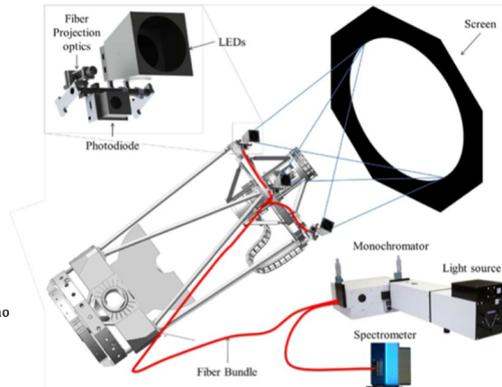




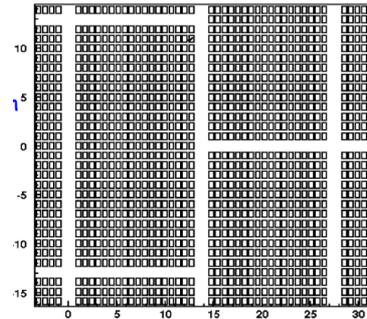
# Illumination, Flat Field, and Pupil Ghost Corrections

DARK ENERGY SURVEY

DECaI and LED Hardware built by Texas A&M.

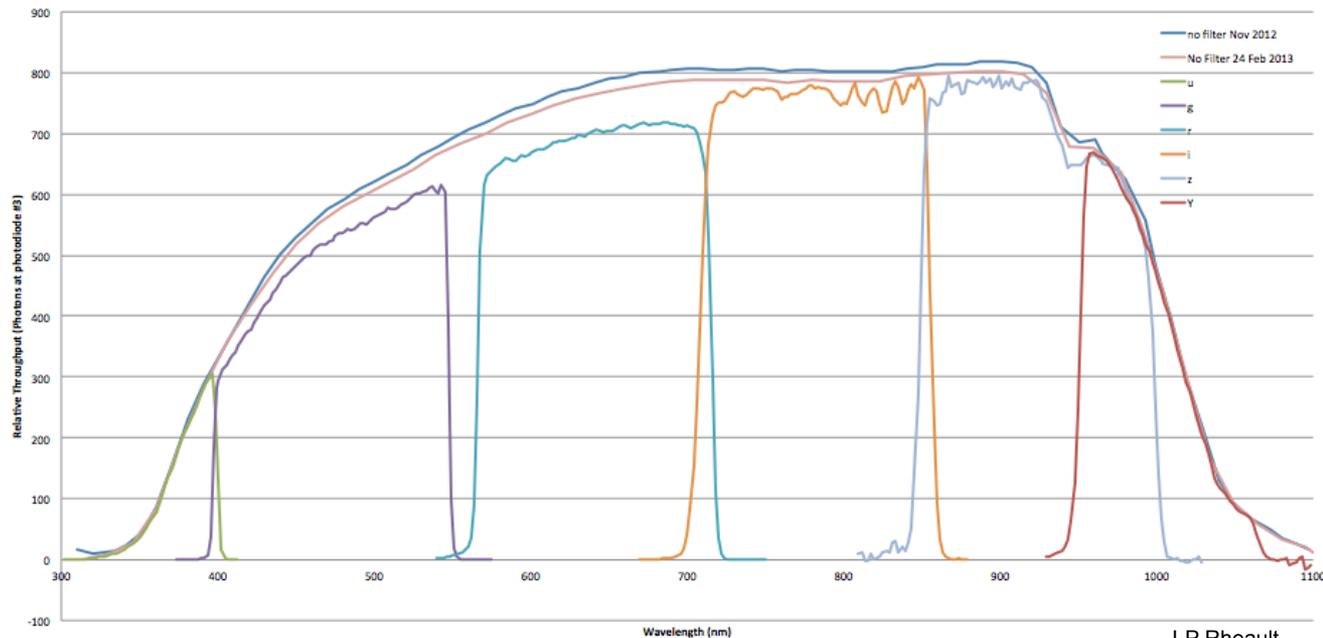


Single wavelength in middle of bandpass as shown  
 u-band: 380 nm    g-band: 500 nm  
 r-band: 650 nm    i-band: 800 nm  
 z-band: 950 nm    Y-band: 1000 nm



Color plots made by subdividing CCD into 18 col x 25 rows and determining a truncated average in each "box" – each box with 110 x 162 = 17.8K pixels. Color scale for relative response.

DECaI Filters response function (averaged over all 70 CCDs)



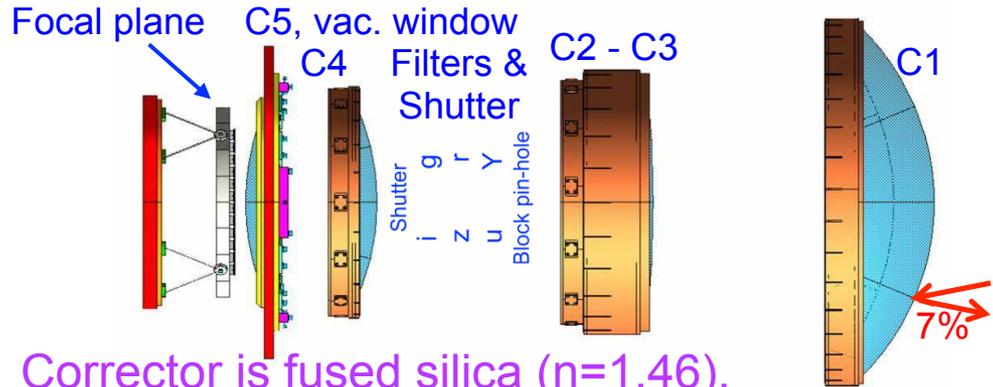
J-P Rheault



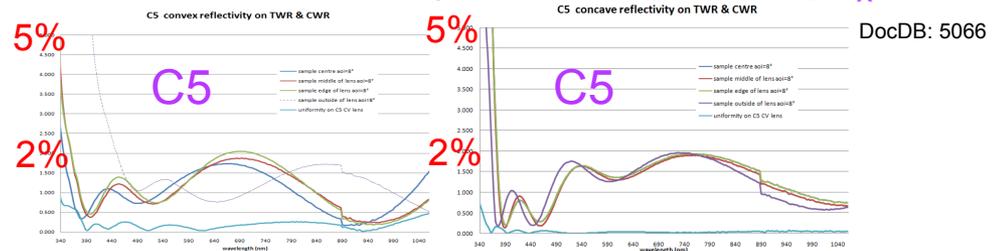
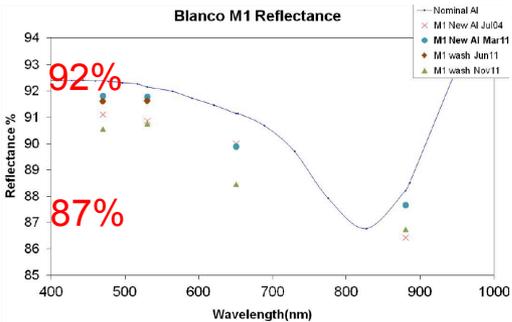
# DECal: System throughput not including atmosphere

DARK ENERGY SURVEY

Primary mirror is Al + dust

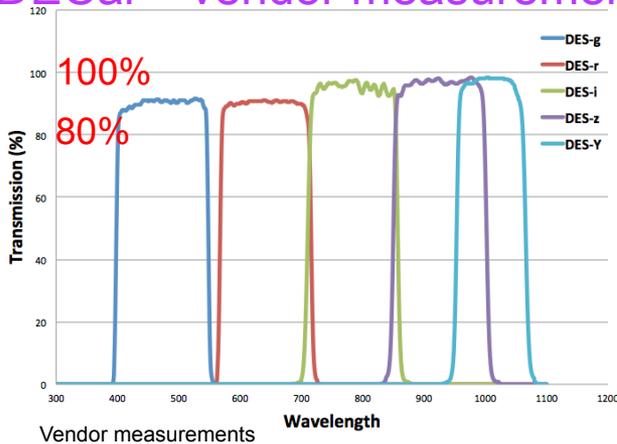


Corrector is fused silica ( $n=1.46$ ).  
C2-C5 have multi-layer coatings of  $MgF_x$ .

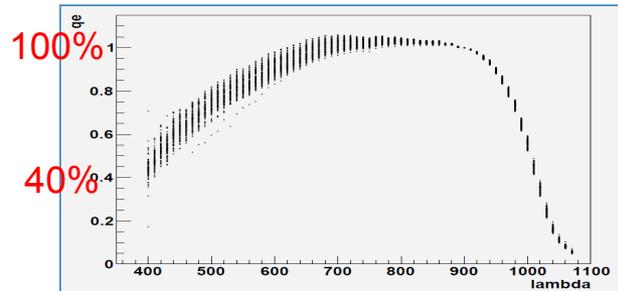


DocDB: 5066

Filters engineered to provide bandpasses with multilayered coatings, DECal + vendor measurements agree.



CCDs QE optimized for red until bandgap ( $\sim 1100\text{nm}$ ) – poly-Si + AR reflectance ITO/SiO<sub>2</sub> cuts short  $\lambda$ 's ( $\sim 350\text{nm}$ )



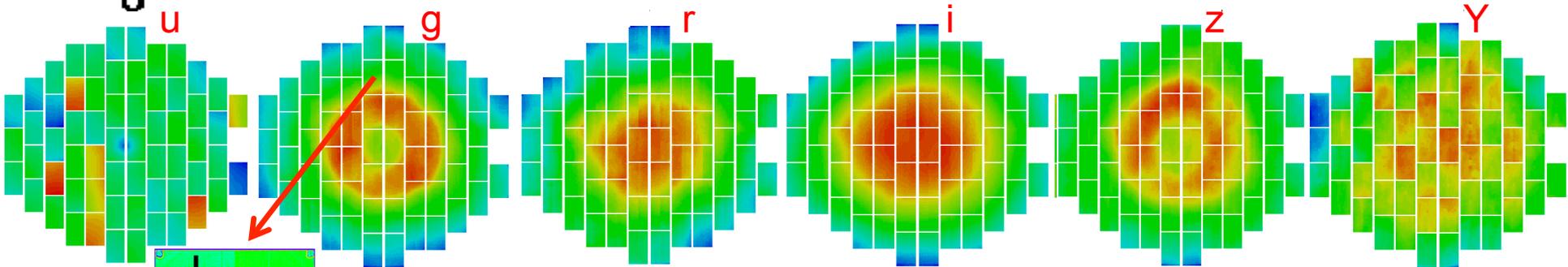
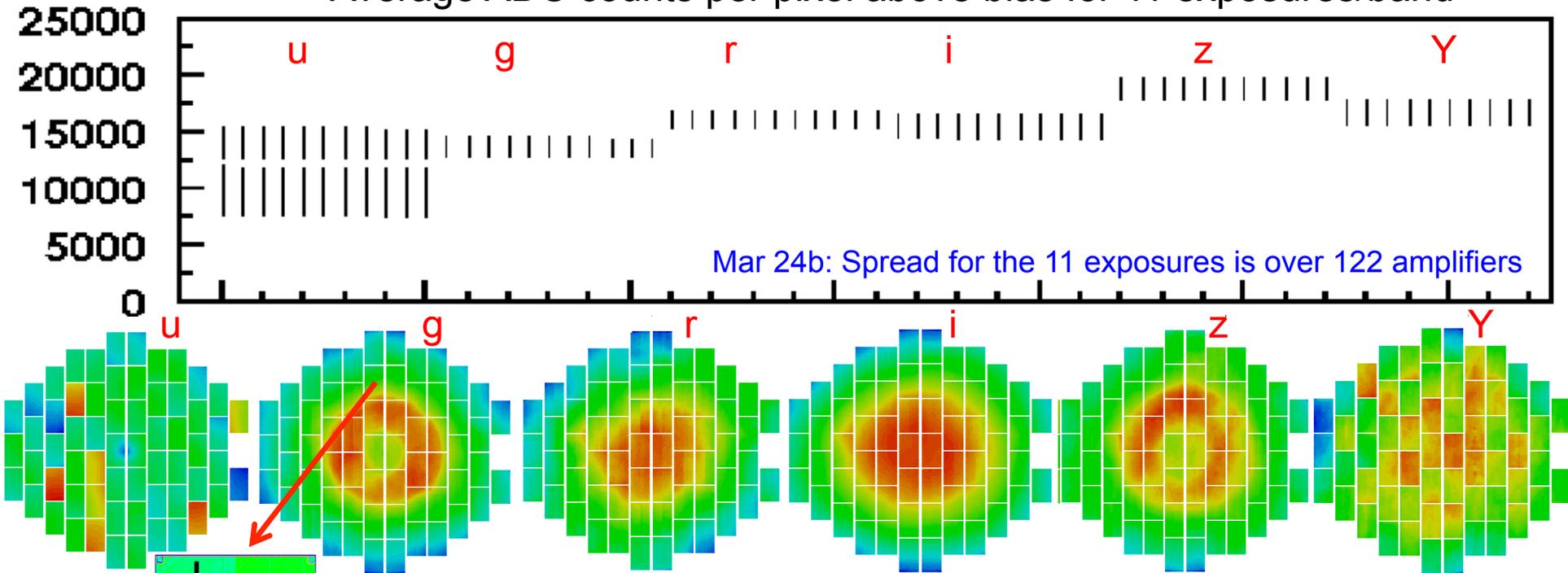
Si Det Lab Measurements  
DocDB: 5410



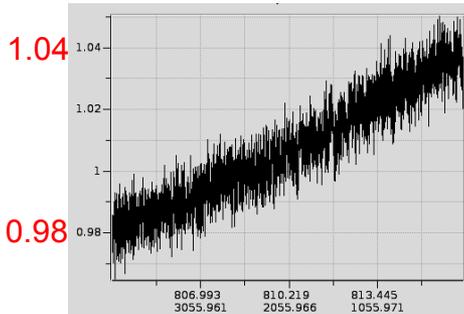
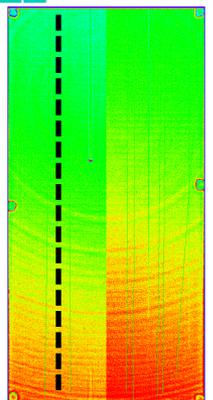
# A look at LED flats

DARK ENERGY  
SURVEY

Average ADC counts per pixel above bias for 11 exposures/band



DESDM  
Superflat  
CCD S6  
(num:30)  
with vert.  
projection

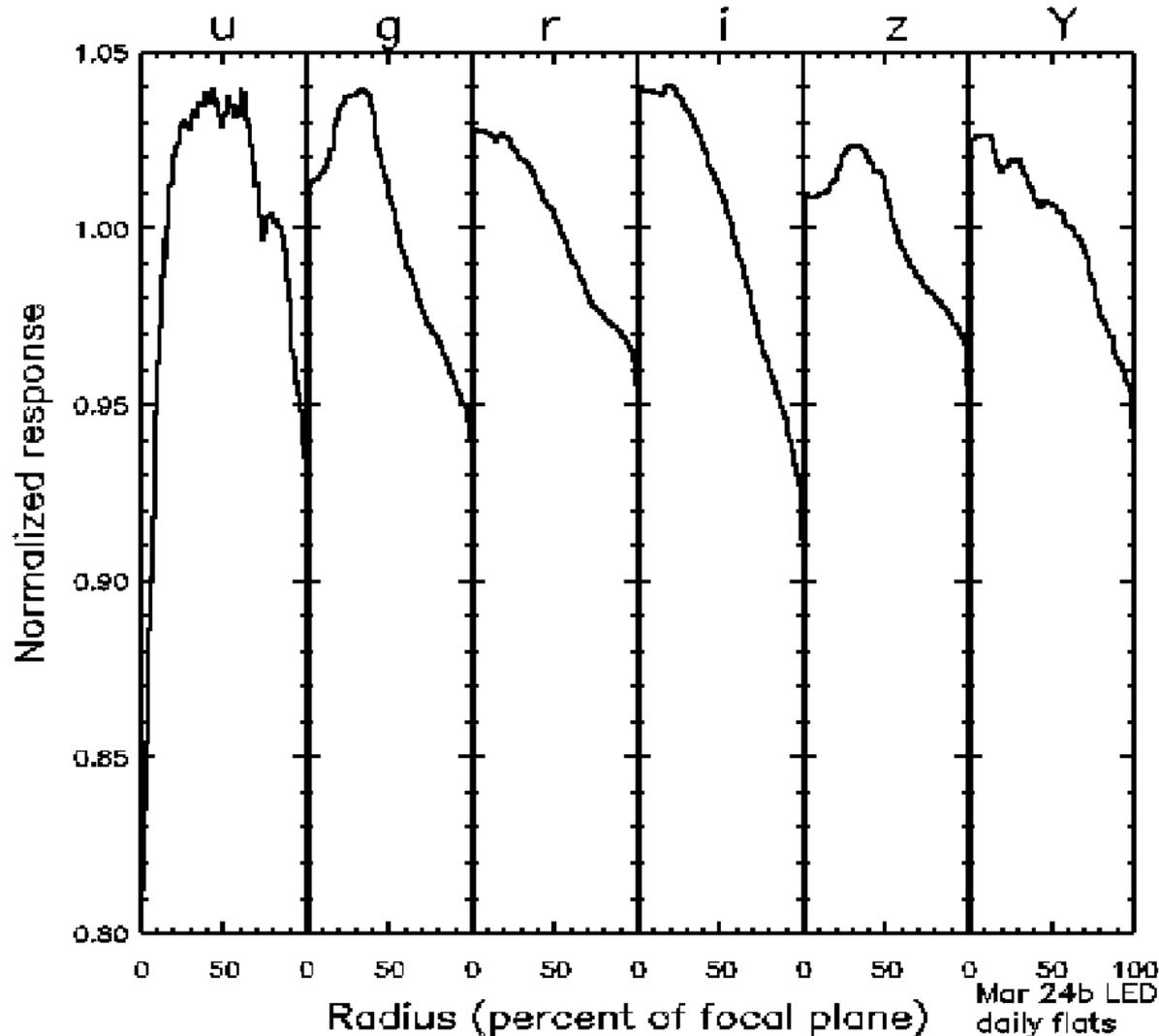


u-band is bifurcated around 12500 counts and shows a small low spot in the middle of the focal plane.  
Note: g-band "edge matching" correction used for u-band. Similarly z-band correction used for Y-band.



DARK ENERGY  
SURVEY

# Radial dependence



Compared with flat  
taken Mar 23 ...  
differences barely  
noticeable.



DARK ENERGY  
SURVEY

# Extra Slides



# Flat Field images vs time

DARK ENERGY  
SURVEY

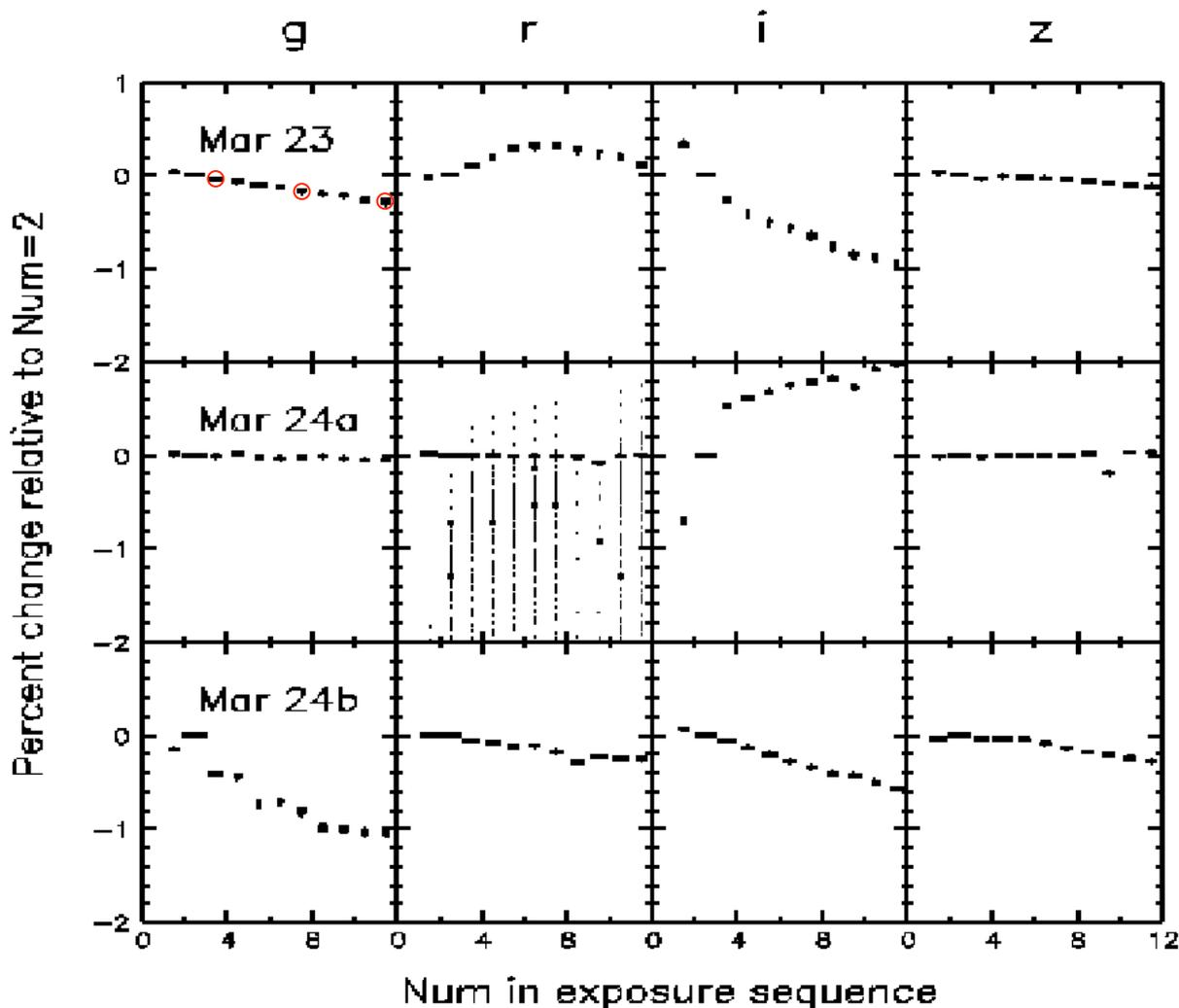
Look closer at the sequence of flat fields. For all the amplifiers, compute the percent change relative to the 2<sup>nd</sup> exposure in the sequence. Vertical spread is across the amplifiers.

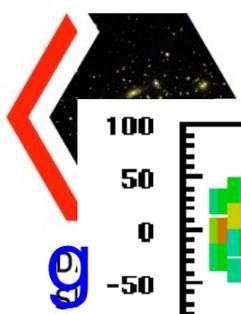
Note that up to 1% variation is observed.

Variation varies within filter sets and on different dates. Note, there is a general downward trend, but not always.

g-band on Mar24a is somewhat discrepant.

On the next slides, the red circles highlight exposures 3, 7, and 11 (all relative to exposure 2) to look at spatial variation.



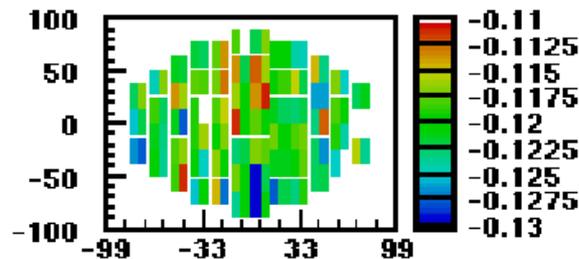
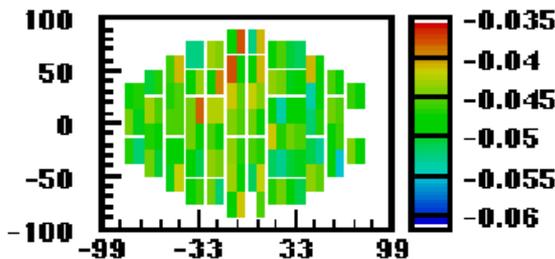
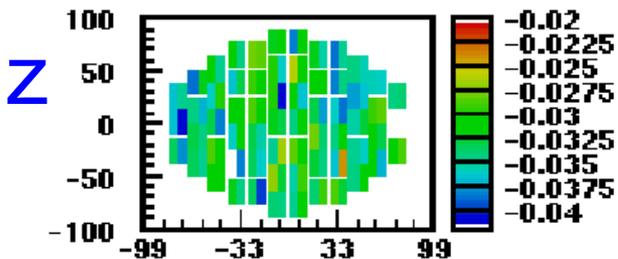
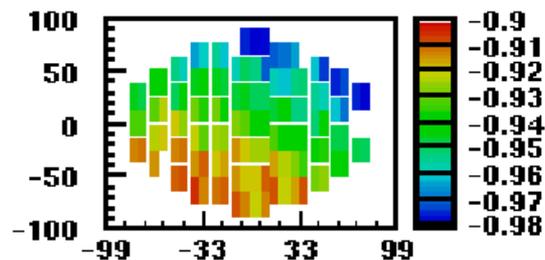
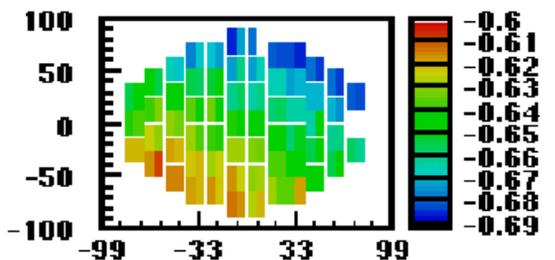
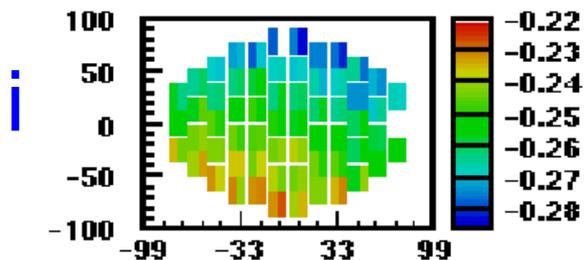
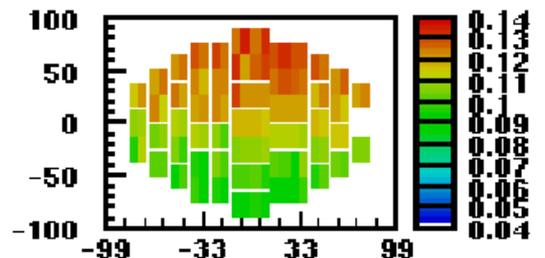
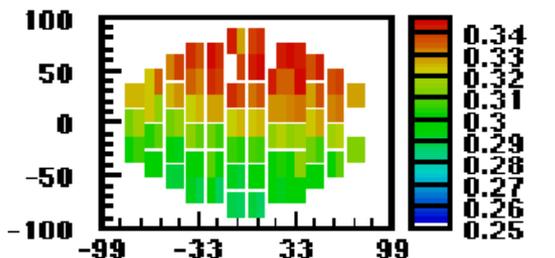
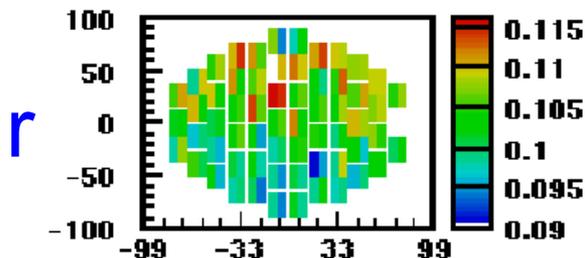
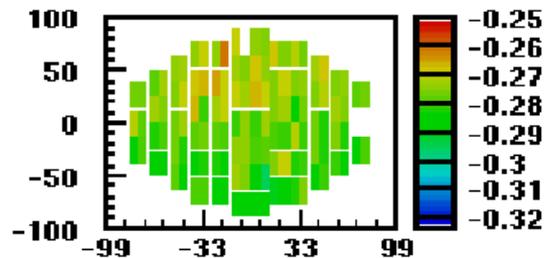
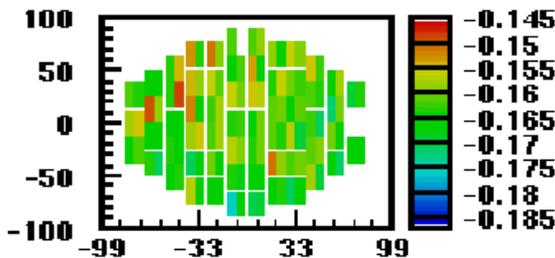
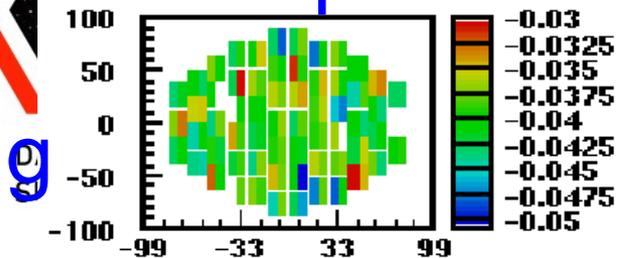


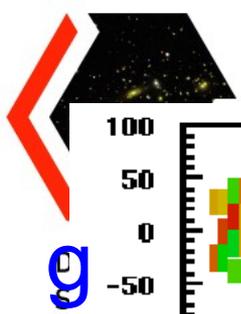
Exp 3-2

7-2

11-2

Mar 23



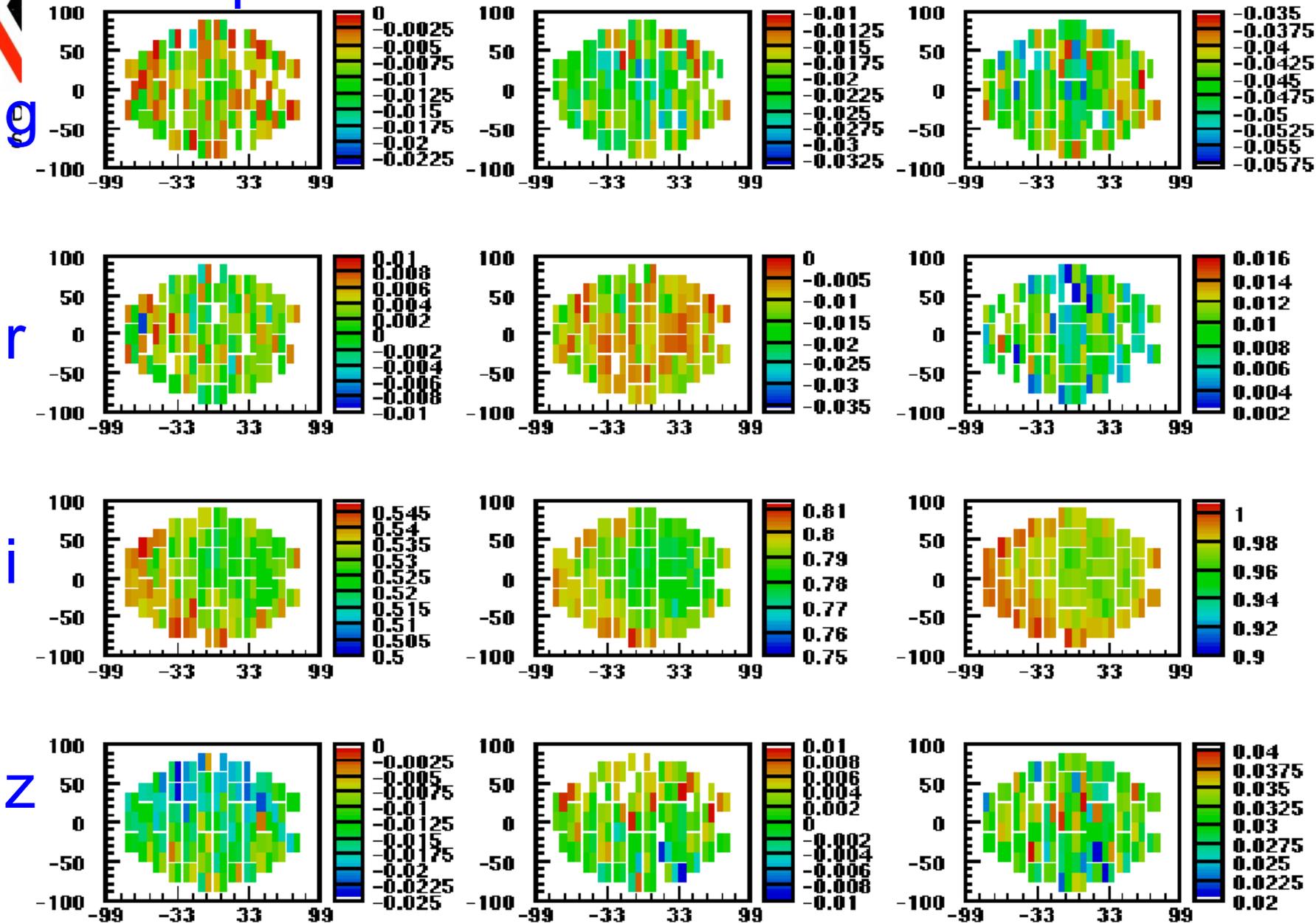


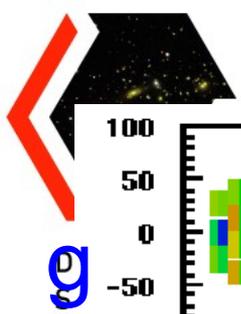
Exp 3-2

7-2

11-2

Mar 24a



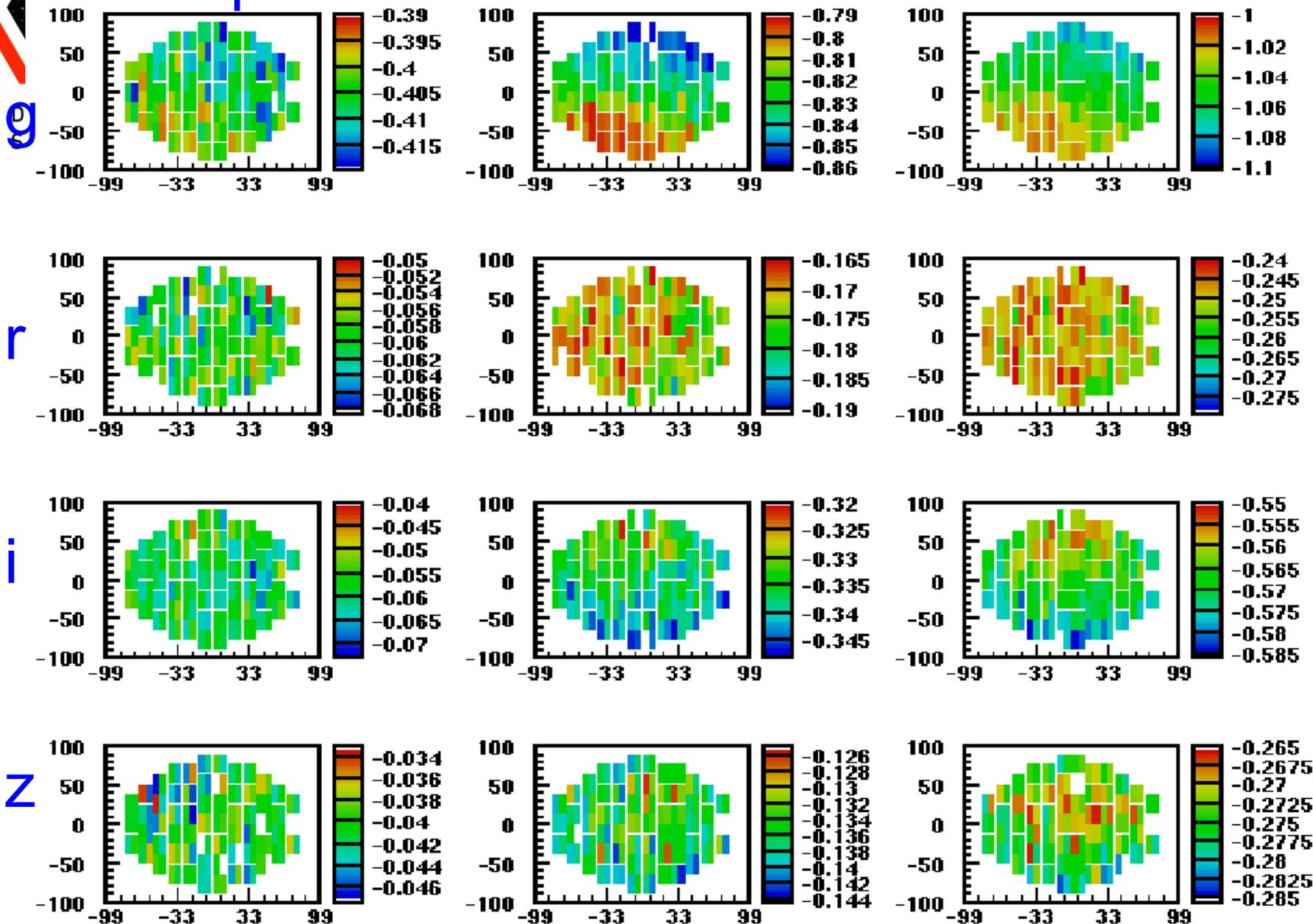


Exp 3-2

7-2

11-2

Mar 24b





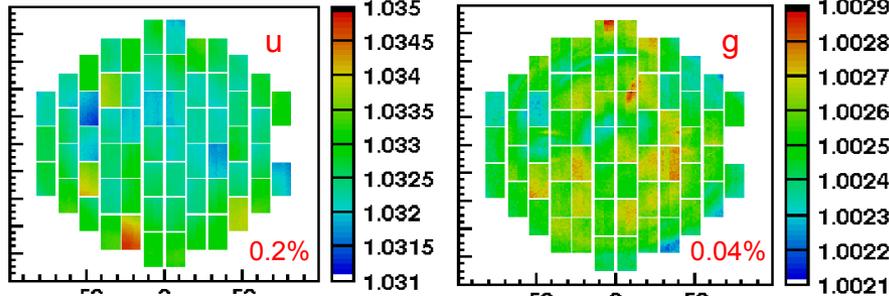
# Stacked Flats vs time

DARK ENERGY  
SURVEY

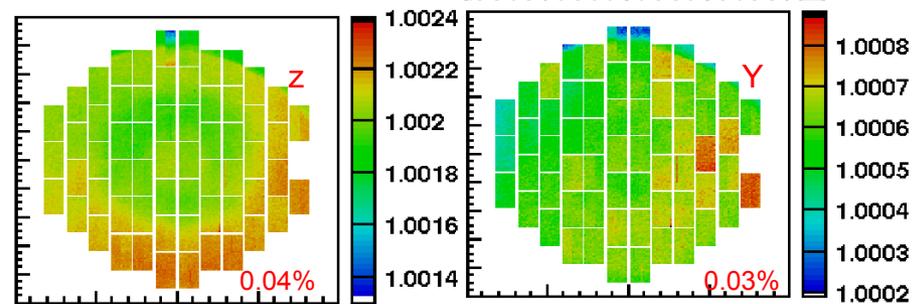
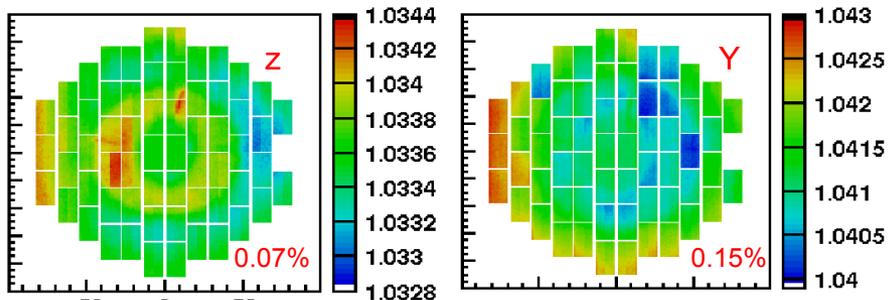
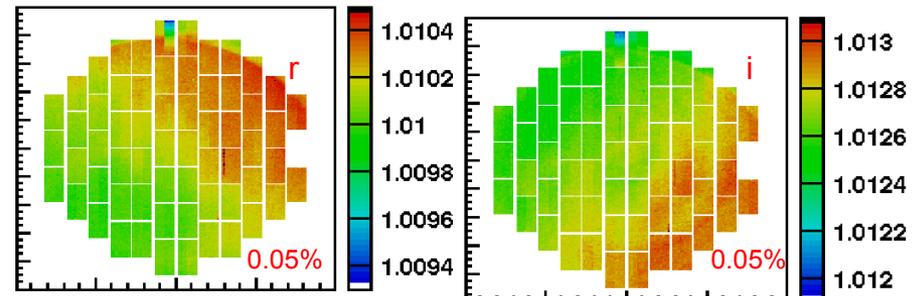
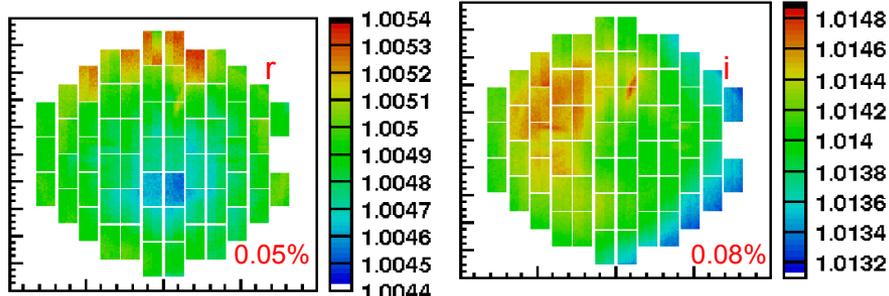
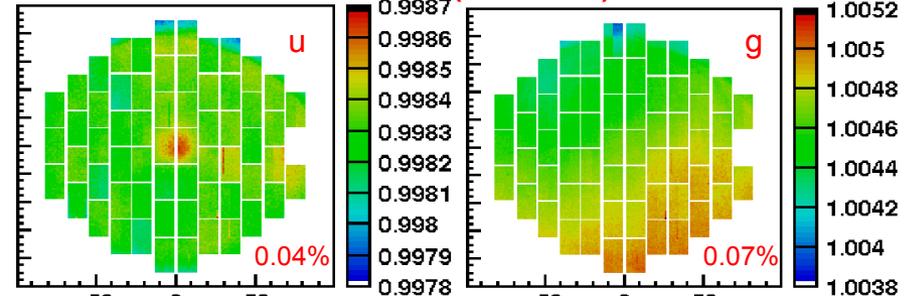
For each sequence, add 10 (skip 1<sup>st</sup>) flats together and then divide filter-by-filter with the Mar 24b sequence

Variation typically < 0.1%  
No obvious 4MAP off effect  
Some structure in ratio of flats

Mar 24a / Mar 24b



Mar 23 / Mar 24b (4MAP off)



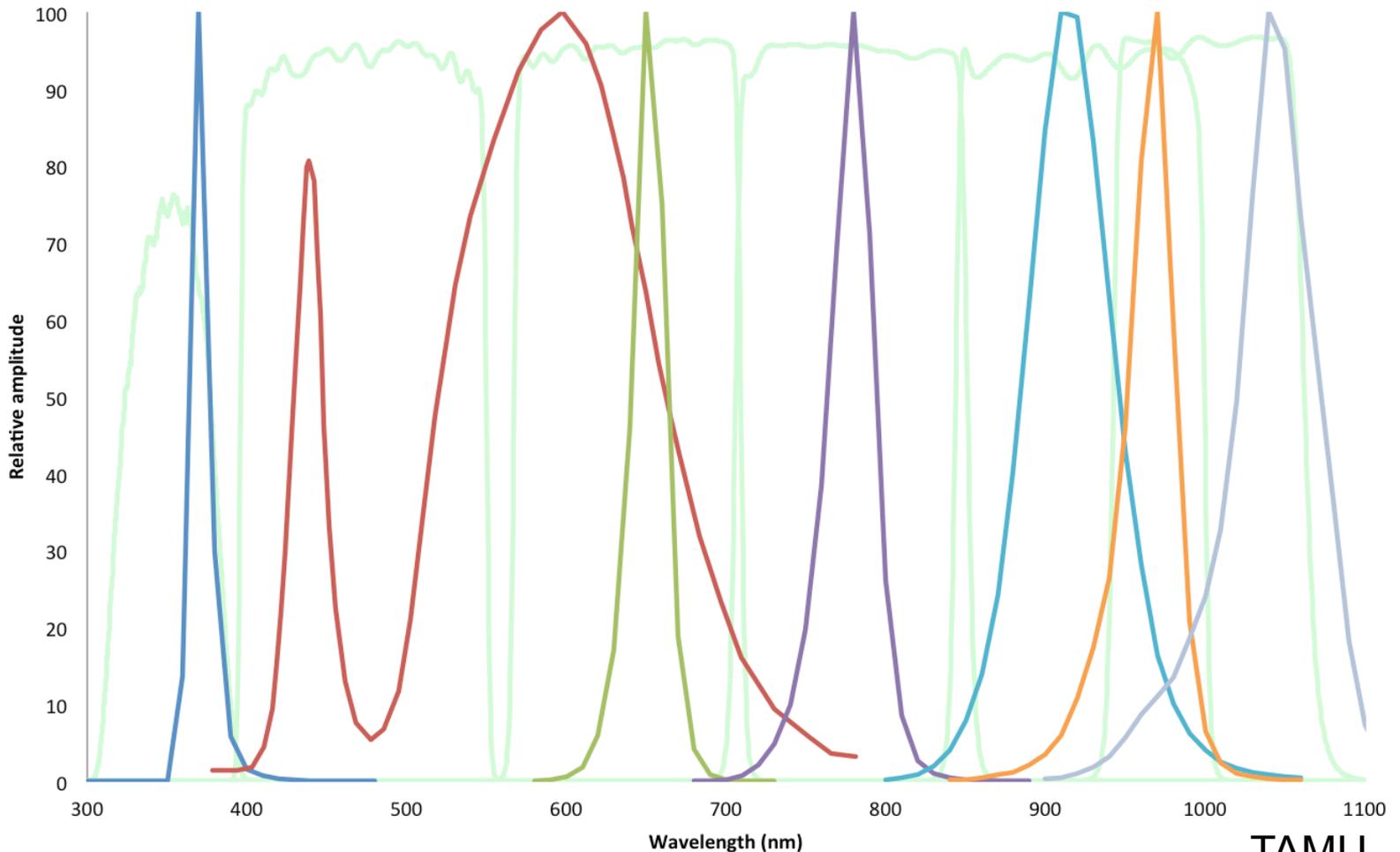


# LED emission

DARK ENERGY  
SURVEY

For reference ...

LED emission spectra



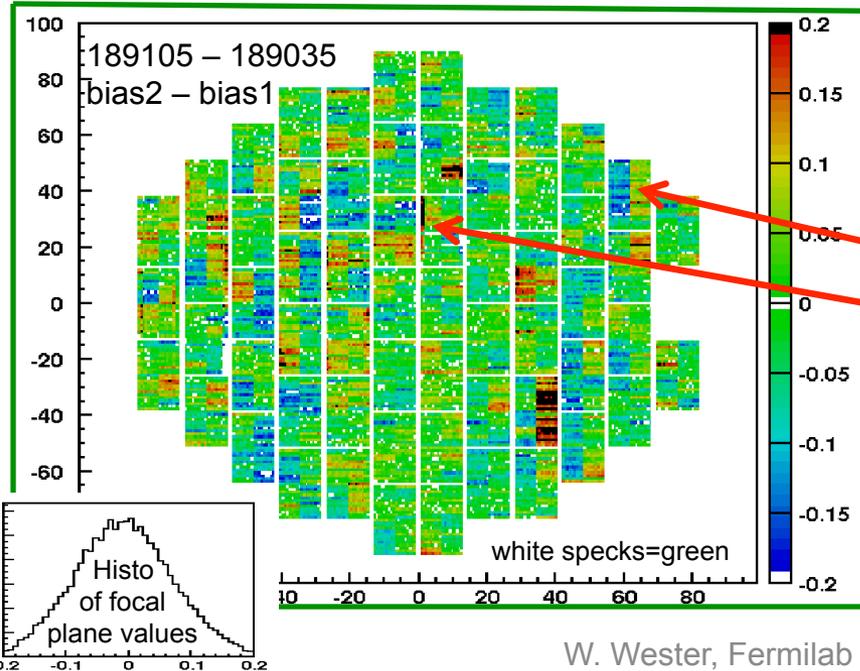
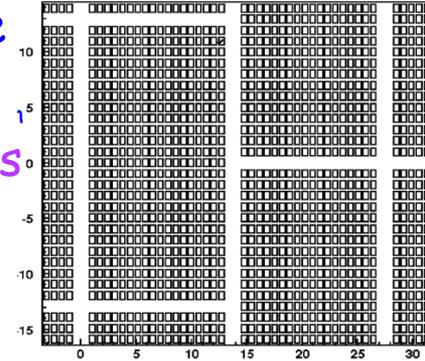
TAMU



# A look at bias exposures

DARK ENERGY SURVEY

- Analyze as DECal exposures (ON-OFF) where ON is the exposure of interest and OFF is a earlier bias exposure
- Compute (middle 68%) average in a little box of 110x162 pixels where each CCD has 18 x 25 boxes (removes edge pixels)
  - griz note: divide the average by a single "edge matching" number per amp
- Study the 11 bias exposures after LED flat field sequence
  - Note: each of the biases has an earlier single bias exposure subtracted from it.



## Difference of two bias exposures

Note: differences are typically < 0.2 cnts.

### Other observations:

- Collection of rows have correlated shifts.
- An occasional discrepant column.

### Small observation:

1<sup>st</sup> of 11 bias exposures has between 0.5-1.6 ADC counts difference per pixel as shown – other exposures < 0.2 cnts.

