EUV Variability Experiment

Multiple EUV Grating Spectrographs (MEGS)

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LASP

Instrument Overview
- MEGS-A 6-38 nm, 0.1-nm resolution
- MEGS-B 35-105 nm, 0.1-nm resolution
- MEGS-P Photometer for HI 121.6 nm
- MEGS-SAM 0.1-7 nm pinhole camera
- Measurement Technique
- Data Products

Calibrations
- Pre-flight calibrations
- In-flight calibrations
- MEGS degradation

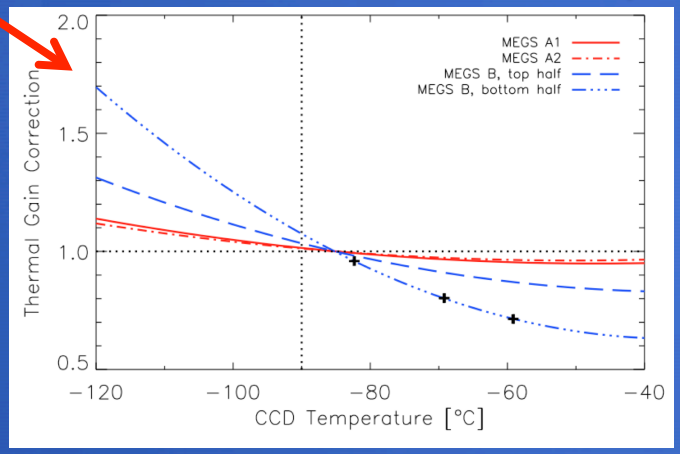
Comparisons to SDO EVE
- MEGS-P Lyman alpha
- MEGS-A and –B to TIMED SEE

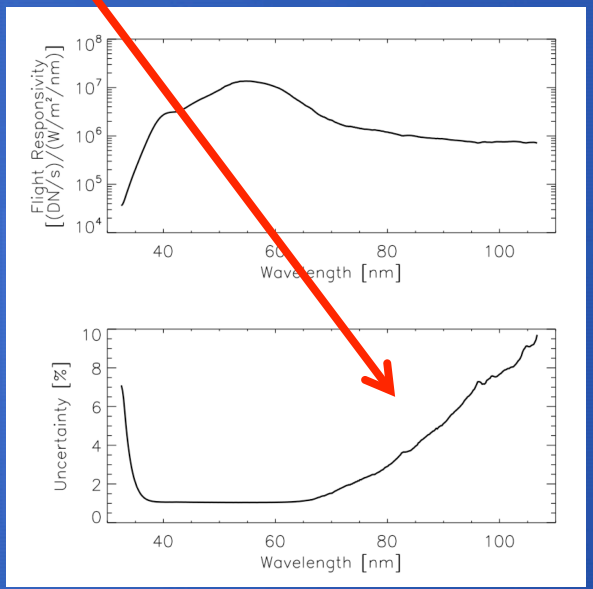
EVE

MEGS Calibration

MEGS Calibration Overview

- Pre-flight Calibrations
  - Selection of filters, gratings, and CCDs
  - Responsivity calibrations at NIST SURF-III with 2-10% accuracy
  - Gain and dark as function of temperature

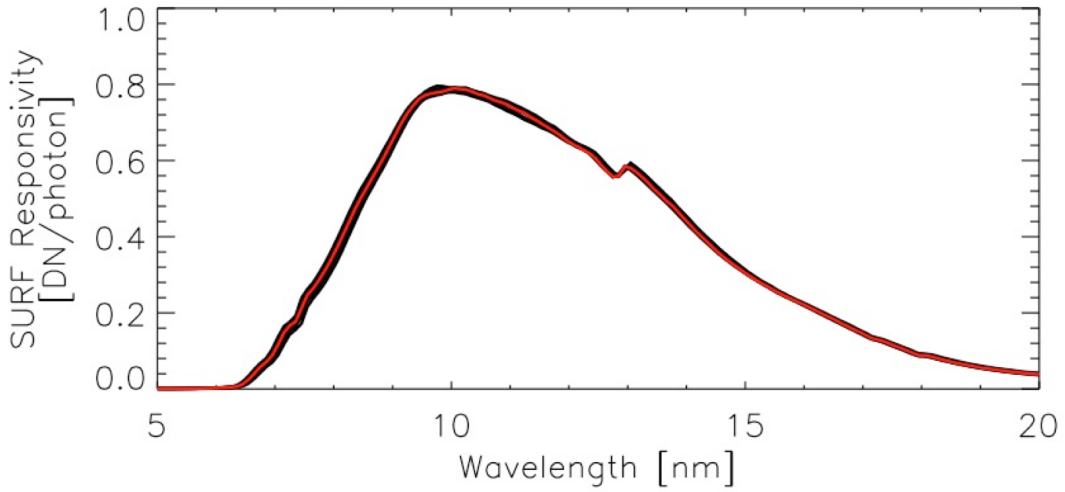


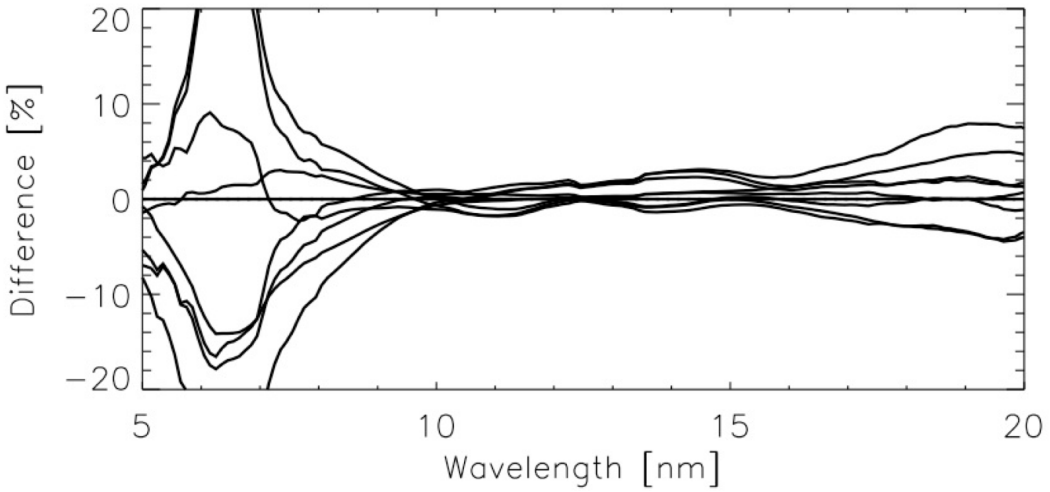


- In-flight Calibrations
  - Rocket underflight calibrations using prototype EVE (about once per year)
    - NIST SURF-III used for the rocket EVE calibrations
  - Redundant filters, flatfield lamps (LEDs), & dark calibrations are done daily
  - FOV maps and cruciform scans are done once a quarter

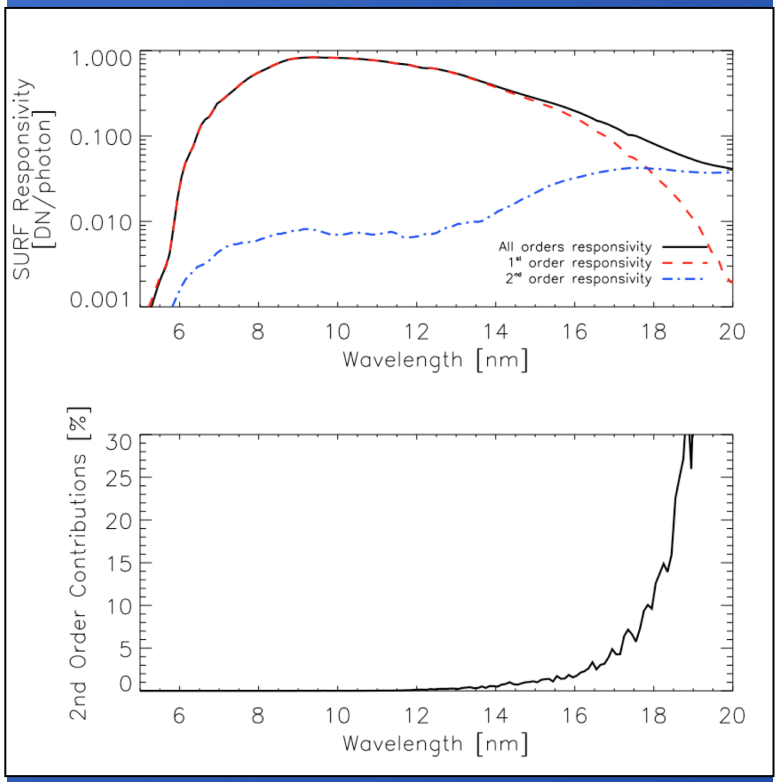
MEGS-A1 Responsivity – FOV Map Data

- MEGS-A1 is for 6-18 nm measurements



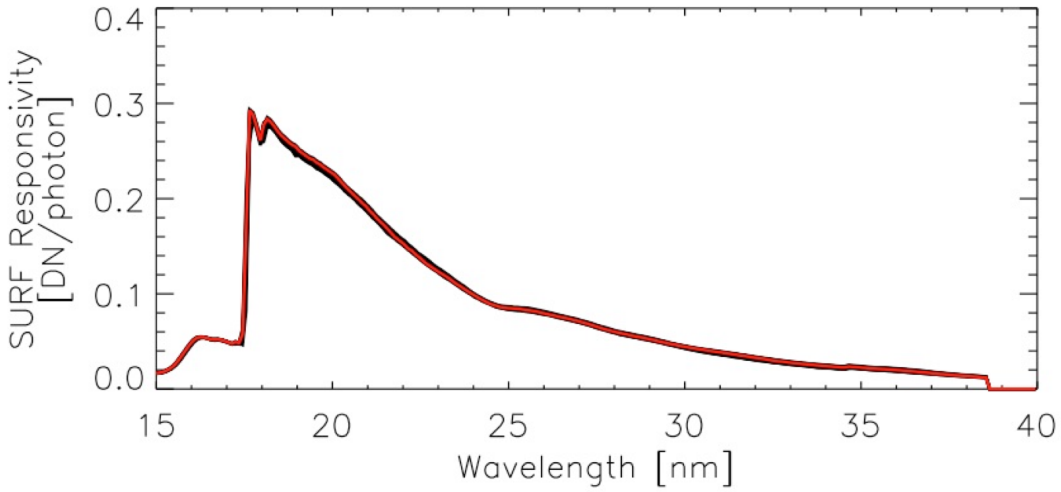


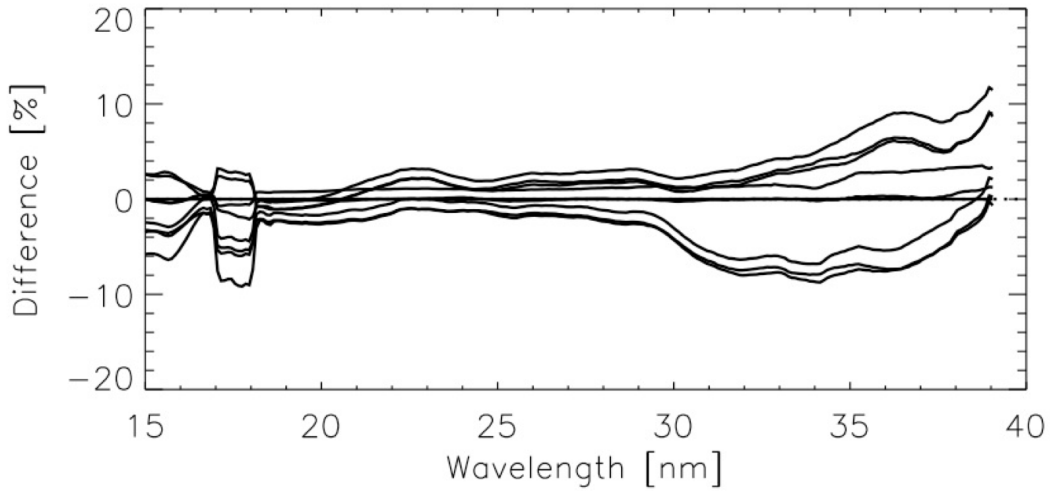
2nd Order Contribution is small



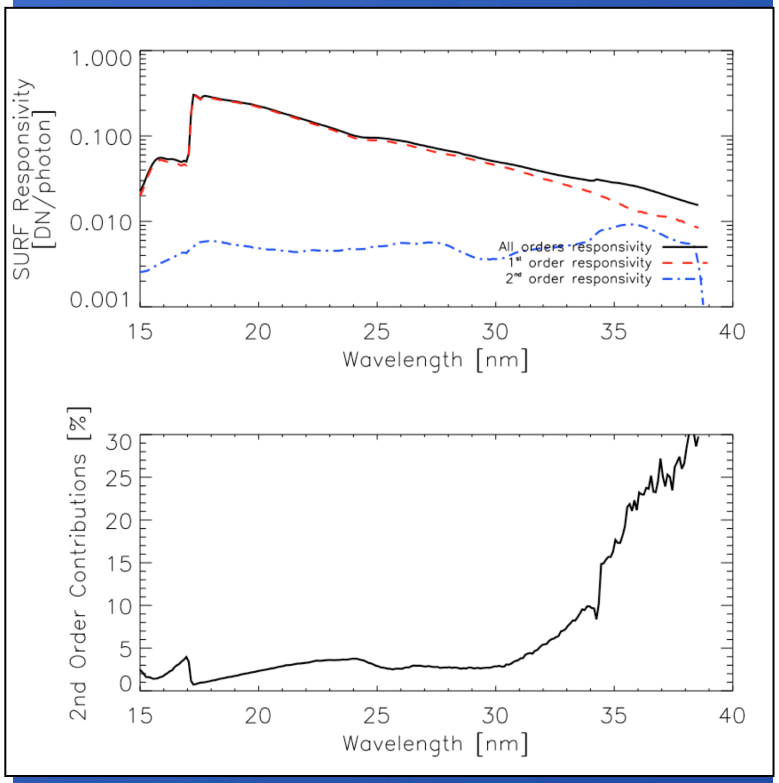
MEGS-A2 Responsivity – FOV Map Data

- MEGS-A2 is for 18-37 nm measurements



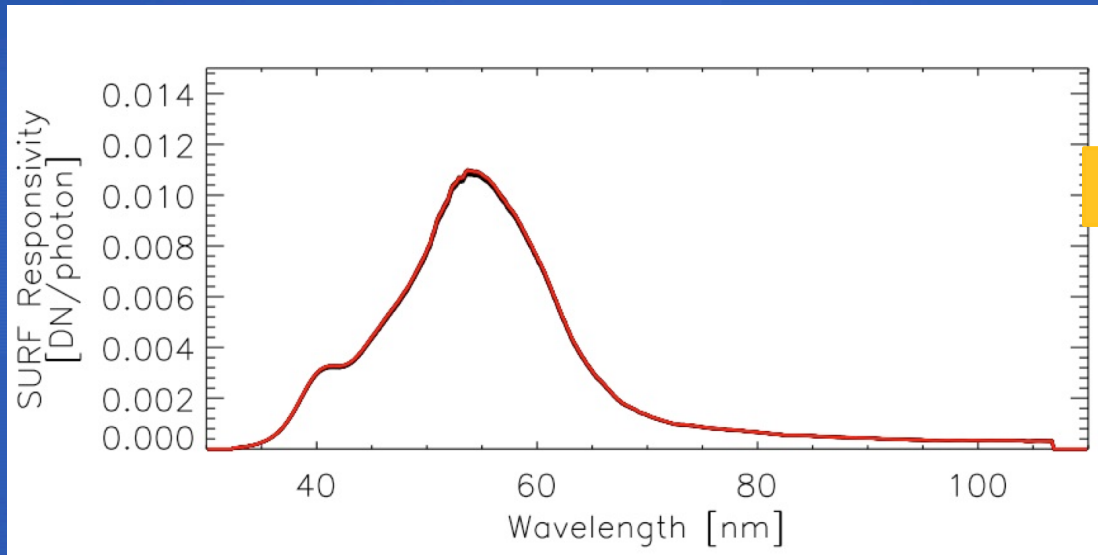


2nd Order Contribution is small

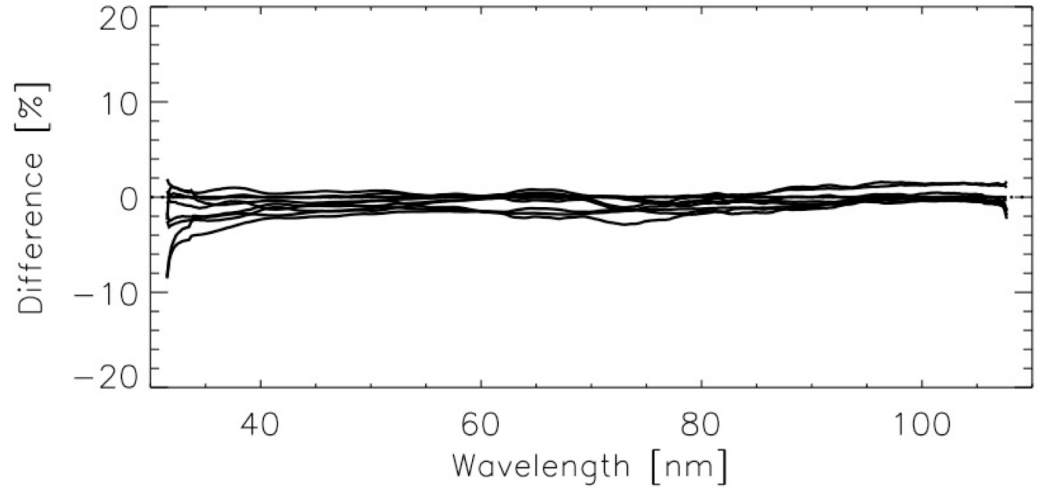


MEGS-B Responsivity – FOV Map Data

- MEGS-B is for 37-105 nm measurements

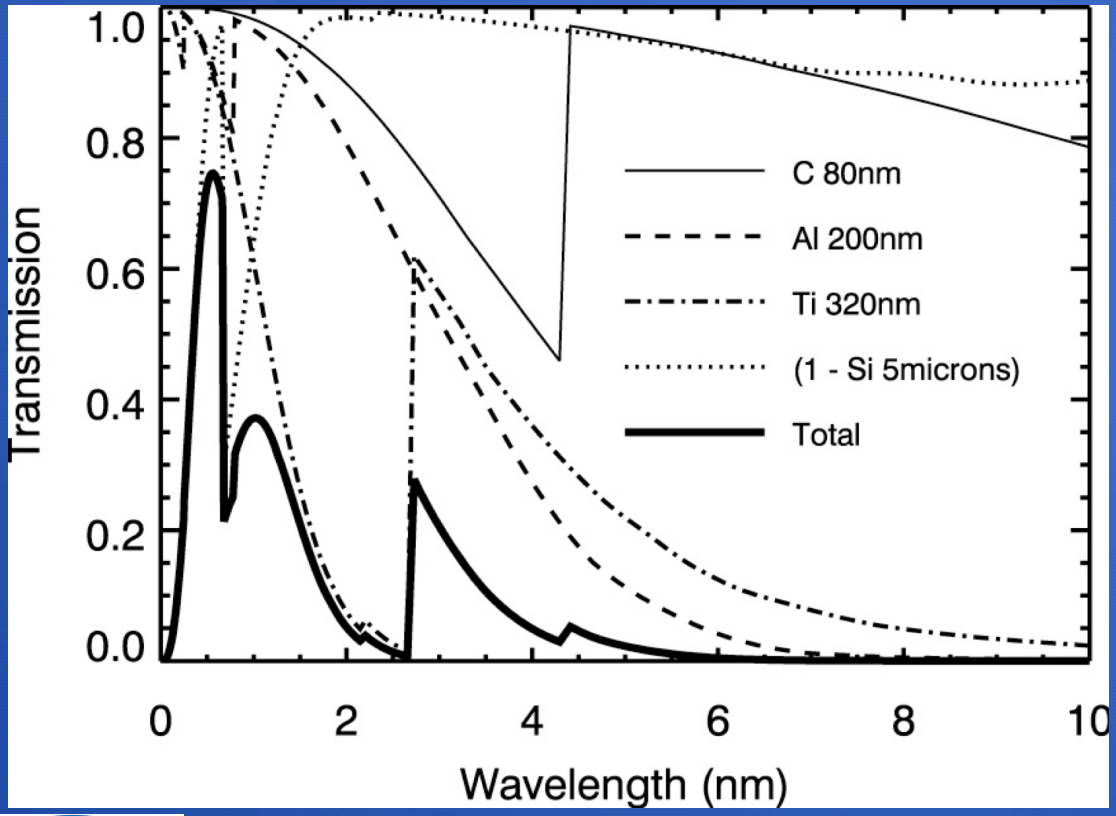


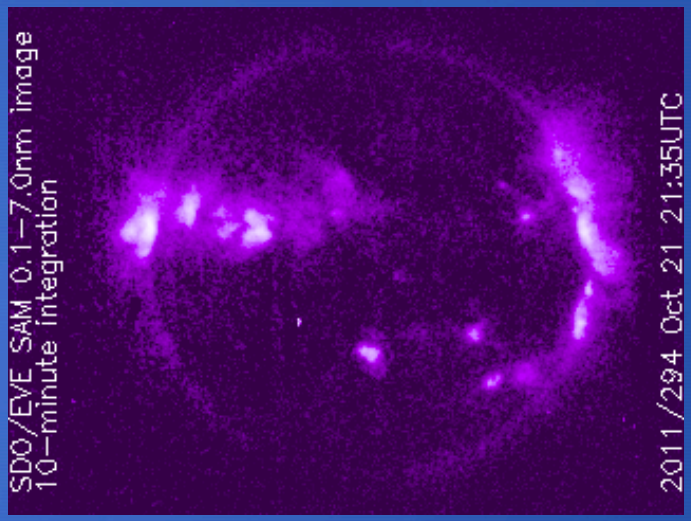
No 2nd Order Contribution



MEGS-SAM – Filter Transmission

- Ti/Al/C filter is in front of pinhole aperture





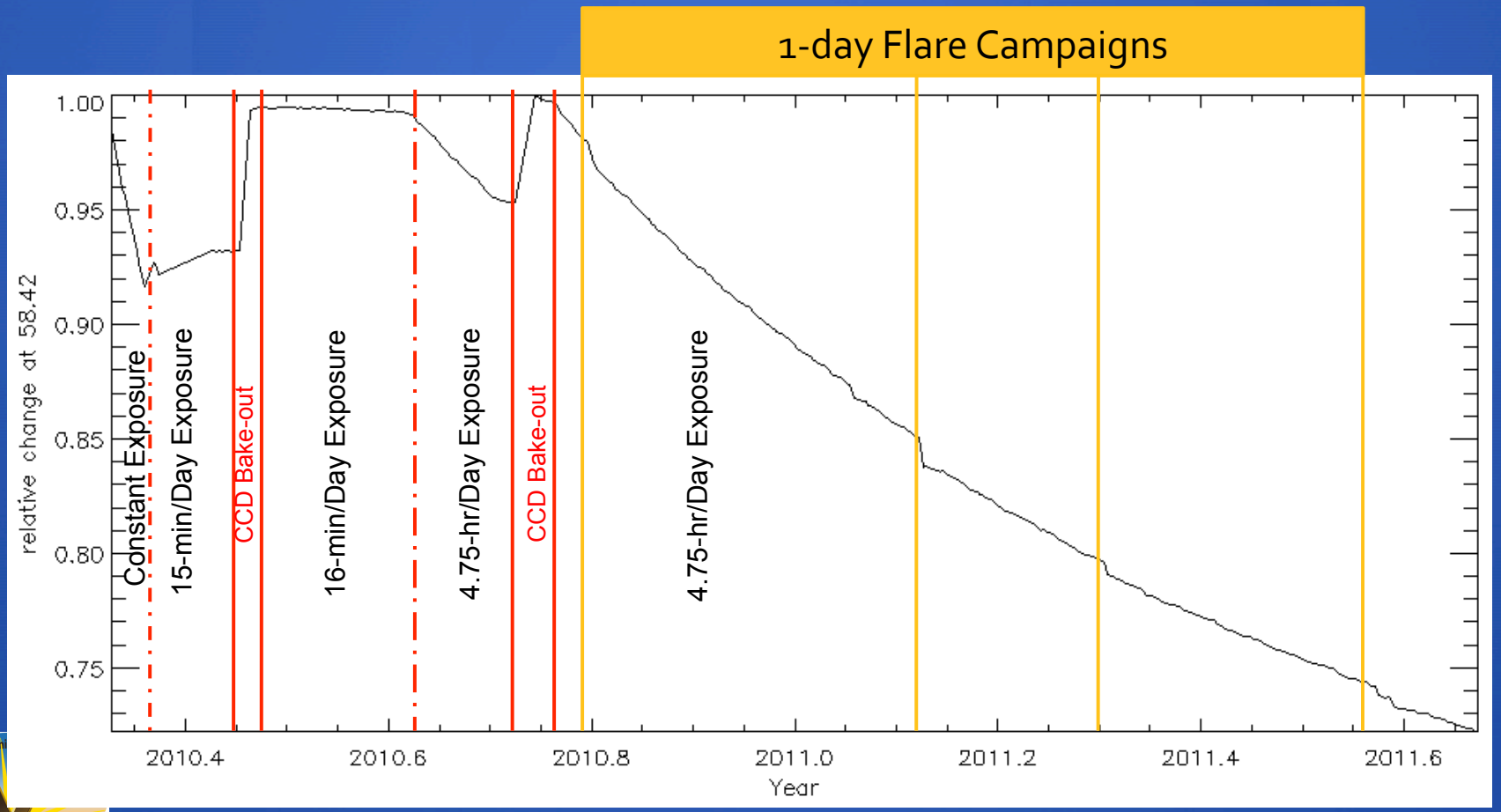
MEGS In-flight Degradation

MEGS Degradation Overview

- CCD Degradation
  - Initial degradation seen for MEGS-B: worst for > 70 nm
  - Burn-in of bright lines for both MEGS-A and MEGS-B
  - Rocket underflight calibrations and daily flatfield lamp calibrations are best at tracking the CCD degradation rate
- Filter (Contamination) Degradation
  - MEGS-A2 (and ESP) filters (Al/Ge/C) are degrading with exposure
    - Thought to be related to contamination on S/C and charging effect of the filter
  - MEGS-A1 filters (Zr/C) are not degrading. No filters on MEGS-B.
  - Daily redundant filter calibrations are best at tracking filter degradation

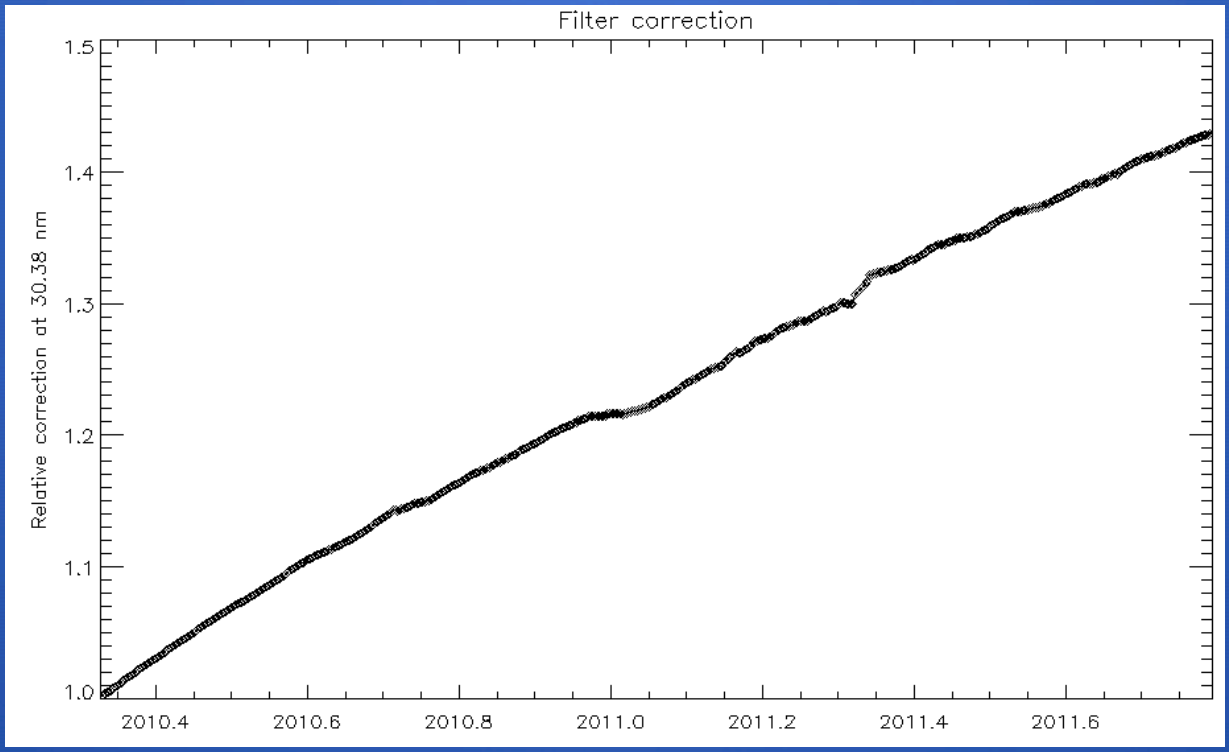
MEGS-B CCD Degradation Trend over Mission

- MEGS-B CCD is degrading faster than expected with exposure, so MEGS-B observations are now limited to about 5 hours per day (instead of 24/7).



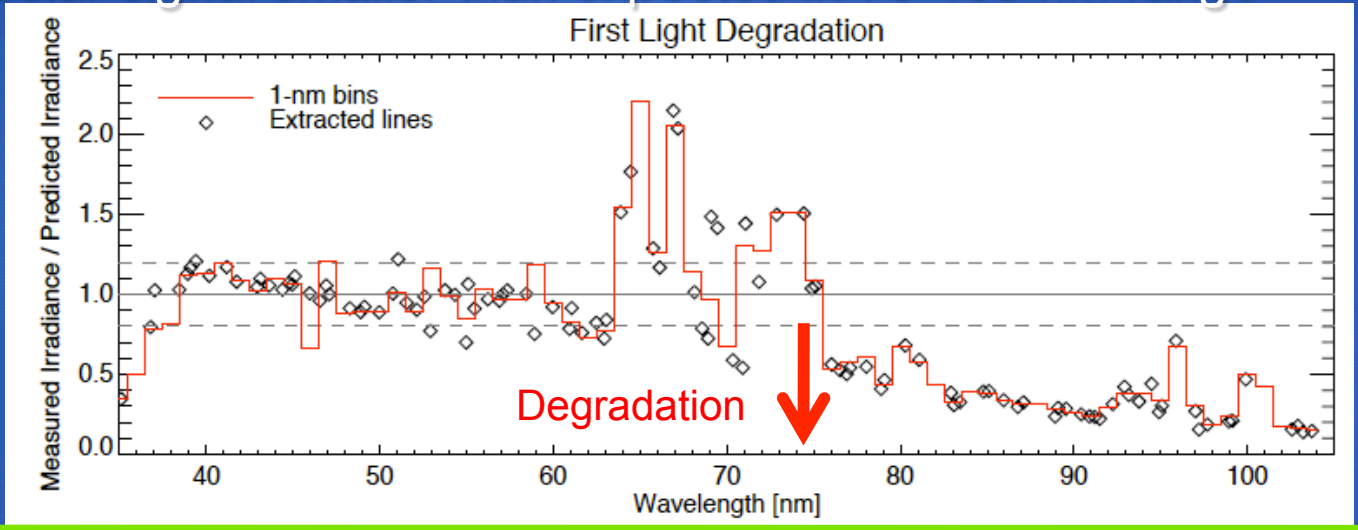
MEGS-A2 Filter Degradation Trend over Mission

- MEGS-A (and ESP & SAM) is used 24/7.
- MEGS-A2 and ESP show a steady degradation that appears to be related to contamination / charging on their foil filters.
- MEGS-A1 filter is not degrading.

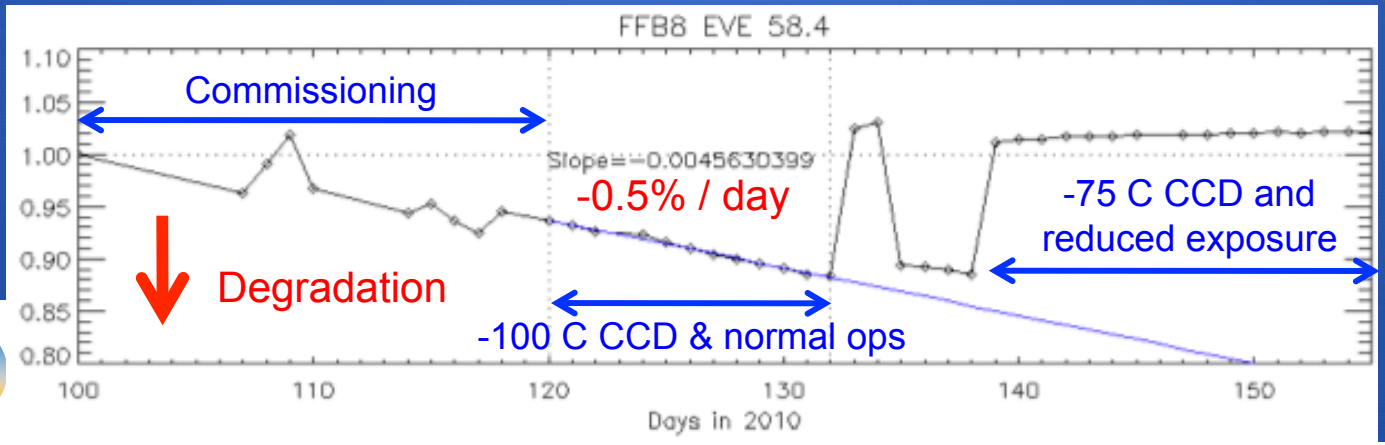


Two Phases of MEGS-B Degradation

- First Light Degradation
  - Solar signal smaller than expected in 70-105 nm range

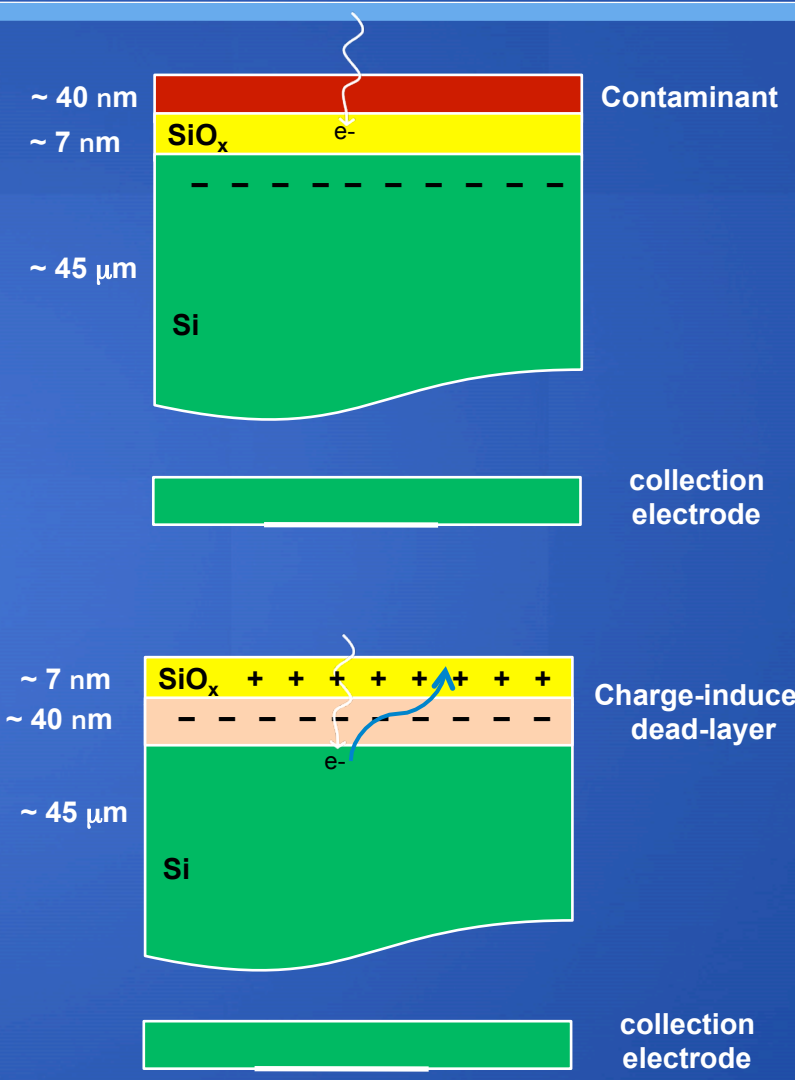


- **Burn-in of bright solar lines into CCD since first light**
  - Burn-in seen in both flat-field (FF) LED images and for solar observations



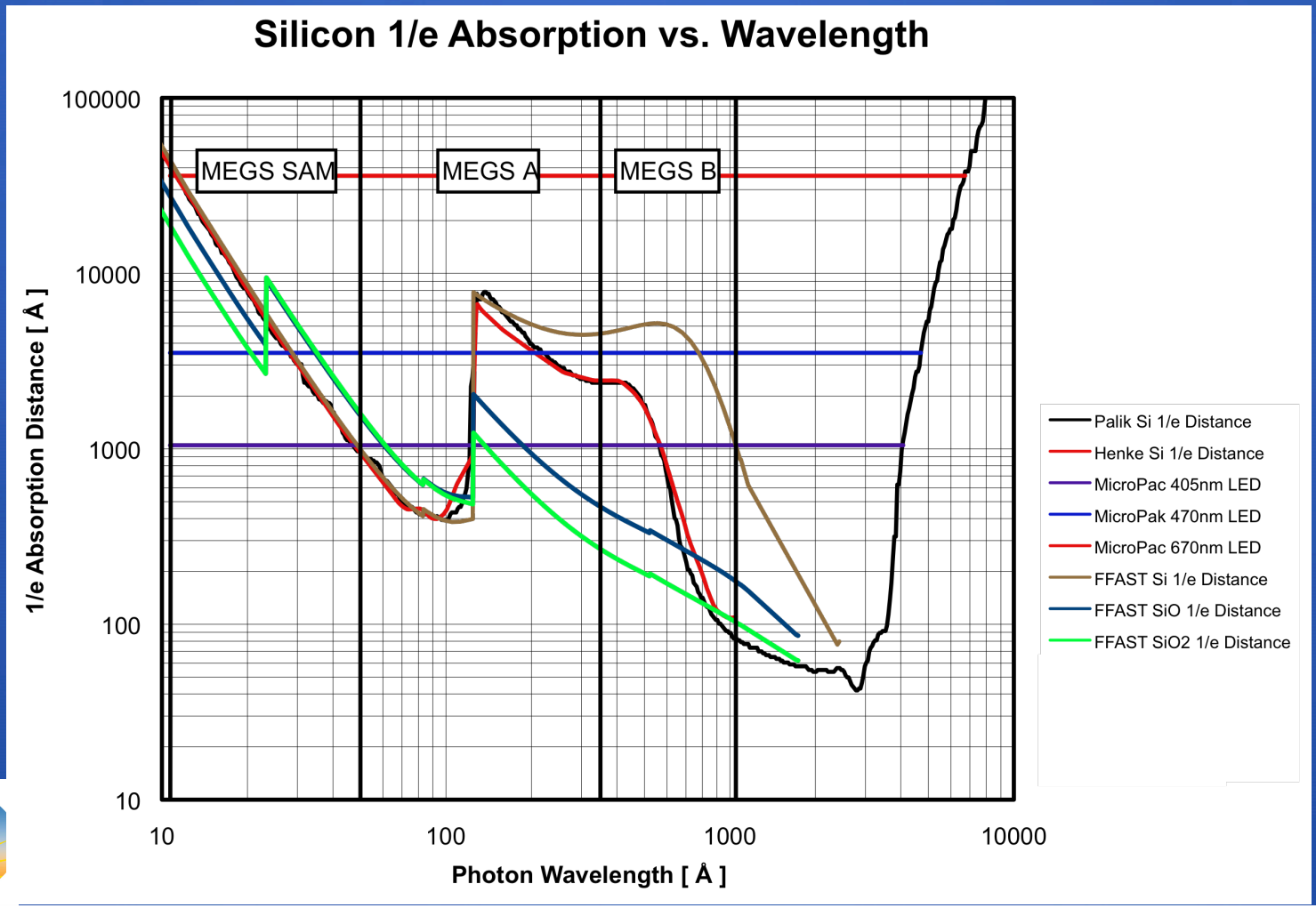
Possible Degradation Scenarios

- Contamination Since Calibration
  - Degradation amount suggests about 20 nm of contaminant on CCD or gratings. Pre-flight monitoring indicates less than 10 nm.
  - Possible sources from EVE itself, purge gas, propulsion.
  - Mitigation: bake-out CCD
- CCD Charging
  - Top layer (SiOx and/or contaminant) can charge up and create Si dead layer inside CCD.
  - Possible sources for charging by protons during GTO and by solar EUV. Could also be charging from purge gas, but unlikely.
  - Mitigation: apply higher voltage across CCD (not option for MEGS)
- Combination of Both Options



CCD (Si) Absorption Curve

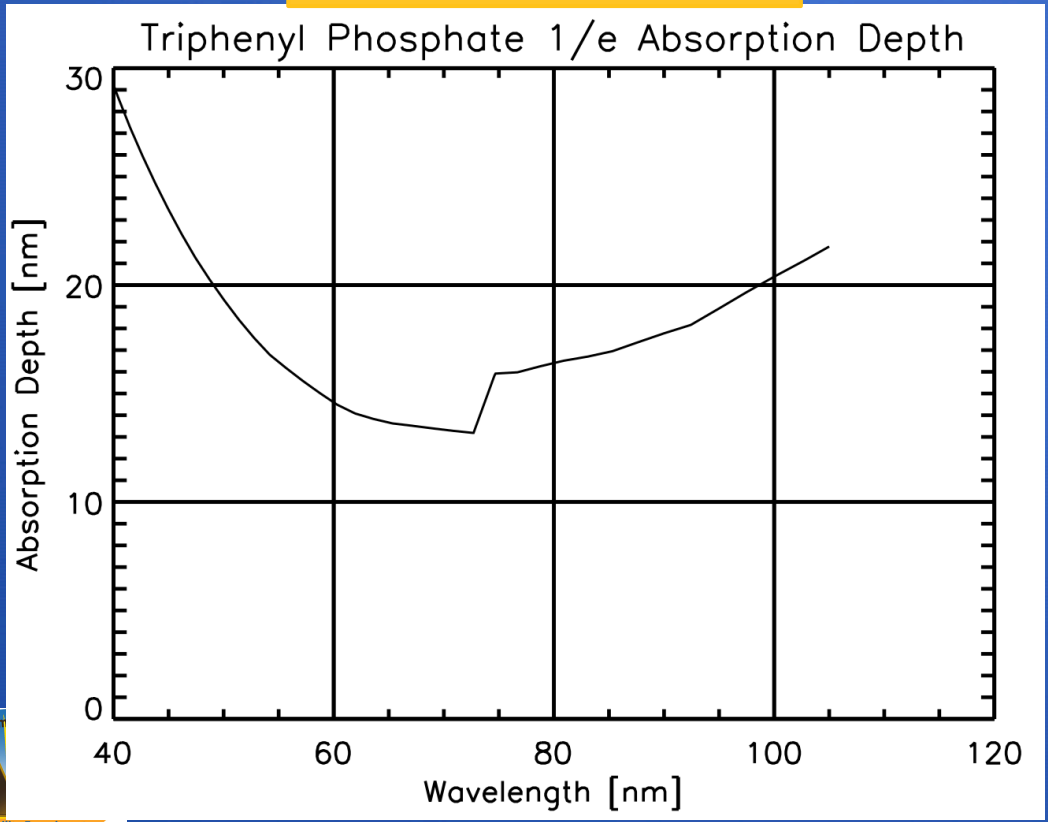
- Blue LED is intended for MEGS-A CCD comparisons
- Violet LED is intended for MEGS-B CCD comparisons

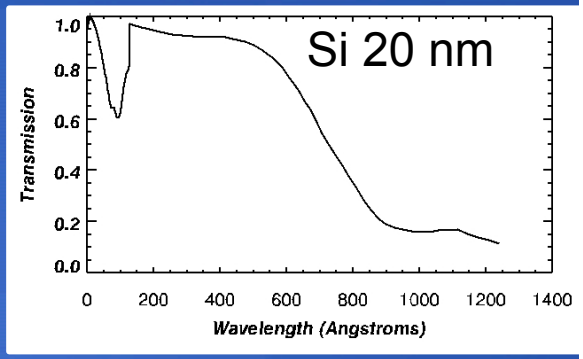


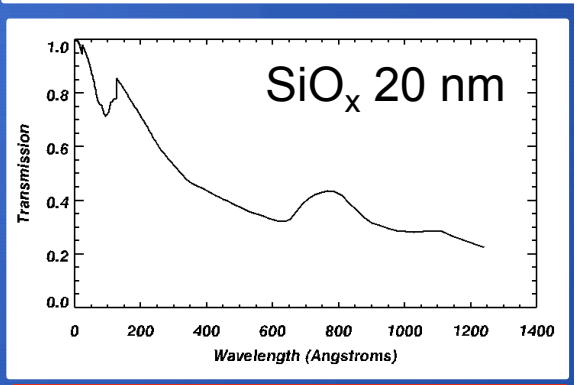
Contaminant Absorption Curves

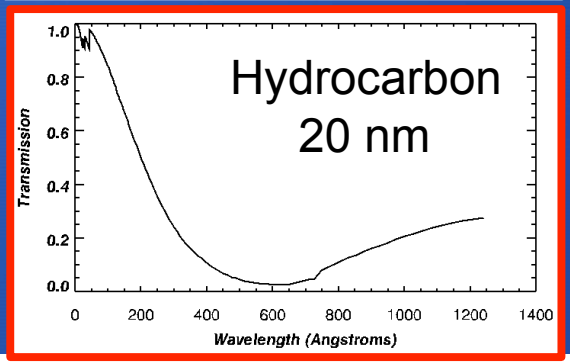
- First Light Degradation curve looks more like Si
  - however, don't see 5-12 nm (50-120 Å) notch for MEGS-A
  - so other type of contaminant is also considered
  - or MEGS-A CCD might not be charged as much

Hydrocarbon Example



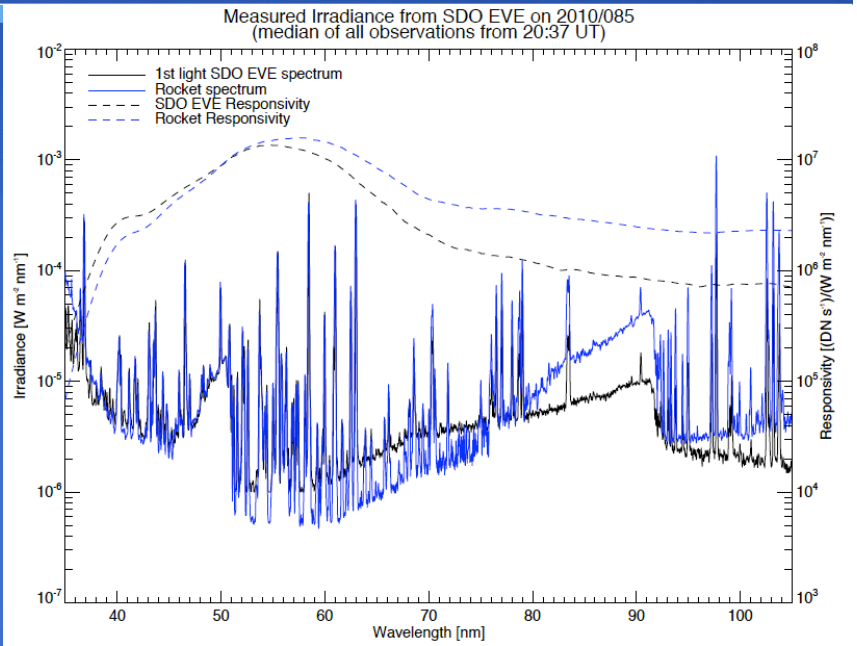


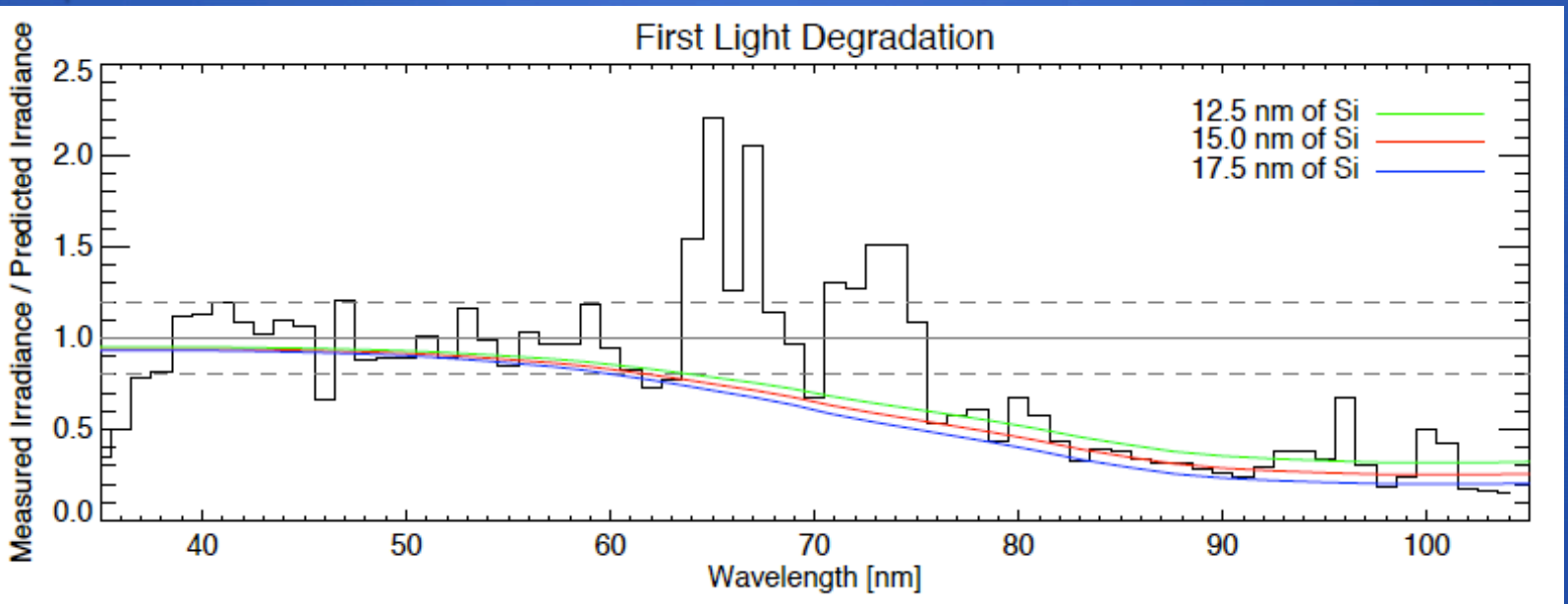




Degradation Seen in First Light Spectrum

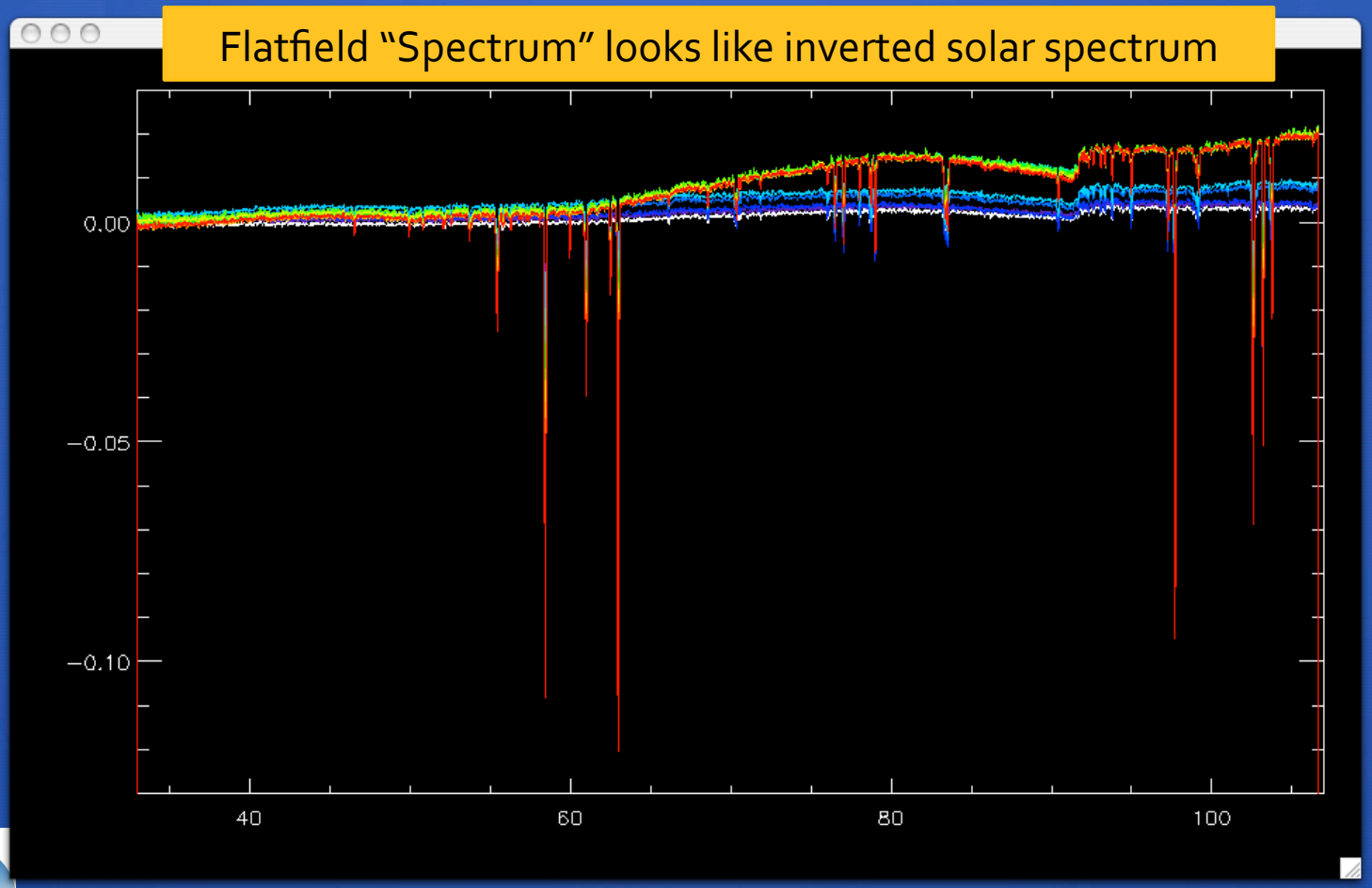
- First minute of solar observations indicate significant decrease in sensitivity from what was expected with SURF calibrations
- Ratio includes correction for solar variability from DOY 085 to 123 (rocket day) by using TIMED SEE data
  - Subtracting dark level impacts background so ratio is better where bright lines are
  - Si dead-layer model suggests charging equivalent to 15 nm Si





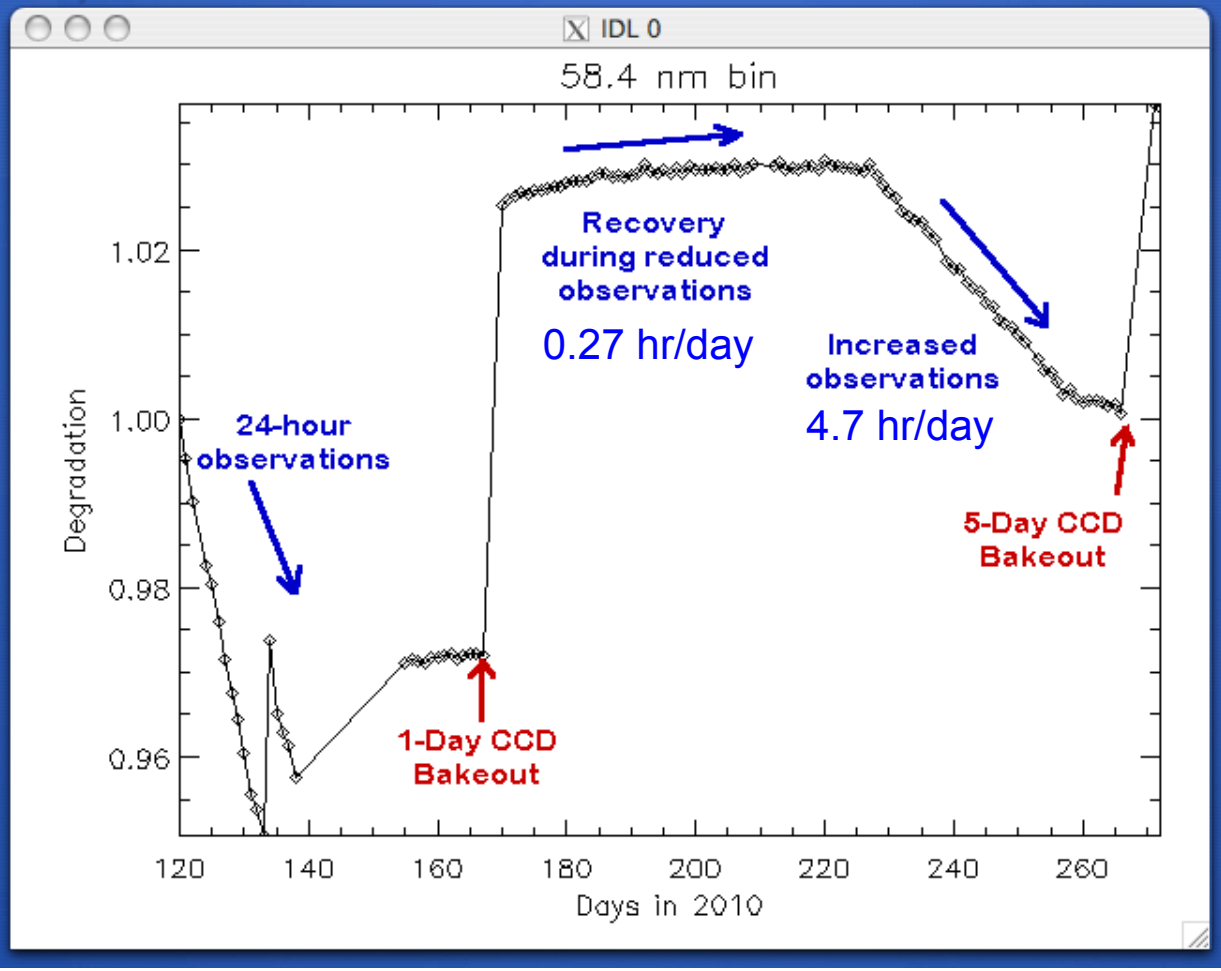
CCD Burn-in Seen for Bright Solar Lines

- CCD Burn-in is best seen in the flatfield LED images that show darker regions where there are bright solar lines



CCD Bake-outs Help to Mitigate Degradation

- Bake-out of CCD helped remove burn-in effects.
  - a 1-day bake appears as good as 5-day bake
- Plan to have CCD bake-outs 1-2 times per year (during eclipse season)

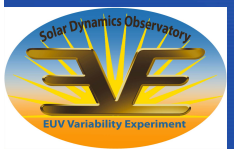


He I 58.4 nm line degrades the fastest

MEGS In-Flight Performance Summary

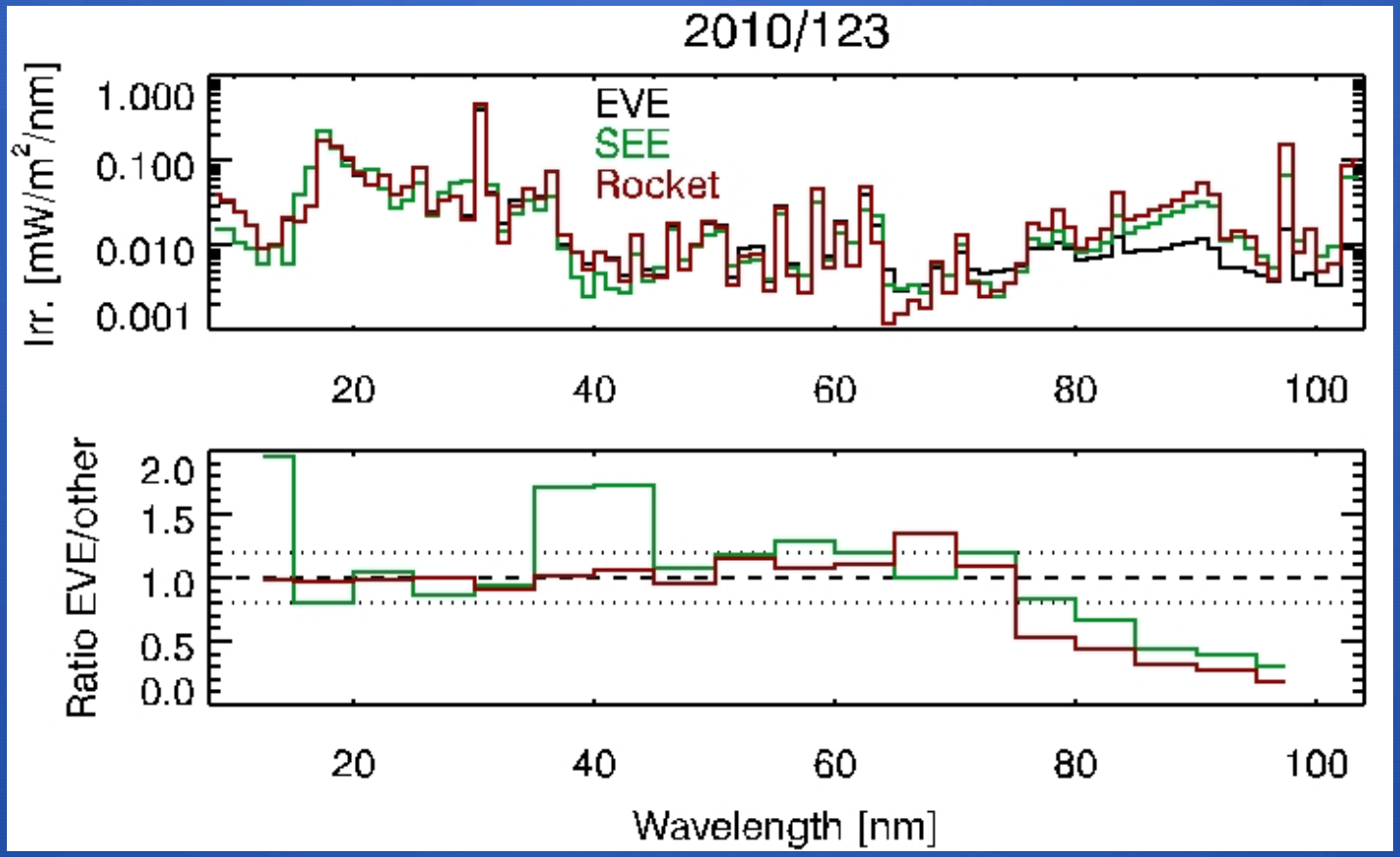
- MEGS-A1 and MEGS-SAM have very little degradation
  - short wavelengths are less sensitive to contamination and CCD exposure effects
- MEGS-A2 has steady degradation of its filter and the few bright lines (e.g. He II 30.4 nm) have burn-in
  - Daily use of redundant filter and flat field lamp does well at tracking most of this degradation; however, the second calibration rocket indicates additional degradation
- MEGS-B has strong initial degradation of CCD at longer wavelengths and additional burn-in for the bright lines
  - MEGS-B observations have been changed to 4.7 hours per day (3-hours campaign and 5-min every hour) and also allow for one 24-hour flare campaign per month
  - MEGS-B data are only released up to 65 nm in Version 2

MEGS Comparisons



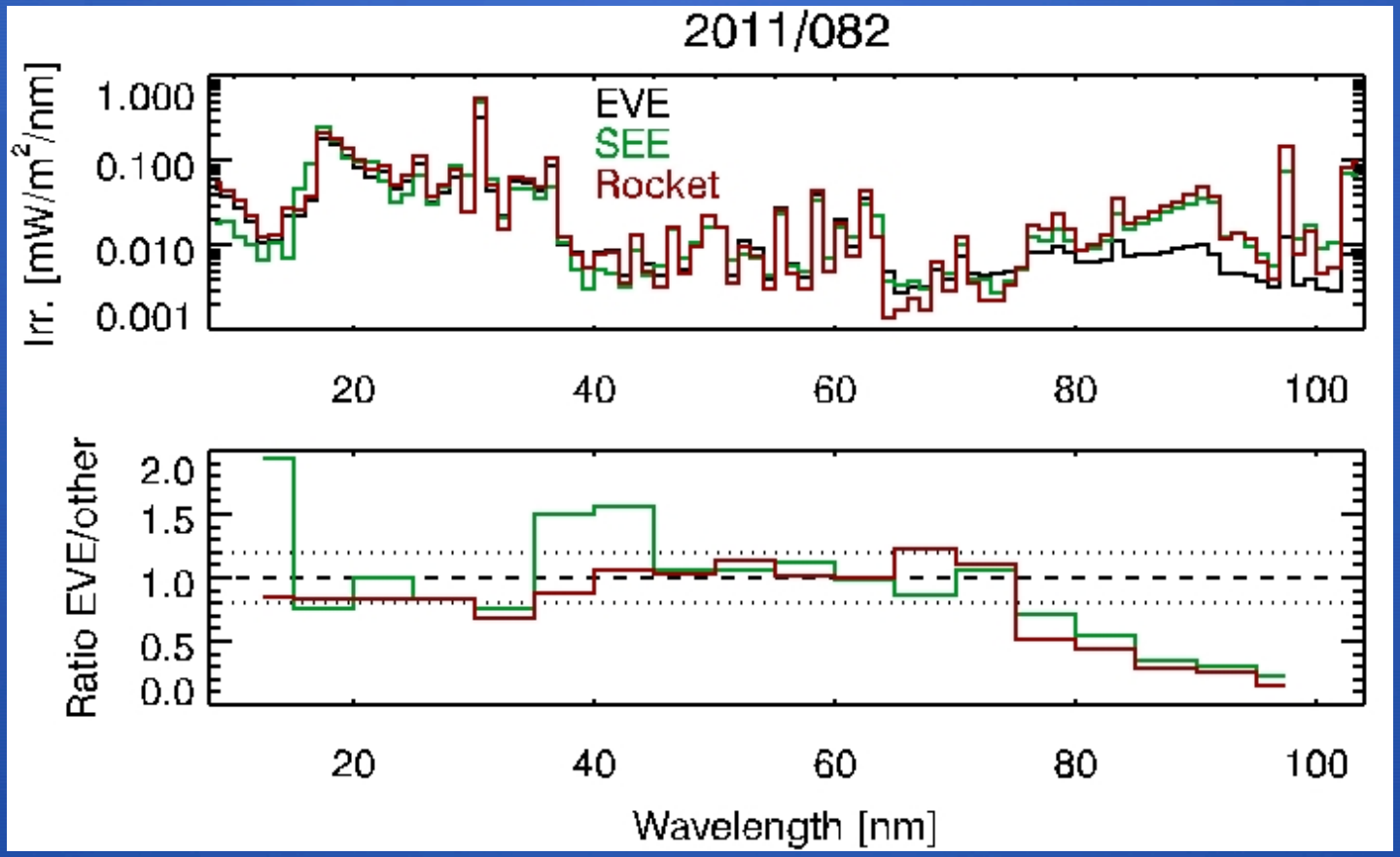
EVE Comparison for First Cal Rocket

- EVE version 3 uses the First Cal Rocket for MEGS-A processing and so good agreement < 38 nm.
- MEGS-B processing has not been updated yet…
- SEE version 11 compares much better to rocket (than SEE ver 10)



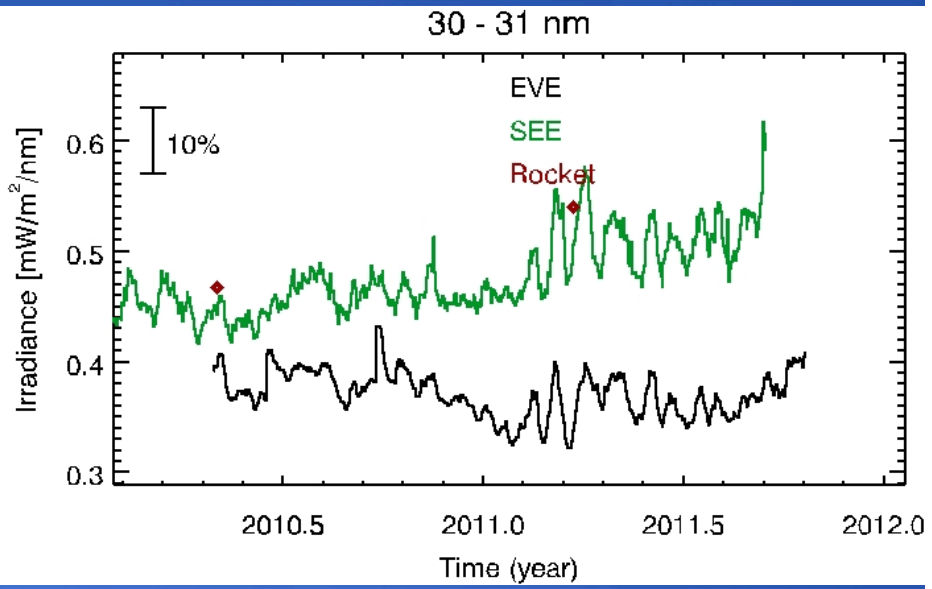
EVE Comparison for Second Cal Rocket

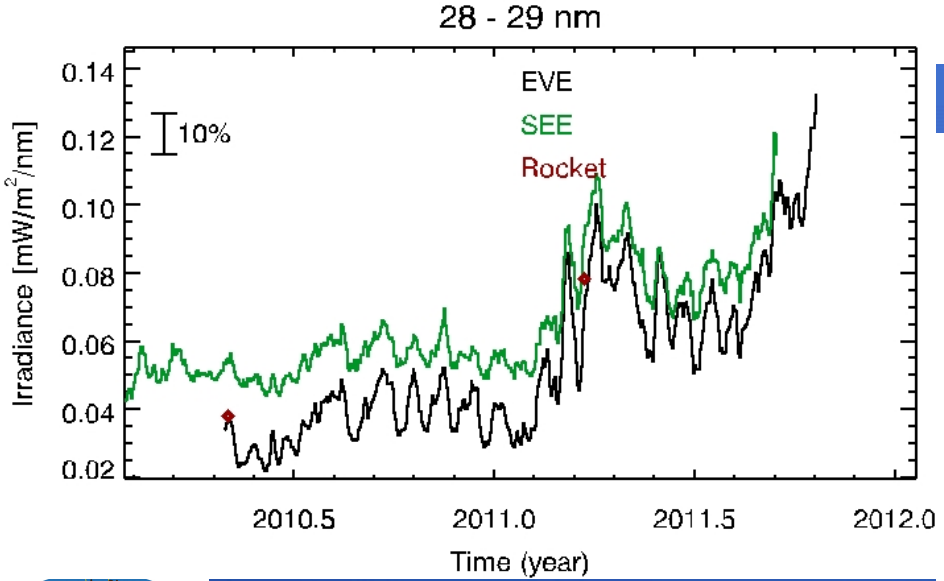
- EVE version 3 processing does not yet use the Second Cal Rocket
  - ~10% extra degradation for MEGS-A needs to be corrected
- SEE version 11 compares much better to rocket (than SEE ver 10)

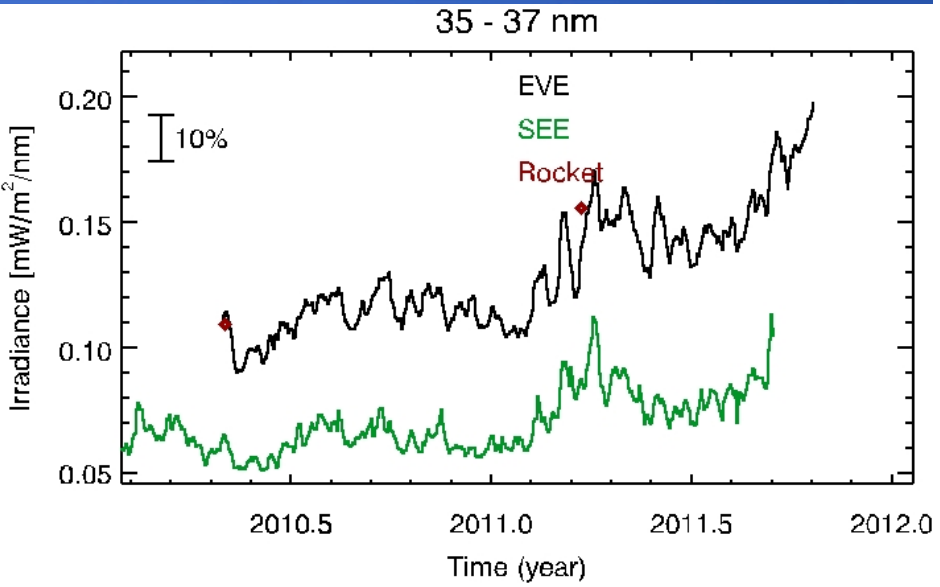


EVE MEGS-A2 Comparison to SEE EGS

- SEE Version 11 is improved over its old version 10
- EVE He II 30.4 nm has additional degradation

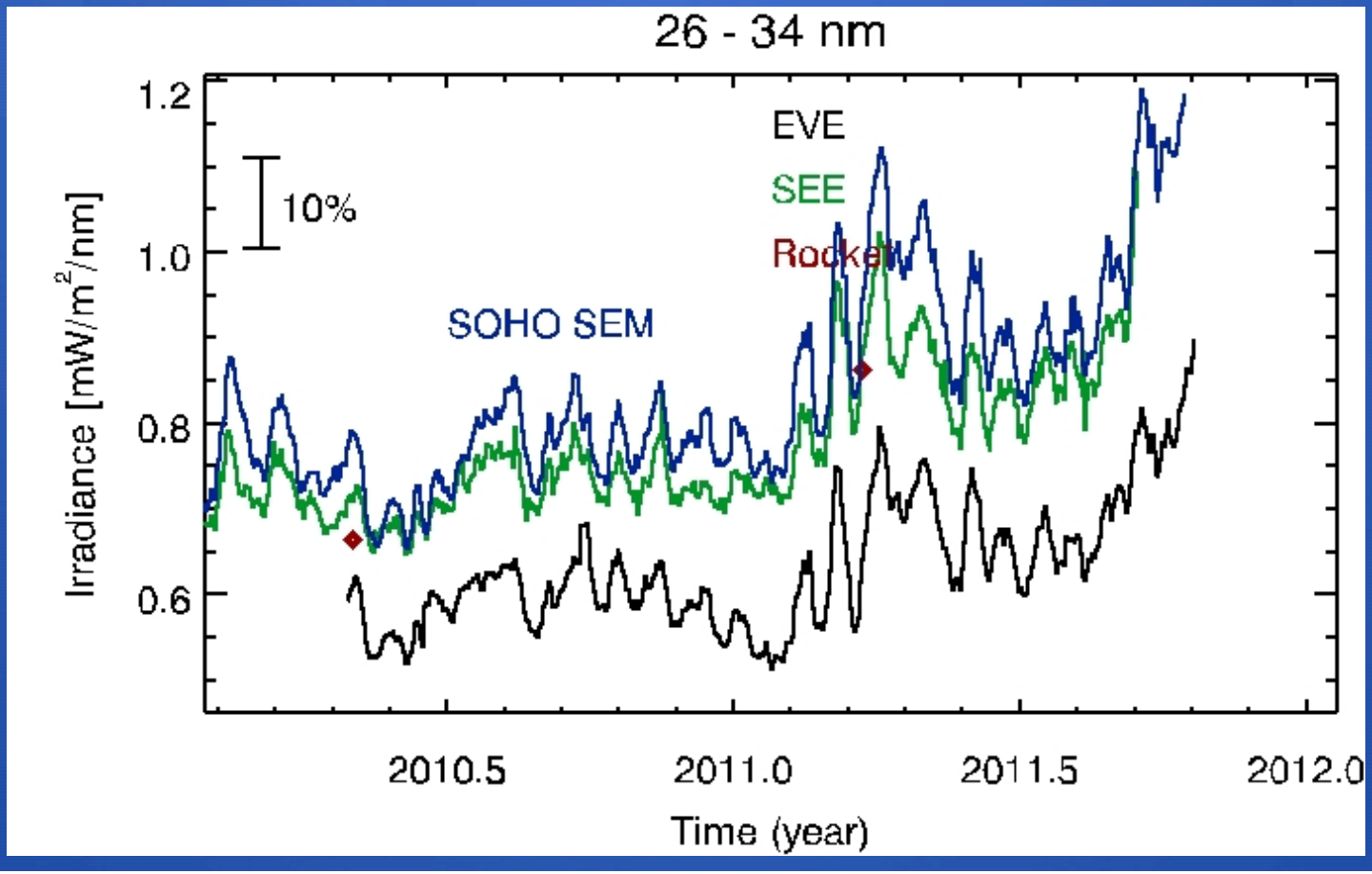






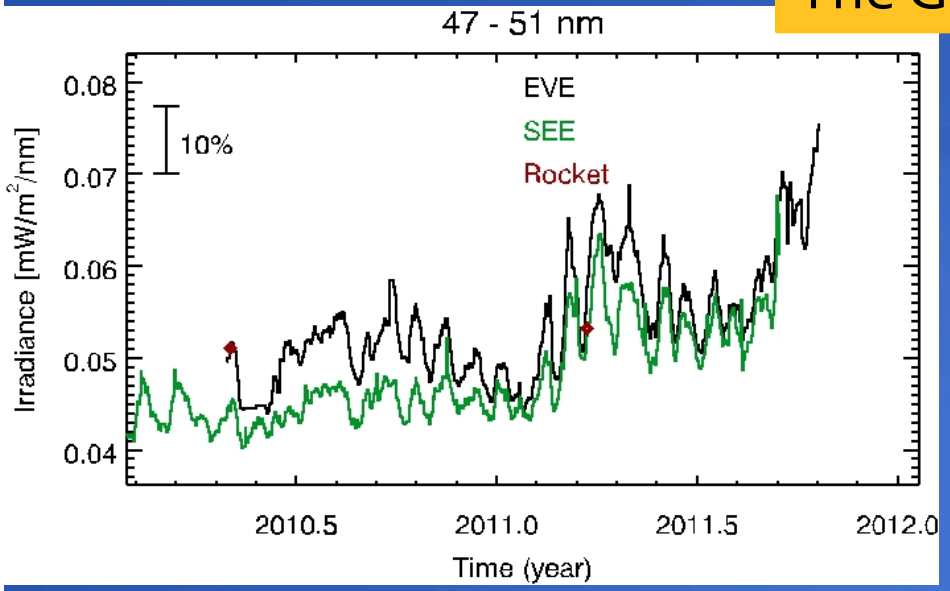
MEGS-A2 Compared to SOHO SEM

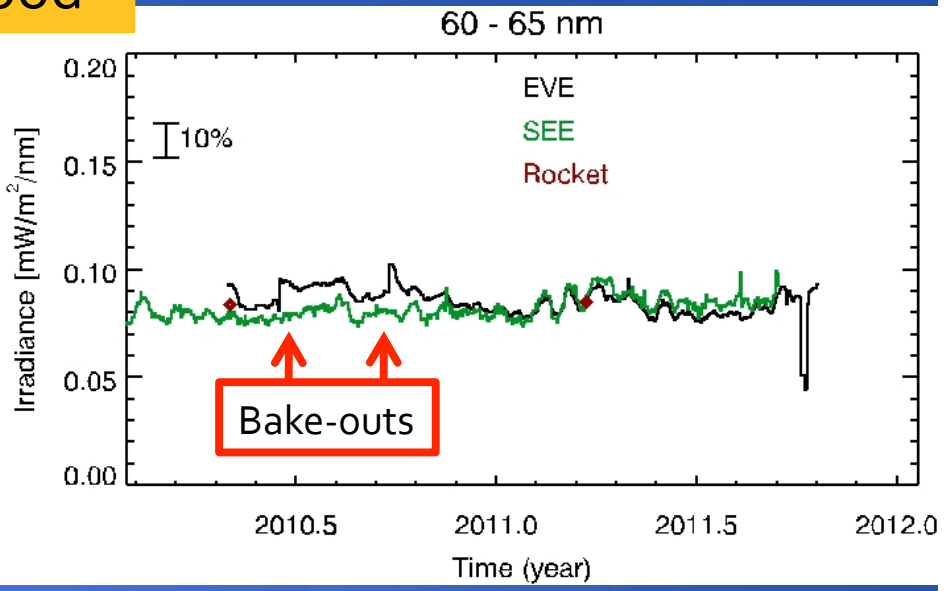
- MEGS-A2 is about 10% lower than rocket MEGS, SEE, and SOHO SEM at beginning of mission and is now about 20% lower. MEGS data processing has not included the second cal rocket result yet.



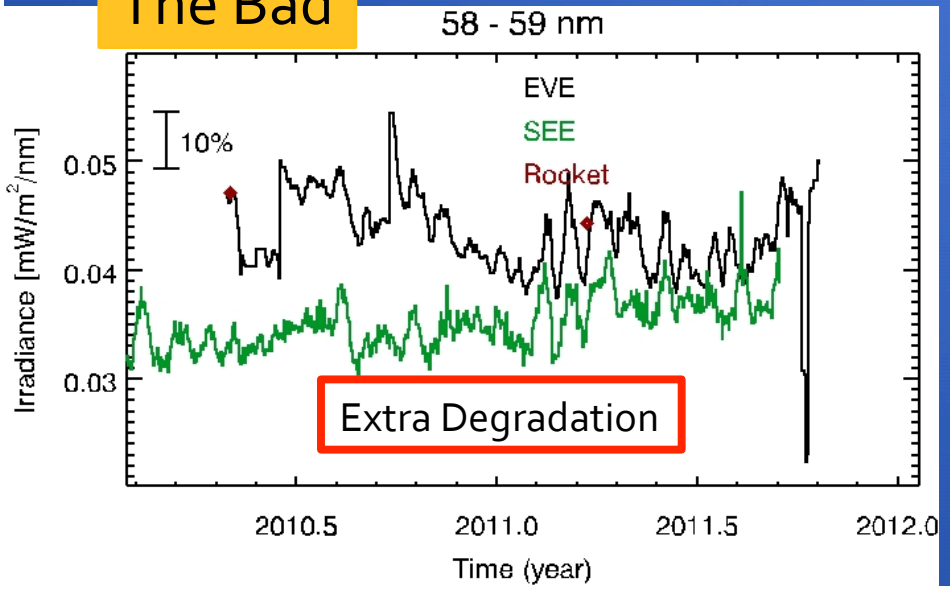
EVE MEGS-B Comparison for SEE EGS

The Good





The Bad



The Ugly