EVOLUTIONARY LINK BETWEEN TYPE 1 AND TYPE 2 QUASARS BY THEIR HOST GALAXIES

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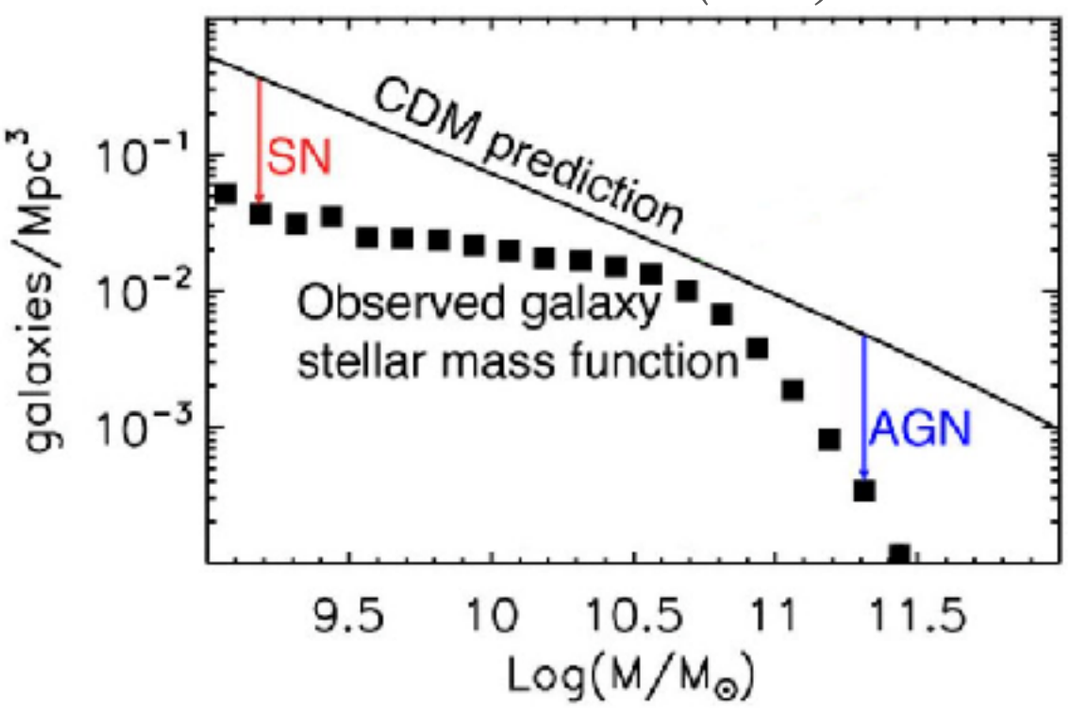
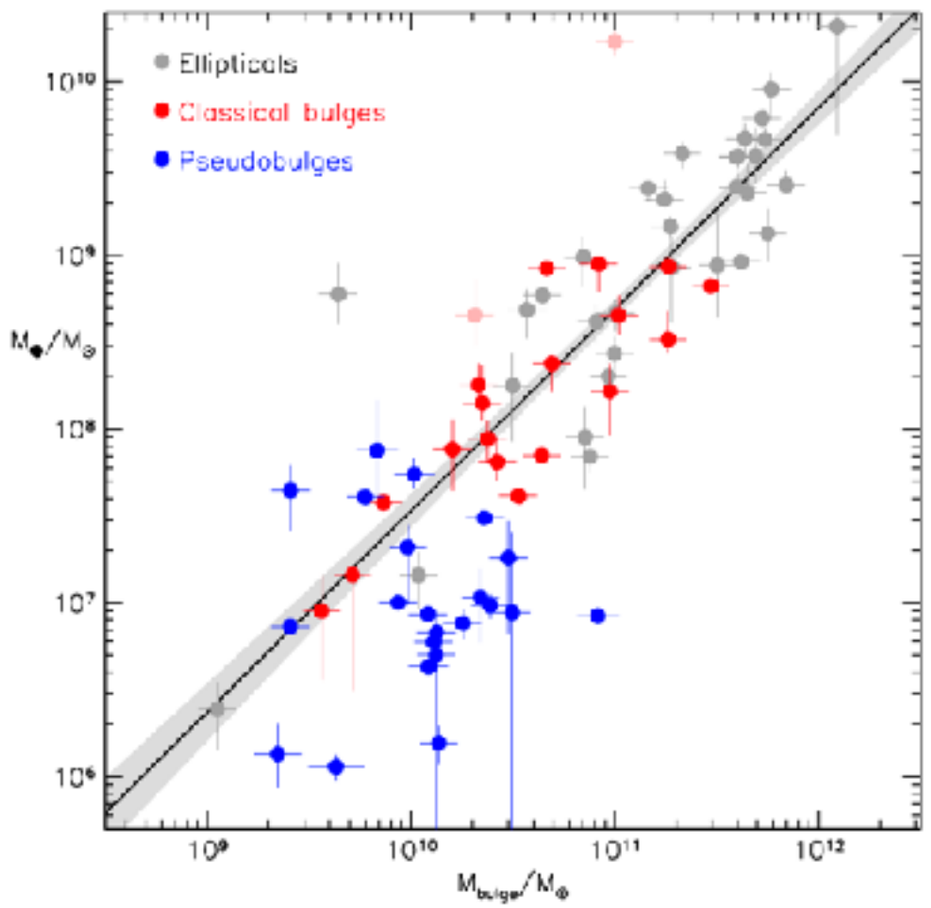
BACKGROUND

- AGNs play an important role in galaxy evolution:
  - AGN feedback
  - BH-bulge mass relation
- How AGNs were triggered?
  - Less luminous AGNs ($L_{bol} \leq 10^{45}$ erg s^{-1}) are explained by secular processes.
  - What about luminous AGNs ($L_{bol} > 10^{45}$ erg s^{-1}, quasars)?

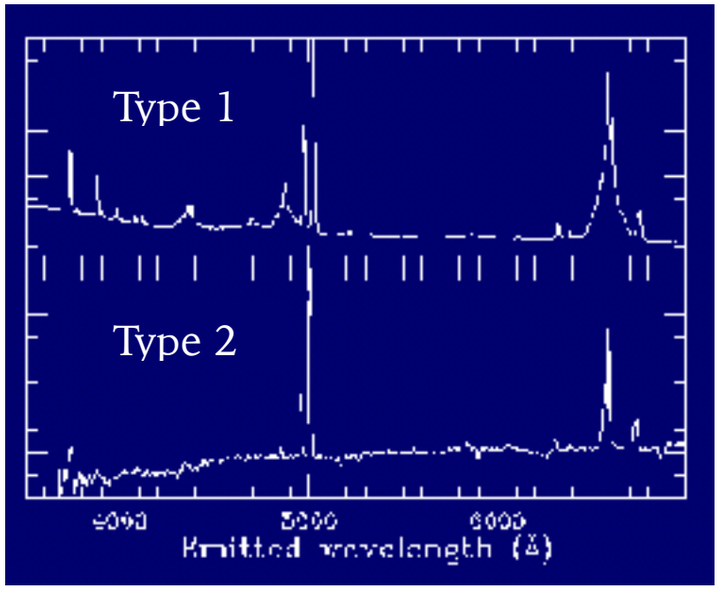
Cattaneo et al. (2009)

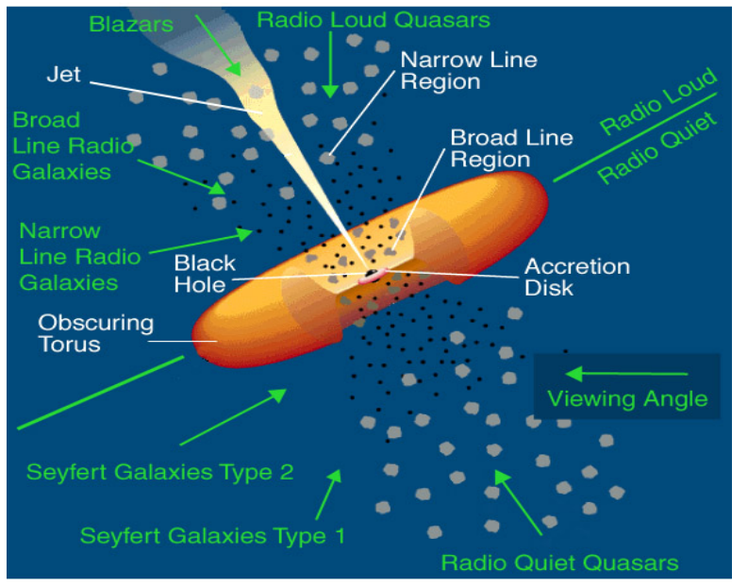


Kormendy & Ho (2003)

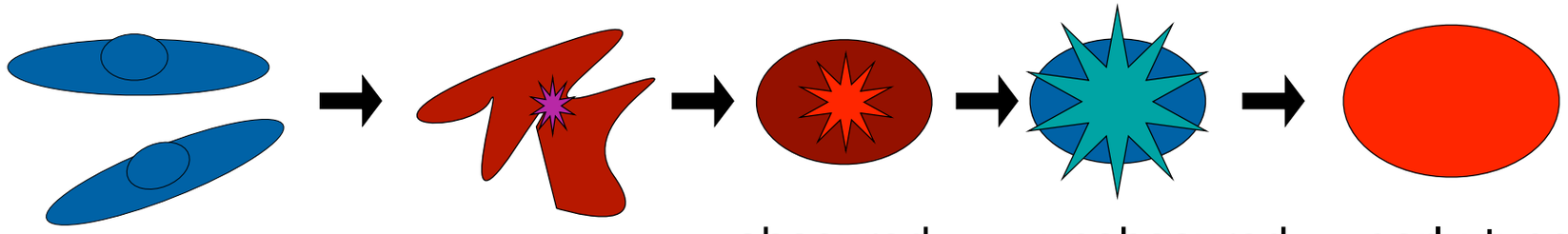


BACKGROUND



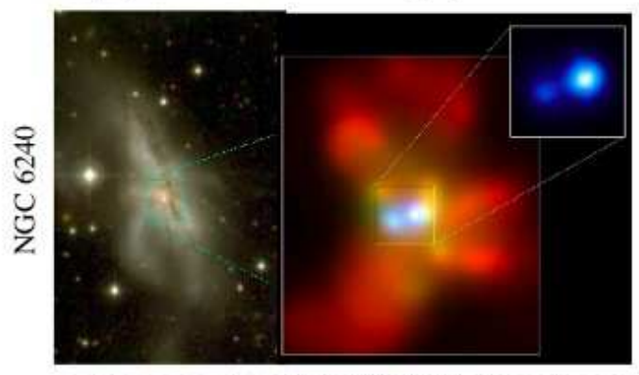


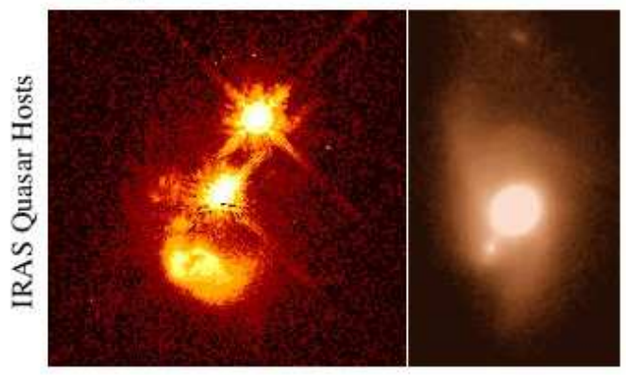
- Type 1 and type 2 quasars
- Gas-rich major merging scenario:
  - obscured type 2 quasars evolve to unobscured type 1 quasars;
  - different properties would be observed in their host galaxies.
- No consistent evidence in observations using quasars with various selections (e.g., radio, X-ray, optical).
- No discussion on the merger triggering scenario in local universe.

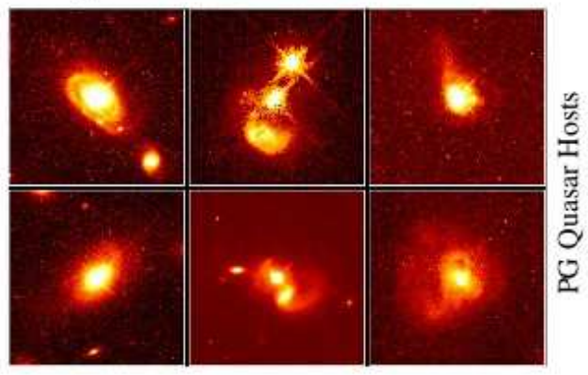


Hopkins+09

Alexander & Hickox+12





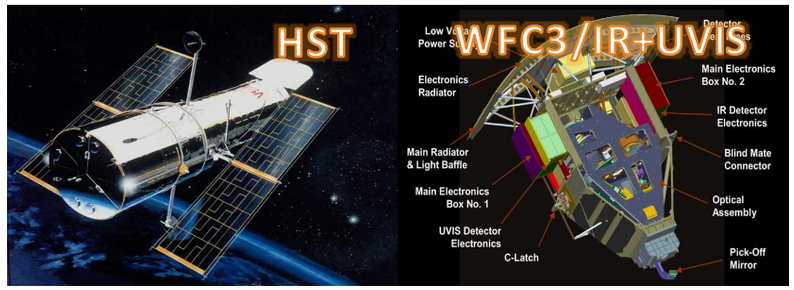


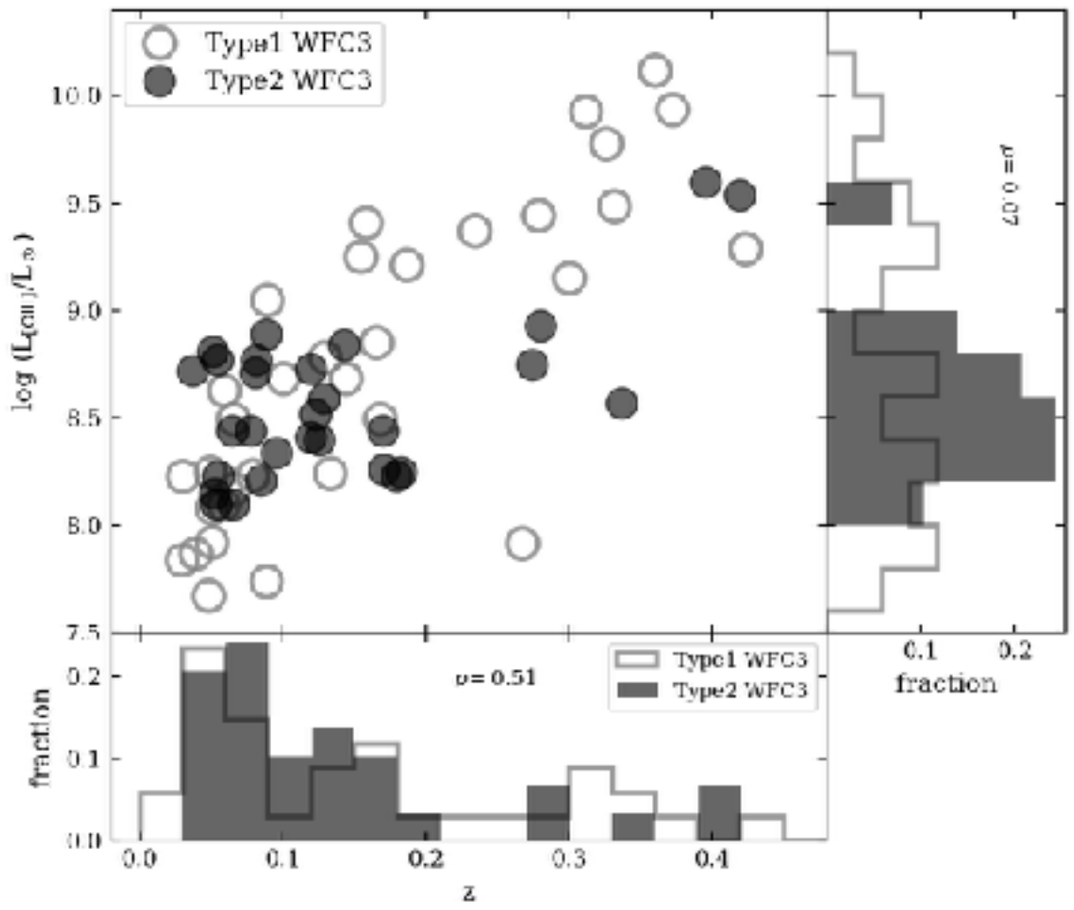
MOTIVATION

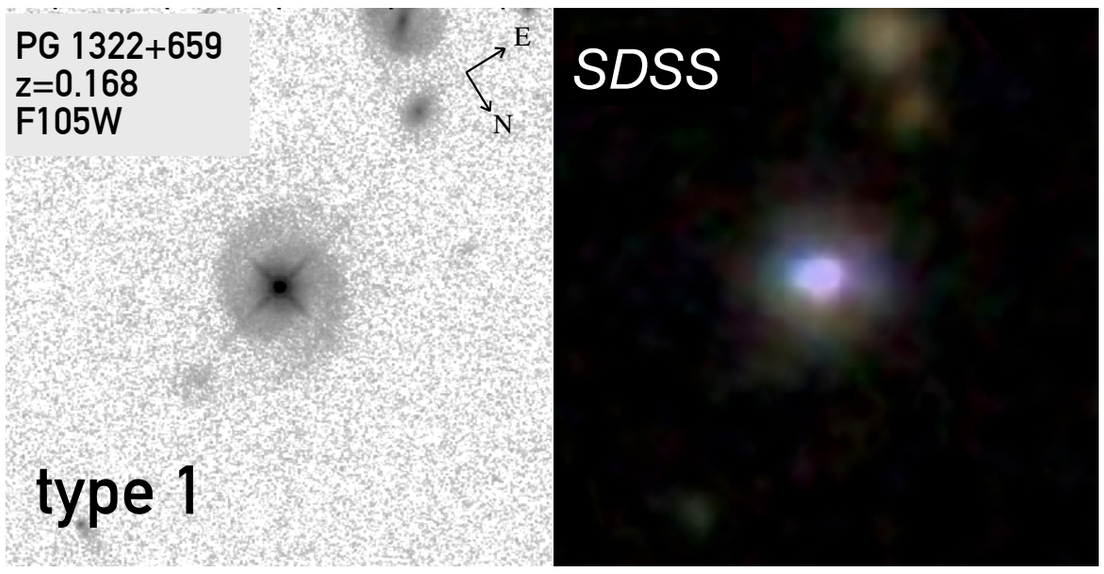
- **What are the stellar properties of host galaxies of type 1 and type 2 quasars?**
  - Studying morphologies, structures, colors and stellar masses of host galaxies
- **Is there an evolutionary link between the host galaxies of type 1 and type 2 quasars?**
  - Comparing properties of host galaxies of type 1 and type 2 quasars
- **Is major merger a prominent mechanism to trigger local luminous AGNs?**

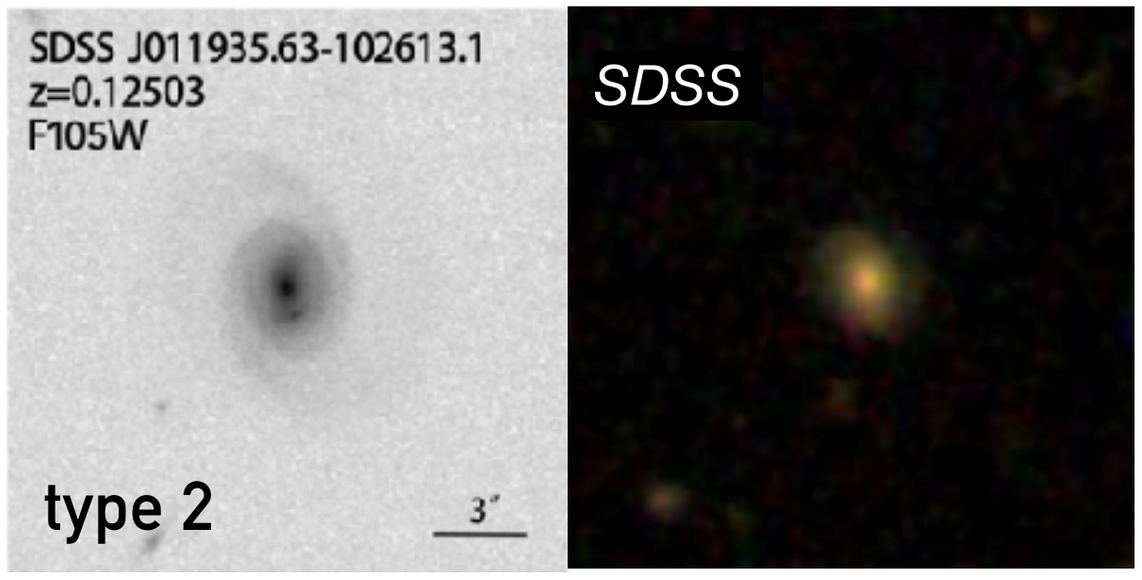
SAMPLE AND DATA

- **35 type 1** quasars randomly selected from UV-selected PG quasars (Schmidt & Green 1983).
- **29 type 2** quasars are selected from parent catalogue of Reyes et al. (2008) which identified 887 type 2 quasars from optical SDSS sample.
- High-quality images taken with HST using WFC3 UVIS and NIR bands (PI: Luis Ho, snapshot mode).
- WFC3 images allow us to study morphologies and structures of quasar host galaxies in great detail.
- Data of HST two bands allow us to measure colors and stellar masses of the host galaxies of quasars.





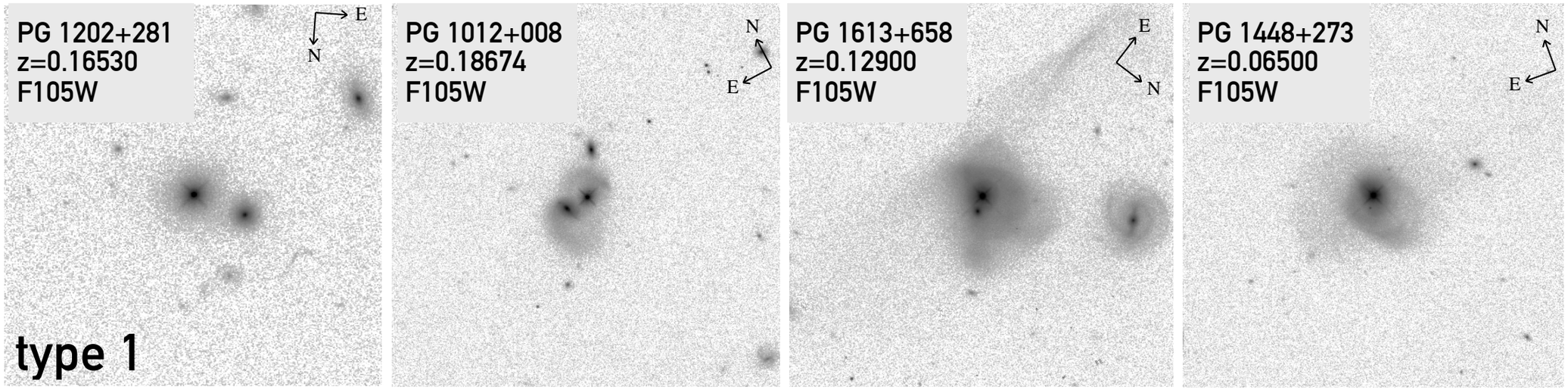


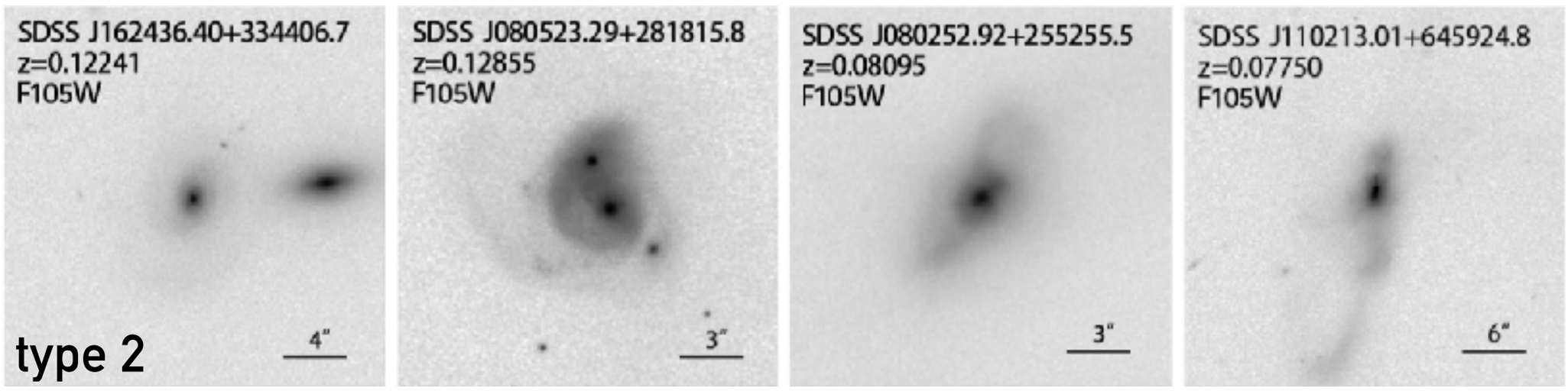


MORPHOLOGY CLASSIFICATION

- Four morphology types:

  1. merging or disturbed morphologies

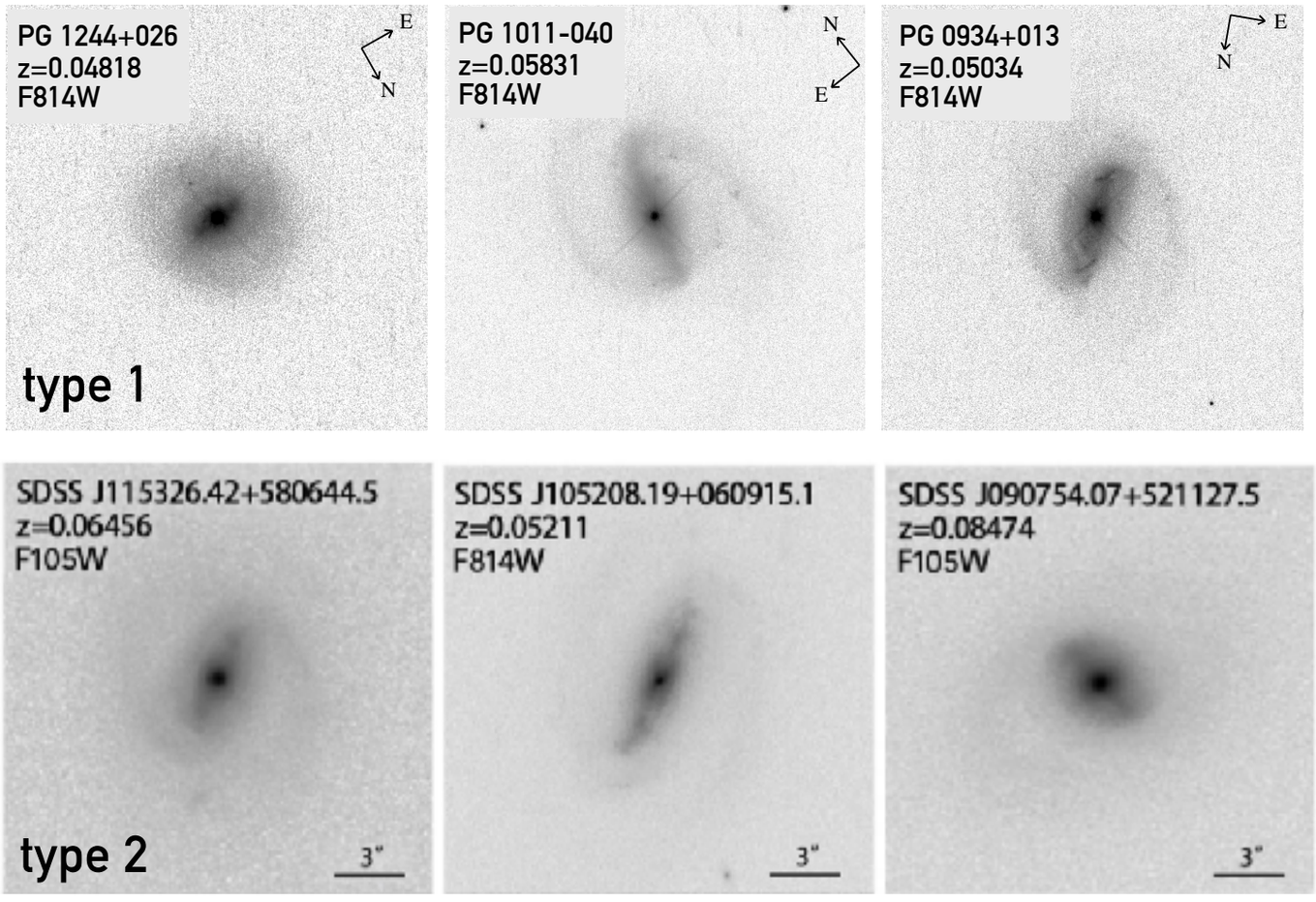




MORPHOLOGY CLASSIFICATION

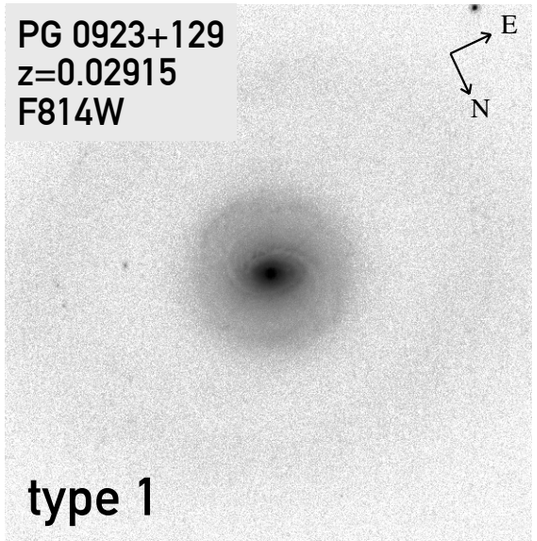
2. late-type galaxies:

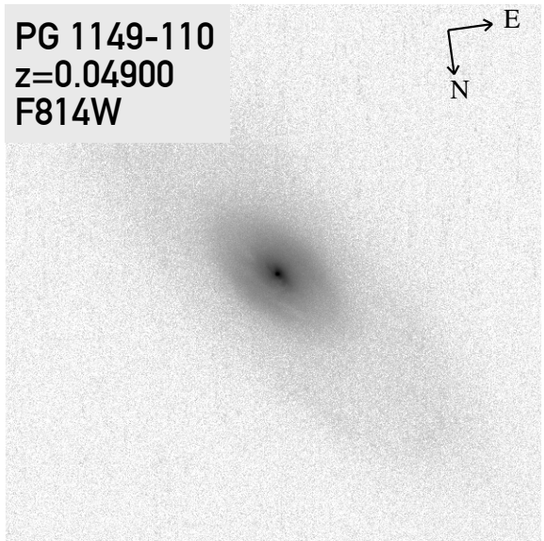
- bar spirals
- pure spirals

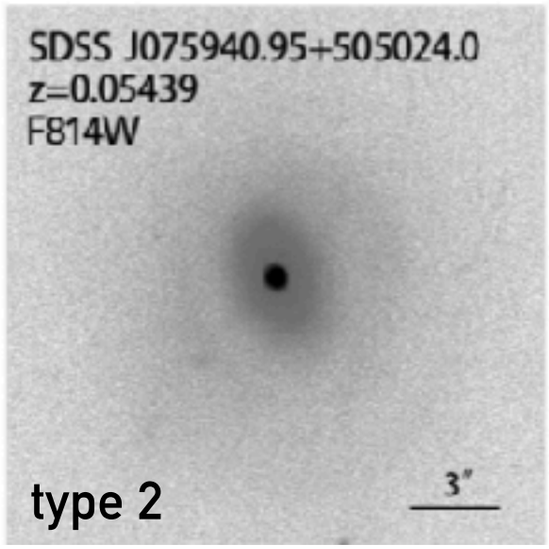


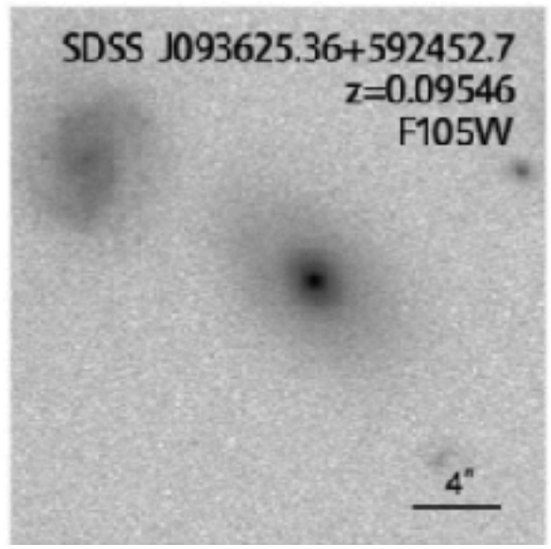
MORPHOLOGY CLASSIFICATION

3. lenticular galaxies

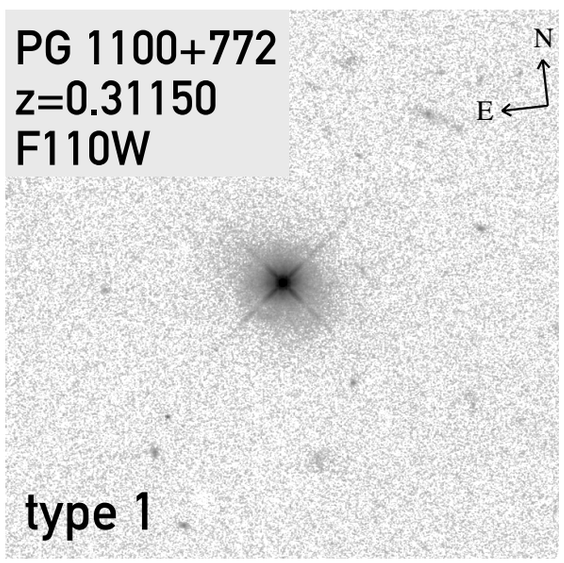


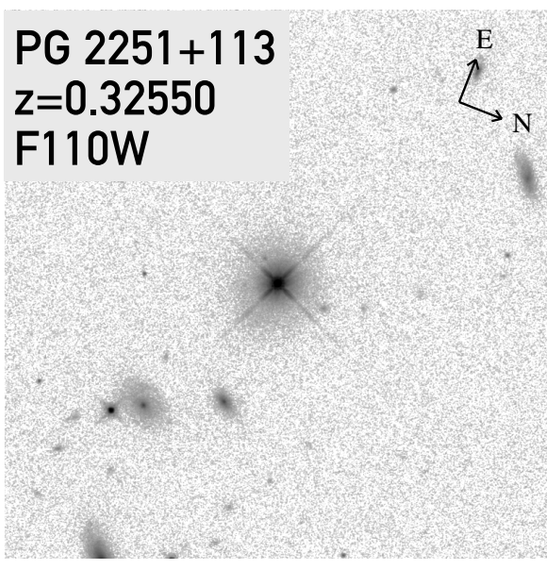


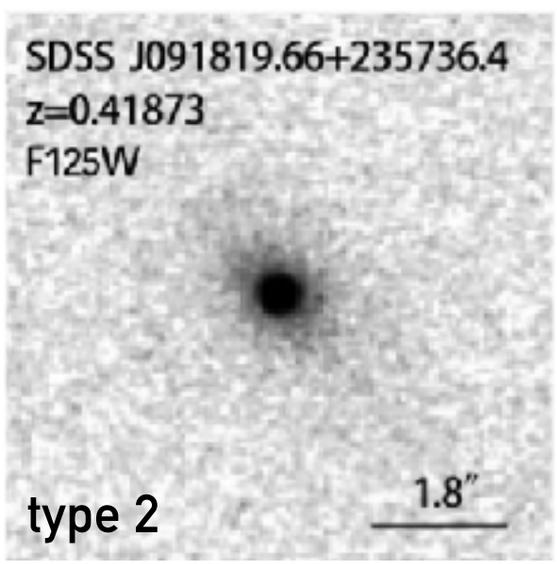


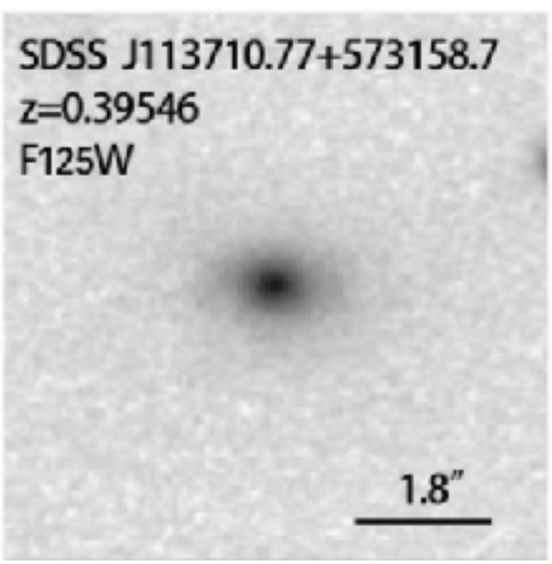


4. elliptical galaxies



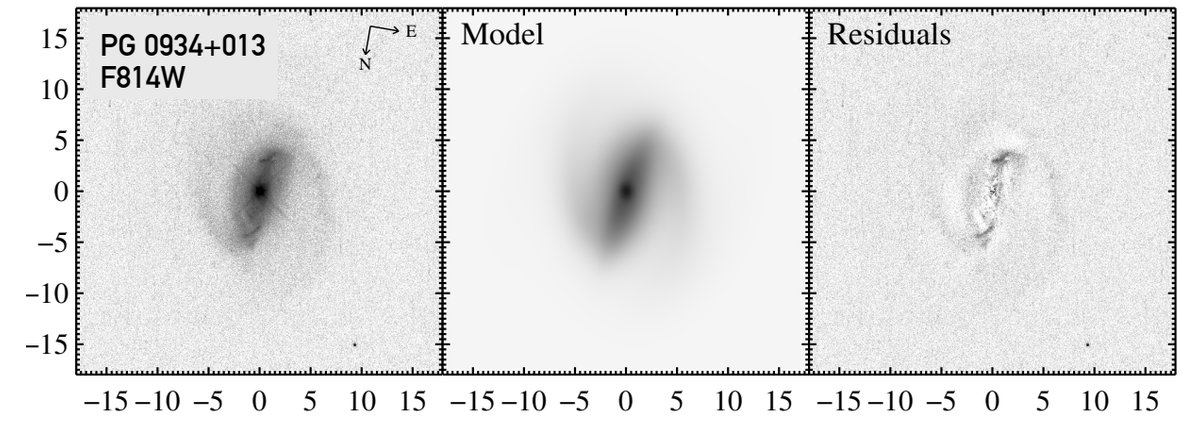


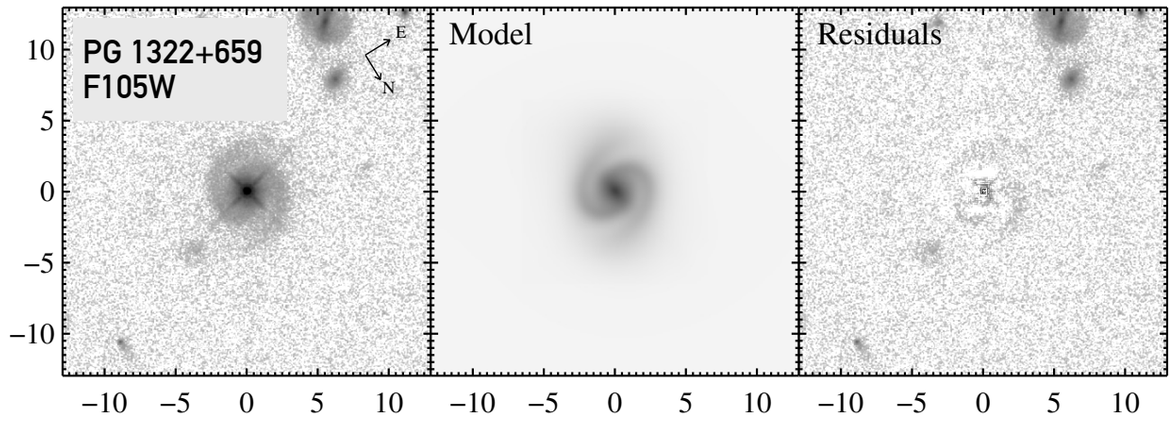


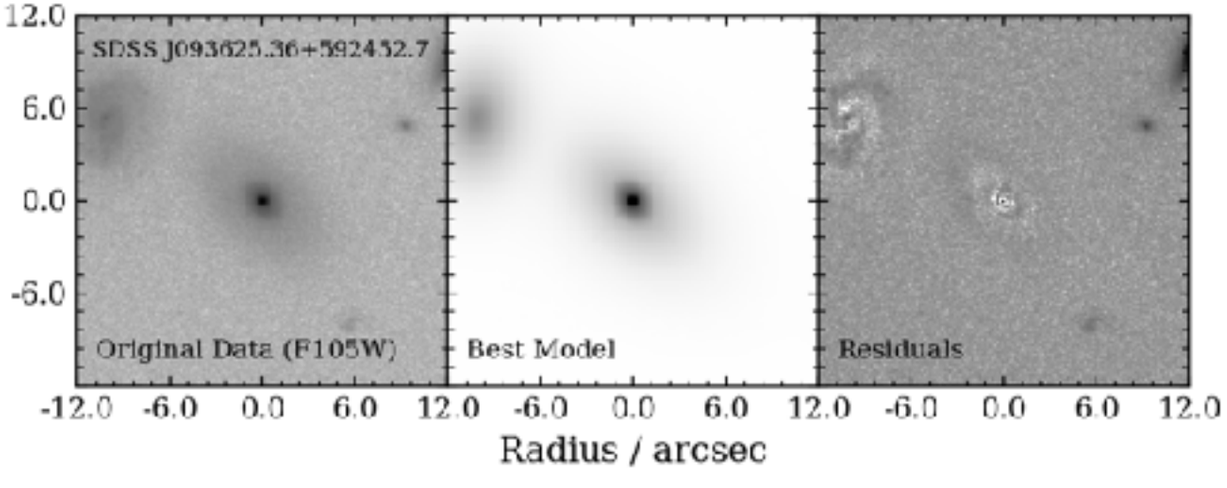


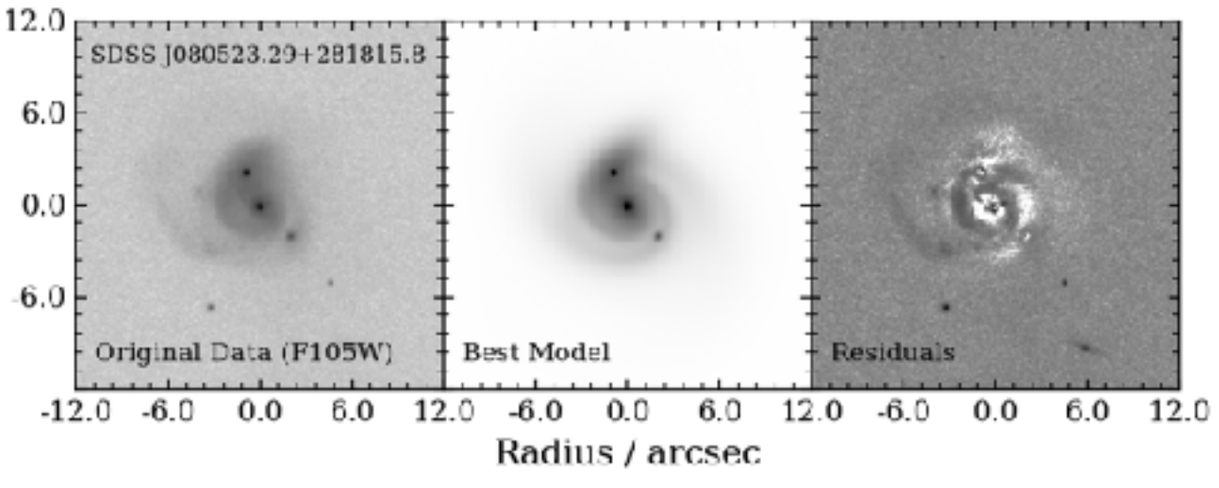
STRUCTURE MEASUREMENT

- Galaxy decomposition by GALFIT using WFC3 images of IR filter.
- Detail components: AGN nucleus, bulge, disk, bar, spiral arms, inner lens
- Magnitude of WFC3 UVIS band is measured by the best-fit model of IR band



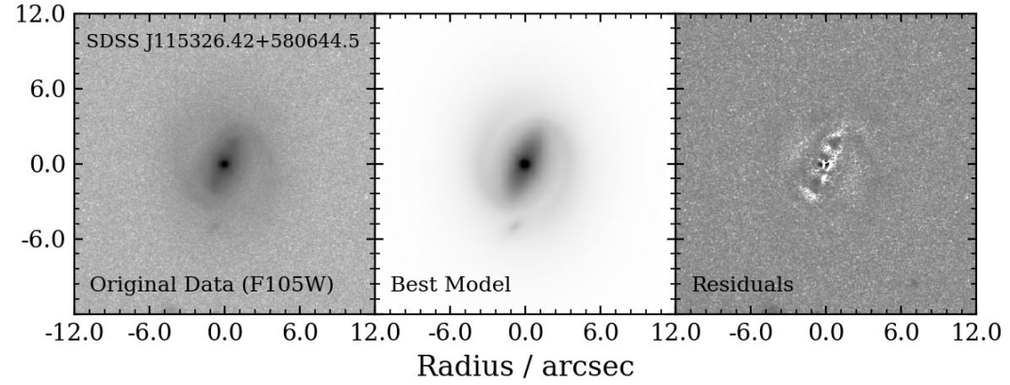


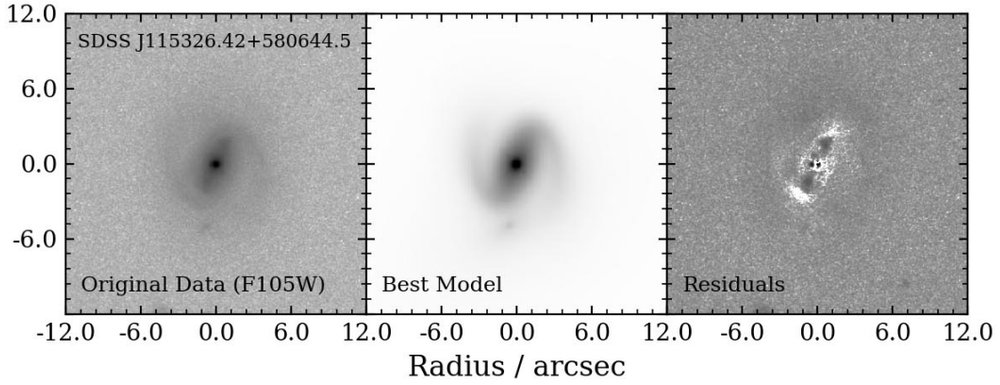


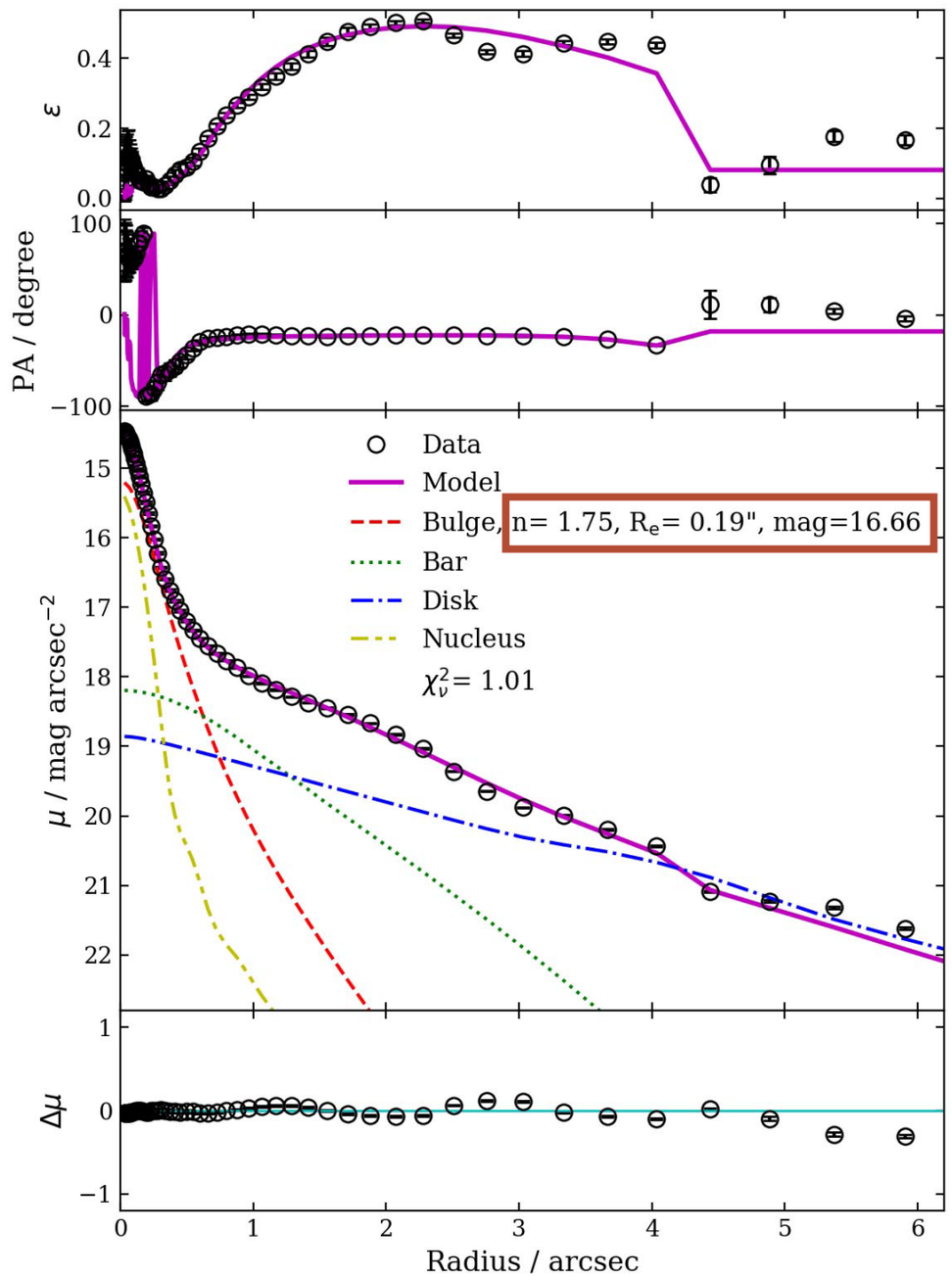


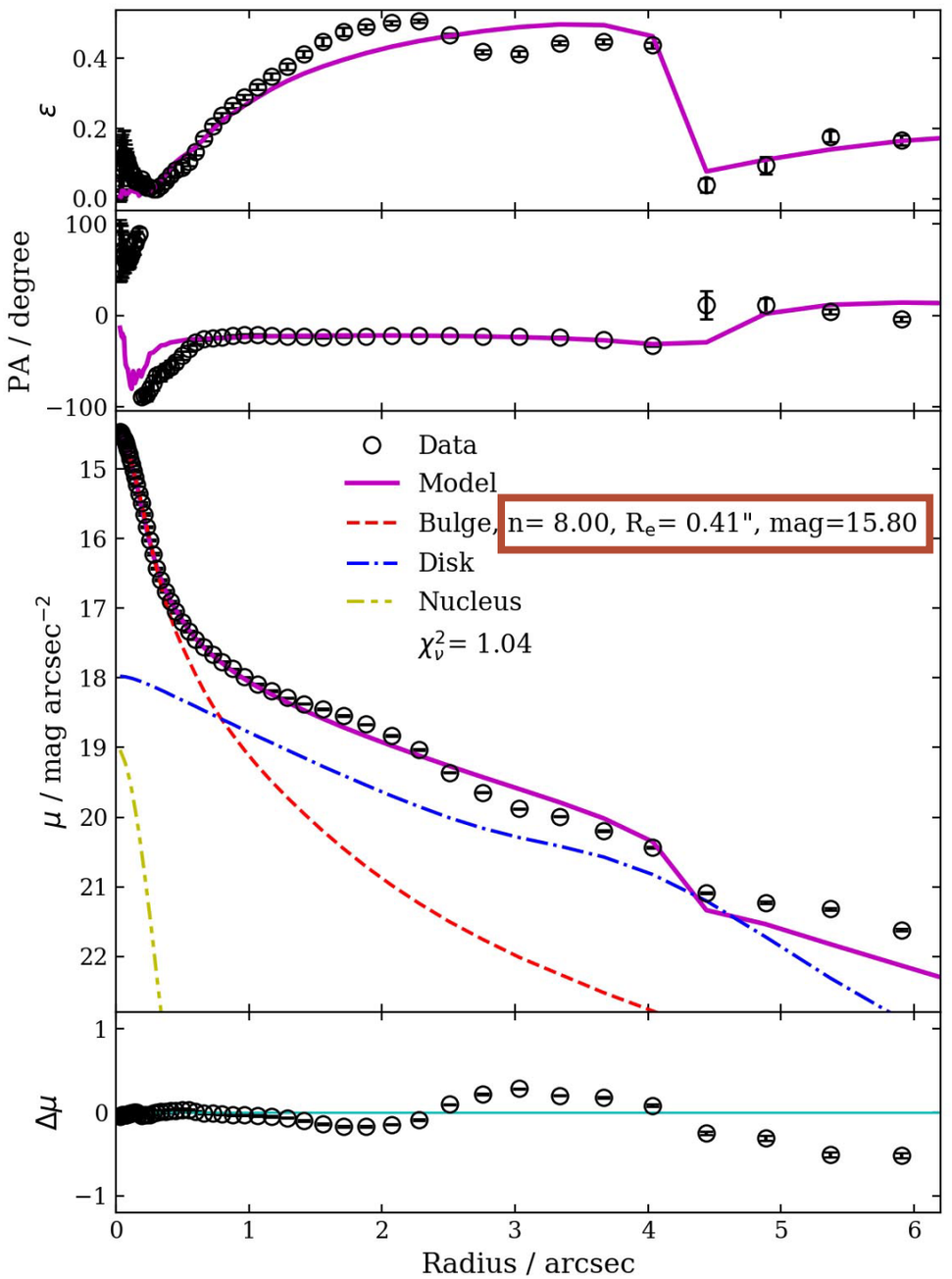
STRUCTURE MEASUREMENT

- Bar component is essential to obtain accurate bulge properties.







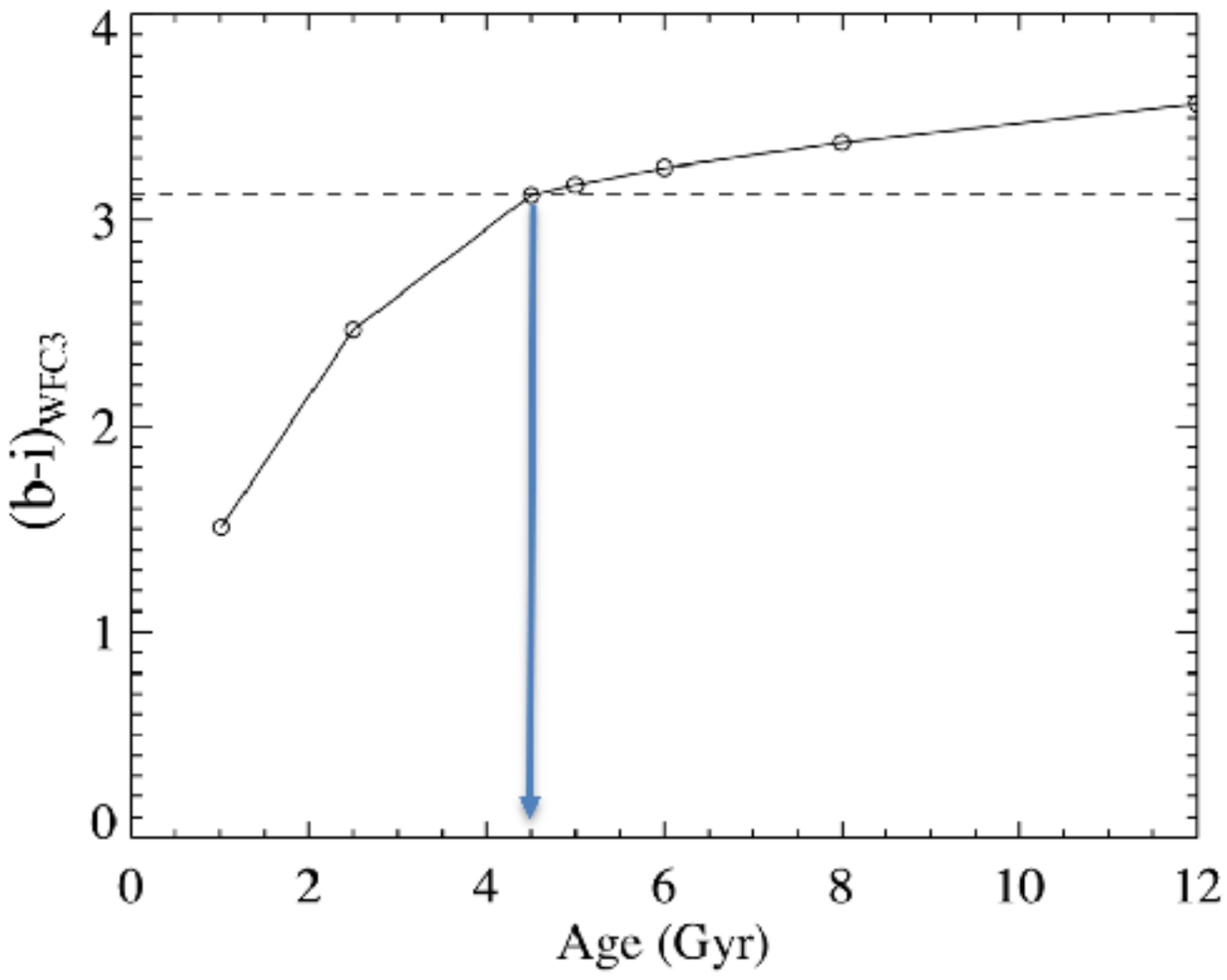


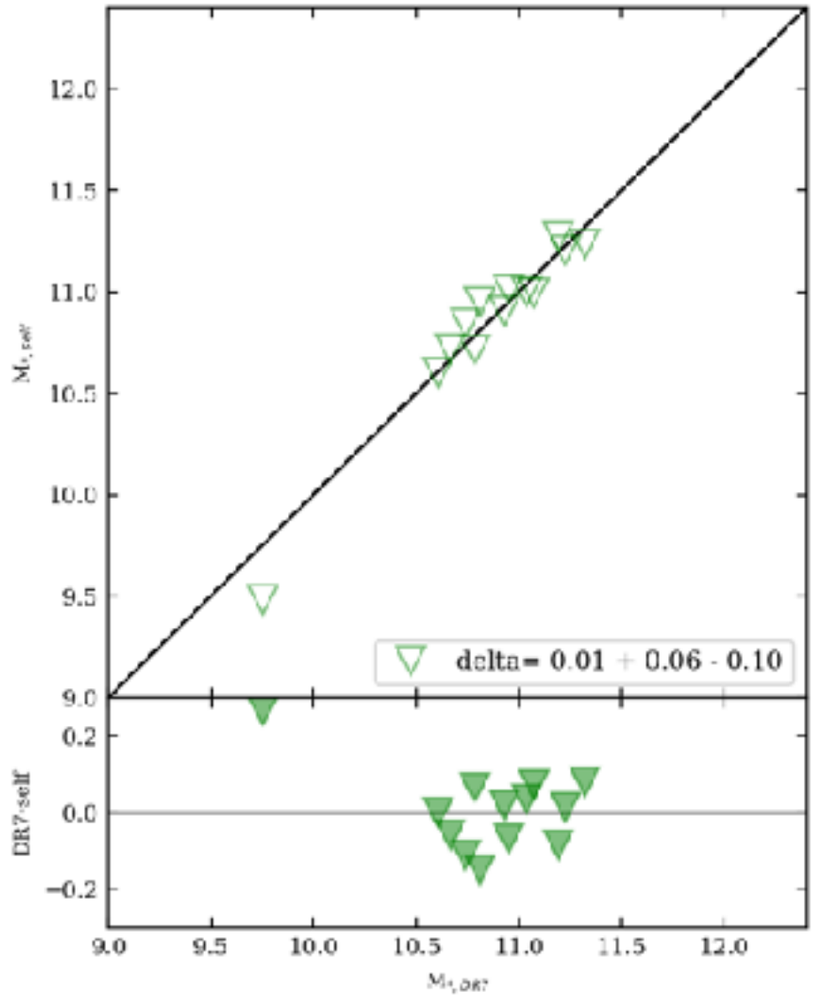
STELLAR MASS ESTIMATION

- Stellar mass is estimated by M/L ratio of Bell et al. (2001):

$$\log_{10}\left(\frac{M_*}{M_\odot}\right) = -0.4(M_{\rm I} - M_{\rm I,\odot}) - 0.394 + 0.439(B-I)$$

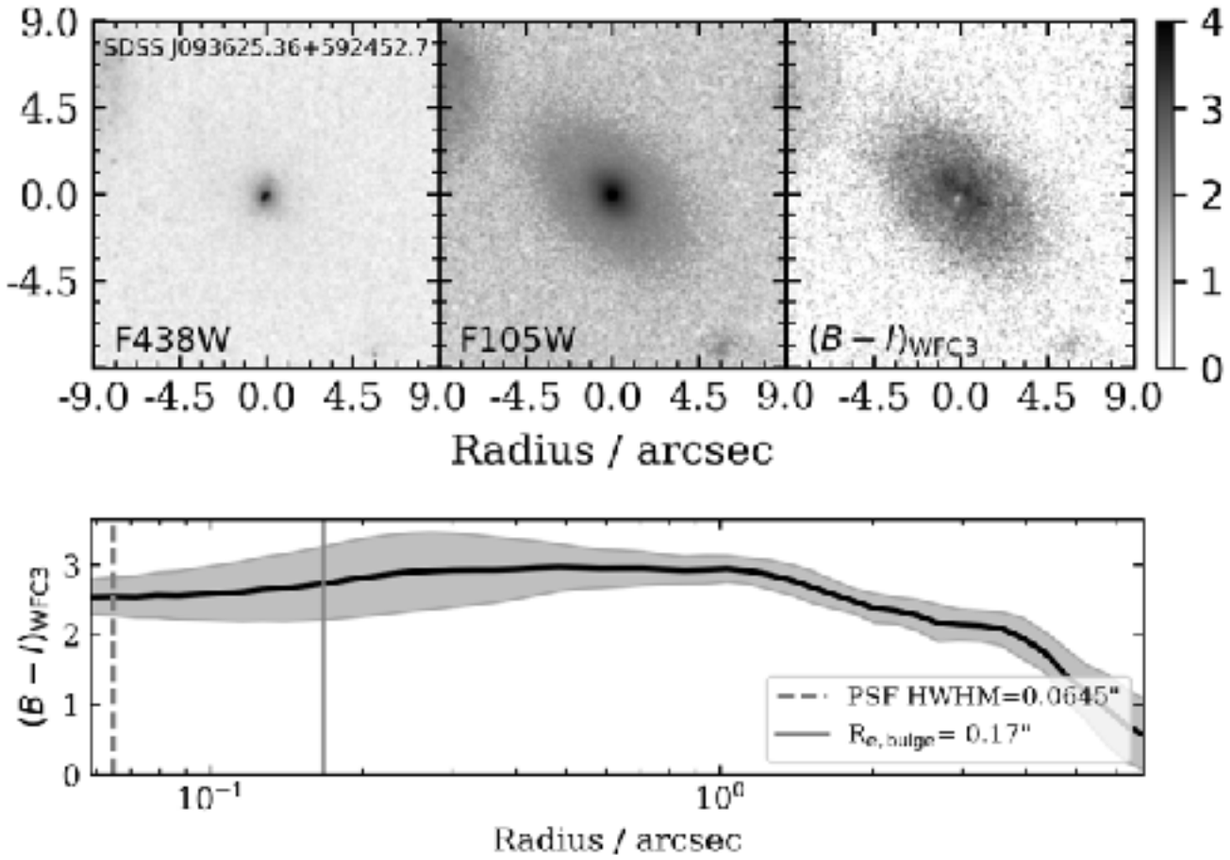
- K-correction is conducted using BC03 stellar population whose age is derived from observed (b-i) color.

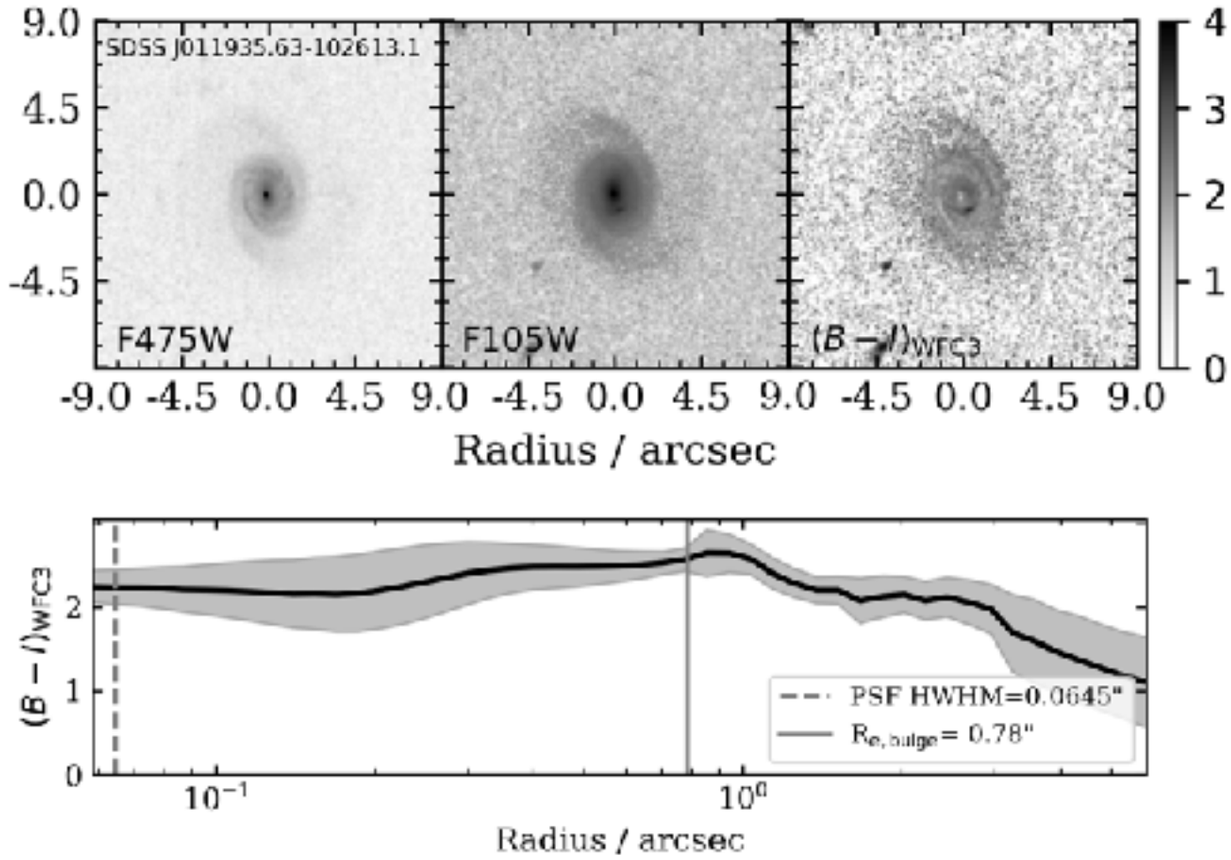




COLOR MAP CREATION

- *B-I* color map is created by using WFC3 UVIS and IR images.
- Color vs. radius shows the color information of different region of quasars host galaxies.



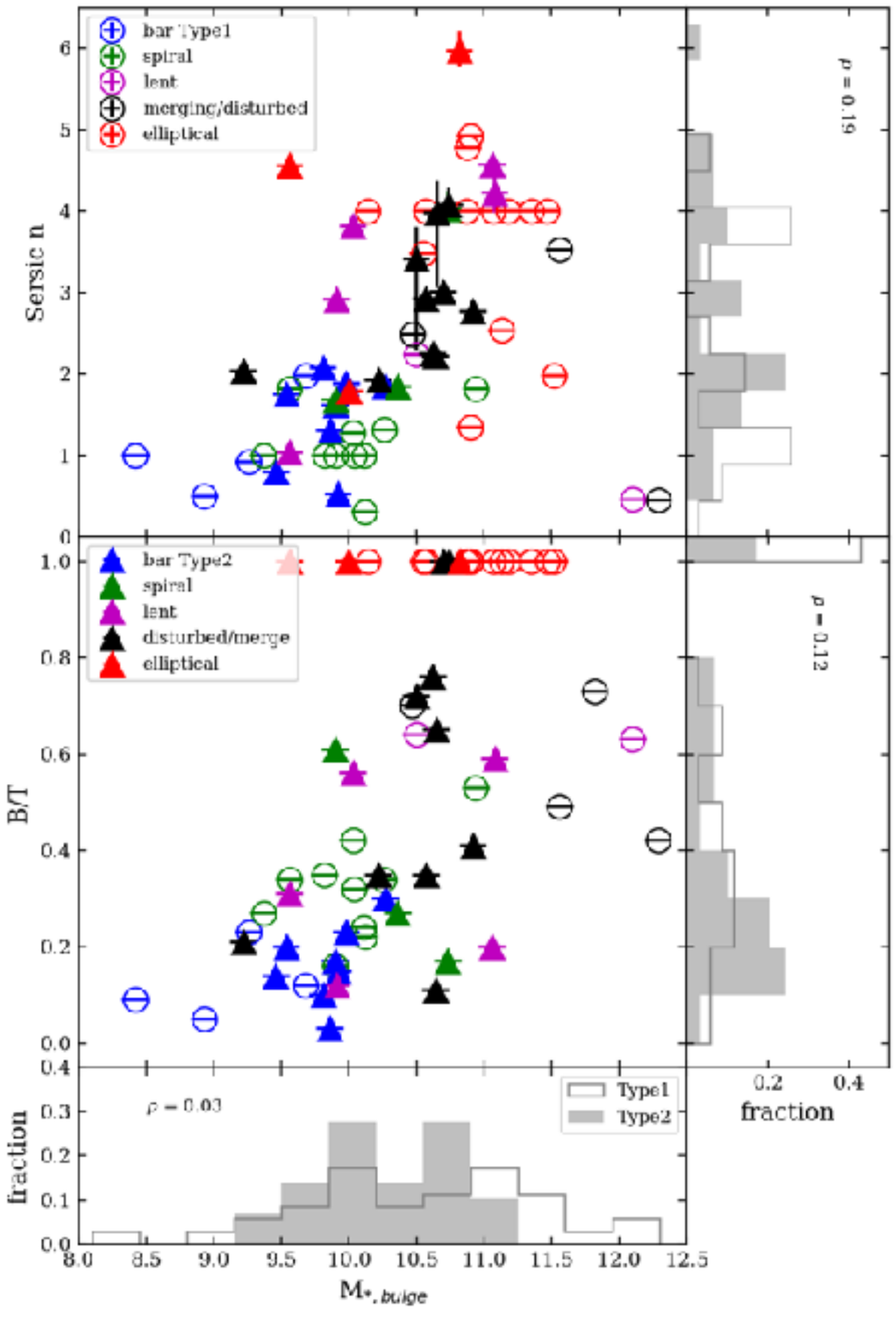


RESULTS: MORPHOLOGIES

- **Type 1 quasars:**
  - 17% in host galaxies of merging/disturbed morphologies;
- **Type 2 quasars:**
  - 35% in host galaxies of merging/disturbed morphologies;

- **Type 1 quasars:**
  - 46% in disk host galaxies (i.e., lenticular, bar spiral, and pure spiral);
  - 40% in late-type host galaxies (i.e., bar spiral and pure spiral).
- **Type 2 quasars:**
  - 55% in disk host galaxies with regular morphology;
  - 38% in late-type host galaxies.

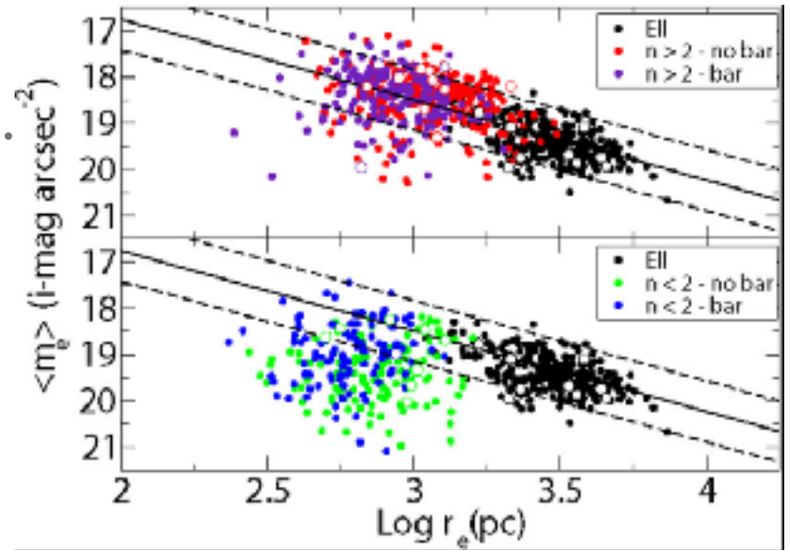
RESULTS: BULGE STRUCTURES

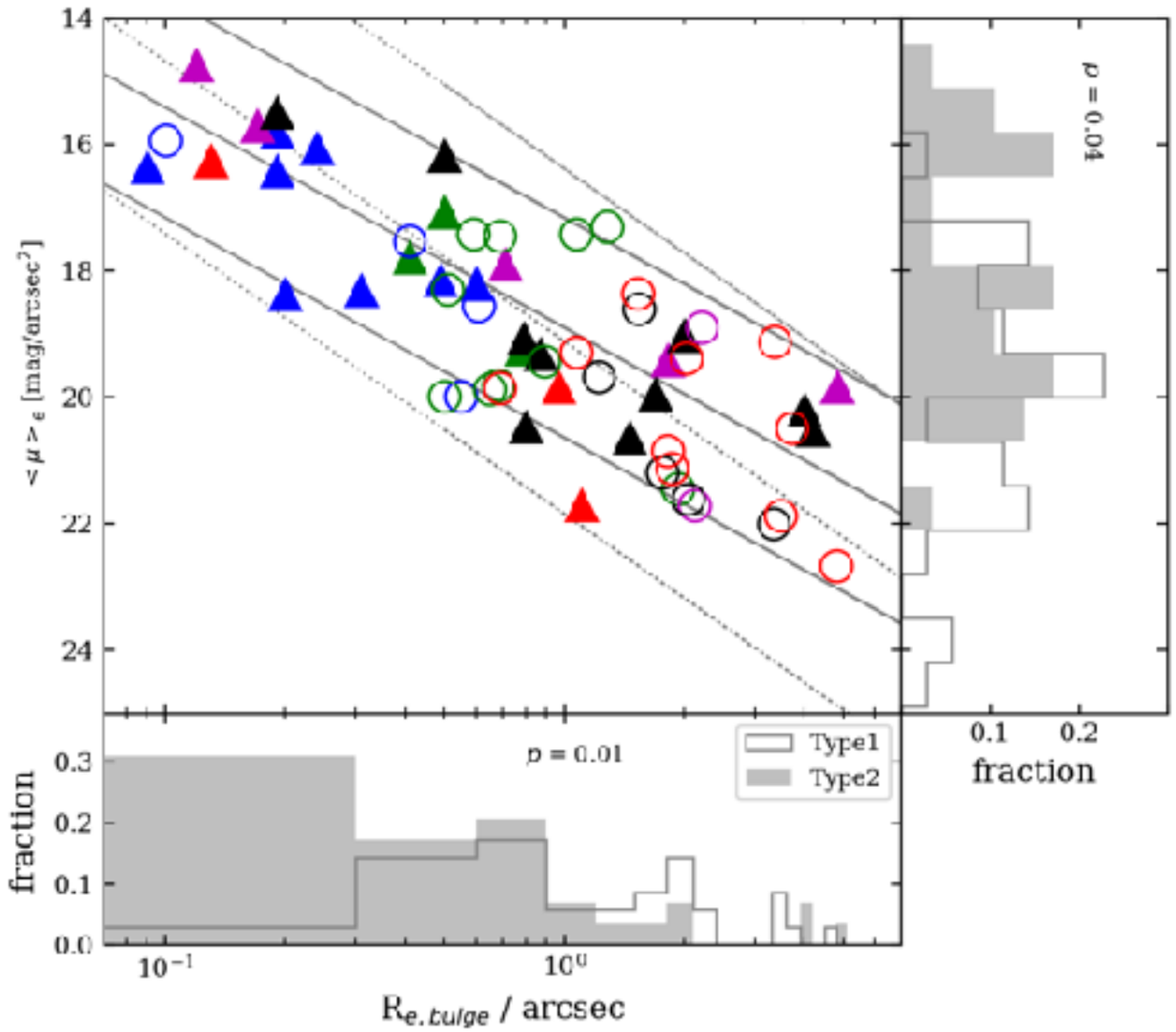


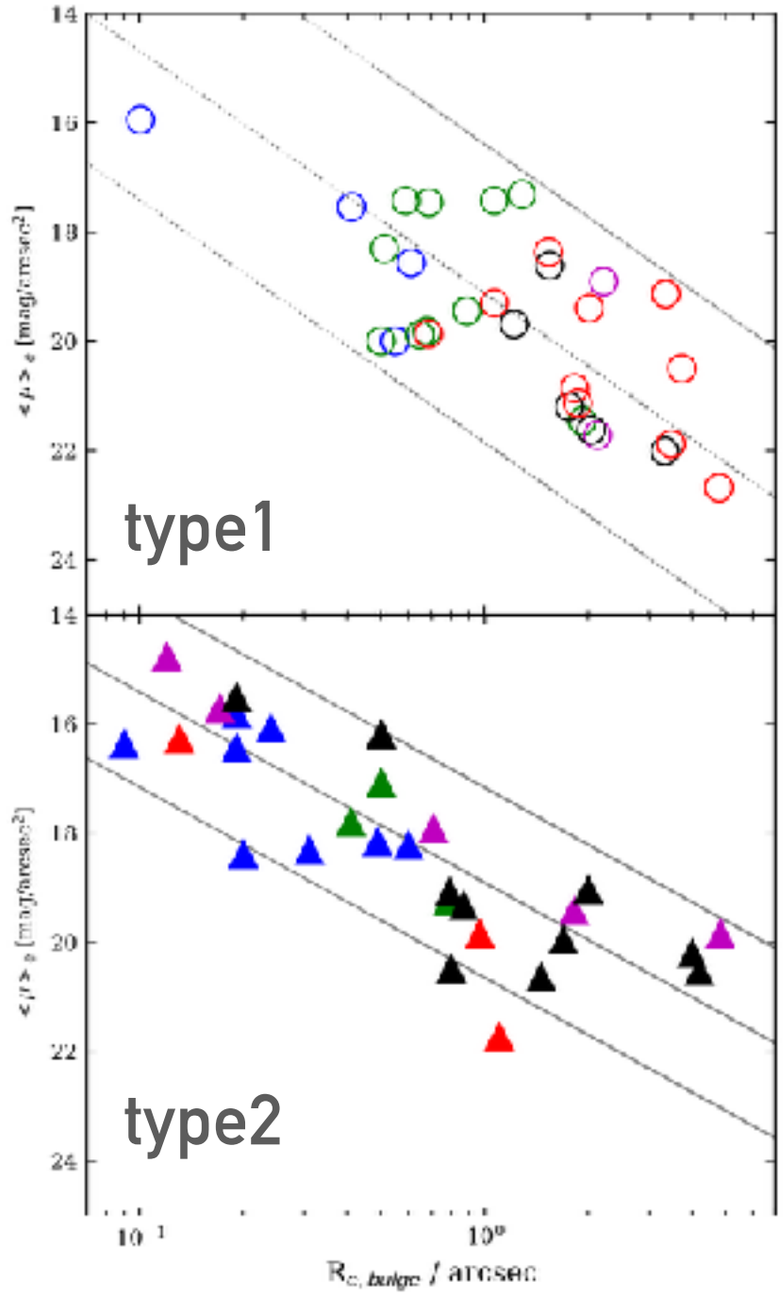
- Bulges of type 1 quasars have similar Sersic index and B/T with bulges of type 2 quasars.
- Host galaxies in merging/disturbed, elliptical and lenticular have classical bulges.
- Host galaxies in late-type morphologies (i.e., bar spiral or pure spiral) possess less massive pseudo-bulges.

RESULTS: KORMENDY RELATION

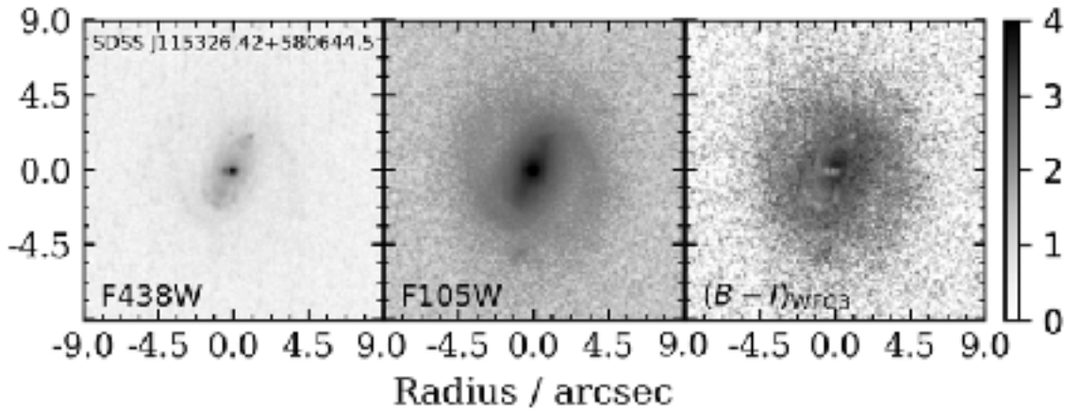
- Bulges of type 1 quasars have similar size and surface brightness with bulges of type 2 quasars.
- Pseudo-bulges of both type 1 and type 2 quasars have high surface brightness distributing closely around the Kormendy relation for the classical bulges.

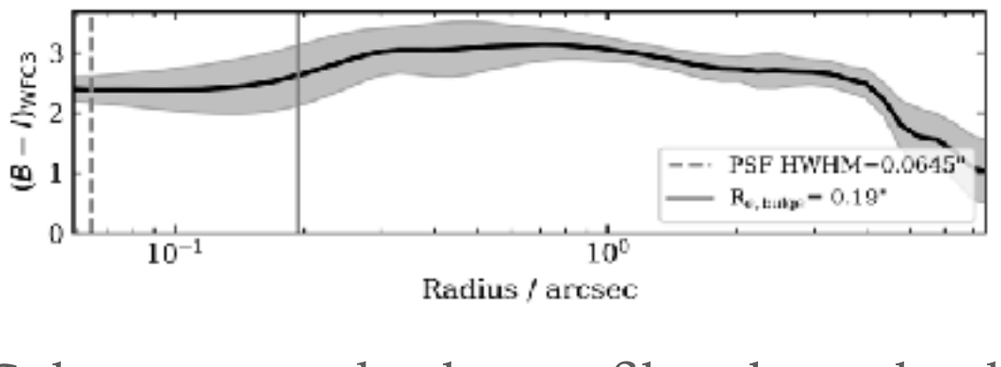


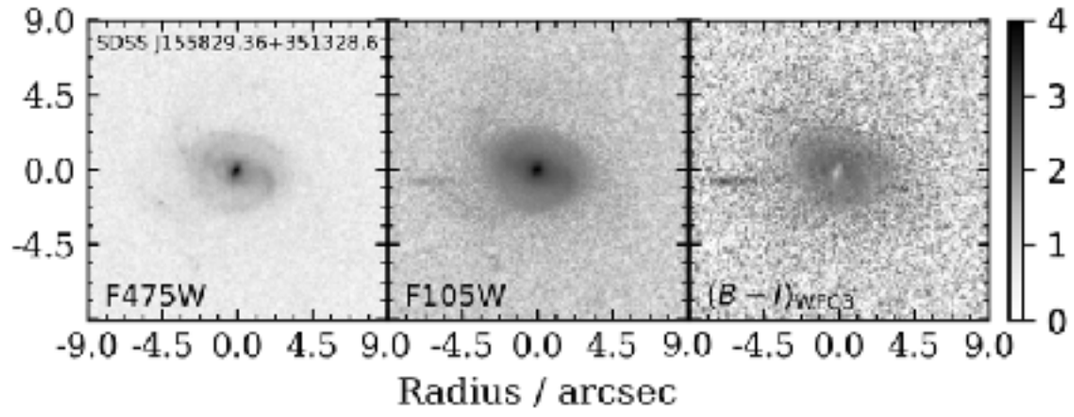


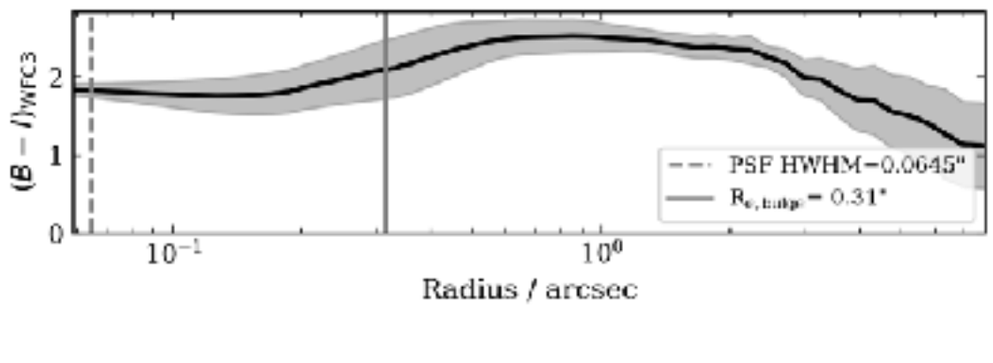


RESULTS: COLORS

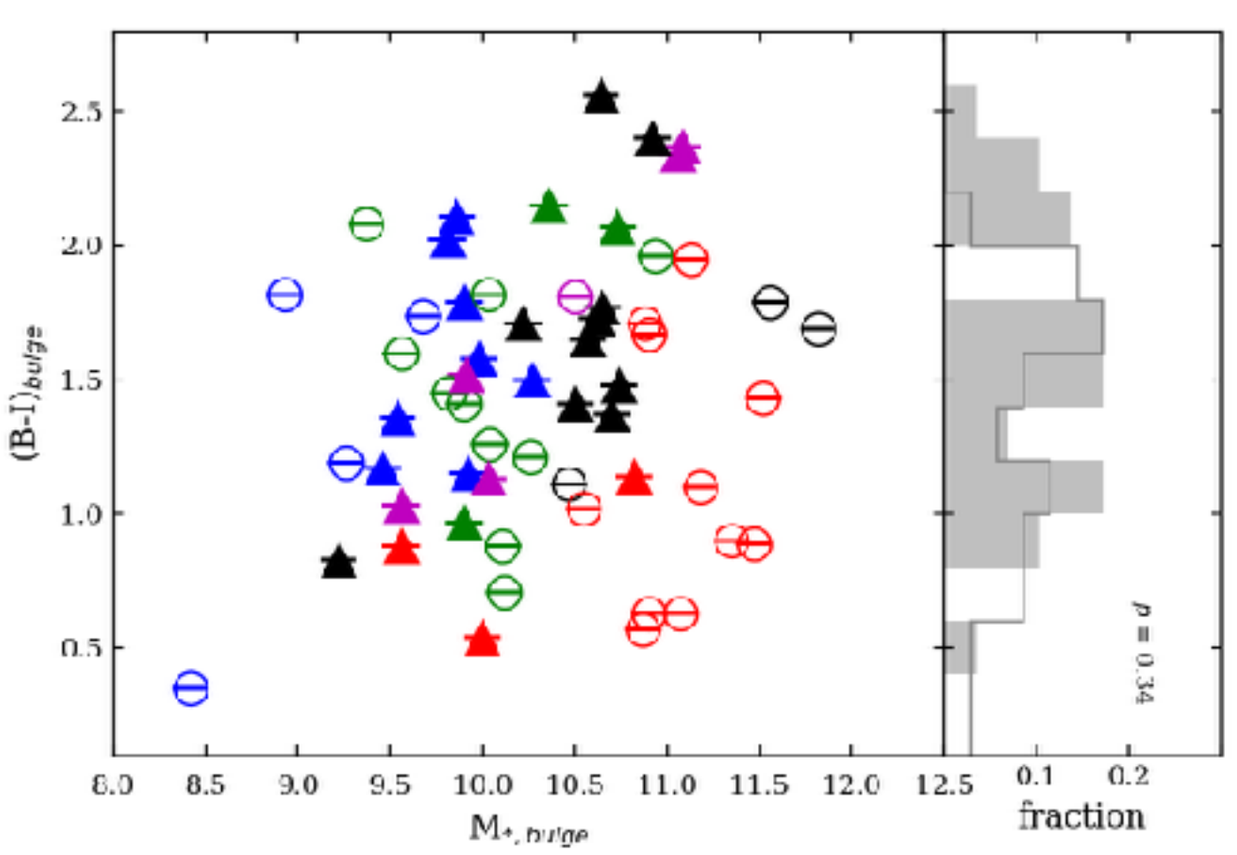




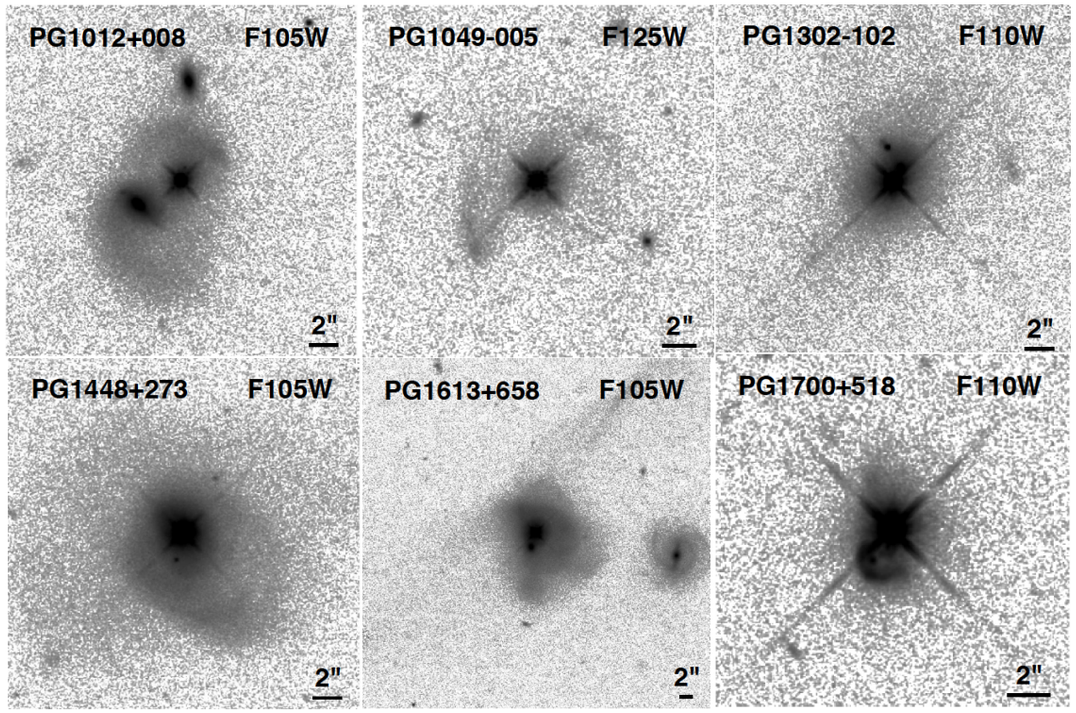




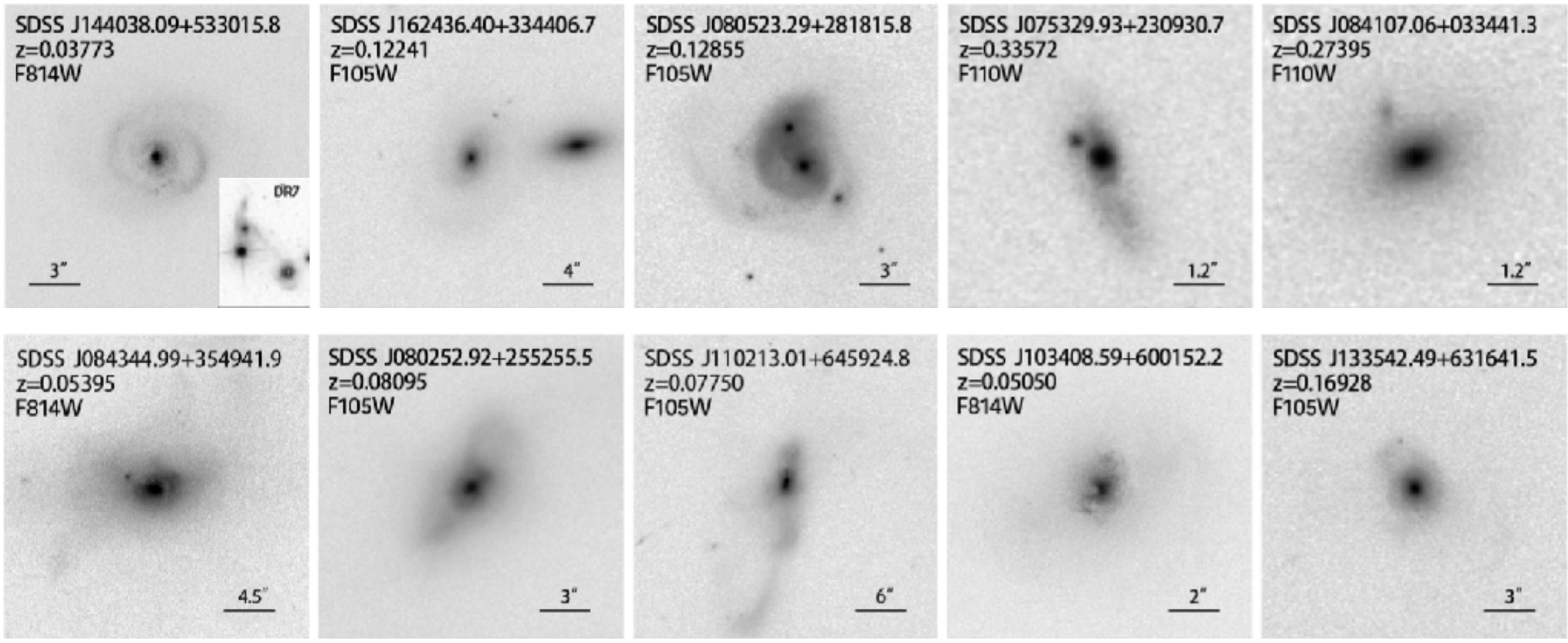
- Color maps and color profiles show clearly the existence of younger stellar populations within/around the central regions of host galaxies while the outer regions are much redder.
- It implies possible association between star formation and AGN activities.
- Type 1 and type 2 quasars have bulges of similar colors.



DISCUSSIONS

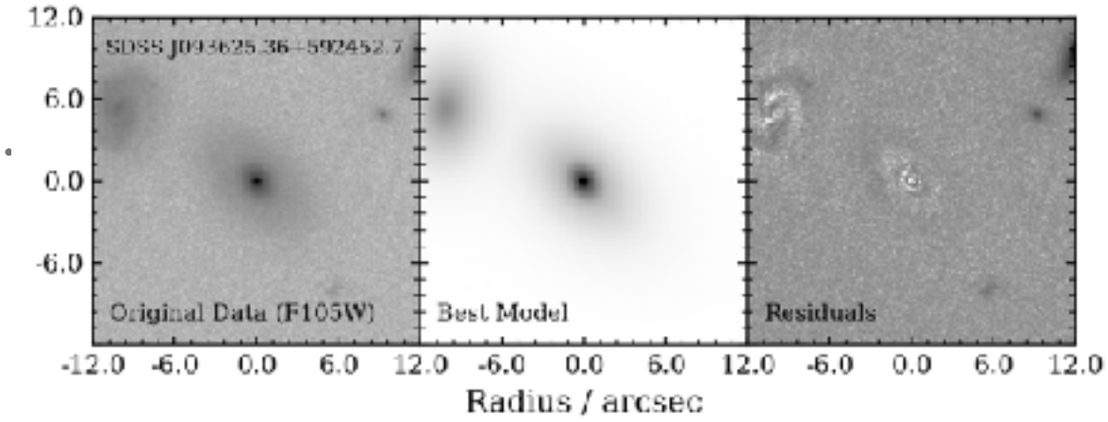


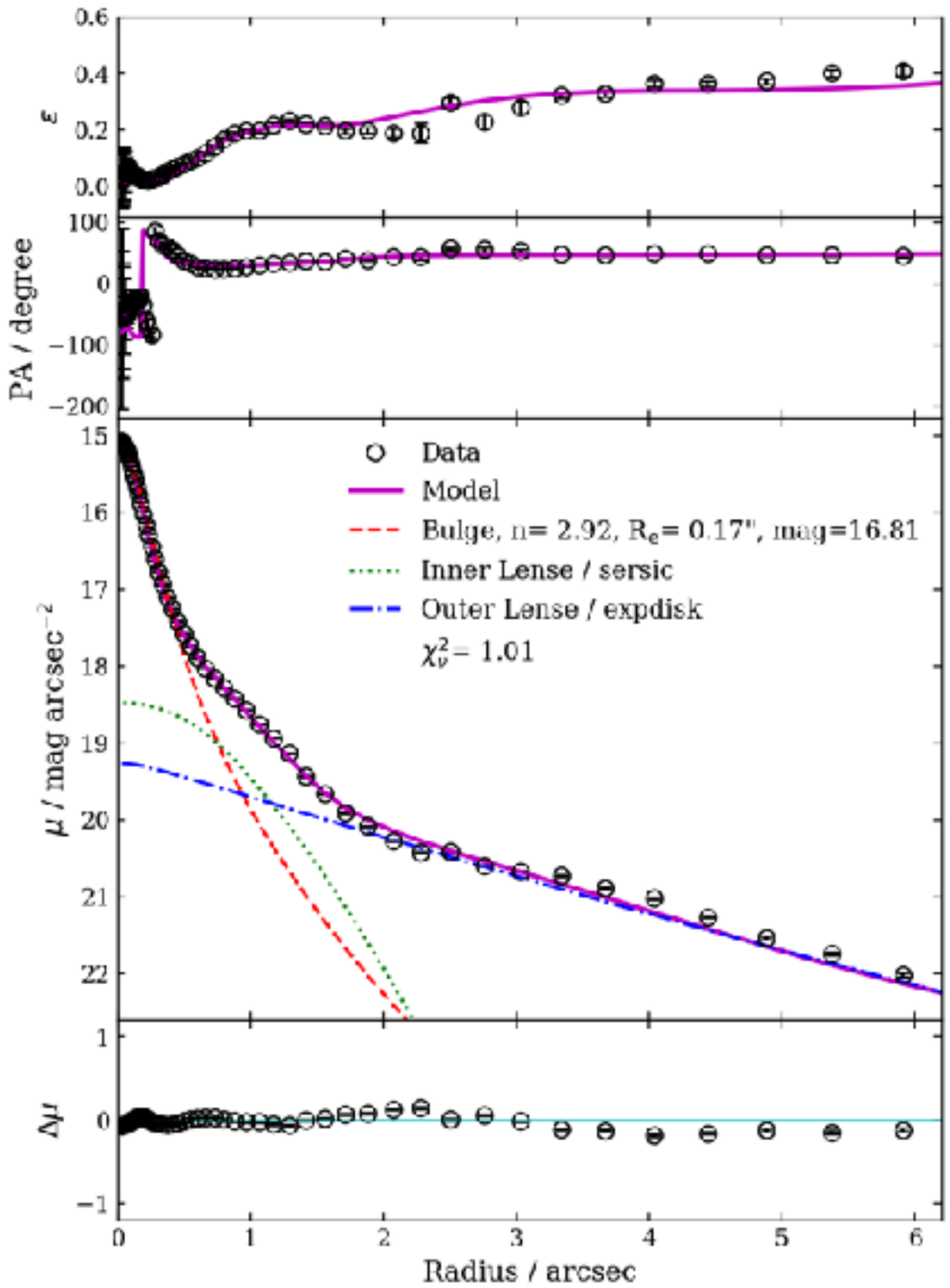
- Major merger do trigger the nearby luminous AGNs, but it is not the primary triggering mechanism in local universe.
- Features of our major-merger host galaxies suggest various phases of merging process, from early phase to intermediate and late phase of mergers, suggesting that AGN activity could be ignited in any period of merging.



DISCUSSIONS

- 16/35 (46%) of type 1 quasars and 16/29 (55%) of type 2 quasars are regular disk galaxies, in which majorities are bar spiral galaxies and lenticular galaxies.
- What are the mechanisms to trigger quasars which are hosted by regular-shape galaxies?
  - inner bar?
  - inner lens?





TAKE HOME MESSAGES

- Type 1 quasars are not distinguished from type 2 quasars. Merging scenario is not supported in local universe.
- Less than 35% of local type 1 & type 2 quasars are in merging or disturbed phase, with massive classical bulges. Major merger is not the dominant mechanism to trigger local luminous AGNs.
- Host galaxies in late-type morphologies have high-surface-brightness pseudo-bulges. They show a bluer central region than outer areas indicating the existence of young populations and implying star formation associating with AGN activities.
- A large fraction of type 1 and type 2 quasars being hosted by regular disk galaxies which challenges the current theories. It seems that (inner) bar and inner lens might be the important structures to induce some specific mechanisms to be able to trigger high-luminosity AGNs.

THANK YOU