KiDS

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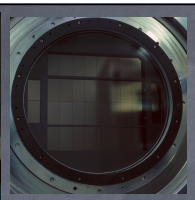
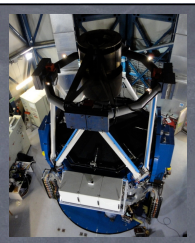

KiDS:
The Kilo-Degree Survey

Konrad Kuijken
Leiden Observatory

kids.strw.leidenuniv.nl

LEIDEN GRONINGEN MUNCHEN
PARIS NAPLES BONN EDINBURGH
CAMBRIDGE QMW OXFORD

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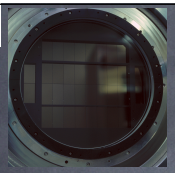
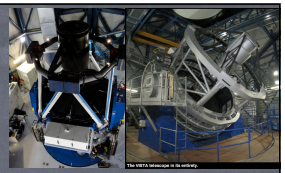
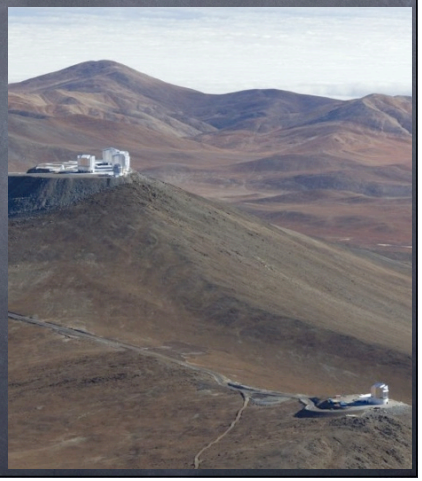


In a nutshell



- 9-band survey u-K with VST/OmegaCAM and VISTA
- 1500 square degrees
- 2mag deeper than SDSS, 2x sharper
- weak lensing + photoz optimized
- started Oct 15 2011



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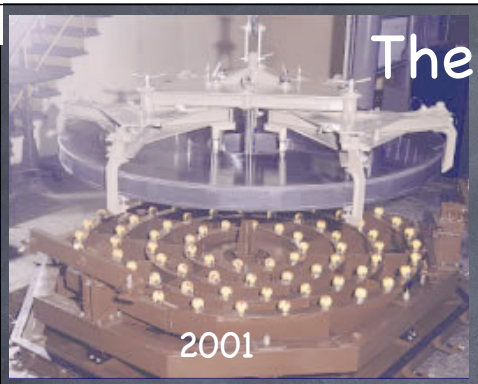
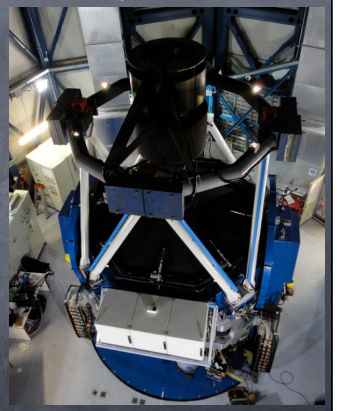
The VST saga...



After 7 years bad luck



INAF/Naples has delivered
a very good telescope!

VST and VISTA

250 nights: VIKING

(PI. Will Sutherland)

440 nights: KiDS

VISTA

4m telescope

0.6 sq.deg. InfraRed camera

16 2kx2k detectors

0.35" pixels

VST

2.6m telescope

1 sq.deg. optical camera (OmegaCAM)

32 2kx4k detectors

0.21" pixels

KiDS-N and KiDS-S

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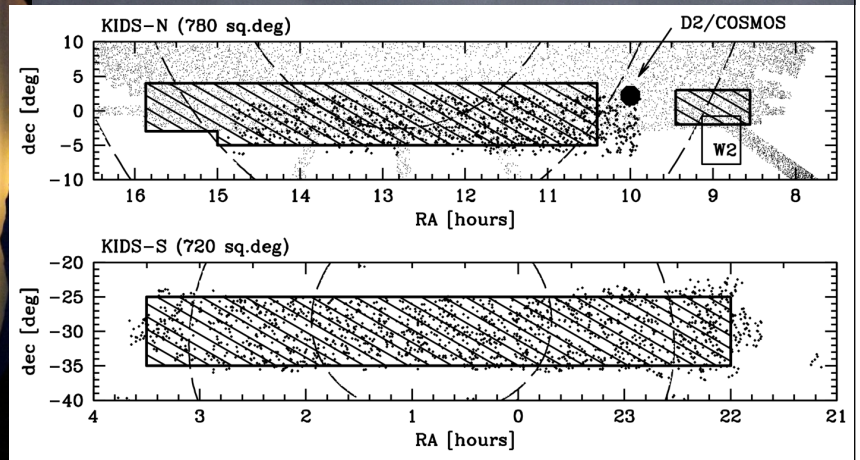

- Overlaps with 2dF and SDSS redshift surveys

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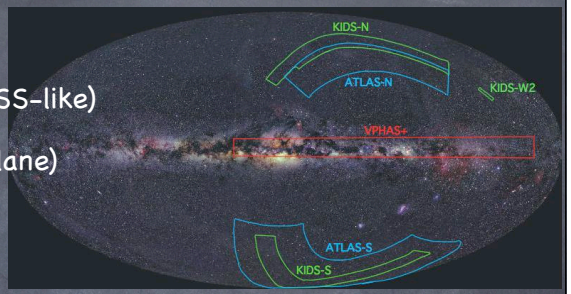
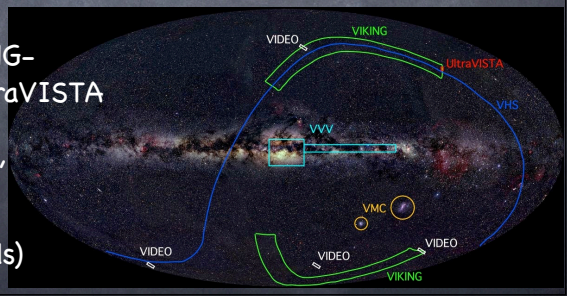
ESO Public Surveys

- VST:
  - ATLAS (SDSS-like)
  - VPHAS+ (plane)
  - KiDS
- VISTA:
  - VHS-VIKING-VIDEO-UltraVISTA
  - VVV (plane, variables)
  - VMC (Clouds)





KiDS and Cousins

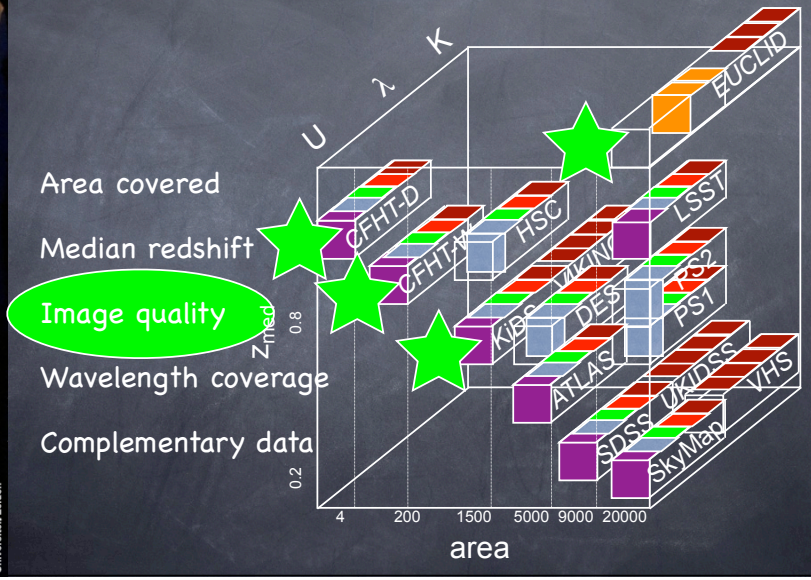
Area covered

Median redshift

Image quality

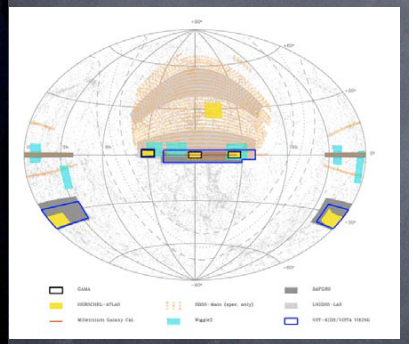
Wavelength coverage

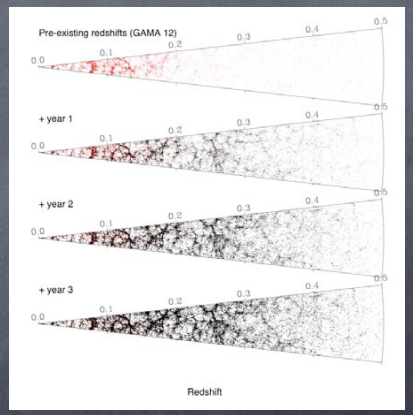
Complementary data



KiDS and Friends

GAMA, Herschel-ATLAS, 2dFGRS, SDSS





"Follow-up" has begun!

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Some numbers

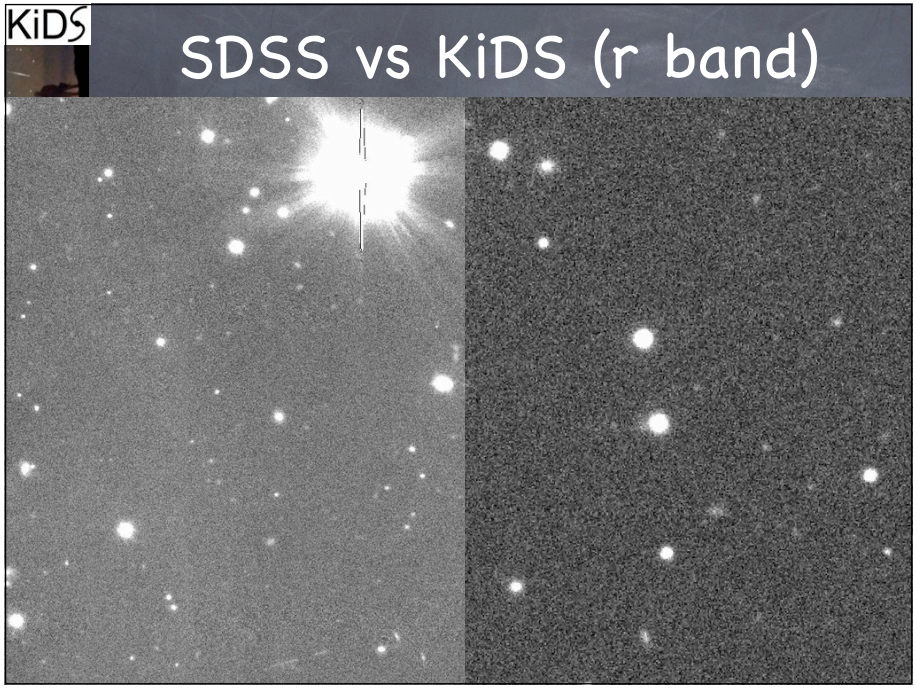
- 1500 sq.deg. of ugri (~400n VST) + ZYJHK (~200n VISTA)
- Deeper in r, with good seeing
- Match seeing distribution on Paranal
- VST 2m deeper than SDSS (1m shallower than CFHTLS)
- VISTA 1.5m deeper than UKIDSS

filter	Exp (s)	5-σ 2" AB	cf. UKIDSS
Z	5[illegible]	23.1	-
Y	400	22.4	+1.6
J	400	22.2	+1.8
H	300	21.6	+1.6
K	500	21.3	+1.3

Seeing / Moon	<0.7" (40%)	0.7-0.9" (20%)	0.9-1.1" (20%)
Dark (5[illegible])	r'	g'	u'
Grey (15%)	-	-	-
Bright (35%)	i'	i'	i'

filter	Exp time (s)	Medn seeing (")	5-σ 2" AB
u'	900	1.0	24.8
g'	900	0.8	25.4
r'	1800	0.7	25.2
i'	1080	0.75	24.2

NO VARIABILITY: ATTAIN FINAL DEPTH IMMEDIATELY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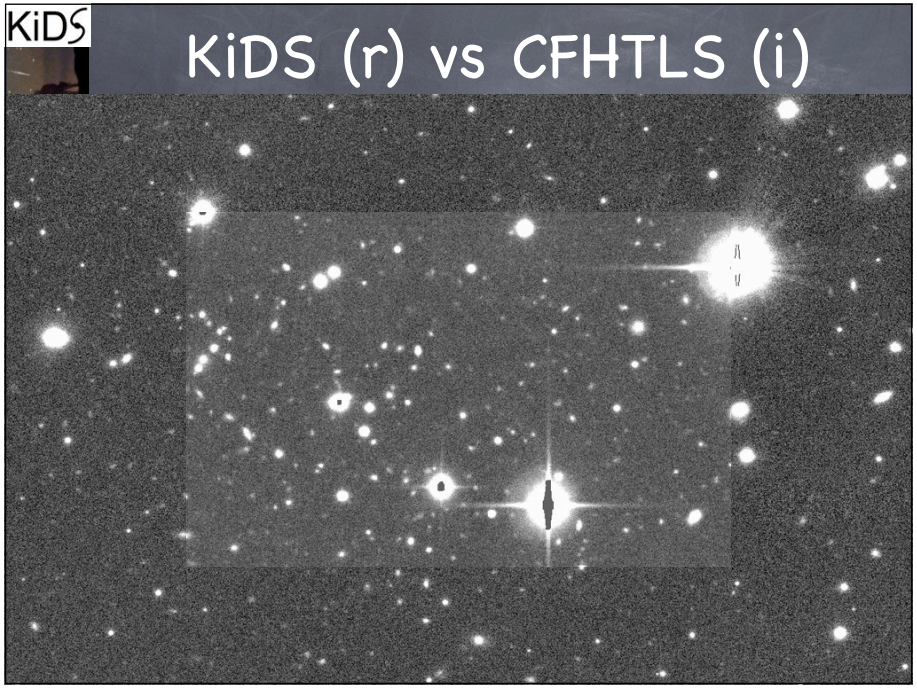
SDSS vs KiDS (r band)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KiDS (r) vs CFHTLS (i)

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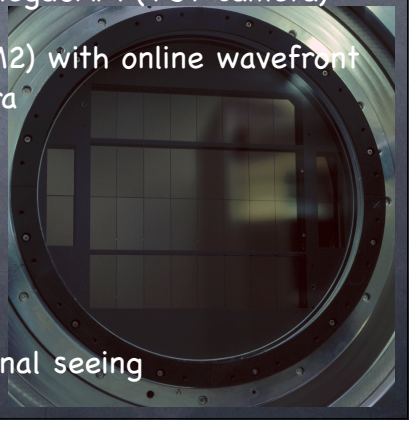
Image Quality

- Main limiting factor for weak lensing measurements (S/N and systematics)
- Key design driver of OmegaCAM (VST camera)
  - active optics (M1 & M2) with online wavefront sensing in CCD camera
  - 2-star guiding
  - Constant plate scale
  - small pixels (0.21")
  - well matched to Paranal seeing



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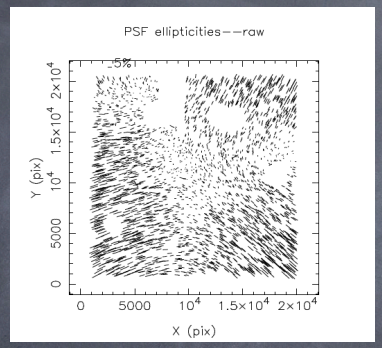
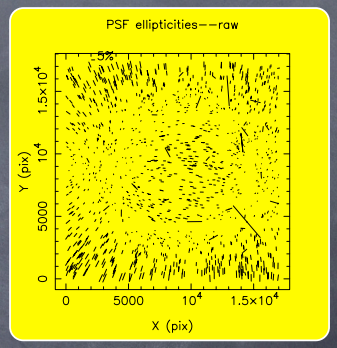
PSF Anisotropy



CFHT Megacam



VST OmegaCAM

- The more benign the pattern, the better
- Advantage of custom-designed f/5.5 Cassegrain over retrofitted f/2 Prime focus!

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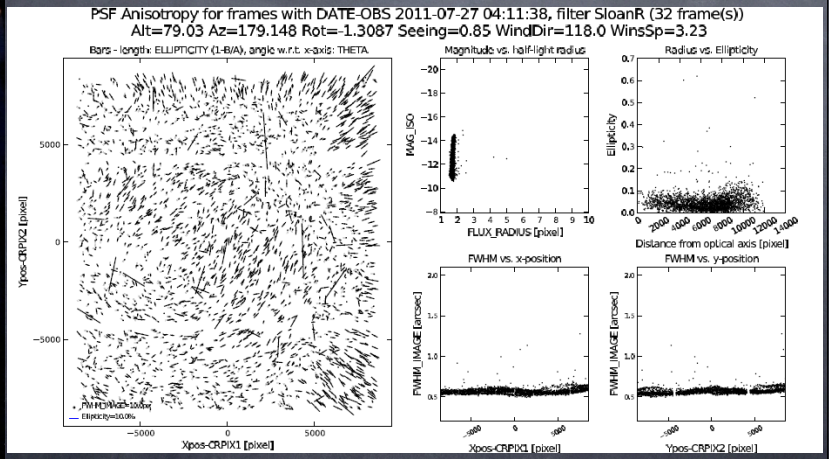
The importance of alignment



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Astro-WISE

- Developed at Groningen University ctr OmegaCEN (Valentijn et al.)
- archive+processing environment
- distributed
- all calibrations traceable
- 'make' paradigm
- processing engine made of well-established code: SExtractor, Swarp, … with lots of own additions
- www.astro-wise.org

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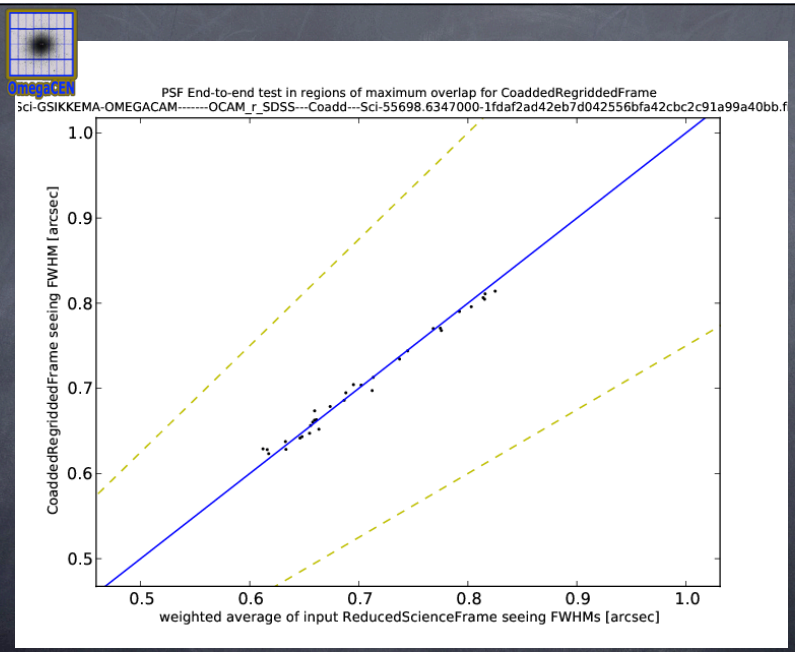

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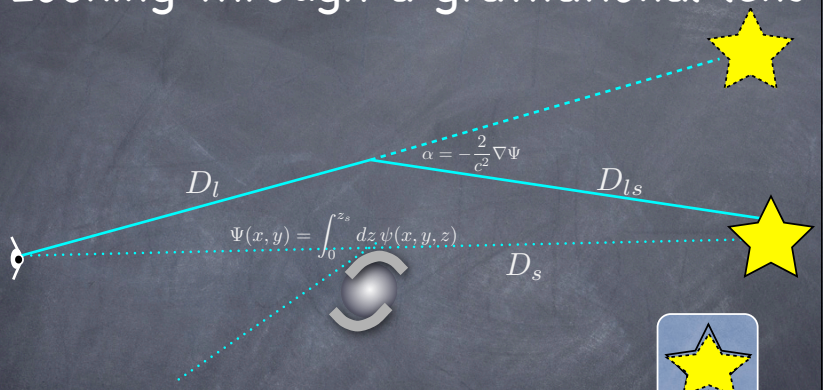
KiDS: a Shear tomography survey

- Intro
- measuring shear
  - PSF Gaussianization
- photometric redshifts
- measuring magnification
- status

Looking through a gravitational lens



- 'Push away' from the lens (!)

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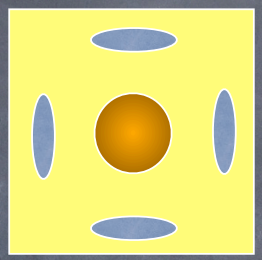
Push and squeeze



- Background sky is pushed away from massive foreground objects
- Push introduces a characteristic distortion: background galaxies tend to orient along circles around massive foreground objects

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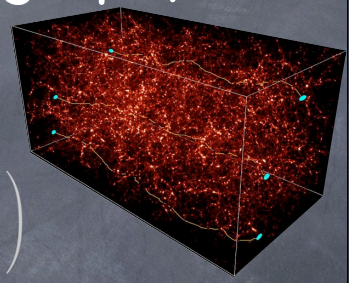
Shear tomography



- Sum 'thin lenses'

$$\Psi(x,y) = \int_0^{z_s} dz\, \psi(x,y,z)$$

$$\begin{pmatrix} \kappa \\ \gamma_1 \\ \gamma_2 \end{pmatrix} = \frac{2}{c^2} \frac{D_l D_{ls}}{D_s} \begin{pmatrix} \Psi_{,11} + \Psi_{,22} \\ \Psi_{,11} - \Psi_{,22} \\ 2\Psi_{,12} \end{pmatrix}$$

- Light rays deflected by ~ 3' by LSS
- Measure gravitational shear as function of source redshift
- Tomographically reconstruct 3D gravity field
- Probes growth of structure: $P_k(z)$

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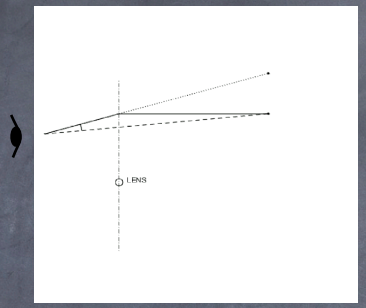
Distance measurements with lensing



- On-sky shift is distance dependent: DISTANCE PROBE
- Same lens affects images of sources at different distance differently
  - Use galaxies or clusters as lensing
  - Xcorr LSS shear fields for difft z_{source}

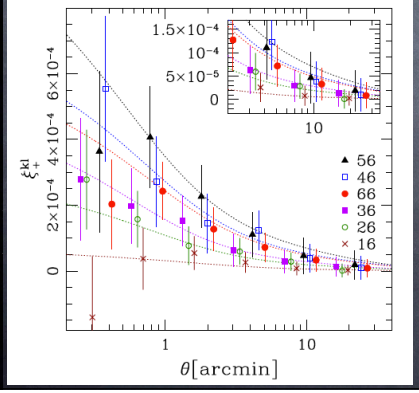
$$\frac{D_{12}}{D_2}\frac{D_3}{D_{13}}$$

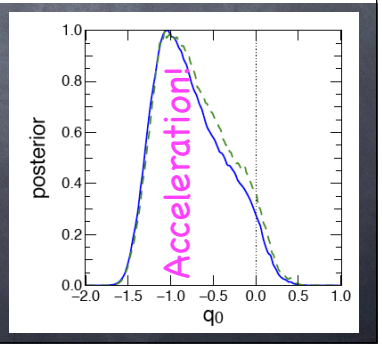
Application to COSMOS (1.6 sqdeg HST)

Schrabback et al. 2010

- Xcorr 6 photo-z bins
- Plausible z-scaling
- geometry + growth
- ΛCDM, no prior on flatness

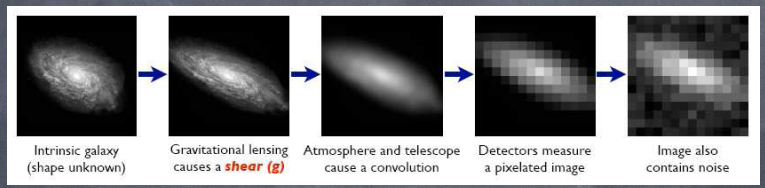
Bin	z_{min}	z_{max}	N	$\langle z \rangle$
1	0.0	0.6	$i^+ < 24 : 22\,294^*$	0.37
			$i^+ > 24 : 29\,817$	
2	0.6	1.0	58 194	0.80
3	1.0	1.3	36 382	1.16
4	1.3	2.0	25 928	1.60
5	2.0	4.0	21 718	2.61
6	0.0	5.0	251 958	1.54 ± 0.15





Shear measurement

- Bayesian model-fitting techniques? lensfit
- Model-independent techniques? KSB++



- Issues of principle: galaxy model; PSF correction
- Practicalities: PSF model interpolation; pixelation

- SNAP-G = shear nulling after PSF Gaussianization
  - Gaussian PSF ==> can calculate KSB-type moments under any shear
  - Test trial shear patterns until isotropic (null)

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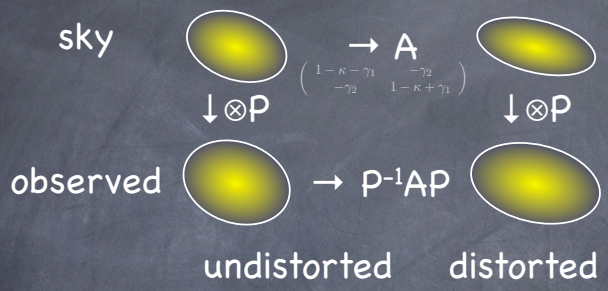
SNAPG



- For weighted second moments & Gaussian PSF the $P^{-1}AP$ step can be done analytically

$$Q_1 = \int I(x,y)(x^2-y^2)e^{-r^2/2w^2}dx\,dy \qquad Q_2 = \int I(x,y)(2xy)e^{-r^2/2w^2}dx\,dy$$

$$Q_1^A = \int I(x,y)w_1^A(x,y)dx\,dy \qquad Q_2^A = \int I(x,y)w_2^A(x,y)dx\,dy$$

- Allows nulling of any shear pattern

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PSF Gaussianization

- Construct appropriate spatially varying kernel
  - (shapelet formalism handy)
- PSF-Gaussianized images very useful
  - shear measurement (SNAP-G; KSB should work!)
  - analytic matched-aperture photometry from different bands, instruments, plate scales, ...
  - star-galaxy separation
  - accurate astrometry (no lopsidesness)

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GaaP photometry

- Intrinsic Gaussian aperture flux, 'radius' W:

$$F_W \equiv \int dx\, dy I(x,y) e^{-r^2/2W^2}$$

- From image with Gaussian PSF, measure

$$F_w; q \equiv \int dx\, dy \left(\int dx'\, dy' I(x',y') \frac{e^{-[(x-x')^2+(y-y')^2]/2q^2}}{2\pi q^2} \right) e^{-r^2/2w^2}$$

- Easy to show that

$$F_{w;q} = \frac{w^2}{w^2+q^2} F_{\sqrt{w^2+q^2}}$$

- I.e., can measure any intrinsic Gauss ap.Flx F_W!
  - (provided aperture wider than PSF)
- Easily generalizes to elliptical apertures and PSFs
- Proper matched aperture photometry even if seeing different

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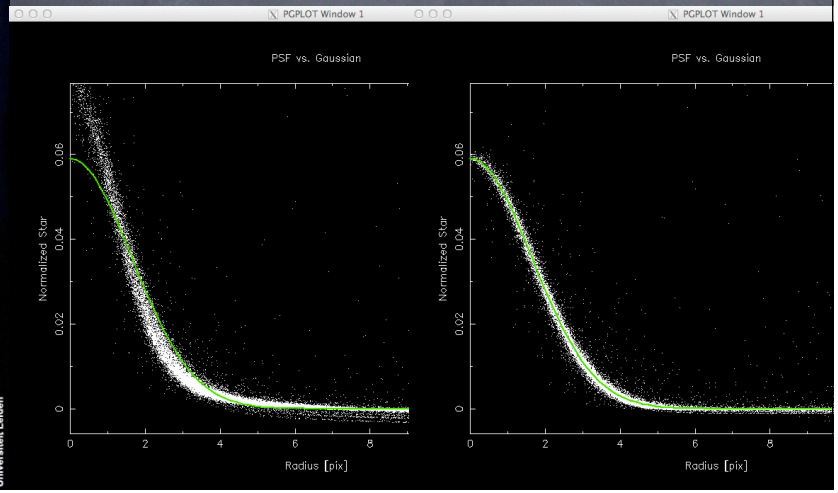
PSF Gaussianization

- Profiles of bright stars, before and after



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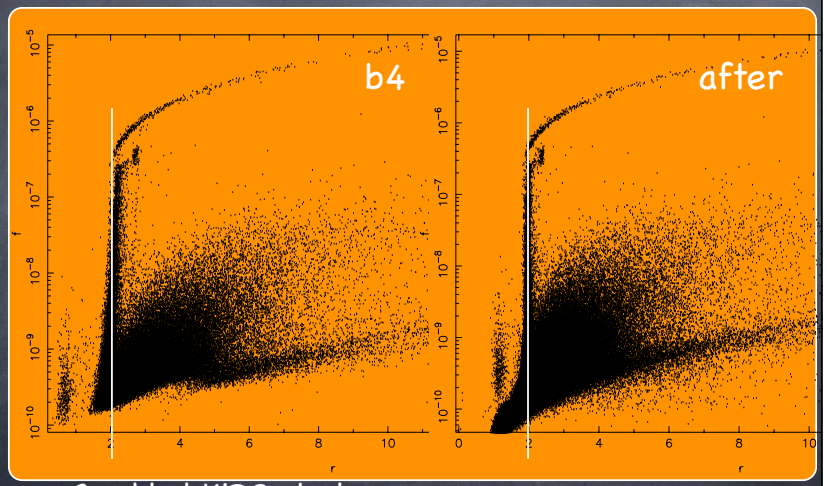
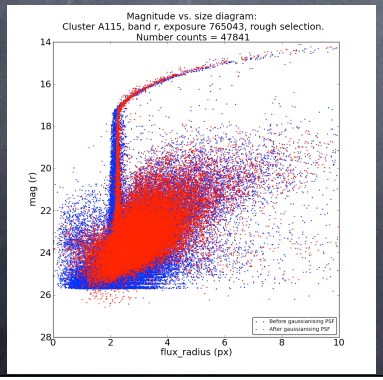
PSF Gaussianization

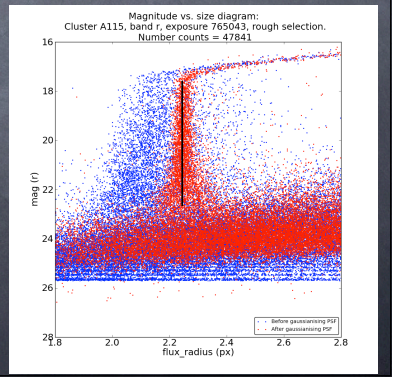


- Coadded KiDS stack
- PSF Gaussianization straightens stellar sequence

PSF Gaussianization

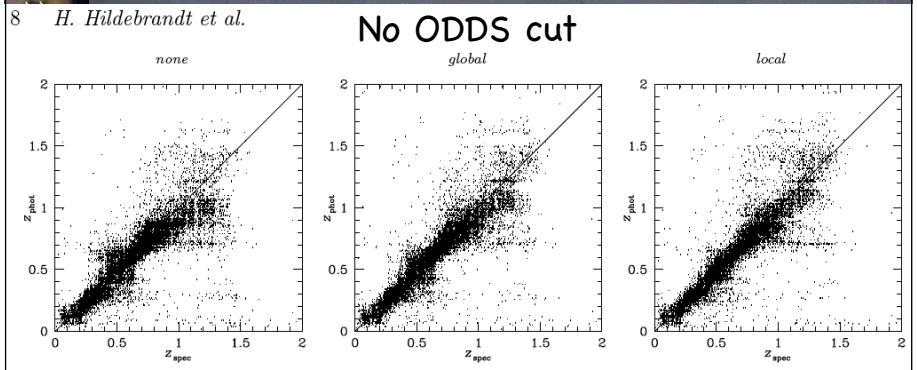
- CFHT data. Unstacked exposure. before & after
- PSF width variation reduced, sequence straightened





It works!

- Application to CFHTLS photo-z's (Hildebrandt + al 2012)



No PSF homog | constant kernel | variable Gaussianization kernel

No post-hoc zeropoint adjustments

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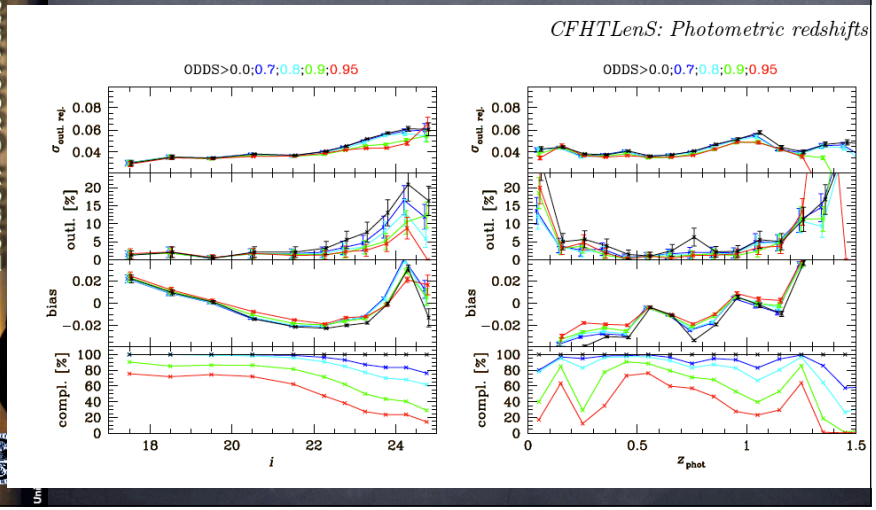
It works!

- Application to CFHTLS photo-z's (Hildebrandt + al 2012)



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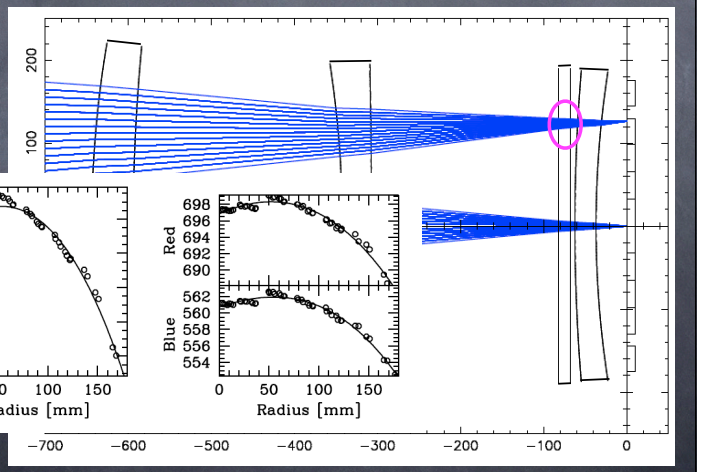
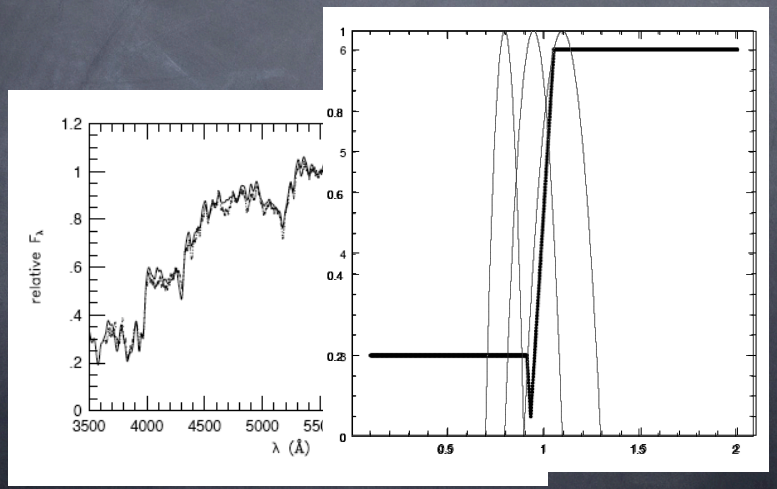
OmegaCAM r filter bandpass



Interference filter + tilted beam = band shift

0.1% photo-z precision?

- "LSG" survey*: simple model for spectral break



* Ludicrously Simple Galaxy survey

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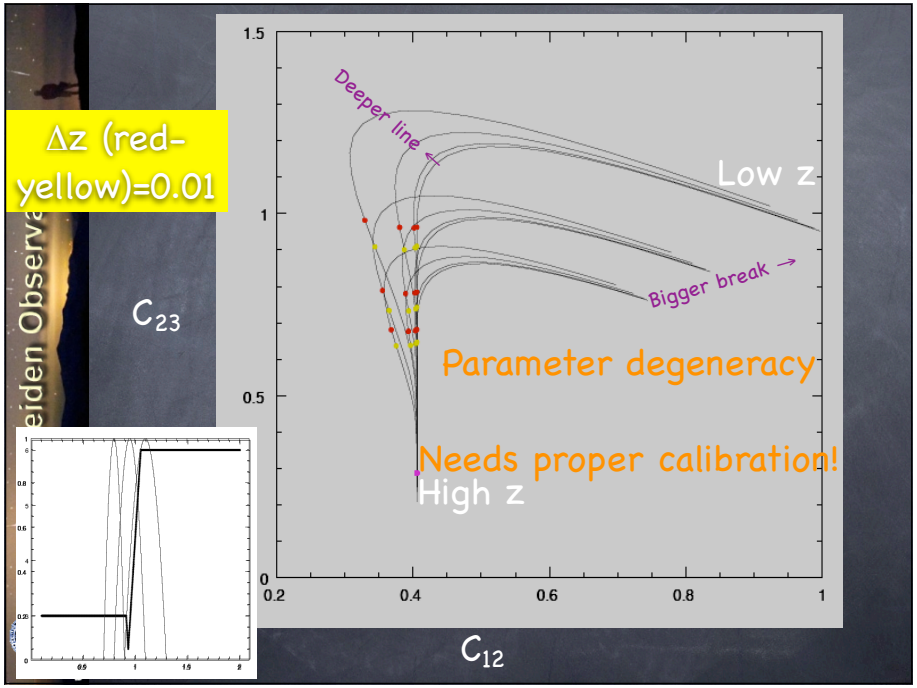
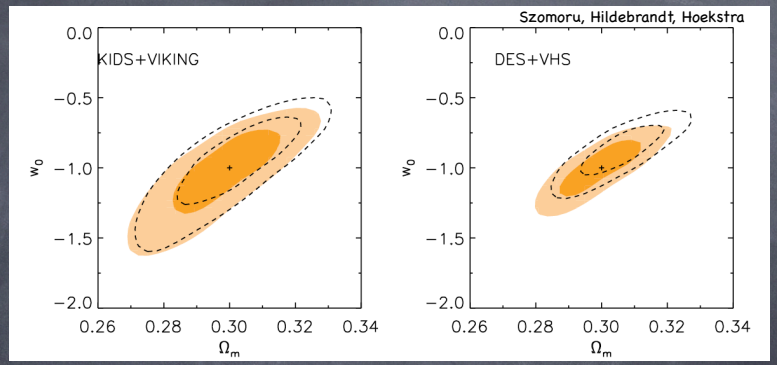


KiDS wk.l. and Dark Energy

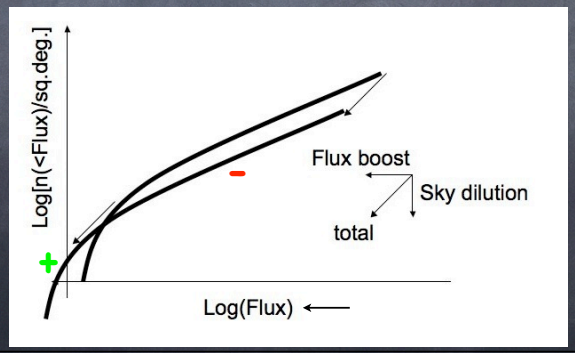


simulated 4-bin tomographic analyses, flat cosmology prior
KiDS: u-K, 1500 sqdeg
DES: no u, JHK much shallower, 5000 sqdeg
orange: use known perfect redshifts
dashed: believe photoz (BPZ, ODDS>0.9)
Bias ~ statistical noise

- Photometric redshift fidelity important!

Magnification mapping

- Lensing magnification is $[(1-\kappa)^2-\gamma^2]^{-1} \approx 1+2\kappa$
- Systematic modification of apparent lum. fn.
- Angular (anti-)correlation lenses x sources
- Can use unresolved sources as well



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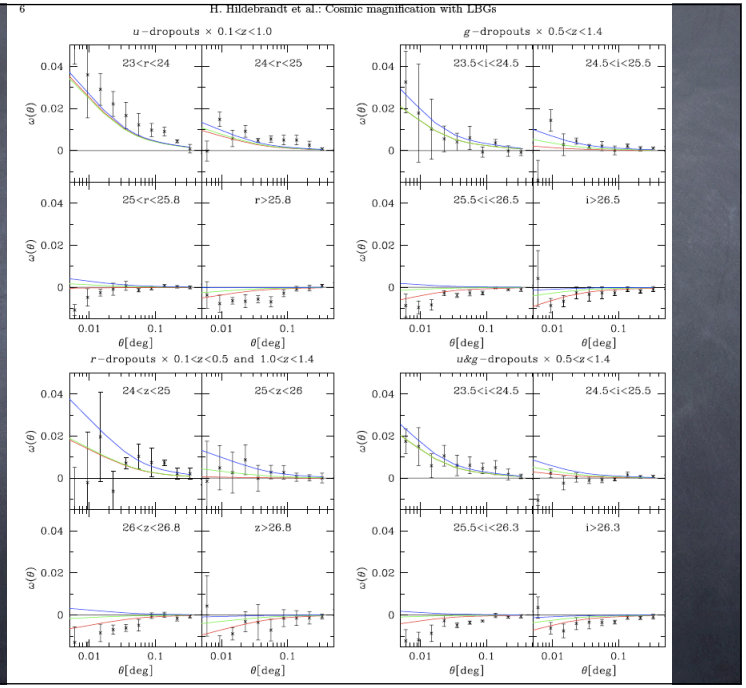
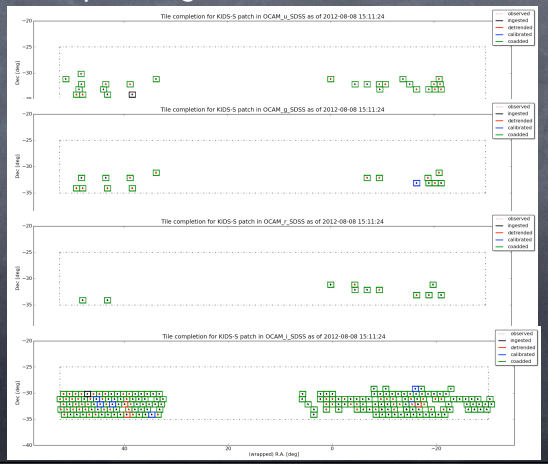


KiDS

Status of KiDS

- Observations ramping up since Oct 15 2011.
- Over 600 pointings in hand (more i, less r).

KiDS-S



u

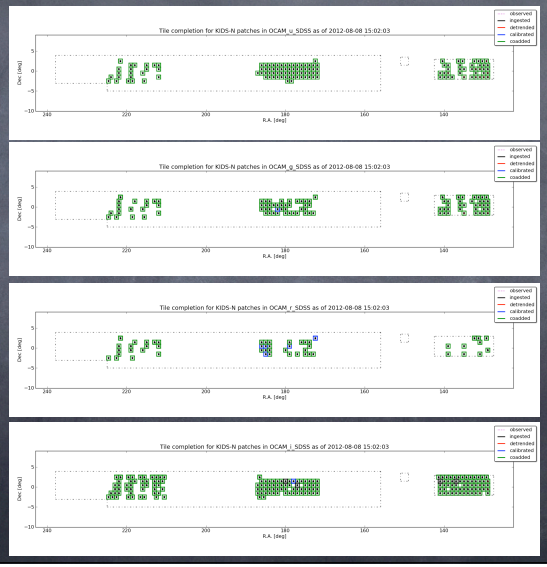
g

r

i

Status

KiDS-N



u

g

r

i

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Looking forward to:

- g-g lensing with excellent tomography
  - halo flattening at few 100kpc radii
  - intrinsic alignments
  - magnification mapping
- group lensing (GAMA catalogues!)
- cluster catalogues, strong lensing features
- strong lensing
- +++, incl high-z qso's, brown dwarfs, Galactic halo, environmental studies of galaxies and AGN, ...
- 2nd pass after a couple of years for proper motions

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Thank you…
…and watch this space
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