

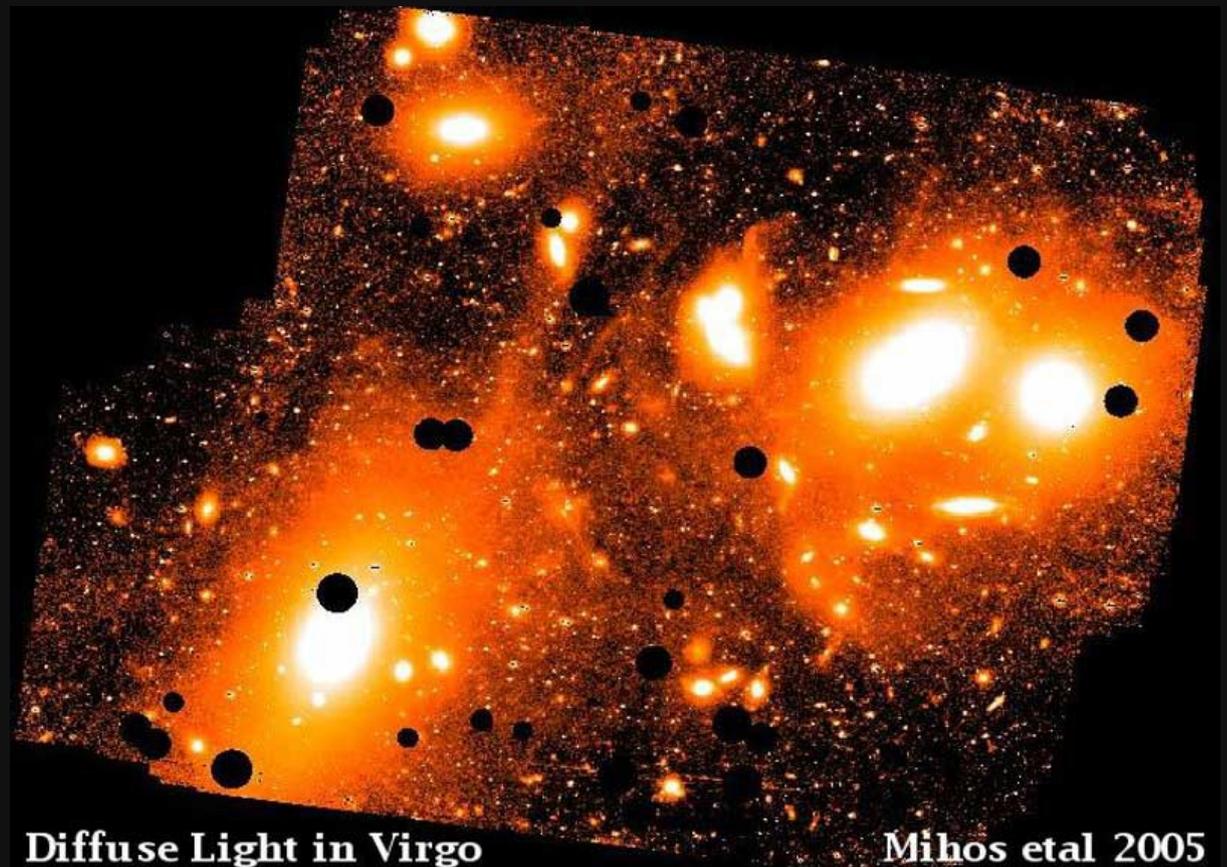
# Intra-cluster light at the **Frontier**: Abell 2744

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# The *Ghost* light

- Light from free floating stars in the intergalactic medium
- They are gravitationally bound to the cluster but not to a particular galaxy



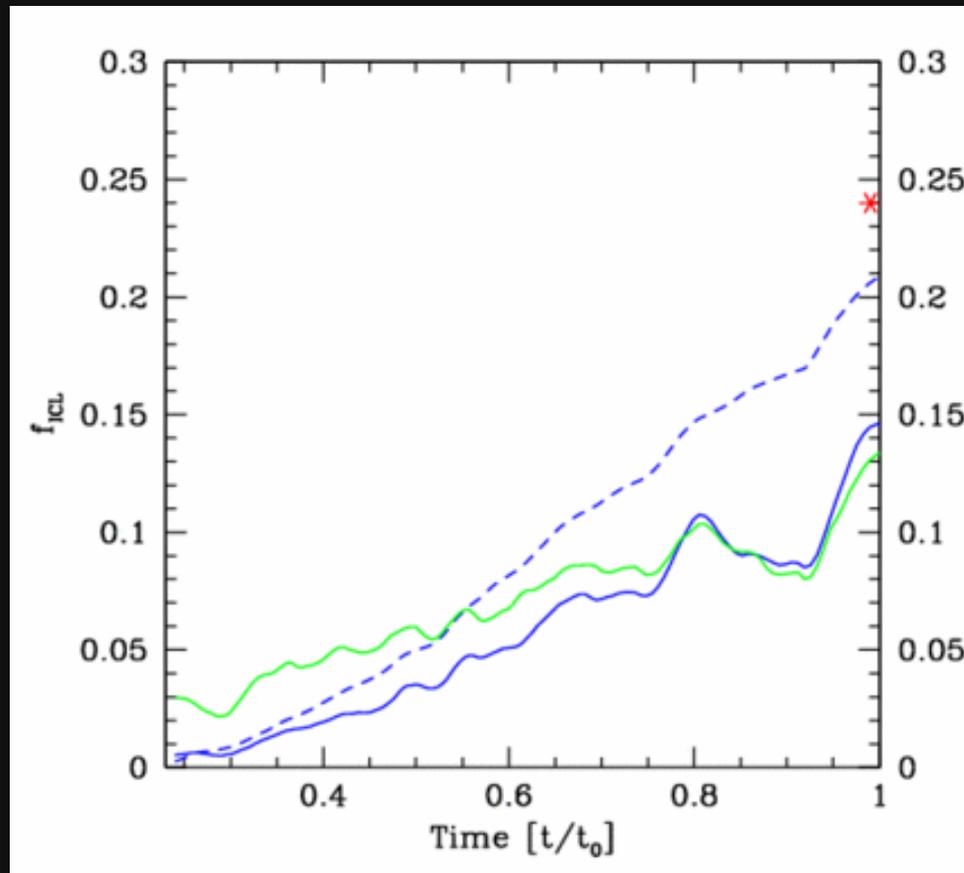
Diffuse Light in Virgo

Mihos et al 2005

# What does the ICL tell us?

- The story of the assembly of the galaxy cluster:
  - How violent it was? → Mass in stars
  - When does it happen? → Age of the stars

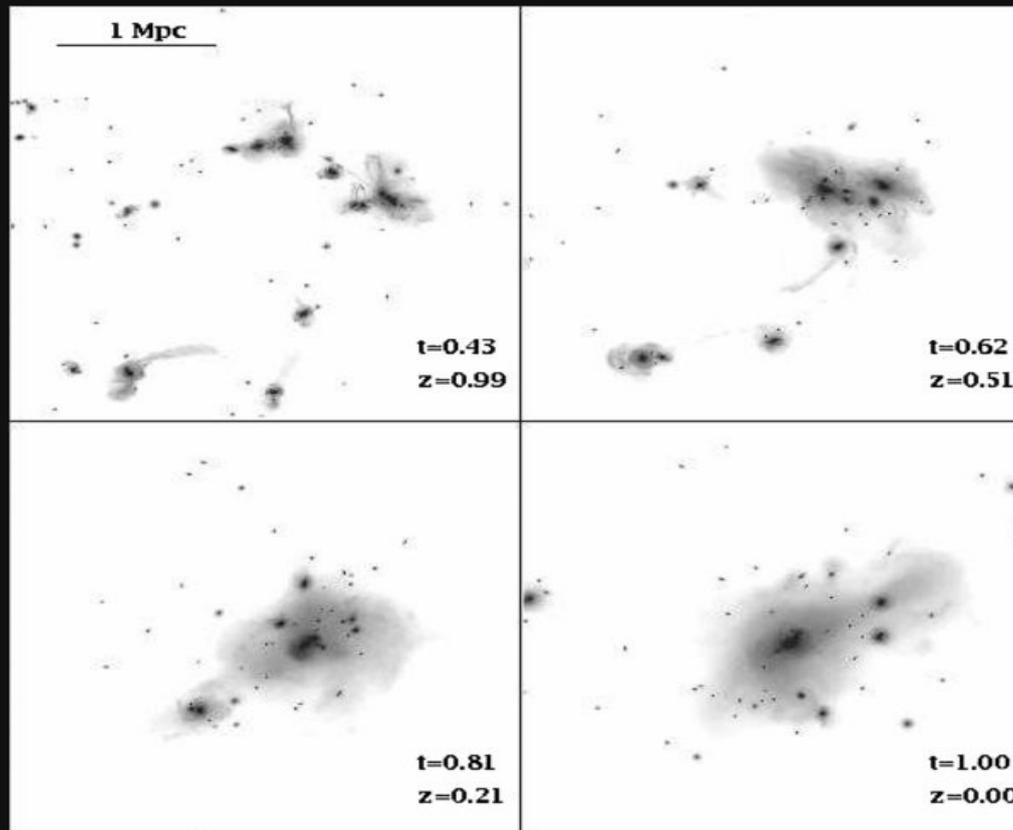
Rudick et al. (2011)



# Theoretical expectations

- Formed by the tidal stripping of satellites infalling into the cluster

Rudick et al. (2009)



- ICL is a relevant remnant of the merging events that formed the cluster

# Theoretical expectations

- ICL produced by the most massive satellites ( $10^{10-11} M_{\text{solar}}$ , Contini et al. 2014)
- Metallicity similar to that of the massive satellites
- ICL formed at  $z < 1$  (Murante et al. 2007)

# What do we know about the ICL?

- $\mu_v > 26.5$  mag/arcsec<sup>2</sup> (Mihos et al. 2005, Zibetti et al. 2005)
- Extend to several hundred kpc
- Contributes to a significant fraction of the light of the cluster (10-20%, Krick et al. 2006, 2007)
- Challenging to observe and characterize
- **Little is know about its characteristics!!**

**We need very deep observations of clusters  
to observe the ICL**

# Hubble Frontier Fields

- Deepest images of clusters using the HST
  - multiwavelength
- 6 clusters,  $0.3 < z < 0.5$ 
  - A period crucial for understanding the formation of the ICL



Credit: NASA, ESA, Z. Levay

# Hubble Frontier Fields

- First release: Abell 2744
- Optical (ACS): F435W (6), F606W (5), F814W (5)
- NIR (WFC3): F105W (24), F125W (12), F140W (10), F160W (24)
- Only complete observations of the NIR

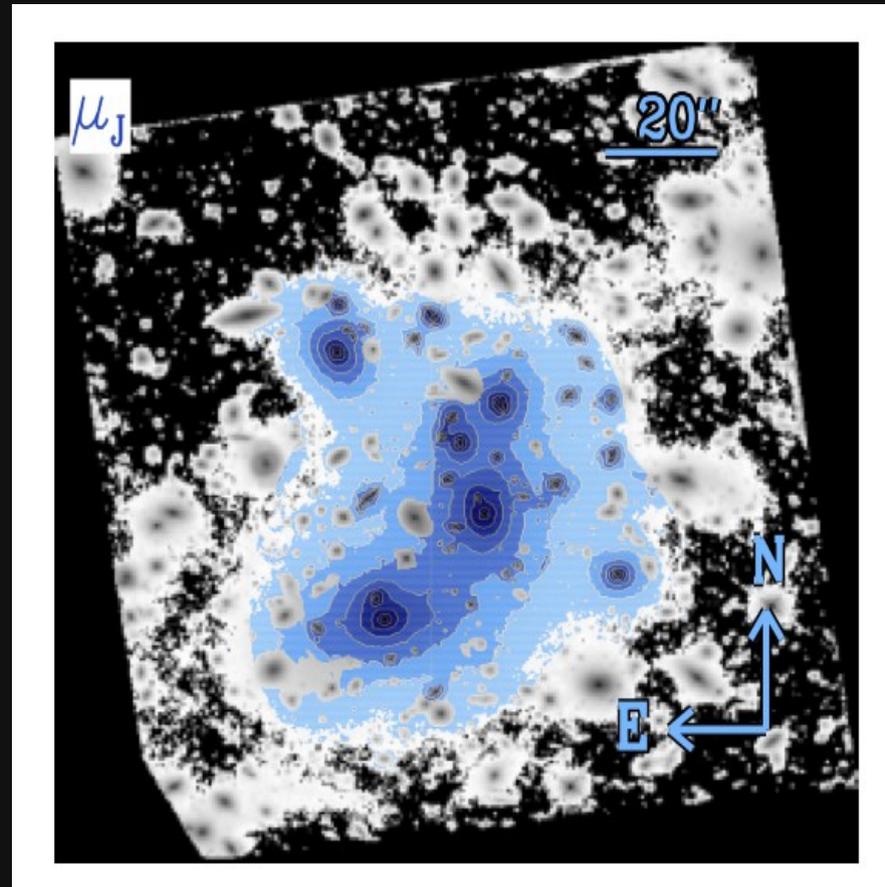
We are studying  
the ICL  $\sim 4$  mag  
above the SB limits!!



Credit: NASA, ESA, Z.Levay

- ACS images shallower  $\Rightarrow$  improve the S/N
  - Rebinned pixel: 5x5 pixel
- $0.06'' \Rightarrow 0.3''$
- Resdhift mask of the cluster to avoid the contamination of background and foreground sources (Owers et al. 2011 + NED)
- Color-color diagrams: g-r vs. i-J
  - Diminish PSF effects
  - Include a NIR band
  - Three different parameters

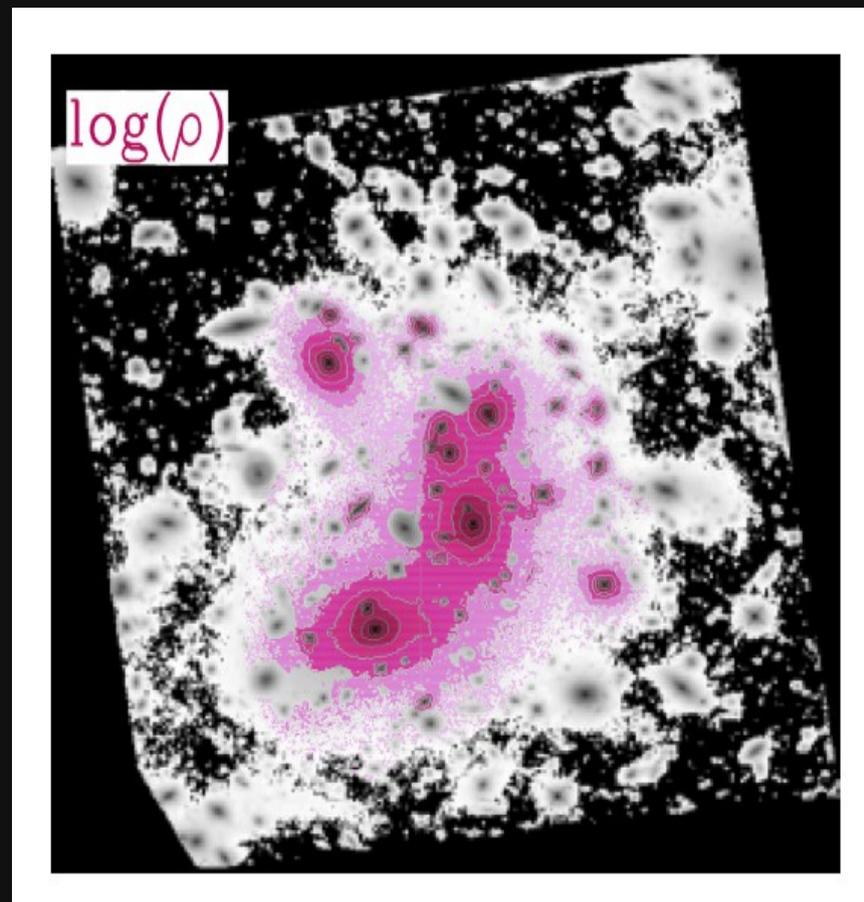
1. Surface brightness in restframe J :  $\mu_J$ 
  - Eight bins in  $\mu_J$ : 16 to 25 mag/arcsec<sup>2</sup>



Color coded bins

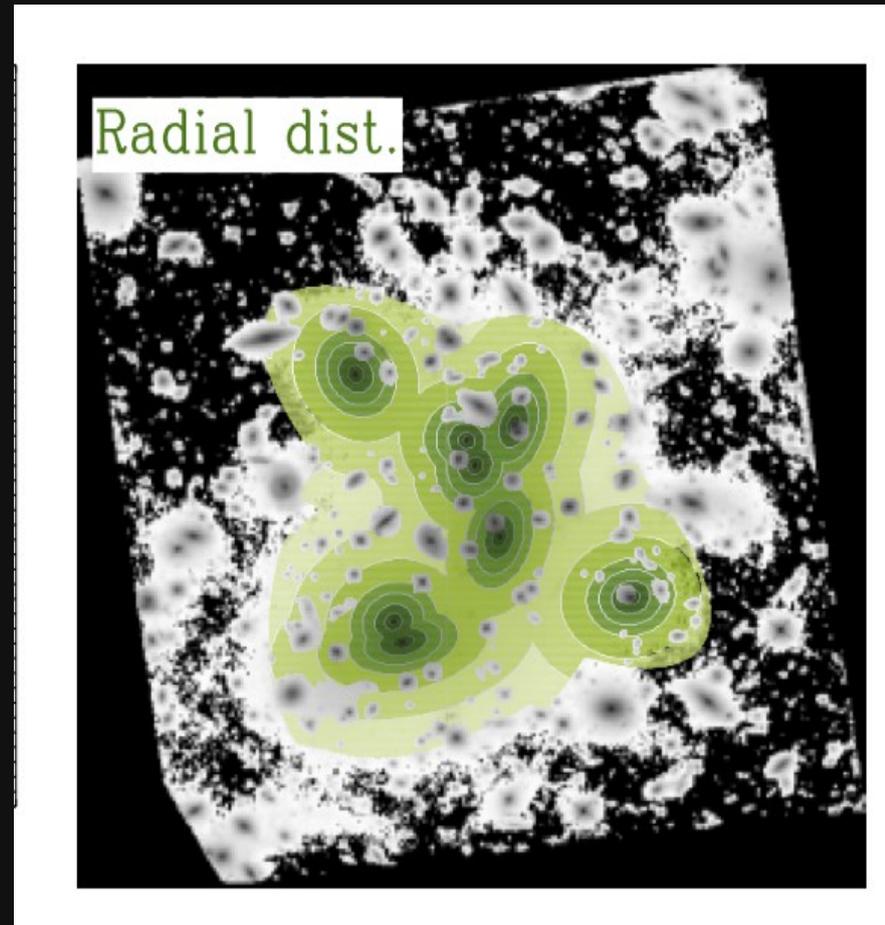
## 2. Logarithm of the stellar mass density: $\log(\rho)$

- r-z color  $\Rightarrow$  M/L ratio  $\Rightarrow$  stellar mass density (Bell et al 2003)
- Eight bins in  $\log(\rho)$ : 4.8 to 0.8 ( $\rho$  in  $M_{\text{solar}}/\text{pc}^2$ )

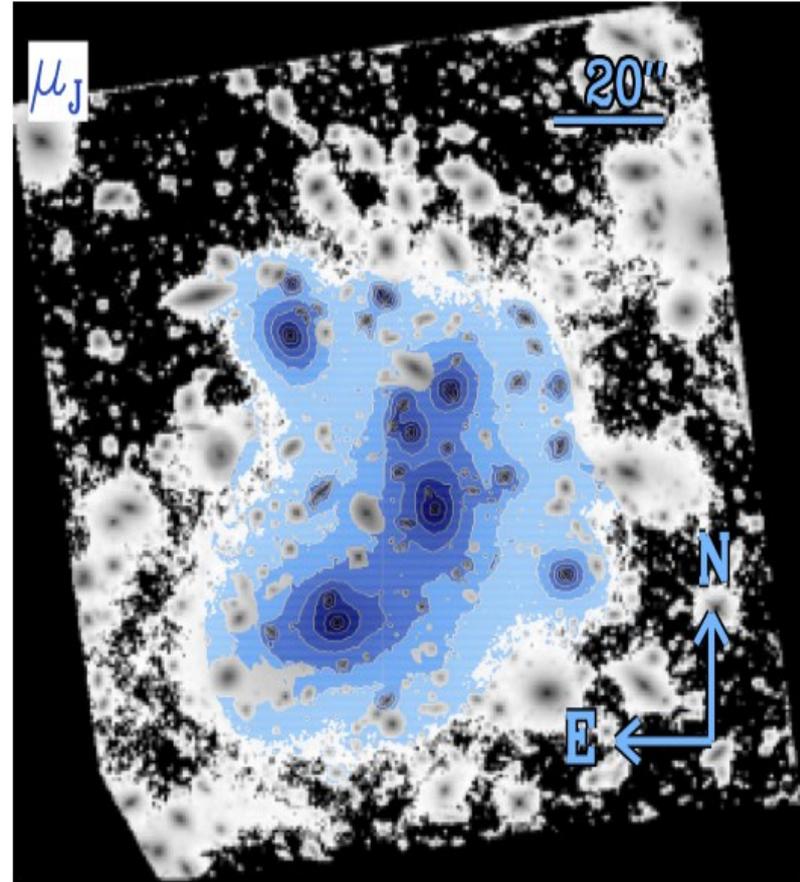
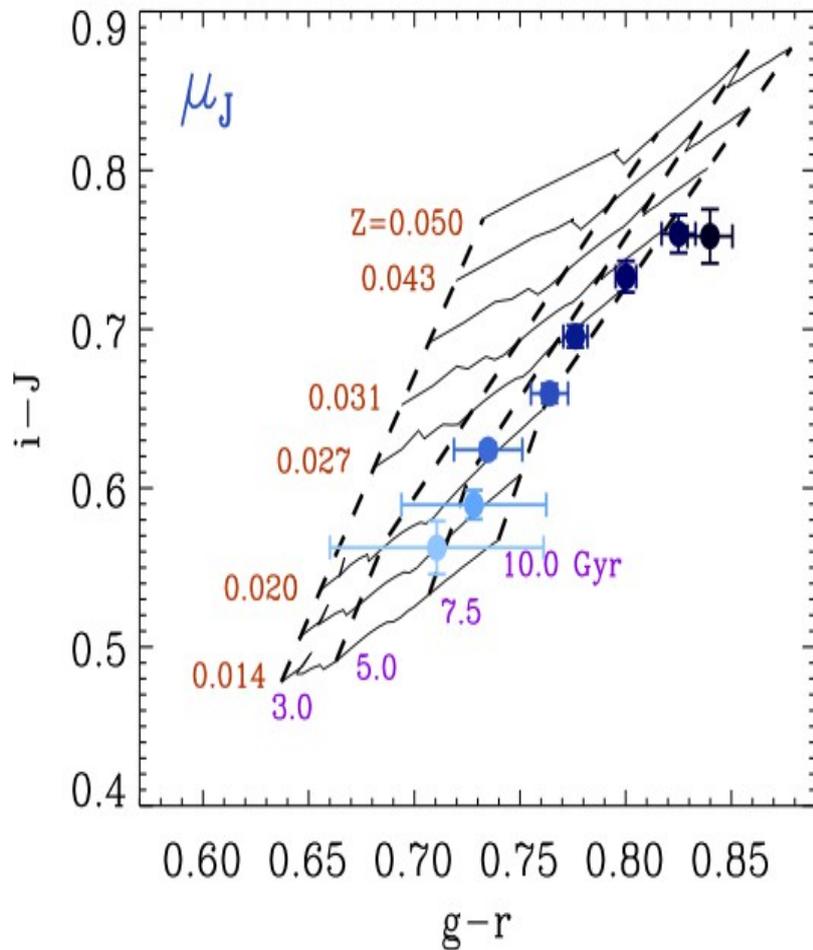


### 3. Radial distance, $R$ , to the most massive galaxies

- Elliptical distances to the centres of the most massive galaxies,  $\mu_j < 17$
- Eight bins in  $R$ : 0 to 120 kpc

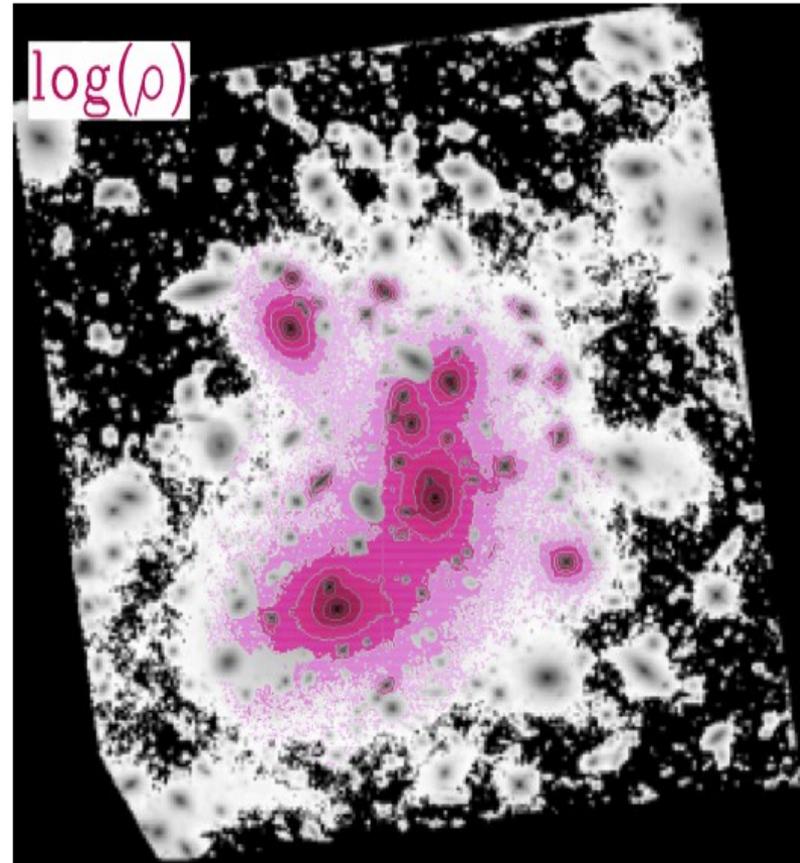
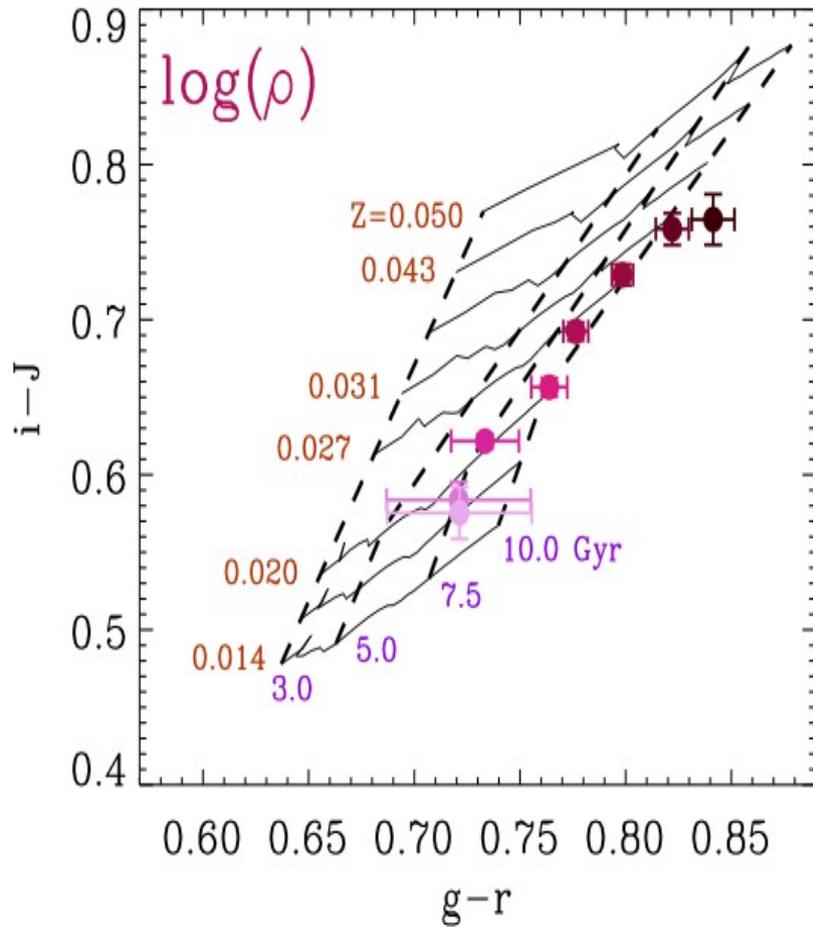


# Results

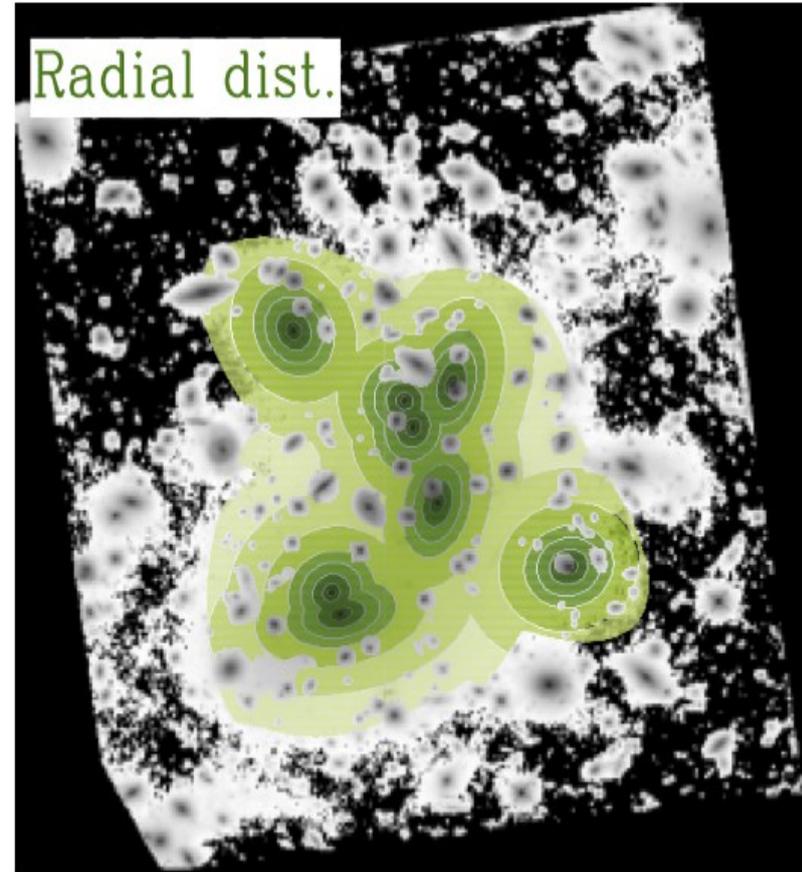
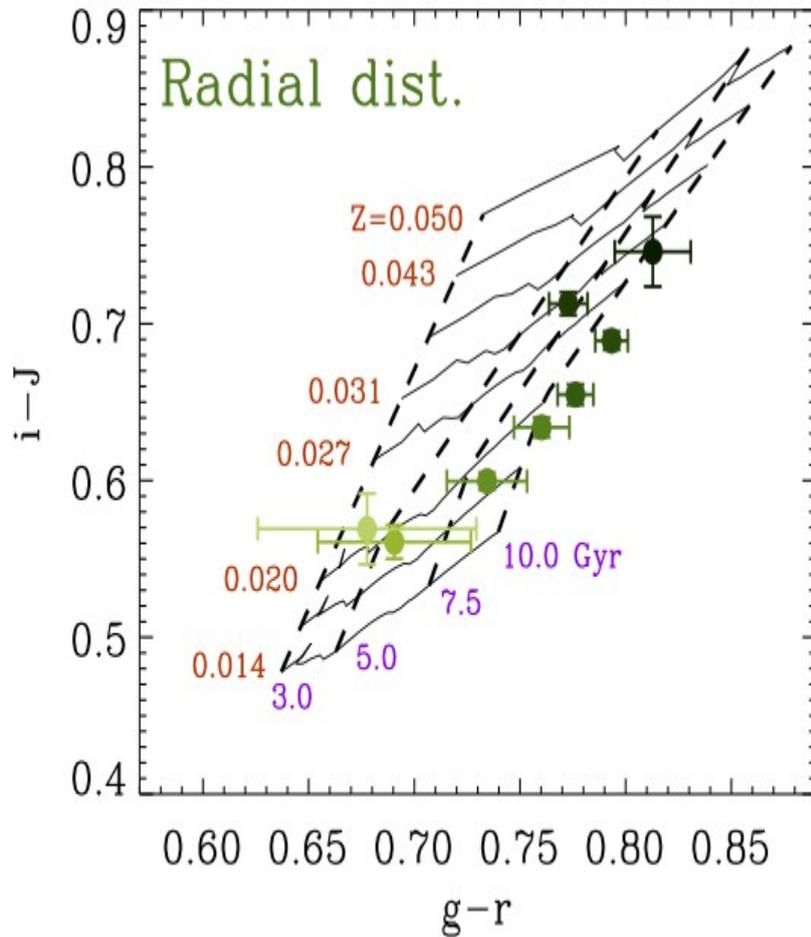


PSF effect:  $<0.03$  mag in  $g-r$  and  $<0.02$  mag in  $i-J$

# Results



# Results

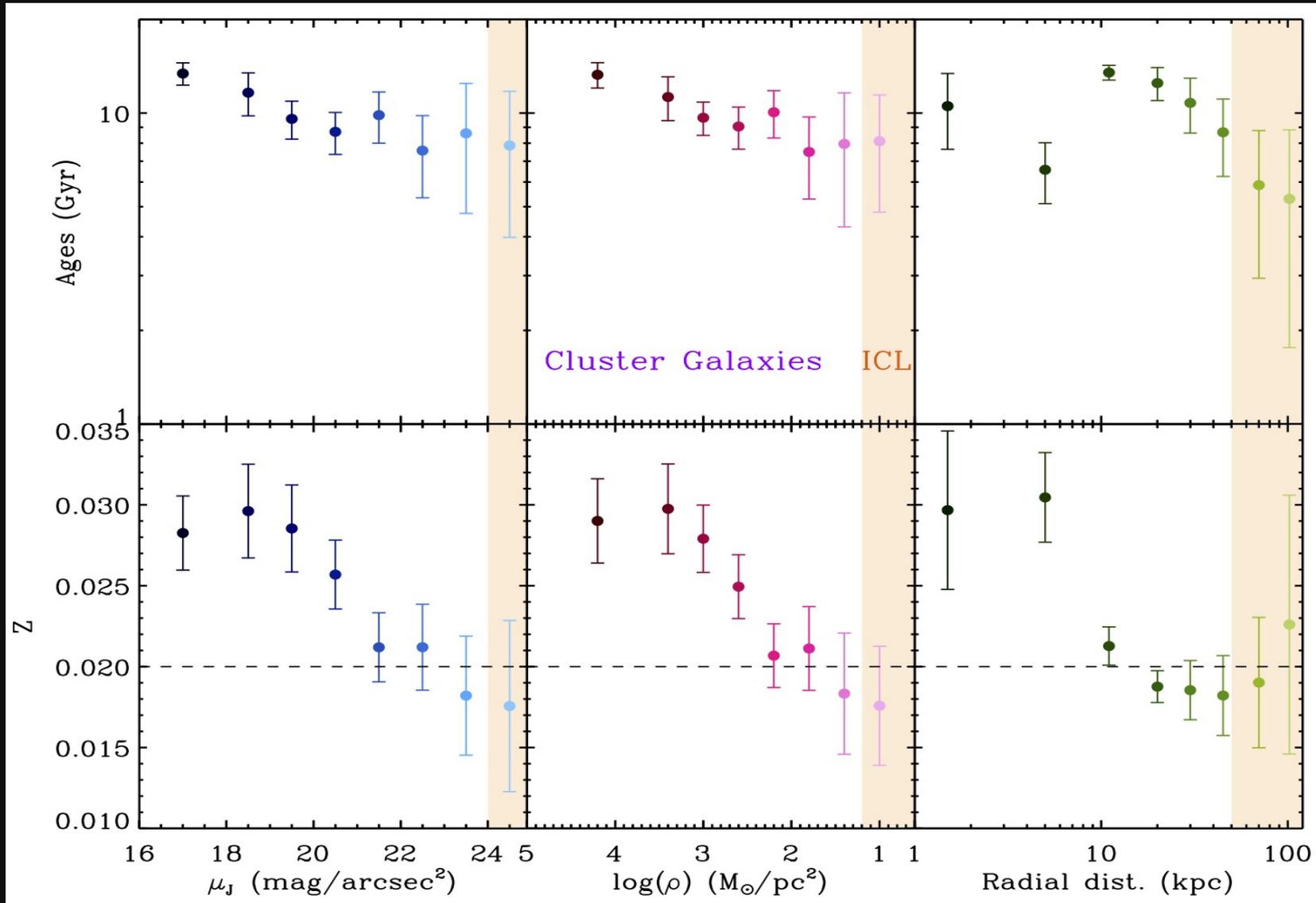


ICL bluer than the most massive galaxies of the cluster!!!

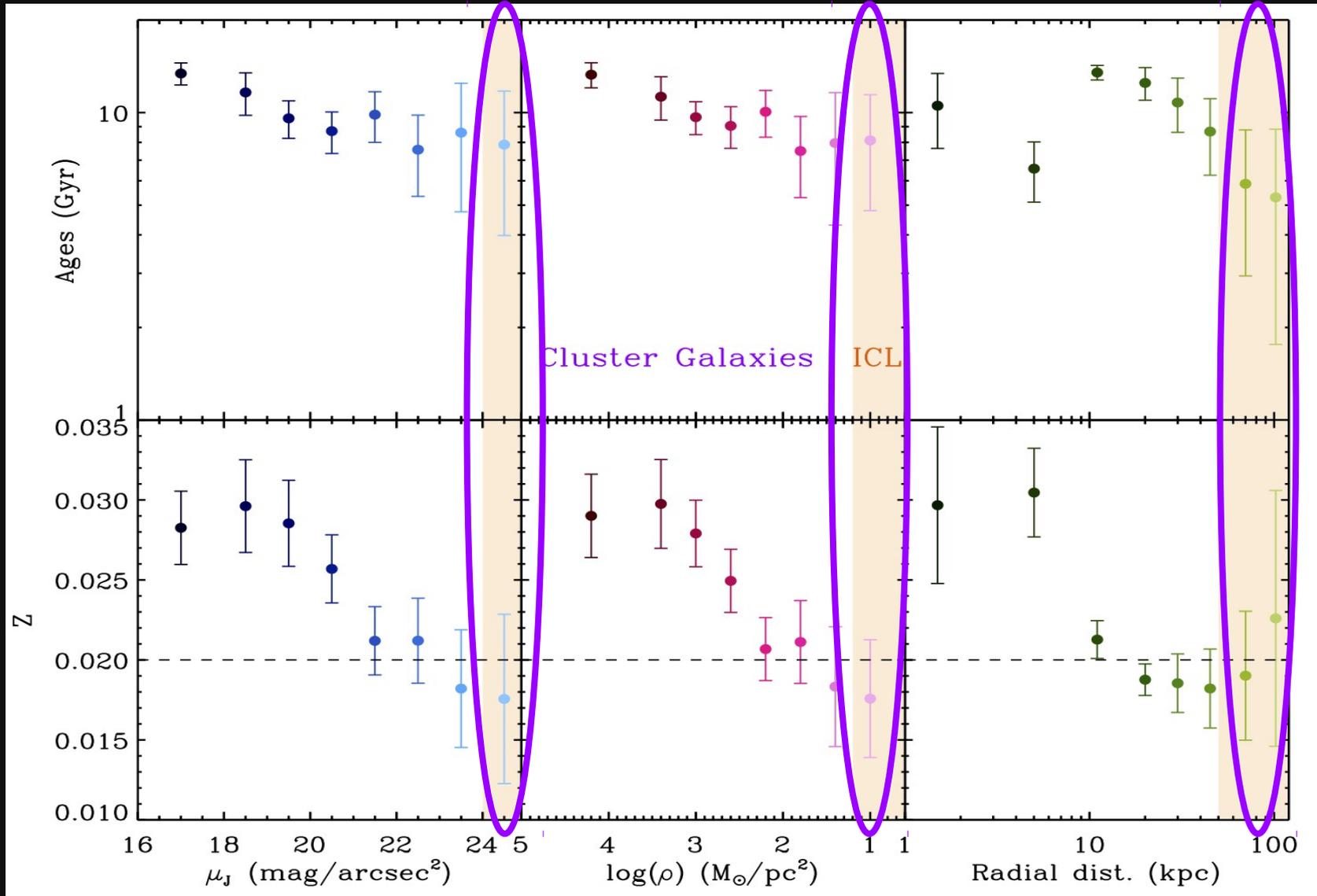


**Stellar population gradients**

# Age and met. gradients



# Age and met. gradients



# ICL of Abell 2744

- $Z \sim 0.018 \pm 0.007$
- Mass  $\sim 3 \times 10^{10} M_{\text{solar}}$  (Gallazzi et al. 2005)
  - ICL produced by galaxies similar to the Milky Way
- ICL age is  $\sim 6$  Gyr younger than the galaxies' age
  - ICL compatible with being assembled at  $z < 1$
- Fraction of ICL: 4-10%
  - Corresponds to: 4-6 Milky Ways
- ICL formed by the stripping of satellites (Dead galaxies )



# Conclusions

- Deep HST observations of the cluster **Abell 2744** to study its ICL
  - Use of NIR to break age-metallicity degeneracy
- ICL is mostly produced by galaxies similar to the **Milky Way**
- Age of the ICL is compatible with being assembled at  $z < 1$

THANK YOU

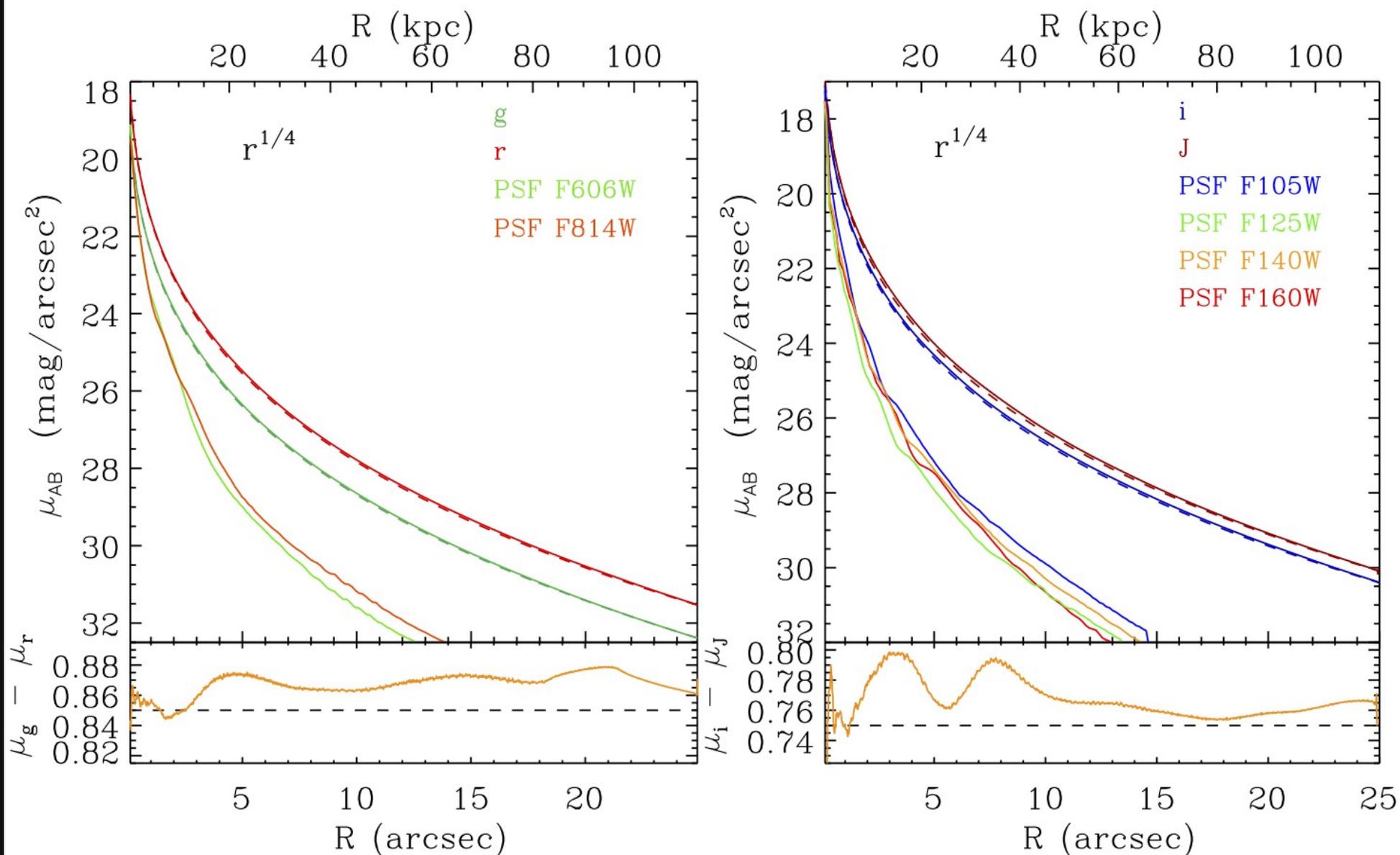






- SB limits:
  - Optical  $\sim 29.2$  mag/arcsec<sup>2</sup>
  - NIR  $\sim 30.0$  mag/arcsec<sup>2</sup>

# PSF Effects



# PSF Effects + ICL

