Star Formation at High Redshift

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Outline

1. Brief Introduction

2. Lesson from HST/COSMOS

BASIC Properties of LAEs & LBGs @ $z = 3 - 7$

L(UV) ~ (0.01 - 1) × 10^{10} Lsun

stellar masses ~ (0.1 - 10) × 10^{9} Msun

stellar ages ~ a few - 1000 Myr

star formation rates ~ sevaral - a few 10 Msun/y

low reddening $A_V << 1$

LBGs vs. LAEs
z = 3 - 7

LBG surveys

➔ may miss faint continuum sources,
but w/ or w/o Lyα doesn't matter

LAE surveys

➔ may miss weak Lyα emitters,
but faint cont. doesn't matter

LBGs vs. LAEs
z = 3 - 7

LAEs tend to be

- younger (larger EW of Lyα)
- less massive (fainter UV)
- …………

than LBGs

But,

not always !

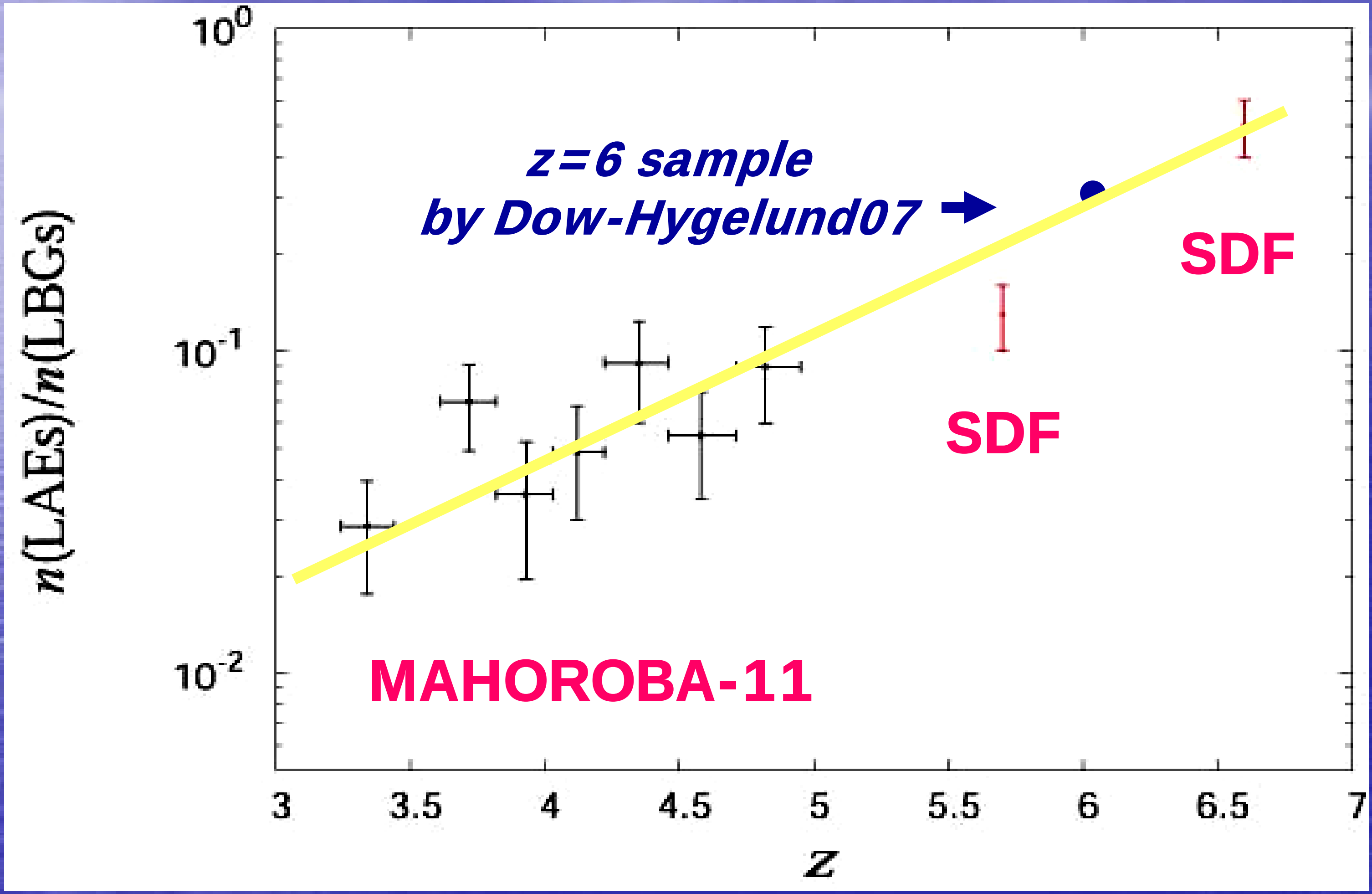
LBGs vs. LAEs

LBGs & LAEs are overlapped
in any physical properties by definition

But, ……

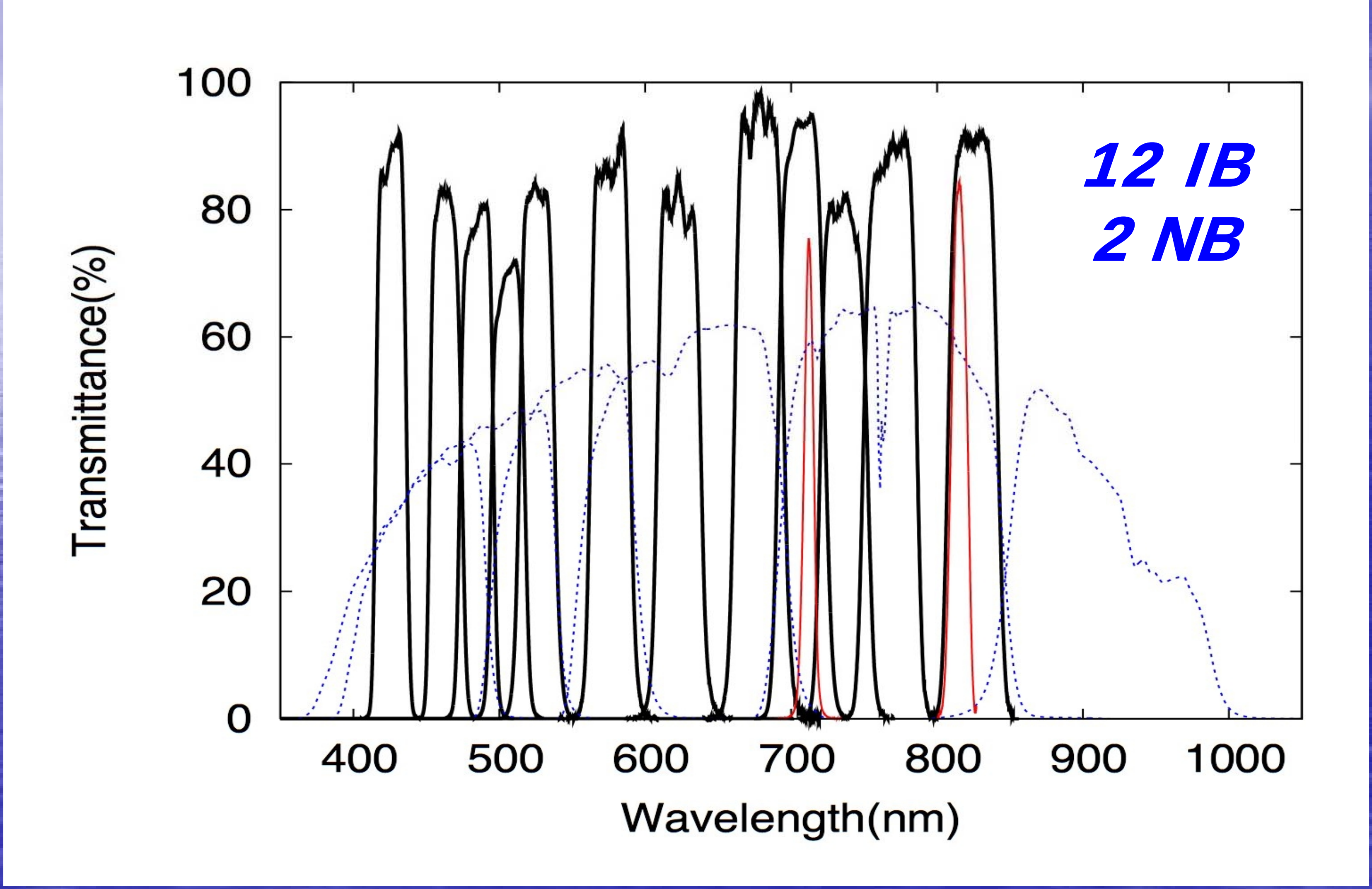
Difference between LBGs & LAEs
as a function of redshift
give us hints to understand
SF history in early universe

LAE to LBG Ratio @ z ~ 3 – 7



(Yamada+05, PASJ, 57, 881; Sumiya+08, in prep.)

COSMOS-20



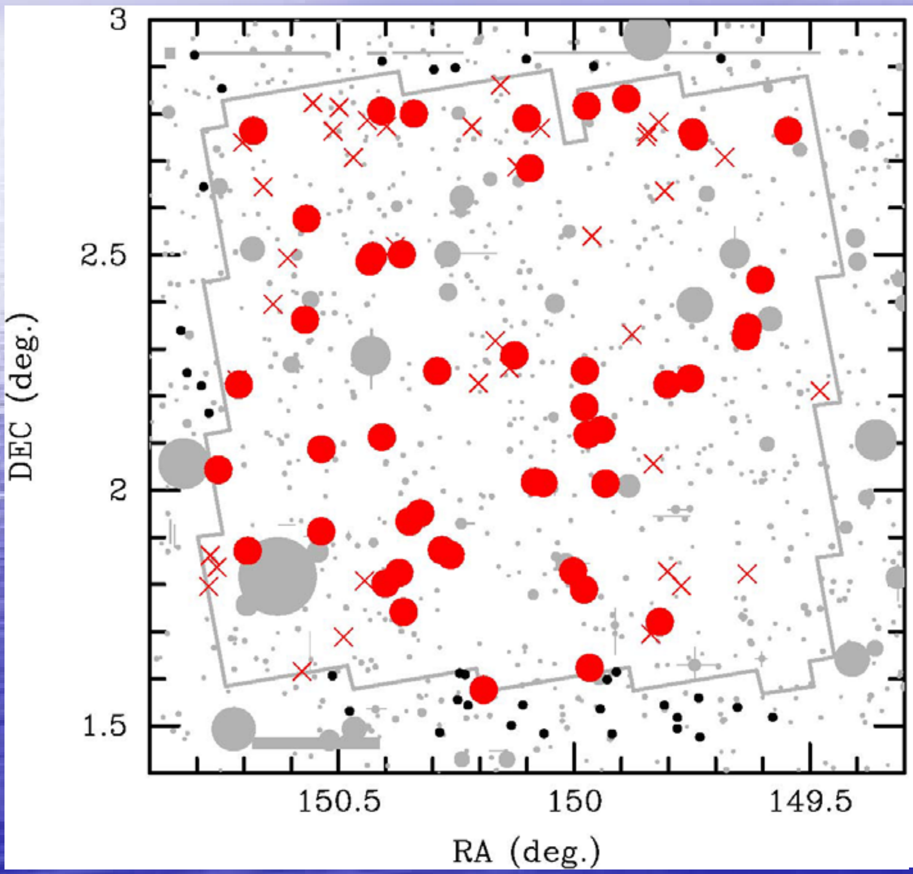
12 IB
2 NB
Transmittance(%)
Wavelength(nm)
0
20
40
60
80
100
400
500
600
700
800
900
1000

Cosmic Evolution Survey

c o s m o s

HST/ACS Imaging of LAEs @ z=5.7 in the COSMOS Field

119 LAEs @ z=5.7 in COSMOS
(Murayama et al. 07, ApJS, 172, 523)
→ 85 LAEs are imaged w/ACS-F814W



● Not imaged w/ACS (34 LAEs)

● Detected w/ACS (47 LAEs)

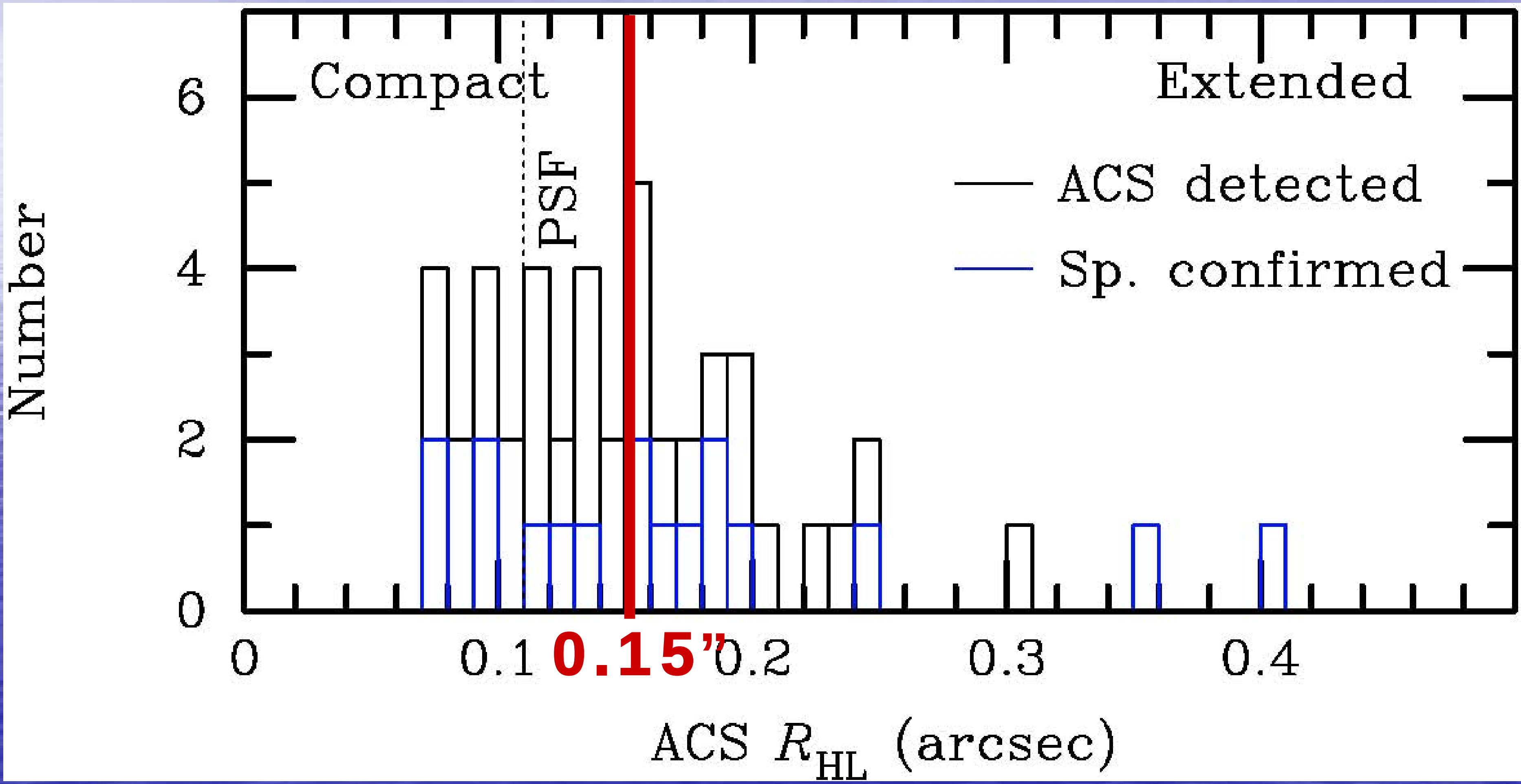
× Not detected w/ACS (38 LAEs)

● Masked out areas

SExtractor - 1.6σ x 9 pix connection

Half-Light Radius (R_{HL})

(1” = 6 kpc @ *z* = 5.7)



47 LAEs detected w/ACS

Compact (R_{HL} <0.15 arcsec)

24 LAEs

$< R_{HL} > = 0.11 \pm 0.02$ arcsec

Extended (R_{HL} > 0.15 arcsec)

23 LAEs

21: single

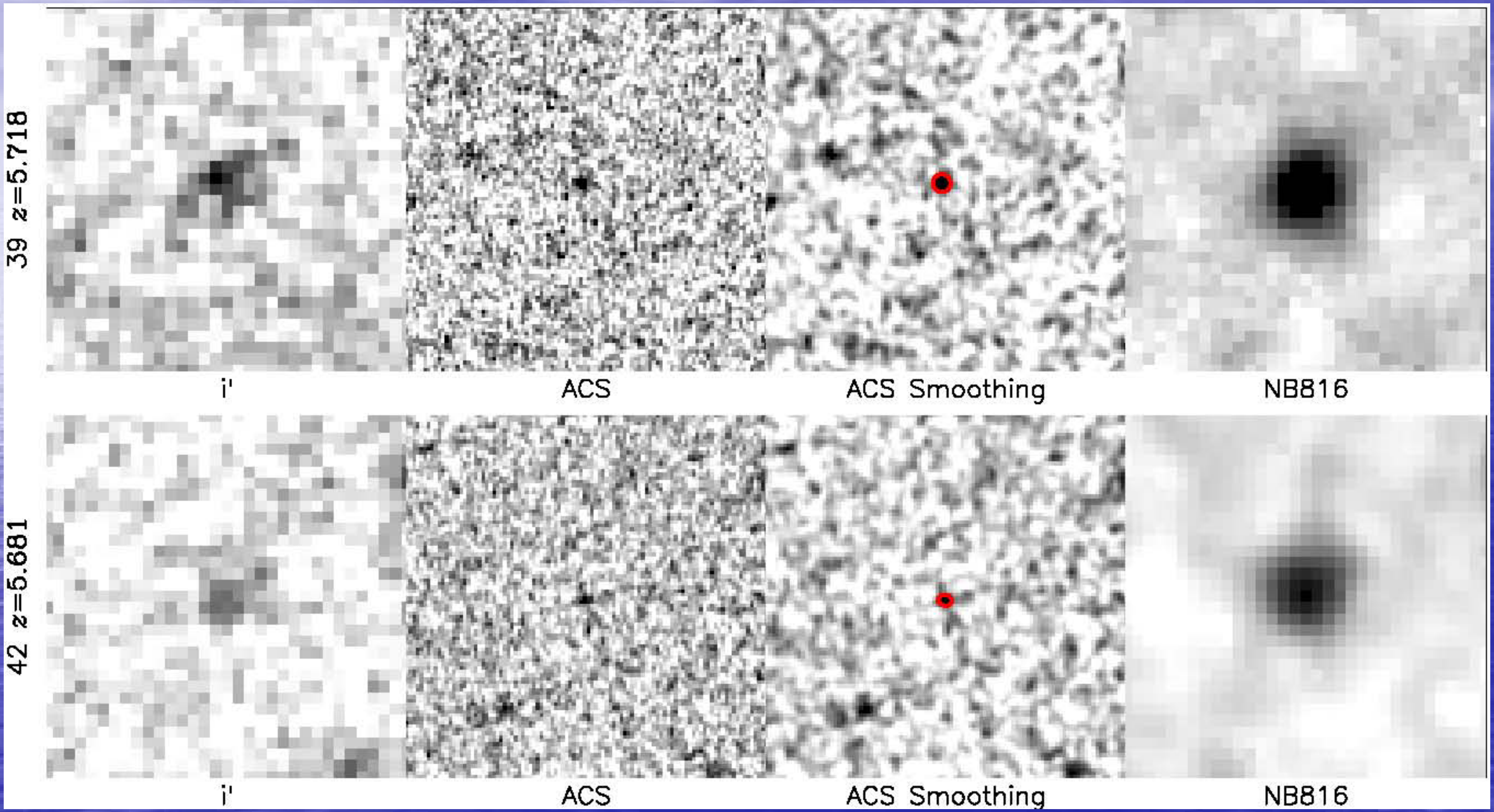
2: double

$< R_{HL} > = 0.21 \pm 0.06$ arcsec

ALL

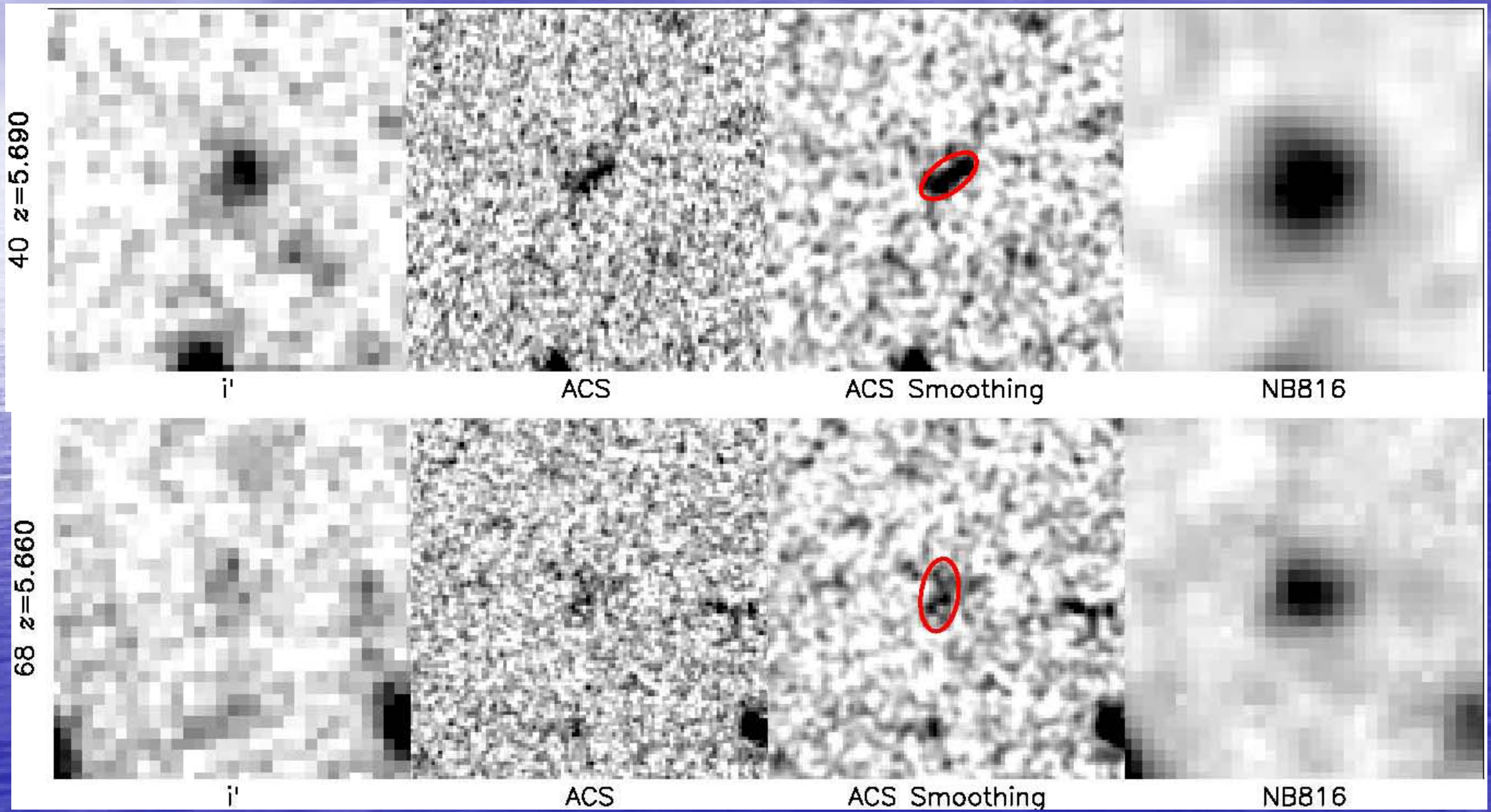
$< R_{HL} > = 0.16 \pm 0.10$ arcsec

Compact

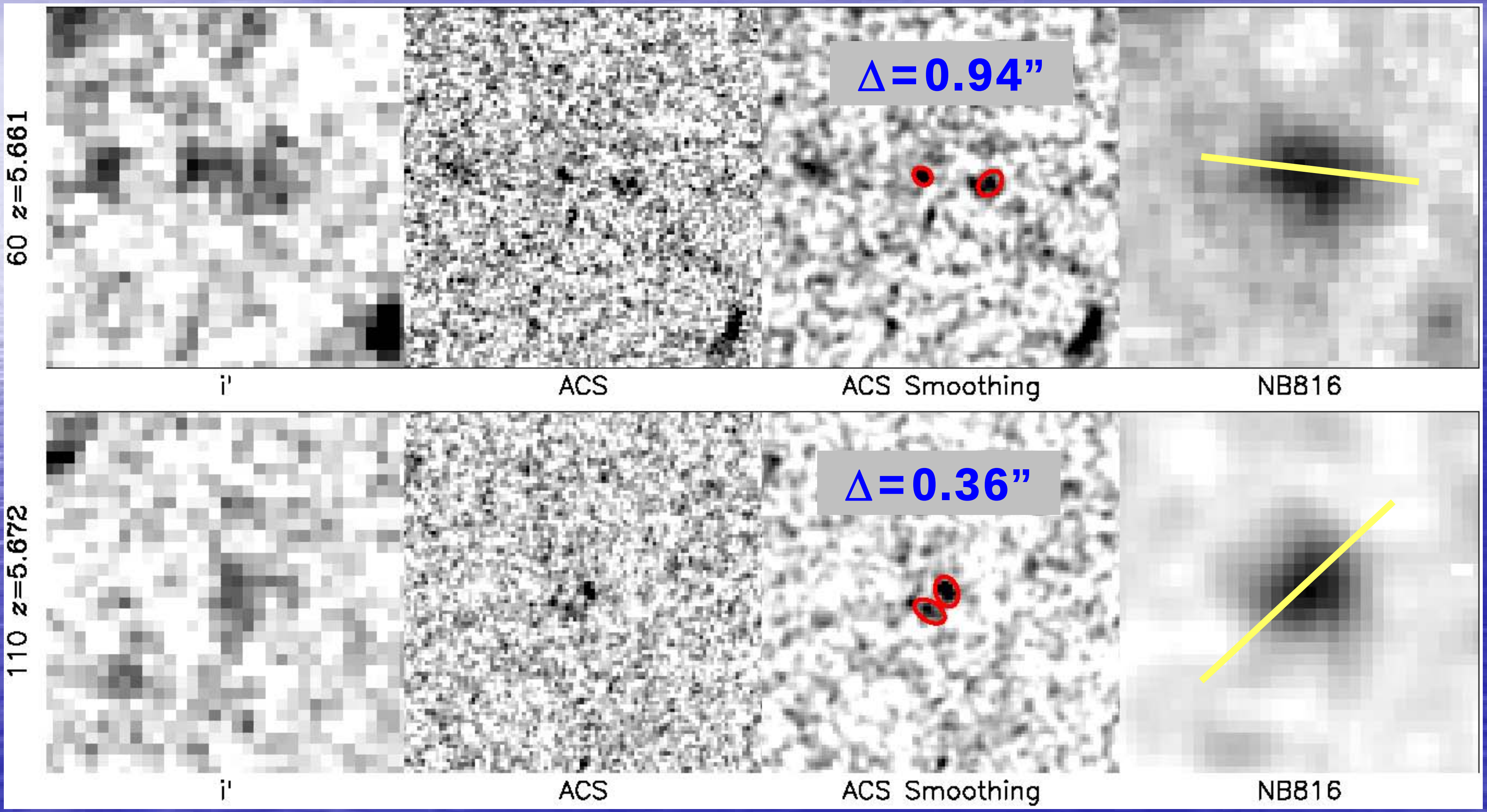


(5”x5” for each panel)

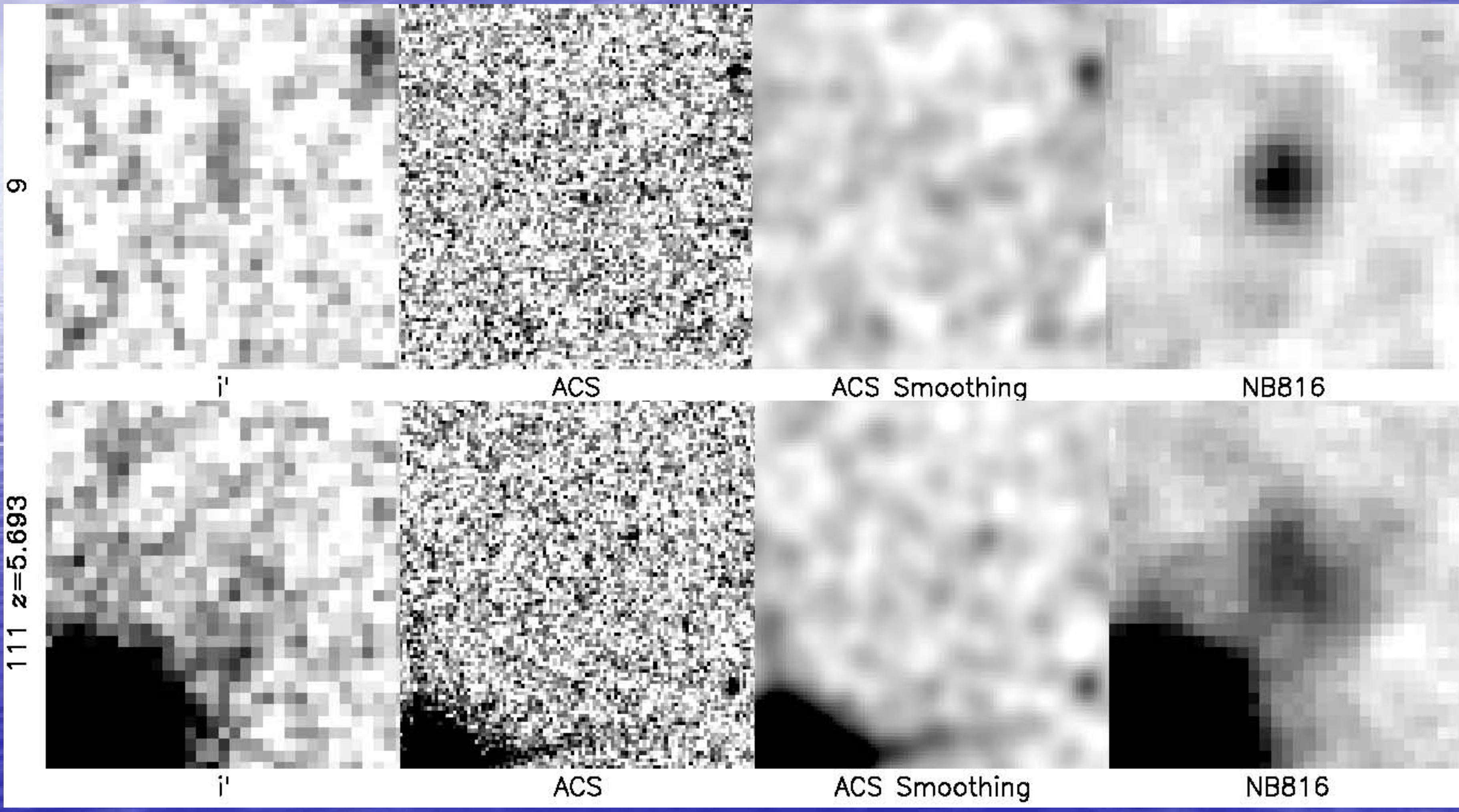
Extended - Single



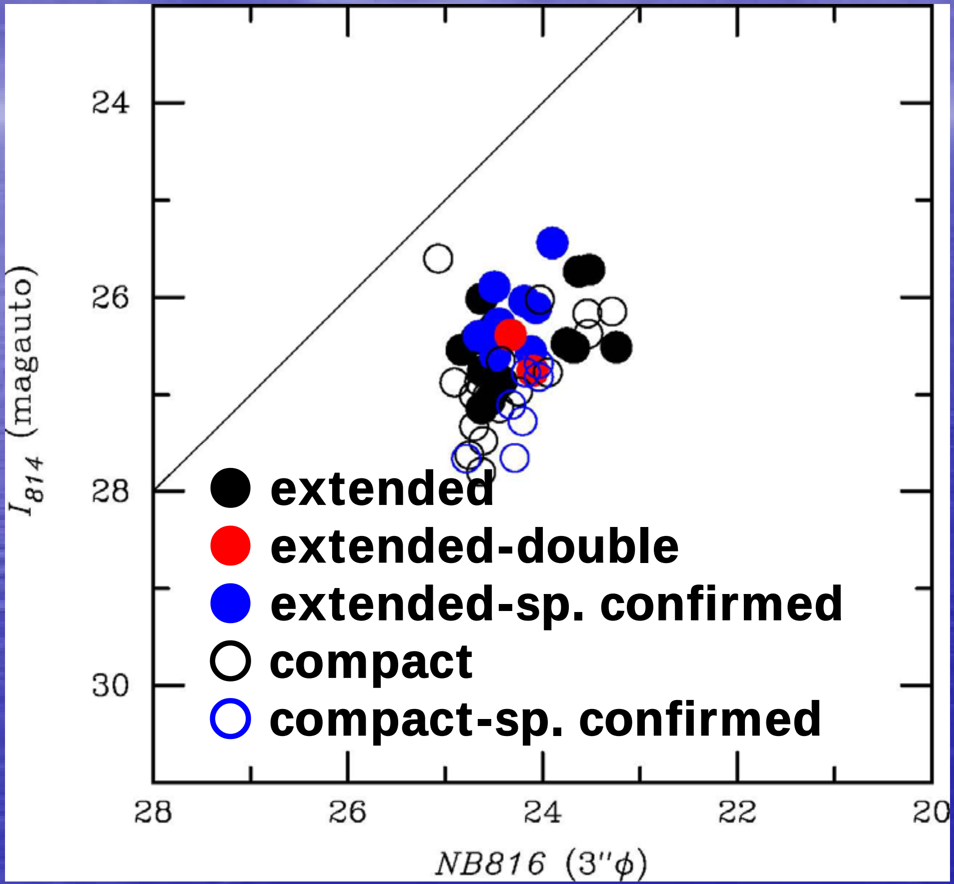
Extended - Double



Non-detection



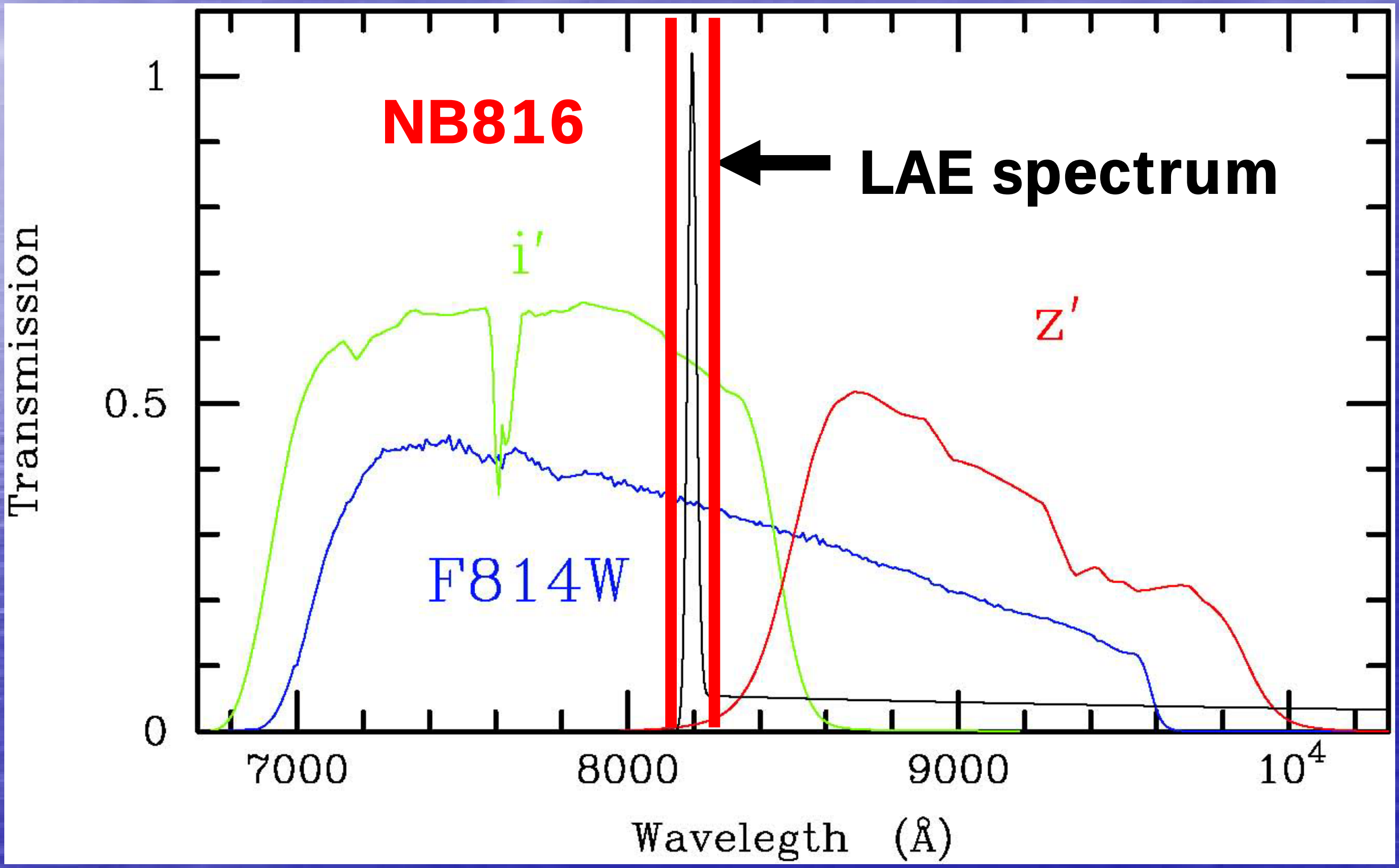
What do we see in F814W?



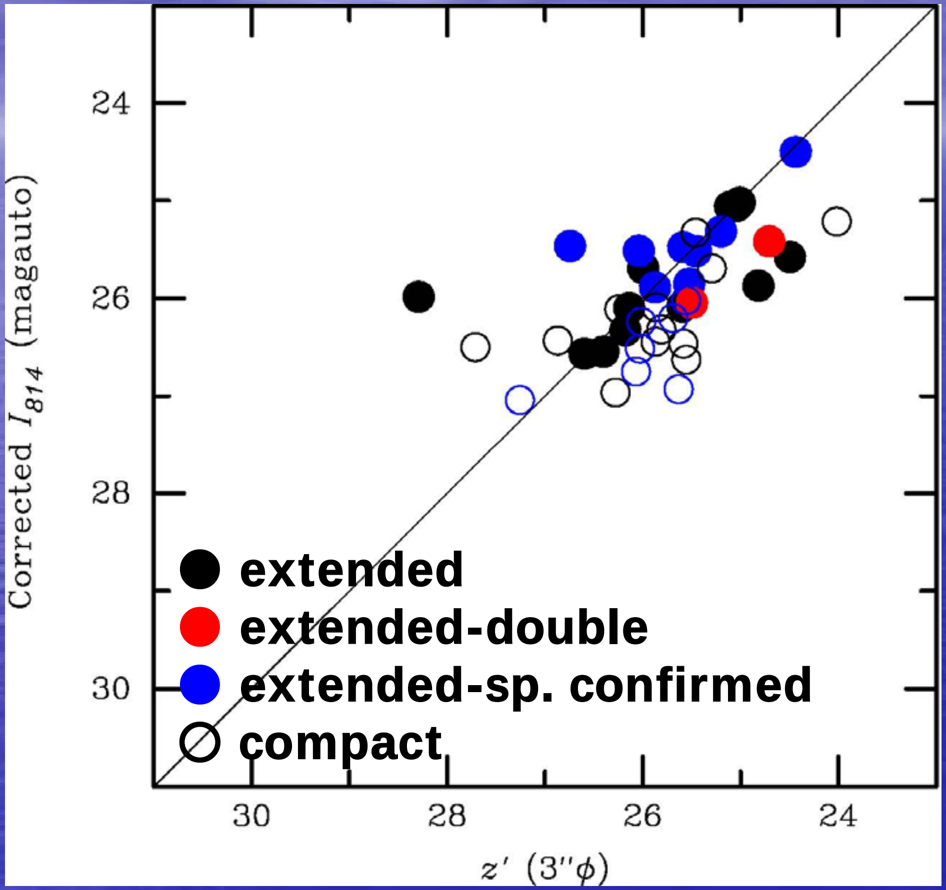
No correlation between I814 & NB816

→ We don't see Lyα emission in I814

What do we see in F814W?



What do we see in F814W?



Good correlation between (I814→z') & z'

→ We see UV continuum (>121.6nm) in I814

Three Topics

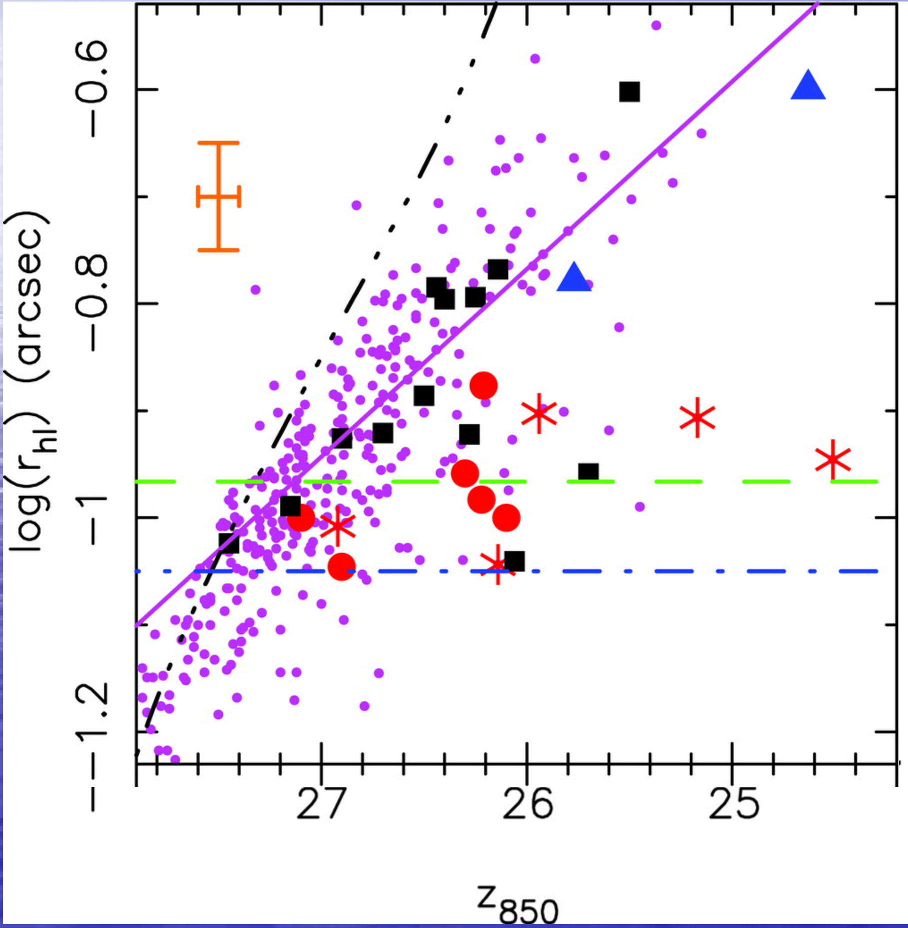
1. Size-Magnitude Relation
2. Age-Mass Relation

    LAE vs LBG

3. Dynamical Structures

    Disk-like or Spheroid-like ?

Size-Magnitude Relation
- R_{HL} vs. z_{850} mag -



● + * : LAEs

■ + ▲ + ●: LBGs

LAEs are more compact

➔

LAEs are younger

than LBGs ?

(Dow-Hygelund+ 07, ApJ, 660, 47)

R_{HL} vs. z850 mag for High-z LAEs and LBGs

z~6

Bouwens06 i-dropout (UDF, UDF-P, GOODS-N&S)
Bunker03 1 LAE @ *z* =5.7
Bunker04 UDF i-dropout
Stanway04a 3 LAEs
Stanway04b 2 LAEs in GOODS-N
Dow-Hygelund07 22 *z* ~6 (UDF&UDF-P)

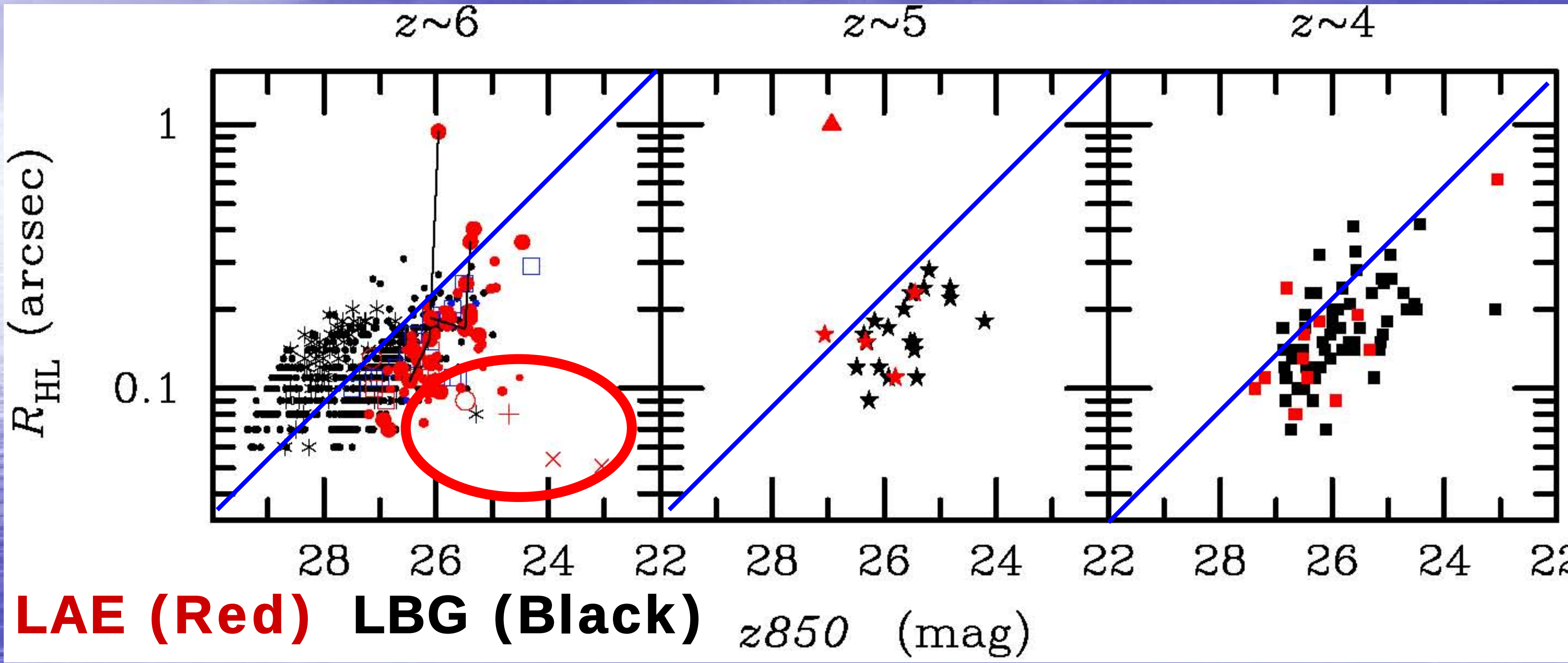
z~5

Rhoads05 1 LAE @ *z* =5.42
Overzier06 23 V dropouts in RG (*z* =5.2) field

z~4

Overzier08 63 g dropouts in RG (*z* =4.1) field
13 spectroscopic confirmed LAEs

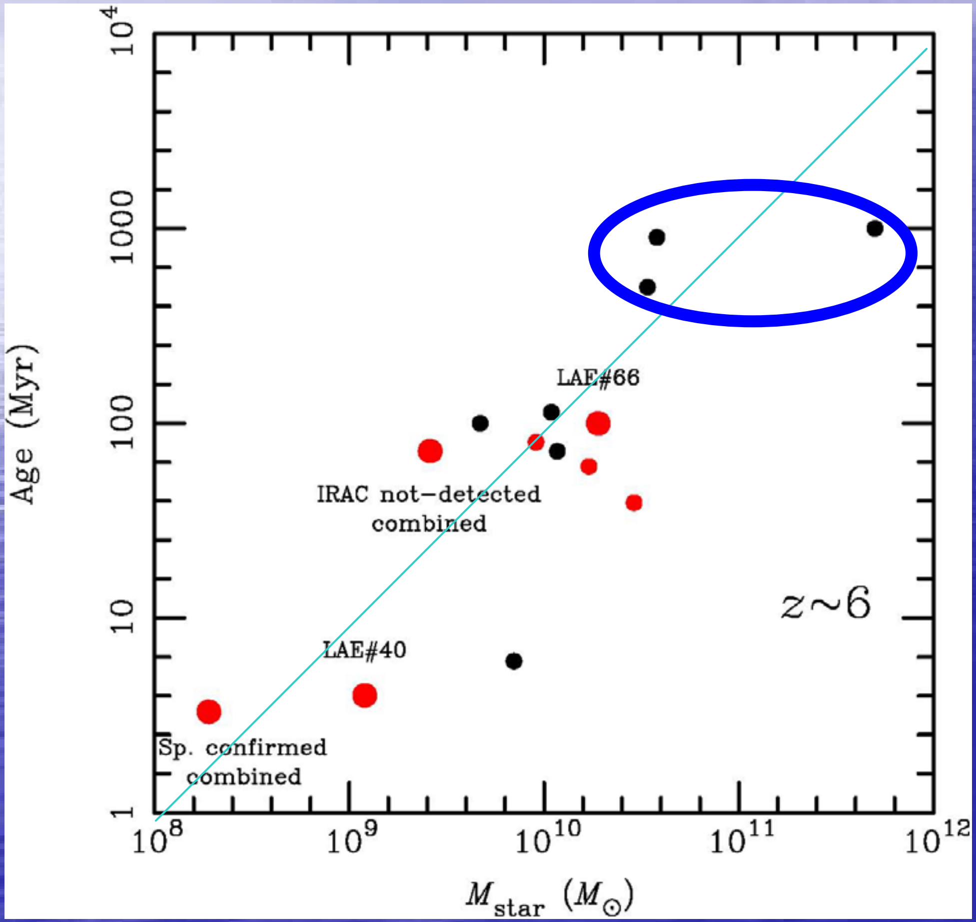
R_{HL} vs z_{850} Relation for High-z LBGs and LAEs



Little difference in sizes between LAEs & LBGs

Little redshift evolution from z=4 to 6

Age-Mass Relation for LBGs & LAEs @ z = 6



LBGs @ z = 6

Dow-Hygelund et al . (2007)
Mobasher et al. (2005)
Eyles et al. (2005)
Yan et al. (2005)

LAEs @ z = 5.7

Lai et al. (2007)
Taniguchi et al. (2008)

R_{HL} vs z_{850} Relation & Age-Mass Relation for High-z LBGs and LAEs

Little difference in sizes between LAEs & LBGs @ each z

Size evolution from z=4 to 6 is weak although LAEs @ z=6 are slightly smaller than those @ z =4 – 5

LAEs tend to be younger & less massive than LBGs

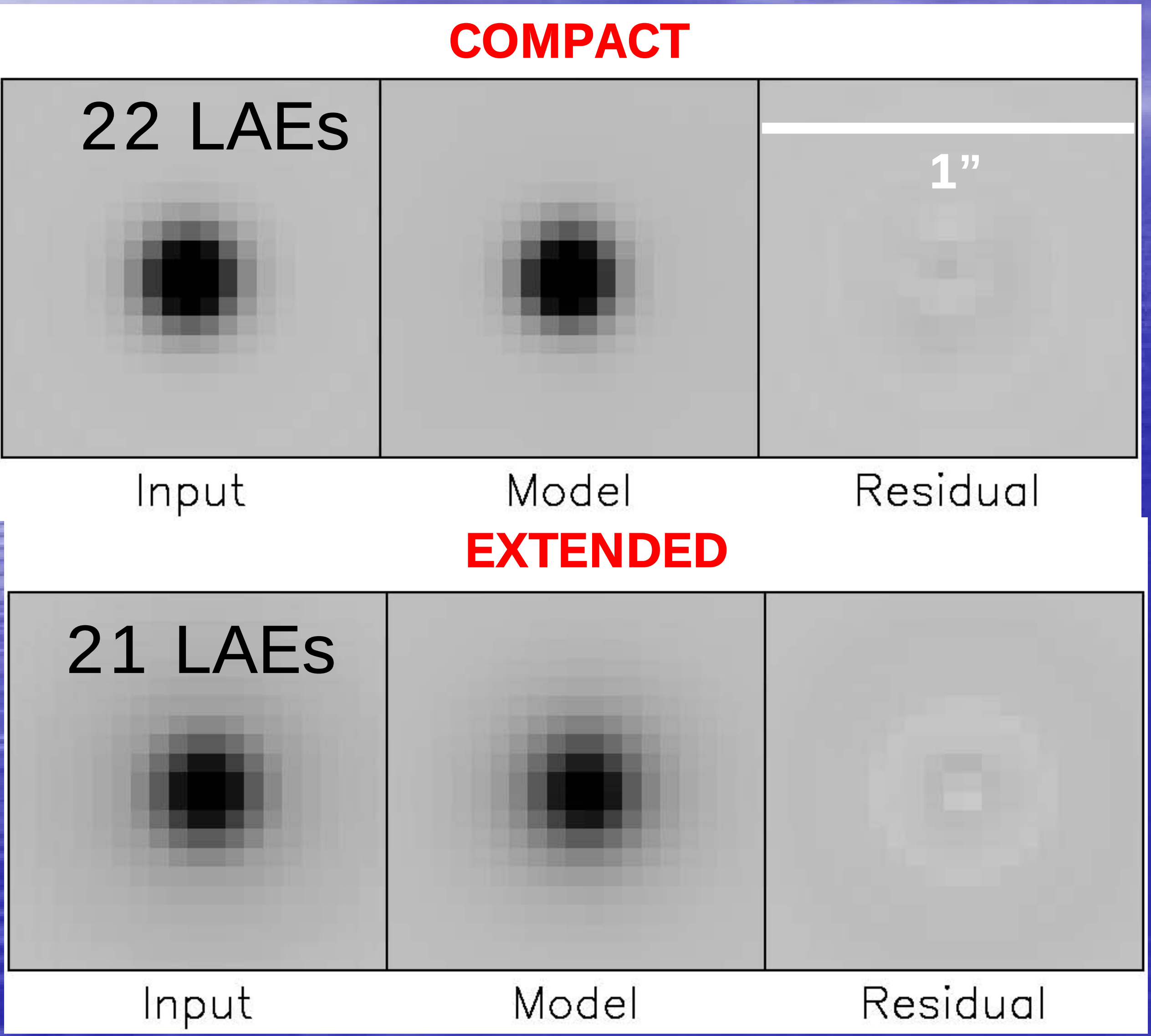
Dynamical Structures of the LAEs @ z=5.7 in COMSOS

Disk-like or Spheroidal-like ?

➔ *Azimuthally-averaged profile w/ PSF deconvolution*

(Hathi et al. 08, arXiv:0710.0007)

Azimuthally Averaged Composite (PSF-deconvolved analysis)



R_{HL}=0.053”
~300 pc
Sersic *n*=0.61

R_{HL}=0.13”
~800 pc
Sersic *n*=1.66

< 1kpc for z~5 LAEs
(Pirzkal+06)

Dynamical Structures of LAEs @ z=5.7 in the COSMOS Field

Disk-like morphology for both compact & extended LAEs

Note that

40% of bright LBGs @ z=2.5 – 5 show disk-like morphology, but 30% show spheroidal-like structures

(Ravindranath+06)

Need systematic analysis of dynamical structures of LBGs & LAEs as a function of z

Summary

There are overlaps in observational properties between LAEs and LBGs by definition.

However, systematic studies of both populations are absolutely necessary to understand the whole history of star formation in early univserse.