Galaxy and Mass Assembly (GAMA): Galaxy Pairwise Velocity Dispersion

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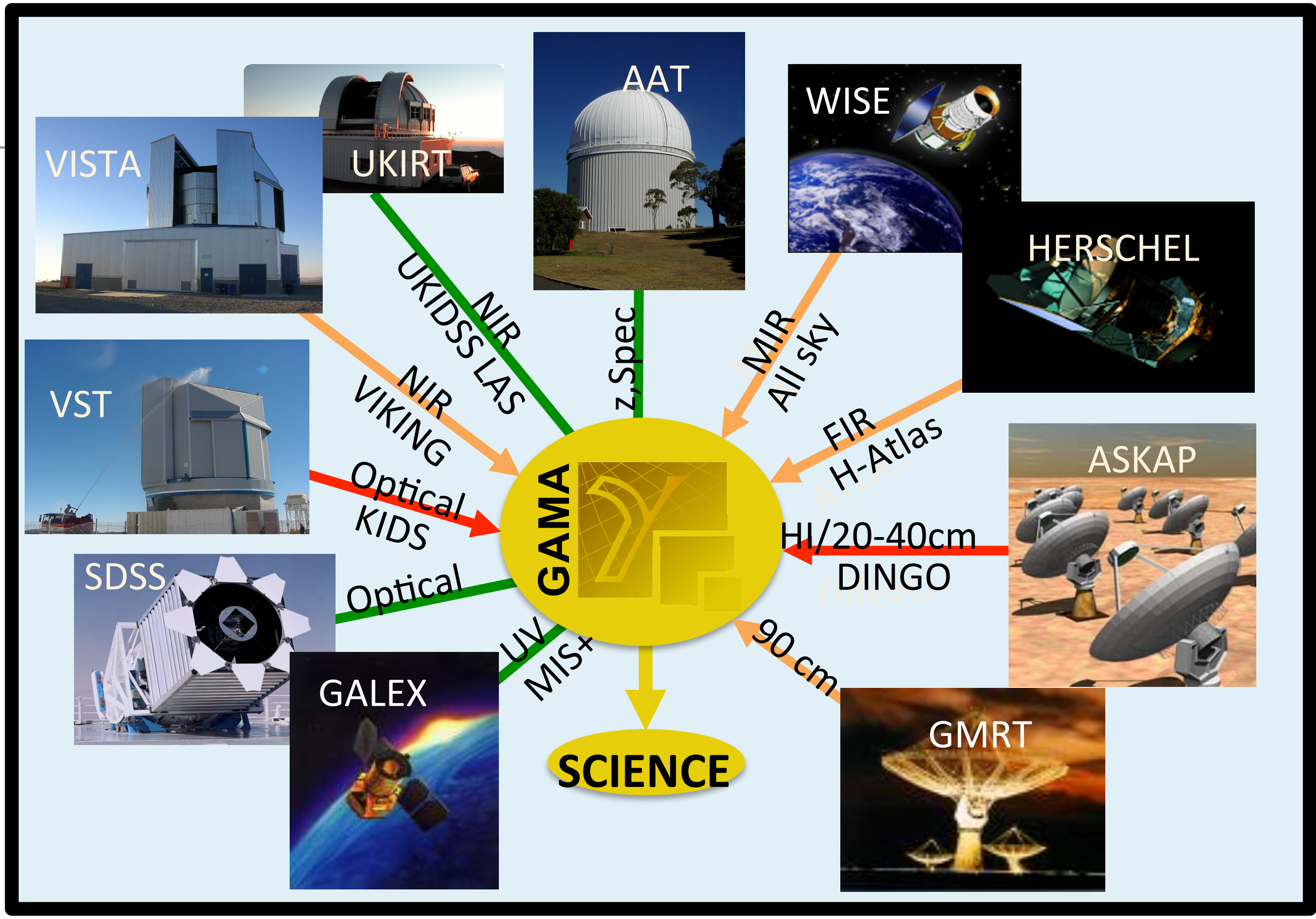
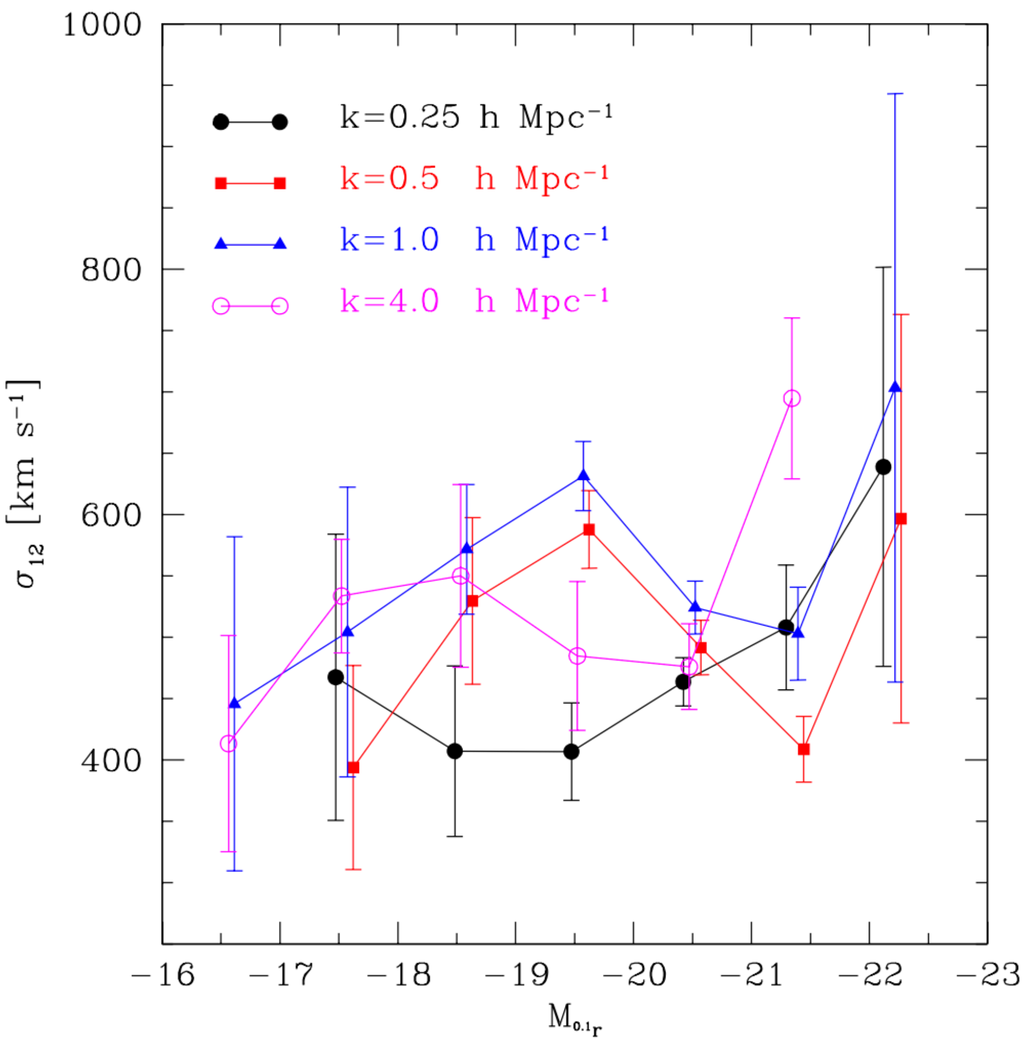


Motivation - why measure PVD?

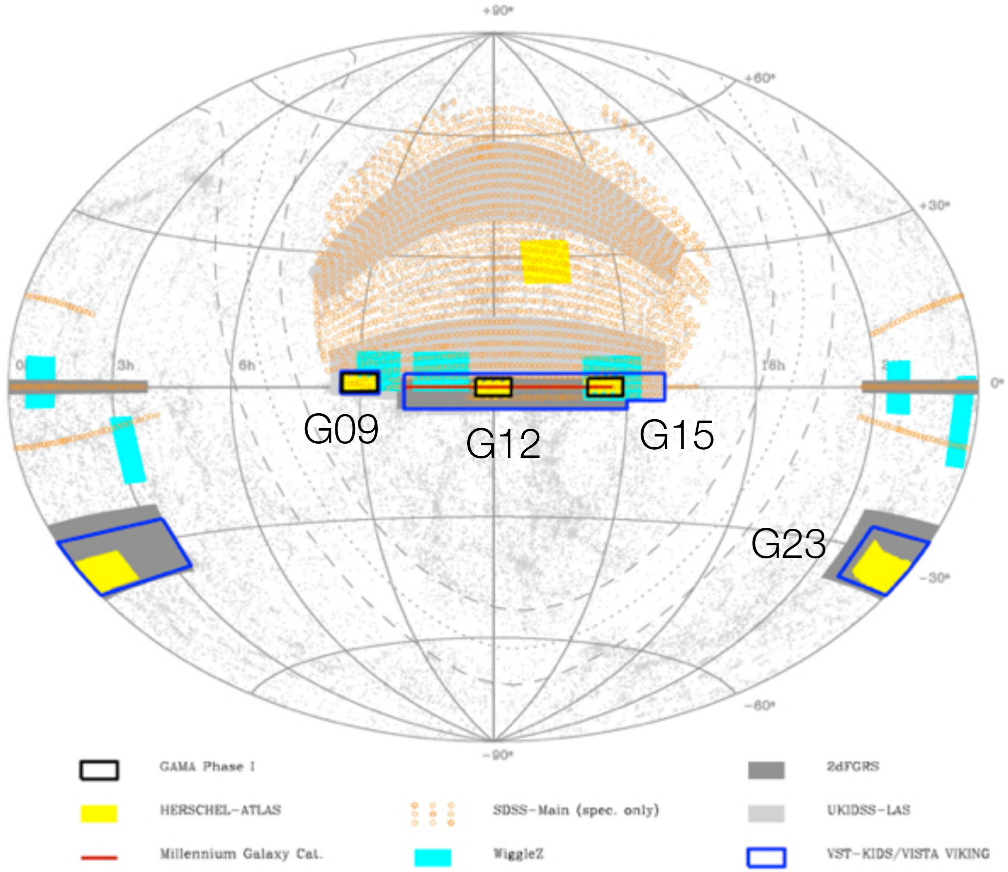
- Quantify FoG effect
  - Needed to model linear infall
- Constrain HOD models (dependence on stellar mass and scale, e.g. Tinker+ 2007)
- Clarify luminosity-dependence
- Test modified gravity models (Wojciech Hellwing, Tuesday)



Li+ 2006, MNRAS, 368, 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, G15) now complete:
  - 183,010 galaxies with reliable redshifts (96.7% success rate)
  - Mean redshift z = 0.23
- Derived parameters: stellar masses, groups, environment
- Matched-aperture photometry GALEX-SDSS-UKIDSS

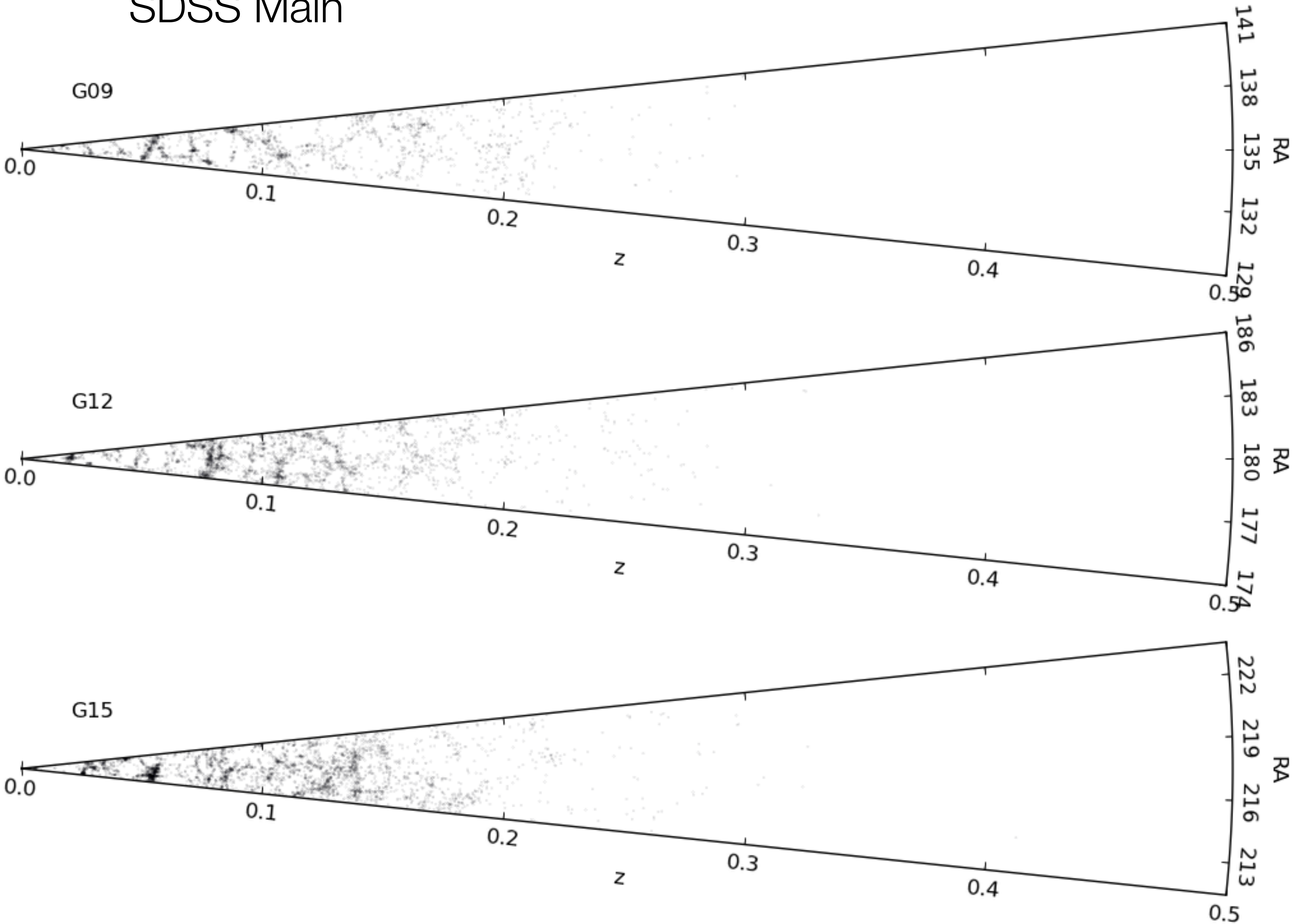


www.gama-survey.org

Advantages of GAMA over SDSS

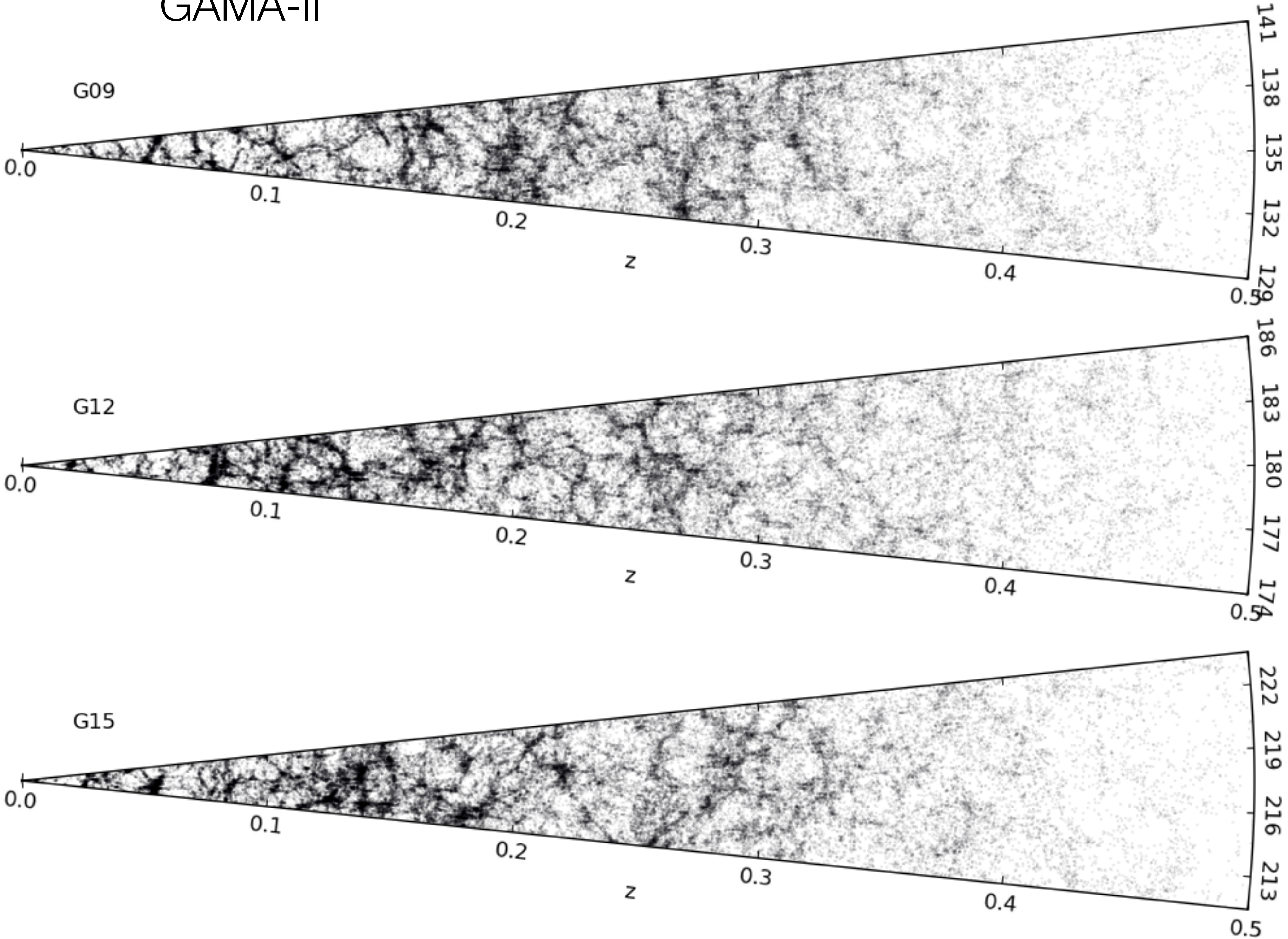
- Twice the depth of SDSS main sample → fair and complete sample 2 mag fainter
- ~98% complete spectroscopic coverage in high-density regions
  - No need to correct for fibre “collisions”
- Wide range of panchromatic observations

SDSS Main



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

GAMA-II



G09
0.0
0.1
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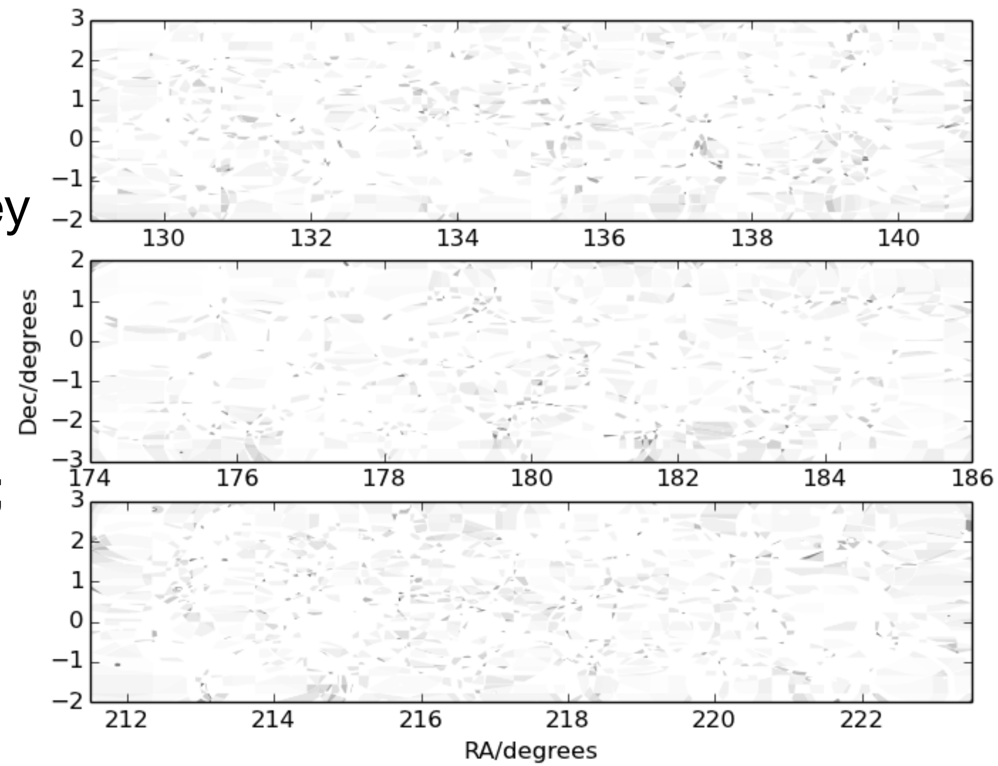
216
213

Galaxy clustering measurements

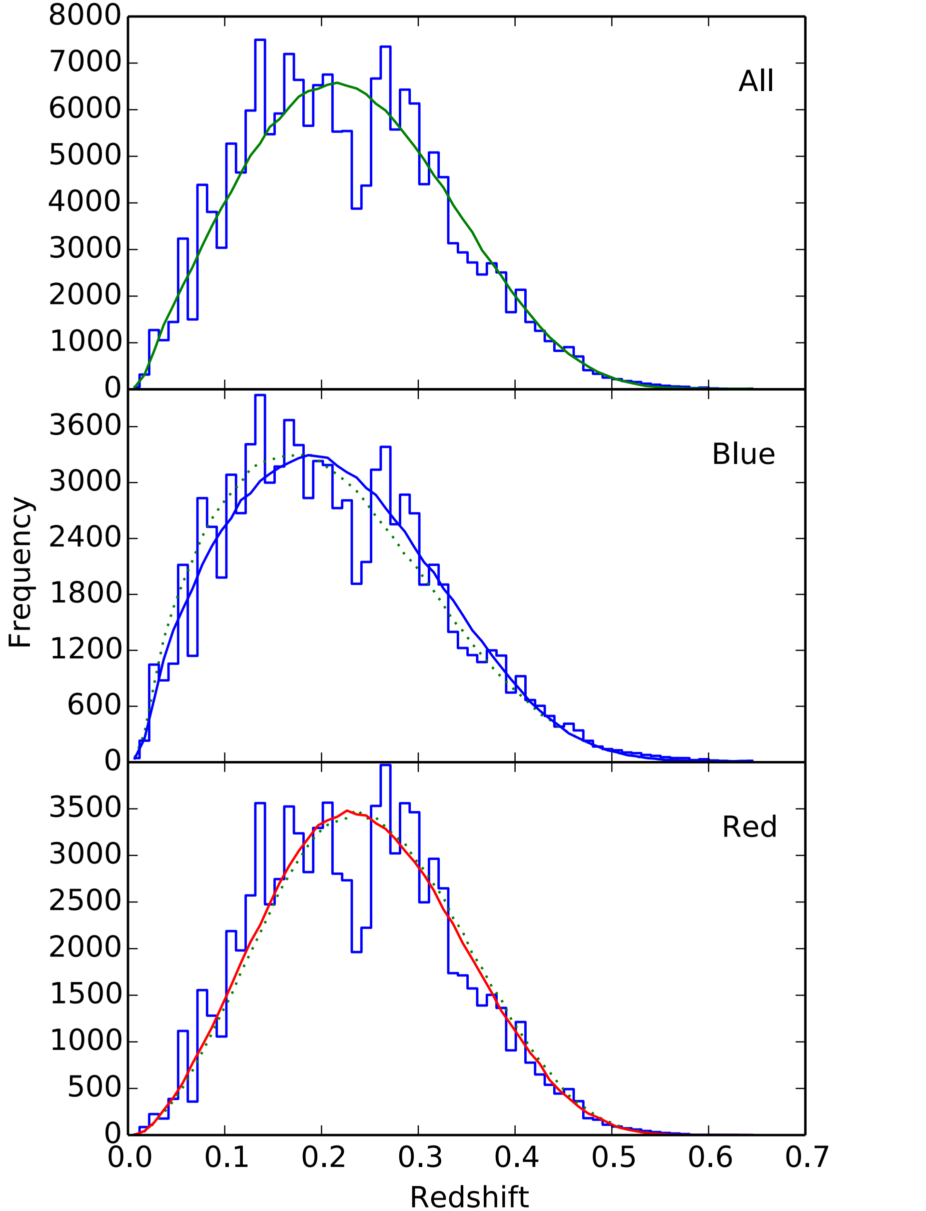
- Two-point correlation function $\xi(r_\perp, r_\parallel)$: excess probability of observing two galaxies separated by distance $r_\perp$ perpendicular to los, $r_\parallel$ parallel to los
- Integrate along los to obtain *projected correlation function* $w_p(r_\perp)$
- Invert to obtain real-space $\xi(r)$
- Use random points to allow for survey geometry and selection function
- Survey geometry (and redshift completeness) tracked using MANGLE (Hamilton & Tegmark 2004; Swanson+ 2008)



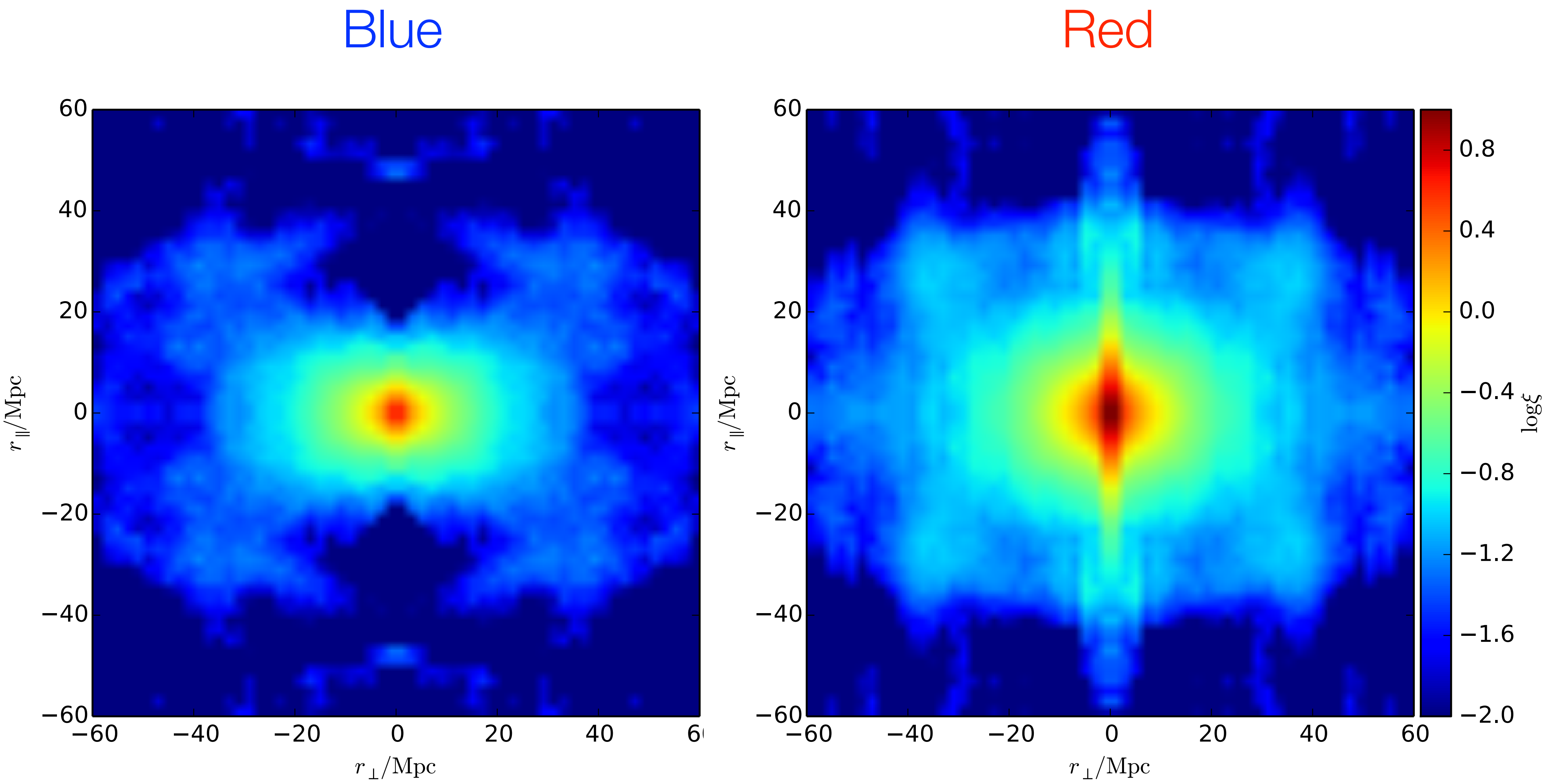
GAMA completeness mask

Radial selection function

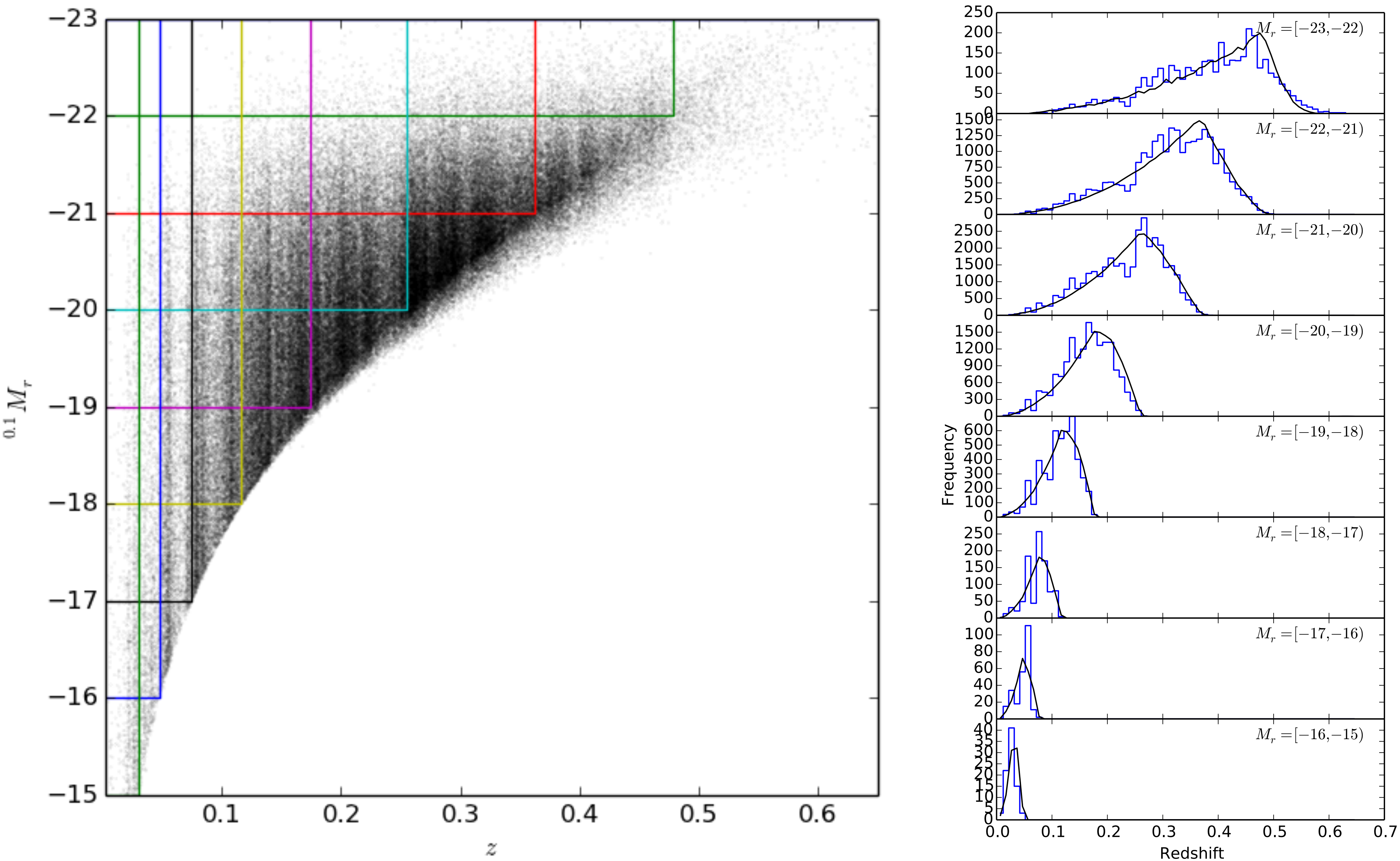
- Radial distribution of random points for any subsample generated using method of Cole 2011:
  - Determine overdensity $\Delta(z)$ in radial shells, LF and its evolution using max-L
  - Luminosity (Q) and density (P) evolution parametrized by (Lin+ 1999):
    - $M_c(z) = M + Q(z - z_0)$
    - $\Phi^*(z) = \Phi^*(0) \times 10^{0.4Pz}$
  - Find $Q \approx 0.7$, $P \approx 1.7$
- For volume-limited sample, simply generate randoms uniformly in $P(z)\, dV/dz$ within $[z_{min}, z_{max}]$



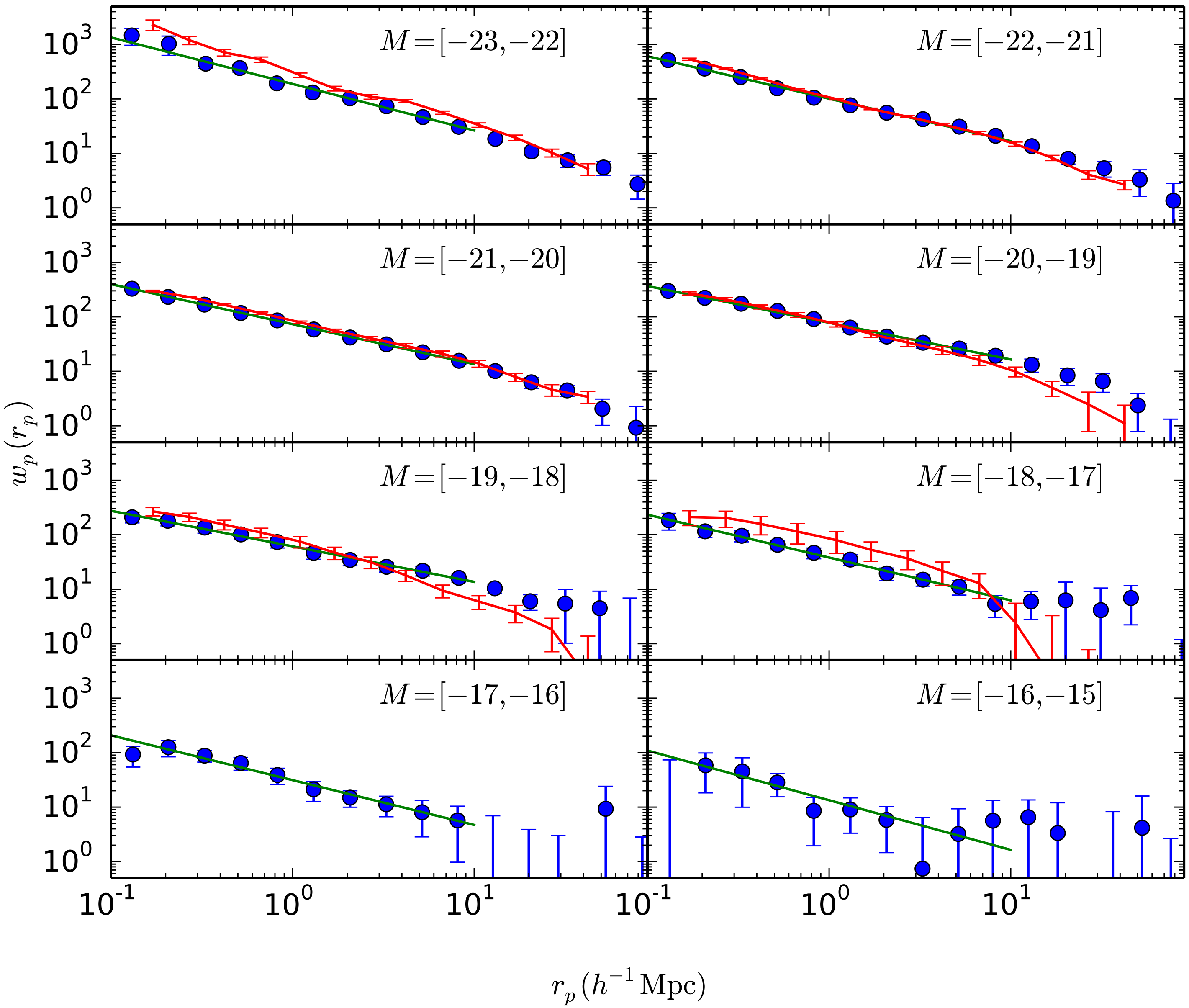
Galaxy clustering by colour



Luminosity subsamples

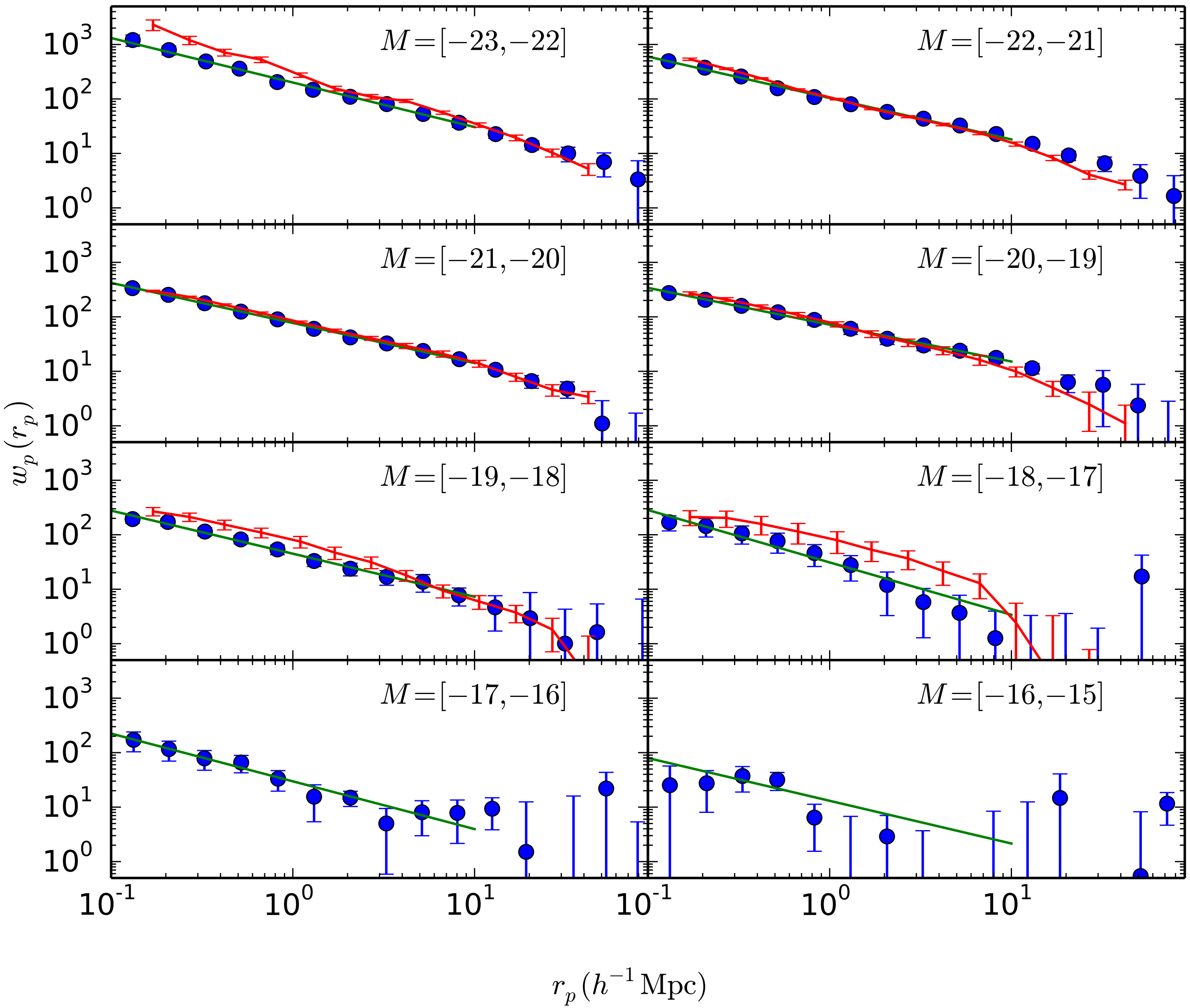


Magnitude-limited luminosity subsamples



SDSS
(Zehavi+ 2011)

Volume-limited luminosity subsamples



SDSS
(Zehavi+ 2011)

Estimating pairwise velocity dispersion (PVD)

- "Streaming model" (Peebles 1980, Davis & Peebles 1983, Zehavi+ 2002):

$$1 + \xi(r_\perp, r_\parallel) = H_0 \int_{-\infty}^{\infty} \left[1 + \xi_r \left(\sqrt{r_\perp^2 + y^2} \right) \right] f(v) dy$$

$$f(v) = \frac{1}{\sqrt{2}\sigma_{12}} \exp\left(- \frac{\sqrt{2}|v|}{\sigma_{12}} \right)$$

$$v \equiv H_0(r_\parallel - y) + \bar{v}_{12}(r)$$

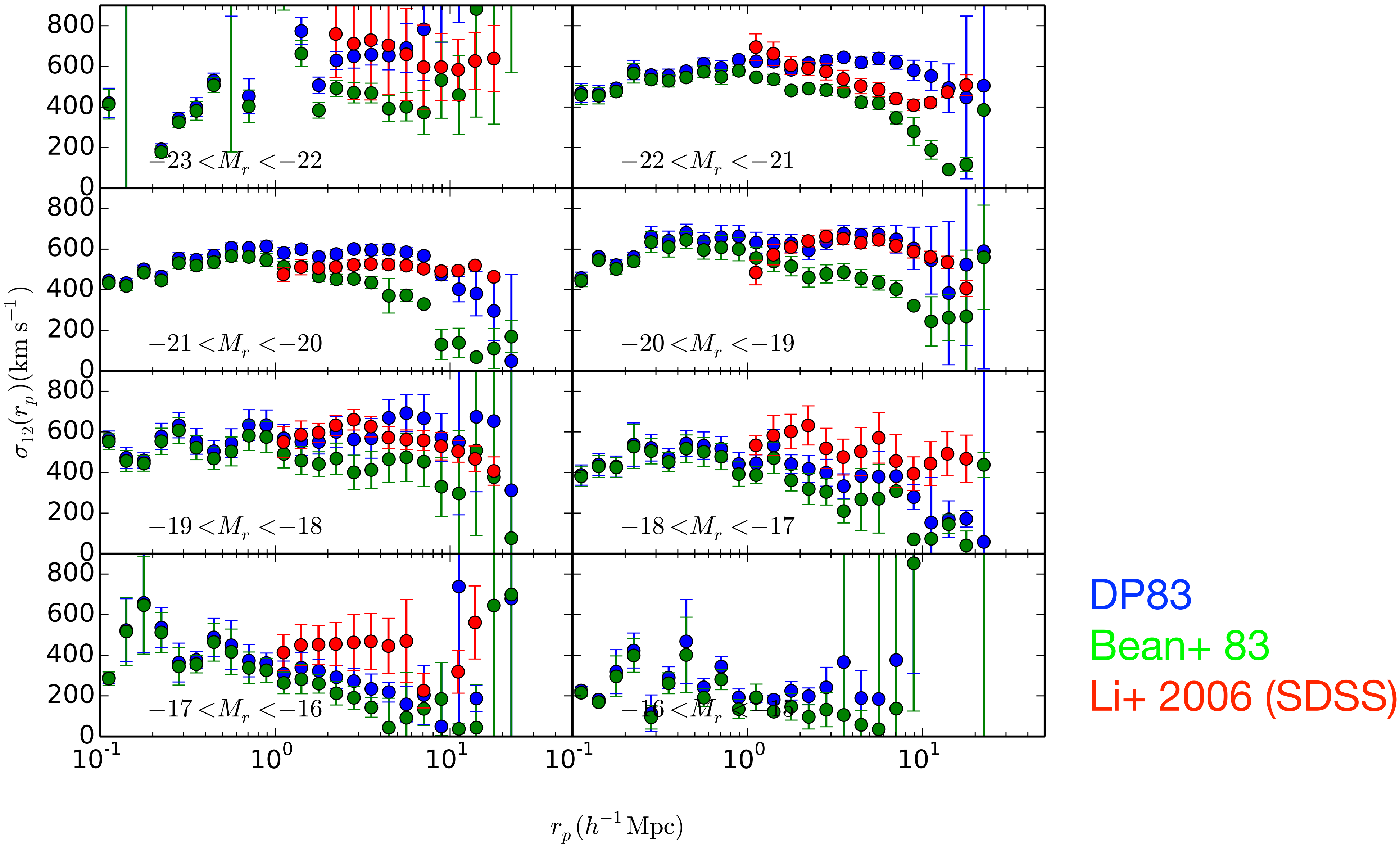
$$\bar{v}_{12}(r) = \frac{H_0 y}{1 + (r/r_0)^2} \quad \text{(DP83)},\ or$$

$$\bar{v}_{12}(r) = \beta H_0 y \frac{\xi(r)}{1 + \xi(r)} \quad \text{where } \beta = f(\Omega)/b \approx 0.5 \text{ (Bean+ 83)}$$

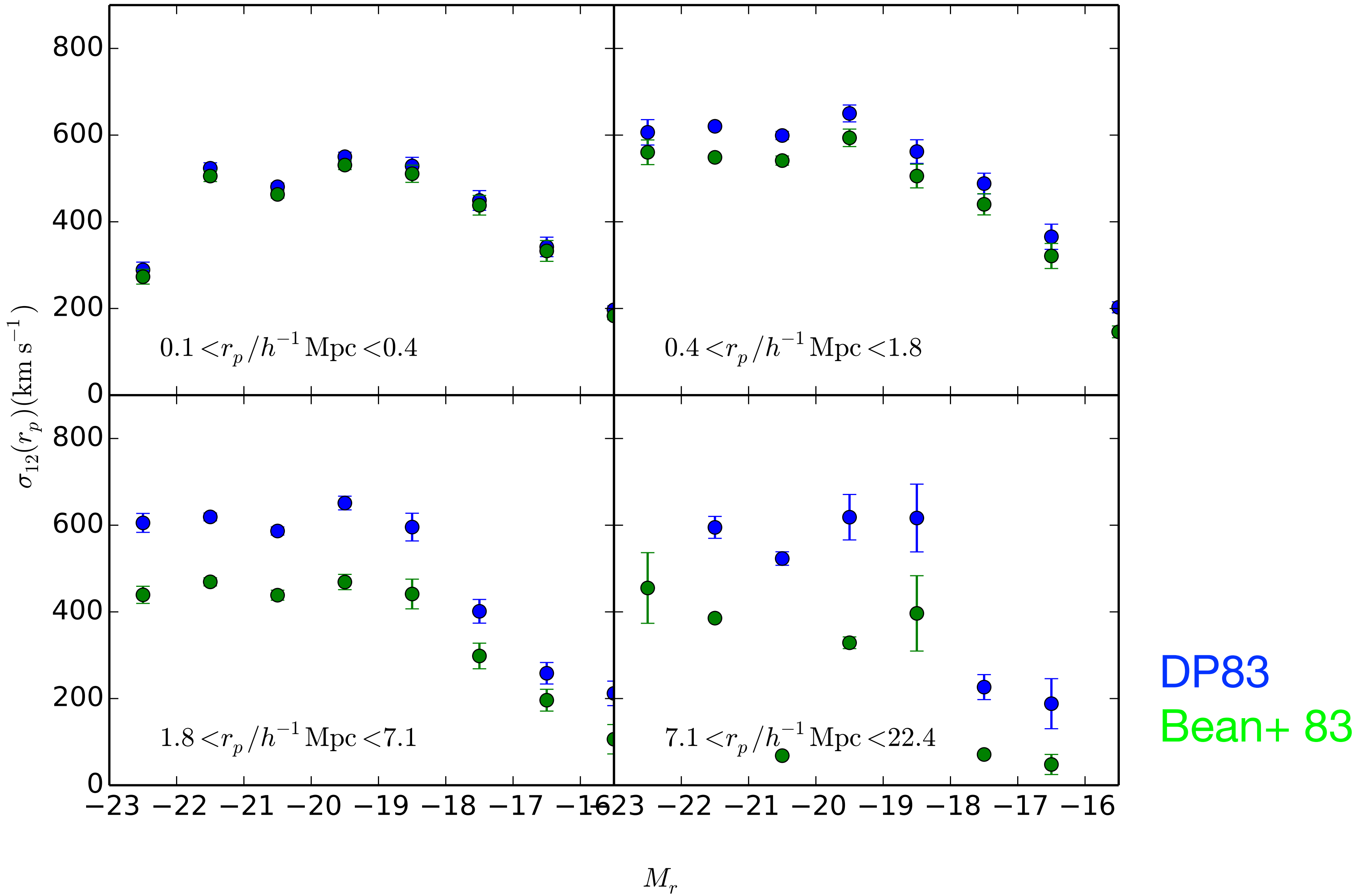
- Alternative ("Kaiser plus damping"; Peacock & Dodds 1994):

$$P_S(k, \mu) = \frac{P(k)(1 + \beta\mu^2)^2}{1 + [k\mu\sigma_{12}(k)]^2/2}$$

PVD scale dependence in luminosity bins



PVD luminosity dependence in separation bins



Summary

- GAMA provides ideal sample for PVD measurements due to:
  - wide variety of galaxy types/masses
  - high redshift completeness in dense regions
- PVD measured to smaller scales and for lower luminosity galaxies than previous work (Jing & Borner 2004, Li et al. 2006)
- No strong scale-dependence for most lim bins
- At small scales, PVD highest (~500 km/s) at intermediate luminosities, drops at both faint and (possibly) bright ends
- Future work:
  - Use covariance in $\xi(r_\perp, r_\parallel)$
  - Test different streaming models using GAMA mocks
  - Simultaneous fitting of $P(k)$, β and σ_{12}
  - Dependence of PVD on location within cosmic web, stellar mass, redshift
  - Test of modified gravity (Hellwing+ 2014)