Appendix B : CCD Camera Data Processing

MathCad 8.0 Professional (MathSoft, Inc.) was used for this data processing.

B1 Band Pass Filtering

The raw data is corrected by a band pass $0 < x < 3000$ for t=200s. Data points with a value $x < 0$ cannot be due to an x-ray photon but are fluctuations in the subtracted background. The upper limit excludes data points from another phenomenon: Some data points show exceptionally high count numbers of several thousands up to 60 000. These numbers can not be due to simple photons (could however be due to electrons which crossed the Al filter) but they have the weight of several photons when the CCD columns are added up. Therefore it is reasonable to set an upper limit for the acceptance of pixel values. From the pre-experimental estimation about 0.6 photons or 750 counts per pixel were expected for 200 s exposure. This is the average expectation for one pixel. An upper limit of 3000 counts therefore is 4 times this value and should cover most of the expected values of counts of the singular pixels.

B2 Data Correction for Camera Tilt Angle

The CCD camera was slightly tilted to the horizontal plane in the experiments. This tilt angle leads to a line broadening if the points are summarized along the CCD columns. That is why the CCD tilt angle was determined and the data sets were corrected using this angle in the summing procedure. For the data set shown in Fig. 5 - 6, the tilt angle was determined to be 1.55 deg. This value was found by comparing the line width of K_{alpha} line after adding up the data columns with different correction angles. The line width was calculated using a Gaussian fit function for two overlapping peaks. The tests were done using MicroCal Origin 6.1 with angles ranging from 1.4 to 1.8 deg. Reliable differences in the calculated line width were found for 0.05 deg step width.

B3 Integration Along CCD Columns

In the experimental setup the second lead aperture was in a low position and blocked part of the diffracted x-rays. Therefore in the CCD picture the lines 1 to about 100 show no line radiation. Furthermore, part of the data points in column 1 to 40 were empty (set to zero) due to the correction of the tilt angle of –1.55 deg. Hence, the CCD lines were only summarized from line 100 to 1023. The result is shown in Fig. B-1.

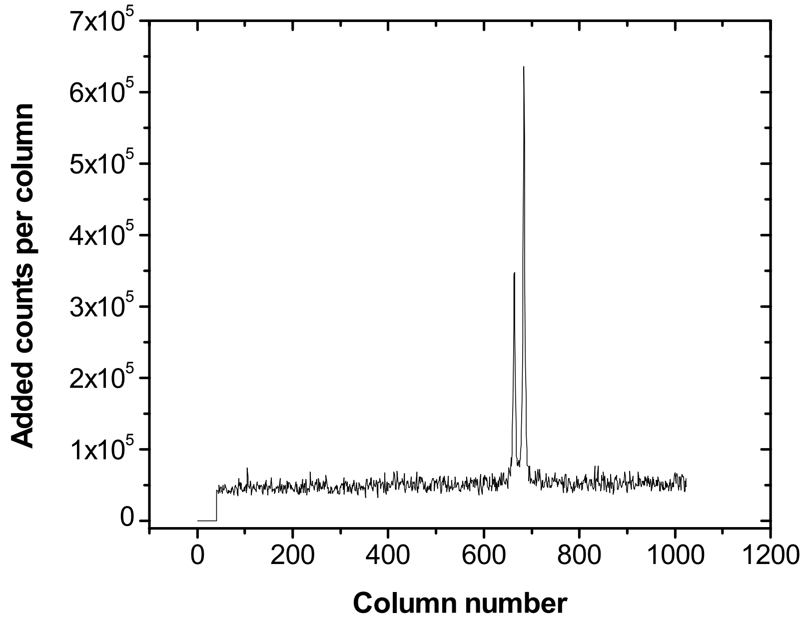

Fig. B-1 : Diffraction pattern after application of band-pass filter and summarizing along the columns.

B4 Subtraction of Noise and Normalization

After applying the band-pass filter and summarizing along the CCD columns, the average noise level is shifted to a level greater than zero. Taking the numbers as shown in Fig. B-1, this is about 5×10^4 cts/(900 pixel×200s) = 0.3 cts/s*pxl. The origin of this offset could be scattered X-rays. The development of noise level after application of the different noise reduction methods is shown in Table B-1. For a proper normalization of the data set, the average noise level after filtering is subtracted. Then the data set is normalized to its maximum peak value (Fig. 5-7). In this final data set only the standard deviation of the corrected and filtered background remains as noise related to the line peaks (which were also treated with these methods).

Table B-1 : Noise averaged over all lines in columns 800…1000 after application of different noise reduction methods (t=200 s).

Data set	Total collected noise per column [cts]	Noise (offset) [cts/s*pix]	Standard deviation [cts/s*pix]
Background data (20°C)	7.88×10^{6}	38.5	0.24
Background corrected signal , tilted 1.55 deg	33896	0.17	0.05
Bg. corrected signal , tilted 1.55 deg, filtered 0<x<3000	53306	0.30	0.038

B5 Drawing of the Experimental Setup

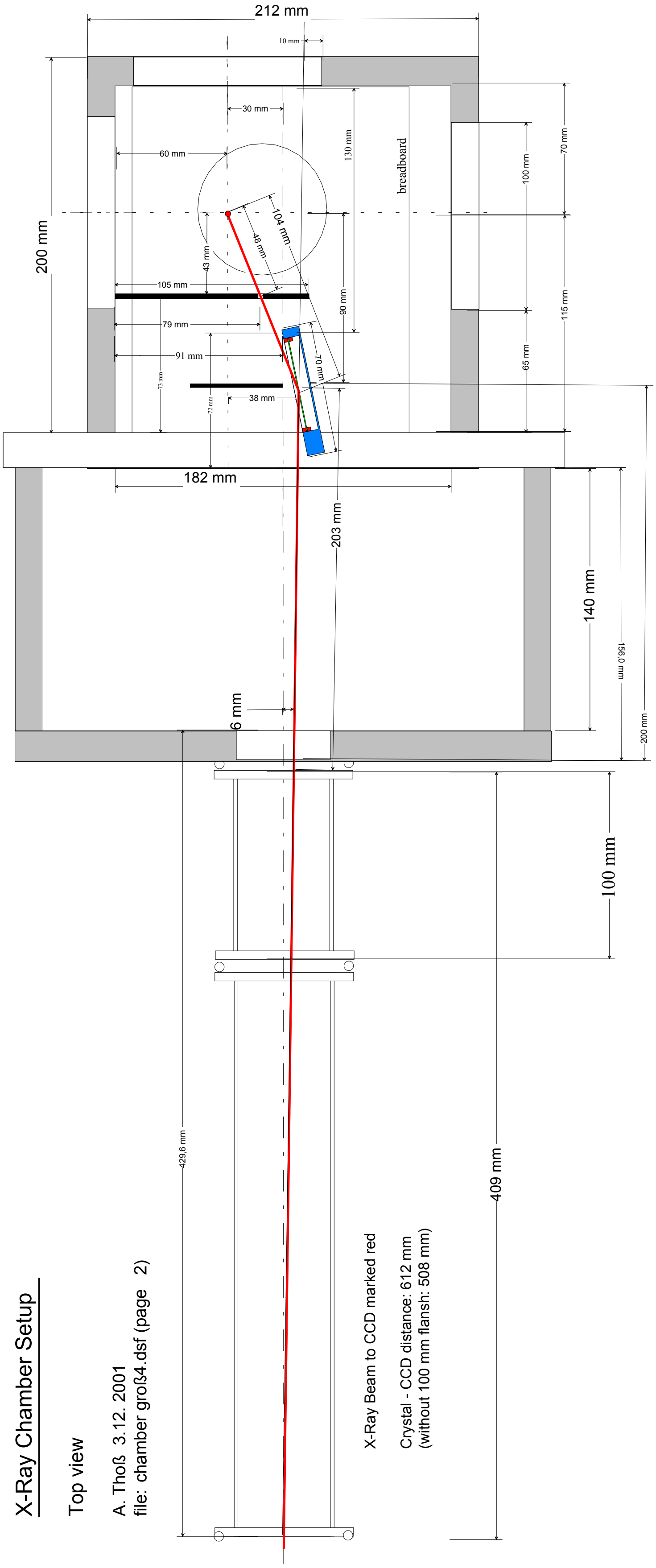

Fig. B-2 : Scaled drawing of the experimental setup for the Bragg diffraction experiments.