NSLS software and products

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Outline

- Data volume
- Data calibration: requirements and strategy
- Software evolution since CFHTLS: some highlights
    - Astrometry / proper motions
    - Star/galaxy separation
    - Galaxy morphometry and shear measurement
- Automatizing quality control
- Ongoing developments

Expected data volume

- $7500 \times 1.2 \times 4 \times 3 \approx 100{,}000$ science exposures
- ~300TB of reduced science pixel data (uncompressed) including weight and flag maps.
  - Similar to or lower than large ongoing sky surveys
- May be a few PB if using external data (“poorman’s LSST”)

Data calibration

- Science from large surveys limited by systematics in the calibration
  - Possible goals (not totally unrealistic by today's standards):
    - relative photometry: 10 mmag RMS (except u-band)
    - relative astrometry: 10 mas RMS (except u-band)
- Importance of having large dithers (e.g. between epochs) for internal calibration, see e.g. *Holmes et al. 2012*
  - Coadds generate abrupt changes in the PSF
    - Multi-epoch / multiband processing required
- Part of a multisurvey?

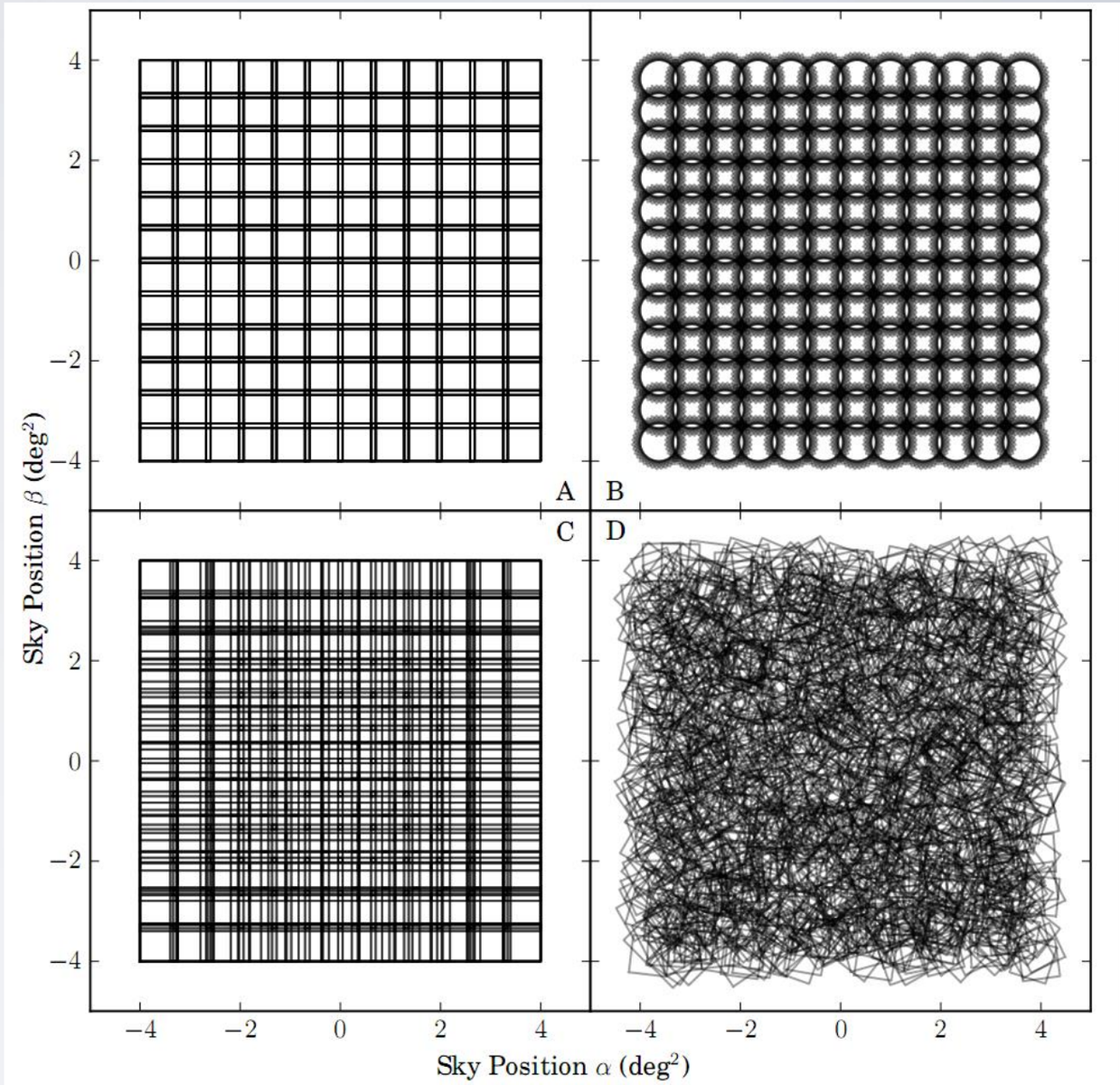
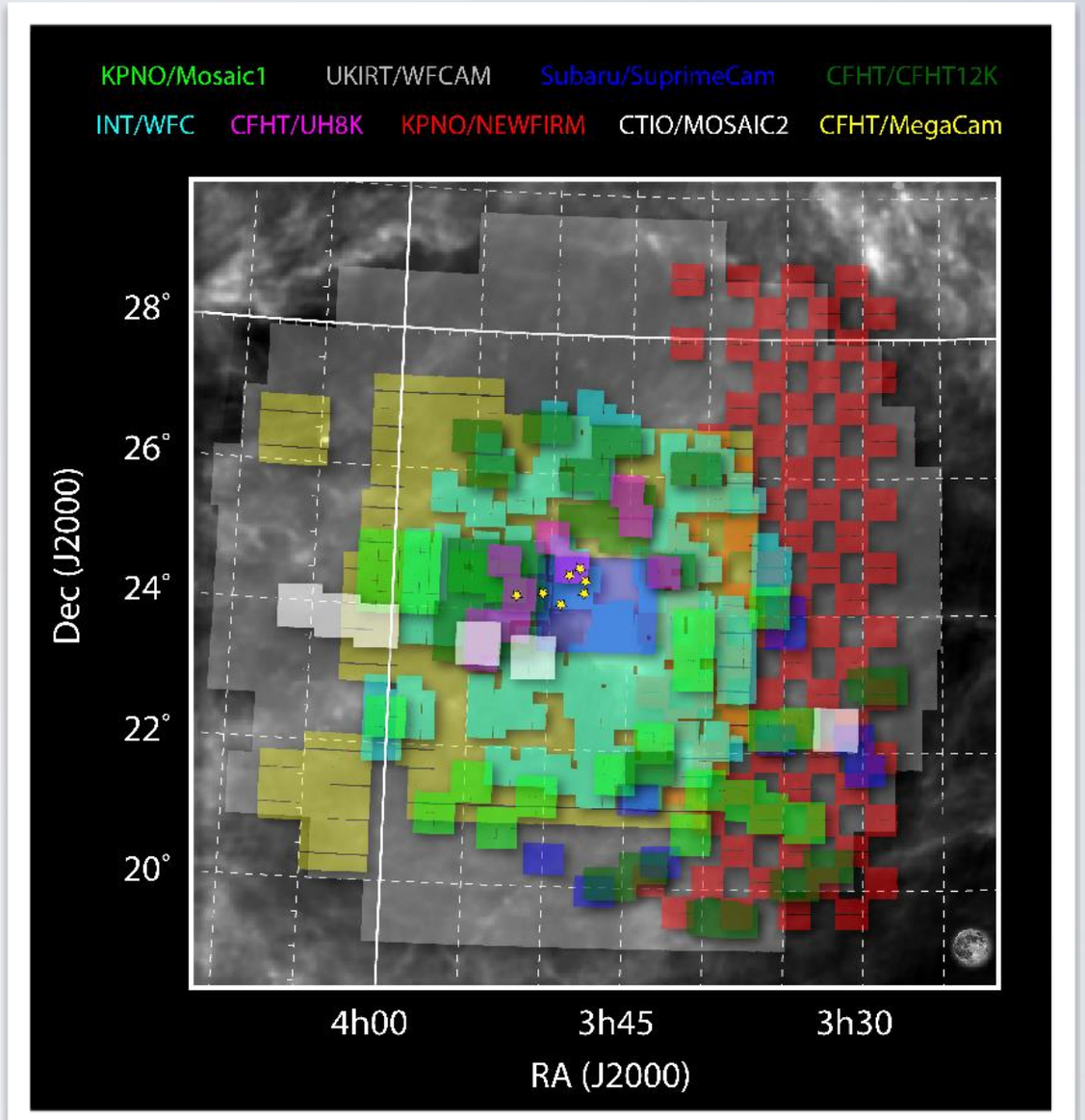


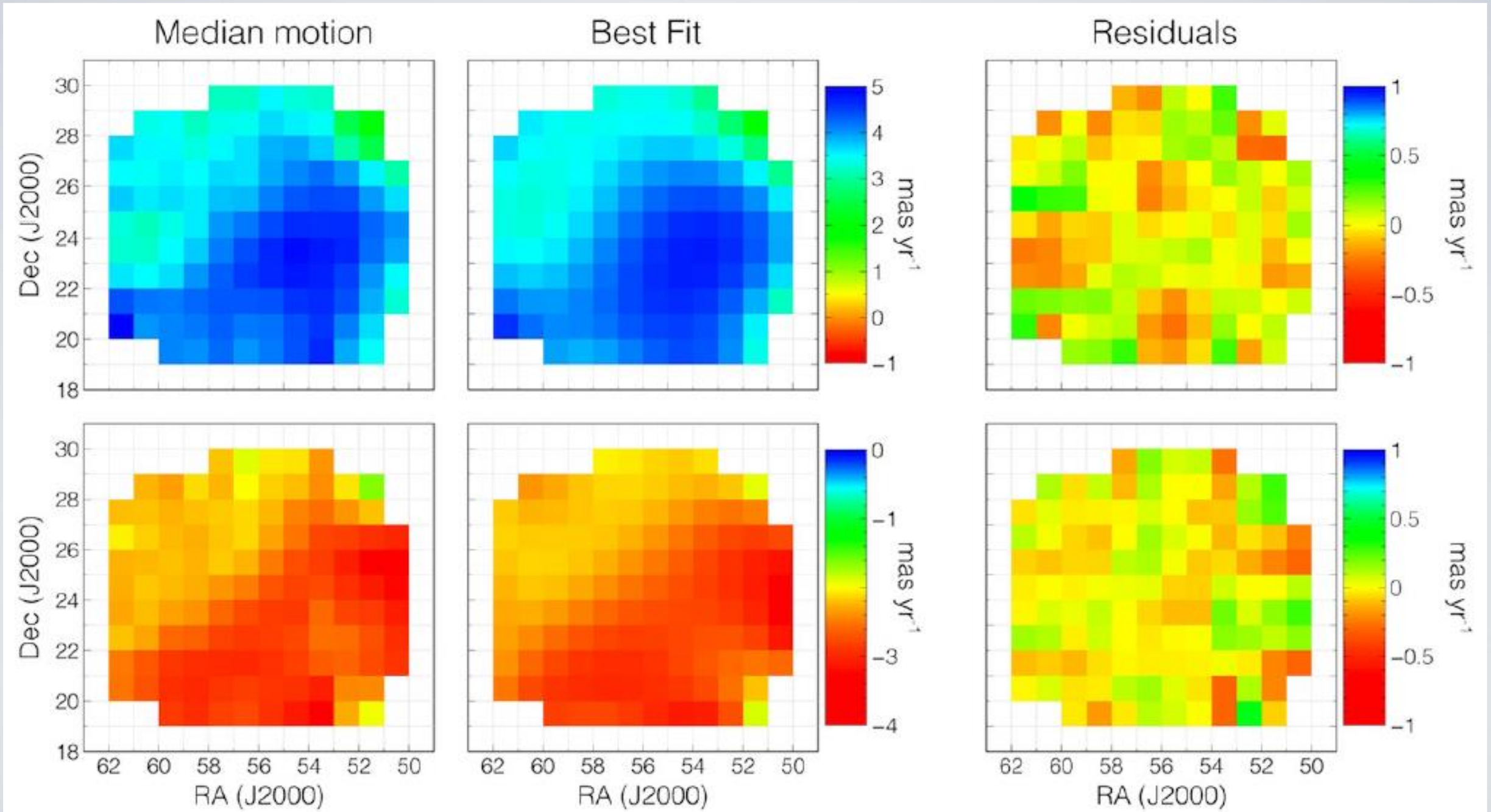
Fig. 2.— Focal-plane footprints projected onto the synthetic sky according to the four simple survey strategies described in Section 5 and summarized in Table 2. Surveys A, B and D have 1296 pointings and survey C has 1290 pointings.

Astrometric calibration

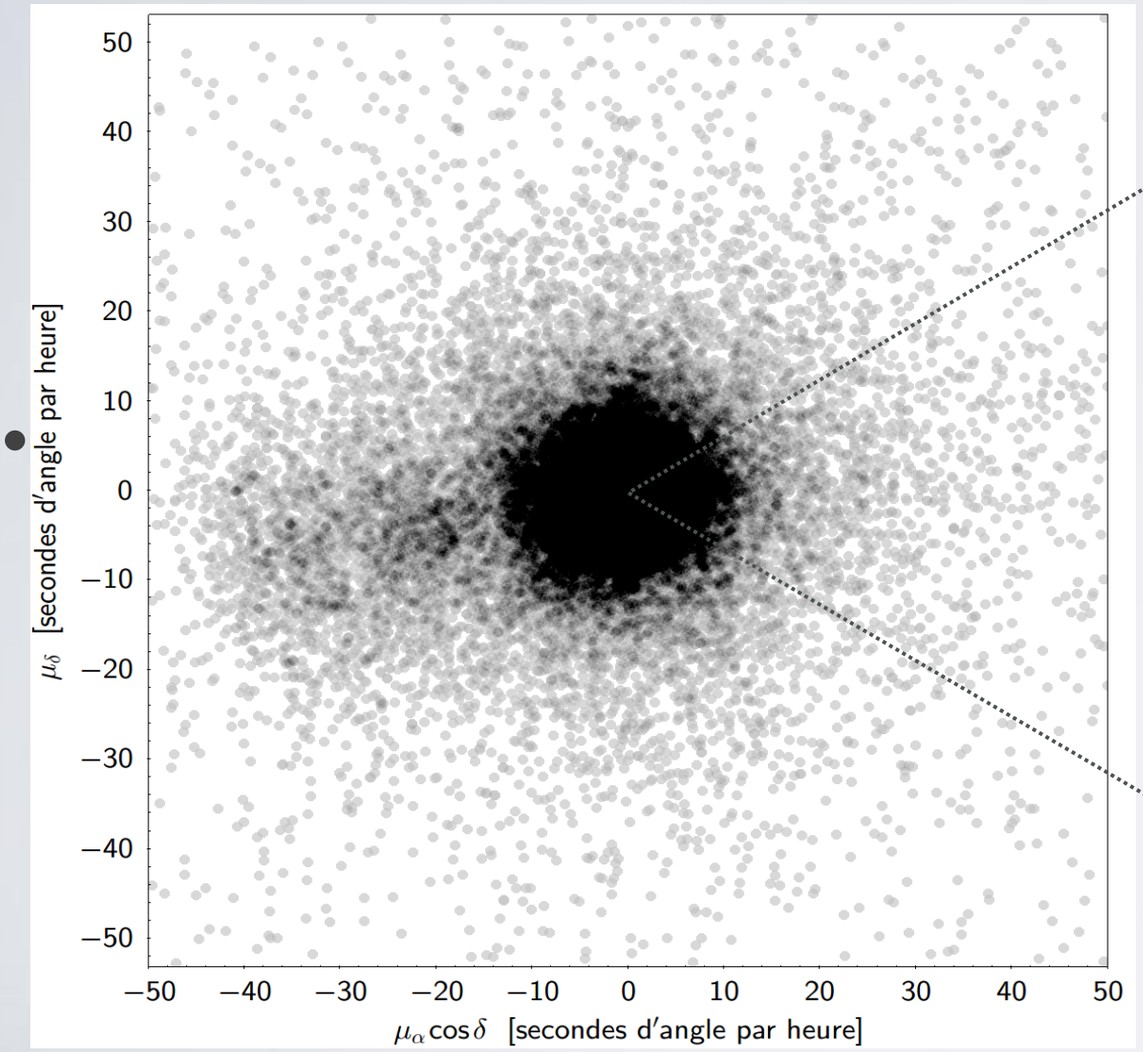
- DANCe project Bouy et al. 2013+
  - Combination of archival and new observations, including MEGACAM
  - 40,000 exposures from a dozen wide-field mosaic cameras processed so far
  - 10^7's of proper motions down to i~24 and $|\sigma_\mu|$~0.3 mas/yr
  - Doubled the number of known Pleiades members

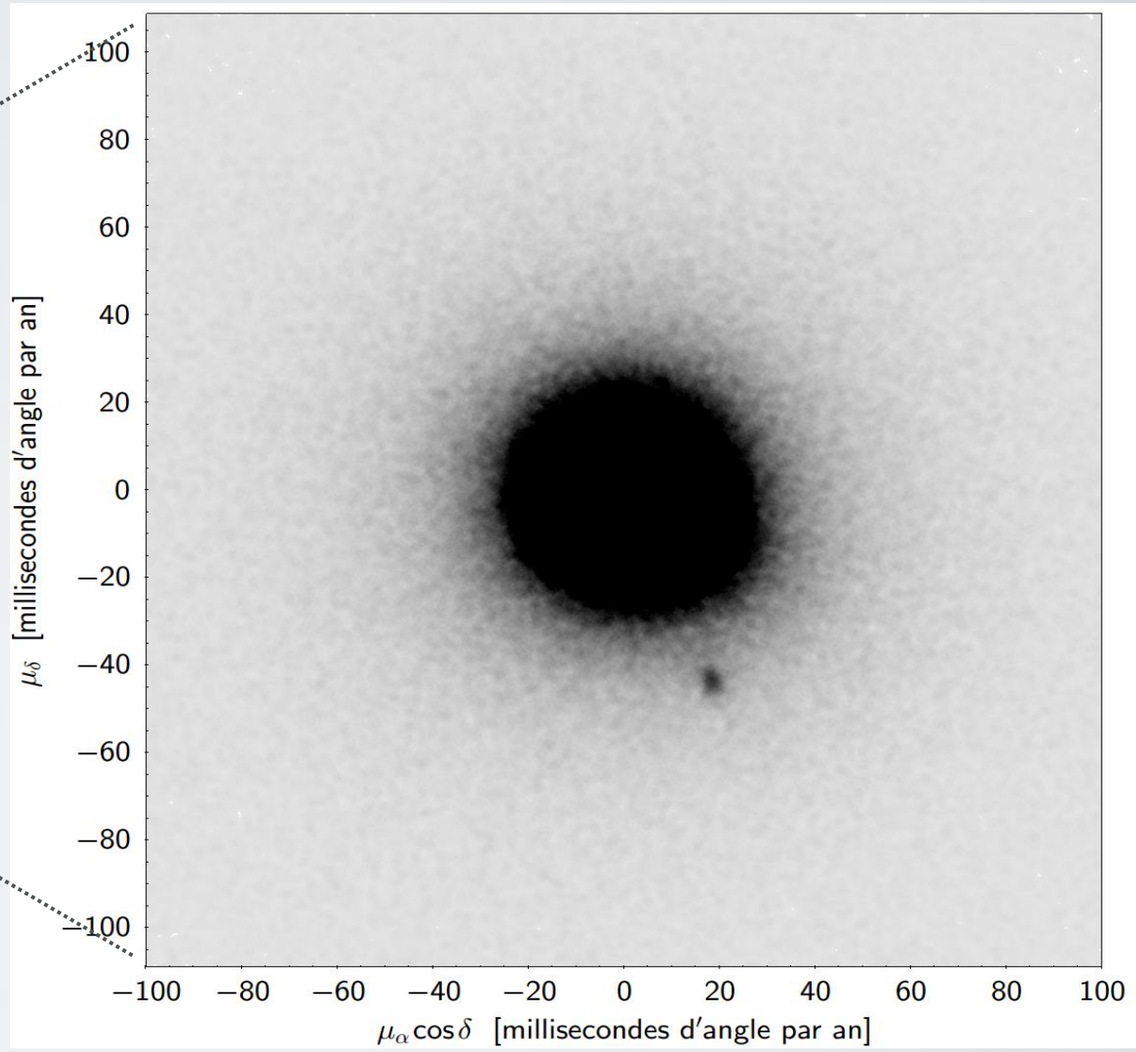


Correcting for bulk stellar motions

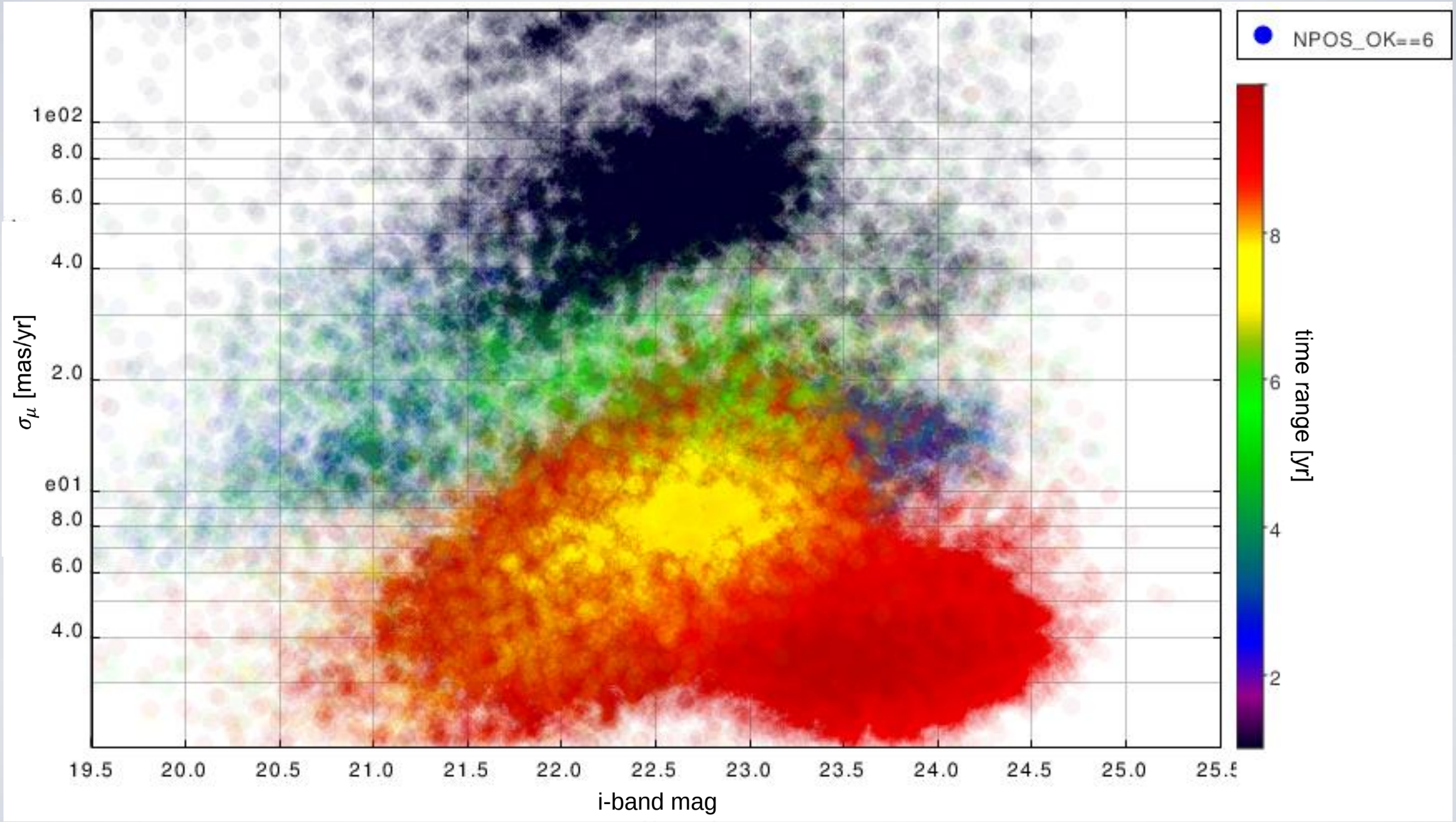


proper motions





Expected pm uncertainties



SPREAD_MODEL : a morphometric estimator

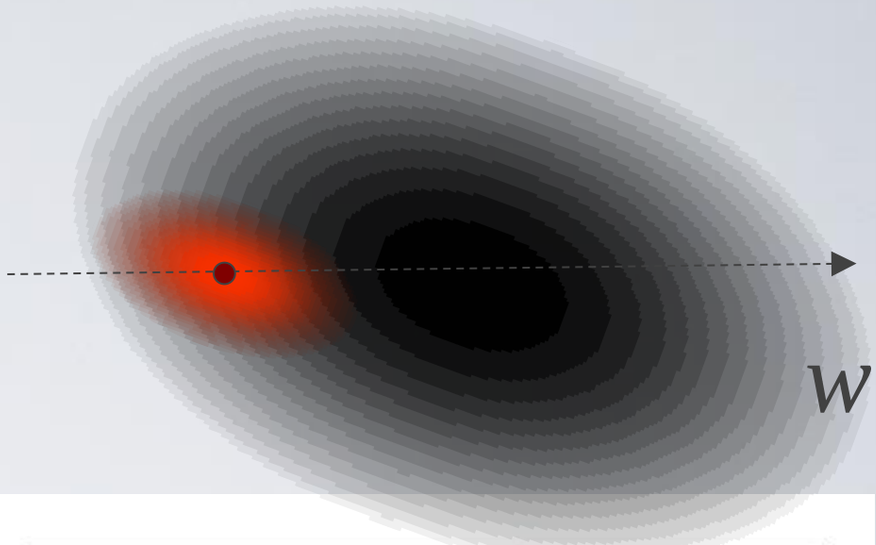
- **SPREAD_MODEL** confronts the object image $\boldsymbol{x}$ to both the local PSF $\boldsymbol{\phi}$ and to a barely resolved, PSF-convolved exponential model $\boldsymbol{G}$
- Linear discriminant analysis: maximize the ratio of inter-class to intra-class scatter

$$\boldsymbol{w}.\boldsymbol{x} = \mathbf{W}(\boldsymbol{\phi} - \boldsymbol{G}).\boldsymbol{x}$$

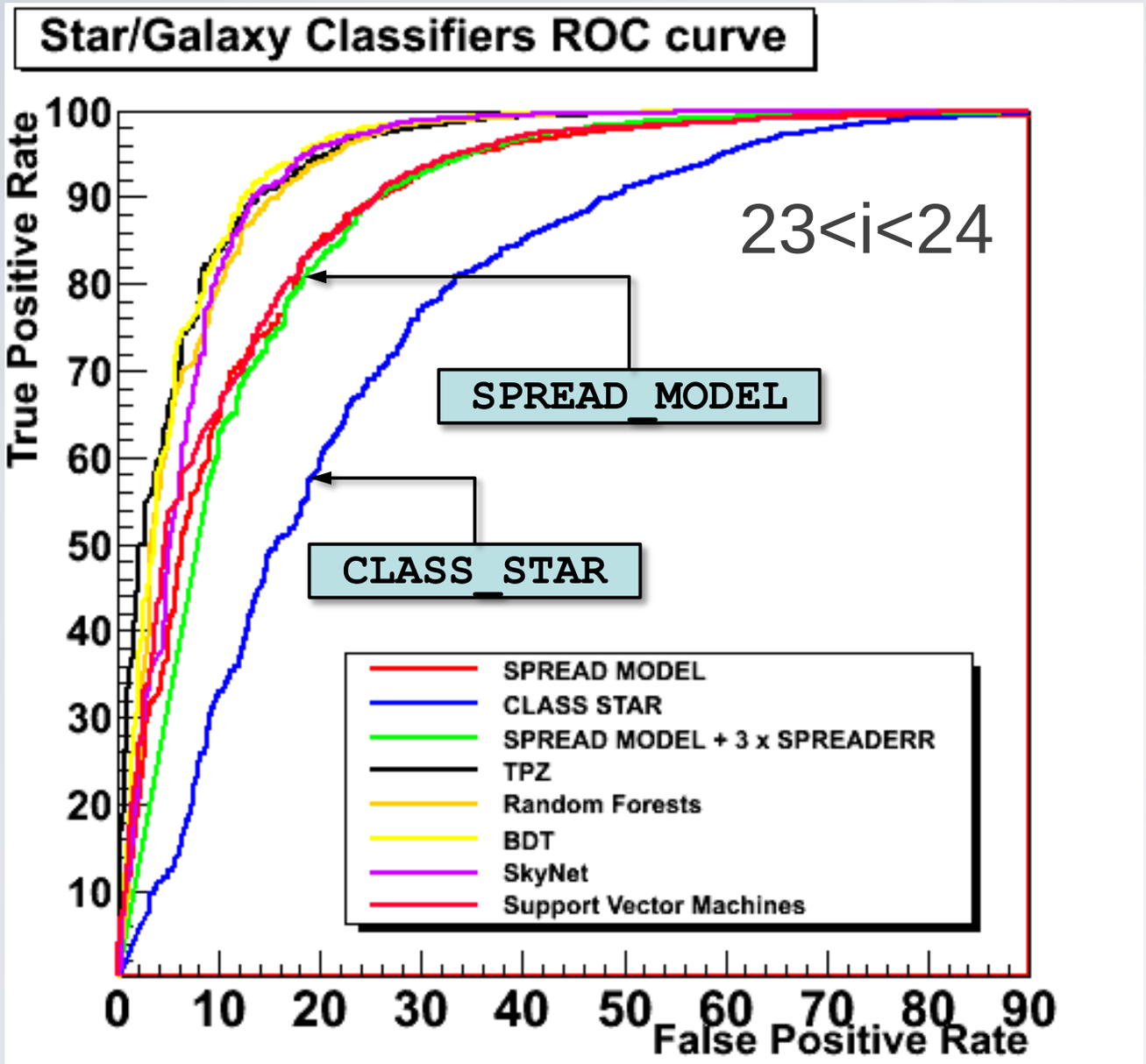
- We normalize with respect to the local PSF and galaxy model:

$$\mathbf{SPREAD\_MODEL} = \frac{\boldsymbol{\phi}^T \mathbf{W} \boldsymbol{x}}{\boldsymbol{\phi}^T \mathbf{W} \boldsymbol{\phi}} - \frac{\boldsymbol{G}^T \mathbf{W} \boldsymbol{x}}{\boldsymbol{G}^T \mathbf{W} \boldsymbol{G}}$$

- $\mathbf{W}$=inverse of the image covariance matrix
- $\boldsymbol{G}$ is the convolution of the local PSF with a circular exponential profile with $r_h = \mathrm{FWHM}/16$
- **SPREADERR_MODEL** can be used to define the decision boundary with respect to the stellar locus



SPREAD_MODEL performance

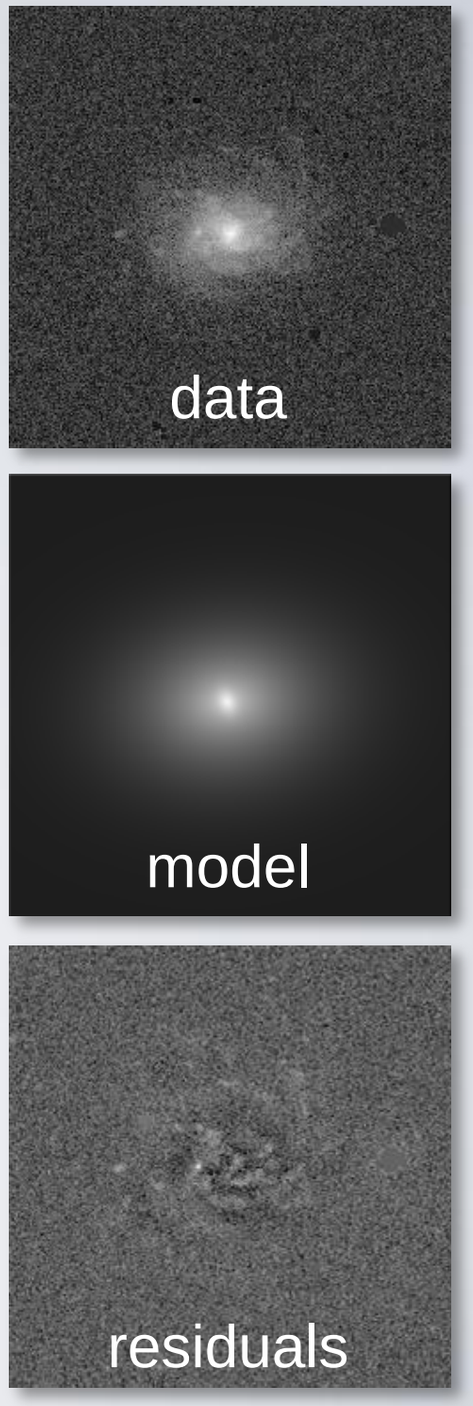


courtesy of I.Sevilla (DES)

- Much better performance than **CLASS_STAR**
- Helps meet Dark Energy Survey requirements (purity ≥ 97%)
- Multiple **SPREAD_MODEL** measurements for the same source can be combined
- The stellar locus itself can be used to monitor things such as the accuracy/stability of the PSF model and consistency of the data

Morphometry and shear measurement

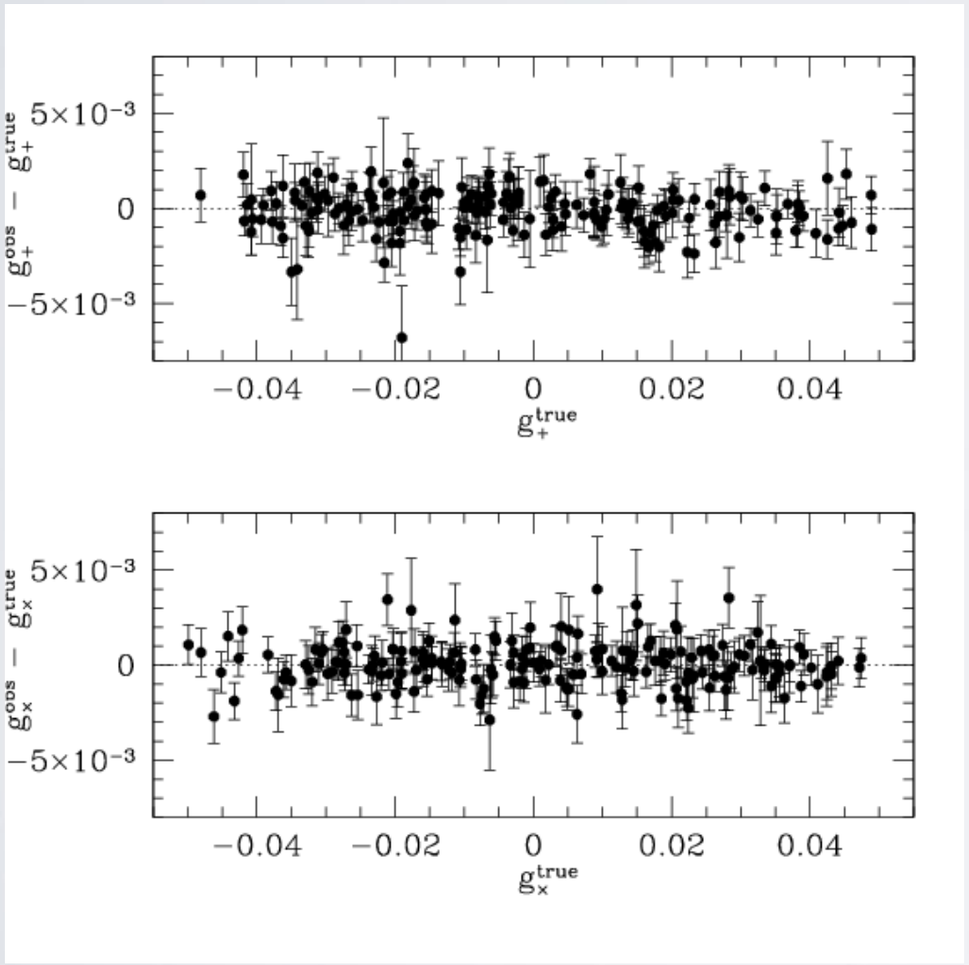
- Galaxy model-fitting
  - ~MLE/MAP point estimation
  - Fast: 1-50 galaxies/s/CPU
  - Uncertainties estimated from the approximate Hessian
  - Choice of models
  - New photometric estimator optimized for color measurements
- Code has matured through collaborations in various contexts and data regimes

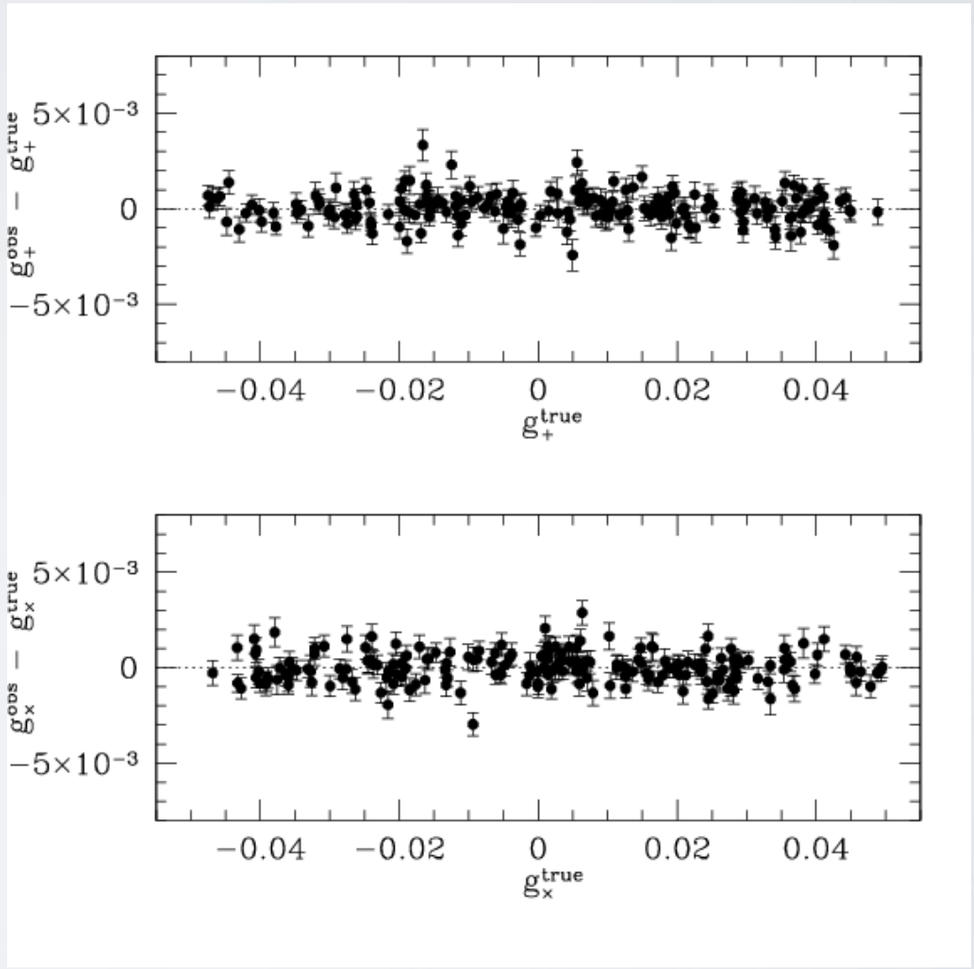


Shear measurements

- PSF-corrected ellipticity measurements and uncertainties available in the output catalog
- Great3 challenge winners all based on point estimation through model-fitting
  - Close to meeting requirements of next-gen surveys for SNRs $\geq 10\sim20$
- Amalgam team working on the measurement of higher order distortions

Ground

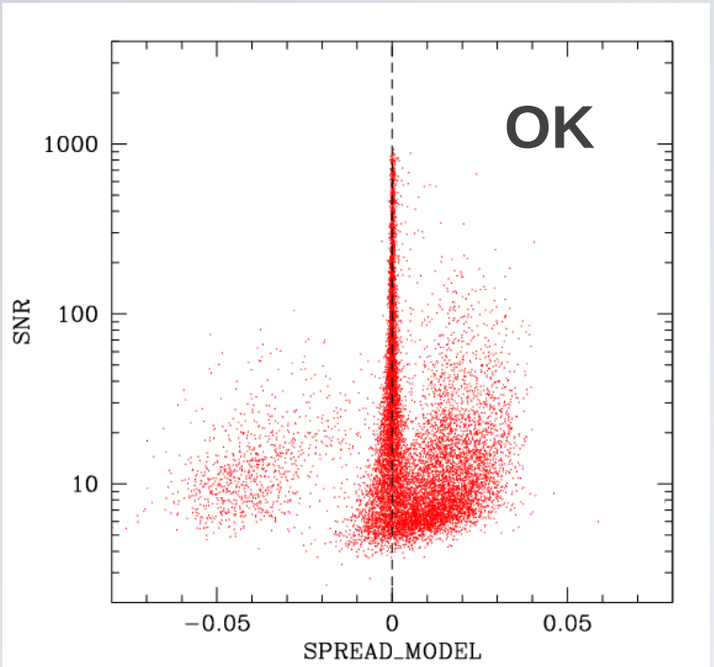


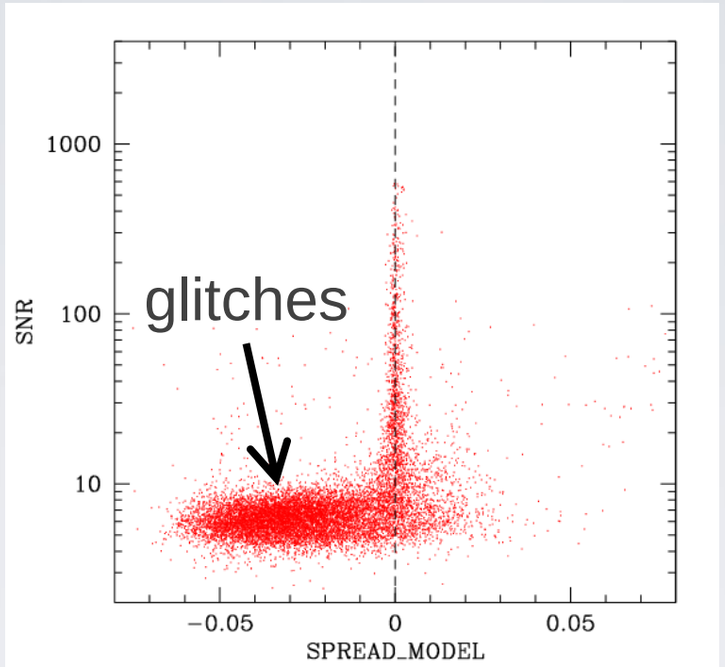


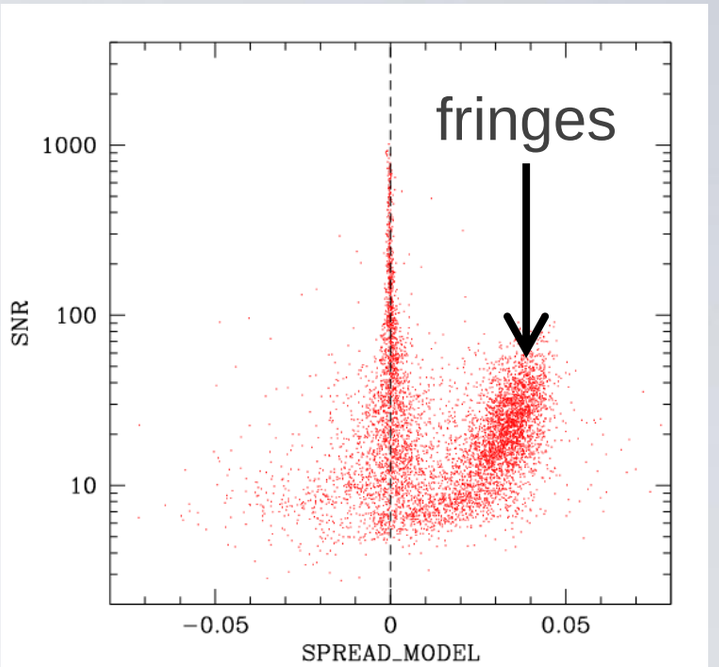
Space

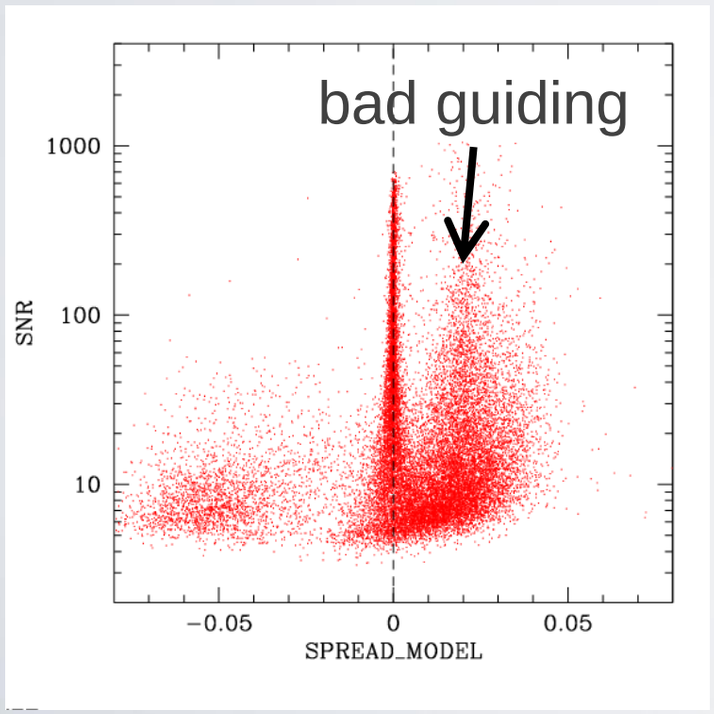
Great3 data courtesy of A.Donnarumma / Amalgam team

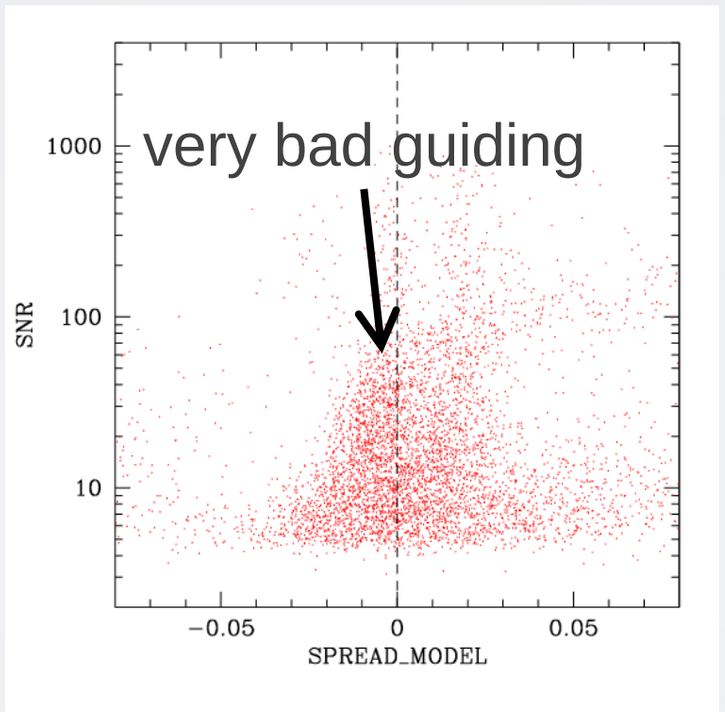
Quality control with **SPREAD_MODEL**

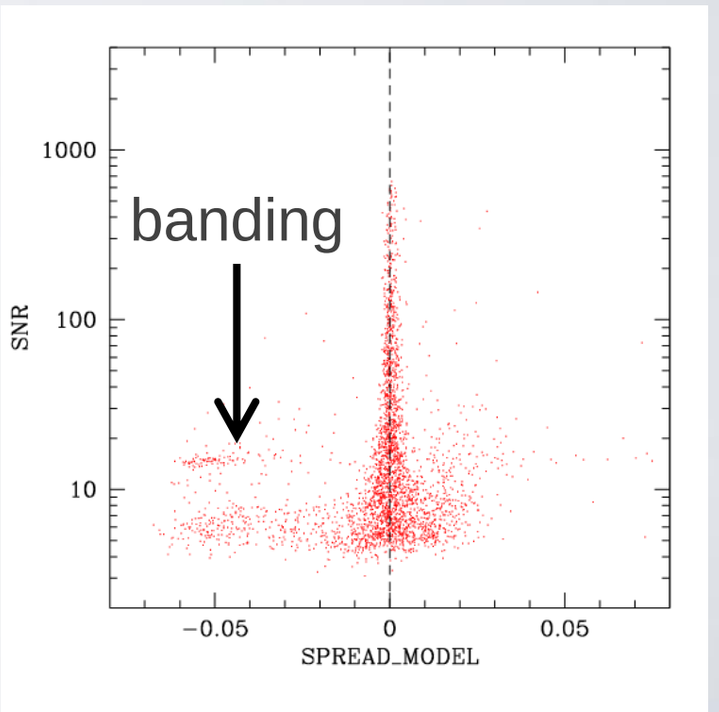












Ongoing developments: SExtractor 3

- Multi-epoch, multi-band, multi-object, multi-grid measurements
  - Data fusion *before* cataloging
  - Get rid of PSF homogenization for surveys with large dithers (e.g., DES)
- Iterative deblending
  - Much better modelling of detections
- Multithreaded