# Testing the current LSST DM Stack Sky Subtraction Using Model Galaxies

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With

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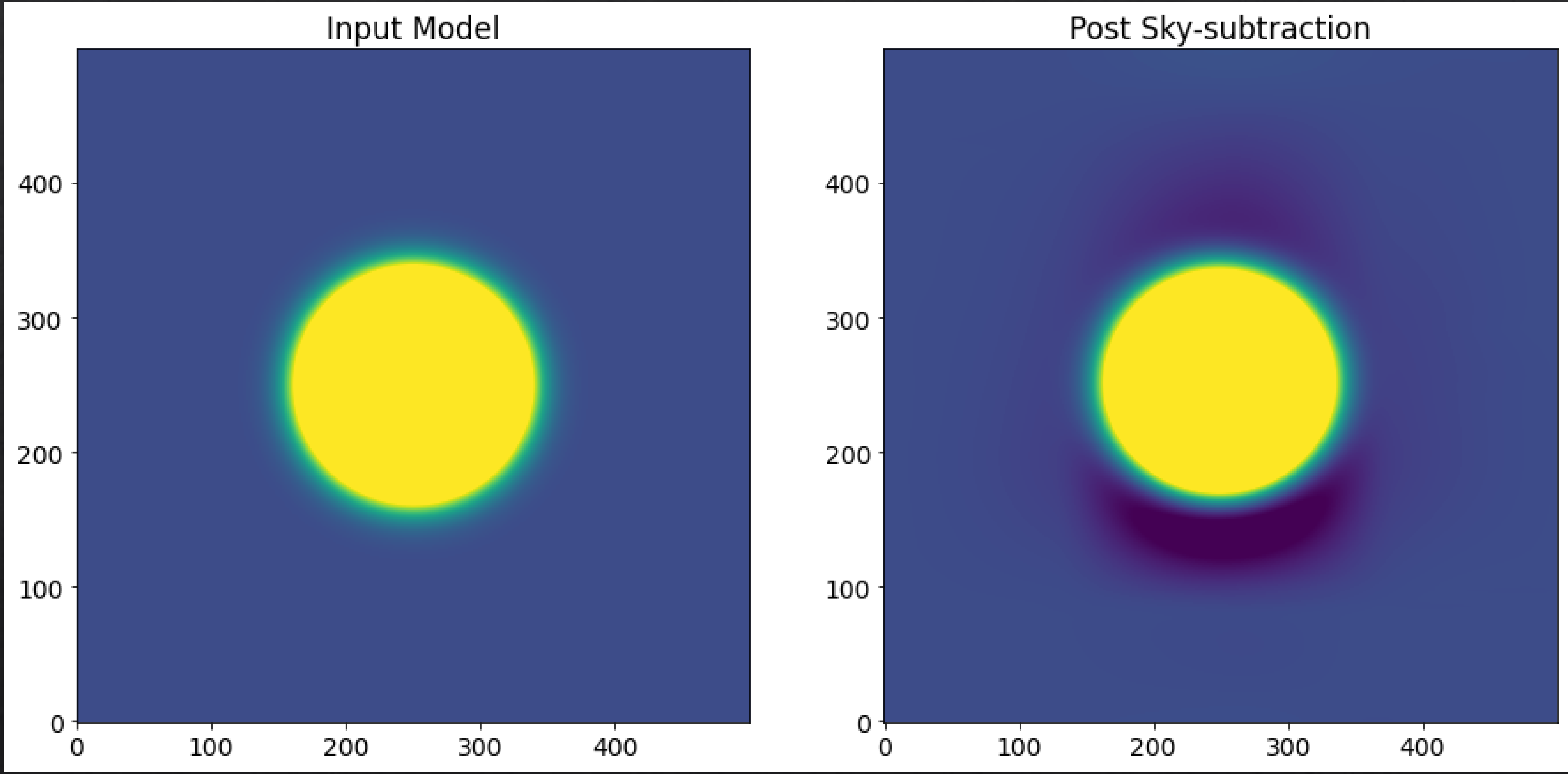
# Brief overview

- Wish to test the effects of the sky subtraction on LSB/galaxies science
- Models (single Sérsic component) are injected into the pipeline at the coadd stage
- Local background subtraction is then applied to the images with the injected models present
  - These tests therefore are showing the effects of the FINAL stage of the sky subtraction, not the chip-to-chip or full-focal-plane sky subtraction (~PDR2)

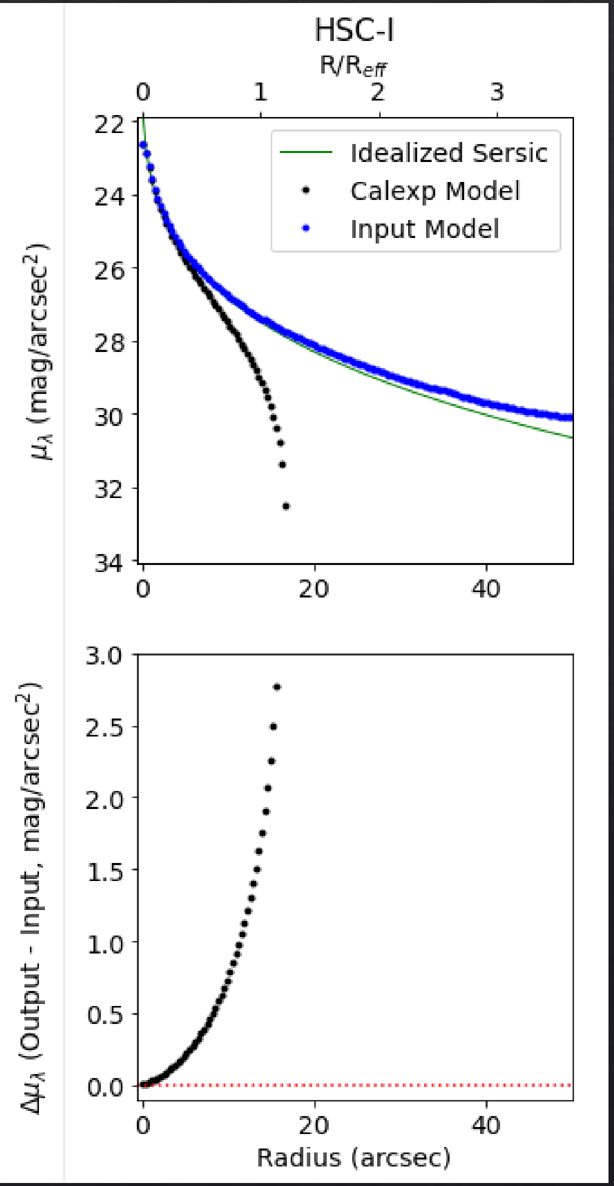
# Visualization: flat model example



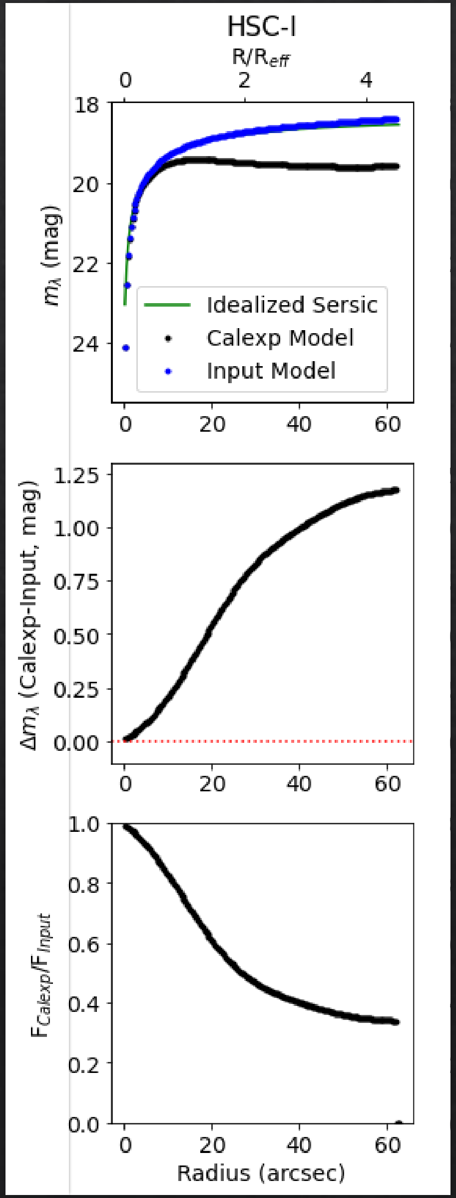
# A single model (n~4): radial profiles

Surface brightness profile

Input (blue) – Calexp (black)




**TAKEAWAY: serious (0.5 mag) over-subtraction starting at $\mu_I$~26**



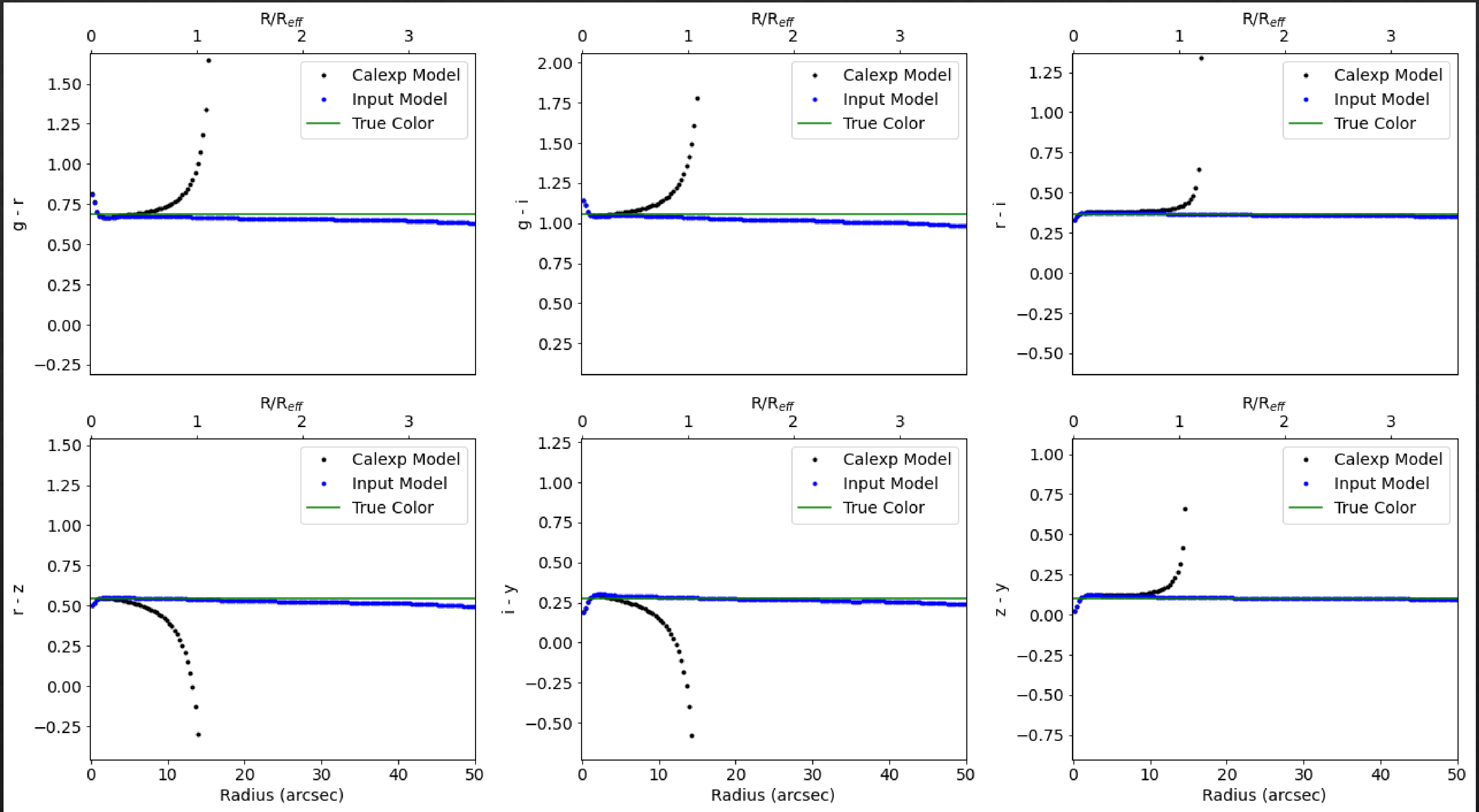

Curve of growth

Input (blue) – Calexp (black)

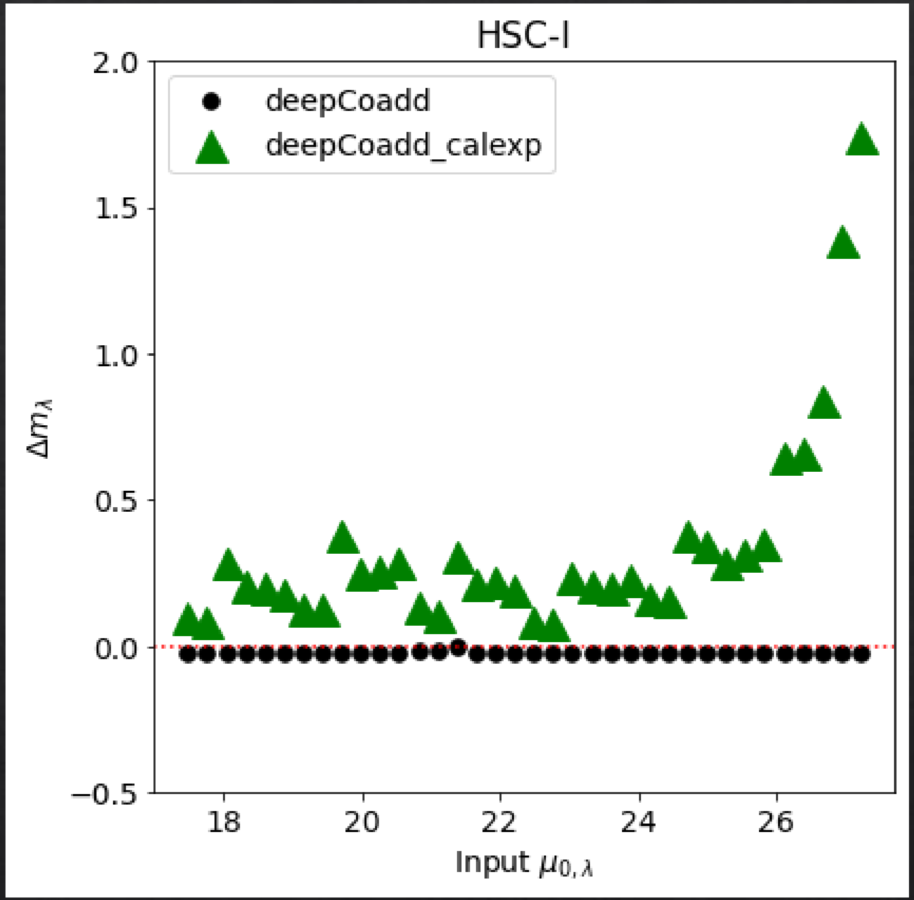
Flux fraction loss

**Over-subtraction leads to integrated magnitude underestimate of ~1.2 mags**

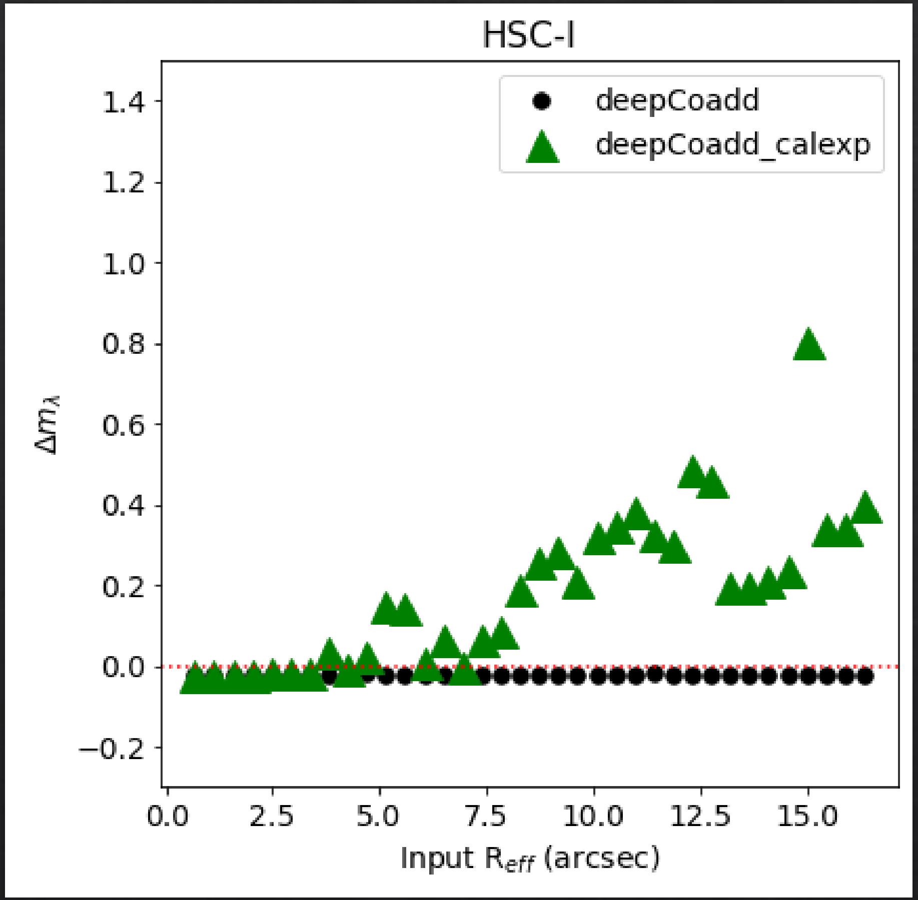
# Influence on colors—n~4 model



# Flat models: testing variable $\mu_0$ & $R_{eff}$



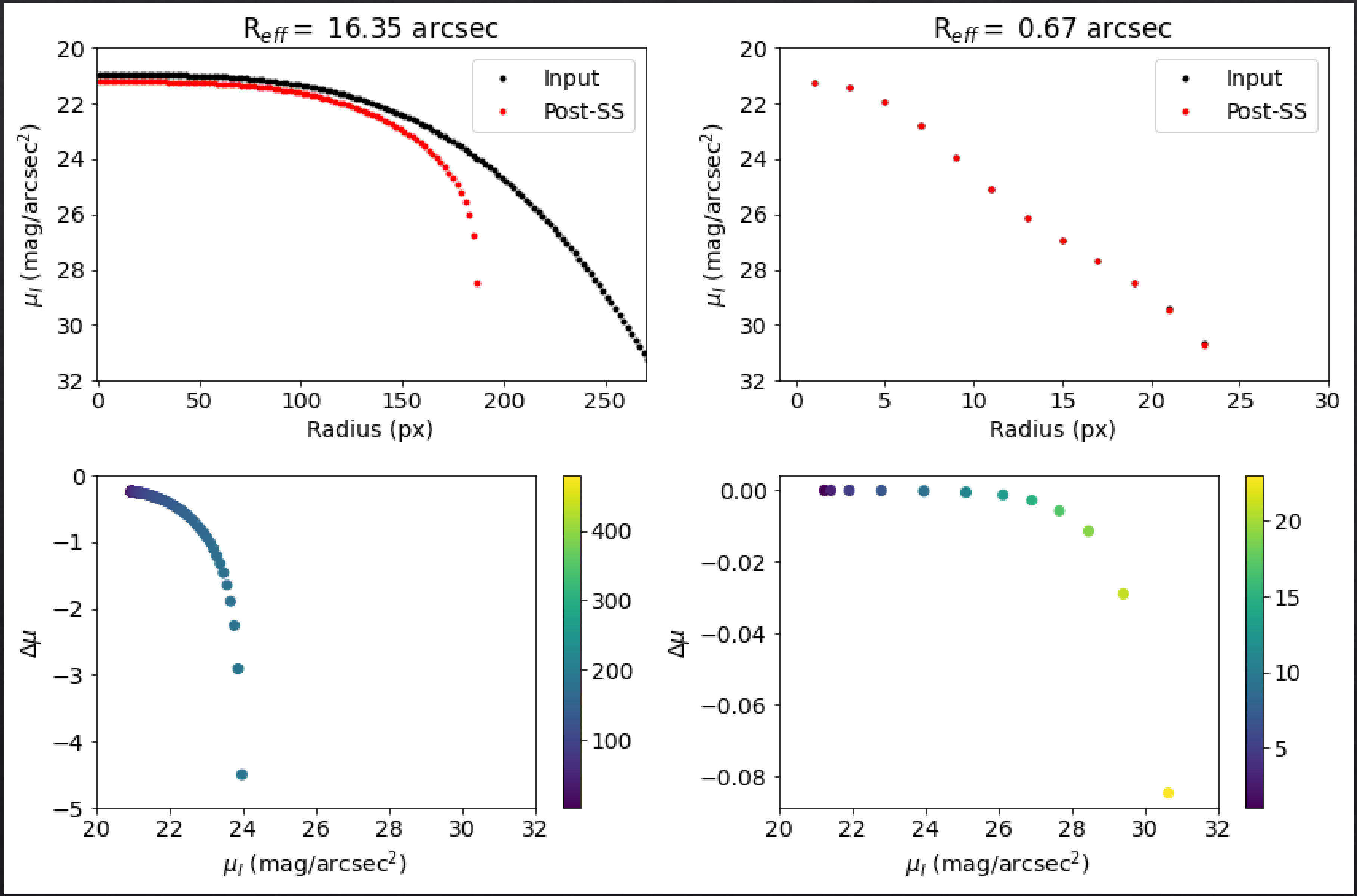

Variable $\mu_0$




Variable $R_{eff}$

TAKEAWAYS: 1.) objects with surface brightness below ~26 strongly impacted
2.) objects with size > 7.5 arcsec also strongly impacted (w/$\mu_0$~21)

# Impact of size on SB profiles



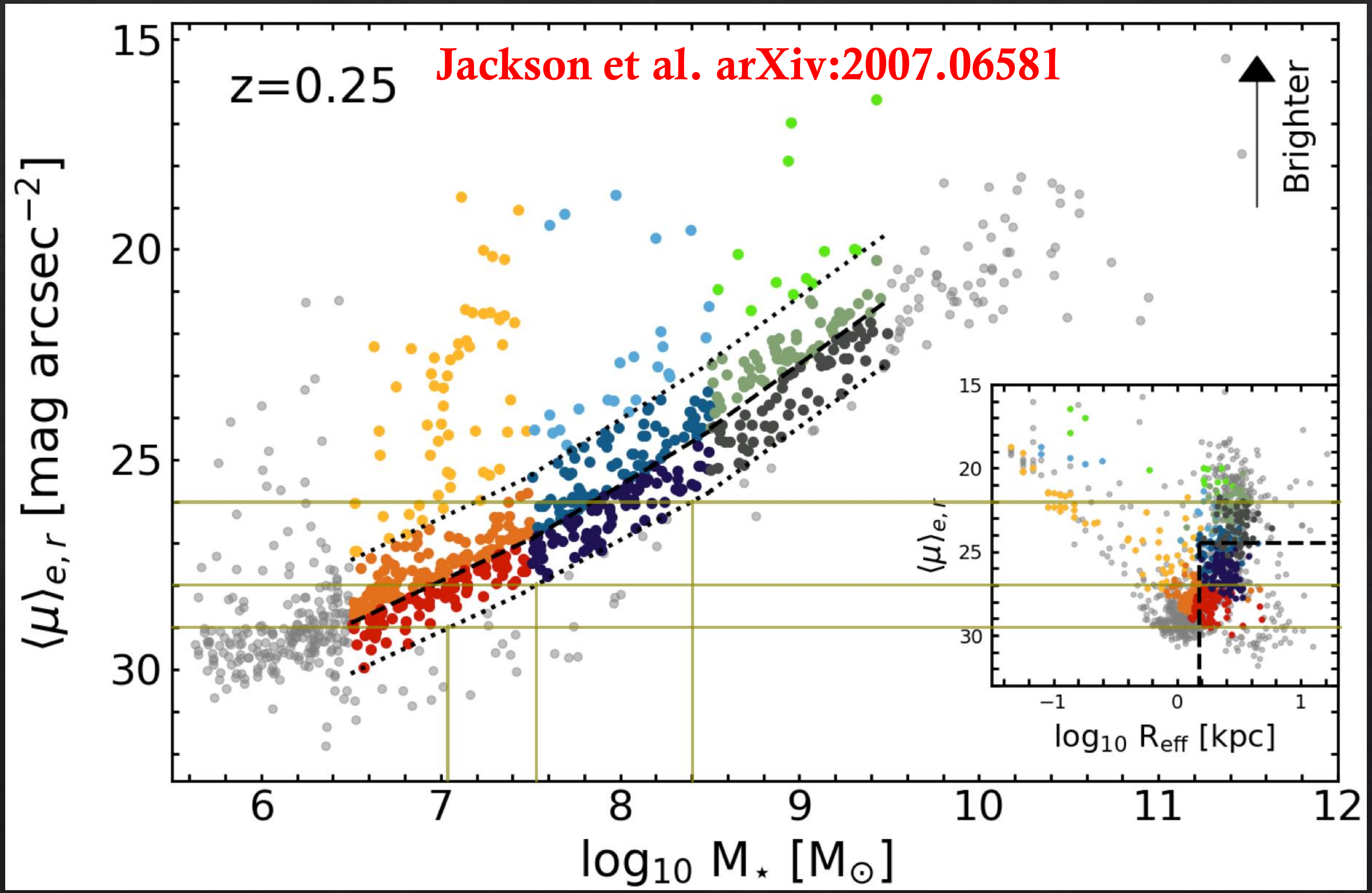

Flat models, $\mu_0 \sim 21$

Left: large, bright objects over-subtracted at all radii

Right: small, bright objects barely affected, even at very low SB (>30)

TAKEAWAY: angular size may have a larger impact than surface brightness

# Impact on galaxy completeness

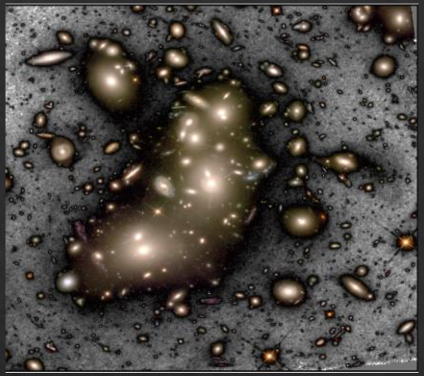



At 26 mag/arcsec$^2$ nearby galaxy population is complete at $10^{8.5}$ $M_\odot$

Need to get down to 28-29 mag/arcsec$^2$ to be able to see dwarf galaxies in the nearby Universe

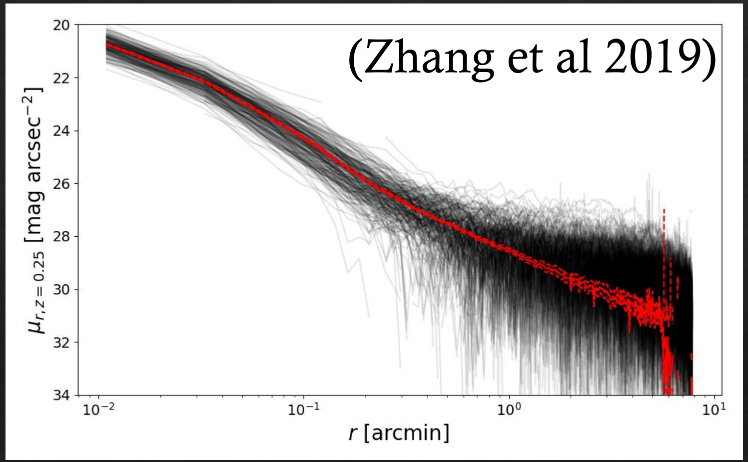
Situation is obviously worse for intermediate and high redshifts

# Impact on ICL studies



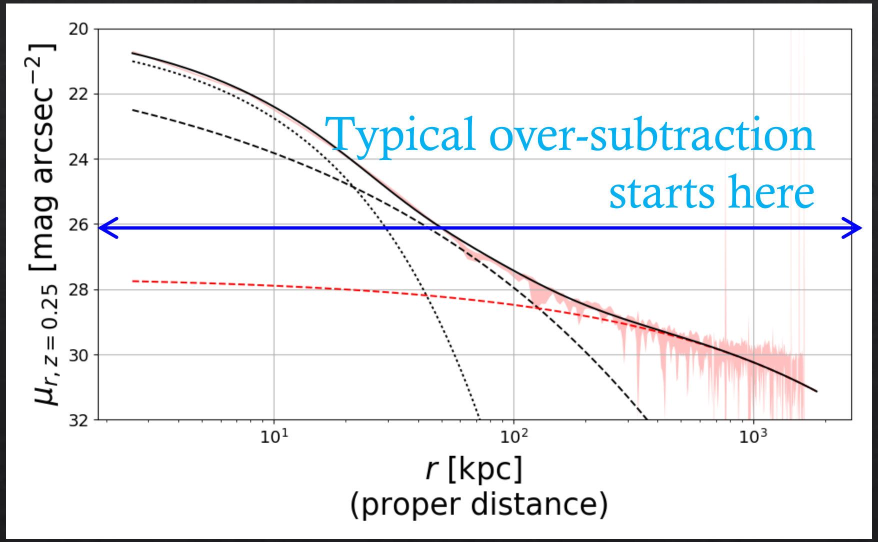
HFF cluster A2744 z=0.348 (Montes & Trujillo 2019)

- ICL constitutes 20-40% of the total cluster stellar light.
- Studies to z>1 are needed to understand cluster evolution and constrain cluster mass distribution ICL (e.g. Burke et al, 2015, Montes & Trujillo 2019, Zhang+ 2019) with deep LSST data




Raw ICL+BCG profiles and stack (red)

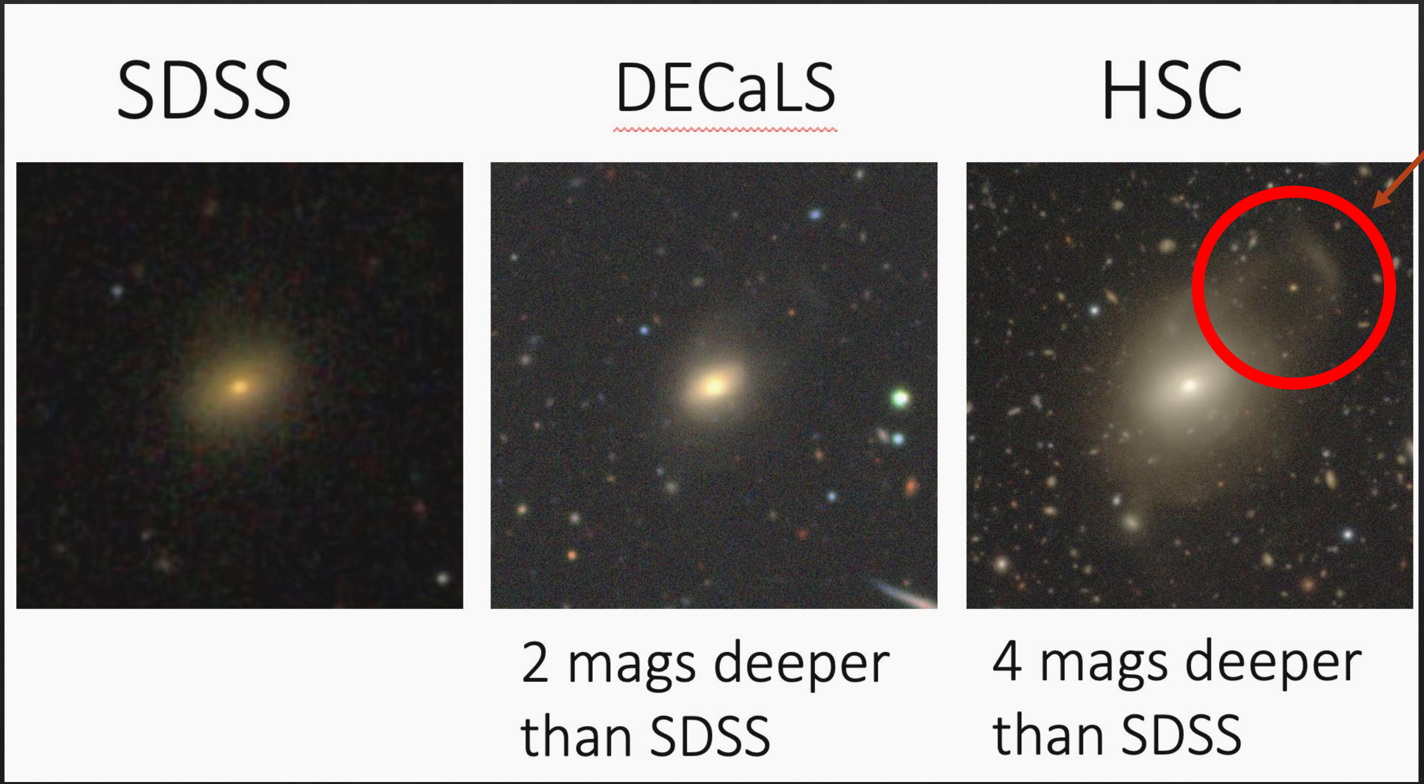
Sample: 300 clusters z=0.2-0.3 from DES Year 1 (Zhang et al 2019)




Diffuse ICL (red) dominates >200 kpc to 1 Mpc at ~28-30 mag arcsec$^2$: this data is typical of rich relatively local clusters at z=0.2-0.3

**Conclusion: current calexp-based pipeline renders intended ICL studies impossible**

# HSC PDR2 vs current pipeline




Preliminary investigation into PDR2 reveals LSB structures at 27+ mag/arcsec$^2$ in nearby galaxies (see tidal features in right-hand panel) can survive

Possible bifurcation of the pipeline to enable LSB science using PDR2 as a starting point?

--Next step: testing PDR2 sky subtraction in the same manner to quantify PDR2 depth

# Summary

- Current pipeline final sky subtraction very clearly over-subtracts backgrounds, resulting in lost flux below ~26 magnitudes/arcsec$^2$ (worse for objects with sizes >= mesh size)
- LSB science evidently hampered by this effect
- Galaxies science generally is hampered: HSB objects larger than ~10 arcsec severely over-subtracted as well
- Will next test PDR2 pipeline's impact (available through current pipeline as 'deepCoadd'), as preliminary indications are that it is better for LSB science
- Potential mitigation: bifurcation of the pipeline?