The MGC and GAMA: structural surveys
Simon Driver (St Andrews)

1) THE MILLENNIUM GALAXY CATALOGUE (15 PAPERS IN PRINT):
   1) THE BARYON BUDGET (BY STELLAR MASS: 60% DISCS, 30% BULGES, 10% ELLIPTICALS)
   2) DUST ATTENUATION (IN B: 0.2-1.2 (DISCS), 0.8-2.5 (BULGES) MAG DEPENDS ON INC.)
   3) BALANCING THE COSMIC ENERGY BUDGET (ATTENUATED STARLIGHT=FAR-IR EMISSION)
   4) IMPLICATIONS FOR GALAXY FORMATION

1) GALAXY AND MASS ASSEMBLY (18 PAPERS IN PROGRESS):
   1) 250K GALAXIES OVER 250 SQ DEG TO R=19.8 (0.0 < Z < 0.6) (50K OBTAINED SO FAR)
   2) FULLY MULTI-WAVELENGTH (UV-OPTICAL-NEAR-IR-FAR-IR-RADIO (20CM, 21CM))
   3) STUDY OF STRUCTURE ON 1KPC TO 1 MPC SCALES:
      1) THE HALO MASS FUNCTION (CLUSTER/GROUP VELOCITY DISPERSIONS)
      2) THE BARYON MASS FUNCTION AND STAR FORMATION EFFICIENCY
      3) THE STELLAR MASS FUNCTION AND FEEDBACK
      4) RECENT MERGER RATES

      } by type, environment & redshift

   5) GENERIC RESOURCE (SPECTRA, BULGE-DISC DECOMP, AND FULL SED FOR ~100K SOURCES)

NGC4565

ESO PR Photo 24a/05 (August 10, 2005)

The Millennium Galaxy Catalogue

UKIRT/LAS 8 nights

SDSS

INT/WFC

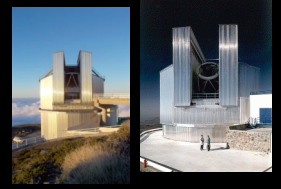
14 nights

AAT/AAΩ

15 nights+2dFGRS

GEMINI/GMOS

3 nights



TNG 4nights
NTT 3nights
2.3m ANU
12 nights

Near-IR (JHK)

ugriz+z's

z, spectra

z, LSBGs

B, morph
B/D decomp

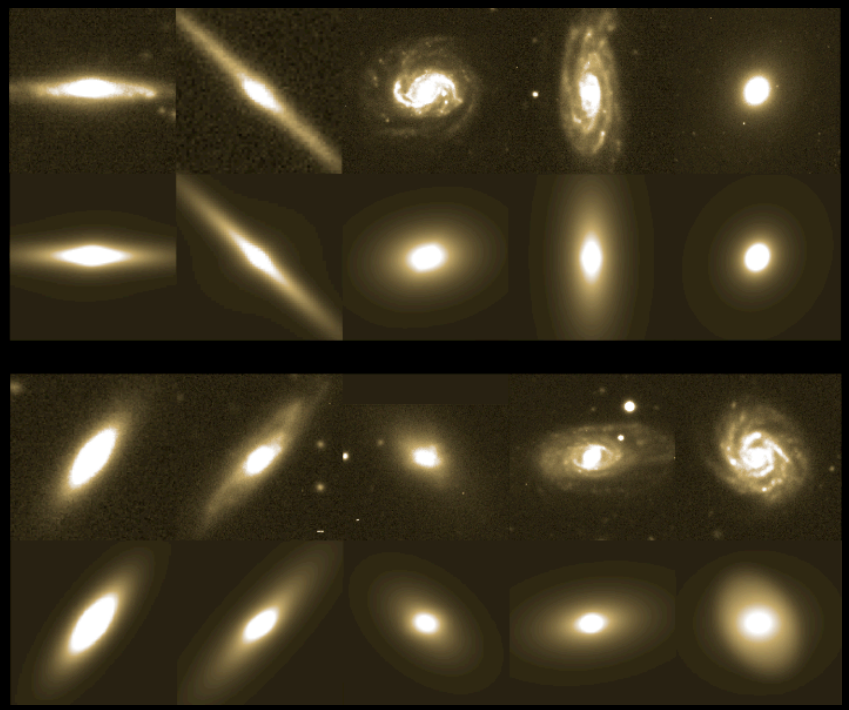
MGC

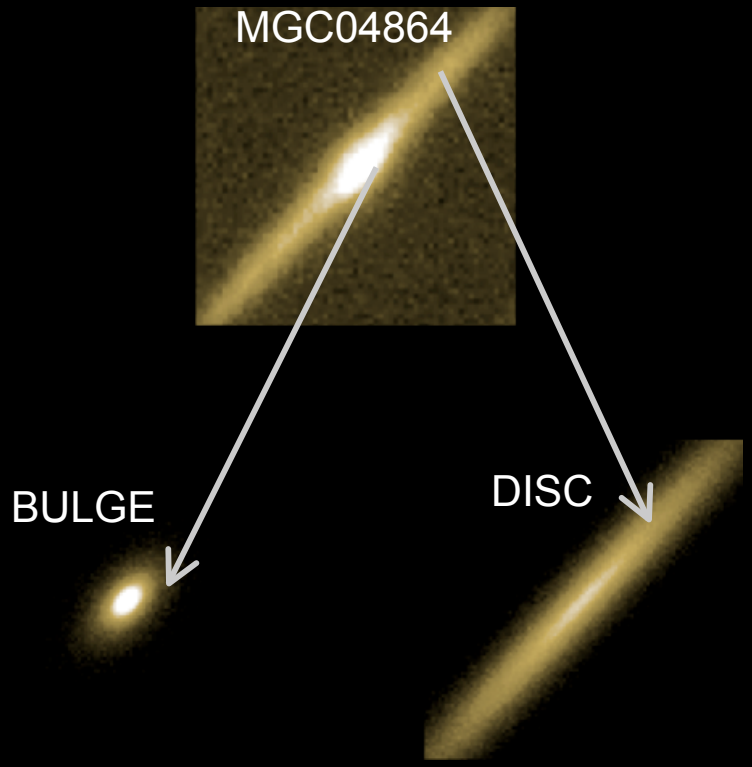
Z, LSBG
HSBGS

SCIENCE

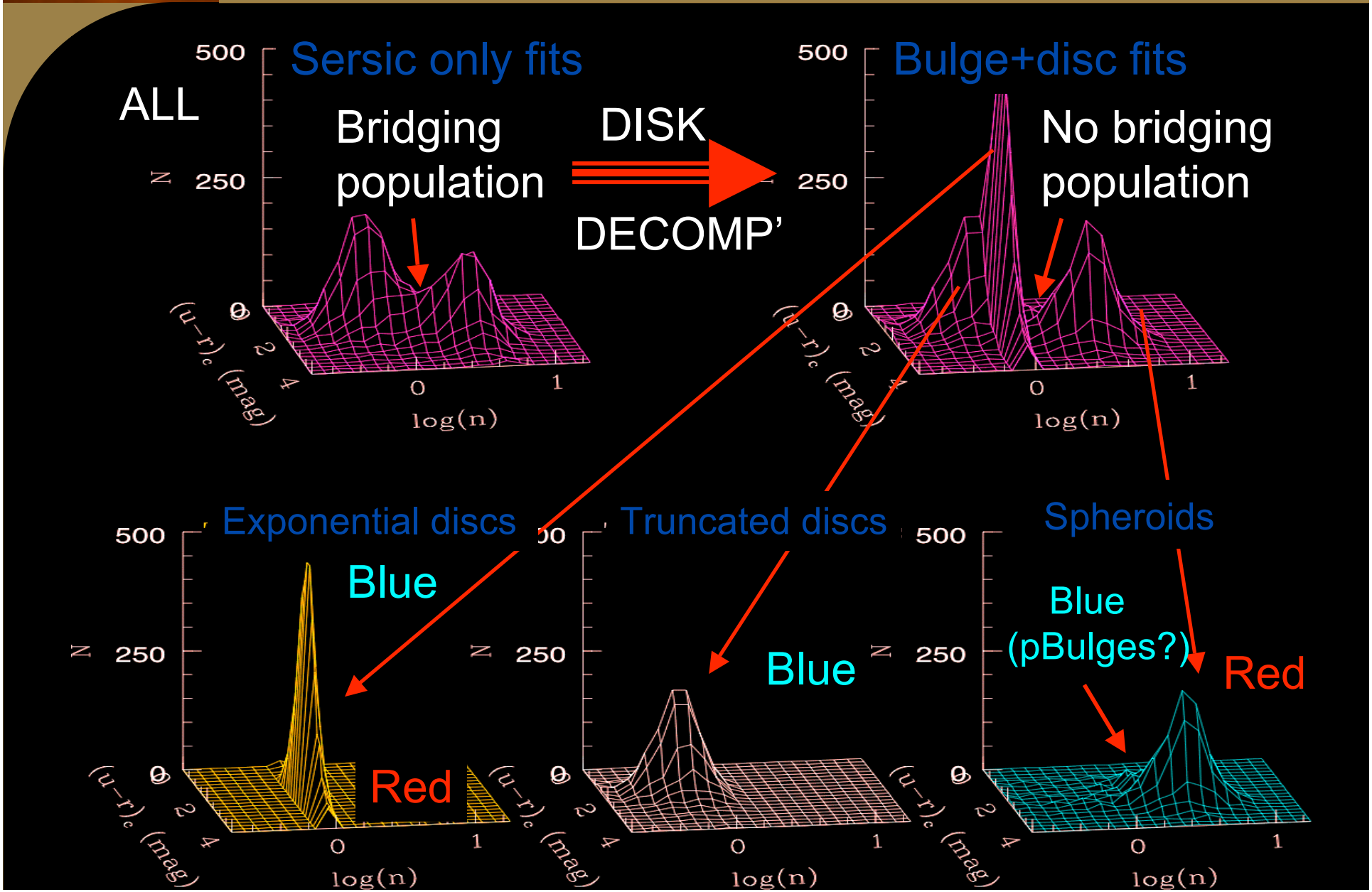
GIM2D bulge/disc decompositions

- Sersic+exponential profiles+PSF convolution via GIM2D, Simard et al (1998)
- 10,095 gals = largest available sample, Allen et al (2006) (robust/reproduceable)
- 96% redshift completeness (AAT/GEMINI) to B=20.0 mag, Driver et al (2005)
- B(INT) + ugriz(SDSS) + YJHK(UKIRT) imaging now 100% complete.
- All data available online: http://www.eso.org/~jliske/mgc/



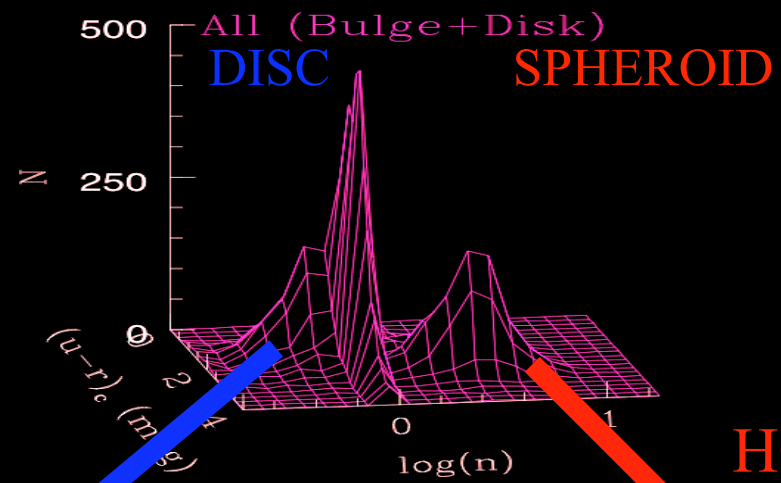


Two pop's or two components ?



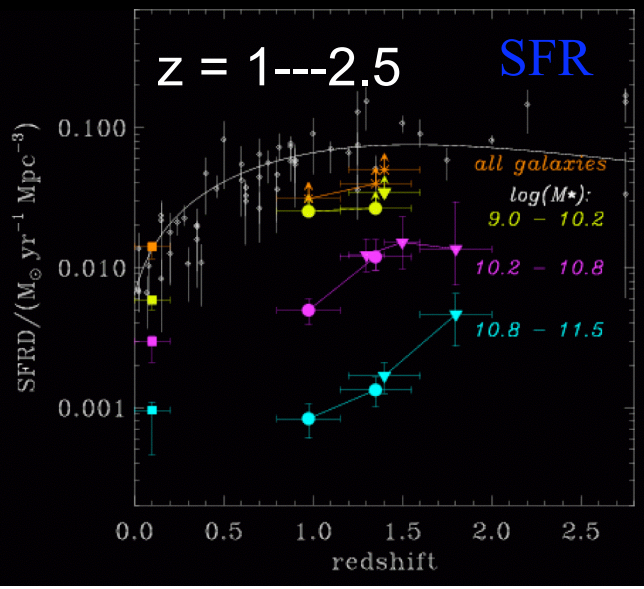
Two distinct modes of evolution ?

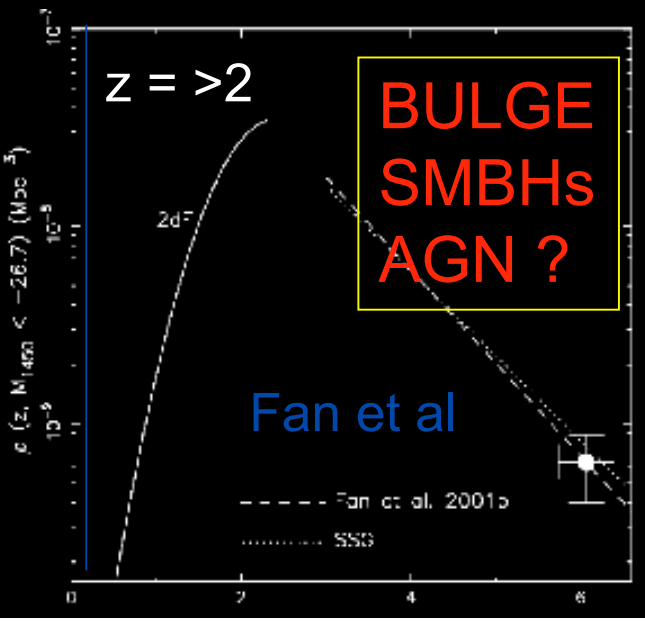
Structure more fundamental than colour.



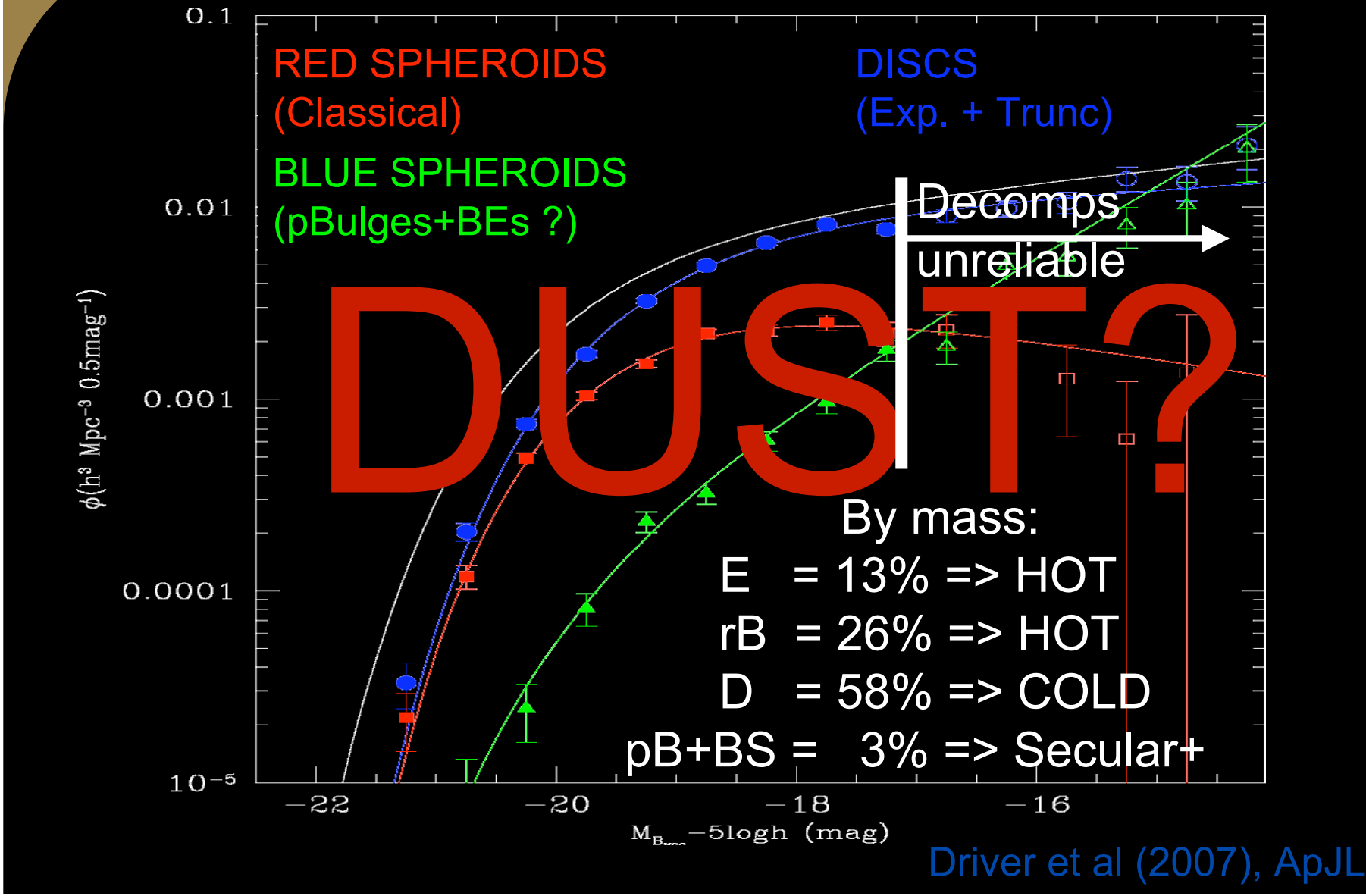
COLD MODE

HOT MODE





The Component Luminosity Functions

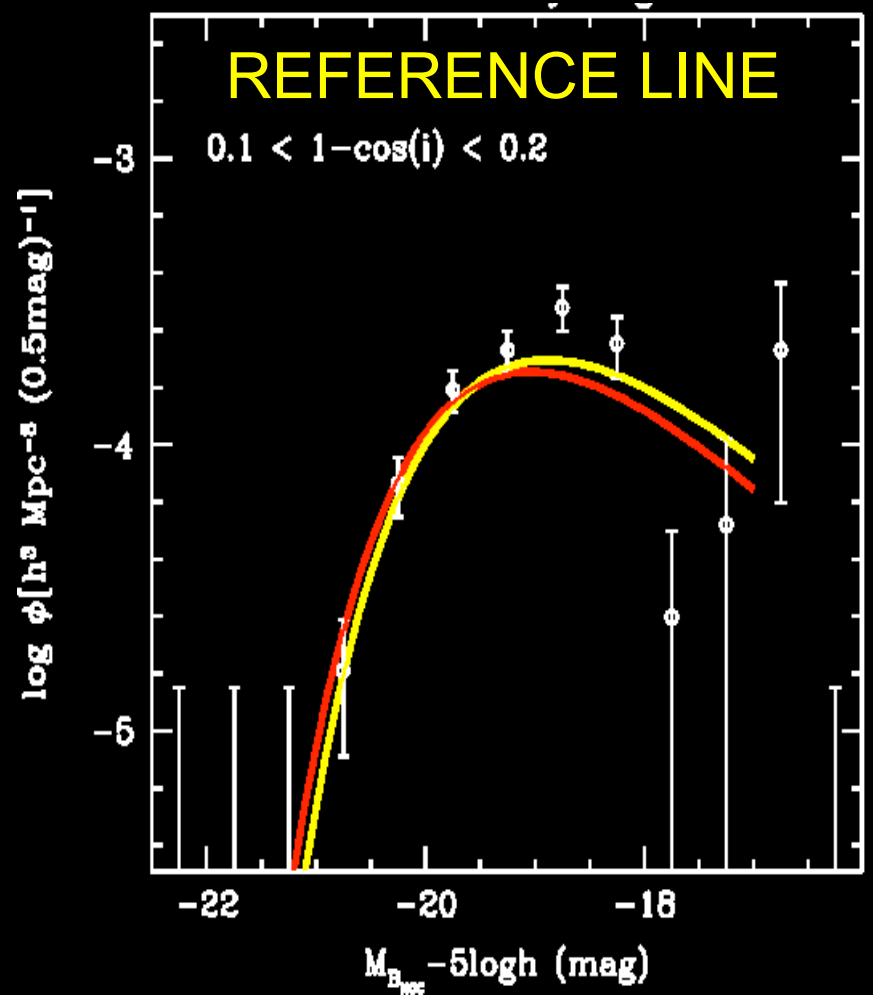


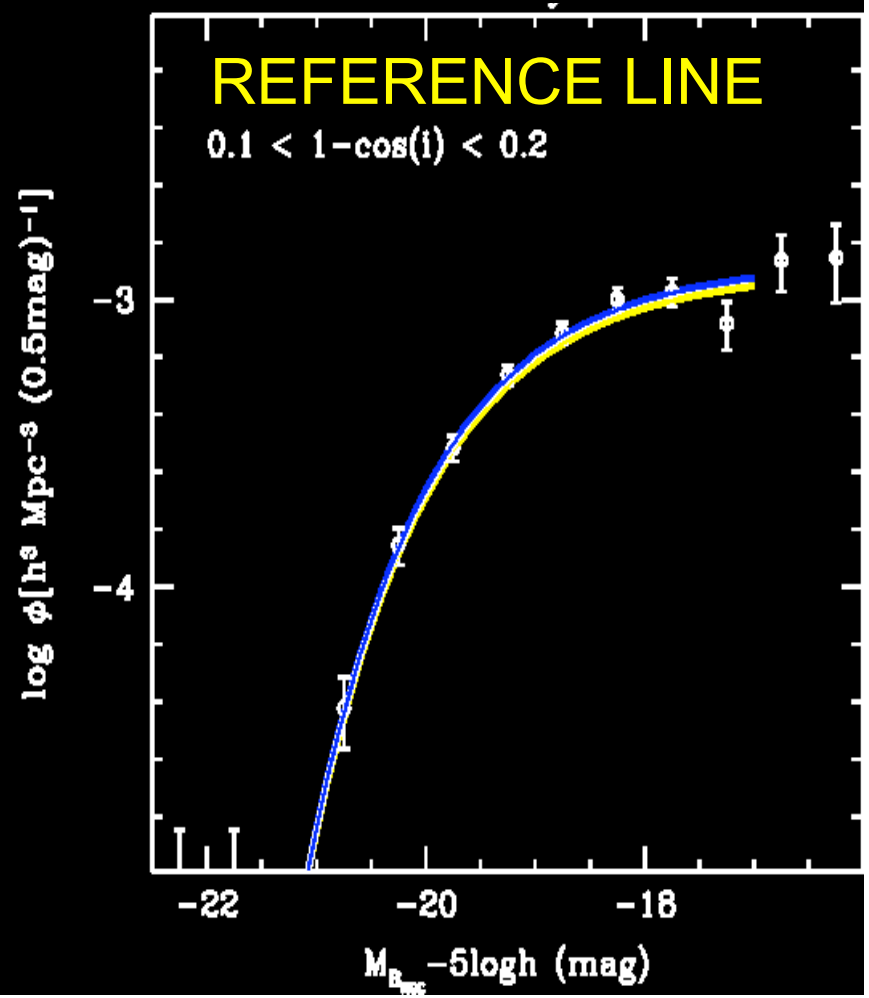
Driver et al (2007), ApJL

Component LFs v cos(*i*)

NEARLY FACE-ON GALAXIES

Bulges 0.1 < 1-cos(*i*) < 0.2 Discs

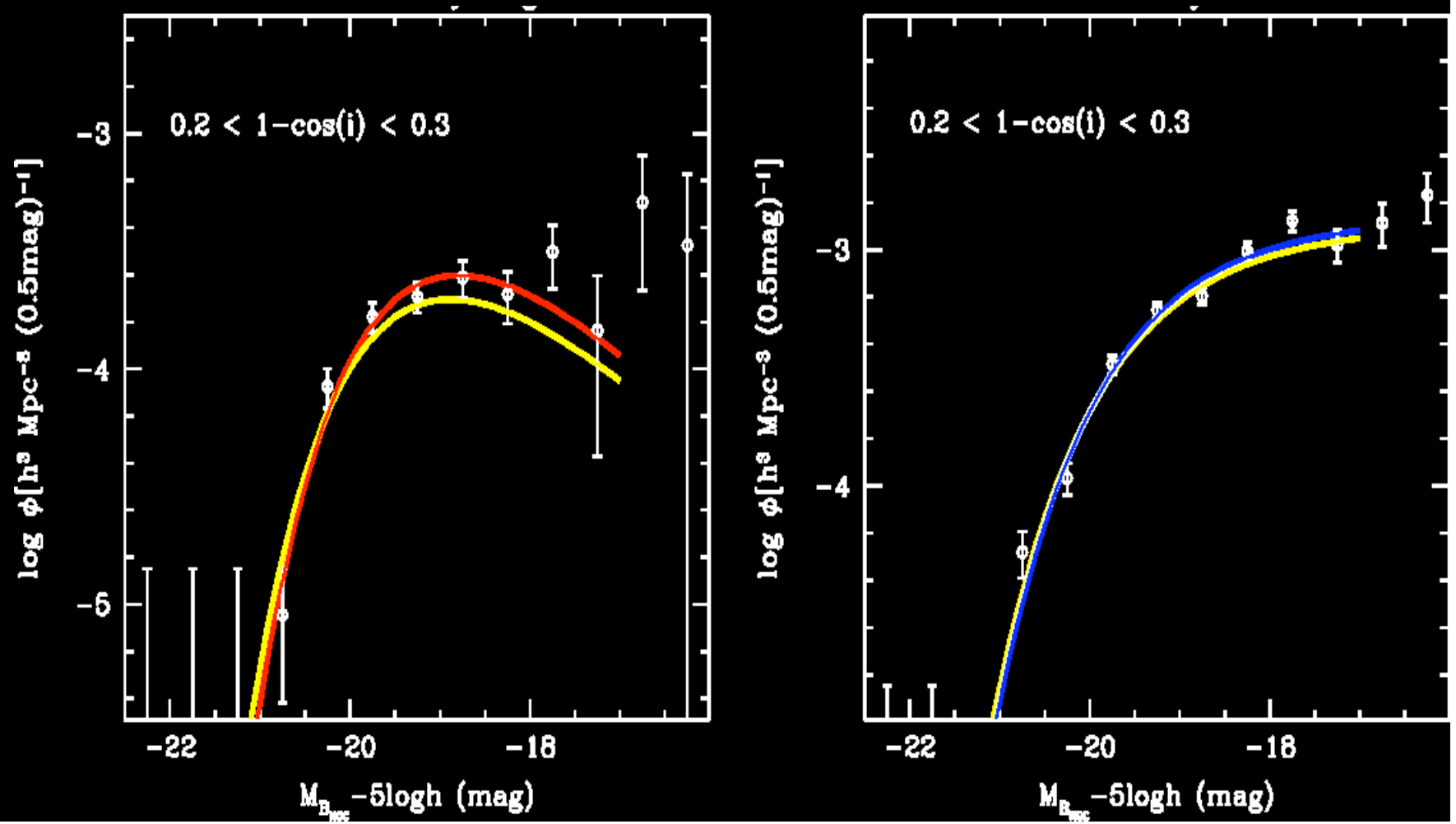




MGC
Millennium Galaxy Catalogue

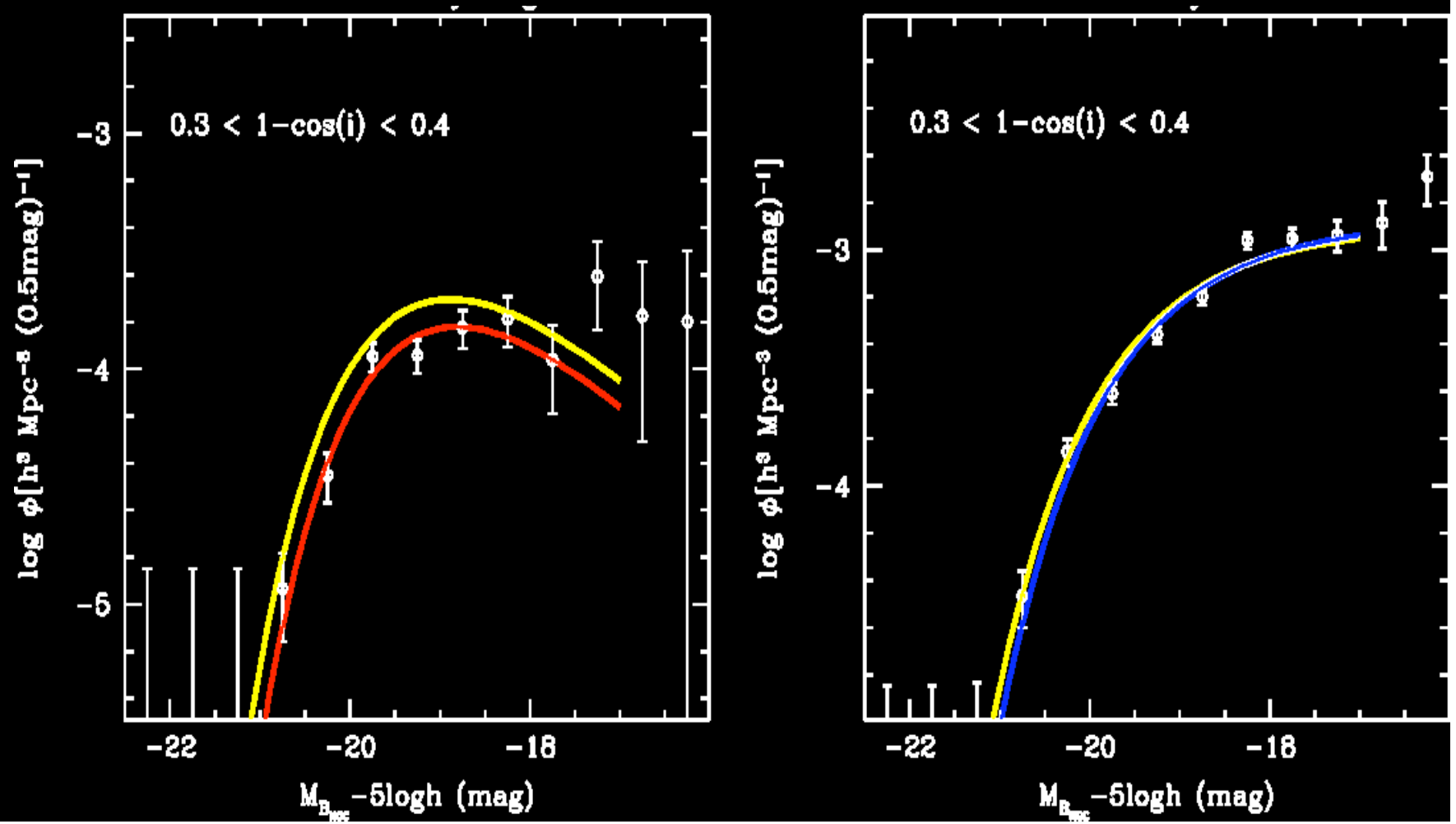
Component LFs v cos(*i*)

Bulges 0.2 < 1-cos(*i*) < 0.3 Discs



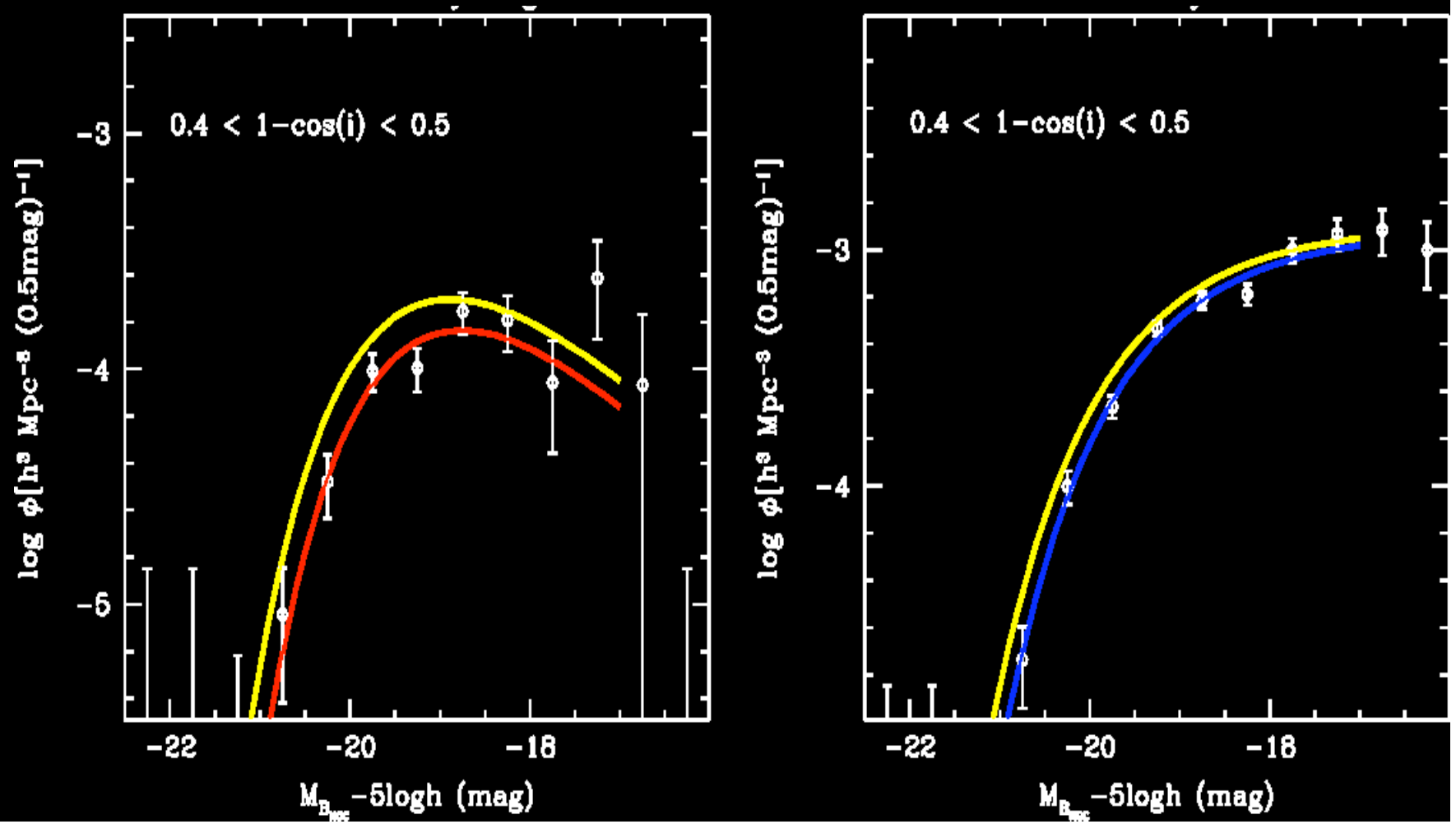
Component LFs v cos(*i*)

Bulges 0.3 < 1-cos(*i*) < 0.4 Discs



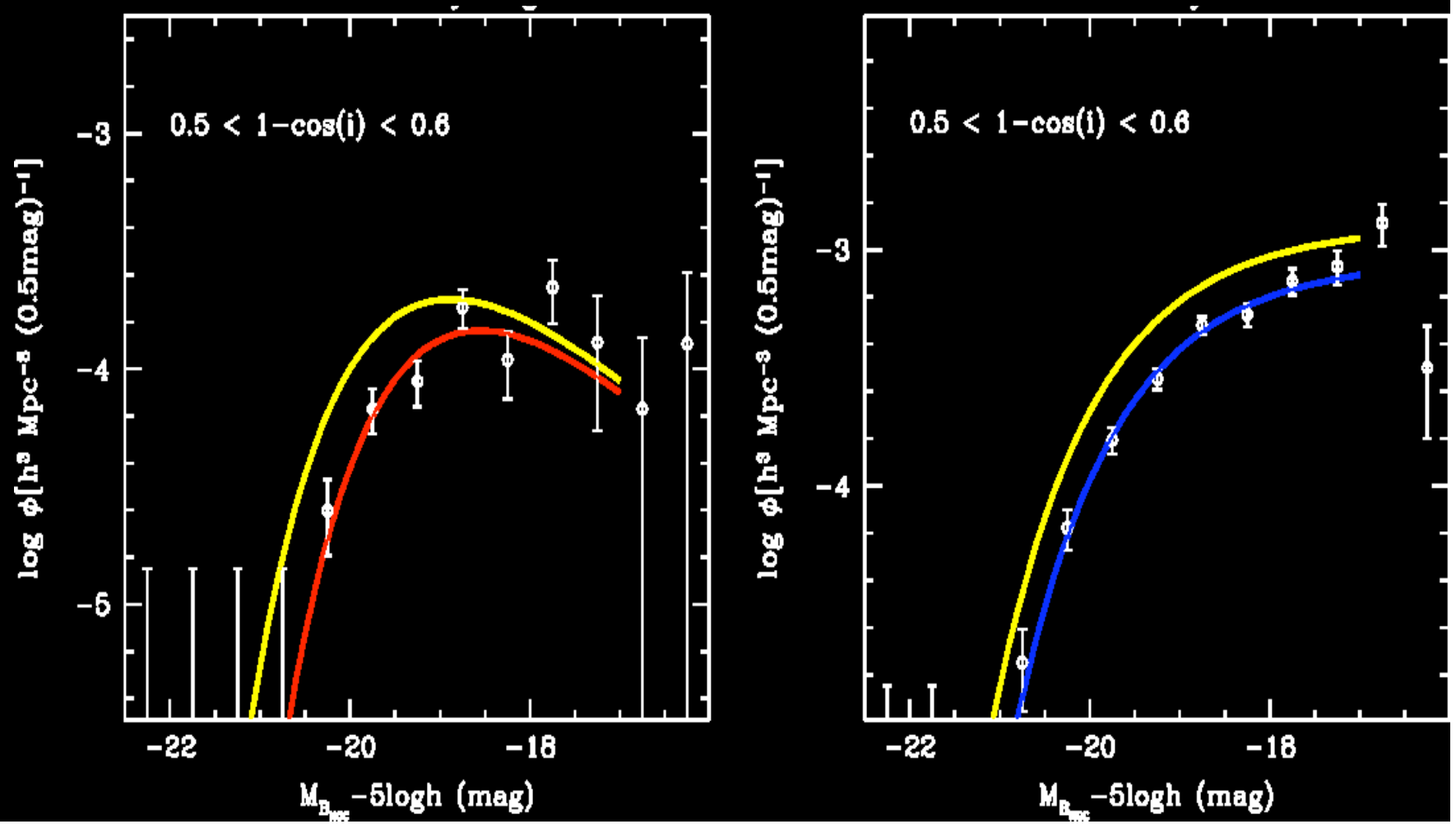
Component LFs v cos(*i*)

Bulges 0.4 < 1-cos(*i*) < 0.5 Discs



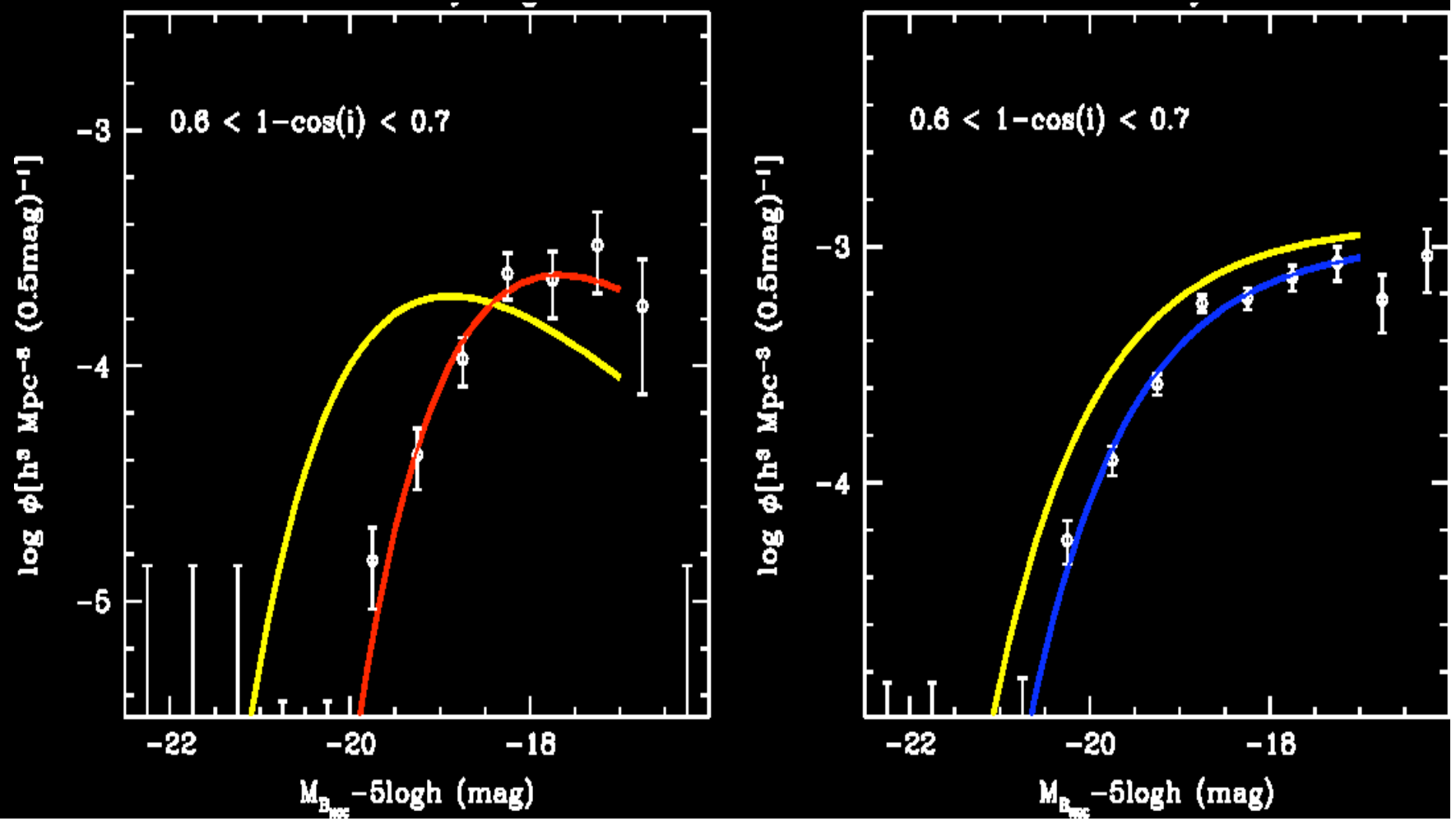
Component LFs v cos(*i*)

Bulges 0.5 < 1-cos(*i*) < 0.6 Discs



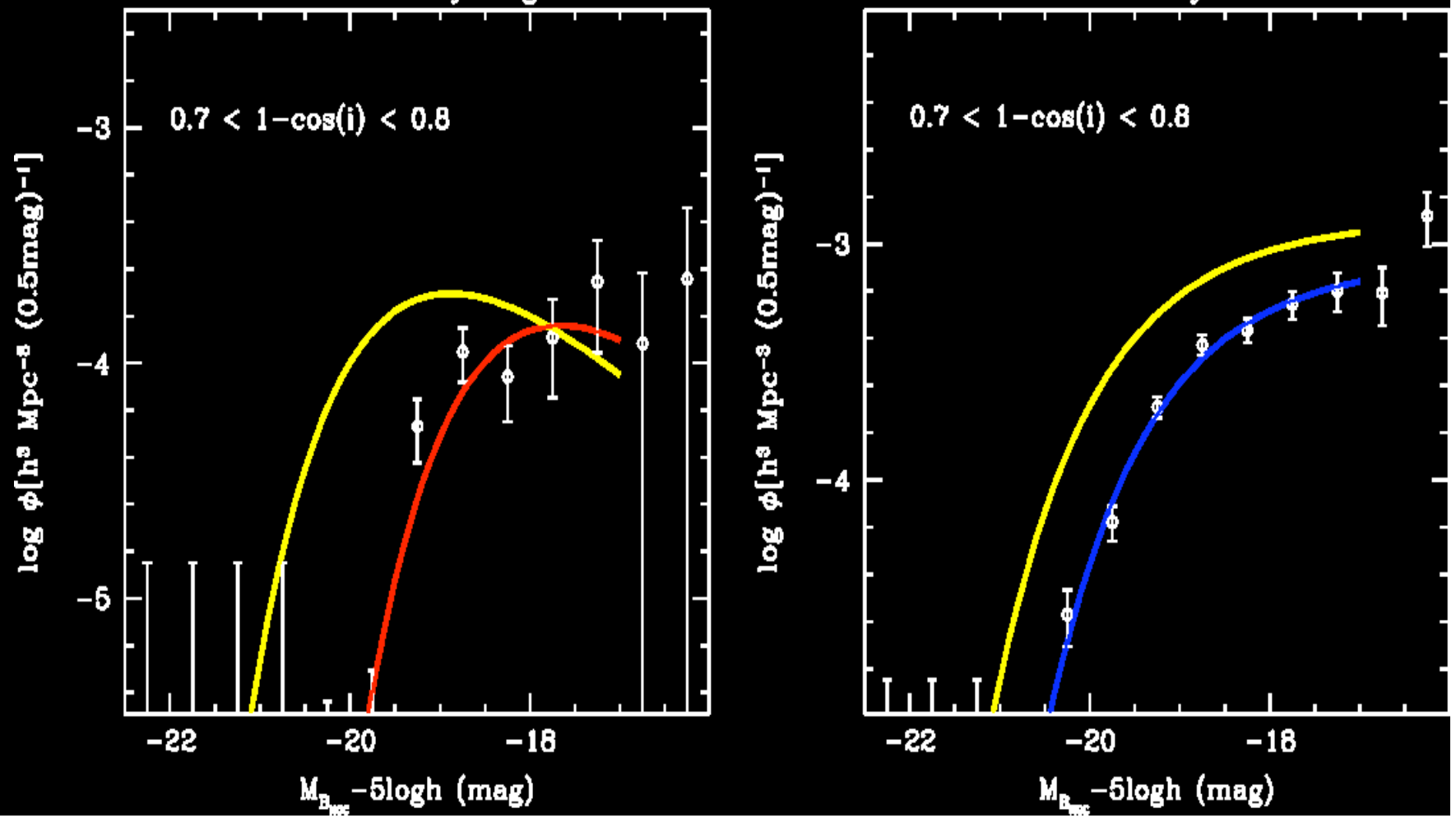
Component LFs v cos(*i*)

Bulges 0.6 < 1-cos(*i*) < 0.6 Discs



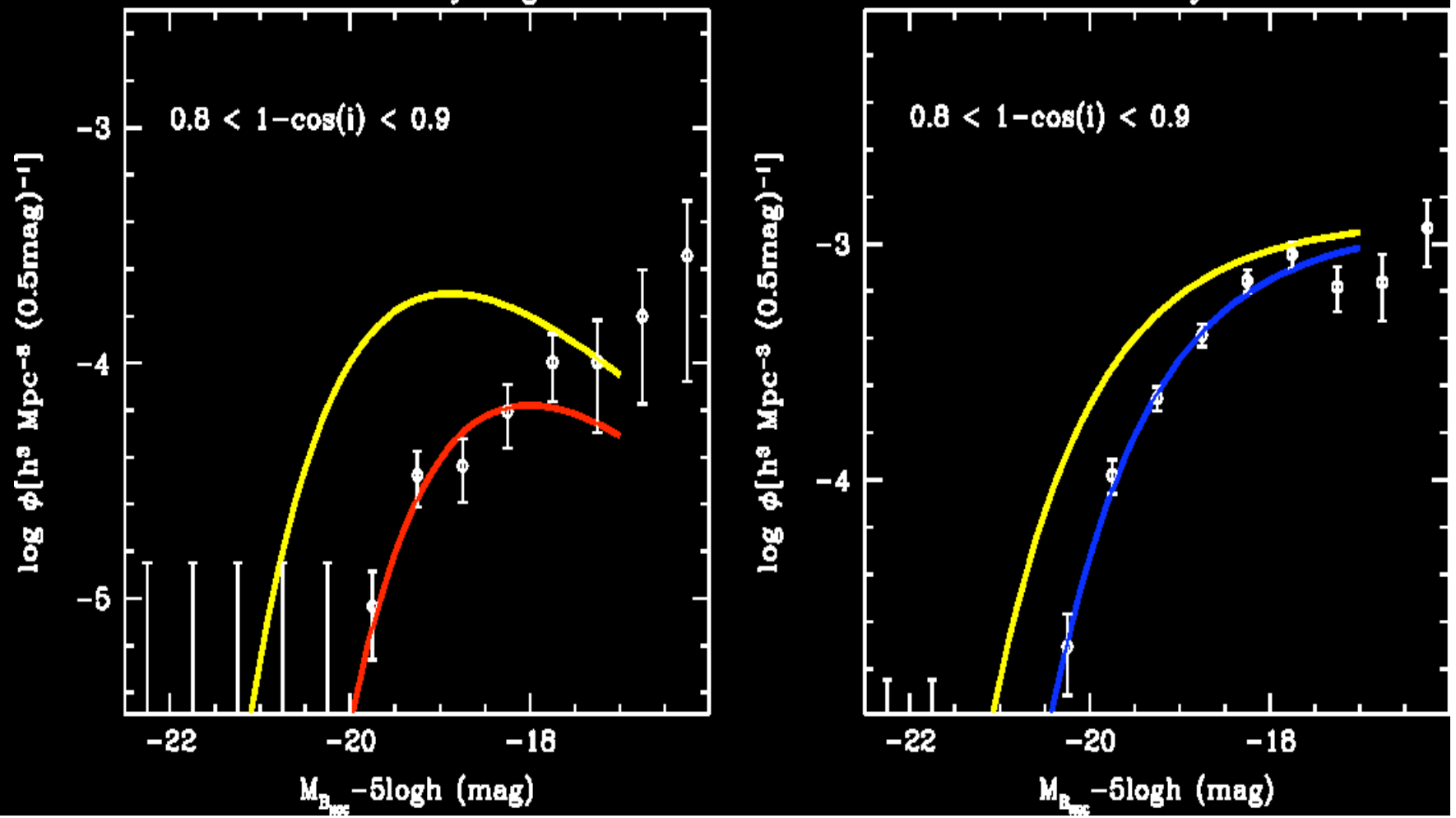
Component LFs v cos(*i*)

Bulges 0.7 < 1-cos(*i*) < 0.8 Discs



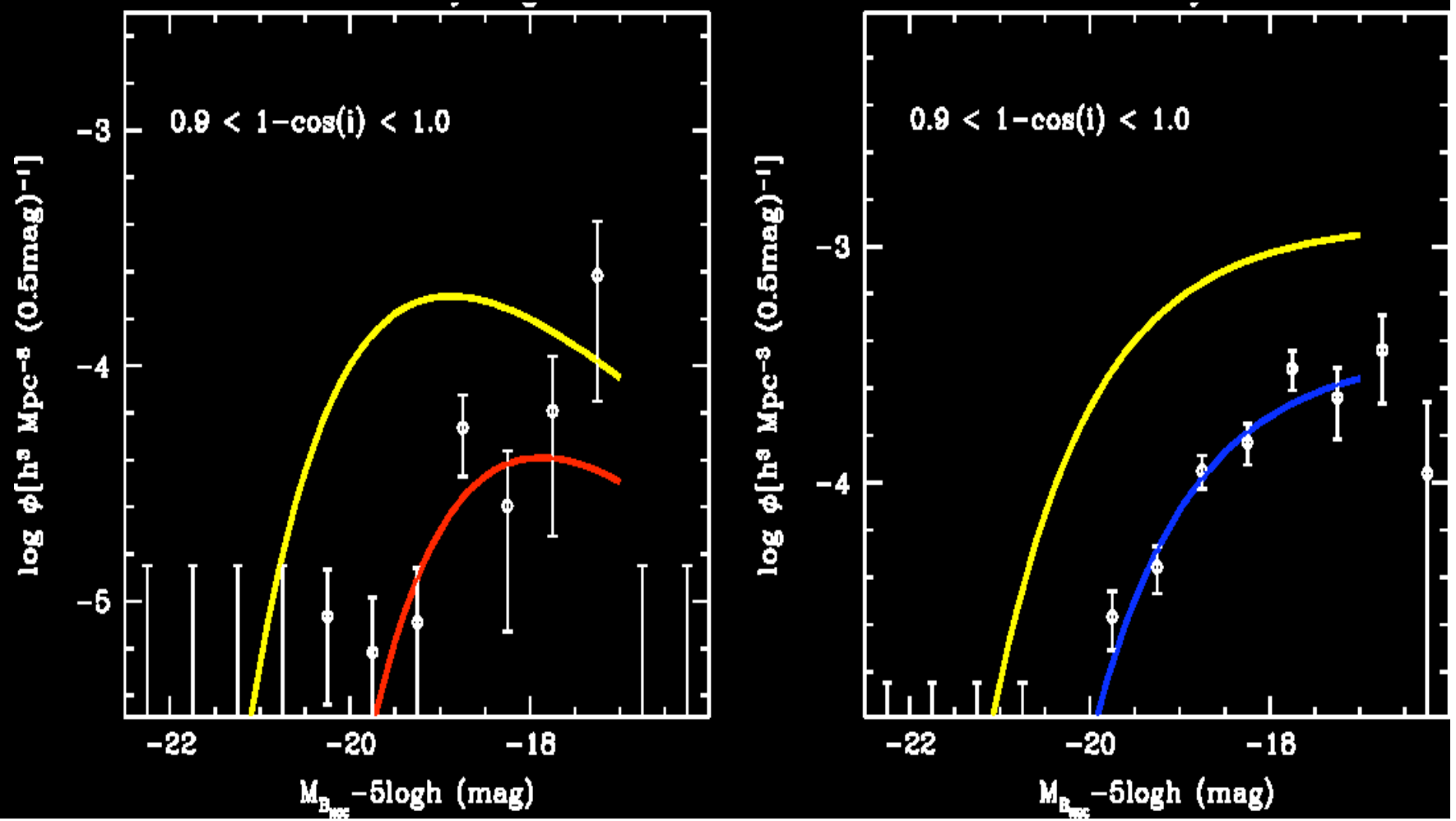
Component LFs v cos(*i*)

Bulges 0.8 < 1-cos(*i*) < 0.9 Discs



Component LFs v cos(*i*)

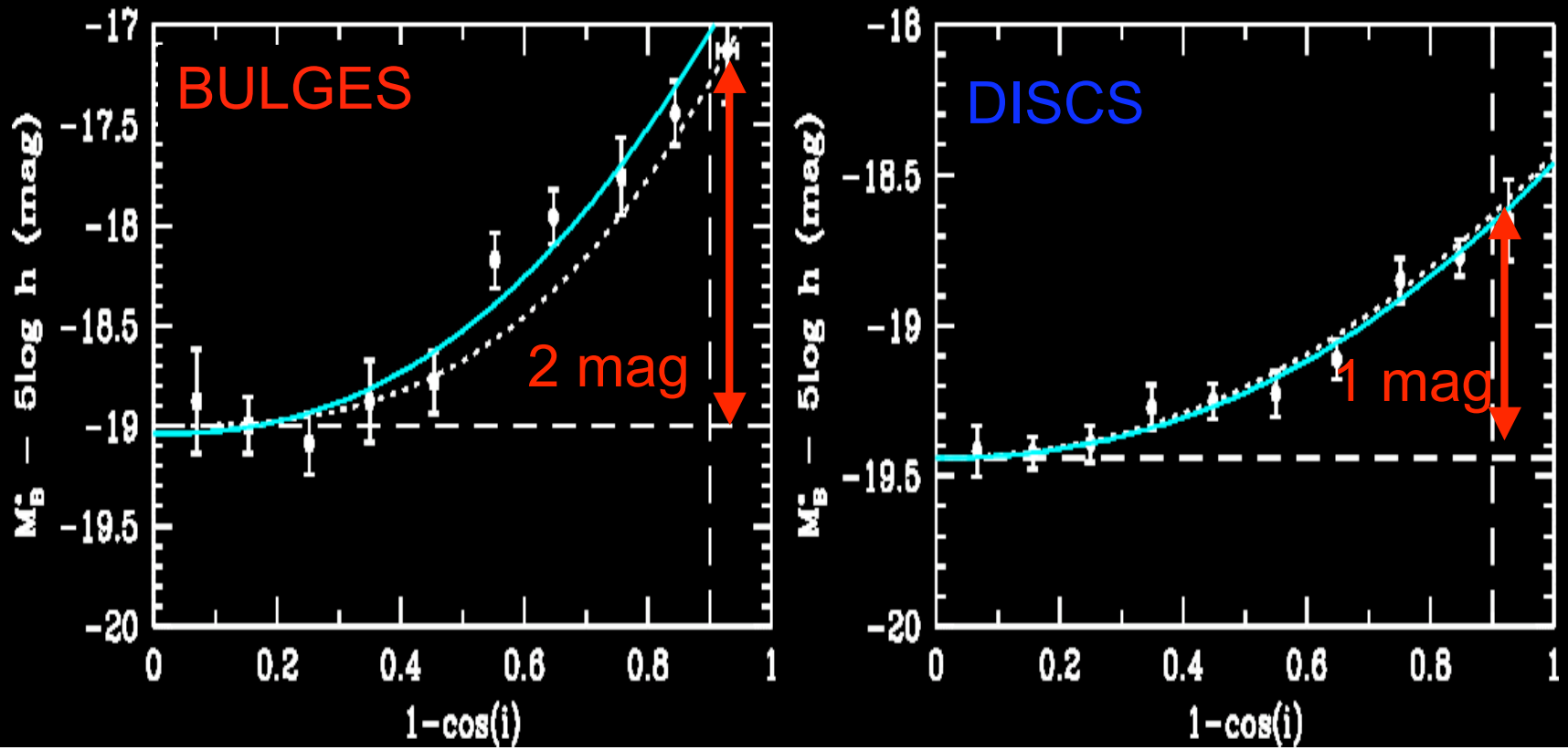
Bulges 0.9 < 1-cos(*i*) < 1.0 Discs



Empirical dust attenuation

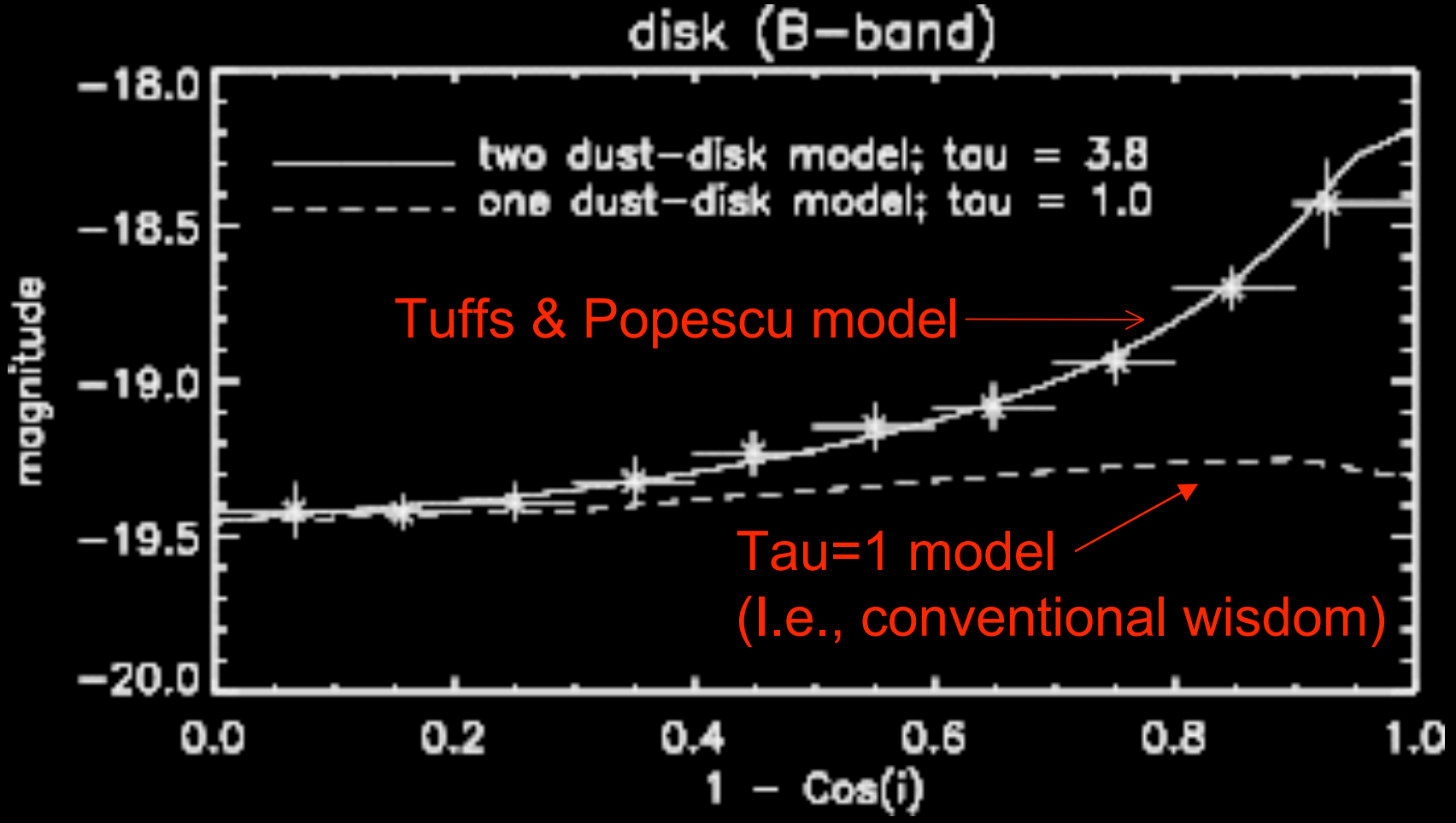
BULGES SEVERELY ATTENUATED IN INCLINED SYSTEMS UP TO 2 MAG EX. FACE-ON CORRECTION !

DRIVER ET AL (2007), MNRAS,(ASTRO-PH/0704.2140)

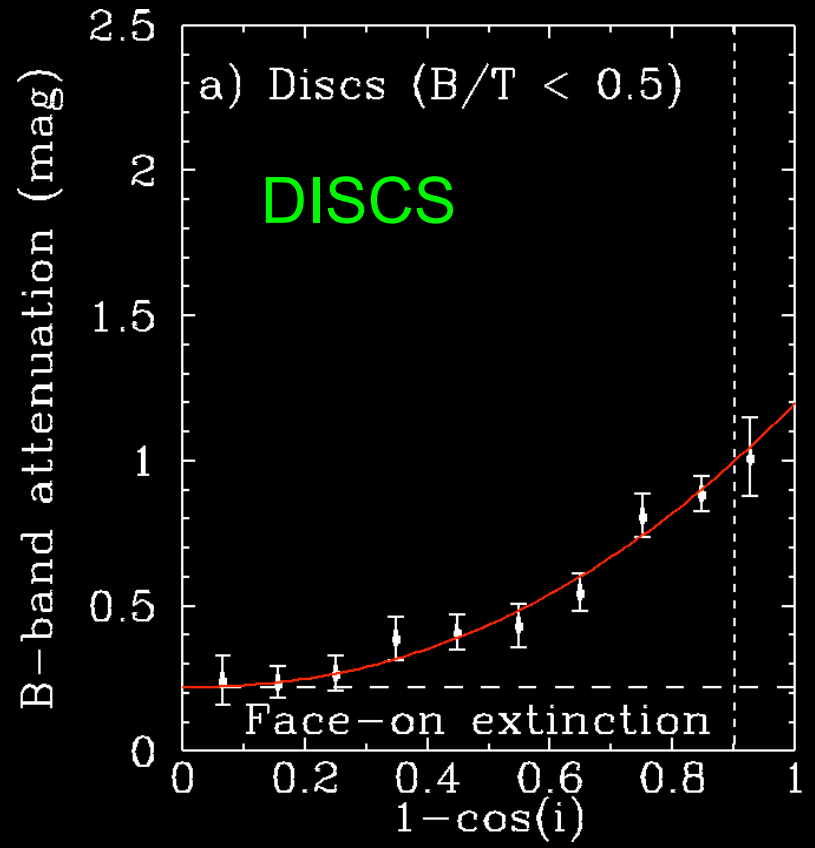


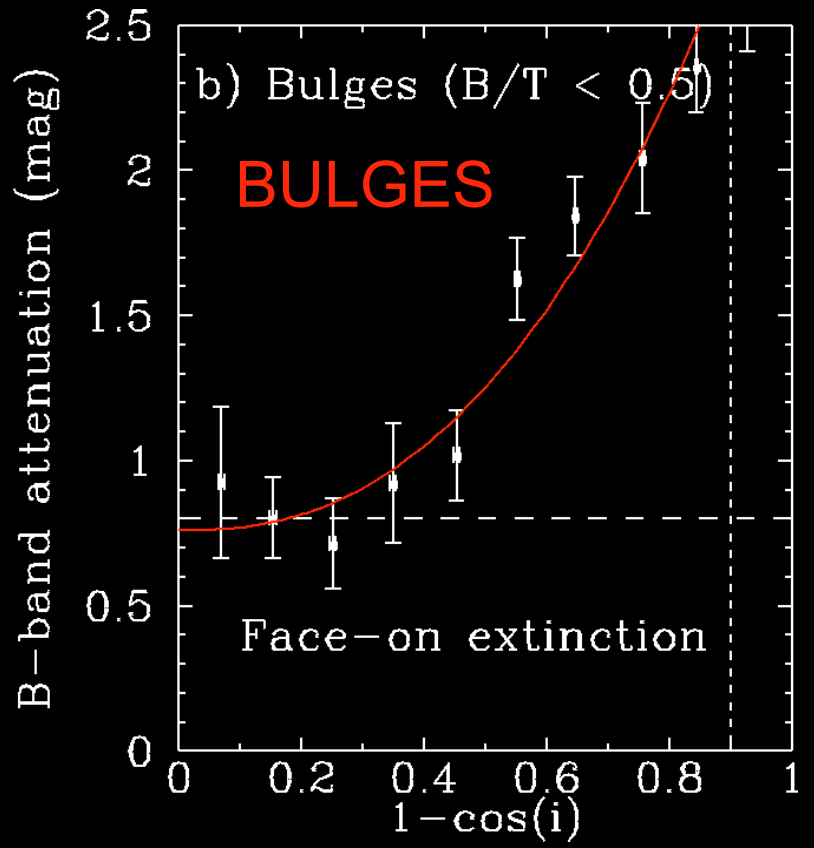
Multiple component dust model required

Dust model previously calibrated to multi-λ NGC891
Leaving one free parameter (the face on central opacity)



Total dust attenuations !!

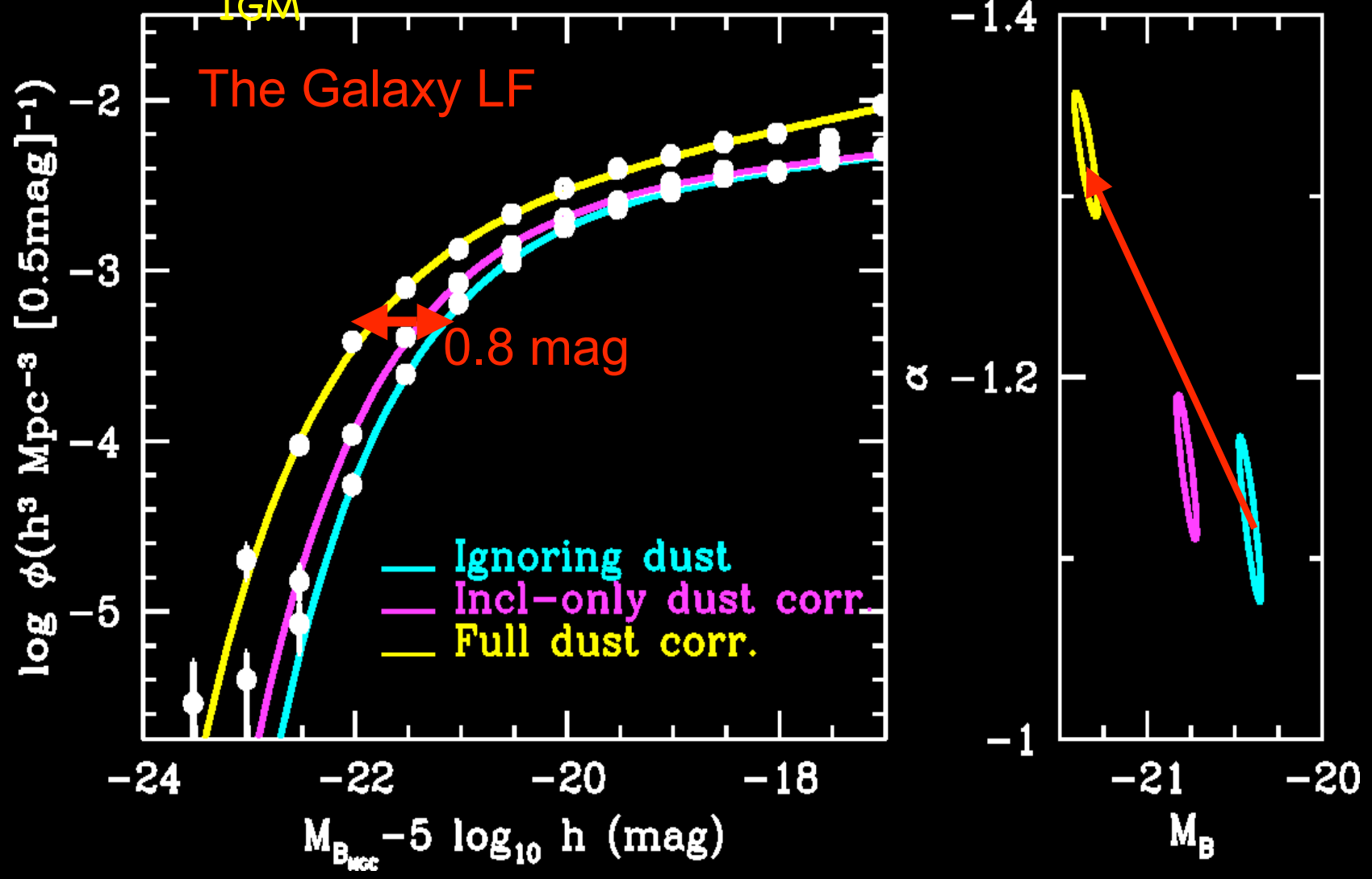




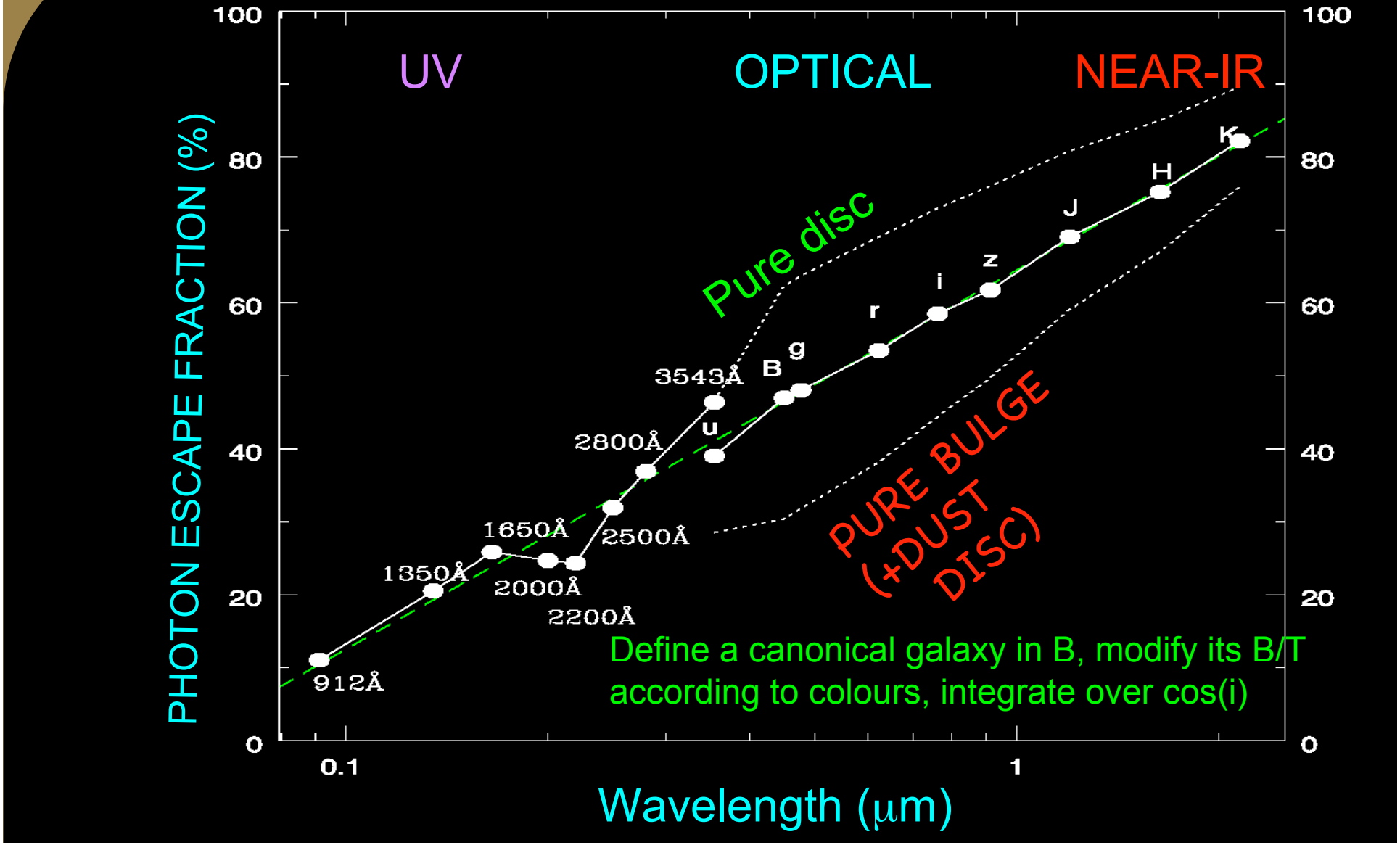
Tuffs & Popescu 3 component dust model implies that discs are on average optically thick in the centres (τ=3.8) and predicts bulge trend.

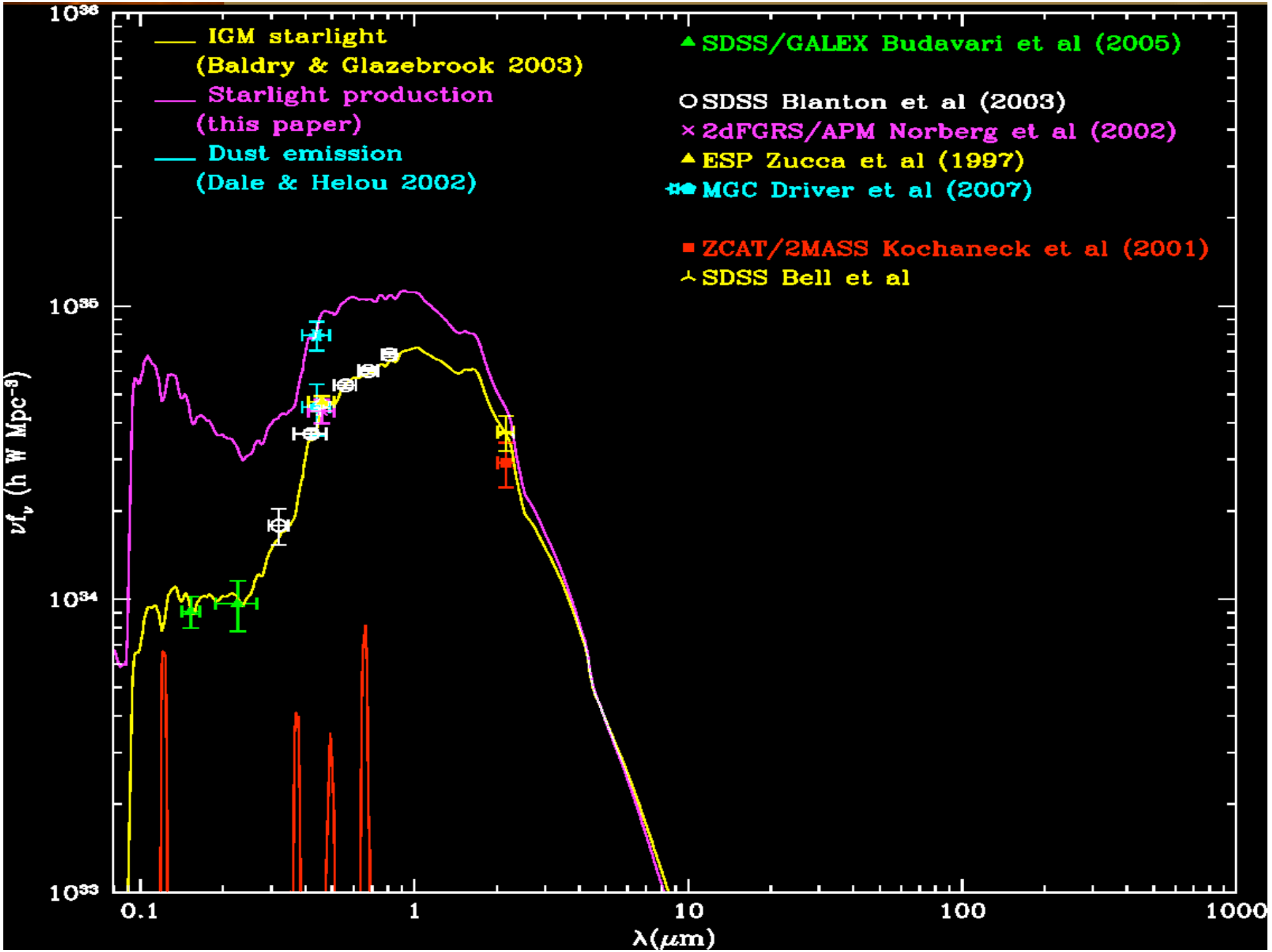
Impact on global B band LF

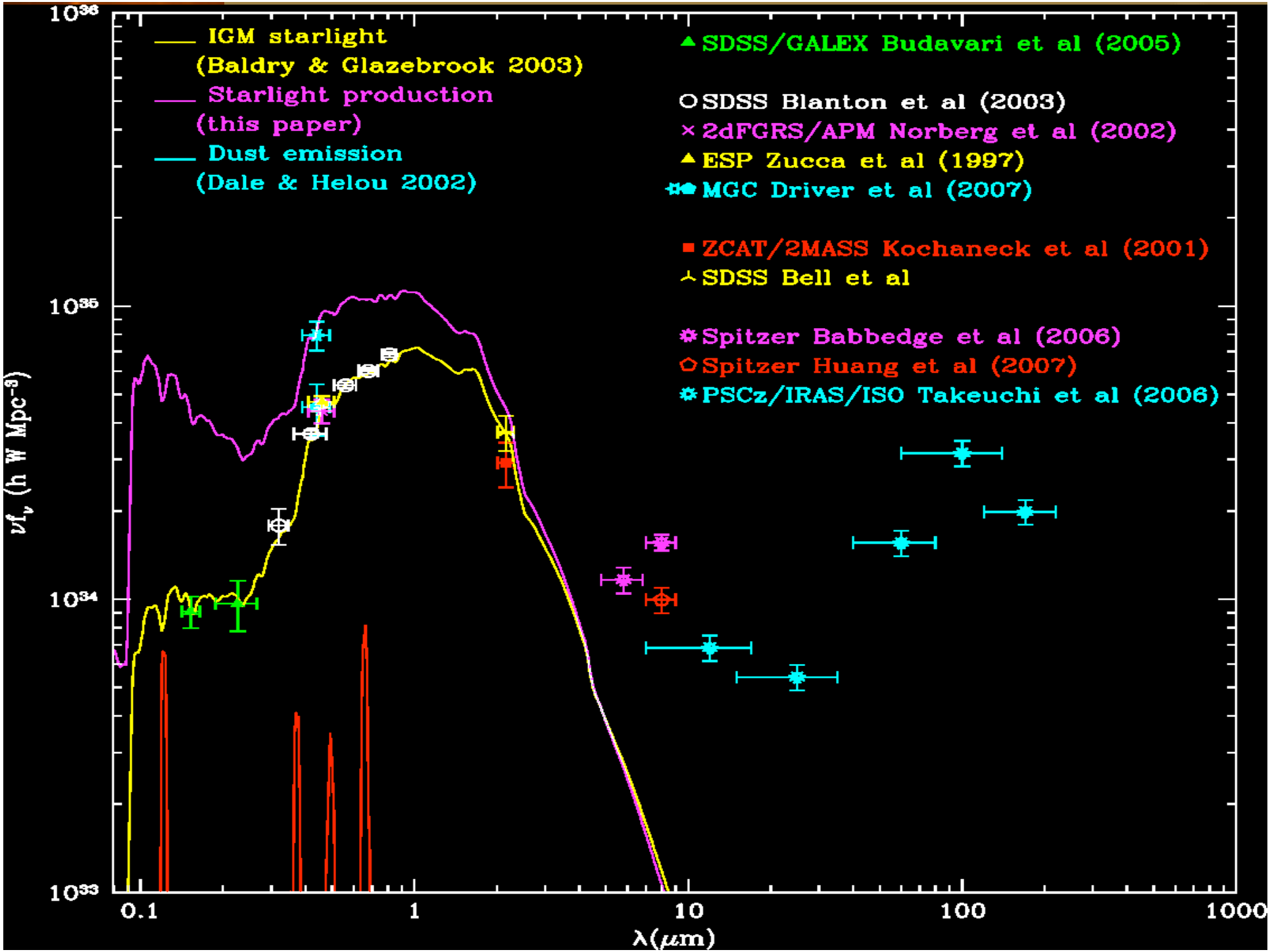
I.E., ONLY 48% OF B-BAND PHOTONS ESCAPE INTO THE IGM



Photon escape fraction averaged over entire nearby galaxy population




IGM starlight
(Baldry & Glazebrook 2003)
Starlight production
(this paper)
Dust emission
(Dale & Helou 2002)
SDSS/GALEX Budavari et al (2005)
SDSS Blanton et al (2003)
2dFGRS/APM Norberg et al (2002)
ESP Zucca et al (1997)
MGC Driver et al (2007)
ZCAT/2MASS Kochaneck et al (2001)
SDSS Bell et al
10^{36}
10^{35}
10^{34}
10^{33}
νI_ν (h W Mpc^{-3})
0.1
1
10
100
1000
$\lambda(\mu m)$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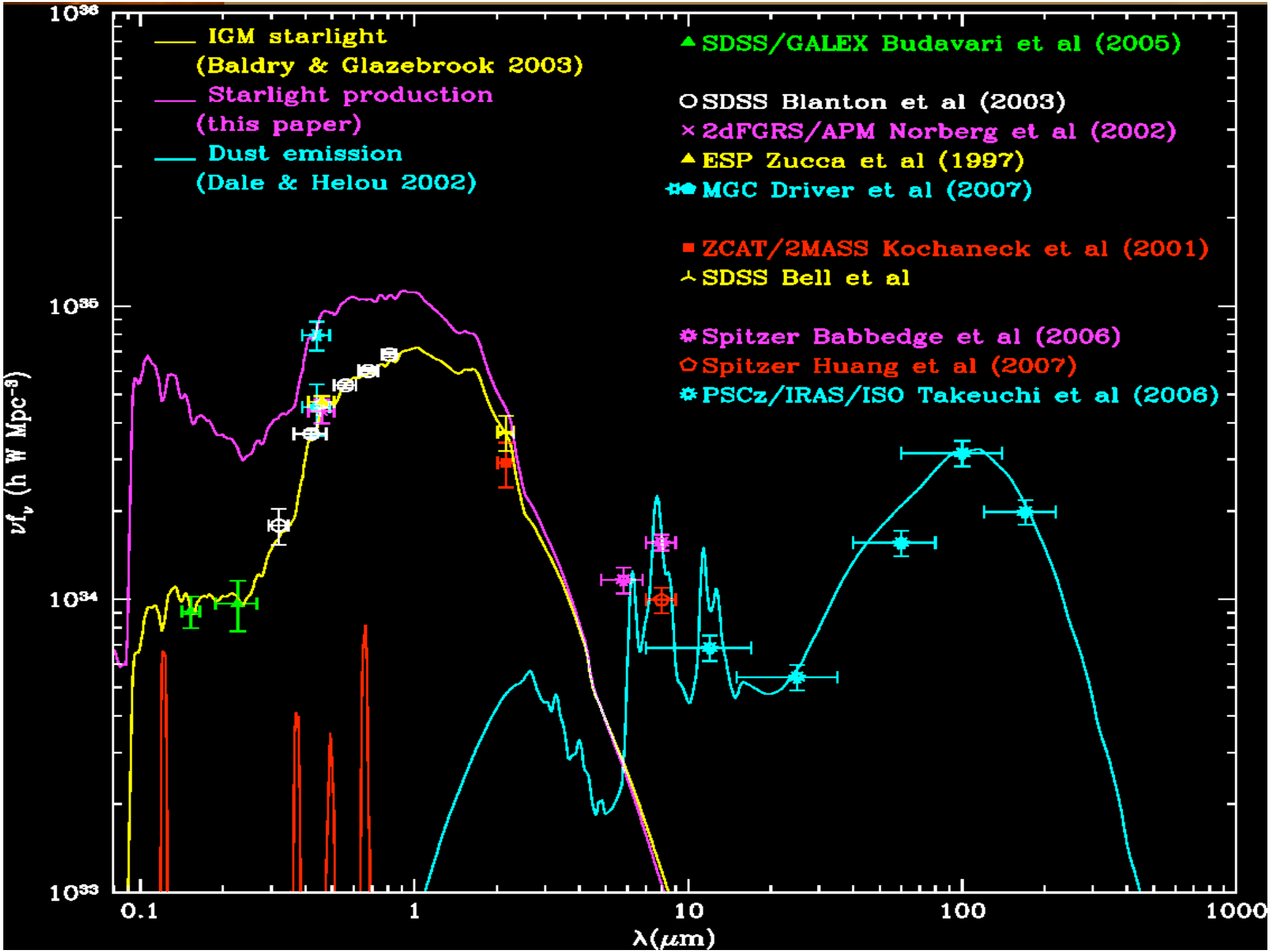
MGC Driver et al (2007)
ZCAT/2MASS Kochaneck et al (2001)
SDSS Bell et al
Spitzer Babbedge et al (2006)
Spitzer Huang et al (2007)
PSCz/IRAS/ISO Takeuchi et al (2006)
10^{36}
10^{35}
10^{34}
10^{33}
νl_ν (h W Mpc^{-3})
0.1
1
10
100
1000
$\lambda(\mu m)$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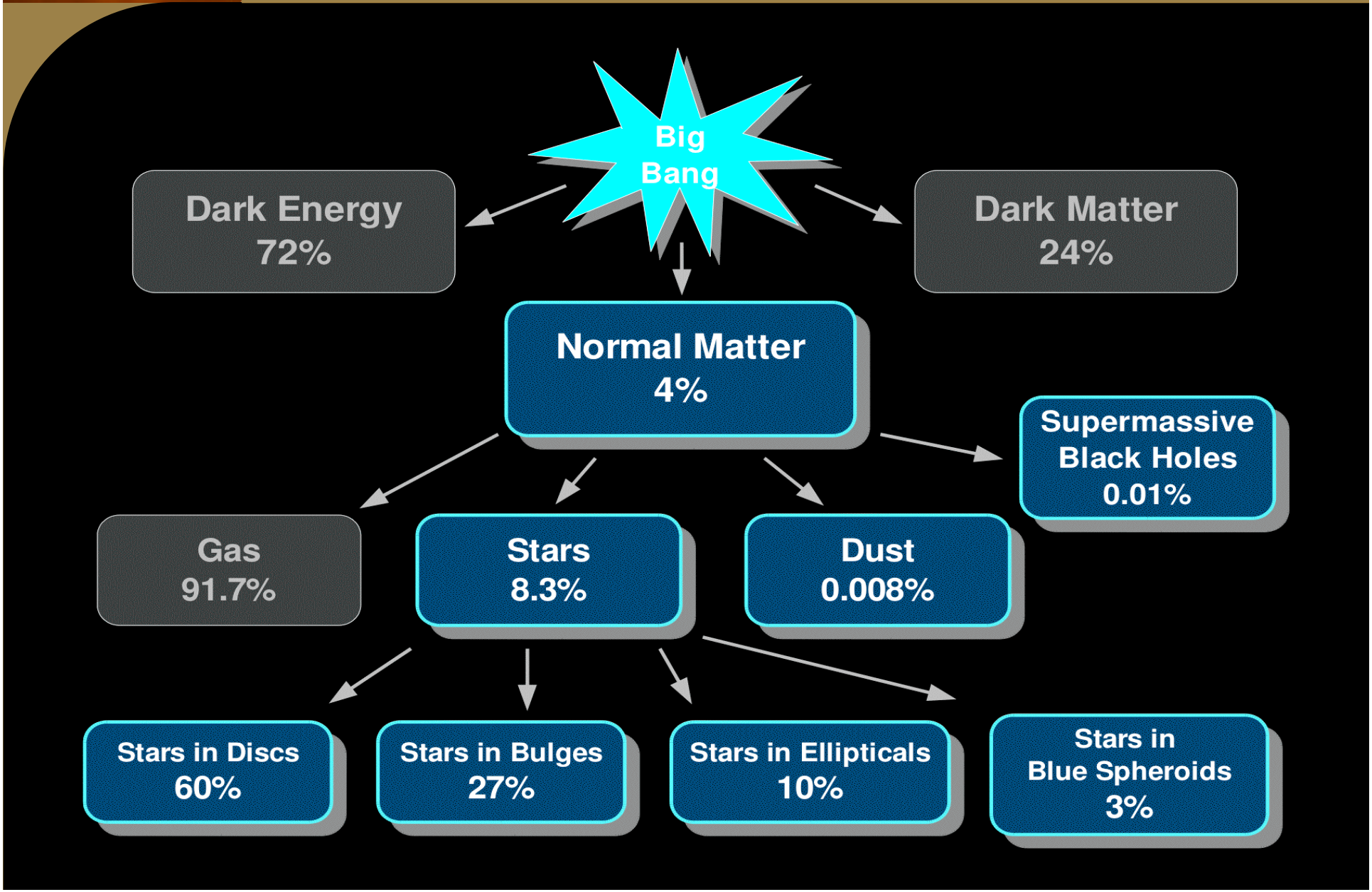
MGC Driver et al (2007)
ZCAT/2MASS Kochaneck et al (2001)
SDSS Bell et al
Spitzer Babbedge et al (2006)
Spitzer Huang et al (2007)
PSCz/IRAS/ISO Takeuchi et al (2006)
10^{36}
10^{35}
10^{34}
10^{33}
νl_ν (h W Mpc^{-3})
0.1
1
10
100
1000
$\lambda(\mu m)$

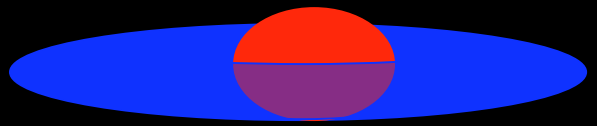
The baryon budget: stars, dust & SMBHs



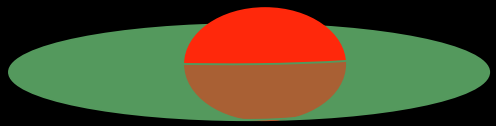
Hubble type transformation ?!

1. MID-TYPE SPIRAL FALLING INTO CLUSTER (COS*I*=0.5):
   B=0.2, D=0.8, B/T=0.2, L=1.0, BLUE
   SC (NB: COS(I)=0.0=SA, COS(I)=1=SD)

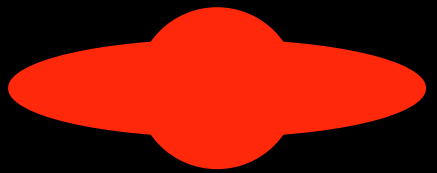
2. *DESTROY DUST* (HEATING):
   B=0.6, D=1.2, B/T=0.3, L=1.8 GREEN
   SAB



3. TRUNCATE STAR-FORMATION IN DISC (STRIPPING):
   B=0.6, D=0.8, B/T=0.4, L=1.4, RED
   SA/S0

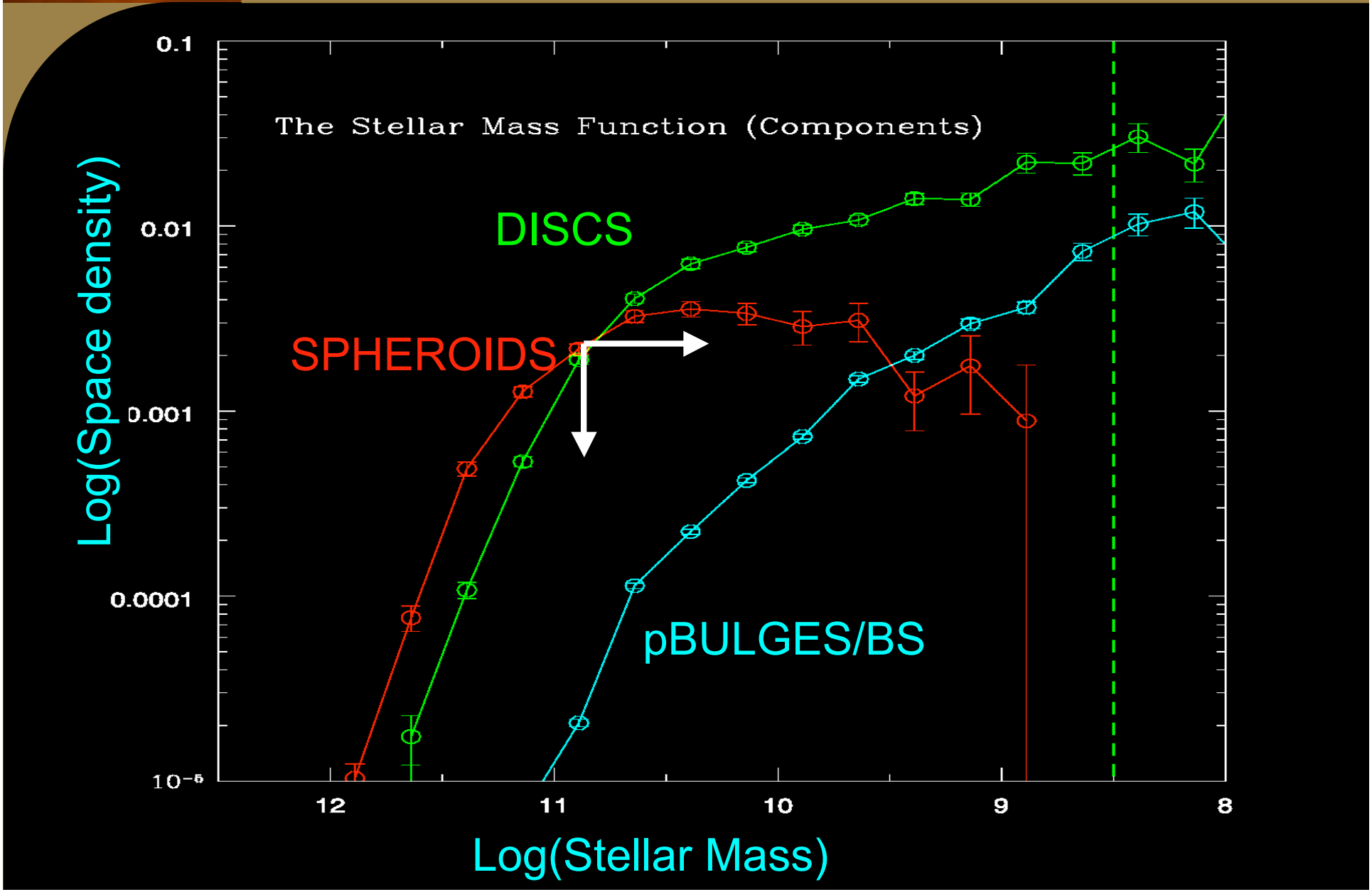


4. FURTHER FADING AND HARASSMENT ETC:
   B=0.6, D=0.6, B/T=0.5, L=1.2, RED
   S0A

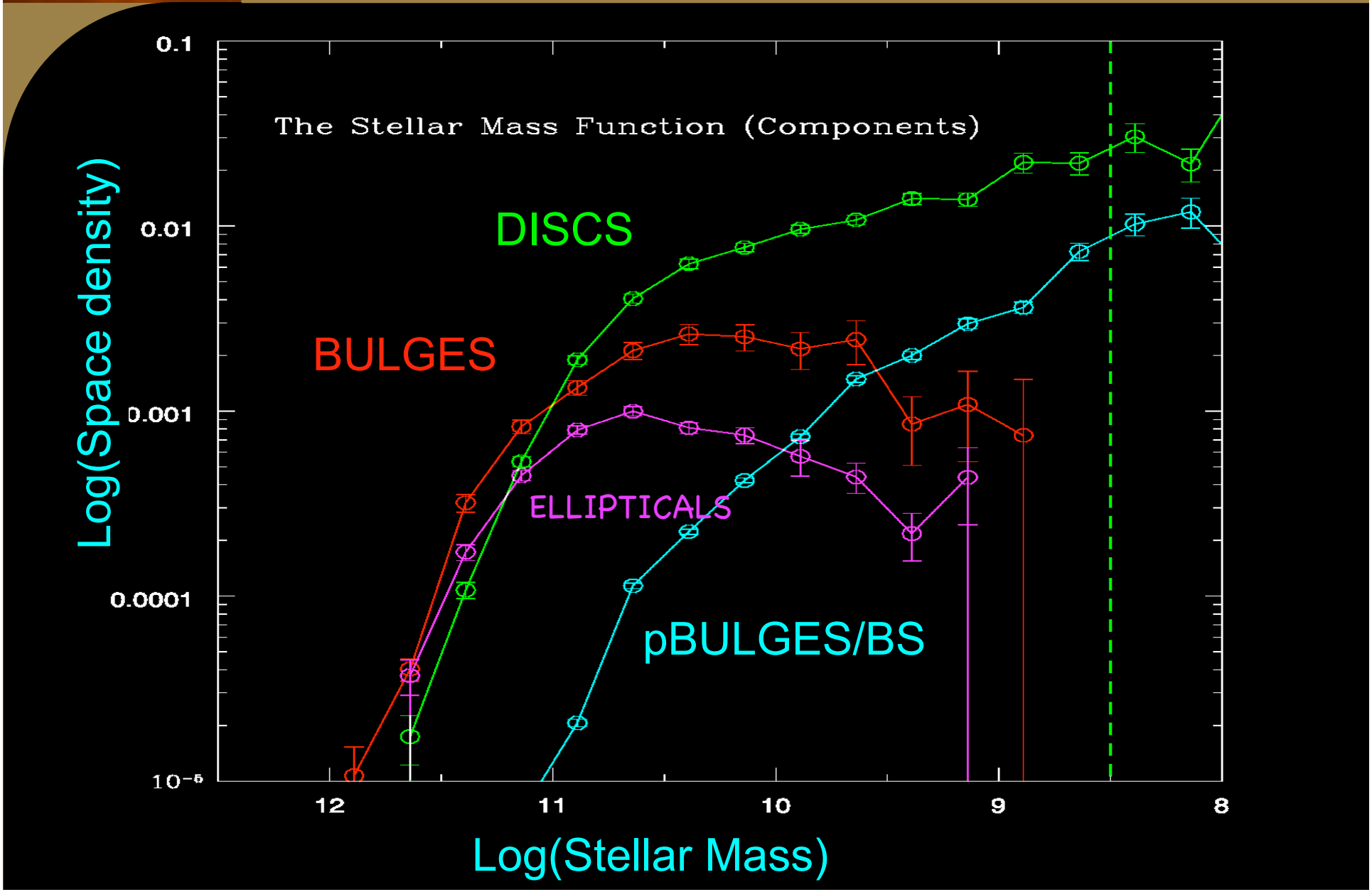


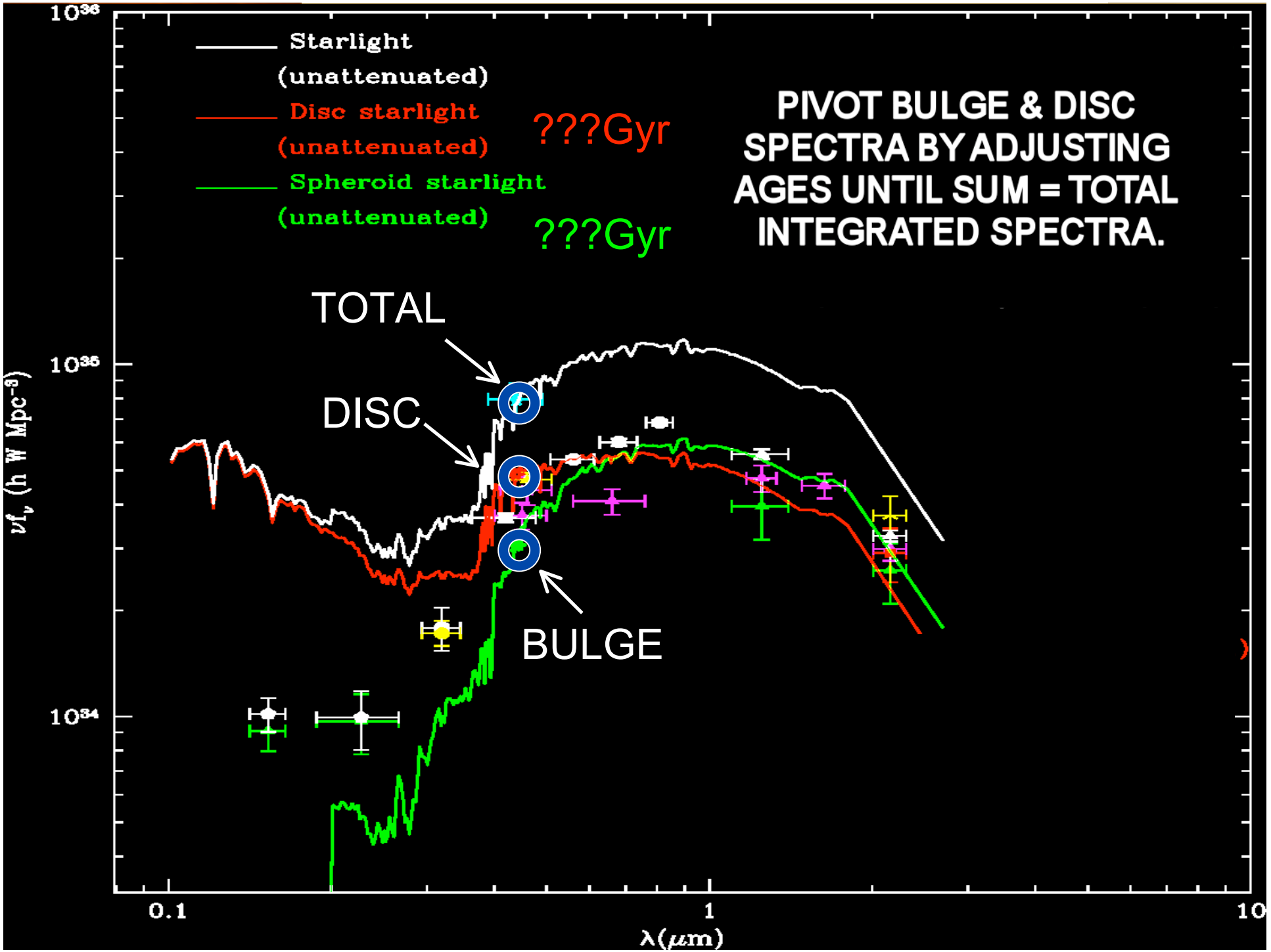
5. TRANSFORMATION FROM SC-S0 PURELY BY REMOVING DUST AND SWITCHING OFF SF! IT GETS ***REDDER*** AND ***BRIGHTER*** WITHOUT DRY MERGERS!

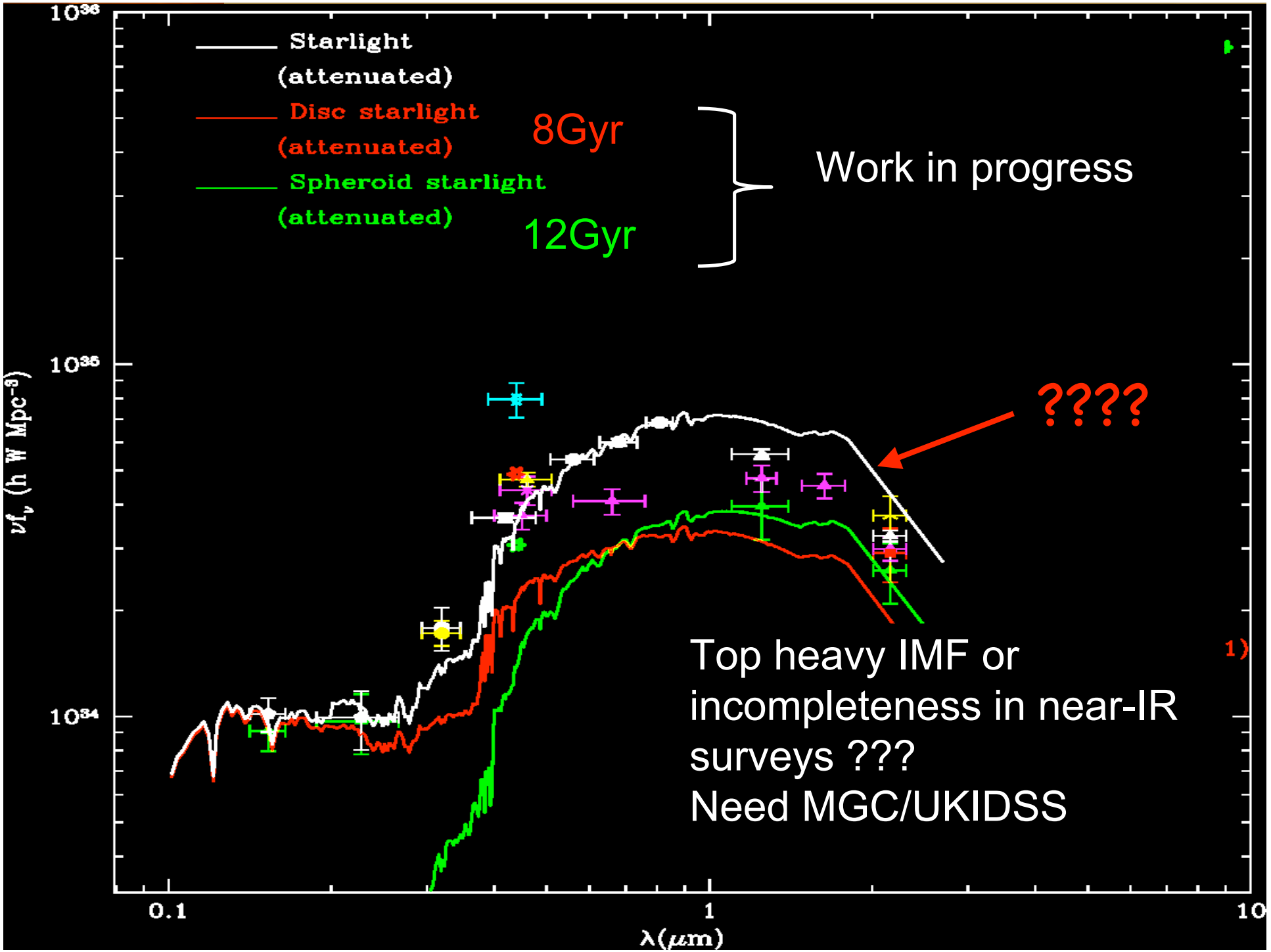
Component Stellar Mass Functions



Component Stellar Mass Functions




Starlight
(unattenuated)
Disc starlight
(unattenuated)
Spheroid starlight
(unattenuated)
???Gyr
???Gyr
PIVOT BULGE & DISC SPECTRA BY ADJUSTING AGES UNTIL SUM = TOTAL INTEGRATED SPECTRA.
TOTAL
DISC
BULGE
10^{36}
10^{35}
10^{34}
νL_ν (h W Mpc^{-3})
0.1
1
10
λ(μm)


Starlight
(attenuated)
Disc starlight
(attenuated)
Spheroid starlight
(attenuated)
8Gyr
12Gyr
Work in progress
????
Top heavy IMF or
incompleteness in near-IR
surveys ???
Need MGC/UKIDSS
10^{36}
10^{35}
10^{34}
νl_ν (h W Mpc^{-3})
0.1
1
10
$\lambda(\mu m)$

MGC
Millennium Galaxy Catalogue

A blueprint for massive galaxy formation ?

8+ GYRS — DM ASSEMBLY VIA RAPID MERGING

- MAJOR MERGERS DESTROY DISCS SO MUST END BEFORE 8GYRS (COINCIDENT WITH SECOND INFLATION?)

10+ GYRS COLLAPSE — SPHEROID FORMATION VIA (PREDOMINANTLY) RAPID

- 37% OF STELLAR MASS (SECONDARY MODE)
- MEAN AGE OF SPHEROIDS 10-13GYRS = AGN PEAK
- ALPHA-ENHANCEMENT = SHORT BURST (AGN MODERATED)
- COLLAPSE INHIBITED DURING DM ASSEMBLY=>DOWNSIZING

8 GYRS — DISC GROWTH VIA INFALL/SPLASHBACK

- 60% OF STELLAR MASS (DOMINANT MODE)
- COUPLED WITH FALLING SFR
- MEAN AGE OF DISCS 8GYRS

0-8 GYRS — PSEUDO-BULGE GROWTH & MORPHOLOGICAL TRANS'S

- AGES UNCHANGED (MATERIAL JUST SHUFFLED)

BUT WHAT IS THE VARIANCE, ENVIRONMENTAL & HALO MASS DEPENDENCIES, AND WHAT ABOUT THE NEUTRAL GAS AND PLASMA?

NEED BARYON/ENERGY BREAKDOWN FOR EACH GALAXY => GAMA

GAMA: Contributing Facilities

UKIRT/LAS

28 nights

VISTA/VIKING

60 nights

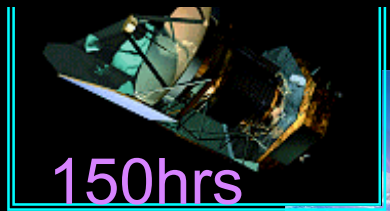
VST/KIDS

96 nights

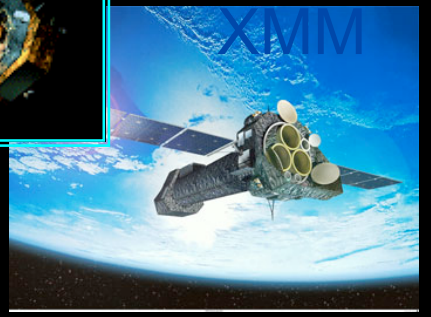
AAT/AAΩ

165 nights

HERSCHEL



150hrs



NEAR-IR

z, spectra

Far-IR

X-ray

z, LSBGs

1 year

HI

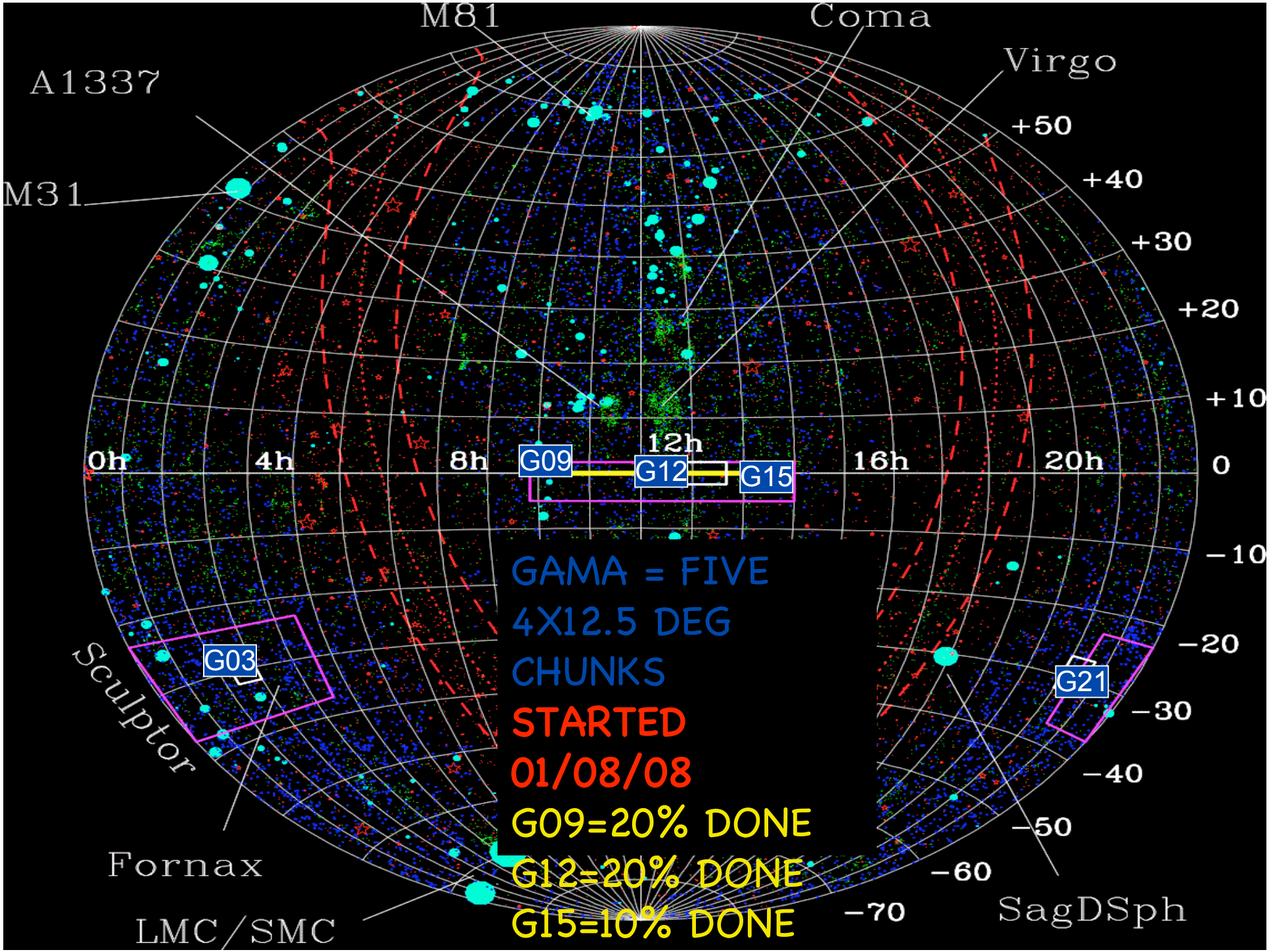
2011

OPTICAL

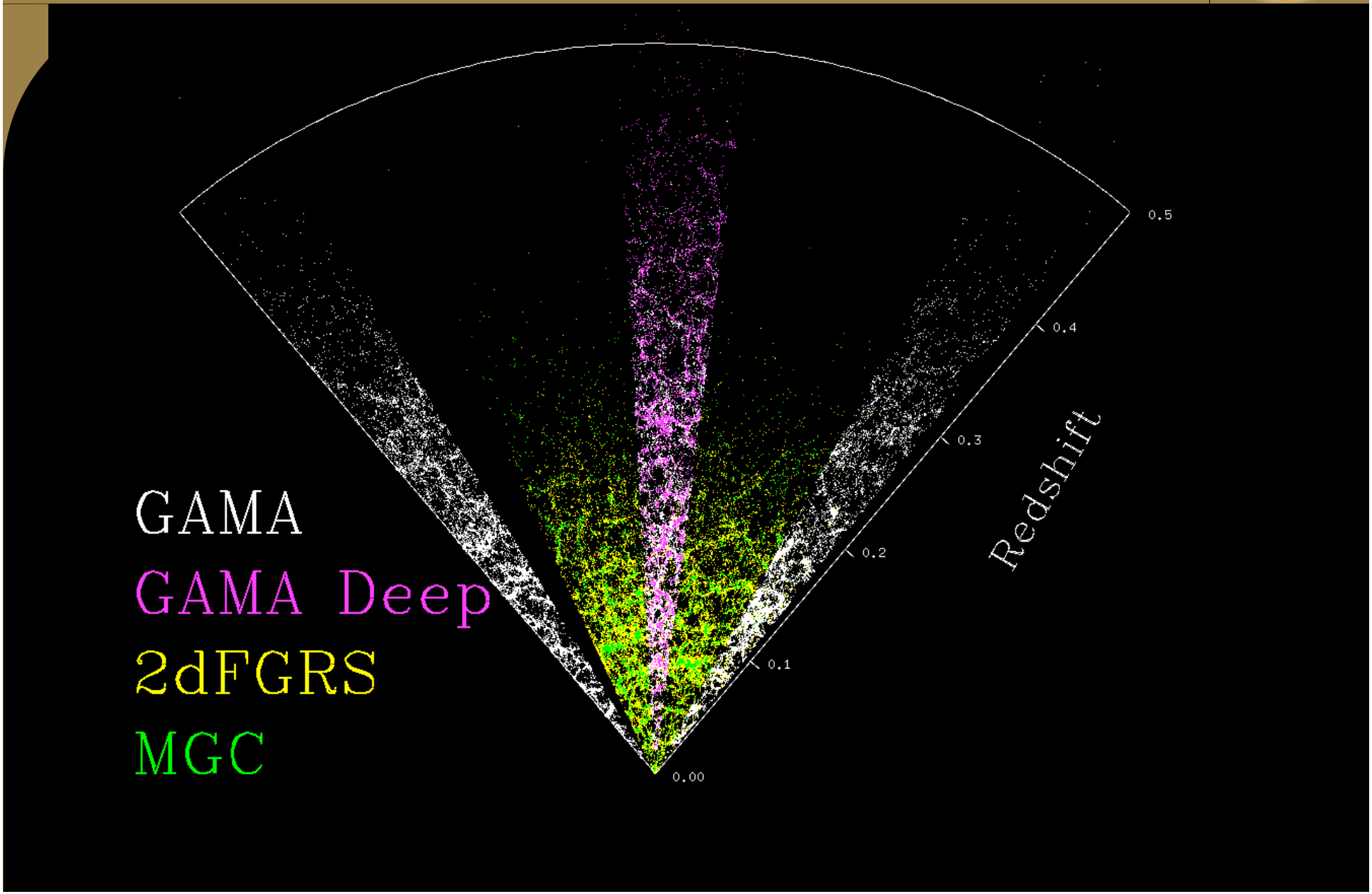
+ SDSS

GAMA

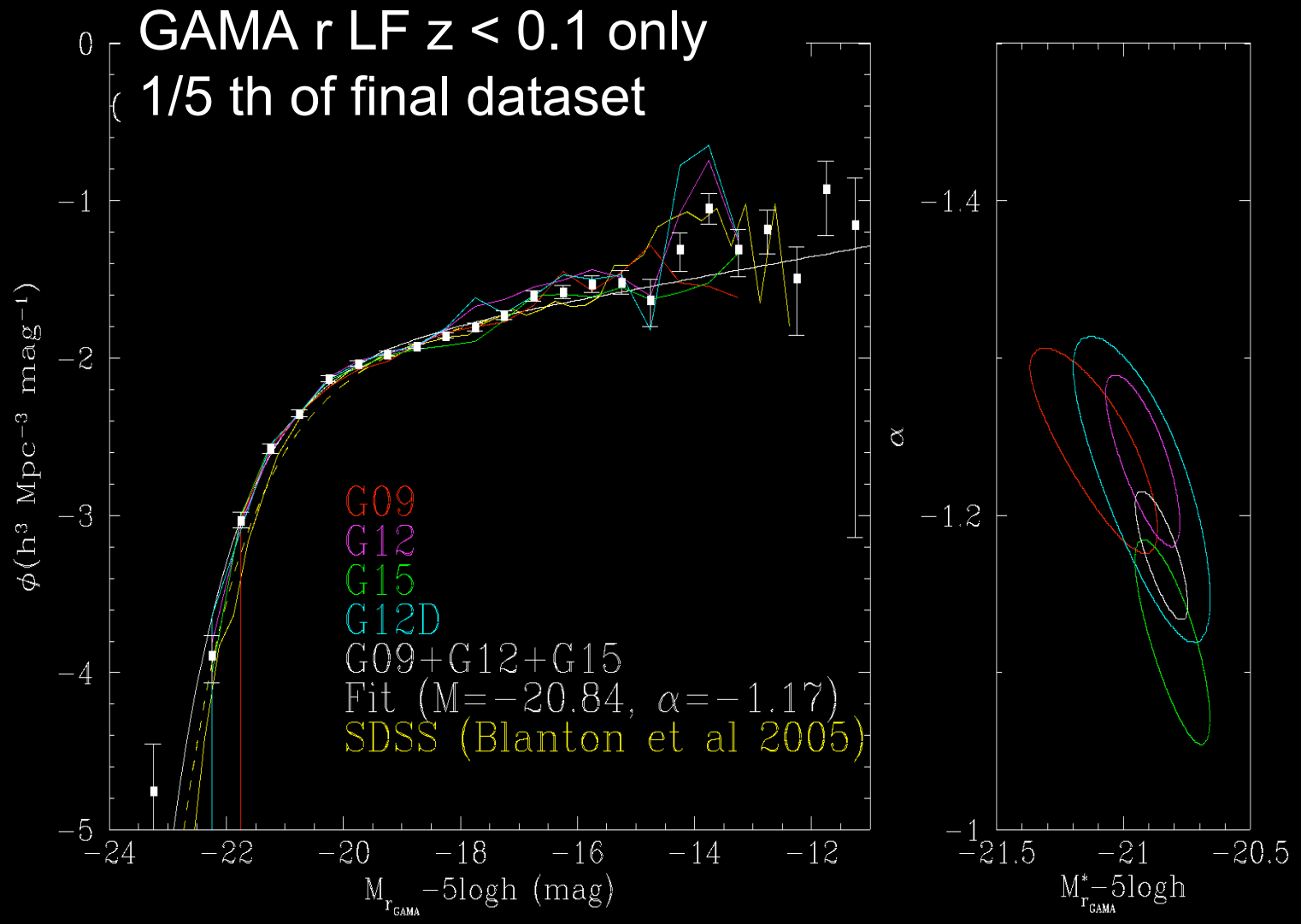
SCIENCE


M81
Coma
Virgo
A1337
M31
+50
+40
+30
+20
+10
0
−10
−20
−30
−40
−50
−60
−70
0h
4h
8h
12h
16h
20h
G09
G12
G15
G03
G21
Sculptor
Fornax
LMC/SMC
SagDSph
GAMA = FIVE
4X12.5 DEG
CHUNKS
STARTED
01/08/08
G09=20% DONE
G12=20% DONE
G15=10% DONE

Current CONE plot (80k z's)

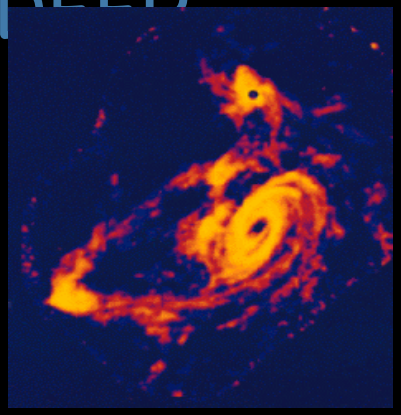


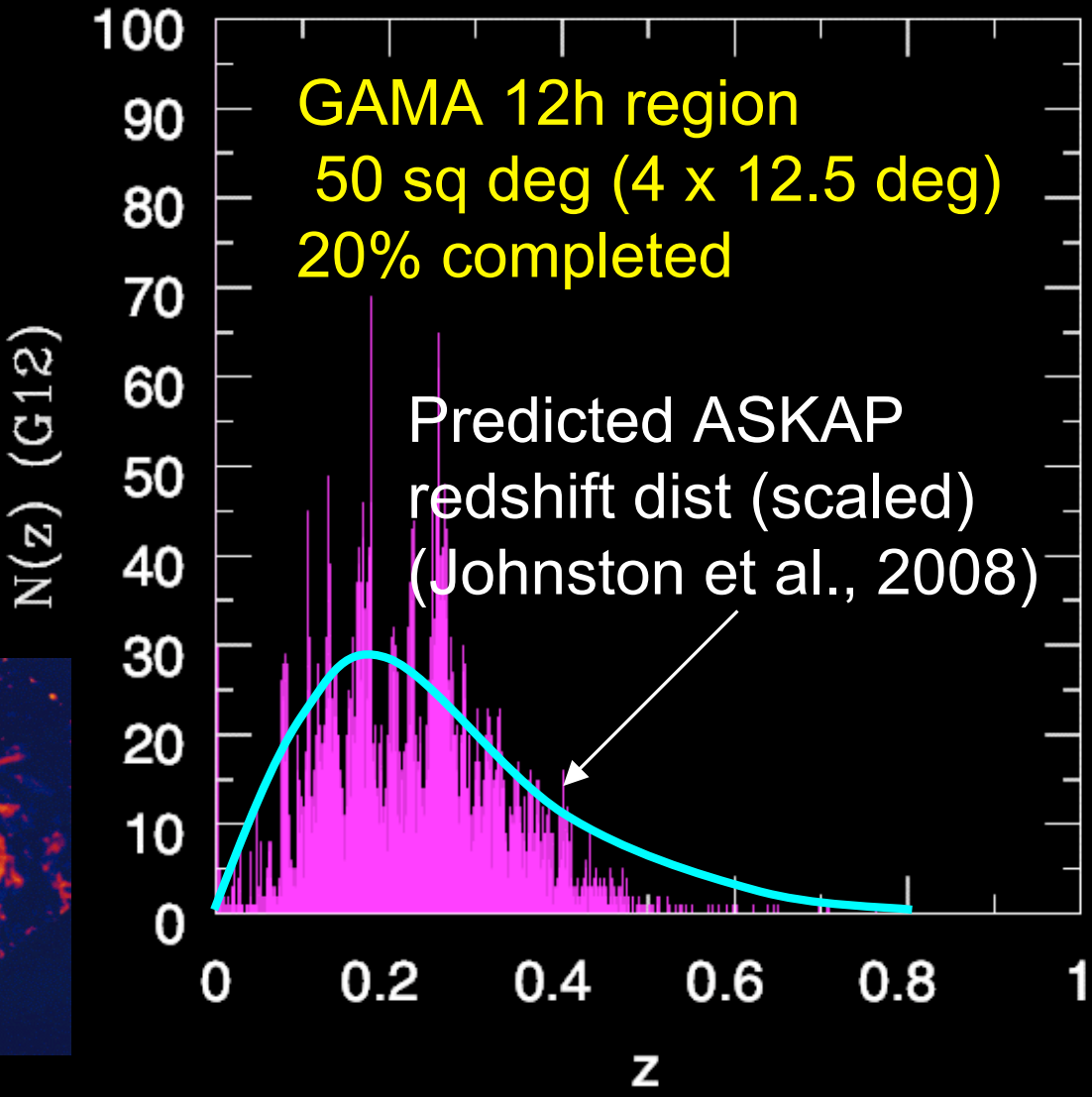
The Global luminosity distribution



HI and continuum coverage via ASKAP

- GAMA DEPTH AND AREA WELL MATCHED TO THE PROPOSED ASKAP DEEP





Summary

- BIMODALITY DUE TO TWO COMPONENT NATURE OF GALAXIES (D06)
  - STRUCTURE MORE FUNDAMENTAL THAN COLOUR: STRUCTURE=TRACER OF FORMATION
    - FAST/HOT MODE (COLLAPSE/RAPID MERGER) > SPHEROIDS/AGN/SMBHS/HIGH-[α/FE], Z > 2
    - SLOW/COLD MODE (ACCRETION[LUMPY]) > DISCS BUILT SLOWLY IN FIELD Z < 2-3
- STELLAR MASS IN EACH COMPONENT: (D07 APJL)
  - DISCS = 60% INFALL MODE (HALF EXPONENTIAL, HALF TRUNCATED?, TRUNC'D BLUER)
  - SPHEROIDS = 37% COLLAPSE/MERGER MODE (ELLIPTICALS 10%, BULGES 27%)
  - PBULGES < 2% SECULAR MODE (ALSO SEE BLUE SPHEROIDS AT SIMILAR LEVEL)
- MEAN DISC DUST OPACITY HIGH, BULGES OBSCURED BY 0.8-2.5 MAGS ! (D07)
  - HTF AN ENVIRONMENTAL EFFECT OF IGM & ICM ?
    - IGM ALLOWS DISC CONSTRUCTION VIA INFALL, DUST PRODUCTION OBSCURES BULGES
    - ICM SHUTS DOWN SF AND DESTROYS DUST DIMINISHING DISC AND UNVEILING BULGE
  - REMOVING DUST MAKES A GALAXY REDDER AND BRIGHTER (DRY MERGERS NOT NEEDED ?)
- COSMIC ENERGY BUDGET: LOST STARLIGHT=FAR-IR DUST EMISSION (D08)

GAMA Team (MGC in yellow)

WORKING GROUPS/HEADS

SCIENCE	CATS	DATABASE	OBS	MOCKS	RADIO	SPEC. PIPE.	IMAGE. PIPE.
Peacock	Baldry	Liske	Driver	Norberg	Hopkins	Loveday	Bamford
(ROE)	(LJMU)	(ESO)	(PI, St And)	(ROE)	(USyd)	(Sussex)	(Nott.)

TEAM MEMBERS

Bridges (AAO)
Bland-Haw'n (U.Syd)
Cameron (St And)
Conselice (Nott.)
Couch (Swin.)
Croom (U.Syd)
Cross (Edin.)
Frenk (Durham)
Graham (Swin)
Hill (StA)
Edmonson (Ports)
Jones (AAO)
Kuijken (Leiden)
Lahav (UCL)
Nichol (Ports.)
Oliver (Sussex)
Parkinson (Edin.)
Phillipps (Bristol)
Popescu (UCLan)
Eales (Cardiff)
Ellis (USyd)
Prescott (LJMU)
Proctor (Swin.)
Sharp (AAO)
Staveley-Smith (UWA)
Sutherland (Camb.)
Tuffs (MPIK)
van Kampen (Innsbruck)
Warren (Imperial)
Dunne (Nottingham)

TEAM AFFILITATIONS:

UKIRT/LAS, VST/KIDS, VISTA/VIKING, HERSCHEL-ATLAS, DURHAM ICC

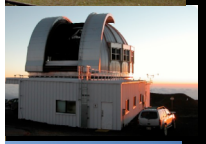
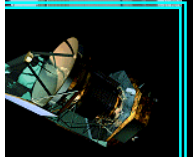
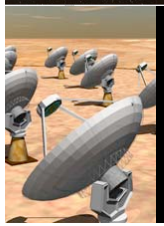
WEBSITE:

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


MGC
Millennium Galaxy Catalogue
Γ

Galaxy And Matter Assembly

- COMPREHENSIVE
  - 250 SQ DEGREES (5X50 SQ DEG. CHUNKS), 250K GALAXIES (25X MGC)
- GENERAL SCIENCE:
  - A STUDY OF STRUCTURE ON 1KPC-1MPC SCALES, WHERE BARYON PHYSICS CRUCIAL
- SPECIFIC GOALS:
  - THE CDM HALO MASS FUNCTION FROM GROUP VELOCITY DISPERSIONS
  - THE STELLAR MASS FUNCTION INTO THE INTERMEDIATE MASS REGIME
  - BUILDING TOTAL SEDS FOR GALAXIES AND THEIR COMPONENTS AT $Z < 0.5$
- GOING MASSIVELY MULTI-WAVELENGTH:
  - X-RAY (XMM), UV (GALEX)
  - OPTICAL: UGRI (VST, SDSS), SPECTRA (AAT)
  - NEAR-IR: ZYJHK (VISTA, UKIRT)
  - FAR-IR (HERSCHEL), SUB-MM SCUBA-II
  - RADIO: 21CM (ASKAP)
- OVERCOME SECONDARY STRUCTURAL ISSUES:
  - NUCLEI-BULGE-BAR-DISC-DISC TRUNCATION DECOMPOSITIONS
- DISENTANGLE ENVIRONMENTAL DEPENDENCIES

GAMA: Facility	Wavelength	Time (on GAMA)	Depth (5σ, AB)	Status
 AAT/AAΩ GAMA	Spectra	165nights	r < 19.8, K=17.0 mag	in progress
 UKIRT LAS	Near-IR (YJHK)	35nights	Y=22.0, J=20.9, H=20.2, K=20.4	in prog.
 VISTA VIKING	Near-IR (YJHK)	75nights	Z=23.8, Y=23.0, J=22.8, K=21.9	Mar 09
 VST VST	Optical (ugriz)	120nights	u=24.8, g=25.4, r=25.2, i=24.2	Mar 09
 HERSCHEL ATLAS	Far-IR	200hours	100,160,250,350,500 microns 67, 94, 45, 62, 53 mJy	Mar 09
 XMM	X-Ray Meeting in Paris April 08 to discuss 100 sq deg survey			?
 ASKAP DEEP	Radio (21cm) Meeting in Perth (April 08) to discuss SKA P'finders			?

Tuffs & Popescu Model

Old stellar bulge:

$$\eta(\lambda, R, z) = \eta^{\rm bulge}(\lambda, 0, 0) \exp(-7.67\, B^{1/4})\, B^{-7/8},$$

$$B = \frac{\sqrt{R^2 + z^2\,(a/b)^2}}{R_e}$$

Old stellar disk:

$$\eta(\lambda, R, z) = \eta^{\rm disk}(\lambda, 0, 0) \exp\left(-\frac{R}{h_{\rm s}^{\rm disk}} - \frac{|z|}{z_{\rm s}^{\rm disk}}\right)$$

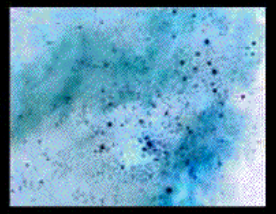
Young stellar disk:

$$\eta^{\rm tdisk}(\lambda, R, z) = \eta^{\rm tdisk}(\lambda, 0, 0) \exp\left(-\frac{R}{h_{\rm s}^{\rm tdisk}} - \frac{|z|}{z_{\rm s}^{\rm tdisk}}\right)$$

Dust disk associated with the old stellar disk:

$$\kappa_{\rm ext}^{\rm disk}(\lambda, R, z) = \kappa_{ext}^{\rm disk}(\lambda, 0, 0)\, \exp\left(-\frac{R}{h_{\rm d}^{\rm disk}} - \frac{|z|}{z_{\rm d}^{\rm disk}}\right)$$

Clumpy component

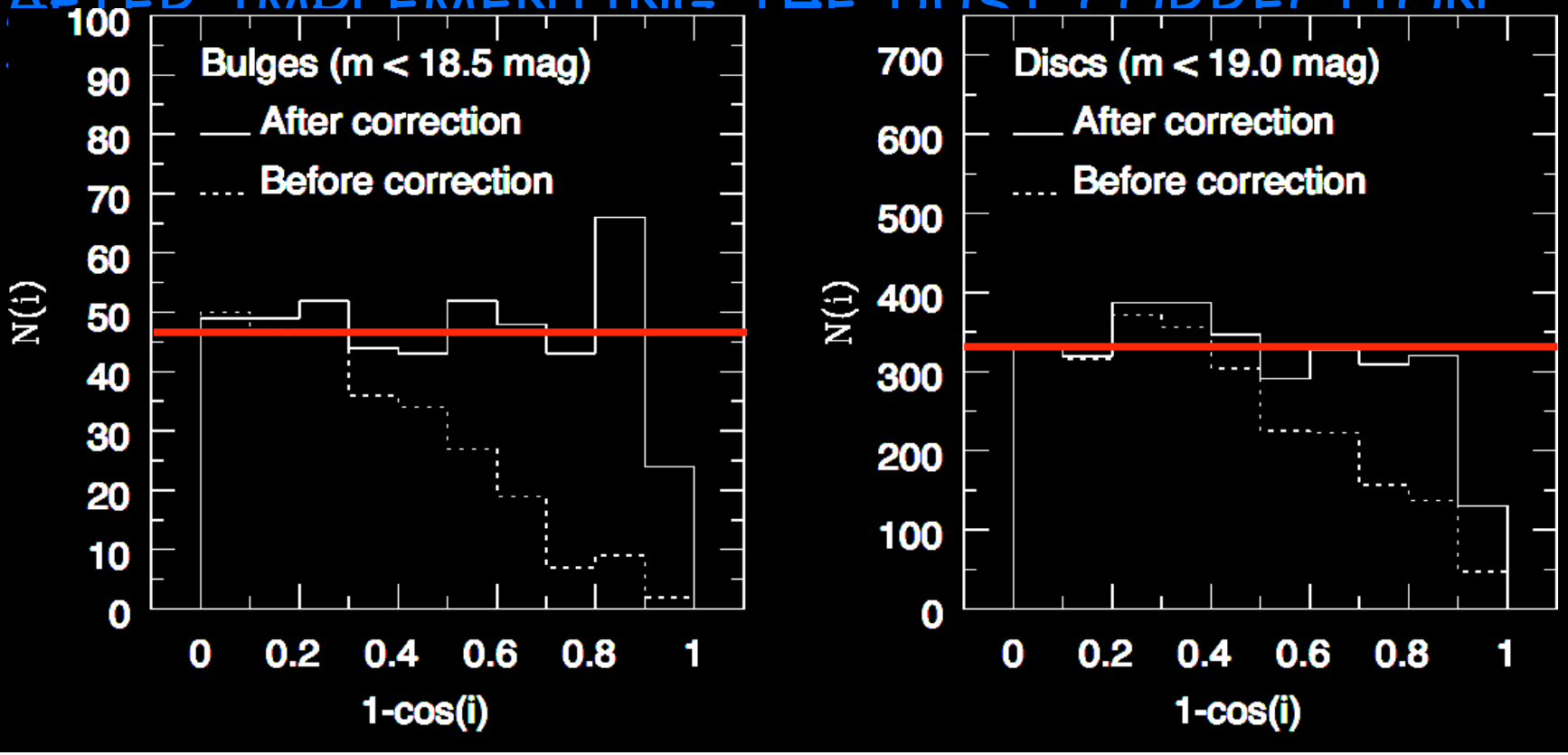


Dust disk associated with the young stellar disk:

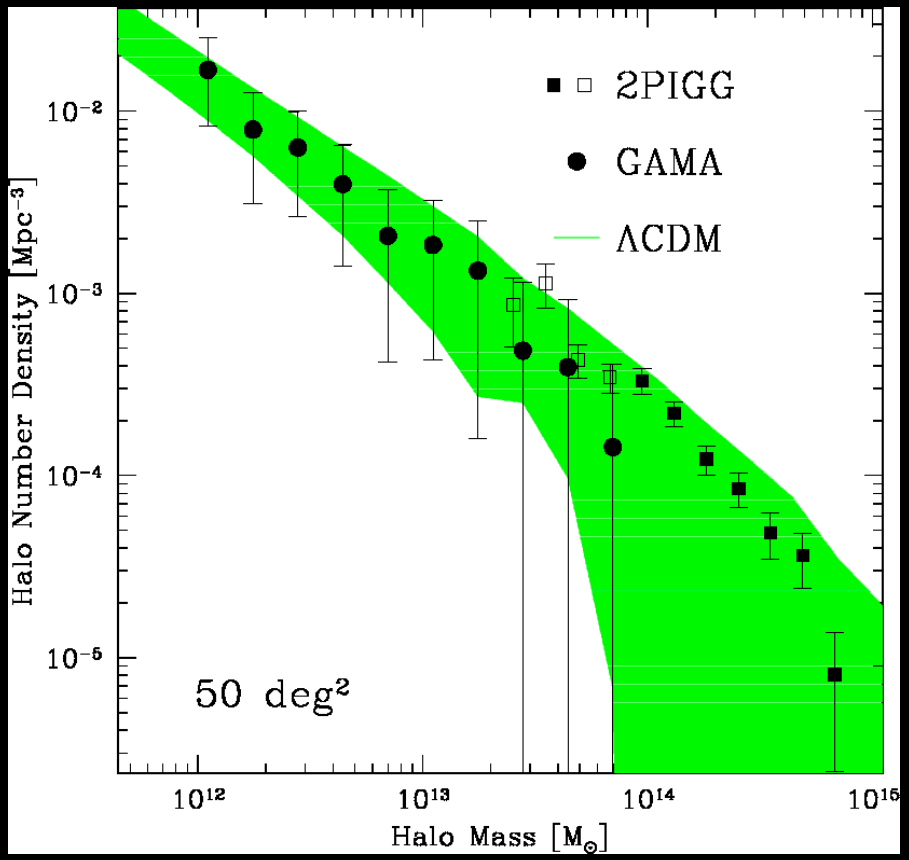
$$\kappa_{ext}^{\rm tdisk}(\lambda, R, z) = \kappa_{ext}^{\rm tdisk}(\lambda, 0, 0)\, \exp\left(-\frac{R}{h_{\rm d}^{\rm tdisk}} - \frac{|z|}{z_{\rm d}^{\rm tdisk}}\right)$$

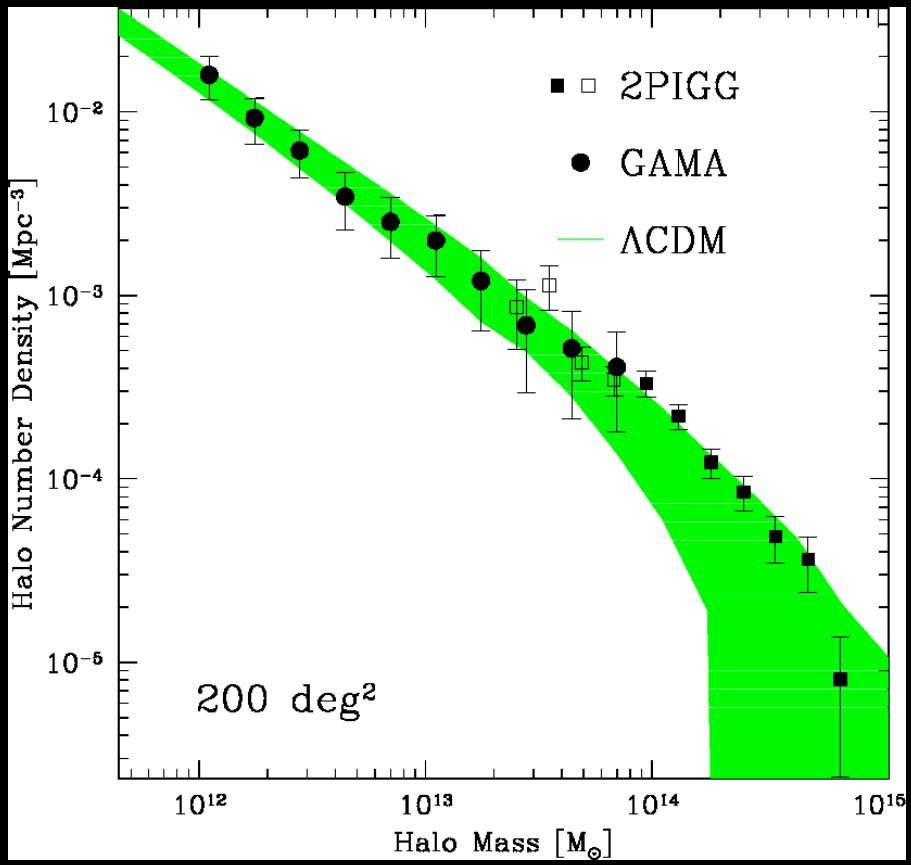
Sanity check I: cos(i) distributions

- IN THE ABSENCE OF DUST THE COS(I) DENSITY DISTRIBUTION SHOULD BE FLAT. INITIALLY THEY'RE NOT.
- AFTER IMPLEMENTING THE DUST CORRECTION



The CDM halo mass fn





The GAMA Stellar Mass fn