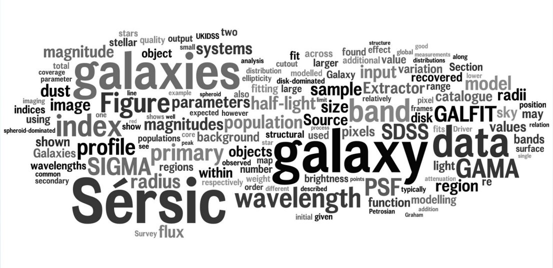

Quantifying Secular Evolution Through Structural Decomposition

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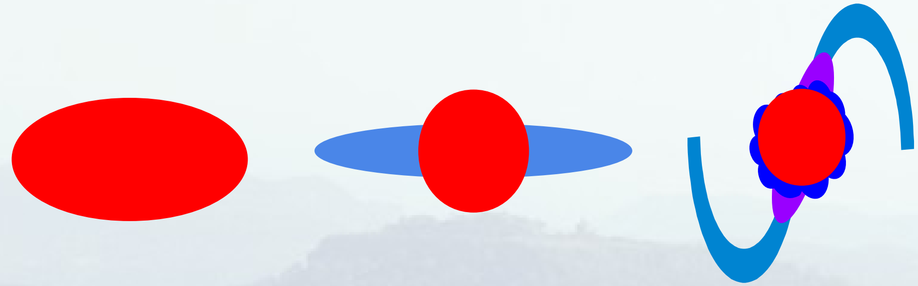
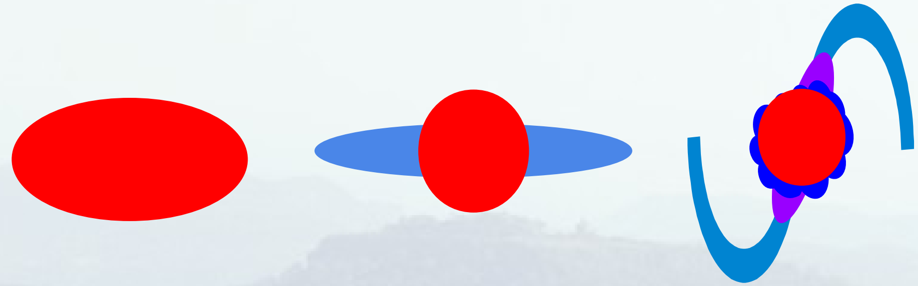


- How do structures form?
    - *bulge → disk → bar → pseudo-bulge*
    - *disk → bulge → ???*
- Are ellipticals and bulges essentially the same?
- How does environment shape galaxy structure?
- How is stellar mass distributed between structure?
- Can structure be used to trace evolution?



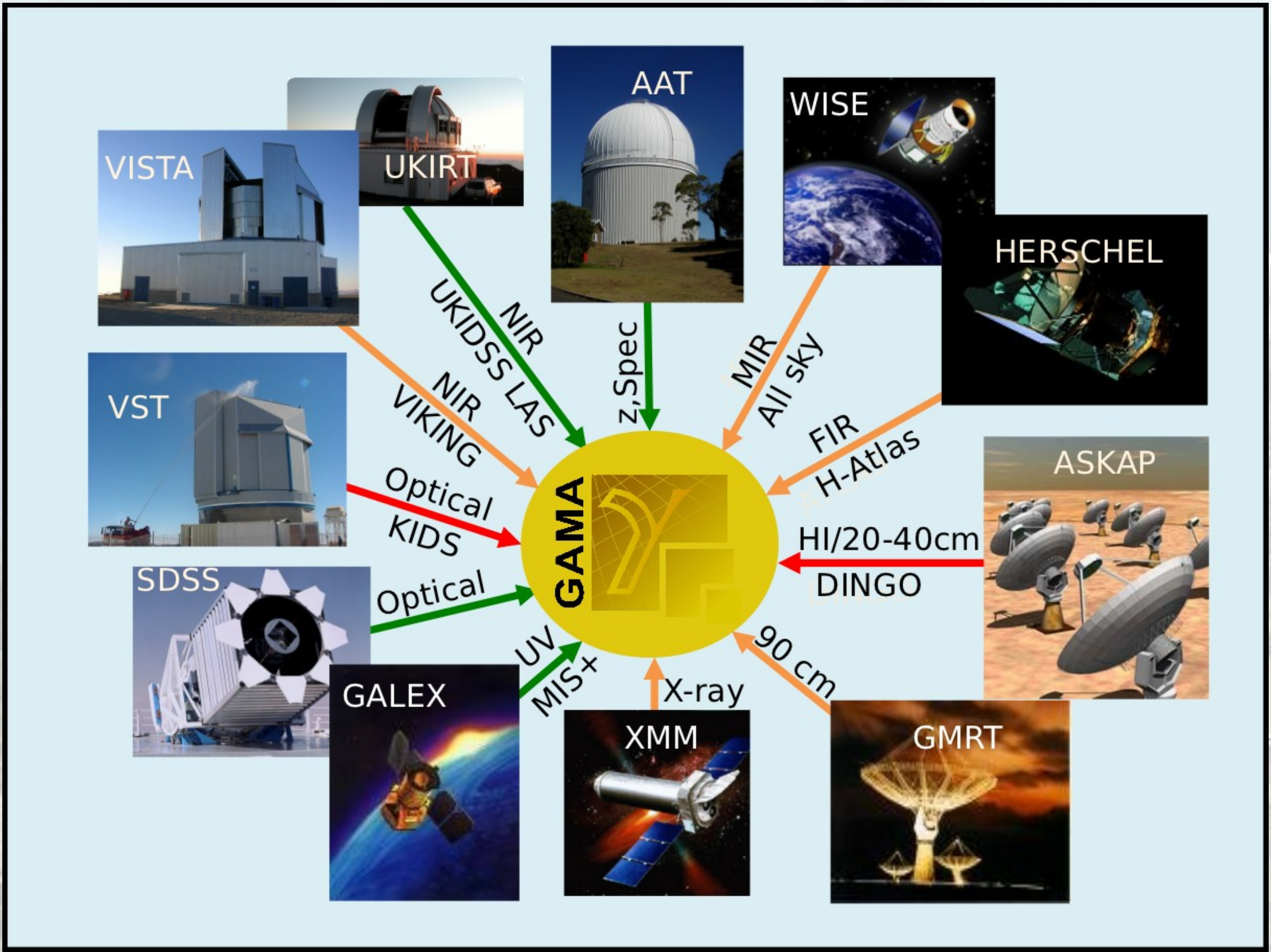
Single-Sérsic Photometry

- Single-Sérsic modelling
- Total size, mag, index
- Wavelength dep. on structural measurements (see Kelvin et al. 2012)

Structural Decomposition

- Multi-component modelling
- Bulge-Disk decompositions
- Stellar mass/light breakdown

Galaxy and Mass Assembly



- ~340,000 galaxies
- r < 19.8 mag
- ~310 deg^2

"study structure on scales of 1 kpc to 1 Mpc"

galaxy...
→ clusters
→ groups
→ mergers
→ structure

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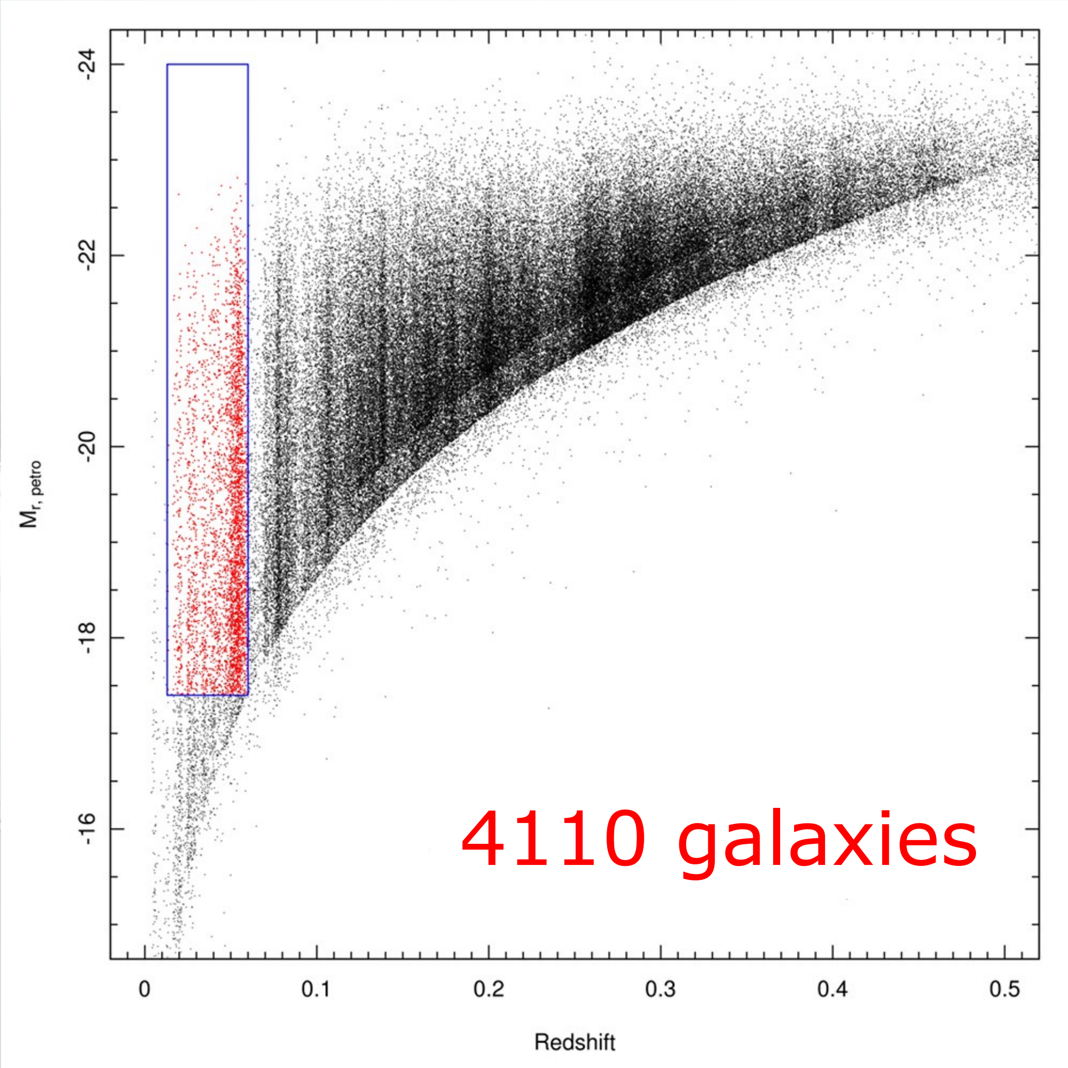
Volume-Limited Sample

Limits:

$0.013 < z < 0.06$
$M_r < -17.4$



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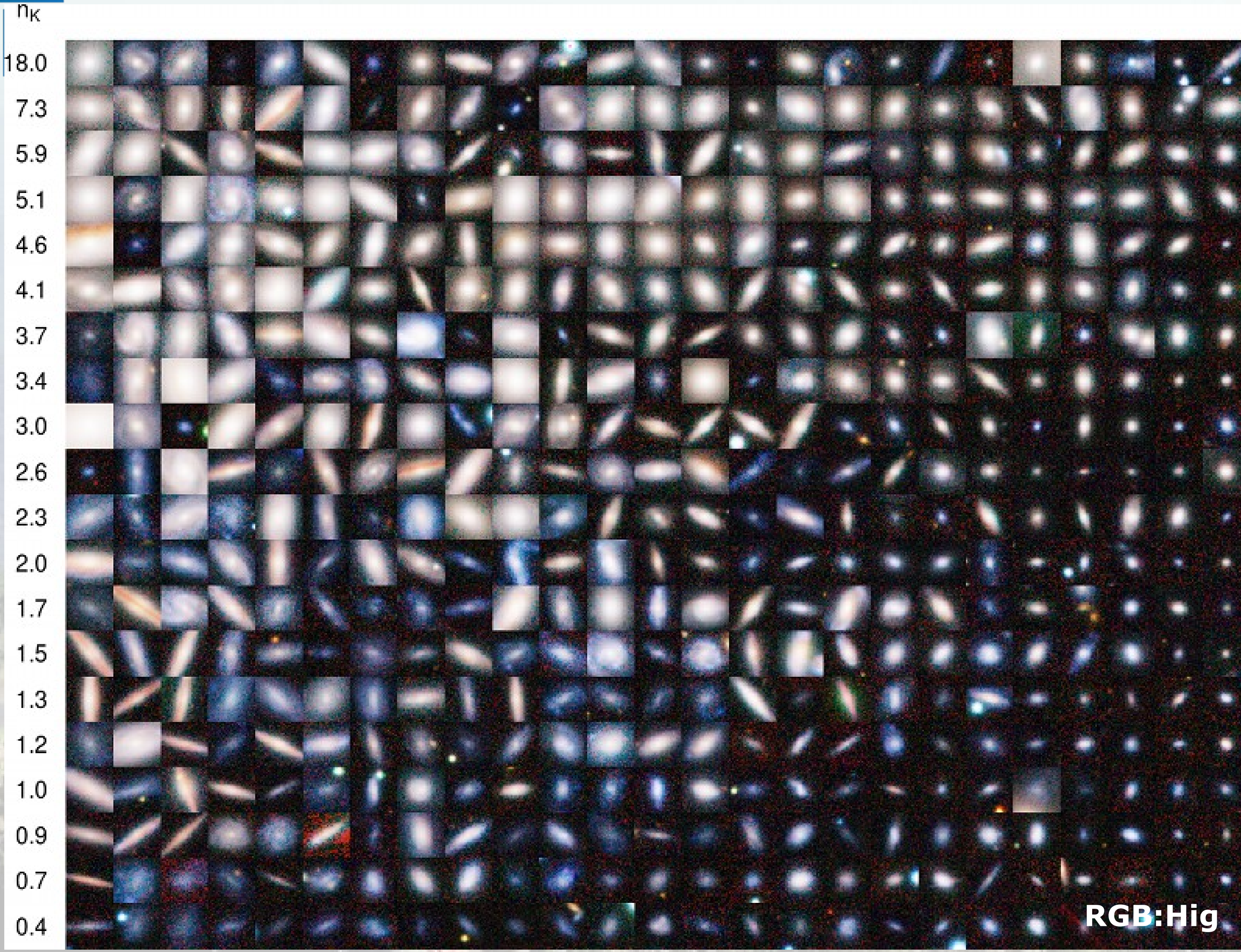
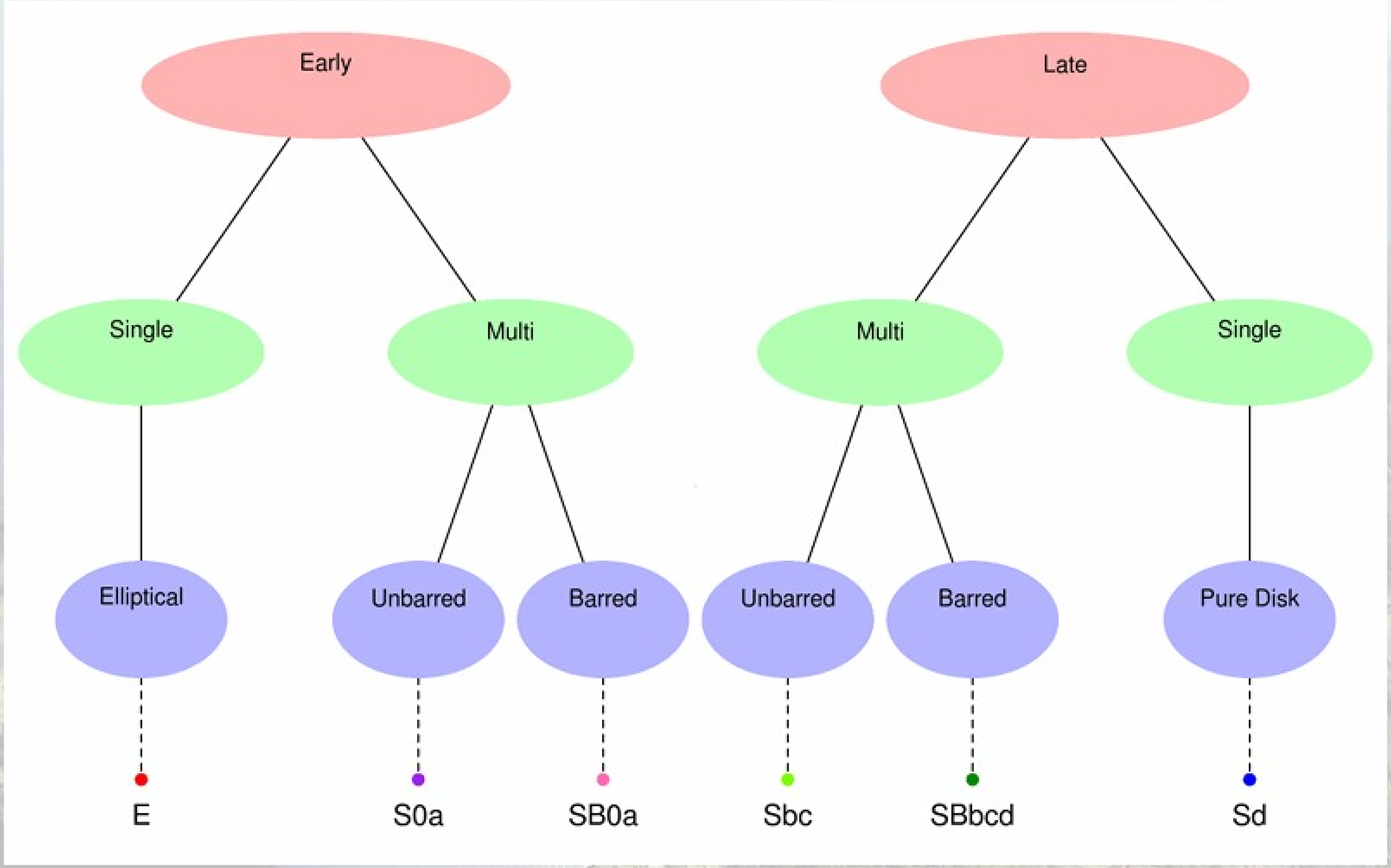
GAMA

Half-Light Radius

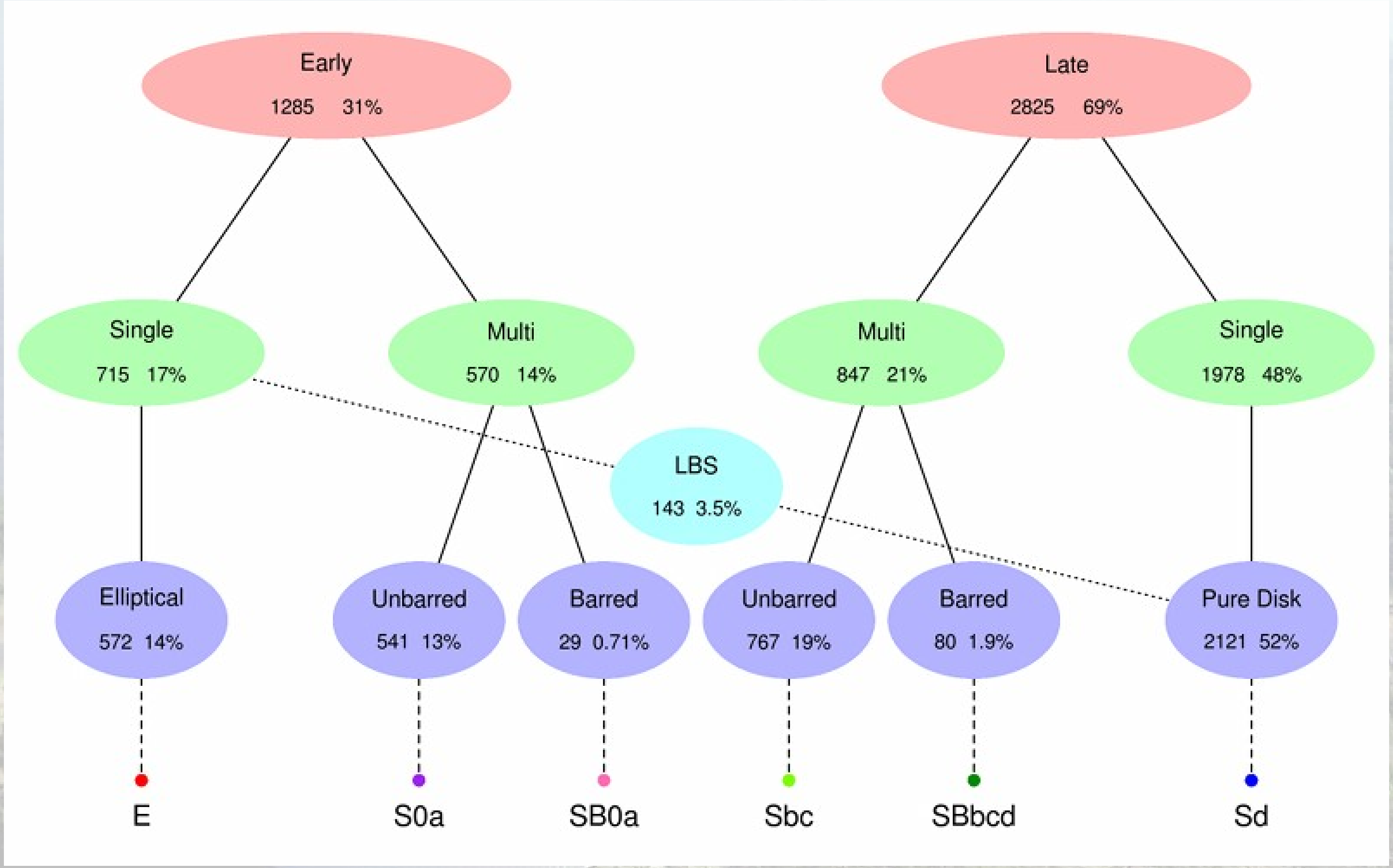


Sérsic Index

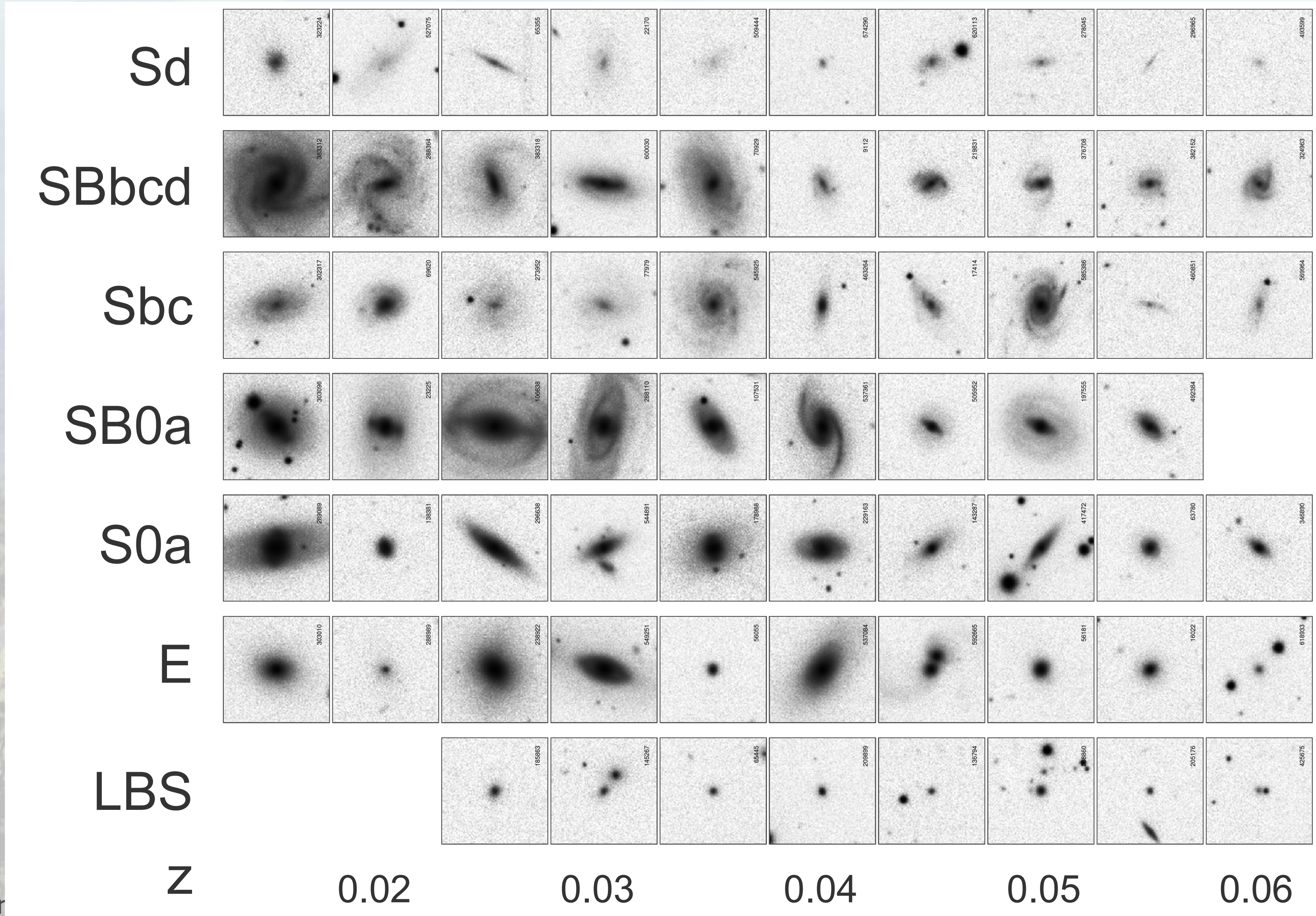
Eyeball Classification



Eyeball Classification



Eyeball Classifications



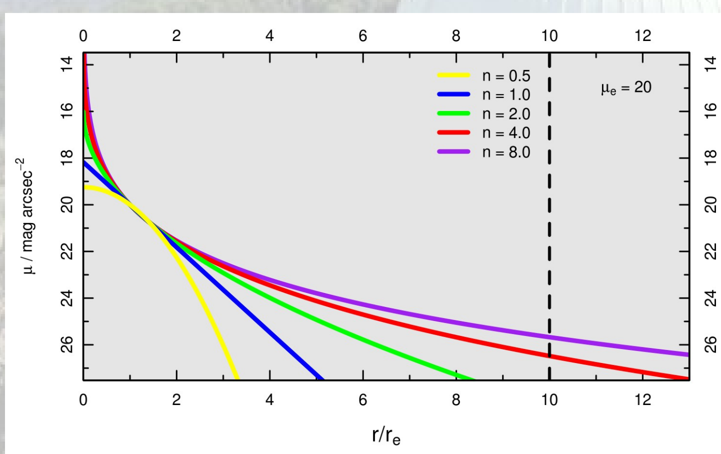
Multi-Component Models

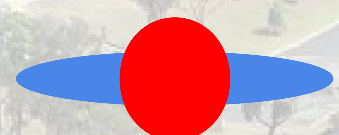
M01: Single-Sérsic

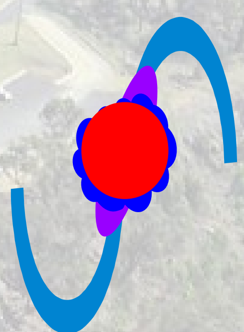
M02: De Vaucouleurs bulge + exponential disk

M03: Sérsic bulge + exponential disk

M04: Sérsic bulge + Sérsic disk







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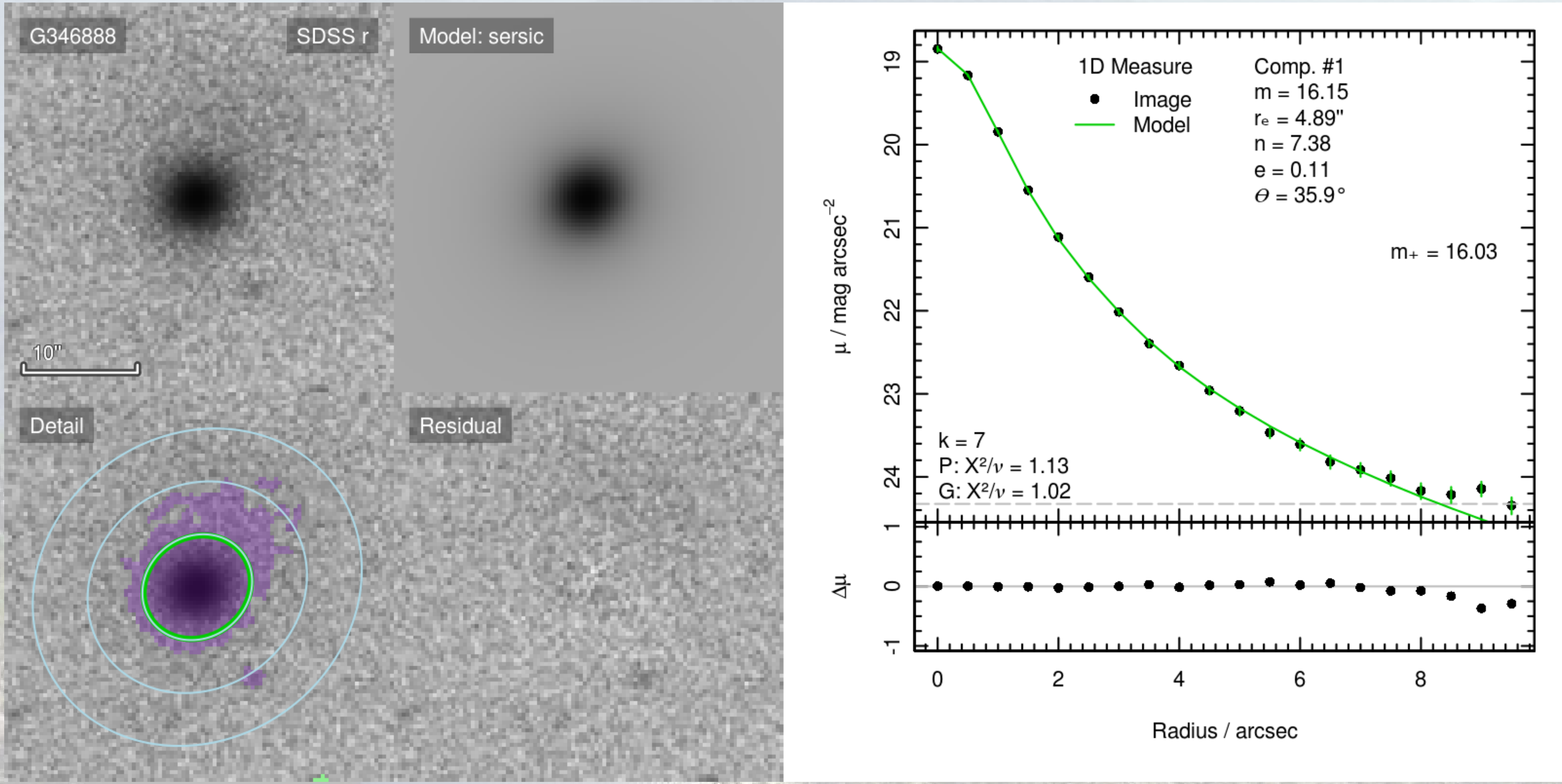
Elliptical: G346888

M01: Single-Sérsic



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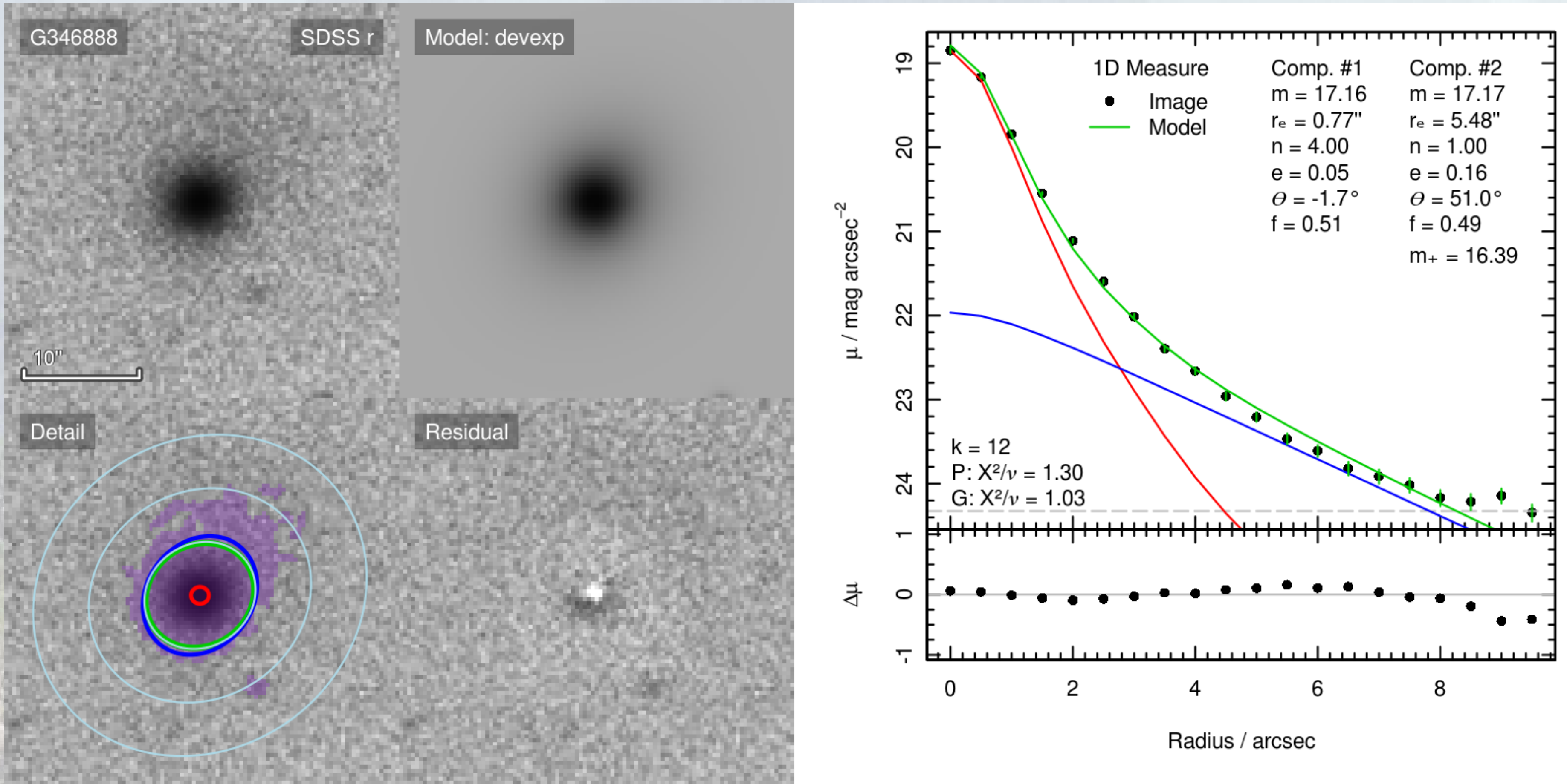
Elliptical: G346888

M02: De Vaucouleurs bulge + exponential disk



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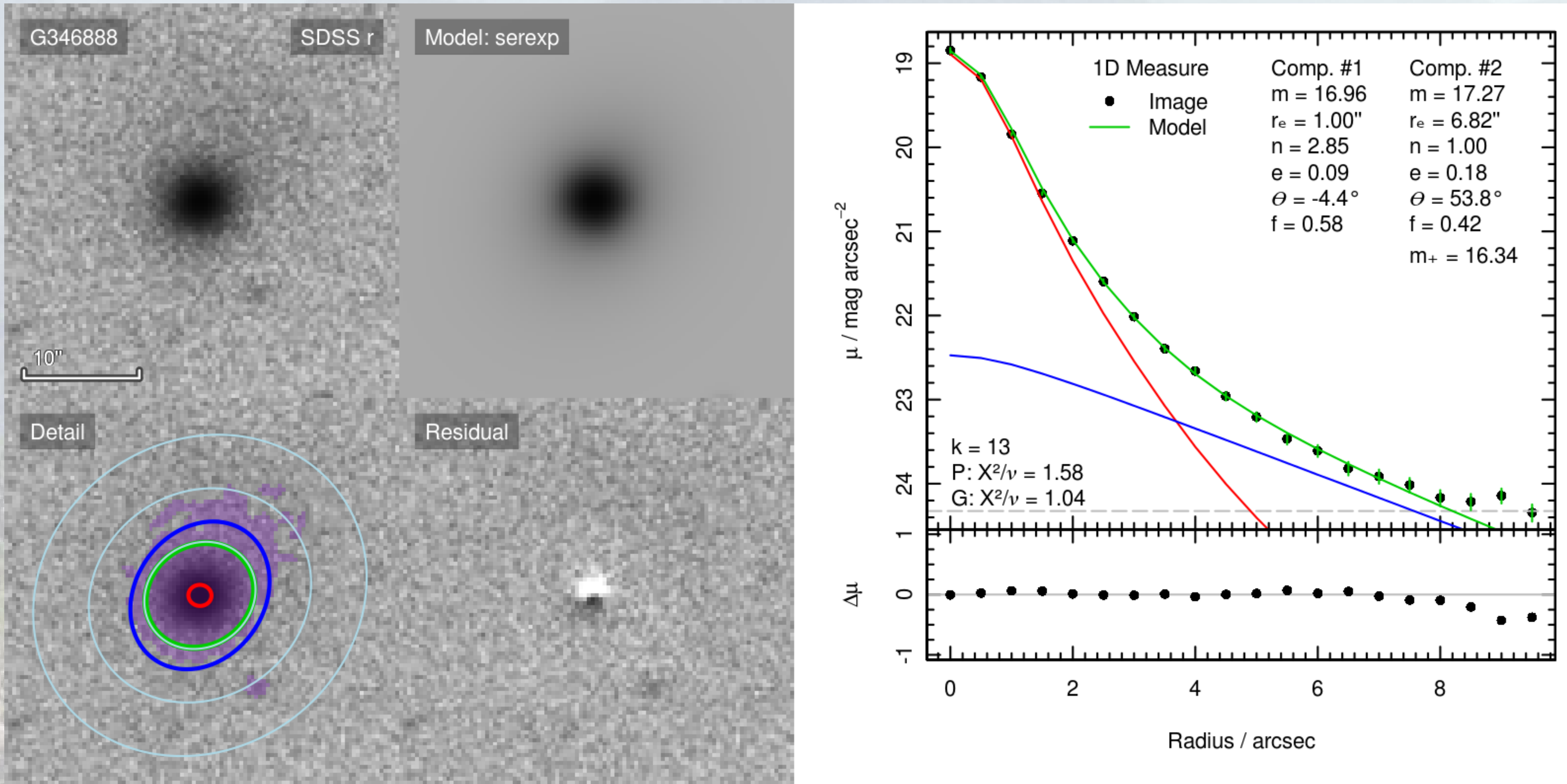
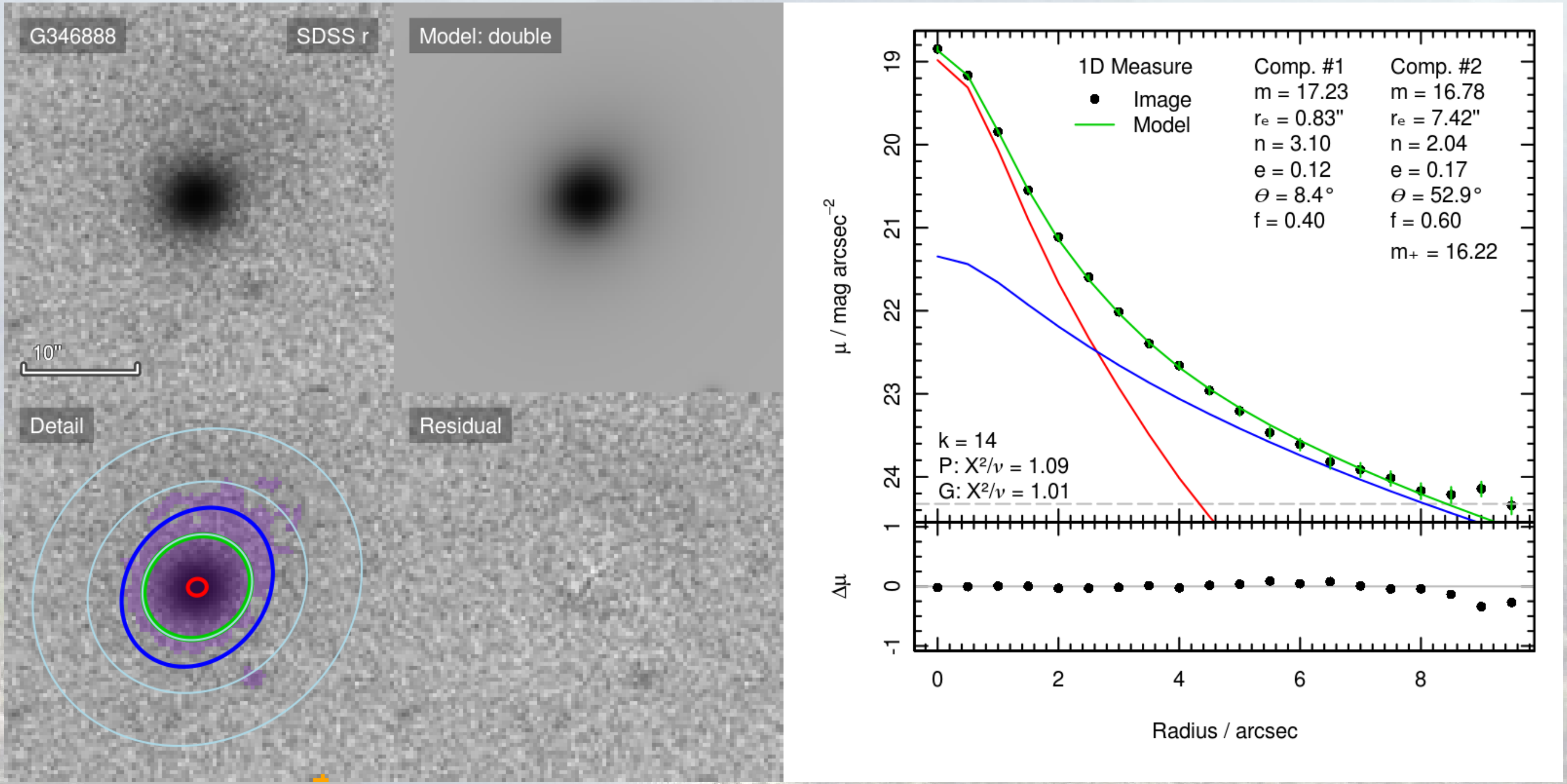
Elliptical: G346888

M03: Sérsic bulge + exponential disk



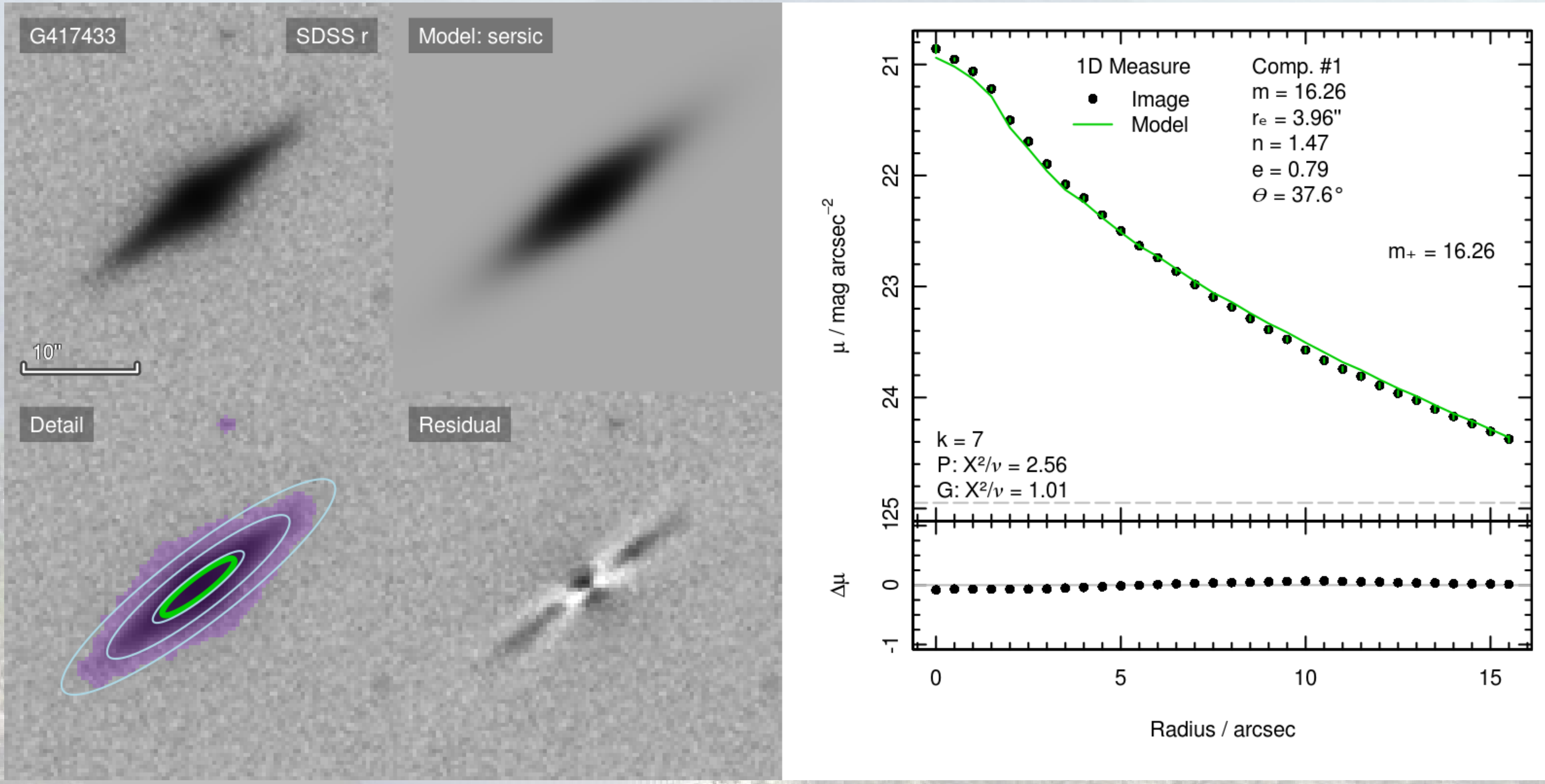
Elliptical: G346888

M04: Sérsic bulge + Sérsic disk



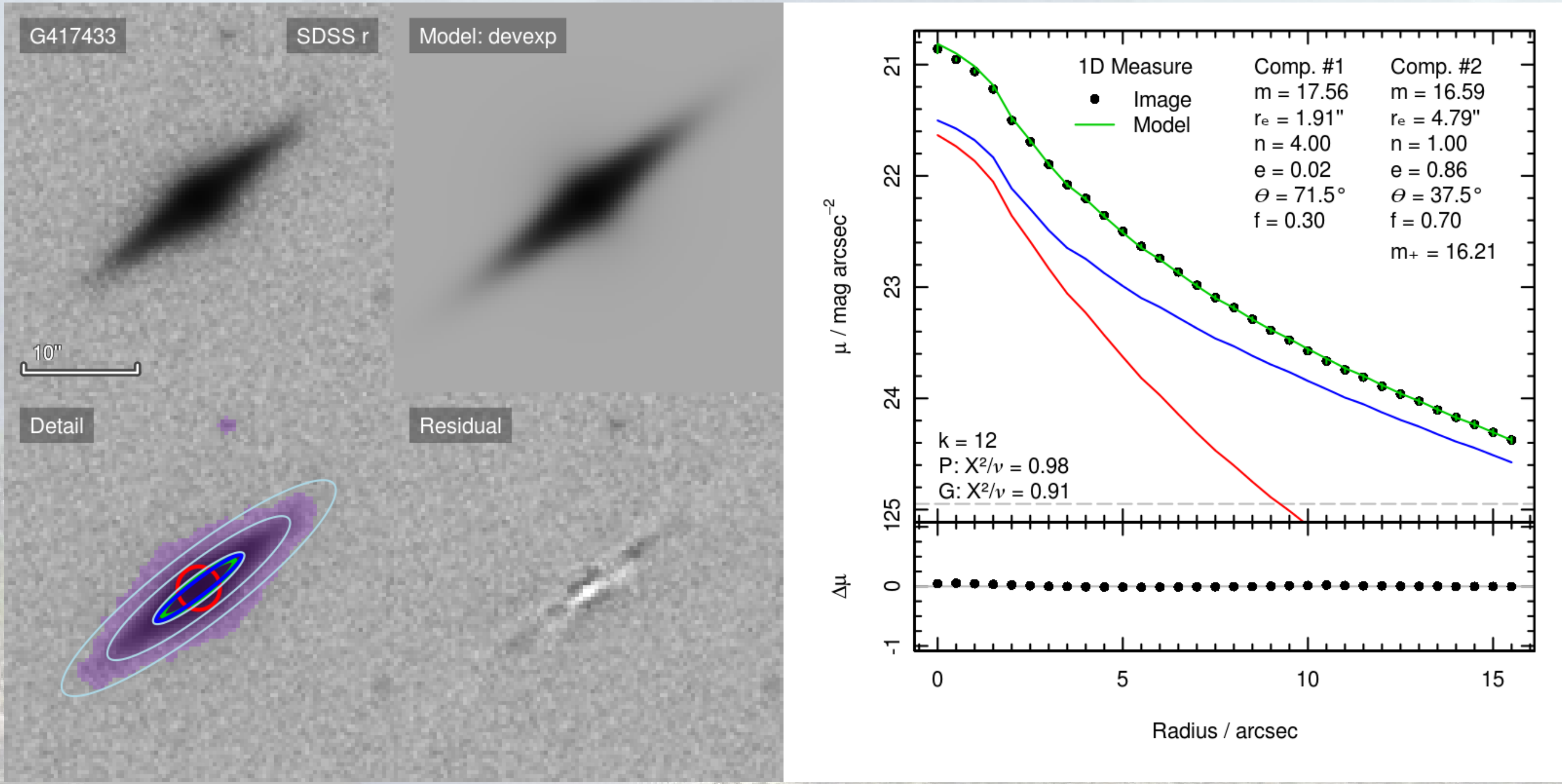
S0a: G417433

M01: Single-Sérsic



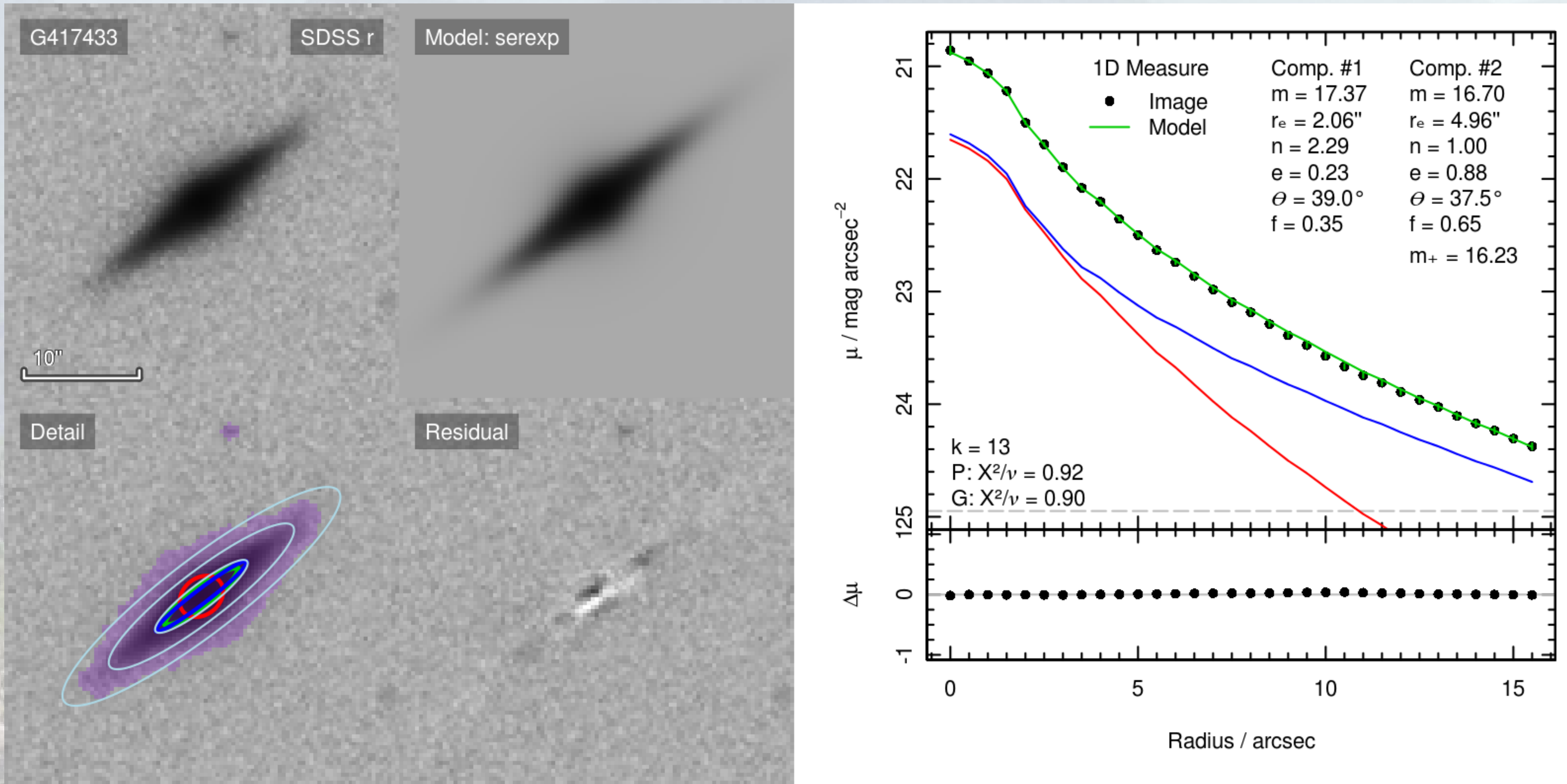
S0a: G417433

M02: De Vaucouleurs bulge + exponential disk



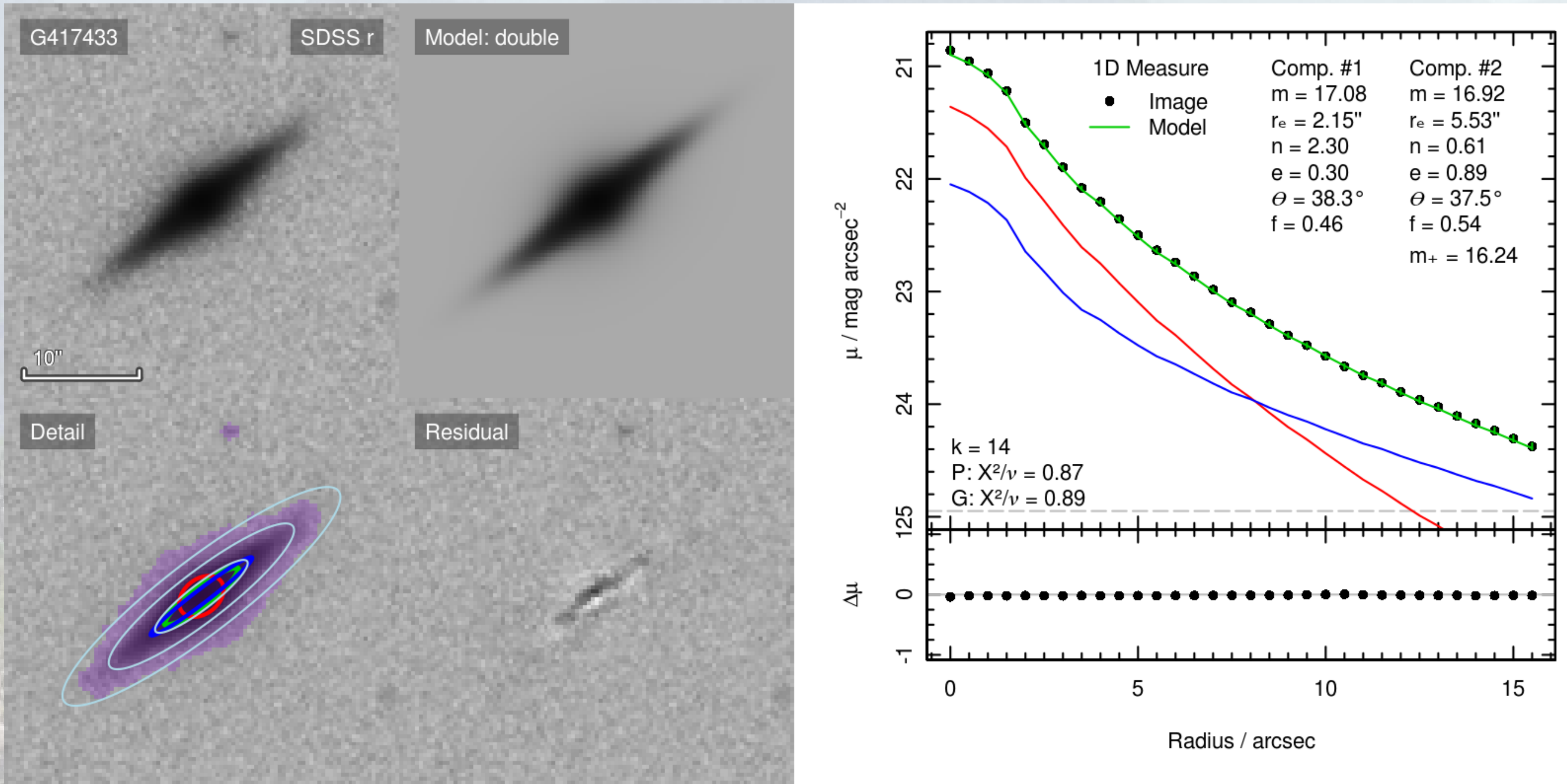
S0a: G417433

M03: Sérsic bulge + exponential disk



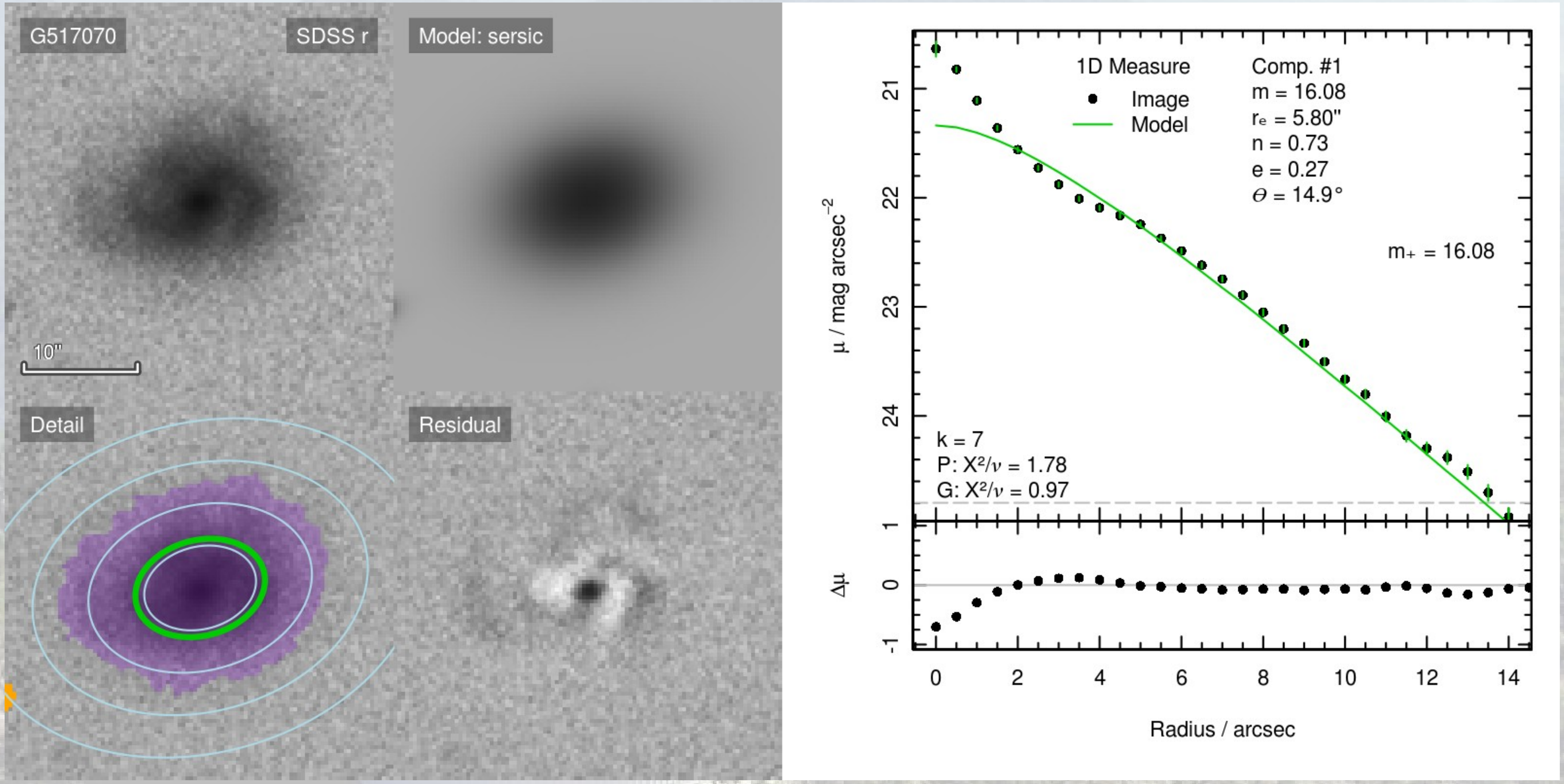
S0a: G417433

M04: Sérsic bulge + Sérsic disk



SBbc: G517070

M01: Single-Sérsic



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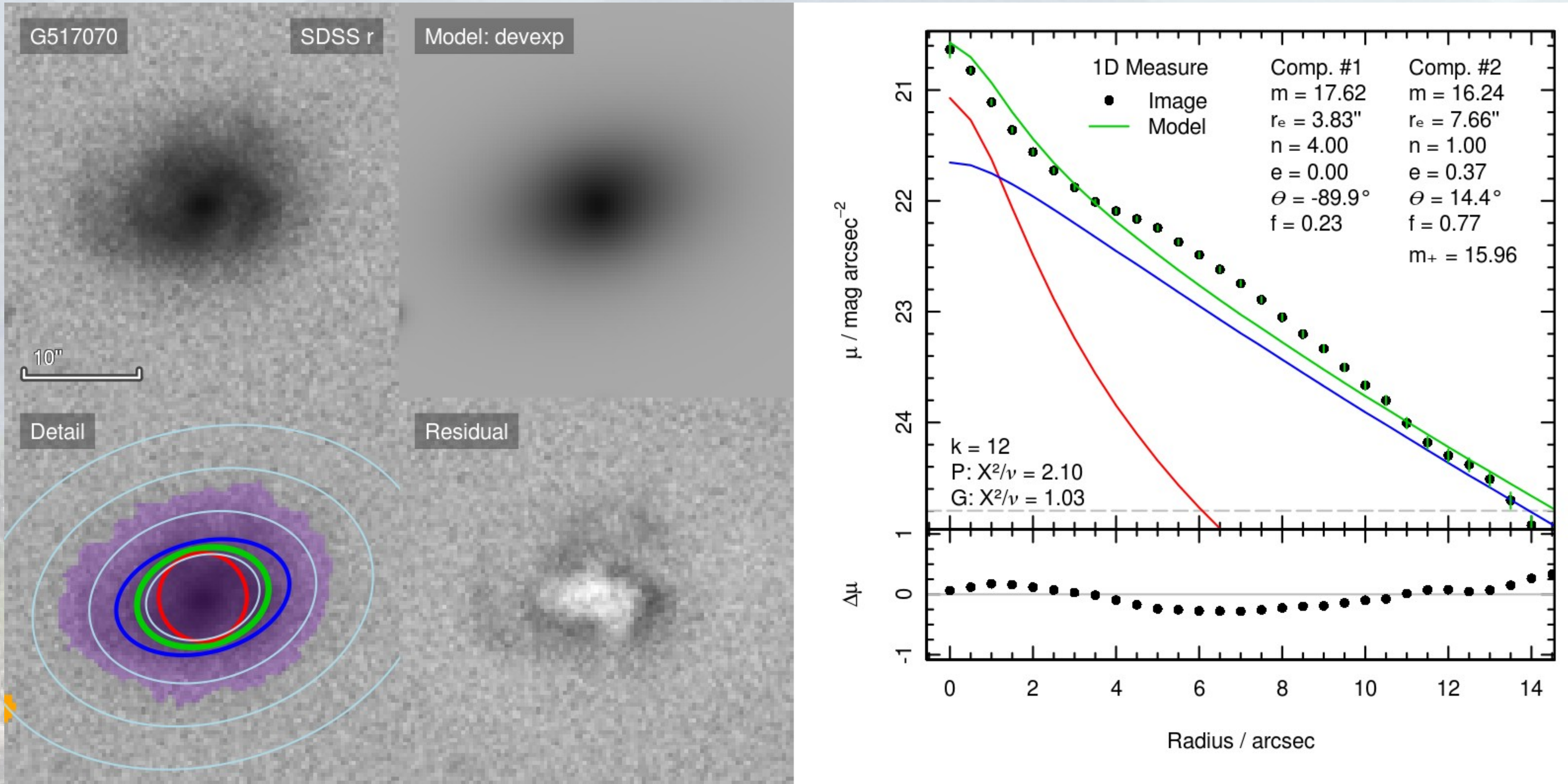
SBbc: G517070

M02: De Vaucouleurs bulge + exponential disk



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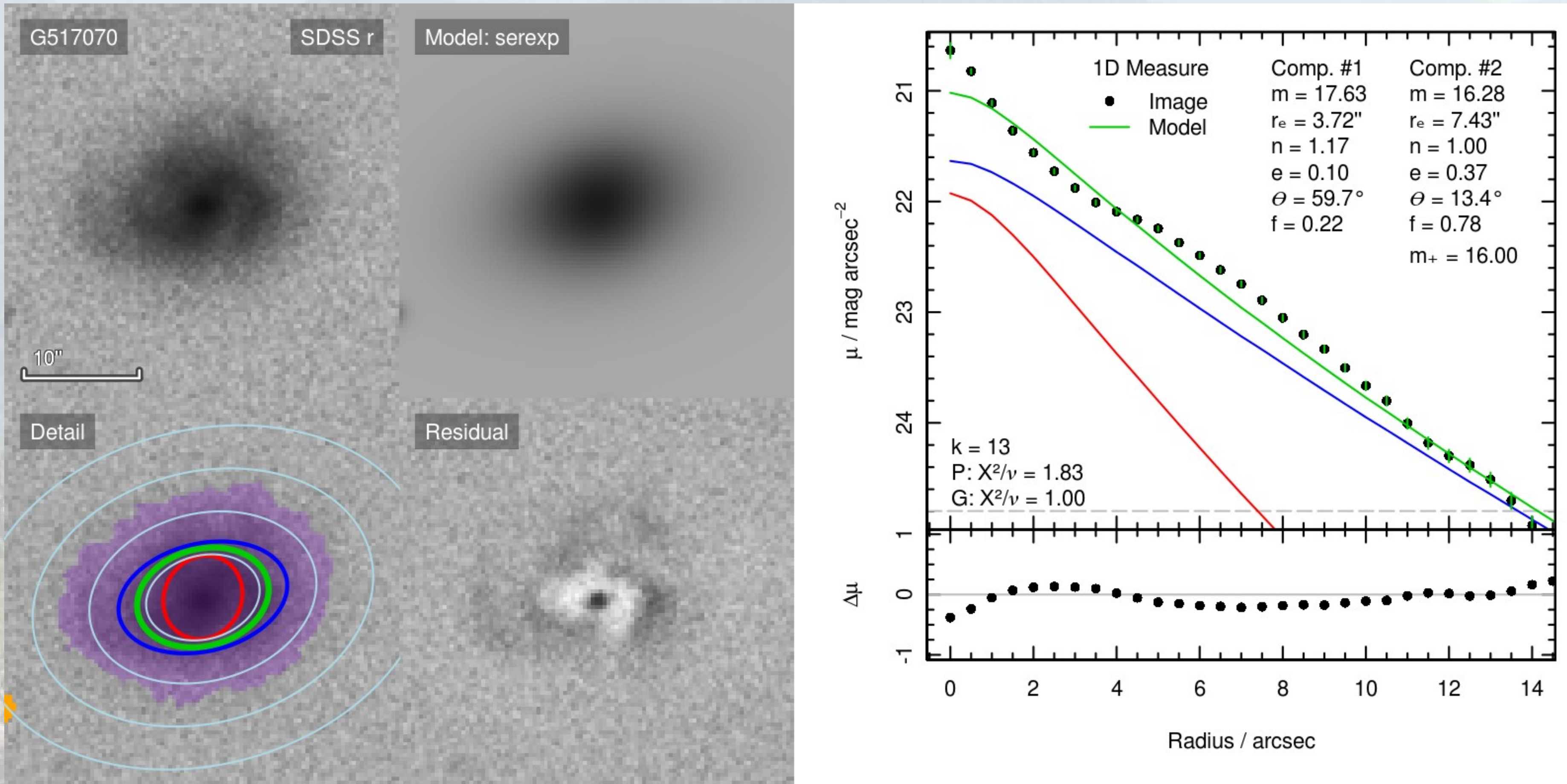
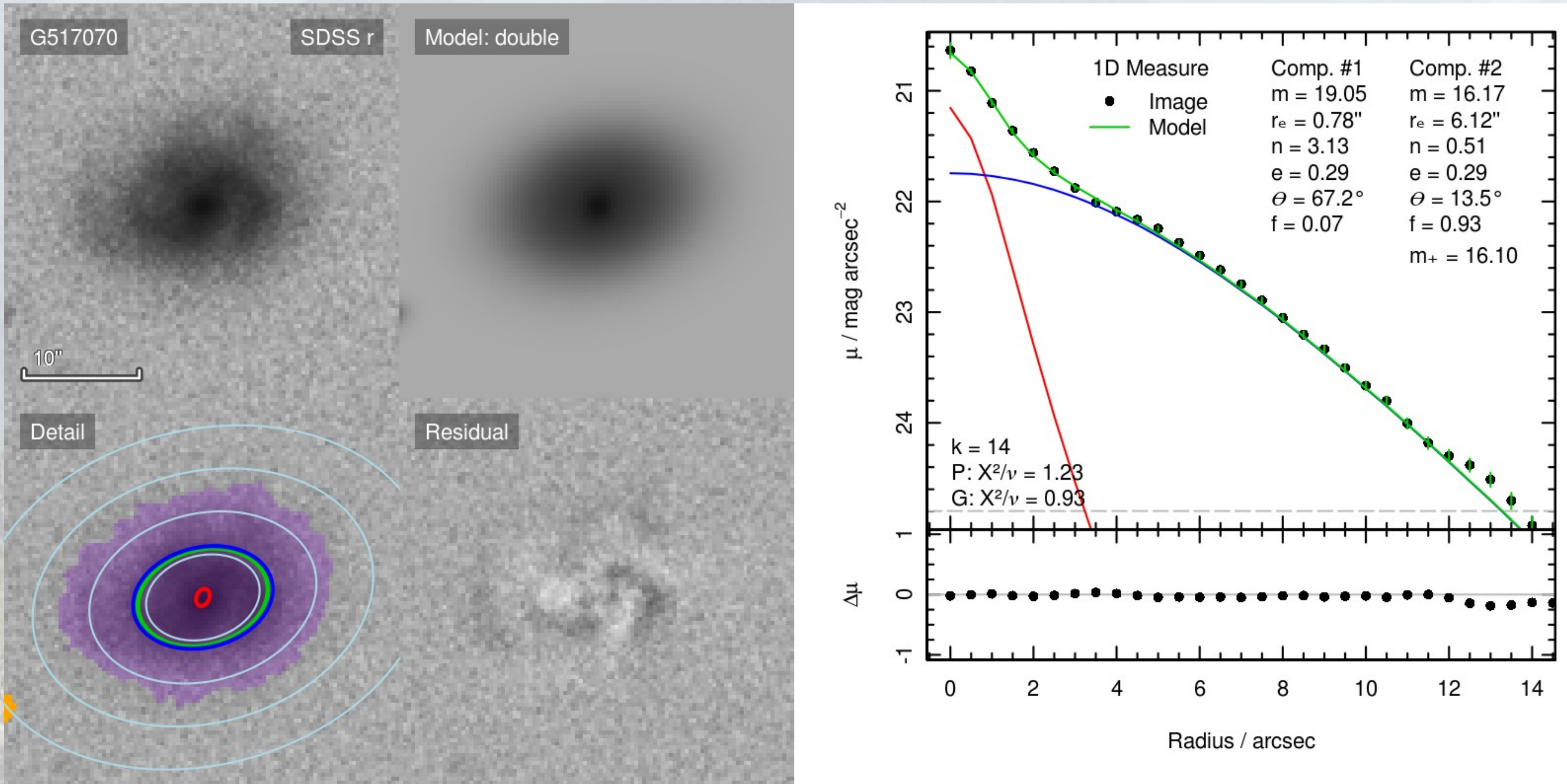
SBbc: G517070

M03: Sérsic bulge + exponential disk



SBbc: G517070

M04: Sérsic bulge + Sérsic disk



Thursday 23rd August 2012

Lee Kelvin

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Model Choice

How do we select the 'best' model?

Model Choice

How do we select the 'best' model?

Bayesian Information Criterion:

$$\mathrm{BIC} = \chi^2 + k \cdot \ln(n)$$

χ^2	total goodness of fit
k	number of free parameters
n	number of contributing pixels

Model Choice

How do we select the 'best' model?

Bayesian Information Criterion:

$$\mathrm{BIC} = \chi^2 + k \cdot \ln(n)$$

χ^2 total goodness of fit
k number of free parameters
n number of contributing pixels

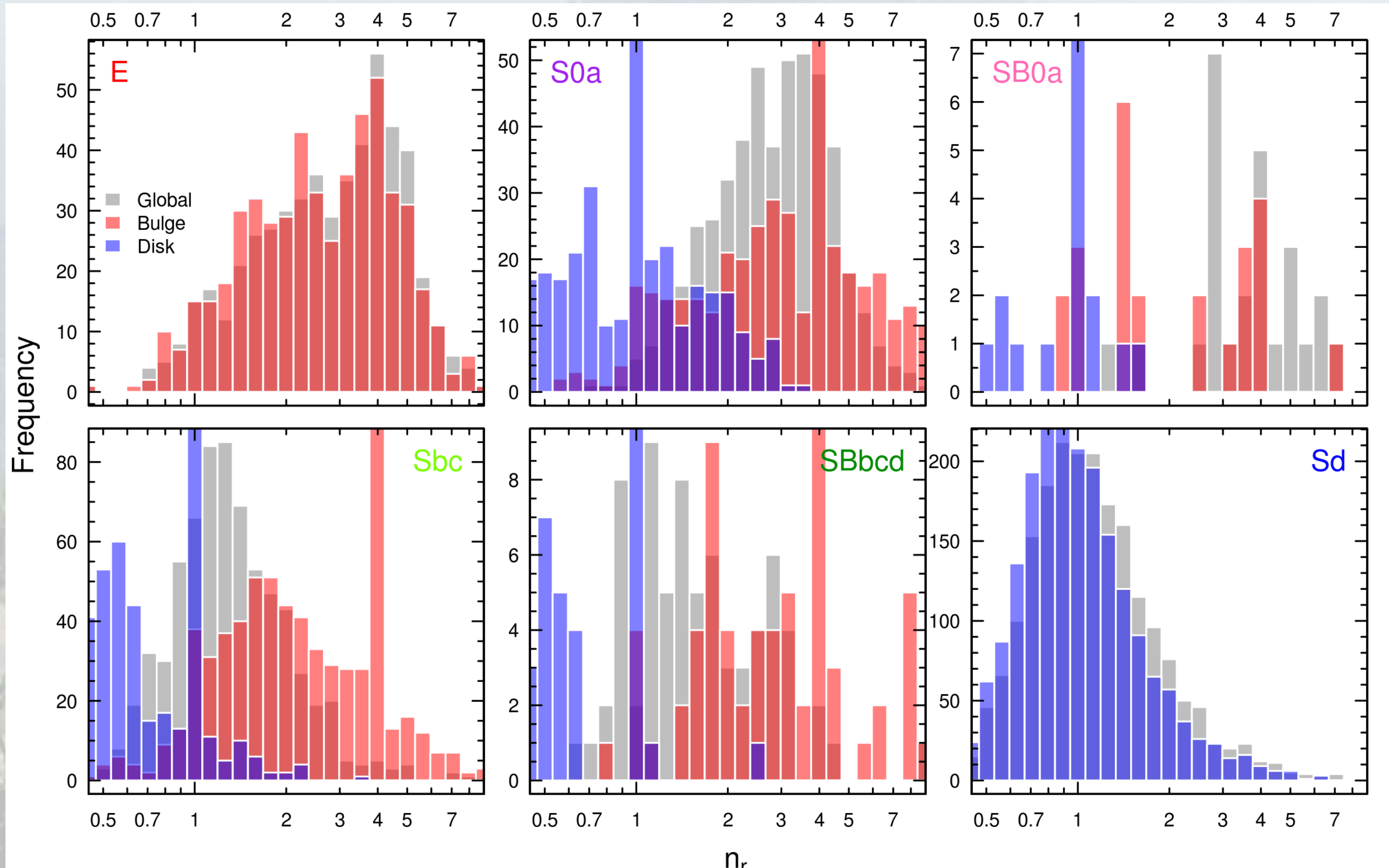
Use visual classifications as a guide:

E/Sd → Single-Sérsic

S0a/Sbc → Multi Component Lowest BIC

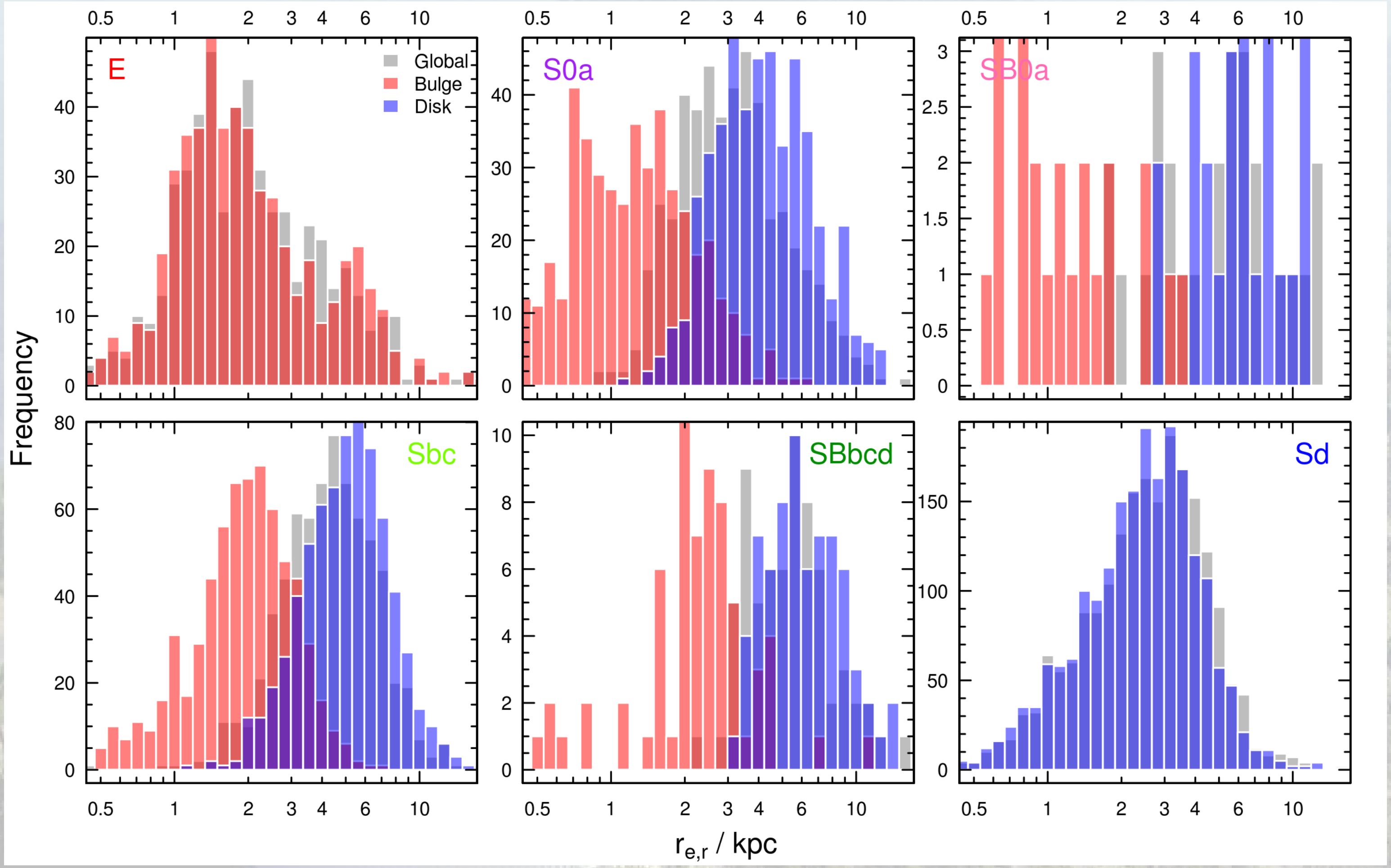
Structural Results

Sérsic index

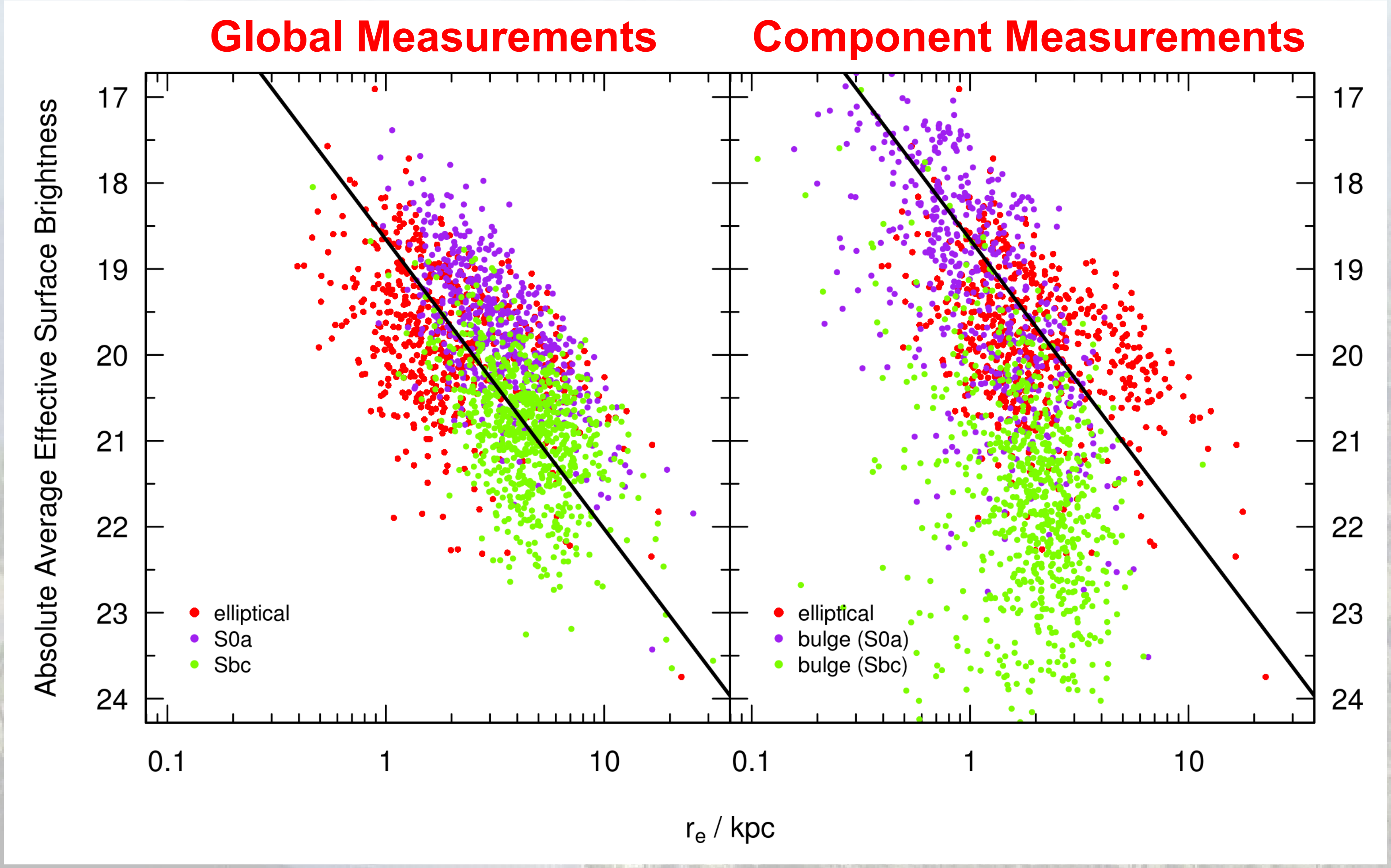


Structural Results

Half-light radius

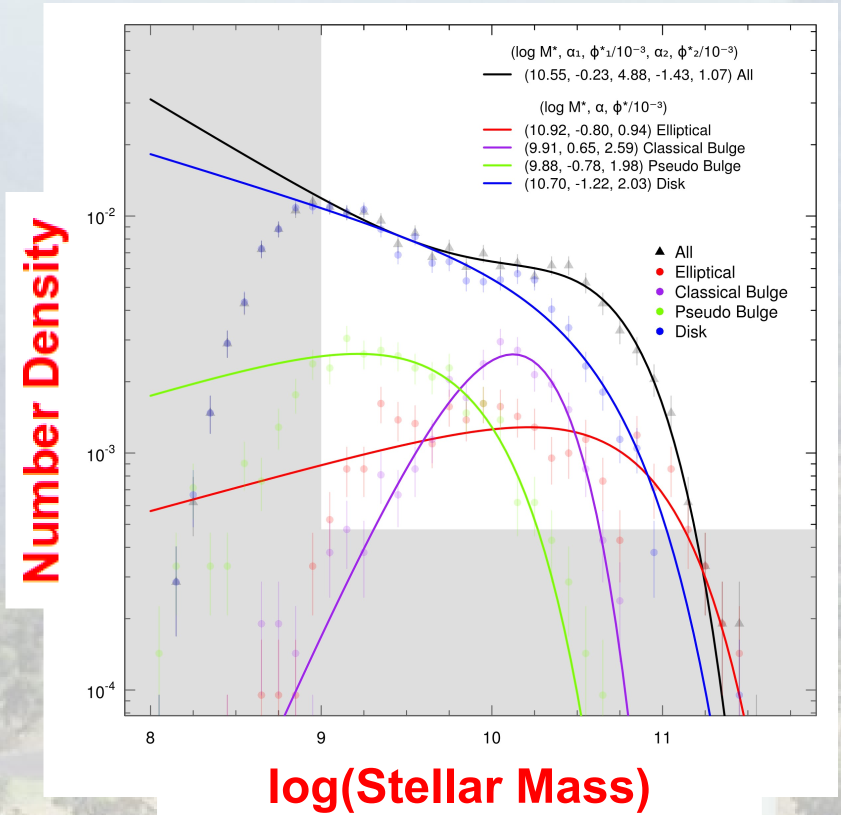


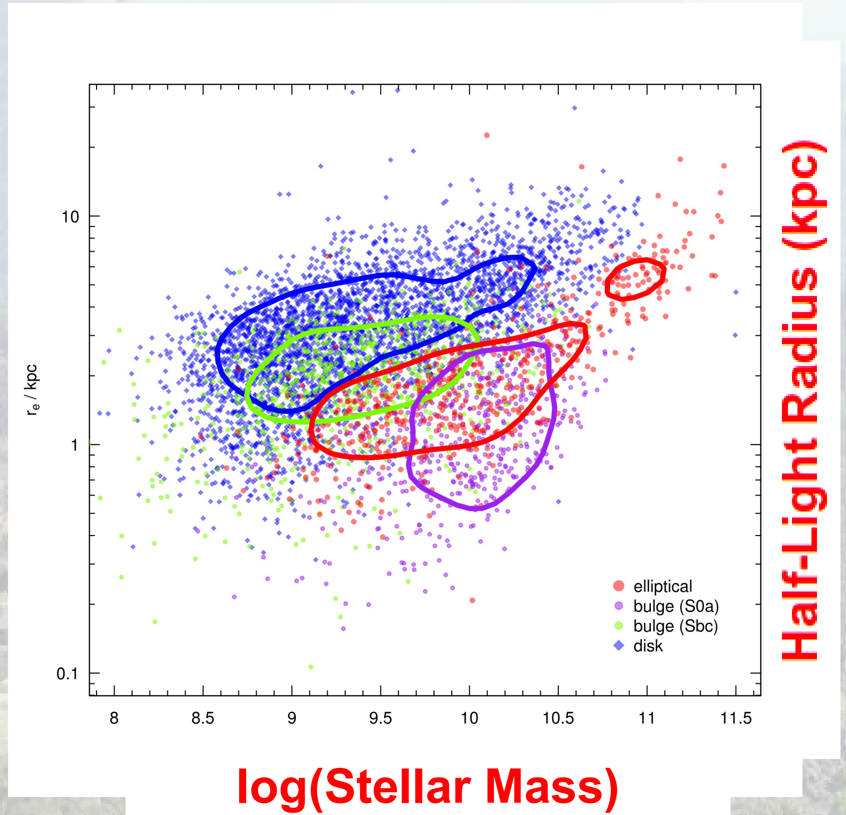
Early/Late type bulges



Component Mass

Stellar Masses: Taylor+ 2011

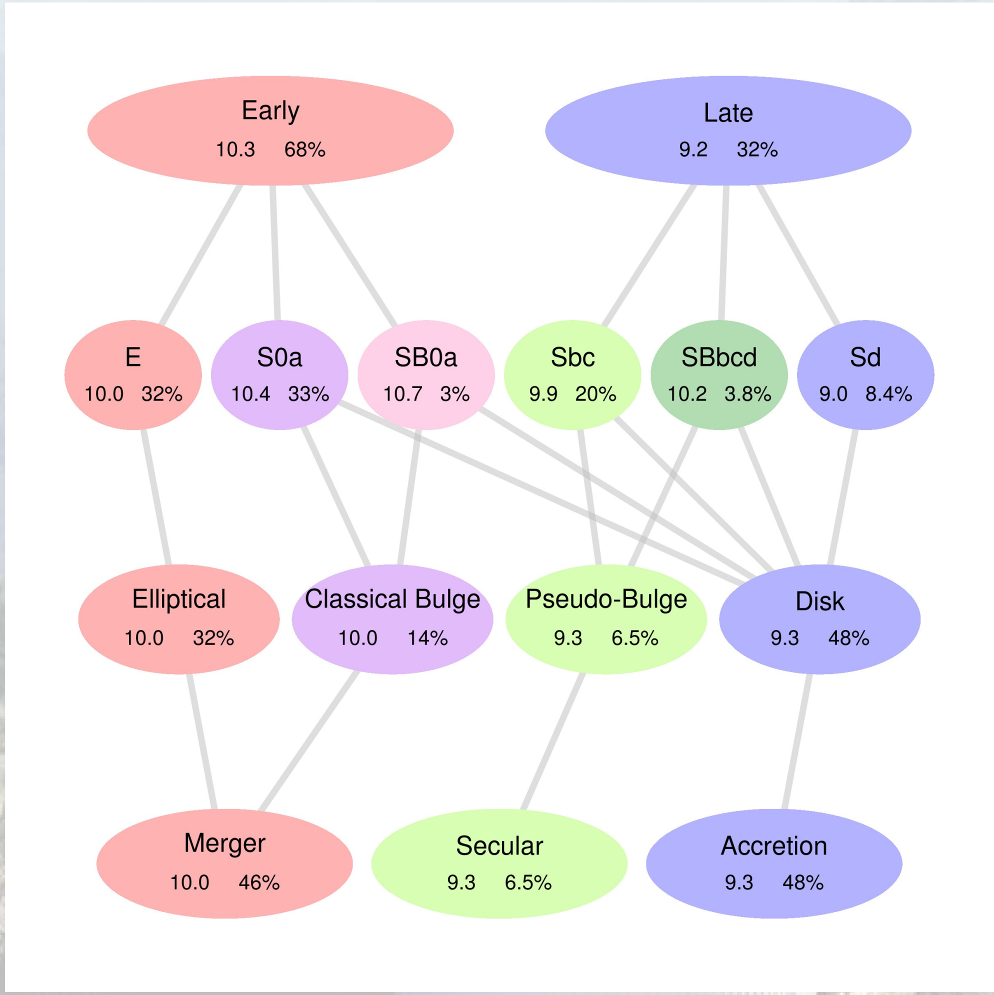




Ellipticals dominate at high-mass, disks at low-mass

Late-type bulges share more in common with disks than early-type bulges

Stellar Mass Breakdown



Mass in the local Universe:

Hierarchical merging	~45.8%
Gas accretion	~47.7%
Secular evolution	~6.5%

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Summary

Automated, fast and robust structural decomposition is essential in order to model increasingly large galaxy datasets to a high level of accuracy.

Early-type bulges are well described by the Kormendy relation, whereas late-type bulges do not follow this relation
→ early-type bulges ~ classical bulge, late-type bulges ~ pseudo-bulge

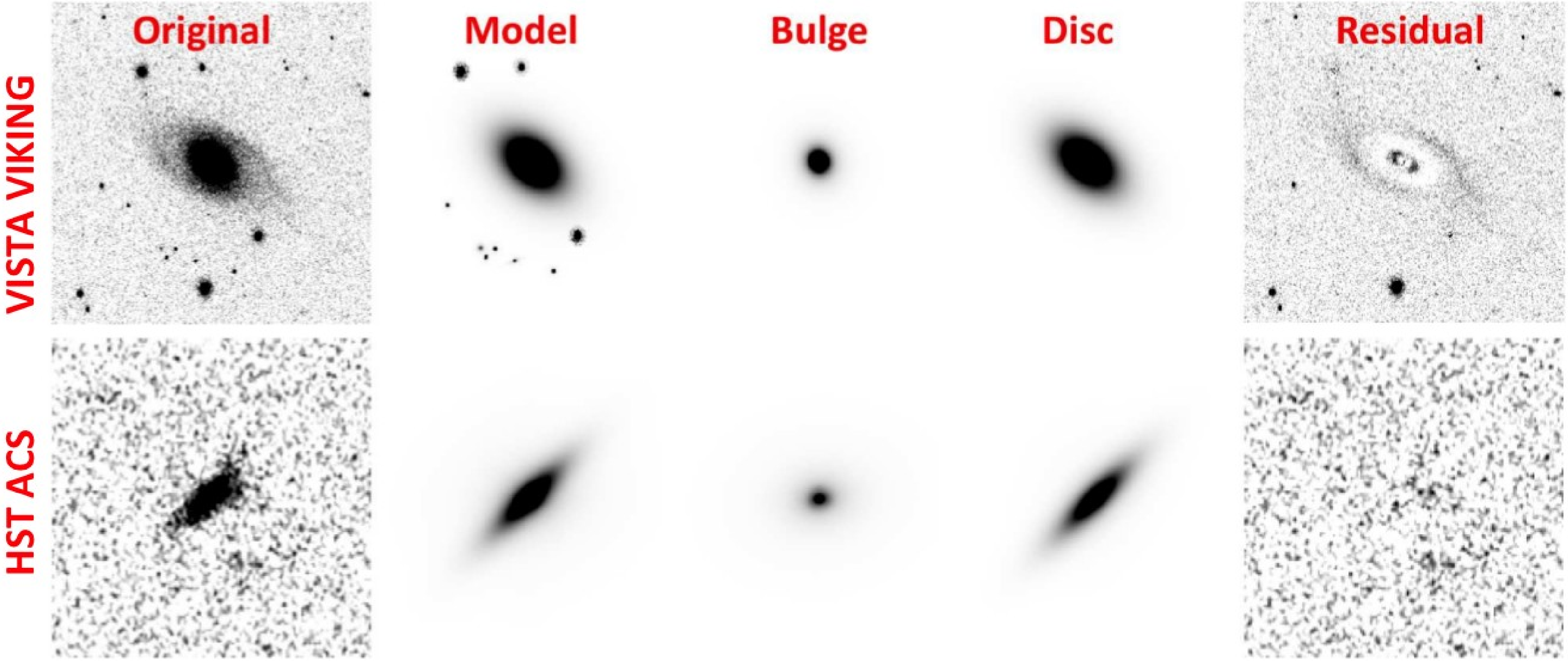
The evolutionary processes of monolithic collapse/merging and gas accretion contribute roughly equal measures of stellar mass in the local universe.

Secular evolutionary processes contribute ~6.5% of the total stellar mass at $z < 0.06$ through the creation of pseudo-bulges.

Future Work

- Bulge-Disk-Bar decomposition (ring, secondary disk, AGN, …)
- Extension of the redshift baseline and imaging quality/depth
  → HST, VST KIDS, VISTA VIKING

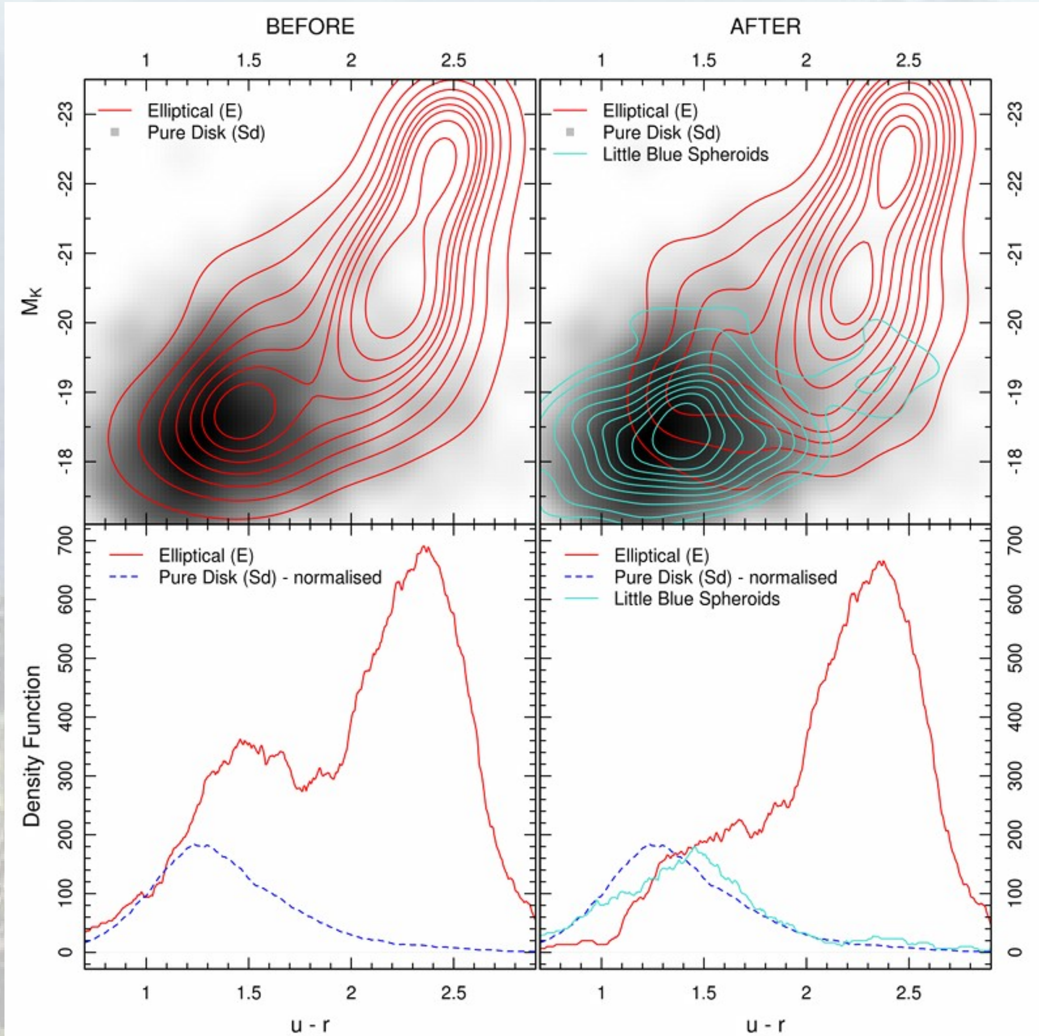
High-Redshift Modelling



Bulge-Disk decomposition essential for a full understanding of galaxy structure and mass breakdown

'Little Blue Spheroids'

'Little Blue Spheroids'



Initially classified as
- early-type
- single-component

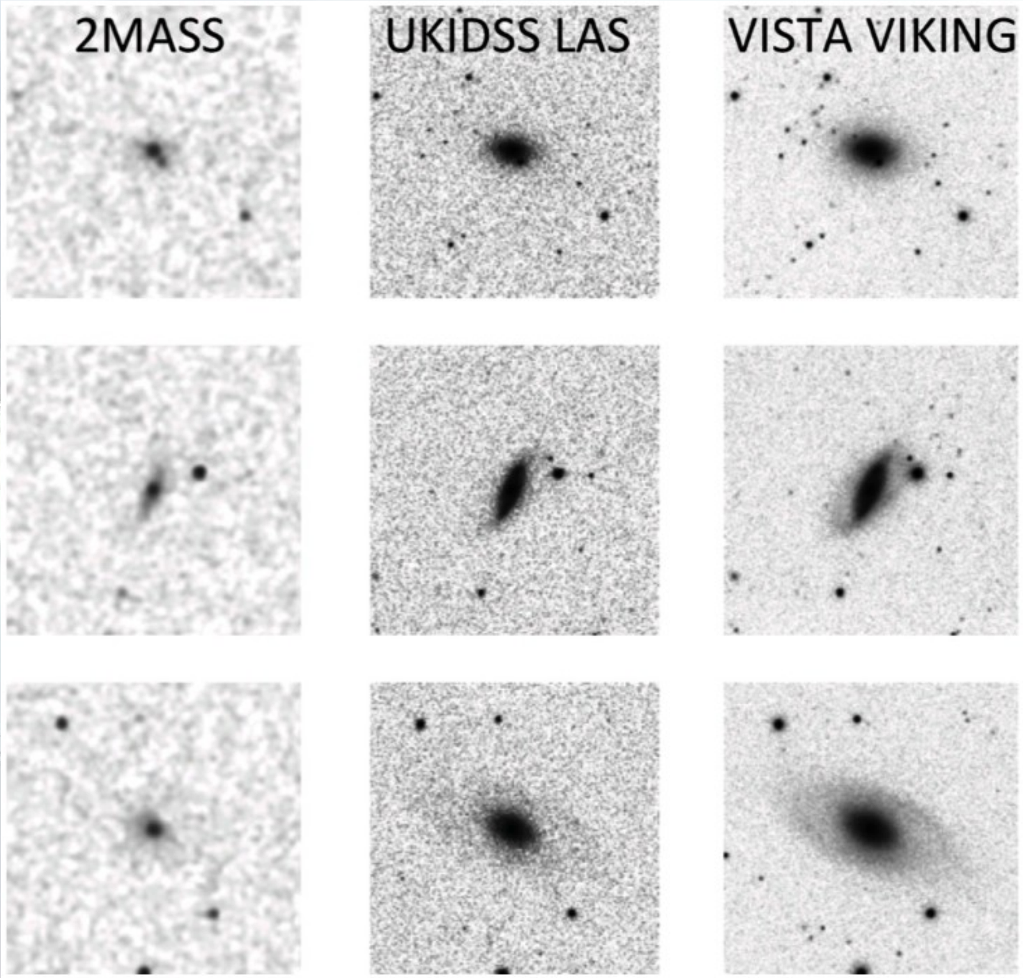
Closer inspection:
- star-forming
- blue

Also noted as 'Little Blue Fuzzies' in Brough et al. (2011)

Reassigned → disk

2MASS - UKIDSS - VIKING

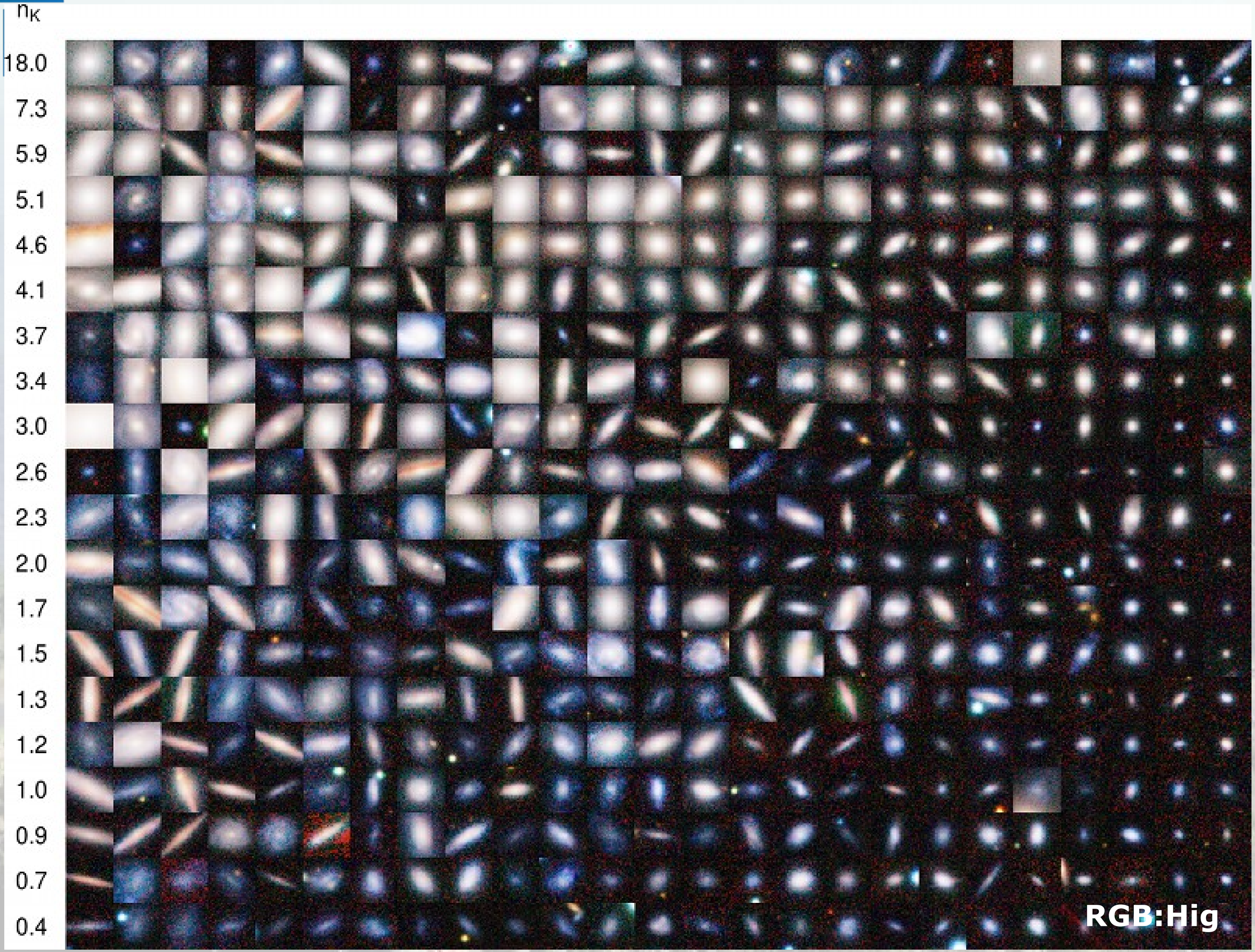
Significant improvements in structural measurements when moving from **previous-generation** to **current-generation** to **next-generation** survey data



GAMA

Half-Light Radius

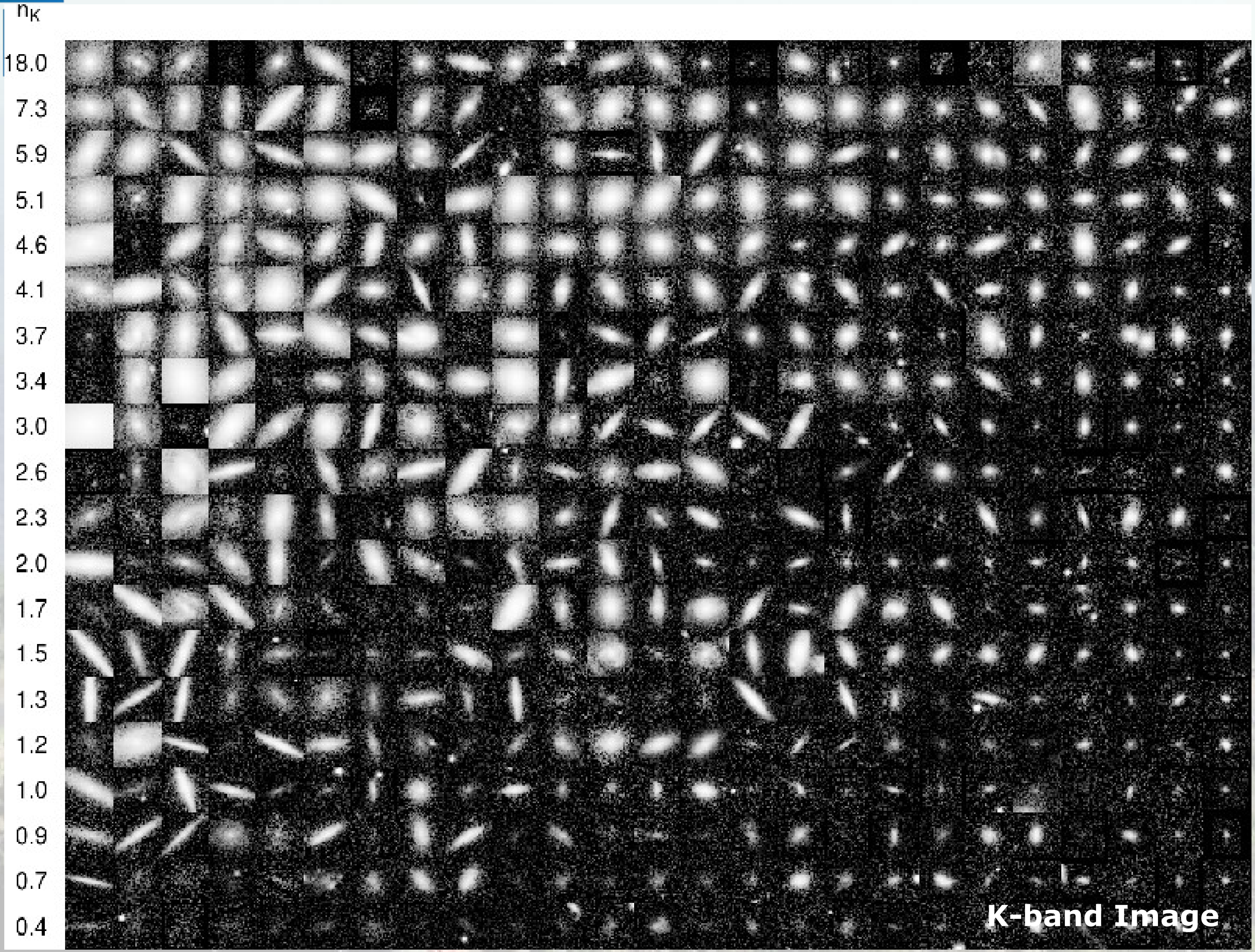
Sérsic Index



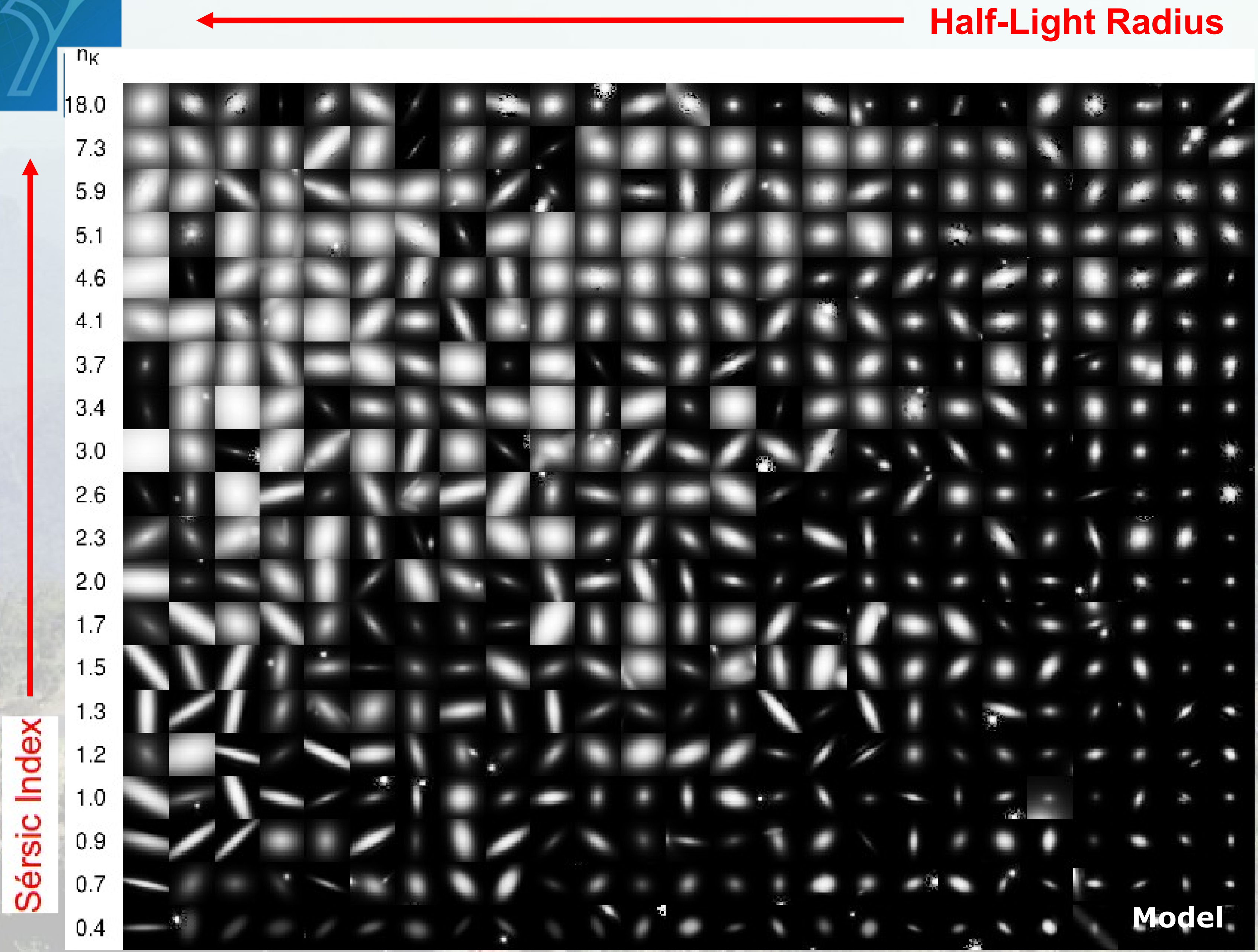
GAMA

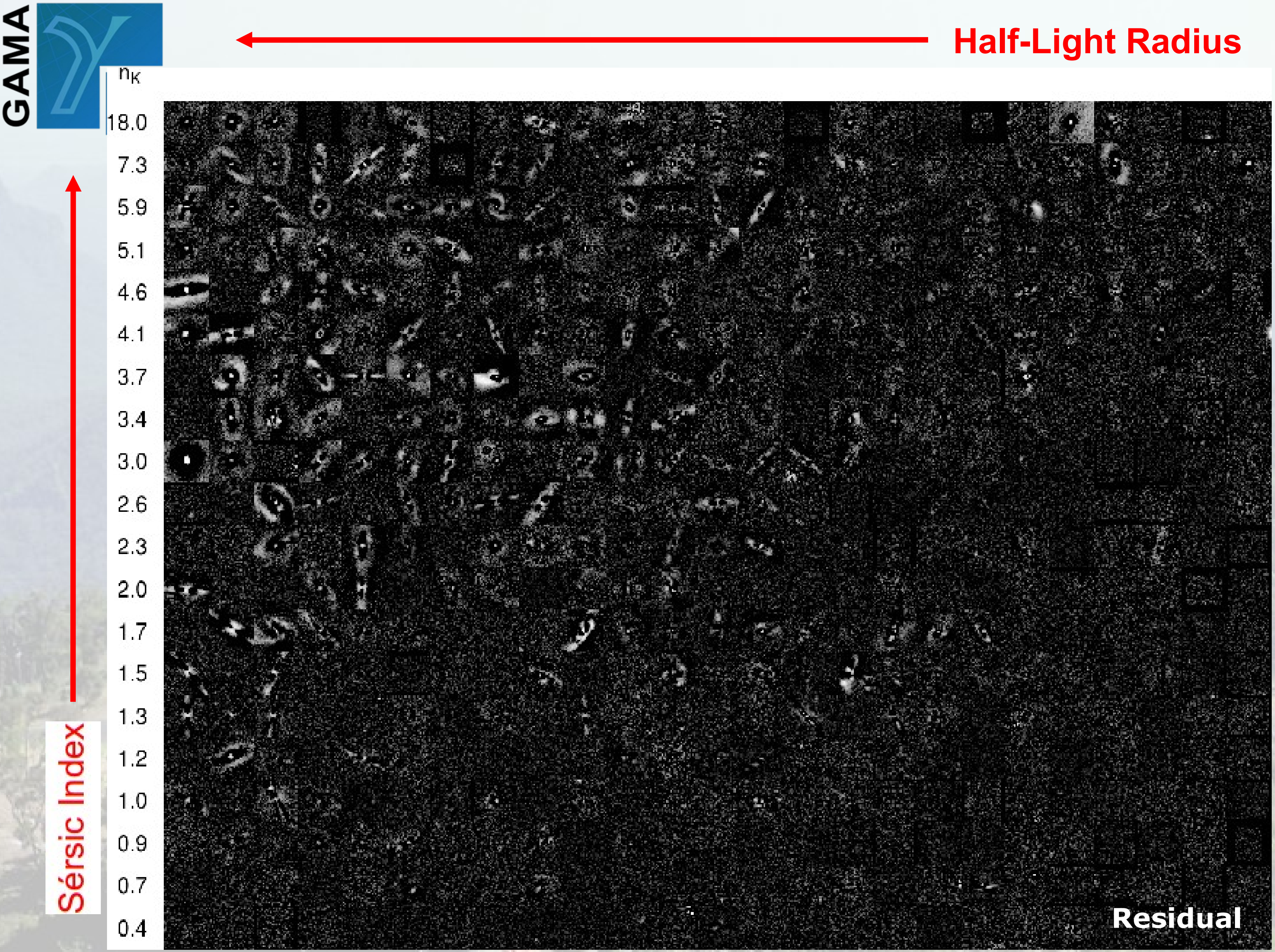
Half-Light Radius

Sérsic Index



GAMA


Half-Light Radius
Sérsic Index
n_K
18.0
7.3
5.9
5.1
4.6
4.1
3.7
3.4
3.0
2.6
2.3
2.0
1.7
1.5
1.3
1.2
1.0
0.9
0.7
0.4
Model



Half-Light Radius
Sérsic Index
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18.0
7.3
5.9
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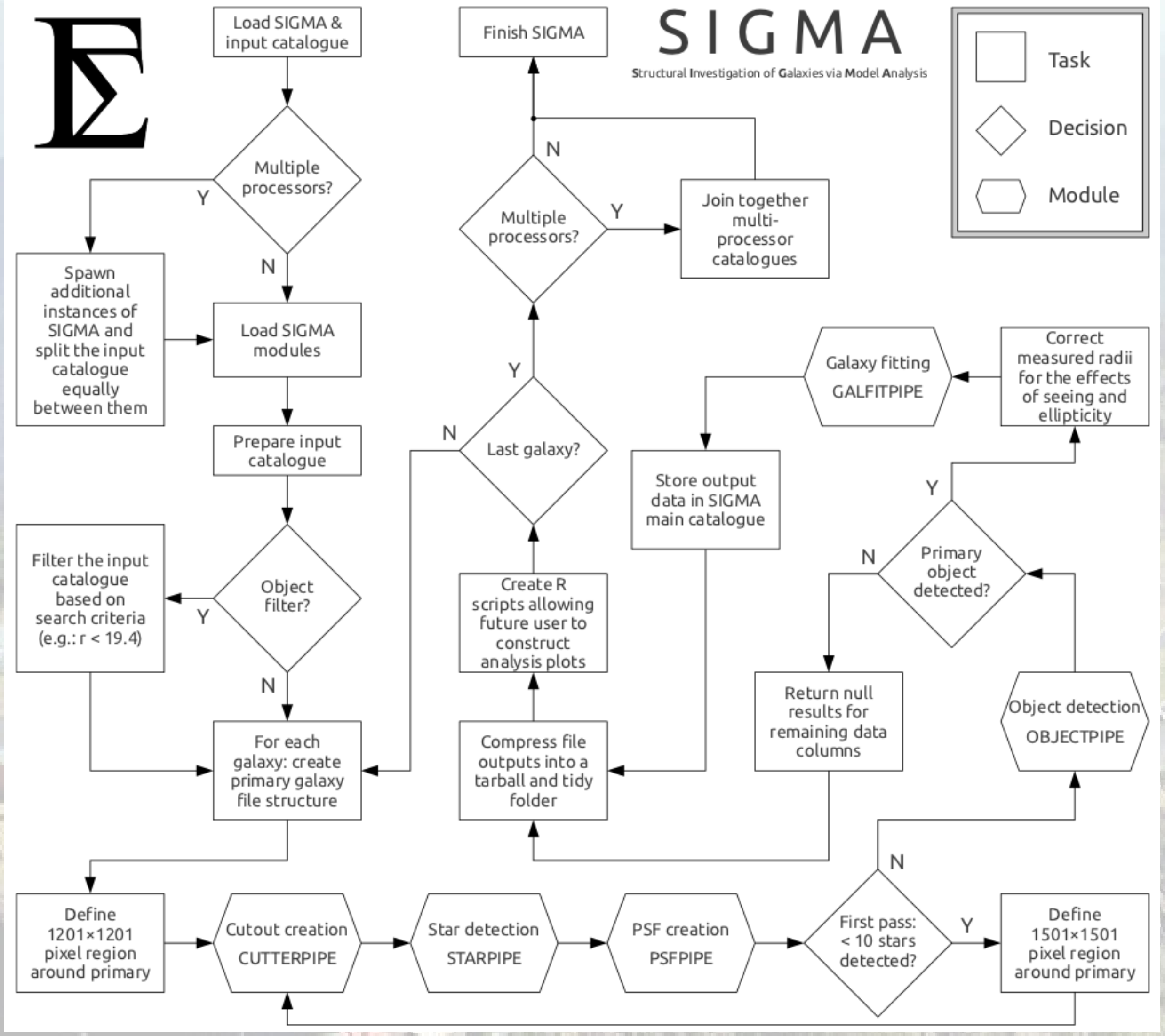
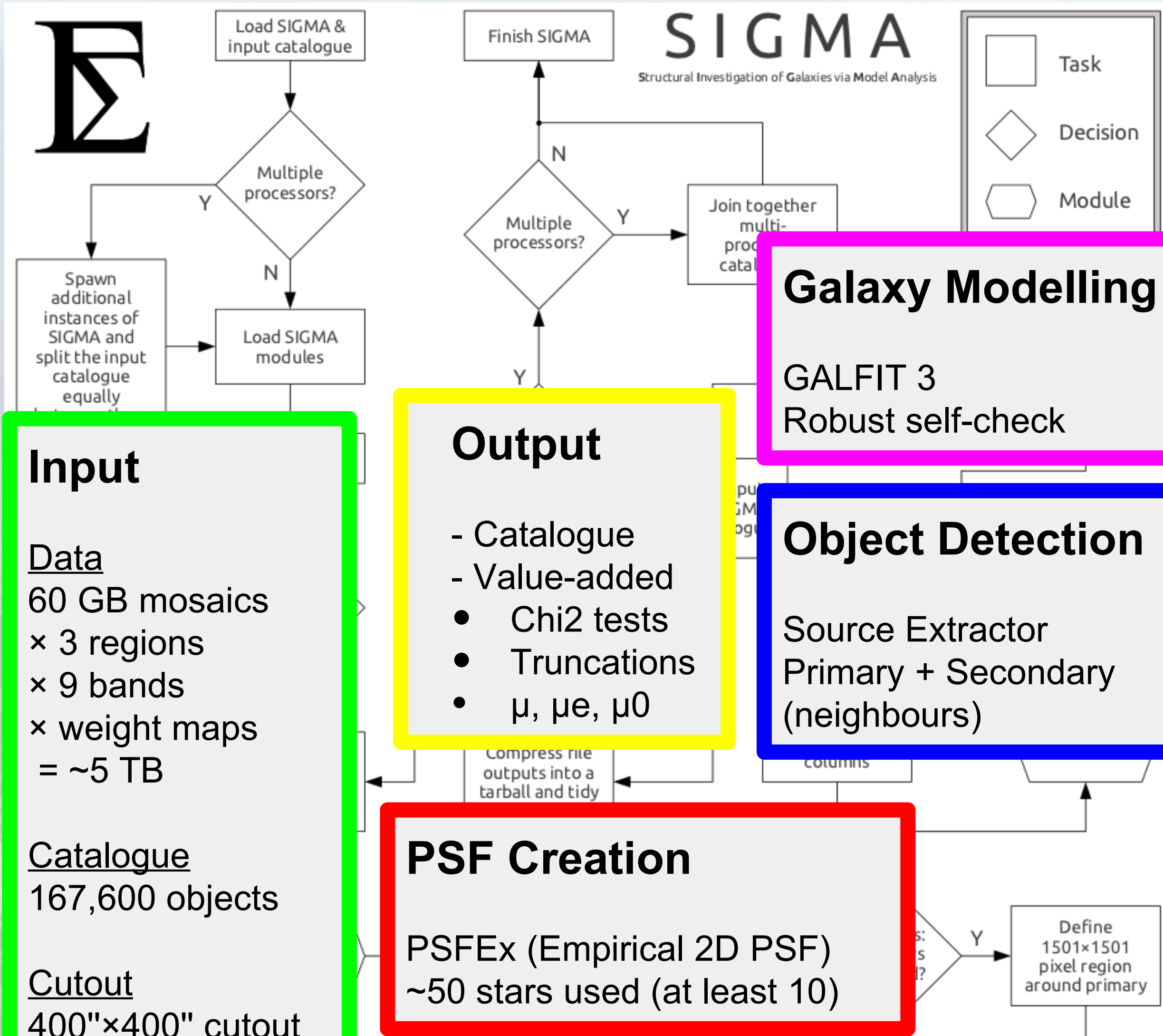
3.4
3.0
2.6
2.3
2.0
1.7
1.5
1.3
1.2
1.0
0.9
0.7
0.4
Residual

SIGMA: Structural Pipeline



SIGMA: Structural Pipeline



Input

Data
60 GB mosaics
× 3 regions
× 9 bands
× weight maps
= ~5 TB

Catalogue
167,600 objects

Cutout
400"×400" cutout

Output

- Catalogue
- Value-added
  - Chi2 tests
  - Truncations
  - μ, μe, μ0

Galaxy Modelling

GALFIT 3
Robust self-check

Object Detection

Source Extractor
Primary + Secondary
(neighbours)

PSF Creation

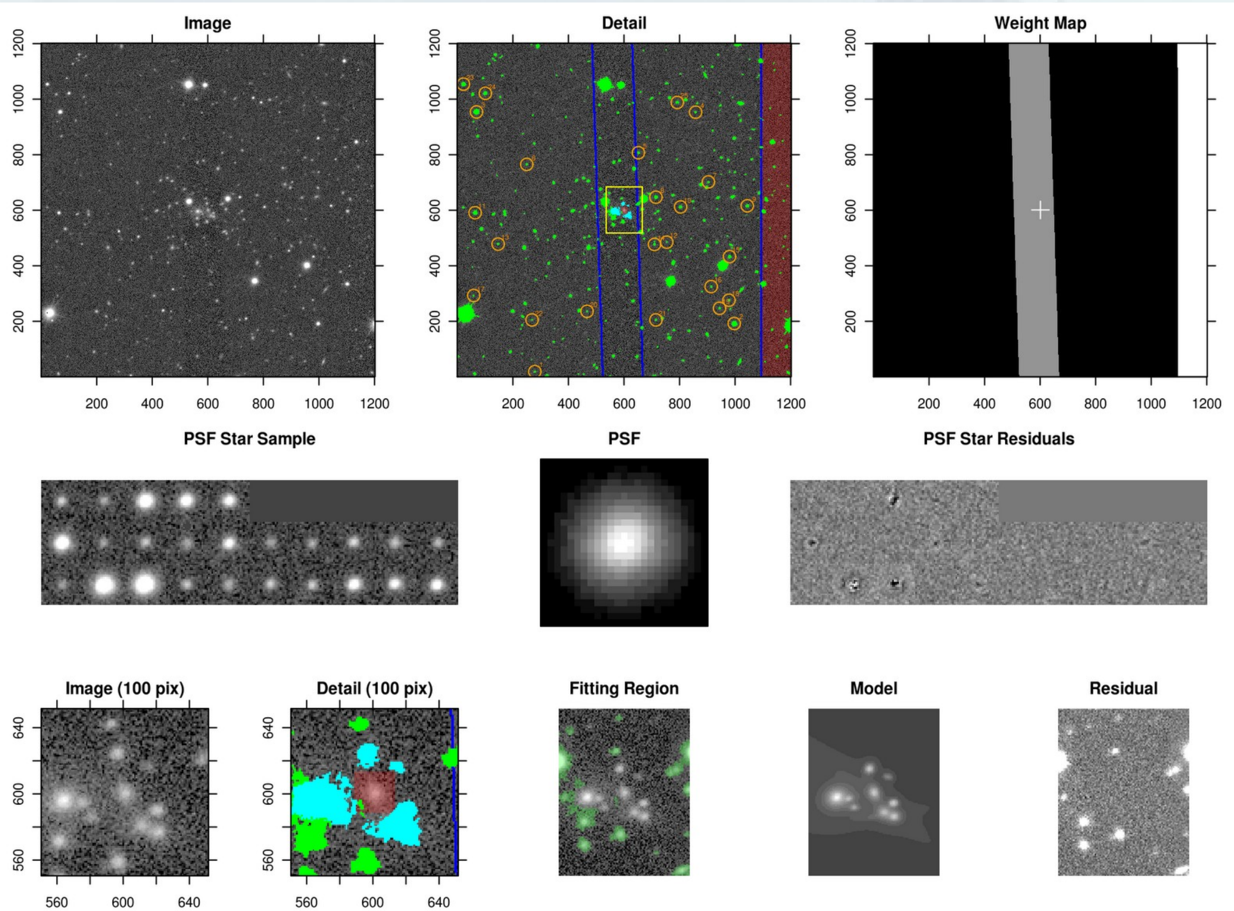
PSFEx (Empirical 2D PSF)
~50 stars used (at least 10)

R Wrapper:
→ Source Extractor
→ PSF Extractor
→ CFITSIO
→ GALFIT 3

Speed:
15 seconds
per galaxy
per passband
per processor

SIGMA

Structural Investigation of Galaxies via Model Analysis



Imaging & Pointing Data

↓

400'' x 400'' cutout

Star identification

Empirical PSF

Galaxy detection

Sérsic modelling

Model self-check

Value added results

↓

Model Fit Parameters

SExtractor
Bertin+ 1996

PSFEx
Bertin 2011

GALFIT3
Peng+ 2010

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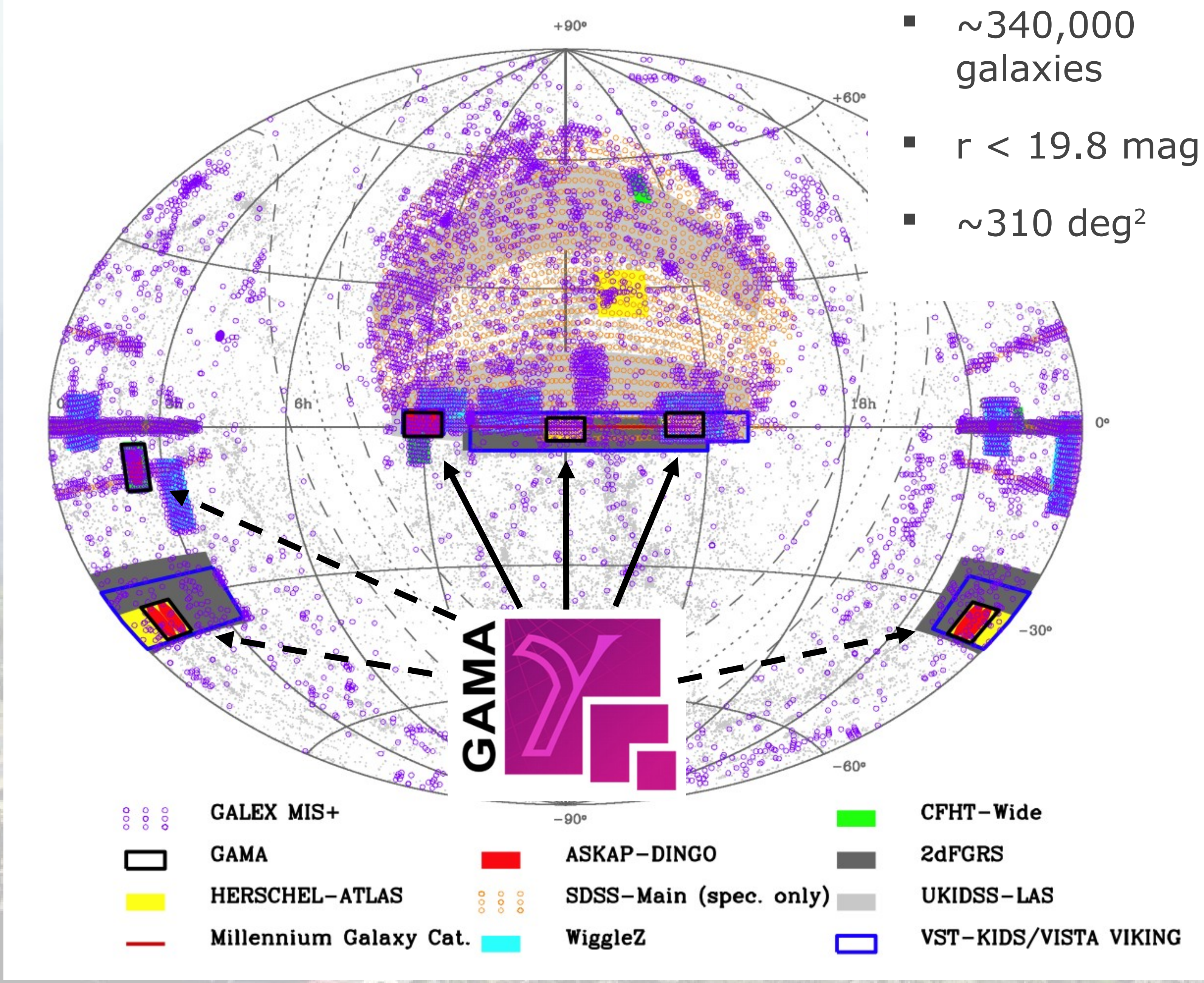

- ~340,000 galaxies
- r < 19.8 mag
- ~310 deg^2