KiDS Photometric Calibration Lessons and implications for meeting Euclid Requirements

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Introduction Photometric Calibrations

Requirements:
-making Euclid covered survey flat < 1% in each EXT passband
-making exposures flat < 0.2% in color over Euclid FOV (0.53 square degree)

KiDS Photometric Calibration

-) KiDS 1500 square degree in ugri (+VIKING z)
-) 1 sq deg. OmegaCam@VST (2.6m)
-) OmegaCam has 4x8 chips = 32 chips

Current procedure Photometric Calibrations

-) Photometric Calibration at exposure level; making single frames flat << 1%

-) Photometric Calibration at coadd level

TBCombined

-) Photometric Calibration at survey level

KiDS Photometric Calibrations

-) currently zp quality of KiDS latest data release (450 sq deg)
-) using Stellar Locus Regression (SLR) + coadd overlaps
-) comparison offsets with SDSS DR9 for coadds:

u (stdev zp offset)	g (stdev zp offset))	r (stdev zp offset)	i (stdev zp offset)
0.020	0.018	0.014	0.015

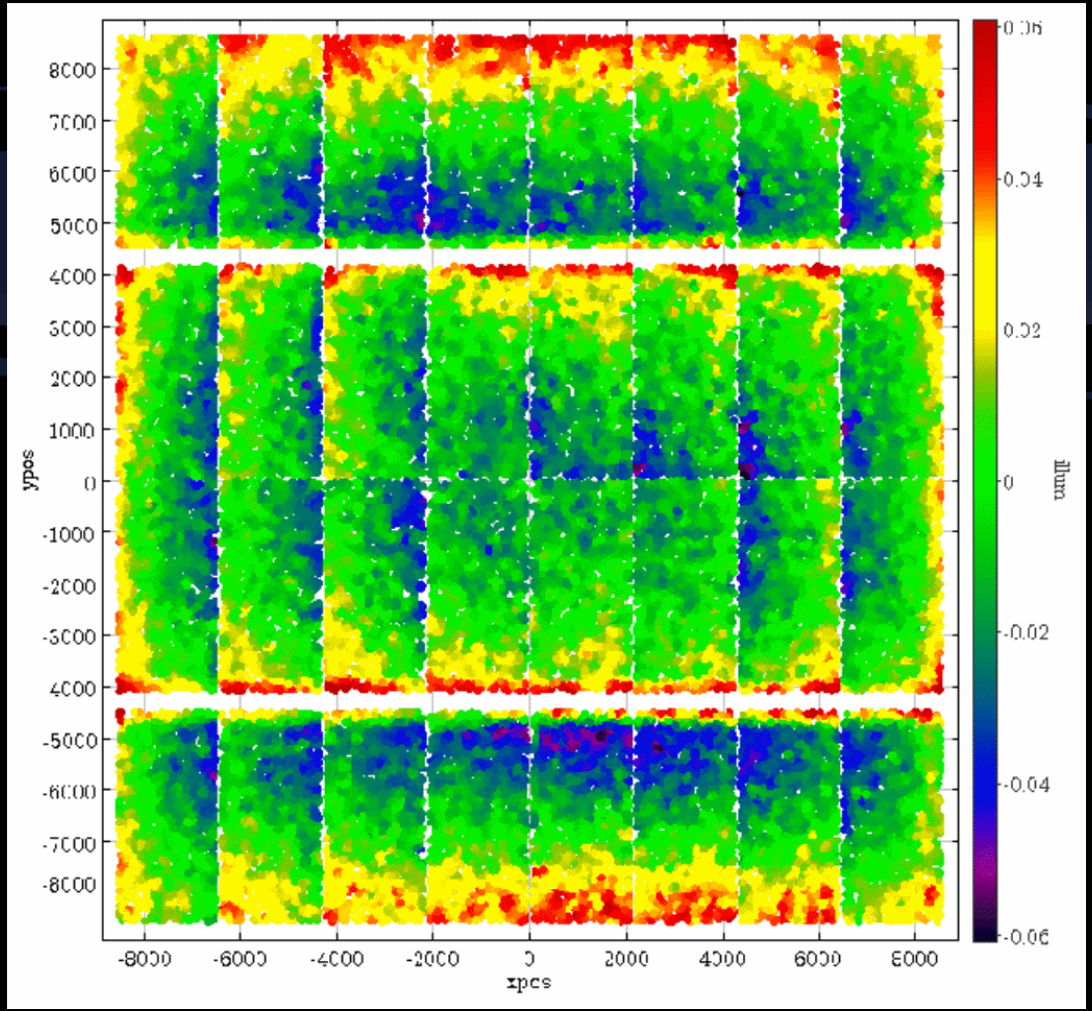
u-g	0.026
g-r	0.013
r-i	0.008

NOTE: SDSS has its own errors, both spatial and random. Future comparison with f.i.: Pan-STARSS, GAIA, ATLAS

Photometric Calibration at exposure level

-) pixel sensitivity(gain) very stable <1% over years <0.1 over month
-) flatfield, combination of twilight and dome.
-) Twilight has rotator angle dependent stray light/vignetting. Use same single flat over years, because of stability this is possible, but: dust speck issues … single dust particles move over time. For KiDS survey no problem…
-) flat field correction: illumination correction

Use fitting polynome to 33 dedicated ditherer data. Majority of regions < 1% but vignetting remains.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-8000
-6000
-4000
-2000
0
2000
4000
6000
8000
0.06
0.04
0.02
0
-0.02
-0.04
-0.06

Photometric Calibration at exposure level

-) Possible Improvement: use only weekly dome flat (fixed rotator angle → fixed stray-light/vignetting)

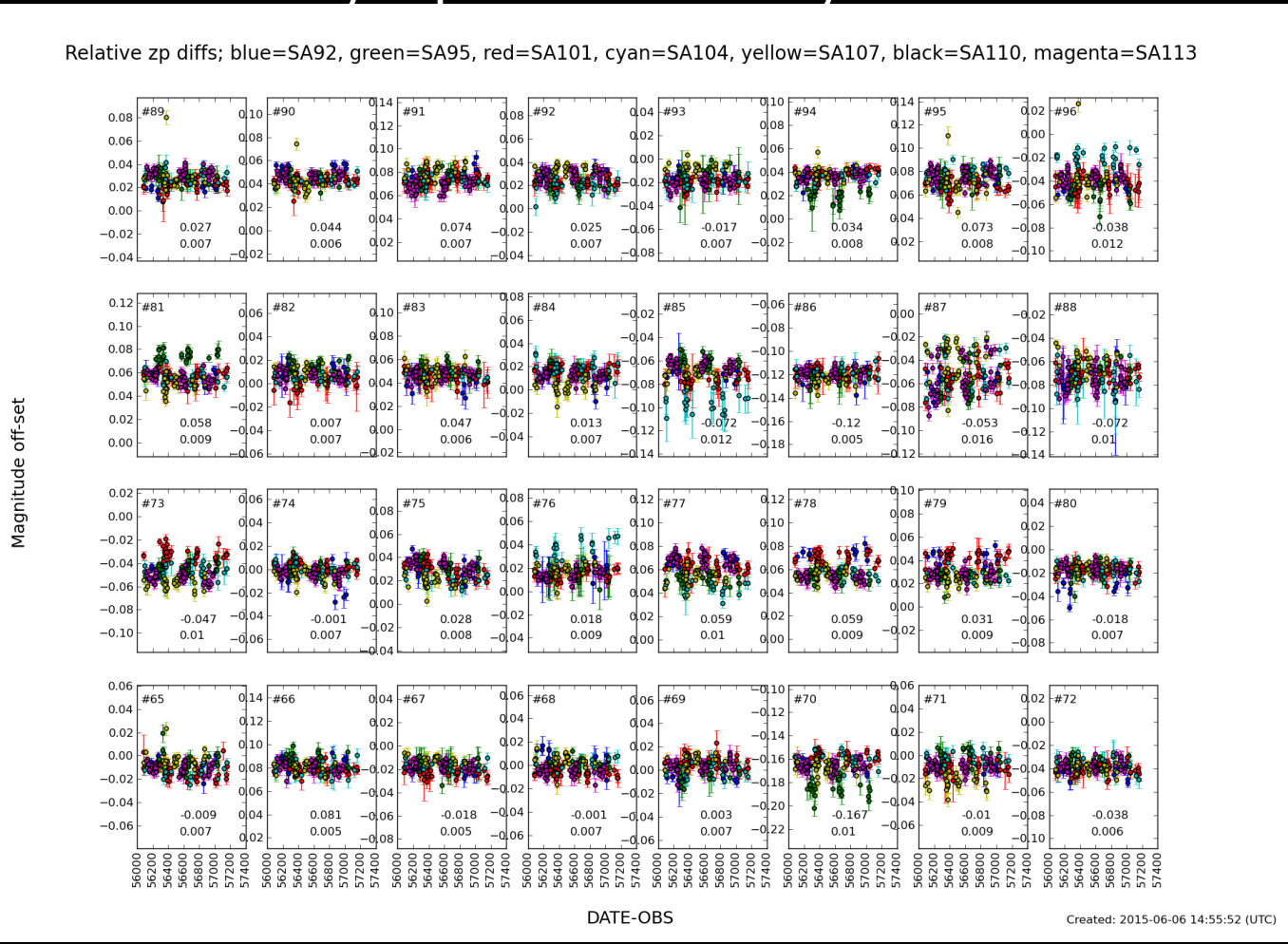
→ solves dust speck issue
→ stable illumination correction.

Relative and Absolute Photometric Calibration at exposure level

-) Relative: within an observing block (5 dithers) : use overlap to calculate zp offsets; improvement: use stability of gains or direct calibration using a reference catalog
-) Absolute: use standard stars; anchors

Make use of a very homogeneous all sky catalog. GAIA Bp and Rp bands?,

Relative Photometry: zp offsets over years ~0.5%



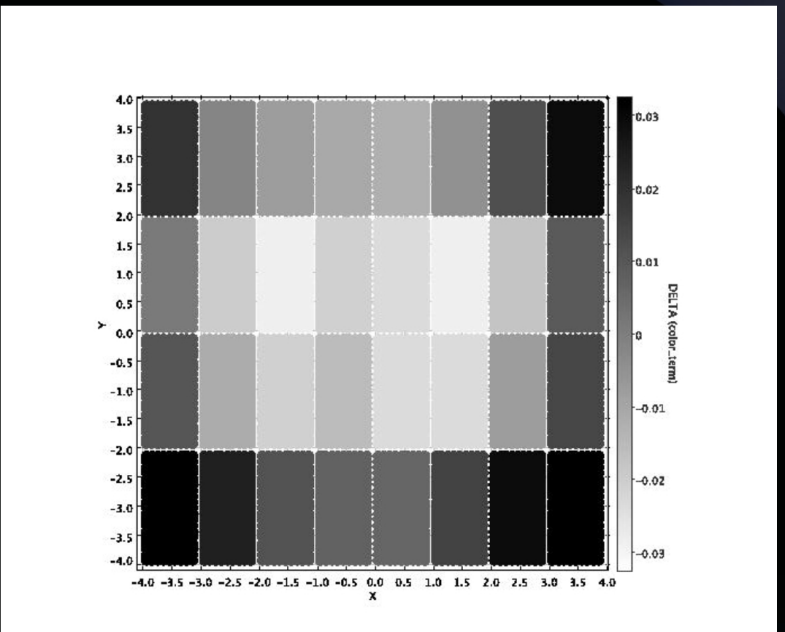
Photometric Calibration at survey level

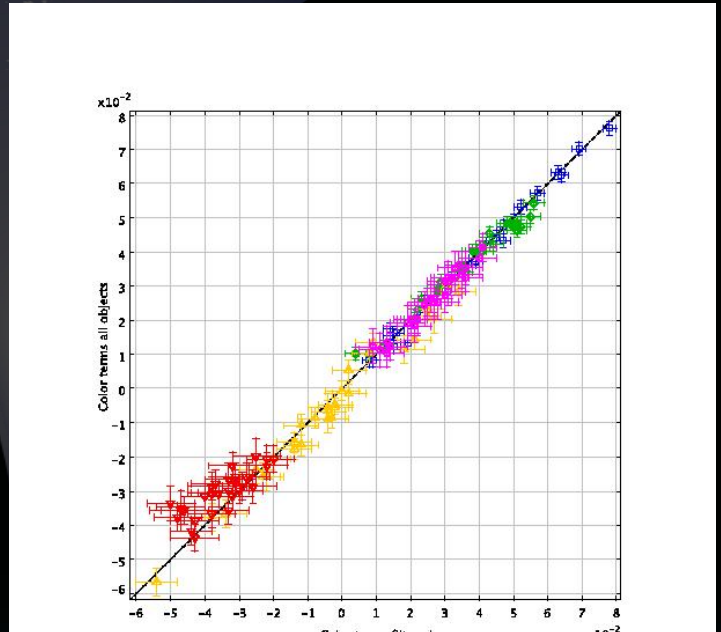
-) Currently in KiDS: overlap of coadds in r band + SLR at tile level

Improvement: overlap en SLR better if flatness better
Improvement: simplified uebercal for all survey exposures.
Improvement: incoorporate VST-ATLAS (shallow)
Improvement: GAIA B and R bands?,

Photometric Calibration in color space

–) positional color term dependency… f.i.: g-r color term varies from 0 to 0.06 from centre to corner
-) <u>improvement:</u> correct for this on catalog level

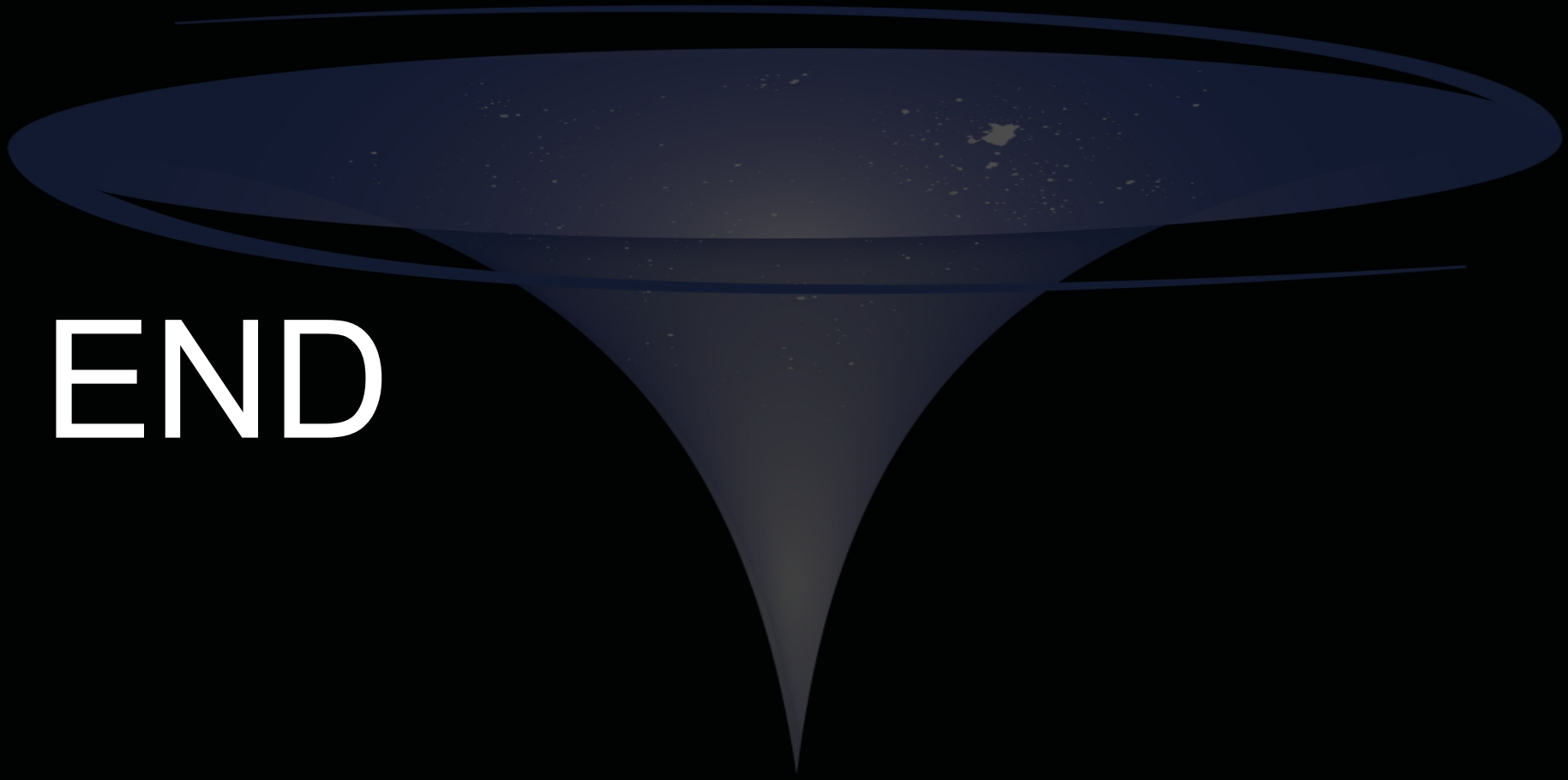




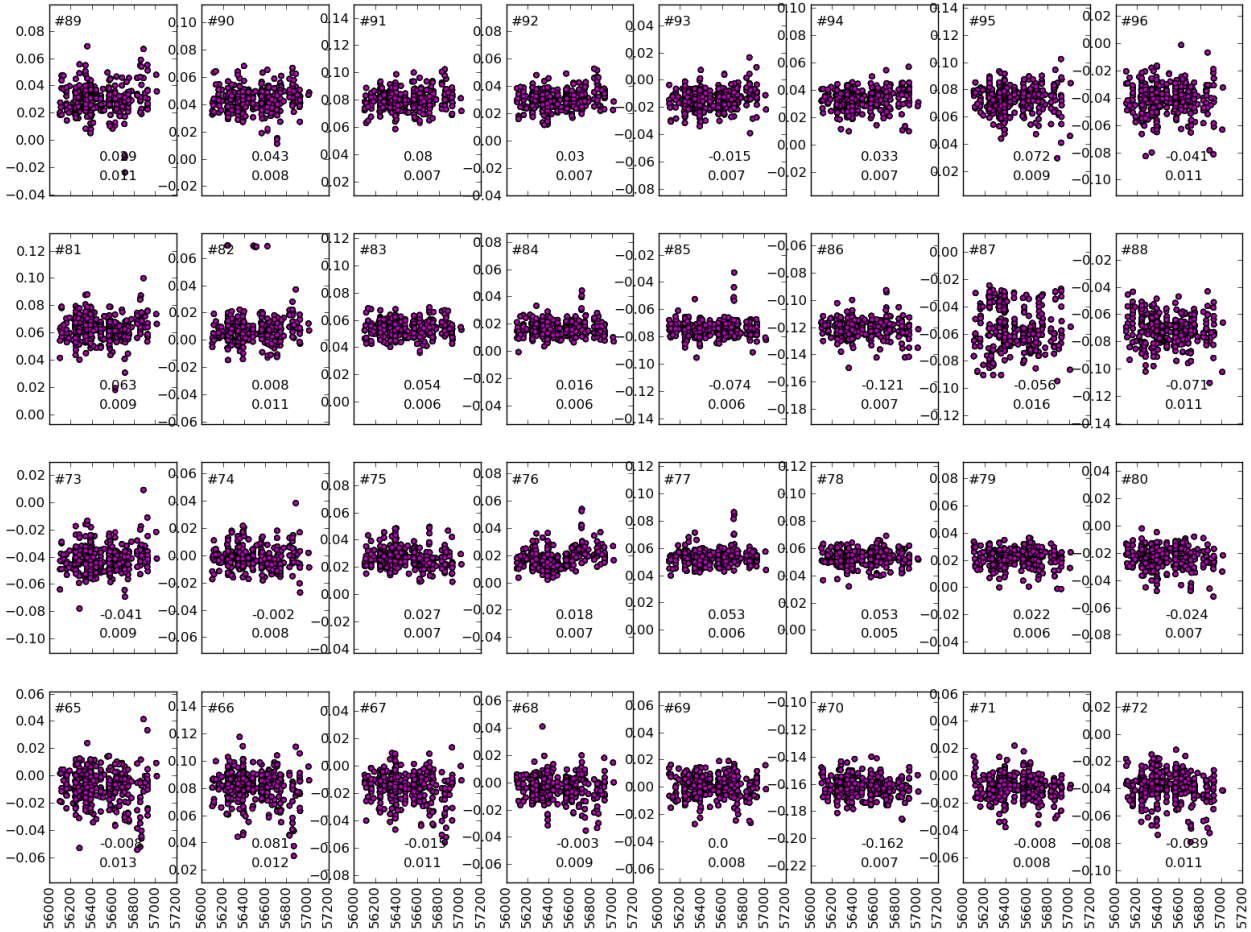
Solutions & Expectations

-) good prospects that 1% homogenous photometry will be reached for KiDS(+ATLAS)

-) Provided that the single frames are flat (illumination correction), a reference catalog like GAIA may solve everything from exposure to survey level! (assuming that a precise transformation between filters can be calculated)


END

Relative zp diffs; blue=SA92, green=SA95, red=SA101, cyan=SA104, yellow=SA107, black=SA110, magenta=SA113



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How to tie together all tiles

Use only GAAP magnitudes

Combine Two independent ways:

-) SLR on tile basis (UGRI)

-) Global Photometry with Overlaps

SLR

SLR: KiDS OMEGACAM filters ~ SDSS filters.
Use principal color coefficients (Ivezic et al. 2004)
Use same derived coefficients for SDSS and apply same method (galactic extinction corrected.
Problems with u band

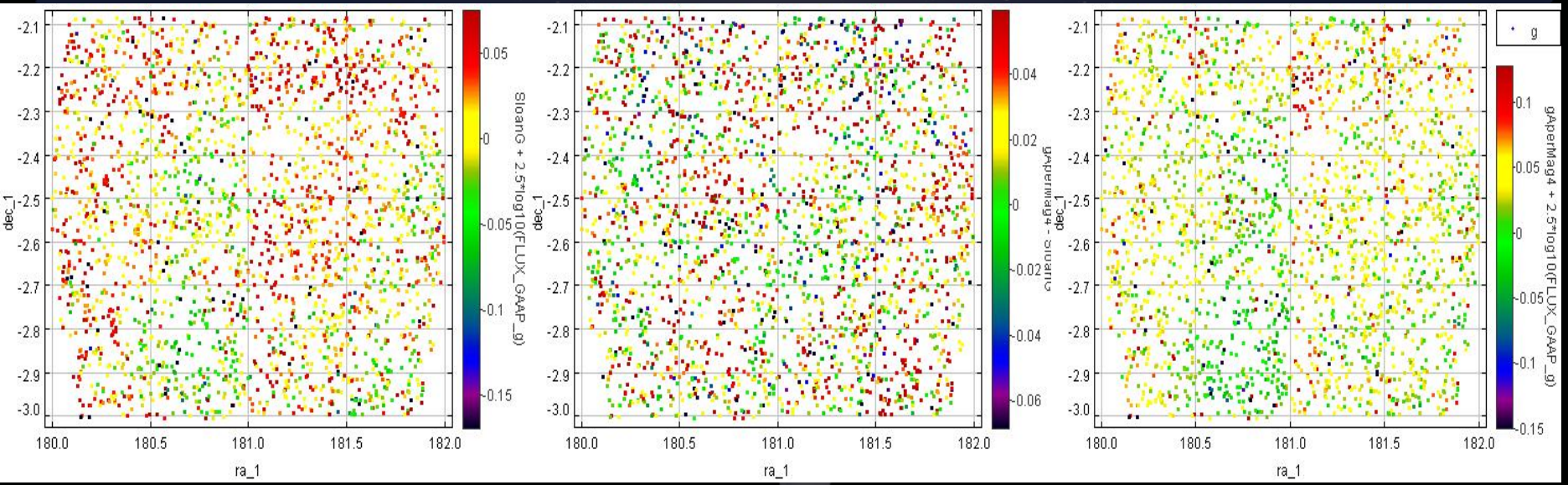
Global Photometry with overlaps

Define Best OBs == Anchors:
-) no large relative extinction within a KiDS science OB
-) no forevers
-) no data prior to april 2012 (CCD82 problem)
-) no large differences between PSF_zeropoint - PSF_science
Anchors about 30% in R band.
Tie all other tiles to anchors.

Results

SLR: Works well for gri not for u ; need absolute calibration
Global Overlaps: works fairly well in all bands, best for r, then i, then g, then u

CONCLUSION for KiDS RELEASE:
-) USE absolute calibration in r band from GP
-) TIE g and i to R using SLR.
-) USE absolute calibration in u band from GP


dec_1
ra_1
SloanG + 2.5*log10(FLUX_GAAP_g)
gAperMag4 - SloanG
gAperMag4 + 2.5*log10(FLUX_GAAP_g)
g

SG CS CG

KiDS Survey Photometry

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KiDS Team

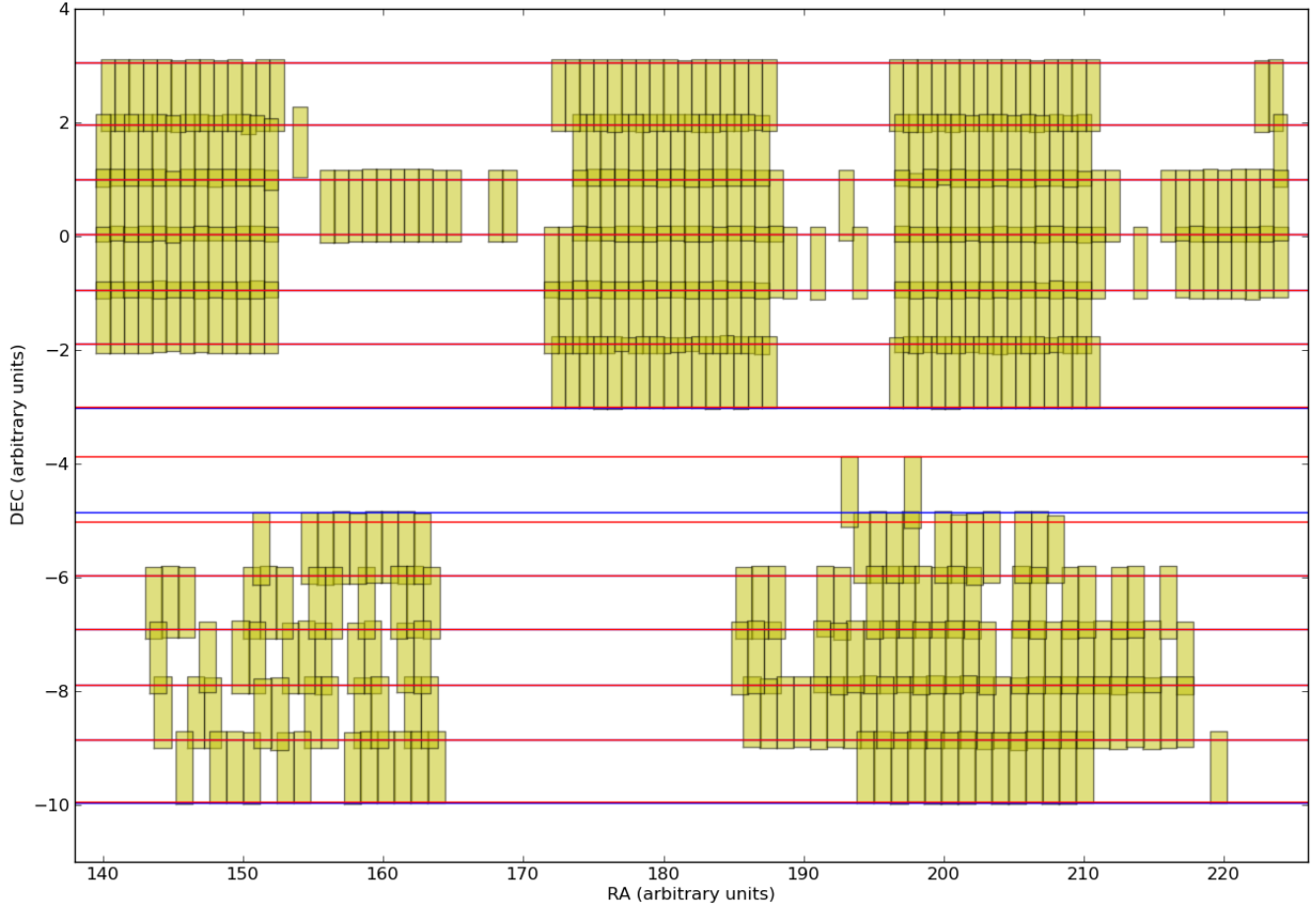
Introduction KiDS Upcoming July delivery (DR3)

440 tiles in ugri = 1760 coadds, catalogs, quality etc.

survey photometric calibration

ESO DR3

several groups



Survey Photometric Calibration

Case of single coadds:
-) Each coadd in each passband calibrated zeropoint of the night using SDSS standard fields. No ZP available: use default.

Survey: connect tiles and coadds: Combine two independent ways, make use of seeing independent, PSF matched magnitudes (GaaP, Kuijken 2008):

-) Stellar Locus Regression (SLR) on tile basis, use colour info (ugri)
-) Overlap Photometry (OP)

Survey Photometric Calibration

SLR: KiDS OMEGACAM filters ~ SDSS filters.

-)Use principal color coefficients (Ivezic et al. 2004)

-) Use same derived coefficients for SDSS and apply same method (galactic extinction corrected.

-)color fitting , no single filter calibration.

Overlap Photometry (OP): provides single filter calibration

Define Best OBs == Anchors; Tie all other tiles to anchors. Best results for r

Results

SLR: Works well for gri , less well for u; need single filter calibration

Overlap Photometry: -) works best for r band;

-) better results for u compared to SLR

CONCLUSION for KiDS ESO DR3 RELEASE:

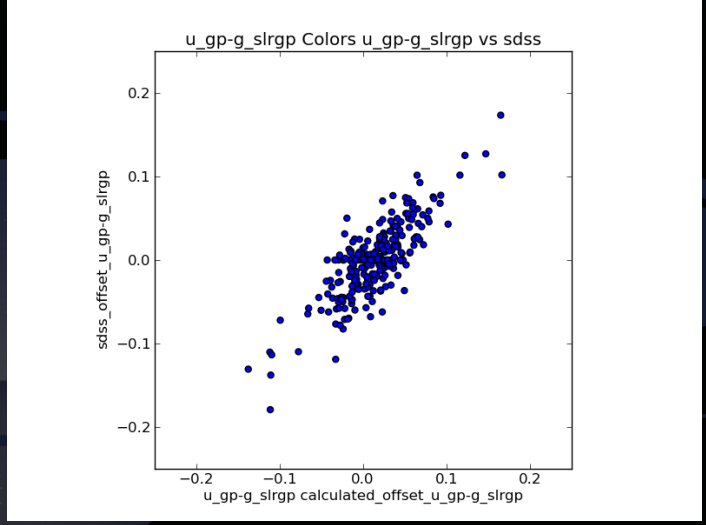
-) USE single filter calibration in r band from Overlap Photometry

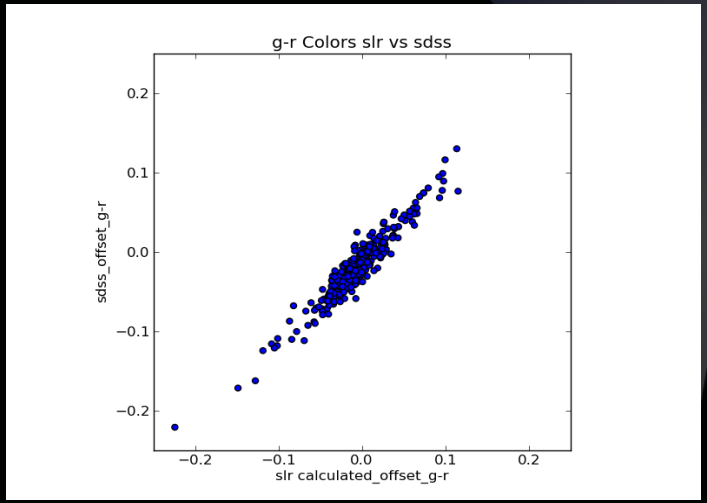
-) TIE g and i to r using SLR.

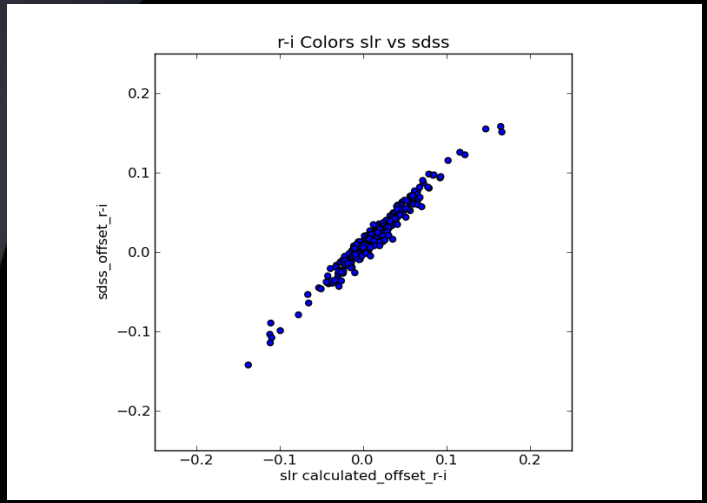
-) USE single filter calibration in u band from OP

TBD: PROBLEM u band SLR

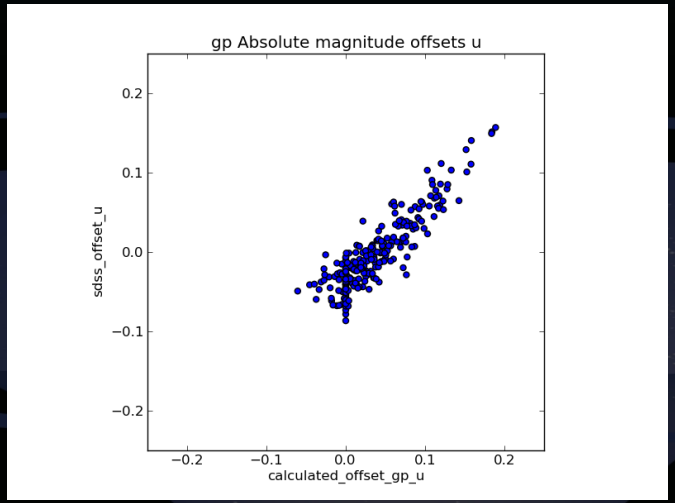
Qualitative Color-Color Comparison with SDSS

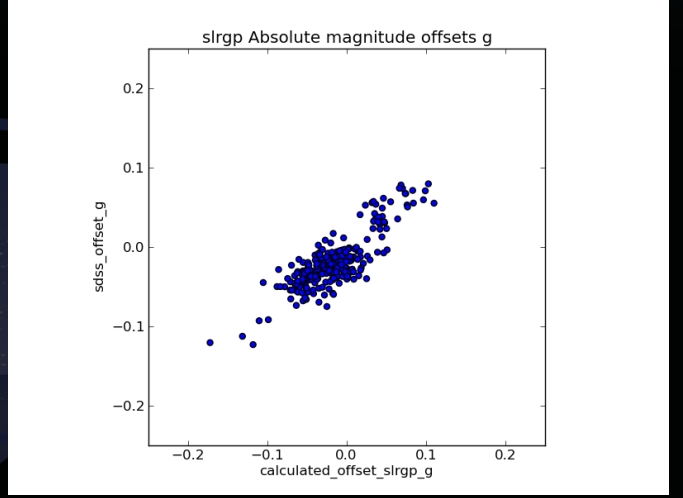


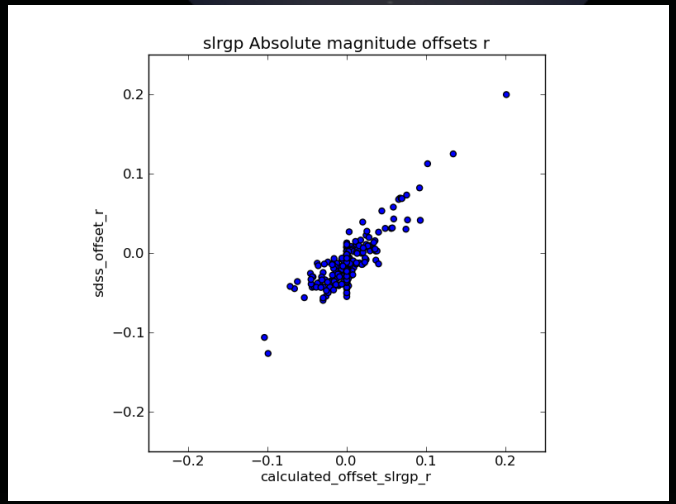


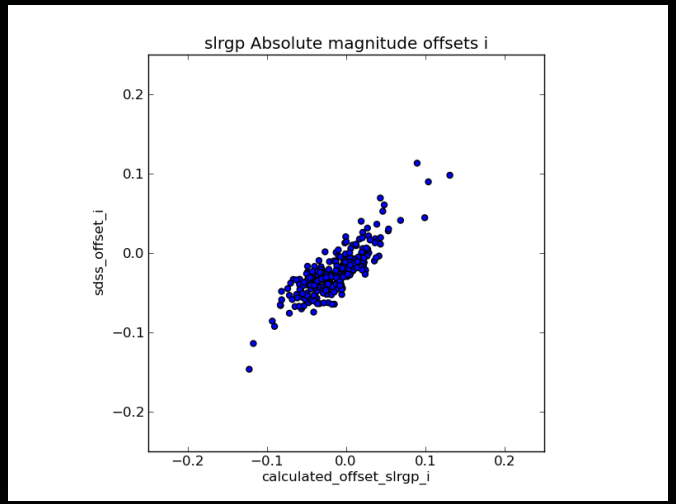


Qualitative ZP Comparison with SDSS









GP + SLR results compared with SDSS (ZP + Colors)

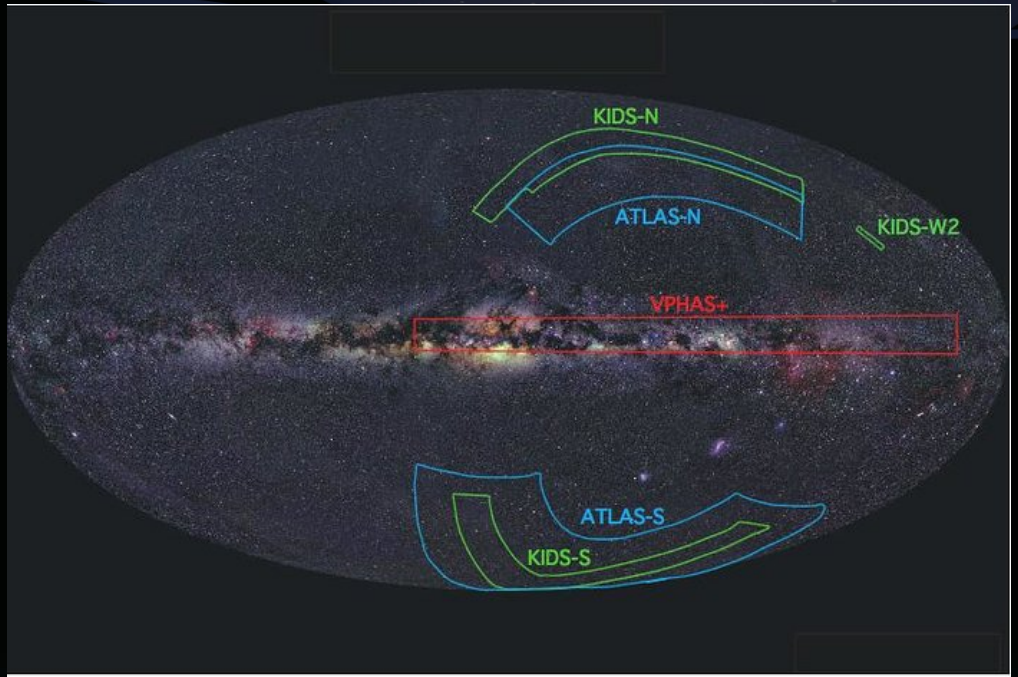
group (#nr)	u	g	r	i
1 (95)	-0.038 +/- 0.024	-0.002 +/- 0.018	-0.008 +/- 0.015	0.004 +/- 0.016
2 (89)	-0.043 +/- 0.017	0.012 +/- 0.017	-0.011 +/- 0.016	-0.007 +/- 0.016
3 (65)	-0.042 +/- 0.019	-0.023 +/- 0.019	-0.029 +/- 0.012	-0.027 +/- 0.012

u-g	-0.014 +/- 0.026
g-r	-0.012 +/- 0.013
r-i	+0.005 +/- 0.008

NOTE: SDSS has its own errors, both spatial and random. To be compared with better data: GAIA, ATLAS

2016 improvements and validation: ATLAS and GAIA

ATLAS: VST Survey that largely overlaps with KiDS. Tiling is different. Photometric check/validation

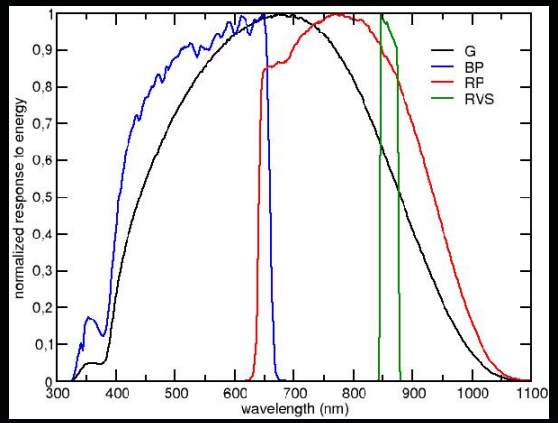


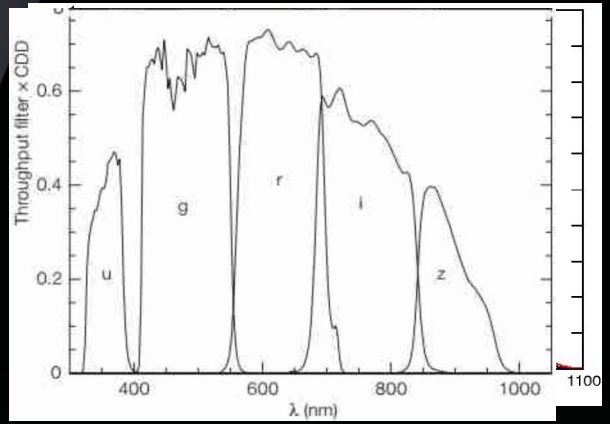
Gaia's photometric potential for EXT

all-sky reference: ugrizy synthetic photometry

Euclidization validator: synthesize G from EXT(u,g,r,i,z) for each survey

joint VIS+EXT photometric calibration using Gaia (start with validator experiment)






END

ESO DR3 specs

Astrometry	0.3” (2D rms wrt 2MASS), 0.03 internal
Photometry	ZP 15 mmag in ri, 20 mmag in u,g (wrt SDSS DR9)

SLR

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