LYRA Calibration: Risks and Chances

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During the LYRA pre-flight calibration, the radiometric model has evolved from year to year:

- 2005, filter and detector performances were measured separately, and three sample spectra from TIMED/SEE were used, a low one from 2005 and two high ones from 2003, incl. one flare.
- 2006, the combined performance (channel responsivity) was measured, once the channels were selected and integrated.
- 2007, responsivities were updated with new BESSY measurements, flatfield considerations were taken into account, and the responsivity of the longer wavelengths was changed due to the Davos tests; additional pre- and post-flare spectra from 2003 were used.
- 2008, the three original sample spectra had drastically changed due to re-calibration of TIMED/SEE and were updated, an additional low (near solar minimum) spectrum from 2008 was introduced, as well as SORCE spectra for longer wavelengths.
- 2009, the Zirconium channels (*-4) were re-defined to include 6-20 nm (instead of 1-20 nm) as nominal interval, the 0.5 nm value of the TIMED/SEE spectrum was included in the radiometric-model simulations, and the long-wavelength responsivities were slightly modified.

The “risks and chances” of the whole enterprise are mainly caused by the ambitious definition of the LYRA nominal intervals. The Lyman-alpha channel includes a portion of the neighbouring continuum, the Herzberg channel is rather defined by its FWHM than its complete range of influence, and the Aluminium and Zirconium channels are both contaminated by a strong SXR influence on their short-wavelength side.

Nevertheless, the challenges can be approached. The advantage of the first two channels is that their purity appears to be rather stable. The advantage of the latter two channels is that – although their purity is highly dependent on the incoming signal – additional information may be gained by a clever signal separation. As soon as the pure signal of the various channels is determined, the relationship to the respective solar irradiance appears quite straightforward – at least, according to radiometric model simulations.

Another advantage of the latter two LYRA channels (*-3 and *-4) is the fact that they have a small overlap in responsivity around 17 nm, which is also the interval in which SWAP observes the Sun.

Therefore, it is suggested that four new “virtual” channels are defined that can be used for cross-calibration with SWAP and TIMED/SEE (SXR part); in the end – given that the approach is successful – these channels may be used for additional LYRA data products: time series of solar irradiance in the 17-18 nm range and in the ranges below 2 nm and below 5 nm.

The table on page 2 shows the enlarged set of channels with their expected total LYRA signal and purities together with the corresponding solar signals.

The figure on page 3 shows purity vs. total signals for the various channels of head 1 (as an example), in order to demonstrate the chance of separating pure signals from residual signals.

This is based on data from new reports on LYRA Calibration Methods (16 Jun 2009)
http://solwww.oma.be/users/dammasch/IED_20090616_Calibration_Methods.pdf
and on Expected Variations of LYRA Output (30 Jul 2009, still under construction)
http://solwww.oma.be/users/dammasch/IED_20090730_LYRA_Expected_Variations.pdf

ch.#	filter	detector	nominal	min,max total signal / nA		min,max solar / (W m^{-2})	
1-1	*Lyman XN*	*MSM12*	120-123 nm	0.283 (26.0%)	0.340 (33.0%)	0.0061	0.0093
1-2	*Herzberg*	*PIN10*	200-220 nm	10.918 (83.7%)	11.710 (83.8%)	0.4454	0.4764
1-3	*Aluminium*	*MSM11*	17- 80 nm	0.054 (86.7%)	2.079 (7.0%)	0.0017	0.0057
1-4	*Zr(300nm)*	AXUV20D	6- 20 nm	0.085 (91.4%)	5.373 (14.1%)	0.0006	0.0034
1-5	*Aluminium*	*MSM11*	17- 18 nm	0.054 (21.3%)	2.079 (1.2%)	0.0002	0.0004
1-6	*Zr(300nm)*	AXUV20D	17- 18 nm	0.085 (27.2%)	5.373 (0.9%)	0.0002	0.0004
1-7	*Aluminium*	*MSM11*	< 5 nm	0.054 (10.1%)	2.079 (92.3%)	0.0001	0.0110
1-8	*Zr(300nm)*	AXUV20D	< 2 nm	0.085 (5.6%)	5.373 (85.6%)	<0.0001	0.0098
2-1	*Lyman XN*	*MSM21*	120-123 nm	0.100 (25.7%)	0.119 (32.8%)	0.0061	0.0093
2-2	*Herzberg*	*PIN11*	200-220 nm	11.690 (83.8%)	12.512 (83.9%)	0.4454	0.4764
2-3	*Aluminium*	*MSM15*	17- 80 nm	0.049 (88.6%)	1.745 (7.8%)	0.0017	0.0057
2-4	*Zr(150nm)*	*MSM19*	6- 20 nm	0.012 (86.1%)	0.787 (12.5%)	0.0006	0.0034
2-5	*Aluminium*	*MSM15*	17- 18 nm	0.049 (21.0%)	1.745 (1.3%)	0.0002	0.0004
2-6	*Zr(150nm)*	*MSM19*	17- 18 nm	0.012 (21.6%)	0.787 (0.7%)	0.0002	0.0004
2-7	*Aluminium*	*MSM15*	< 5 nm	0.049 (8.6%)	1.745 (91.6%)	0.0001	0.0110
2-8	*Zr(150nm)*	*MSM19*	< 2 nm	0.012 (6.1%)	0.787 (86.0%)	<0.0001	0.0098
3-1	*Lyman N+XN*	*AXUV20A*	120-123 nm	0.269 (32.5%)	0.317 (42.1%)	0.0061	0.0093
3-2	*Herzberg*	*PIN12*	200-220 nm	9.389 (83.5%)	10.055 (83.6%)	0.4454	0.4764
3-3	*Aluminium*	*AXUV20B*	17- 80 nm	0.907 (91.8%)	16.701 (16.1%)	0.0017	0.0057
3-4	*Zr(300nm)*	*AXUV20C*	6- 20 nm	0.087 (89.4%)	5.375 (14.1%)	0.0006	0.0034
3-5	*Aluminium*	*AXUV20B*	17- 18 nm	0.907 (16.6%)	16.701 (2.0%)	0.0002	0.0004
3-6	*Zr(300nm)*	*AXUV20C*	17- 18 nm	0.087 (26.6%)	5.375 (0.9%)	0.0002	0.0004
3-7	*Aluminium*	*AXUV20B*	< 5 nm	0.907 (4.8%)	16.701 (83.0%)	0.0001	0.0110
3-8	*Zr(300nm)*	*AXUV20C*	< 2 nm	0.087 (5.5%)	5.375 (85.6%)	<0.0001	0.0098

Table: Channel definition, with expected LYRA signals (purities) and corresponding solar signals.

Please note:
Channel *-5 is a subset of channel *-3.
Channel *-6 is a subset of channel *-4.
The pure signals of channel *-3 and channel *-7 are mutually exclusive and add up to almost 100% of the total signal.
The pure signals of channel *-4 and channel *-8 are mutually exclusive and add up to almost 100% of the total signal.

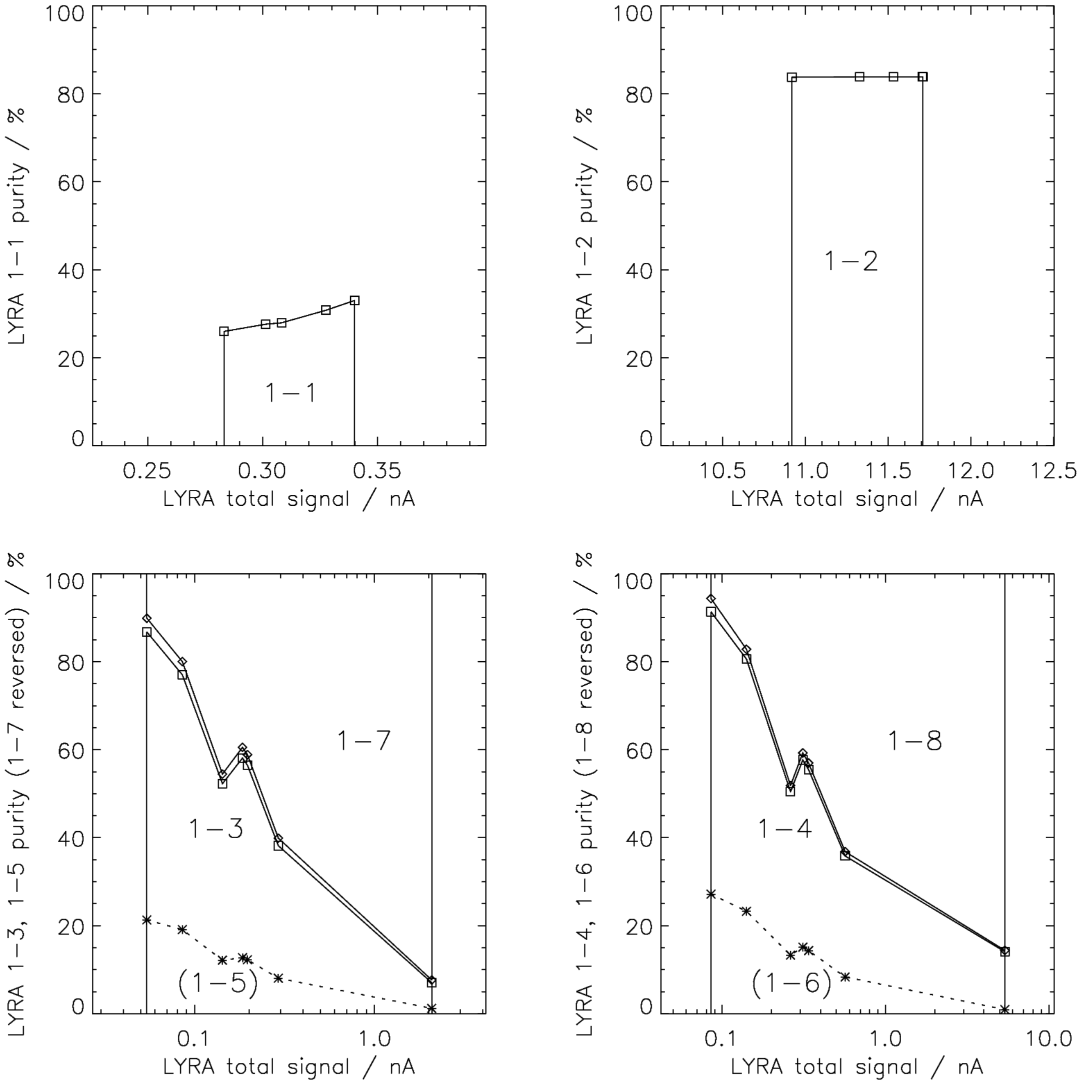

Figure: Purity vs. total expected signal for LYRA head 1.

The long-wavelength channels (Lyman-alpha, 1-1, and Herzberg, 1-2) are shown on a linear scale. Observations falling into the central interval will later, in the Lev2 FITS files, receive “warning” code 0 (safe), observations within the adjacent intervals will be extrapolated and receive code 1 (unsafe), observations out of these intervals will receive code 2 (improbable), except when they are <0 or >999 and receive code 3(impossible). - The simulated expected data are more or less uniformly distributed on a relatively small interval.

The short-wavelength channels (Aluminium, 1-3, and Zirconium, 1-4) are shown on a logarithmic scale. The adjacent unsafe intervals are a factor 2 smaller or larger, resp. - The simulated data vary over approx. two orders of magnitude; the corresponding spectra from left to right are: the 2008 solar min, the 2005 min, the high-flux and the two pre-flare examples from Oct/Nov 2003, the X3.9 flare, and the X17 flare. If the three middle points were substituted by their average to get a straighter line, this would hint to variation and possible error of ~ 5%.

It is obvious that the continuum irradiance is hardly affected by flares, while the Lyman-alpha irradiance becomes relatively stronger in flares. In the other channels, the SWAP interval moves to saturation, i.e. its irradiance is hardly affected by flares, while the the SXR parts 1-7 and 1-8 (“contamination”) dominate the higher total signals instead of the nominal parts 1-3 and 1-4 which dominate the lower total signals.