

The Intrinsic Shapes of High-Redshift Galaxies

Yu-Yen Chang

with

Arjen van der Wel (MPIA),

Hans-Walter Rix (MPIA),

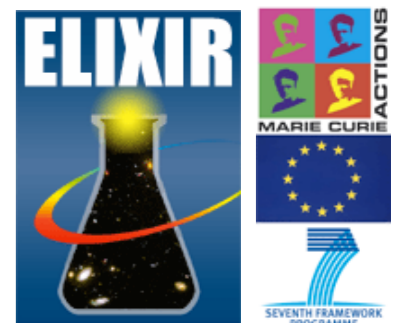
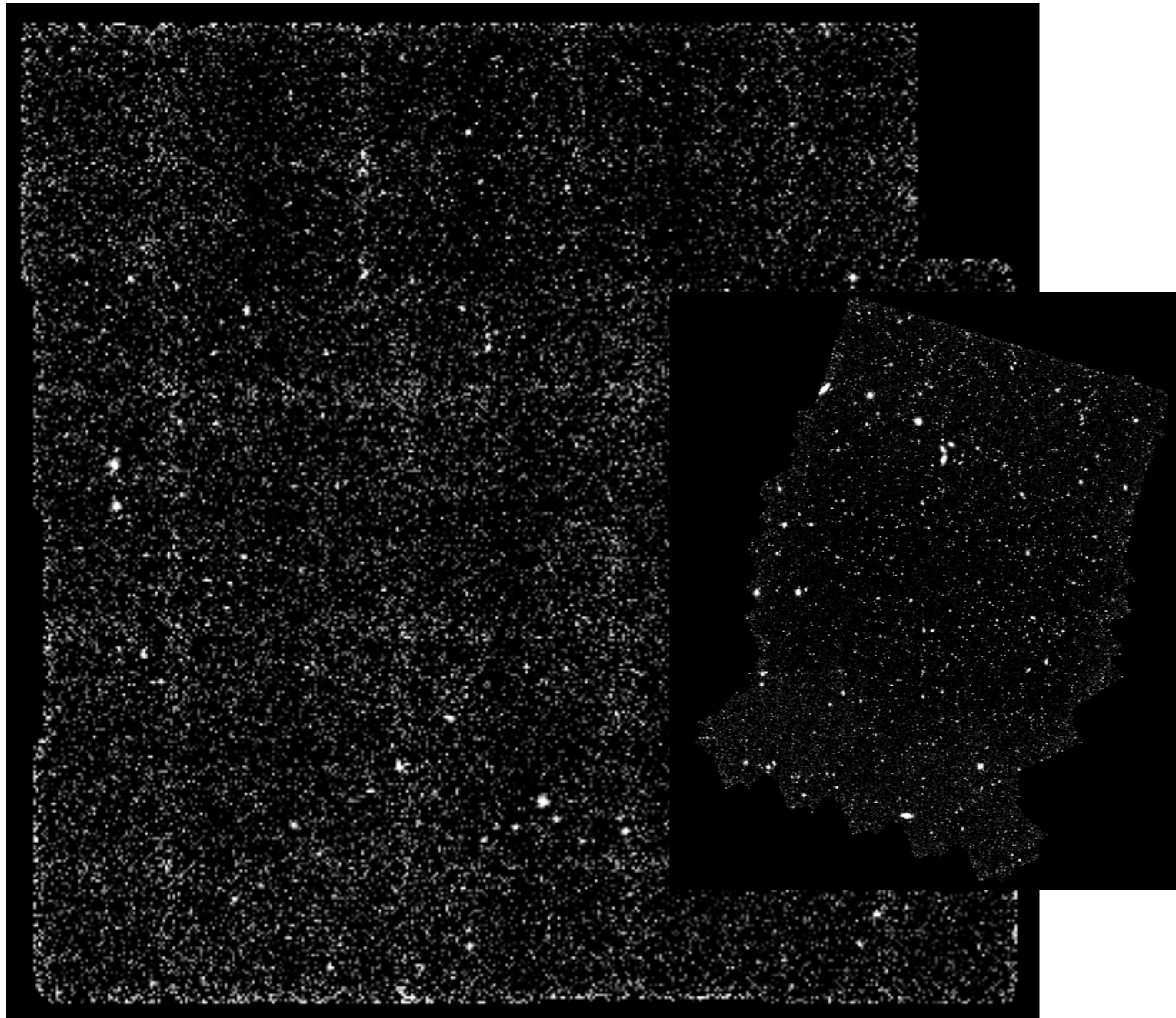
Stijn Wuyts (MPE),

Stefano Zibetti (INAF),

Balasubramanian Ramkumar (MPIA),

Bradford Holden (UCO/LICK),

and CANDELS team

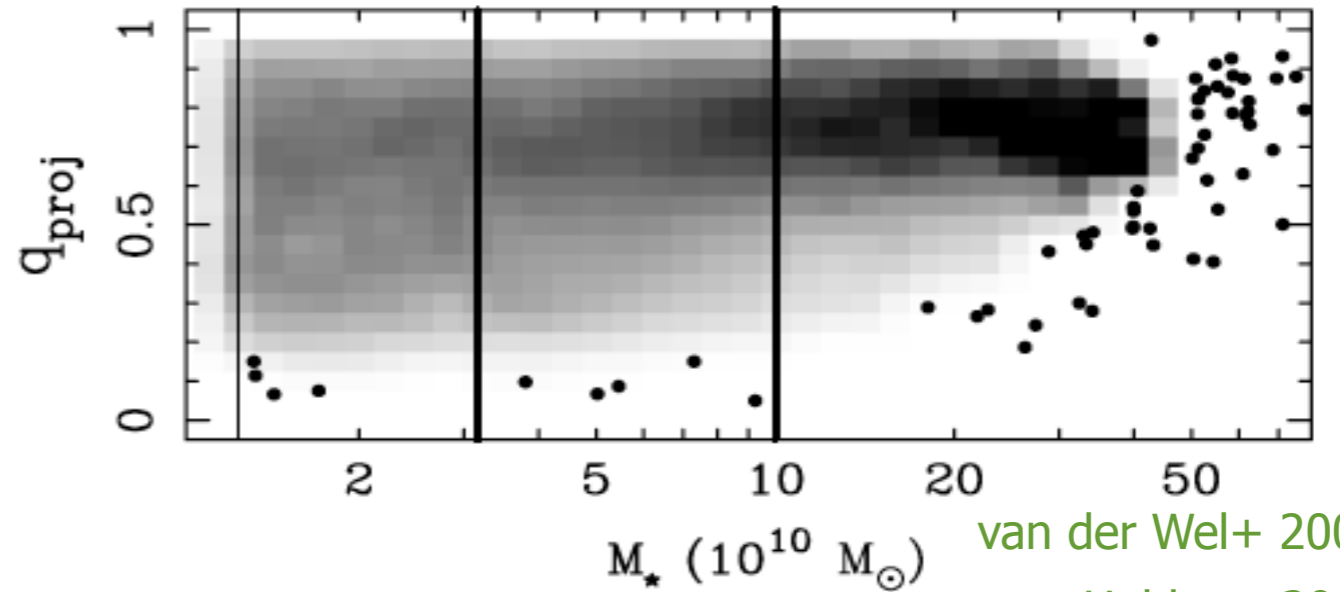
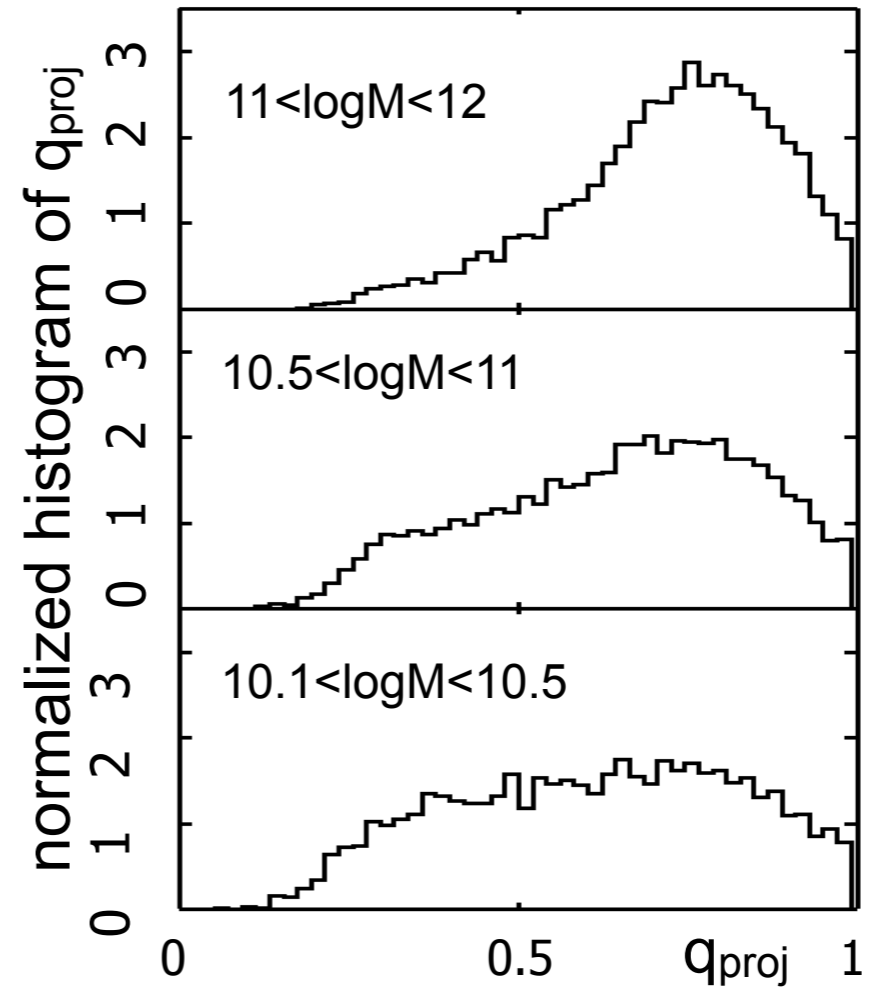
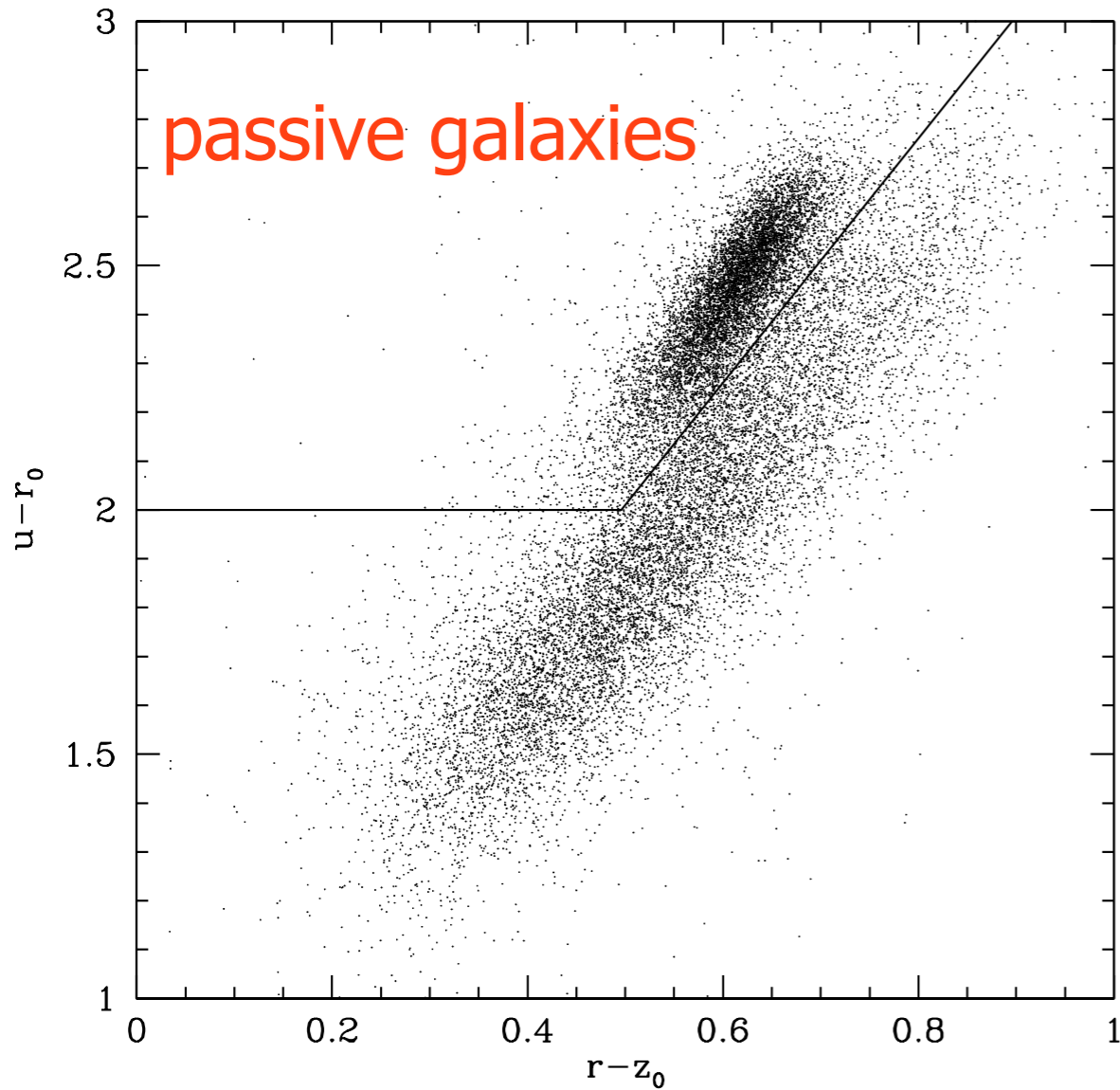


13 November 2012

ELIXIR Final Meeting

SDSS Galaxies

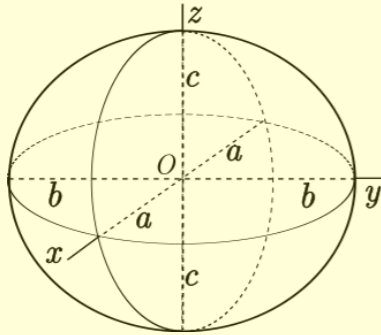
$0.04 < z < 0.08$



van der Wel+ 2009
Holden+ 2012

A Good Model for SDSS: Triaxial+Oblate

triaxial

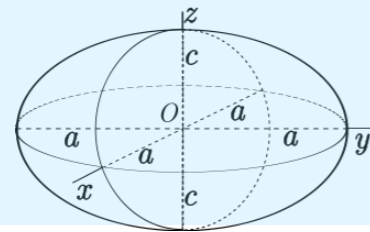


$$T = (a^2 - b^2) / (a^2 - c^2)$$

(triaxiality)

$$\epsilon = 1 - c/a \quad (\text{ellipticity})$$

oblate



$$b = c \quad T = 0$$

$$\bar{T} \quad \sigma_T$$

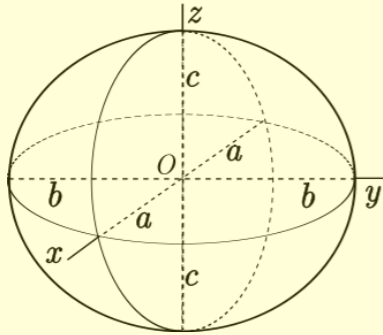
$$\bar{\epsilon} \quad \sigma_{\epsilon}$$

$$\bar{b} \quad \sigma_b$$

$$f_{\text{ob}}$$

A Good Model for SDSS: Triaxial+Oblate

triaxial



$$T = (a^2 - b^2) / (a^2 - c^2)$$

(triaxiality)

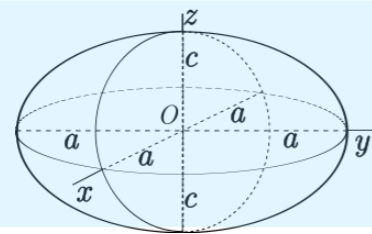
$$\epsilon = 1 - c/a \quad (\text{ellipticity})$$



\bar{T} σ_T

$\bar{\epsilon}$ σ_ϵ

oblate



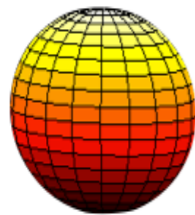
$$b = c \quad T = 0$$



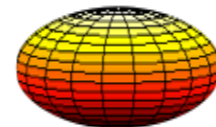
\bar{b} σ_b

f_{ob}

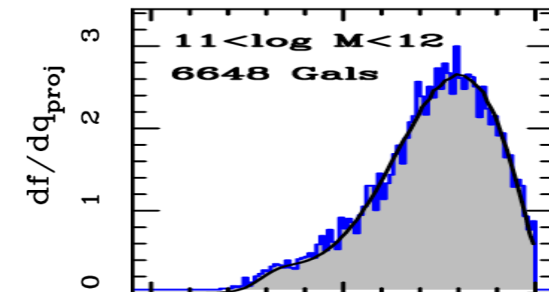
87%



+13%

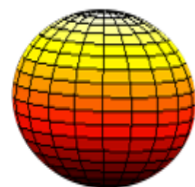


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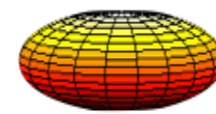


11 < log M < 12

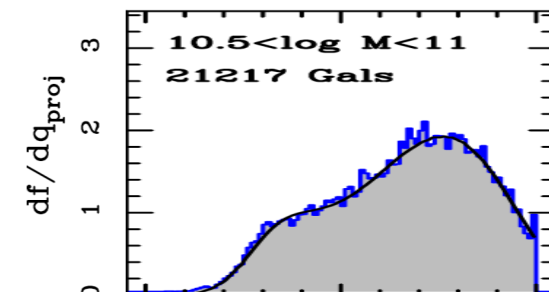
46%



+54%

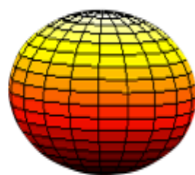


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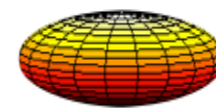


10.5 < log M < 11

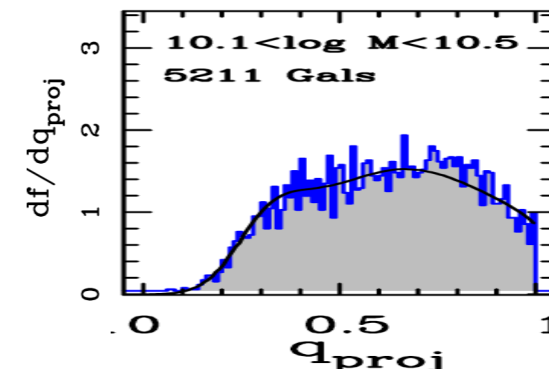
28%



+72%



=

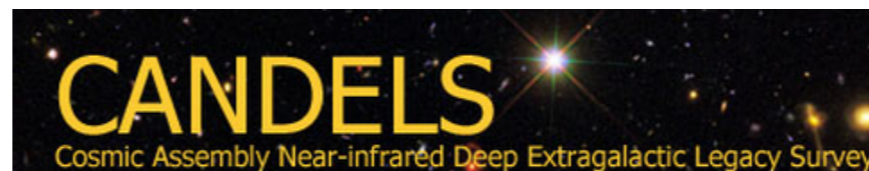
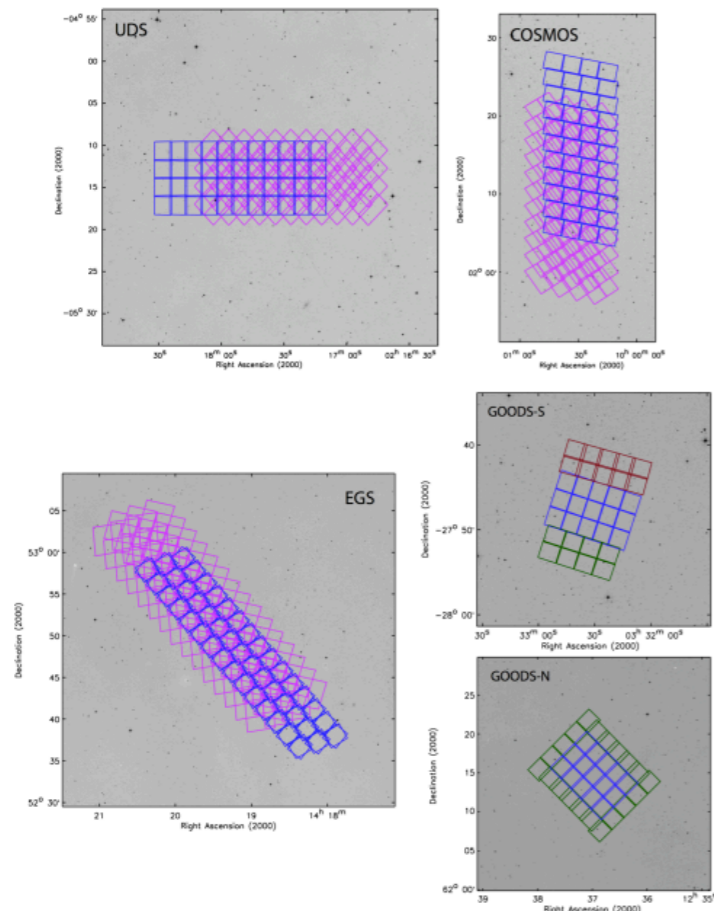
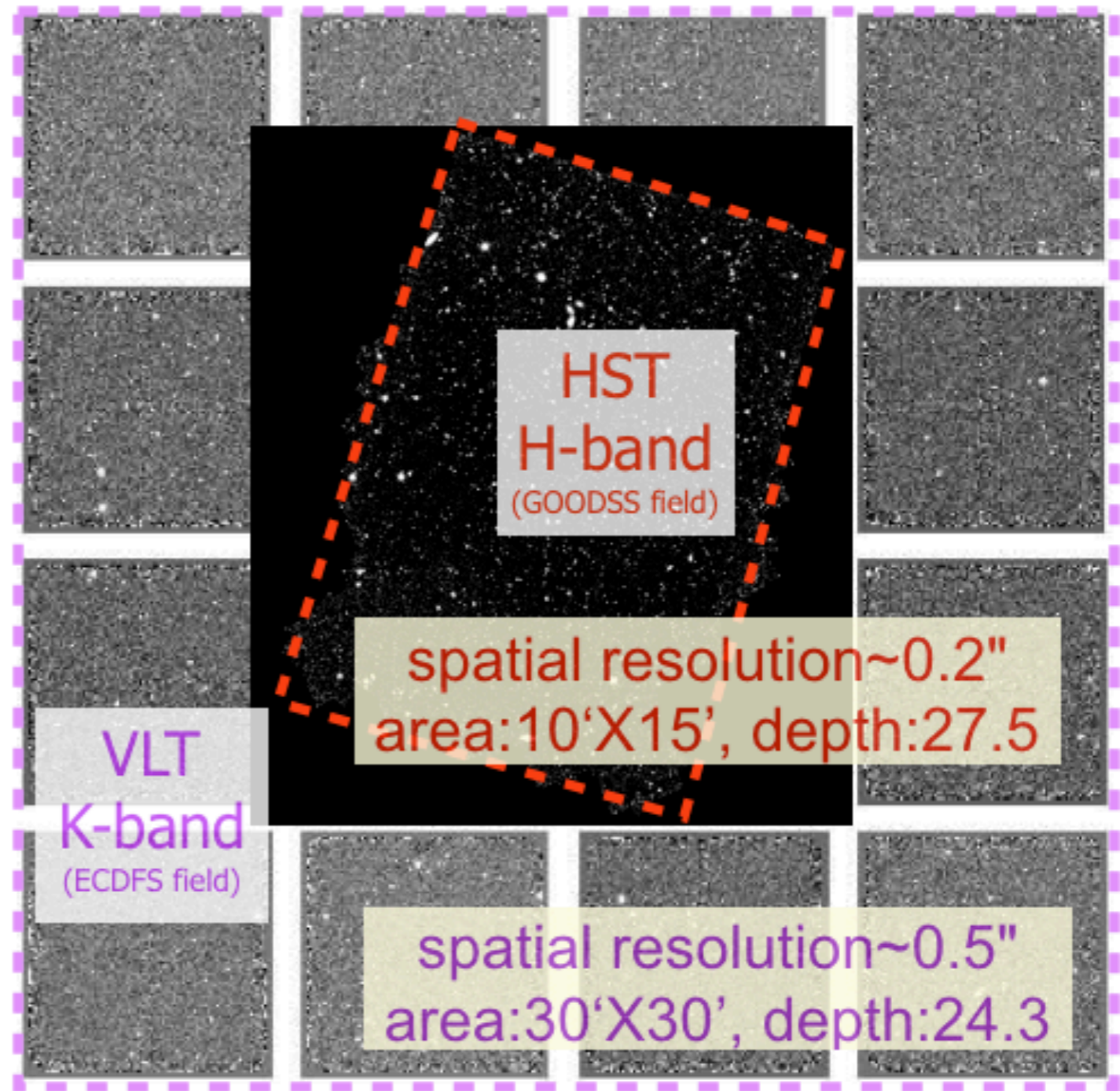


10.1 < log M < 10.5

HST and VLT data

We need:

1. Near-IR (high-z)
2. Deep (further)
3. Wide (more)
4. High Resolution



Data

VLT HAWK-I

Stefano Zibetti's data

images

HST Images
(CANDELS)

Multi-Cycle Treasury Program
on HST (>900 orbits)
(PIs: Faber & Ferguson)

multiwavelength catalog
(Cadamone et al. 2009)

+

SED modeling
(from Stijn Wuyts)

z
M*
SFR

multiwavelength catalog
(CANDELS team)

+

SED modeling
(from Stijn Wuyts)

$0.8 < z < 1.8$
 $M_* > 5 \cdot 10^{10} M_\odot$
 $sSFR < 1/3 t_H(z)$

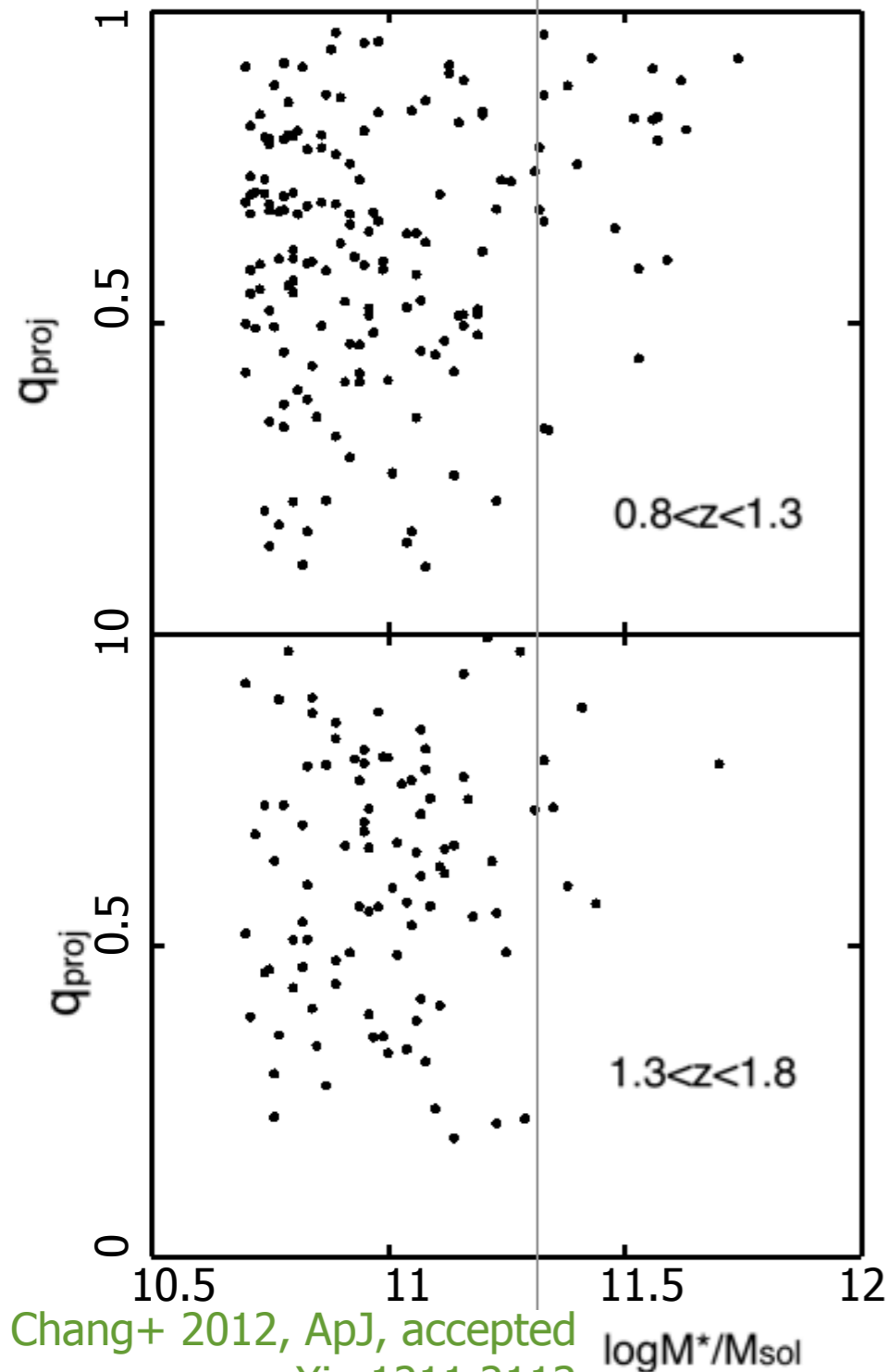
selections

$0.5 < z < 2.5$
 $M_* > 10^{10} M_\odot$
UVJ/sSFR selection

Mass-Shape Plots at $z > 1$

VLT/HAWK-I: $0.8 < z < 1.8$

K-band E-CDFS (PI: V. Padilla)



Chang+ 2012, ApJ, accepted
arXiv:1211.2113

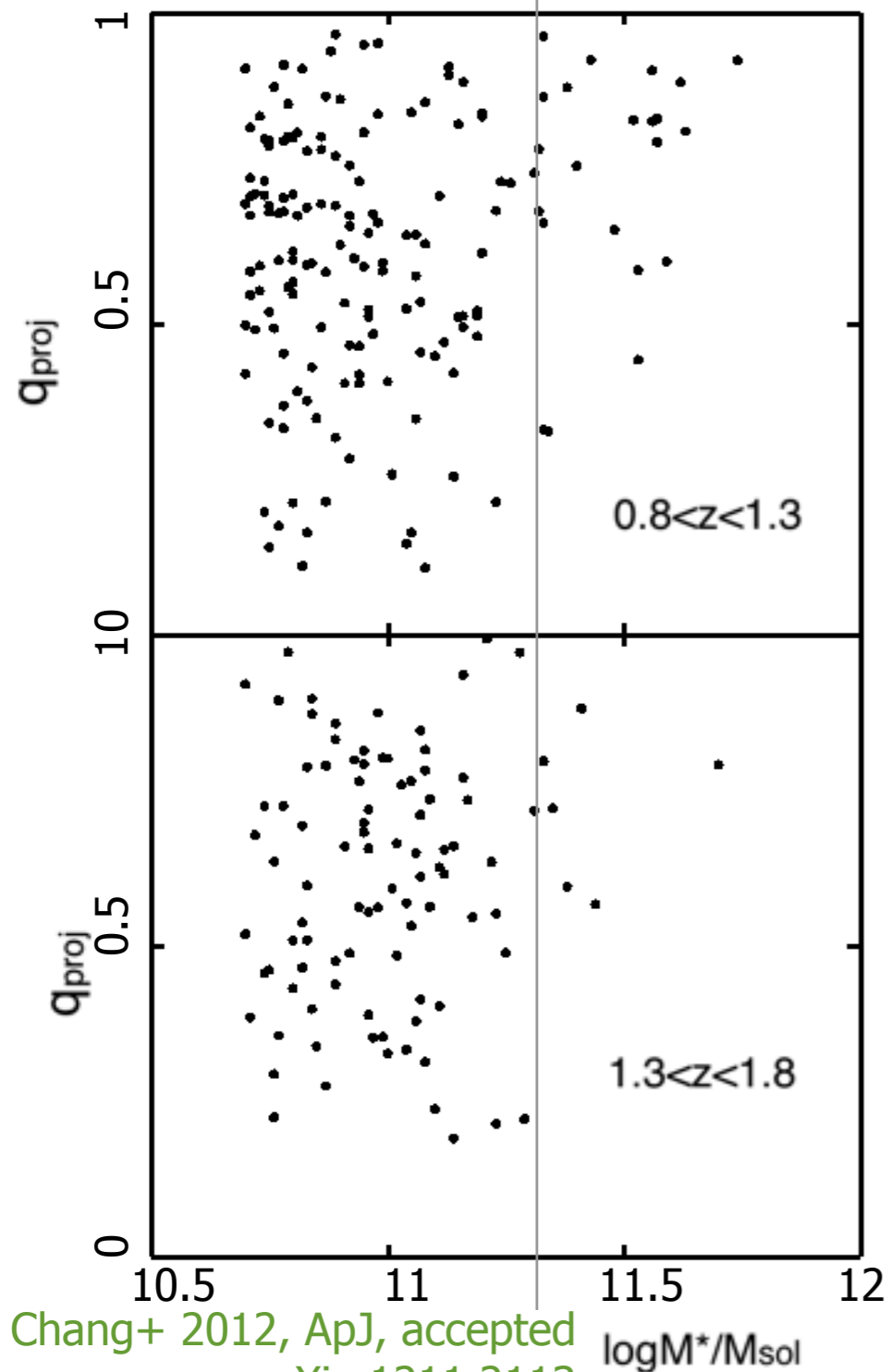
Results:

- **The most massive** early-type galaxies are still **roundest** compare to **lower masses**
- $z > 1$ **massive** early-type galaxies are more **disk-like** compare to **local universe**

Mass-Shape Plots at $z > 1$

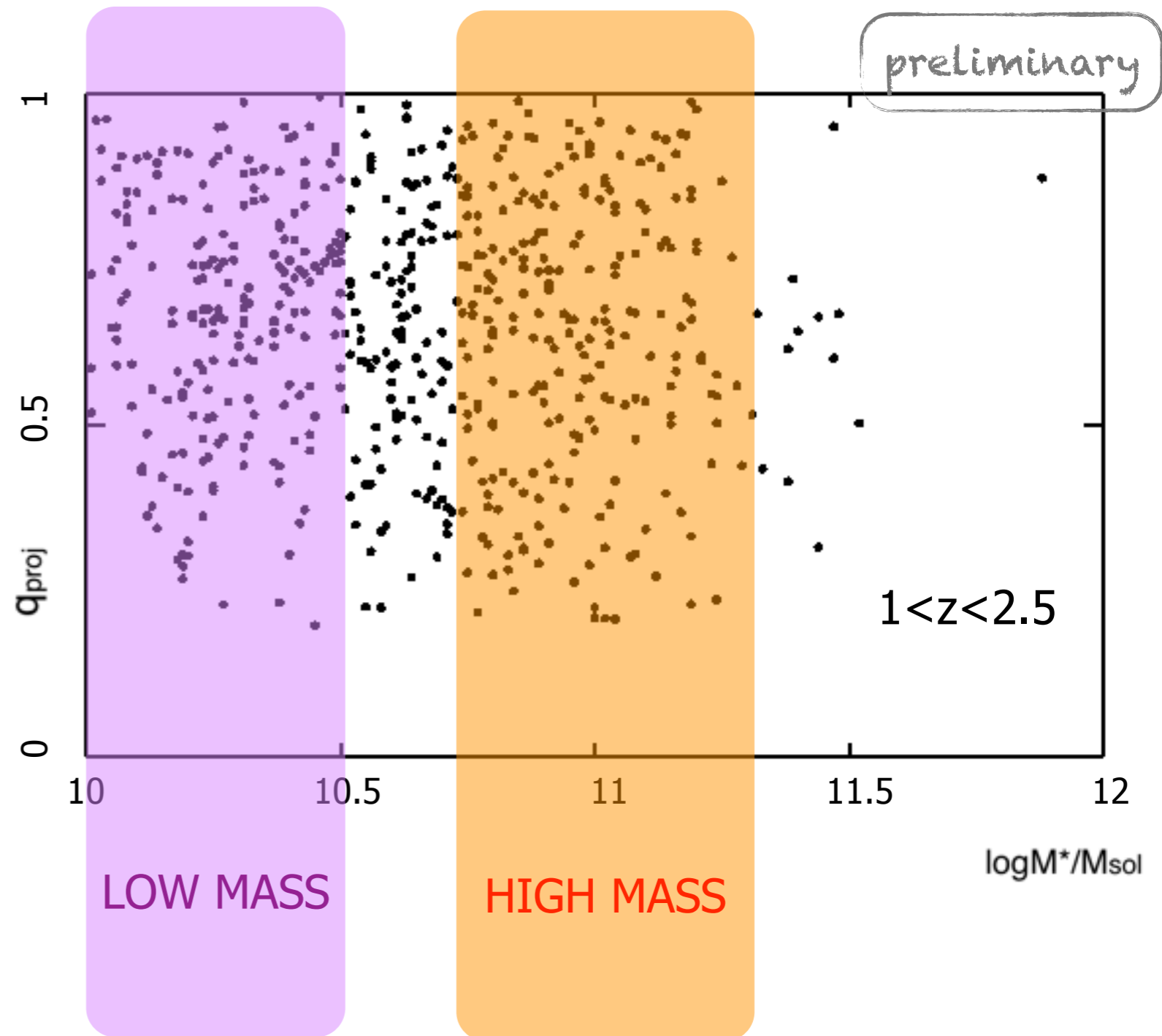
VLT/HAWK-I: $0.8 < z < 1.8$

K-band E-CDFS (PI: V. Padilla)



Chang+ 2012, ApJ, accepted
arXiv:1211.2113

CANDLES (GOODSS+UDS): $1 < z < 2.5$



High Mass Passive Galaxies are **Flatter** than Local Galaxies at $1 < z < 2$

$10.7 < \log M < 11.3$

black: SDSS (17155#)

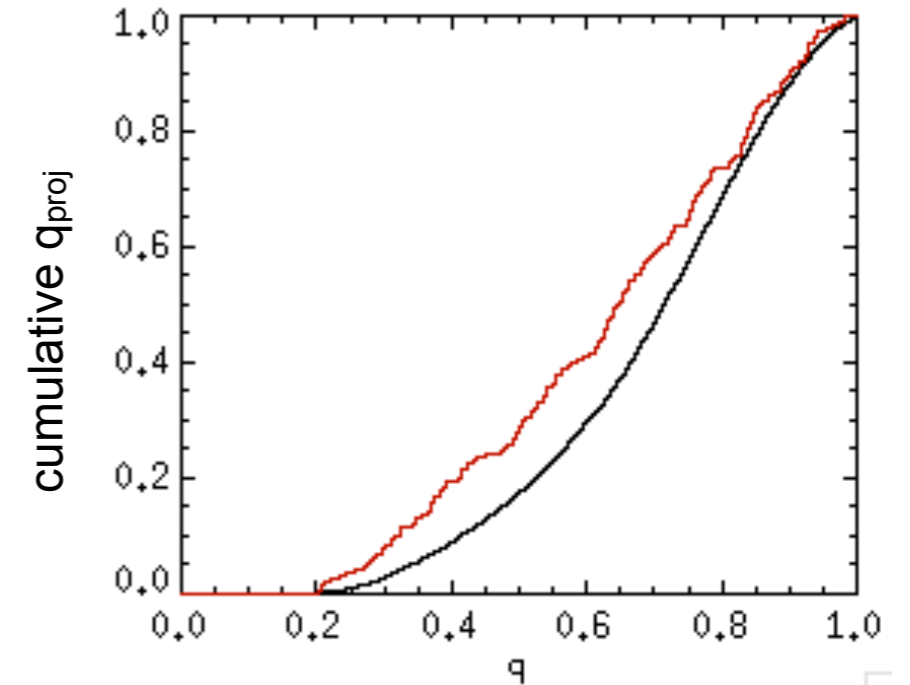
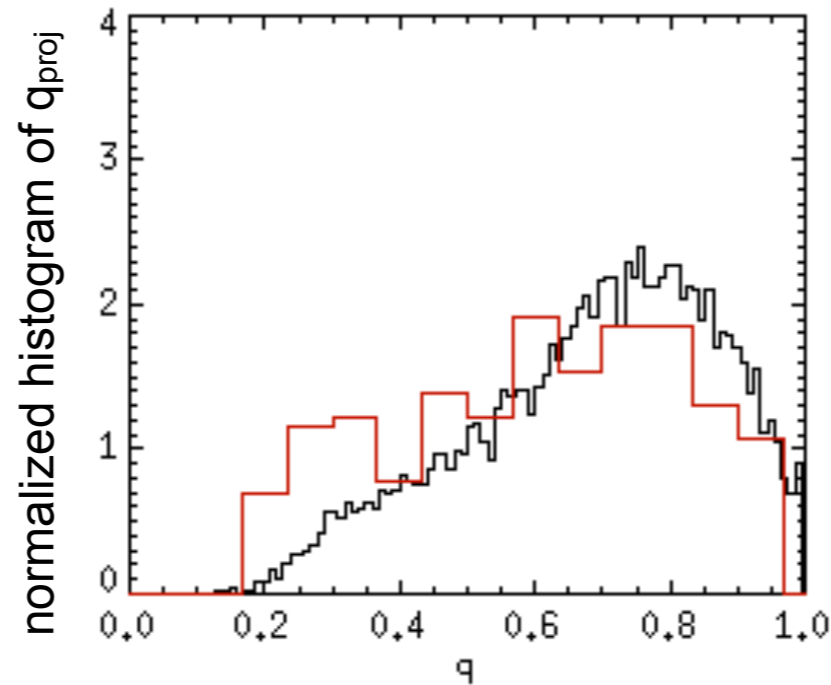
red: $1 < z < 2$ (208#)

$P(\text{KS}) = 0.00063$ (3.42σ)

$P(\text{MW}) = 0.00020$ (3.72σ)

MW: Mann-Whitney test

preliminary



Consistent with Chang+ 2012

High Mass Passive Galaxies are **Flatter** than Local Galaxies at $1 < z < 2$

$10.7 < \log M < 11.3$

black: SDSS (17155#)

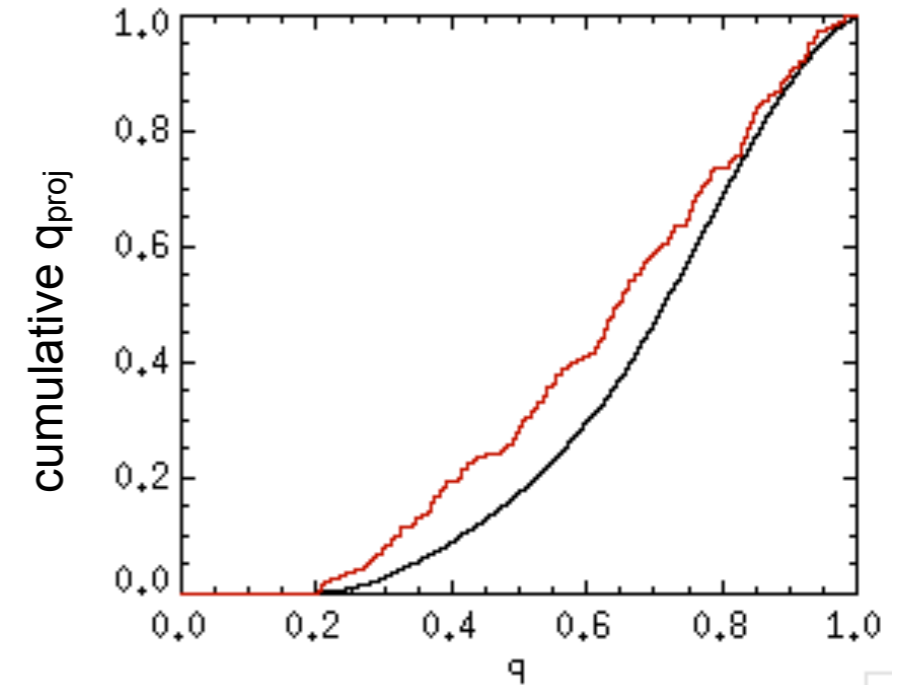
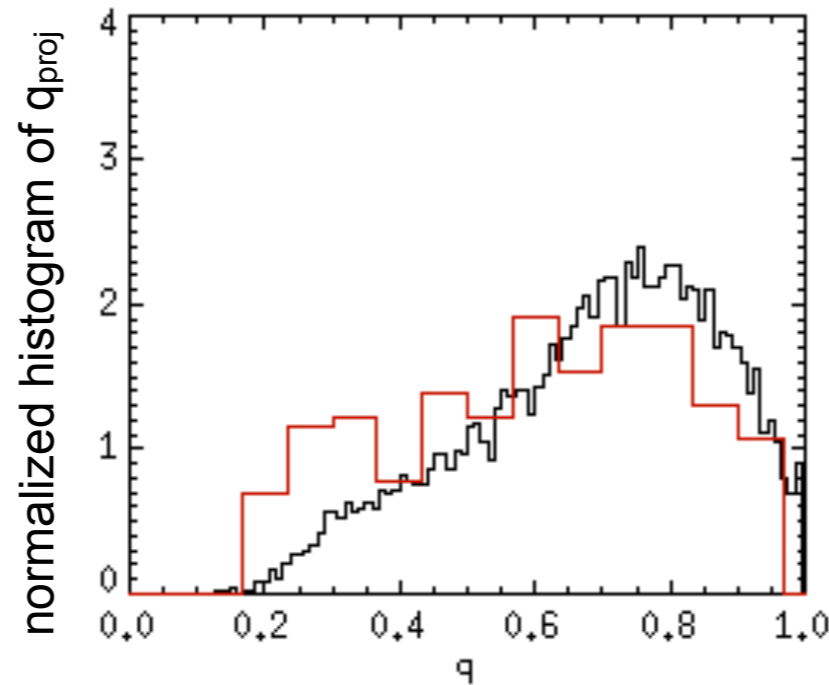
red: $1 < z < 2$ (208#)

$P(\text{KS}) = 0.00063$ (3.42σ)

$P(\text{MW}) = 0.00020$ (3.72σ)

MW: Mann-Whitney test

preliminary



Consistent with Chang+ 2012

Low Mass Passive Galaxies are **Rounder** than Local Galaxies at $1 < z < 2$

$10.1 < \log M < 10.5$

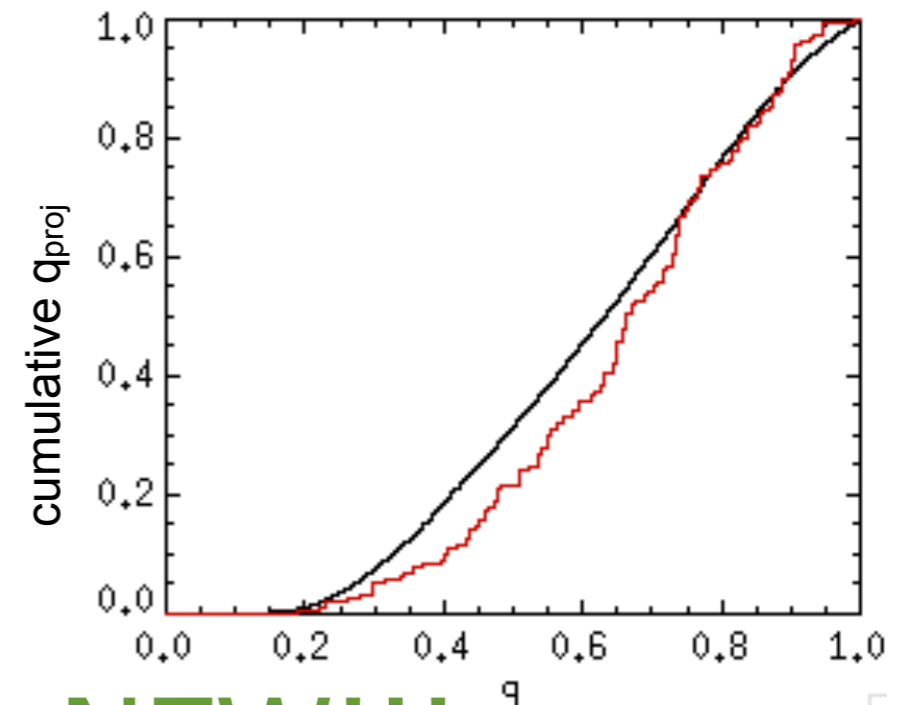
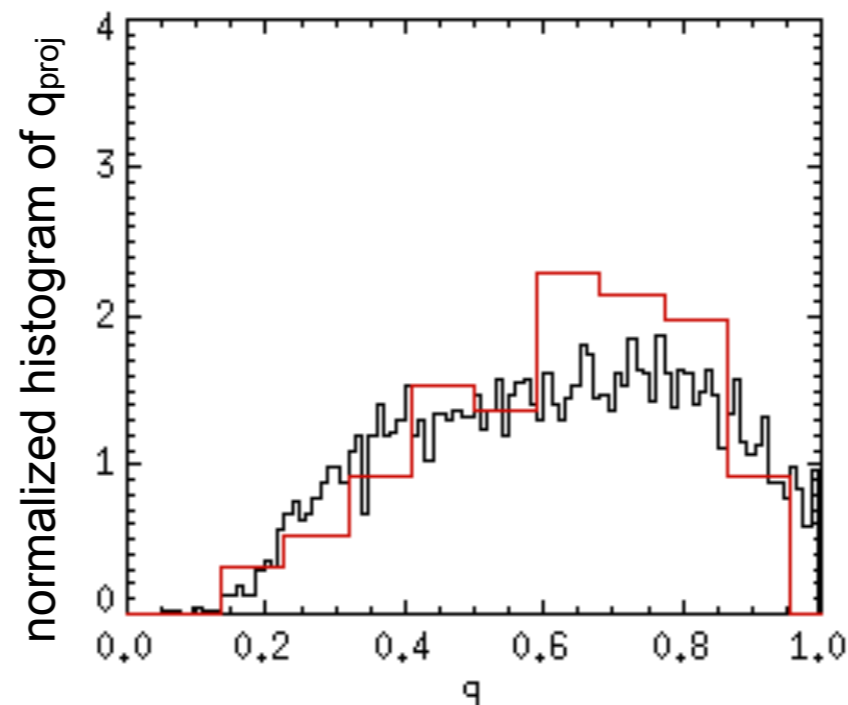
black: SDSS (5211#)

red: $1 < z < 2$ (157#)

$P(\text{KS}) = 0.0151$ (3.17σ)

$P(\text{MW}) = 0.0075$ (3.37σ)

preliminary

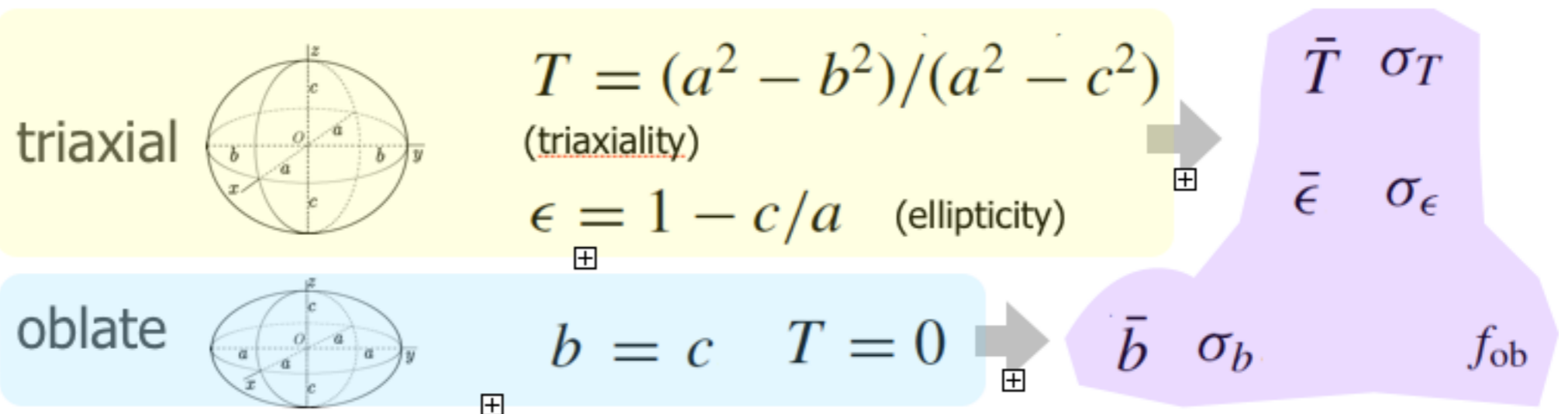
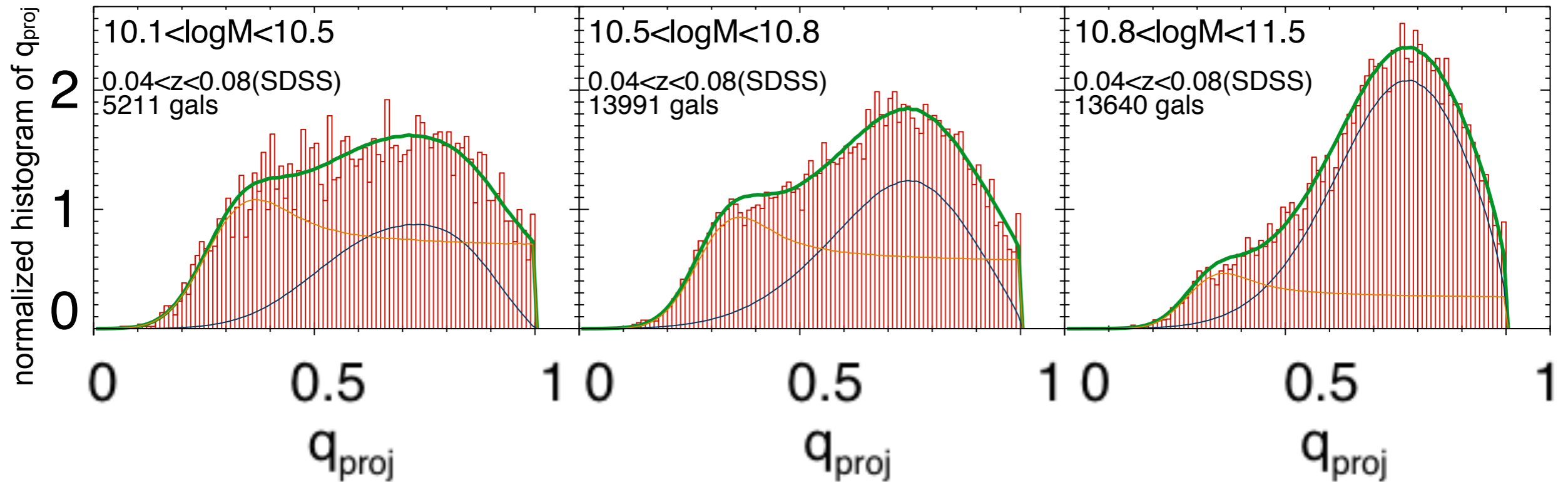


NEW!!!

Models for Passive Galaxies at $z \sim 0$: 7 parameters

\bar{T} σ_T $\bar{\epsilon}$ σ_ϵ \bar{b} σ_b f_{ob}

Low Mass High Mass

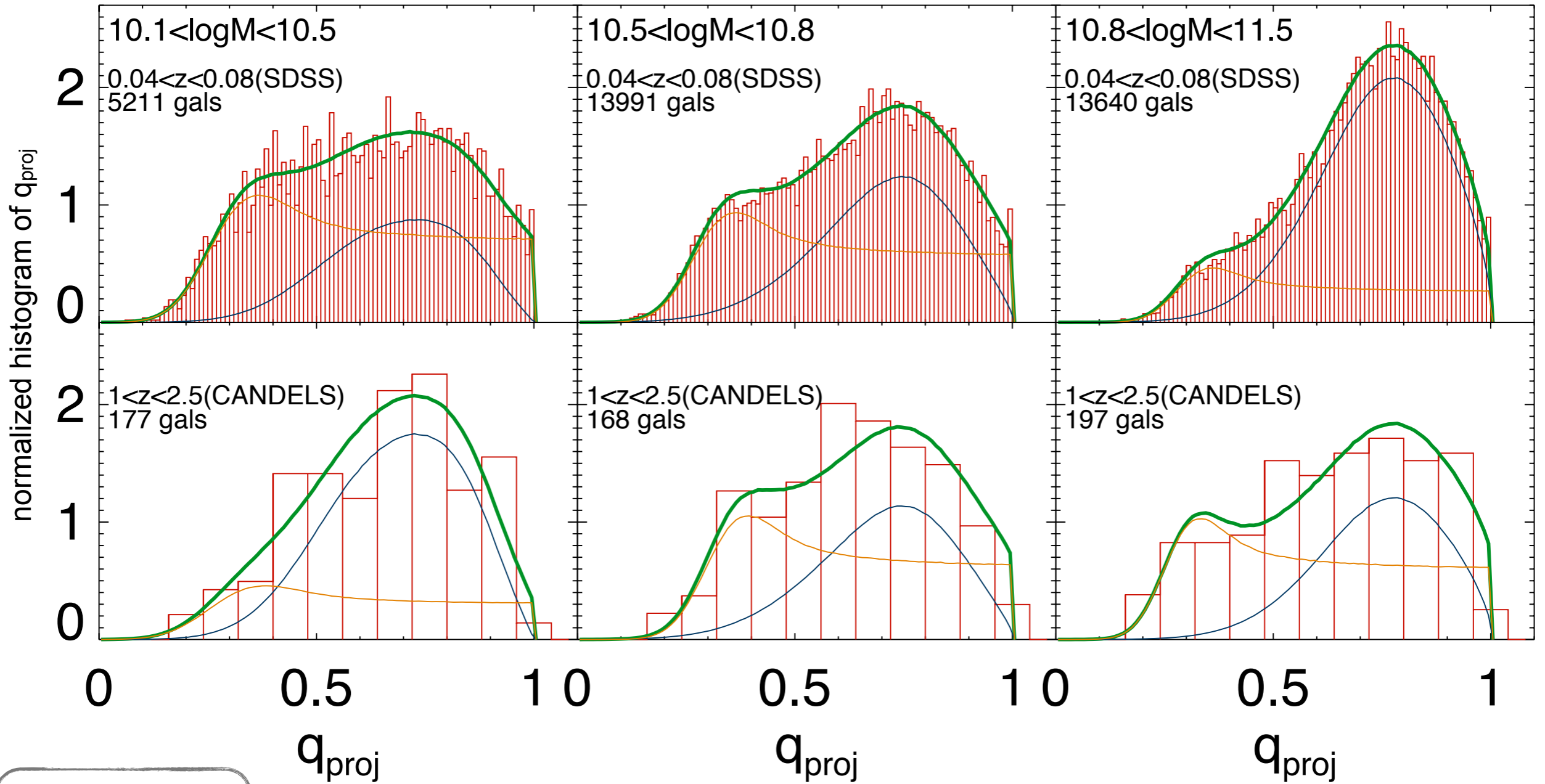


preliminary

Models for Passive Galaxies at $z \sim 2$: 3 parameters

\bar{T} σ_T $\bar{\epsilon}$ σ_ϵ \bar{b} σ_b f_{ob}

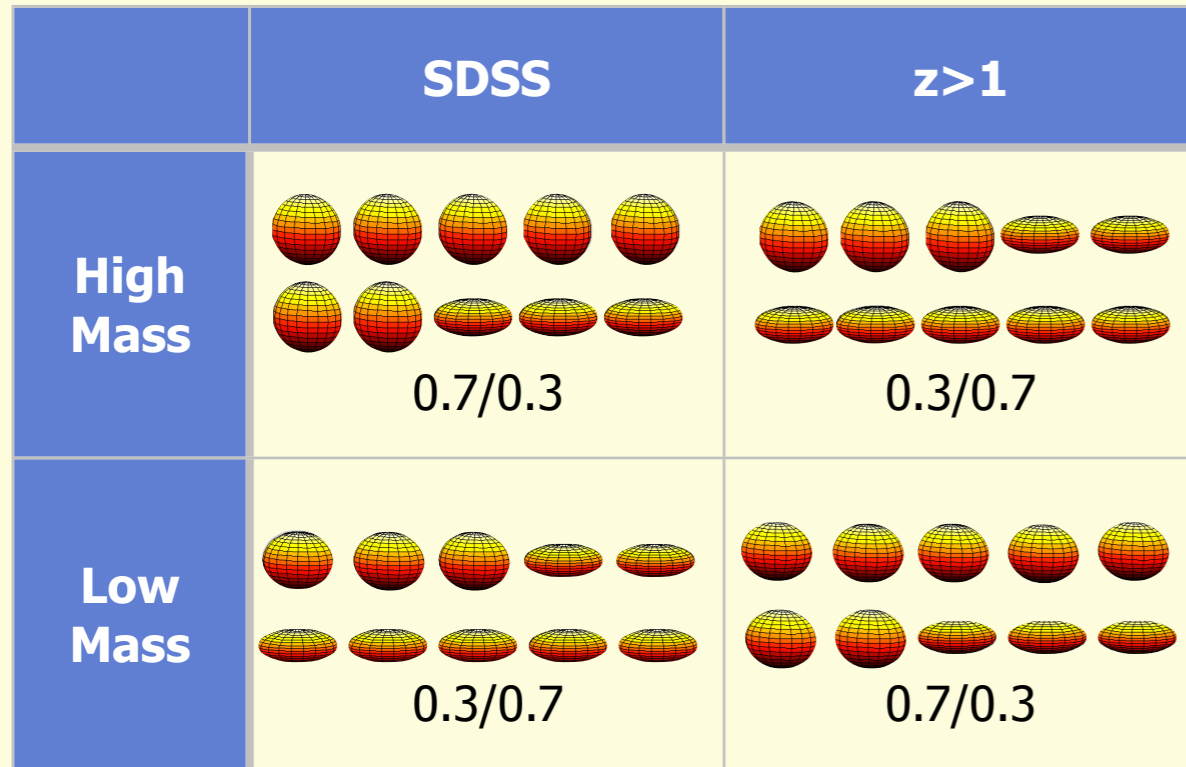
Low Mass High Mass



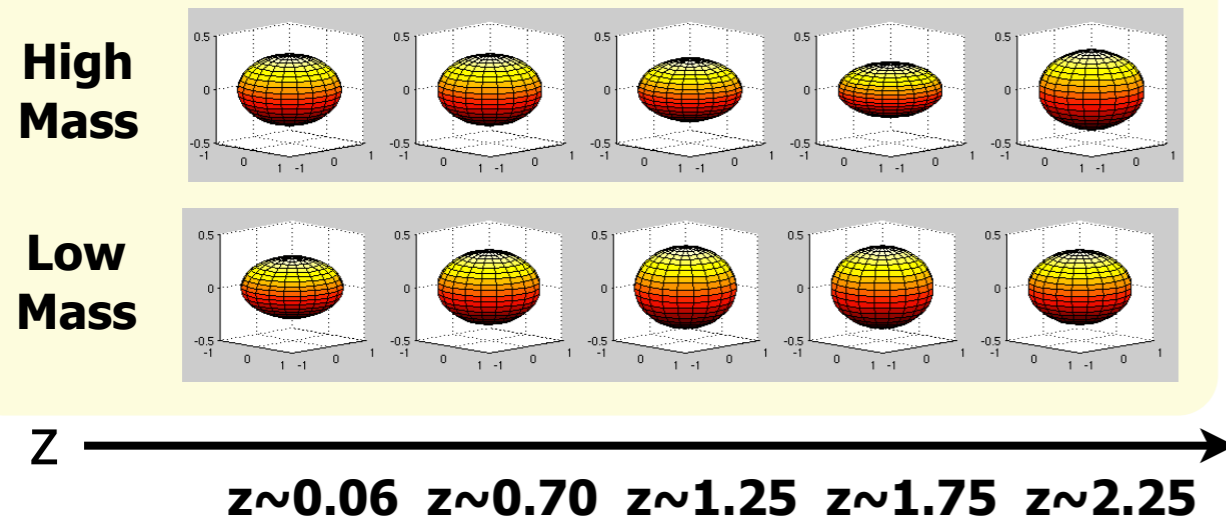
preliminary

Two Components as SDSS

Model: Oblate Fraction f_{ob}

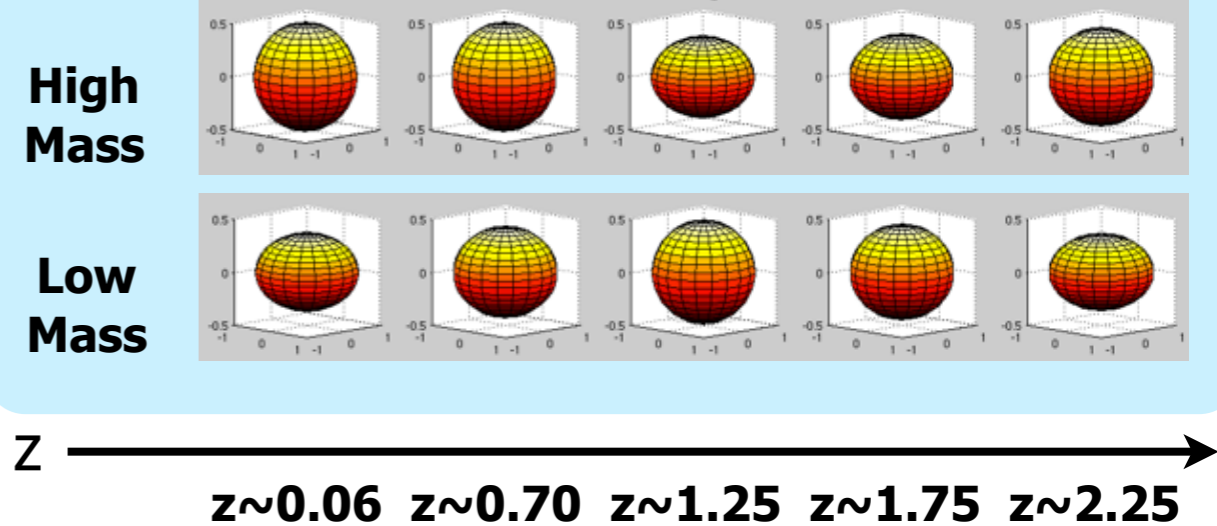


Model: Oblate Component \bar{b}



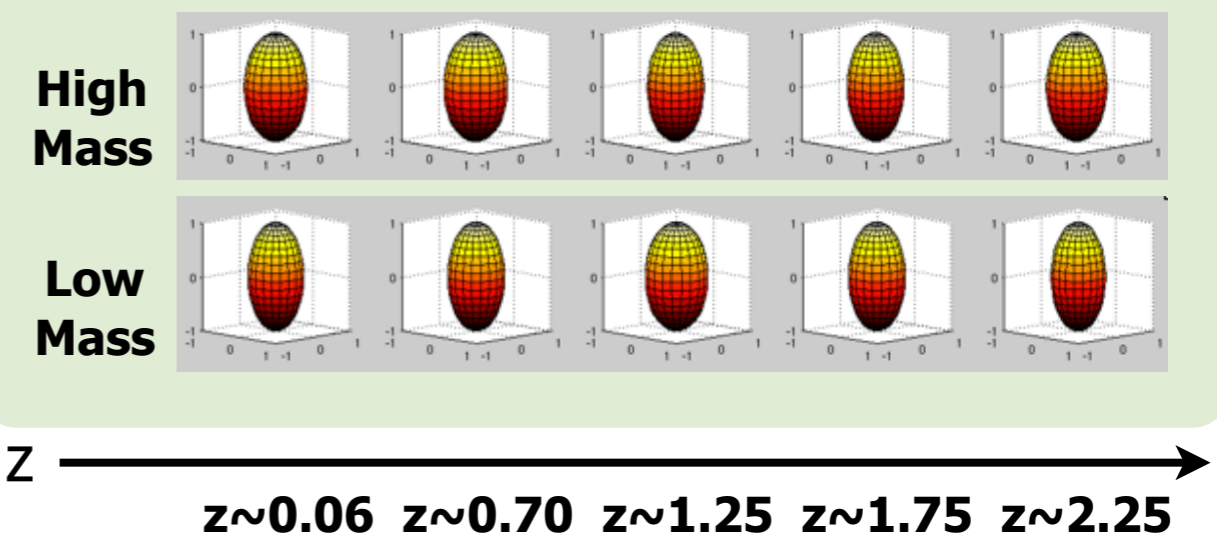
or...
Single Component

Model: Single Oblate





preliminary

Model: Single Prolate



Conclusions

- **High mass** ($\sim 10^{11} M_{\odot}$) passive galaxies
 - **flatter** at high- z 
 - gas had time to settle into disk before SF stopped
 - merging can explain both shape and size evolution
- **Low mass** ($\sim 10^{10} M_{\odot}$) passive galaxies
 - **rounder** at high- z 
 - environmental effects (gas stripping) ?
 - produce disk-like early-type satellite galaxies in dense environments
 - 40% of local red galaxies ($\sim 10^{10} M_{\odot}$) are satellites? (van den Bosch+08)
 - presumably far fewer such satellites at $z > 1$