Rubin Observatory

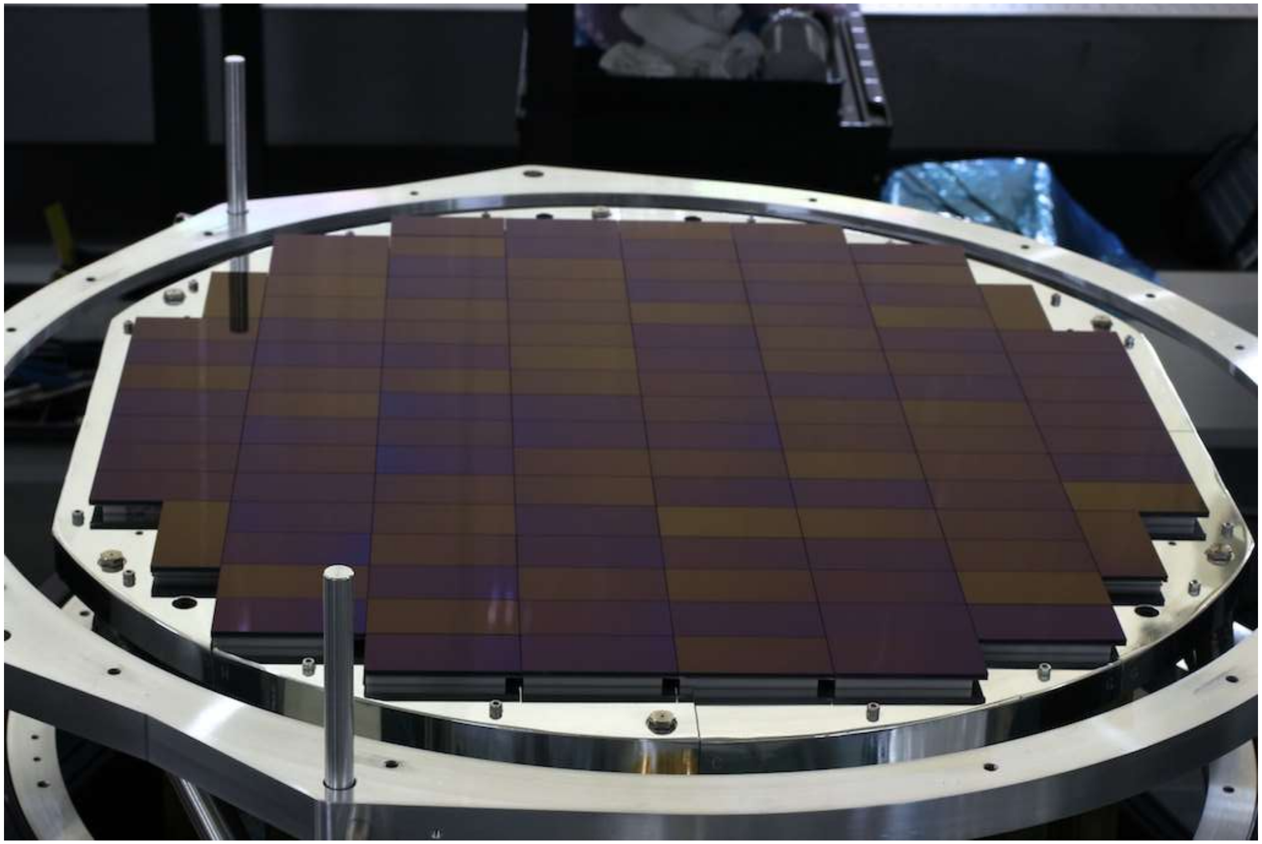
Project plans for ISR and Atmospheric Characterisation

Robert Lupton, Princeton University
LSST Pipeline/Calibration Scientist

2020-03-17

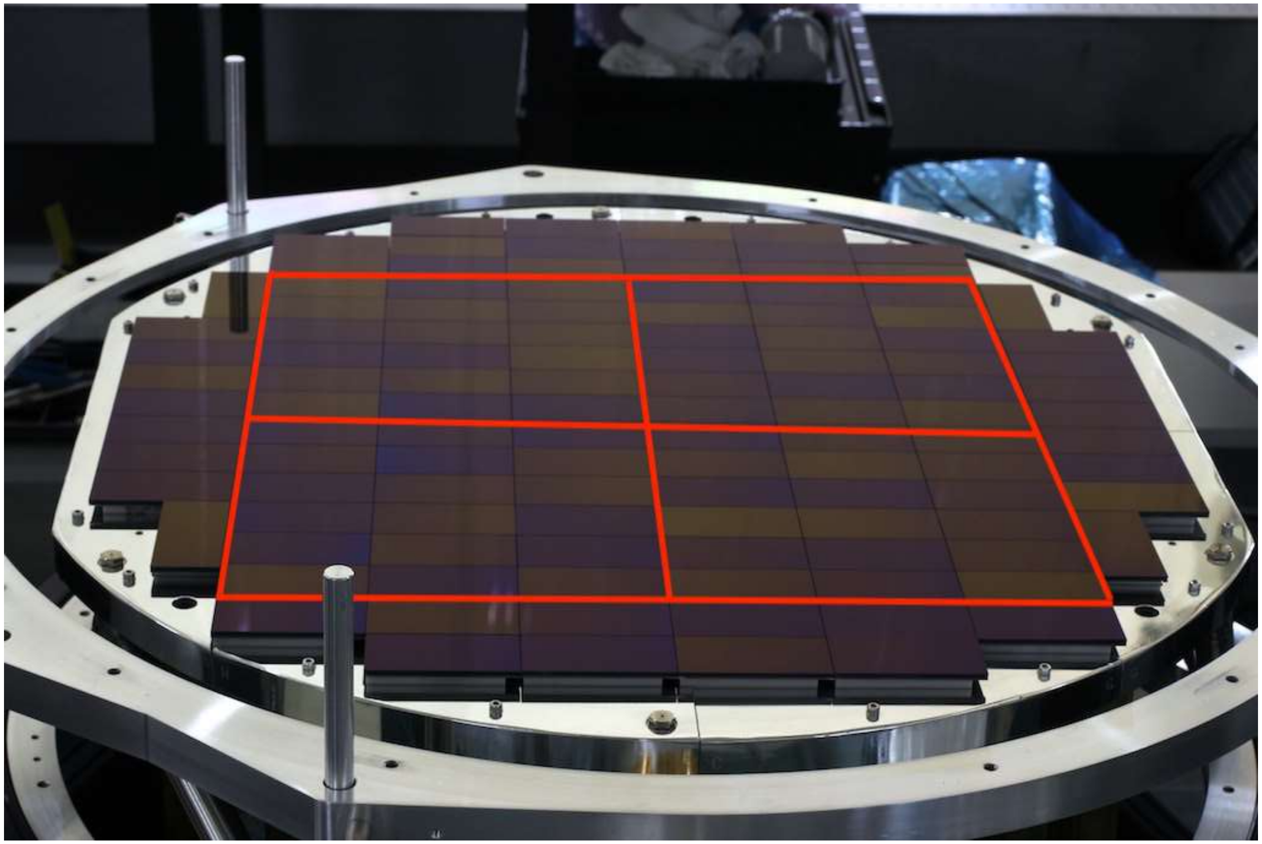
Rubin Algorithm Workshop, 17-19th March 2020

HSC



112 2k×4k Hamamatsu 15 μm CCDs (*cf.* 62 4k×4k LSST 10μmCCDs)

HSC



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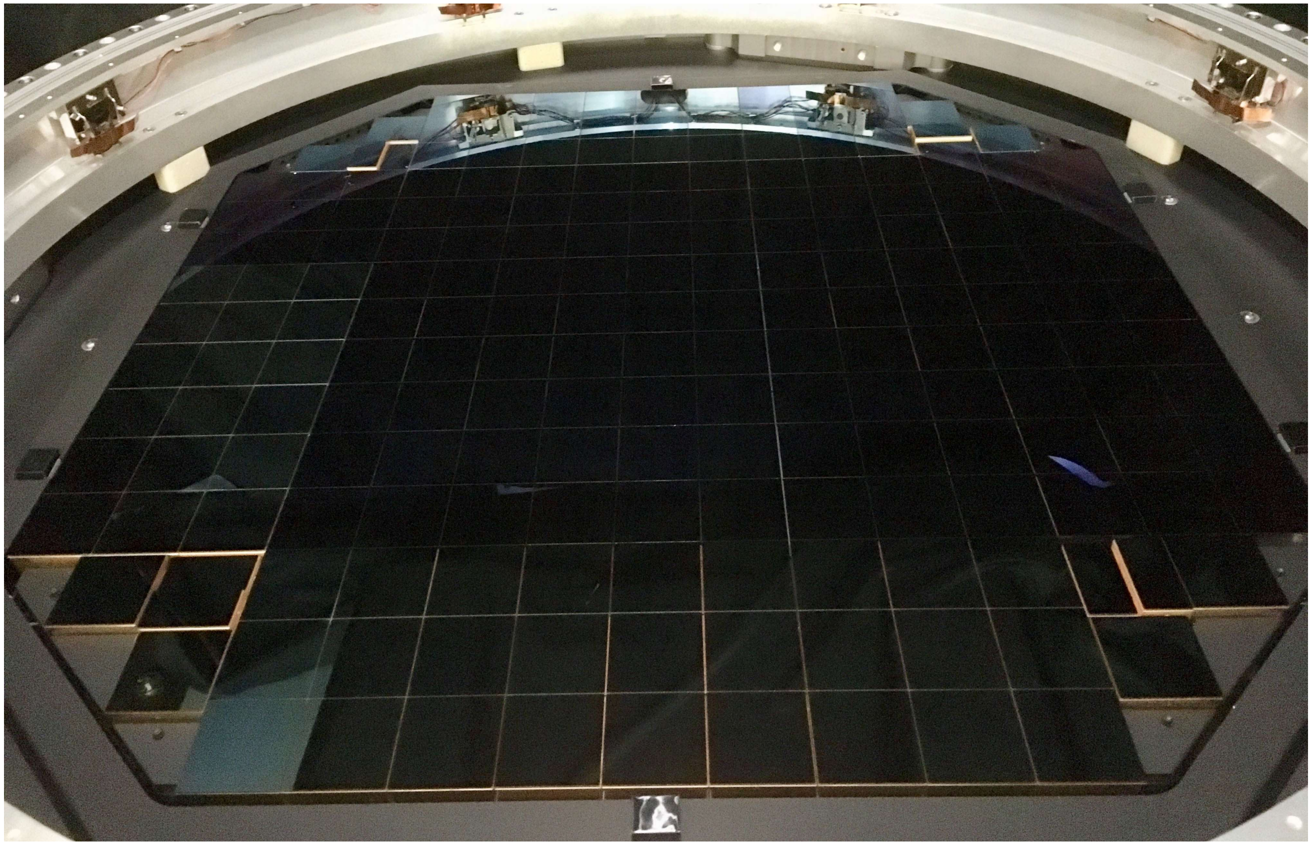
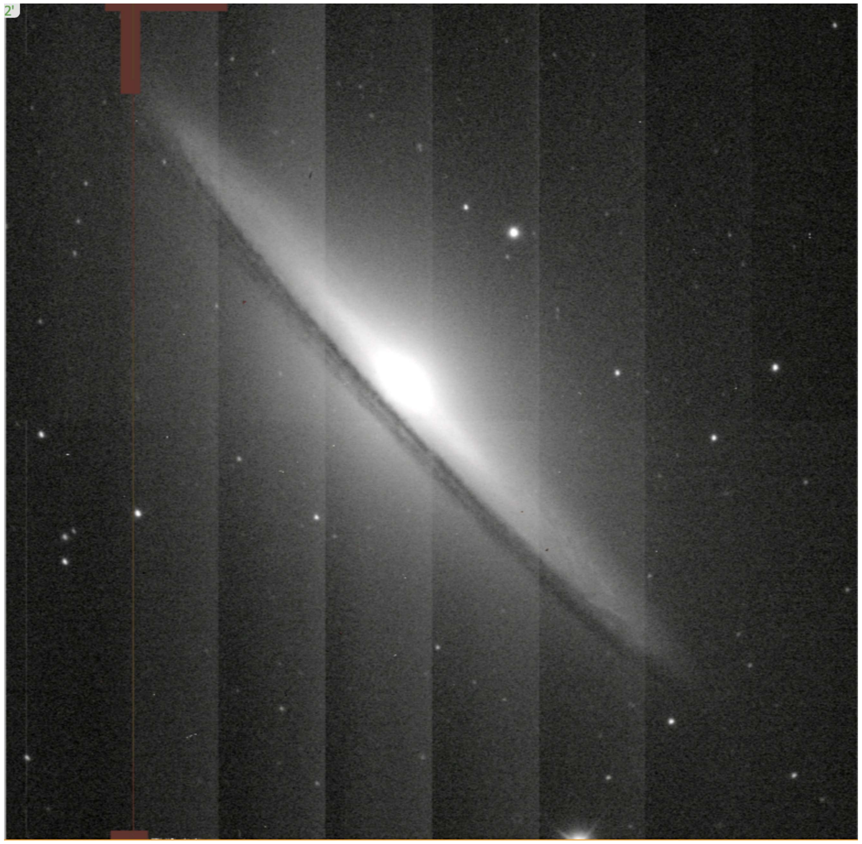


(189 + 12) 4k$\times$4k E2V/ITL 10 μm CCDs

AuxTel; M104



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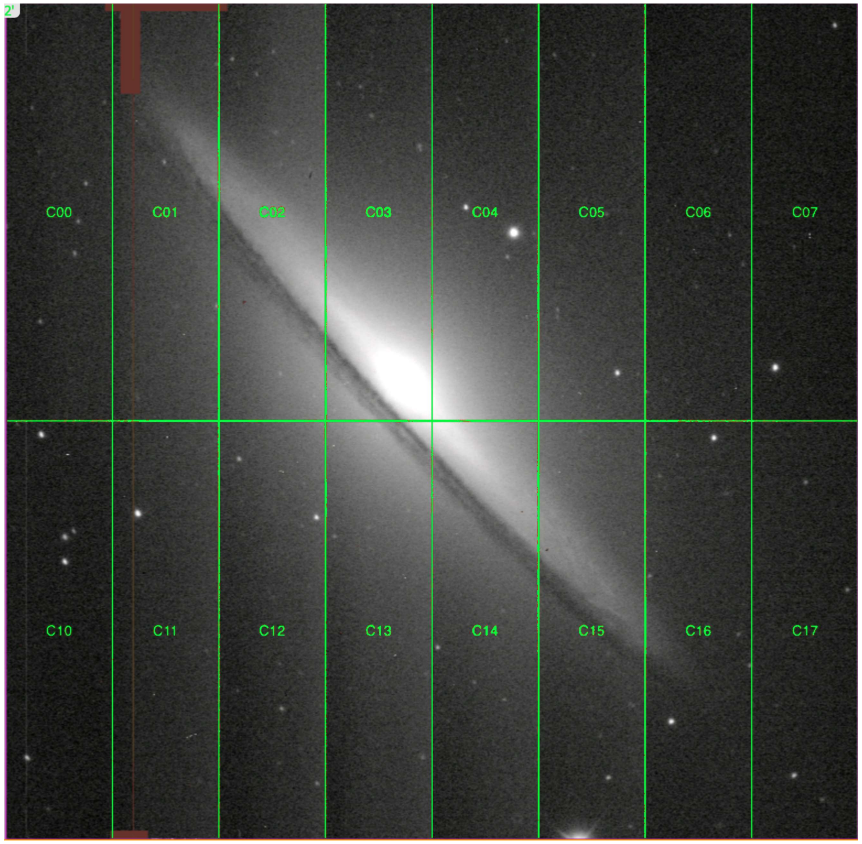

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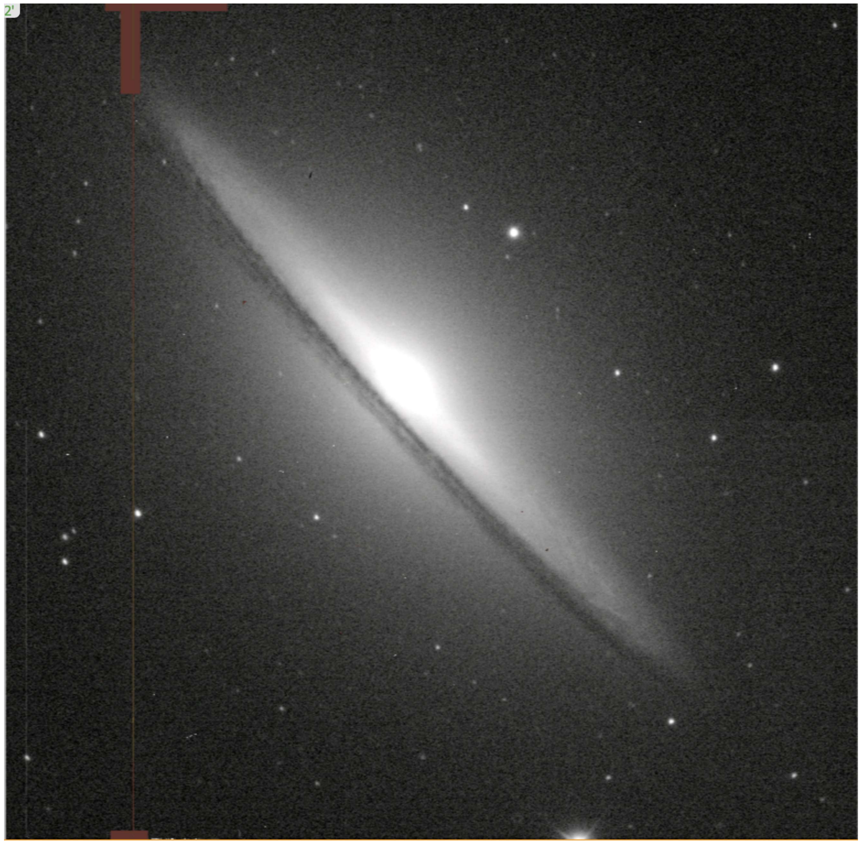

4k×4k ITL 10 μm CCD

bias subtracted

Instrumental Signature Removal

Photons per second per pixel:

$$F_i'(\nu) = \frac{1}{h\nu} F_{\nu,i} S^{atm} A S_b^{tel} (\partial\theta/\partial u)(\partial u/\partial x) S_i^{CCD} \tag{4.1a}$$

Electrons per pixel

$$C_i = \sum_k a_{i-k} \left[\sum_j K_{i-j} \left[F_j' t\mathrm{exp} + \epsilon_P(F_j' t\mathrm{exp}) \right] \right] \left[\sum_j K_{k-j} \left[F_j' t\mathrm{exp} + \epsilon_P(F_j' t\mathrm{exp}) \right] \right] + D_i t_{\mathrm{dark}} + \epsilon_P(D_i t_{\mathrm{dark}}) \tag{4.1b}$$

Electrons at the sense node: ($n.b.$ C_i and thus C_i' includes the Poisson noise)

$$C_i' = \kappa_i(C_i) + [1 - \kappa_i](C_{i+1}) \tag{4.1c}$$

Voltage at the sense node ($n.b.$ C_i' and thus U_i includes the noise in C_i):

$$U_i = G_{SN}(C_i') \tag{4.1d}$$

Digitized signal ($n.b.$ U_i includes the noise in C_i'):

$$I_i = G_A(G_C(\sum_l [\delta_{il} + c''_{il}][G_p(\sum_k [\delta_{lk} + c'_{lk}][G_F \left(\sum_j [\delta_{kj} + c_{kj}][U_j + B_j + \epsilon_{N,j}] \right) - \overline{B}_k]) + \epsilon_{p,l}] + B_i')) \tag{4.1e}$$

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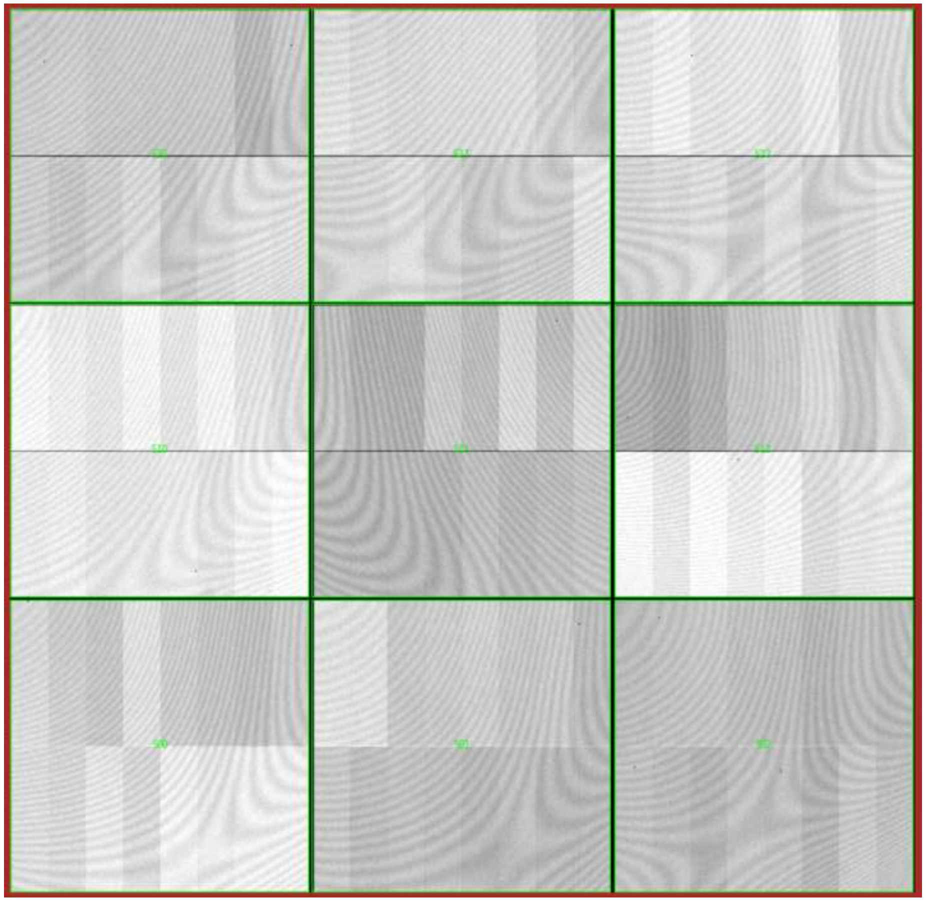

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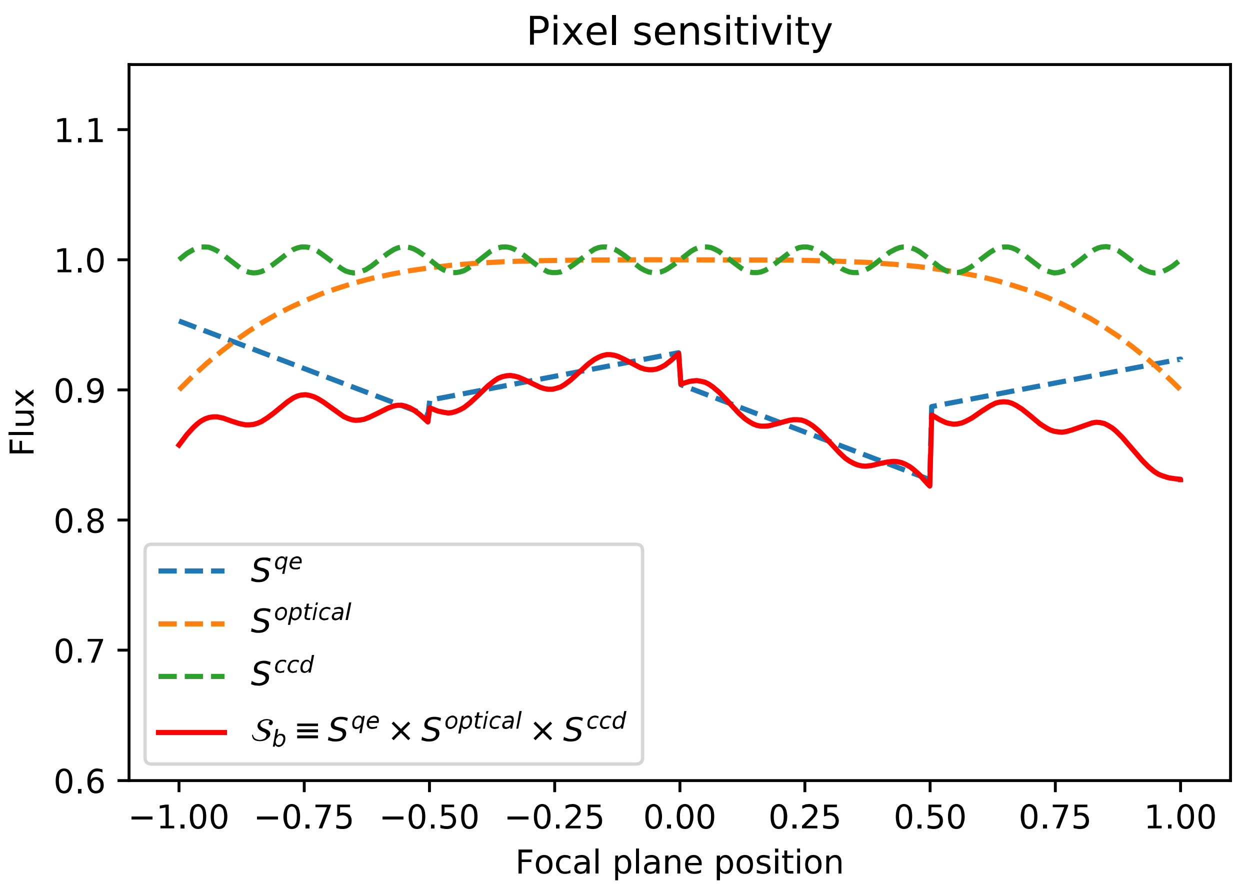
You may be thinking, "That's what a flatfield is for!"

What's in a flat field?



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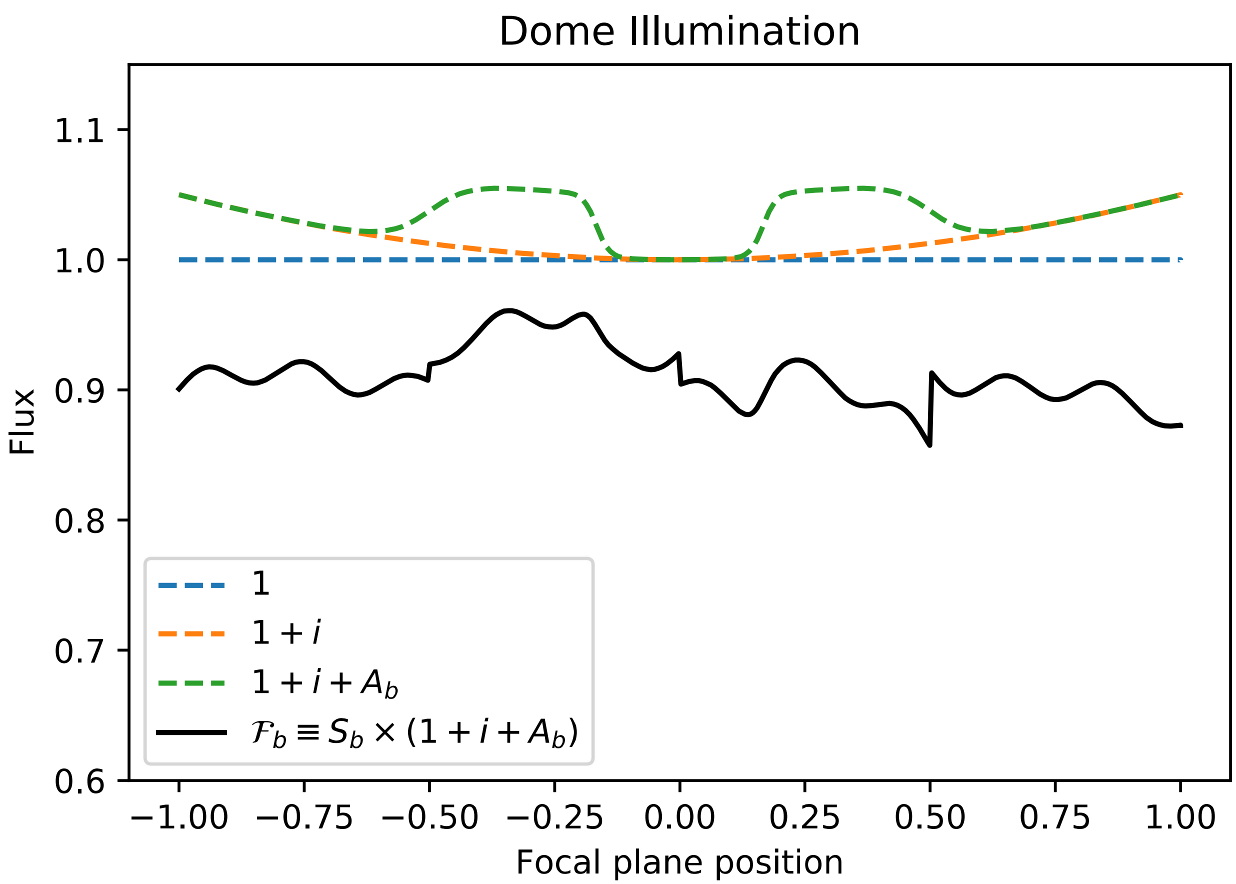

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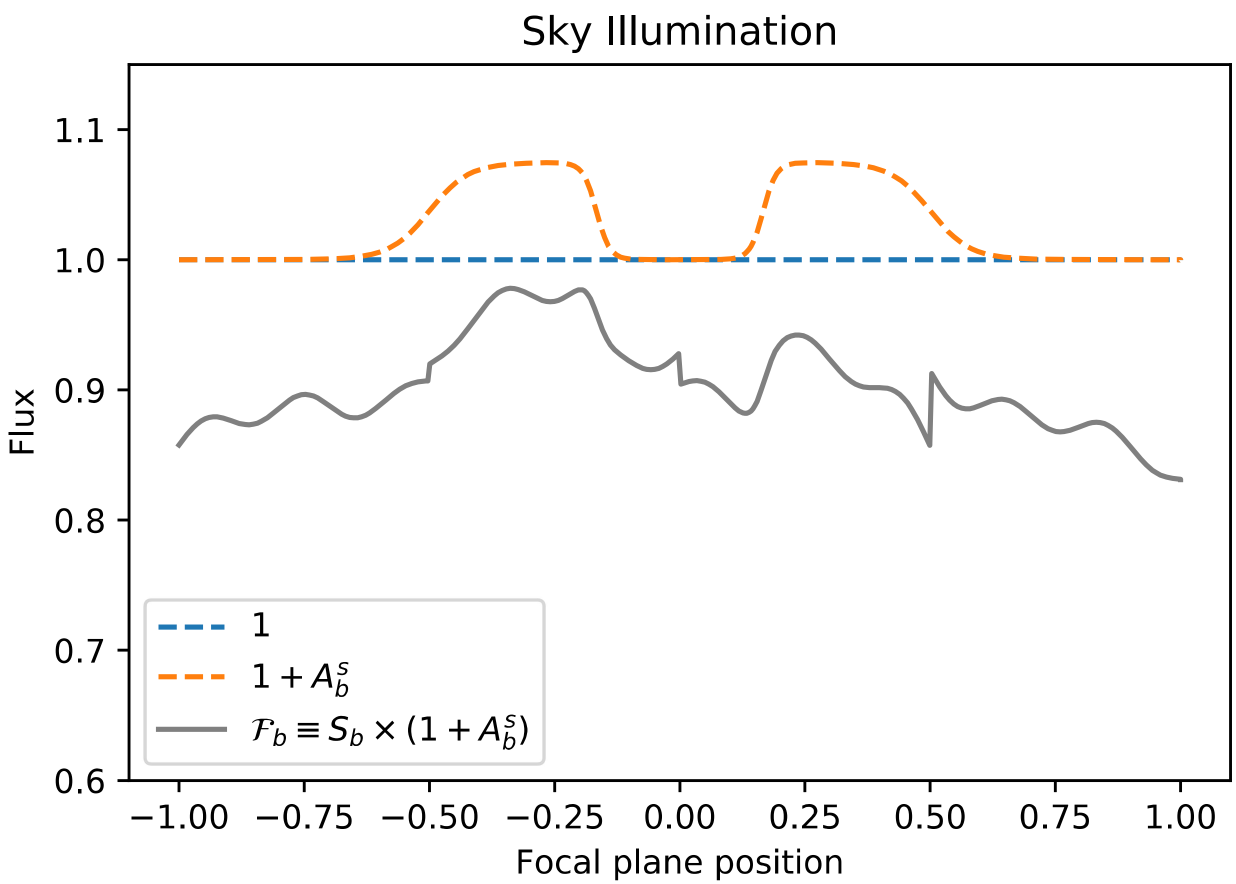

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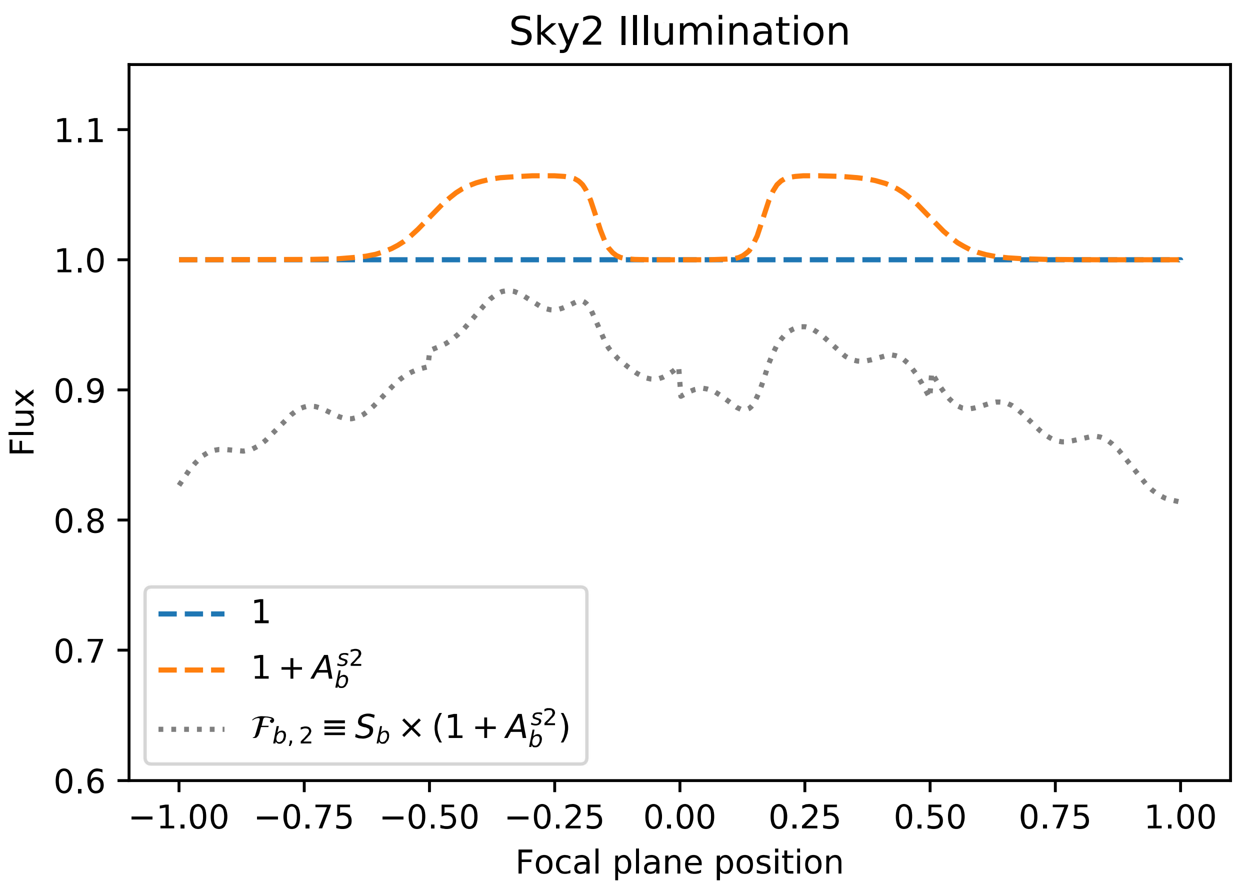

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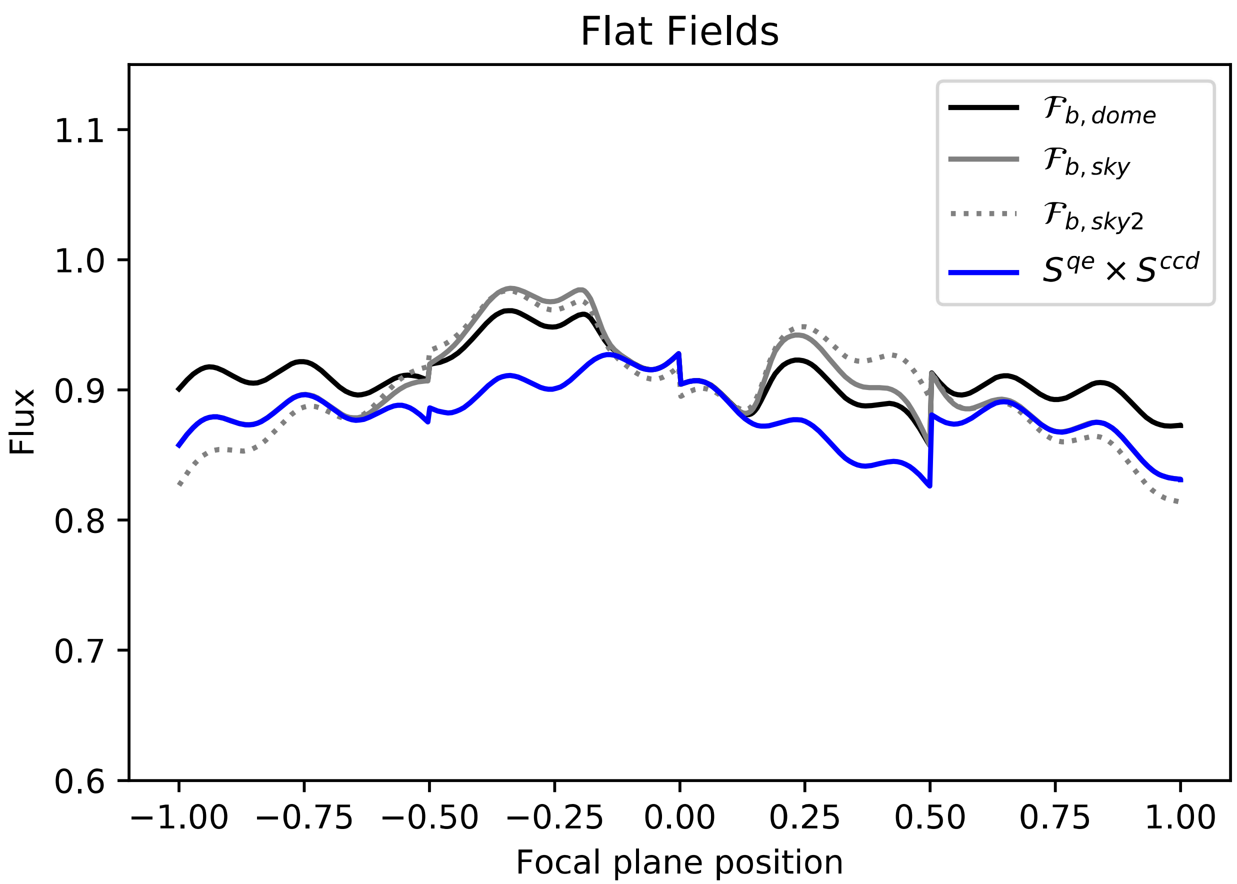

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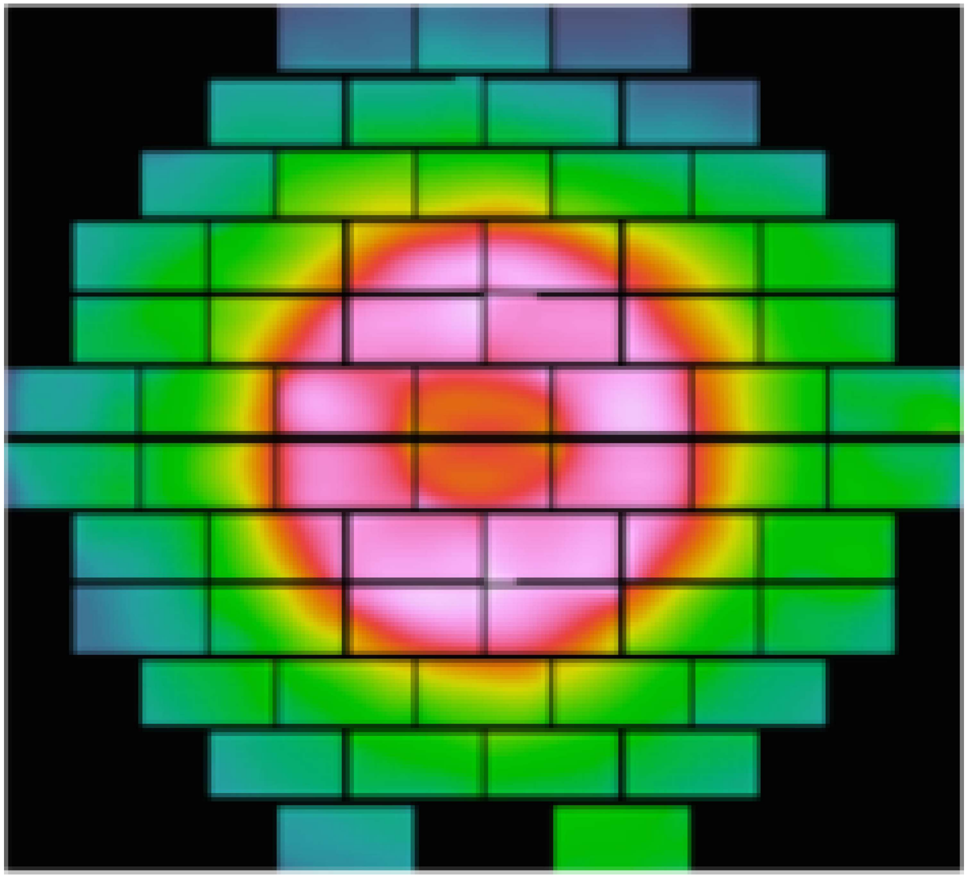
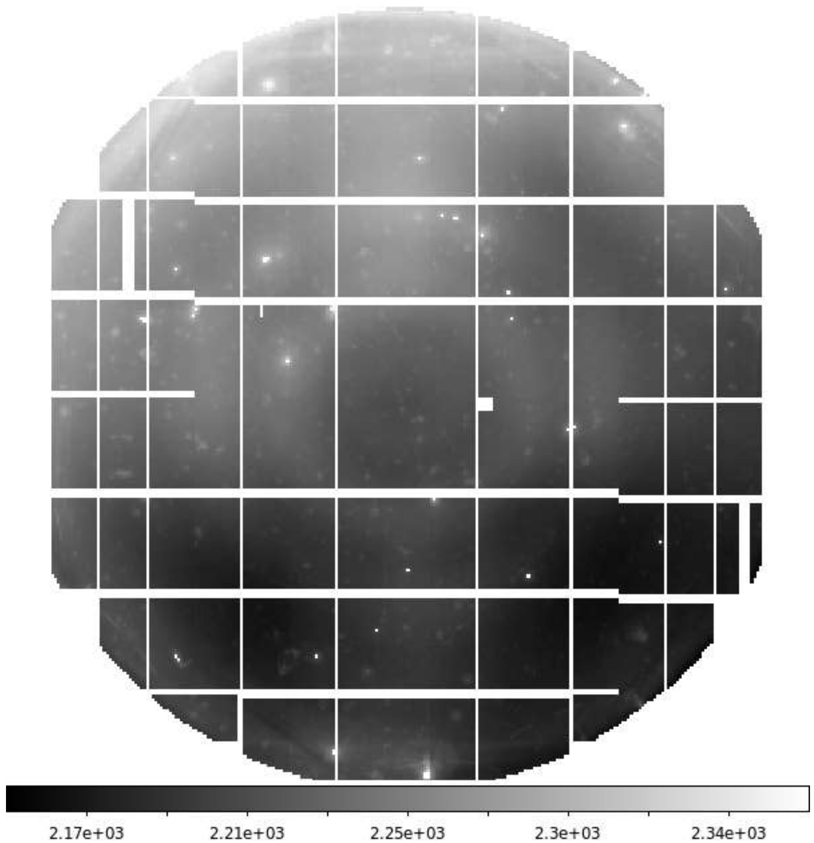


DES *g* star flat (Bernstein et al.)

Flatfielding



HSC *i*; visit 1330 flatfielded using dome flats; 300s

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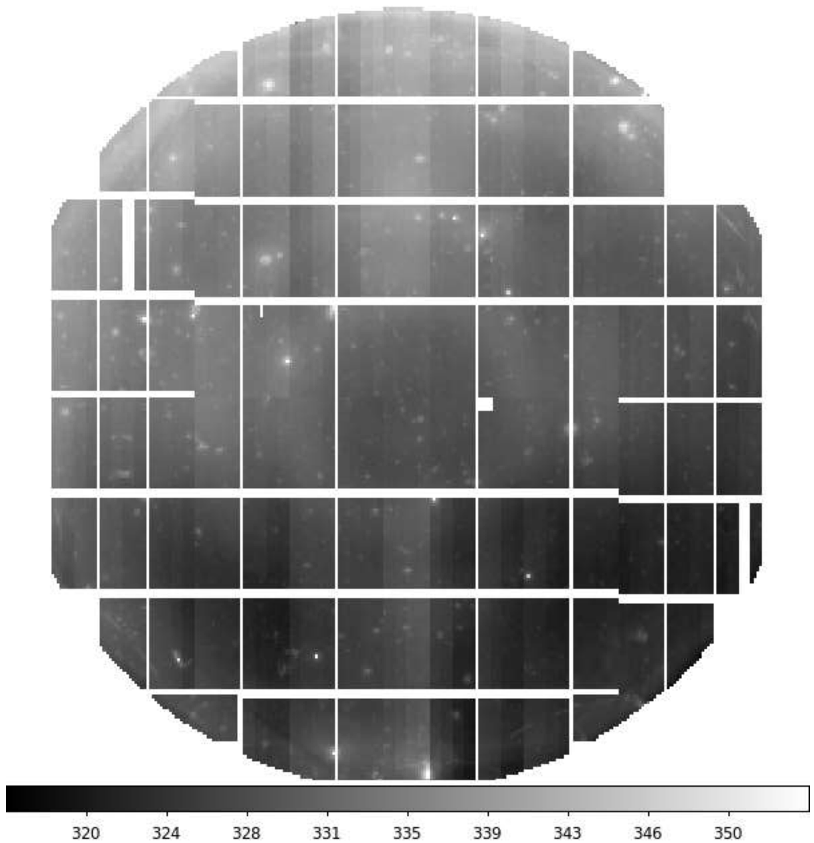

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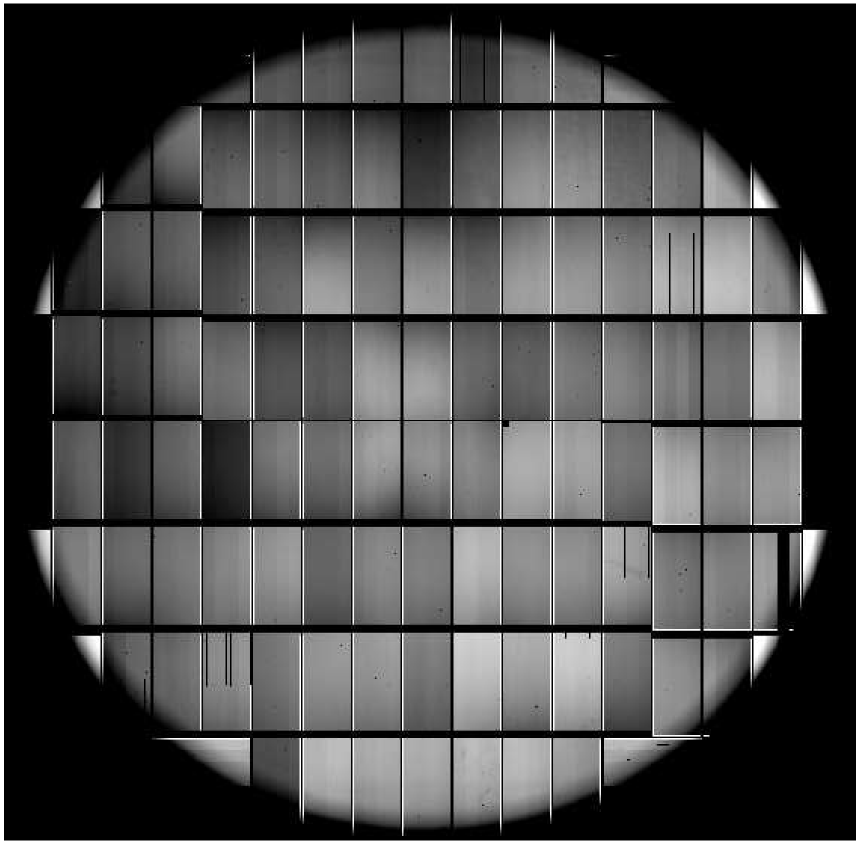

HSC g $\pm 7\%$; overscan, gain, QE, vignetting, Jacobian, corrected; Dome

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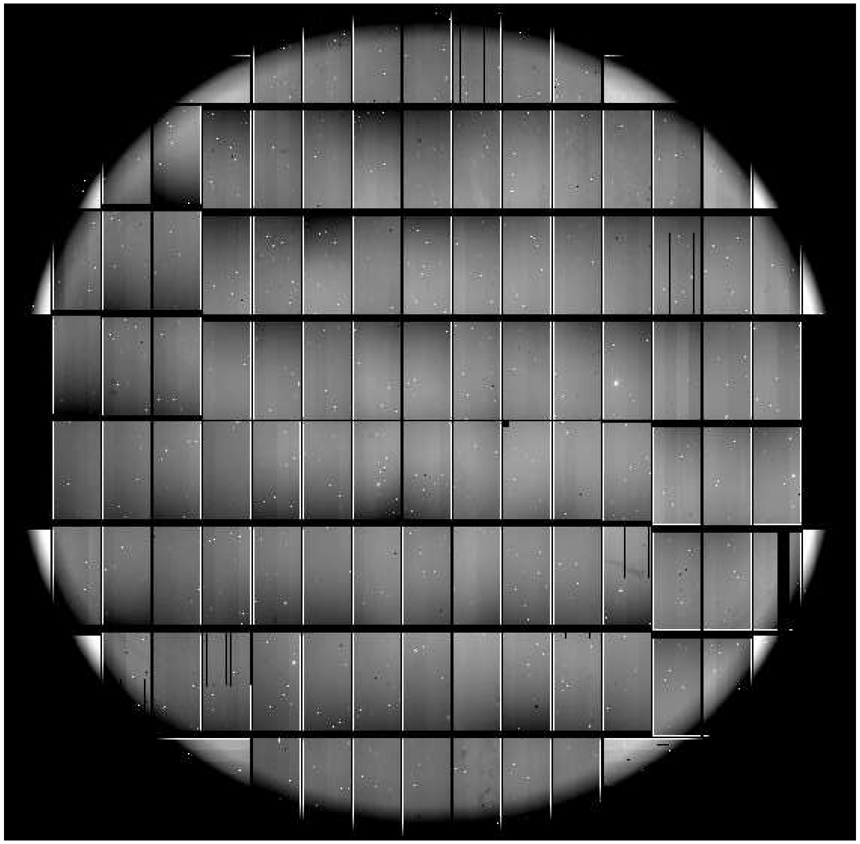

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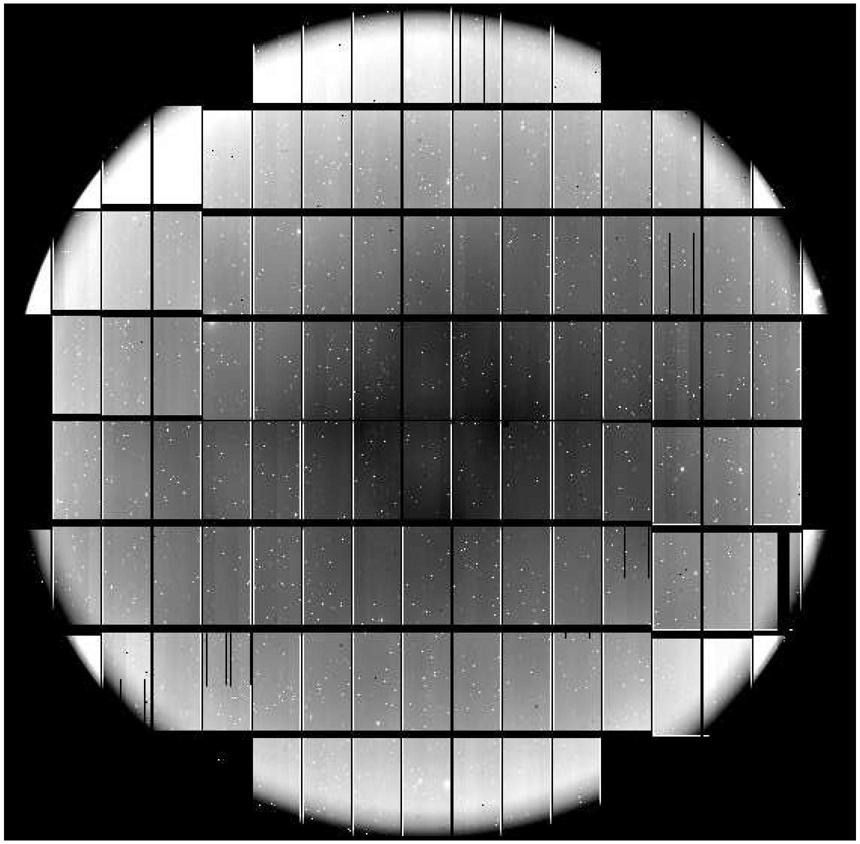

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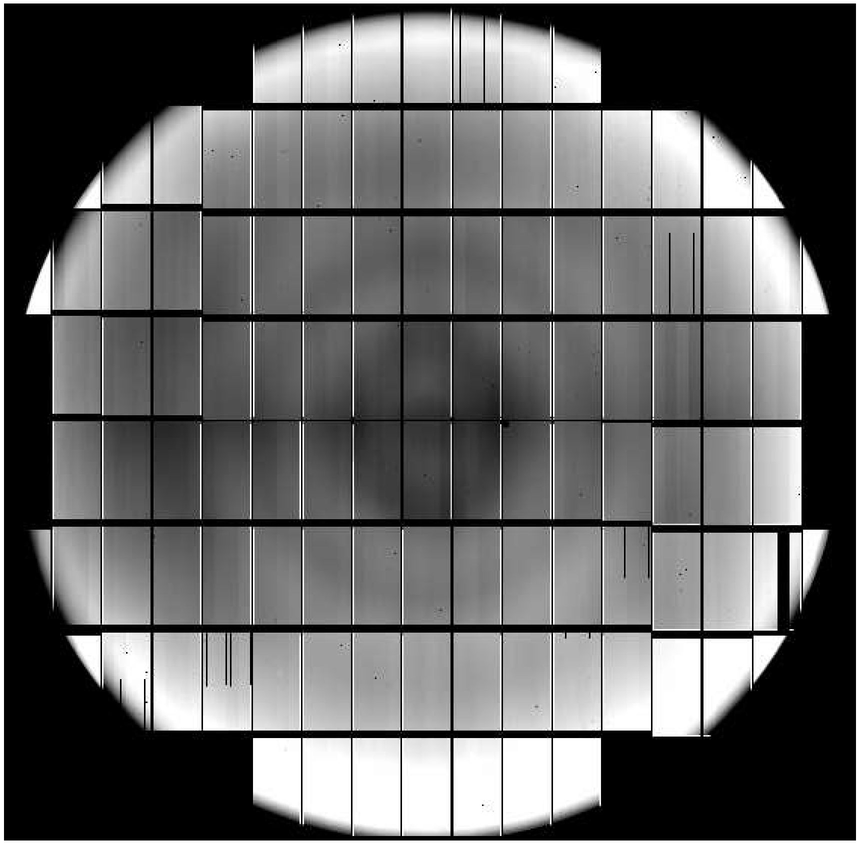

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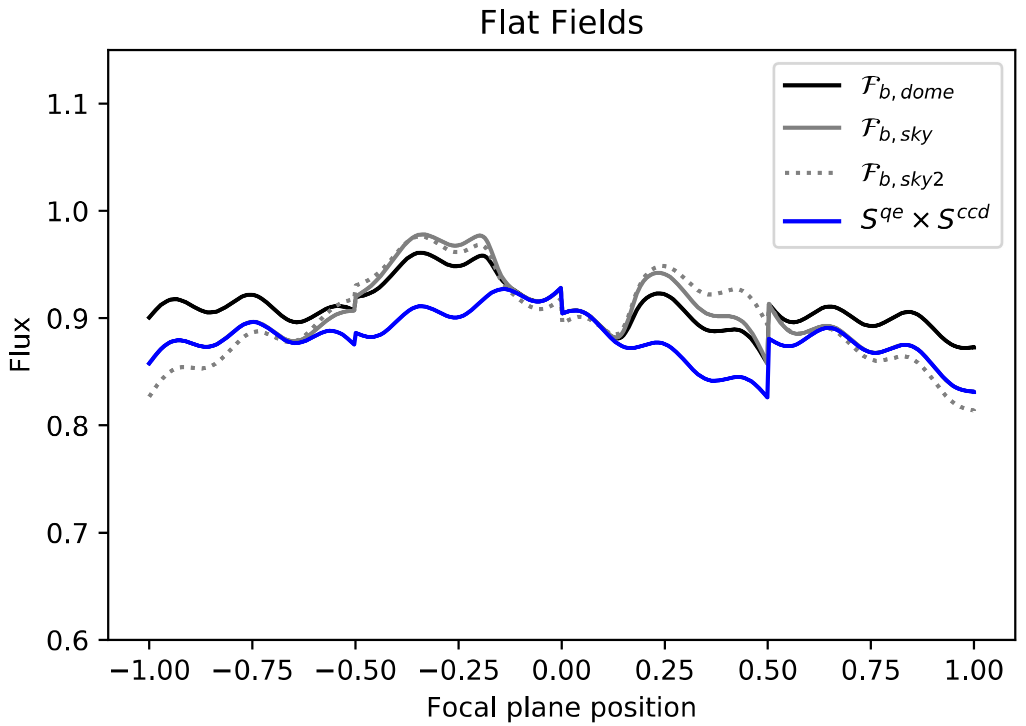

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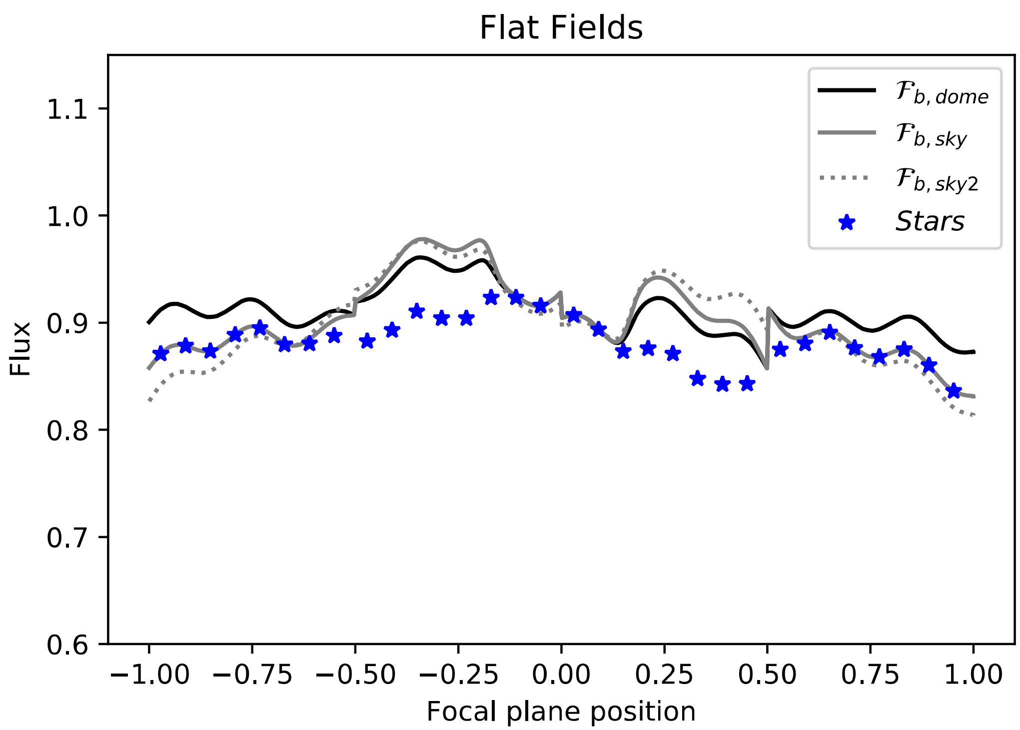

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Flatfielding in LSST

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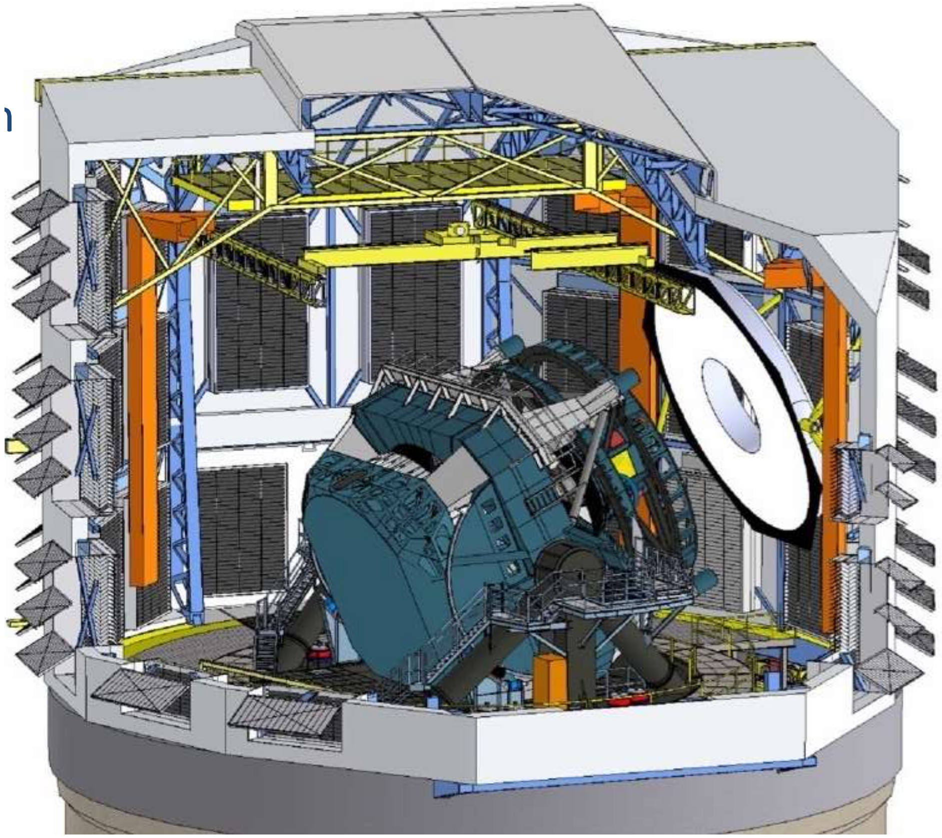

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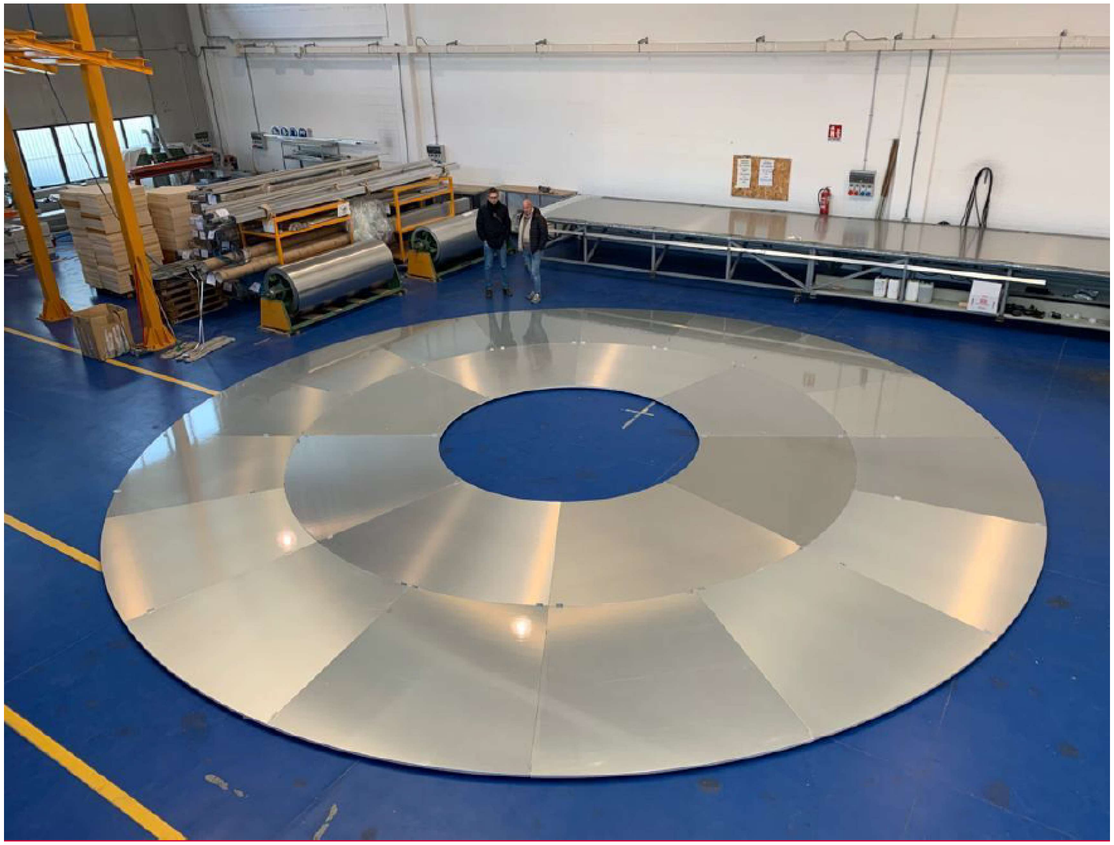
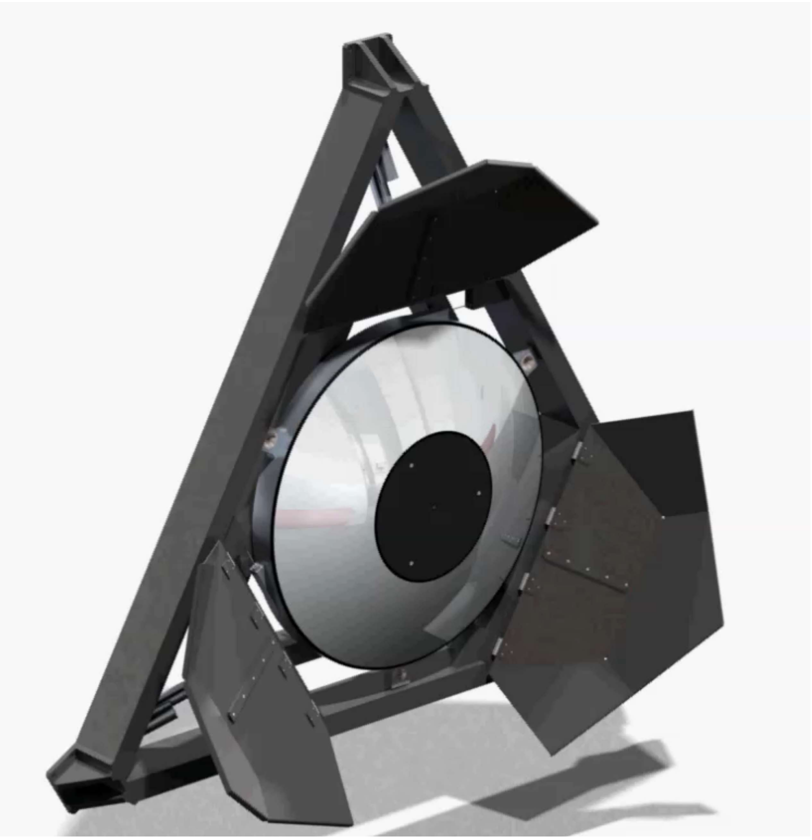
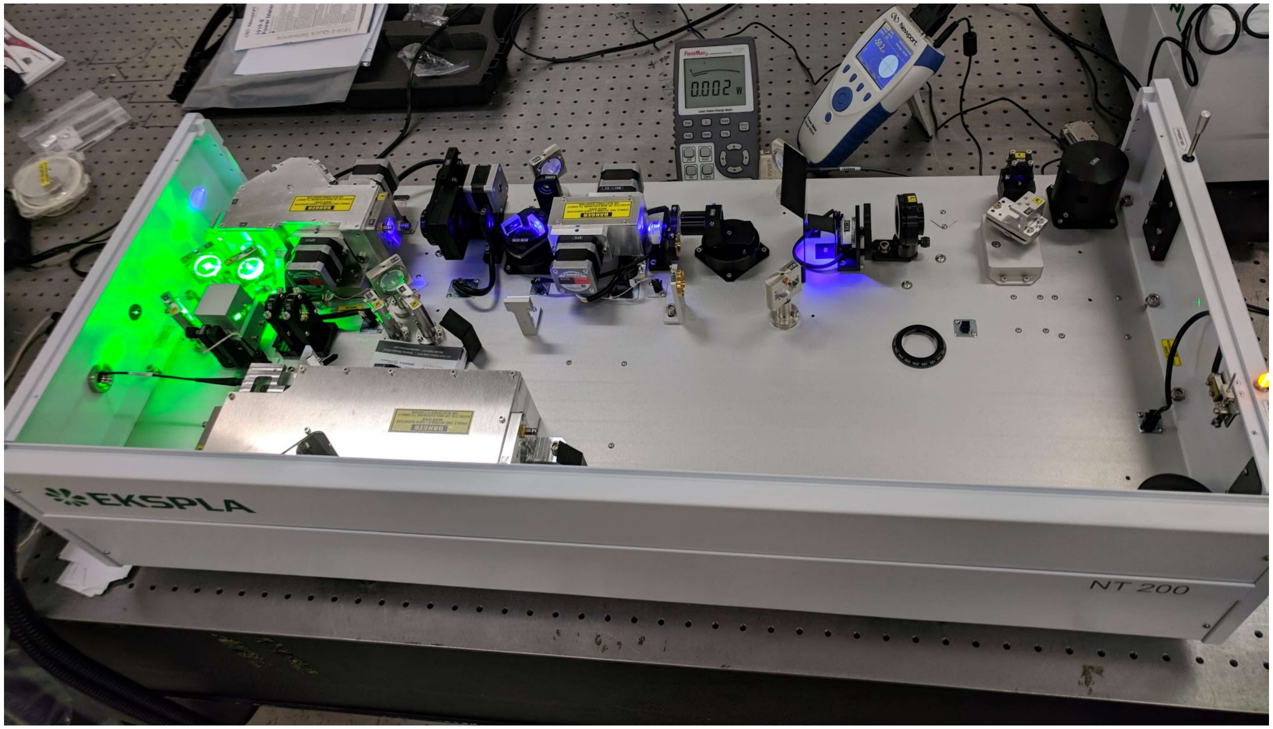




Flatfielding in LSST

At the Rubin Observatory we'll have a flatfield screen.
And a class IV tunable laser.



I.e. we can measure a set of monochromatic (dome) flats.

Flatfielding in LSST; the CBP

We'll also be able to separate direct from ghost/ghoul light using the Collimated Beam Projector, the *CBP*.

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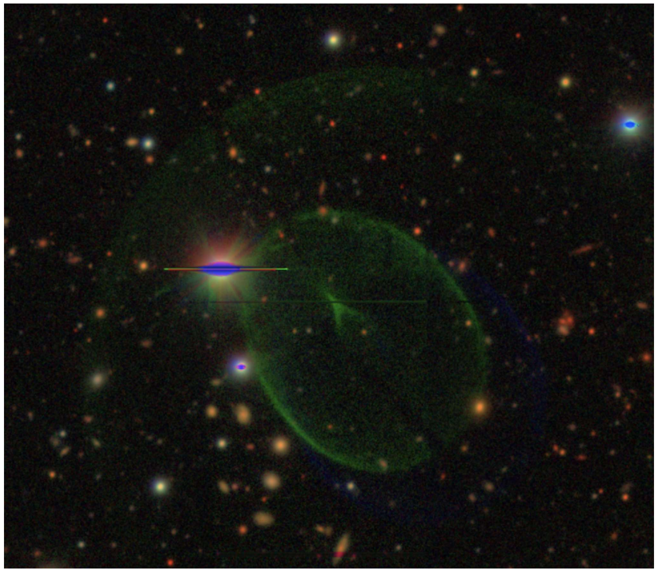
- Ghost: deterministic unwanted light due to partial transmission and reflection of light at optical surfaces
- Ghoul: unwanted light that ray-tracing codes cannot predict, e.g. scattering off baffles



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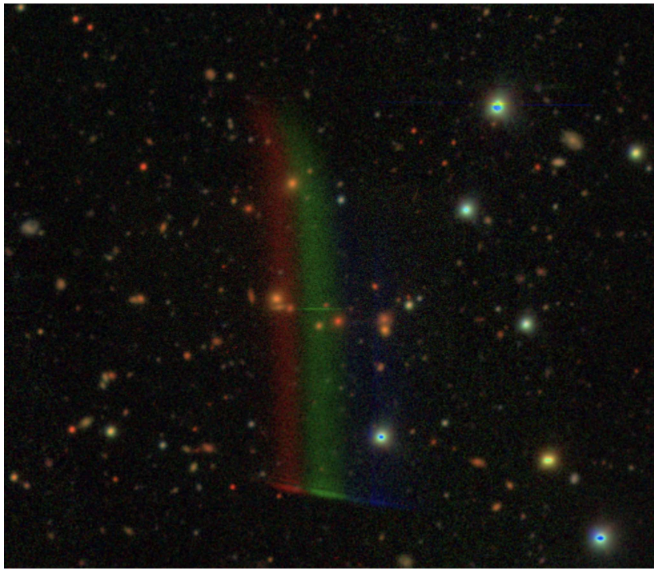

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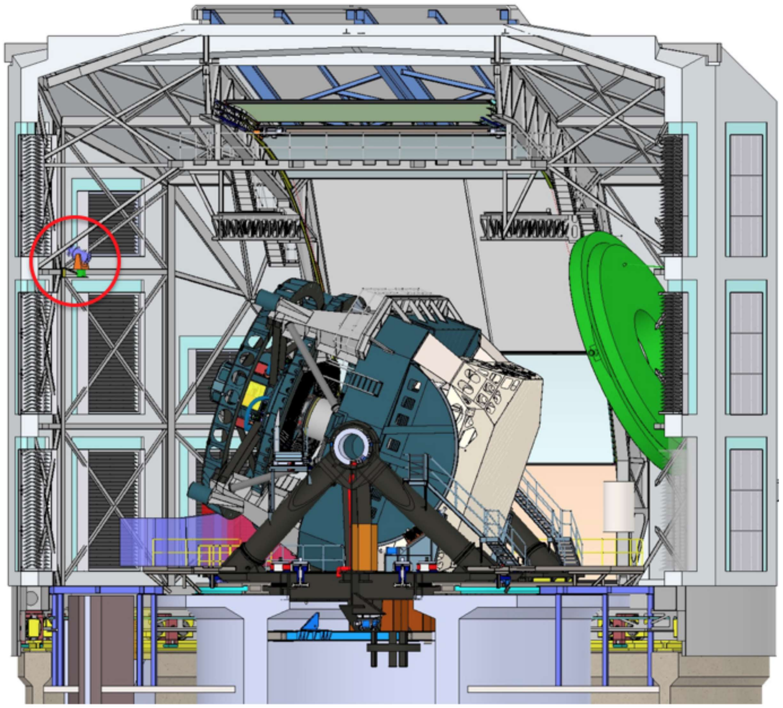

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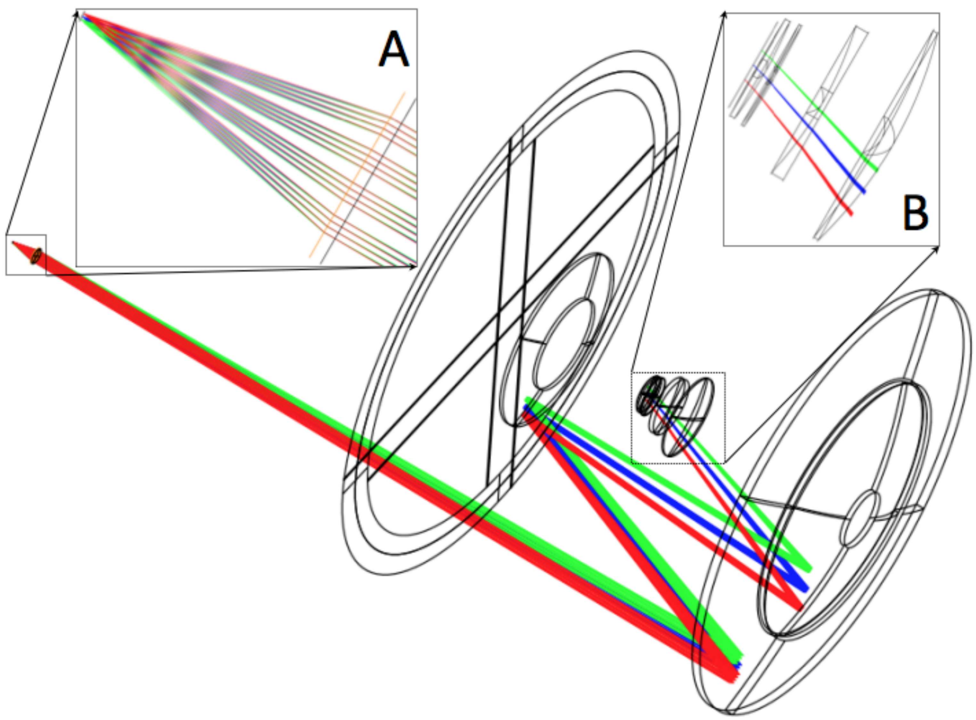

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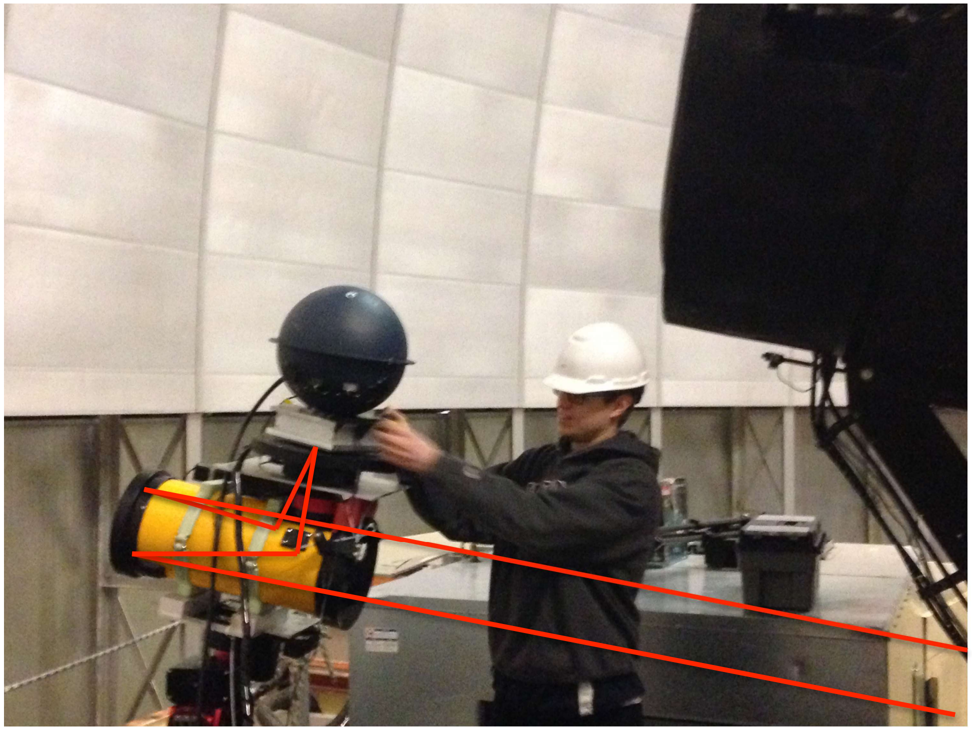

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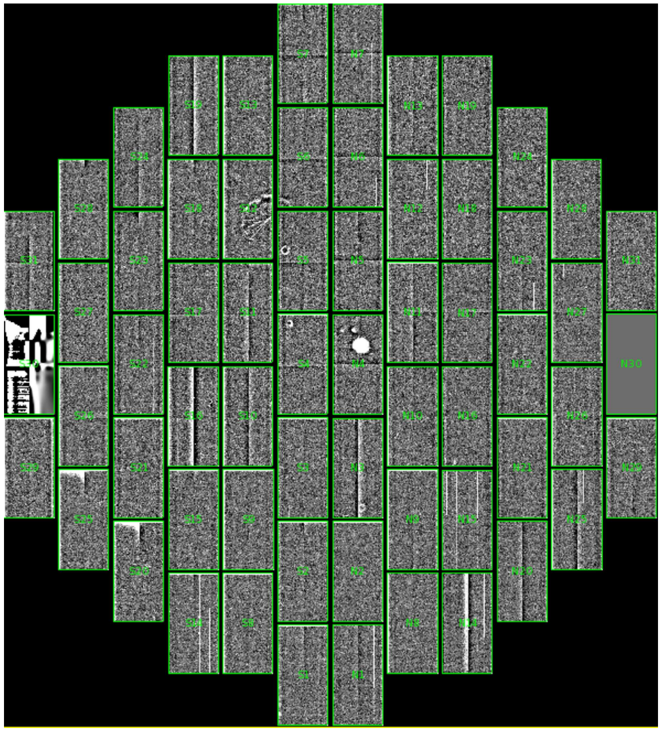

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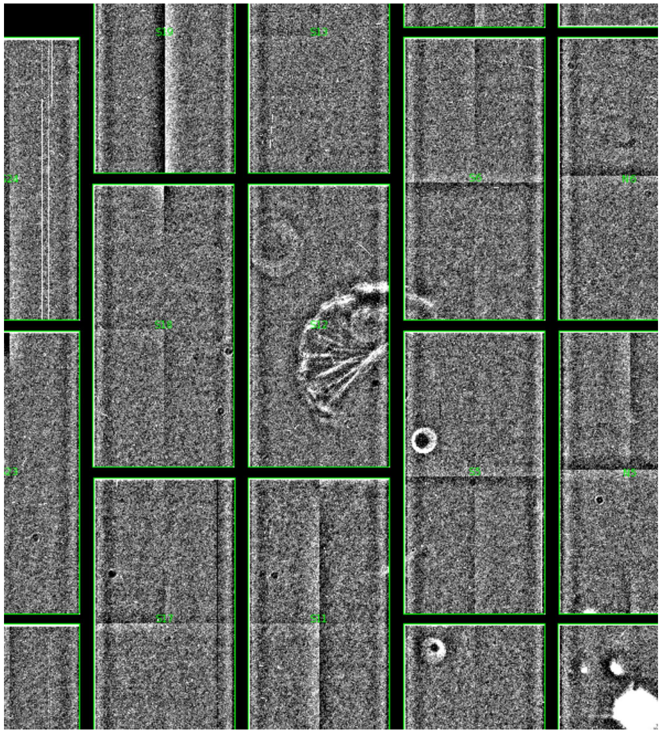

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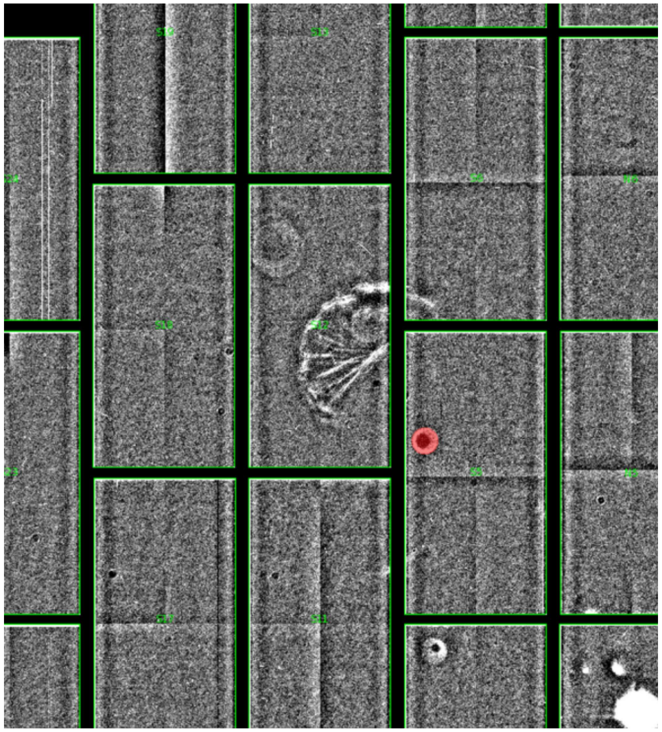

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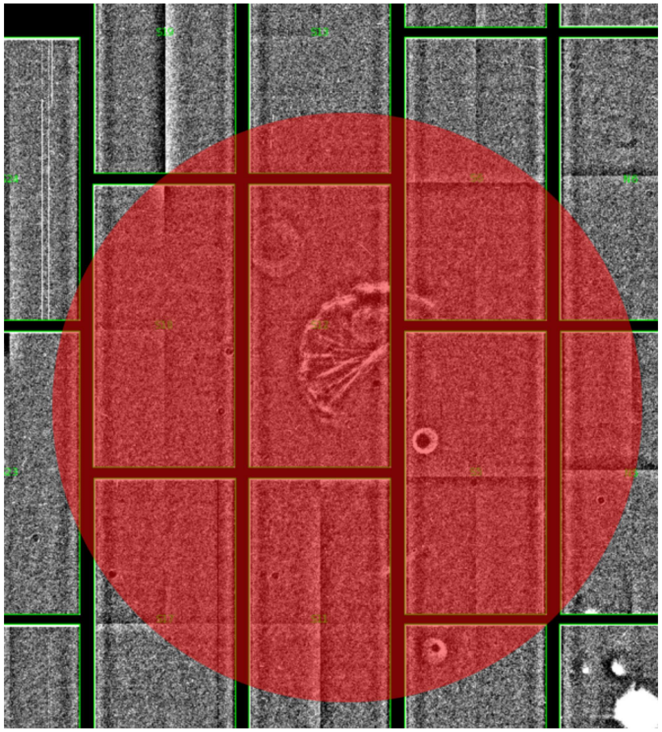

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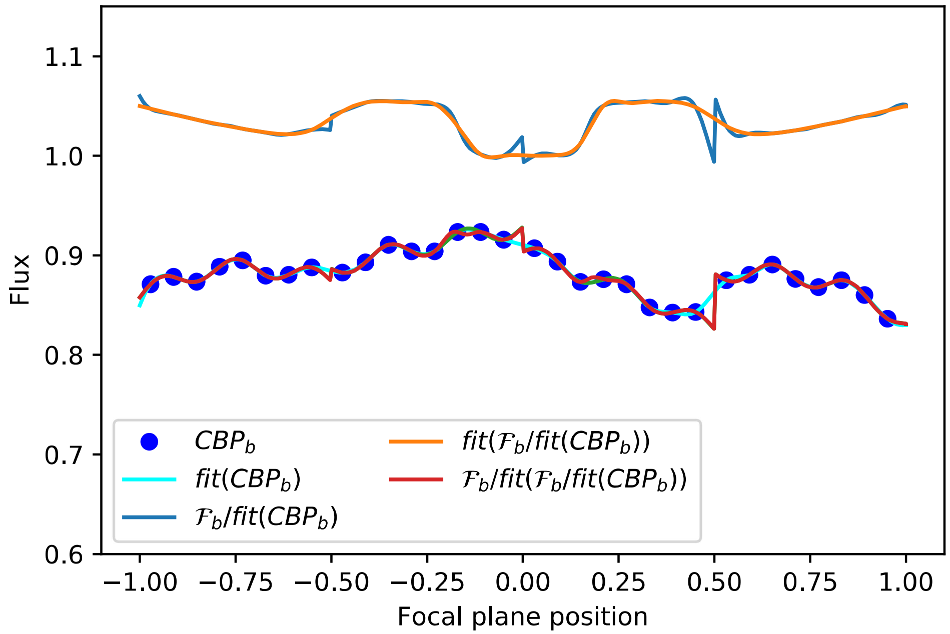

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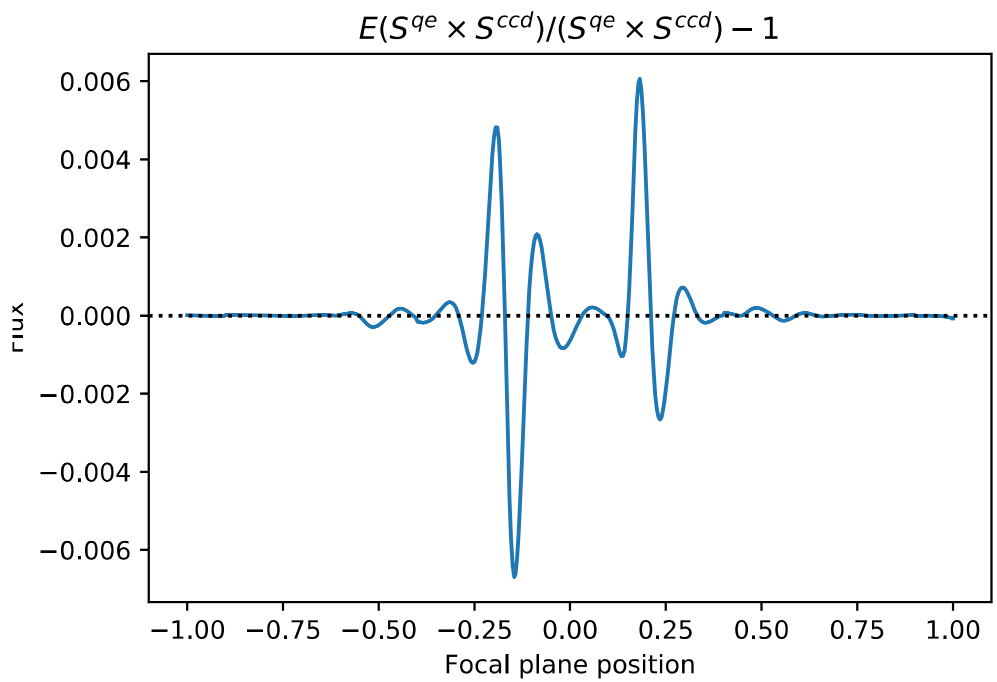

Flatfielding in LSST

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- Object Flux *or*
- Surface Brightness

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Enter the Auxiliary Telescope.

AuxTel

A 1.2m telescope

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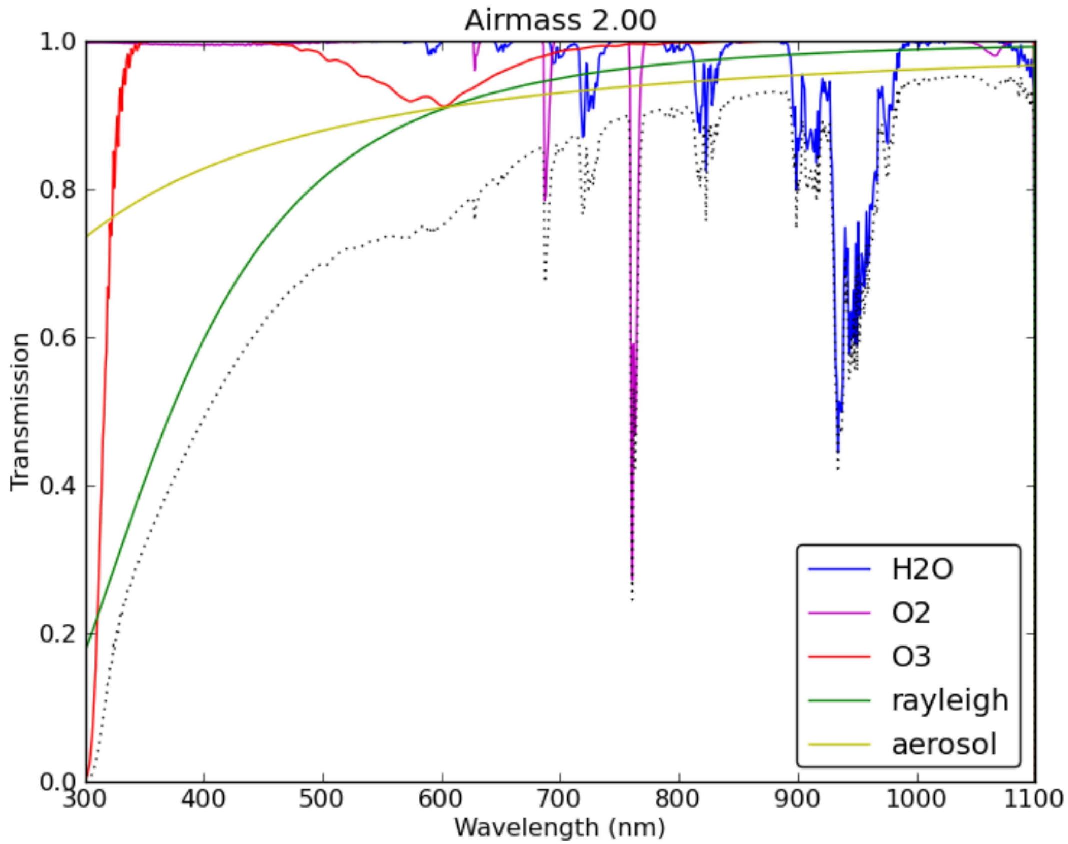
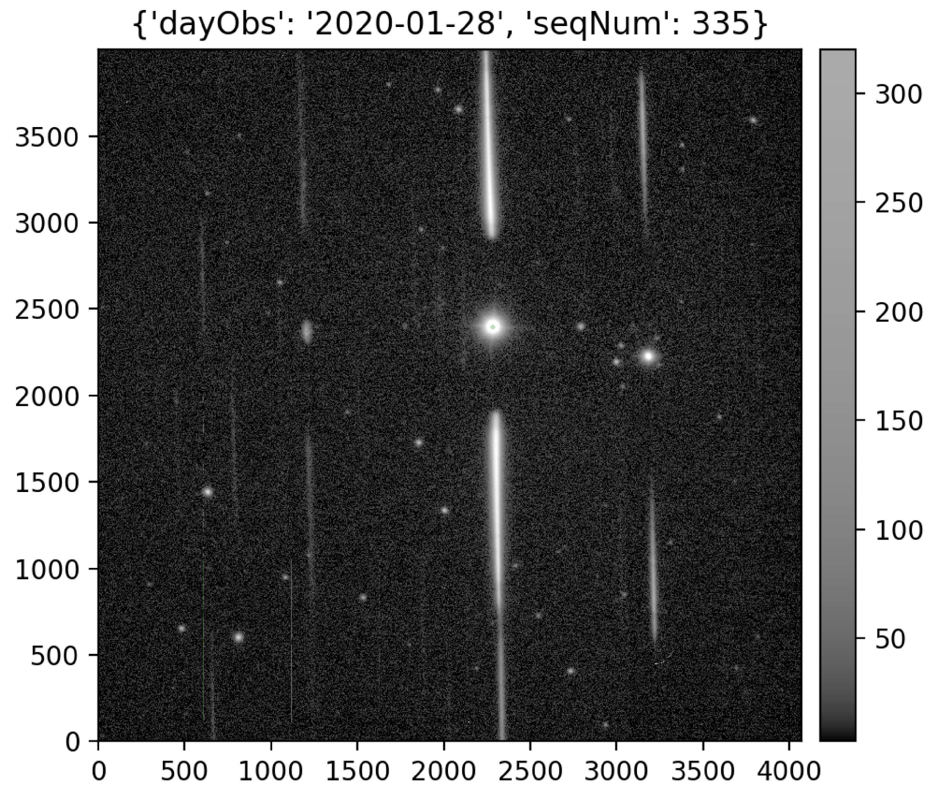
A 1.2m telescope with a slitless spectrograph

AuxTel

A 1.2m telescope with a slitless spectrograph to monitor the atmospheric transmission.



HD 107696



90 line/mm Ronchi grating   4k$\times$4k ITL 10 μm CCD

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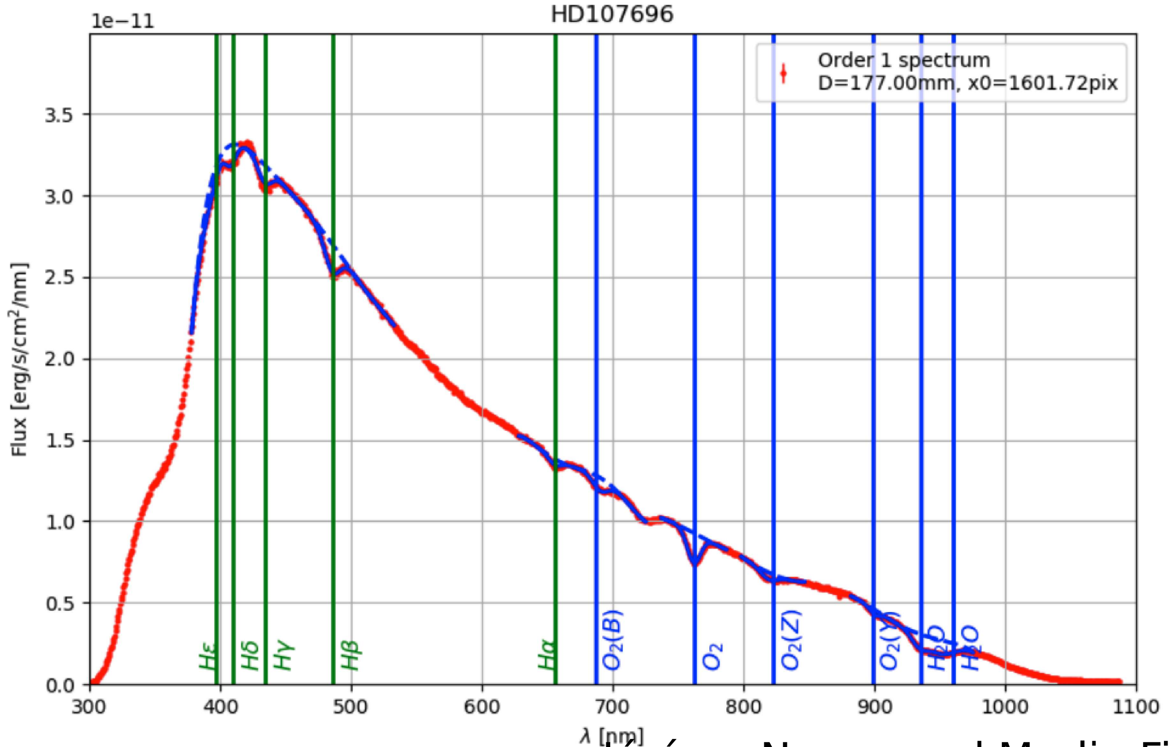
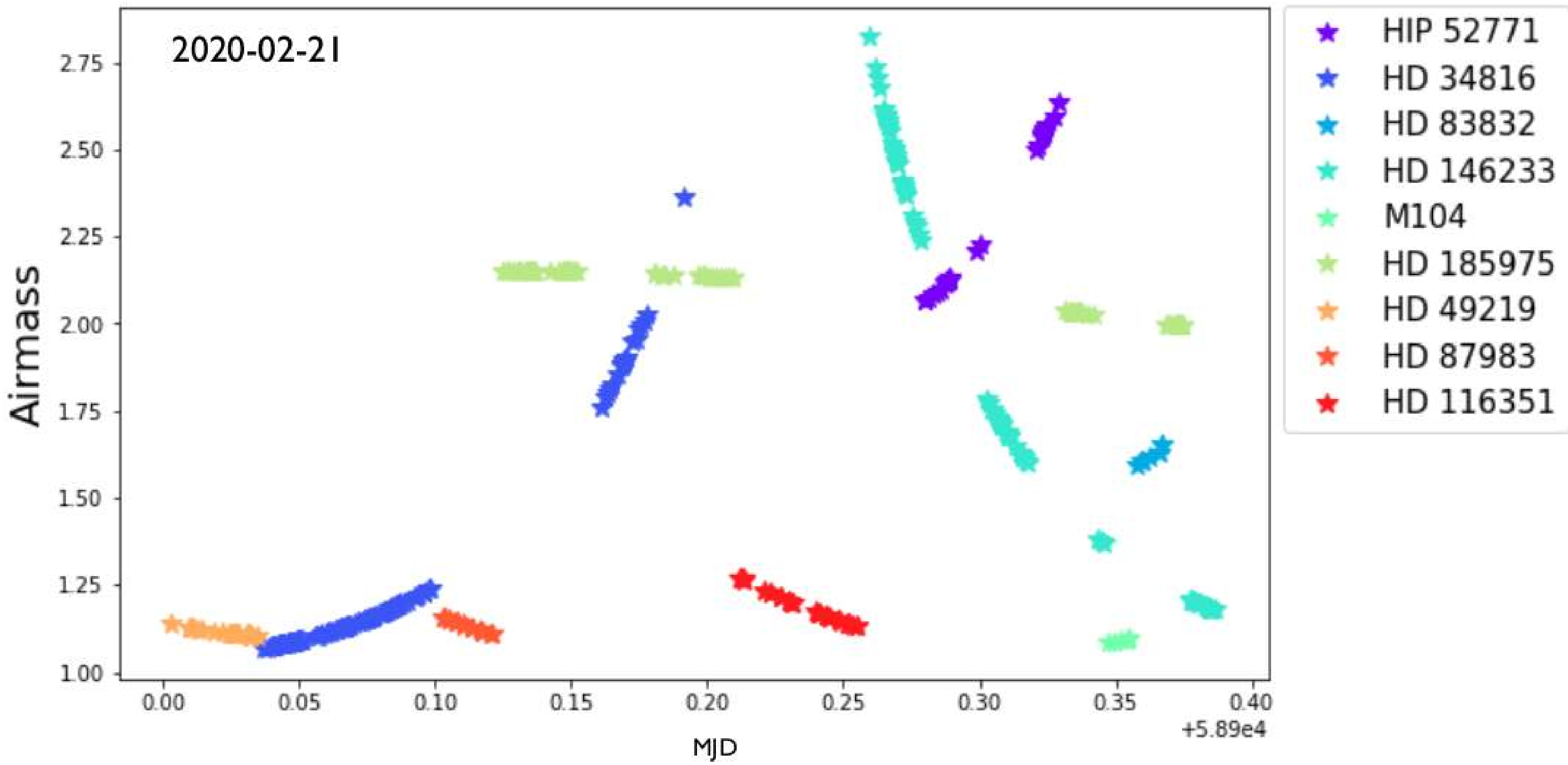


Jérémy Neveu and Merlin Fisher-Levine

90 line/mm Ronchi grating 4k×4k ITL 10 μm CCD

AuxTel observing strategy



Observing strategy last dark run.

Merlin Fisher-Levine

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Whether or not we need it to reduce the stellar photometry, we will be able to probe the variation of the components of atmospheric absorption as a function of time, azimuth, and altitude. With the intention of reducing all Rubin lsstCam photometry to a common atmosphere and airmass, allowing for the source's SED.

The End

AuxTel

A Condor over Cerro Pachón

AuxTel

A Condor over Cerro Pachón