

Did bulges form first and discs later ?

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1. Galaxy bimodalities (colour and structure)
2. **Two populations or two components ?**
3. Morphology & bulge-disk decomposition
4. **The sequence of galaxy formation ?**
5. Summary/Problems/Future directions
6. GAMA database @ St Andrews



INT WFC: 37 sq deg to B=26mag/s arcsec

~1 million galaxies

SDSS DR4: ugriz to B~25mag/sq arcsec

AAT 2dF: 10k z_s to B=20 mag (96%)

GEMINI: z_s for extreme-LSBGs (30%)

12 science papers in print/under review

The MGC Team

Simon Driver (St Andrews)

Jochen Liske (ESO)

Paul Allen (St Andrews/RSAA)

Alister Graham (RSAA)

Ewan Cameron (St Andrews/RSAA)

MGC Collaborators

Nicholas Cross (ROE)

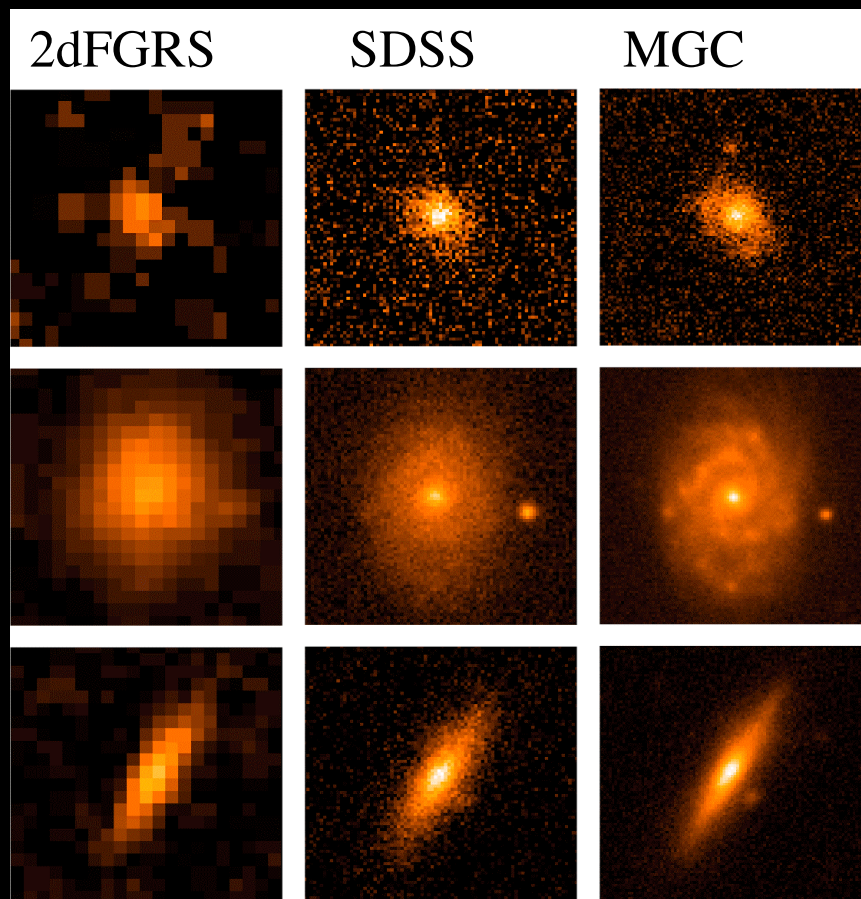
Roberto De Propriis (CTIO)

Simon Ellis (AAO)

Steve Phillipps (Bristol)

Warrick Couch (UNSW)

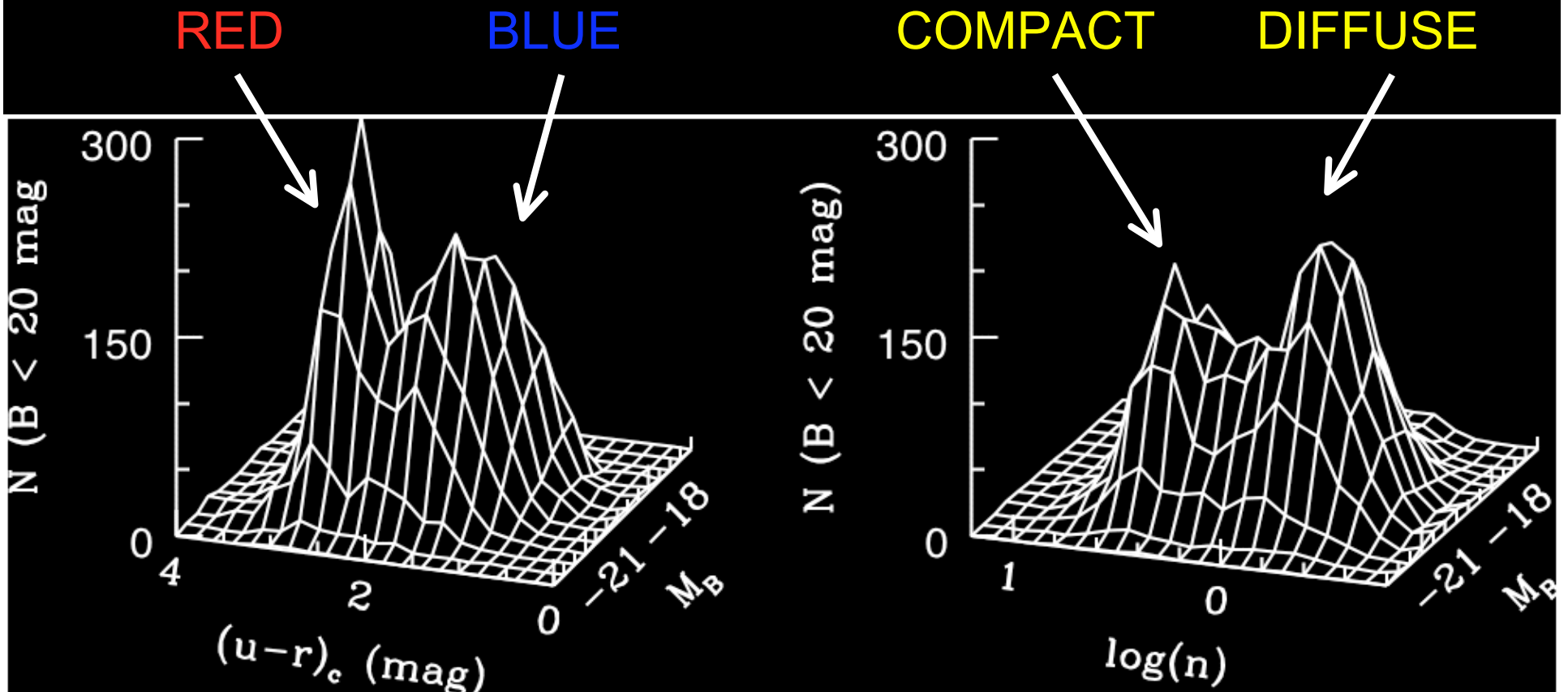
<http://www.eso.org/~jliske/mgc/>



Galaxy Bimodality

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

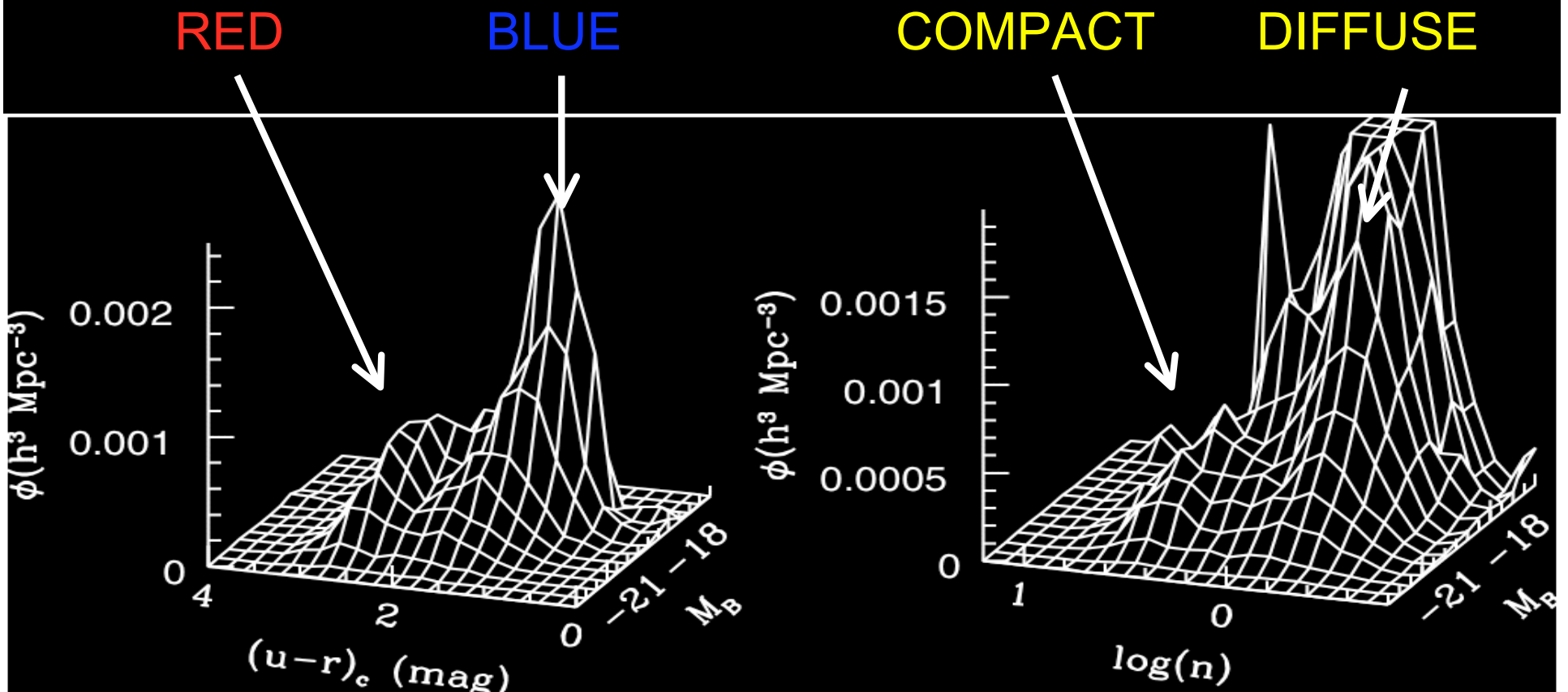
OBSERVED DISTRIBUTIONS ($M_B < -16$)



Galaxy Bimodality

Observe strong colour ($u-r$) and structural ($\log n$) bimodalities
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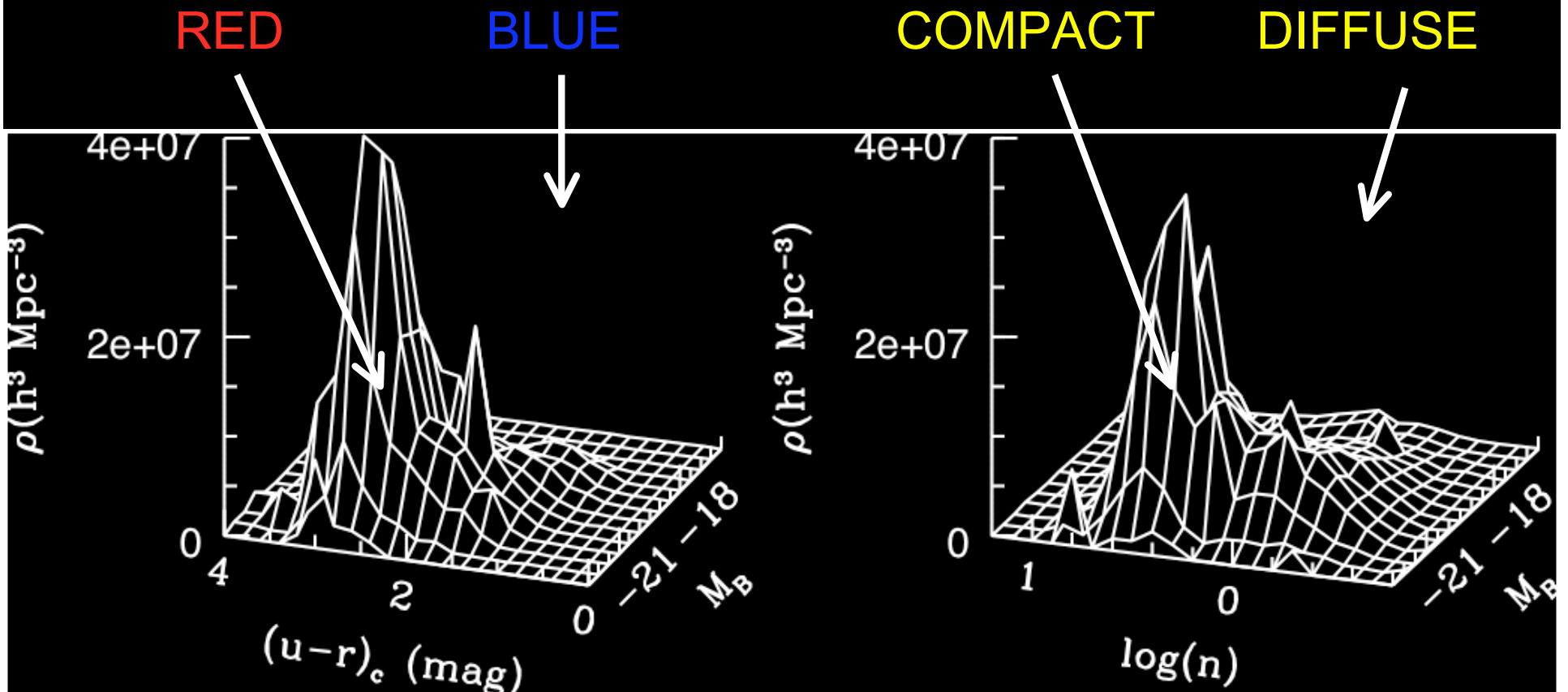
VOLUME CORRECTED (NUMBER DENSITY)



Galaxy Bimodality

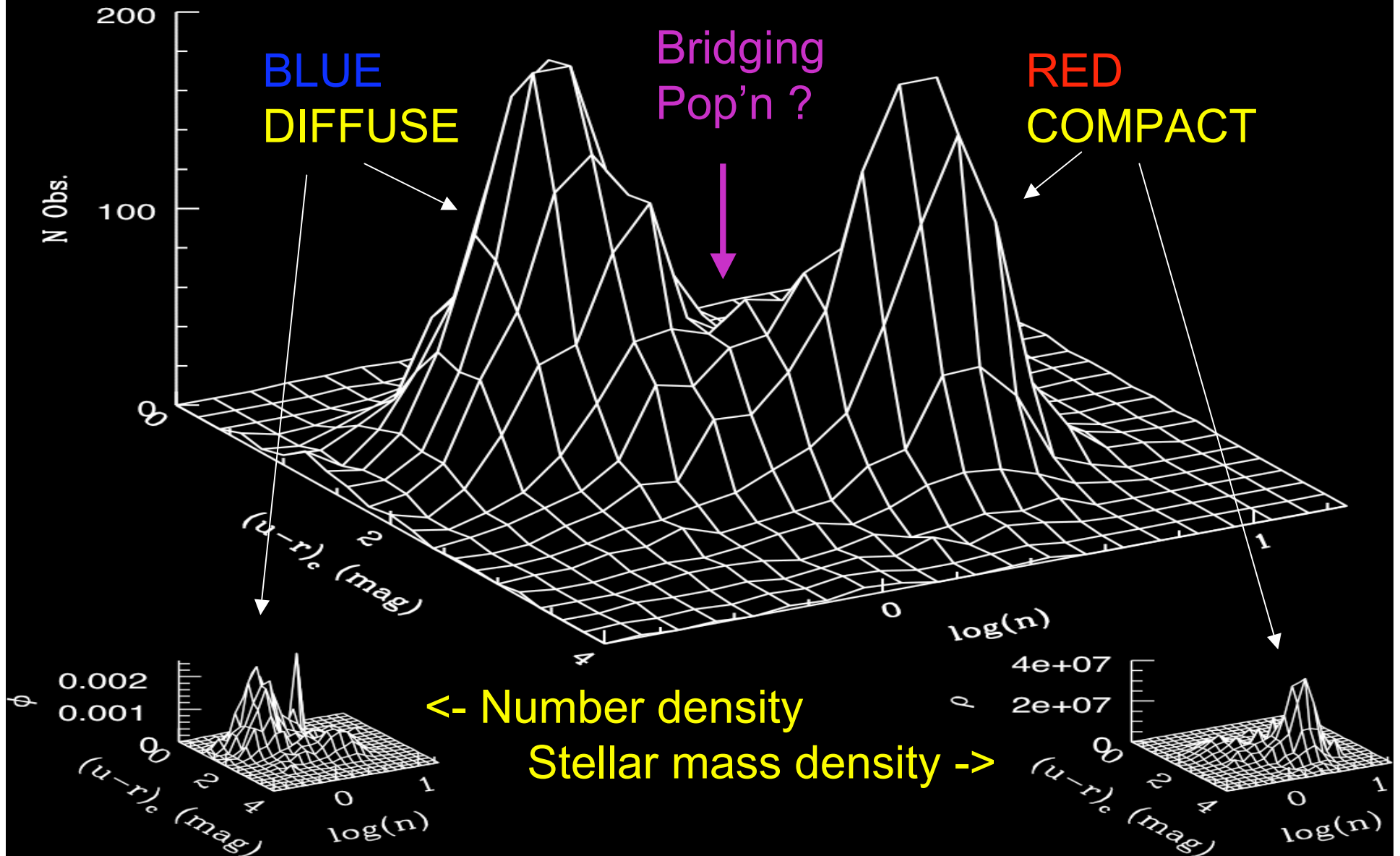
Observe strong colour ($u-r$) and structural ($\log n$) bimodalities
(Strateva et al 2001; Baldry et al 2004; Driver et al 2006)

VOLUME CORRECTED (MASS DENSITY)



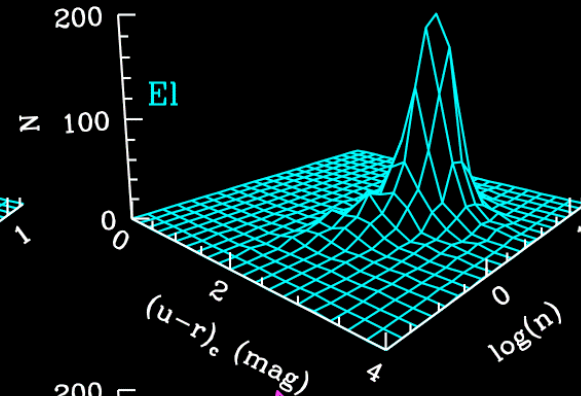
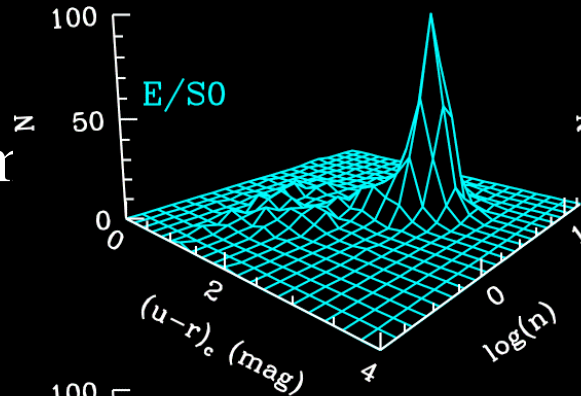
Bimodality in (u-r)-log(n)

(Driver et al, 2006, astro-ph/0602240)



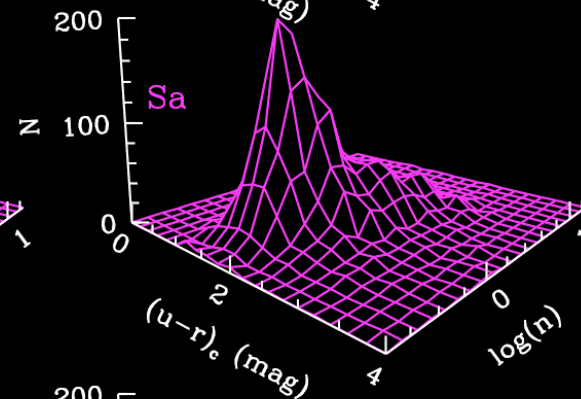
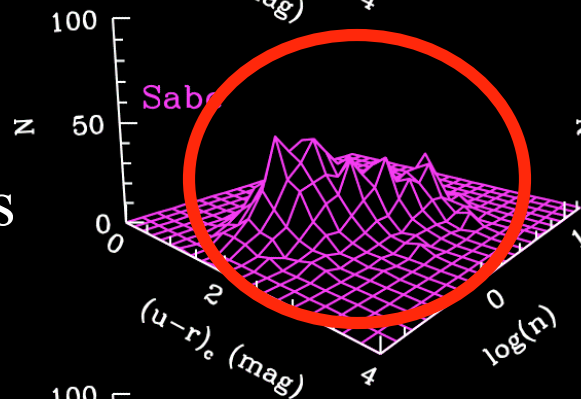
Two populations or two components ?

E/S0s
Bulge system



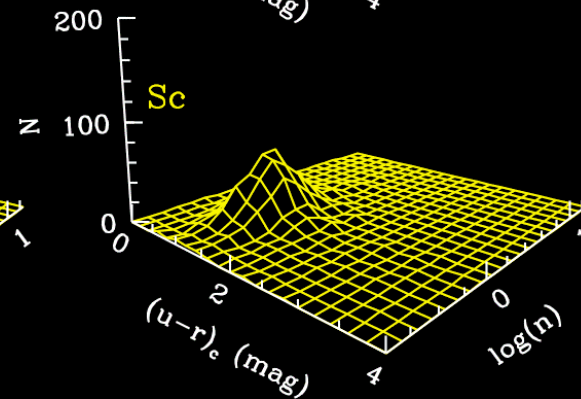
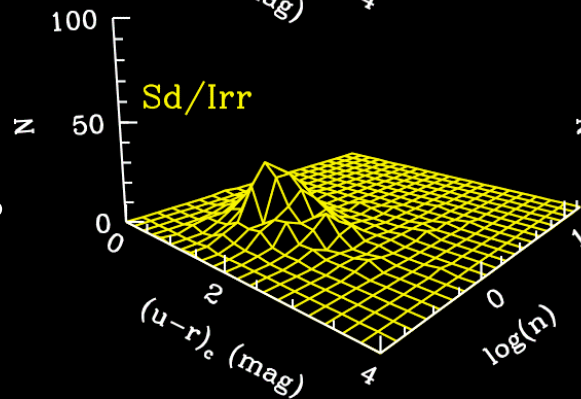
E1(Old)

Sabc
Bulge+Disks



Sa(Interm.)

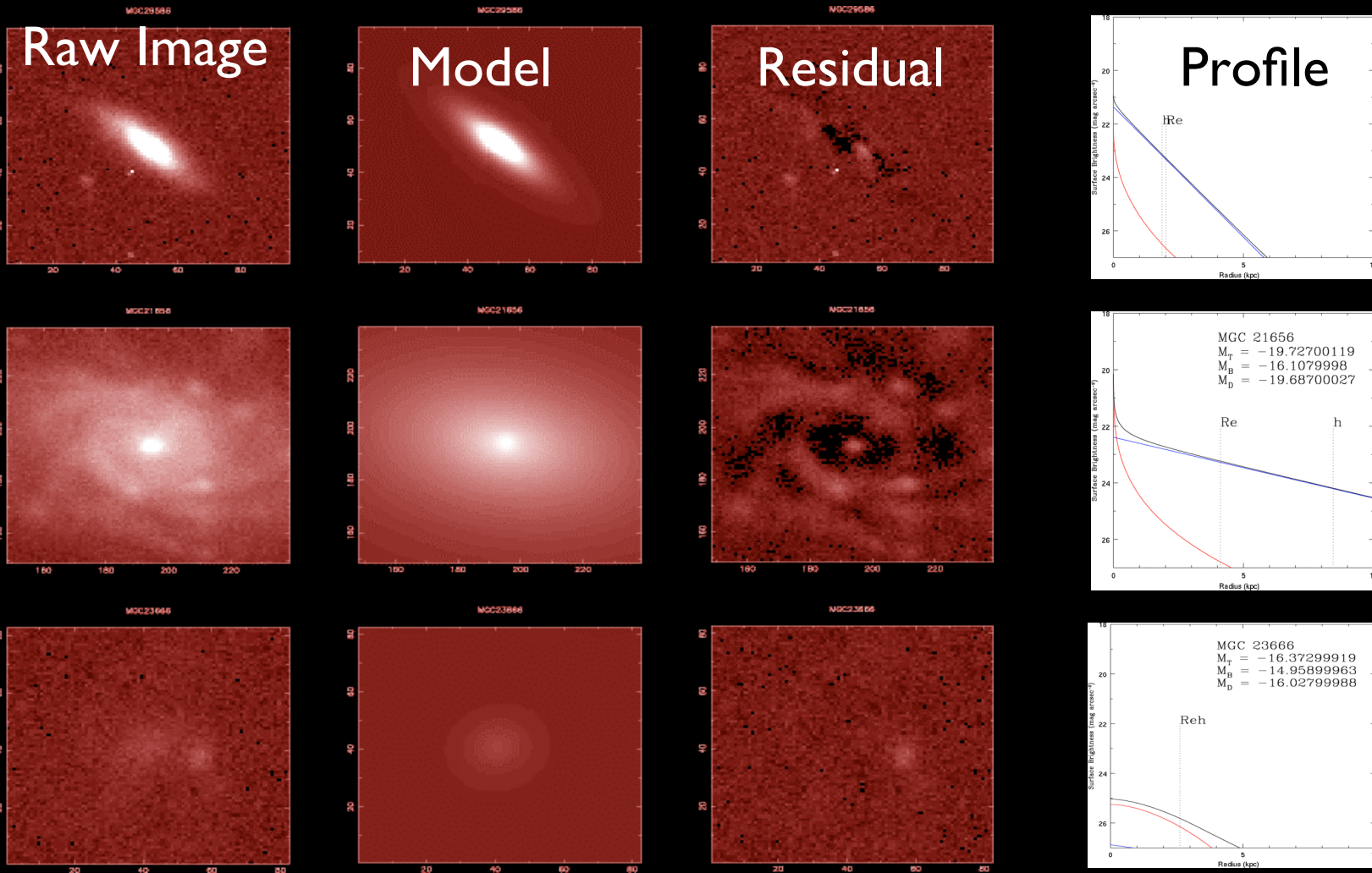
Sd/Irr
Disk systems



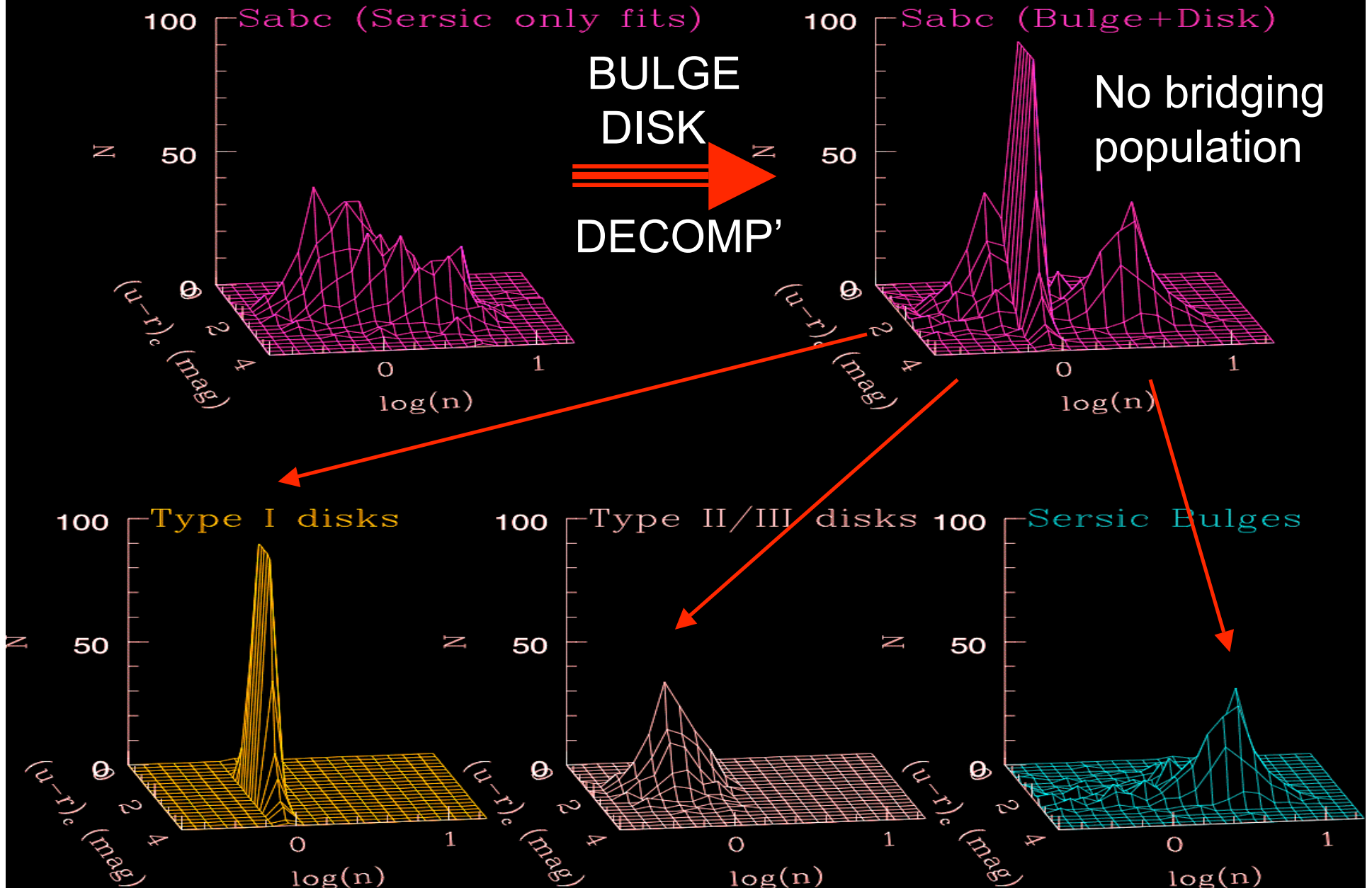
Sc(Young)

MGC Structural Analysis (GIM2D)

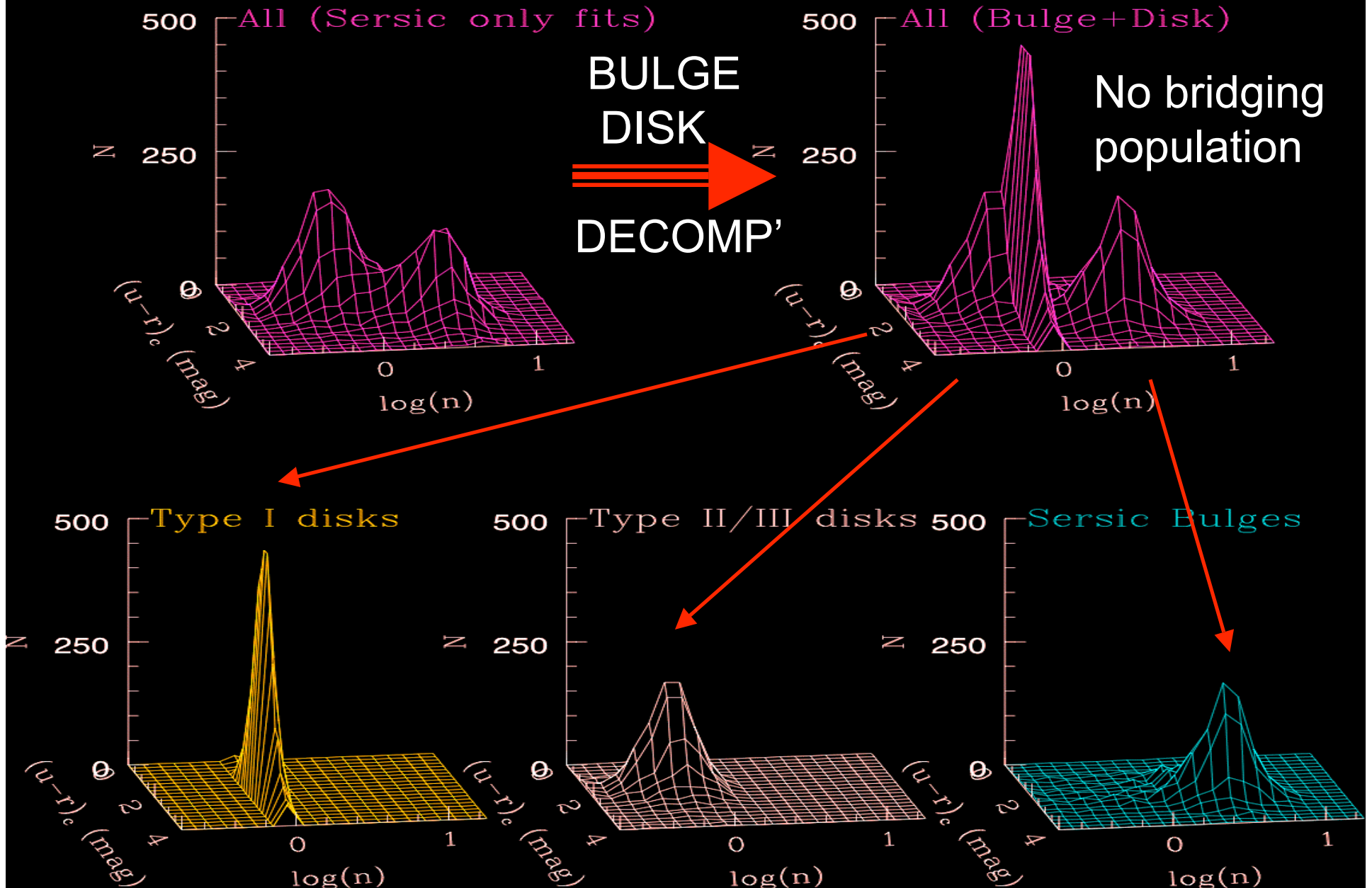
- o 12 Dimensional minimisation (Sersic+exponential profiles+PSF convolution)
- o 10,095 galaxies now completed, largest available sample, [Allen et al \(2006\)](#)



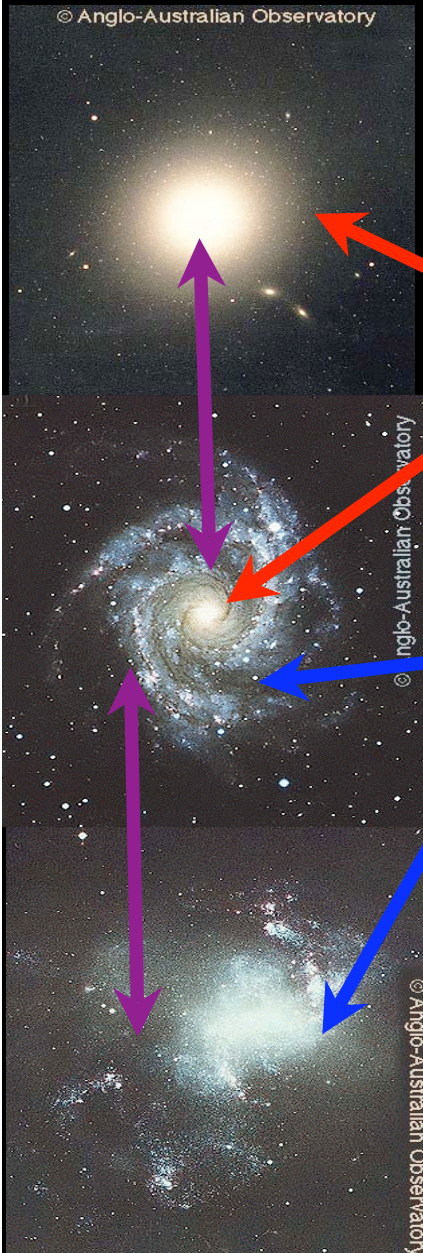
Two populations or two components ?



Two populations or two components ?



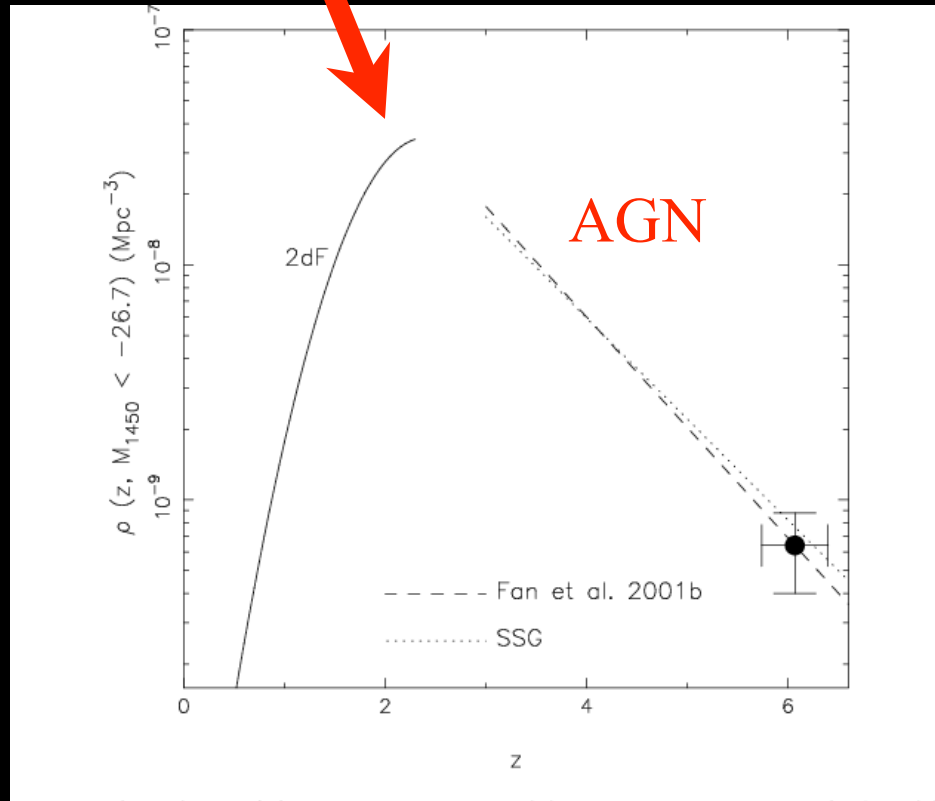
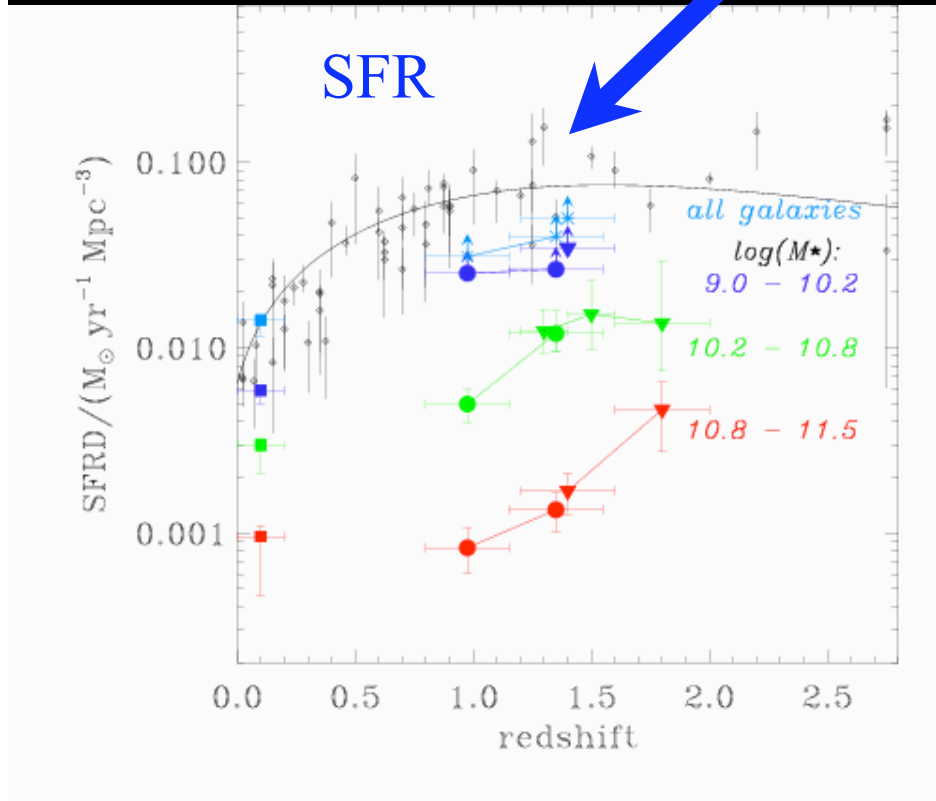
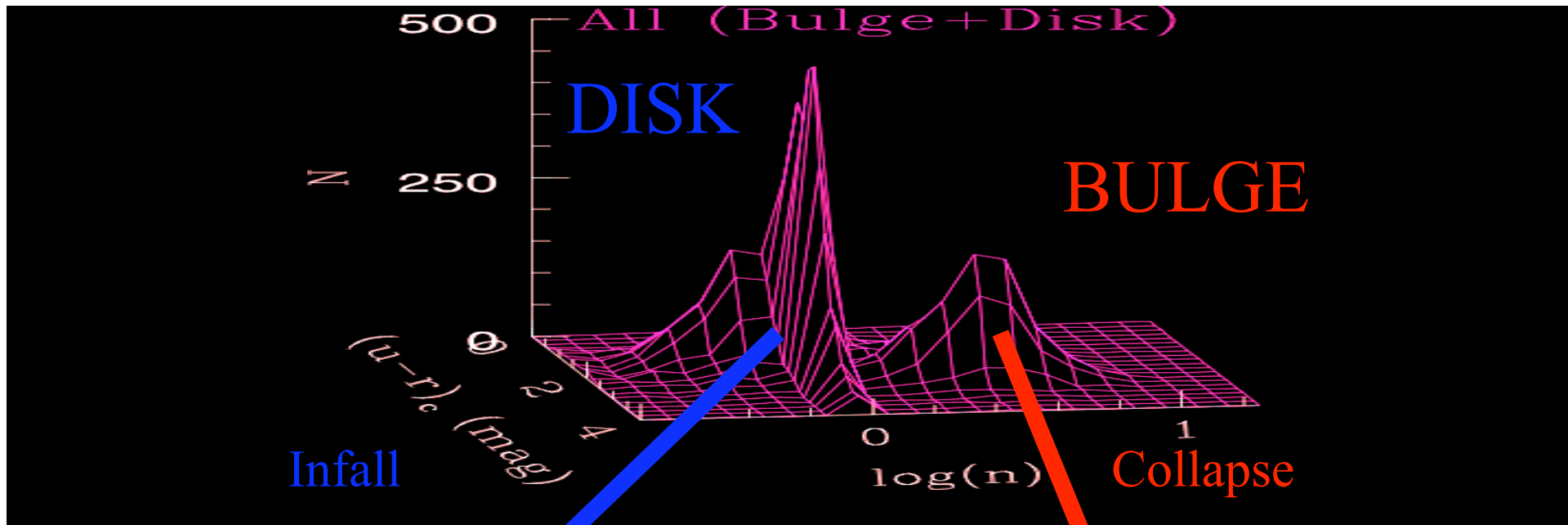
Galaxy formation ?



SPHEROIDS/BULGES: Red, old, hot, empty, SMBH bulge relations, L-size (Kormendy rel), $z_{\text{form}} = \text{AGN peak and Ly-break systems}$.

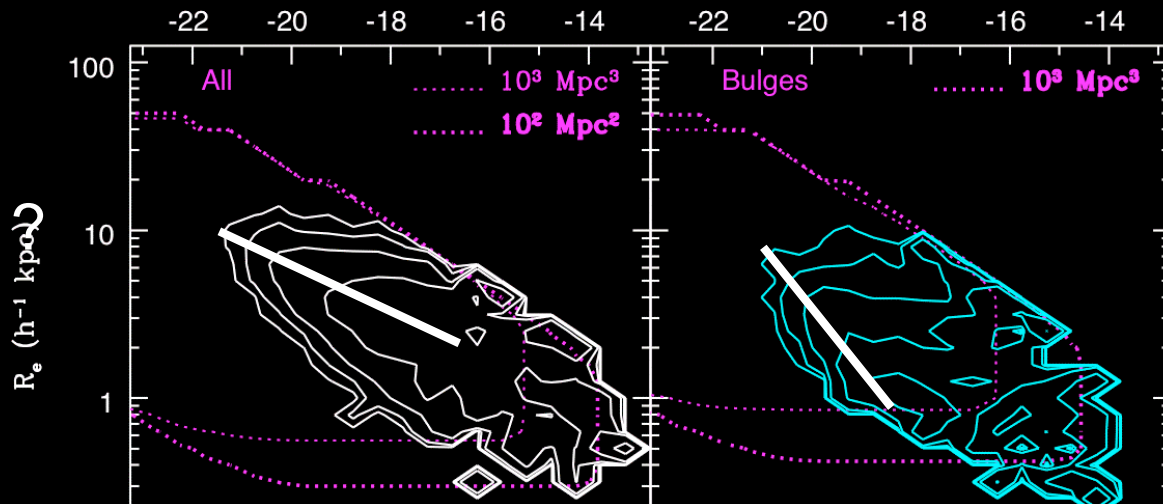
DISCS & IRRs: Blue, young/inte., dusty, rotating, no SMBHs?, L-size (Freeman Law), $z_{\text{form}} = \text{SFR and HDF asymmetry at } z=1-2$

2 DISTINCT FORMATION MECHANISMS AND ERAs ?



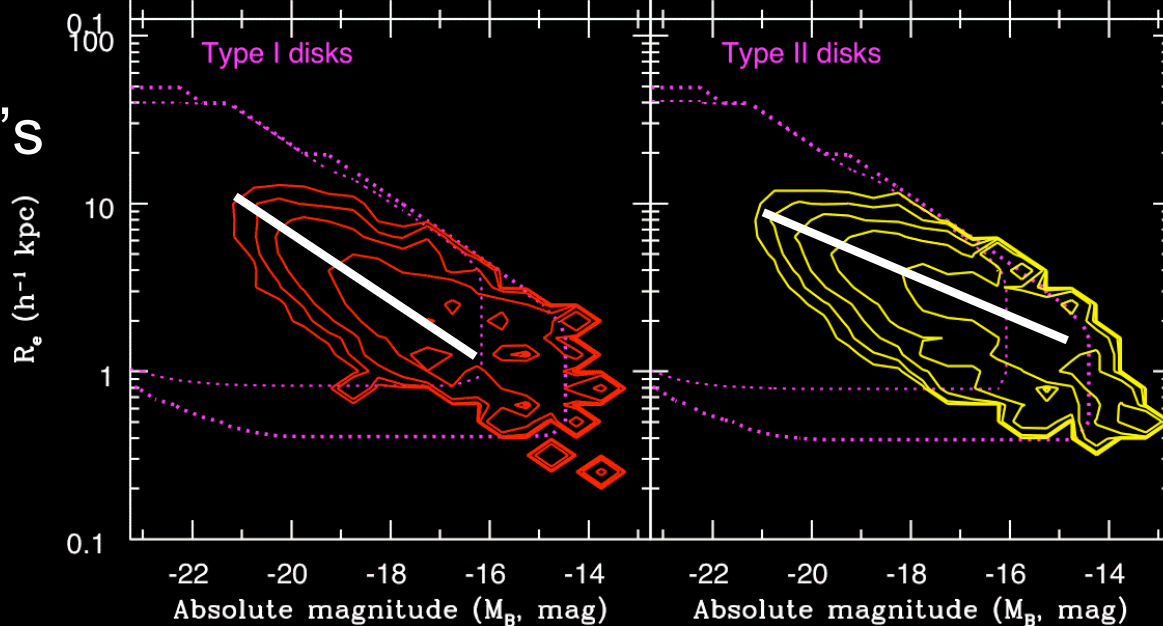
Luminosity-size relation(s)

Global Relation



Kormendy Relation ?

Freeman's Law ?



De Jong & Lacey ?

Summary/Problems/Future directions

- Disks and bulges occupy distinct non-overlapping regions in the colour-structure plane...(no obvious crossover pop!)...independent ?
- **Must entertain notion of bi(tri)-modal galaxy formation scenario?**
 1. Dark matter halo assembly
 2. Bulge formation via monolithic/frag. collapse (Bulge/AGN/SMBH trinity)
 3. Disk formation through splashback, accretion & infall
- Today 50% of stars by mass in spheroids/bulges and 50% in disks
- **Must abandon the Hubble tuning fork and morphology**
- **May also need to abandon global measurements ?**
 - ⇒ Luminosity-size relation of bulges and disks (HST, JWST)
 - ⇒ Star-formation rates of bulges and disks (IFUs)
- **Routine bulge-disk decomposition needed to unravel gal. evol.**
 - Requires deeper higher resolution data ($1'' \sim 1\text{kpc}$ at $z=0.1$)
 - Near-IR (Dust & star-formation major problems in optical profiling)
 - Disk truncation & nuclei fitting major unsolved issues
 - Need to develop robust fast codes (e-science application) **GAMA ==>**
 - Selection bias extremely complex (12D surface inside the 12D datacube)

Galaxy And Matter Assembly (GAMA) Database @ St Andrews

- New 300 sq degree survey combining:
 - MGC, SDSS-DR4, UKIDSS
 - VST KIDS deep high resolution optical imaging (x2 res, +3mag)
 - VISTA KIDS deep high resolution near-IR imaging (near-IR, +3 mag)
 - AAT AAOmega redshifts (to B~21.5 mag, +1.5mag, x2 spec. res)
 - GEMINI/VLT/SALT redshifts and IFU follow-up (eLSBGs, dynamics)
- Science goals:
 - Testing CDM on kpc to Mpc scales (3 tests: Halo MF, LF, merger tree)
 - Tracing bimodality and global SFR to z=0.6
 - Structural decomposition of ~100 000 galaxies (MGC x10)
 - Comprehensive study of the dwarf galaxy domain (MB to -11 mag)

4 year SUPA Fellowship available at St Andrews, see AAS April Job Register for details or <http://star-www.st-and.ac.uk/> or e-mail: spd3@st-and.ac.uk