



# CANDELS Multi-band GalfitM Catalogues

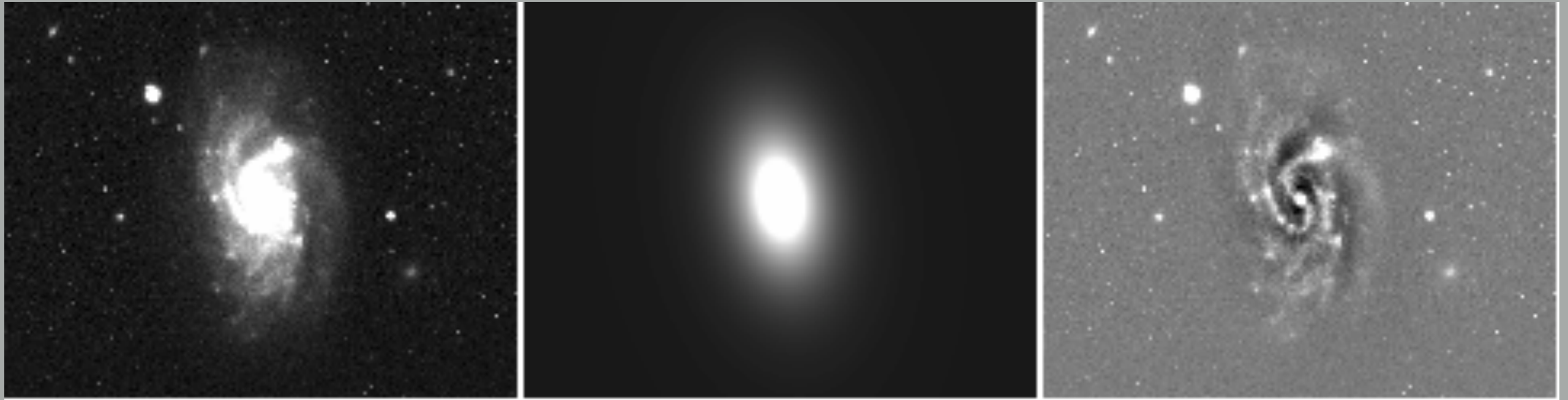
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Boris Häußler (ESO/Chile)



# Galfit: Galaxy Light Profile fitting

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smooth, parametric models –

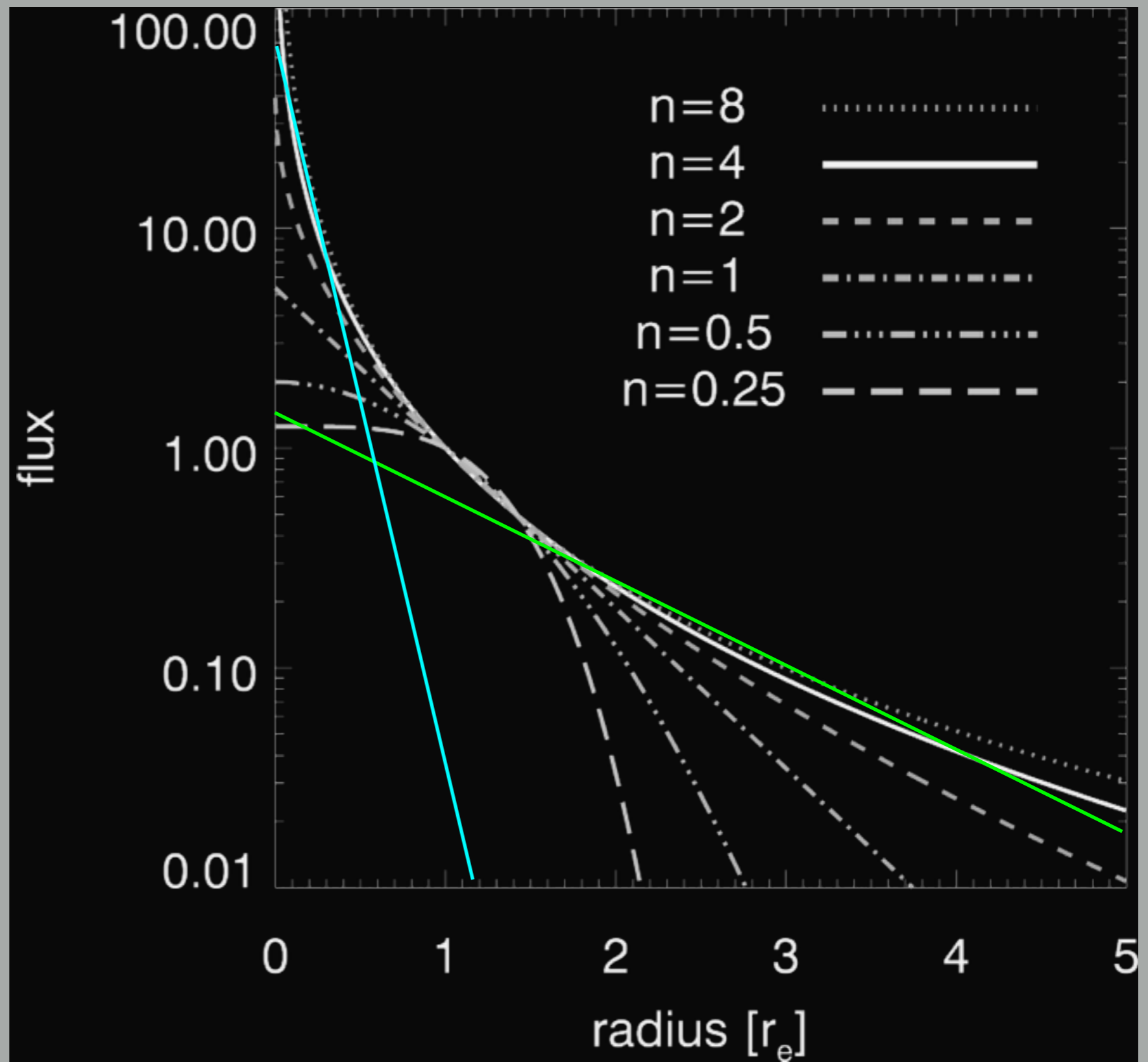
one component 'easy'\*

two components more difficult

\*but see Häußler et al. 2007 & 2013, Kelvin et al. 2012 (GAMA), vdW 2012 (CANDELS) and many others

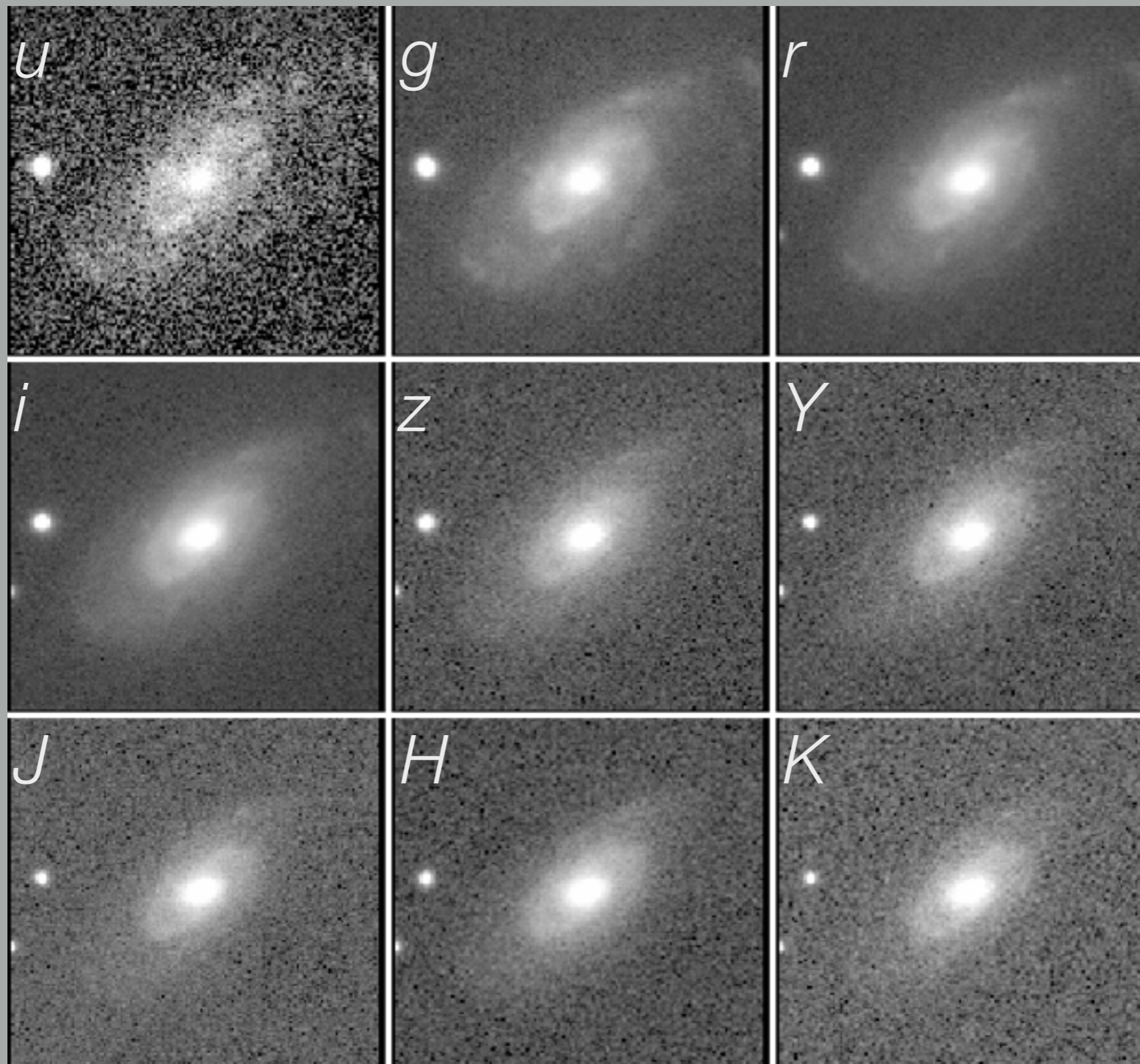
# Objects with $n > 2.5$

- Arjen vdWel has created such a (great) catalogue for CANDELS
- Problem:
  - 2 components can mimic a single component, their separation is very tricky and potentially ambiguous

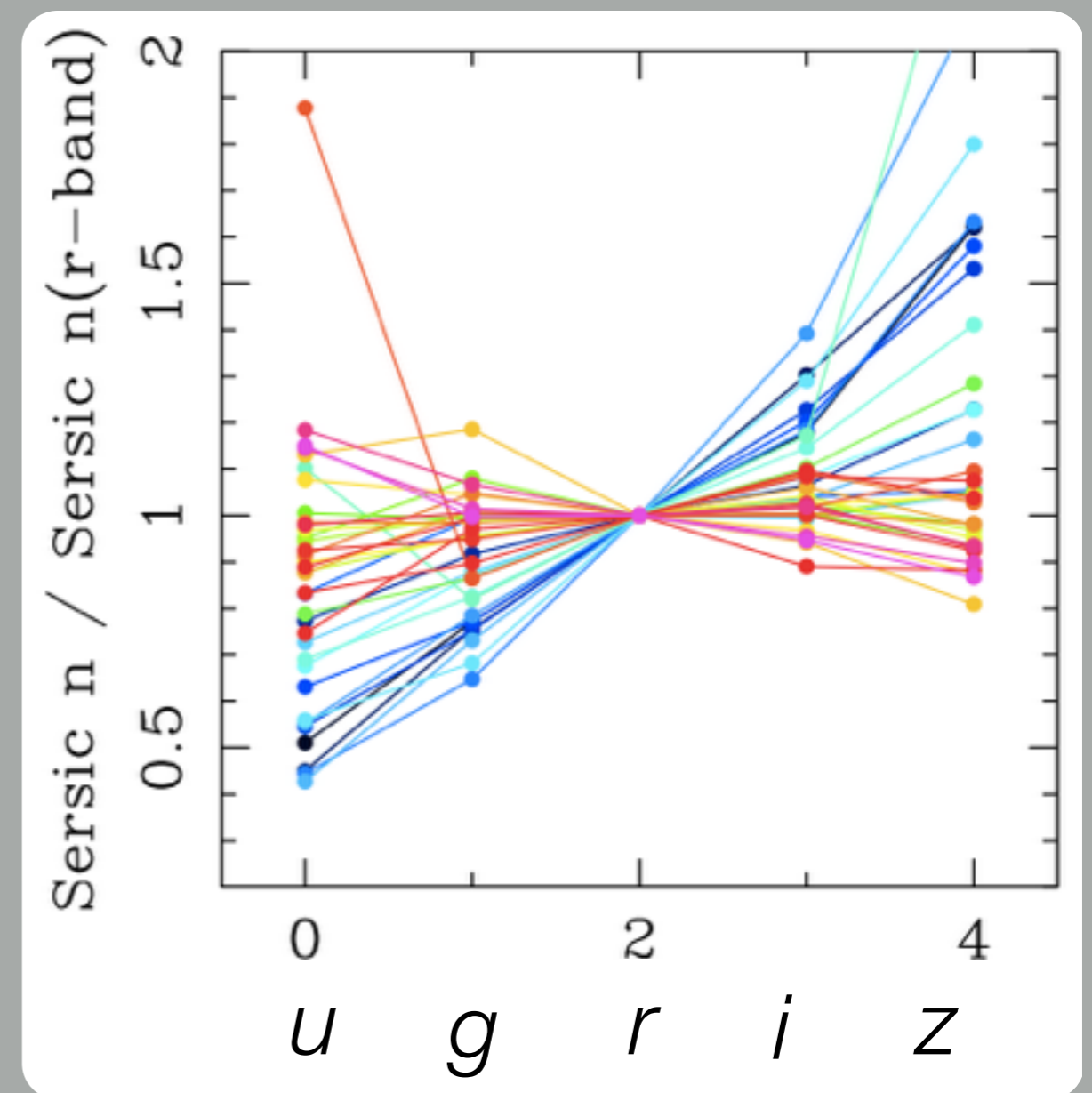
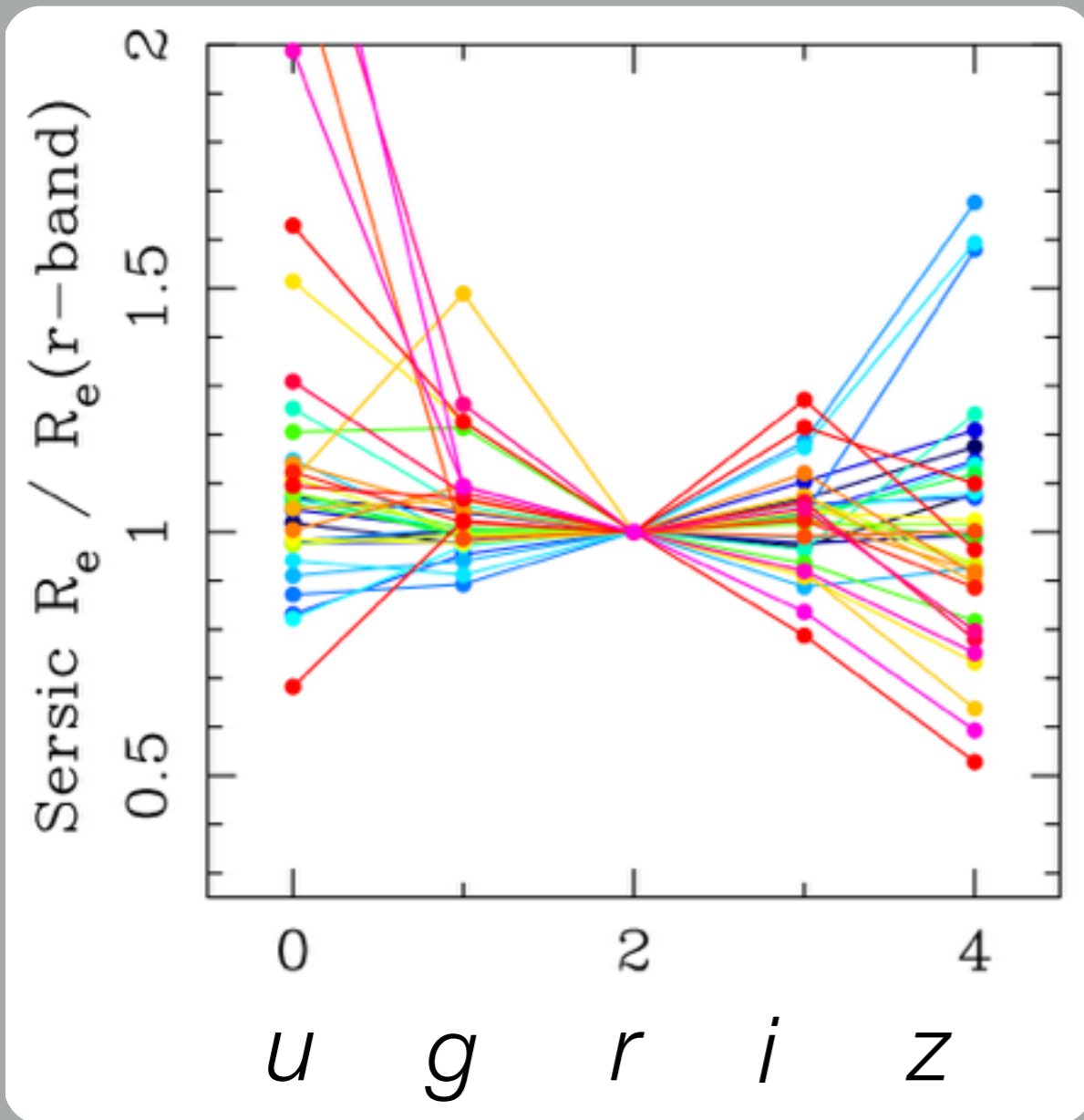


# Today's data: multiple bands

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# Results dependent on choice of band



Even more tricky when galaxies span a wide range of redshifts!

# Colour is valuable information

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monochromatic observations

# Colour is valuable information

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colour observations (degraded HST images)

# Galfit adaptations

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- Galfit adaptations -> GalfitM:
  - Uses multi-wavelength data
  - Each standard GALFIT parameter replaced by a polynomial function of wavelength (Chebyshev polynomials)

$$f(\lambda) = \sum_{i=0}^m c_i T_i(\lambda)$$

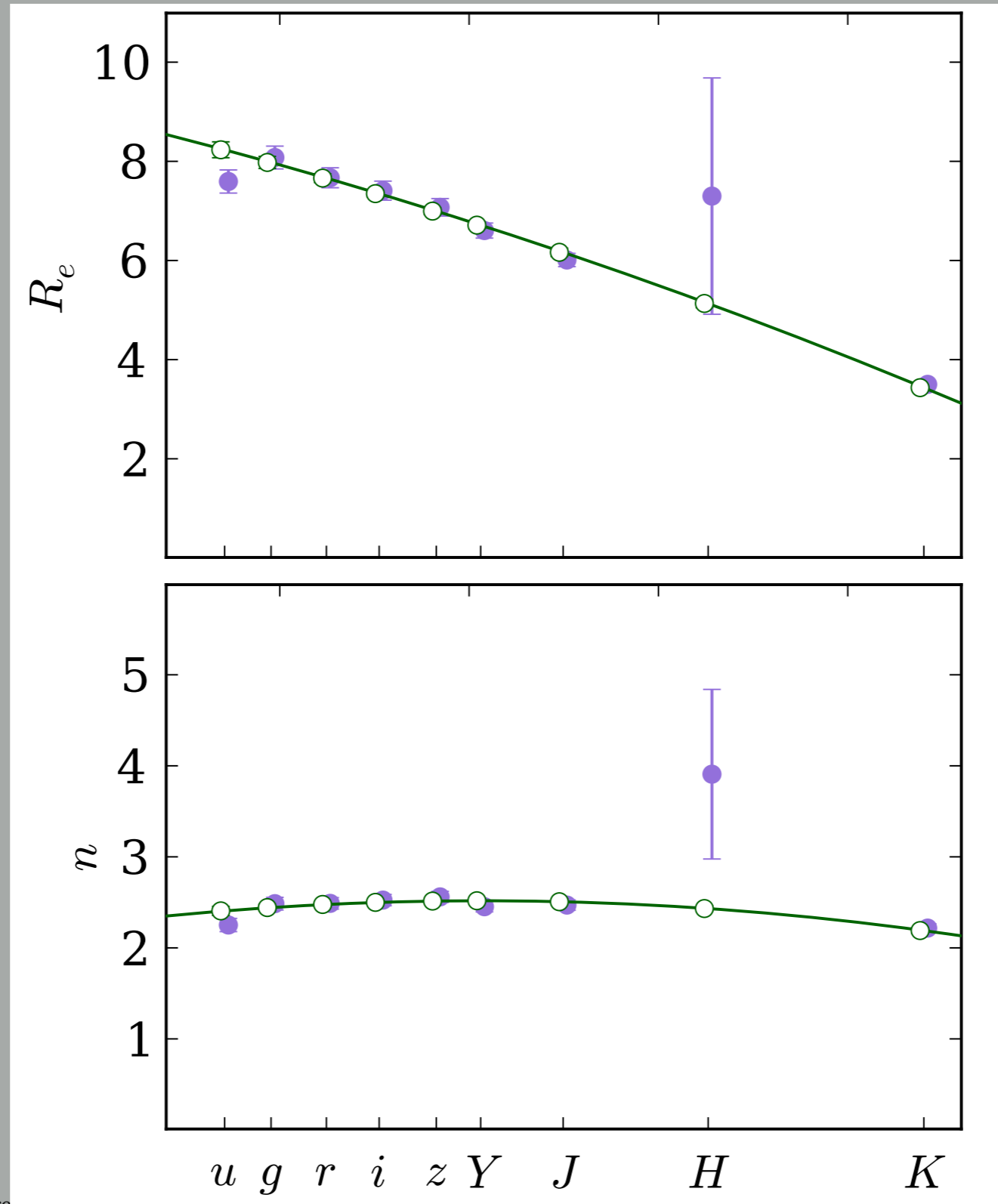
$$I(r) = I_e \exp(-b_n [(r/r_e)^{1/n} - 1])$$


$I_e(\lambda)$        $r_e(\lambda)$        $n(\lambda)$

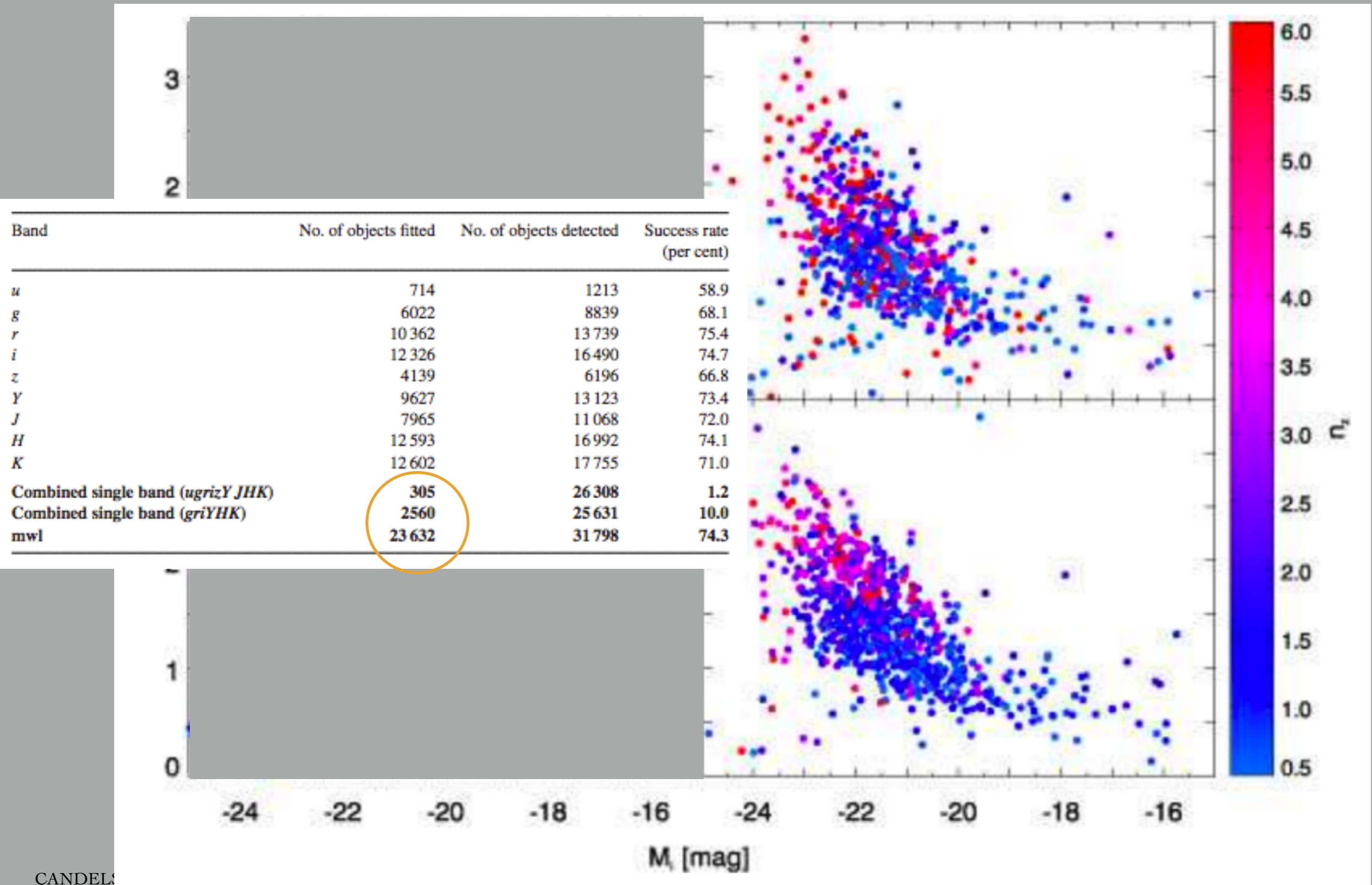
- Easy and backwards compatible user interface



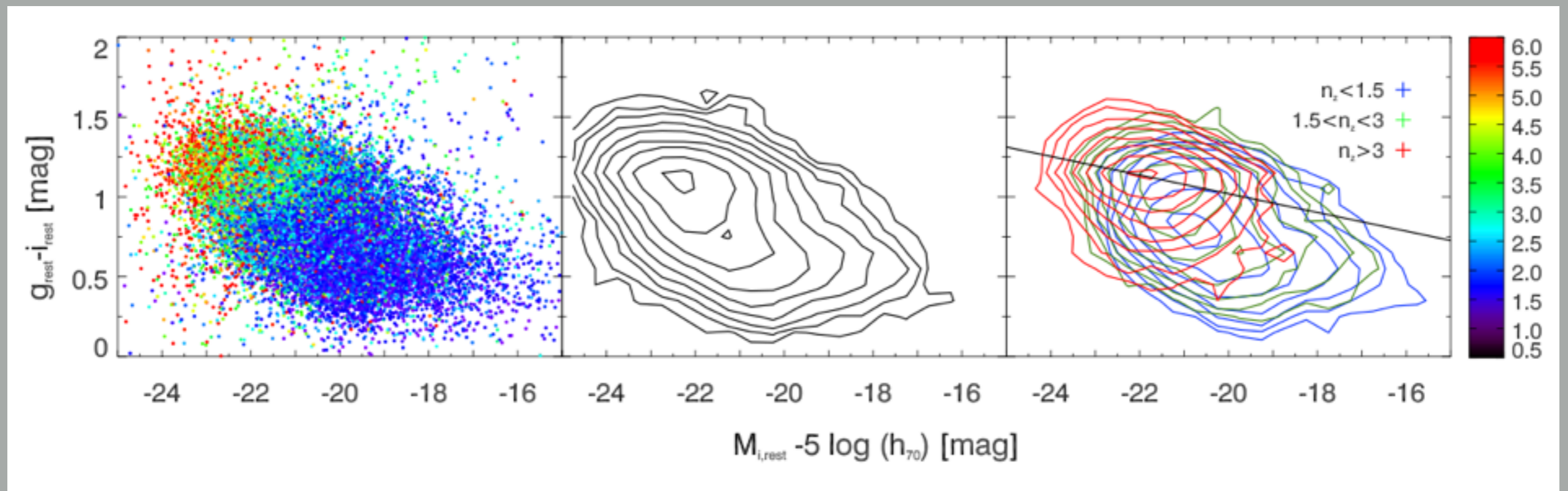
# Helps with noisy bands



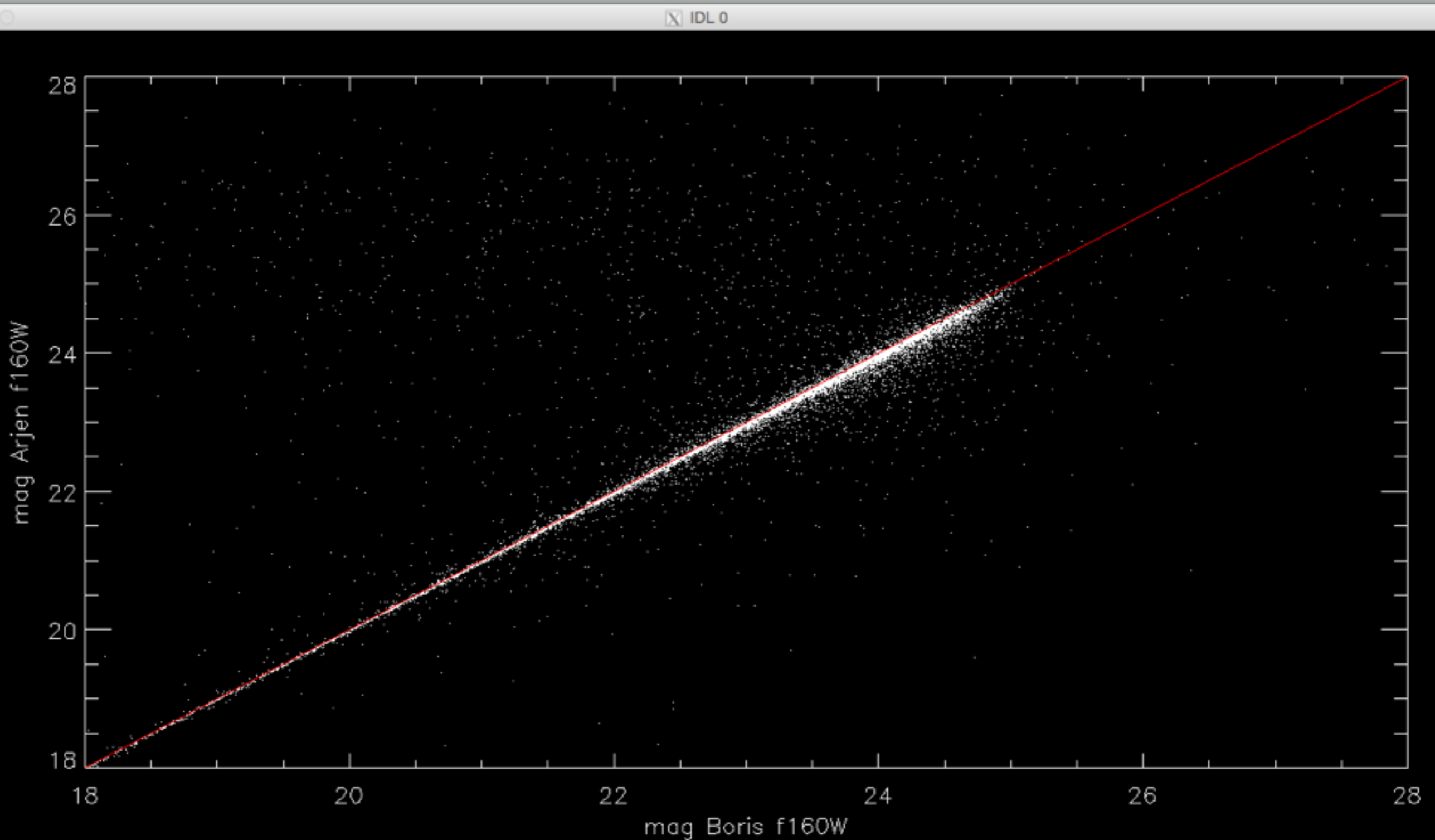
# Improved colour-mag diagram



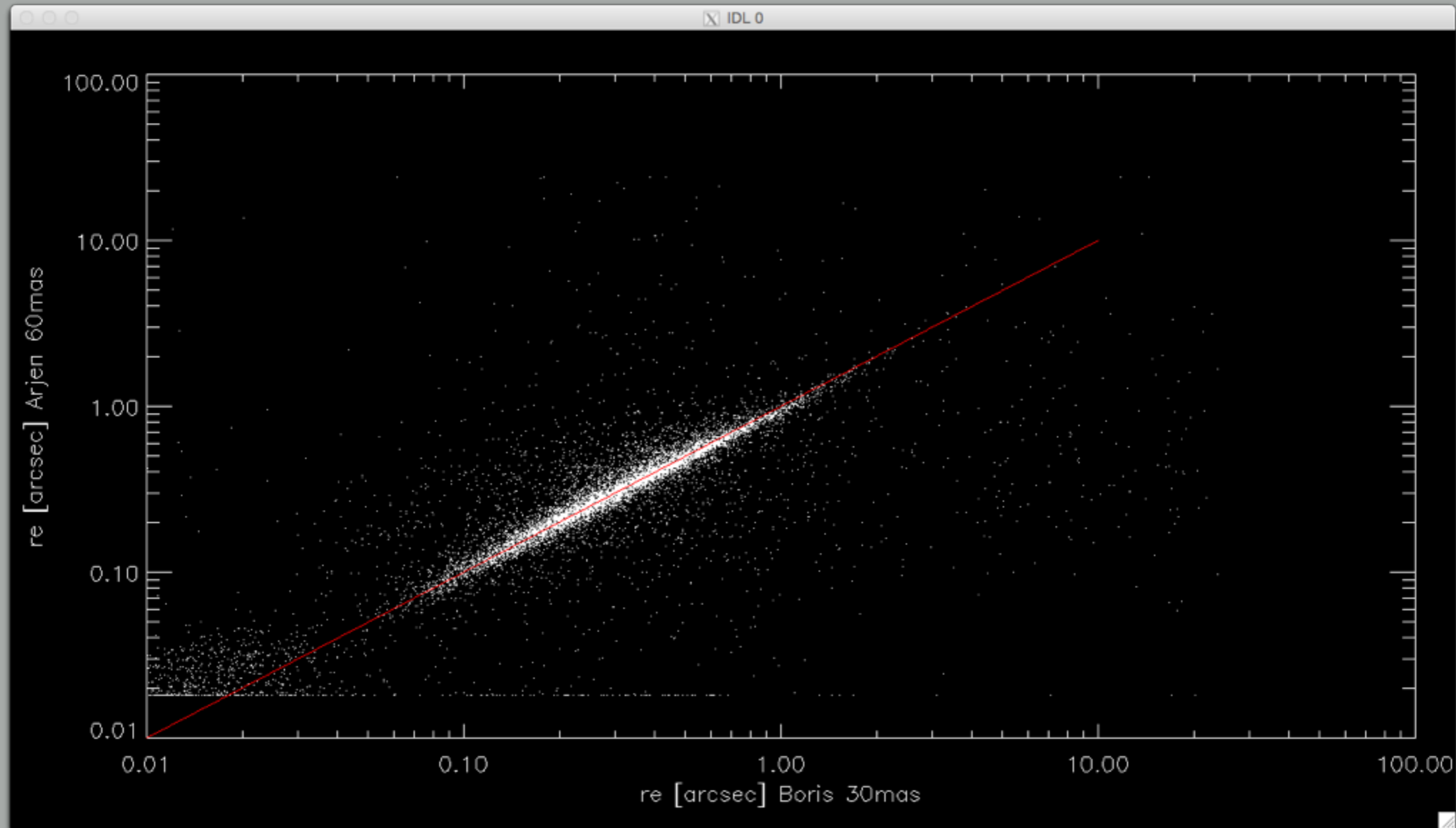
# Improved colour-mag diagram



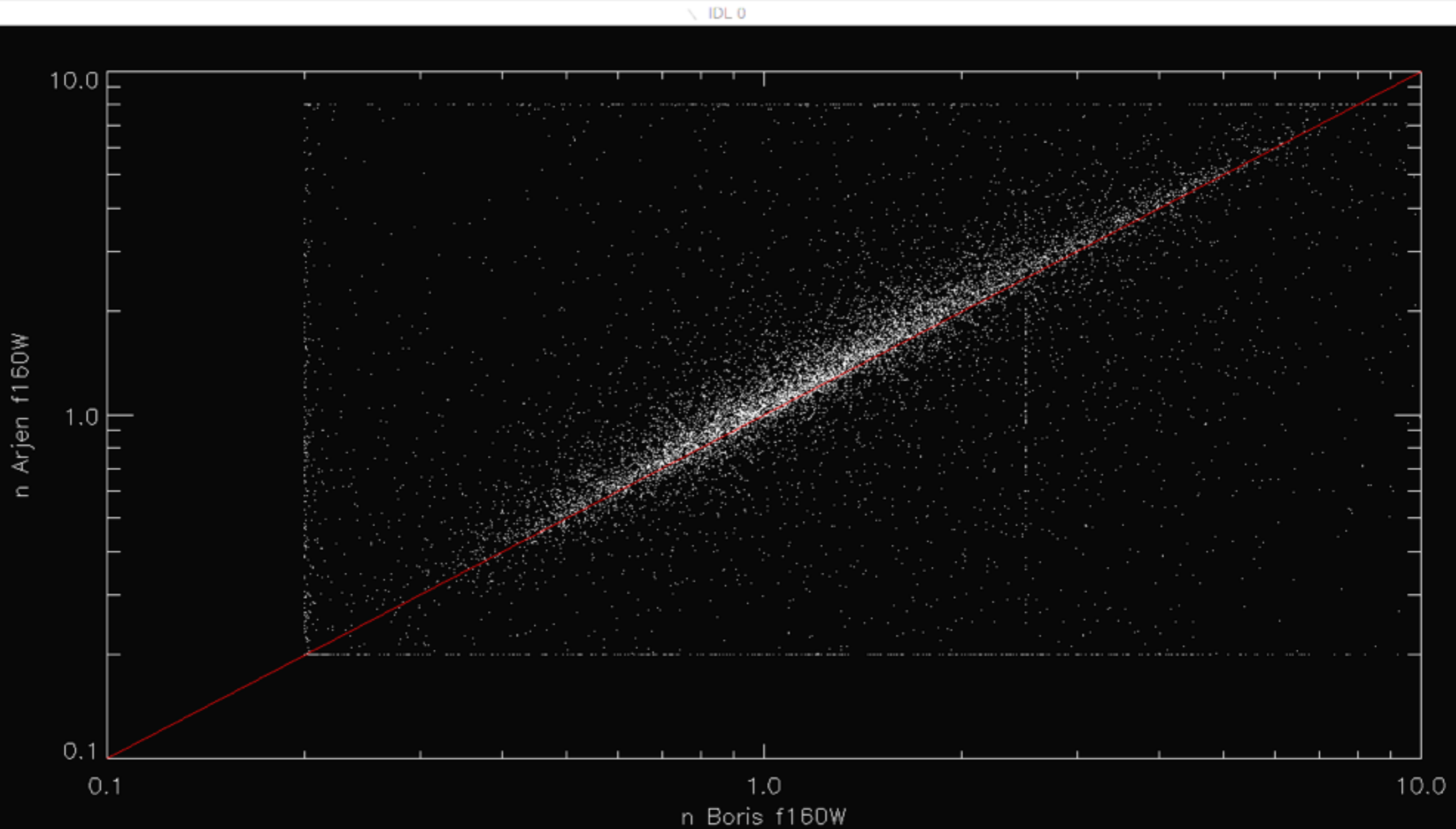
# B/D compares well with other work



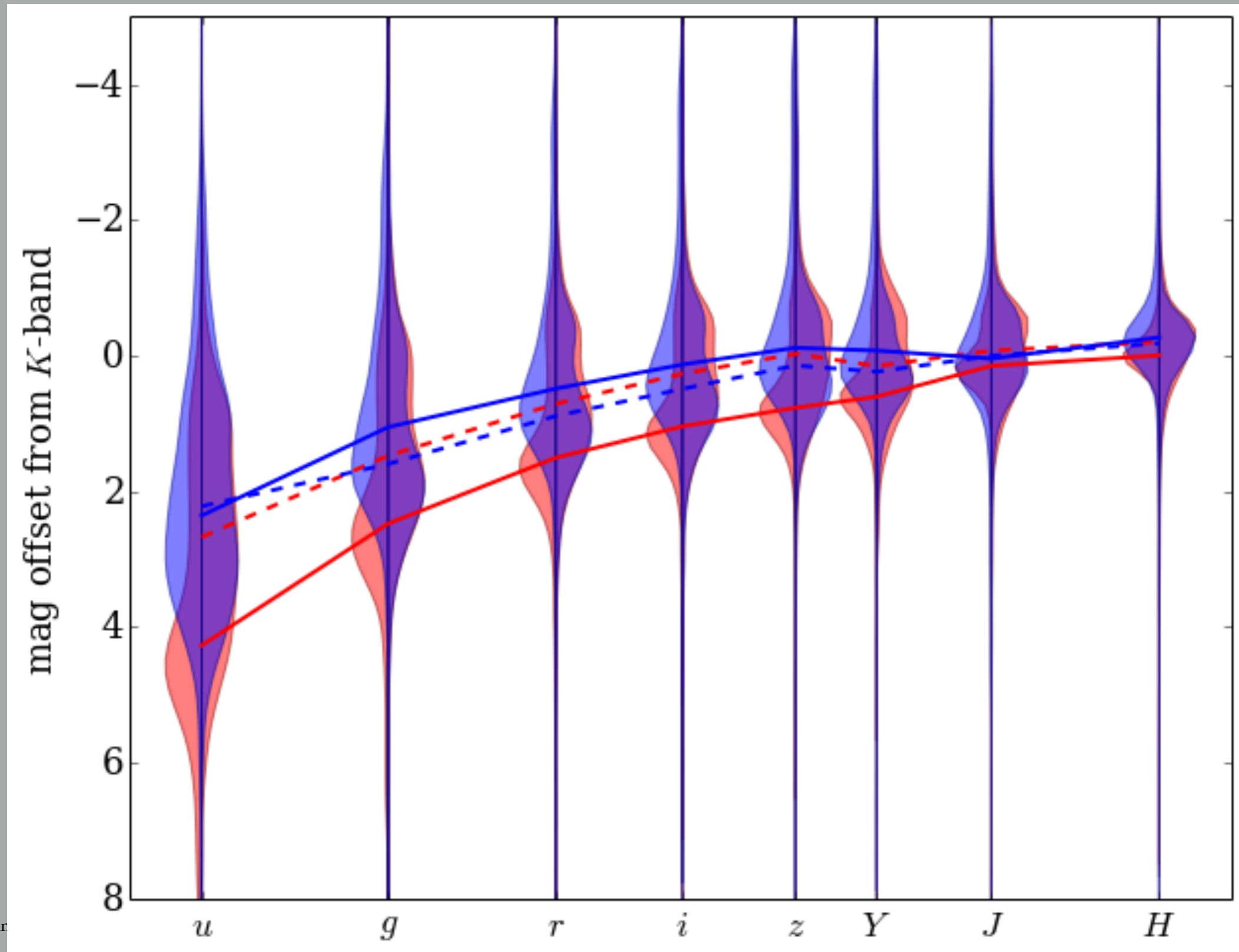
# B/D compares well with other work



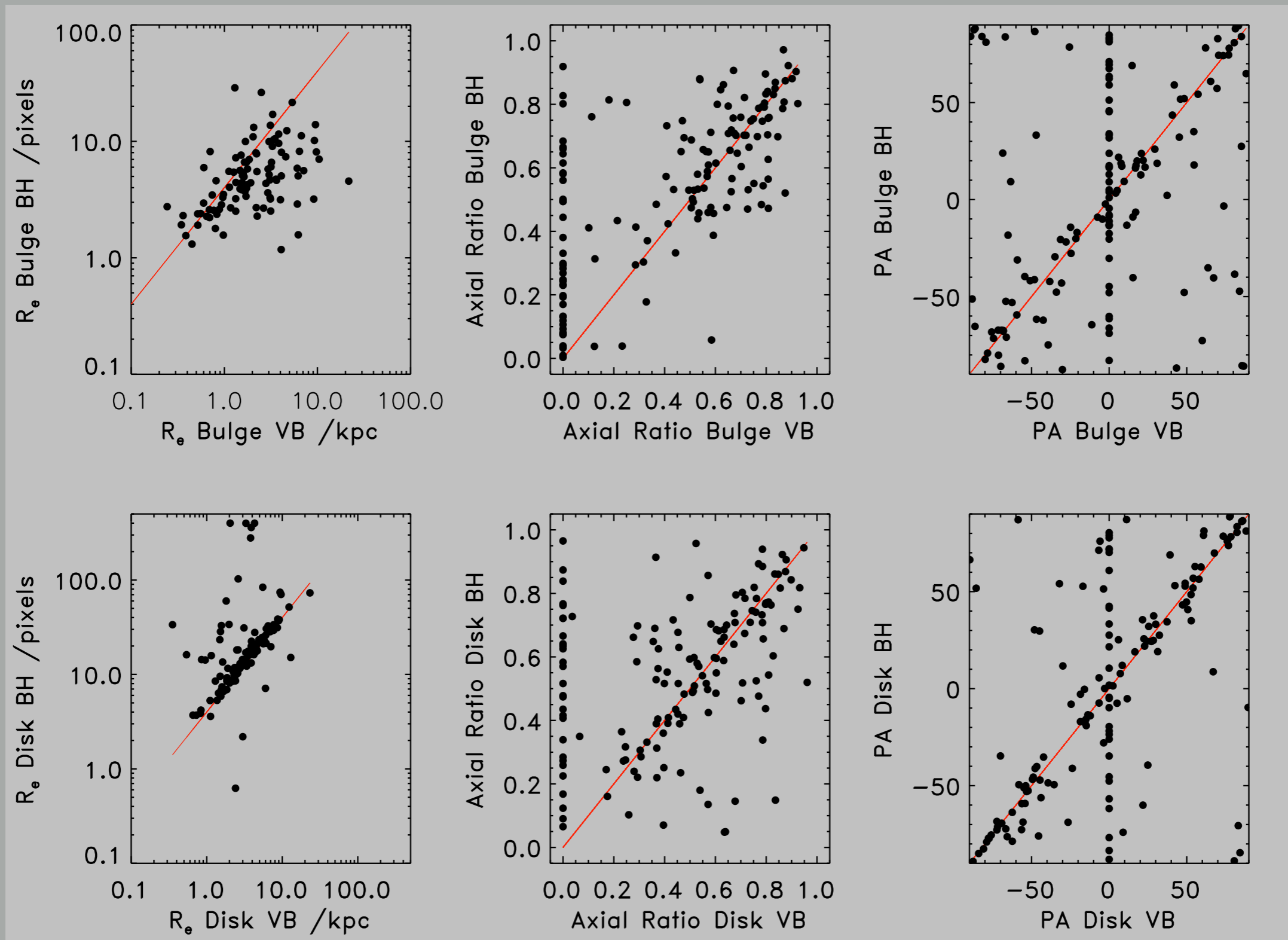
# B/D compares well with other work



# Cleaner B/D decomposition

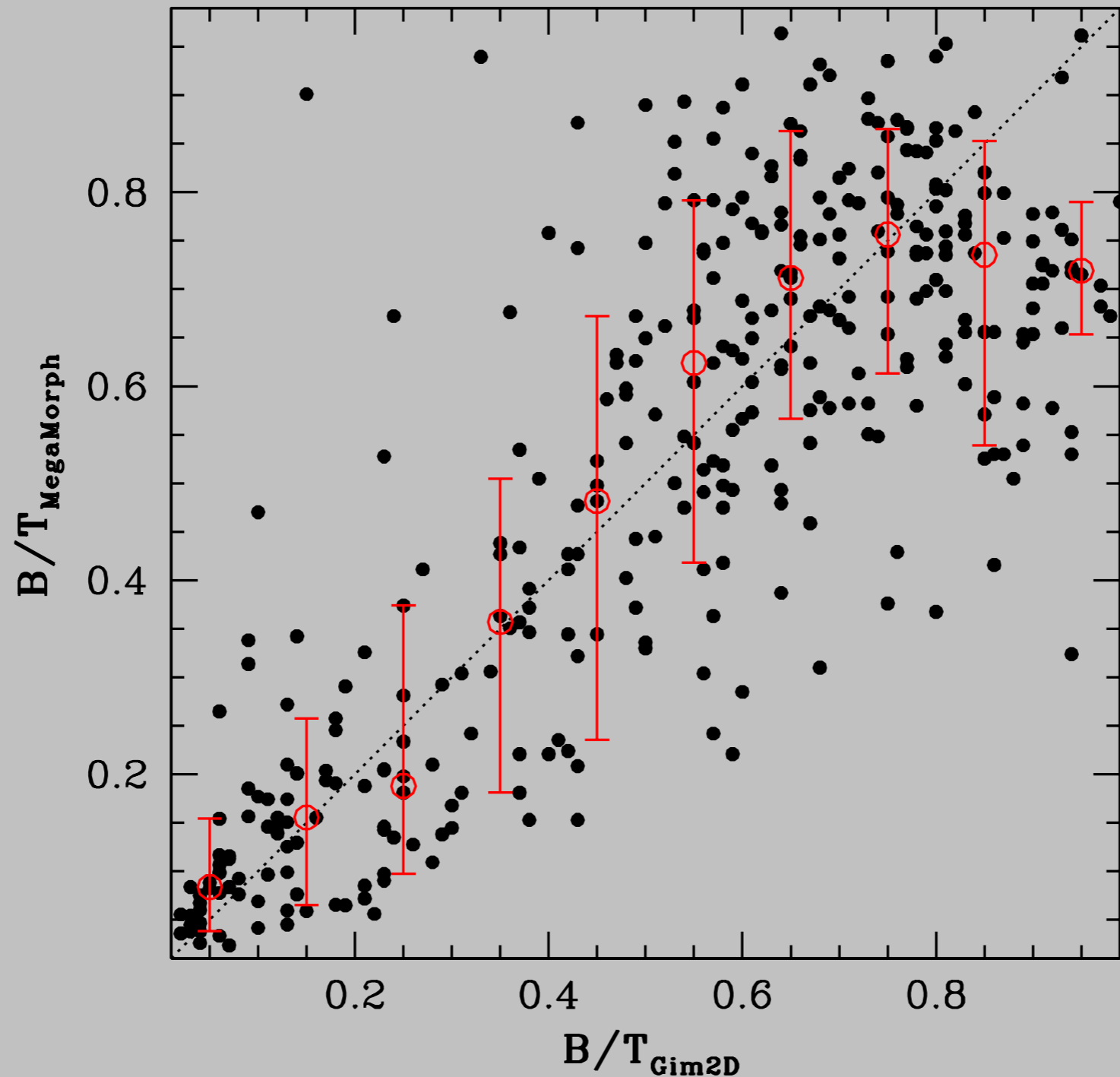


# B/D compares well with other work

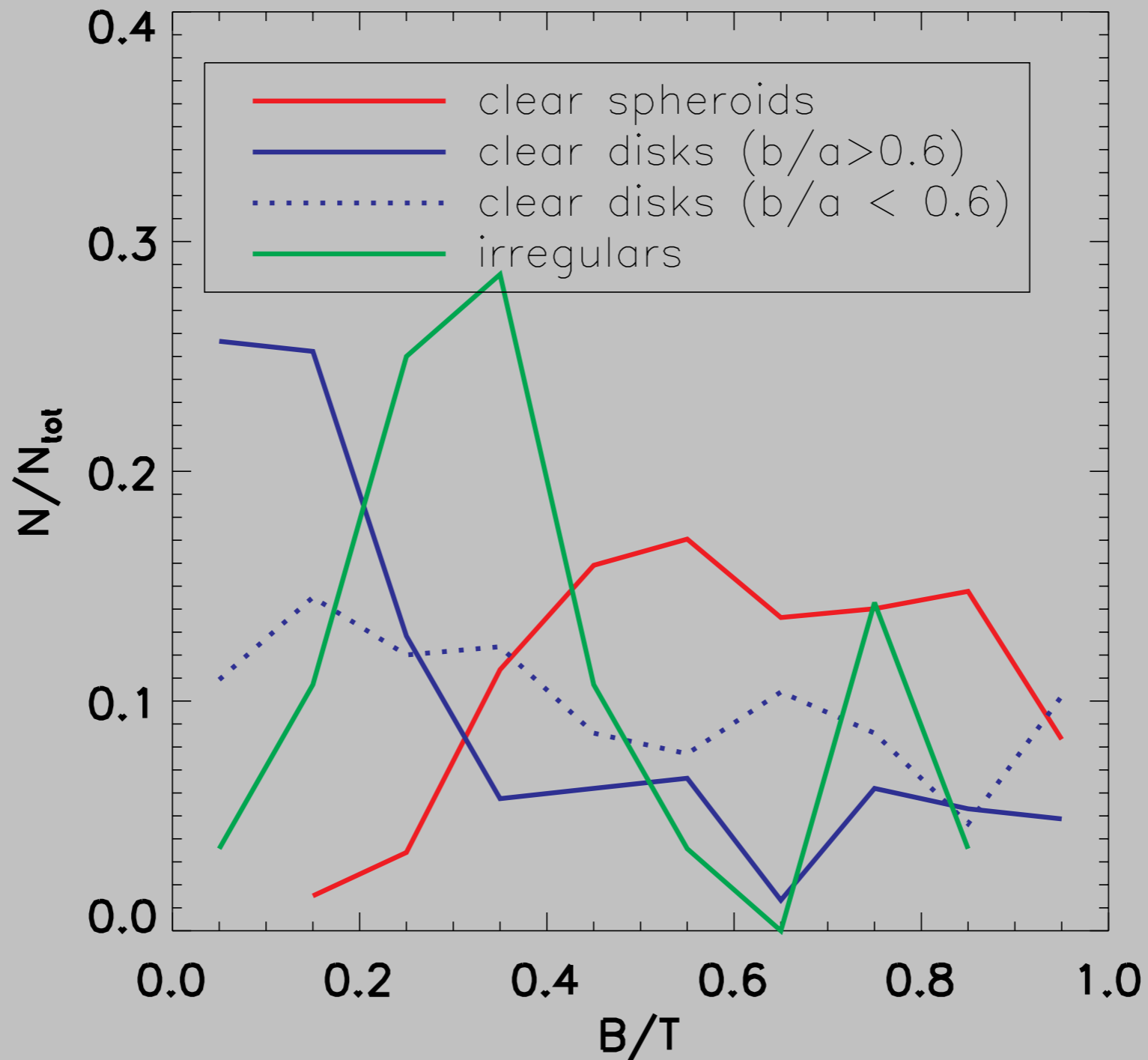




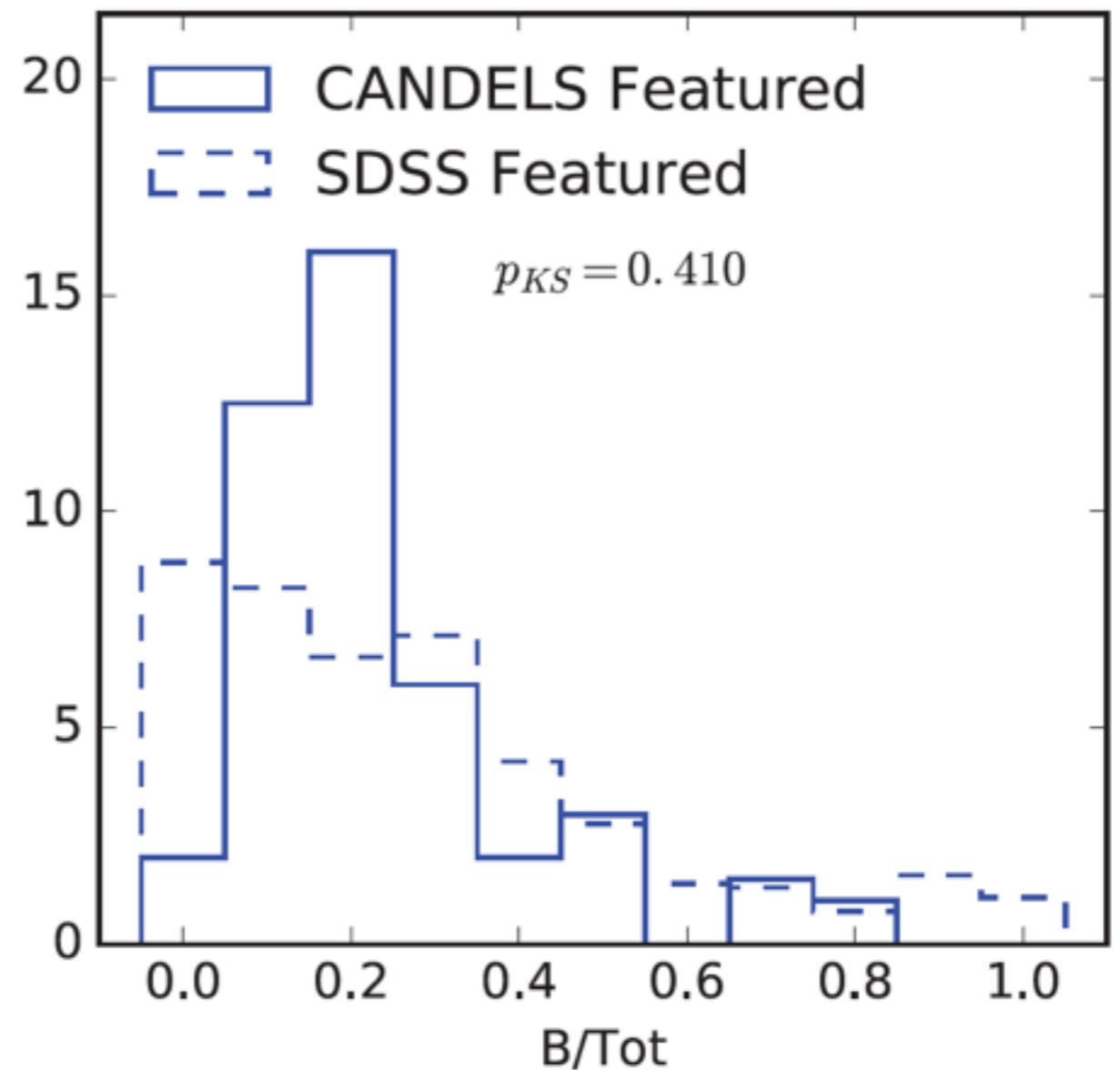
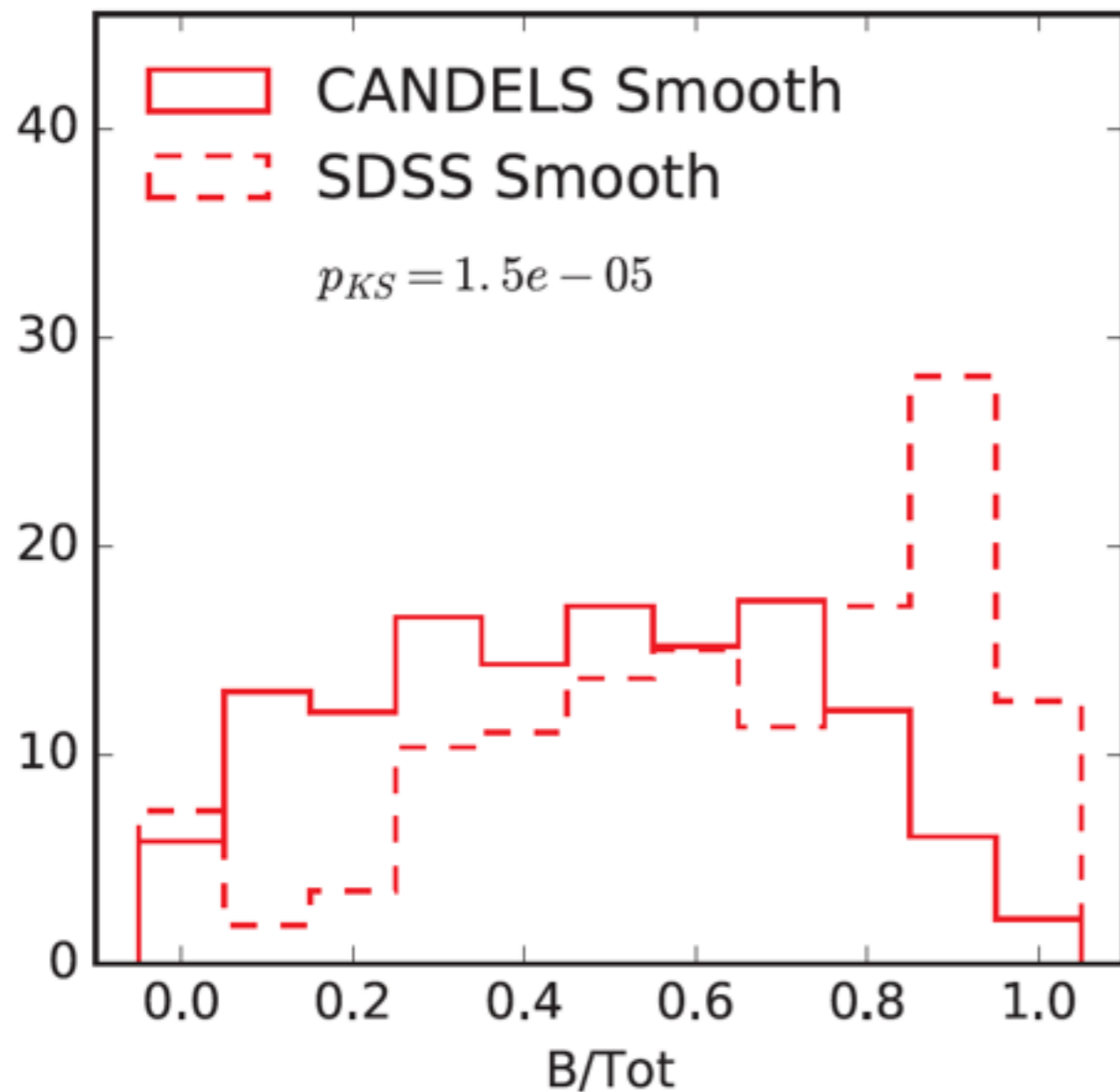
# B/D compares well with other work



# Compares well with “visual classes”



# Compares well with visual classes



# Candels catalogues - General

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- 8 catalogues in total (for now?)
- Differences to Arjens catalogues:
  - multi-band fits that use *ALL* data simultaneously -> parameters less noisy
  - full B/D fits for all objects. B/D fits should be more reliable in multi-band fits
  - The fits use 30mas images (Arjen used 60mas images). A test showed no systematic differences between using one or the other, but better resolution has potential (obvious) advantages.

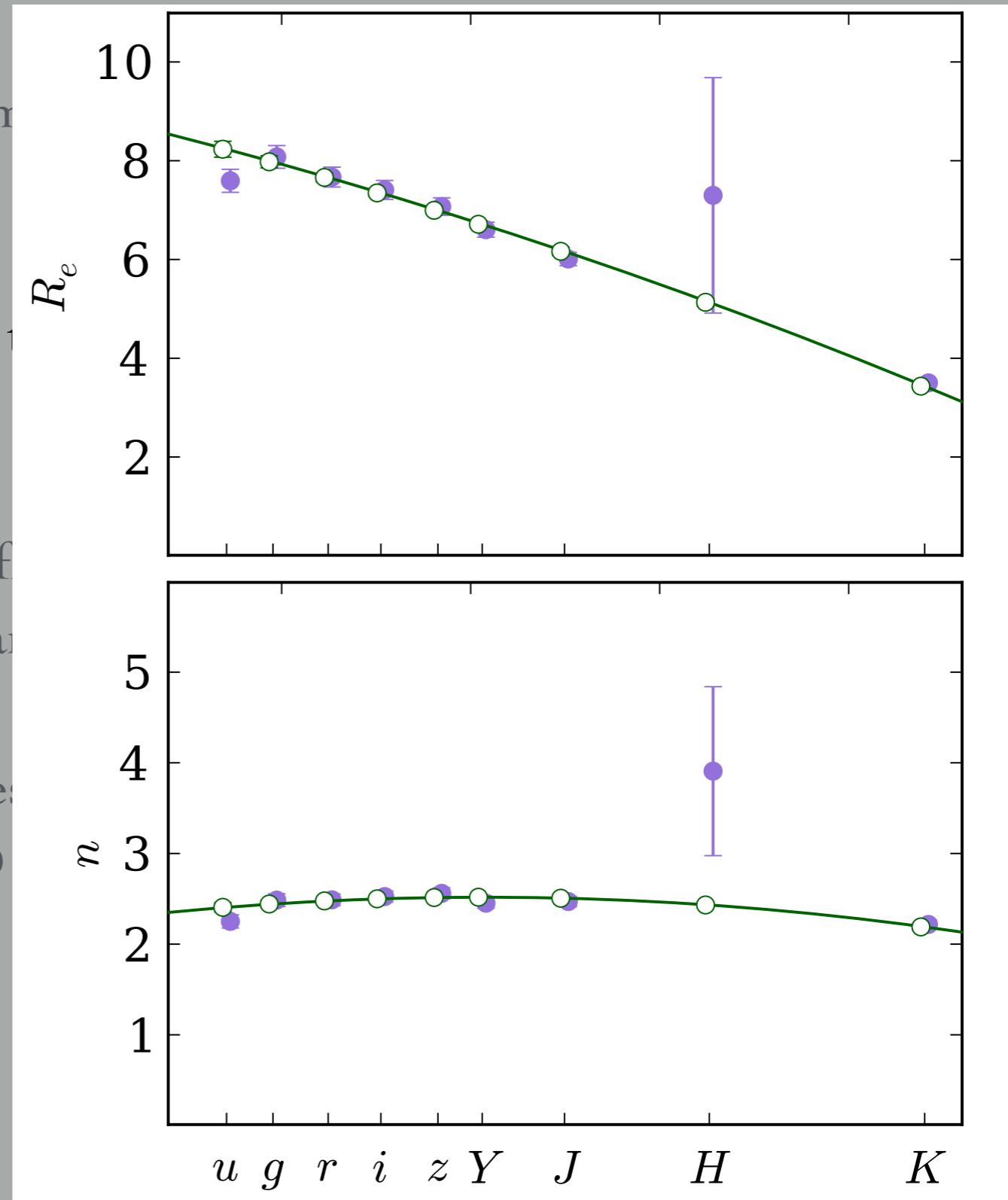
# Candels catalogues - General

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- All detections in the H-band
  - not following the standard setup from the Wiki
  - manually cleaned for mis-detections
- catalogues only contain the values of the PRIMARY source, no neighbours
- 183 columns, including
  - 24 SExtractor columns
  - 6 Galapagos parameters (e.g. sky & flags)
  - 58 single-sérsic fit parameter (e.g. parameters, error bars, flags, CPU time, etc)
  - 91 B/D parameters (e.g. parameters, error bars, flags, CPU time, etc)
  - Many parameters are arrays of values, can not be used in TopCat.
  - \*\_galfit\_CHEB and \*\_galfit\_BAND contain the same information, \*CHEB can be used to derive restframe values
- Values for all purposes

# Candels catalogues - General

- All detections in the H-band
  - not following the standard setup from
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  - Many parameters are arrays of values
  - \*\_galfit\_CHEB and \*\_galfit\_BAND be used to derive restframe values
- Values for all purposes



# Candels catalogues - EGS

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- 27213 objects
- 5 filters (f606w, f814w, f125w, f140w, f160w)
- Single-Sérsic fit (27052 objects):
  - magnitudes free in each image
  - $r_e$  linear with wavelength
  - $n$  linear with wavelength
  - rest constant with wavelength in single-sérsic fits (but free in the fit)
- B/D fits (26908 objects):
  - all parameters (but magnitudes) constant with wavelength
  - bulge sérsic index a FREE parameter.
- 388 GB data volume

# Candels catalogues - EGS II

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- 27239 objects
- 5 filters (f606w, f814w, f125w, f140w, f160w)
- Single-Sérsic fit (27009 objects):
  - magnitudes free in each image
  - $r_e$  quadratic with wavelength
  - $n$  quadratic with wavelength
  - rest constant with wavelength in single-sérsic fits (but free in the fit)
- B/D fits (26886 objects):
  - magnitudes free
  - $r_e$  linear with wavelength
  - $n$  linear with wavelength (effectively allowing colour gradients within the galaxy components)
  - rest (but magnitudes) constant with wavelength
  - bulge sérsic index a FREE parameter.



# Candels catalogues - Cosmos

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- 22755 objects
- 4 filters (f606w, f814w, f125w, f160w)
- Single-Sérsic fit (22656 objects):
  - same setup as EGS field
- B/D fits (22583 objects):
  - same setup as EGS field
- 143 GB data volume

# Candels catalogues - Goods-N

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- 24770 objects.
- 9 filters (f435w, f606w, f775w, f814w, f850l, f105w, f125w, f140w, f160w)
- Single-Sérsic fit (23892 objects):
  - same setup as EGS field
- B/D fits (23090 objects):
  - same setup as EGS field
- 859 GB data volume

# Candels catalogues - Goods-N II

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- 24804 objects.
- 9 filters (f435w, f606w, f775w, f814w, f850l, f105w, f125w, f140w, f160w)
- Single-Sérsic fit (23769 objects):
  - same setup as EGS II field
- B/D fits (23035 objects):
  - same setup as EGS II field

# Candels catalogues - Goods-S

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- 18418 objects (includes the H-UDF)
- 9 filters (f435w, f606w, f775w, f814w, f850l, f105w, f125w, f140w, f160w)
- Single-Sérsic fit (18370 objects):
  - same setup as EGS field
- B/D fits (17574 objects):
  - same setup as EGS field
- 161 GB data volume

# Candels catalogues - Goods-S II

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- 18418 objects (includes the H-UDF)
- 9 filters (f435w, f606w, f775w, f814w, f850l, f105w, f125w, f140w, f160w)
- Single-Sérsic fit (18378 objects):
  - same setup as EGS II field
- B/D fits (17622 objects):
  - same setup as EGS II field

# Candels catalogues - UDS

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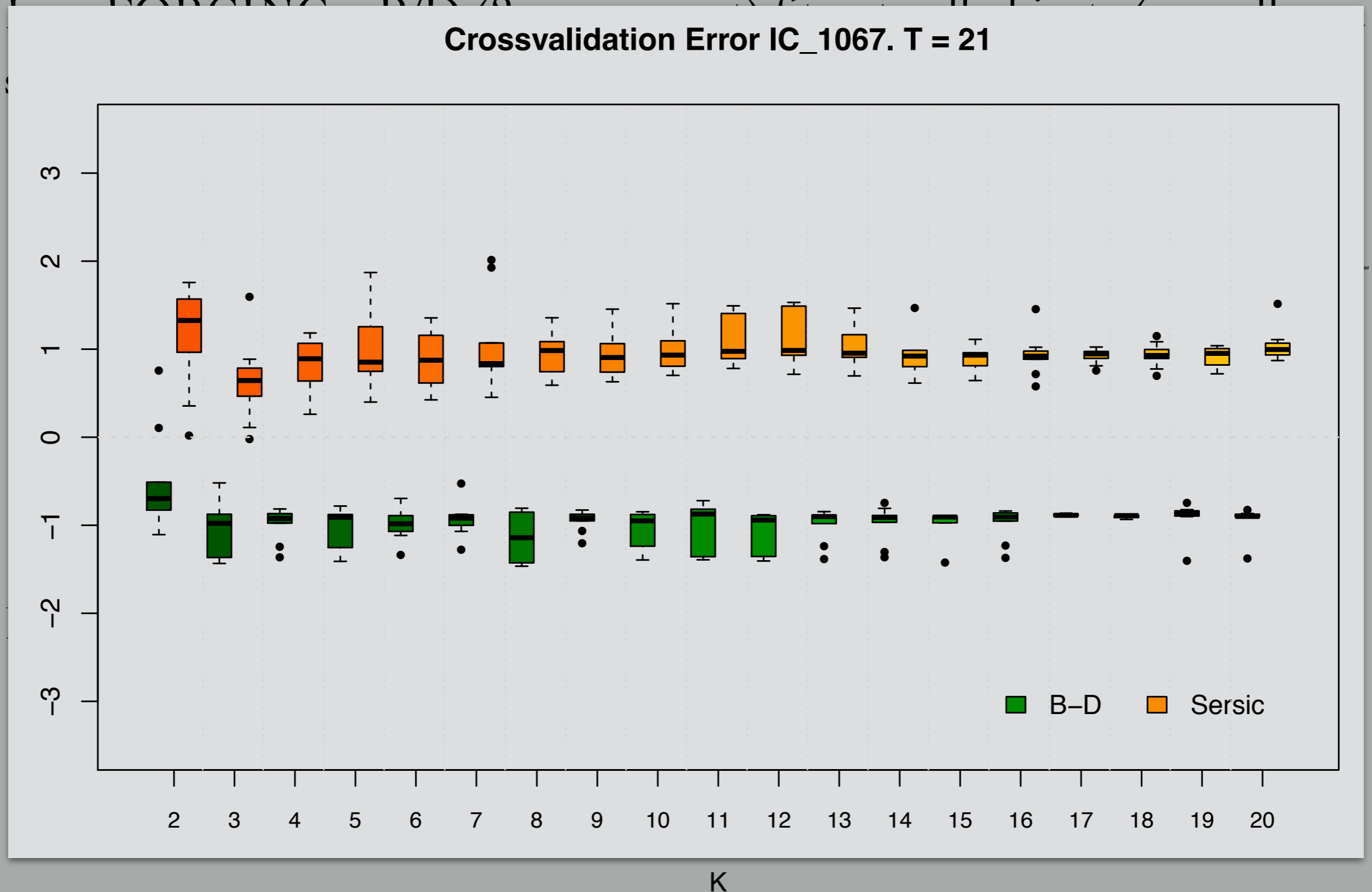
- 21458 objects
- 4 filters (f606w, f814w, f125w, f160w)
- Single-Sérsic fit (21436 objects):
  - same setup as EGS field
- B/D fits (21369 objects):
  - same setup as EGS field
- 81 GB data volume

# Candels catalogues - General

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- I am FORCING a B/D (2-component) fit onto all objects (as well as a single-sersic fits)! During this, the bulge has a FREE (!) sersic index.
  - $B/T = 0.5$ , might be a disk-only galaxy where both profiles fit the same component.
  - For now, there is no criteria provided which tells you whether the single-sersic or the B/D fit are the better model (I assume Marc Huertas-Company will talk about this).
  - Some catalogue cleaning is possible (e.g. not believing faint components and/or bulges with  $n \sim 1$  and similar AR/PA as the disk), but on an individual basis, this will be tricky.
- Ideas welcome, can easily be included into Galapagos itself

# Candels catalogues - General



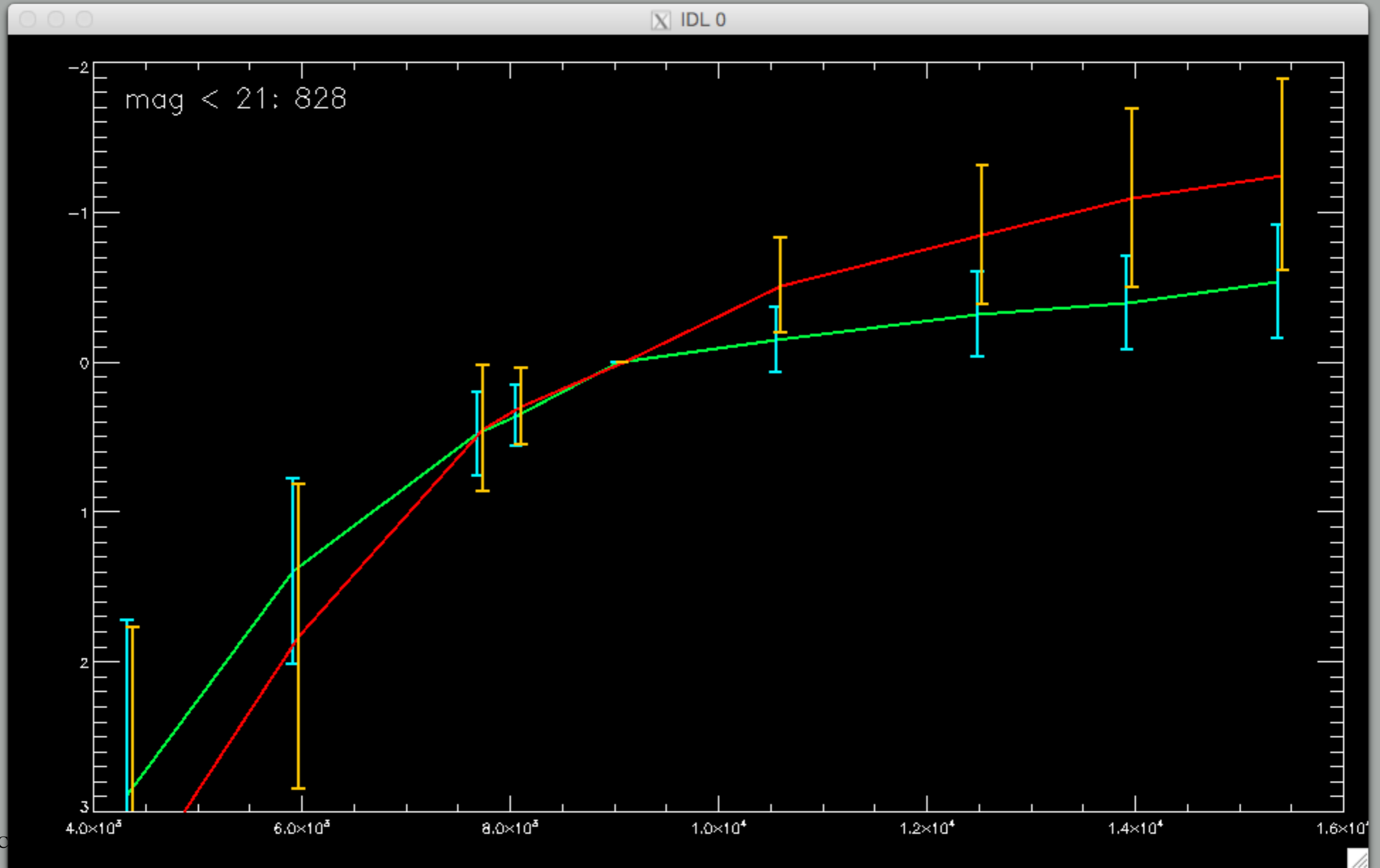


# Candels catalogues - General

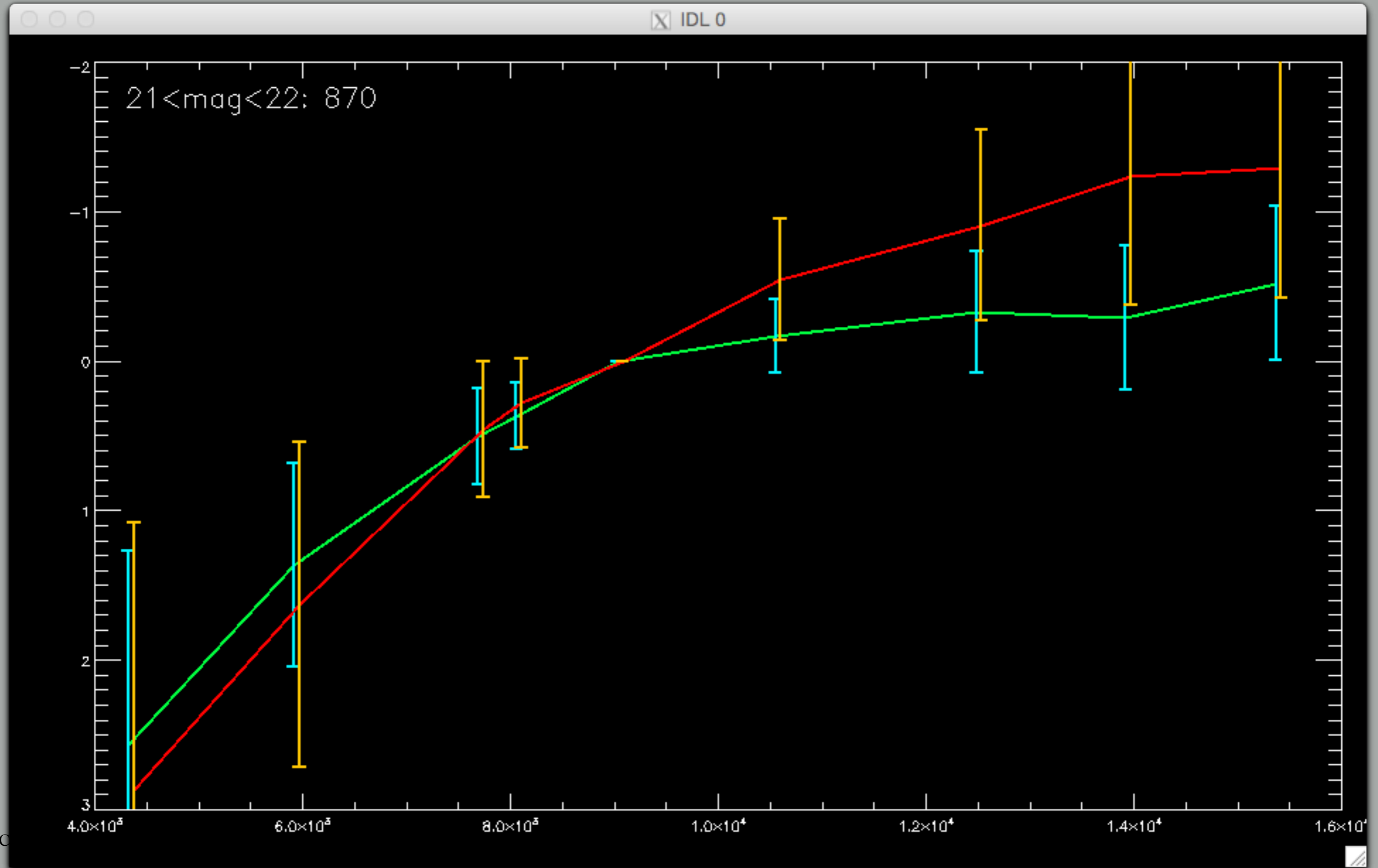
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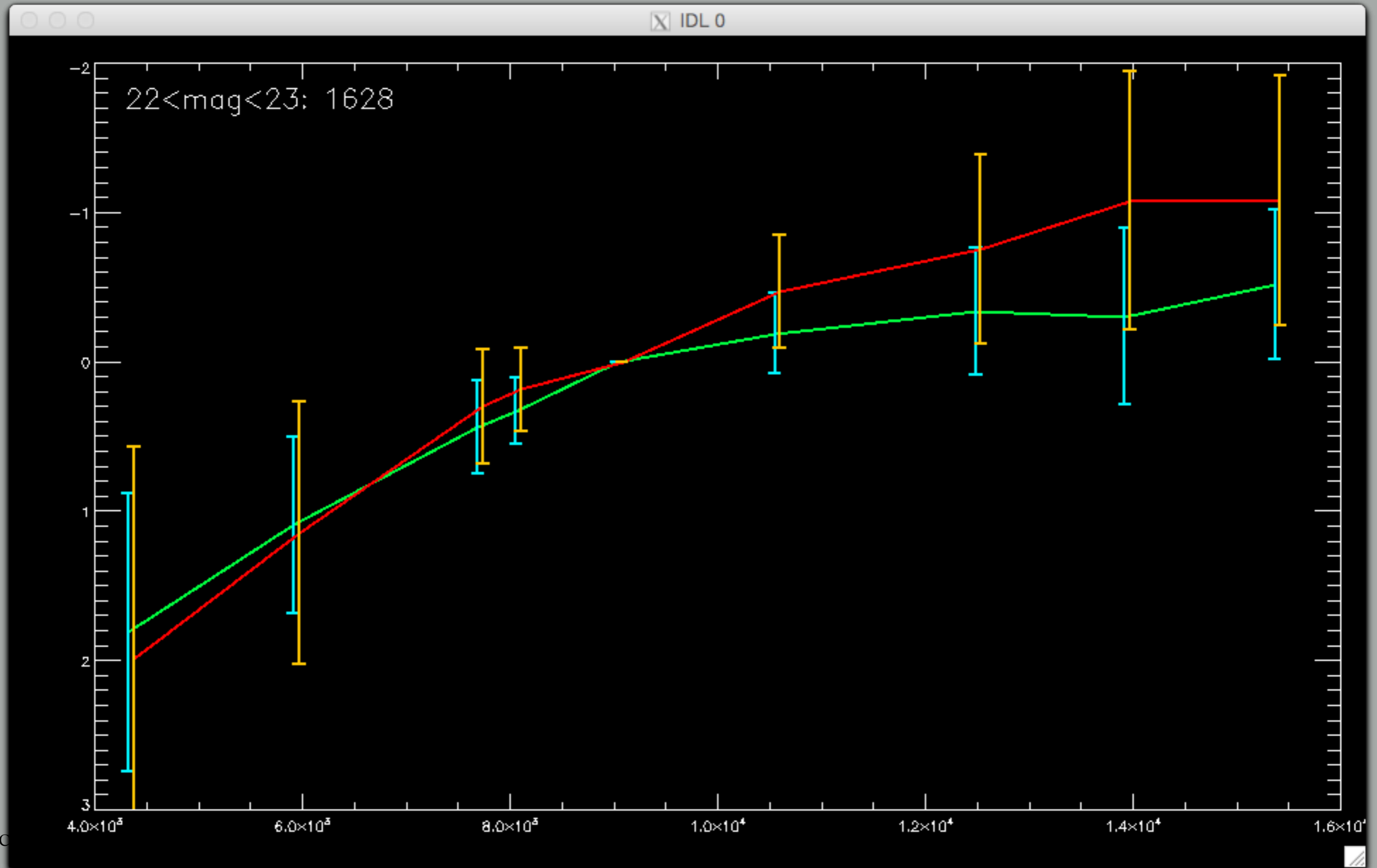
# Bulge Disk separation



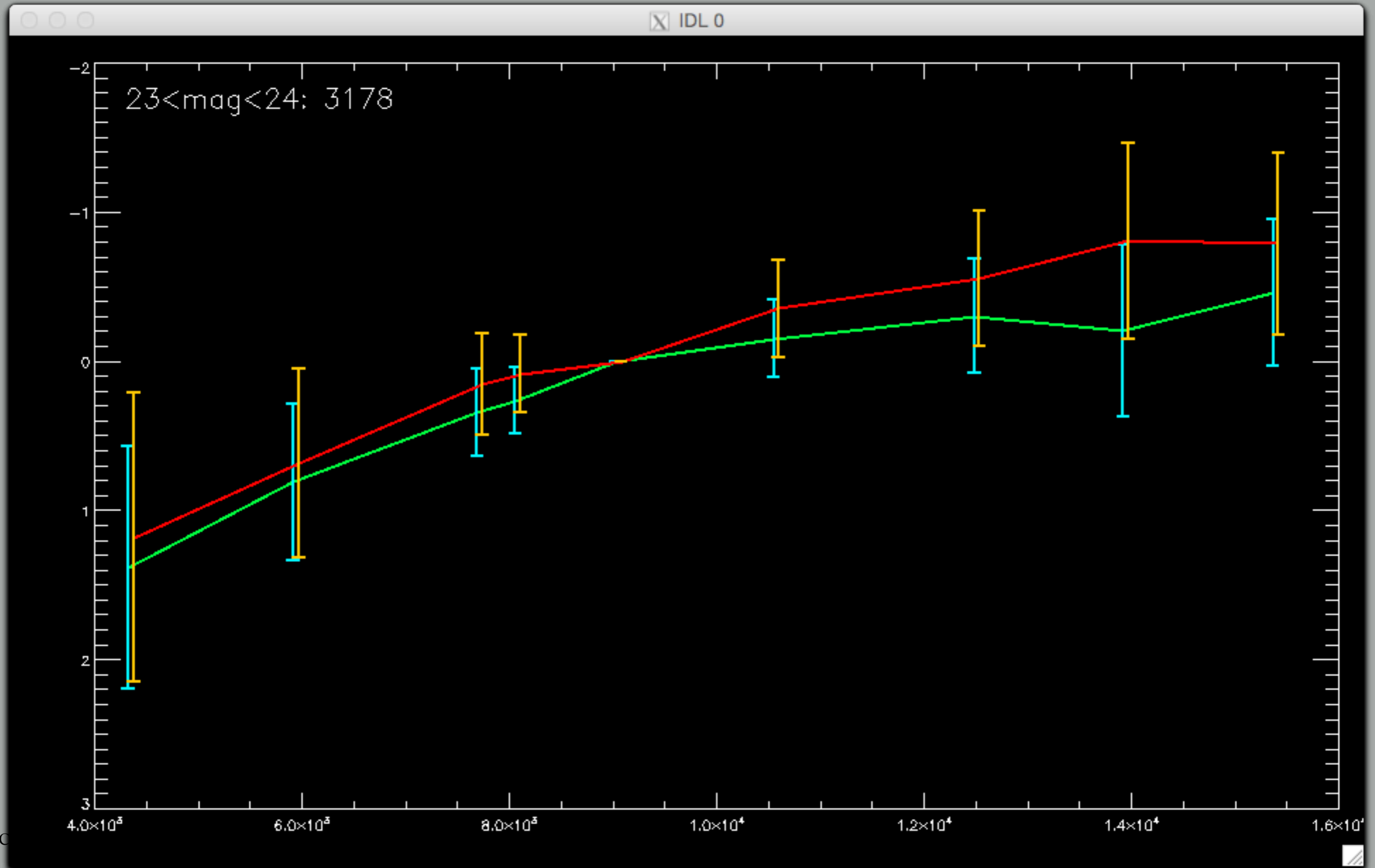
# Bulge Disk separation



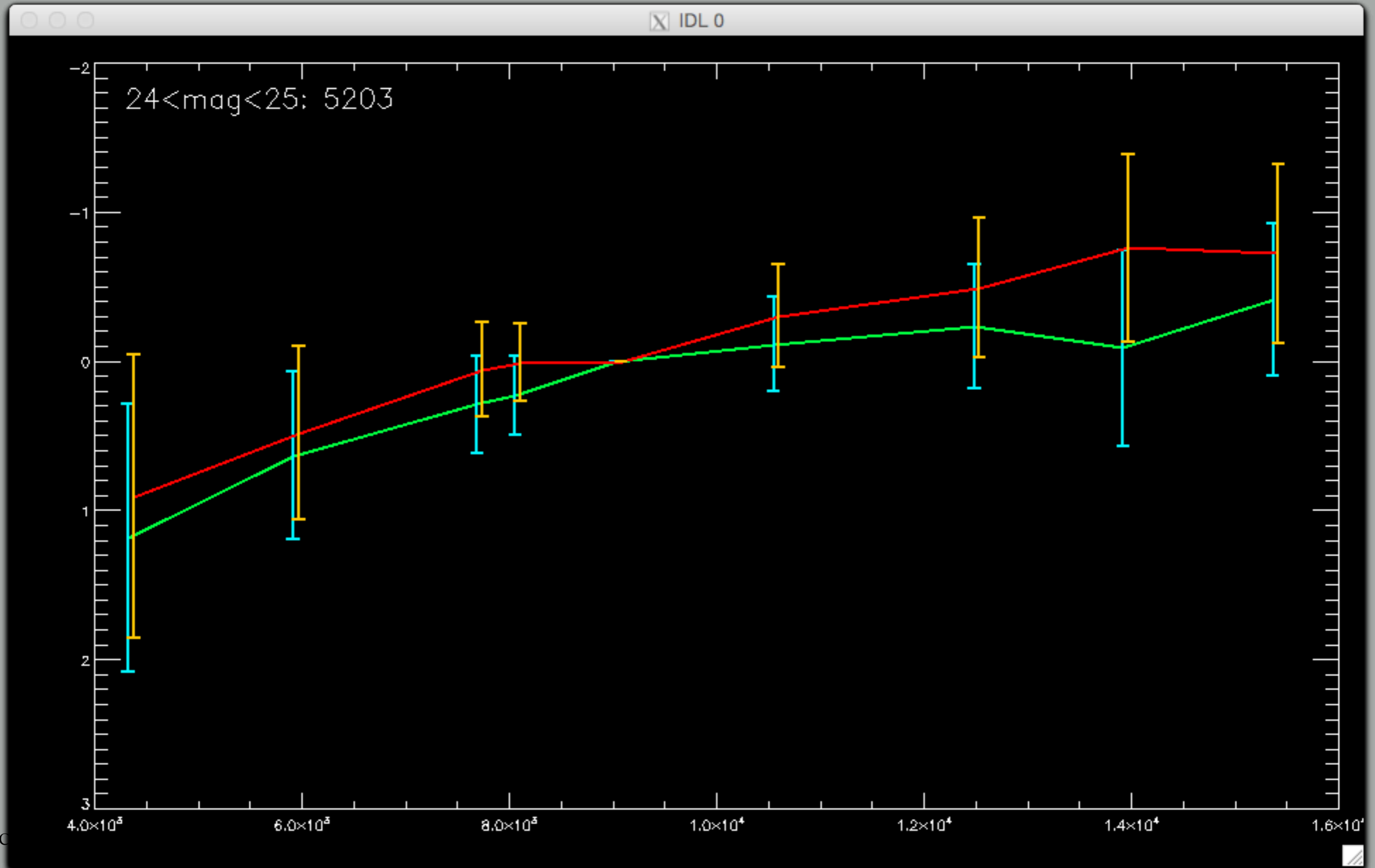
# Bulge Disk separation



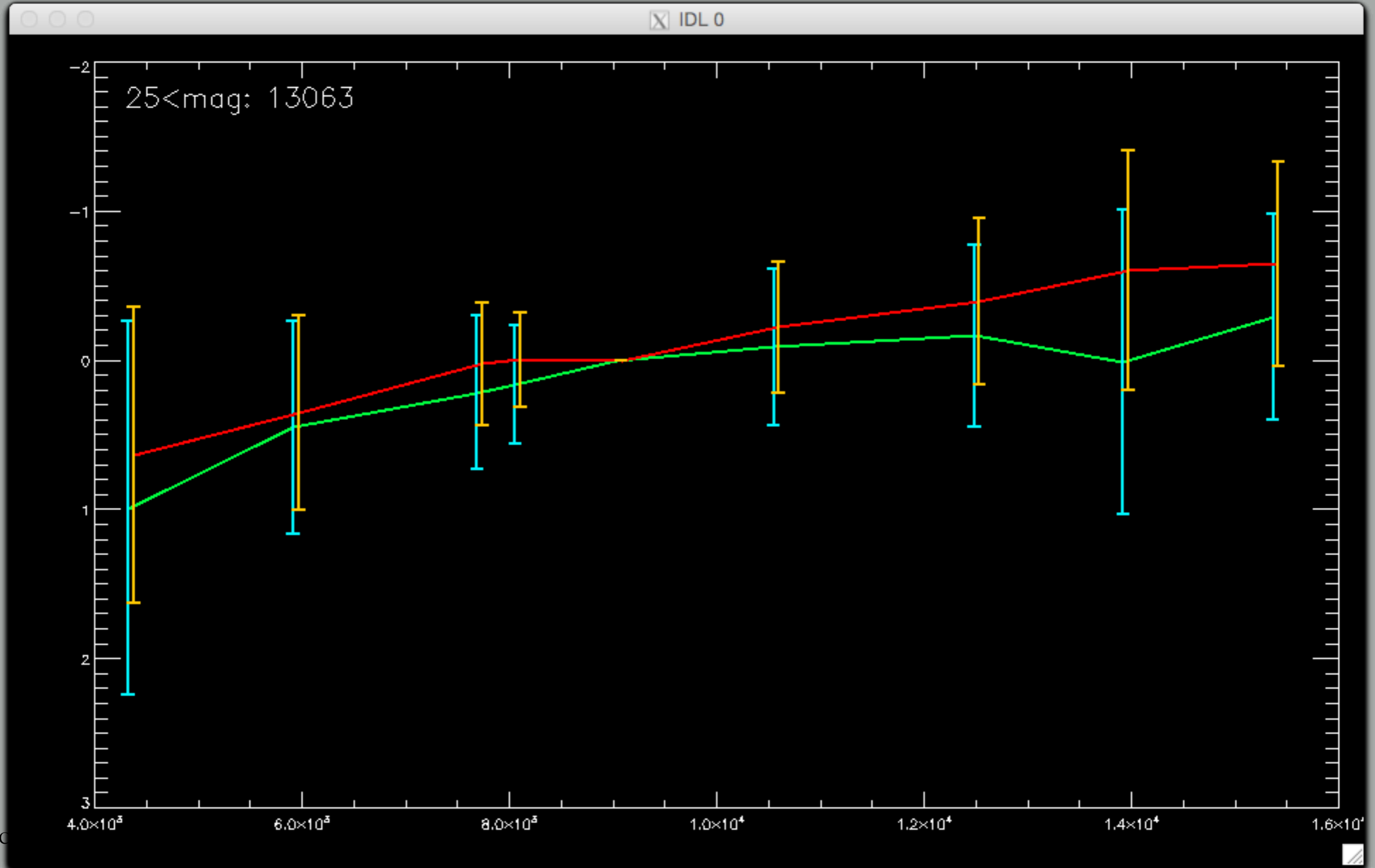
# Bulge Disk separation



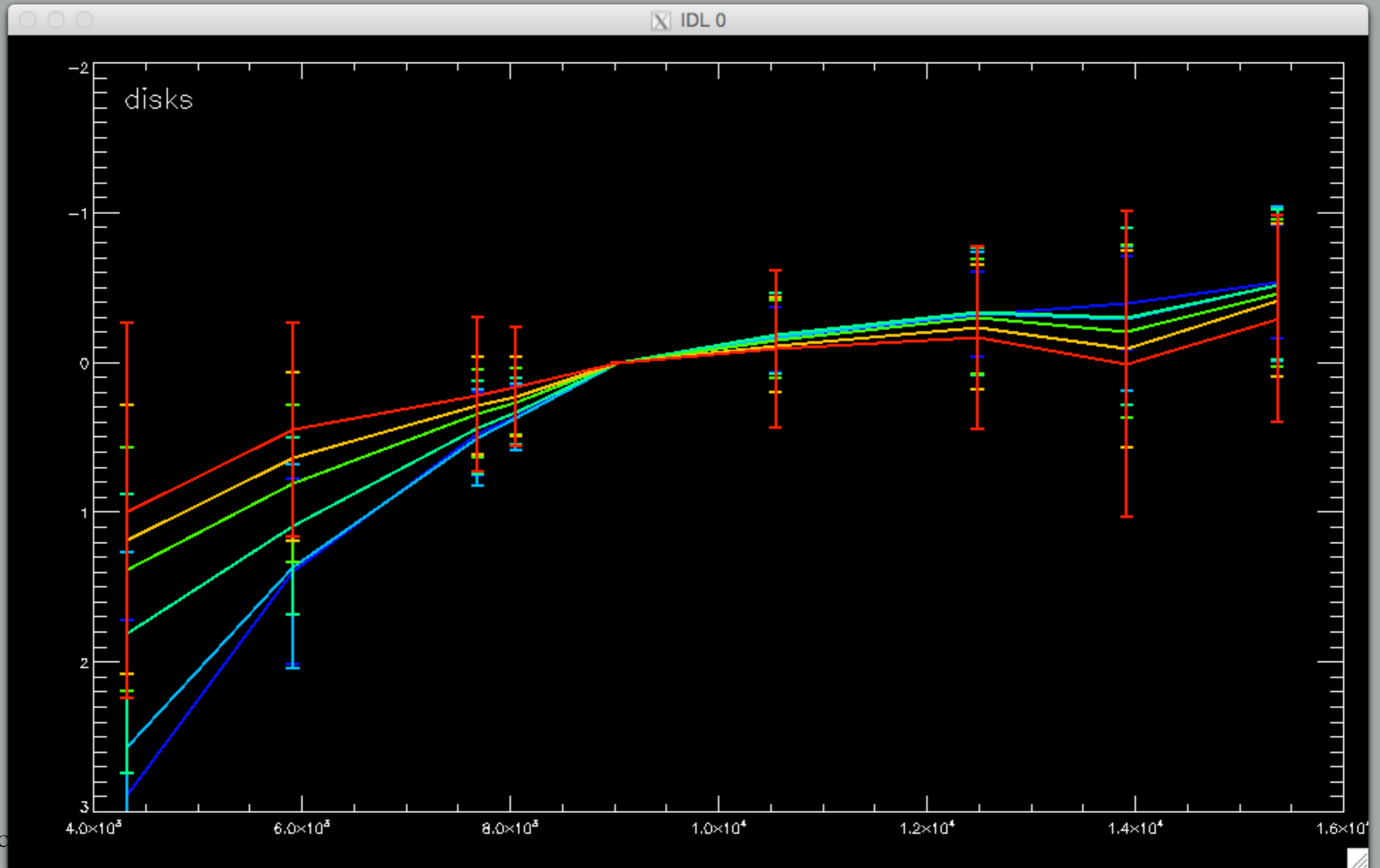
# Bulge Disk separation



# Bulge Disk separation

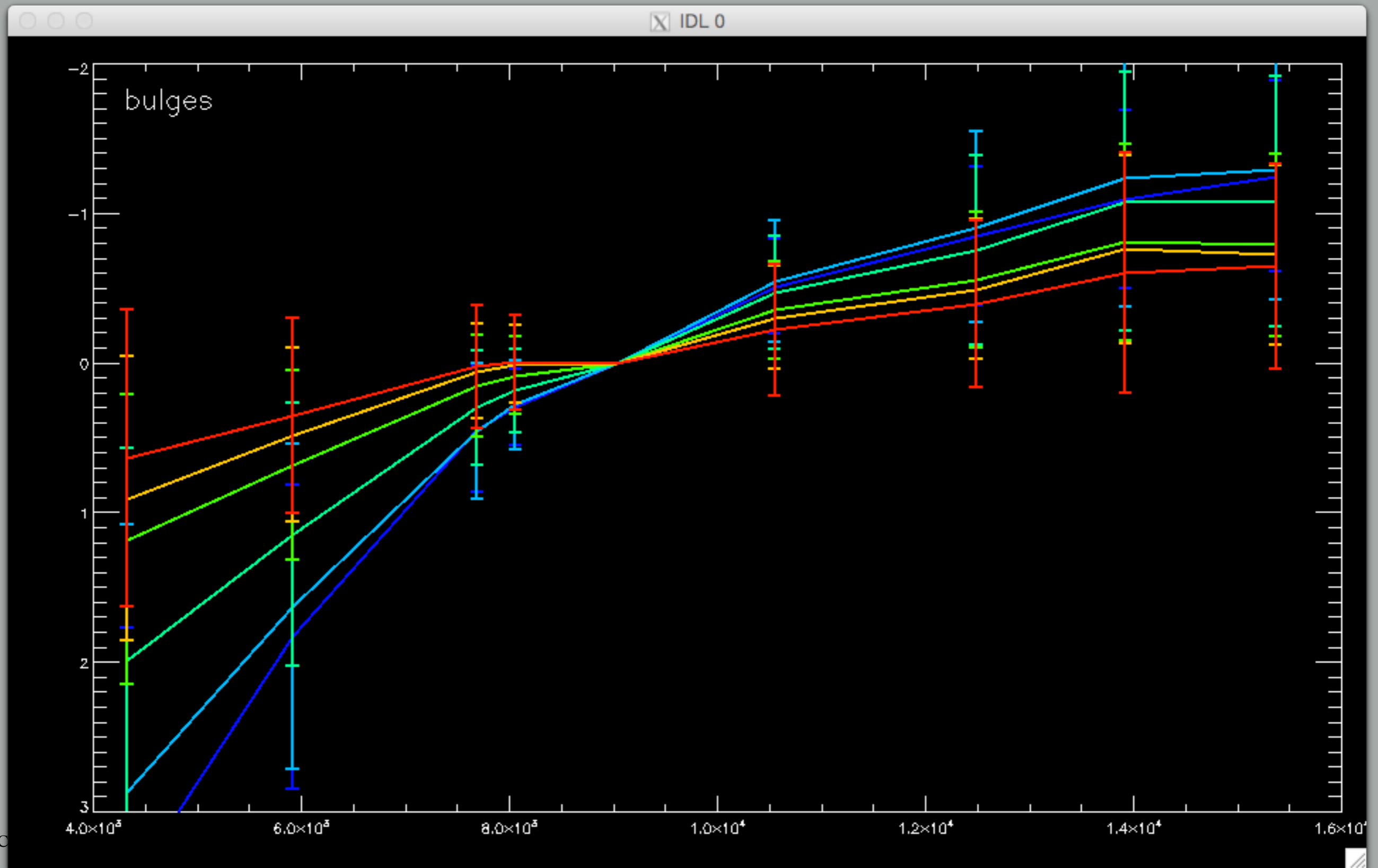


# Disks with magnitudes





# Bulges with magnitudes



# Candels catalogues - General

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- I can provide the full setup to anyone interested in the details.
- suitable for follow-up fits/analysis, trivial to provide galfit input files with all (!) files needed to run the fit and e.g. adding a point source. Already down with Jeyhan (no residuals, but script to create those)
- All I need is a list of
  - catalogue IDs (not the official CANDELS IDs)
  - or RA/DEC
- Can not share ALL data (1.5TB), but happy to do if somebody has the server space for it.

# Candels catalogues - General

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- MCMC fits?
  - HAS been implemented into GalfitM, but is at experimental stage and takes an infinite amount of time for such large samples.
  - Trivial to switch on and do the MCMC fit for individual cases, should you require this (takes ~200 times longer than the LM-fit for single-band image). Let me know if you are interested in this and I can tell you how to use it.

# Open Issues - PSF

FIELD	Filter	Filename	Source	field used for PSF
Cosmos	f606w	Liz_psf_gs_old_acs_f606w_30mas_c	Liz	GOODS-S
	f814w	Brooke_cosmos_f814w_psf_norm.fits	Brooke Simmons	Cosmos
	f125w	Liz_cos_2epoch_wfc3_f125w_030ma	Liz	Cosmos
	f160w	Liz_cos_2epoch_wfc3_f160w_030ma	Liz	Cosmos
EGS	f606w	Liz_psf_gs_old_acs_f606w_30mas_c	Liz	GOODS-S
	f814w	Brooke_cosmos_f814w_psf_norm.fits	Brooke Simmons	Cosmos
	f125w	Liz_egs_all_wfc3_ir_f125w_030mas_	Liz	EGS
	f140w	Clash_wfc3ir_f140w.psfmos.30mas.fi	CLASH	unknown
	f160w	Liz_egs_all_wfc3_ir_f160w_030mas_	Liz	EGS
GOODS-N	f435w	Liz_psf_gs_old_acs_f435w_30mas_c	Liz	GOODS-S
	f606w	Liz_psf_gs_old_acs_f606w_30mas_c	Liz	GOODS-S
	f775w	Liz_psf_gs_old_acs_f775w_30mas_c	Liz	GOODS-S
	f814w	Brooke_cosmos_f814w_psf_norm.fits	Brooke Simmons	Cosmos
	f850lp	Liz_psf_gs_old_acs_f850l_30mas_ce	Liz	GOODS-S
	f105w	Liz_goodsn_wfc3_ir_f105w_030mas_	Liz	GOODS-N
	f125w	Liz_goodsn_wfc3_ir_f125w_030mas_	Liz	GOODS-N
	f140w	Clash_wfc3ir_f140w.psfmos.30mas.fi	CLASH	unknown
	f160w	Liz_goodsn_wfc3_ir_f160w_030mas_	Liz	GOODS-N
GOODS-S	f435w	Liz_psf_gs_old_acs_f435w_30mas_c	Liz	GOODS-S
	f606w	Liz_psf_gs_old_acs_f606w_30mas_c	Liz	GOODS-S
	f775w	Liz_psf_gs_old_acs_f775w_30mas_c	Liz	GOODS-S
	f814w	Brooke_cosmos_f814w_psf_norm.fits	Brooke Simmons	Cosmos
	f850lp	Liz_psf_gs_old_acs_f850l_30mas_ce	Liz	GOODS-S
	f105w	Liz_goodsn_wfc3_ir_f105w_030mas_	Liz	GOODS-N
	f125w	Liz_goodsn_wfc3_ir_f125w_030mas_	Liz	GOODS-N
	f140w	Clash_wfc3ir_f140w.psfmos.30mas.fi	CLASH	unknown
	f160w	Liz_goodsn_wfc3_ir_f160w_030mas_	Liz	GOODS-N
UDS	f606w	Liz_psf_gs_old_acs_f606w_30mas_c	Liz	GOODS-S
	f814w	Brooke_cosmos_f814w_psf_norm.fits	Brooke Simmons	Cosmos
	f125w	Liz_uds_all_wfc3_f125w_030mas_v0	Liz	UDS
	f160w	Liz_uds_all_wfc3_f160w_030mas_v0	Liz	UDS

# Open Issues

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- Are more models required?
  - If you require a specific set of slightly altered fits (e.g. where the bulge is  $n=4$  FIXED!), this is trivial and I can run this for you immediately.
  - Especially B/D fits (only) are quick to repeat (a few days each field).
- potential re-run with a 'white-light' detection image, to increase sample sizes (e.g. fainter and outside the H-band footprint)

# Summary

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- Multi-band galaxy profile fits (both single-component and 2 component fits) provided for ~114000 objects
- Should provide more reliable 1-component fits than single-band
- Should provide much more reliable B/D decomposition in a consistent manner
- Several different setups for fields with >5 images/bands
  
- PLENTY of information and possible projects
- Easy to use (though not TopCat)
- Easy to provide fitting data/setups for follow-up projects
  
- Possible re-run with better PSFs and/or white-light detection image