Astrometric Error Measurements using a dithered array of 40,000 stars

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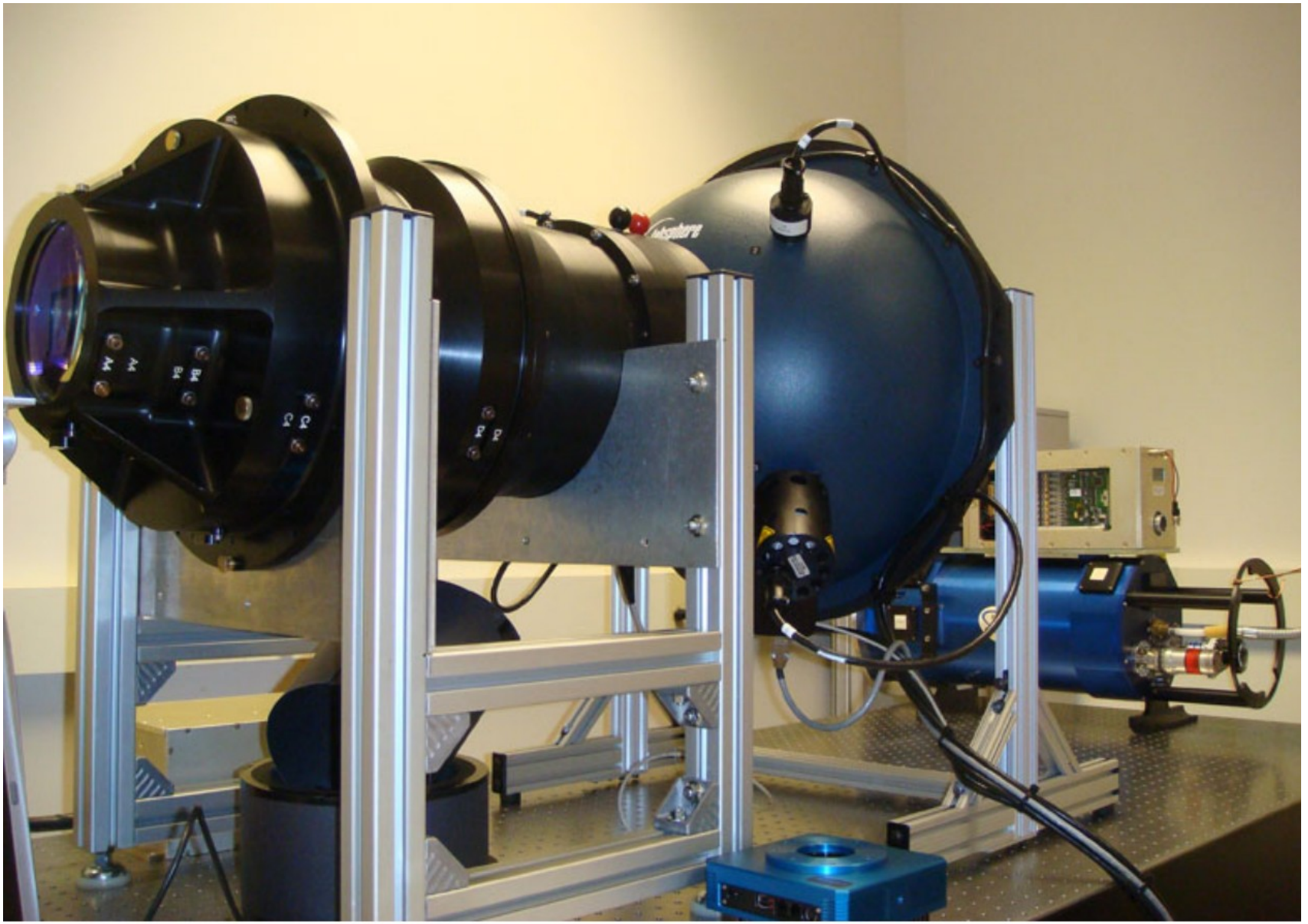
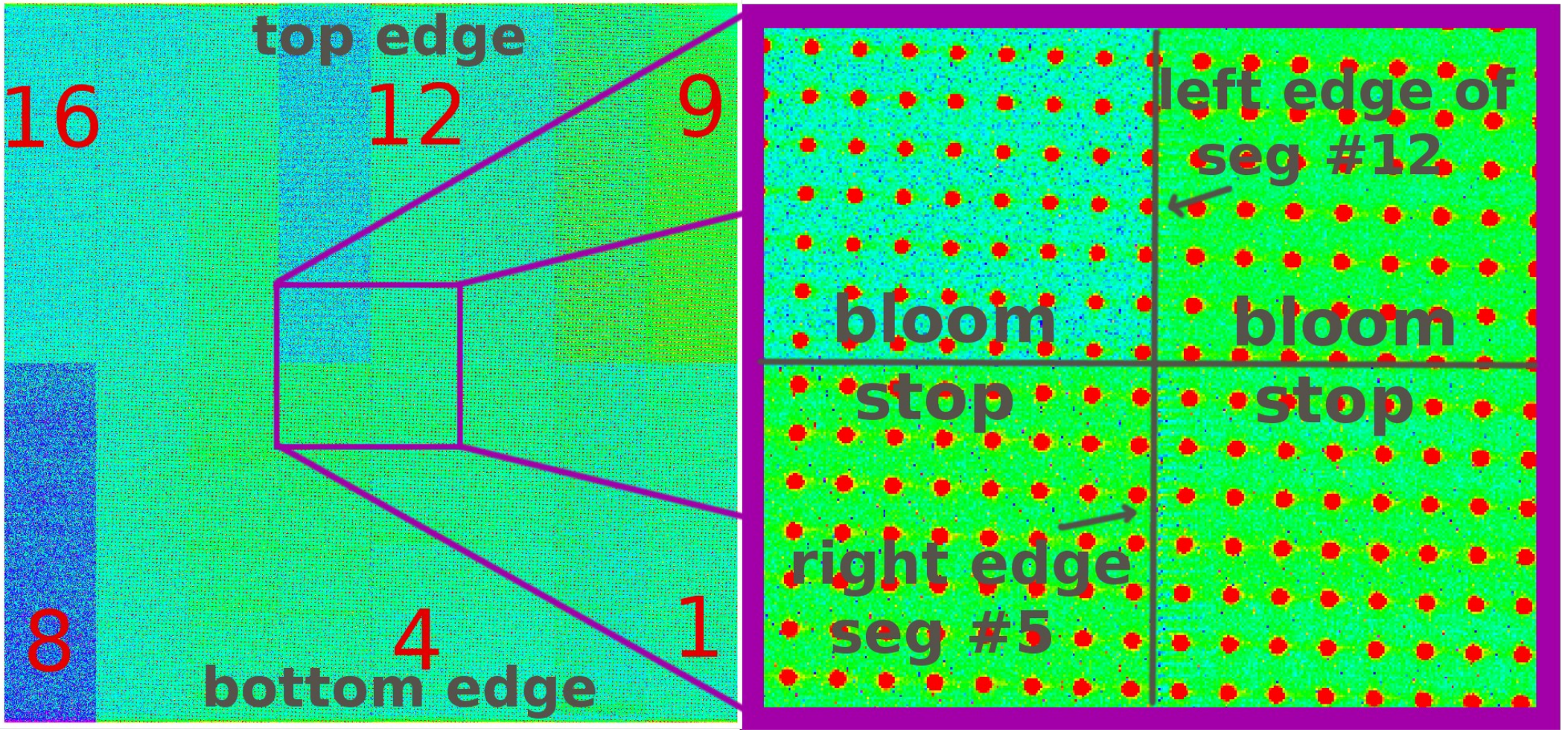
Outline

1) Our f/1 beam simulator lab, 40k pinhole array and dither method
2) Overview analysis method for CCD segments
3) Modeling of edge occultation effect
4) Astrometric residuals near edges of segments
5) Modeling pixel boundary shift at edges and qualitative comparison to measurements

LSST f/1 Beam Simulator @ UCD

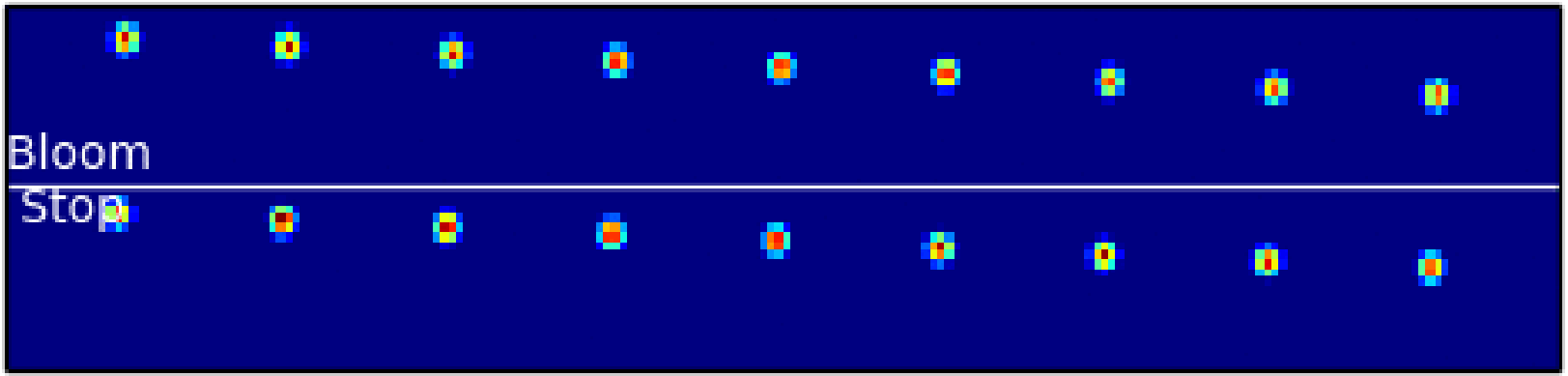


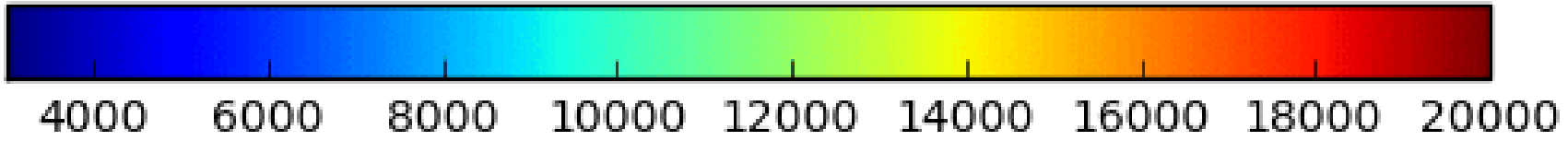
STA 1920A layout & naming conventions

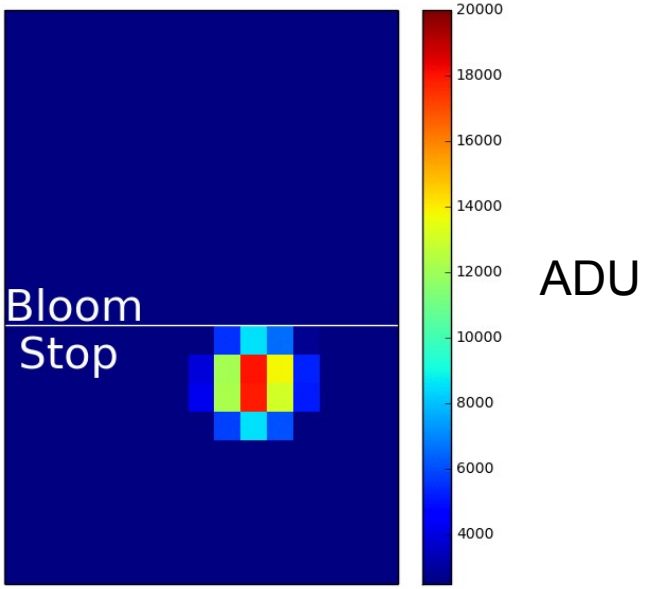


40,000 pinholes, 30 micron diameter, spaced 200 microns

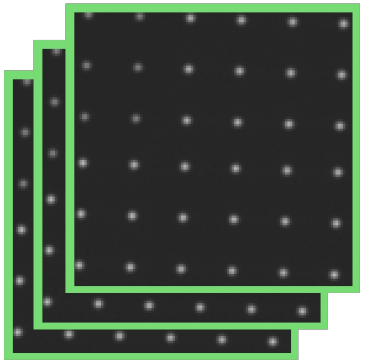
Dither animations



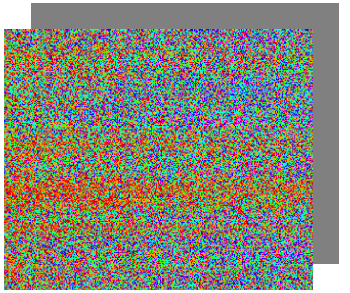




Analysis pipeline (1)



- Acquire exposures:
  - 300 dithered images w/ X&Y sub-pix shifts
  - 6 illumination levels, max=1,000→60,000 e-
  - Only R filter so far

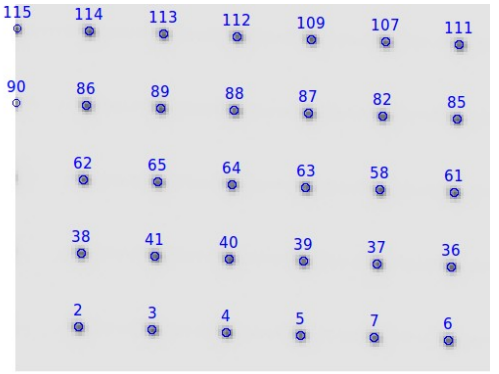


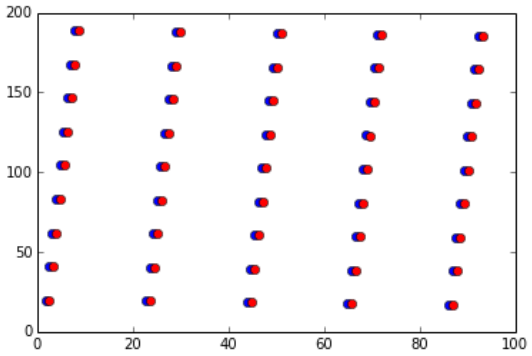
- Debias subsegment:
  - Create master bias from 250 bias frames
  - Use overscan to remove intermittent line noise
  - Subtract master bias (overscan subtracted) from sub-segment (also overscan subtracted)

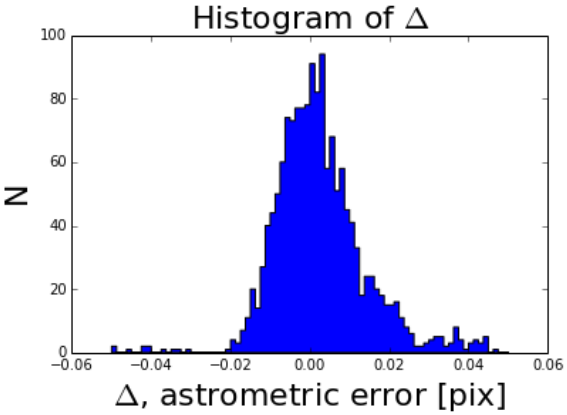
Analysis pipeline (2)

- Identify ~2000 pinholes in each segment frame using SExtractor
  - Catalog created has precision X&Y centroids, fluxes, & shapes measured
- Use python to read in consecutive catalogs and compute **median shift** of all pinholes in X & Y
- Measure deviation, Δ, from **median shift** in region of interest (i.e. edges, bloom stops)
  - Median shift known to better than .05 pixel

CPU time per 300 images: ~100min

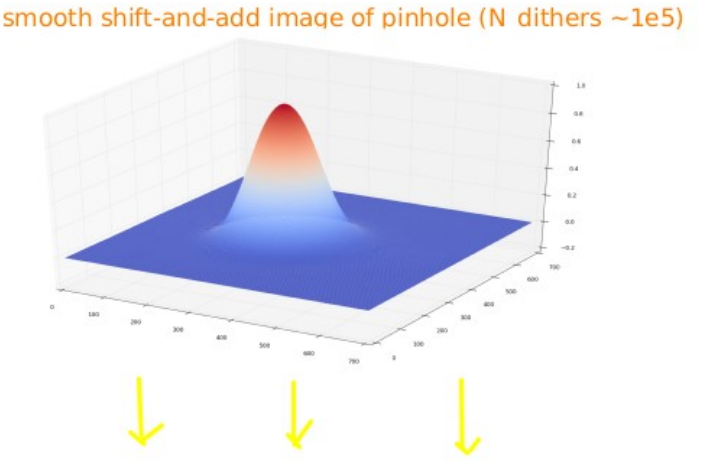


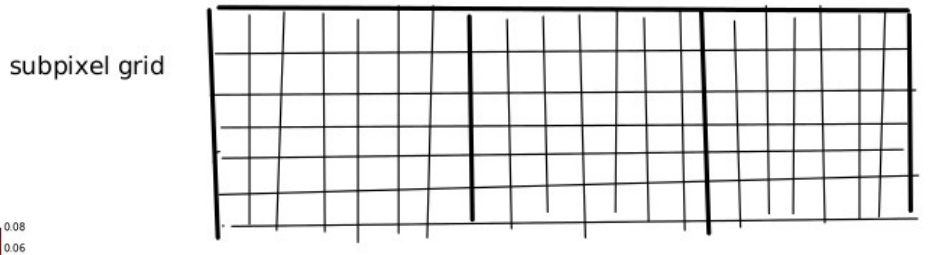


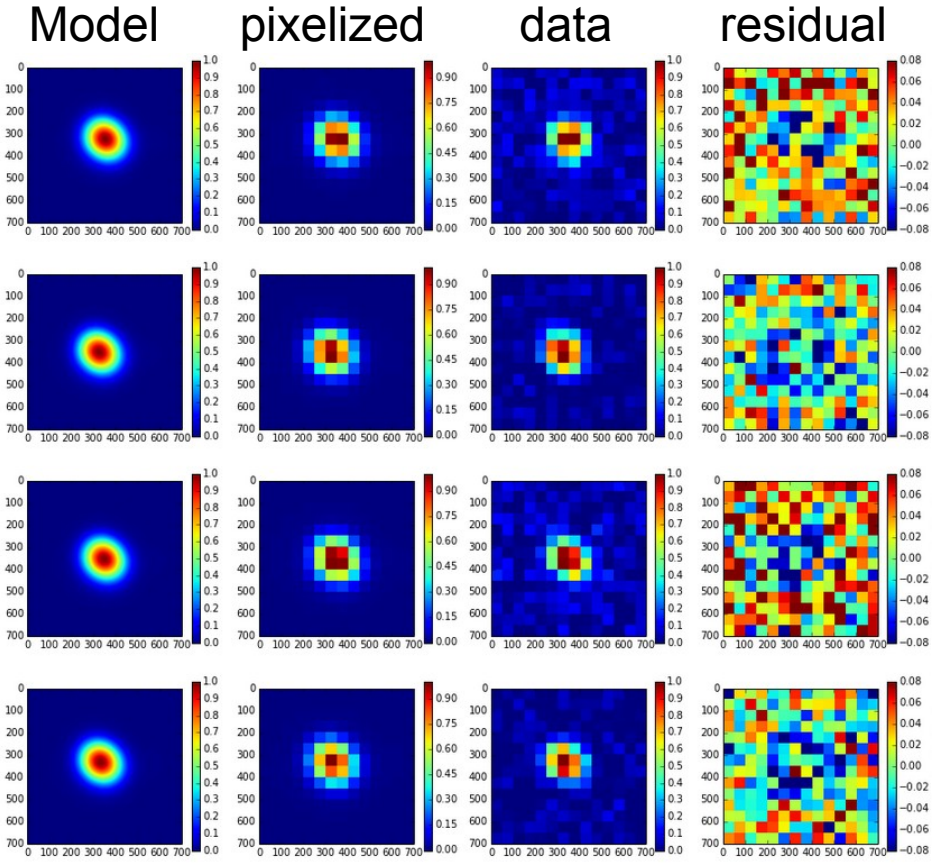


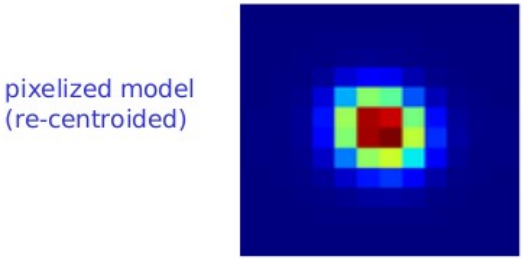
How to model a pixelized pinhole image

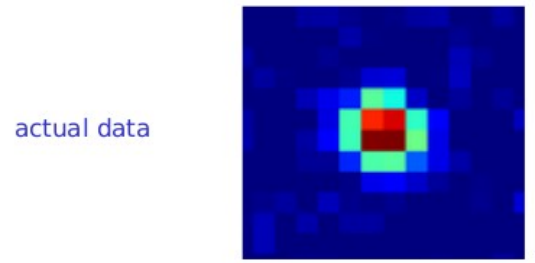
(Necessary for modeling the occultation effect at each edge)



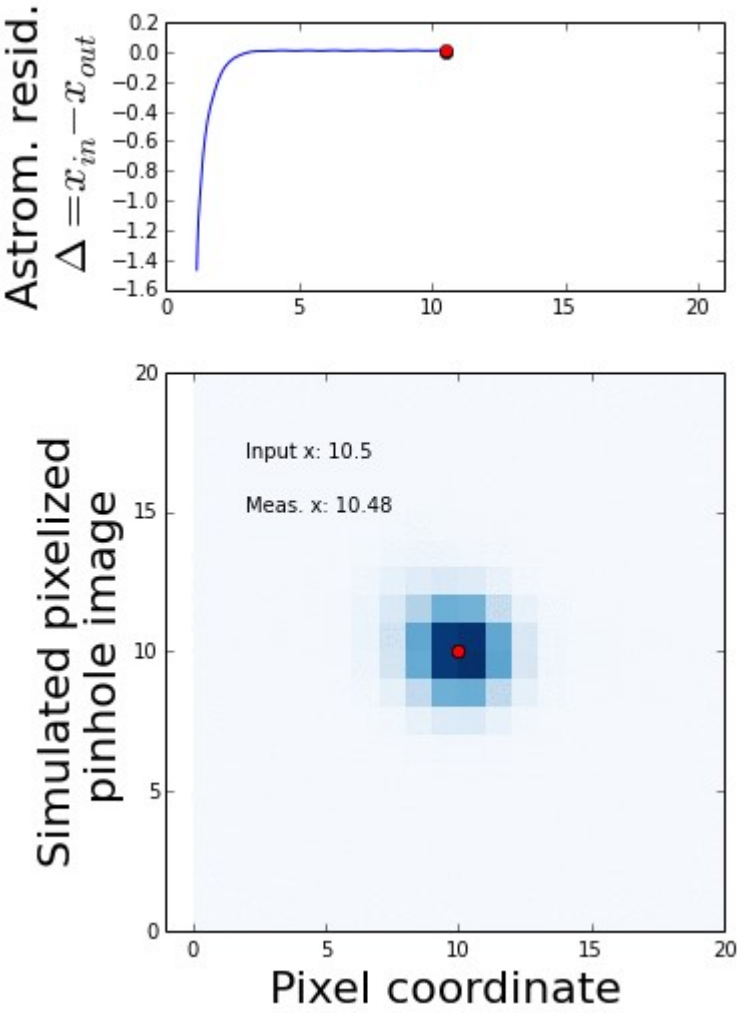




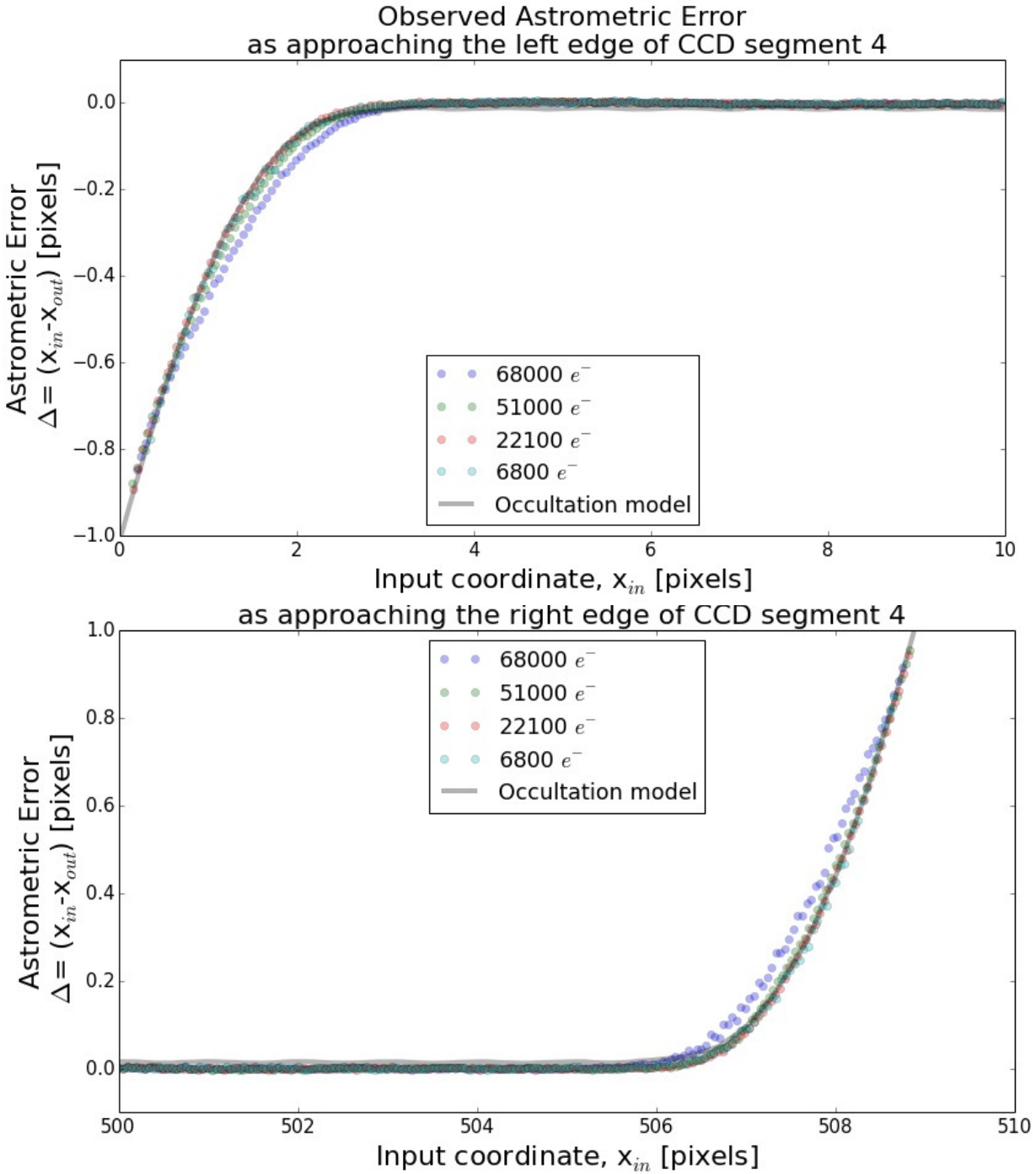




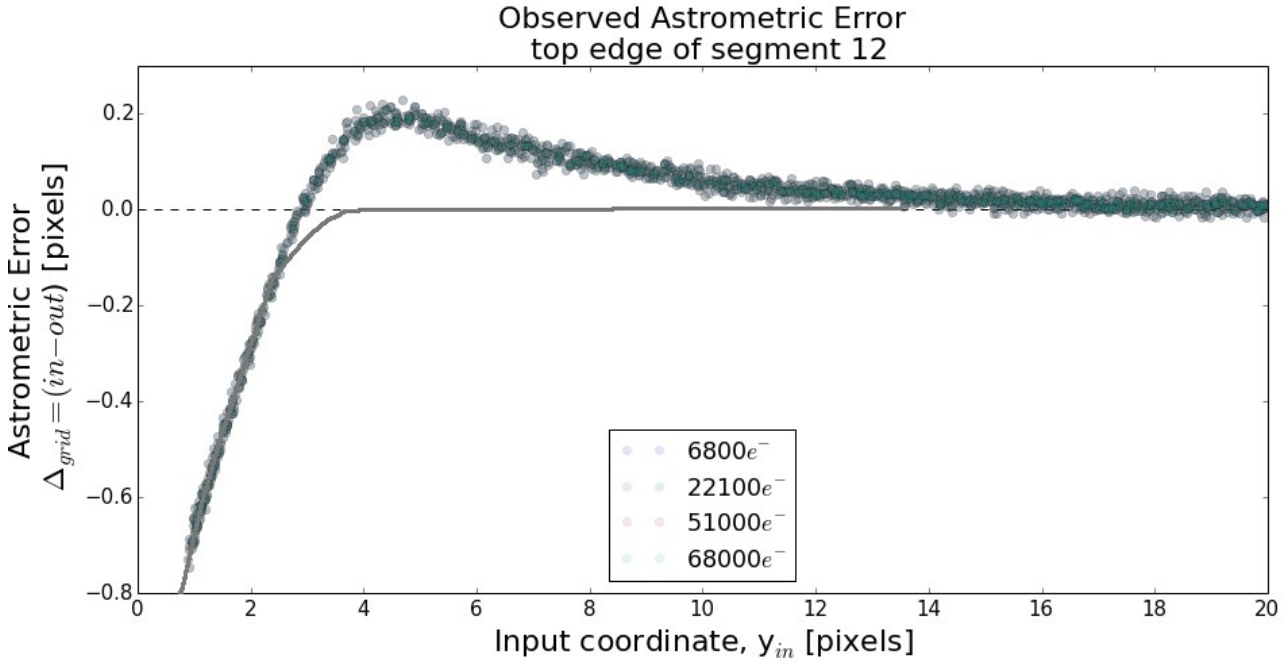
Animation of model pixelized PSF approaching an edge

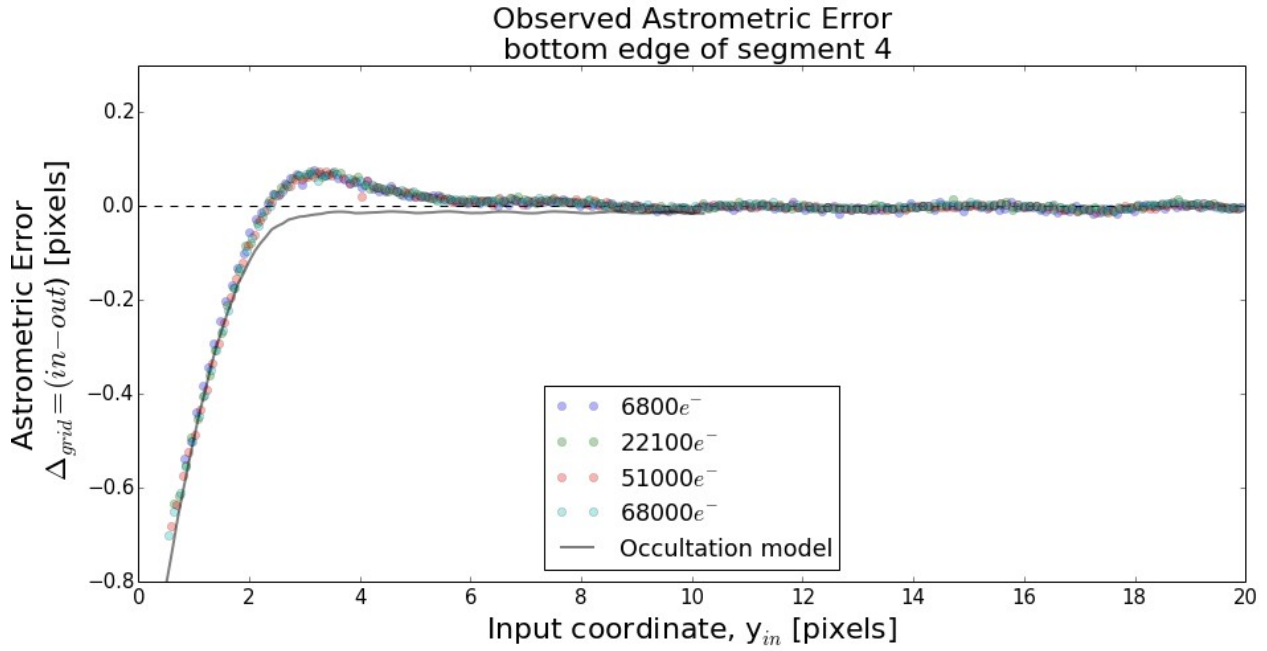


@ left & right edge of seg # 4

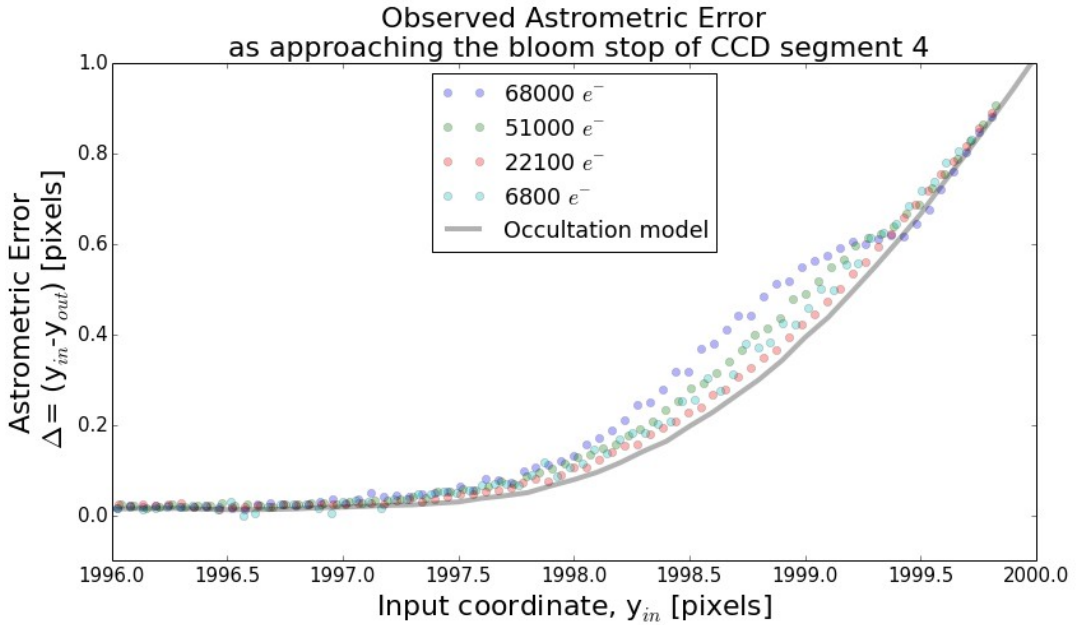


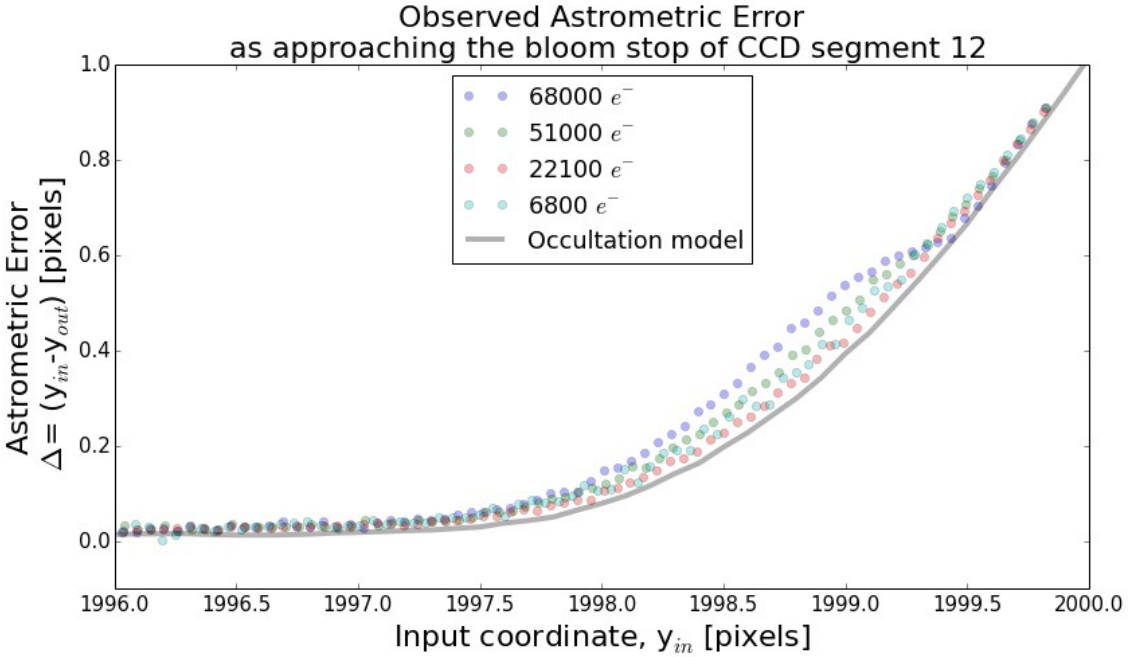
@ top, bottom of CCD (seg # 12, 4)



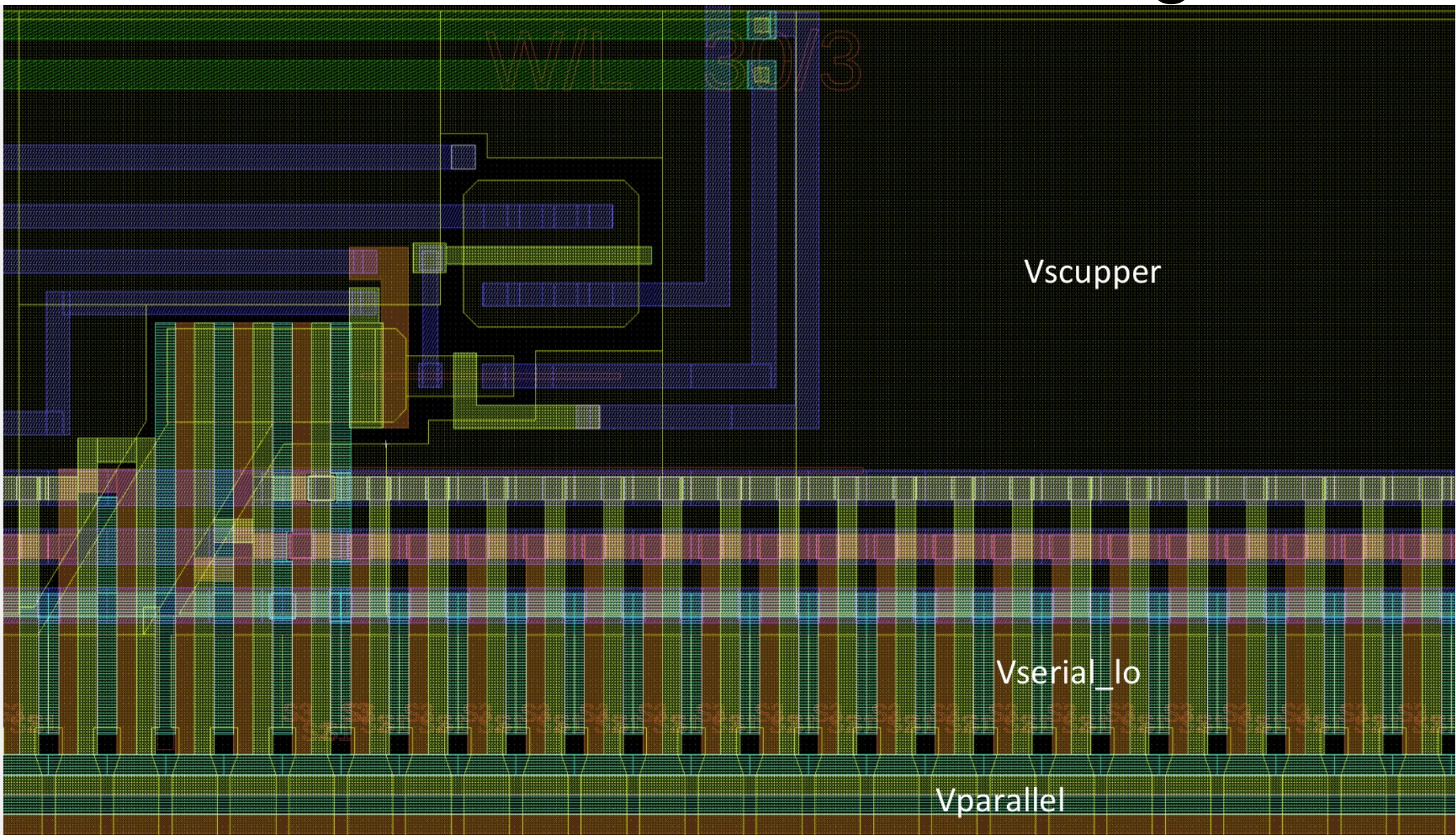


@ bloom stop approached from below (4) and above (12)



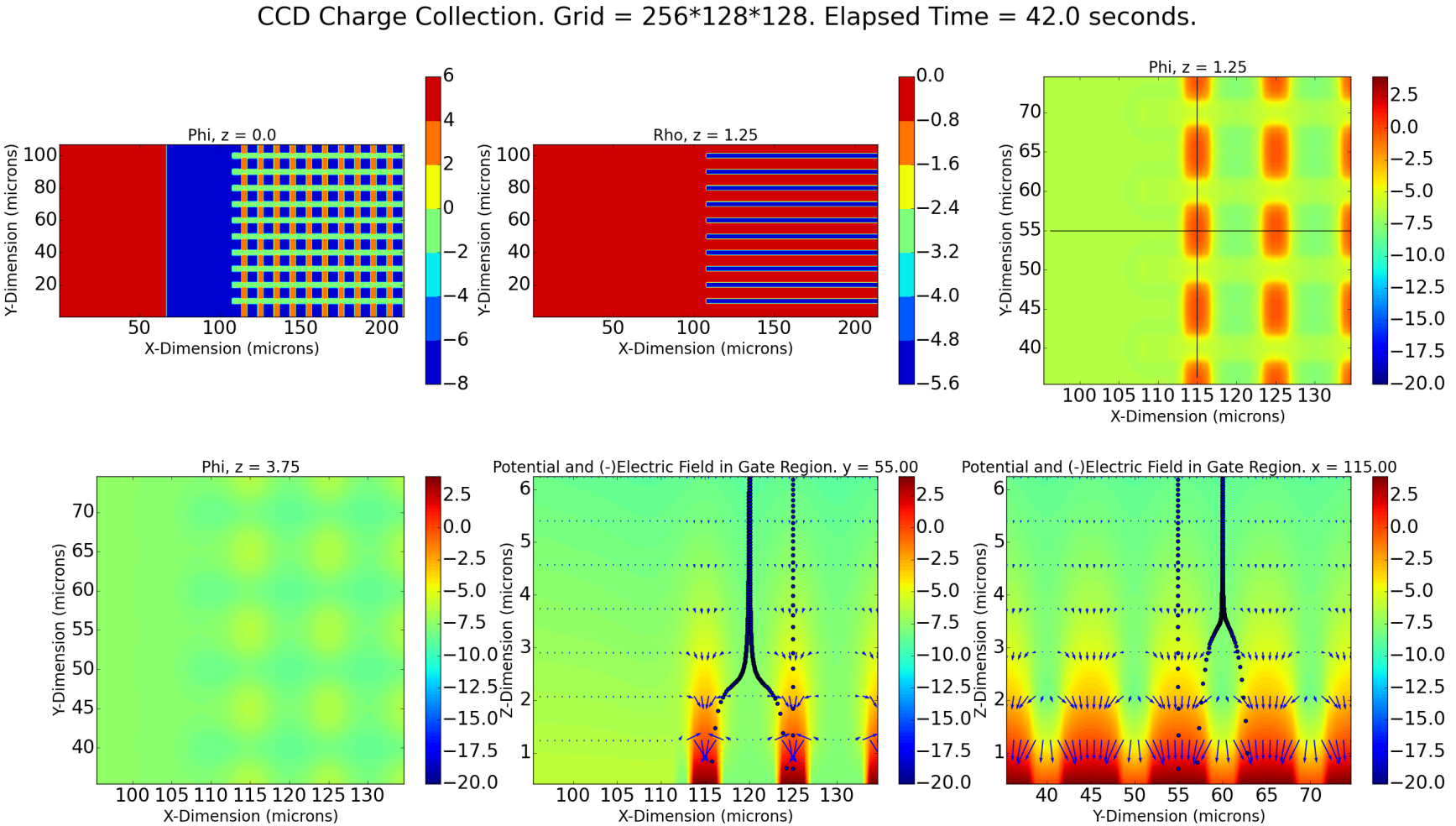


CAD masks near serial edge

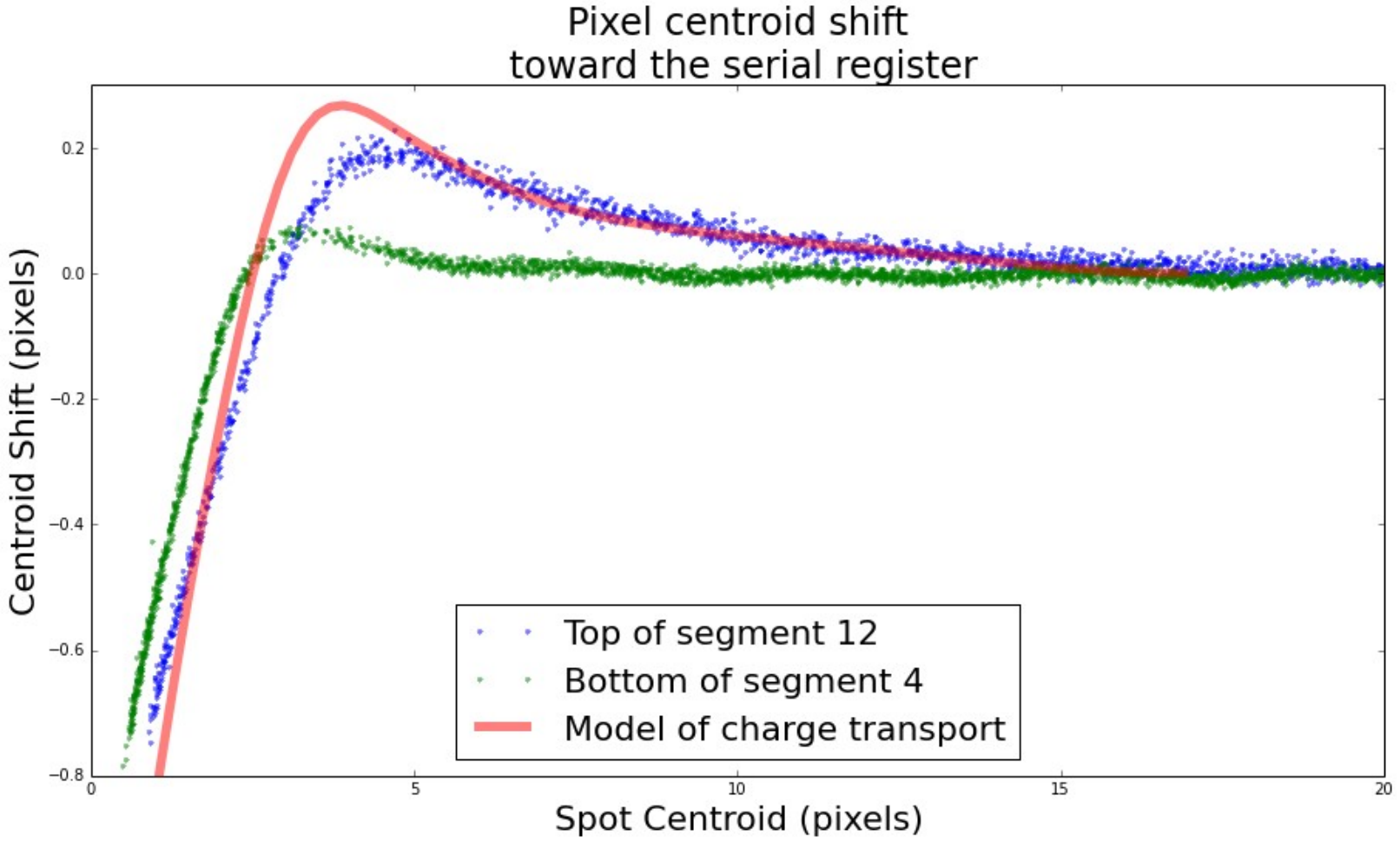


Potential map near serial edge

Use **toy Poisson model** of scupper, serial, and parallel potentials to predict charge deflection → calculated approx. pixel boundaries shift near serial reg.



Toy model of pixel shift near serial has similar shape & amplitude



Conclusions

- CCDs are not perfect detectors, but are quirky and need to be understood for precision cosmology
- Optimizing CCD performance requires rigorous characterization
- **Future work on characterization:**
  - Changing wavelength/filter
  - Backside bias
  - Variable sky level
  - Pinhole size (3 micron mask ready to use)
  - Pinhole shape
- Questions, comments, ideas!