Observation of the X9.3 flare on September 6 2017 in UV/EUV by PROBA2/LYRA

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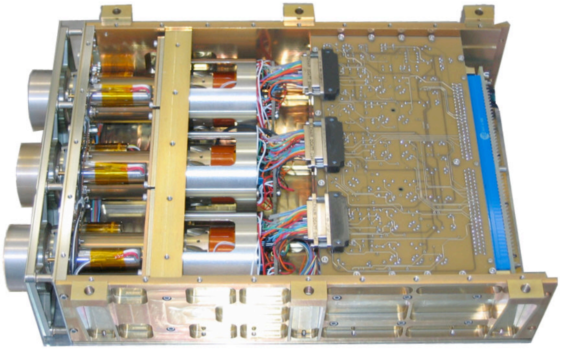
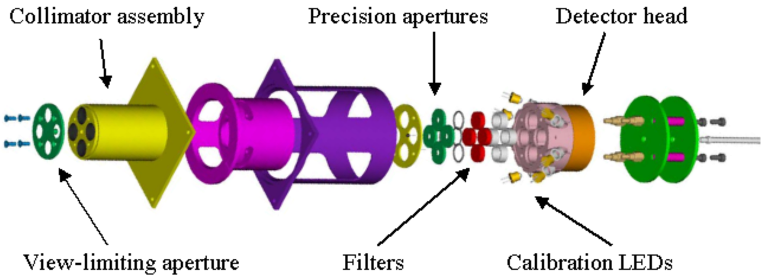
PROBA2/LYRA fact sheet

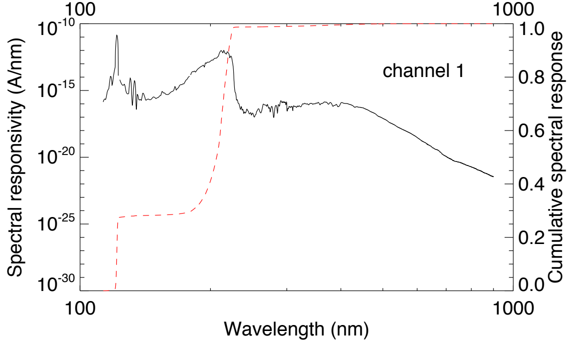




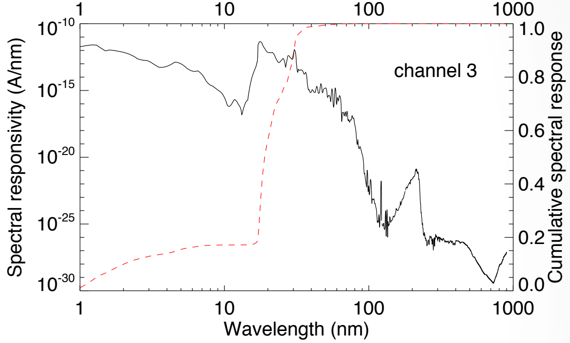
- **3 redundant units** protected by separated covers
- **4 broad-band channels**
- High acquisition cadence: **nominally 20Hz**
- 3 types of detectors:
  - standard silicon
  - 2 types of **diamond detectors**: MSM and PIN
    - radiation resistant
    - blind to radiation > 300nm
- **Calibration LEDs** with λ of 370 and 465 nm

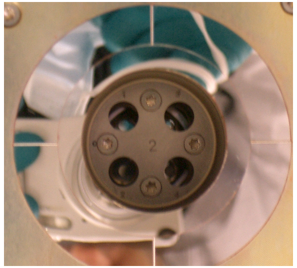
LYRA channels spectral response to quiet-Sun

Channel 1 – Lyman alpha: 120-123 nm

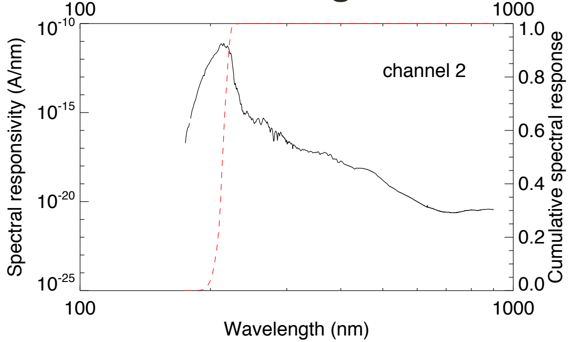


Channel 3 – Aluminum: 17-80 nm + < 5nm

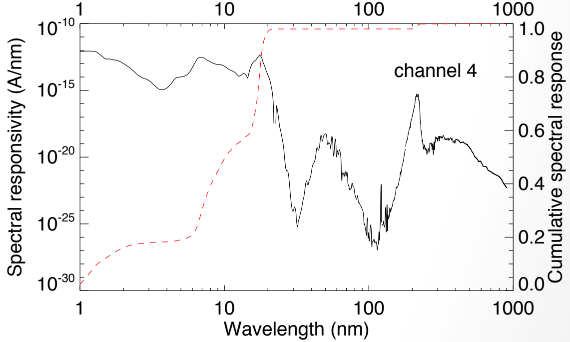




Channel 2 – Herzberg: 190-222 nm

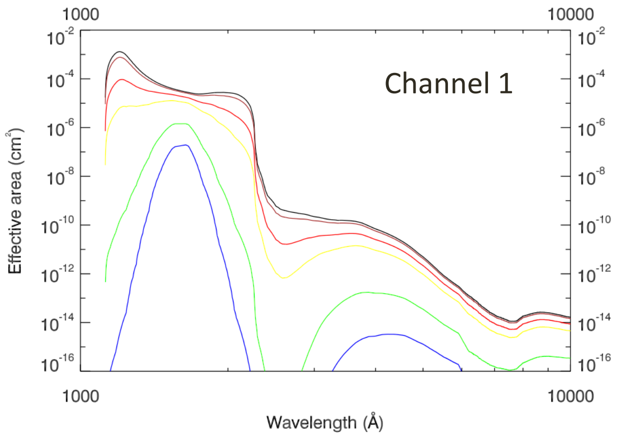


Channel 4 – Zirconium: 6-20 nm + < 2nm

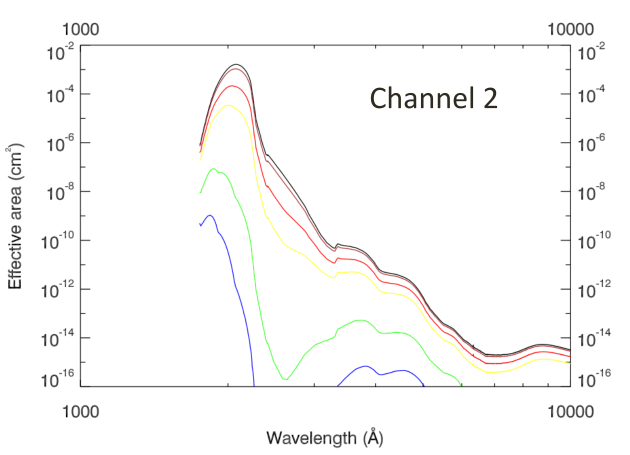


Impact of degradation: Carbon contamination

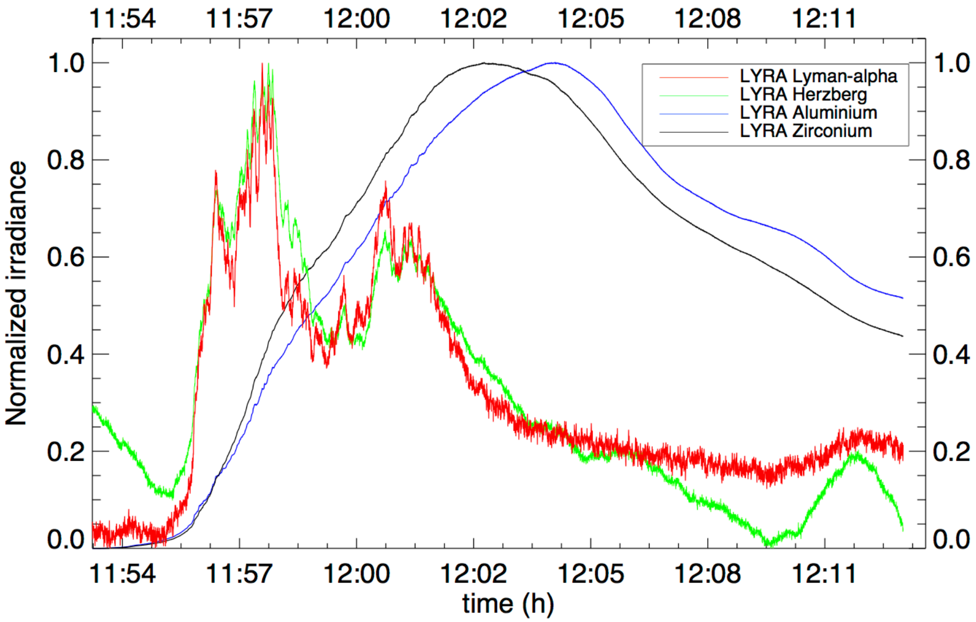
- During the flares: special observation campaign with the least degraded unit (unit 1)
- Loss of signal in channels 1 and 2: 50% and 25% respectively. Can be explained by a layer of ~10 nm of C

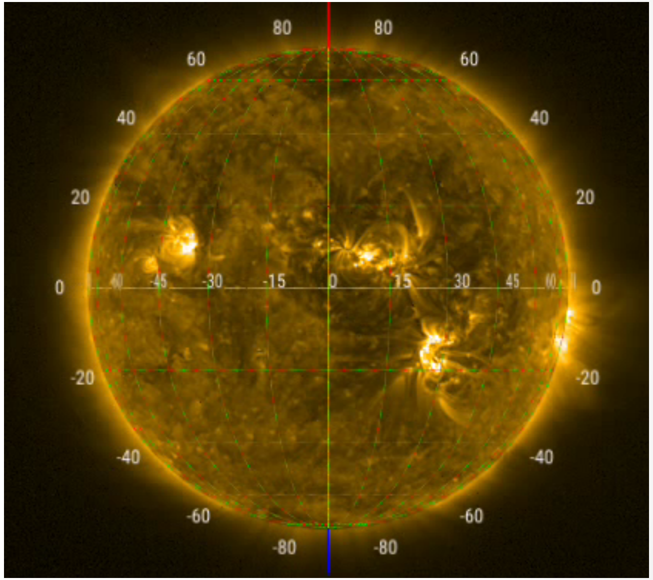


	C layer (nm)
black line	0
brown line	10
red line	50
yellow line	100
green line	300
blue line	500



The X9.3 flare on September 6, 2017 as seen by PROBA2





PROBA2/SWAP

Seen in all four channels of LYRA, first flare seen by the channel 2 (herzberg channel)!

Origin of the flare emission in channel 2

- Hypotheses:
  - The flare signal in this channel primarily comes from an increase of the H Balmer continuum
  - Emission is produced by an optically dense chromospheric slab of thickness L ≈ 130 km (density scale height)
  - T = 10000 K
  - Emitting surface estimated on SDO/HMI observations = 400 Mm^2

$$E_{\lambda,cont} = \left[\frac{6.48 \times 10^{-14}}{4\pi\lambda^2}\right]\left[\frac{n_e^2 L T^{-3/2}}{n^3}\right] \times exp\left[\frac{1.58 \times 10^5}{n^2 T}\frac{1.44 \times 10^8}{\lambda T}\right] \times S$$

Kerr and Fletcher, 2014

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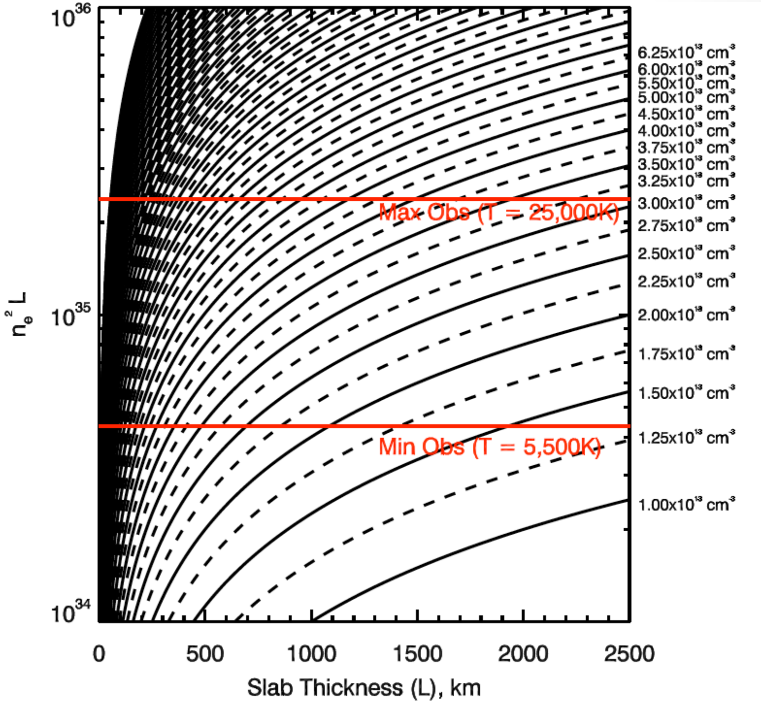

Kerr and Fletcher, 2014

Origin of the flare emission in channel 2

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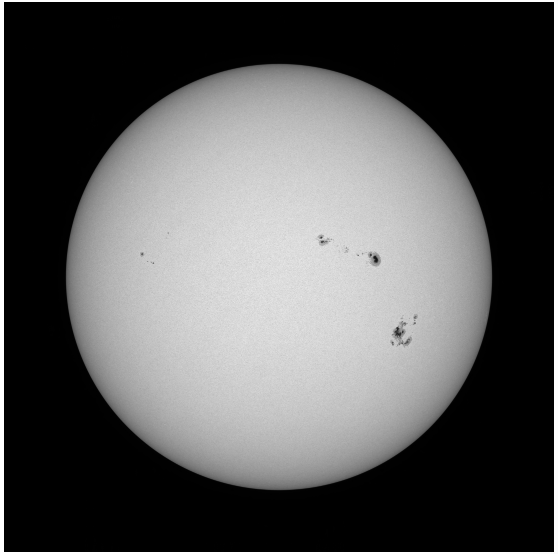
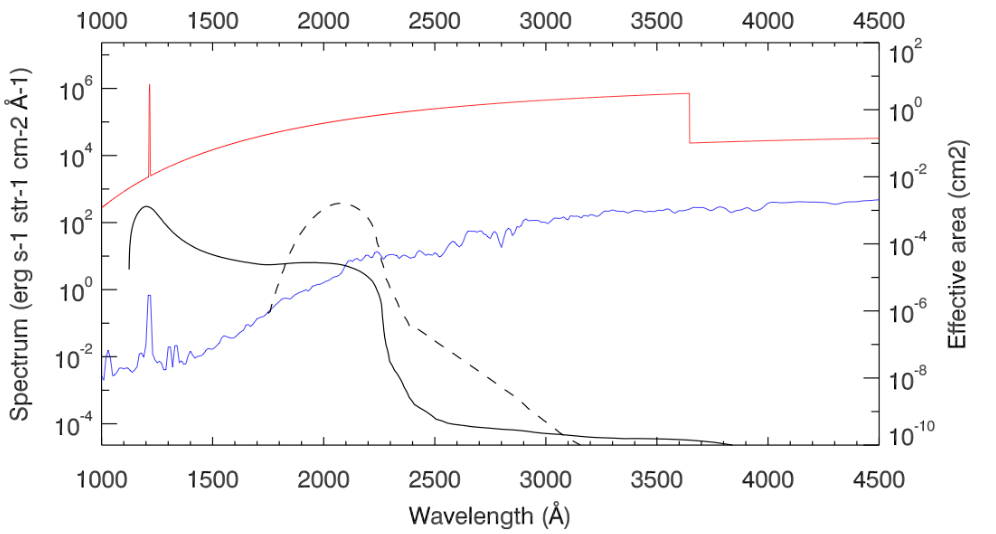
  - The flare signal in this channel primarily comes from an increase of the H Balmer continuum
  - Emission is produced by an optically dense chromospheric slab of thickness $L \approx 130$ km (density scale height)
  - $T = 10000$ K
  - Emitting surface estimated on SDO/HMI observations = 400 Mm^2



Origin of the flare emission in channel 2

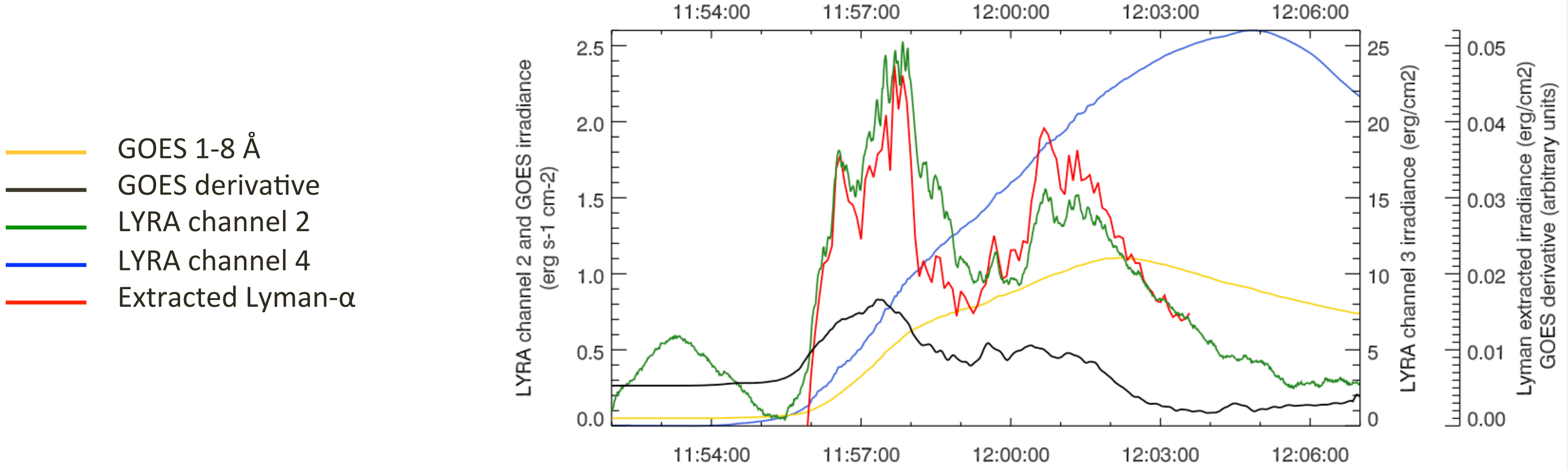
- Determination of n_e:
  - The modeled spectrum multiplied by the channel spectral response and integrated over the passband matches the measurements:

=> n_e at peak time ≈ 10^{13} cm^{-3}



Realistic, comparable to other similar studies (e.g. Neidig et al., 1993; Kerr and Fletcher, 2014; Heinzel et al., 2017)

Extraction of the out-of-band contribution from channel 1



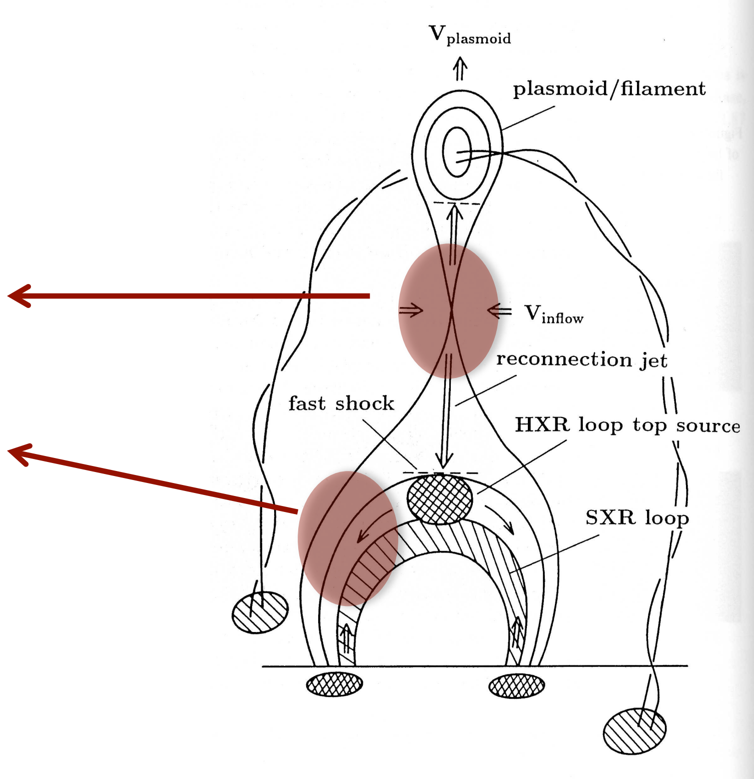
channel	Bandpass in Å	Pre-flare irradiance in $erg\ s^{-1}cm^{-2}$	Peak irradiance in $erg\ s^{-1}cm^{-2}$	Flare increase in $erg\ s^{-1}cm^{-2}$	Flare increase in %
channel 1 (Lyman alpha)	1200 – 1230[b]	6.85	6.92	0.07	0.97
channel 2 (Herzberg)	1900 – 2220	690.1	692.6	2.5	0.35
channel 3 (Aluminum)	1 – 800	4.2	30.0	25.8	614.3
channel 4 (Zirconium)	1 – 200	1.45	25.5	24.05	1658.6
extracted Lyman-α	1200–1550	-	-	0.05	-
GOES	1 – 8	0.00023	0.44	0.43977	191204.3

Quasi-periodic pulsations (QPPs)

Two main mechanisms evoked (see e.g. Nakariakov and Melnikov, 2009) :

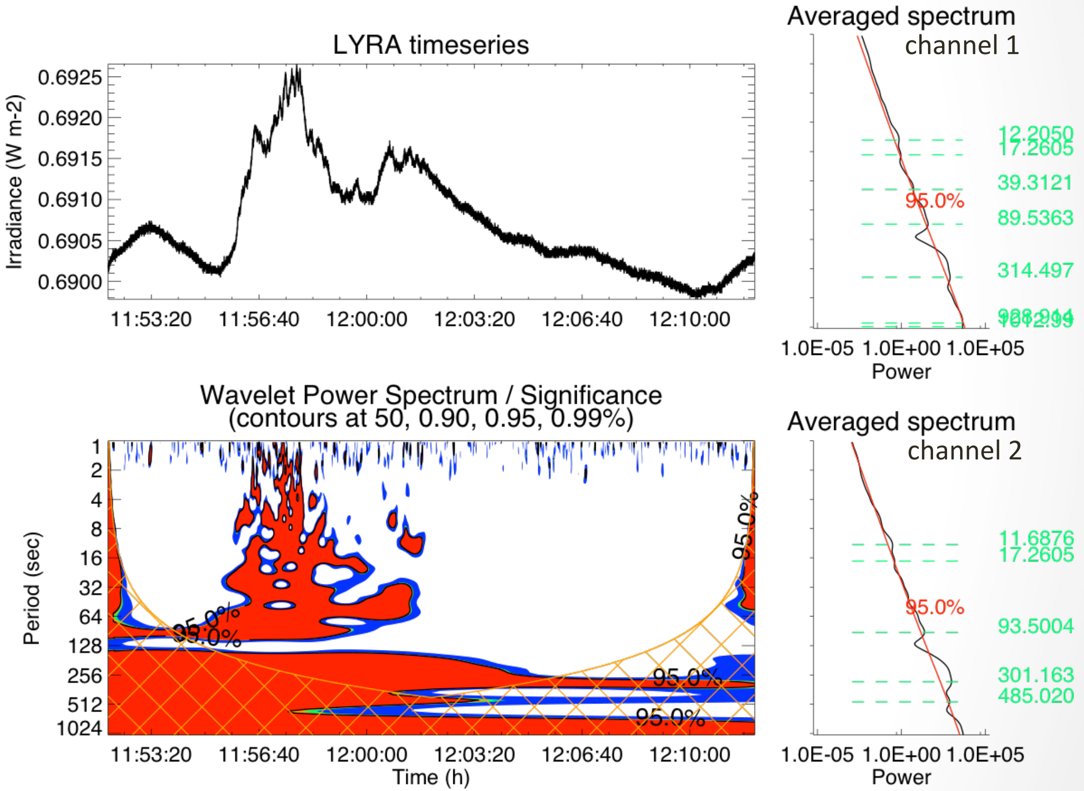
1. Reconnection = quasi-periodic process
2. Modulation of the electron beam and loop system by an MHD wave

Usually easier to detect in non-thermal emission (bigger amplitude)



QPPs in channels 1 and 2

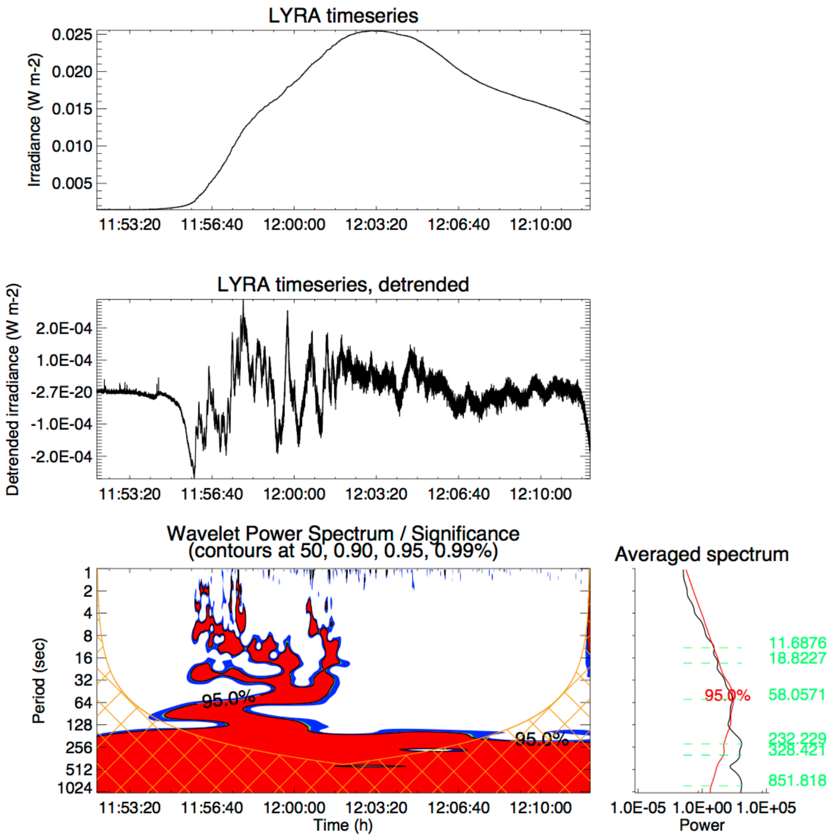
- No detrending needed
- Common periods detected: 12 s, 17 s, 90 s and 300 s
- One additional period in channel 1: 40 s
- Period at 300 s might be linked to the acoustic cut-off frequency of the chromosphere
- Periods consistent with Kolotkov et al., 2018



QPPs in channel 4

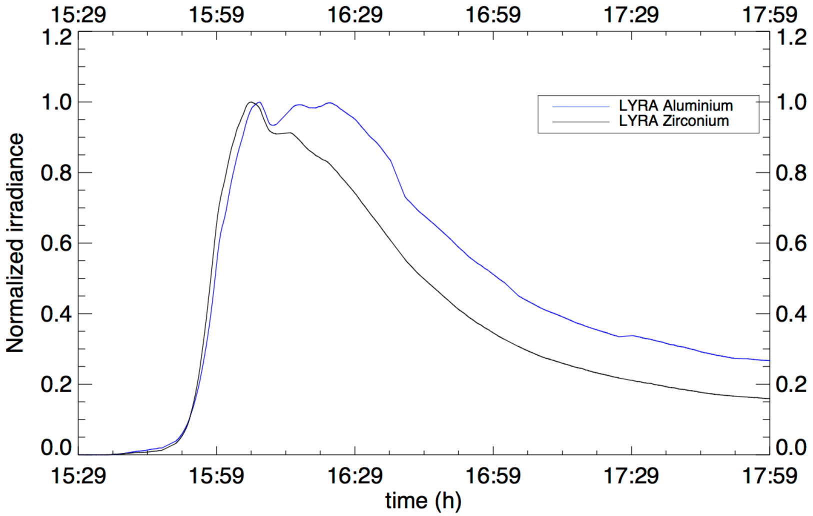
- Detrending needed (here 60 s)
- Periods at 12 s and 19 s consistent with the ones of channels 1 and 2
- Detection at 58 s caused by the detrending process

(Dominique et al., 2018)



X8.2 flare on September 10, 2017

- No signature in LYRA channels 1 and 2
- Flare behind the limb (at least one footpoint occulted)



Conclusions

- We report on the first flare signature observed in the channel 2 of LYRA
- This flare also produced a signature in Lyman-α
- Most of the flare emission seen in the channel 2 is associated to an increase of the H Balmer continuum
- QPPs were observed in all four channels of LYRA, in particular periods of ~12 and ~19 s.

Thank you!