The Luminosity-Size relation of galaxies

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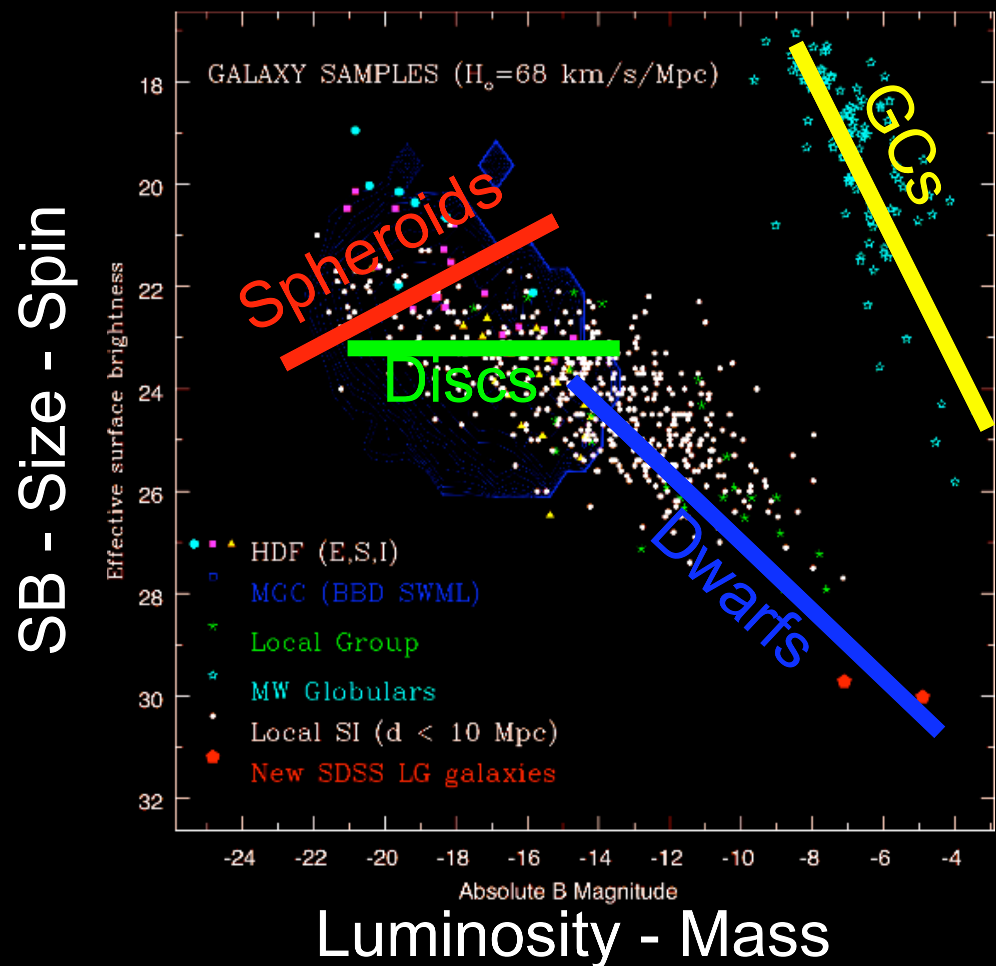
1. The Luminosity-Size relation: Obs <======>Theory
2. Comparison of the MGC and UDF to z=1
3. Problems
   - Bias: Luminosity, Size and ***Shape***
   - Bimodality: two evolutionary paths !
   - Dust: severe inclination dependent attenuation
4. Galaxy evolution: a two stage problem ?

The Luminosity-size/SB relation



The BBD or LSP can provide a crude connection between observation and theory:

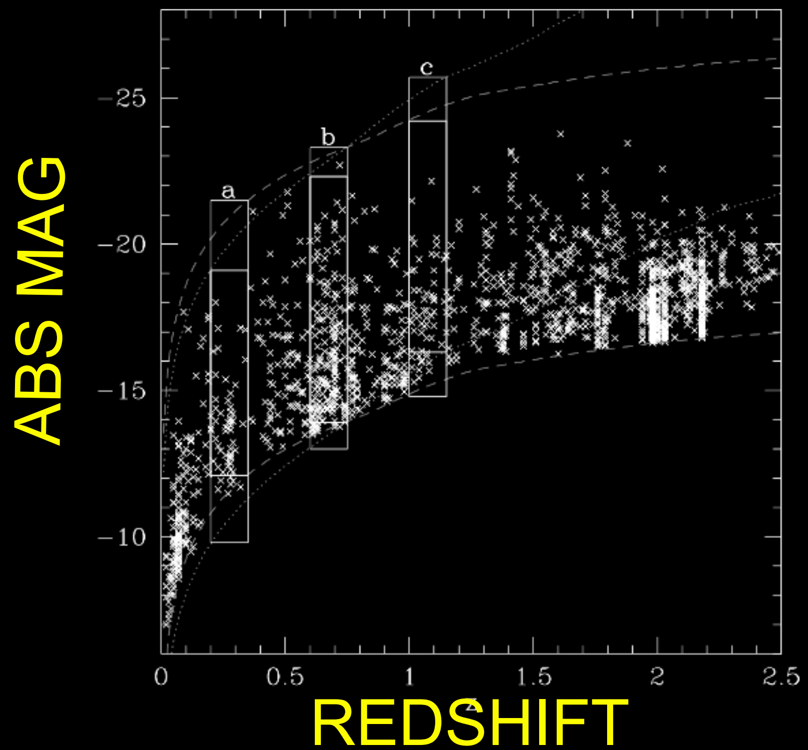
$$\lambda \sim r$$

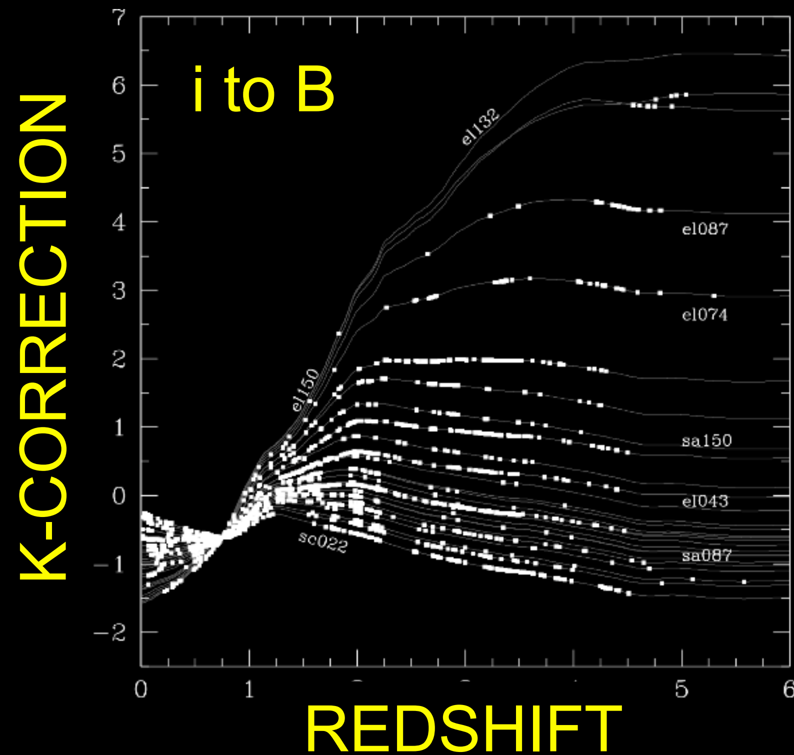
e.g., Fall & Efstathiou 1980
Dalcanton, Spergel & Summers 1997

Distinct structures with distinct trends are seen: spheroids, discs, dwarfs and GCs

The UDF and MGC

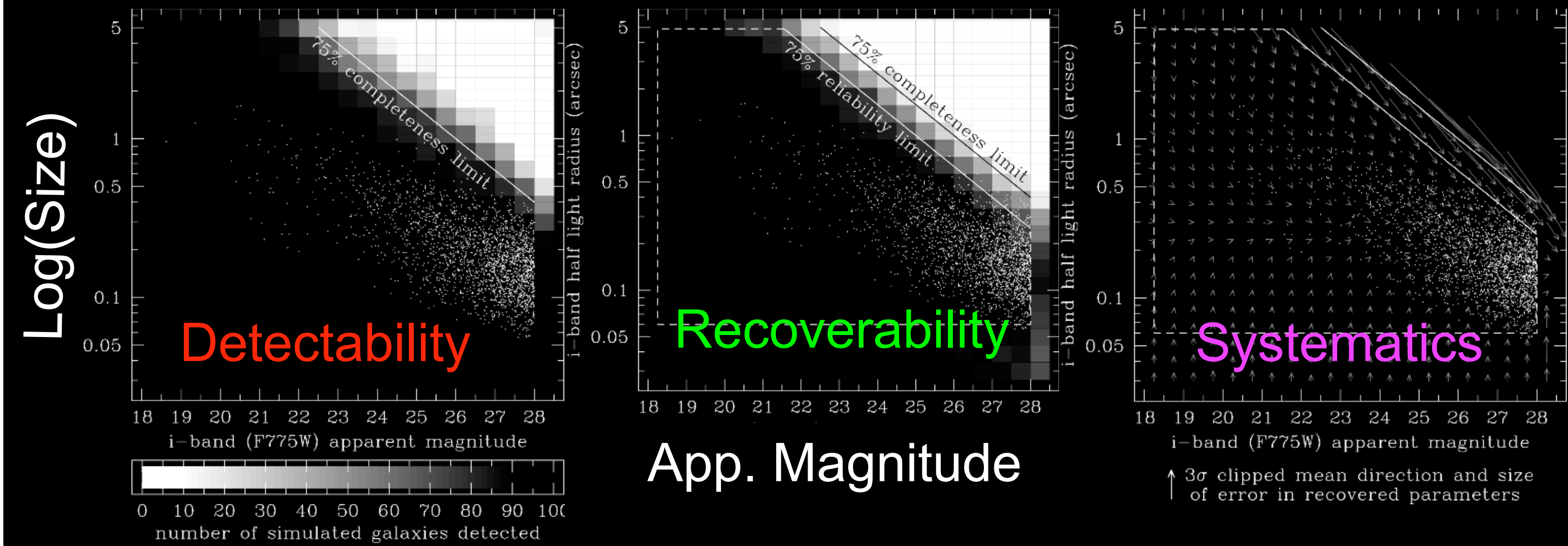
- UDF provides deepest data to date
- But even UDF has z limits
- K-corrections severe requiring bandpass shifting
- Near-IR data not deep enough to probe below M* for z >1
- Understanding selection bias key to robust results





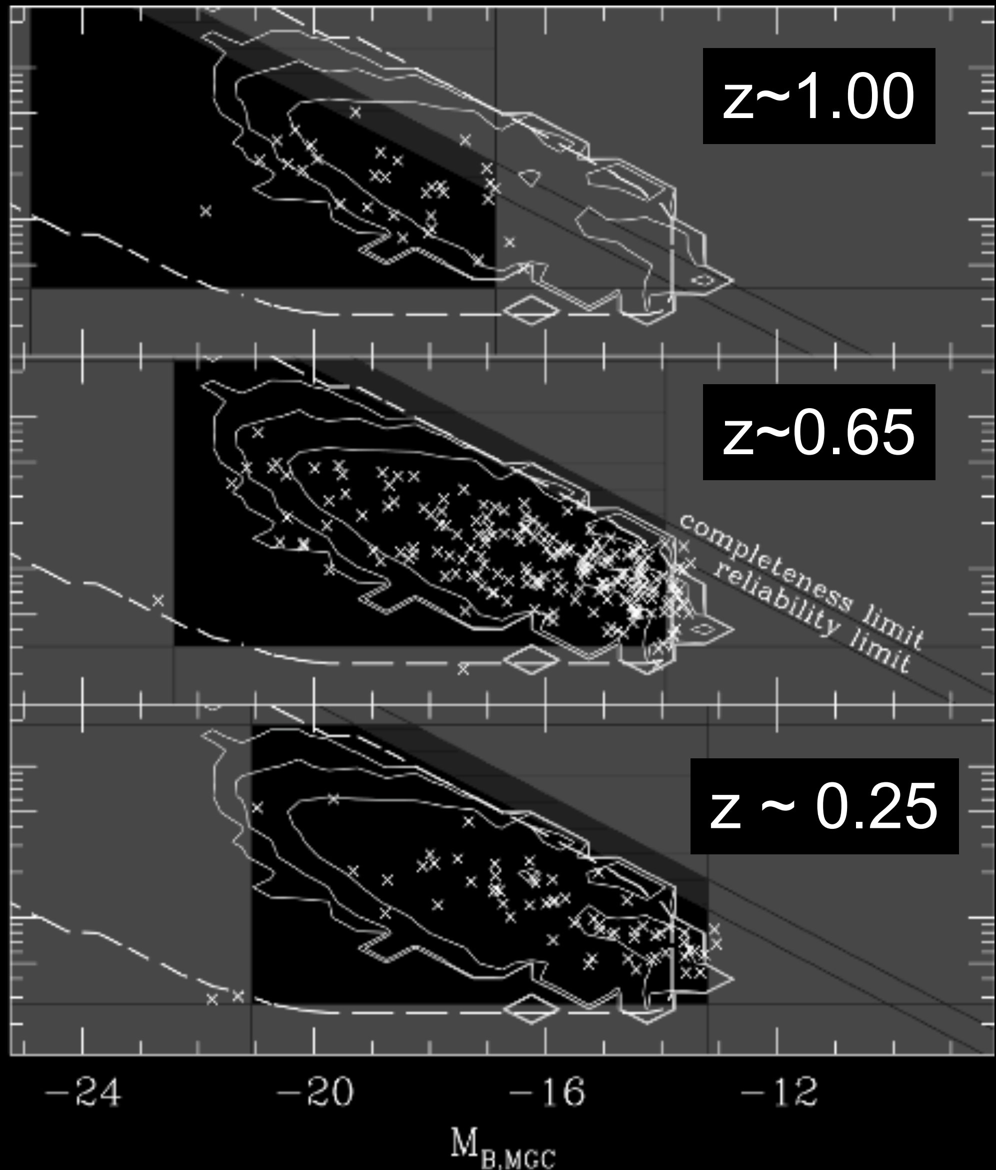
Detectability and recoverability

- Detailed and realistic simulations are required
- Simulated disc galaxies are thrown into real UDF data etc…
- Robustness is not defined by detectability but by ***recoverability***
- Galaxies identified in grey area have huge systematics
- Systematic trend is to push galaxies to low flux and smaller sizes (!) which can be miss-interpreted as luminosity-size evolution



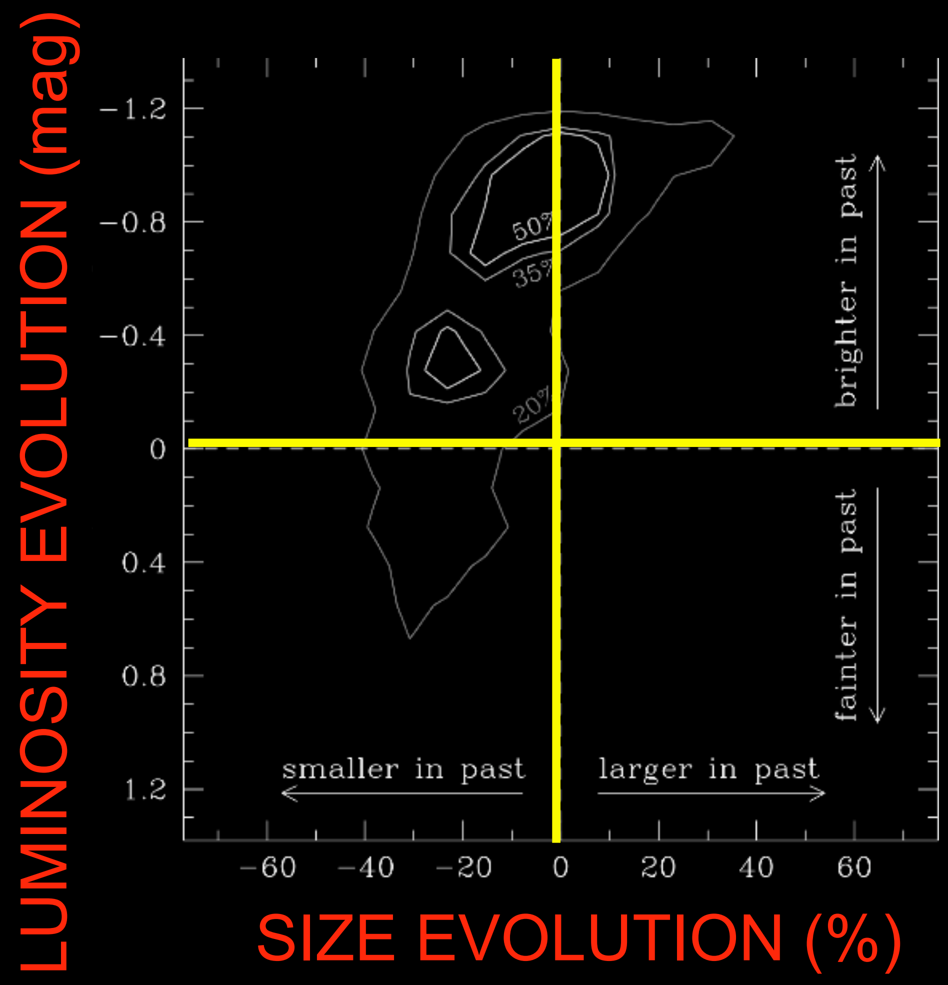
UDF v MGC results

- UDF comparison window is narrow
- Define comparison boundaries from reliability plots for MGC and UDF
- MGC = z=0 reference sample (Driver et al 2006)
- At z=1 UDF SB boundary brighter than reference sample, I.e., large diffuse objects' sizes and fluxes will be underestimated….



Galaxy Evolution to z=0.7

Results are consistent with 1 mag of luminosity evolution and no size evolution.

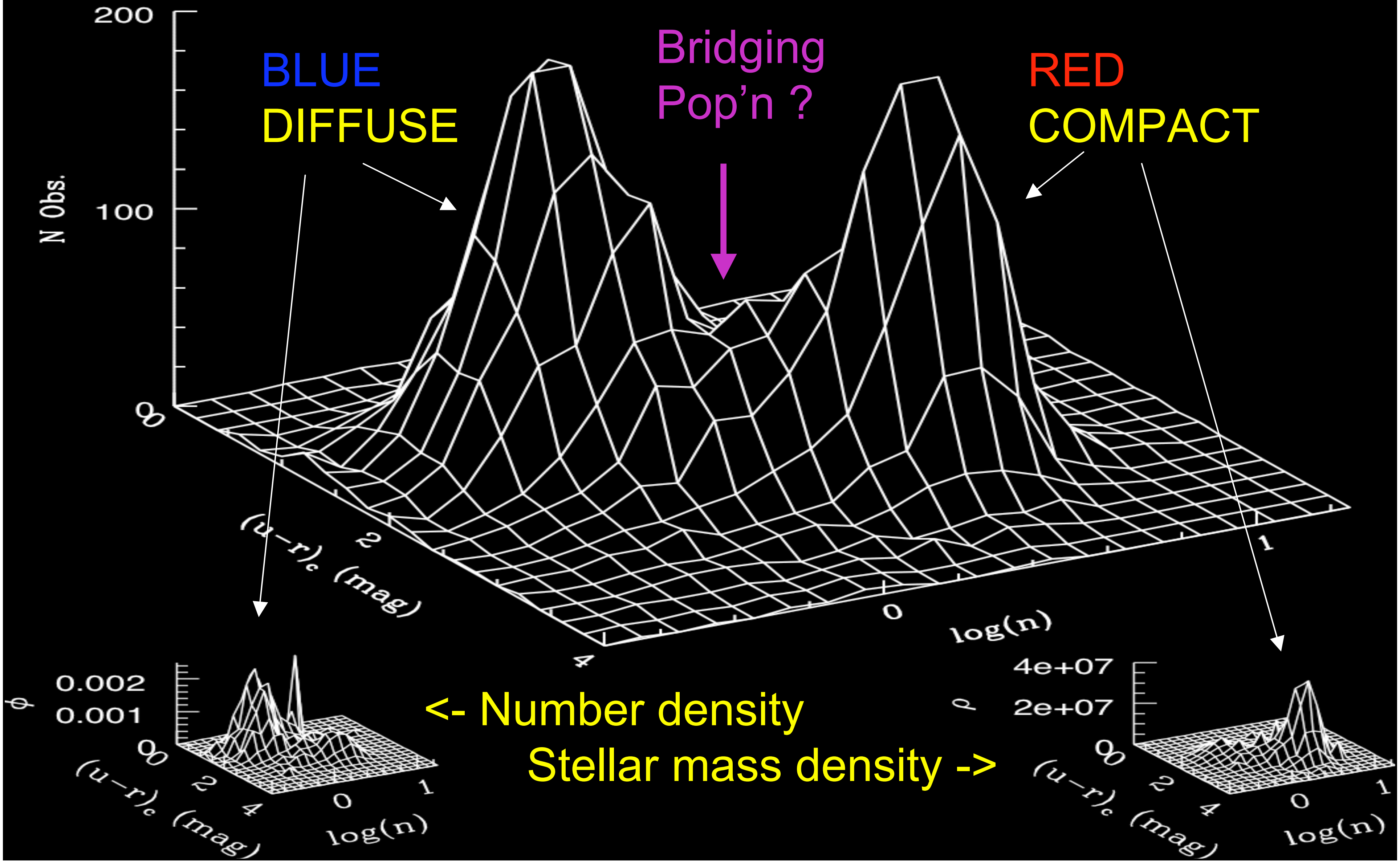


3 Major Additional Problems !

- This analysis has ignored three important issues:
- Bimodality and structural multiplicity of galaxies:
  - Spheroids (inc bulges) and discs are fundamentally different beasts, could they have distinct evolutionary paths ? (Driver et al 2006a)
- Shape/profile bias:
  - Previous simulations assumed all galaxies were n=1 discs, but they're not (Cameron, Driver & Freeman 2006)
- Dust attenuation:
  - MGC results suggest attenuation much more severe than previously thought and dependent on inclination and B/T ratio (Driver et al 2006b)

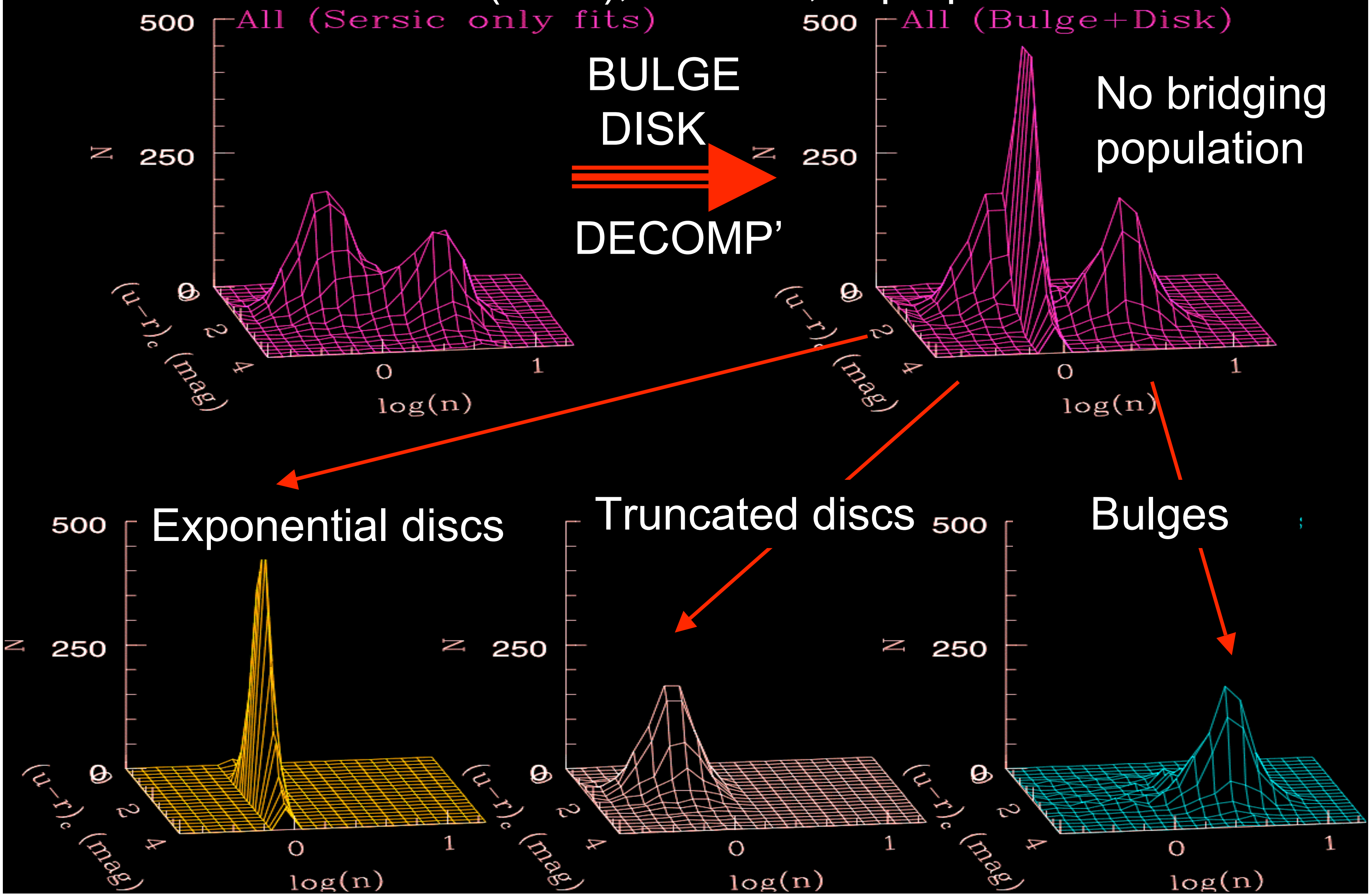
Bimodality in (u-r)-log(n)

Driver et al, 2006a, MNRAS, astro-ph/0602240

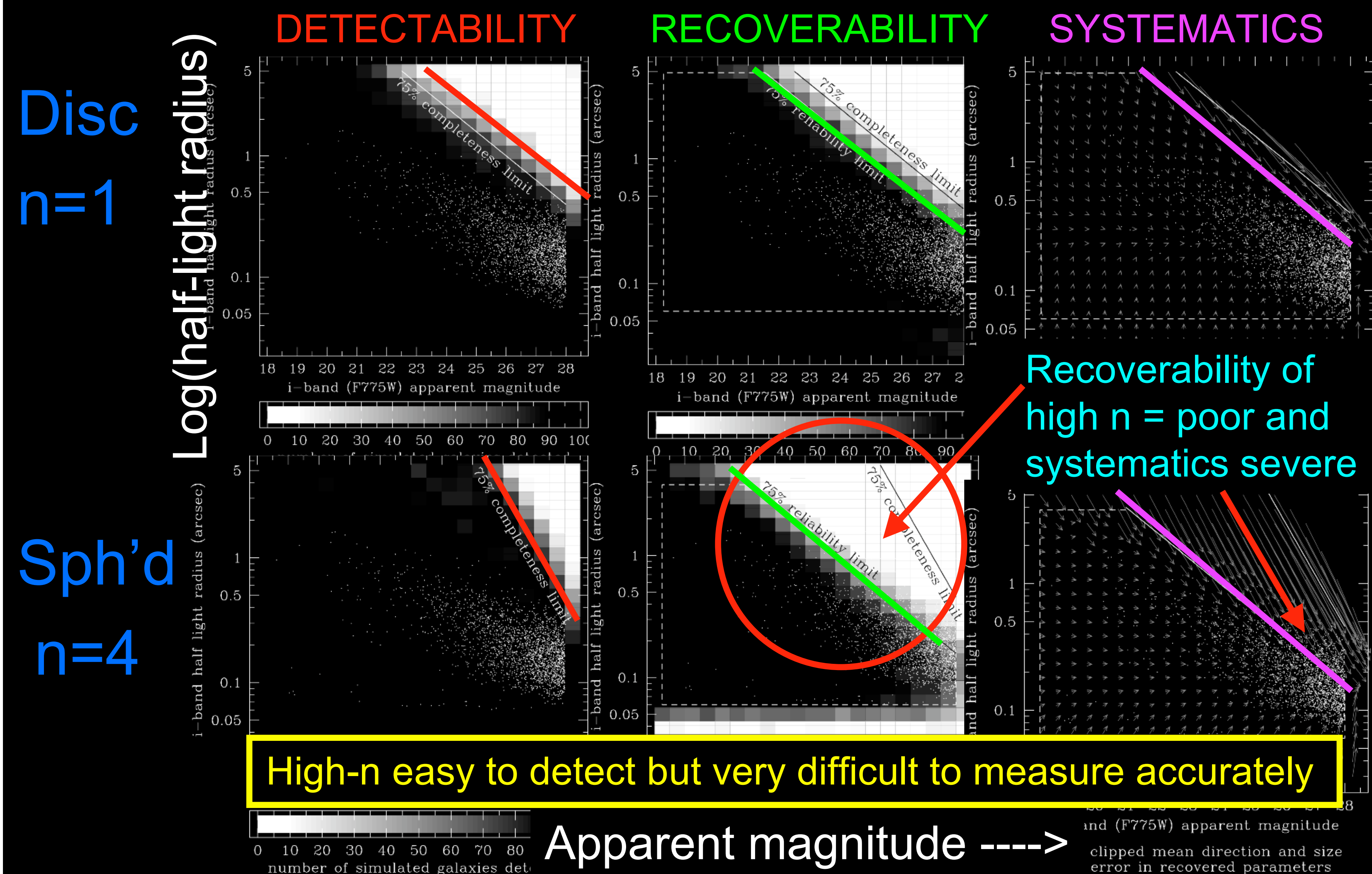


Two populations or two components ?

Driver et al (2006), MNRAS, in preparation



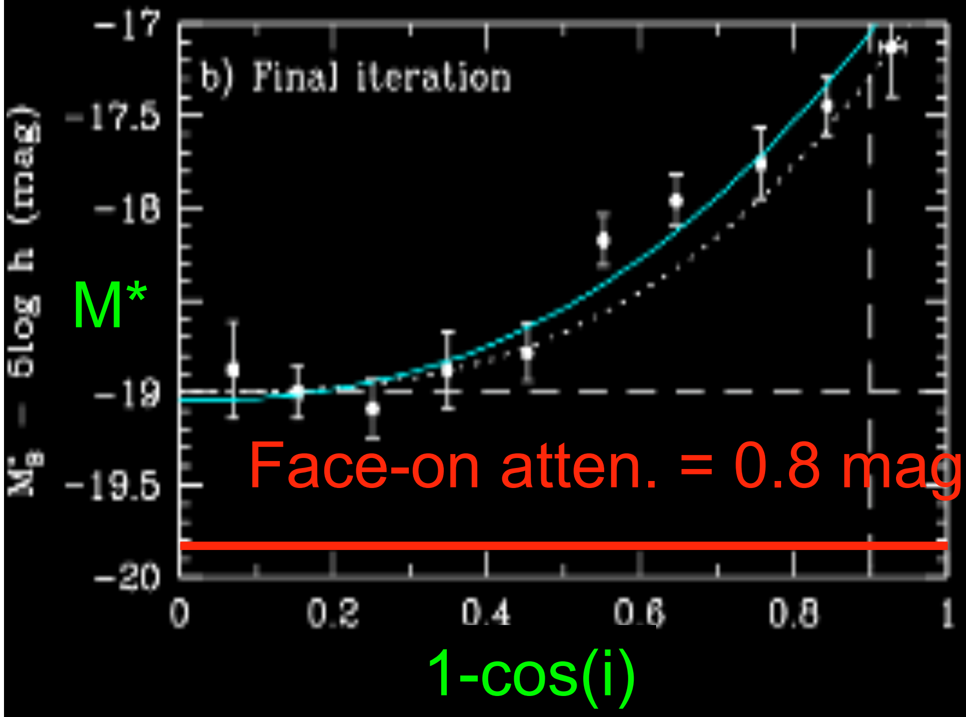
Shape or Sersic index bias



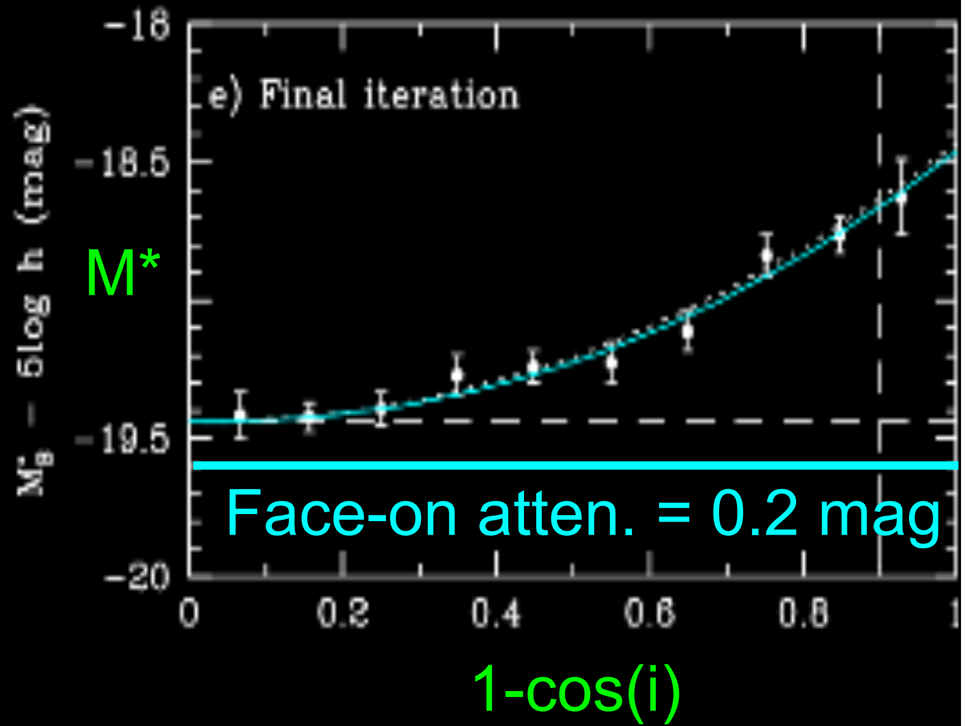
Empirical dust attenuation-inclination relations

- **Derive M* for discs in various inclination bins (with α fixed)**
- **Find that M* gets fainter for more inclined systems**: Dust attenuation

Bulges: 0 - 2 mag !



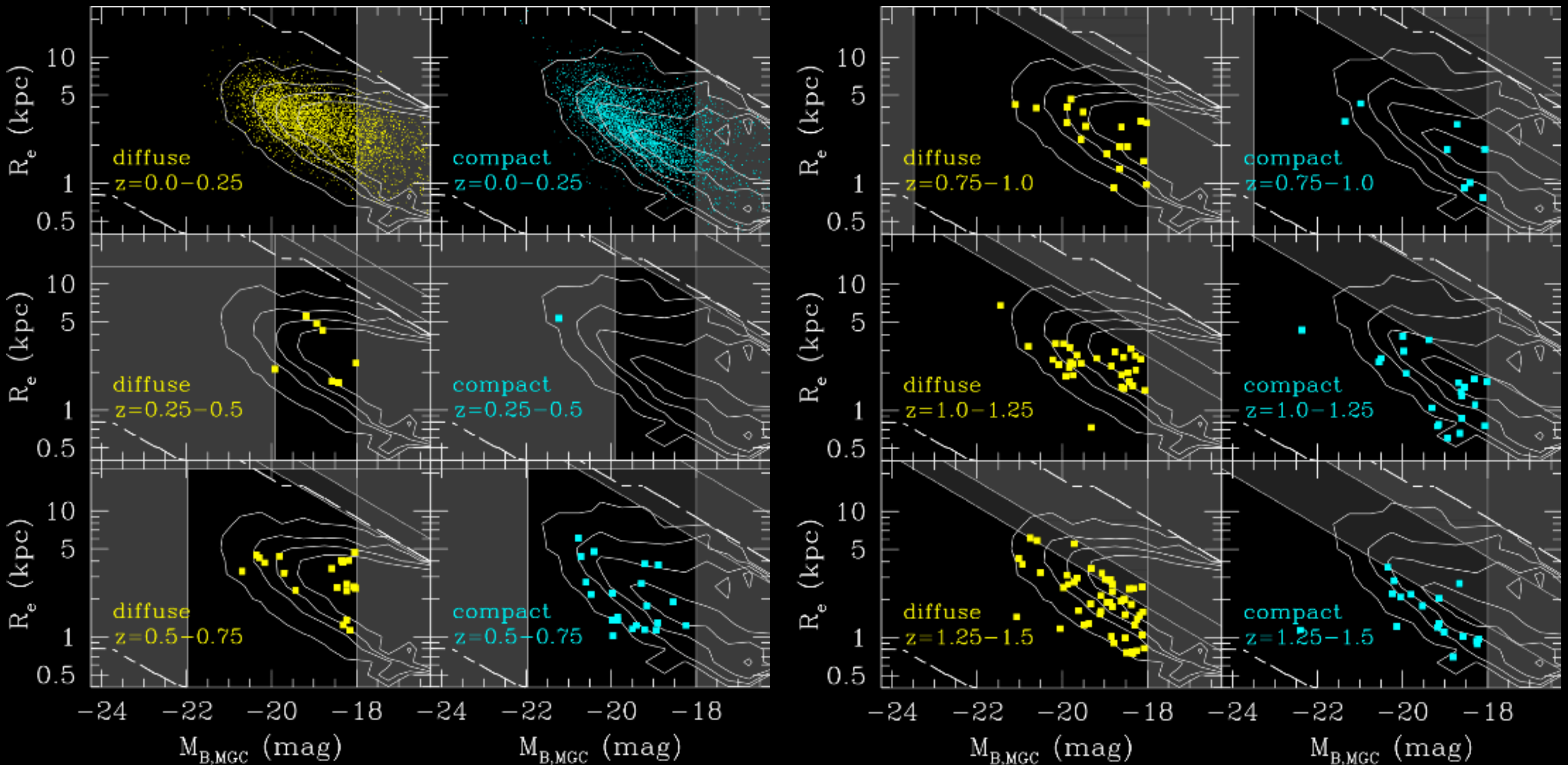
Disc: 0.0 - 0.8 mag !



Face-on attenuation based on Tuffs and Popescu dust models

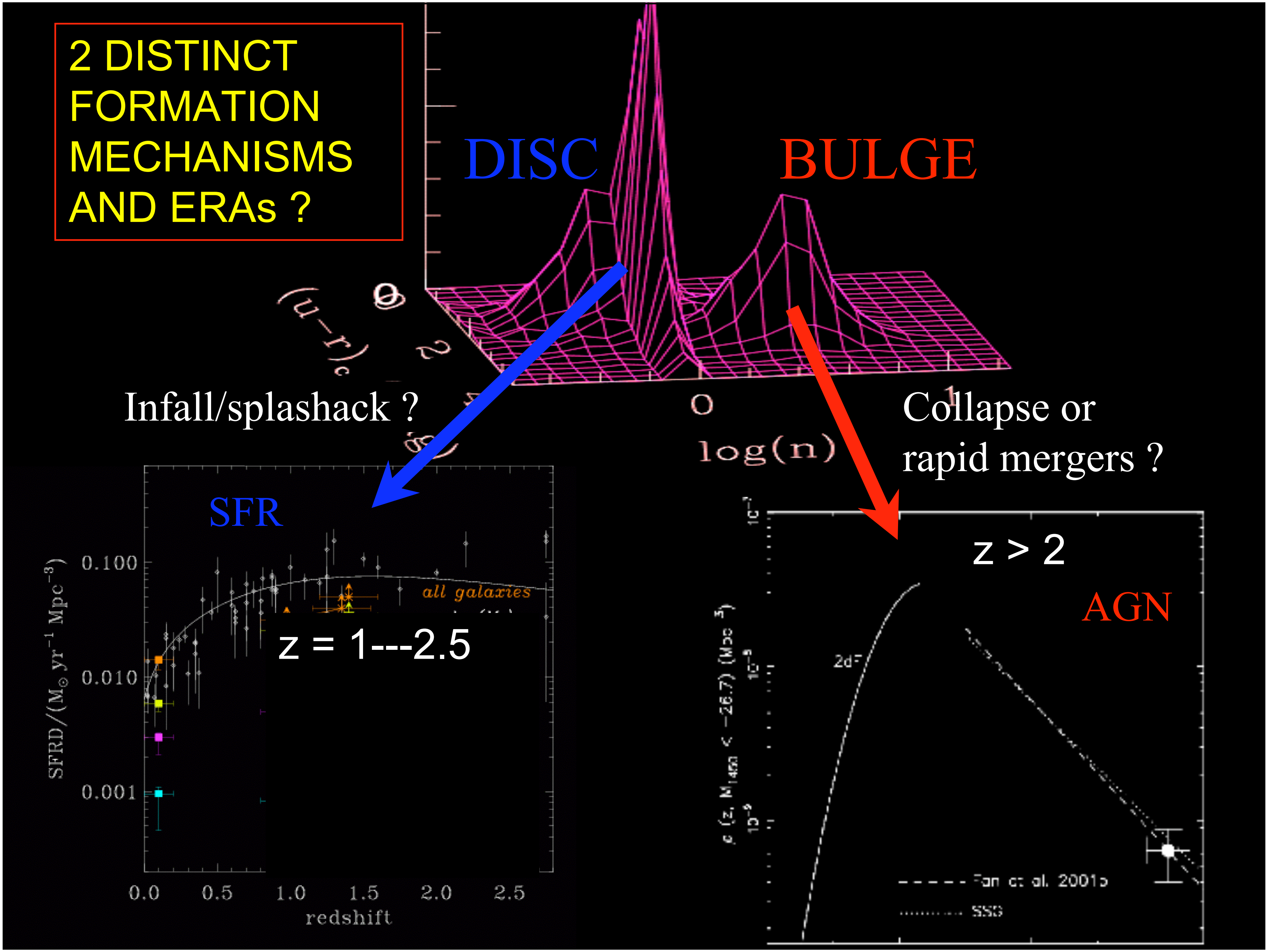
Results incorporating shape bias

Qualitatively we see little evidence for any luminosity and size evolution to z=1.5 !



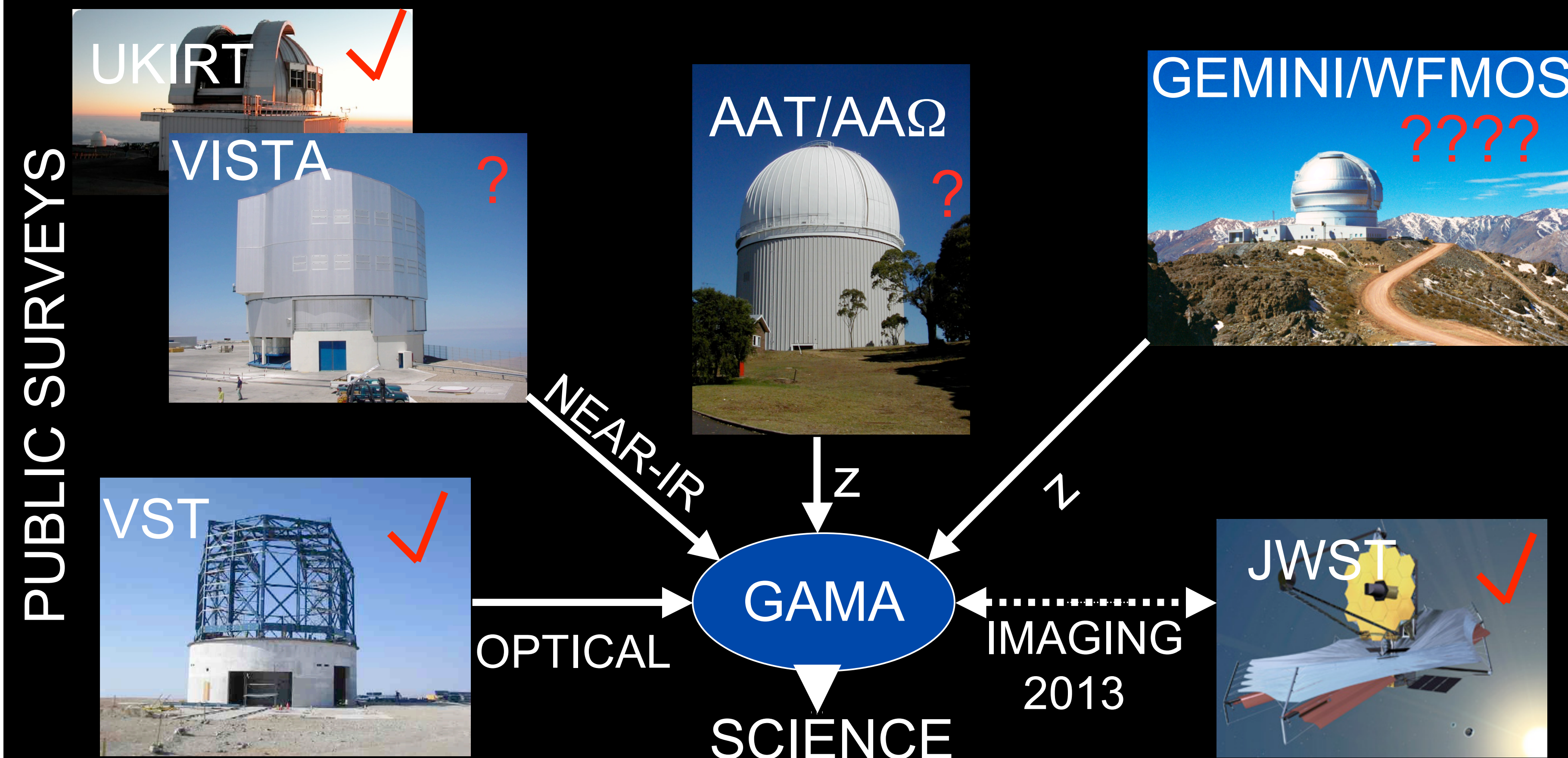
Summary

- All figures from Ewan Cameron's thesis (Cameron 2007) and Cameron & Driver (2006, submitted); Cameron, Driver & Freeman (2007; in prep)
- Luminosity-size is an important meeting ground between theory and observation (spin --> size, luminosity --> mass)
- UDF enables comprehensive comparison only to z ~ 1.2 for sub-M*
- Selection bias extremely severe and must be modelled for both the UDF and the local reference sample. DETECTABILITY ≠ RECOVERABILITY
- Globally the population shows minimal L-r evolution to z=1 (1mag fading)
- Bimodality, shape bias and dust demand bulge-disc decompositions
- Dividing by Sersic index (n) we find minimal evolution to z=1.5
- Bulge-disc decomposition could reveal distinct disc and bulge evolution but too hard to model correctly given severe dust attenuation, need JWST
- Time to redefine galaxy properties at z=0 in K = GAMA
- Galaxy evolution a two path process ? (bulge=early collapse, disc=infall)


2 DISTINCT FORMATION MECHANISMS AND ERAs ?
DISC
BULGE
(u−r)c
log(n)
Infall/splashack ?
Collapse or rapid mergers ?
SFR
z = 1---2.5
SFRD/(M⊙ yr−1 Mpc−3)
0.100
0.010
0.001
all galaxies
0.0 0.5 1.0 1.5 2.0 2.5
redshift
z > 2
AGN
Fan et al. 2001b
SSG

Galaxy And Matter Assembly

- **300 sq deg ugrizJHK sub-arcsec** deep imaging and spectroscopic survey
- St Andrews (Driver), Edinburgh (Peacock), LJMU (Baldry), ESO (Liske)
- 4 tests of CDM structure plus generic galaxy resource on scale of SDSS
- Zero redshift near-IR benchmark for JWST (launch 2013)



Summary

- Disks & bulges occupy distinct regions in the colour-structure plane
- Must entertain notion of bi(tri)-modal galaxy formation scenario?
  - Bulk of dark matter halo assembly at high-z (rapid) ???
  - Bulge formation via collapse of baryons + residual mergers (Bulge/AGN/SMBH trinity) z > 2 (Low mass blue spheroids suggest downsizing of bulge formation) ?
  - Disk formation through later splashback, accretion & infall ? (truncated disks still growing I.e., inside out formation) ???
- Must abandon HTF/global approach and routinely dismantle galaxies into their key components (bulges and discs)
- 20% of baryons in stars (almost half emergent B flux attenuated)
- 50% of stars in bulges 50% in discs
- Dust attenuation in B a big issue (bulges heavily attenuated)
  disks 0.2-1.1 mag, bulges: 0.8 - 3.4 mag ! τ_B~3.8 +/- 0.7
- Switch to near/far-IR now essential to overcome dust issues: GAMA