Galaxy and Mass Assembly (GAMA): LF Evolution, bivariate brightness distribution and luminosity-size relation

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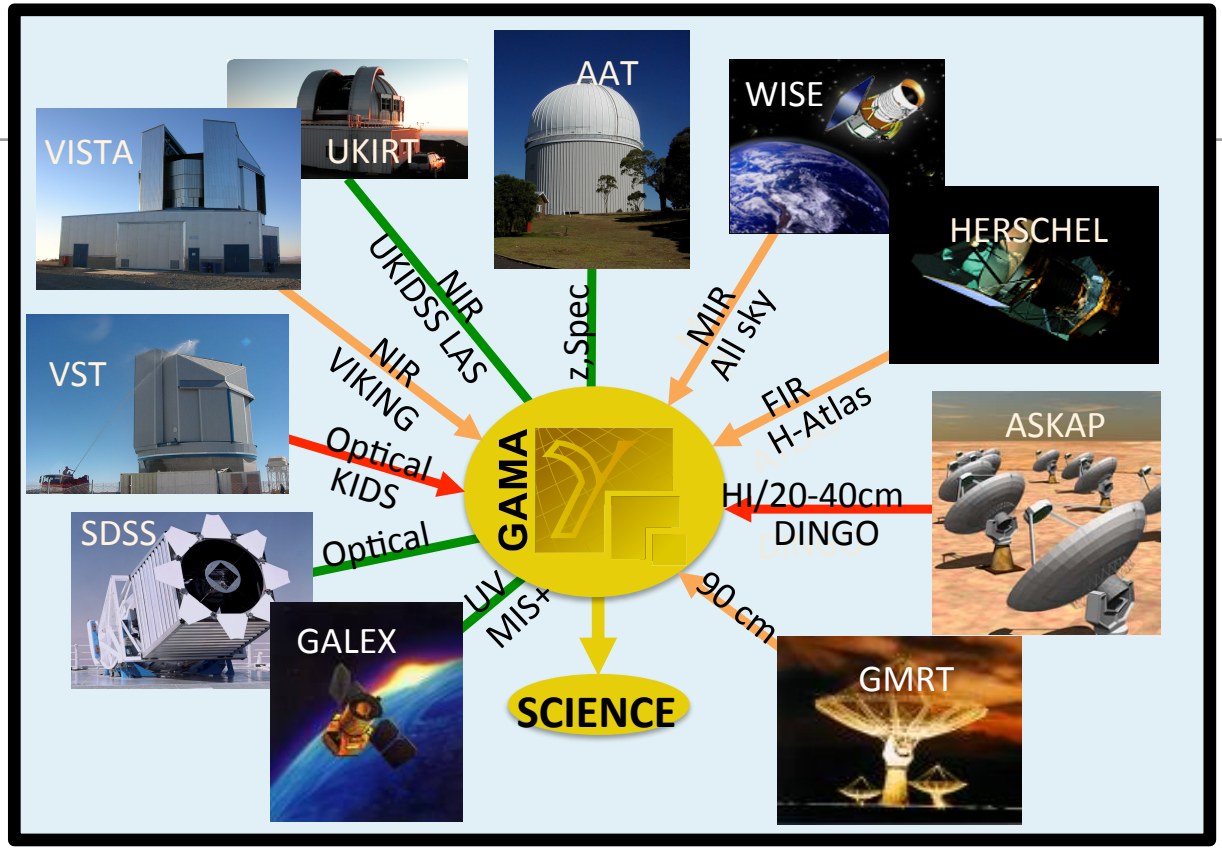

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Outline

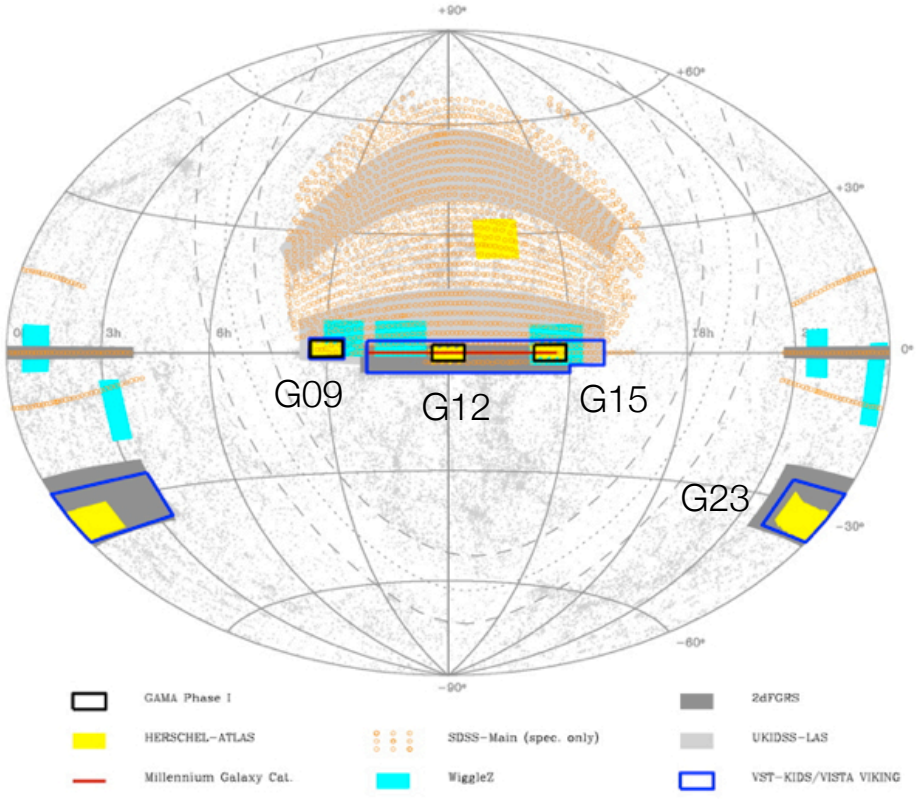
- Quick GAMA summary
- Luminosity function
  - Joint stepwise maximum likelihood method
  - Luminosity function and evolution by Sersic type
- Multivariate distribution functions
  - Bivariate brightness distribution (BBD)
  - Luminosity-size relation
  - Evolution with redshift
- Summary

All results here are preliminary!

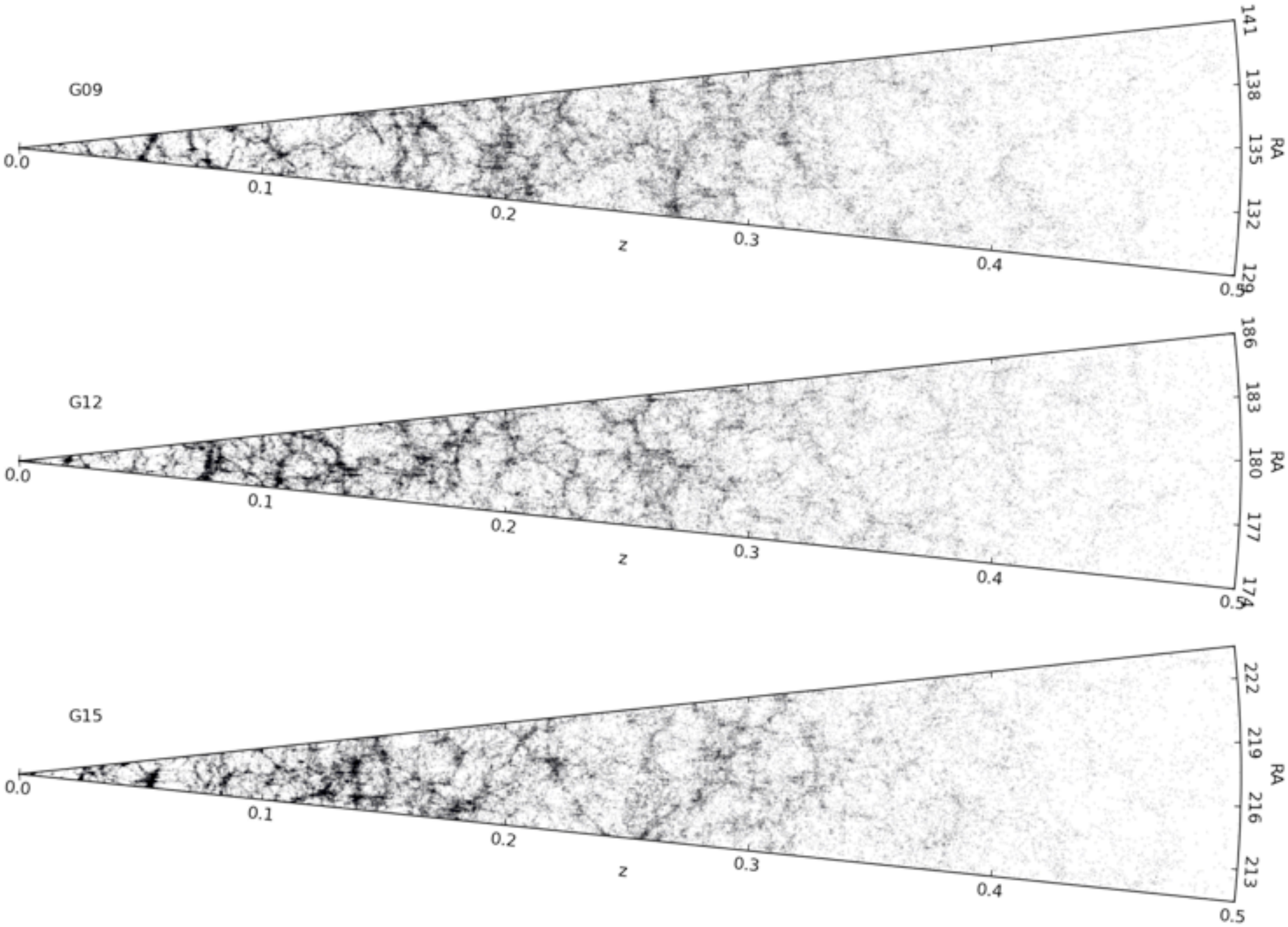
Assume $h = 1$

GAMA-II

- Four 12 x 5 deg fields to SDSS r = 19.8: G09, G12, G15, G23
- Target density ~1000/deg^2
- Fully automated redshifts
- Equatorial regions (G09, G12, G1 now complete:
  - 183,010 galaxies with reliable redshifts (96.7% success rate
  - Mean redshift z = 0.23
- Derived parameters: stellar mass groups, environment
- Matched-aperture photometry GALEX-SDSS-UKIDSS



www.gama-survey.org


G09
G12
G15
z
RA
0.0
0.1
0.2
0.3
0.4
0.5
141
138
135
132
129
186
183
180
177
174
222
219
216
213

Luminosity function, radial density and evolution

- Use Cole (2011) *joint stepwise maximum likelihood* (JSWML) method
- Radial density fluctuations $\Delta(z_i)$ and LF iteratively solved by maximising

$$\mathcal{L} = \Pi_\alpha p_\alpha, \qquad p_\alpha = \frac{\Delta(z_\alpha)\frac{\mathrm{d}V(z_\alpha)}{\mathrm{d}z}\phi(L_\alpha)}{\int \Delta(z)\frac{\mathrm{d}V}{\mathrm{d}z}\int_{L^{\min}(z)}^{\infty}\phi(L)\,\mathrm{d}L\,\mathrm{d}z},$$

- $\Delta(z_i)$ → density-corrected $V_{\max}$ for each galaxy → LF $\Phi(M_j)$
- Luminosity (Q) and density (P) evolution parametrized by (Lin et al 1999)
  - $M_c(z) = M + Qz$
  - $\Phi^*(z) = \Phi^*(0) \times 10^{\,0.4Pz}$
- Cole derived iterative method for finding P, $\Delta(z_i)$, $\Phi(M_j)$ given assumed Q, motivated by generating random catalogues for clustering

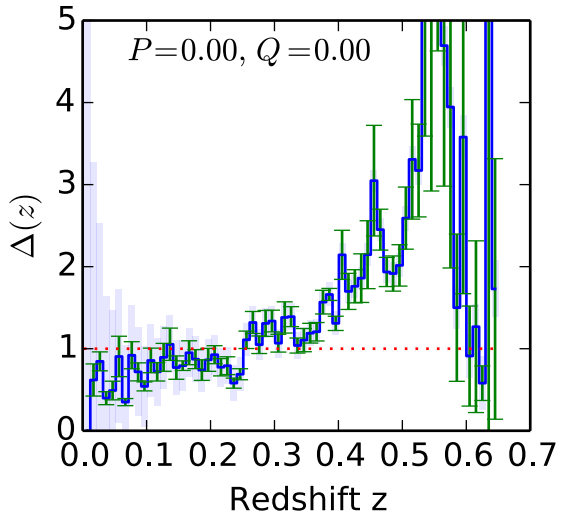
Issues

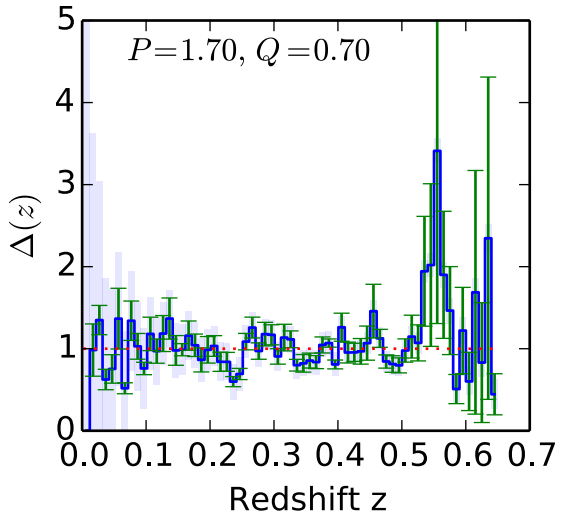
1. Cole (2011) iterative solution includes factor $d \ln \varphi^*/dP$ which is independent of P for chosen form of density evolution
2. As lum evolution parameter Q varies:
   - V_{max} needs to be recalculated for all galaxies - very slow
   - Absolute magnitudes shift — need careful binning to conserve galaxy number and have no empty mag bins (likelihood includes $\ln \varphi_j$)

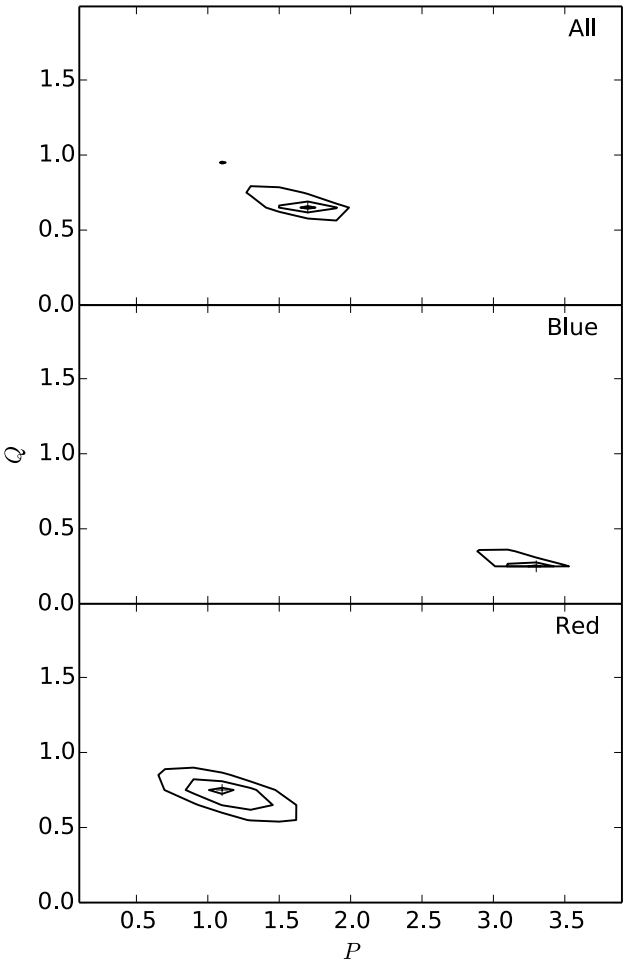
- Partially resolved by:
  1. Searching over both P, Q
  2. Maximising geometric mean probability rather than likelihood, or by minimising χ^2 from $\Delta(z_i)$ and between LFs measured in redshift slices
- Fit for $\Delta(z_i)$, Q, P using SDSS r-band Petrosian magnitude (GAMA selection band); K-corrections from SED fits using KCORRECT
- For subsequent multivariate distributions, keep Q, P fixed, fitting only for $\Delta(z_i)$ and $\Phi(M_j)$

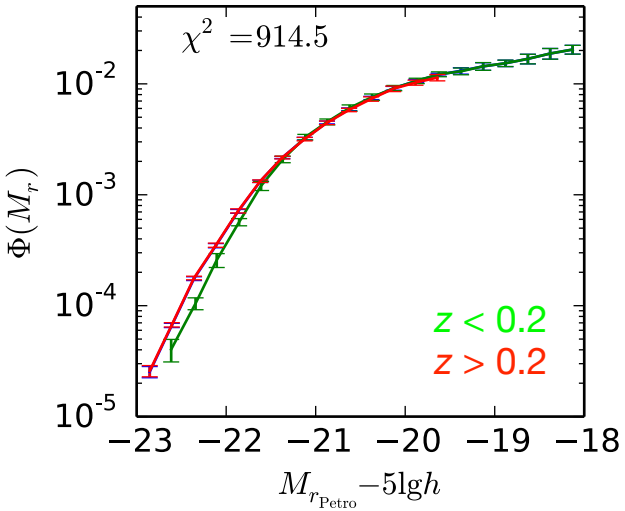
Fitting for evolution

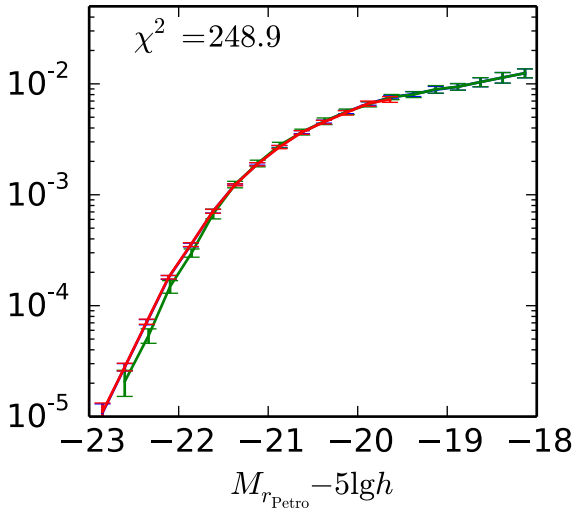
$$\chi^2 = \sum_{p \neq q} \sum_i \frac{(\phi_i^p - \phi_i^q)^2}{\mathrm{Var}(\phi_i^p) + \mathrm{Var}(\phi_i^q)} + \sum_p \frac{(\Delta_p - 1)^2}{\sigma_p^2}$$



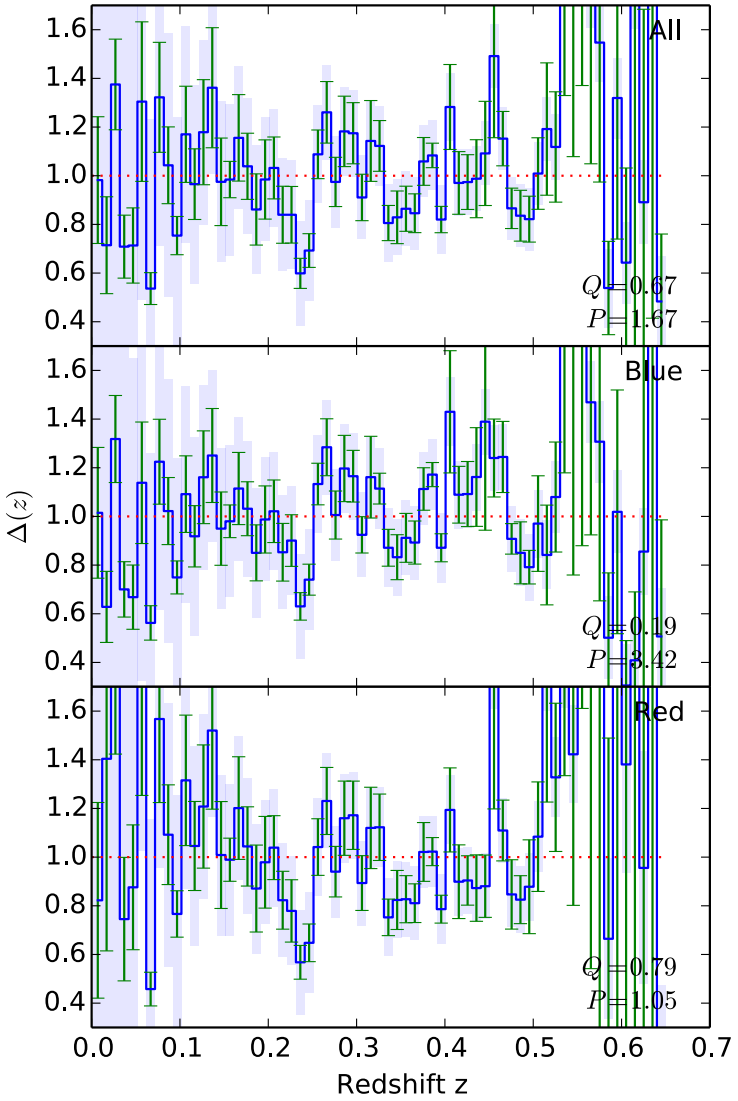


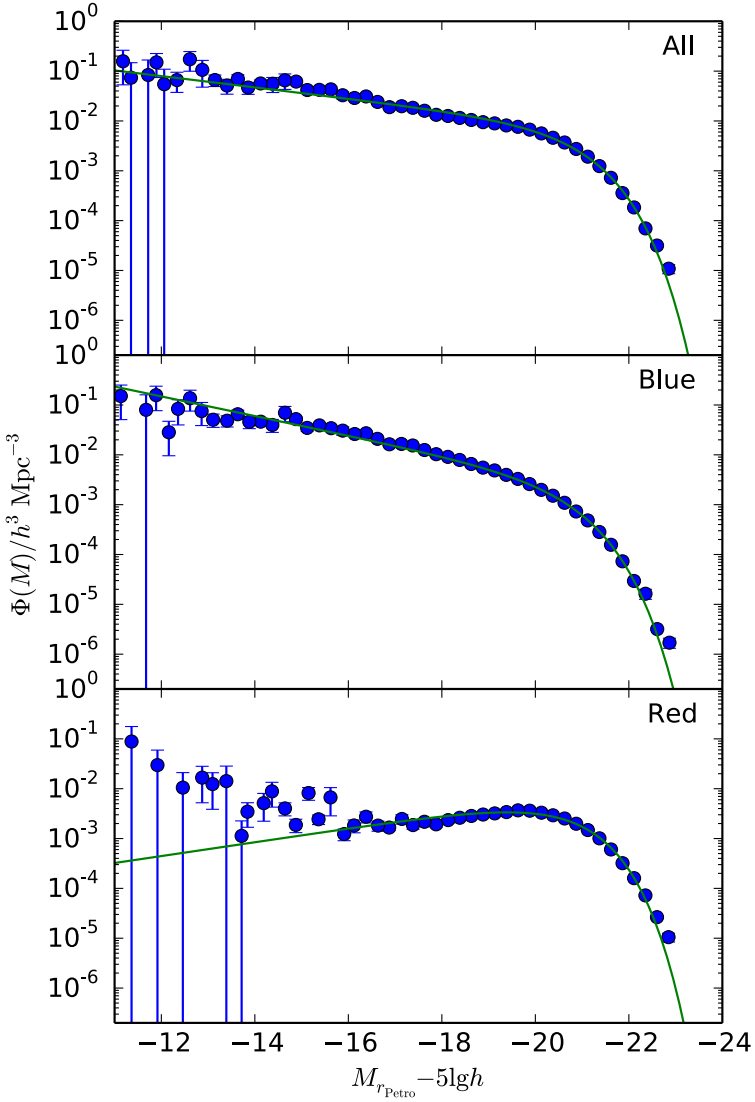






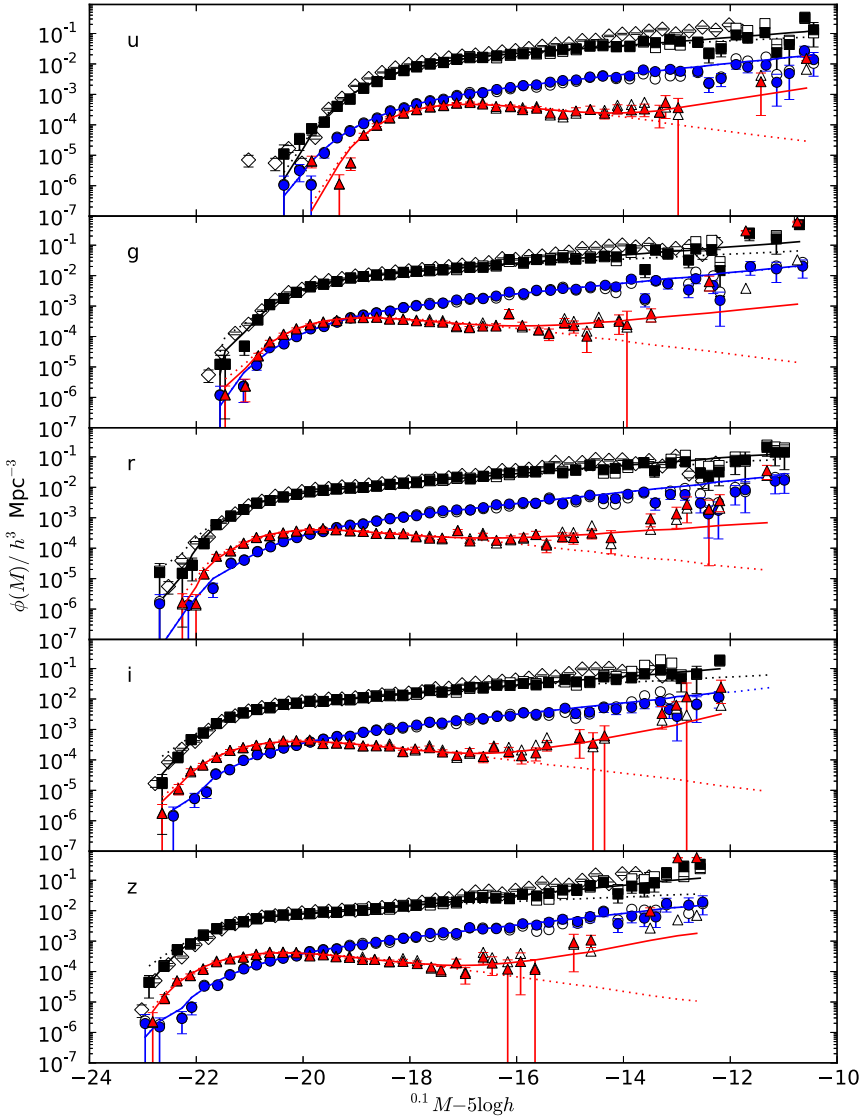
GAMA-II *r*-band LF split by colour





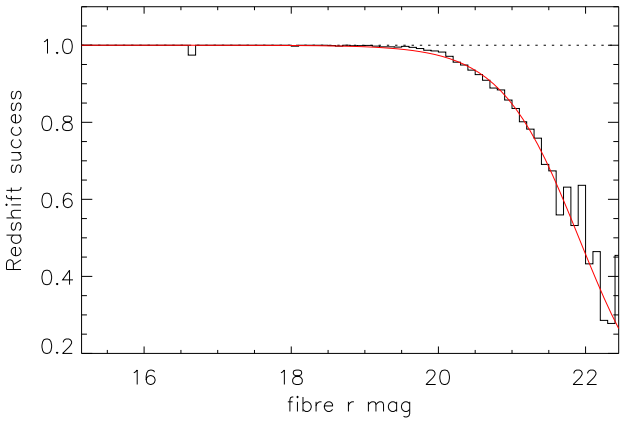
GAMA-II *r*-band LF split by colour

- Consistent with Loveday+ 2012
- (STY evolving Schechter fn plus SWML in redshift slices)



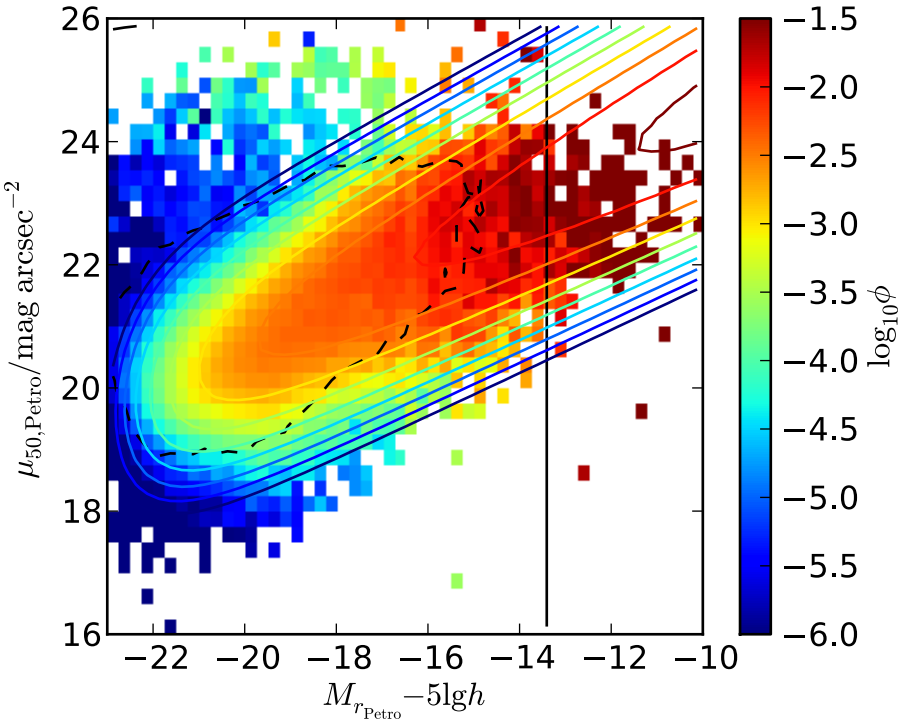
Multivariate distribution functions

- Always have SDSS Petrosian *r*-band magnitude as a parameter
- Other parameters:
  - Sersic *r*-band 10 R_e magnitude and effective surface brightness
  - Circularised effective radius
- Advantages of Sersic over Petrosian (Kelvin+ 2012):
  - Elliptical apertures
  - Seeing corrected
  - Larger fraction of flux measured
- Incompleteness corrections follow Loveday+ 2012:
  - Imaging (Petrosian SB, Blanton+ 2005)
  - Redshift (fibre mag)
- All errors from jackknife sampling

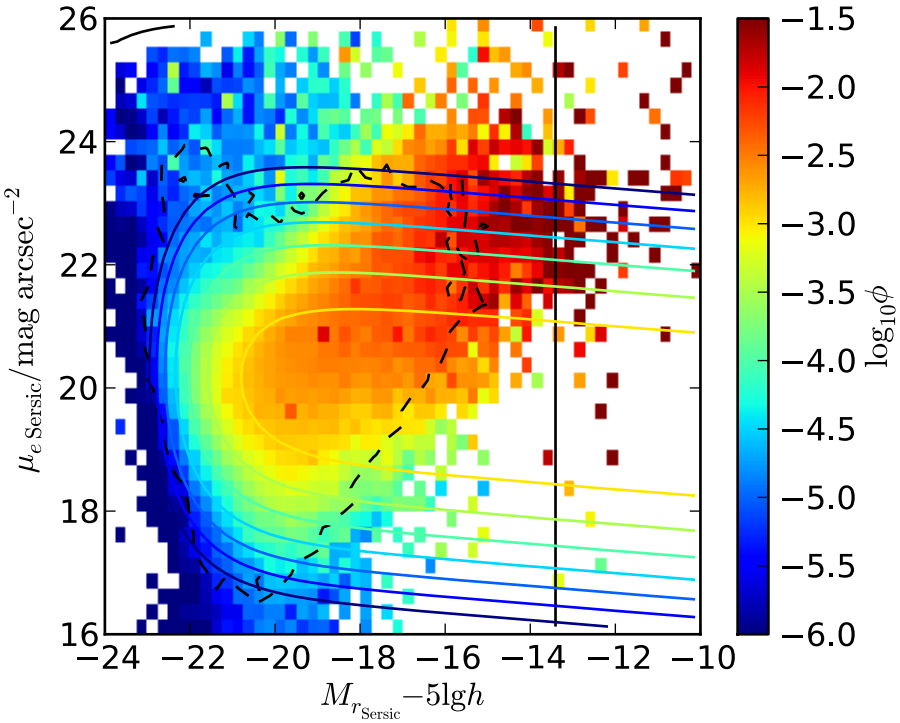


Bivariate brightness distribution (BBD)

Petrosian



Sersic



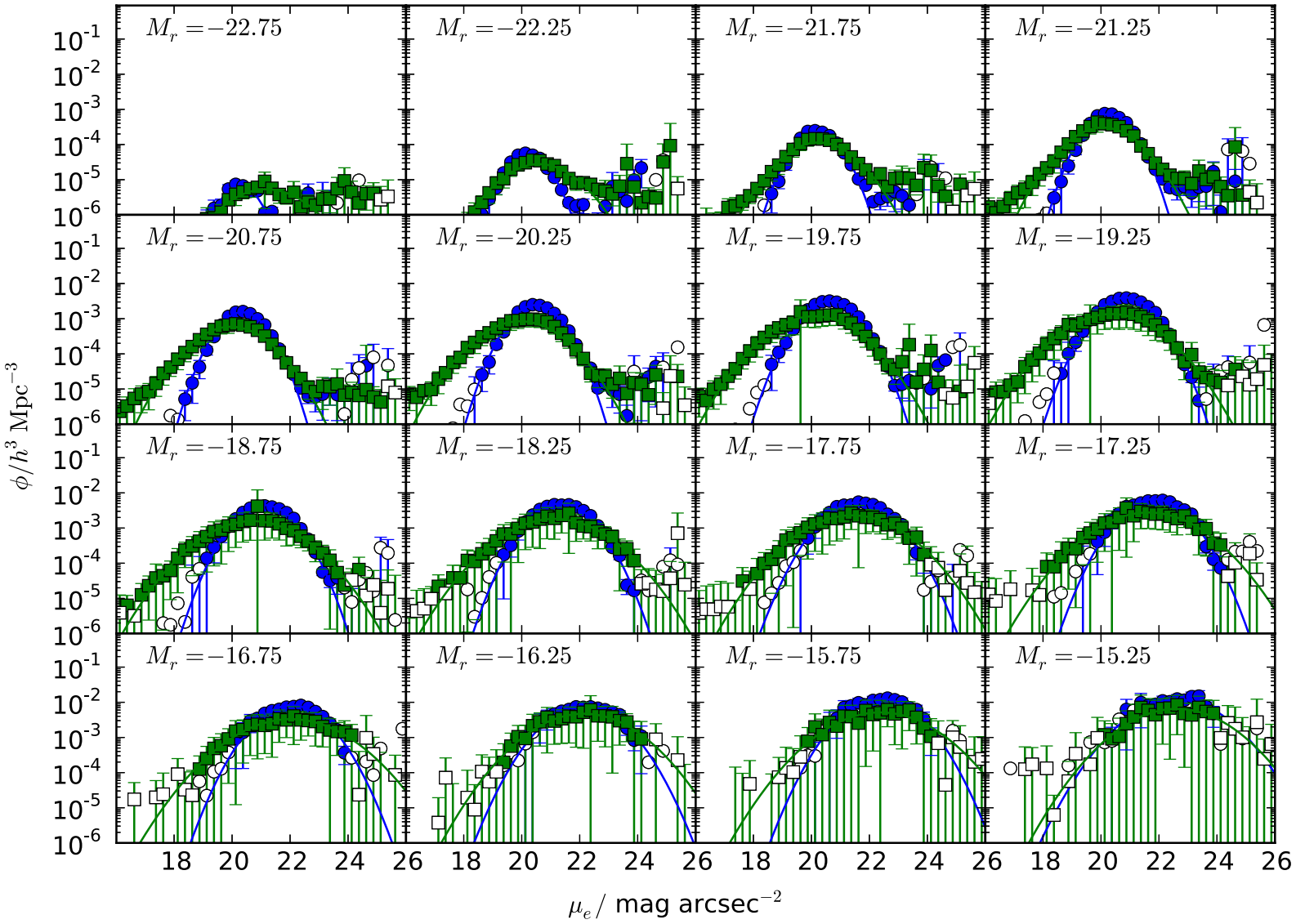
- Choloniewski function v poor fit ($\chi^2/\nu \sim 15$)
- Sersic BBD much broader than Petrosian
- NB imaging completeness correction > ×2 for $\mu_r \gtrsim 23$ mag arcsec^{-2}

——— $V = 1800\ h^{-3}\,\rm Mpc^3$

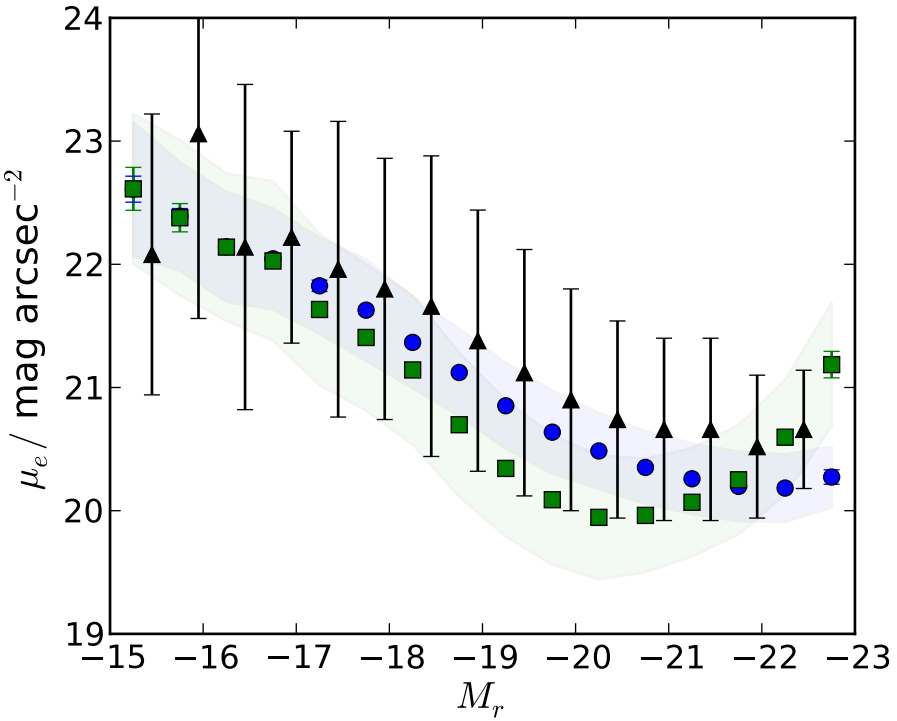
- - - - - $N_{\rm gal} = 16$

BBD sliced by magnitude

Petro
Sersic



BBD Gaussian fit parameters



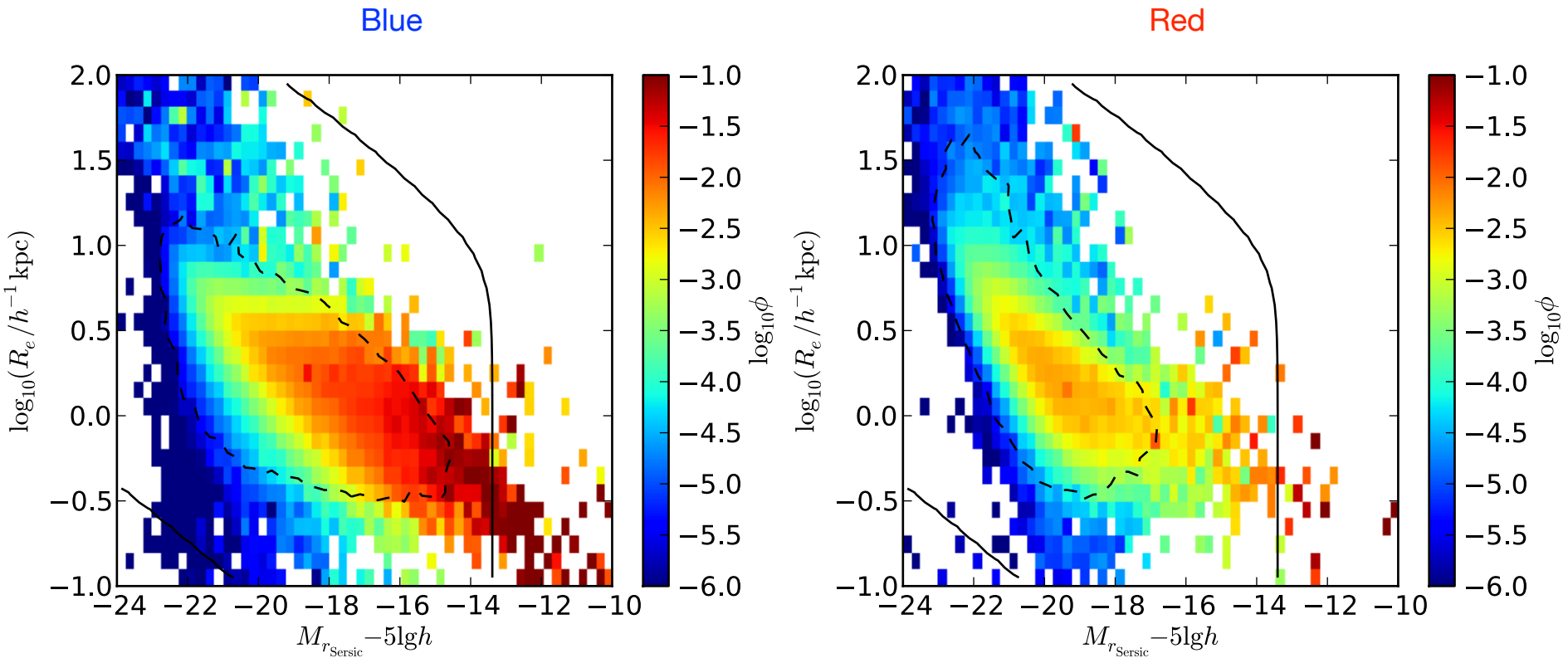
Petro/Sersic Gaussian centre

1 sigma

▲ Driver+ 2005 ($M_{r,Petro} = M_{B,MGC} - 1.2$)

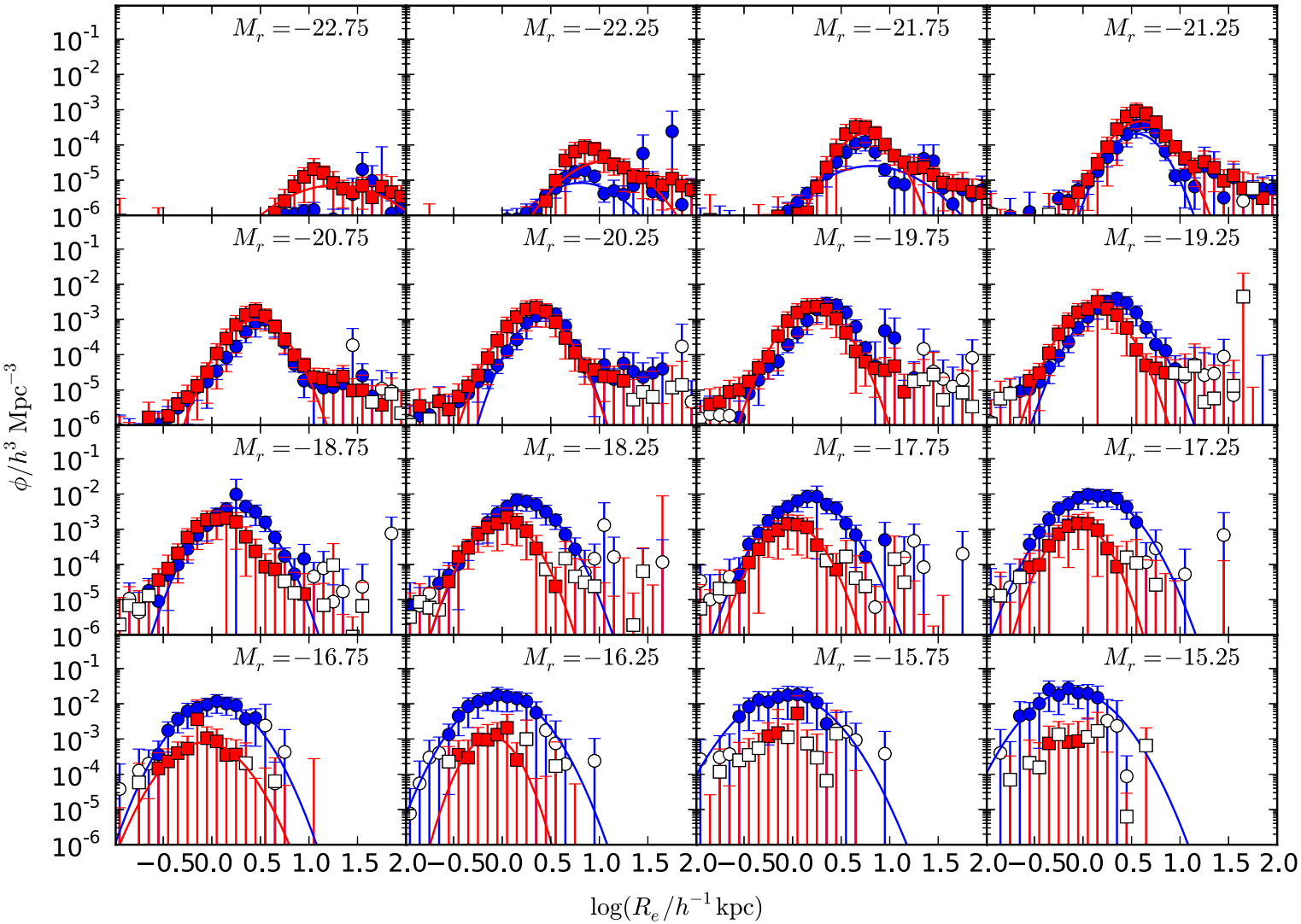
- Sersic BBD broader than Petro, but narrower than Driver+ 2005
- Shows maximum SB $\mu_r \approx 20$ mag arcsec^{-2} at $M_r \approx -21$ mag
- Petro SB of most compact galaxies underestimated by seeing?
- For lum-size relation, we just show Sersic parameter results

Luminosity-size relation by Sersic index

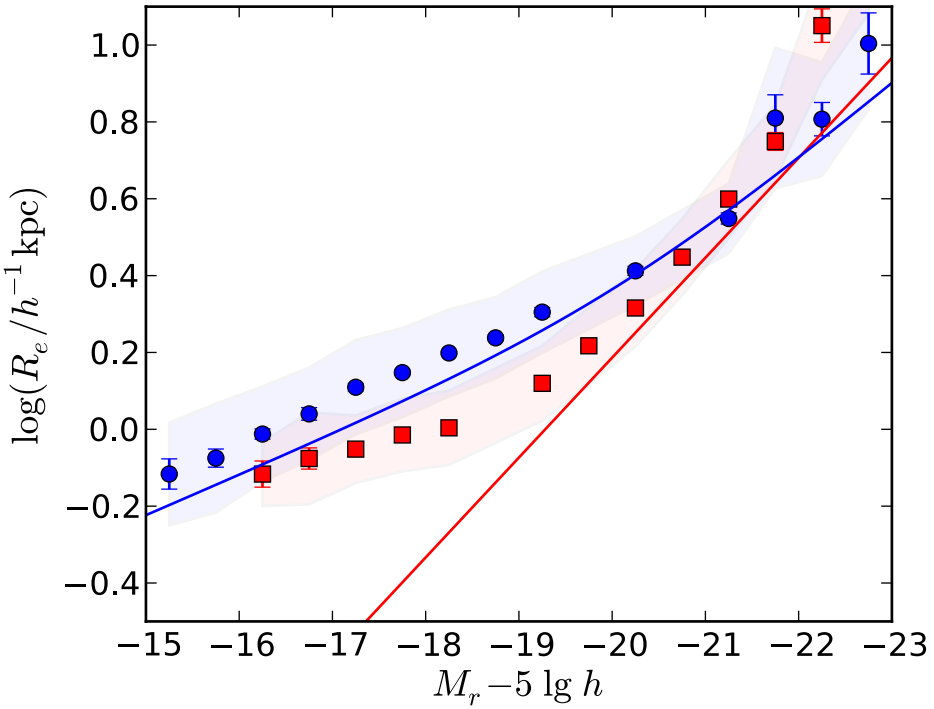


Luminosity-size relation sliced by magnitude

Blue
Red



Luminosity-size relation Gaussian fit parameters



- Blue
- Red

Lines from Shen+ 2003 (n = 2.5)

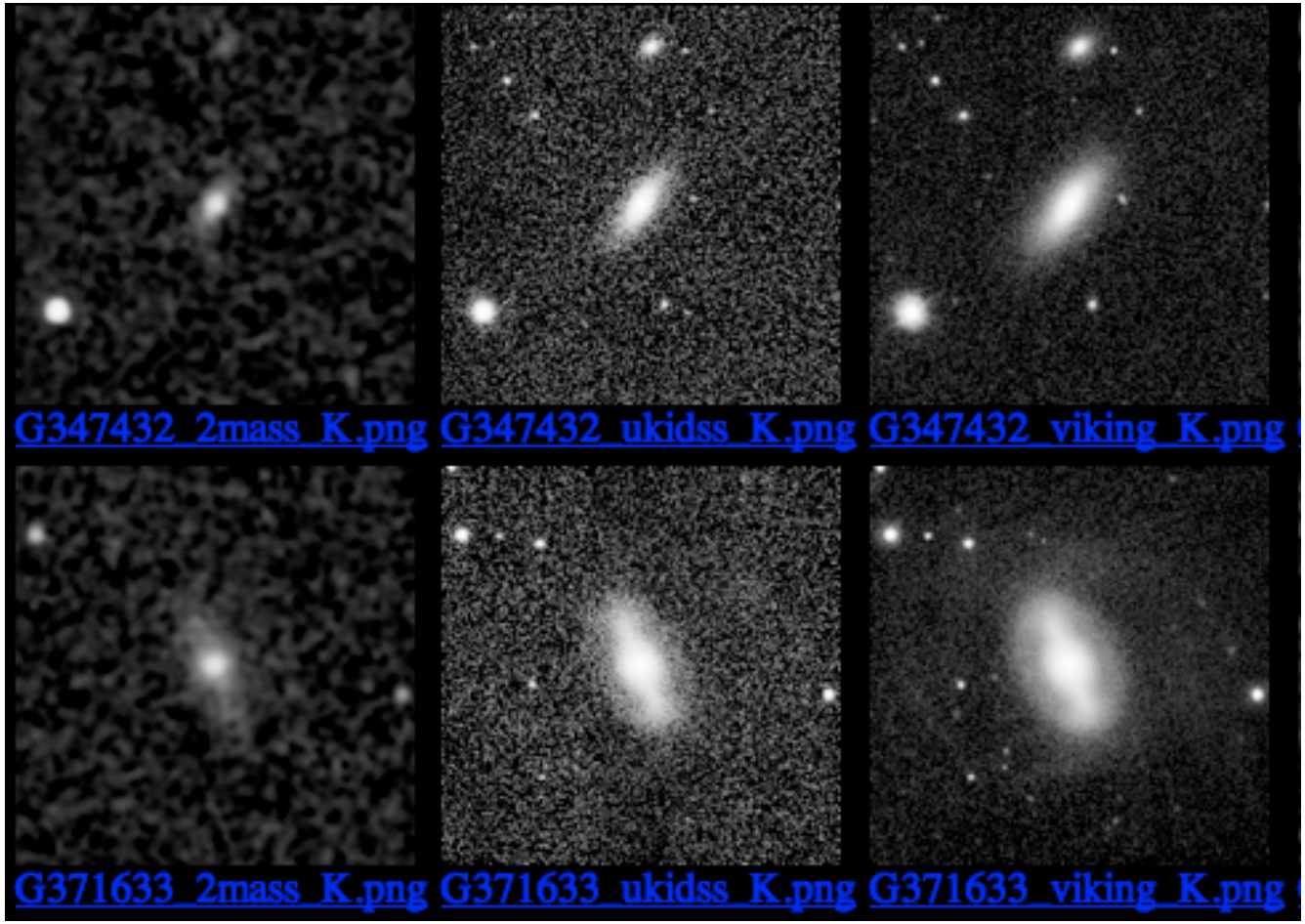
- Blue – red size difference larger at low luminosities
- Offset wrt Shen+ 2003 results in same sense as discrepancy with Driver+ 2005
- Shen+ early-type relation only measured for M_r – 5 lg 0.7 < –19)

Summary

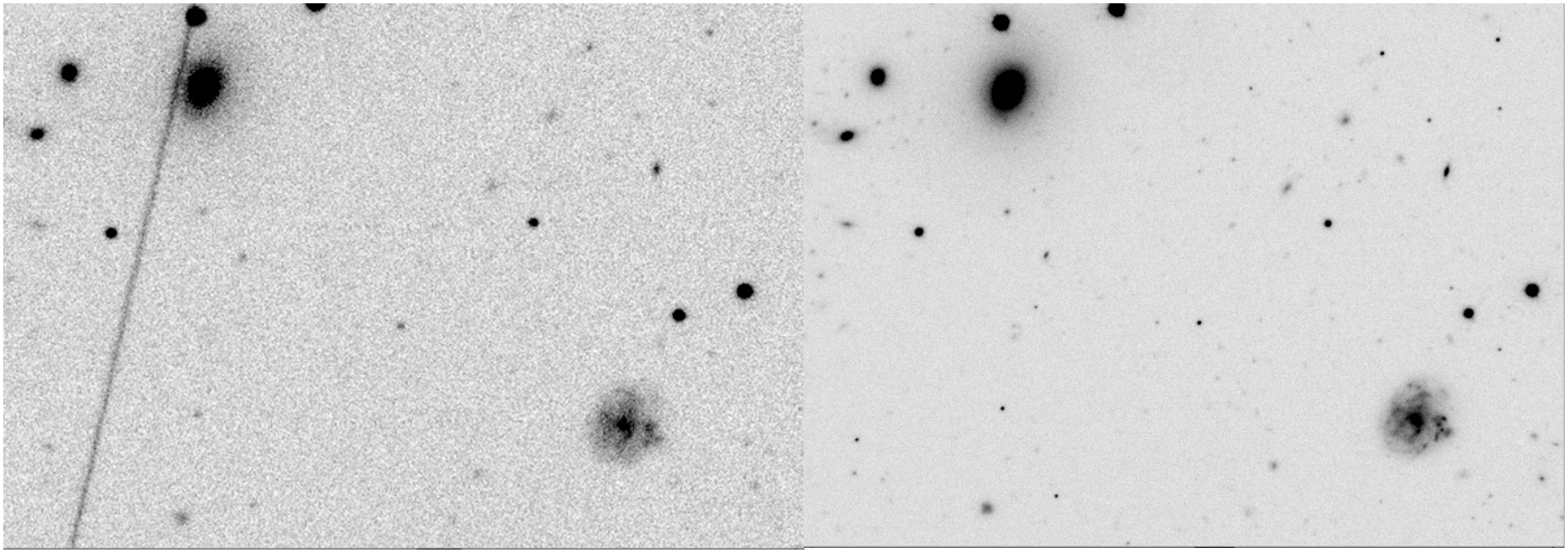
- *r*-band LF fit simultaneously with radial overdensity and evolution parameters
- BBD not well fit by Choloniewski function
  - SB peaks at μ_e = 20 mag arcsec^{-2} for ~L* galaxies
  - SB distribution broadens at fainter luminosities
- (e-corrected) luminosity-size distribution:
  - No sig evolution for late-type galaxies
  - Early-types grow by ~5% since $z \sim 0.2$
- Future work:
  - Use VST KIDS imaging
    - More reliable size measurements
    - Readdress SDSS imaging completeness
  - Interpolate radius to fixed restframe band
  - Investigate environmental dependence
  - Use SPS model fits to estimate individual lum evoln parameters *Q*

Imaging improvements: NIR

2MASS UKIDSS VISTA



Imaging improvements: optical



SDSS *g* ~1 deg^2 KIDS *g*