Luminosity and Stellar Mass Functions from the 6dF Galaxy Survey

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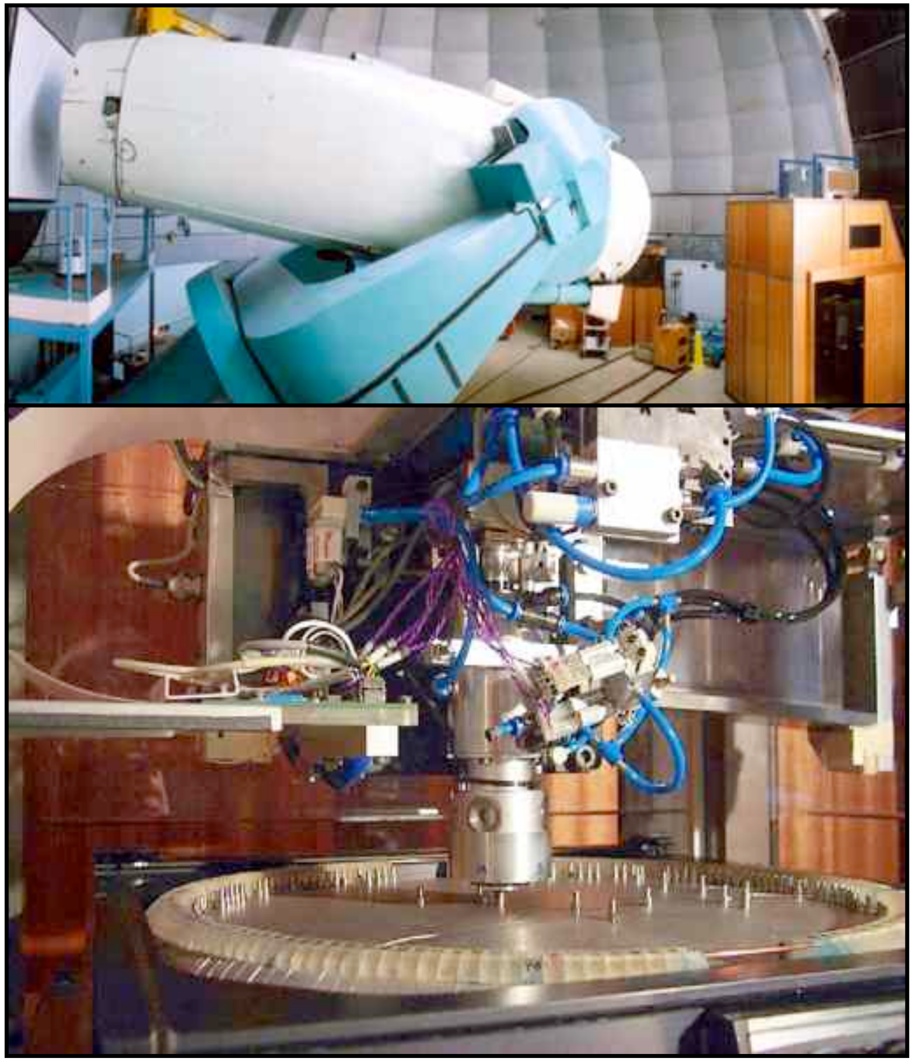
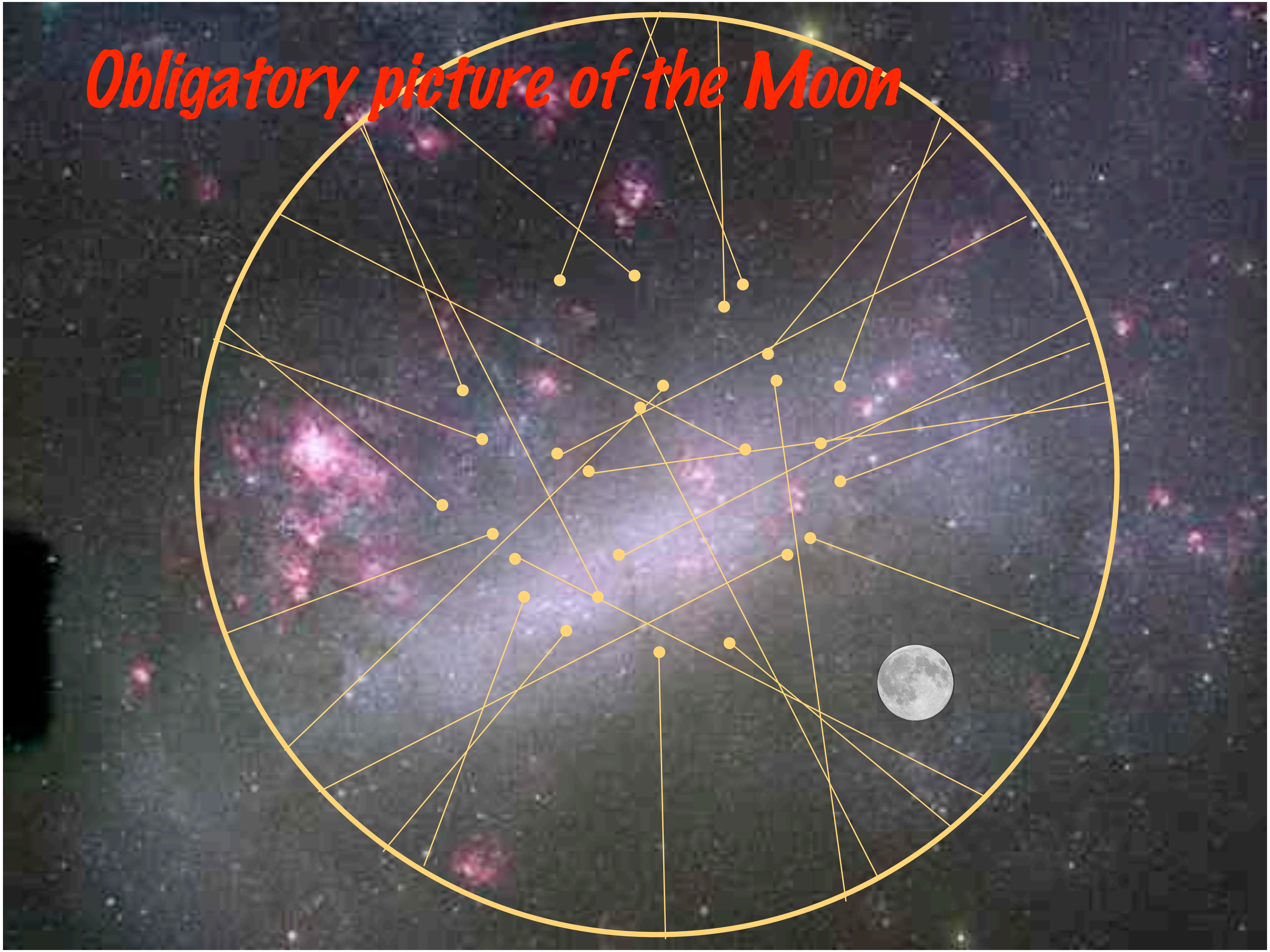
Durham, August 2006

The 6dF Galaxy Survey - an introduction

- **The 6dFGS is a combined redshift and peculiar velocity survey of the local volume of the universe...**
  - Near-infrared selected primary sample (from 2MASS)
  - Also redshift survey of other 'interesting' source samples
  - Peculiar velocities from Fundamental Plane distances
- **The survey uses the 6dF spectrograph on the AAO's UK Schmidt Telescope...**
  - 5.7° diameter FoV (25.5 deg^2)
  - up to 150 objects simultaneously




Obligatory picture of the Moon

The 6dF Galaxy Survey - an introduction

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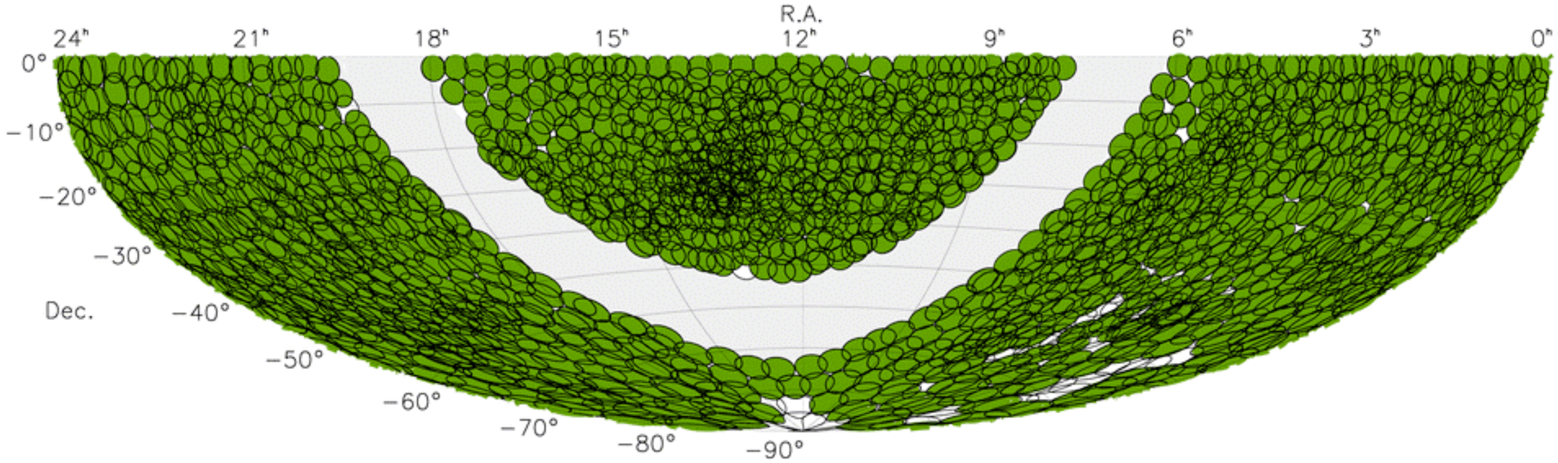
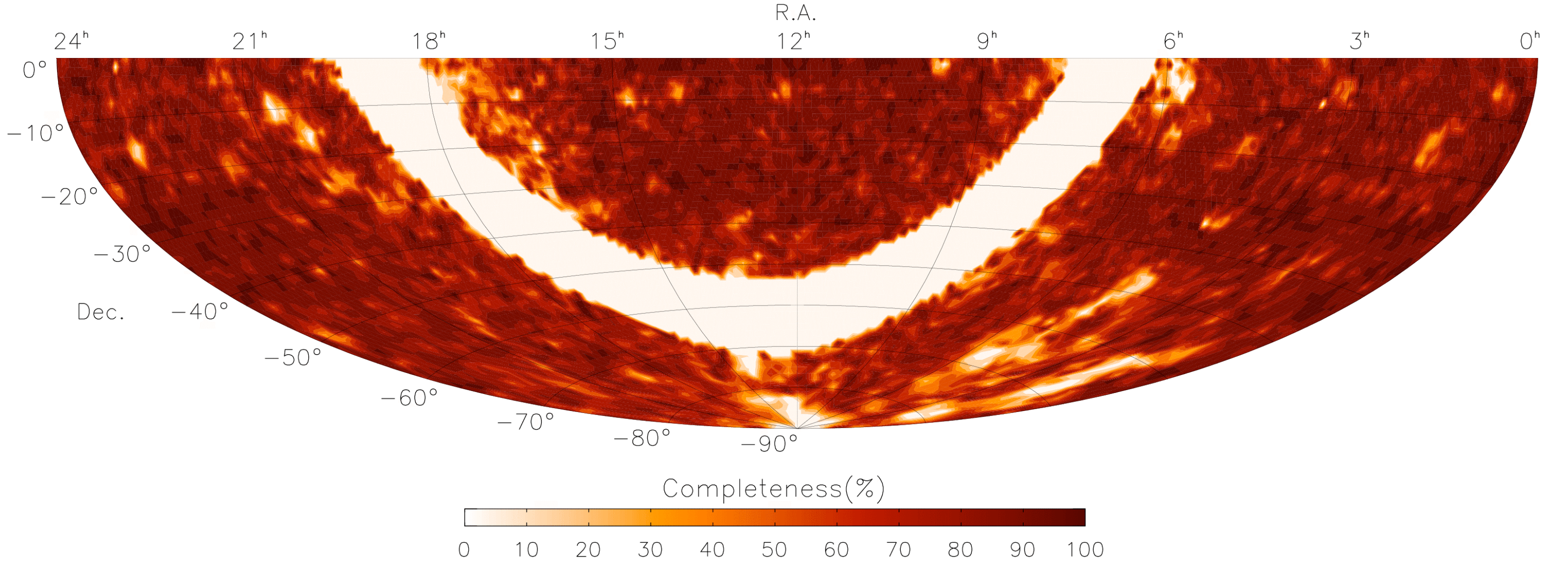
  - Near-infrared selected redshift survey of the local universe
  - Also redshift surveys of other 'interesting' sources
  - Peculiar velocities from Fundamental Plane distances
- **Survey strategy...**
  - Cover the whole southern sky with $|b|>10^{o}$
  - Primary sample selected from 2MASS to $K_{tot}<12.75$
  - Secondary samples: H<13.0, J<13.75, r<15.6, b<16.75
  - 11 additional samples: radio, X-ray, IRAS...
  - Peculiar velocity sample: 15,000 brightest early-type galaxies
- **Observations now complete: May 2001 to Jan 2006**
  - 137k spectra, 124k galaxy redshifts over 80% of southern sky
  - Data releases: Dec 2002, Mar 2004, May 2005 & Nov 2006

Sky coverage and redshift completeness

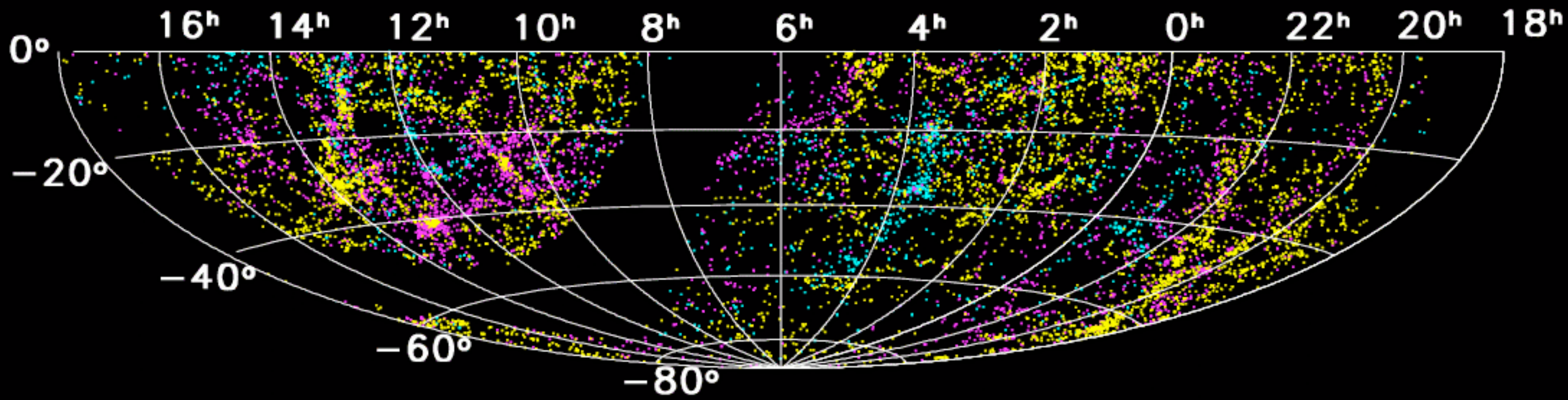


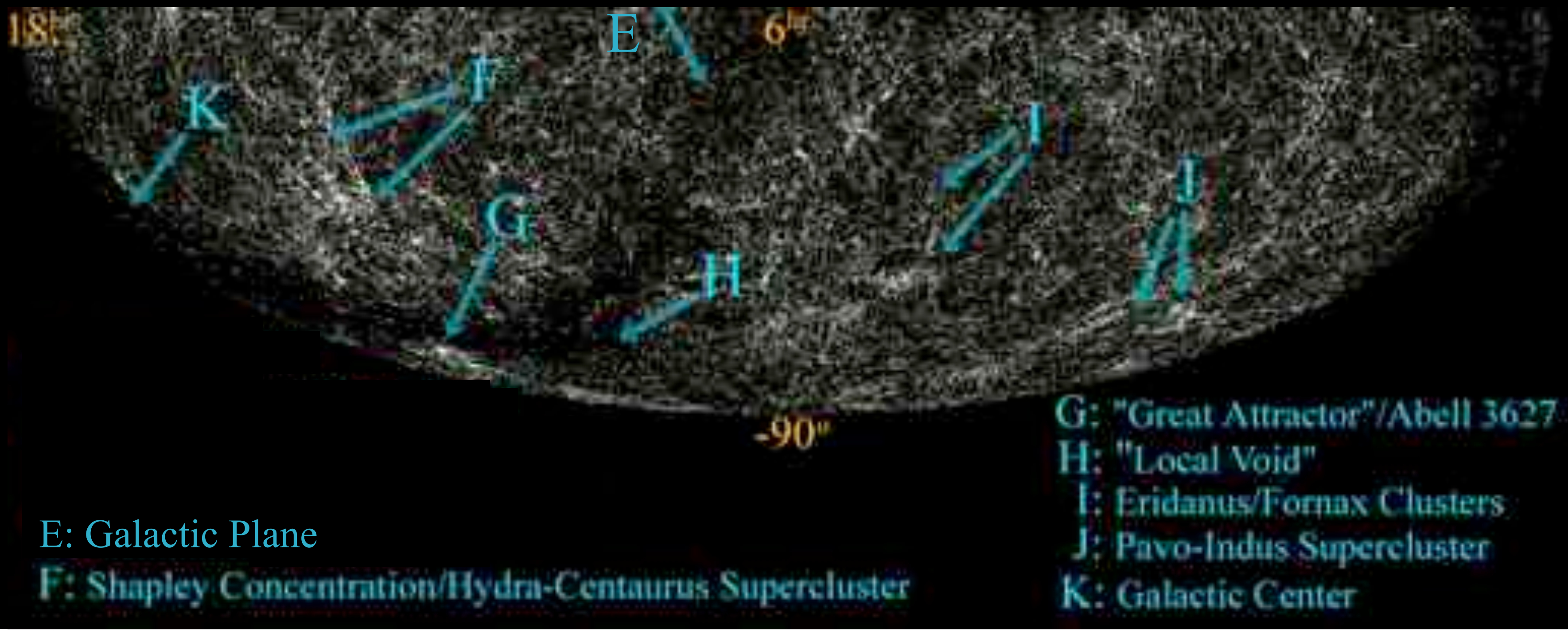
Observed 1464/1598 fields; 92% of the southern sky with |b|>10°



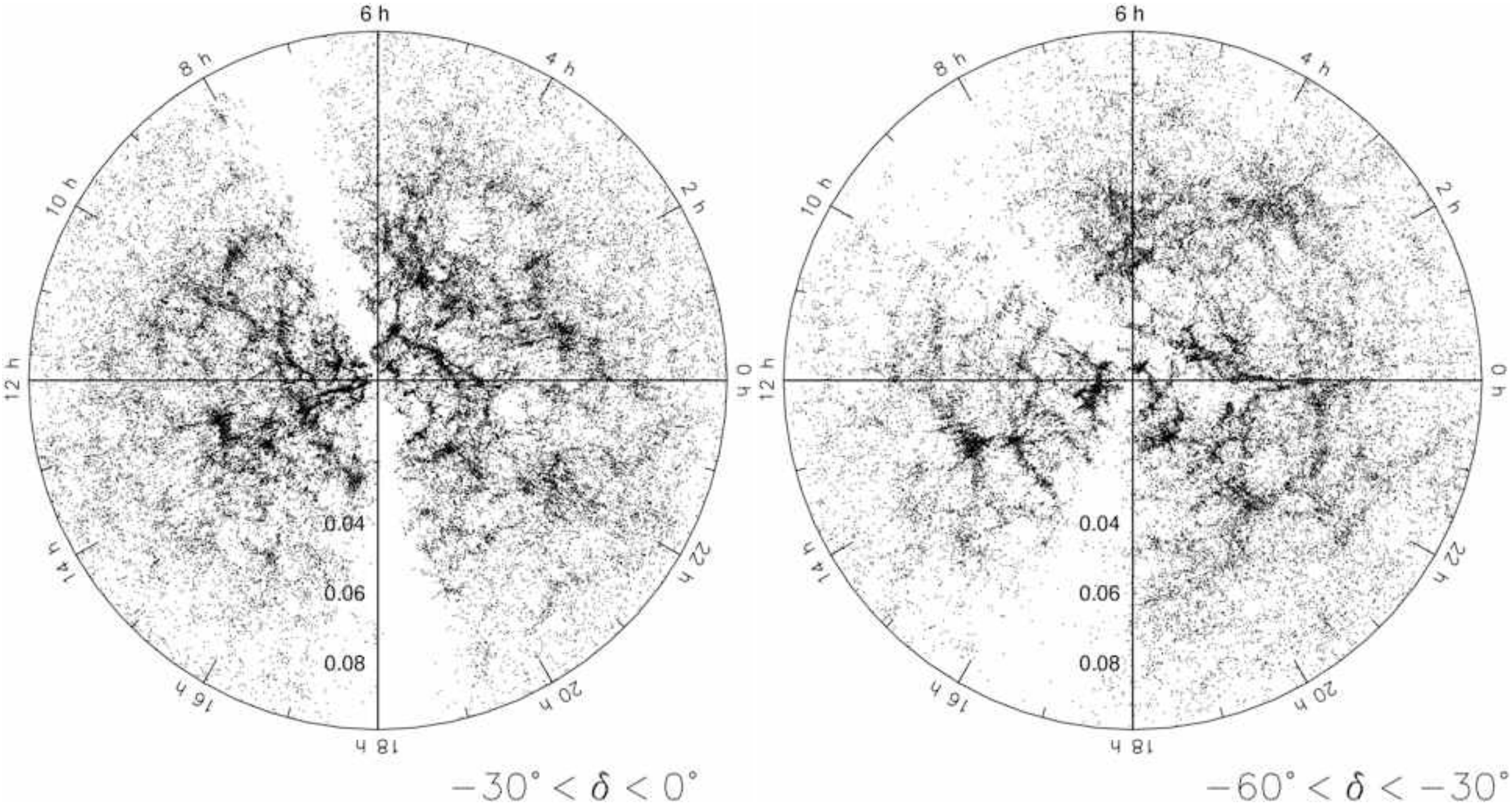
Mean redshift completeness for the K-band primary sample is 88%

Local large-scale structures



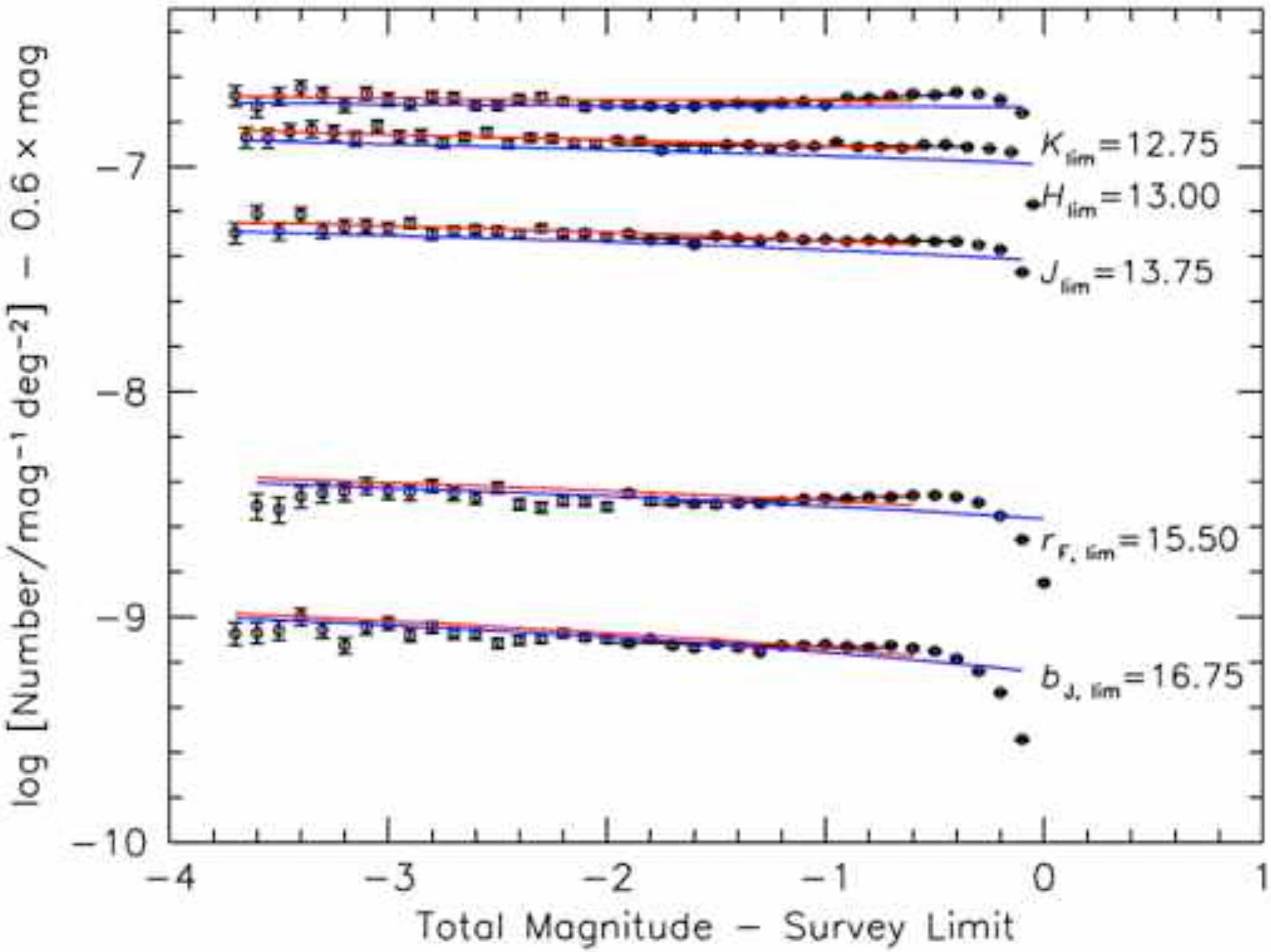


Redshift space maps



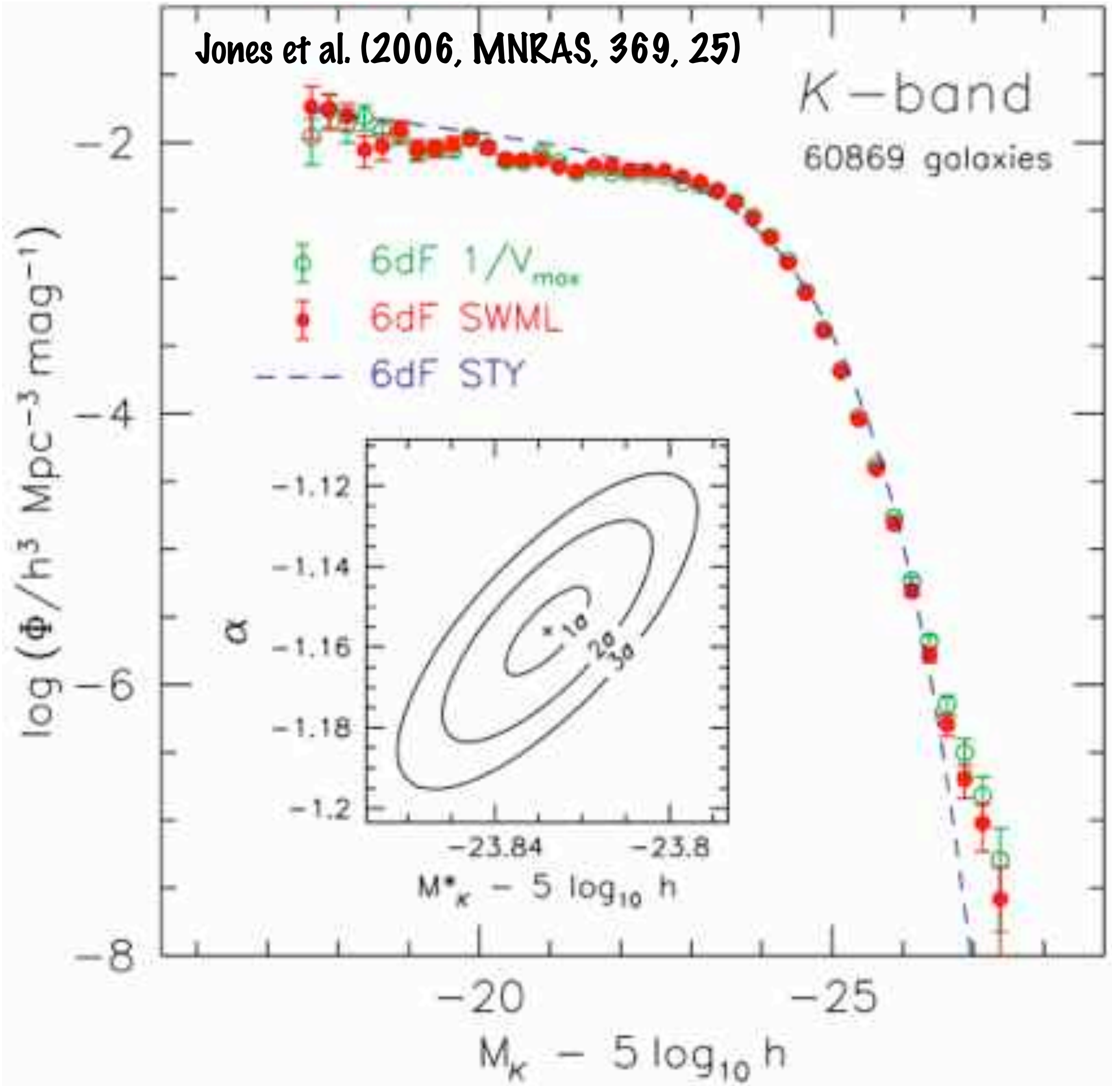
Galaxy number counts

- Number counts in all optical and NIR bands are close to the Euclidean slope at these relatively bright magnitudes

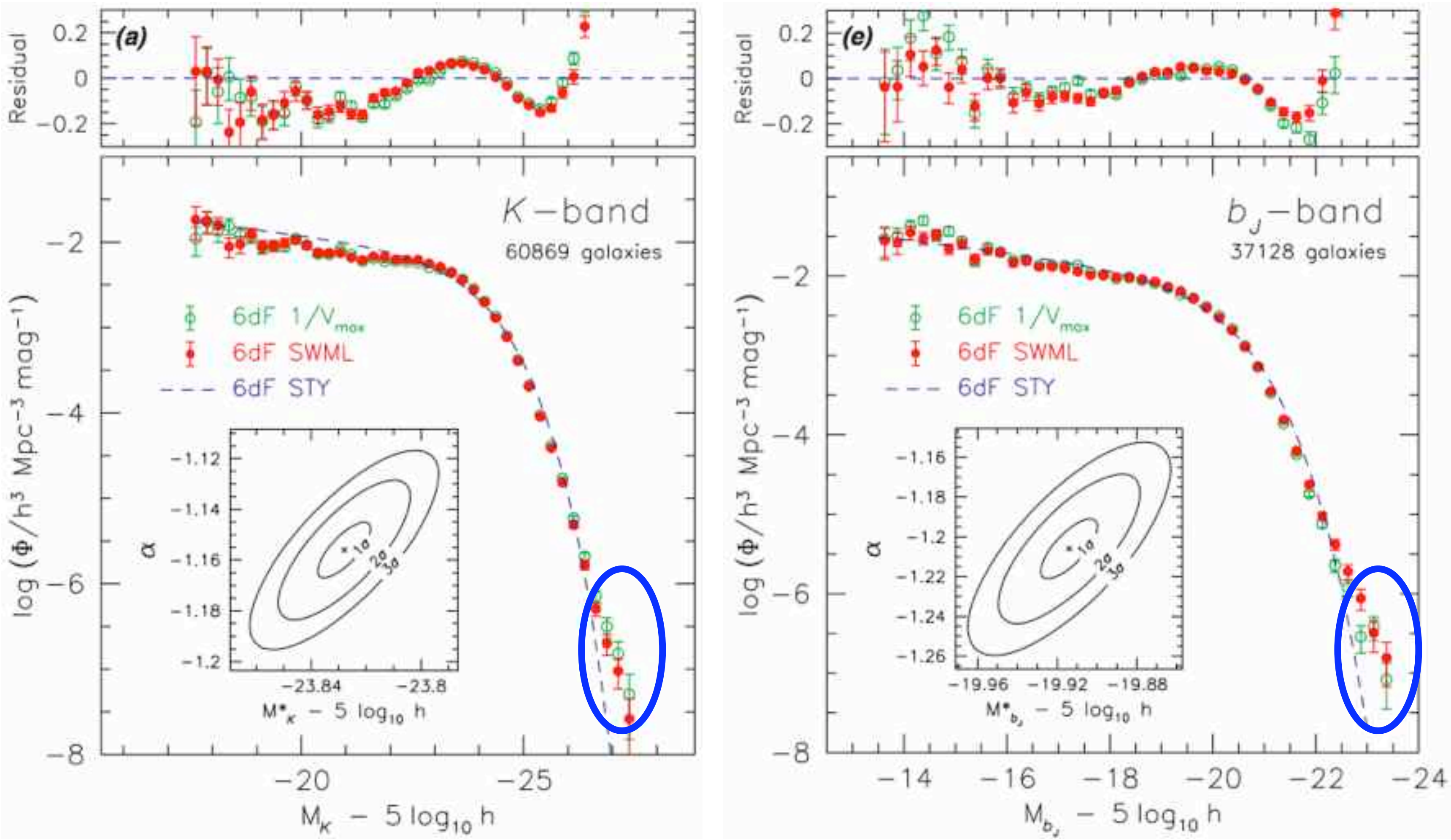


Near-infrared luminosity functions

- *The 6dFGS K-band LF extends 1.5-2 mags further at both bright and faint ends (covers a factor of 10^4 in L)*
- *Agrees with other recent LF measurements up to small differences between magnitude systems*
- *Previous, smaller samples have larger uncertainties in their normalisations*

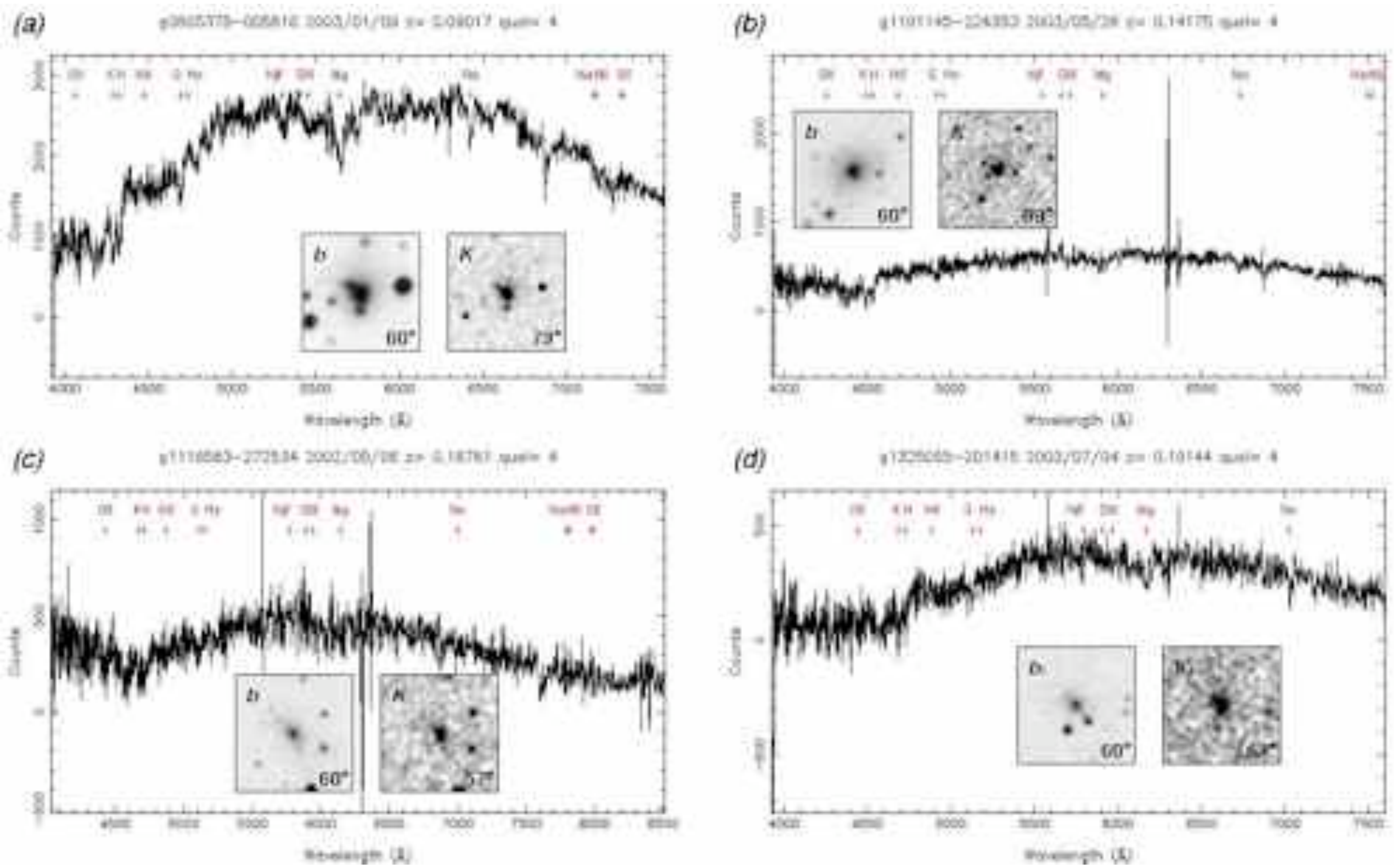


Schechter function fits to the LFs

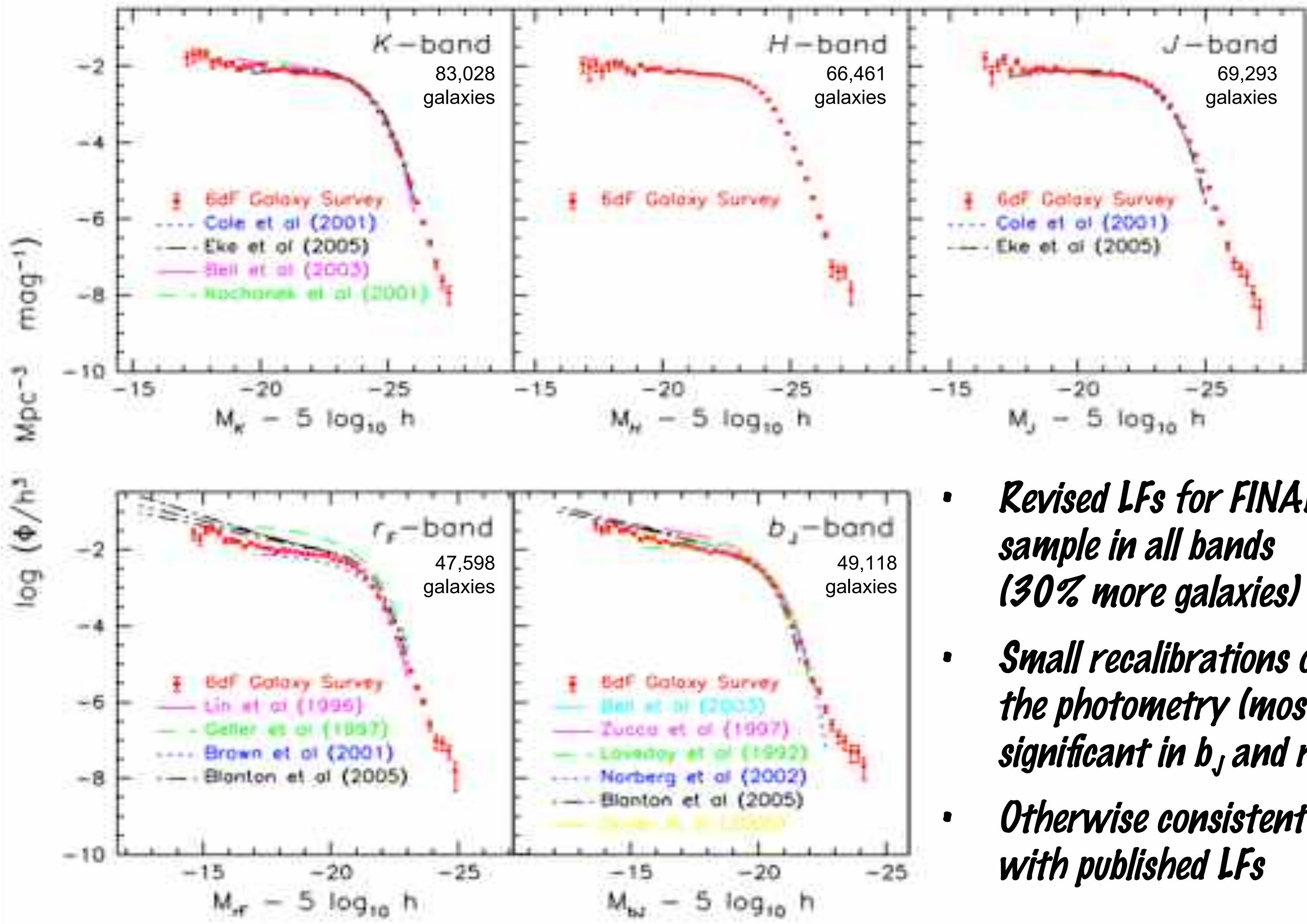


- *Schechter functions are inadequate approximations to the luminosity functions.*
- *LFs sufficiently precise to show real deviations, esp. for the brightest galaxies.*

The brightest galaxies

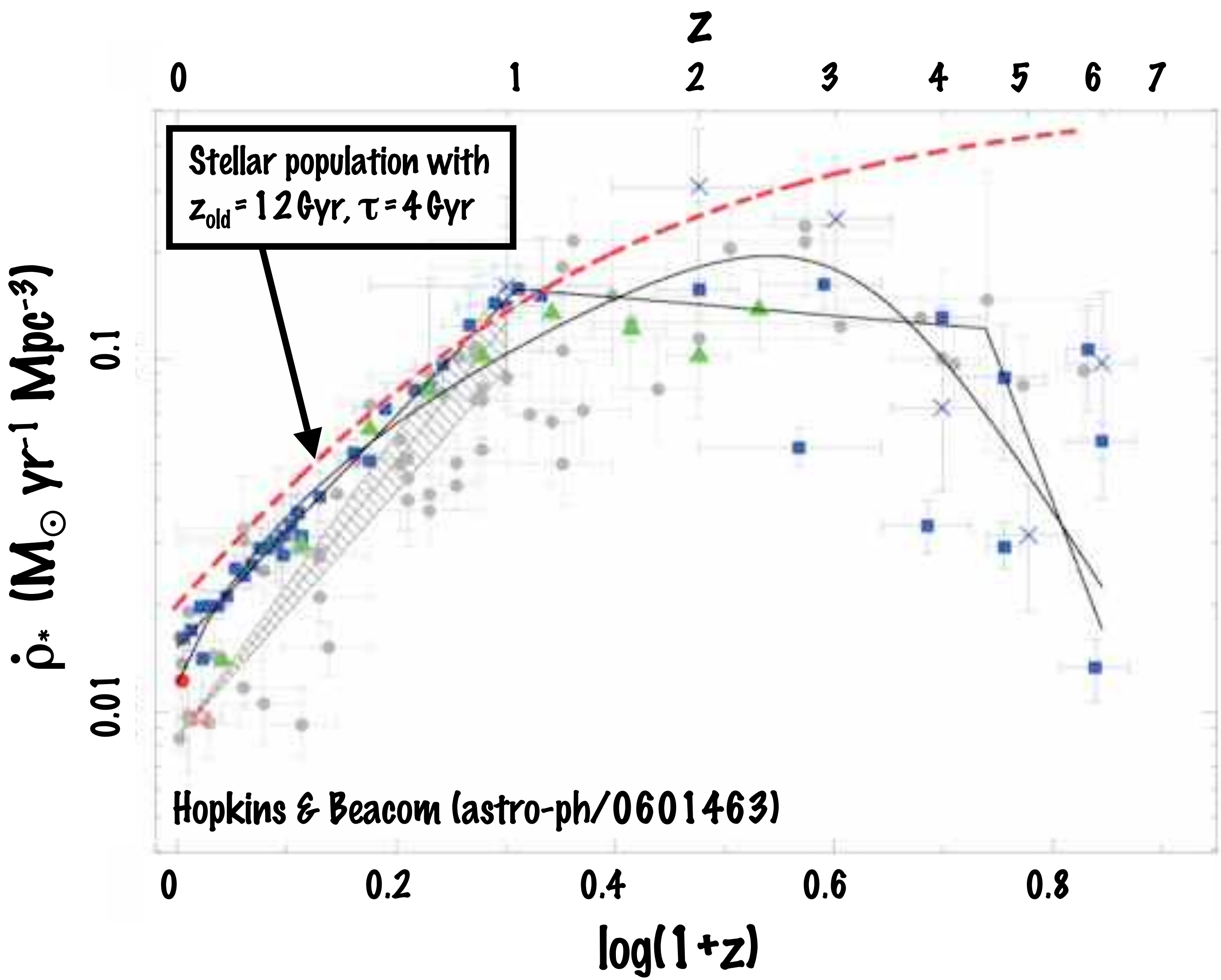


Final NIR and optical luminosity functions



- *Revised LFs for FINAL sample in all bands (30% more galaxies)*
- *Small recalibrations of the photometry (most significant in b_J and r_F)*
- *Otherwise consistent with published LFs*

Cosmic star-formation history



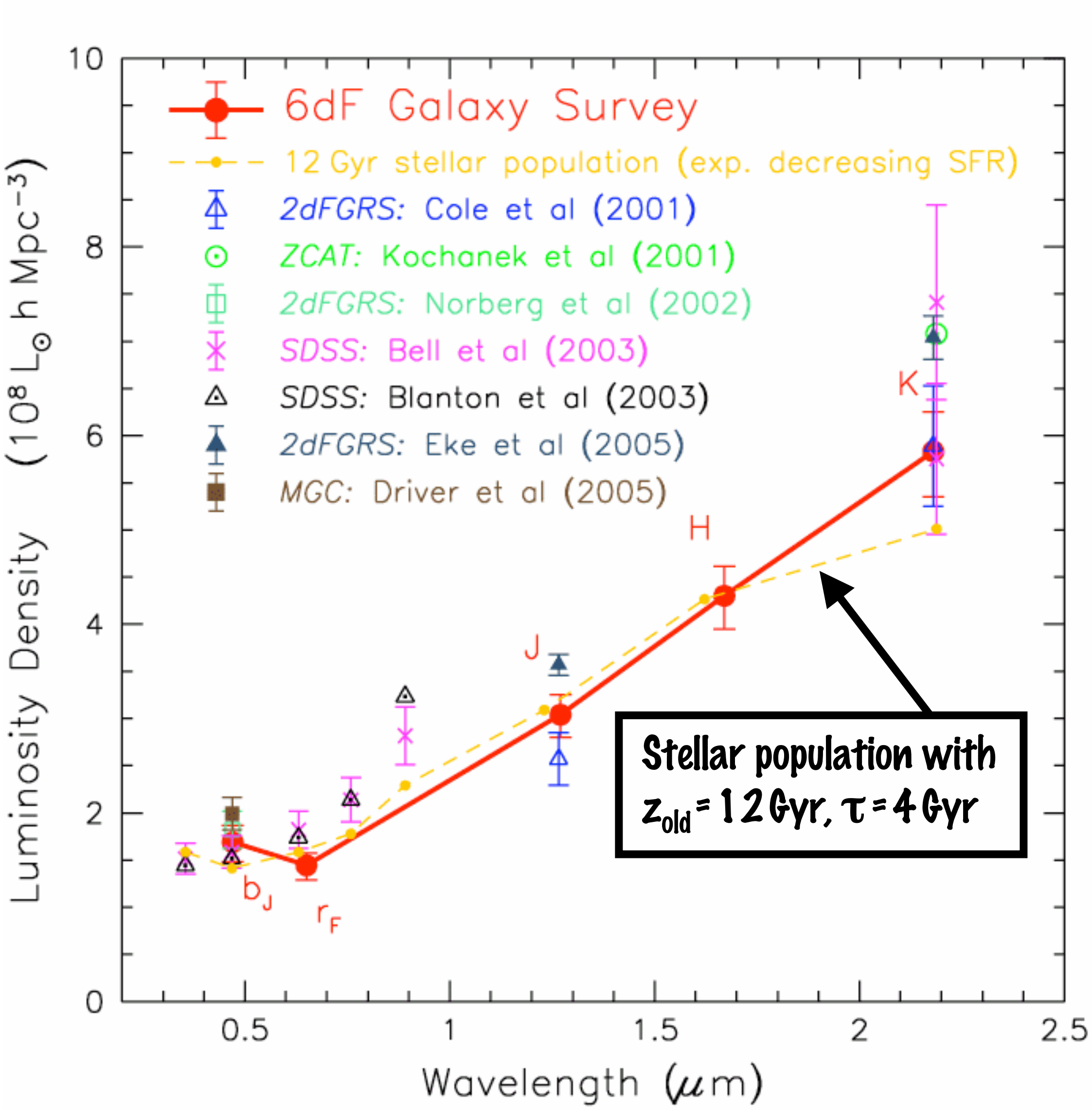
Given the observed star-formation history...

...is it consistent with the observed luminosity densities in optical and NIR bands?

...is it consistent with the observed total stellar mass in the present-day universe?

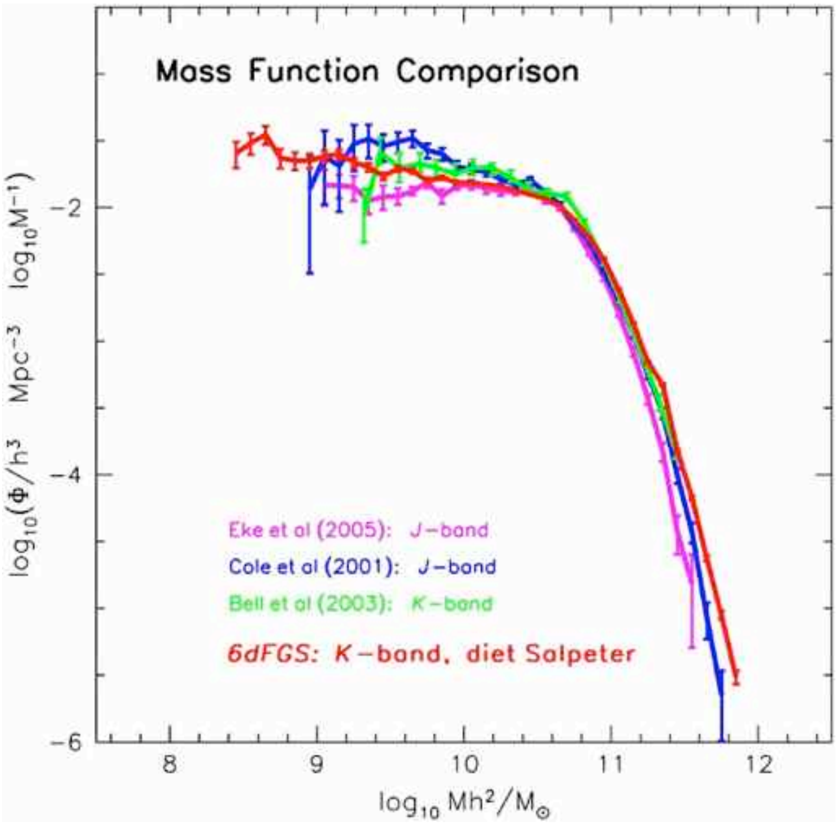
Luminosity density in optical and NIR

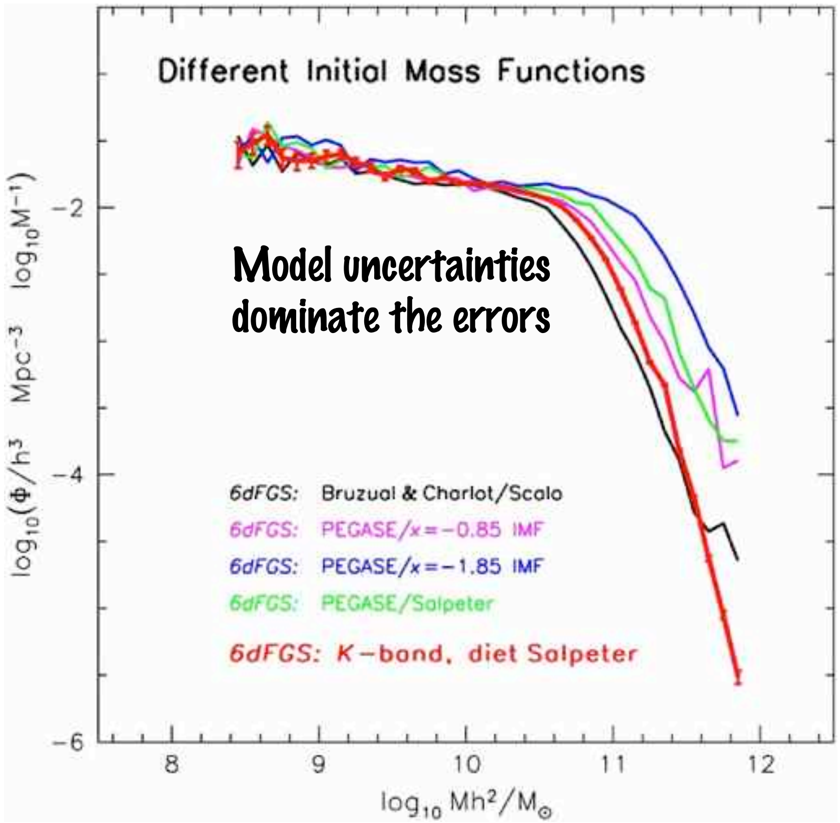
- *The luminosity densities in optical and NIR estimated from 6dFGS are broadly consistent with the 2dFGRS and SDSS results*
- *K-band luminosity density lies at lower end of range*
- *From optical through NIR, the variation of luminosity density with wavelength is consistent with models for an old stellar population*



Stellar mass function

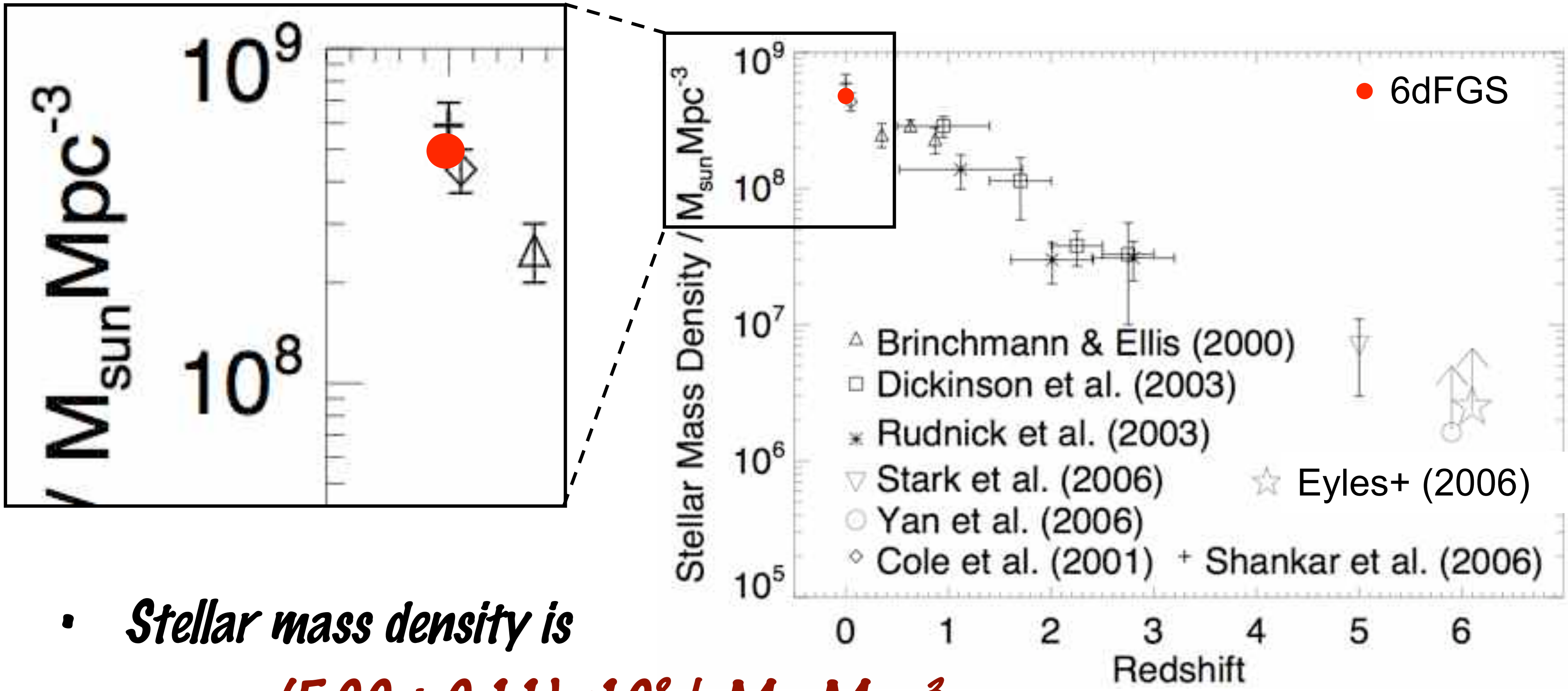
- *NIR luminosities are good proxies for the total stellar masses in galaxies, so we can estimate the stellar mass function from the K-band luminosity function...*
  - *NIR light is dominated by the older and cooler stars comprising the bulk of the stellar mass*
  - *NIR mass-to-light ratios are well constrained, and k-corrections & extinctions are smaller in NIR*





The present-day stellar mass density

- *The 6dFGS data provides (up to systematic errors in the models) the most precise measurement of the stellar mass density today*



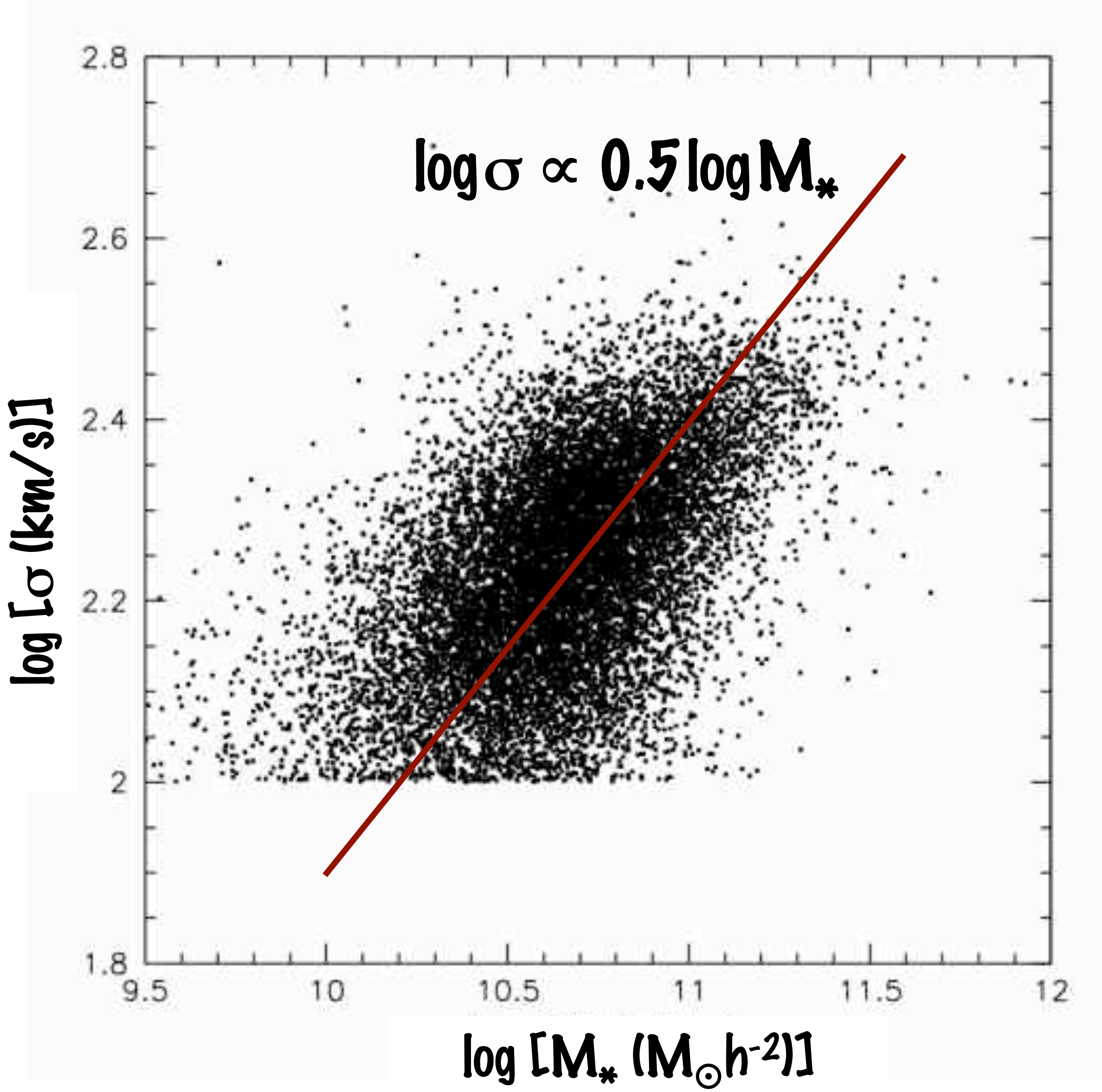
- *Stellar mass density is*

$$\rho_* = (5.00 \pm 0.11) \times 10^8\, h\, M_\odot\, Mpc^{-3}$$

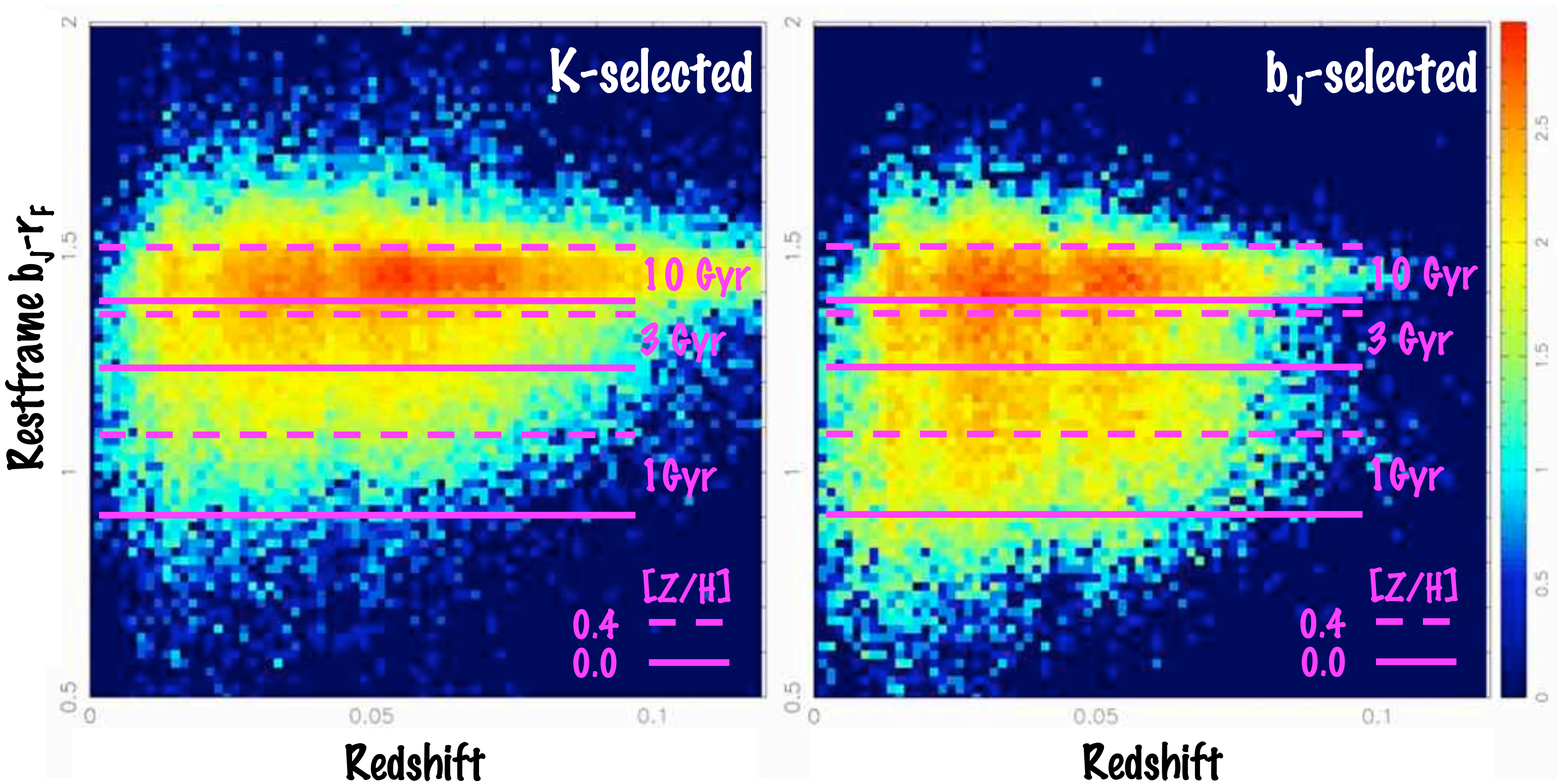
$$\Omega_* h = (1.80 \pm 0.04) \times 10^{-3}$$

Stellar and dynamical masses

- *The relation between velocity dispersion and stellar mass is consistent with $M_* \propto \sigma^2$*
- This is implies that star-formation efficiency in galaxies is roughly independent of their dynamical masses - i.e.
  $$M_*/M_{dyn} \approx const$$
  (cf. Gallazzi+ 2006, MNRAS, 370, 1106)
- The scatter in the relation translates to a scatter in star-formation efficiency of about 40%

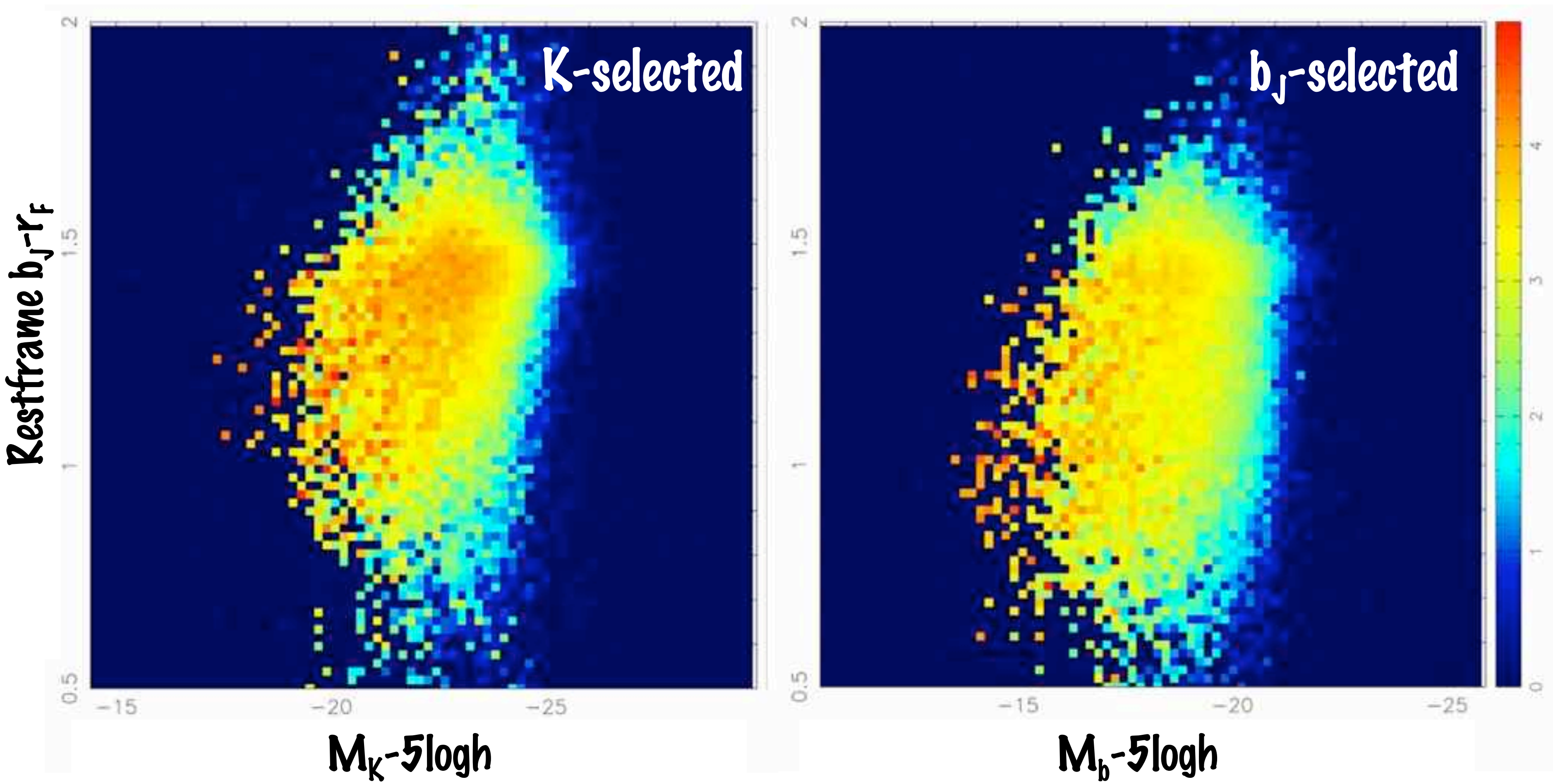


Galaxy colours and stellar populations



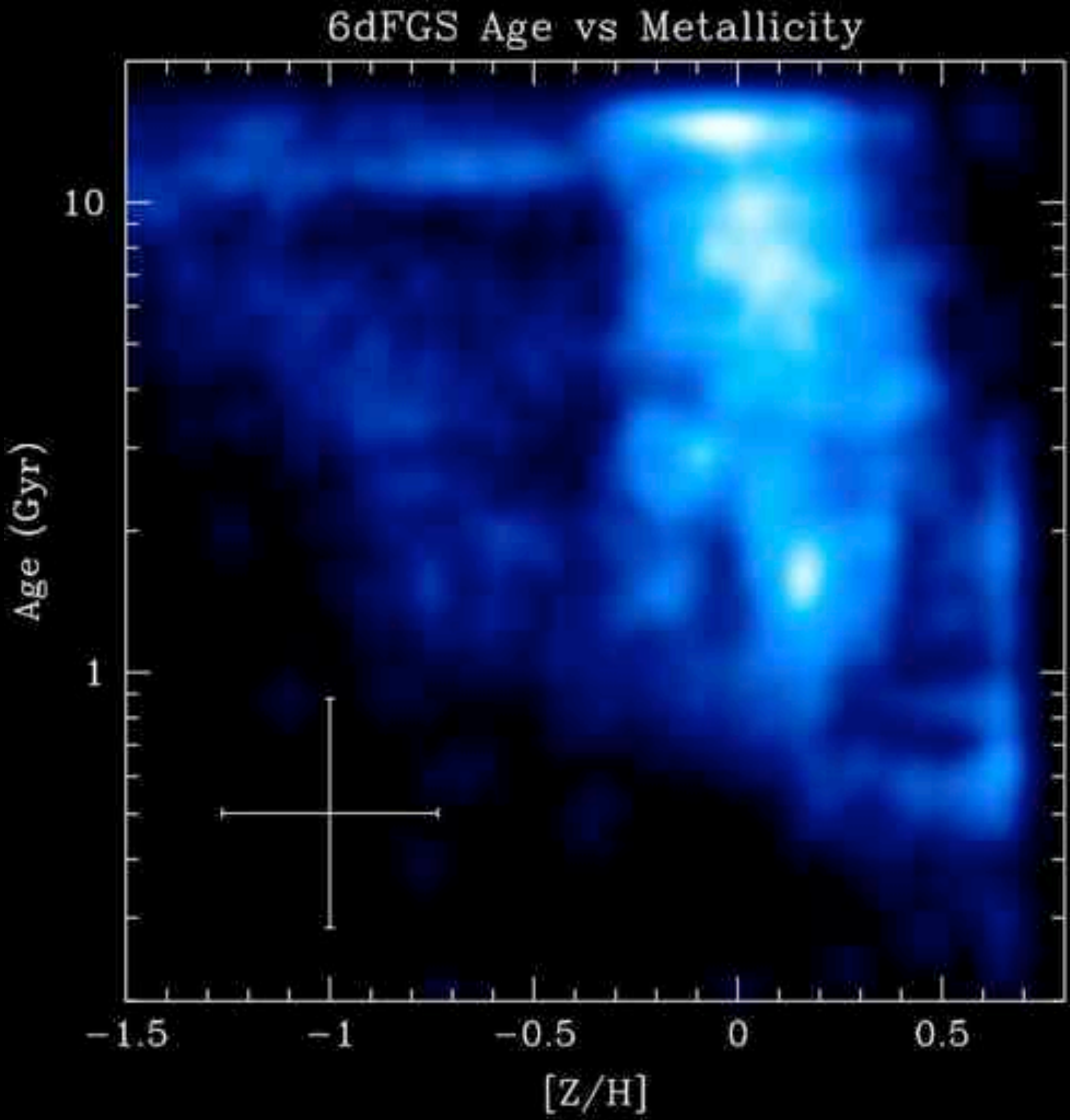
- *NIR and optical samples have different mixes of galaxy types*
- *Age and metallicity are substantially degenerate w.r.t. colours*

Distribution of luminosity and colour



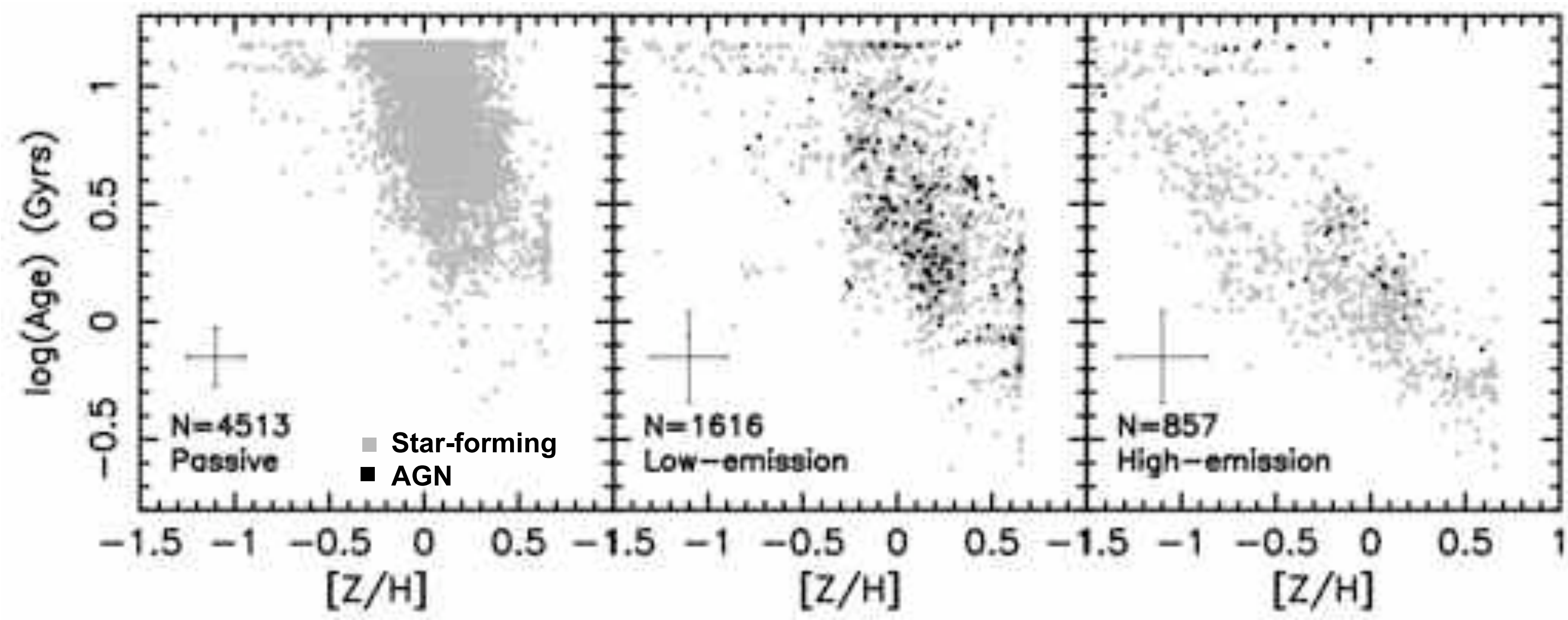
Galaxy ages and metallicities

- For 7000 DR1 galaxies we can measure Lick indices and emission lines at high S/N and get ages & metallicities
- The distribution of ages & metallicities shows...
  - Most galaxies have -0.2<[Z/H]<0.3
  - The youngest galaxies have higher minimum metallicities
  - The least metal-rich galaxies have older minimum ages



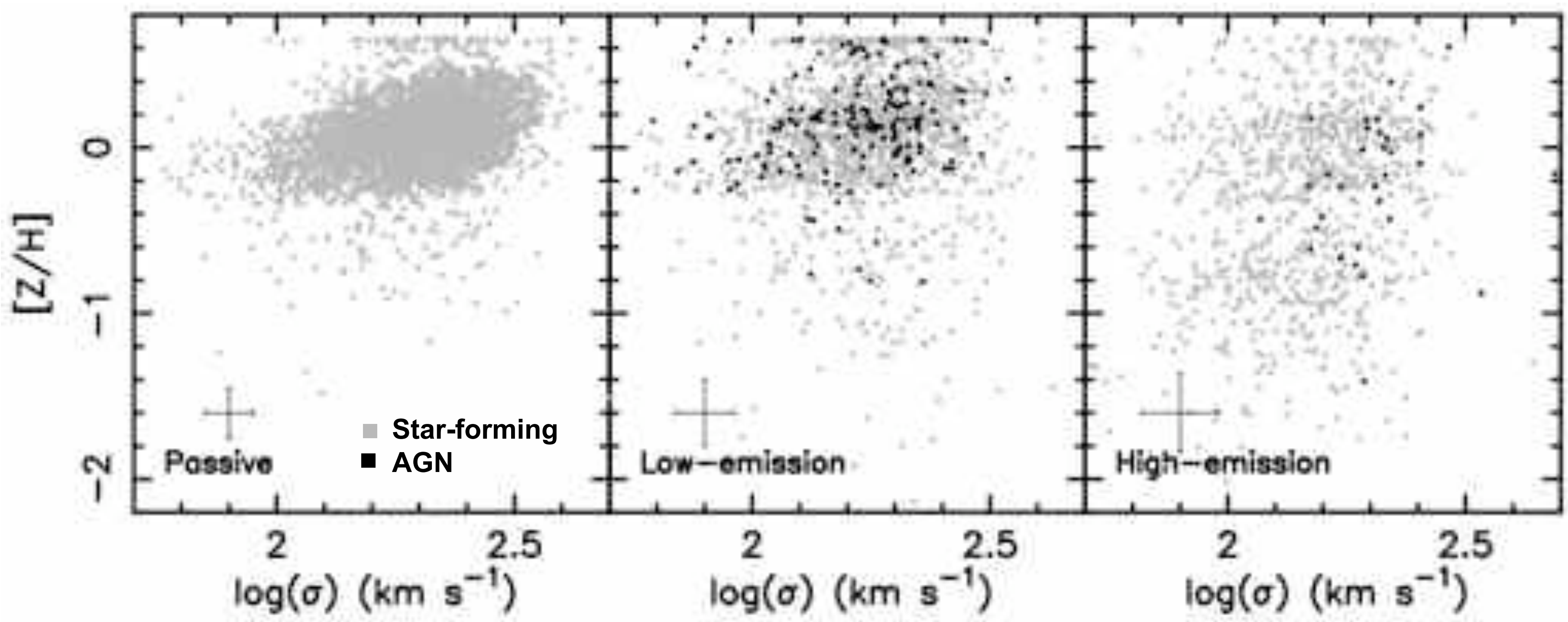
Trends in ages and metallicities

- *Split galaxy sample into 'passive', 'low-emission' & 'high-emission' sub-samples*
- *All sub-samples show trends in age with metallicity (simulations show these are real, and not just the product of correlated errors in age and metallicity)*
- *Passive and low-emission galaxies show a steep decrease in mean age over a modest range of increase in metallicity; high-emission galaxies show a more gradual trend over a wider range of ages and metallicities*



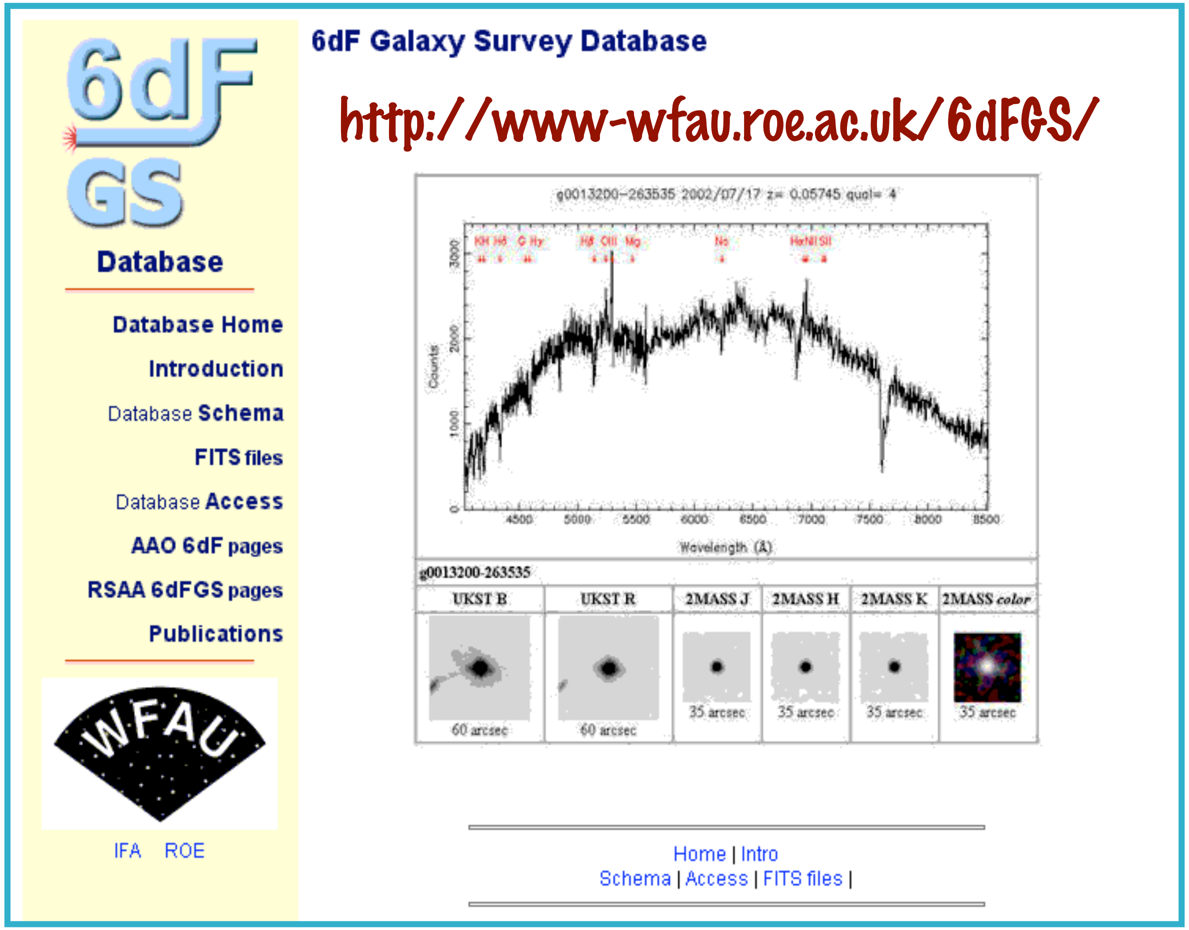
Metallicity and velocity dispersion

- Using the same sub-samples, we can look at metallicity as a function of velocity dispersion (taken as a proxy for dynamical mass)
- The well-known correlation of increasing metallicity with increasing velocity dispersion is seen for both the passive galaxies and the low-emission galaxies
- The high-emission sample shows a much broader range in metallicity and no obvious correlation between metallicity and velocity dispersion
- No evidence for correlation between age & dispersion in any of the sub-samples



6dFGS database

- Current - Data Release 2
  - Released April 2005
  - Data Jan 2002-Oct 2004
  - 89211 spectra
  - 83014 unique redshifts
  - 936 fields
- Final Data Release
  - Expected <u>Nov 2006</u>
  - Complete dataset from May 2001 to Jan 2006
  - 137k spectra
  - 130k unique redshifts
  - 1464 fields



- *6dFGS online database*
  - Searchable using either SQL query commands or a WWW form
  - Each source has its own multi-extension FITS file, including spectra & postage stamps
  - The different target catalogues are also fully searchable online