LYRA Radiometric Model Simulations: Report

IED 18 Aug 2006

In order to understand the radiometric model, I tried to re-calculate the simulations as presented on the LYRA web pages. With the help of Ali, I could solve the following problems:

- To get the files containing the values of (a) spectral irradiance, (b) filter transmittance, (c) detector responsivity, the best source is within the directory /projects/lyra/rm/.
- The right file for the "Davos" irradiance data is LYRAdavos.dat, not sun-davos-new.dat.
- The right file for the solar "maximum" irradiance data is timed-see-high.dat, not timed-see-maximum.dat.
- Although it says on the web page, "XN" is the "currently considered" filter for the Lyman alpha channels, for LYRA channel 3-1 it is "N+XN" which is stated as "now discarded".
- Although it only says "Zirconium" on the web page table, it is Zr (150nm) for channel 2-4 and Zr (300nm) for the other two.
- Although the aperture area is given as 7.06858e-08 square meter on the web page, calculations obviously were always done with 7.06858e-06, which is correct.

Purity definitions:

- The Herzberg channel is always given as 200-220 nm.
- The Zirconium channel is given as 0-20 nm or 1-20 nm.
- The Aluminium channel is given as 17-70 nm (or as "n/a") in the "LYRA" paper, ASR 2006; (I think I also read 30.4 +/- 2.5 nm somewhere, but cannot remember where.) I used 17-80 nm, as it says on the web pages.
- The Lyman alpha channel is given as 115-125 nm or 121.6 +/- 2.5 nm in the "LYRA" paper, ASR 2006. On the web pages it just says 121.5 nm. I used a 2.5 nm interval around 121.5, i.e. 121.5 +/- 1.25 nm. I hope this is correct. On the other hand, there is only one single significant Lyman alpha value in the TIMED/SEE solar flux data, anyway.

My first simulations differed significantly from the calculations on the web pages. The reason was my wrong understanding of those spectral areas where filters and detectors were undefined: there, I used the nearest defined value, but Ali told me that the filters and detectors were actually zero (for physical reasons) where undefined, i.e. above or below certain physical thresholds. After that correction, my simulations were quite close to those on the web pages. While there are still small differences, I would consider them to be caused by my rather primitive integration procedure, e.g., I do not use interpolations.

After the theoretical response (with filter and detector values treated separately), I simulated the response with the measured combined response values from directory /projects/lyra/rm/webtable-2/. Again, my values were quite close to the values on the web page.

Then I tried to figure out the "calibration" factors with which one could re-calculate the measured solar irradiance (TIMED/SEE "minimum", "maximum" and "high") from the estimated output of the various channels. I do not know if this has already been done by others, and I would be happy to compare my results with such calculations.

Maybe it is possible to use knowledge about the general structure of the spectral irradiance curve for this "re-calculation" (i.e. applying the radiometric model backwards). But from my understanding, one has to multiply the LYRA channel output signal (in Ampere) with a factor (in W A-1 m-2) to estimate the solar signal in the corresponding interval (in W m-2). This calibration factor depends on the purity (which can vary), the aperture area (which is constant), and a response factor that depends on the average filter transmittance and detector responsivity in the spectral interval corresponding to the channel (which should be more or less constant).

```
LYRA signal * purity / area / response factor = solar signal
[A]           [%]      [m2]   [A W-1]           [W m-2]

              \______________________________/
                    calibration factor
```

The question is if one can deduce the calibration factor from the simulations, despite the fact that it involves an integral of various multiplied curves, and if this factor is constant.

*-1 (Lyman alpha channels +/- 121.5 nm)
The purity appears to grow linear with the irradiance, therefore the calibration factor is not constant. But maybe it can be calculated in a straightforward way, using the LYRA signal itself. (In the double-filter channel 3-1 the purity values are closer together.)

*-2 (Herzberg channels 200-220 nm)
The purity appears to be constant, and the resulting calibration factor is also constant. On the other hand, the values seem to be estimated from irradiance measurements which are completely identical, at least in the spectral interval of interest.

*-3 (Aluminium channels 17-80 nm)
The purity is heavily dependent on the solar irradiance: for high solar flux, the LYRA signal is dominated by shorter wavelengths and the purity goes towards 2-10%. Maybe the solar minimum and maximum have to be treated separately?

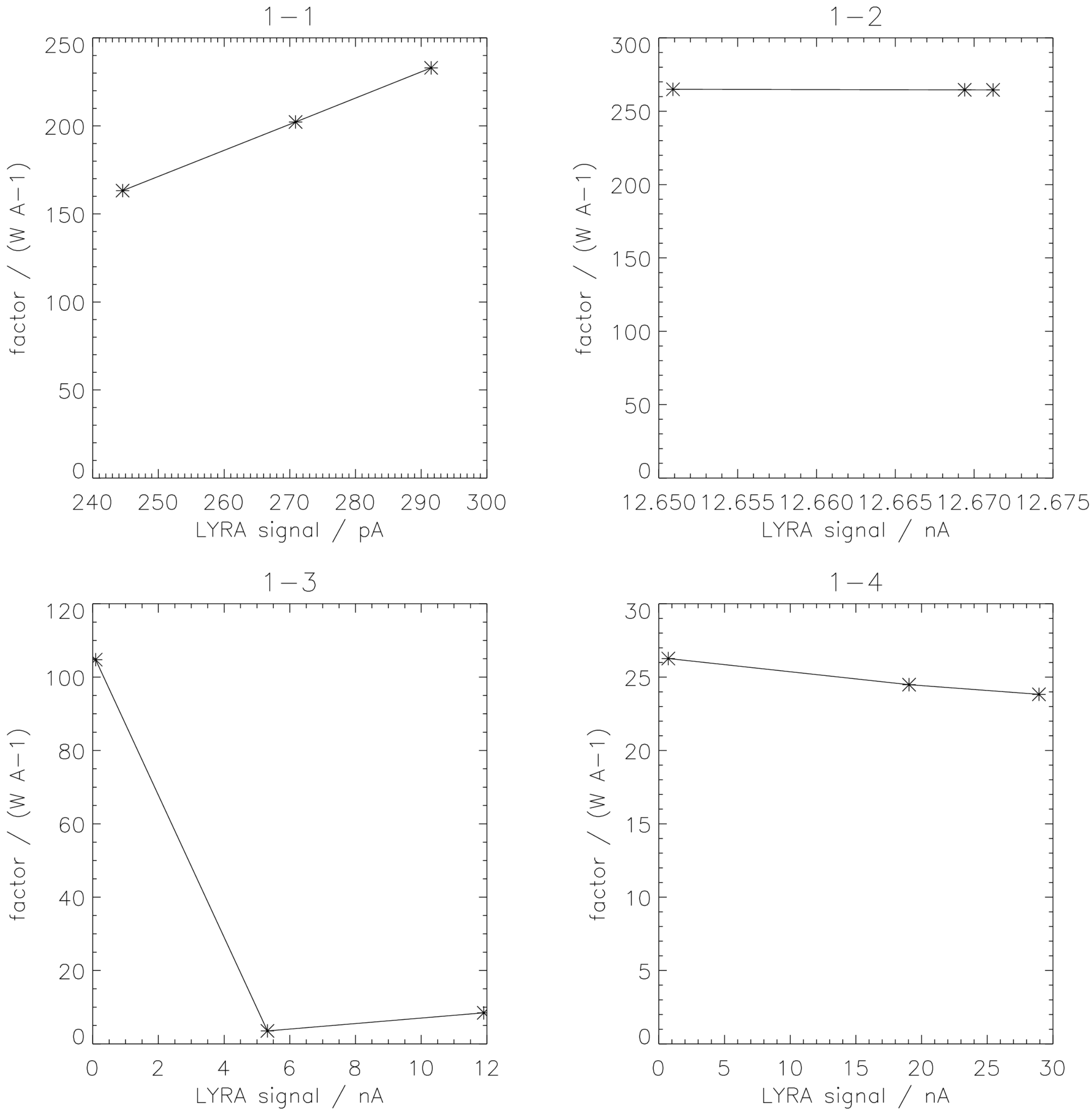
*-4 (Zirconium channels 1-20 nm)
The purity is always constant in an almost ideal way (~100%), the additional influence of the double filter (channels 1-4, 3-4) being less than 0.1%. The responsivity (influence of very short wavelengths!) appears to be higher for higher irradiance, so the calibration factor declines, but in an almost linear way. Maybe it can also be calculated in a straightforward way, using the LYRA signal itself.

Maybe it would be useful to estimate the calibration factors with more solar irradiance samples than just the three samples from TIMED/SEE.

Head 1

ch. flux	LYRA signal * [A]		purity [%]		/area / [m2]		resp.factor = [A W-1]		solar signal [W m-2]
1-1	**Ly XN + MSM12**								
min	244.548 pA	*	23.6732	/	A	/	0.00145018	=	0.00564762
max	291.520 pA		33.7892		A		0.00145035		0.00960818
high	270.879 pA		29.3251		A		0.00145022		0.00774904
1-2	**Herzberg + PIN10**								
min	12.6509 nA		83.8327		A		0.00316396		0.474210
max	12.6694 nA		83.7100		A		0.00316396		0.474210
high	12.6712 nA		83.6982		A		0.00316396		0.474210
1-3	**Aluminium + MSM11**								
min	0.0884 nA		61.0785		A		0.00583021		0.0013105
max	11.9076 nA		4.7316		A		0.00717245		0.0111131
high	5.3192 nA		2.5320		A		0.00559629		0.0034047
1-4	**Zr (300nm) + AXUV20D**								
min	0.7201 nA		99.9920		A		0.0380640		0.0026762
max	28.9357 nA		99.9972		A		0.0419707		0.0975310
high	19.0501 nA		99.9993		A		0.0408429		0.0659849

A=7.06858e-06 m2

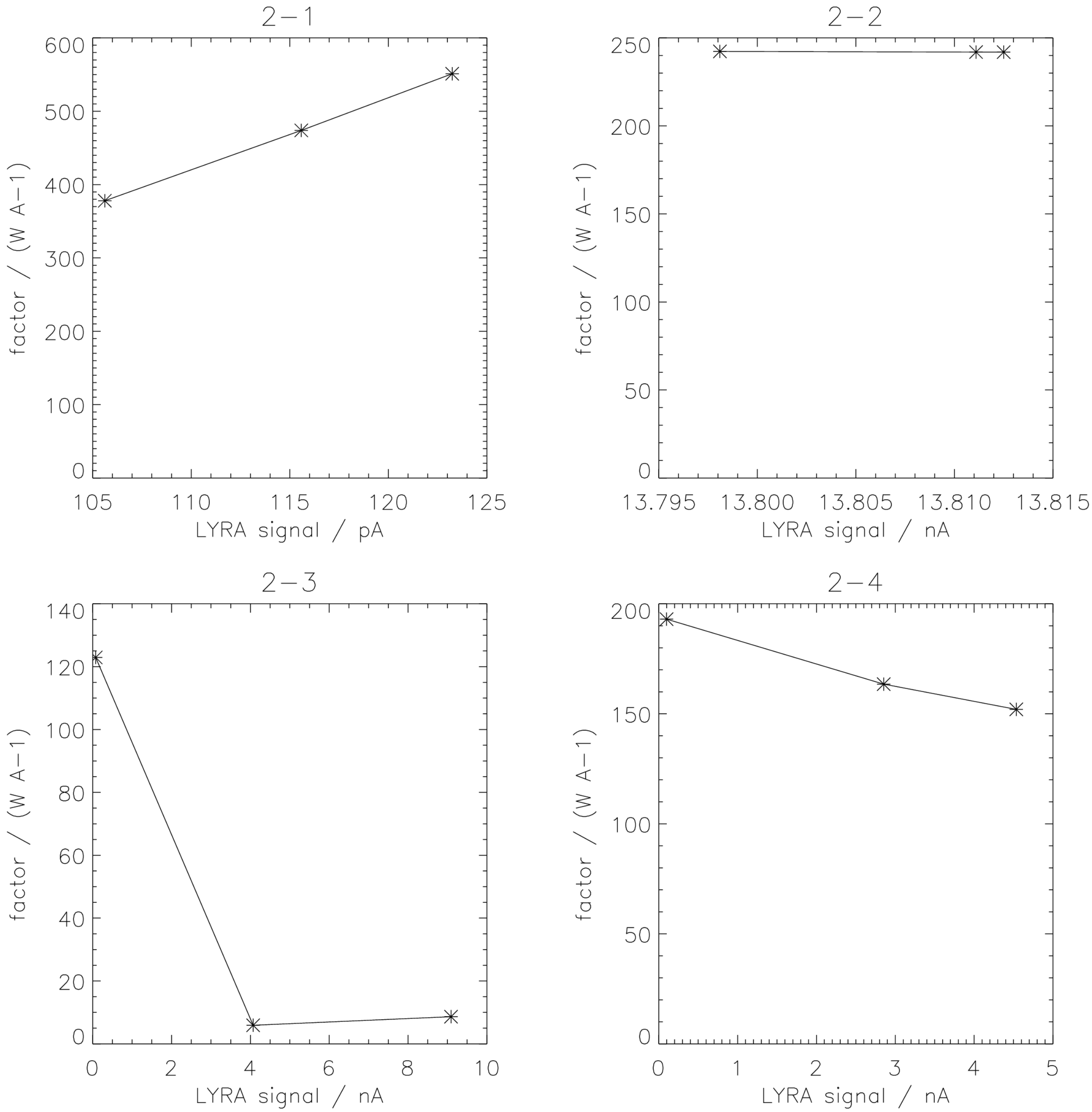


Caption for this and the following figures:

Separately for the four channels of one LYRA head, the factors are shown that are necessary to convert the simulated output signal back to the input signal of interest.

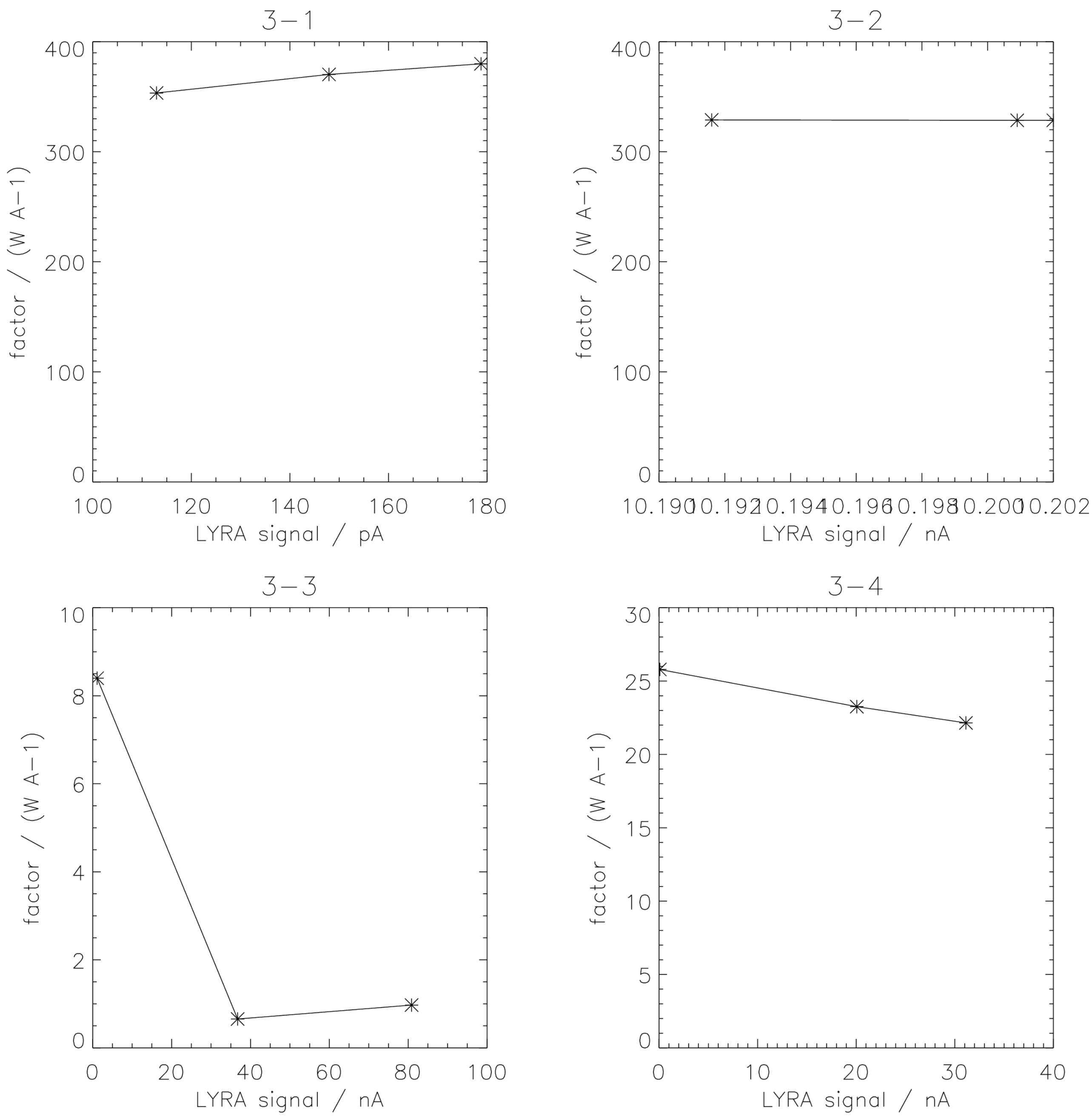
Head 2

```
ch.   LYRA signal *  purity   /area /  resp.factor =  solar signal
flux  [A]            [%]       [m2]    [A W-1]        [W m-2]
====  ===========    =======    ===    ==========     ==========

2-1   Ly XN + MSM21
-------------------
min   105.615 pA  *  20.4182  /  A  /  0.000540186 =  0.00564762
max   123.239 pA     29.7734     A     0.000540260    0.00960818
high  115.582 pA     25.6005     A     0.000540203    0.00774904

2-2   Herzberg + PIN11
----------------------
min   13.7981 nA     84.0515     A     0.00345989     0.474210
max   13.8111 nA     83.9724     A     0.00345989     0.474210
high  13.8125 nA     83.9639     A     0.00345989     0.474210

2-3   Aluminium + MSM15
-----------------------
min   0.07535 nA     62.1494     A     0.00505581     0.0013105
max   9.09185 nA      5.5091     A     0.00637630     0.0111131
high  4.06936 nA      2.7505     A     0.00465076     0.0034047

2-4   Zr (150nm) + MSM19
--------------------------
min   0.09801 nA     99.9166     A     0.00517676     0.0026762
max   4.53508 nA     99.9749     A     0.00657658     0.0975310
high  2.85311 nA     99.9934     A     0.00611665     0.0659849



A=7.06858e-06 m2
```


2-1
factor / (W A-1)
LYRA signal / pA
2-2
factor / (W A-1)
LYRA signal / nA
2-3
factor / (W A-1)
LYRA signal / nA
2-4
factor / (W A-1)
LYRA signal / nA

Head 3

```
ch.   LYRA signal *  purity   /area /  resp.factor =  solar signal
flux  [A]            [%]       [m2]    [A W-1]        [W m-2]
====  ===========    =======    ===    ==========     ==========

3-1   Ly N+XN + AXUV20A
-----------------------
min   112.943 pA  *  79.4972  /  A  /  0.00224913  =  0.00564762
max   178.780 pA     85.4482     A     0.00224930     0.00960818
high  147.934 pA     83.2798     A     0.00224919     0.00774904

3-2   Herzberg + PIN12
----------------------
min   10.1916 nA     83.7435     A     0.00254619     0.474210
max   10.2009 nA     83.6672     A     0.00254619     0.474210
high  10.2020 nA     83.6583     A     0.00254619     0.474210

3-3   Aluminium + AXUV20B
-------------------------
min    1.1030 nA     74.3664     A     0.088551       0.0013105
max   80.8530 nA     10.3437     A     0.106464       0.0111131
high  36.7403 nA      5.6494     A     0.086244       0.0034047

3-4   Zr (300nm) + AXUV20C
--------------------------
min    0.7335 nA     99.9909     A     0.0387750      0.0026762
max   31.1312 nA     99.9970     A     0.0451552      0.0975310
high  20.0586 nA     99.9992     A     0.0430052      0.0659849


A=7.06858e-06 m2
```


3-1
factor / (W A-1)
LYRA signal / pA
3-2
factor / (W A-1)
LYRA signal / nA
3-3
factor / (W A-1)
LYRA signal / nA
3-4
factor / (W A-1)
LYRA signal / nA