Sensor Features and Simulations

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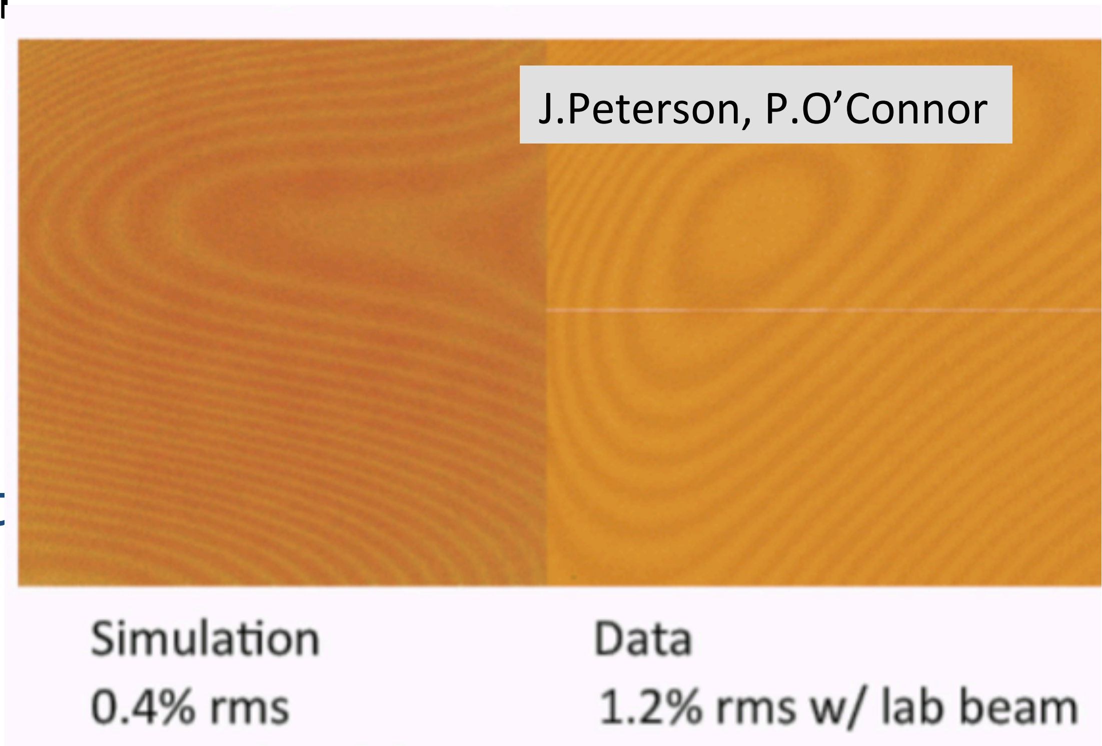
BNL involvement in LSST simulations

- Validation of sensor effects in PhoSim (silicon.txt)
  - Edge and anti-bloom stop roll-off effects
  - Tree rings
  - Fringes
  - Brick-wall pattern from laser annealing
  - Intensity dependence
  - Crosstalk in sensors and rafts
  - ..
- Simulation of lab setups
  - Modification of optics file to model spot projector (optics.txt)

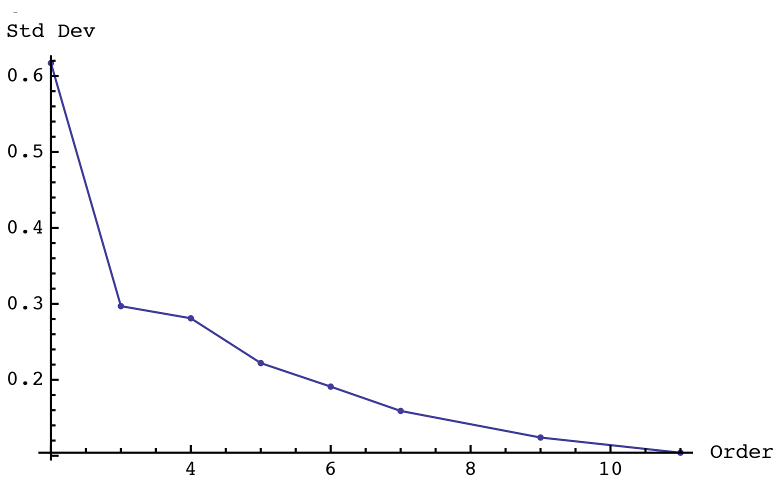
Fringes

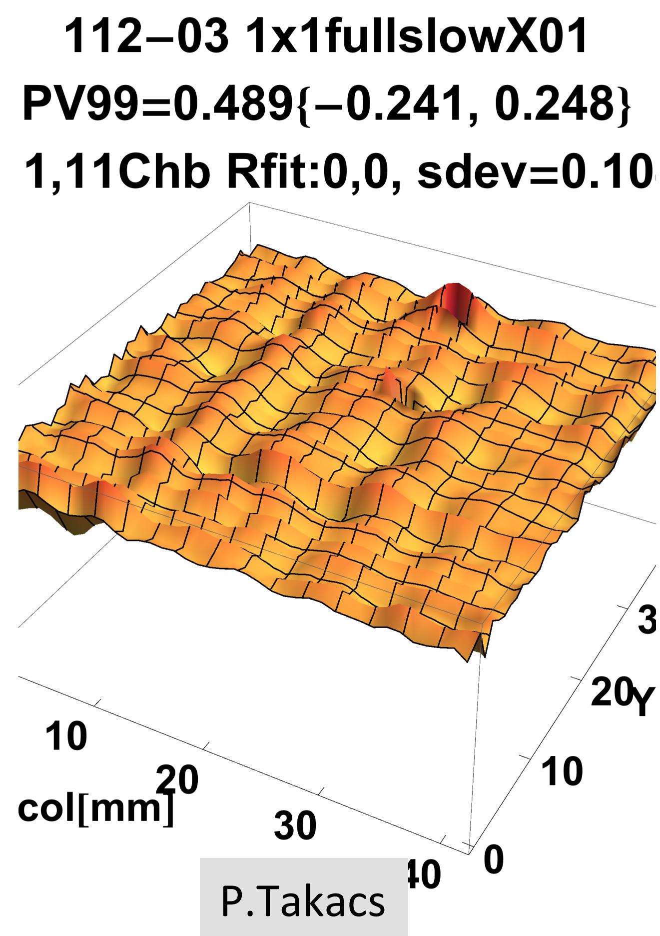
- Surface described with Zernike polynomials
- Use a random surface with some flatness
- Assumes that the backside is flat
  - Fringe data at different wavelengths should allow to extract the backside flatness
- We provided flatness data for 112-03, work in progress to compare to simulations



Surface description

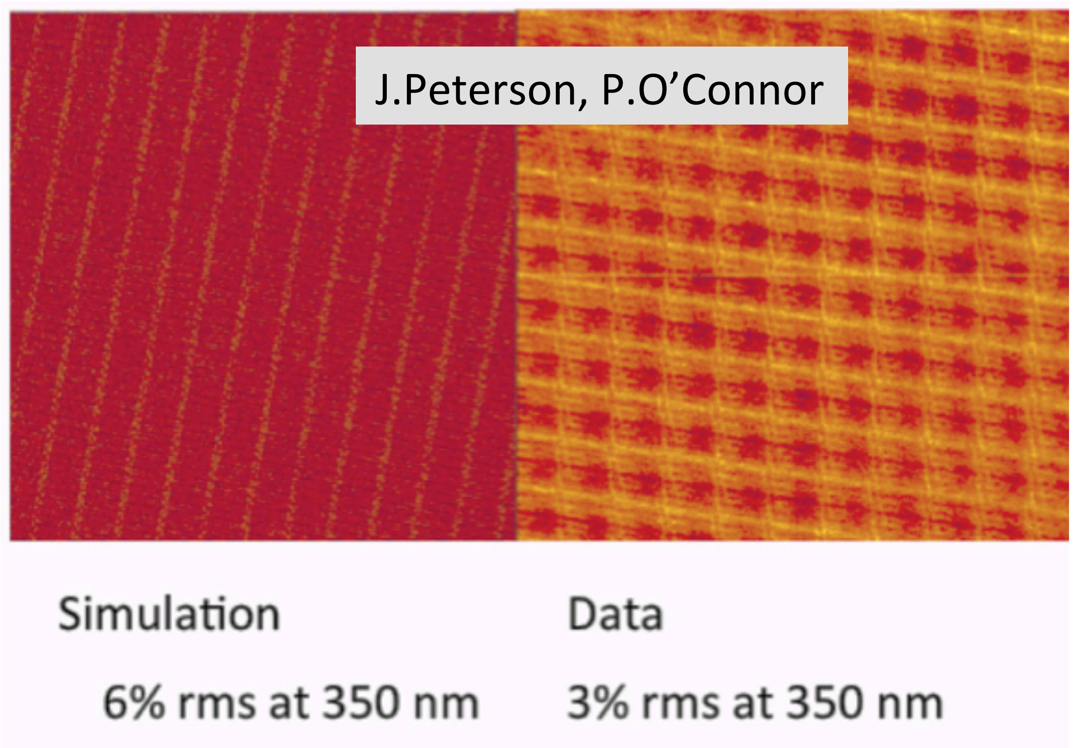
- Chebyshev describe better corners, more appropriate for square shape
- Order 10 appear to be adequate



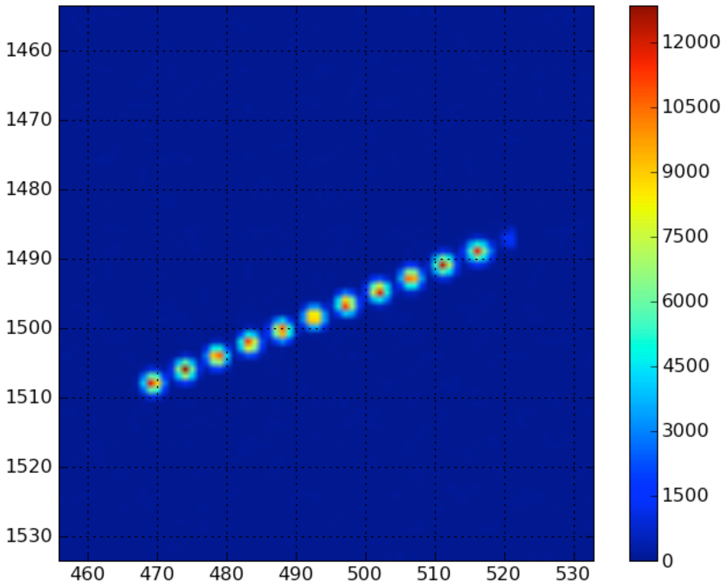


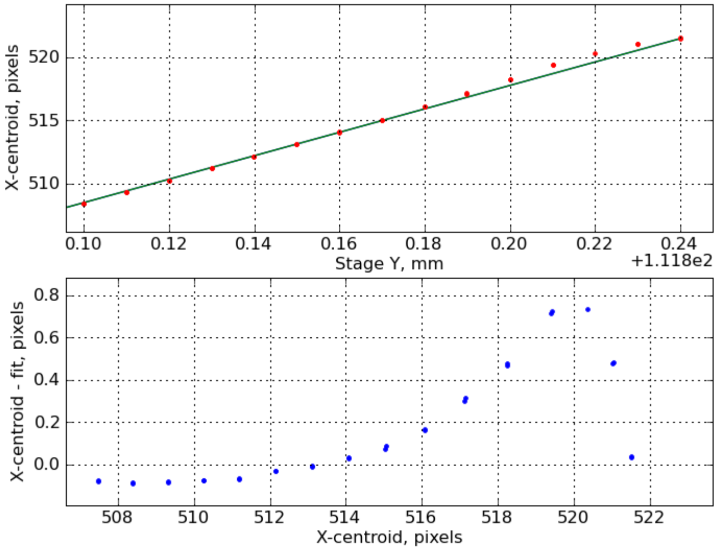
Brick-wall pattern

- From laser annealing of back side
- Described in silicon.txt with 11 parameters
- Needs tuning



Laser Spots in CCD

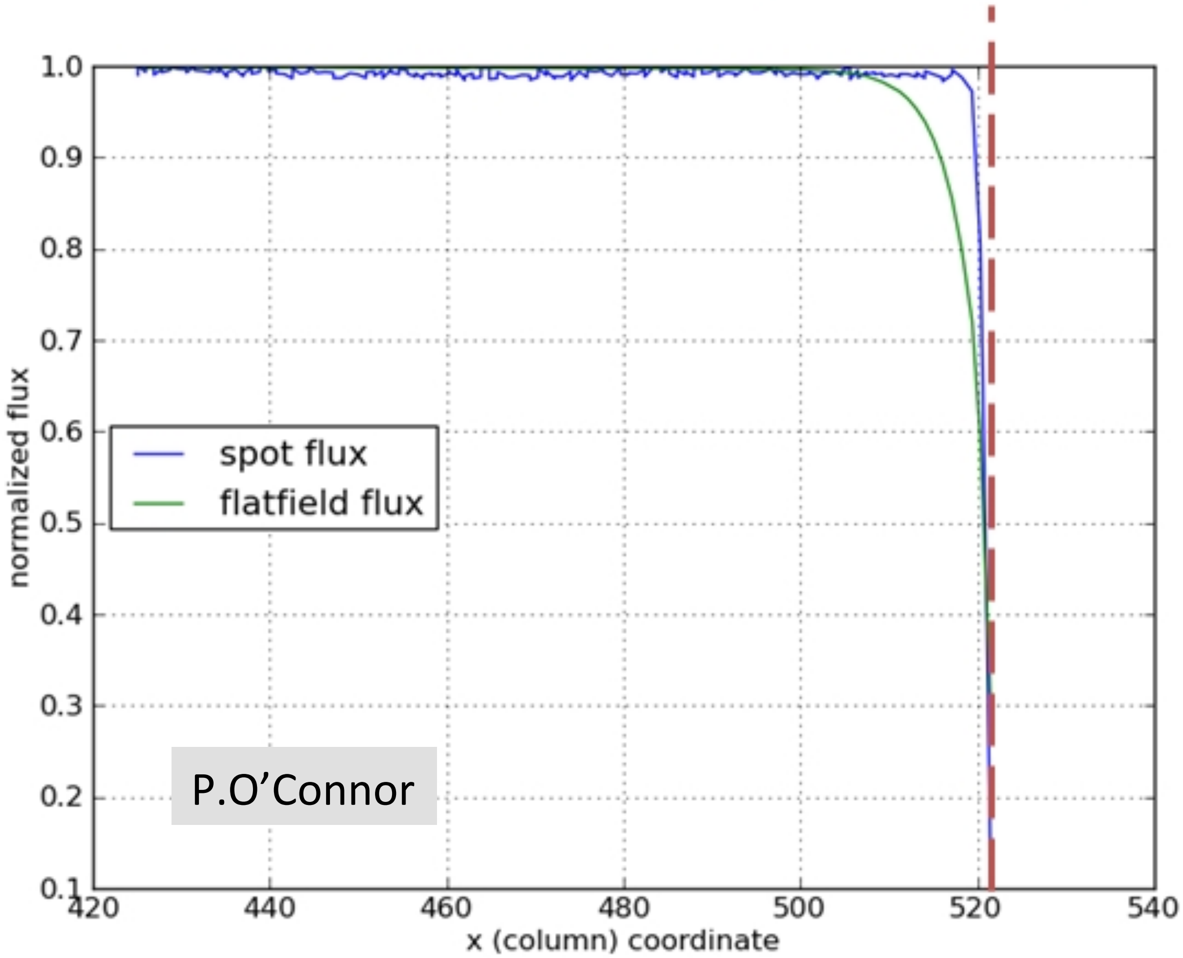




P.O'Connor

- Non-linearity on the edge, up to 50% effect

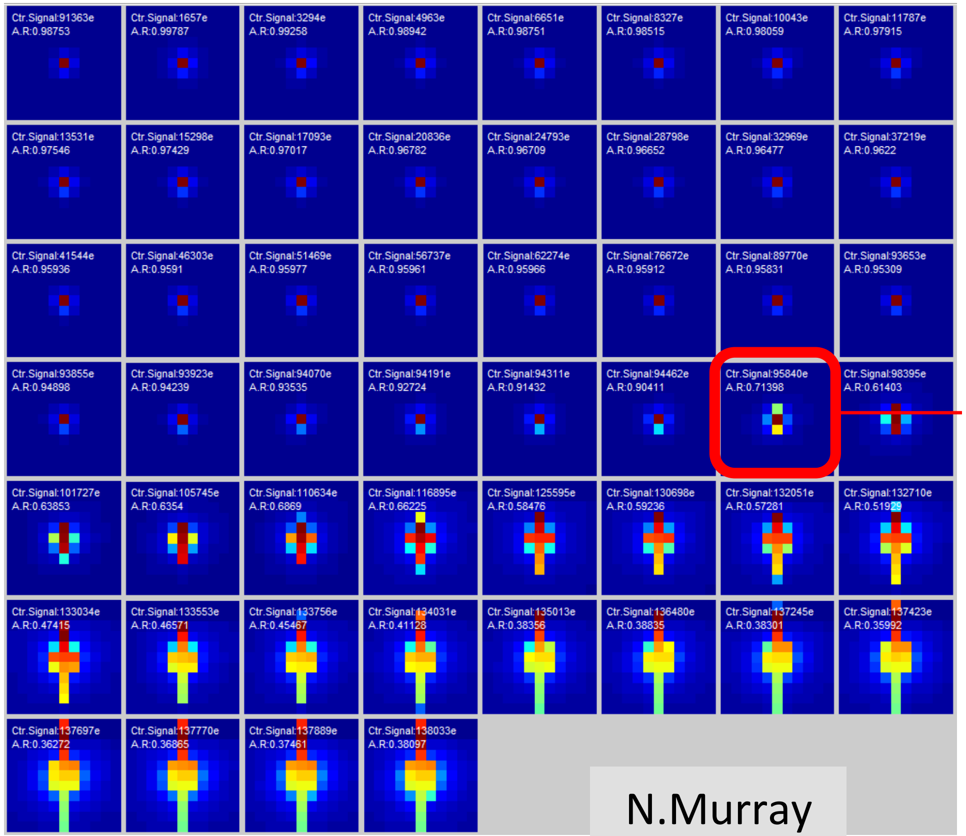
Spot flux does not trace flatfield flux

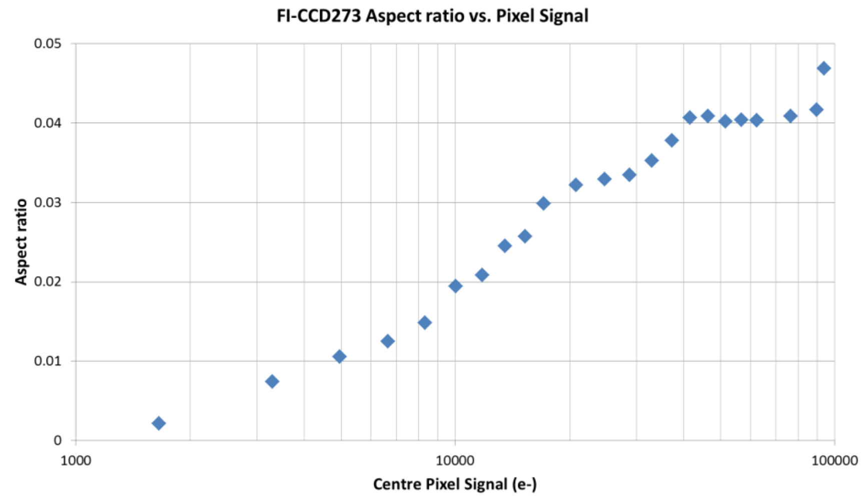


Spots and flat field behave differently

– due to space charge effects?

Laser Spots in CCD



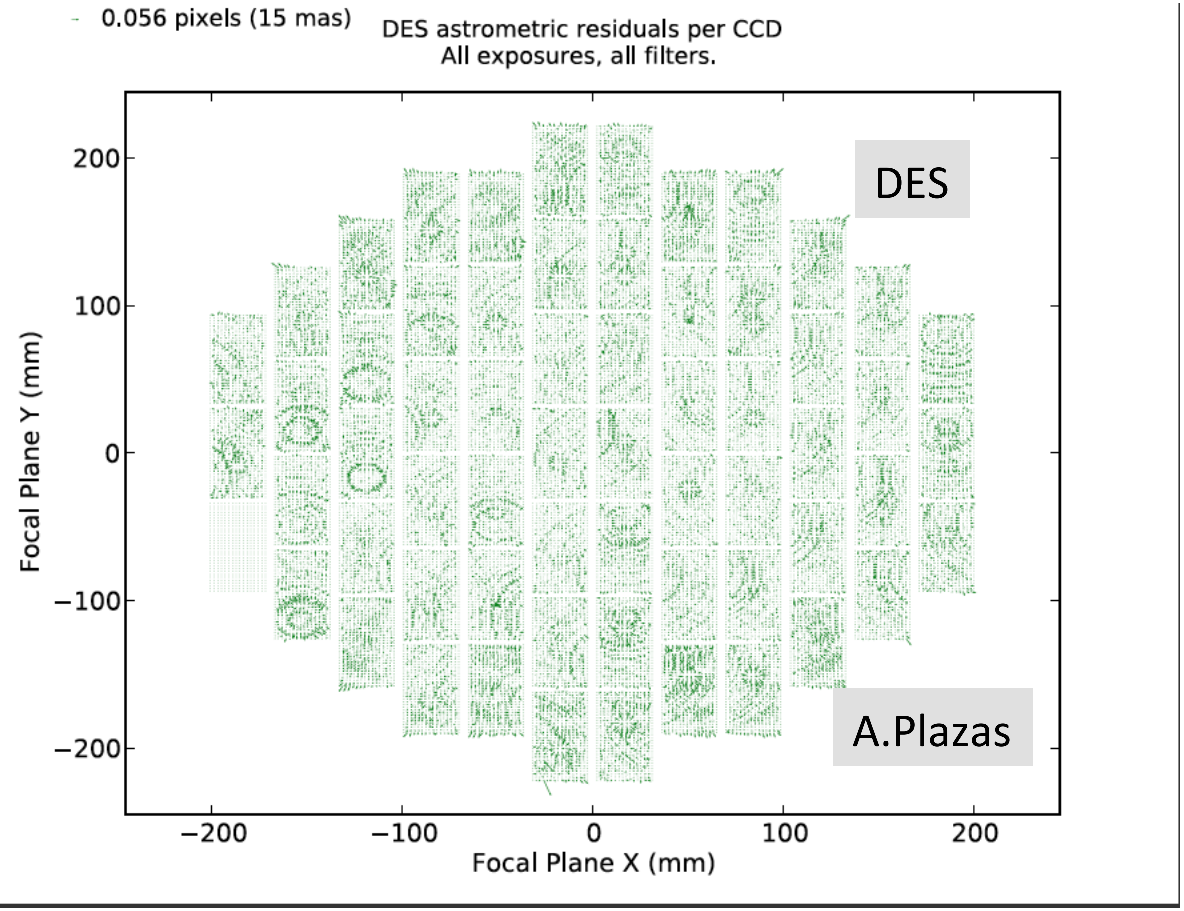


Point Spread Function intensity dependence, up to 10% effect on ellipticity

- Characterize and correct

- Need to model saturation of PTC?

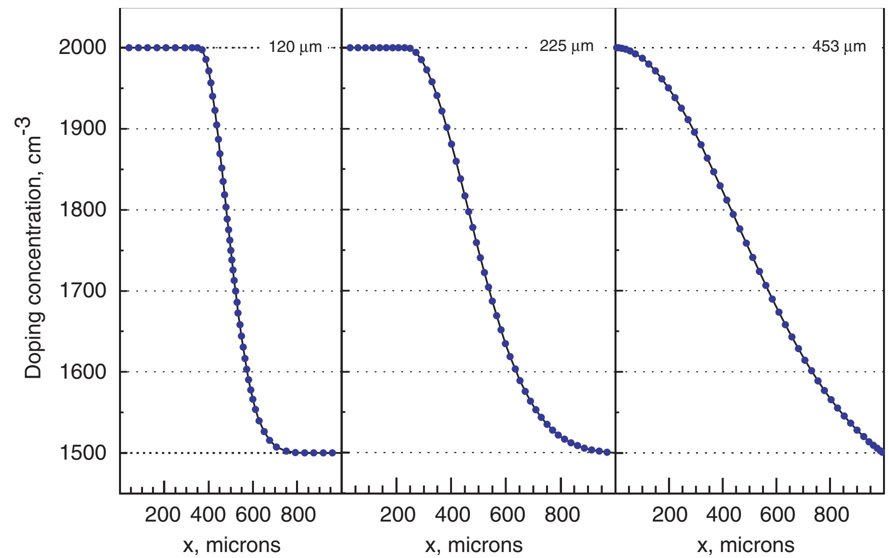
Tree Rings in DES and LSST



- Due to uneven doping of silicon wafers
  - Good example of synergy between LSST and DES

Tree rings

- Discussions on correct implementation
  - Lateral field described by parabola



Electric fields in nonhomogeneously doped silicon. Summary of simulations

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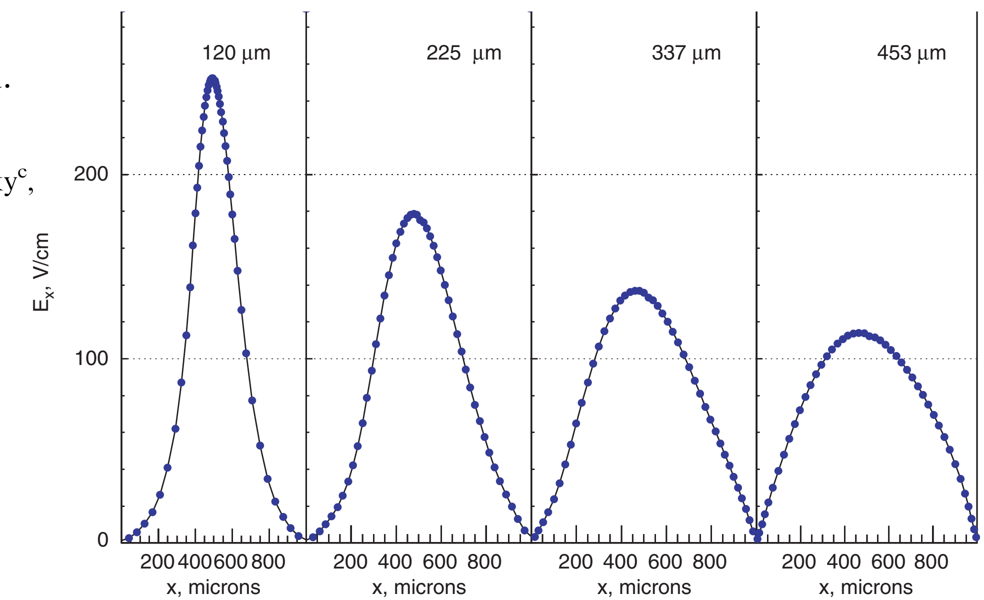

Tree rings

Lateral charge displacement in fully depleted CCD

A.Nomerotski, 6 August 2013

The drift field depends on the drift distance linearly, if the applied voltage is equal to the depletion voltage.

$$E_x = E_0 + K_x \cdot \frac{x}{d}$$

where K_x is a constant, x is the coordinate along the drift distance and d is the thickness of the sensor. The lateral field due to the variation of the doping along the x-axis must be zero at the top and bottom surfaces of the sensor because of the boundary conditions and can be approximated with a parabola, see the bottom right figure in Fig.4 [1], which should be a realistic representation of the effect. The parabola has maximum the half way between the top and bottom of the sensor:

$$E_y = K_y \cdot \frac{4x}{d}\left(\frac{x}{d} - 1\right)$$

The lateral deviation of a photoelectron originated in point x is given by:

$$\Delta y = \int_x^d dy$$

Where y is orthogonal to x and

$$dy = dt\ v_y = dt\ \mu E_y;\ \ dx = dt\ v_x = dt\ \mu E_x$$

Hence

$$dy = dx \frac{E_y}{E_x}$$

and

$$\Delta y = \int_x^d dx \frac{E_y}{E_x} = \frac{4\ K_y}{K_x} \int_x^d dx\ \left(\frac{x}{d} - 1\right) = \frac{2\ K_y d}{K_x} \cdot \left[\frac{x}{d} - 1\right]^2 \Bigg|_x^d = -\frac{2\ K_y d}{K_x} \cdot \left[\frac{x}{d} - 1\right]^2$$

References

[1] I.V. Kotov, T.J. Humanic, D. Nouais, J. Randel, A. Rashevsky, Electric fields in nonhomogeneously doped silicon. Nucl.Inst.Meth A 568 (2006) 41–45.

Other issues

- X-rays in simulations?
- Vizualization tools in PhoSim for sensors and optics?
- Other sensor effects, which we hope to eliminate (like tearing) – need them in simulations?