Correction for the time dependent PSF of ACS

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The ACS Pure Parallel Cosmic Shear Survey

The data

- Public data from GO parallel proposal 9480 (PI: J. Rhodes)
- Observed between August 2002 and March 2003
- Filter: F775W = **i-band** of the SDSS

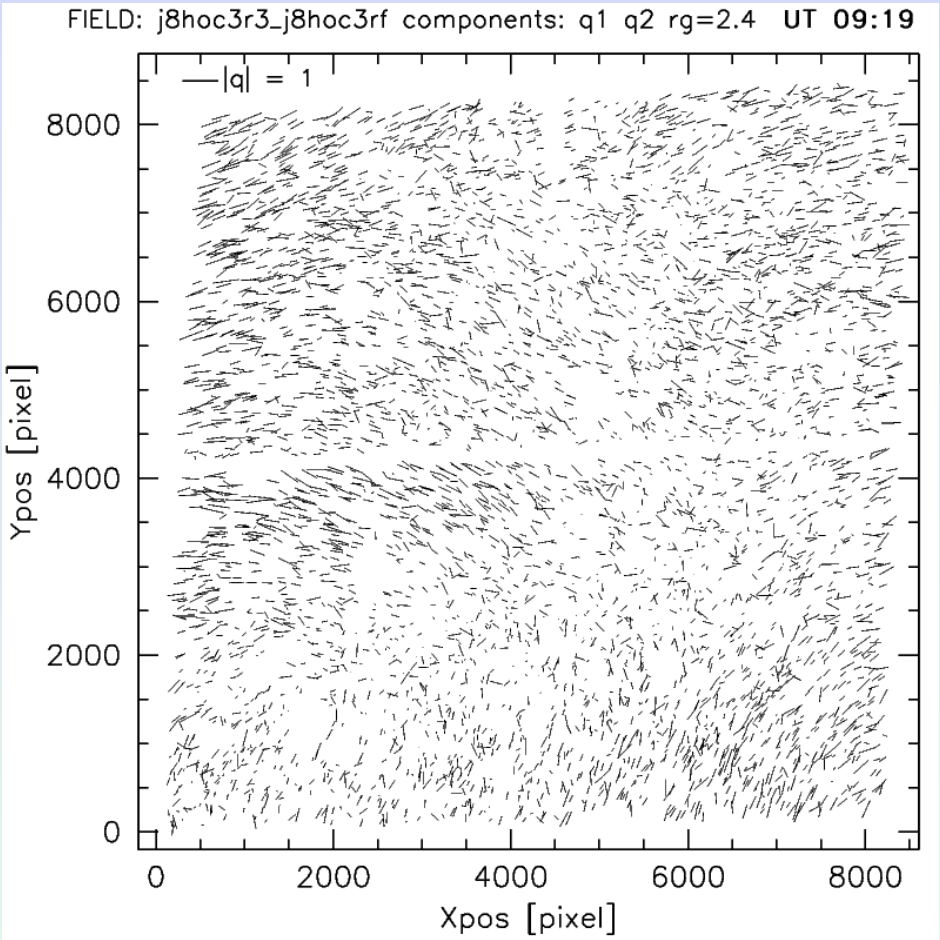
Fields

- **59 galaxy fields**: $|b| > 25°$, at least 3 exposures
- **64 star fields** for PSF analysis

Pipeline

- Object detection with **SExtractor** (Bertin & Arnouts 1996)
- **KSB+** implementation of Erben et al. (2001) as used be Schrabback for STEP I:

Temporal Variations of the PSF Anisotropy



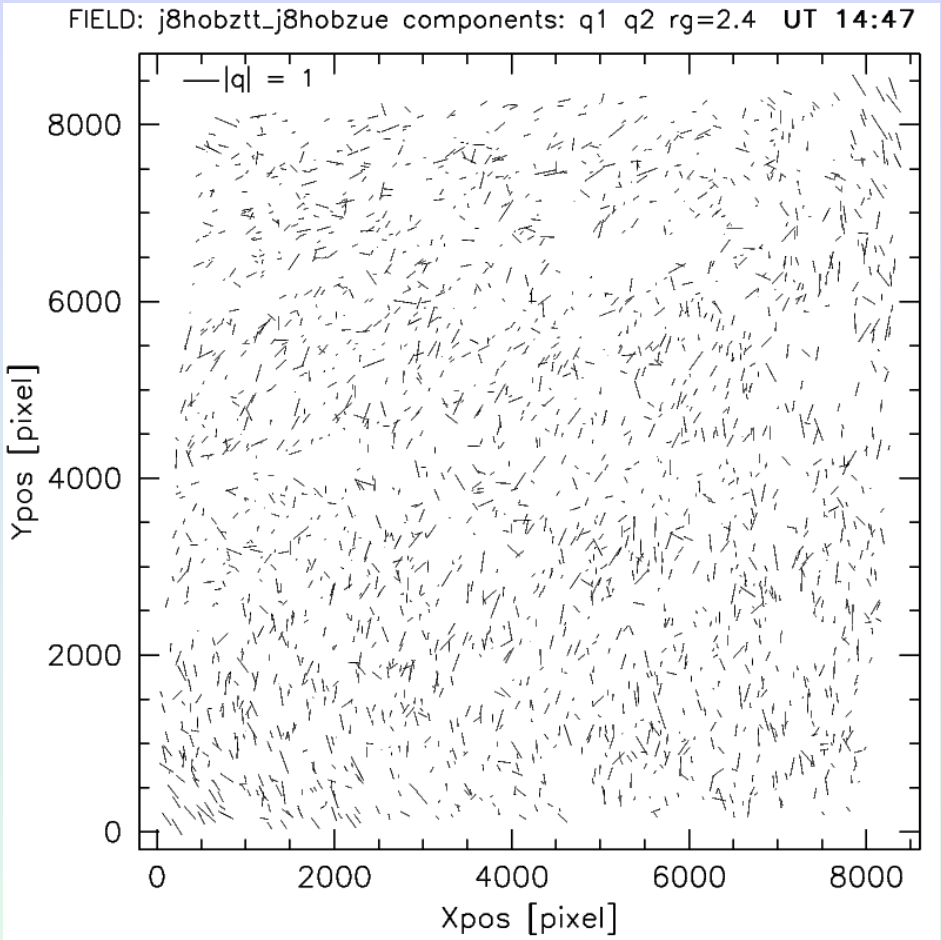


Figure: Time variations of the anisotropy kernel q^* due to thermal breathing measured in star fields taken on August 28th 2002. Variations are also seen by Krist(2003); Jee et al. (2005); Heymans et al. (2005).

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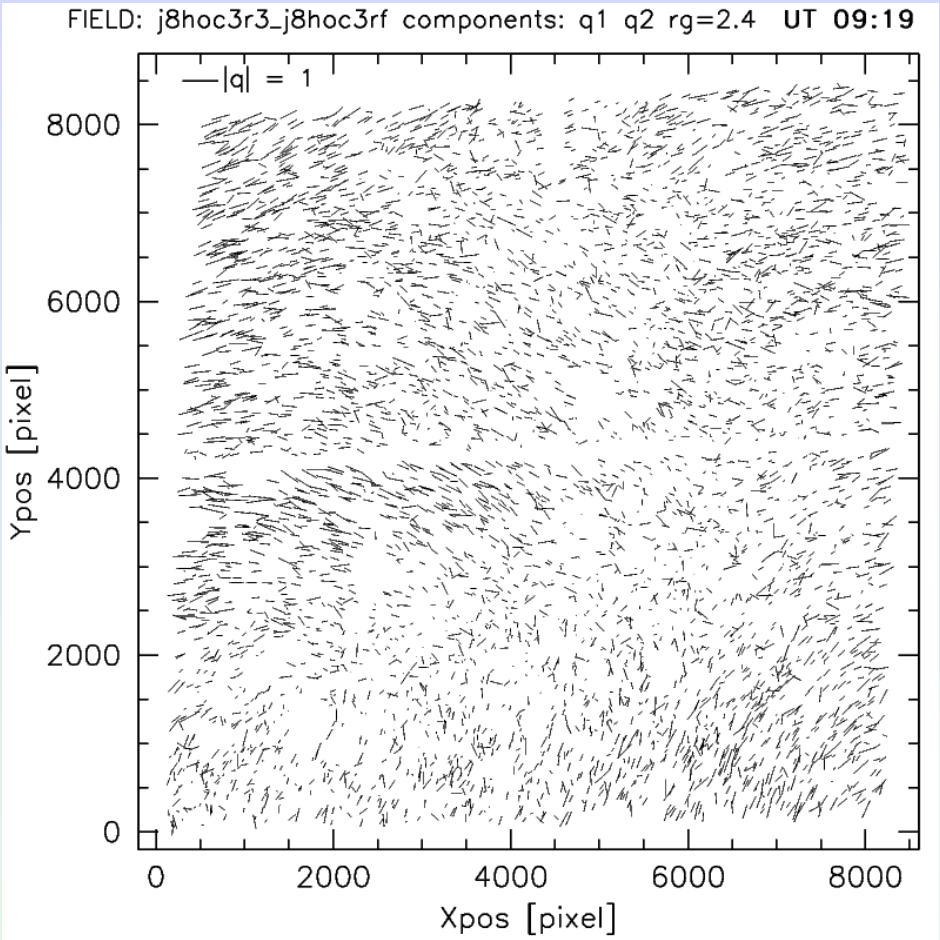

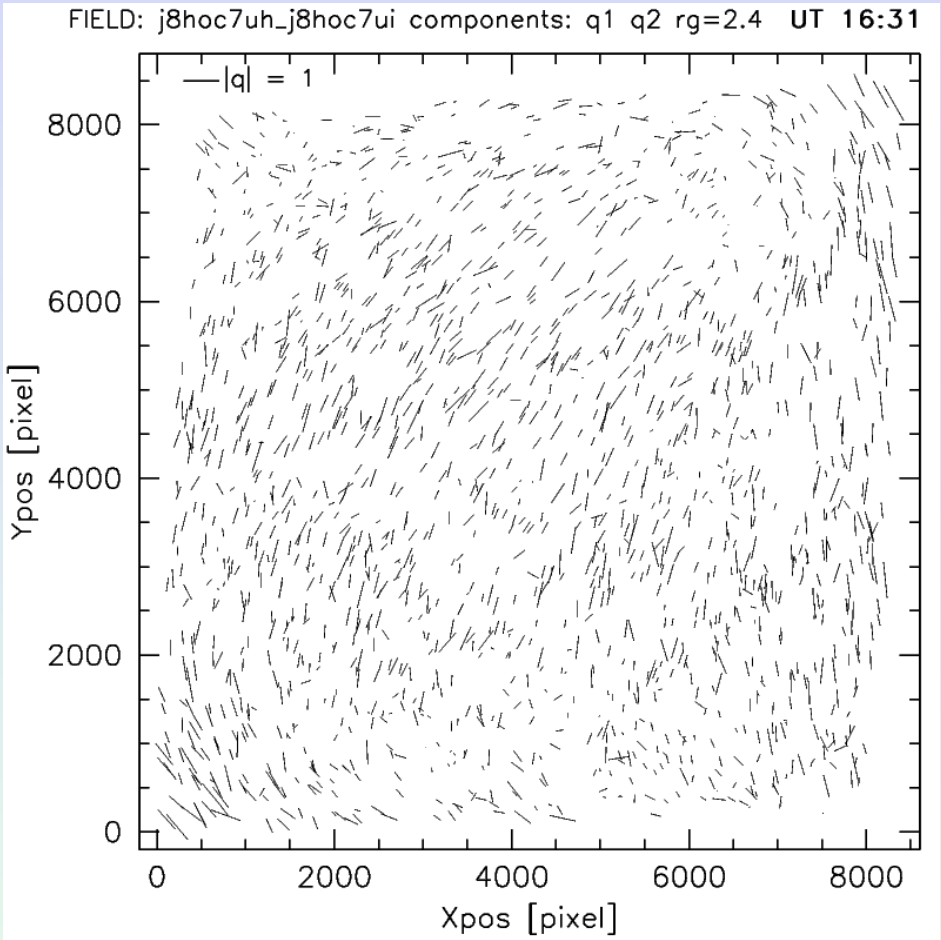

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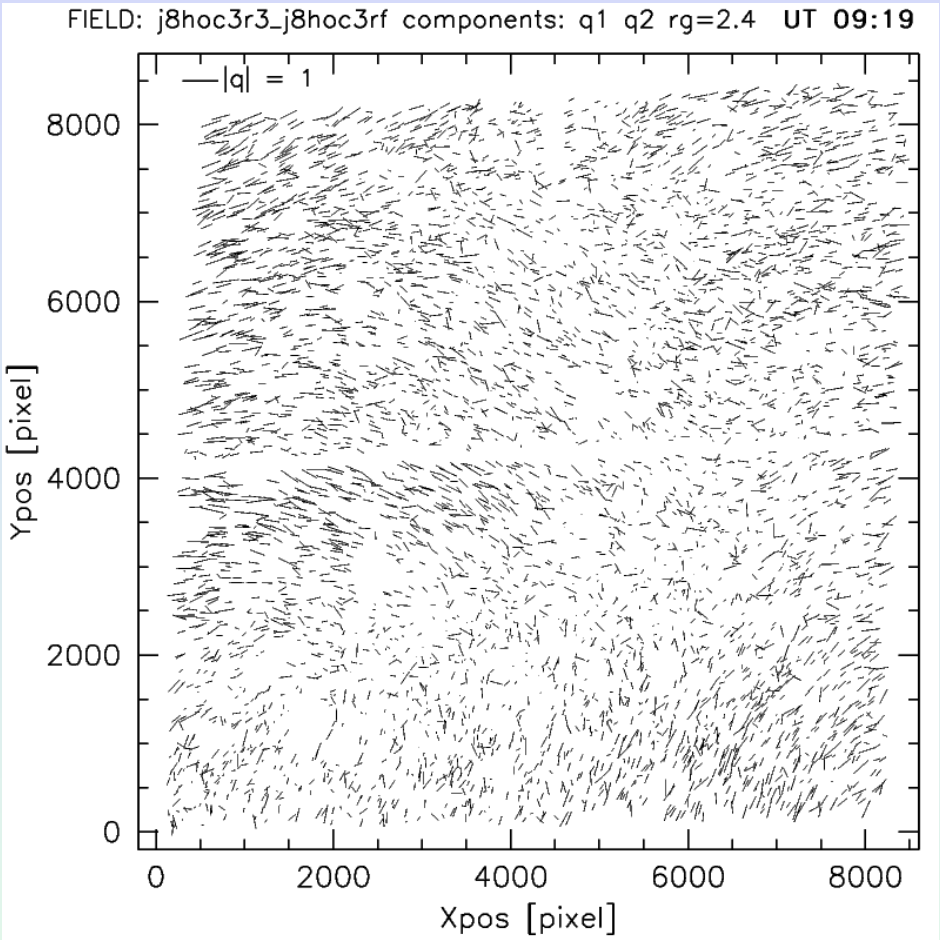

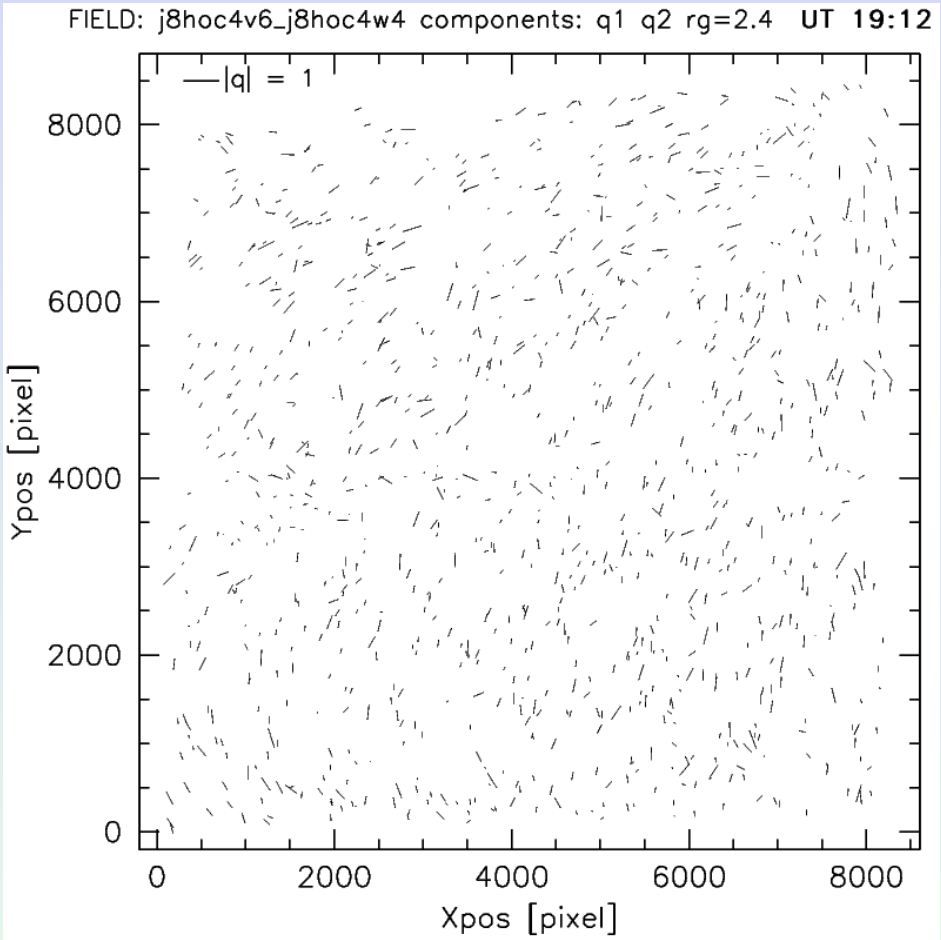

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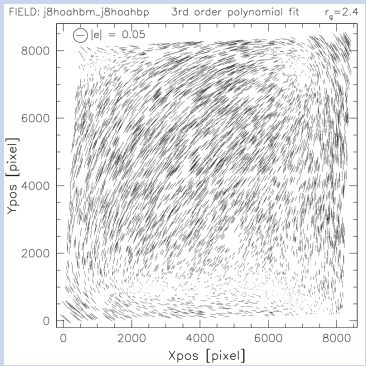
Anisotropy Correction of the Galaxy Fields

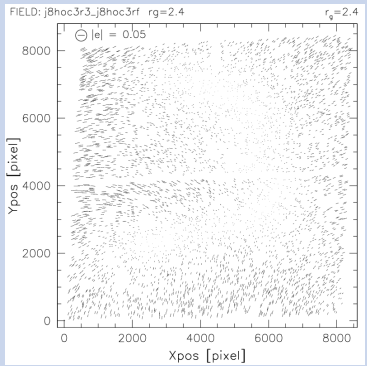
Problems for galaxy fields

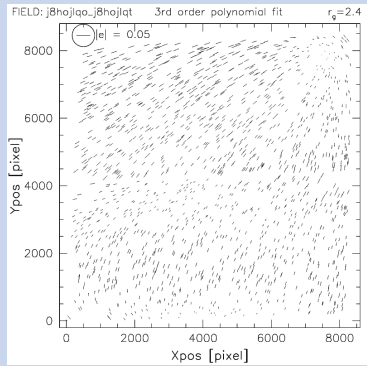
- Often only $15 - 30$ stars
  $\Rightarrow$ **No direct model (polynomial fit) possible**
- Time variations seen in star fields
  $\Rightarrow$ **Cannot apply model from a single star field to the galaxy fields** ("scaled model")

Template Superposition Fit

Since only a **few typical PSF anisotropy patterns** with variable "amplitude" occur (depending on focus position), fit with a **superposition of templates**:

$$\text{Fit} = A\times$$ 

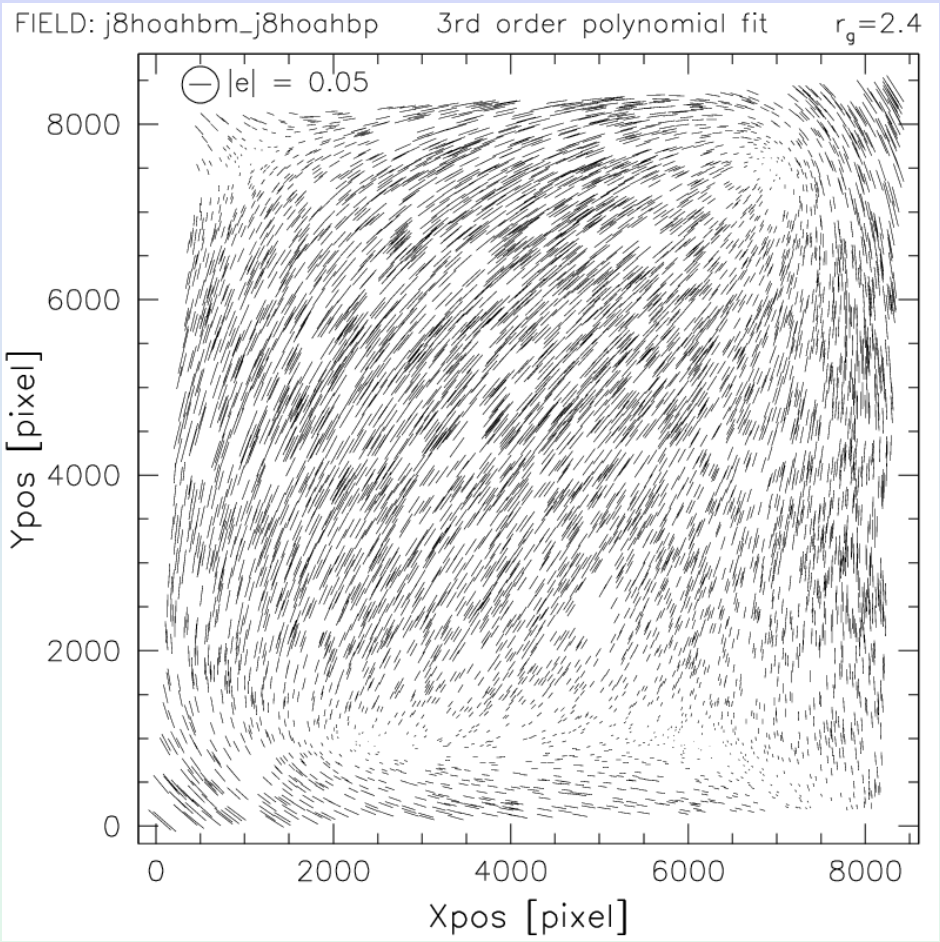
$$+B\times$$ 

$$+C\times$$ 

$$+\text{Const}$$

- Less fitting parameters $\Rightarrow$ better constrained than polynomial fit
- Use polynomial fits from typical star fields as templates
- Determine "best" templates by applying method to all star fields
- Constant important e.g. for tracking errors
- Measure and apply q^* as a function of r_g (Hoekstra et al. 98)

Template Superposition Fit: Main Templates



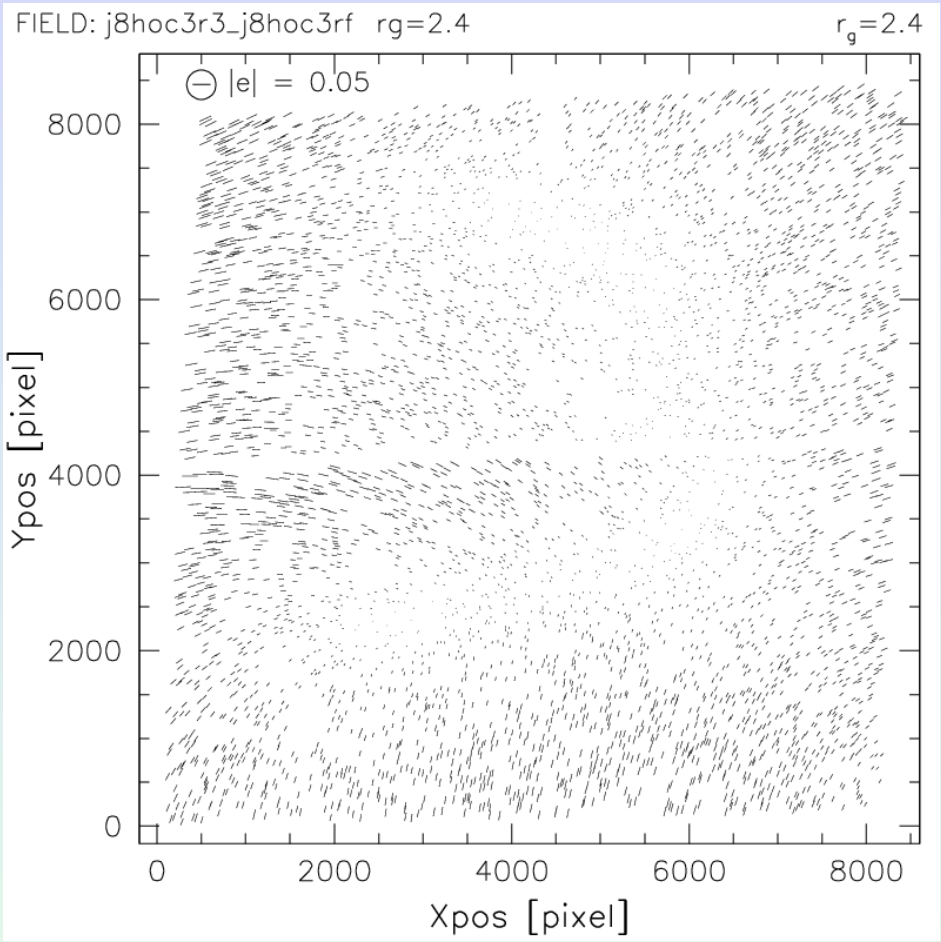


Figure: The first two templates for $r_g = 2.4$ pixels. They were found by fitting all star fields with all possible pairs.

Template Superposition Fit: Accuracy

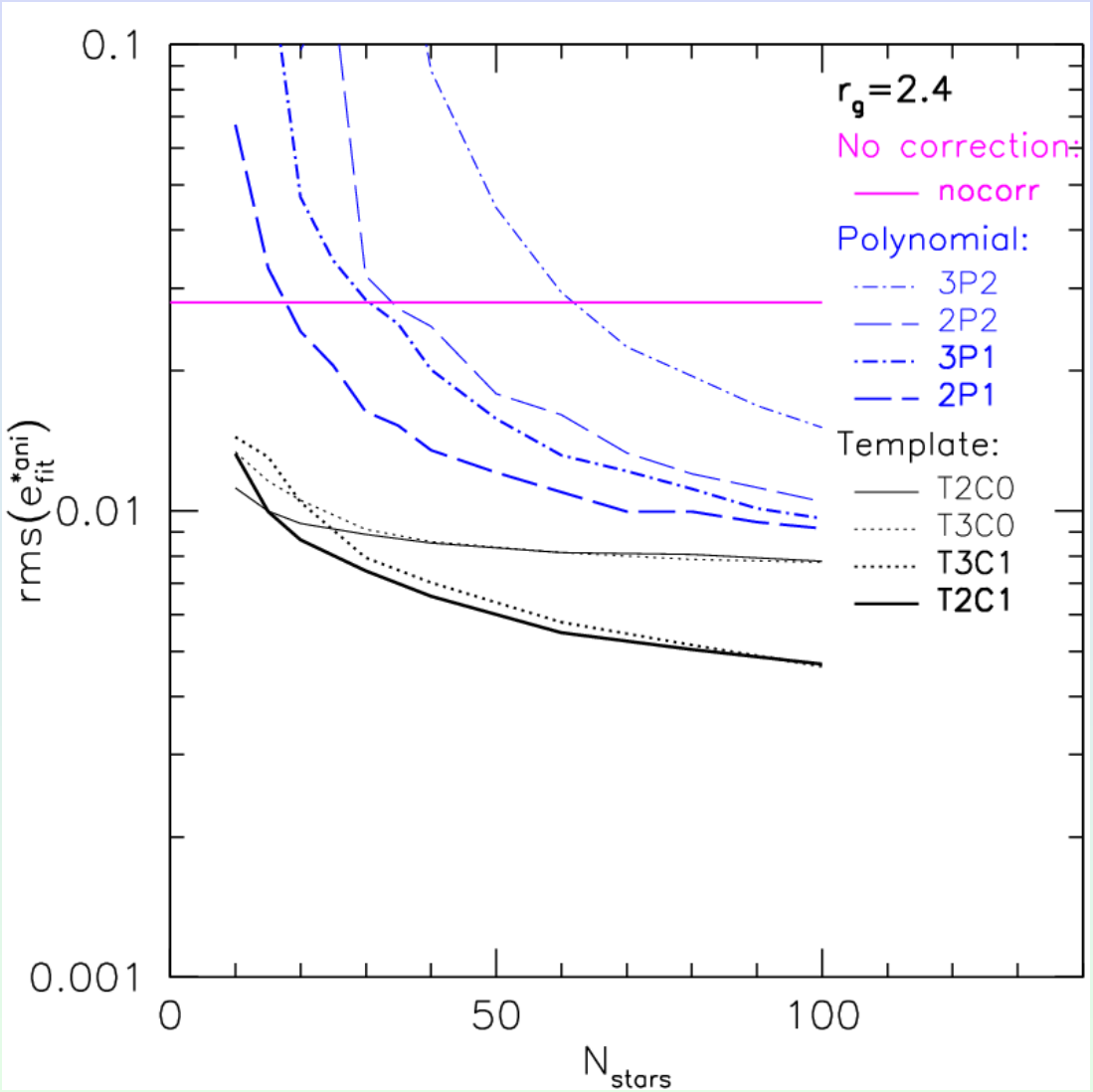


Figure: Remaining systematic rms ellipticity after anisotropy correction with different methods. To simulate the low number of stars in galaxy fields random subsets of stars were used to determine the correction for the stellar fields (similar to Hoekstra 2004). We fitted the residual ellipticities in order to separate the systematic PSF pattern from the noise in the ellipticity measurement.

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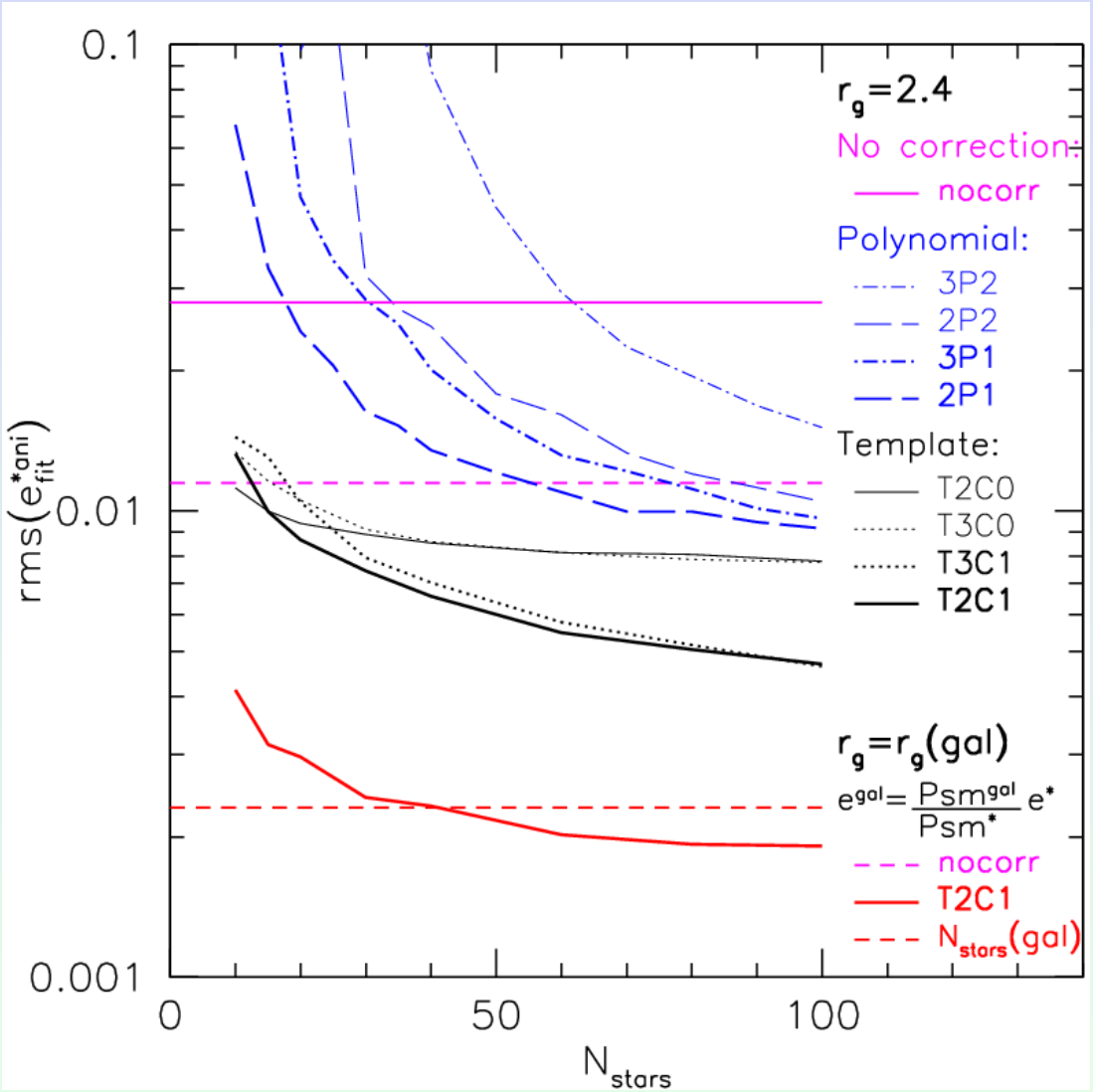

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Anisotropy Correction for the Galaxies

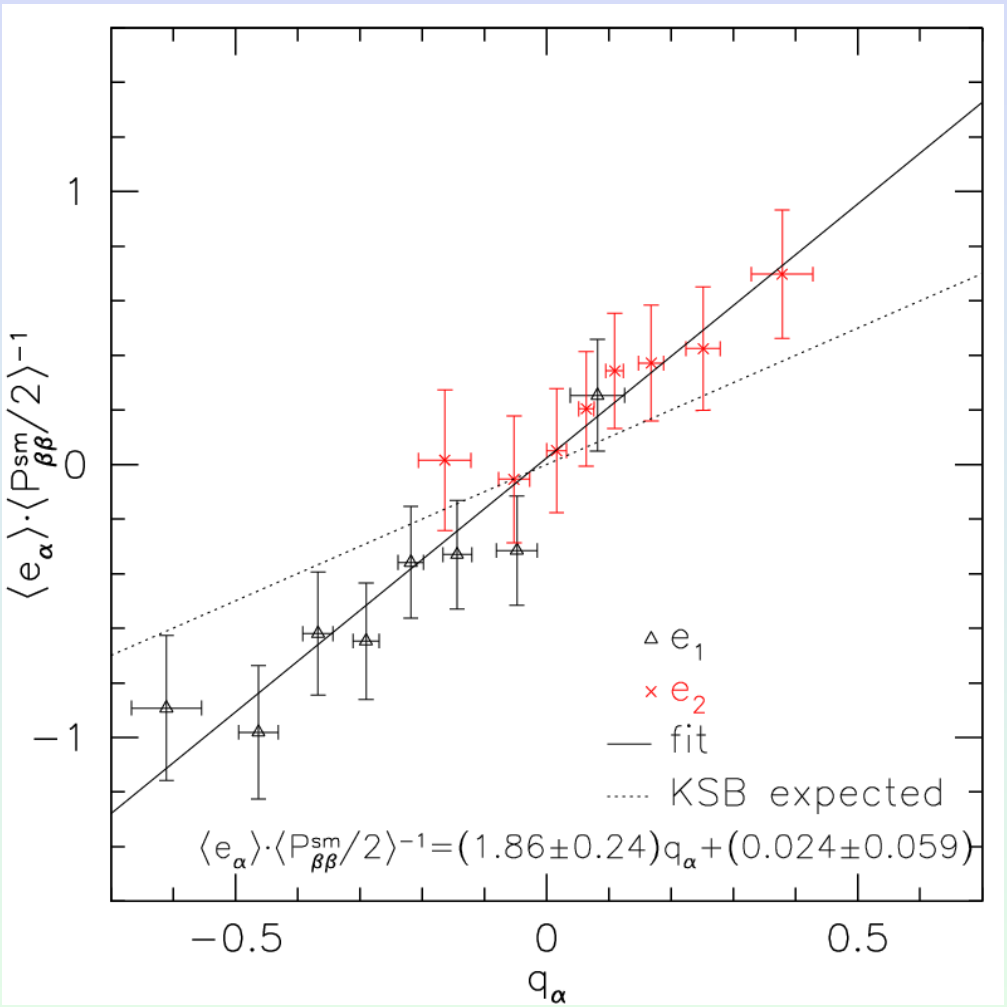

Figure: $\langle e_\alpha \rangle \langle P^{\rm sm}_{\beta\beta}/2 \rangle^{-1}$ of the galaxies versus the fitted anisotropy kernel q_α. For a perfect correction a slope of $m = 1$ is expected.

Underestimate of anisotropy correction

KSB+: $e^{\rm ani}_\alpha = e_\alpha - m P^{\rm sm}_{\alpha\beta} q_\beta(r_g)$

$\Longrightarrow$ expect $m = 1$ in Figure

But: $m = 1.86 \pm 0.24$

$\Longrightarrow$ our KSB+ implementation underestimates anisotropy correction (but ok for STEP I)

Anisotropy Correction for the Galaxies

Underestimate of anisotropy correction

- We take into account:
  - Measure q^* as a function of r_g (Hoekstra et al. 1998)
  - Integrate stars out to 15 pixels (wings!)
  - Make S/N cuts to minimize PSF selection bias (Kaiser 2000; Bernstein & Jarvis 2002)
  - Include σ-rejection in fit
- Our guess: Need higher moments ignored by KSB
  $\Longrightarrow$ different method
- Any idea?
- Space-STEP will hopefully answer the question

Conclusions

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- The ACS PSF varies on the time scale of hours
- With a superposition of typical templates we can reduce the impact of the systematic PSF anisotropy on the shear measurement to $\mathrm{rms}(e) \sim (0.0023 \pm 0.0009)$ assuming KSB can be applied.
- However our KSB implementation seems to underestimate the anisotropy correction $\Longrightarrow$ maybe use different methods.