



Modeling and Correcting the Time-Dependent ACS PSF for Weak Lensing

Jason Rhodes, JPL

With:

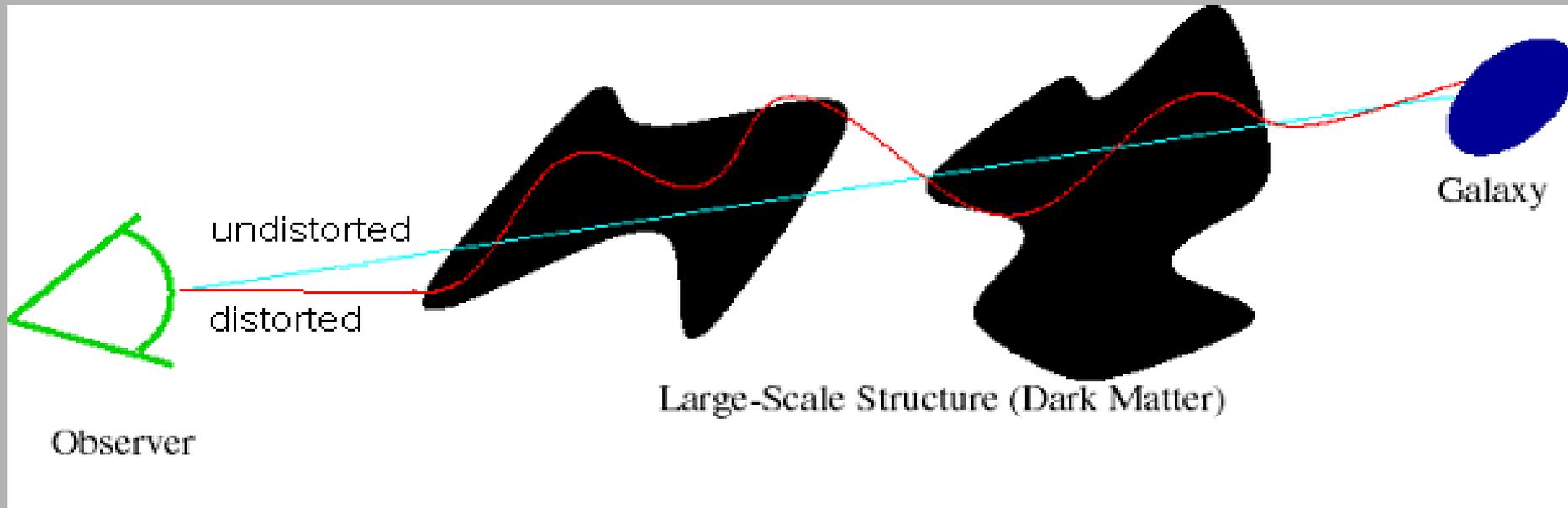
Justin Albert (Caltech)

Richard Massey (Caltech)

HST Calibration Workshop

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Motivation : Weak Lensing



- Statistical measurement on many galaxies
- Lensing induced ellipticities 1-2%
- Telescope Point Spread Function (PSF) is the primary systematic concern –it changes shape (ϵ)!

Two Main Problems



1. Aliasing of the PSF during distortion correction re-pixellization (Multidrizzle)

2. Time variation of PSF due to thermally induced focus changes

Data Sets



- **Cosmos 2 Square degree field**

- Taken cycles 12-13

- 590 orbits of F814



Not enough stars per field to model PSF

- **ACS Parallels**

- Taken cycles 11-13

- 500 fields of F775W



- **Stellar Fields (globular clusters)**

- Taken cycles 11-13

- A few fields in F775W and F814W



Not take often enough to account for time variation

TinyTim



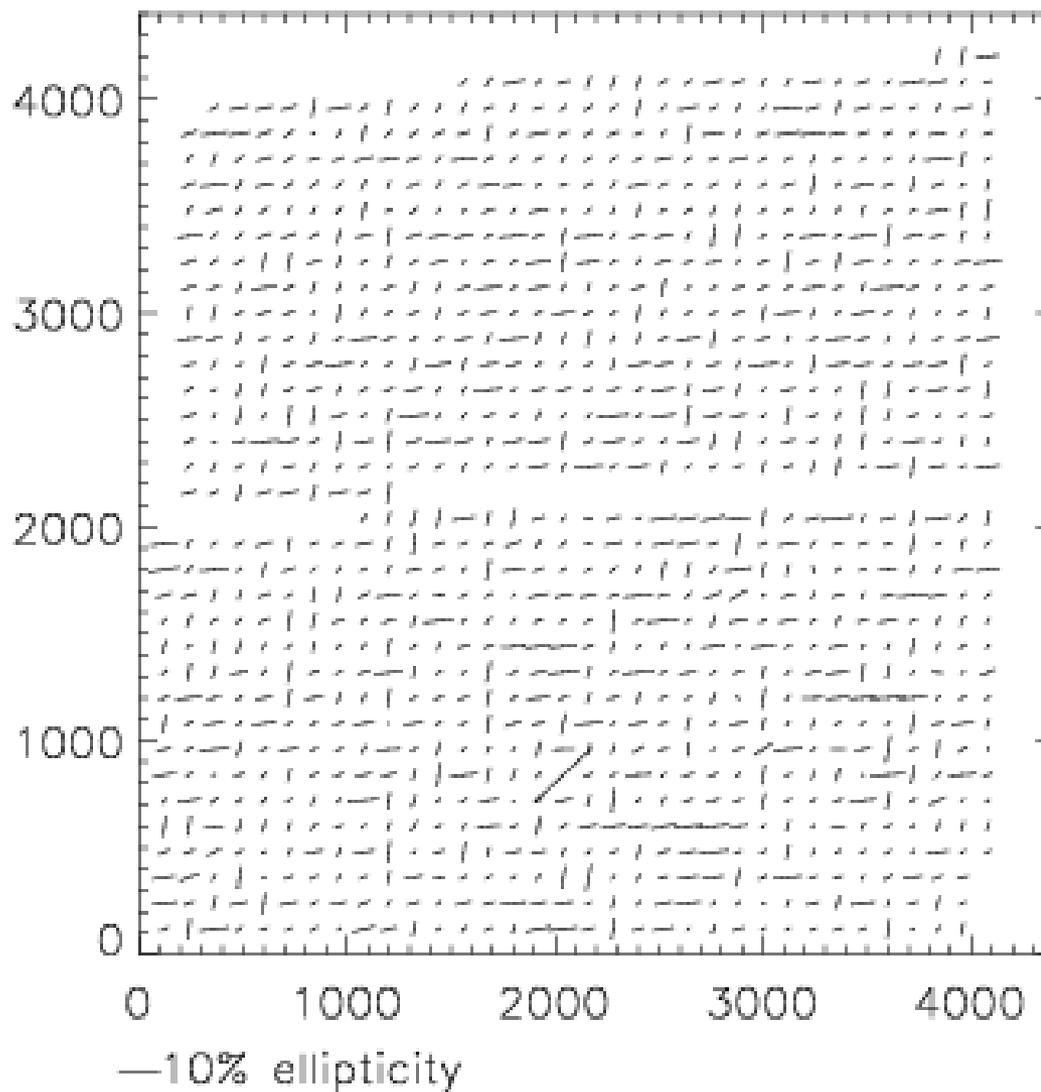
- **TinyTim Version 6.3 written by John Krist**
(<http://www.stsci.edu/software/tinytim/tinytim.html>)
- **Creates a PSF anywhere on the ACS chip with any filter and spectrum**
- **Can be highly oversampled**
- **Includes diffraction, distortion and charge disffusion**
- **Produces stars as we see in raw (distorted) ACS images**

How We Use TT

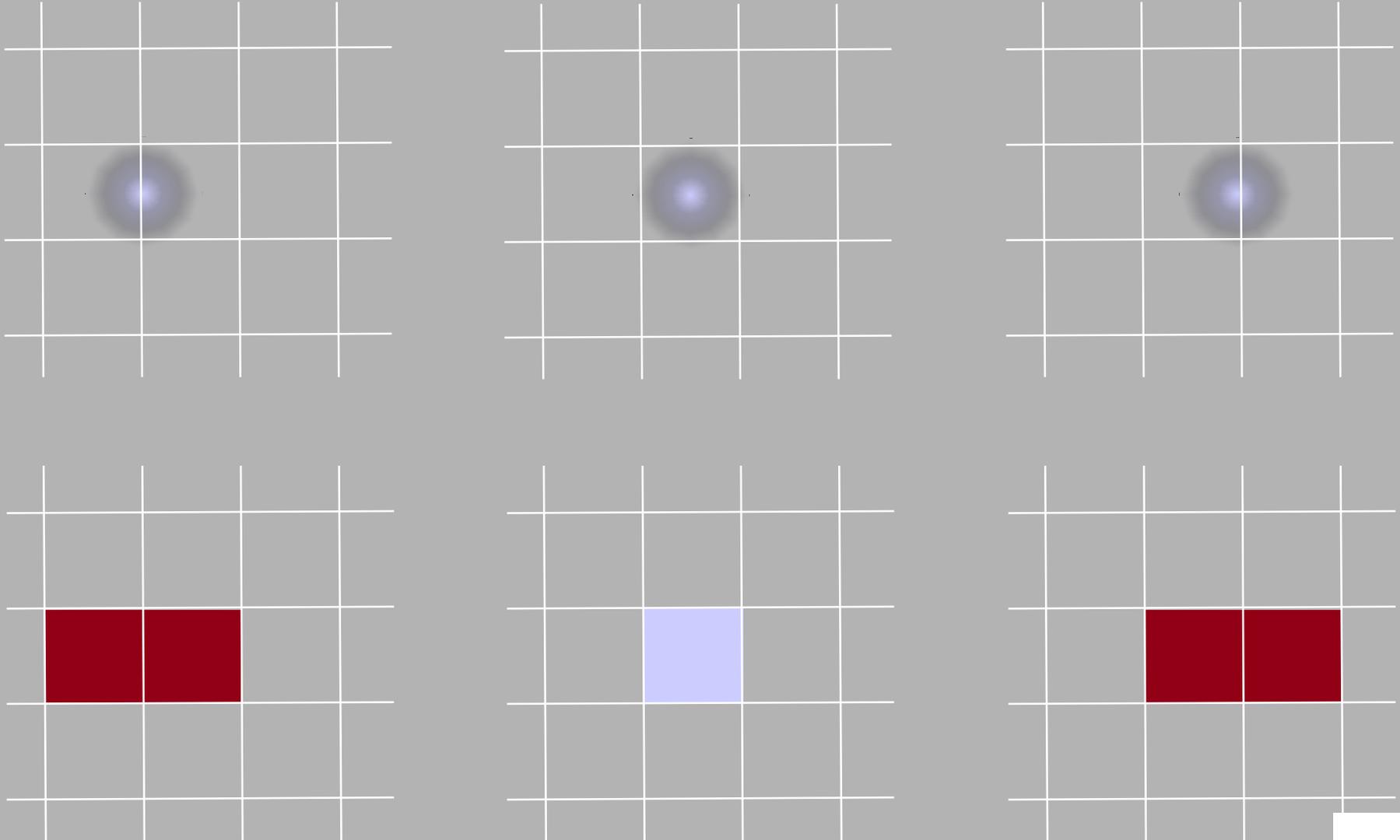


- We use F814W filter, and single wavelength 800nm
- We modify the code to measure the effects of multidrizzle
- We created a version of multidrizzle that only adds distortion across the field
- We modify the code to produce undistorted (post multidrizzle) stars
- We manually add charge diffusion as a convolution with a distorted kernel
- We avoid the complications of multidrizzle on our model stars

Aliasing From Multidrizzle



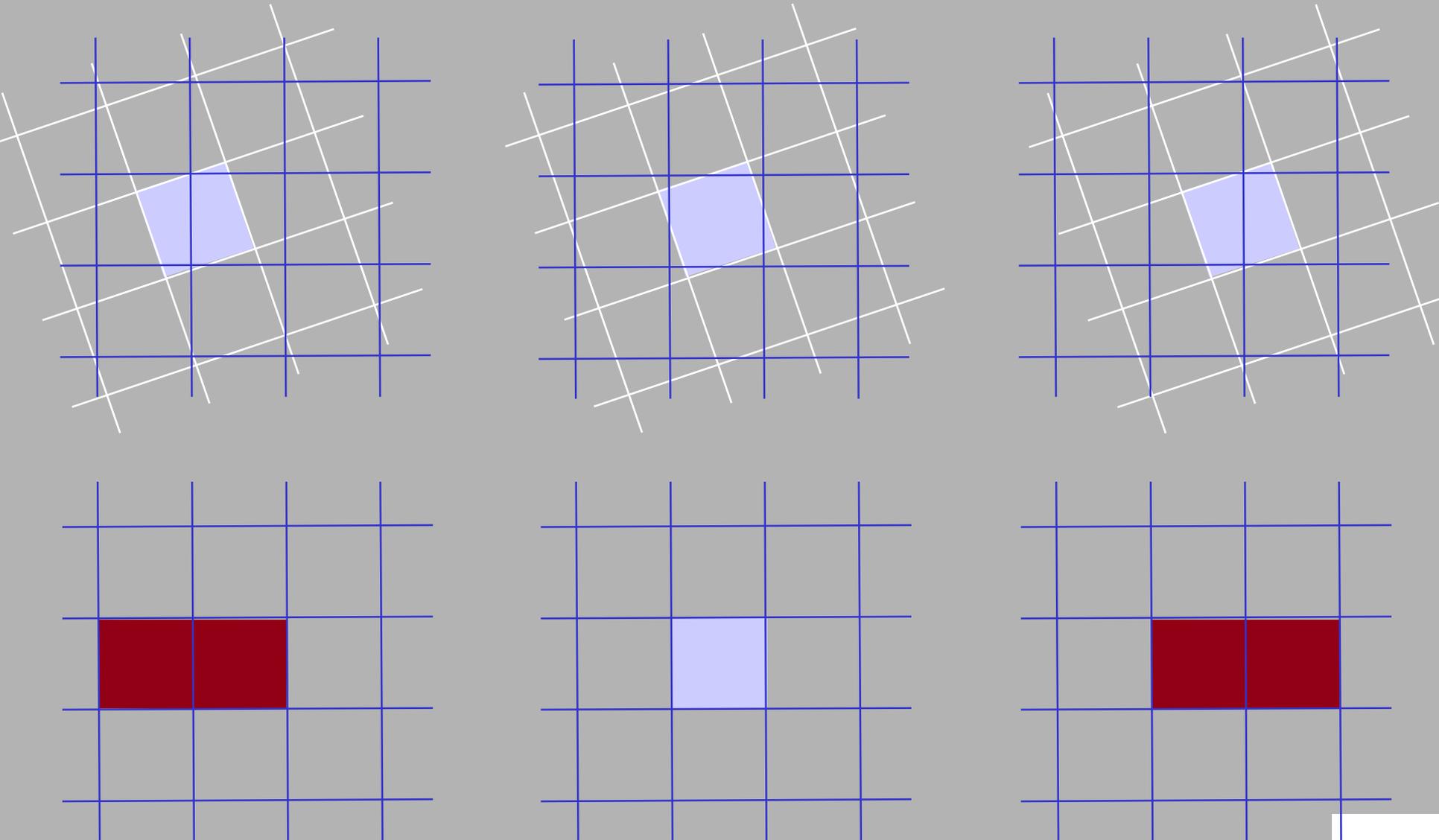
“Aliasing” from pixellization



Unfortunately, a star's sub-pixel position affects its observed shape.



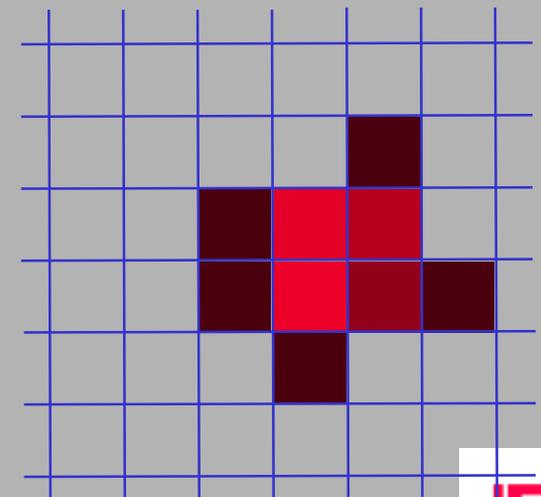
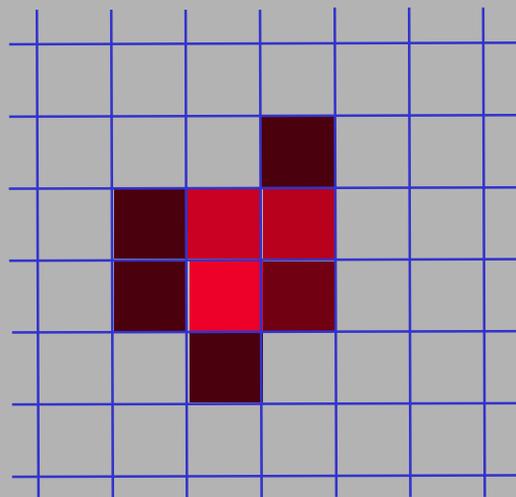
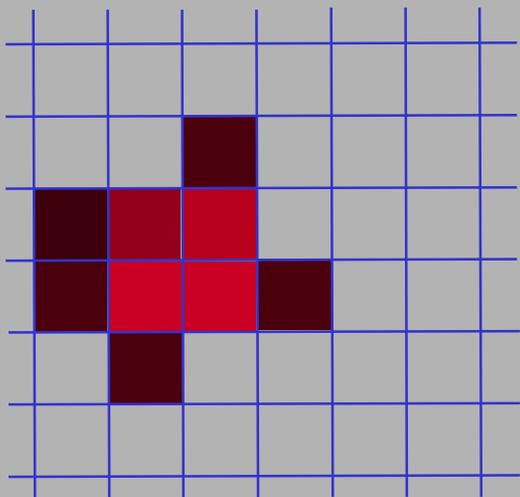
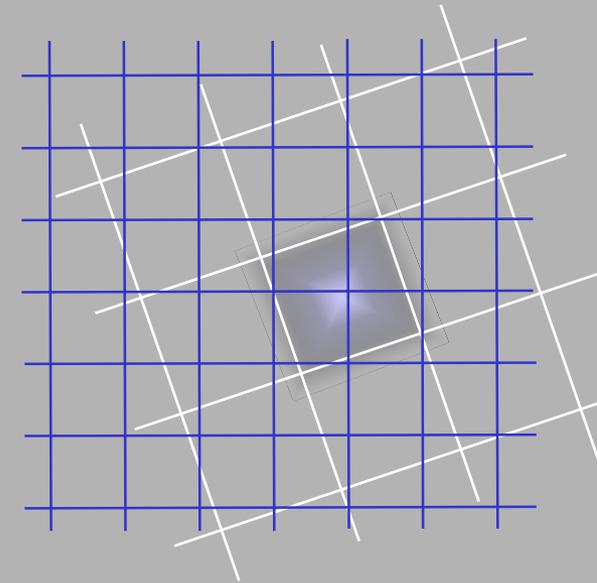
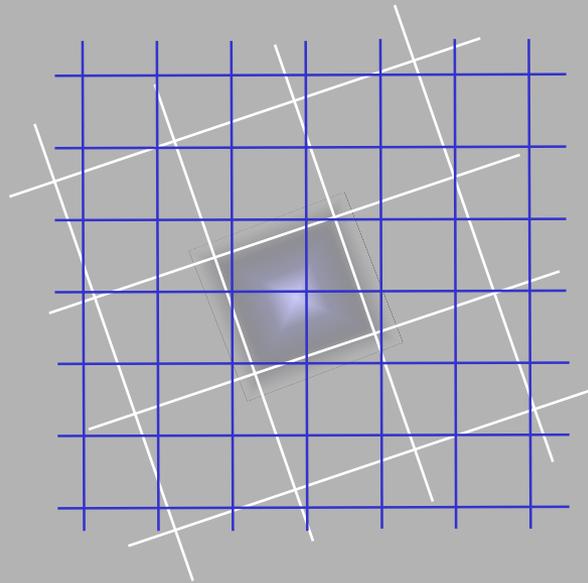
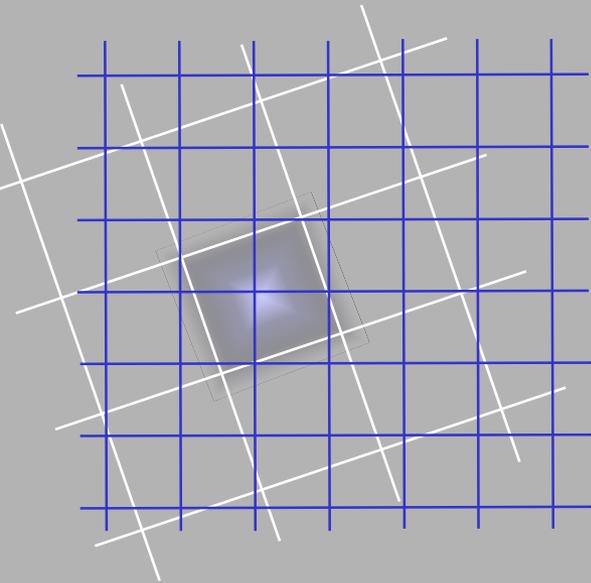
“Aliasing” from second Pixellization



Then it happens again during DRIZZLE! This at least must be avoidable...



Adjust Pixel scale & DRIZZLE kernel

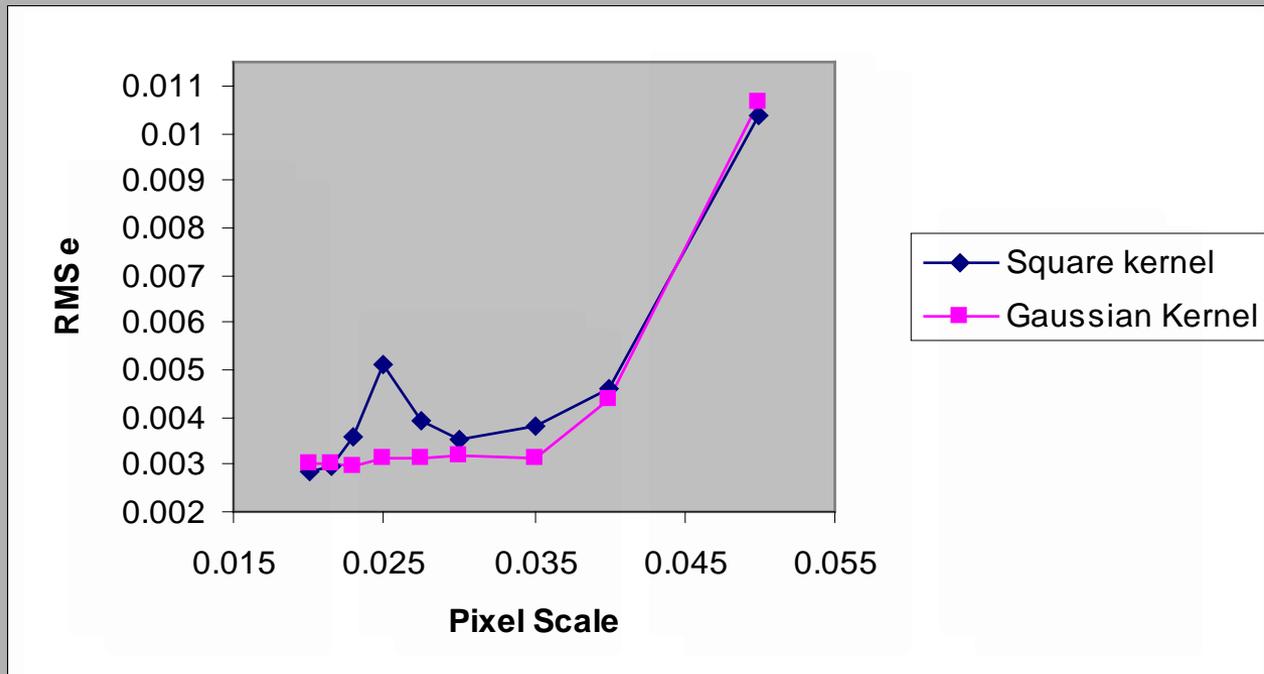


...it is!

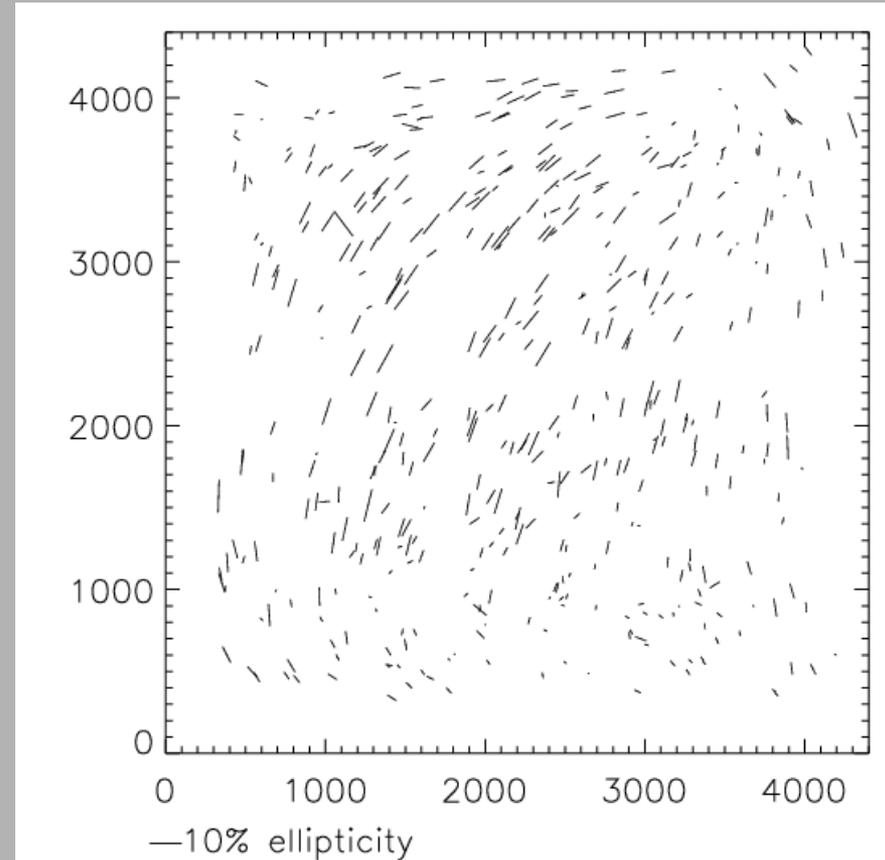
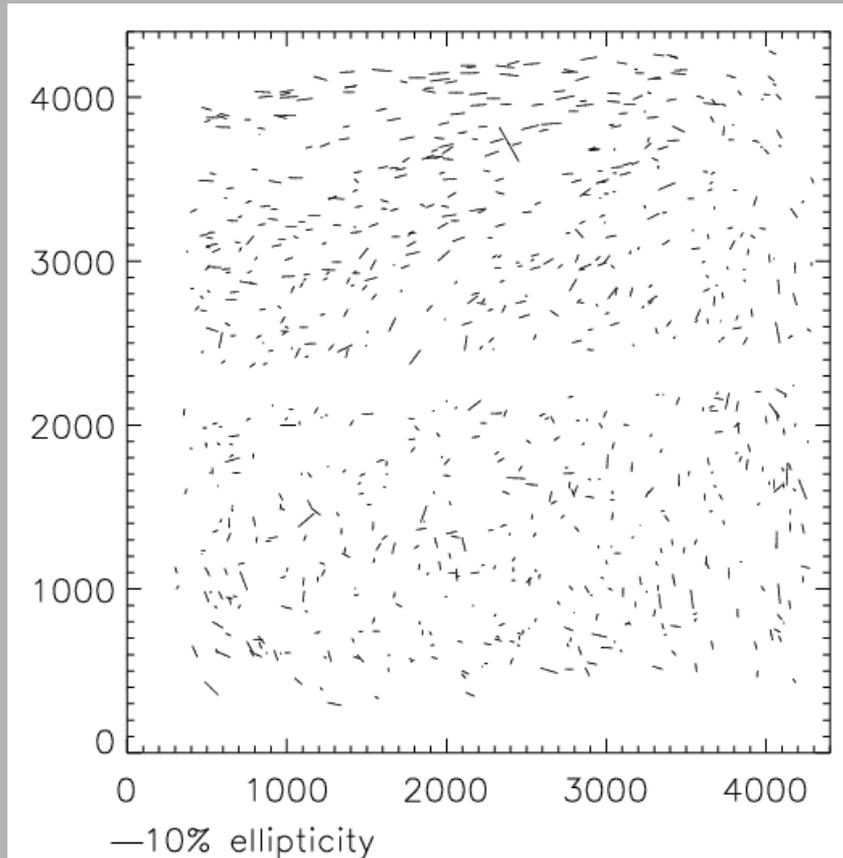


Recommended Multidrizzle Parameters

- Created TinyTim models with same diffraction everywhere, only distortion is different
- Run through multidrizzle w/ various parameters
- Large improvement going from 0.05 to 0.03 arcsecond pixels
- Gaussian kernel has lower RMS(e) and is more stable

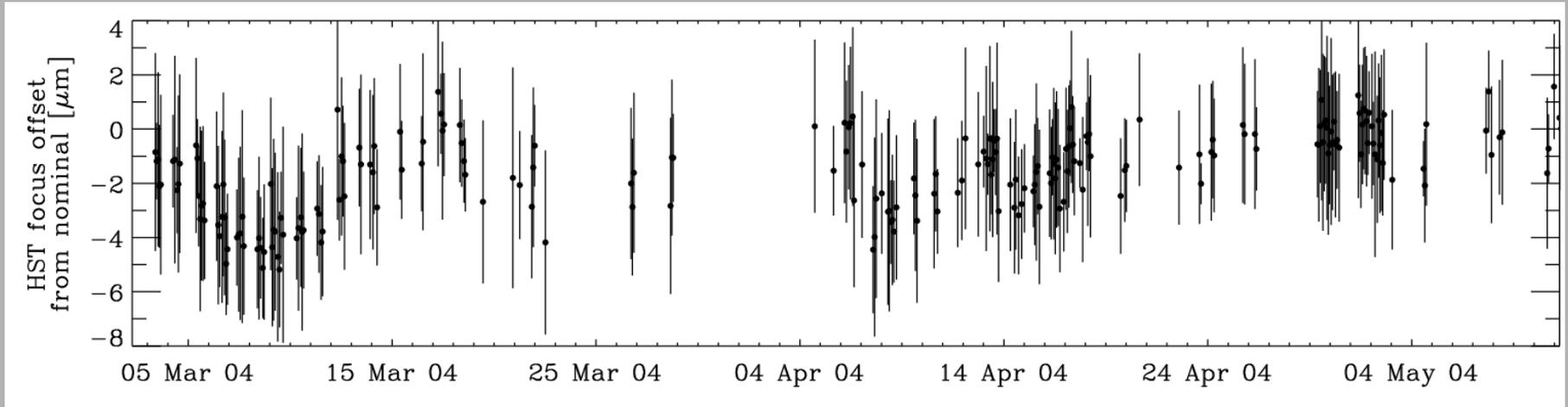


The PSF Problem



The PSF pattern is time dependent

Periodic Focus Variation



- COSMOS data
- ~20 day time scale
- Determined by fitting to TinyTim models

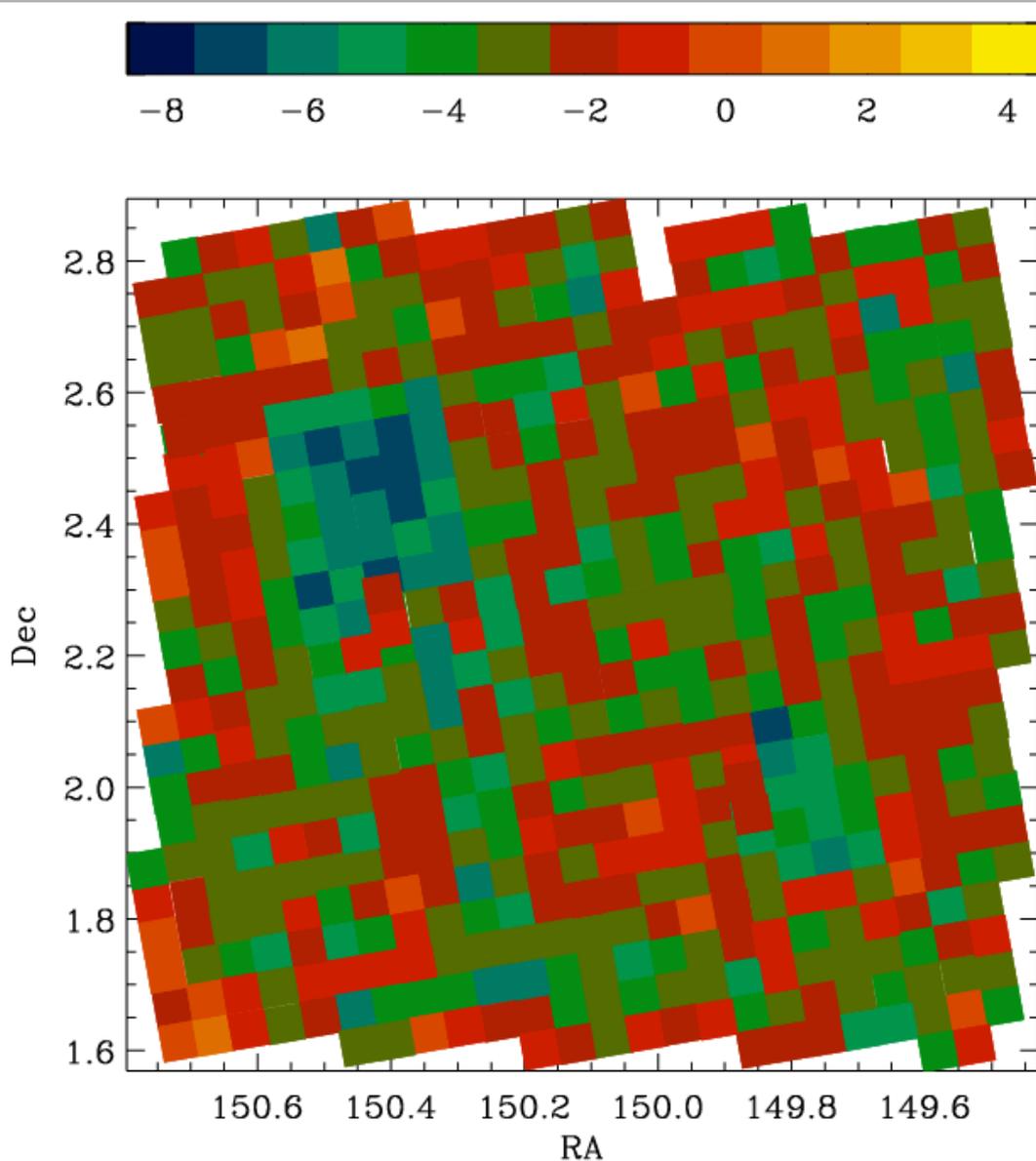
Our Solution



- Not enough stars→ Make our own!
- Use TinyTim PSF modeling software
- Create stars without geometric distortion (but with diffraction and other PSF effects)
- Required modification of TinyTim program

- Create dense stellar grids (up to 50x50 across field)
- Create at range of focus positions (-10 to +5 μm)
- Use stars in each COSMOS field (~10 to 20) to pick the best focus value
- Use the template at that focus value to perform correction
- Eliminates need for interpolation between stars

Focus Values in COSMOS

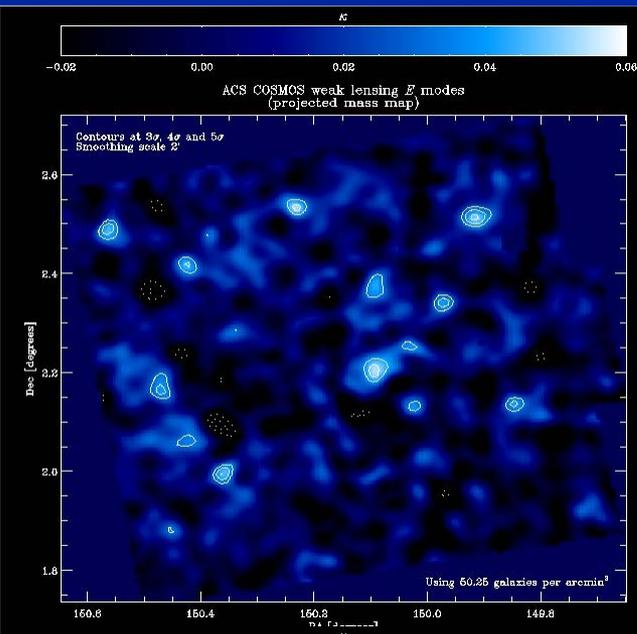


Focus values cluster!

COSMOS Results

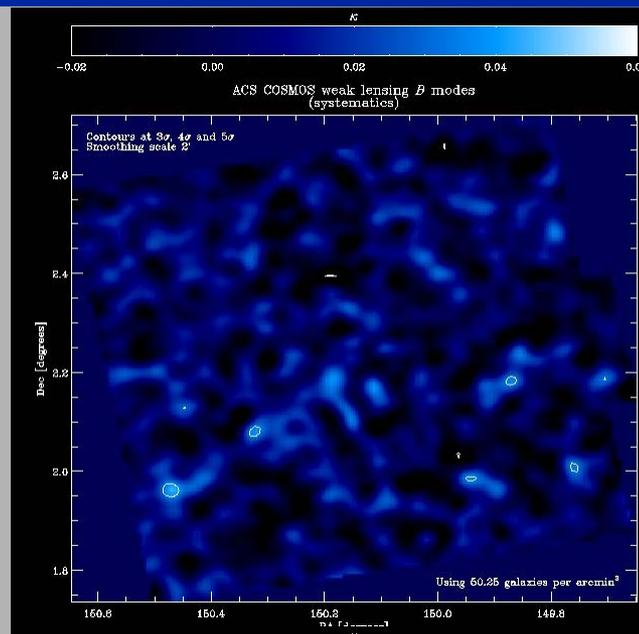


E
modes

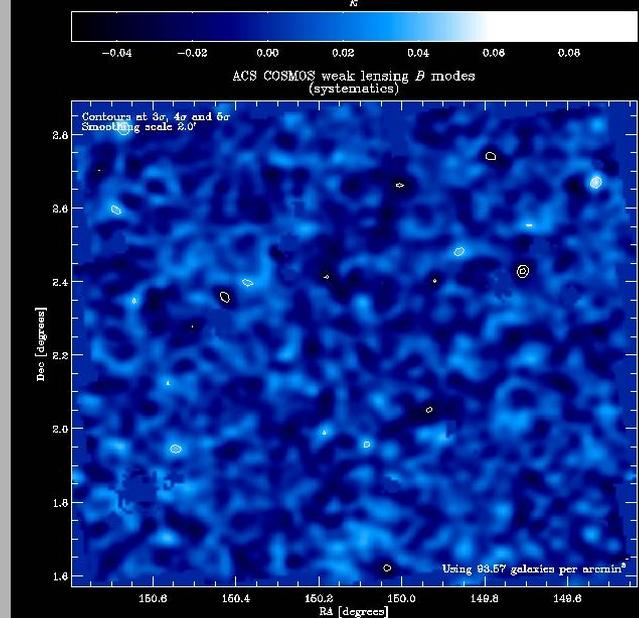
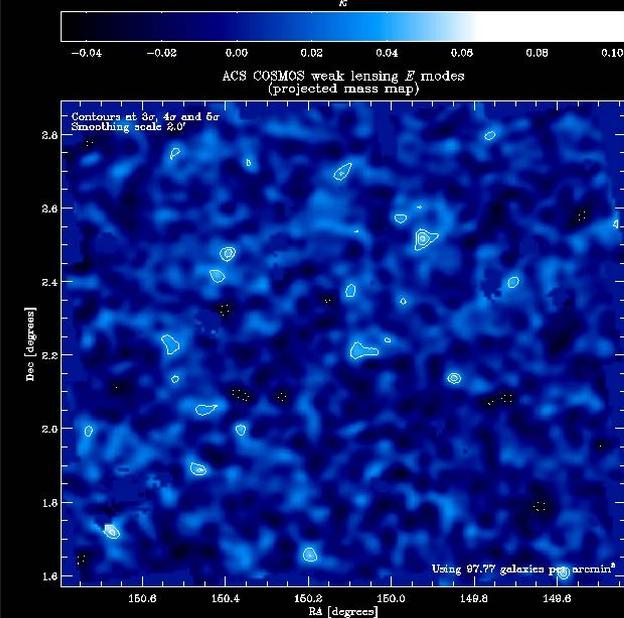


Before
TT

B
modes



After
TT



Remaining Work and Conclusions



- **Still some work to be done**
 - mapping chip height variations with globular clusters
 - TinyTim stars still slightly too small (diffusion convolution?)
 - What effect does CTE have on the PSF?
 - Compare to other methods (e.g. principle component analysis; see Jarvis and Jain astro-ph/0412234)
- **Method greatly reduces PSF systematics**
- **Can easily be extended to other filters**
- **Useful for more than weak lensing**