The Luminosity and Mass Functions of Low-Mass Stars in the Galactic Disk: The Field

Bochanski et al. 2010

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Stellar Populations

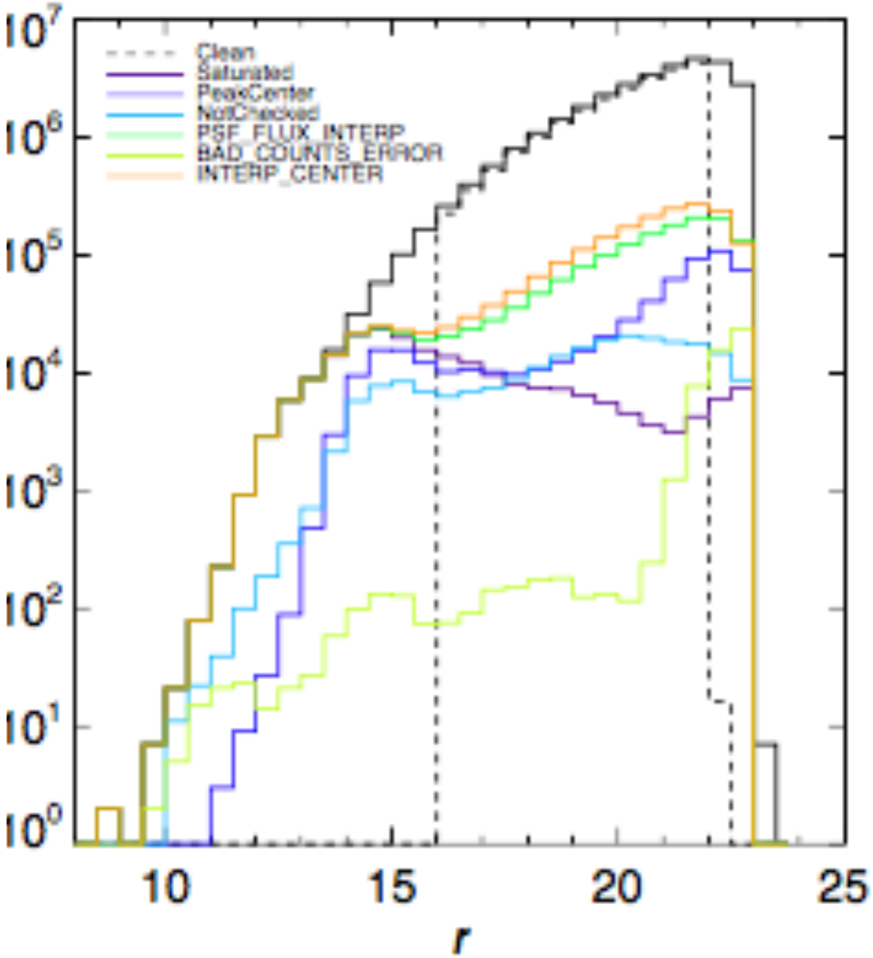
Overview

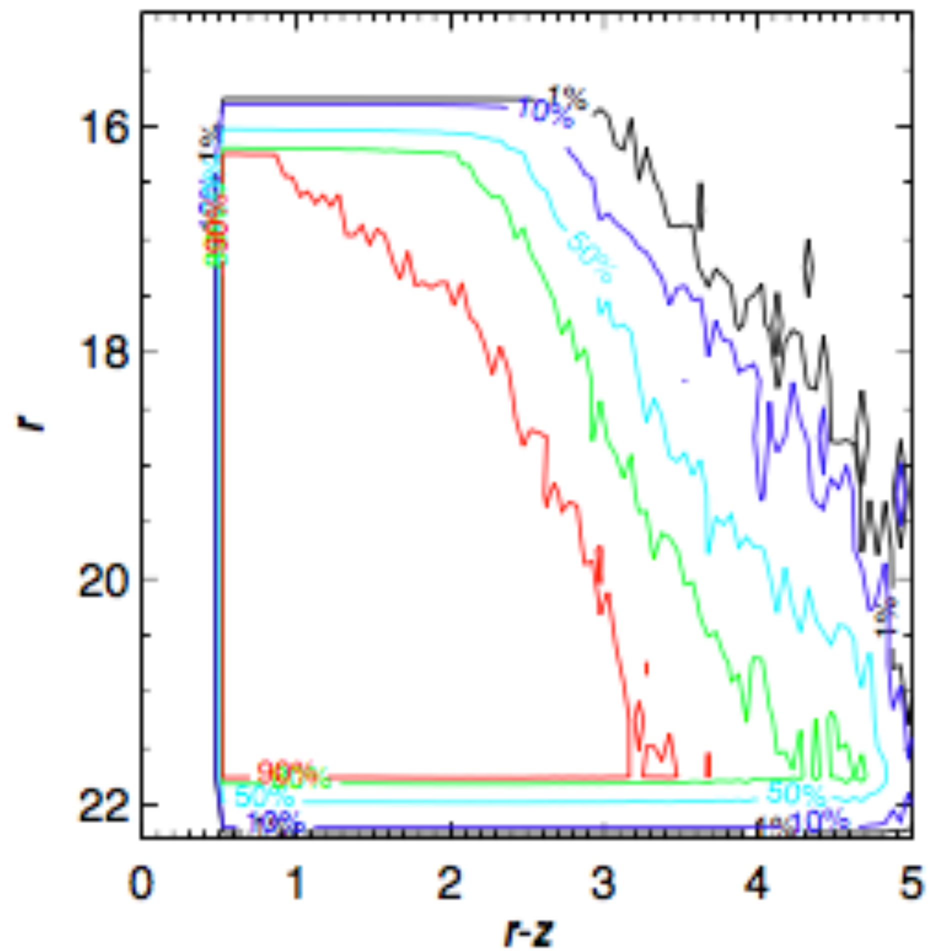
- Measurement of LF and MF of field low mass dwarfs
- SDSS Data Release 6, ~15 million low mass stars over 8,400 square degrees (0.1-0.8 M_sun)
- System MF, from -1.0 <log(M/M_sun) <-0.1, described by log normal distribution with Mo = 0.25 M_sun.

Two main observing techniques

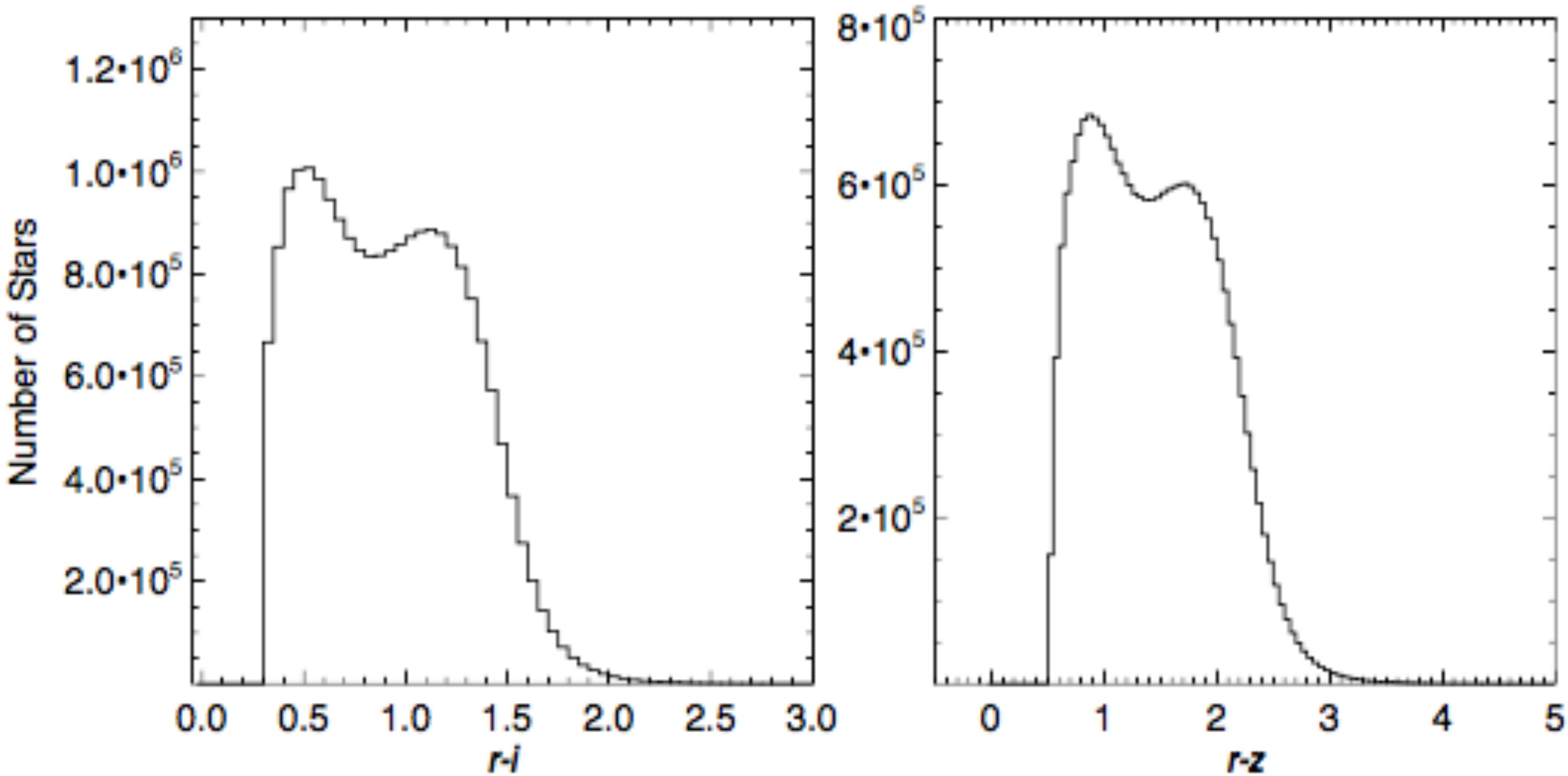
- Two techniques resulting from a trade-off in observing strategy:
  - Nearby, volume limited studies of trig. Parallax stars
  - Pencil-beam surveys of distant stars over a small solid angle
- Both yield sample sizes of a few thousand stars, prohibiting statistical measurements
- There is considerable disagreement between these two techniques (Reid & Gizis 1997, Zheng et al. 2001)

Detailed Sample Selection





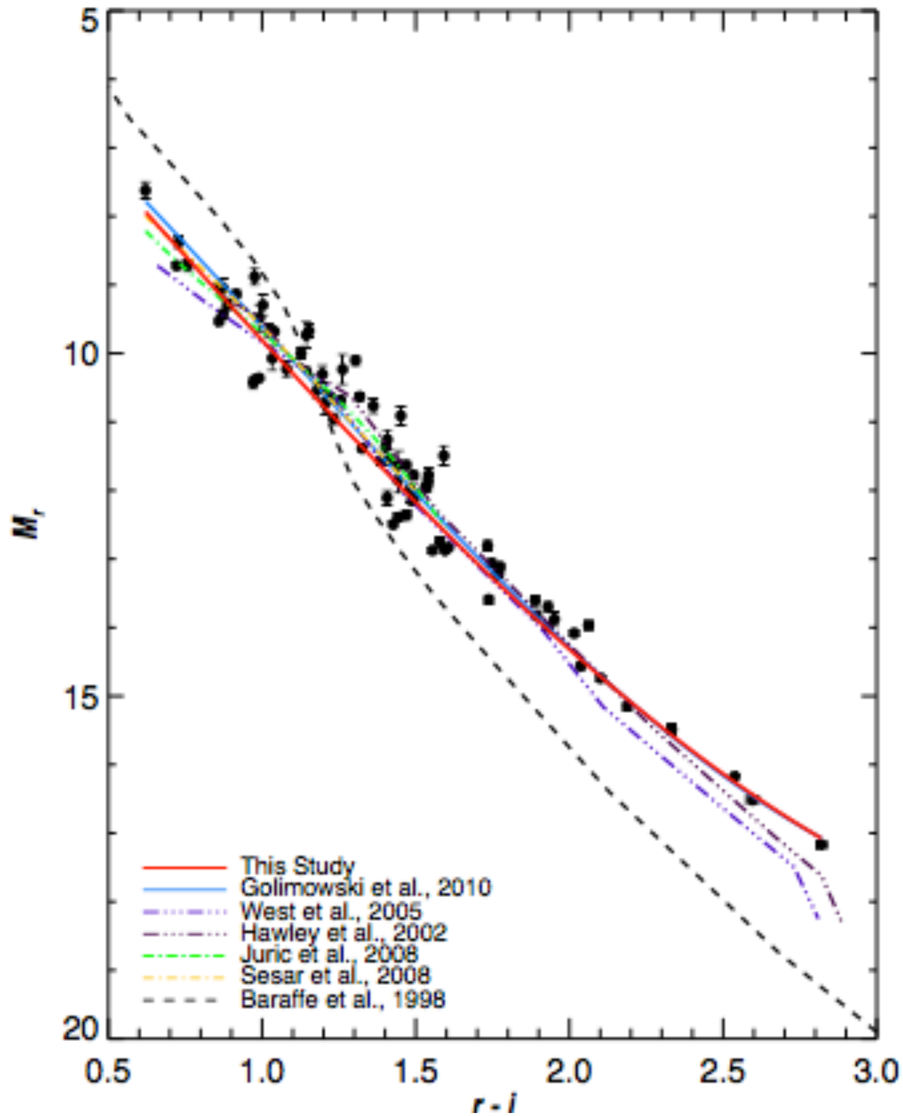
Histograms of color for final stellar sample



Photometric Parallax

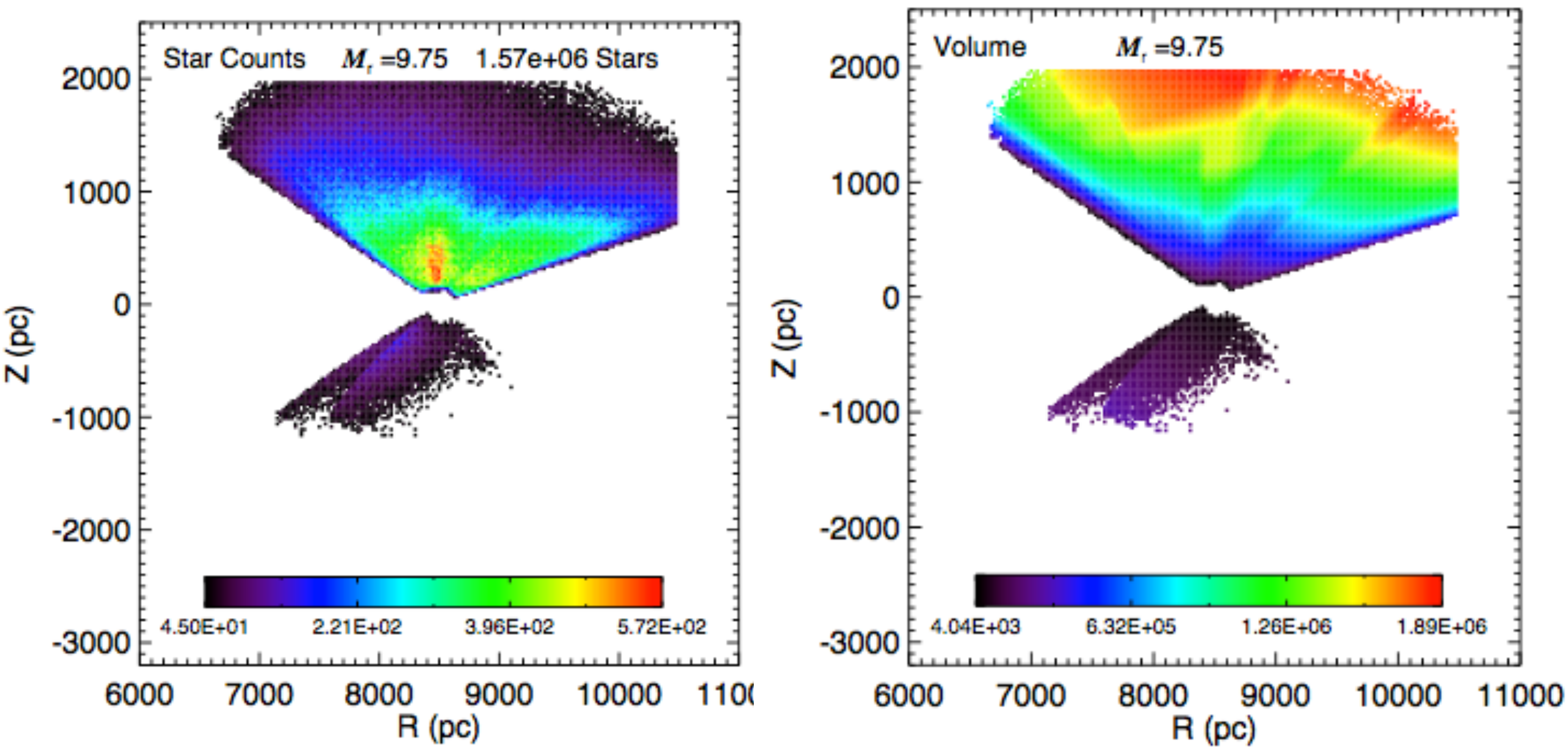
- Trig parallaxes not available for most faint SDSS stars
- Photometric parallaxes use a star's color to determine absolute magnitude

$$m_{\lambda,1} - M_{\lambda,1}(m_{\lambda,1} - m_{\lambda,2}) = 5\log d - 5$$



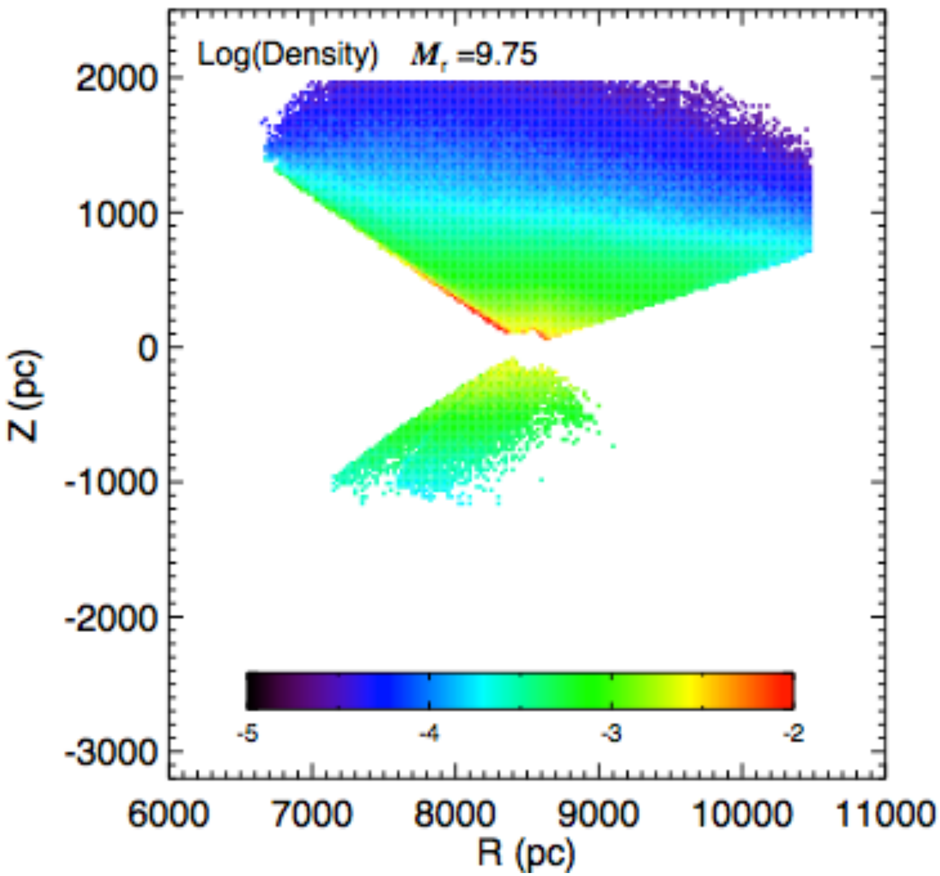
Approximating the Density Profile

- Data-set three orders of magnitude higher than any previous LF study
- 8,400 square degrees is 300 times larger than next largest sample
- Others assumed constant density or calculated Galactic density profile along one line of sight
  - This is not good enough when sample is millions of stars over ¼ of the sky



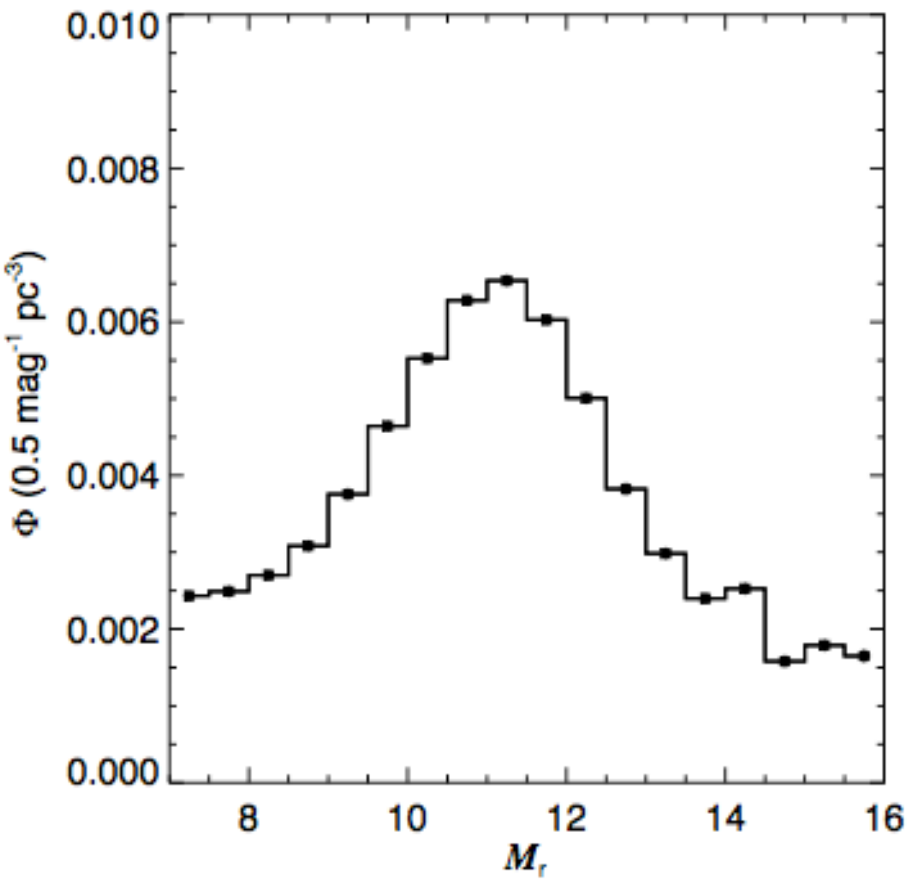
$$\rho(R, Z) = \frac{N(R, Z)}{V(R, Z)}$$

Density Map



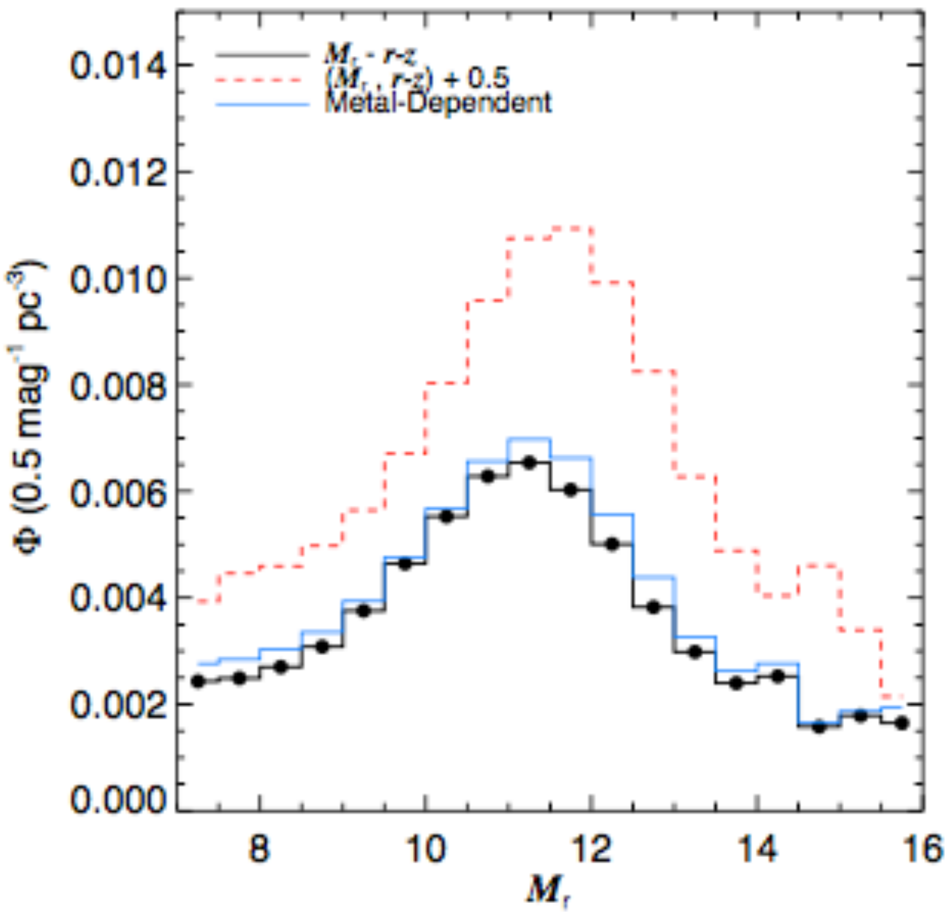
- Density [stars pc^-3] as a function of Galactic R and Z.
- Disk structure of Milky Way is clearly evident with smooth decline in density towards large R and increase toward plane (Z = 0)

Raw Luminosity Function



- Constructed from local densities of each absolute magnitude slice and derived from M_R, r-z CMR
- Needs correction for systematics: unresolved binaries, metallicity gradients, Malmquist bias, interstellar extinction

Metallicity Corrections



- From Ivezic et al. 2008, adopted metallicity gradient

$$[Fe/H] = -0.0958 - 2.77 \times 10^{-4}|Z|$$

- Correction to abs. mag:

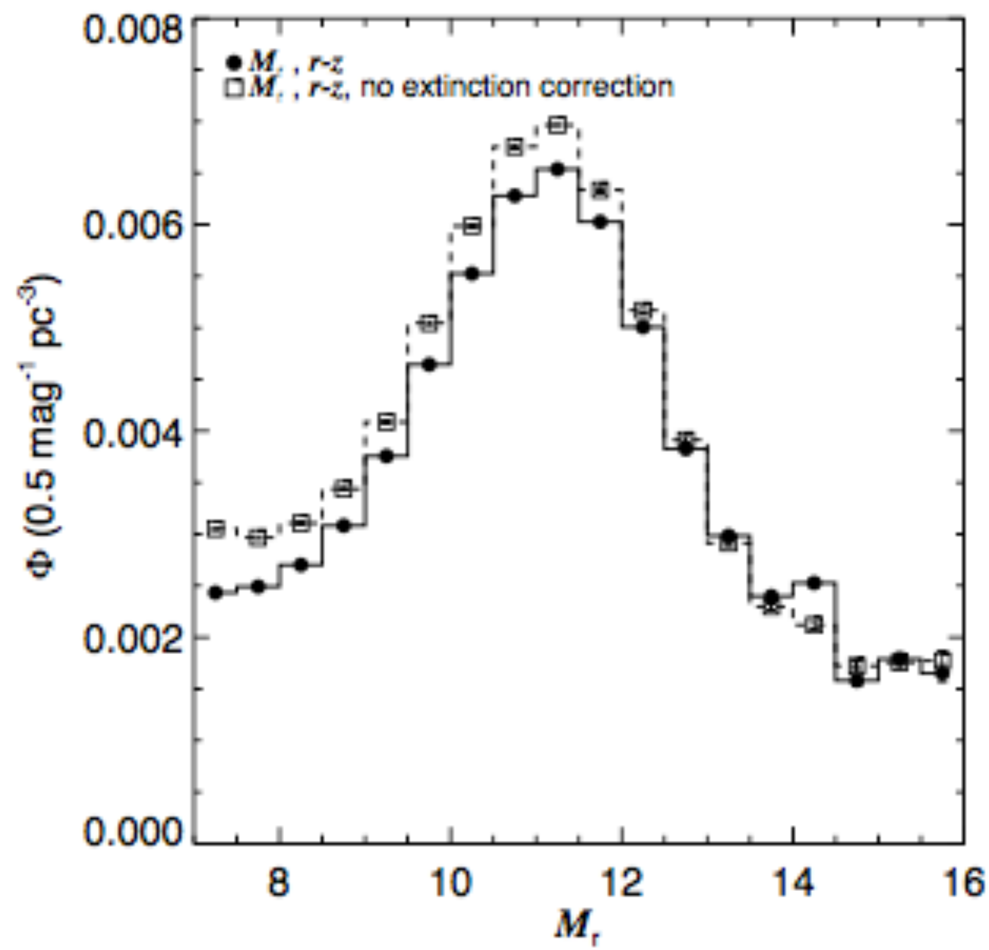
$$\Delta M_r = -0.10920 - 1.11[Fe/H] - 0.18[Fe/H]^2$$

- These eqns lead to star's actual height:

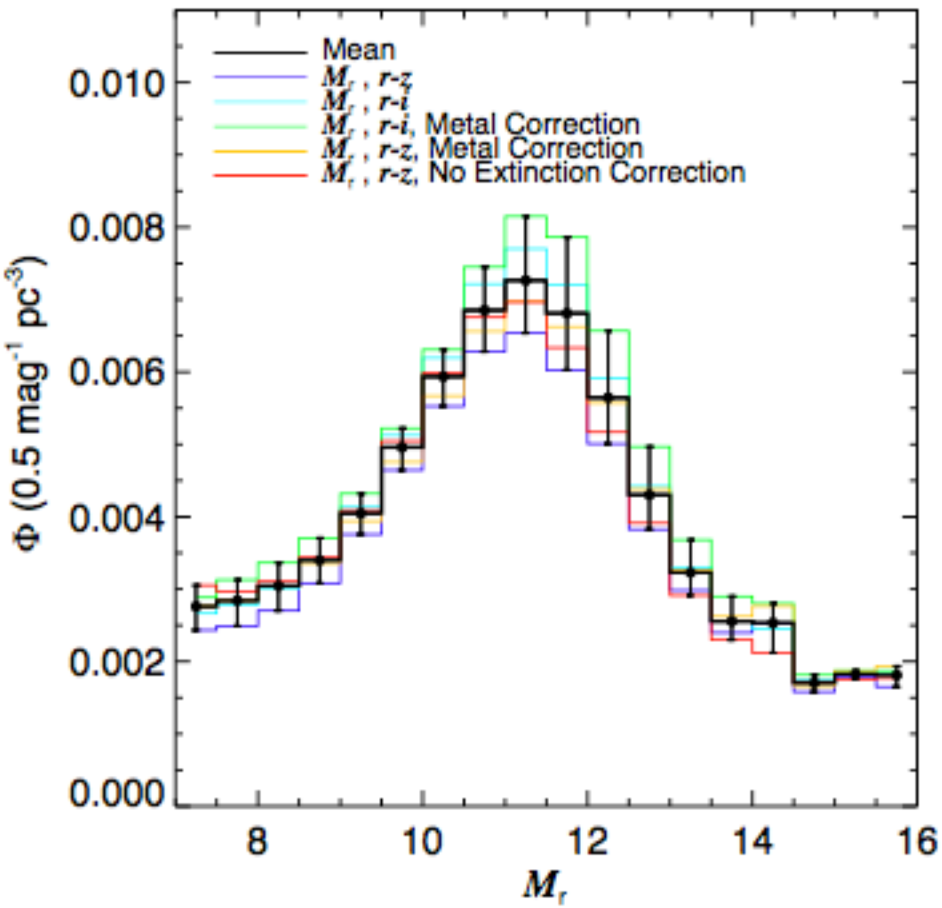
$$Z_{\rm true} = Z_{\rm ini} 10^{\frac{-\Delta M_r(Z_{\rm true})}{5}}$$

Extinction/Reddening

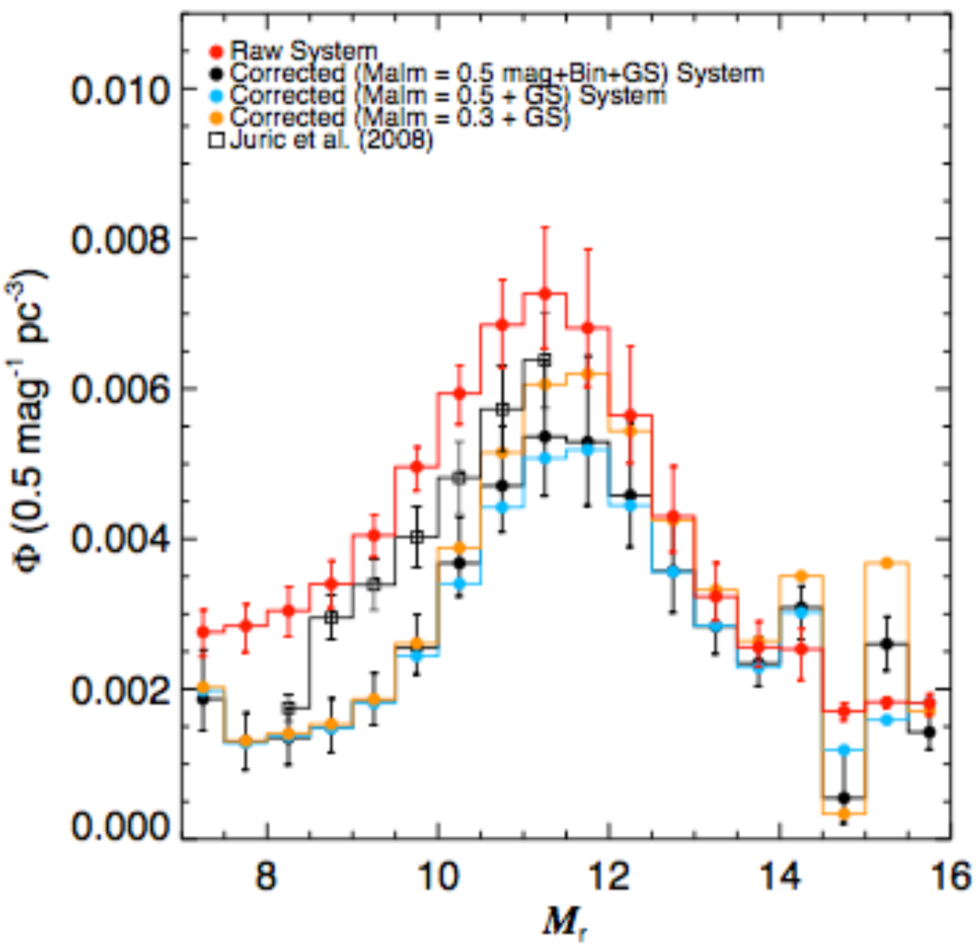
- Typical abs mag diff. due to reddening range up to ~1 mag, yielding a ~40pc distance correction
- Reddening of stars causes the stellar absolute magnitudes to be underestimated.



Mean Observed System LF

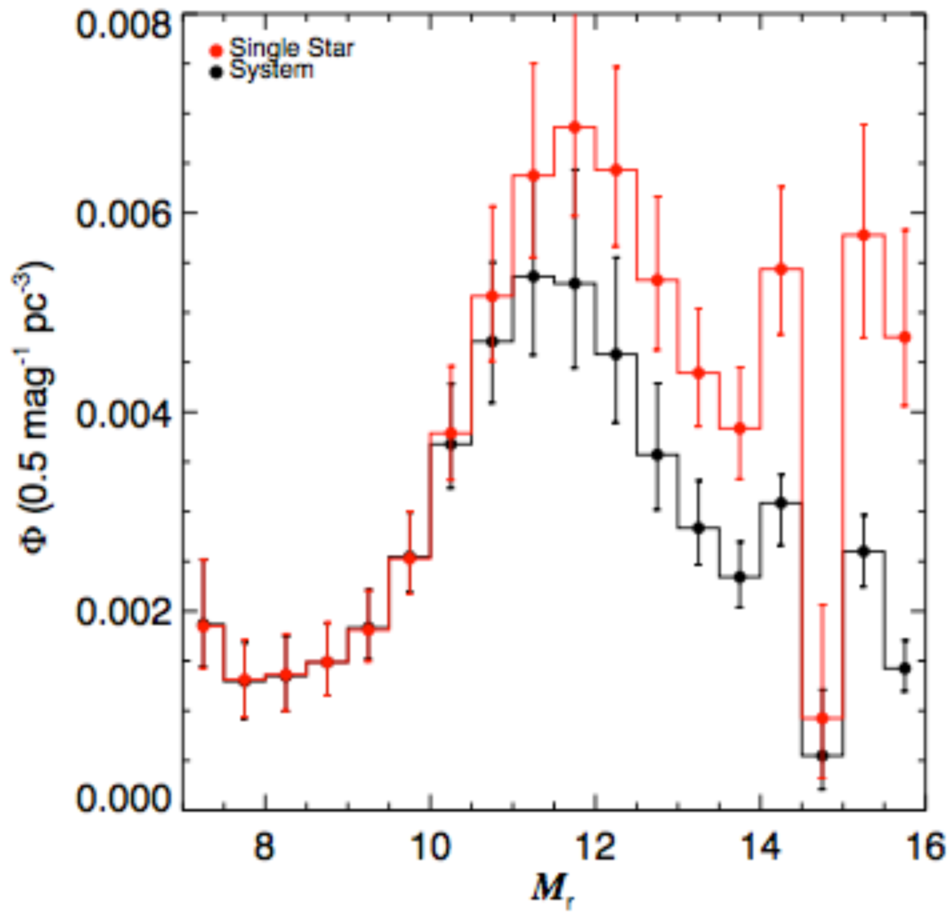


Malmquist Bias

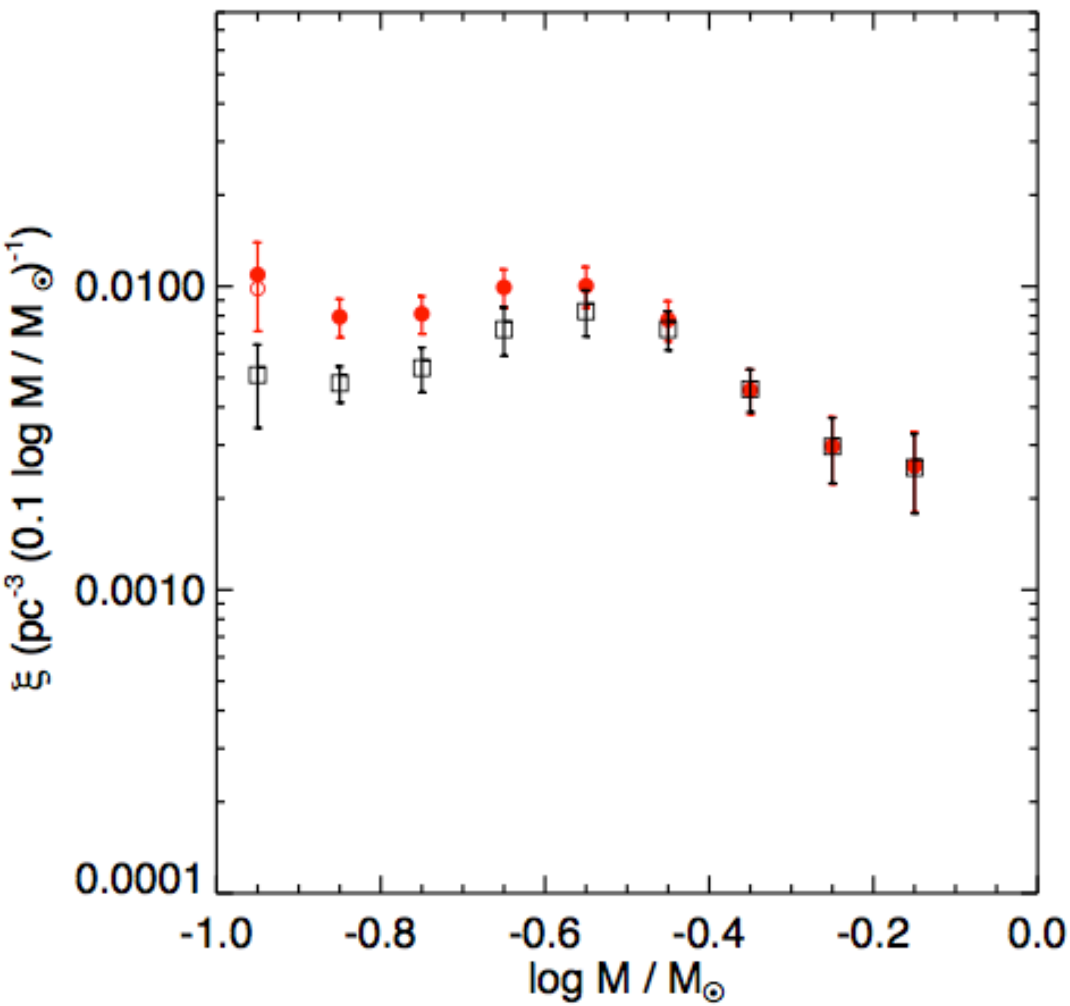


In flux limited surveys, distant stars with higher abs mag scatter into survey volume, have their abs mags overestimated which leads to underestimated distances, thus inflating density and lowering scale height

Unresolved Binaries



Mass Function

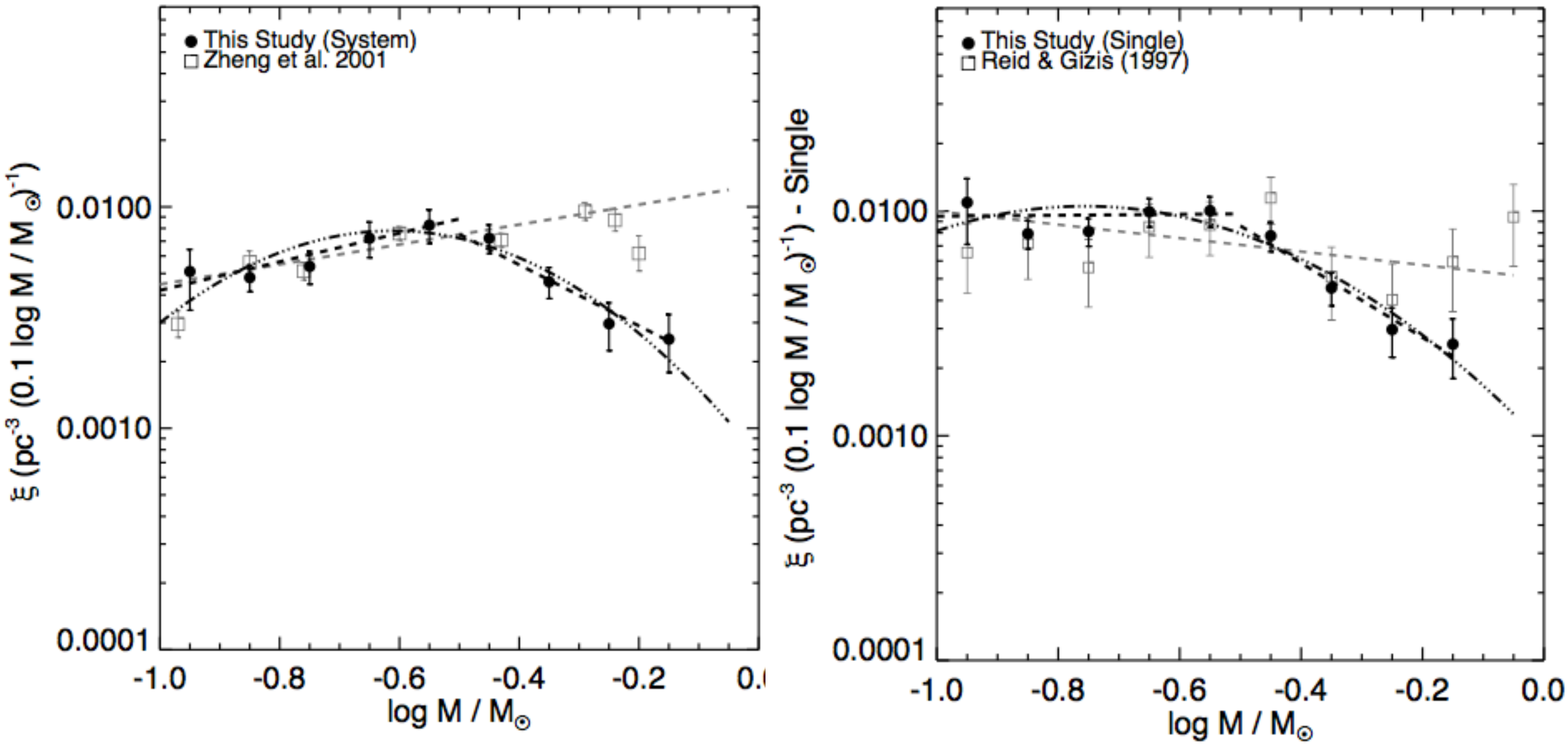


The Mass function was
calculated from the M_J LFs and the Mass-Luminosity relation from Delfosse et al. 2000

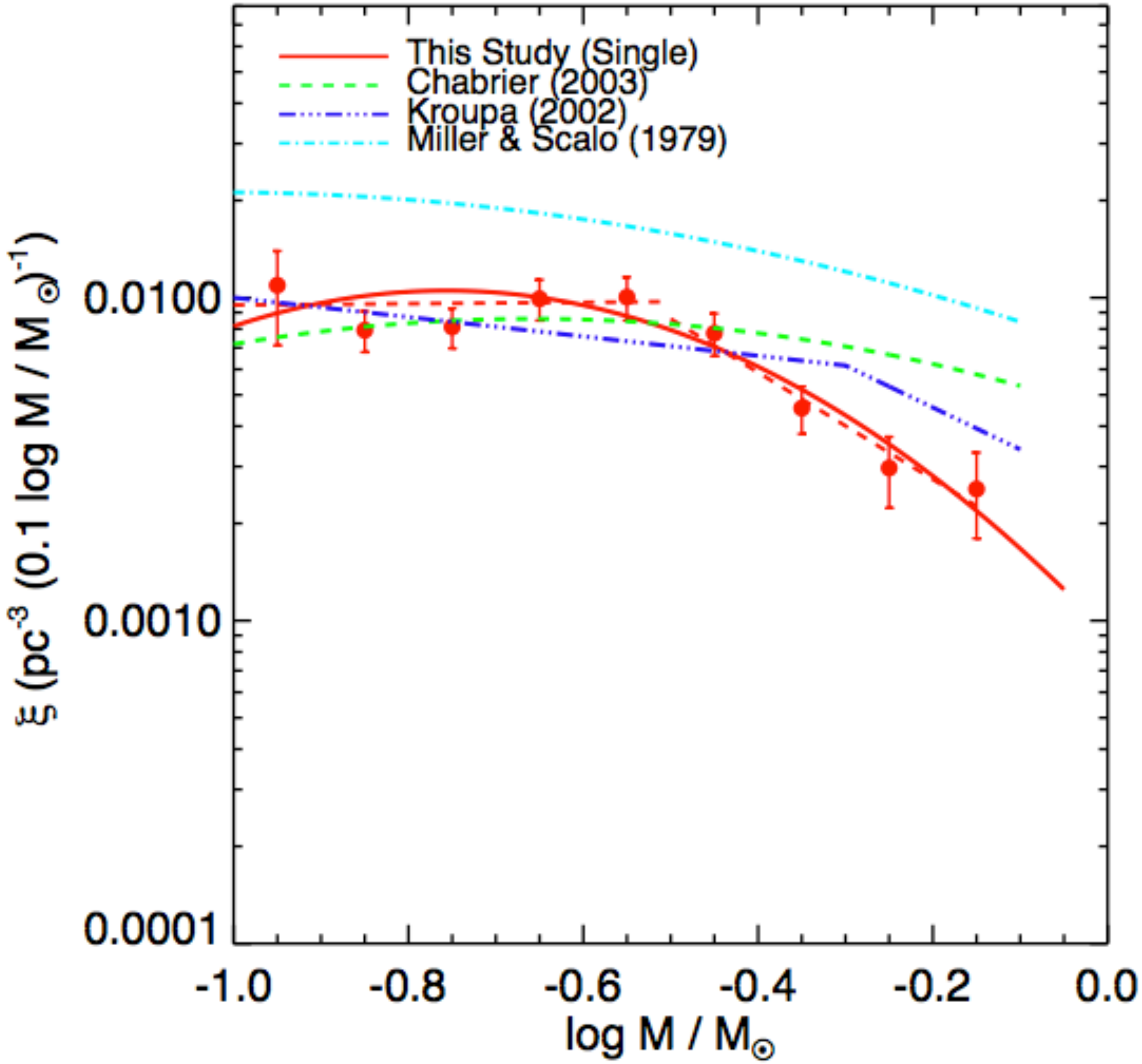
-red: single star

-open: system MF

MF for Single Stars and Star Systems



MF in comparison with others



Possible Physical Processes

- Turbulent Fragmentation

  -shape depends on Mach number
- Accretion and ejection
  - Characteristic mass set by accretion rate
- Thermal cooling
  - Insensitivity of IMF to initial conditions

Conclusion

- The measured field MF traces the IMF of low-mass stars averaged over the star formation history of the Milky Way.
- The field IMF is not a useful tool for investigating changes in the IMF due to physical conditions in star forming regions.
- Overall, this is the largest set of photometric observations of M dwarfs to date and used it to study the low-mass stellar luminosity and mass functions.