Did bulges form first and discs later ?

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1. The MGC (release) = 10,095 galaxies with B/D decomp.
2. Galaxy bimodality = two components not two types
3. The sequence of galaxy form. = Haloes, bulges, discs ?
4. Disc opacity and the cosmic inventory = τ_B=3.8 !
5. GAMA = 300 sq deg VST+VISTA+AAT to B=21.5 mag

MGC
Millennium Galaxy Catalogue
Liske et al (2002); Cross et al (2003); Driver et al (2004)

INT WFC: 37 sq deg to B=26mag/s arcsec
~1 million galaxies
SDSS DR4: ugriz to B~25mag/sq arcsec
AAT 2dF: 10k zs to B=20 mag (**96%**)
GEMINI: zs for extreme-LSBGs (30%)
15 science papers in print/under review

The MGC Team

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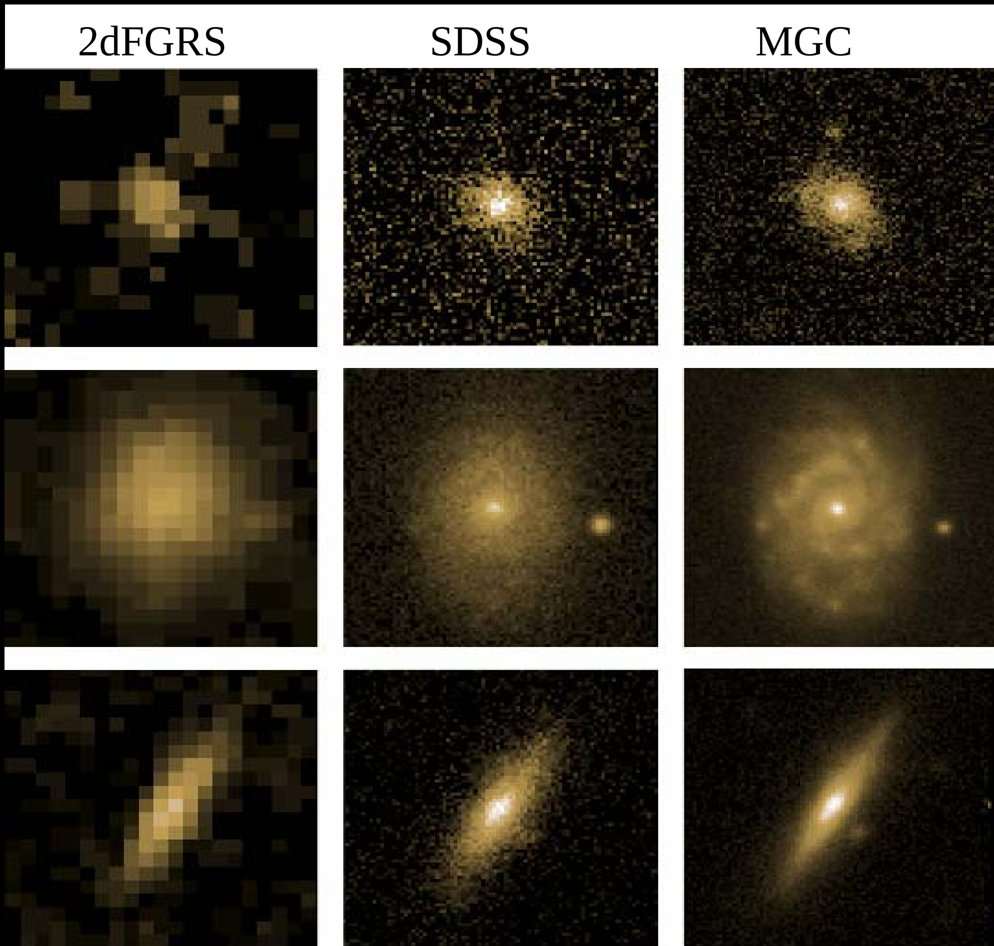
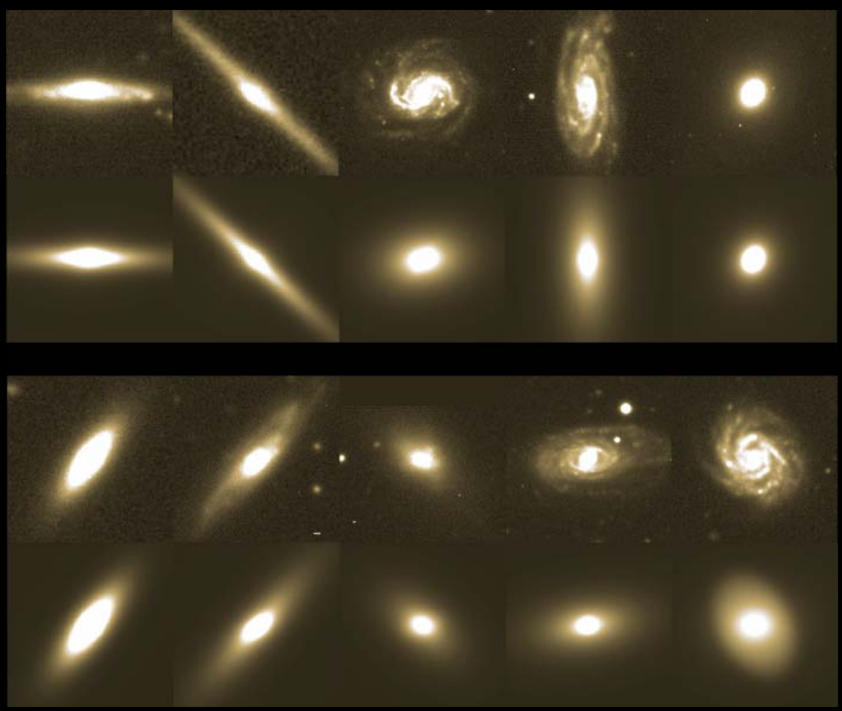
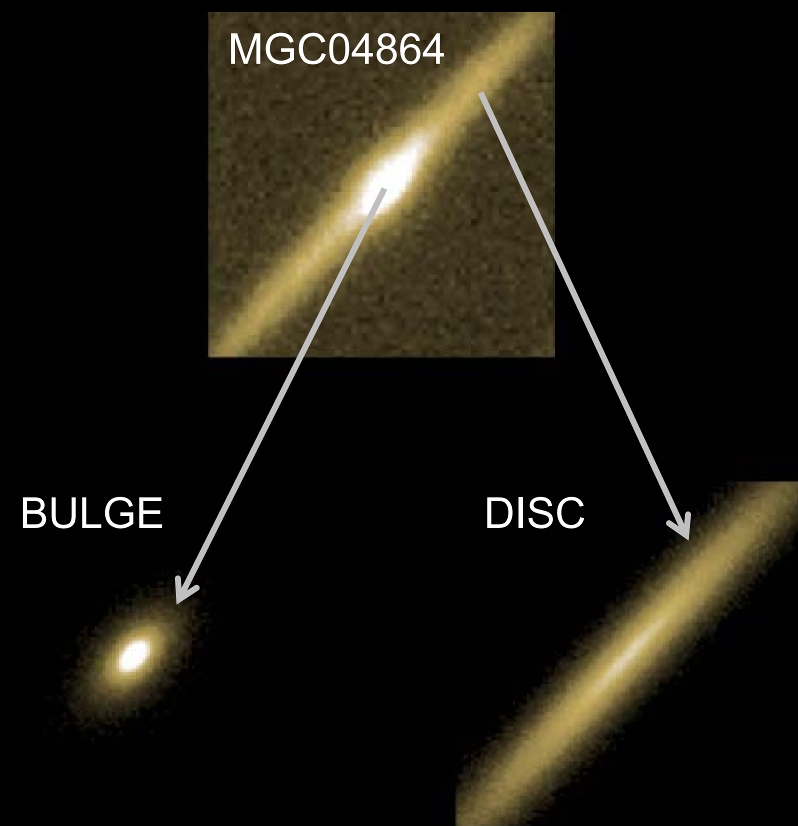


http://www.eso.org/~jliske/mgc/

MGC Bulge/disc decomposition

- Sersic+exponential profiles+PSF convolution via GIM2D, Simard et al (1998)
- 10,095 gals = largest available sample, Allen et al (2006)
- 96% redshift completeness (AAT/GEMINI) to B=20.0 mag, Driver et al (2005)
- B(INT) + ugriz(SDSS) + zYJHK(UKIRT) imaging now complete.
- All data available from Friday 18th August online: http://www.eso.org/~jliske/mgc/

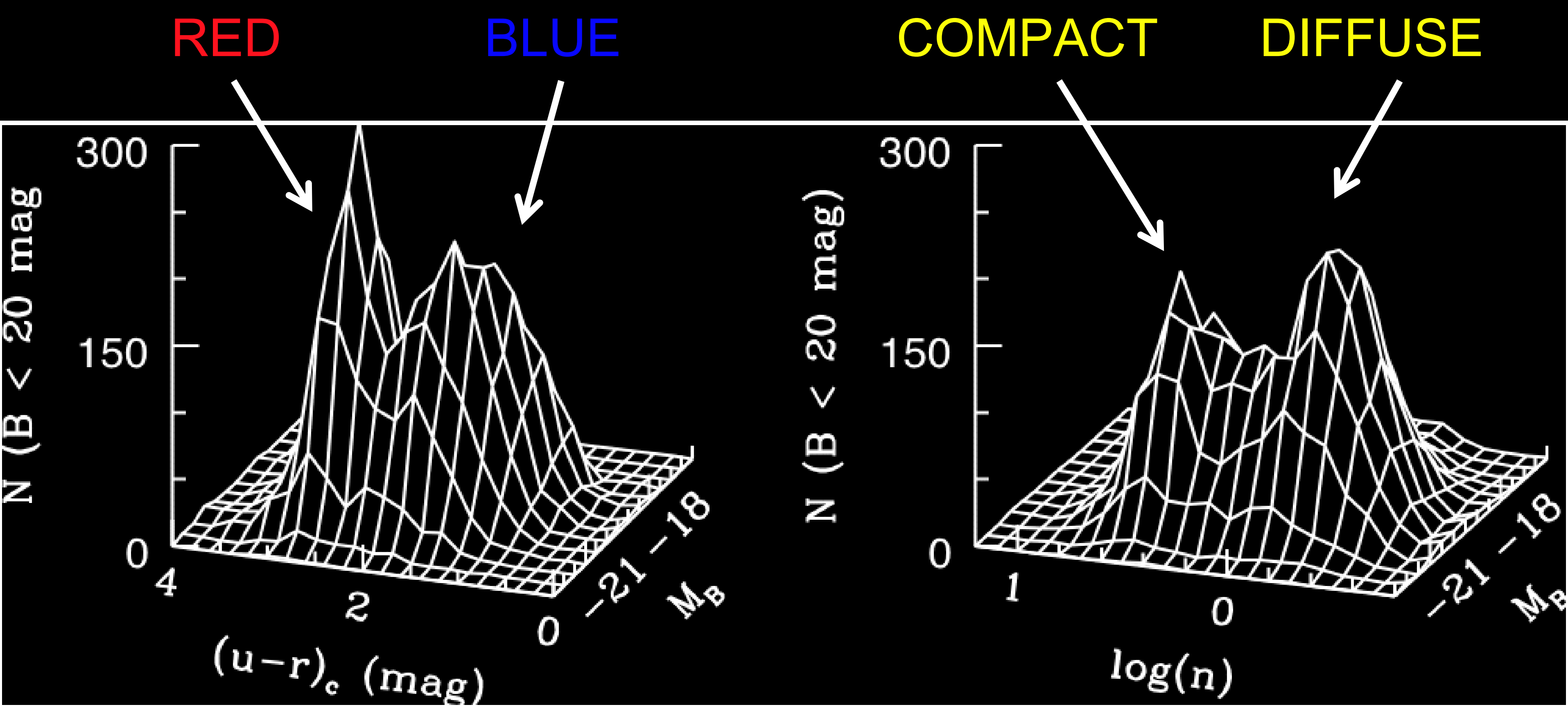




Galaxy Bimodality

Observe strong colour *(u-r)* and structural (log*n*) bimodalities (Strateva et al 2001; Baldry et al 2004; Driver et al 2006)

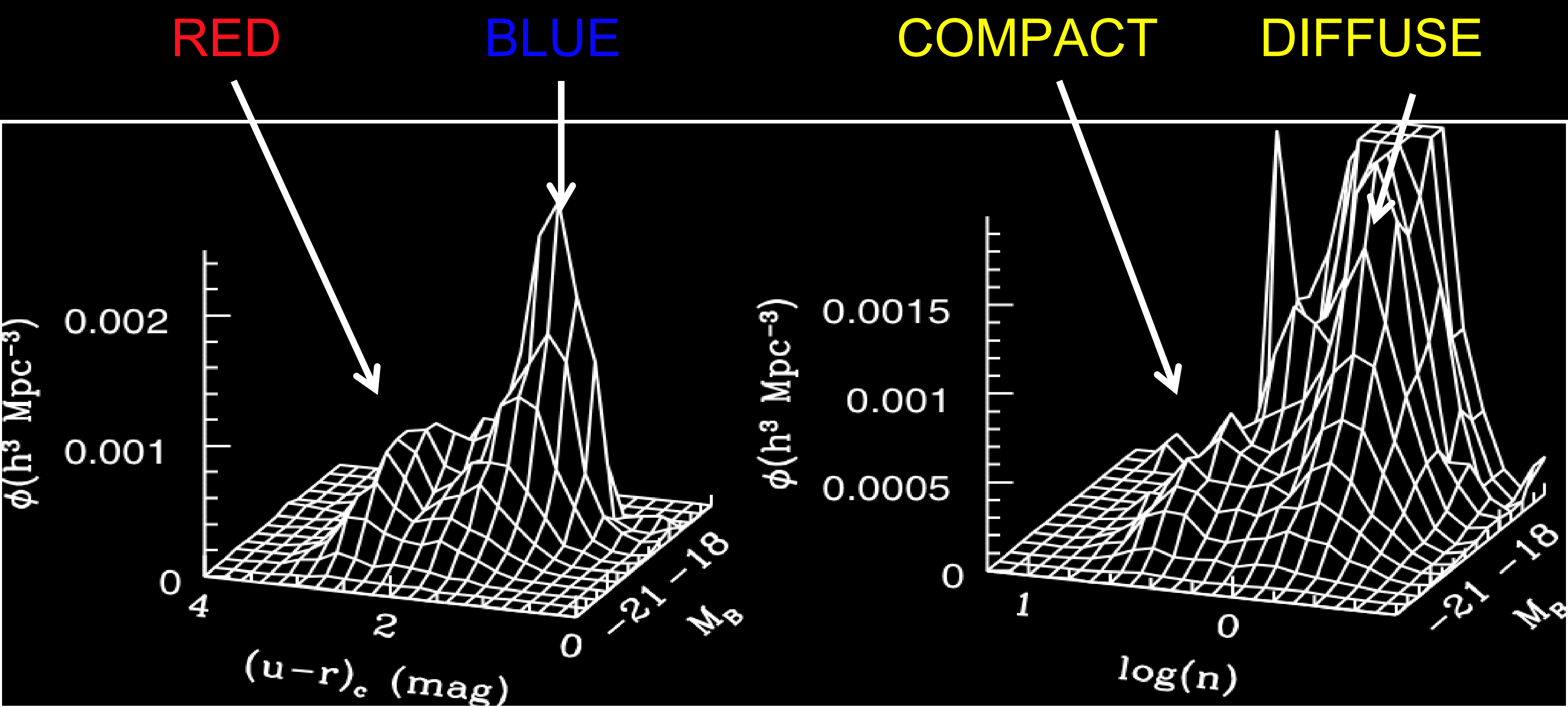
OBSERVED DISTRIBUTIONS (M_B < -16)



Galaxy Bimodality

Observe strong colour *(u-r)* and structural (log*n*) bimodalities (Strateva et al 2001; Baldry et al 2004; Driver et al 2006)

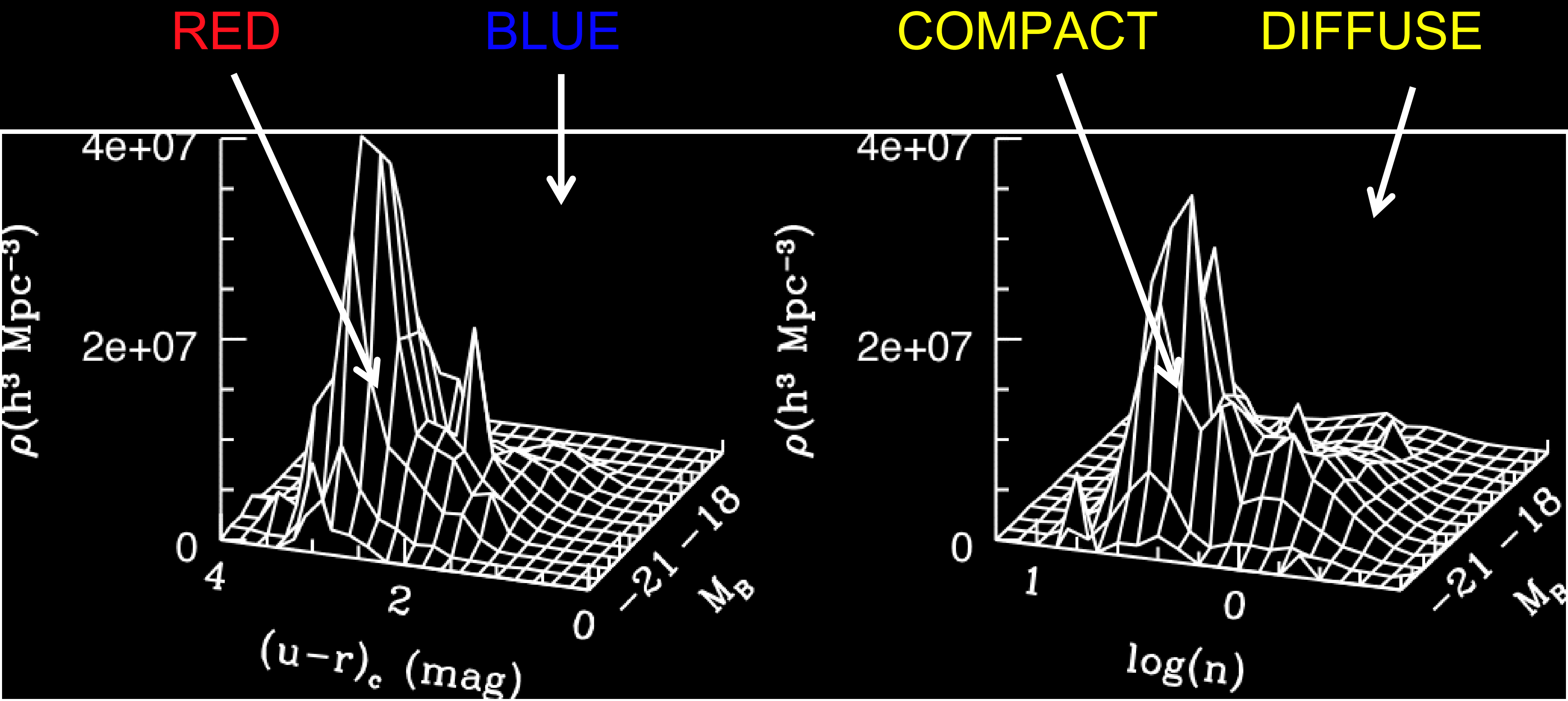
VOLUME CORRECTED (NUMBER DENSITY)



Galaxy Bimodality

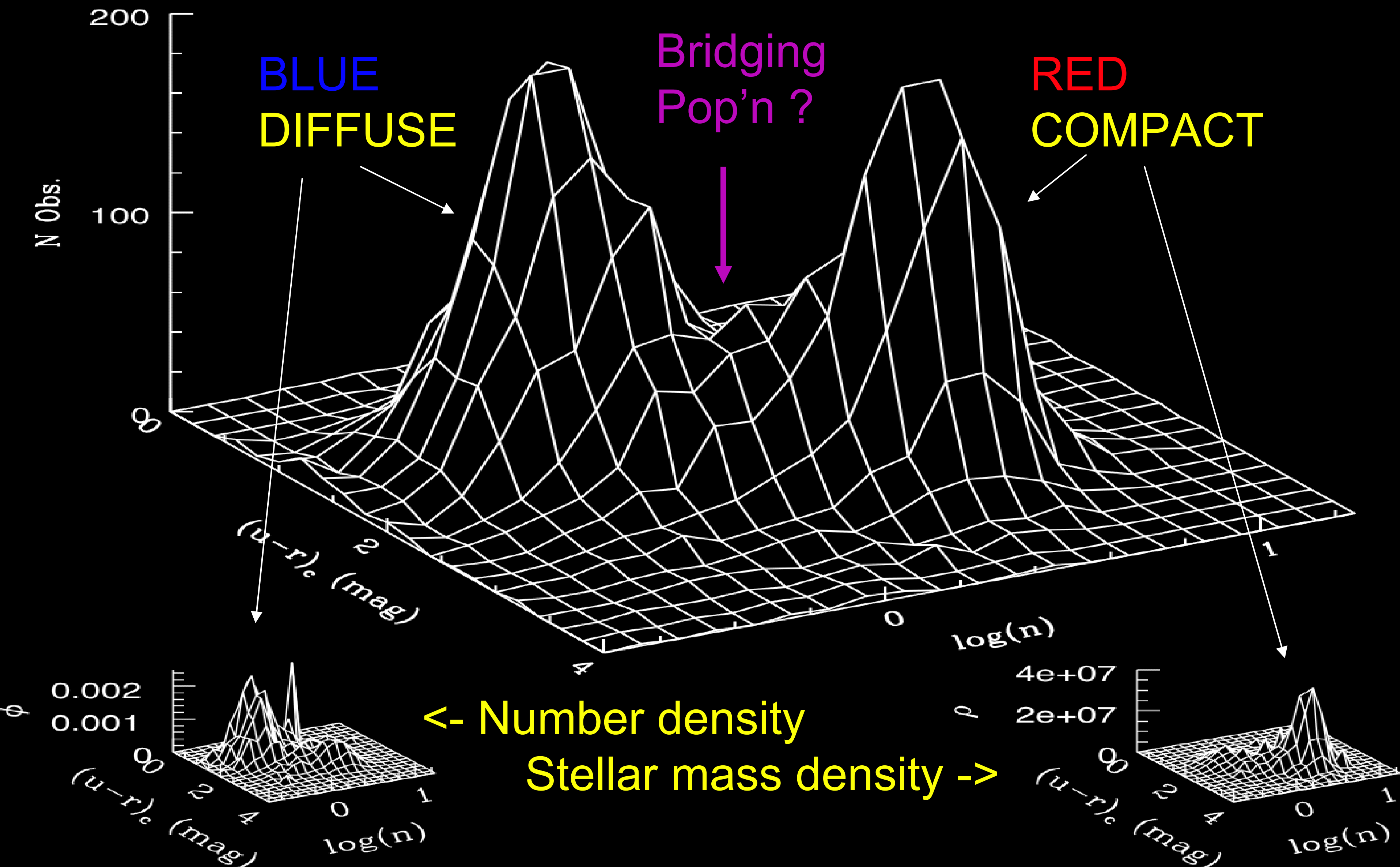
Observe strong colour *(u-r)* and structural (log*n*) bimodalities (Strateva et al 2001; Baldry et al 2004; Driver et al 2006)

VOLUME CORRECTED (MASS DENSITY)



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

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



Two populations or two components ?

E/S0s

Bulge systen

El(Old)

Sabc

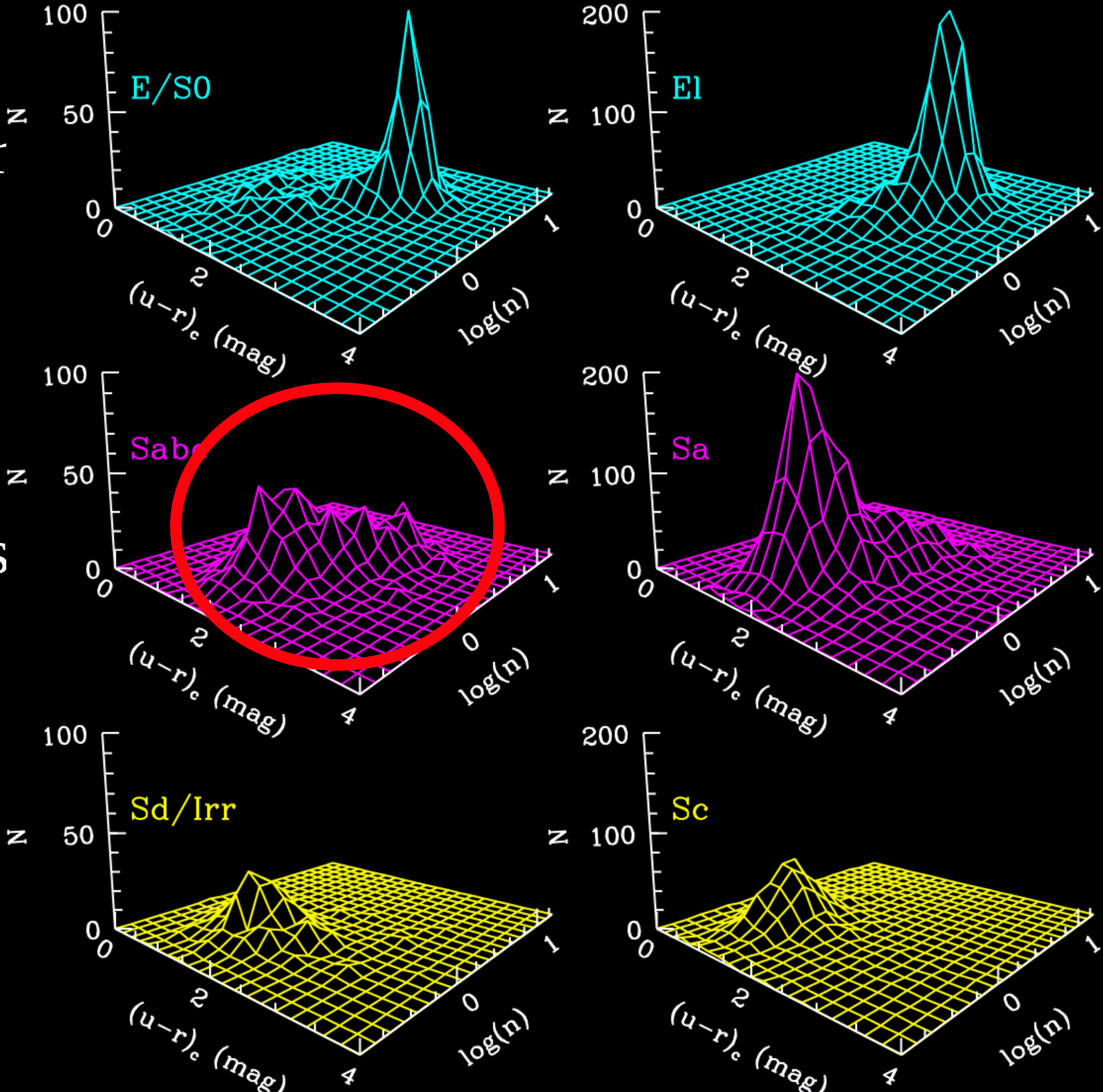
Bulge+Disks

Sa(Interm.)

Sd/Irr

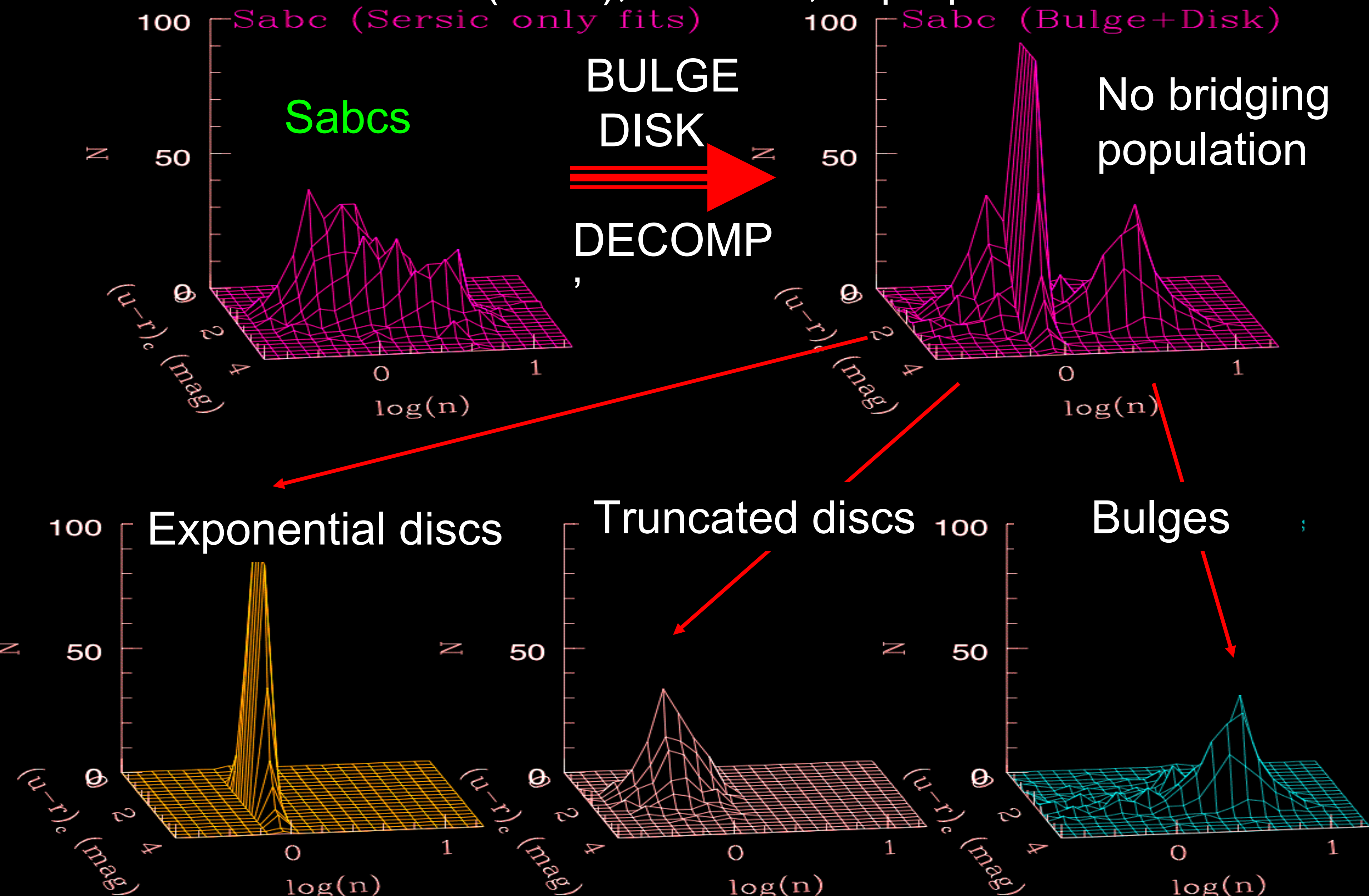
Disk systems

Sc(Young)



Two populations or two components ?

Driver et al (2006), MNRAS, in preparation



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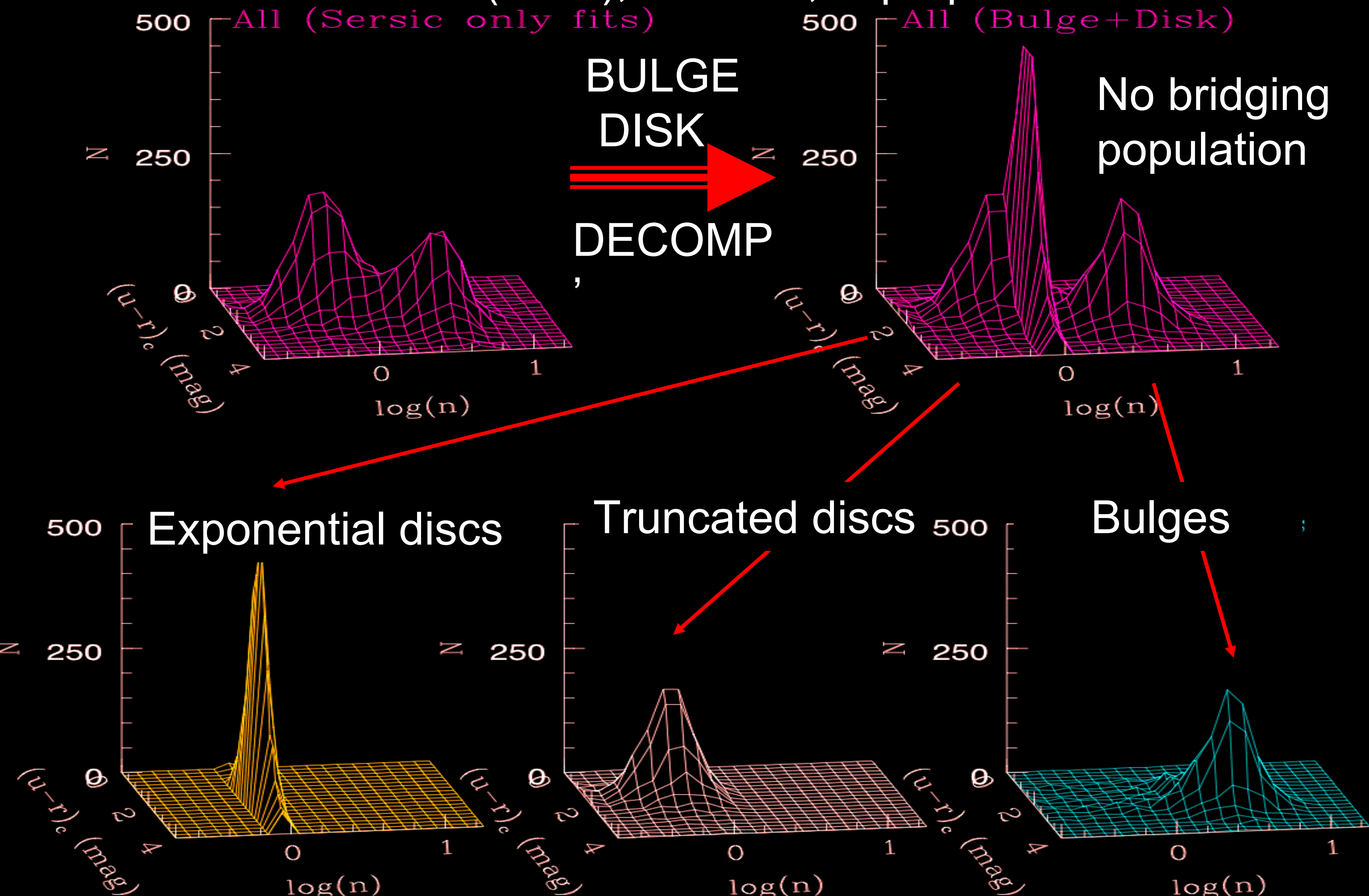
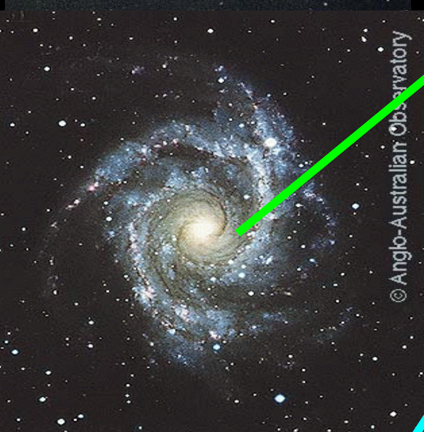
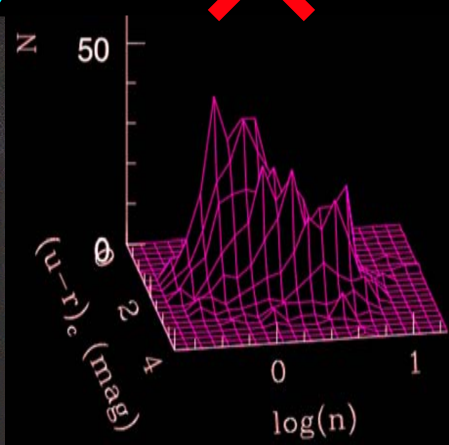
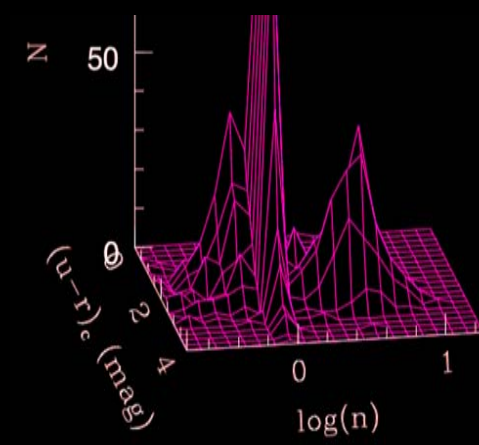


Galaxy types v components ?

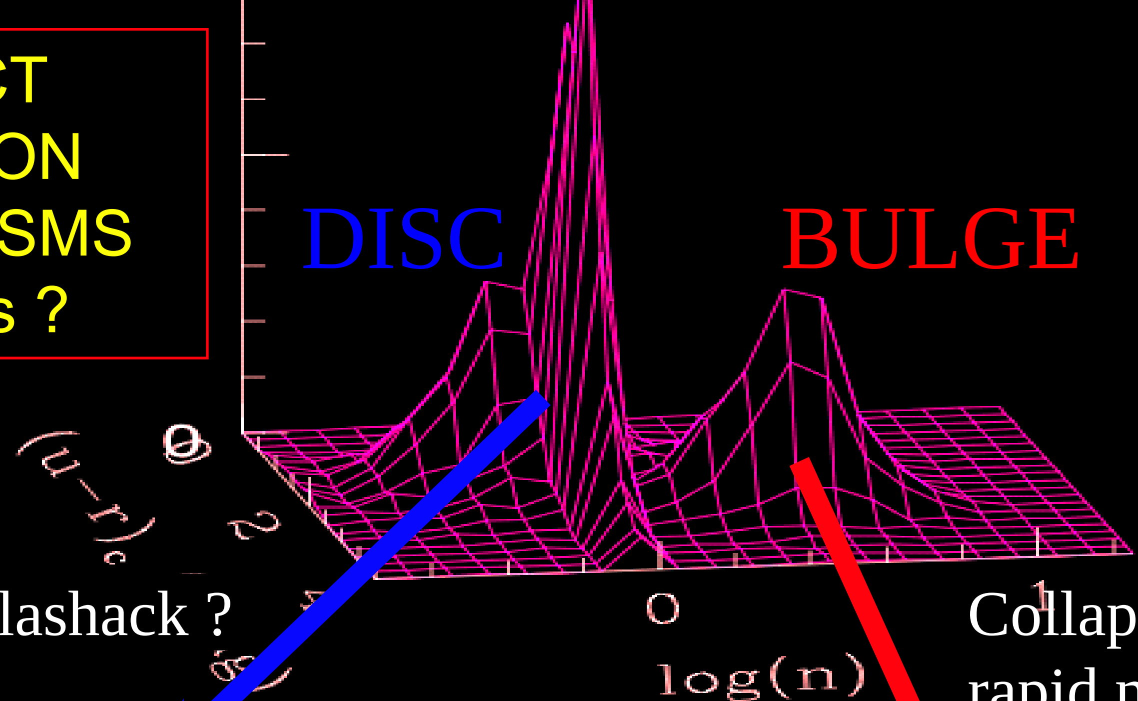


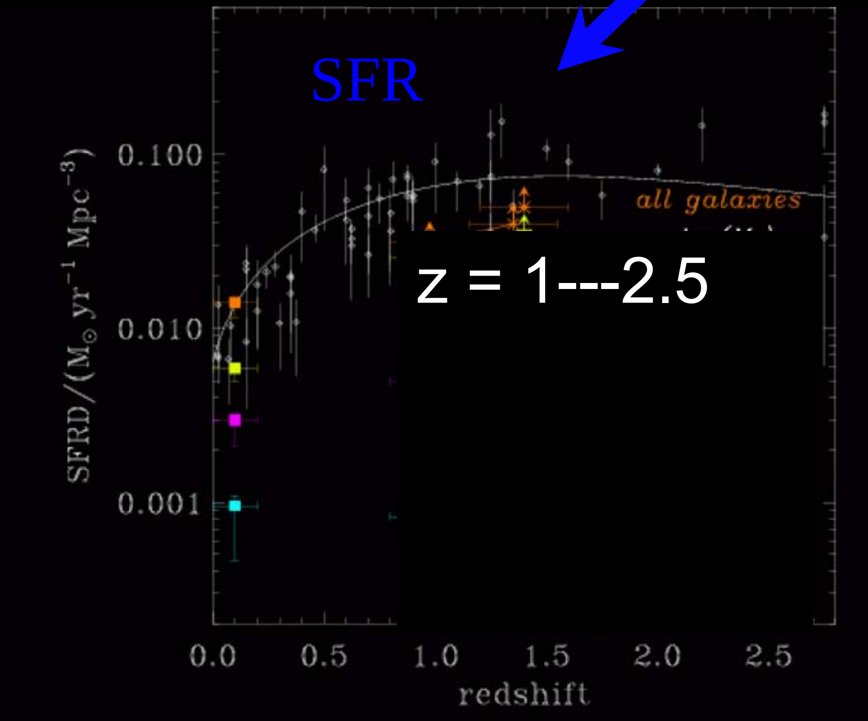
(z > 0.1)	(z < 0.1)
E/S0s(red)	Spheroids & Bulges
Sabc (red&blue)	Discs
Sd/Irrs(blue)	

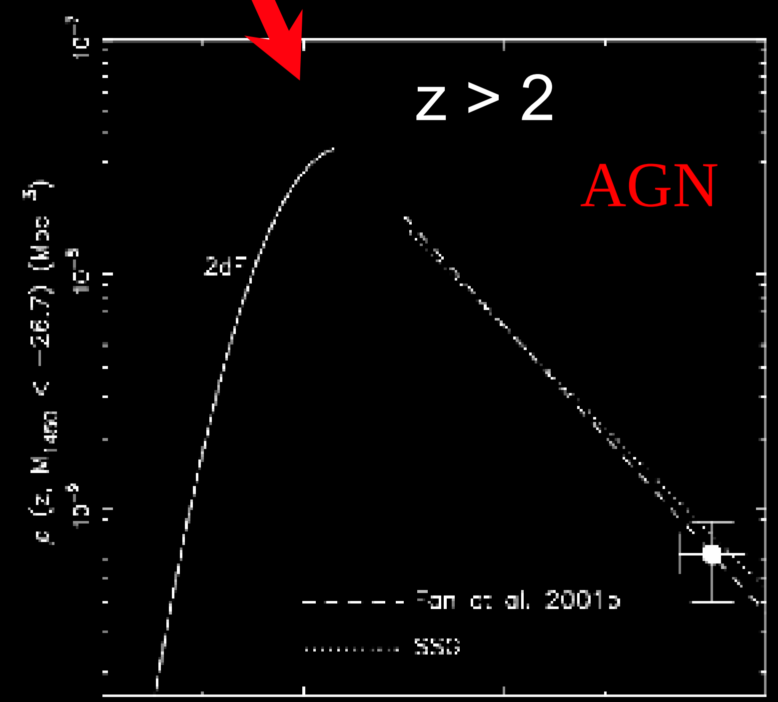




2 DISTINCT FORMATION MECHANISMS AND ERAs ?

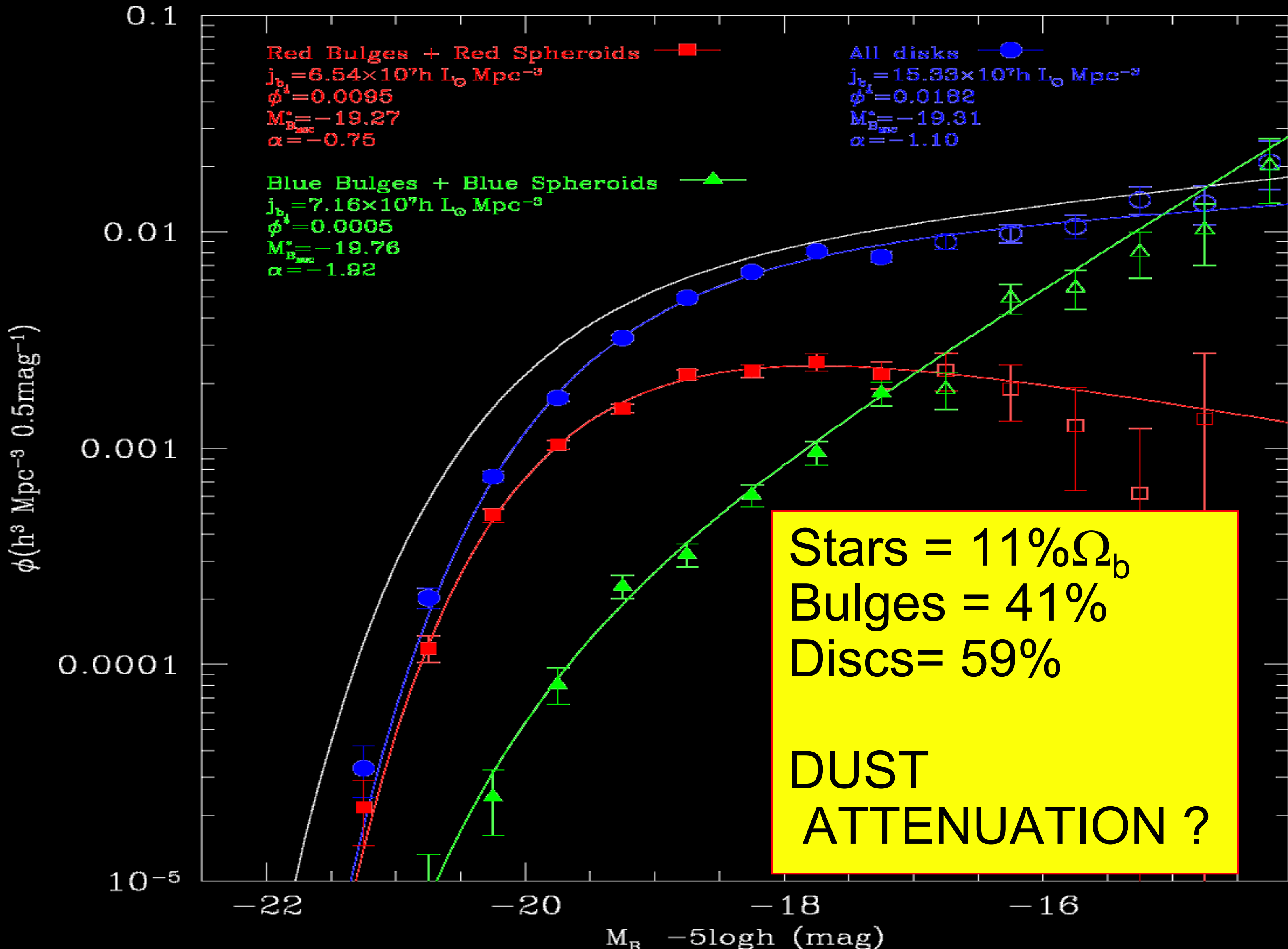






The Component Luminosity Functions

Allen et al (2006), ApJL, submitted

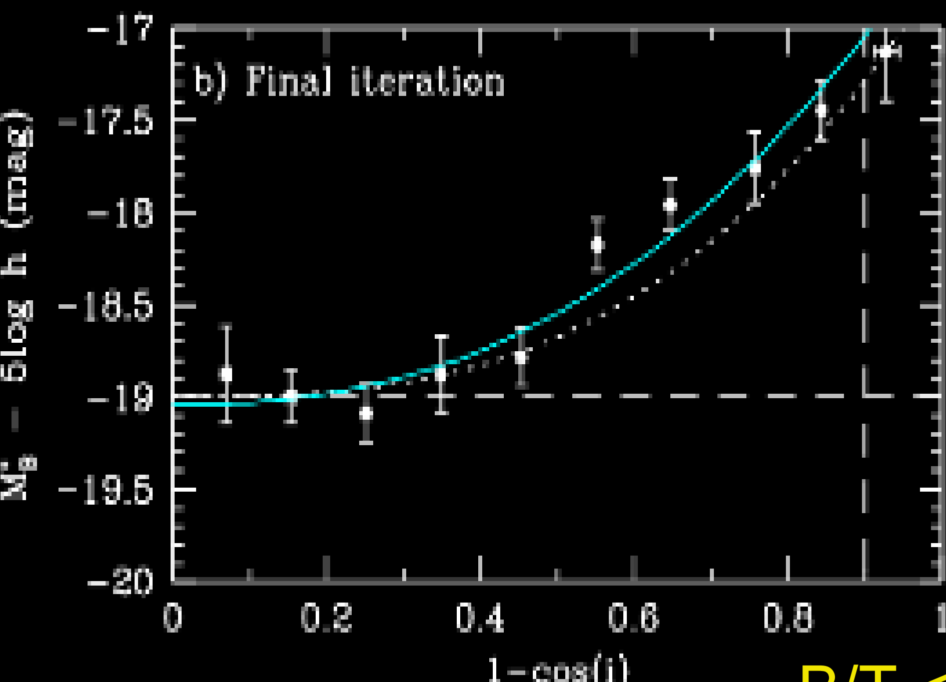


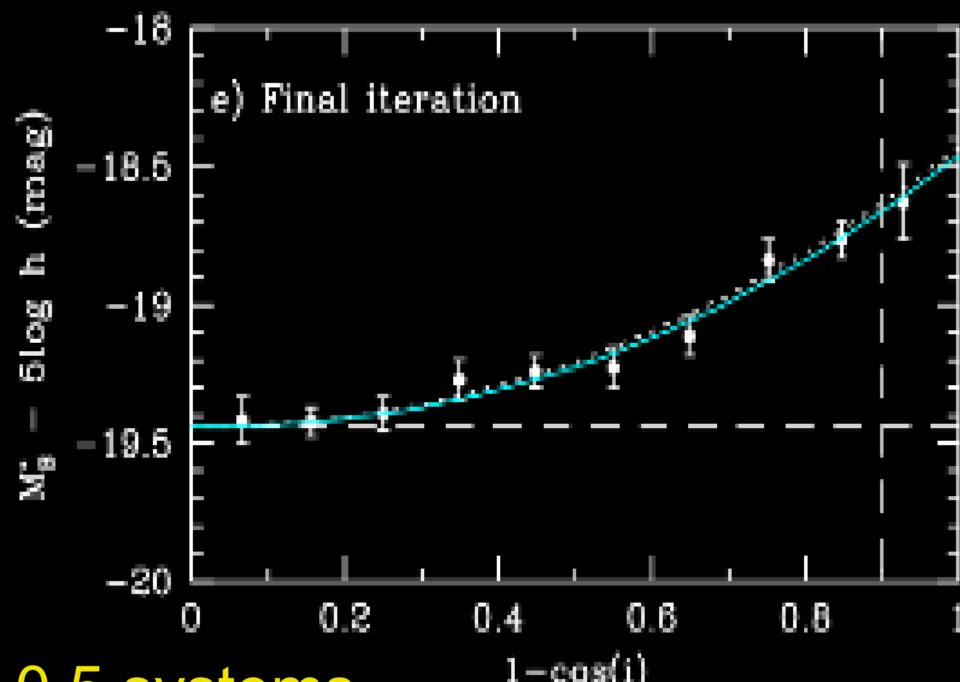
Empirical dust attenuation-inclination relations

- **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 mags !

Disc: 0 - 0.8 mag !

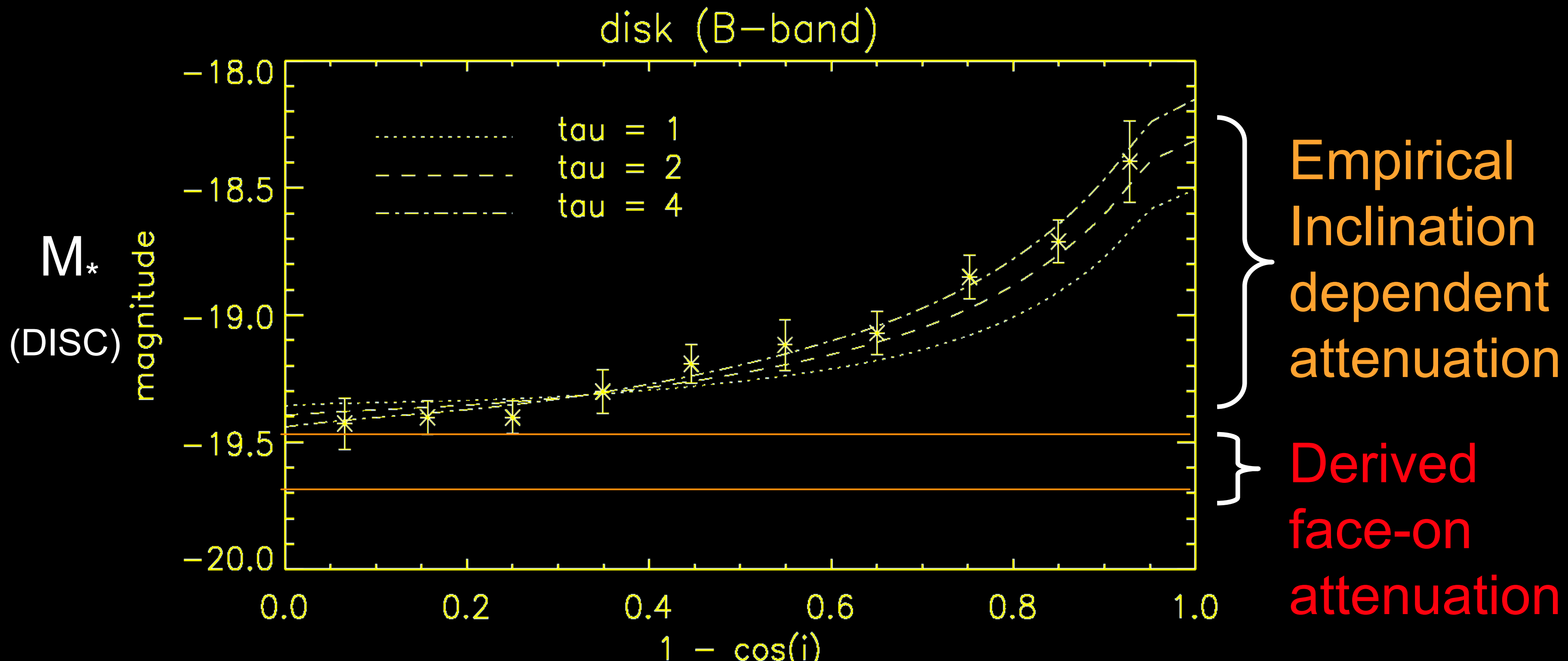




B/T < 0.5 systems

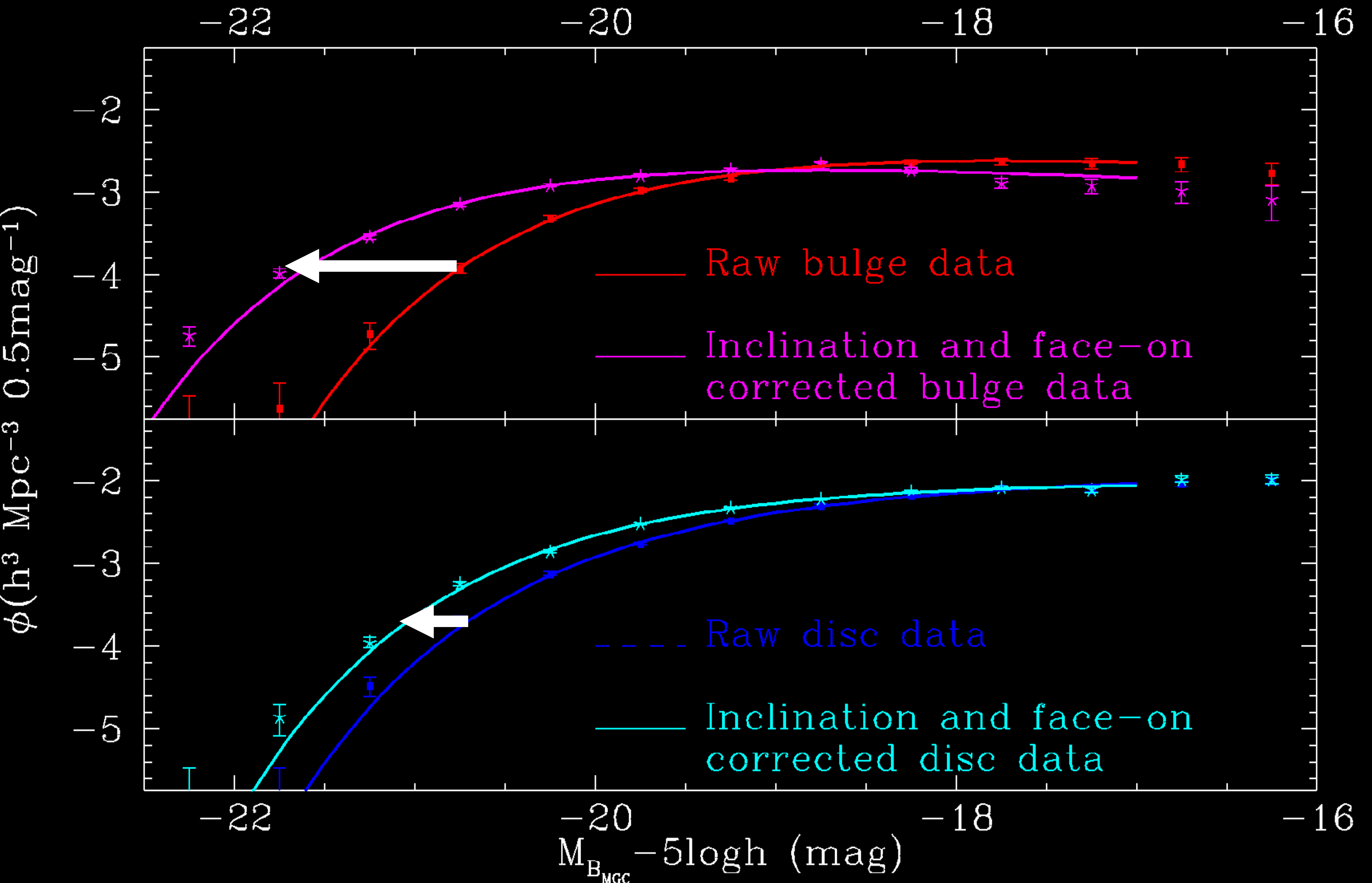
Dust modelling

- We fit the Tuffs and Popescu dust model and derive: τ_B= 3.8 +/- 0.7
  (Popescu et al 2000; Tuffs et al 2004; Popescu et al 2005; Mollenhoff et a 2006)
- Model based on UV+ugrizJHK+Spitzer data of 6 nearby galaxies
- One free parameter = core dust density



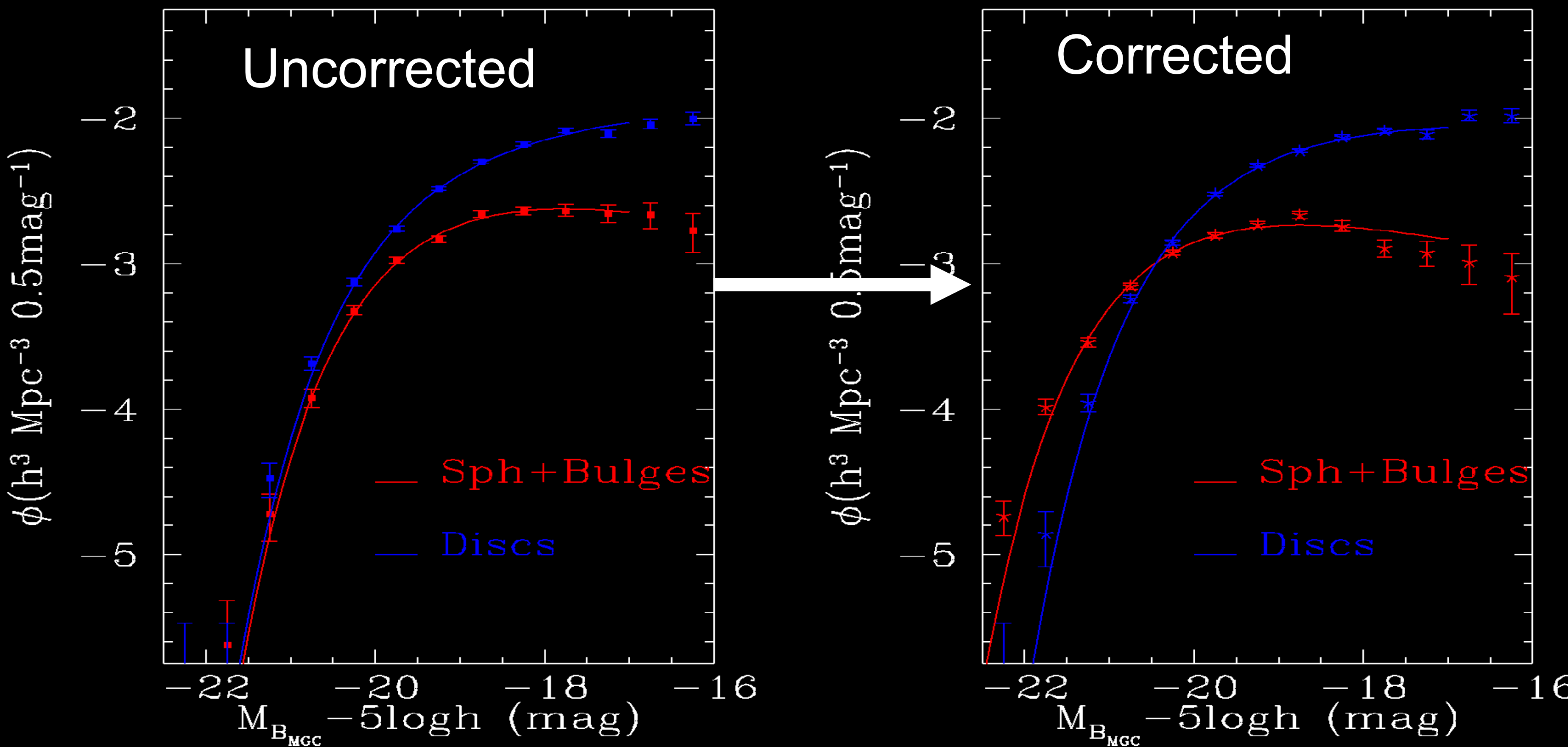
- Face-on attenuation correction in B: Discs = 0.20 mag; Bulges = 0.84 mag
- Total attenuation in B: Discs = 0.2 - 1.1 mag; Bulges = 0.8 -3.4 mag !!!

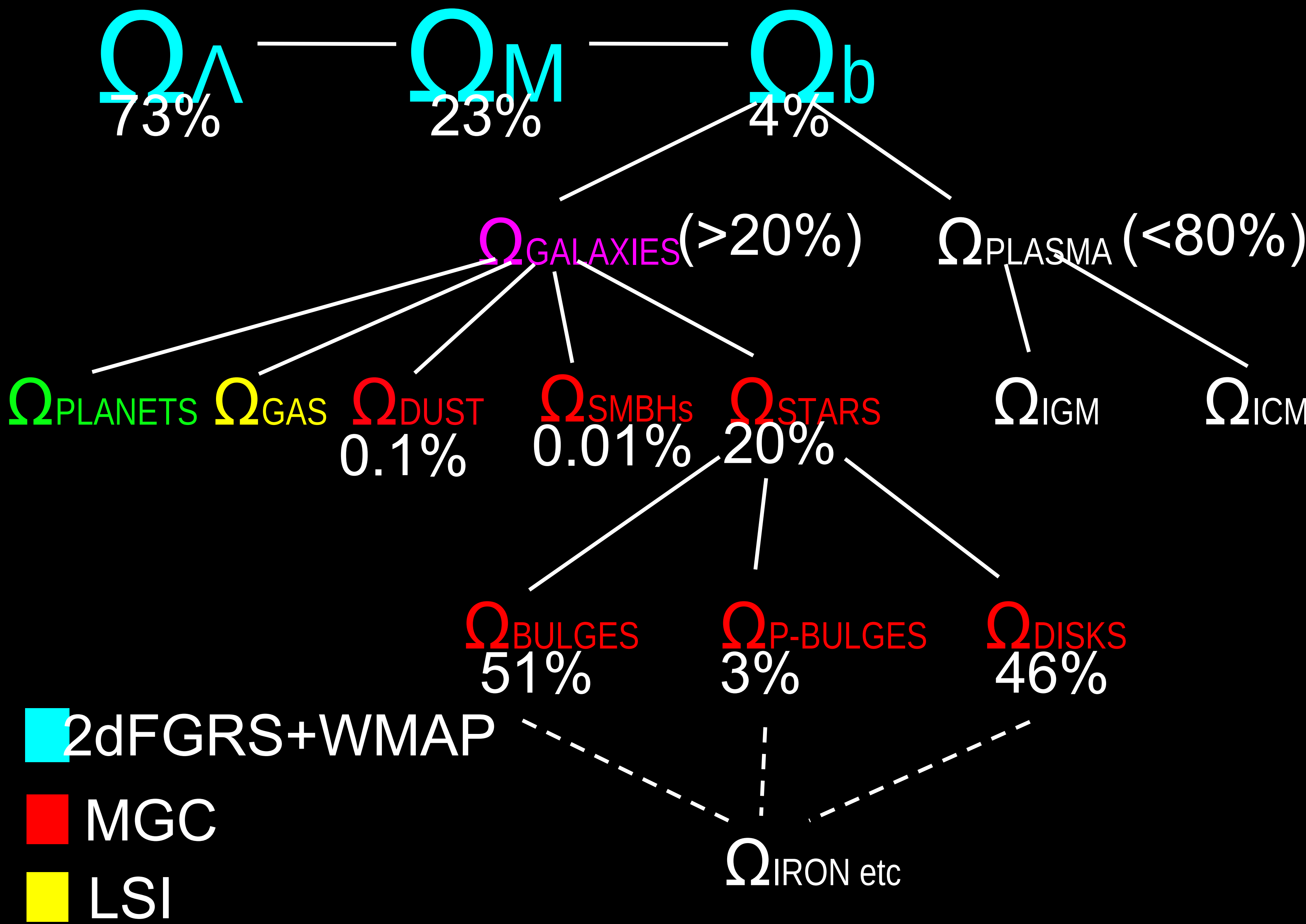
Dust corrected LFs !



Dust corrected LFs !

- Bulge LD up 100%; Disc LD up 40%
- Bulge mass up 150%; Disc mass up 50%
- Similar results derived from scaling up face-on LFs + offsets




ΩΛ
73%
ΩM
23%
Ωb
4%
ΩGALAXIES (>20%)
ΩPLASMA (<80%)
ΩPLANETS
ΩGAS
ΩDUST
0.1%
ΩSMBHs
0.01%
ΩSTARS
20%
ΩIGM
ΩICM
ΩBULGES
51%
ΩP-BULGES
3%
ΩDISKS
46%
2dFGRS+WMAP
MGC
LSI
ΩIRON etc

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

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 benchmark for JWST (launch 2013)