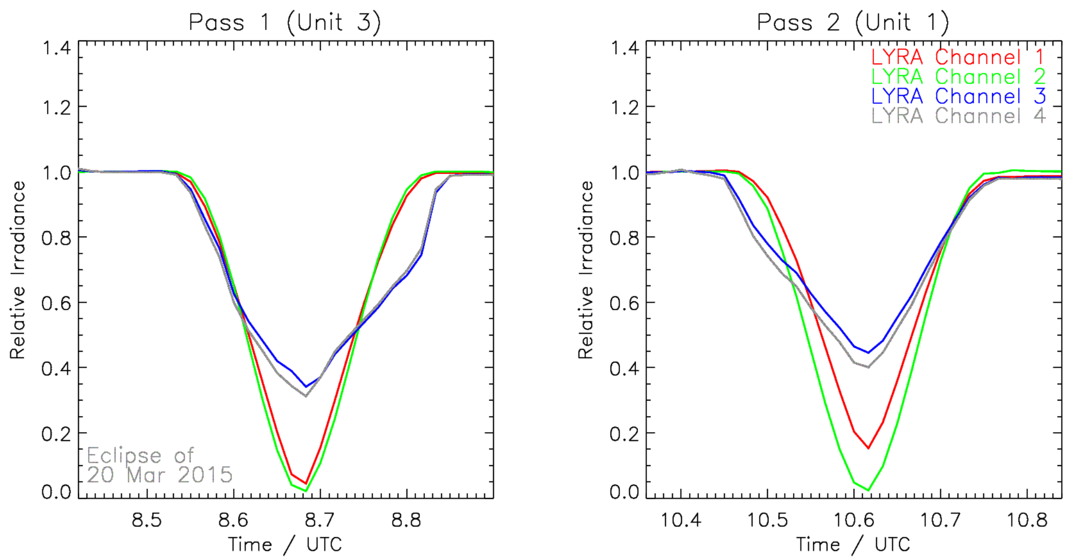
LYRA and the Eclipse of 20 March 2015

IED 24 Mar 2015

This is the “official” LYRA image on the SIDC website:

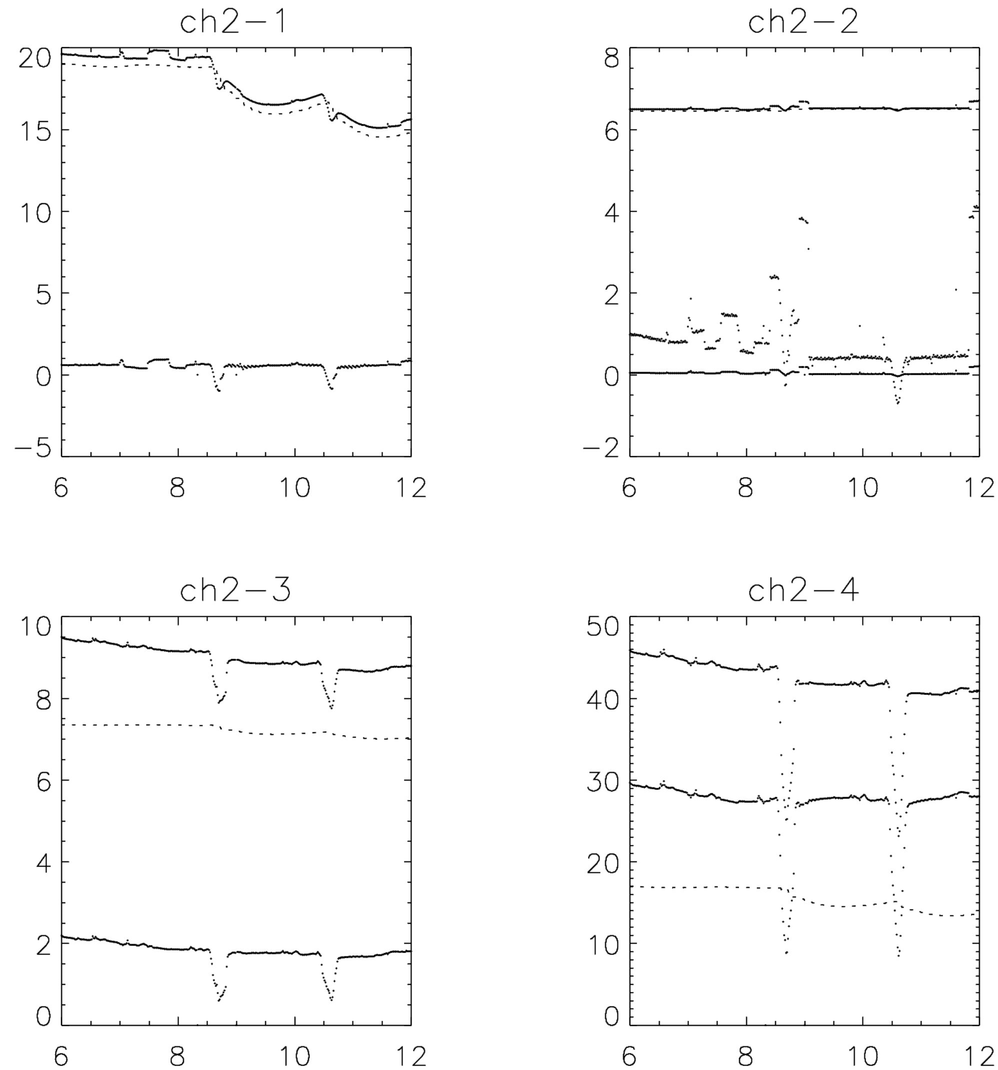


The first pass of the Moon was taken with Unit 3 as back-up unit, the second pass was taken with Unit 1 as back-up unit. As usual, the curves of the longer-wavelength channels 1 (Lyman-alpha) and 2 (Herzberg) are rather symmetric which implies that the solar disk in these wavelength bands is rather homogeneous. The shorter-wavelength channels 3 (Aluminium) and 4 (Zirconium) show asymmetries; the bright active regions produce a major input to the irradiance observed in these wavelength bands. During the first pass, when the Moon has passed the solar disk, there is still an active region at the west limb covered while the rest of the Sun is already uncovered. Thus, the absorption lasts approx 3 minutes longer than for the longer-wavelength channels. During the second pass, the opposite holds: The active region at the east limb is already covered by the moon while the rest of the Sun is still uncovered, thus the absorption in the shorter-wavelength channels starts approx 2 minutes earlier than the rest. - All this can be observed in the SWAP movies, e.g. here:
http://proba2.oma.be/Events/2015-Mar-20-SolarEclipse/movies/swap_eclipse_2015_03_20_logos_compressed.mp4

For the shorter-wavelength channels 3 and 4, the Moon only covers approx 55-65% of the solar disk, because of the extended corona observed in these spectral bands. For channel 2, almost 100% are covered both times, because the moon has approx the same size as the solar disk, i.e. the photosphere and lower chromosphere as observed around 200nm. For channel 1, this depends on the spectral degradation. In the second pass, one recognizes significantly less absorption in channel 1 as compared to channel 2. According to the estimates based on the calibration campaigns, after approx 100 hours of exposure of unit 1, 53% response were left in ch1-1 (status: March 2014; currently 52%). Degradation appears to be heaviest between 100 and 300 nm, but a part of the upper chromosphere must still be present in the observations of ch1-1, thus relatively less coverage of the solar disk results, as seen by this Lyman-alpha channel. - In the first pass, the Lyman-alpha channel of unit 3 basically shows the same structure as the Herzberg curve. After 1500 hours of exposure, 63% response was still present in ch3-1 (currently 61%). How can this apparent contradiction be explained, when for the Herzberg channel of unit 1 after 100 hours exposure 77% response are still present, while for the Herzberg channel of unit 3 after 1500 hours of exposure only 19% of response are still left? In other words, Herzberg degradation depends on exposure, Lyman-alpha degradation does not? Why should the Lyman-alpha channel behave so differently? The answer lies in the spectral response of ch3-1: Only about one third of its response originates from the nominal spectral interval around 121nm, and obviously this part has practically vanished. The two thirds that are still left must originate from longer wavelength bands which degrade slower or not at all and which do not respond to the upper chromosphere, but only to the lower chromosphere or photosphere, somewhat similar as the Herzberg channel. - To demonstrate this, please compare the appearances of the Sun in the different spectral (or temperature) intervals, last page.

In parallel, the two eclipses were also observed with nominal Unit 2, which has suffered from much degradation in channels

1, 2, and 3 (less so in channel 4) after 1500 days of exposure (again, status: March 2014). The curves are therefore more noisy, and - since the signals of channels 1 and 2 are dominated by their respective dark currents, which in turn can not be directly measured but only estimated from the units' temperature - the net signal (i.e., the solar signal) has to be treated with some attention.



The figures show the irradiances of the four channels of Unit 2, measured in counts/ms, vs hours UTC around the eclipse. The upper straight line is the total observed signal, the dotted line is the estimated dark current. The solar signal is thus the difference. For the longer-wavelength channels this difference results in a straight line around zero which shows that the dark-current estimate must be approximately correct. A relatively small term is added in the next figure such that the values do not drop below zero. The curve of ch2-2 is so small that it is repeated in 20x magnification to show the eclipses.

The absolute differences show that what is left in ch2-3 and ch2-4 corresponds well with the values of the last degradation update (1.1 and 16.6 counts/ms, resp., both slightly down, taking the solar variability into account). Between 1.5 and 1.6 counts/ms are left from ch2-1, which indeed has been assumed to be flat at this value for several years now. Likewise, ch2-2 has been assumed to be flat at 2.5 counts/ms, but this seems to be too optimistic. Actually, the first pass of the eclipse shows an absolute difference of 0.13 and the second pass of 0.06 counts/ms. This channel is so low now that it is dominated by irregular jumps, one of these occurring right before the first pass, so the second pass is more trustworthy. In other words, 0.3% is left from ch2-1 while only 0.01% is left from ch2-2, because the response of the Herzberg channel is restricted to 190-222nm where degradation is heaviest. The Lyman-alpha channels' spectral response extends well into longer wavelengths (especially for ch3-1 whose degradation has almost stopped, see above).

The current status as of 20 Mar 2015, percentage of remaining response relative to First Light Day, loss compared to last report:

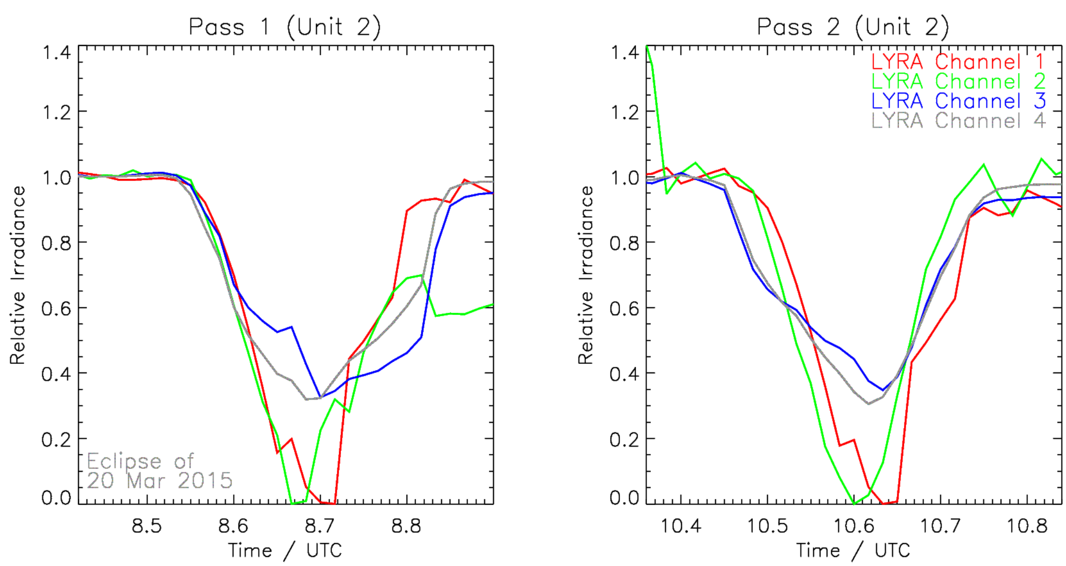
ch1-1	52% (1300 -> 673)	small loss
ch1-2	75% (613.4 -> 462)	small loss
ch1-3	100% (17.2 -> 17)	same as last report
ch1-4	100% (30.3 -> 30)	same as last report
ch2-1	0.3% (492 -> 1.5)	same as last report
ch2-2	0.01% (703.5 -> 0.06)	loss
ch2-3	7% (16.6 -> 1.1)	small loss
ch2-4	44% (37.5 -> 17)	loss
ch3-1	61% (920 -> 562)	small loss
ch3-2	10% (545.5 -> 56)	loss
ch3-3	21% (273.6 -> 58)	loss
ch3-4	72% (30.0 -> 22)	small loss

Units are in counts/ms. Shorter-wavelength channels are corrected for solar activity: Assuming that ch1-4 has not degraded, solar activity in channels 3 and 4 should be 1.75 times higher than on First Light Day. - For comparison, see the last report, here:

http://solwww.oma.be/users/dammasch/IED_20141006_LyraStatusAfter1500Days.pdf

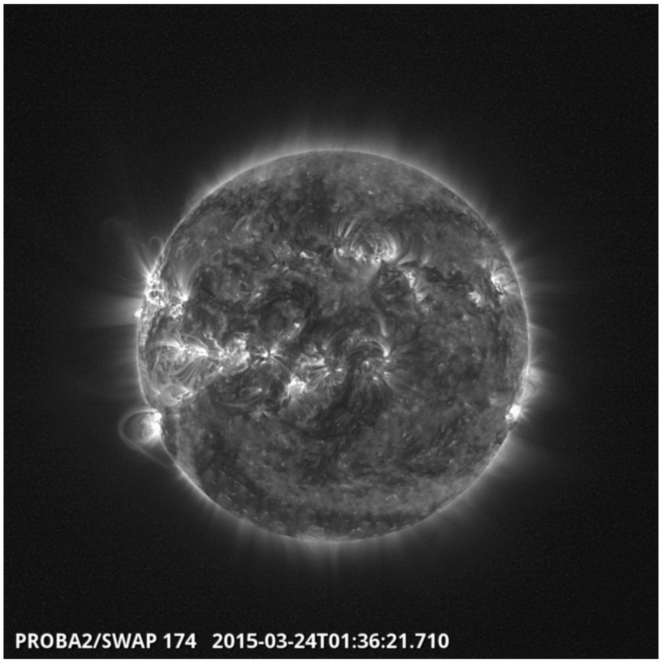
A more detailed analysis of the degradation within the last year will follow.

Assuming that ch2-1 and ch2-2 behave similar to Unit 3 and are practically zero at maximum coverage, this leads to the following LYRA curves of the nominal unit:

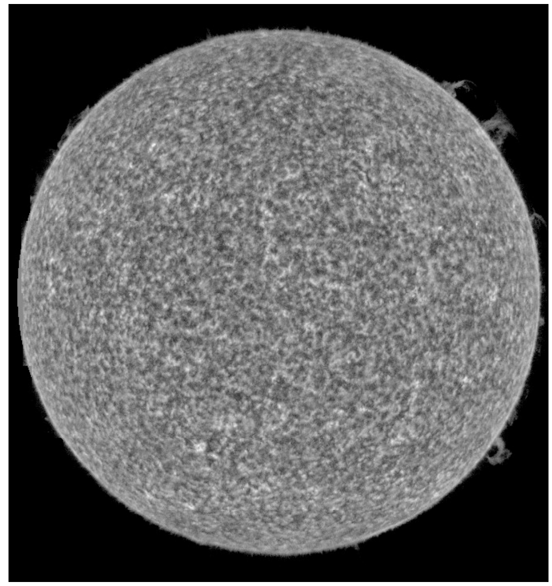


Again, for the shorter-wavelength channels, solar irradiance is only covered by approx 60%. The structure of the asymmetric coverage (3 minutes late in the first pass, 2 minutes early in the second pass) remains visible, even in this noisy pattern.

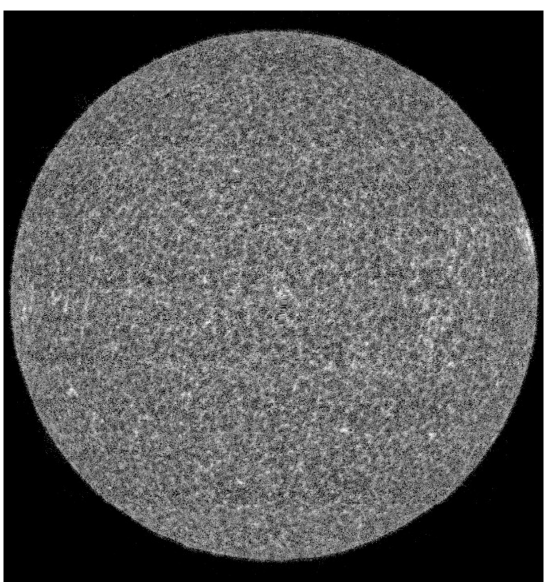
The following page shows the solar disk in different passbands.



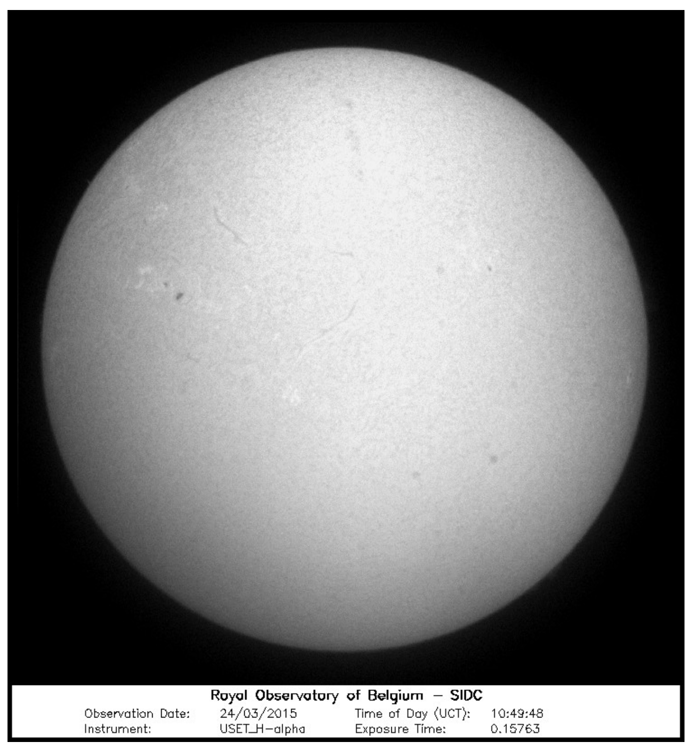
Corona:
what LYRA ch3 and ch4 observe
(SWAP, 17.4nm)



Upper chromosphere:
what LYRA ch1 observes before degradation
(SUMER, H I Lyman delta)



Lower chromosphere:
approx what LYRA ch2 observes
(SUMER, continuum around 155nm)



Photosphere:
what LYRA ch1 probably observes after degradation
(USET, visible red light)