SOHO/Solar EUV Monitor (SEM) and SDO/EVE/EUV SpectroPhotometer (ESP) Calibration, Degradation and Comparisons

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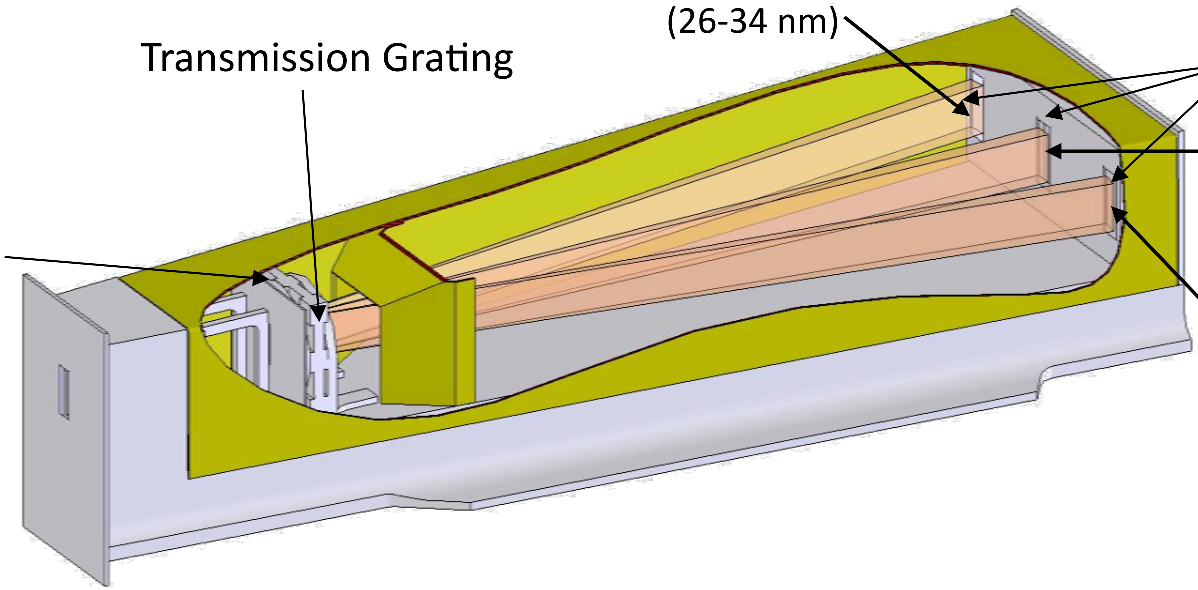
Overview

- SOHO/SEM and SDO/EVE/ESP instrument descriptions and how irradiance values are calculated from count rates
- SEM and ESP Calibration history and current status
- Degradation we have observed in these instruments
- General comparisons among SEM, ESP, and EVE/MEGS

SOHO/SEM

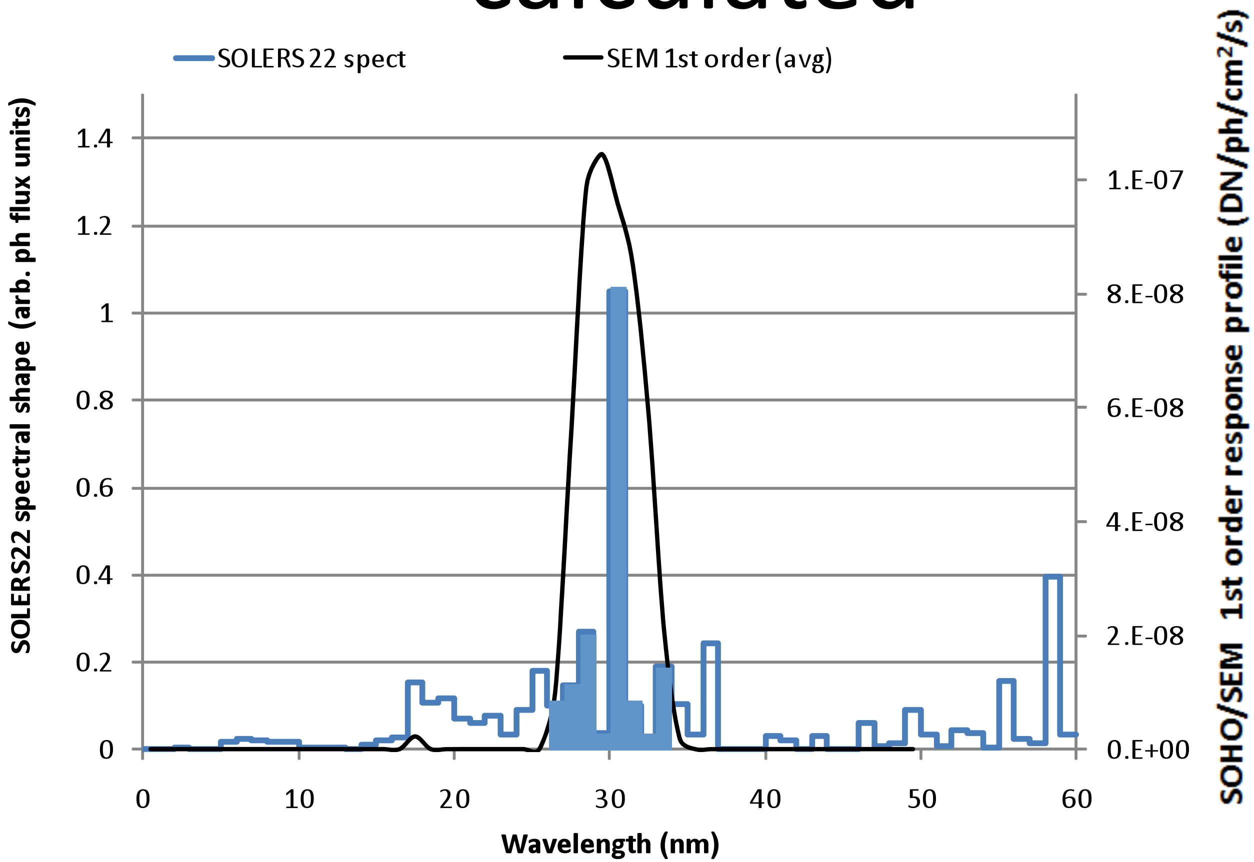
SEM Instrument

- SOHO/CELIAS/SEM has been providing nearly continuous (with the exception of the summer of 1998 when SOHO went offline) EUV irradiance measurements for all of the >17 yrs. SOHO has been in operation
- Measures solar flux in two bandpasses: 26-34 nm(+/- 1st order) and 0.1-50 nm (0-order)
- Calibration is maintained based on sounding rocket underflights – no in-flight calibration capabilities



SEM first order 26-34nm band

How first order (26-34 nm) flux is calculated



- NIST measured instrument efficiencies
- SOLERS22 composite reference spectrum [Woods, T., H. Ogawa, K. Tobiska, and F. Farnik, Solers 22 WG-4 and WG-5 Report for The 1996 Solers 22 Workshop, Solar Physics, 511, 1998]

How first order (26-34 nm) irradiance is calculated

$$\textbf{SEM EUV flux} = k_1 \frac{DN_{SEMch} - bkgrd}{\left(\dfrac{A\int_{\lambda_1}^{\lambda_2} \eta \cdot \phi_{S22} \cdot f_{carbon-trans} \cdot d\lambda \cdot f_{1AU}}{\int_{\lambda_1}^{\lambda_2} \phi_{S22} \cdot d\lambda} \right)}$$

where:

k_1 = correction for SEM sensitivity band which extends slightly beyond 26-34 nm (including second order contributions from wavelengths near 17 nm)

$bkgrd$ = background signal due to diode/electrometer dark current and residual light leaks

DN_{SEMch} = data channel raw count rate

A = entrance aperture area

η = SEM channel efficiency from NIST calibration

φ_{S22} = Solar flux from SOLERS22 reference spectrum

$f_{carbon-trans}$ = transmission through carbon contamination layer, f(time)

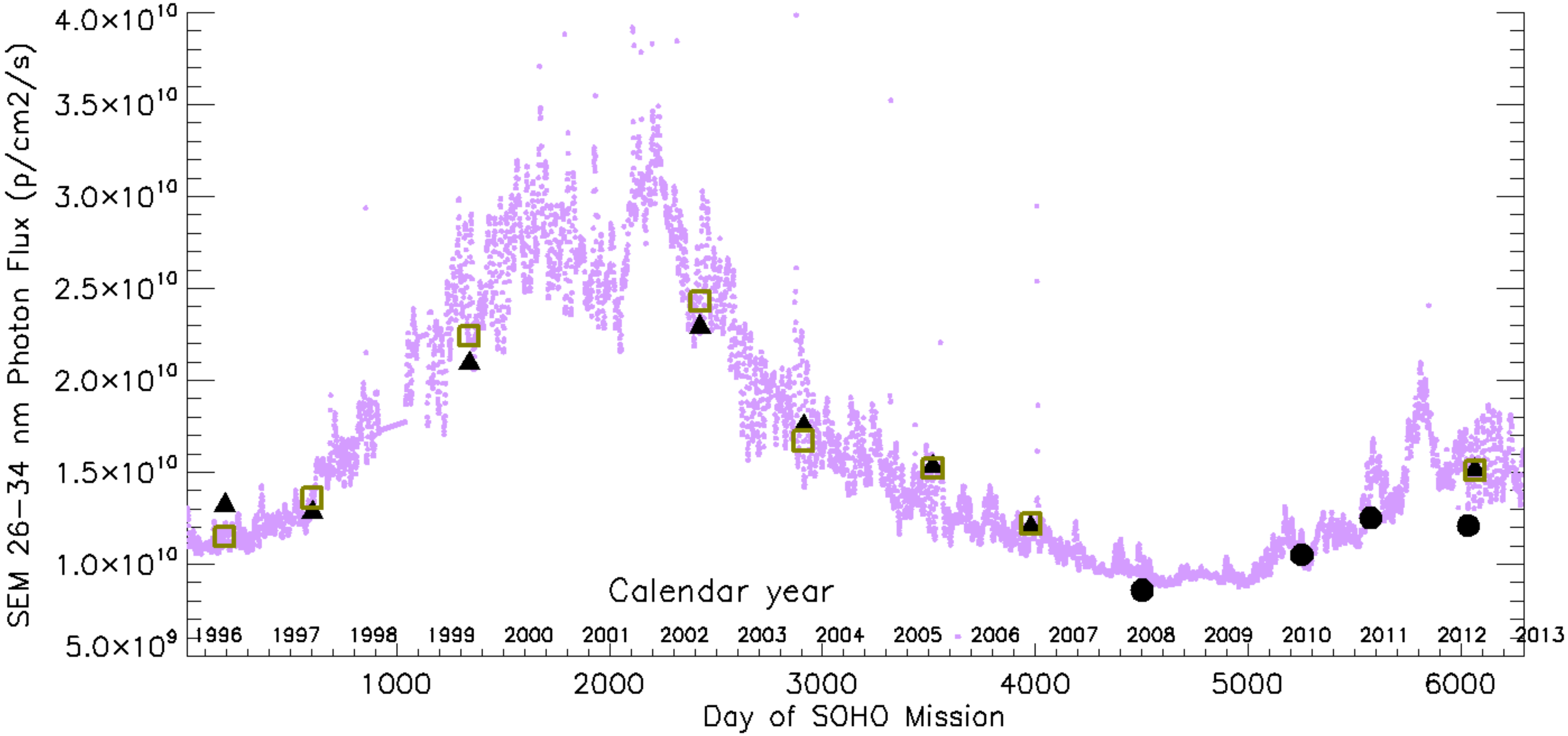
f_{1AU} = correction for 1 AU, and

λ_1 - λ_2 = range of wavelengths over which SEM the first order channel is sensitive

all functions of λ

$$k_1 = \frac{\int_{26nm}^{34nm} \phi_{S22} \cdot d\lambda}{\int_{\lambda_1}^{\lambda_2} \phi_{S22} \cdot d\lambda}$$

SEM 26-34 nm photon flux



- Time series, January 1996 – Present. Pink dots are the SOHO/SEM daily average flux values. Green squares, black triangles and black circles represent sounding rocket measurements using a Rare Gas Ionization Cell (RGIC), the SEM clone instrument, and the SDO/EVE/ESP clone instrument, respectively

SOHO/SEM Version 3.1 comparison with sounding rocket measurements

Date	Rocket Flight	SOHO/SEM 26-34 nm flux (ph/cm^2/s)	SEM clone 26-34 nm flux (ph/cm^2/s)	26-34 nm flux RGIC (ph/cm^2/s)	ESP Ch9 flux (SEM) 26-34nm (ph/cm^2/s)	SOHO/SEM over SEM clone (26-34nm) ratio	SOHO/SEM over RGIC (26-34nm) ratio	SOHO/SEM over ESP (26-34nm) ratio
6/26/1996	36.147	1.21E+10	1.32E+10	1.15E+10		0.92	1.05	
8/11/1997	36.164	1.42E+10	1.28E+10	1.36E+10		1.11	1.04	
8/18/1999	36.181	2.22E+10	2.09E+10	2.24E+10		1.06	0.99	
8/6/2002	36.202	2.28E+10	2.29E+10	2.43E+10		1.00	0.94	
12/5/2003	36.211	1.78E+10	1.75E+10	1.67E+10		1.02	1.07	
8/3/2005	36.227	1.57E+10	1.53E+10	1.52E+10		1.03	1.03	
11/7/2006	36.236	1.26E+10	1.20E+10	1.22E+10		1.05	1.03	
4/14/2008	36.24	9.50E+09			8.60E+09			1.10E+00
5/3/2010	36.258	1.18E+10			1.05E+10			1.12E+00
3/23/2011	36.275	1.37E+10			1.25E+10			1.10E+00
6/23/2012	36.286	1.31E+10			1.21E+10			1.08E+00
7/24/2012	36.263	1.48E+10	1.51E+10	1.51E+10		0.98	0.98	

all SOHO/SEM sounding rocket flux measurements are calculated using SOLERS22 as a reference spectrum

red text indicates SDO/EVE sounding rocket measurements

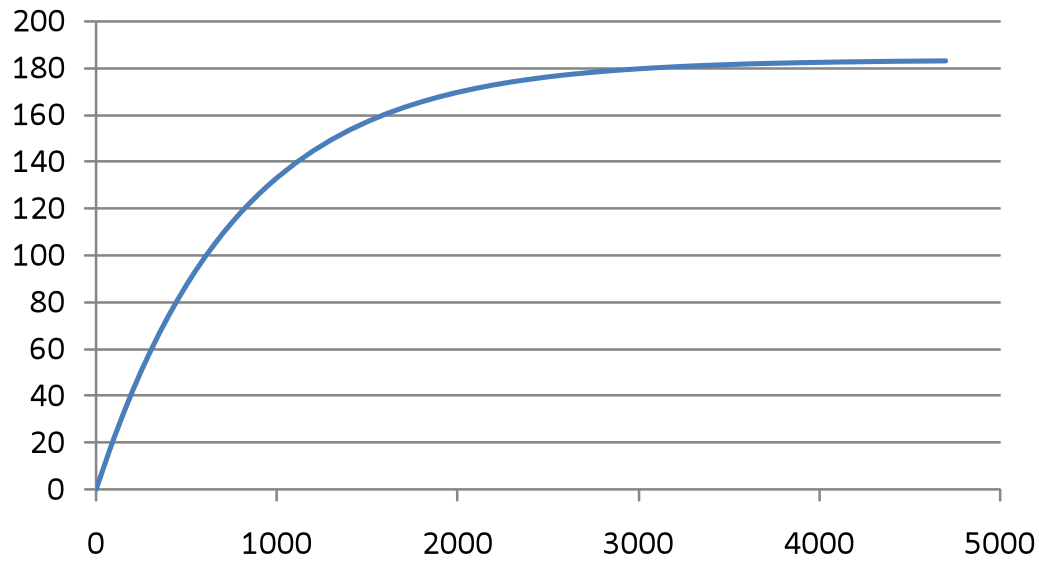
Degradation model

The time and wavelength dependence of the decrease in SOHO/SEM response is described by a "carbon equivalent" contamination layer

Thickness, τ (in Å) as a function of time (in days) is given by:

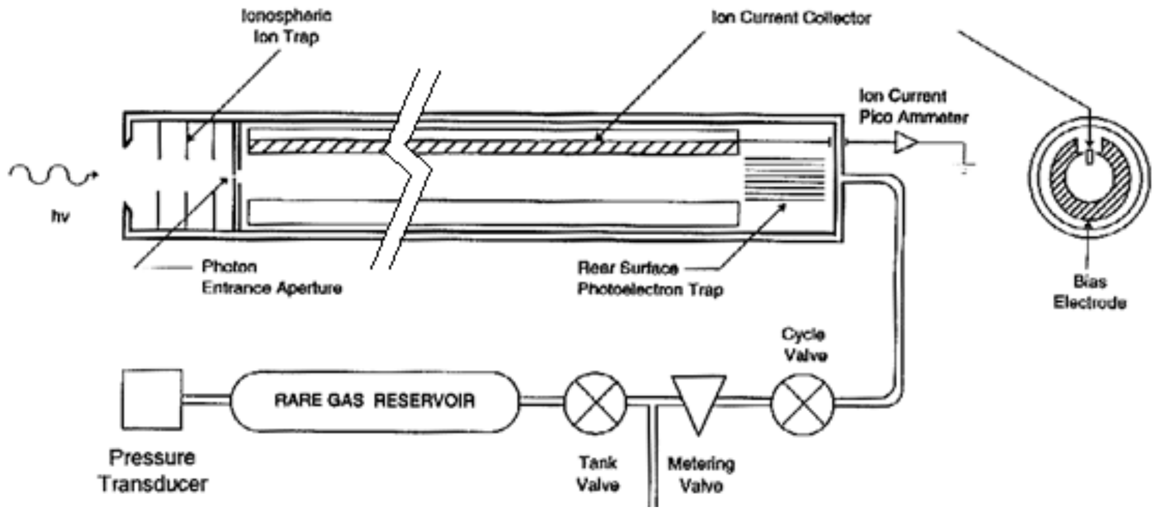
$$\tau(t) = 275.36 - 183.3e^{-t/773.19}$$

And the wavelength dependence is based on Carbon total photoabsorption cross sections



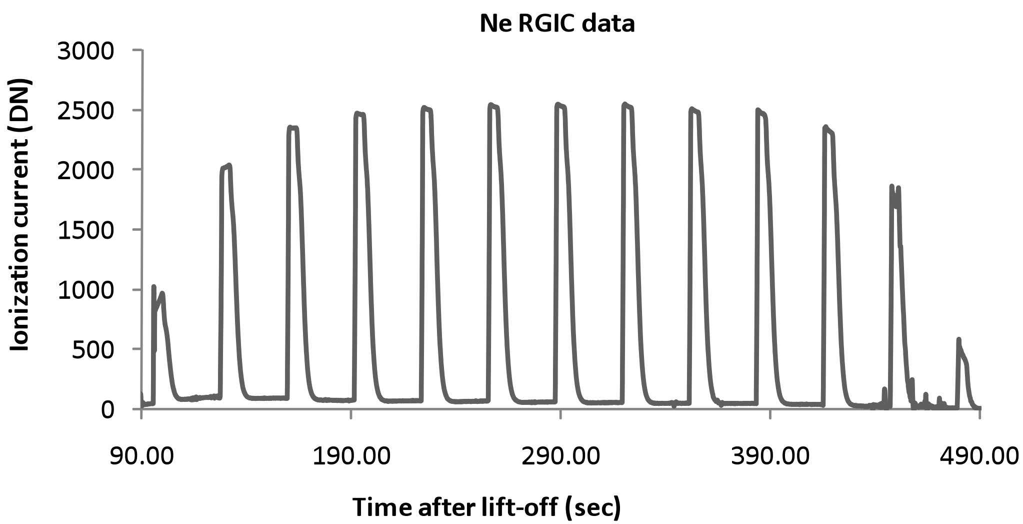
Ne RGIC

- Operates optically **thick**
- Windowless; no optical surfaces to degrade
- Target gas is periodically cycled through the cell

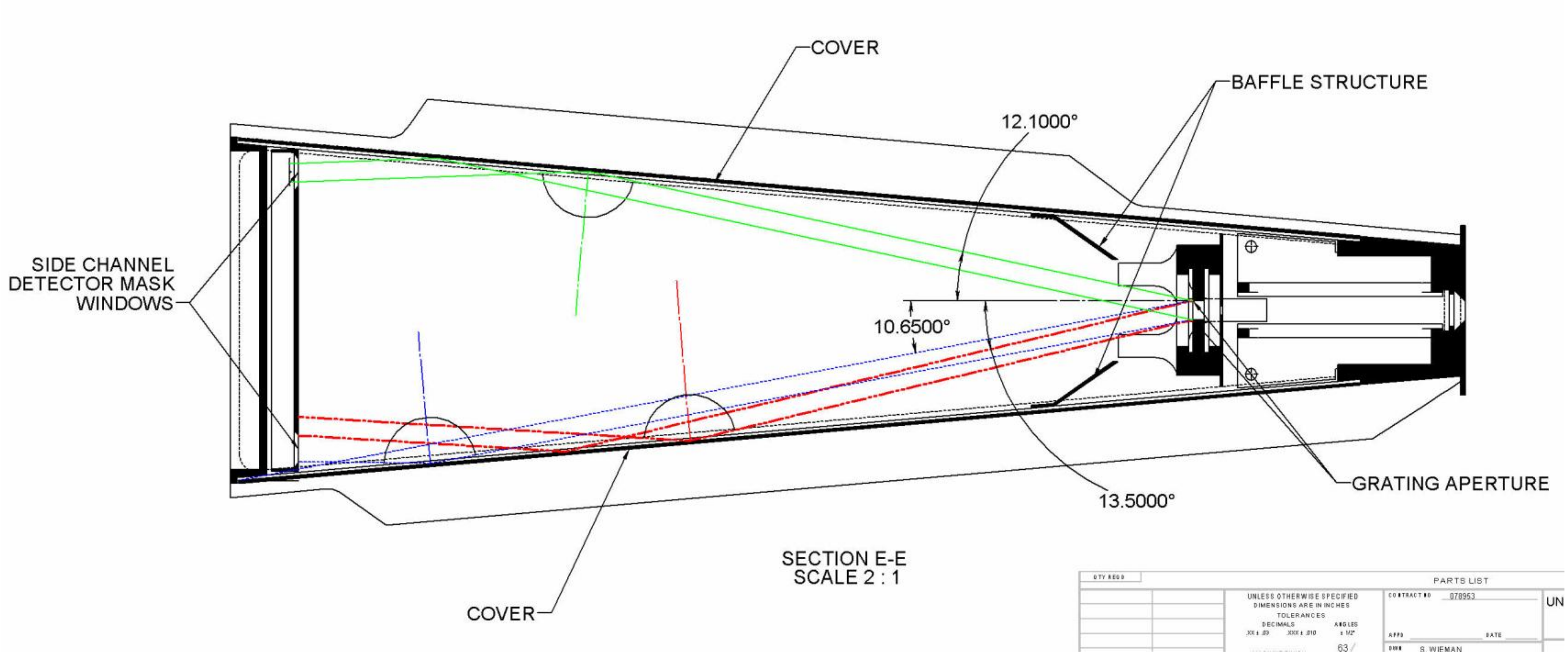


Schematic of the Ne rare gas ionization cell and gas supply system

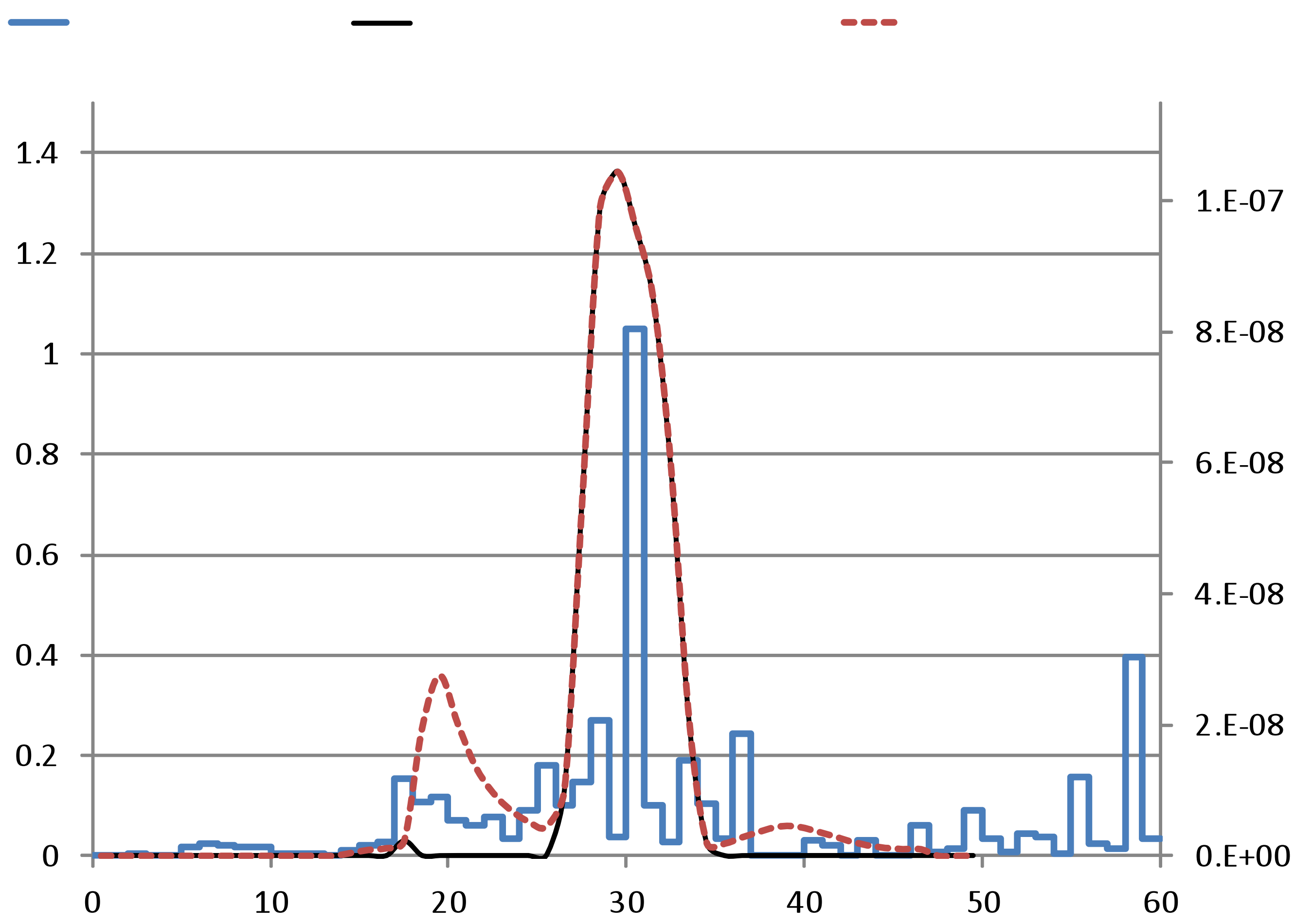
Typical Ne RGIC sounding rocket data . Periodic gas pulses give rise to peaks in ionization current. Peaks are highest near flight apogee (~ 300 sec after lift-off) where atmospheric EUV absorption is at a minimum



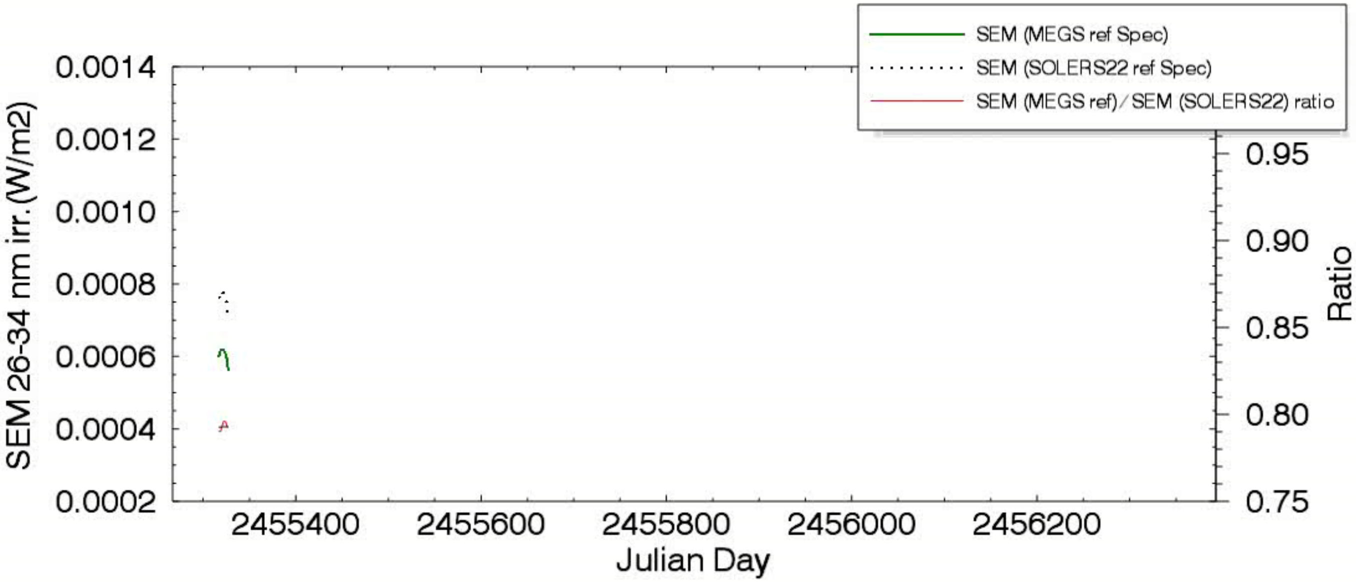
Developments in SEM data processing: revised efficiency profile

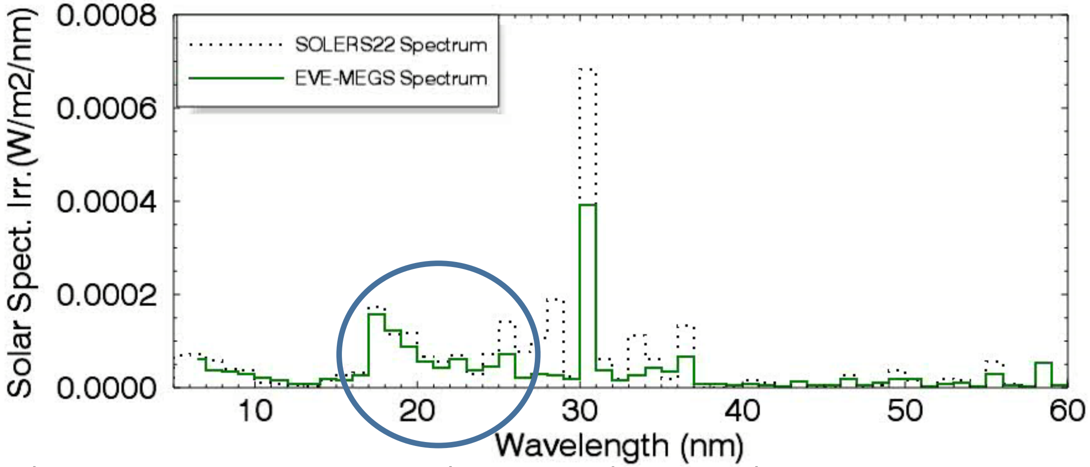


Developments in SEM data processing since SDO: revised efficiency profile

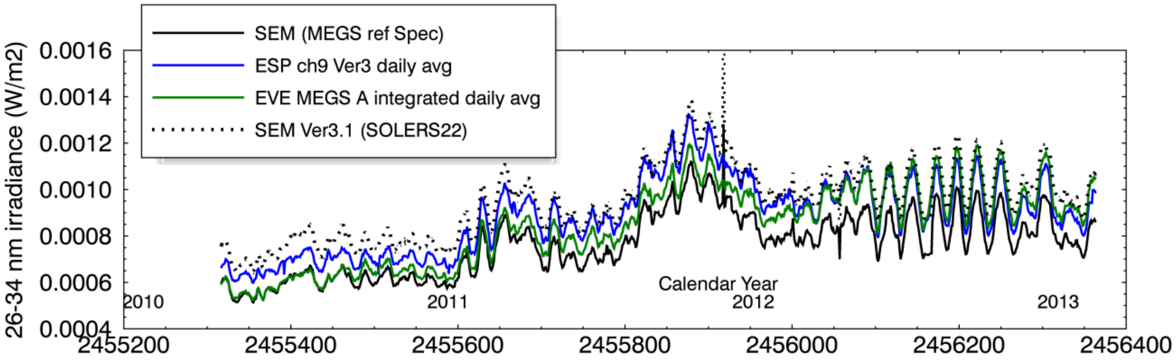


Developments in SEM data processing since SDO: measured (EVE) reference spectra

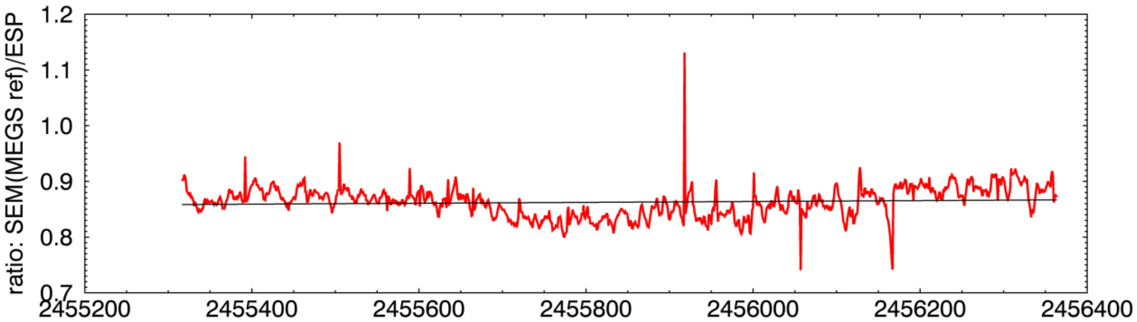




SEM first order (26-34nm) irradiance comparison with EVE Version 3 ESP Ch9 and MEGS integrated spectra – daily average

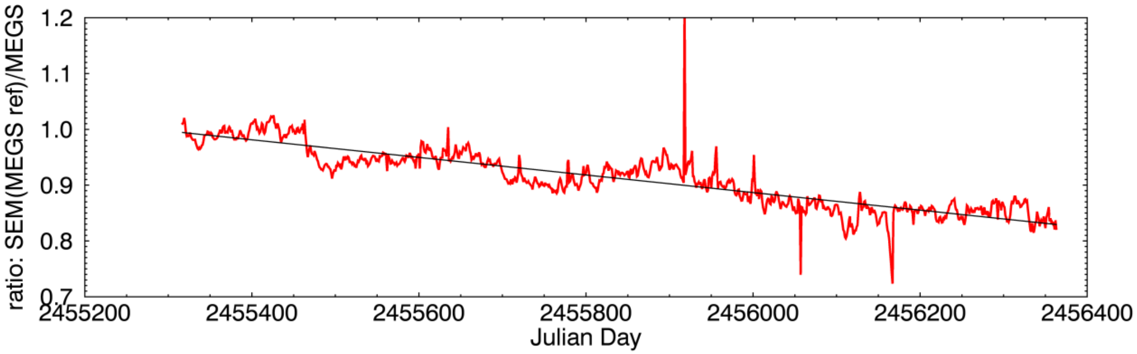


SEM/MEGS ratios decrease steadily with time/solar cycle while SEM/ESP ratios remain comparatively flat



$$\frac{SEM(26-34nm)_{MEGS\ ref}}{EVE\ ESP}$$

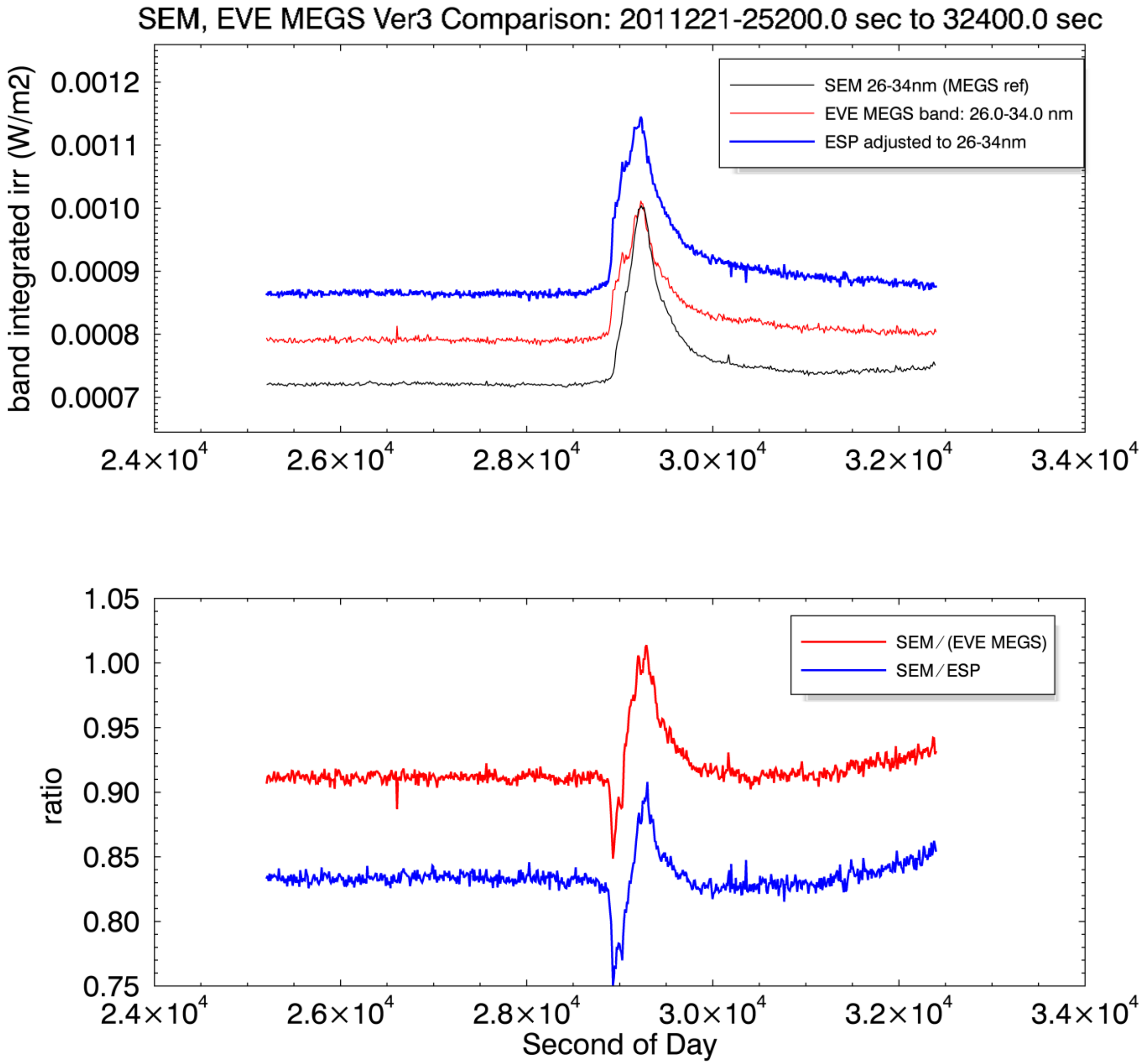
Mean value: 0.86
Line fit slope: 7.94e-6 day^{-1}
Slope (within 1σ): 2.61e-5 day^{-1}



$$\frac{SEM(26-34nm)_{MEGS\ ref}}{EVE\ MEGS\ A}$$

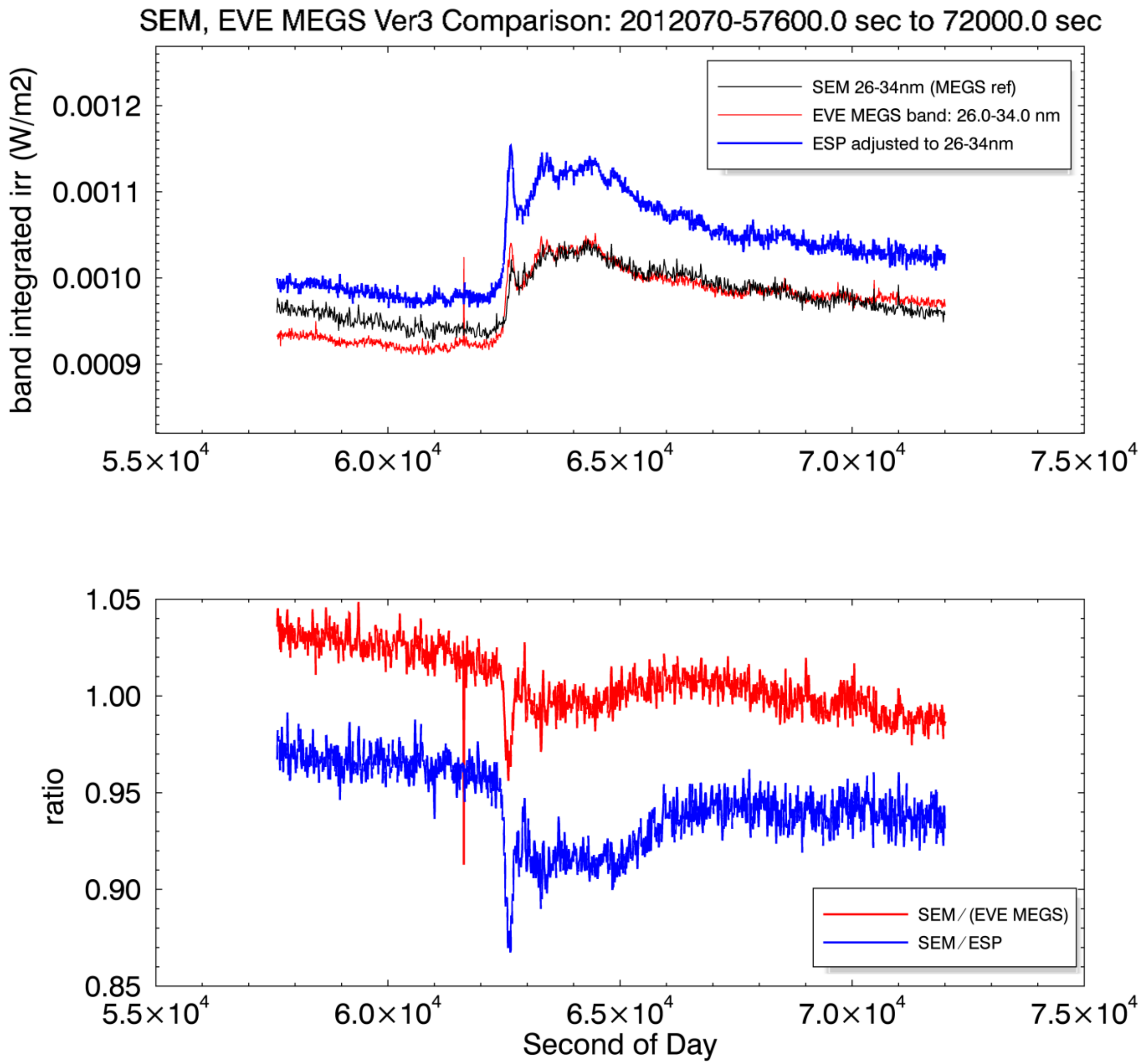
Mean value: 0.91
Line fit slope: -1.58e-4 day^{-1}
Slope (within 1σ): 5.13e-5 day^{-1}

SEM first order (26-34nm) irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare



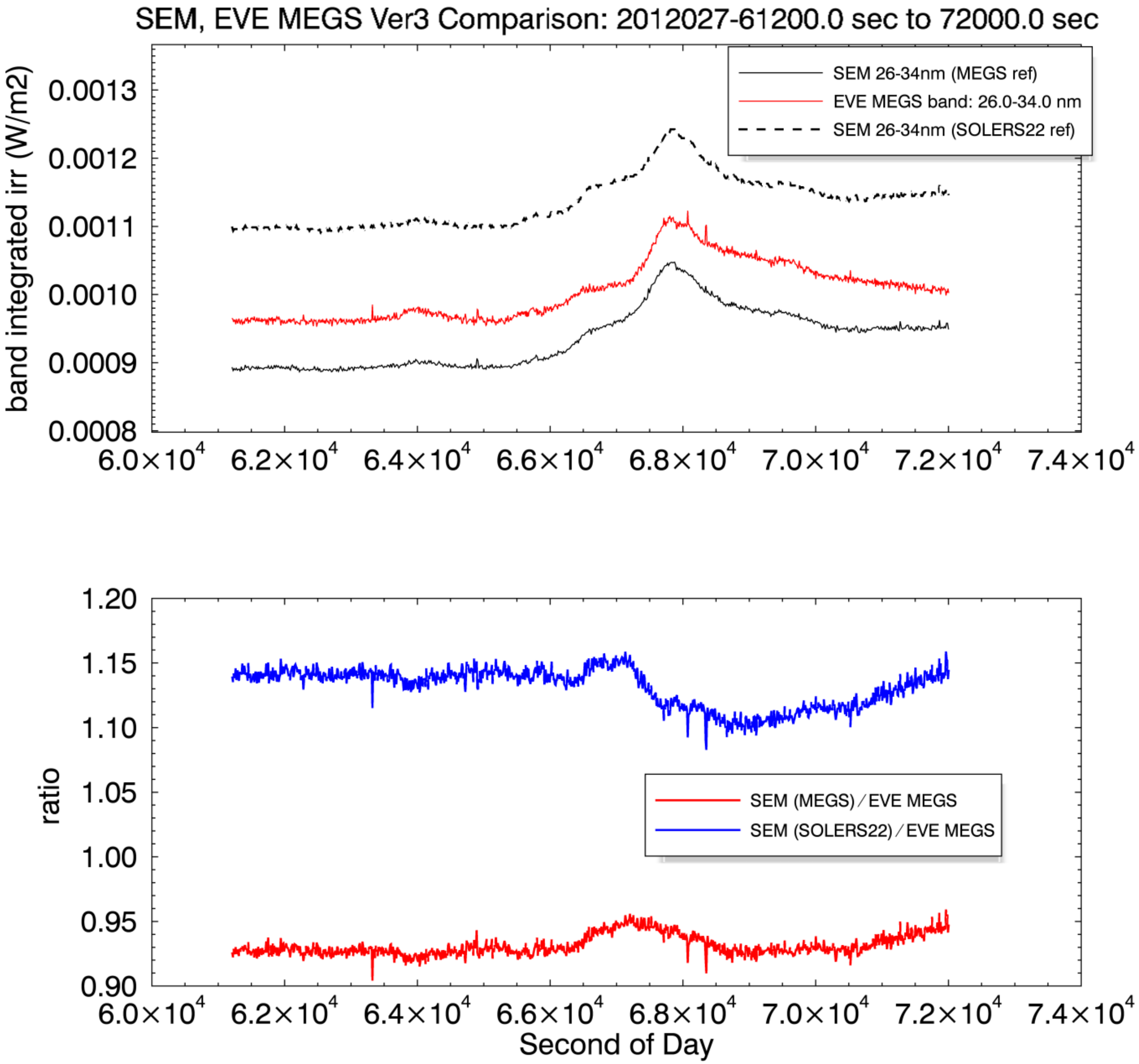
For the X6.9 (N14W69) flare of 8/9/2011, SEM has a greater flare/pre-flare irradiance compared to EVE/ESP and MEGS as indicated by the increased ratio values at the peak of the flare . . .

SEM first order (26-34nm) irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare



. . .while for the M8.4 (N17W24) flare of 3/10/2012, SEM has a lower flare/pre-flare irradiance compared to EVE/ESP and MEGS as indicated by the decreased ratio values at the peak of the flare . . .

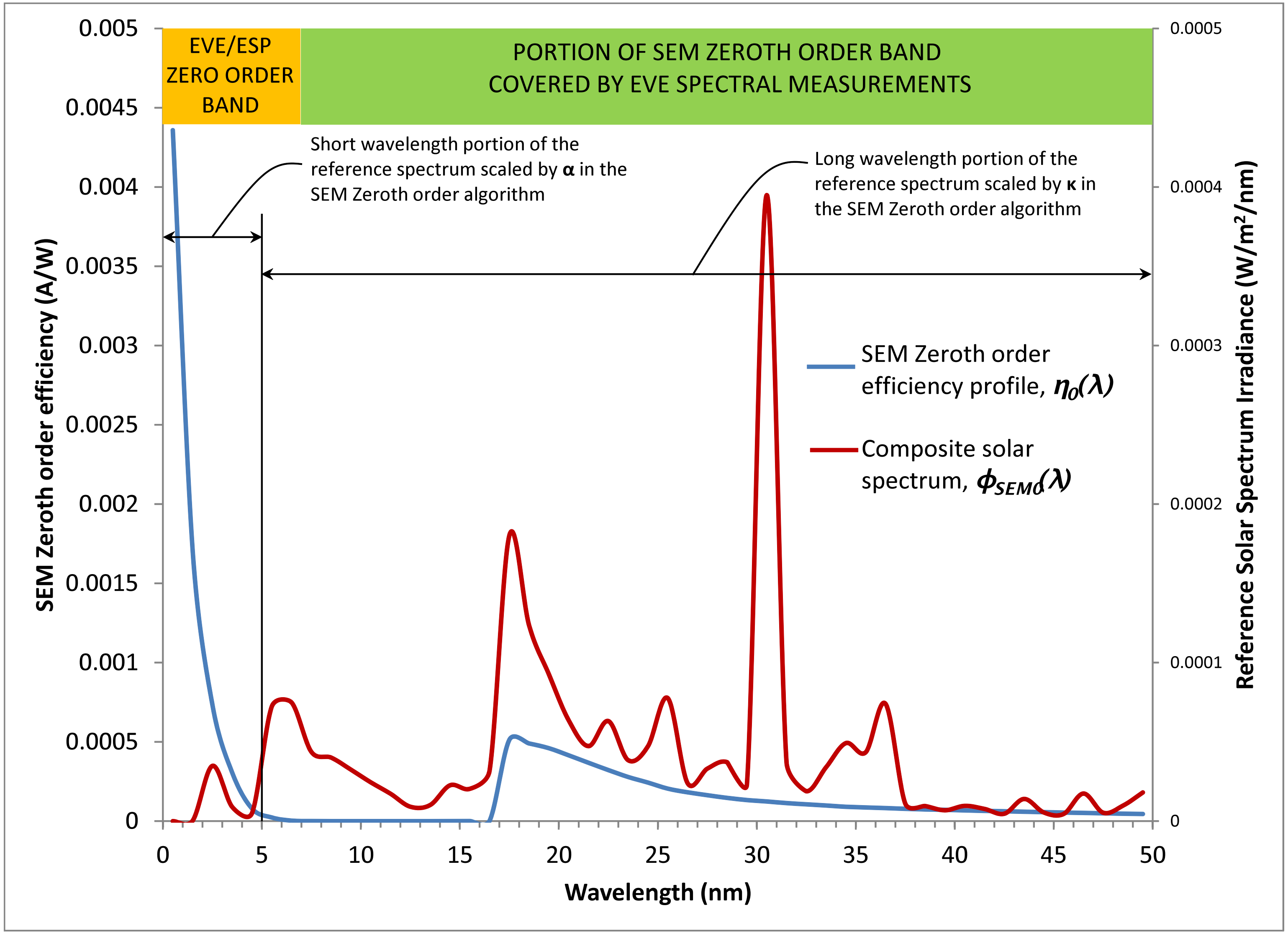
SEM first order (26-34nm) irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare



. . . and for the X1.7 (N33W85) flare of 1/27/12, it depends on which reference spectrum is used (SEM/MEGS ratio increases near the peak of the flare when MEGS ref spectrum is used but decreases when SOLERS22 is used).

SEM zeroth order 0.1-50nm band

How zero order (01.-50 nm) irradiance is calculated



How zero order (01.-50 nm) irradiance, $\Phi_{SEM\,0}$, is calculated

$$\Phi_{SEM\,0} = \int_{0.1nm}^{50nm} \phi_{SEM\,0}\, d\lambda$$

where:

$$\phi_{SEM\,0}\,(\lambda) = \begin{cases} \alpha \cdot \phi_{SOLERS22}(\lambda), & \lambda = 0.1 - 5nm \\ \kappa \cdot \phi_{SOLERS22}(\lambda), & \lambda = 5 - 50nm \end{cases}$$

Or, when SDO/EVE spectra are available:

$$\phi_{SEM\,0}\,(\lambda) = \begin{cases} \alpha \cdot \phi_{SOLERS22}(\lambda), & \lambda = 0.1 - 5nm \\ \kappa \cdot \phi_{SOLERS22}(\lambda), & \lambda = 5 - 7.0nm \\ \kappa \cdot \phi_{SDO/EVE}(\lambda), & \lambda = 7.0 - 50nm \end{cases}$$

How zero order (01.-50 nm) flux, $\Phi_{SEM\ 0}$, is calculated

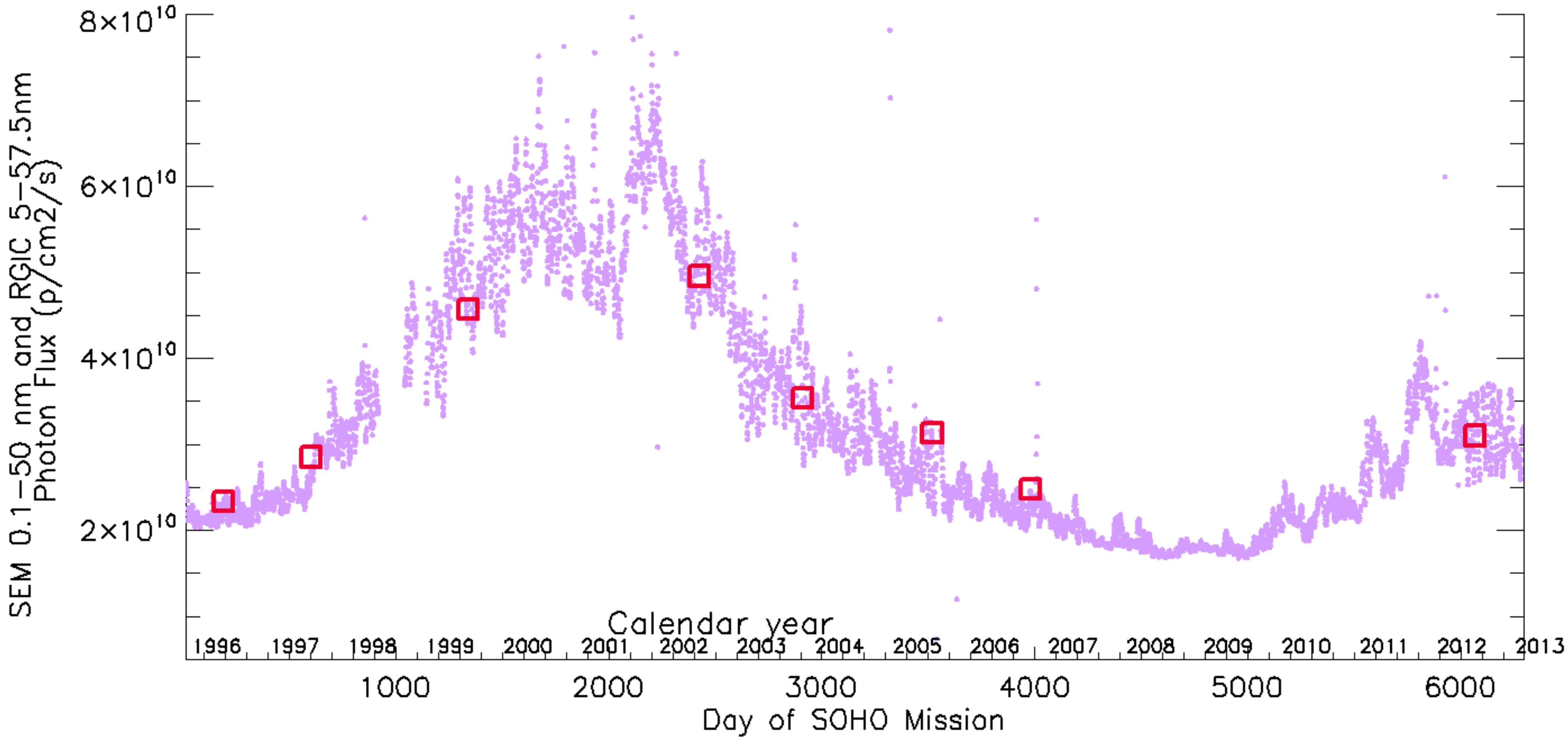
$$\kappa = \frac{\Phi_{SEM1}}{\int_{26nm}^{34nm} \phi_{SOLERS22} * \ d\lambda}$$

$$\alpha = \frac{\Omega_0 - \int_{5nm}^{50nm} \kappa \cdot \phi_{SOLERS22} * \cdot \eta_0 \ d\lambda}{\int_{0.1nm}^{5nm} \phi_{SOLERS22} \cdot \eta_0 \ d\lambda}$$

* - or $\phi_{SDO/EVE}$ when available

Where effective counts, Ω_0, is equal to raw counts minus background (i.e. dark counts) and corrected for 1 AU and entrance aperture area, and a time and wavelength dependent degradation factor is applied to the zero order efficiency profile, $\eta_0(\lambda)$

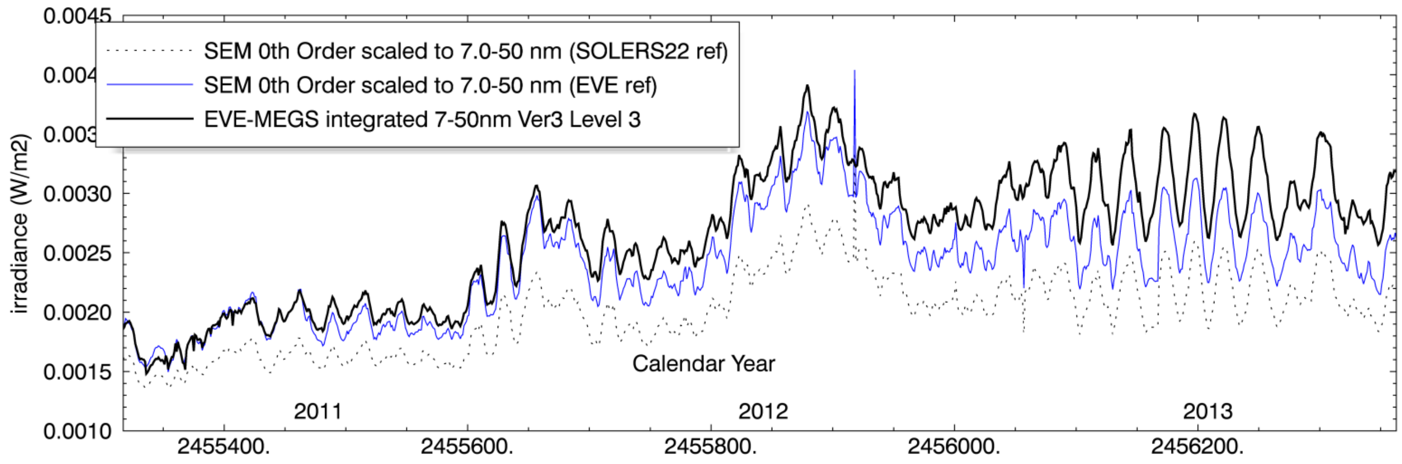
SEM 0.1-50nm time series

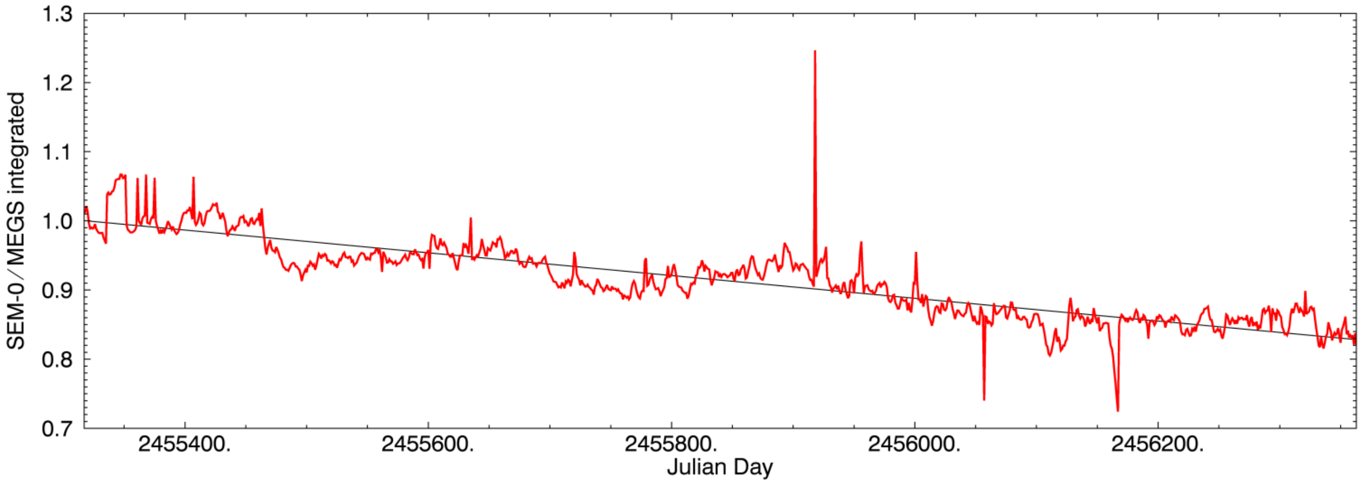


Pink dots – SEM 01.-50nm flux; Red squares- RGIC 5-57.5 sounding rocket measurements

Date	6/6/1996	8/11/1997	8/18/1999	8/6/2002	12/5/2003	8/3/2005	11/7/2006	7/24/2012
SEM 0.1-50 nm	2.31E+10	2.73E+10	4.48E+10	4.58E+10	3.50E+10	3.08E+10	2.43E+10	2.98E+10
RGIC 5-57.5 nm	2.34E+10	2.85E+10	4.57E+10	4.95E+10	3.54E+10	3.13E+10	2.48E+10	3.10E+10
Ratio RGIC/SEM	1.01	1.04	1.02	1.08	1.01	1.02	1.02	1.04

SEM zero order (7-50nm portion) irradiance comparison with EVE Version 3 MEGS 7-50nm integrated spectra – daily average





- Use of EVE reference spectrum results in higher flux in the 5-50nm portion of the SEM zero order channel
- MEGS irradiances show a significant increase relative to SEM with time/solar cycle (as expected from 26-34nm comparison)

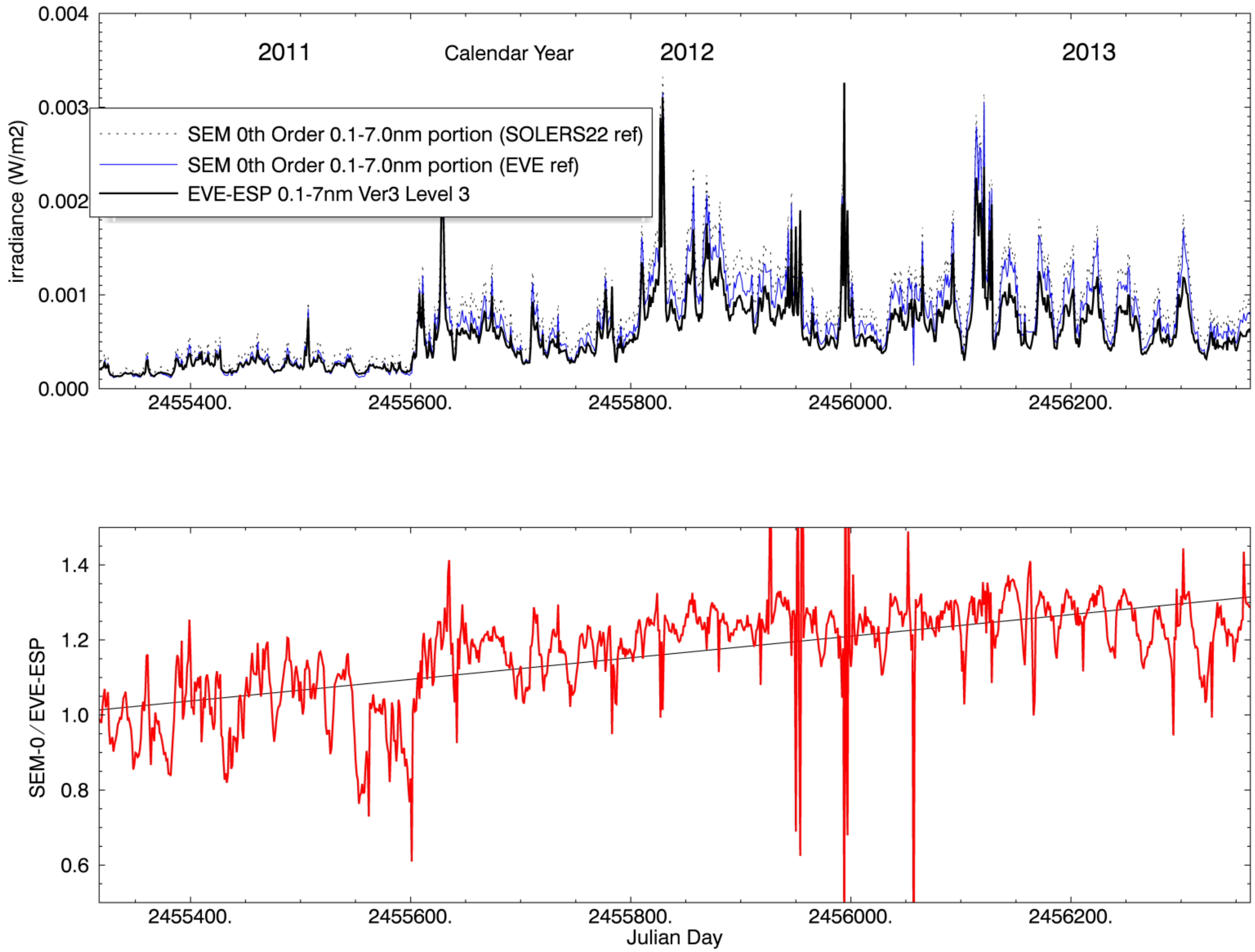
$$\frac{SEM(7-50nm)_{MEGS\ ref}}{EVE\ MEGS\ A}$$

Mean value: 0.91

Line fit slope: 1.64e-4 day^{-1}

Slope (within 1σ): 5.37e-5 day^{-1}

SEM zero order (0.1-7nm portion) irradiance comparison with ESP zero order 0.1-7nm irradiance – daily average



- Use of EVE reference spectrum results in lower irradiance in the 5-50nm portion of the SEM zero order channel (a shift in the SEM signal related to soft x-rays vs EUV)
- ESP-0 irradiances show a decrease relative to SEM with time/solar cycle

$$\frac{SEM_{EVE\ ref}}{EVE\ MEGS\ A}$$

Mean value: 1.16

Line fit slope: 2.87e-4 day^{-1}

Slope (within 1σ): 1.35e-4 day^{-1}

Summary of SEM comparisons with SDO/EVE

- SEM first order (using MEGS reference) versus EVE/MEGS Ver3 differences vary from ~0% at the beginning of the SDO mission to ~17% currently
- SEM first order (using MEGS reference) versus EVE/ESP Ver 3 differences remain fairly constant at ~14% throughout the SDO mission
- Differences in SEM first order response to flares (flare peak/pre-flare irradiance) compared to EVE/MEGS and EVE/ESP varies depending on the flare. Investigation of these differences could provide information on the source of discrepancy between SEM and EVE/MEGS and EVE/ESP.
- The soft x-ray portion of the SEM zeroth order channel compared to ESP zeroth order differs between ~0% at the beginning of the SDO mission to ~30% currently

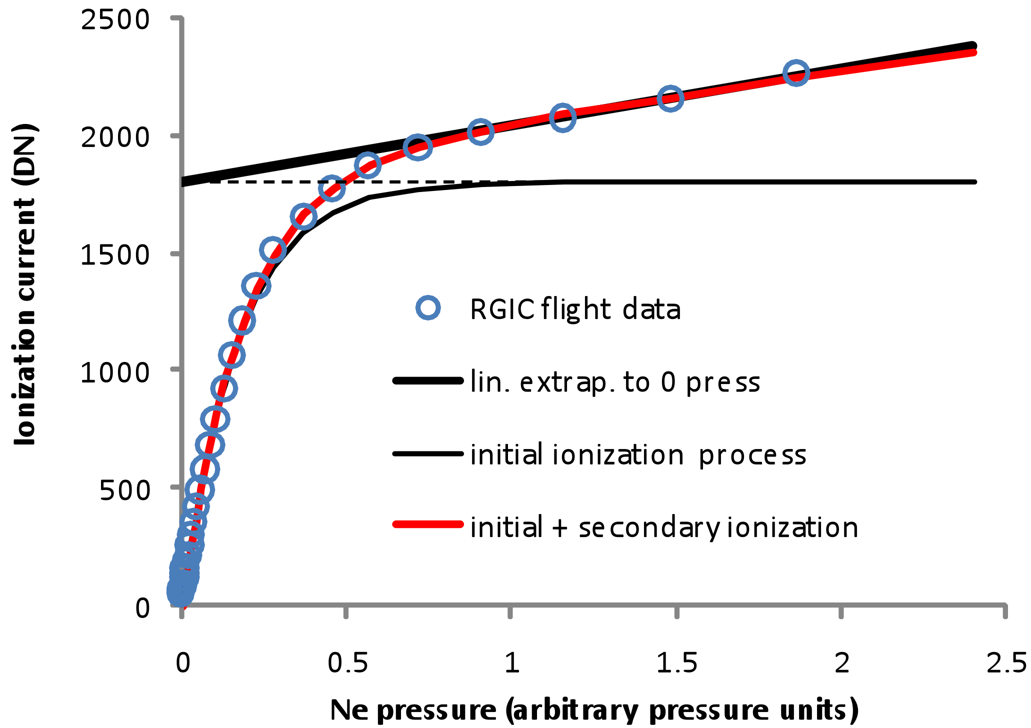
Sources of uncertainty in SEM measurements

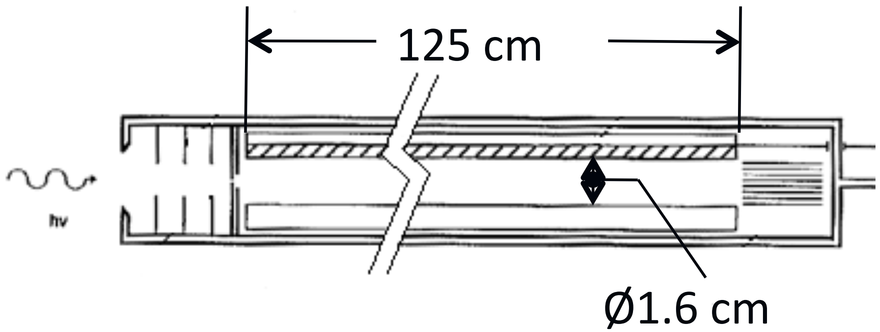
- The effect of housing internal reflection on the SOHO/SEM efficiency profile is modeled based on NIST measurements of the rocket clone instrument and may be different for the flight version
- Dark count rates are assumed to be stable at pre-launch values while some degradation may have occurred (although observed trends and discrepancies do not appear to be correlated with temperature/ orbital location as dark counts typically are)
- The SEM zero order 0.1-50nm channel response profile is partially modeled (in the soft x-ray spectral range)
- The spectral profile of soft x-ray irradiance, needed for converting SEM zero order count rates to irradiances, is not well known

Backup SEM slides

Ne RGIC

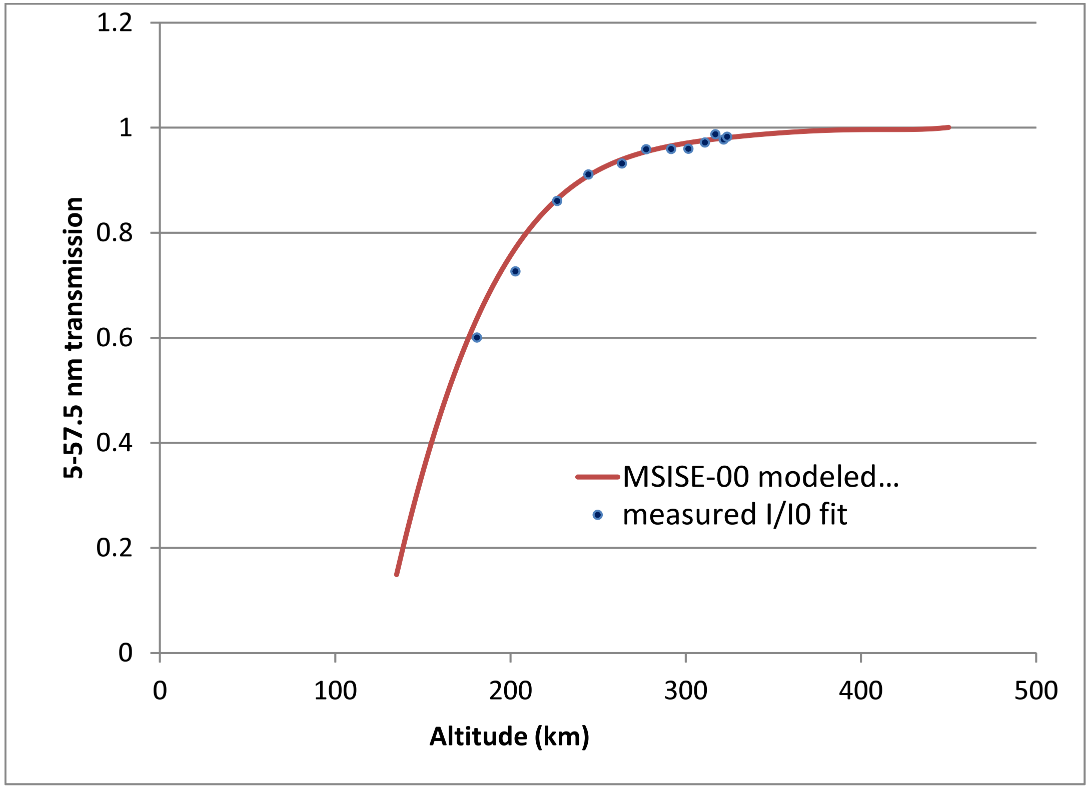
- Solar flux is determined from ionization vs. pressure curve from each purge-fill cycle (linear portion of curve is extrapolated back to zero pressure current corresponding to current with no contribution from secondary ionization)
- Geometry of cell (long along optic axis with small radius) makes it optically thick for EUV but “optically thin” for ejected photoelectrons





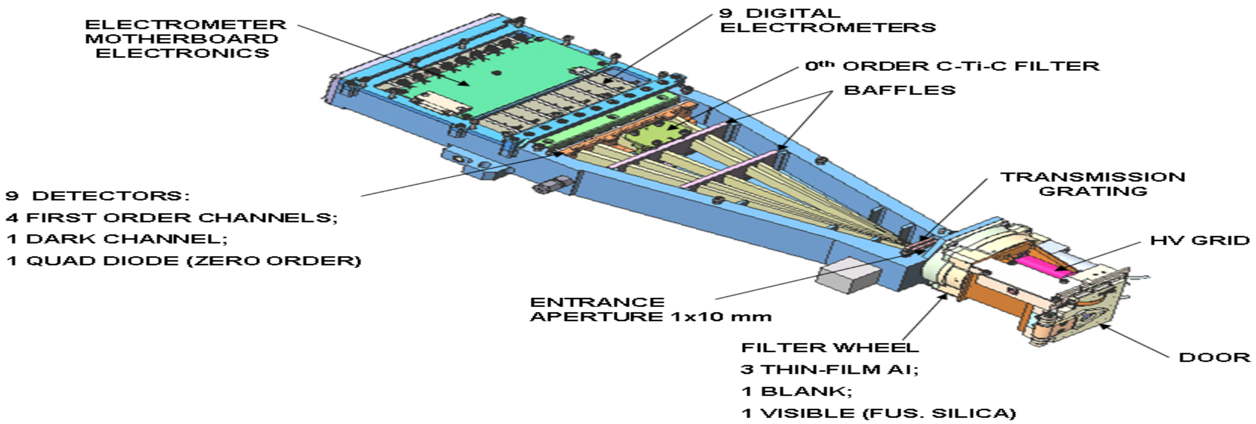
Ne RGIC

- Atmospheric absorption modeled with NRLMSISE-00



SDO/EVE/ESP

ESP *Instrument*



	SEM	ESP
Made at	USC	USC
Channels	3	9
1st-order	2	4
0th-order	1	QD
Dark channel	No	Yes
Gain Correction	No	Yes
Filter Wheel	No	Yes

Enhanced in-flight calibration capability

1st-order:

36, 25, 19, 30 nm;

0th-order: 4 channels (QD) with 0 – 7 nm

How ESP Irradiance is Calculated

$$E_i(\lambda, t) = \frac{C_{i,eff}[1 - \frac{dG_i(T,V,TID)}{\Delta t}]}{A \frac{\int_{\lambda 0-\Delta\lambda}^{\lambda 0+\Delta\lambda} R_i(\lambda,\alpha,\beta)\frac{\lambda}{hc}F_i(\lambda)d\lambda}{\int_{\lambda 0-\Delta\lambda}^{\lambda 0+\Delta\lambda} F_i(\lambda)d\lambda} f_{i,degrad}(t) f_{1AU}(t)} - E_{OS}$$

$$C_{i,eff}(t_j) = C_{i,meas}(t_j) - C_{i,ch.dark}(t_j) - C_{i,particleBG}(t_j) - \Delta C_{i,vis}(t_j),$$

- See details: Didkovsky, L., D. Judge, S. Wieman, T. Woods, and A. Jones, "EUV SpectroPhotometer (ESP) in Extreme Ultraviolet Variability Experiment (EVE): Algorithms and Calibrations", Solar Physics, p. 182, doi: 10.1007/ s11207-009-9485-8, Dec. 2009 (open access) or at http://www-rcf.usc.edu/~leonid/papers/SolPhys2010.pdf

ESP Calibration: Current and Planned

- ESP public products (e.g. Level 1) are absolute Solar Spectral Irradiance (SSI) in the ESP pass-bands;
- For accurate determination of the SSI we update the Level 1 equations for the following parameters based on ESP in-flight daily and weekly calibrations:
  - dark counts,
  - filters transmission, e.g. degradation,
  - electronics gain: stable,
  - energetic particle contamination: small,
  - visible light: small,
  - spectral variability: use MEGS-A spectra for the first-order channels,
  - angular offsets: SDO guiding is stable,
  - a distance from s/c to the Sun: regularly updated.
- Use Sounding Rocket under-flight and inter-comparison data
- Plan ESPR zeroth-order calibration at new SURF SXR beamline or Berlin Electron Storage Ring Society for Synchrotron Radiation (BESSY II)
- Plan to upgrade the EVE/SAM instrument to measure solar spectra during EVE underflights

Measurements and Calculation of the Darks

Approach prior to 2012:

- Use daily calibration runs to measure dark counts and the temperature with the dark filter in place.
- Determine the equation (for each channel) to fit the measured dark counts with the dark proxy as a function of temperature.
- Use the dark thermal proxy to calculate darks for any instant temperature.

After the summer of 2012:

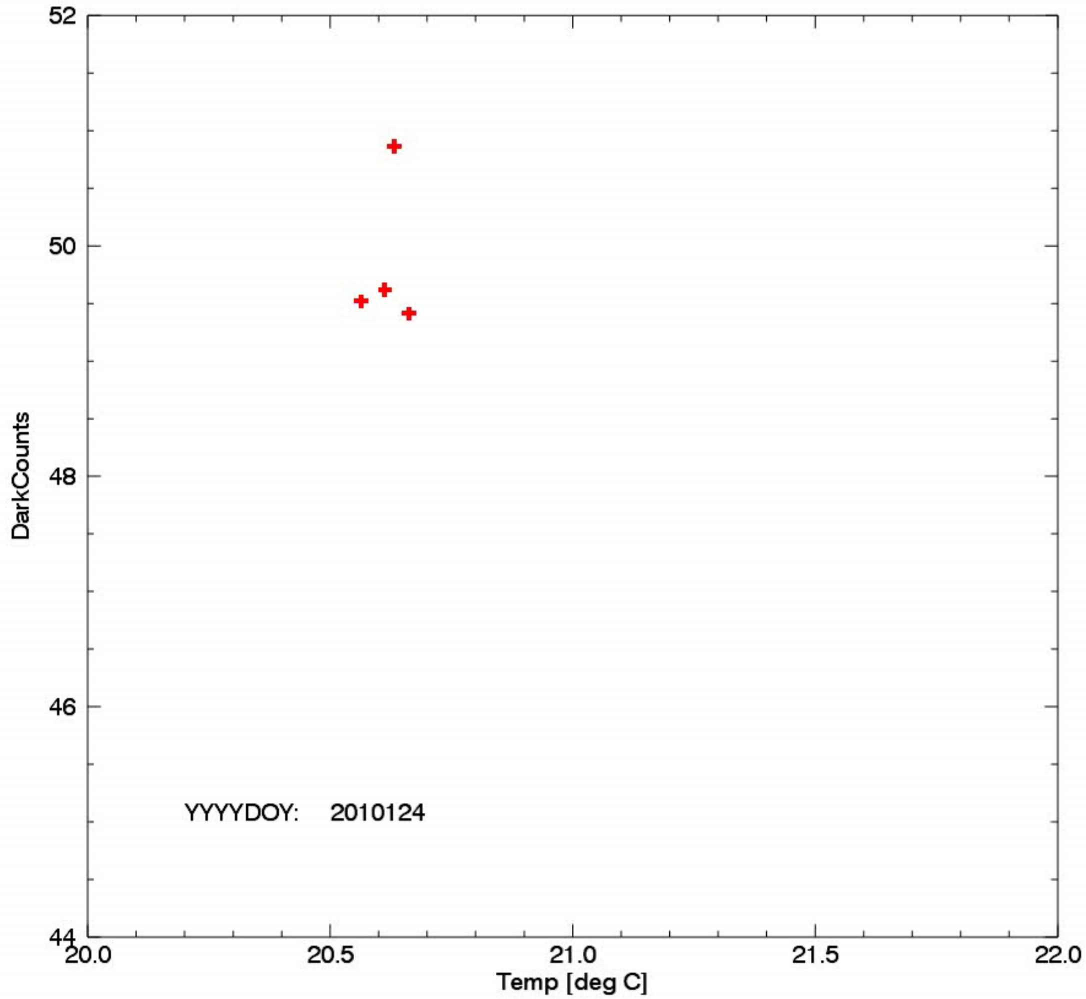
- Use daily calibration runs to measure dark counts and the temperature with the dark filter in place.
- Use the most recent dark measurements in the determination of effective counts rather than a value from a temperature based model (prior dates have been recalculated in EVE Ver. 3)

What Do We Know About Changes Detected in the ESP Darks

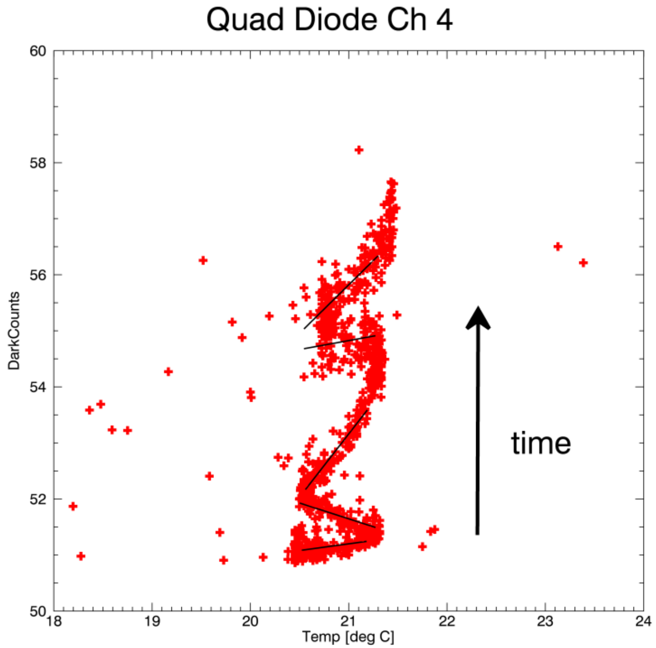
- The changes occurred during 2012 are significantly larger for the zeroth-order (QD) channels than for the first-order channels, up to 6 cnt/0.25 sec in Ch5.
- The changes in QD channels (Ch4-Ch7) are in opposite directions: increased for Ch4 and Ch7 and decreased for Ch5 and Ch6. This results in a small change for the QD as one zeroth-order channel.

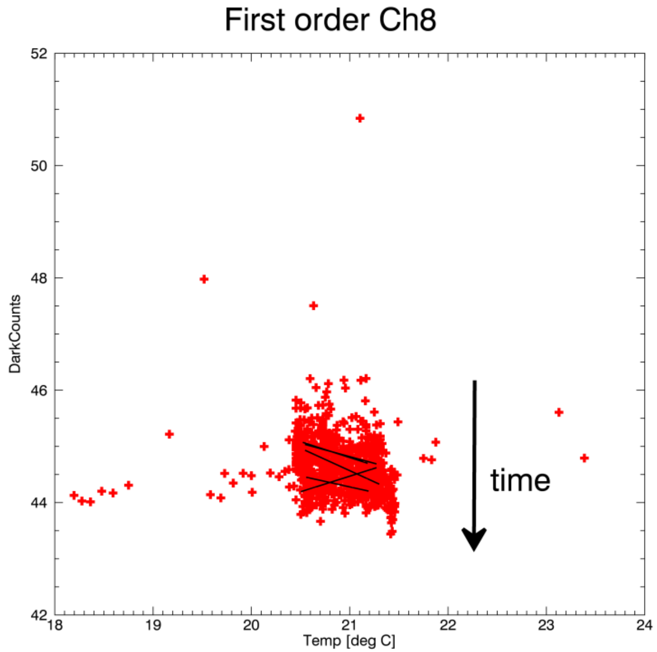
Evolution of dark measurement temperature dependence

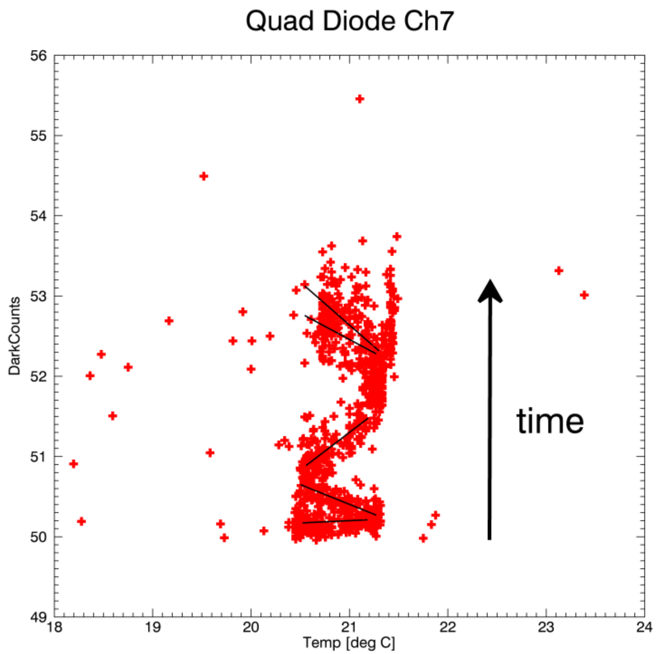
Example: Zeroth order quad-diode quadrant (channel 6)

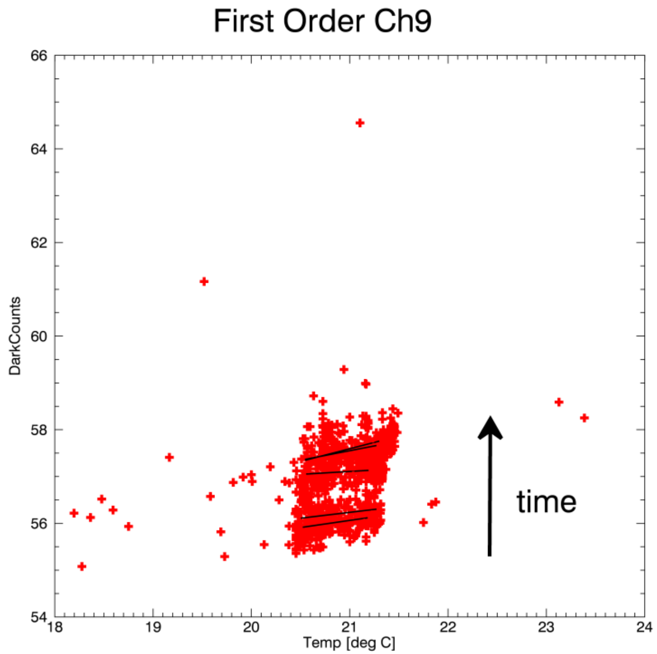


Evolution is not uniform or yet predictable

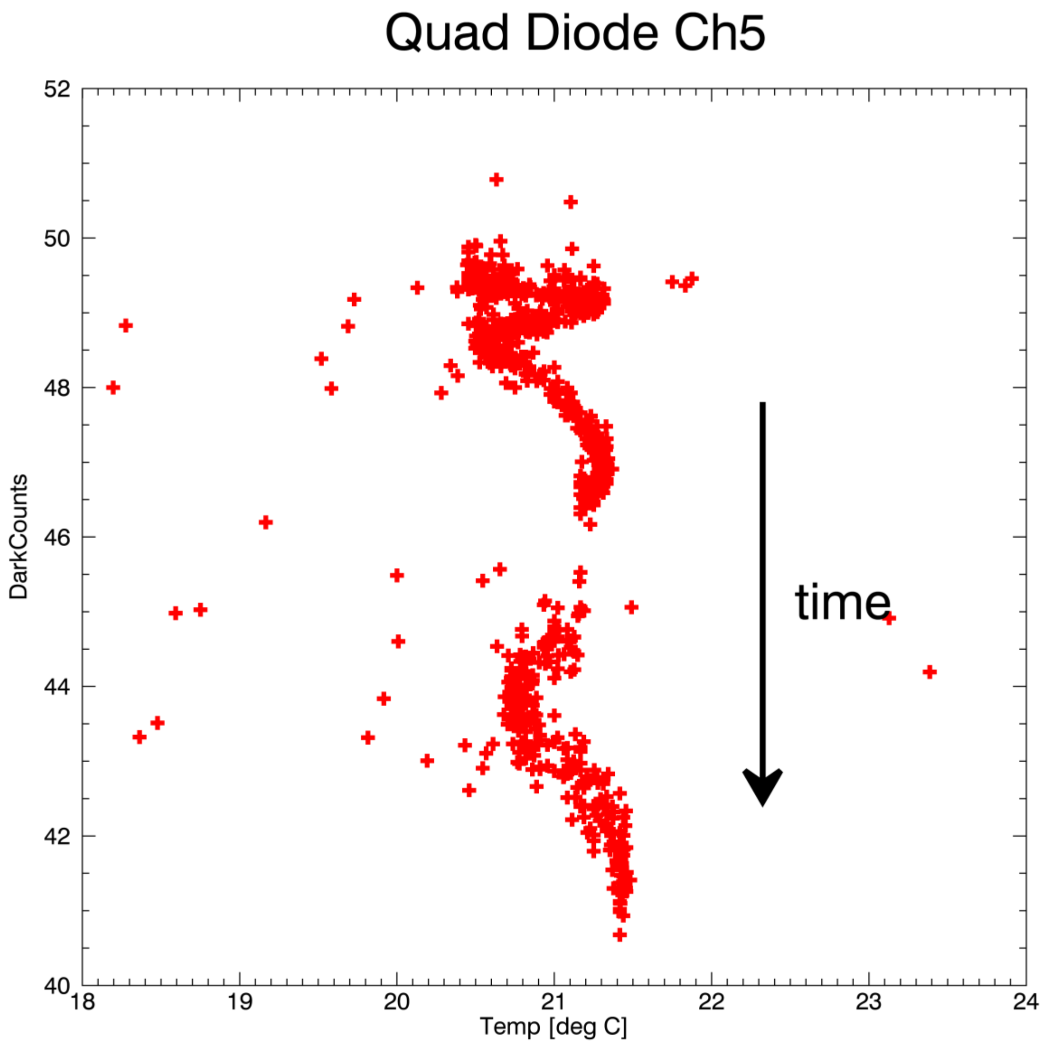




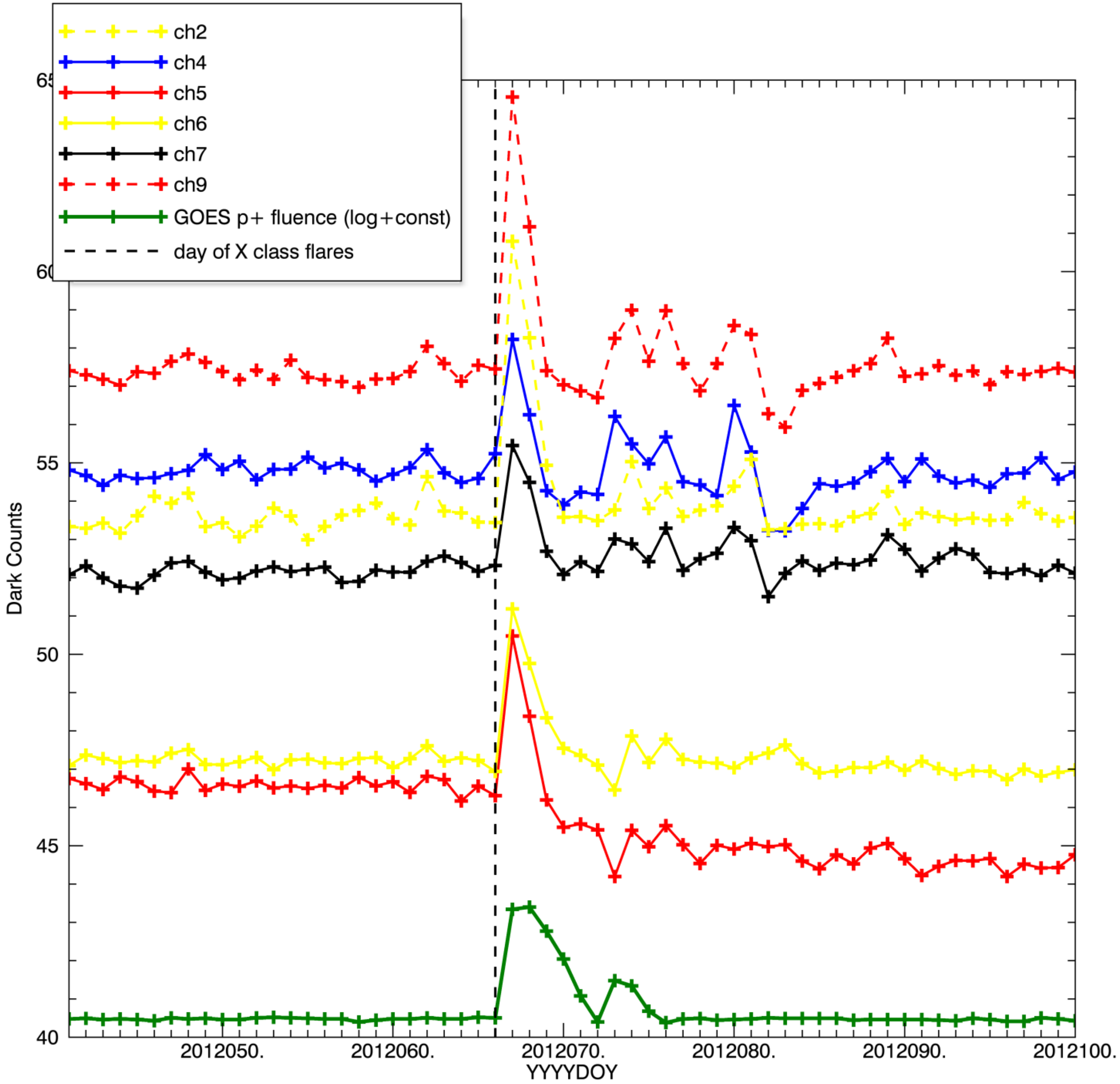




Rapid shift occurring in Spring 2012



The shift is correlated with the post-flare proton event



Factors that Could Affect the Darks

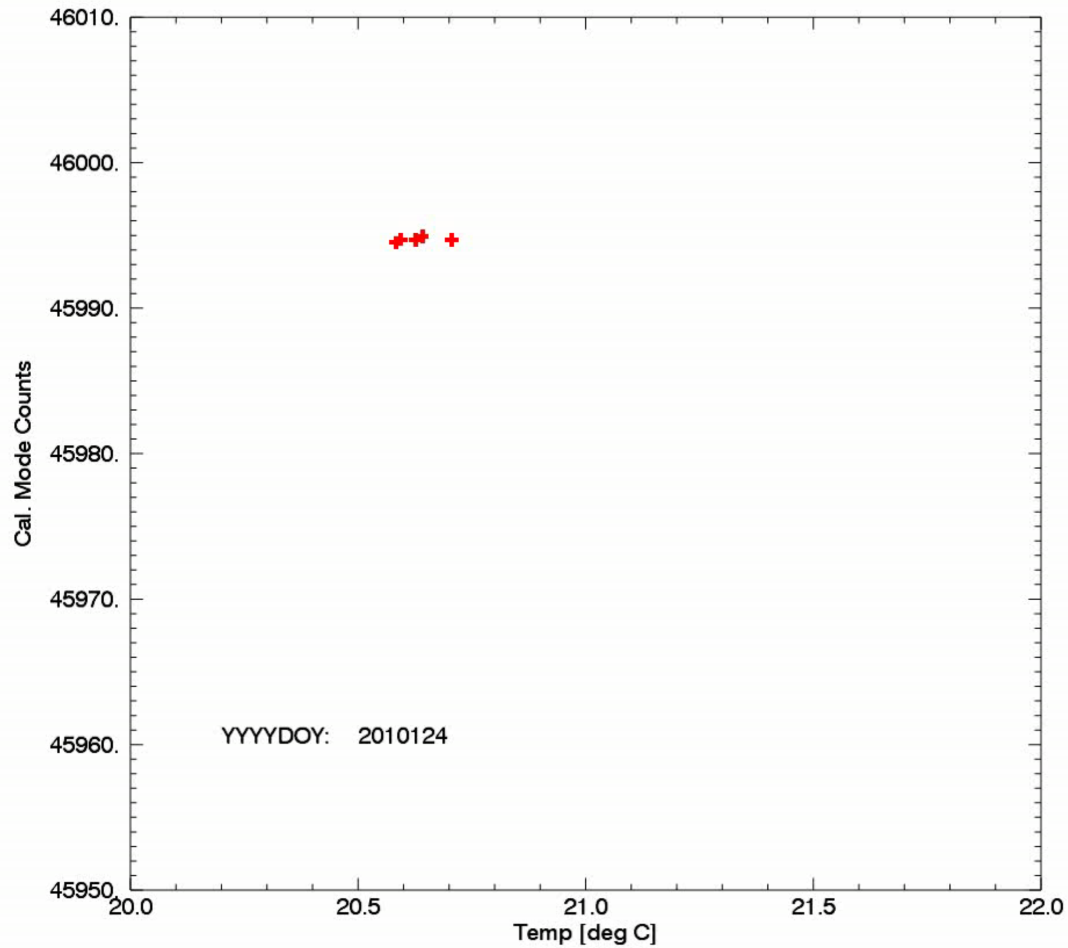
$$\mathrm{DN_d} = [I_d(°\mathrm{C}, S, t) + I_{offset}] * k1_{OPA}(t, TID) * k2_{VFC}(\mathrm{t, TID})$$

$$\mathrm{DN_L} = [(I_L + I_d)\ (°\mathrm{C}, S, t) + I_{offset}] * k1_{OPA}(t, TID) * k2_{VFC}(\mathrm{t, TID})$$

- The changes of the Vref (VFC) gain (*k2*). Analysis of the Vref counts does not confirm this version.
- The change of the internal structure of the photodiode, e.g. its shunt resistance due to the space environment. Cannot be tested inflight.
- The change of the electronics offset for the darks (*Ioffset*). Cannot be tested inflight.

Evolution of VFC (cal. mode measurements) temperature dependence

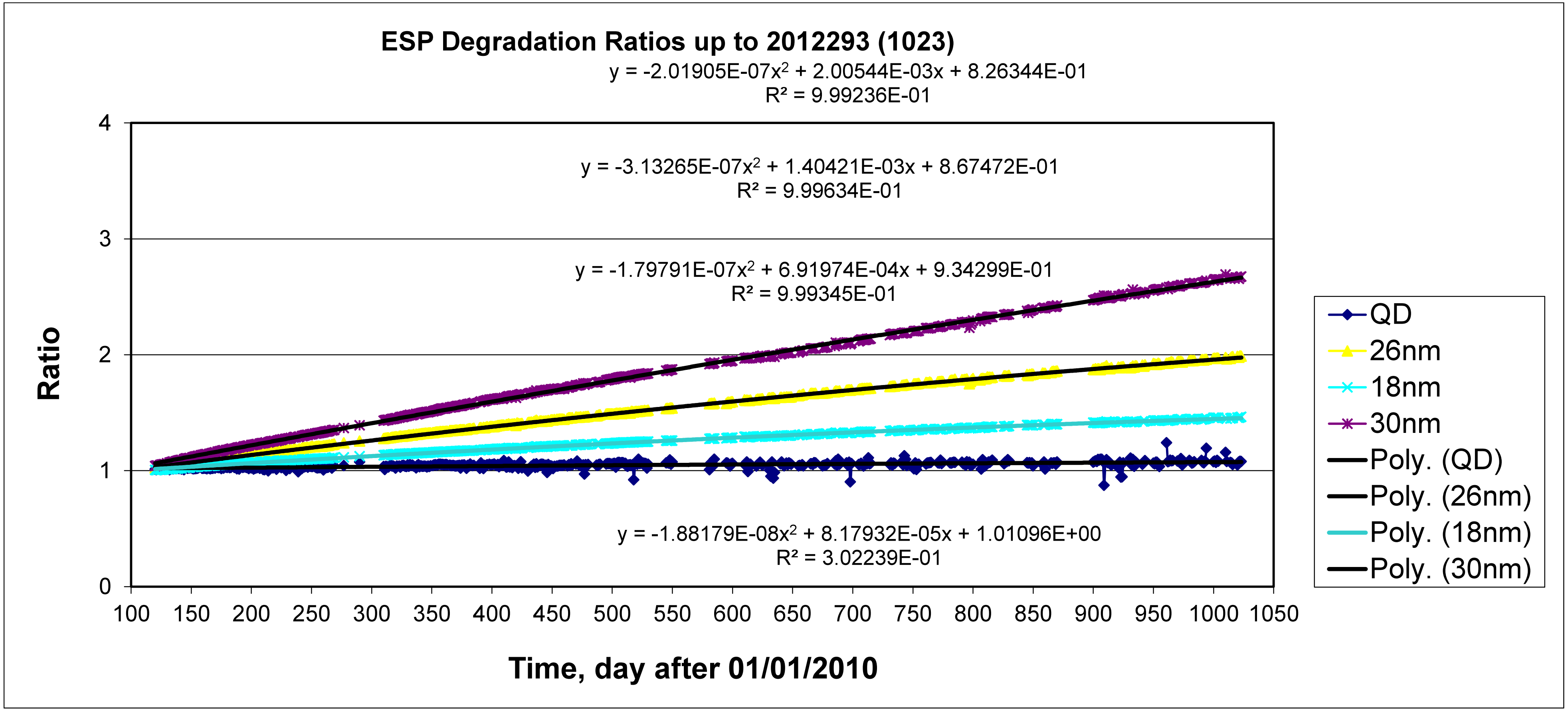
- Example: Count rate for "calibration mode" reference voltage applied to VFC
- Stable temperature response shown is typical of all channels
- not likely a factor in the change of dark counts



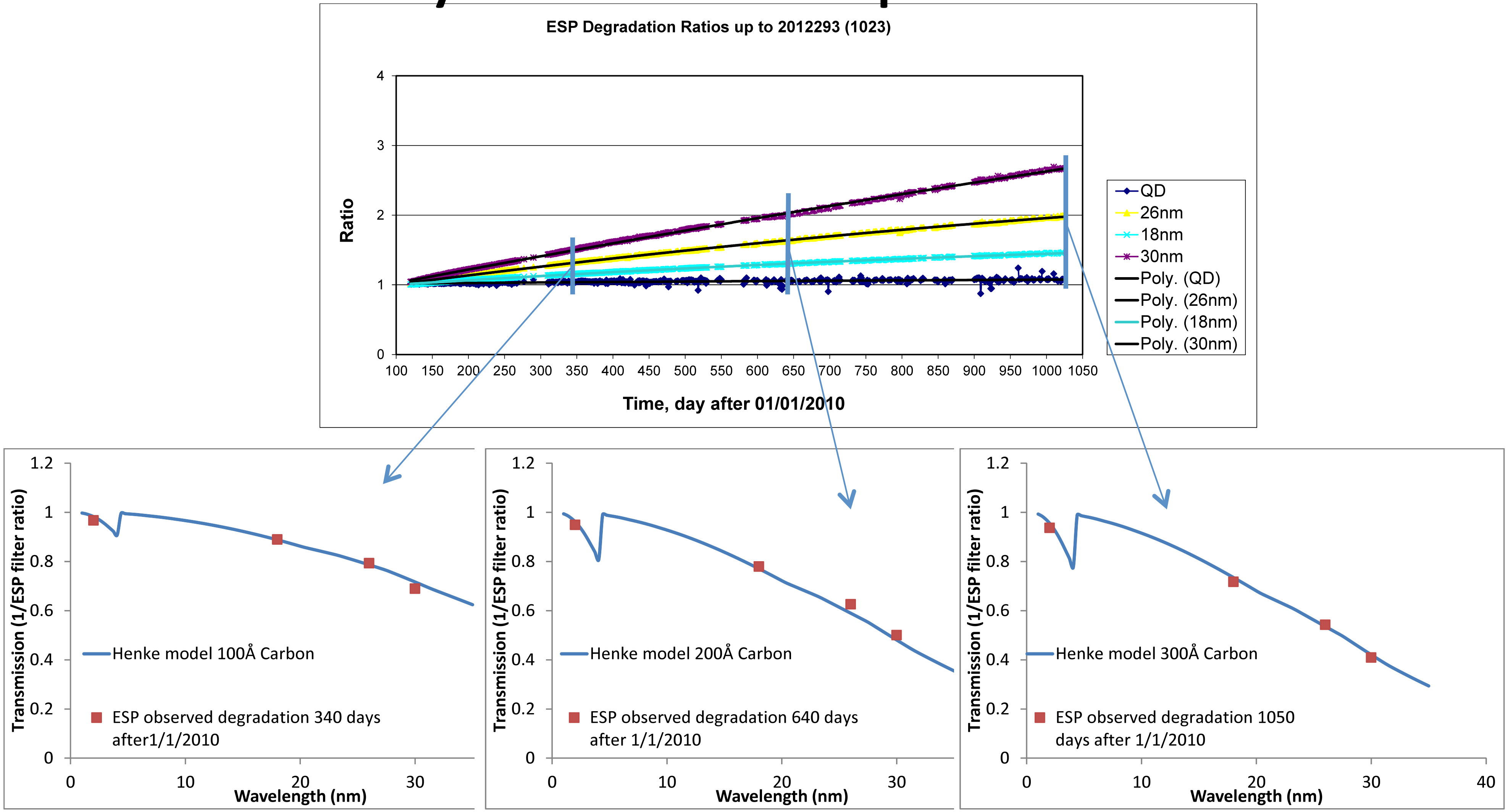
How Degradation of the Thin-Film Al Filter is Determined

- Use daily calibration runs and compare counts for the primery Al filter (F3) with the counts from one of spare Al filters (F4).
- Most of the mission time F4 is outside of the solar light and it is significantly less degraded than F3.
- The ratio F4/F3 shows F3 degradation (decreased transmission through the filter due to deposition of hydro-carbons).

Degradation Ratios for up to 2012293 (Oct 19, 2012)



ESP measured degradation compared to SEM-style carbon-equivalent model

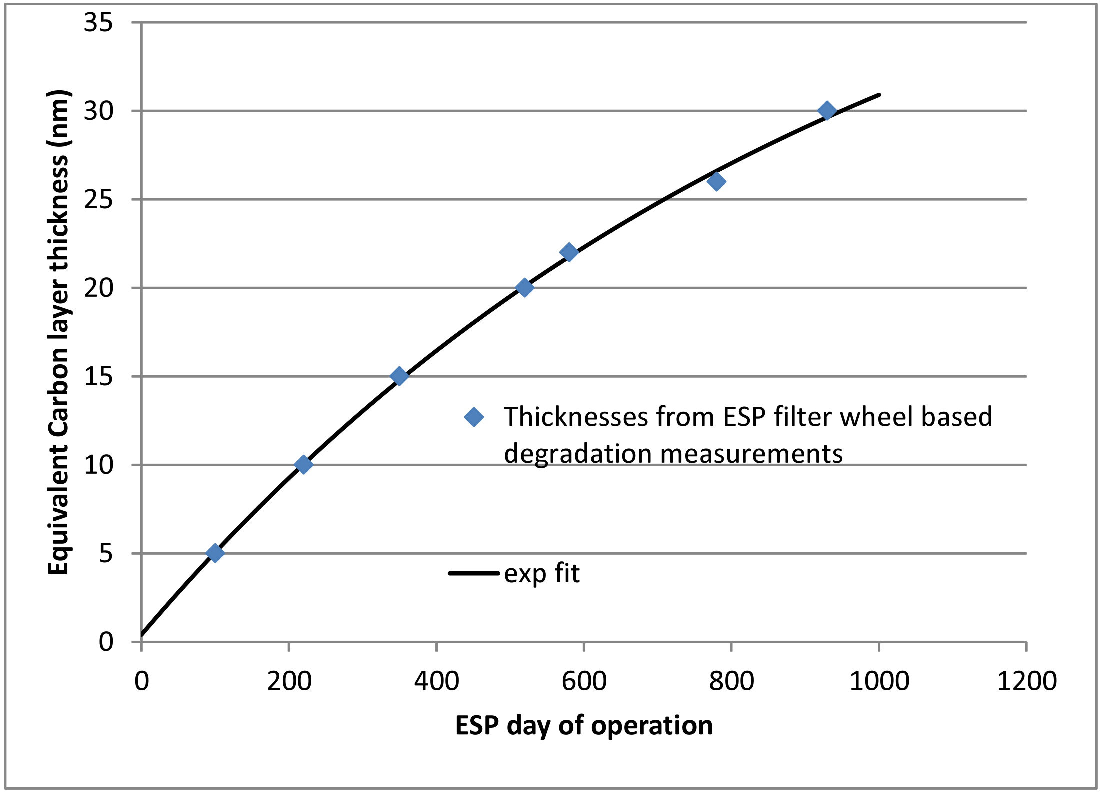


Degradation model

A “carbon equivalent” contamination layer model similar to that used for SEM degradation also describes well the time and wavelength dependence observed for the the decrease in SDO/EVE/ESP response

Thickness, τ (in Å) as a function of time (in days) is given by:

$$\tau(t) = 476.64 - 472.58e^{-t/964.61}$$



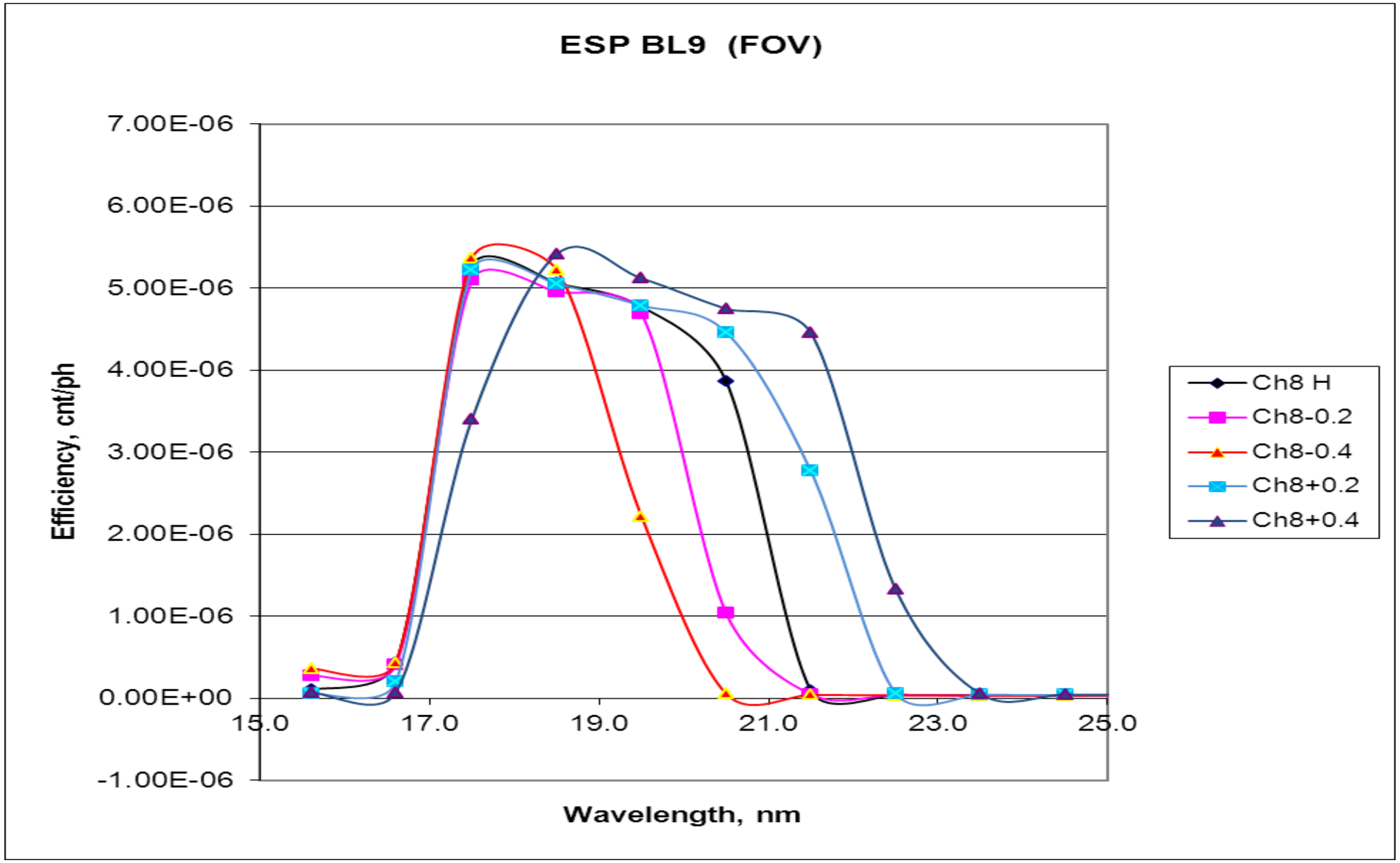
First-Order Bandpass Edges

$$\text{Eff}\ \odot(\lambda) \ = \ \sum_{\alpha}(W_{\alpha} * E_{\lambda,\alpha})$$

Where Eff for the disk is a sum over 535 areas (from -0.267 to +0.267 deg with Δα =0.001 deg) of the weight W_{α} of the area multiplied by the interpolated efficiency $E_{\lambda,\alpha}$ for the area.

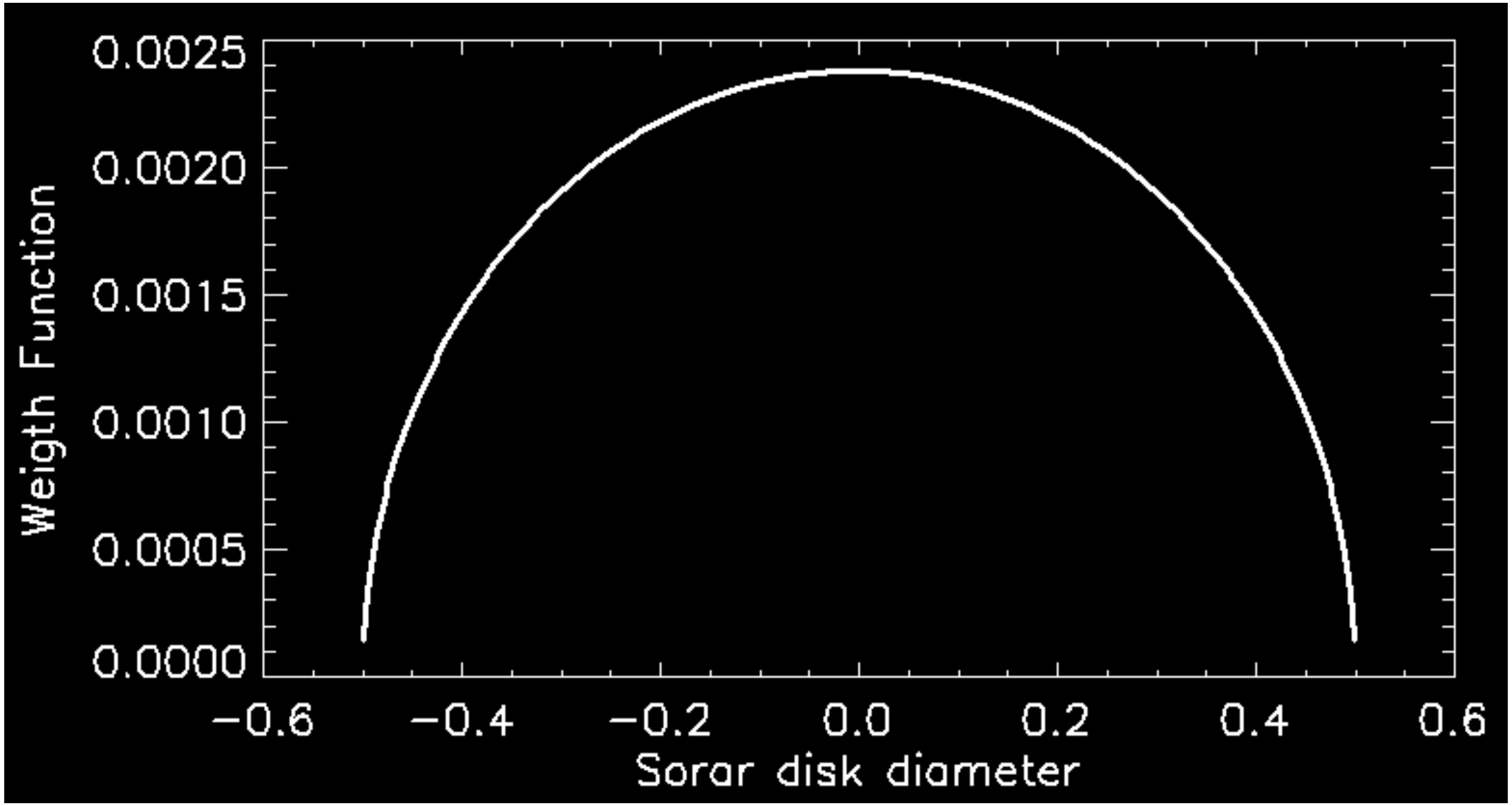
The edges for the first order channels were determined at the level of 10% from the maximum value of the calculated efficiency profile.

Efficiency Profiles for the Centered and Off-Axis Positions



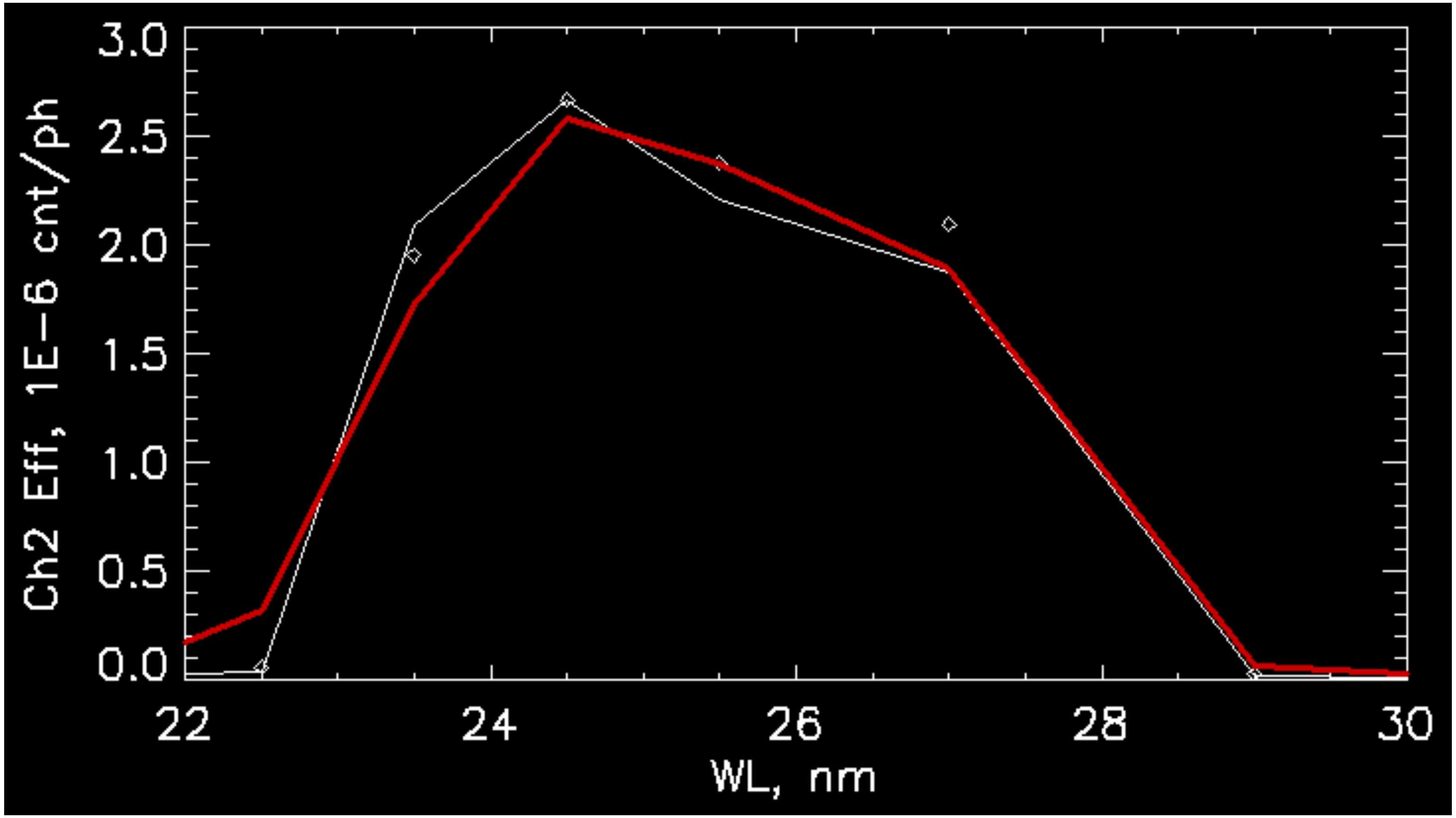
The edges (Dec 2011 – Jan 2012) were determined using SURF BL-9 Flight efficiency profiles (Ch8 shown) for both centered and tilted (± 0.4 and (± 0.2 deg) ESP positions.

Weight Function



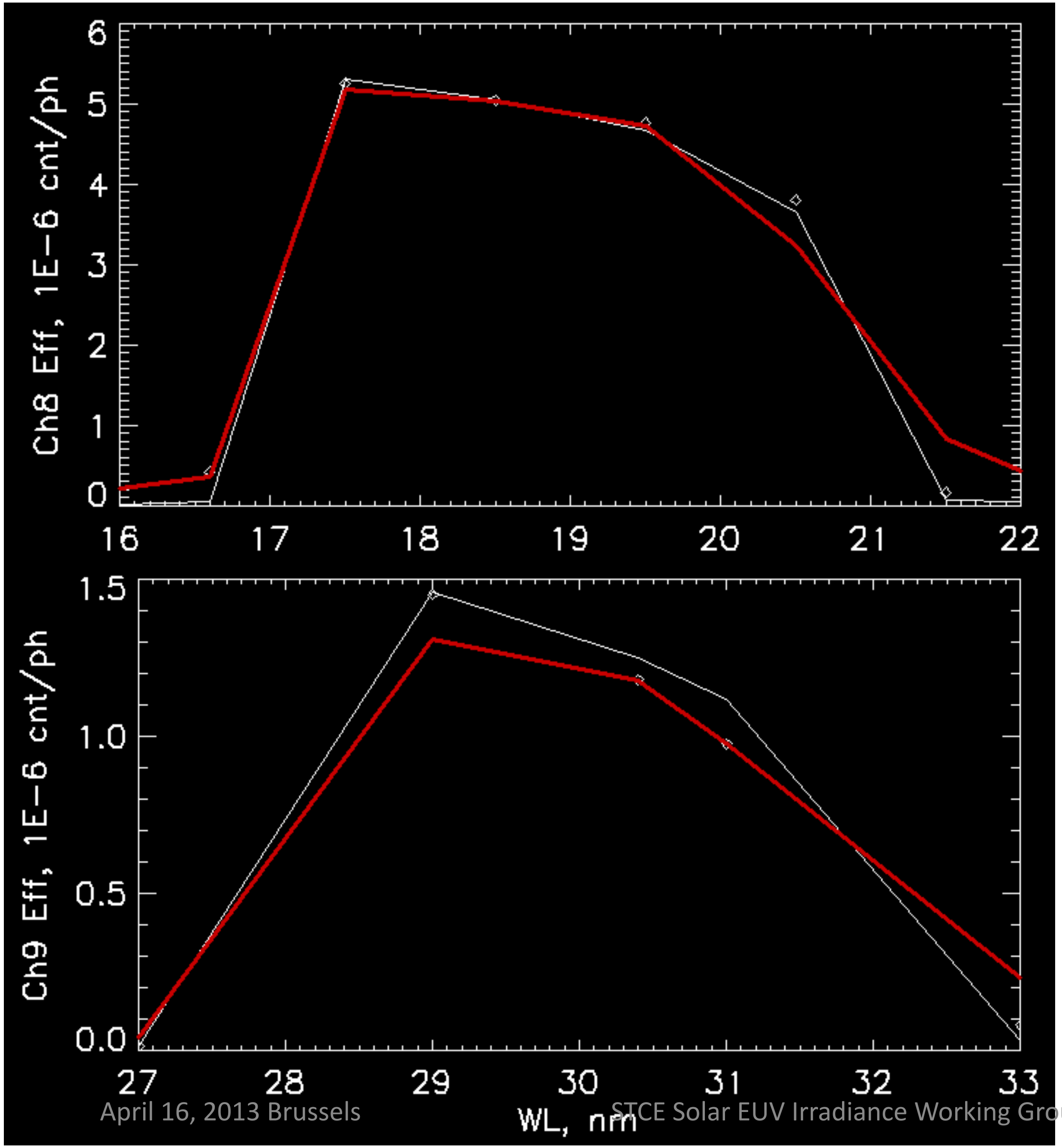
The whole disc area (-0.267 to +0.267 deg) was divided on 535 slices ($\Delta\alpha$ =0.001 deg) along the dispersion direction. Weight of each slice (*W*) and interpolated efficiency (*Eff*) were determined.

A Comparison of Efficiency Profiles



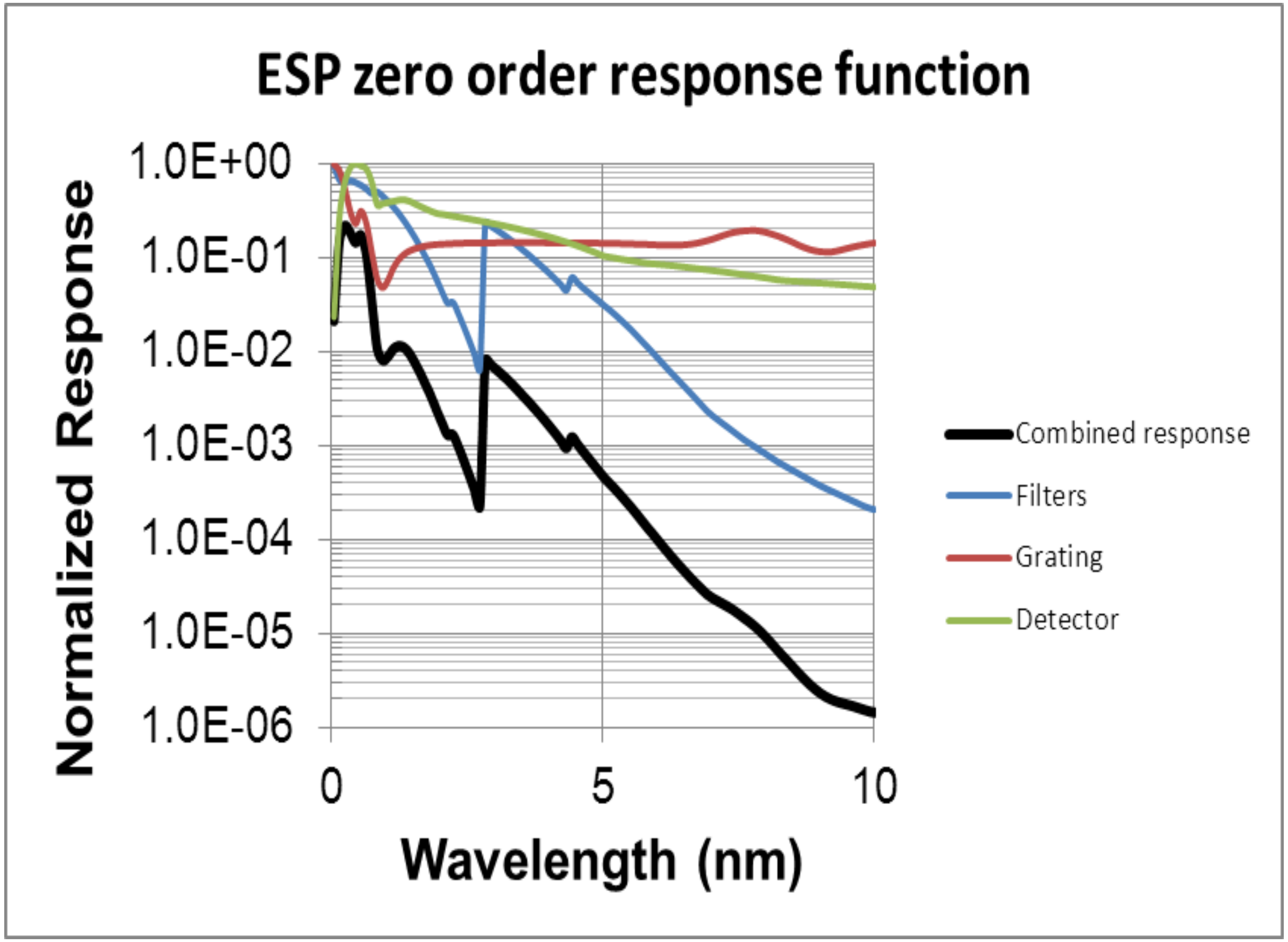
Calculated profiles (red) are compared to the original ESP flight efficiency profiles (thin white line) previously used as inputs for convolution with the slit function. Diamonds are based on TW suggestion to use three area model (central with the weight of 0.94 and two edge areas with the weight 0.03 each).

Same for Ch8 and Ch9



Detailed information about the change of the first-order bandpasses was provided in the EVE monthly report for Dec 2011.

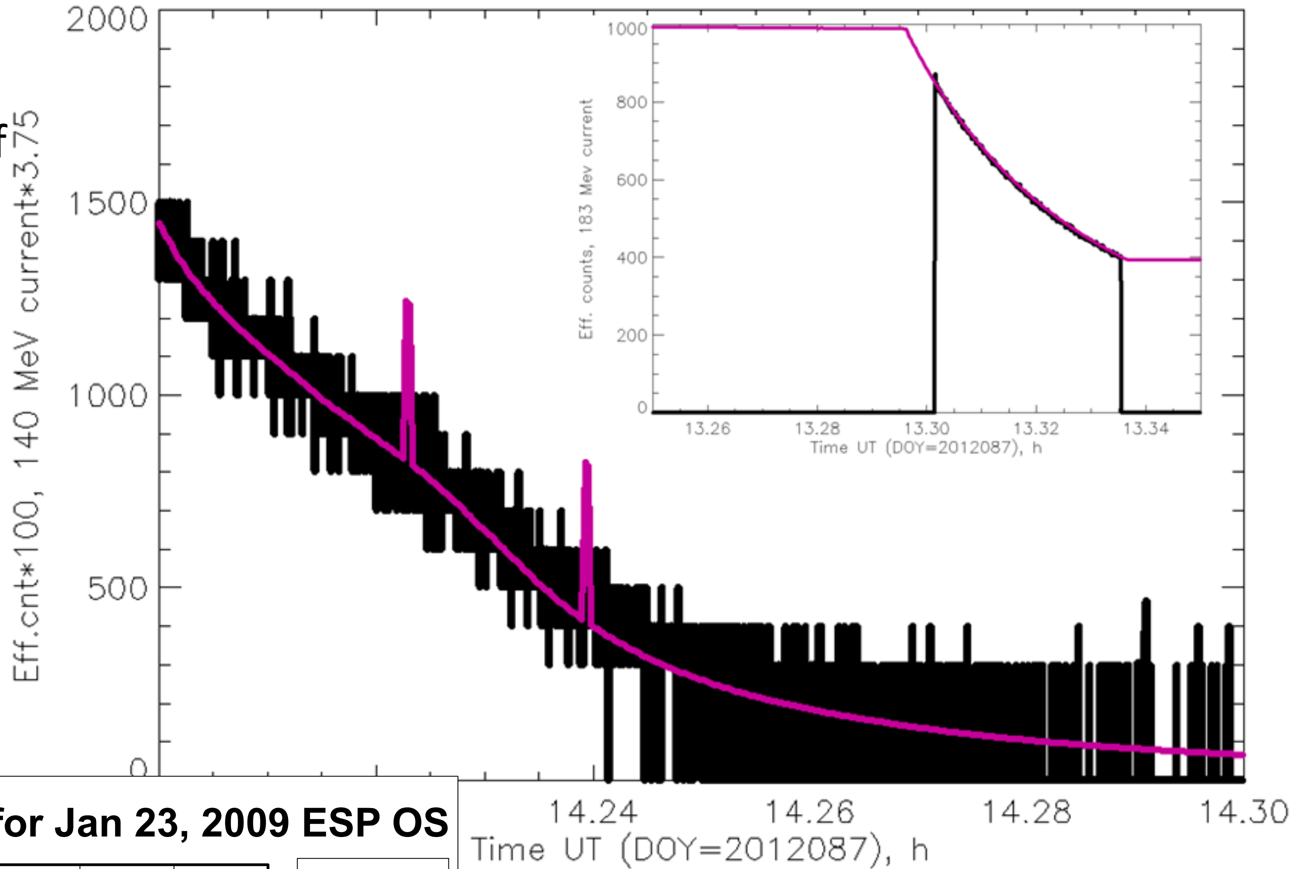
ESP/QD Calculated Response Function

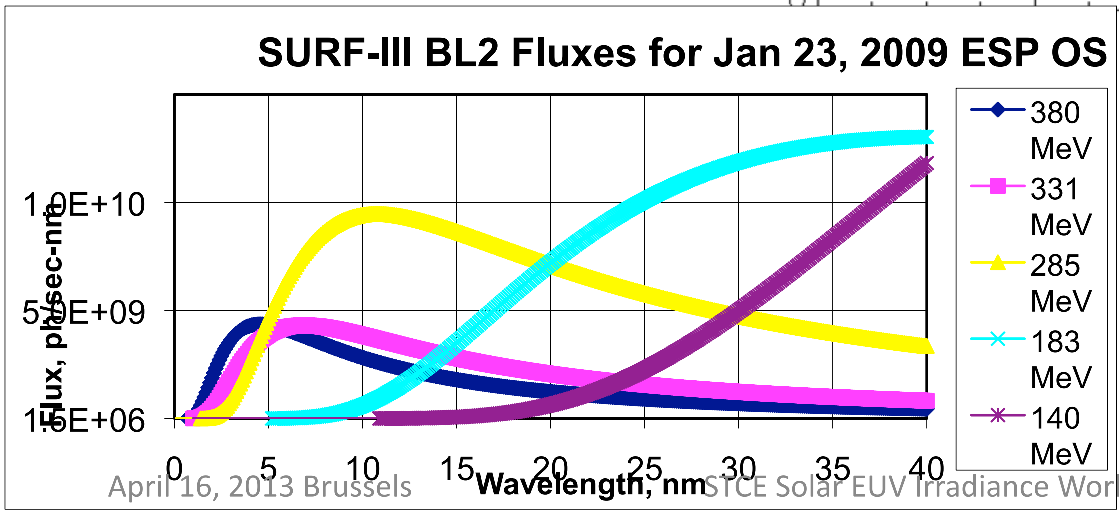


- Note, response at the right edge (7 nm) is about 4 orders of magnitude smaller than at the left edge.

ESP QD BL Calibration: Why It Is Not Sufficient

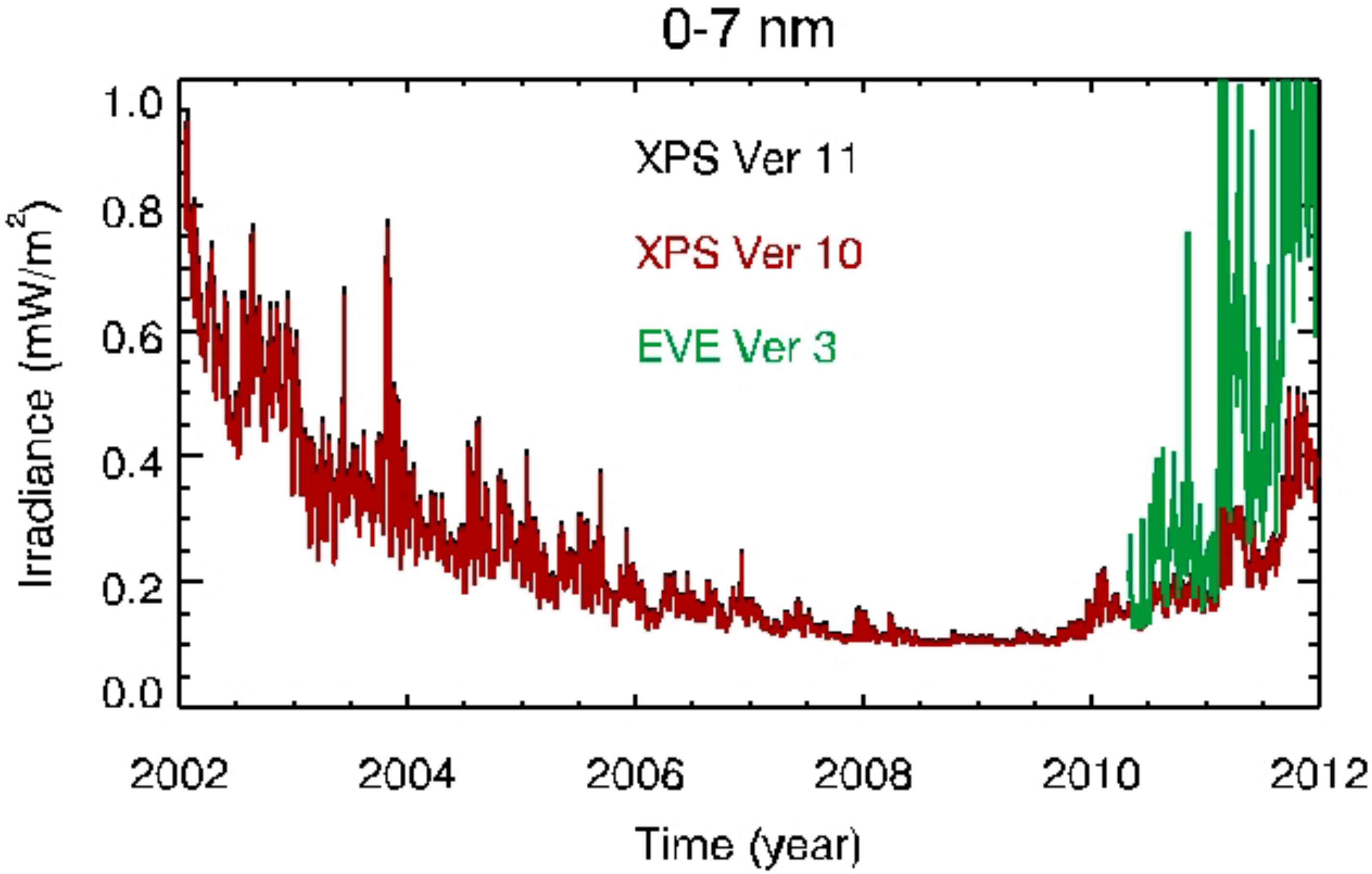
Linearity of the ESP QD SXR channel from March 2012 SURF radiometric calibration of the EVE rocket instrument. Effective counts (black lines) are compared to the beam intensity (beam current is shown as magenta curves). The insert on the top right shows the result for 183 MeV. Two spikes on the beam current line (140 MeV) do not represent real changes of the current, only its scale changes





A comparison of BL-2 fluxes

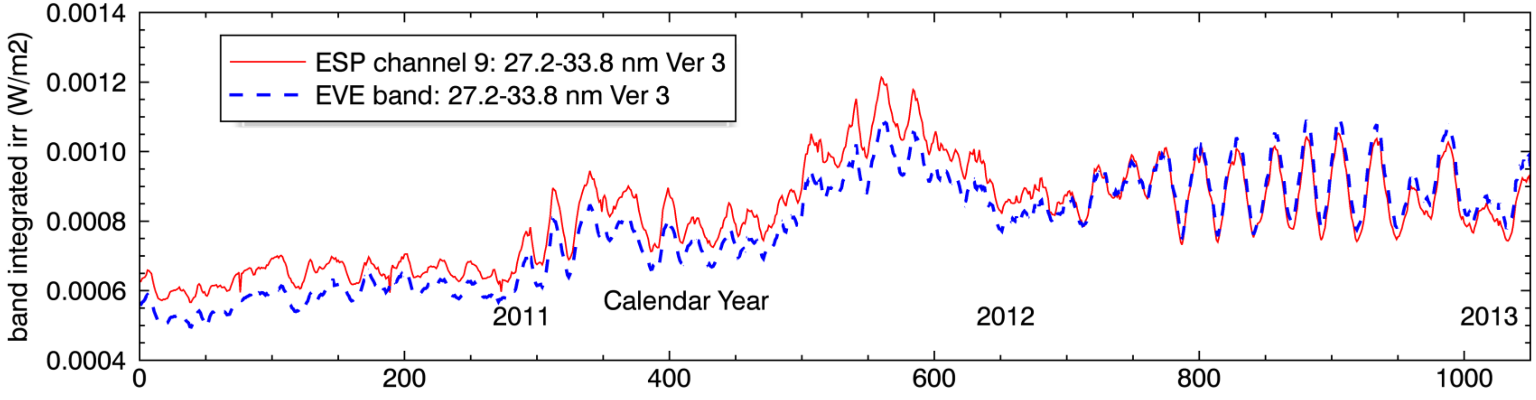
ESP Zeroth-Order Band: A Problem

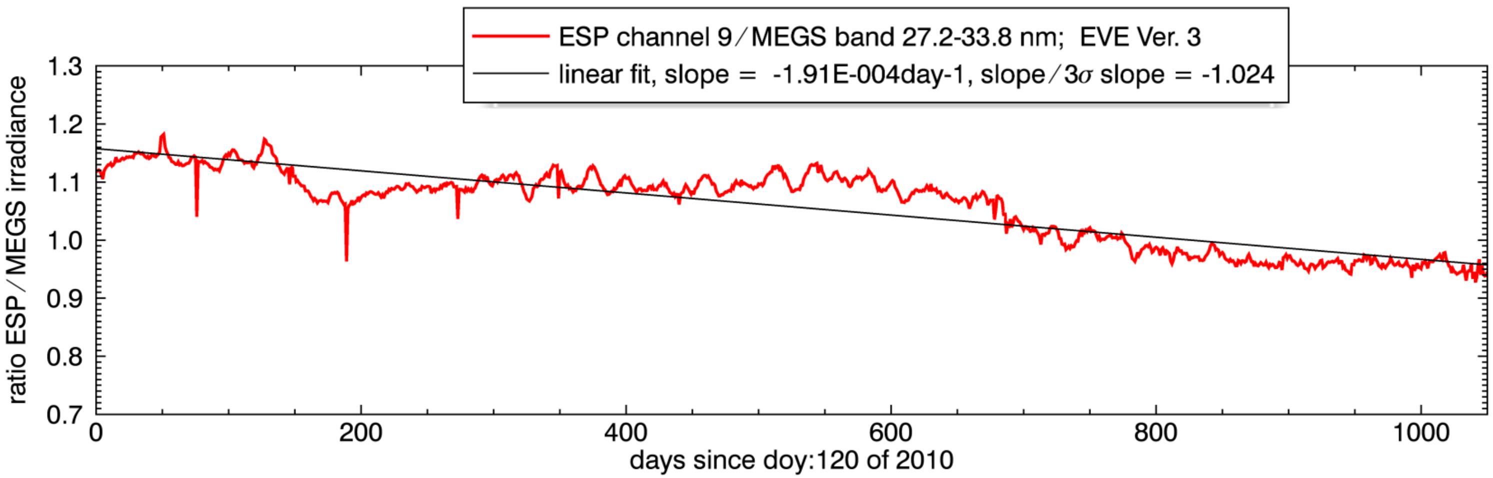


*A comparison **(Tom Woods)** of XPS (Ver 10 and Ver 11, black (buried in the red) and red, accordingly) irradiance from TIMED/SEE and SORCE with SDO/EVE/ESP Quad Diode (zeroth-order) channel data (green).*

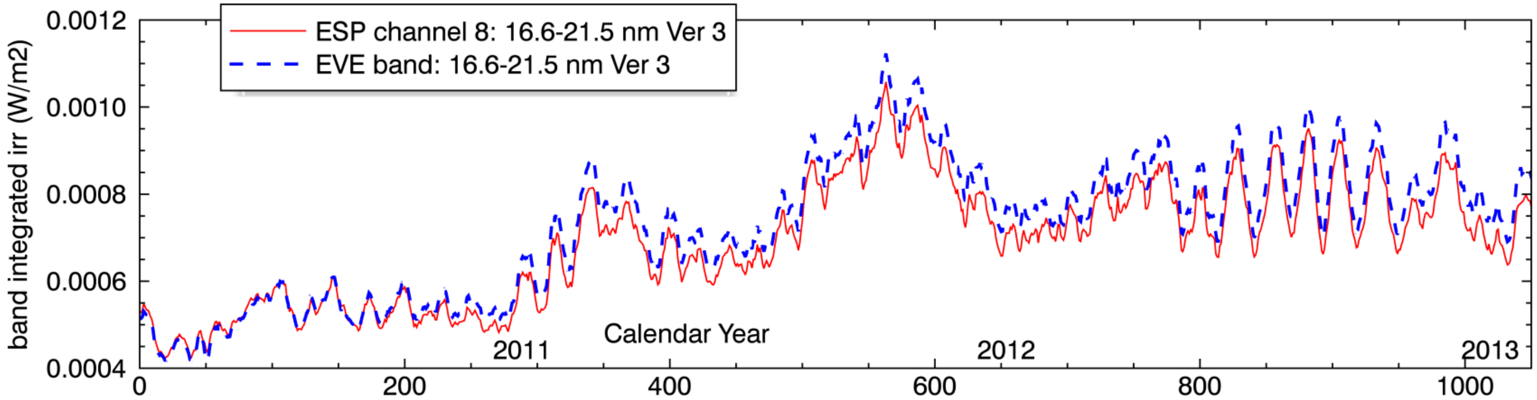
ESP Ch9 comparison with MEGS integrated spectra – daily averages

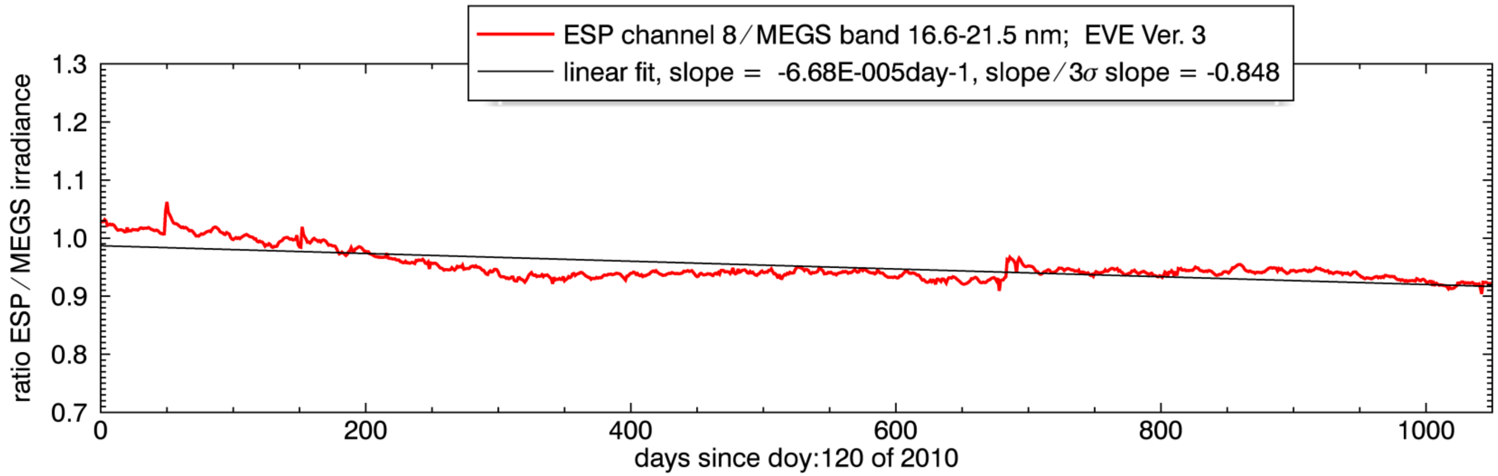
ESP/MEGS ratios decrease steadily with time/solar cycle



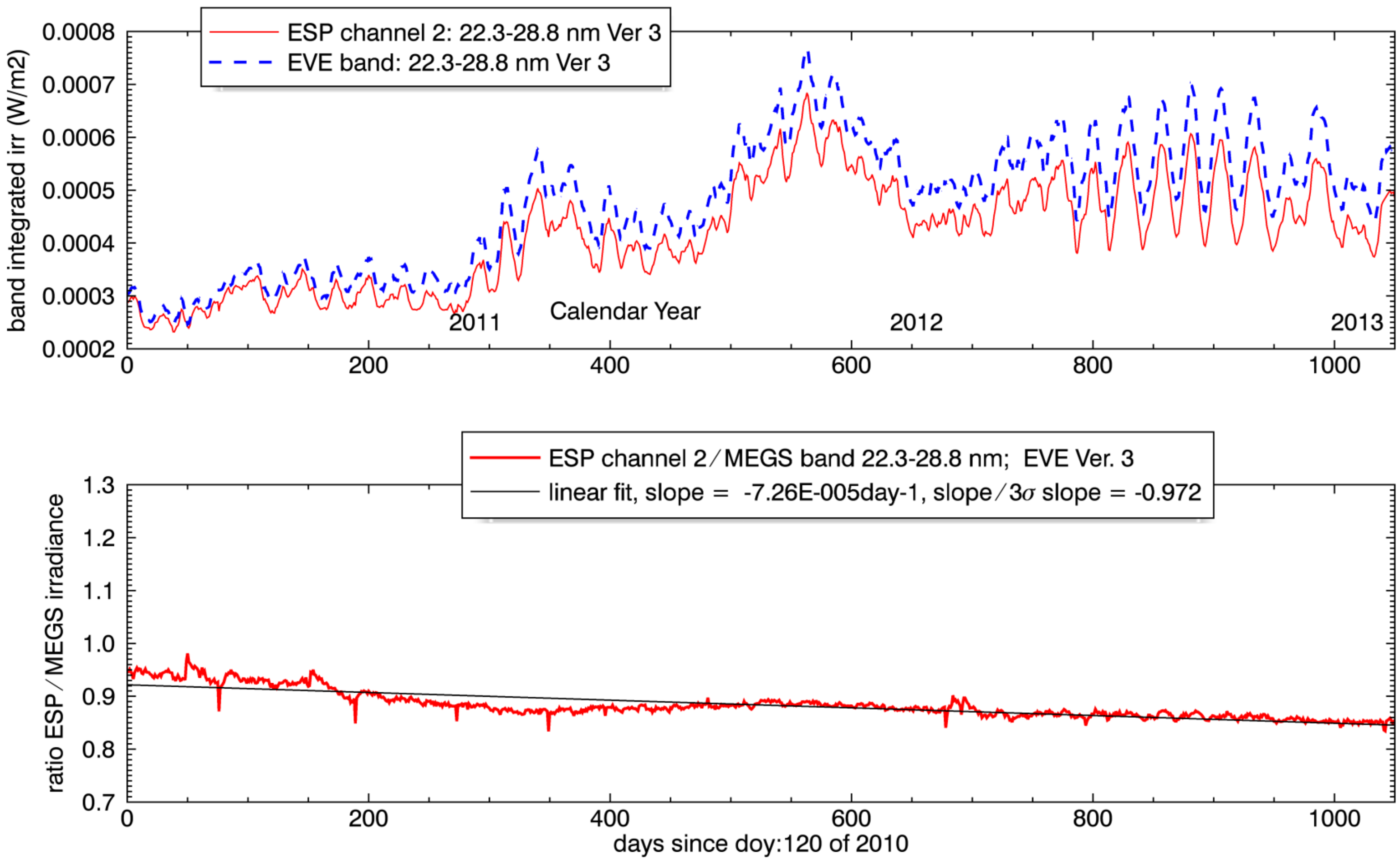


ESP Ch8 comparison with MEGS integrated spectra – daily averages

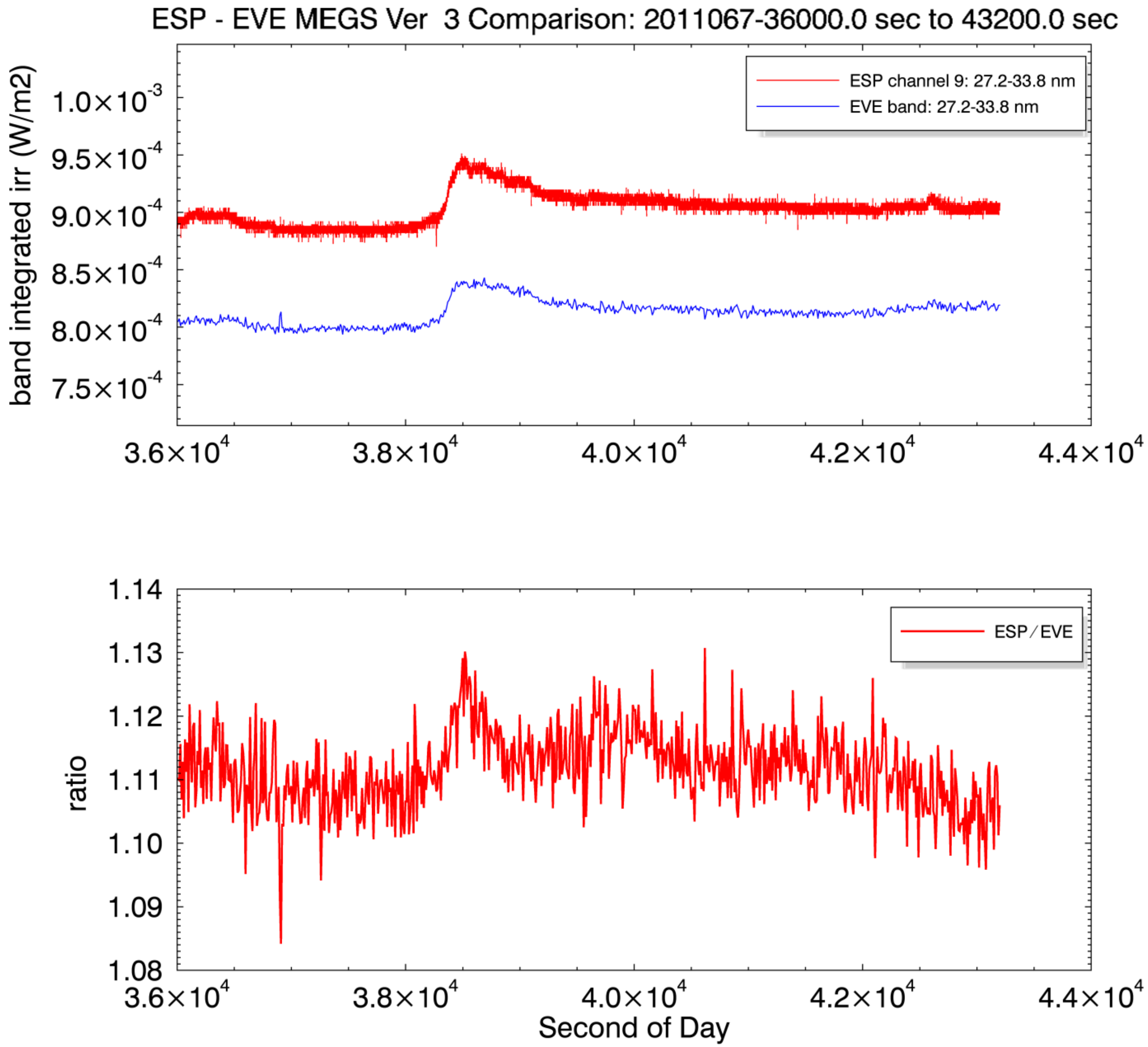




ESP Ch2 comparison with MEGS integrated spectra – daily averages

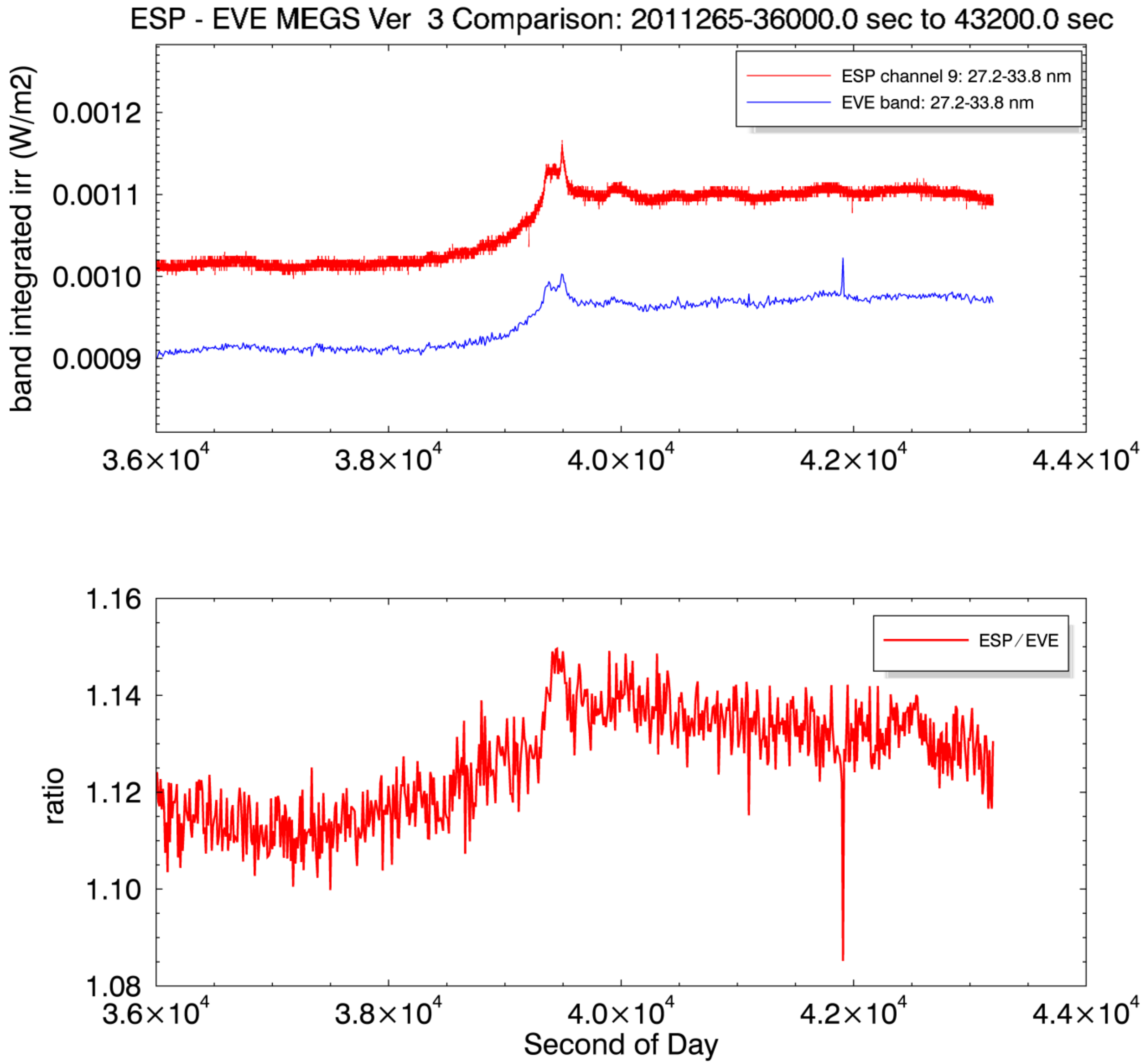


ESP Ch9 irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare



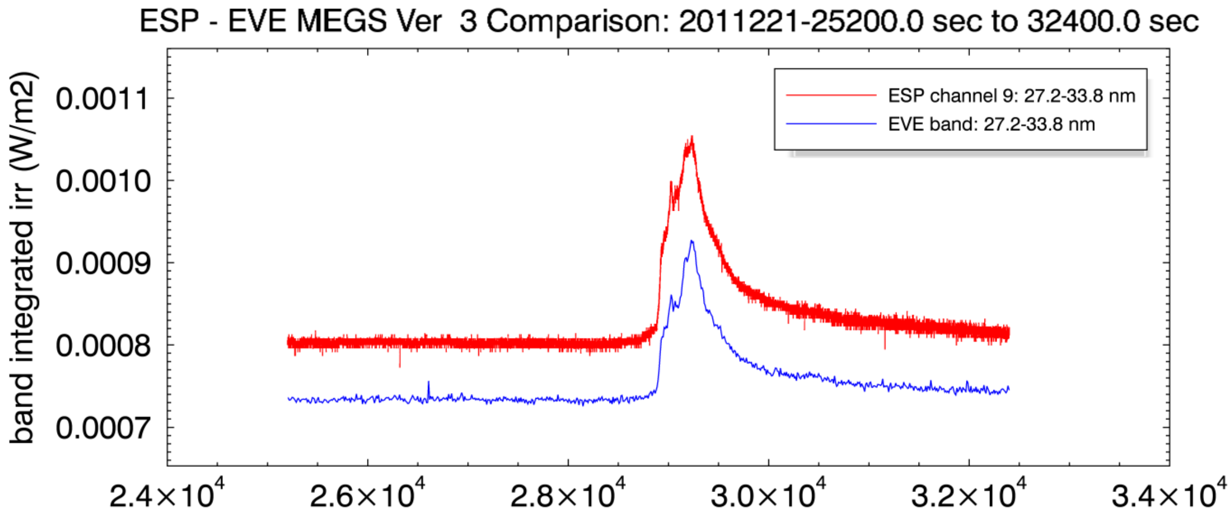
- For moderate to large flares (M5.3 shown here) the ratio remains close to the pre-flare level throughout the flare peak
- Ch2 and Ch8 results are similar

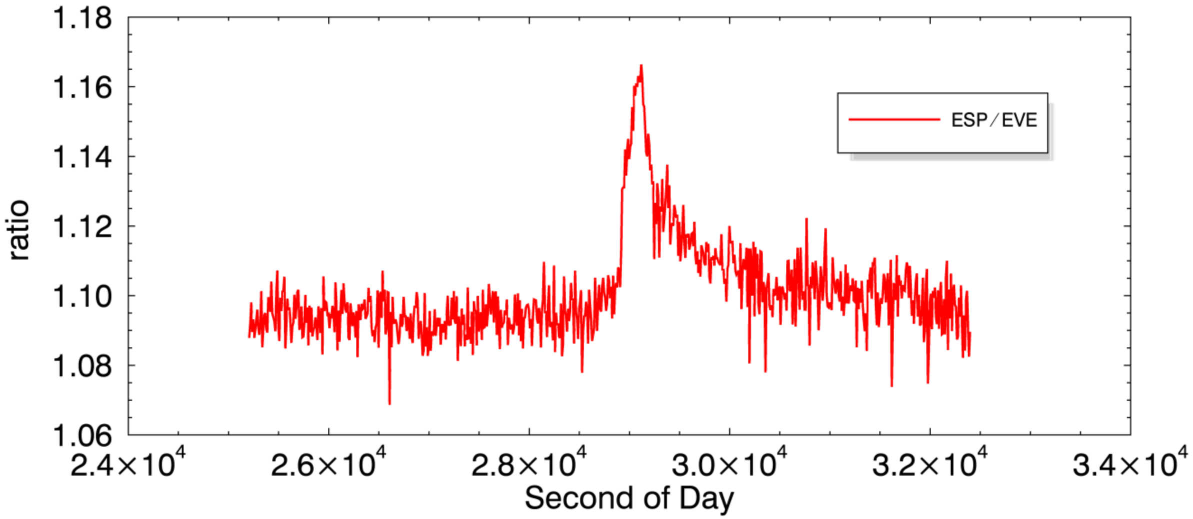
ESP Ch9 irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare



- For larger flares (X1.4 shown here) the ratio remains close to the pre-flare level throughout the flare peak
- Ch2 and Ch8 results are similar

ESP Ch9 irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare





- For significantly larger flares (X6.9 shown here) the increase in the ratio becomes significant around the peak of the flare
- Ch2 and Ch8 results are similar

Summary of ESP comparisons with MEGS

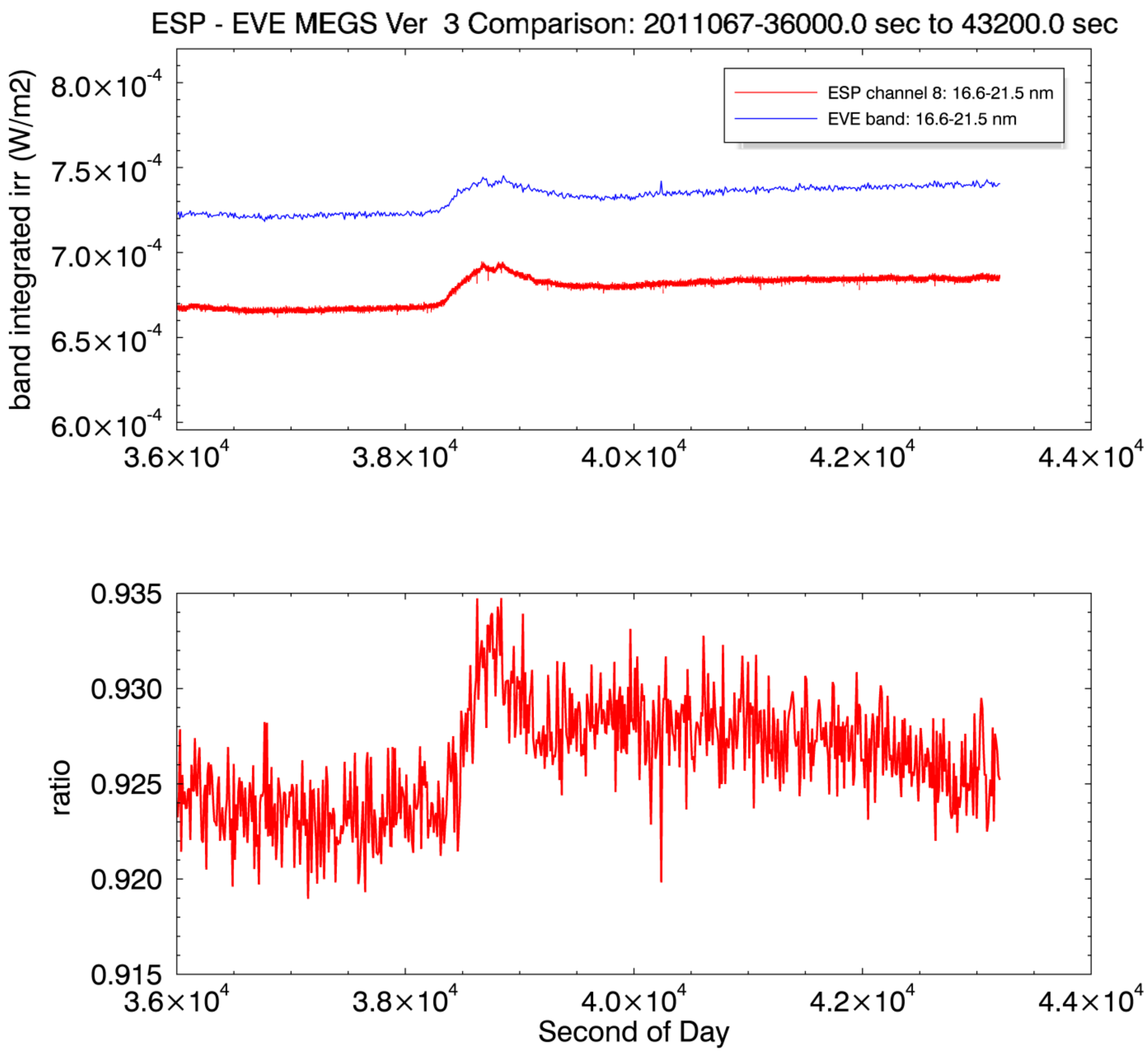
- Long-term (from 4/30/2010 to present) comparisons between ESP and MEGS Ver. 3 show a trend of increasing MEGS irradiance values relative to ESP for all ESP first order bandpasses
- During small to moderately large flares ESP/MEGS ratios remain constant at a value close to the current daily average value (i.e. the larger inconsistencies typical of the SEM-MEGS flare time comparisons are not seen).
- More significant shifts in the ratio around the peak of the flare are seen during large flares.

The Largest Uncertainties that Affect ESP In-Flight Calibration

1. Unexpected changes of the dark currents. There is some source of large change of the dark currents which was detected in the middle of 2012. Requires some better statistics for understanding the nature of such change and the way to calculate it.
2. The edges of the spectral bands, mostly for the zeroth-order channel due to strong spectral variability in the soft X-ray;
3. Zeroth-order channel responsivity in about 0.1 – 7.0 nm is currently modeled, not measured

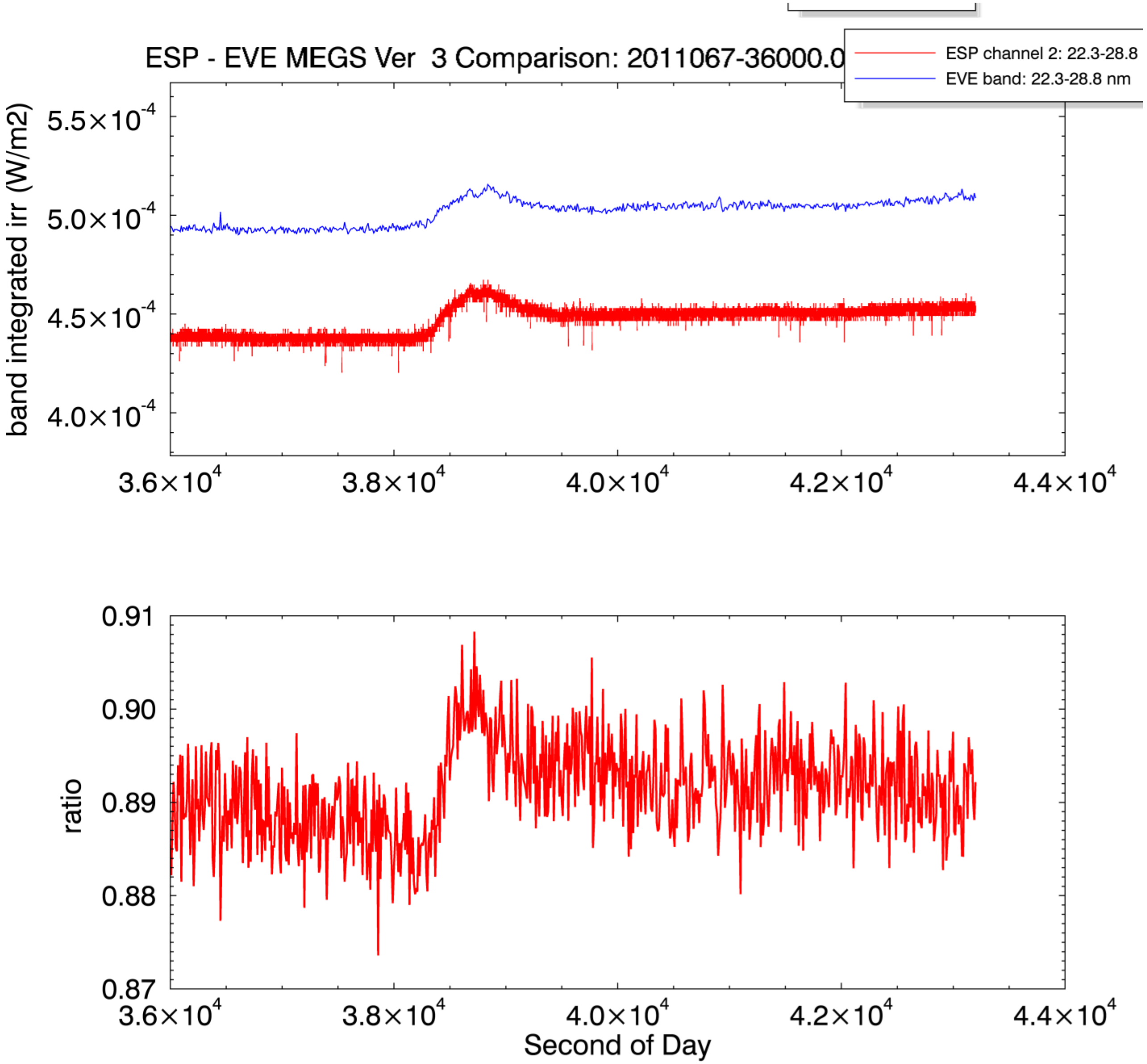
Backup Slides

ESP Ch8 irradiance comparison with EVE Version 3 MEGS integrated



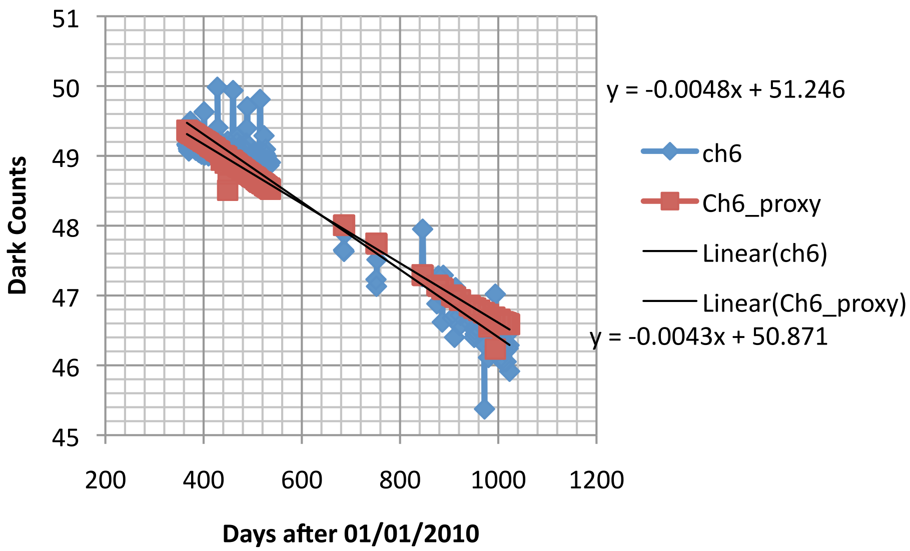
- For moderate to large flares (M5.3 shown here) the ratio remains close to the pre-flare level throughout the flare peak
- Ch2 and Ch9 results are similar

ESP Ch2 irradiance comparison with EVE Version 3 MEGS integrated spectra – during flare

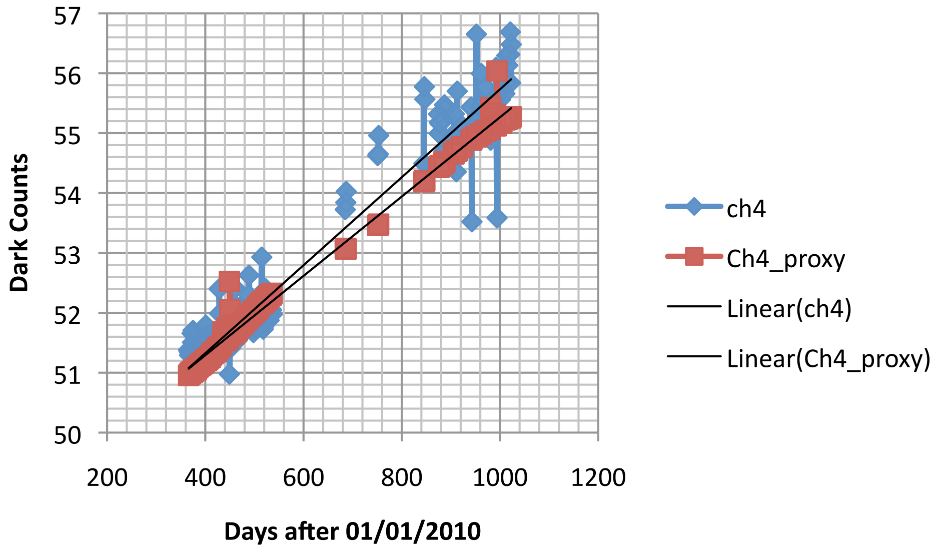


- For moderate to large flares (M5.3 shown here) the ratio remains close to the pre-flare level throughout the flare peak
- Ch9 and Ch8 results are similar

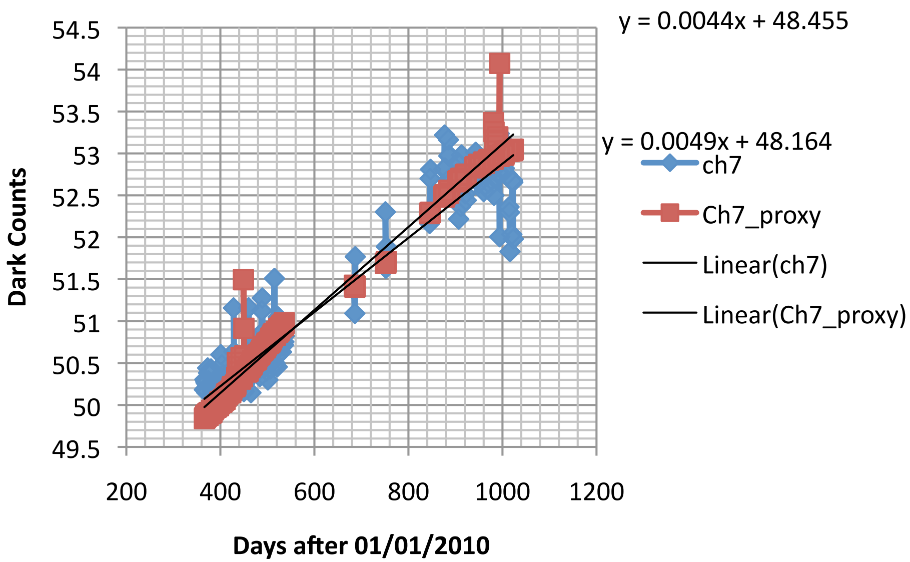
V3 Status



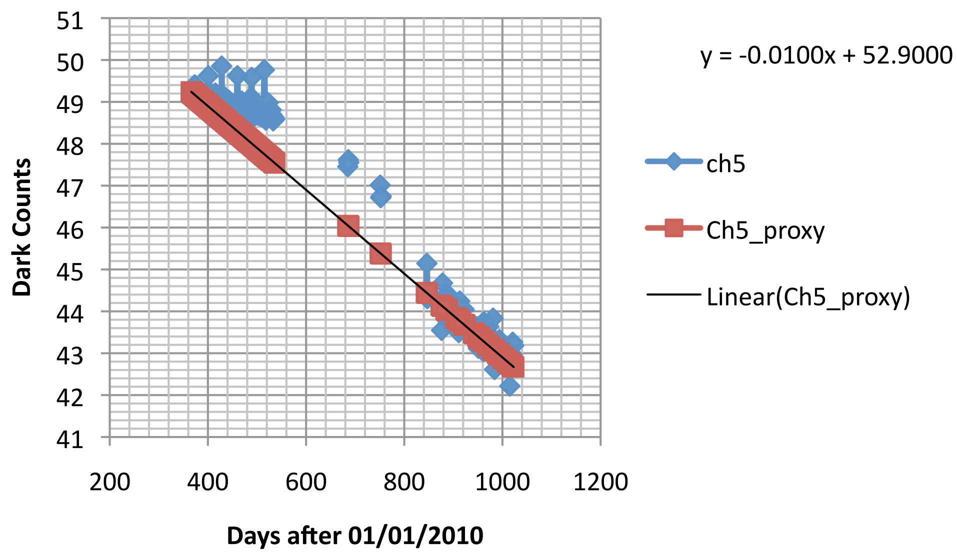
y = -0.0048x + 51.246
y = -0.0043x + 50.871
ch6
Ch6_proxy
Linear(ch6)
Linear(Ch6_proxy)
Dark Counts
51
50
49
48
47
46
45
200
400
600
800
1000
1200
Days after 01/01/2010



ch4
Ch4_proxy
Linear(ch4)
Linear(Ch4_proxy)
Dark Counts
57
56
55
54
53
52
51
50
200
400
600
800
1000
1200
Days after 01/01/2010

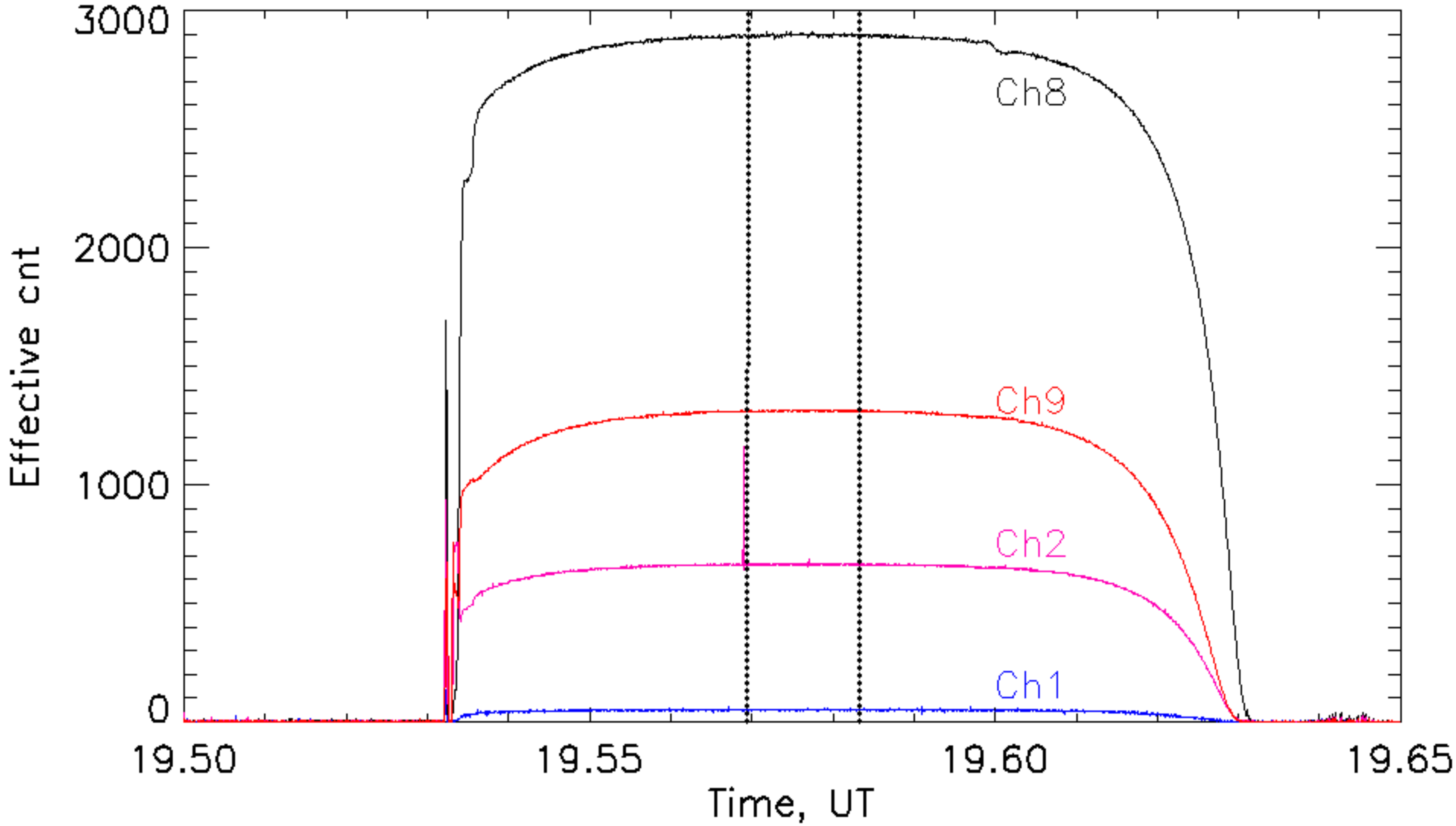


y = 0.0044x + 48.455
y = 0.0049x + 48.164
ch7
Ch7_proxy
Linear(ch7)
Linear(Ch7_proxy)
Dark Counts
54.5
54
53.5
53
52.5
52
51.5
51
50.5
50
49.5
200
400
600
800
1000
1200
Days after 01/01/2010



y = -0.0100x + 52.9000
ch5
Ch5_proxy
Linear(Ch5_proxy)
Dark Counts
51
50
49
48
47
46
45
44
43
42
41
200
400
600
800
1000
1200
Days after 01/01/2010

ESP Data Analysis From EVE Rocket Underflight (NASA 36.286) on June 23, 2012



Apogee portion used for the analysis is marked with dotted vertical lines

Dark and **Effective Count-Rates**: Rocket (top) and Flight (bottom)

ESP channel (WL)	Dark, cnt/sec [1000:1200] and [2750:2800]	Effective, cnt/sec [1800:2000]
Ch1 (36 nm)	42.5155	51.072
Ch2 (25 nm)	23.6522	663.54
Ch8 (17 nm)	44.0967	2895.53
Ch9 (30 nm)	31.8807	1310.726
QD Ch4 (3.5 nm)	38.9208	246.088
QD Ch5 (3.5 nm)	31.6965	210.807
QD Ch6 (3.5 nm)	41.9102	181.036
QD Ch7 (3.5 nm)	37.0351	228.317
QD sum		866.25

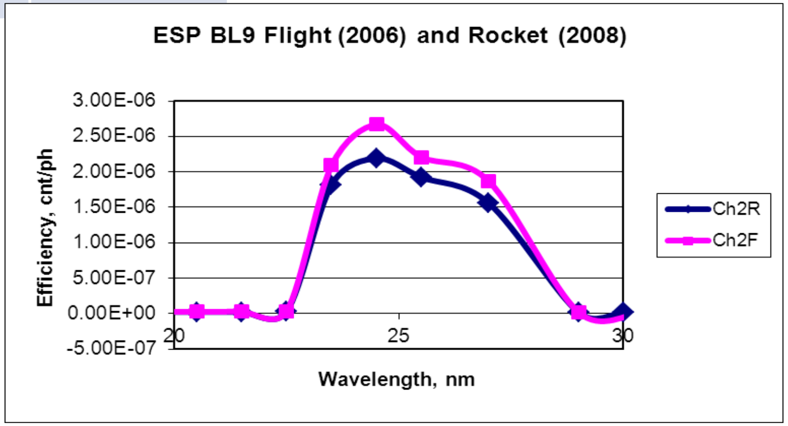
ESP channel (WL)	Dark, cnt/sec [daily calibration]	Effective, cnt/sec [19:34:30 – 19:34:50]
Ch1 (36 nm)	5.9	32.3433
Ch2 (25 nm)	53.7664	452.707
Ch8 (17 nm)	45.1711	2079.66
Ch9 (30 nm)	57.3684	499.803
QD Ch4 (3.5 nm)	54.5855	254.396
QD Ch5 (3.5 nm)	43.8684	243.136
QD Ch6 (3.5 nm)	47.0066	148.371
QD Ch7 (3.5 nm)	52.8947	158.974
QD sum		804.88

$$E(\lambda, t) = \frac{C_{eff}(A, f_{degrad}(t), G_{SM})}{A * k(\lambda, R_M, F_W) * f_{degrad}(t) * f_{1AU}(t)}$$

$$k(\lambda, R_M, F_W) = \frac{\sum_{\lambda 1}^{\lambda 2} R_M(\lambda) * F_i(\lambda) * \Delta\lambda}{\sum_{\lambda 1}^{\lambda 2} F_i(\lambda) * \Delta\lambda}$$

Comparison of (R) and (F) Eff. Counts Corrected for Degradation and Response Functions

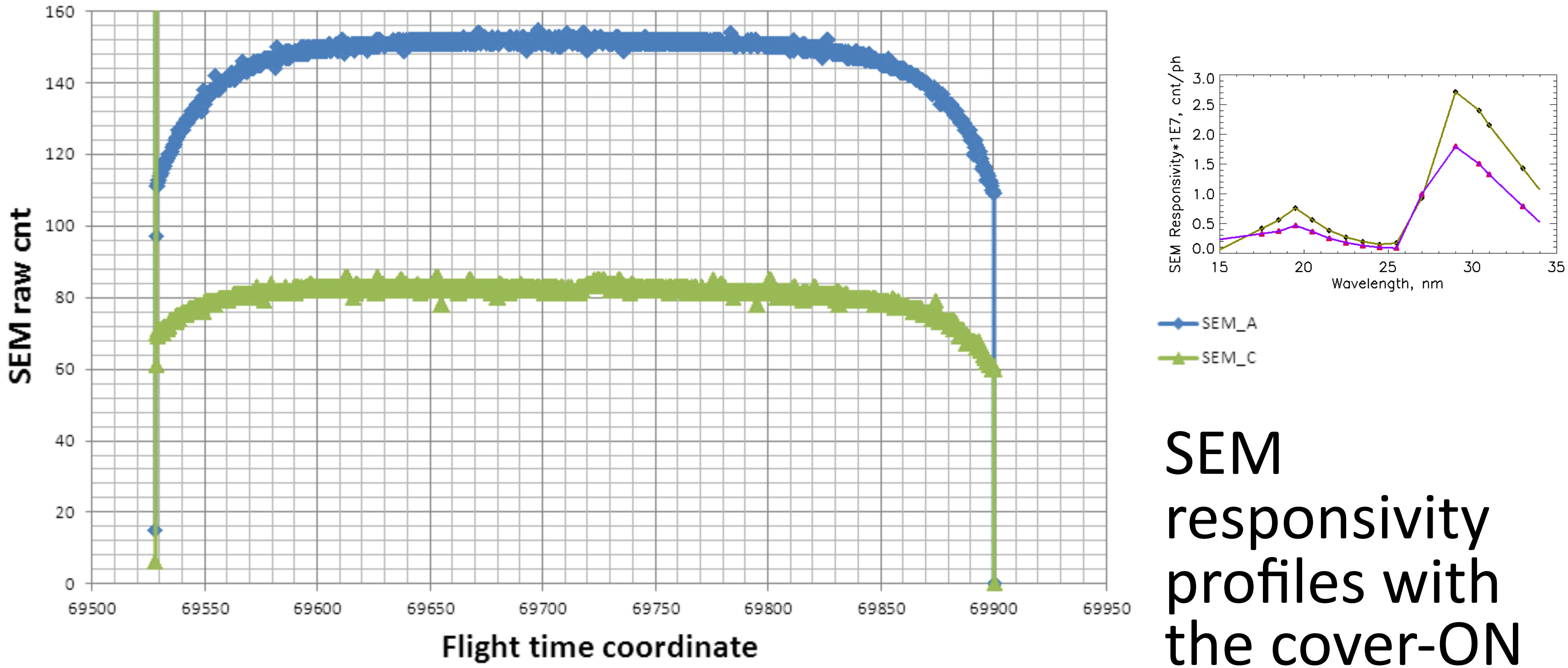
ESP Ch	Rocket Eff cnt/sec	Flight Eff cnt/sec (not corr for degrad)	Degrad Ratio @ 2012175	Flight Eff cnt/sec (corr for degrad)	Ratio R/F
Ch1	51.072	32.3433	noisy	-	
Ch2	663.54* 809.5	452.707	1.87	846.56* 693.90	0.96
Ch8	2895.53	2079.66	1.41	2932.32	0.99
Ch9	1310.726	499.803	2.54	1269.50	1.03
QD	866.3	804.9	1.08	869.3	0.99



Angular Offsets and Atmosphere Transmissions are Corrected

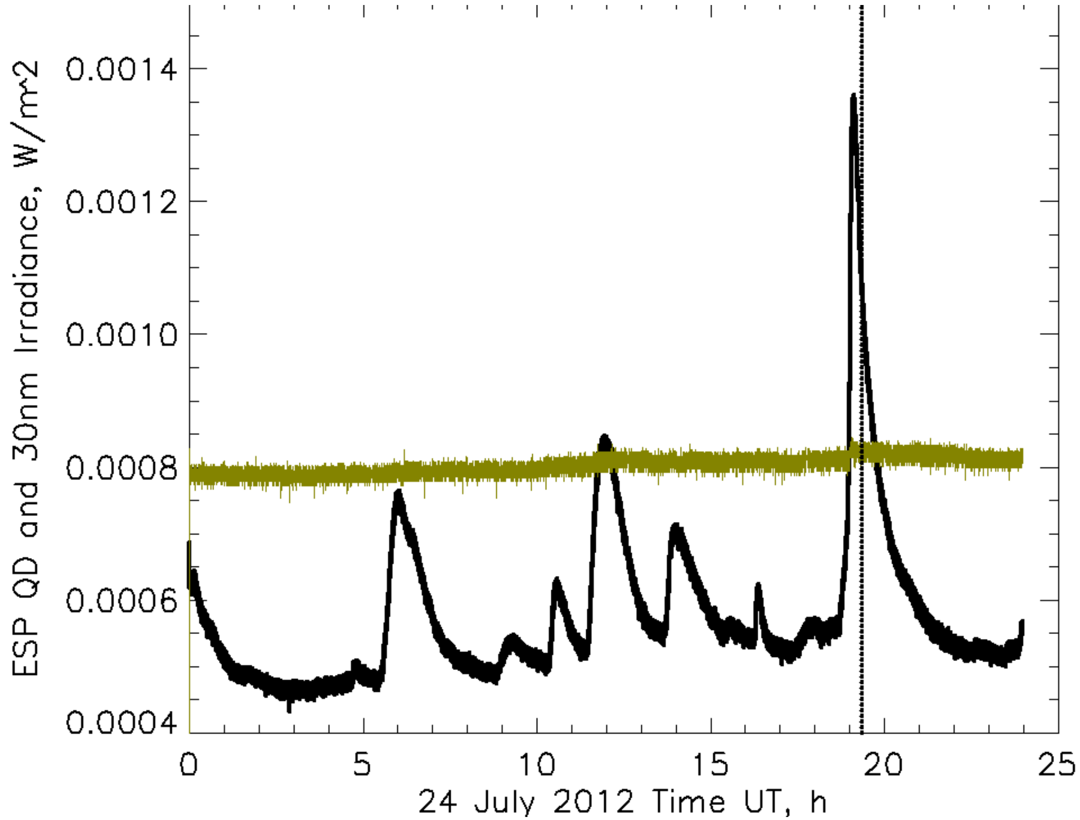
ESP Ch	Ratio R/F (Initial)	Ratio R/F (R Ang. Offset)	Ratio R/F (R and F Ang. Offset)	Ratio R/F (Atm. Transmiss.)	Final R/F Ratio
1					
2	0.96	0.97	1.02	1.03	**1.03**
8	0.99	0.99	0.99	1.00	**1.00**
9	1.03	1.03	1.03	1.05	**1.05**
QD	0.99	0.99	0.99	0.99	**0.99**

SEM 36.263 (24 July 2012 / 2012206)
Rocket Profiles



SEM responsivity profiles with the cover-ON calibration

ESP Irradiance Profiles for 2012206



ESP Ch9 (27.16 – 33.8 nm) irradiance for the 36.263 flight apogee time (dotted line) is **8.2E-4 W/m^2**.

SEMR apogee irradiances are: 7.90E-4 (SEM-C) and 8.85E-4 (SEM-A) W/m^2. SEM mean apogee irradiance is **8.54E-4 W/m^2** (4% higher than ESP)

SEMF apogee time irradiances are: **9.7E-4 W/m^2** (No cover-ON efficiencies, SOLERS22);

8.1E-4 W/m^2 (cover-ON efficiencies, MEGS v2 refer. Spectrum)