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Supporting information for article:

Approximating the near-edge mass absorption coefficients for Ni using an ultra-thin bimetal foil

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Supporting information for this article includes a brief summary of the characteristics of a beam position monitor using a Ti-Ni foil, plus an extended table of all the mass absorption coefficients determined from the fs-Ni experiment in the energy range of 8.256-9.006 keV using both the XCOM and FFAST models. It is important to note that all absorption measurements beyond 9.006 keV were measured in discrete steps. It is possible, therefore, that there may be small oscillations in the mass absorption coefficient data from 9-10 keV that are not fully represented by a linear interpolation as presented in the main manuscript tables and figures.

S1. Performance of a Ti-Ni foil beam position monitor.

Figure S1 illustrates the estimated transmission characteristics of the Ti-Ni foil compared to the Cr foil. For this comparison, the Cr foil is 0.5- μm thick and the Ti-Ni foil is shown with two different thicknesses, one at 0.5/0.5- μm and the other at 0.97/0.67- μm (Ti/Ni) as used in this study. At 5 keV, the transmission is still a reasonable 68 %, compared to 82 % at the Cr K-edge. Transmission would be closer to the Cr values if the thicknesses were similarly matched at 0.5- μm each.

Figure S2 shows a cutaway view of the FMB Oxford beam position monitor device. As shown, X-rays travel through the device from left to right. The foil holder is mounted to a pneumatic plunger that installs and removes the foil from the beam path. This device is linked to a pressure sensor that keeps the foil out of the air evacuation path until the vacuum level is appropriate for lowering the foil. The foil is always positioned downstream of the photodiodes to ensure any powder diffraction lines generated from the metal foil will be too weak to interfere with the fluorescence signal. The foil is mounted to a metal ring, with a minimum ring internal diameter of 10mm. Under normal operating conditions, the foil is left in the beam, allowing continuous readings at all energies.

Figure S3 displays photodiode current generated by Ti-Ni fluorescence as a function of energy. Because the emission energy of Ti is lower than that of Cr, the output signal is reduced by about a factor of 2 below the Ni K-edge. Gain in signal above the Ni K-edge occurs because the emission energy from Ni is much higher than that given off by Cr. This increase in emission energy results in a factor of 3 or more gain in signal strength over the Cr signal. The signal loss/gain combination serves to flatten out the electrometer gain requirements as a function of energy. As a result, only a single electrometer gain setting ($4 \times 10^7 \text{ V/A}$) is needed to monitor the incoming beam at 19BM over the entire energy range of 6-13.5 keV. Although infrequently used, this setting should also be optimal for all energies below 6 keV.

Figure S4 displays a vertical calibration scan using BPM-1 at 8.2 keV. At any given energy, beam position varies linearly with intensity, just as it does using a Cr metal foil, over the central calibration range of 1mm. However, below the Ni K-edge, the calibration slope decreases with energy at a rate of

about 1 % from 6-8.33 keV. As the energy crosses the K-edge, a one-time slope decrease of 4.7 % occurs due to the addition of Ni fluorescence. From the slope transition point beyond the K-edge, the calibration slopes decreases at a rate of 0.5 % with increasing energy.

S2. Ni foil determined mass absorption coefficients

Table S1 lists the mass absorption coefficients obtained by scanning the energy range 8.265-9.006 keV. Absorption measurements were made using the nominal 8- μm -thick fs-Ni foil and the ion chamber, as outlined in the text. Mass absorption coefficients have been calculated based on the computed fs-Ni-xc thickness of $7.722 \pm 0.055 \mu\text{m}$ ($\pm 0.71 \%$) determined from the Ti-Ni fit using XCOM values. FFAST modelling resulted in an fs-Ni-ff thickness of $7.844 \pm 0.063 \mu\text{m}$ ($\pm 0.80 \%$), producing a different set of coefficients. Experimental mass absorption coefficient errors are estimated from the fs-Ni thickness error, which is slightly different between the two models.

Table S1 fs-Ni mass absorption coefficients calculated using thicknesses determined from Ti-Ni fit coefficients based on XCOM and FFAST models. XCOM database coefficients are reported from NIST database values. FFAST database coefficients are interpolated via curve fit from NIST parameters and are not available right at the edge boundary.

#	Energy (keV)	XCOM		fs-Ni-ff	FFAST
		fs-Ni-xc (cm ² /g)	database (cm ² /g)	(cm ² /g)	(cm ² /g)
1	8.256	43.90	45.41	43.22	43.71
2	8.257	43.97	45.39	43.29	43.69
3	8.258	43.92	45.38	43.24	43.68
4	8.259	43.88	45.36	43.20	43.66
5	8.260	43.97	45.35	43.29	43.65
6	8.261	43.94	45.33	43.26	43.64
7	8.262	43.87	45.32	43.19	43.62
8	8.263	43.83	45.30	43.15	43.61
9	8.264	43.85	45.29	43.17	43.59
10	8.265	43.91	45.27	43.23	43.58
11	8.266	43.90	45.26	43.22	43.57
12	8.267	43.76	45.24	43.08	43.55
13	8.268	43.87	45.23	43.19	43.54
14	8.269	43.85	45.21	43.17	43.53
15	8.270	43.88	45.20	43.20	43.51
16	8.271	43.81	45.18	43.13	43.50
17	8.272	43.81	45.17	43.13	43.48
18	8.273	43.78	45.15	43.10	43.47

19	8.274	43.84	45.14	43.16	43.46
20	8.275	43.79	45.12	43.11	43.44
21	8.276	43.81	45.11	43.13	43.43
22	8.277	43.76	45.09	43.08	43.42
23	8.278	43.84	45.08	43.16	43.40
24	8.279	43.80	45.06	43.12	43.39
25	8.280	43.69	45.05	43.01	43.37
26	8.281	43.81	45.03	43.13	43.36
27	8.282	43.82	45.02	43.14	43.35
28	8.283	43.75	45.00	43.07	43.33
29	8.284	43.79	44.99	43.12	43.32
30	8.285	43.69	44.97	43.01	43.31
31	8.286	43.67	44.96	43.00	43.29
32	8.287	43.76	44.94	43.08	43.28
33	8.288	43.83	44.93	43.15	43.26
34	8.289	43.76	44.91	43.08	43.25
35	8.290	43.78	44.90	43.10	43.24
36	8.291	43.78	44.89	43.10	43.22
37	8.292	43.88	44.87	43.20	43.21
38	8.293	43.87	44.86	43.19	43.20
39	8.294	43.86	44.84	43.18	43.18
40	8.295	43.86	44.83	43.18	43.17
41	8.296	43.84	44.81	43.16	43.16
42	8.297	43.82	44.80	43.14	43.14
43	8.298	43.81	44.78	43.13	43.13
44	8.299	43.79	44.77	43.11	43.11
45	8.300	43.85	44.75	43.17	43.10
46	8.301	43.90	44.74	43.22	43.09
47	8.302	43.91	44.72	43.23	43.07
48	8.303	43.95	44.71	43.27	43.06
49	8.304	44.01	44.69	43.32	43.05
50	8.305	44.03	44.68	43.34	43.03
51	8.306	44.02	44.66	43.34	43.02
52	8.307	44.08	44.65	43.39	43.01
53	8.308	44.15	44.63	43.47	42.99
54	8.309	44.17	44.62	43.49	42.98
55	8.310	44.24	44.60	43.55	42.97
56	8.311	44.32	44.59	43.63	42.95
57	8.312	44.45	44.57	43.76	42.94
58	8.313	44.51	44.56	43.82	42.93

59	8.314	44.55	44.55	43.86	42.91
60	8.315	44.70	44.53	44.01	42.90
61	8.316	44.83	44.52	44.13	42.88
62	8.317	44.91	44.50	44.21	42.87
63	8.318	45.05	44.49	44.35	42.86
64	8.319	45.16	44.47	44.46	42.84
65	8.320	45.41	44.46	44.71	42.83
66	8.321	45.60	44.44	44.89	42.82
67	8.322	45.88	44.43	45.17	42.80
68	8.323	46.15	44.41	45.43	42.79
69	8.324	46.59	44.40	45.87	42.78
70	8.325	47.07	44.38	46.34	
71	8.326	47.69	44.37	46.95	
72	8.327	48.46	44.35	47.71	
73	8.328	49.68	44.34	48.91	
74	8.329	51.53	44.33	50.73	
75	8.330	55.46	44.31	54.60	
76	8.331	65.04	44.30	64.03	
77	8.332	84.53	44.28	83.22	
78	8.333	110.04	44.28	108.34	
79	8.334	133.75	329.30	131.67	
80	8.335	150.20	329.30	147.87	
81	8.336	159.58	329.20	157.11	
82	8.337	166.75	329.10	164.17	
83	8.338	175.92	329.00	173.19	
84	8.339	187.08	328.90	184.18	
85	8.340	197.58	328.80	194.51	
86	8.341	207.98	328.70	204.75	
87	8.342	221.23	328.60	217.80	
88	8.343	238.41	328.50	234.71	
89	8.344	258.99	328.40	254.97	
90	8.345	281.93	328.30	277.56	
91	8.346	305.91	328.20	301.17	
92	8.347	327.49	328.10	322.41	
93	8.348	341.98	328.00	336.68	
94	8.349	348.83	327.90	343.43	
95	8.350	349.65	327.80	344.24	
96	8.351	346.86	327.70	341.49	
97	8.352	343.10	327.60	337.79	
98	8.353	340.84	327.50	335.56	

99	8.354	342.30	327.40	336.99	
100	8.355	347.97	327.30	342.58	
101	8.356	359.31	327.20	350.13	
102	8.357	364.38	327.10	356.33	
103	8.358	365.28	327.00	358.14	
104	8.359	362.58	326.90	356.96	
105	8.360	358.65	326.80	353.09	
106	8.361	355.05	326.70	349.55	
107	8.362	351.84	326.60	346.39	
108	8.363	348.12	326.60	342.73	
109	8.364	343.71	326.50	338.39	
110	8.365	339.71	326.40	334.44	
111	8.366	337.03	326.30	331.80	
112	8.367	335.47	326.20	330.27	
113	8.368	334.36	326.10	329.17	
114	8.369	333.76	326.00	328.59	
115	8.370	333.85	325.90	328.67	
116	8.371	334.86	325.80	329.67	
117	8.372	337.18	325.70	331.96	
118	8.373	340.65	325.60	335.37	
119	8.374	344.71	325.50	339.37	333.81
120	8.375	349.38	325.40	343.96	333.69
121	8.376	354.45	325.30	348.96	333.58
122	8.377	359.86	325.20	354.28	333.47
123	8.378	365.06	325.10	359.40	333.35
124	8.379	370.30	325.00	364.56	333.24
125	8.380	374.72	324.90	368.91	333.12
126	8.381	377.54	324.80	371.69	333.01
127	8.382	378.47	324.70	372.61	332.90
128	8.383	377.75	324.60	371.90	332.78
129	8.384	375.45	324.50	369.63	332.67
130	8.385	371.87	324.40	366.11	332.56
131	8.386	367.25	324.30	361.56	332.44
132	8.387	361.90	324.30	356.29	332.33
133	8.388	356.59	324.20	351.06	332.22
134	8.389	351.49	324.10	346.05	332.10
135	8.390	347.00	324.00	341.62	331.99
136	8.391	343.01	323.90	337.69	331.87
137	8.392	339.40	323.80	334.14	331.76
138	8.393	336.54	323.70	331.32	331.65

139	8.394	334.46	323.60	329.27	331.53
140	8.395	333.32	323.50	328.15	331.42
141	8.396	332.85	323.40	327.69	331.31
142	8.397	332.93	323.30	327.77	331.19
143	8.398	333.12	323.20	327.95	331.08
144	8.399	333.07	323.10	327.91	330.97
145	8.400	332.54	323.00	327.39	330.85
146	8.401	331.91	322.80	326.76	330.74
147	8.402	331.30	322.70	326.16	330.62
148	8.403	330.94	322.60	325.81	330.51
149	8.404	330.85	322.50	325.72	330.40
150	8.405	331.25	322.40	326.11	330.28
151	8.406	332.27	322.40	327.12	330.17
152	8.407	333.54	322.30	328.37	330.06
153	8.408	334.98	322.20	329.79	329.94
154	8.409	336.32	322.10	331.10	329.83
155	8.410	337.26	322.00	332.03	329.71
156	8.411	338.14	321.90	332.90	329.60
157	8.412	339.14	321.80	333.88	329.49
158	8.413	340.27	321.70	335.00	329.37
159	8.414	341.78	321.60	336.48	329.26
160	8.415	343.73	321.50	338.40	329.15
161	8.416	345.86	321.40	340.50	329.03
162	8.417	348.03	321.30	342.64	328.92
163	8.418	350.15	321.20	344.73	328.81
164	8.419	351.93	321.10	346.47	328.69
165	8.420	353.81	321.00	348.33	328.58
166	8.421	355.81	320.90	350.30	328.46
167	8.422	357.85	320.80	352.31	328.35
168	8.423	360.00	320.70	354.42	328.24
169	8.424	362.55	320.70	356.93	328.12
170	8.425	365.08	320.60	359.42	328.01
171	8.426	367.92	320.50	362.22	327.90
172	8.427	370.61	320.40	364.87	327.78
173	8.428	373.11	320.30	367.33	327.67
174	8.429	375.12	320.20	369.30	327.56
175	8.430	376.81	320.10	370.97	327.44
176	8.431	377.58	320.00	371.73	327.33
177	8.432	377.75	319.90	371.90	327.21
178	8.433	377.28	319.80	371.43	327.10

179	8.434	376.00	319.70	370.17	326.99
180	8.435	374.20	319.60	368.40	326.87
181	8.436	371.87	319.50	366.11	326.76
182	8.437	369.22	319.40	363.50	326.65
183	8.438	366.41	319.30	360.73	326.55
184	8.439	363.41	319.30	357.78	326.44
185	8.440	360.26	319.20	354.67	326.33
186	8.441	357.21	319.10	351.68	326.22
187	8.442	354.23	319.00	348.74	326.11
188	8.443	351.19	318.90	345.75	326.00
189	8.444	348.38	318.80	342.98	325.89
190	8.445	346.15	318.70	340.78	325.78
191	8.446	344.37	318.60	339.03	325.68
192	8.447	342.58	318.50	337.27	325.57
193	8.448	341.08	318.40	335.79	325.46
194	8.449	339.23	318.30	333.97	325.35
195	8.450	337.01	318.20	331.79	325.24
196	8.451	334.36	318.10	329.18	325.13
197	8.452	331.70	318.00	326.56	325.02
198	8.453	328.82	317.90	323.72	324.91
199	8.454	326.01	317.90	320.96	324.80
200	8.455	323.34	317.80	318.33	324.70
201	8.456	321.07	317.70	316.47	324.59
202	8.457	319.92	317.60	314.96	324.48
203	8.458	318.66	317.50	313.72	324.37
204	8.459	317.94	317.40	313.01	324.26
205	8.460	317.77	317.30	312.85	324.15
206	8.461	318.04	317.20	313.11	324.04
207	8.462	318.81	317.10	313.87	323.93
208	8.463	320.21	317.00	315.25	323.83
209	8.464	321.60	316.90	316.62	323.72
210	8.465	323.36	316.80	318.35	323.61
211	8.466	325.40	316.70	320.36	323.50
212	8.467	327.41	316.70	322.34	323.39
213	8.468	329.67	316.60	324.56	323.28
214	8.469	331.84	316.50	326.70	323.17
215	8.470	333.94	316.40	328.76	323.06
216	8.471	335.79	316.30	330.59	322.96
217	8.472	337.41	316.20	332.18	322.85
218	8.473	338.71	316.10	333.46	322.74

219	8.474	339.54	316.00	334.28	322.63
220	8.475	340.05	315.90	334.78	322.52
221	8.476	340.09	315.80	334.82	322.41
222	8.477	339.87	315.70	334.60	322.30
223	8.478	339.24	315.60	333.98	322.19
224	8.479	338.52	315.50	333.28	322.08
225	8.480	338.07	315.50	332.83	321.98
226	8.481	337.60	315.40	332.36	321.87
227	8.482	337.60	315.30	332.37	321.76
228	8.483	338.16	315.20	332.91	321.65
229	8.484	339.22	315.10	333.96	321.54
230	8.485	341.32	315.00	336.03	321.43
231	8.486	344.11	314.90	338.77	321.32
232	8.487	347.32	314.80	341.93	321.21
233	8.488	350.99	314.70	345.55	321.11
234	8.489	354.86	314.60	349.36	321.00
235	8.490	358.70	314.50	353.14	320.89
236	8.491	362.24	314.40	356.63	320.78
237	8.492	365.20	314.40	359.54	320.67
238	8.493	367.92	314.30	362.22	320.56
239	8.494	369.72	314.20	363.98	320.45
240	8.495	371.10	314.10	365.35	320.34
241	8.496	372.18	314.00	366.42	320.24
242	8.497	373.02	313.90	367.23	320.13
243	8.498	373.39	313.80	367.60	320.03
244	8.499	373.78	313.70	367.98	319.92
245	8.500	373.80	313.60	368.01	319.82
246	8.501	373.56	313.50	367.77	319.71
247	8.502	373.00	313.40	367.22	319.61
248	8.503	372.17	313.40	366.40	319.50
249	8.504	370.95	313.30	365.20	319.40
250	8.505	369.32	313.20	363.60	319.29
251	8.506	367.32	313.10	361.62	319.19
252	8.507	364.82	313.00	359.17	319.09
253	8.508	361.90	312.90	356.29	318.98
254	8.509	358.66	312.80	353.10	318.88
255	8.510	355.17	312.70	349.67	318.77
256	8.511	351.50	312.60	346.05	318.67
257	8.512	347.52	312.50	342.13	318.56
258	8.513	343.21	312.40	337.89	318.46

259	8.514	338.93	312.40	333.67	318.36
260	8.515	334.54	312.30	329.36	318.25
261	8.516	330.10	312.20	324.98	318.15
262	8.517	325.79	312.10	320.74	318.04
263	8.518	321.67	312.00	316.68	317.94
264	8.519	317.84	311.90	312.91	317.83
265	8.520	314.35	311.80	309.47	317.73
266	8.521	311.53	311.70	306.70	317.63
267	8.522	309.21	311.60	304.42	317.52
268	8.523	307.59	311.50	302.82	317.42
269	8.524	306.49	311.50	301.74	317.31
270	8.525	306.24	311.40	301.49	317.21
271	8.526	306.66	311.30	301.91	317.10
272	8.527	307.62	311.20	302.85	317.00
273	8.528	309.12	311.10	304.33	316.90
274	8.529	311.09	311.00	306.27	316.79
275	8.530	313.28	310.90	308.42	316.69
276	8.531	315.78	310.80	310.89	316.58
277	8.532	318.29	310.70	313.35	316.48
278	8.533	320.79	310.60	315.82	316.37
279	8.534	323.27	310.60	318.26	316.27
280	8.535	325.59	310.50	320.54	316.17
281	8.536	327.79	310.40	322.71	316.06
282	8.537	329.78	310.30	324.67	315.96
283	8.538	331.60	310.20	326.46	315.85
284	8.539	333.23	310.10	328.07	315.75
285	8.540	334.53	310.00	329.34	315.64
286	8.541	335.64	309.90	330.43	315.54
287	8.542	336.49	309.80	331.28	315.44
288	8.543	337.03	309.70	331.81	315.33
289	8.544	337.18	309.70	331.96	315.23
290	8.545	337.38	309.60	332.15	315.12
291	8.546	337.24	309.50	332.01	315.02
292	8.547	336.98	309.40	331.75	314.91
293	8.548	336.62	309.30	331.40	314.81
294	8.549	336.21	309.20	331.00	314.71
295	8.550	335.75	309.10	330.54	314.60
296	8.551	335.41	309.00	330.21	314.50
297	8.552	334.92	308.90	329.73	314.39
298	8.553	334.38	308.80	329.20	314.29

299	8.554	333.91	308.80	328.73	314.18
300	8.555	333.34	308.70	328.17	314.08
301	8.556	332.66	308.60	328.76	313.98
302	8.557	333.17	308.50	328.00	313.87
303	8.558	332.32	308.40	327.17	313.77
304	8.559	331.39	308.30	326.26	313.67
305	8.560	330.41	308.20	325.29	313.57
306	8.561	329.75	308.10	324.64	313.47
307	8.562	329.13	308.00	324.03	313.37
308	8.563	328.86	308.00	323.76	313.27
309	8.564	328.90	307.90	323.80	313.17
310	8.565	329.33	307.80	324.23	313.07
311	8.566	330.04	307.70	324.92	312.97
312	8.567	331.29	307.60	326.16	312.87
313	8.568	332.81	307.50	327.65	312.77
314	8.569	334.62	307.40	329.43	312.67
315	8.570	336.50	307.30	331.28	312.57
316	8.571	338.37	307.30	333.12	312.47
317	8.572	340.33	307.20	335.05	312.37
318	8.573	341.96	307.10	336.66	312.27
319	8.574	343.48	307.00	338.15	312.17
320	8.575	344.79	306.90	339.45	312.07
321	8.576	345.81	306.80	340.45	311.97
322	8.577	346.81	306.70	341.43	311.87
323	8.578	347.63	306.60	342.24	311.77
324	8.579	348.23	306.50	342.83	311.67
325	8.580	348.67	306.50	343.27	311.57
326	8.581	348.99	306.40	343.58	311.47
327	8.582	349.21	306.30	343.80	311.37
328	8.583	349.27	306.20	343.85	311.27
329	8.584	349.04	306.10	343.63	311.17
330	8.585	348.56	306.00	343.16	311.07
331	8.586	347.88	305.90	342.49	310.97
332	8.587	347.00	305.80	341.62	310.87
333	8.588	345.98	305.80	340.61	310.77
334	8.589	344.62	305.70	339.28	310.67
335	8.590	342.96	305.60	337.64	310.57
336	8.591	341.20	305.50	335.91	310.47
337	8.592	339.40	305.40	334.13	310.37
338	8.593	337.31	305.30	332.08	310.27

339	8.594	335.27	305.20	330.07	310.17
340	8.595	333.18	305.10	328.02	310.07
341	8.596	330.95	305.00	325.82	309.97
342	8.597	328.86	305.00	323.77	309.87
343	8.598	326.76	304.90	321.70	309.77
344	8.599	324.77	304.80	319.74	309.67
345	8.600	322.81	304.70	317.80	309.57
346	8.601	321.15	304.60	316.17	309.47
347	8.602	319.54	304.50	314.58	309.37
348	8.603	318.26	304.40	313.33	309.27
349	8.604	317.07	304.30	312.16	309.17
350	8.605	316.12	304.30	311.22	309.07
351	8.606	315.32	304.20	310.44	308.97
352	8.607	314.63	304.10	309.75	308.86
353	8.608	314.16	304.00	309.29	308.76
354	8.609	313.82	303.90	308.95	308.66
355	8.610	313.68	303.80	308.82	308.56
356	8.611	313.66	303.70	308.80	308.46
357	8.612	313.71	303.70	308.84	308.36
358	8.613	313.76	303.60	308.89	308.26
359	8.614	313.91	303.50	309.04	308.16
360	8.615	314.03	303.40	309.17	308.06
361	8.616	314.01	303.30	309.14	307.96
362	8.617	313.97	303.20	309.11	307.86
363	8.618	313.89	303.10	309.02	307.76
364	8.619	313.96	303.00	309.10	307.67
365	8.620	313.94	303.00	309.08	307.57
366	8.621	313.97	302.90	309.10	307.47
367	8.622	313.97	302.80	309.11	307.38
368	8.623	313.95	302.70	309.09	307.28
369	8.624	313.89	302.60	309.02	307.19
370	8.625	313.82	302.50	308.95	307.09
371	8.626	313.79	302.40	308.92	306.99
372	8.627	313.76	302.30	308.90	306.90
373	8.628	313.82	302.30	308.95	306.80
374	8.629	313.87	302.20	309.01	306.70
375	8.630	313.97	302.10	309.10	306.61
376	8.631	314.05	302.00	309.18	306.51
377	8.632	314.26	301.90	309.38	306.42
378	8.633	314.65	301.80	309.78	306.32

379	8.634	315.00	301.70	310.12	306.22
380	8.635	315.37	301.70	310.48	306.13
381	8.636	315.65	301.60	310.76	306.03
382	8.637	316.15	301.50	311.24	305.93
383	8.638	316.61	301.40	311.70	305.84
384	8.639	317.17	301.30	312.26	305.74
385	8.640	317.63	301.20	312.71	305.65
386	8.641	318.03	301.10	313.10	305.55
387	8.642	318.48	301.10	313.55	305.45
388	8.643	318.80	301.00	313.86	305.36
389	8.644	319.25	300.90	314.30	305.26
390	8.645	319.58	300.80	314.63	305.16
391	8.646	319.80	300.70	314.84	305.07
392	8.647	320.15	300.60	315.19	304.97
393	8.648	320.44	300.50	315.48	304.88
394	8.649	320.63	300.50	315.66	304.78
395	8.650	320.70	300.40	315.73	304.68
396	8.651	320.92	300.30	315.94	304.59
397	8.652	321.10	300.20	316.12	304.49
398	8.653	321.23	300.10	316.25	304.39
399	8.654	321.50	300.00	316.52	304.30
400	8.655	321.65	299.90	316.66	304.20
401	8.656	322.78	299.90	316.96	304.11
402	8.657	322.97	299.80	317.08	304.01
403	8.658	323.22	299.70	317.35	303.91
404	8.659	323.35	299.60	317.53	303.82
405	8.660	323.69	299.50	317.87	303.72
406	8.661	323.92	299.40	318.18	303.62
407	8.662	324.14	299.30	318.56	303.53
408	8.663	324.54	299.30	318.99	303.43
409	8.664	324.89	299.20	319.28	303.34
410	8.665	325.25	299.10	319.69	303.24
411	8.666	325.56	299.00	319.99	303.14
412	8.667	325.95	298.90	320.43	303.05
413	8.668	326.07	298.80	320.77	302.95
414	8.669	326.24	298.70	320.95	302.86
415	8.670	326.36	298.70	321.30	302.76
416	8.671	326.21	298.60	321.15	302.66
417	8.672	326.07	298.50	321.02	302.57
418	8.673	325.89	298.40	320.84	302.47

419	8.674	325.51	298.30	320.46	302.37
420	8.675	325.08	298.20	320.04	302.28
421	8.676	324.54	298.10	319.51	302.18
422	8.677	323.90	298.10	318.88	302.09
423	8.678	323.29	298.00	318.28	301.99
424	8.679	322.59	297.90	317.59	301.89
425	8.680	321.96	297.80	316.97	301.80
426	8.681	321.10	297.70	316.12	301.71
427	8.682	320.40	297.60	315.44	301.61
428	8.683	319.52	297.60	314.57	301.52
429	8.684	318.73	297.50	313.79	301.43
430	8.685	317.93	297.40	313.00	301.34
431	8.686	317.10	297.30	312.18	301.24
432	8.687	316.31	297.20	311.41	301.15
433	8.688	315.50	297.10	310.61	301.06
434	8.689	314.87	297.00	309.99	300.97
435	8.690	314.12	297.00	309.25	300.87
436	8.691	313.49	296.90	308.63	300.78
437	8.692	313.06	296.80	308.20	300.69
438	8.693	312.79	296.70	307.94	300.60
439	8.694	312.62	296.60	307.77	300.50
440	8.695	312.33	296.50	307.49	300.41
441	8.696	312.22	296.50	307.38	300.32
442	8.697	312.33	296.40	307.48	300.22
443	8.698	312.30	296.30	307.46	300.13
444	8.699	312.35	296.20	307.51	300.04
445	8.700	312.36	296.10	307.51	299.95
446	8.701	312.41	296.00	307.57	299.85
447	8.702	312.36	296.00	307.52	299.76
448	8.703	312.33	295.90	307.49	299.67
449	8.704	312.22	295.80	307.39	299.58
450	8.705	312.09	295.70	307.25	299.48
451	8.706	311.75	295.60	306.92	299.39
452	8.707	311.46	295.50	306.63	299.30
453	8.708	311.02	295.40	306.20	299.21
454	8.709	310.48	295.40	305.67	299.11
455	8.710	309.81	295.30	305.01	299.02
456	8.711	309.29	295.20	304.50	298.93
457	8.712	308.51	295.10	303.73	298.84
458	8.713	307.81	295.00	303.04	298.74

459	8.714	307.10	294.90	302.34	298.65
460	8.715	306.33	294.90	301.58	298.56
461	8.716	305.76	294.80	301.02	298.46
462	8.717	305.19	294.70	300.46	298.37
463	8.718	304.81	294.60	300.09	298.28
464	8.719	304.76	294.50	300.04	298.19
465	8.720	304.65	294.40	299.92	298.09
466	8.721	304.56	294.40	299.84	298.00
467	8.722	304.45	294.30	299.74	297.91
468	8.723	304.50	294.20	299.78	297.82
469	8.724	304.54	294.10	299.82	297.72
470	8.725	304.59	294.00	299.87	297.63
471	8.726	304.58	293.90	299.86	297.54
472	8.727	304.45	293.90	299.73	297.45
473	8.728	304.49	293.80	299.77	297.35
474	8.729	304.56	293.70	299.84	297.26
475	8.730	304.38	293.60	299.66	297.17
476	8.731	304.40	293.50	299.68	297.08
477	8.732	304.41	293.40	299.69	296.98
478	8.733	304.43	293.40	299.71	296.89
479	8.734	304.44	293.30	299.72	296.80
480	8.735	304.55	293.20	299.83	296.70
481	8.736	304.66	293.10	299.94	296.61
482	8.737	304.72	293.00	299.99	296.52
483	8.738	304.86	292.90	300.13	296.43
484	8.739	304.80	292.90	300.08	296.33
485	8.740	304.97	292.80	300.24	296.24
486	8.741	305.18	292.70	300.45	296.15
487	8.742	305.26	292.60	300.53	296.06
488	8.743	305.26	292.50	300.53	295.97
489	8.744	305.46	292.40	300.73	295.88
490	8.745	305.54	292.40	300.80	295.79
491	8.746	305.60	292.30	300.86	295.71
492	8.747	305.82	292.20	301.08	295.62
493	8.748	305.94	292.10	301.19	295.53
494	8.749	306.12	292.00	301.37	295.44
495	8.750	306.22	292.00	301.47	295.35
496	8.751	306.42	291.90	301.67	295.26
497	8.752	306.50	291.80	301.75	295.17
498	8.753	306.73	291.70	301.98	295.08

499	8.754	306.79	291.60	302.03	294.99
500	8.755	306.97	291.50	302.21	294.90
501	8.756	306.49	291.50	302.30	294.81
502	8.757	306.57	291.40	302.44	294.72
503	8.758	306.74	291.30	302.53	294.63
504	8.759	306.72	291.20	302.65	294.54
505	8.760	306.90	291.10	302.79	294.46
506	8.761	306.92	291.00	302.88	294.37
507	8.762	306.92	291.00	302.80	294.28
508	8.763	307.05	290.90	302.94	294.19
509	8.764	307.19	290.80	303.15	294.10
510	8.765	307.27	290.70	303.24	294.01
511	8.766	307.27	290.60	303.38	293.92
512	8.767	307.34	290.60	303.34	293.83
513	8.768	307.44	290.50	303.40	293.74
514	8.769	307.50	290.40	303.46	293.65
515	8.770	307.52	290.30	303.59	293.56
516	8.771	307.57	290.20	303.61	293.47
517	8.772	307.58	290.10	303.61	293.38
518	8.773	307.57	290.10	303.65	293.29
519	8.774	307.58	290.00	303.65	293.21
520	8.775	307.43	289.90	303.72	293.12
521	8.776	307.36	289.80	303.61	293.03
522	8.777	307.35	289.70	303.46	292.94
523	8.778	307.27	289.70	303.40	292.85
524	8.779	307.09	289.60	303.29	292.76
525	8.780	307.03	289.50	303.16	292.67
526	8.781	306.78	289.40	303.07	292.58
527	8.782	306.64	289.30	302.86	292.49
528	8.783	306.41	289.20	302.55	292.40
529	8.784	306.10	289.20	302.29	292.31
530	8.785	305.74	289.10	301.97	292.22
531	8.786	305.31	289.00	301.70	292.13
532	8.787	304.93	288.90	301.32	292.04
533	8.788	304.64	288.80	300.89	291.96
534	8.789	304.16	288.80	300.46	291.87
535	8.790	303.73	288.70	300.04	291.78
536	8.791	303.20	288.60	299.54	291.69
537	8.792	302.79	288.50	299.16	291.60
538	8.793	302.42	288.40	298.78	291.51

539	8.794	302.01	288.40	297.33	291.42
540	8.795	301.66	288.30	296.99	291.33
541	8.796	301.27	288.20	296.60	291.24
542	8.797	300.92	288.10	296.25	291.15
543	8.798	300.57	288.00	295.91	291.06
544	8.799	300.28	287.90	295.62	290.97
545	8.800	299.96	287.90	295.31	290.88
546	8.801	299.86	287.80	295.22	290.79
547	8.802	299.72	287.70	295.07	290.71
548	8.803	299.52	287.60	294.88	290.62
549	8.804	299.37	287.50	294.73	290.54
550	8.805	299.31	287.50	294.67	290.45
551	8.806	299.15	287.40	294.51	290.36
552	8.807	299.07	287.30	294.43	290.28
553	8.808	299.05	287.20	294.42	290.19
554	8.809	299.00	287.10	294.36	290.10
555	8.810	299.05	287.10	294.42	290.02
556	8.811	298.94	287.00	294.30	289.93
557	8.812	299.00	286.90	294.36	289.85
558	8.813	298.96	286.80	294.33	289.76
559	8.814	298.90	286.70	294.26	289.67
560	8.815	298.89	286.70	294.26	289.59
561	8.816	298.85	286.60	294.21	289.50
562	8.817	298.67	286.50	294.04	289.42
563	8.818	298.73	286.40	294.10	289.33
564	8.819	298.55	286.30	293.93	289.24
565	8.820	298.42	286.30	293.80	289.16
566	8.821	298.36	286.20	293.74	289.07
567	8.822	298.26	286.10	293.63	288.98
568	8.823	298.03	286.00	293.41	288.90
569	8.824	297.82	285.90	293.20	288.81
570	8.825	297.65	285.90	293.04	288.73
571	8.826	297.43	285.80	292.82	288.64
572	8.827	297.17	285.70	292.57	288.55
573	8.828	296.93	285.60	292.33	288.47
574	8.829	296.60	285.50	292.00	288.38
575	8.830	296.34	285.50	291.74	288.29
576	8.831	296.12	285.40	291.53	288.21
577	8.832	295.87	285.30	291.29	288.12
578	8.833	295.55	285.20	290.97	288.04

579	8.834	295.30	285.10	290.72	287.95
580	8.835	295.03	285.10	290.46	287.86
581	8.836	294.91	285.00	290.34	287.78
582	8.837	294.75	284.90	290.19	287.69
583	8.838	294.54	284.80	289.98	287.60
584	8.839	294.39	284.70	289.83	287.52
585	8.840	294.25	284.70	289.69	287.43
586	8.841	294.21	284.60	289.65	287.35
587	8.842	294.00	284.50	289.44	287.26
588	8.843	293.87	284.40	289.32	287.17
589	8.844	293.72	284.30	289.17	287.09
590	8.845	293.57	284.30	289.02	287.00
591	8.846	293.48	284.20	288.93	286.92
592	8.847	293.32	284.10	288.77	286.83
593	8.848	293.21	284.00	288.66	286.74
594	8.849	293.00	283.90	288.45	286.66
595	8.850	292.71	283.90	288.17	286.57
596	8.851	292.64	283.80	288.10	286.48
597	8.852	292.47	283.70	287.94	286.40
598	8.853	292.35	283.60	287.82	286.31
599	8.854	292.14	283.50	287.62	286.23
600	8.855	292.11	283.50	287.58	286.14
601	8.856	292.28	283.40	287.75	286.05
602	8.857	292.17	283.30	287.64	285.97
603	8.858	292.11	283.20	287.58	285.88
604	8.859	291.99	283.10	287.47	285.79
605	8.860	292.01	283.10	287.48	285.71
606	8.861	292.03	283.00	287.50	285.62
607	8.862	291.93	282.90	287.41	285.54
608	8.863	291.94	282.80	287.41	285.45
609	8.864	291.91	282.70	287.38	285.37
610	8.865	291.95	282.70	287.43	285.29
611	8.866	291.94	282.60	287.42	285.20
612	8.867	292.02	282.50	287.50	285.12
613	8.868	292.08	282.40	287.55	285.04
614	8.869	292.14	282.40	287.61	284.95
615	8.870	292.21	282.30	287.68	284.87
616	8.871	292.22	282.20	287.69	284.79
617	8.872	292.34	282.10	287.81	284.70
618	8.873	292.40	282.00	287.86	284.62

619	8.874	292.54	282.00	288.00	284.54
620	8.875	292.53	281.90	288.00	284.45
621	8.876	292.69	281.80	288.15	284.37
622	8.877	292.73	281.70	288.19	284.29
623	8.878	292.87	281.60	288.33	284.20
624	8.879	292.92	281.60	288.38	284.12
625	8.880	293.02	281.50	288.47	284.04
626	8.881	293.13	281.40	288.58	283.95
627	8.882	293.40	281.30	288.85	283.87
628	8.883	293.62	281.30	289.07	283.79
629	8.884	293.67	281.20	289.12	283.70
630	8.885	293.84	281.10	289.29	283.62
631	8.886	294.01	281.00	289.45	283.54
632	8.887	294.15	280.90	289.59	283.45
633	8.888	294.23	280.90	289.67	283.37
634	8.889	294.25	280.80	289.69	283.29
635	8.890	294.40	280.70	289.83	283.20
636	8.891	294.48	280.60	289.91	283.12
637	8.892	294.64	280.50	290.07	283.04
638	8.893	294.67	280.50	290.10	282.95
639	8.894	294.75	280.40	290.18	282.87
640	8.895	294.65	280.30	290.08	282.79
641	8.896	294.76	280.20	290.19	282.70
642	8.897	294.65	280.20	290.09	282.62
643	8.898	294.72	280.10	290.15	282.54
644	8.899	294.64	280.00	290.08	282.45
645	8.900	294.41	279.90	289.85	282.37
646	8.901	294.18	279.90	289.62	282.29
647	8.902	294.10	279.80	289.54	282.20
648	8.903	293.93	279.80	289.37	282.12
649	8.904	293.70	279.70	289.15	282.04
650	8.905	293.43	279.60	288.89	281.95
651	8.906	293.15	279.50	288.61	281.87
652	8.907	292.80	279.50	288.26	281.79
653	8.908	292.68	279.40	288.15	281.70
654	8.909	292.38	279.30	287.85	281.62
655	8.910	292.14	279.20	287.62	281.54
656	8.911	291.78	279.10	287.26	281.45
657	8.912	291.58	279.10	287.06	281.37
658	8.913	291.28	279.00	286.76	281.29

659	8.914	291.04	278.90	286.52	281.20
660	8.915	290.90	278.80	286.40	281.12
661	8.916	290.72	278.80	286.22	281.04
662	8.917	290.39	278.70	285.89	280.95
663	8.918	290.21	278.60	285.71	280.87
664	8.919	290.09	278.50	285.59	280.79
665	8.920	289.85	278.40	285.36	280.70
666	8.921	289.71	278.40	285.22	280.62
667	8.922	289.51	278.30	285.02	280.54
668	8.923	289.35	278.20	284.86	280.45
669	8.924	289.20	278.10	284.72	280.37
670	8.925	289.01	278.10	284.53	280.29
671	8.926	288.90	278.00	284.42	280.21
672	8.927	288.85	277.90	284.37	280.13
673	8.928	288.69	277.80	284.21	280.05
674	8.929	288.63	277.80	284.15	279.97
675	8.930	288.44	277.70	283.96	279.89
676	8.931	288.31	277.60	283.84	279.81
677	8.932	288.17	277.50	283.70	279.73
678	8.933	288.12	277.40	283.65	279.65
679	8.934	287.90	277.40	283.44	279.57
680	8.935	287.87	277.30	283.41	279.49
681	8.936	287.90	277.20	283.44	279.40
682	8.937	287.81	277.10	283.34	279.32
683	8.938	287.76	277.10	283.30	279.24
684	8.939	287.49	277.00	283.03	279.16
685	8.940	287.58	276.90	283.12	279.08
686	8.941	287.39	276.80	282.94	279.00
687	8.942	287.38	276.80	282.93	278.92
688	8.943	287.26	276.70	282.80	278.84
689	8.944	287.21	276.60	282.75	278.76
690	8.945	287.11	276.50	282.66	278.68
691	8.946	287.02	276.40	282.58	278.60
692	8.947	286.99	276.40	282.54	278.52
693	8.948	286.86	276.30	282.41	278.44
694	8.949	286.76	276.20	282.31	278.36
695	8.950	286.62	276.10	282.18	278.28
696	8.951	286.45	276.10	282.01	278.19
697	8.952	286.33	276.00	281.90	278.11
698	8.953	286.10	275.90	281.66	278.03

699	8.954	285.98	275.80	281.55	277.95
700	8.955	285.91	275.80	281.48	277.87
701	8.956	285.90	275.70	281.47	277.79
702	8.957	285.79	275.60	281.36	277.71
703	8.958	285.61	275.50	281.18	277.63
704	8.959	285.56	275.50	281.13	277.55
705	8.960	285.40	275.40	280.97	277.47
706	8.961	285.38	275.30	280.95	277.39
707	8.962	285.16	275.20	280.74	277.31
708	8.963	285.08	275.10	280.66	277.23
709	8.964	284.76	275.10	280.35	277.15
710	8.965	284.75	275.00	280.34	277.07
711	8.966	284.71	274.90	280.30	276.98
712	8.967	284.56	274.80	280.15	276.90
713	8.968	284.43	274.80	280.02	276.82
714	8.969	284.16	274.70	279.75	276.74
715	8.970	283.92	274.60	279.52	276.66
716	8.971	283.85	274.50	279.45	276.58
717	8.972	283.78	274.50	279.38	276.50
718	8.973	283.62	274.40	279.22	276.42
719	8.974	283.48	274.30	279.09	276.34
720	8.975	283.29	274.20	278.90	276.26
721	8.976	283.20	274.20	278.81	276.18
722	8.977	283.04	274.10	278.66	276.10
723	8.978	282.96	274.00	278.58	276.02
724	8.979	282.84	273.90	278.46	275.94
725	8.980	282.63	273.90	278.25	275.86
726	8.981	282.56	273.80	278.18	275.77
727	8.982	282.50	273.70	278.12	275.69
728	8.983	282.37	273.60	277.99	275.61
729	8.984	282.06	273.60	277.69	275.53
730	8.985	282.17	273.50	277.79	275.45
731	8.986	282.11	273.40	277.73	275.38
732	8.987	281.99	273.30	277.62	275.30
733	8.988	281.92	273.30	277.55	275.22
734	8.989	281.83	273.20	277.46	275.14
735	8.990	281.79	273.10	277.42	275.06
736	8.991	281.67	273.00	277.31	274.99
737	8.992	281.68	273.00	277.31	274.91
738	8.993	281.58	272.90	277.22	274.83

739	8.994	281.39	272.80	277.03	274.75
740	8.995	281.35	272.70	276.99	274.67
741	8.996	281.22	272.70	276.86	274.59
742	8.997	281.25	272.60	276.89	274.52
743	8.998	281.23	272.50	276.87	274.44
744	8.999	281.16	272.40	276.80	274.36
745	9.000	281.10	272.30	276.74	274.28
746	9.001	281.03	272.30	276.67	274.20
747	9.002	280.97	272.20	276.62	274.13
748	9.003	280.92	272.10	276.57	274.05
749	9.004	280.84	272.00	276.49	273.97
750	9.005	280.84	272.00	276.48	273.89
751	9.006	280.76	271.90	274.89	273.81

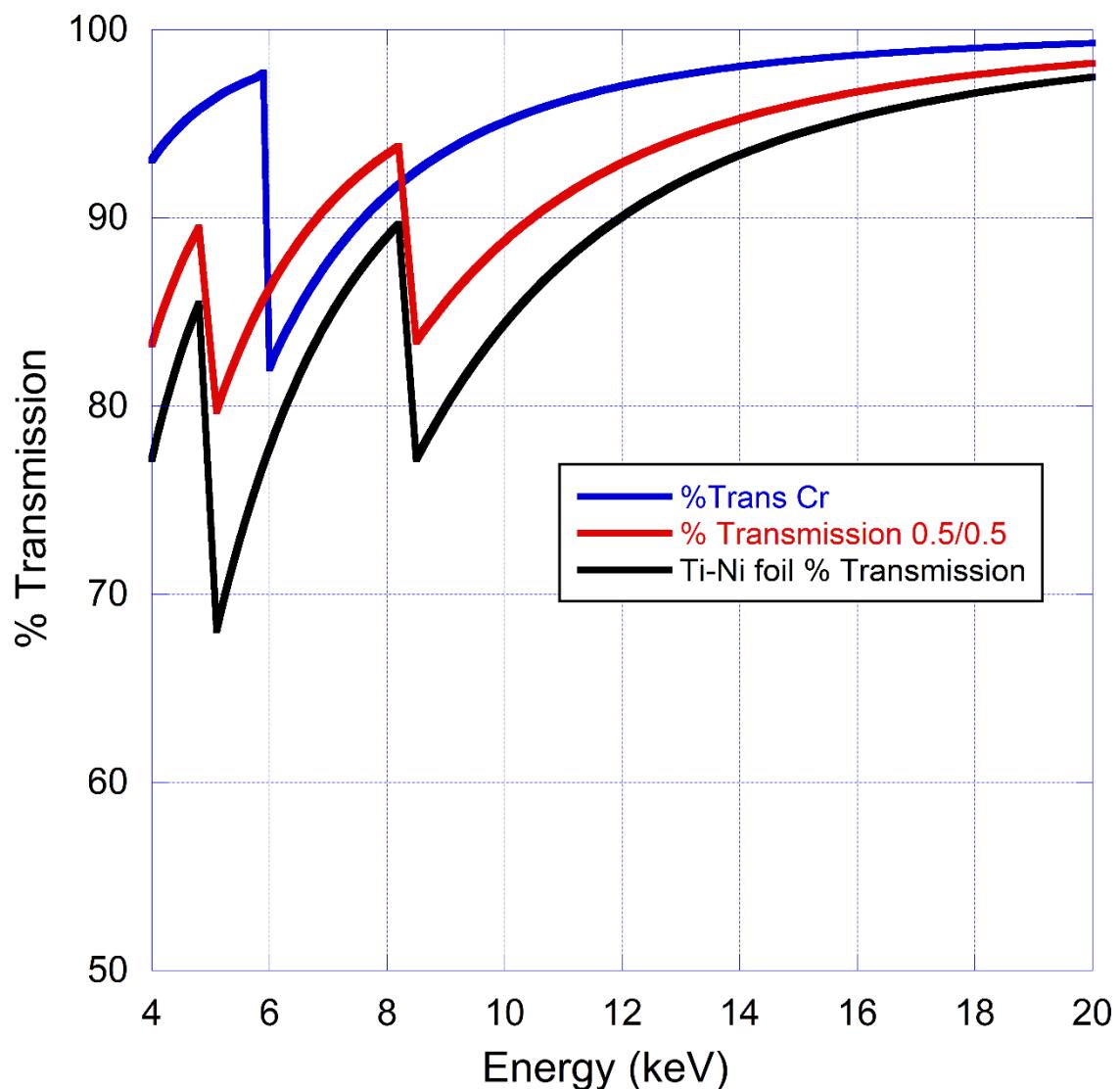


Figure S1 Estimated percent transmission through ultra-thin Cr and Ti-Ni foils. For this plot the Cr foil has a thickness of 0.5- μm . Ti-Ni foils are plotted with matching 0.5- μm thicknesses and 0.97/0.67- μm thicknesses as measured in this study.

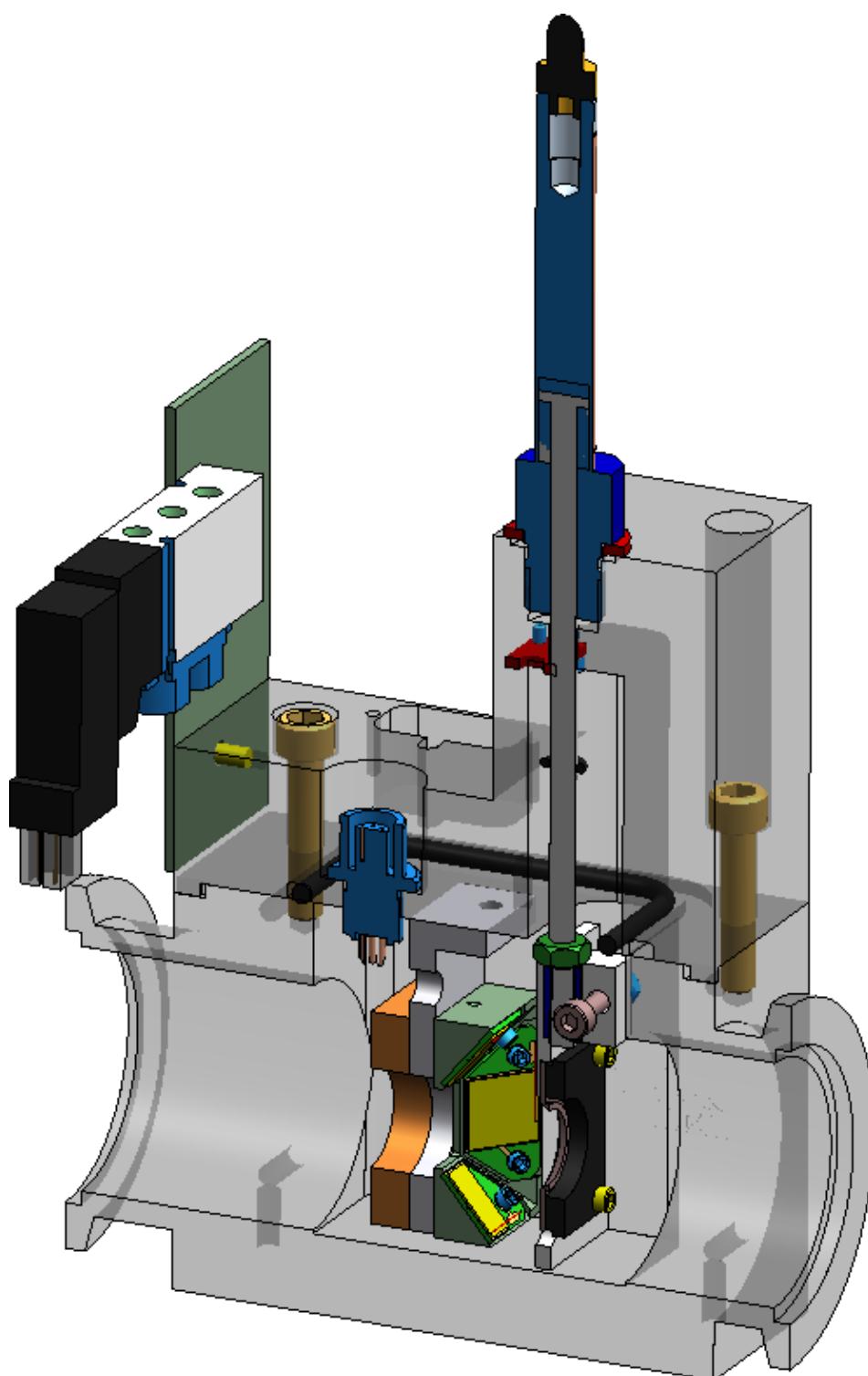


Figure S2 Cutaway view of the FMB Oxford HV QBPM beam position monitor device. X-rays pass through the device from left to right. The Ti-Ni foil is positioned downstream of the photodiodes to avoid powder diffraction lines from the foil that could interfere with measured fluorescence intensity.

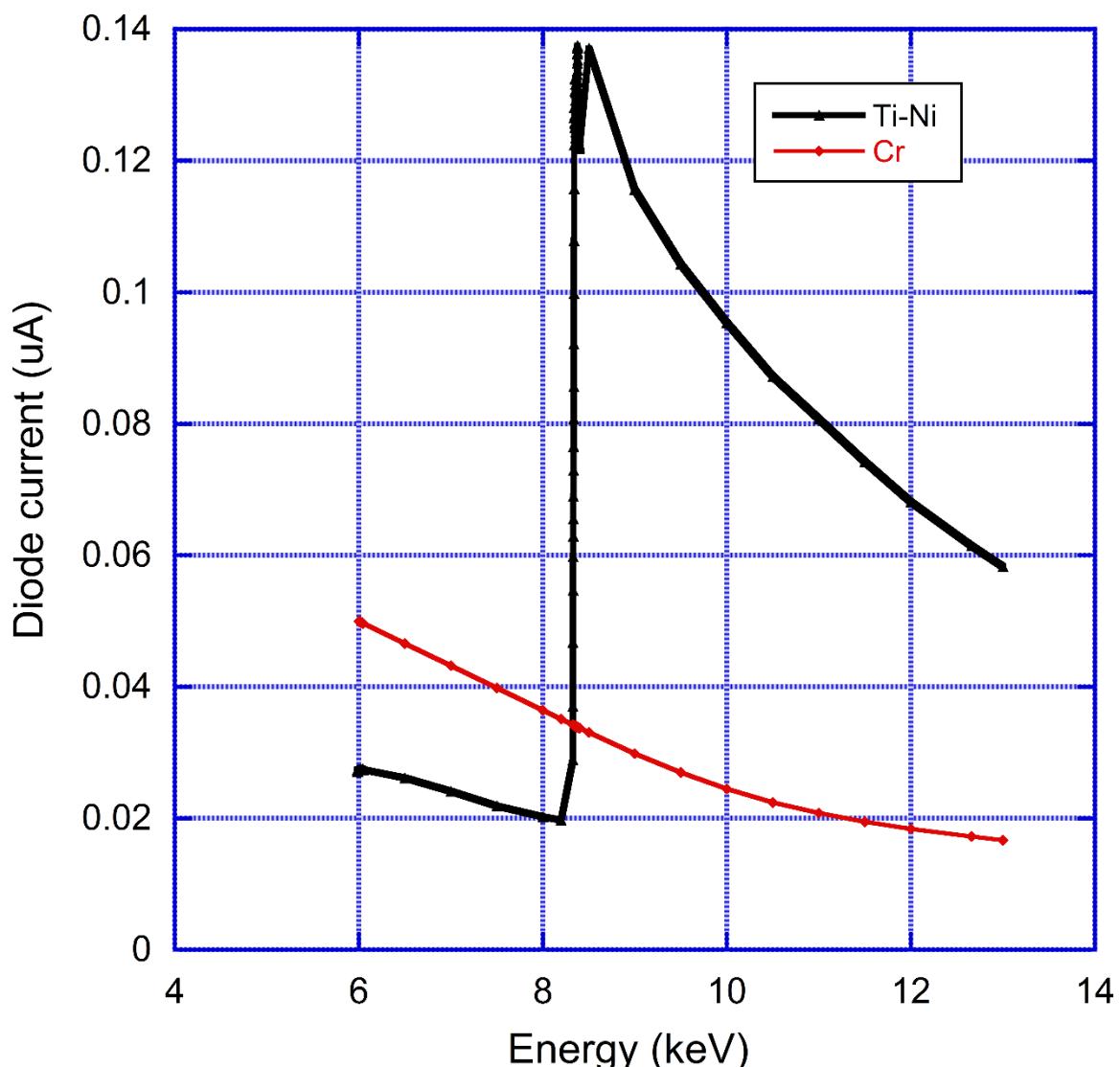


Figure S3 Photodiode current (μA) as a function of energy with separate Cr and Ti-Ni foils. Signal levels are 50 % lower in the region where only Ti fluorescence occurs, compared to Cr, but increase by a factor of 3 or more above the Ni K-edge.

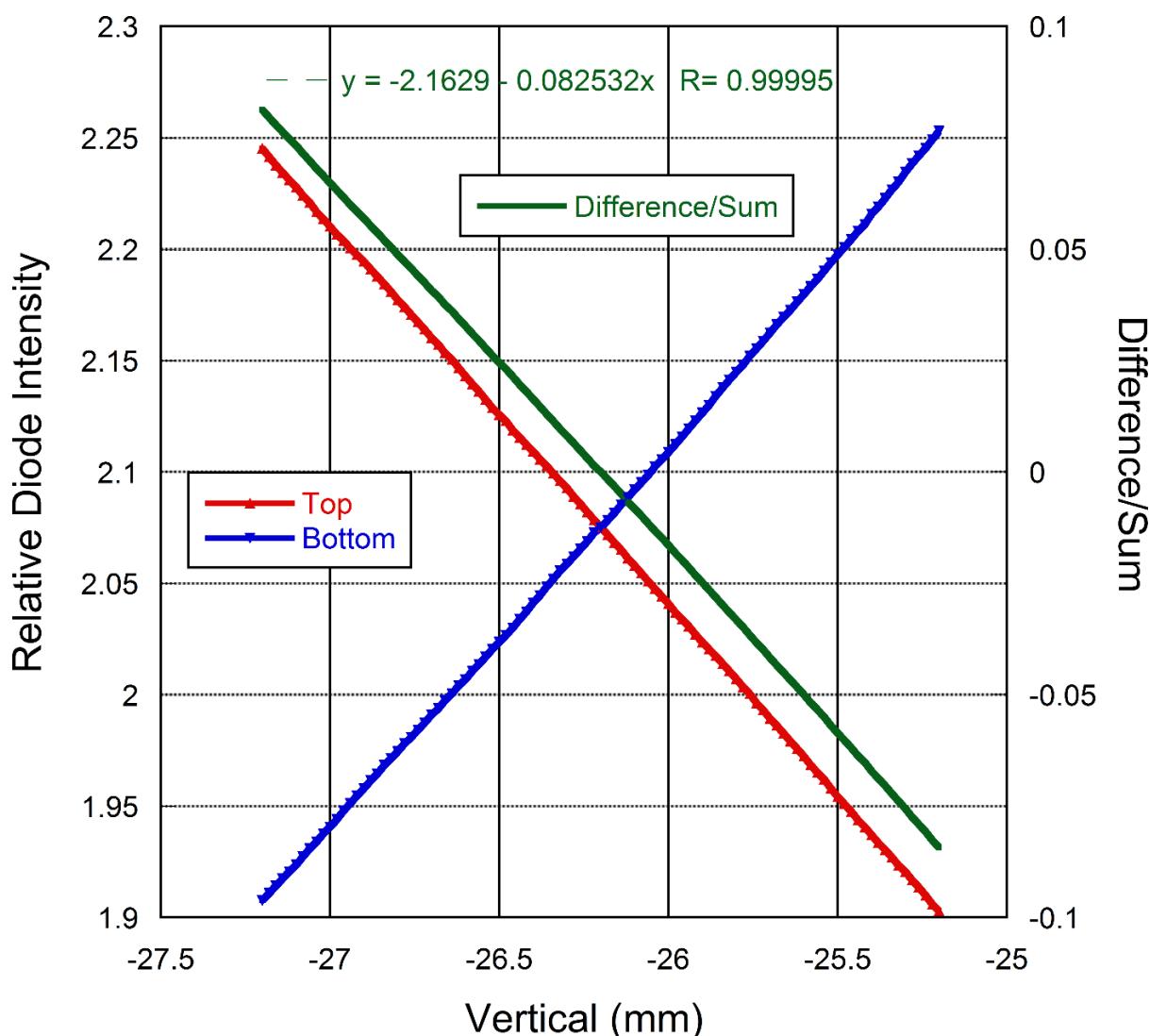


Figure S4 Vertical calibration at 8.2 keV. Beam position varies linearly with intensity over the central calibration range of 1 mm using the Ti-Ni foil, just as it does with the Cr foil.