# Cross-calibration of LYRA with SEE and EVE

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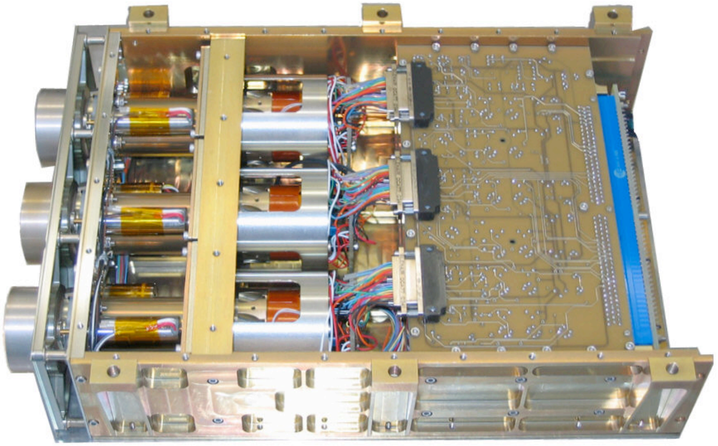
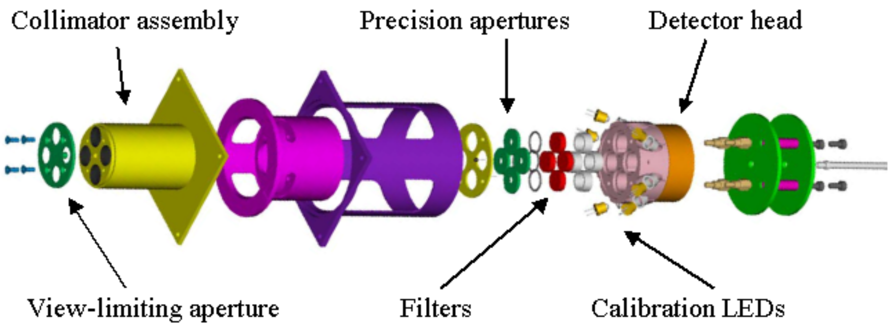
# LYRA highlights

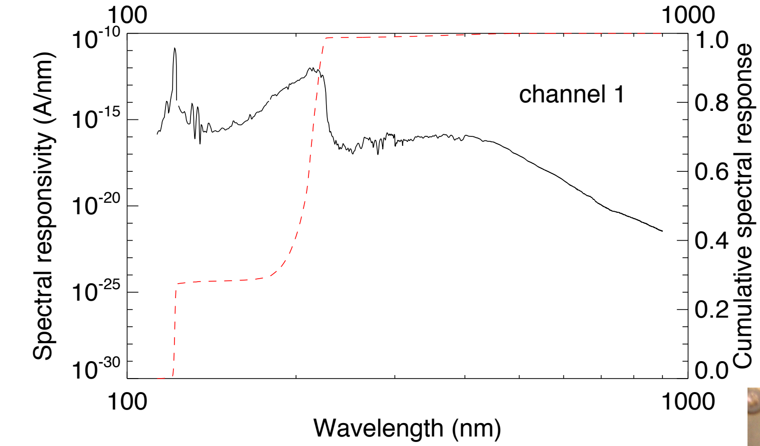




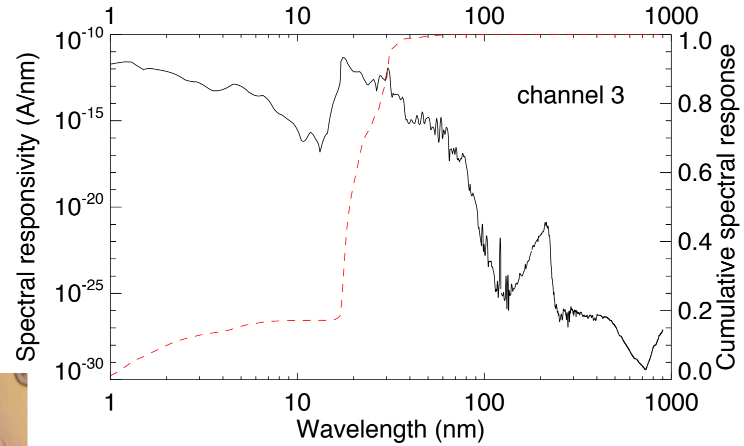

- **3 redundant units** protected by separated covers
- **4 broad-band channels**
- High acquisition cadence: **nominally 20Hz**
- 3 types of detectors:
  - standard silicon
  - 2 types of **diamond detectors**: MSM and PIN
    - radiation resistant
    - blind to radiation > 300nm
- **Calibration LEDs**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

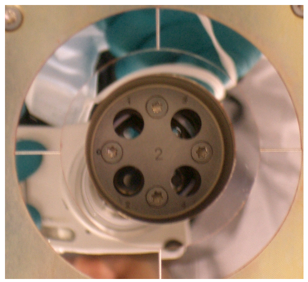
# Details of LYRA channels multiplied by a quiet Sun spectrum

## Channel 1 – Lyman alpha 120-123 nm

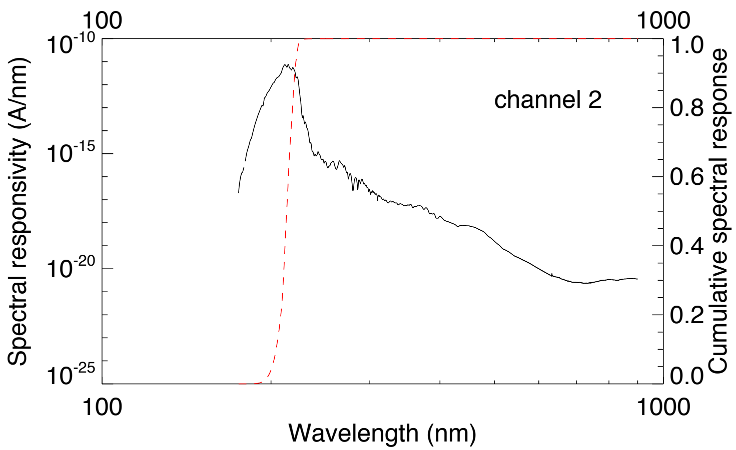



## Channel 3 – Aluminum 17-80 nm + < 5nm

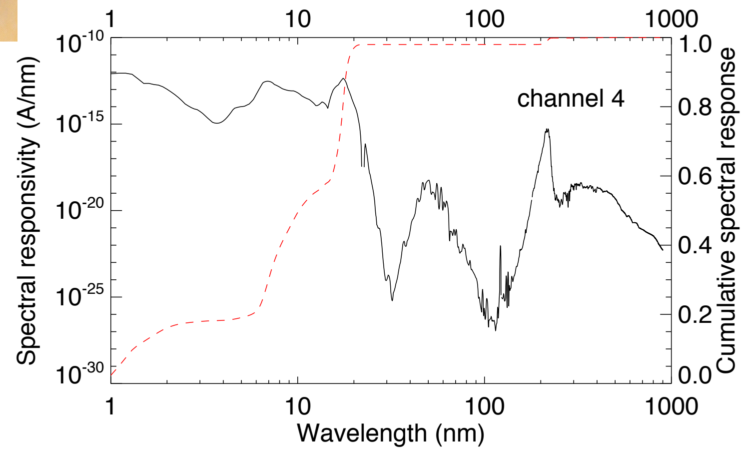


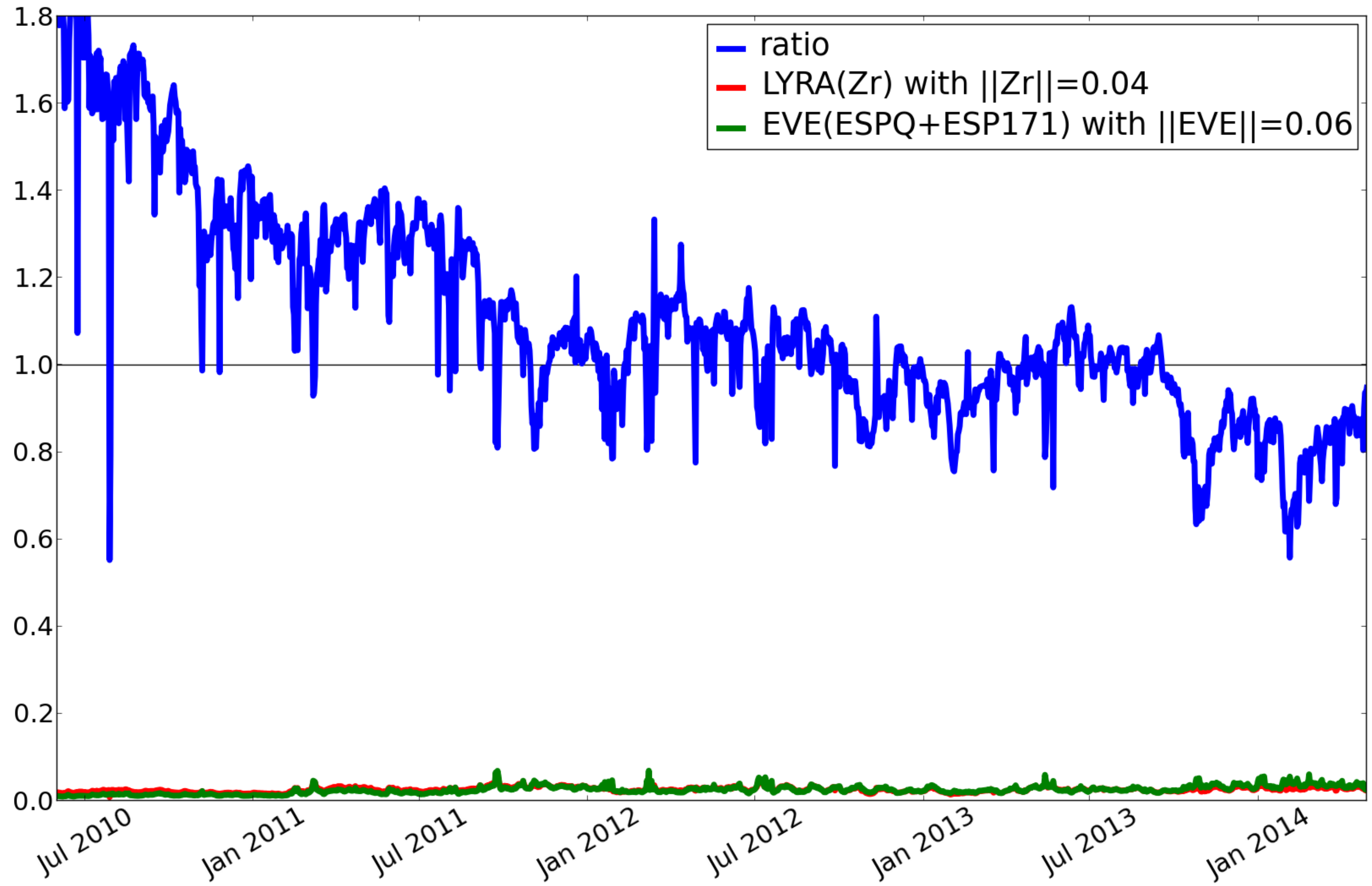
## Channel 2 – Herzberg 190-222 nm




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

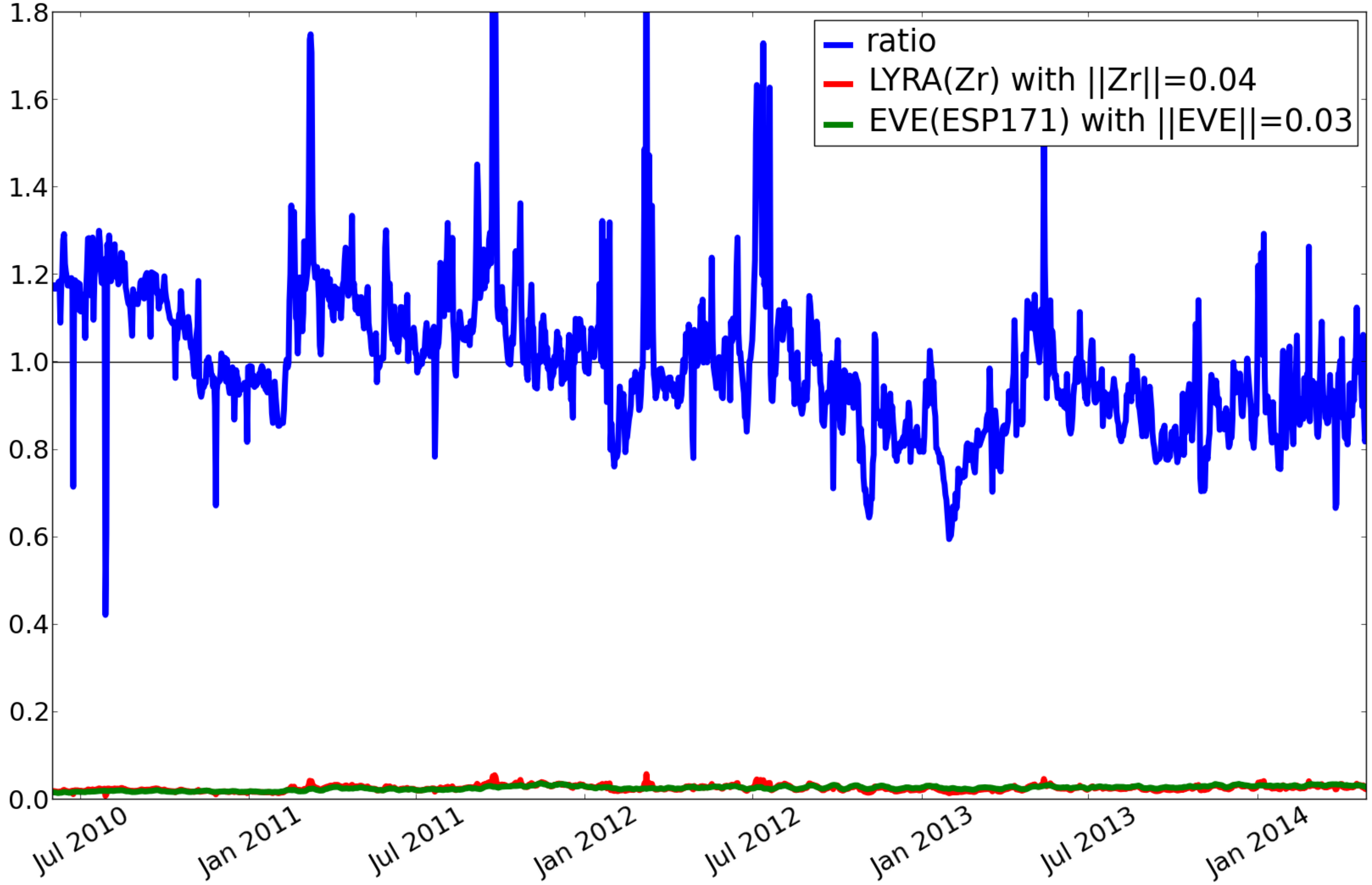


# Comparison LYRA to ESPQ(0.1-7nm) + ESP 171 of EVE



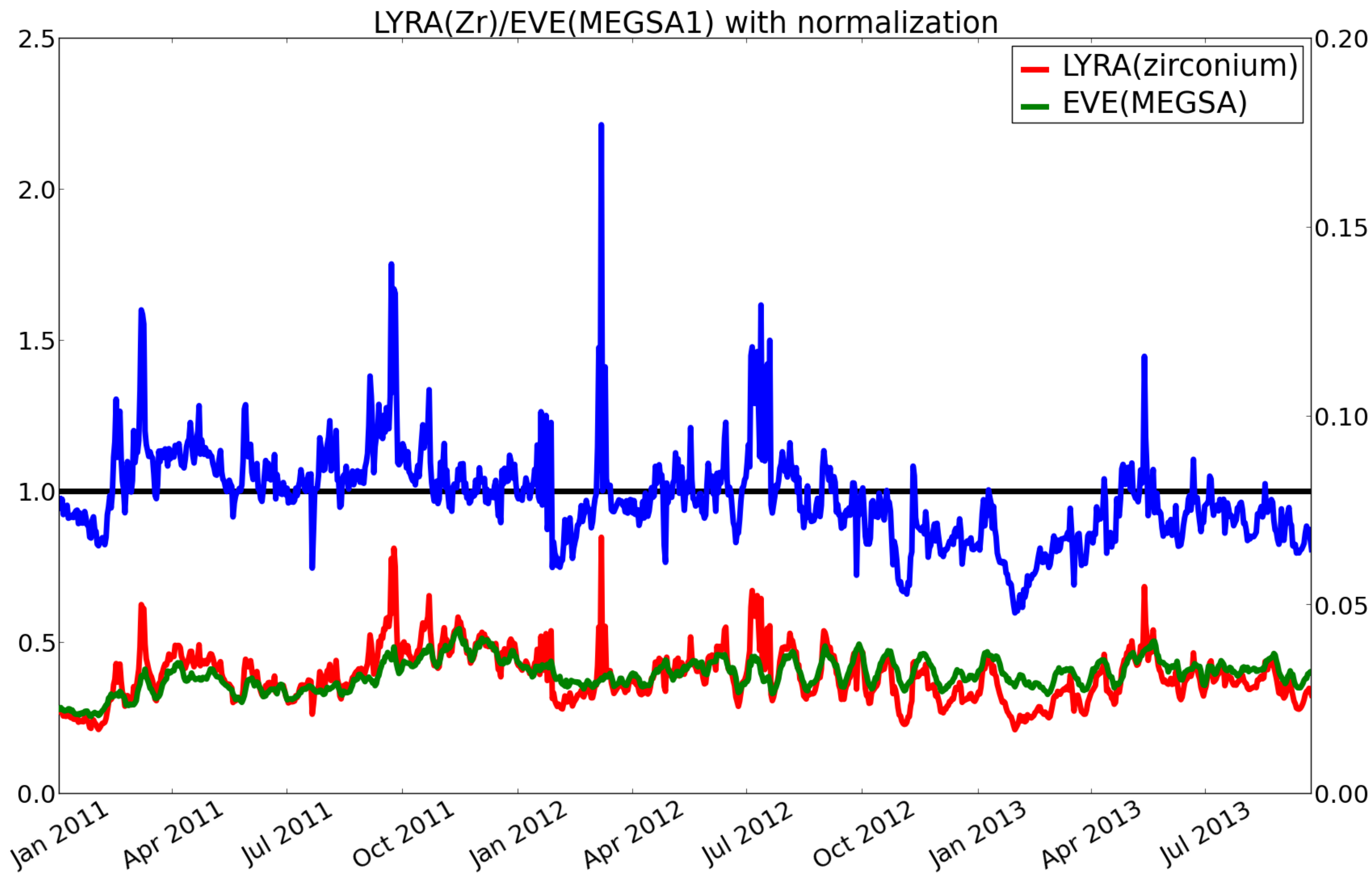

- X-Ray flares taken into account.
- Decrepency before August 2011.

# Comparison LYRA (zirconium: 6-20nm) to EVE (ESP171)



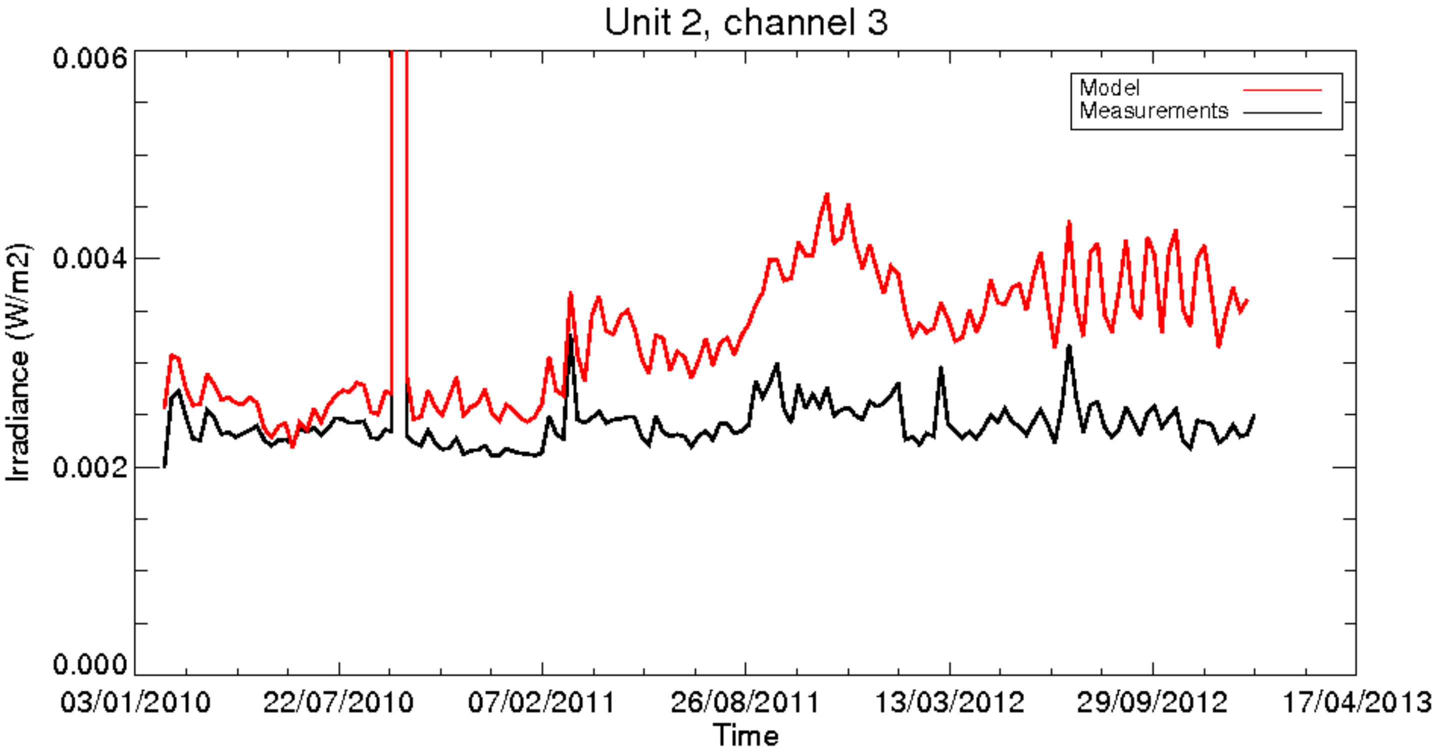

- X-Ray flares are taken into account in LYRA.

# Comparison between LYRA(zirconium) and EVE (MGSA)




- X-Ray flares taken into account in LYRA.
- Otherwise ratio close to one.

# Reconstruction of LYRA channel 3




The effect of degradation is still present on the long term!

# Degradation affecting the nominal unit (diamond detectors)

Remaining response after 1500 *days*:

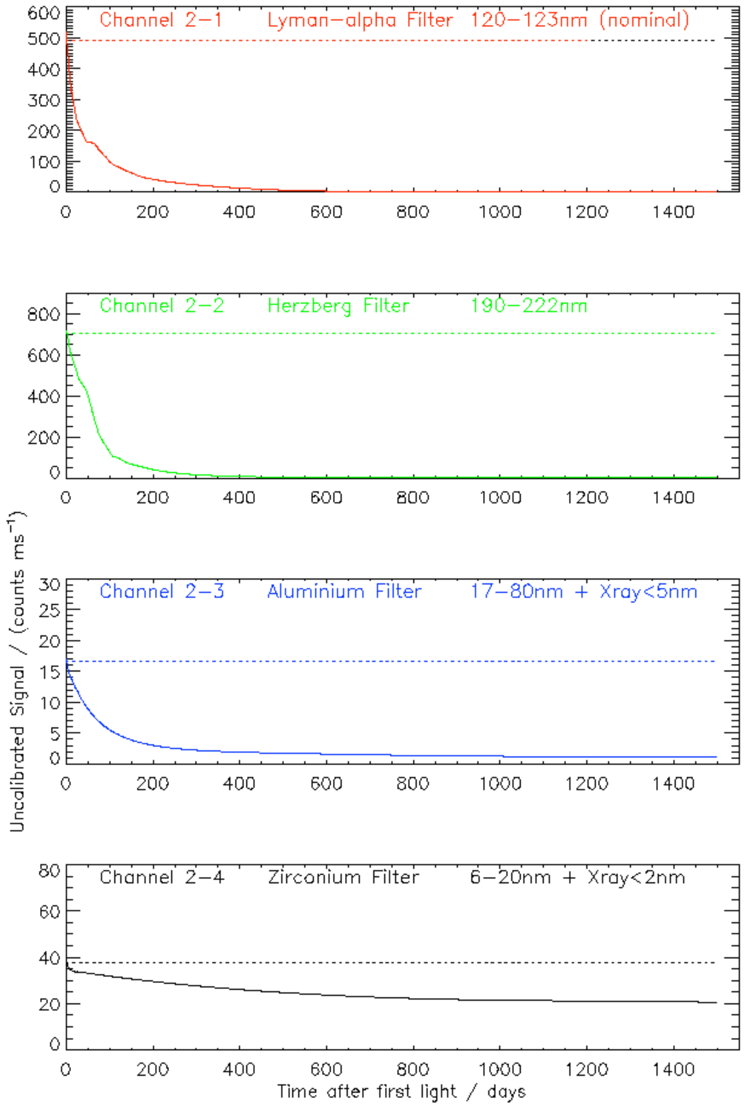
ch2-1 < 0.5%

ch2-2 < 0.5%

ch2-3 7%

ch2-4 53%

The most important source of degradation (by far!) is contamination!



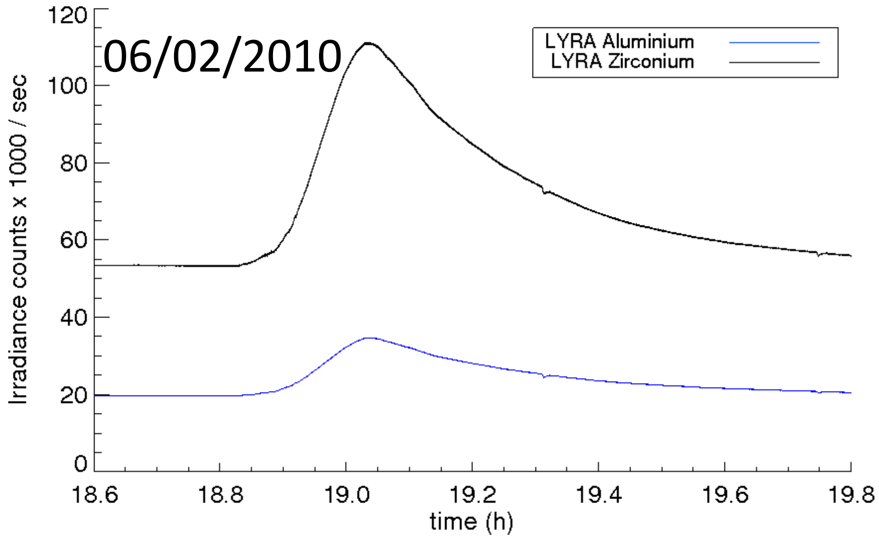
# Calibration

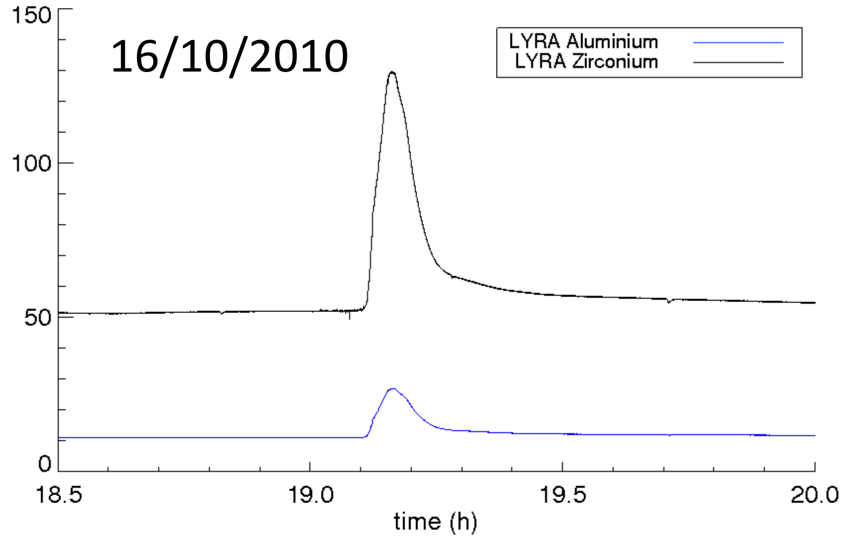
**Includes:**

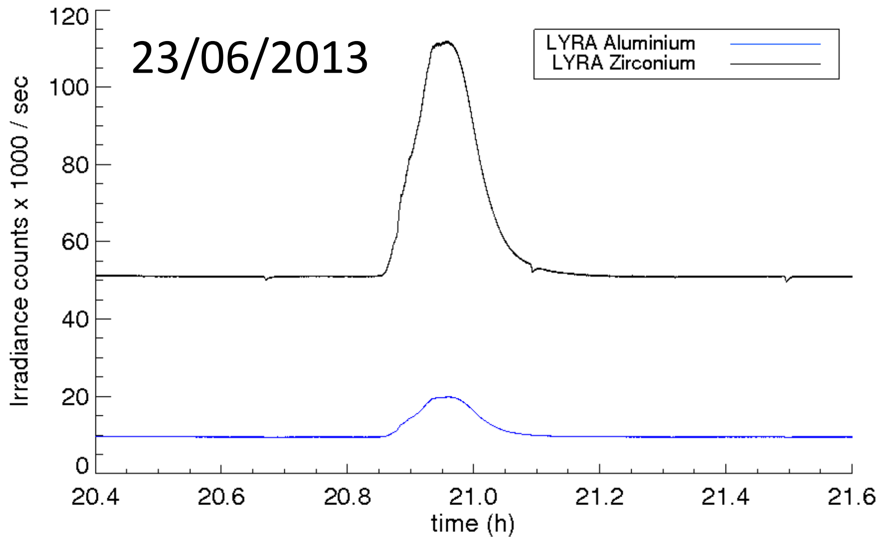
- Dark-current subtraction
- Rescaling to 1 AU
- Conversion from counts/ms into physical units (W/m2)

  WARNING: this conversion uses a synthetic spectrum from SORCE/SOLSTICE and TIMED/SEE at first light
- **Additive correction of degradation**

# Why an additive correction?



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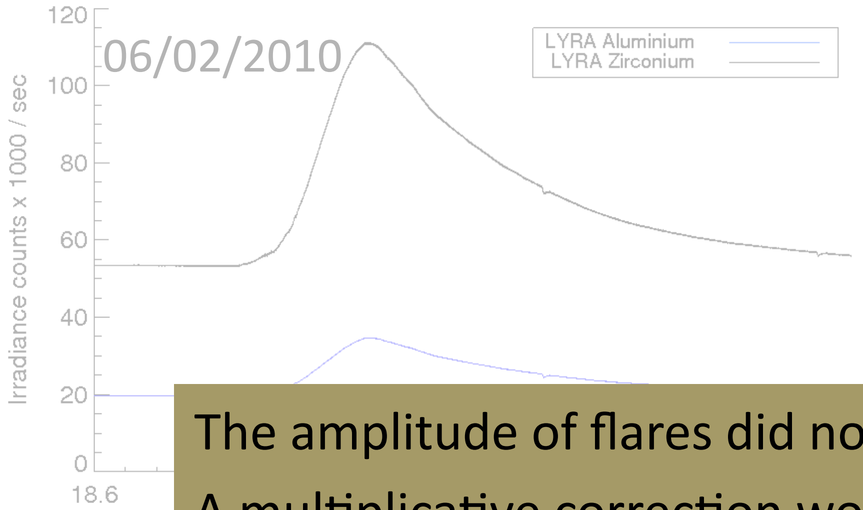
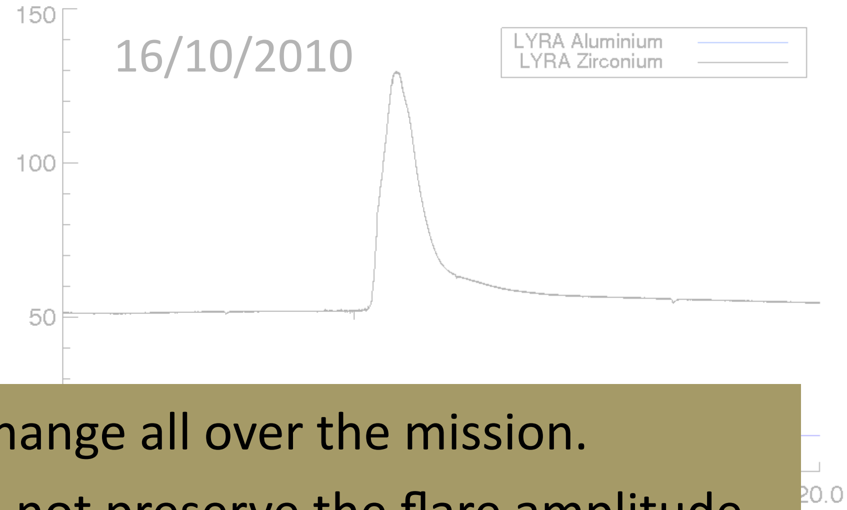
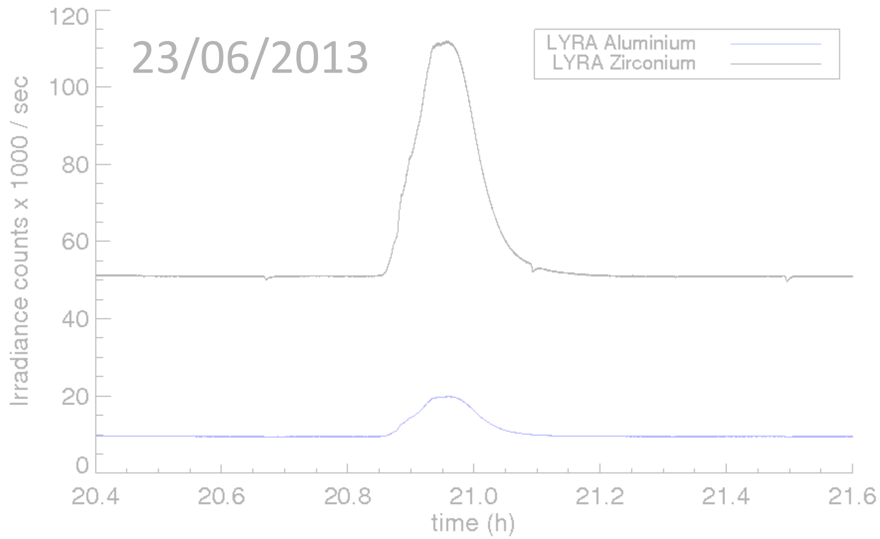


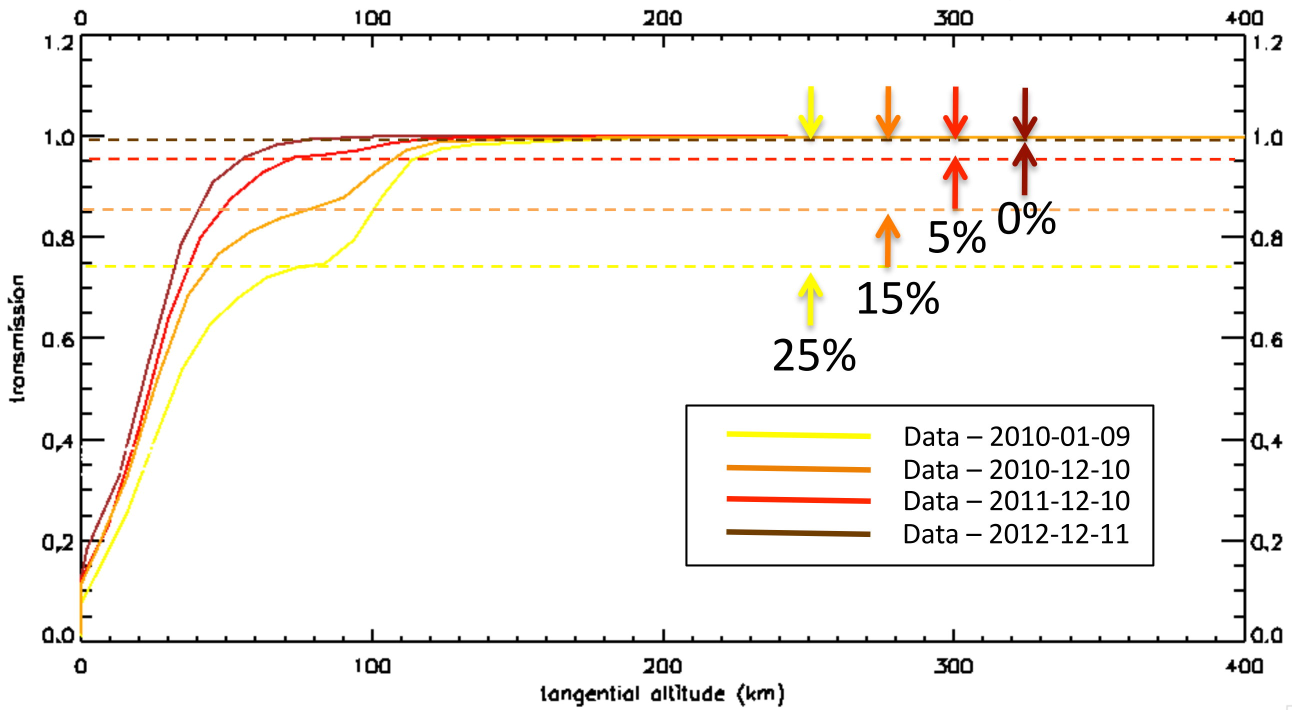




The amplitude of flares did not change all over the mission.

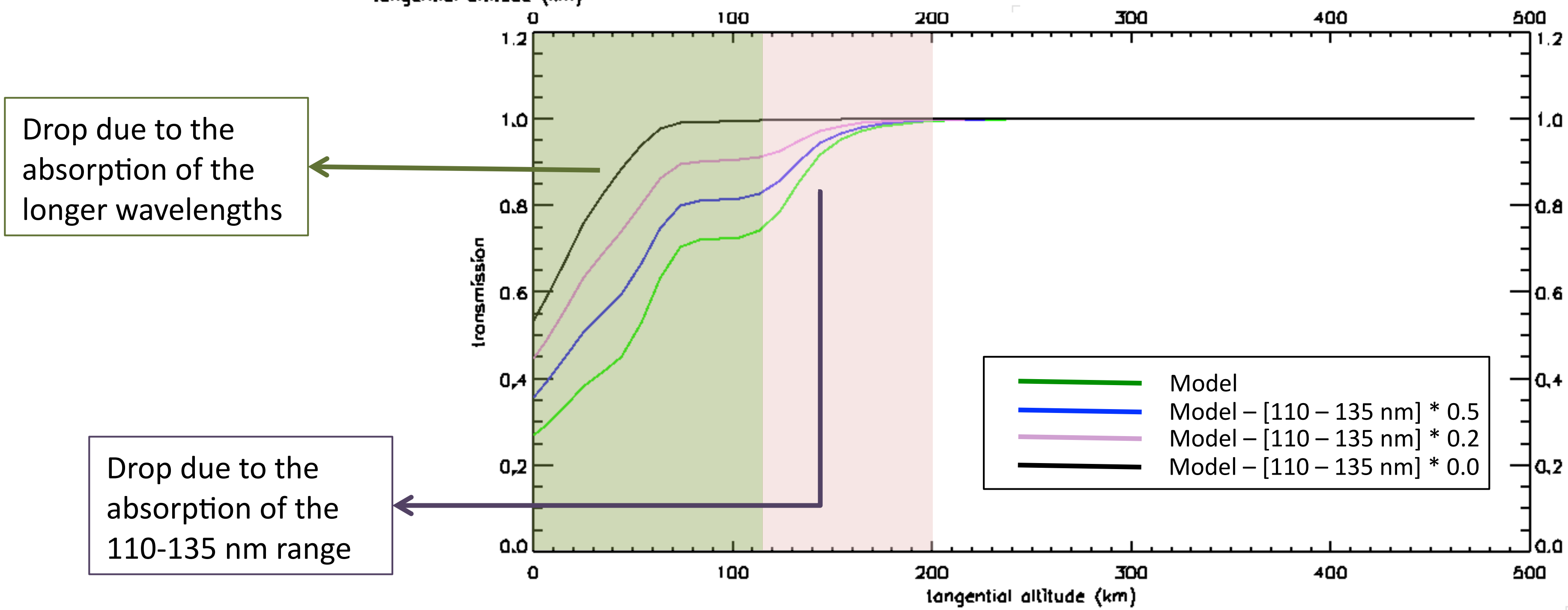
A multiplicative correction would not preserve the flare amplitude.



# Spectral degradation



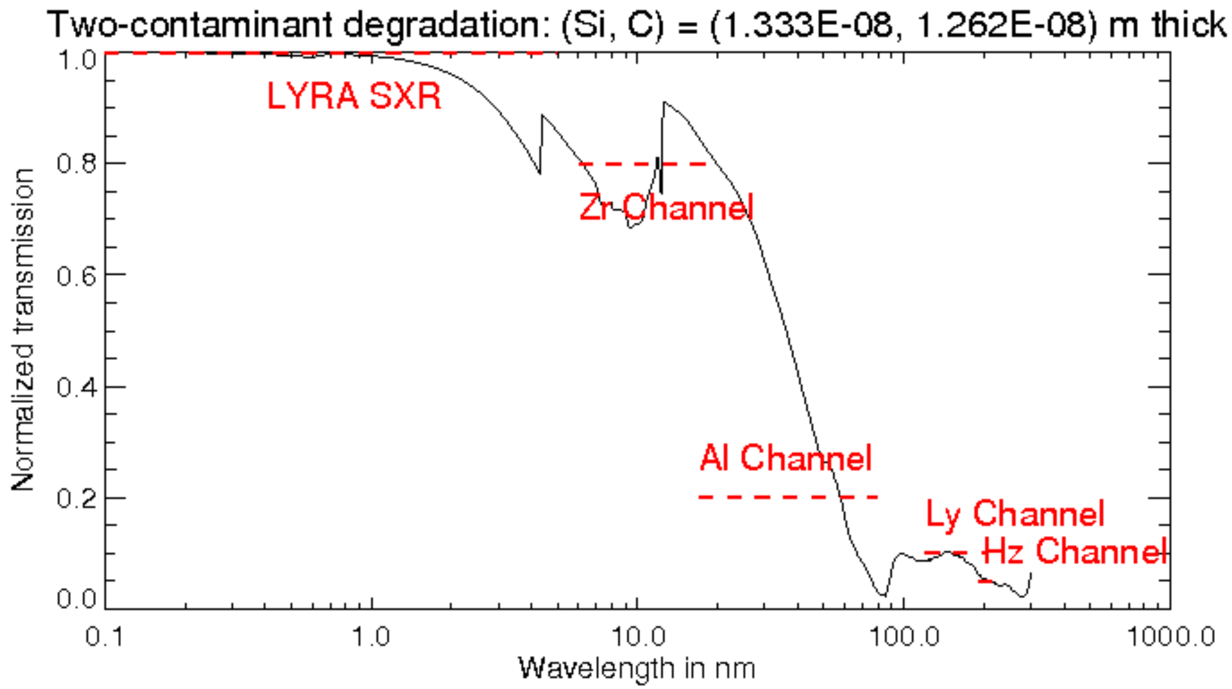

The evolution of the purity of the channel can be estimated from the occultation profile



# Model of degradation due to a contaminant layer

Two identified candidates, both in the front door mechanism:

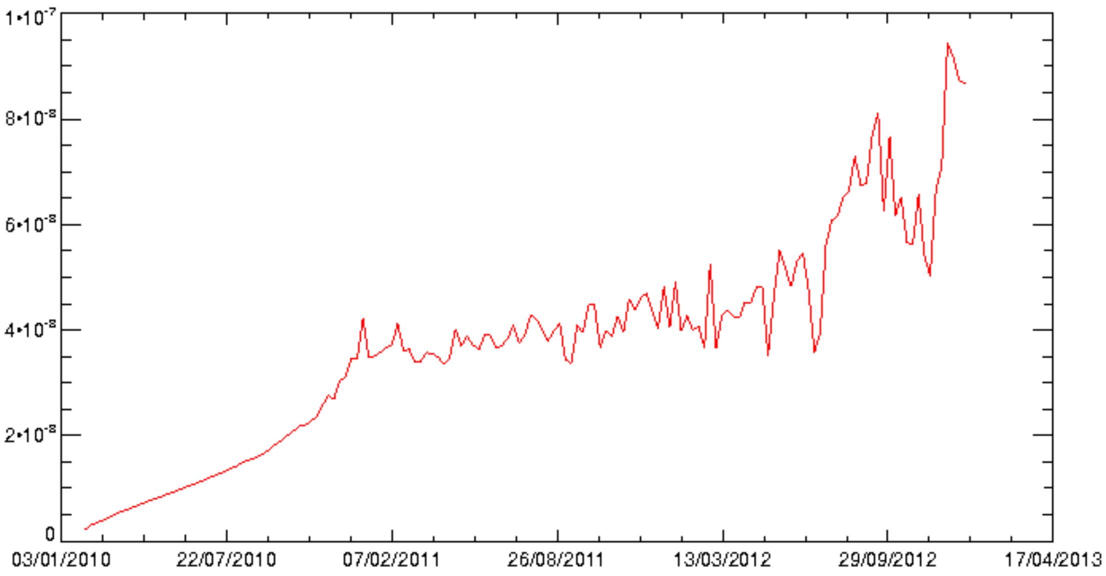
- Silicone RTV566
- EpoxyAV138 / HV 998




Henke et al (1993), Palik (1991), Hubbell et al. (NIST website), Boller K. et al. (1983)

# Model of degradation due to a contaminant layer

- Evolution of the contaminant layers with time



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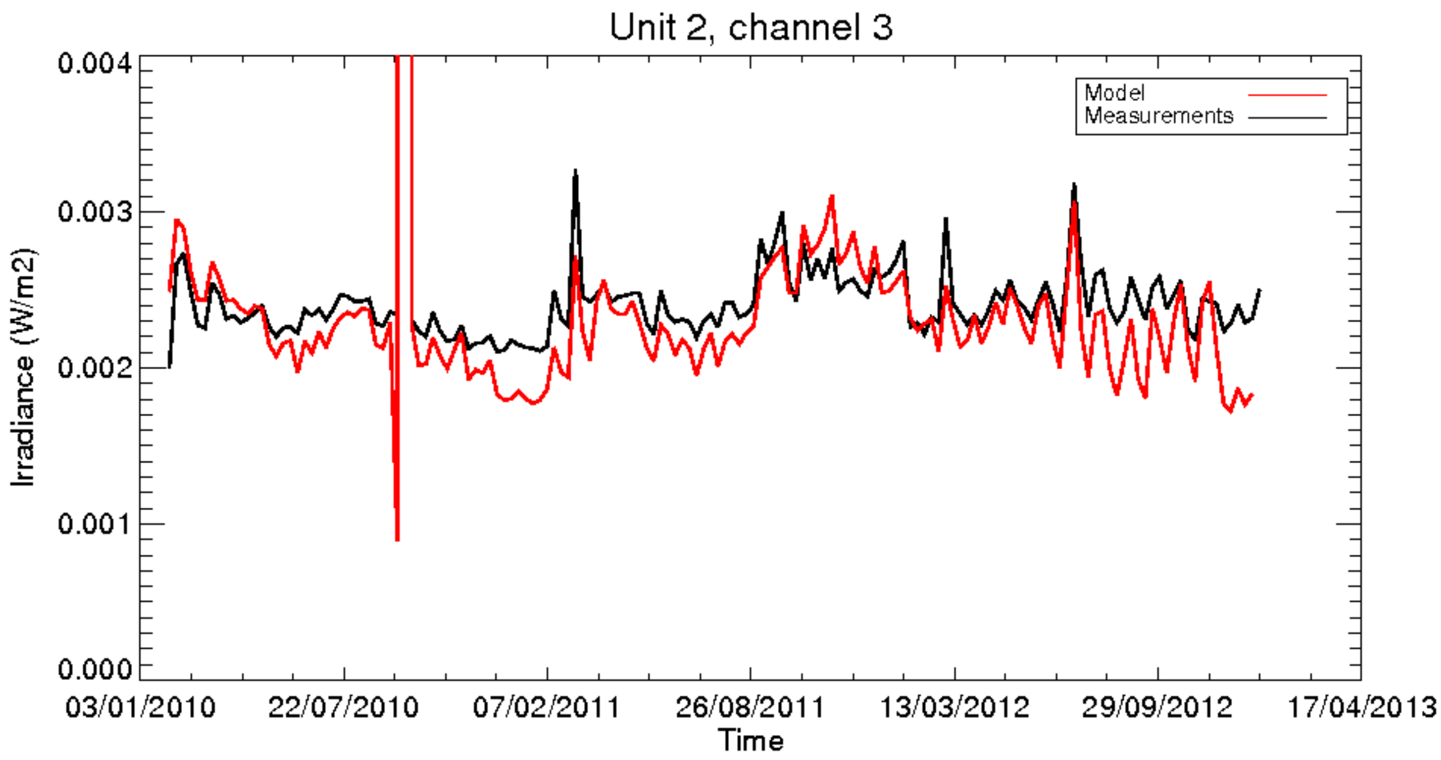

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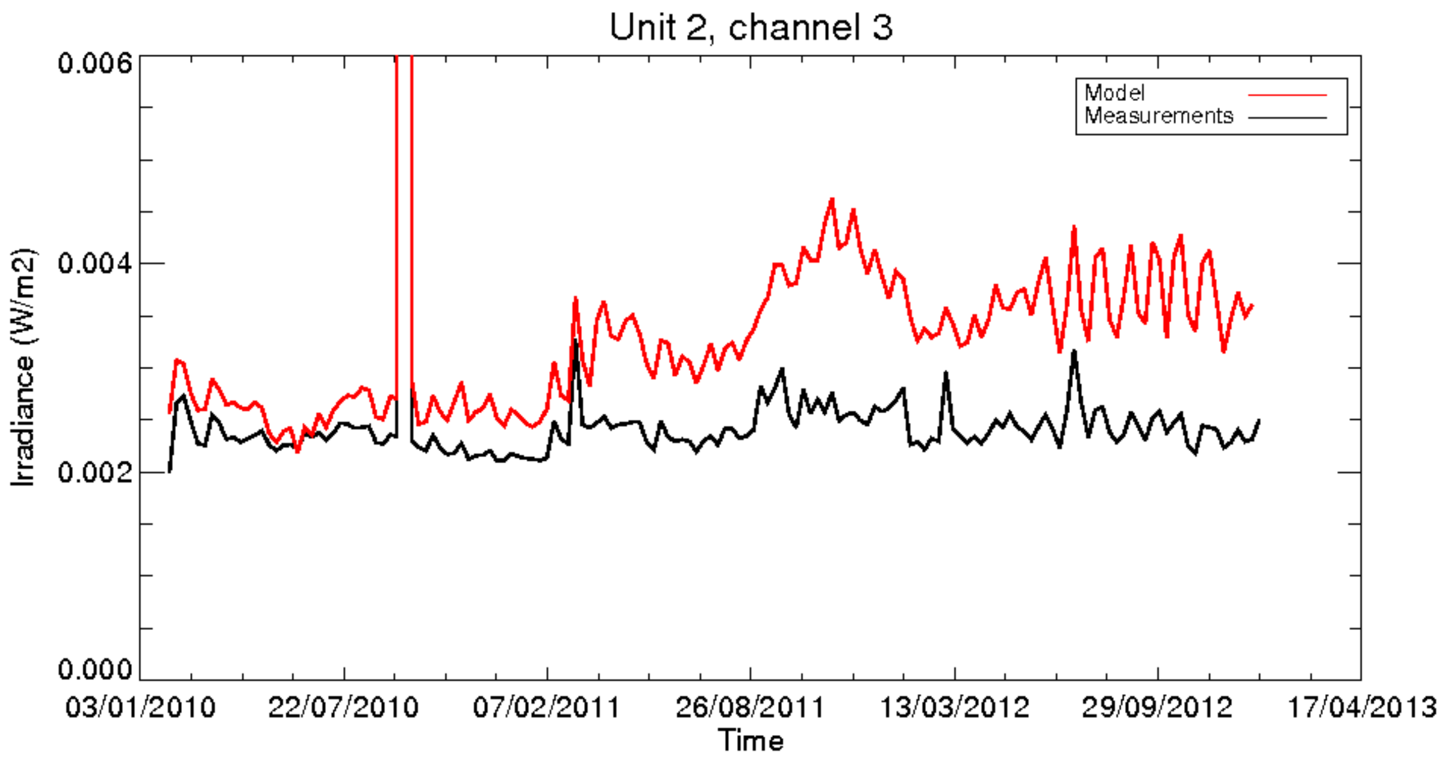


The effect of degradation is still present on the long term!

# How can we use this model for calibrating LYRA data?

- We need an external solar spectrum
  - Option 1: we rely on a general pre-defined spectrum
    - The correction can be applied in “real-time”
    - Does not take into account the evolution of the solar spectrum, especially during flares
  - Option 2: we use a measured spectra
    - Not in “real-time”

# Conclusions

- How did we investigate the degradation process?
  - Dark current evolution (detector ageing)
  - Response to LED signal acquisition (detector spectral evolution)
  - Spectral evolution (detector + filter evolution):
    - Occultations
    - Cross-calibration
    - Response to specific events like flares
  - Measurements in the laboratory on spare filters and detectors
- We possibly identified contaminants
- Work still in progress …

# Conclusions (2)

- Prevention of degradation
  - Strict cleanliness policy during the development, storage and transport (in purged storages) of the instrument!!! Even for cheap missions!
  - Specific material restrictions for EUV missions
  - Wide bandgap detectors are rad-hard and behave relatively well even without any cooling system
  - Use independent covers

# Conclusions (3)

- Monitoring degradation
  - Redundancy
  - Pre-launch calibration with standard facilities, extending well beyond the official limits of the bandpass … if possible repeated right before the launch
  - In-flight monitoring: use independent covers and well-known stable sources, cross-calibration.
  - Temperature sensors close to the detectors

# Conclusions (4)

- Correction for degradation
  - Bake-out ???
  - Identification of contaminant
    - Cross-calibration
    - Occultations

# Thank you!

LYRA data are available on
http://proba2.oma.be/