Impact of the Particle Environment on LYRA Data

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PROBA2 workshop, May 04 2012, Brussels

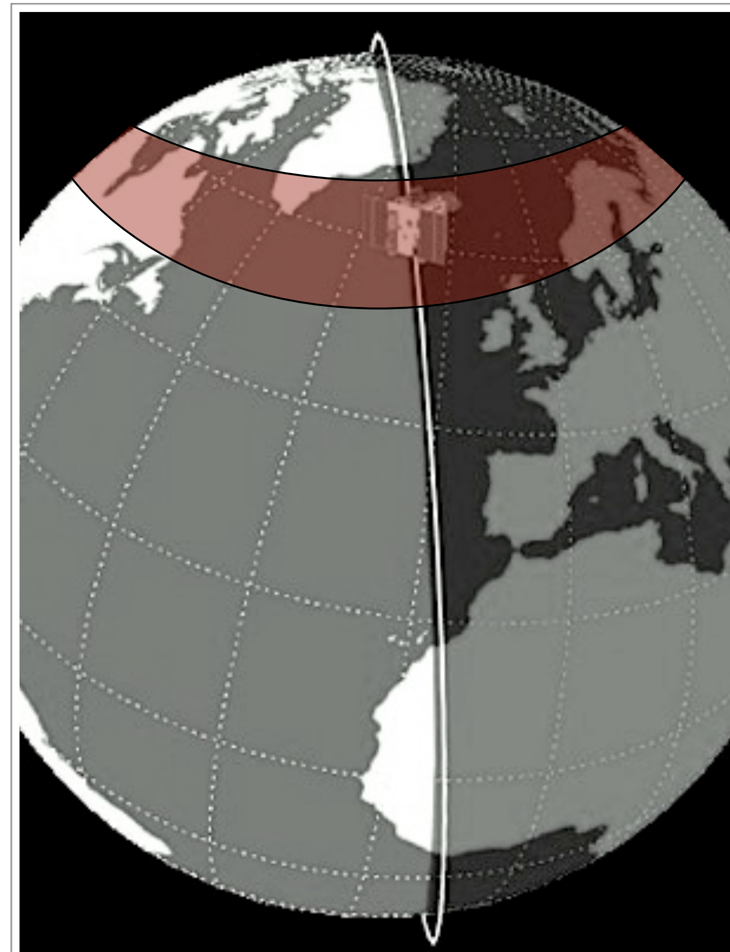
PROBA2: Project for On-Board Autonomy

PROBA2 orbit:

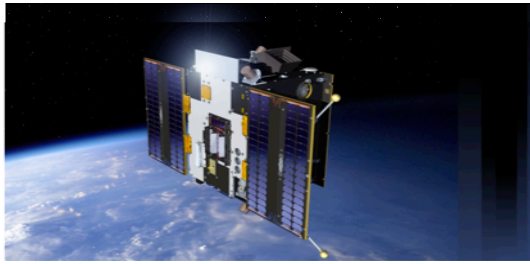
- Heliosynchronous
- Polar
- Dawn-dusk
- 725 km altitude
- Duration of 100 min

→

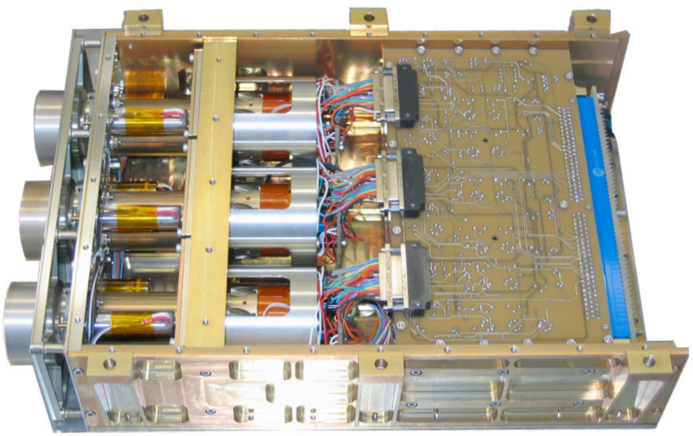
- Crosses the SAA about 8 times a day
- Crosses the auroral oval 4 times an orbit

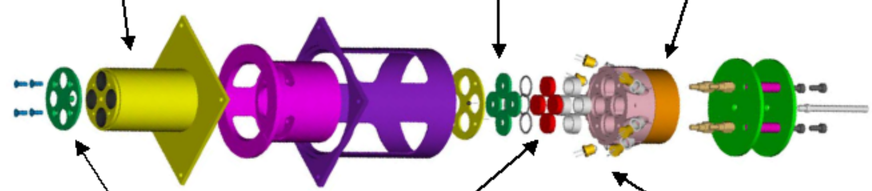


launched on November 2, 2009



LYRA highlights



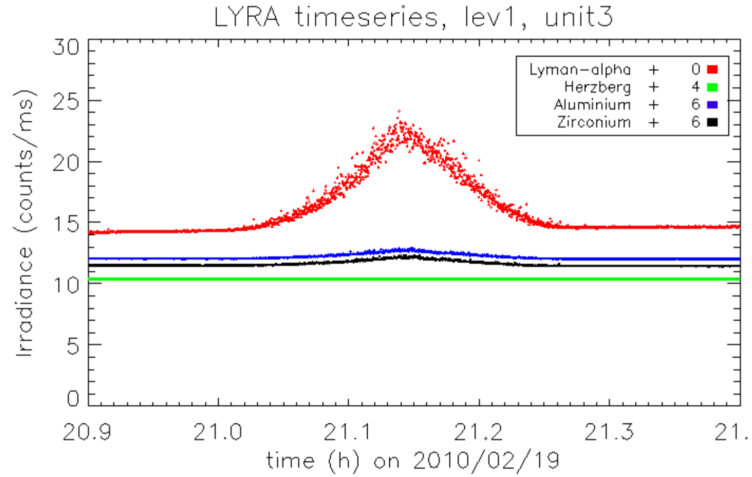


	Ly	Hz	Al	Zr
	120-123 nm	190-222 nm	17-80 nm + <5nm	6-20 nm + <2nm
Unit1	MSM - diamond	PIN- diamond	MSM- diamond	P-N Silicon
Unit2	MSM- diamond	PIN- diamond	MSM- diamond	MSM- diamond
Unit3	P-N Silicon	PIN- diamond	P-N Silicon	P-N Silicon

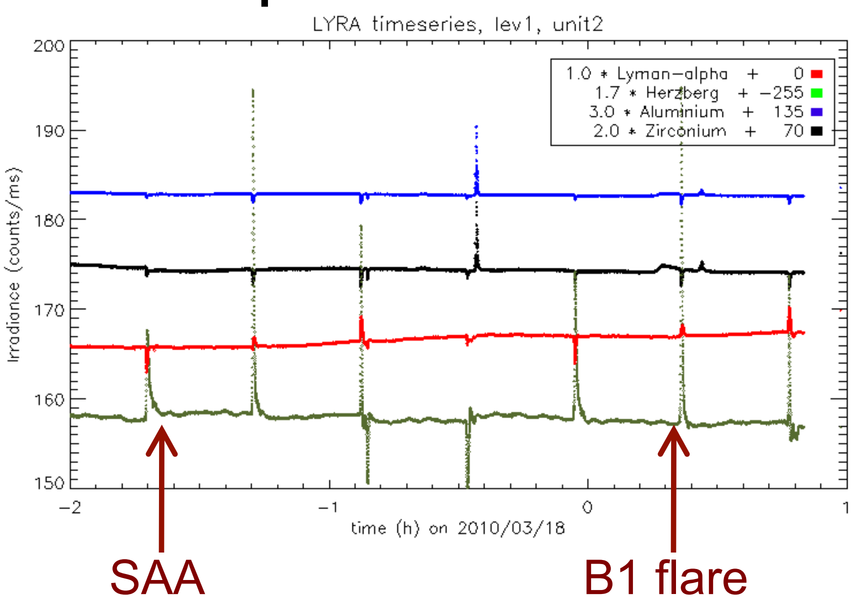
South Atlantic Anomaly

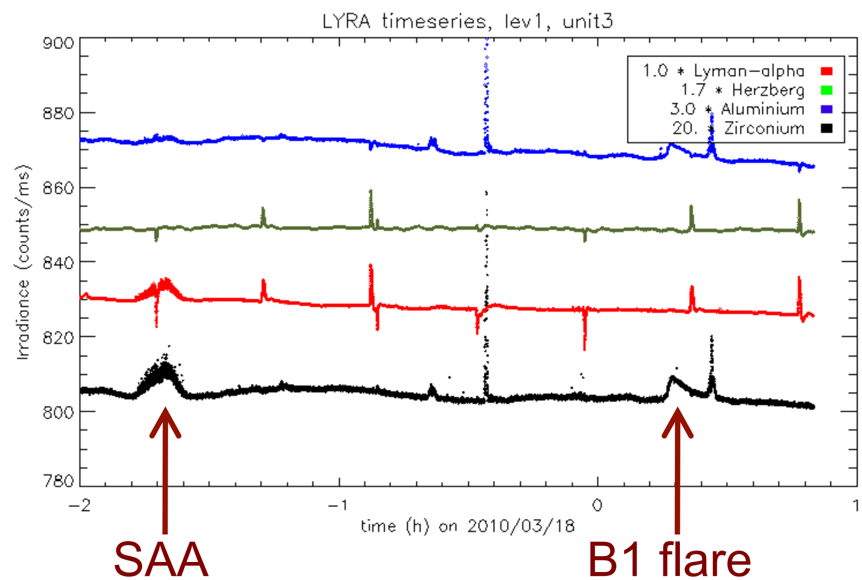
SAA: effect on LYRA

In 2010
Cover closed:



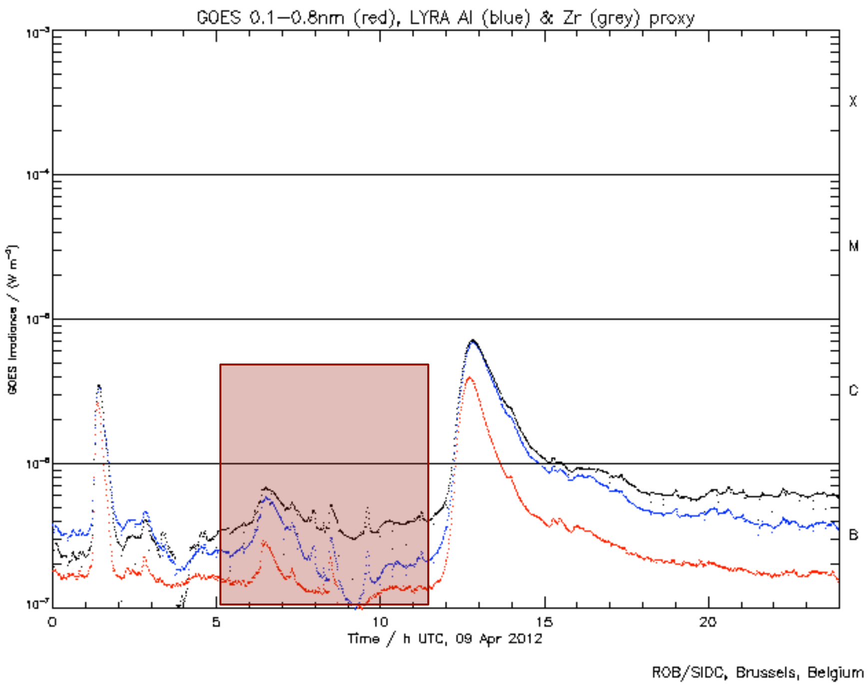
Covers open:





SAA: effect on LYRA

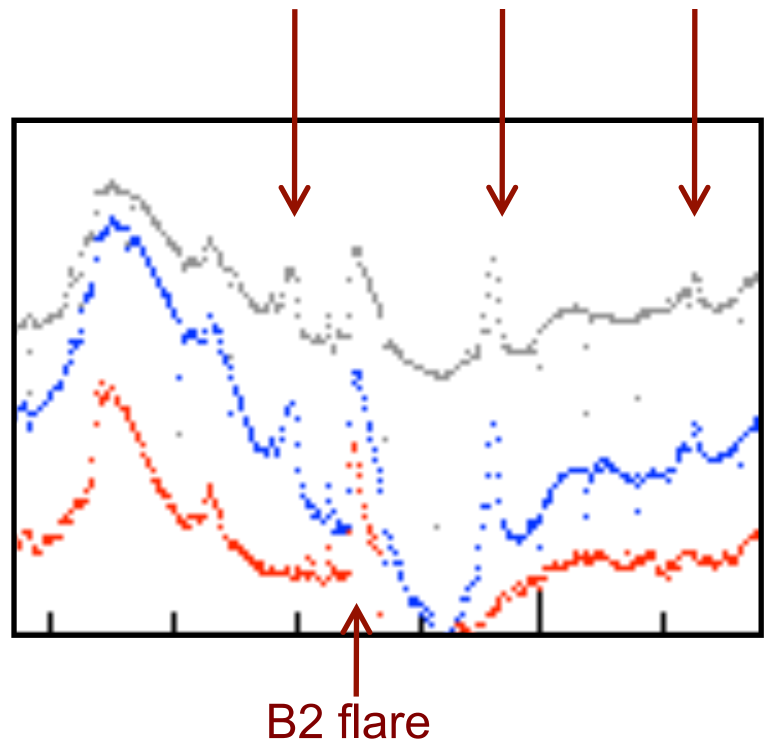
In 2012

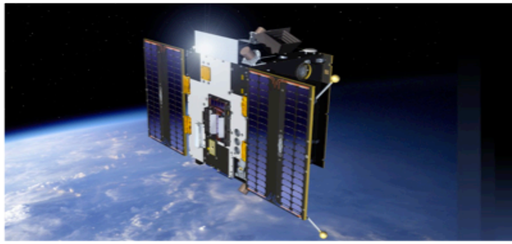


- ❑ Effect of SAA constant
- ❑ Overall responsivity decreased (ageing)

=> SAA now visible in MSM diamond detectors of the nominal unit

SAA produces peaks of amplitude equivalent to a B2 flare in unit 2



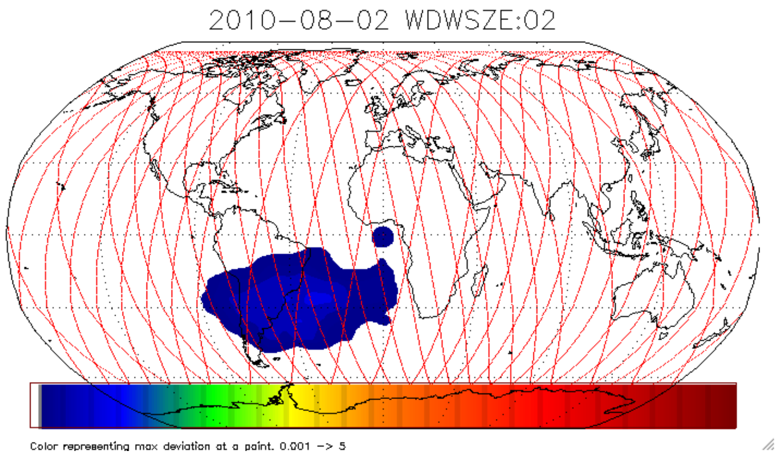


SAA summary

- Independent on the pointing direction and on the covers status
- Independent on the spectral range
- Absolute amplitude of perturbation constant over the mission (~0.5 counts/ms in Si, ~0.05 counts/ms in MSM diamond)
- Dependent on the detector material/type

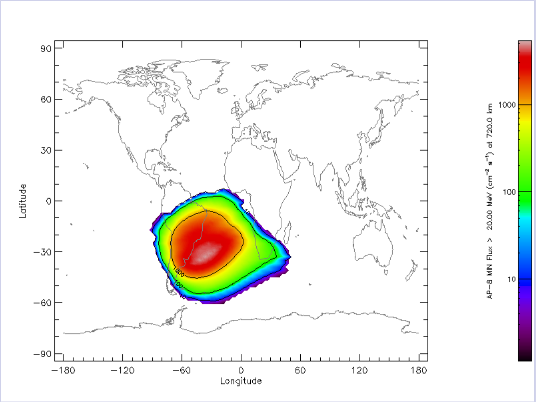
SWAP	LYRA		
	Diamond PIN	Diamond MSM	SI
✔	X	Low sensitivity	✔

SAA

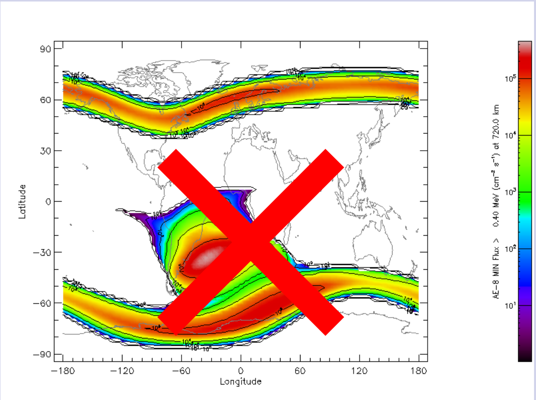


NASA AP-8/AE-8 Trapped radiation particle flux (SPENVIS)

Protons > 20MeV



Electrons > 0.4 MeV

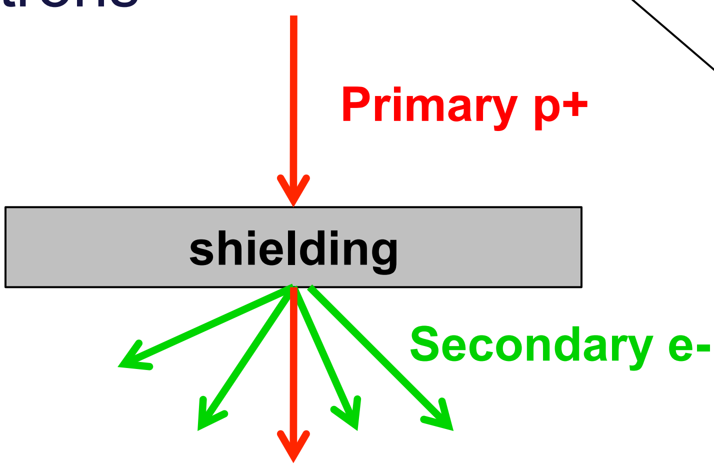


SAA

Energy deposition due to energetic protons

The surrounding shielding causes:

- ❑ slowdown the protons
- ❑ generation of secondary electrons



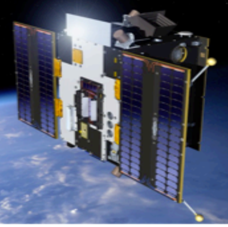
Collected in the bulk of the detector material

Energy needed to create 1 electron-hole pair is

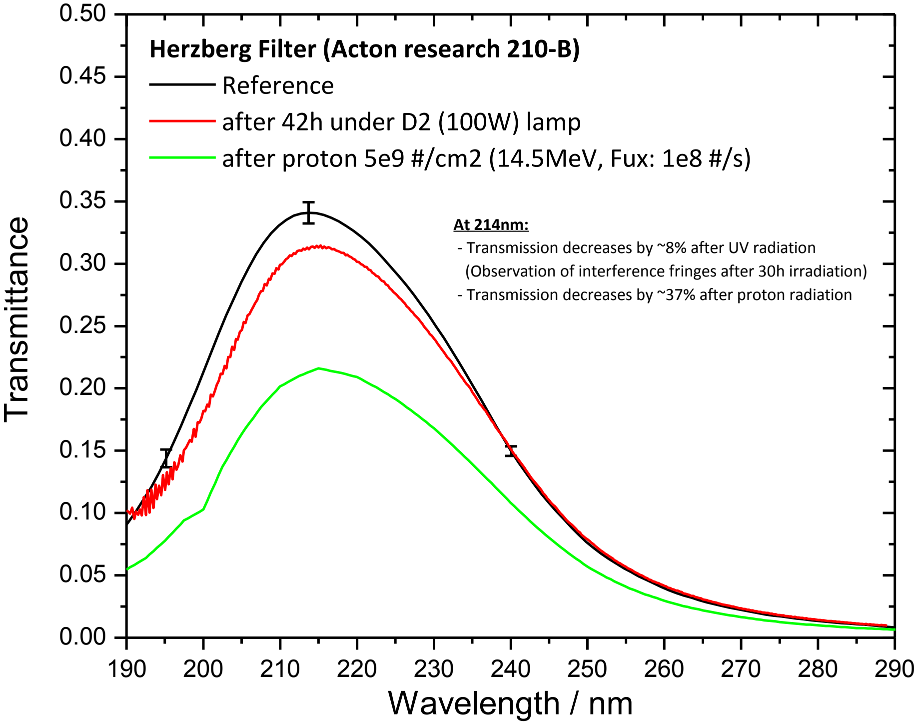
- ❑1.1eV for Silicon
- ❑5.5 eV for diamond

Collected in surface:

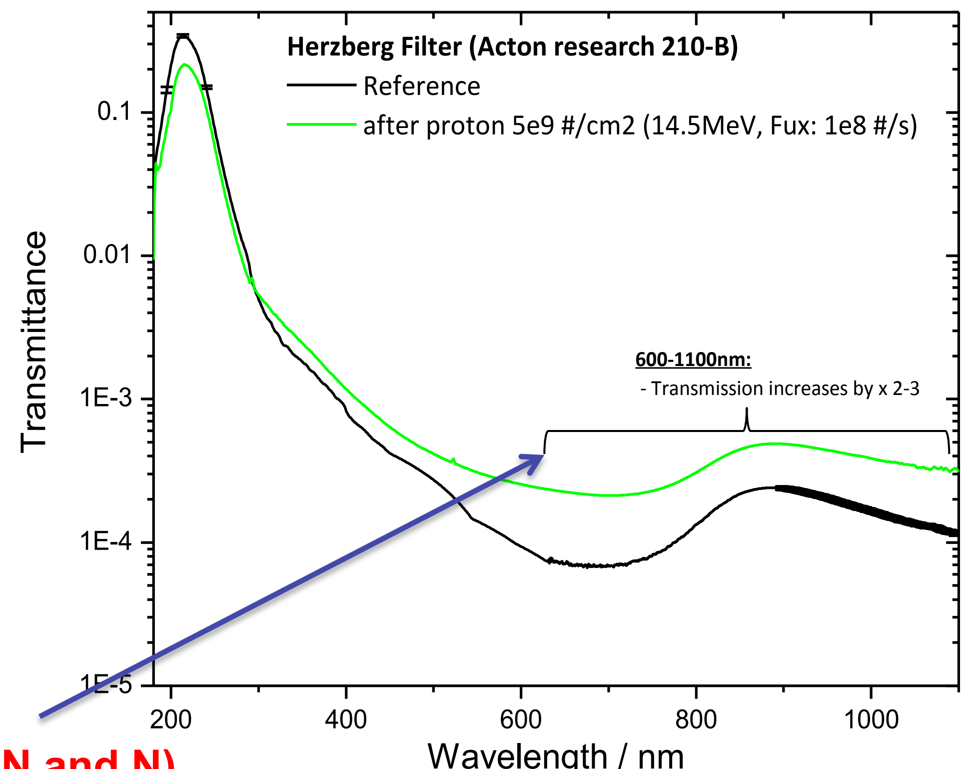
- ❑PIN diamond is not sensitive
- ❑MSM diamond (planar structure) is slightly more sensitive
- ❑PIN silicon is very sensitive.



LYRA's filters (Hz) after proton tests (@14.5MeV)



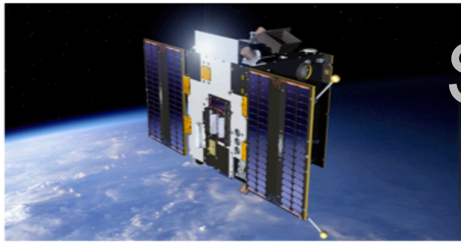
After more than 2 years in orbit
→ acc. fluence 7.1E9 (>10MeV)



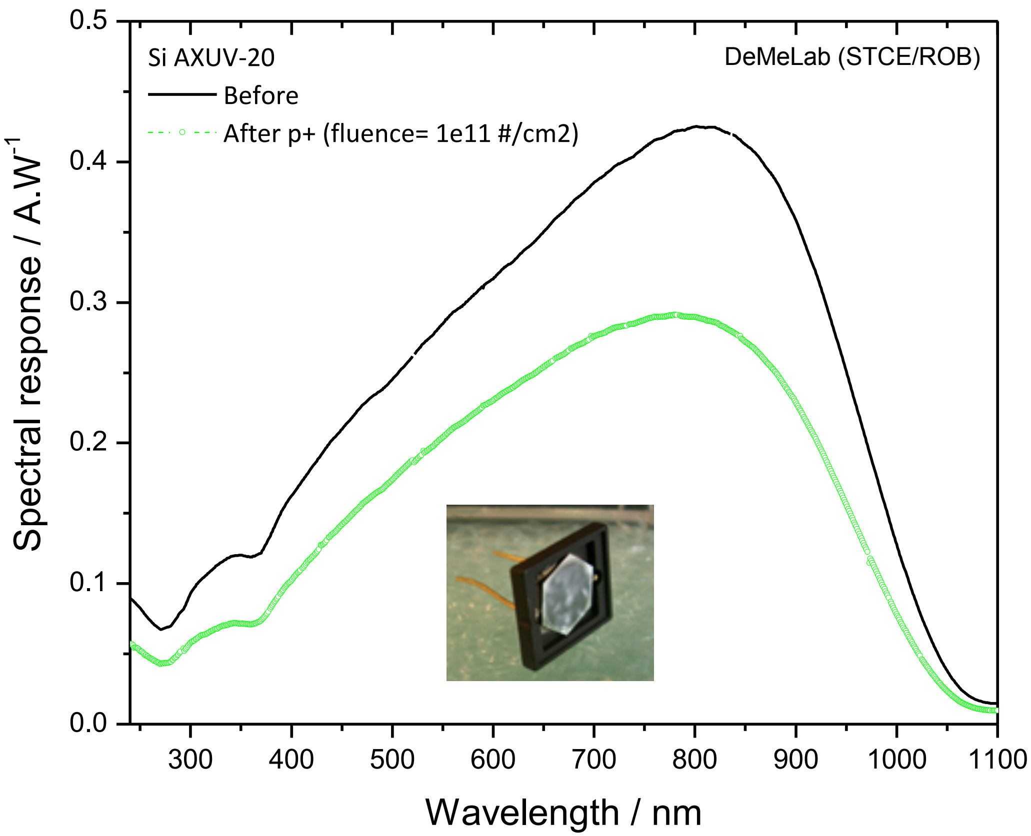
Acton filters

Remark: same observation for Ly-a filters (XN and N)

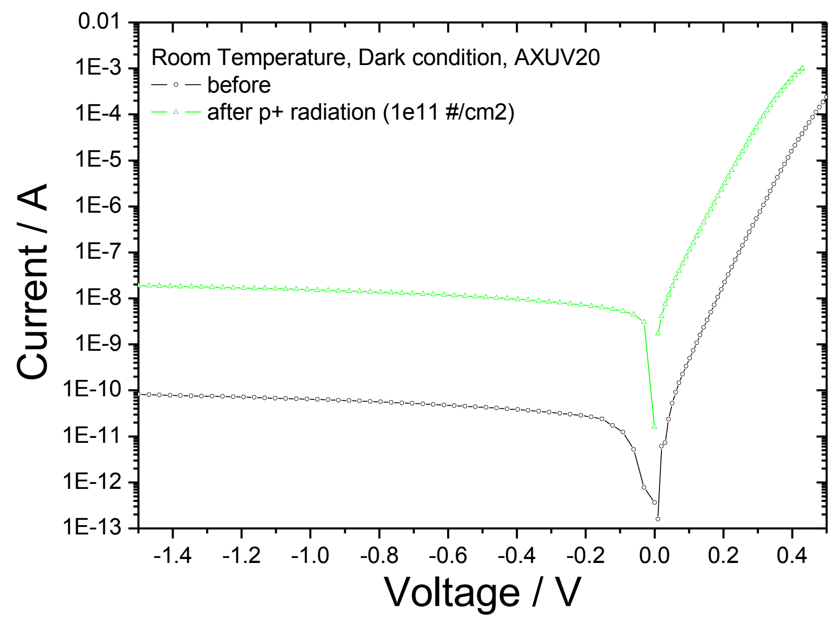
Si detector (AXUV) after proton tests (@14.5MeV)

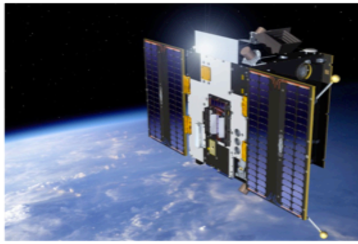


NUV-VIS spectral response decreases (factor 1.5)



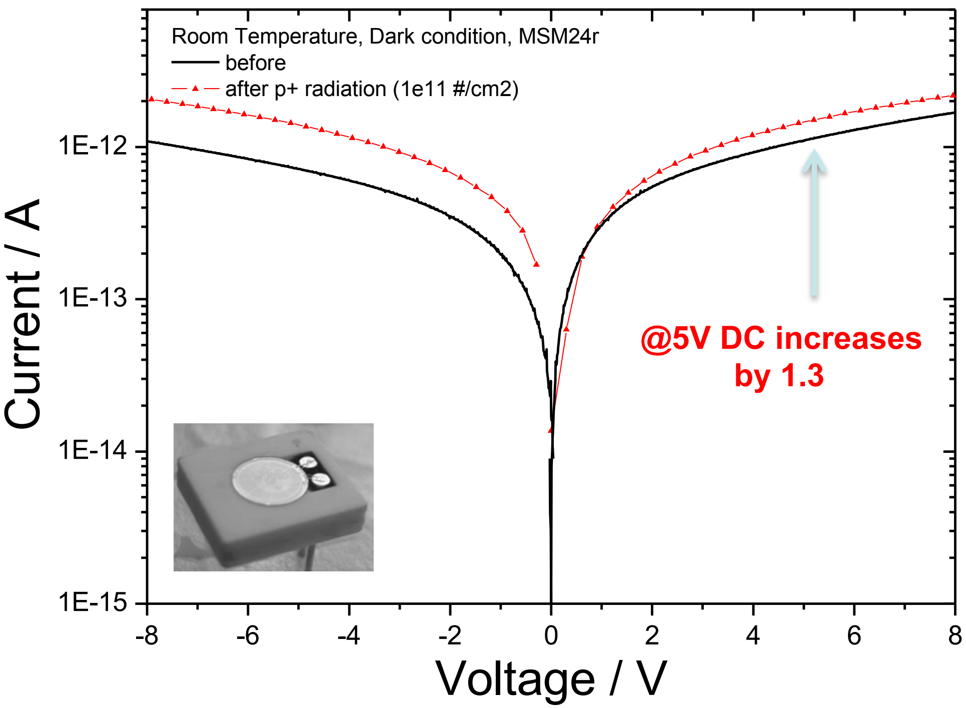
Dark current increases (x100)





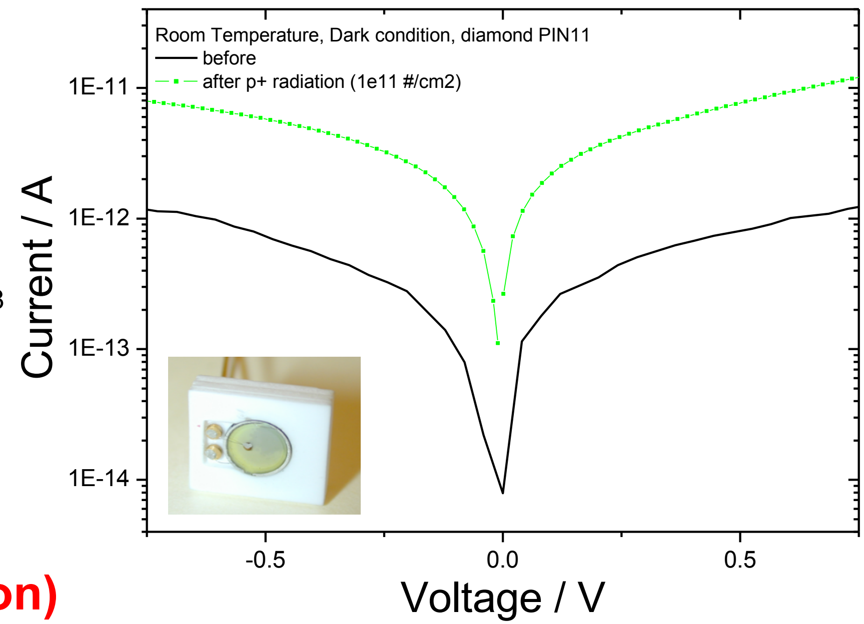
Diamond detectors after proton tests (@14.5MeV)

Dark current MSM24r



Dark current (PIN11)

DC increases (x7) but still negligible (> pA @ 0V)

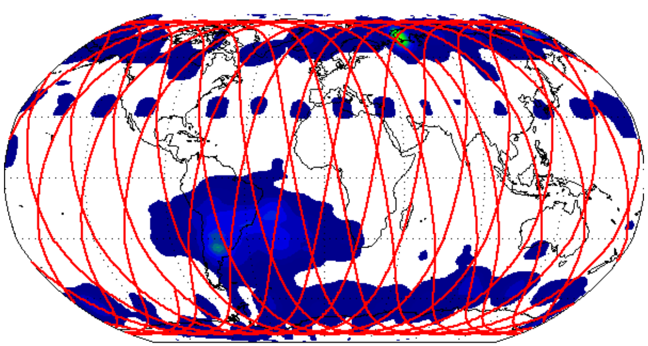


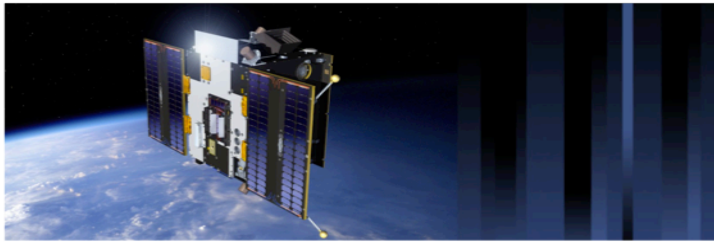
→ spectral response to be measured (soon)

Perturbations in the auroral zone

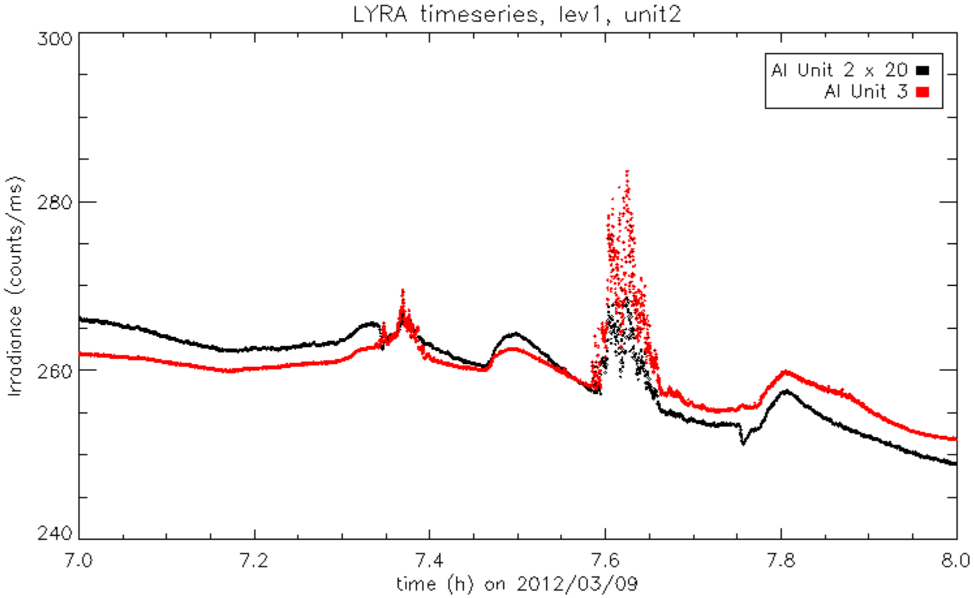
Auroral Oval

- Perturbations appearing around 75° latitude
- 2-3 days after a CME, flare ...
- Associated to geomagnetic perturbations of Kp >= 4
- Only in Al and Zr channels
- Seems to be sensitive to the ageing of the channel
- Not seen with covers closed





Ageing effects?

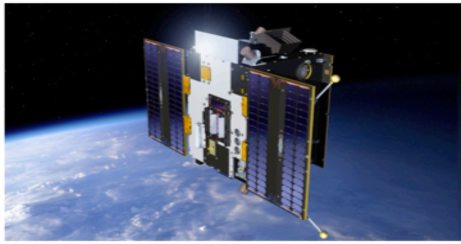


Channel 3 in units 2 lost 95% of its sensitivity

BUT

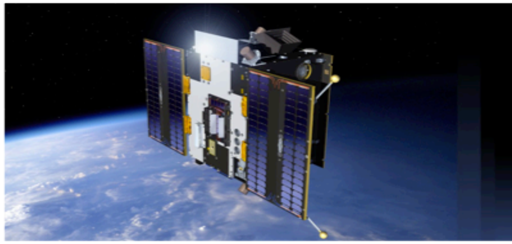
The perturbations in channel 2 amplified by a factor 20 do not appear 20 X bigger than in channel 3.

=> The perturbation amplitude might be affected by the channel degradation



Possible origins of the auroral effect

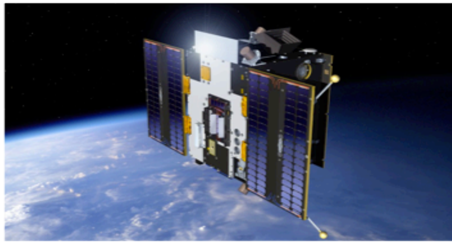
- Galactic Cosmic Rays
- Protons or ions ejected by the Sun (SEP)
- Highly energetic electrons
- Photons
- ???



GCR

- The region in which the GCR are sensed is slightly wider after a geomagnetic storm, but it exists all the time
- GRC should be detected all over the polar caps

Incompatible with the zero-detection under normal geomagnetic conditions



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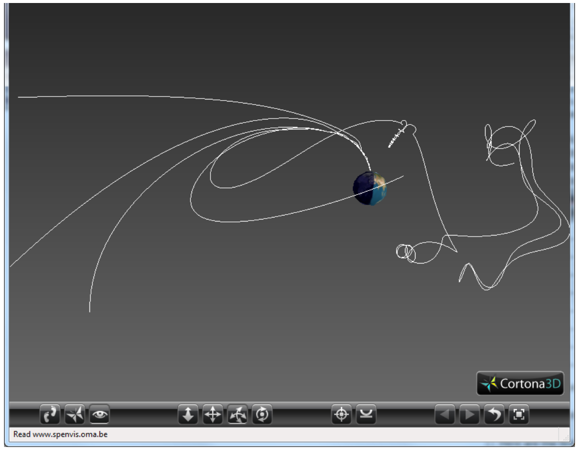
- ❑ Photons
- ❑ ???

SEP

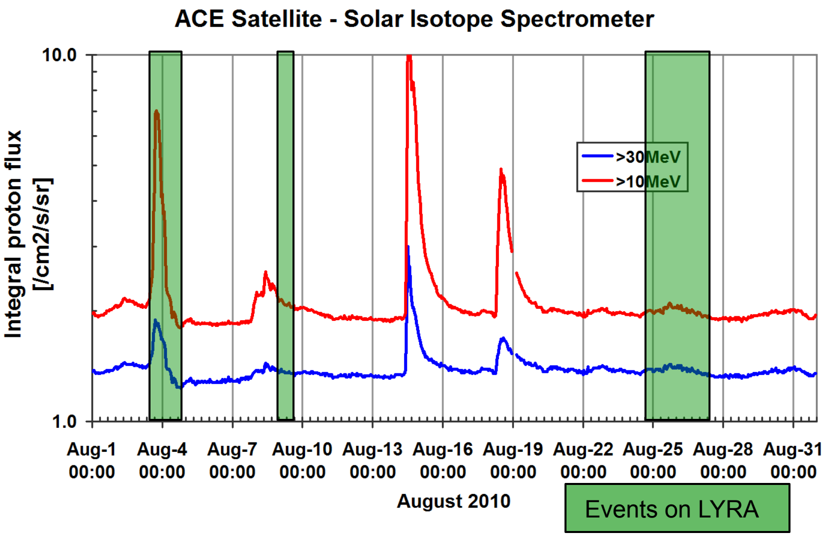
Simulation with Magnetocosmics (SPENVIS):

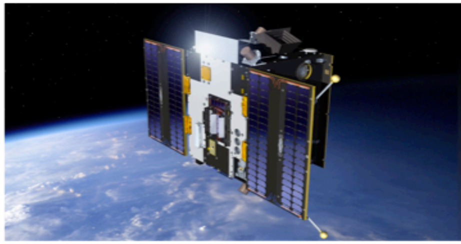
protons form outside the magnetosphere should be able to reach the altitude of the spacecraft for energy > 30 MeV



BUT

The occurrence of SEP is not always correlated with the auroral perturbations observed by LYRA





Possible origins of the auroral effect

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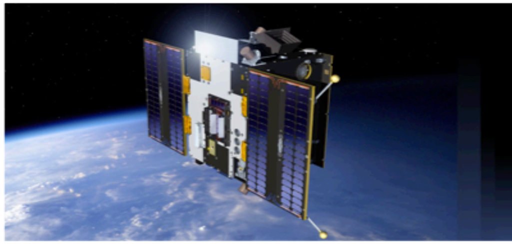
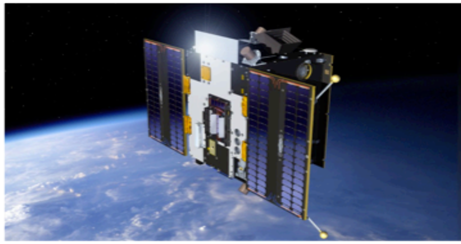


Highly energetic electrons

- stopped by shielding except in the line of sight — OK
- not seen by SWAP because of its off-line axis configuration — OK
- only seen in Al and Zr => only explained if stopped by the thick interferential filters (~7mm) and not by the metallic ones (Al = 158nm & Zr = 148 or 300nm) — ?
- ageing effects unexplained — Non OK

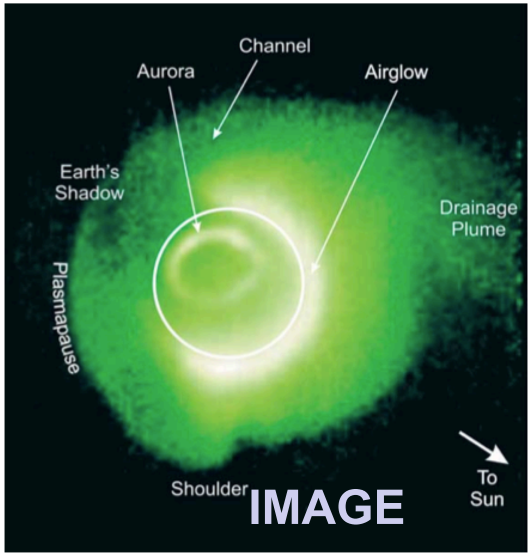


Possible origins of the auroral effect

- ❑ Galactic Cosmic Rays ✗
- ❑ Protons or ions ejected by the Sun (SEP) ✗
- ❑ Highly energetic electrons ✗
- ❑ Photons
- ❑ ???

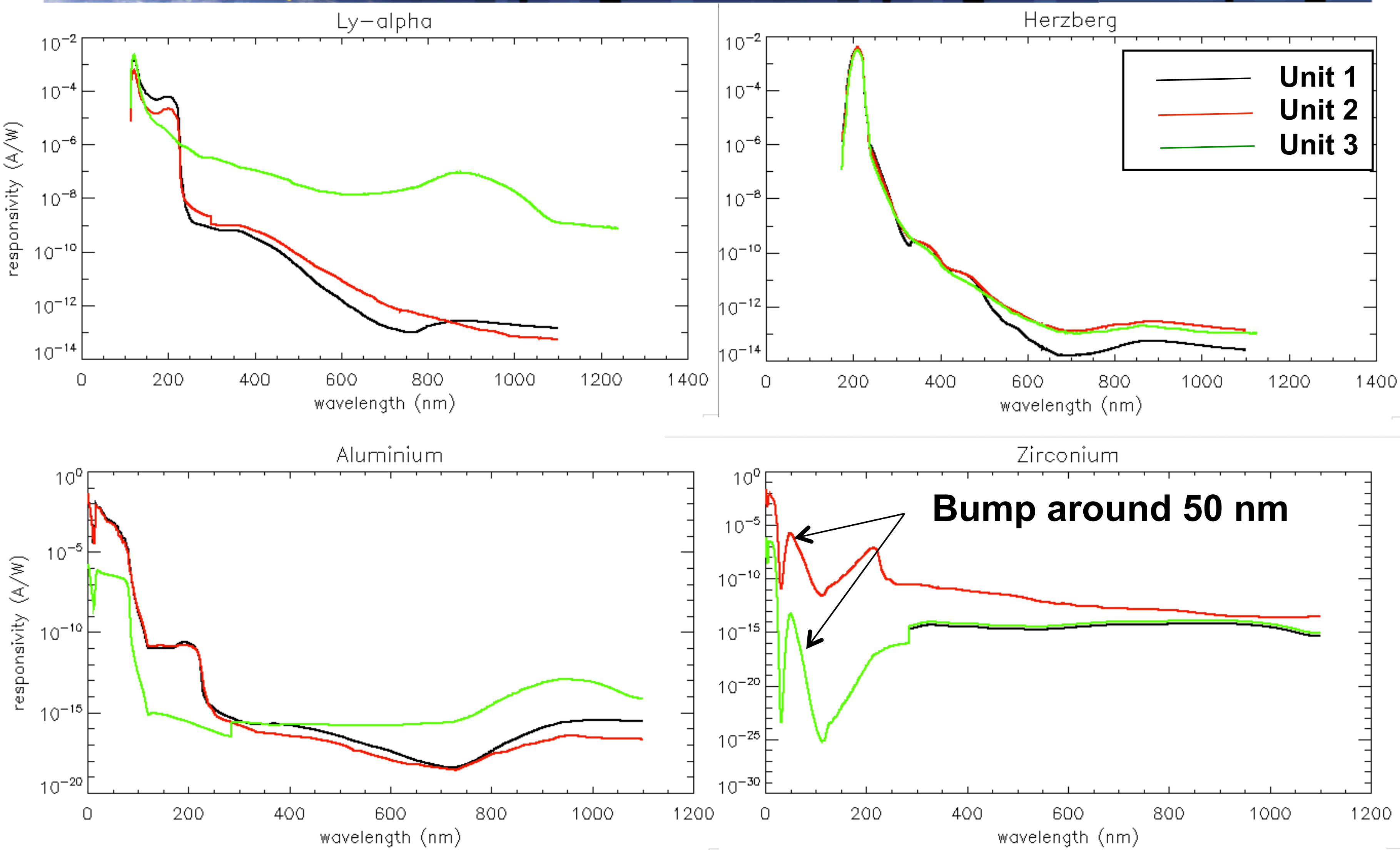
Photons

- Auroral:
  - O+ line at 53.9 nm
  - emission in the F layer, mostly below the altitude of PROBA2
- Airglow:
  - He+ 30.4-nm, He 58.4-nm, O+ 53.9-nm
  - emission region up to 1.25 ER
- Others?



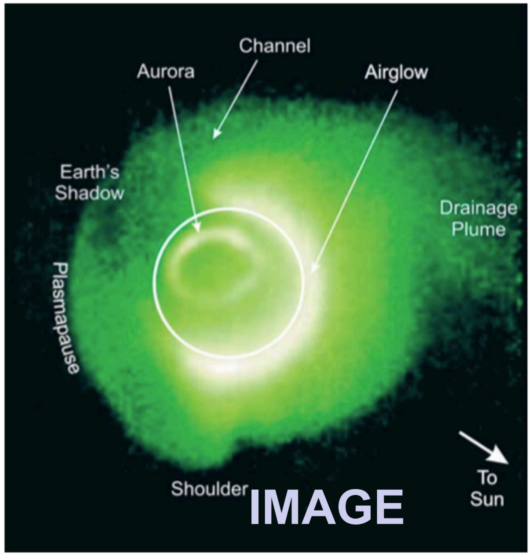
From Sandel, B. R., et al., Space Sci. Rev., 109, 25, 2003.)

Filter + detector responsivity



Photons

- Auroral: **Too low altitudes**
  - O+ line at 53.9 nm
  - emission in the F layer, mostly below the altitude of PROBA2
- Airglow: **In auroral zones only**
  - He+ 30.4-nm, He 58.4-nm, O+ 53.9-nm
  - emission region up to 1.25 ER
- Others?



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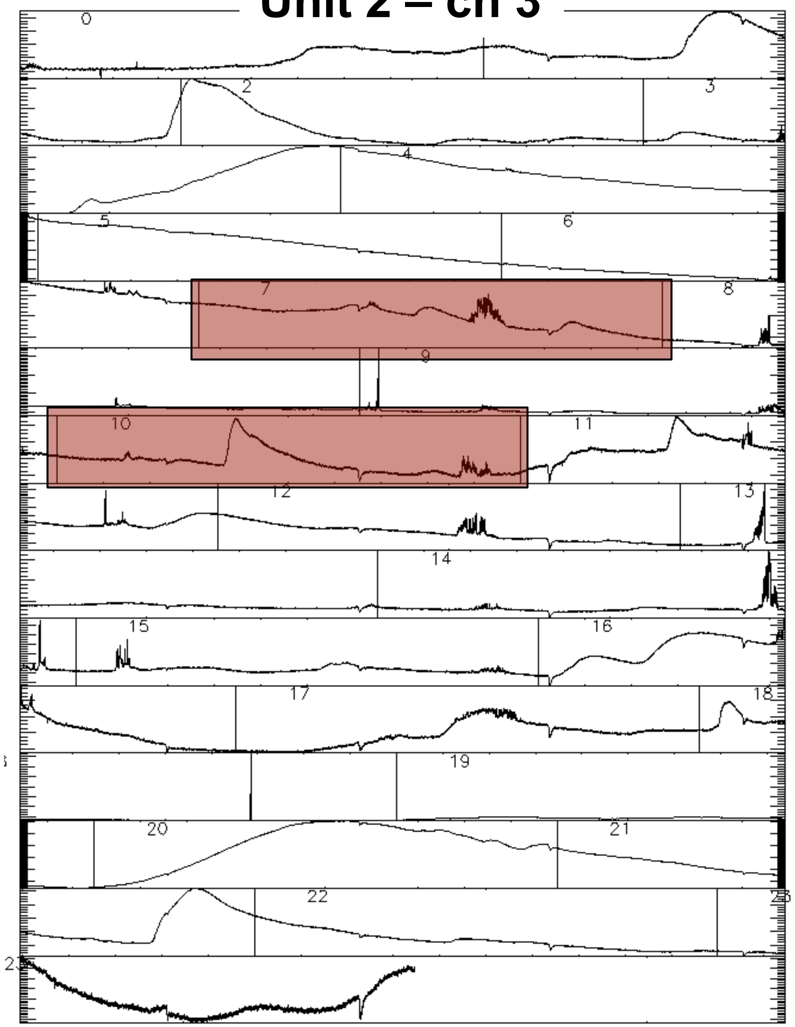
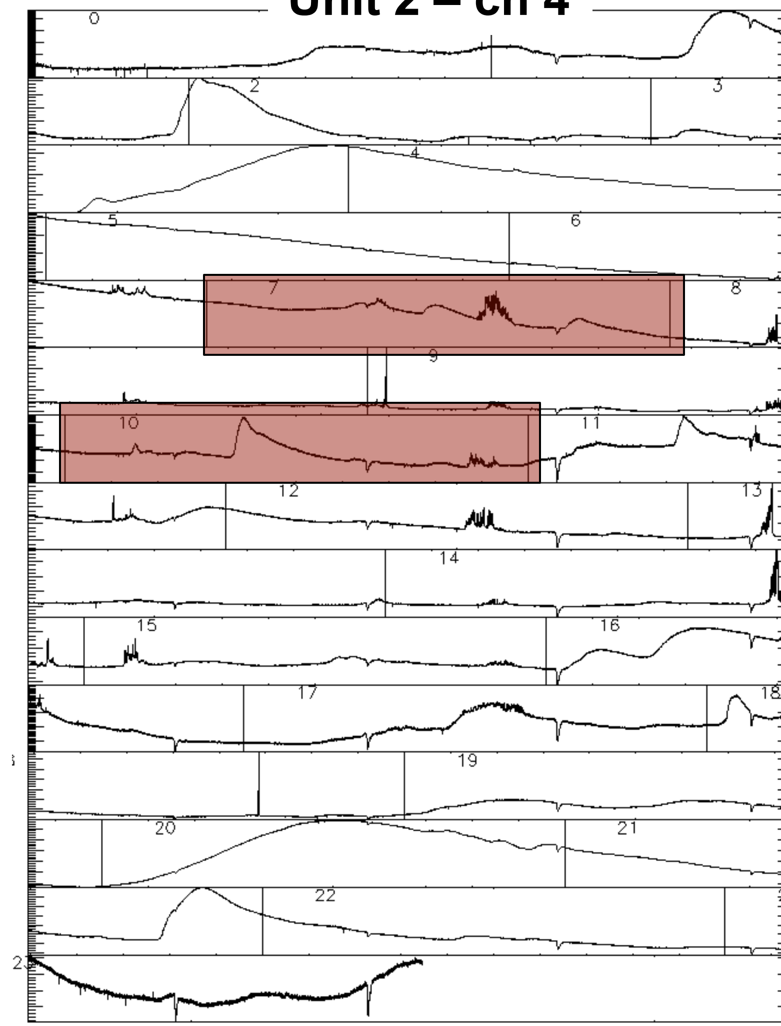
Al vs Zr in unit 2 (degraded)

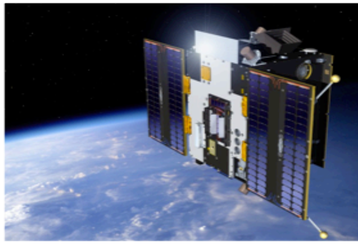
09/03/2012

Unit 2 – ch 3



Unit 2 – ch 4





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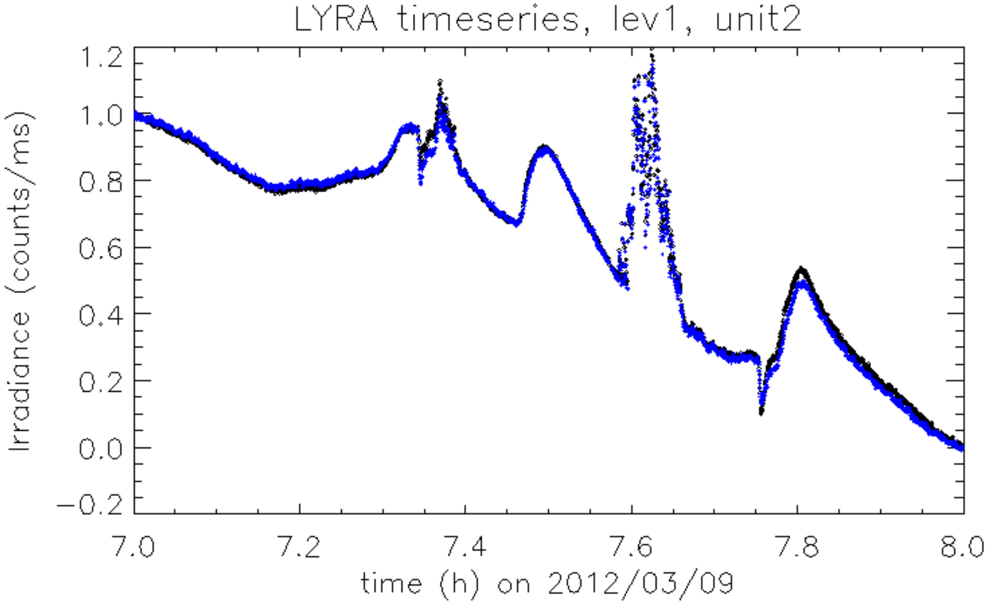
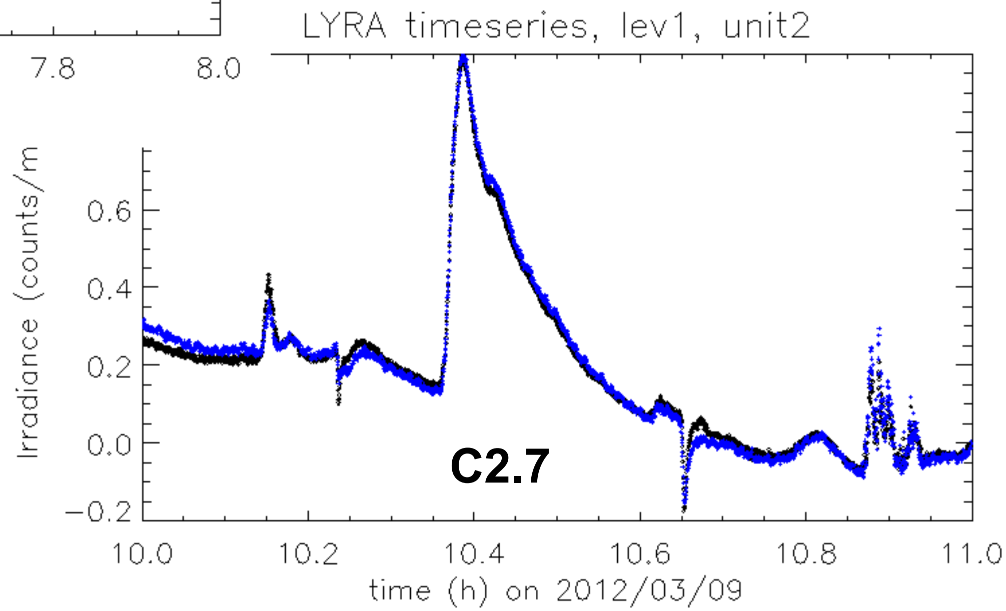
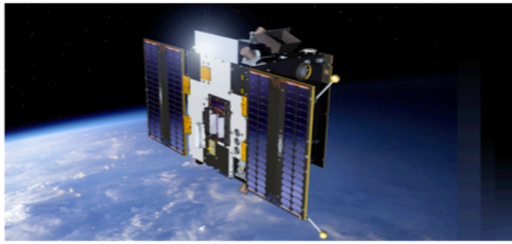


In unit 2 (degraded unit), Al and Zr are identical

=> SXR photons?

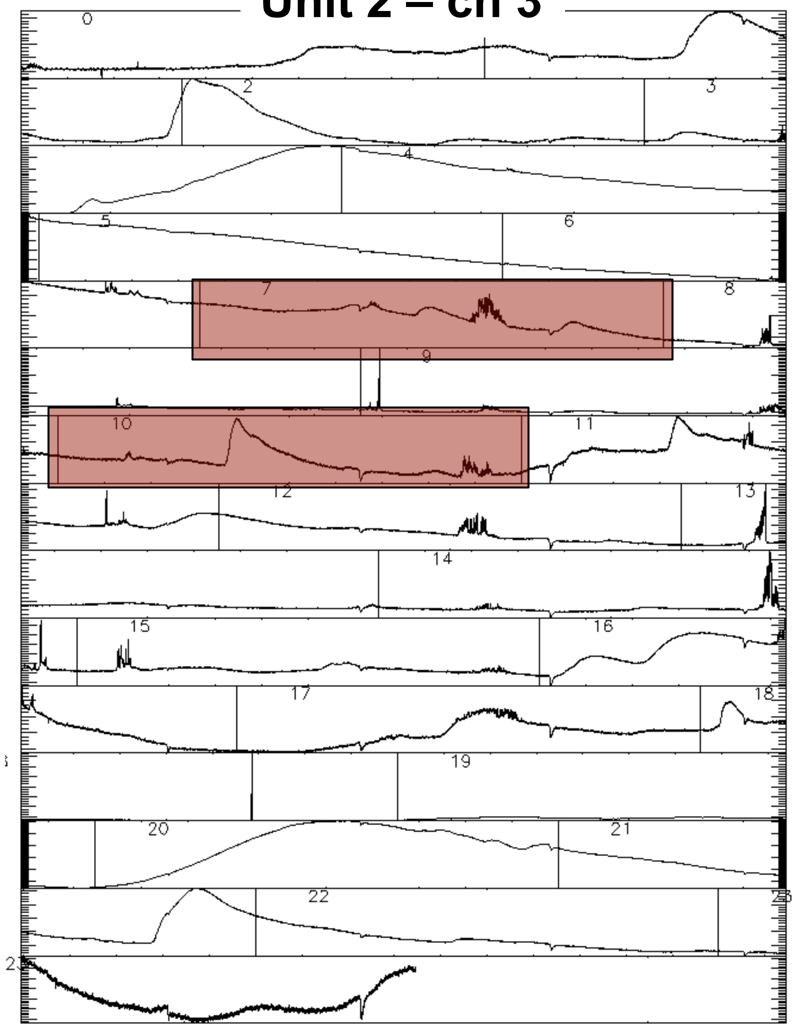




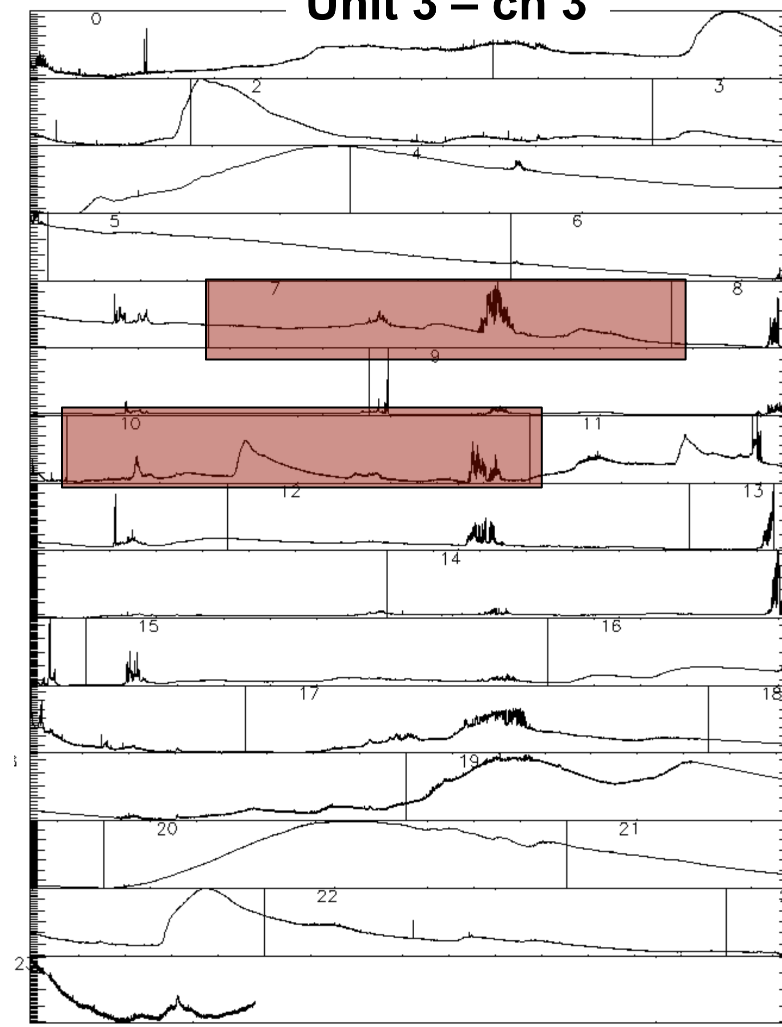
Aurora in Al channel

09/03/2012

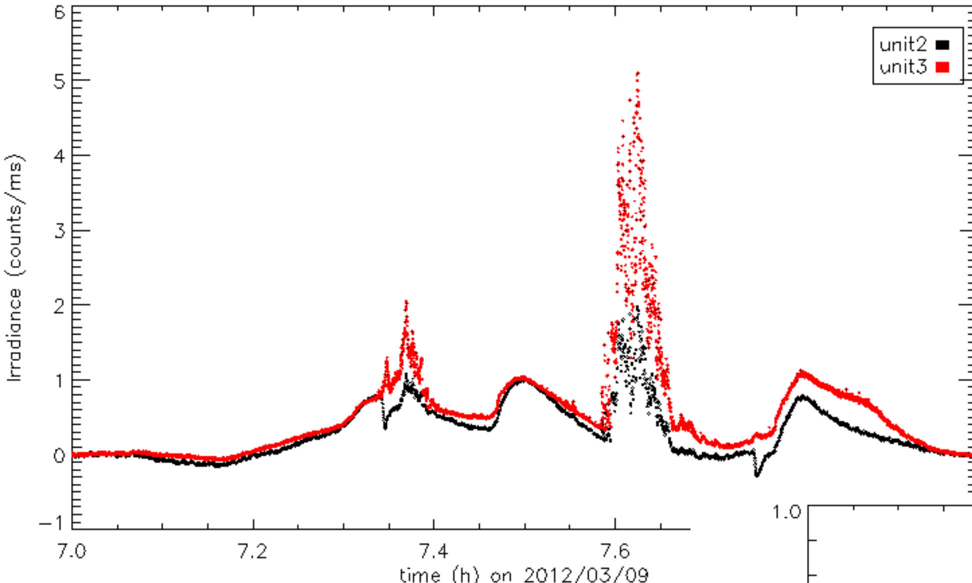
Unit 2 – ch 3



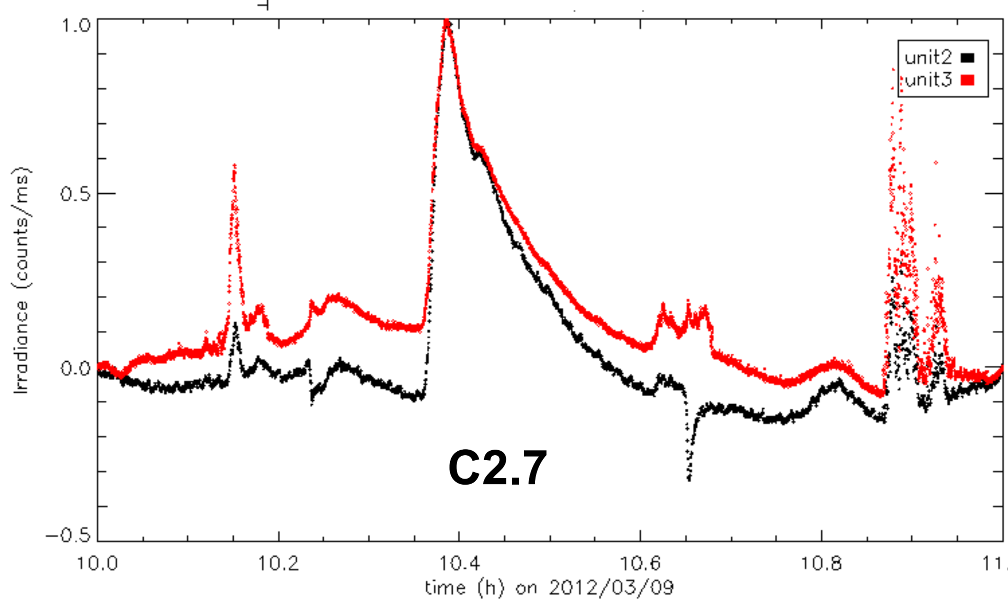
Unit 3 – ch 3

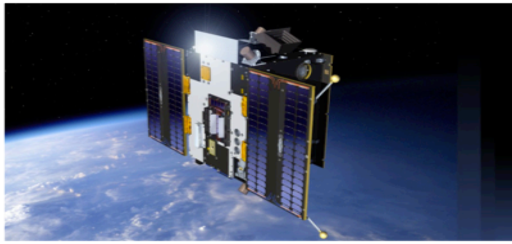


Aurora in Al channel

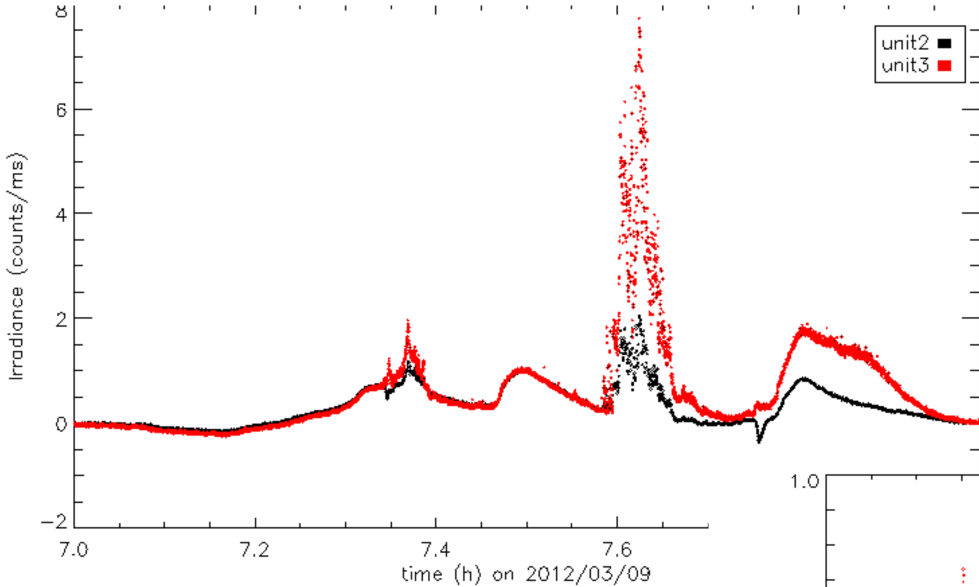


The amplitude of the auroral perturbation is more important in unit 3 (Si detectors, low degradation) than in unit 2 (diamond detectors, high degradation)



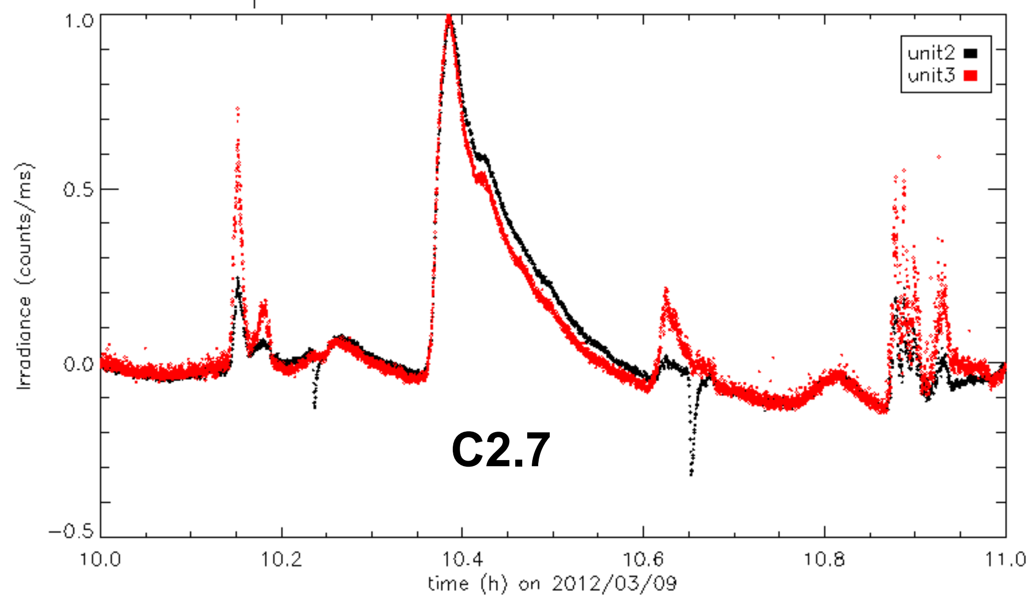


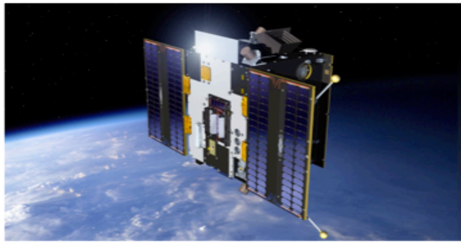
Aurora in Zr channel



Again, perturbation in unit 3 > in unit 2

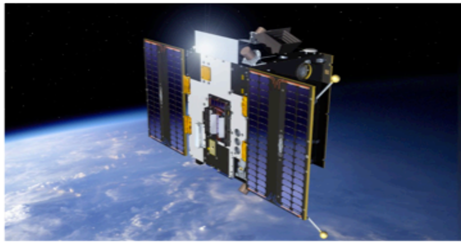
=> Do we see EUV photons in the less degraded unit?





Possible origins of the auroral effect

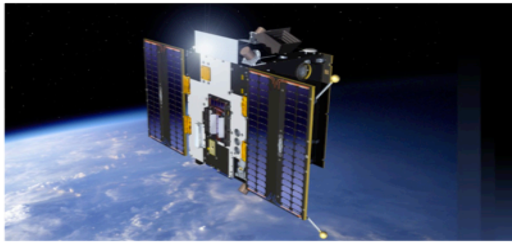
- ❑ Galactic Cosmic Rays ✗
- ❑ Protons or ions ejected by the Sun (SEP) ✗
- ❑ Highly energetic electrons ✗
- ❑ Photons ?
- ❑ ???



Conclusions

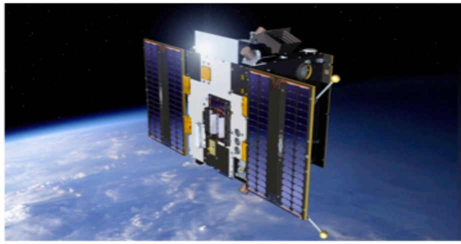
	GCR	SEP	Electrons	EUV Photons	Others (Brems-strahlung ?)
Covers open only	?	?	V	V	?
In auroral zone	X	V	V	V	?
After major solar event	X	V	V	V	?
In Al and Zr only	X	X	?	V	?
ageing effect	X	X	X	V	?
Al and Zr of same amplitude in 2012	?	X	V	V	?

X = incompatible
V = compatible



Conclusions

- The underlying process is still not clear to us. Both SWAP and LYRA sense energetic trapped protons in SAA
- LYRA senses an auroral signature in its two shorter wavelength channels.
- Work still in progress …



Thanks

esa

European Space Agency

belspo

Belgian Science Policy Office

http://proba2.sidc.be/

SPENVIS

The Space Environment Information System