

MEGAMORPH

Measuring messy galaxies with a non-parametric component

Steven Bamford

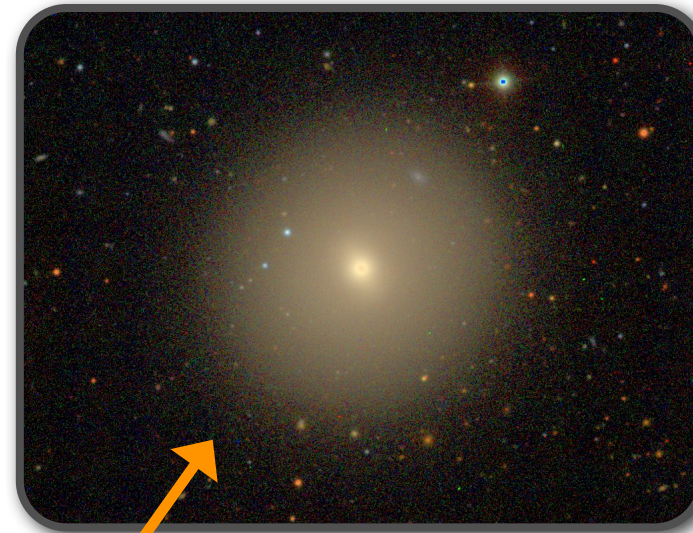
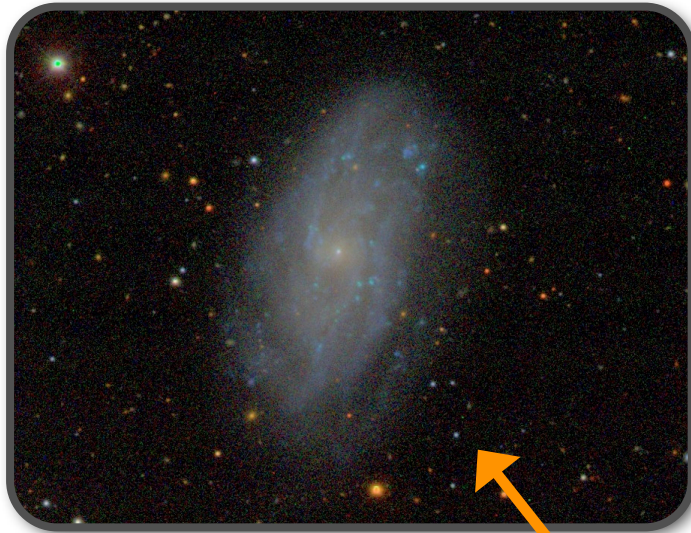
Marina Vika, Boris Häußler, Alex Rojas



The University of
Nottingham



Two distinct components



MEGAMORPH

disks

spheroids



MEGAMORPH

More **meaningful** profile fits
to galaxies in very **large**
imaging surveys

MEGAMORPH

Making being **reckless**
more **reliable**

A deep-field astronomical image showing a large, diffuse galaxy with a bright, yellowish-white central core. The galaxy is surrounded by a vast field of smaller, distant stars and galaxies, creating a rich, multi-colored star field. The colors range from bright yellow and white to deep blues and reds. The text "Galaxies are simple" is overlaid in the center in a bold, white, sans-serif font.

Galaxies are simple

Galaxies are simple

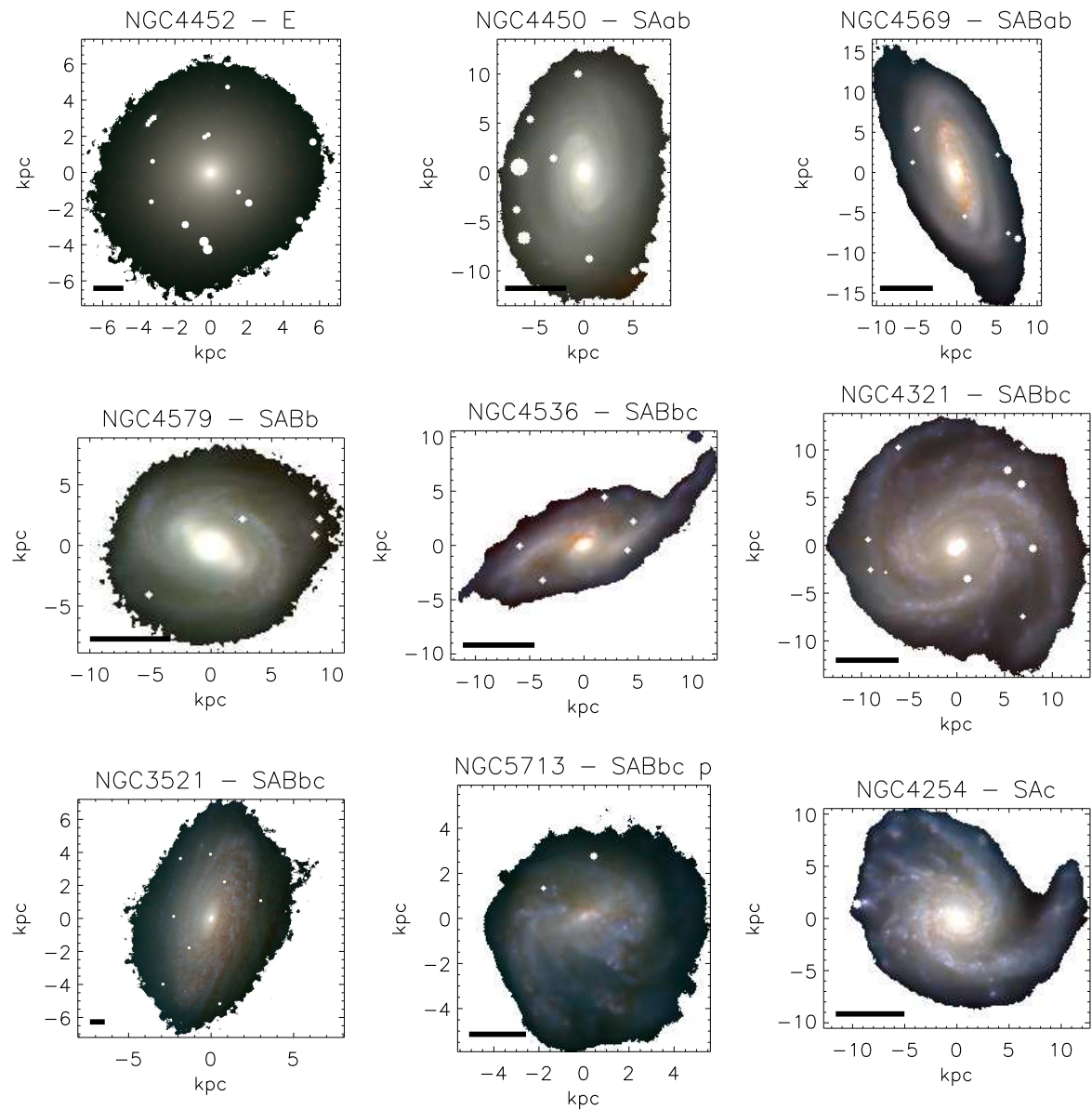


Sérsic profiles still work well

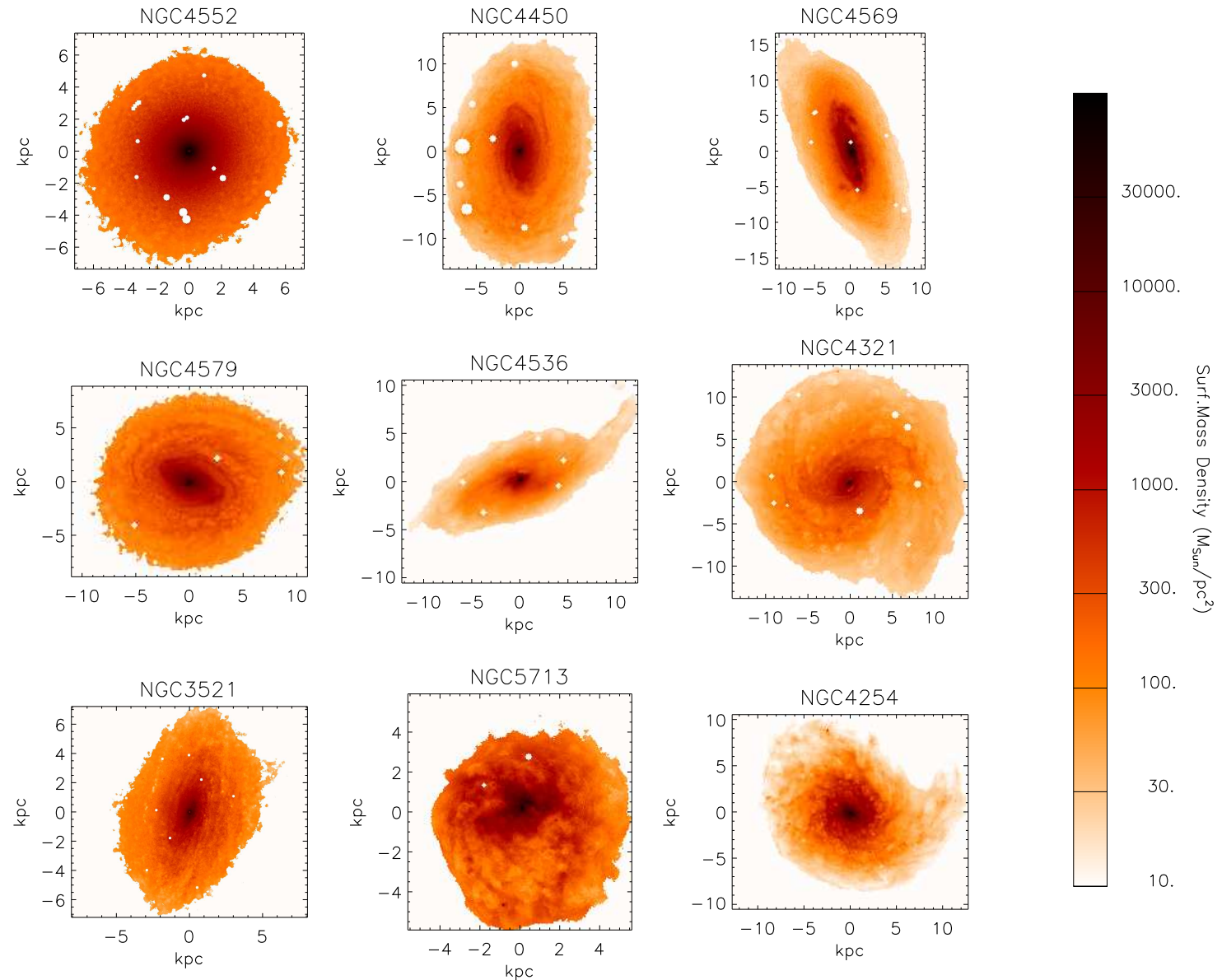
The image shows a dark, grainy astronomical field, likely a galaxy cluster. The background is black with numerous small, multi-colored stars (yellow, orange, red, blue, white) scattered throughout. A faint, diffuse blueish-white glow is visible in the center, suggesting a galaxy core or a region of high star formation. Overlaid on this scene is the text "Galaxies are messy" in a bold, white, sans-serif font with a slight drop shadow.

Galaxies are messy

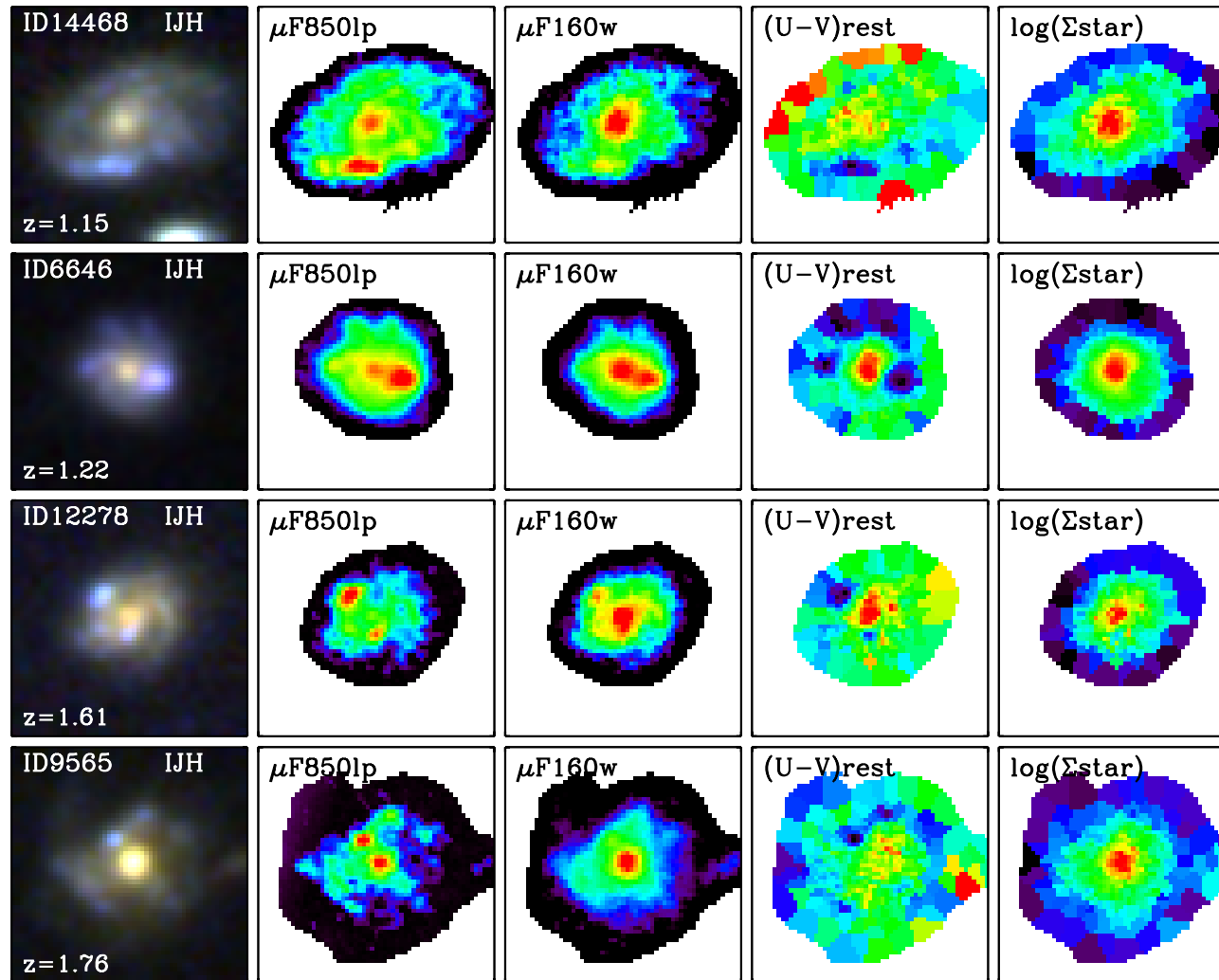
Messiness is in M/L



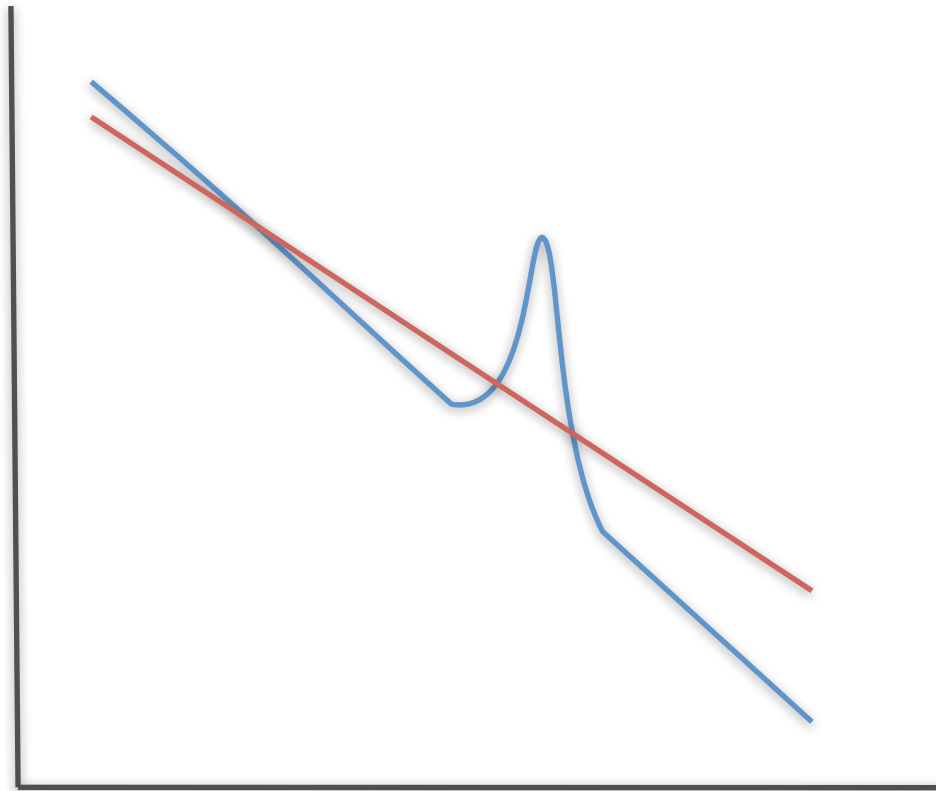
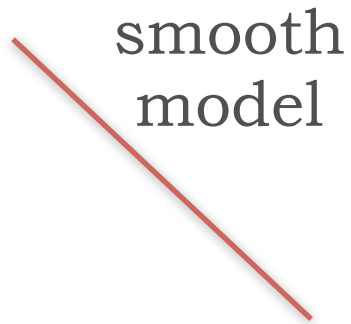
Messiness is in M/L



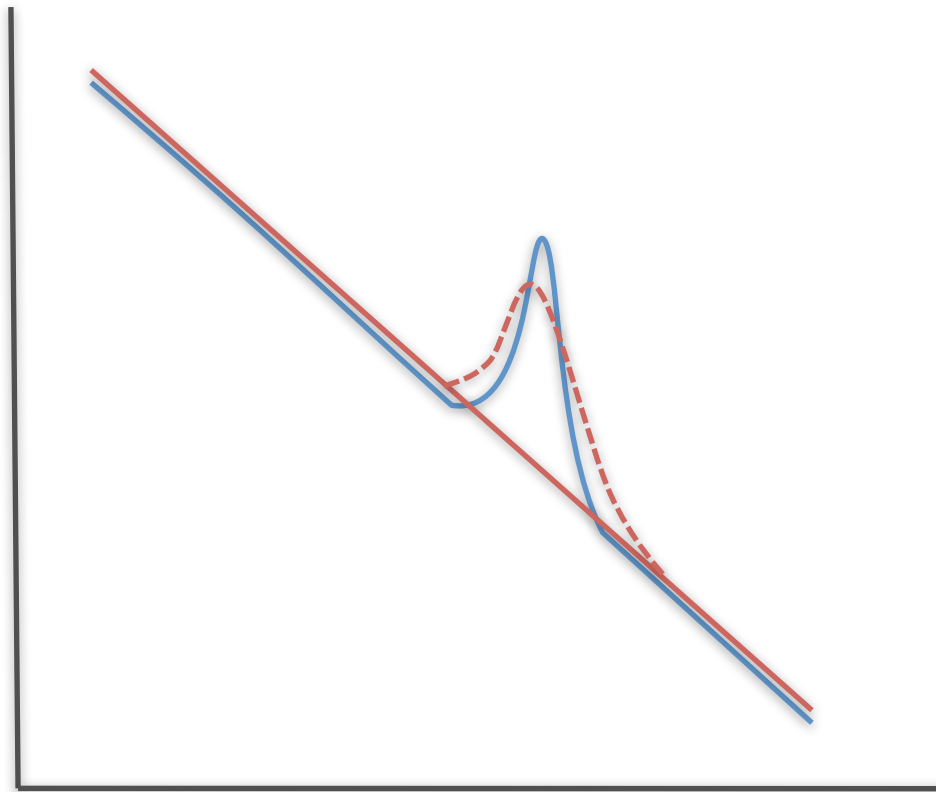
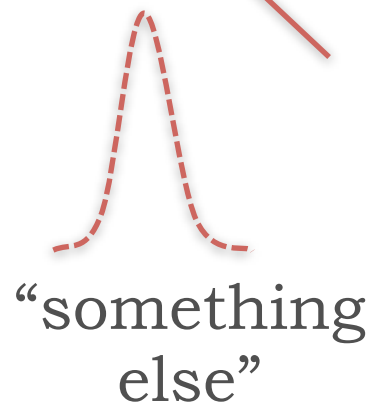
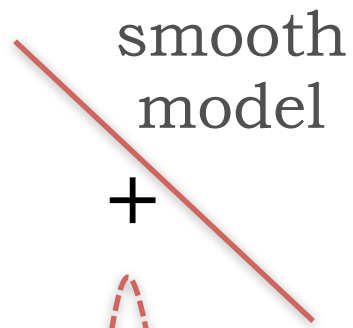
Messiness is in M/L



What can we do?



What can we do?

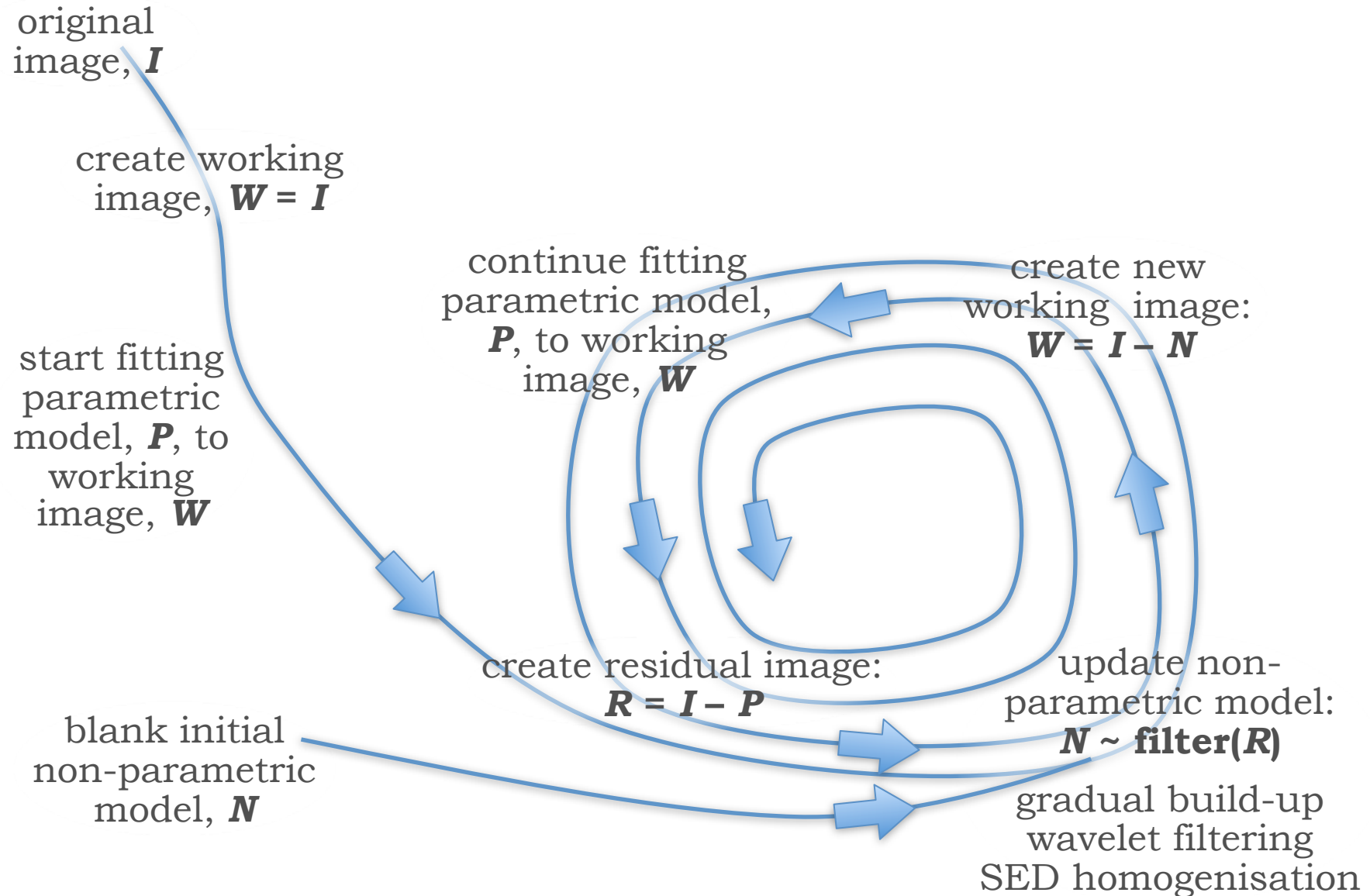




**Dust and wider wavelengths...
not yet.**

3D radiative
transfer models
– *but still smooth*

Non-parametric components



Non-parametric components

Tunable parameters:

- schedule for build-up of non-parametric image
- wavelet filtering threshold
- SED homogenisation on/off

Reasonable defaults.

Multi-band

Optional SED homogenisation



GALFITM input file

```
=====
# IMAGE and GALFIT CONTROL PARAMETERS
A) sersicexp3n.fits          # Input data image (FITS file)
B) imgblock3.fits          # Output data image block
C) none                     # Sigma image name (made from data if blank or "none")
D) none #                   # Input PSF image and (optional) diffusion kernel
E) 1                        # PSF fine sampling factor relative to data
F) none                     # Bad pixel mask (FITS image or ASCII coord list)
G) none                     # File with parameter constraints (ASCII file)
H) 1 300 1 300             # Image region to fit (xmin xmax ymin ymax)
I) 300 300                 # Size of the convolution box (x y)
J) 30.0                    # Magnitude photometric zeropoint
K) 1.0 1.0                 # Plate scale (dx dy) [arcsec per pixel]
O) regular                 # Display type (regular, curses, both)
P) 0                       # Choose: 0=optimize, 1=model, 2=imgblock, 3=subcomps

#
# INITIAL FITTING PARAMETERS
#
# For object type, the allowed functions are:
#   nuker, sersic, expdisk, devauc, king, psf, gaussian, moffat,
#   ferrer, powersersic, sky, and isophote.
#
# Hidden parameters will only appear when they're specified:
#   C0 (diskyness/boxyness),
#   Fn (n=integer, Azimuthal Fourier Modes),
#   R0-R10 (PA rotation, for creating spiral structures).
#
# -----
#   par)      par value(s)   fit toggle(s)   # parameter description
# -----

# Object number: 1
0) sersic          # object type
1) 150.0 150.0 1 1 # position x, y
3) 15.0           1      # Integrated magnitude
4) 30.0           1      # R_e (half-light radius) [pix]
5) 2.0            1      # Sersic index n (de Vaucouleurs n=4)
```



GALFITM input file

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=====
# IMAGE and GALFIT CONTROL PARAMETERS
A) sersicexp3n.fits      # Input data image (FITS file)
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J) 30.0               # Magnitude photometric zeropoint
K) 1.0  1.0          # Plate scale (dx dy) [arcsec per pixel]
O) regular            # Display type (regular, curses, both)
P) 0                  # Choose: 0=optimize, 1=model, 2=imgblock, 3=subcomps
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#-----

# Object number: 1
0) sersic      # object type
1) 150.0  150.0  1 1  # position x, y
3) 15.0        1      # Integrated magnitude
4) 30.0        1      # R_e (half-light radius) [pix]
5) 2.0         1      # Sersic index n (de Vaucouleurs n=4)
```



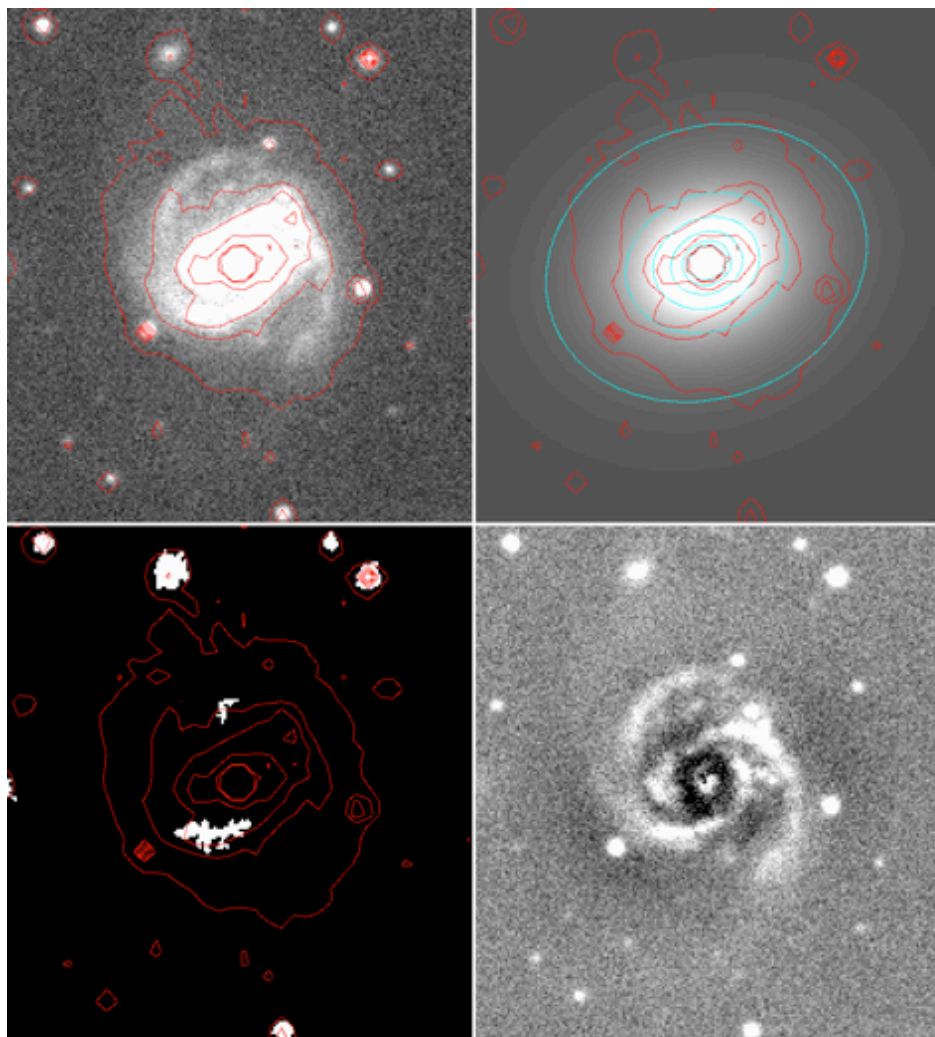
Some specific examples

Using a non-parametric
component to remove
spiral arms

SED homogenisation on

data

standard model



mask

standard residuals

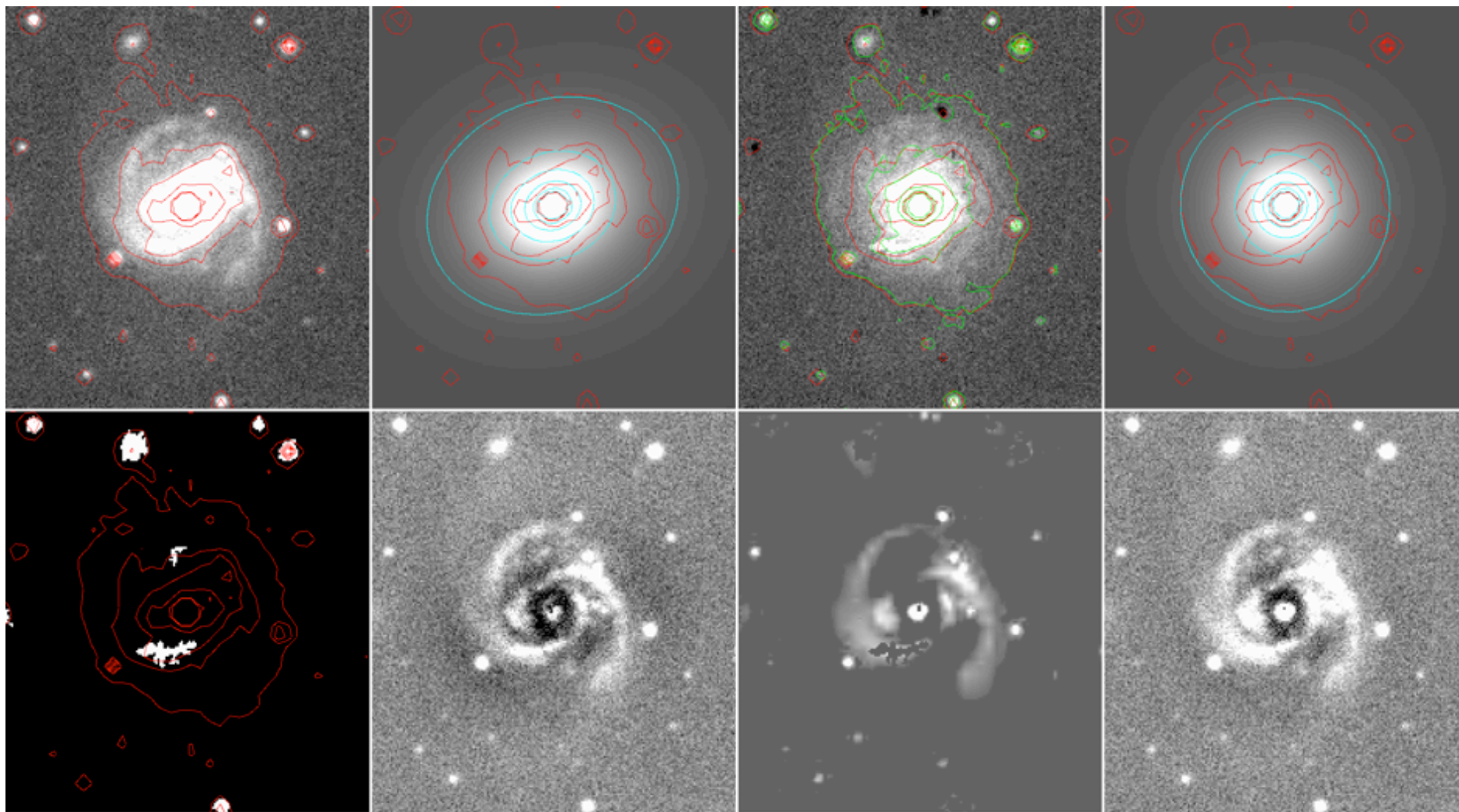
NGC 4321 SDSS *r*-band @ $z=0.05$

data

standard model

data - nonparam

non-param model



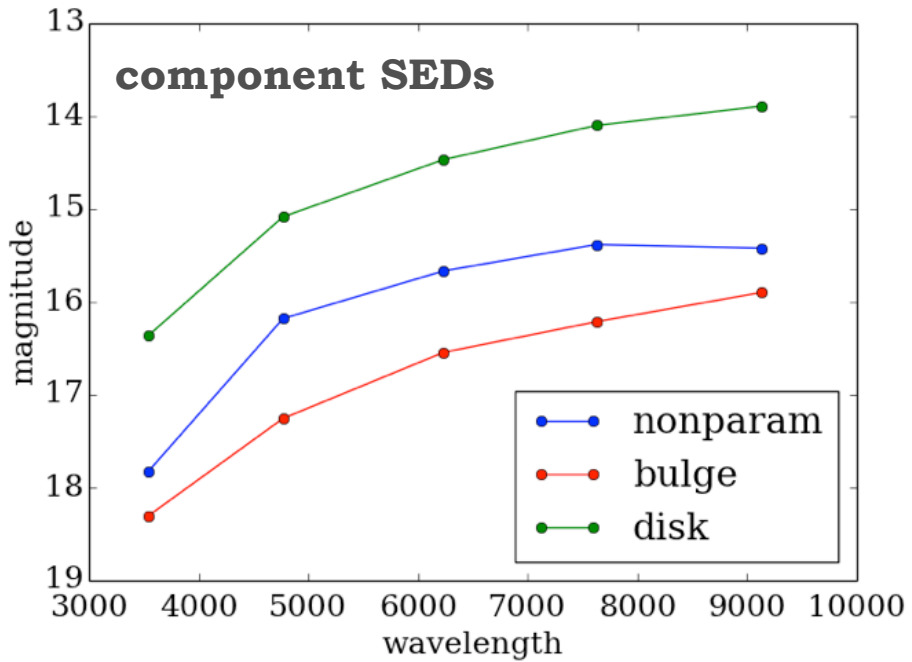
mask

standard residuals

nonparam image

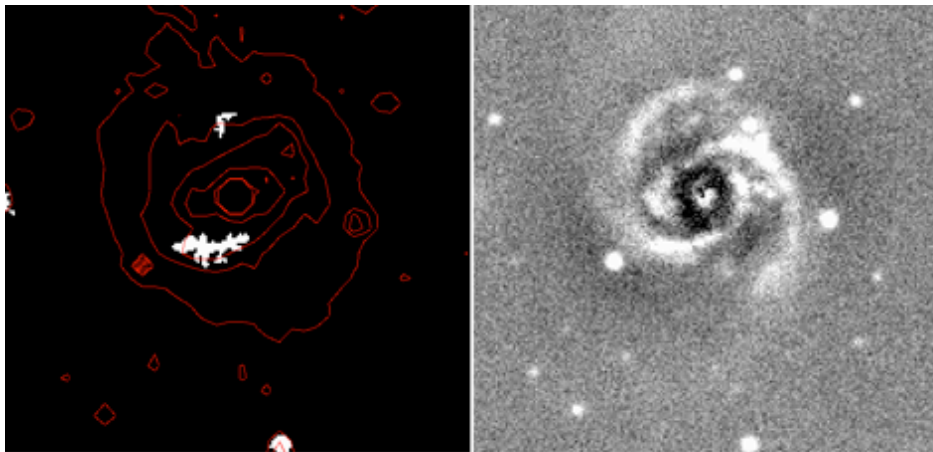
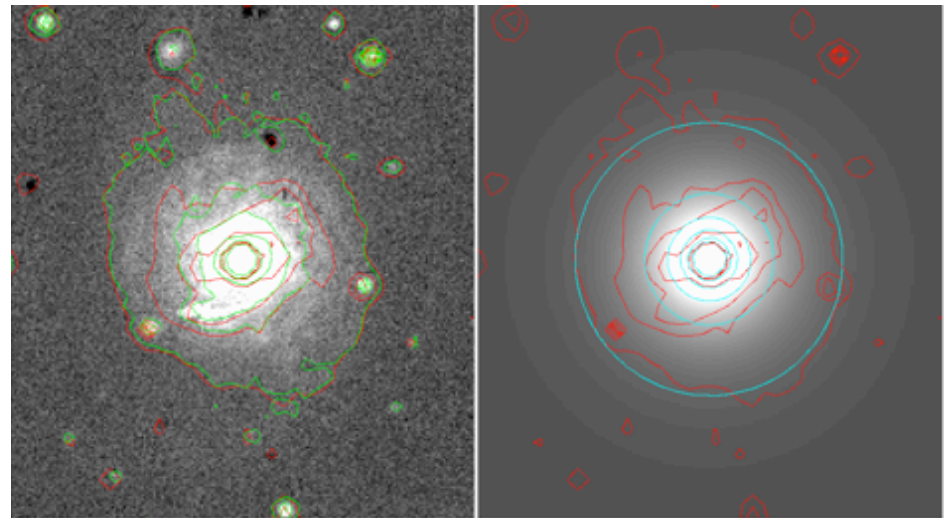
nonparam residuals

NGC 4321 SDSS *r*-band @ $z=0.05$



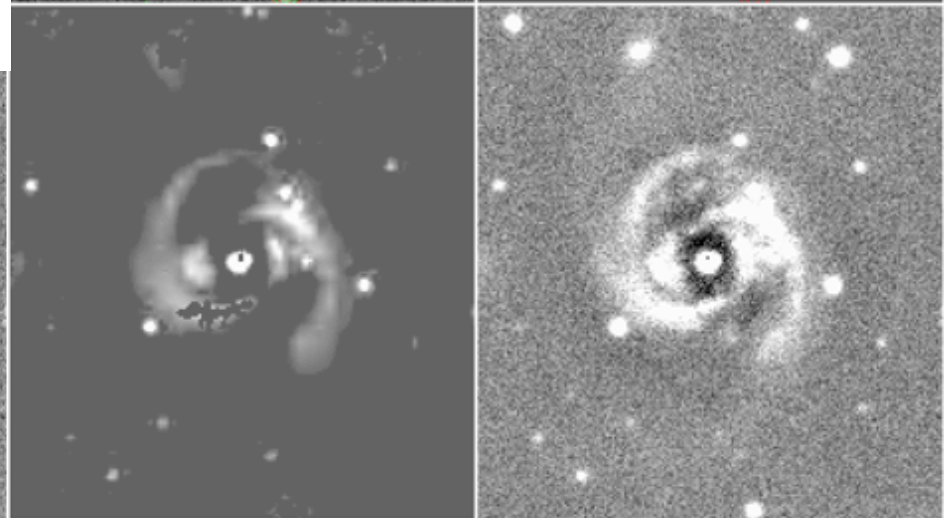
data - nonparam

non-param model



mask

standard residuals



nonparam image

nonparam residuals

NGC 4321 SDSS *r*-band @ $z=0.05$

Specific examples

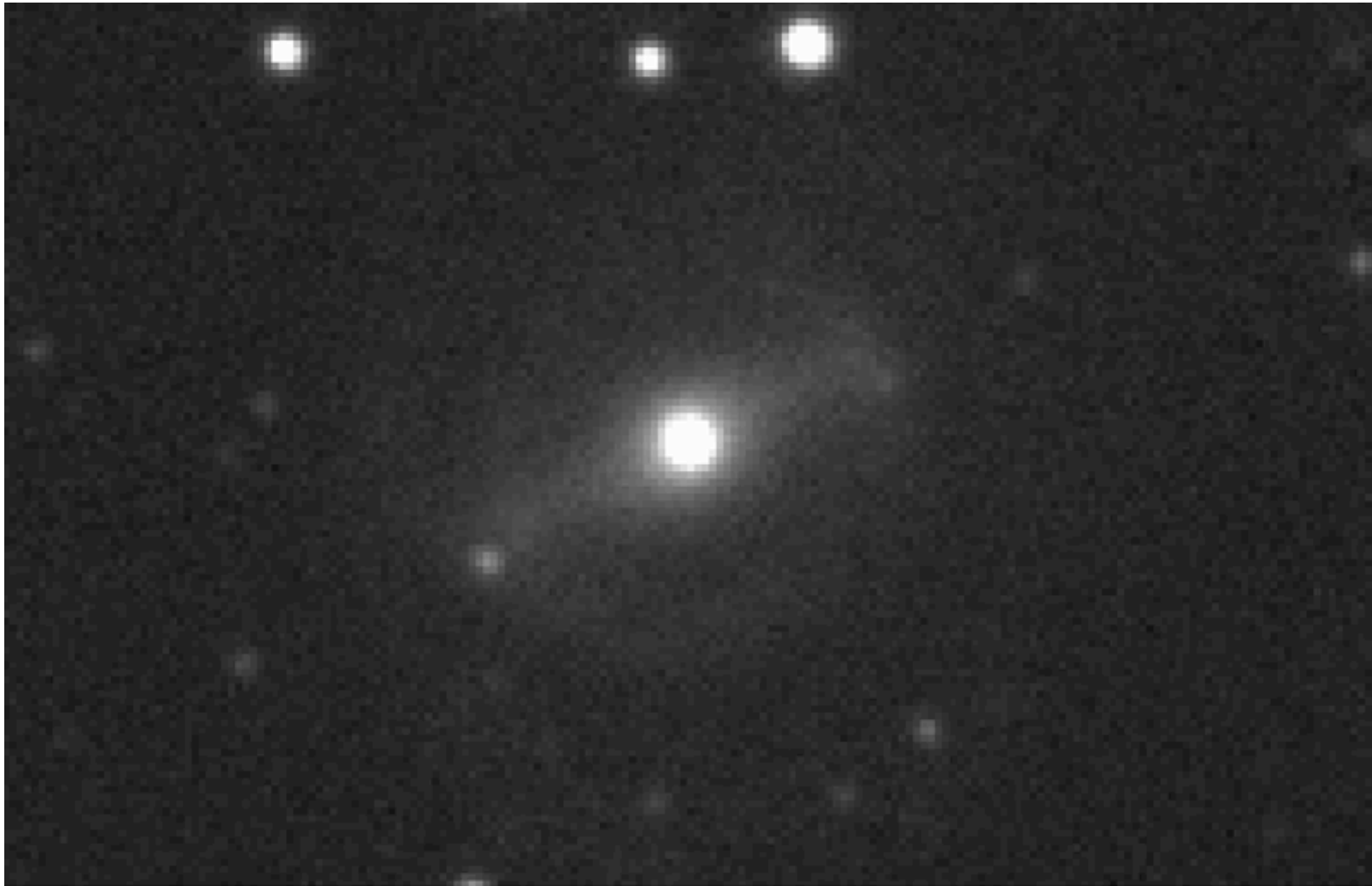
Using a non-parametric component to remove bar features and other oddities

SED homogenisation on



NGC 5850 SDSS *r*-band

original data - intermediate scale



NGC 5850 SDSS *r*-band @ $z=0.05$

artificially-redshifted data



nonparametric image



NGC 5850 SDSS *r*-band

original data - faint scale



NGC 5850 SDSS *r*-band

original data - intermediate scale



NGC 5850 SDSS *r*-band

original data - bright scale



NGC 5850 SDSS *r*-band

original data - bright scale - zoom



NGC 5850 SDSS *r*-band

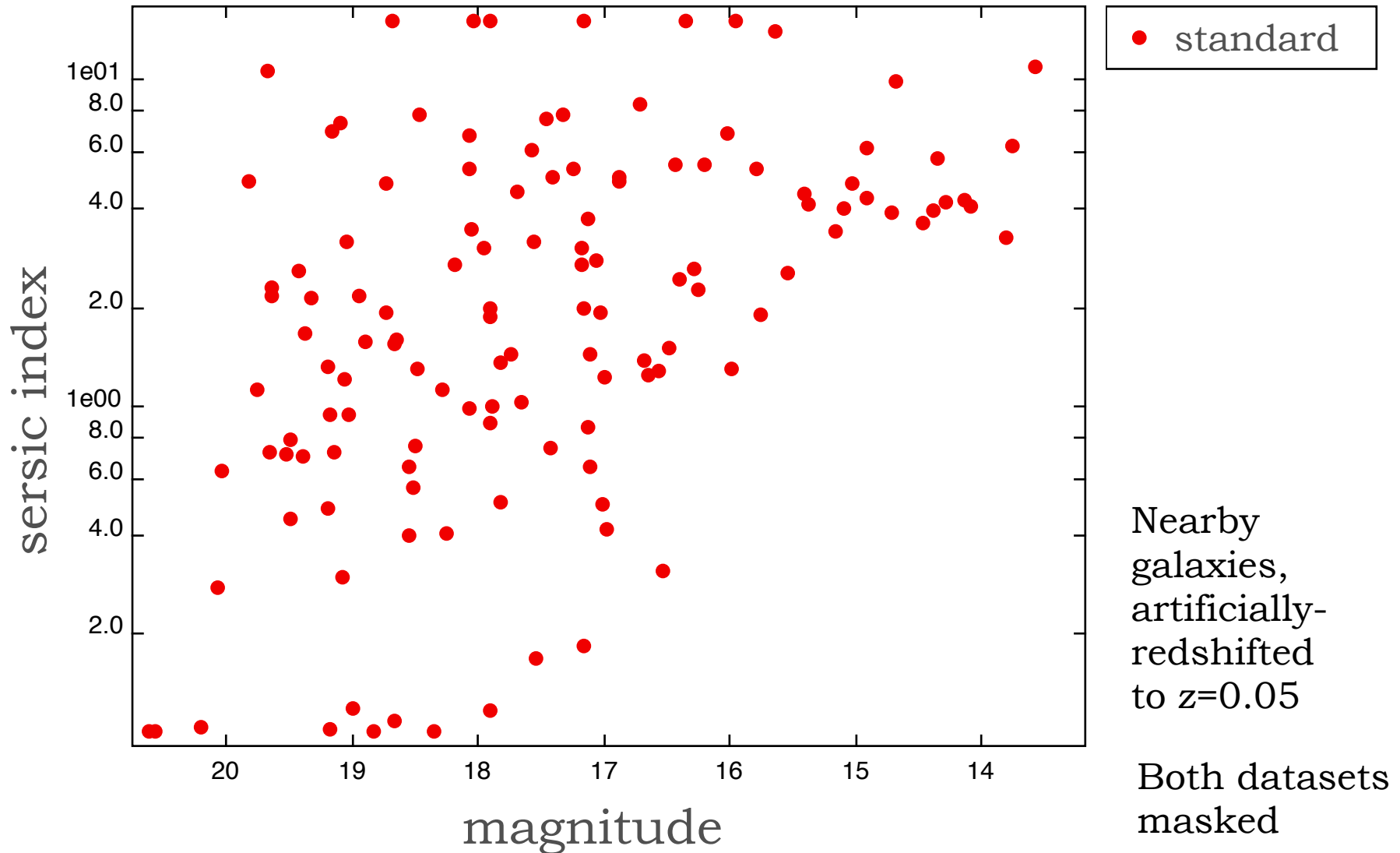
nonparametric image - zoom

General parameter improvement

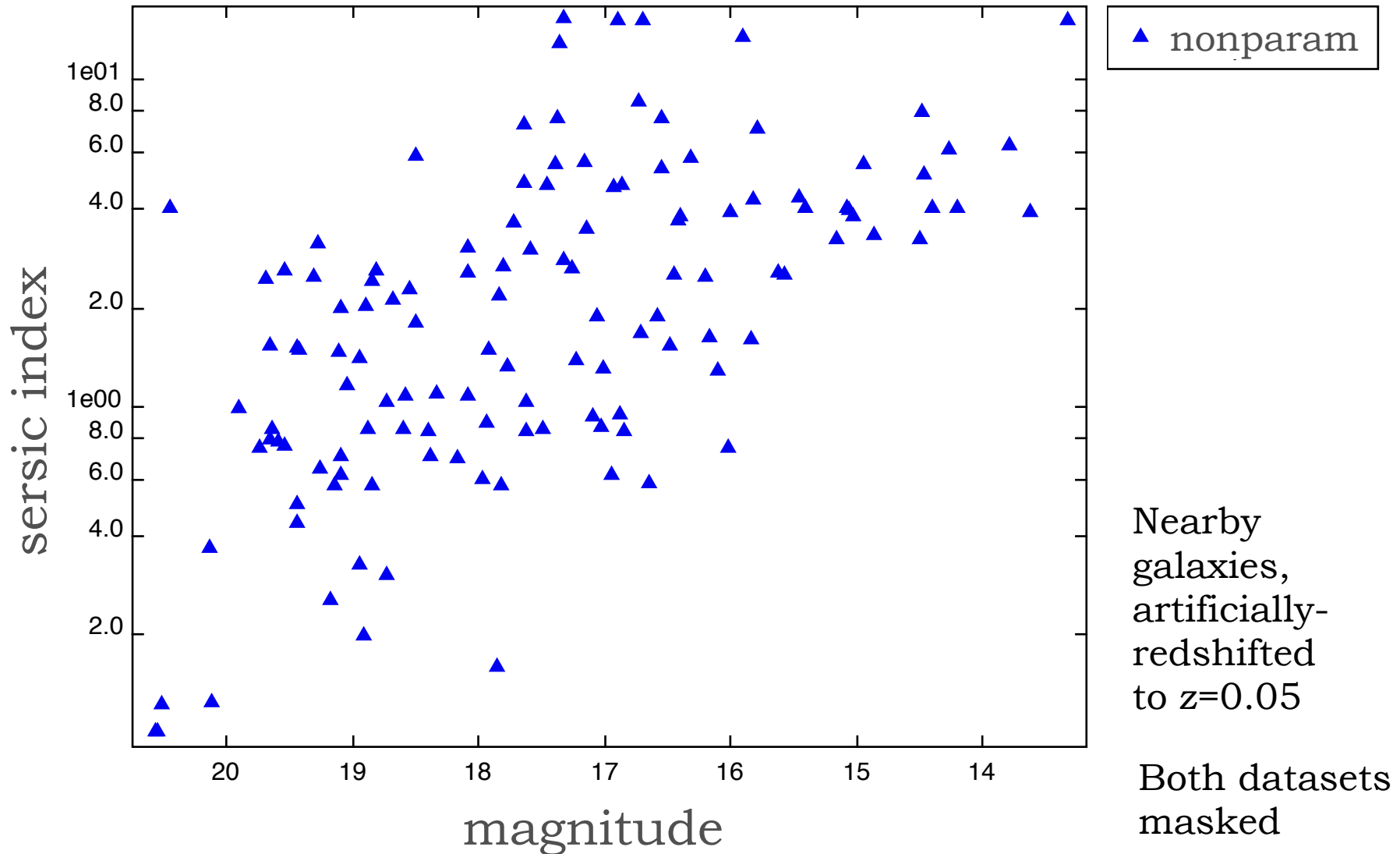
Standard versus
non-parametric

SED homogenisation on

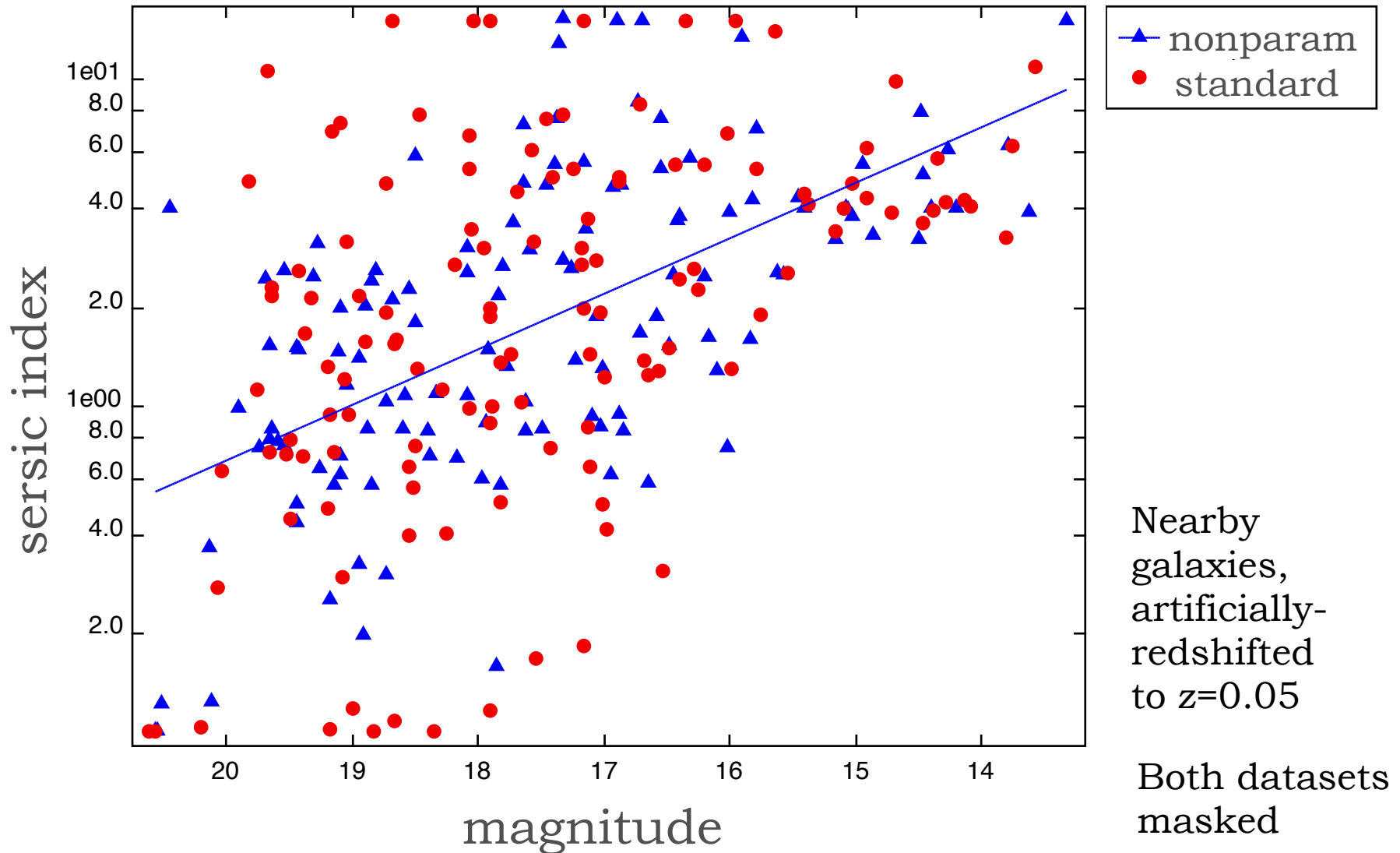
General parameter improvement



General parameter improvement



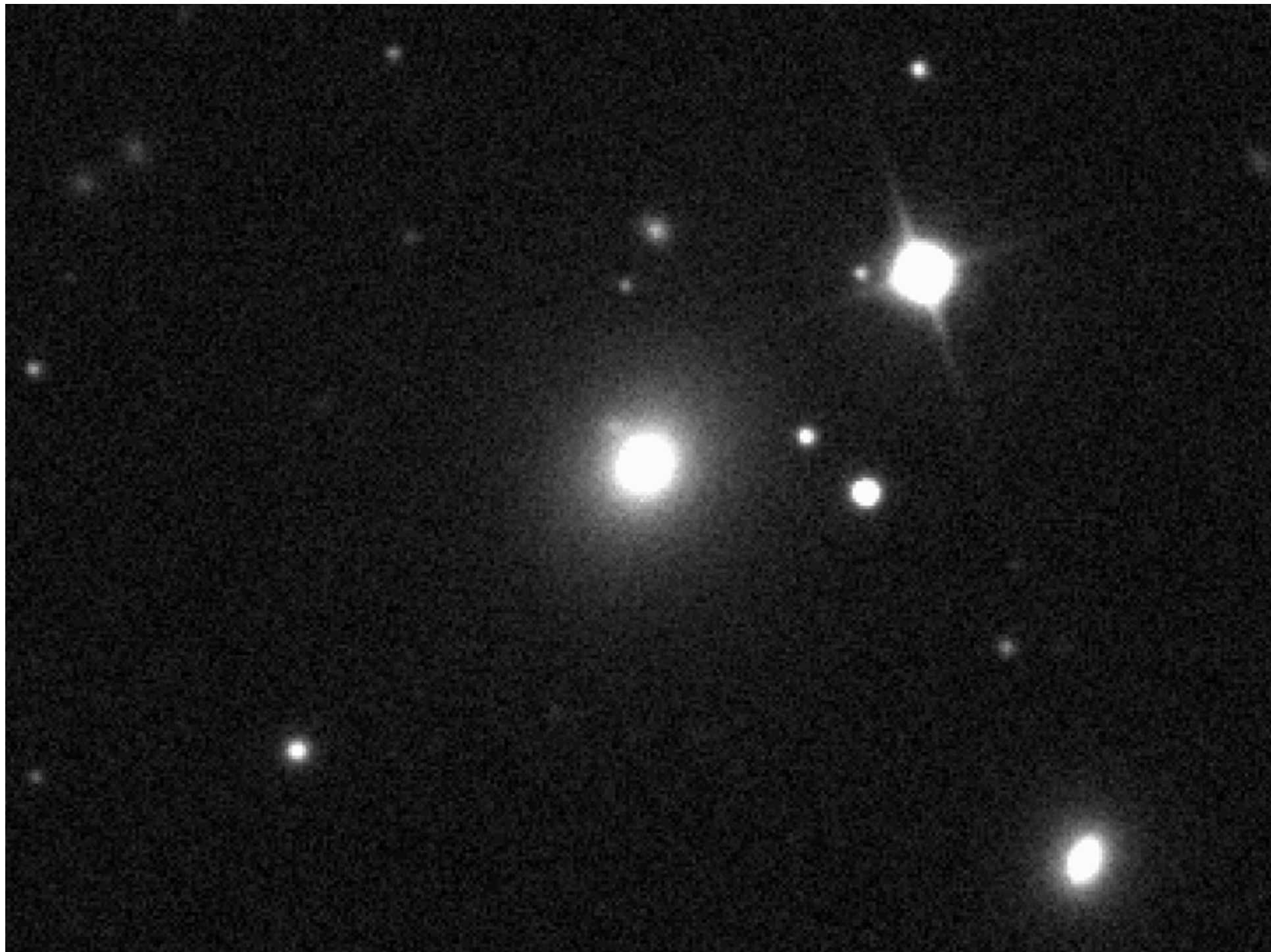
General parameter improvement

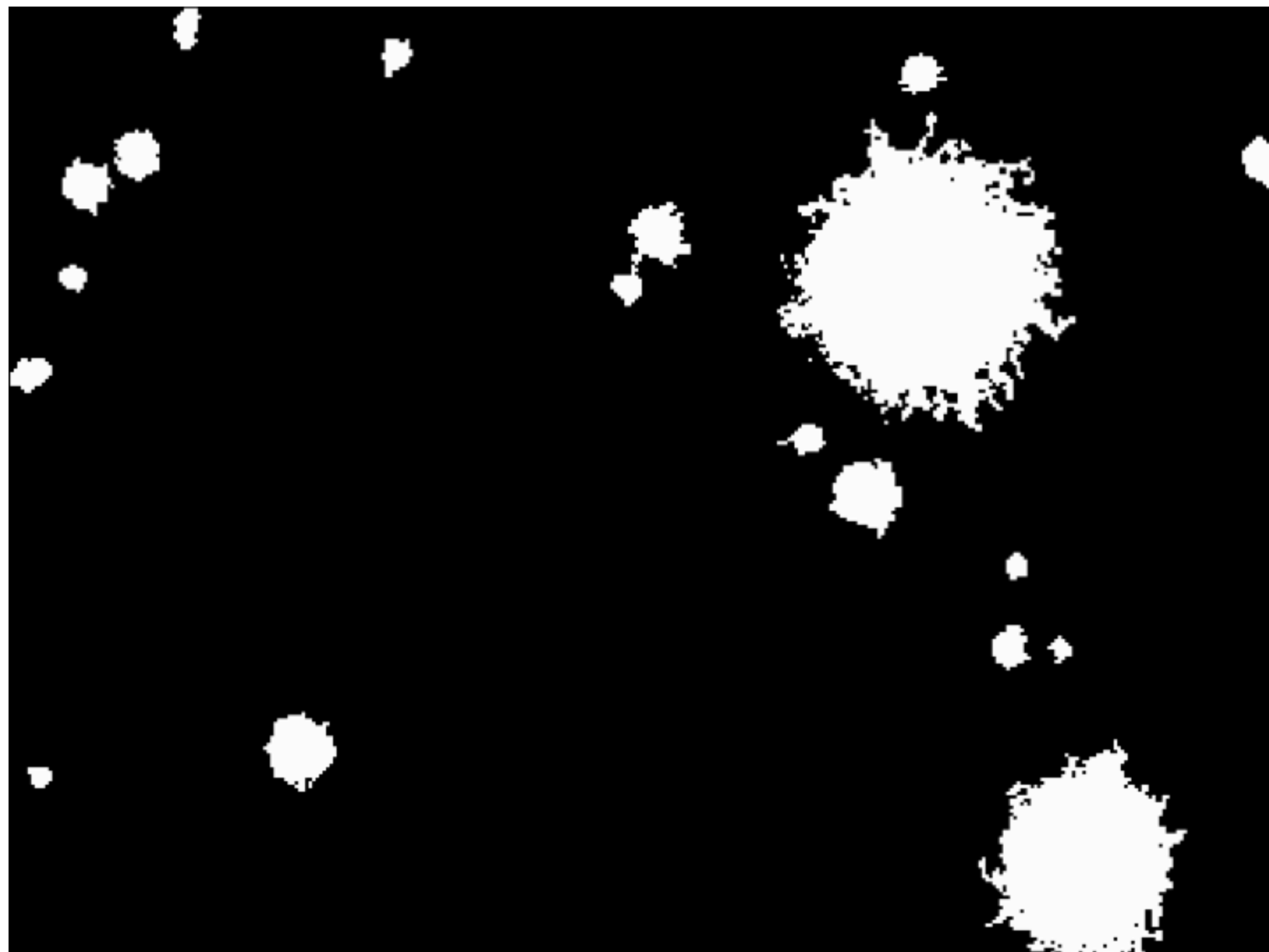


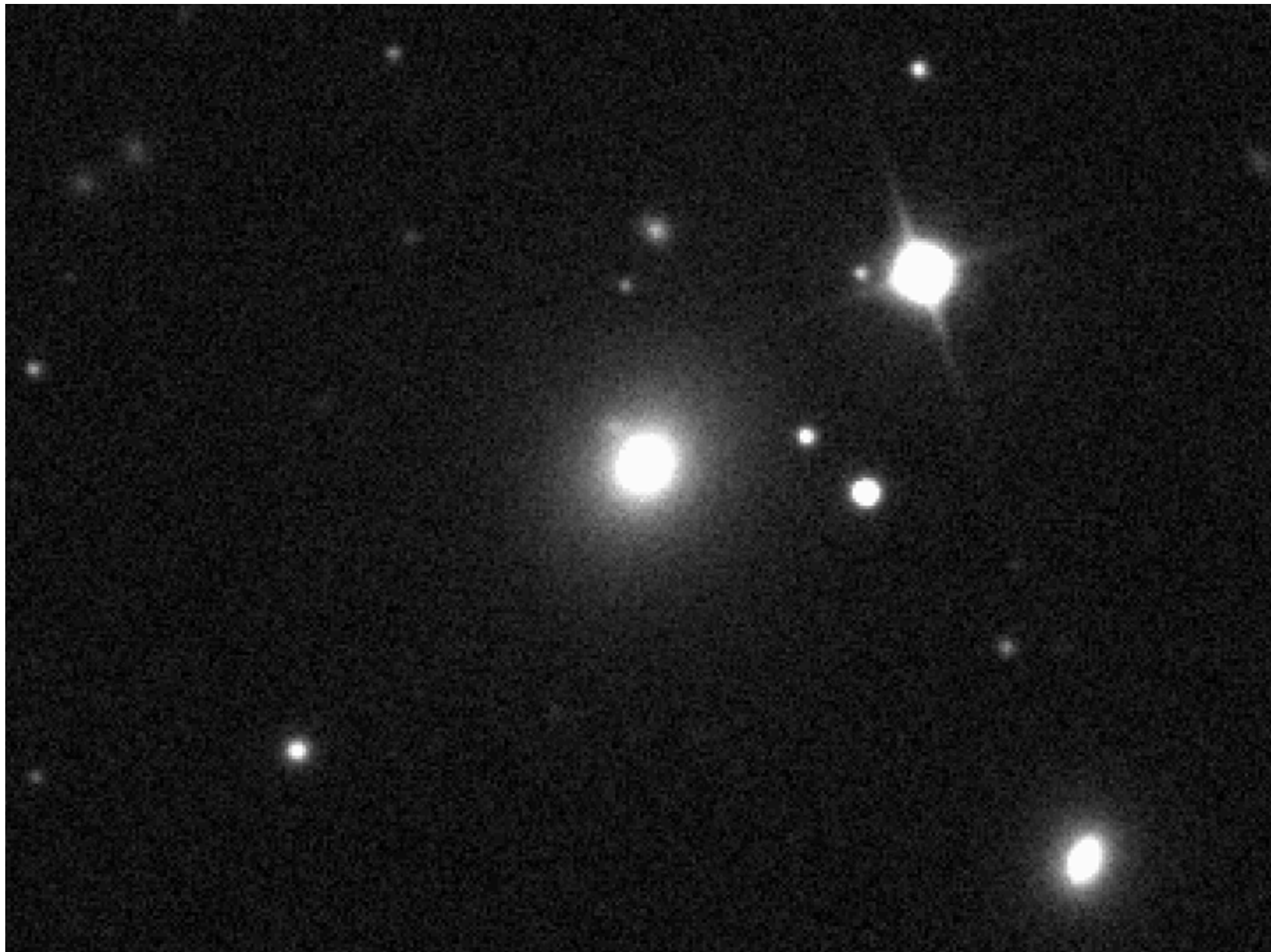
Specific examples

Using a non-parametric
component instead of
masking neighbours

SED homogenisation off







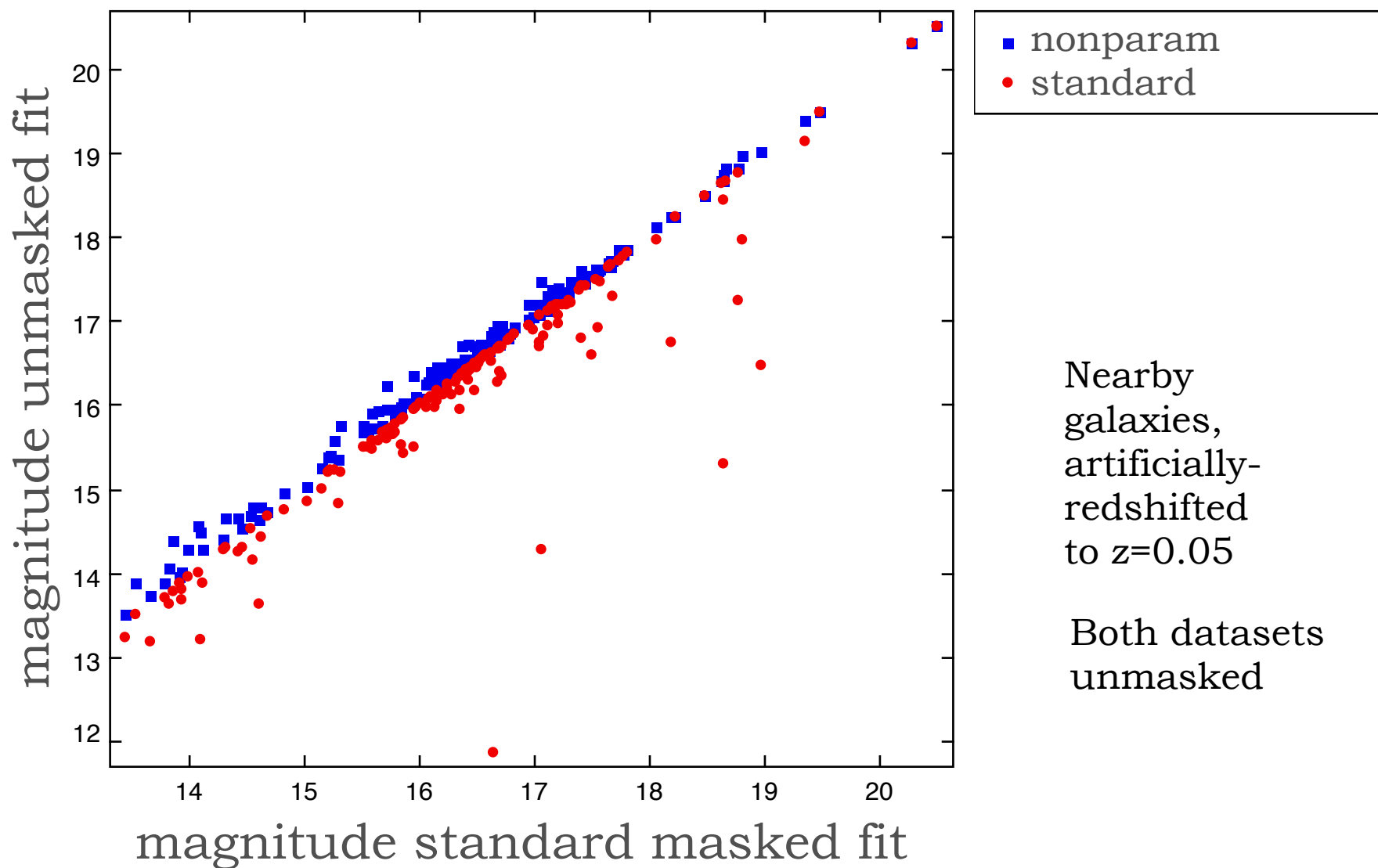


General parameter improvement

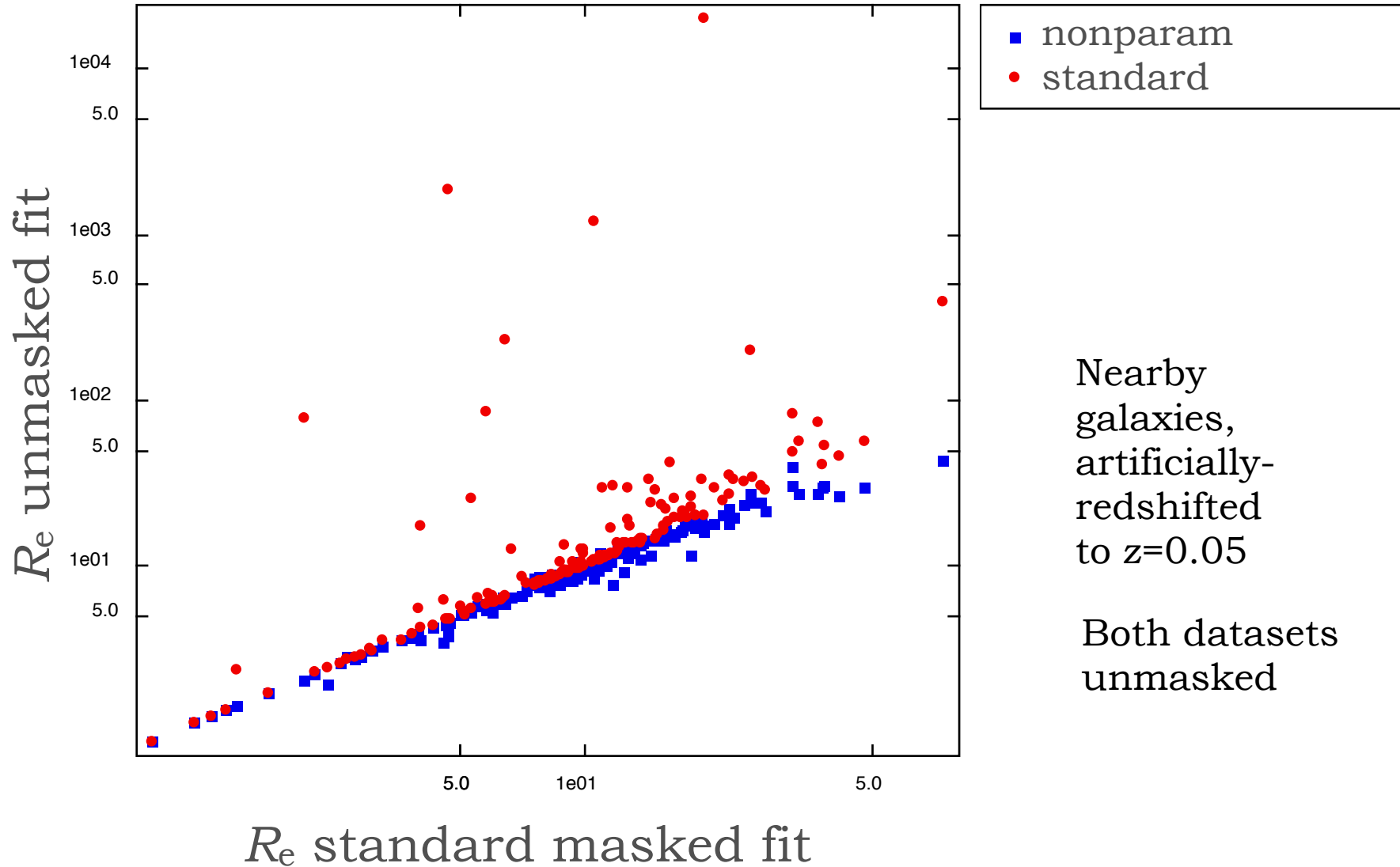
Non-parametric as
alternative to masking

SED homogenisation off

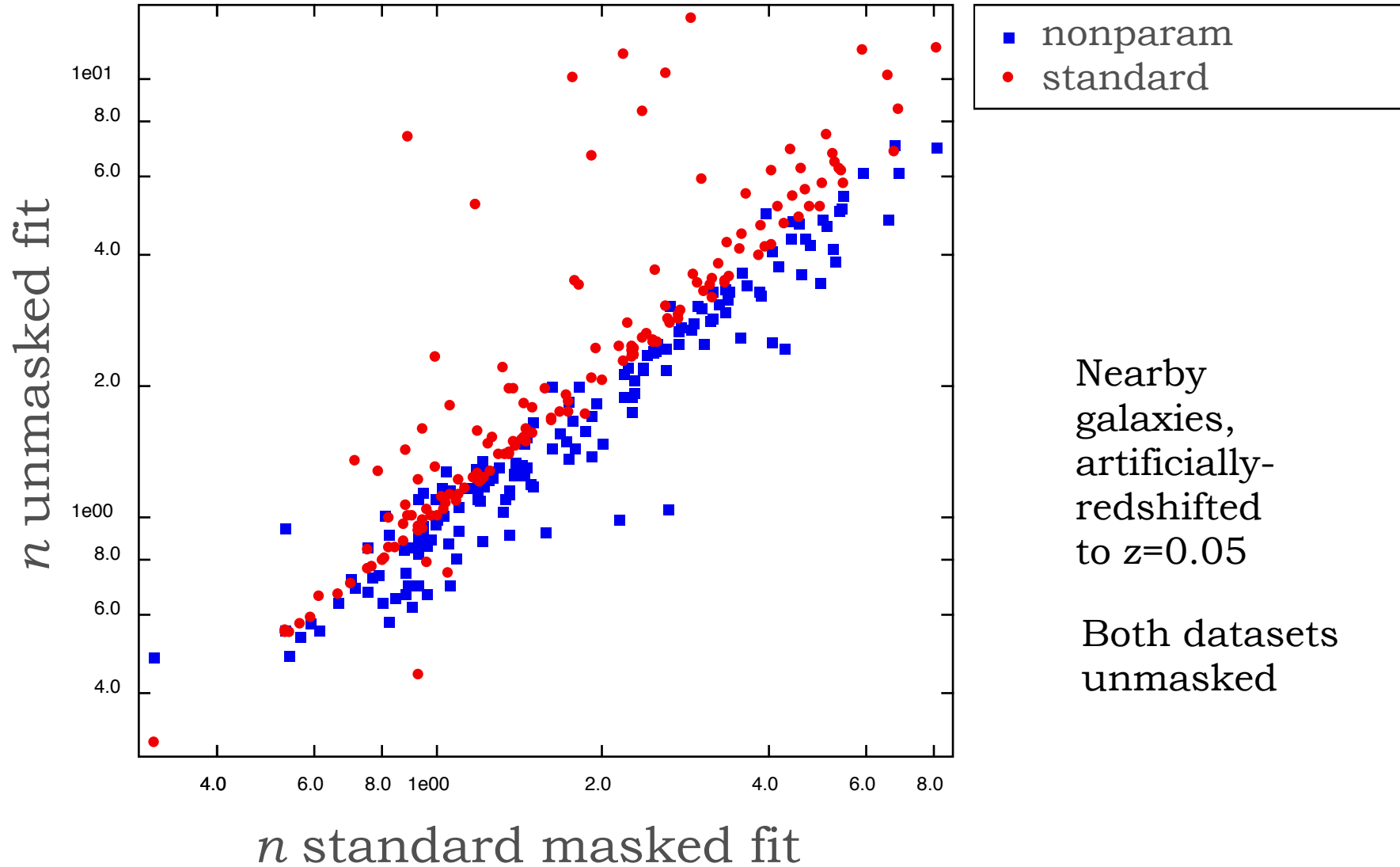
General parameter improvement



General parameter improvement



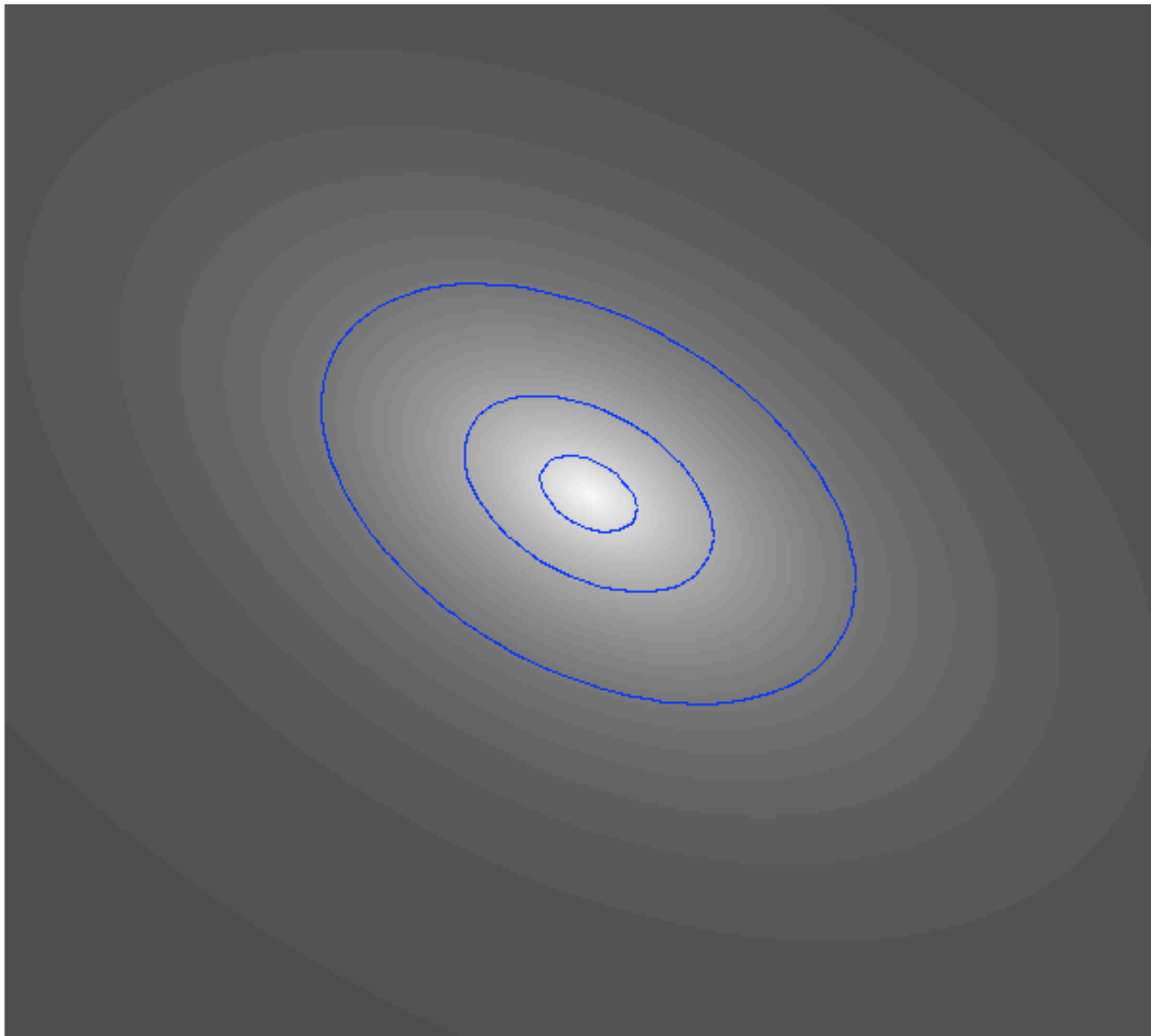
General parameter improvement



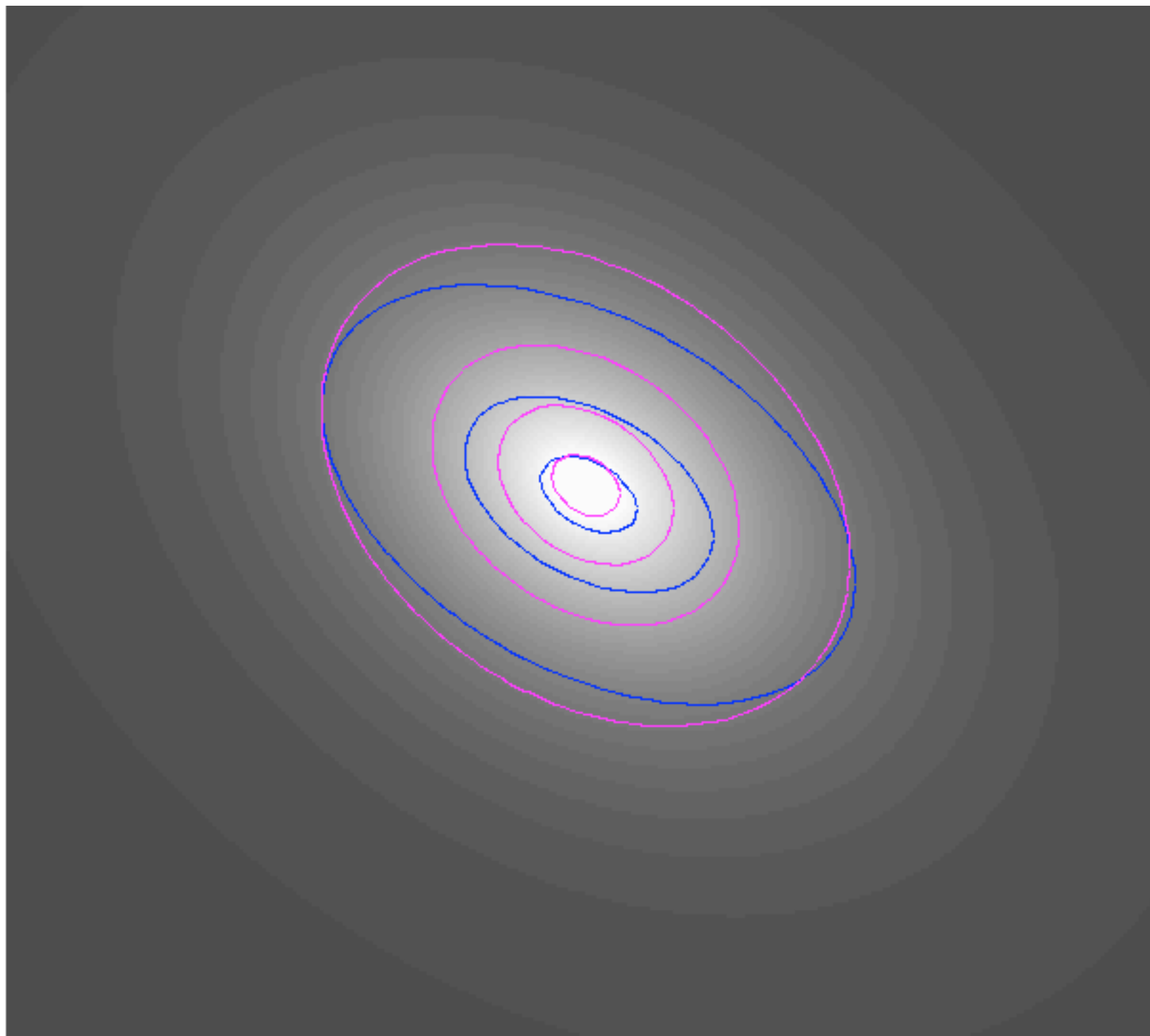
A stringent test

Exponential + Sérsic

Standard







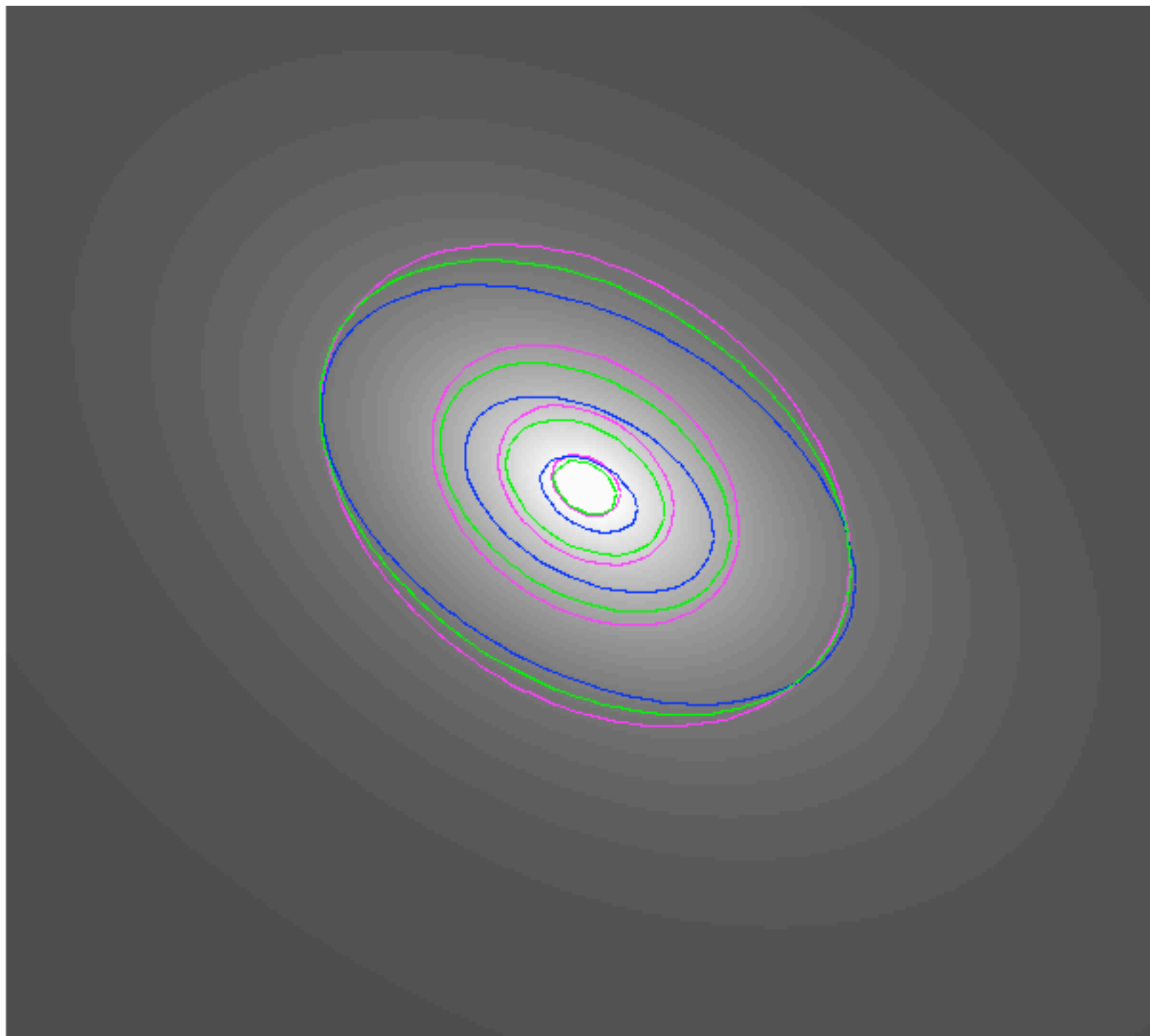


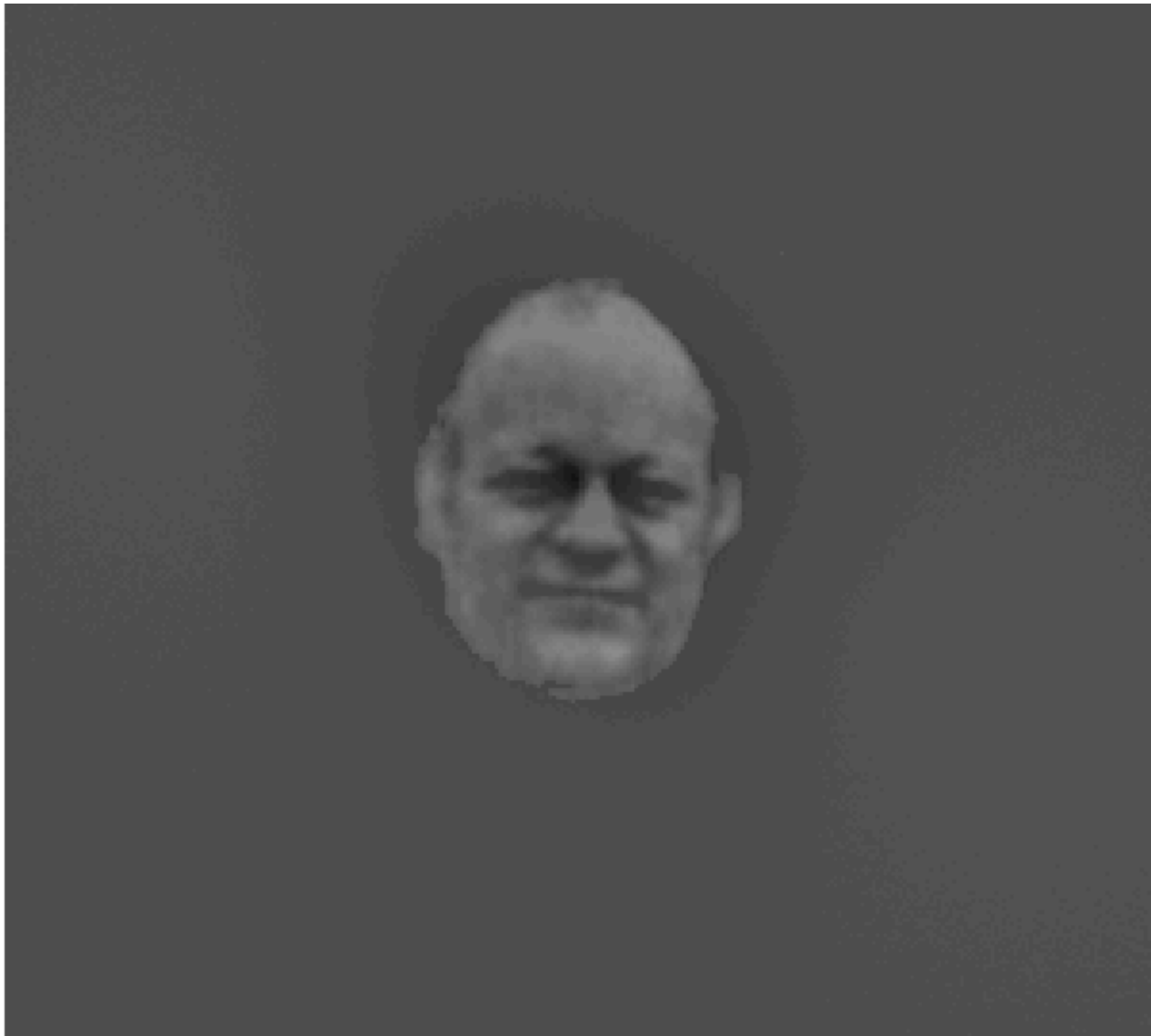
A stringent test

Exponential + Sérsic

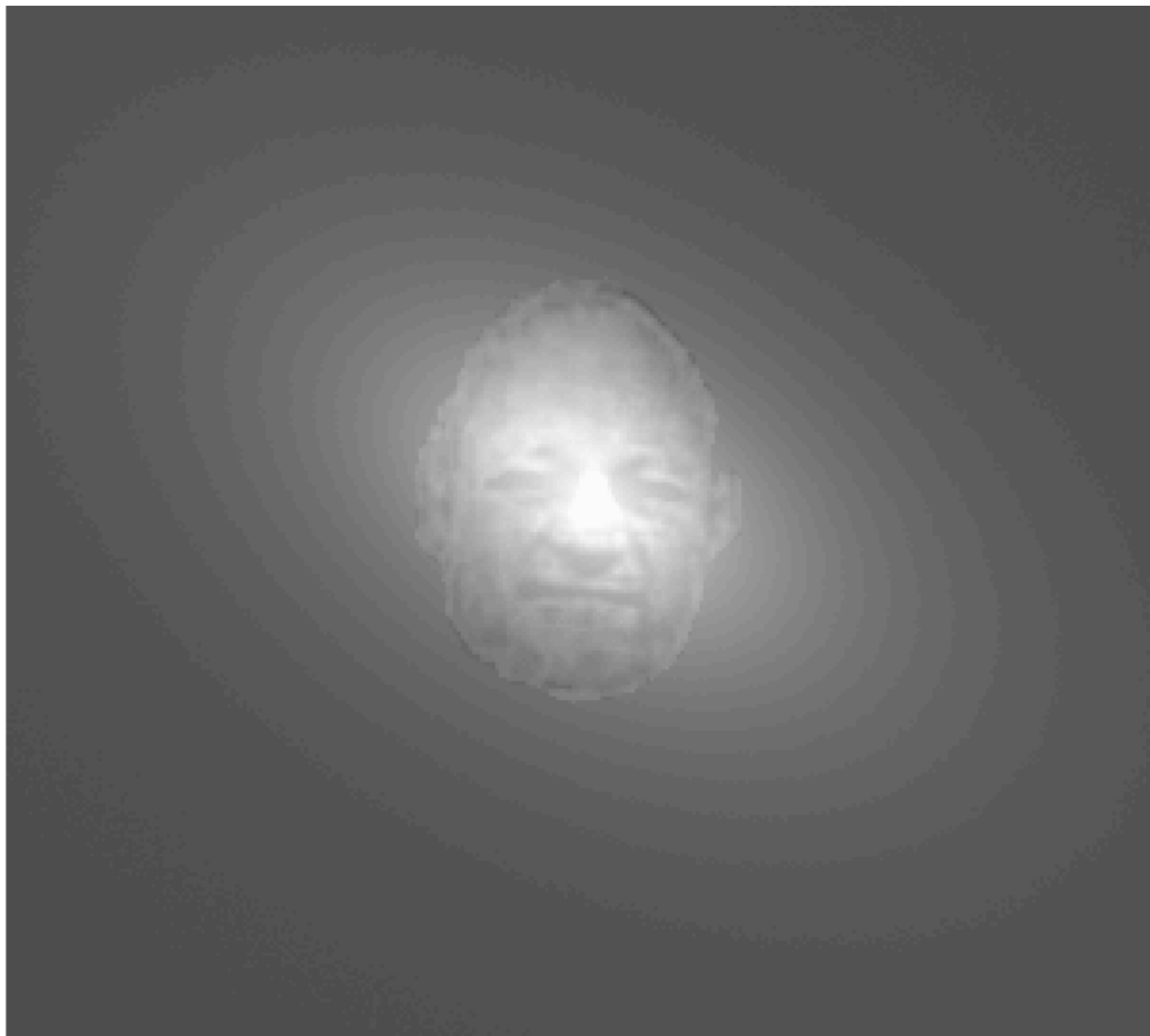
Non-parametric

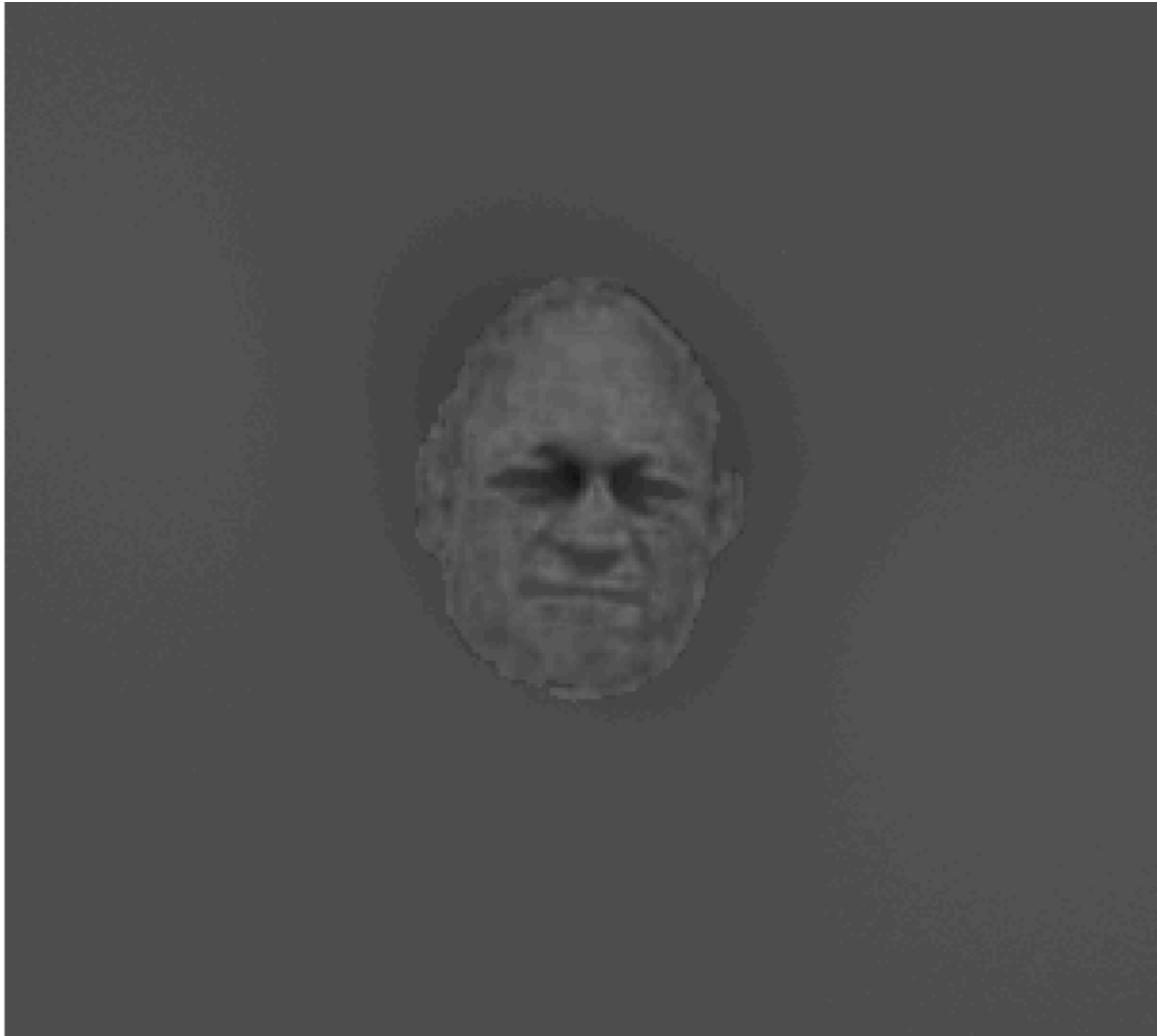












MEGAMORPH

Non-parametric component

- Simple to turn on in GALFITM
- Effective at removing ‘problematic’ galaxy features
- Automatic ‘inconsistency’ masking
- Works well in specific cases
- (Less well in some cases)
- Overall produces more meaningful measurements
- Demonstration paper in prep.
- Software available:

<http://www.nottingham.ac.uk/astronomy/megamorph/>



**Sérsic profiles will be
around for a long time yet**