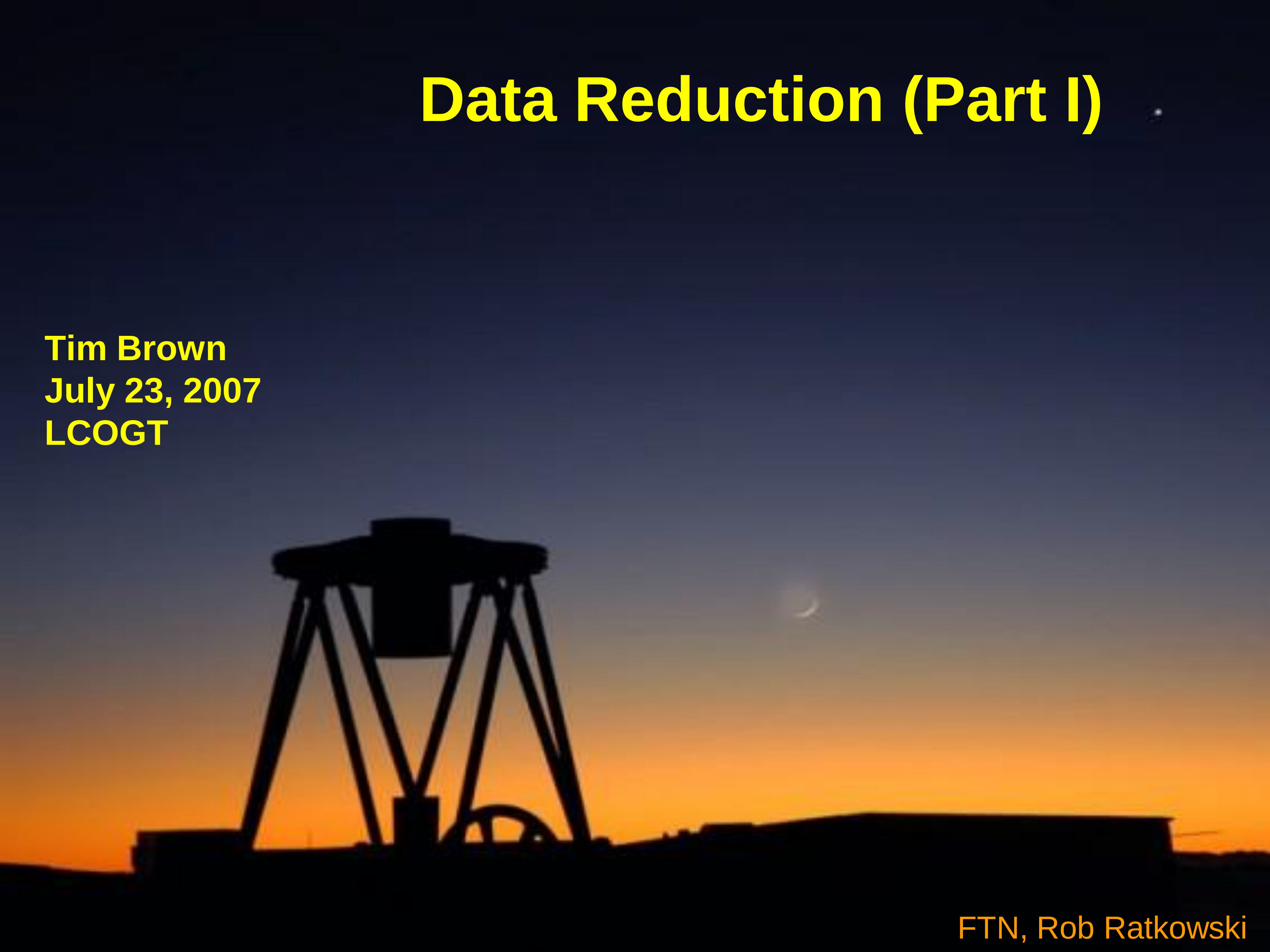
Data Reduction (Part I)

Tim Brown
July 23, 2007
LCOGT



FTN, Rob Ratkowski

We want to produce the cleanest possible Time series of flux from a target star, or of Doppler shift from same.

How do we do this?

That’s a very good question…

First Rule: Crafty data analysis will not compensate for crappy data.

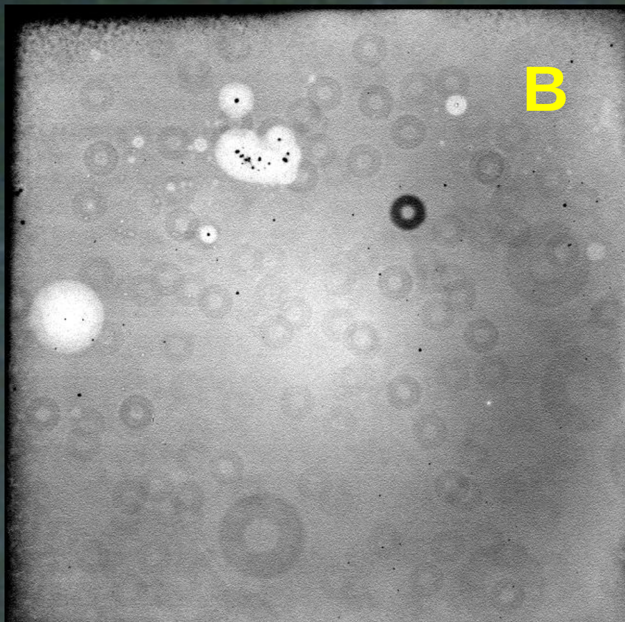
Second Rule: All data are crappy; the differences are a matter of degree.

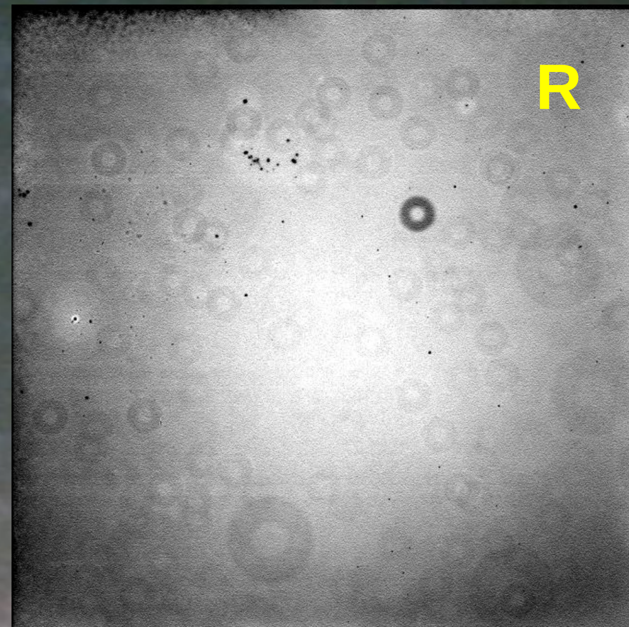
Conclusion: Work hard on your instruments. Then work hard on your data analysis.

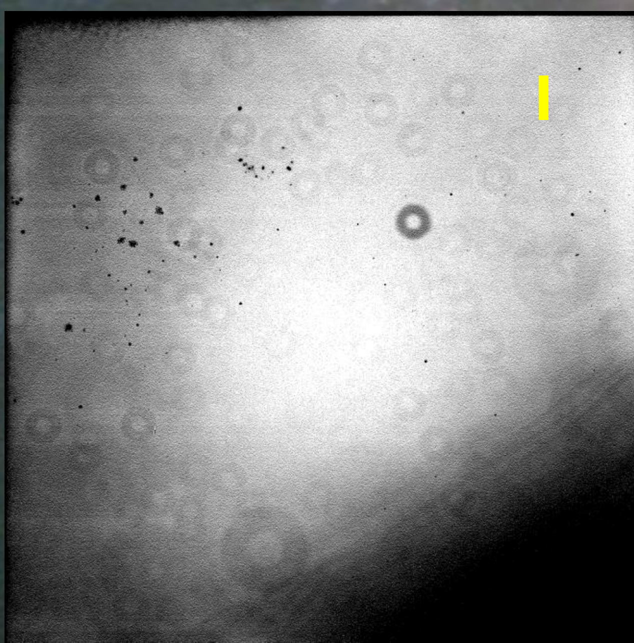
CCD Detectors

Bias
Dark current (esp. with TE cooling)
Gain (small & large scale)
(Non) Linearity
Saturation
Bad pixels/Bad columns/Traps
Residual Charge
Cosmic rays (esp with deep-depletion CCDs, spacecraft)
Harmonic noise
Readout oddities

Flat Fields





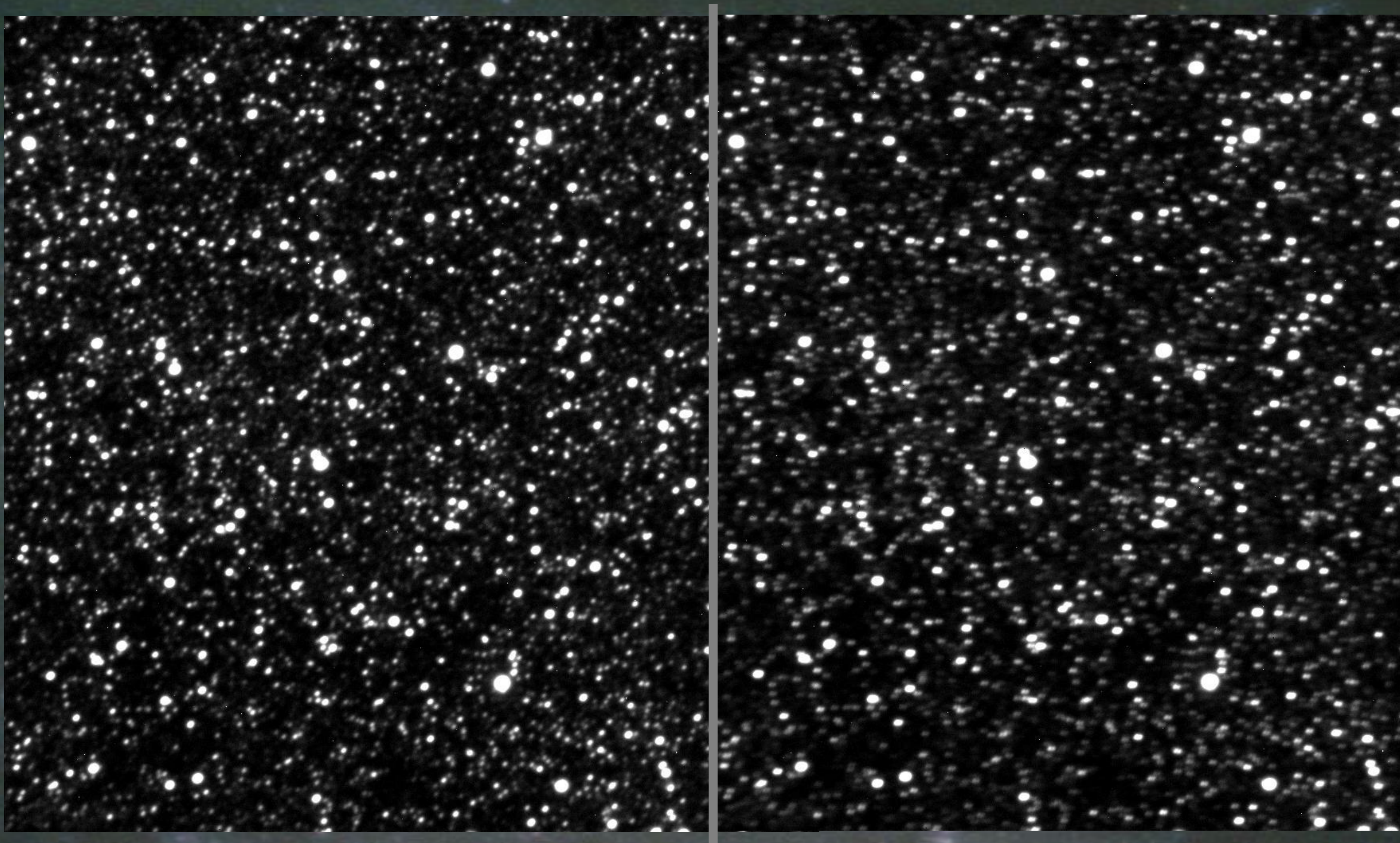


Flat fields are typically messy, color-dependent, and hard to determine well (especially on the large scales). These are sky flats from the Tenagra telescope, with dynamic range of +/- 0.02

Optics, Imaging, and Pointing

Focus
Collimation/Aberrations
Seeing
Pointing Drift/Jitter
Fringing
Filter/detector passband variation

PSF Changes

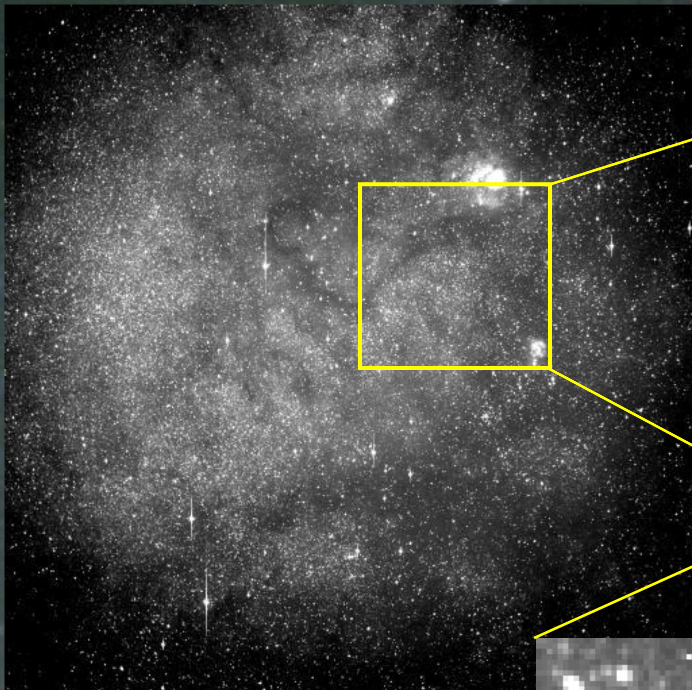


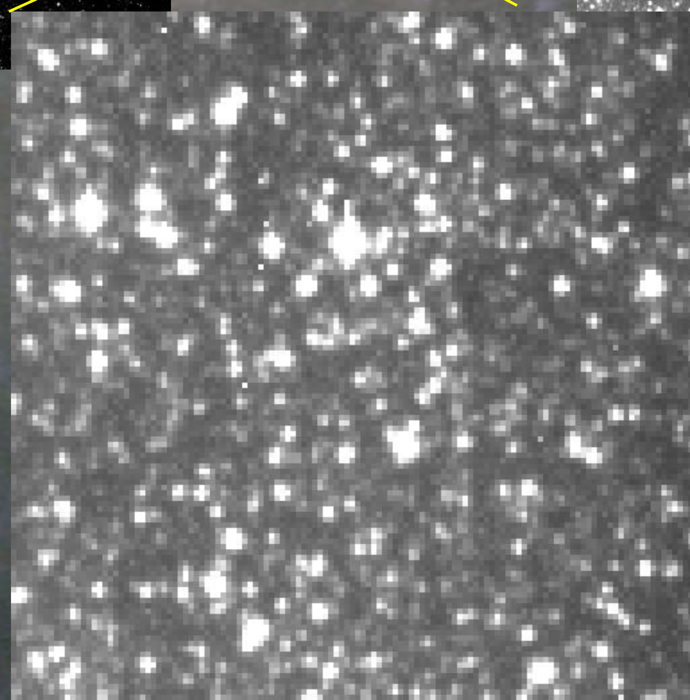
Stuff like this confuses image-subtraction photometry algorithms

Fringing and Readout Anomalies

Fringing in I-band, plus row-wise readout anomalies that change from image to image.

Crowding





Almost always a problem with wide-field searches, and pretty often even with much larger image scales.

Color, Extinction, & Sky

- Rayleigh scattering
- Aerosol scattering/absorption
- Water vapor absorption
- Comparison star colors
- Airglow
- Moon background
- Artificial light background (often line emission)
- Atmospheric dispersion
- Differential atmospheric refraction
- Differential abberration of starlight

Characterizing TrES-3

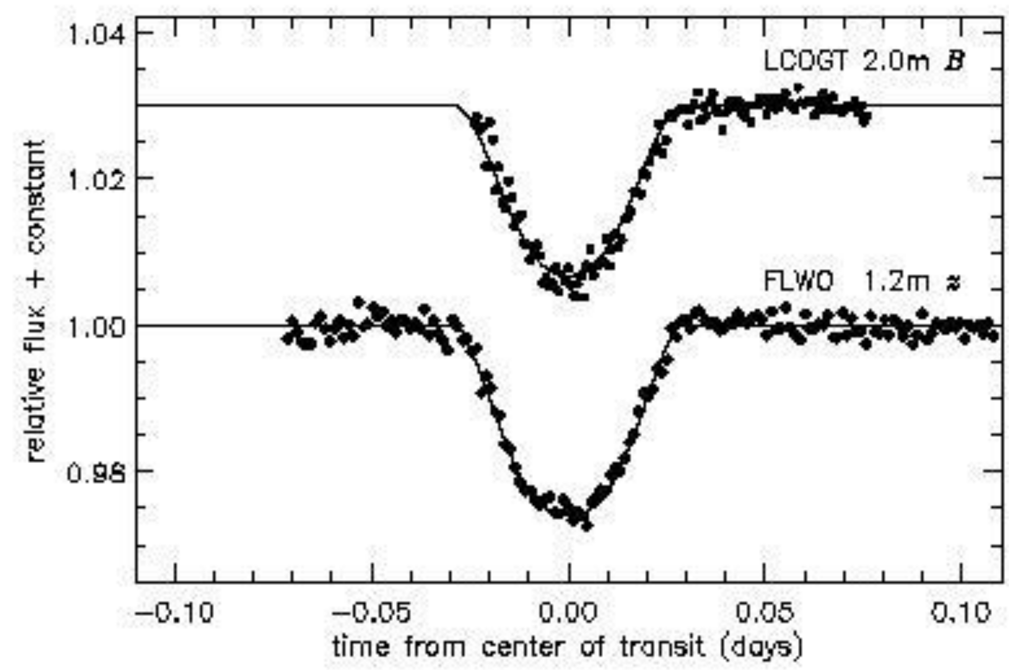


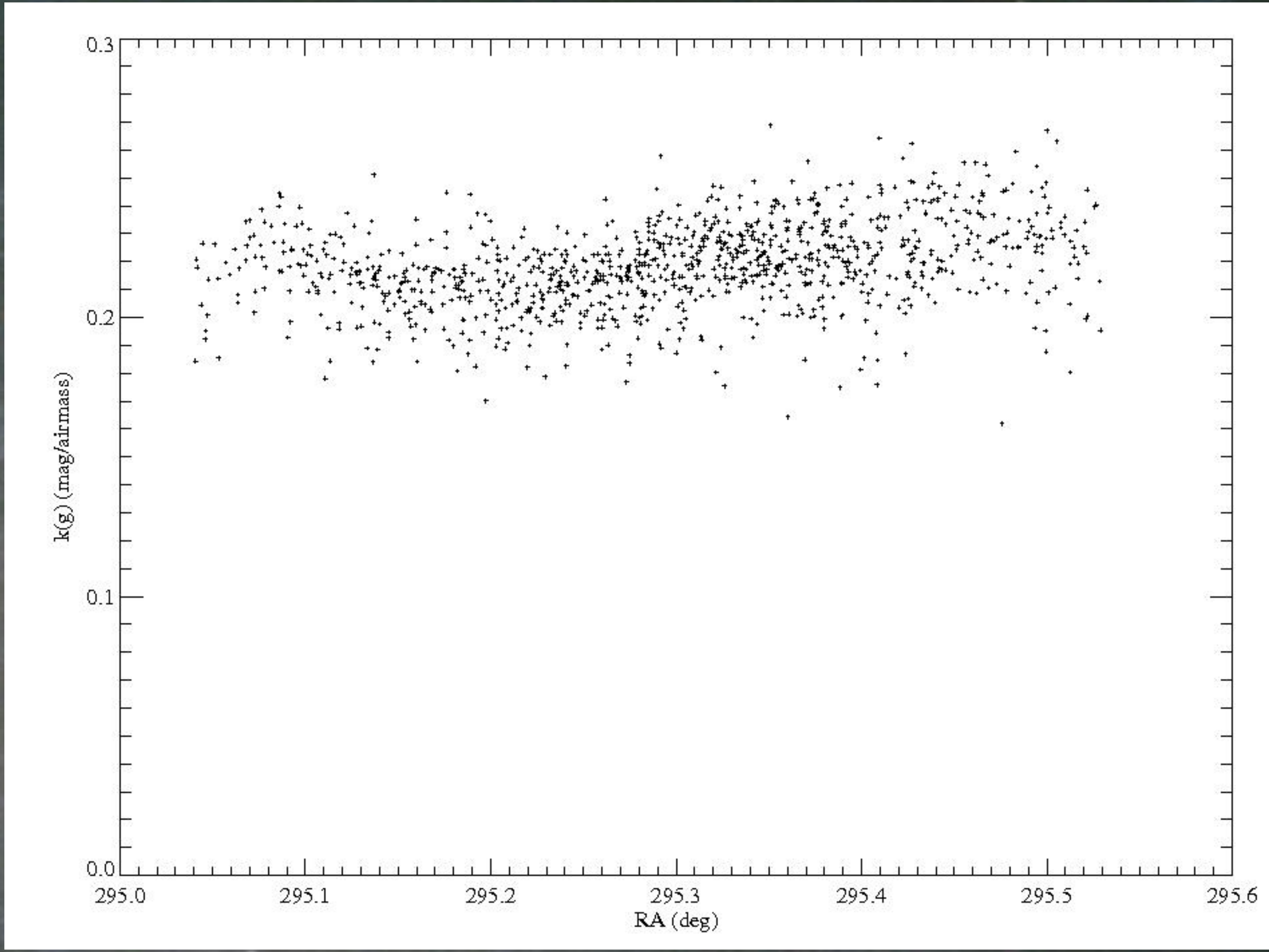
Fig. 2.— Relative flux of the TrES-3 system as a function of time from the center of transit, adopting the ephemeris in Table 3, and including the residual color–dependent extinction correction (§3). Each of these follow-up light curves is labeled with the telescope and filter employed. We have overplotted the simultaneous best–fit solution, adopting the appropriate quadratic limb–darkening parameters for each band pass.

O'Donovan et al. (2007)

Bandpass vs spatial position

Extinction per unit airmass for Keplercam data in SDSS g band, shown as a function of RA (!?!).

The only plausible explanation that occurs to me is that the system bandpass varies substantially with position in the camera FOV.

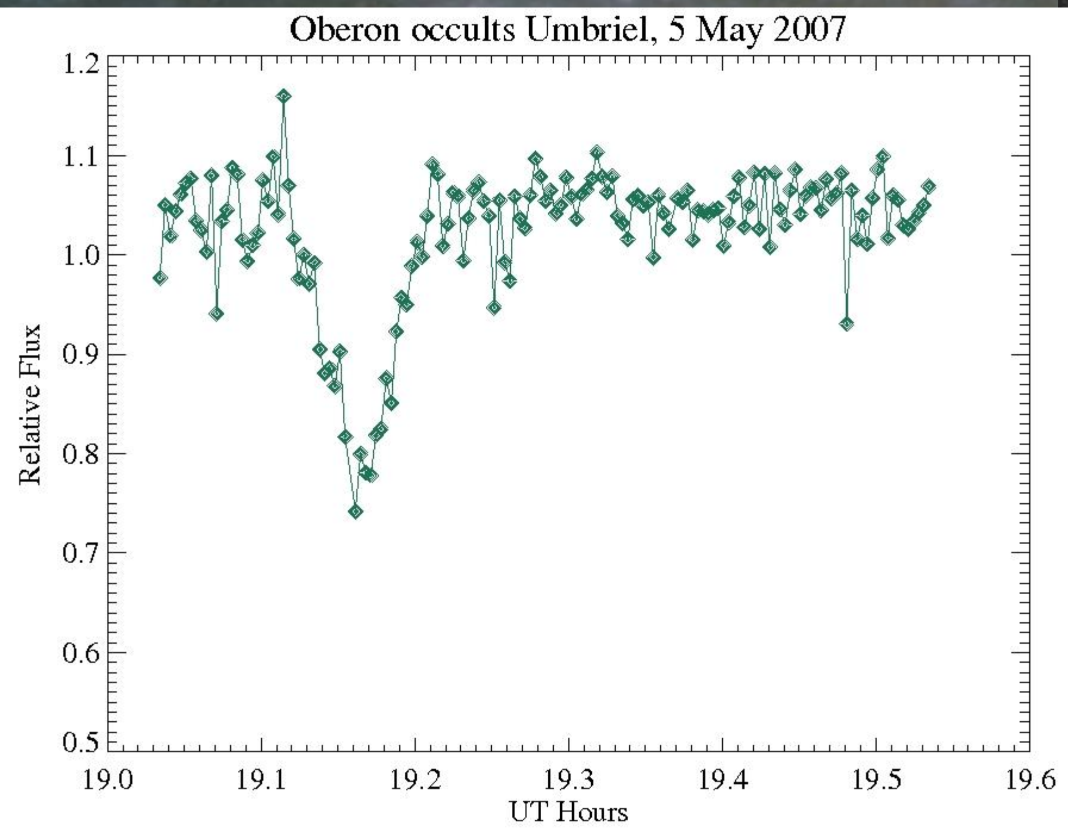


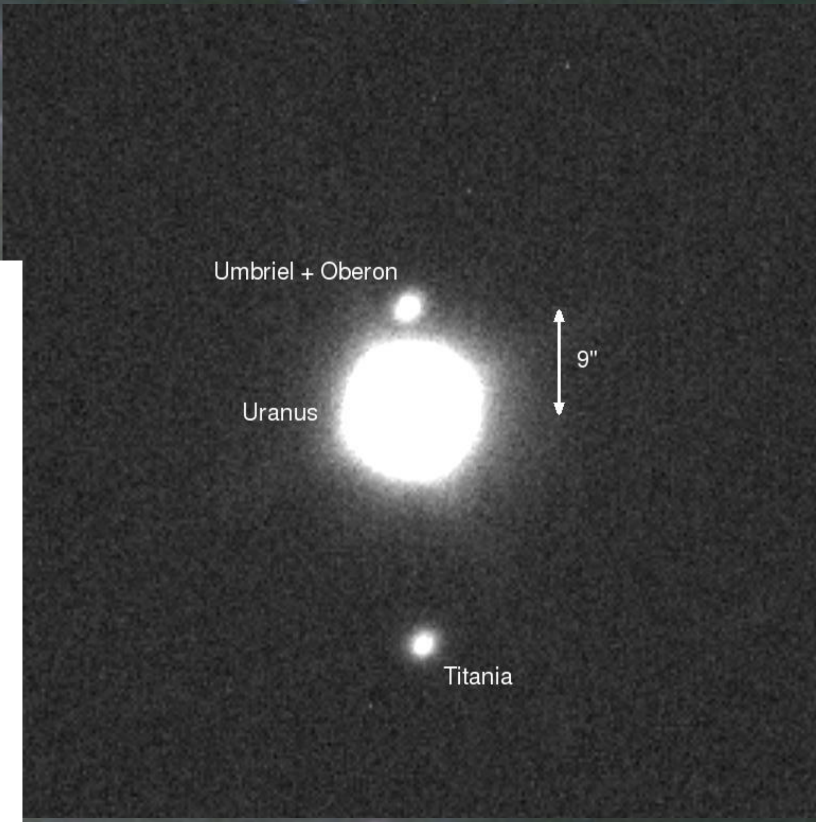
Astronomy Stuff

Crowding/PSF changes!
Crowding/PSF changes!
Hierarchical triple star sysetms
Crowding/ Natural variability
Asteroids
Meteor/satellite/airplane trails

Mutual Events of Uranian Moons

A. Christou, Armagh Obs.
M. Hidas, LCOGT





Conclusions and Hints

The most important error sources vary profoundly from one kind of observation to another.

Be careful about basic CCD calibrations. They're cheap (except for getting good flats) but important. Understand your detector.

Use image-subtraction photometry whenever you can. But note it is a bad idea for high-S/N out-of-focus applications.

Use post-processing (SYSREM or de-correlation) to take residual noise out of time series.