Assessing the impact of the pipeline sky subtraction on LSB science using model galaxies

Aaron E. Watkins, LJMU PDRA

with Chris Collins (LJMU) & Sugata Kaviraj (Hertfordshire)

LIVERPOOL JOHN MOORES UNIVERSITY

University of Hertfordshire UH

VERA C. RUBIN OBSERVATORY

Motivation: the LSB Universe

- A pipeline that treats LSB flux well treats *all* extended objects well
- LSB science comprises much of the extra-galactic discovery space with LSST and other surveys
- Past surveys (e.g., SDSS) had high limiting SB (~24—25 mag/arcsec^2)
- LSST potentially capable of reaching 30—31 mag/arcsec^2
  - LSST covers the southern sky, so has overlap with SKA, ASKAP, and MeerKAT
- If so, many areas of science will open or expand
  - Dwarf galaxies/UDGs (right)
  - Intracluster/intragroup light
  - Tidal features/galactic halos
  - Galactic cirrus/extended emission regions
  - Comet tails
- **But LSB science requires LSB-specific data reduction!**
  - Specifically, **sky subtraction** must be accurate

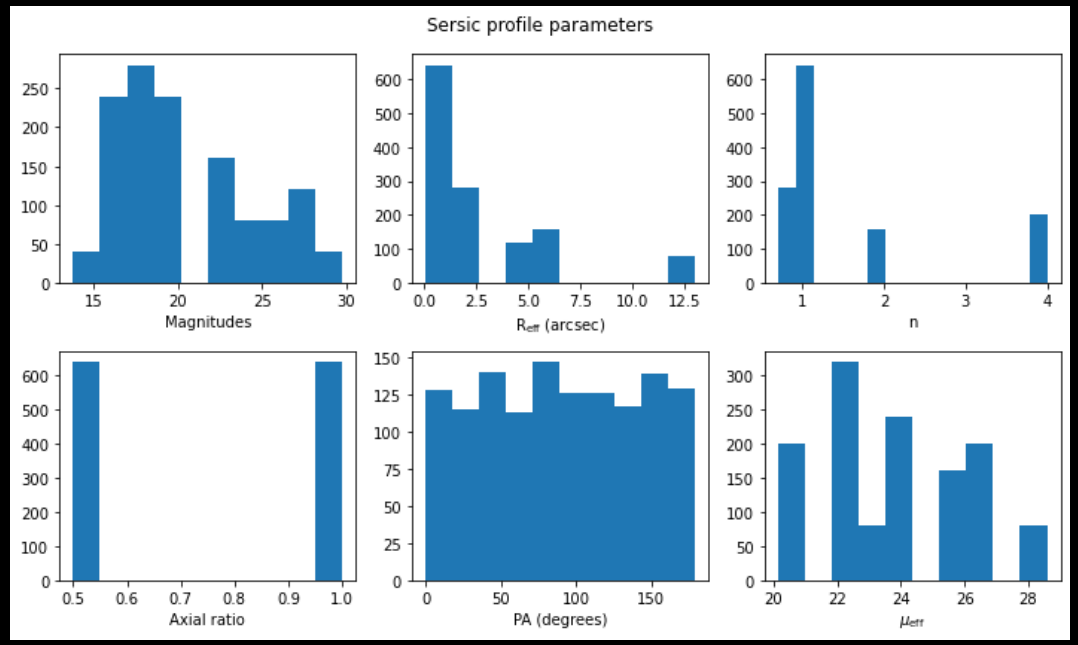
DF44 (van Dokkum et al. 2015)
"Ultra-diffuse galaxy"
Image credit: Teymoor Saifollahi and NASA/HST

Pipeline Testing Strategy

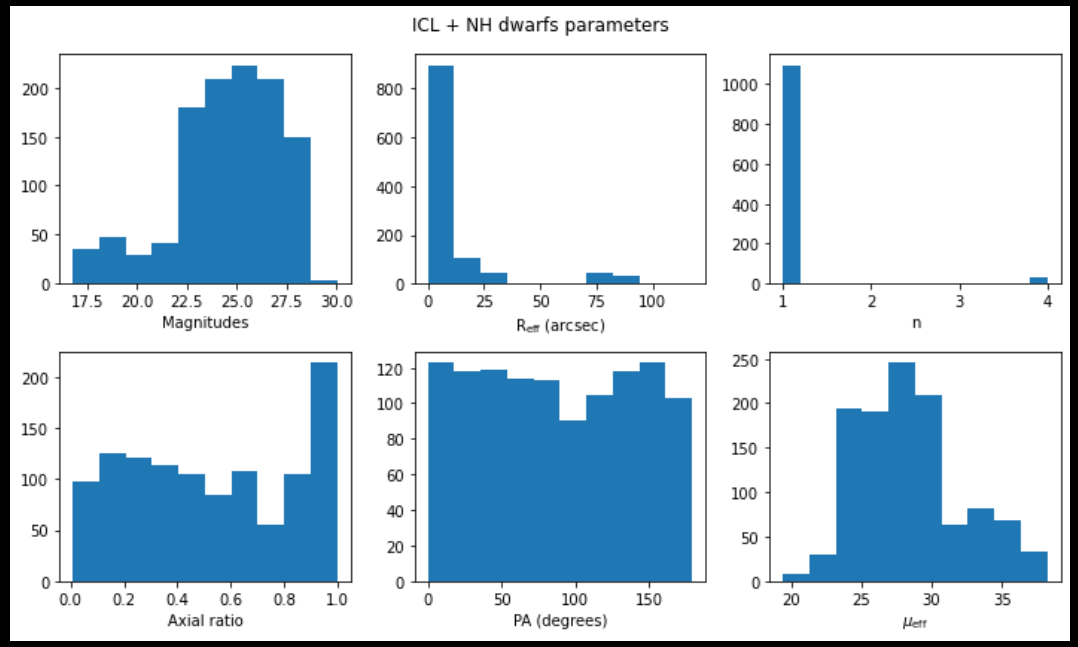
- Want to see how sky subtraction is doing for LSB flux
- Always testing the *current* version of the pipeline
- Injecting catalogues of model galaxies (next slide) into HSC tract 9615
- Aperture photometry: measuring model profiles at pixel-level both before and after **full-focal-plane** SS, then comparing
  - Already tested final, local sky subtraction step: *deepCoadd_calexp* are unusable for LSB science
- Primary metric: change in model magnitudes post-sky-subtraction
- Alternative metrics:
  1. Change in model flux/area post-SS
  2. Change in model surface brightness profiles post-SS

Model Suites Summary

- Suite 1: single Sérsic profiles, parameters in grid drawn from scaling relations
- 40 repeats per grid point, distributed semi-randomly through Tract 9615 in GAMA-15 fields
- For bright galaxy outskirts, LSB disks, dwarfs, and UDGs

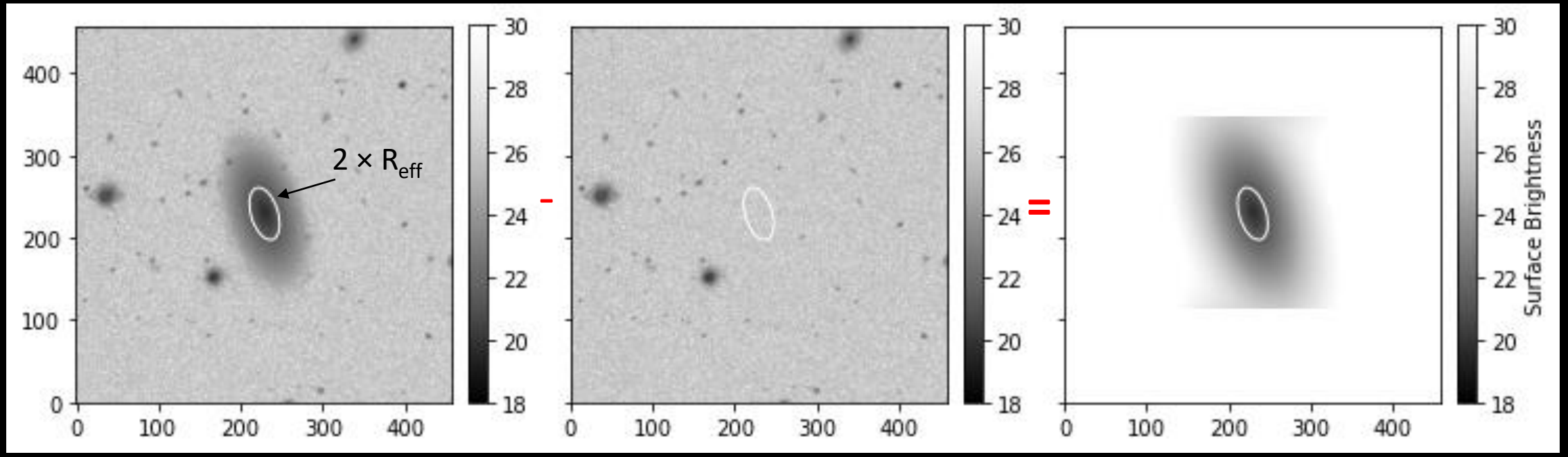


NOTE: truncating all models at $\mu = 32$ mag/arcsec^2



- Suite 2: ICL models and New Horizon dwarfs
- ~100 ICL + ~1000 dwarfs
- Using same tract (to preserve dithering pattern)
- For large angular size, LSB objects and higher redshift LSB dwarf galaxies

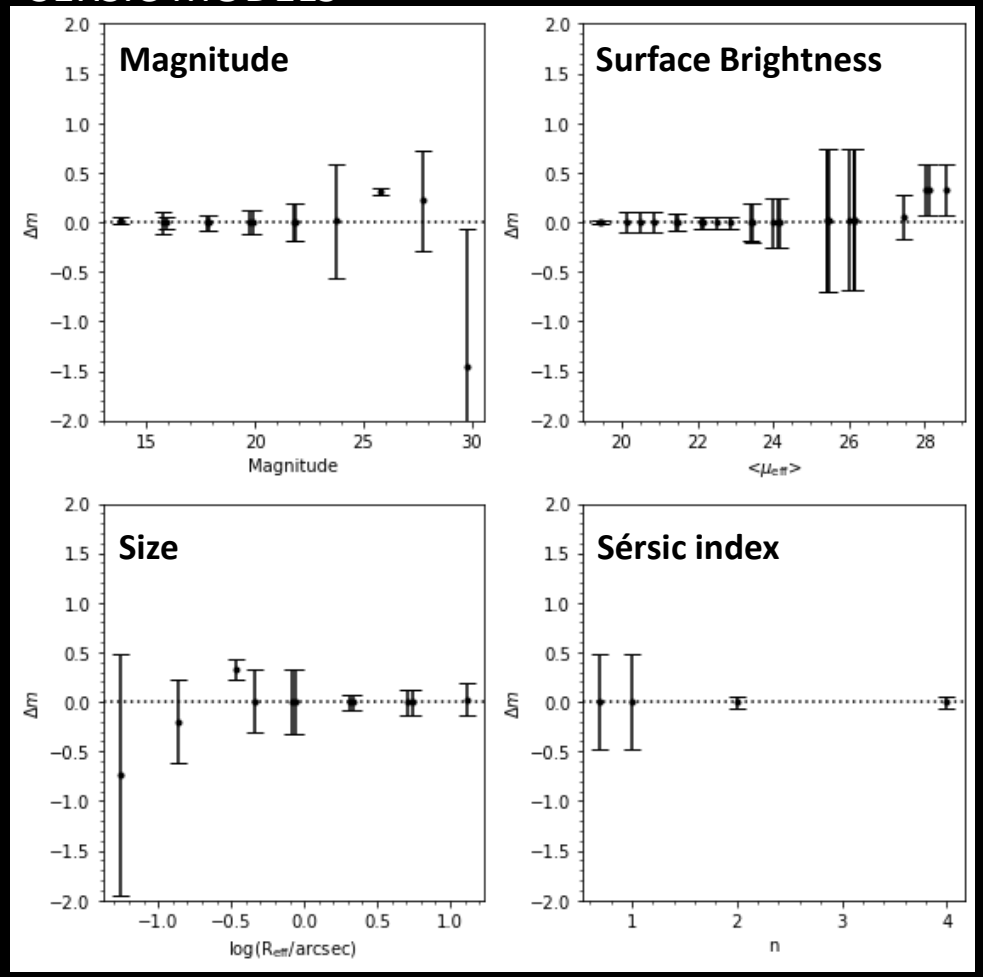
Photometry Demonstration



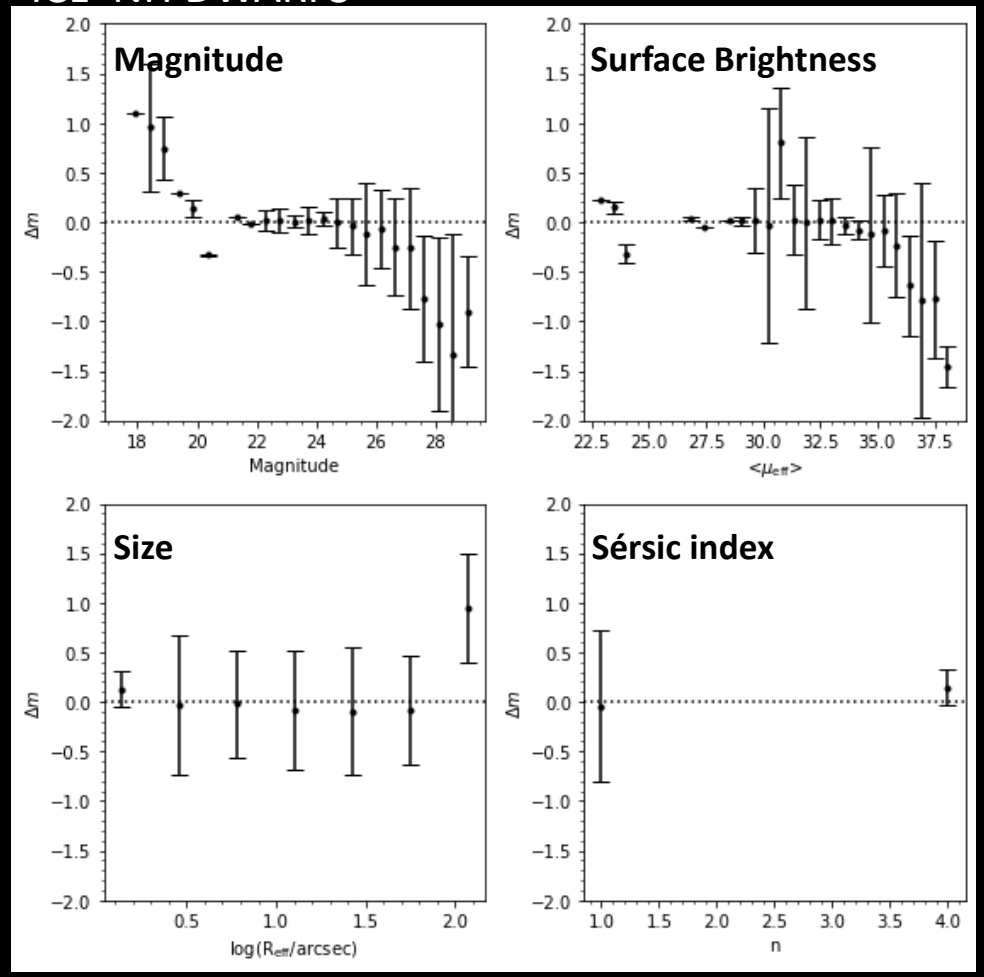
- Image with model, subtract image without model, yields only the model
- Do the same on image post-SS, yields only model post-SS

Model Magnitude Changes

SÉRSIC MODELS

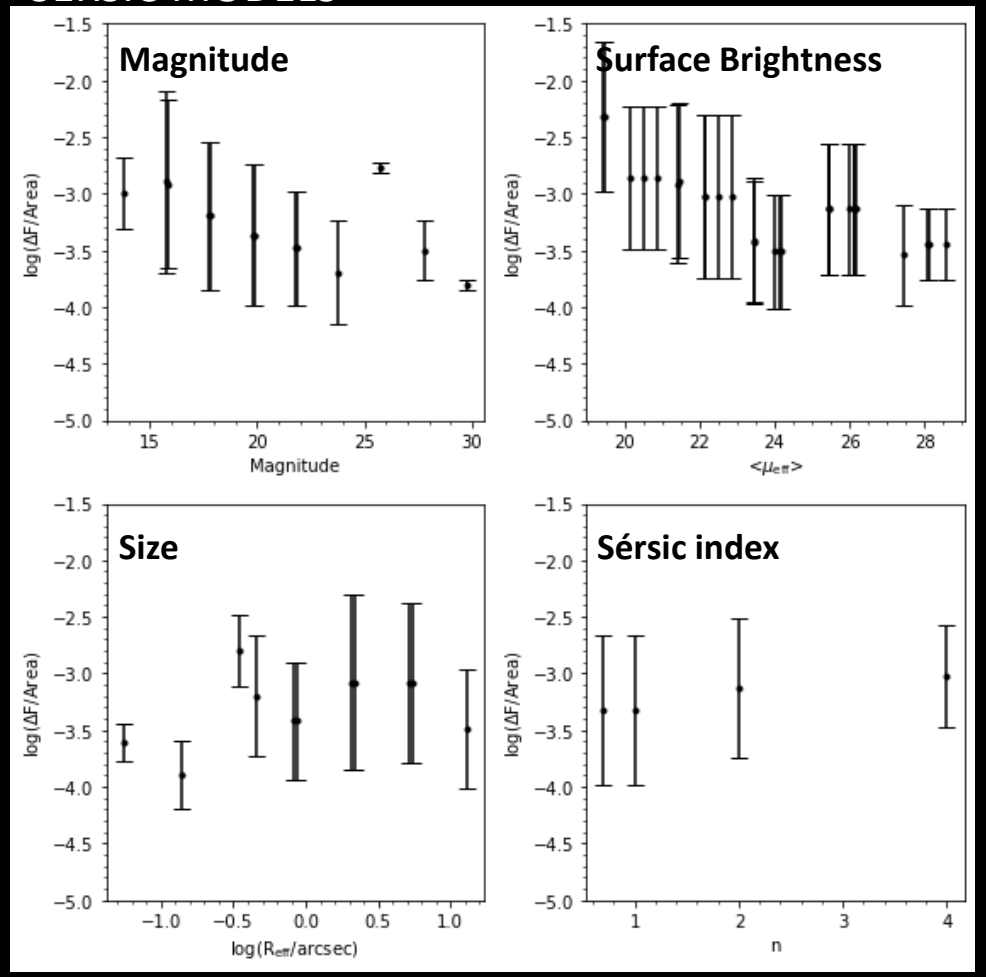


ICL+NH DWARFS

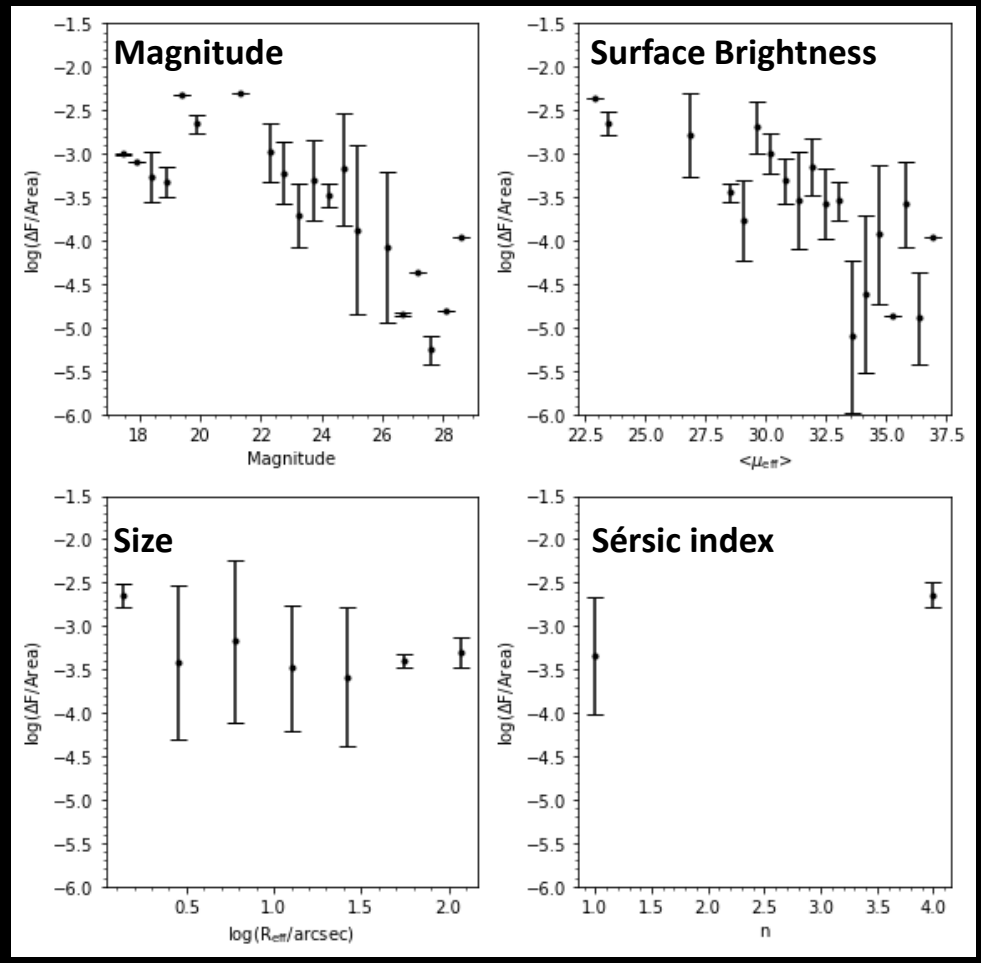


Total Flux Lost per Unit Area

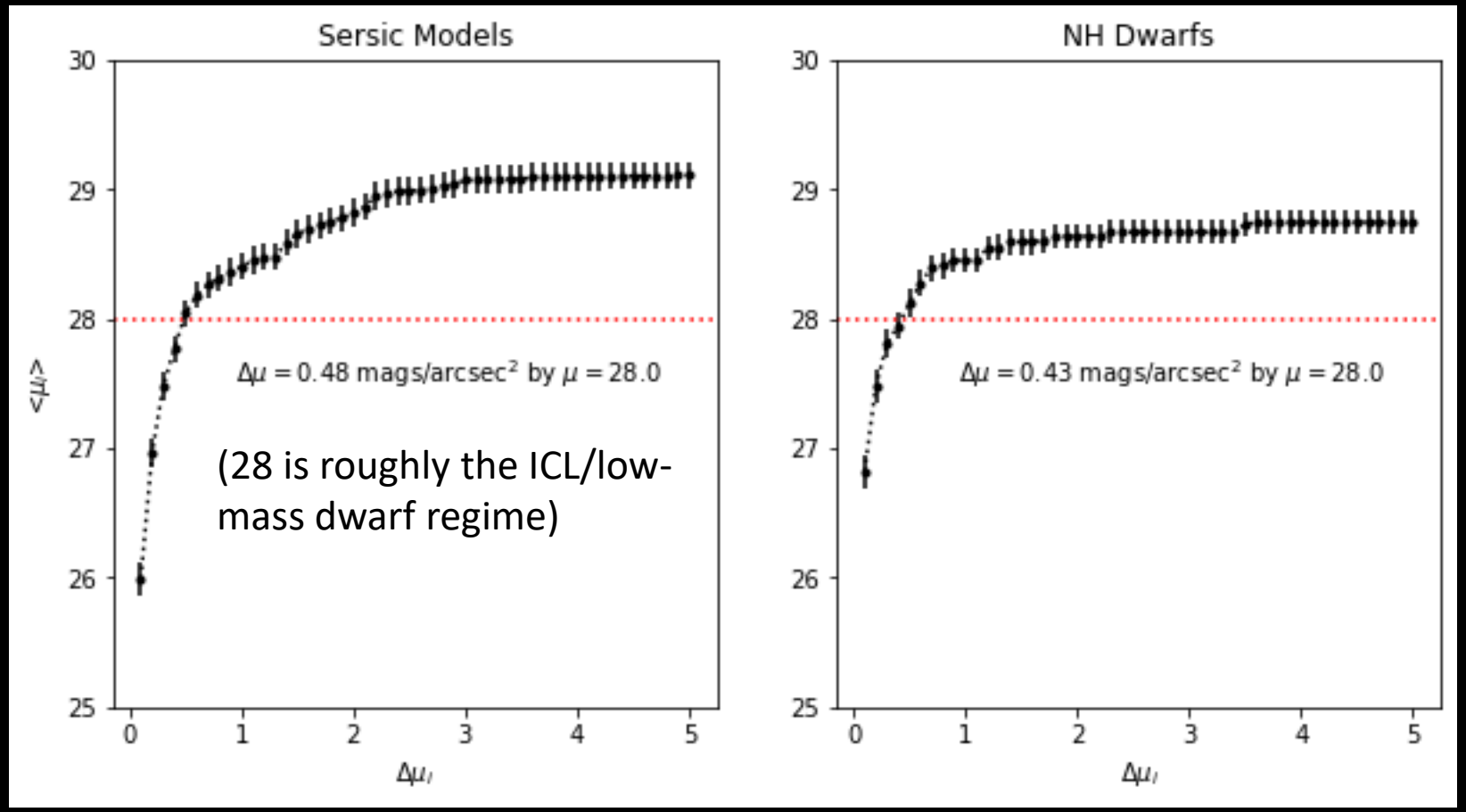
SÉRSIC MODELS



ICL+NH DWARFS



Over-subtraction vs. Surface Brightness



(28 is roughly the ICL/low-mass dwarf regime)

- X-axis = amount of over-subtraction in surface brightness profiles post-SS
- Y-axis = median SB of isophote among all models at which that amount of over-subtraction occurs
- Dark ring problem (HSC PDR1) has not vanished, but has moved to lower SB

SUMMARY: most flux lost below μ≈26; LSB models show biggest magnitude changes

Summary

- We are testing the current version of the LSST sky-subtraction using model galaxy injections
- We have identified a systematic >10% over-subtraction of flux for μ>26 mag/arcsec^2
  - Amount of over-subtraction scales w/model brightness, modulo model size
  - All models are affected, but LSB objects show largest change in magnitude as more of their flux lies below 26 mag/arcsec^2
- Fainter surface brightnesses are affected much more than brighter surface brightnesses, resulting in dark donuts in models' faintest wings
- Next step: mitigation, to preserve flux as much as possible