
Automated model fitting in DESDM
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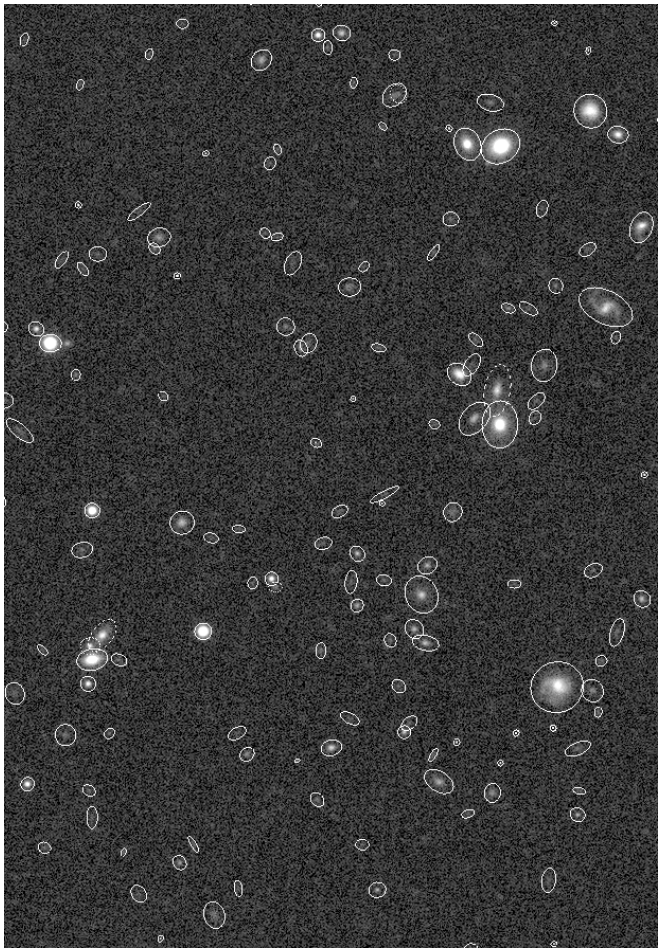
Model fitting

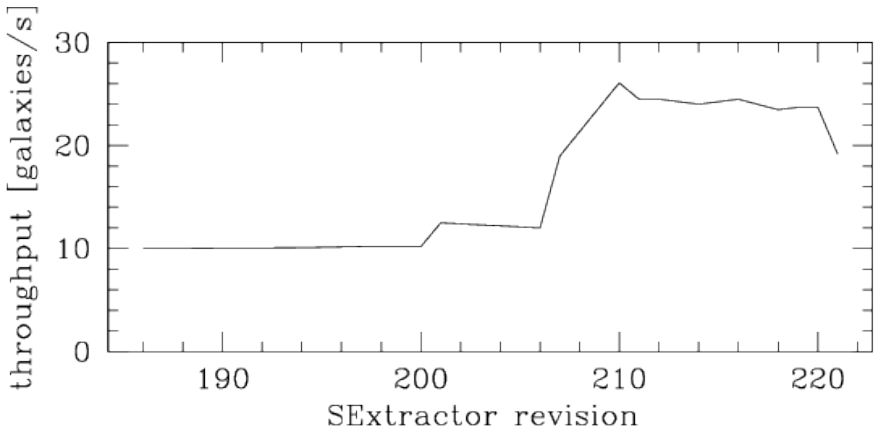
- History
- SExtractor
  - Source detection
  - PSF modeling
  - Modeling PSF variations
- Model fitting in the DESDM
  - Specific features
  - Control of systematics
  - Pending issues and forthcoming developments

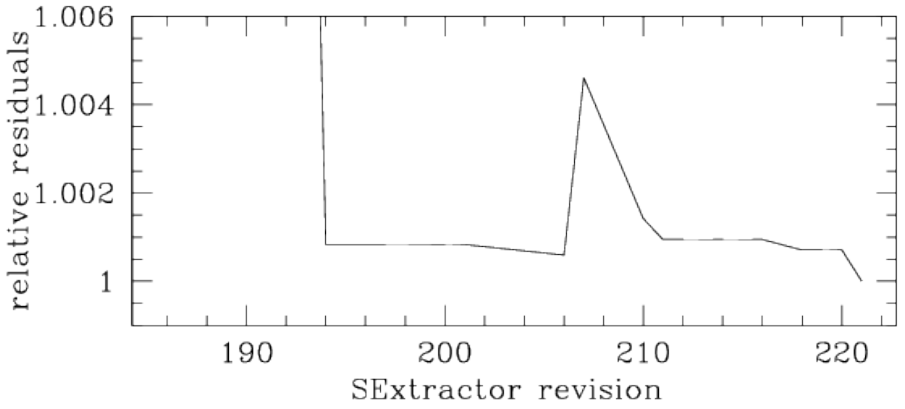


Model-fitting

History

- SExtractor's first release was in 1994.
  - For years people would use scripts that would combine SExtractor and model-fitting software (GalFit, GIM2D.,,) to perform morphometry on large galaxy samples
- EFIGI project in 2005-2007
- DES
  - Apply to PSF-homogenized data
  - Performance improvements and control of systematics

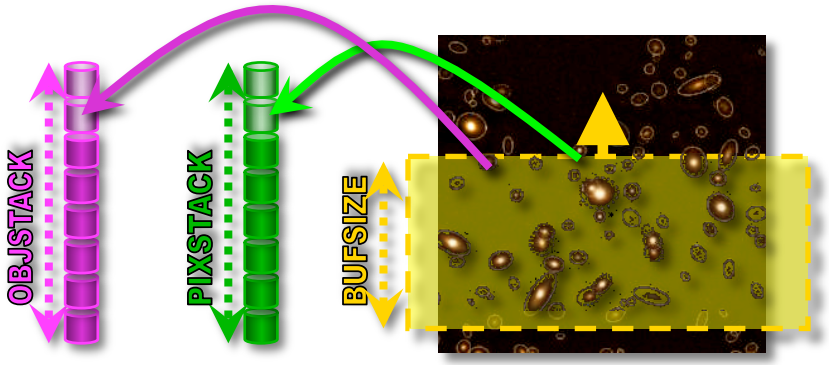


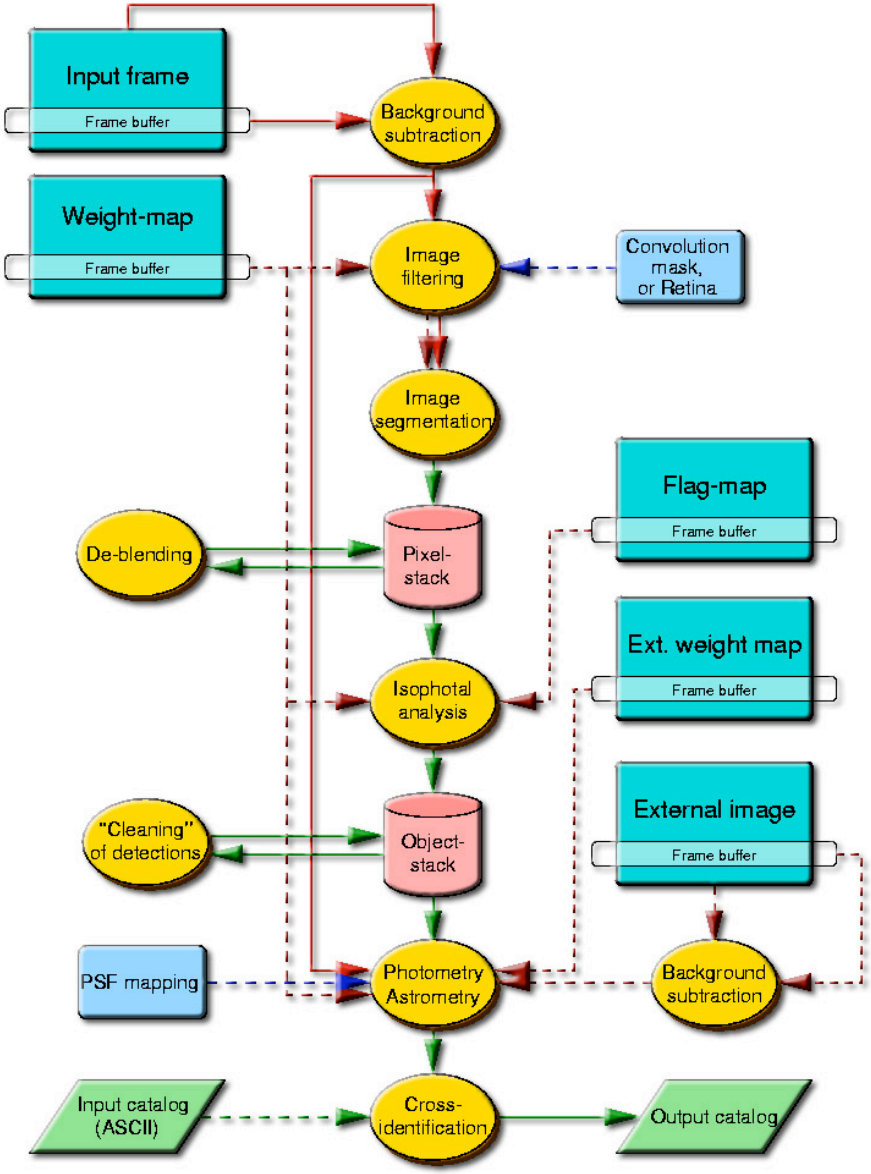


Model-fitting

Sextractor's internal pipeline

- Image and detection buffers are handled as FIFO stacks:

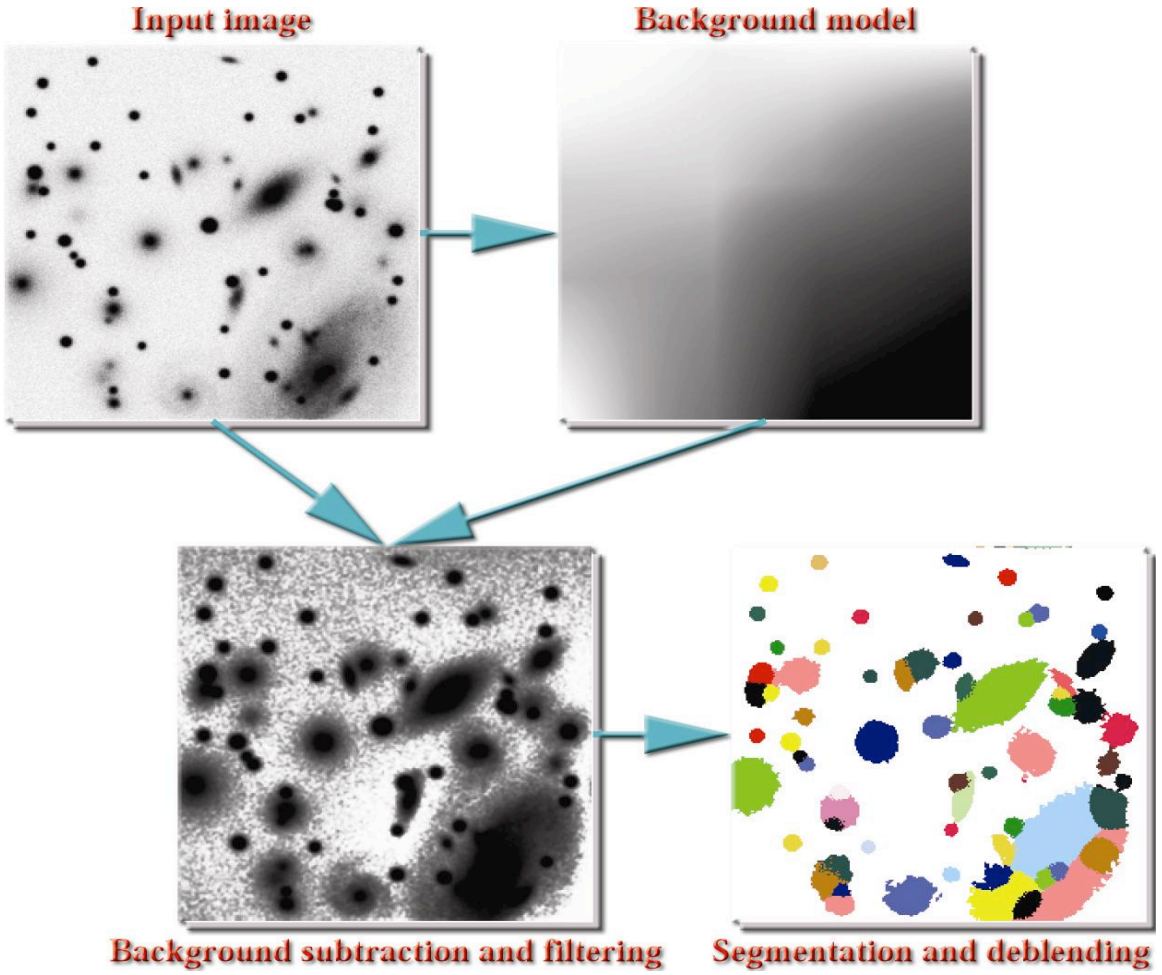




Model-fitting

How sources are detected in SExtractor

- 4 steps:
  - Sky background modeling and subtraction
  - Image filtering at the PSF scale (matched filter)
  - Thresholding and image segmentation
  - Merging and/or splitting of detections

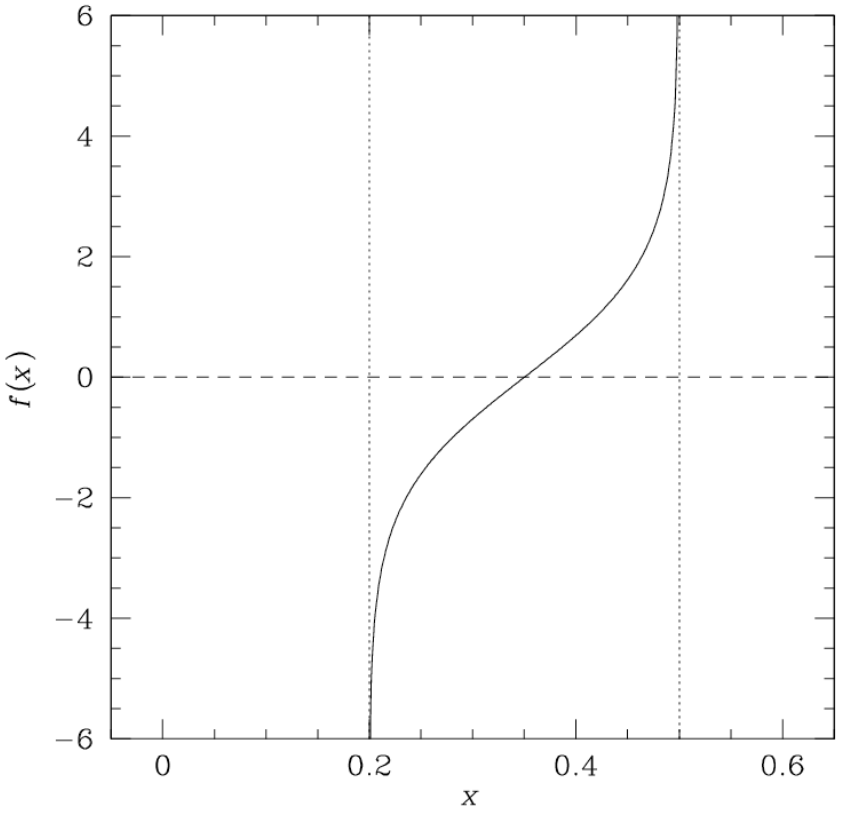


Model-fitting: implementation

- PSF modeled using ***PSFEx***
  - Sampling automatically adjusted depending on image
  - Many improvements and bugfixes done over time
- Models are computed using a grid size that depends on sampling and on the object
  - Image and model rasters are rebinned for very large objects
- Several model components currently available:
  - Background level
  - Dirac peak (2 + 1 parameter)
  - Sersic (2 + 5 free parameters)
  - De Vaucouleurs (2 + 4 free parameters)
  - Exponential (2 + 4 free parameters)
  - others currently in development
- Automatic sharing of component parameters (e.g. x,y,…)
- Minimization uses the ***LevMar*** implementation of the Levenberg-Marquardt algorithm by M.Lourakis
  - Adaptive Jacobian
  - Initial parameter guesses made from « classical » SExtractor measurements
  - Bright pixels from neighbours automatically masked by SExtractor.
  - Robust fitting

Model-fitting: fighting degeneracies

- It is mandatory to include some implicit priors in the χ^2:
  - positivity constraints for fluxes
  - ellipticity constraints for the bulge
- Implementation of the box-constrained algorithm by Kanzow, N. Yamashita and M. Fukushima (2004) in *levmar* did not lead to satisfactory results.
- House-made trick: map free parameters from a « bounded space » to an « unbounded space »
  - A sigmoid function works fine!
  - In some cases a free parameter can get stuck at one of the boundaries
  - Covariance matrix also mapped back to « bounded space »



Robust model-fitting

- The sky around galaxies is not « clean » because of overlapping stars, galaxies or defects.
  - The old SExtractor « CLEANer » masks out the pixels from bright neighbours, but it is not efficient enough
- The « perfect fit » does not exist, except may be for some ellipticals and spheroidals
  - dust, star formation regions, overlapping objects,…
- Minimizing fractional errors instead of absolute ones is more appropriate for bright parts of the profile
- Proposition: replace the usual residuasl in

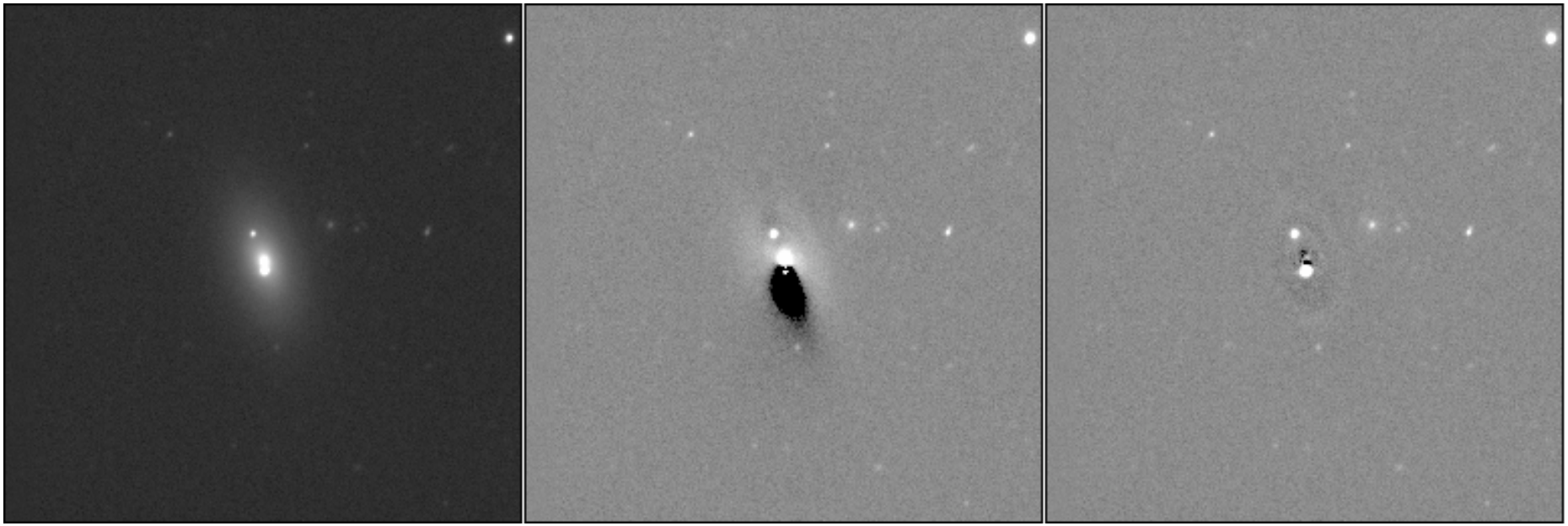
$$\chi^2 = \sum_i \frac{I_i - f(x_i)}{\sigma^2}$$

with

$$\chi^2 = \sum_i g\left(\frac{I_i - f(x_i)}{\sigma}\right)^2 \quad \text{where } g(u) = \begin{cases} \log(1+\kappa u) & \text{if } u \geq 0 \\ -\log(1-\kappa u) & \text{otherwise} \end{cases}$$

- κ ~1: linear close to the noise and continuously derivable

Robust profile-fitting (cont.)

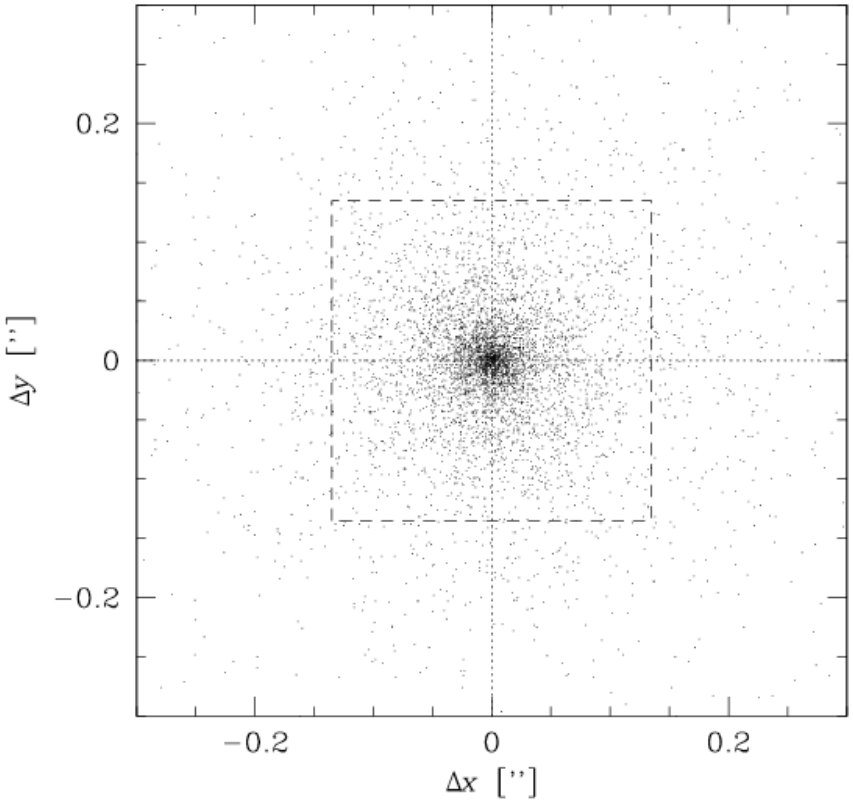


Galaxy | Linear weighting | Non-linear weighting

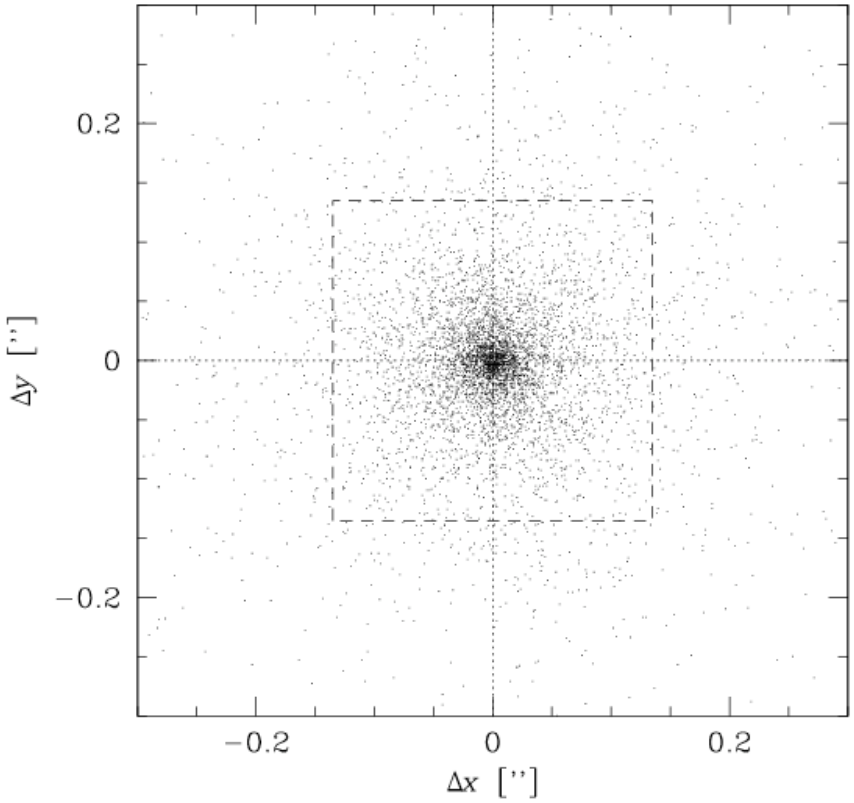
- More robust towards bright interlopers
- In rare cases, the minimization algorithm may accidentally “lock” on some bright, non-galaxy feature

Model-fitting

Positional accuracy



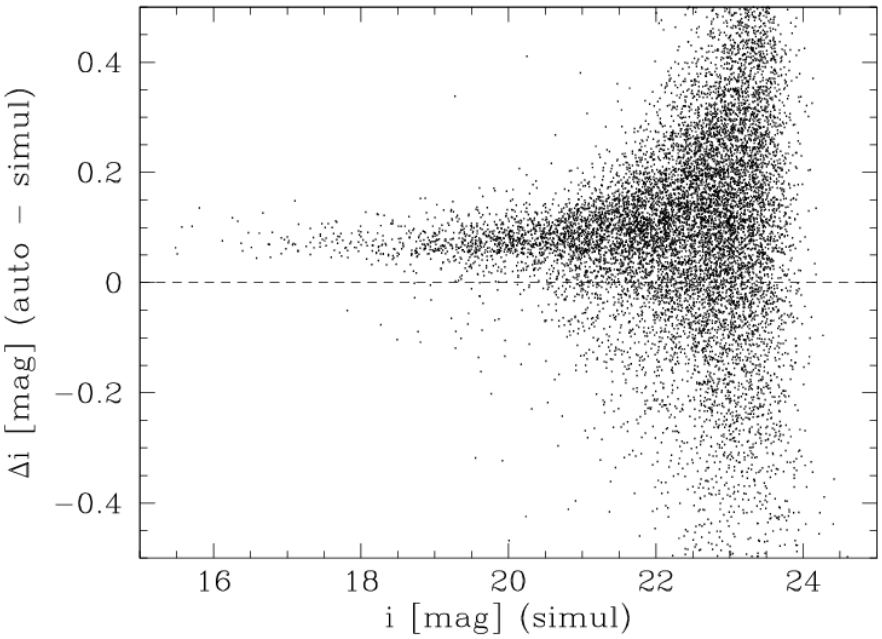
X/YWIN (i<22)



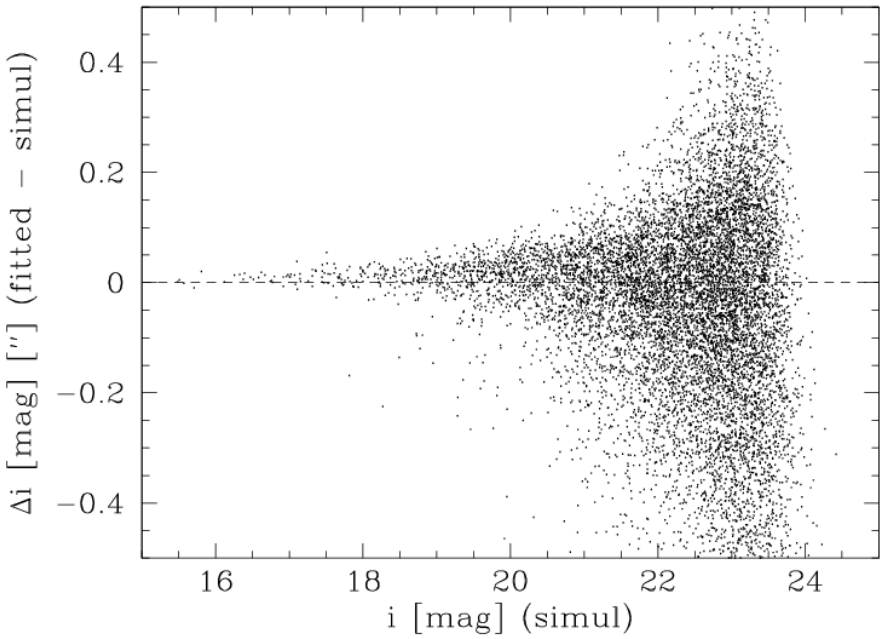
Sersic + Exponential fit (i<22)

Model-fitting

“Total” magnitudes



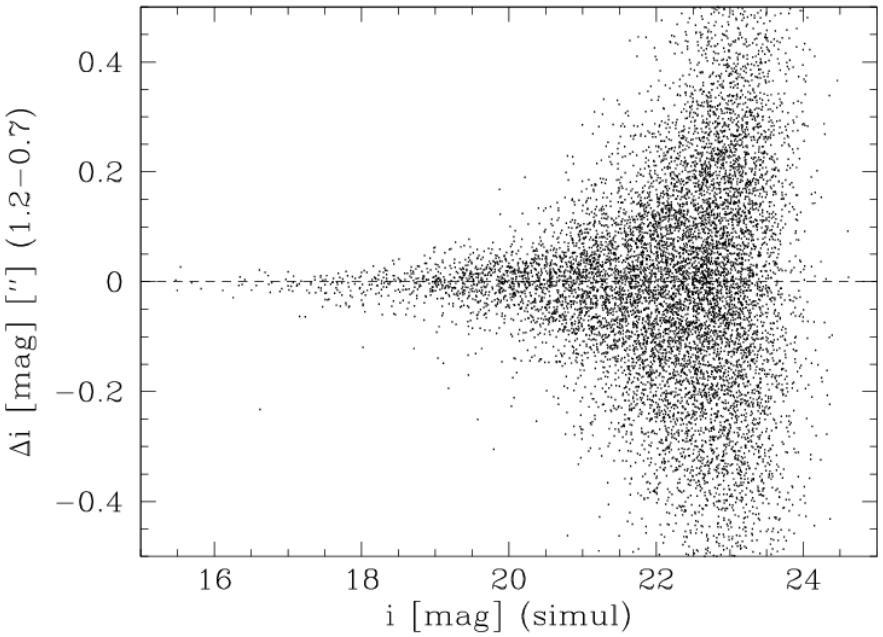
MAG_AUTO (Kron-like)



Asymptotic from Sersic+Exponential fit

Model-fitting

“Total” magnitudes: seeing dependency



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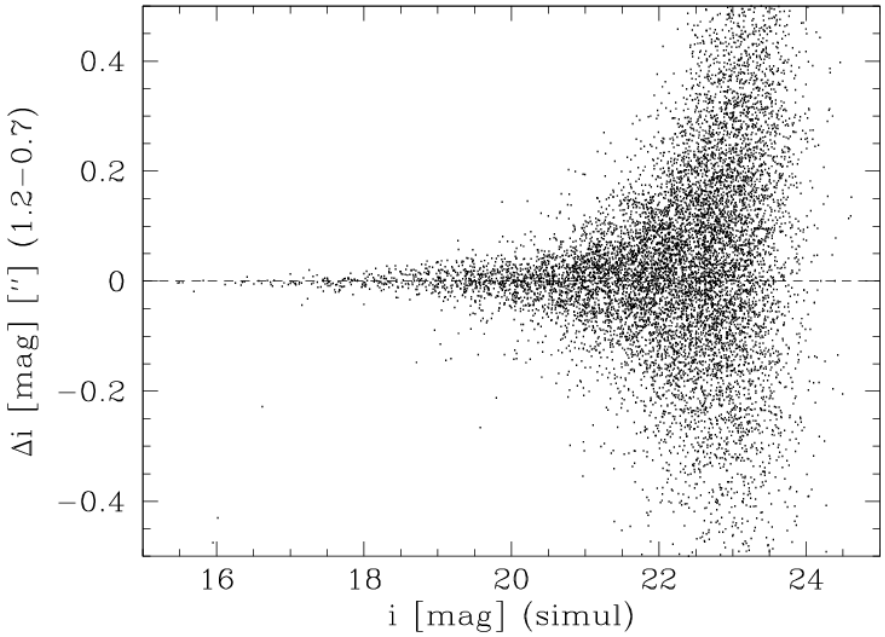
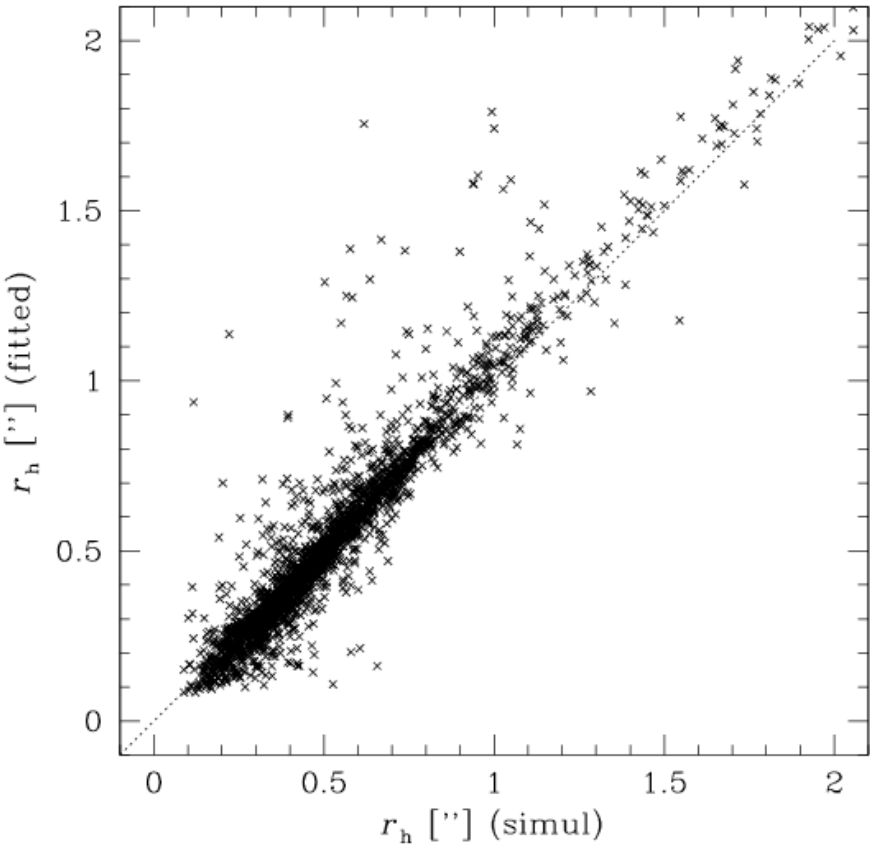
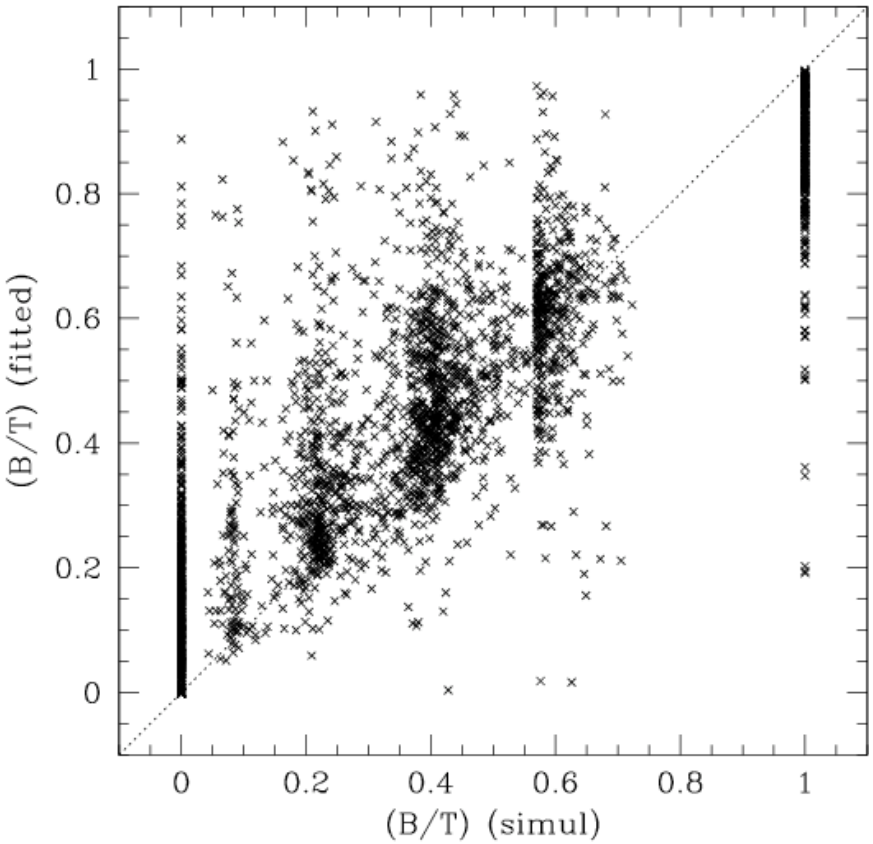


Asymptotic from Sersic+Exponential fit

Model-fitting

Recovered galaxy parameters



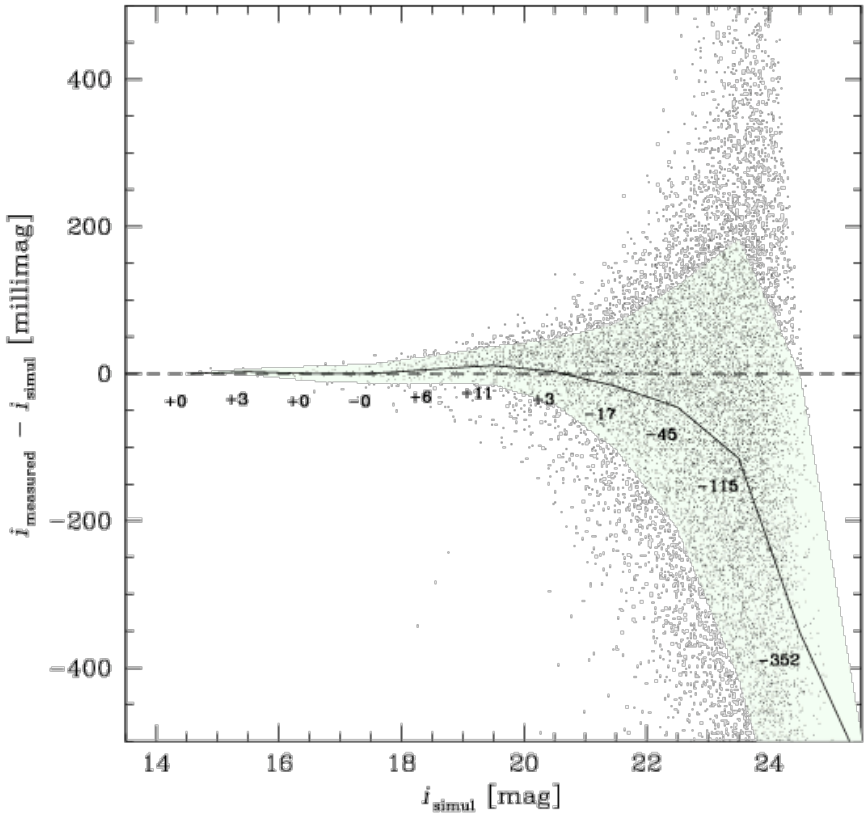


Sersic (n=4) + Exponential fit for i<21

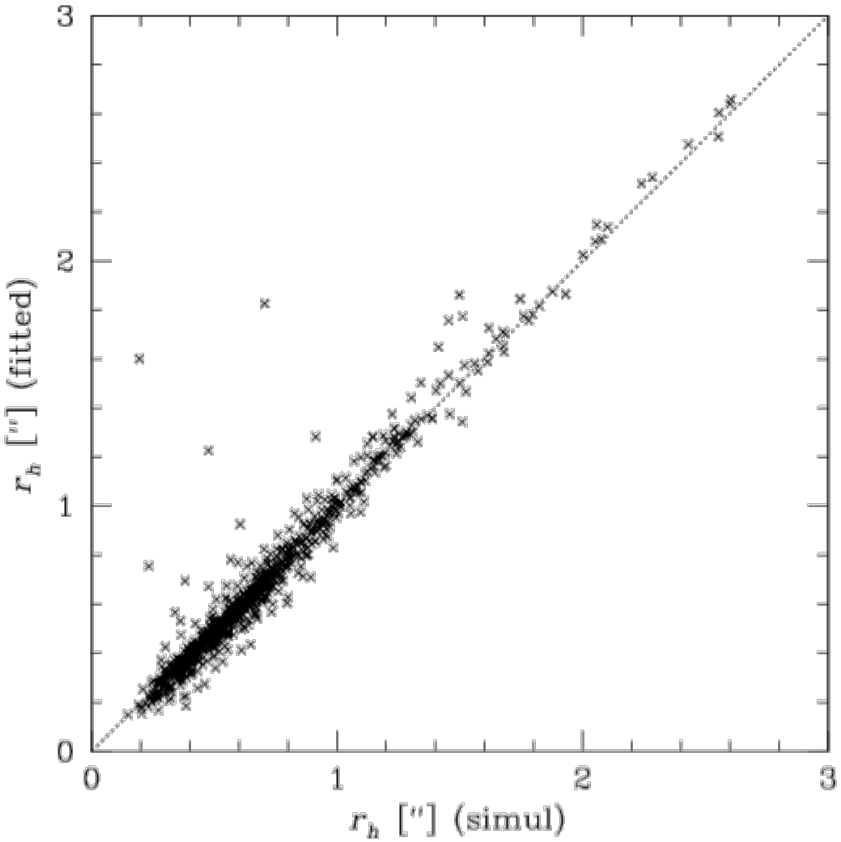
Model-fitting

Galaxy measurements on homogenized simulations

Stack of 16 homogenized exposures with 0.65”<FWHM<1.3” (including ≈0.5 ’’ coma)



Asymptotic magnitude



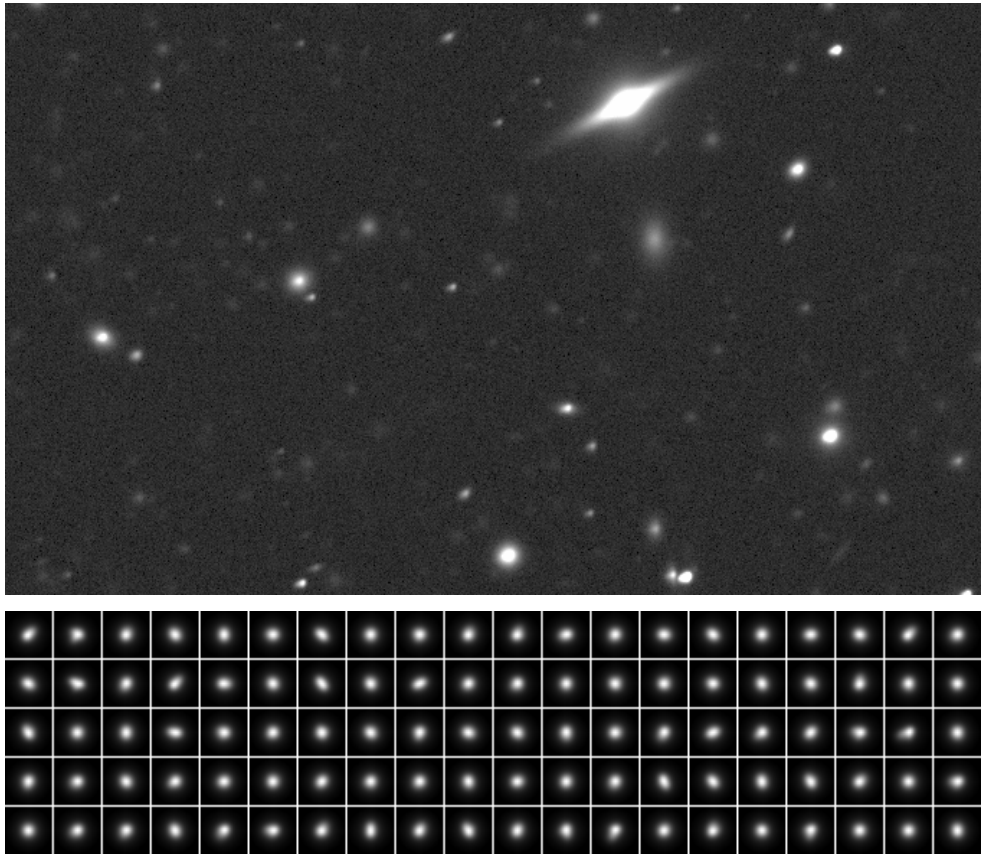
Disk scalelength (i<21)

Sersic+Exponential fit

Model-fitting

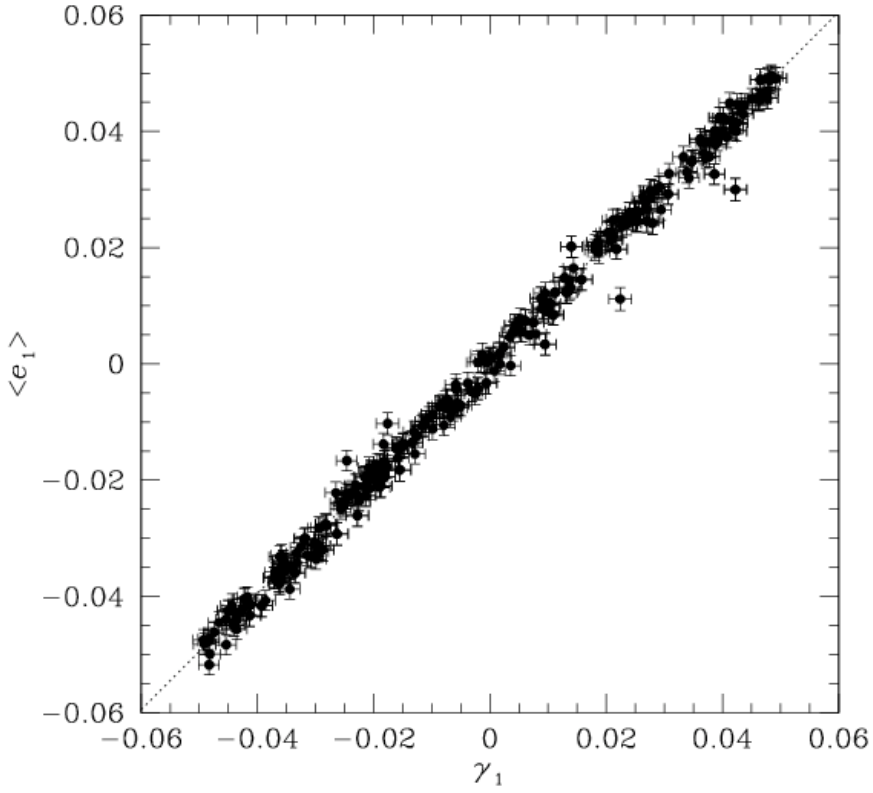
Control of systematics and weak shear measurements with SExtractor

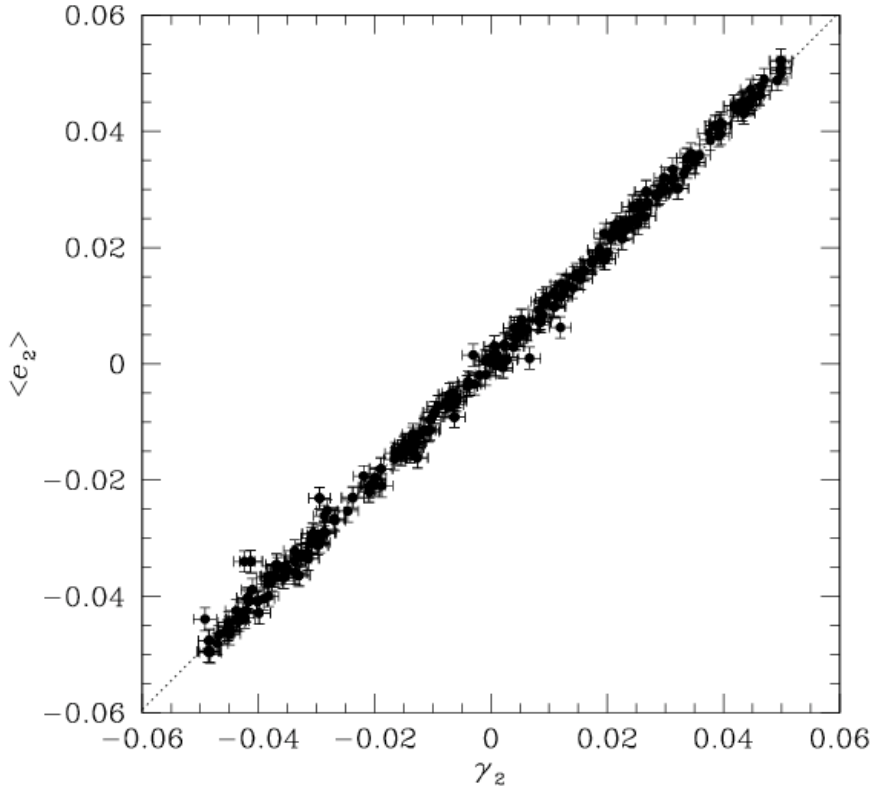
- Good test bed for estimating ellipticity / position angle measurement biases in model-fitting
  - With a good model of the PSF and a simple Sersic model for galaxies, is it possible to measure shear to a fairly good accuracy, at least on two-component simulated galaxies (Voigt and Bridle 2010)?
  - Test in realistic conditions (random positions, crowding, non-symetric PSF aberrations)
  - Analysis restricted to SNRs≥20



Model-fitting

Weak shear measurements with Sextractor (cont.)

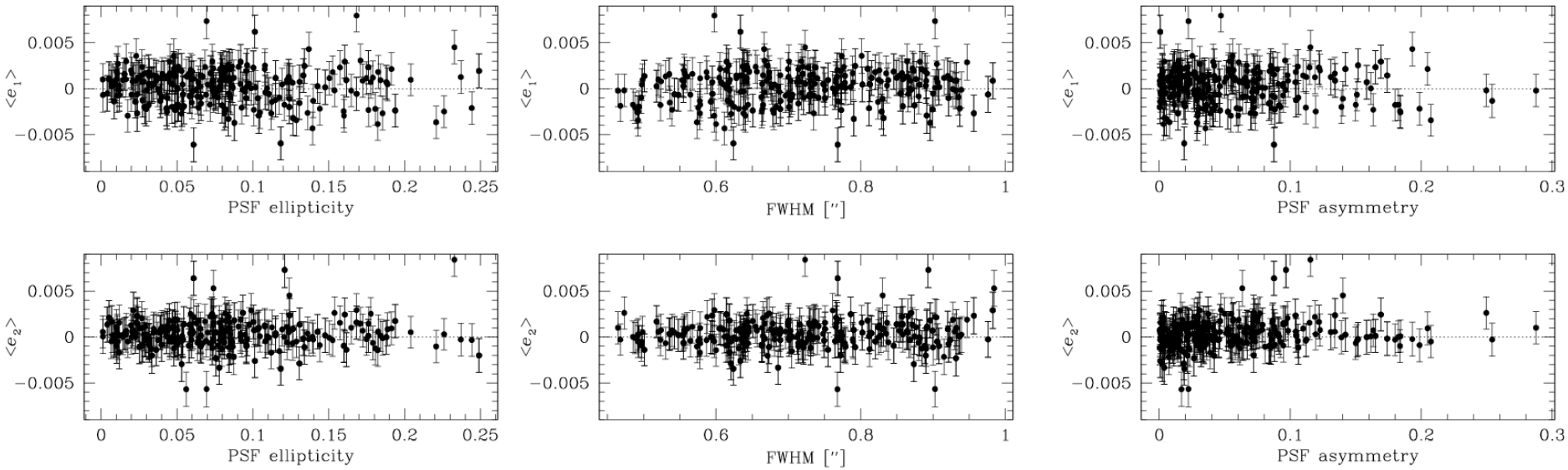




Model-fitting

Weak shear measurements with Sextractor (cont.)

- No obvious trend seen as a function of PSF ellipticity, FWHM, or asymmetry



Model-fitting

Pending issues and future improvements

- Magnitude estimates
  - SDSS model/cmodel equivalents
  - Aperture magnitude + asymptotic correction
  - Improved simulations?
- Multiband fitting
- Parallelizing the code
  - Manage to have every tile processed in less than 24h
- Multiple galaxy fit as part of deblending
- Star/galaxy separation
  - **`CLASS_STAR`** appears to be more reliable than **`SPREAD_MODEL`** in DC5 (and in other tests)
  - Adaptive **`CLASS_STAR`**?
- Improve background noise modeling and subtraction