Stellar Haloes of galaxies in the SDSS Stripe 82 Survey

Lee Kelvin

University of Innsbruck

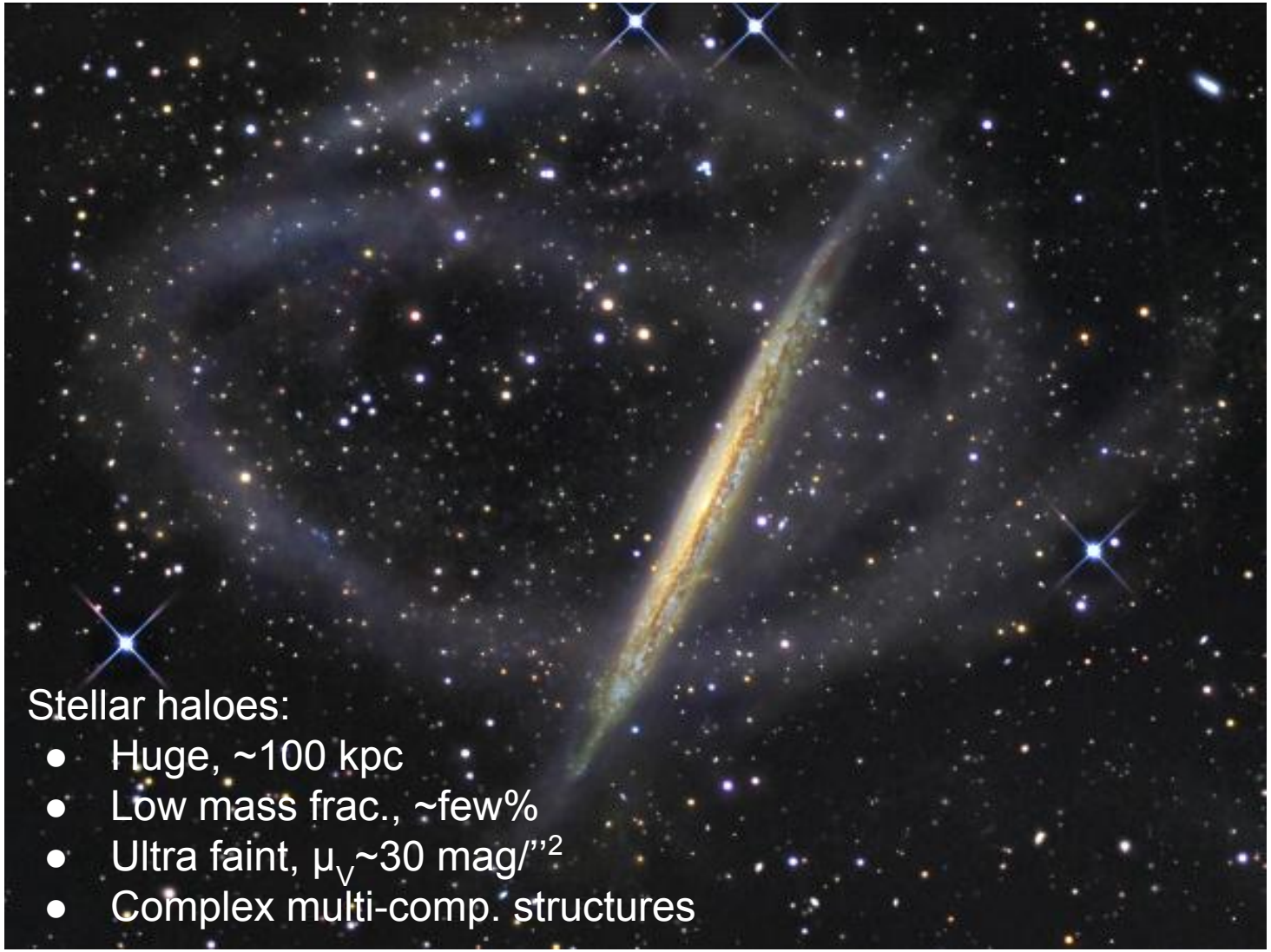
Ignacio Trujillo, Jürgen Fliri, Mauricio Cisternas (IAC)

The Star Streams of NGC 5907

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

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

The Star Streams of NGC 5907



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Galactic Archaeologists

Extragalactic astronomy has entered a new era of mass galactic archaeology.

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Figure 19. Examples of ETGs with post- major merger signatures: inner dust lanes, strongly perturbed morphology and prominent tidal tails. From left to right, composite true colour images of NGC 5557, NGC 1222 and NGC 2764.

ATLAS3D: Duc et al. 2015

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Space Cowboy *Archaeologist*

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Why are stellar haloes important?

- Signatures of merging and harassment events which have shaped galaxy evolution
- Provide a track record of galaxy mass assembly
- Give further insights into, e.g., feedback, SFR, metal enrichment

Stellar haloes believed to be ubiquitous and diverse, however:

Contemporary observations 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.

Why Stellar Haloes?

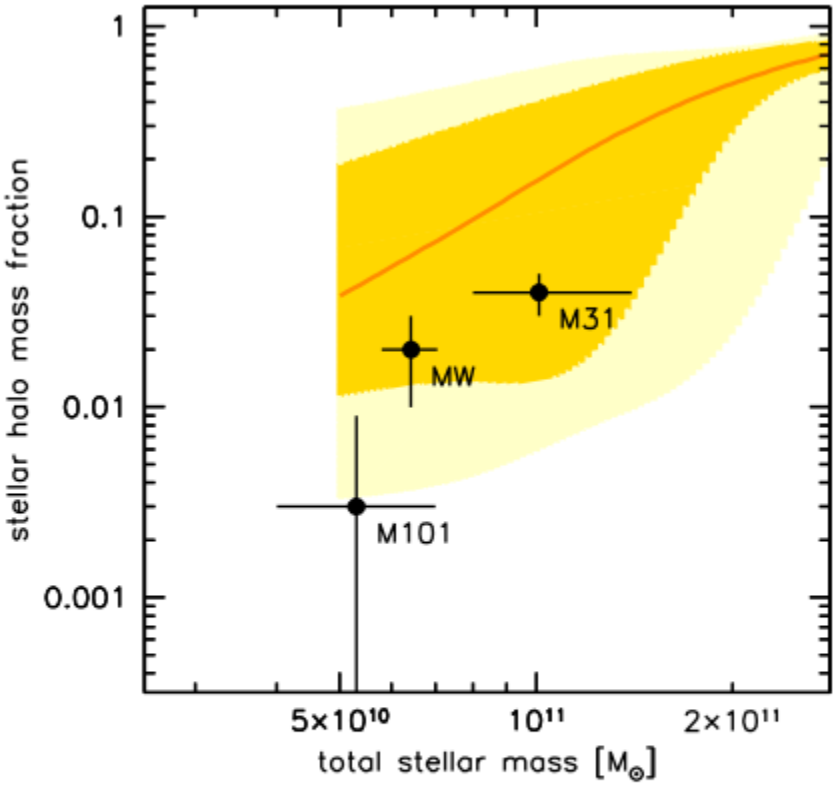


Figure 4. The mass fraction in the stellar halo as a function of the total stellar mass. The stellar halo of M101 has significantly lower mass than those of the Milky Way and M31. The orange line is the predicted median relation between the accreted mass fraction and the total stellar mass from numerical 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

Are simulations in (dis) agreement with current observations?

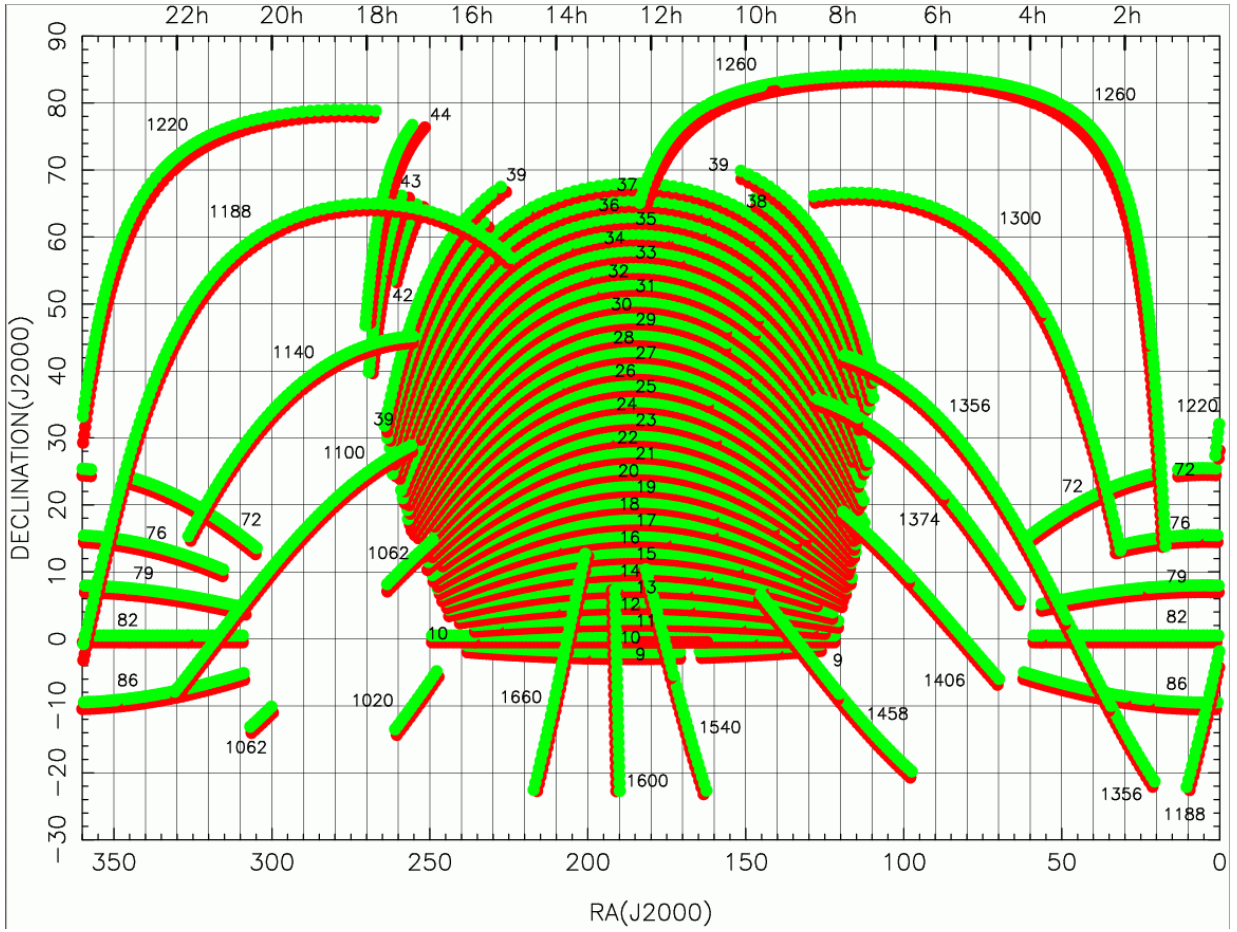
SDSS Stripe 82

SDSS-II Supernova Survey along SDSS Stripe 82

270 deg^2 area

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

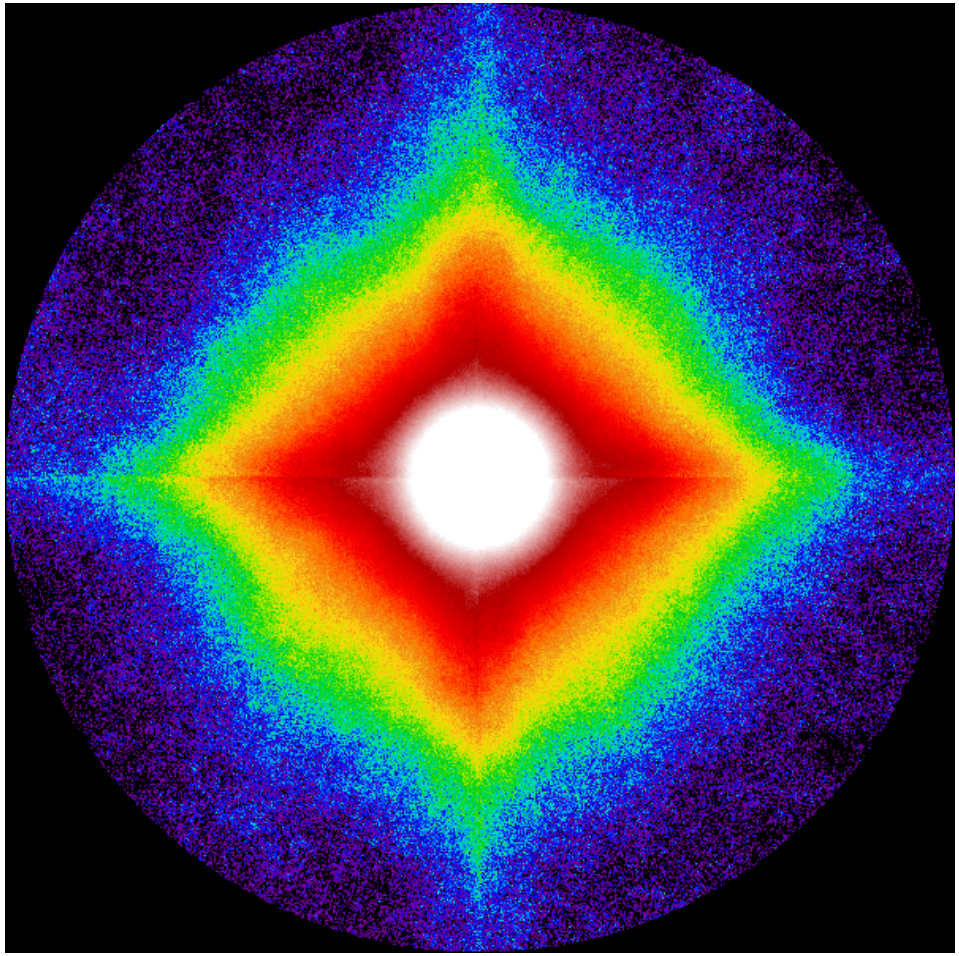
303 runs, avg. 80 exposures per pixel



Sloan Digital Sky Survey

Mapping the Universe

SDSS Stripe 82 Legacy Survey



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.

iac.es/proyecto/stripe82

Sloan Digital Sky Survey
Mapping the Universe

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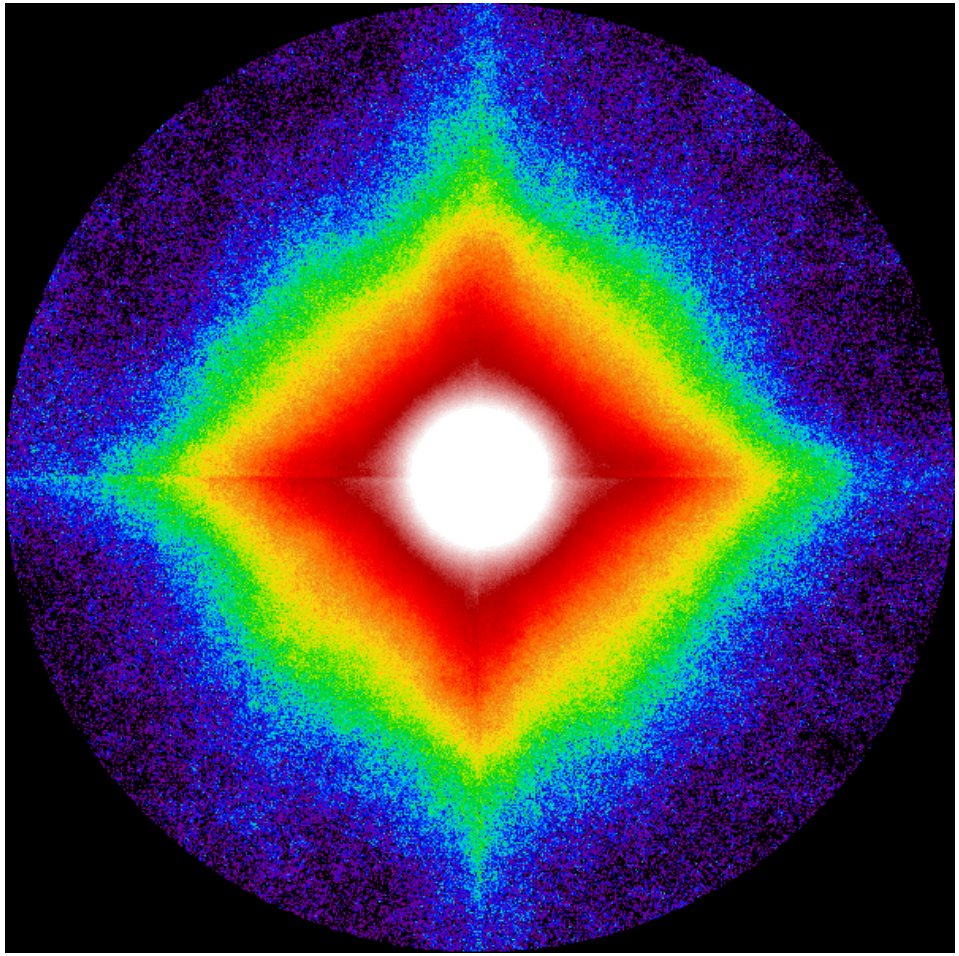

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iac.es/proyecto/stripe82

"You can't get fainter than 27-28 magnitudes in large surveys"

→ Azimuthally averaged limiting surface brightnesses of **~30 mag/arcsec^2** (r-deep)

SDSS Stripe 82 Legacy Survey

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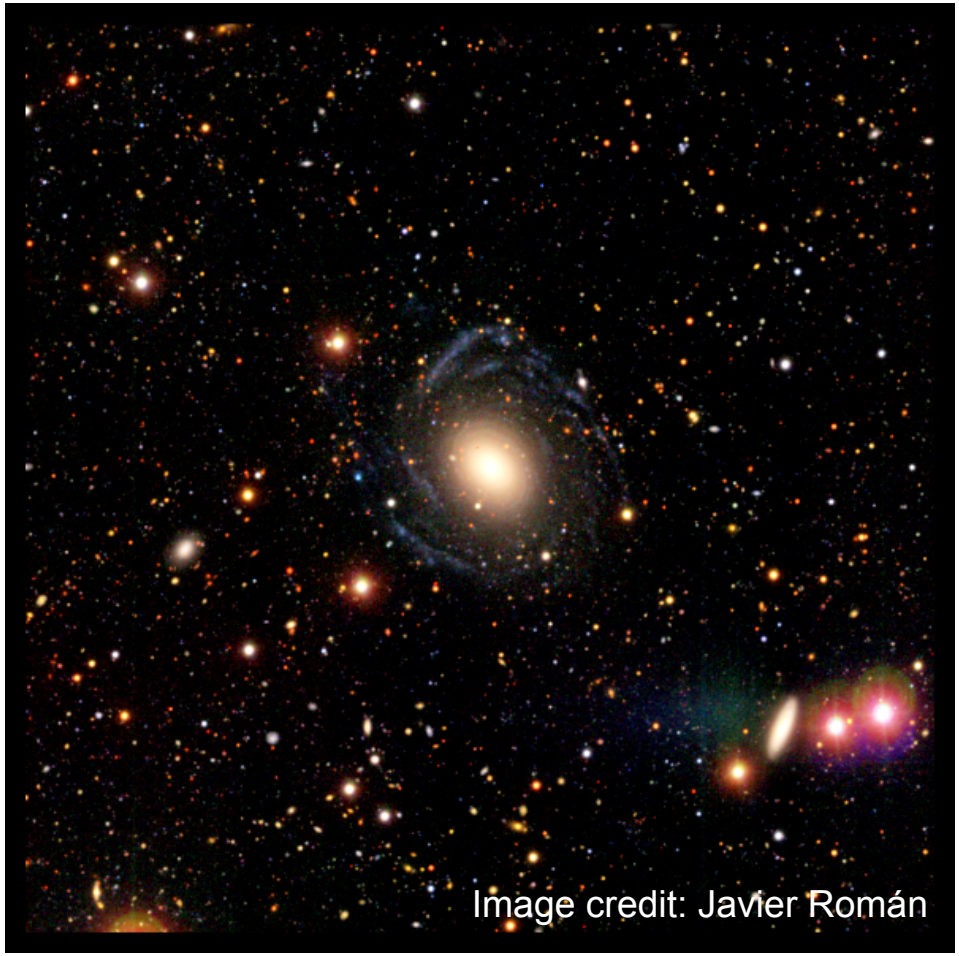


Sloan Digital Sky Survey
Mapping the Universe

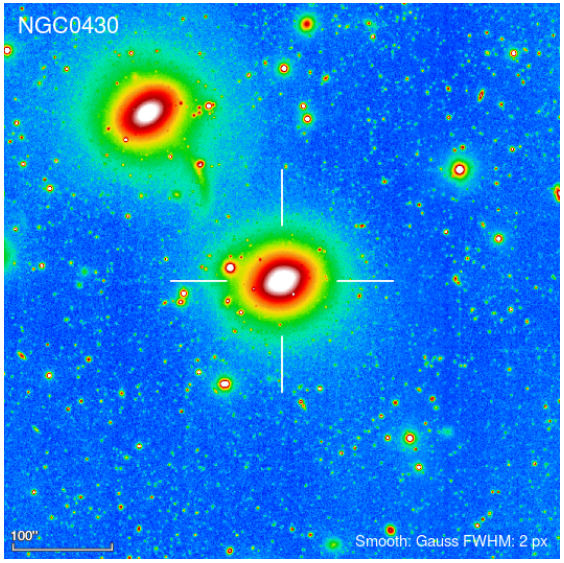
Stripe 82 Sample

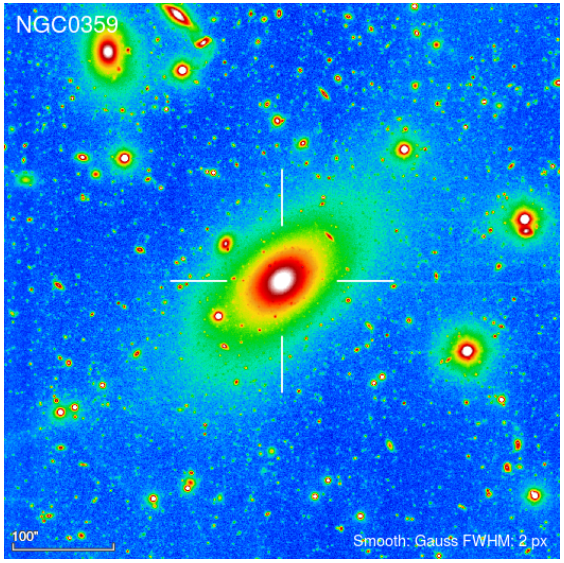
Hyperleda

http://leda.univ-lyon1.fr

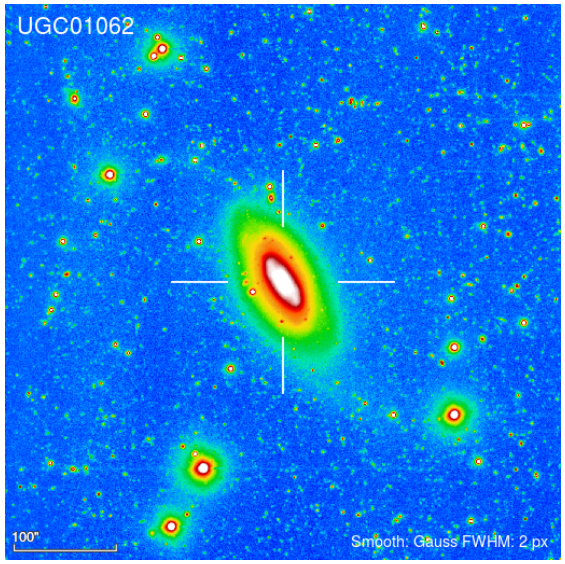
Select all ‘G’ (galaxy type) objects

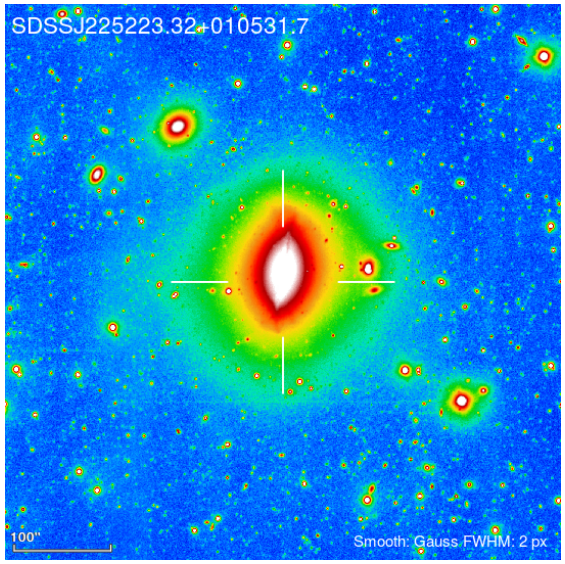
Redshift range
$0.005 < z < 0.025$

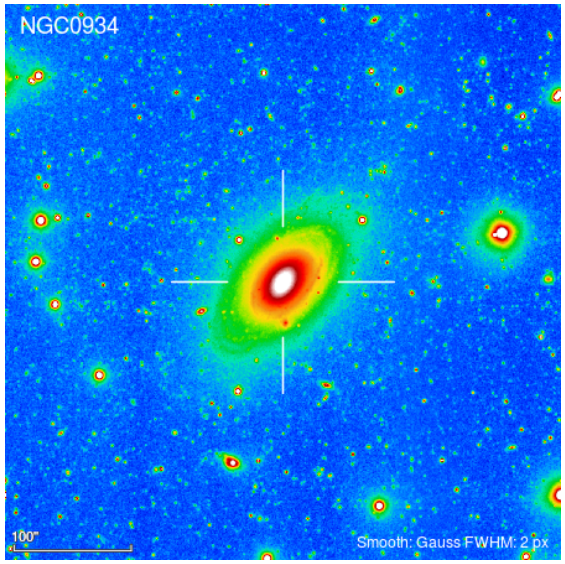




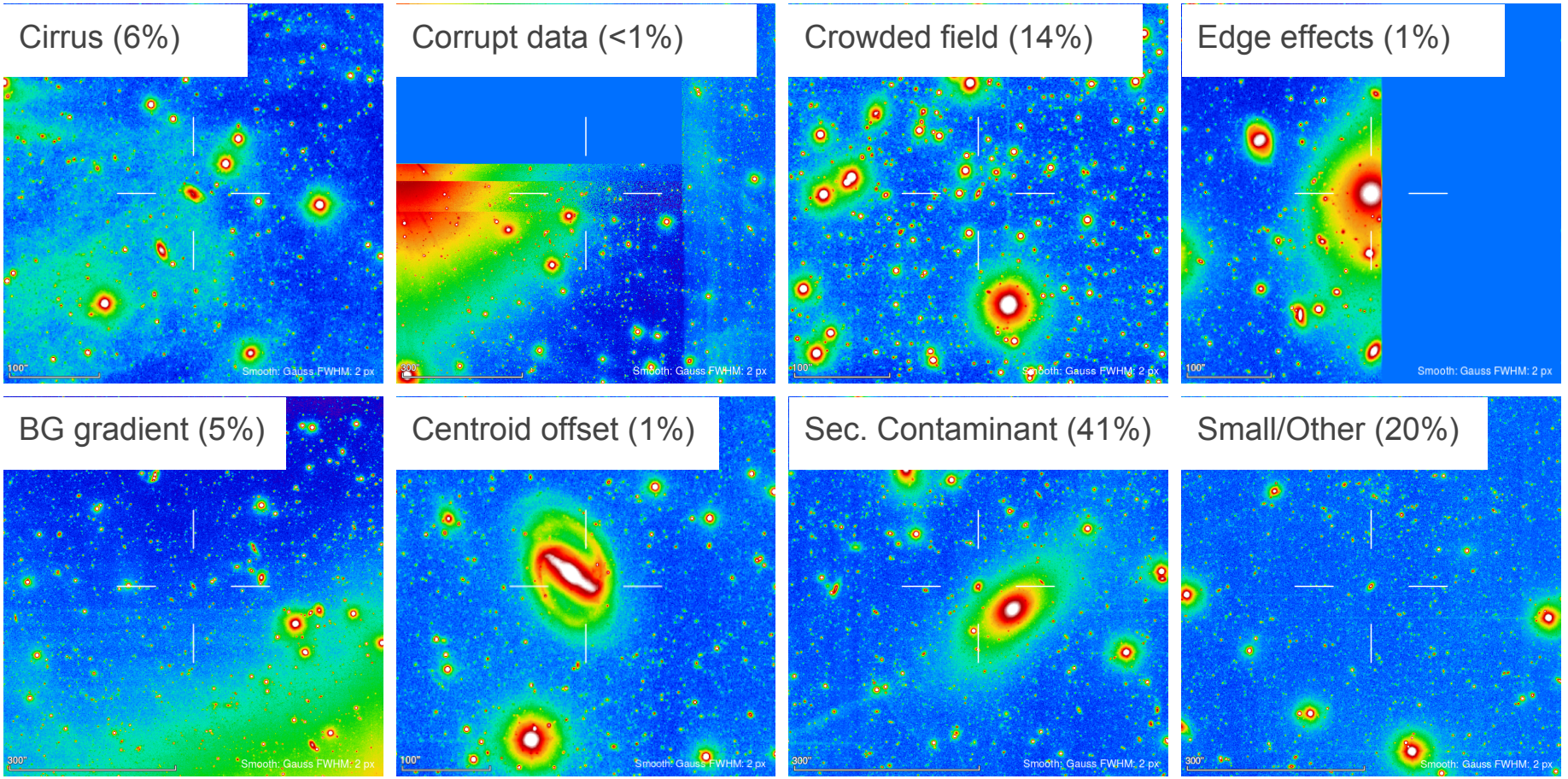
1101
candidates





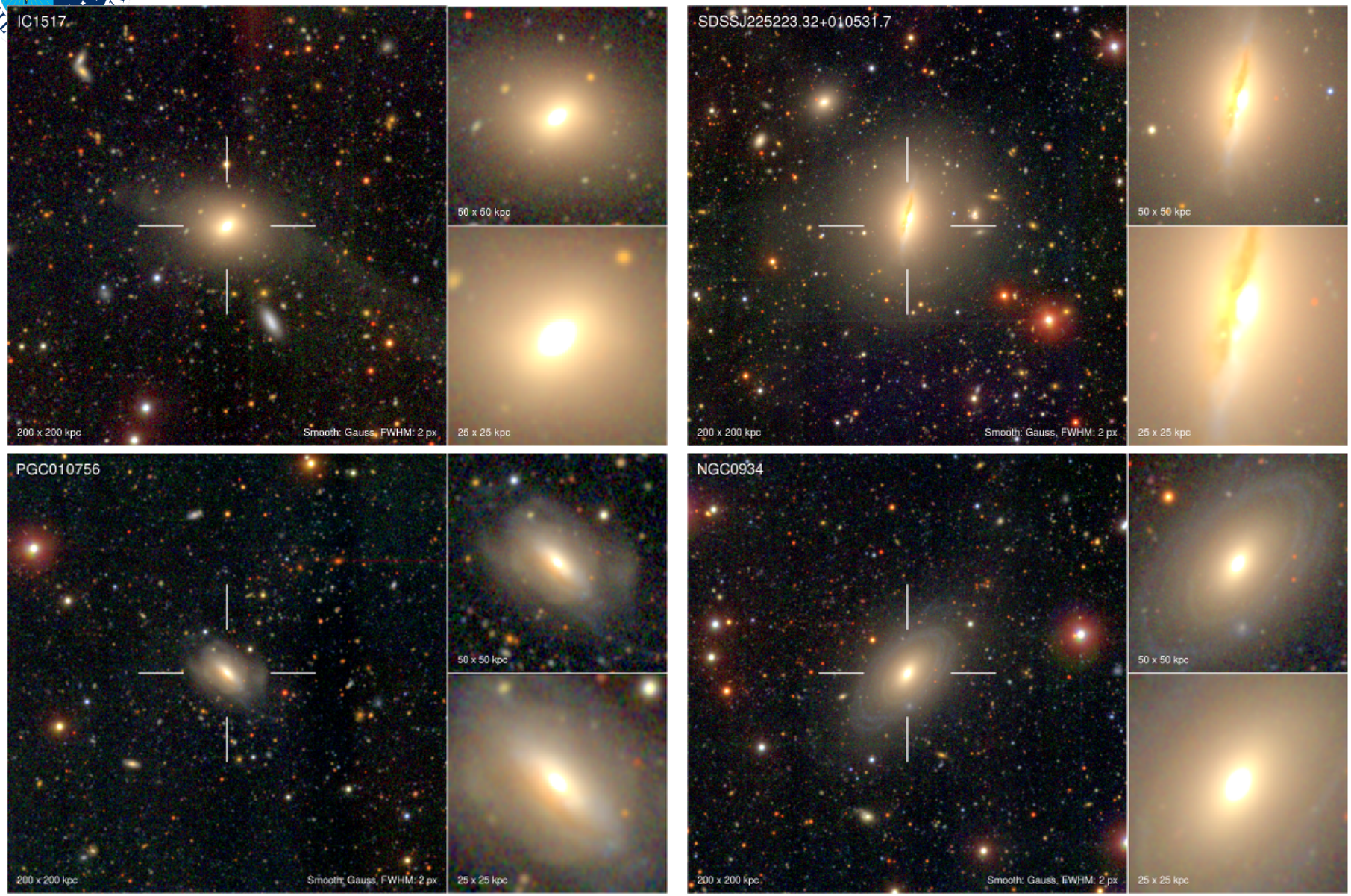


Visual Inspection



Visual inspection reduces our sample from **1101 potential** objects to **129 suitable** candidate galaxies.

Final Sample: A Mixed Bag



Composite SDSS Stripe 82 gri images

Image Preparation

1) Secondary object cleaning
   → via Source Extractor fitting (Bertin & Arnouts 1996)

Thanks: Aldée Charbonnier

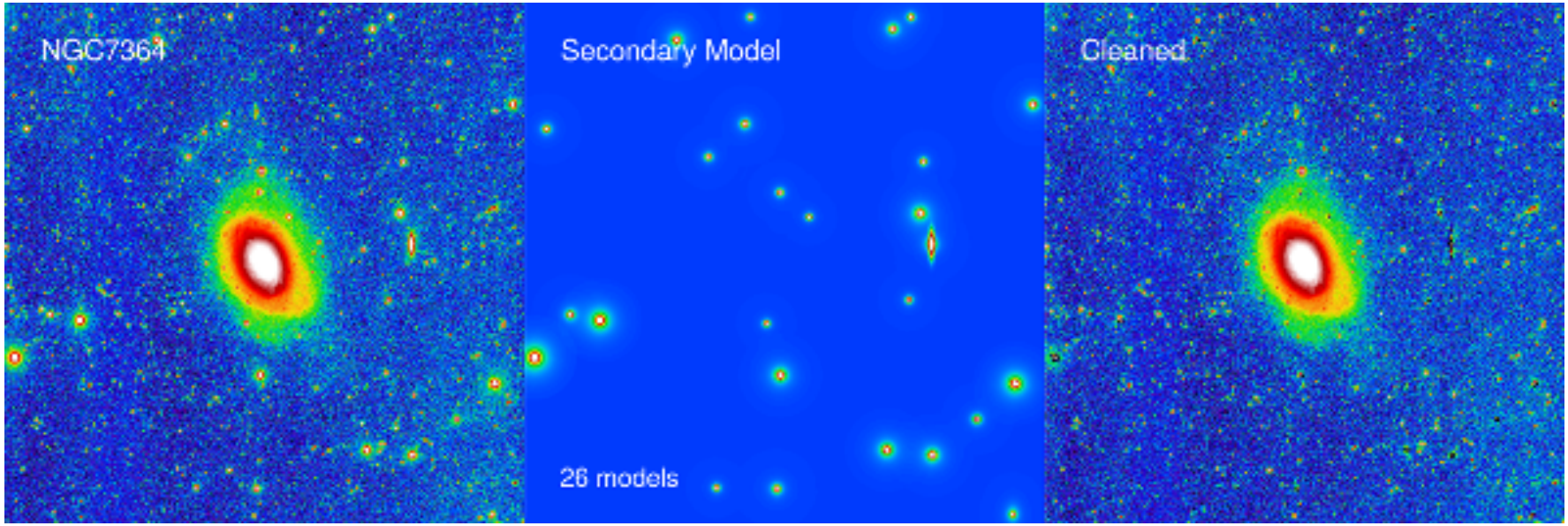
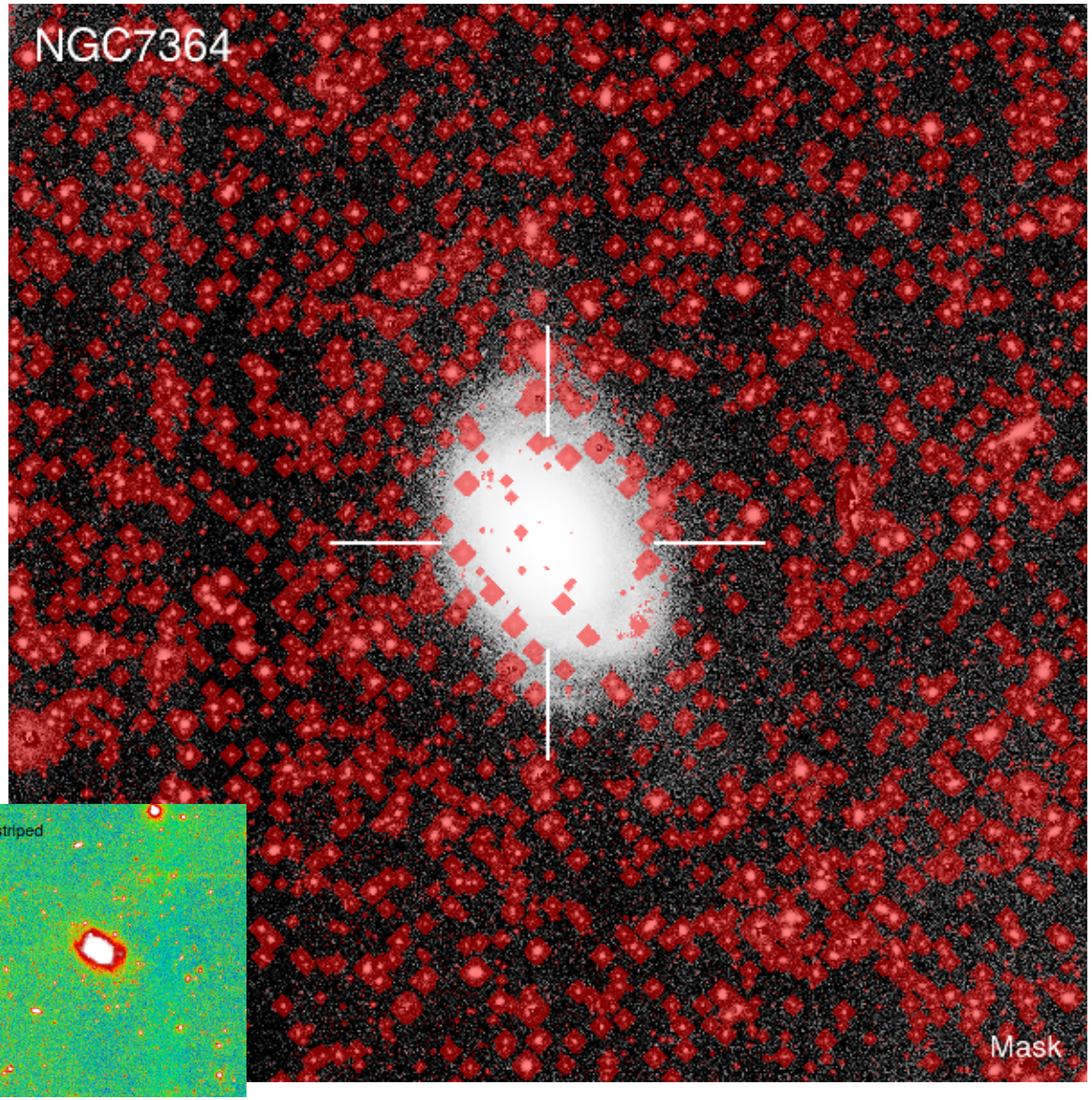


Image Preparation

2) Masking via azimuthally avg. ellipse profile analysis (Schombert 2007)

3) Removal of image artefact stripes



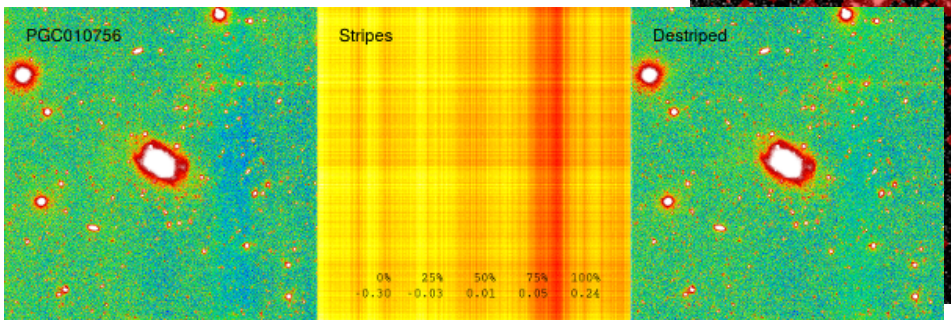
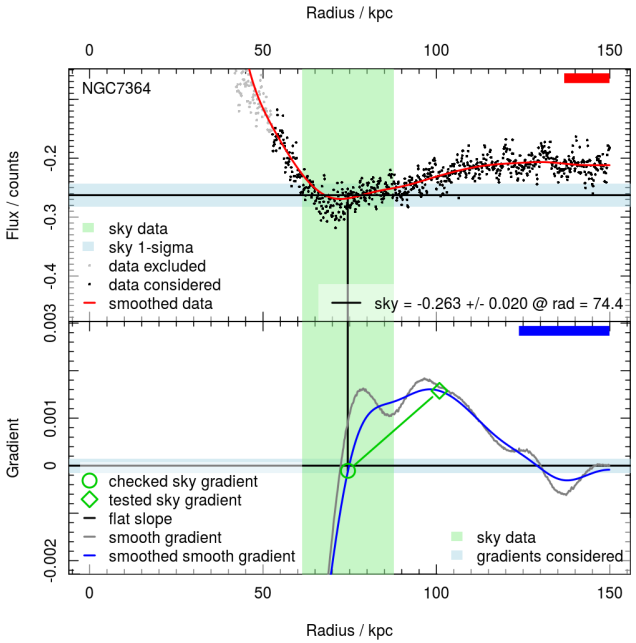
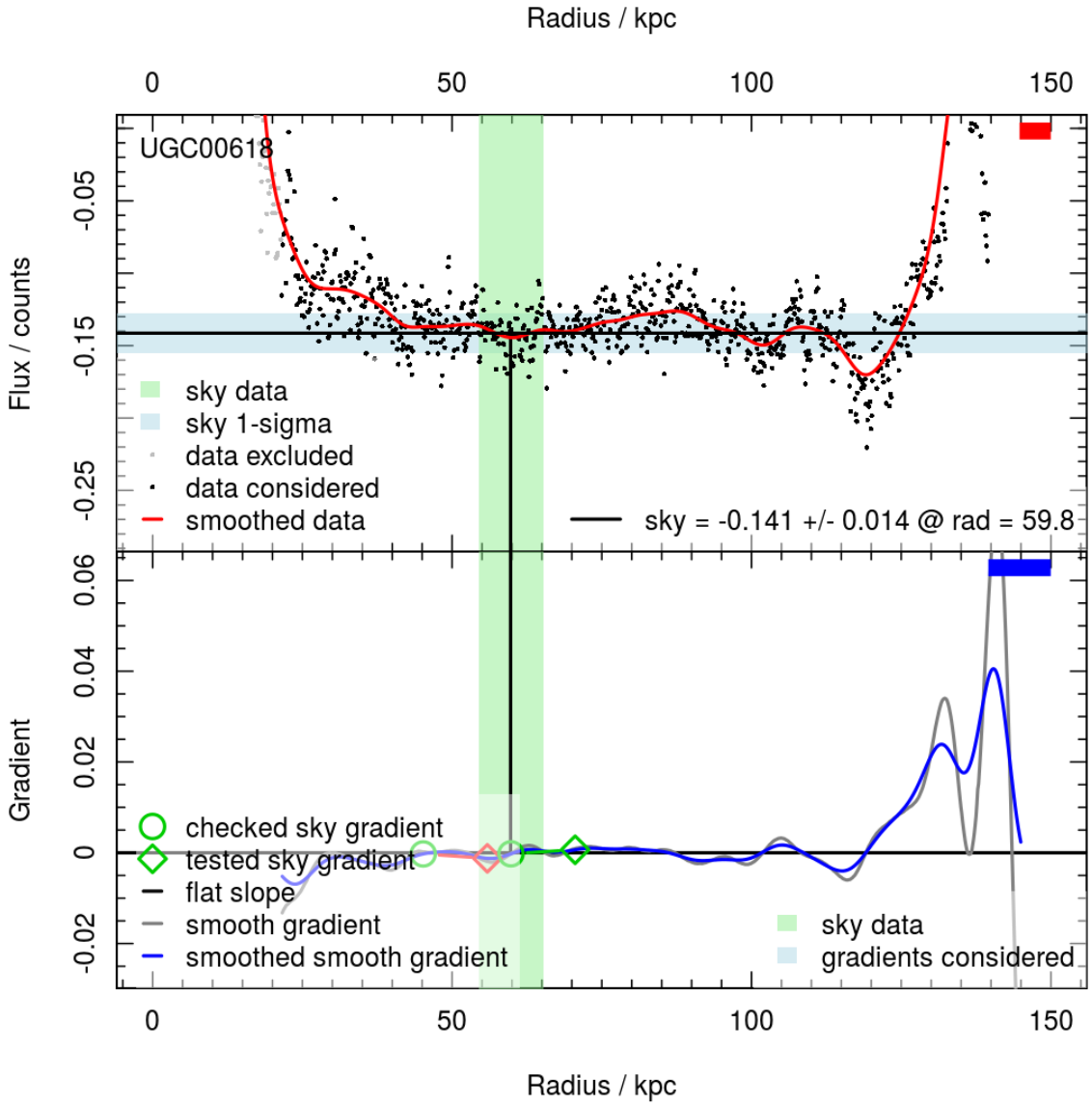


Image Preparation

4) Sky estimation via flux profile gradient analysis





How do we extract LSB data?

1) Parametric automated profile fitting
   a) GALFIT (Peng+ 2010)
   b) IMFIT (Erwin 2015)
2) Parametric manual profile fitting
3) Non-parametric isophotal analysis
   a) Unsharp masking (see poster: Sreevarsha Sreejith)
   b) Isophotal ellipse fitting

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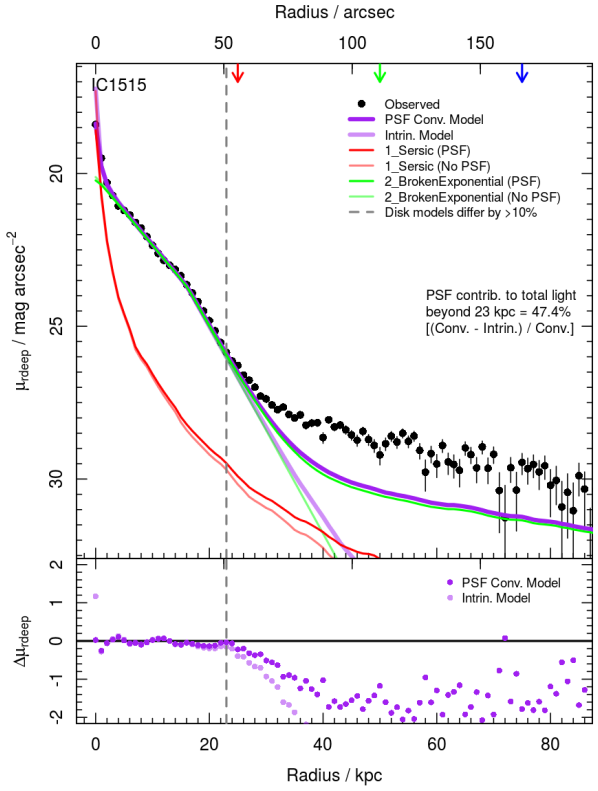
Choice of method to be determined by our understanding of what type of structure we seek to measure
e.g., does a stellar halo extend to the core of a galaxy?

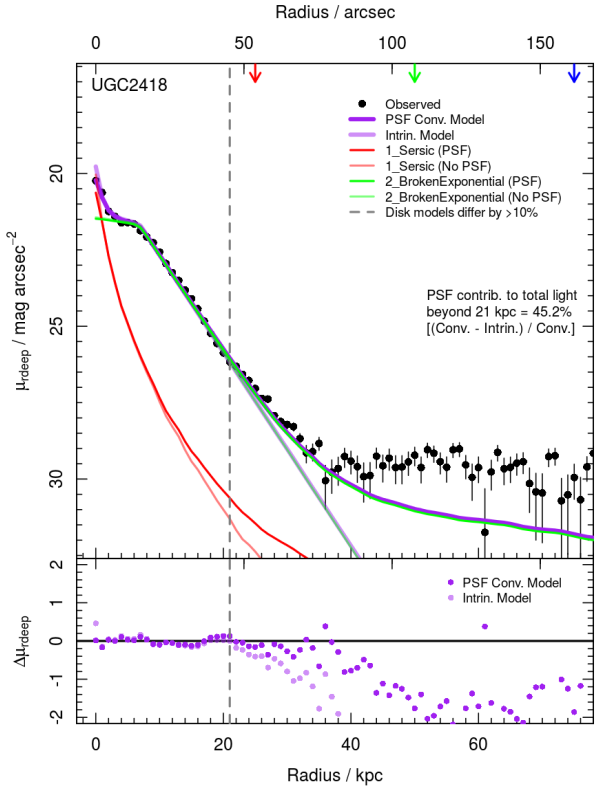
What's happening at low SB?

Many sources of data/potential confusion...

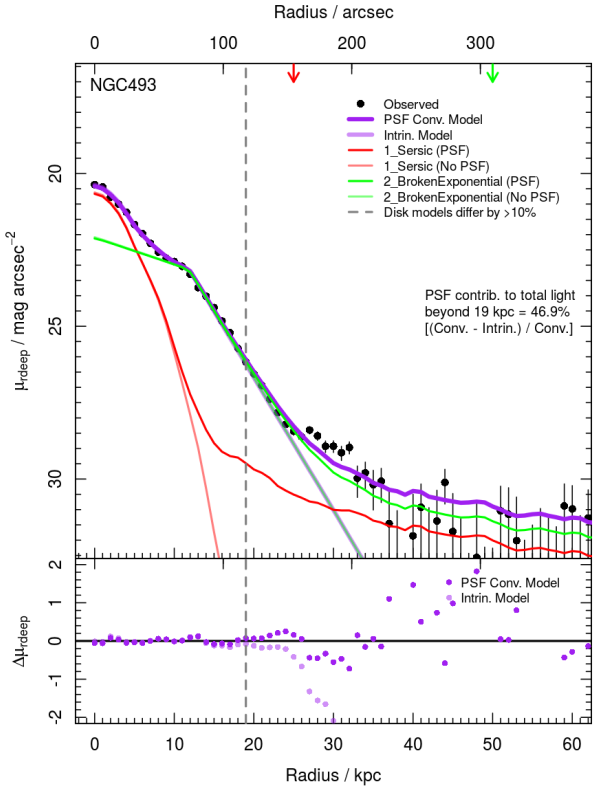
Stellar Halo



Galactic Cirrus
(see Duc+ 2015)



PSF Scattered Light
(see Sandin 2015)



Peters+ 2015, in prep.

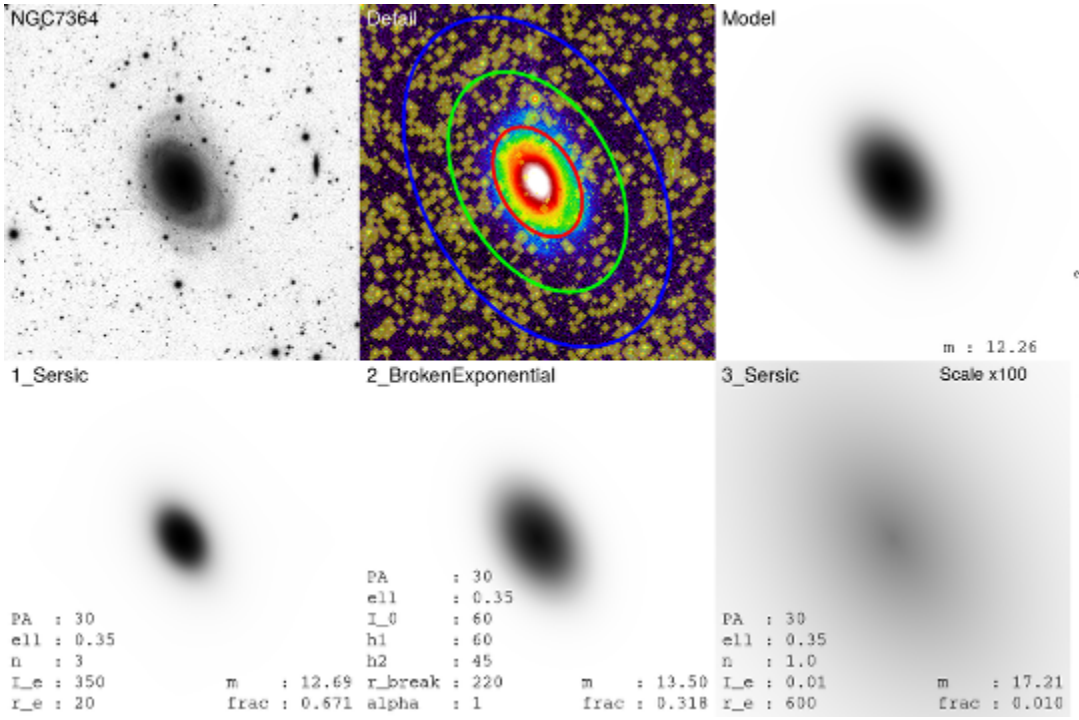
(Stephan Peters, Piet van der Kruit, Johan Knapen, Ignacio Trujillo, Jürgen Fliri, Lee Kelvin)

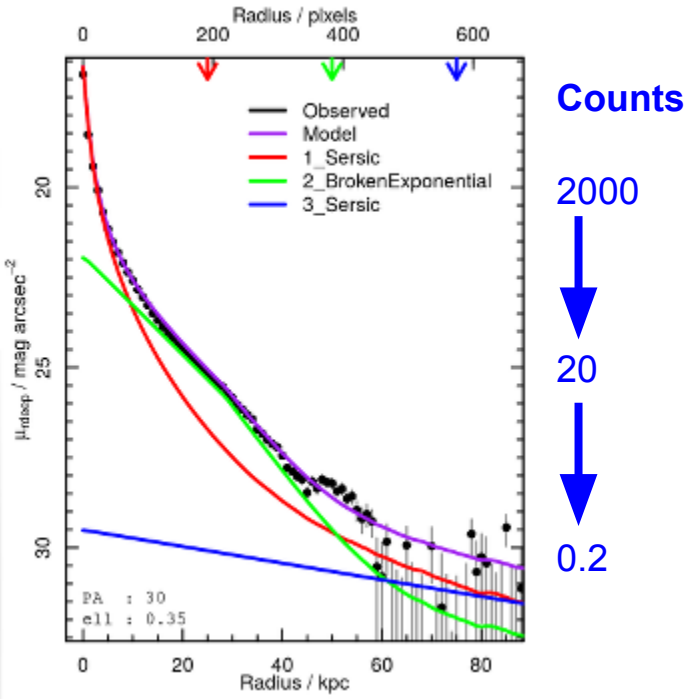
See poster: Johan Knapen

Results

Final processed imaging down to ~30 mag/arcsec^2 (r-deep)

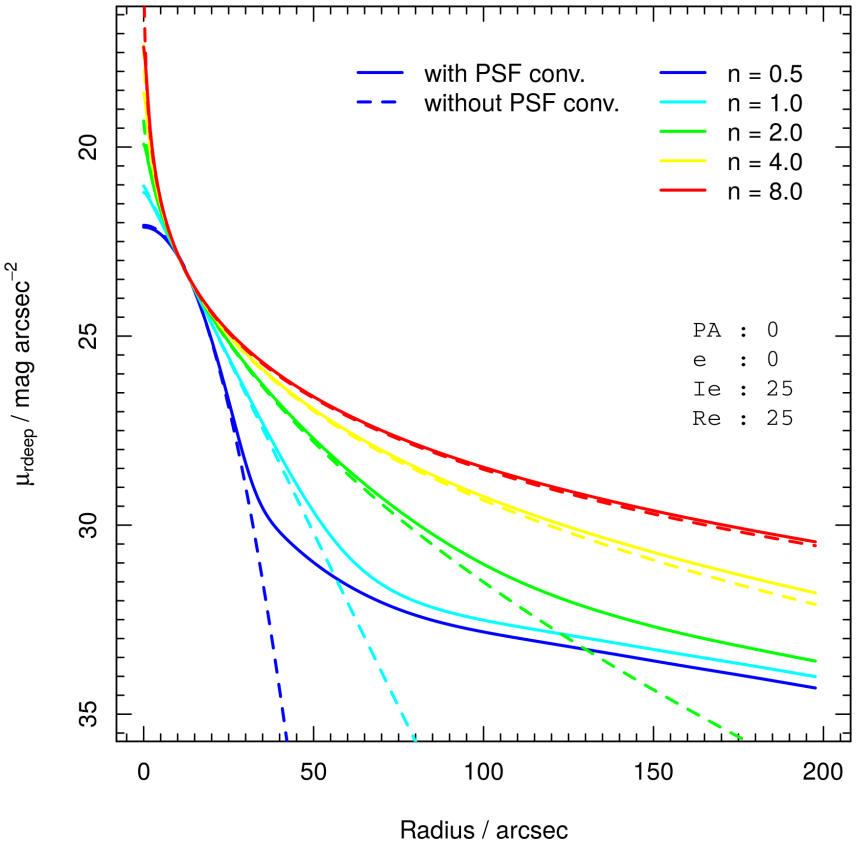
We find robust parametric stellar halo component in ~30% of observed galaxies.





Results

PSF contribution in outer regions
<~50% of outer flux

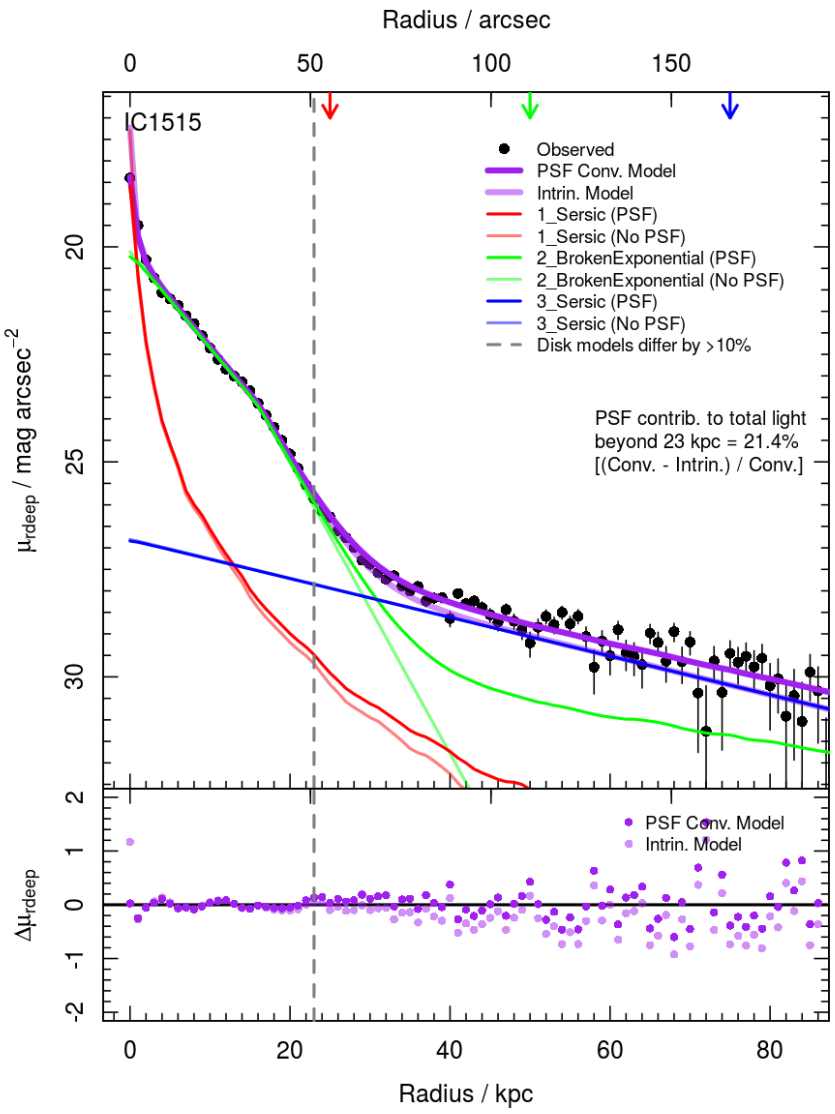


Results

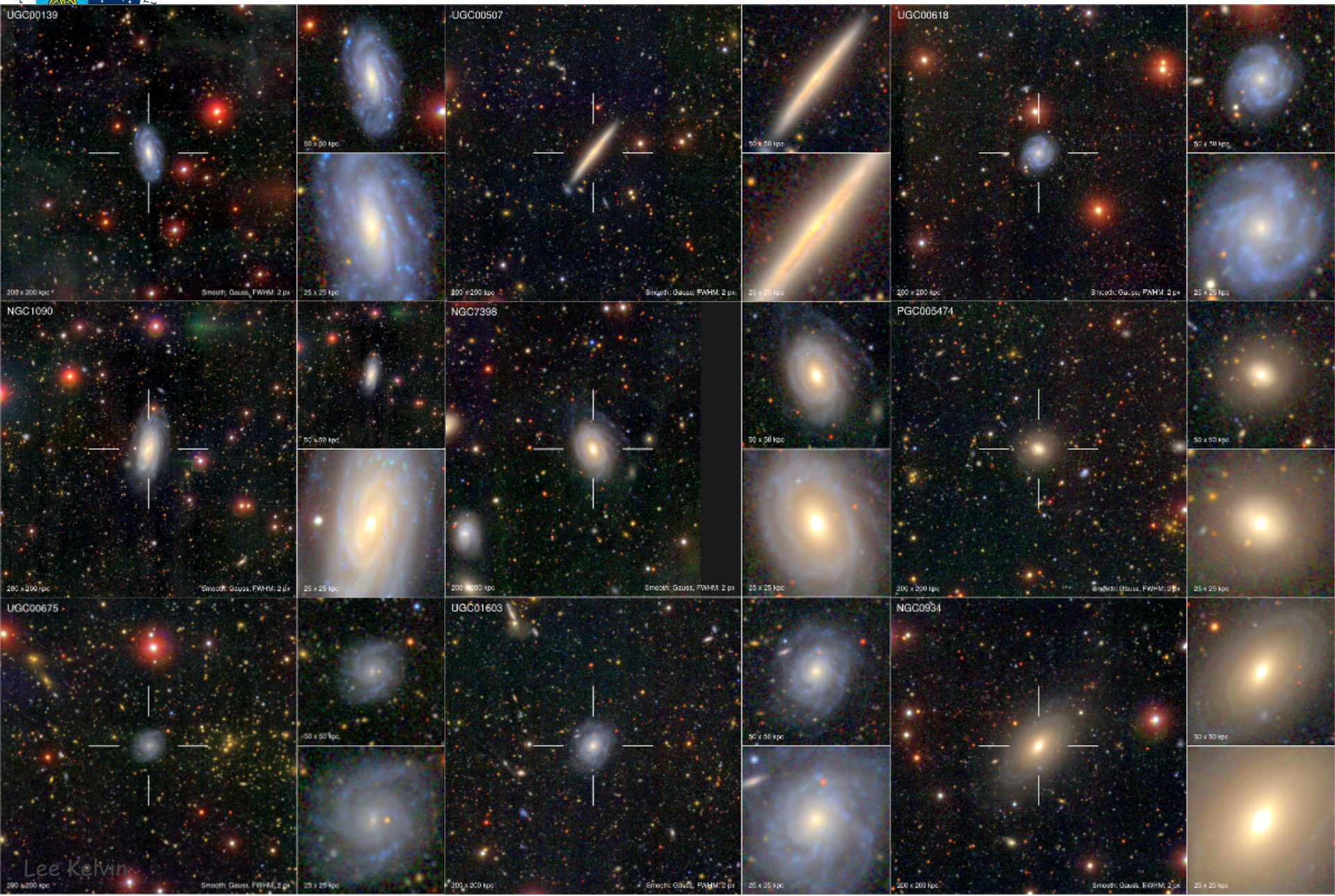
PSF contribution in outer regions <~50% of outer flux

So far, 50 galaxies processed, 15 optimised

Typical parametric stellar halo component 0.5% - 5%



Ongoing Efforts



Summary

We have established a sample of 129 candidate galaxies from the SDSS Stripe 82 Legacy Survey ideally suited for analysis of the low surface brightness regime down to μ_r~30 mag/arcsec^2 out to >100 kpc.

Images are cleaned, masked, and a robust sky estimated on a per-galaxy basis.

A range of flux profiling software are being tested, including both parametric and non-parametric methods.

PSF contributes ~50% of galactic flux in outer galaxy regions.

Typical parametric stellar halo component in the range 0.5% - 5% of total galaxy light.