Examining the morphological properties of GAMA galaxies using MegaMorph

Boris Häußler (also 'Haeussler')
University of Oxford
University of Hertfordshire

& Steven Bamford (Nottingham) , Benedetta Vulcani (IMPU), Marina Vika, Alex Rojas (CMU, Qatar), and many others (e.g. the entire GAMA team!)

ESO workshop, Santiago, Nov 22th 2013

Overview

- Todays profile fitting
- Todays data
- Brief introduction to MegaMorph
    - Idea
    - Some test Results
- Sérsic fits and changing parameters with wavelength
- some B/D decomposition results

Today’s fitting codes

single-band data profile fitting, 1D or 2D

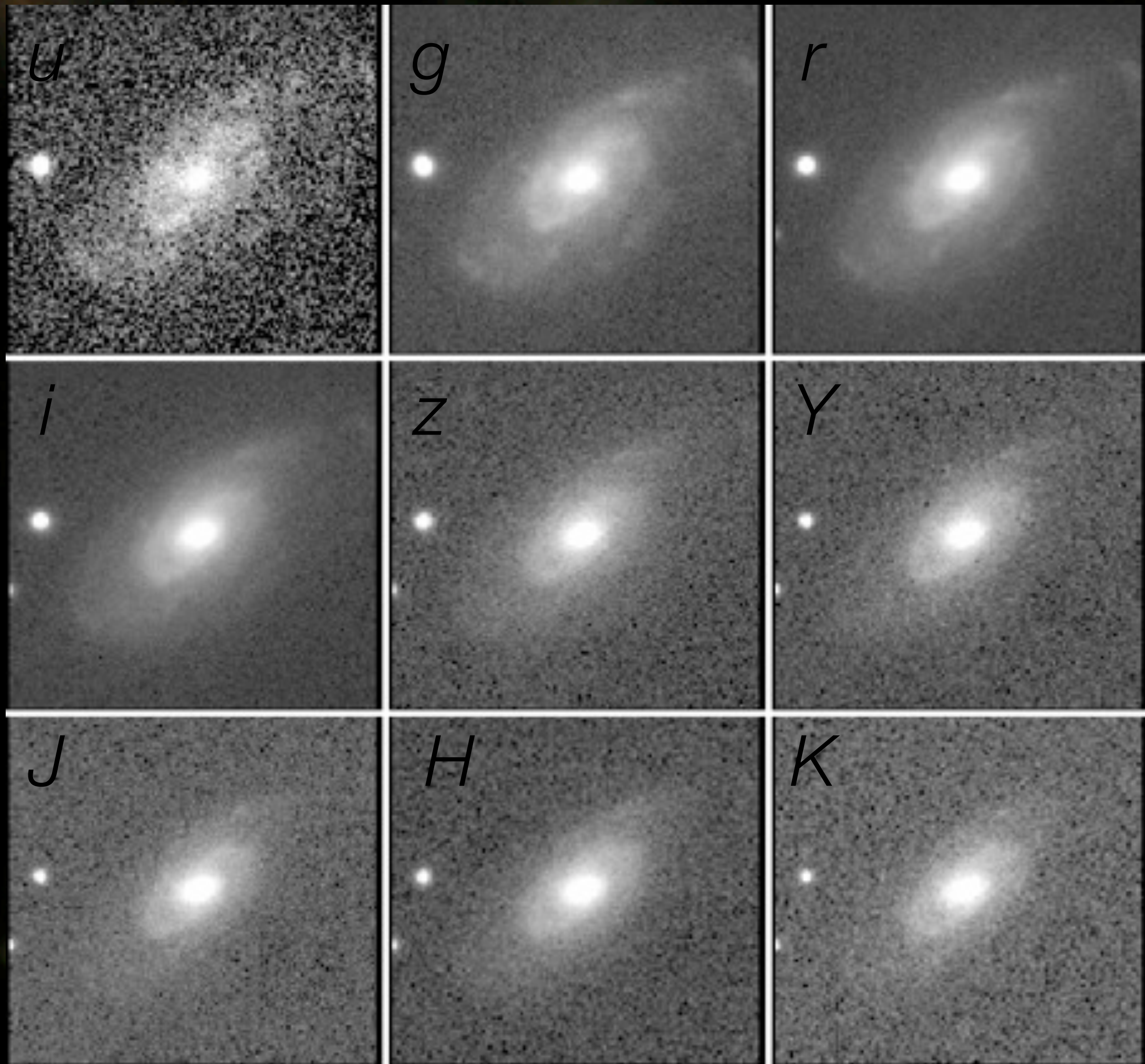
GALFIT, GIM2D, GalMorph, BUDDA, ...

smooth, parametric models –
one component 'easy'*
two components more difficult

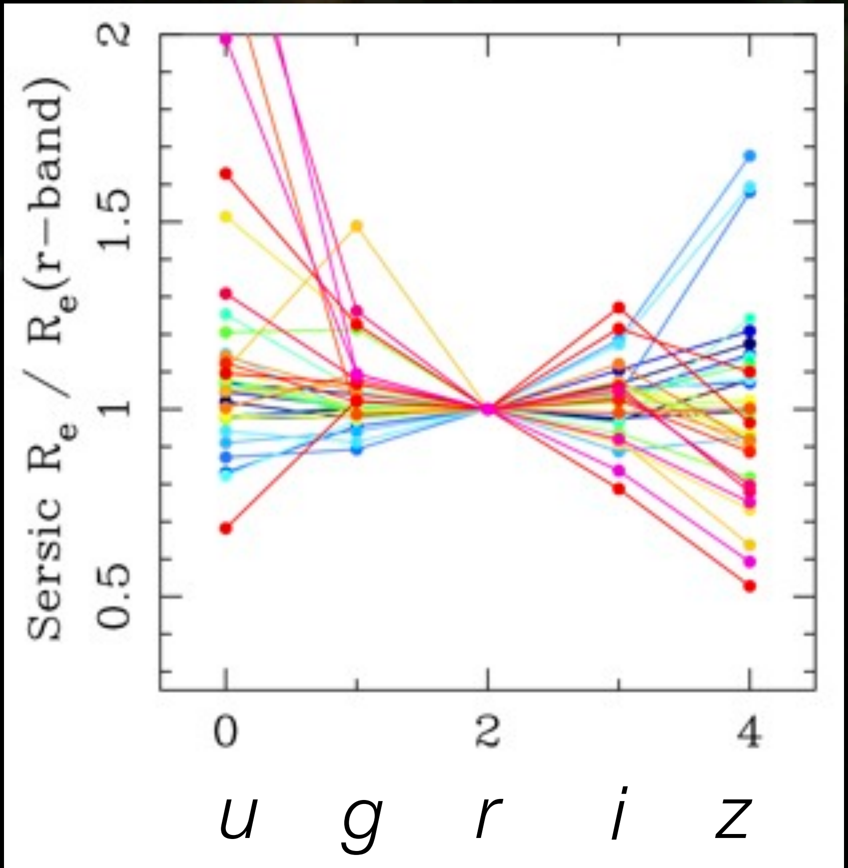
bulge-disk → ~25% fits ‘fail’

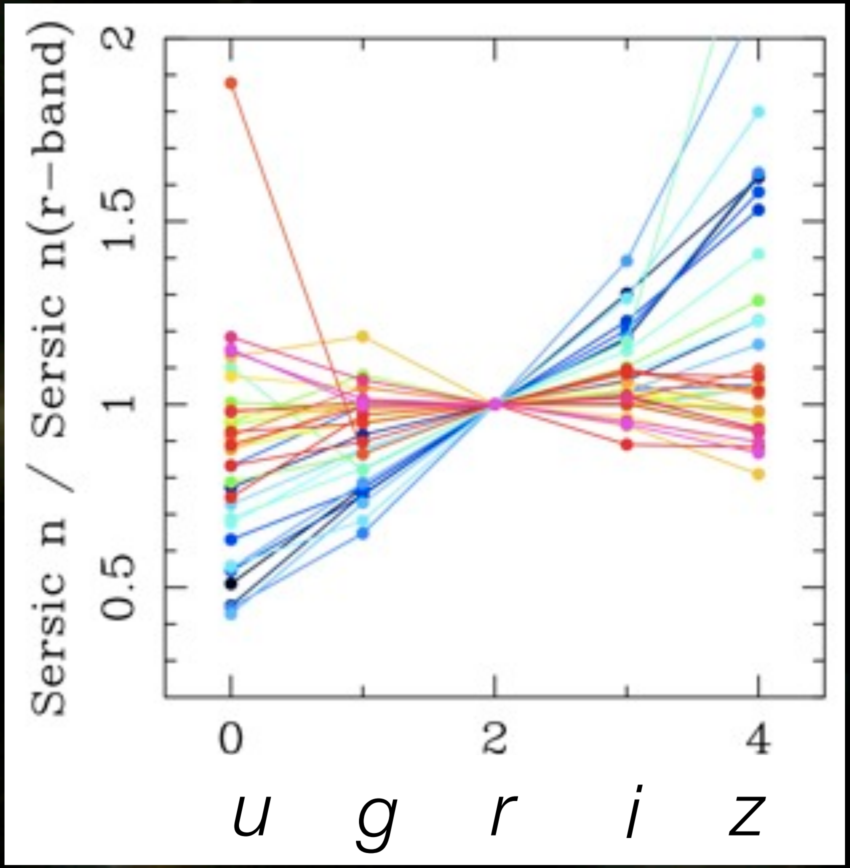
*but see Häußler et al. 2007, Kelvin et al. 2012

Today's data



Today's data + today's fitting codes





inconsistent fits between bands

The value of colour information

degraded monochromatic observations

The value of colour information

degraded colour observations

MegaMorph – What do we do?

Address the issues with current software, but:

- Implement multi-band fitting (also see poster by S. Bamford)
- Incorporate non-parametric components (see talk S. Bamford)
- Implement bulge-disk decomposition (also see talk by M. Vika)
- use different minimization algorithms (see poster by S. Bamford)
- Accurate model selection (single Sérsic or B/D,...) (in progress)
- Ensure it's fast enough to process large surveys
  - (e.g. adapting to supercomputer)

MegaMorph so far...

GALFIT by C.Y.Peng, et al.

GALAPAGOS by M. Barden, B. Häußler, et al.
(also poster by A. Hiemer)

SExtractor by E.Bertin

MultiNest by F. Feroz & M. Hobson

MegaMorph data I

simulated
data

real
data

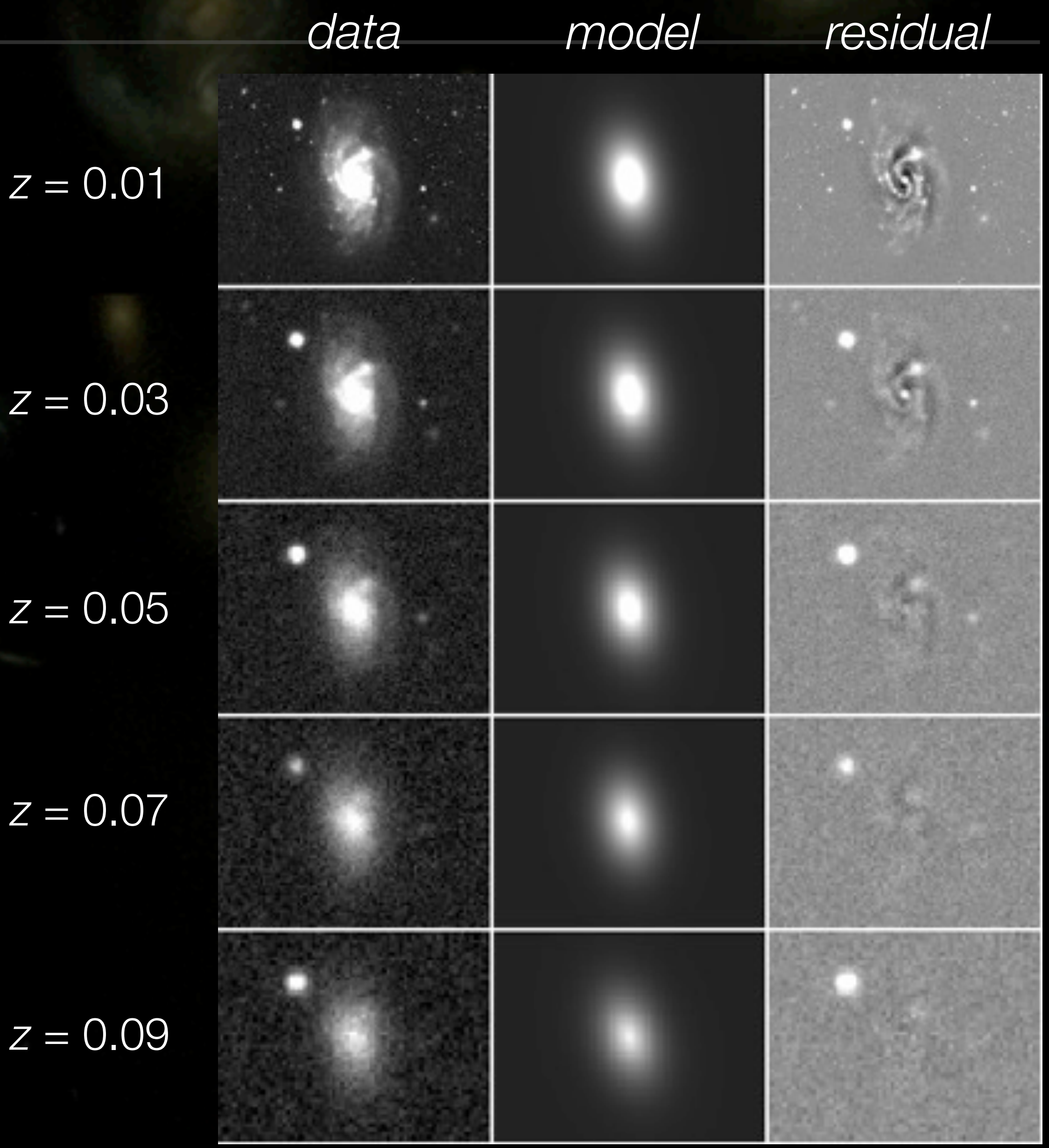
In same manner as
Häußler et al. 2007

MegaMorph data II

- ~165 NGC galaxies
- SDSS *ugriz* imaging
- Artificially redshifted using:

Full and **E**fficient **R**edshifting of **E**nsembles of **N**earby **G**alaxy **I**mages

Barden, Jahnke & Häußler, 2008, ApJS, 175, 105



MegaMorph data III

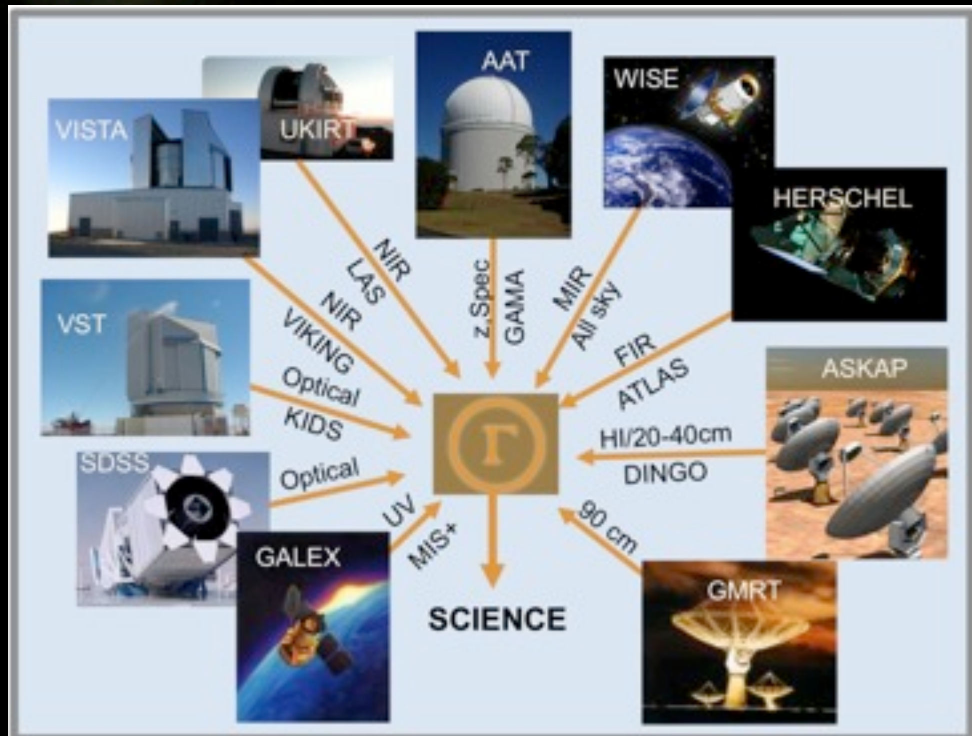
GAMA:

- Redshift survey & multiwavelength database
- Registered mosaics
  - 150 sq. deg
  - SDSS *ugriz*

    \+ UKIDSS *YJHK*

  → VST KIDS

    \+ VISTA VIKING



GALFIT adaptations

- Each standard GALFIT parameter replaced by a polynomial function of wavelength

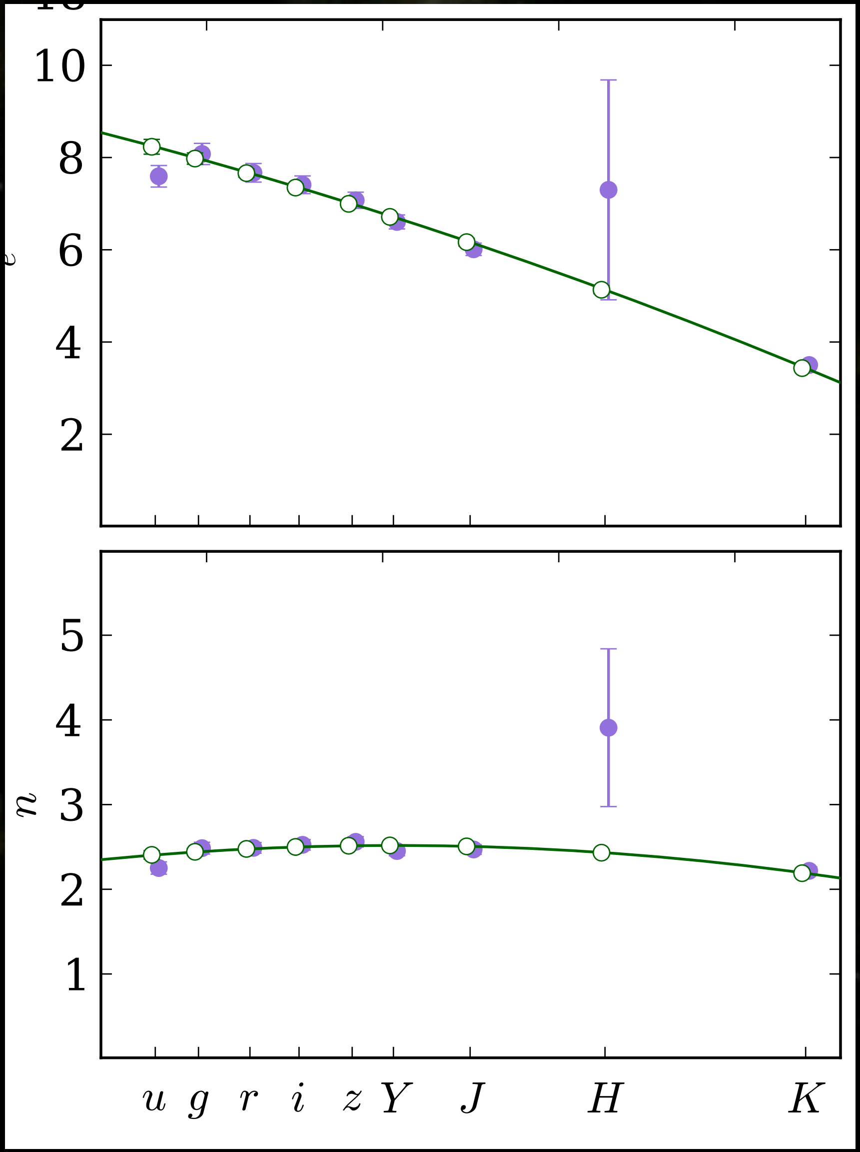
$$f(\lambda) = \sum_{i=0}^{m} c_i T_i(\lambda)$$

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

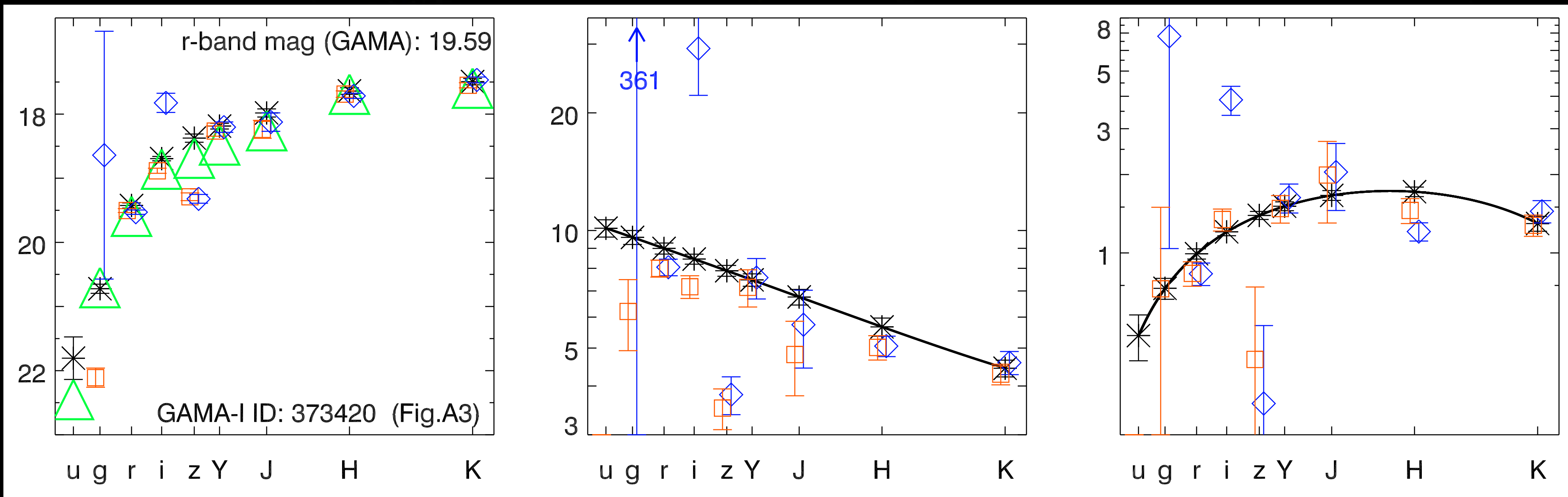
$$I_e(\lambda) \qquad r_e(\lambda) \qquad n(\lambda)$$

- very similar input file
- (nearly) backwards compatible
- smarter output

Idea: It helps with noisy bands

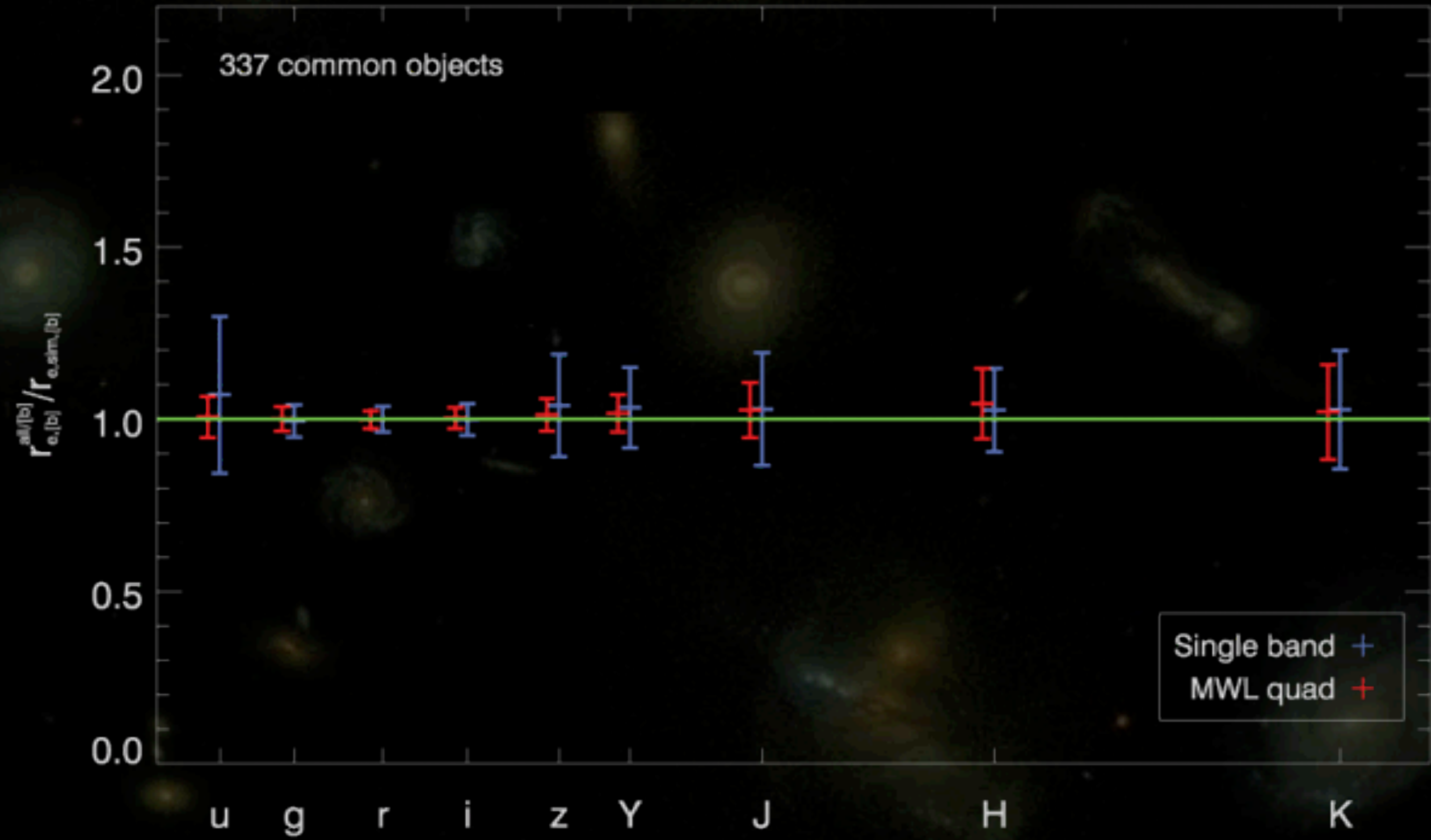


Helps with noisy bands

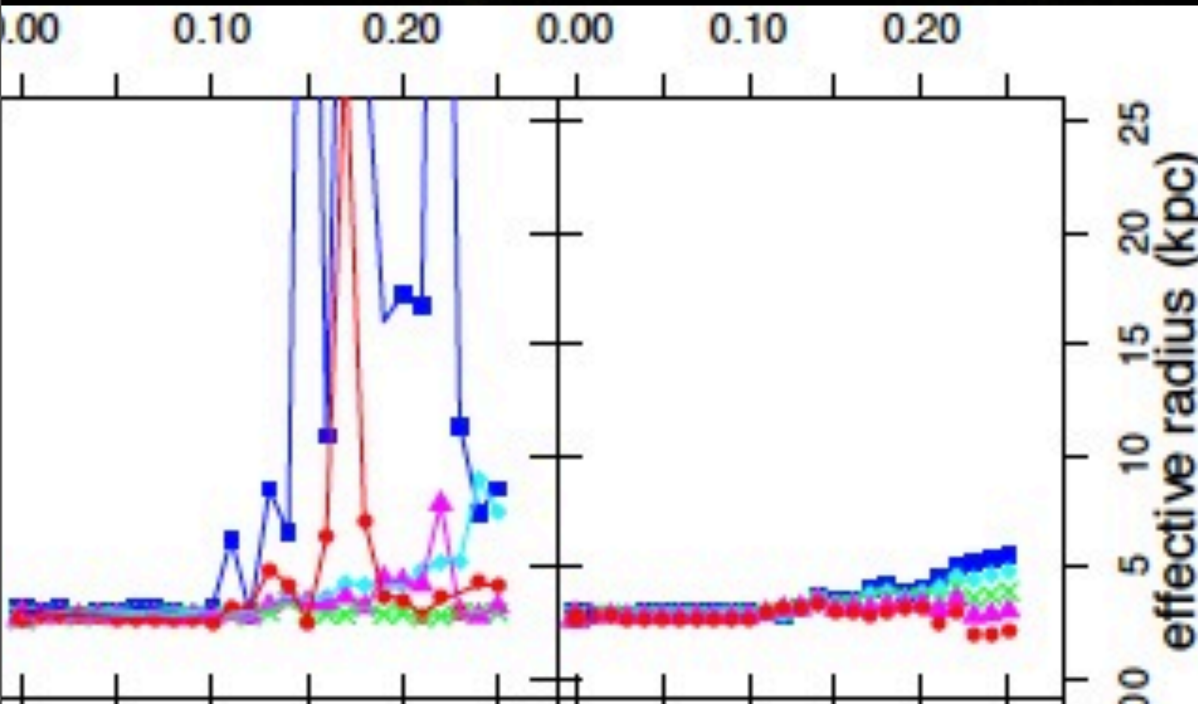


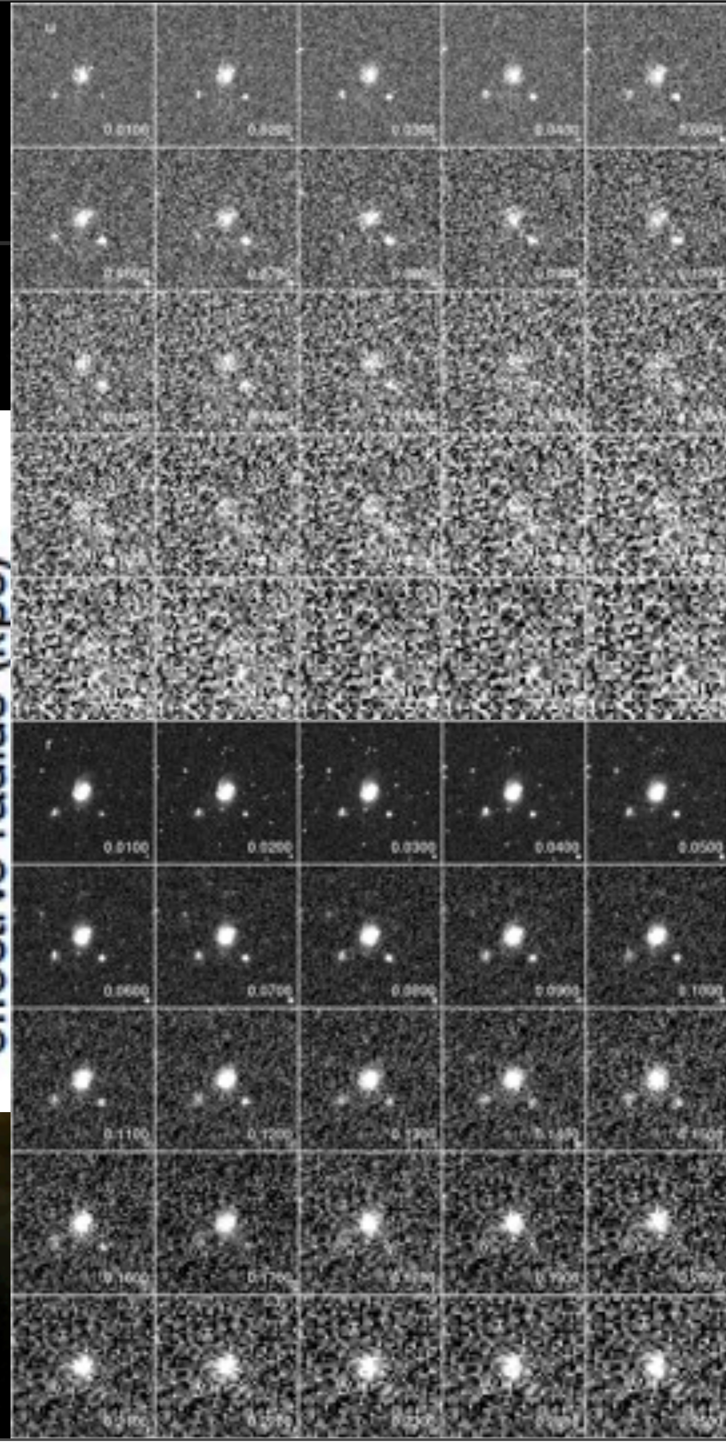
- also allows easy read-off of restframe values (not when using many degrees of freedom)

reduces measurement uncertainties

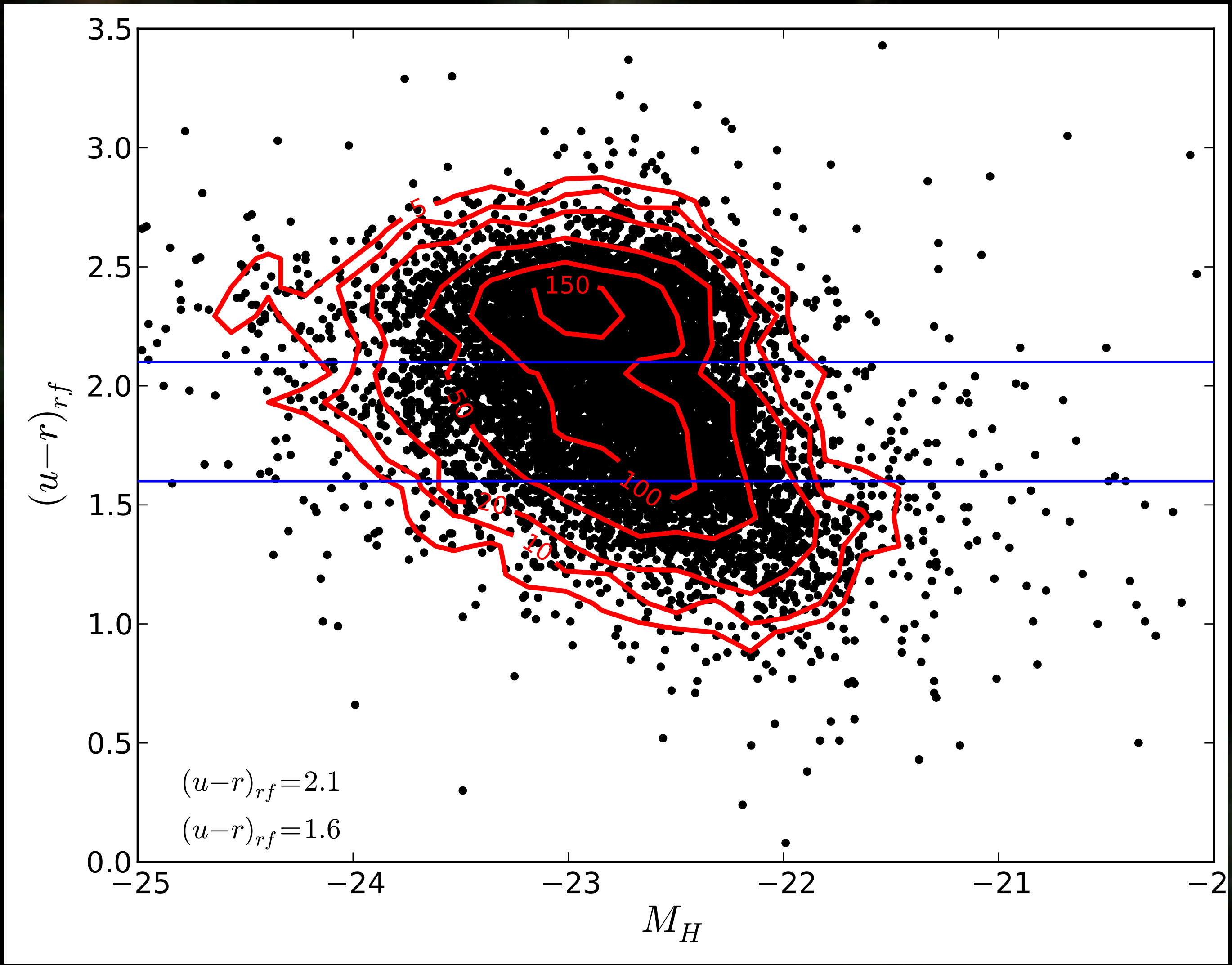


higher redshifts

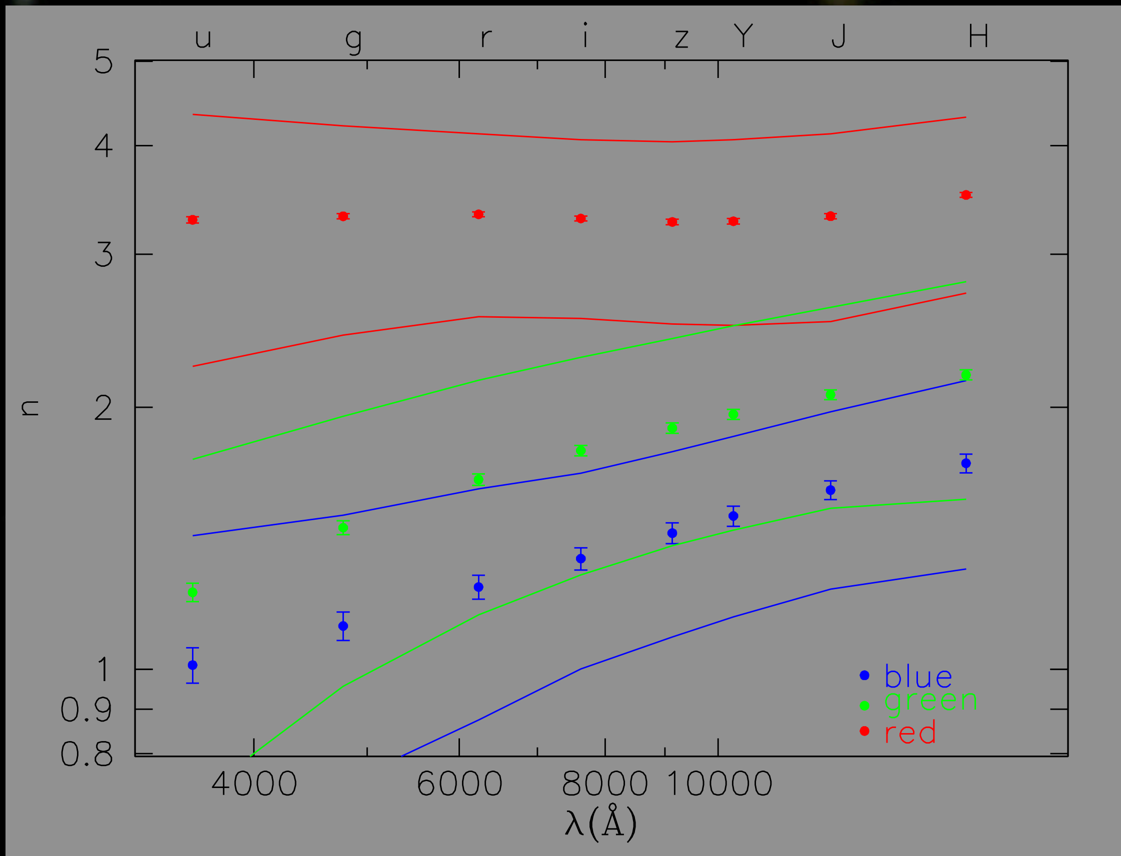




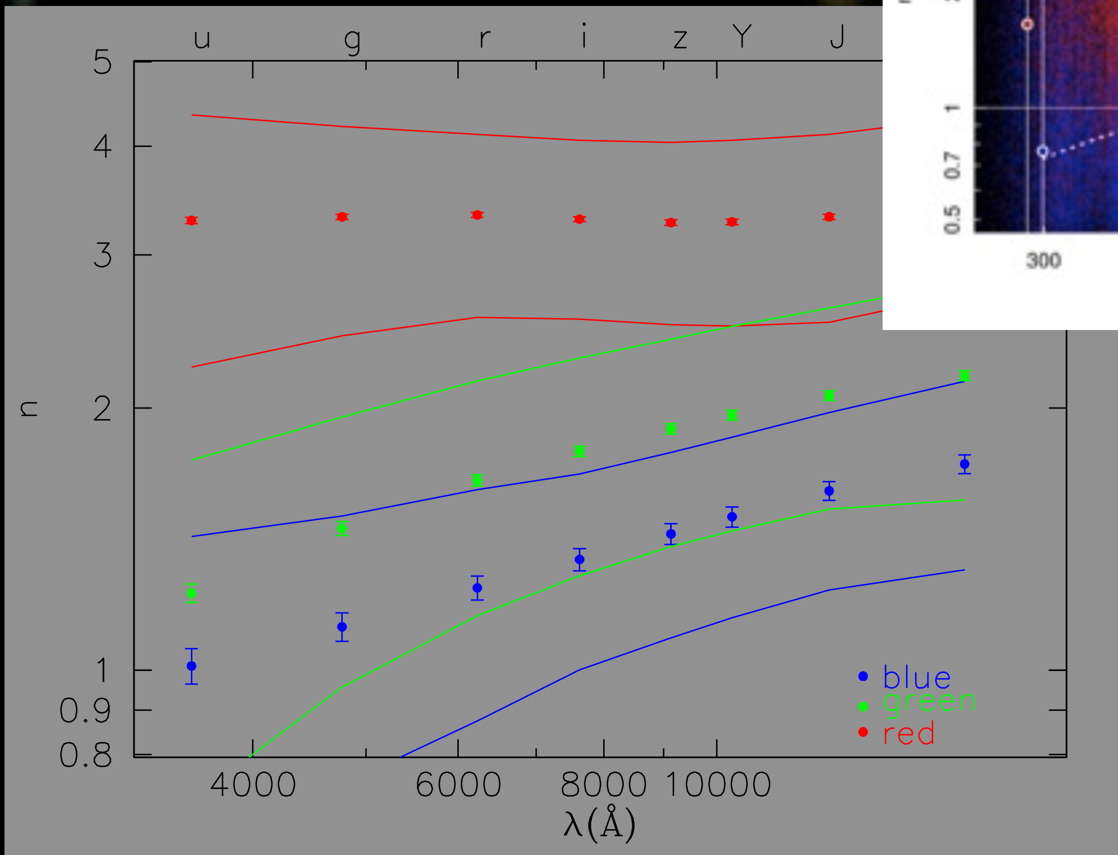
GAMA sample split by colour

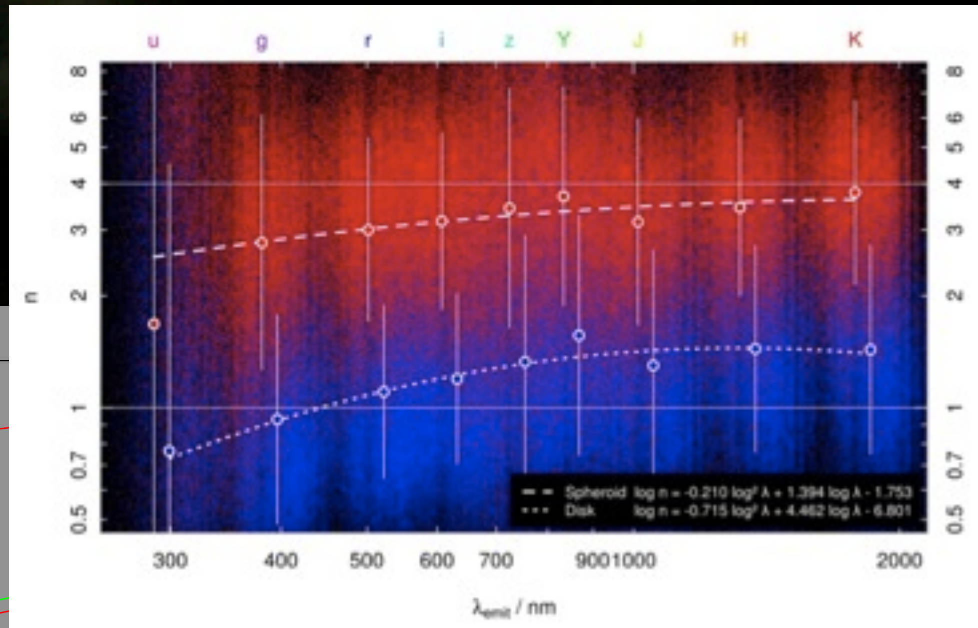


Sérsic index changes with wavelength

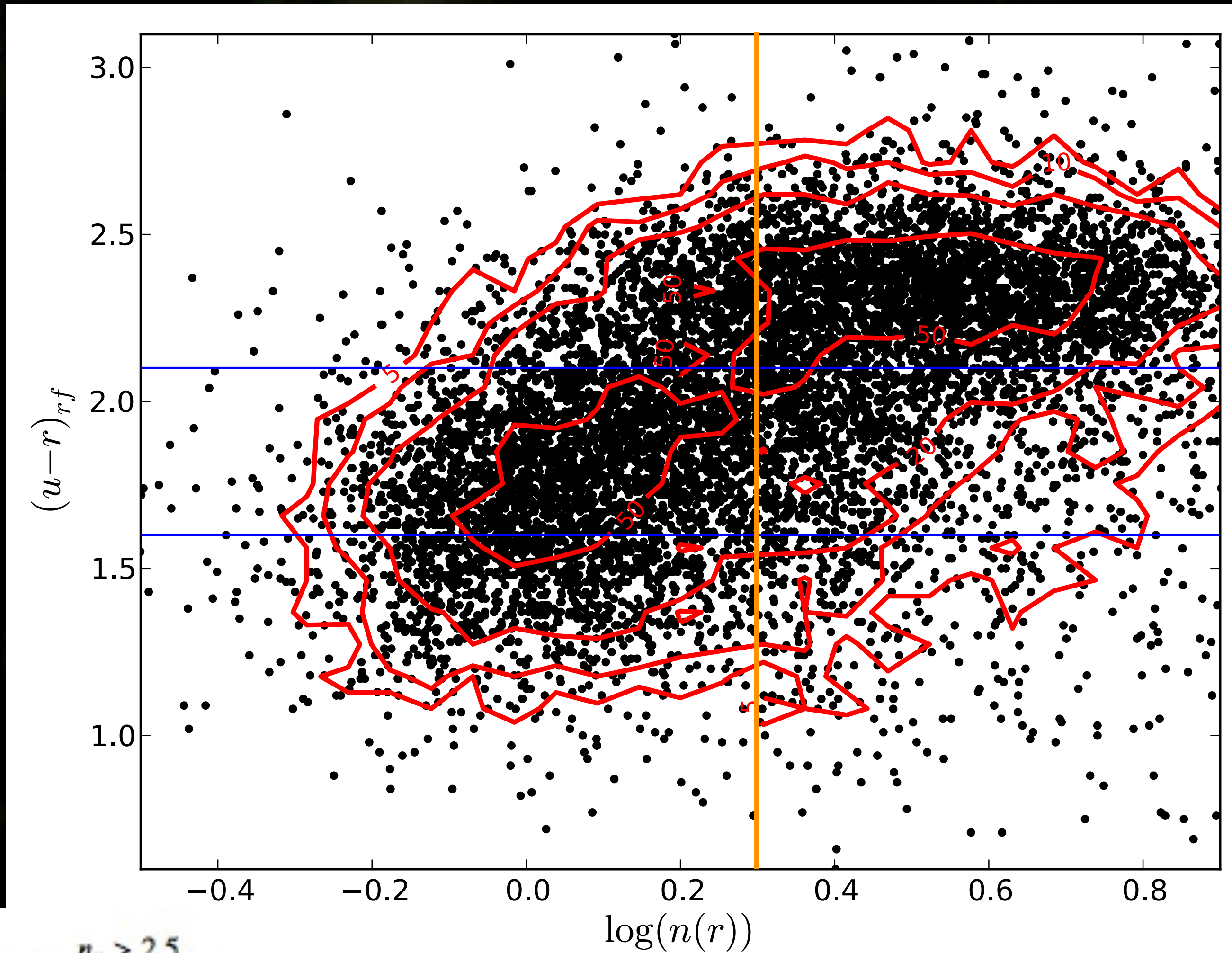


Sérsic index changes with wavelength



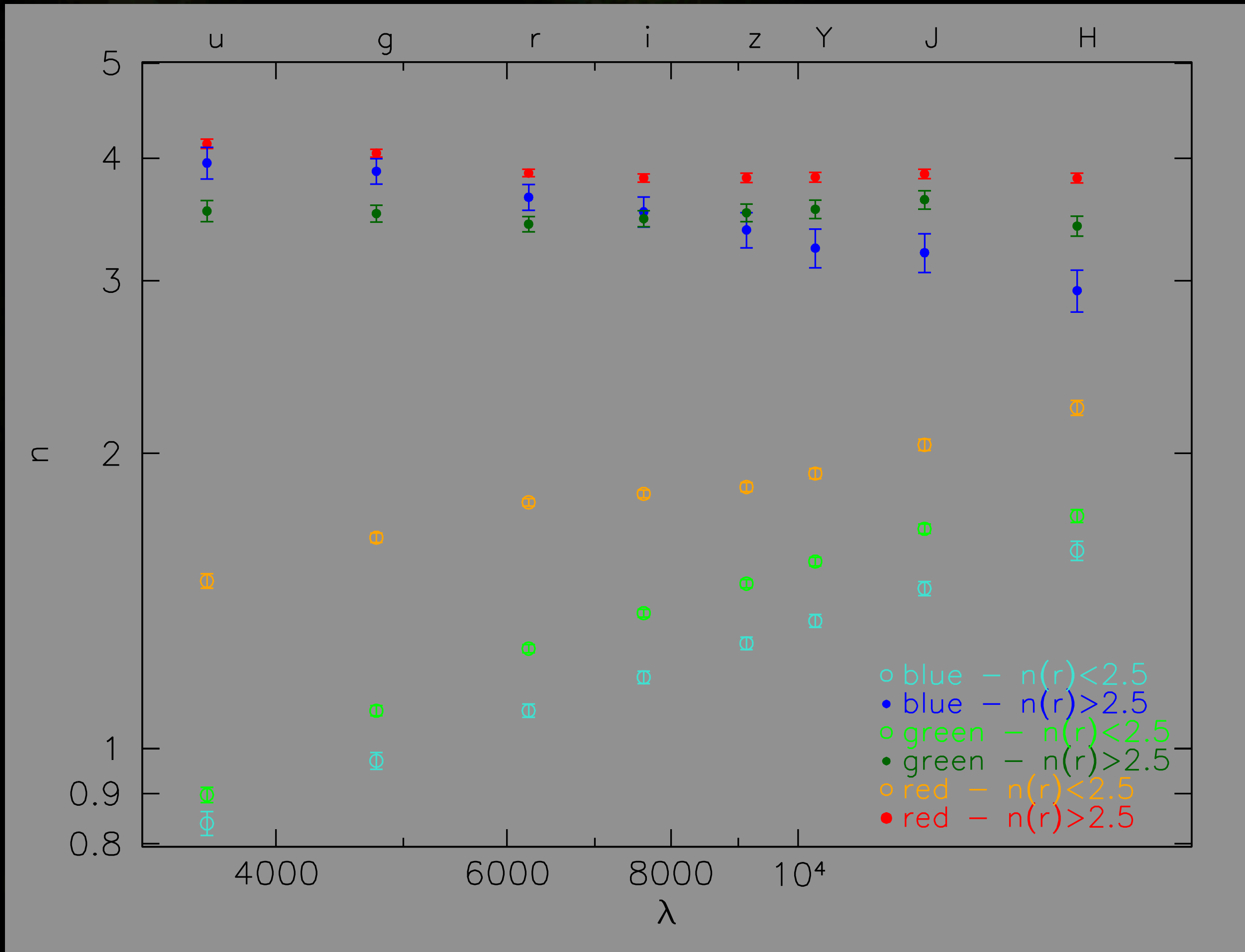


GAMA sample split by sérsic index

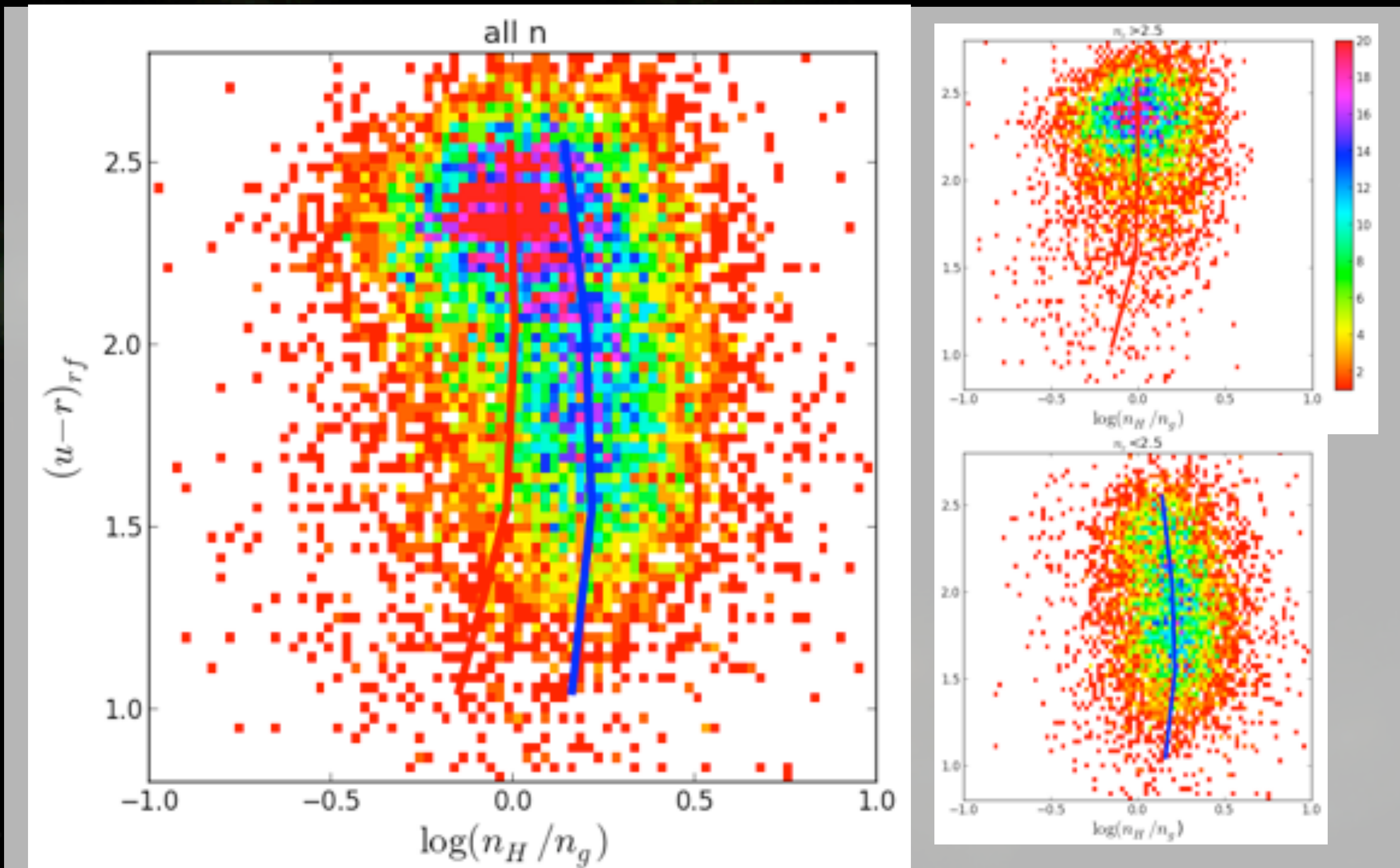


Colour	$n_r < 2.5$		$n_r > 2.5$	
blue	1424	10.2 ± 0.2 %	309	2.2 ± 0.1 %
green	3207	22.9 ± 0.4 %	1195	8.5 ± 0.2 %
red	2336	16.7 ± 0.3 %	5505	39.4 ± 0.4 %

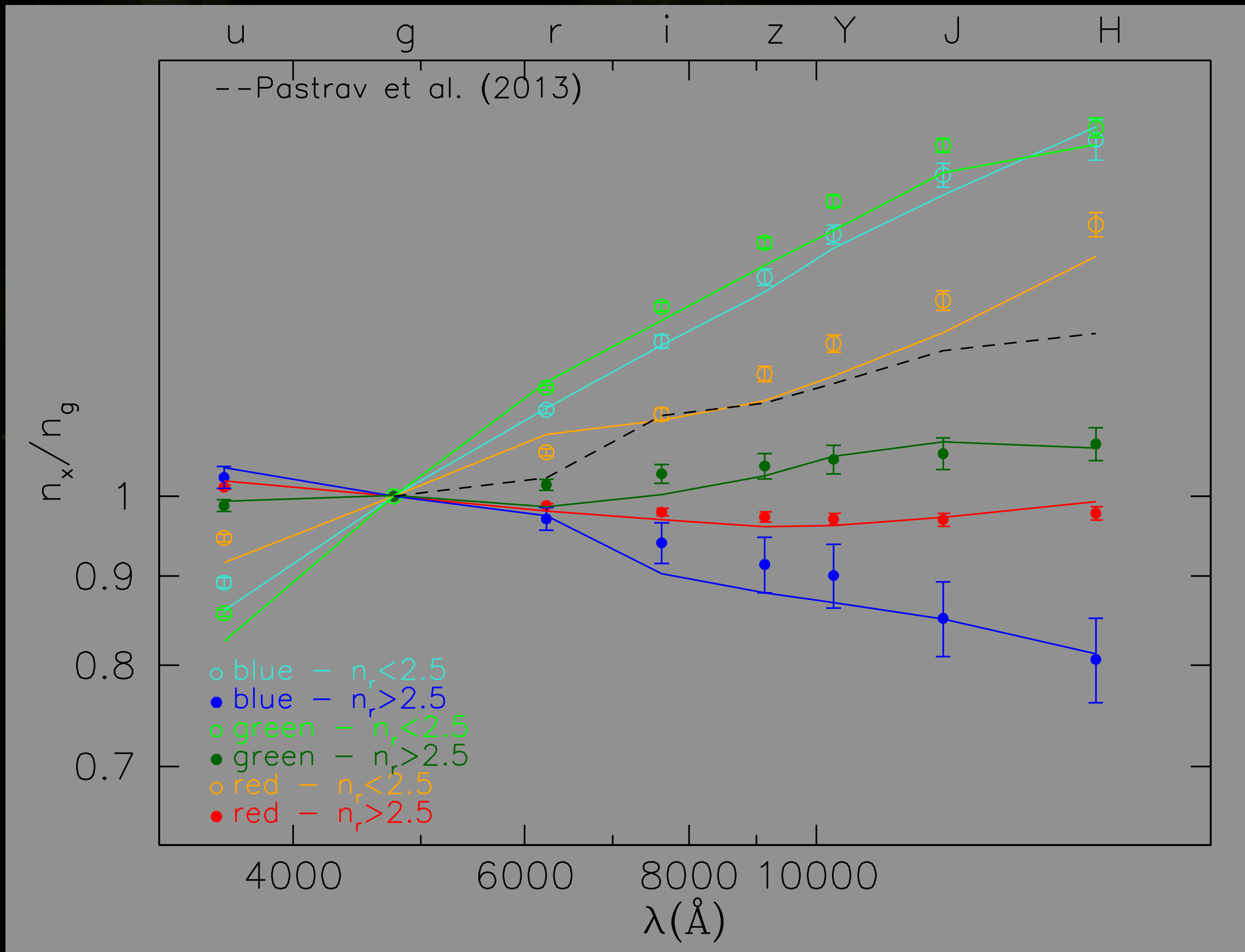
sérsic index by colour and n_r



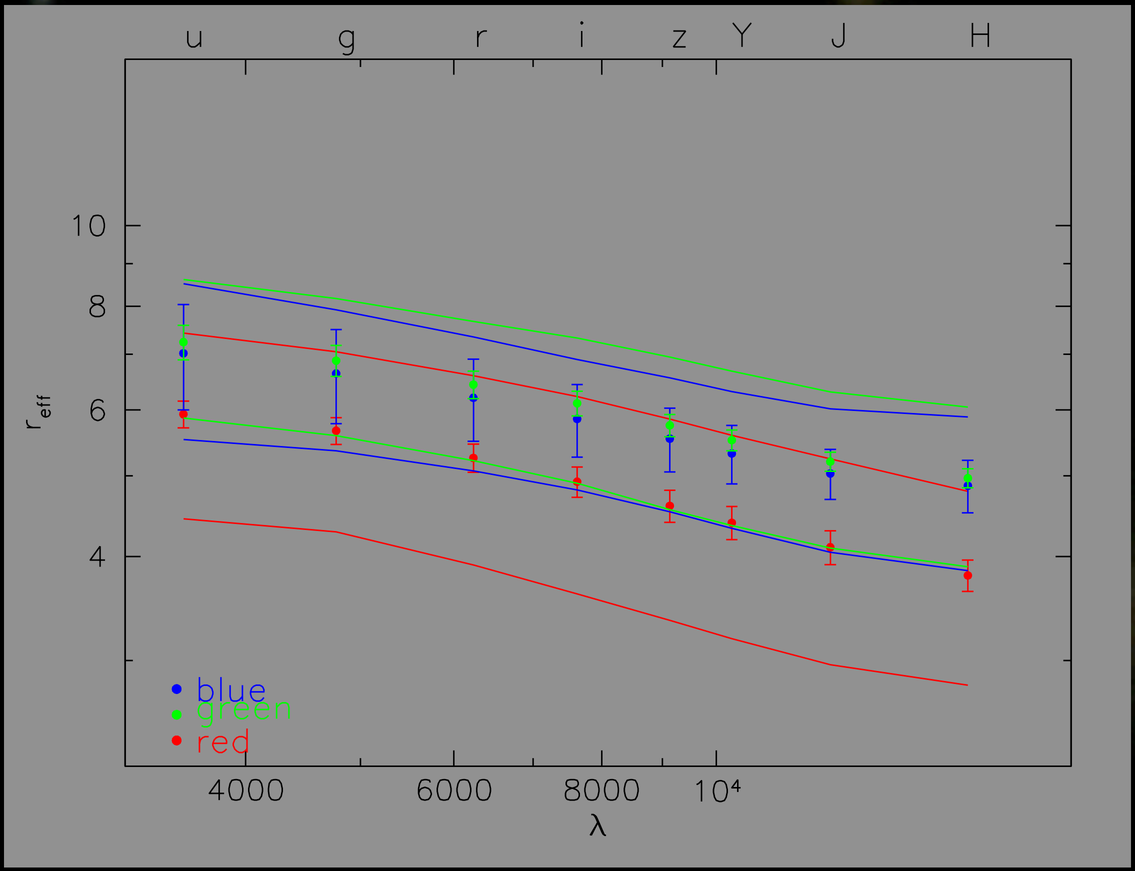
$\mathscr{n}=n_H/n_g$ for individual galaxies



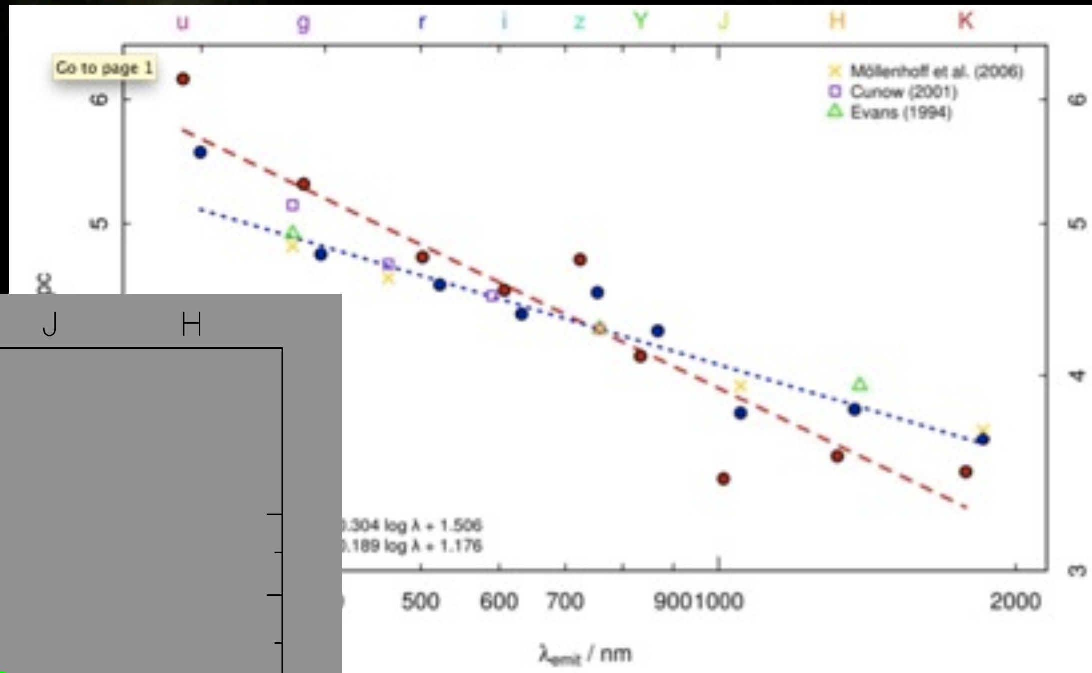
𝓃 depends on n and colour

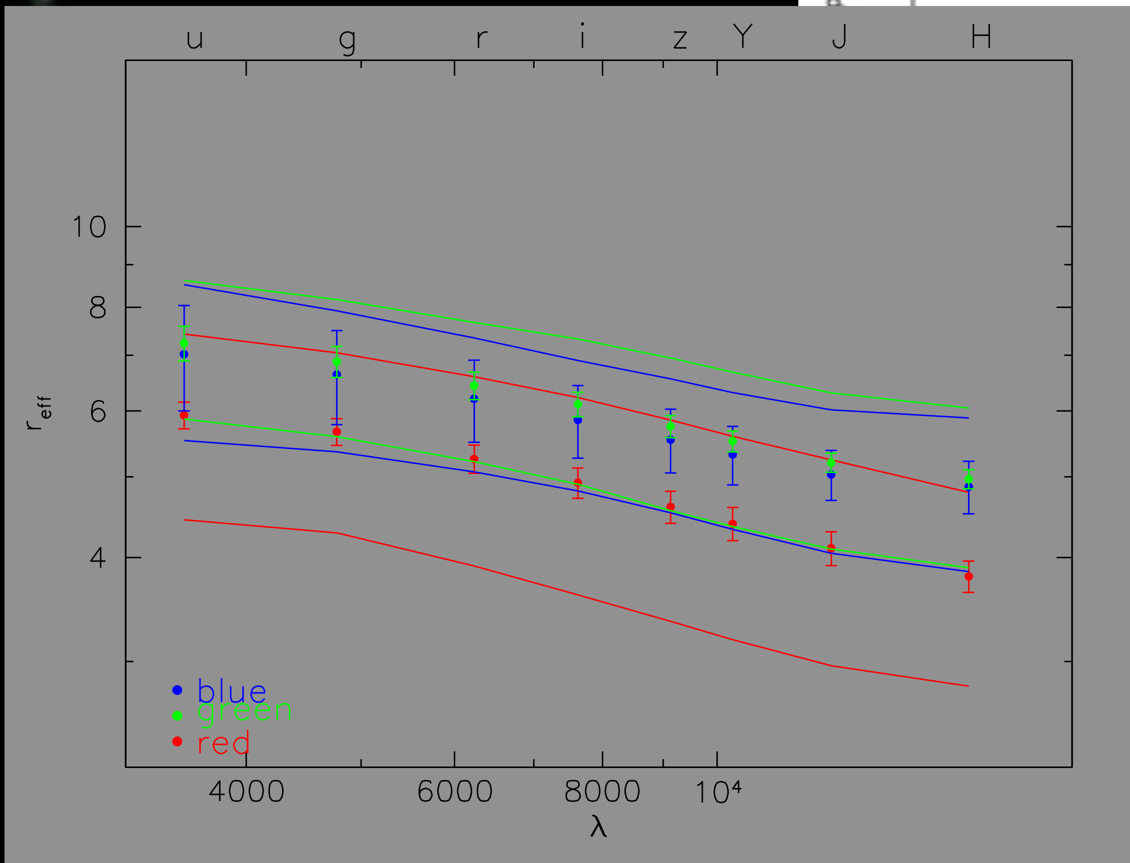


radius r_e with wavelength



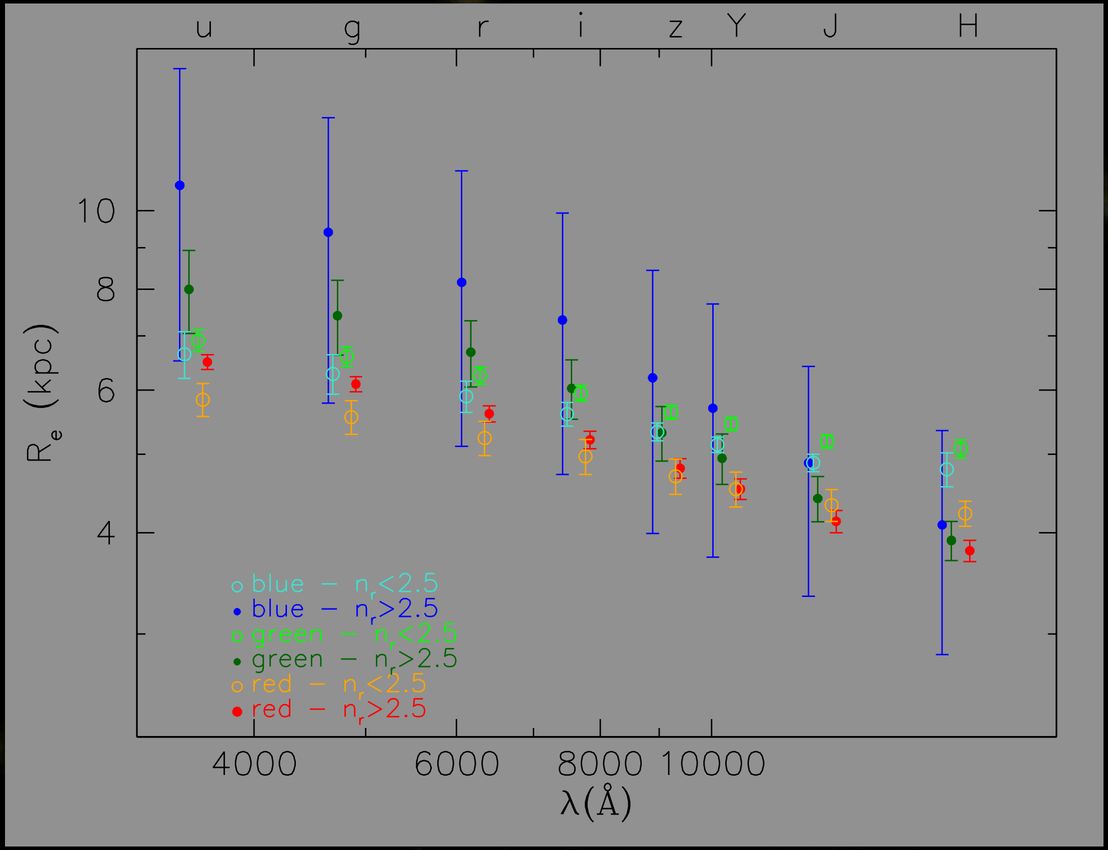
radius r_e with wavelength





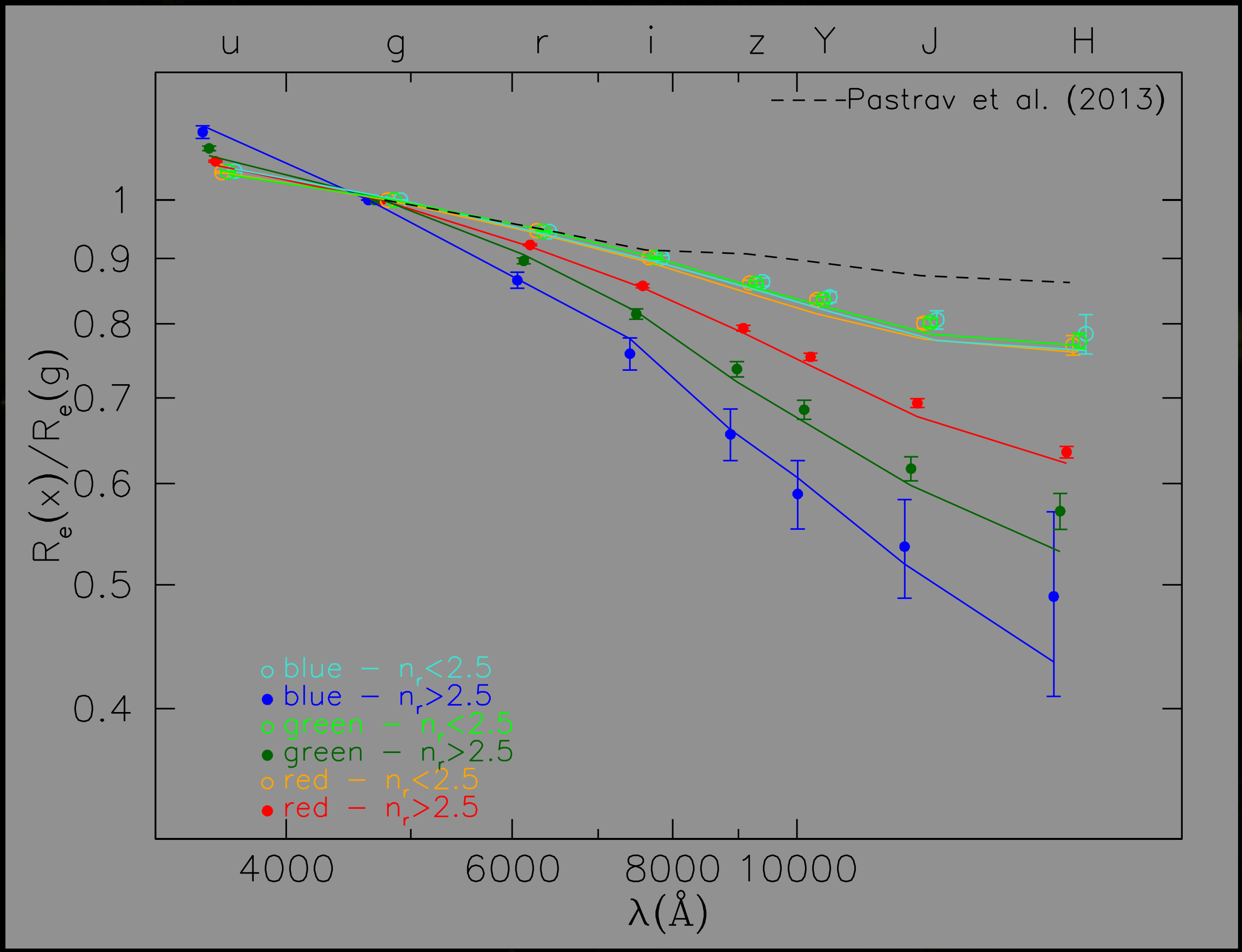
radius r_e by colour and n_r

- n>2.5 shows steeper decrease
- red n>2.5: constant n, but re decreases



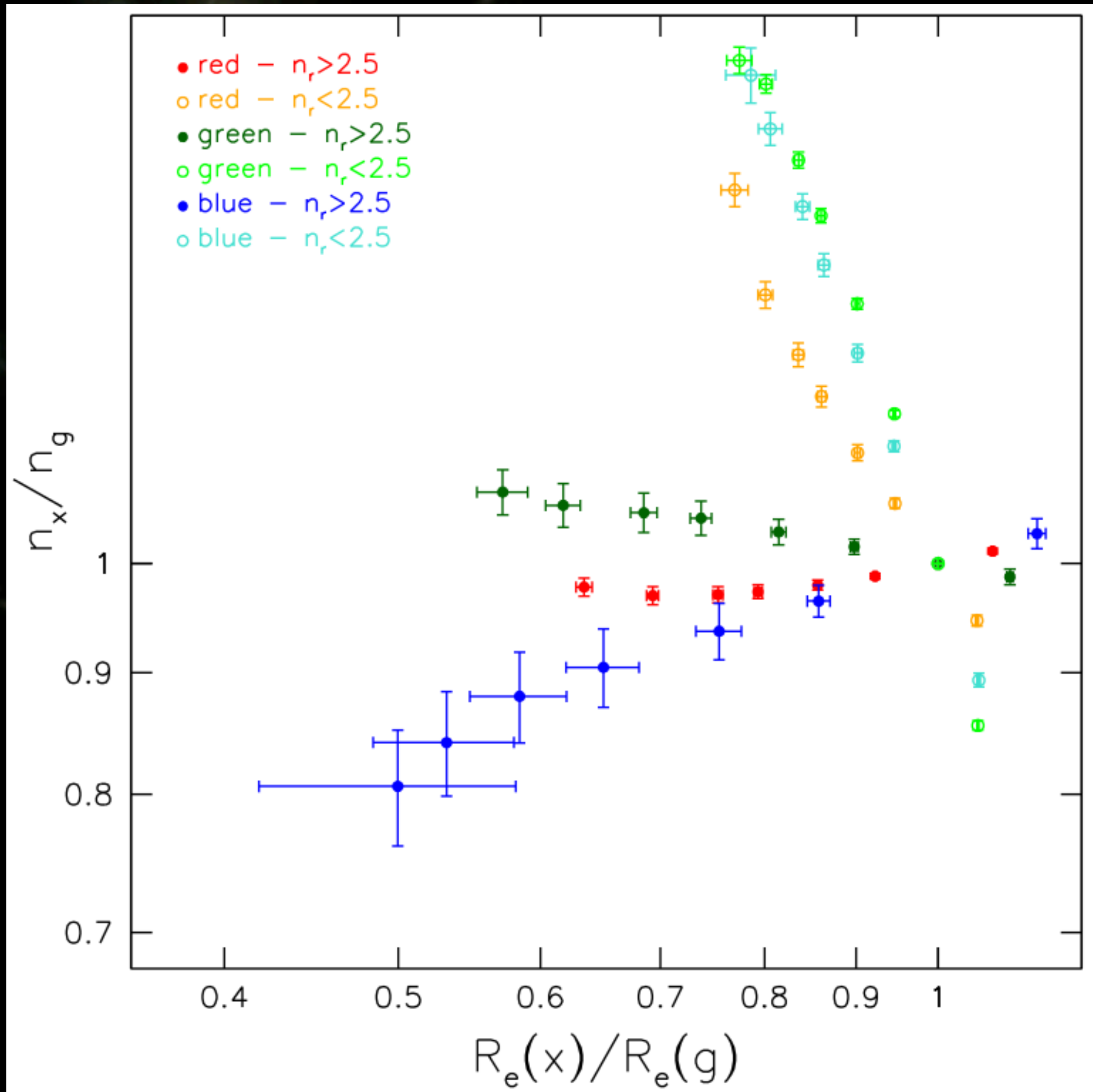
$\mathcal{R} = r_e$ ratio

- n<2.5 indistiguishable

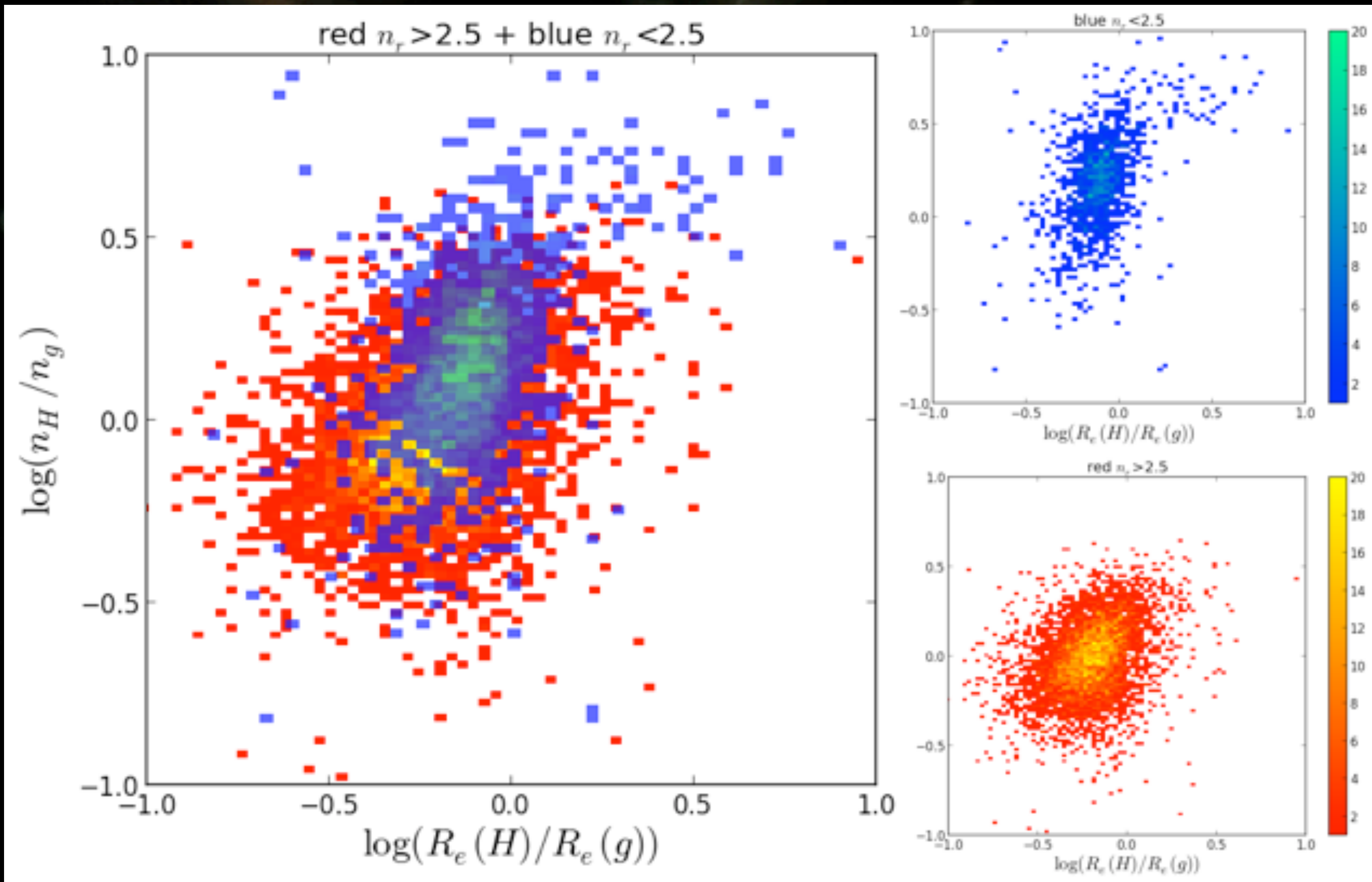


𝒩 vs. ℛ

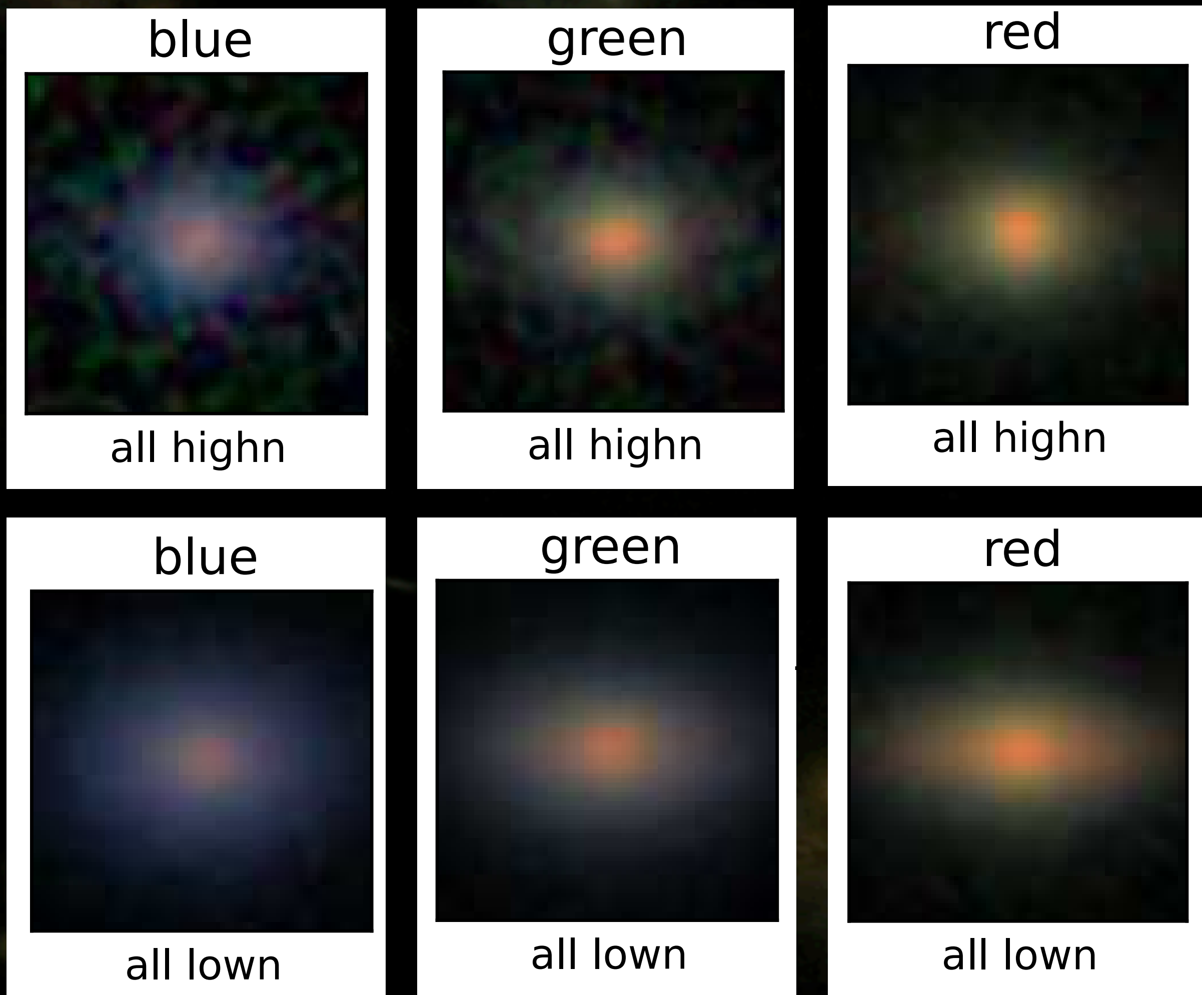
- low-n galaxies show constant ℛ, varying 𝒩
- high-n galaxies show constant 𝒩, varying ℛ
- -> classification without using n or colour itself



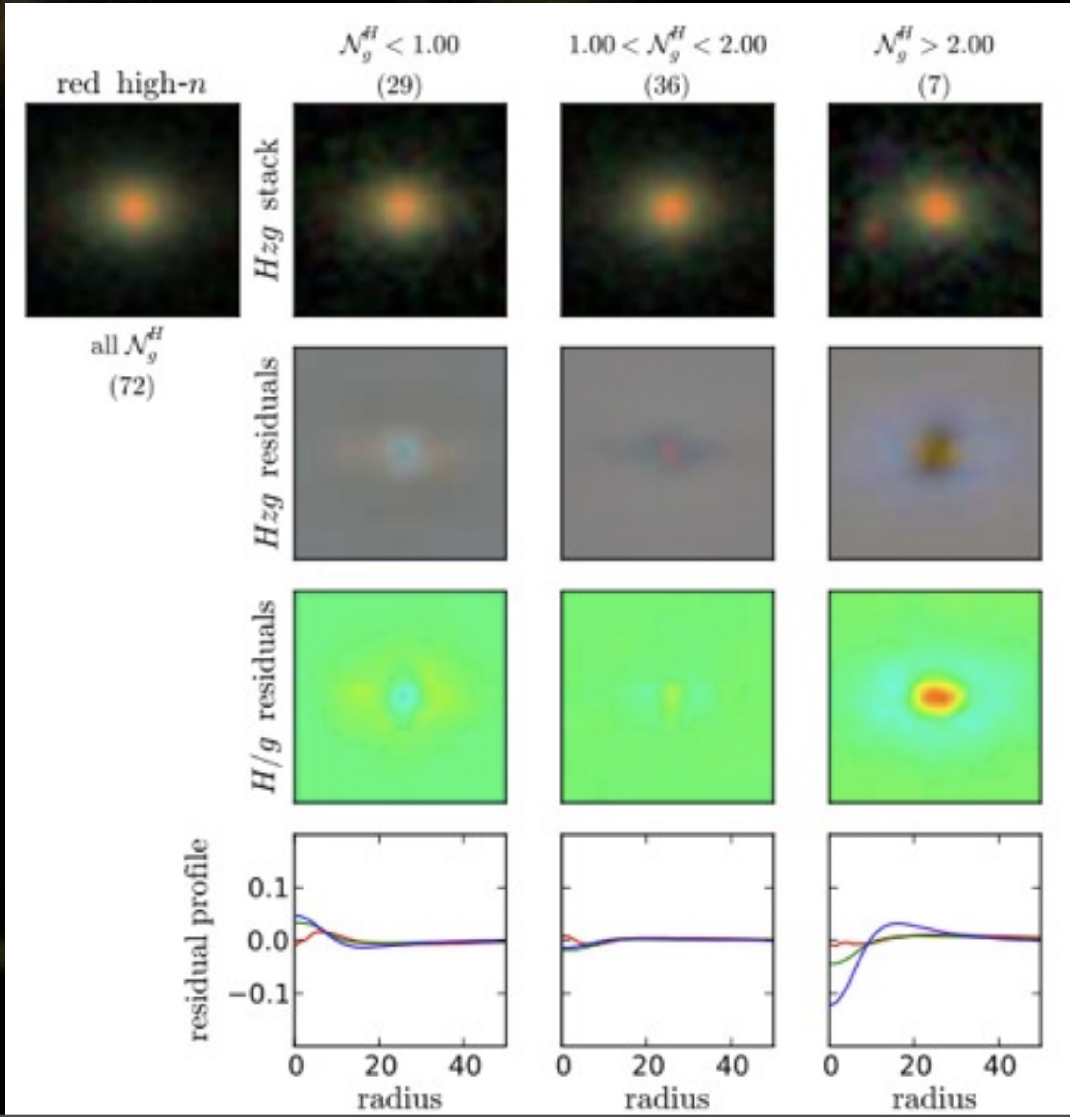
But not good by itself



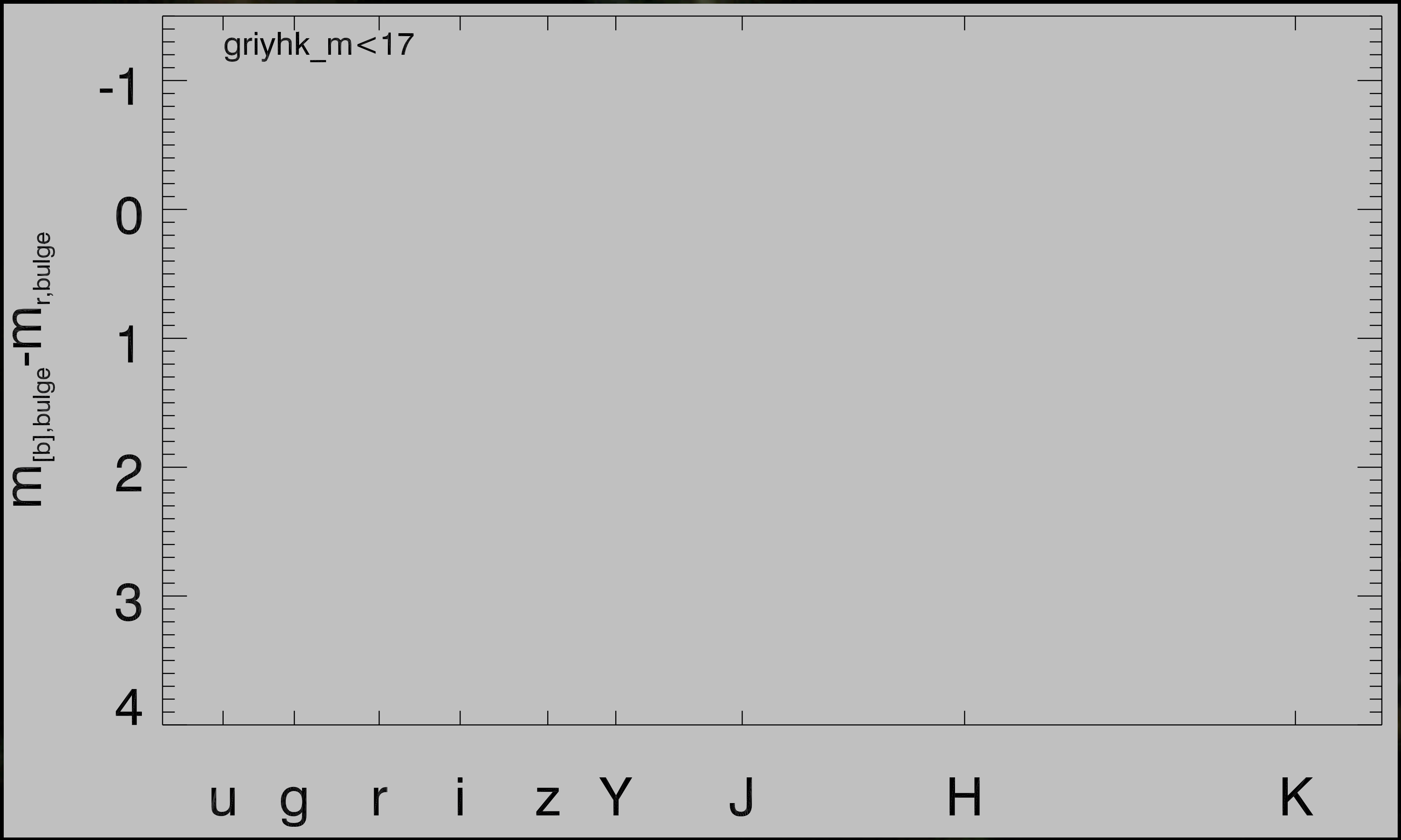
What do $\mathcal{N}$ and $\mathcal{R}$ mean?



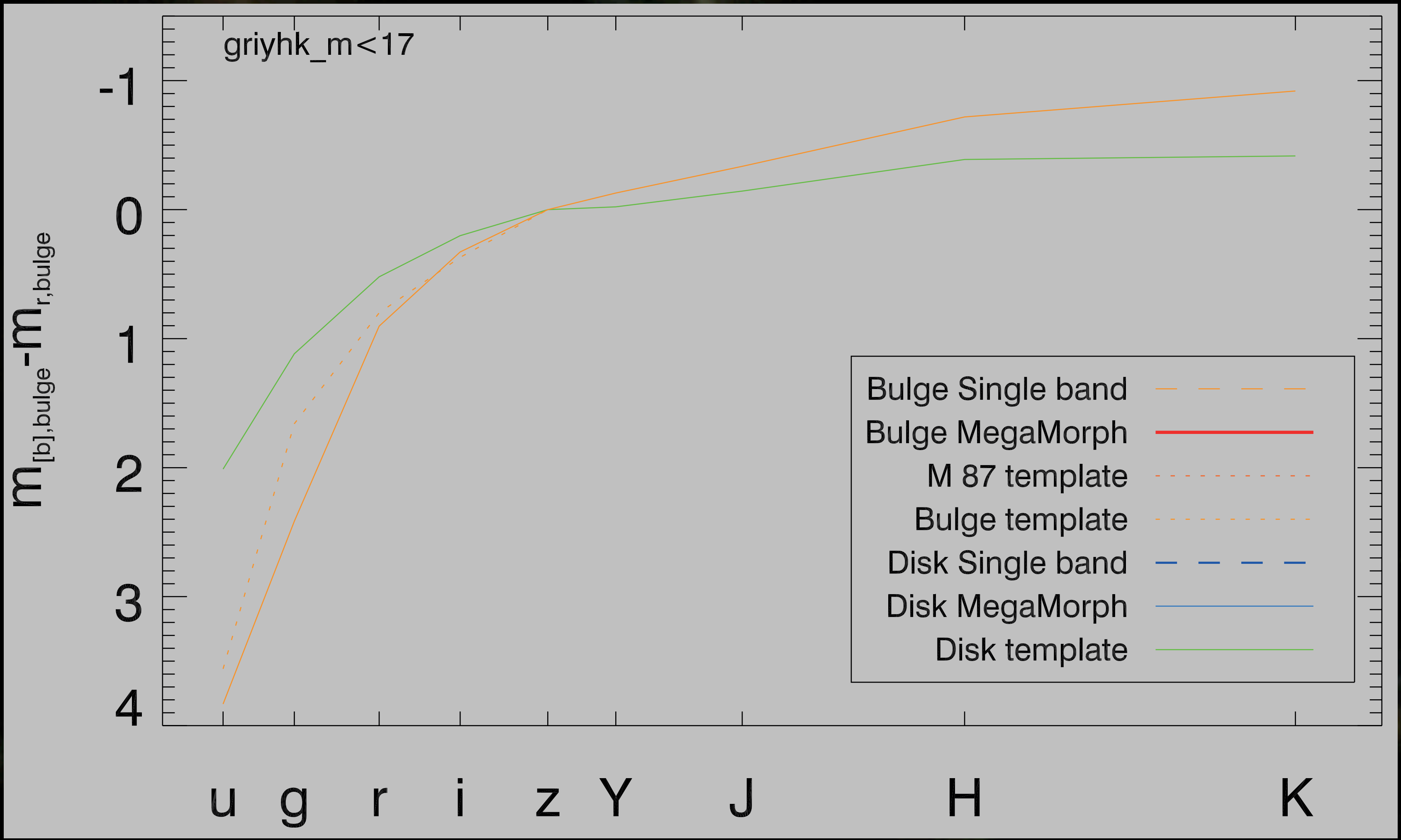
What do $\mathcal{N}$ and $\mathcal{R}$ mean?



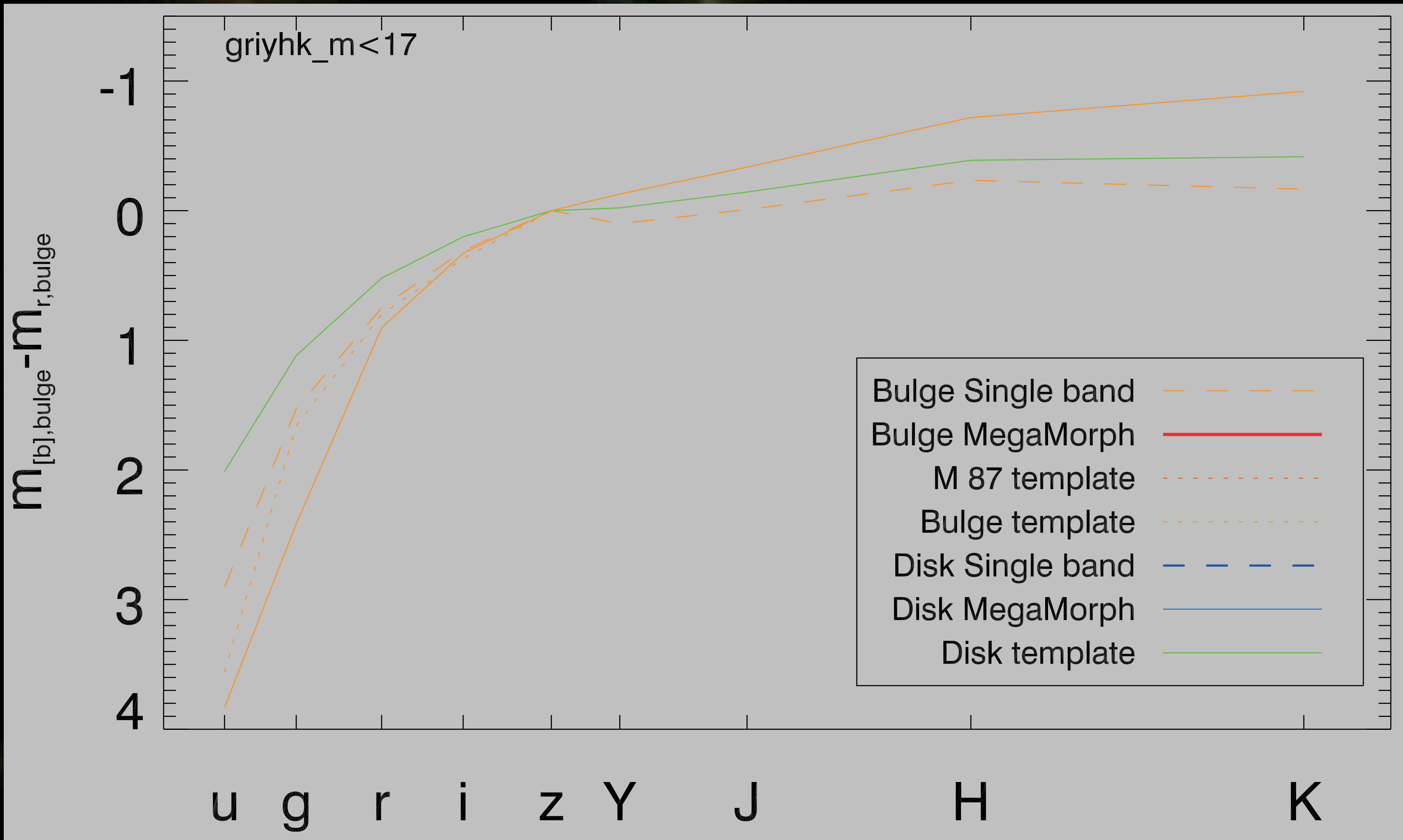
Hugely improves component SEDs



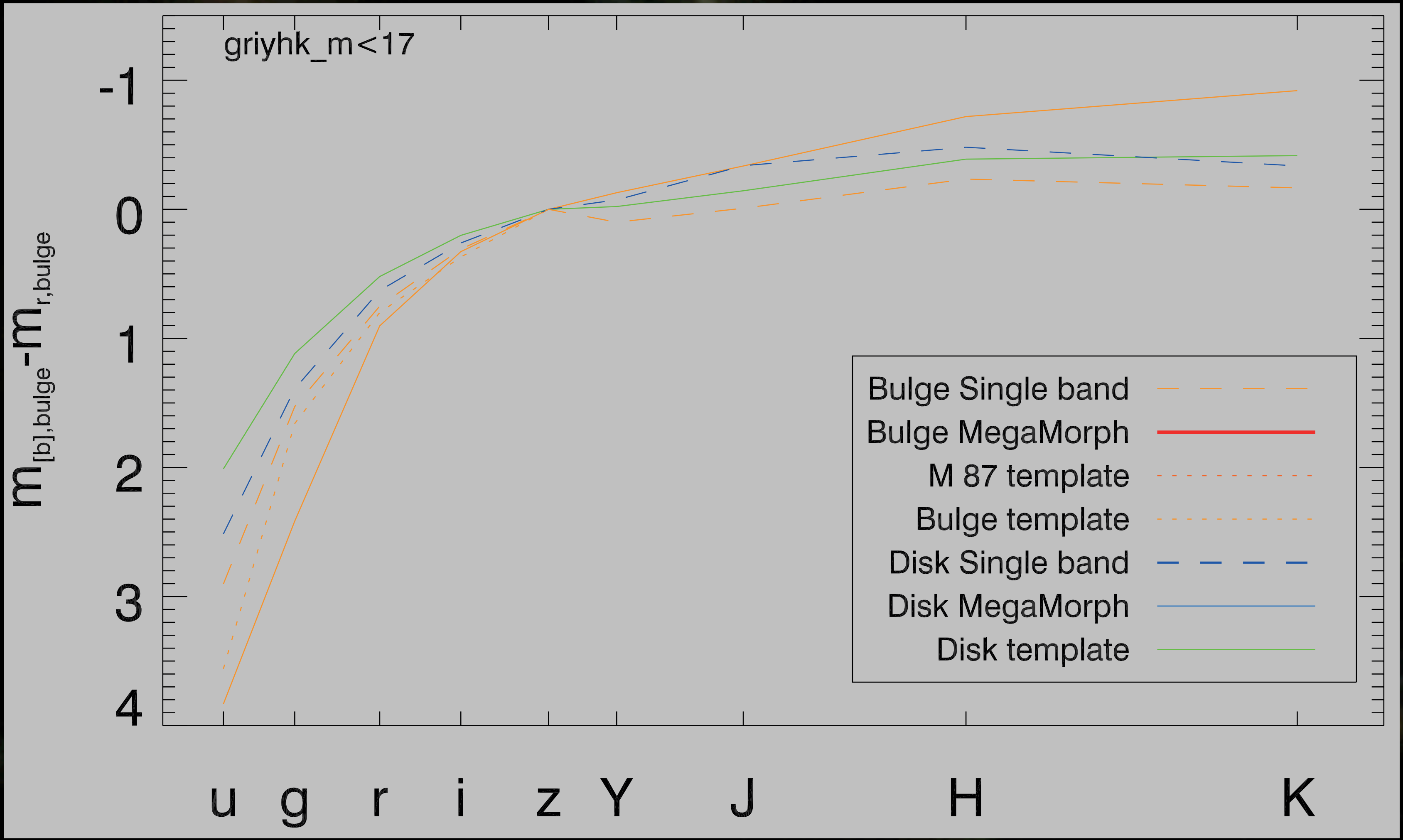
Hugely improves component SEDs



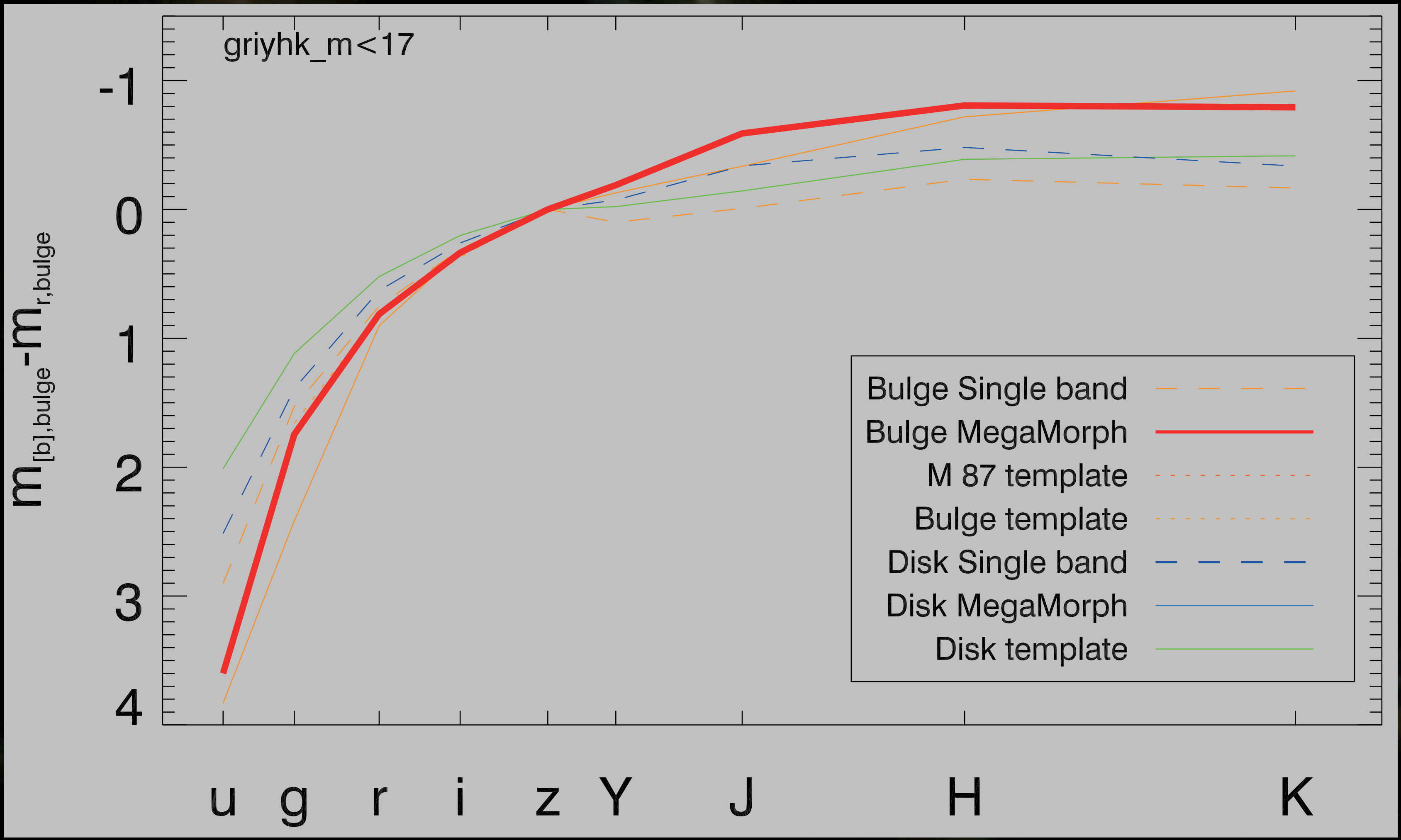
Hugely improves component SEDs



Hugely improves component SEDs

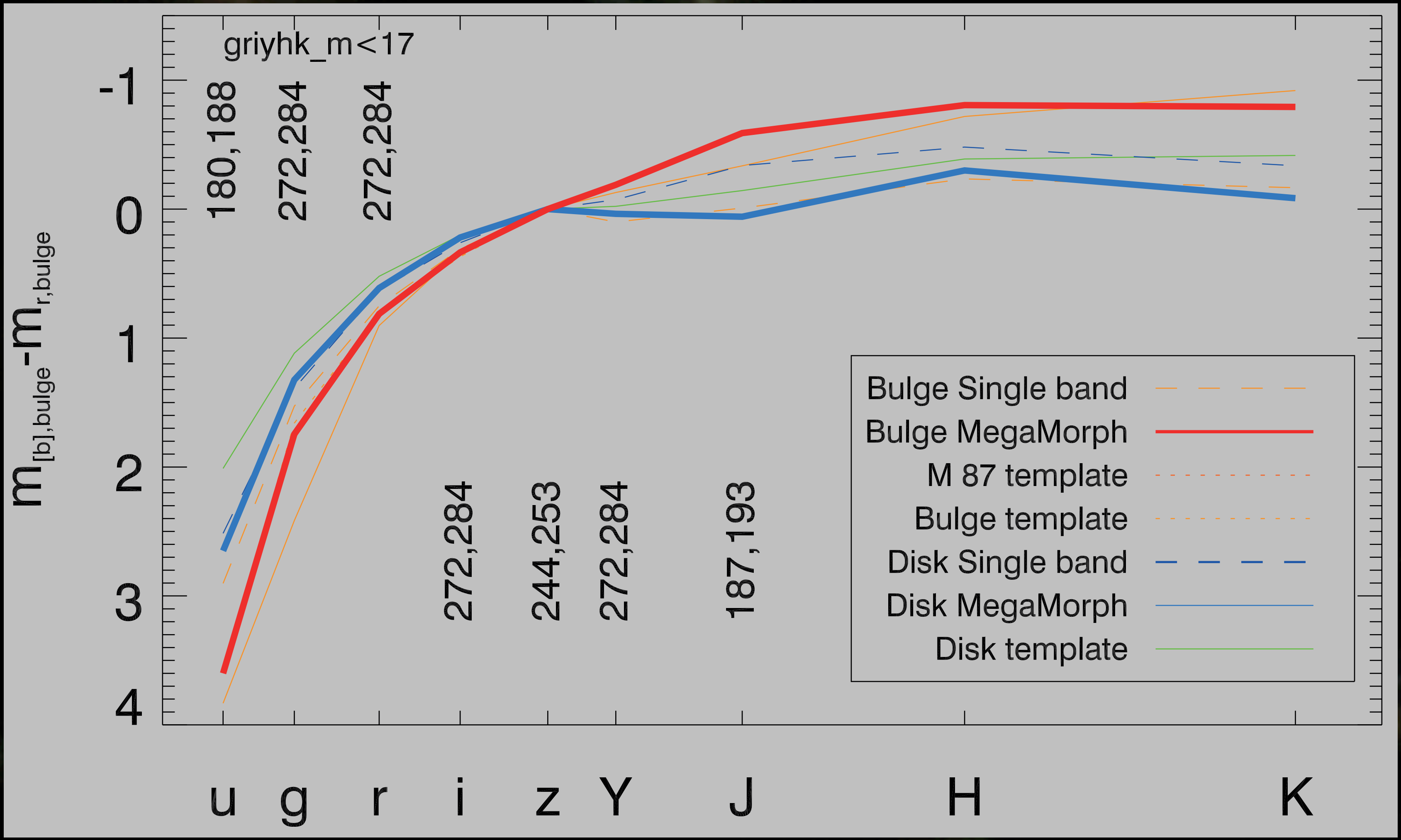


Hugely improves component SEDs

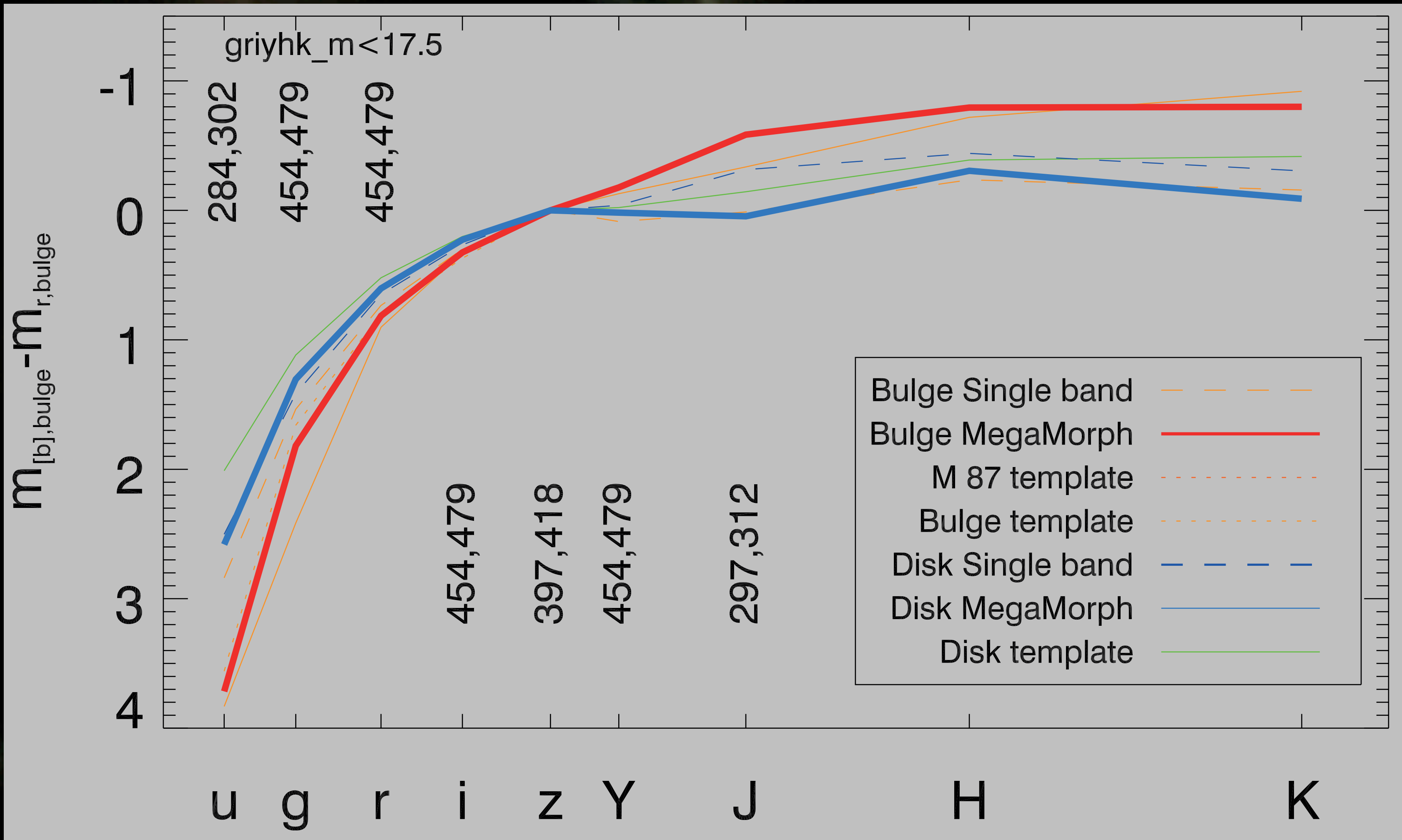


Friday, November 22, 2013

Hugely improves component SEDs

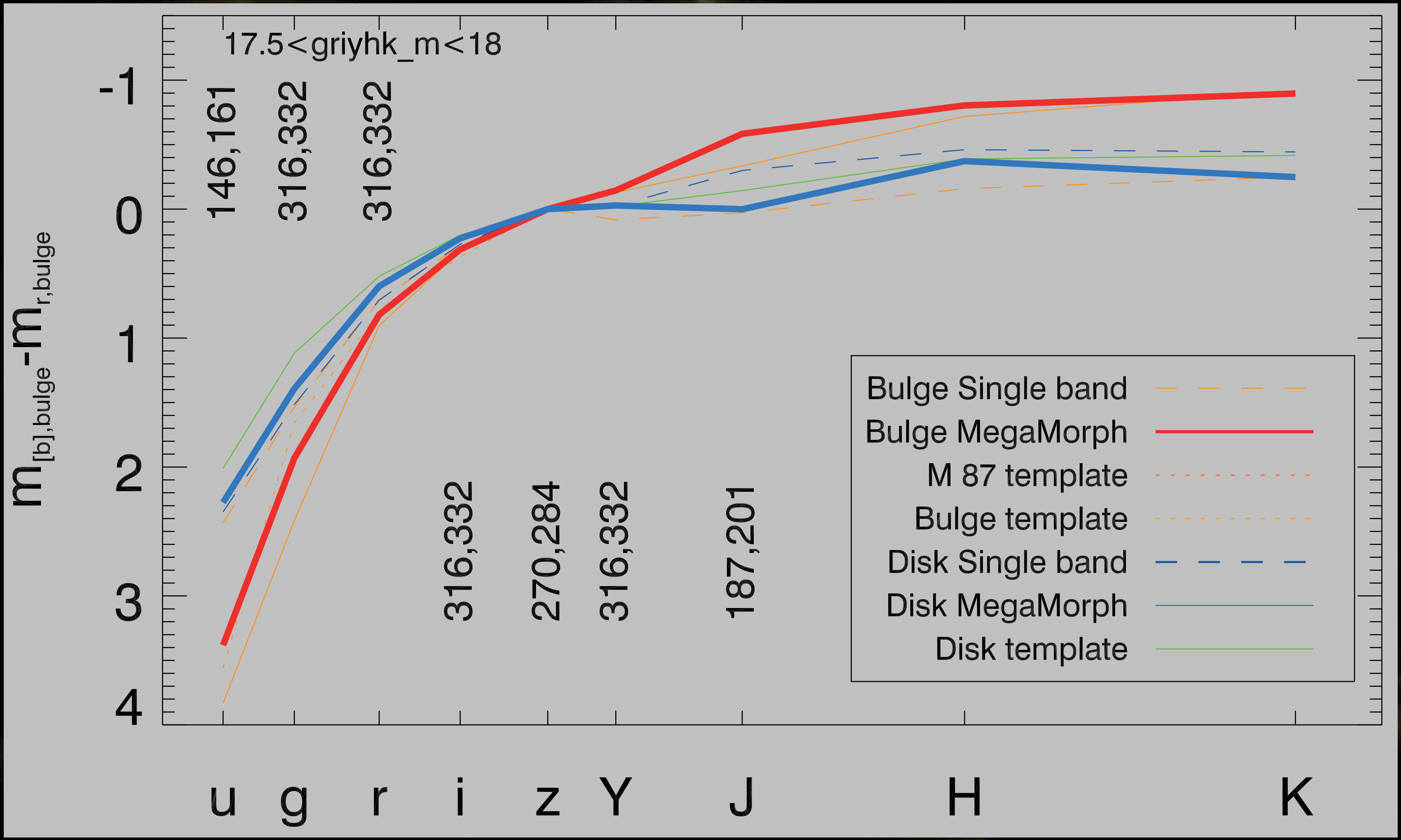


Hugely improves component SEDs

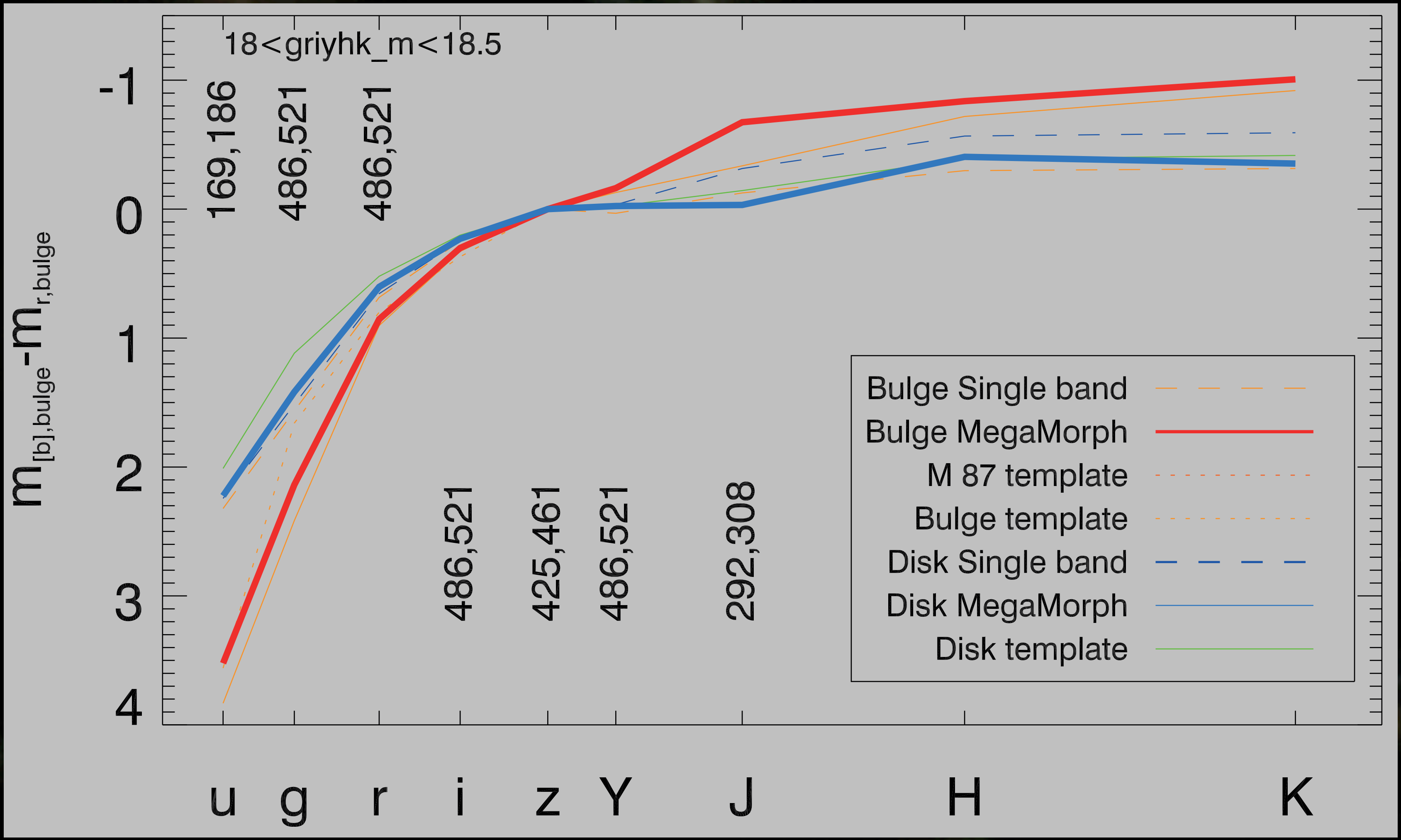


Friday, November 22, 2013

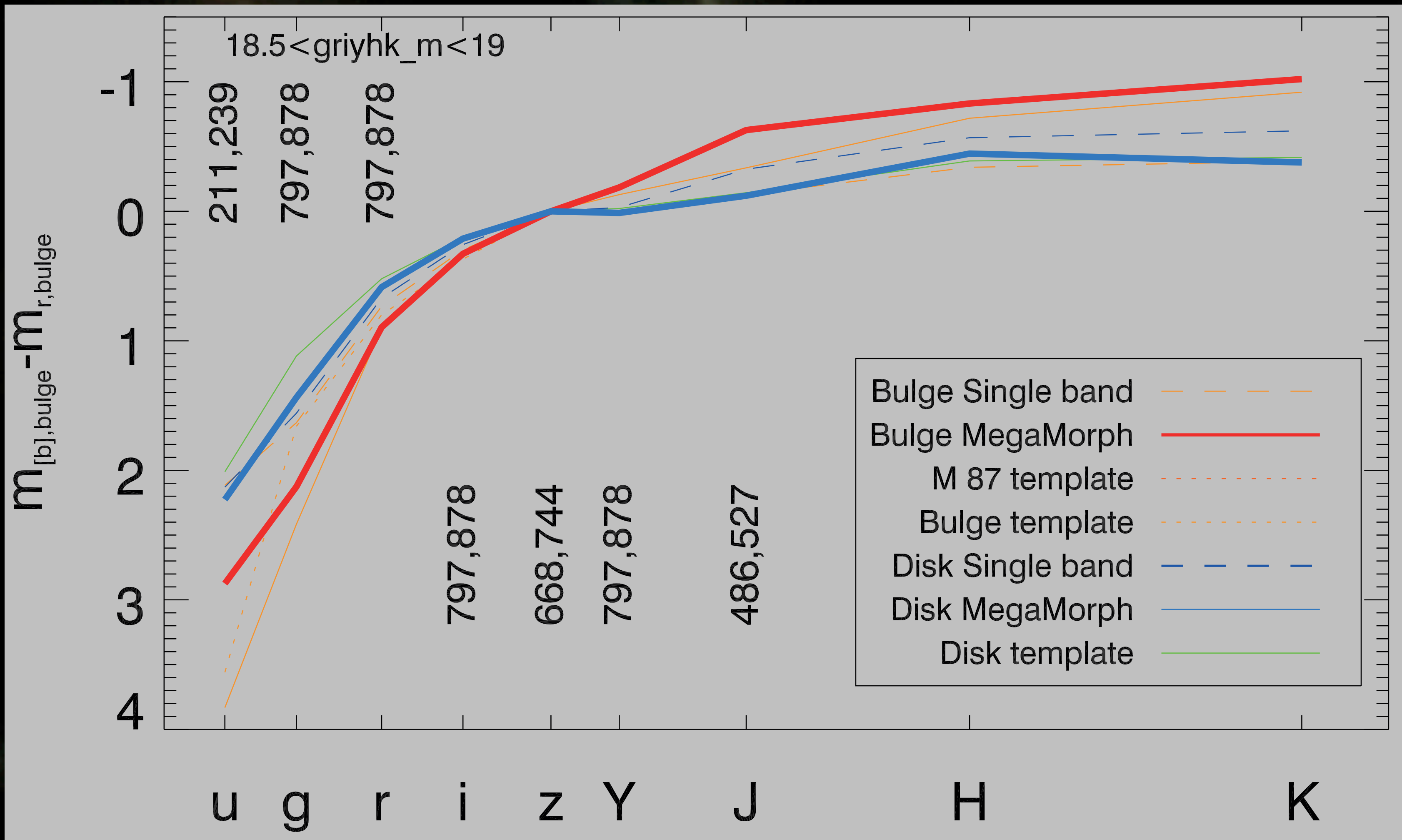
Hugely improves component SEDs



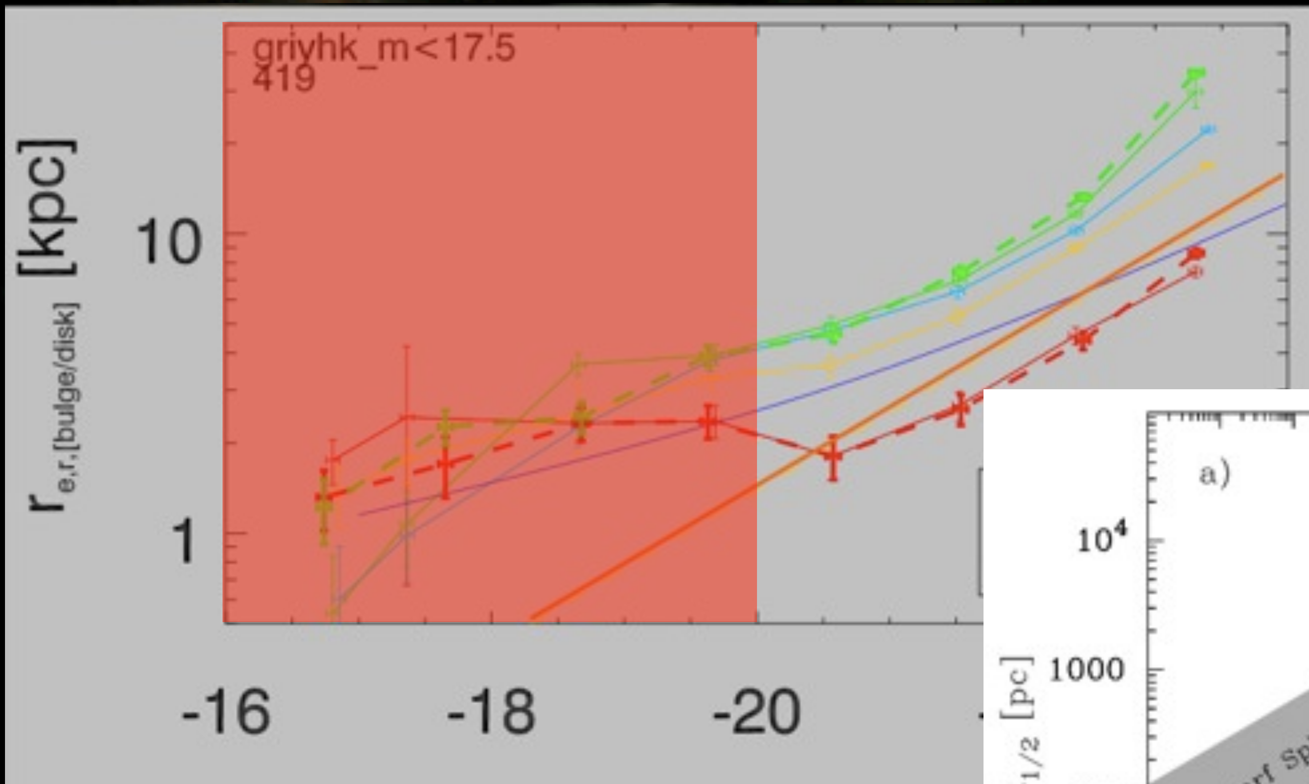
Hugely improves component SEDs

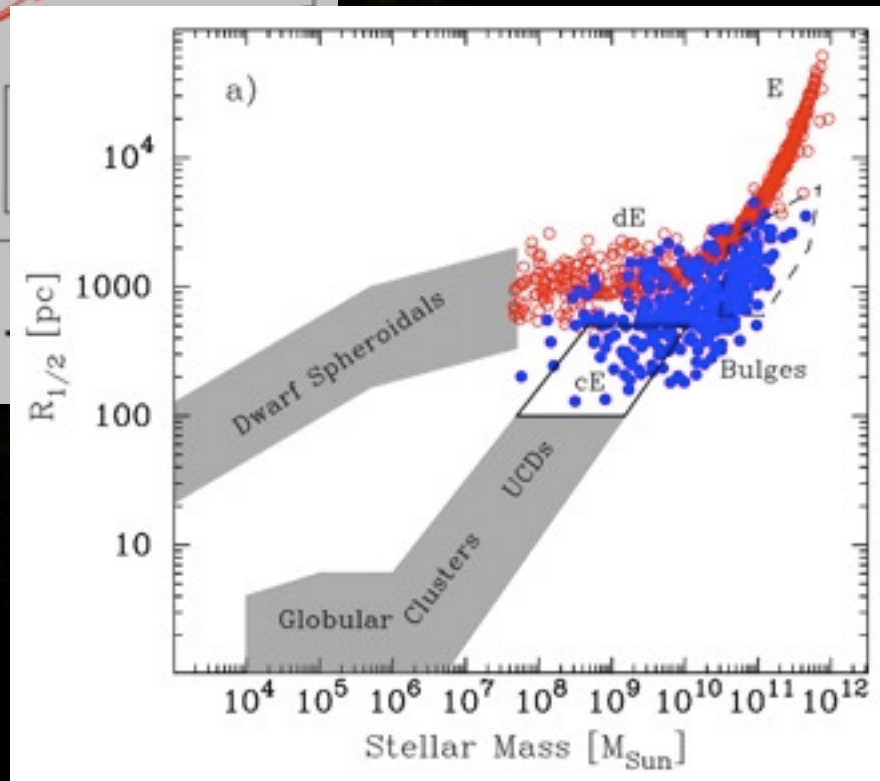


Hugely improves component SEDs



mag-size-relation for components





Summary

- MegaMorph multi-band fitting:
  - enables **more accurate** measurements of morphological parameters at **fainter** magnitudes and **higher redshifts**.
  - allows the measurement of **galaxy internal colour gradients**.
  - can more successfully separate **individual galaxy components**.
- $\mathcal{N}$ and $\mathcal{R}$ reveal the internal structure, and hence formation history, of different types of galaxies (all conclusions for bright galaxies)
  - high-n systems: largely on component systems; supports **2-stage formation scenario** for early-type galaxies
  - mostly red centers -> picture of old, large component and small blue, inner disk largely ruled out, at least at low z
  - low-n systems: 2-component systems with red and blue components
  - allows identification of interesting objects (e.g. Ellipticals with blue cores, passive disks)
- Work presented in Vulcani 2013, (nearly) submitted
- code published soon (ask us if interested)
- it's spelled 'Haeussler'