### WHAT DO WE MISS WHEN WE RAY-TRACE?

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# HOW DO WE SIMULATE?



## DIFFERENT TWINKLES

#### Atmosphere RTM FTM



Pay attention to speckles, ellipticity, sizes, centroid motions, etc.

### IS RTM A GOOD APPROXIMATION?



• Speckles disappear in the long exposure limit.

## A PREVIOUS STUDY CLAIMED THAT



RTM is not an accurate method of modeling atmospheric PSF ellipticity (de Vries et al. 2007).

## WHY DO WE CARE ABOUT RTM vs. FTM NOW?

- PHOSIM uses RTM and will be the main tool for weak-lensing image simulations for LSST.
- Identify limitations of RTM in the context of weak-lensing.
- Suggest solutions to make LSST PHOSIM become more realistic.

# USEFUL COMPARISONS

- Seeing
- Ellipticity
- Kurtosis
- Absolute and Differential centroid motion
- Wavefront sensor data

## SEEING

# COLOR vs. SEEING





## ELLIPTICITY

#### 15s Exposure

FTM (-)1%



/////

11

11

||||

0.20

11

0.15



No large oversampling effect is seen.

#### 15s Exposure - Residual

-|%







RTM's ellipticity is systematically lower by ~12%.



## KURTOSIS

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#### Excess Kurtosis

$$\gamma_2 = \frac{\kappa_4}{\kappa_2^2} = \frac{\mu_4}{\sigma^4} - 3$$

## RTM PSF is less peaked.



# WL Implication

- In RTMWL simulation, any PSF correction scheme that assumes a Gaussian PSF will fail.
- Compared to FTM PSFs, RTM PSFs will overcorrect the dilution by ~20%.

## PSF Centroid



0.002 0.004 0.006 0.008 0.010 (arcsec)

### RESIDUALS



The difference in centroid shift is negligible!

# RTM PSFs

- can be computed fast.
- can mimic the spatial variation of ellipticity.
- weakly depend on the sampling rate.

- do not exhibit wavelength-dependence.
- under-predict ellipticity.
- possess flatter cores and truncated wings.
- weakly depend on the sampling rate.

# CONCLUSIONS

- RTM PSFs mimic FTM PSFs nicely in the global pattern.
- In important details such as kurtosis, magnitude of ellipticity, wavelength-dependence, WL simulation with RTM is not realistic.
- PHOSIM should address these issues before the LSST WL community uses the software to carry out the DESC tasks.
- In the future, we will investigate the difference in the wavefront sensor data (donuts) between the two methods.