Simulated Tree Rings in LSST Sensors

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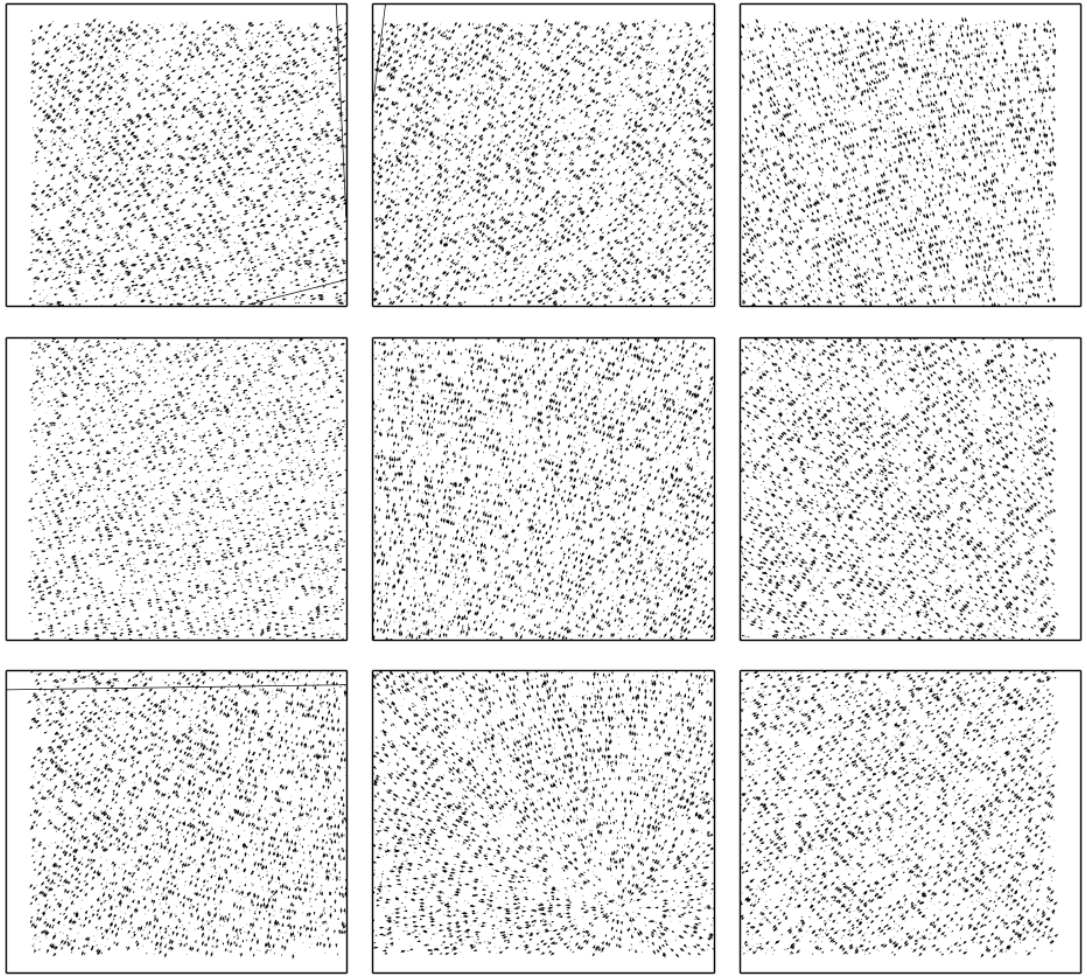
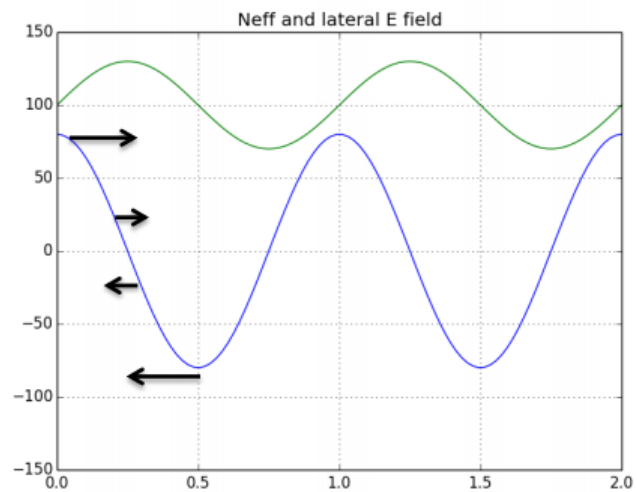
Presentation Overview

- Tree Ring Basics
- Brief PhoSim Overview
- Techniques and Results
- Current Plans/ Direction

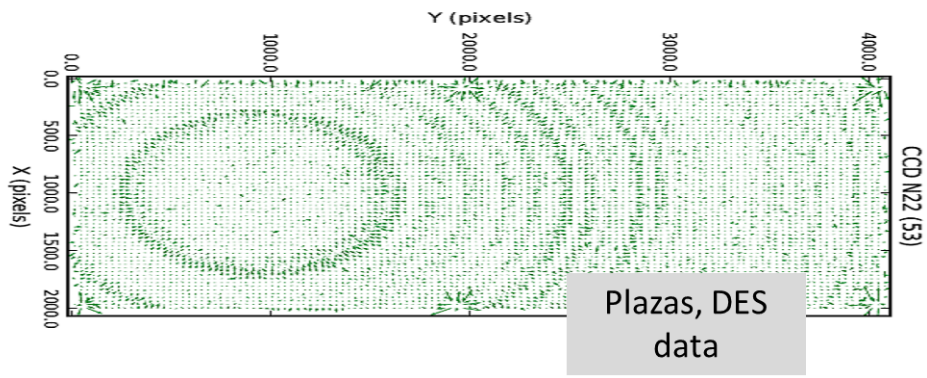


Basic Tree Ring Physics

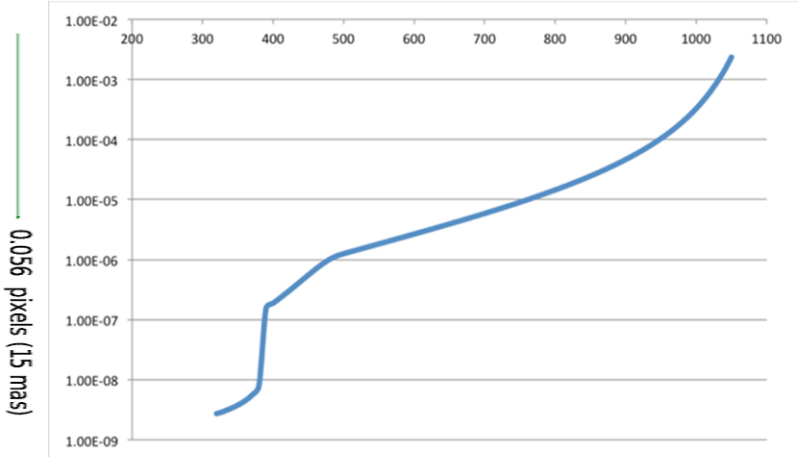
- Tree rings: circular variation of Si wafer doping resulting in astrometric distortions
- Lateral Field Strength proportional to dopant concentration gradient.
- Color dependence expected from varying penetration depths in Silicon.



A. Nomerotski

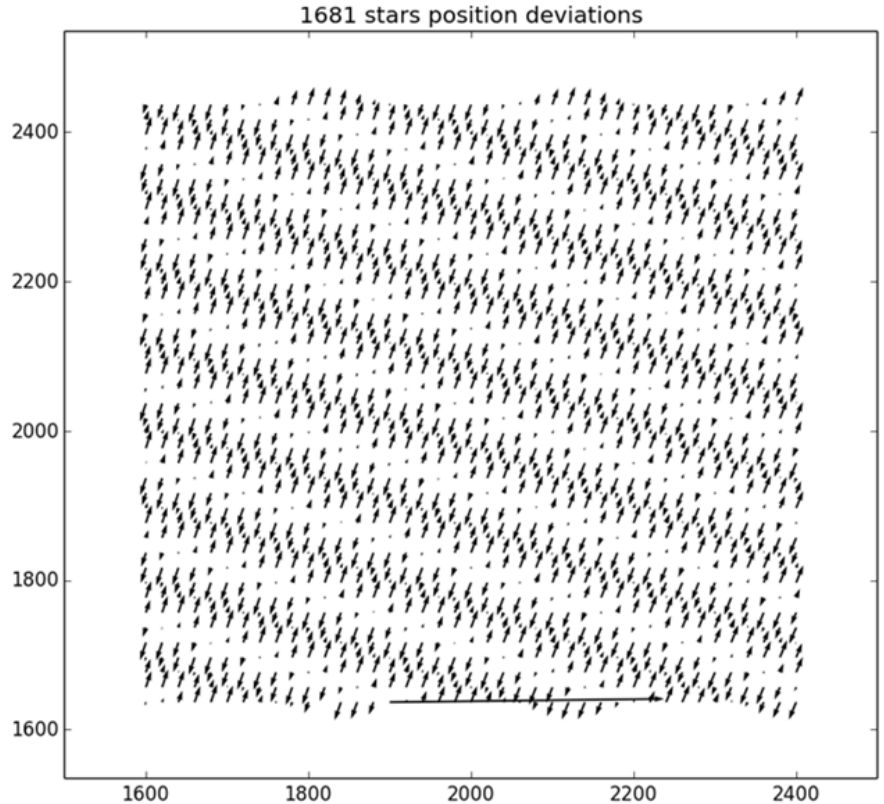


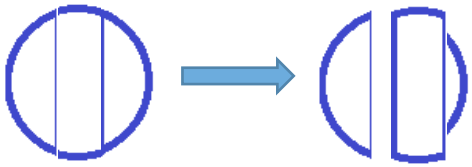
Plazas, DES data



Expected Impacts of Tree Rings

- Astrometric shift along radial direction; Depends on color/R
- Ellipticity/Orientation
- Object Size Oscillations
- Possible Non-elliptical shape distortion

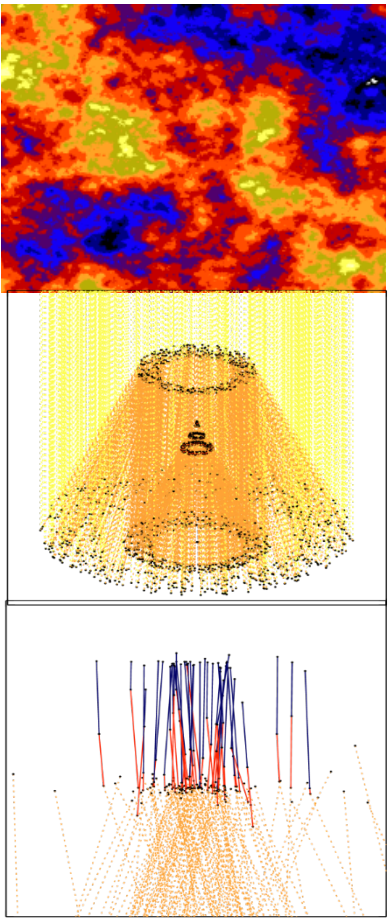




Photon Simulator (PhoSim)

Optical Survey Telescope Simulator

Used to simulate high fidelity images of stars and galaxies one photon at a time



Atmosphere

Telescope

Camera

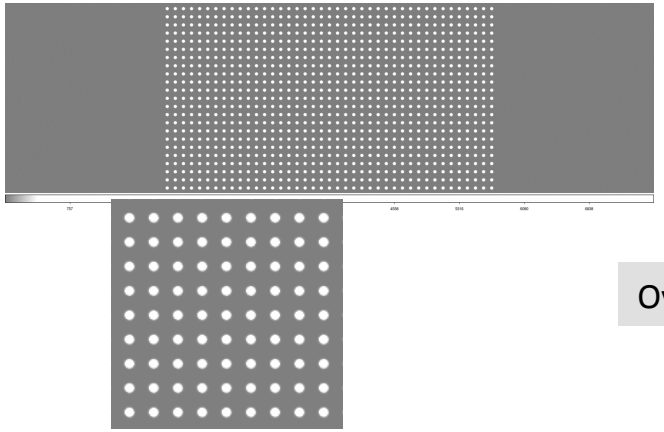
Use Photon Monte Carlo Approach and describe physics of atmosphere, telescope, and camera in terms photon manipulations

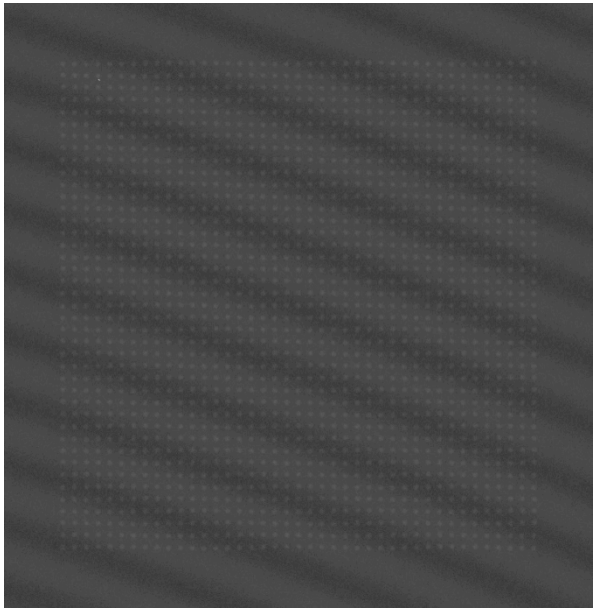
J. Peterson, June DESC Meeting 2014, Penn

Phosim Usage

- Simulations done without Background, Atmosphere, Jitter, or Optical imperfections.
- Grid of identical sources with no object overlap.
- Find stars, measure centroids and ellipticity parameters with SourceExtractor.

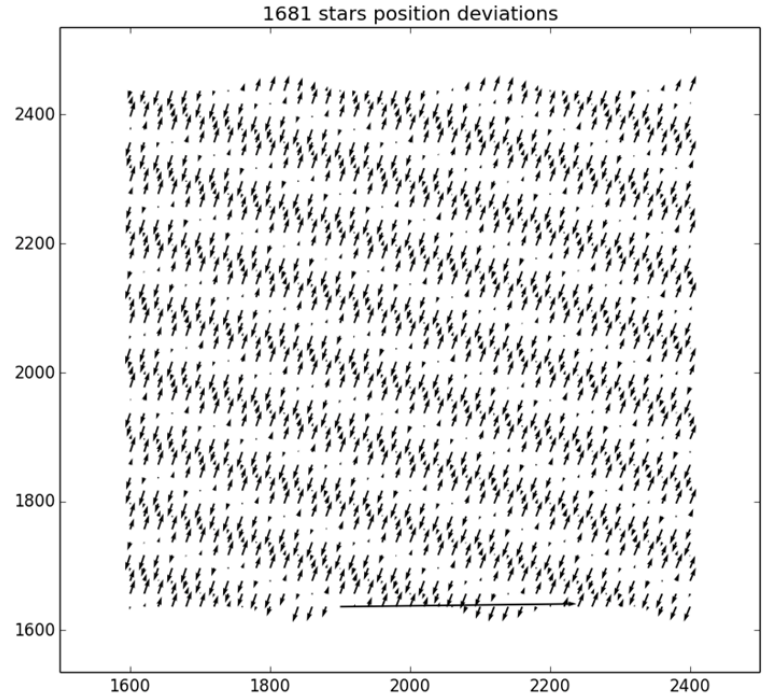
- Compare centroid positions to a reference simulation with identical physics settings but without doping variations.



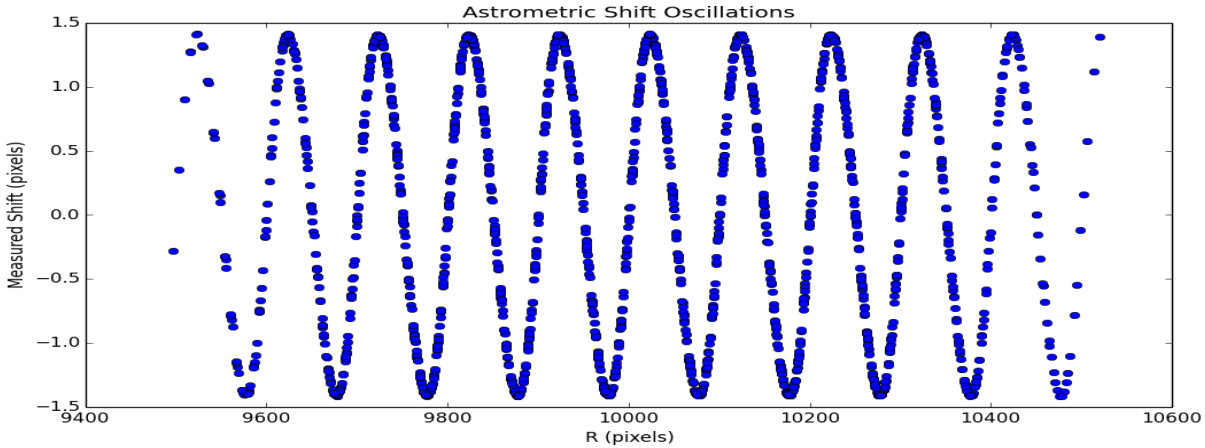


Overlaid tree rings (visible in background) and stars

Astrometric Shift

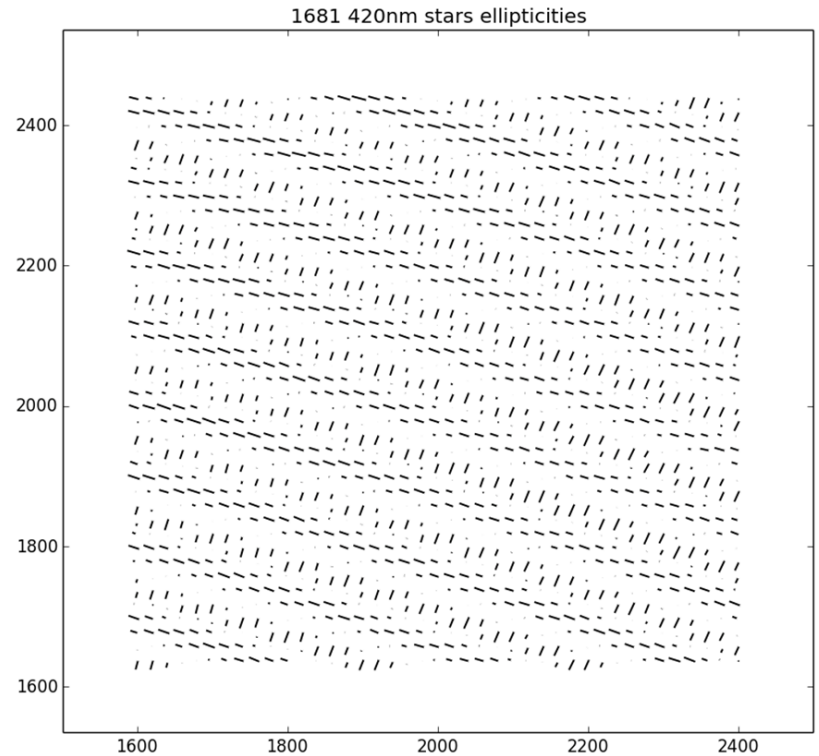


- Astrometric Shift is proportional to the local lateral field strength, so relatively simple (w/ our current approximations)
- Amplitude of the astrometric shift variations is found by fitting a sine wave which is symmetric about the origin of the TR.

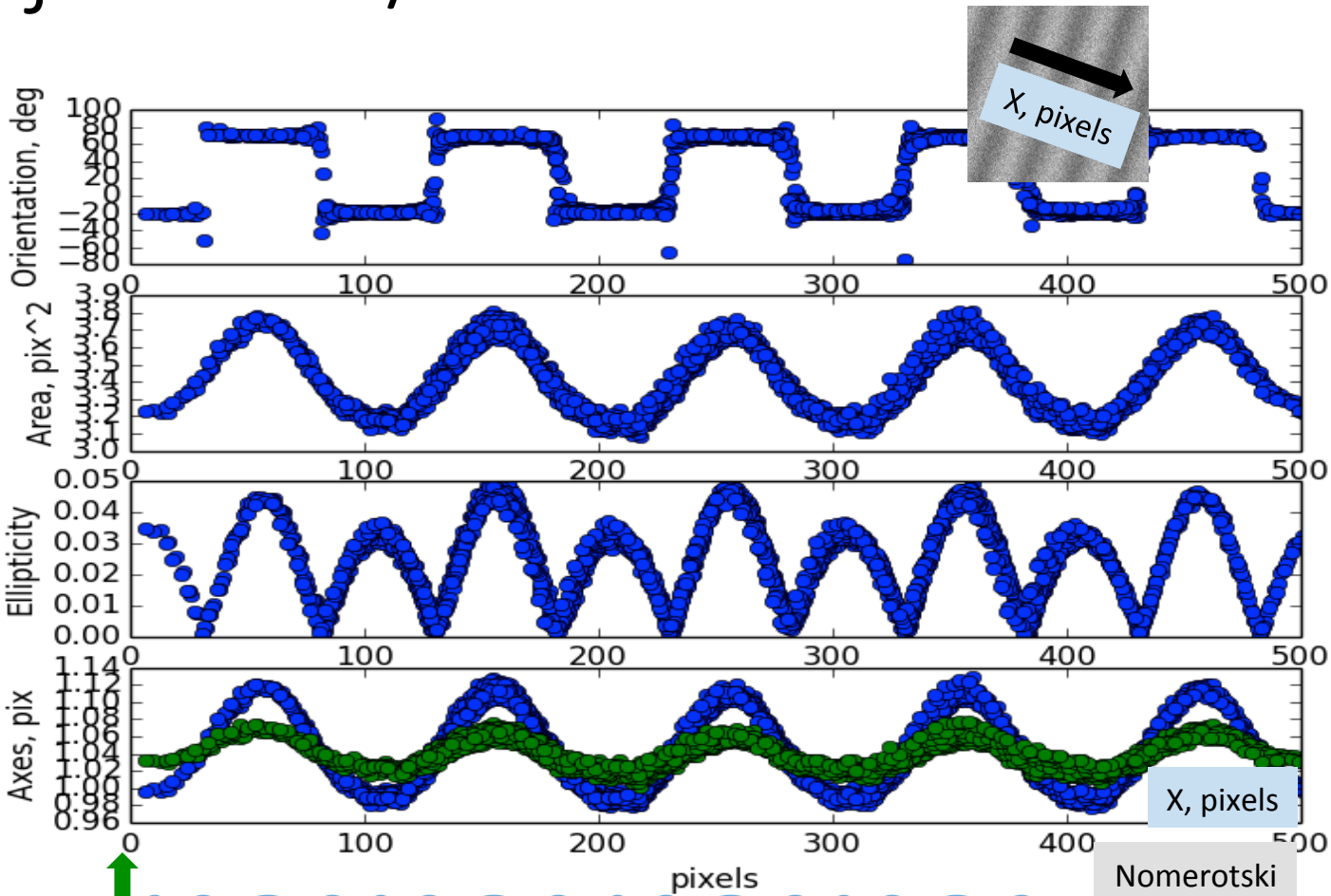


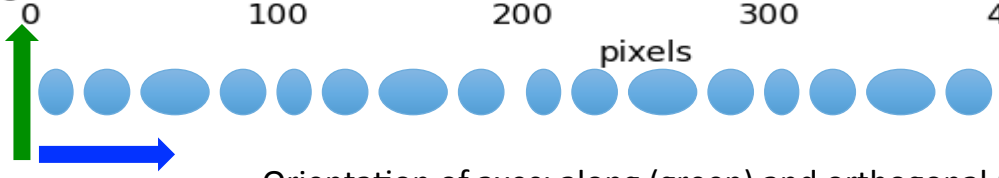
Induced Ellipticity

- Initially unexpected behavior
- “Flips” from having ellipticity aligned along the radial direction in the lateral E-field troughs to being aligned perpendicular to the radial direction of the TR at the peaks.



Object Size/Axis Oscillations

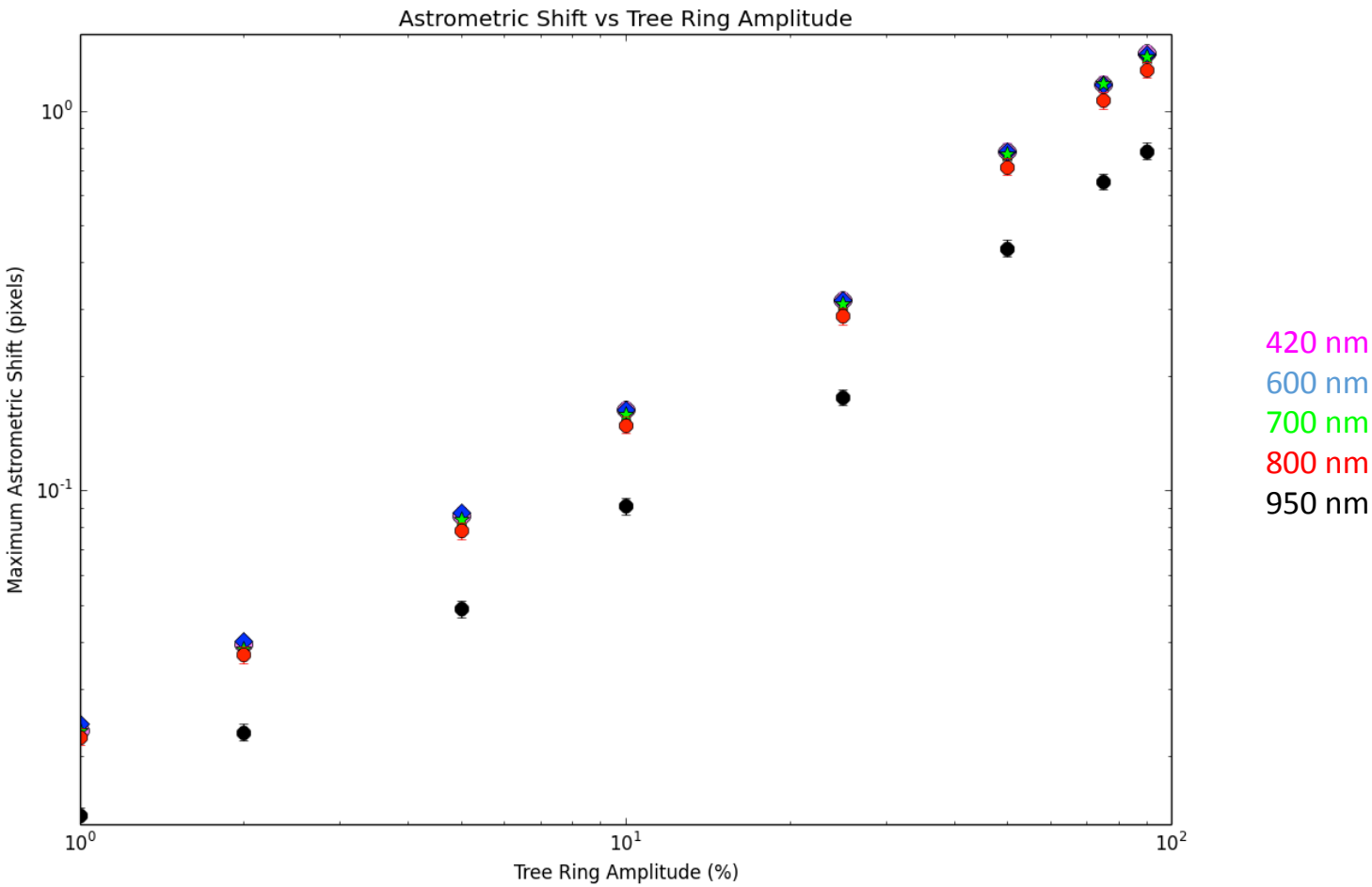




Orientation of axes: along (green) and orthogonal (blue) to tree rings

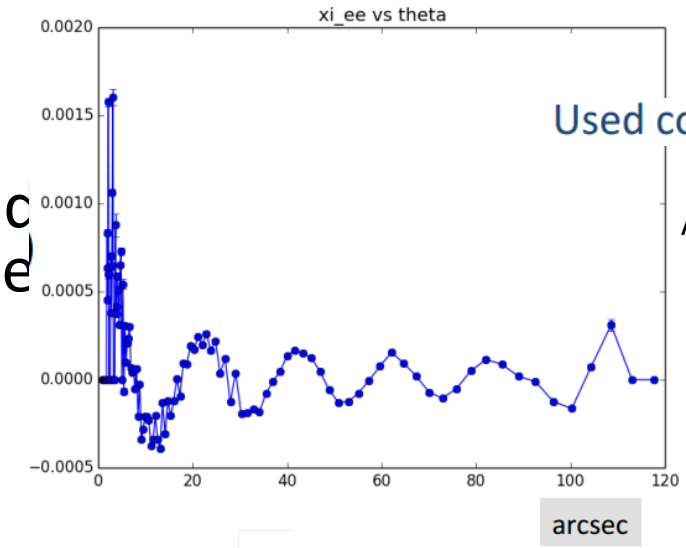
Astrometric Shifts vs Color

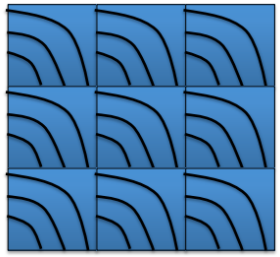
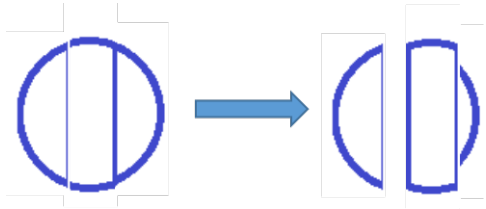
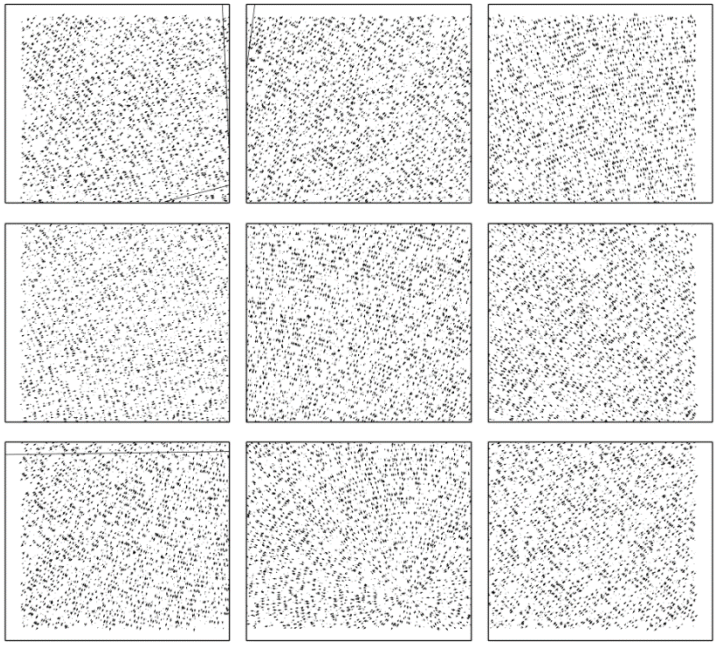
- Infrared is shifted less as expected
- First steps in study of chromatic effects caused by sensors



Current Plans

- Evaluate Tree Ring-based correlations within single CCD chip and across multiple chips (arrangement considerations)
- Shape Oscillation Possibility
  - Should be minor?
- Simulate DES sensors to compare PhoSim results to experimental data.



Used corr2 by M.Jarvis

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