Two studies with LYRA:

- ✦ Ly-α flare observations
- ✦ Long-term trend

Matthieu Kretzschmar

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in collaboration with M. Dominique, I.E. Dammasch, and others

PROBA2 science days & Degradation workshop, ROB, 4 May 2012

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- ✦ Ly-α flare observations *(Submitted to Solar Physics)*
- ✦ Long-term trend *(Submitted to SWSC)*

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LYRA

the **L**arge-**Y**ield **Ra**diometer onboard PROBA2

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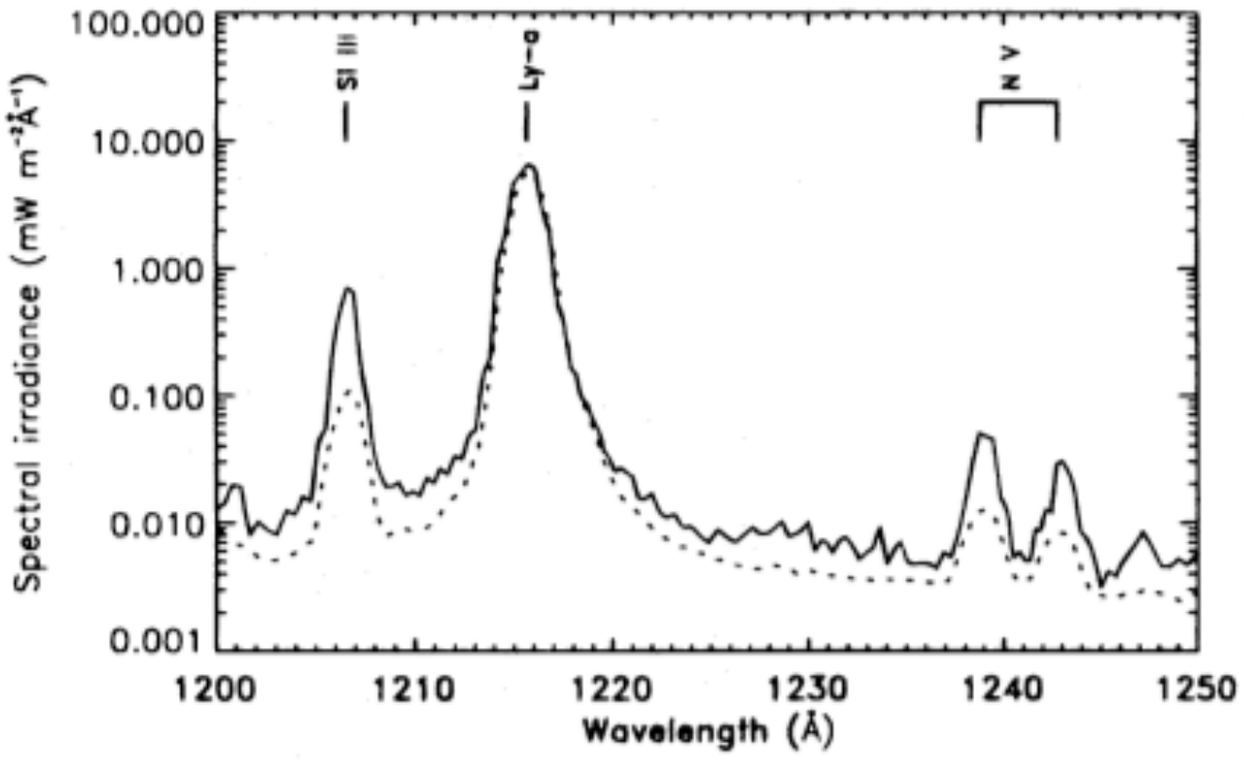
Lyman-α flare

- ✓ Very few observations: instrumental or solar ?
- ✓ Only two* in Sun-as-a-star measurements (Brekke et al., 1996; Woods et al., 2004)
- ✓ But most intense line of the solar spectrum ! Relevant for flare physics and Solar-Terrestrial physics

X3 flare on 27 February 1992



* Now 3: Milligan et al., 2012

Lyman-α flares seen by LYRA

Table 1. Flares with a signature in Lyman-α observed by LYRA

Date	*SXR class*	*Unit*	*NOAA region*	*Quality*
SOL2010-01-20T10:59	M1.8	2	1041	medium (detector not stabilized)
SOL2010-02-06T07:04	C4.0	2	1045	good
SOL2010-02-06T18:59	M2.9	2	1045	medium (pointing manoeuvre)
SOL2010-02-07T04:52	C9.9	2	1045	medium (pointing manoeuvre)
SOL2010-02-07T21:15	C4.2	2	1045	good
SOL2010-02-08T03:58	C2.4	2	1045	medium (pointing manoeuvre)
SOL2010-02-08T06:06	C6.8	2	1045	medium (pointing manoeuvre)
SOL2010-02-08T13:47	M2.0	2	1045	good
SOL2010-02-08T21:23	M1.0	2	1045	medium (faint, occultation)
SOL2011-05-29T21:20	C8.7	3	1227	medium (pointing manoeuvre)
SOL2011-09-08T15:46	M6.7	3	1283	medium (pointing manoeuvre)

- ✓ Observations early in the mission because of degradation (but see unit 3)
- ✓ Most of the flares occurred in the same AR

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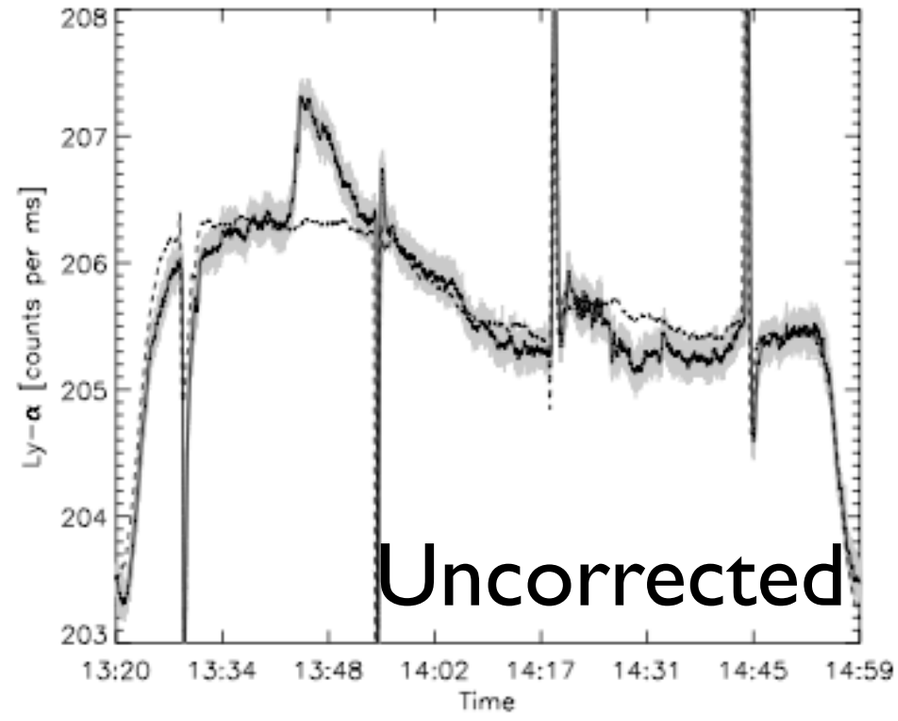
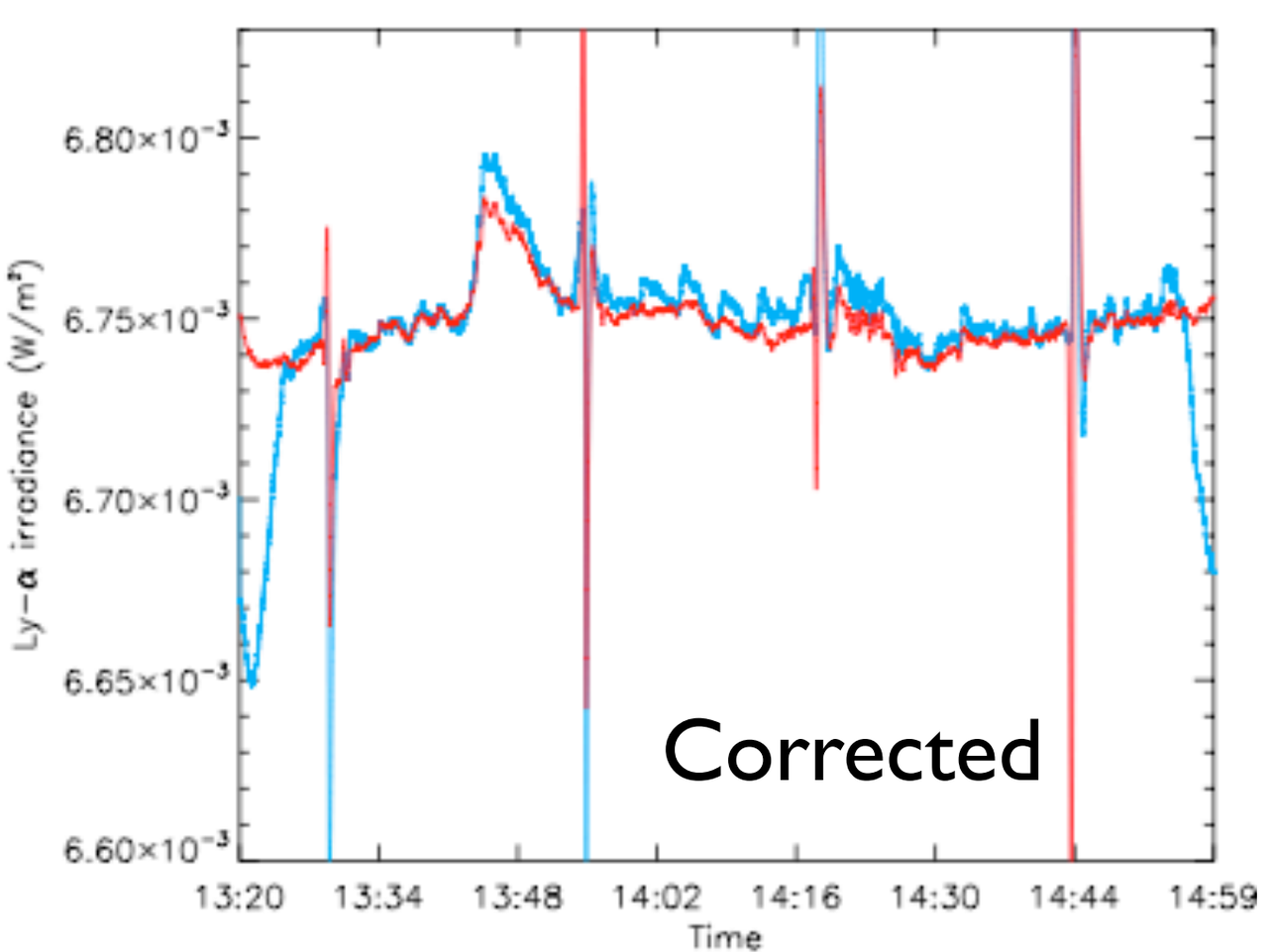
M2 flare on 10 Feb. 2010

- ✓ LYRA data needs additional processing for this event.
- ✓ Dark current ... x4 (!) or subtract average orbital variations.
- ✓ Correct degradation by a multiplicative factor
- ✓ Absolute calibration based on SORCE/SOLSTICE





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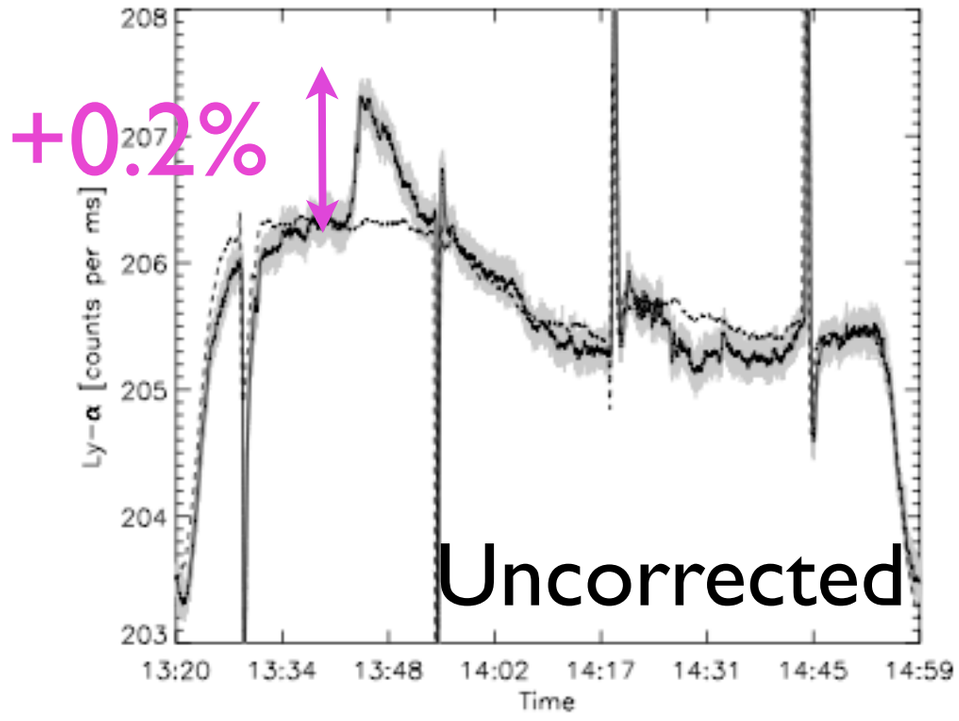
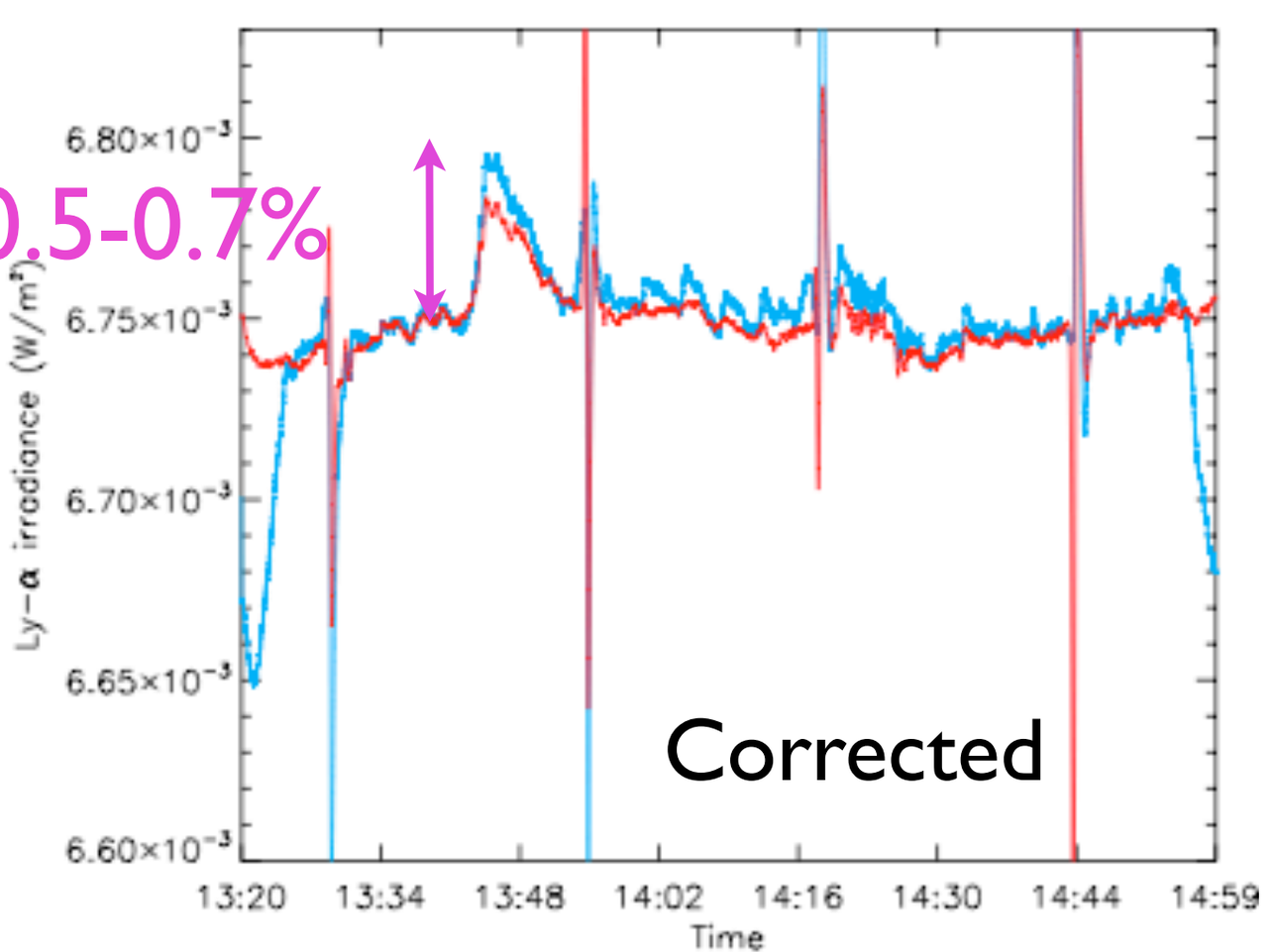
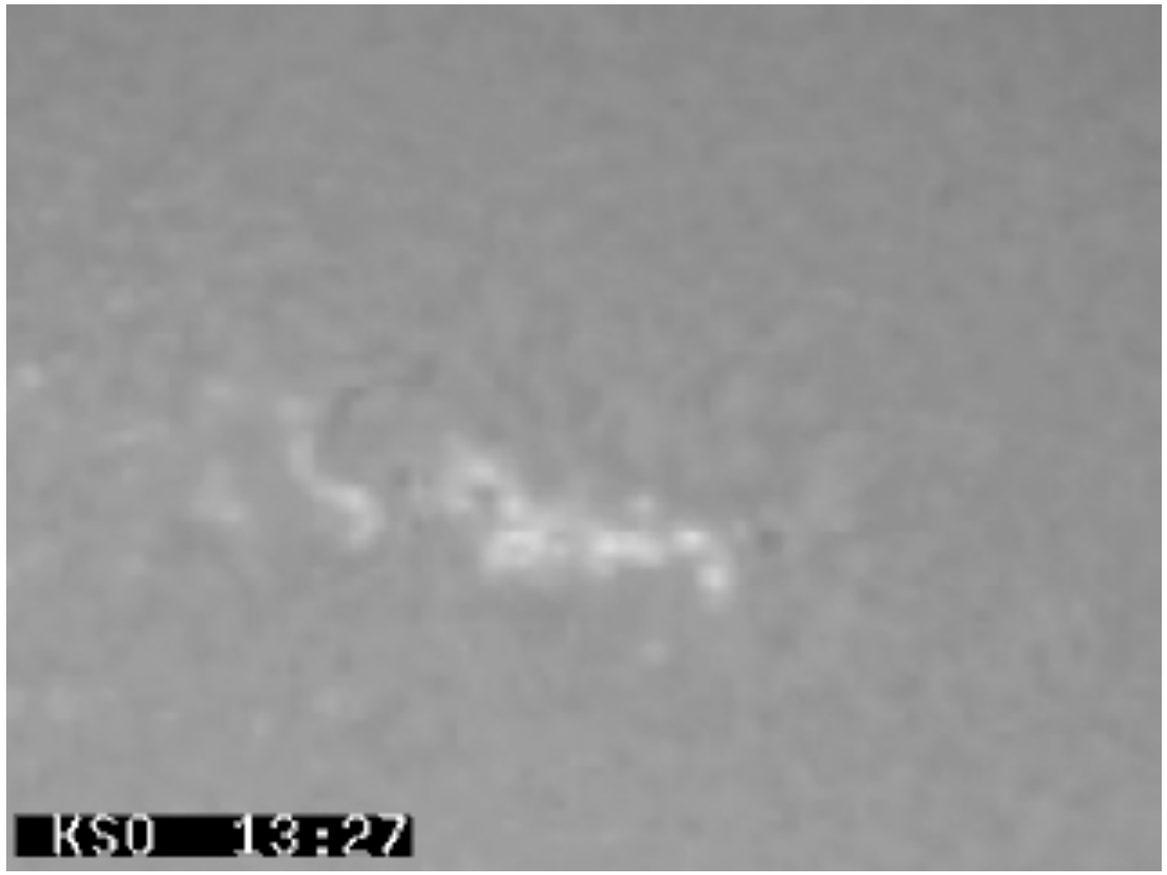
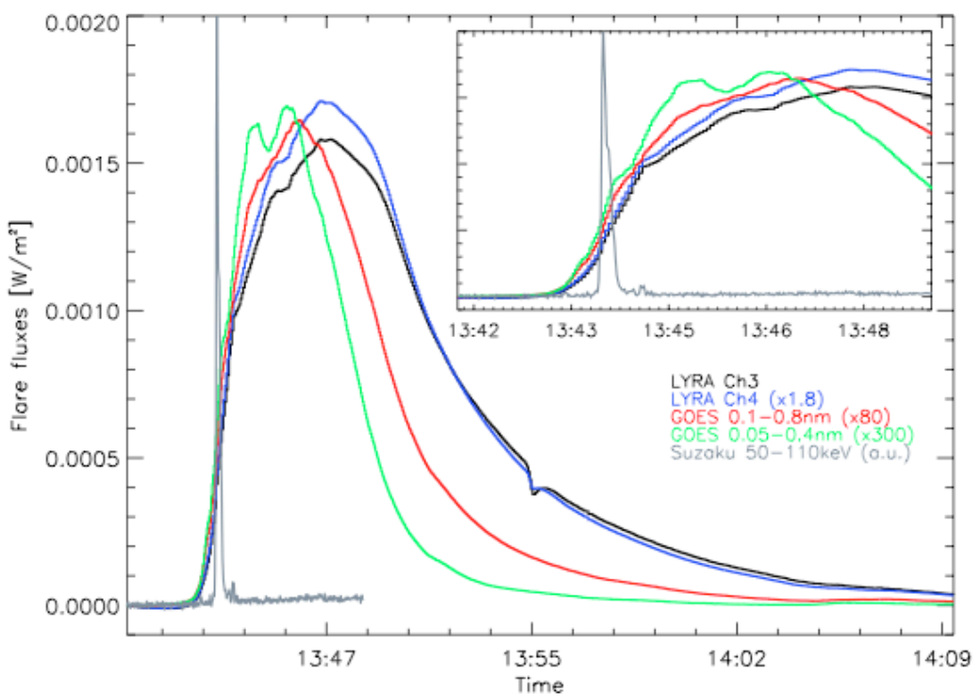


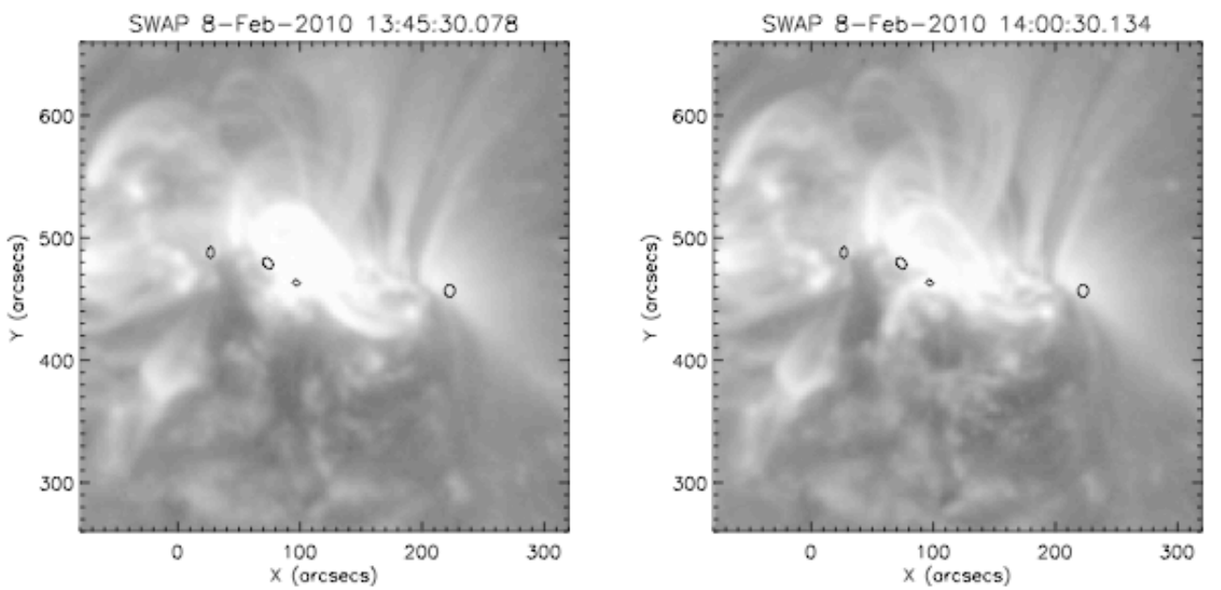


Context

- ✓ No modification of the AR in the photosphere/chromo/ corona
- ✓ Looks confined (very localised)- but a small type III radio burst occurred



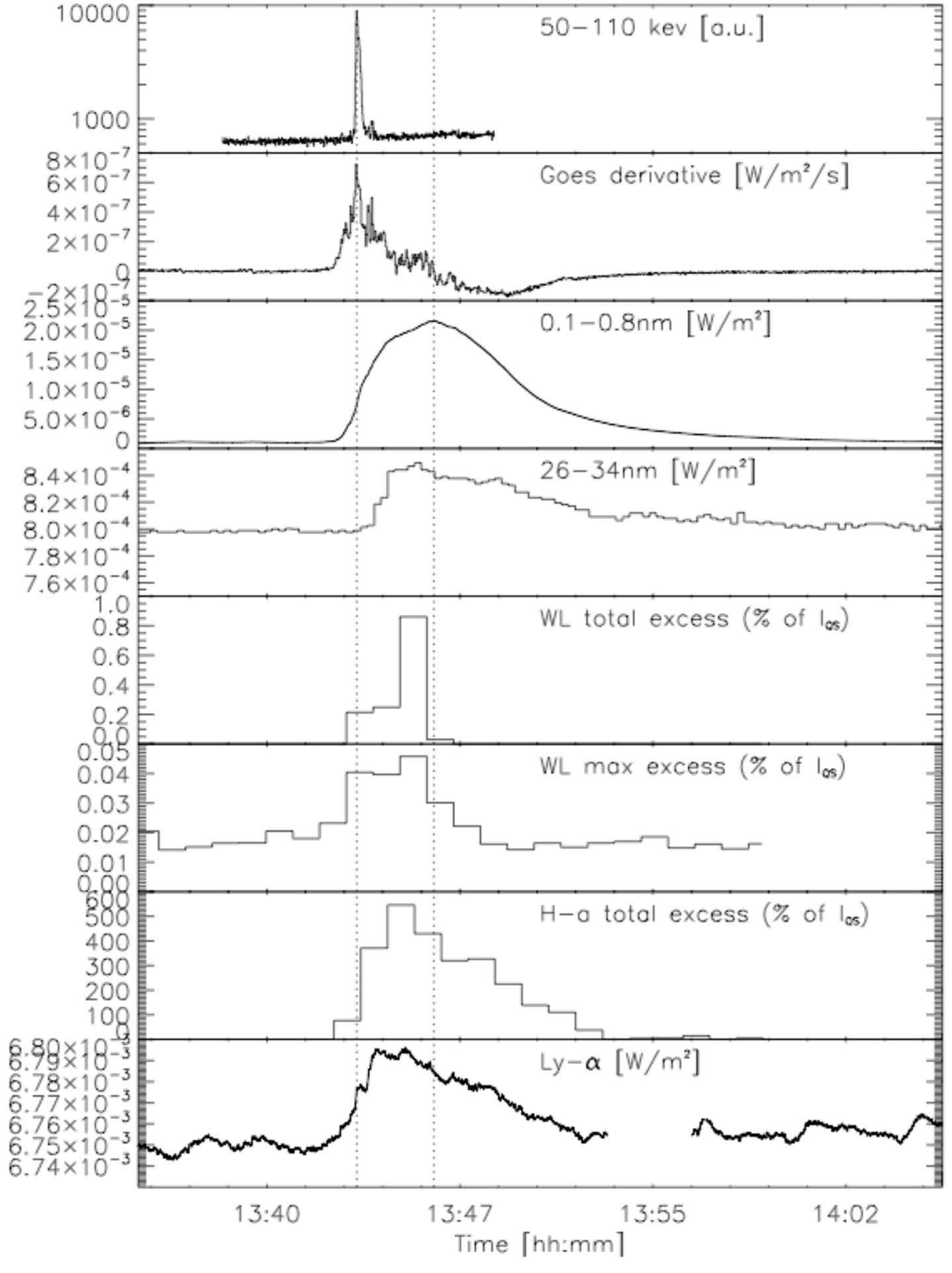




- ✓ Neupert effect holds.

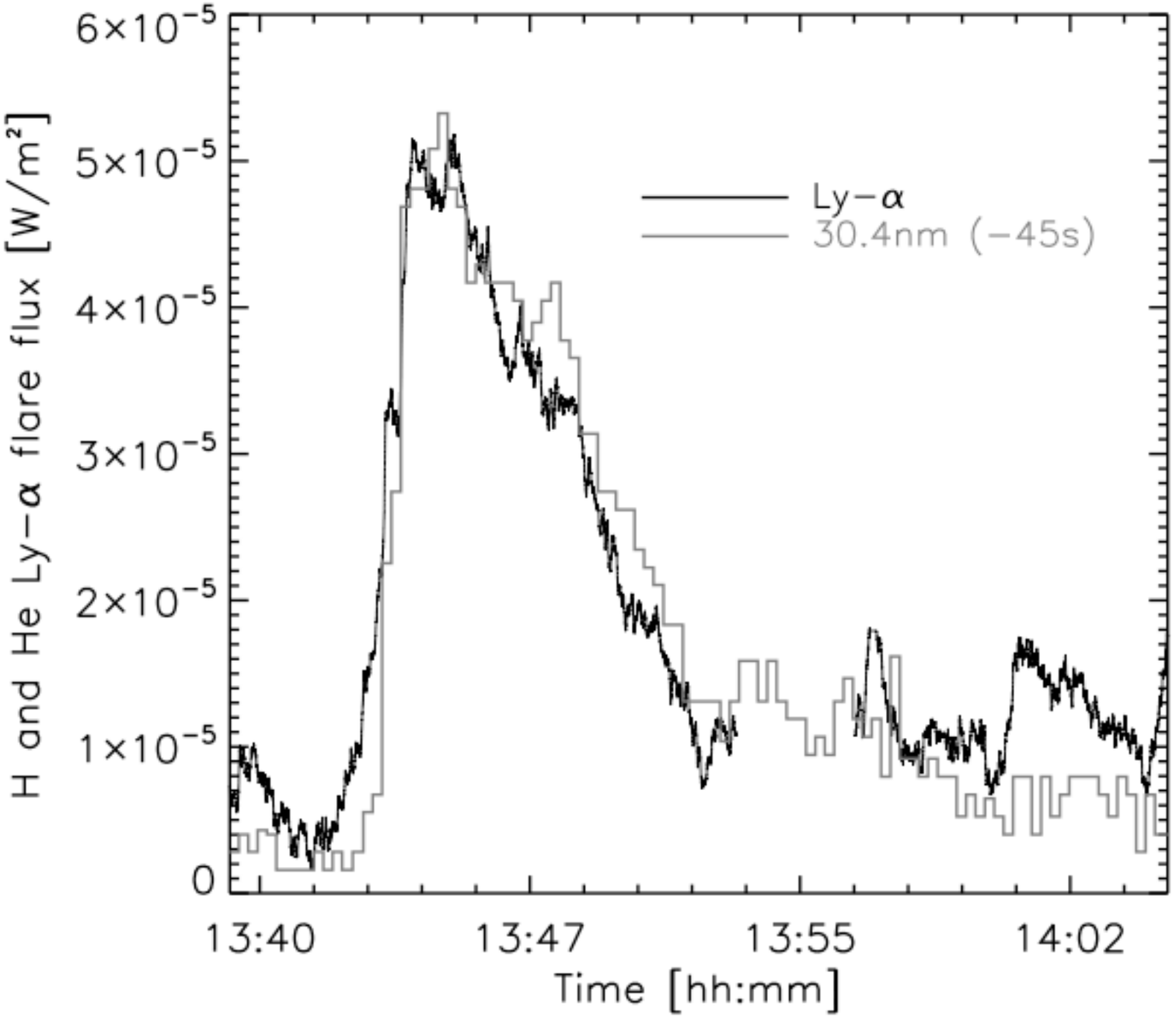
Overall flare evolution

- ✓ Very brief impulsive phase.
- ✓ Ly-α peaks before all other wavelengths..
- ✓ but mostly follows the gradual phase.
- ✓ Looks well correlated with H-α at the time resolution



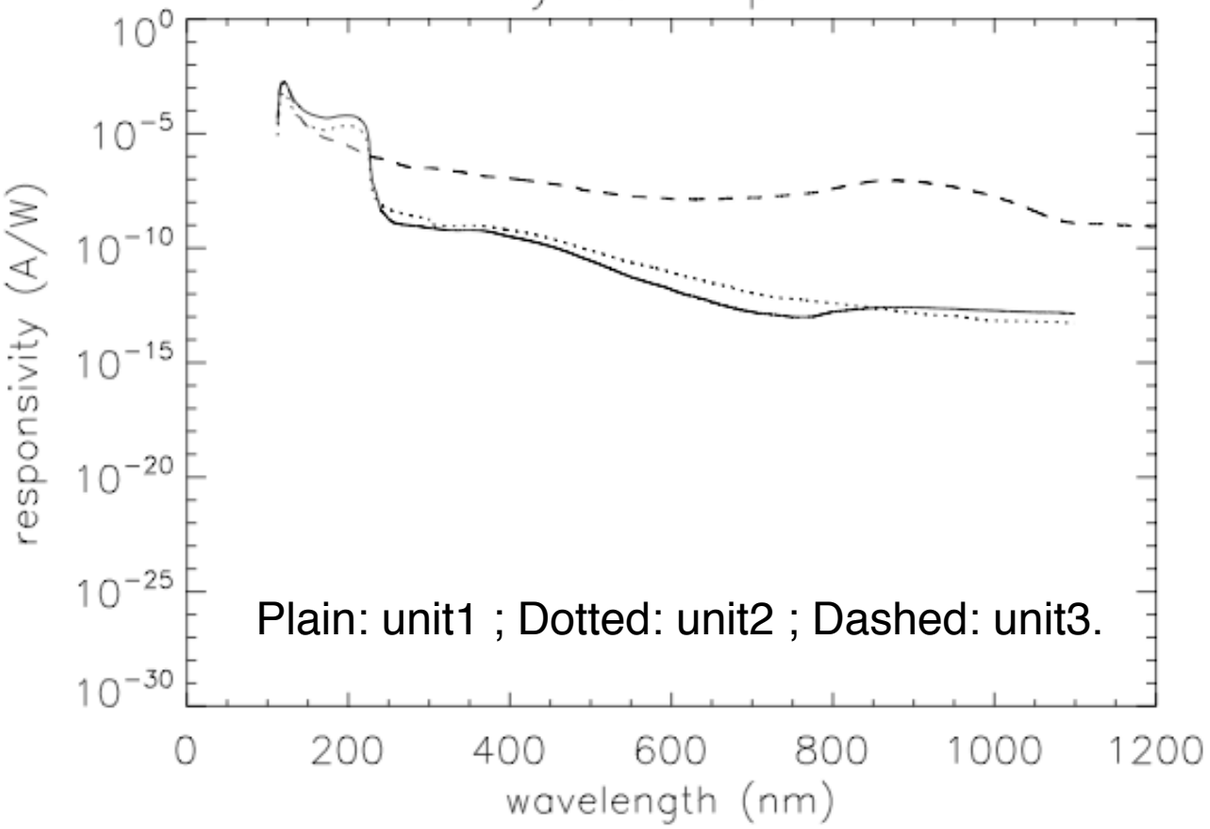
Chromospheric emission

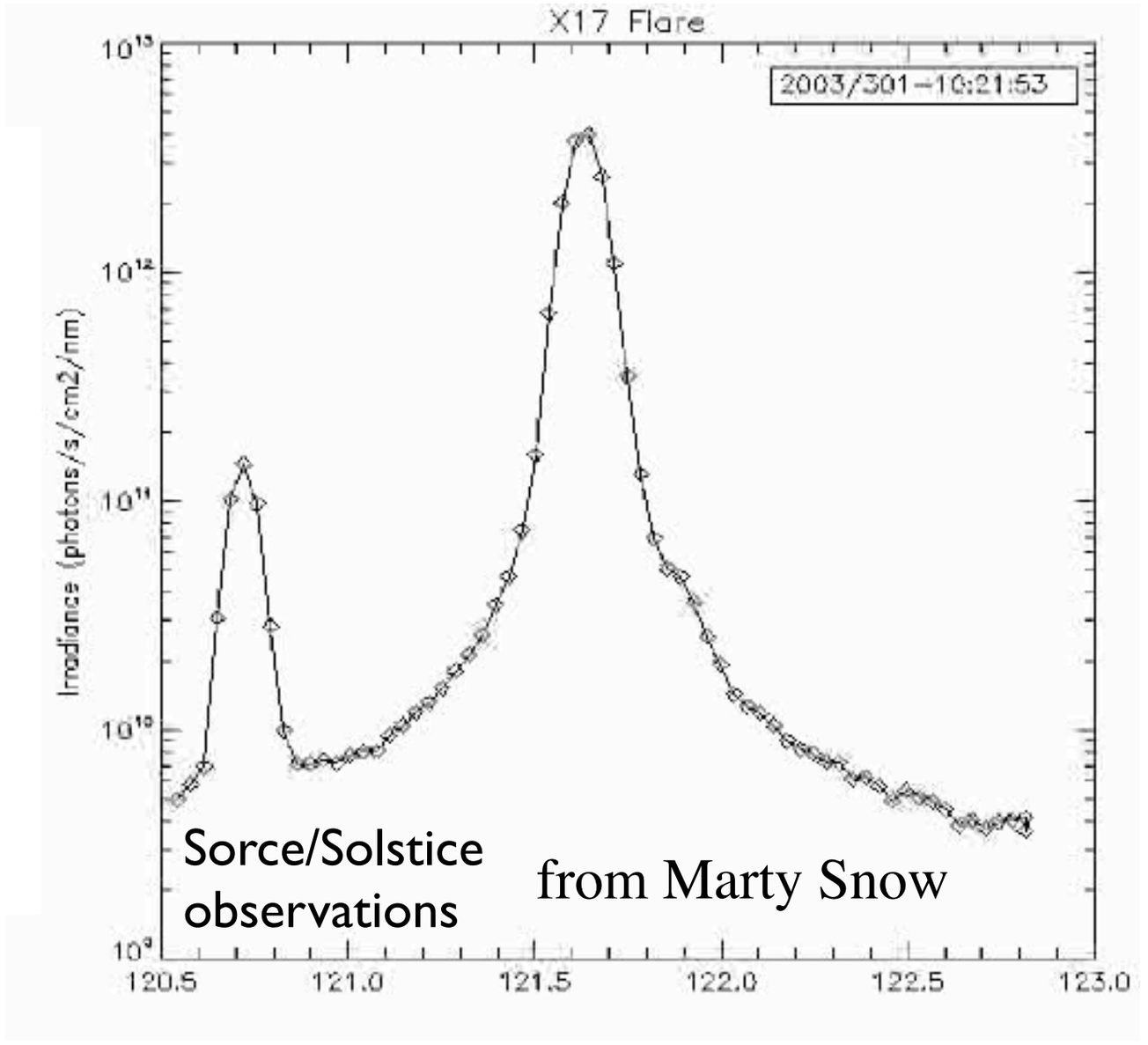
- ✓ Very good agreement between Ly-α and 30.4nm (if delayed by 45s)
- ✓ Ly-α has ~ twice the emission in GOES 0.1-0.8nm.
- ✓ Radiative loss between 7 10^{24} erg/s and 1.4 10^{25} erg/s
- ✓ as observed by LYRA..



SORCE/SOLSTICE

LYRA responsivity

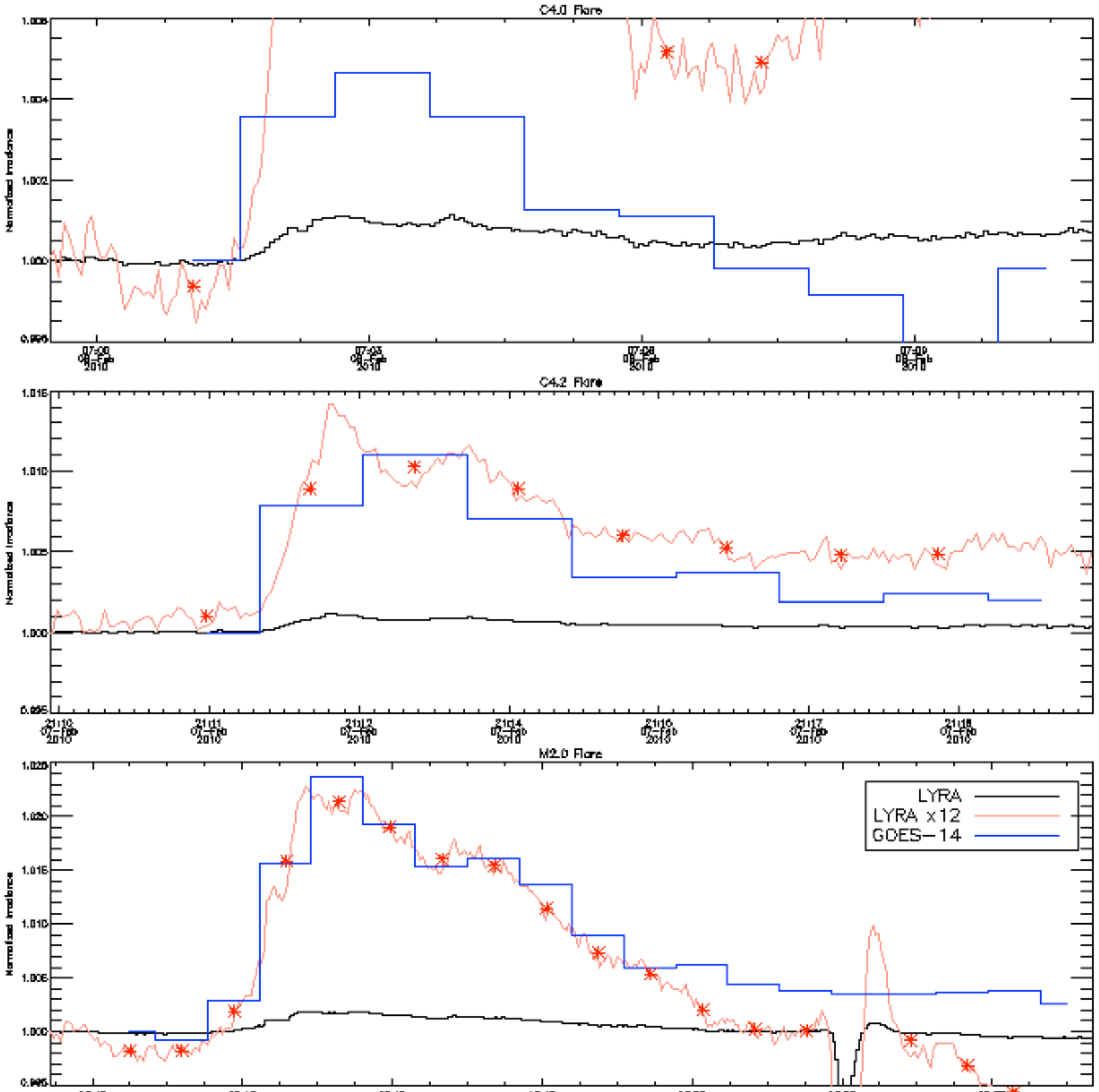




✓ How does the actual spectral range observed by LYRA influence the observed increase ?

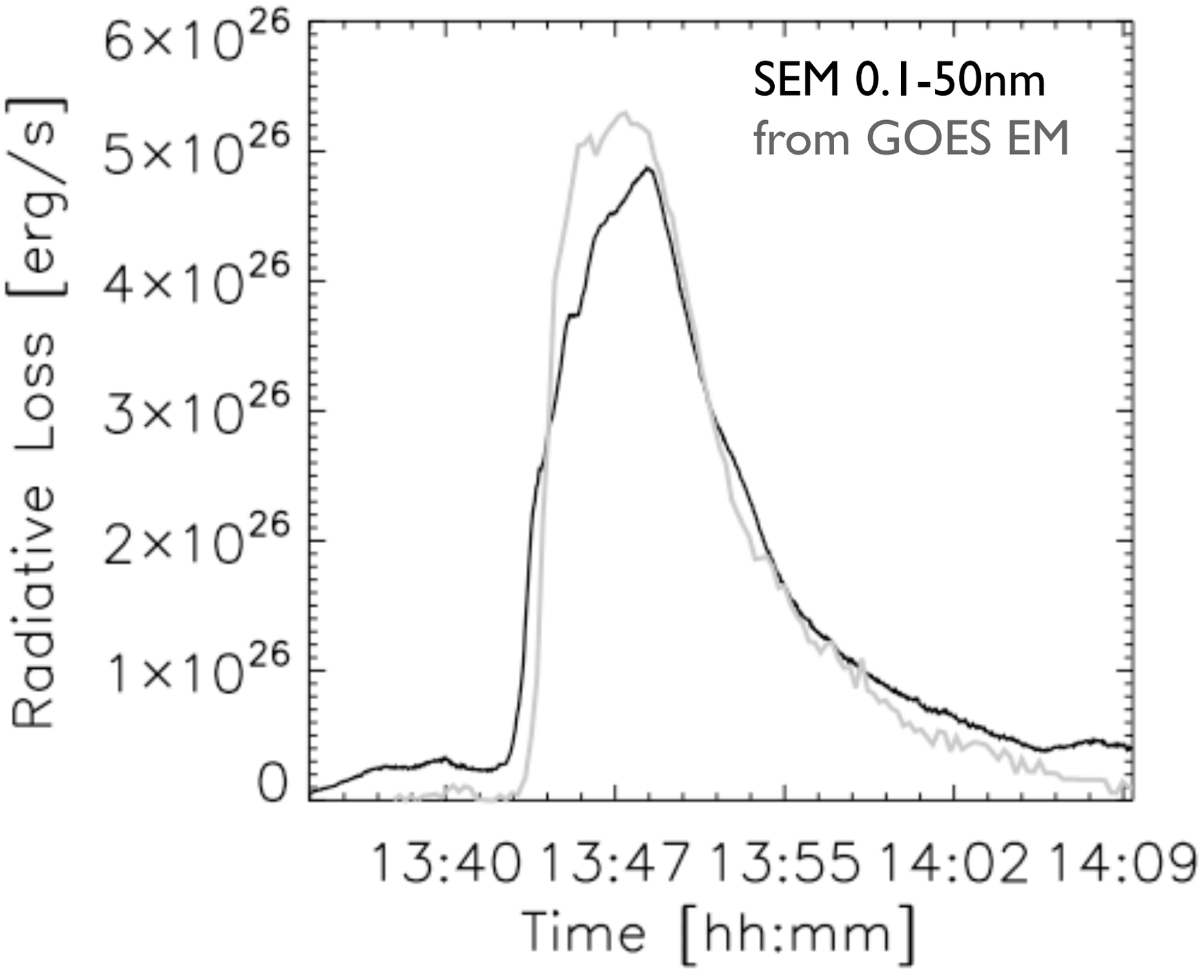
GOES/LYRA comparison

- ✓ from LYRA level2 data.
- ✓ Time profiles agree.
- ✓ but not the increase. LYRA underestimates it by a factor 10. (Radiative loss ~ 10^{26}erg/s)
- ✓ LYRA degradation that fast ?



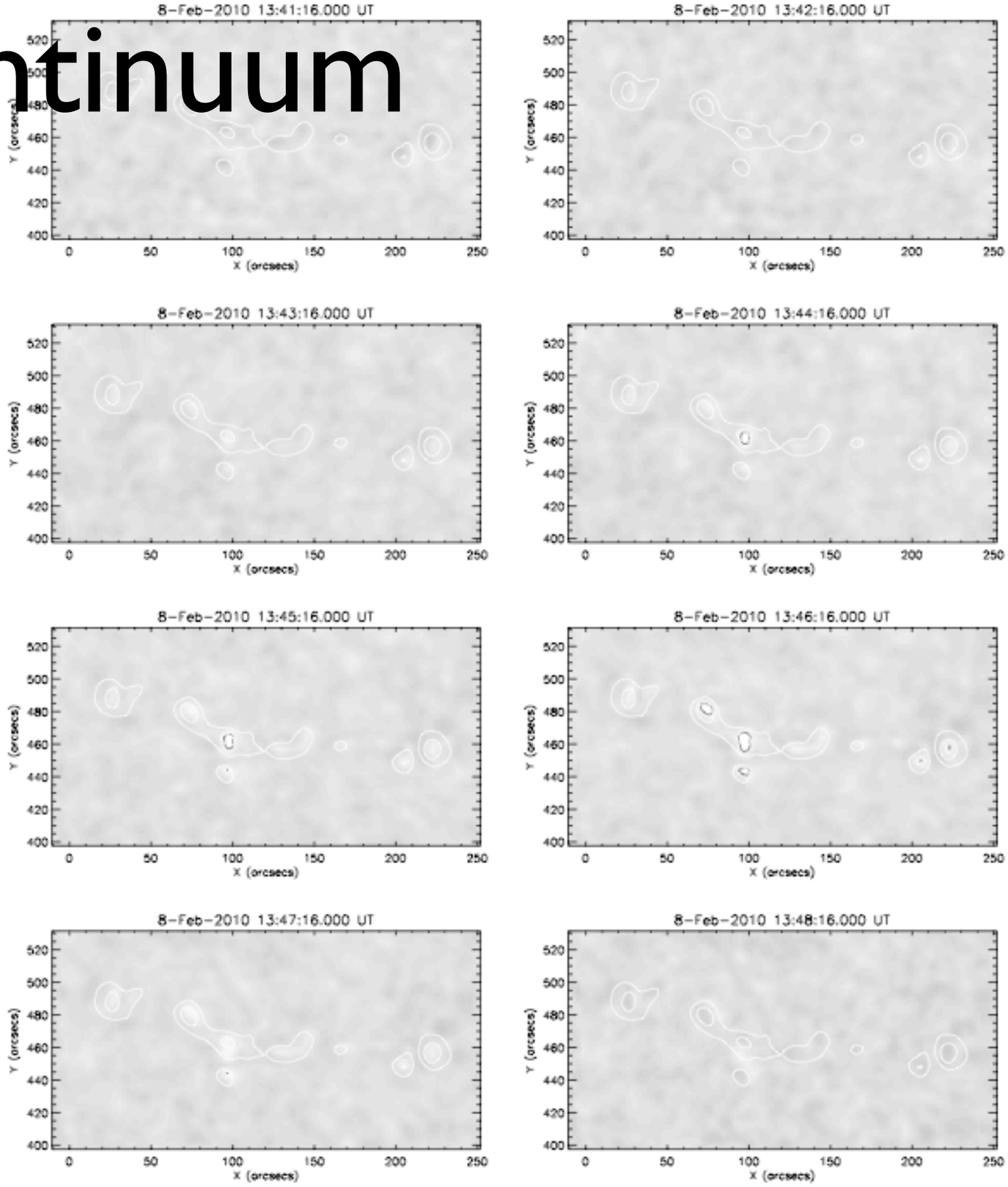
from Marty Snow

Coronal radiative loss



Visible continuum

- ✓ Visible continuum both in impulsive and gradual phase.
- ✓ Contour indicates 3% increase wrt to QS.
- ✓ Can account for a radiative loss of ~1.7 10^{28} erg/s



Conclusion for this event

- ✓ Although the flare looks confined, nothing particular was noted.
- ✓ Ly-α has ~ twice the emission in GOES 0.1-0.8nm and a radiative loss between 7 10^{24} erg/s and 1.4 10^{25} erg/s. LYRA probably underestimates the Ly-α flare flux due to its large pass-bands (a factor10 at most).
- ✓ The Ly-α emission alone is small wrt to the total energy release.
- ✓ The response to flares of the low D region of the ionosphere is not modified when flares have a Ly-α irradiance signature (Raulin, Trottet, Kretzschmar, et al., subm.)

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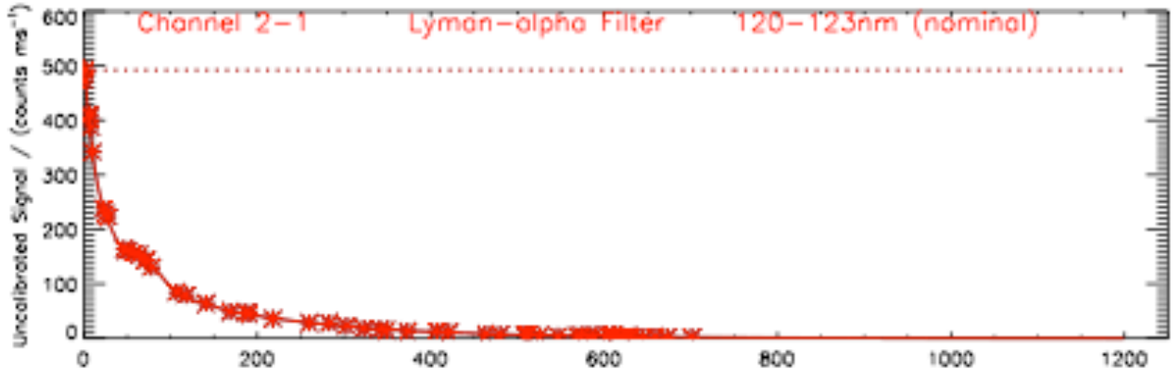
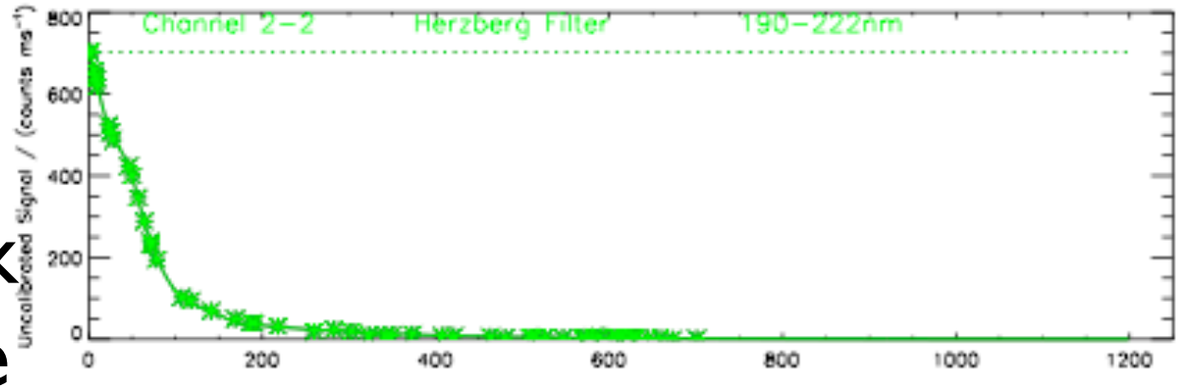
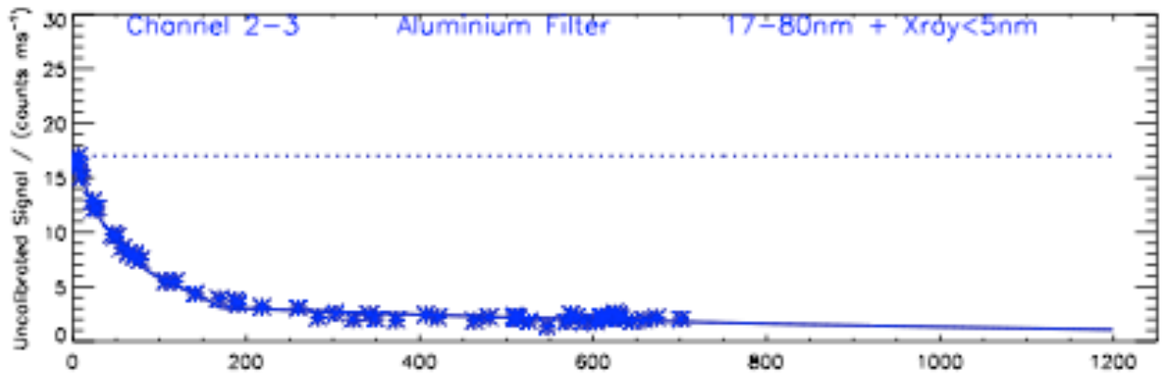
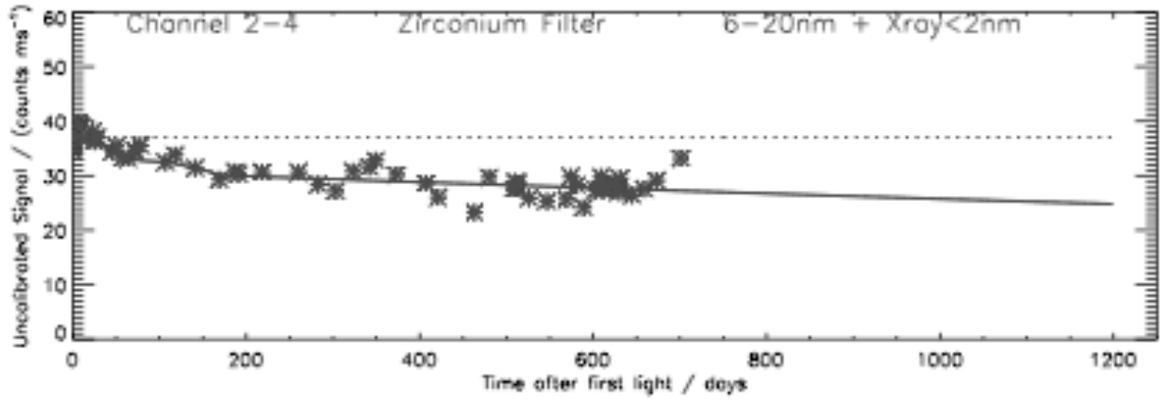
Degradation

- ✓ Huge degradation in the two first channels of the nominal unit.
- ✓ For the two other channels, back up units are used to monitor the degradation (see Ingolf's talk of yesterday).
- ✓ which is corrected by addition.



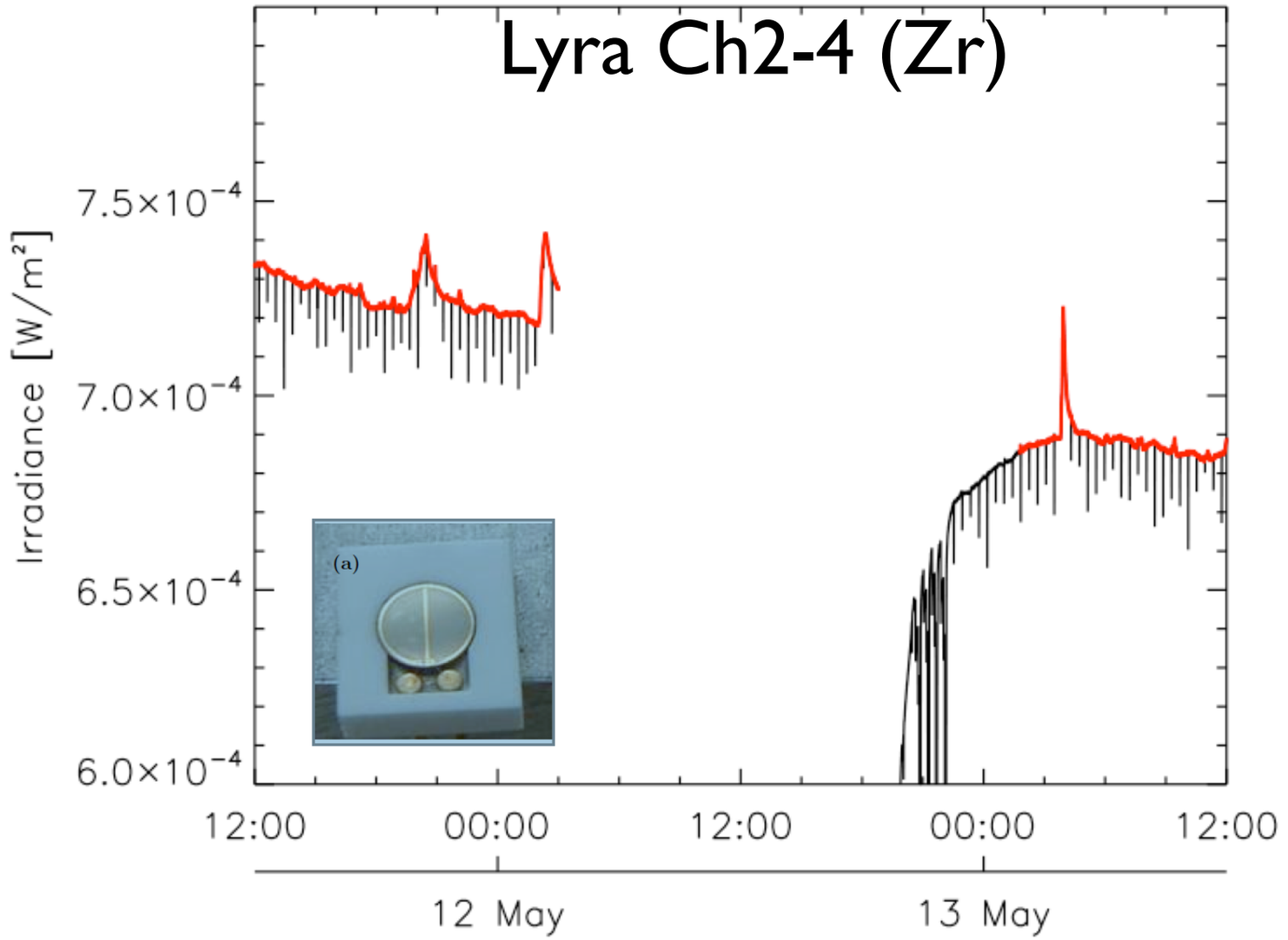


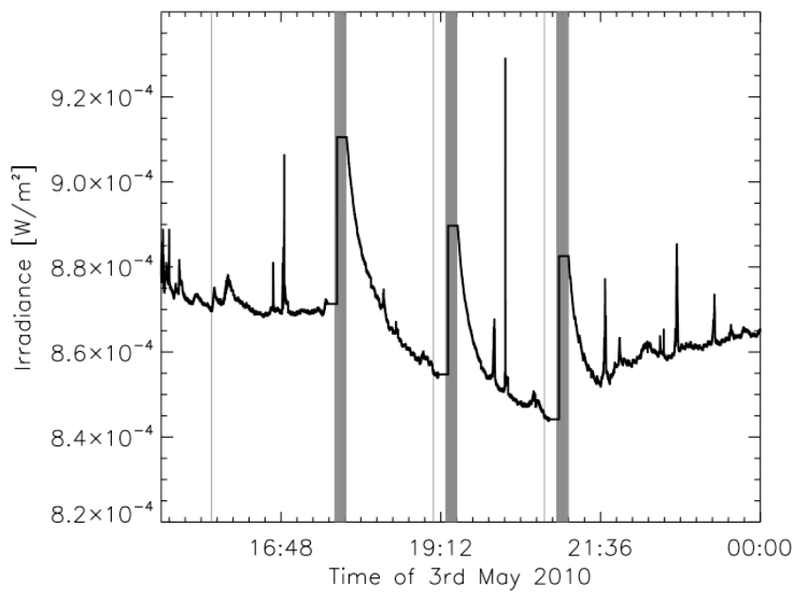




Other effects

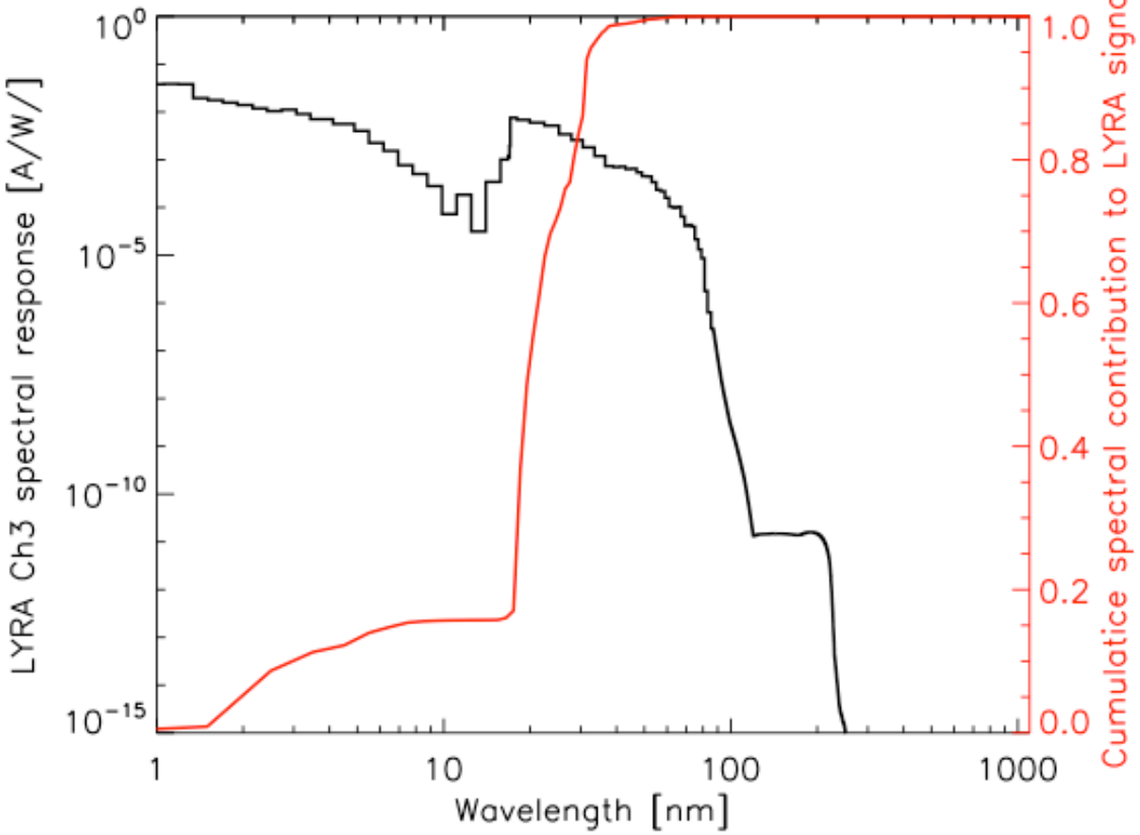
- ✓ Both LYRA and PROBA2 have innovative features that reflect themselves in the data.
- ✓ Diamond detectors + LARs
- ✓ Slow response time
- ✓ Reboots
- ✓ Eclipse and occultations
- ✓ Needed to compute daily average value.



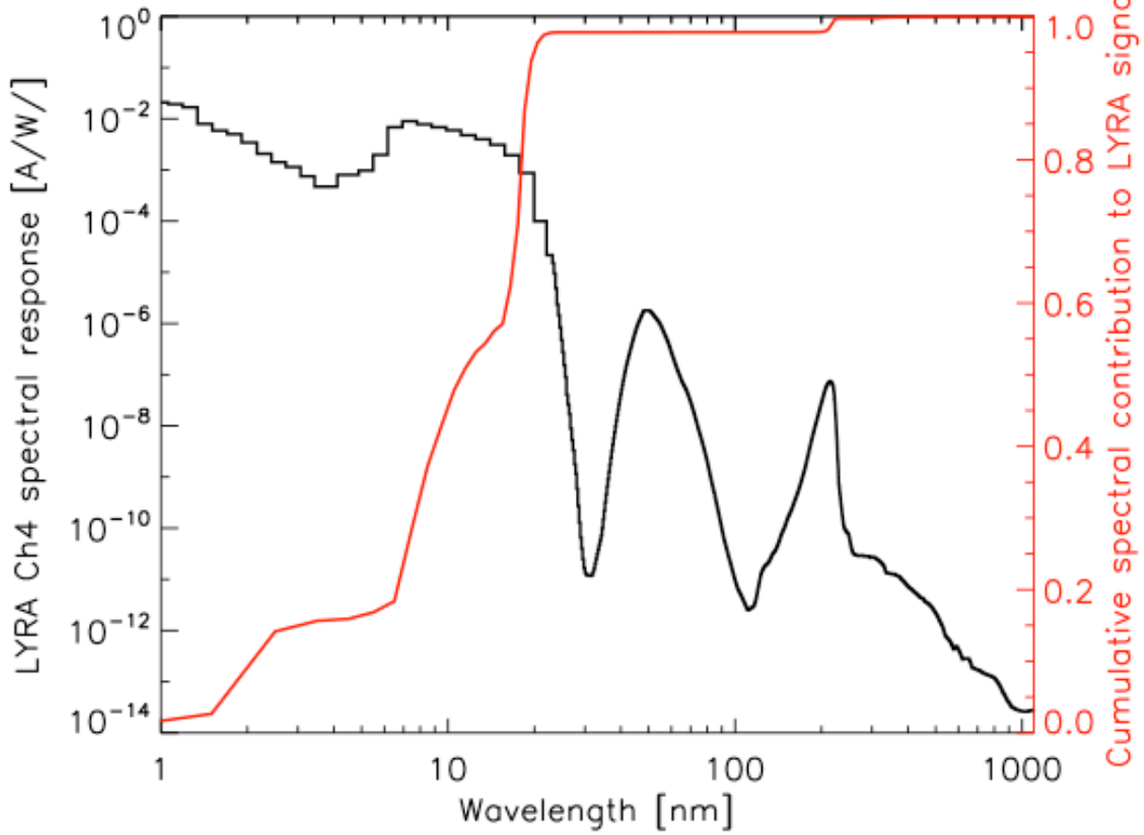


Spectral response

Ch2-3



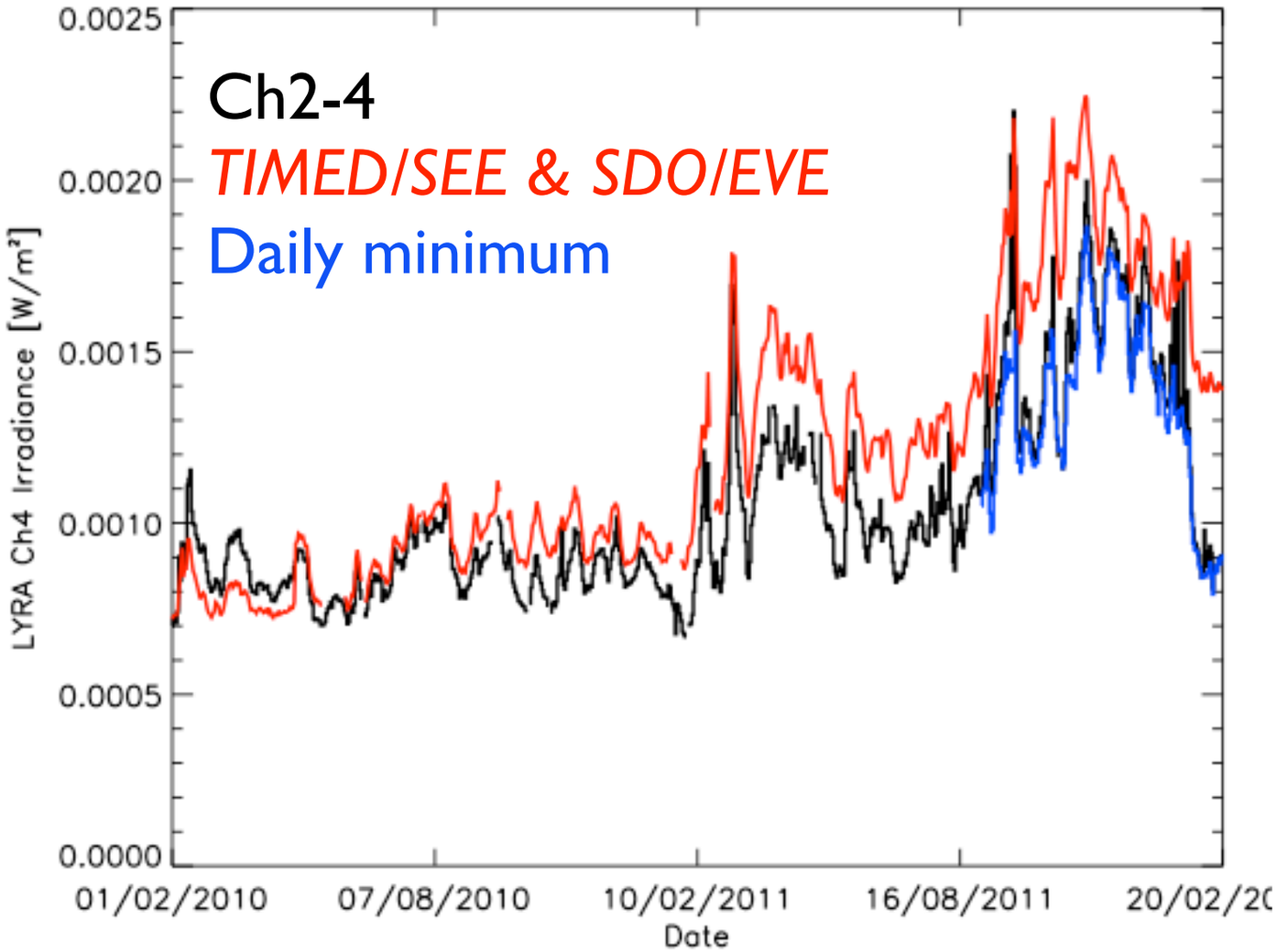
Ch2-4



- ✓ We will use TIMED/SEE and SDO/EVE data to simulate LYRA ch2-3 and ch2-4 and compare with our results

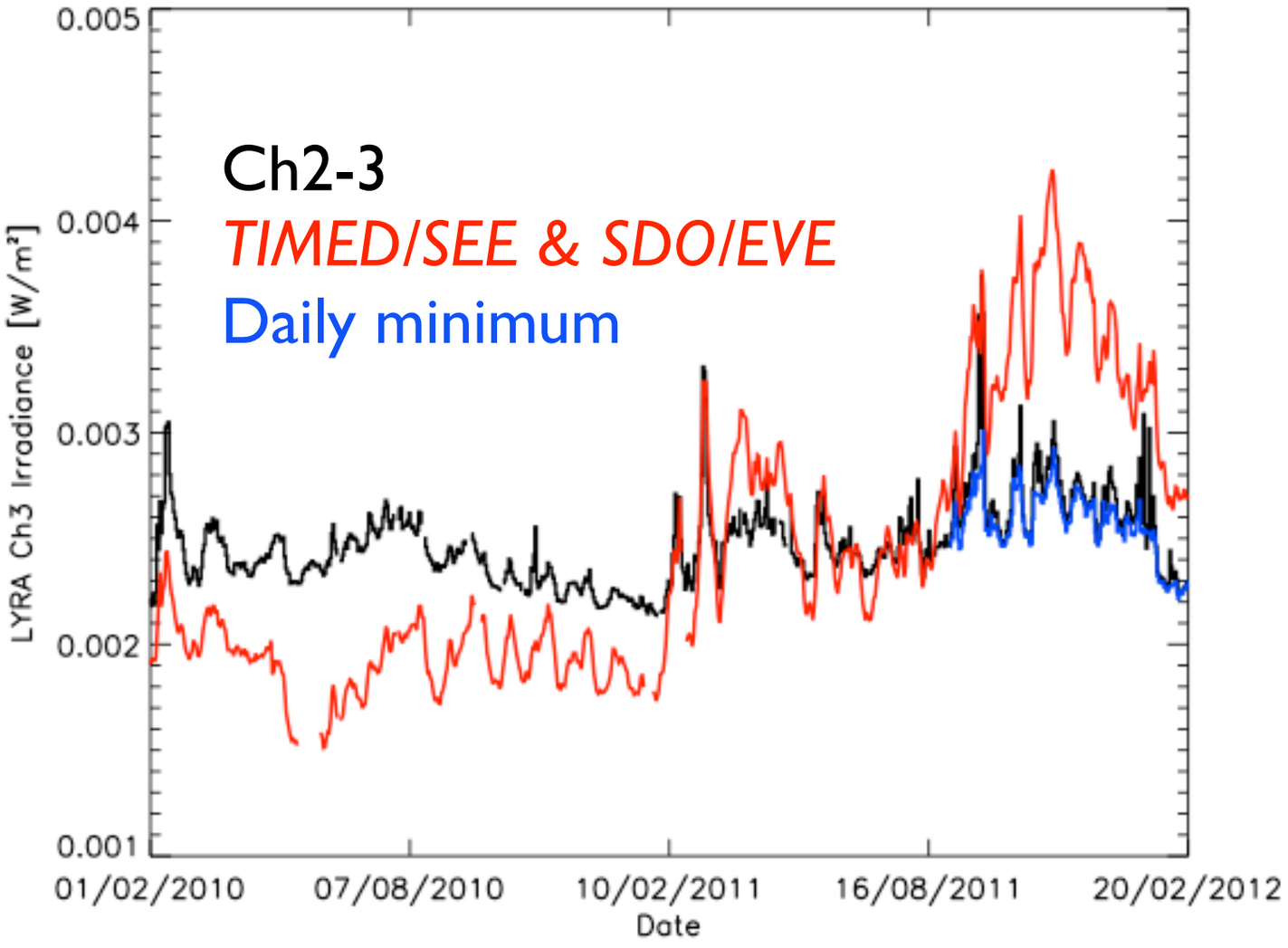
Ch2-4: long term

- ✓ Agrees with manual selection of daily value.
- ✓ Absolute value is good.
- ✓ slightly stronger trend with solar cycle for SDO/EVE
- ✓ but both degradation correction are version 2 only
- ✓ Up to now, increase by a factor of 2.

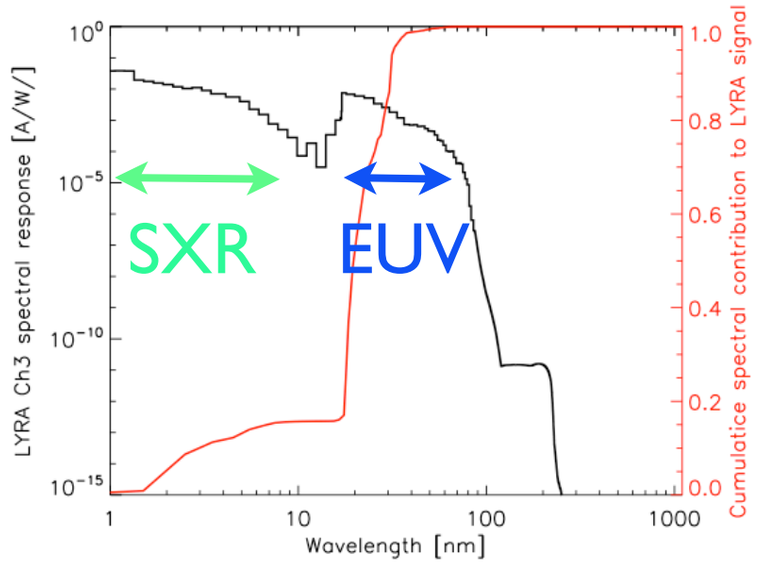


Ch2-3: long term

- ✓ Agrees with manual selection of daily value.
- ✓ Absolute value is ok.
- ✓ Much larger variations with solar activity for SDO/EVE.



- ✓ Use SDO/EVE to investigate the degradation of different spectral ranges.



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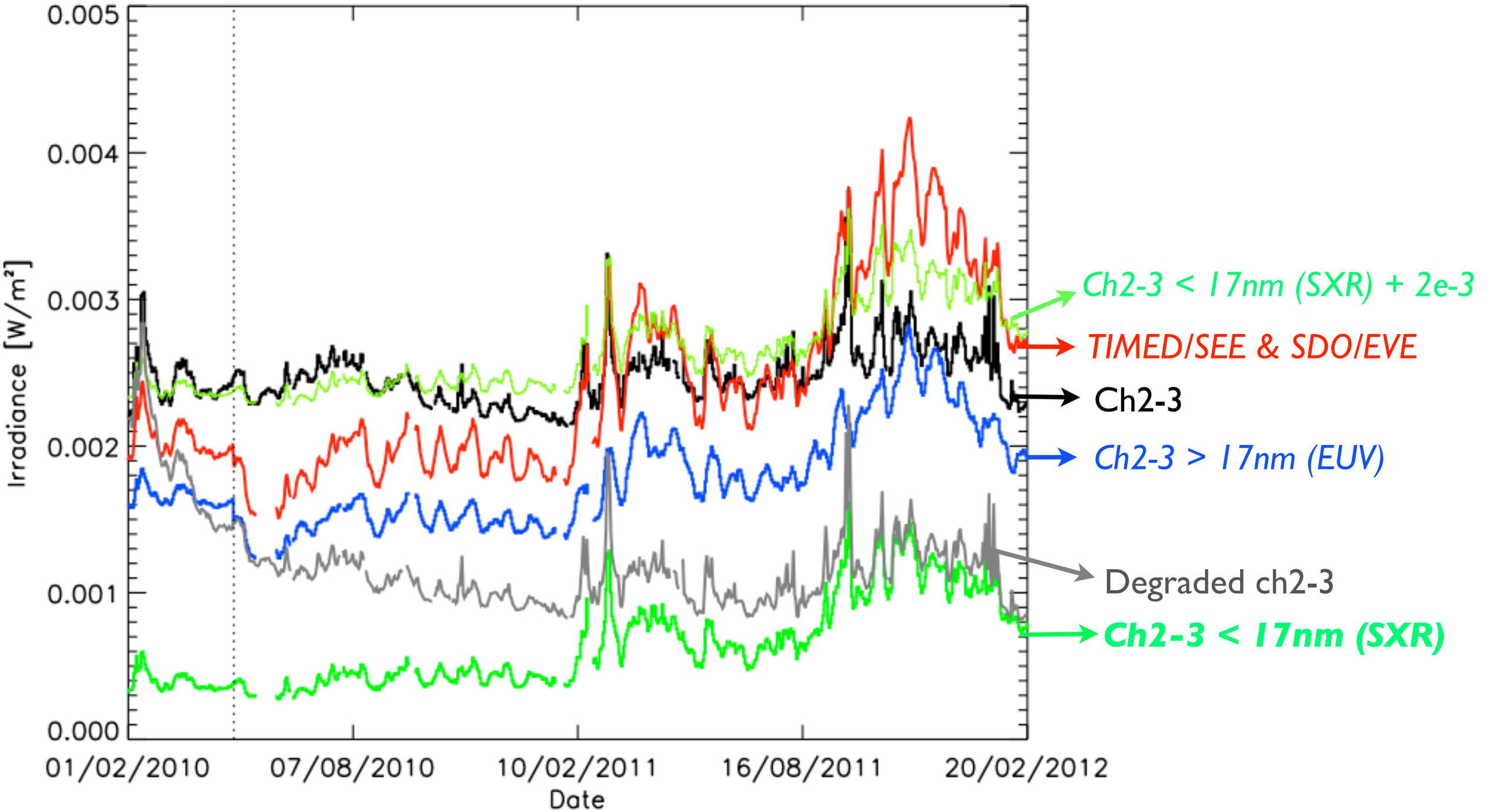
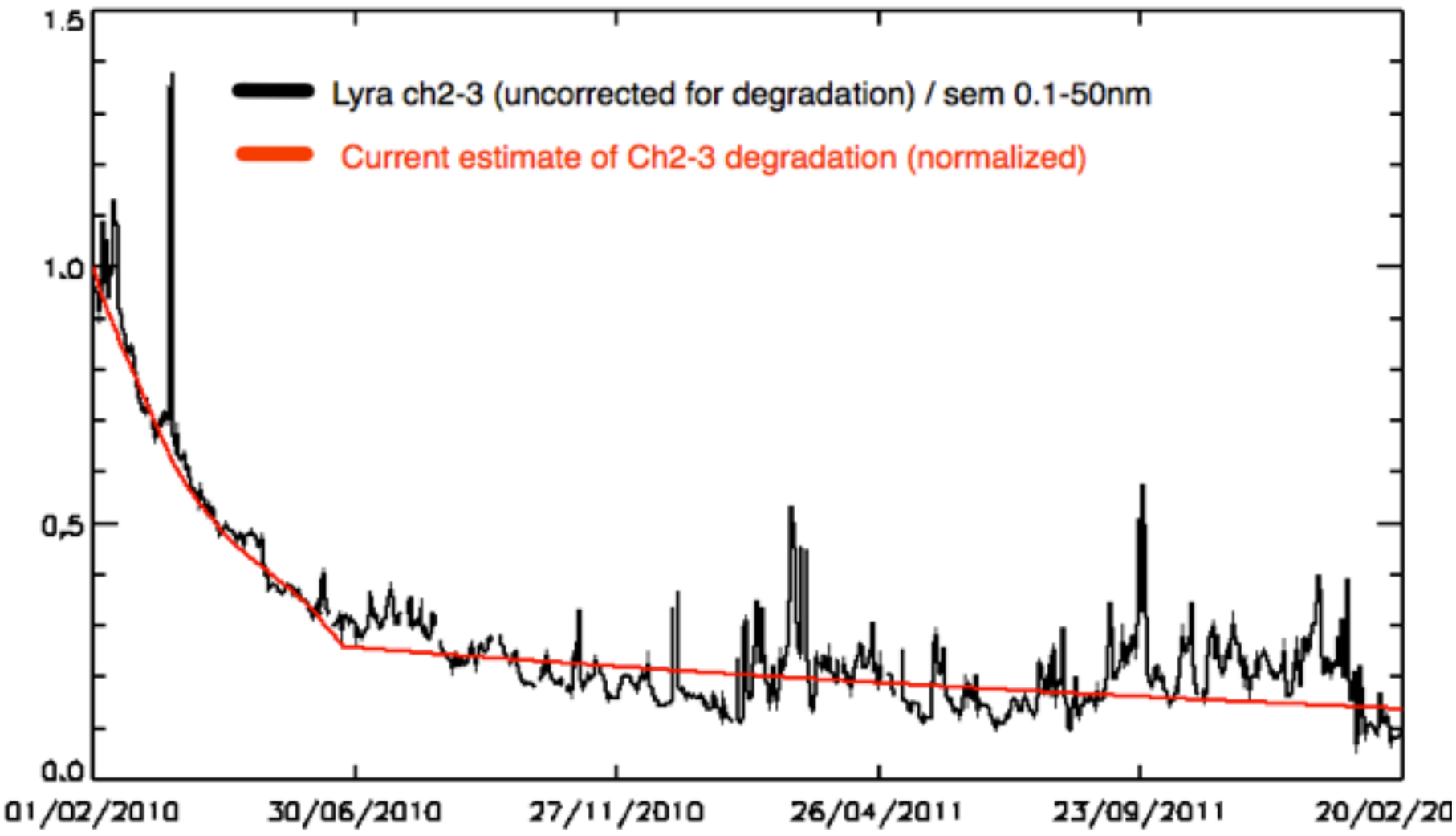


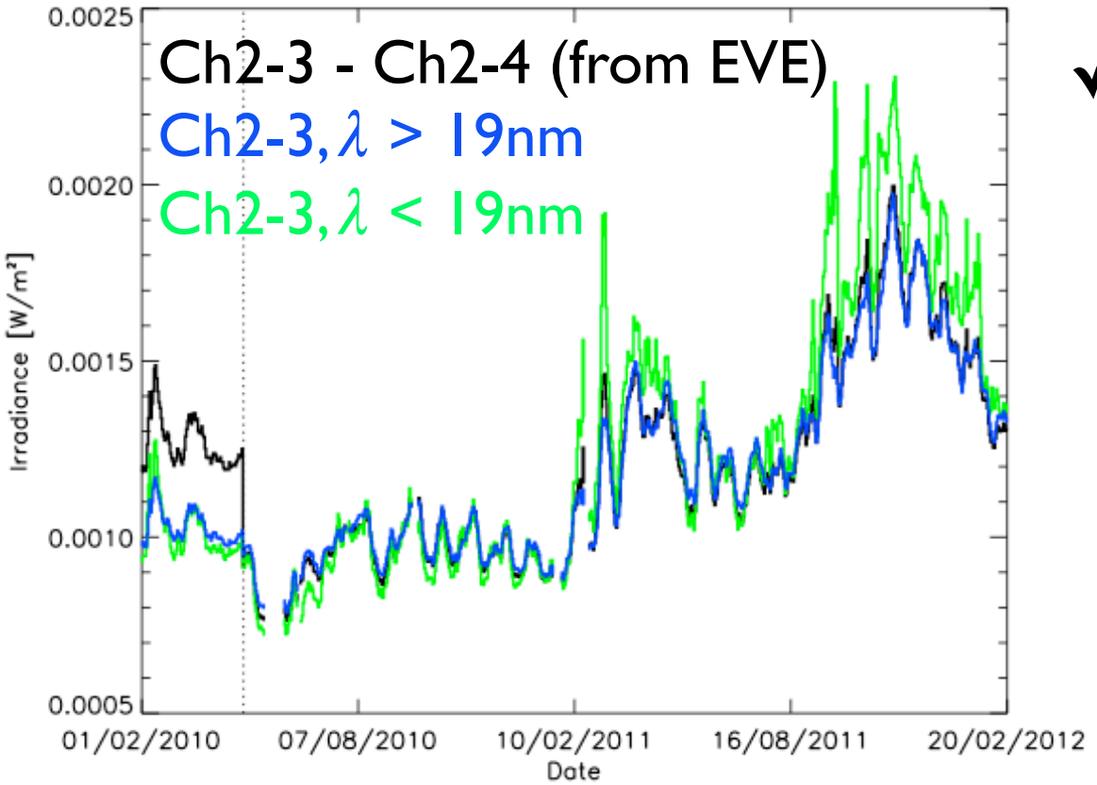
- ✓ EUV contribution to ch2-3 has strongly decreased.
- ✓ The additive correction for degradation corrects for absolute level but not for the variability.

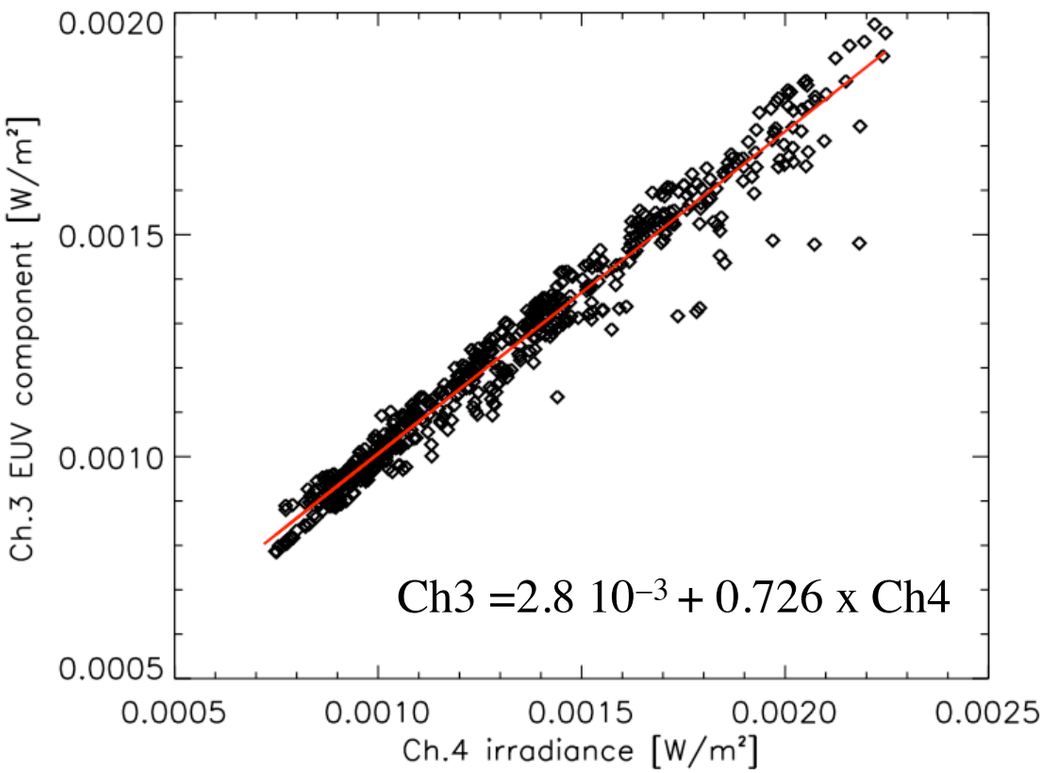
Confirmed by comparison with SEM.



✓ Can we retrieve the EUV component of ch2-3 with LYRA only ?

Modeling of the degradation of the EUV component of ch2-3





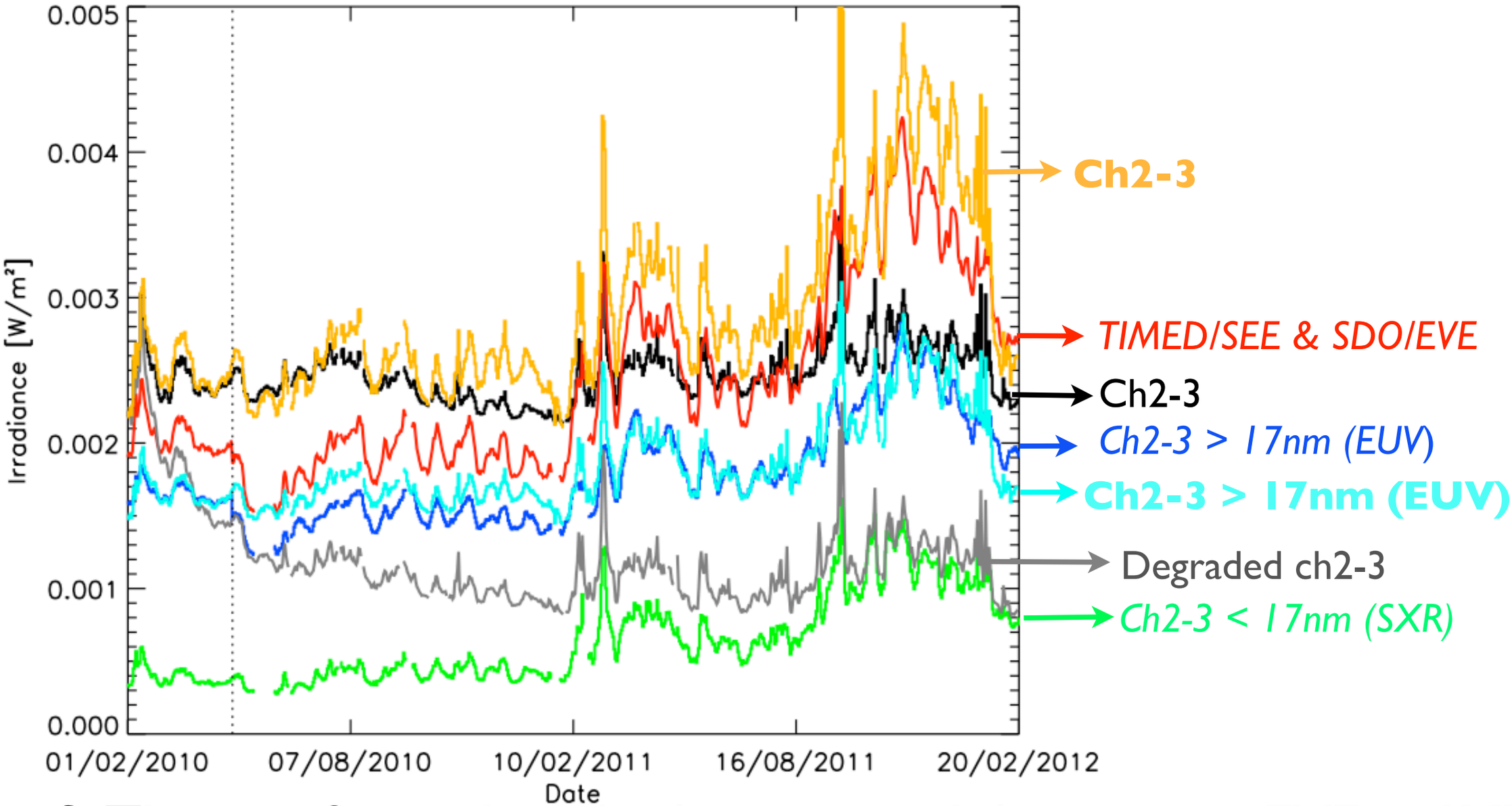
✓ The difference between channel3 and channel4 matches the EUV component of ch3

➡ The difference between the non corrected ch3 and the corrected ch4 leads to an estimate of the EUV component of the uncorrected ch2-3 signal.

✓ The simulated EUV component of ch3 is very well correlated with the simulated channel4

➡ Assuming ch2-4 is correctly corrected, we can estimate the undegraded EUV component of ch2-3 and retrieve the degradation curve from the ratio of the two.

Modeling of the EUV component of ch2-3



✓ This confirms that the lower variability wrt to EVE in LYRA ch2-3 is due to the loss of EUV sensitivity.

✓ This can be recover (as far as the SNR is sufficient..) by using a multiplicative correction for degradation

Conclusion

- ✓ We have built daily average time series for LYRA ch2-3 and ch2-4 (validated).
- ✓ Long term trend of ch2-4 agrees with SDO/EVE (within uncertainty).
- ✓ The EUV contribution to ch2-3 has almost disappeared... It can be retrieved (at least for the begining of the mission) using a combination of ch2-3 and ch2-4.
- ✓ EUV irradiance has increased by a factor ~2 up to now.

Thank you and bon appétit !