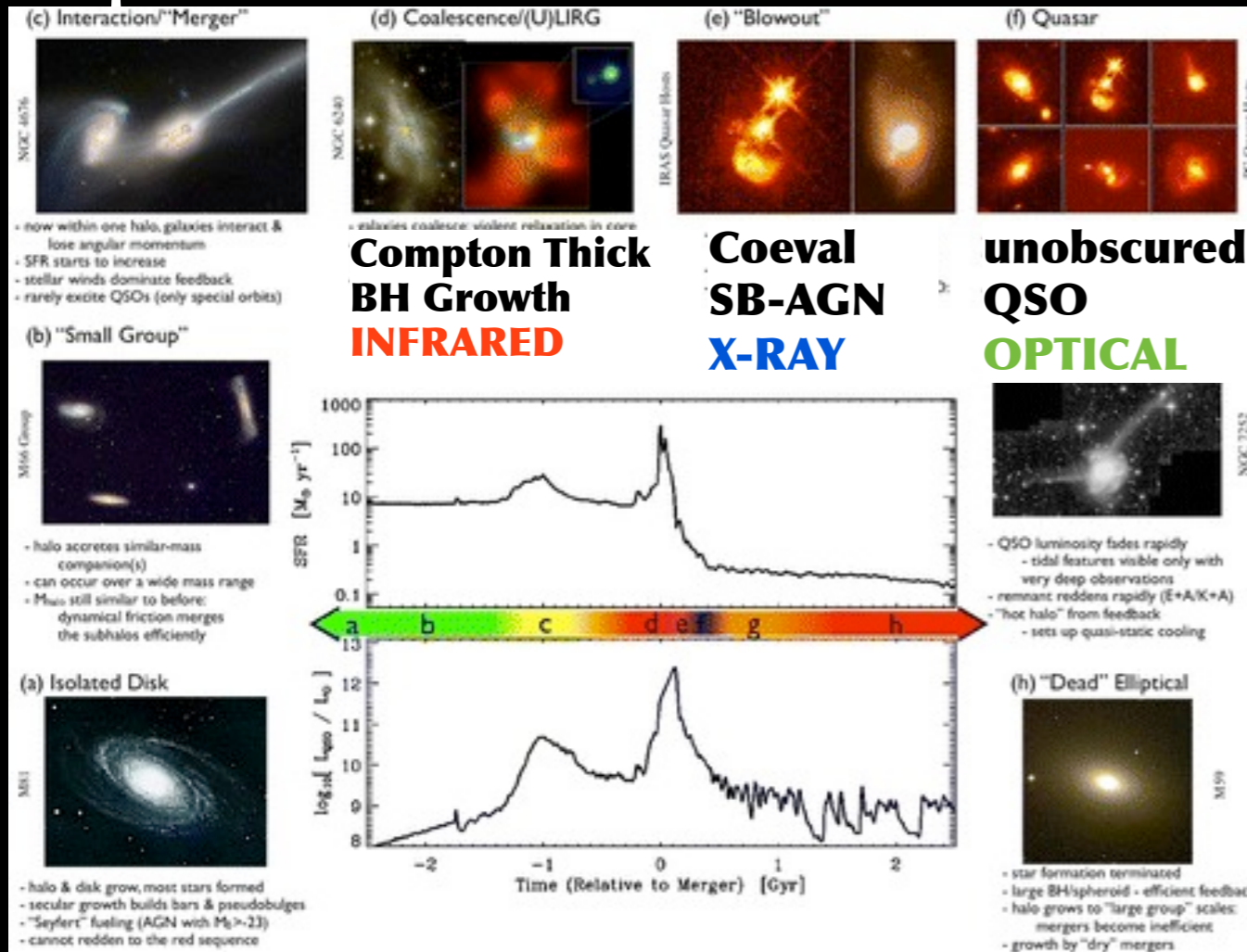 - optical/X-ray classifications agree at 80% level

- **Evolutionary models:**
  - "phase"
  - AGN emission is obscured by host galaxy dust
    (and, maybe, absorbed by torus)

  - time critical (absorption more common at
    high-z)

mergers scenario (ULIRGs-QSO sequence)

Hopkins et al. 2008

Compton Thick BH Growth **INFRARED**
Coeval SB-AGN **X-RAY**
unobscured QSO **OPTICAL**

(e.g. Sanders et al. 1988, Silk & Rees 1998, Granato et al. 2004, Di Matteo et al. 2005, Hopkins et al. 2006-2009, Croton et al. 2006, Fontanot et al. 2006, De Lucia et al. 2006, Sijacki et al. 2007, Menci et al. 2008, Marulli et al. 2009)

Early on

Mergers between gas rich galaxies drive gas which fuel both SF and BH activity;

Violent starbursts episodes (ULIRGS);

Heavily obscured BH growth

When galaxies coalesce

Accretion peaks;

SMBH becomes X-ray and optically "visible"

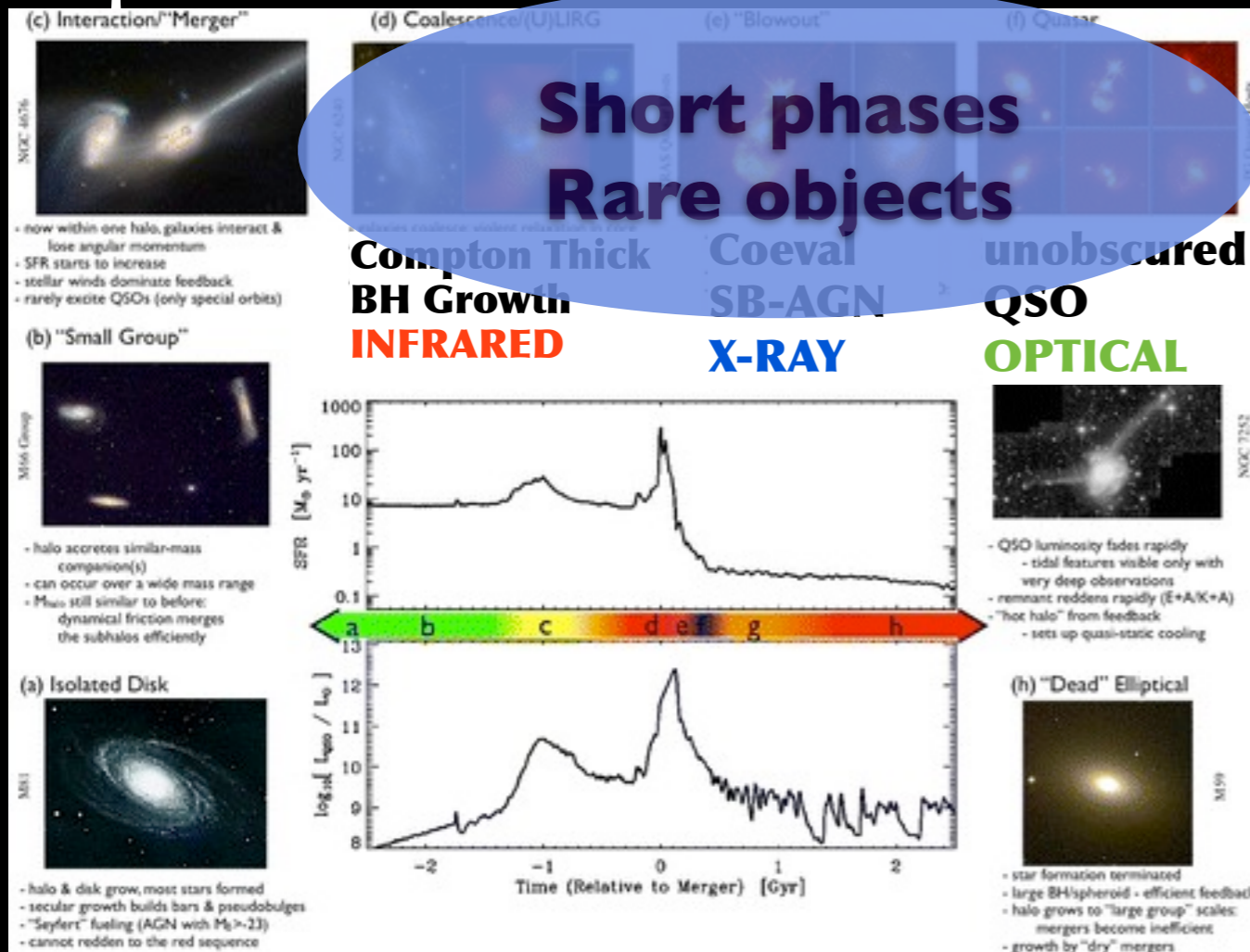QSO phase follow, AGN winds blow out gas

Later times

SF & BH accretion quenched;

Dead quasars in red galaxies (passive evolution)

mergers scenario (ULIRGs-QSO sequence)

Hopkins et al. 2008

Short phases
Rare objects

Compton Thick
BH Growth
INFRARED

Coeval
SB-AGN
X-RAY

unobscured
QSO
OPTICAL

(e.g. Sanders et al. 1988, Silk & Rees 1998, Granato et al. 2004, Di Matteo et al. 2005, Hopkins et al.2006-2009, Croton et al. 2006, Fontanot et al. 2006, De Lucia et al. 2006, Sijacki et al. 2007, Menci et al. 2008, Marulli et al. 2009)

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N.B.
X-ray selection includes
also optical QSO but
not CT ones!

Is this valid for all systems?
(Starburst-AGN sequence)

Kormendy et al. 2011

A population of galaxies evolved without mergers does clearly exist (**disks are observed at z~2**; e.g. Genzel+2006, 2008; **see also Giulia Rodighiero talk**)

no correlation between M_{BH} and disk or pseudobulge properties (Kormendy et al. 2011; see also Graham et al. 2010)

Stochastic/secular accretion can **explain some classes of low-L AGN (NLS1)** observed at low-z (see also Davies talk)

Dichotomy in formation history of galaxies

mergers vs. secular

(weak) activity driven stochastically by local processes (galaxies encounters, inflow, disks/bars instabilities etc.; Croton+2006, Ciotti&Ostriker, Cen 2011, Bournaud+2011, Di Matteo+2011)

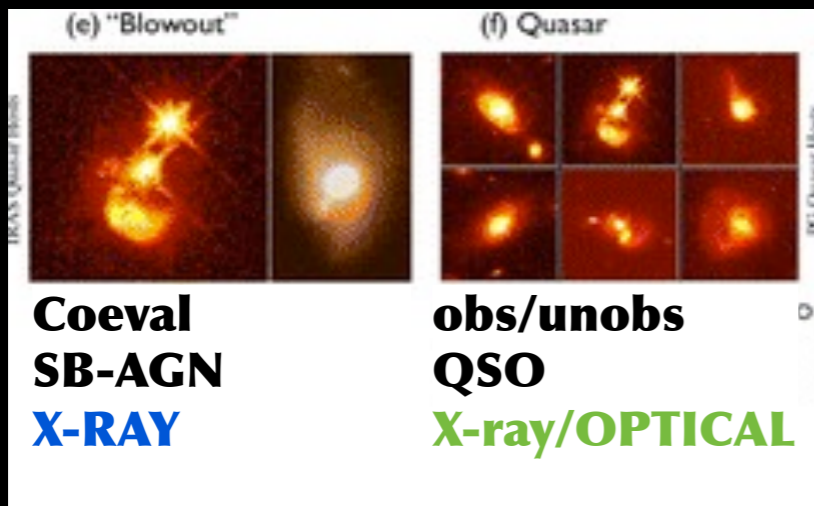**see also Viviana Casasola talk for local UNiverse studies**
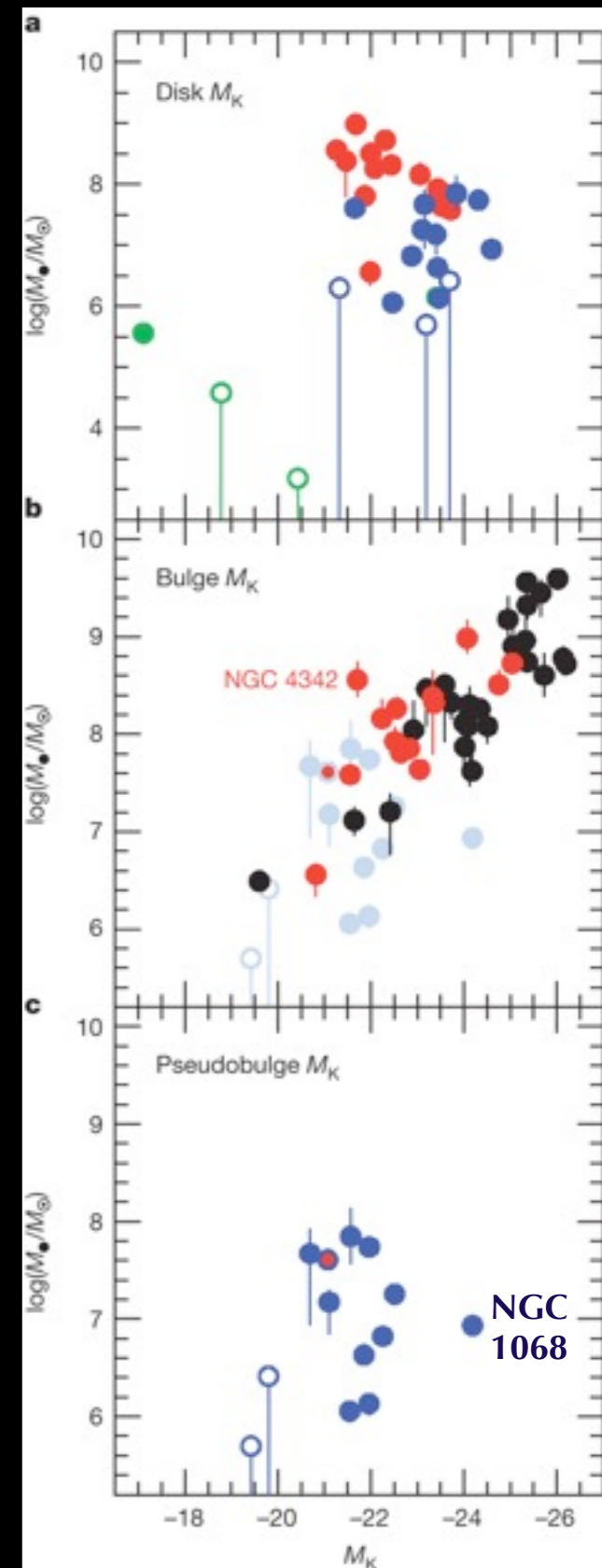
Tools: (hard) X-ray surveys

most complete (modulo Compton Thick sources)

least contaminated (normal galaxies and stars emerge only in deepest exposures)

catch AGN in blowout and QSO phase

Coeval   **obs/unobs**
**SB-AGN**   **QSO**
X-RAY   **X-ray/OPTICAL**

<u>Multiwavelength coverage</u> to assure identification, redshift determination, SED studies, host galaxy properties, and alternative AGN selection (e.g. Compton Thick census)

COSMOS field, 2 deg² (Scoville+07)
XMM 1.55 Ms (Hasinger+07, Cappelluti+09, Brusa+10)
Chandra 1.8 Ms (Elvis+09, Civano+in prep)
    down to ~1e-15 cgs, ~1800 objects soft 0.5-2.0 keV
          medium 2.0-4.5 keV
          hard 4.5-10.0 keV
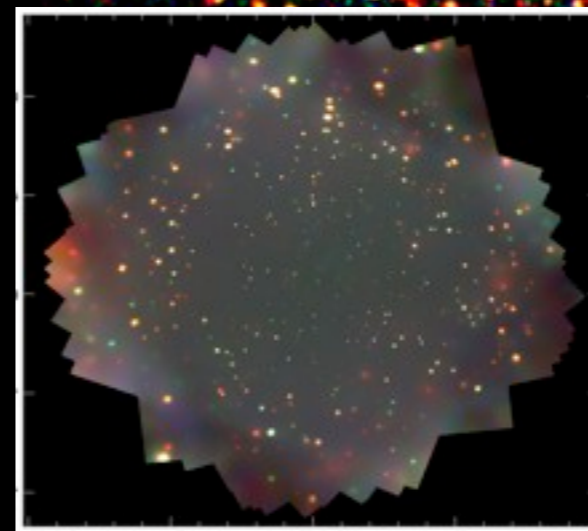
CDFS Chandra 1-2-4Ms
      XMM 3 Ms
~0.1 deg2, ~4e-17 cgs
300-750 objects
(Giacconi+2002, Alexander
+2003, Luo+ 2008,10, Xue
+2011, Comastri+2011)

Ony two among the many (~40) XMM & Chandra surveys in russian-doll style

All wavelengths, very deep coverage available
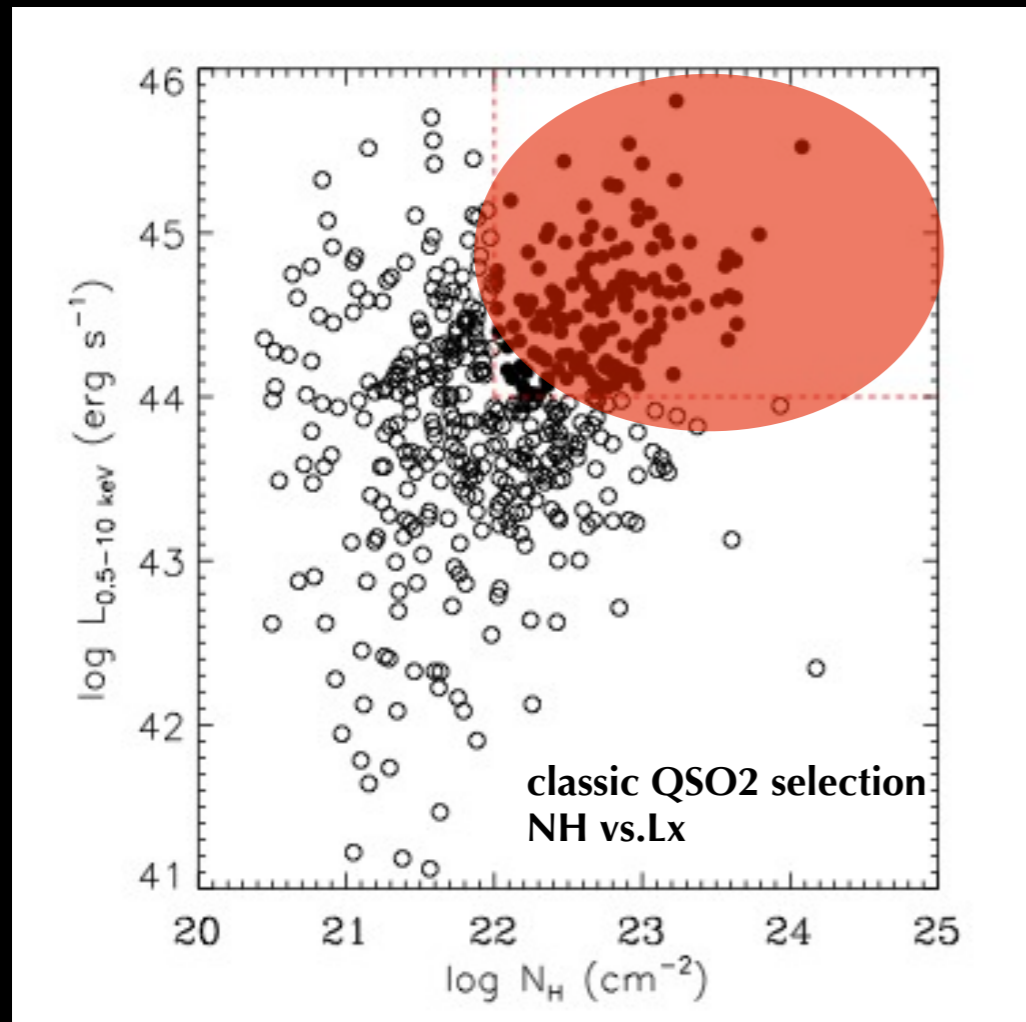

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HOW: efficiently isolating obscured QSO

Use X-ray selection (most unbiased etc. etc.)
Use correlations between observables for objs with spec-z and classifications

classic QSO2 selection
NH vs.Lx

proposed by Fiore, MB +03; see also Brusa et a. 2005, Barger+05, Eckart+06 etc.

RED Objects

Mainieri et al. 2011

XMM-COSMOS quasars
logNH>22, logLx > 44

sampling X-ray obscuration
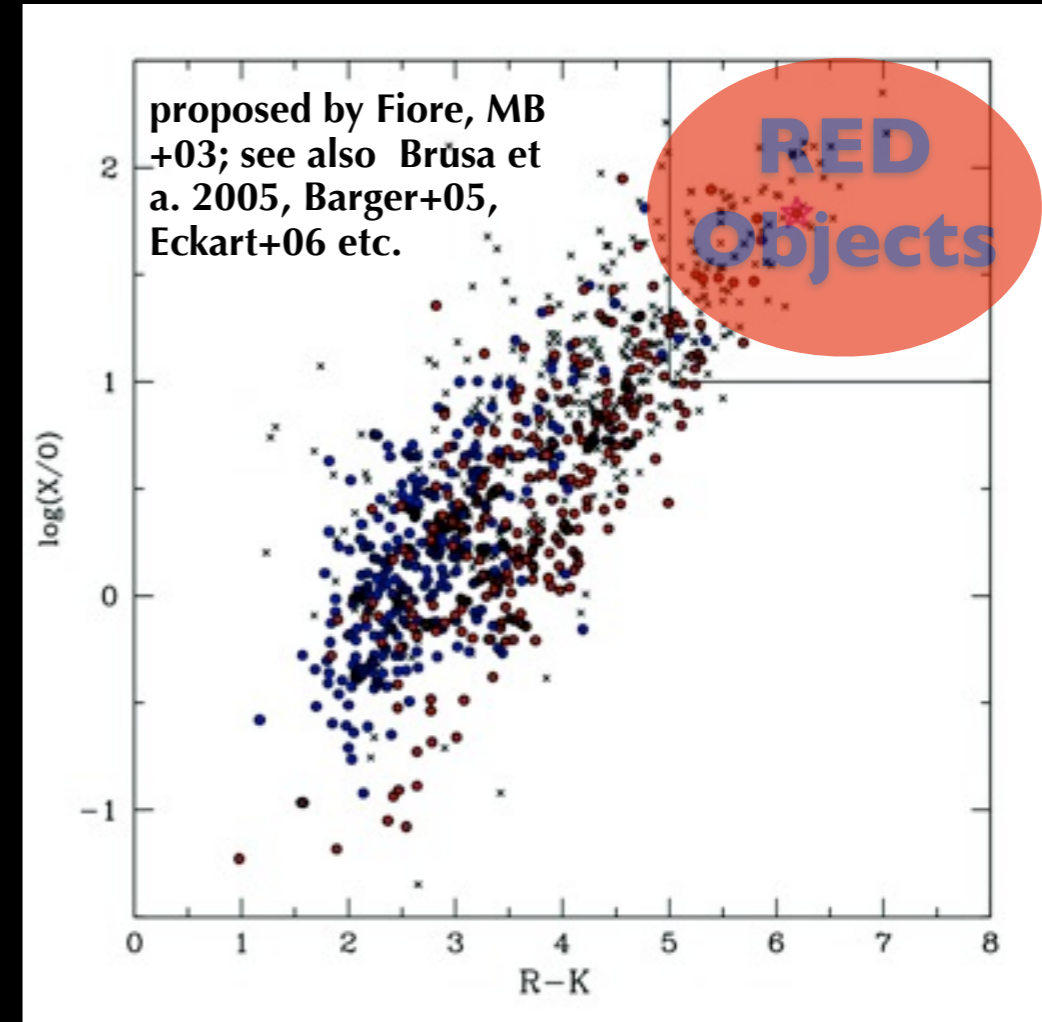
Brusa et al. 2010

XMM-COSMOS luminous obscured AGN
logX/O > 1, R-K>5

sampling X-ray and optical obscuration
(complemented by similar diagnostics from
Spitzer, e.g. Fiore+2009 diagnostics)

Alternative approach: INFRARED

- AGN (unobs and obs) are expected to have **warm power-law sed** at >1micron (≠ from elliptical/starburst)

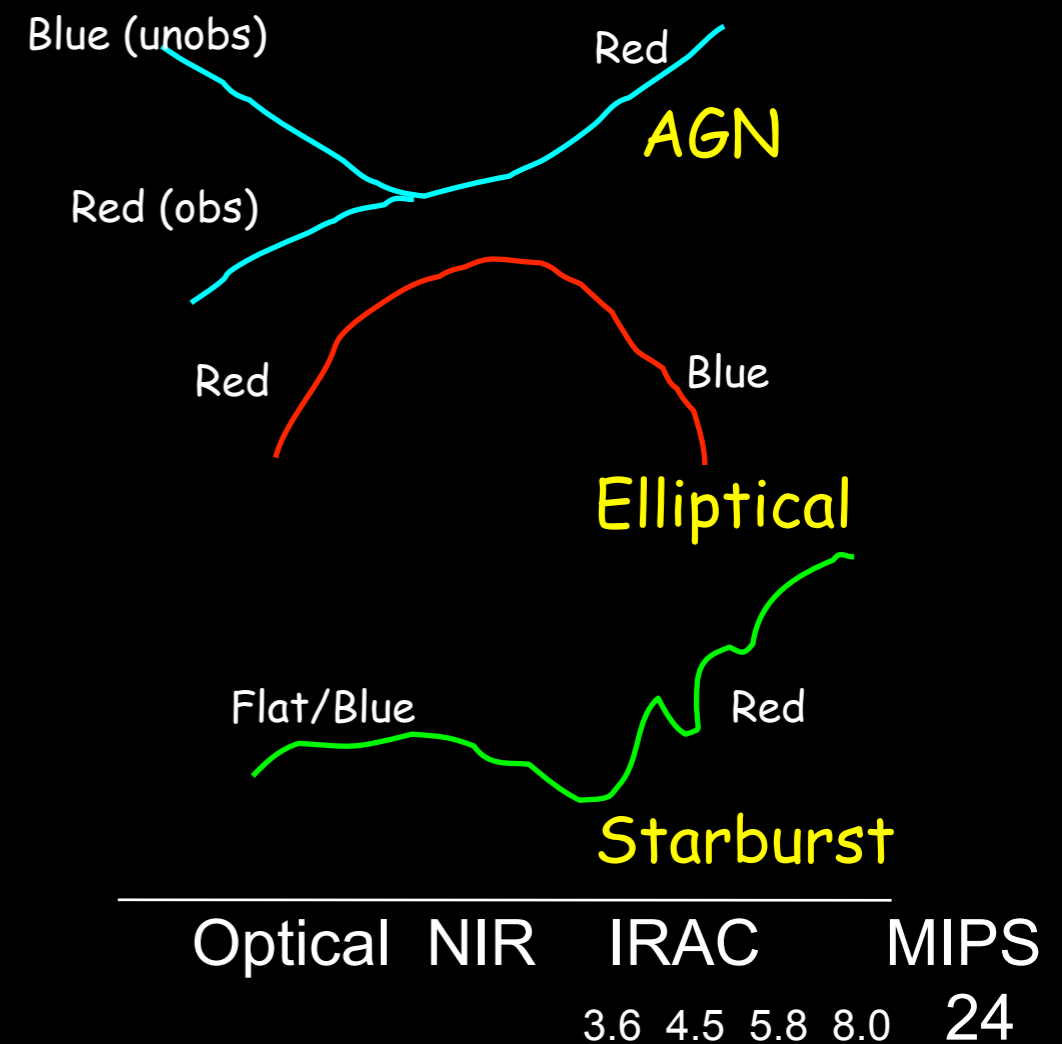AGN (both type 1 and 2) can be isolated

in NIR/MIR diagrams and they are ~ same order of magnitude of X-ray selected obscured AGN

(Lacy et al. 2004, Hatziminaouglou et al. 2005, Stern et al. 2005, Donley et al.2008, Pope et al. 2008, Daddi et al. 2007; Fiore et al. 2008, 2009, Luo et al. 2011)

Main issues:

reliability (are only AGN selected?)
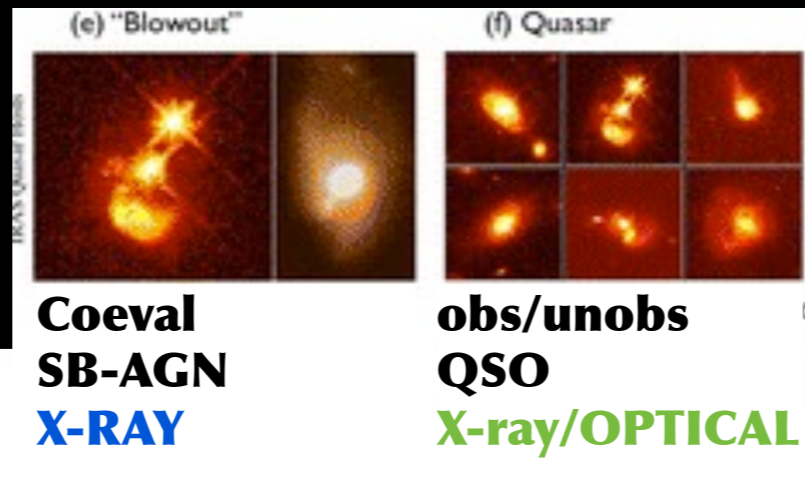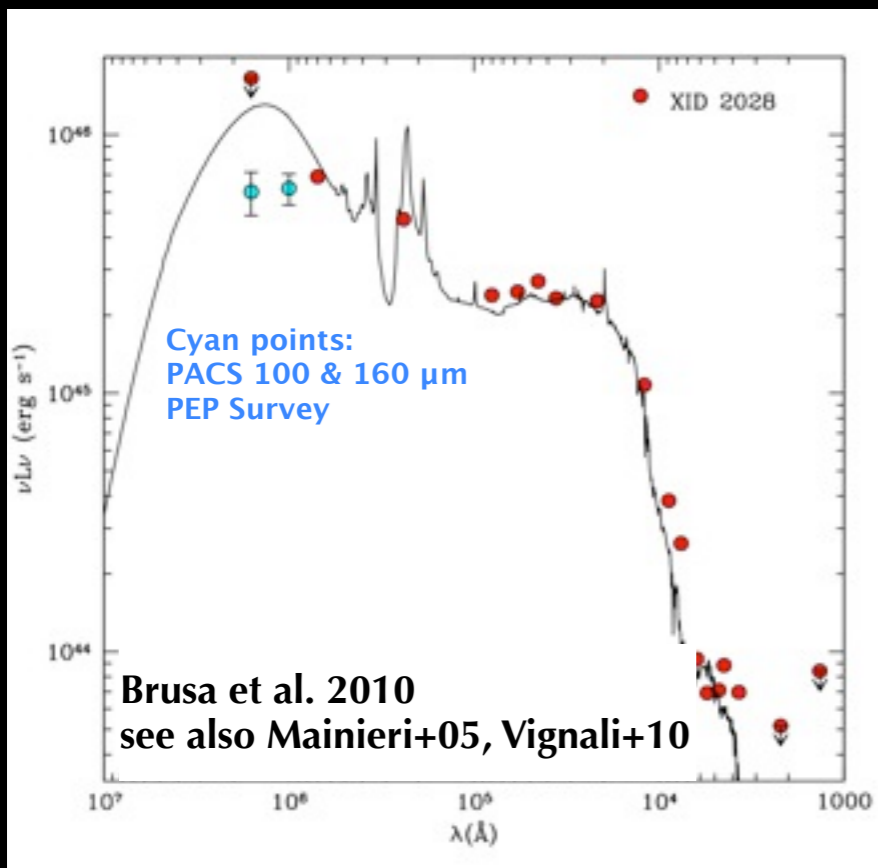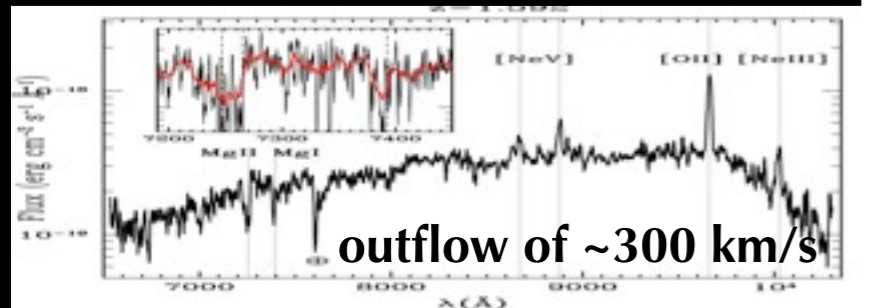**completeness** (are all AGN selected?)

Blue (unobs)   Red
                                    AGN
Red (obs)

Red   Blue

                        Elliptical

Flat/Blue   Red

                        Starburst

Optical NIR   IRAC   MIPS
                    3.6 4.5 5.8 8.0   24

see Brusa et al. 2010
Donley et al. 2012

During or Post ?

Most **luminous**, **obscured X-ray selected** sources at z>1 are red
--> effect of (negative) feedback efficient in stopping star formation, or AGN is in dusty environment? Evidences for *both* ! --> **different phases/timescales are sampled**

evidence of SF both in FIR and optical spectra (see also Brusa +2009, Santini+2011)

ULIRG-QSO2

outflow of ~300 km/s

Cyan points:
PACS 100 & 160 μm
PEP Survey

Brusa et al. 2010
see also Mainieri+05, Vignali+10

(e) "Blowout"   (f) Quasar

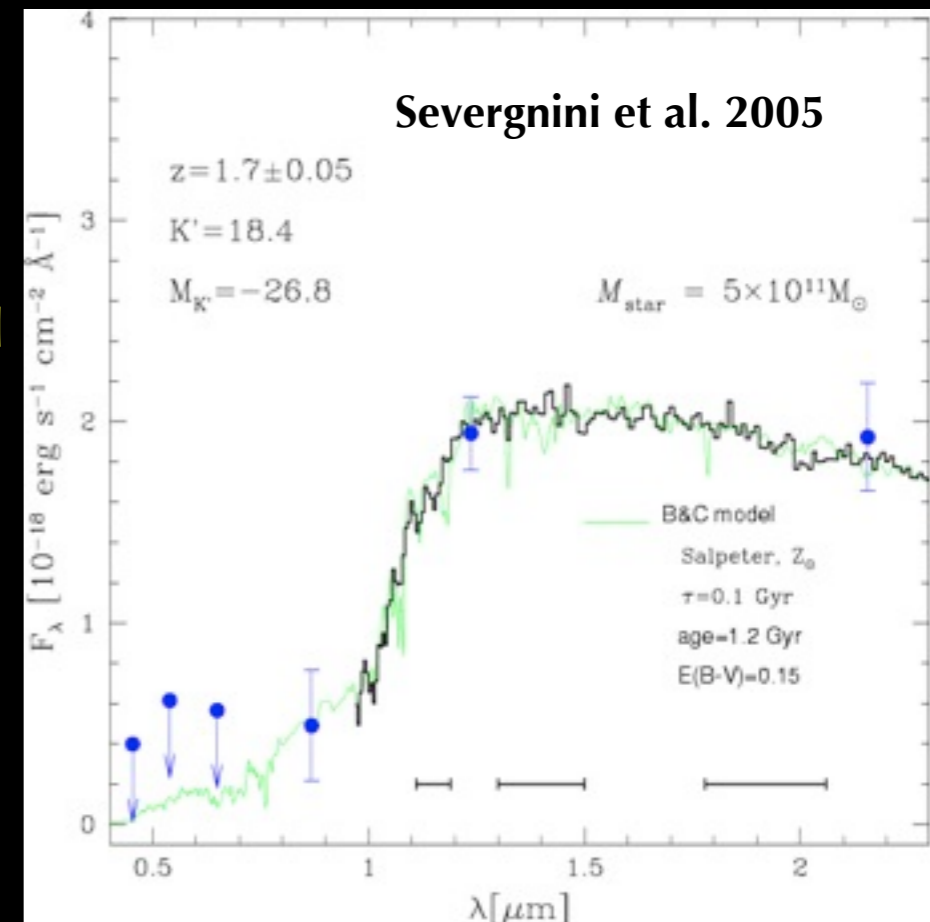**Coeval   obs/unobs
SB-AGN   QSO
X-RAY   X-ray/OPTICAL**

Very short phase (<< 1Gyr): need large & bright samples (RARE OBJECTS!!)

Importance of X-ray selection, prospects for large area X-ray surveys (SWIRE/XMM-XXL/ eROSITA)

Ideal targets for WFC3/ X shooter/ ALMA/JWST follow-up and deep spectroscopy
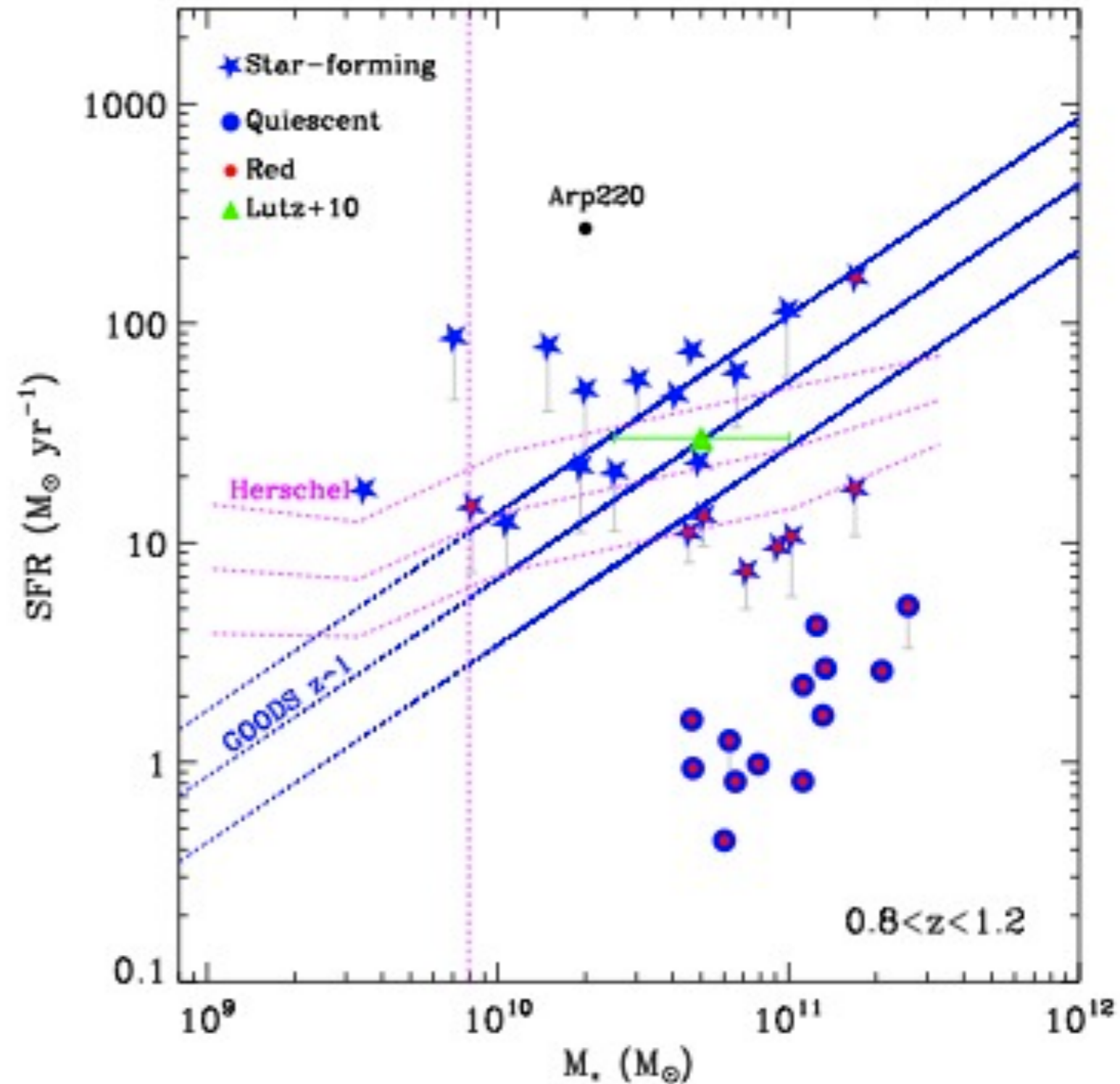
SYNERGIES !

passive ellipticals/early type spectra without any sign of SF (see also Mignoli+2004, Brusa+2005, Daddi +2005....)

QSO2

Severgnini et al. 2005

Host properties of QSO2

Mainieri et al. 2011
XMM-COSMOS
QSO2 sample

all these sources are indistinguishable from an X-ray point of view, most likely to be in the QSO blow-out phase

Host properties of QSO2
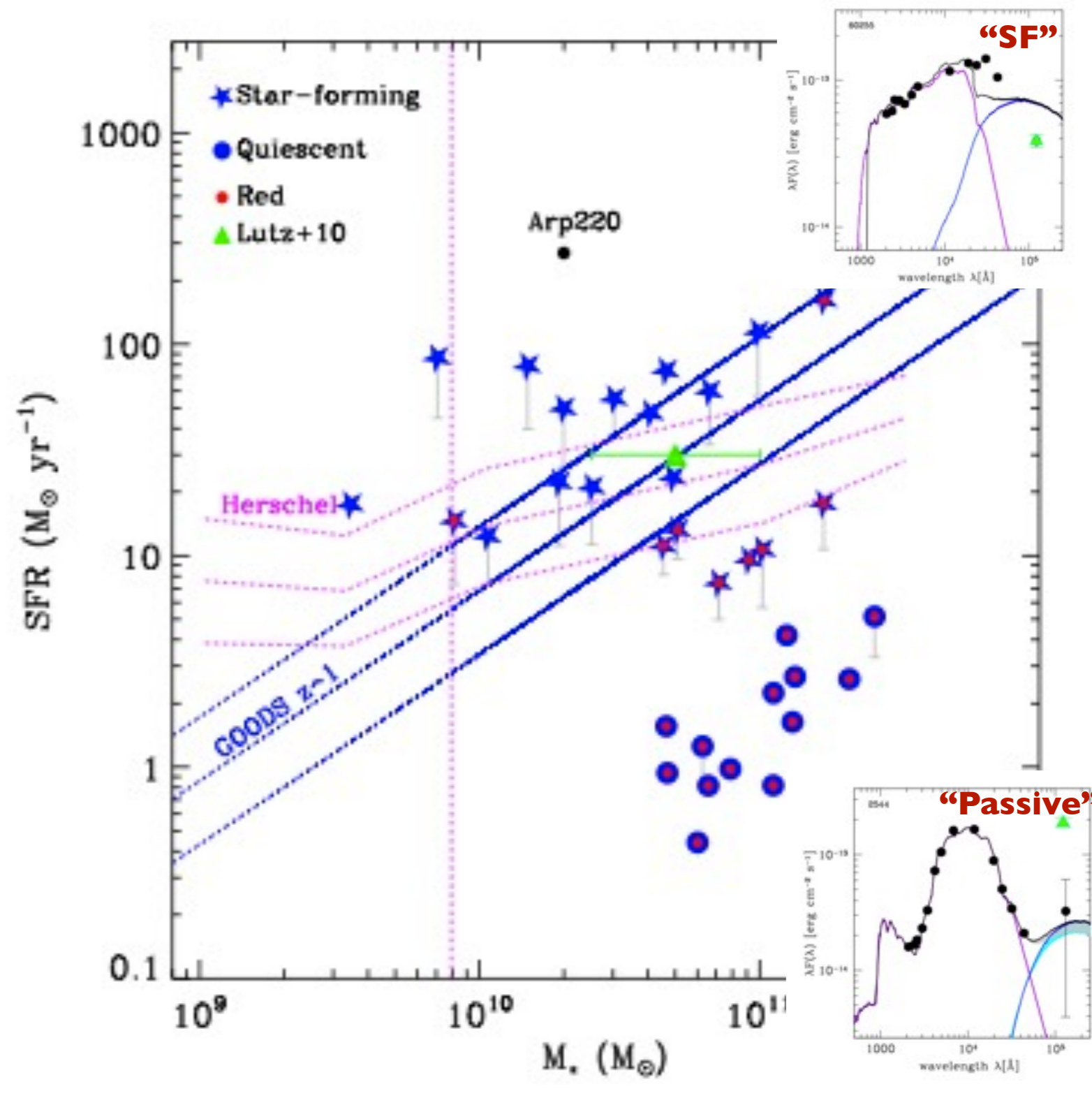
Mainieri et al. 2011

XMM-COSMOS
QSO2 sample

all these sources are
indistinguishable from
an X-ray point of view,
most likely to be in the
QSO blow-out phase

Host galaxies both

passive or **star-forming**

--> different phases!

**SF = objects at the beginning of
blowout phase**
**PASSIVE = QSO feedback
already effective in stopping SF**

How to test if objects are really caught in the blow-out phase, at 2 different times?

- SFR should be tested/validated against FAR-IR -->
  PACS/PEP measurements/checks
  "SFR ladder" also for AGN? (Wuyts et al. 2011)

- Gas mass in SF QSO2 (still available) should be higher than in passive QSO2 (already diminished/exhausted) -->
  IRAM and ALMA CO luminosities vs. LIR

- BH masses should be higher (or the same) in passive QSO2 (subsequent phase) than in SF QSO2 -->
  IR (SINFONI, Xshooter, LUCIFER) spectroscopy for selected sample to observe Halpha

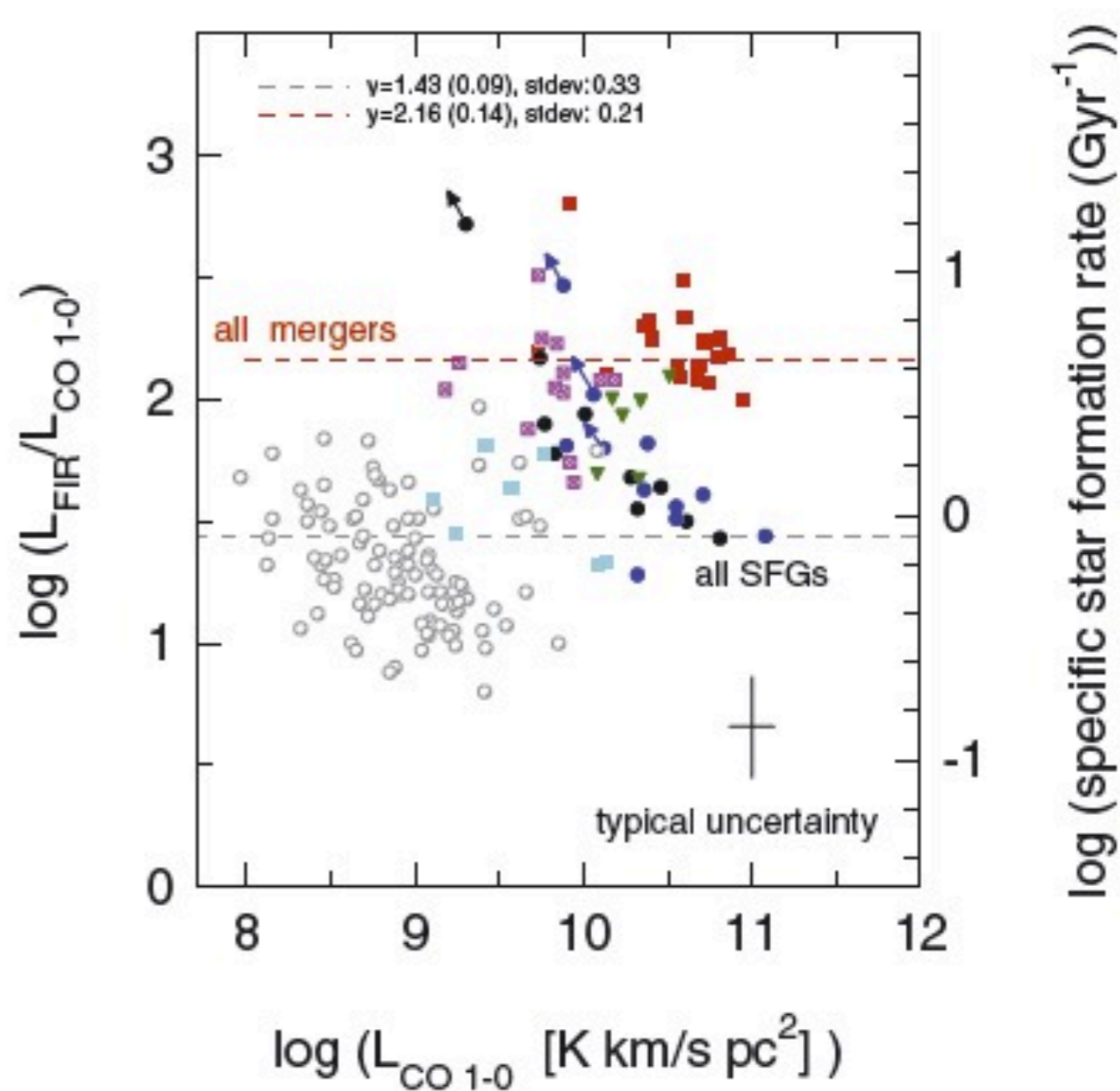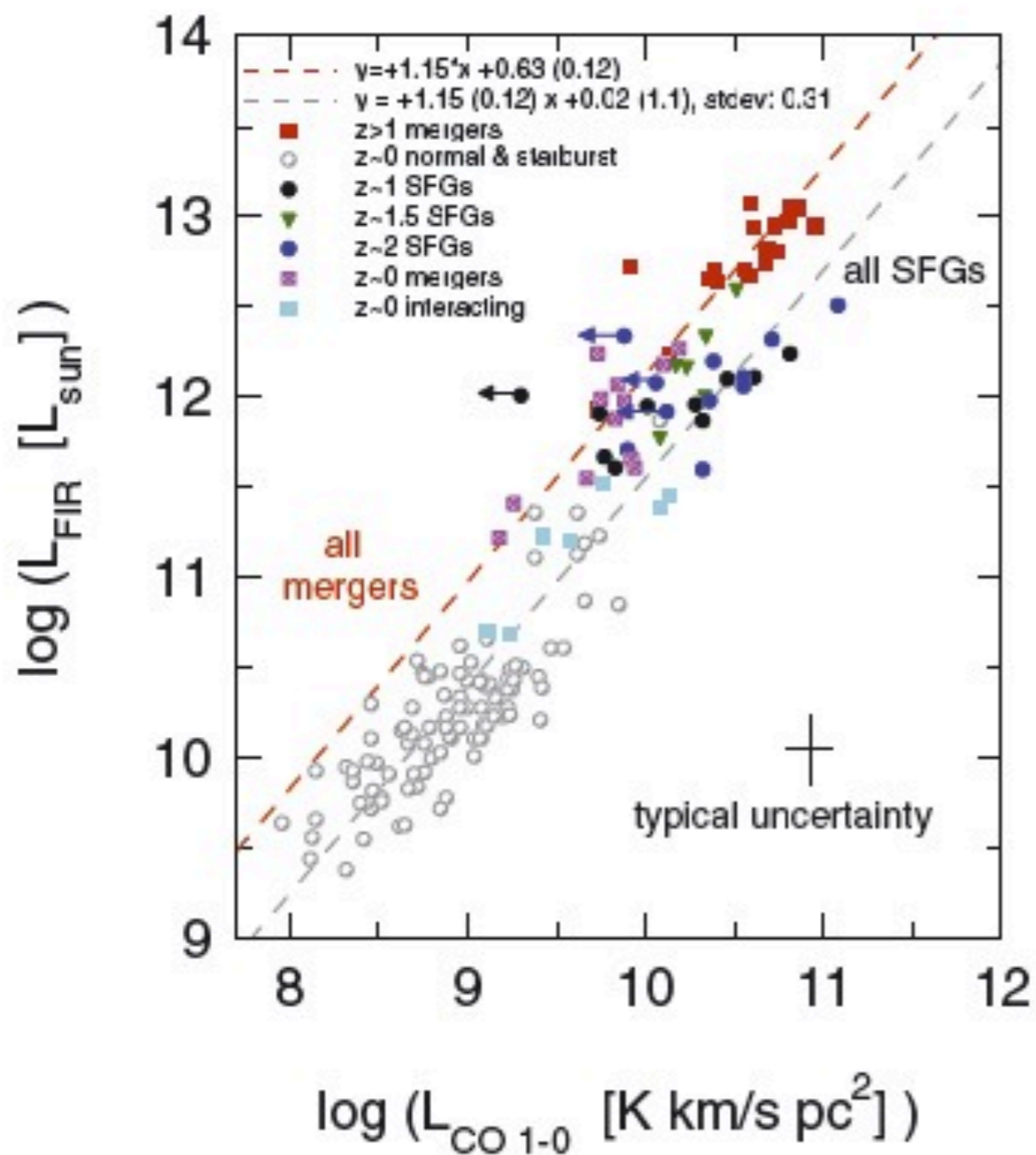# IRAM observations/results
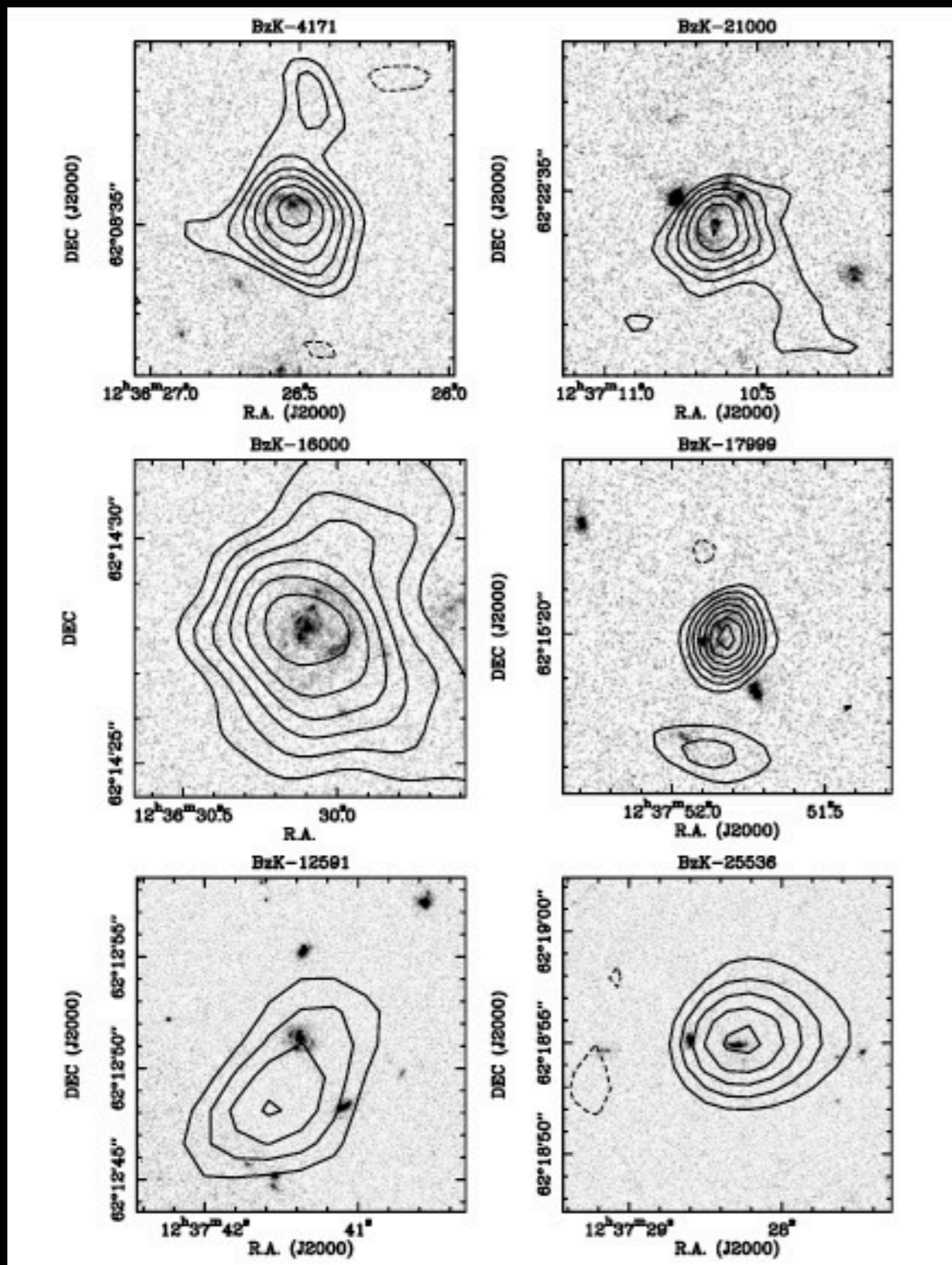
Daddi et al. 2010
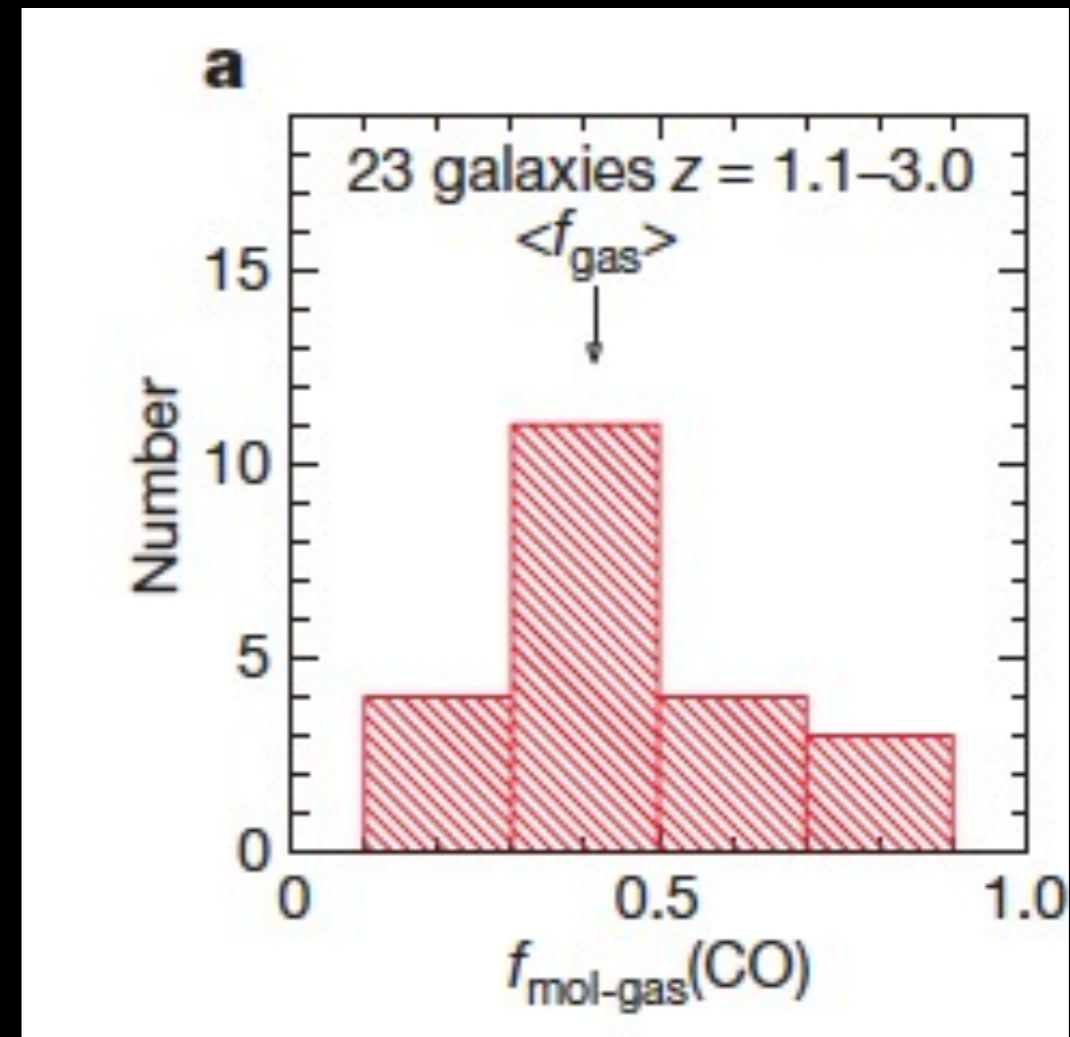
Tacconi et al. 2010

IRAM detection of BzK and SMG gas fraction higher than in local SB

it is time to extend these studies to AGN and larger samples --> ALMA! (see high prio program by Lonsdale)

Mergers vs. smooth accretion in mm

Two families (sequences):

low SFE and spatially extended gas reservoirs (disks)
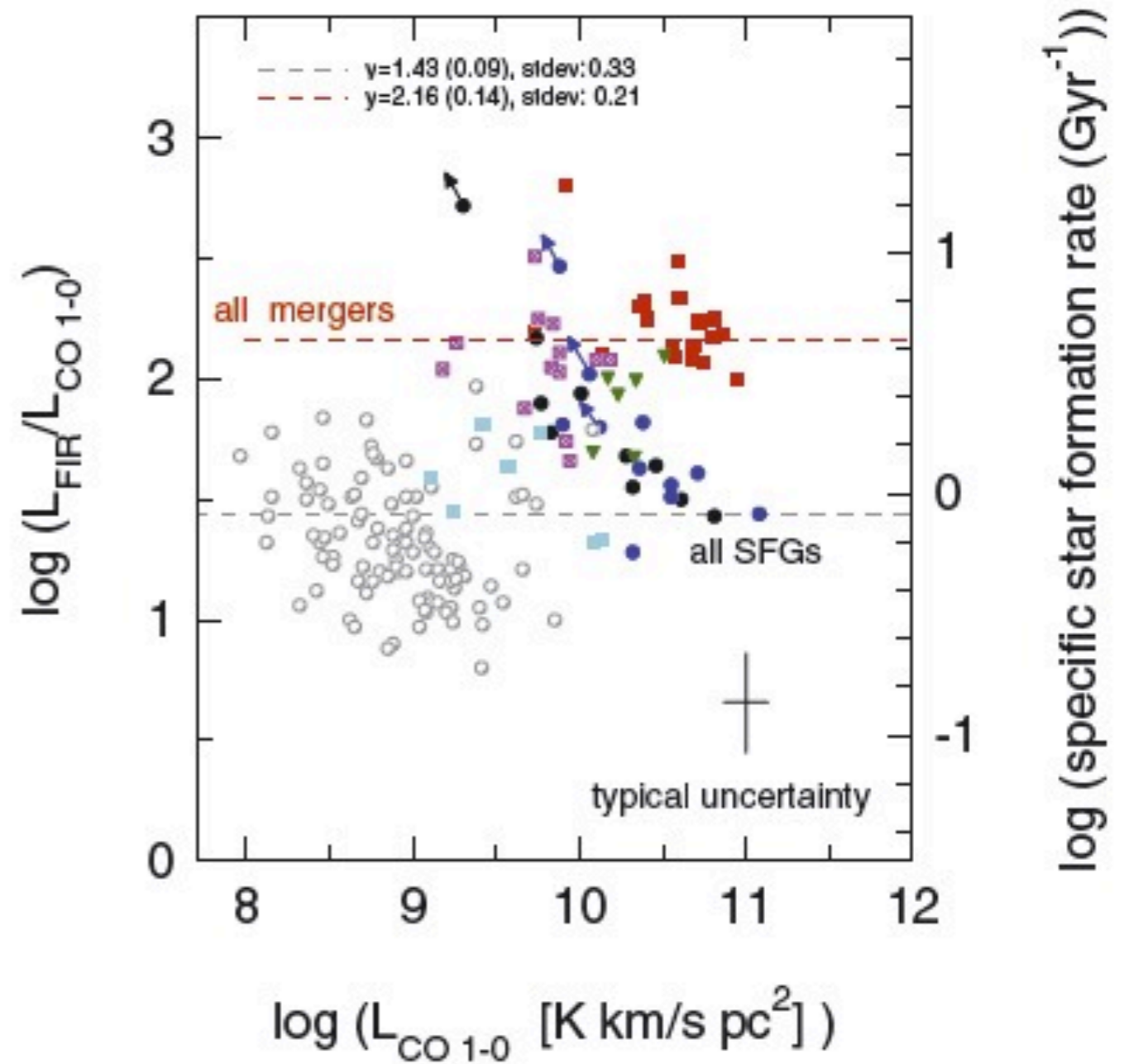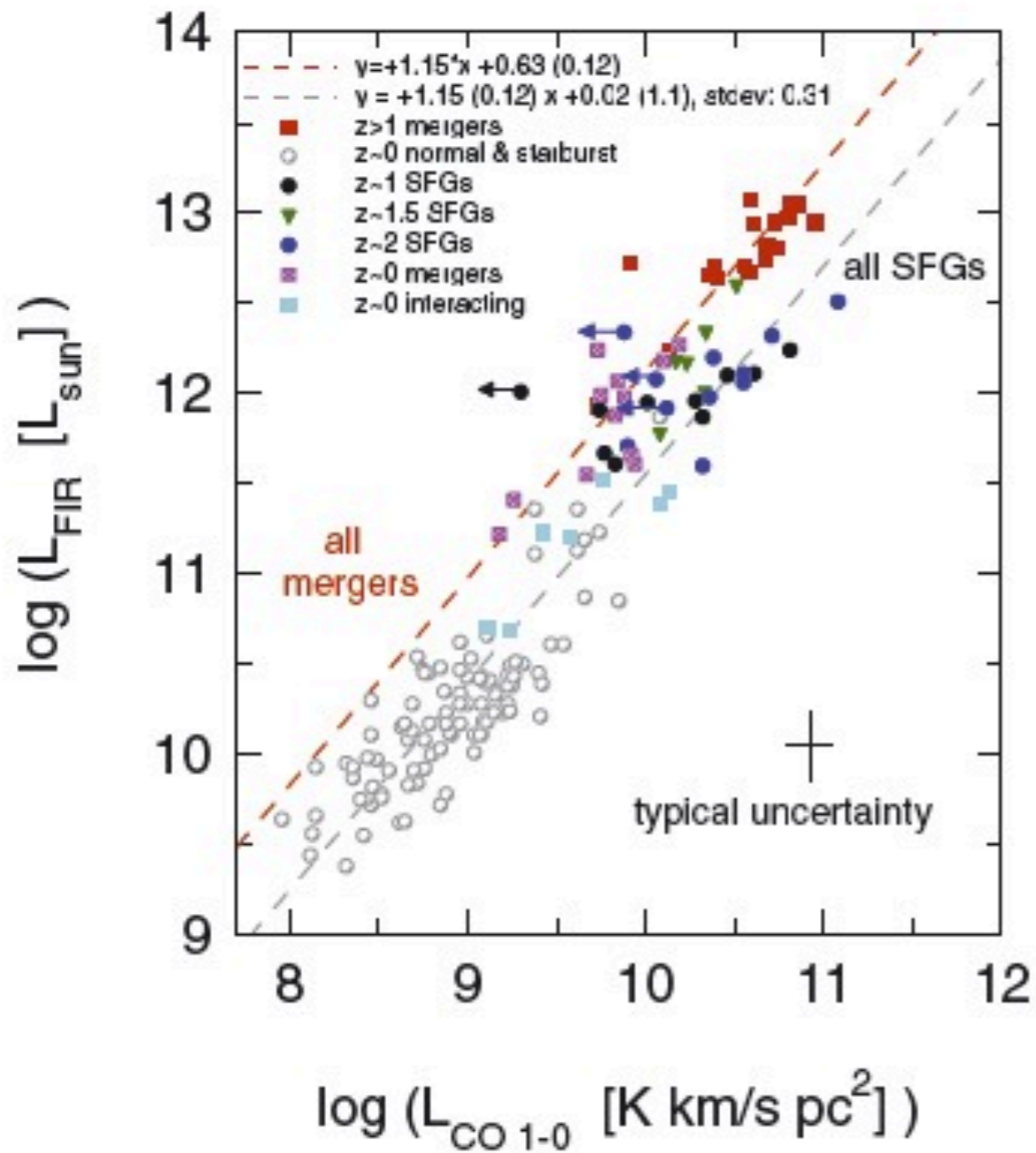
high SFE and compact gas reservoirs (mergers)

Genzel et al. 2010

see also Daddi et al. 2010

(Leslie Hunt talk)

Two families (sequences):

low SFE and spatially extended gas reservoirs (disks)

Low-LAGN

high SFE and compact gas reservoirs (mergers)

high-LAGN

Genzel et al. 2010

see also Daddi et al. 2010

(Leslie Hunt talk)

Summary

- **AGN in "feedback" phase** can be isolated through X-ray surveys (we know how to do it..)

- **Caveat on IR selection** (X-ray still the most reliable...)

- **ALMA/mm observations can help in disentangling models** of galaxy-BH co-evolution (mergers vs. smooth accretion)

- **ALMA "survey" programs** to preselect high-z candidate for follow-up studies of QSO outflows (full ALMA for CO or [CII] - see Roberto Maiolino talk)

- Natural X-ray (XMM, Chandra..) + mm (ALMA) **synergies**