ASTRO-H

INSTRUMENT CALIBRATION REPORT
NATURAL LINE SHAPES
OF SXS ONBOARD CALIBRATION SOURCES
ASTH-SXS-CALDB-LINEFIT

Version 0.1

05 March 2016

ISAS/ GSFC

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Table of Contents

CHANGE RECORD PAGE (1 of 1)

DOCUMENT TITLE: Natural Line Shapes of SXS Onboard Calibration Sources			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 0.1	March 2016	All	First Release

Introduction

1.1 Purpose

This document describes the natural line shapes of the characteristic x-ray radiation produced by the SXS onboard calibration sources. These include Mn Kα and Kβ lines from the ^{55}Fe sources on the filter wheel and the small source directed at the calibration pixel, Cr and Cu lines produced by the direct modulated x-ray source (MXS), and Al and Mg lines produced by the indirect (fluorescent) MXS. These complexes will be used to calibrate the SXS energy scale and to monitor the SXS line-spread function.

1.2 Scientific Impact

The natural line shapes described in this CALDB file are used by the task `sxsgain` while fitting the calibration lines to determine the SXS gain scale as a function of time.

2 Release CALDB 20160310

Filename	Valid data	Release data	CALDB Vrs	Comments
ah_gen_linefit_20140101v001.fits	2014-01-01	20160310	001	original filename: LineShapes_v2.pdf

2.1 Data Description and Data Analysis

The line shapes are derived from the literature; corresponding references are given in Section 2.2.

Each line complex is described as a sum of Lorentzians, or, in a few cases, as a single Lorentzian. The individual Lorentzians are given by $A/(1+(2*(E–E_0)/FWHM)^2)$, where A is the amplitude, E_0 is the centroid in eV, and FWHM is the full-width-at-half-maximum width in eV.

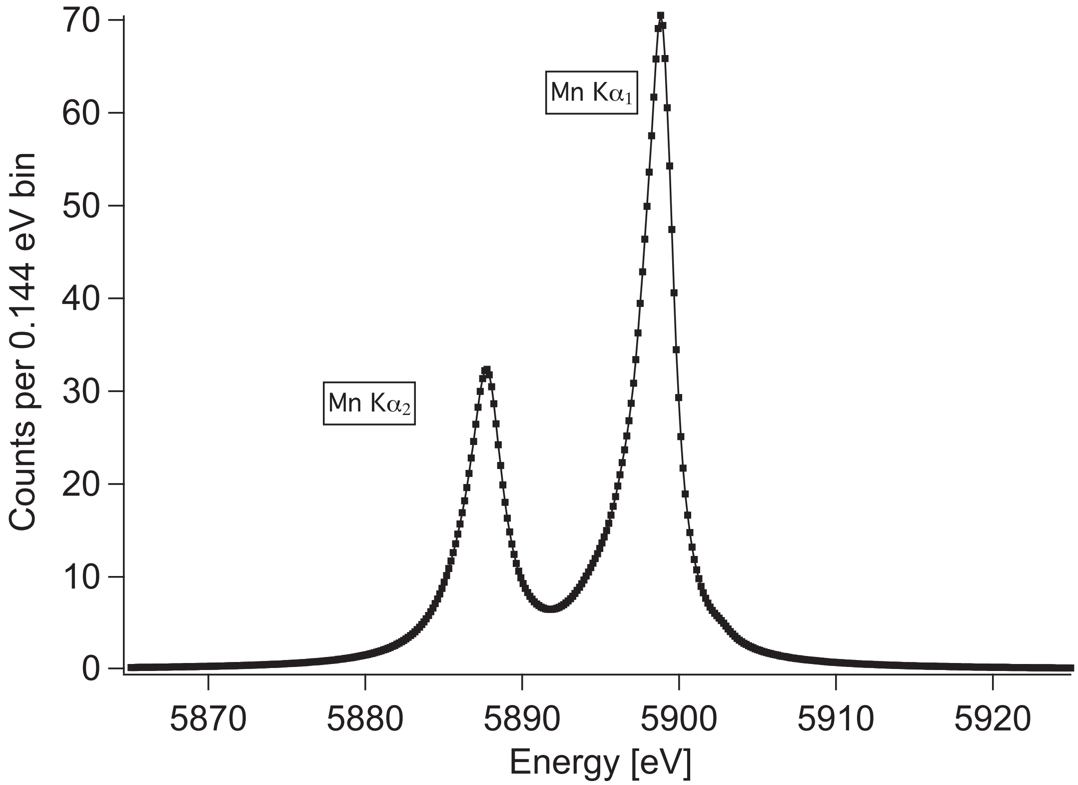
2.2 Results

The CALDB file contains the parameters used to calculate each line complex (E_0, FWHM, and amplitude). There is a separate extension for each line complex. For most complexes we also provide an “Area” column that provides the relative areas contributed by each Lorentzian component, for reference.

The following pages list the line complexes in the order given in the CALDB file.

Extension 1: Mn Kα complex – Produced by the ^{55}Fe sources

Eight-Lorentzian model: seven-Lorentzian model from Holzer et al. (1997) with modifications based on Holzer and Porter (private communication, 1997). The modifications include the addition of $K\alpha_{16}$ line (row 6 in Table 1); a change in the intensity of the $K\alpha_{15}$ line (row 5; the intensity given in Holzer et al. (1997) is wrong by a factor of ten), and change of the intensity of the $K\alpha_{22}$ line (row 8) to 0.1 (fixing a typo).



	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	5898.853	1.715	0.790	0.353
2	5897.867	2.043	0.264	0.141
3	5894.829	4.499	0.068	0.079
4	5896.532	2.663	0.096	0.066
5	5899.417	0.969	0.0714	~0.05
6	5902.712	1.5528	0.0106	
7	5887.743	2.361	0.372	0.229
8	5886.495	4.216	0.1	0.110

Table 1 Lorentzian coefficients for the Mn Kα complex.

Mn Kα center of mass = 5894.62 eV

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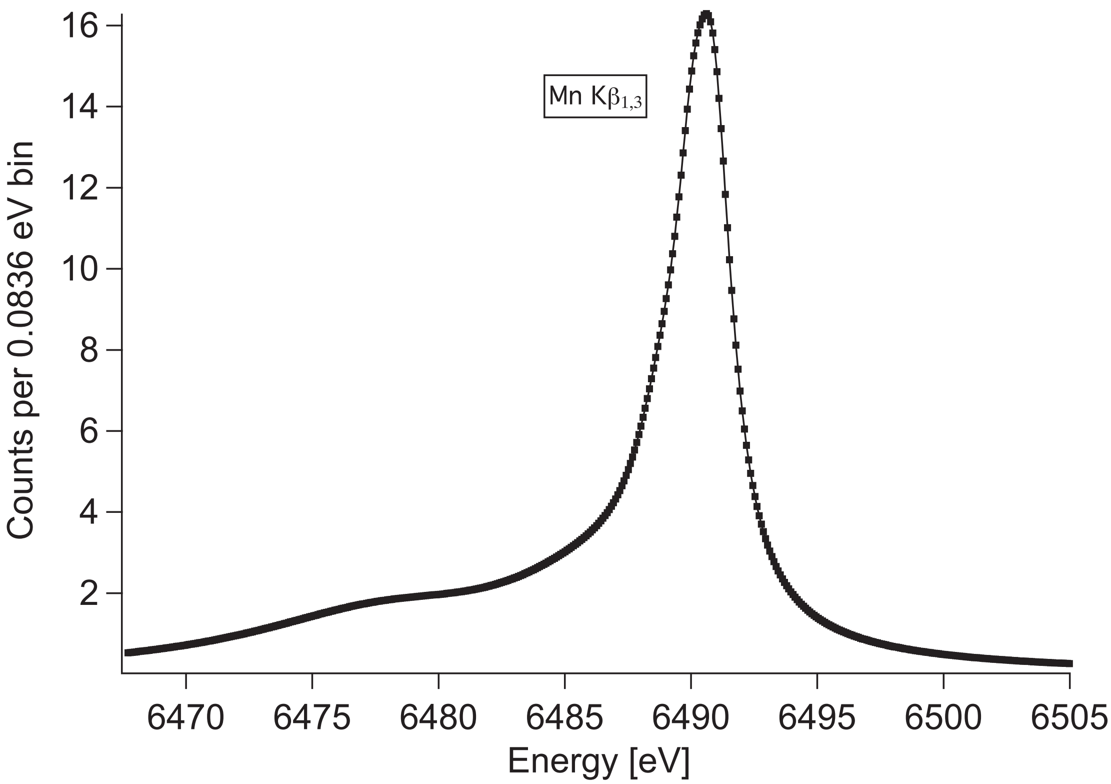
Extension 2: Mn Kβ complex – Produced by the ^{55}Fe sources

Five-Lorentzian model from Holzer et al. (1997).



	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	6490.89	1.83	0.608	0.254
2	6486.31	9.4	0.109	0.234
3	6477.73	13.22	0.077	0.234
4	6490.06	1.81	0.397	0.164
5	6488.83	2.81	0.176	0.114

Table 2 Lorentzian coefficients for the Mn Kβ complex

Mn Kβ center of mass = 6486.37 eV

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Extension 3: Cr Kα complex – Produced by the direct MXS

Seven-Lorentzian model from Holzer et al. (1997).

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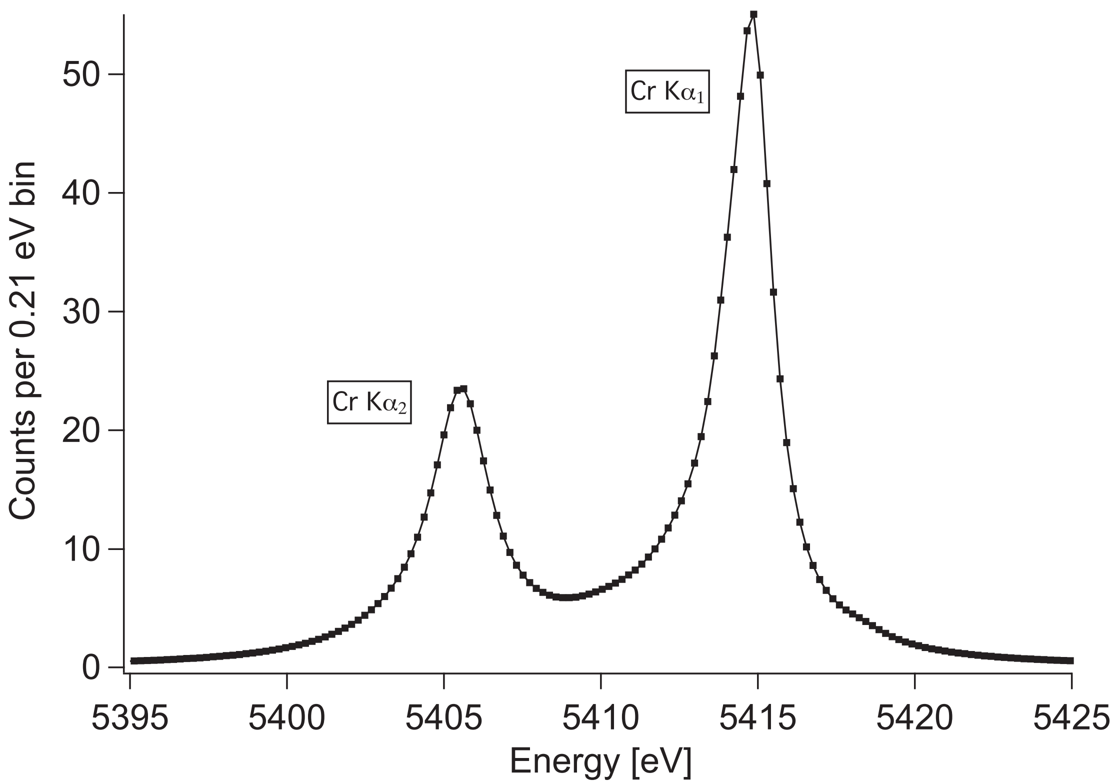

	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	5414.874	1.457	0.822	0.378
2	5414.099	1.760	0.237	0.132
3	5412.745	3.138	0.085	0.084
4	5410.583	5.149	0.045	0.073
5	5418.304	1.988	0.015	0.009
6	5405.551	2.224	0.386	0.271
7	5403.986	4.740	0.036	0.054

Table 3 Lorentzian coefficients for Cr Kα complex

Cr Kα center of mass = 5411.20 eV

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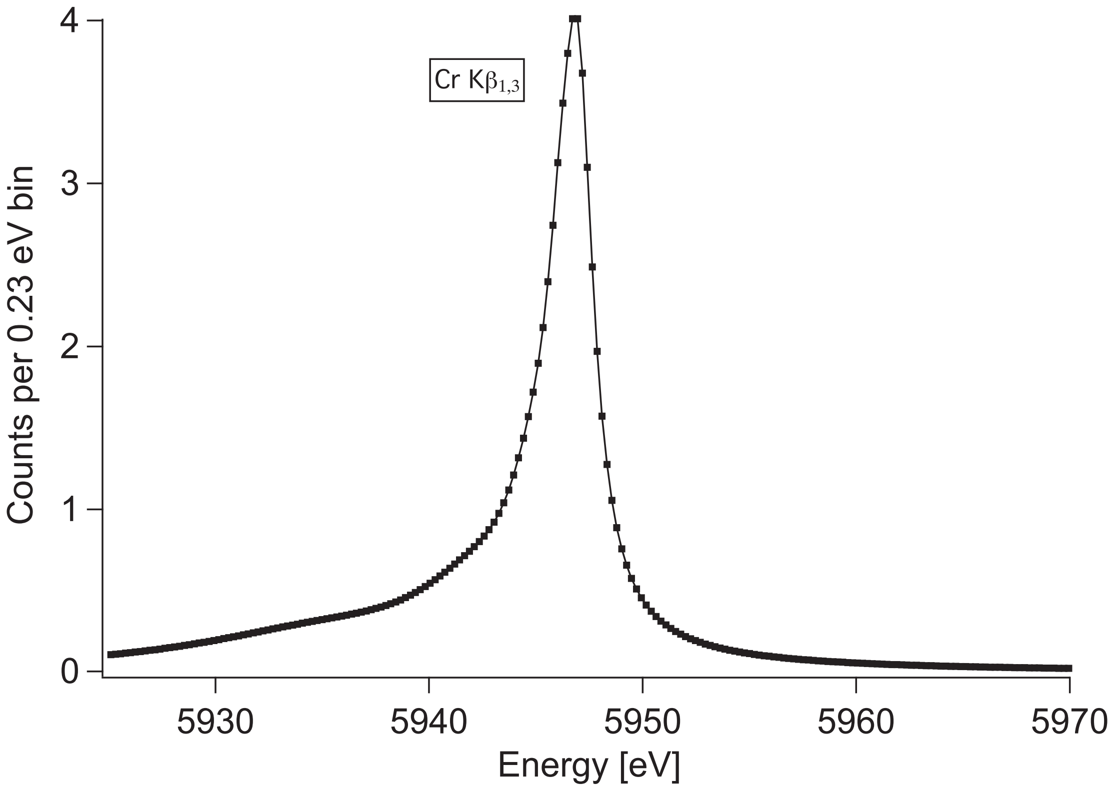
Extension 4: Cr Kβ complex – Produced by the direct MXS

Five-Lorentzian model from Holzer et al. (1997).



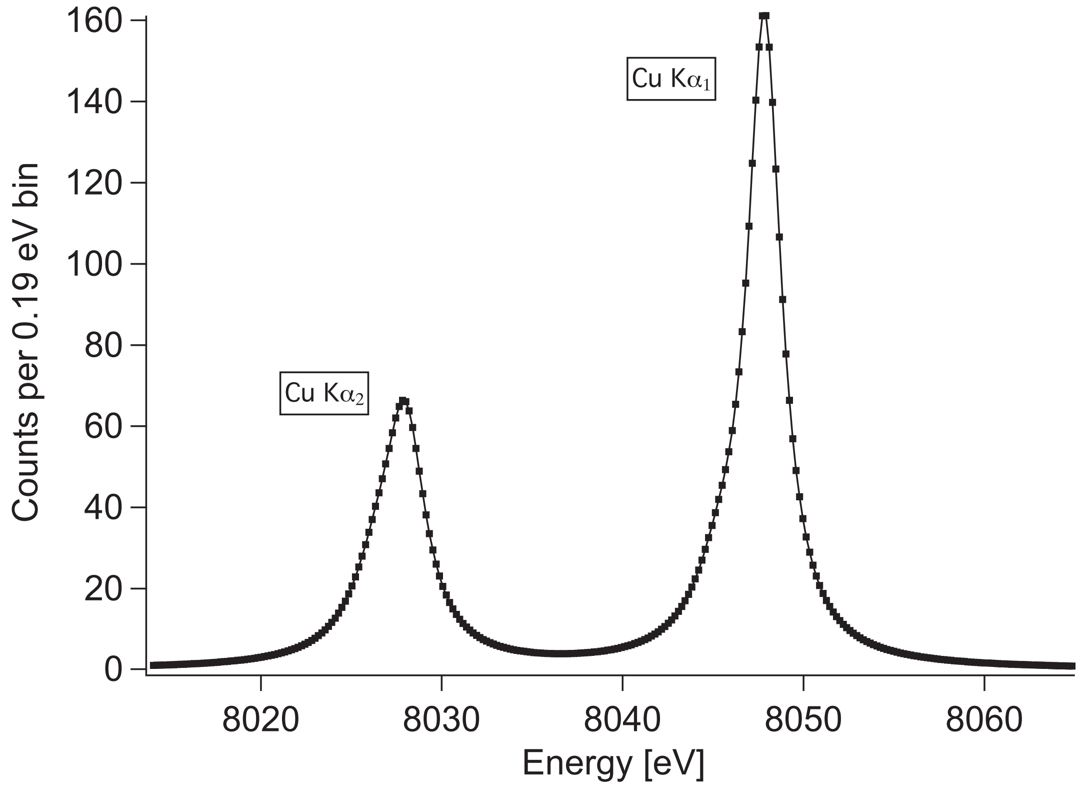
	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	5947.00	1.70	0.670	0.307
2	5935.31	15.98	0.055	0.236
3	5946.24	1.90	0.337	0.172
4	5942.04	6.69	0.082	0.148
5	5944.93	3.37	0.151	0.137

Table 4 Lorentzian coefficients for Cr Kβ complex

Cr Kβ center of mass = 5943.09 eV

Extension 5: Cu Kα complex – Produced by the direct MXS

Four-Lorentzian model from Holzer et al. (1997).



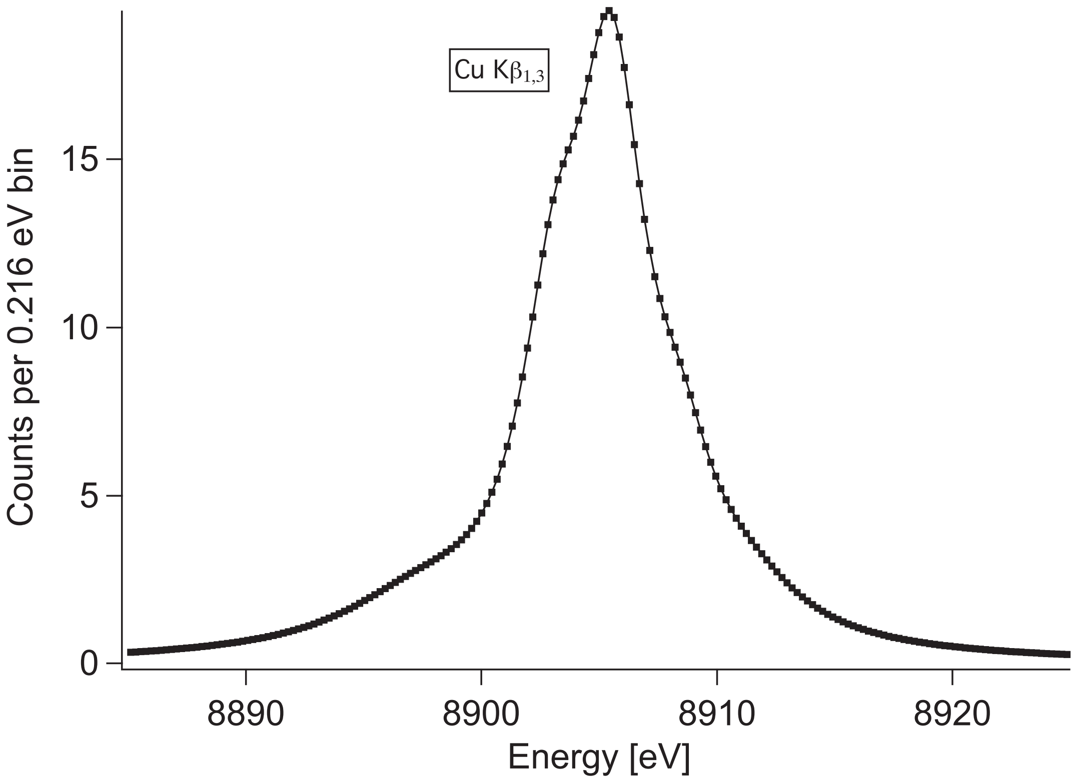
	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	8047.837	2.285	0.957	0.579
2	8045.367	3.358	0.090	0.080
3	8027.993	2.666	0.334	0.236
4	8026.504	3.571	0.111	0.105

Table 5 Lorentzian coefficients for Cu Kα complex

Cu Kα center of mass = 8040.72 eV

Extension 6: Cu Kβ complex – Produced by the direct MXS

Five-Lorentzian model from Holzer et al. (1997).



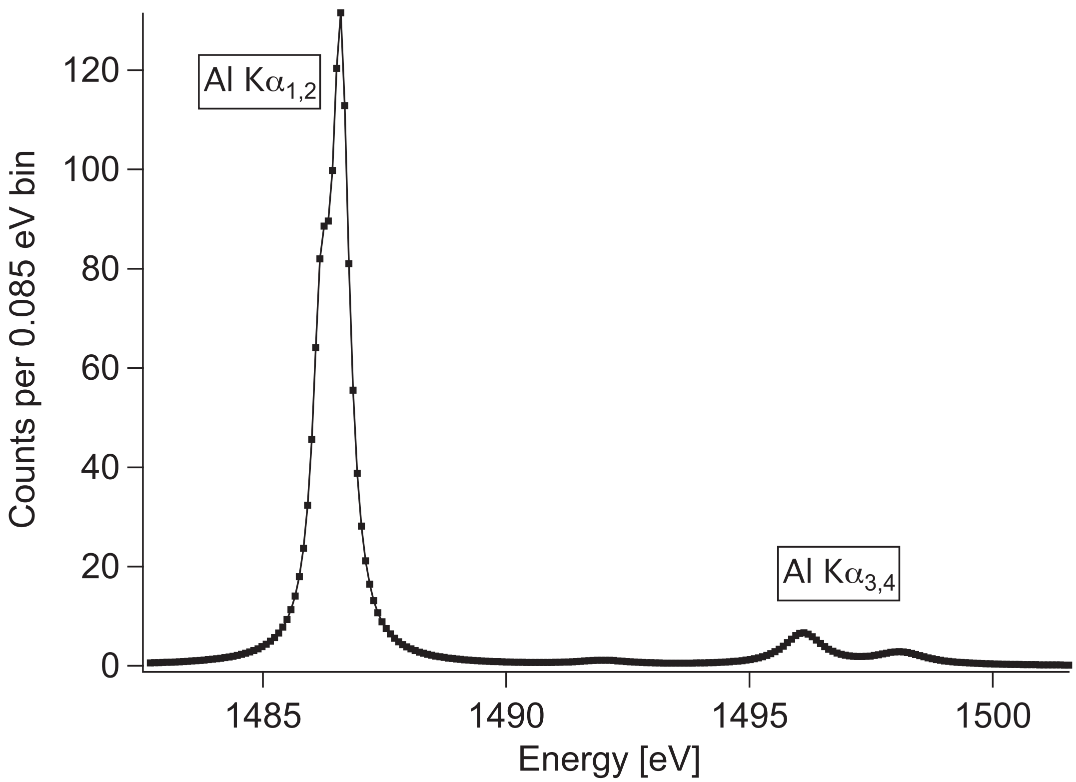
	E_0 [eV]	FWHM [eV]	Amplitude	Area
1	8905.532	3.52	0.757	0.485
2	8903.109	3.52	0.388	0.248
3	8908.462	3.55	0.171	0.110
4	8897.387	8.08	0.068	0.100
5	8911.393	5.31	0.055	0.055

Table 6 Lorentzian coefficients for Cu Kβ complex

Cu Kβ center of mass = 8904.76 eV

Extension 7: Al Kα complex – Produced by the indirect (fluorescent) MXS

Line positions from Fischer and Baun (1965). Line widths for Al Kα_1 and Kα_2 (rows 1 and 2) from Krause and Oliver (1979); widths for Al Kα_3 and Kα_4 (rows 4 and 5) from Nordfors (1955).



	E_0 [eV]	FWHM [eV]	Amplitude
1	1486.9	0.43	1
2	1486.5	0.43	0.5
3*	1496.4	0.96	0.05375
4*	1498.4	1.252	0.04121
5*	1492.3	1.34	0.03851

Table 7 Lorentzian coefficients for Al Kα complex

Al Kα12 center of mass = 1486.77 eV

* The literature values of the non-diagram lines (Kα', Kα_3, Kα_4) are given for reference only. Because these lines change based on details of the x-ray generator, the lines produced by the MXS will likely be slightly different from the values in Table 7. If fitting for gain or line-spread function parameters, we suggest using Kα_{12} only (rows 1 and 2).

Extension 8: Al Kβ complex – Produced by the indirect (fluorescent) MXS

Line positions from Bearden et al. (1967).

	E_0 [eV]	FWHM [eV]	Amplitude
1	1557.4	0.5*	1

Table 8 Lorentzian coefficient for Al Kβ complex

Extension 9: Mg $K\alpha_{12}$ – Produced by the indirect (fluorescent) MXS

Line position and width from Schweppe et al. Because $K\alpha_1$ and $K\alpha_2$ are only 0.25 eV apart, we model them as a single Lorentzian.

	E_0 [eV]	FWHM [eV]	Amplitude
1	1253.6	0.36	1

Table 9 Lorentzian coefficients for Mg $K\alpha_{12}$ complex

Not incorporated in CALDB file: Mg Kβ – Produced by the indirect (fluorescent) MXS

Line positions from Bearden et al. (1967).

	E_0 [eV]	FWHM [eV]	Amplitude
1	1302.2	0.4*	1

Table 10 Lorentzian coefficients for Mg Kβ complex

*Note: there is no reference for this width, so this is our best estimate based on the width of Mg Kα.

2.3 Final Remarks

This is the first official release of this document.

3 References

[1] Bearden. *Rev. Modern Physics,* **39,** 78 (1967).

[2] D.W. Fischer and W.L. Baun, *J. Appl. Phys.,* **36,** 534 (1965).

[3] G. Holzer, M. Fritsch, M. Deutsch, J. Hartwig, and E. Forster. "Kα_{12} and Kβ_{13} x-ray emission lines of the 3d transition metals." *Phys. Rev. A,* **56,** 4554–4568 (1997).

[4] M. O. Krause and J. H. Oliver. "Natural widths of atomic K and L levels, Kα X-ray lines and several KLL Auger lines," *J. Phys. Chem. Ref. Data,* **Vol 8, No 2,** 329-338 (1979).

[5] B. Nordfors. *Proc. Phys. Soc. A,* **68,** 654 (1955).

[6] J. Schweppe, R.D. Deslattes, T. Mooney, and C.J. Powell. *Electron Spectrosc. Relat. Phenom.,* **67,** 463 (1994).

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