Investigation of shear analysis using ellipticity parameters

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Future surveys, such as LSST, will contain many billions of galaxies and will cover the entire sky. Weak lensing studies will need to be able to take advantage of this vast catalogue in the most efficient way possible, without losing useful information in the process. We present studies of how to best take advantage of a full-sky survey while preserving the maximum cosmic shear information.

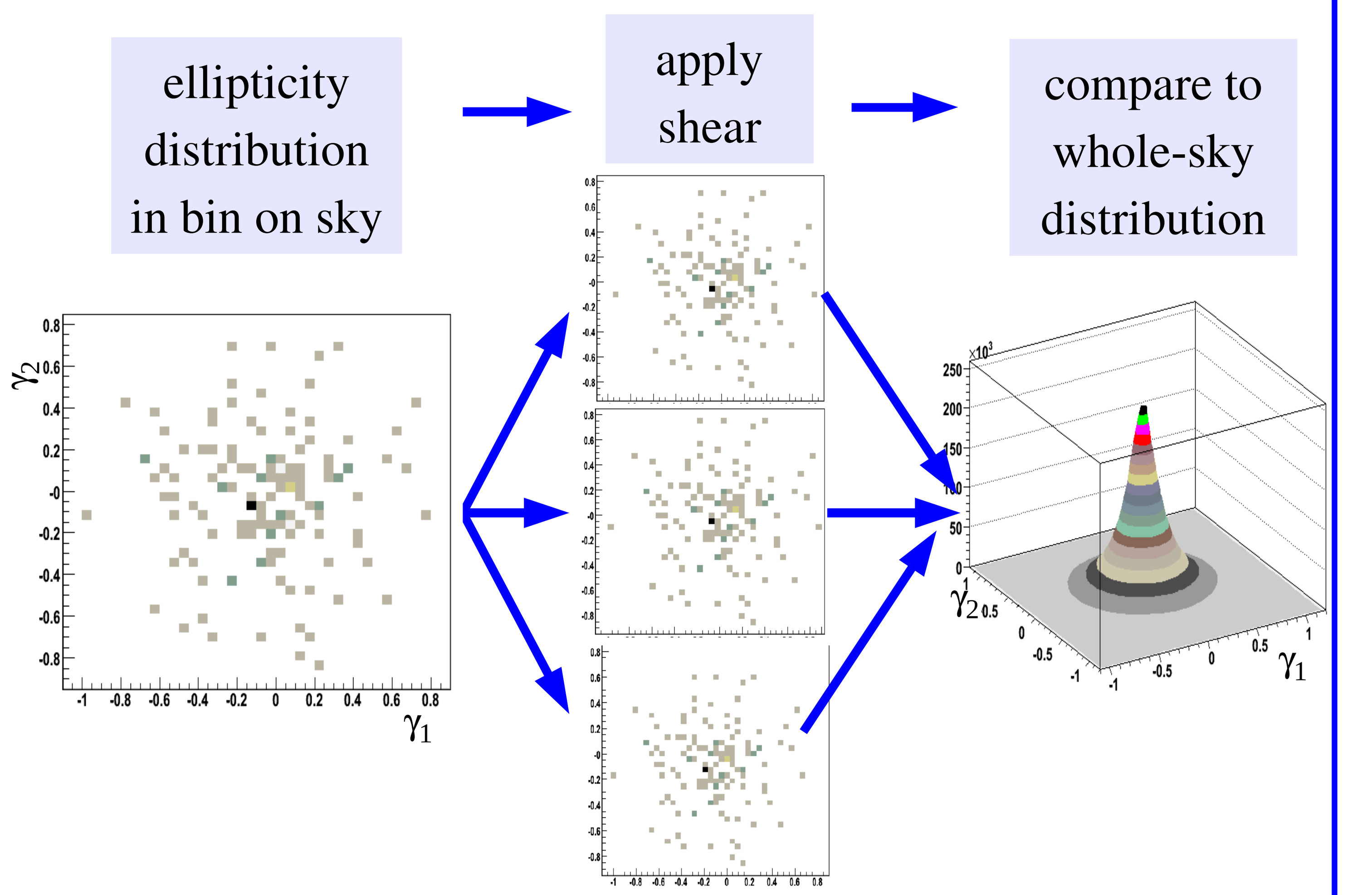
Introduction

Large future surveys will contain too many galaxies for galaxy-galaxy shear correlation studies to be performed. Some binning will be necessary, and in this study we consider how best to use the information contained in the ensemble of galaxies in the bin. Rather than using the traditional weak lensing approach of calculating the ellipticity of a single galaxy and averaging over many galaxies, we approach the problem in a more fundamental manner. We consider the cosmic shear that must be applied to a selection of galaxies in a certain area of the sky by comparing the multi-dimensional distribution of ellipticity parameters of these galaxies to the distribution of ellipticity parameters of similarly selected galaxies over the whole sky, assuming that the whole sky represents an un-sheared average.

We apply this technique to the SDSS [1] and COSMOS [2] galaxy shape catalogues, and compare our derivations of cosmic shear with those obtained using more conventional methods.

Methodology

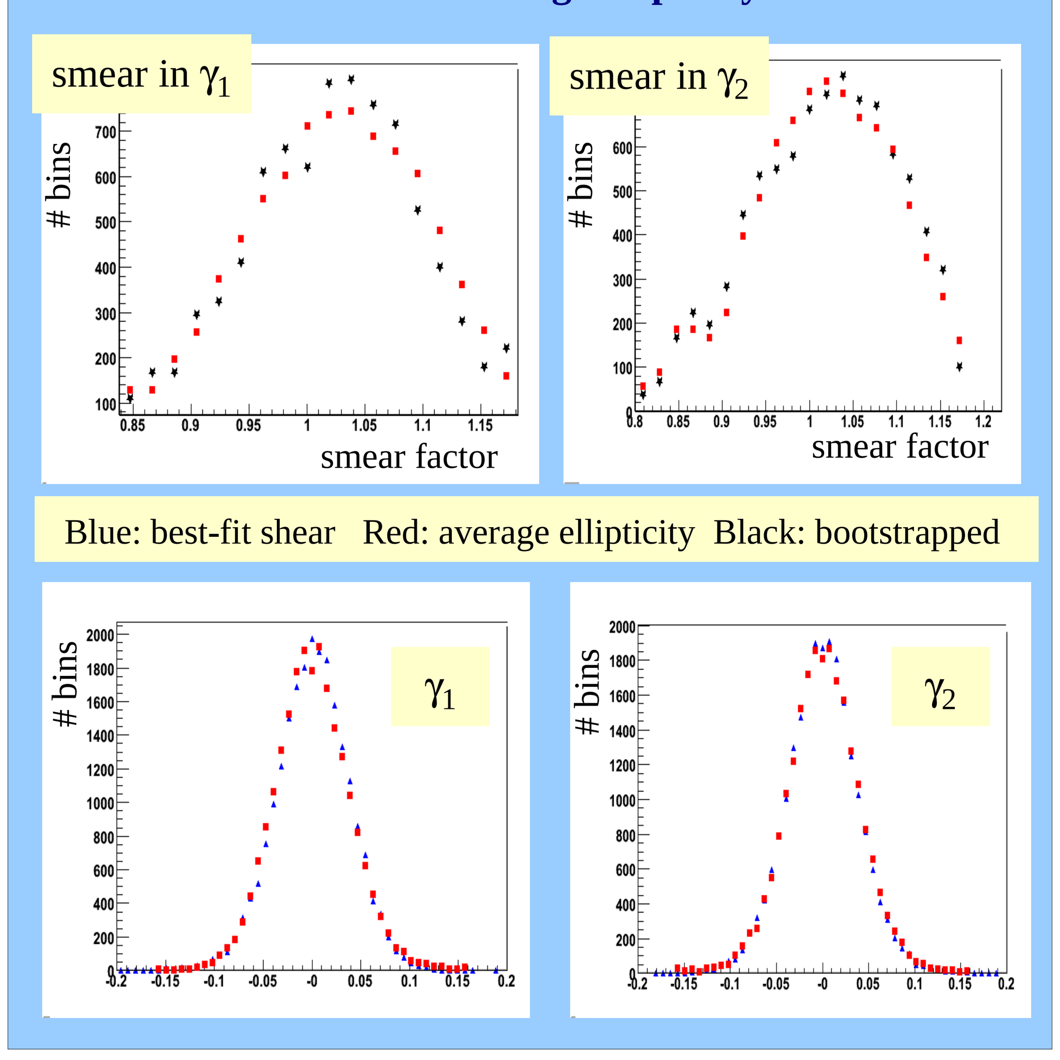
Galaxy selections	SDSS	COSMOS
# galaxies?	18 million	0.5 million
bin sizes?	8x8 arcmin	1x1 arcmin
# bins?	22300	5500
galaxies/bin?	123	78
γ_1 /γ_2 ellipticity	adaptive moments	KSB-estimated
average γ_1 ,γ_2	-0.02, -0.01	0.001, 0.0001



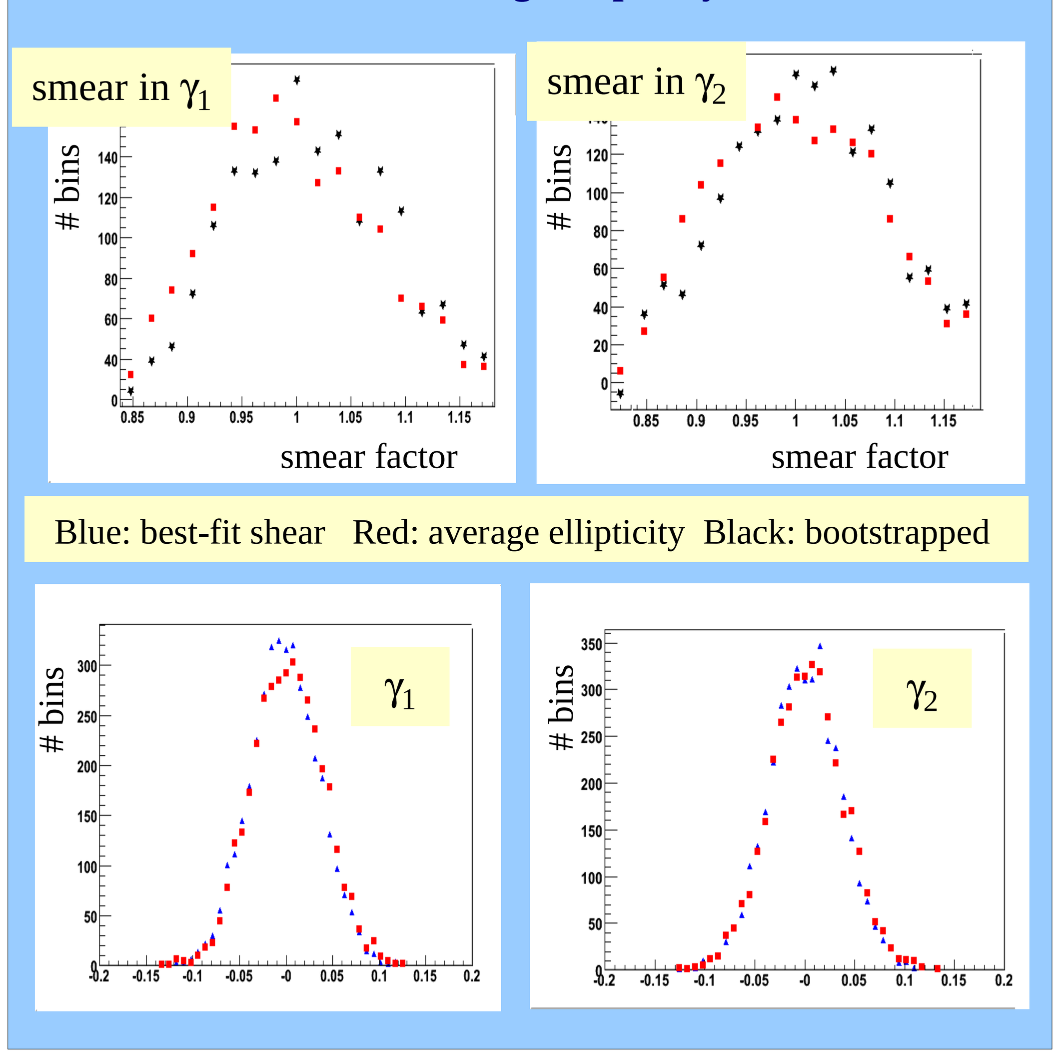
We simulate the effect of cosmic shear on each bin of galaxies by systematically shifting and smearing the ellipticity parameters in small increments, and comparing the sheared distributions to the ensemble of ellipticities over the whole sky using a two-dimensional Kolgomogorov-Smirnoff test [3]. The shift which best fits the whole-sky distribution is taken as the best-fit cosmic shear in that part of the sky.

- **2D KS** test implemented using python/PYROOT.
- KS test uses distance between pseudo-CDFs obtained from 2D histogram of γ_1:γ_2 . In 2D the order for generating the pseudo-CDF is arbitrary, so use two pairs of pseudo-CDFs, one starting from γ_1 axis and the other from γ_2 axis.
- Max distance is average of two max distances obtained.
- Very computer-intensive!

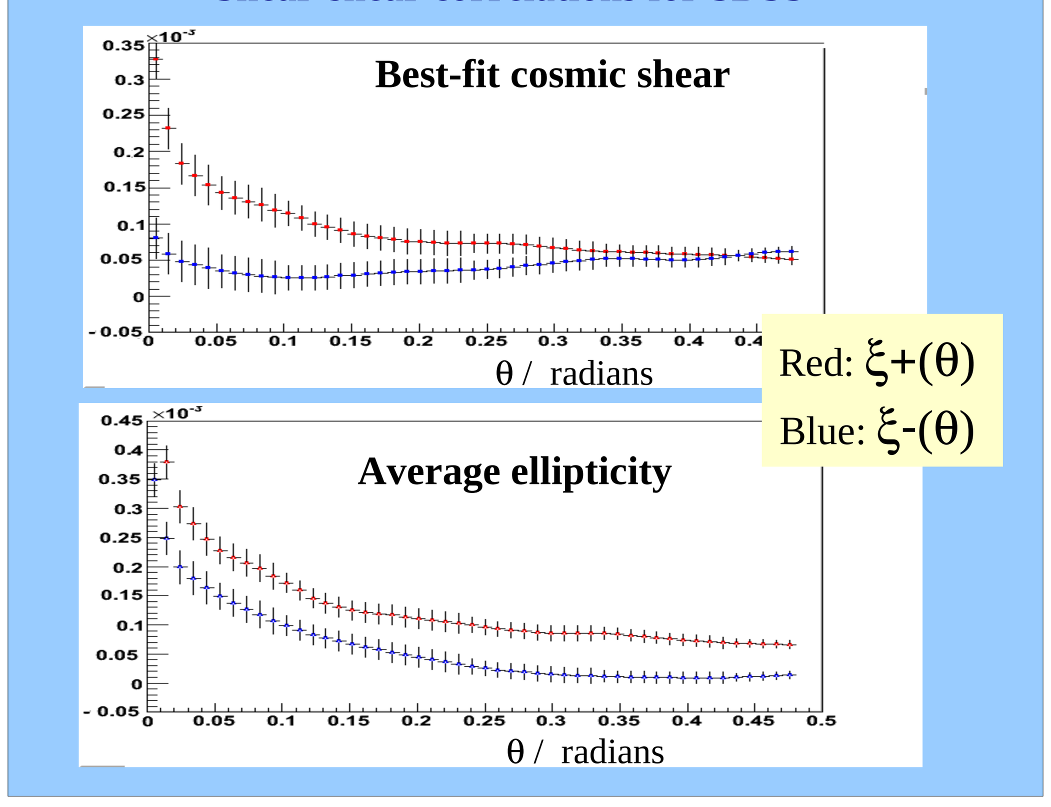
Best-fit shear and average ellipticity for SDSS



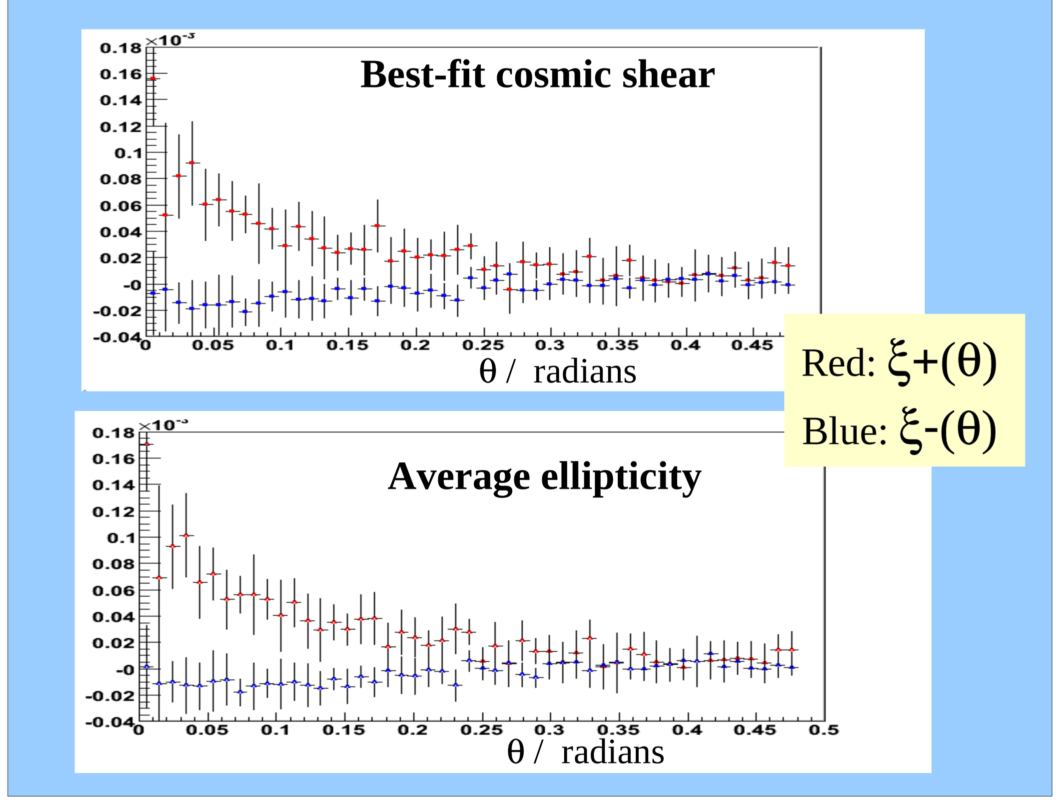
Best-fit shear and average ellipticity for COSMOS



Shear-shear correlations for SDSS



Shear-shear correlations for COSMOS



Results

- Calculate shear-shear correlation from pairs of bins of galaxies $\xi\pm(\theta)$, from galaxy pairs separated by θ, using the tangential (γ_T) and 45 degree rotated (γ_x) shear components calculated relative to the separation vector.
- For SDSS sample require that two bins contain data taken on different nights, to avoid as far as possible correlations due to instrumental effects.
- Errors obtained from bootstrapping galaxy positions.

Conclusions

- In both the SDSS and COSMOS surveys we see a clear rise at small bin separations in the shear-shear correlations for the best-fit shear as well as the average ellipticity. The COSMOS correlation is in good agreement with previously published results [4].
- Finding the best-match shear for area on the sky yields comparable results to taking average ellipticity for that area.
- We find that the average ellipticity captures most of the information available with a simple two-dimensional parameterisation of the ellipticity.
- Future work will look at decomposing the ellipticity into more components – is there more information in higher-dimensional ellipticity space that would be missed by averaging?

References

[1] http://cas.sdss.org/astrodr7

[2] very kindly provided by **Tim Schrabback**.

[3] http://root.cern.ch

[4] Schrabback *et al*, A&A **516**, A63 (2010).