THE STELLAR HALOS OF MASSIVE RED GALAXIES OUT TO 400 KPC

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Introduction

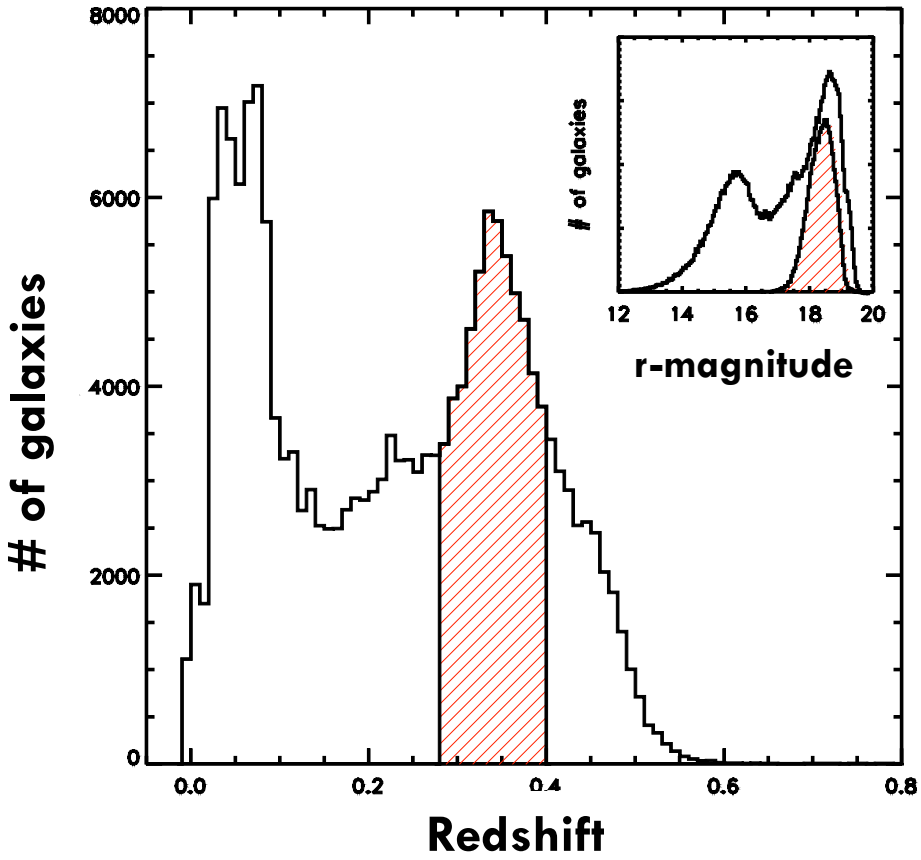
- Recent studies show significant size evolution of massive galaxies since z=2
- Physical mechanisms for growing massive galaxies
- Full sizes of stellar bodies are unknown even at z=0
- Direct observations are hard (background, flat fielding, PSF)
- Only a handful of galaxies have been observed to r>30 kpc

Direct Observations vs. Stacking

- Deep observation of single objects
  - Potential understanding of physical processes
  - Light can be dominated by neighboring sources
- Averaging many similar sources
  - Selection is important for sample homogeneity
  - Can reach unprecedented background flatness
  - No new observations required

Sample Selection

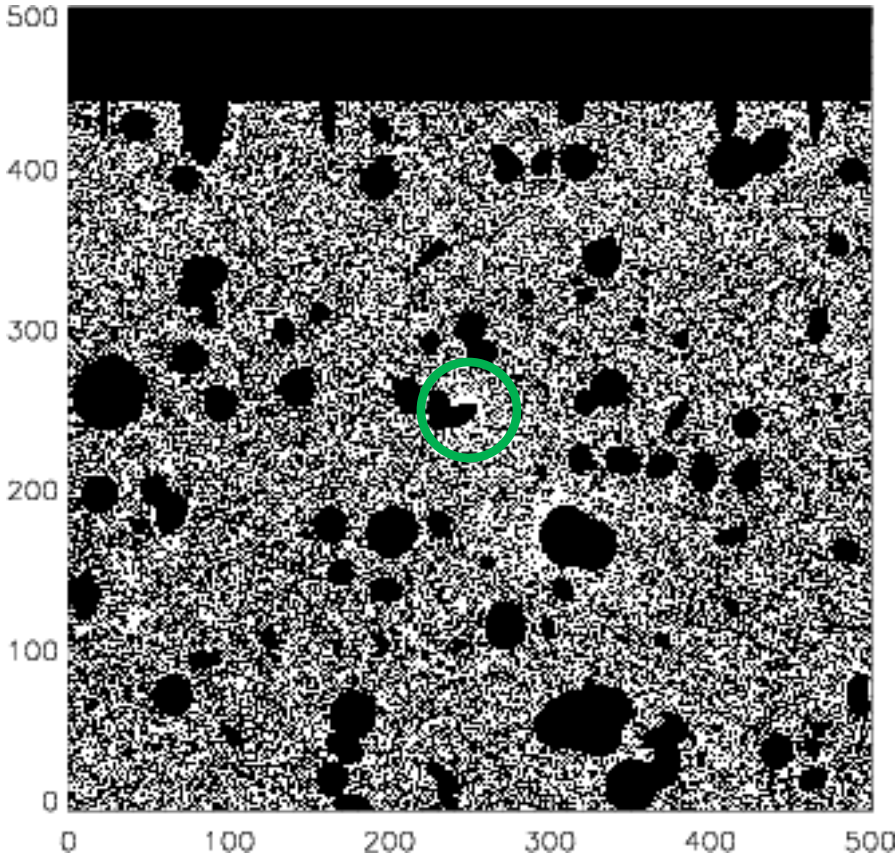
- Luminous Red Galaxies from SDSS
- Narrow redshift range ($0.28 < z < 0.4$) to restrict evolutionary effects
- Resultant typical galaxy: $\sim 3L^*$ at $z \sim 0.34$



Stacking of LRG imaging

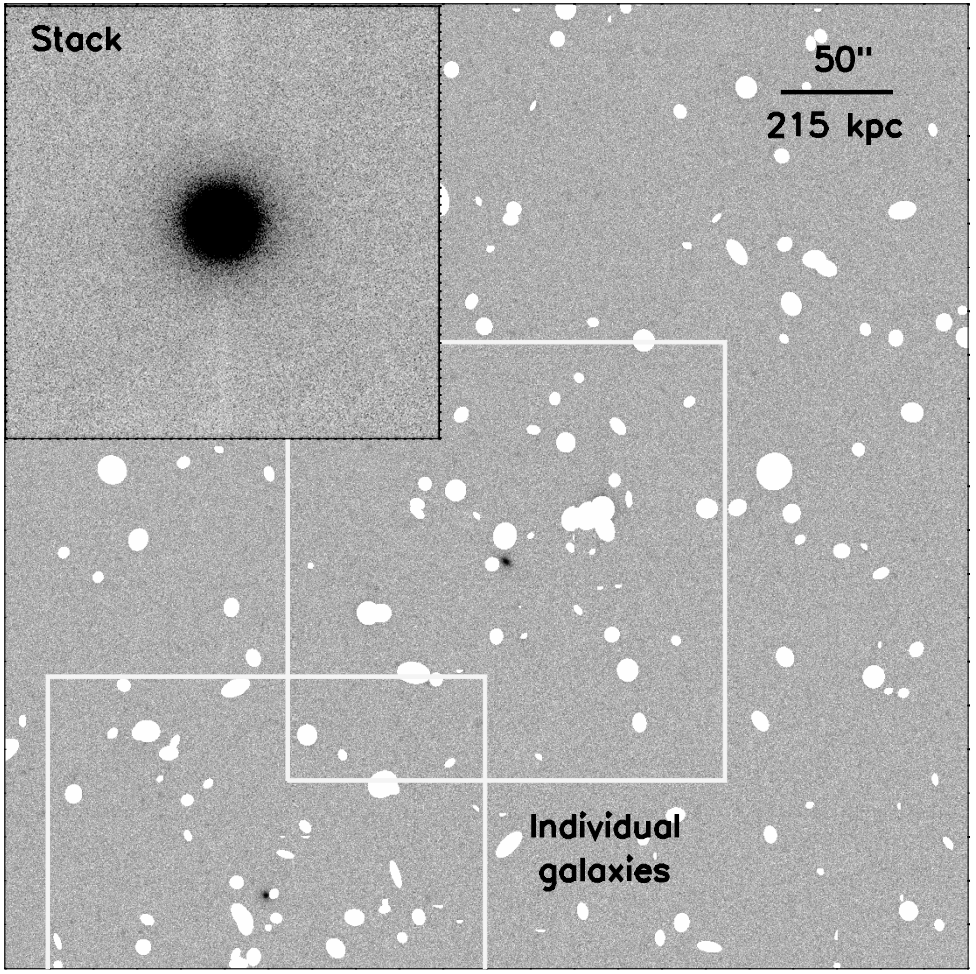
- For each object:
  - Mask all background and foreground objects
  - Normalize (magnitude bins)
- Co-add images

+ Details (**background subtraction**, bookkeeping etc.)



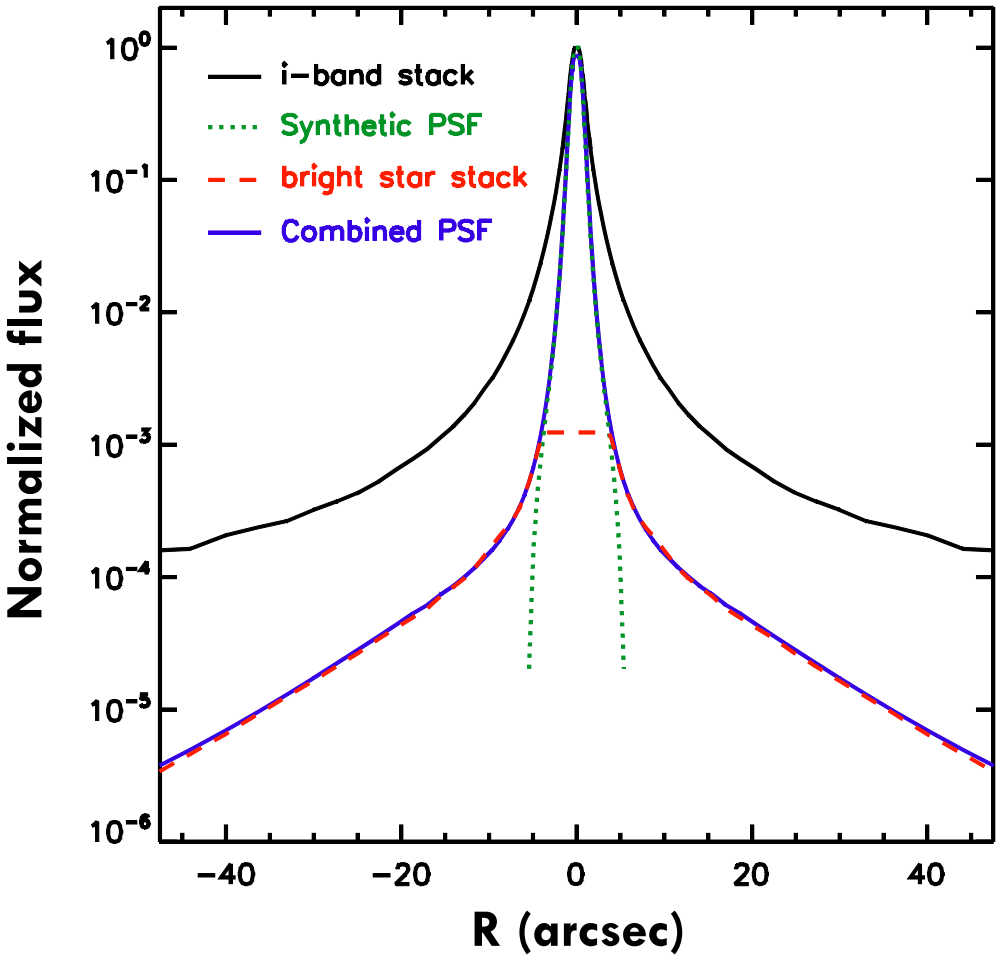
Stacking

- Stacks of >42000 images in u,g,r,i,z
- 2.3 Msec integration time, equivalent to 40 hours on 10m class telescope
- Background removed using random stacks



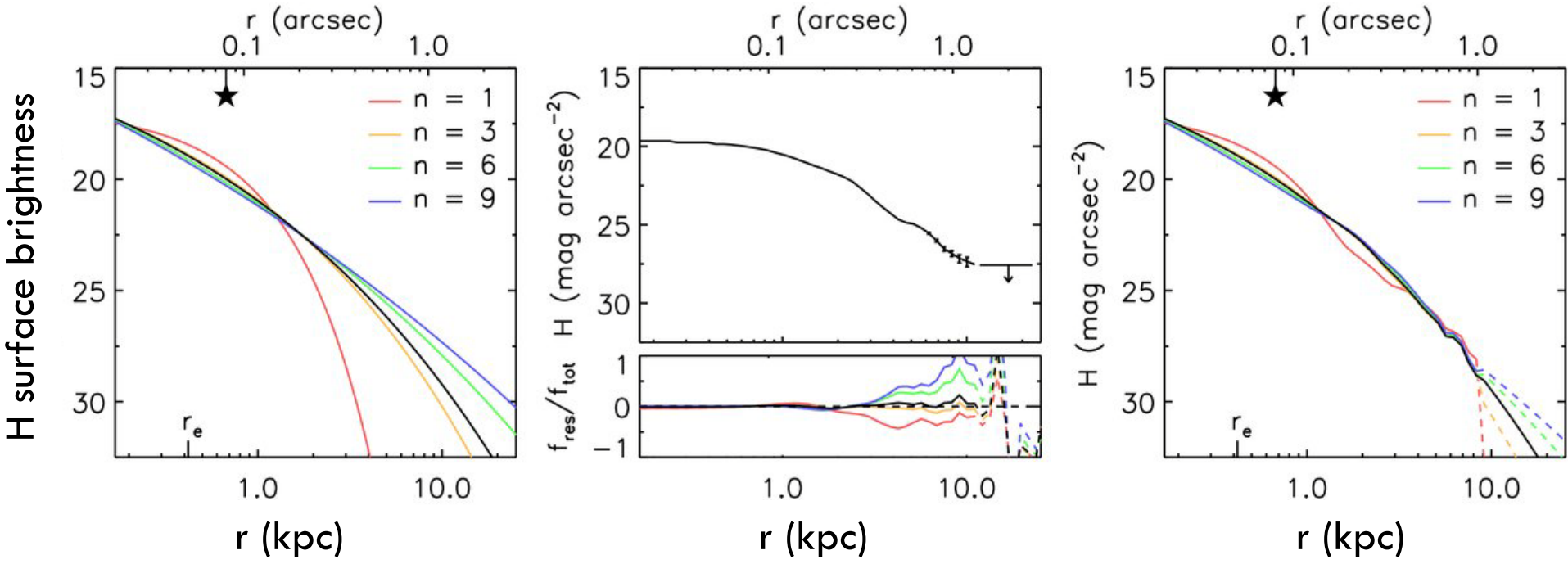
Removal of PSF Effects

- The PSF is significant at all radii
- PSF deconvolution - Lucy, σ-clean etc.
- Instead - PSF-free model reconstruction (Szomoru et al 2010)



PSF free model reconstruction

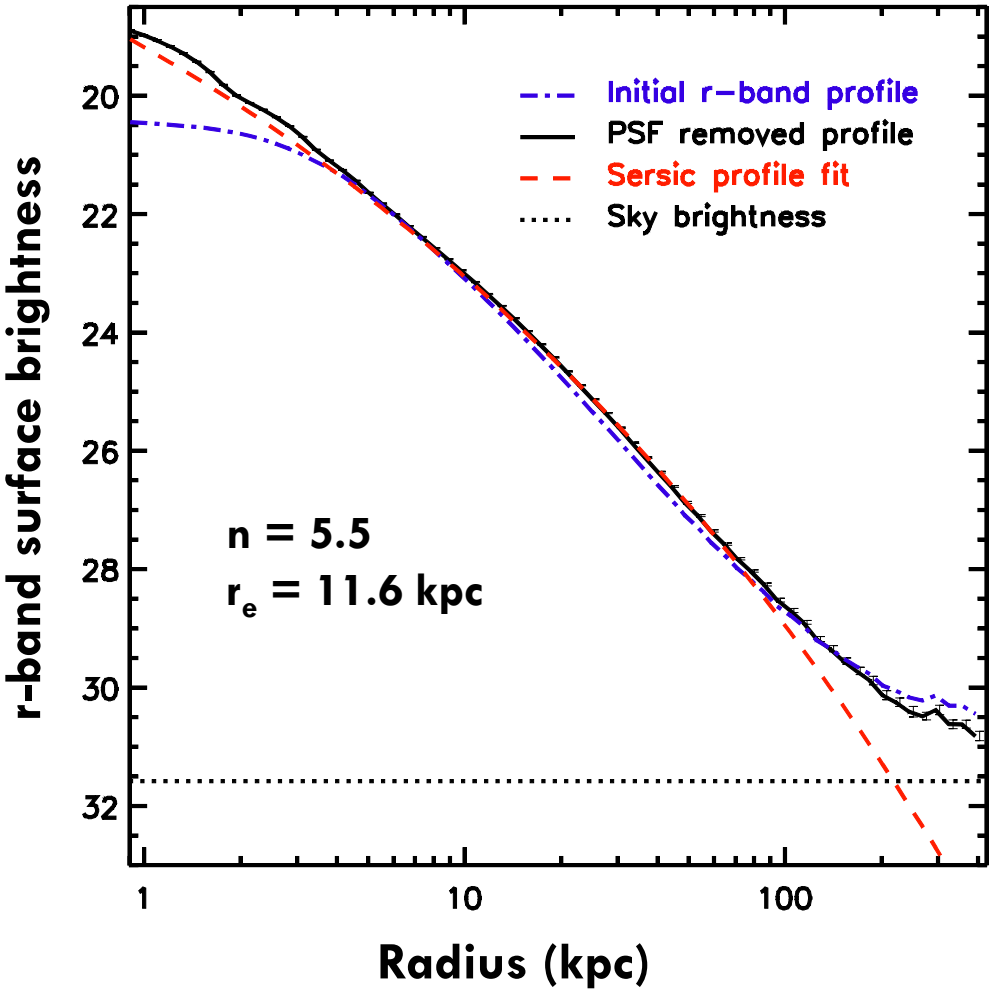
Insensitive to specific fit parameters



Szomoru et al., 2010

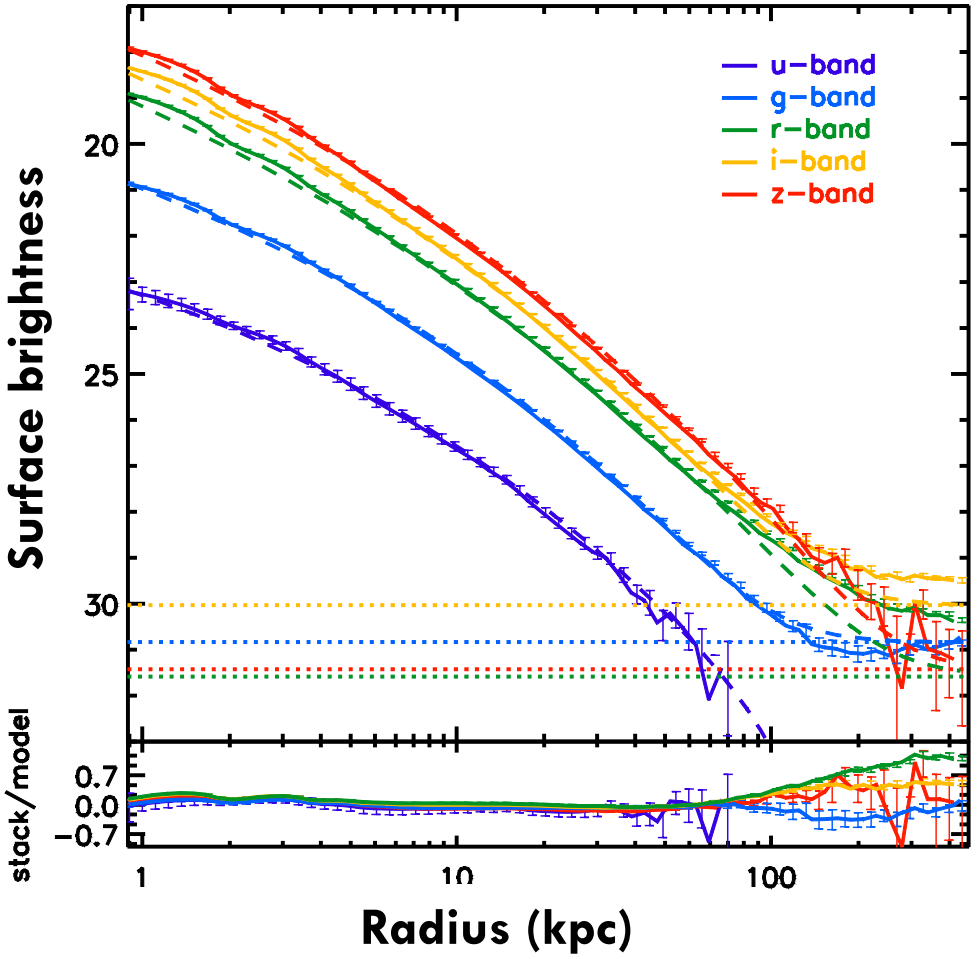
Light Profiles

- Reach surface brightness of 30-31.5 mag arcsec^{-2}
- Can be traced out to 400 kpc
- Well fitted with single Sersic parameter set out to 100 kpc
- Sizes typically underestimated by 10% and flux by 20%



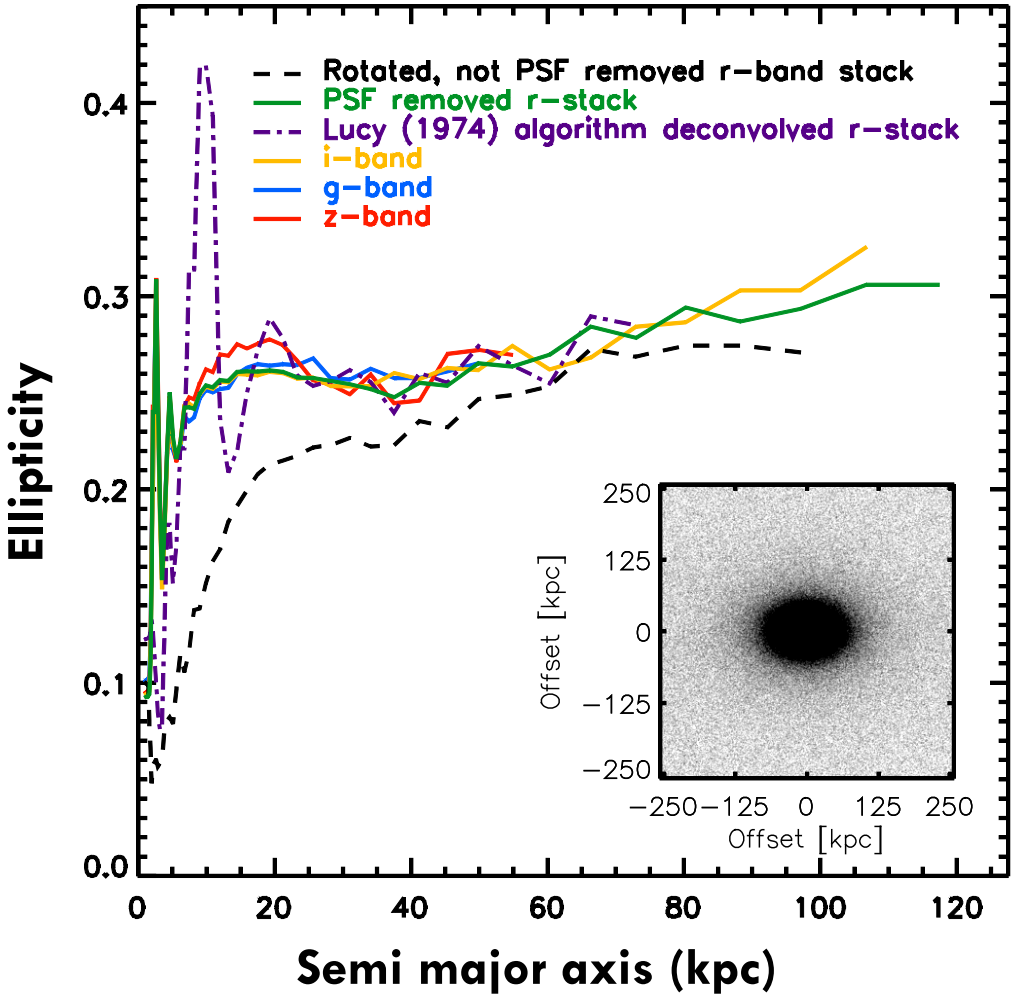
Light Profiles

- Extra light at r>100 kpc in r, i and z bands
  - Unresolved sources
  - Associated with the galaxies but follows a different potential
  - Reflects intragroup (intracluster) light



Ellipticity profile

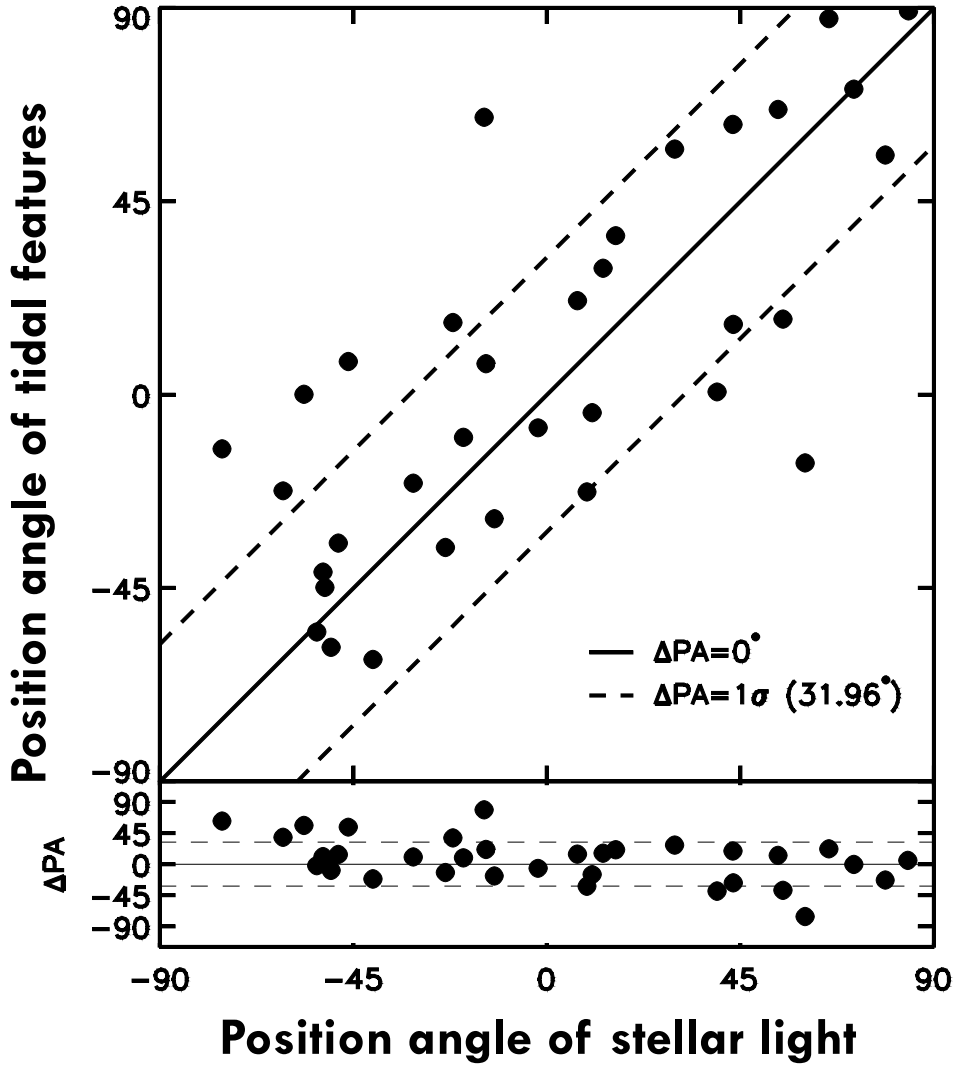
- Rotate each galaxy prior to stacking
- Stack ellipticity flat out to r~60 kpc
- Outskirts physically associated with center



Minor Mergers

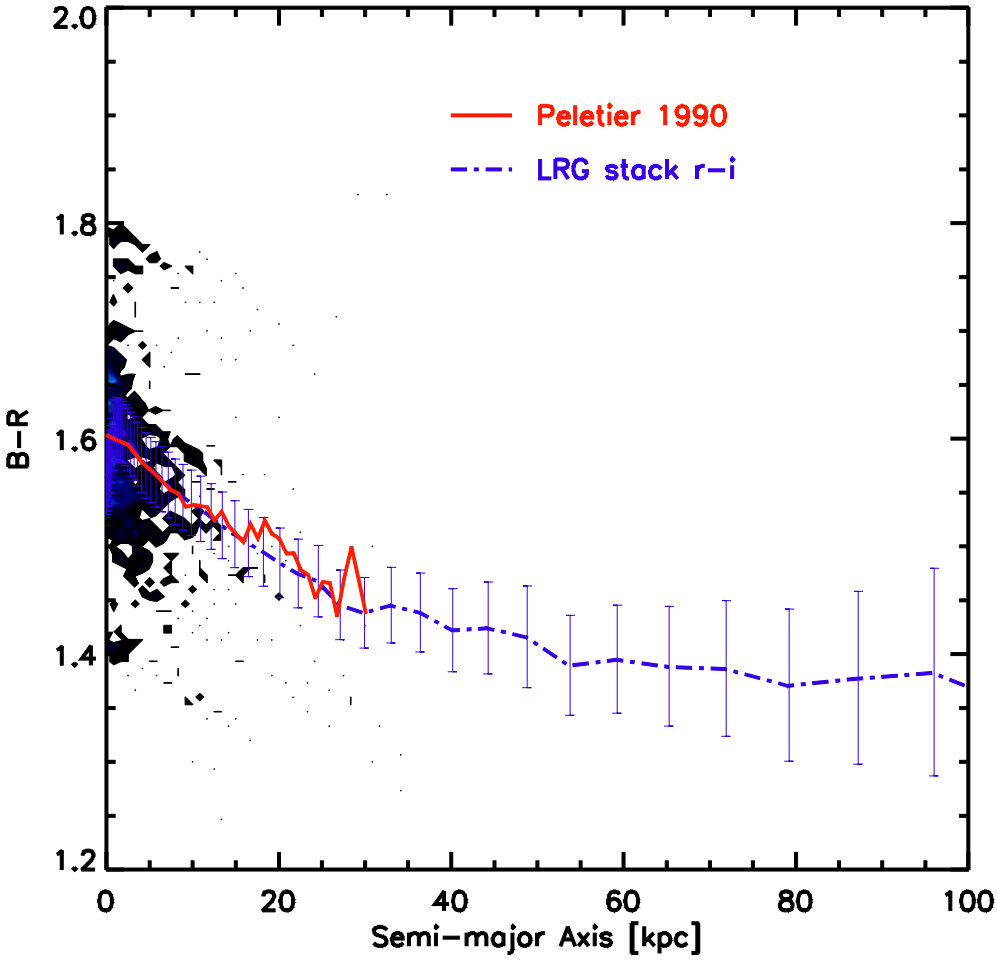
For individual galaxies:

- Correlation between galaxy and tidal feature orientation
- Supports the minor mergers scenario



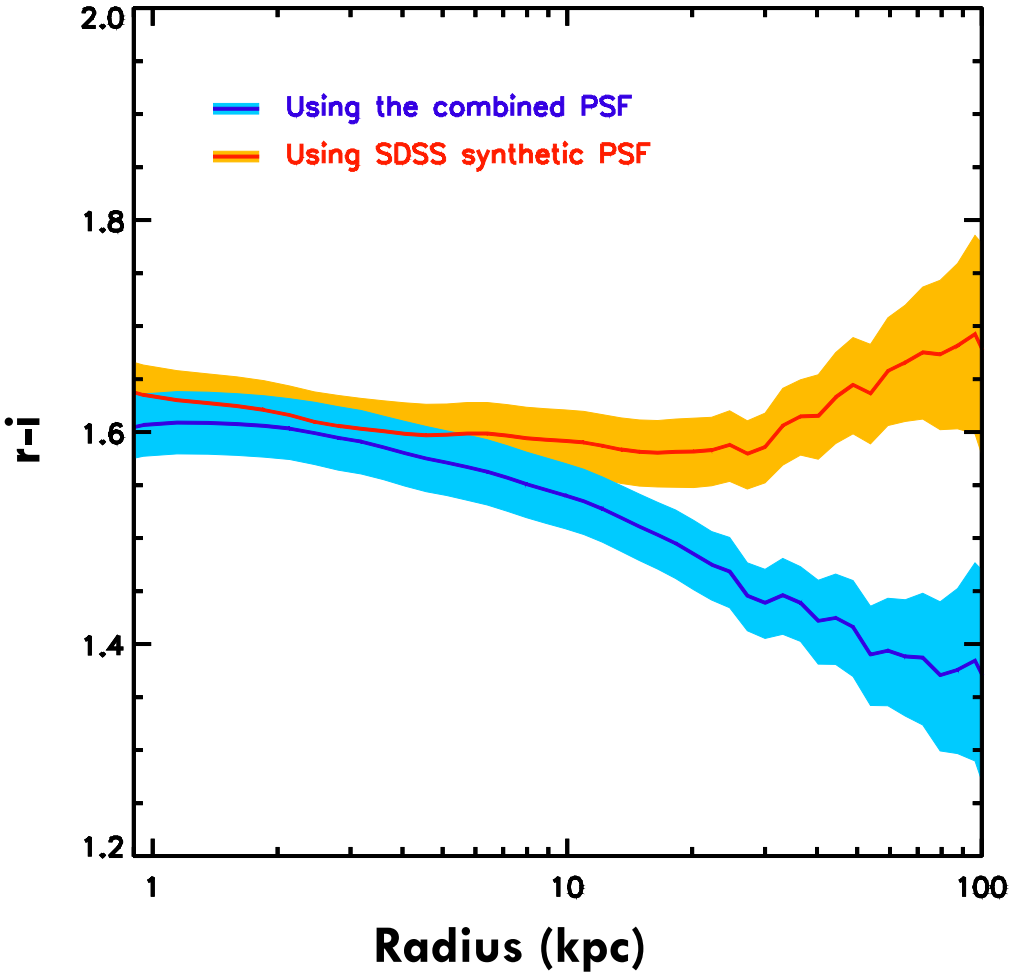
The stack color profile

- Profile in inner ~30 kpc matches nearby galaxies
- Flattens out at ~40 kpc out to 100 kpc
- Hints on minor mergers



The wings of the PSF

- Non-negligible effect at very large radii (de jong 2008)
- Most pronounced in the i-band
- Can create a red “halo” if not properly modeled



Summary

- **We now know the sizes of nearby galaxies**

- Single Sersic profile out to r~100 kpc
- Extra light at r>100 kpc
- Sizes and masses typically underestimated
- 40% of the light outside of 20 kpc
- Our results support the inside-out growth model

- Next: “data points” at higher redshift