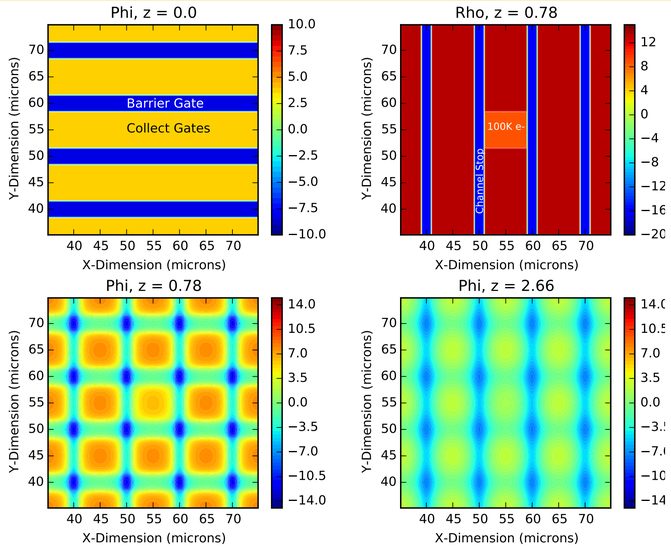
Measurements and Simulations of the Brighter-Fatter Effect

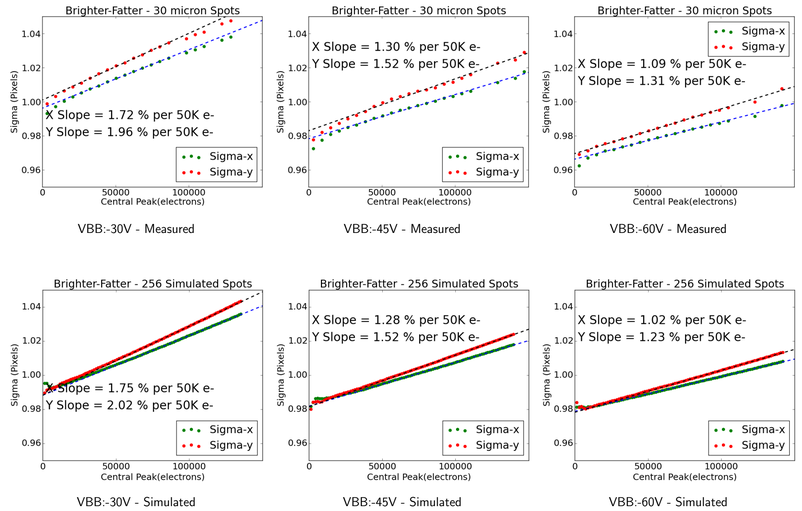
Craig Lage - UC Davis - Dec 14, 2015

Acknowledgements:Tony Tyson, Andrew Bradshaw, Kirk Gilmore, Perry Gee

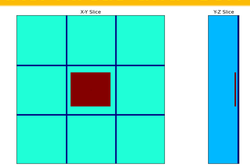
Pixel Array Summary Plot



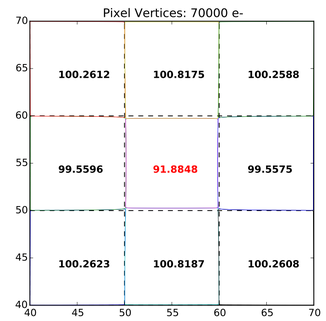
B-F Slopes vs VBB, Measurements and Simulations

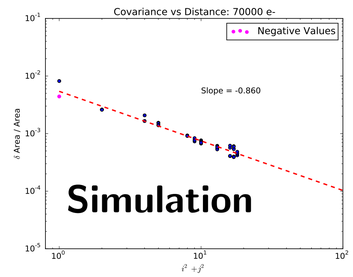


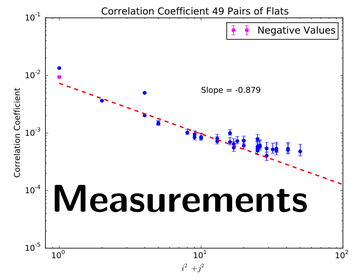
Pixel Areas and Correlations - 70,000 e- in Central Pixel



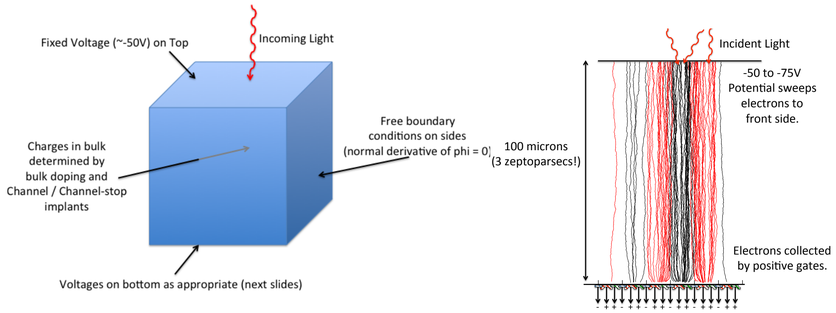
Charge Distribution (Assumed)







Typical Simulation $100\mu m$ Cube.



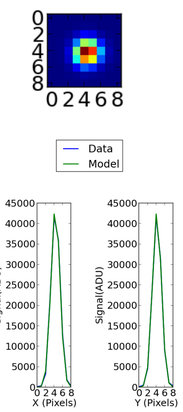
$100\mu m$ Cube. - 10 X 10 pixels in X and Y.

32 grid cells per pixel - cell size = 0.31 μ.

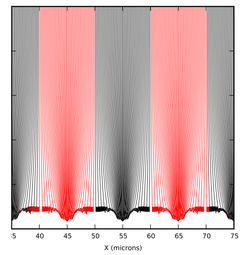
A B-F run with 256 spots, 3 million electrons (300,000 in central spot) takes about 6 hours.

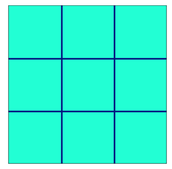
Forward modeling of Discrete Spots

- Use sextractor to identify a list of spots.
  - Typically 1000-2000 in one CCD segment.
  - Use sextractor central pixel location only.
  - Use a constant 9x9 window ("postage stamp") for all spots.
- Assume all spots have the same shape, but allow variable peak intensity and offset.
  - Calculate first moment of postage stamp to determine offset within central pixel.
- Assume a 2D Gaussian, calculate expected signal in each pixel
- $I = I_0(\mathrm{erf}(\frac{x_{max}}{\sqrt{2}\sigma_x}) - \mathrm{erf}(\frac{x_{min}}{\sqrt{2}\sigma_x})) * (\mathrm{erf}(\frac{y_{max}}{\sqrt{2}\sigma_y}) - \mathrm{erf}(\frac{y_{min}}{\sqrt{2}\sigma_y}))$
- Find (σ_x, σ_x) which minimizes: $\sum_{Nspots}\sum_{x,y}(\mathrm{Measured}_{n,x,y} - \mathrm{Calculated}_{n,x,y})^2$

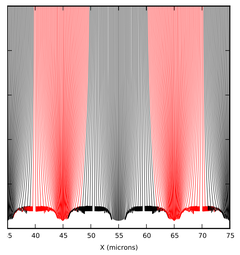


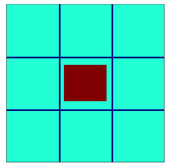
Basics of the Brighter-Fatter Effect





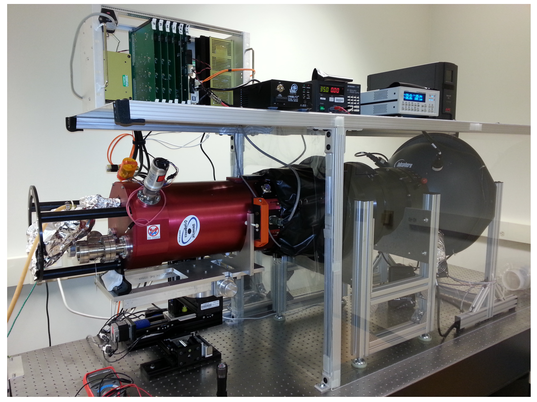
Pixel empty of charge



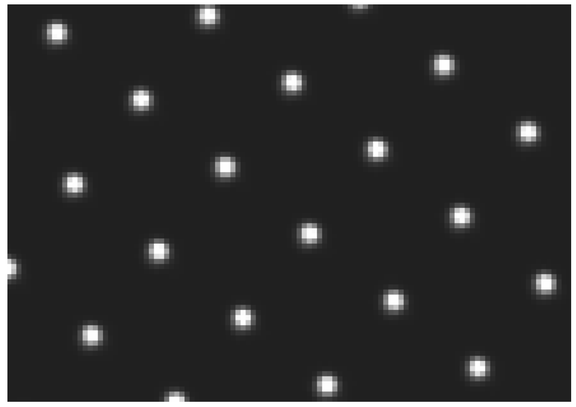


Pixel with 100K e-

LSST Optical Simulator



Simulation Strategy for B-F effect.

- Solve Poisson's equation for postage stamp with all pixels empty.
- Choose a random location within the central pixel.
- Determine starting locations for N electrons in a 2D Gaussian spot.
- Propagate these electrons down to their collecting gates.
- Re-solve Poisson's equation with these wells now containing the appropriate charge.
- Repeat with N more electrons.
- I have been using 10,000 electrons per step, which places about 1000 electrons in the central pixel, so about 100 iterations are needed to fill the central pixel.
- In practice, repeat for more than one spot (typical 256), each with a different central location.

Typical Image of 30 micron Spots