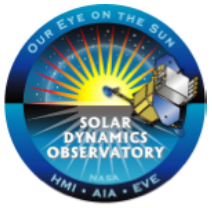

SDO EVE Calibration Workshop

MEGS In-flight Calibrations

1) MEGS-A Filters
2) Flatfields

Don Woodraska
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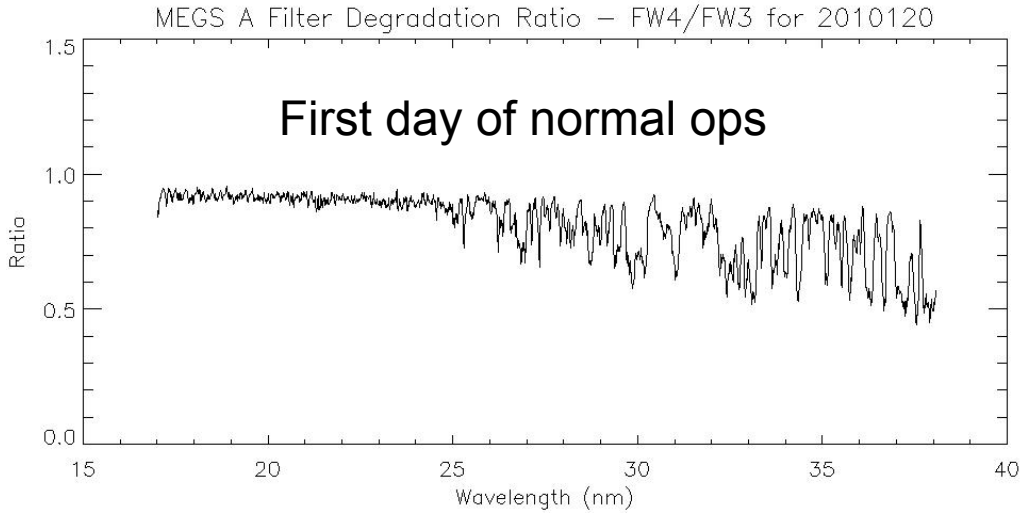
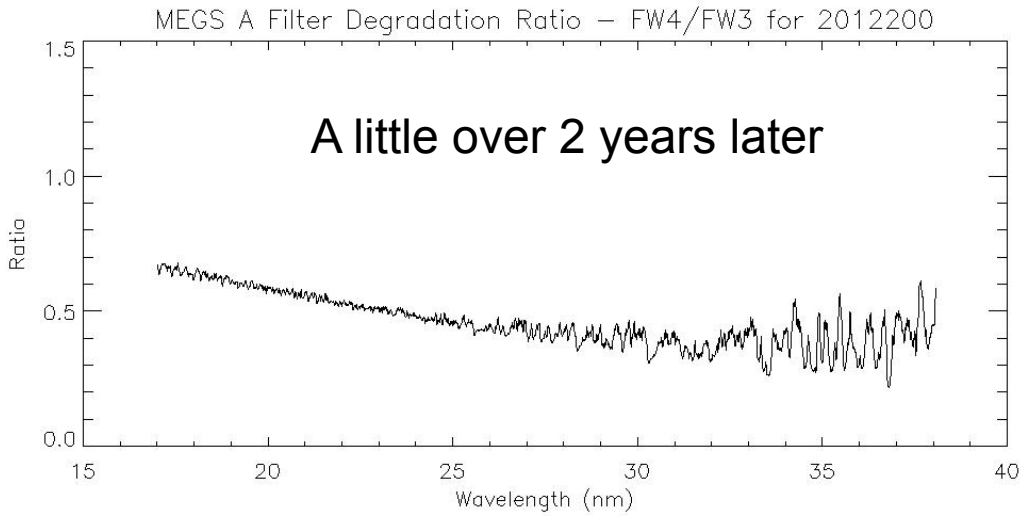
(303)-735-5617
Brian Templeman provided much of the content

Filter Changes

- Filter routine operation
  - Filter 4 is primary (normal science)
  - Filter 3 is exposed for only 70 seconds / day
  - Filter 5 is exposed for only 70 seconds / week (now)
    - Except during the first part of the mission
- Early mission differences are consistent with filter variations observed in SURF calibrations from similar filters
- Comparisons are level 1 irradiance spectra
  - No degradation, or rocket calibrations applied





Filter Changes for Selected Lines

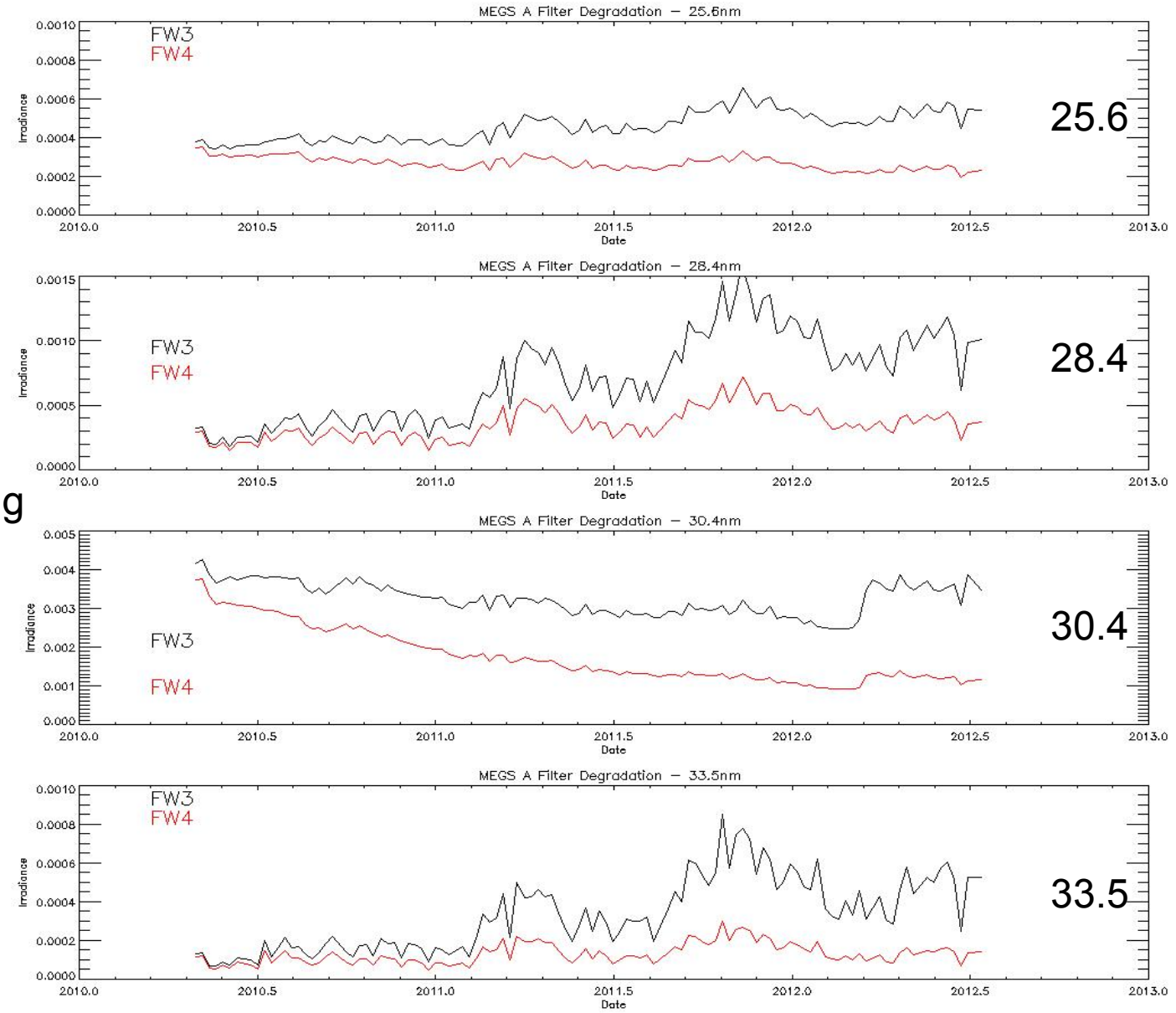
Not all days are shown.

Irradiance from different filters are drifting further apart.

Filter 4 is degrading relative to filter 3.

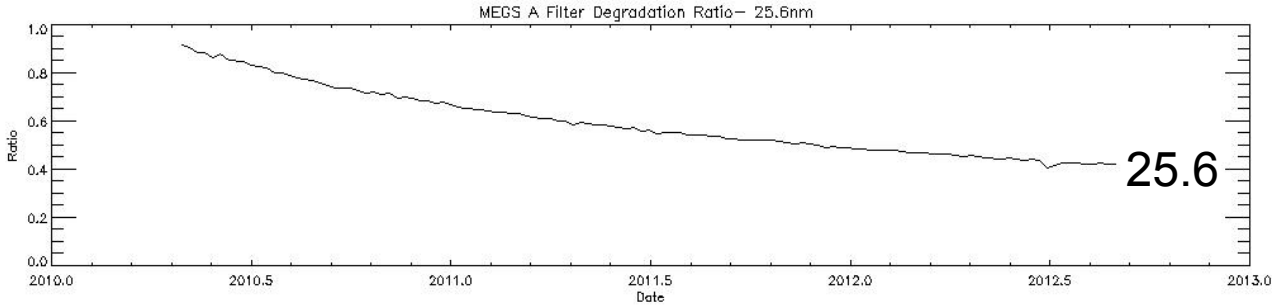
No degradation corrections applied.

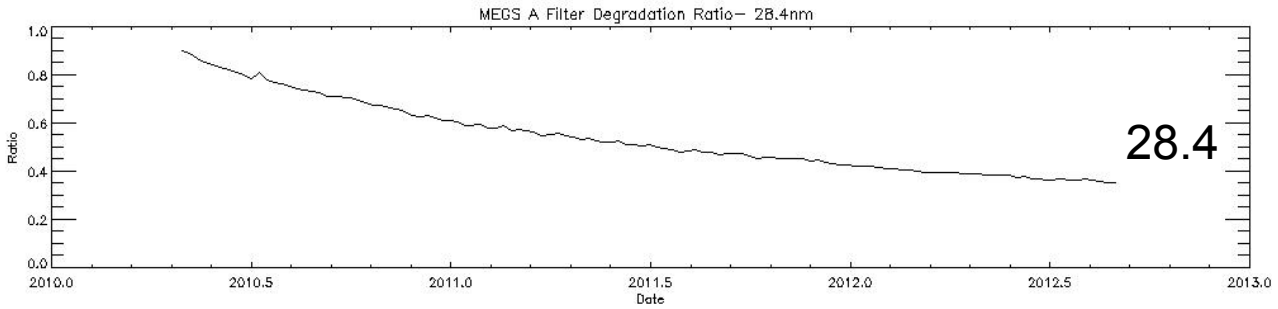
Don't panic.

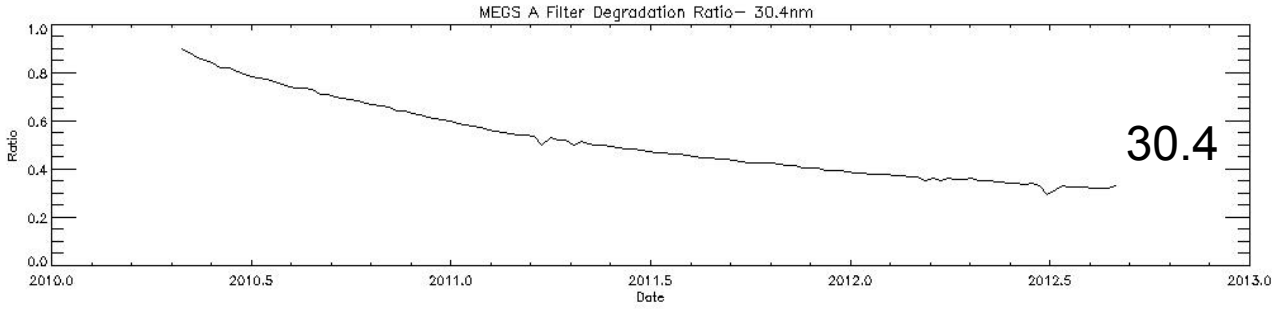


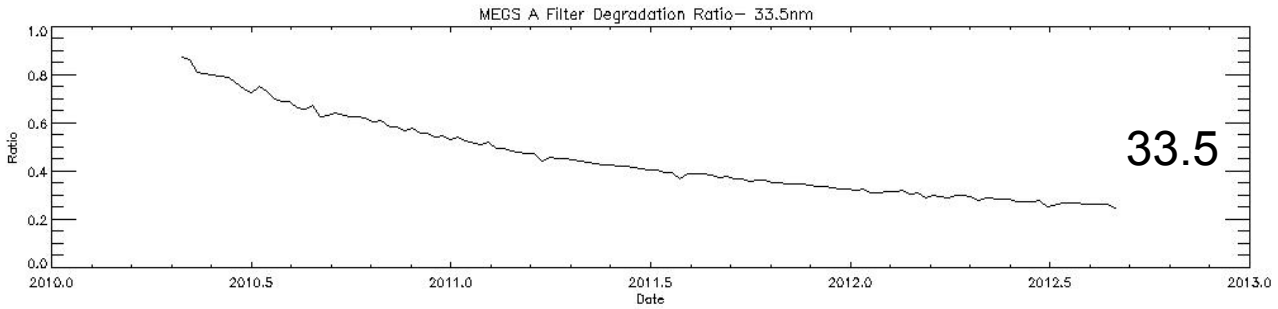
MEGS-A Filter Ratios

- Ratio of irradiances from level 1
- Large changes seem to be prevalent at all bright lines
  - Ratios are not normalized so initial differences are included
    - Possible early ops degradation
- The filter appears to be trending similarly across all wavelengths



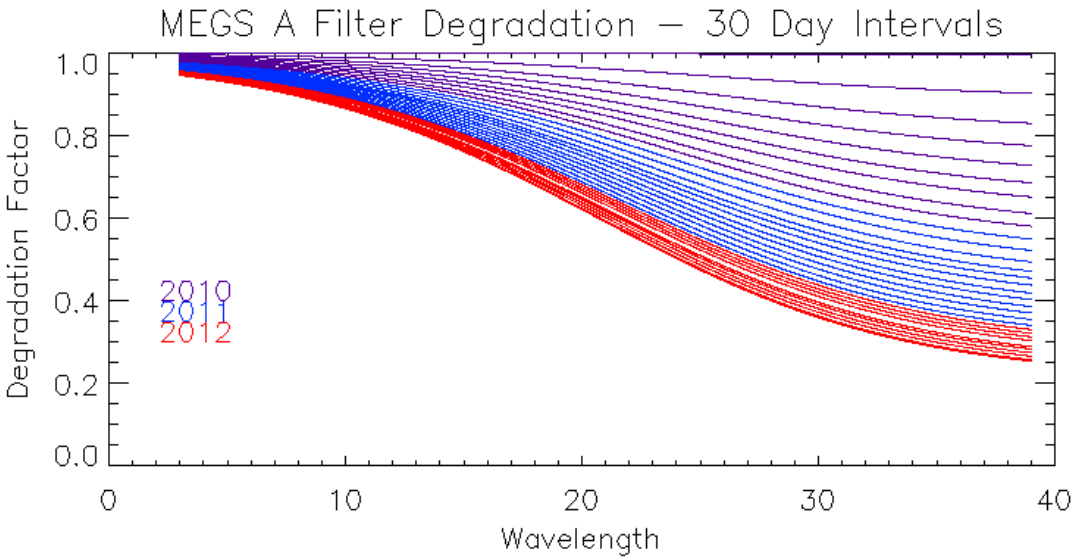






MEGS-A Filter Degradation Trend

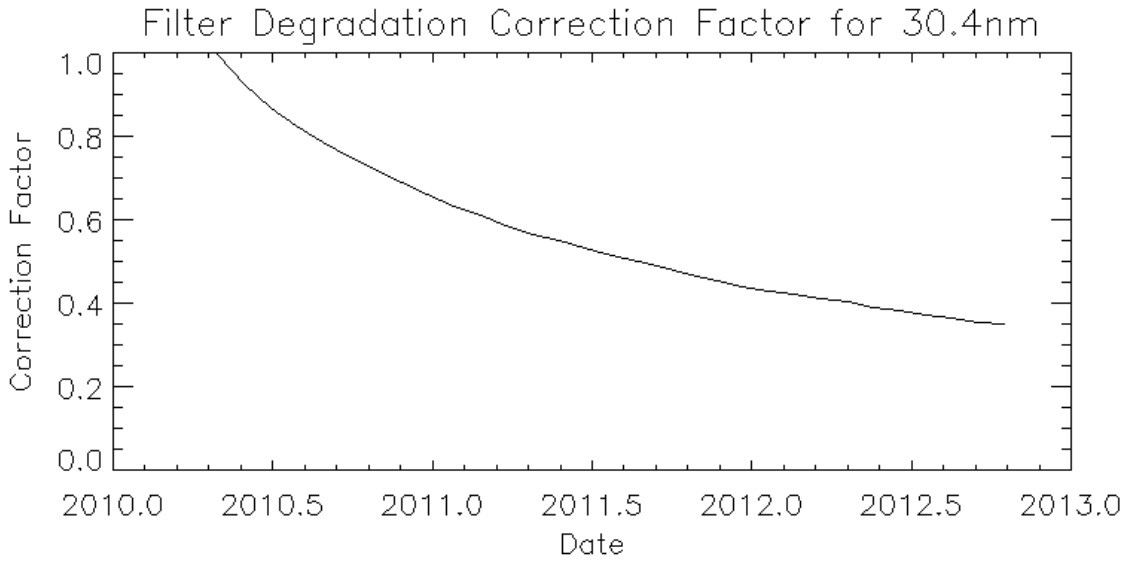
- Separation of variables for contaminant deposition (Hock, Thesis 2012)
  - Filter exposure time component
  - Wavelength component
    - Just bright lines where second order is not an issue



$$f_{FilterDeg} = \exp\left(\frac{-z(t)}{\tau(\lambda)}\right)$$

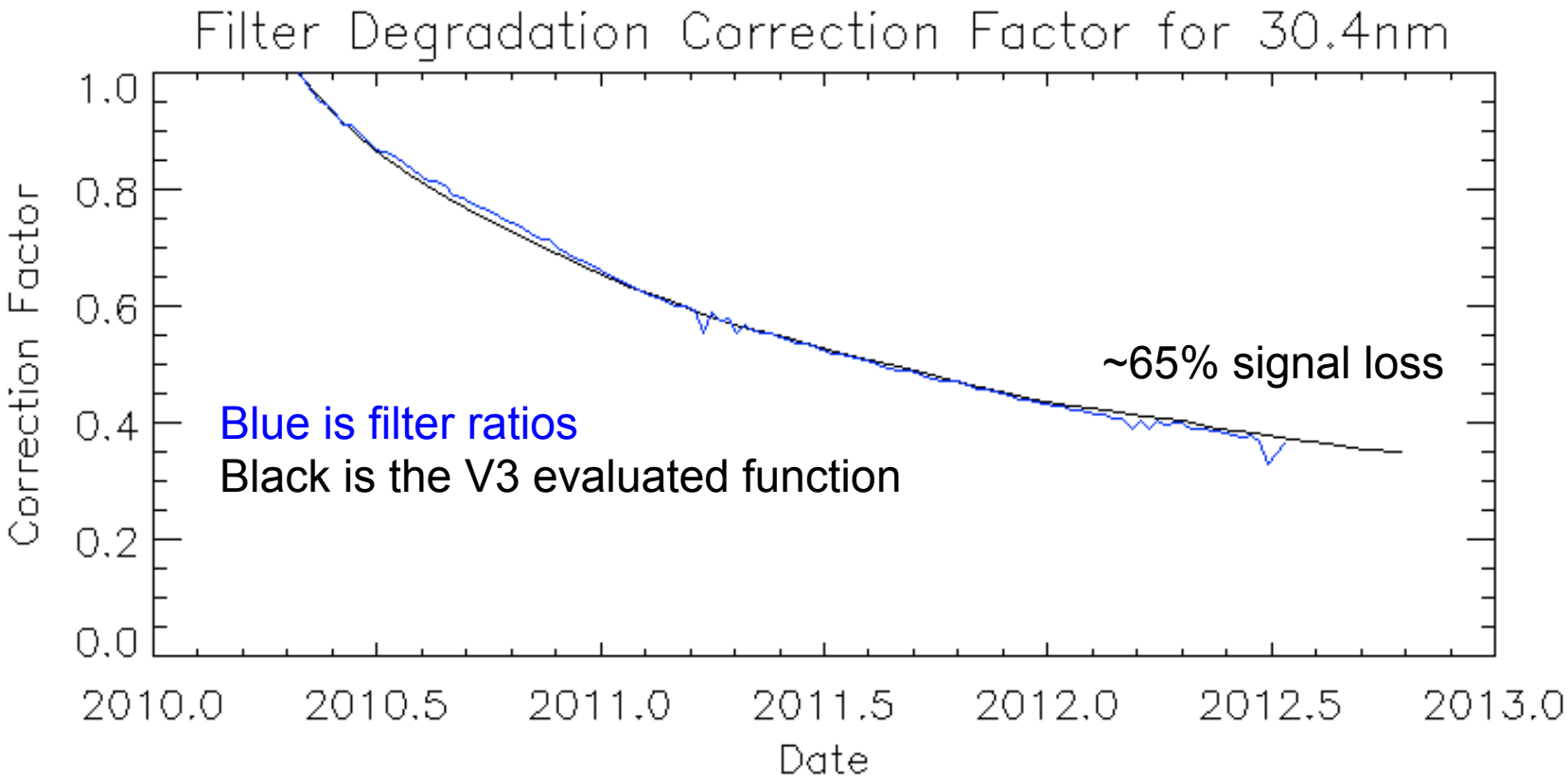
$$\tau(\lambda) = 32.97 \cdot 3.27^{-0.12\cdot\lambda}$$

$$z(t) = \left\langle -\tau(\lambda)\ln\left[\frac{E_4(t,\lambda)}{E_3(t,\lambda)}\right]\right\rangle$$



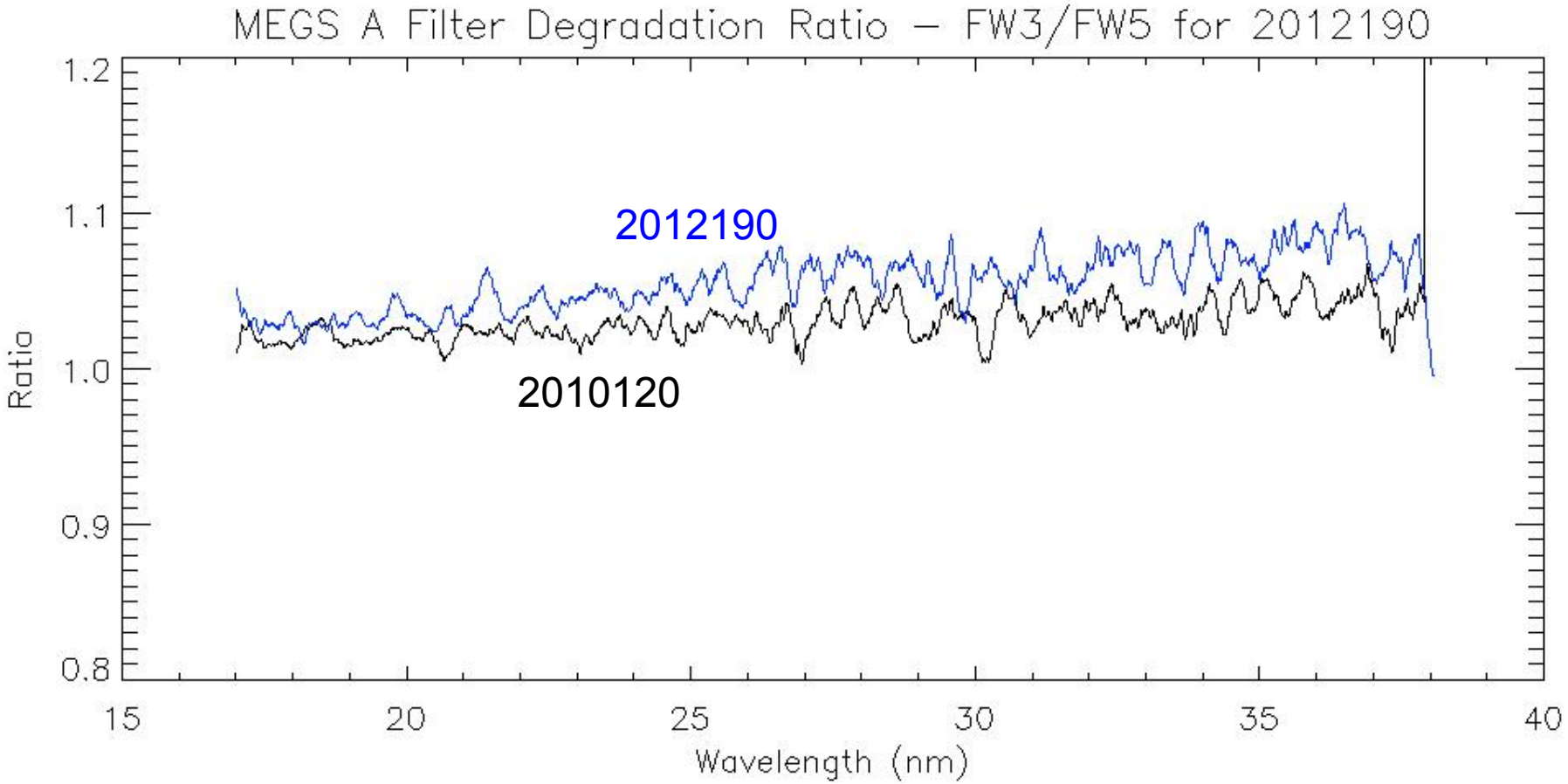
Theoretical Relationship

- The separation of variables concept fits the measurements fairly well, and isn't sensitive to the noise.



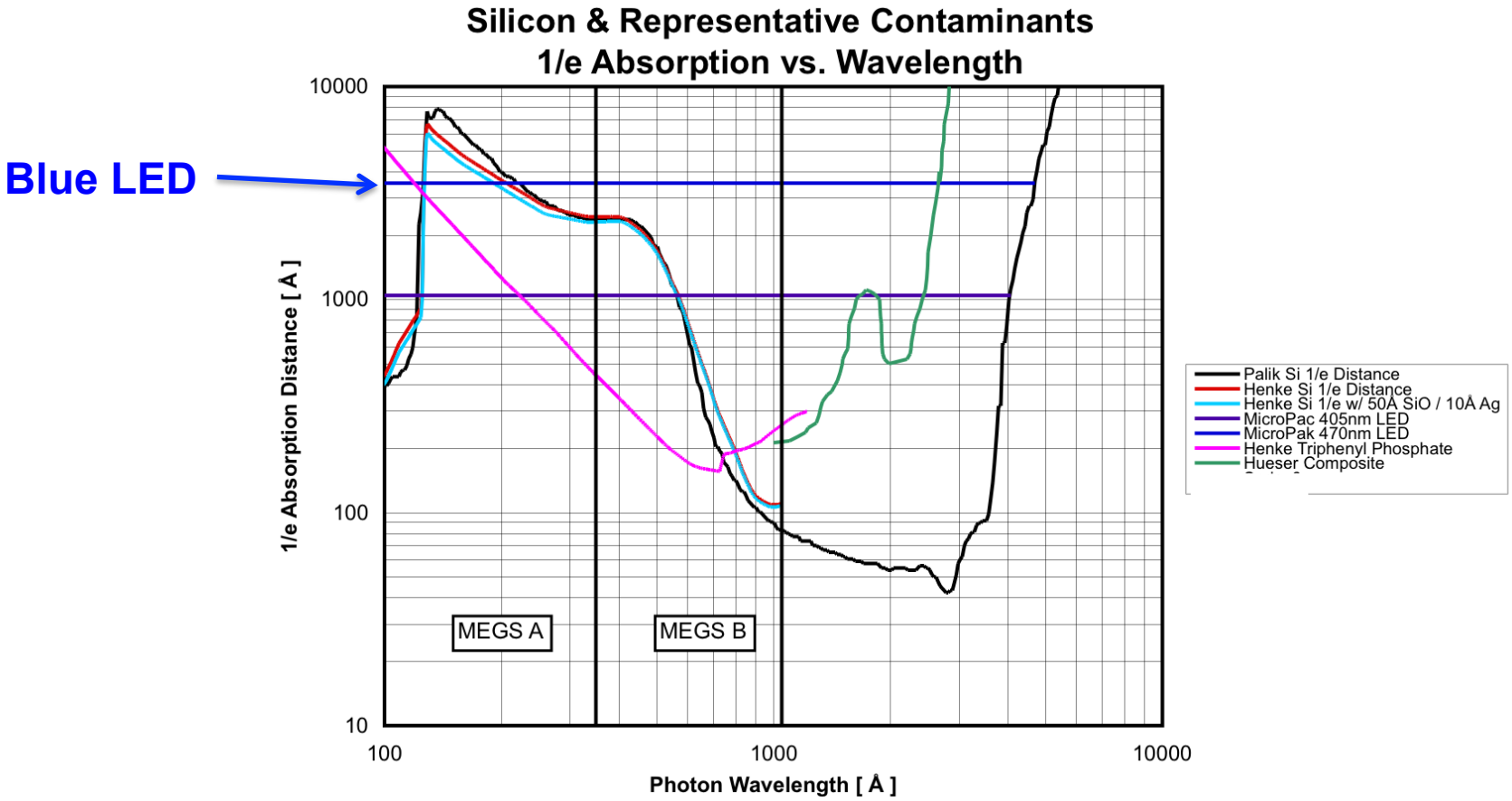
Lowest Exposure Filter

- Filter 5 to 3 ratios show a small trend of a few percent over two years
  - Save for version 4
  - Exposure for filter 3 and 5 was the same up to 2010310, then 5 was changed to weekly exposure



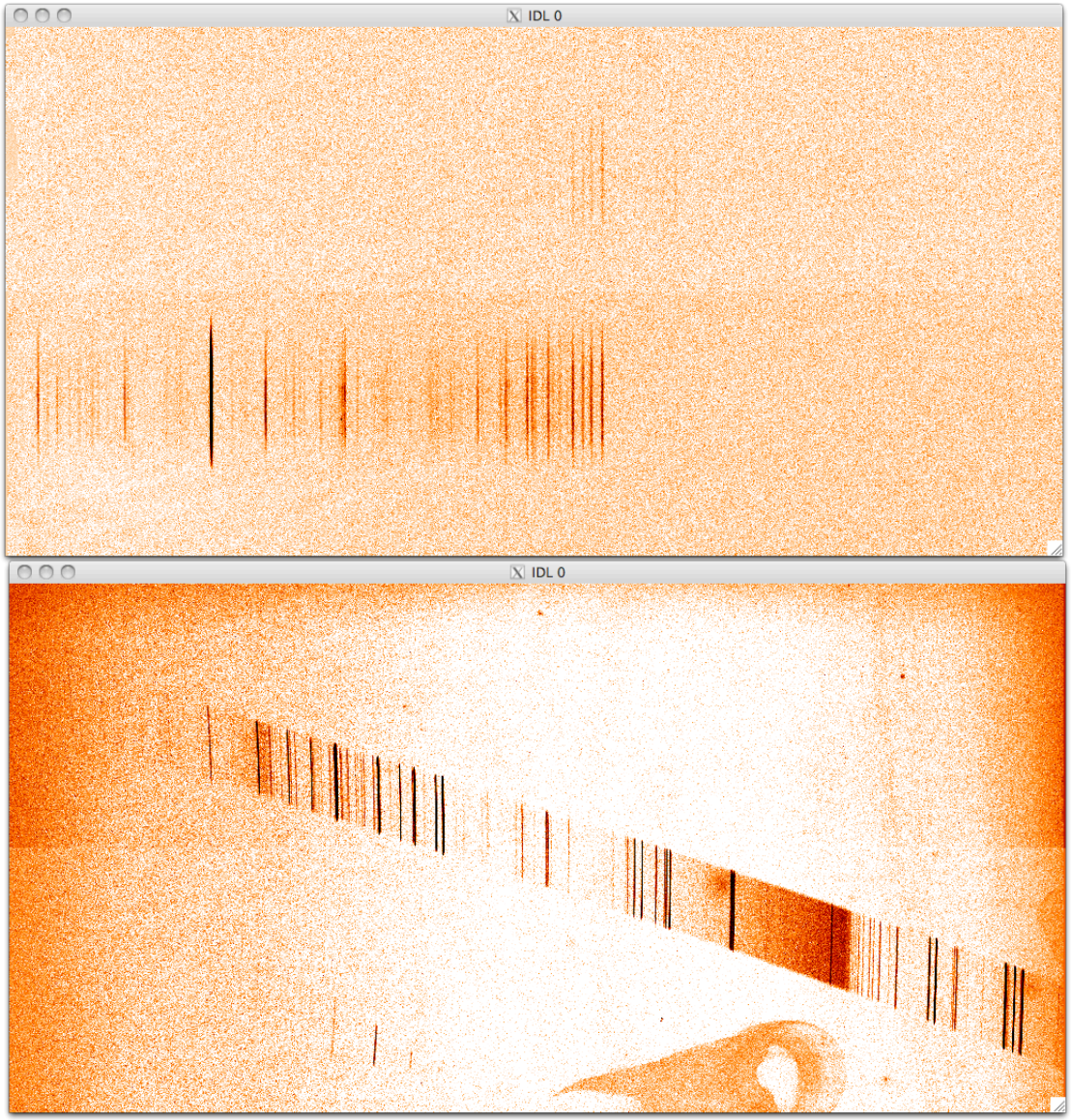
Flatfields

- On-board LEDs are used to illuminate the CCD with a reproducible pattern
  - Visible light (blue LED) is energized for 70 seconds each day with the filter in the dark position
  - Pre-flight concept: Blue light has comparable penetration depth to EUV from 10-20 nm (Courtesy of Greg Ucker)



Flatfield Images

- Image differences from 2012001 to 2010120 are shown for MEGS-A and B
  - The slit 2 lines appear darkened (less light)
  - MEGS-B lines that are shown have degraded
  - Dark offsets have changed
  - LED brightness has changed
  - New bad pixels are developing

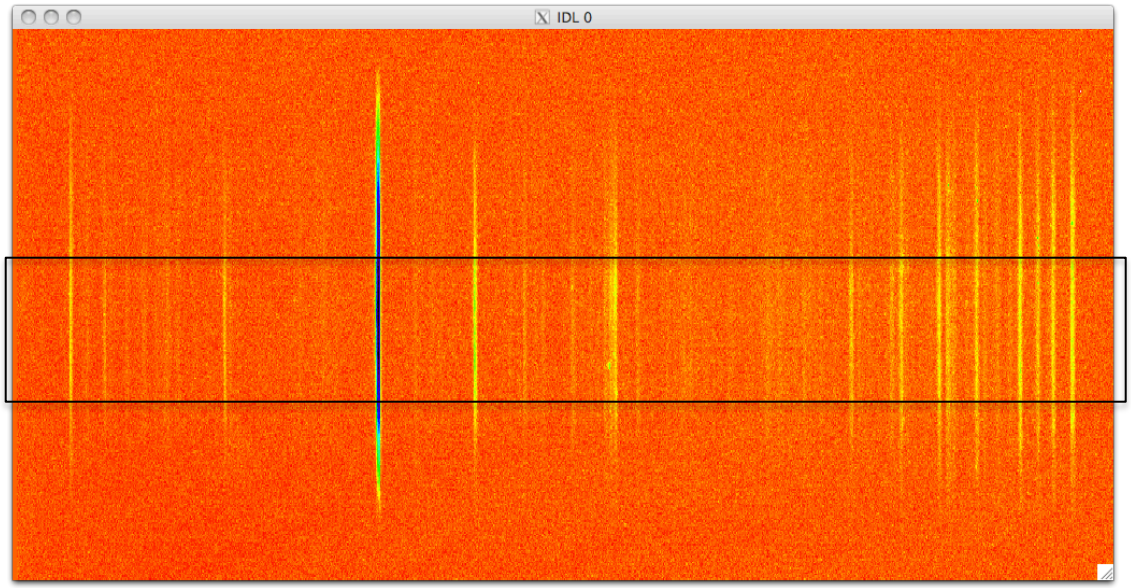


Using the Flatfield Images

- Flatfields are normalized to the first day of operations to remove the LED illumination profile
  - Signals are about a few thousand DN per pixel near center (bright)
- The images are converted from images to spectra, same as solar measurements
  - Additional normalization required since LEDs show changes after bakeouts that last days to a few weeks
  - Gross trend is upwards (LEDs are getting brighter)
  - Darks are also changing

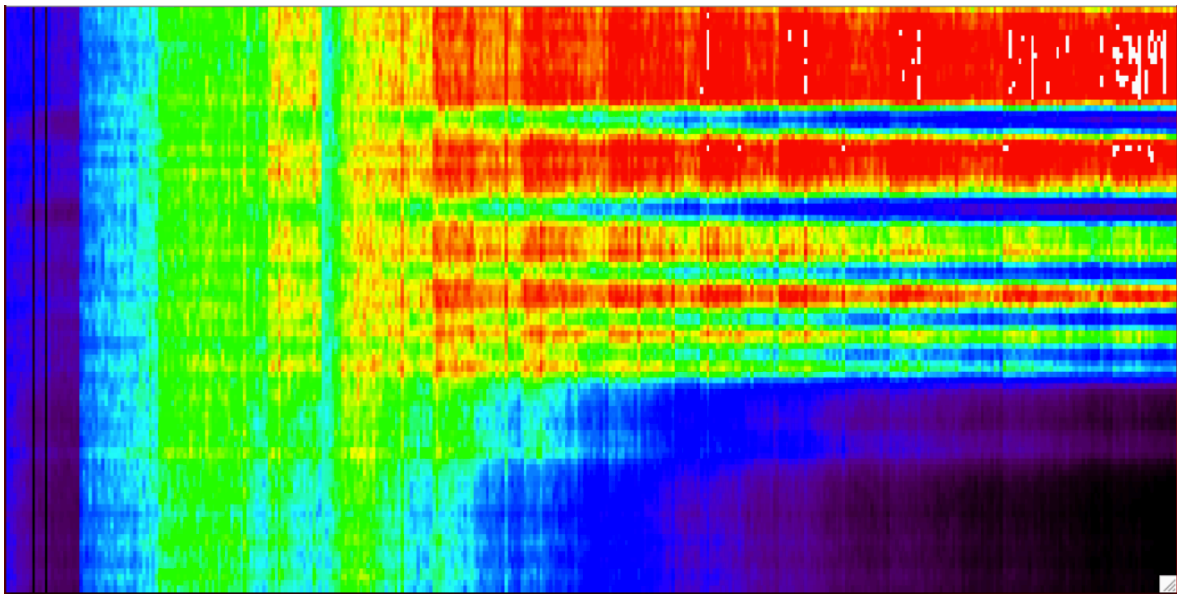
MEGS-A Slit 2 flatfield difference Jan 2012 minus April 2010, 30.4 is largest change

Northern Hemisphere active region burn-in



Non-normalized MEGS-B Flatfield

Normalized only to the first day



Between-line “recovery” is LED drift

Line degradation

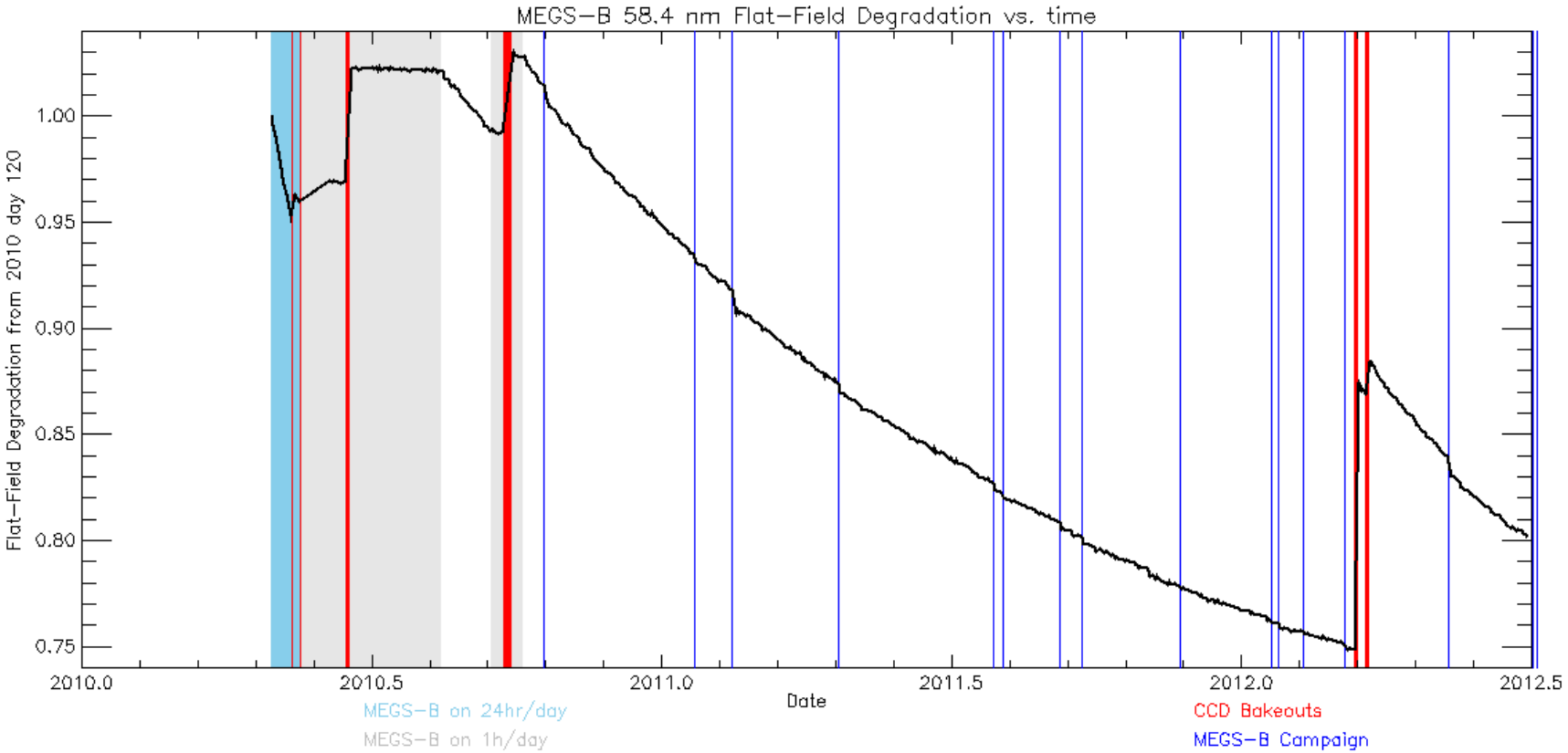
H-Continuum Peak

Time

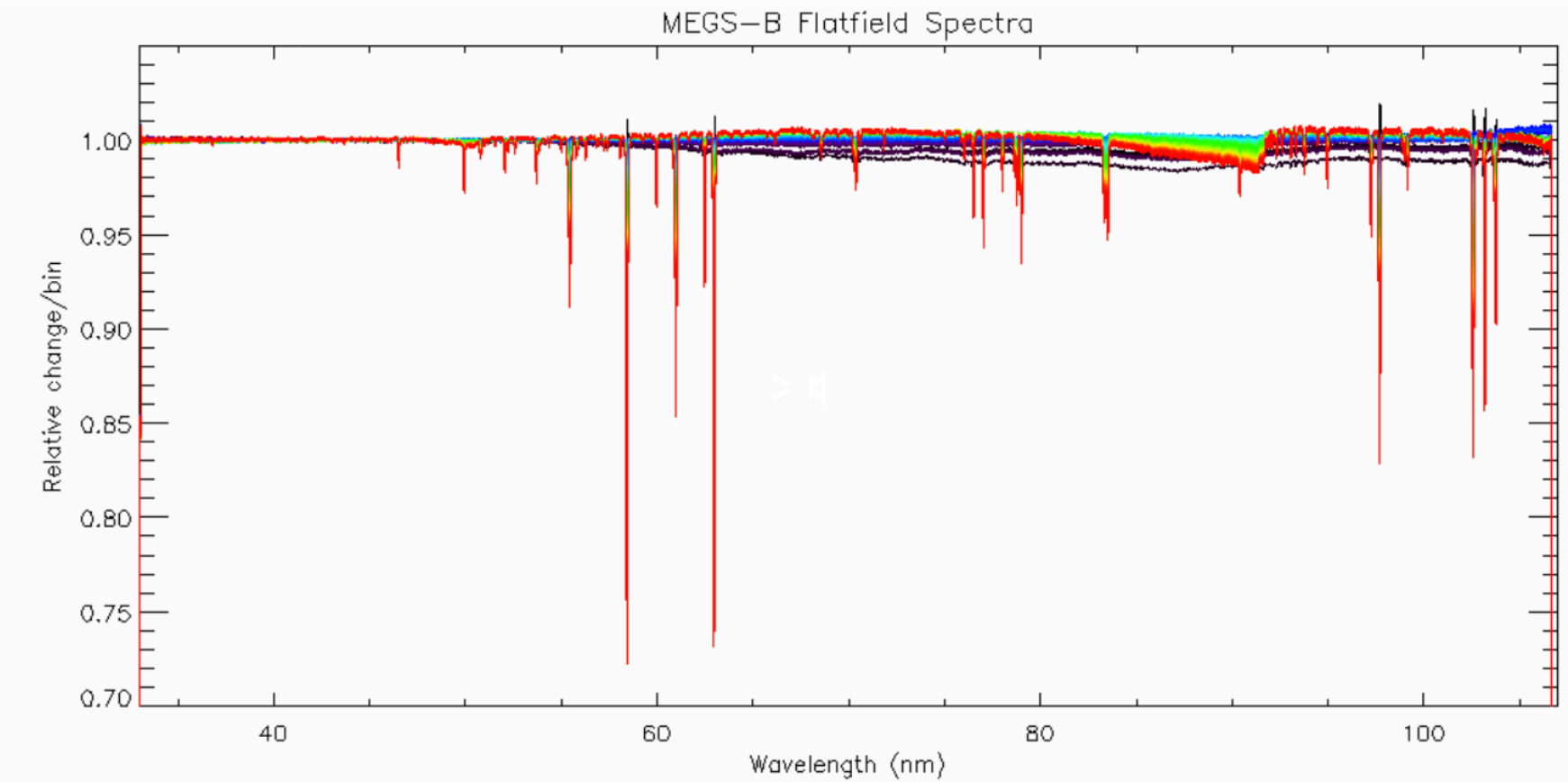
Normalization to the non-solar portions of the detector remove the LED upward drift-trends

Flatfield Trends, MEGS-B

- Flatfields are normalized to the first day of operations to remove the LED illumination profile
  - Signals are about 10,000 DN per pixel near center (bright)
- The images are converted from images to spectra, same as solar measurements
  - Additional normalization required since LEDs show slow changes after bakeouts



MEGS-B Flatfield "Spectrum"

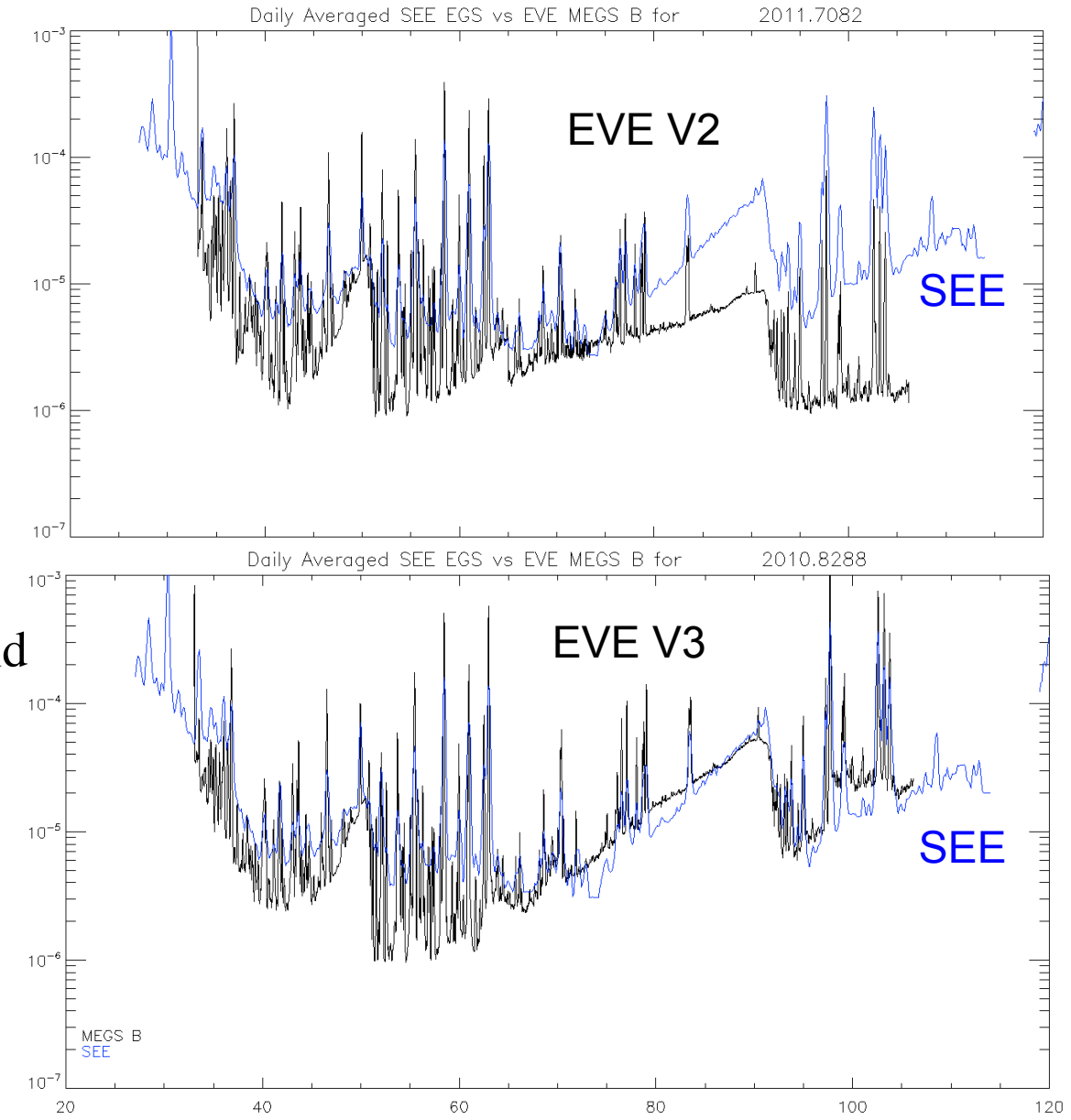


MEGS-B Irradiance Comparisons

- Blue is TIMED-SEE version 11
- Version 3 calculates the flatfield degradation

$$f_{FFDeg} = 1 - \left[(1 - T(t,\lambda)) \cdot f(\lambda) \right]$$

$T(t,\lambda)$ is the normalized flatfield linear trend evaluated at t,λ



Flatfield, f term

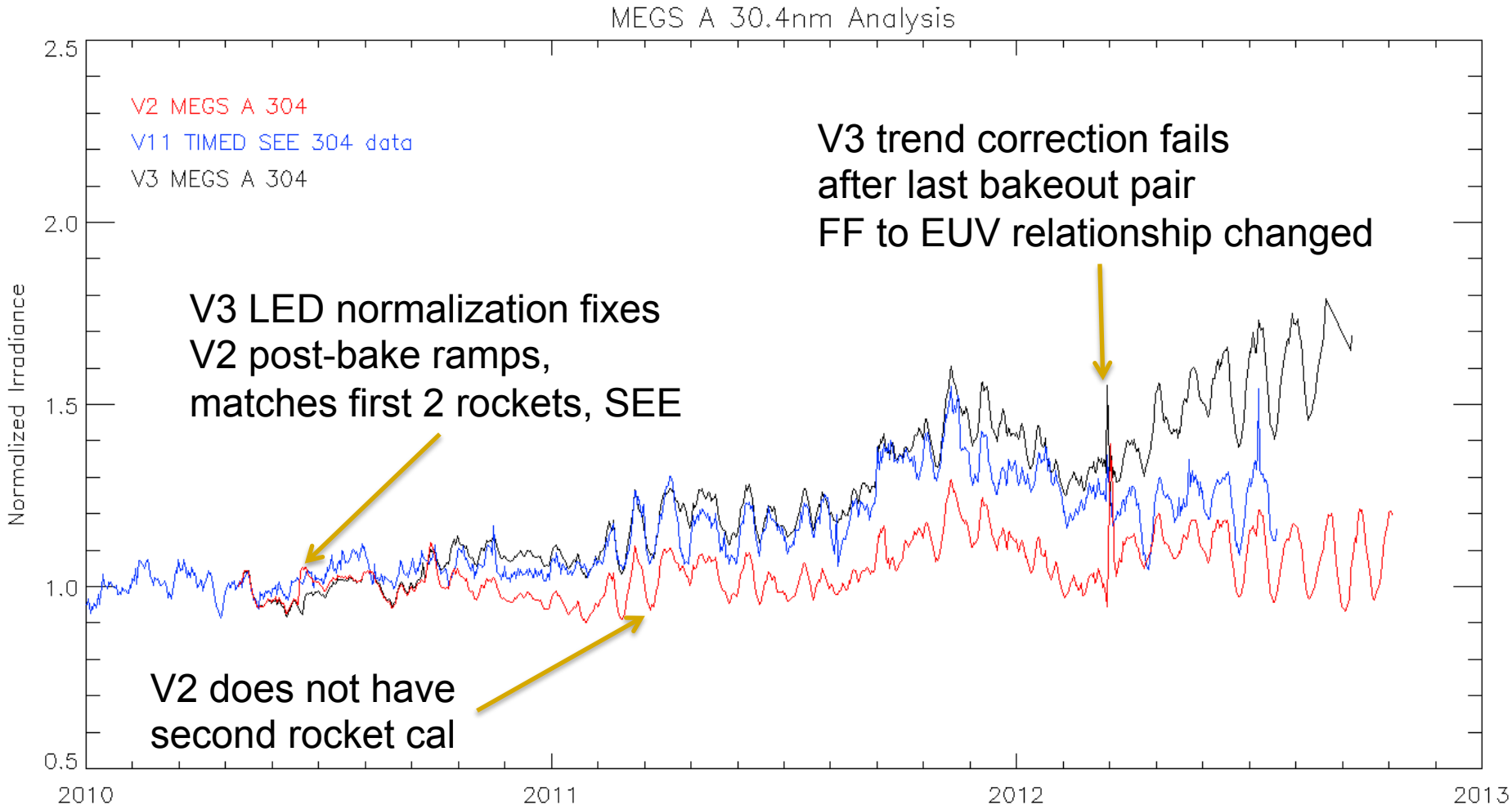
$$f_{FFDeg} = 1 - \left[(1 - T(t, \lambda)) \cdot f\left(\lambda\right) \right]$$

- The f term is an attempt to make the measureable flatfield changes in wavelength and time match the changes observed in the rockets
  - Ratio of the 2011 to 2010 rockets to the normalized flatfield ratios on the same days
    - A ratio of two ratios
  - Limited by the rocket
    - Rocket uncertainties are finite
    - Different resolution, wavelength shifts, dark, etc.
    - Some lines decreased which would make EVE decrease
  - **Assumes the relationship between the flatfield and irradiance is constant**

- For MEGS-A, the value is a constant (4.21) except at 30.4 (2.797)
  - This will likely change later since most lines have little degradation so it does not matter much for those yet
    - Version 4

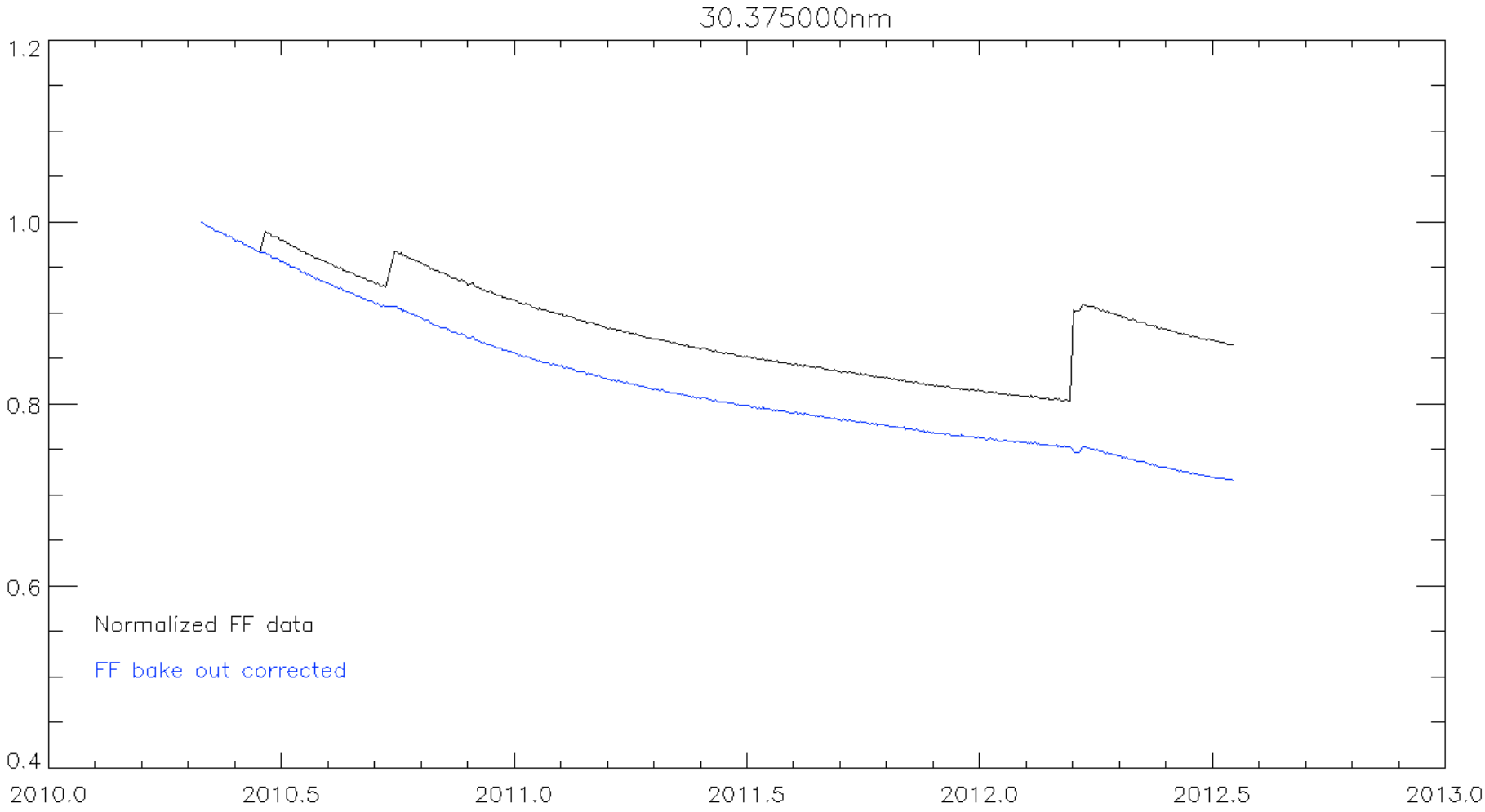
MEGS-A 30.4 nm Line Irradiance Comparisons

- 30.4 is compared for version 2, version 3, and TIMED-SEE
  - Version 3 EVE agrees with SEE version 11 up to the last bakeout



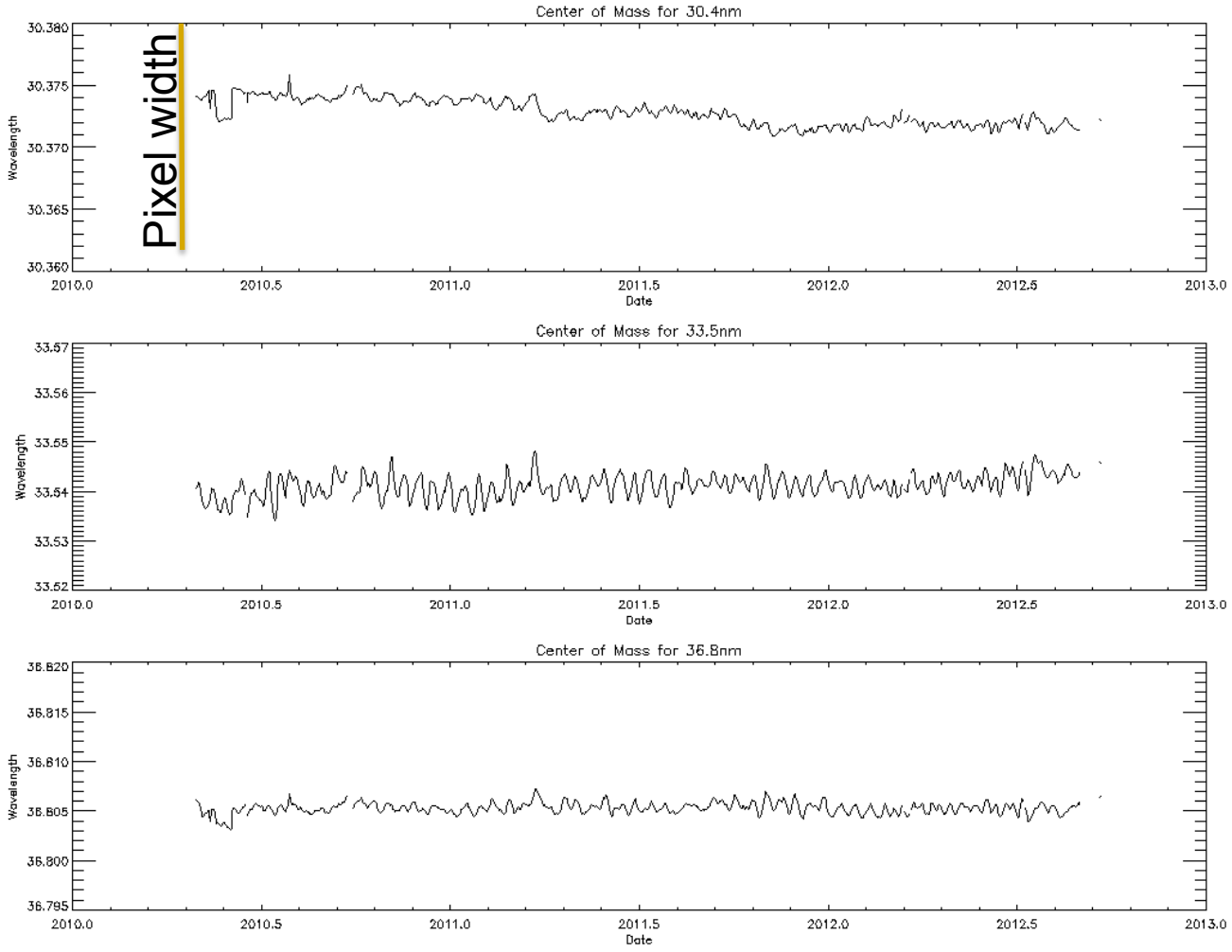
Flatfield Trends, MEGS-A

- MEGS-A 30.4 shows trend changes after CCD “bakeouts”



Line centroid

- No motion beyond thermal changes is detected
- Wavelength map pixels are about 0.0186 nm at 30.4



Discussion

- Relative filter trends appear to behave predictably
  - Consistent with slow changing contaminant deposition
    - Curve is flattening slowly
  - Expect filter 4 to last the whole mission
  - Version 4 may incorporate the filter 5 changes

- Flatfield changes are very difficult
  - Dark changes, LED brightness changes, etc.
  - The 30.4 line has challenges
  - All of MEGS-B is challenging (can MEGS-P help?)

- The relationship between trends in the flatfield and EUV changed after the 2012 bakeout
  - We need a fix for version 3
  - Version 4?