GEMS in the sky: Quasar host galaxies from 0.5 $< z <$ 2.8

Knud Jahnke, Sebastián F. Sánchez, Lutz Wisotzki
+the GEMS collaboration,
09.10.2003

The GEMS collaboration

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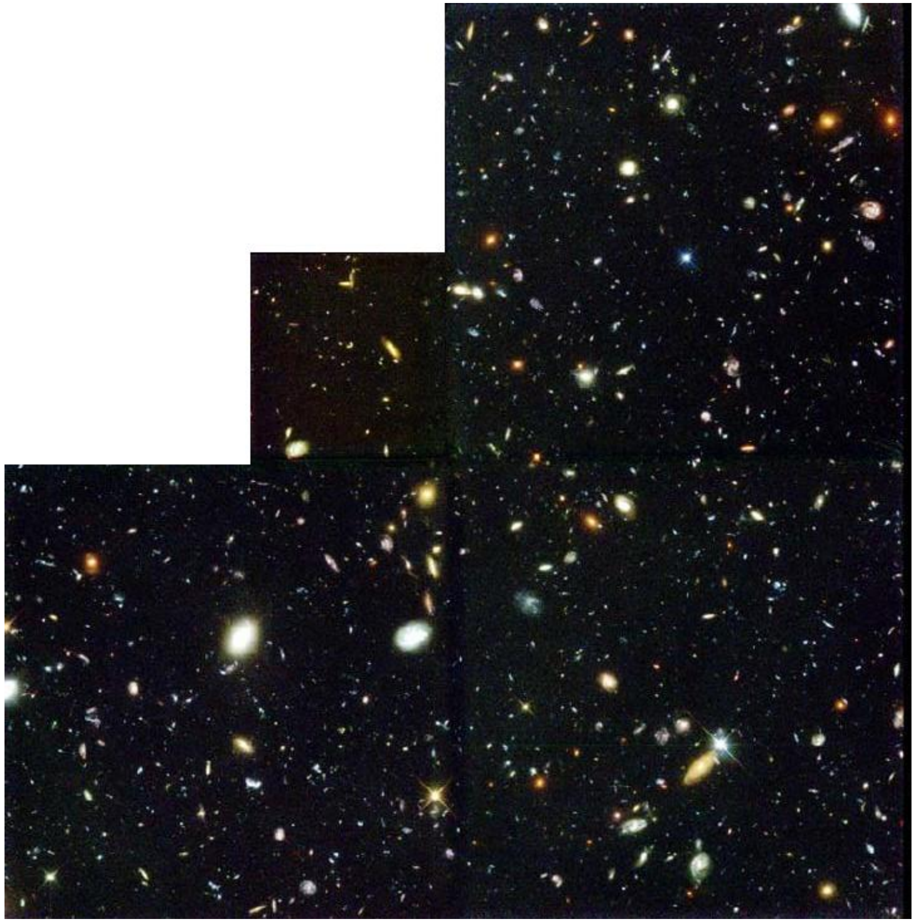
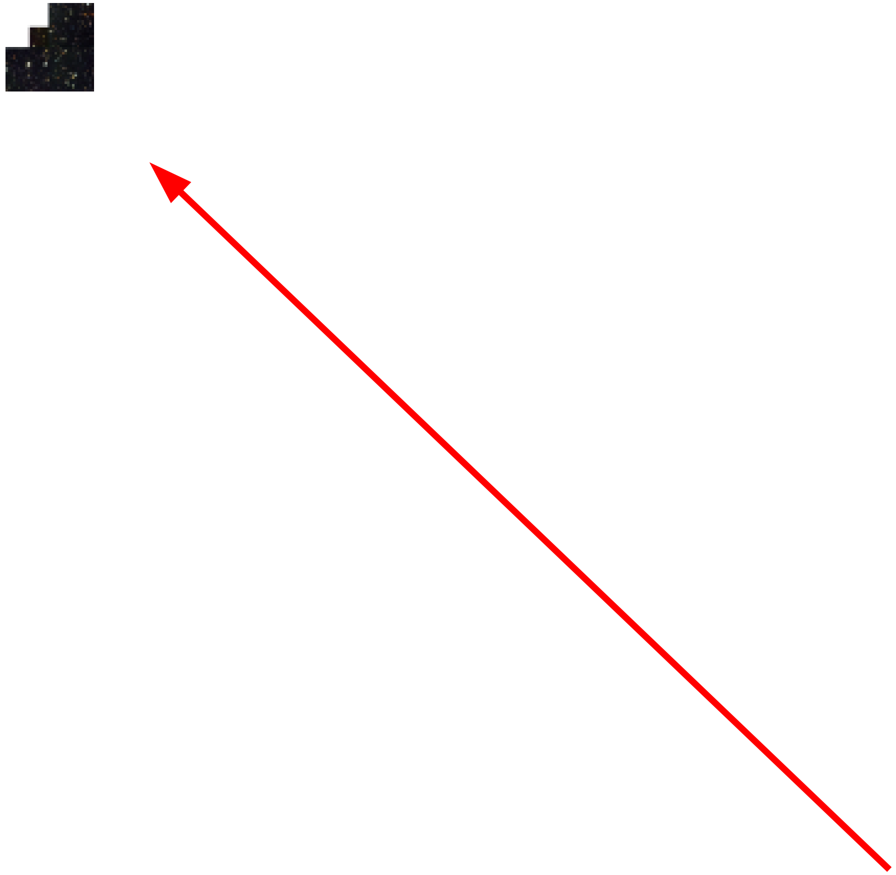
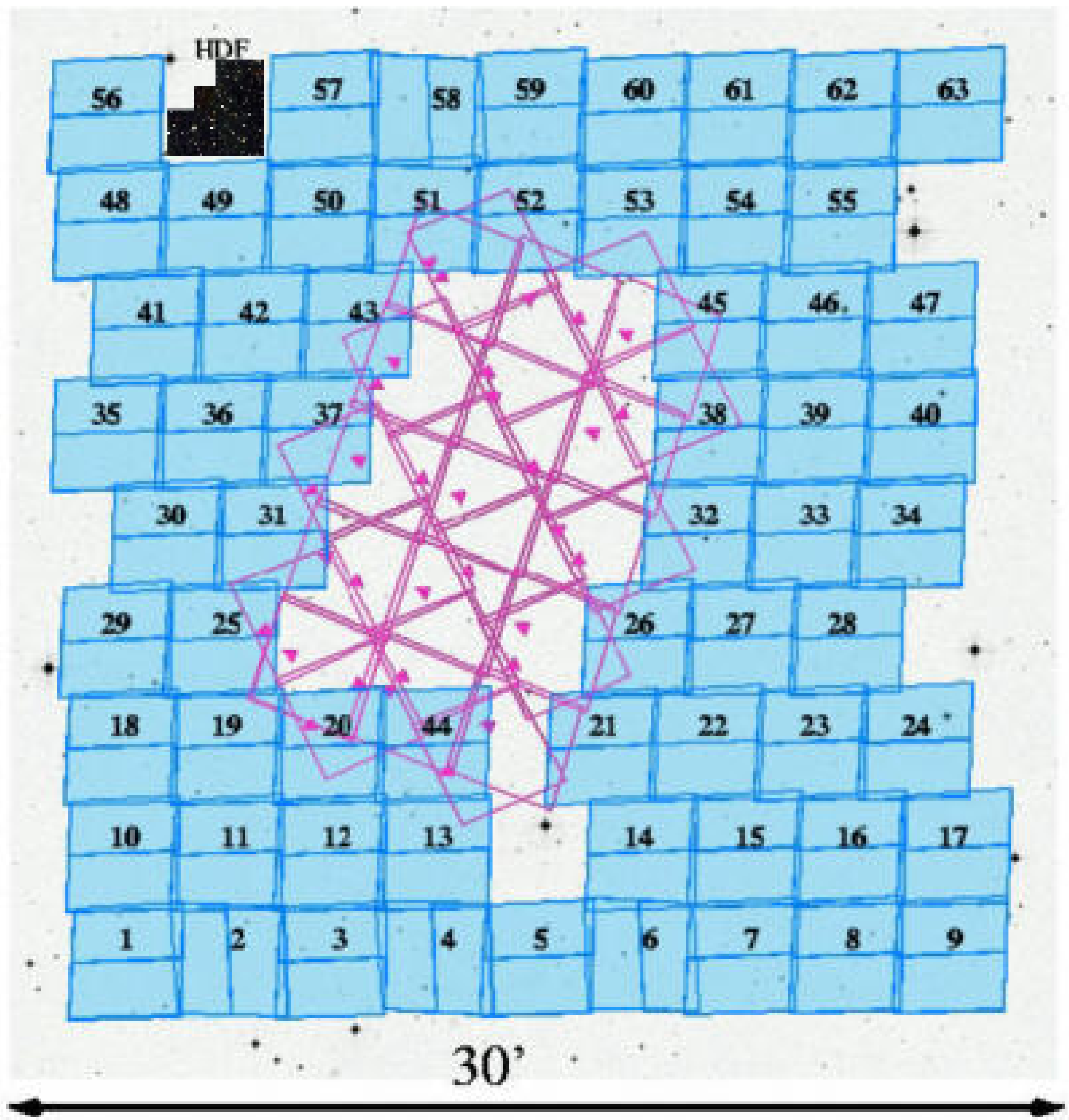
1996:
The Hubble Deep Field
size: $2'40'' \times 2'40''$
$\sim$300 galaxies with redshifts



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The GEMS project

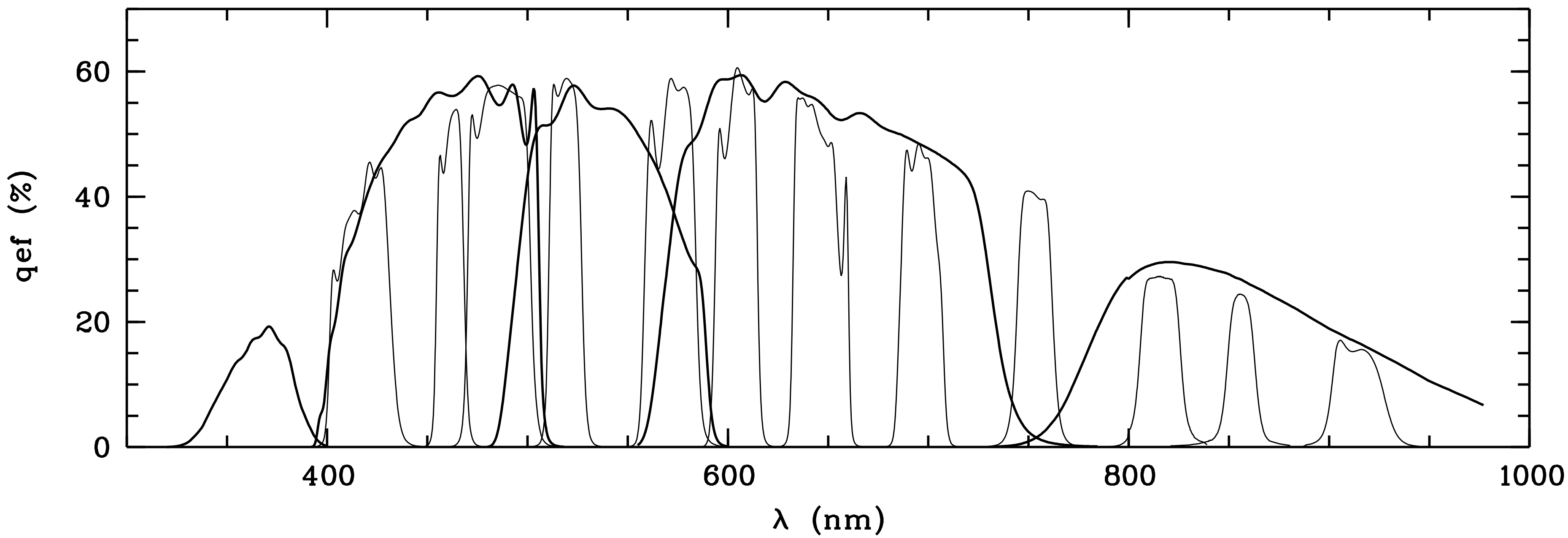
GEMS: Galaxy **E**volution from **M**orphologies and **S**EDs

- imaging survey with ACS onboard HST
- area of $\sim 27' \times 27'$, $\sim$120 HDF images
- region of Chandra Deep Field South (CDFS)
- sampling $0\farcs03$/pixel ($\longrightarrow$ $\sim$3000 Megapixel)
- two filters, F606W ($\sim V$-band) and F850LP ($\sim z$-band)
- one orbit per band per field
- 5σ depth of $V \sim 28.3$ mag and $z \sim 27.1$ mag
- central $\sim$1/4 of GEMS incorporates GOODS data

The GEMS project: Science Goals

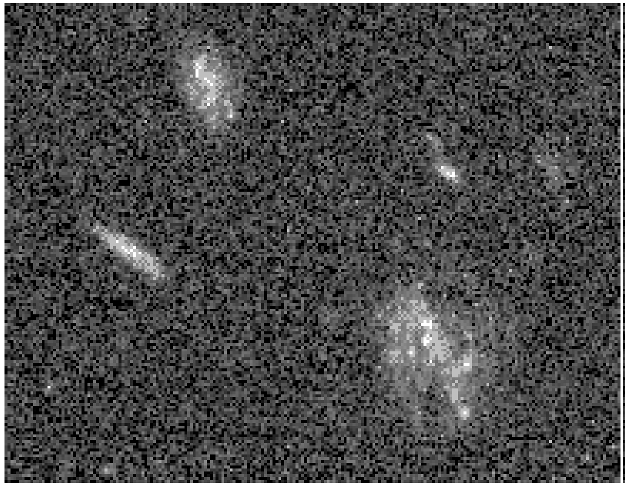
- Galaxy evolution over redshift range $0.2 < z < 1.1$
- $\sim$10 000 galaxies with redshifts, morphologies and SEDs.
- Relation between the morphology and evolution
- Evolution of structural parameters of inactive galaxies: bars, merger rates...
- Relation between clustering properties and evolution
- Study of AGN host galaxies $0.5 < z < 3$

COMBO-17



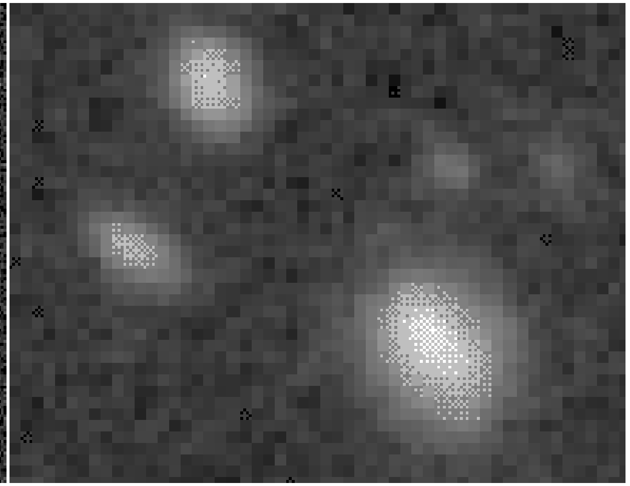
- 5 broad band, 12 medium band filters with ESO WFI
- four fields of 0.25 deg^2 each, one of them CDFS
- reliable classification for galaxies, AGN and stars
- photometric redshifts with precision $\sigma_z/(1+z) < 0.02$
- completeness limit: R$<$24

The GEMS project: The data



F606W

F850LP

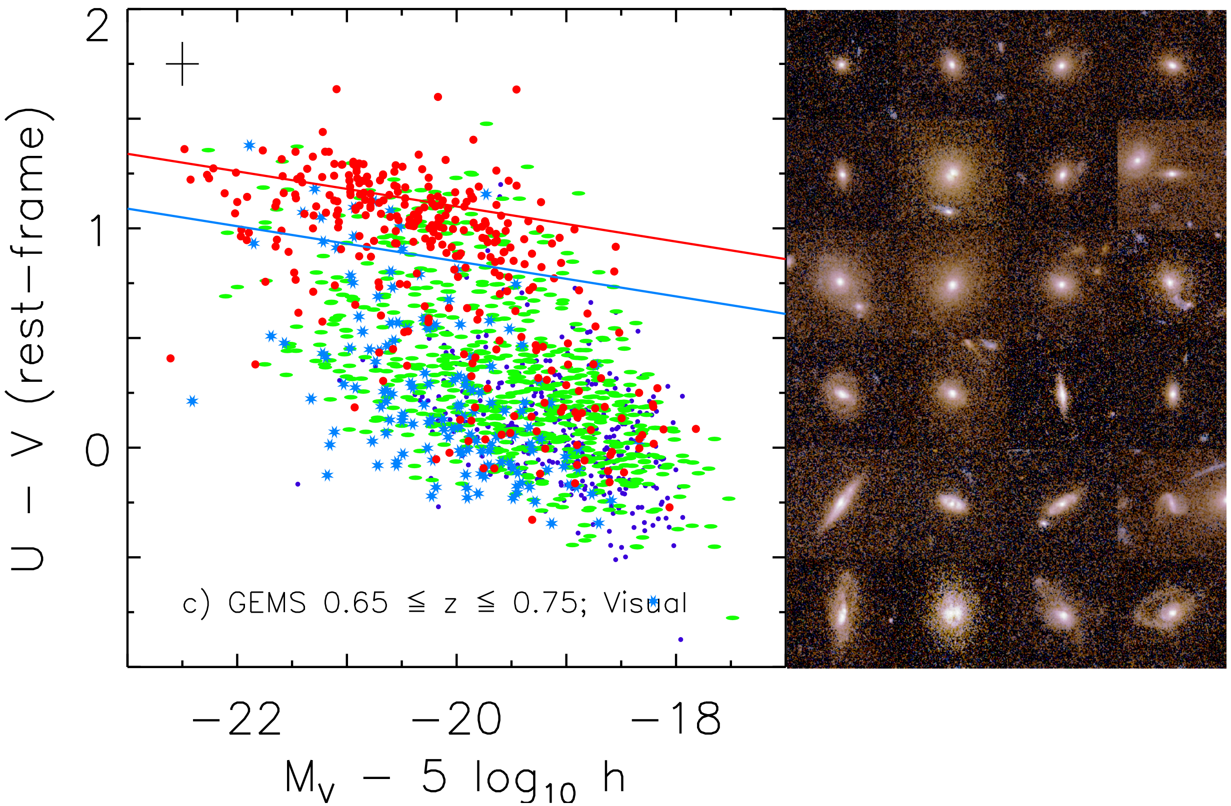


COMBO-17

The GEMS project: First Results

1492 galaxies,
$0.65 < z < 0.75$

Red = early type
Green = Sa–Sm
Blue = Strong interaction
(Bell et al. 2003, ApJL, submitted)



The GEMS project: First Results

In preparation:

- Evolution of disk galaxies (Barden et al.)
- Merging and bar statistics (Jogee et al.)
- Semianalytic modelling of evolution (Somerville et al.)
- Stellar masses of galaxies (Borch et al.)
- Galaxy–galaxy correlation (Phleps et al.)
- Weak galaxy–galaxy lensing (Taylor, Heymans et al.)
- and: quasar host galaxies (Wisotzki, Sánchez, Jahnke)

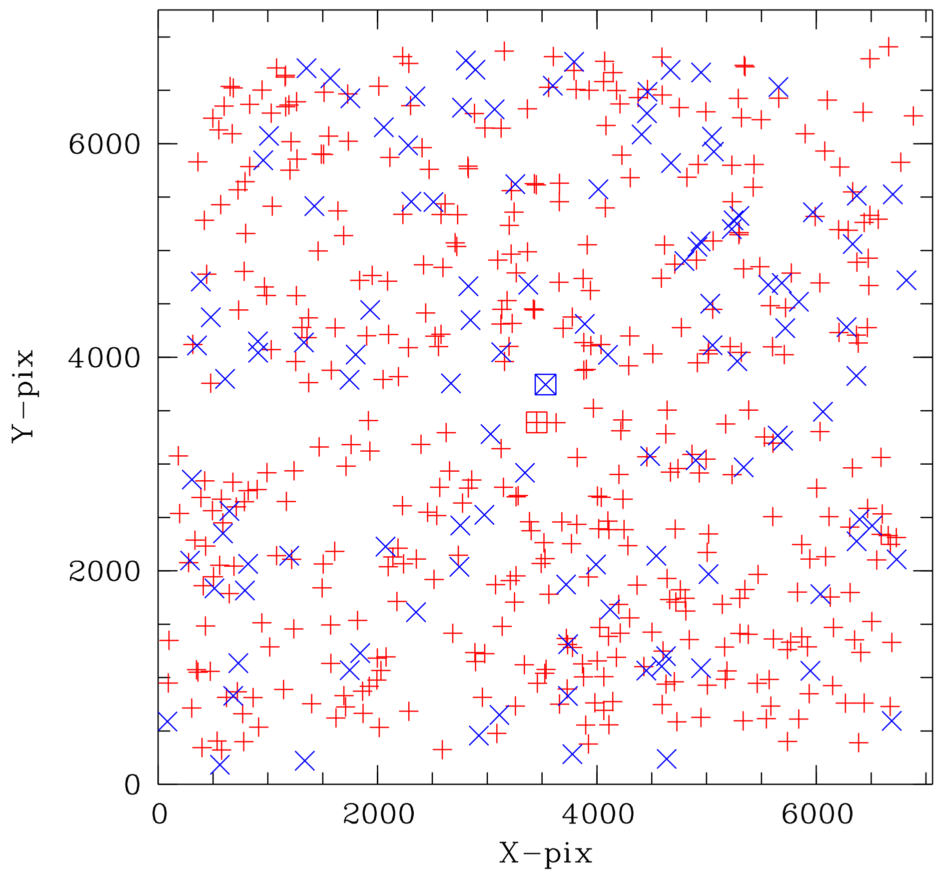
GEMS QSOs/AGN

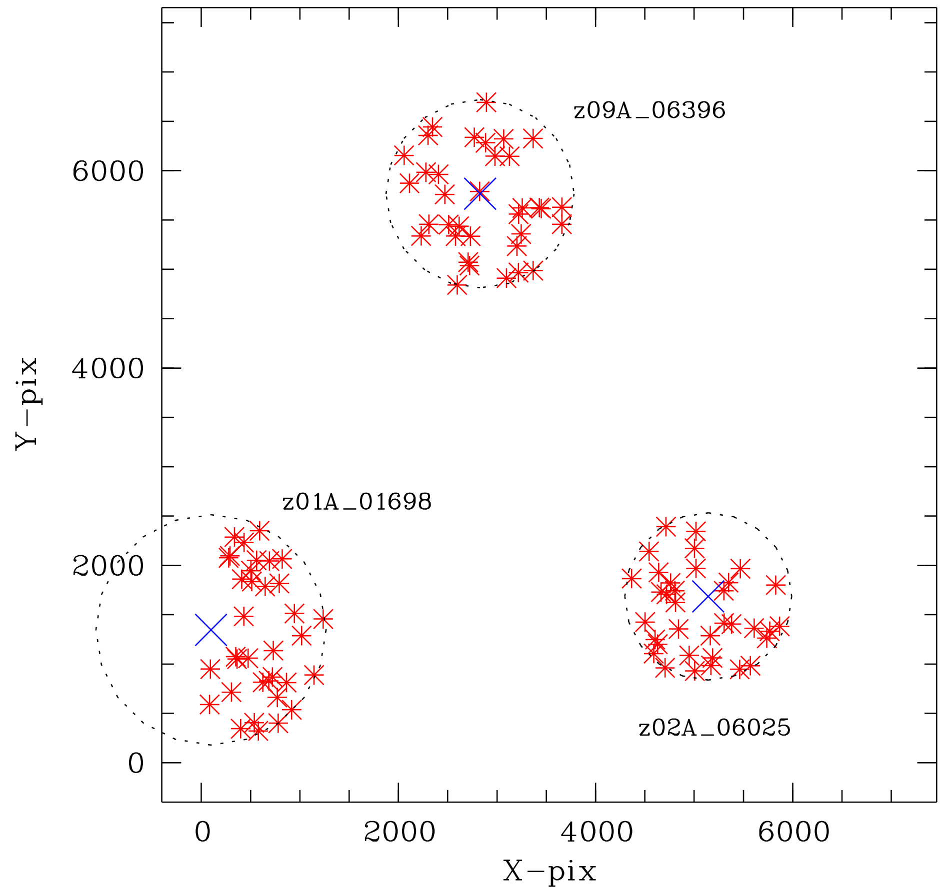
- $\sim$150 QSOs in the GEMS field
- For **redshift** and **classification** reliability: $R_{\mathrm{combo}} < 24$ mag, yields $\sim$80 clear QSOs
- $\longrightarrow$ complete, flux limited sample, by far largest at these z
- Science Goals: Properties (magnitudes, colours, morphologies, SFRs, etc.) of the host galaxies (**HG**) and comparison with inactive galaxies
- Initially addresses: two subsamples in well defined redshift slices

Host galaxy extraction

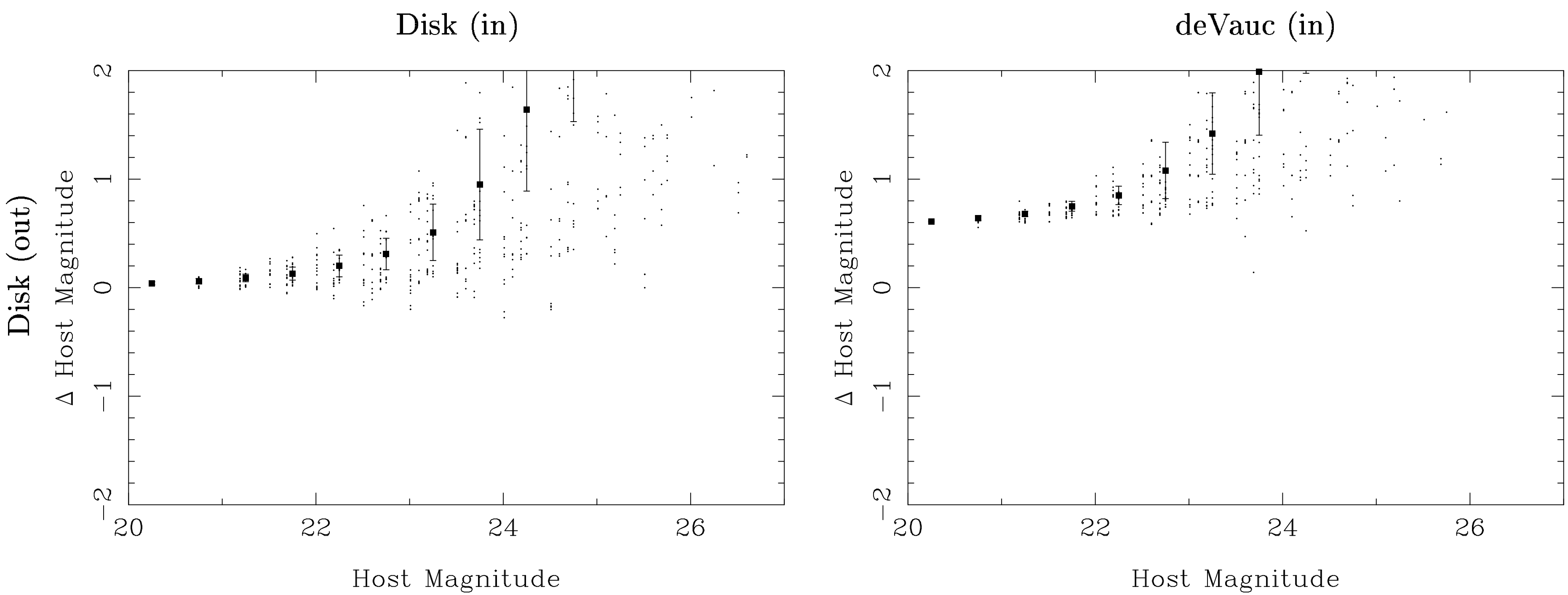
- Problem: nucleus outshines the host
- But: nucleus is point-like
- Solution: characterize nucleus and determine nucleus & host flux
- Used here: 2d modelling of light distribution
- Detection test: PSF peak scaling
- Error determination with extensive simulations ($>$4000 models)

Host galaxy extraction: PSF stars





Host galaxy extraction: Simulations



from ∼4000 simulated quasar & host galaxies

Host galaxy extraction: Simulations

- **NUCLEUS** magnitude is best recovered parameter, even for faint objects ($z \sim 25$, error<0.15 mag)
- best **HG** magnitude estimation comes from direct aperture measurement in the recovered **HG** image
- **HG** magnitude is recovered within a error of $\sim$0.1/0.5/1.5 mag for a $z\sim$22.0/23.5/25.0 magnitude **HG**

The current samples

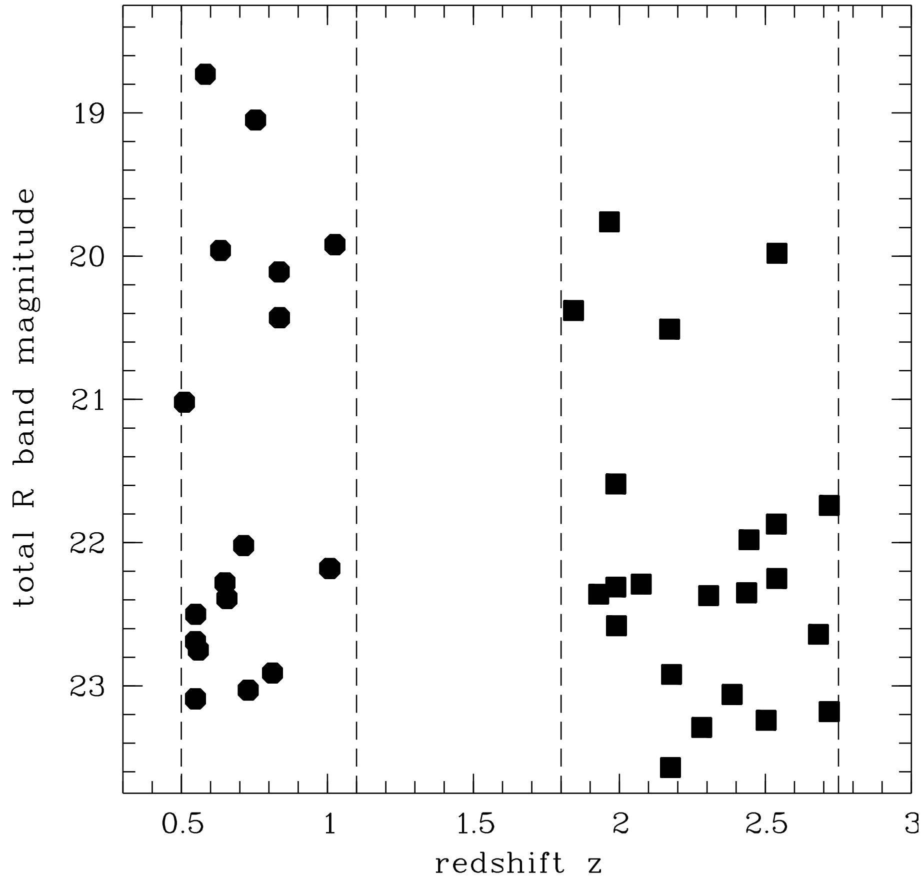
'low'-z:

- $0.5 < z < 1.1$ (16 quasars)
- V-band blueward, z-band redward of 4000Å break
- z-band traces mass of older population
- V-band traces star formation
- all objects similar physical scale

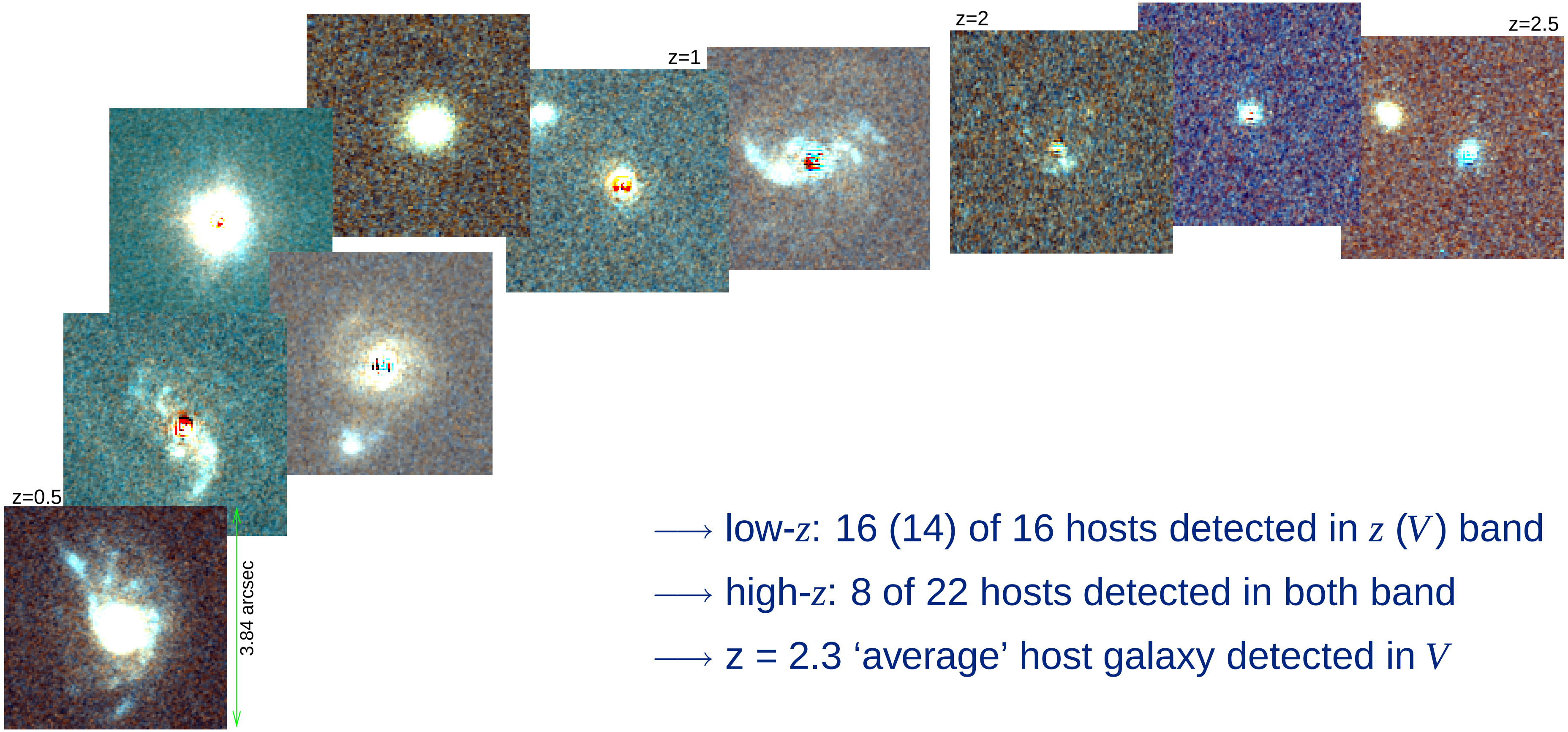
high-z:

- $1.8 < z < 2.8$ (22 quasars)
- largest studied sample so far, and first complete sample
- both bands shortward of 4000Å break
- V-band free of extended Lyα emission
- samples UV continuum flux

‘Low’ & High-*z* sample



Results



$\longrightarrow$ low-z: 16 (14) of 16 hosts detected in z (V) band

$\longrightarrow$ high-z: 8 of 22 hosts detected in both band

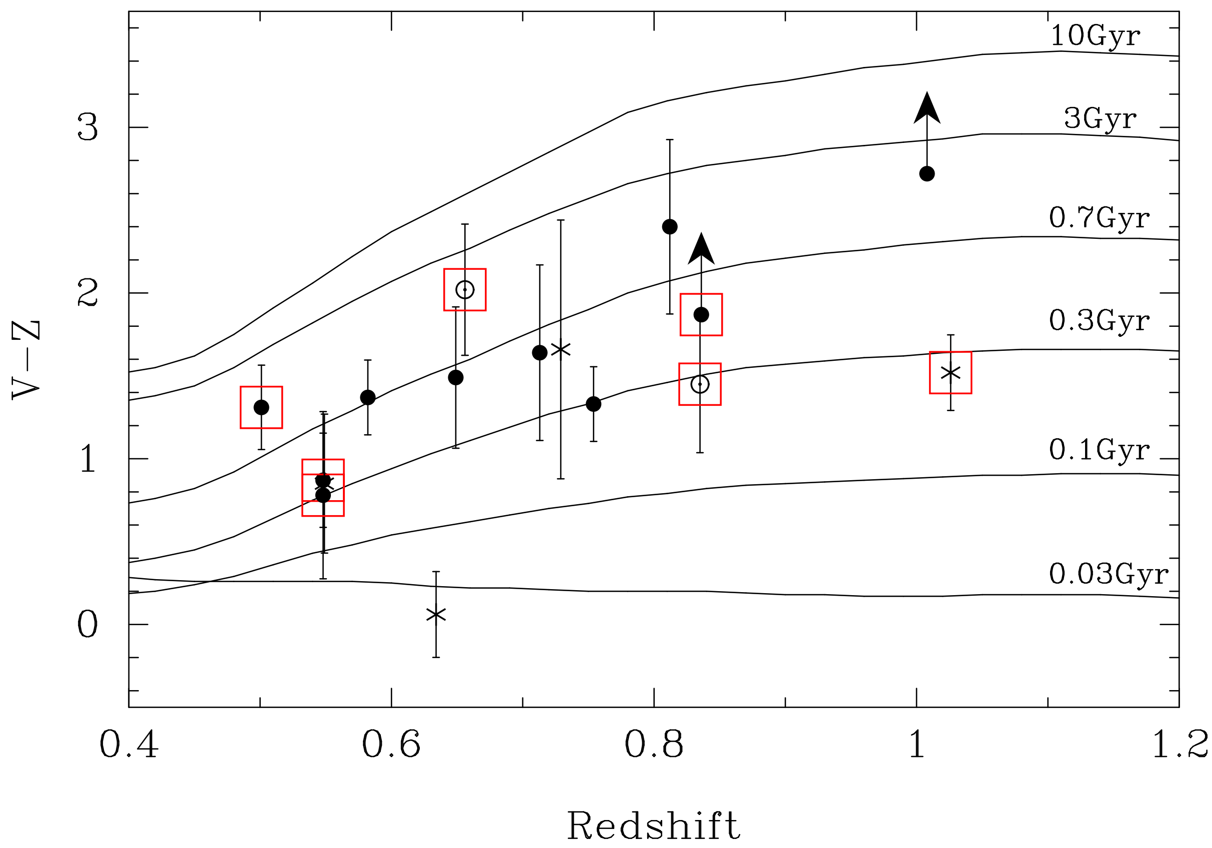
$\longrightarrow$ z = 2.3 ‘average’ host galaxy detected in V

Results: low-z

- **HG** comprises $\sim$60% ($\sim$30%) of the z-band (V-band) flux
- Morphology of the **HGs**: **63%** ellipticals, **25%** Disks, **13%** in between
- physical scale is $r_{1/2}$ $\sim$1.9 kpc with spread 0.8 kpc
- **7** (maybe 8) **HGs** show evidence of recent merger or nearby ($<$20 kpc) companions, i.e. $\sim$**44% (50%)** interacting

Results: low-*z* colours

Filled-circles = ellipticals
Stars = disks
Open-circles = in between
Squares = merger/interacting



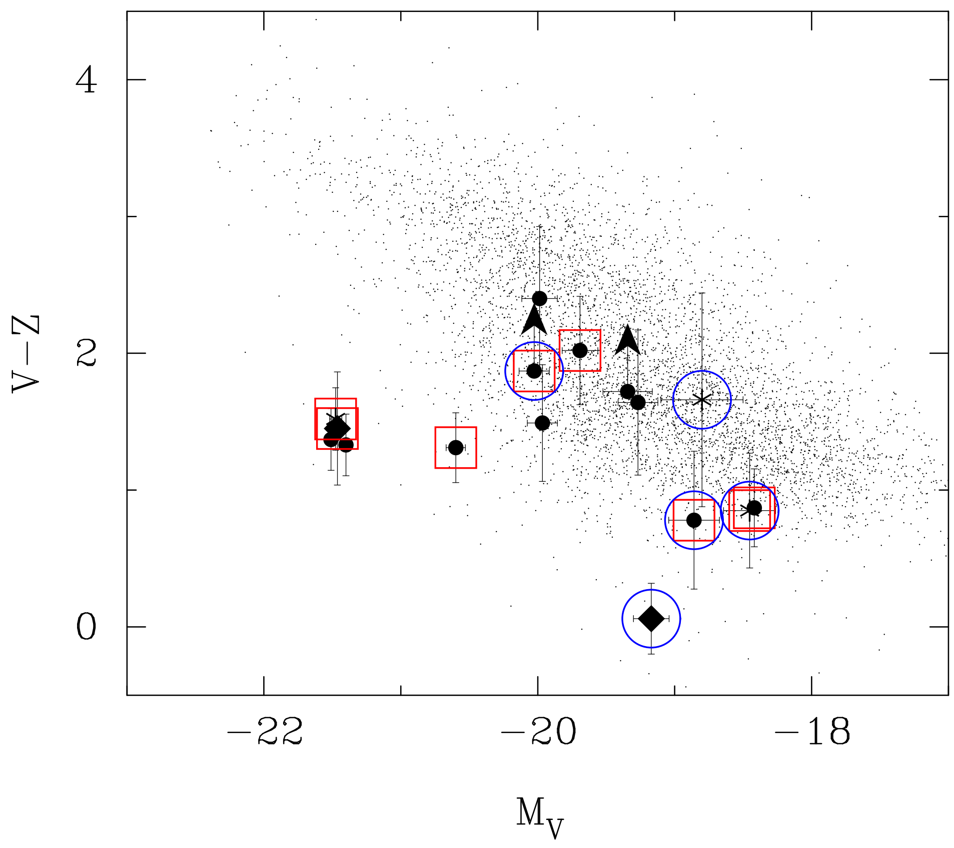
Results: low-z colours

Results:

1. despite morphology, all but 1 **HG** have a stellar population between 0.3 Gyr and 3 Gyr (average $\sim$0.7 Gyr).
2. all **HG** are observed during strong starformation period. Are they bluer than inactive galaxies? $\longrightarrow$ GEMS inactive galaxy comparison sample!
3. $M_{V,\mathrm{HG}}$=–22.16$\pm$1.18 mag ($H_o = 70$, $\Omega_o = 1$ and converting observed z-band to rest frame V-band)
4. They are in the range of the brightest galaxies for the same redshift (e.g. Bell et al. 2003, for the GEMS inactive galaxies).

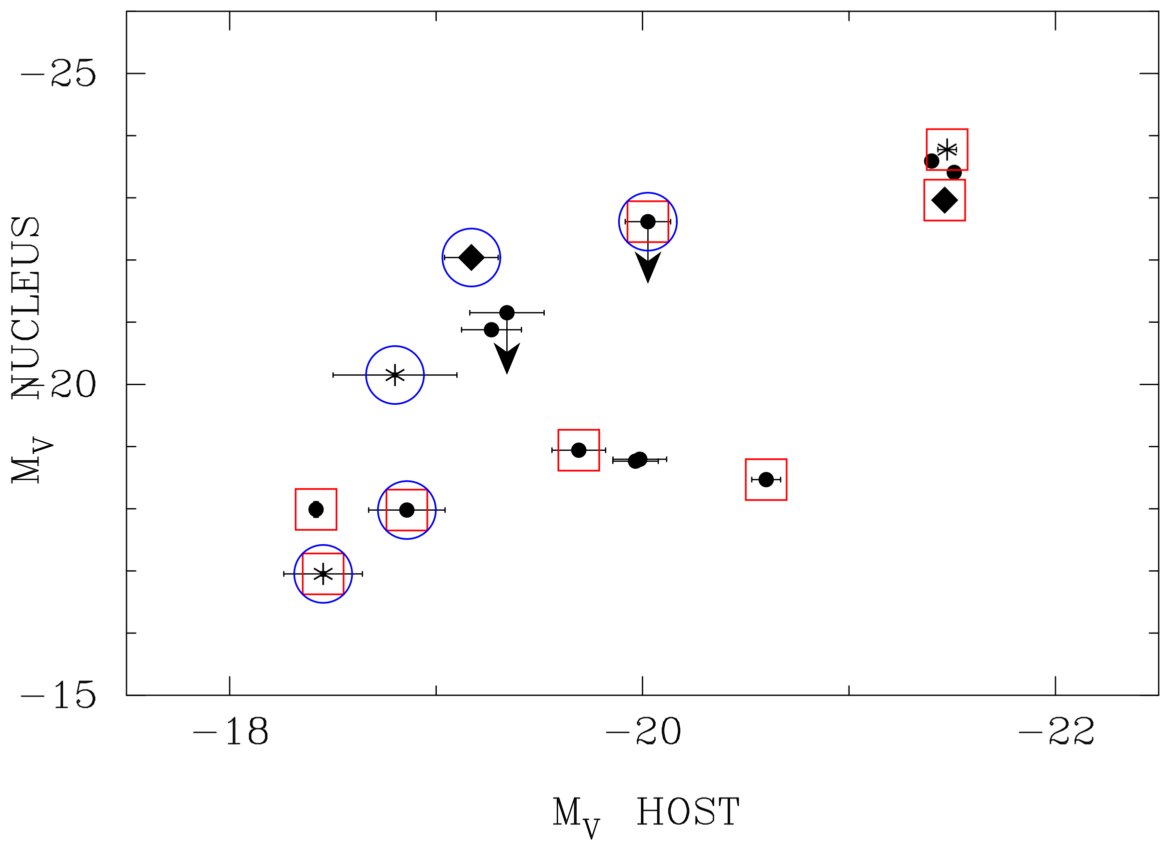
Results: low-*z* colours

Position in Color-Magnitude diagram compared with inactive galaxies.

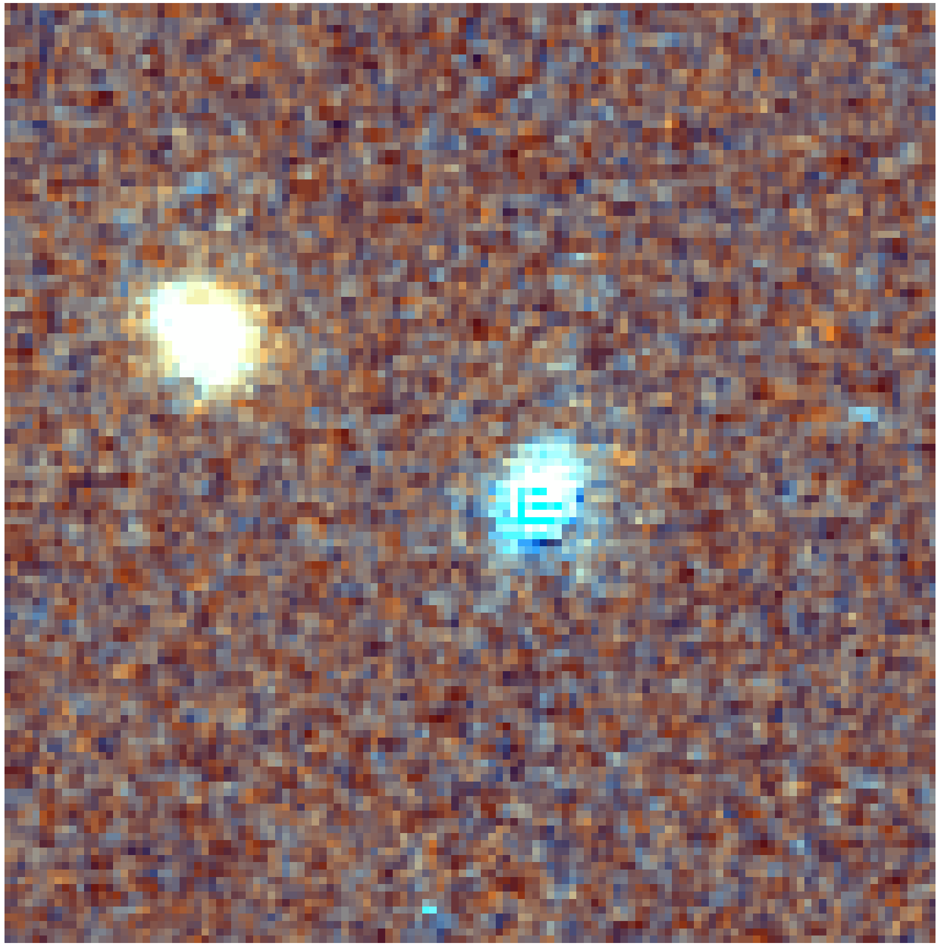


Results: low-z

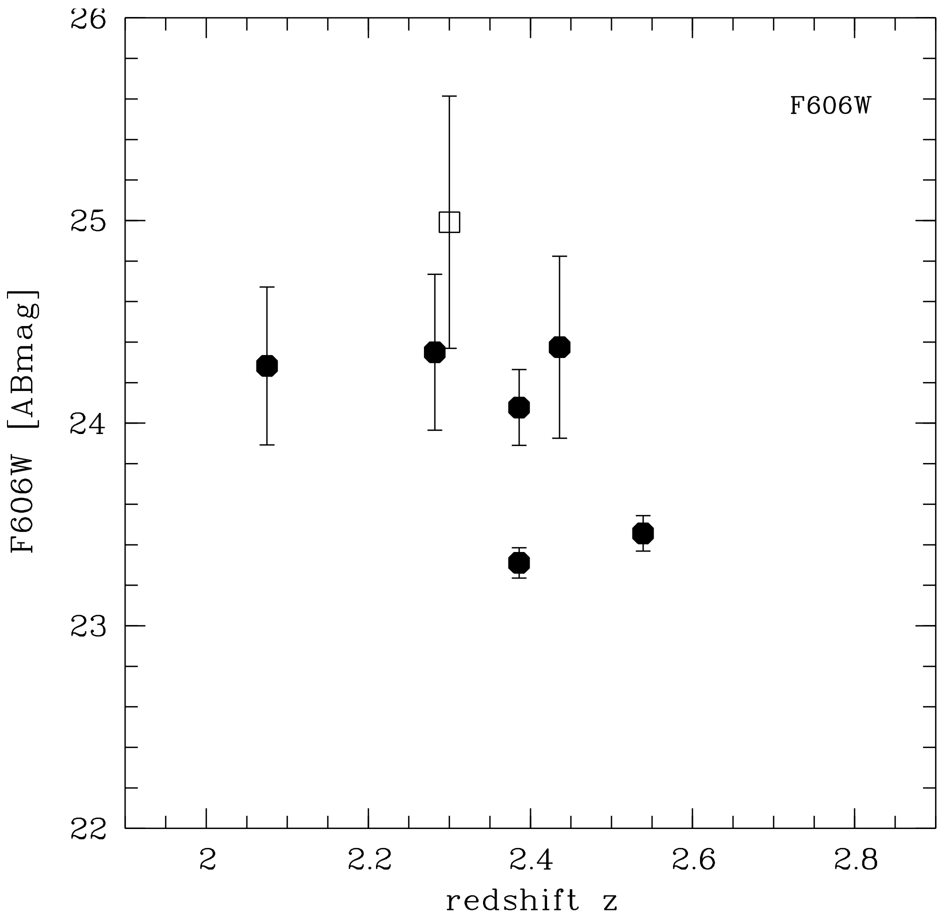
NUCLEUS flux and **HG** flux correlated (as seen by Sánchez & González-Serrano 2003)
$\longrightarrow$ Narrow range of efficiencies for QSO feeding?

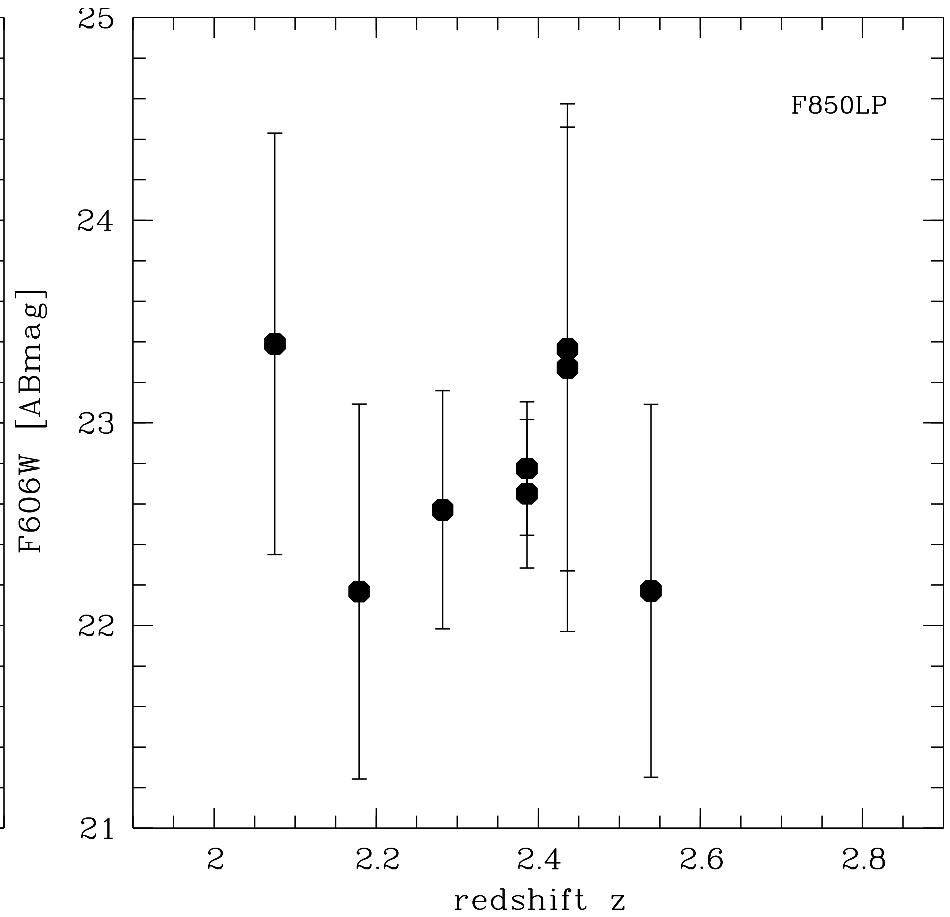


QSO 11922, $z = 2.539$

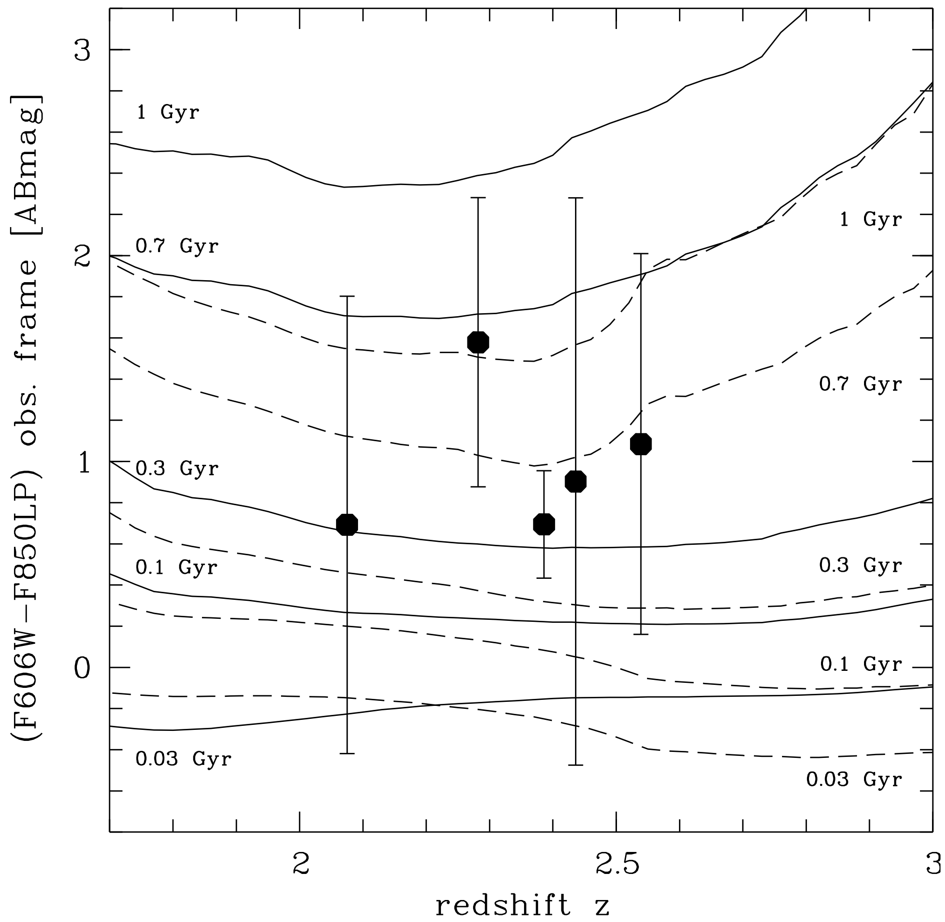


Results: high-z magnitudes

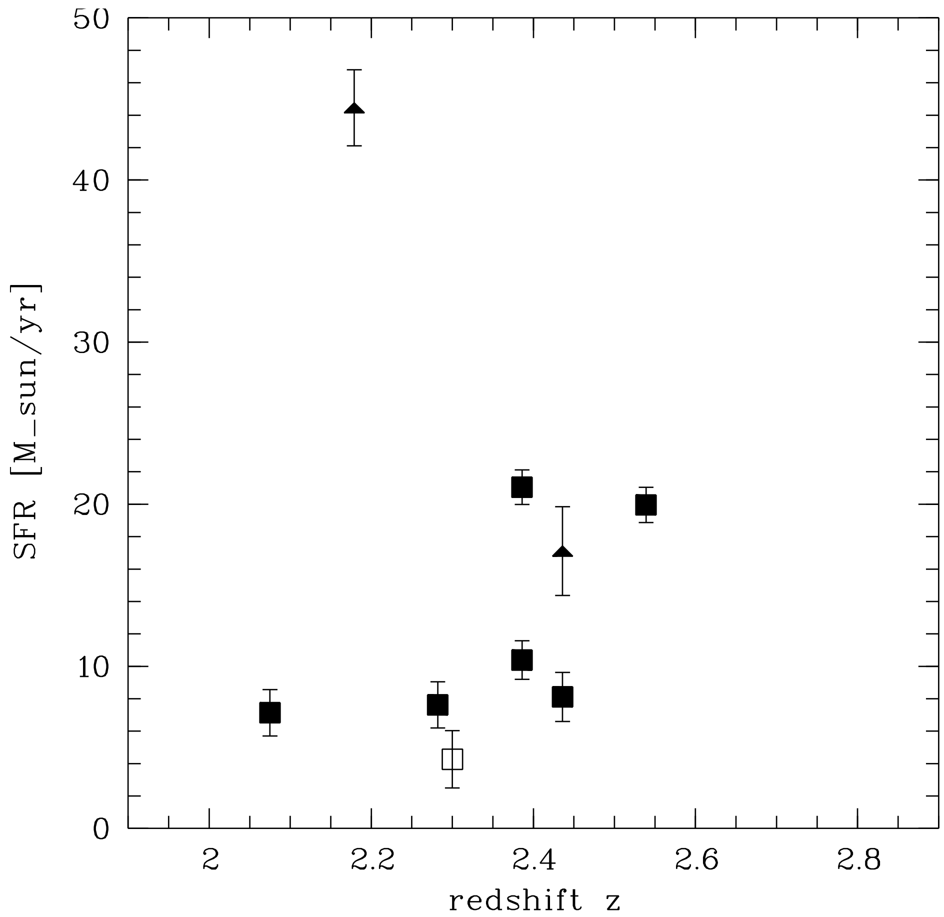




Results: high-z colours



Results: high-z star formation rates



Conclusions?

Technically: With GEMS...

- ...quasar host galaxies can be resolved up to $z = 2.5$
- ...morphologies up to $z > 1$
- ...colours up to $z = 2.5$

Scientifically:

- Stars in quasar hosts are rather young ($\sim$0.7 Gyr)
- Clearly different colours than (most) inactive ellipticals
- Strong evidence for enhanced star formation in interm. luminous AGN hosts for all epochs

$\longrightarrow$ Clear connection between enhanced star formation and AGN activity
$\longrightarrow$ Connection between interaction and AGN activity? To be investigated in the near future...