

MEGAMORPH - Measuring the physical properties of galaxies in modern multi-wavelength surveys

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Vulcani (IPMU), Marina Vika (Athens), Alex Rojas (CMU, Qatar)
and others (e.g. GAMA team!)



The University of
Nottingham



STFC



Q NRF

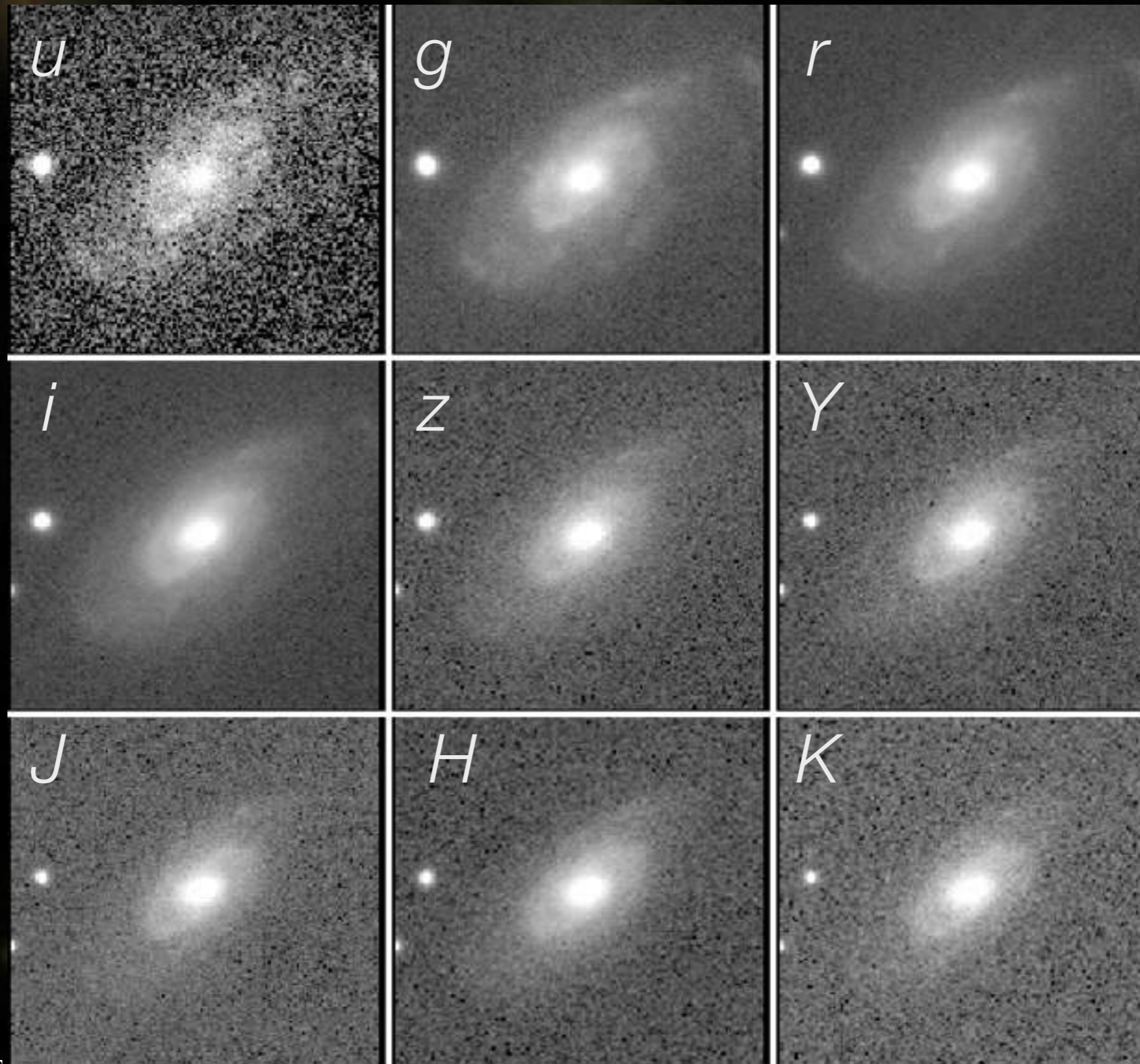
الاصفاد القطري لارضية البحث العلمي
Qatar National Research Fund

جامعة كارنيغي ميلون في قطر
Carnegie Mellon Qatar

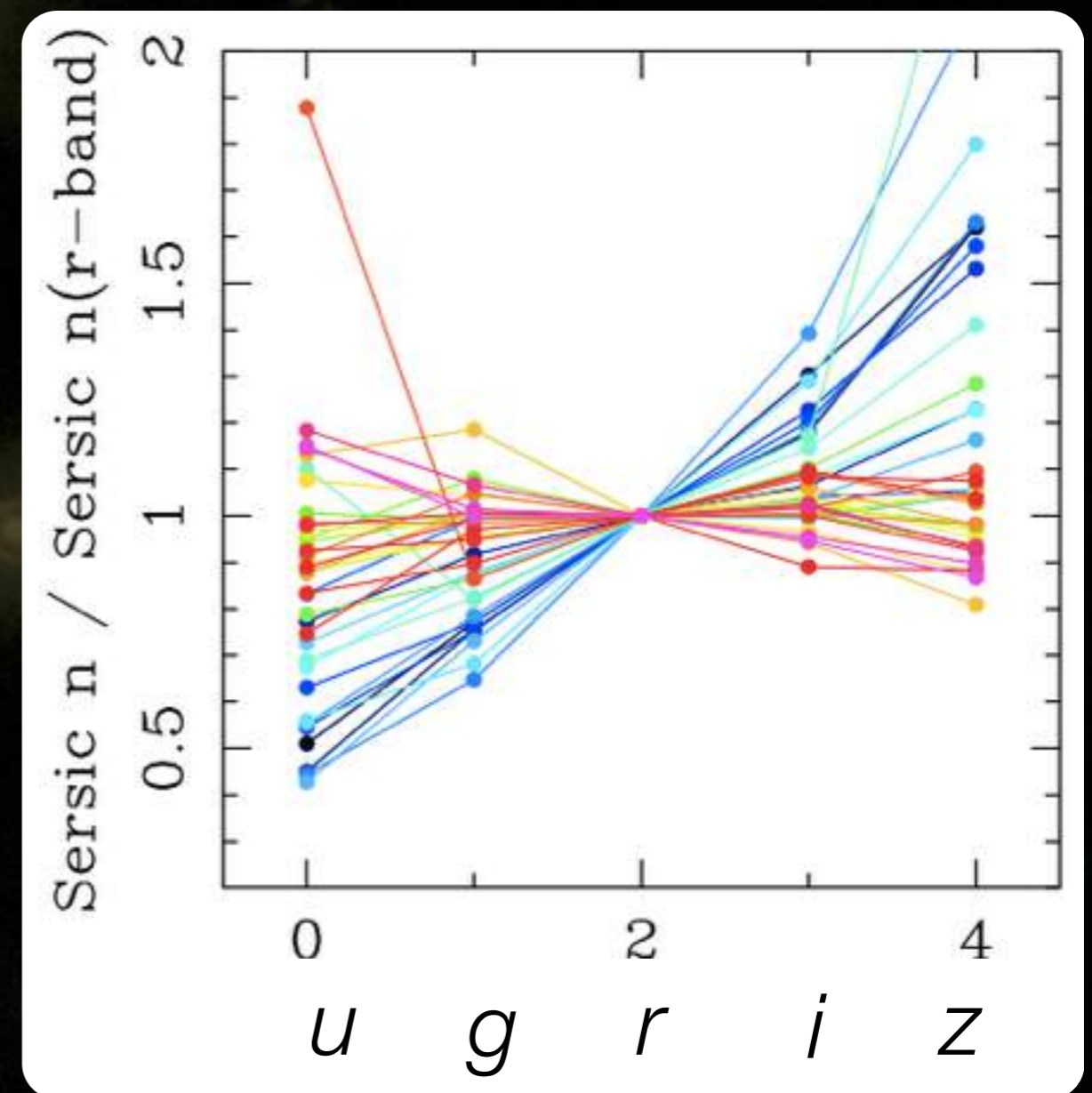
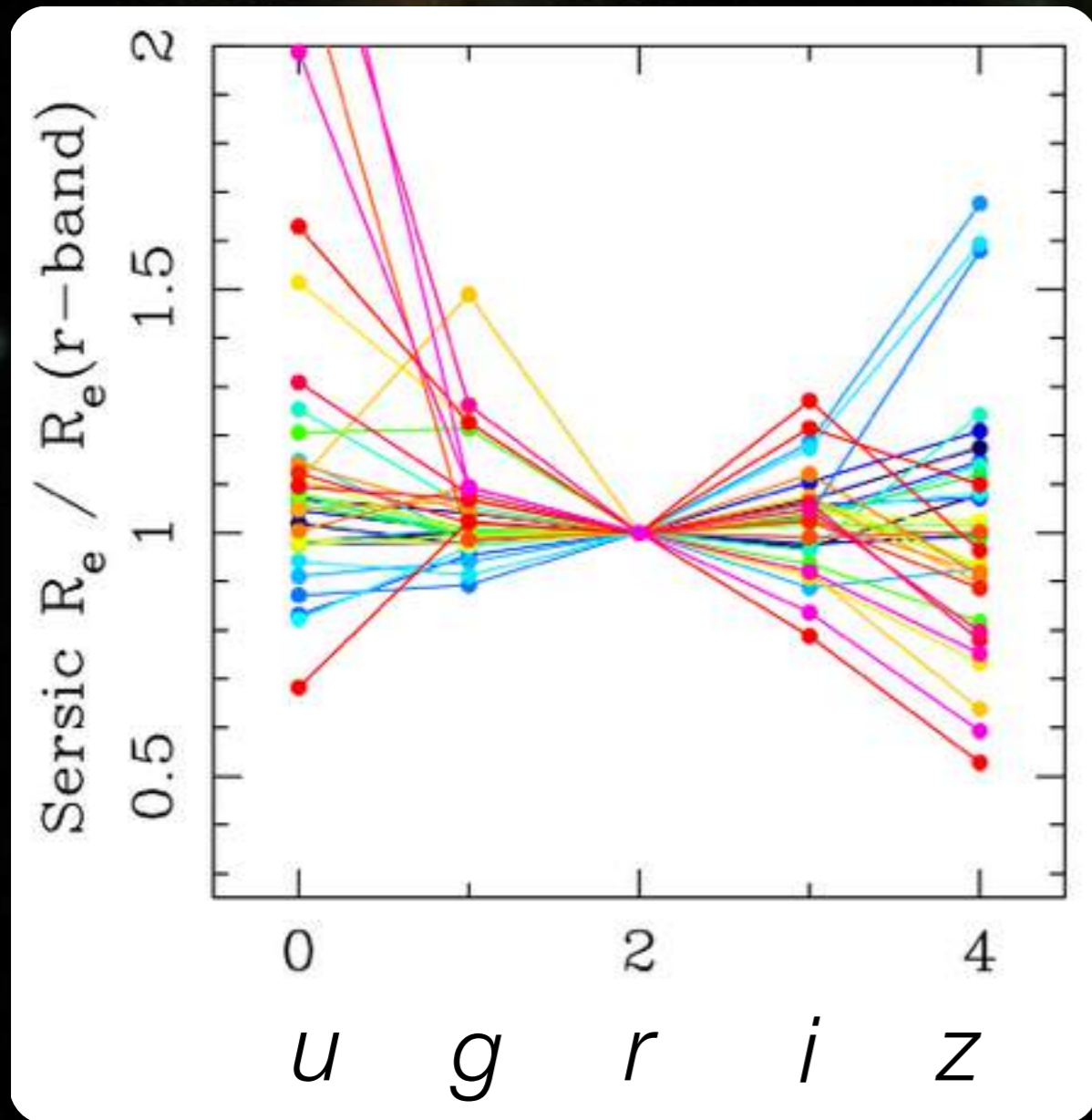
Galactic Girths, Kashiwa City, February 3rd 2015



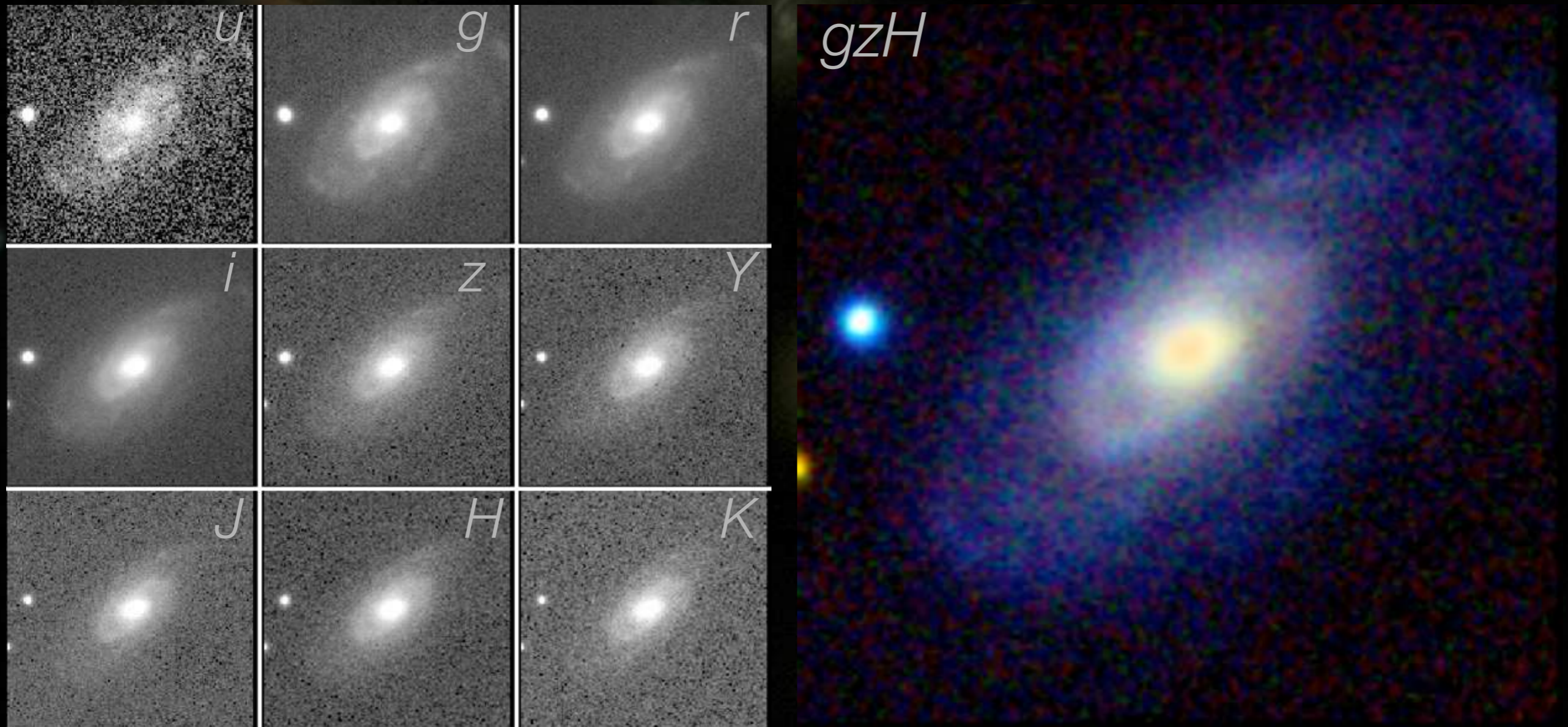
Today's data: multiple bands



Results dependent on choice of band

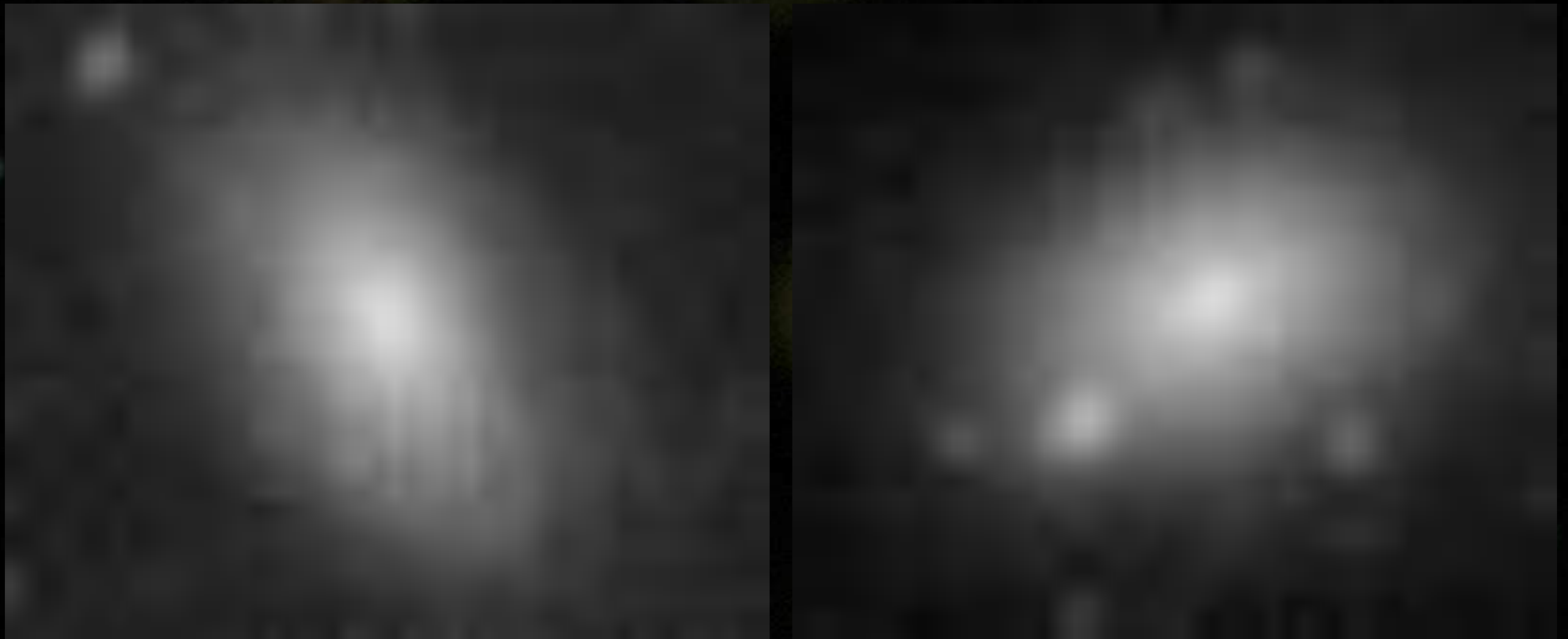


Multi-band data hosts more information



multi-band data = more information +
discriminatory power

Colour is valuable information



simulated monochromatic observations

Colour is valuable information



simulated colour observations
(degraded HST images)

MegaMorph



- Collaboration between astronomers, statisticians and computer scientists
- Funded by Qatar National Research Fund (QNRF)
- Address the issues with current software [Done, this talk]
- Implement multi-band bulge-disk decomposition [Done, Talk Vika], even in a spectral sense on IFU data [in progress, Johnston, in prep]
- Accurate model selection (single Sérsic or B/D,...) [In progress]
- Ensure fast enough to process large surveys [Somewhat in progress]
- Implement non-parametric fitting [please ask, Talk Bamford?]
- Implement MCMC minimization [please ask]

MegaMorph data - Redshifted

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

Full and
Efficient Redshifting
of Ensembles of
Nearby
Galaxy
Images

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

$z = 0.01$

$z = 0.03$

$z = 0.05$

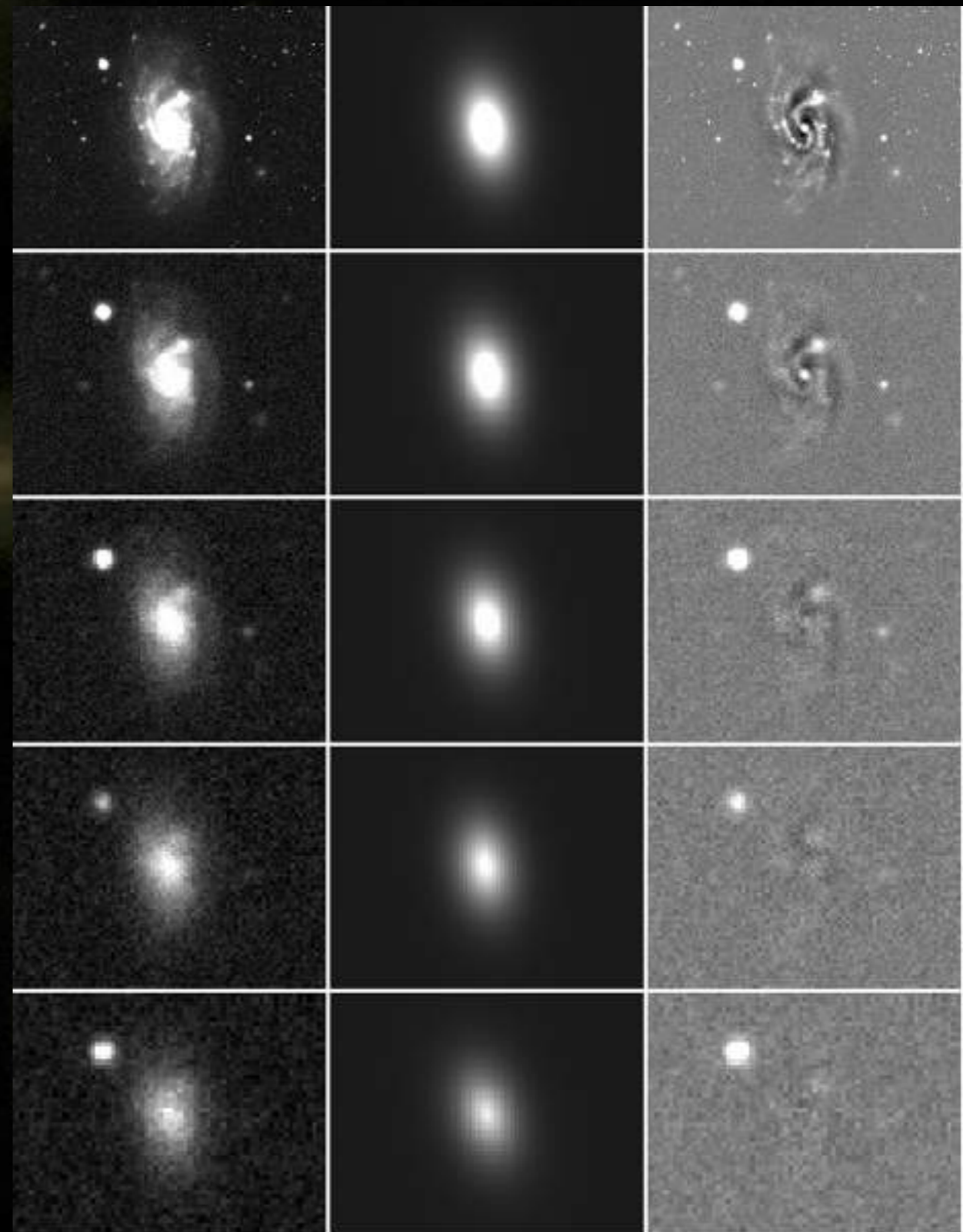
$z = 0.07$

$z = 0.09$

data

model

residual

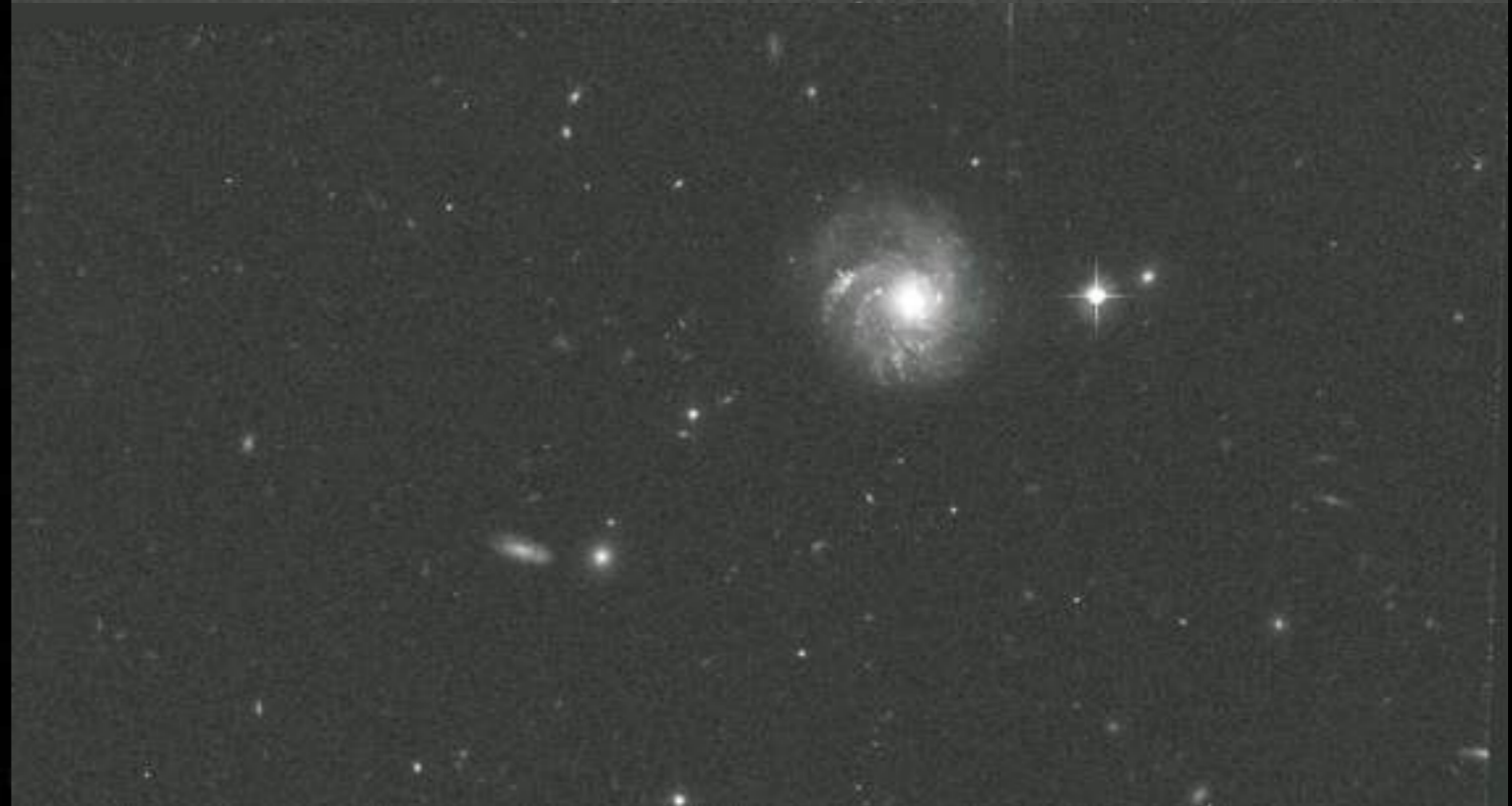


MegaMorph data - Simulated

simulated
data



real
data



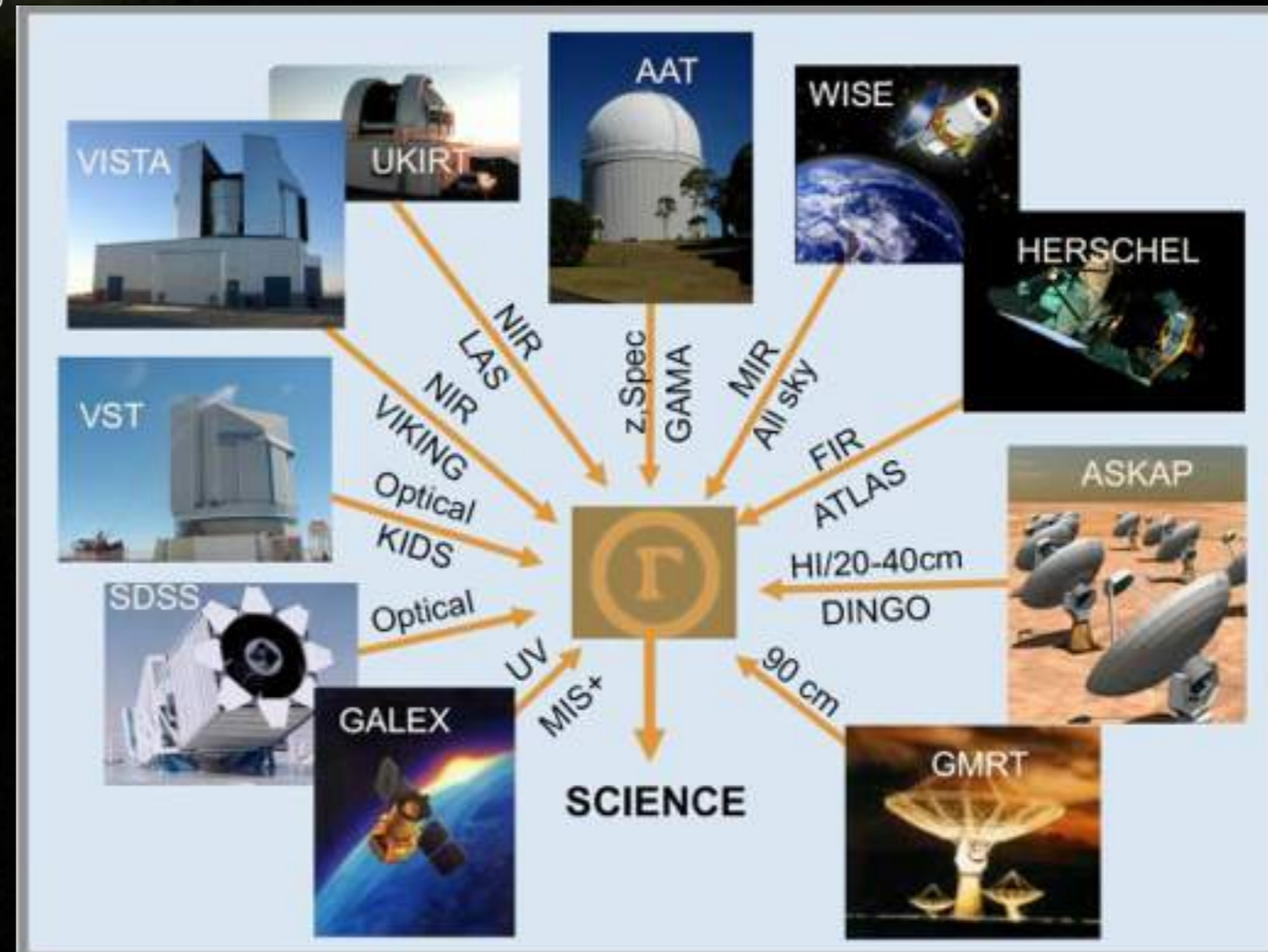
In same manner as
Häußler et al. 2007

MegaMorph data - GAMA



- Redshift survey & multiwavelength database
- Registered mosaics
 - 150 sq. deg
 - SDSS ugriz
 - + UKIDSS YJHK

→ VST KIDS
+ VISTA VIKING



MegaMorph Software

GALAPAGOS

by M. Barden, B. Häußler, et al.
(C-version by A. Hiemer)

GALFIT

by C.Y.Peng, et al.

SExtractor

by E.Bertin

MultiNest by F. Feroz & M. Hobson

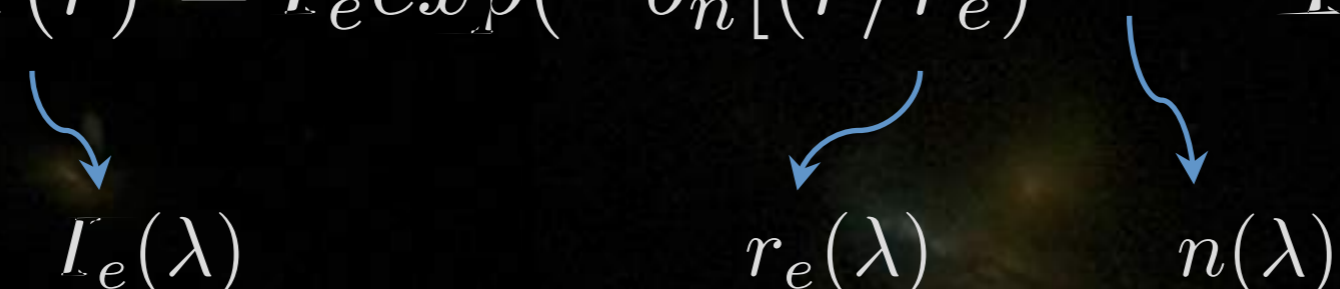
GALAPAGOS

- Galaxy Analysis over Large Areas: Parameter Assessment by GALFITting Objects from SExtractor (Barden, Häußler et al., 2012):
 - Run SExtractor to detect objects, mosaik
 - Cut postage stamps for each object
 - Decide on automated basis on neighbours:
 - Deblending or masking?
 - Run neighbour-sensitive sky estimation
 - Set up GALFIT start file
 - Run GALFIT
 - Write all results to one big catalogue
- Used for GEMS, STAGES, CANDELS (and other)
- ONE BAND!
- (also exists as C-code now that runs on super-computers, by Andreas Hiemer, Innsbruck)

GALFIT adaptations

- GALFIT adaptations:
 - Uses multi-wavelength data
 - Non-parametric component
 - Can use different minimization algorithms (LM, Multinest-MCMC)
 - Each standard GALFIT parameter replaced by a polynomial function of wavelength (Chebyshev polynomials)

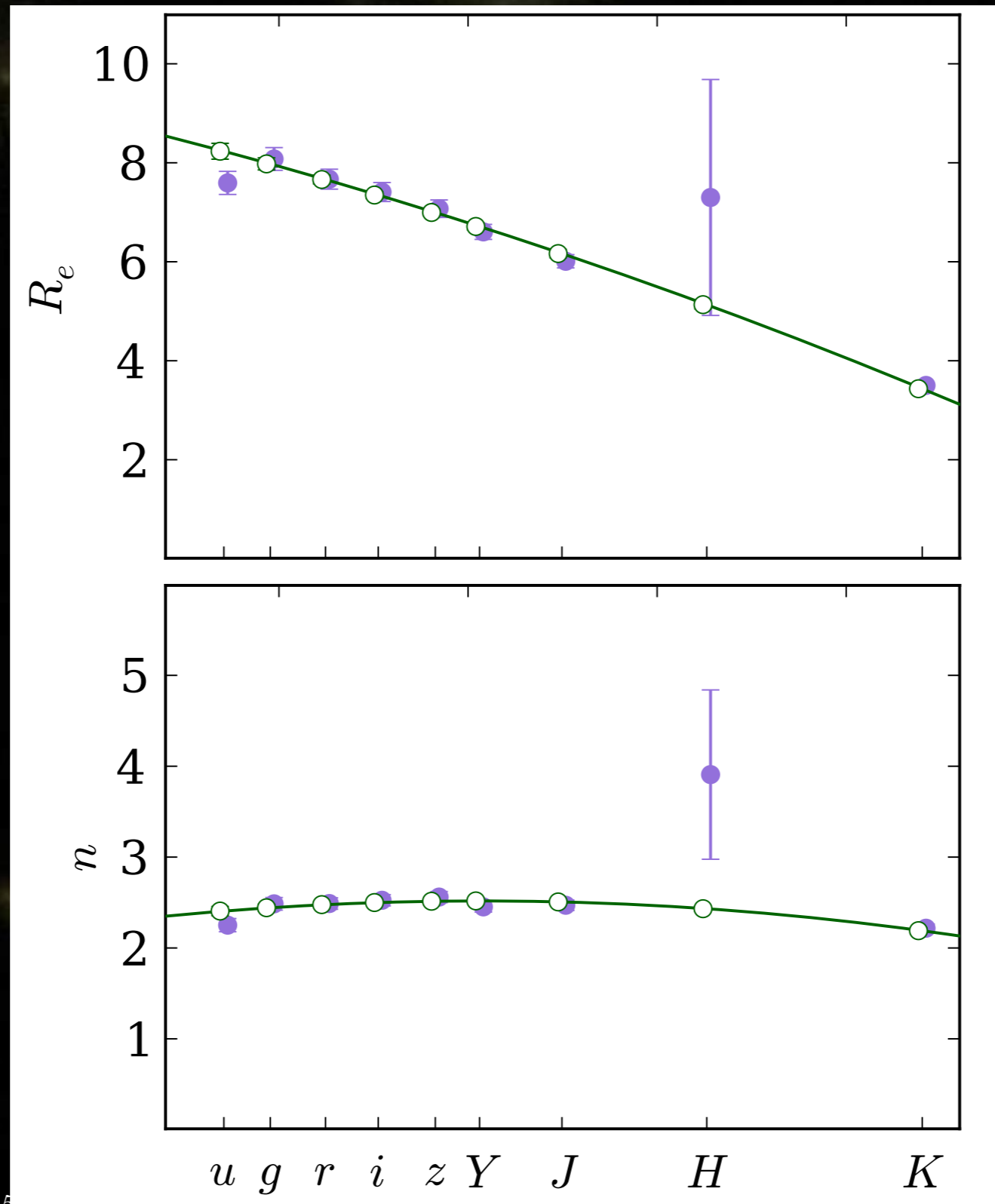
$$f(\lambda) = \sum_{i=0}^m c_i T_i(\lambda)$$

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


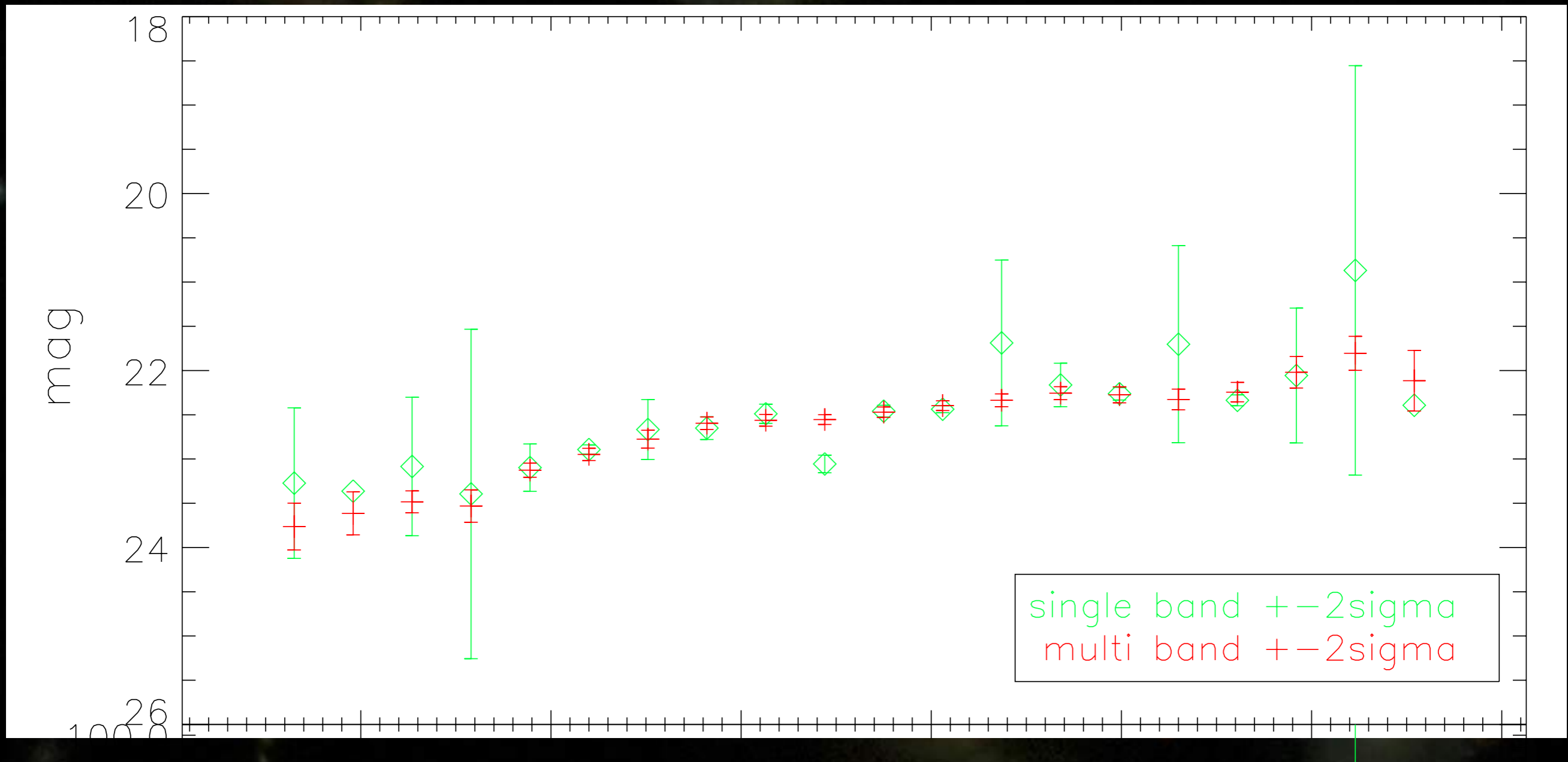
$I_e(\lambda)$ $r_e(\lambda)$ $n(\lambda)$

- Easy and backwards compatible user interface

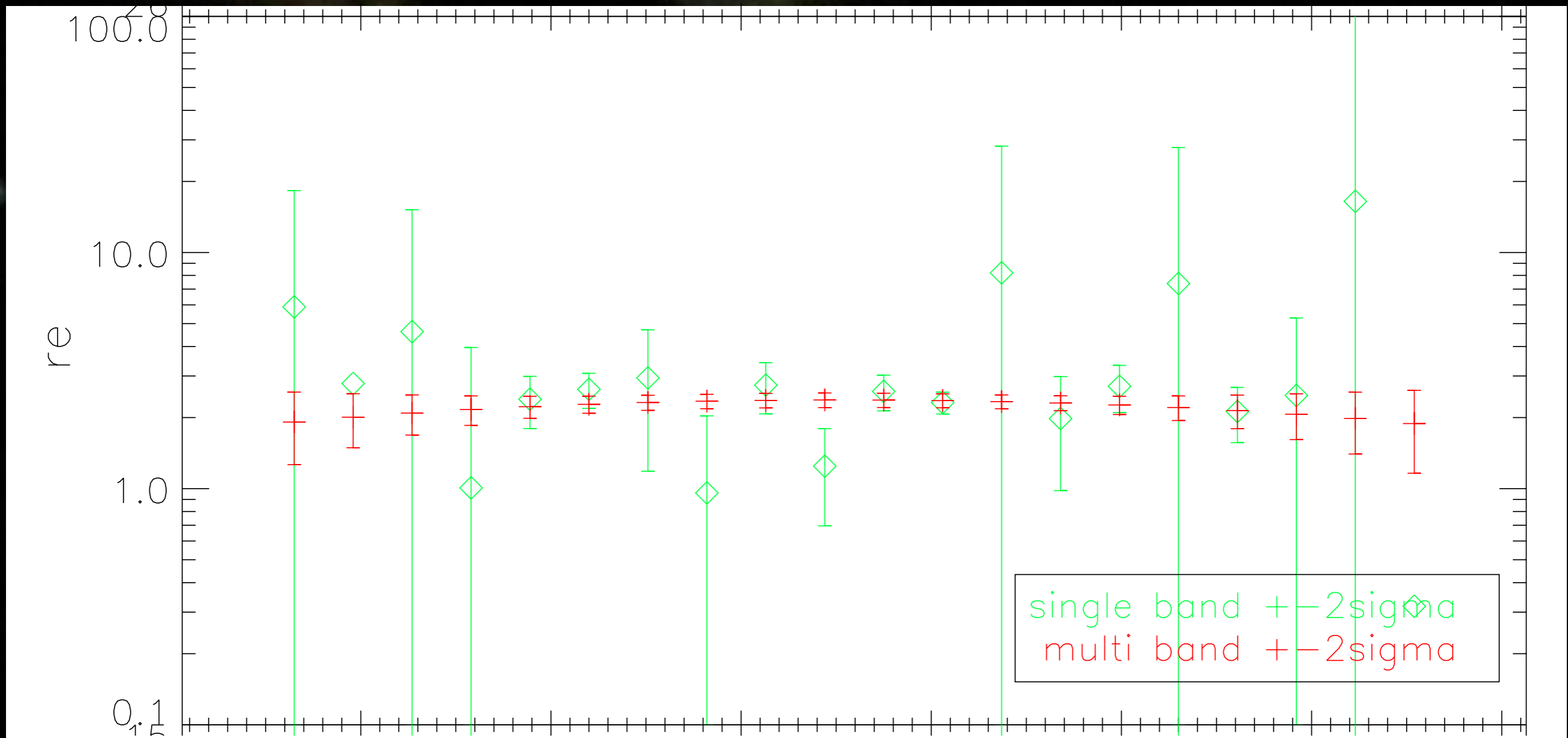
Helps with noisy bands



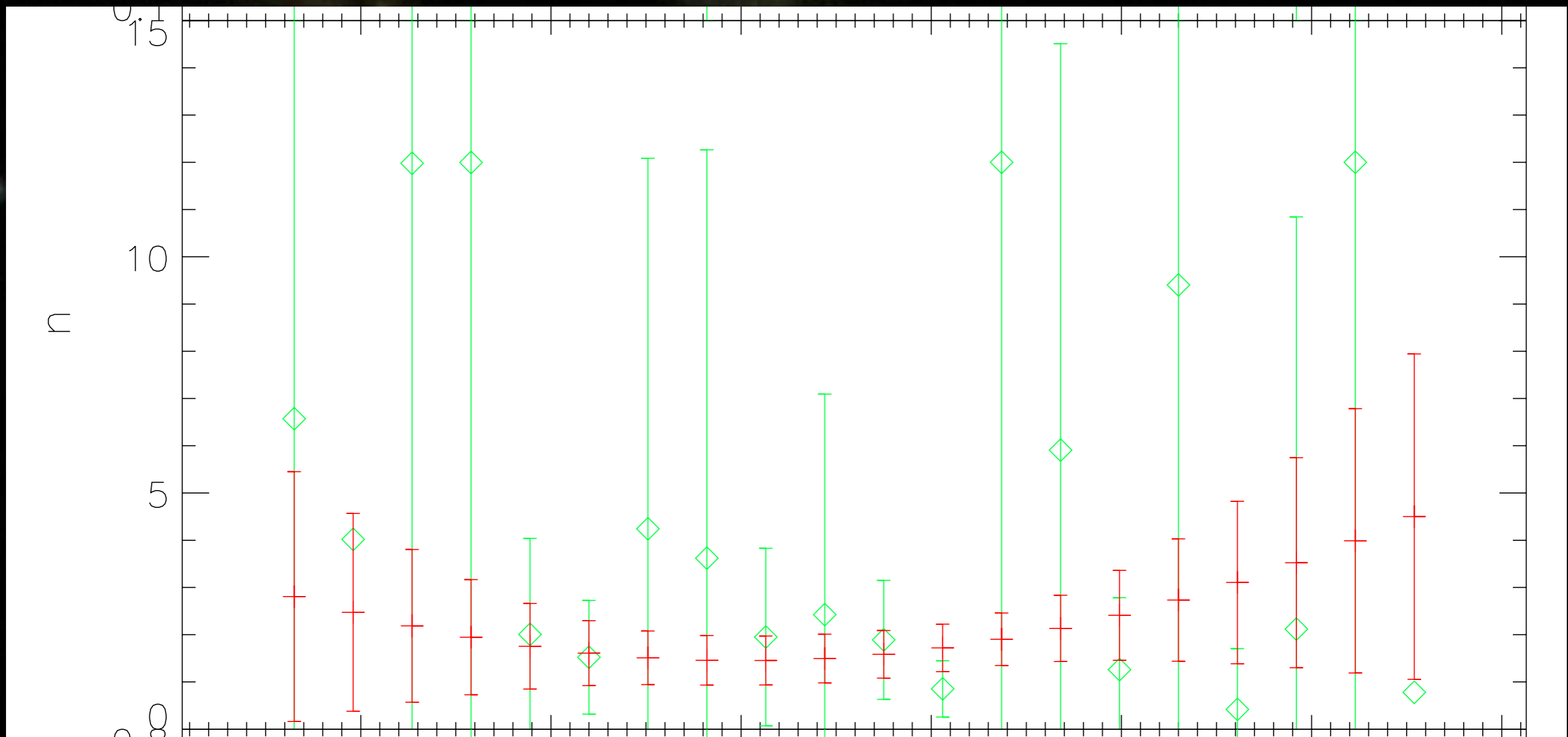
Helps with noisy bands



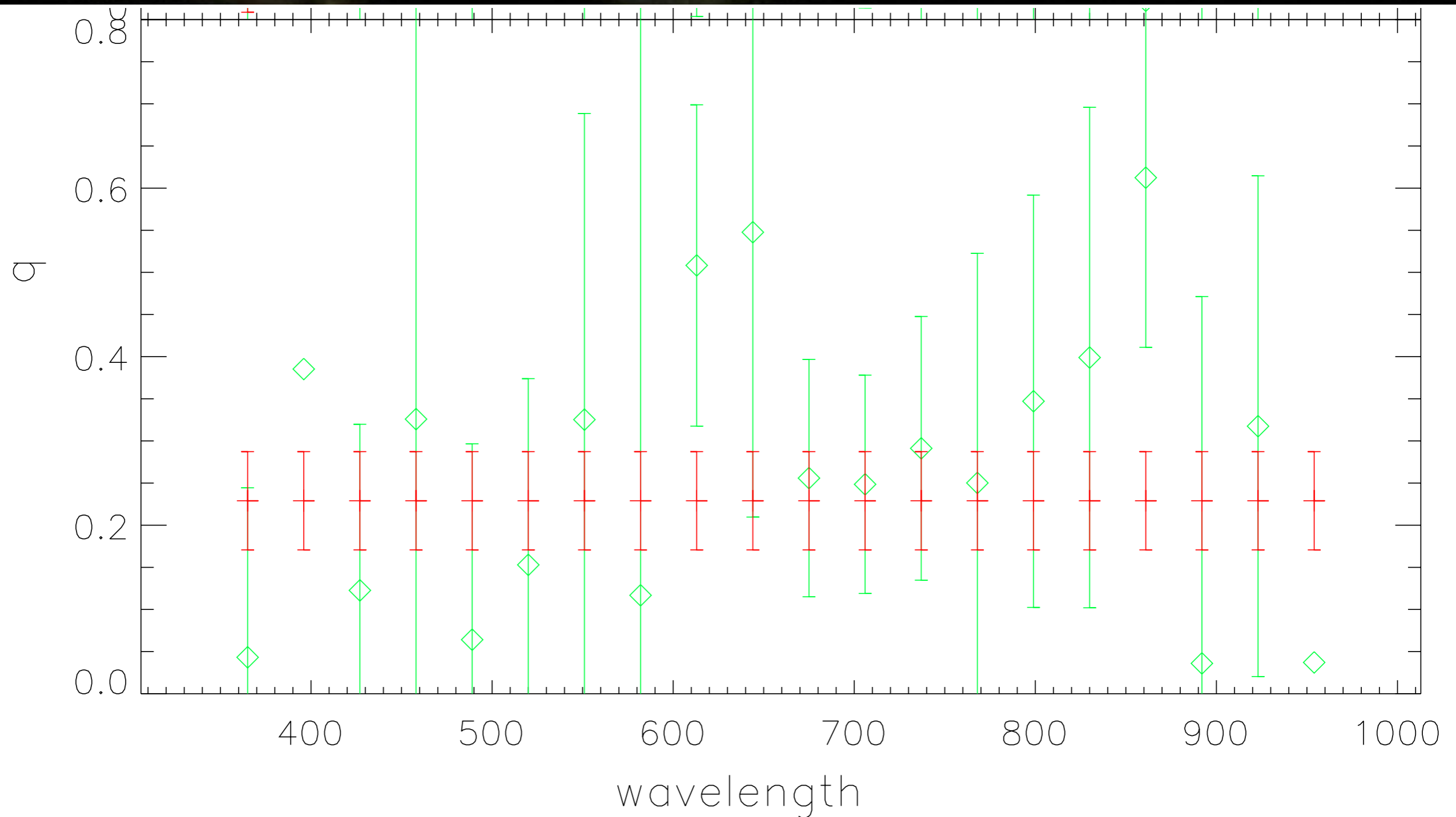
Helps with noisy bands



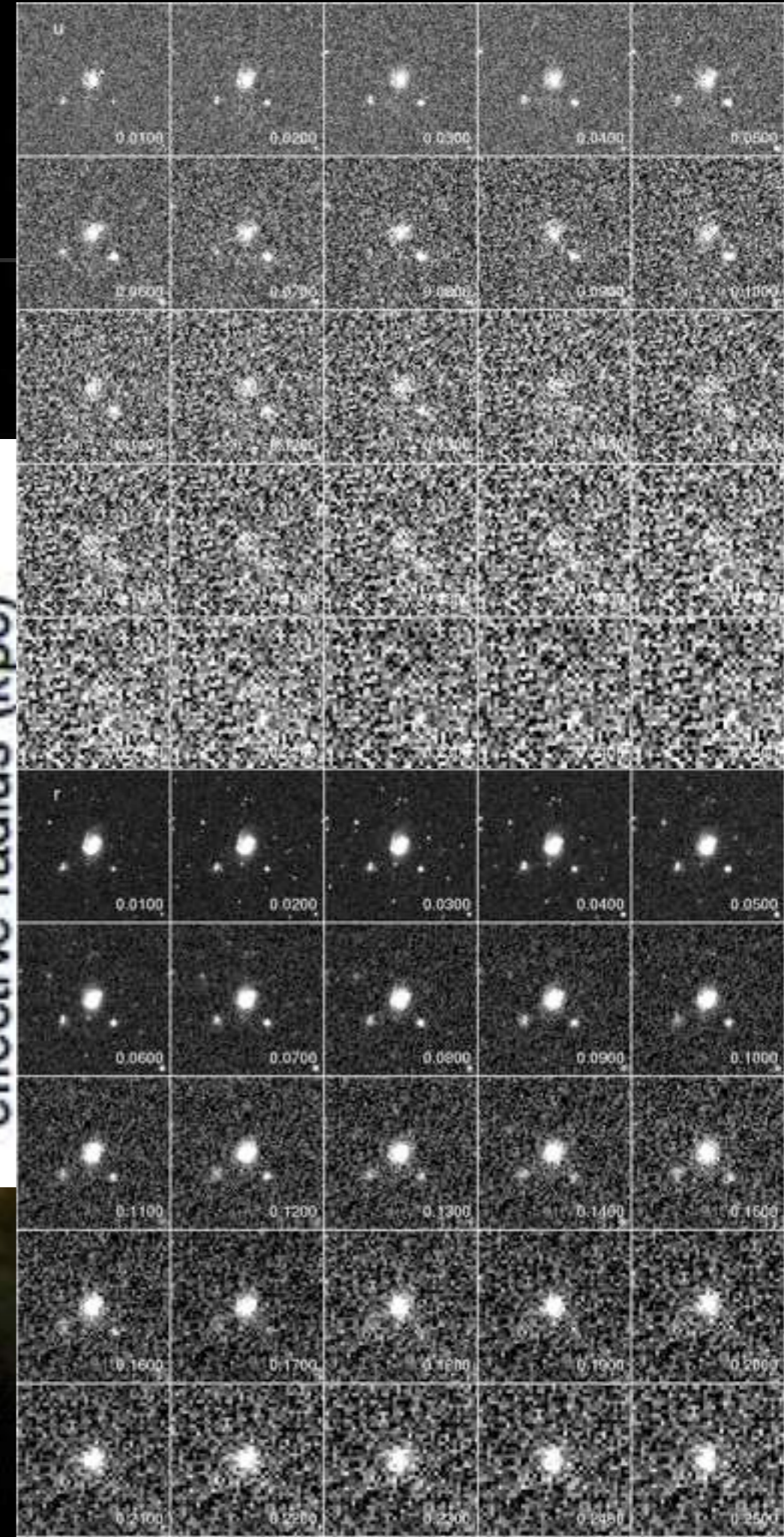
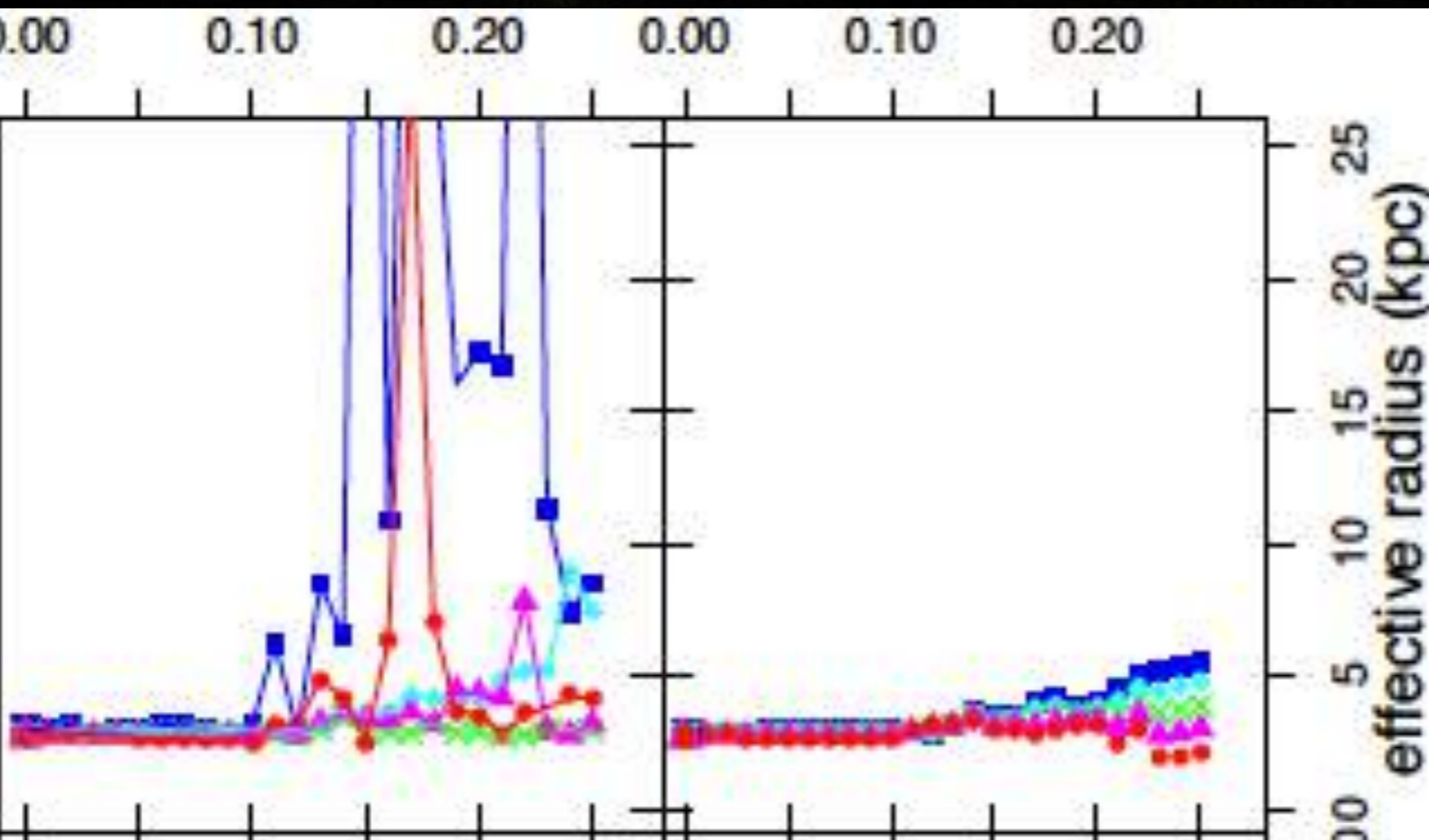
Helps with noisy bands



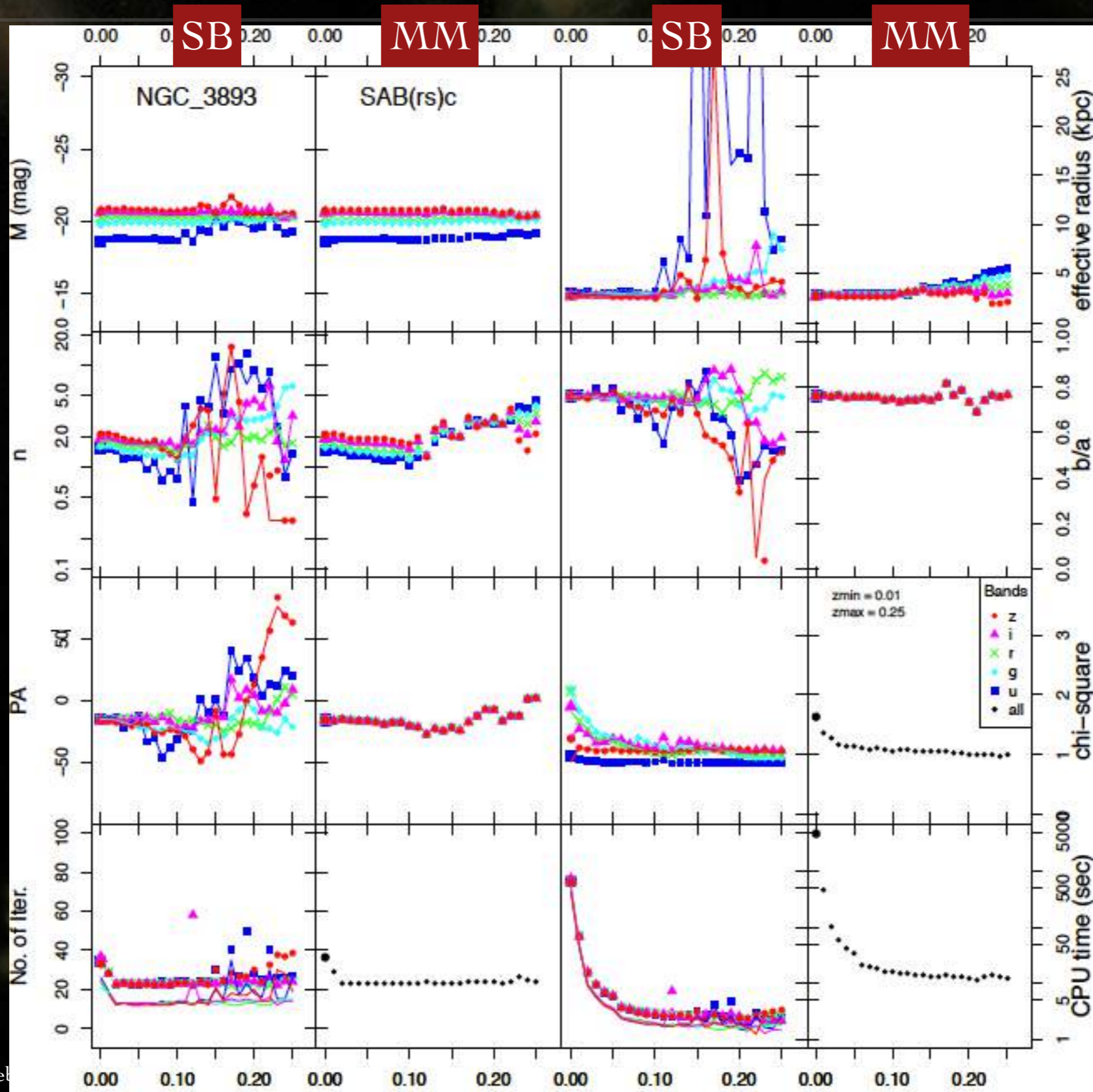
Helps with noisy bands



Parameters more stable

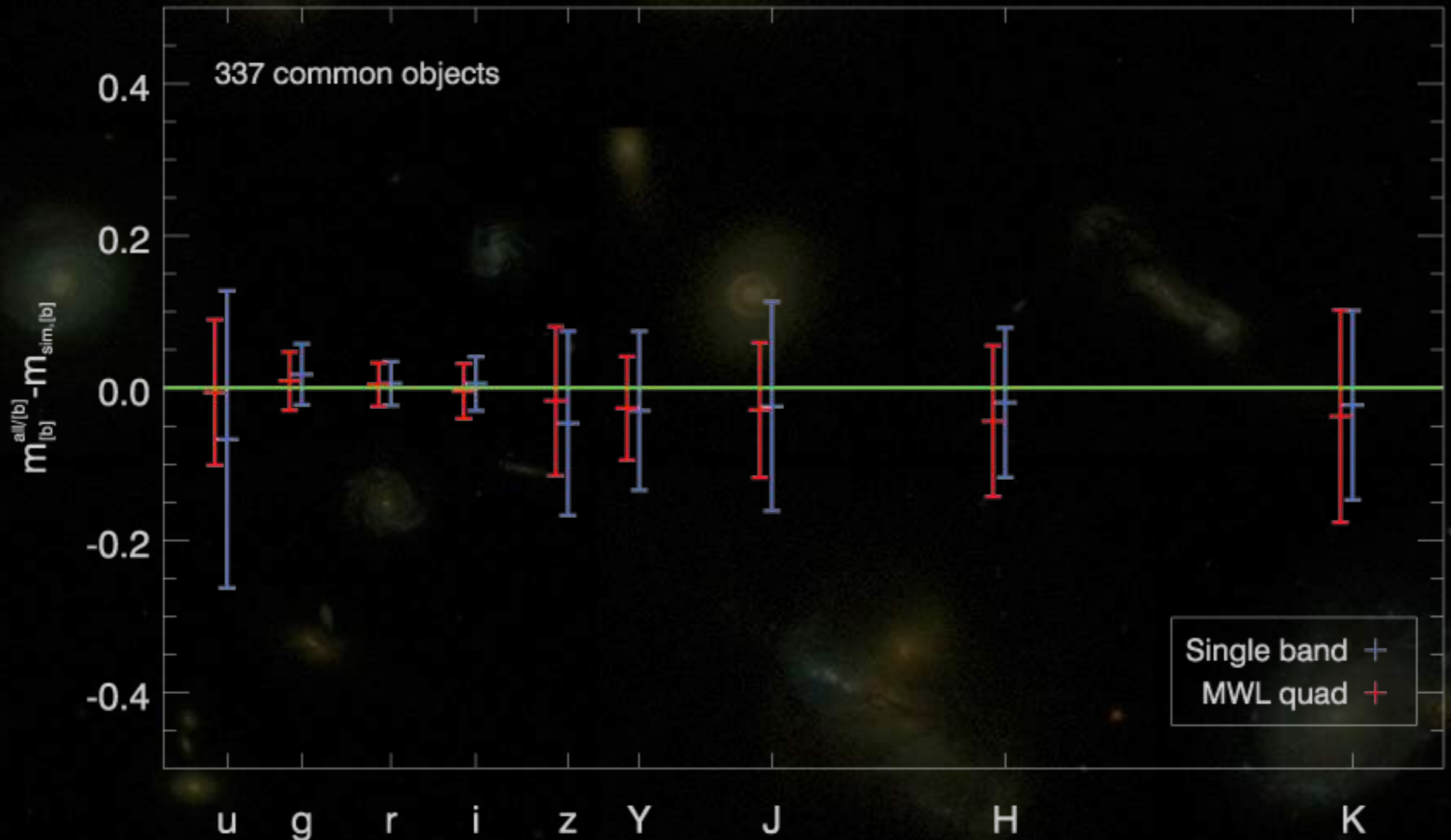


Parameters more stable

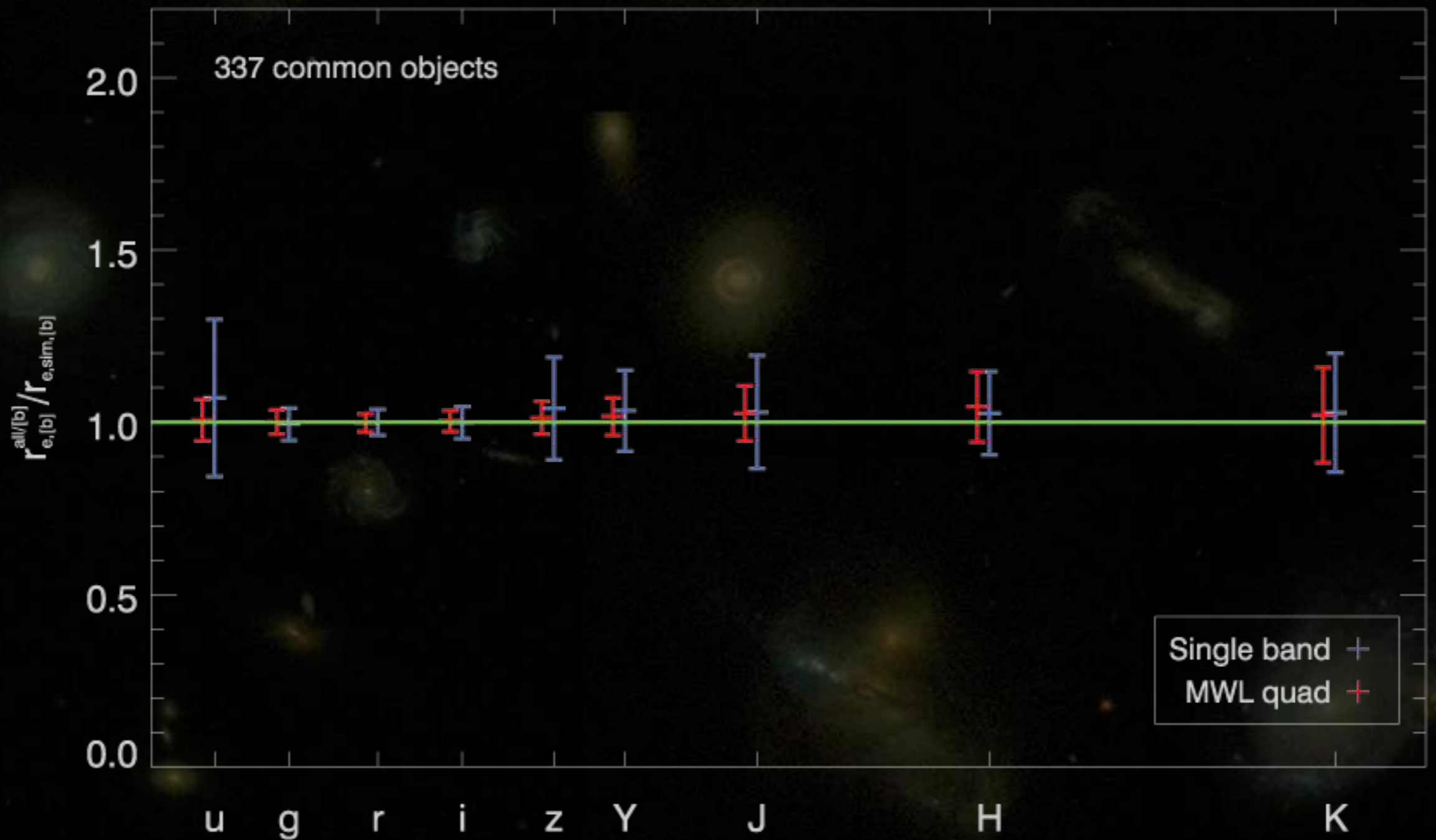


Parameters more accurate

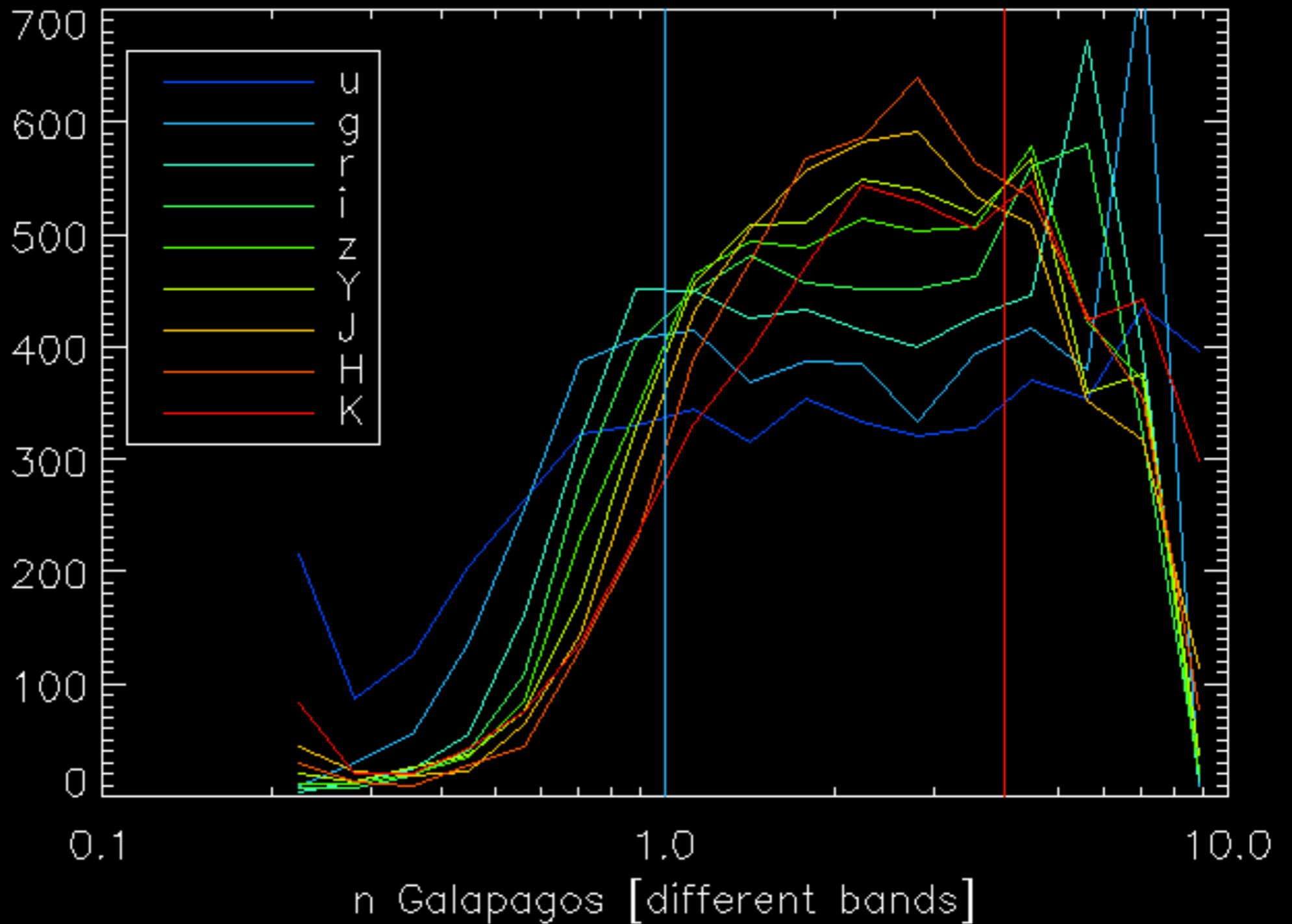
Simulations



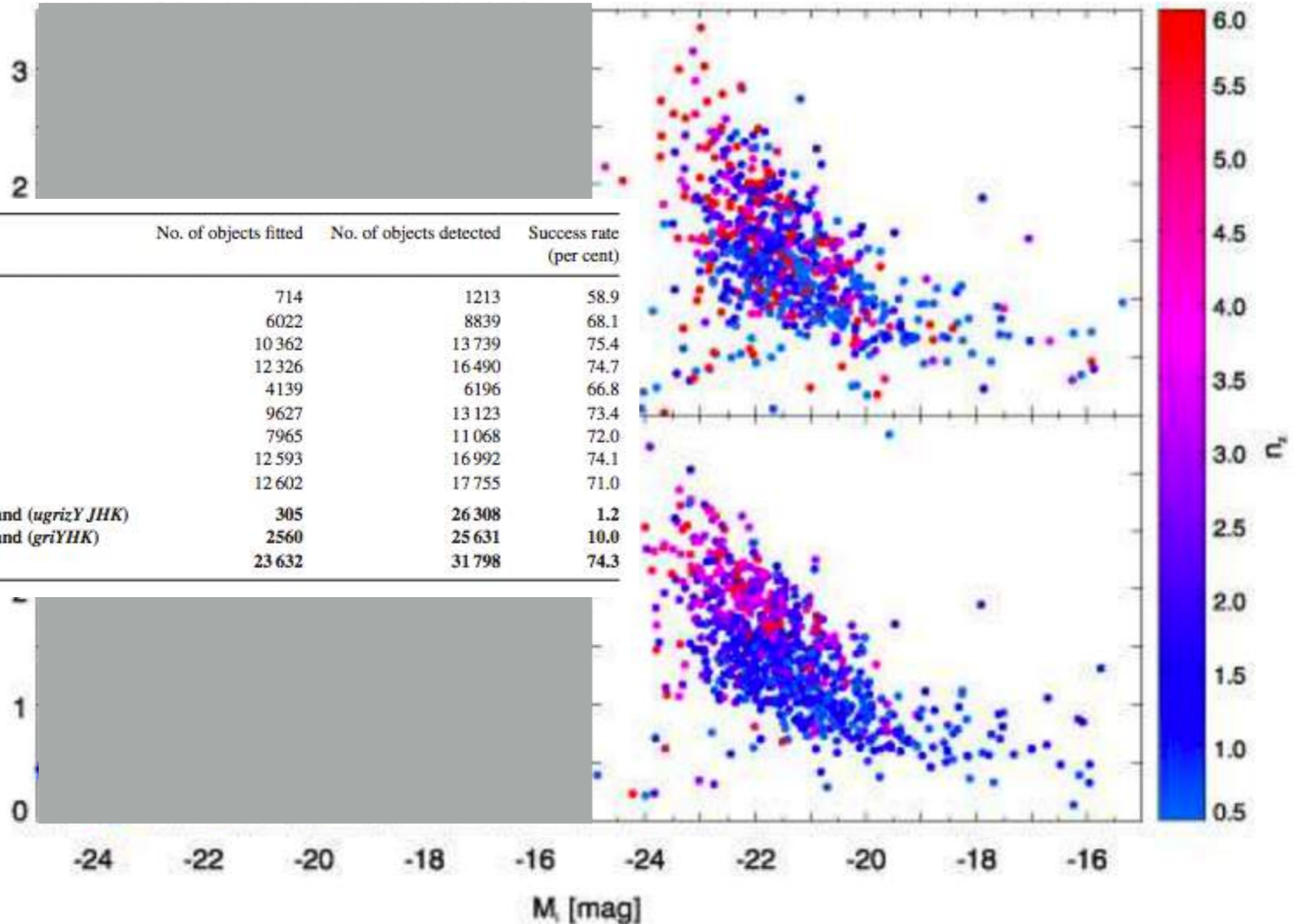
Parameters more accurate



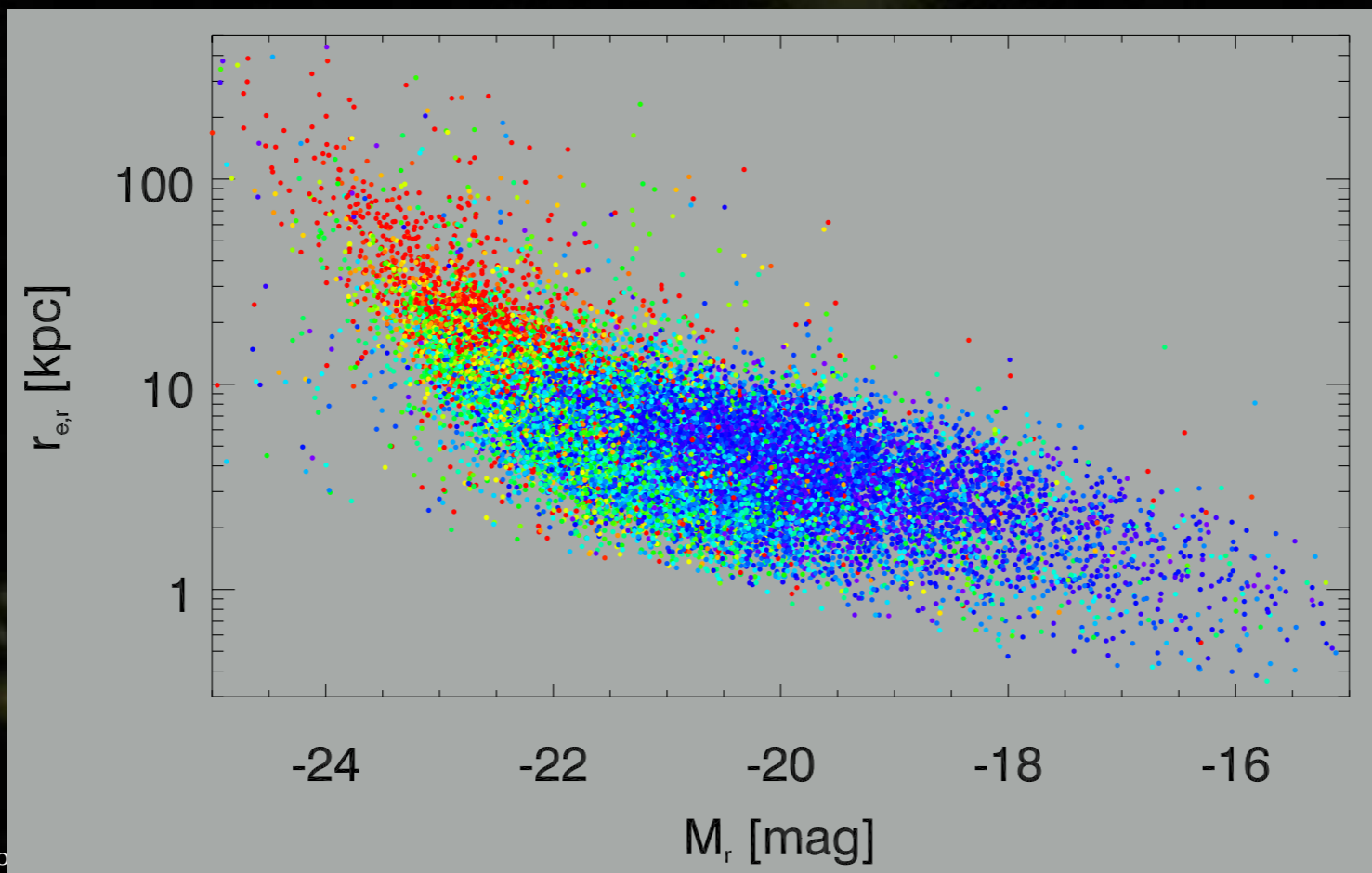
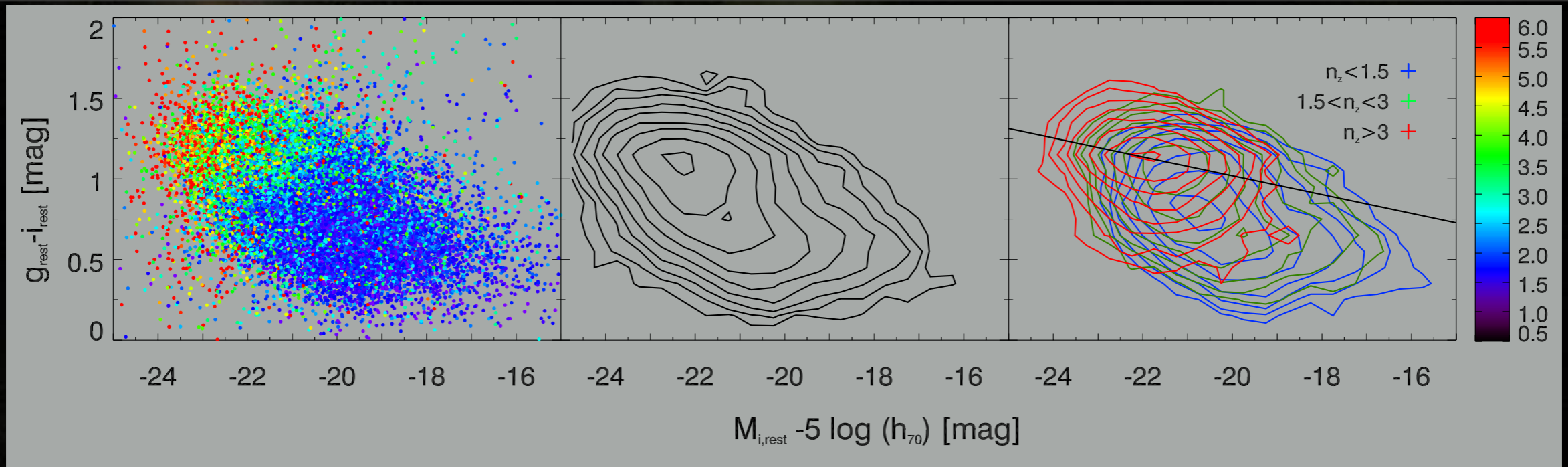
Science sanity checks



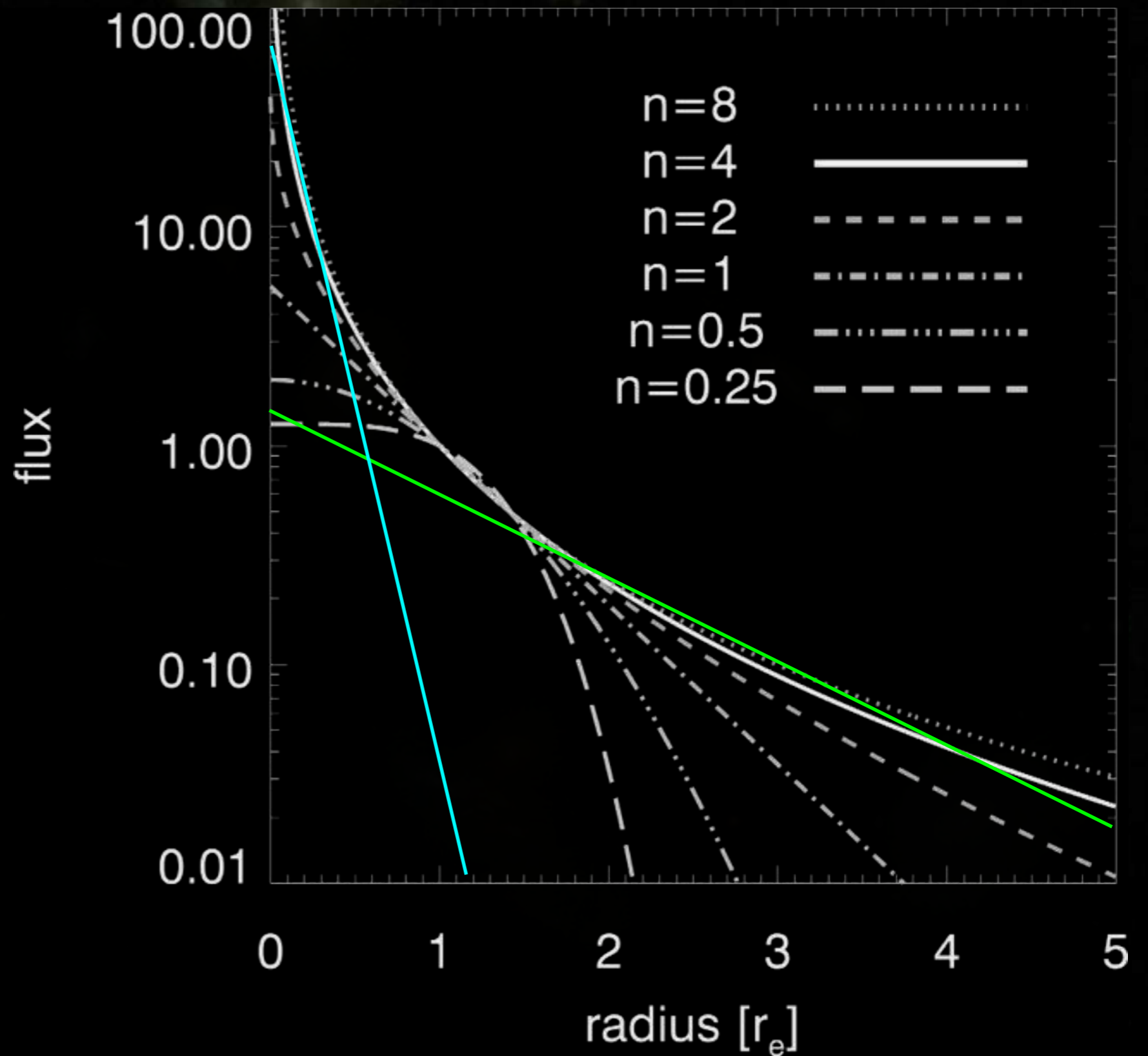
Science sanity checks



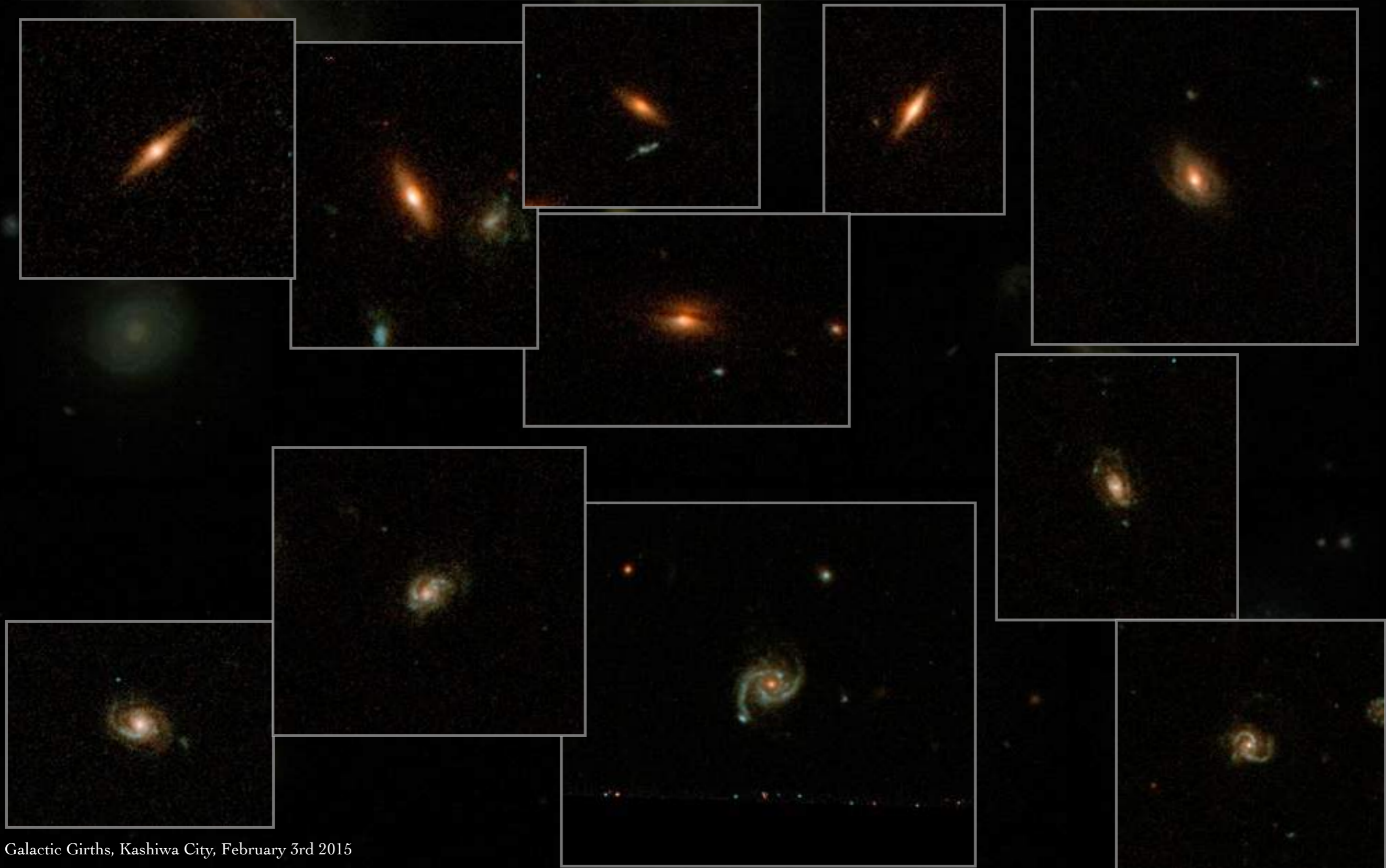
Science sanity checks



Possible contamination



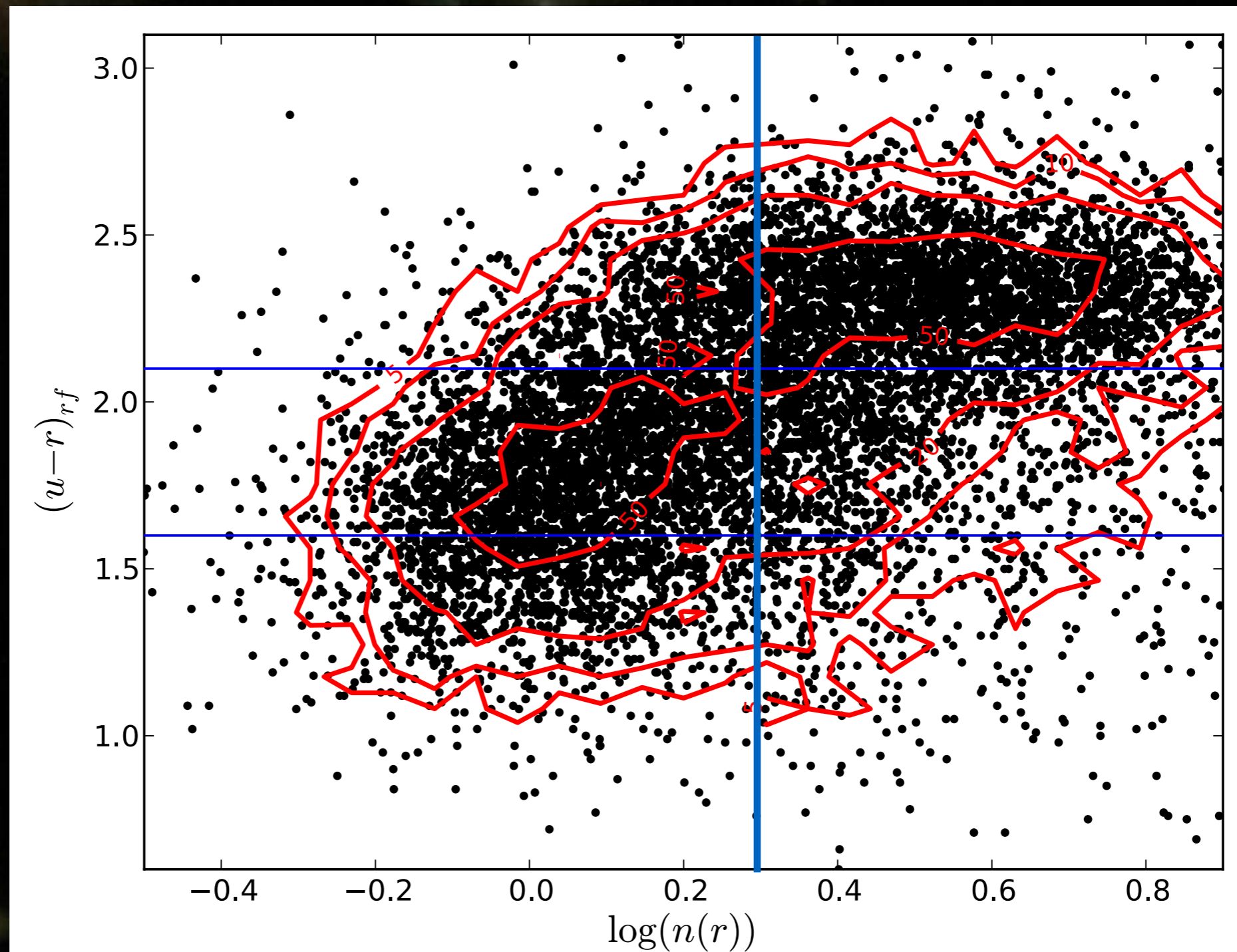
Possible contamination



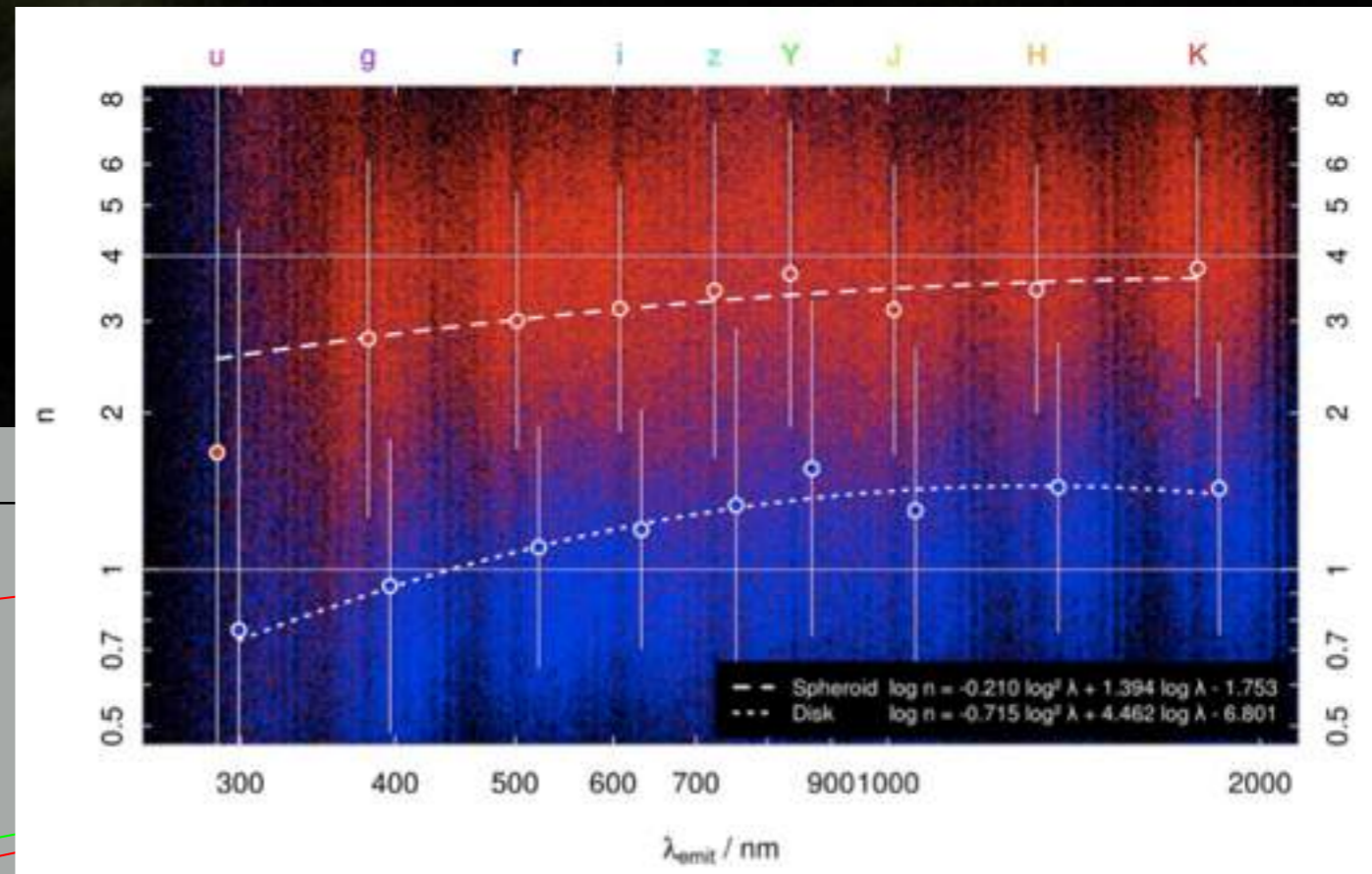
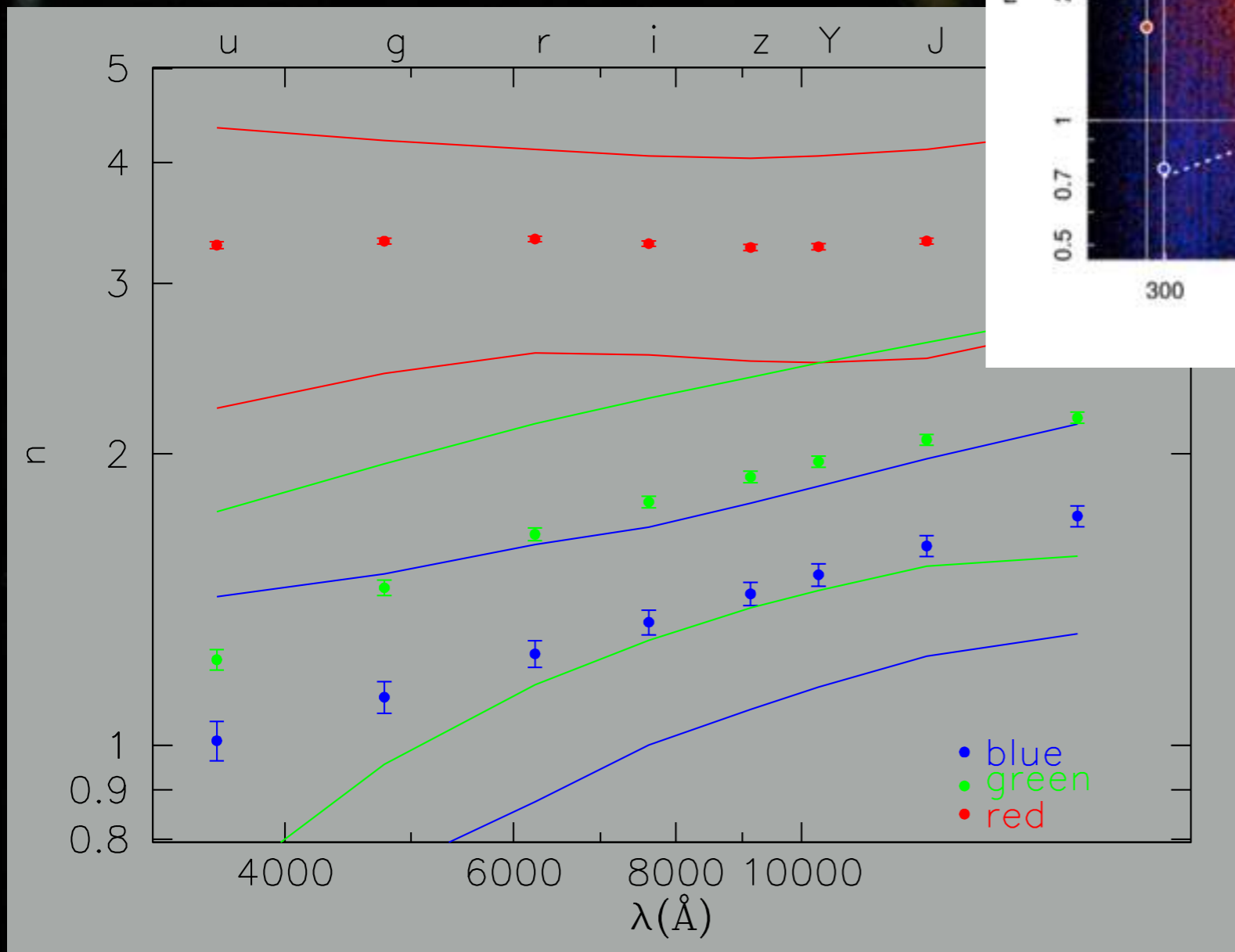
Code & Test-Summary

- Multi-wavelengths fitting:
 - slightly improves the accuracy for recovering mags and colours
 - increases fitting reliability for sizes and Sérsic indices
 - increases the sample size that can be used for science!!
 - allows higher quality fits out to higher redshifts
- Public tool(s) for everyone to use (public on website and github!)
 - (just google 'MegaMorph' and find our G+ community)
 - (ignore the Morphsuits)

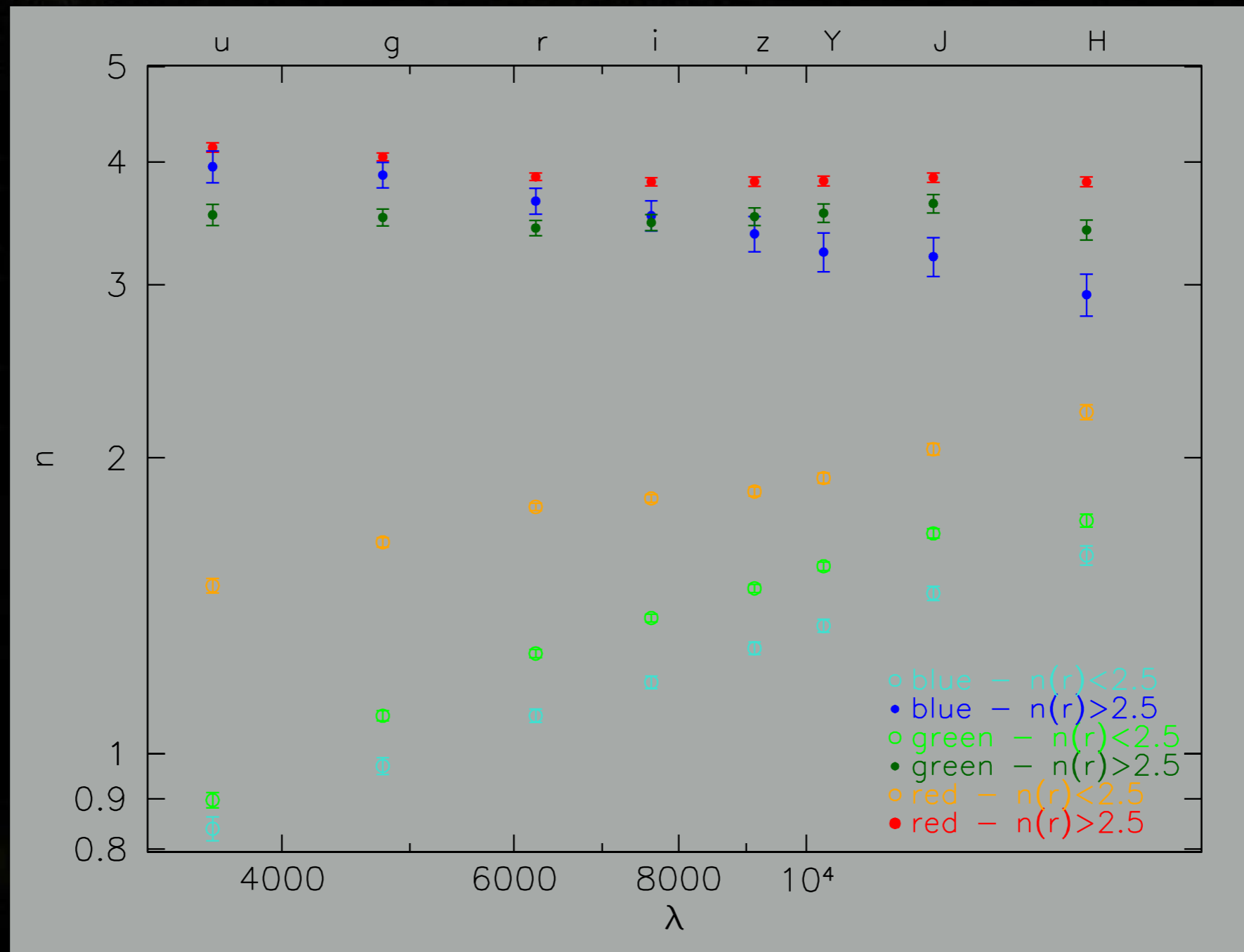
Usual classifications (u-r, n) don't work



Sérsic index changes with wavelength

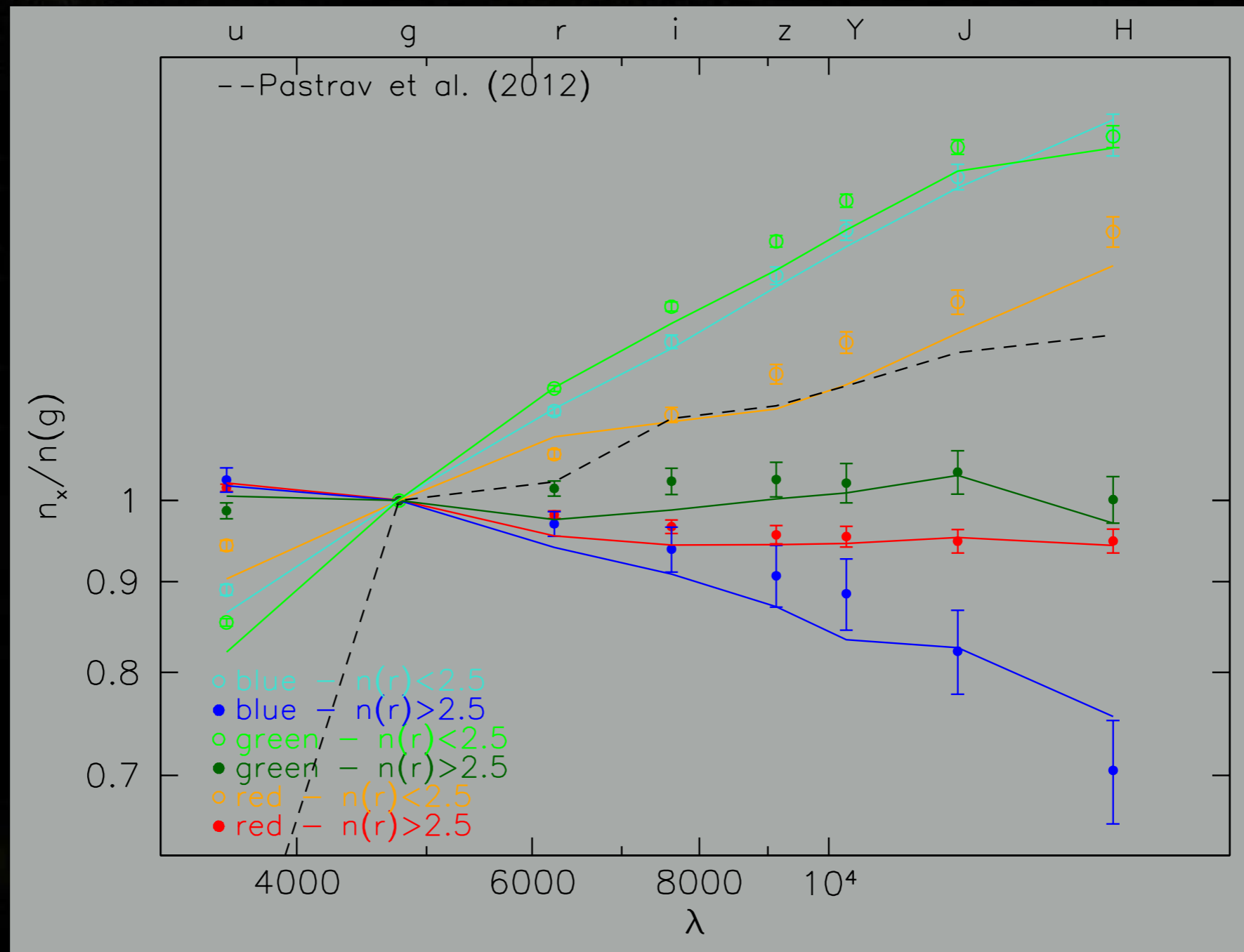


Un-mixing populations

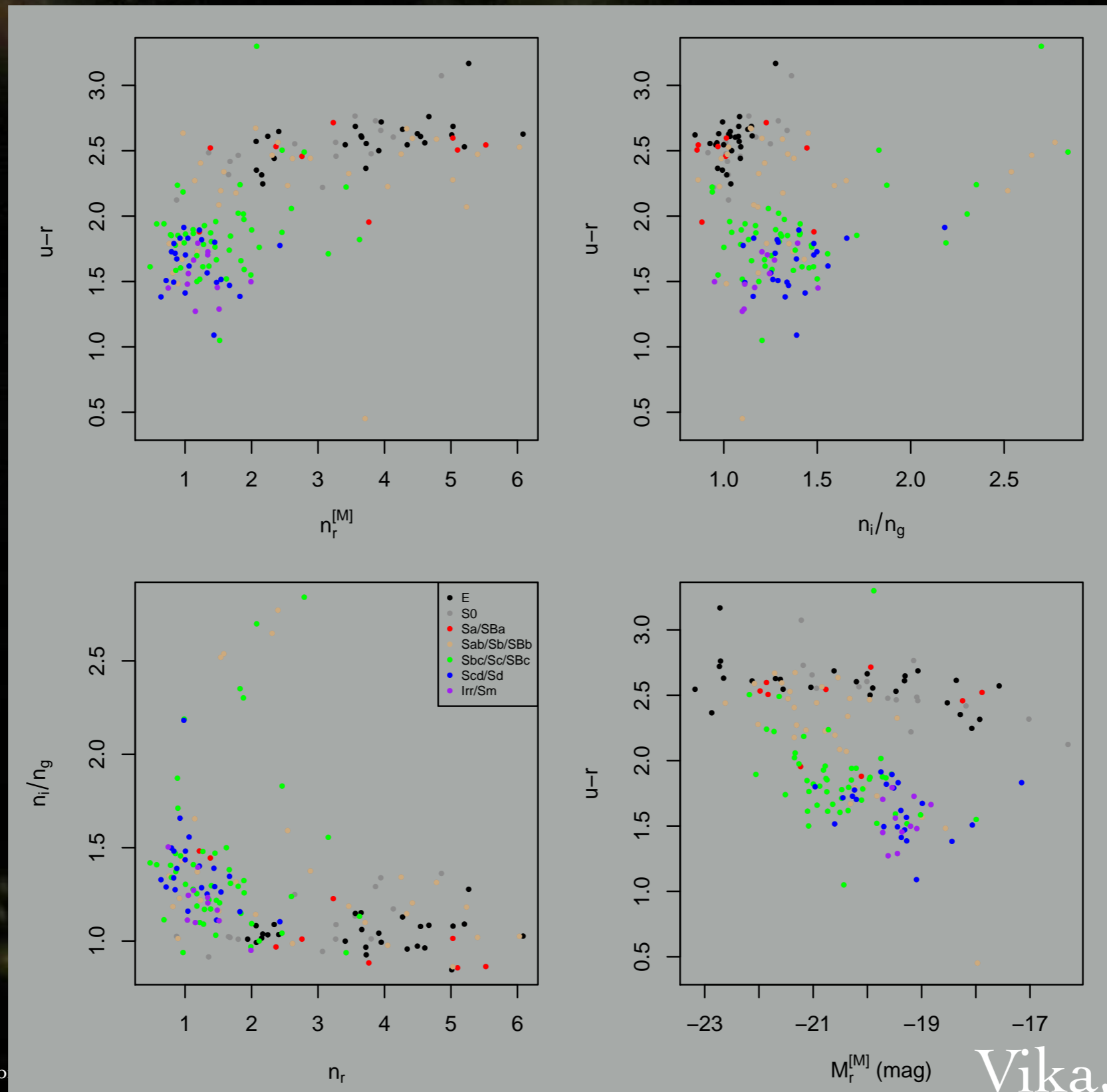


Defining \mathcal{N} as n ratios

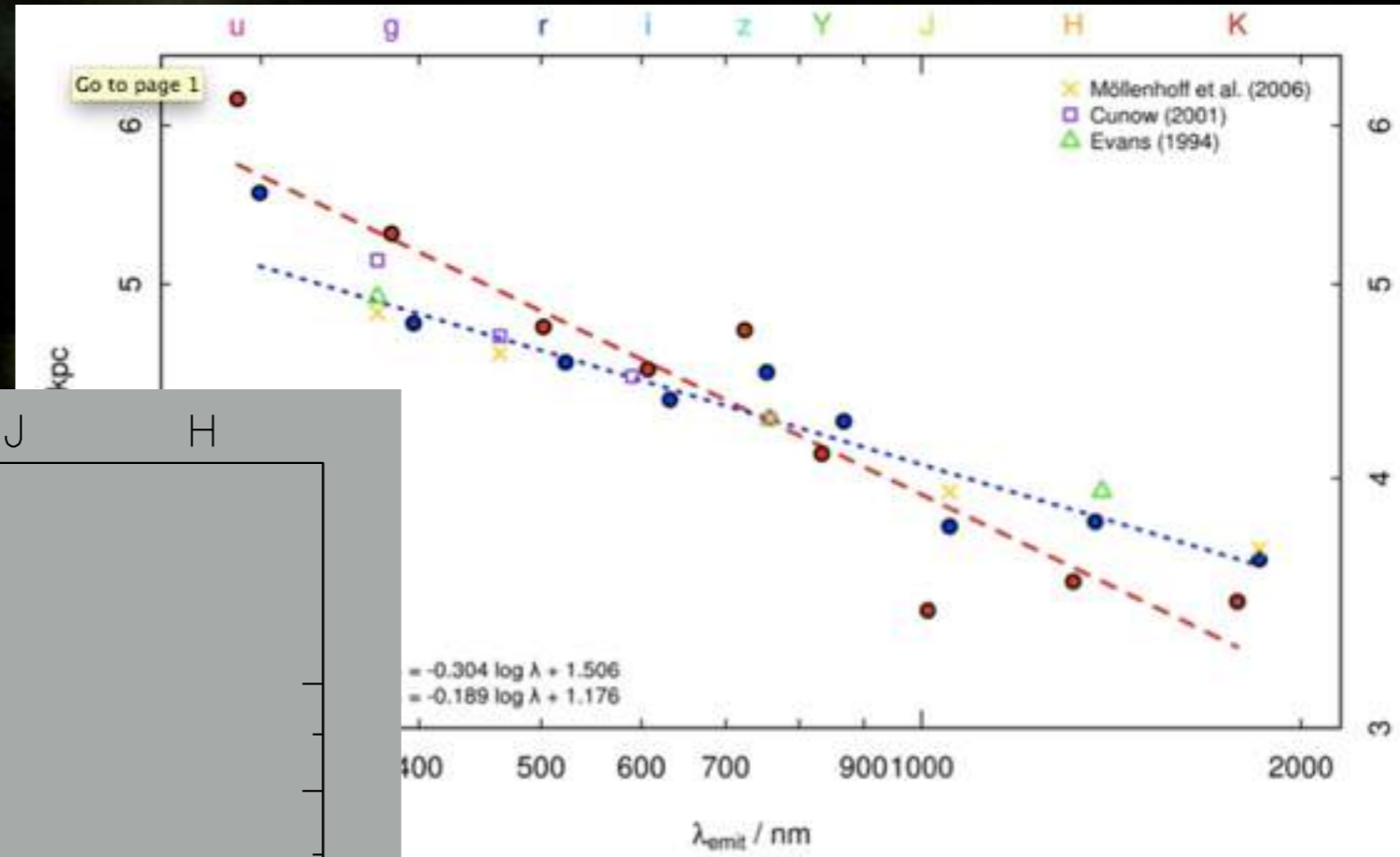
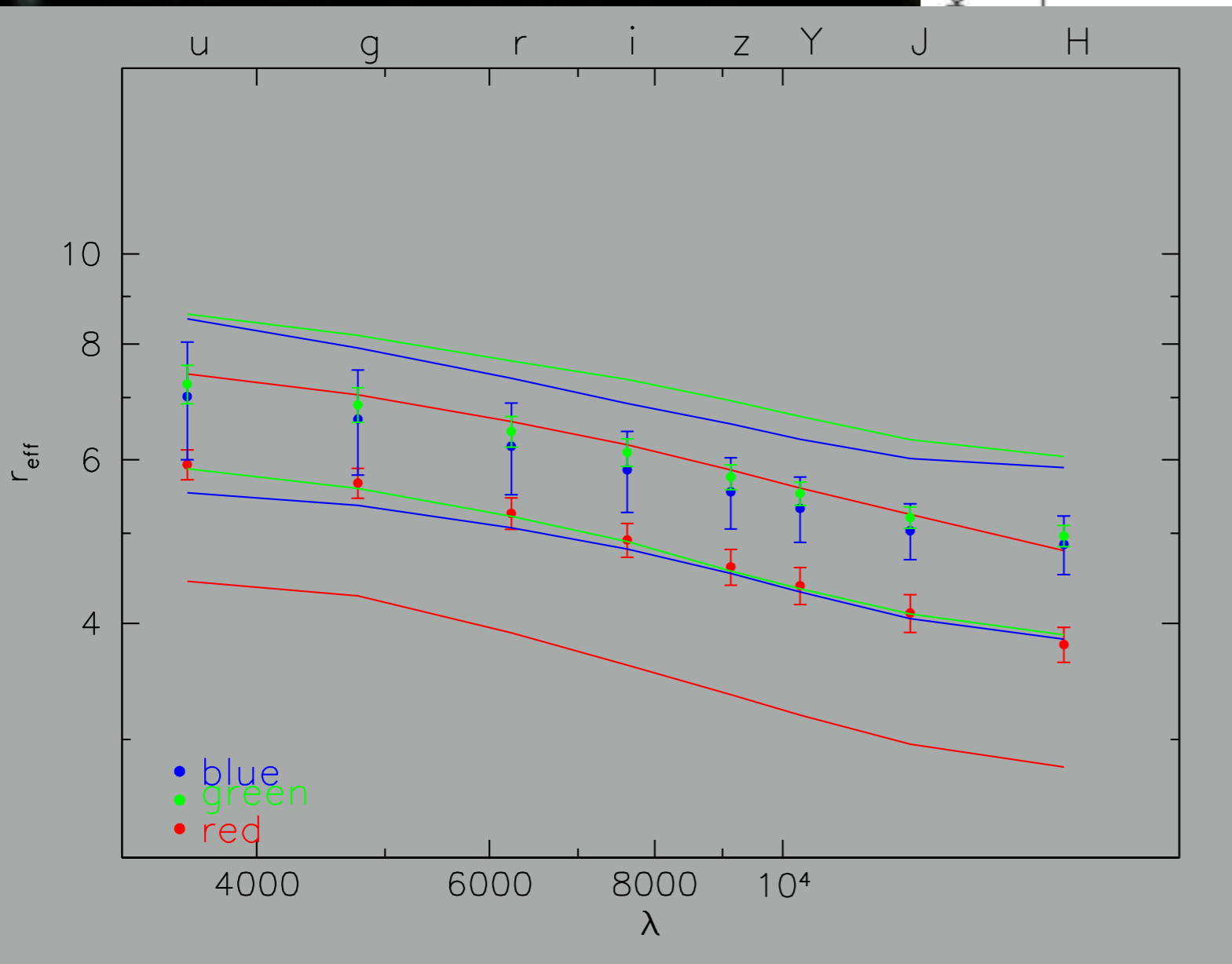
- possibly some dust effect



Is \mathcal{N} usable to classify galaxies?

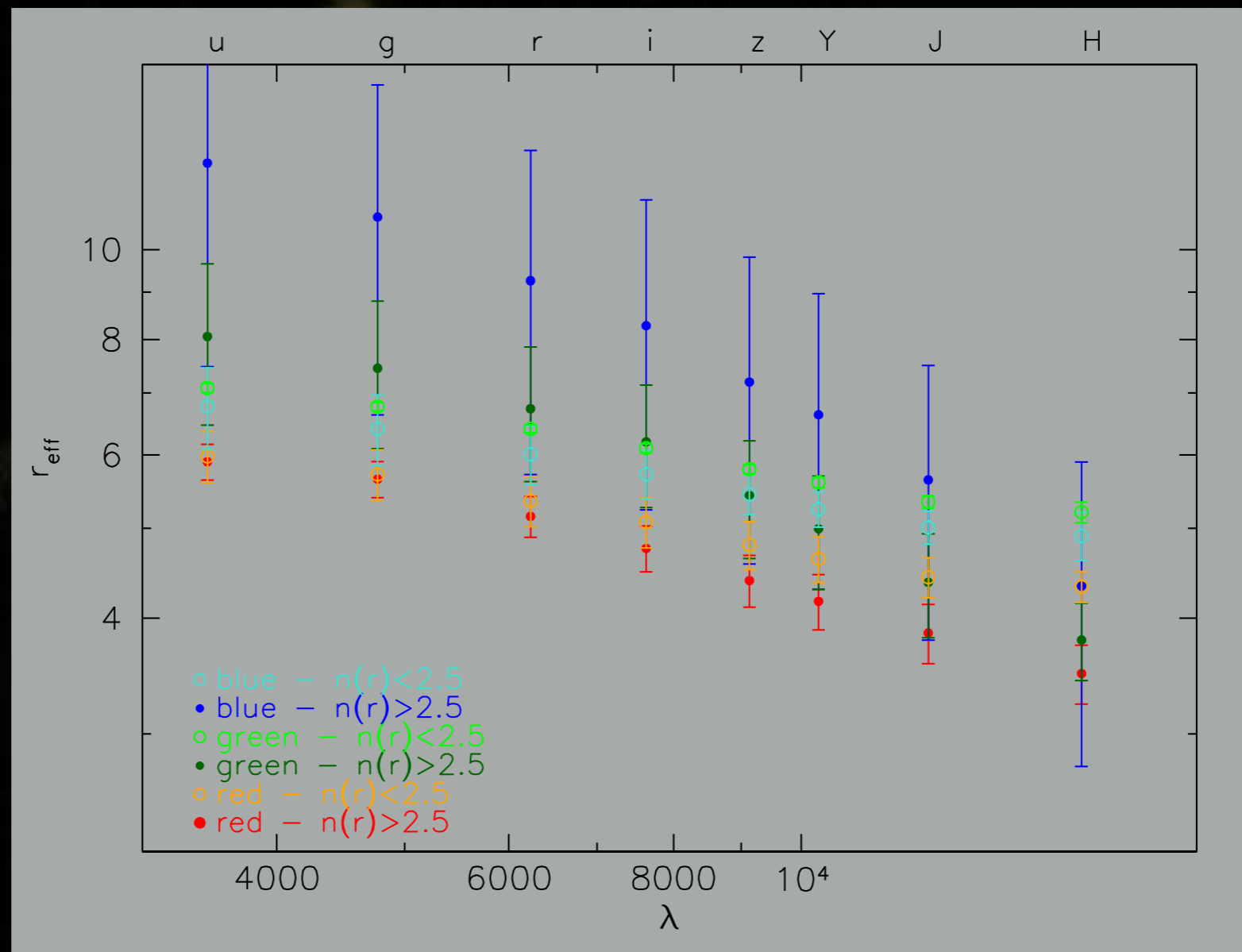


Radius r_e changes with



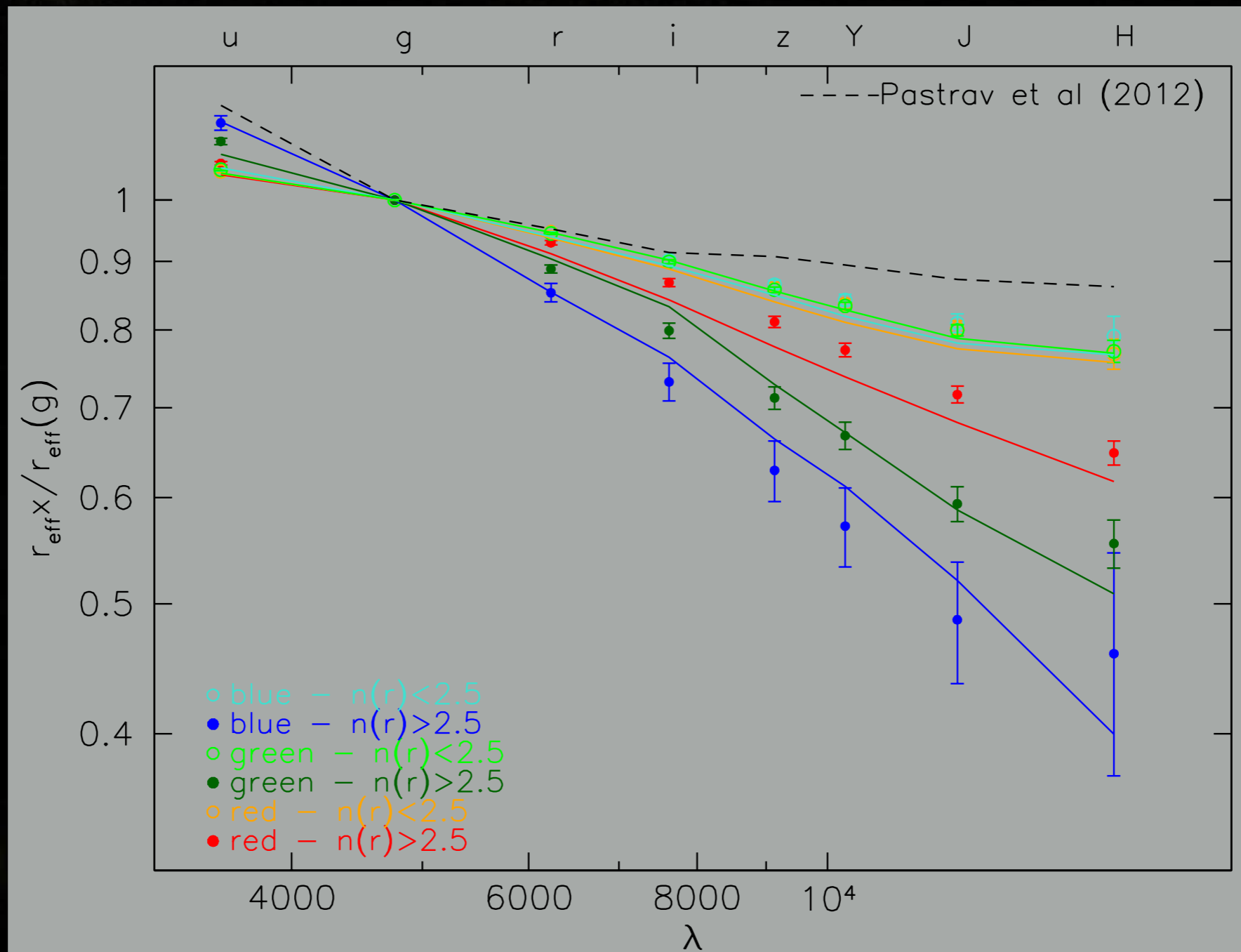
Un-mixing populations

- $n > 2.5$ shows steeper decrease
- red $n > 2.5$: constant n , but r_e decreases nearly by factor of 2!



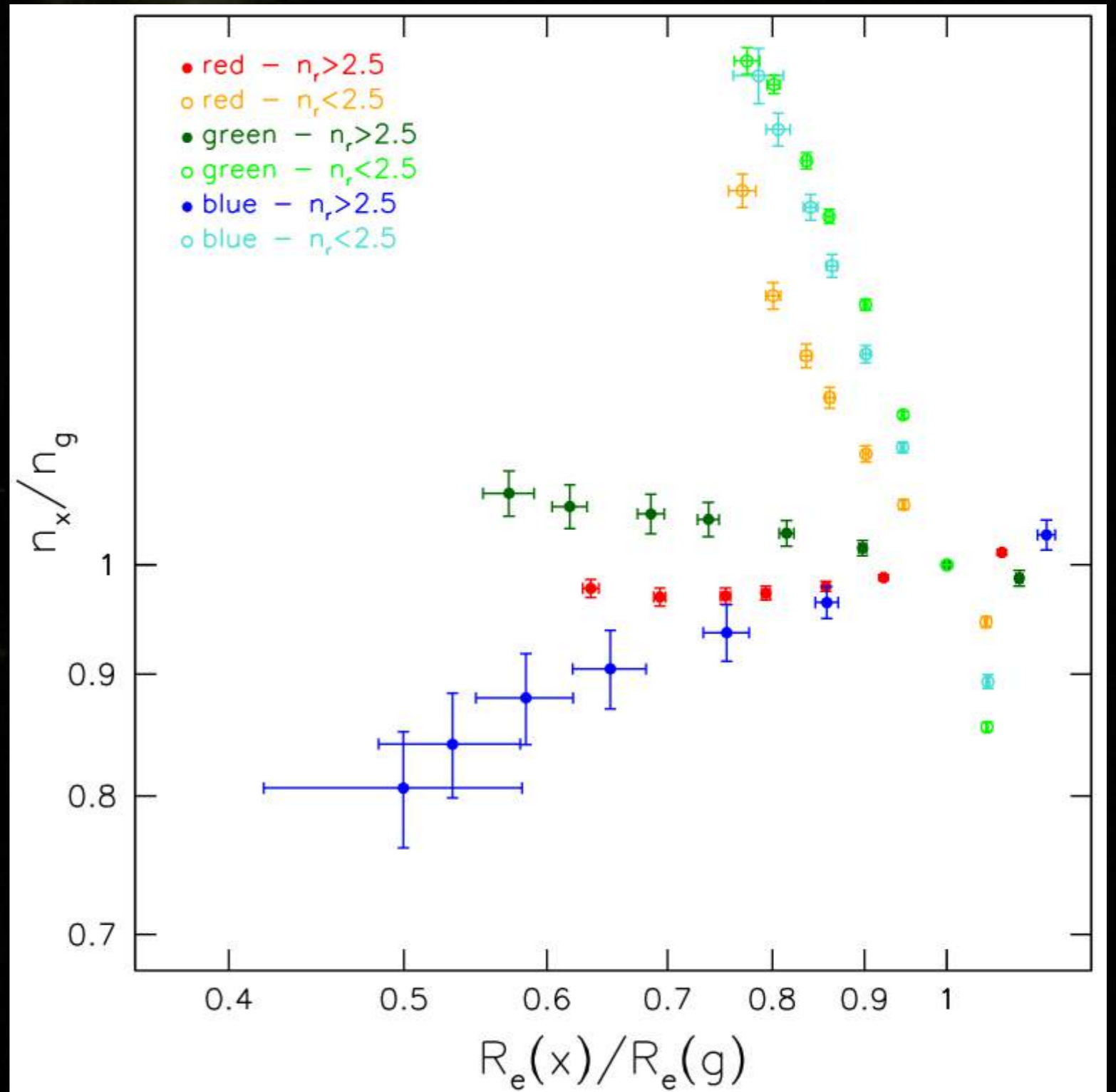
Defining \mathcal{R} as re ratios

- $n < 2.5$ indistinguishable

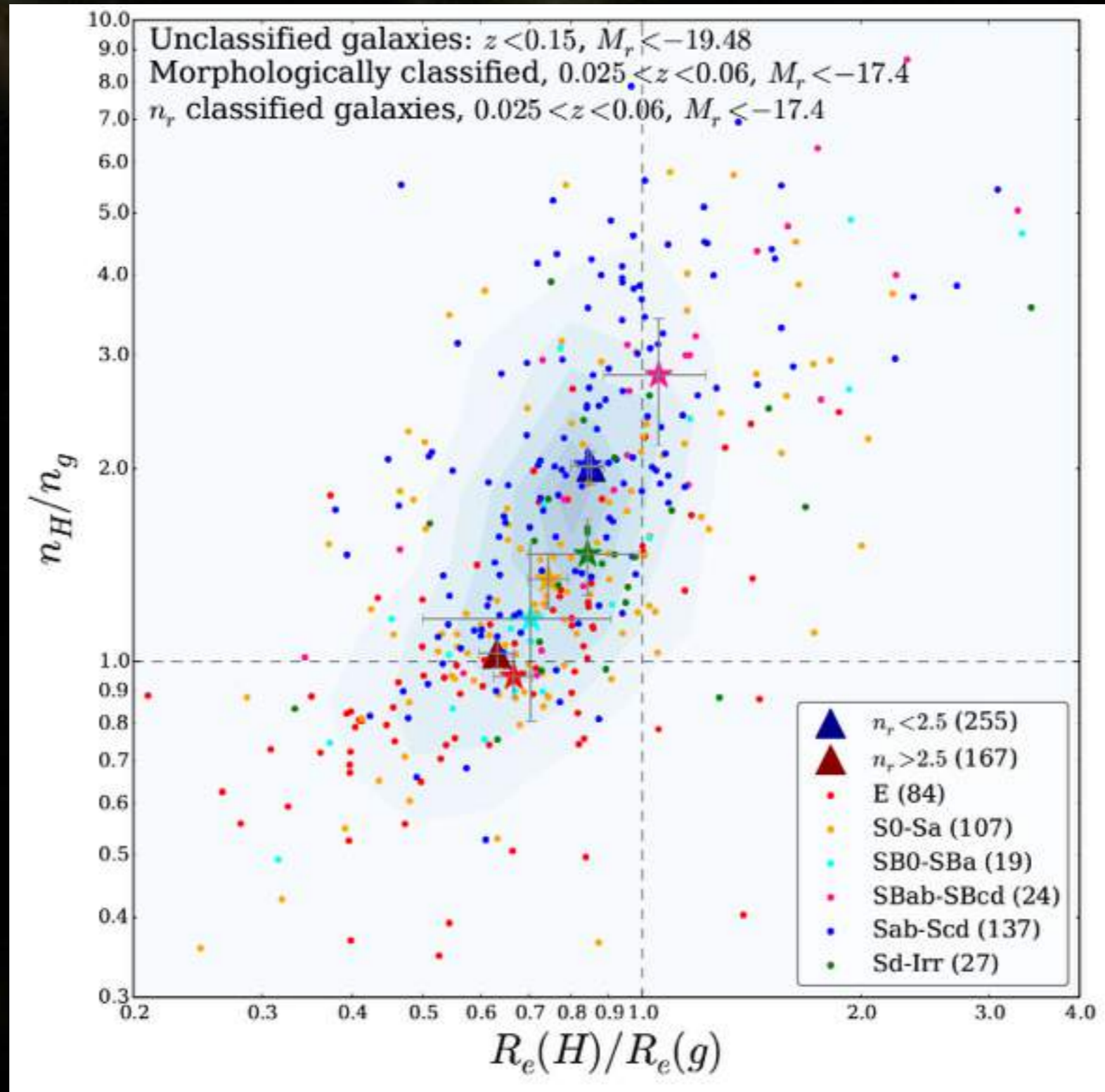


\mathcal{N} vs. \mathcal{R}

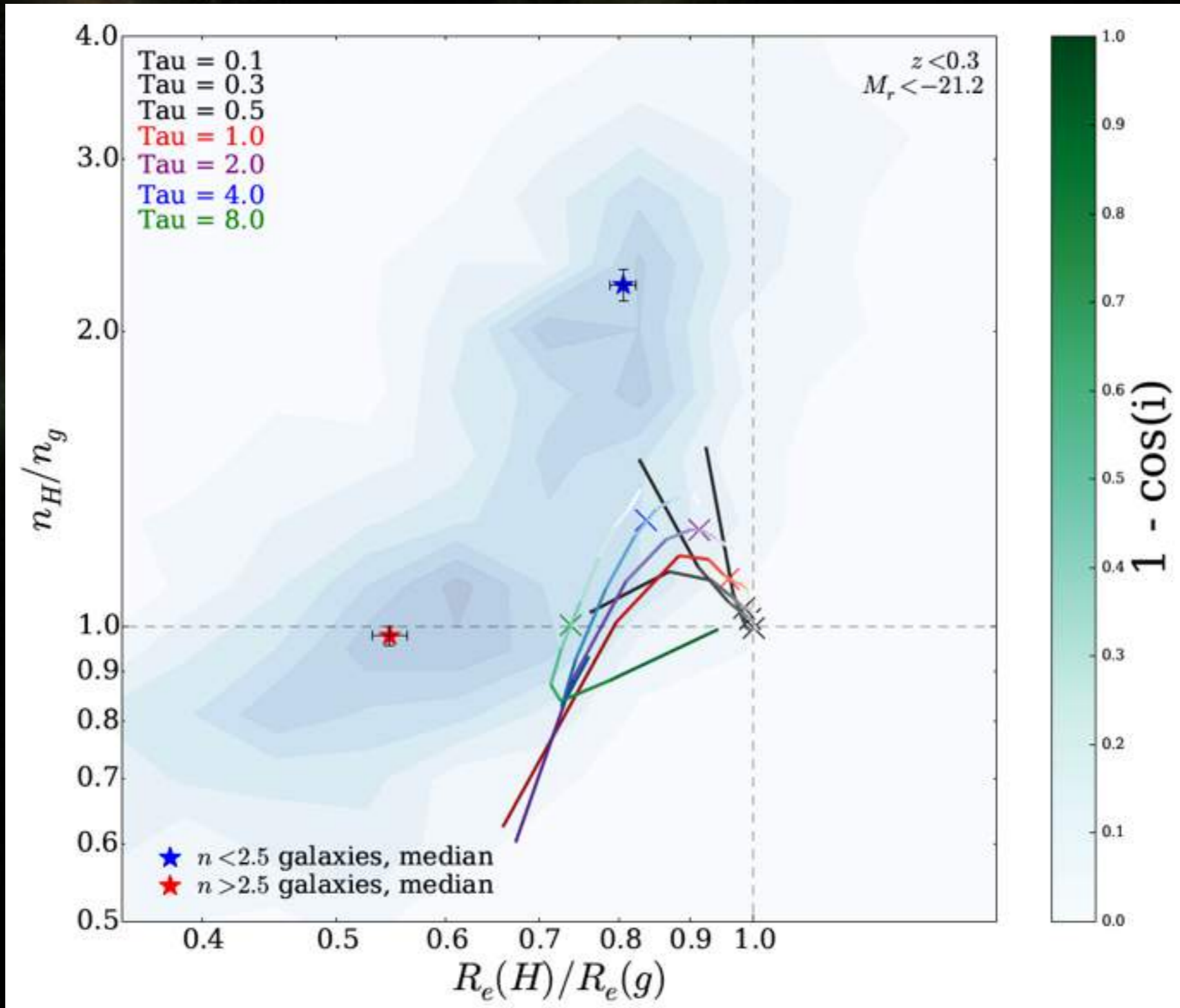
- low- n galaxies show constant \mathcal{R} , varying \mathcal{N}
- high- n galaxies show constant \mathcal{N} , varying \mathcal{R}
- -> classification without using n or colour itself?
- These results are independent of redshift (Kennedy, in prep)



\mathcal{N} and \mathcal{R} 'agree' with visual classification



Dust opacity and inclination cause scatter

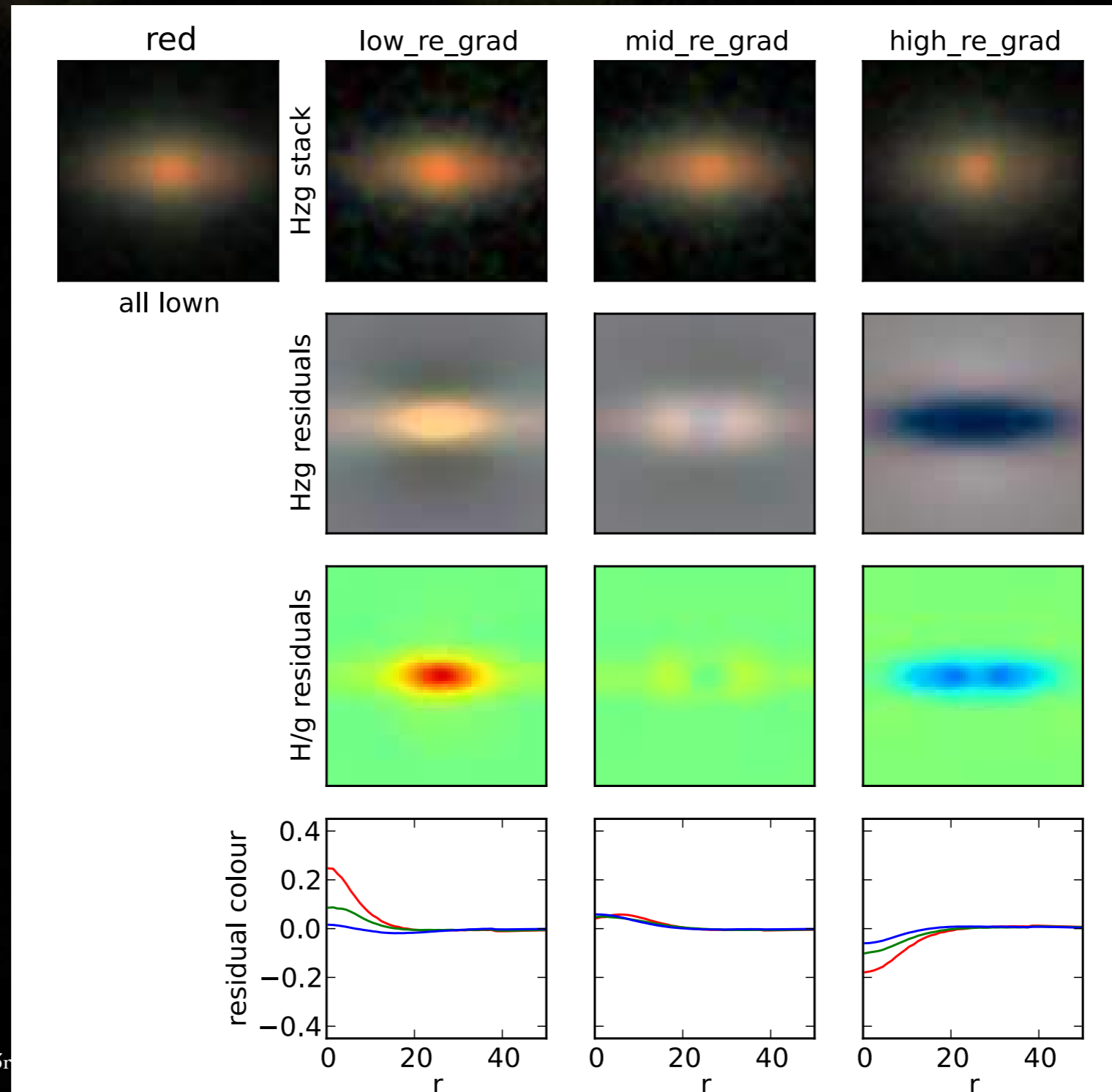


Possible interpretation?

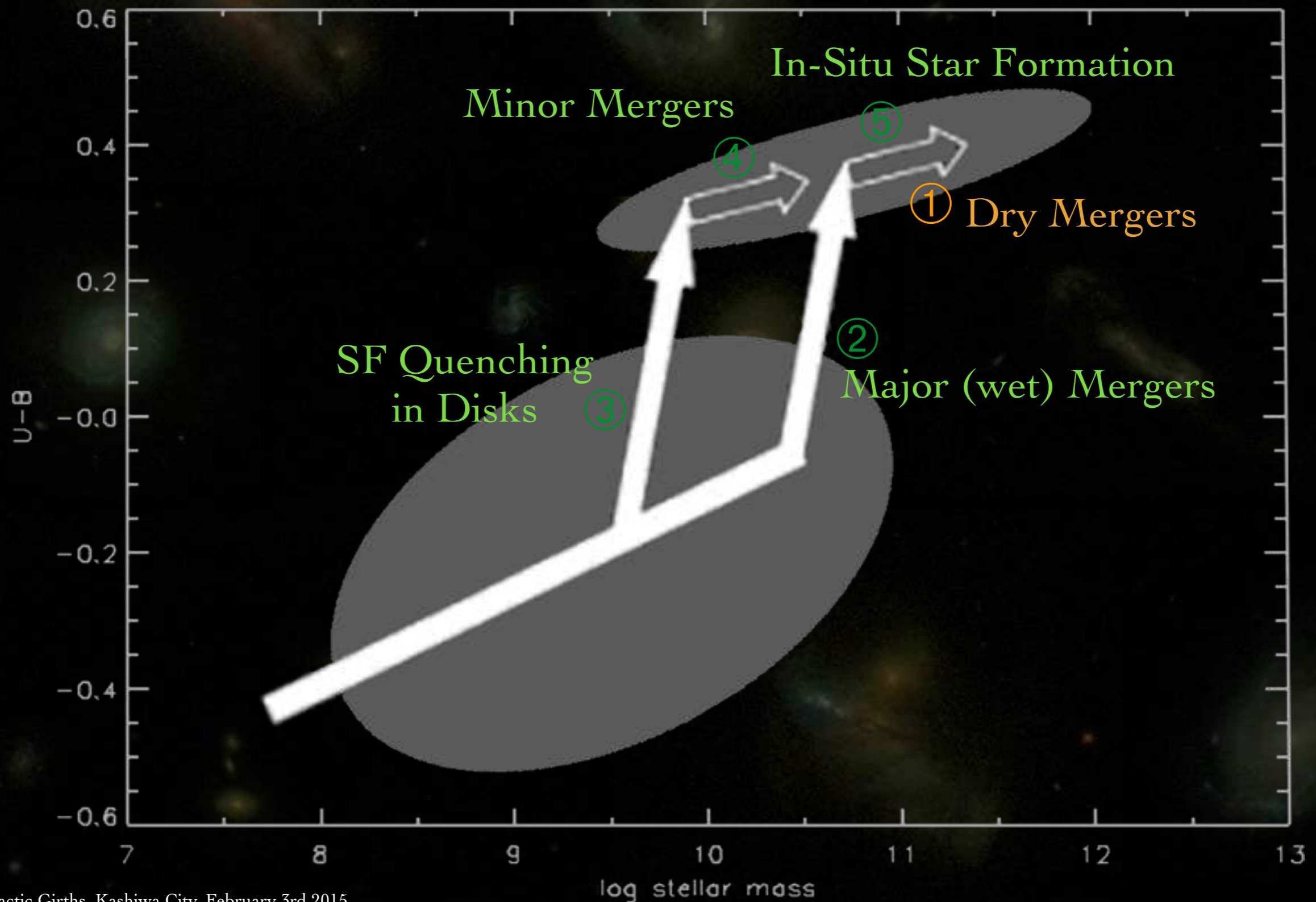


Possible interpretation?

- $\mathcal{N} = n_H/n_g$ and $\mathcal{R} = r_H/r_g$ describe colour gradient!



Colour Gradients are important



Summary

- Don't waste Photons! They contain valuable information!
- MegaMorph improves fitting accuracy!
accurate measurements, higher redshift, bigger samples, internal colour gradients, separate individual galaxy components
- Change in Sérsic index with wavelength reflects galaxy structure (robust to $z = 0.3$, Kennedy, in prep.)
- MegaMorph can help us identify key observables in the evolution of galaxies
- More cool stuff to come! E.g. B/D papers and using this technique on IFU data in order to get the spectra of the individual components (Johnston, in prep.)
- Code released on github and websites. Please ask and/or use it! And adapt it!
- For Bulge/Disk decompositions, wait for Marina Vikas talk.
- I don't have any question. Do you?