Method	S/N Cut	m $[10^{-2}]$	c $[10^{-5}]$
überseg	$S/N > 10$	$+0.5 \pm 0.4$	-3.8 ± 5.8
überseg	$S/N > 15$	-0.0 ± 0.4	-4.4 ± 6.2
überseg	$S/N > 20$	$+0.1 \pm 0.5$	-5.3 ± 6.9
überseg+MOF	$S/N > 10$	-1.3 ± 0.5	-7.1 ± 8.1
überseg+MOF	$S/N > 15$	-1.7 ± 0.6	-6.3 ± 8.7
überseg+MOF	$S/N > 20$	-1.6 ± 0.7	-3.6 ± 9.7

Table 4. These numbers will change, adding more statistics

5.5 METACALIBRATION and Deblending

We used simulations to test the effect of blended objects, as well as objects fainter than the detection threshold. We used the same galaxy models described in §5.4, with a maximum magnitude for the COSMOS catalog of approximately 25.2. We also added a lower flux population by simply scaling the flux such that the faintest magnitude was about 27.5, and scaled the sizes by a factor of 0.5. Half the objects were sheared by 0.01 and half were sheared by 0.02, such that the mean shear was close to 0.015.

All images were convolved by a Moffat PSF with FWHM = 0.9 arcsec, and ellipticity 0.025 in the reduced shear convention. We added noise appropriate for year 5 DES depths, such that the 5-sigma detection limit was about magnitude 24. Note most of the objects in these images are much fainter than the detection limit.

We generated images similar to DES coadds. We verified that number density of objects in the resulting SEXTRACTOR catalog matched that in DES data. We placed objects in the images randomly, with no spatial correlation. We found that the number of blends of detected objects is similar to typical DES coadds field, but is not representative of fields with relatively low redshift galaxy clusters. Thus these images are appropriate for testing cosmic shear measurements, but not necessarily for testing shear cross-correlations such as cluster lensing studies. Note that most of the galaxies images were well below the detection threshold, so there are a large number of undetected blends.

We then ran SEXTRACTOR on the images with settings similar to those used in DES, created MEDS files, and ran the METACALIBRATION shear code with identical settings used for the real data. We ran the shear code in two modes: one using the überseg algirithm only, and one subtracting the light of neighbors as measured using the MOF algorithm in addition to überseg masking.

The results are shown in table 4.

ESS: will add more description when statistics are added

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5.6 METACALIBRATION and PSF Modeling Bias

The Y1 PSF modeling and interpolation exhibit small biases both in the size and shape (see §3), which result in additive and multiplicative errors.

The additive errors come about due to PSF "leakage": the deconvolution process used in METACALIBRATION is inaccurate, resulting in some remnant of PSF ellipticity remaining in deconvolved images of circular sources. We will calculate approximate empirical corrections for the additive bias in the shear correlation function (see Troxel 2017).

MAT: Should update later to make sure this matches with the section Niall writes in the other paper.

PSF size bias results in a multiplicative error in the shear estimation from galaxy images, again due to inaccurate deconvolution. We will discuss this in detail in §5.6.1. There is an additional multiplicative bias due to stellar contamination in the source sample because, when the PSF is misestimated, stars do not have zero response $\boldsymbol{R}$ on average. We discuss this further in §5.6.2.

5.6.1 METACALIBRATION *Shear Bias from PSF Modeling Errors*

As discussed in §3.2, our PSF model does not perfectly model the true PSF. Most aspects of the PSF modeling errors manifest as additive shear errors (cf. §6.2); however, the mean error in the size estimate of the PSF manifests as a multiplicative error.

Figure 7 showed that the measured sizes of stars are slightly larger than the PSF model due to the "brighter-fatter effect", even after removing the brightest stars where the effect is most pronounced. The size of the PSF models are thus systematically wrong by of $\langle \Delta T/T \rangle \sim 8.3 \times 10^{-4}$, the mean size difference for stars reserved from use in constructing the models.

In addition, the variance in the residual size is much larger: $\langle (\Delta T/T)^2 \rangle^{1/2} \sim 3 \times 10^{-2}$ because the PSF model interpolation is a smooth polynomial, while the true PSF has significant power on small scales due to atmospheric turbulence (Heymans et al. 2012a).

To measure the shear biases caused by these effects, we created further bulge+disk+knots simulations with a range of S/N. The minimum galaxy S/N used for these simulations was about 50 (in order to measure the shear bias at high S/N), but we saw no evidence that the magnitude of the effect depends on the galaxy S/N, so we expect these results to hold for our full galaxy sample.

We kept the nominal PSF model identical in all cases, using a Moffat profile (Moffat 1969) with $\beta = 2.5$, a size corresponding to $0\farcs9$ FWHM, and $(e_1, e_2) = (0, 0.03)$. We then created several versions of the simulation with different true PSFs: (1) the same as the nominal PSF, (2) a constant PSF that was larger by $\Delta T/T = 8.3 \times 10^{-4}$, (3) a variable PSF with the correct mean size but varying in a normal distribution with $\sigma(T)/T = 3 \times 10^{-2}$, and (4) a variable PSF with both the larger mean and this variance.

The shears were measured with the same code used to process the DES data using the nominal PSF, not the true PSF. We applied a cut on the size as we do in the data, and applied the appropriate shear and selection responses. Case 1 showed no measurable bias, as expected. For case 2 with an overall PSF size error but no variance, we found a multiplicative shear bias of $m \approx 0.001$, independent of the size cut. With the additional size variance (case 4) the mean bias increased to nearly $m = 0.002$. In these cases, the bias was independent of galaxy size for $T/T_{\rm PSF} > 0.3$, but we saw some variation for smaller sizes. This partly motivated the choice to cut at $T/T_{\rm PSF} > 0.5$ for our final shear catalogs.

We do not expect this simulation to produce an exact measure of the shear bias present in the real data, because it undoubtedly depends on the details of the morphology distribution of the galaxies and the precise distribution of the PSF errors around the mean value. We therefore attempt no correction for this effect. Rather, we take the results of this simulation as an estimate of a systematic uncertainty σ_m in the multiplicative error from this effect. We conservatively take the value of $\sigma_m = 0.003$. See §7.6.1 for a summary of all systematic uncertainties.

5.6.2 METACALIBRATION *Shear Bias From Stellar Contamination*

Stars do not bias METACALIBRATION shear recovery when the PSF is accurately known, since they should yield $\langle e \rangle = \langle \boldsymbol{R} \rangle = 0$ (Shel-