Stellar Haloes of galaxies in the SDSS Stripe 82 Survey

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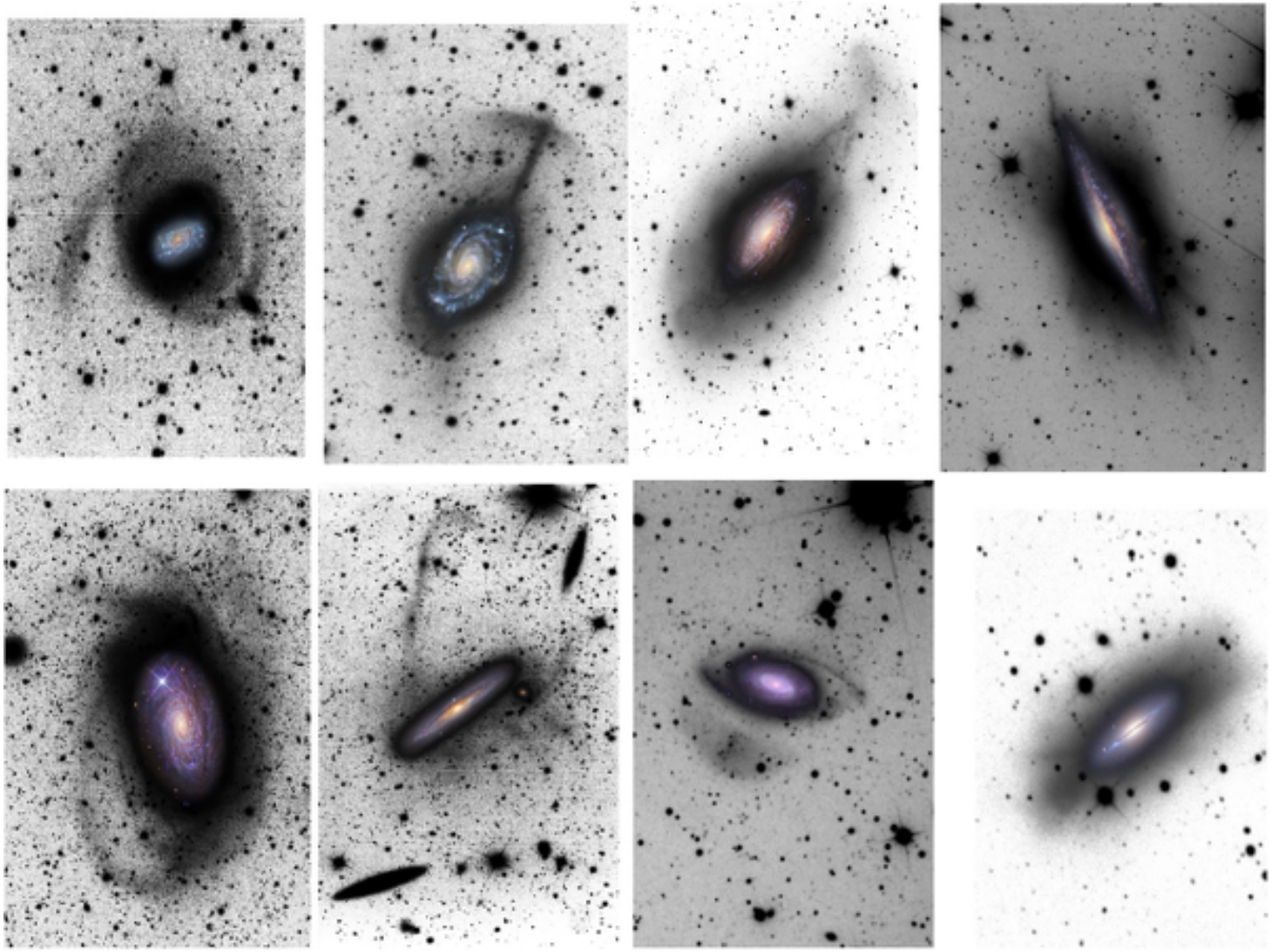
The Star Streams of NGC 5907

R Jay Gabany (Blackbird Observatory), David Martínez-Delgado (IAC) et al.

http://apod.nasa.gov/apod/ap080619.html

Streams, Plumes, Umbrellas, Clouds, Spikes, Cones...



D. Martínez-Delgado et al. 2010

Why Stellar Haloes?

- Signatures of merging events which have shaped galaxy evolution
- Provide a record of galaxy mass assembly
- Imply a history of feedback, SFR, metal enrichment

Stellar haloes believed to be ubiquitous and diverse, however:

Current observational studies limited to small cosmological volume/low mass (e.g.; Mouhcine, Ibata & Rejkuba 2010; Ibata, Radburn-Smith et al. 2011)

A wide, deep and robust extragalactic survey of extended and diffuse stellar components is required to provide the ultimate test of ΛCDM hierarchical merging scenarios.

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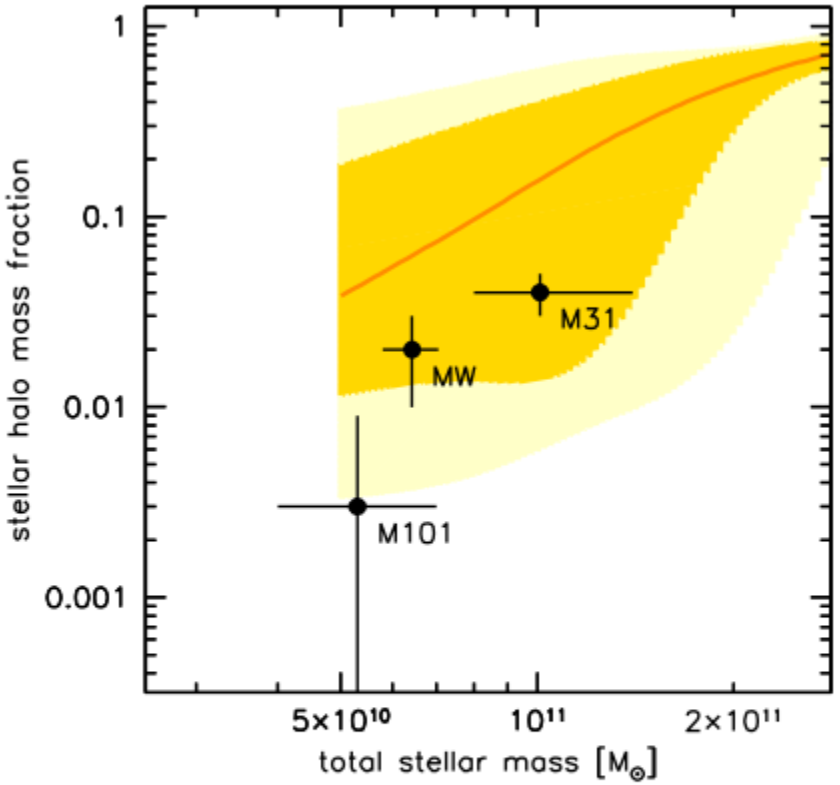


Figure 4. The mass fraction in the stellar halo as a function of the total stellar mass. The stellar halo of M101 has significantly lower mass than those of the Milky Way and M31. The orange line is the predicted median relation between the accreted mass fraction and the total stellar mass from numerical simulations (Cooper et al. 2013; see text). The yellow and brightyellow regions indicate the 68 % and 95 % galaxy-to-galaxy variation in the simulations.

van Dokkum et al. 2014

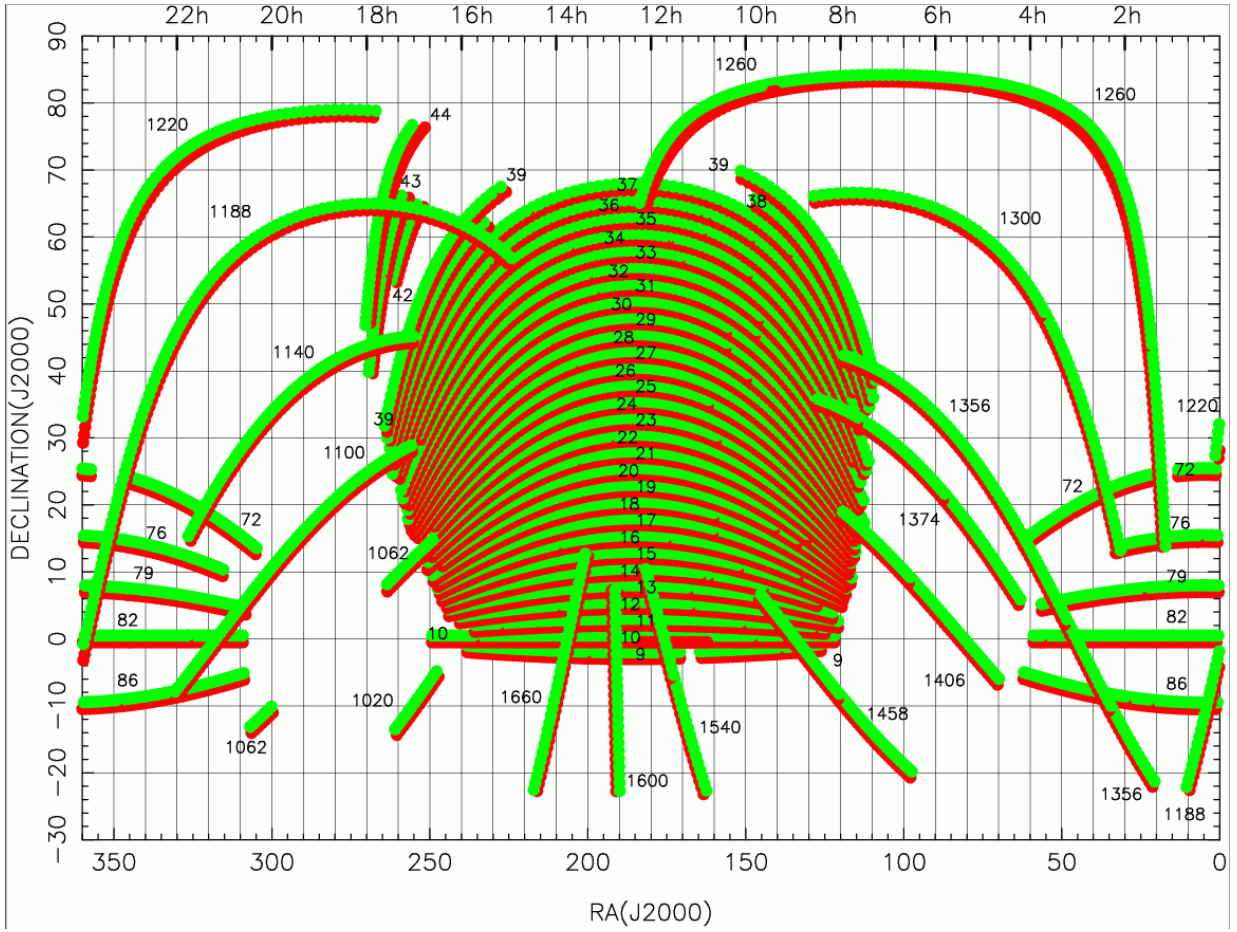
SDSS Stripe 82

SDSS-II Supernova Survey along SDSS Stripe 82

270 deg^2 area

- $-50 < \alpha < 59$
- $-1.25 < \delta < 1.25$

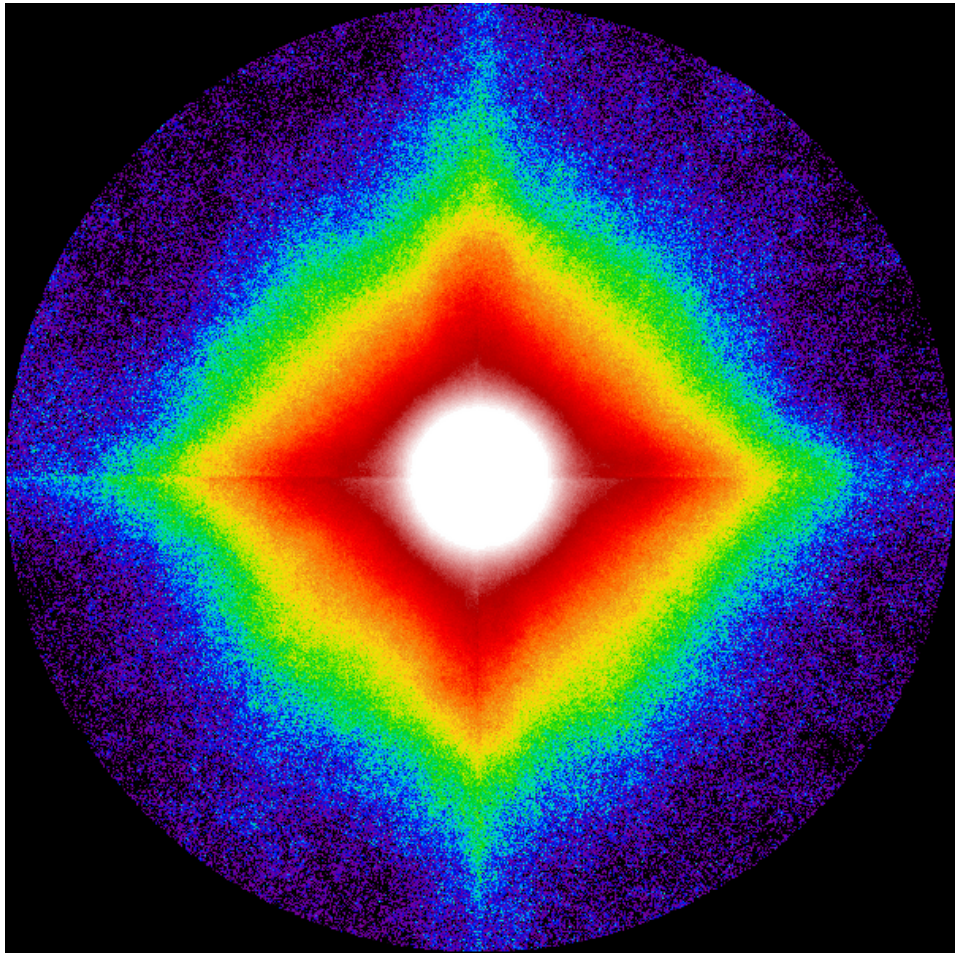
303 runs, avg. 80 exposures per pixel



Sloan Digital Sky Survey

Mapping the Universe

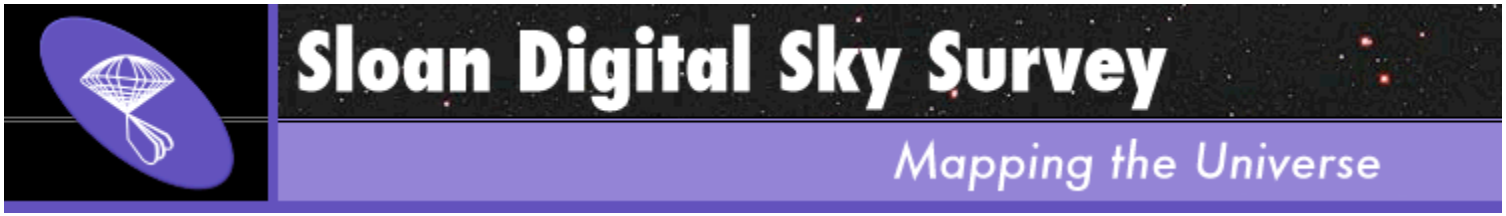
SDSS Stripe 82



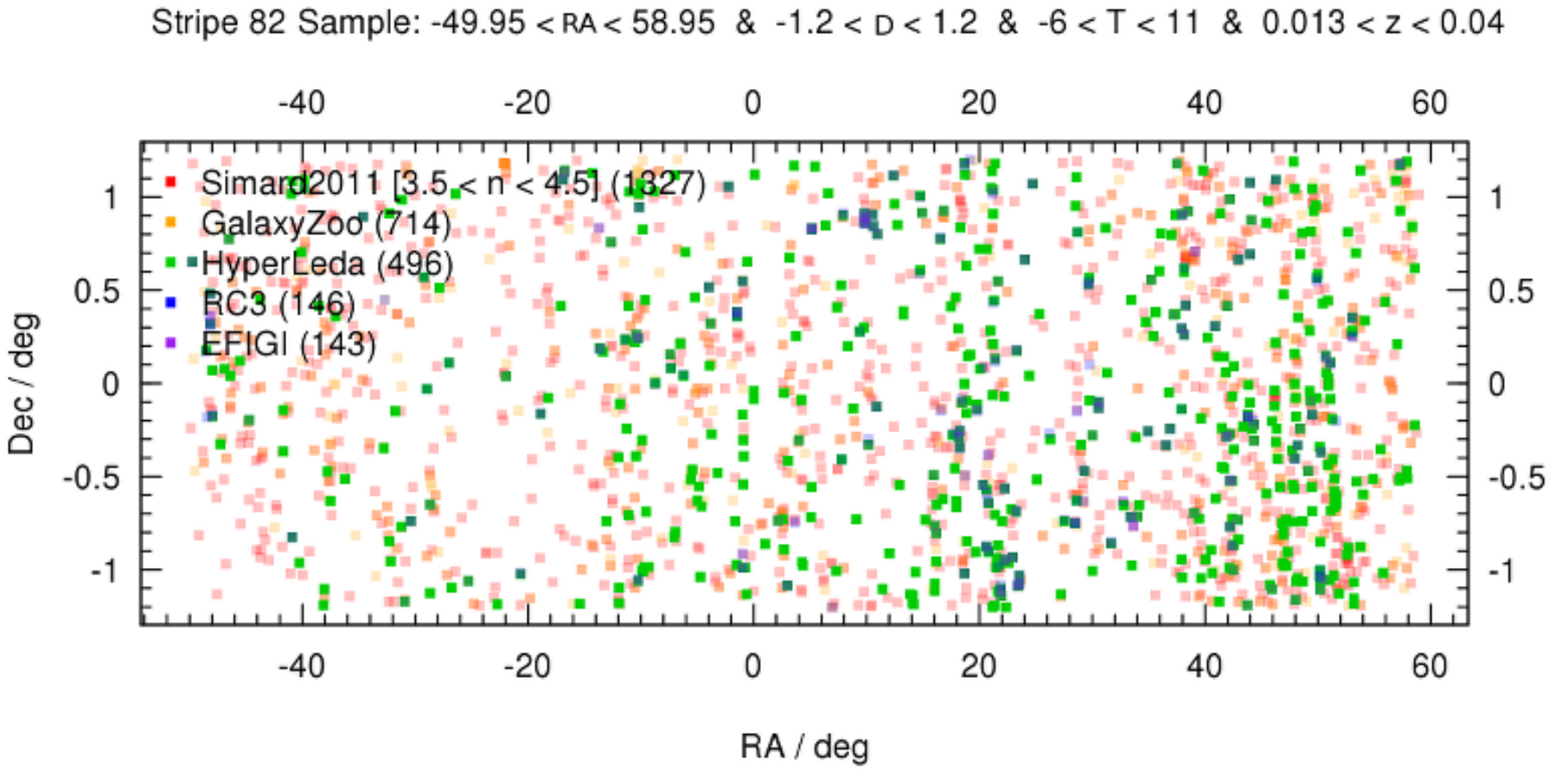
Reprocessed at the IAC:
(Jürgen Fliri, Mauricio Cisternas)

- minimally aggressive sky subtraction
- stack *gri* bands to produce *r-deep* passband
- PSF stacking to produce large (~800''x800'') PSFs

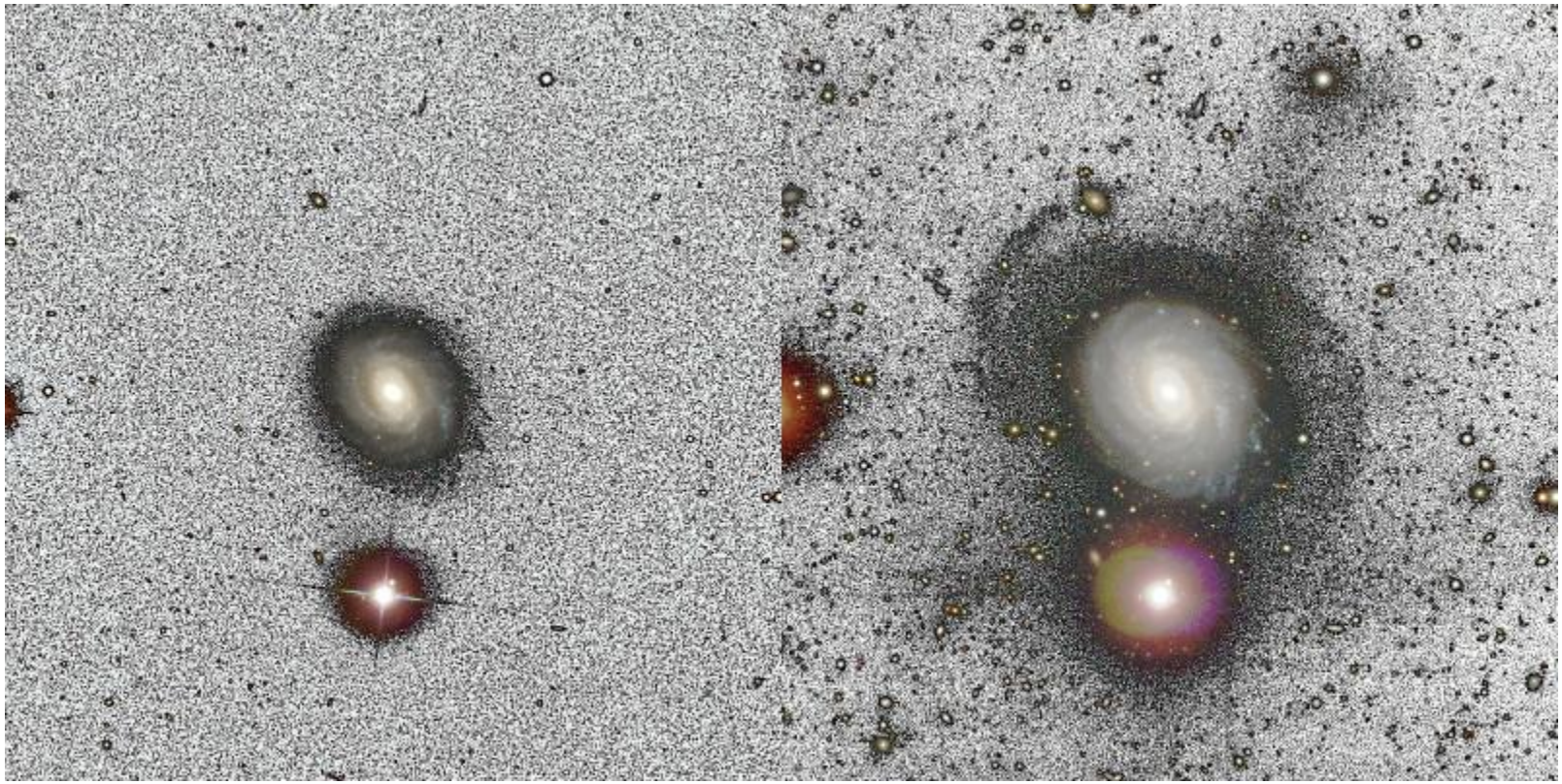
See Fliri & Trujillo, 2015, in prep.



SDSS Stripe 82

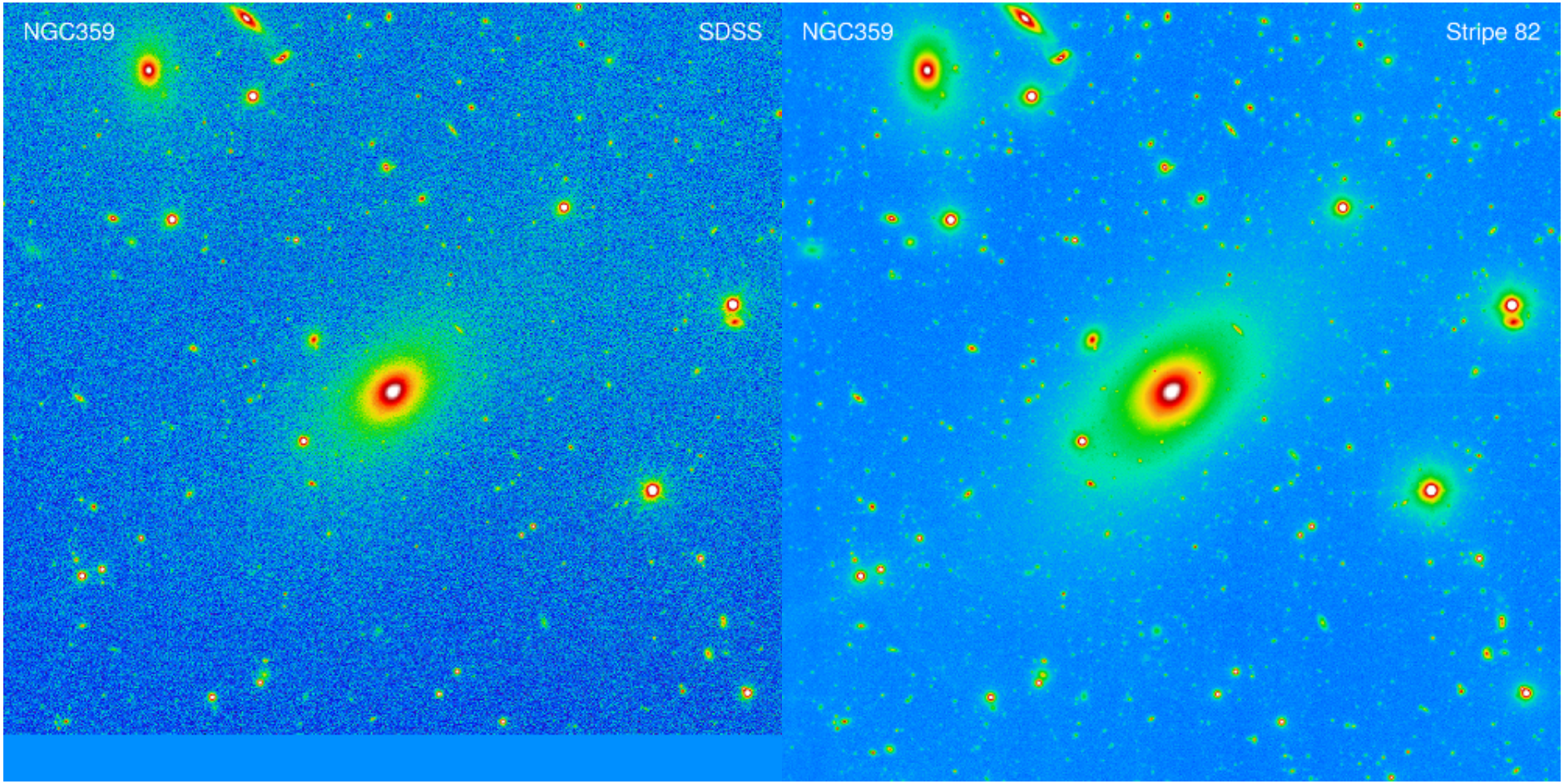


NGC 7716



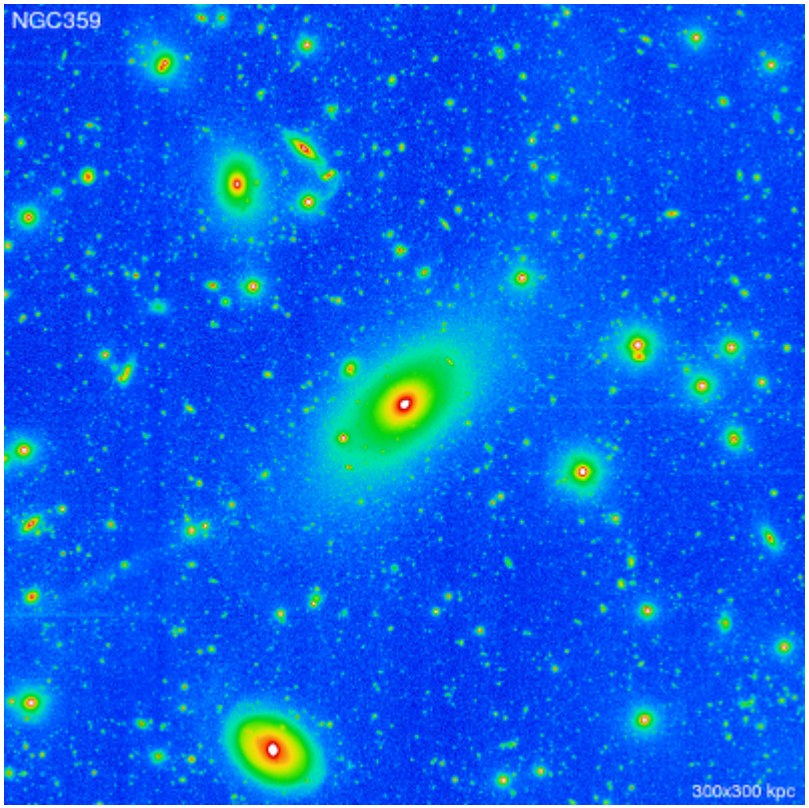
SDSS DR7 vs SDSS Stripe 82 (Bakos & Trujillo 2011)

NGC 359

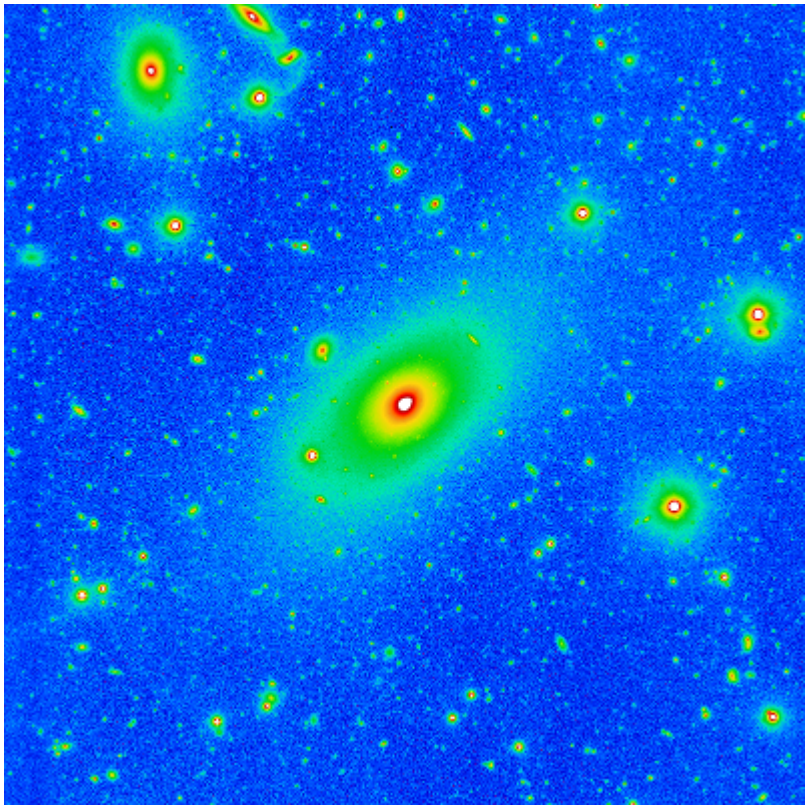


SDSS DR7 vs SDSS Stripe 82 (Kelvin et al., 2015, in prep.)

NGC 359: Image Processing

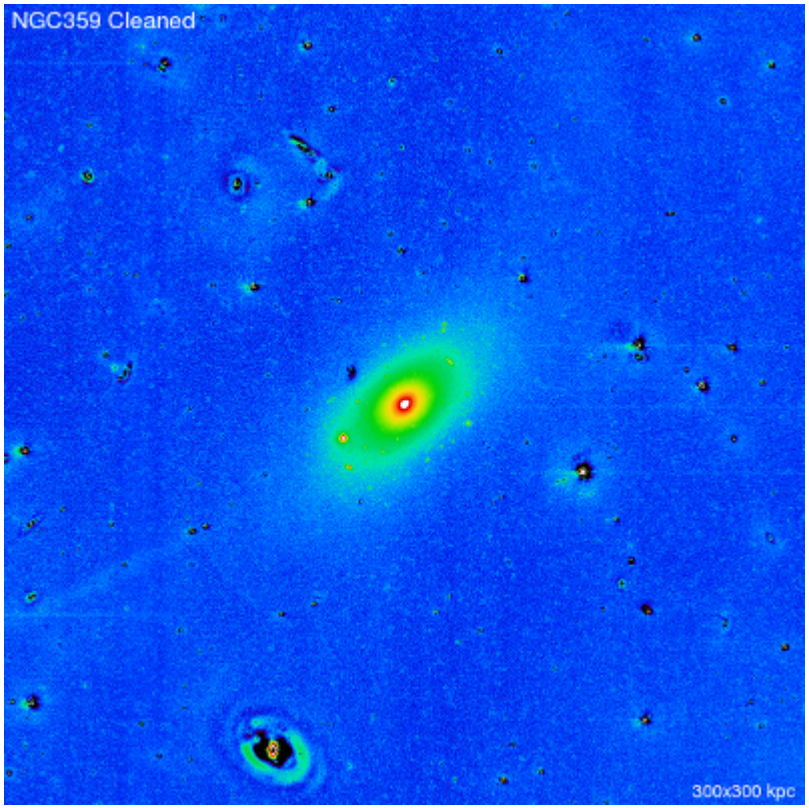


300 kpc x 300 kpc

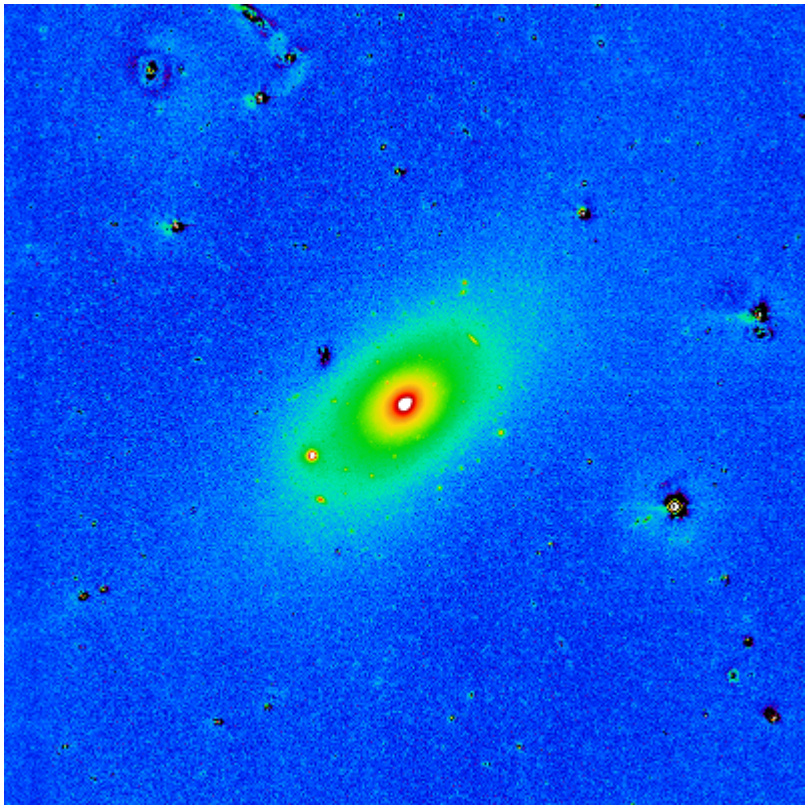


200 kpc x 200 kpc

NGC 359: Cleaning

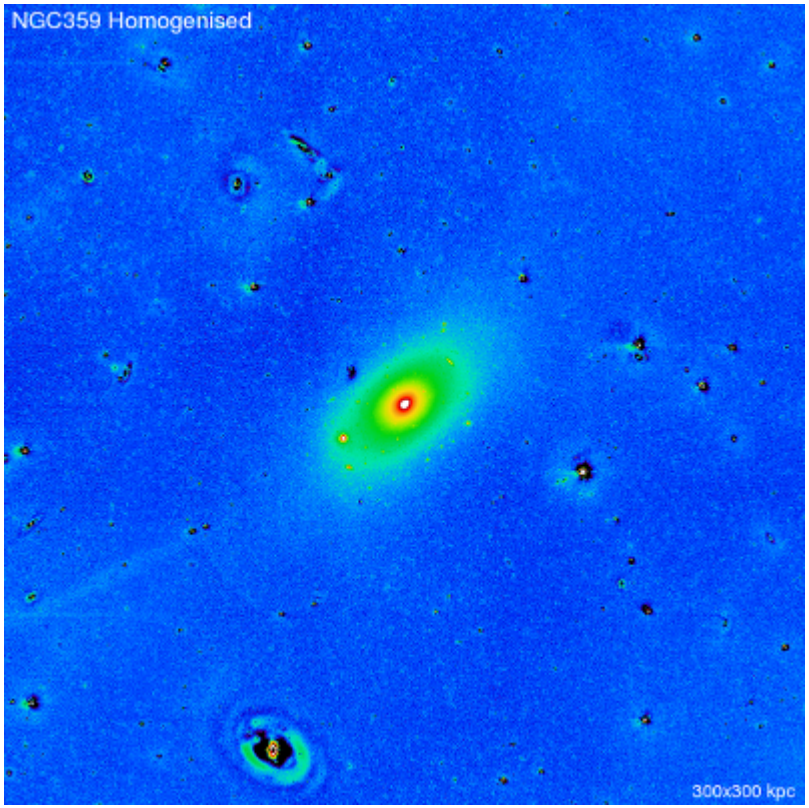


300 kpc x 300 kpc

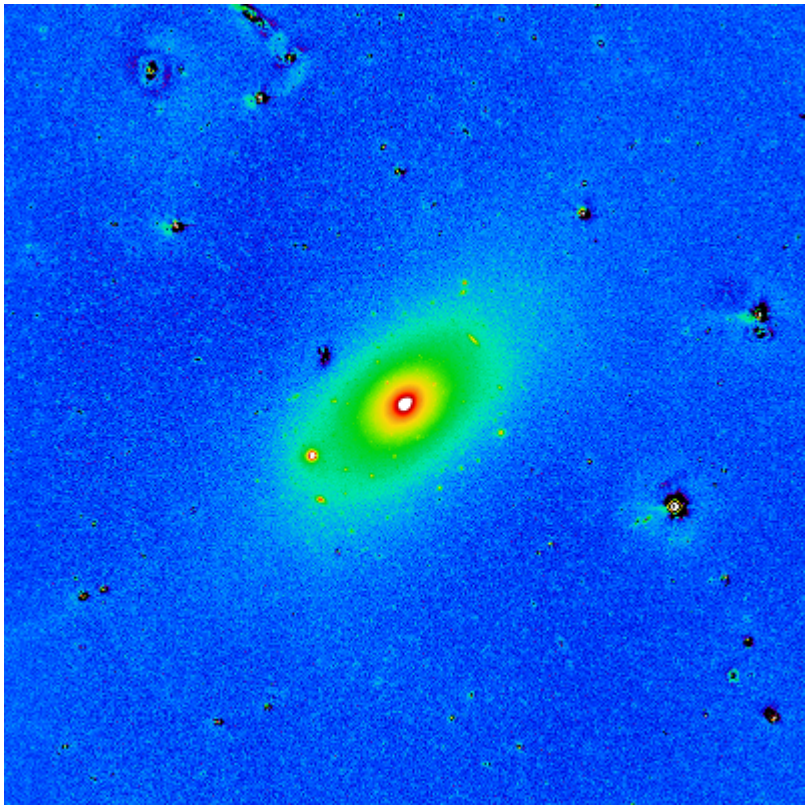


200 kpc x 200 kpc

NGC 359: De-Striping

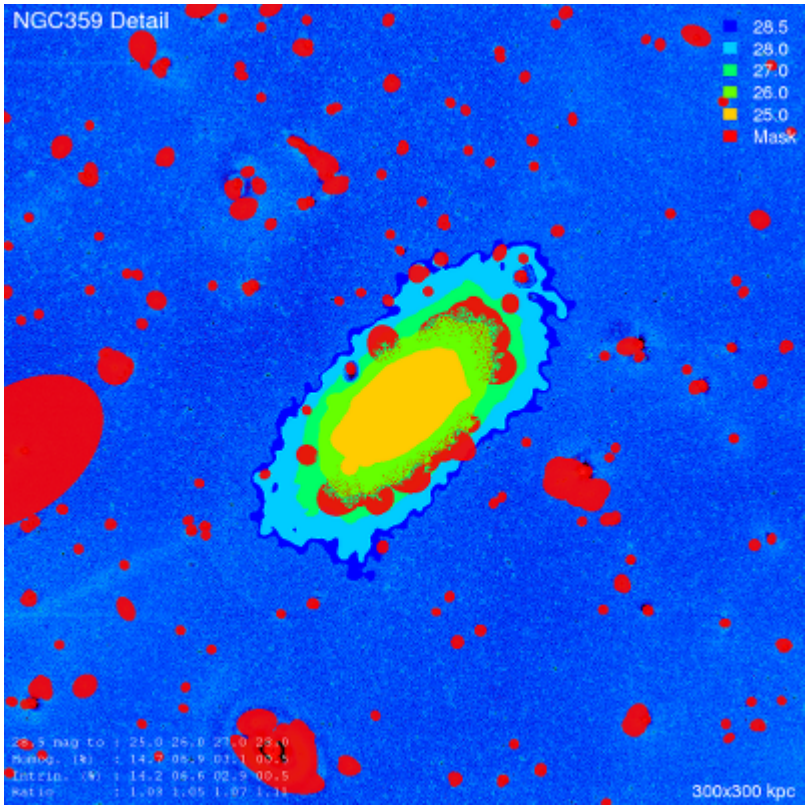


300 kpc x 300 kpc

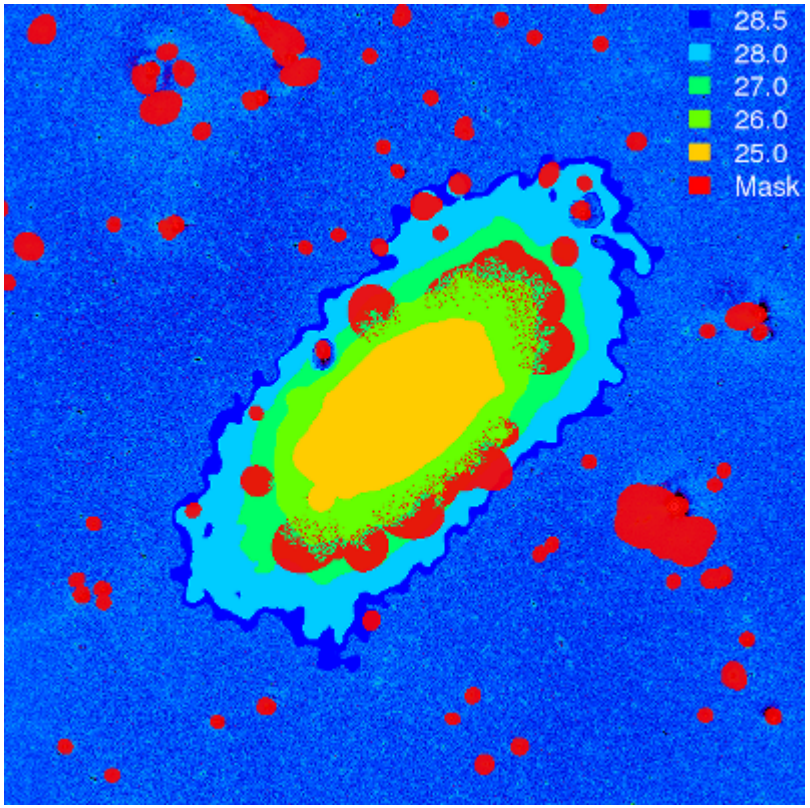


200 kpc x 200 kpc

NGC 359: Surface Brightnesses

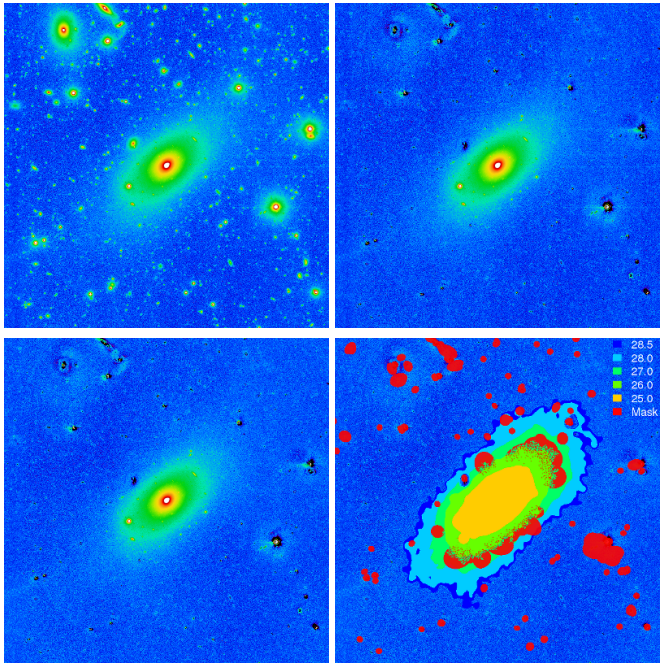


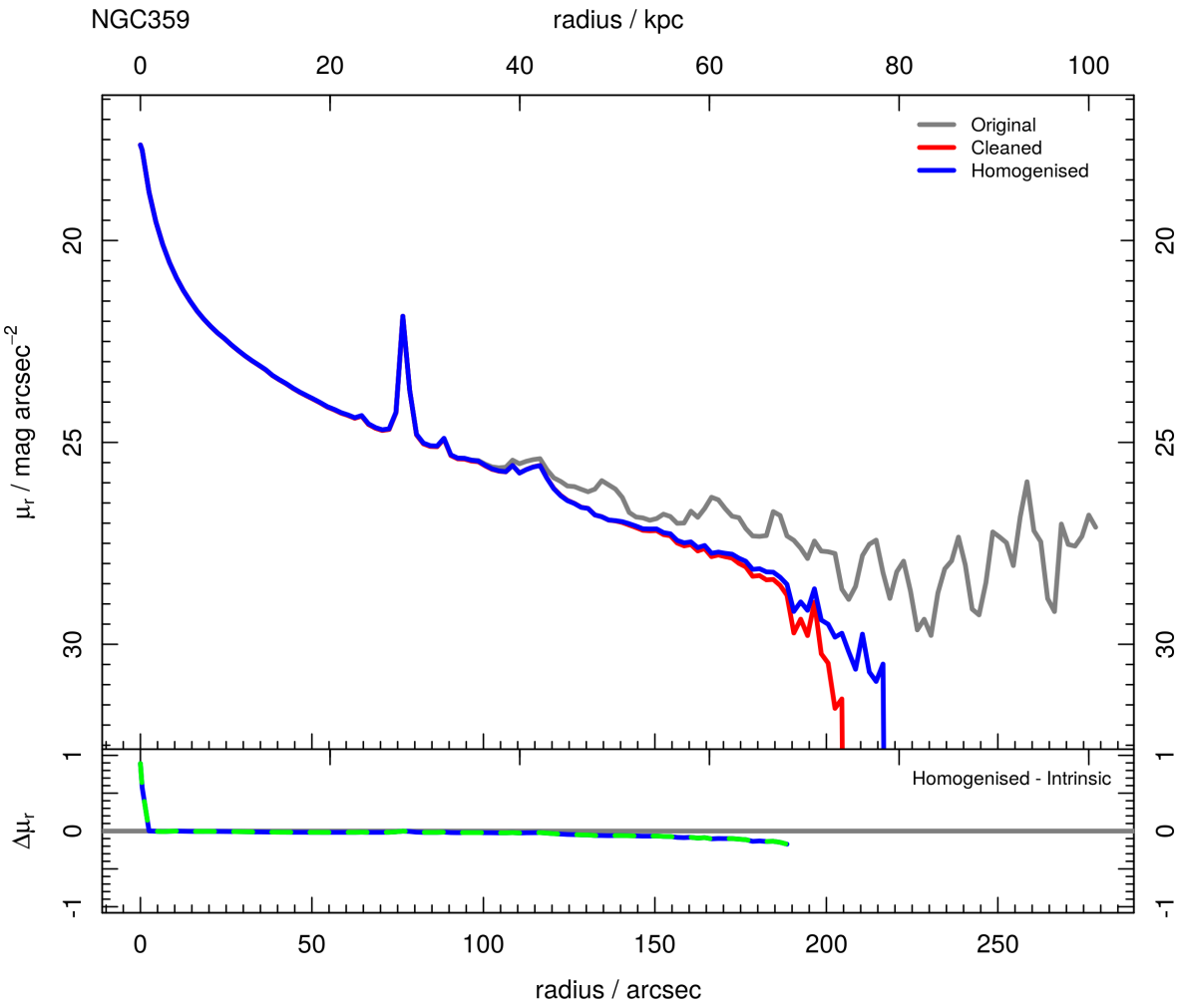
300 kpc x 300 kpc



200 kpc x 200 kpc

NGC 359





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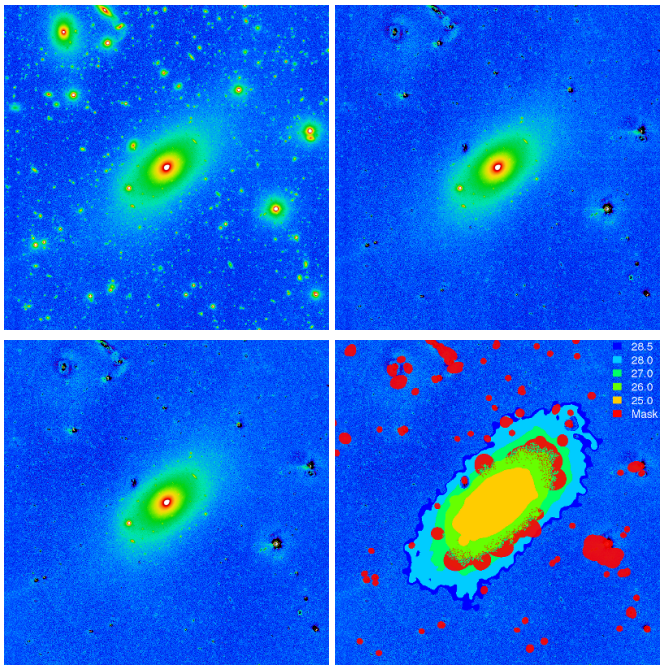
NGC 359

Parametric profiles out to ~80 kpc
Streams out to ~150 kpc



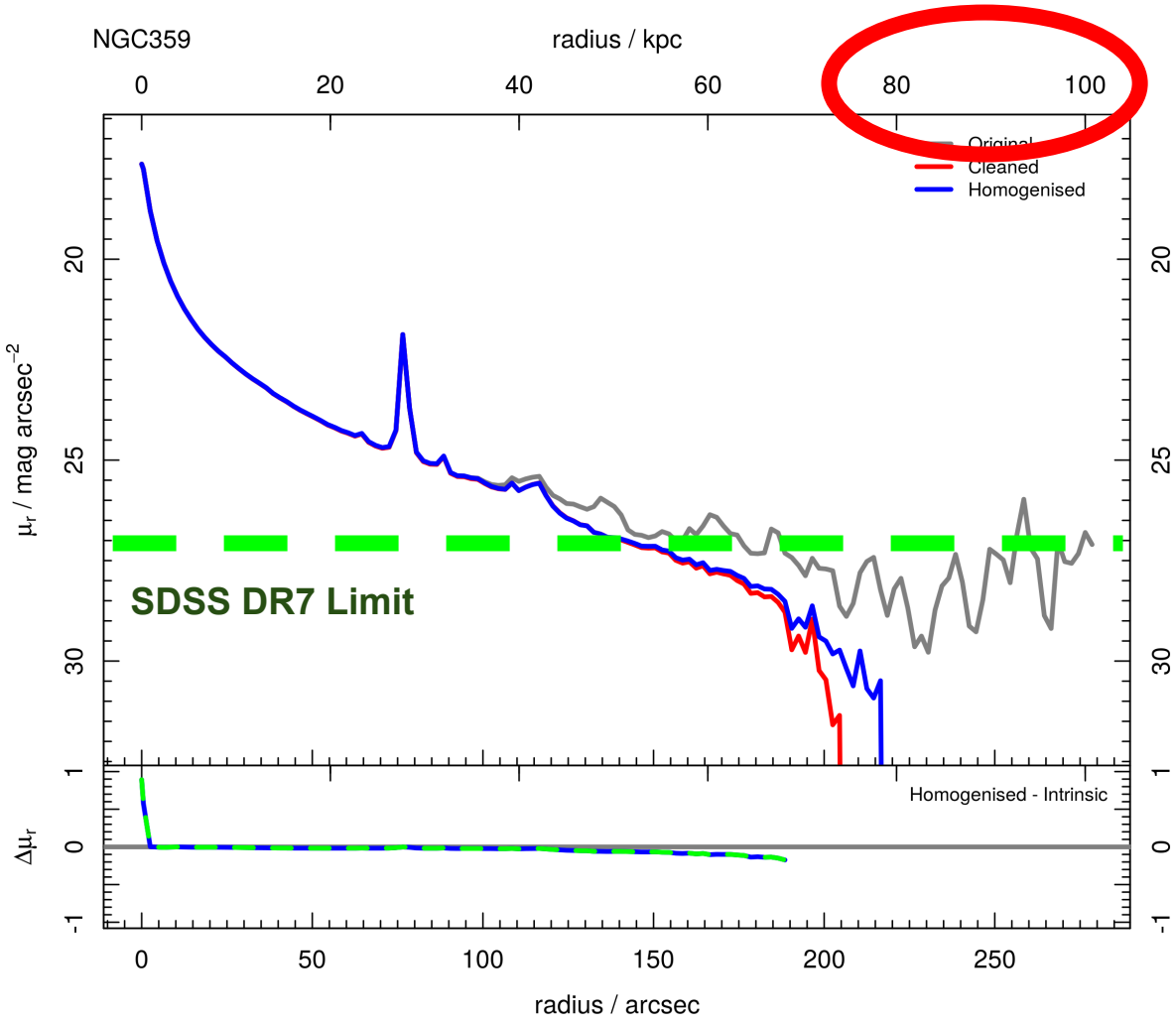


Image processing of Stripe 82 data allows for an extra ~3 mag depth cf. DR7

Ultra Faint Flux

What's behind it?

1. Stellar Halo! Low-μ, low mass, extended, complex structure.

Ultra Faint Flux

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2. PSF Contamination, primarily caused by breaks or truncations in the surface brightness profile.

Ultra Faint Flux

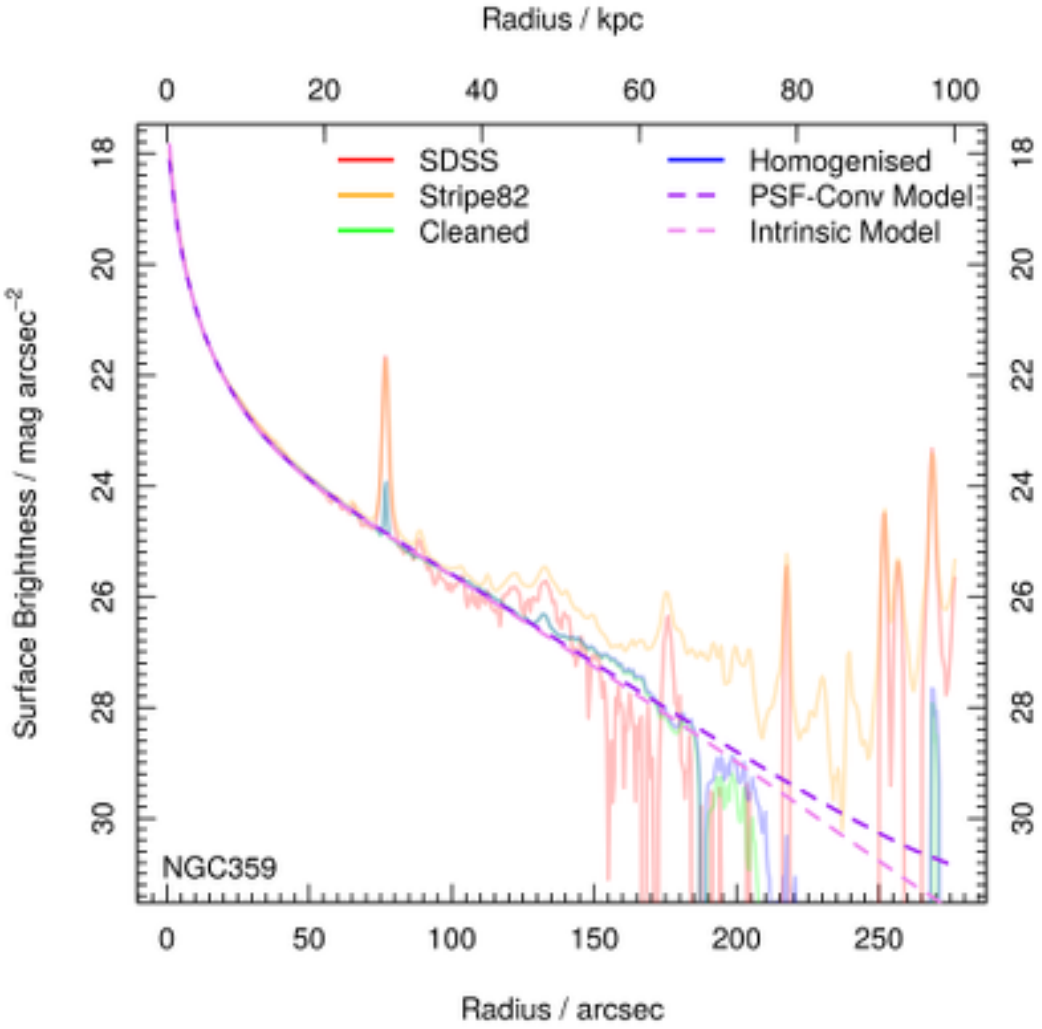
What's behind it?

1. Stellar Halo! Low-μ, low mass, extended, complex structure.

2. PSF Contamination, primarily caused by breaks or truncations in the surface brightness profile.

    - Fit PSF-Convolved model using GALFIT (Peng+ 2010) / IMFIT (Erwin 2014)
    - Subtract PSF-Convolved model
    - Add Intrinsic model to create an intrinsic image
    - Use pre-defined contour map to ascertain flux contribution at large radii due to effect of PSF convolution.

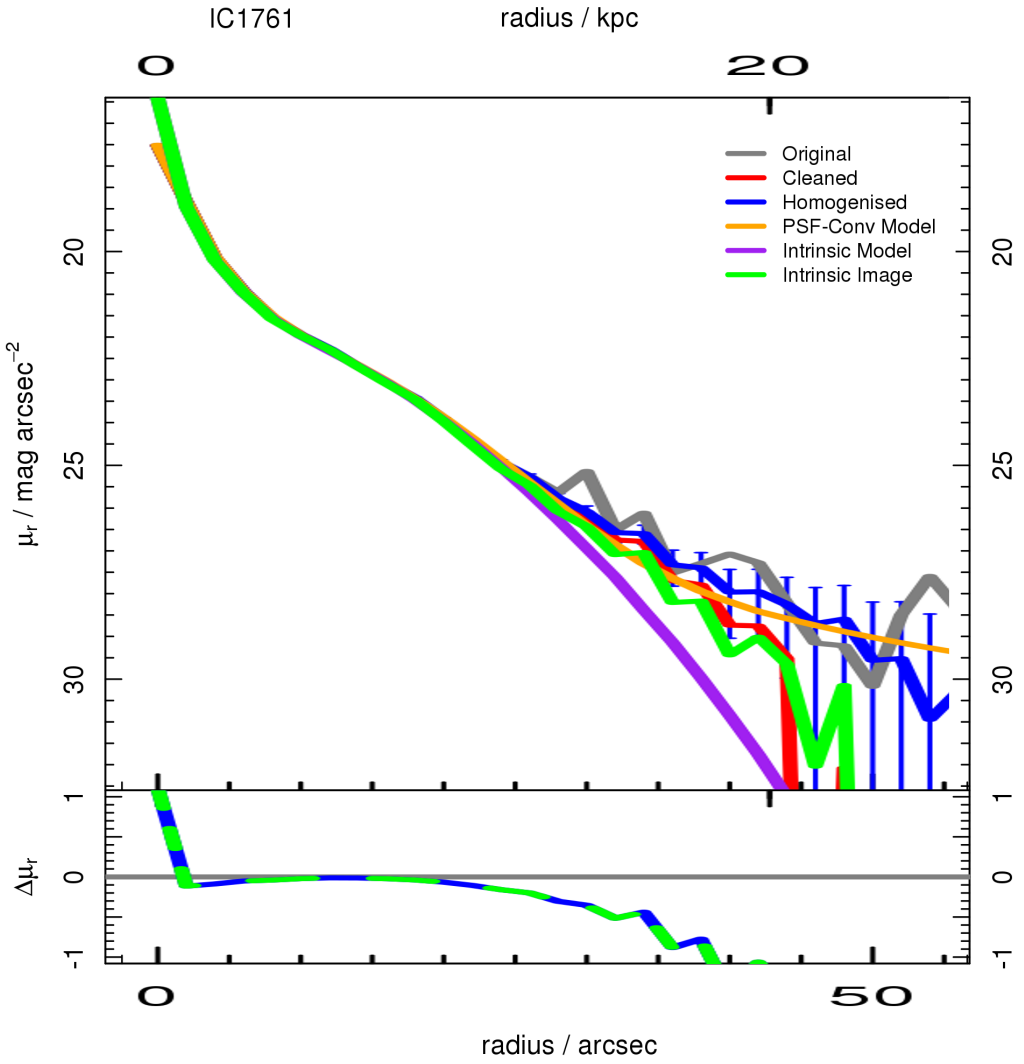
NGC 359



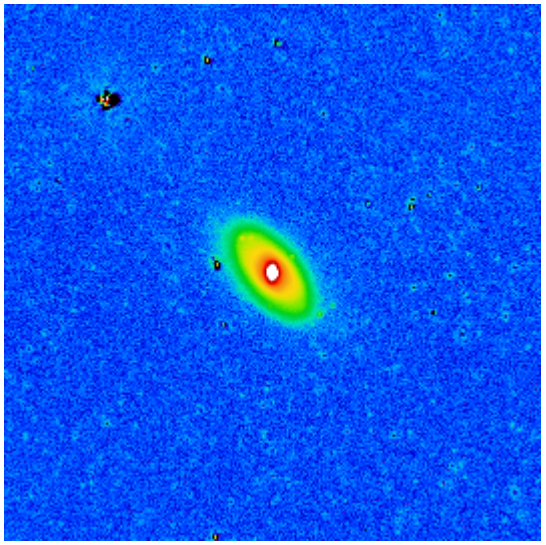
From μ=28.5 to	25	26	27	28
PSF-Conv	17.0%	7.8%	2.2%	0.2%
Intrinsic	16.6%	7.5%	2.0%	0.2%

For NGC 359, negligible PSF contamination at faint surface brightnesses.

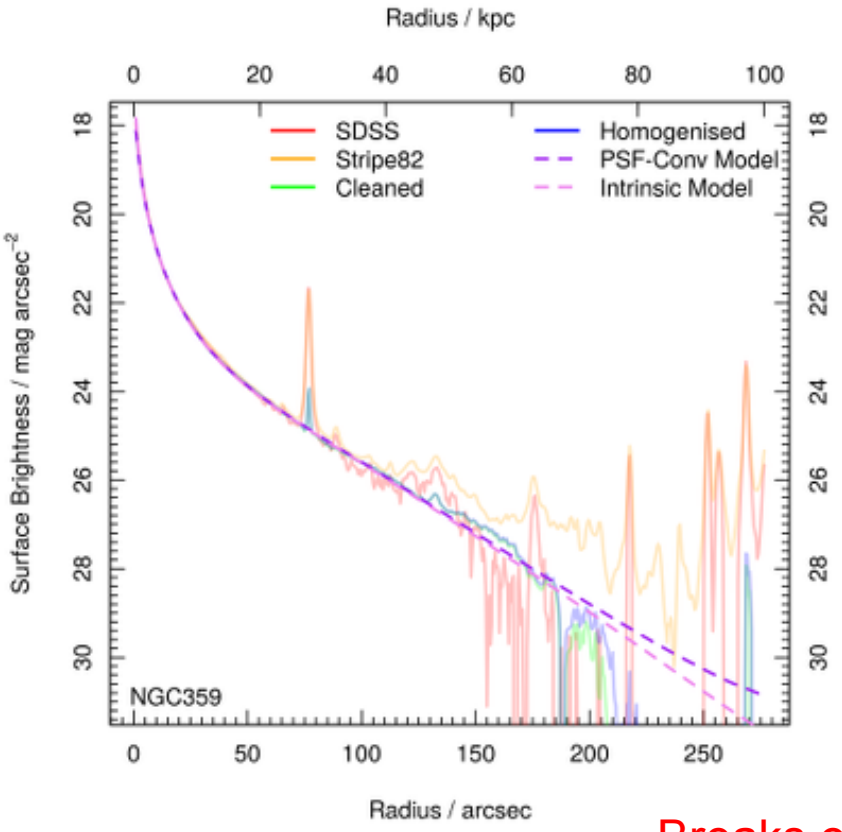
IC 1761

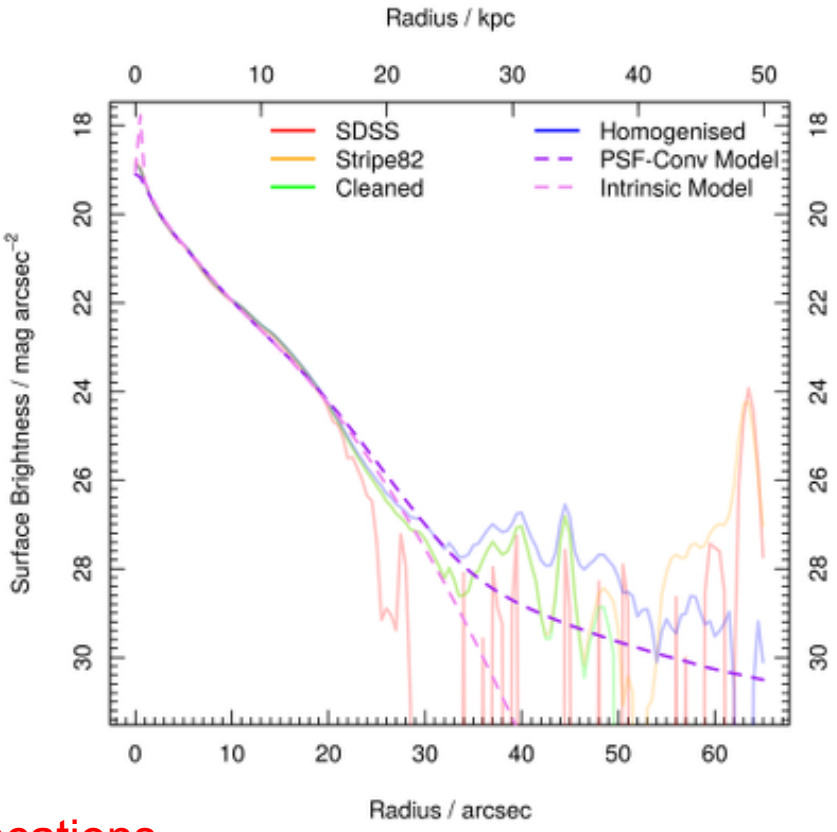


Systems with a distinct break at large radii potentially **overestimate halo flux by a factor of 2**.



Impact of the PSF





PSF stellar halo contamination

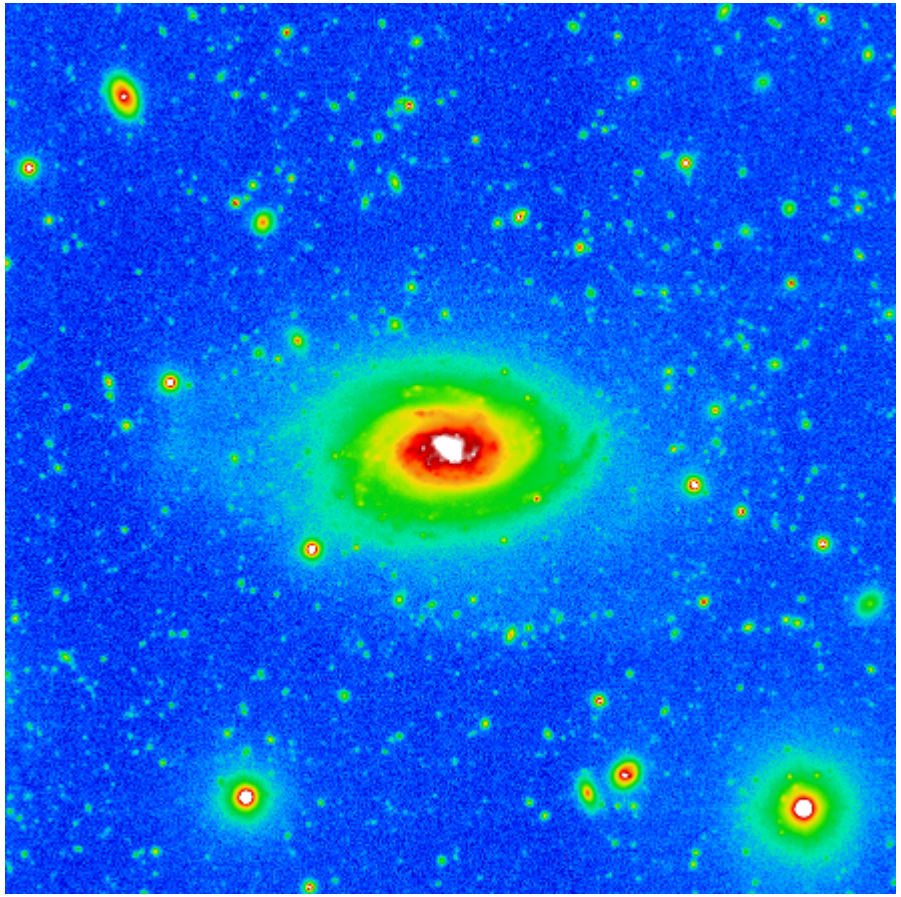
~x1

Breaks or truncations at large radii have substantial effects on the measured stellar halo flux fraction (Sandin, 2014)

PSF stellar halo contamination

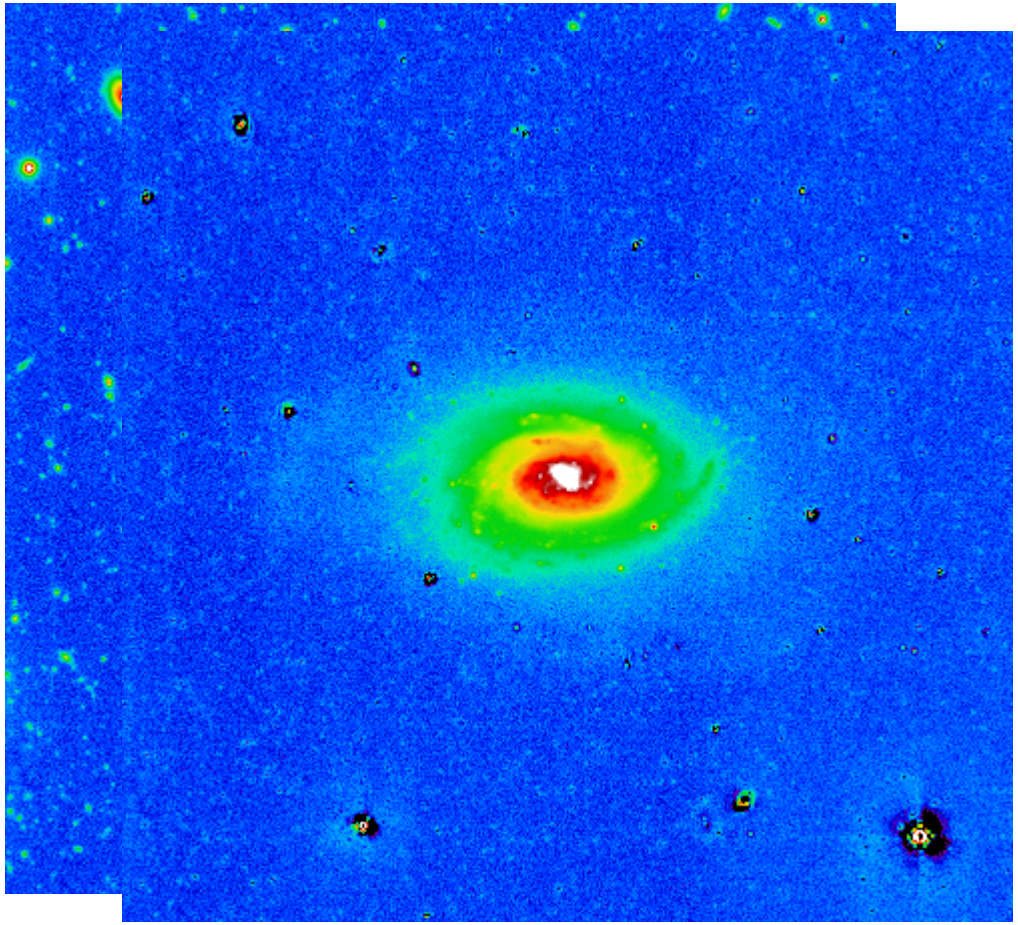
~x2

NGC 237



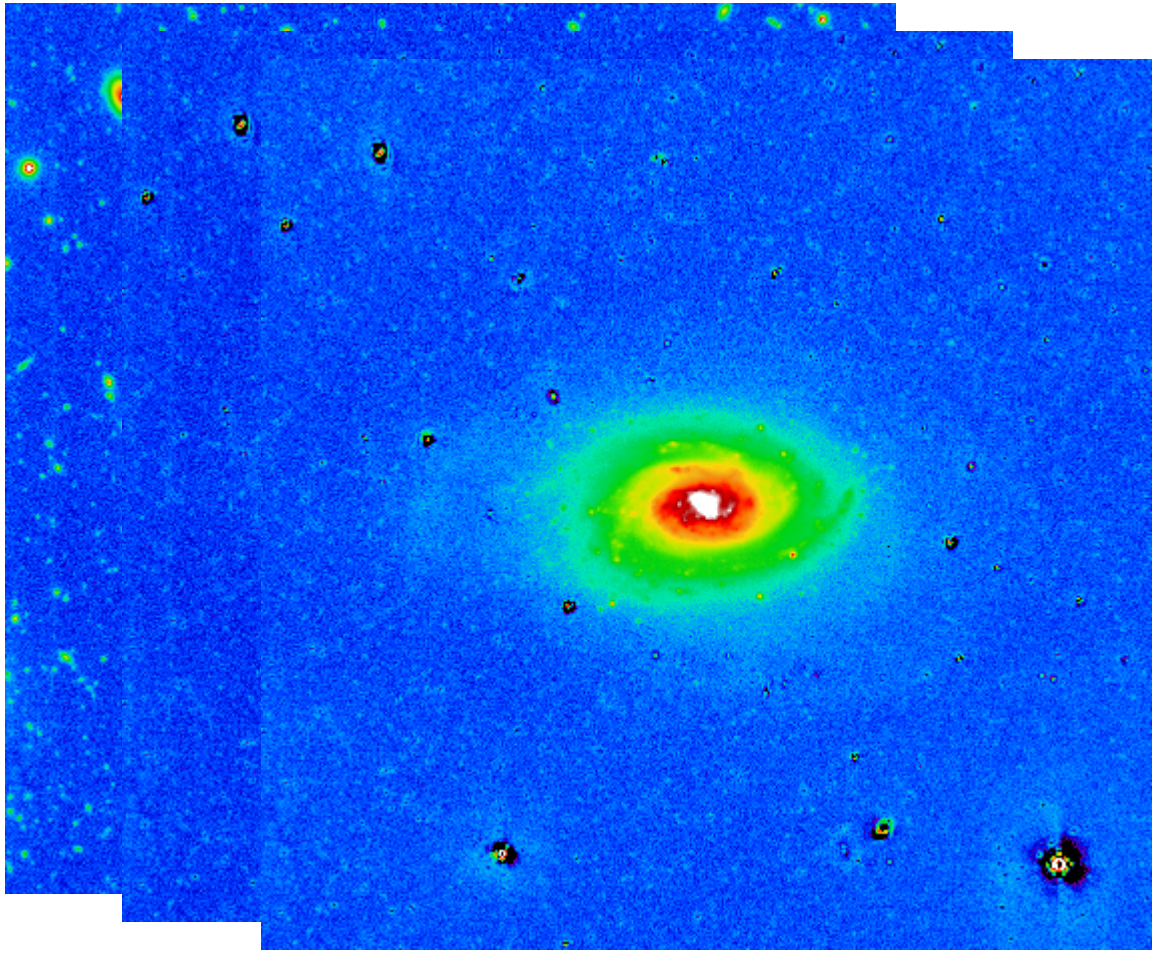
Stripe 82

NGC 237



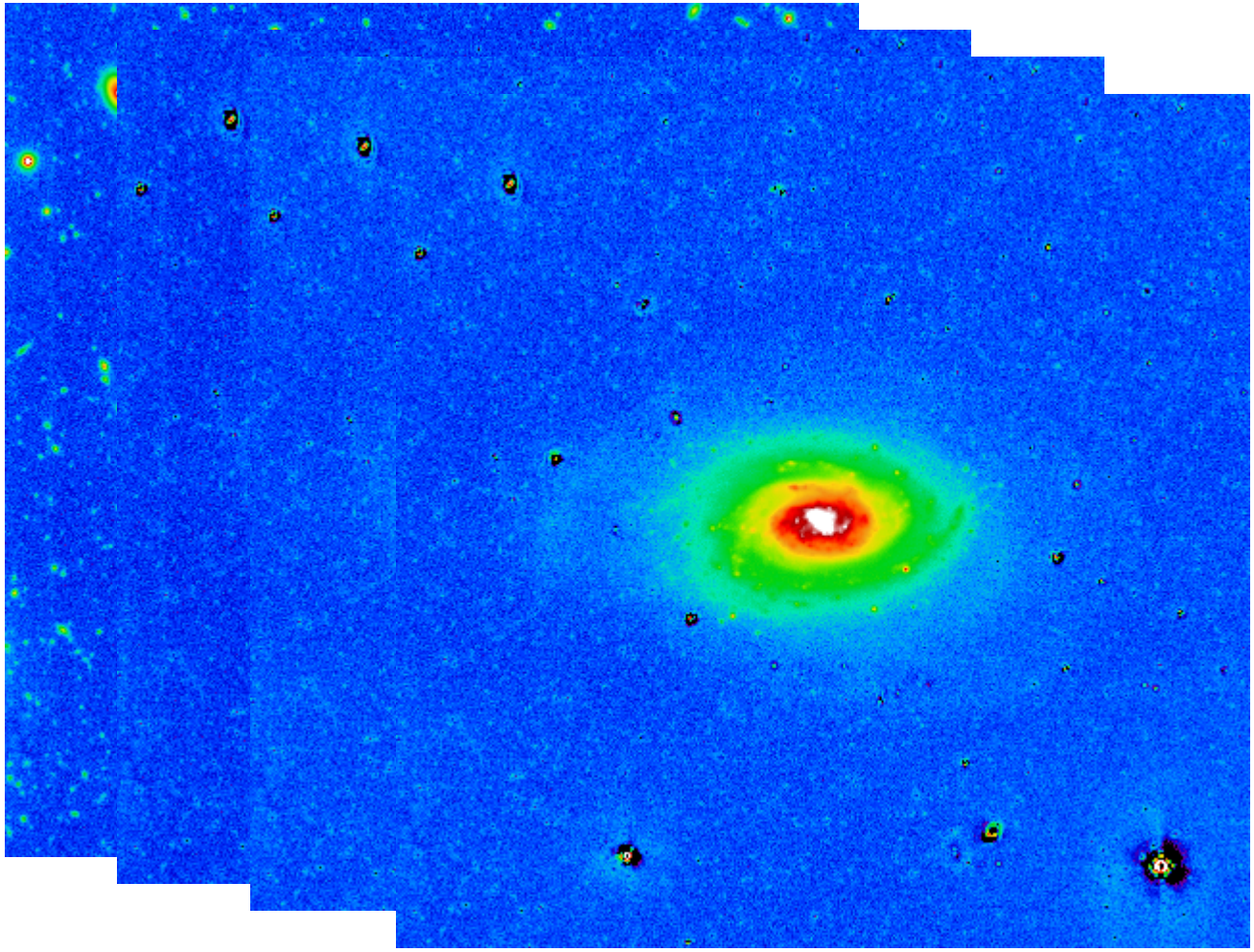
Cleaned

NGC 237



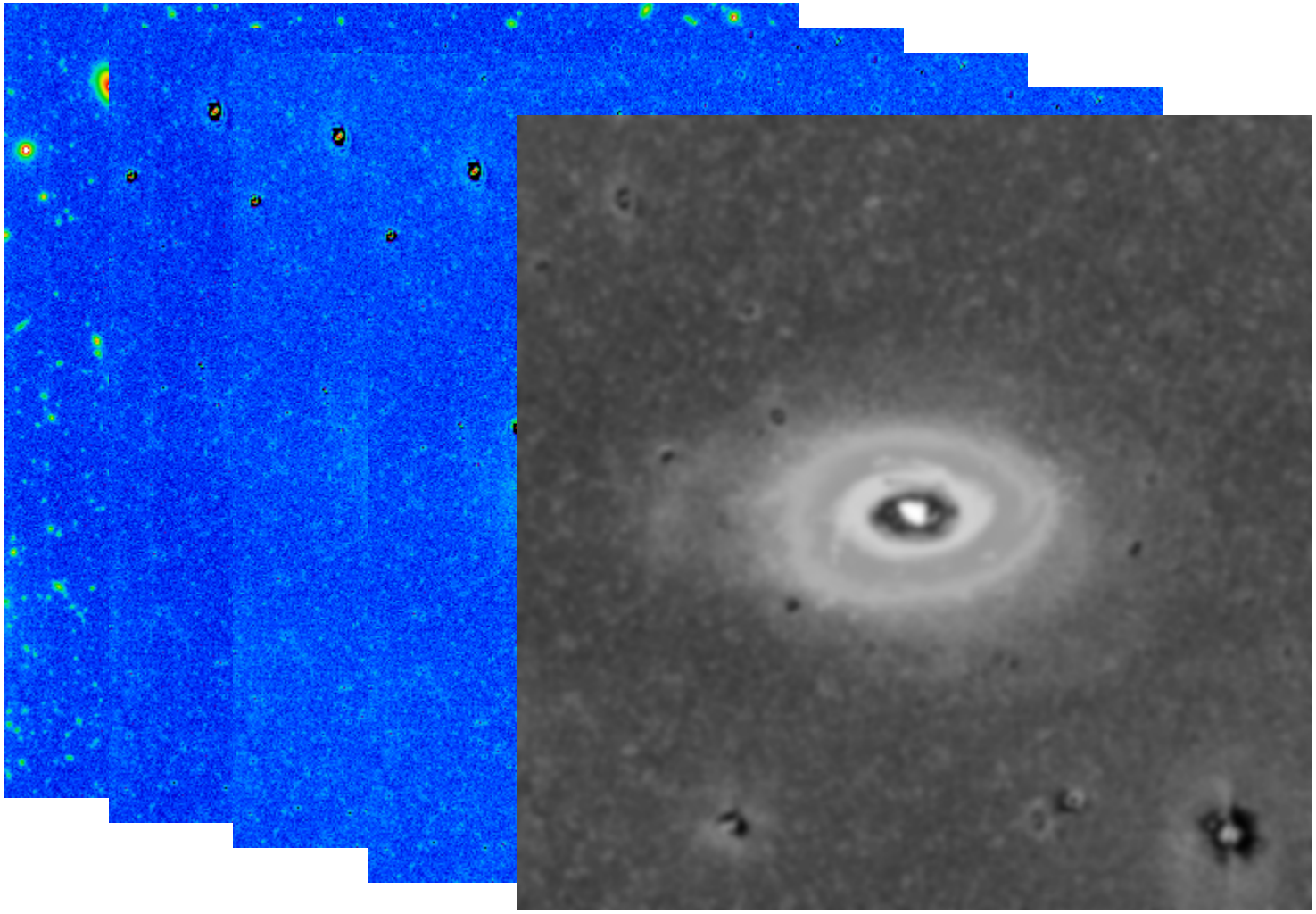
De-Striped

NGC 237

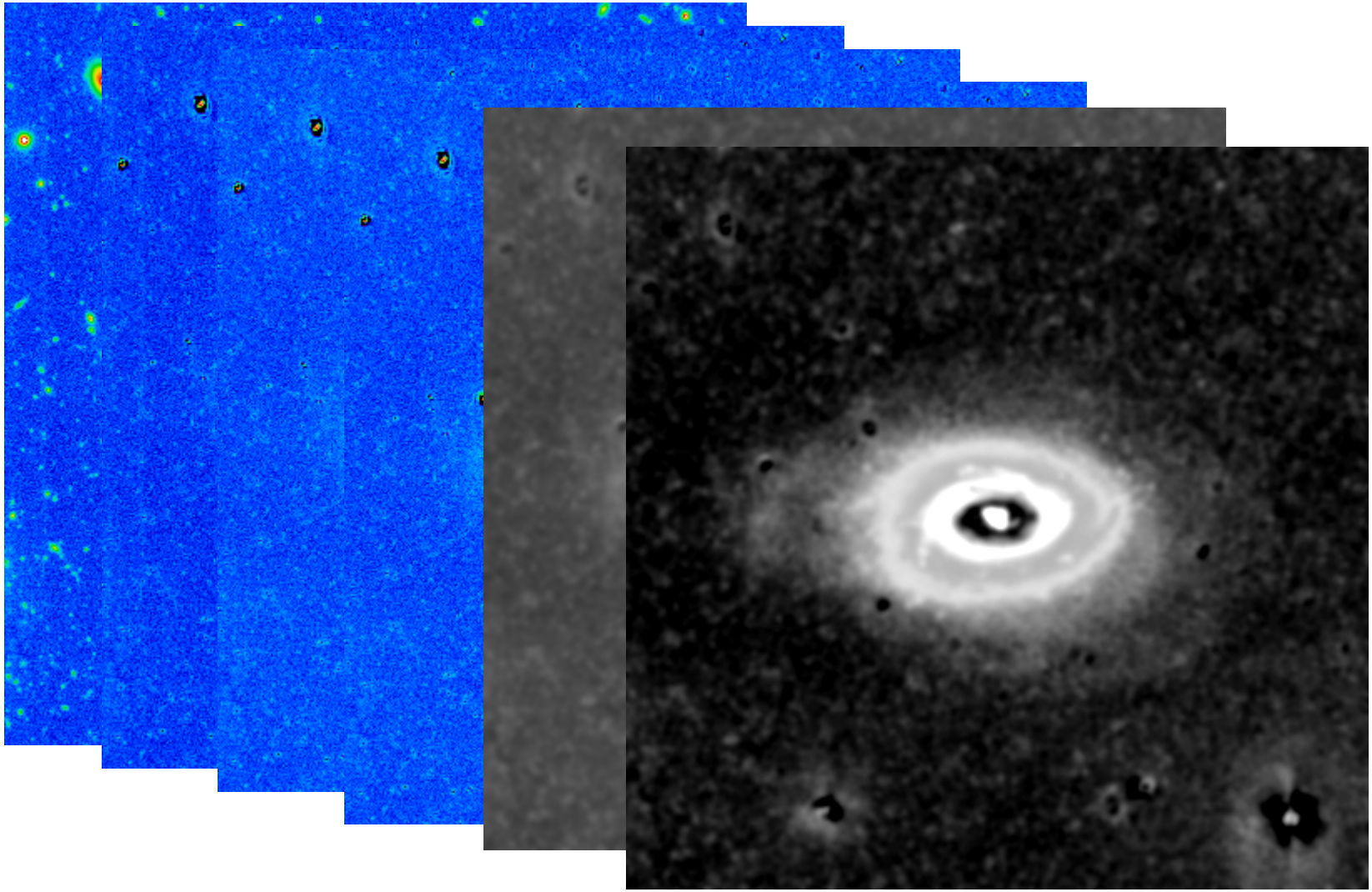


Intrinsic Image

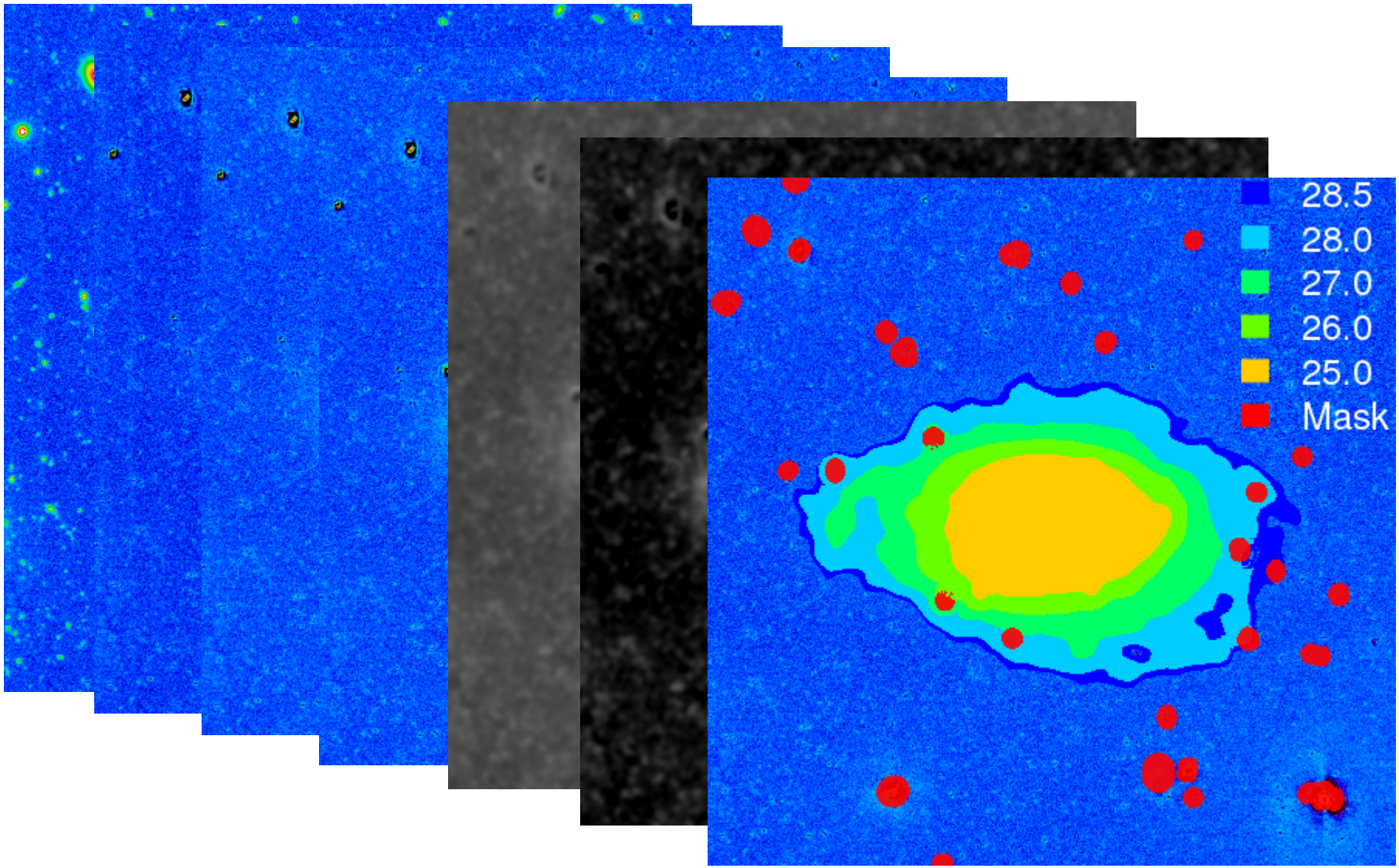
NGC 237



NGC 237



NGC 237



Summary

Summary

SDSS Stripe 82 legacy survey allows for an increase in depth over standard SDSS imaging **by ~3 mag, down to μ=28.5**.
Parametric structure visible out to ~100 kpc.
Chaotic complex structure (streams, shells) visible out to ~150 kpc.
The effect of PSF convolution on galaxy breaks or truncations can artificially contaminate stellar halo flux fractions by **a factor of ~2**.

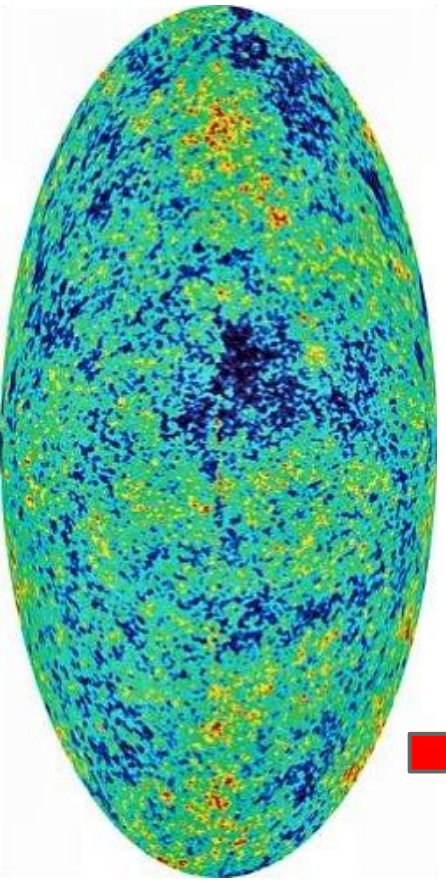
Next Steps

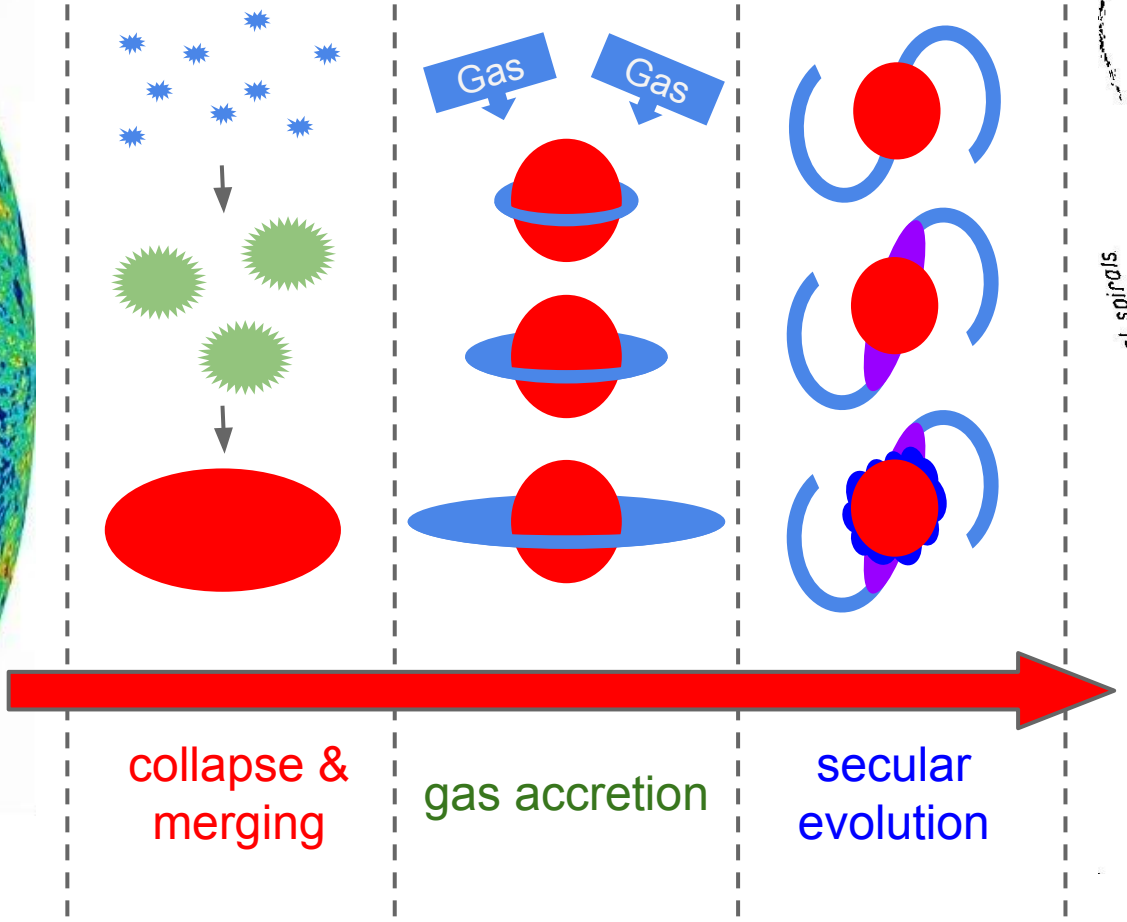
Automatically process several hundred galaxies within Stripe 82.
Create robust, 'intrinsic' images for each system to remove PSF effects.
Systematically measure stellar halo contribution via parametric model fits.

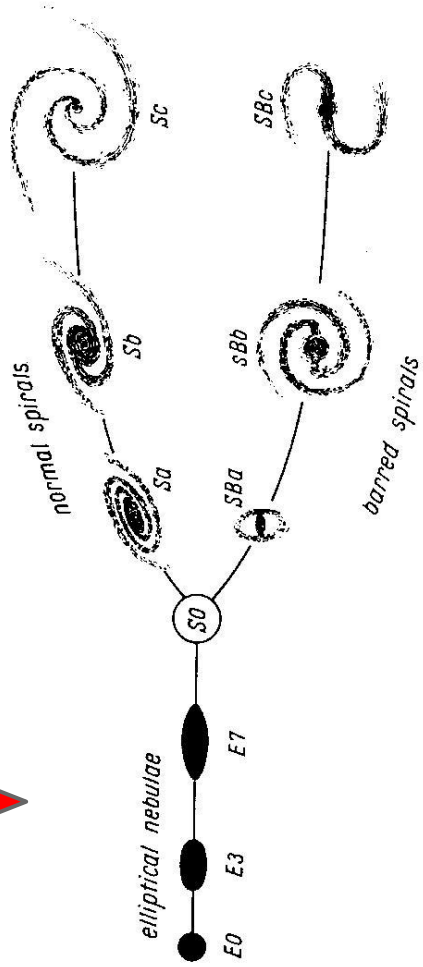
Upcoming Publications

Kelvin et al., 2015, in prep.
Fliri & Trujillo, 2015, in prep.

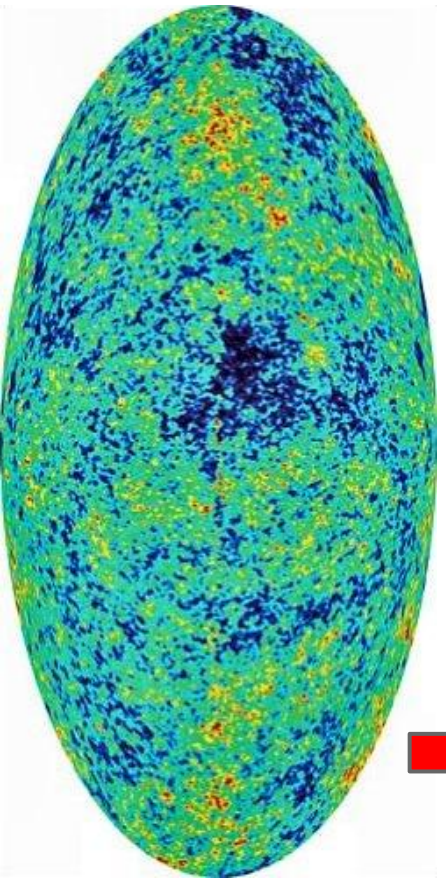
Evolutionary Mechanisms

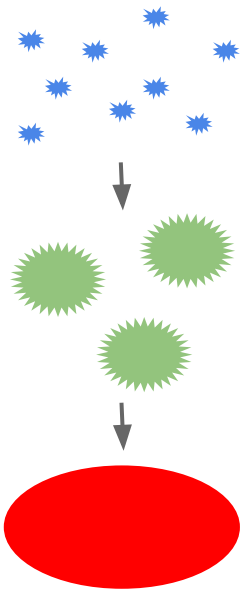






Evolutionary Mechanisms



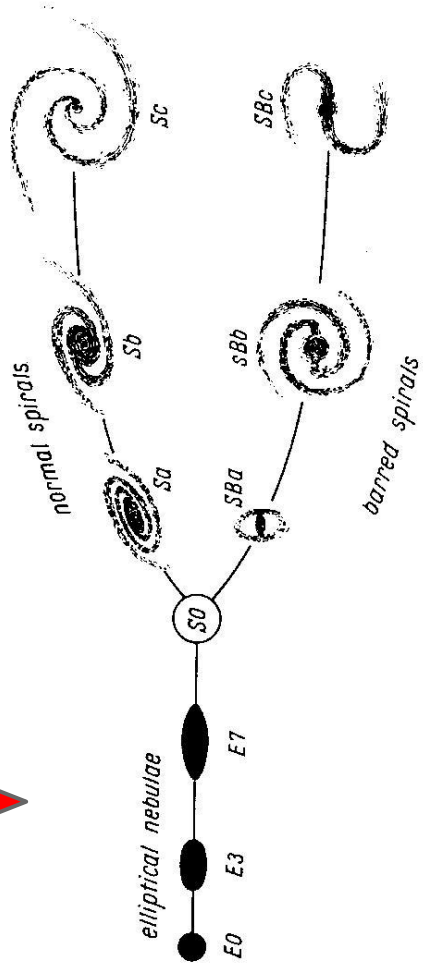


Hierarchical merging → stellar haloes

Eggen, Lynden-Bell & Sandage 1962
Toomre & Toomre 1972
Searle & Zinn 1978
Steinmetz & Muller 1995
Cole et al. 2000
Bekki & Chiba 2001
Samland & Gerhard 2003

Stellar haloes:

- Ultra faint, μ_V=30 mag/''^{2}
- Huge, ~100 kpc
- Low mass frac., ~few%
- Complex multi-comp. structures



collapse & merging

gas accretion

secular evolution