

LYRA

the Large-Yield Radiometer onboard PROBA2

Five years of EUV solar irradiance evolution, from short to long timescales as observed by PROBA2/LYRA

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Liege, Belgium, 17-21 Nov 2014



Contents

- Introduction

- What is PROBA2 ?
- What is LYRA ?
- What data products are delivered ?

- Achievements

- Long-term comparison with other instruments
- Periodicities present in the signal
- Sun-Moon eclipses, Sun-Earth occultations
- Analysis of degradation processes
- Flares (comparison to GOES, Lyman-alpha signatures, quasi-periodic pulsation, flare strength prediction)



PROBA2

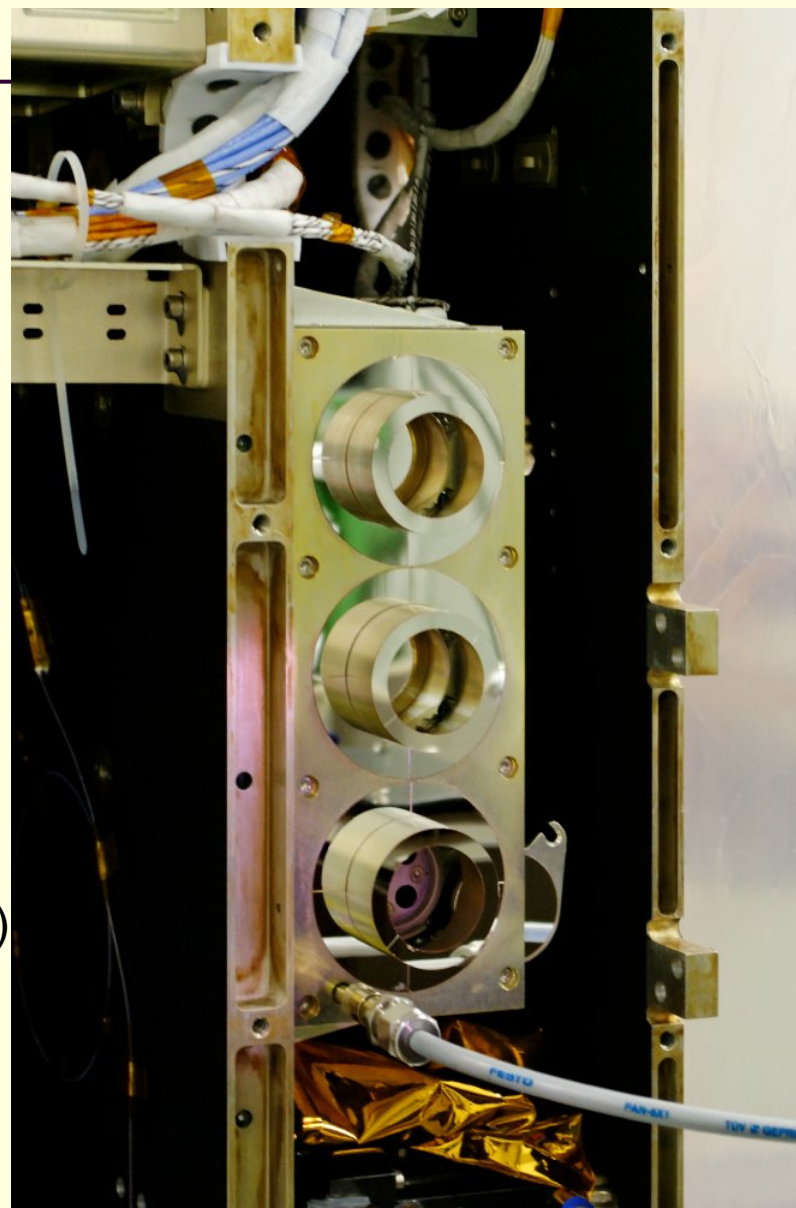


- ESA's “Project for On-Board Autonomy”
- Belgian microsatellite in Sun-synchronous orbit
- Polar, dawn-dusk, approx. 100 min
- Occultation season (max. 20 min per orbit) October to February
- 725 km altitude
- Launched 02 Nov 2009
- Nominal operations since March 2010
- Technology *and* science mission
- 4 innovative instruments and 17 technological experiments for in-orbit demonstration
- Among them the EUV imager SWAP and the radiometer LYRA



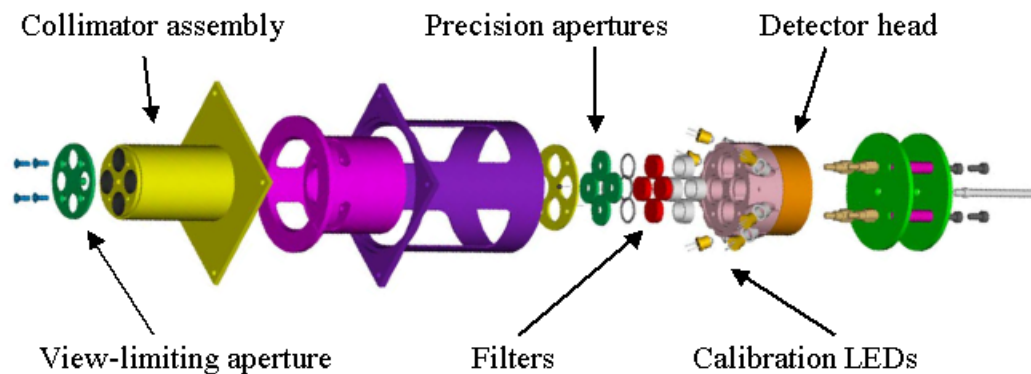
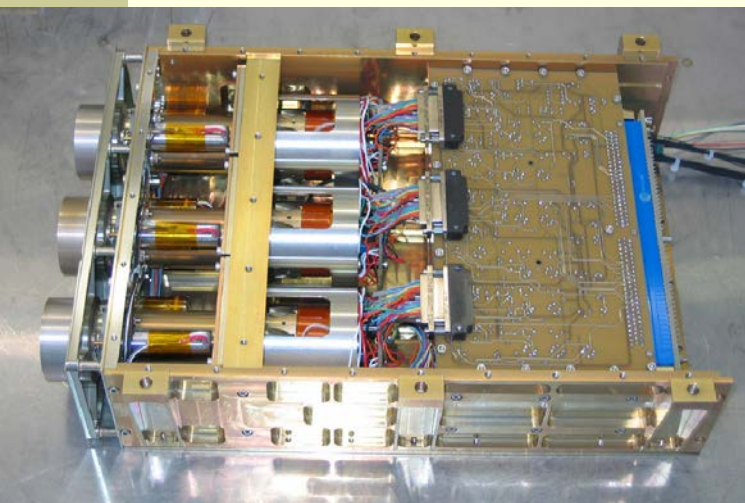
LYRA

- 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
- 2 calibration LEDs per detector
 - ($\lambda = 465 \text{ nm}$ and 390 nm)
- High cadence up to 100 Hz (nom. 20)
- First Light 06 Jan 2010
- Quasi-continuous acquisition during mission lifetime





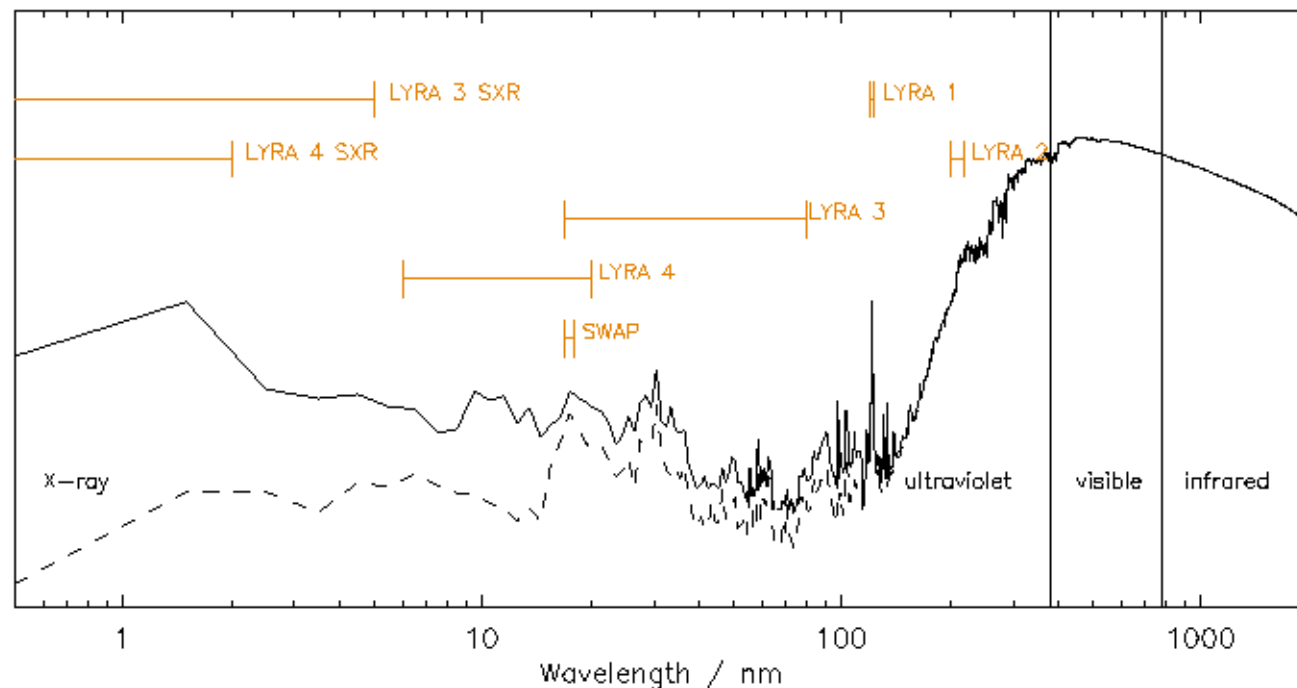
LYRA design and filter-detector combinations



	Ly (120-123nm)	Hz (190-222nm)	Al (17-80nm + <5nm)	Zr (6-20nm + <2nm)
Unit1 (spare)	MSM	PIN	MSM	Si
Unit2 (nominal)	MSM	PIN	MSM	MSM
Unit3 (campaigns)	Si	PIN	Si	Si



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)

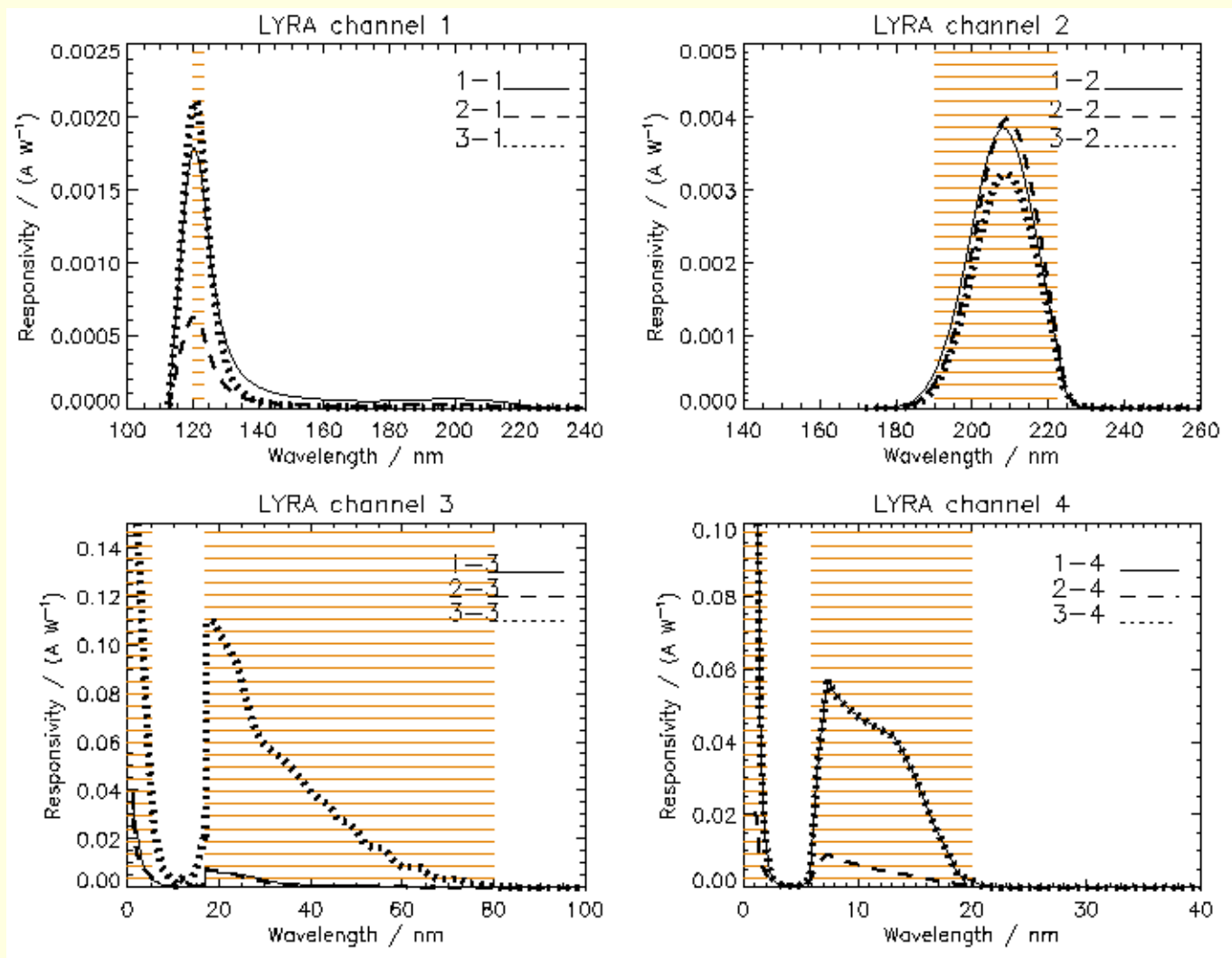
LYRA channel 3: the 17-80 nm **Aluminium** filter range incl the He II 30.4 nm line (+ <5nm X-ray)

LYRA channel 4: the 6-20 nm **Zirconium** filter range with highest solar variability (+ <2nm X-ray)

SWAP: the range around 17.4 nm including coronal lines like Fe IX and Fe X



LYRA spectral response





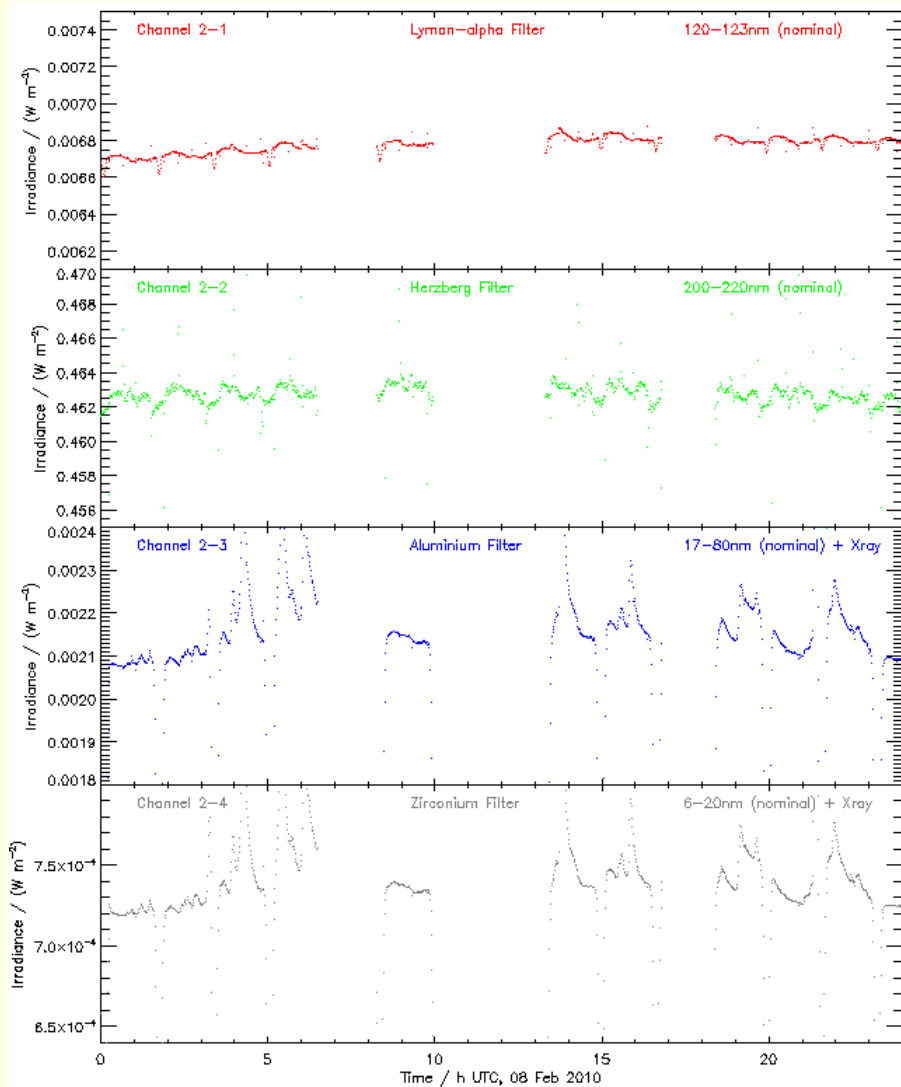
LYRA data products

- Daily FITS file (uncalibrated, full resolution): “Lev1”
- Daily FITS file (calibrated, full resolution): “Lev2”
- Daily FITS file (calibrated, 1-minute averages): “Lev3”
- Daily overview graphic
- Daily flare list
- Daily GOES proxy
- 3-day overview graphic
- Monthly, yearly, complete overview graphics
- SSA service (“Space Situational Awareness”, with SWAP)
- ... all updated several times per day, after satellite downlink

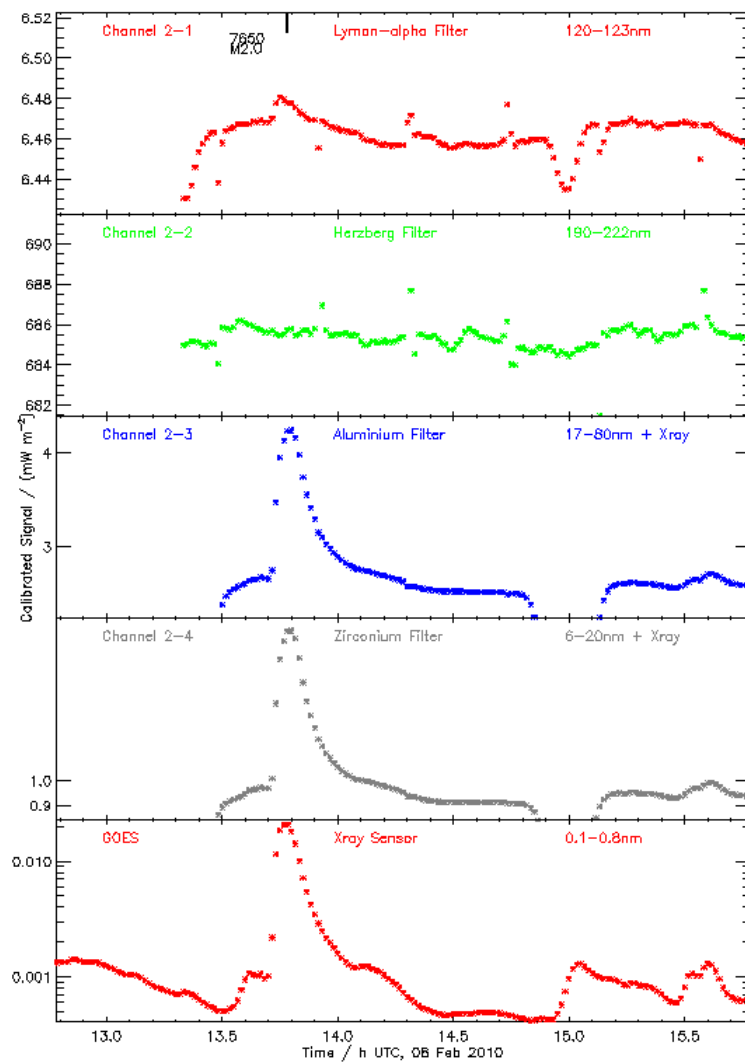
<http://proba2.sidc.be>



LYRA data products: Daily list. Flare list

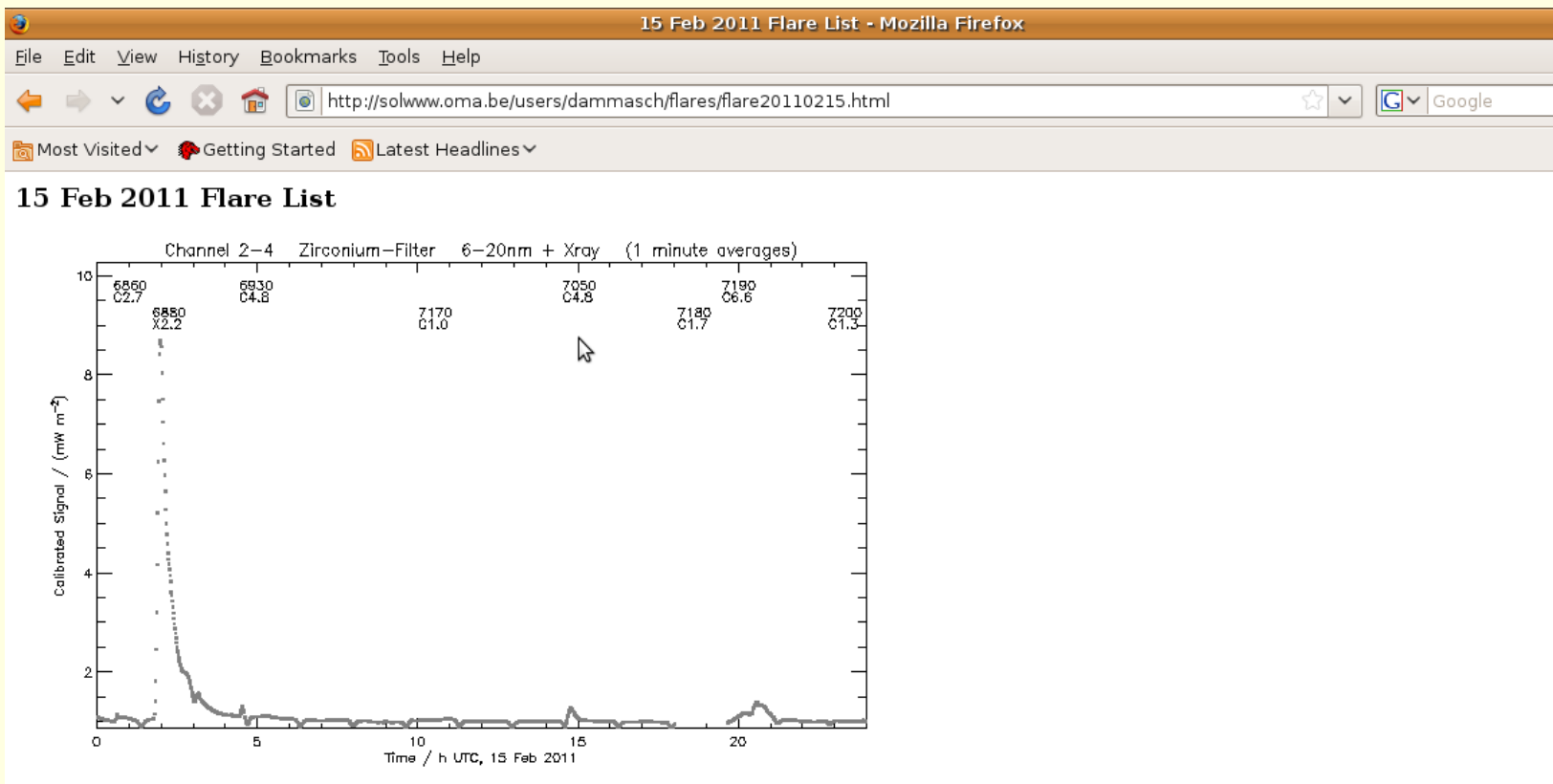


ROB/SIDC, Brussels, Belgium



(1 minute averages)

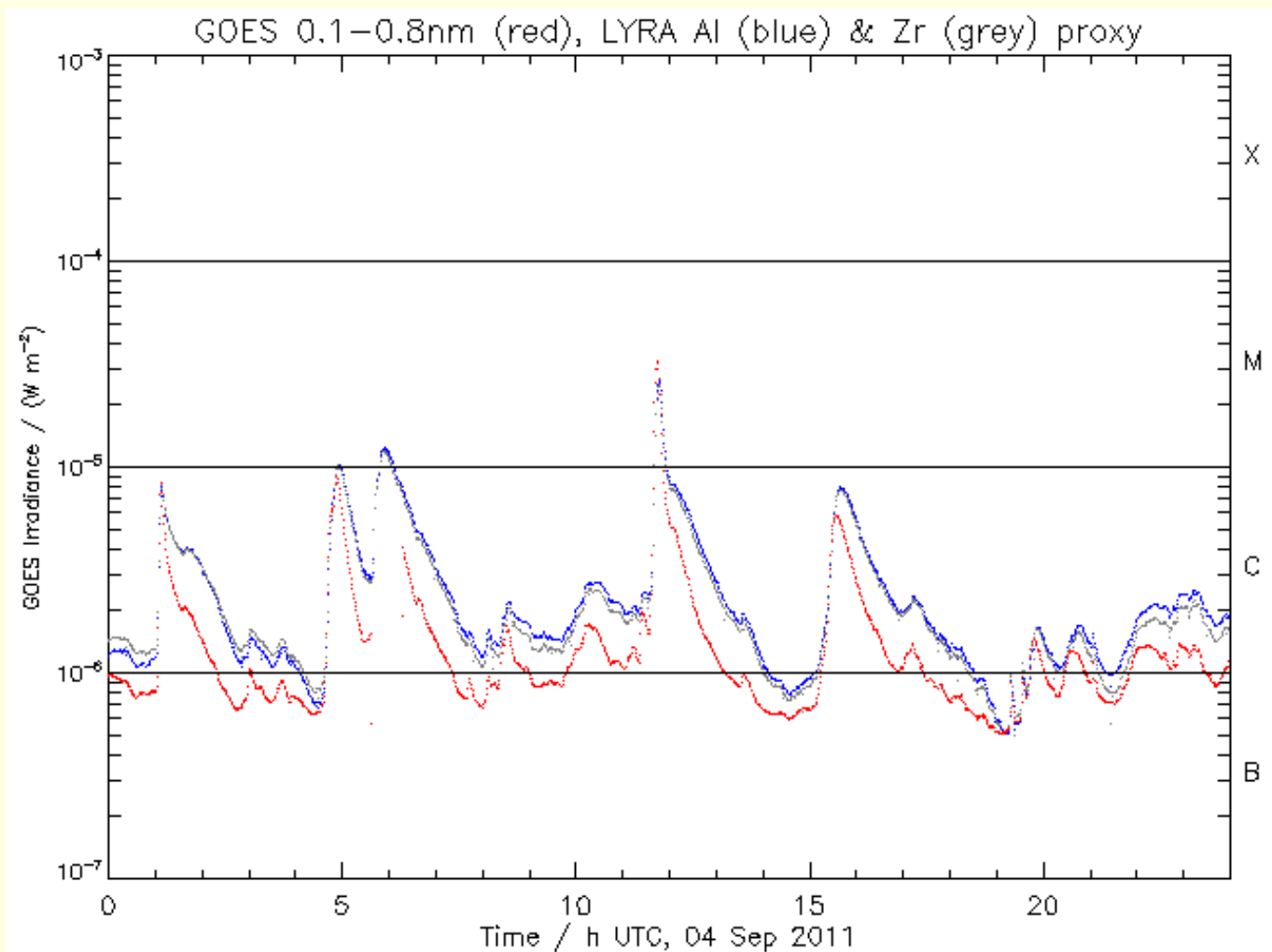
LYRA data products: Flare list



event	begin	max	end	class	region
6860	00:31	00:38	00:48	C2.7	
6880	01:44	01:56	02:06	X2.2	1158
6930	04:27	04:32	04:37	C4.8	
7170	10:02	10:07	10:16	C1.0	
7050	14:32	14:44	14:51	C4.8	1158
7180	18:07	18:44	18:57	C1.7	1158
7190	19:30	20:33	20:53	C6.6	1158
7200	22:49	22:54	22:56	C1.3	1158



LYRA data products: GOES vs. LYRA proxies





... also used for space weather service



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Space Situational Awareness, services provided by PROBA2

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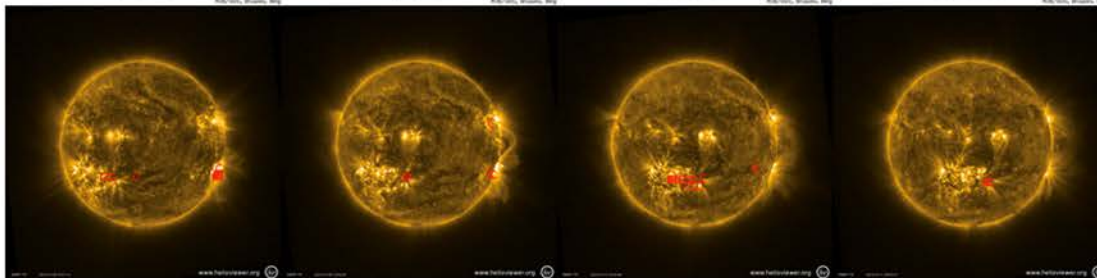
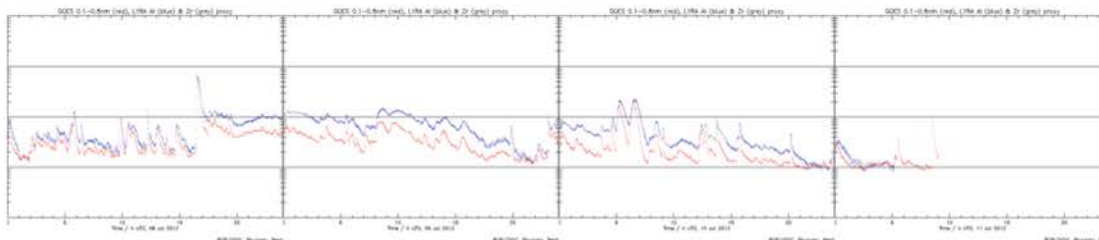
Today

2012-07-08

2012-07-09

2012-07-10

2012-07-11

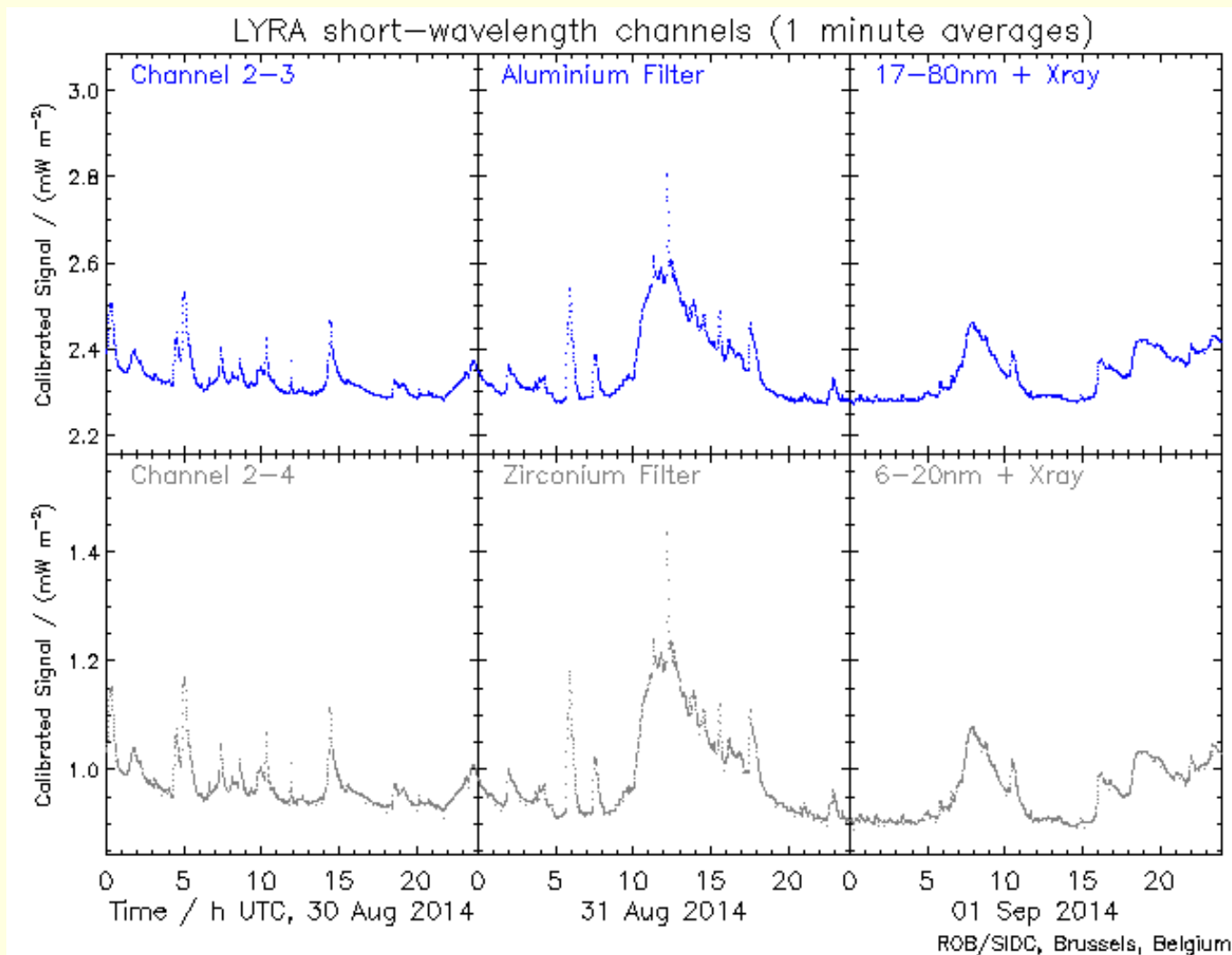


[SWAP movie](#) | [SWAP diff](#)
[SWAP movie](#) | [SWAP diff](#)
[SWAP movie](#) | [SWAP diff](#)
[SWAP movie](#) | [SWAP diff](#)

Date	Start	Peak	Stop	Flare class	Location	NOAA region
2012-07-11	08:24	08:31	08:37	C9.9	S22W04	1521
2012-07-11	05:26	05:33	05:38	C3.4	S22W01	1521
2012-07-10	23:57	00:09	00:23	C3.0	S15W114	1515

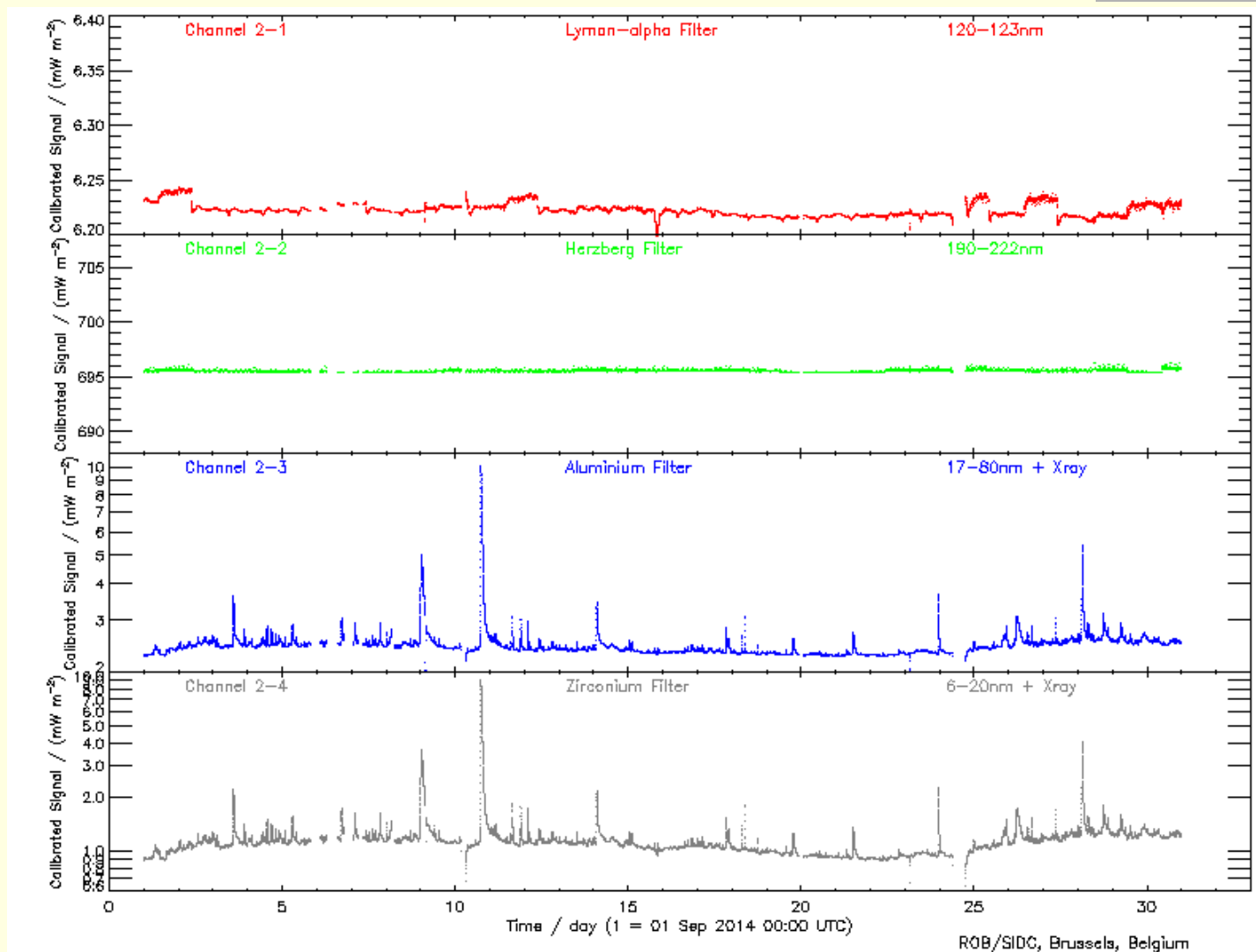


LYRA data products: 3-day overview



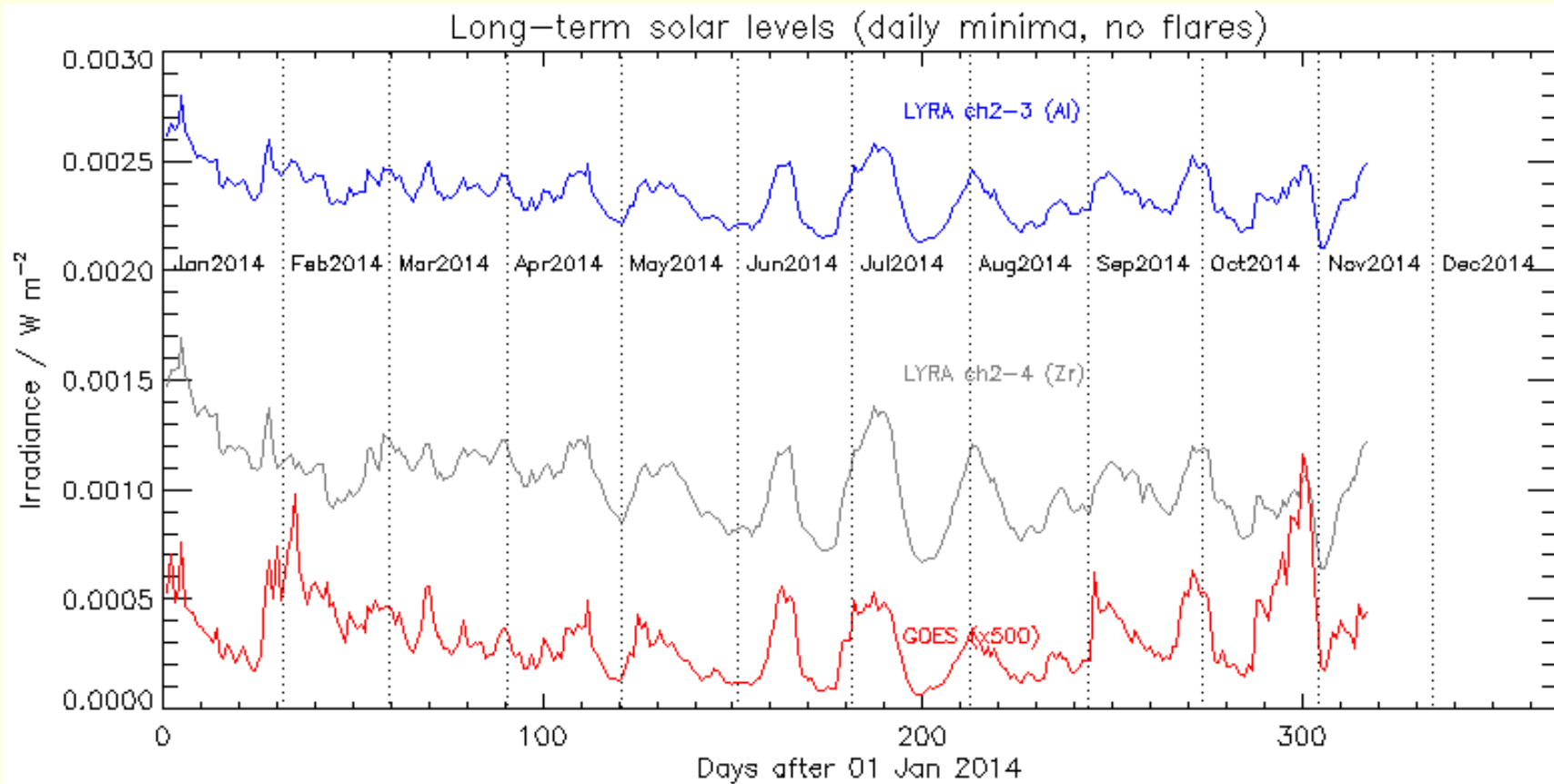


LYRA data products: Monthly overview





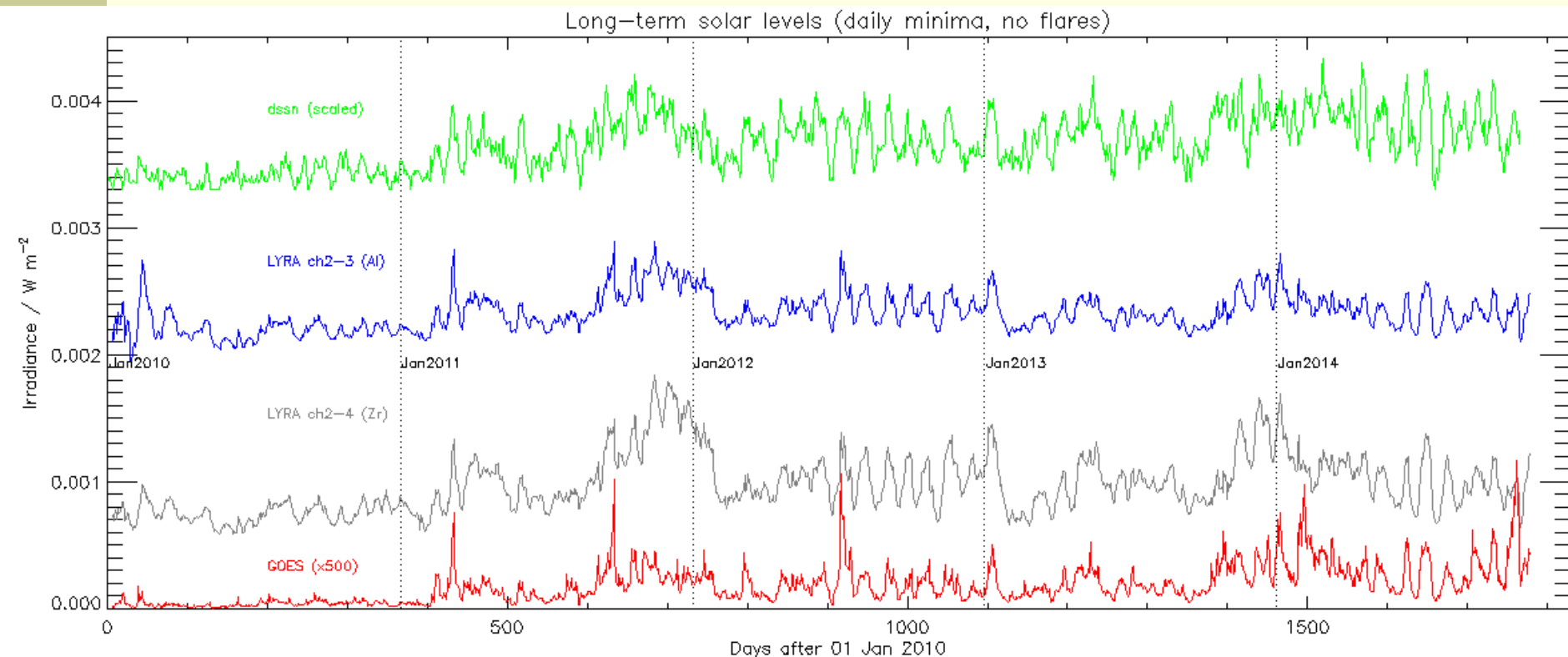
LYRA data products: Long-term irradiance



Development of daily minimum, i.e. without flares, Jan 2014 – Nov 2014



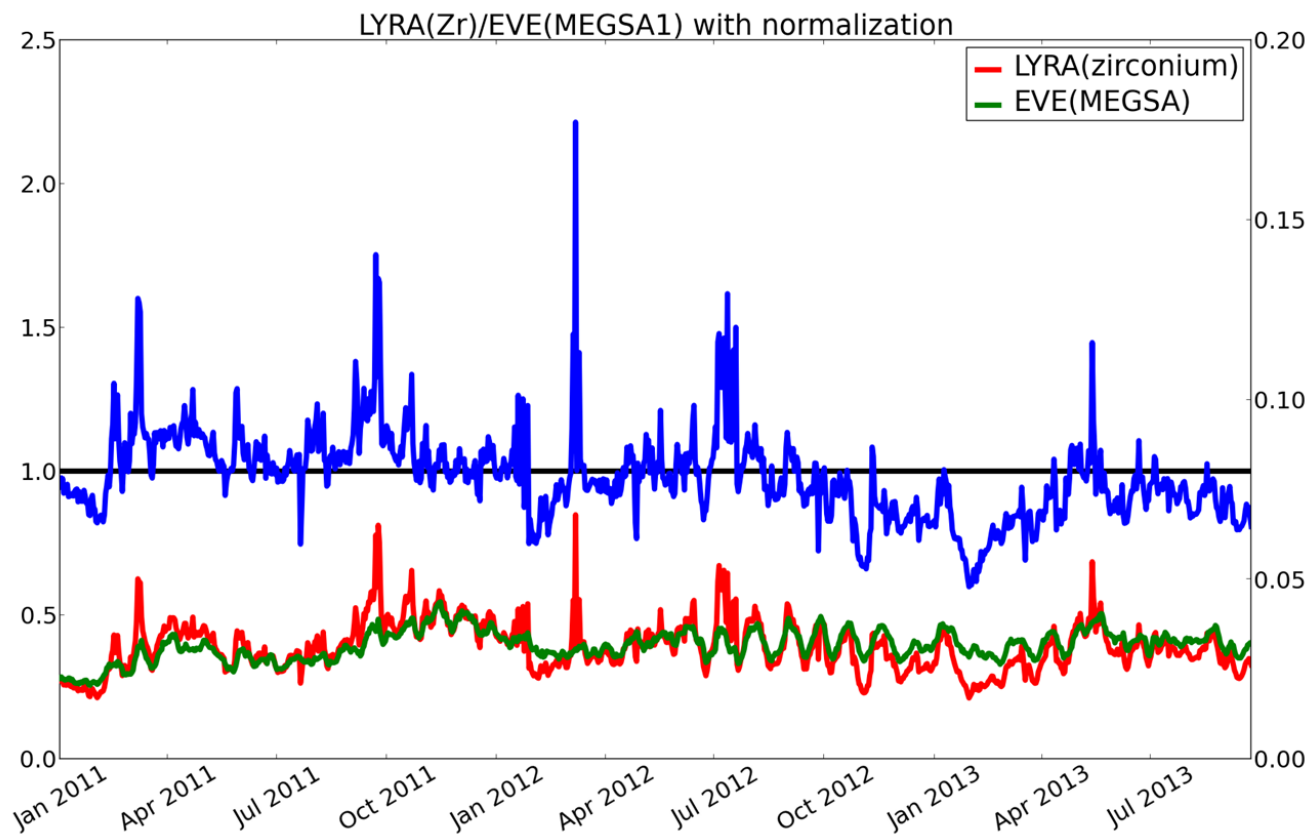
Long-term comparison



Sunspot number, LYRA Aluminium and Zirconium channels, GOES soft X-ray
(January 2010 – November 2014)



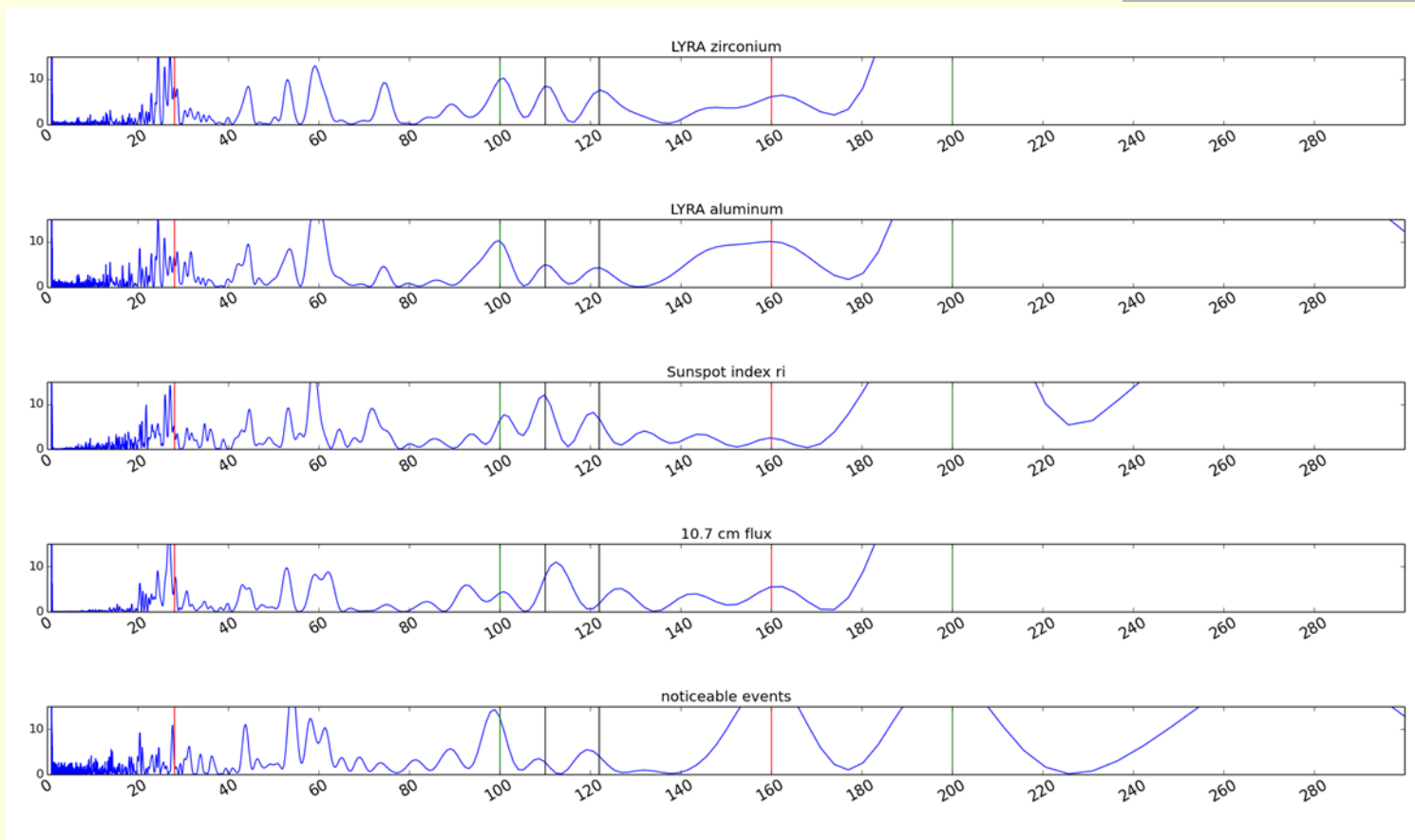
Long-term comparison



Ratio (blue) between LYRA Zirconium channel and 6-36nm integrated SDO/EVE/MEGS-A spectrum (similar comparisons exist with SWAP)



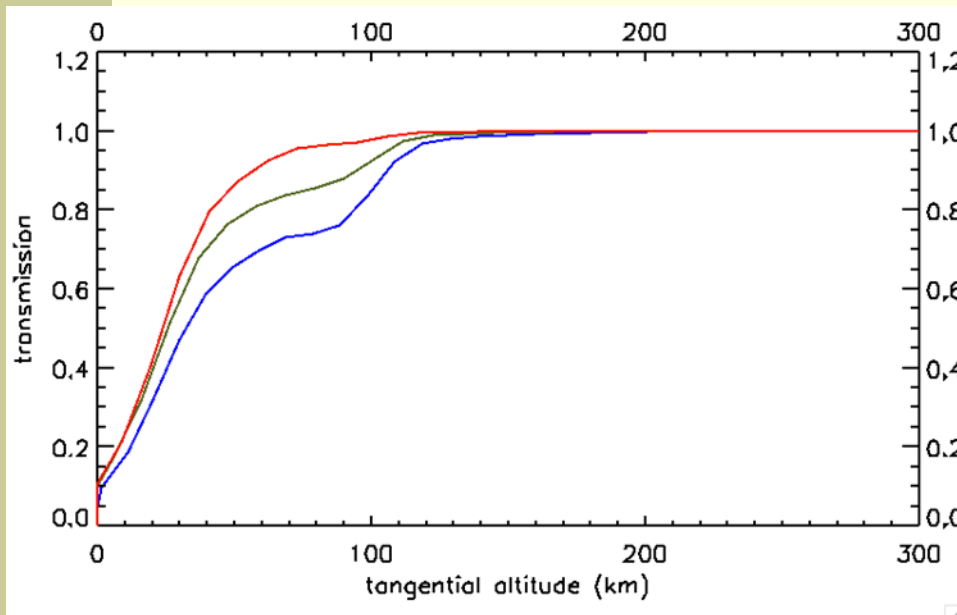
Periodicities present in the signal



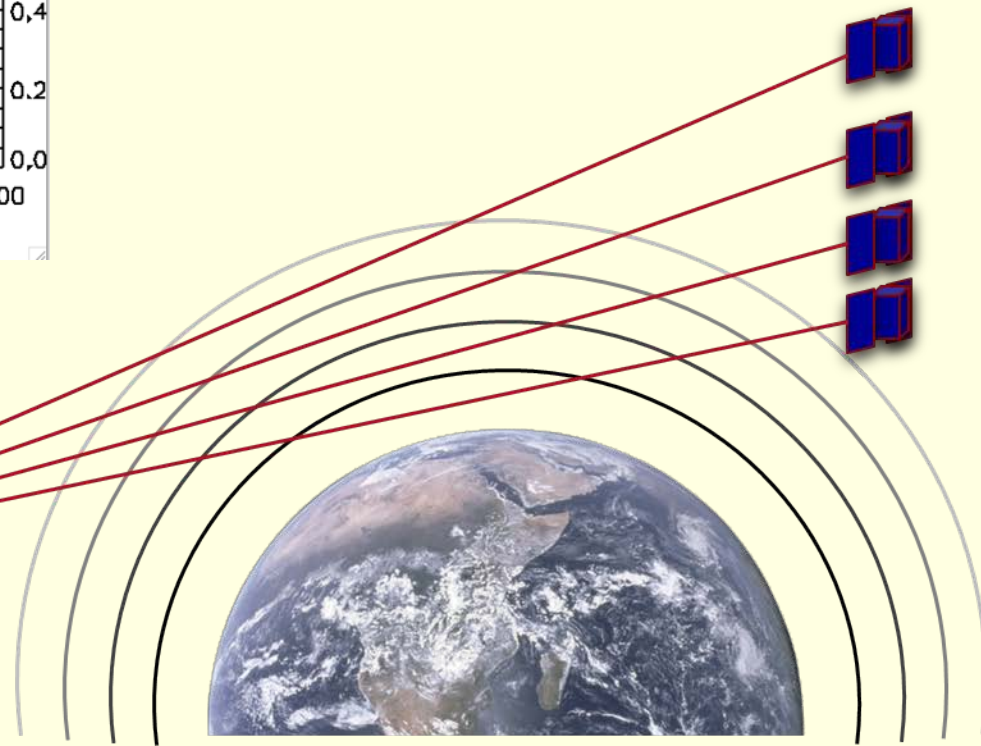
The periods at 28 days (solar rotation) and 160 days (Rieger periodicity) are well known, while a period at 100 days is not mentioned in the literature.



Occultations

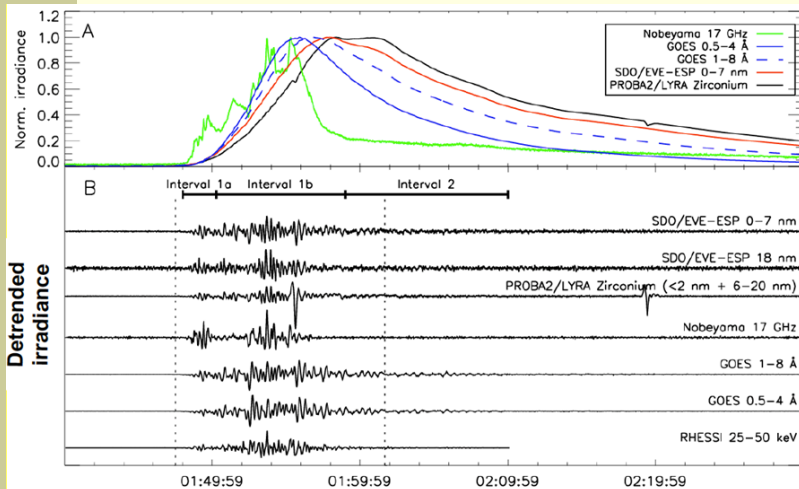


Demonstrating the evolution of spectral bandpasses

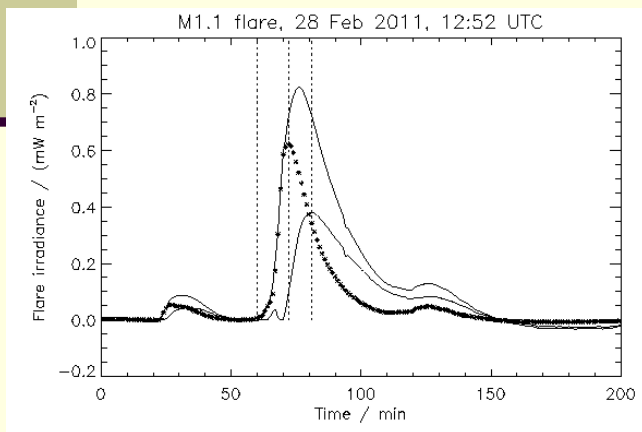




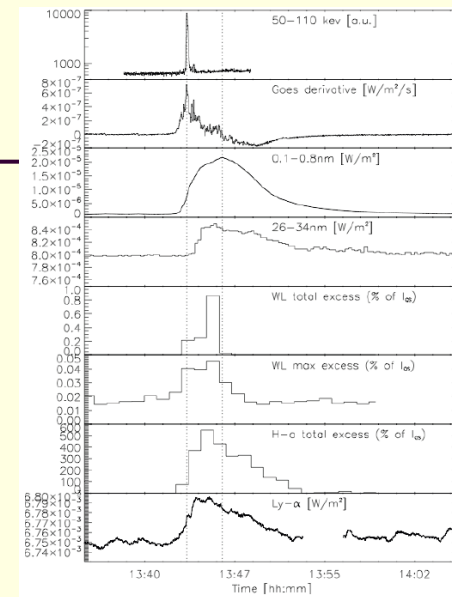
Flares



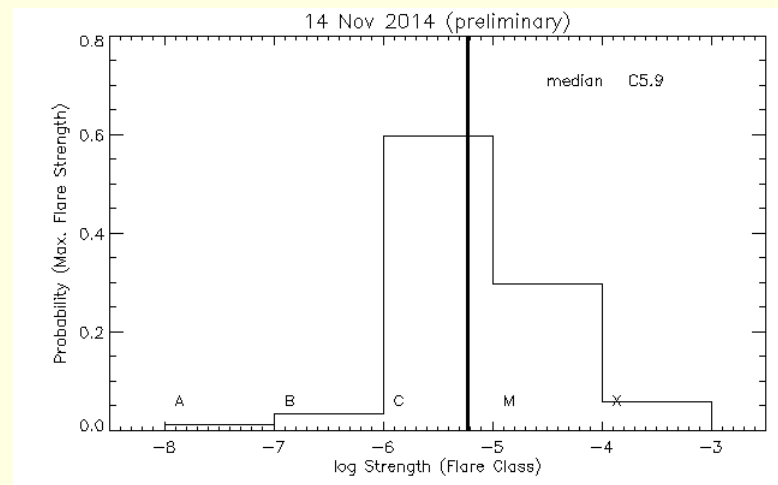
Quasi-periodic pulsations



Multi-wavelength/-temperature analysis



Detection of Lyman-alpha flares



Flare-strength forecast attempt



Reminder

- Please note:
- Poster 6, today, by M. Dominique (“High-frequency QPP”)
- Poster 17, today, by D. Ryan (“New flare detection algorithm”)
- Poster 8, Wednesday, by A. Katsiyannis (“In-situ detection of space weather”)
- The PROBA2 fair stand on Wednesday
- We will tell you how to get our data...

