LYRA

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

Flares observed by LYRA on PROBA2

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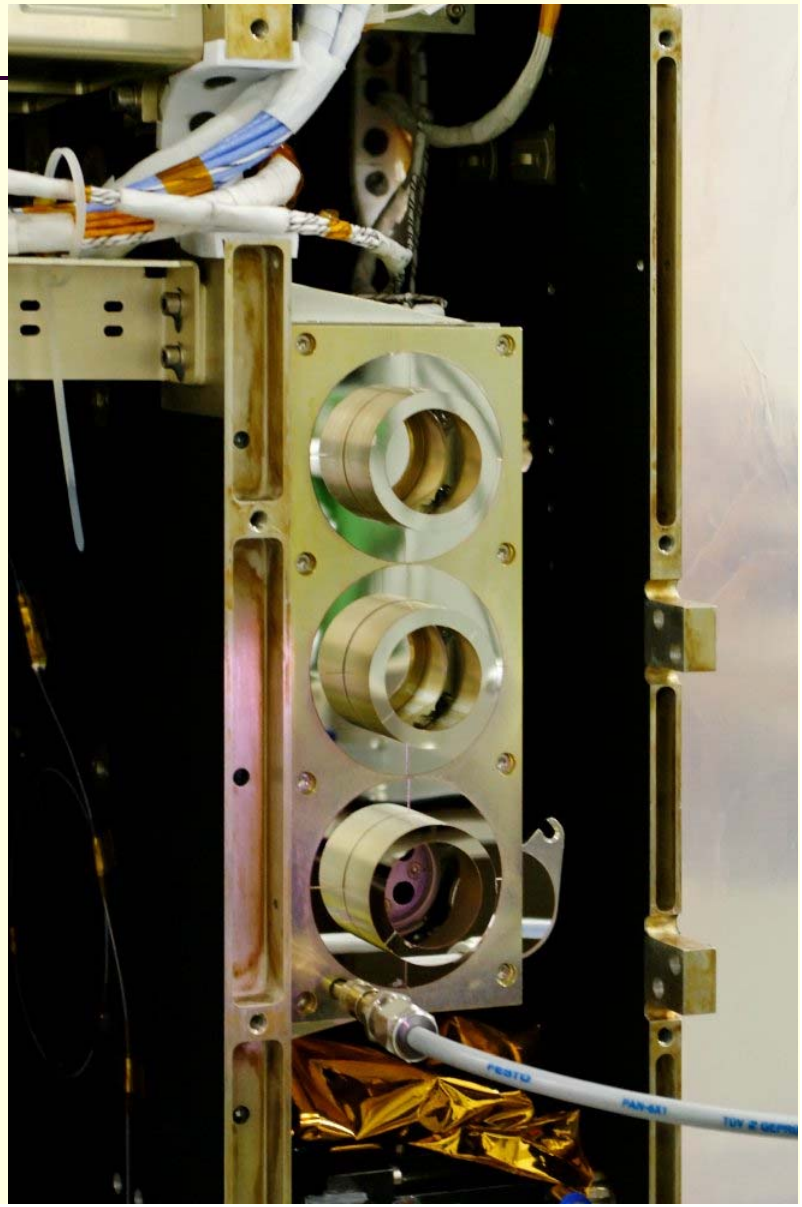
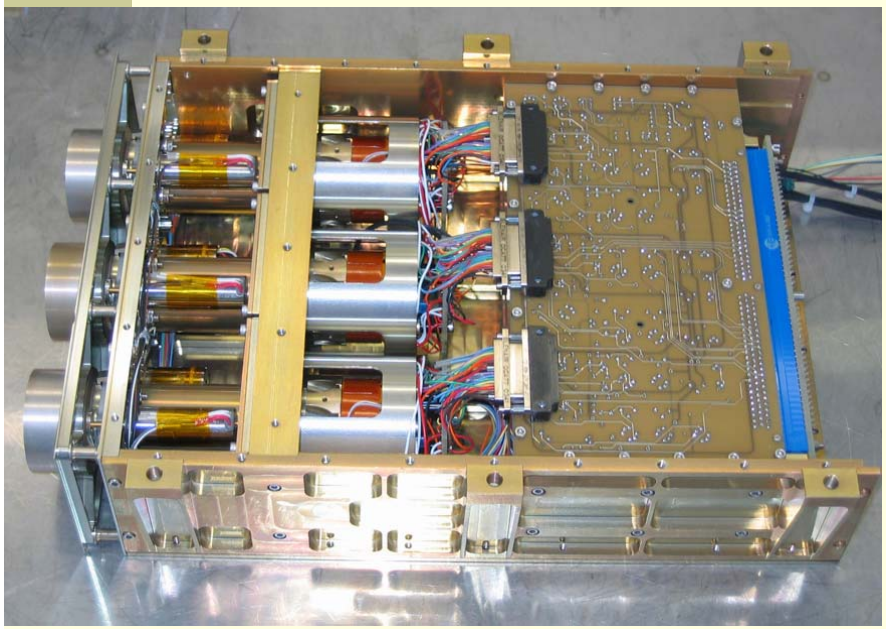
Solar and Heliospheric Influences on the Geospace
Bucharest, Romania, 01-05 October 2012

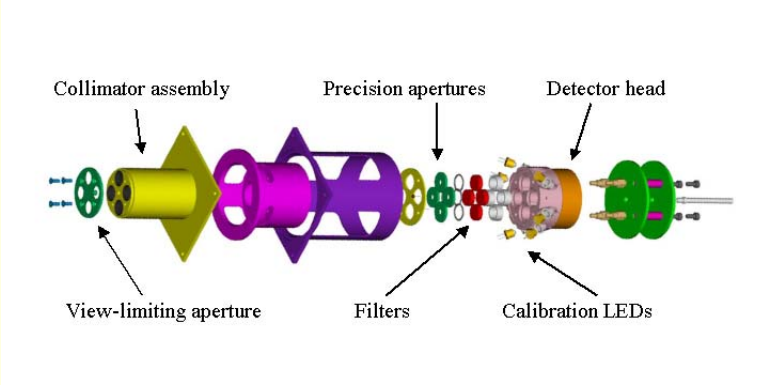
LYRA: the Large-Yield RAdiometer

- 3 instrument units (redundancy)
- 4 spectral channels per head
- 3 types of detectors,
  Silicon + 2 types of
  diamond detectors (MSM, PIN):
  - radiation resistant
  - insensitive to visible light
    compared to Si detectors
- High cadence up to 100 Hz



LYRA highlights





- Royal Observatory of Belgium (Brussels, B)
  Principal Investigator, overall design, onboard software specification, science operations
- PMOD/WRC (Davos, CH)
  Lead Co-Investigator, overall design and manufacturing
- Centre Spatial de Liège (B)
  Lead institute, project management, filters
- IMOMEC (Hasselt, B)
  Diamond detectors
- Max-Planck-Institut für Sonnensystemforschung (Lindau, D)
  calibration
- science Co-Is: BISA (Brussels, B), LPC2E (Orléans, F)…

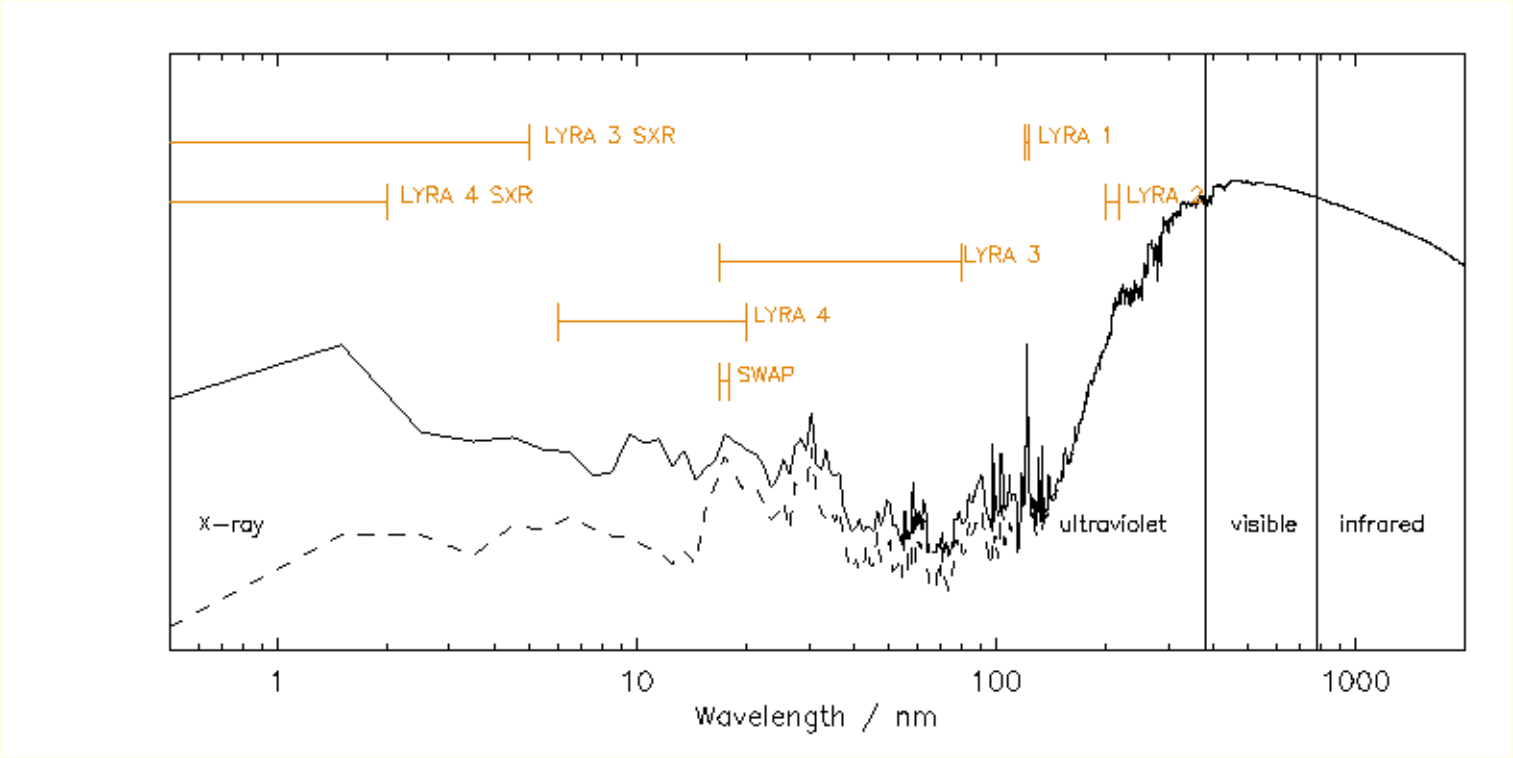
LYRA highlights

- 4 spectral channels covering a wide emission temperature range
- Redundancy (3 units) gathering three types of detectors
  - Rad-hard, solar-blind diamond UV sensors (PIN and MSM)
  - AXUV Si photodiodes

	Ly	Hz	Al	Zr
Unit1	MSM	PIN	MSM	Si
Unit2	MSM	PIN	MSM	MSM
Unit3	Si	PIN	Si	Si

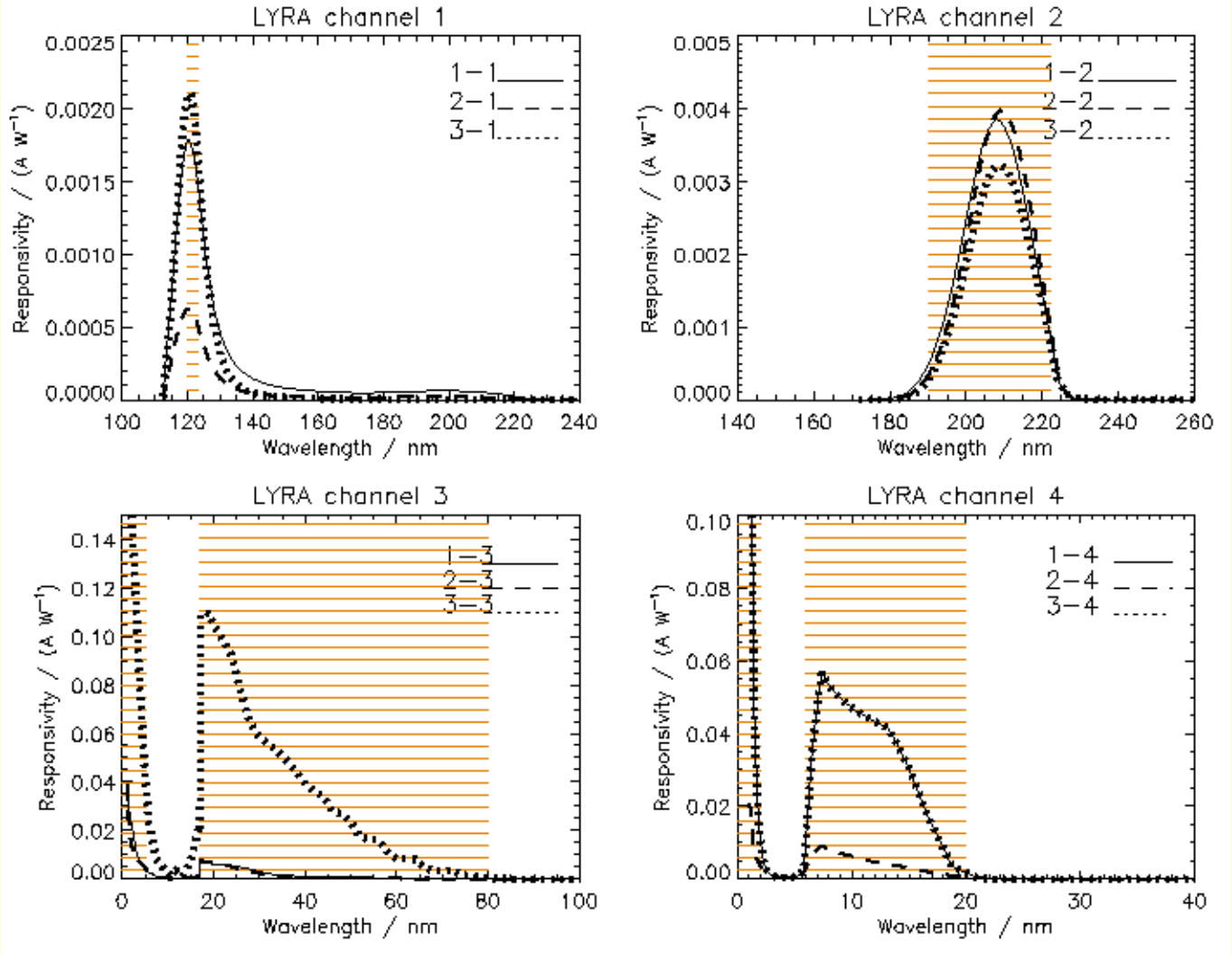
- 2 calibration LEDs per detector (λ = 465 nm and 390 nm)
- High cadence (up to 100Hz)
- Quasi-continuous acquisition during mission lifetime

SWAP and LYRA spectral intervals for solar flares, space weather, and aeronomy



LYRA channel 1: the H I 121.6 nm Lyman-alpha line (120-123 nm)
LYRA channel 2: the 200-220 nm Herzberg continuum range (now 190-222 nm)
LYRA channel 3: the 17-80 nm Aluminium filter range incl the He II 30.4 nm line (+ <5nm X-ray)
LYRA channel 4: the 6-20 nm Zirconium filter range with highest solar variablility (+ <2nm X-ray)
SWAP: the range around 17.4 nm including coronal lines like Fe IX and Fe X

LYRA spectral response



LYRA data products and manuals…

…available at the PROBA2 Science Center:

http://proba2.sidc.be/

Summary: FITS File Structure

- lyra_20100609_000000_lev1_***.fits
- where: *** = met, std, cal, rej, (bst, bca, bre)
- generally: header + binary extension table(s)
- extension = header + data (variable length)
- Lev1 met = HK, STATUS, VFC
- Lev1 std = uncalibr. irradiance (counts/ms)
- Lev2 std = calibr. irradiance (W/m²)
- Lev3 std = calibr. aver. irradiance (W/m²)
- per line: time, ch1, ch2, ch3, ch4, qual.

Product Definition

- (“Level 0”, telemetry from PROBA2, internal)
- Level 1 = full raw data (LY-EDG output)
- Level 2 = calibrated physical data (LY-BSDG output) Caution: preliminary status. Require versioning.
- Level 3 = processed products (e.g. averages)
- Level 4 = plots of products
- Level 5 = event lists (optionally with plots)

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http://proba2.sidc.be/lyra/data/Level4calibrated/

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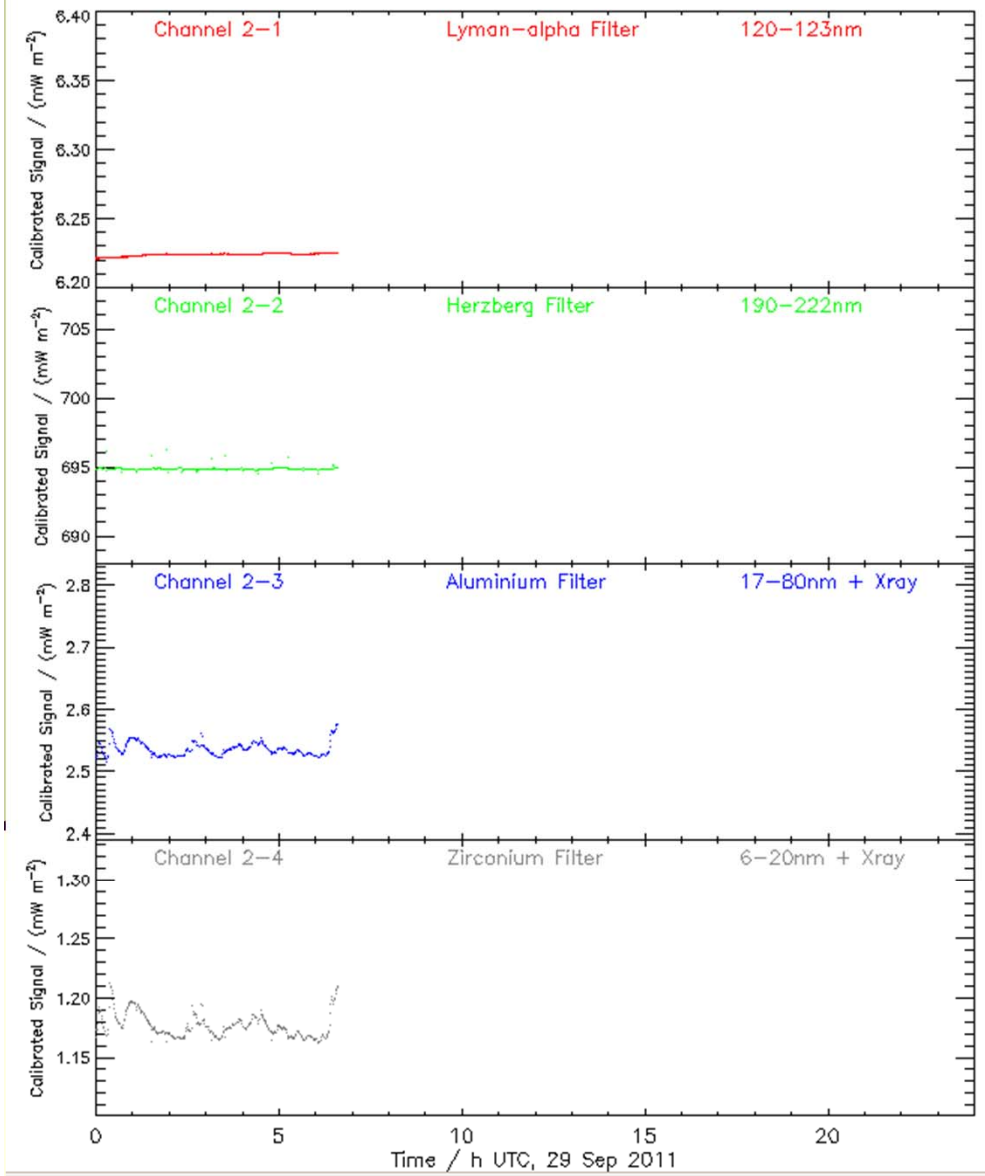
2011 LYRA Level 4 (Calibrated)



now

http://proba2.sidc.be/lyra/data/Level4calibrated/LyraL4C20110116.png

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http://proba2.sidc.be/lyra/data/3DayQuicklook/

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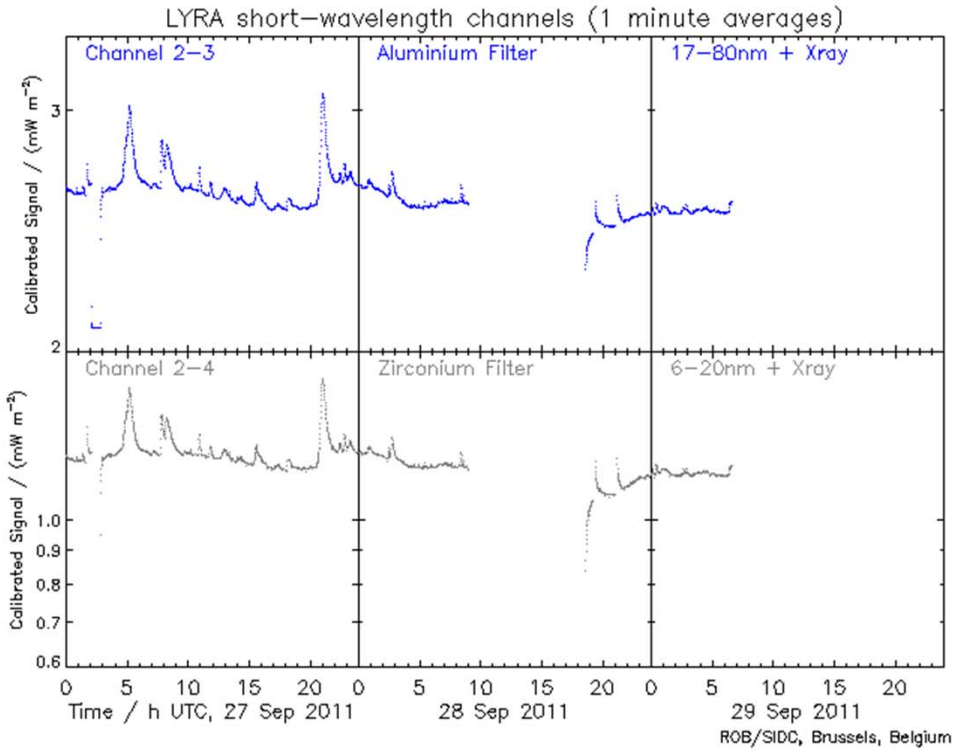
2011 LYRA Level4B Images (3days,2channels,calibrated)



now

Please note:

- "Calibrated" currently means that the dark currents were subtracted, the trend due to instrumental degradation was removed, and the LYRA count rates were converted to physical units with the aid of a comparison to other instruments on LYRA's First Light Day. Daily and orbital variations of the channels due to on-board temperature changes were corrected using the HK temperatures contained in the Level-1-metadata FITS file. The curves still include four regular disturbances per orbit due to spacecraft rotations, and possible disturbances due to commanding. Gaps may be caused by missing downlinks or calibration campaigns.
- From November to January, PROBA2 experiences "eclipse season". For several minutes during each orbit, the solar disk is occulted by the Earth, and the observed irradiances decrease to dark-current levels - thus the strange comb-like shape of the curves.
- The "event" on 31 Jan 2011 05:00 UTC is an instrument artifact, not a flare.
- In case of doubt about data gaps or unusual data, please check and follow the related links to the Google Calendars at the bottom of the P2SC homepage.

Done

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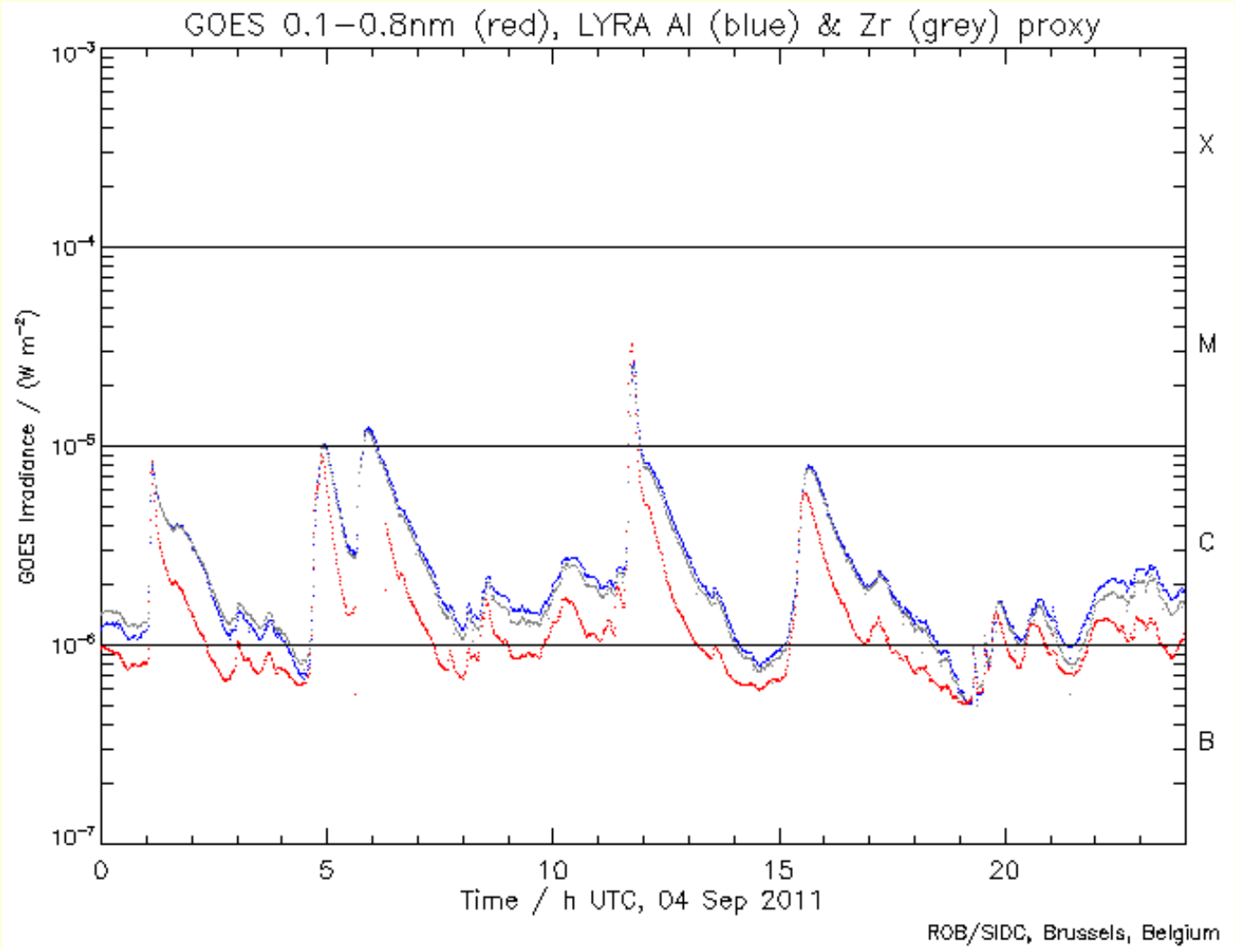
LYRA data products: GOES vs. LYRA proxies



18 Jul 2011 Flare List - Mozilla Firefox

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http://solwww.oma.be/users/dammasch/flares/flare20110718.html

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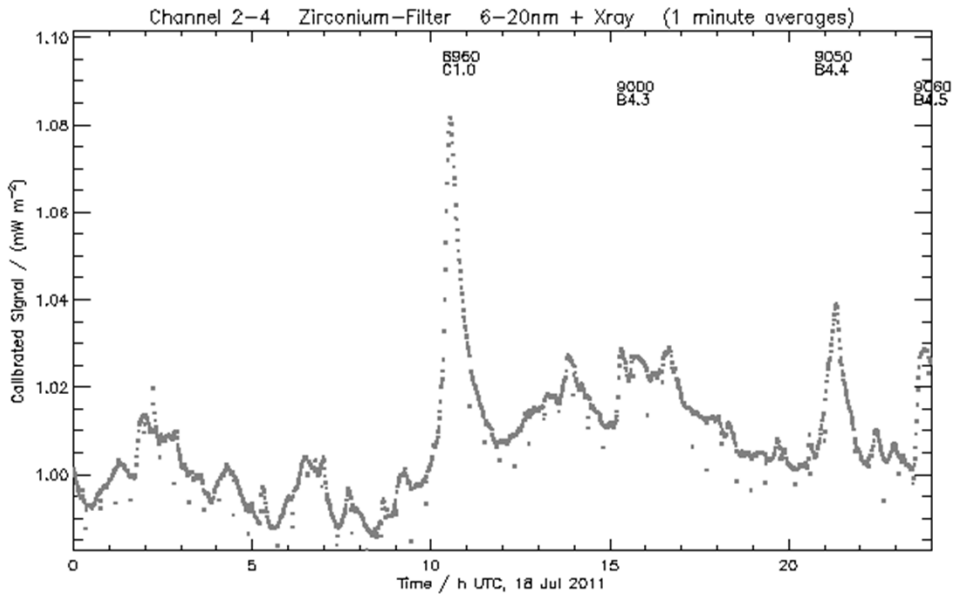
18 Jul 2011 Flare List



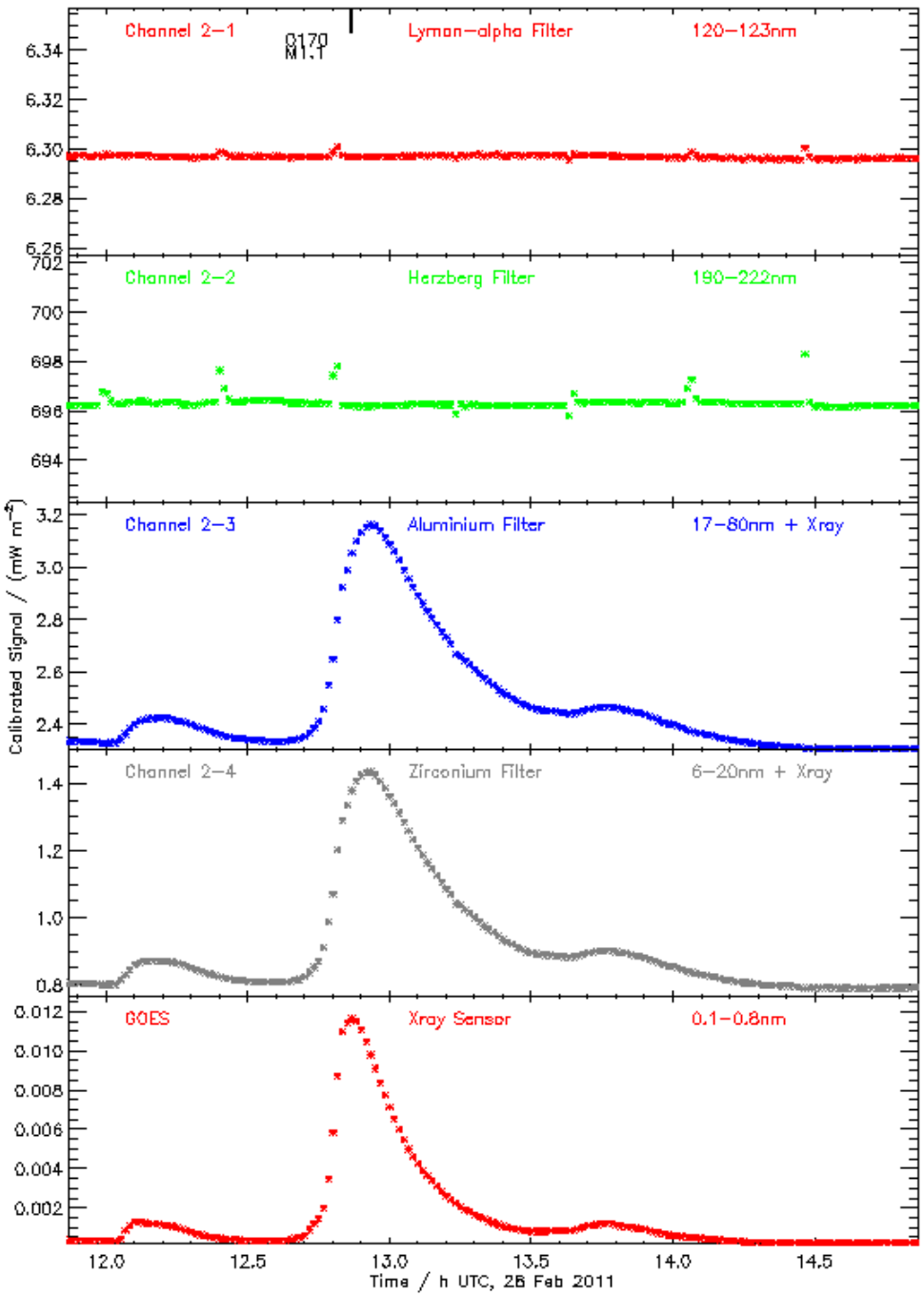
event	begin	max	end	class	region
8960	10:19	10:28	10:38	C1.0	1254
9000	15:12	15:17	15:24	B4.3	1254
9050	20:44	21:14	21:29	B4.4	
9060	23:31	23:40	23:58	B4.5	1255

http://solwww.oma.be/users/dammasch/flares/flare20110718_8960.png

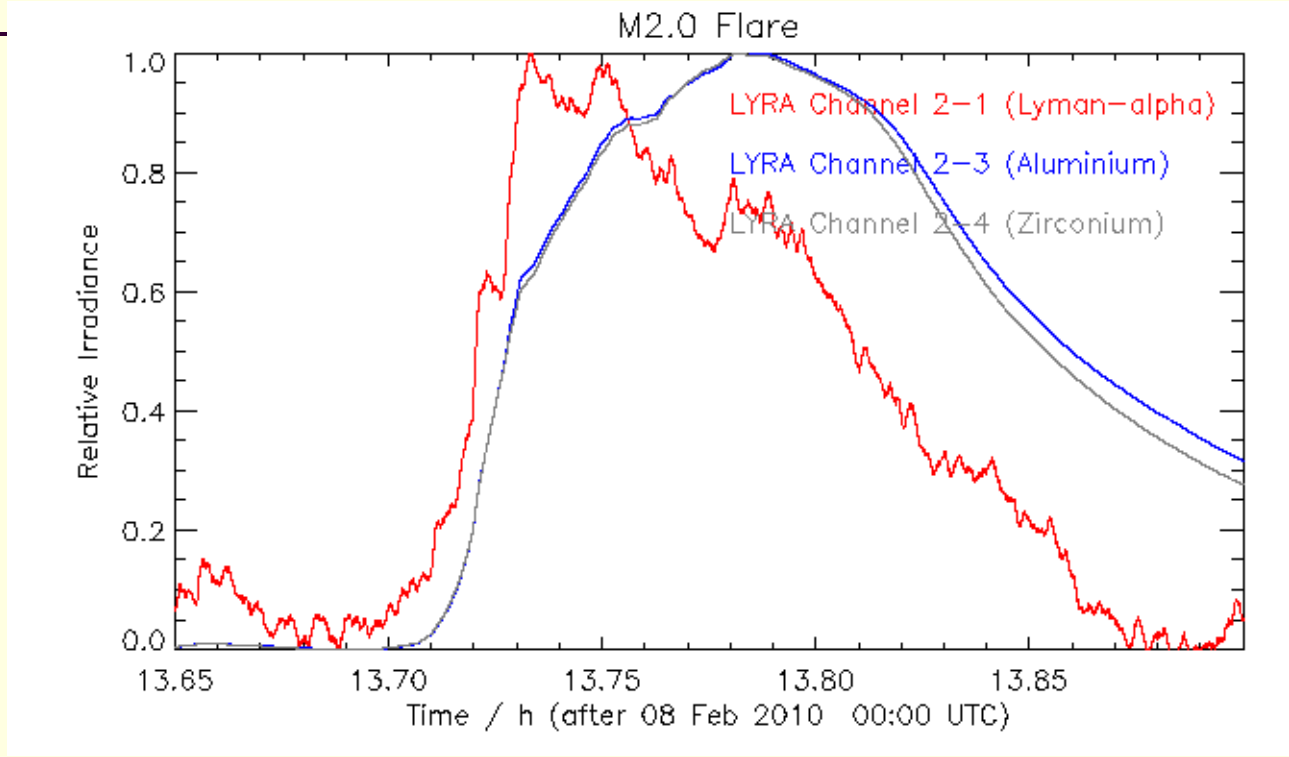
LYRA data products: Flare List

Example:
M1.1 flare, 28 Feb 2011

- start to rise at same time
- parallel in impulsive phase
- GOES peaks earlier
- LYRA decreases slower
- linear factor in pure flare irradiance



Lyman-alpha signal



- LYRA in early 2010
- signal peaks in rising phase
- log(T)<6

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Previous Next 11 of 16 150%

SOHO/SUMER

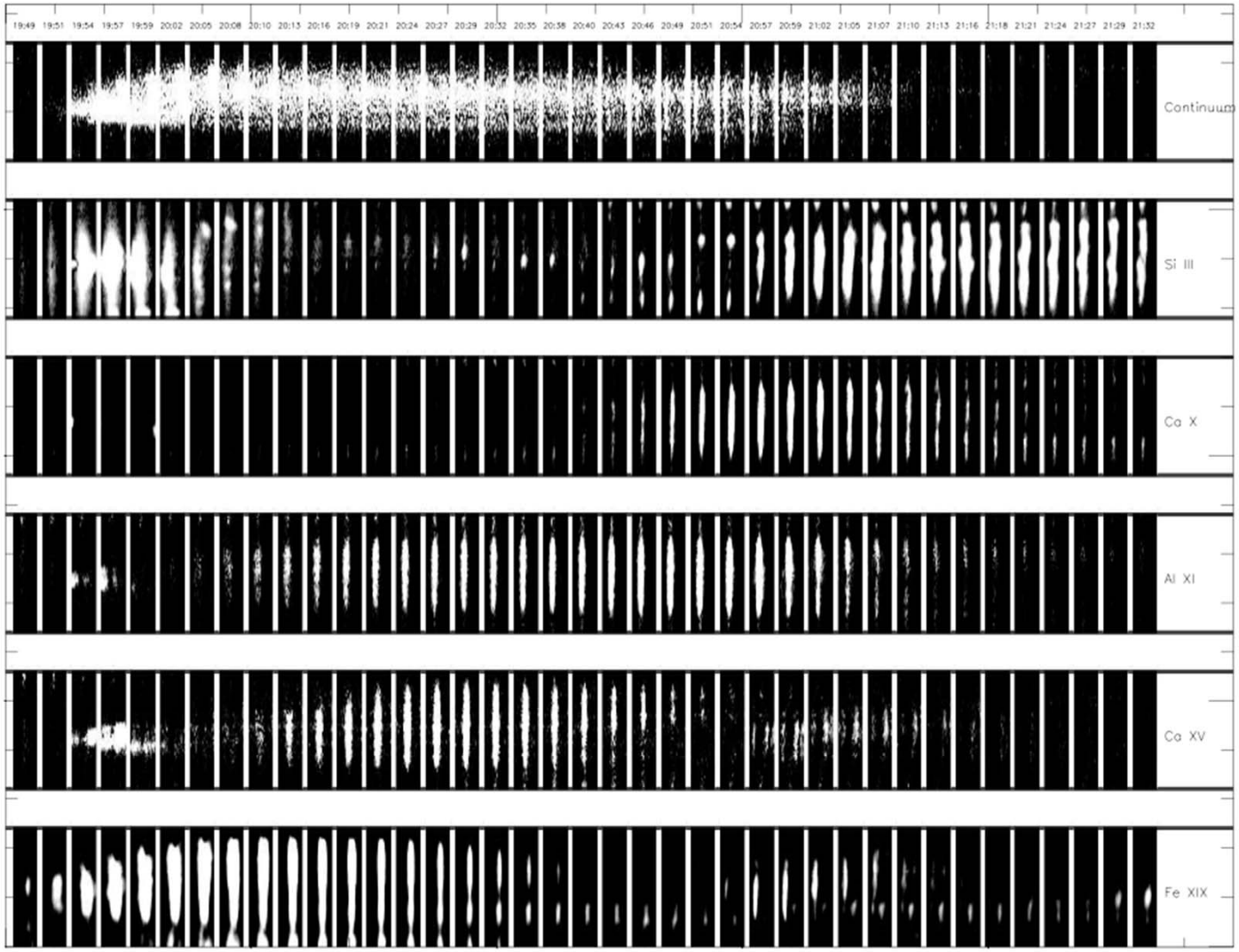
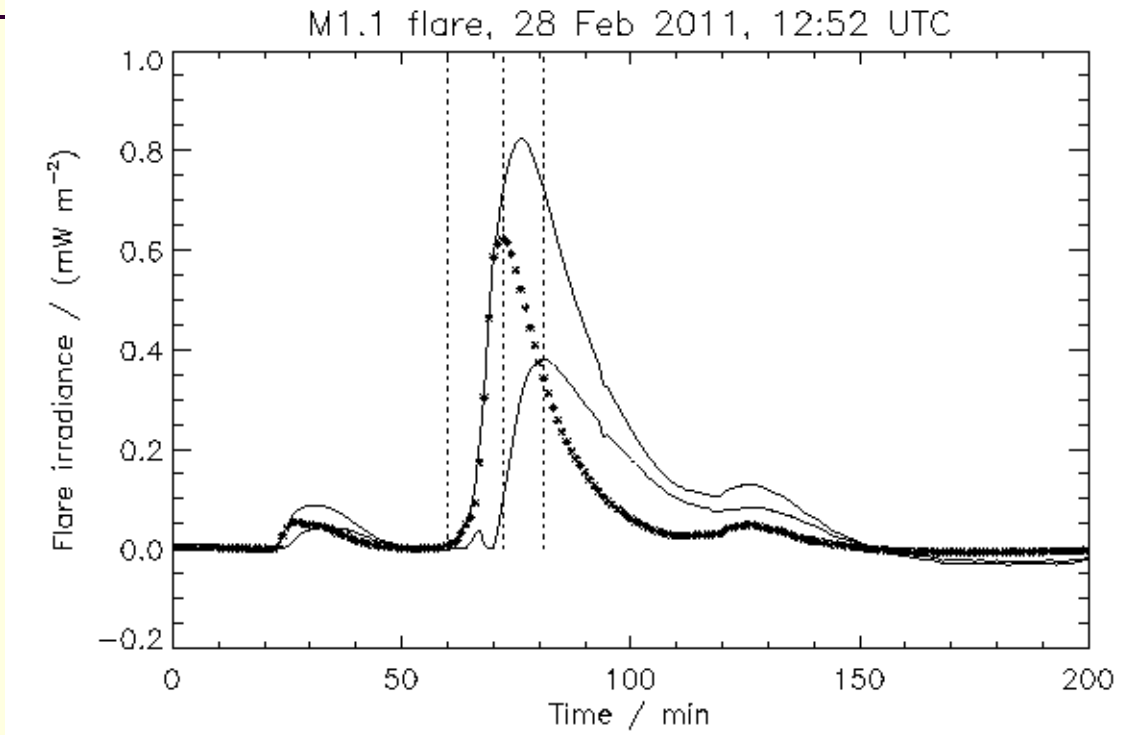


FIG. 8.—Background-subtracted spectra for the free-free continuum, for Si III, Ca X, Al XI, Ca XV, and Fe XIX, as a function of time. A Ne VI second-order line is present in the Fe XIX spectral window between 20:50 and 21:10 UT.

Flare components

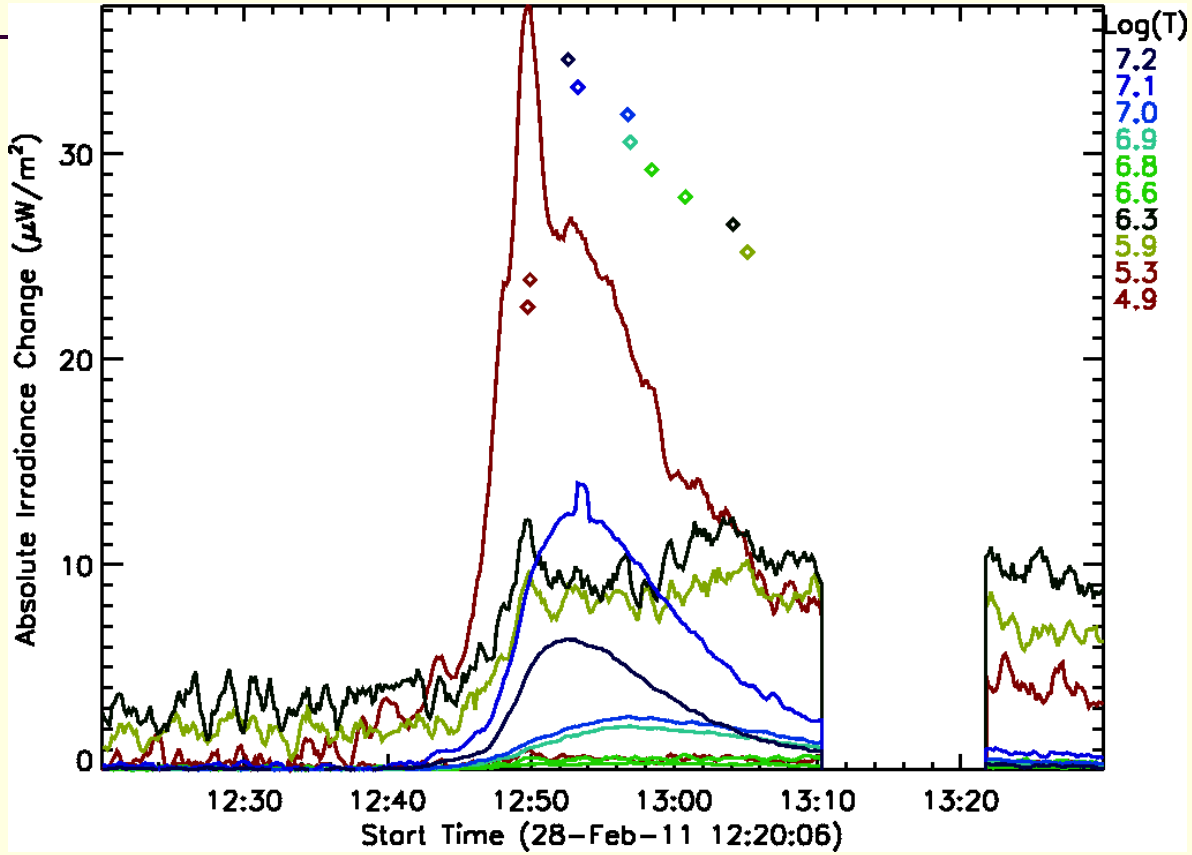
ch2-3 = SXR+EUV



- “SXR”: emission with log(T)>7
- “EUV residual”: emission with 6<log(T)<7
- “little bump”: emission with log(T)<6

Compare with SDO/EVE:

Thermal evolution plot



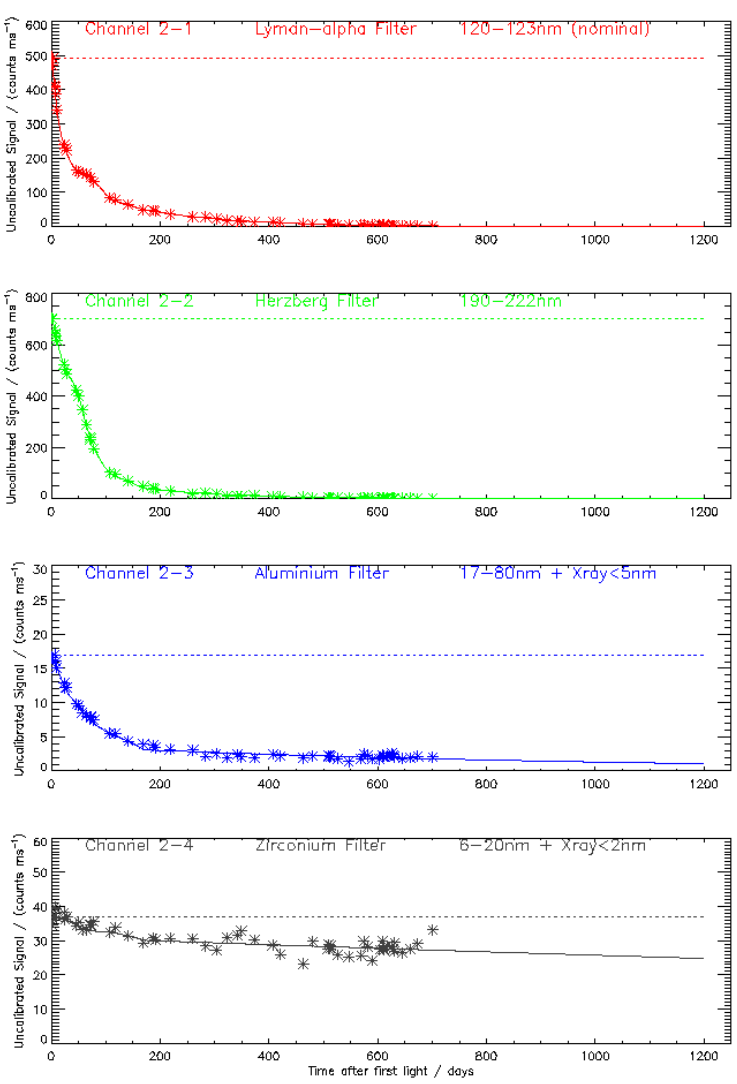
based on:

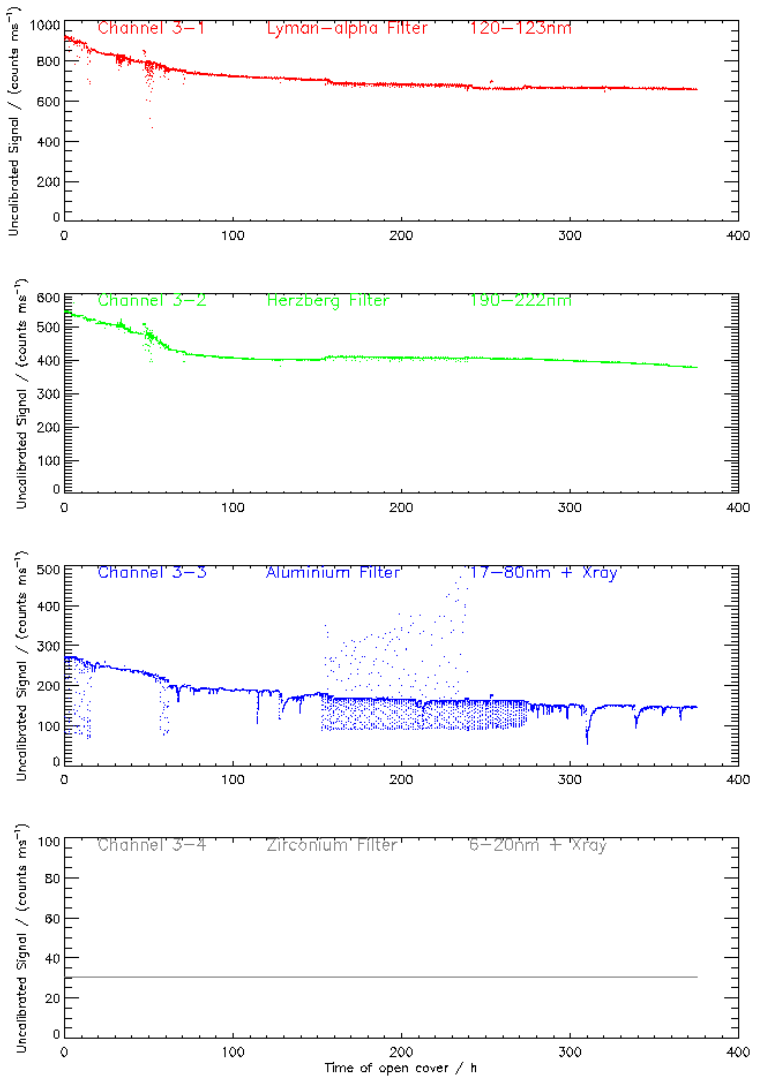
- solar spectra observed by SDO/EVE
- contribution functions from the CHIANTI atomic database

(Chamberlin, Milligan & Woods, Solar Physics 279, 23-42, 2012)

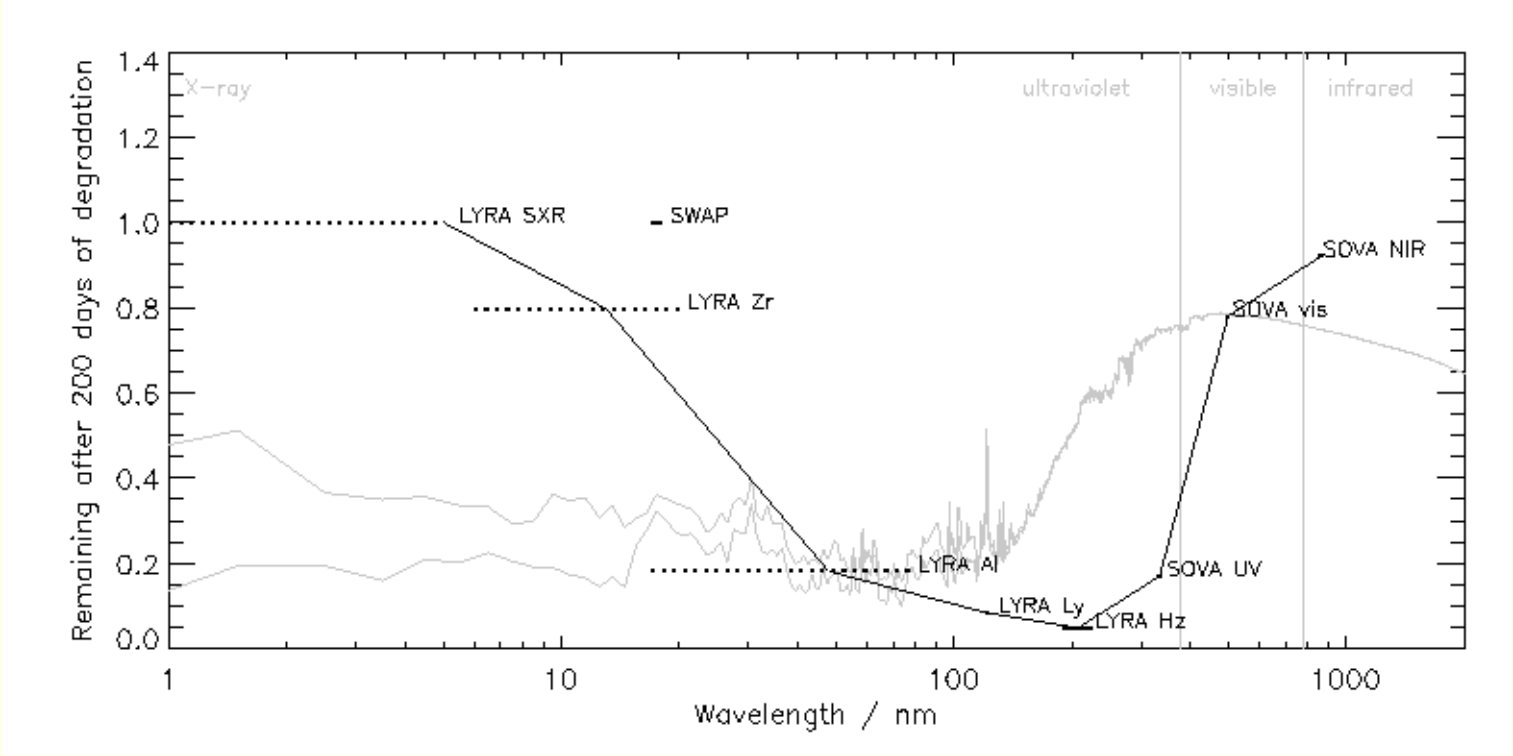
Problem: LYRA degradation

nominal unit 2 (days), spare unit 3 (hours)



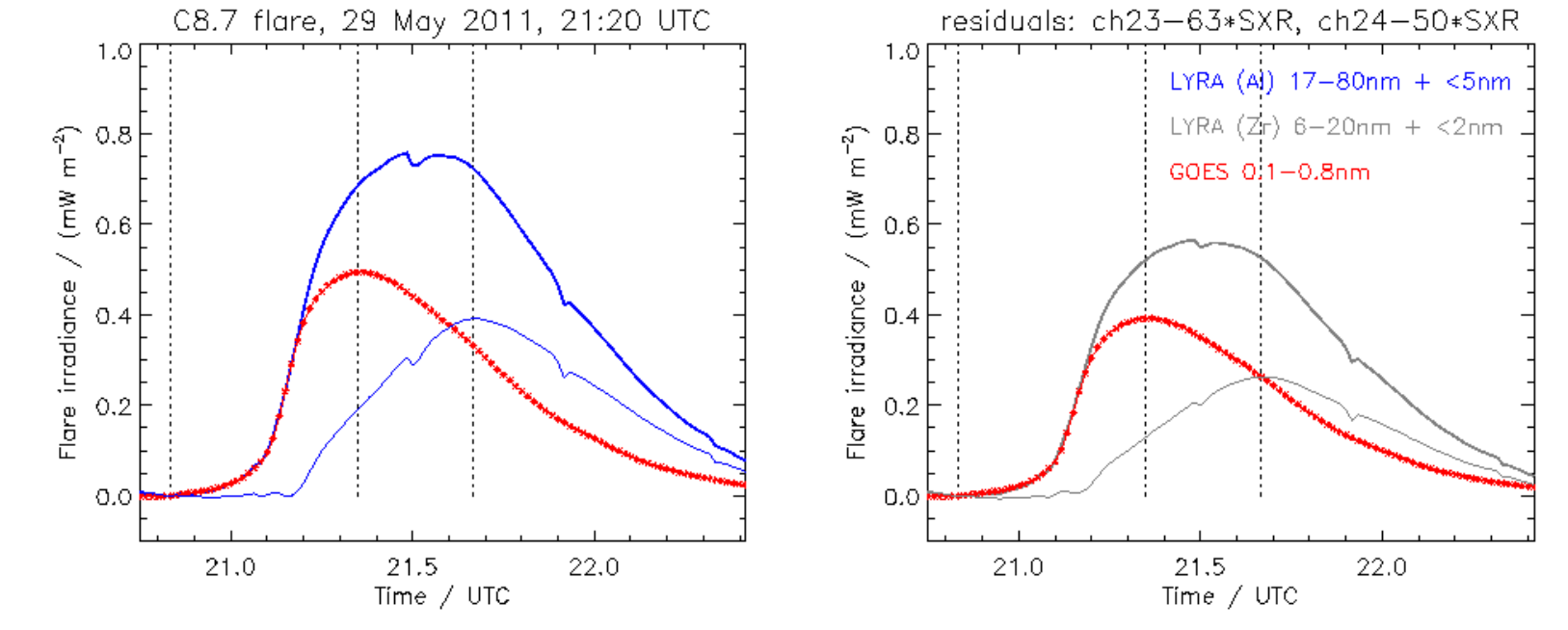


Spectral degradation after 200 days in space



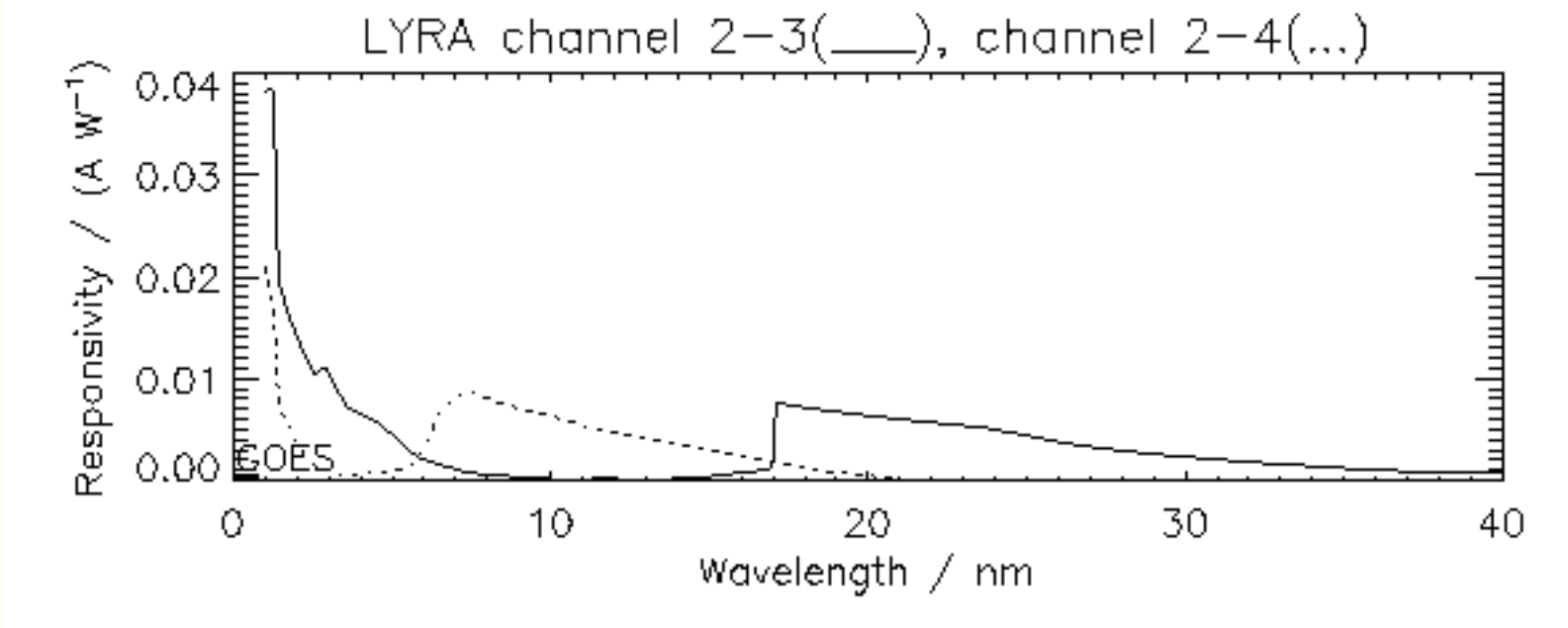
Experience from SOVA (1992/93) and LYRA (2010/11) combined ("molecular contamination on the first optical surface … caused by UV-induced polymerization")

C8.7 thermal evolution with LYRA unit 2



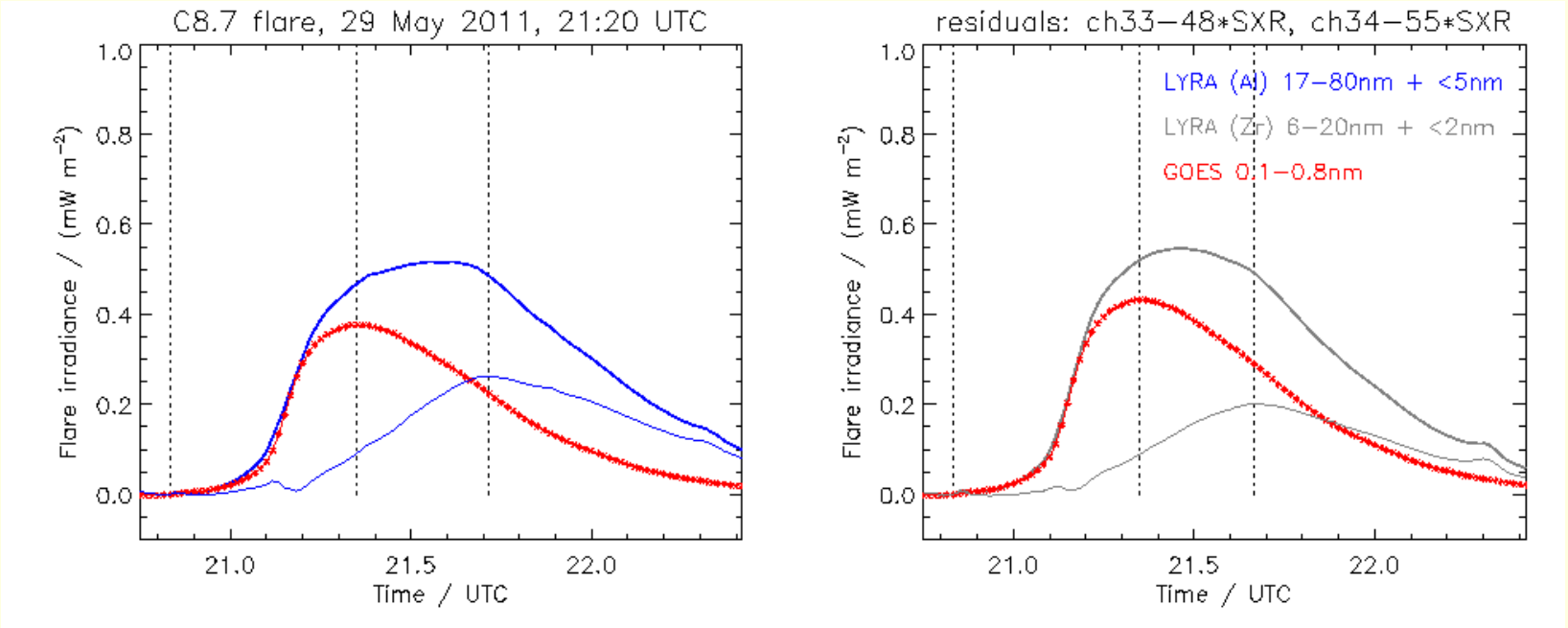
- Unit 2 has degraded more than unit 3
- Identical residuals for Al and Zr channels
- “Cool” component peaks 19 minutes later than “hot” component

Reminder: LYRA spectral response



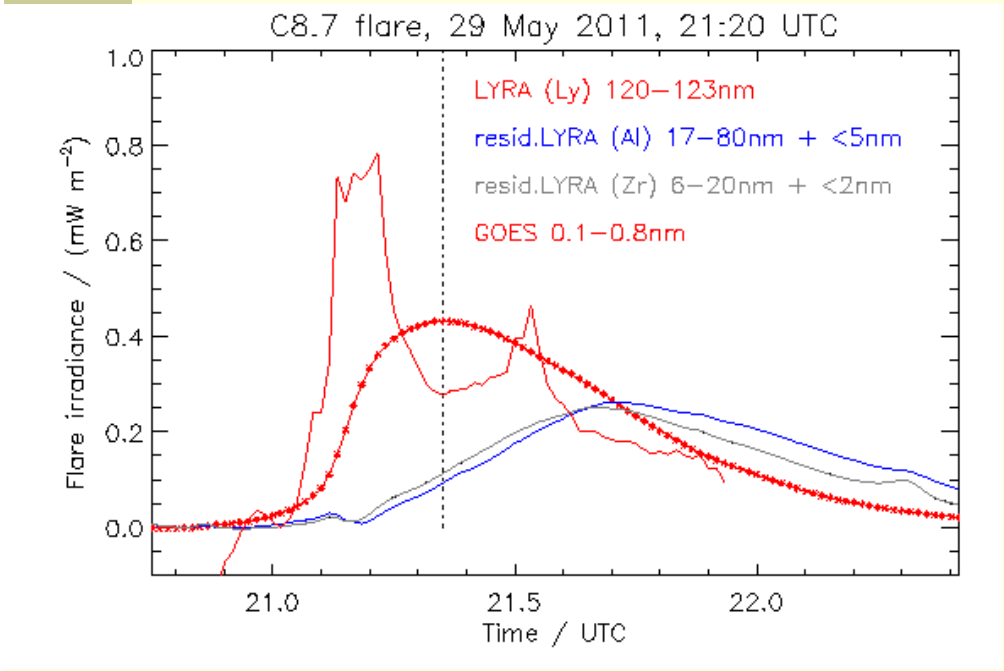
- channel 2-3: Aluminium filter, nominally 17-80nm
- channel 2-4: Zirconium filter, nominally 6-20nm
- pre-launch calibration at BESSY
- additional SXR components <5 nm, <2 nm
- for comparison: GOES 0.1-0.8 nm

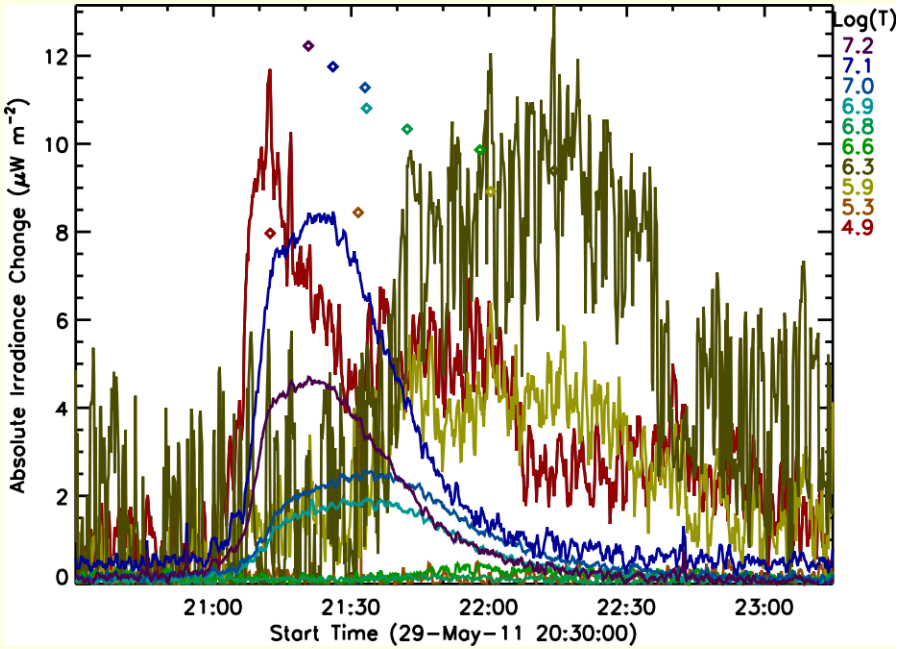
C8.7 thermal evolution with LYRA unit 3



- Unit 3 has degraded less than unit 2
- Slightly different residuals for Al and Zr channels
- “Cool” component peaks 22 or 19 minutes later than “hot” component

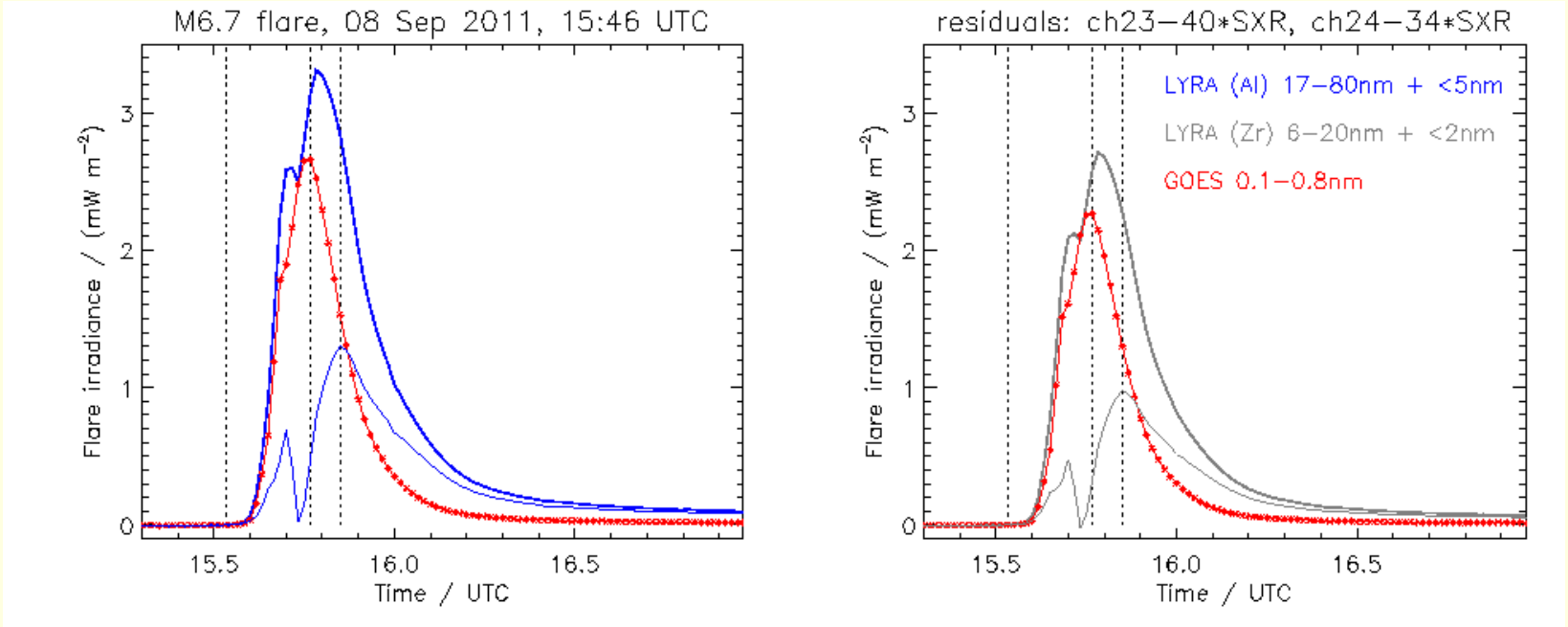
LYRA-GOES vs. SDO/EVE (C8.7)





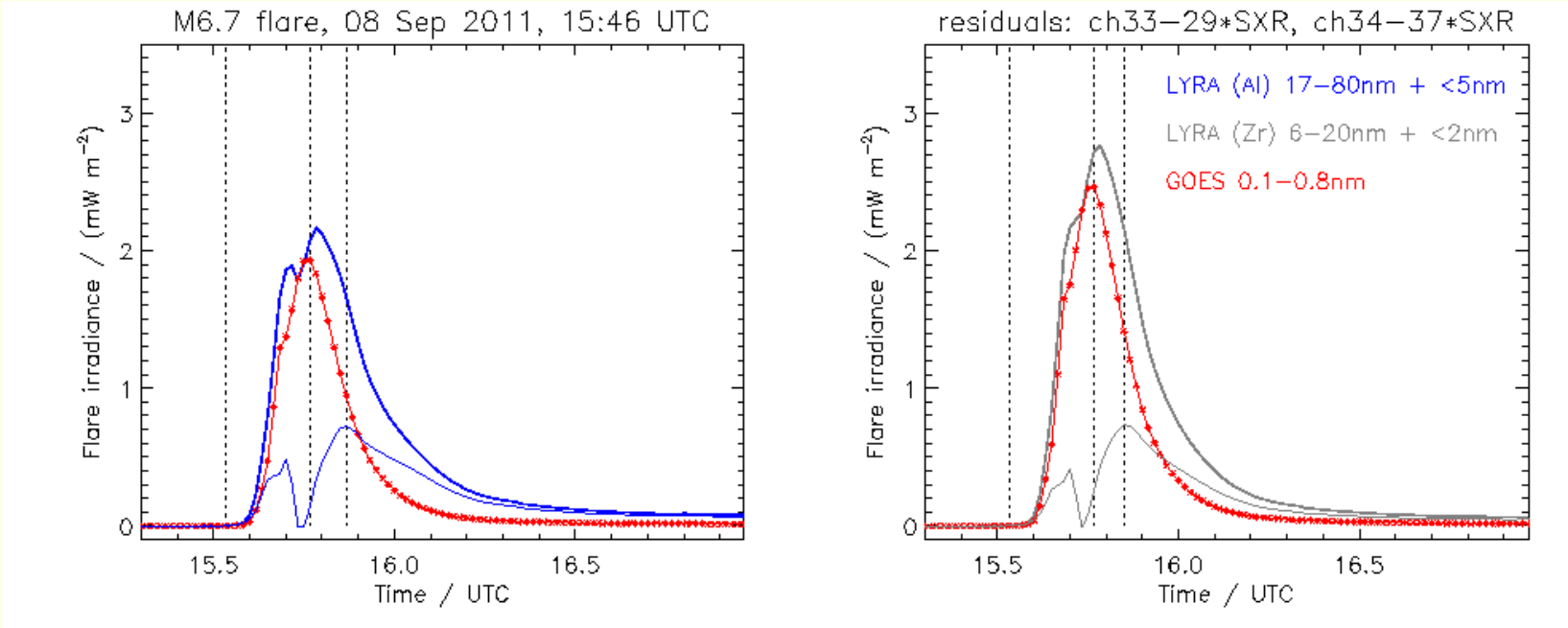
Corresponding temporal structures can be observed at various temperature levels..

M6.7 thermal evolution with LYRA unit 2



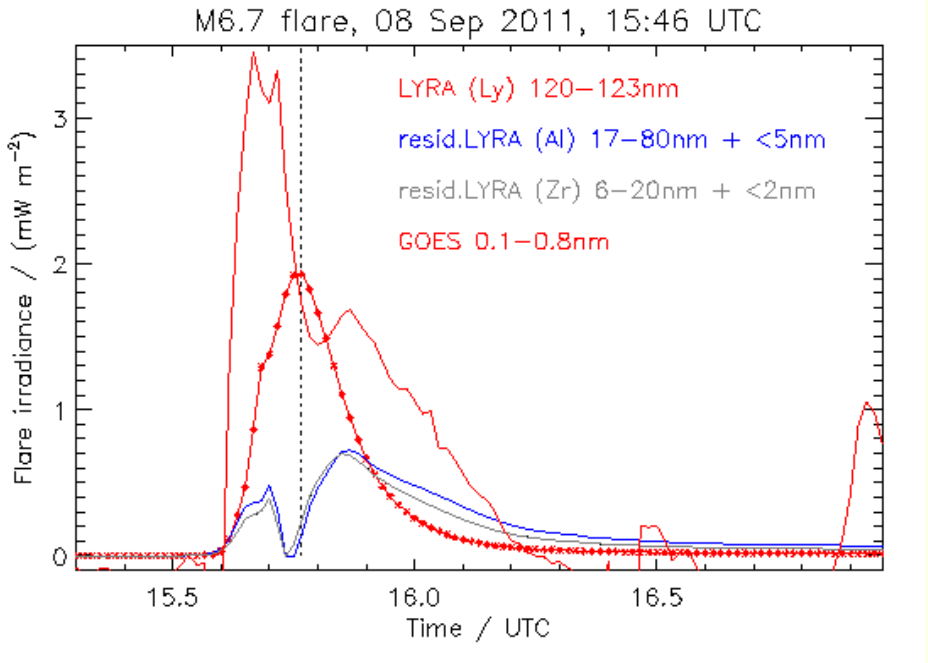
- Unit 2 has degraded more than unit 3
- Identical residuals for Al and Zr channels
- “Cool” component peaks 5 minutes later than “hot” component

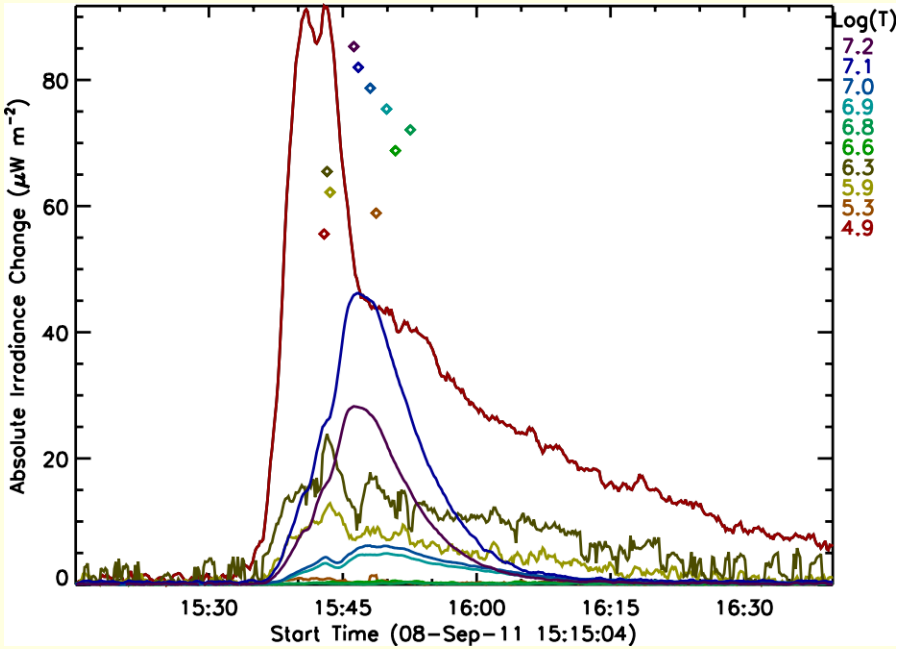
M6.7 thermal evolution with LYRA unit 3



- Unit 3 has degraded less than unit 2
- Slightly different residuals for Al and Zr channels
- “Cool” component peaks 6 or 5 minutes later than “hot” component

LYRA-GOES vs. SDO/EVE (M6.7)





Again, corresponding temporal structures can be observed at various temperature levels.

Conclusions

- Not the right person to tell you what this means as consequences for the thermosphere, the ionosphere, the geosphere.
- Eventually, LYRA and GOES together may be able to tell you something about the thermal evolution of flares…
- … with high temporal resolution, and without being full-blown spectrographs.
- Or, for future missions: How to get max information with min suitable components?
- Of course, we are still working on the radiometric calibration, together with our colleagues from SDO/EVE.
- So far, the shapes look similar, but we still have to attach the correct mW/m² to the curves.
- See you next time around ☺