

ESO Phase 3 Data Release Description

| | |
|------------------------|----------------|
| Data Collection | KiDS |
| Release Number | 3.1 |
| Data Provider | Konrad Kuijken |
| Date | 27.12.2016 |

Abstract

This catalogue data release contains the weak lensing shear measurements from the KiDS-450 data set, which corresponds to the survey area of the third public release of the Kilo-Degree Survey (KiDS). KiDS is an ESO public survey carried out with the VLT Survey Telescope and Omega-CAM camera, that will image 1500 square degrees in four filters (u, g, r, i), in single epochs per filter. KiDS is designed to be a weak lensing shear tomography survey, and has as its core science drivers mapping of the large-scale matter distribution in the universe and constraining the equation-of-state of Dark Energy. The catalogue released here constitutes the first weak lensing shear data set from KiDS with which these questions have been addressed (Hildebrandt & Viola et al. 2017, MNRAS, 465, 1454).

The data were taken under ESO programme IDs: 177.A-3016(A), 177.A-3016(B), 177.A-3016(C), 177.A-3016(D), 177.A-3016(E), 177.A-3016(G), 177.A-3016(J), 177.A-3016(K), 177.A-3017(A), and 177.A-3018(A).

Overview of Observations

The DR3.1 shear catalogue is based on observations of 454 KiDS survey tiles in all four filters (u, g, r, i). Figure 1 shows the locations of the included tiles within the survey fields.

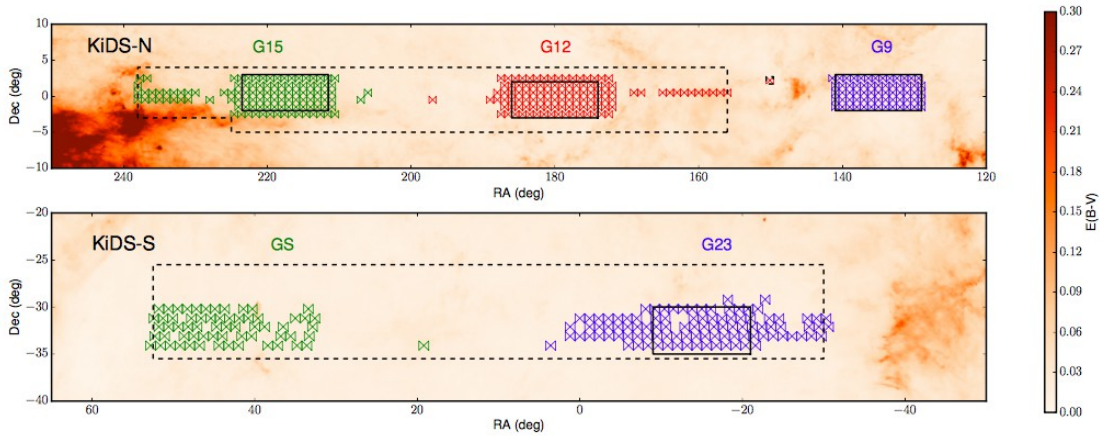


Fig. 1: Sky distribution of tiles included in the catalogue. The dashed and solid lines outline the full KiDS survey area and the areas observed by the GAMA spectroscopic survey, respectively. Coloured symbols correspond to included pointings, with the colours representing five patches (G9, G12, G15, G23, GS). The background shows $E(B-V)$ reddening maps from Schlegel et al. (1998, ApJ. 500, 525).

Release Content

Based on the 454 KiDS tiles indicated in Fig. 1, the total area covered by the shear catalog is 449.7 sq.deg. after trimming of the edges of individual tiles. Masking of bright stars, satellite trails and other image defects results in an effective area of 360.3 sq.deg. Source detection was done on

stacked *r*-band images, after which galaxy shapes were measured on individual sub-exposures. The included photometry and photometric redshifts are based on 4-band *ugri* image stacks.

Only galaxies with reliable shape measurements are included in this catalogue. Unreliable sources have been rejected based on several criteria listed in Hildebrandt & Viola et al. (2017, MNRAS, 465, 1454). The faint limit of the catalogue is $r = 25.0$, corresponding to a typical signal-to-noise of 5σ . The catalogue contains a total of 14,650,348 sources, is made up of 455 files (454 data files and 1 metadata file), and has a total data volume of 4.14 GB

Release Notes

Data processing for this release was performed by the KiDS collaboration and is extensively described in a number of publications. Below is a very brief description with references and links to the more detailed sources.

Data Reduction and Calibration

Two data reduction pipelines were used for the production of this data release.

The *r*-band data of the included tiles was reduced with the THELI pipeline (Erben et al. 2013, MNRAS, 433, 2545) and source detection was done on the resulting stacks. Shapes of objects were measured with *lensfit* (Miller et al. 2013, MNRAS, 429, 2858; Fenech Conti et al. 2016) on the single *r-band* exposures to avoid any systematics introduced by resampling or stacking.

The photometry included in the catalogue was measured from *ugri* stacks produced with AstroWISE (McFarland et al. 2013, ExA, 35, 45), following the same procedures as used for KiDS DR3. Photometric redshifts were derived using the Bayesian template fitting method BPZ (Benítez, 2000, ApJ, 536, 571). The following documents and publications provide detailed information regarding the various data processing steps.

KiDS *r*-band THELI processing and photometric methods and redshifts:

- [Kuijken et al. 2015, MNRAS, 454, 3500](#)

Lensfit shape measurements:

- [Hildebrandt & Viola et al., 2017, MNRAS, 465, 1454](#)
- [Fenech Conti et al. 2016, MNRAS, submitted, arXiv:1606.05337](#)

KiDS *ugri* processing and photometric calibration:

- De Jong et al. 2017, in prep.
- [KiDS DR3 website and release notes](#)

Data Quality

The quality and reliability of the KiDS data and the derived photometry, redshifts and shape measurements are reviewed in great detail in the following publications:

KiDS photometric redshifts and *r*-band image quality:

- [Kuijken et al. 2015, MNRAS, 454, 3500](#)

Lensfit shape measurements:

- [Hildebrandt & Viola et al., 2017, MNRAS, 465, 1454](#)

KiDS *ugri* data and photometry:

- [de Jong et al. 2015, A&A, 582, A62](#)
- De Jong et al. 2017, in prep.

Known issues

Please note that the source IDs in this catalogue may differ slightly from the ones included in the KiDS DR3.0 release.

c-terms

In the KiDS-450 cosmic shear analysis Hildebrandt & Viola et al. (2017) found small residual c-terms (non-zero average shear). These were subtracted patch by patch, and tomographic bin by tomographic bin, before computing the shear-shear correlation functions. Any science analysis for which c terms are deemed important should determine these from the data. Note that the *lens*-fit weights should be used to compute the averages.

Previous Releases

This catalogue release constitutes the first official release of weak lensing shear data by KiDS and corresponds almost exactly with the area for which other data products were released in the preceding general KiDS data releases (DR1, DR2 and DR3).

Scientific publications

Use of these data in rigorous scientific analyses is the ultimate test of the data quality. The following scientific analyses were performed using this shear catalogue prior to release:

- [Hildebrandt & Viola et al., 2017, MNRAS, 465, 1454](#)
- [Fenech Conti et al. 2016, MNRAS, submitted, arXiv:1606.05337](#)
- [Joudaki et al. 2016, MNRAS, submitted, arXiv:1610.04606](#)

Data Format

Files Types

Because of size restrictions the catalogue is submitted in multiple files, and consists of a metadata file and a catalogue data file for each tile. The data files have the central coordinates of the corresponding tile encoded in the filename, following the convention:

```
KiDS_DR3.1_131.0_-0.5_ugri_shear.fits
```

The metadata file, which contains only metadata and no catalogue data, is called:

```
KiDS_DR3.1_ugri_shear.fits
```

Catalogue Columns

The table below lists the columns that are present in the KiDS DR3.1 shear catalogue. It is divided in a number of subsections grouping columns resulting from a common data product or software package.

In the following, we provide additional information on a number of columns.

- KIDS_TILE**: name of the KiDS survey tile in which the source is located. Searching the ESO archive with this **OBJECT** name will link to further data products for this tile.
- THELI_NAME**: name for the survey tile in the THELI pipeline; for scripting reasons the '.' and '-' characters are replaced with 'p' and 'm', respectively.
- MASK**: bit mask indicating sources affected by different types of defects. Automatic and manual masks produced during data processing flag areas affected by bright stars (e.g. saturated pixels, reflection halos, diffraction and readout spikes) and other severe image defects. In the released catalogue the most strongly affected regions are already removed,

leaving only sources with reliable measurements. As a result, only the following bit mask values are present:

| Mask bit value | Type of area |
|----------------|-------------------------------|
| 2 | Faint stellar reflection halo |
| 64 | u-band AstroWISE manual mask |
| 128 | g-band AstroWISE manual mask |
| 256 | r-band AstroWISE manual mask |
| 512 | i-band AstroWISE manual mask |

- iv. **Flag:** SExtractor extraction flag. Many sources that are flagged during source detection are removed from the catalogue based on the *lensfit* results because they do not provide reliable shape measurements. The flag values that are still present in the catalogue are:

| Flag value | Type |
|------------|--|
| 1 | The object has neighbours, bright and close enough to significantly bias the photometry, or bad pixels (more than 10% of the integrated area affected) |
| 2 | The object was originally blended with another one |
| 16 | Objects's aperture data are incomplete or corrupted |

- v. **SG_FLAG:** star-galaxy separator based on analysis of the second and fourth order image moments of the source; 0 = star, 1 = galaxy
- vi. **MAG_u/g/r/i:** the magnitudes are based on Gaussian Aperture and Photometry (GAaP) measurements and are dereddened and colour-calibrated using stellar locus regression. **Note:** these aperture magnitudes are mainly intended for colour measurements, since they only probe the central regions of the source. They are not total magnitudes, except in the case of unresolved or point sources.
- vii. **MAG_LIM_u/g/r/i:** local limiting magnitude, defined as the magnitude corresponding to a flux equal to the 1σ flux error.
- viii. **ZPT_offset:** the magnitudes reported in this catalogue have been colour-calibrated, but their absolute calibration has only been homogenized per survey tile, not over the full area. Based on a comparison (see de Jong et al. 2016, in prep) of the *r*-band magnitudes with the GAIA DR1 (GAIA Collaboration, 2016, arXiv:1609.04172) we provide these additional photometric offsets that can be used to homogenize the photometry over the whole catalogue. The reported offsets are with respect to the GAIA photometry, but can be used to calibrate the photometry to the SDSS photometric system as follows:

$$\text{mag}_{u/g/r/i_homogenized} = \text{mag}_{u/g/r/i} - \text{ZPT_offset} + 0.049$$
Note: if used, these offsets must be applied to the magnitudes in *all* filters!
- ix. **T_B:** the best-fit spectral template for each source; these values correspond to the following types, where fractional types can occur because the templates are interpolated: 1=CWW-Ell, 2=CWW-Sbc, 3=CWW-Scd, 4=CWW-Im, 5=KIN-SB3, 6=KIN-SB2 (Capak, 2004, PhD. thesis, Univ. Hawai'i).
- x. **ODDS:** a measure of the uni-modality of the redshift Probability Distribution Function; a higher value indicates a higher reliability of the best photo-z estimate.
- xi. **fitclass:** *lensfit* object class; the only classes included in the catalogue are 0 (galaxy, no issues) and -9 (large galaxy, overfills 48 pixel postage stamp size). The latter class is retained to avoid ellipticity selection bias in the brightest galaxy sample.
- xii. **n_exposures_used:** the number of *r*-band sub-exposures for which *lensfit* measured the shape of the source. Due to the dither pattern, or near tile edges, some sources are only present in a subset of the 5 sub-exposures.

- xiii. e_1 or e_2 : *lensfit* shear estimators. Note: the e_2 component is defined relative to the RAJ2000, DECJ2000 grid; depending on the user's definition of angles in this reference frame, the sign of e_2 may need to be changed.
- xiv. PSF_e1 and PSF_e1_exp[k]: model PSF ellipticities at the location of the object, in this case the real part of ϵ_{PSF} . PSF_e1_exp[k] is the PSF ellipticity in sub-exposure number k, while PSF_e1 refers to the average over all exposures used.
- xv. m: the multiplicative shear calibration correction which should be applied in an ensemble average, rather than on a galaxy-by-galaxy basis (see Fenech Conti et al 2016 arXiv:1606.05337). Averaged catalogued ellipticities should be divided by $1+\langle m \rangle$, where the ellipticities should be weighted with the *lensfit* weight.

| Label | Format | Unit | Description |
|----------------------------------|--------|-------|--|
| General source parameters | | | |
| ID | 25A | | Source identifier |
| RAJ2000 | 1D | deg | Right ascension of barycenter (J2000) |
| DECJ2000 | 1D | deg | Declination of barycenter (J2000) |
| Patch | 3A | | Patch (G9, G12, G15, G23 or G5) |
| SeqNr | 1J | | Running object number within the patch |
| KIDS_TILE | 16A | | Name of survey tile |
| THELI_NAME | 16A | | THELI name for the tile |
| MASK | 1J | | Mask value at the object position |
| SG_FLAG | 1E | | Star-galaxy separator (0=star, 1=galaxy) |
| r-band SExtractor output | | | |
| KRON_RADIUS | 1E | pixel | Scaling radius of the ellipse for magnitude measurements |
| Xpos | 1E | pixel | Object position along x in the r-band THELI stack (non unique) |
| Ypos | 1E | pixel | Object position along y in the r-band THELI stack (non unique) |
| FWHM_IMAGE | 1E | pixel | r-band FWHM assuming a Gaussian core |
| FWHM_WORLD | 1E | deg | r-band FWHM assuming a Gaussian core |
| Flag | 1J | | r-band SExtractor extraction flags |
| FLUX_RADIUS | 1E | pixel | r-band half-light radius |
| CLASS_STAR | 1E | | r-band SExtractor S/G classifier output |
| Photometry measurements | | | |
| MAG_u | 1E | mag | Magnitude in the u-band (GAAP, dereddened) |
| MAGERR_u | 1E | mag | Magnitude error in the u-band |
| MAG_g | 1E | mag | Magnitude in the g-band (GAAP, dereddened) |
| MAGERR_g | 1E | mag | Magnitude error in the g-band |
| MAG_r | 1E | mag | Magnitude in the r-band (GAAP, dereddened) |
| MAGERR_r | 1E | mag | Magnitude error in the r-band |
| MAG_i | 1E | mag | Magnitude in the i-band (GAAP, dereddened) |
| MAGERR_i | 1E | mag | Magnitude error in the i-band |
| MAG_LIM_u | 1E | mag | Local 1σ limiting magnitude in the u-band |
| MAG_LIM_g | 1E | mag | Local 1σ limiting magnitude in the g-band |
| MAG_LIM_r | 1E | mag | Local 1σ limiting magnitude in the r-band |
| MAG_LIM_i | 1E | mag | Local 1σ limiting magnitude in the i-band |
| ZPT_offset | 1E | mag | Zeropoint offset derived from GAIA DR1 G photometry |

| Label | Format | Unit | Description |
|----------------------------|--------|--------|--|
| BPZ output | | | |
| Z_B | 1E | | BPZ best redshift estimate; peak of posterior probability distribution |
| Z_B_MIN | 1E | | Lower bound of the 95% confidence interval of Z_B |
| Z_B_MAX | 1E | | Upper bound of the 95% confidence interval of Z_B |
| T_B | 1E | | Spectral type corresponding to Z_B |
| ODDS | 1E | | Empirical ODDS of Z_B |
| lensfit output | | | |
| fitclass | 1I | | Lensfit fit class |
| bias_corrected_scalelength | 1E | | Lensfit galaxy model scalelength |
| bulge_fraction | 1E | | Lensfit galaxy model bulge-fraction B/T |
| model_flux | 1E | counts | Lensfit galaxy model flux |
| pixel_SNRratio | 1E | | Lensfit data S/N ratio |
| model_SNRratio | 1E | | Lensfit model S/N ratio |
| contamination_radius | 1E | pixel | Distance to nearest contaminating isophote |
| PSF_e1 | 1E | | Lensfit PSF model mean ellipticity e1 |
| PSF_e2 | 1E | | Lensfit PSF model mean ellipticity e2 |
| PSF_Strehl_ratio | 1E | | Lensfit PSF model mean pseudo-Strehl ratio |
| PSF_Q11 | 1E | | 2nd order brightness moment Q11 of the PSF |
| PSF_Q22 | 1E | | 2nd order brightness moment Q22 of the PSF |
| PSF_Q12 | 1E | | 2nd order brightness moment Q12 of the PSF |
| n_exposures_used | 1E | | Number of r-band exposures used in lensfit measurements |
| PSF_e1_exp1 | 1E | | Lensfit PSF model ellipticity e1 of exposure 1 |
| PSF_e2_exp1 | 1E | | Lensfit PSF model ellipticity e2 of exposure 1 |
| PSF_e1_exp2 | 1E | | Lensfit PSF model ellipticity e1 of exposure 2 |
| PSF_e2_exp2 | 1E | | Lensfit PSF model ellipticity e2 of exposure 2 |
| PSF_e1_exp3 | 1E | | Lensfit PSF model ellipticity e1 of exposure 3 |
| PSF_e2_exp3 | 1E | | Lensfit PSF model ellipticity e2 of exposure 3 |
| PSF_e1_exp4 | 1E | | Lensfit PSF model ellipticity e1 of exposure 4 |
| PSF_e2_exp4 | 1E | | Lensfit PSF model ellipticity e2 of exposure 4 |
| PSF_e1_exp5 | 1E | | Lensfit PSF model ellipticity e1 of exposure 5 |
| PSF_e2_exp5 | 1E | | Lensfit PSF model ellipticity e2 of exposure 5 |
| e1 | 1E | | Lensfit galaxy e1 expectation value |
| e2 | 1E | | Lensfit galaxy e2 expectation value |
| weight | 1E | | Lensfit inverse variance shear weight |
| m | 1E | | Multiplicative shear calibration |

Acknowledgements

Users of these data should include the following acknowledgment to the source of the data:

Based on data products from observations made with ESO Telescopes at the La Silla Paranal Observatory under programme IDs 177.A-3016, 177.A-3017 and 177.A-3018.

and should cite Hildebrandt & Viola et al. (2017), Fenech Conti et al. (2016) and accompanying papers as follows:

We use cosmic shear measurements from the Kilo-Degree Survey (Kuijken et al. 2015, Hildebrandt et al. 2017, Fenech Conti et al. 2016), hereafter referred to as KiDS. The KiDS data are processed by THELI (Erben et al. 2013) and Astro-WISE (McFarland et al. 2013, de Jong et al. 2015). Shears are measured using lensfit (Miller et al. 2013), and photometric redshifts are obtained from PSF-matched photometry and calibrated using external overlapping spectroscopic surveys (see Hildebrandt & Viola et al. 2017).