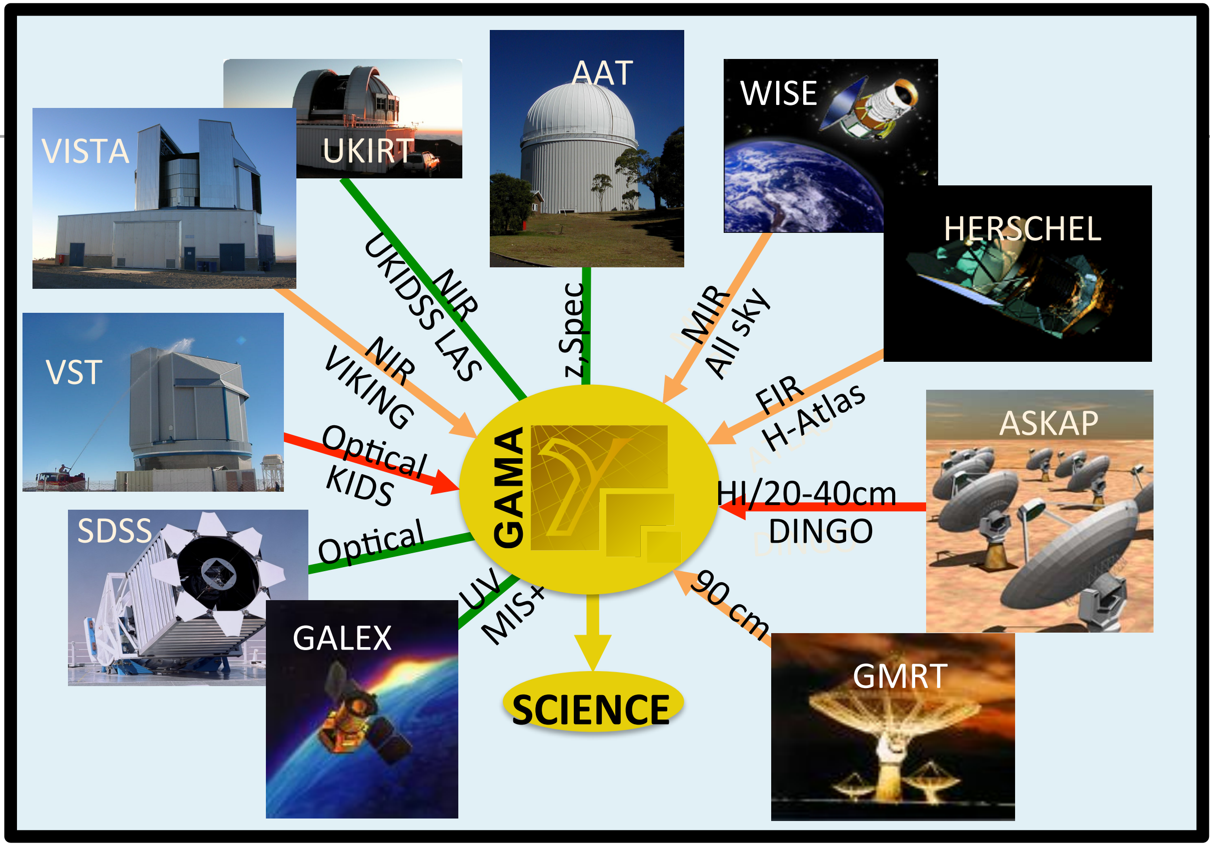
Galaxy and Mass Assembly (GAMA): Evolution of the mass-size relation

Jon Loveday
University of Sussex



University of Sussex

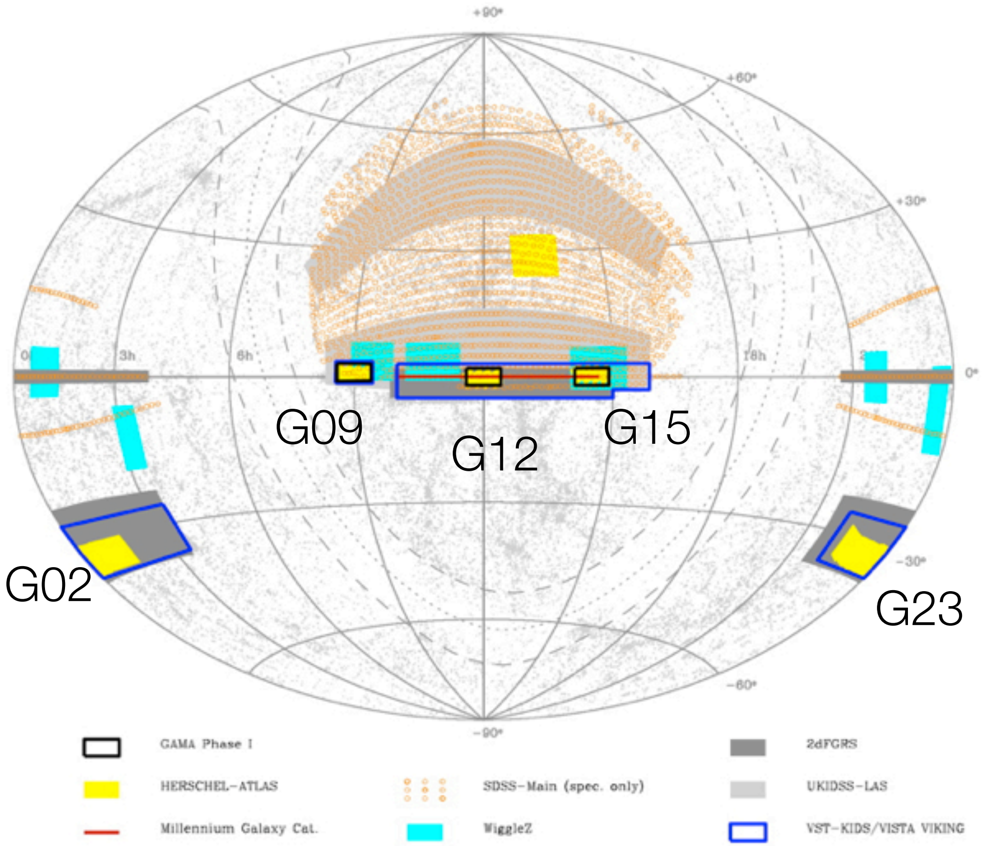
Outline

- GAMA update
  - GAMA I
  - GAMA DR2
  - GAMA II
- Luminosity function
  - Joint stepwise maximum likelihood method
  - Luminosity function and evolution by Sersic type
- Multivariate distribution functions
  - Bivariate brightness distribution (BBD)
  - Luminosity-size relation
  - Mass-size relation
- Summary

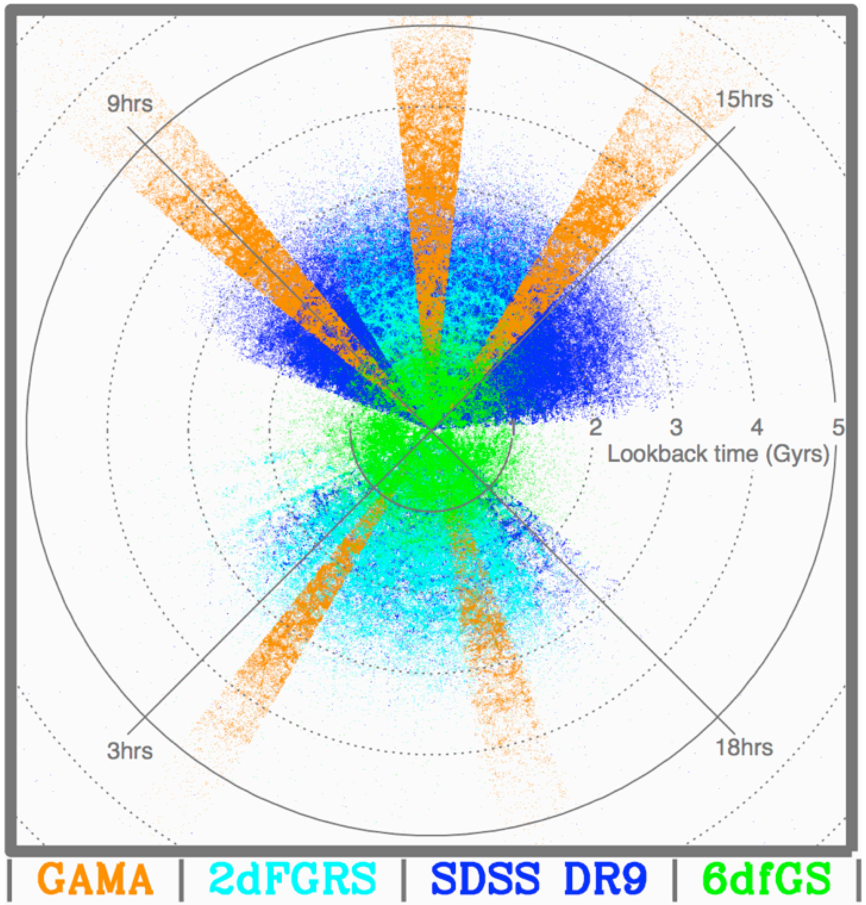
All results here are preliminary!

Assume $h = 1$

GAMA Fields



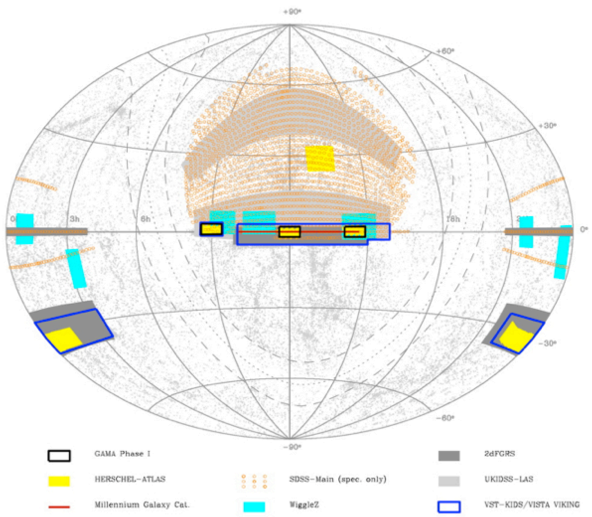
+90°
+60°
+30°
0°
-30°
-60°
-90°
0
3h
6h
18h
G09
G12
G15
G02
G23
GAMA Phase I
HERSCHEL-ATLAS
Millennium Galaxy Cat.
SDSS-Main (spec. only)
WiggleZ
2dFGRS
UKIDSS-LAS
VST-KIDS/VISTA VIKING



9hrs
15hrs
3hrs
18hrs
2
3
4
5
Lookback time (Gyrs)
| GAMA | 2dFGRS | SDSS DR9 | 6dfGS |

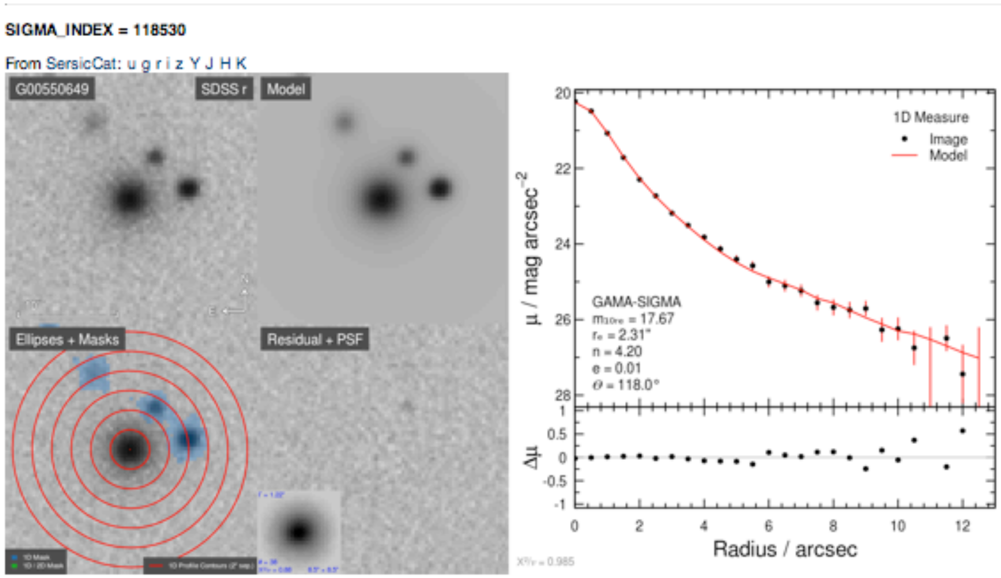
GAMA-I (Driver et al. 2011)

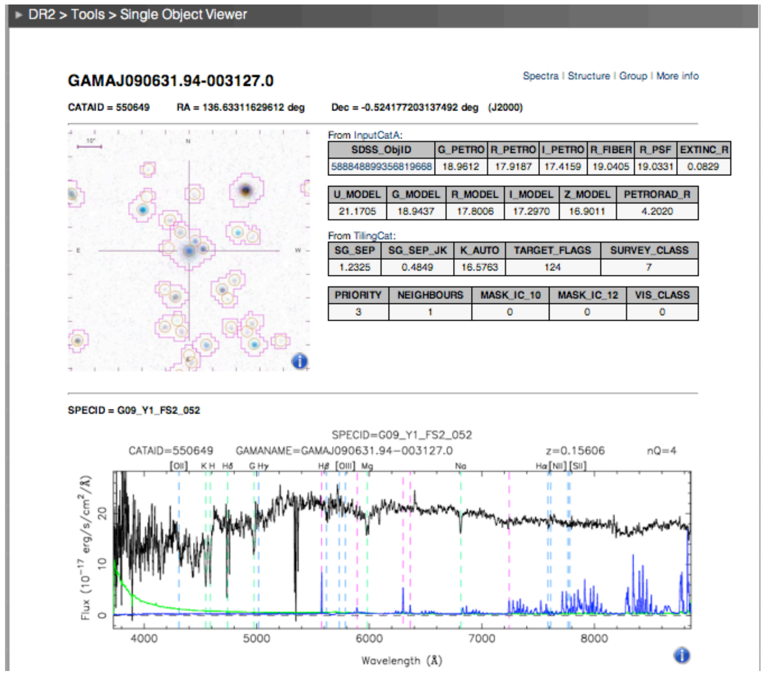
- Three 12 x 4 deg fields
  - G09, G15 to *r* = 19.4
  - G12 to *r* = 19.8
- SDSS, UKIDSS-LAS *ugrizYJHK* aperture matched and Sersic photometry (Hill et al. 2010, Kelvin et al. 2012)
- GALEX FUV, NUV photometry
- 130,301 spectra yielding 98% reliable redshifts (111,655 new)
- Derived parameters:
  - Spectral line and SFR measurements
  - Stellar mass estimates (Taylor et al. 2011)
  - Local density measurements
  - Group catalogue (Robotham et al. 2011)
- 32 refereed publications



GAMA Data Release 2 (Liske et al. in prep.)

- Provides GAMA-I data to r = 19.0 (G09, G12), r = 19.4 (G15)
- 72,225 objects, 98% with reliable redshifts
- Available since May 2013 from http://www.gama-survey.org/dr2/
  - SQL interface to catalogues
  - Single object viewer
  - Links to images, spectra

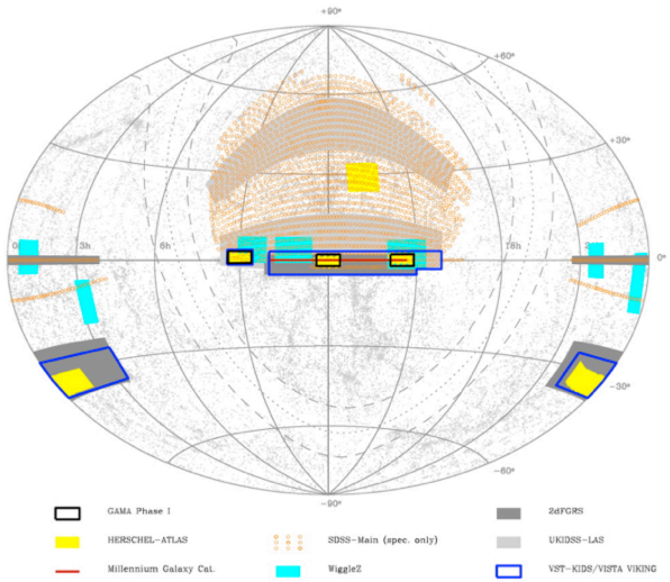


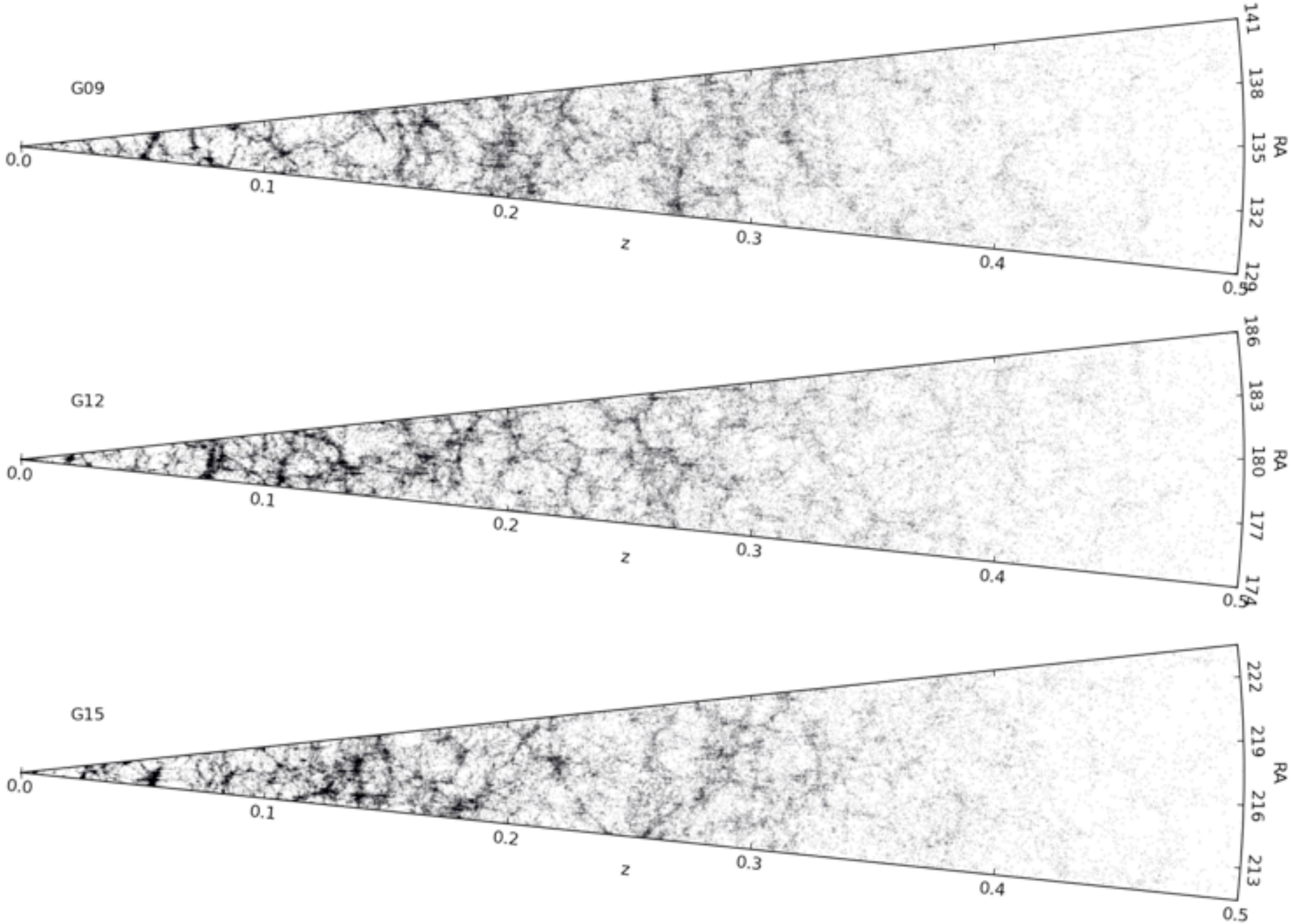


GAMA-II

- Four 12 x 5 deg fields to r = 19.8: G09, G12, G15, G23
- Smaller area (tbd) in G02
- Fully automated redshifts
- Equatorial regions (G09, G12, G15) now complete:
  - 183,010 galaxies with reliable redshifts (96.7% success rate)
  - Mean redshift z = 0.23

- Derived parameters (stellar masses, groups, environment) in progress



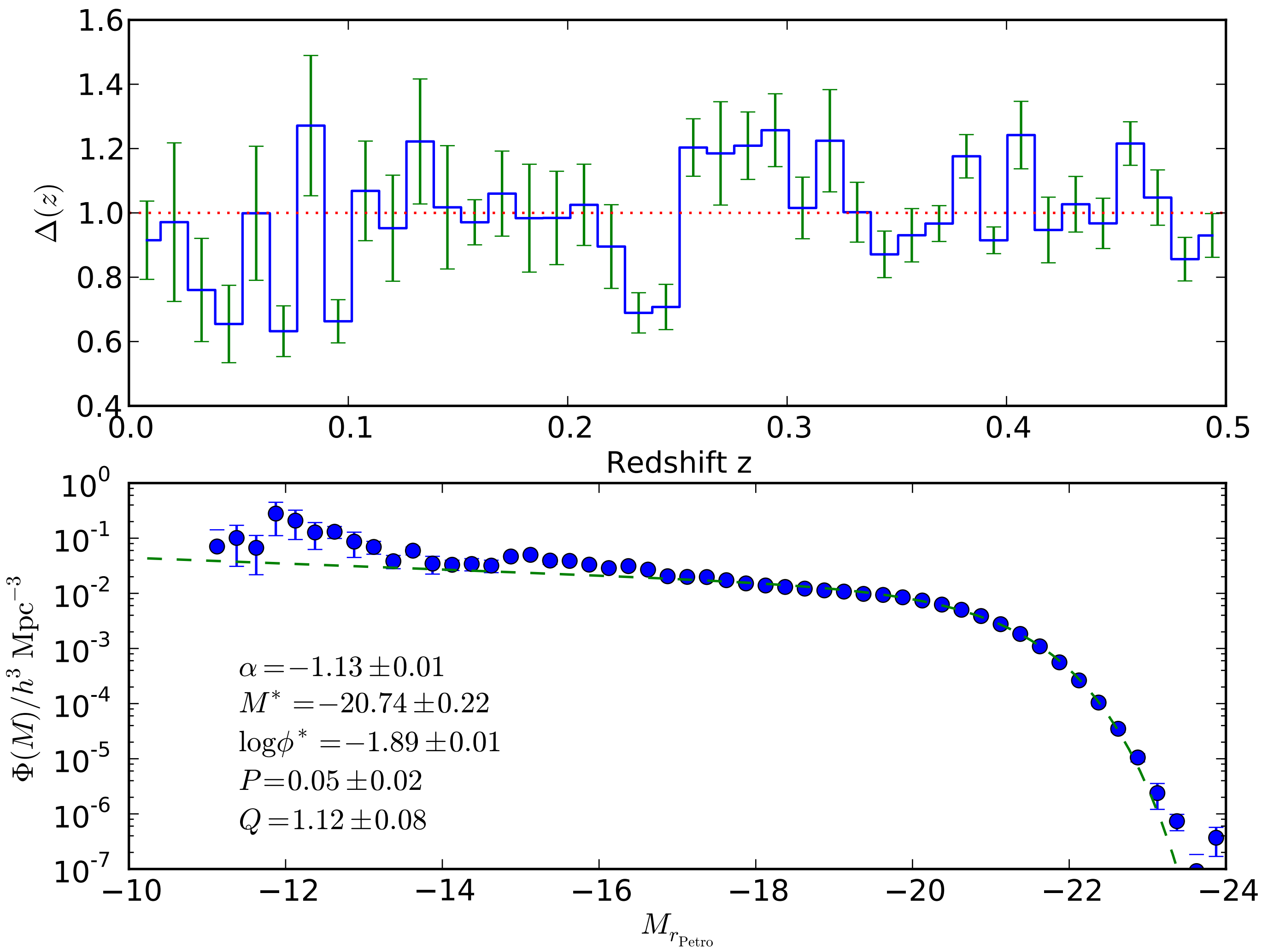


G09
0.0
0.1
0.2
0.3
0.4
0.5
z
141
138
135
132
129
RA
G12
0.0
0.1
0.2
0.3
0.4
0.5
z
186
183
180
177
174
RA
G15
0.0
0.1
0.2
0.3
0.4
0.5
z
222
219
216
213
RA

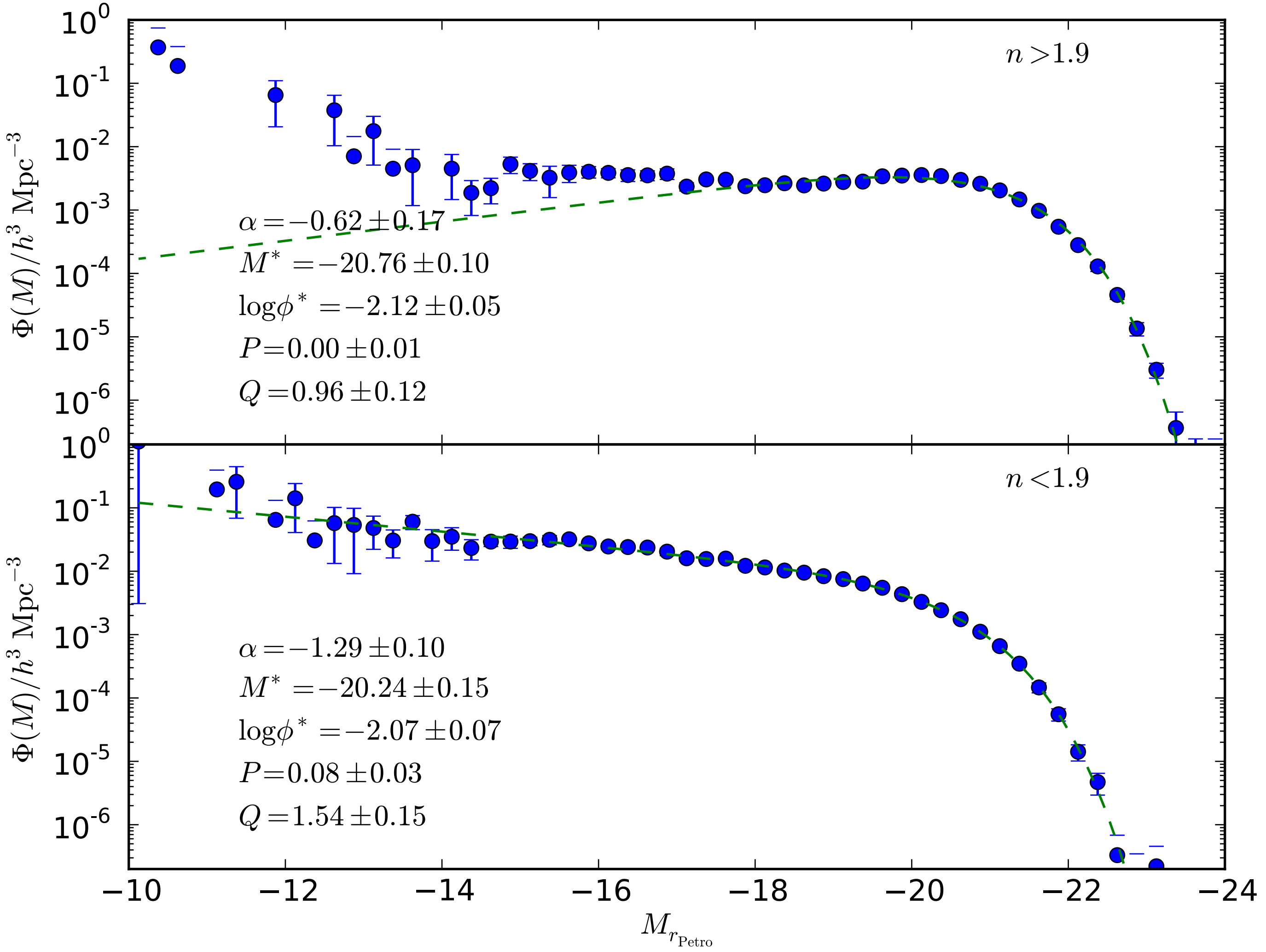
Luminosity function

- Use Cole (2011) *joint stepwise maximum likelihood* (JSWML) method
- Radial density fluctuations $\Delta(z_i)$ and luminosity function $\Phi(M_j)$ fit jointly along with luminosity (Q) and density (P) evolution parameters:
  - $M_c(z) = M + Qz$
  - $\Phi^*(z) = \Phi^*(0) \times 10^{0.4Pz}$
- Iteratively solve for $\Delta(z_i)$, Q, P by minimising slope of straight line fit to $\Delta(z_i)$
  - Need tight prior on P to achieve convergence
- Use $\Delta(z_i)$ to find density-corrected $V_{\rm max}$ for each galaxy → LF $\Phi(M_j)$
- Fit for $\Delta(z_i)$, Q, P using 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 $\Phi(M_j)$
- Evolution correction applied *only* to luminosity

GAMA-II r-band LF

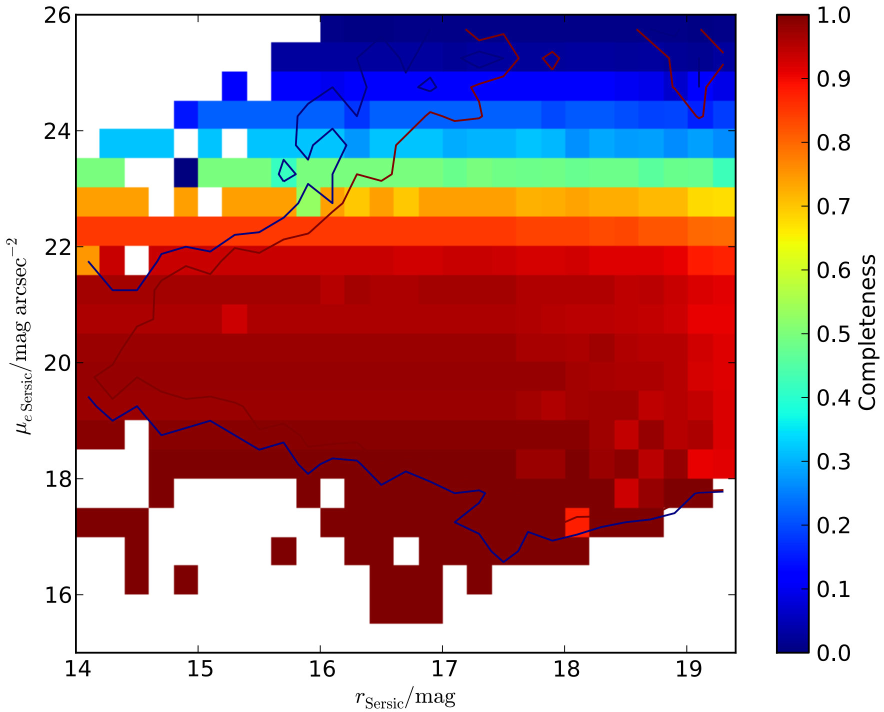


GAMA-I r-band LF Split by Sersic index

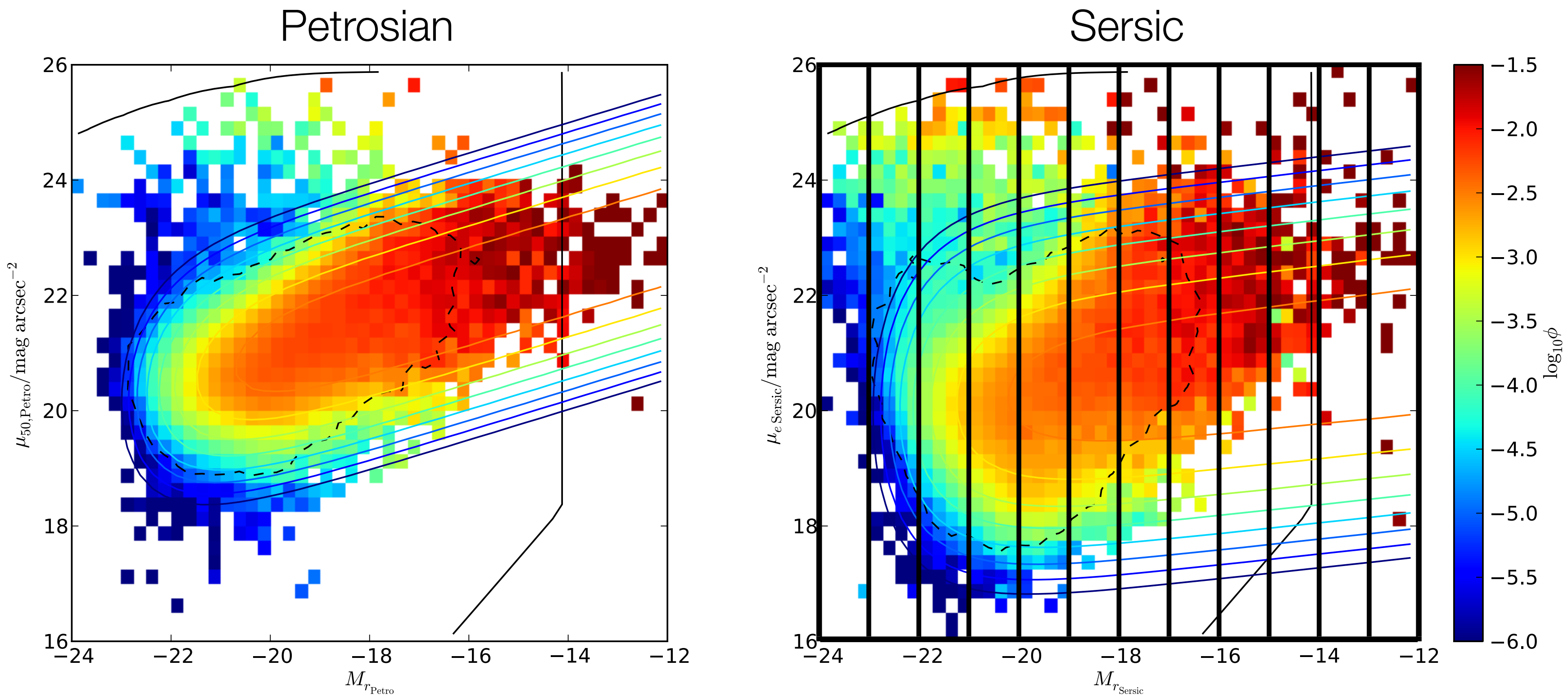


Multivariate distribution functions (GAMA-I)

- 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
  - Stellar mass
- Advantages of Sersic over Petrosian:
  - Elliptical apertures
  - Seeing corrected
  - Larger fraction of flux measured
- Map redshift completeness in bins in multidimensional parameter space, also including estimated imaging completeness (Blanton et al. 2005)
- Sum over parameters not of interest



Bivariate brightness distribution (BBD)

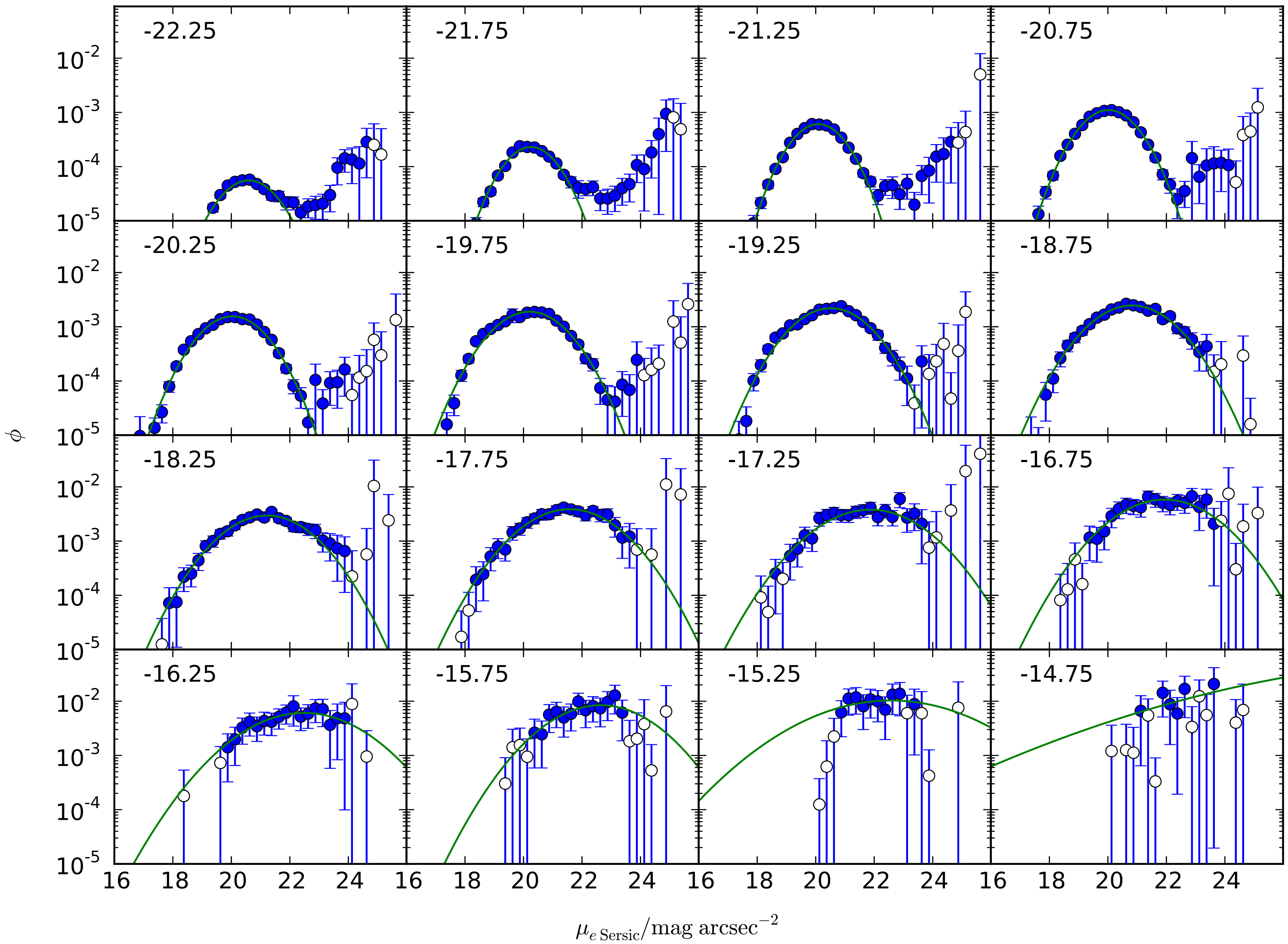


- Choloniewski function v poor fit ($\chi^2/\nu \sim 15$)
- Sersic BBD much broader than Petrosian
- NB imaging completeness correction > 2 for $\mu_r \gtrsim 23$ mag arcsec^{-2}

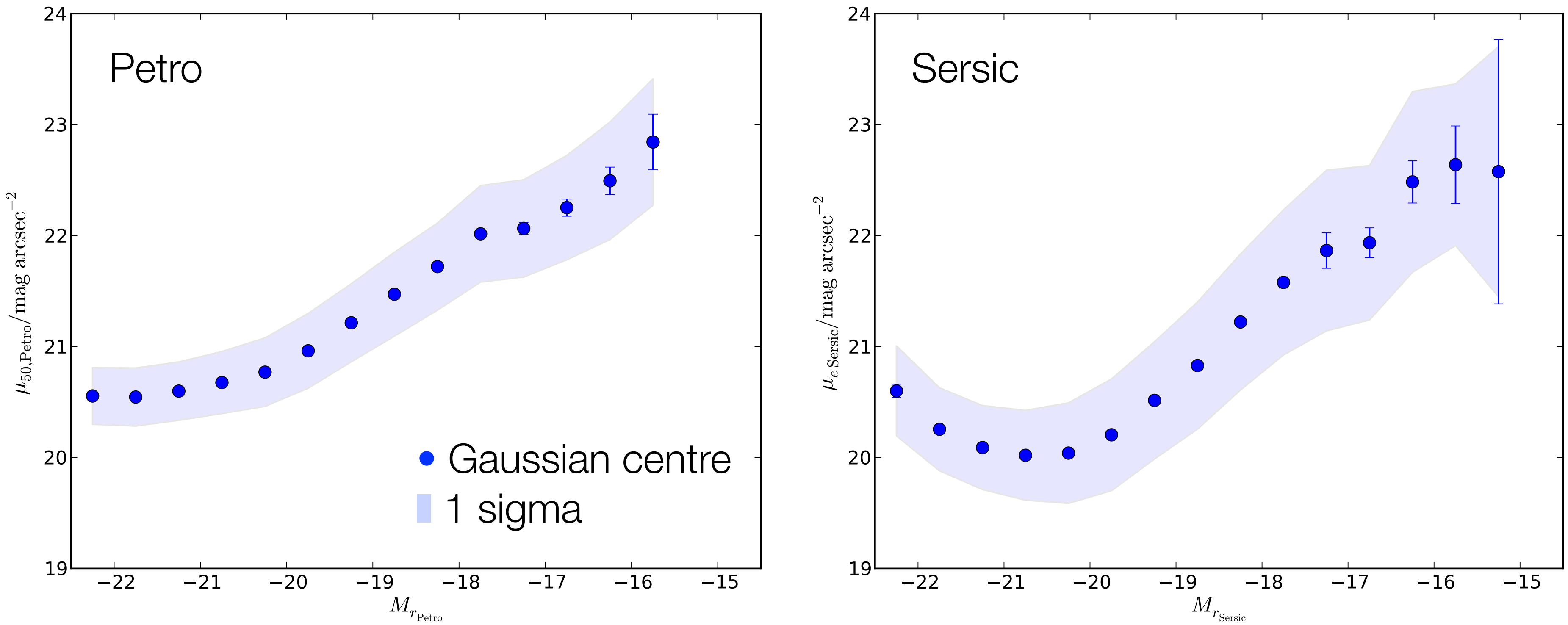
—— $V = 1800\ h^{-3}$ Mpc^3

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

Sersic BBD sliced by magnitude

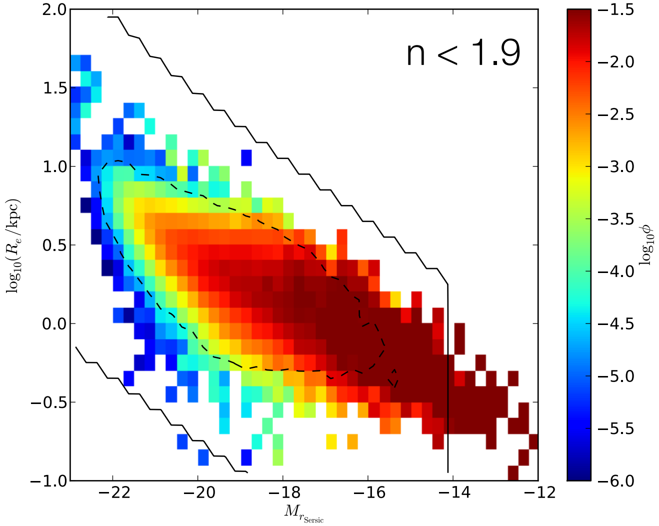


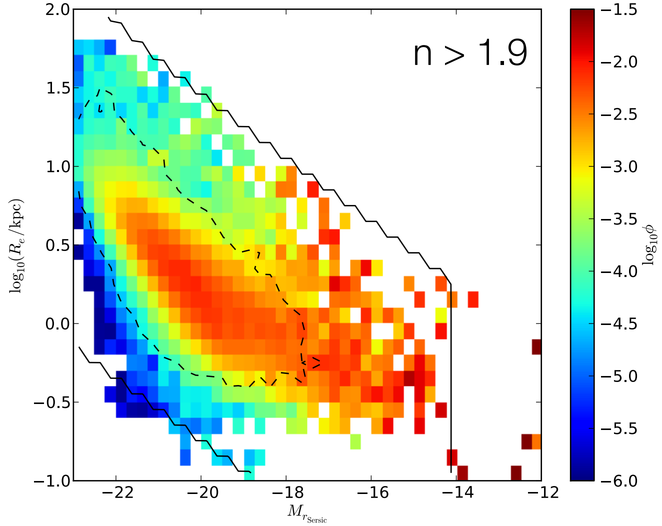
Gaussian fit parameters

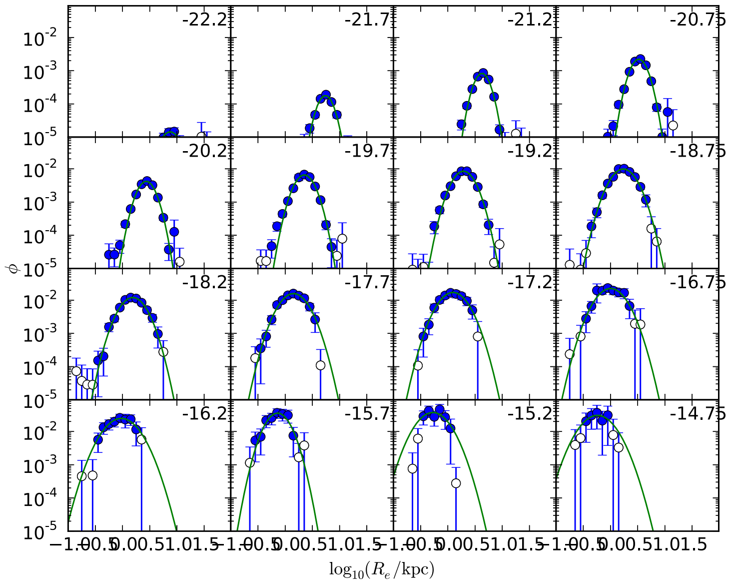


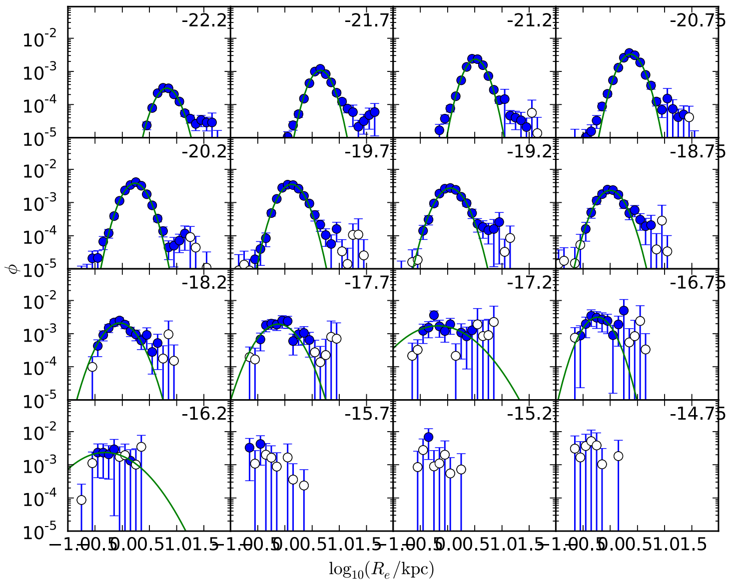
- Sersic BBD broader than Petro
- Shows maximum SB $\mu_r \approx 20$ mag arcsec^{-2} at $M_r \approx -21$ mag
- Petro SB of most compact galaxies underestimated by seeing?
- From now on just show Sersic parameter results

Luminosity-size relation by Sersic index

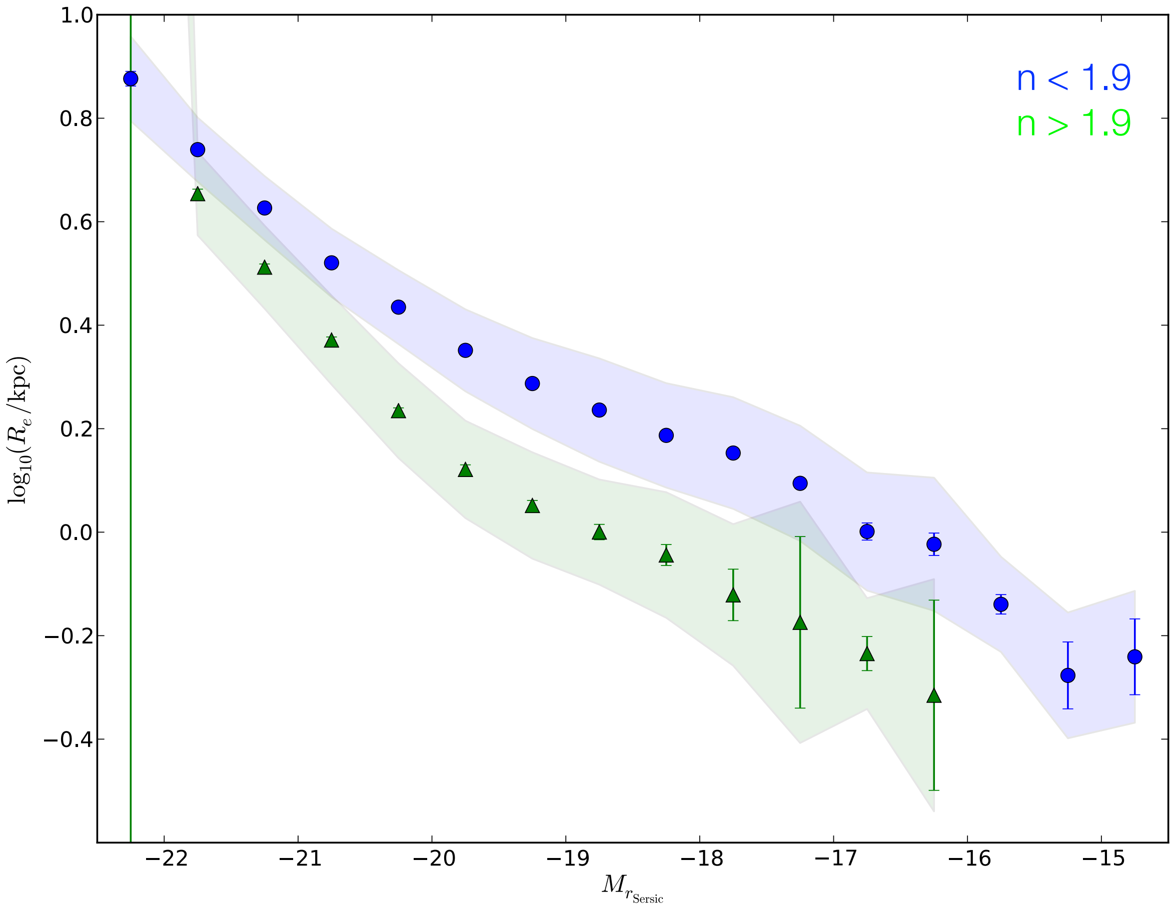




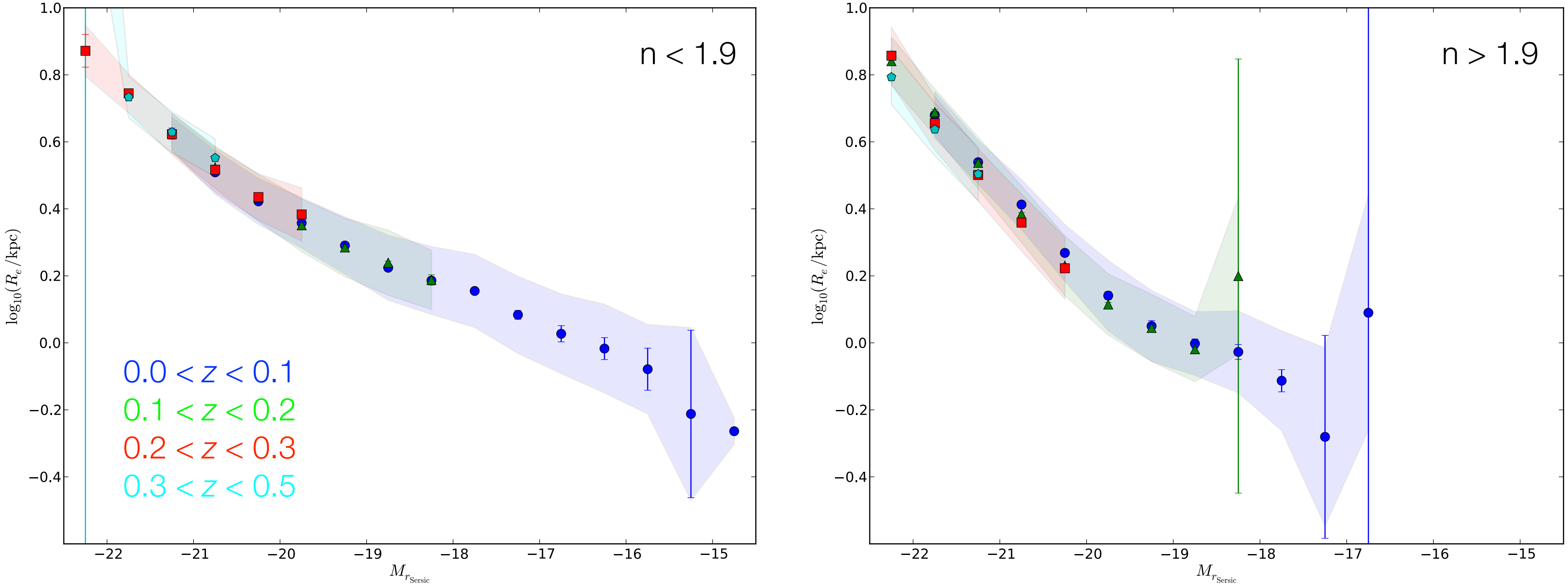




Luminosity-size relation by Sersic index

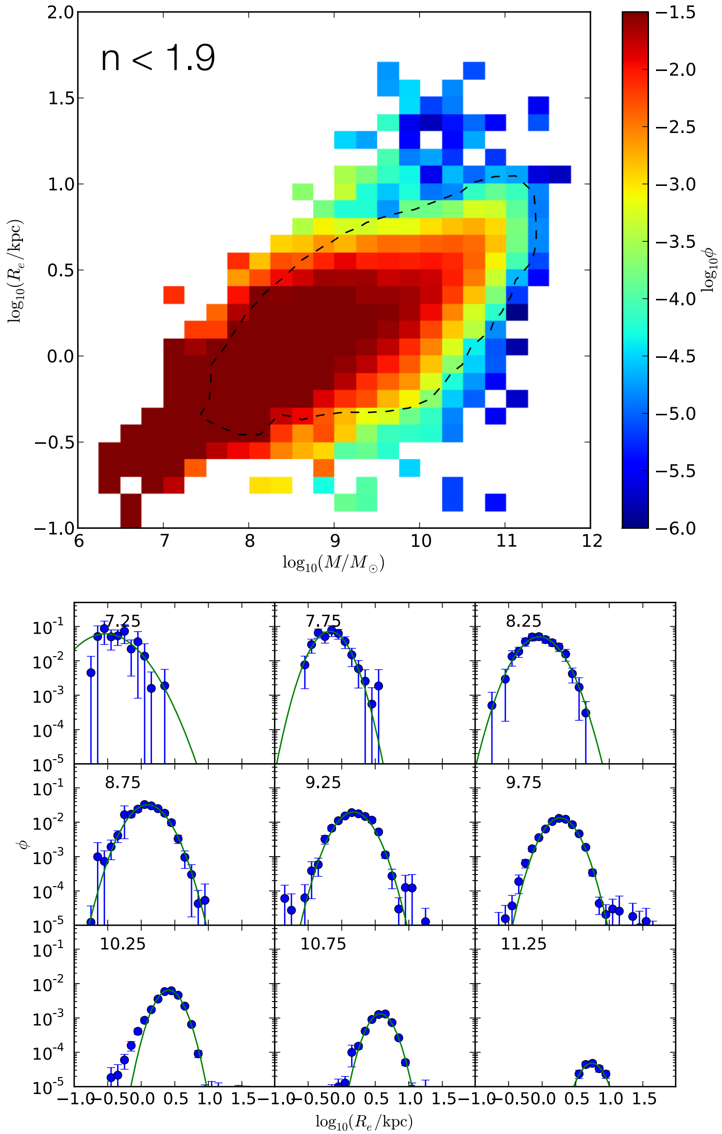


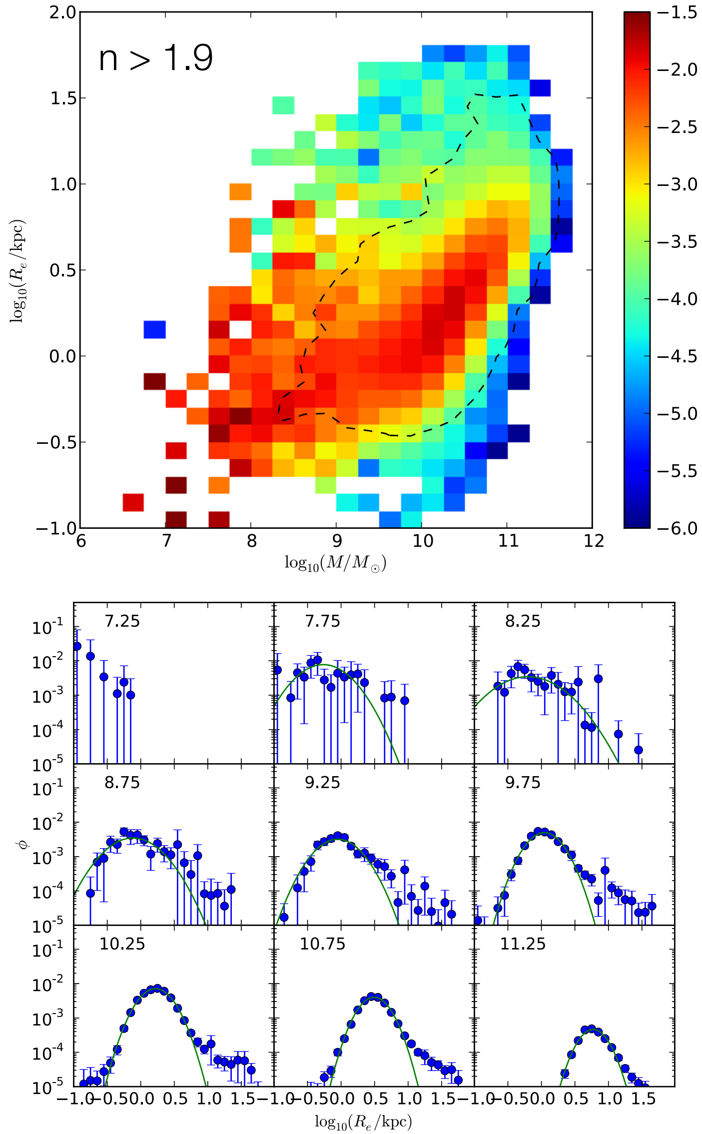
Evolution of luminosity-size relation



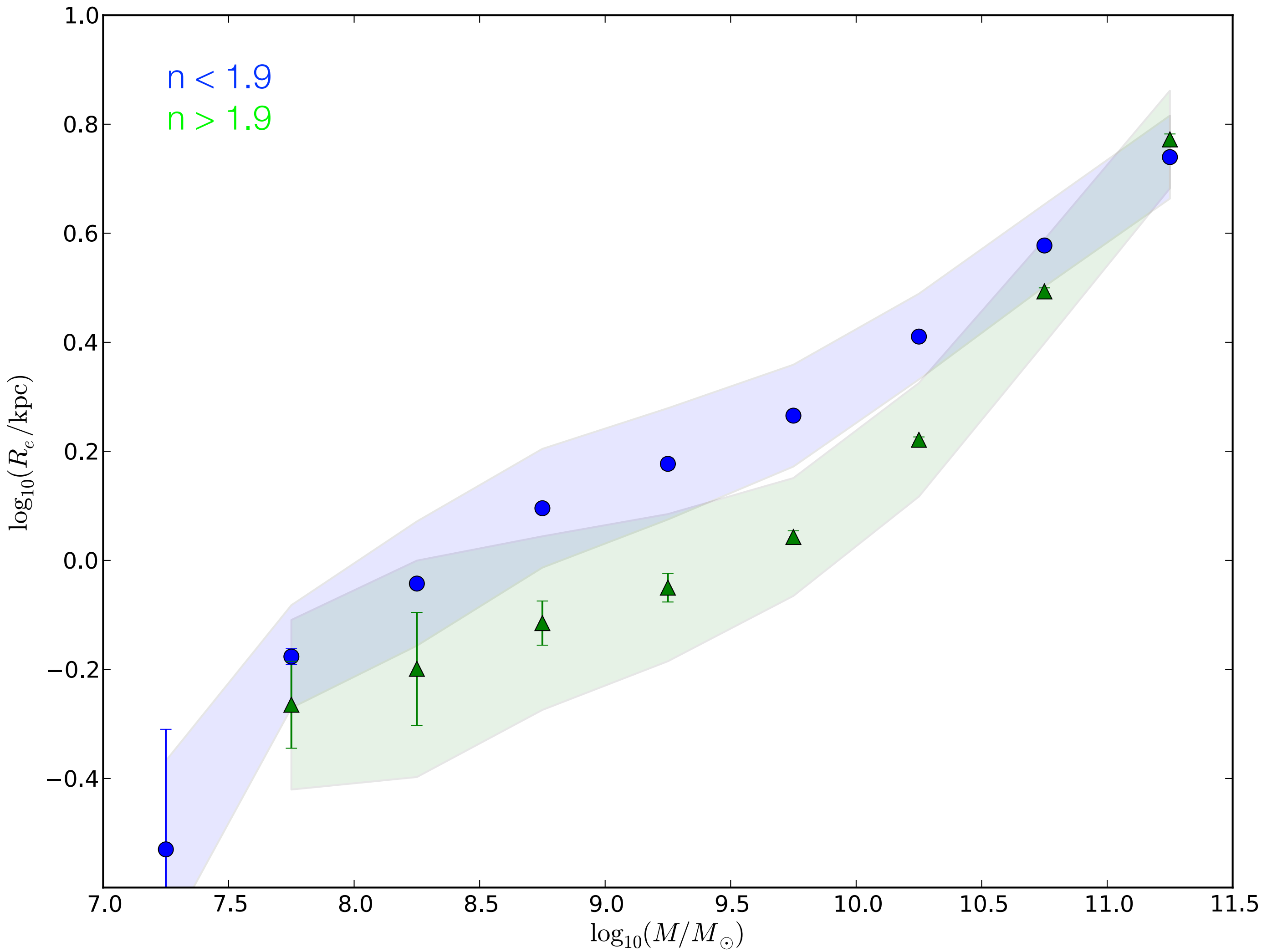
- No size evolution for exponential-profile galaxies
- For de-Vauc profile galaxies, R_e has increased by ~10% since z ~ 0.2

Mass-size relation by Sersic index

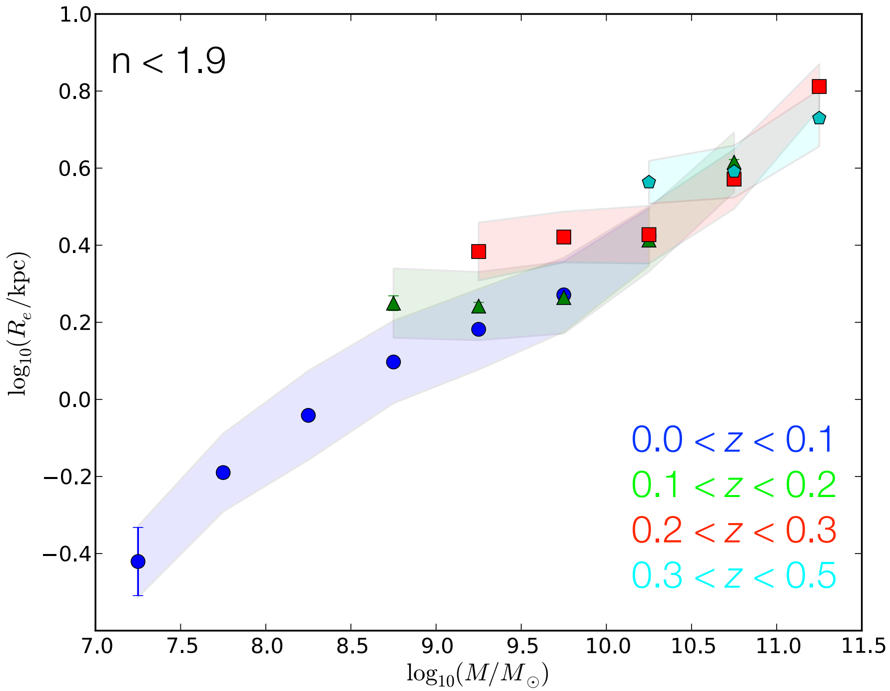


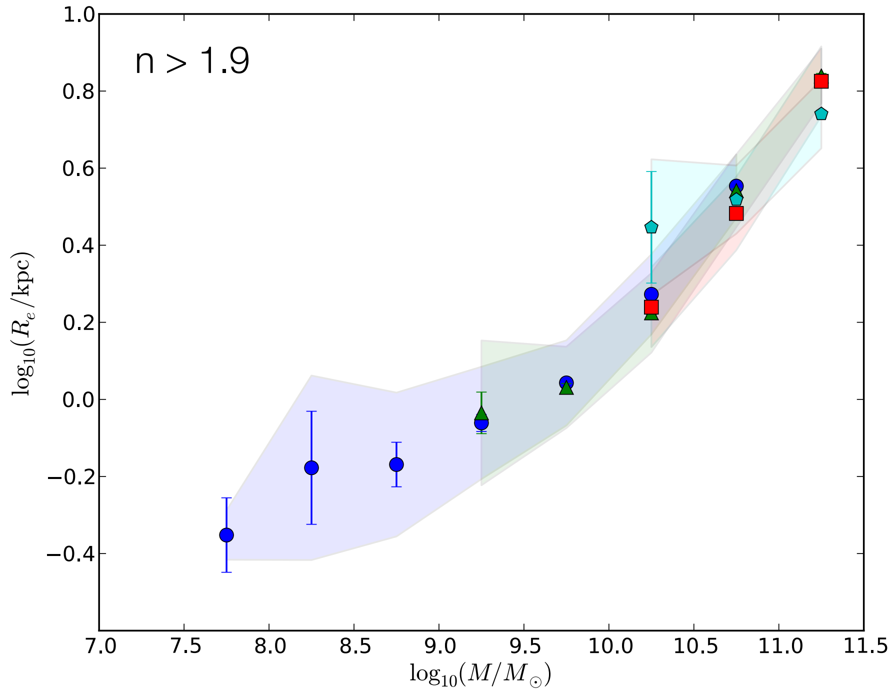


Mass-size relation by Sersic index



Evolution of mass-size relation





- In fixed mass bins, exponential-profile galaxies were larger in the past (fading?)
- For de-Vauc profile galaxies, R_e has increased by ~10% since z ~ 0.2
- NB no mass evolution assumed

Summary

- GAMA-II *r*-band LF well fit by evolution model with Q = 1.12, P = 0.05
- 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 ~10% since z ~ 0.2
- (Non e-corrected) mass-size distribution:
  - Late-type galaxies larger in past in fixed mass bins
  - Early-types grow by ~10% since z ~ 0.2
- Future work:
  - Apply to GAMA-II dataset, later VST KIDS imaging
  - Interpolate radius to fixed restframe band
  - Investigate environmental dependence