Weak Lensing - PSF Calibrations

Steve Kent Jan 5, 2005

- **Motivation for studies:**
  - **1. Finish off requirements for DES corrector**
  - **2. Evaluate advantage, disadvantage of ADC (atmospheric dispersion corrector) for DES corrector for weak lensing**
  - **3. Compare DES corrector with proposed VISTA, LSST designs.**
  - **4. Evaluate ground vs. space performance for SNAP.**

Weak Lensing Equation

Apparent Image **Instrinsic Image** **Gravitational shear**

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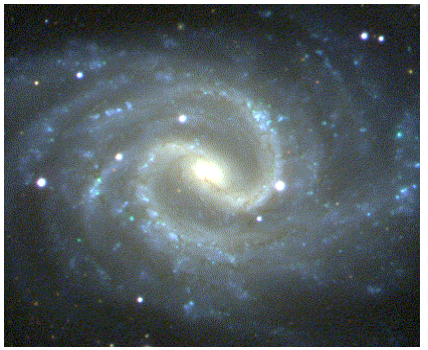

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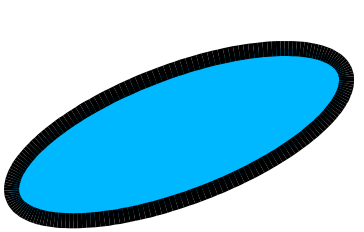

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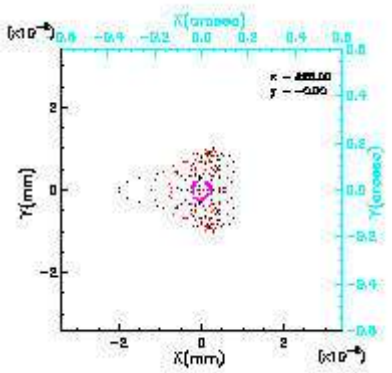


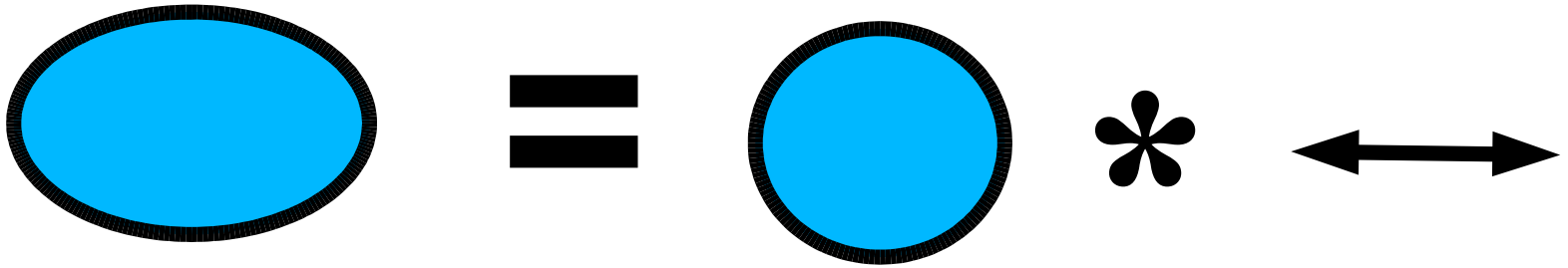
Point Spread Function

PSF is measured from bright stars near a sample galaxy

Metrics for weak lensing

- **Accurate knowledge of PSF is required to extract gravitational shear signal**
- **Shear signal: (1 - b/a) ~ 1%**
- **Require systematic errors to be "small" compared to statistical errors**
  - **==> error in PSF shear ~ 0.1% for 0.6 arcsec FWHM seeing.** ***(i.e., my top-level requirement is the accuracy for measuring ellipticity of an intrinsically round image of a specified FWHM).***

Model of a PSF



Elliptical PSF Circular PSF "Whisker"

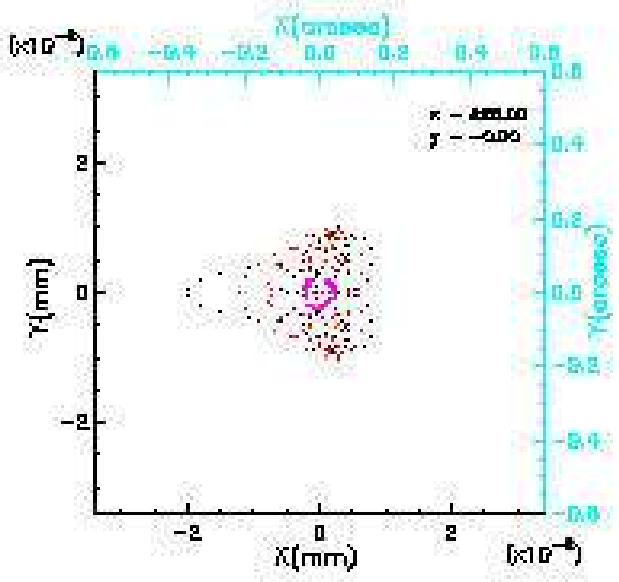
Circular PSF has contributions from intrinsic PSF & seeing
Whisker PSF has contributions from intrinsic PSF & tracking errors.

I will use the amplitude of a "whisker" from the intrinsic PSF as my metric for weak lensing calibration, since this mimics the gravitational shear signal and is easy to calculate.

For convolution, FWHM's add in quadrature.

A 0.1% error in shear for 0.6" FWHM seeing => 0.03" FHWM error in the equivalent PSF "whisker".

Example

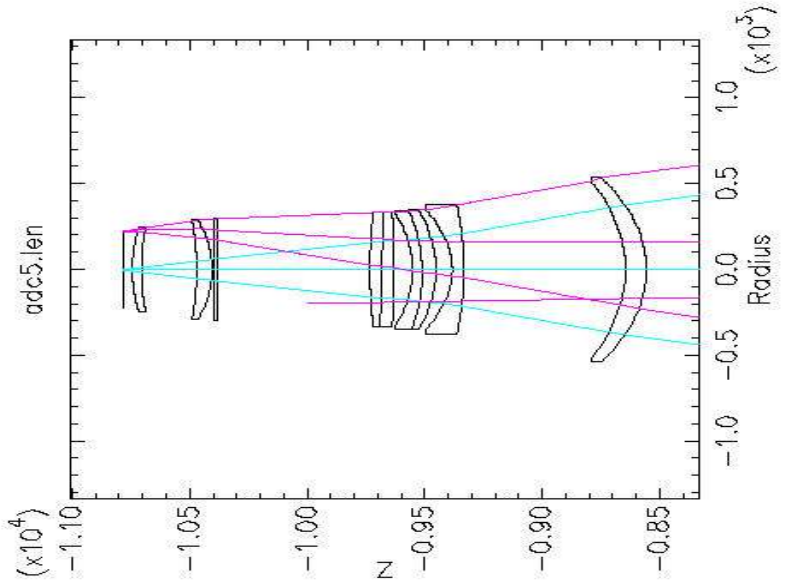


Design: may11
Location: Edge of field (225 mm radius)
Filter: r' (0.56 and 0.69 microns)
FWHM: 0.2"
Whisker length: 0.1"
Whisker orientation: 90°

(Note: shear patterns are *tensors:* $\langle x^2 \rangle$, $\langle xy \rangle$, $\langle y^2 \rangle$)

Telescope/corrector designs:

- **DES: may11**
- **Revised DES: may11a**
- **adc5: Existing may11 design plus ADC**
- **VISTA (Proposed DarkCam corrector for VISTA 4 m telescope)**



adc5 design

Effect of ADC - Whisker length vs. zenith angle

Filt	zen	may11		may11a		adc5		vista	
		FWHM	diff	FWHM	diff	FWHM	diff	FWHM	diff
g	0	0.27	0.00	0.27	0.00	0.24	0.00	0.28	0.00
g	35	0.39	0.44	0.39	0.43	0.25	0.12	0.29	0.14
g	55	0.82	0.84	0.82	0.84	0.25	0.15	0.31	0.24
r	0	0.15	0.00	0.12	0.00	0.18	0.00	0.15	0.00
r	35	0.18	0.17	0.18	0.17	0.18	0.10	0.15	0.06
r	55	0.36	0.35	0.36	0.35	0.20	0.16	0.18	0.13
i	0	0.22	0.00	0.18	0.00	0.16	0.00	0.23	0.00
i	35	0.23	0.09	0.20	0.09	0.16	0.09	0.22	0.10
i	55	0.26	0.20	0.21	0.20	0.18	0.14	0.22	0.13
z	0	0.27	0.00	0.22	0.00	0.09	0.00	0.27	0.00
z	35	0.27	0.05	0.22	0.05	0.10	0.07	0.26	0.11
z	55	0.28	0.11	0.23	0.11	0.11	0.10	0.25	0.16

ADC: -------NO----- ----- NO----- ------ YES----- ------YES------

Whisker length variation across focal plane (3' spacing)

Filt	zen	may11		may11a		adc5		vista	
		FWHM	diff	FWHM	diff	FWHM	diff	FWHM	diff
g	0	0.17	0.07	0.18	0.07	0.23	0.09	0.20	0.06
r	0	0.13	0.06	0.14	0.06	0.20	0.08	0.13	0.05
i	0	0.11	0.05	0.11	0.05	0.17	0.06	0.11	0.05
z	0	0.05	0.04	0.04	0.03	0.07	0.04	0.09	0.05

Whisker length vs. +/- 25 micron defocus

Filt	zen	may11		vista	
		FWHM	diff	FWHM	diff
g	0	0.18	0.07	0.21	0.11
r	0	0.11	0.10	0.14	0.09
i	0	0.11	0.12	0.13	0.09
z	0	0.12	0.14	0.12	0.09

Whisker length vs. primary mirror decenter

Filt	zen	0.5 mm		1 mm	
		FWHM	diff	FWHM	diff
g	0	0.25	0.21	0.31	0.33
r	0	0.23	0.22	0.31	0.32
i	0	0.22	0.22	0.32	0.32
z	0	0.22	0.22	0.33	0.32

Conclusions

- **ADC helps in g', r' bands but is of little or no use (or even a detriment) in i', z'**
- **VISTA has better performance in g', r' but comparable or slightly worse in i', z'**
- **Many effects, such as refraction, defocus, intrinsic focal plane variation, primary mirror decenter, affect PSF at levels larger than the desired PSF accuracy.**