2DPHOT

(La Barbera et al. 2008, PASP to appear)

Francesco La Barbera
Reinaldo R. de Carvalho

Scott Dodelson
Marcelle Santos

Roy Gal
Lori Lubin

João L.Kohl
Nilson S'Antanna
Rafael Santos

- Image catalogue by S-Extractor
- Star/Galaxy separation
- PSF fitting (1D+2D)
- Structural/Morphological parameters
  - Sersic parameters (1D and 2D)
  - Petrosian parameters (seeing corrected)
  - Growth curve parameters (seeing corrected)
  - Profiles of galaxy ellipticity, PA, A_n and B_n
- Completeness/Contamination

2DPHOT

(La Barbera et al. 2008, PASP to appear)

Francesco La Barbera
Reinaldo R. de Carvalho

Scott Dodelson
Marcelle Santos

Roy Gal
Lori Lubin

João L.Kohl
Nilson S'Antanna
Rafael Santos

Which Data Flow is Needed ?

Reduced image

Moving from the image space to catalog space
2DPHOT

2DCLUST
Datamining
Visualization
OpenSkyQuery
VO

Applying 2DPHOT to Survey data

- SDSS and UKIDSS-LAS
- CFHTLS- wide and deep
- LFC/HST-ACS data
- WFI/2.2m
- VST images

HOW IT WORKS

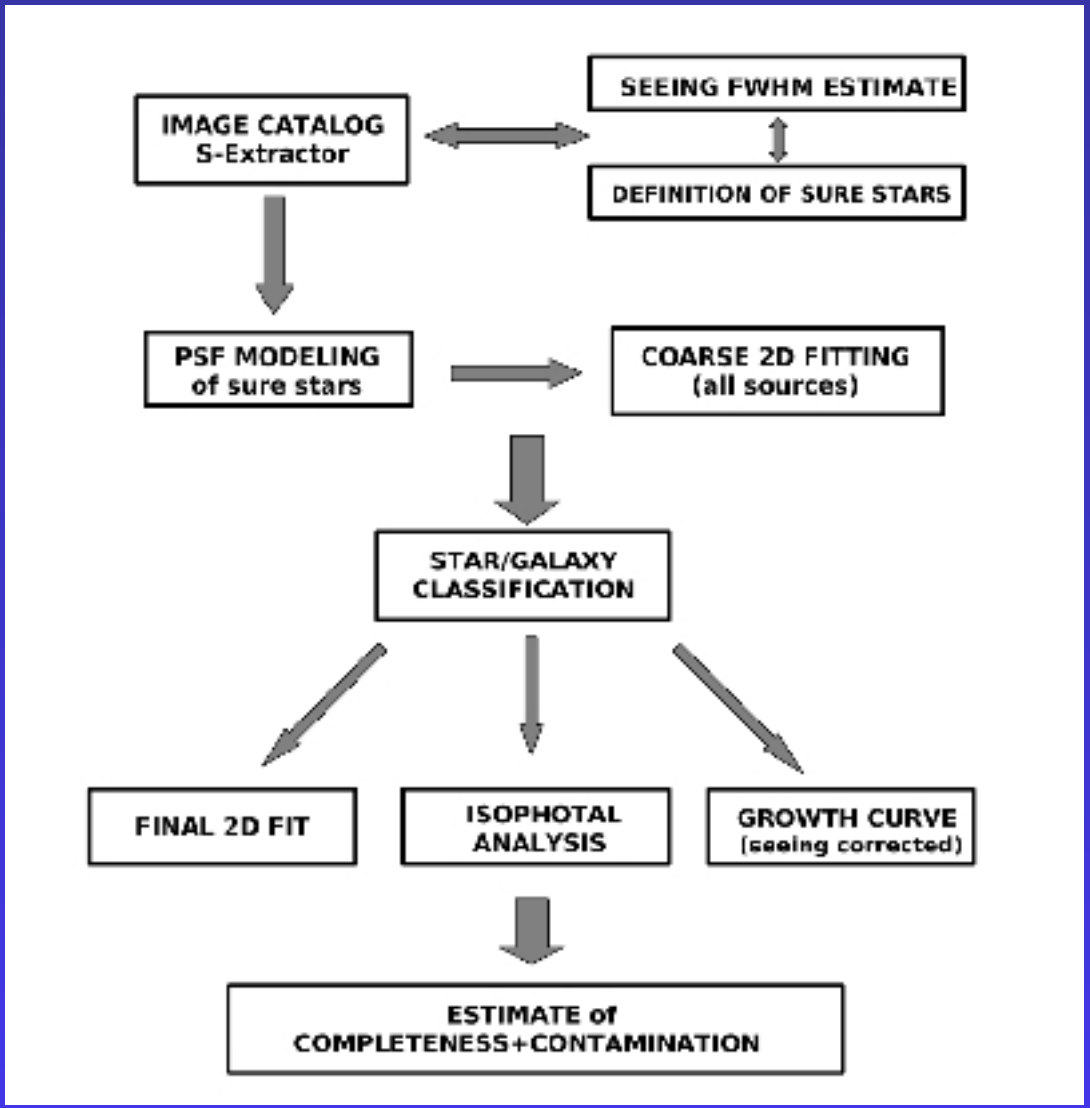
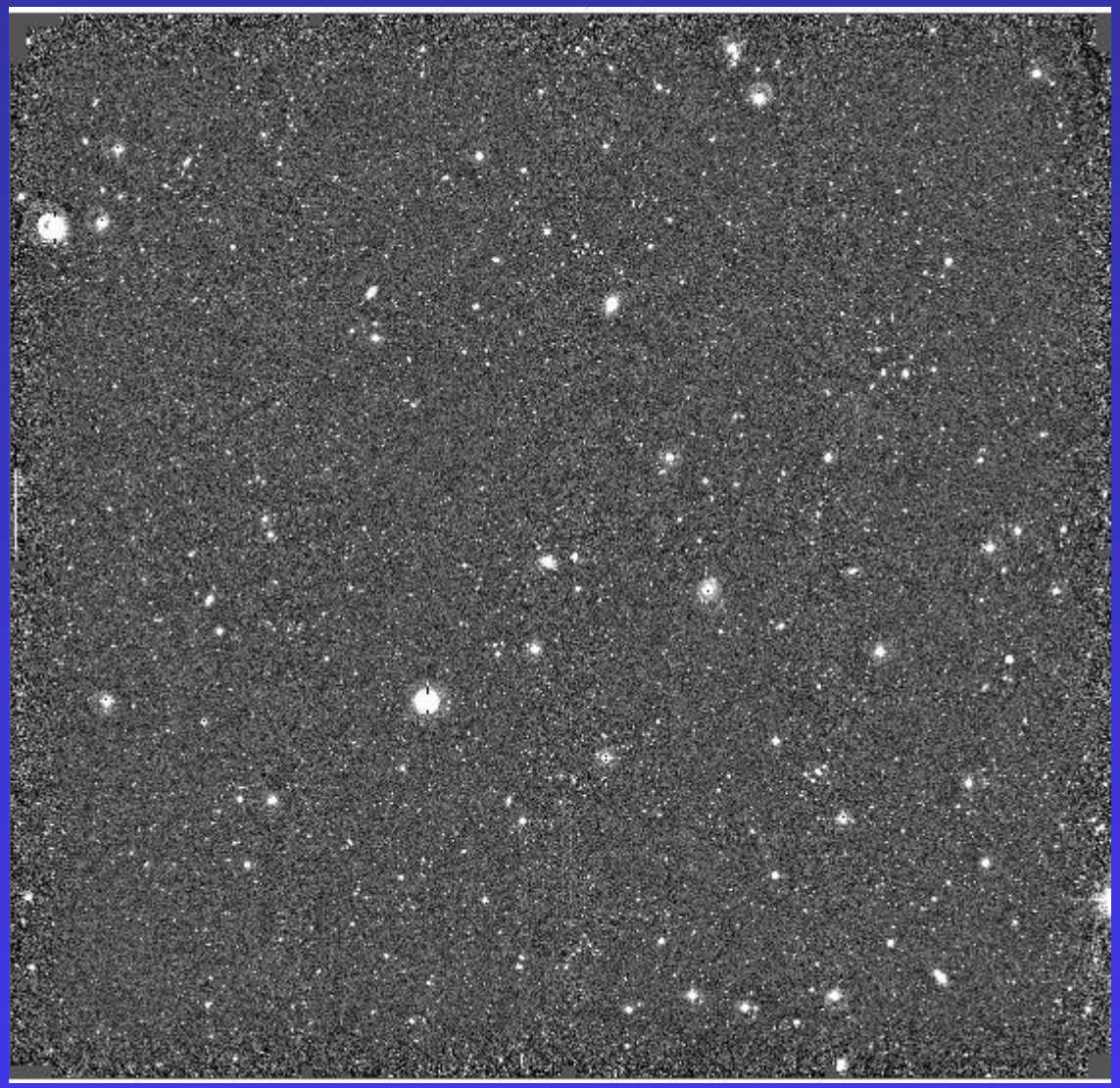


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

INPUT IMAGES



ESO 2.2m telescope
WFI image
field name: 3c273 (R_c band)

image size

9k x 9k (8700x8900)

pixel scale 0.238"/pixel

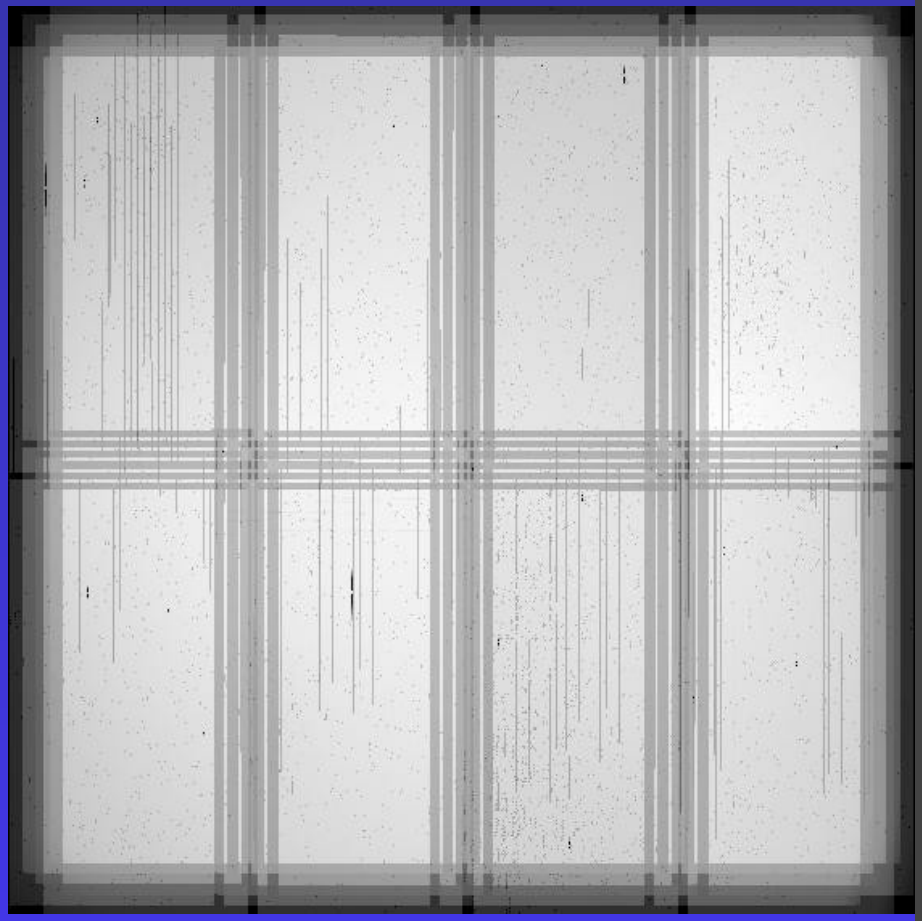
34.5'x35' (¼ square degree)

MAXIMUM SIZE
12k x 12k

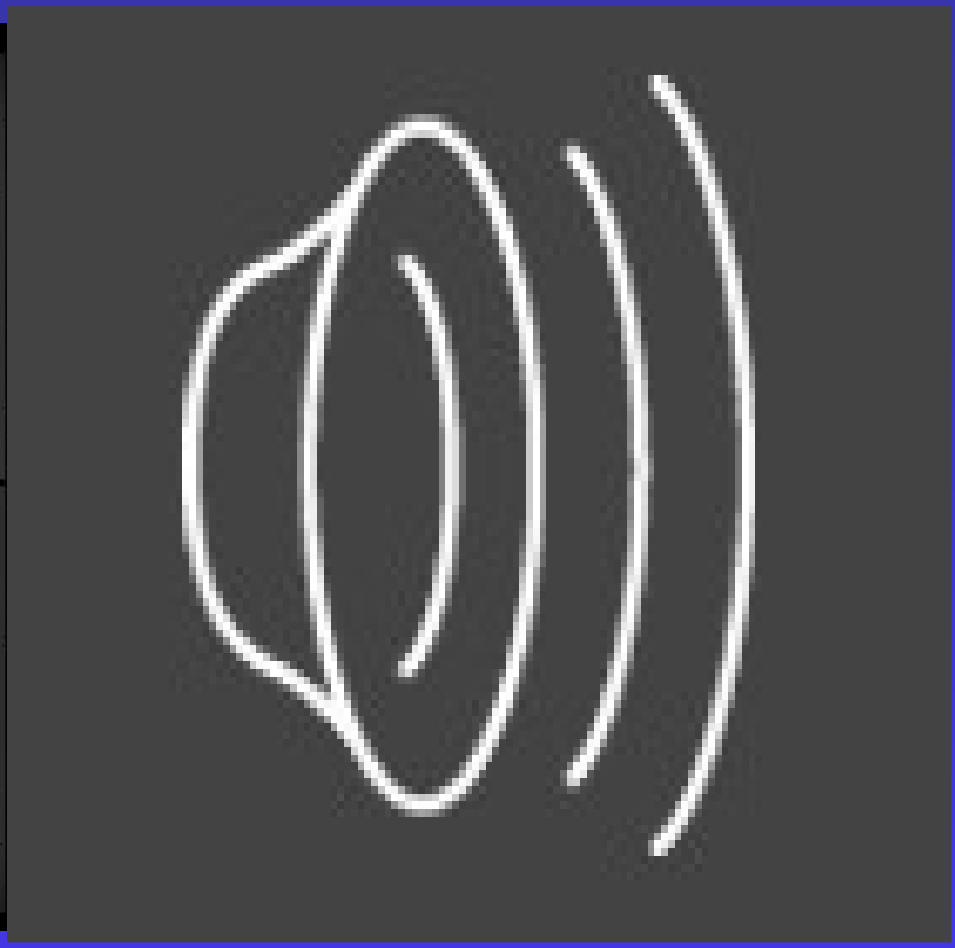
20k x 20k

INPUT IMAGES

WEIGHT MAP



MASK IMAGE



INPUT FILES/OPTIONS

- fits image
- weight map
- mask image
- default.sex
- default.param

-l	Minimum S/N ratio required to perform 2D final fitting and surface photometry.		8, 9
-x	Stamp sizes are proportional to the S-Extractor ISOAREA parameter. This parameter provides the proportionality factor.	*EXPND*	4
-z	Maximum size of the stamp images. This parameter can be used to prevent overly large stamp frames.		4
-i	Minimum S/N ratio required to define sure stars.		3
-f	Maximum S/N ratio required to define sure stars.		3
-j	Number of Moffat/Gaussian functions for 1D PSF fitting.		9.2
-m	Number of Moffat/Gaussian functions for 2D PSF fitting.	*NSMAX*	5
-g	Functions used in the 2D PSF fitting (0=Moffat, 1=Gaussian).		5
-t	Number of cos/sin terms used for the expansion of star isophotes in the 2D PSF fitting.		5
-d	Minimum S/N ratio to perform 2D fitting with expansion of the galaxy model into a cos/sin series.		8
-b	Label providing the cos terms used for the expansion of the galaxy model in 2D final fitting (e.g. -b 34 makes 2DPHOT calculate the a_3 and a_4 coefficients)		8, 9.1
-c	Label providing the sin terms used for the expansion of the galaxy model in 2D final fitting.		8, 9.1
-e	Minimum distance of an object to the image edges, in units of its FWHM. Objects that are closer to the edge this distance are not analyzed.	*REDGE*	3
-s	Maximum number of sure stars used in a cell to perform PSF modeling.	*NSIZE*	5, 9.2
-a	Flag that determines the 2D PSF fitting method. When equal to zero, this option forces all sure stars in a given cell to be fitted simultaneously. When equal to one, a single fit to each sure star is performed.		5
-n	Size (in pixels) of the grid cells where PSF modeling is performed.		5
-o	The user can choose to process only some objects in the image by providing a list of x and y coordinates on the image. This feature is enabled with -o 1.		3

HOW IT WORKS

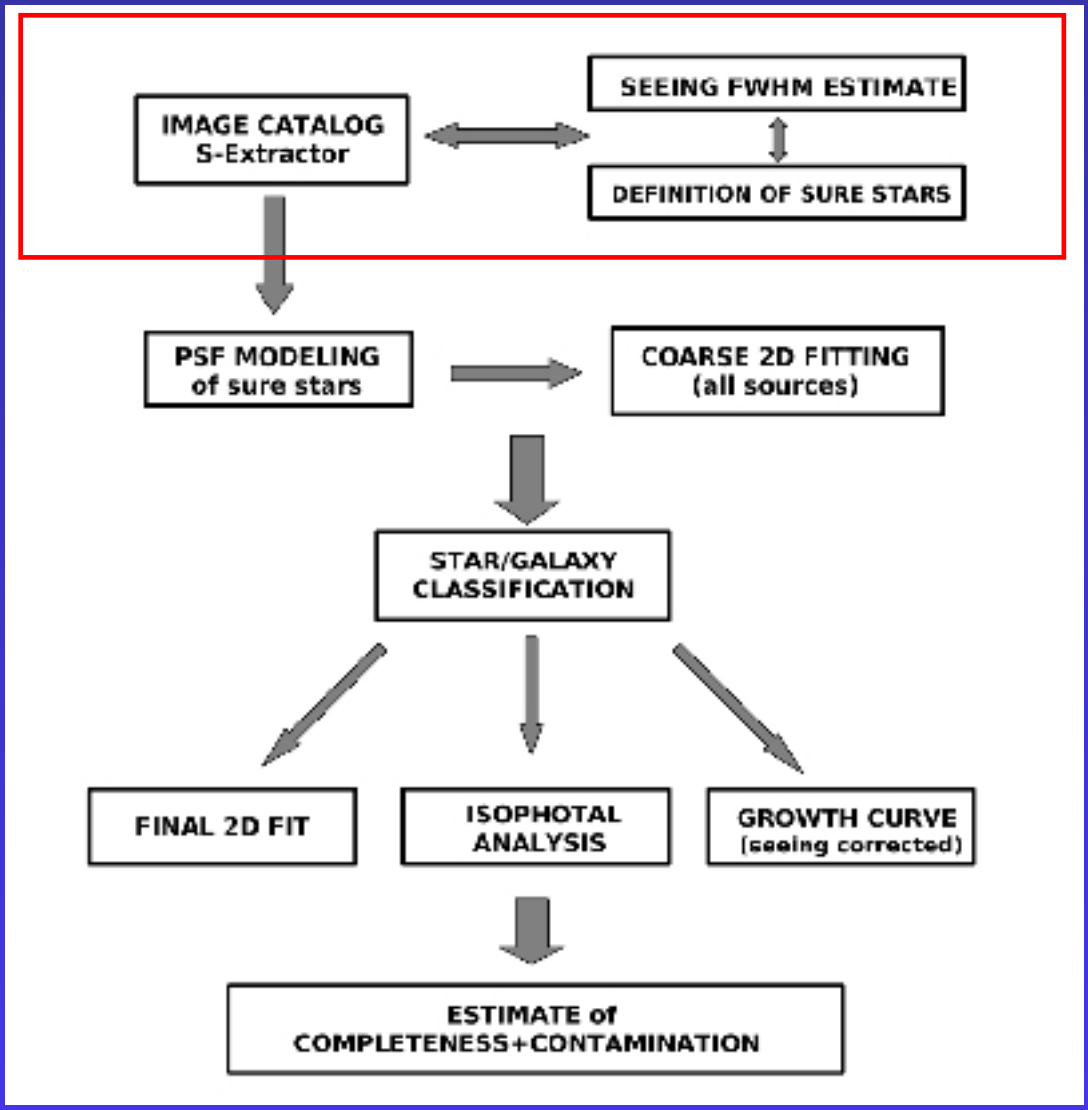


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

THE CATALOG

The catalog includes 9445 sources out of 10899 (before cleaning)

S-Extractor

↓

SEEING_FWHM

↓

S-Extractor

↓

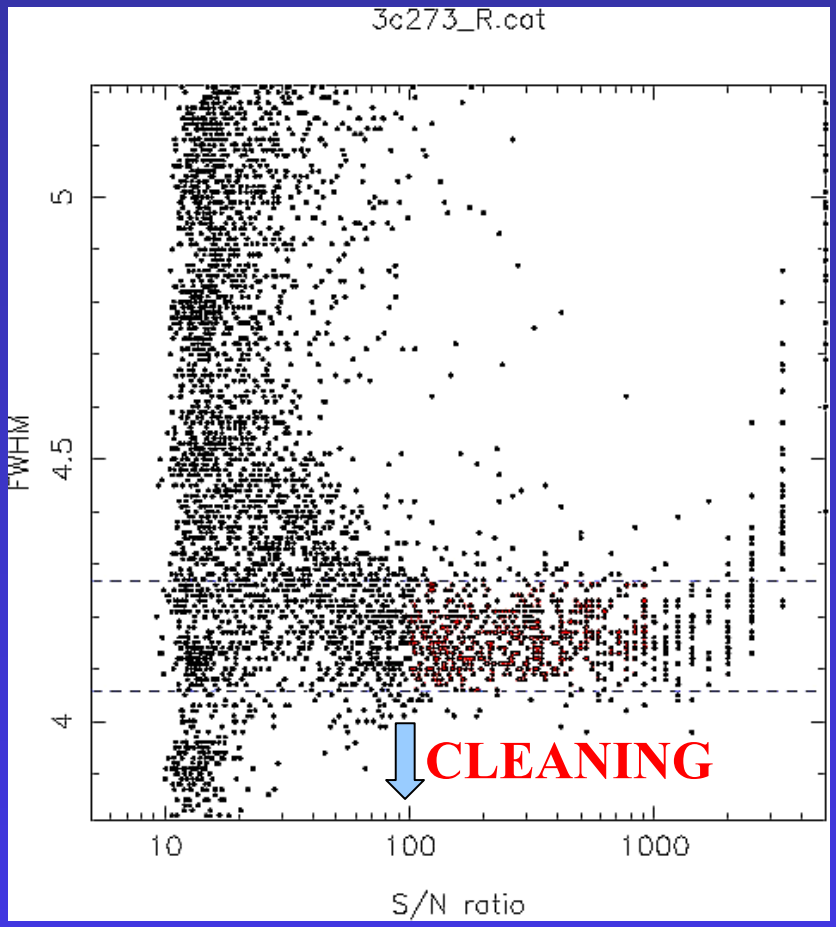
CLEANING

- mask image
- borders
- low FWHM

↓

S-Extractor

SEEING ESTIMATE - *SURE STARS*



First selection of stars (ellipticity <=0.1, S/N ratio cut)

The seeing value is obtained by applying the bi-weight estimator

Definition of *sure stars*

HOW IT WORKS

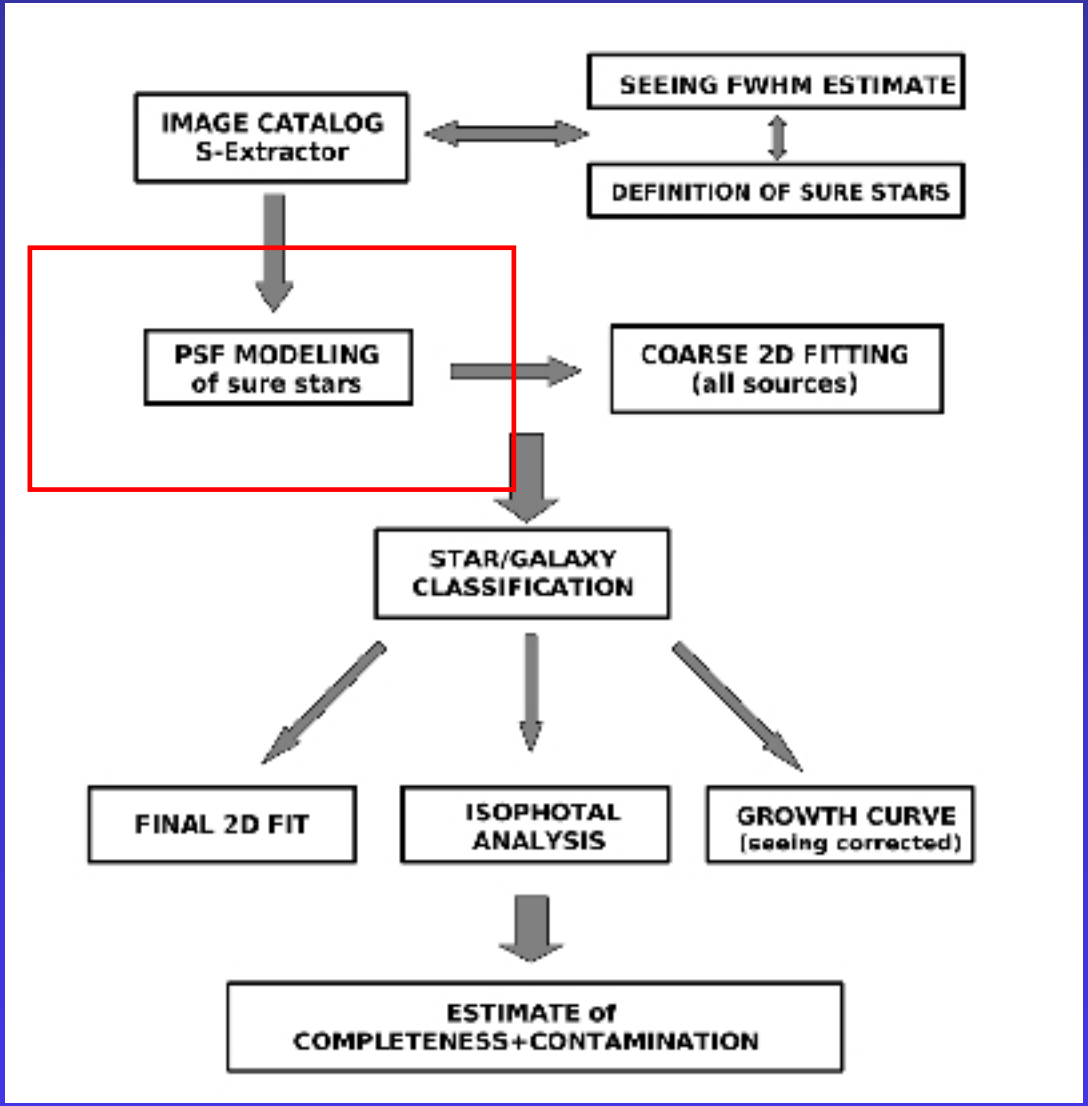
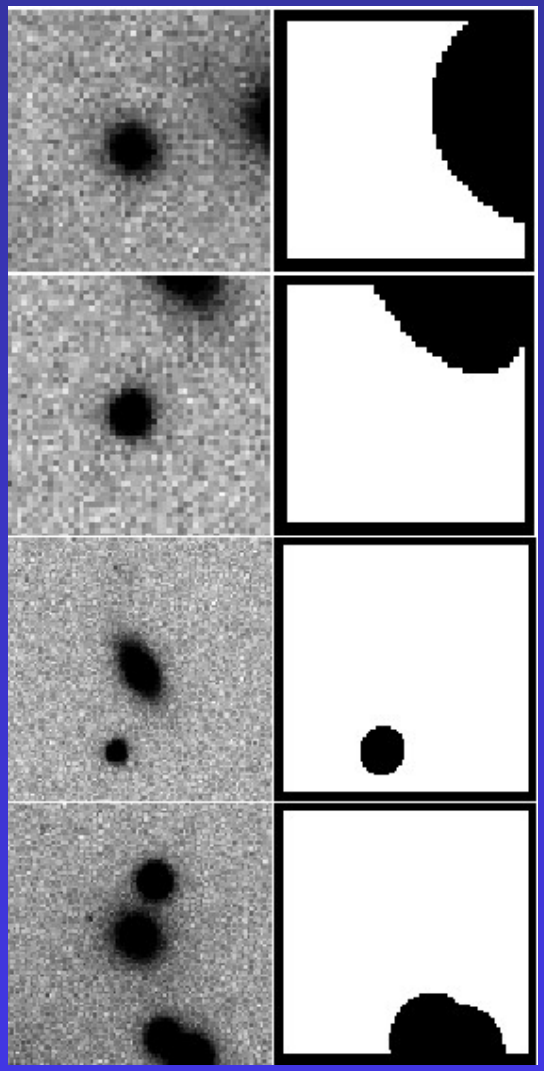


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

STAMPS AND MASKING

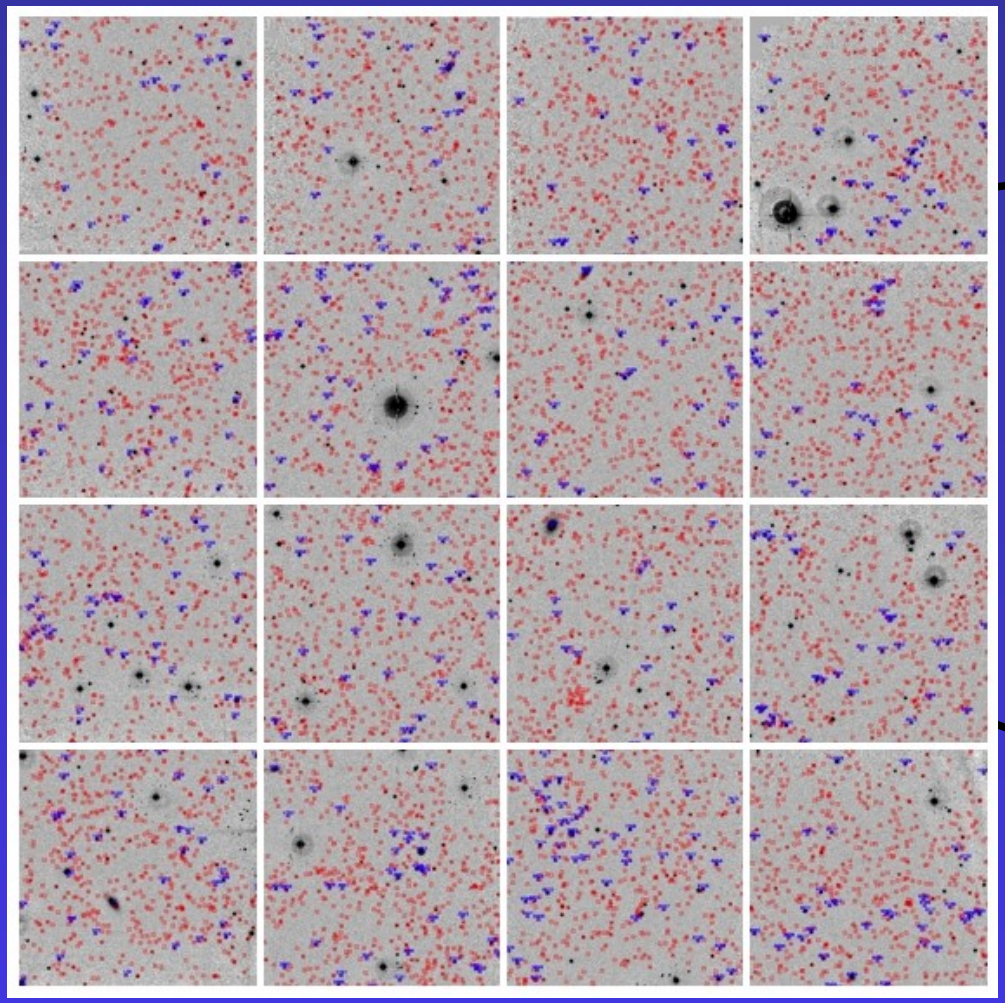


For each source, a stamp image is extracted by using S-Extractor parameters (ISOAREA, PA, ELLIPTICITY)

PSF MODELING

- **simultaneous fitting of several SURE STARS**
- **PSF fitting is done in both 1D and 2D**
- **PSF model: sum of Moffat/Gaussian functions**
  (integrated on image pixels)
- **PSF distortions are corrected for by expanding isophotes in a sin/cos series**
- **PSF variations with position are also accounted for ....**

PSF MODELING: SPATIAL VARIATION



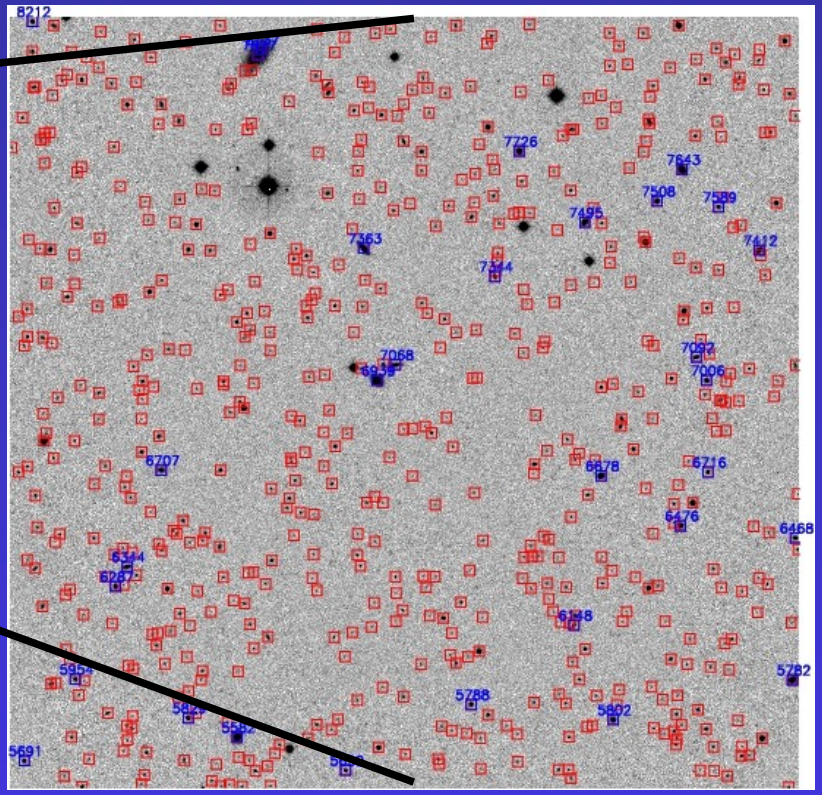
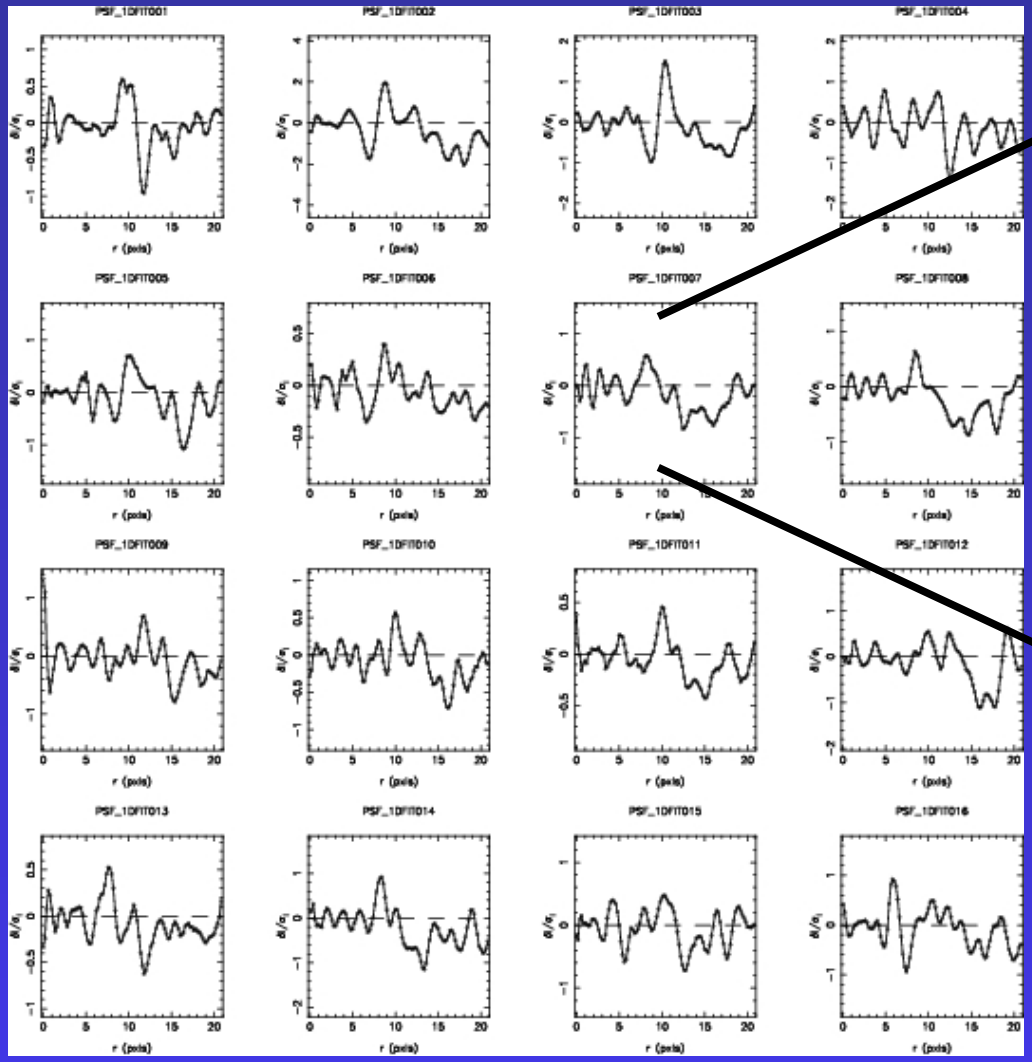
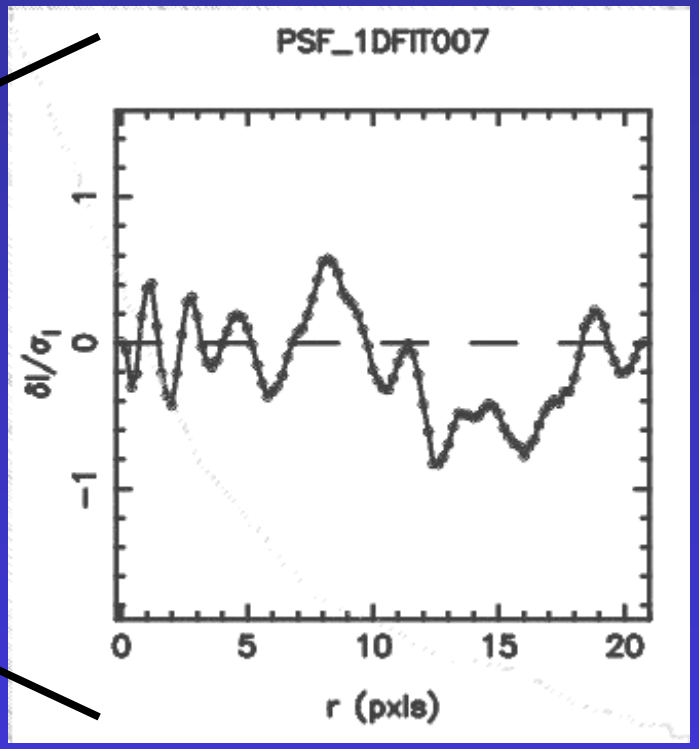


Image has been processed on a 4x4 grid, with the cell size being equal to the short side of each CCD. PSF models (both 1D and 2D) are created independently for each cell.

PSF MODELING: 1D CASE

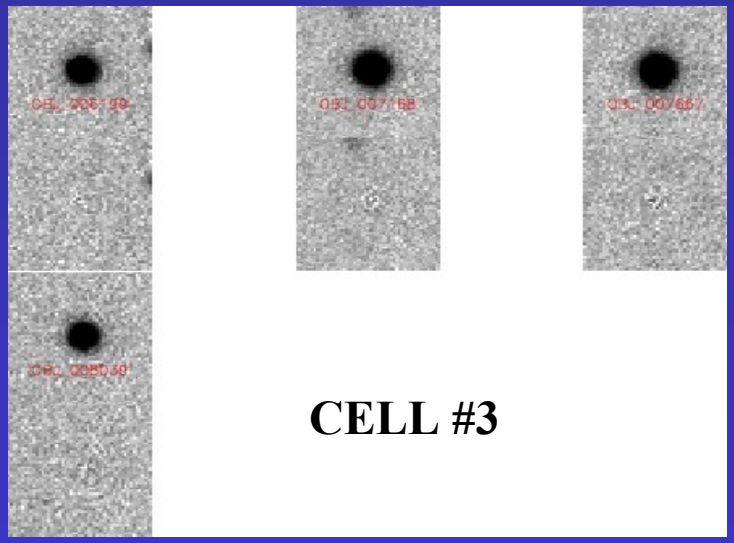




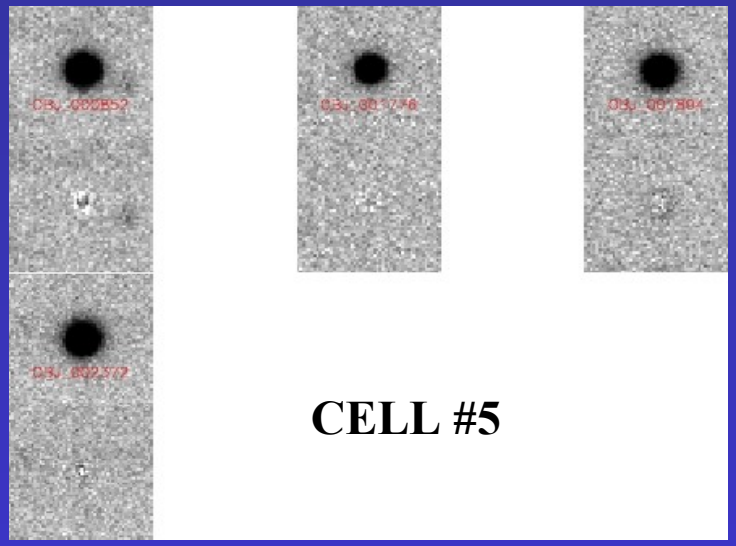
NORMALIZED RESIDUALS AFTER MODEL SUBTRACTION

Each panel shows the fitting residuals in a given cell.

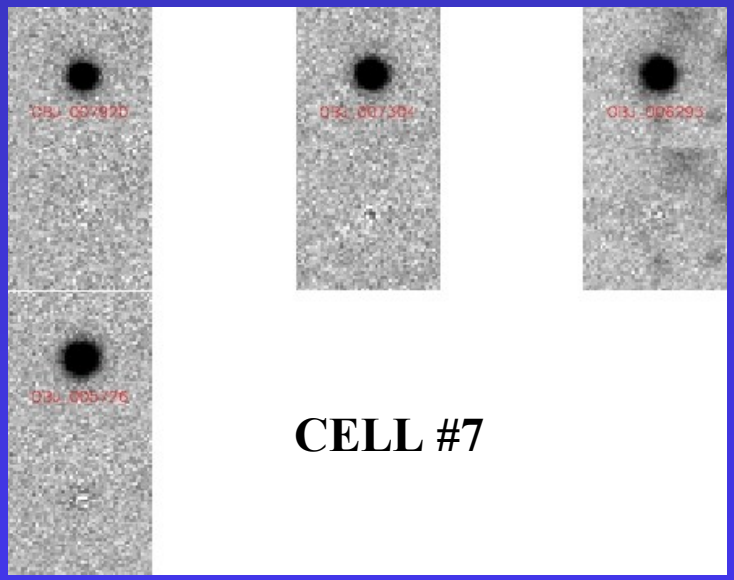
PSF MODELING: 2D CASE



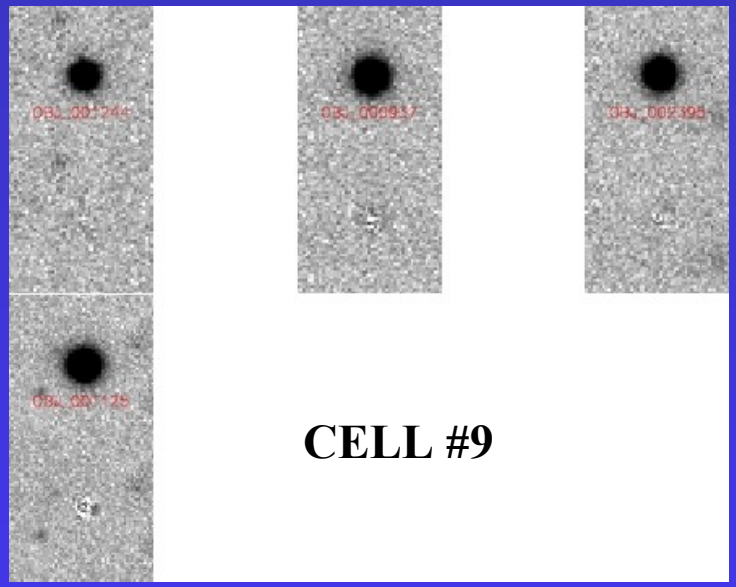
CELL #3



CELL #5



CELL #7



CELL #9

HOW IT WORKS

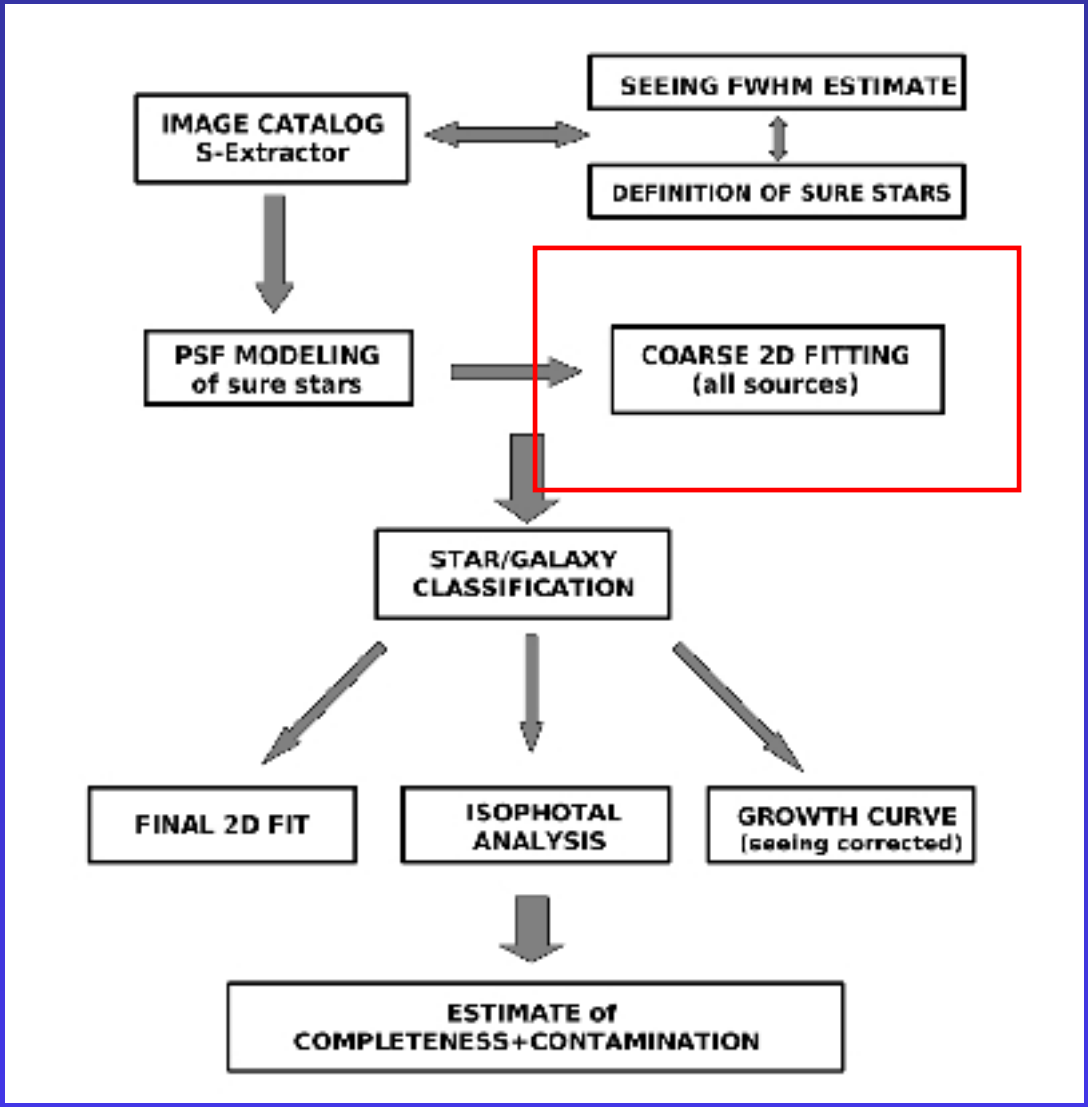
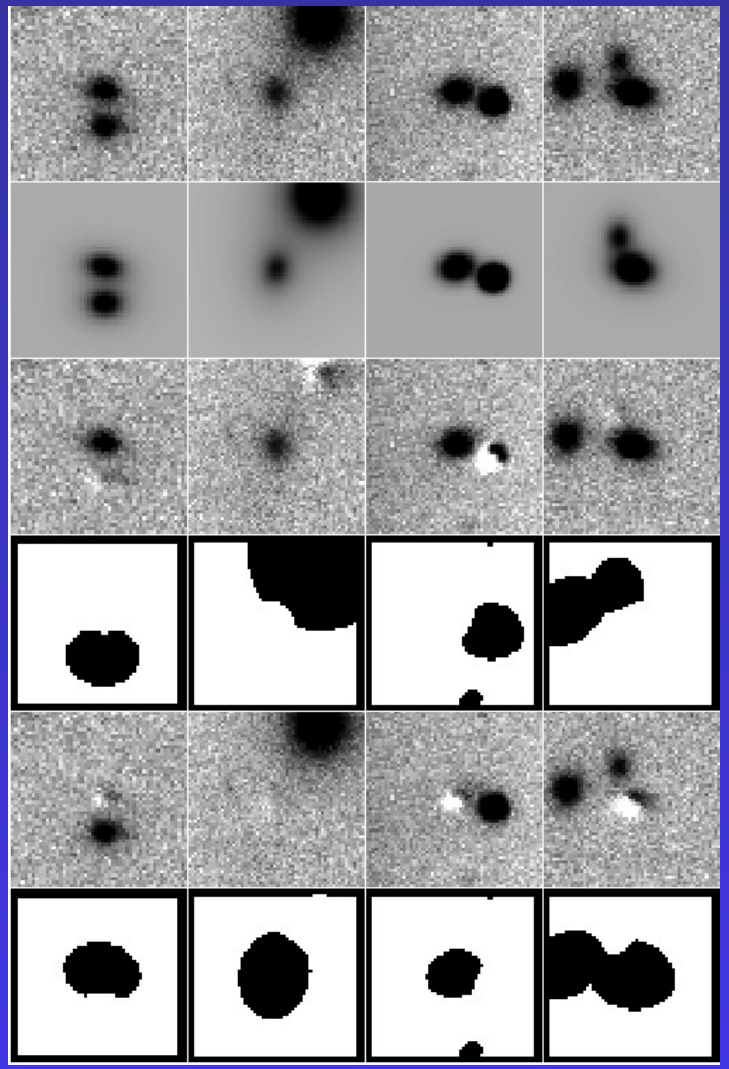


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

COARSE FITTING (ALL SOURCES)

- Moffat 2D fit
- Overlapping sources are 'reduced' to the case of single sources
- A first rough 2D fit is done by using PSF convolved 2D Sersic models
- Sersic parameters (r_e, m_{tot}, n) are varied on a (8x3x3) adaptive grid of values



Moffat fitting of overlapping sources from one image of the PACS (Gal et al.'00)

HOW IT WORKS

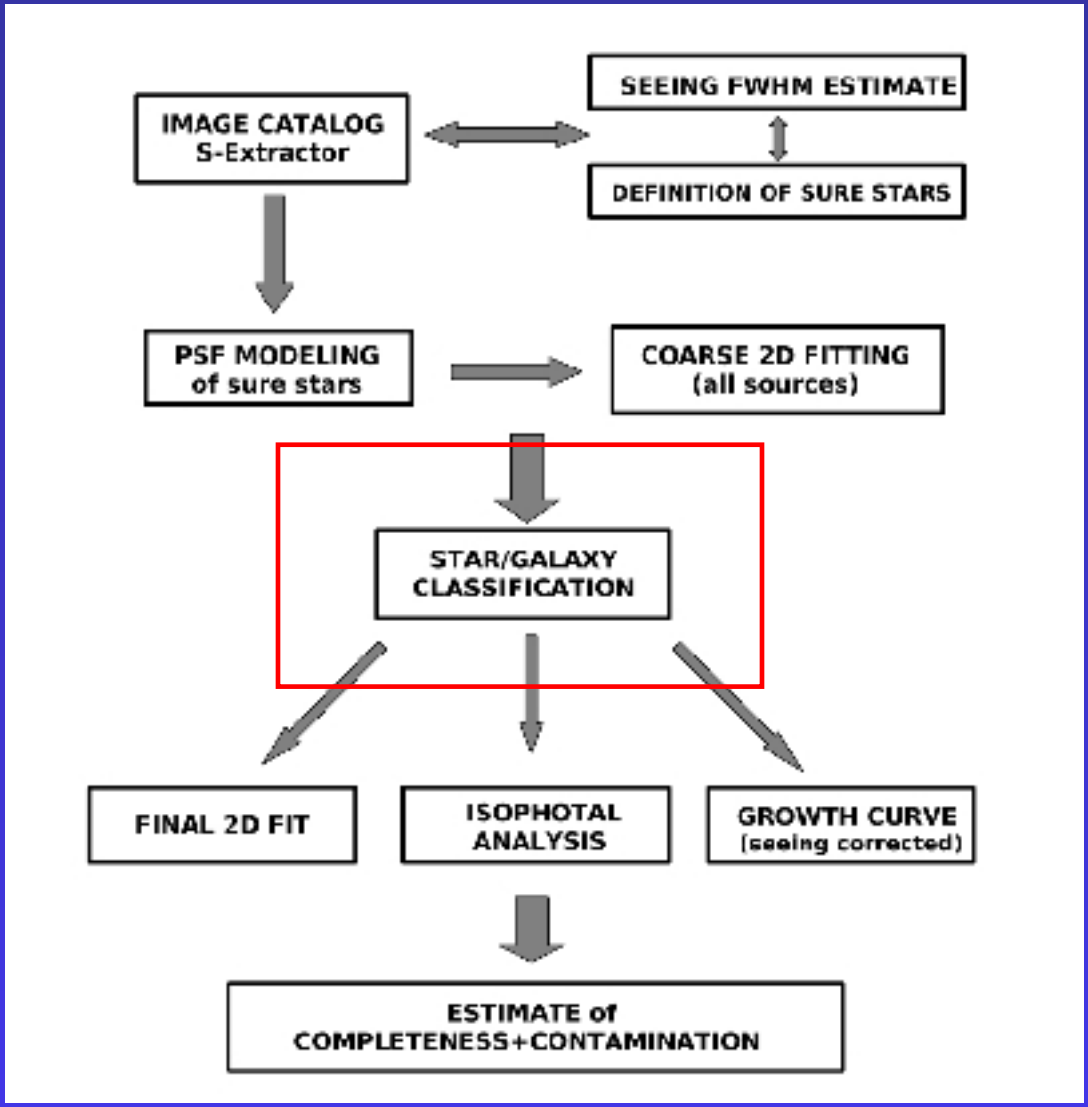
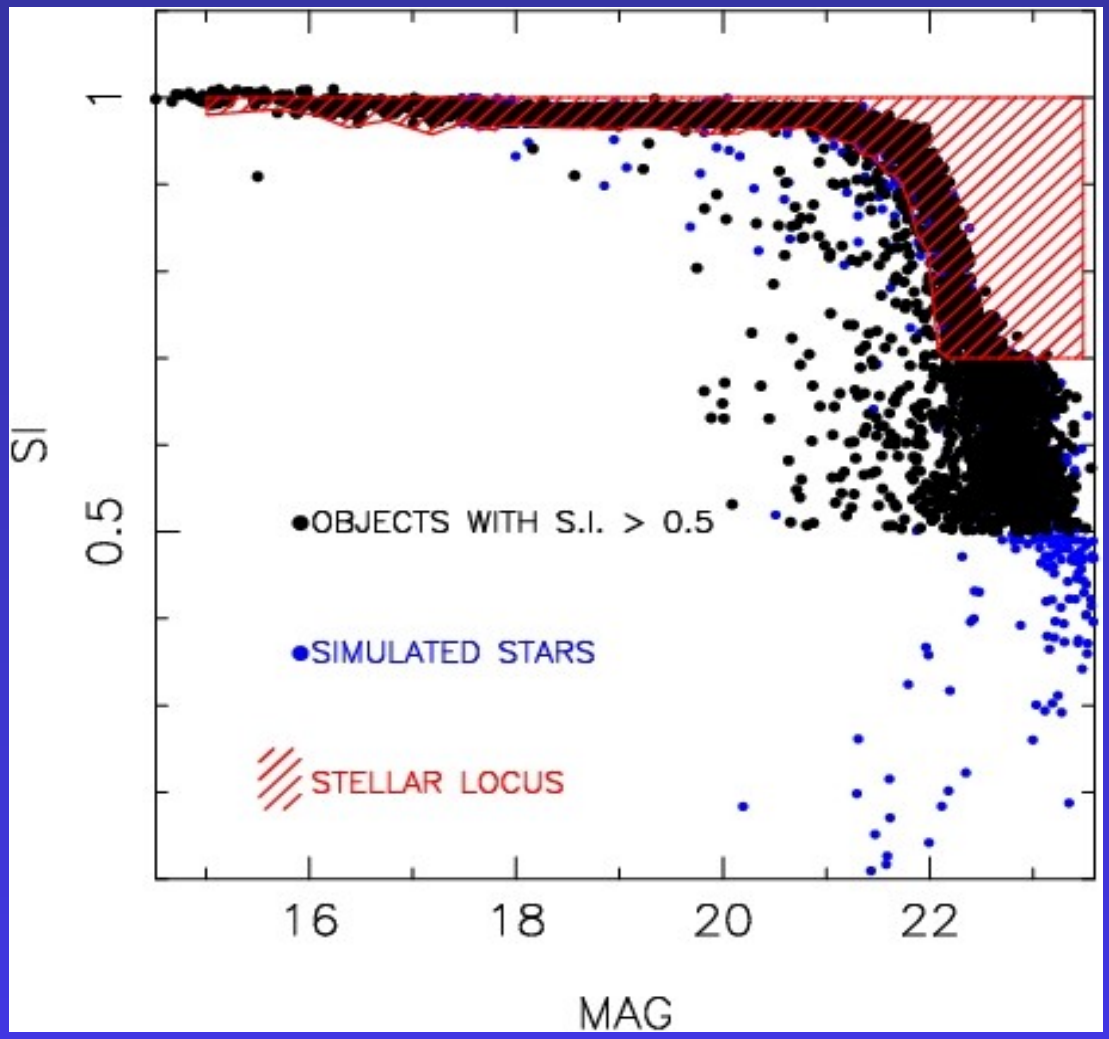


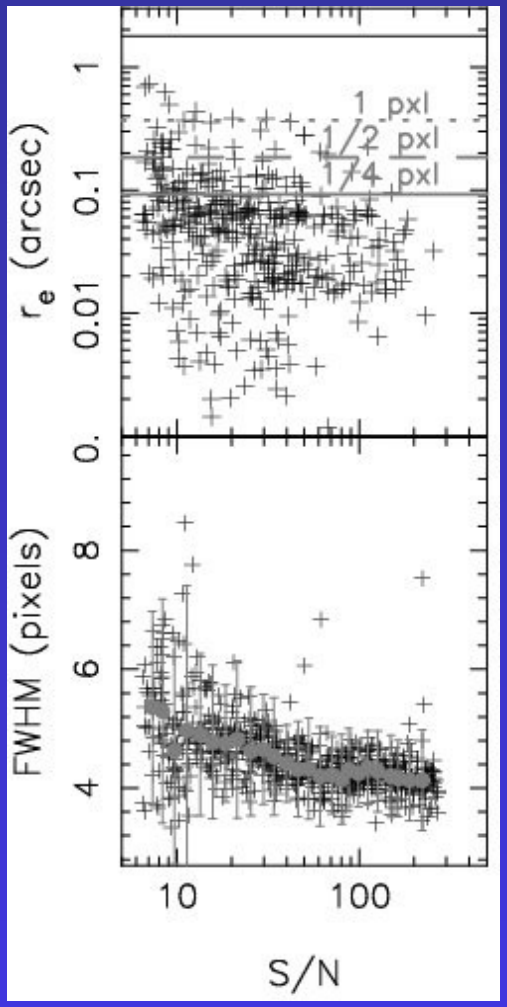
IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

SIMULATED STARS – STELLAR LOCUS

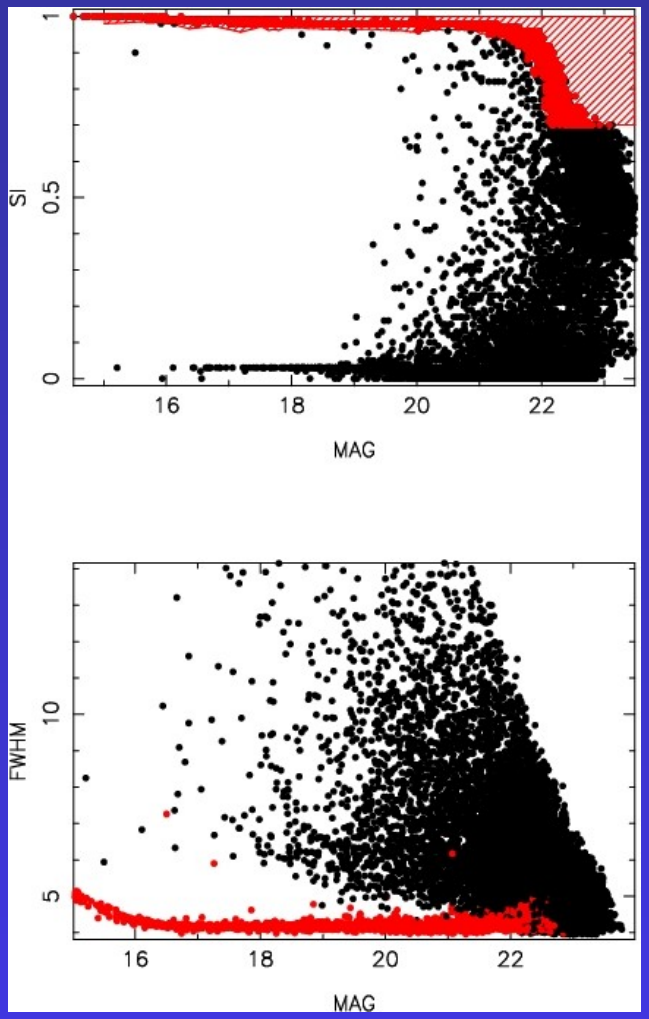


Simulated stars are added to the input image. The number density of these stars is chosen to be negligible with respect to that of observed sources.

STAR/GALAXY CLASSIFICATION



Simulated stars always have a deconvolved effective radius smaller than ~1pxl (result from several simulated stellar fields).



Stars and galaxies are separated according to both the stellar locus and the value of r_e.

HOW IT WORKS

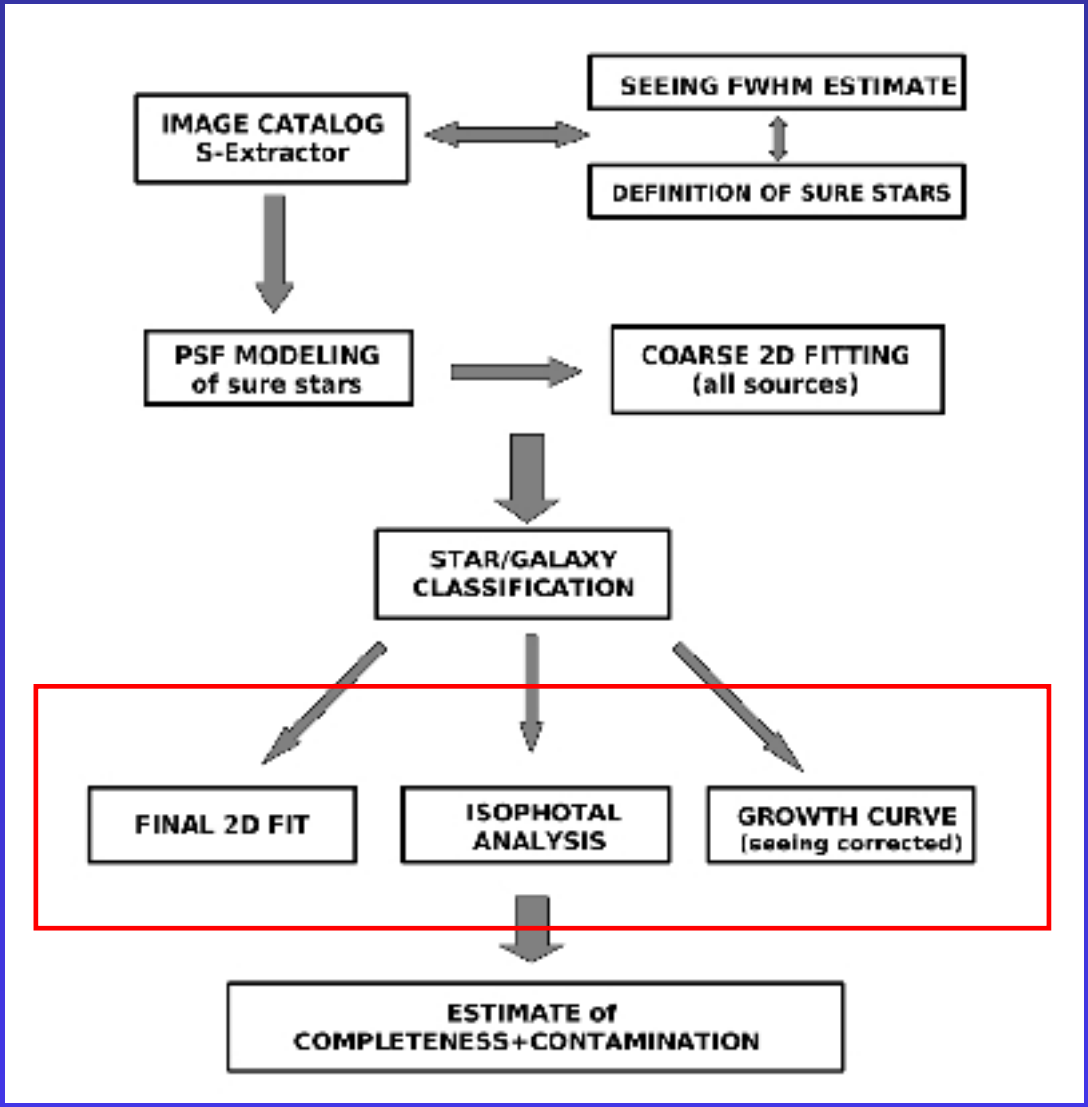
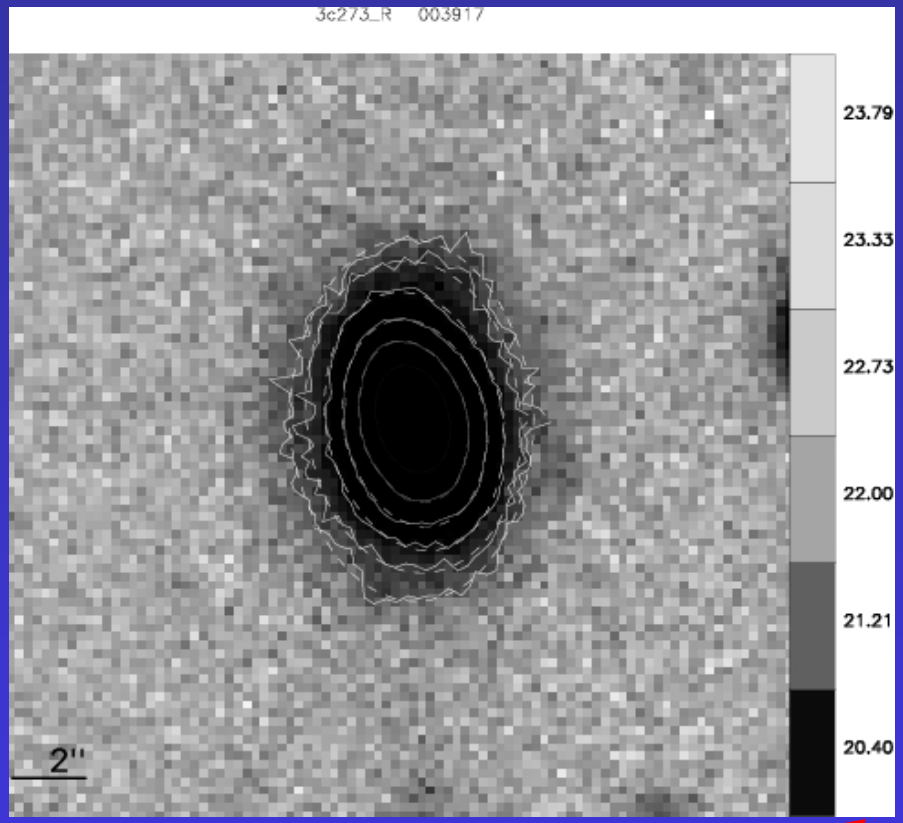
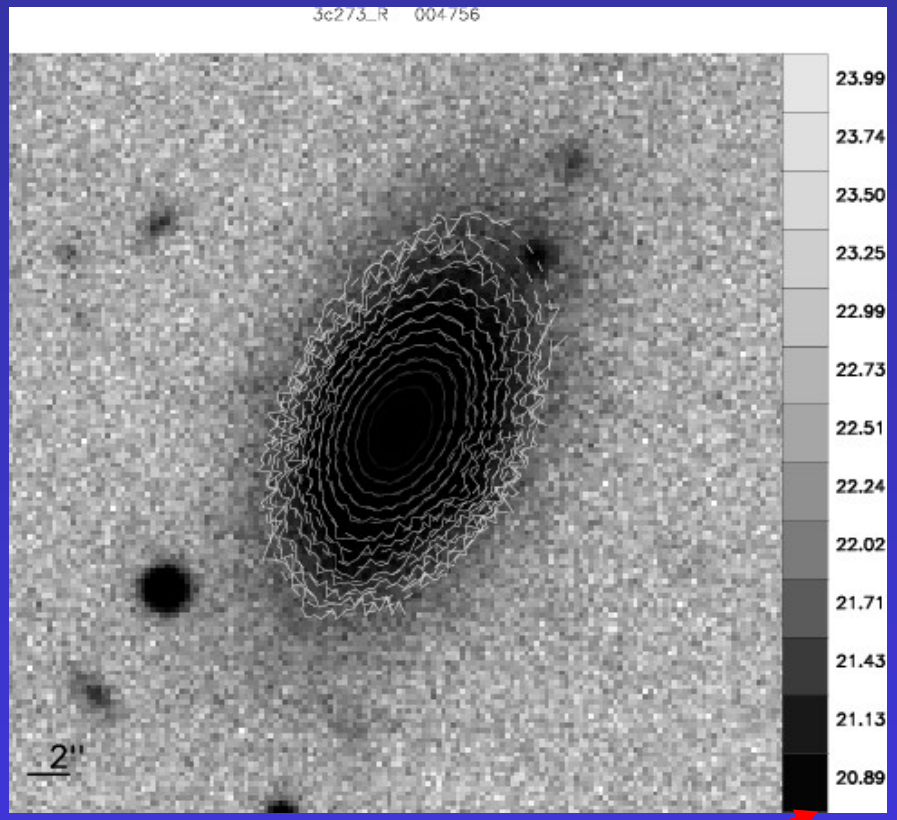


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

ISOPHOTAL ANALYSIS

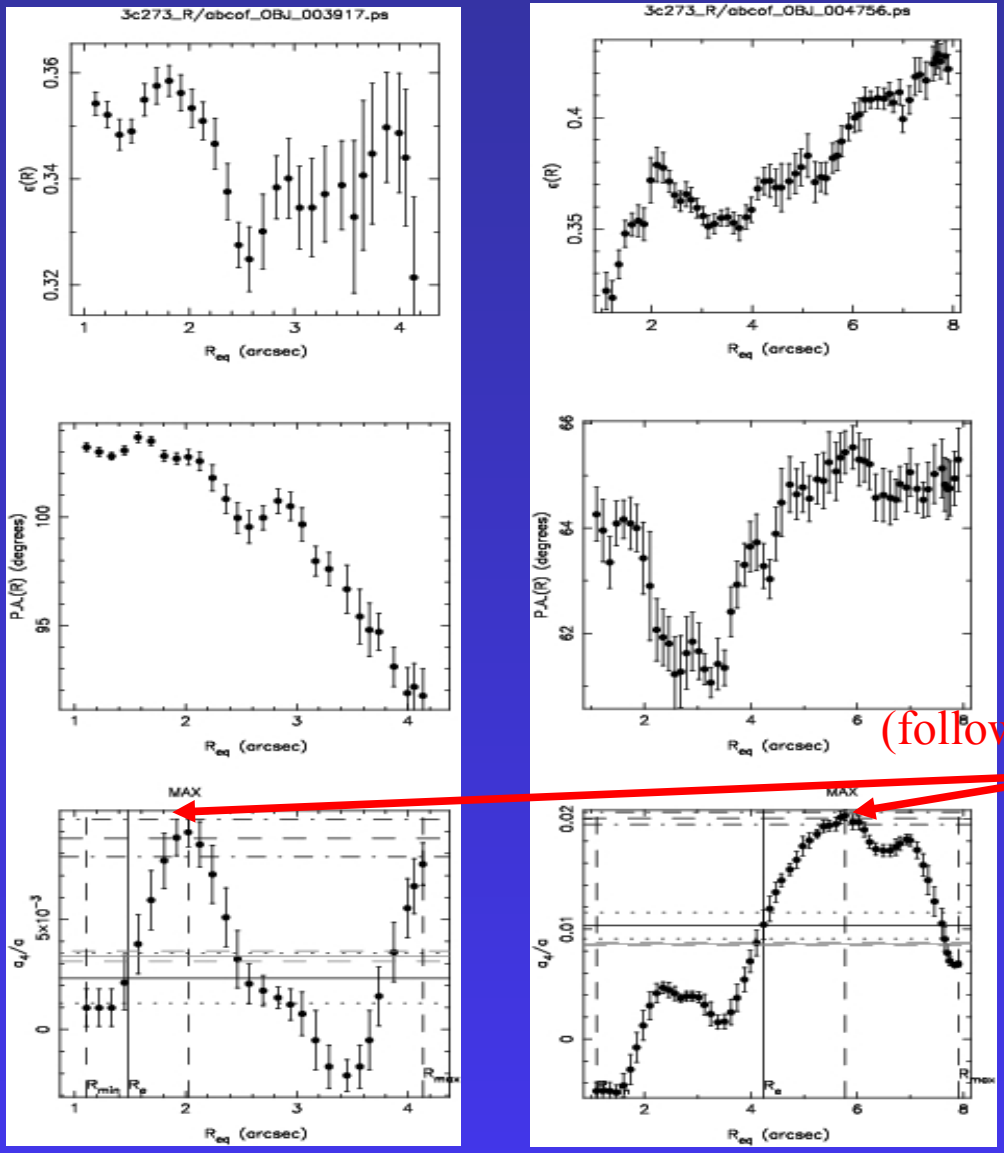




Isophotes are approximately equally spaced with respect to their equivalent radius (up to 3σ over the background mean value). For each isphote, center coordinates, axis ratio, PA, A_n, B_n are fitted.

Color encoding of surface brightness values

ISOPHOTAL ANALYSIS: OUTPUT



PROFILES

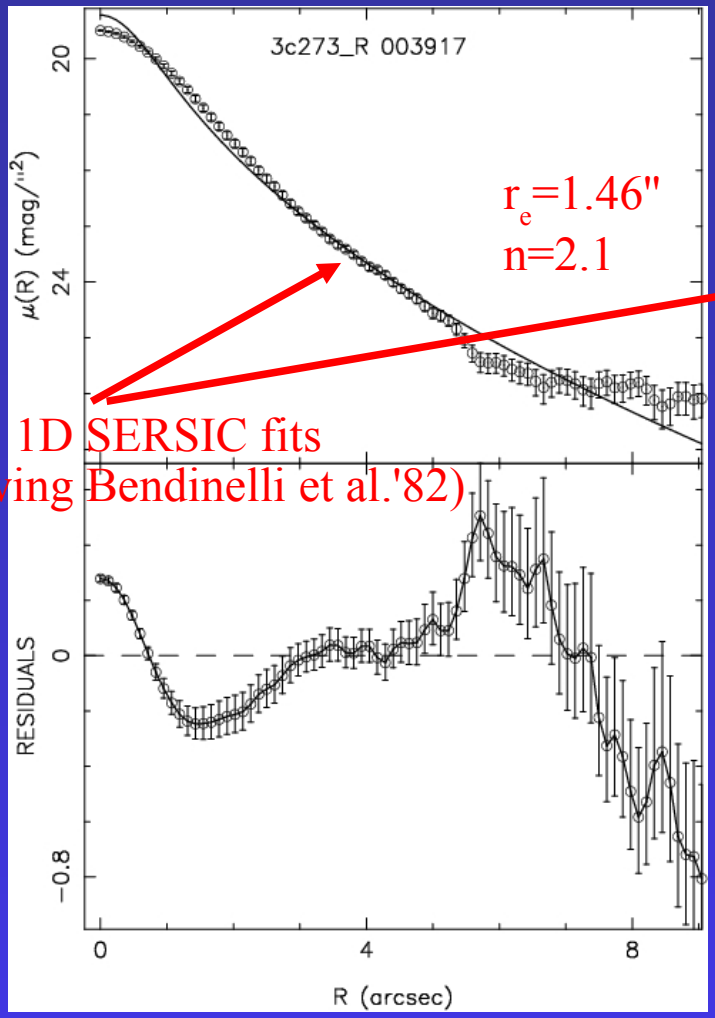
Ellipticity

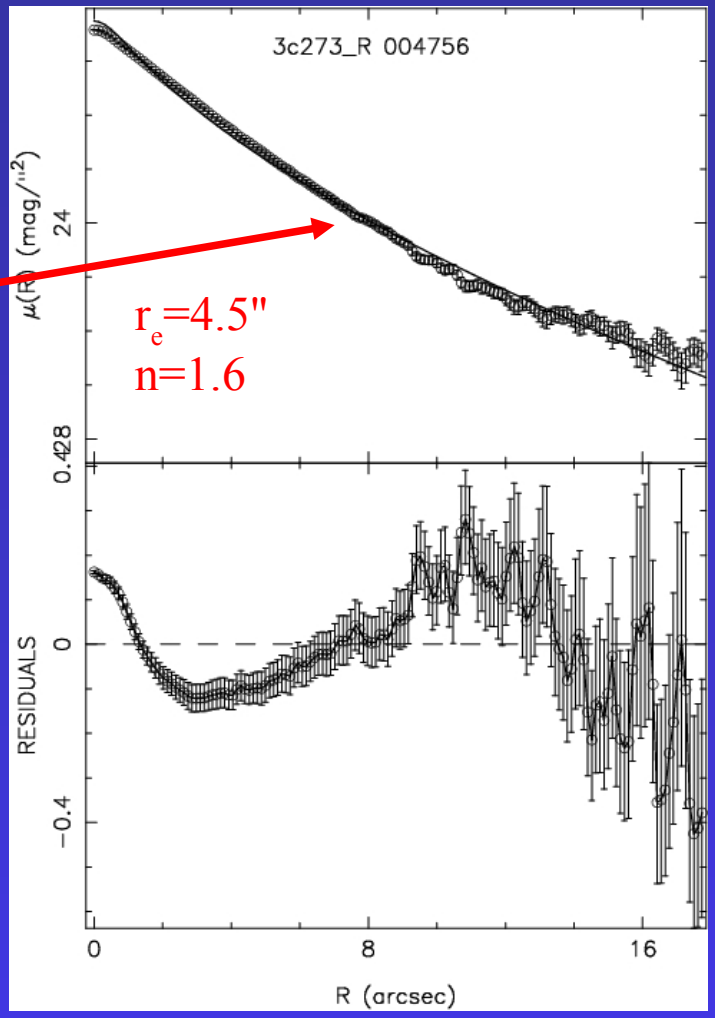
Position Angle

A_4 value
(following Bender et al.'89)

A_n, B_n

ISOPHOTAL ANALYSIS: 1D PROFILE

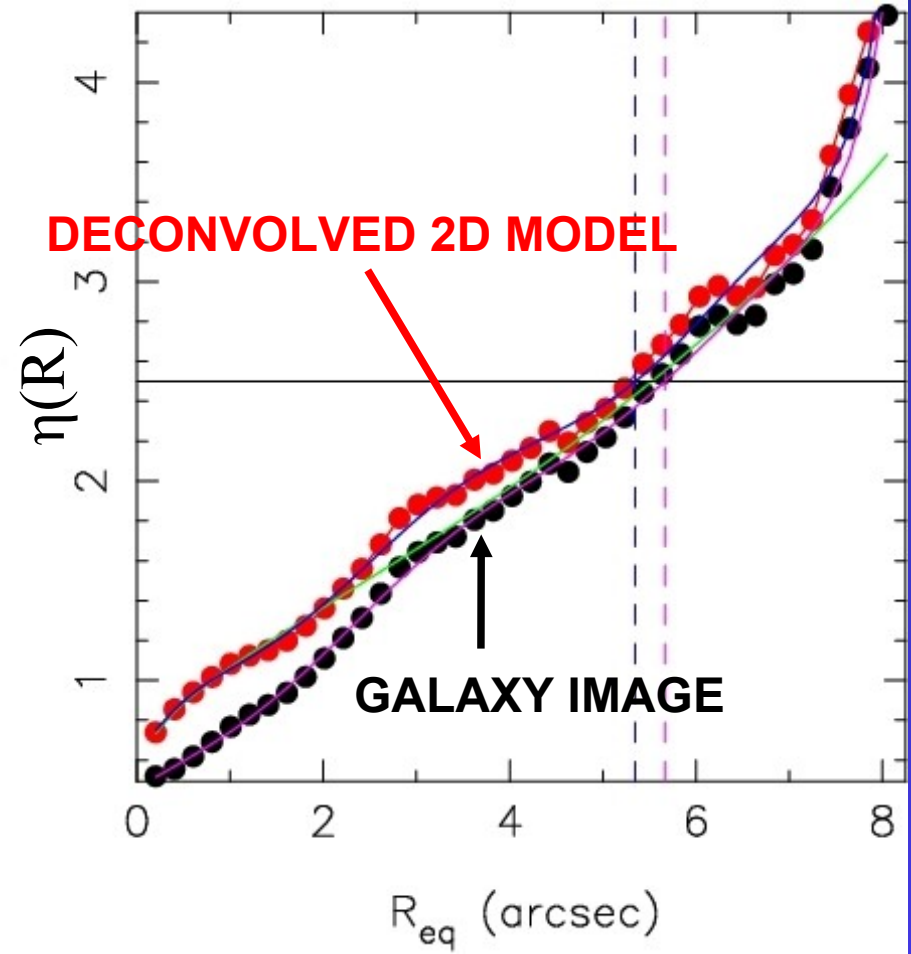




1D SERSIC fits
(following Bendinelli et al.'82)

The 1D surface brightness profile is extracted along concentric isophotes with same PA, b/a, A_n and B_n parameters

PETROSIAN PARAMETERS



The η(R) function is defined as the logarithmic ratio of the mean surface brightness within a given radius and surface brightness at that radius.

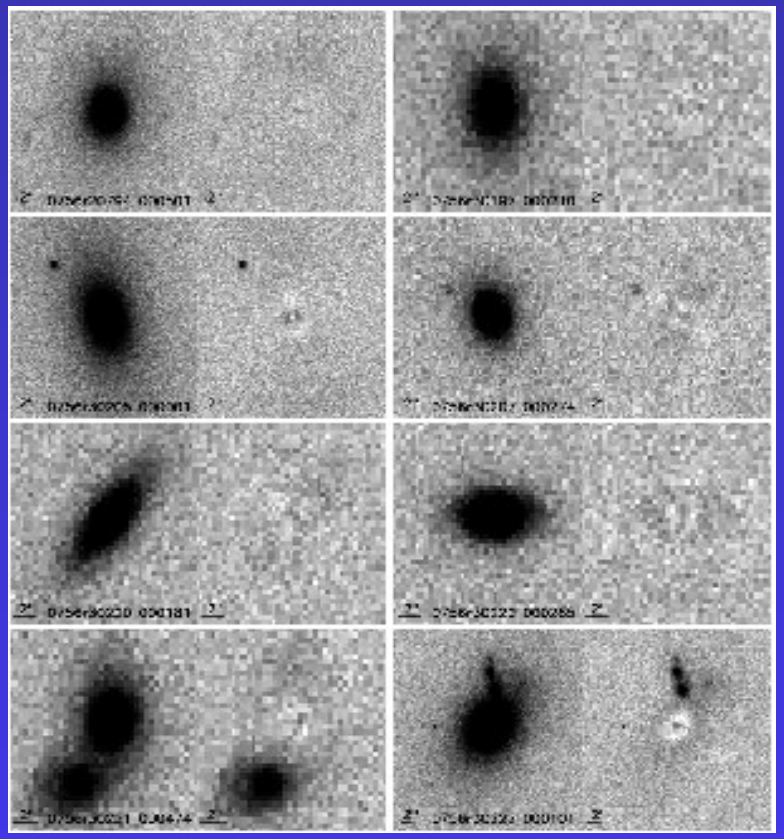
SEEING CORRECTION BY USING THE 2D MODEL

SEEING CORRECTED MAGNITUDES

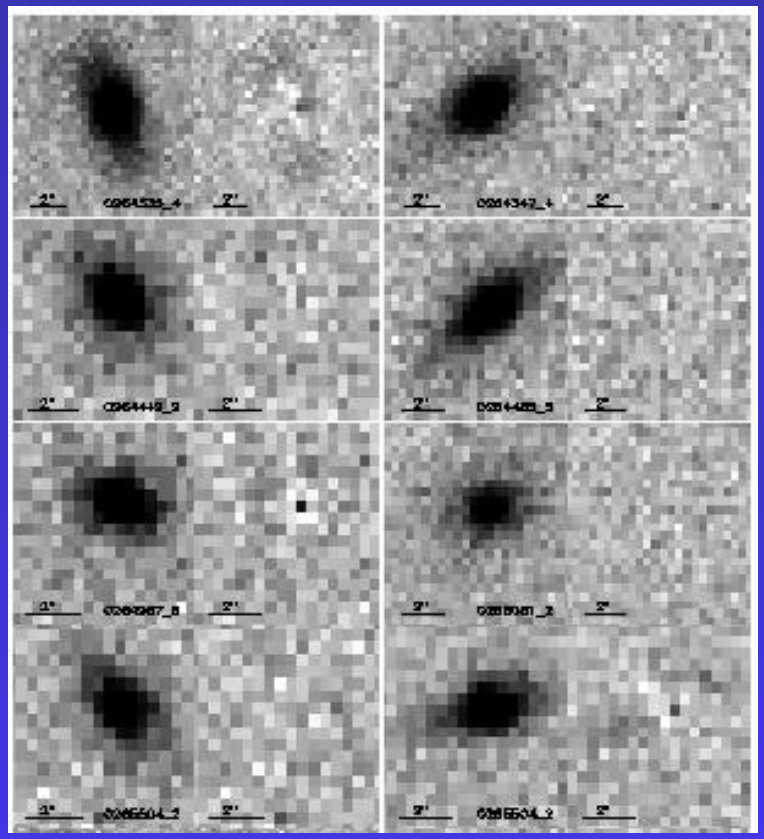
2D FITTING

$$I_s(x,y)=I_0 \cdot Exp[-b_n(r/re)^{1/n}] \Leftrightarrow I_{obs}(x,y)=I_s \circ PSF(x,y)$$

SDSS r band

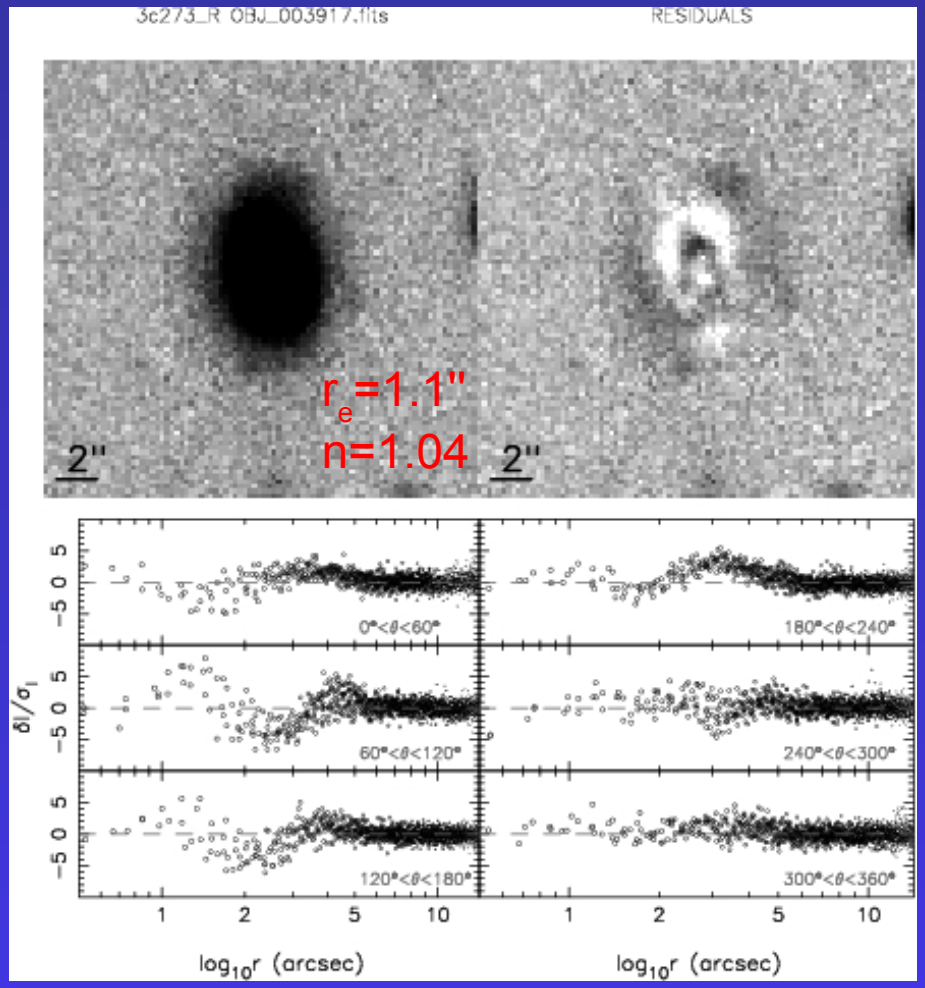


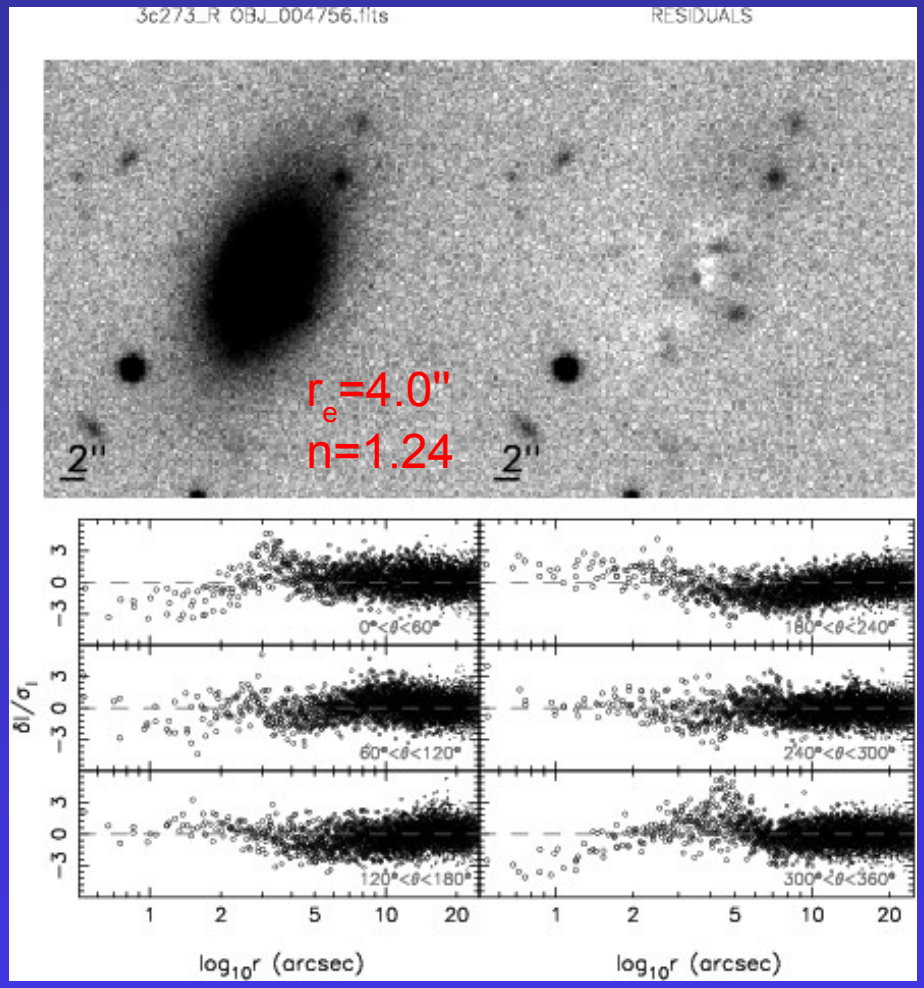
UKIDSS K band



Examples of 2D fitting for SDSS and UKIDSS early-type galaxies. Effective radii for these galaxies are in the range of 0.8-2.0".

2D FITTING





2D fitting of galaxies in the field of 3c273. These plots are automatically produced by 2DPHOT. Normalized residuals are plotted as a function of the distance to the galaxy center in differents bins of the polar angle.

HOW IT WORKS

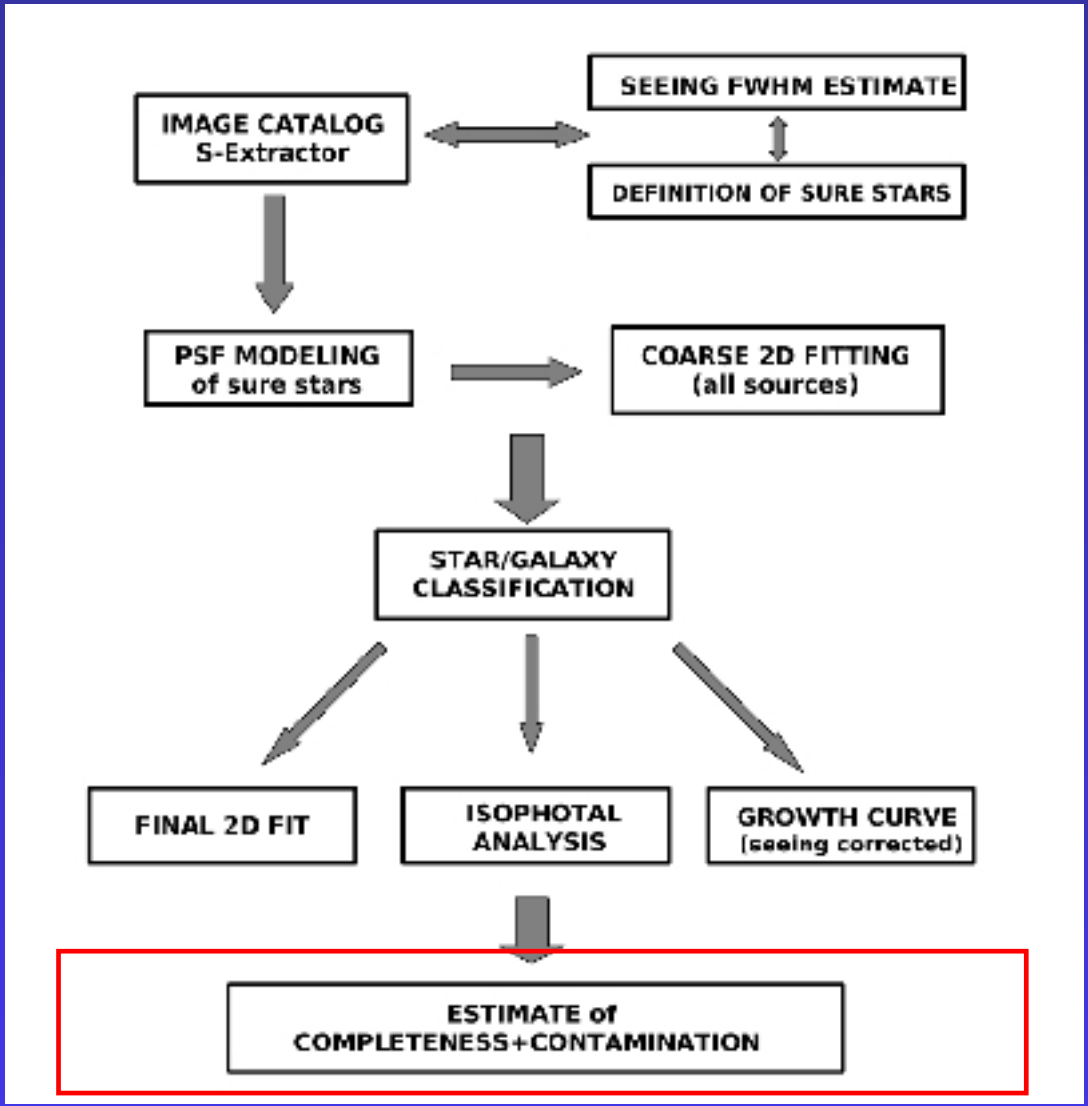
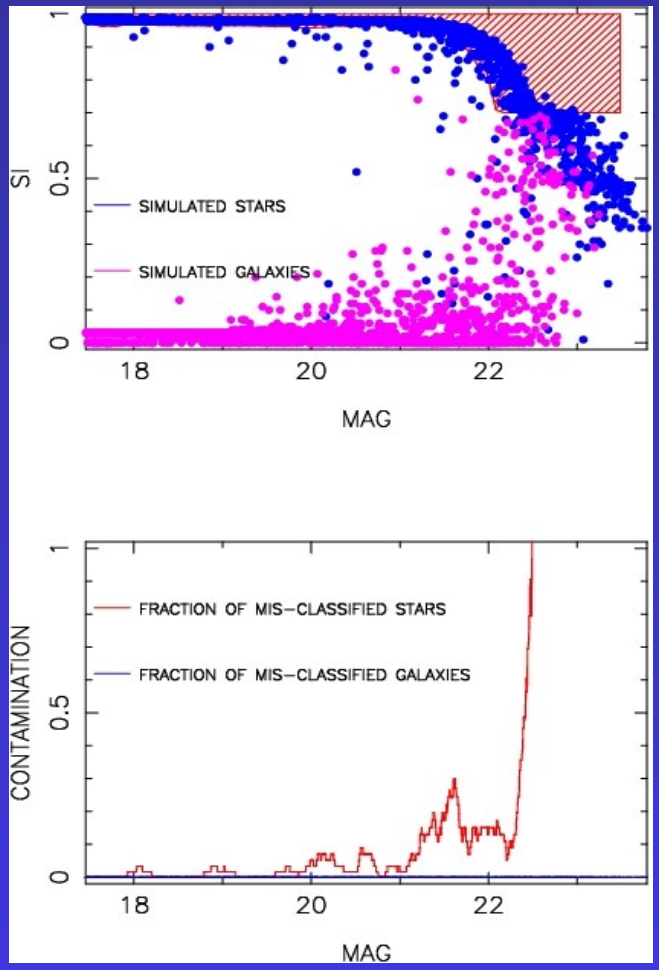
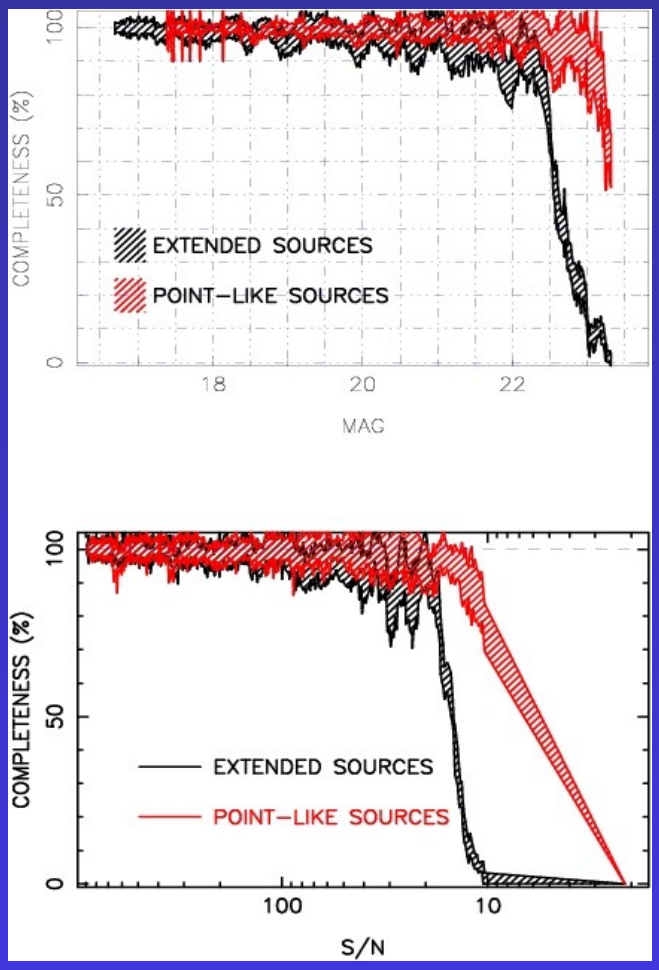


IMAGE CATALOG
S-Extractor
SEEING FWHM ESTIMATE
DEFINITION OF SURE STARS
PSF MODELING
of sure stars
COARSE 2D FITTING
(all sources)
STAR/GALAXY
CLASSIFICATION
FINAL 2D FIT
ISOPHOTAL
ANALYSIS
GROWTH CURVE
(seeing corrected)
ESTIMATE of
COMPLETENESS+CONTAMINATION

CONTAMINATION/COMPLETENESS

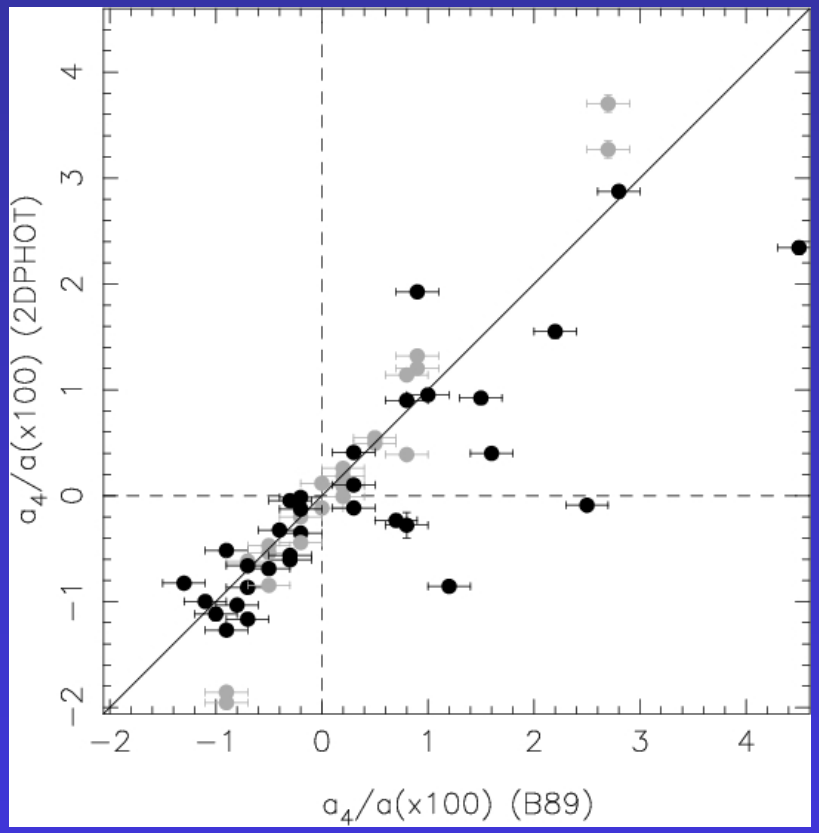




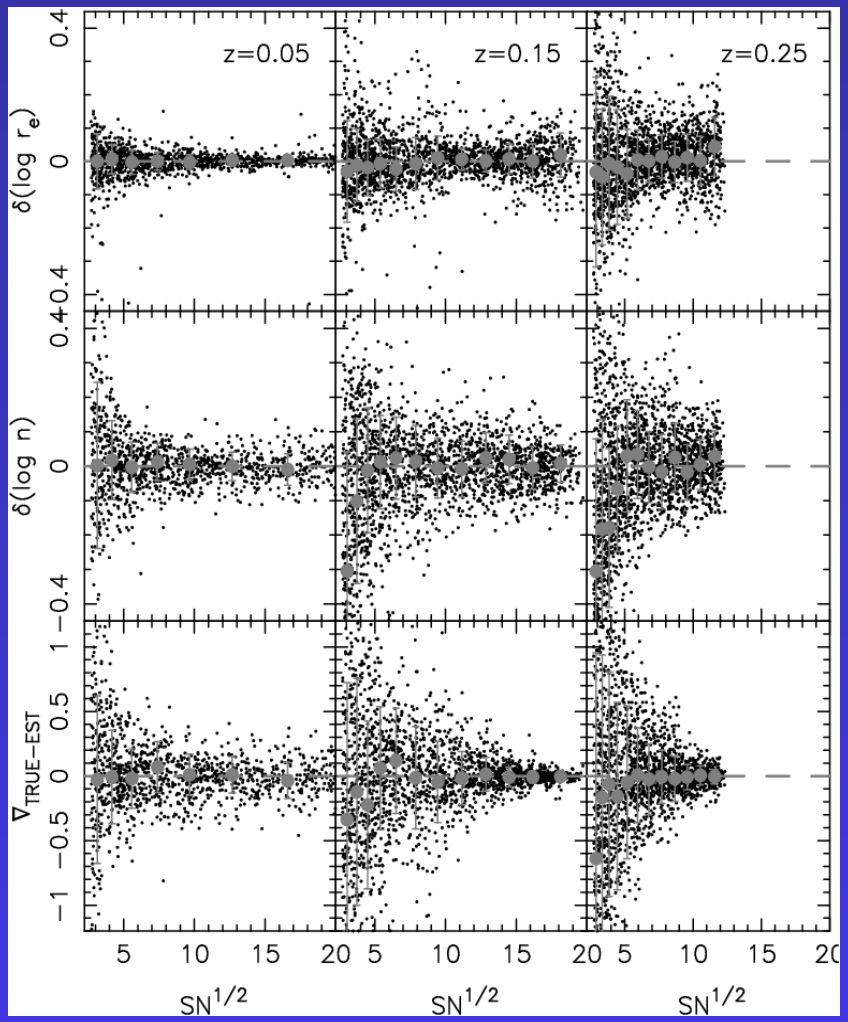
Simulated galaxies are added to the image (according to the measured galaxy structural parameters). For both simulated stars and galaxies, the fraction of misclassified sources (contamination) and the fraction of not detected sources (completeness) is measured.

TESTING 2DPHOT WITH DATA AND SIMULATIONS

ISOPHOTAL AND STRUCTURAL PARAMETERS

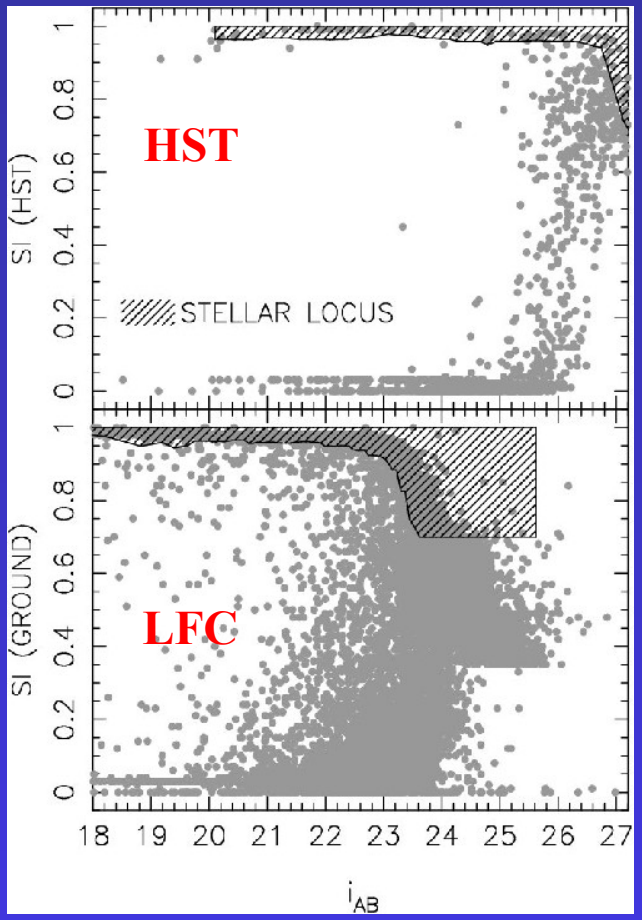


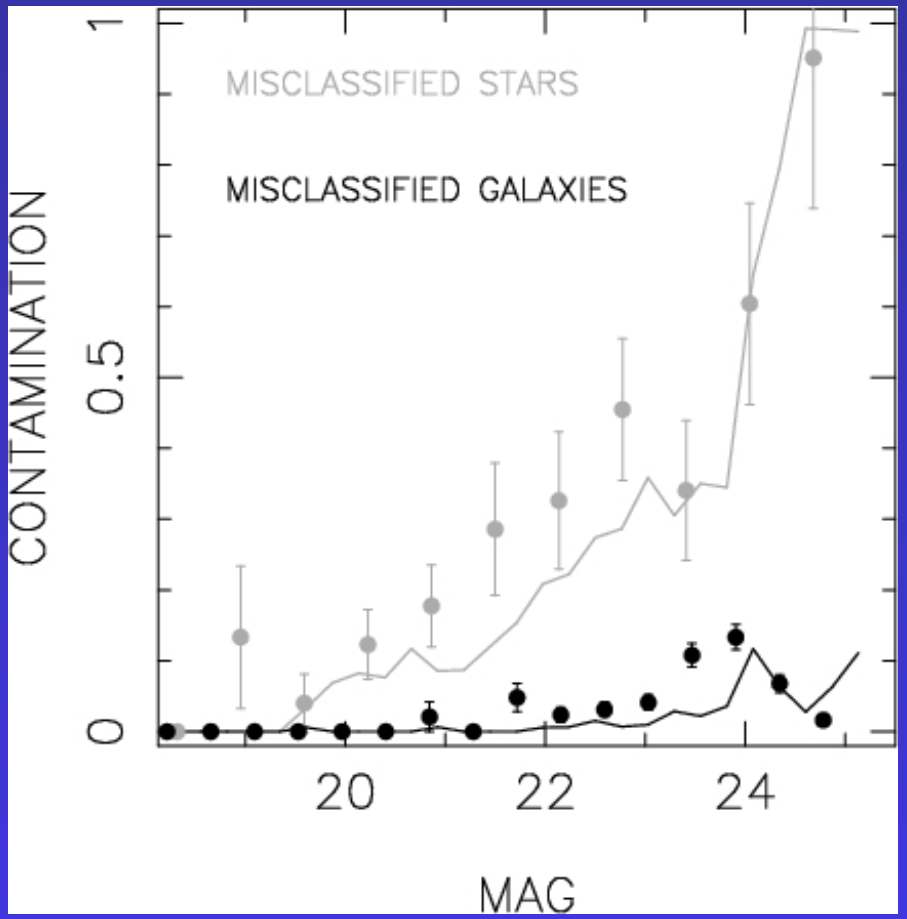
Comparison of a4 values for (42) galaxies in common between SDSS-DR5 and Bender et al.'89.



Comparison of structural parameters for simulated cluster galaxies at z=0.05, 0.15, 0.25.

HST vs. GROUND-BASED COMPARISON





Comparison of star/galaxy classification from ground-based and HST images. Ground-based photometry consists of 2 LFC (Palomar 200") pointings (0.12 deg^2) of the z=0.9 cl1604 supercluster (Gal et al. 2004, 2005). HST data consist of 15 ACS pointitng on the same field.

CONCLUSIONS

graphical interface: 2DGUI (running+inspecting results)

2 min/galaxy on a 2.4GHz Intel processor

cluster (25 nodes) at INPE-Sao Paolo (BR)
~110 processors

University of Naples (IT)
SCOPE consortium
~500 processors

The code is available.....