High Diffraction Efficiency, Broadband, Diffraction Crystals for Use in Crystal Diffraction Lenses.

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CRYSTALS WITH CURVED CRYSTALLINE PLANES

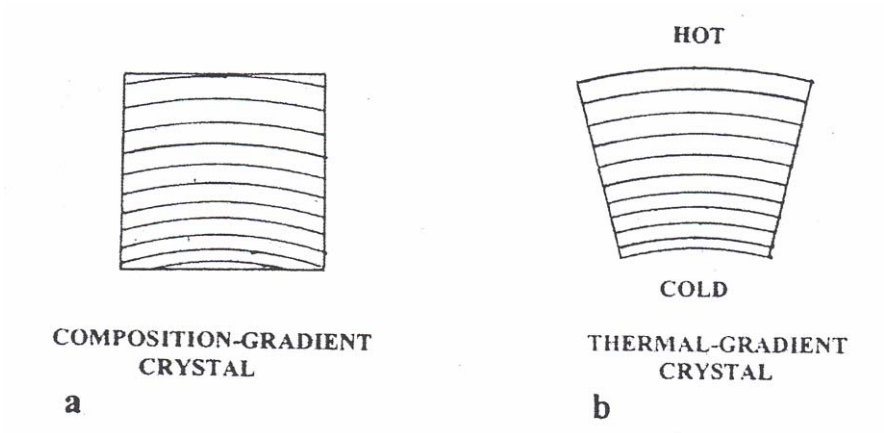

Figure 1a shows the curved crystalline planes in a Si-Ge two-component crystal where the higher concentration of Ge is at the top of the crystal. Figure 1b shows the curved crystalline planes in a thermal gradient crystal where the hot surface is the top surface.

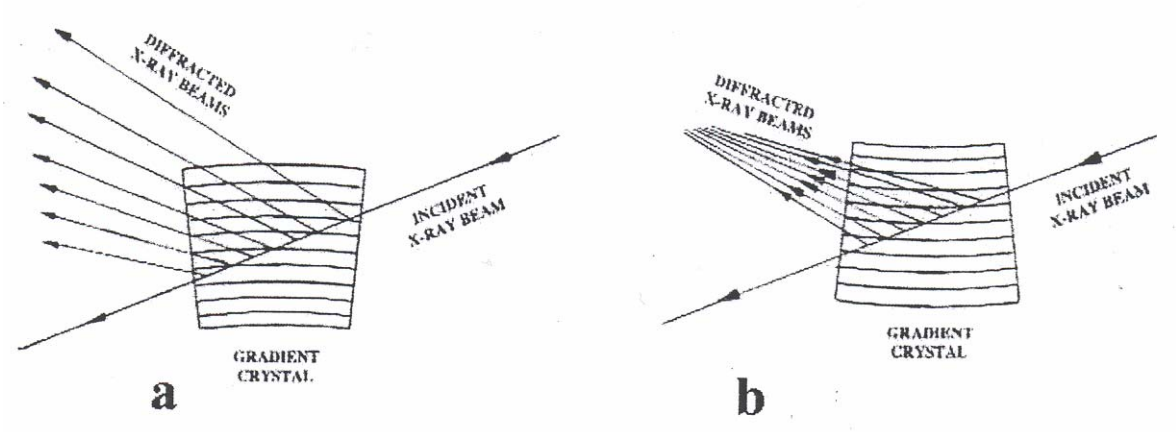

Figure 2a. Shows the diffraction of gamma ray beam that is incident on the convex side of the curved crystalline planes and figure 2b Shows the diffraction of gamma ray beam that is incident on the concave side of the curved crystalline planes.

THERMAL GRADIENT CRYSTALS

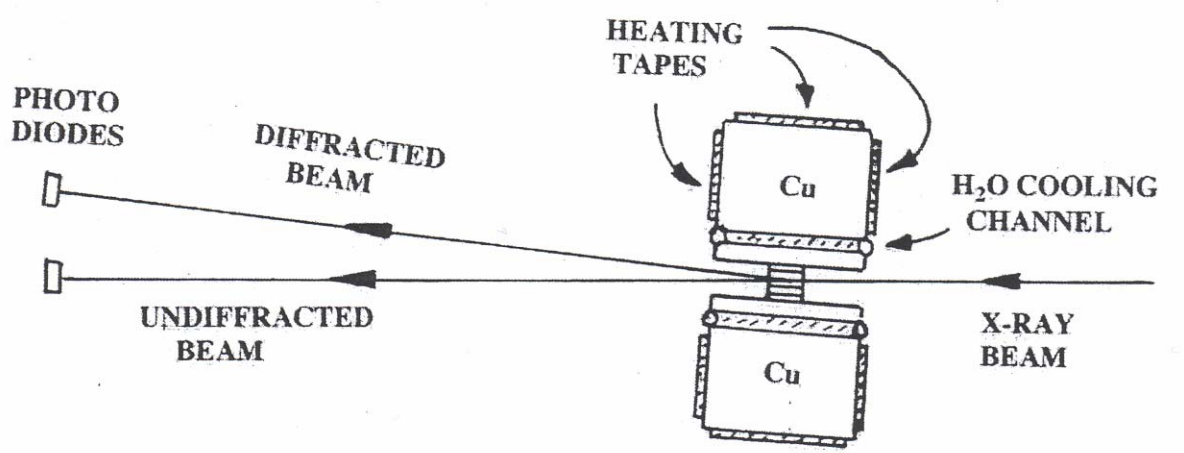

Figure 3. The experimental set up use in the thermal gradient experiments.

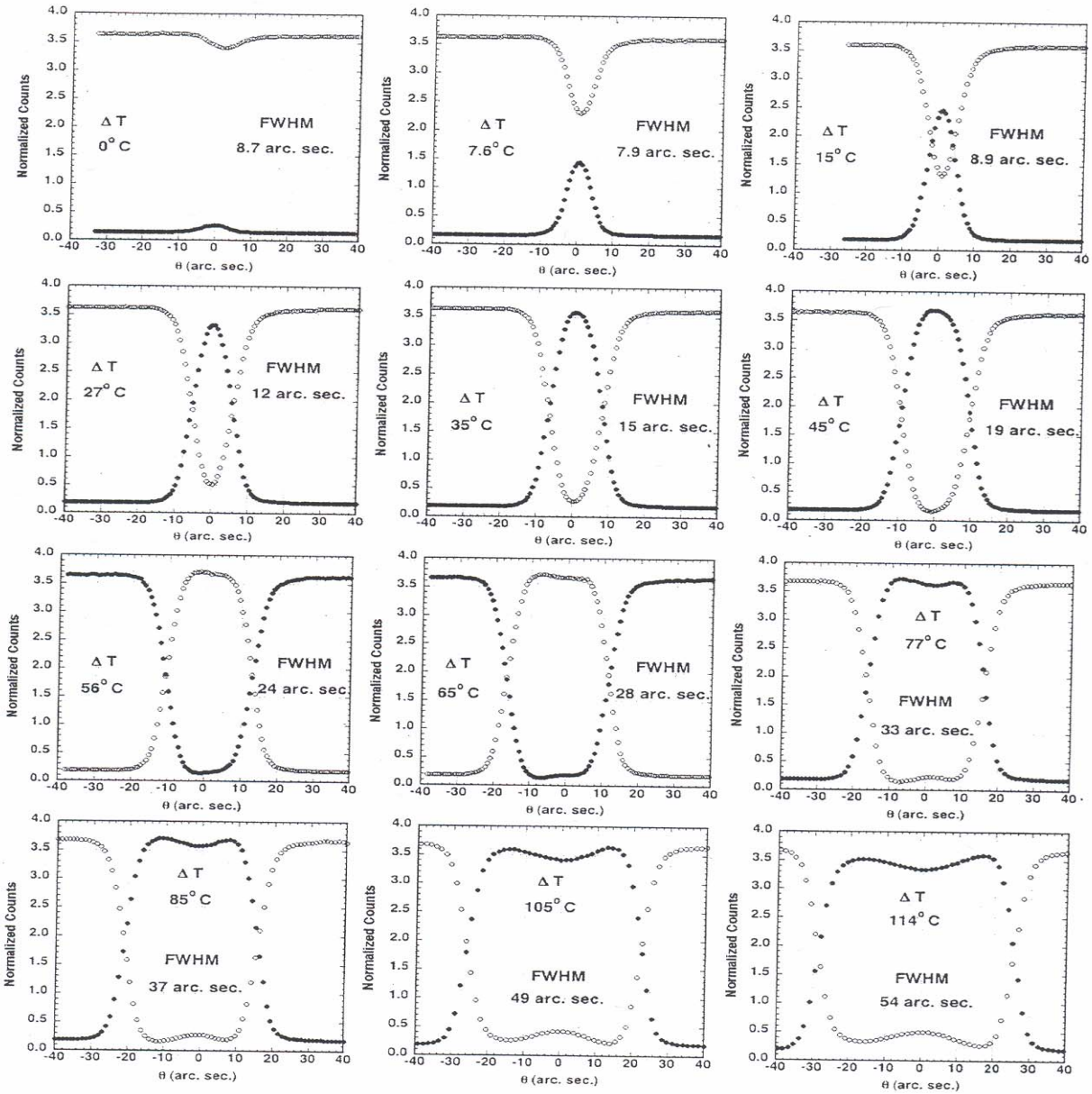

Figure 4. Data taken with a pure silicon crystal using the [111] planes with the cold top geometry and a 96.6 keV x-ray beam. The thermal gradients, DT, are in units of °C/cm.

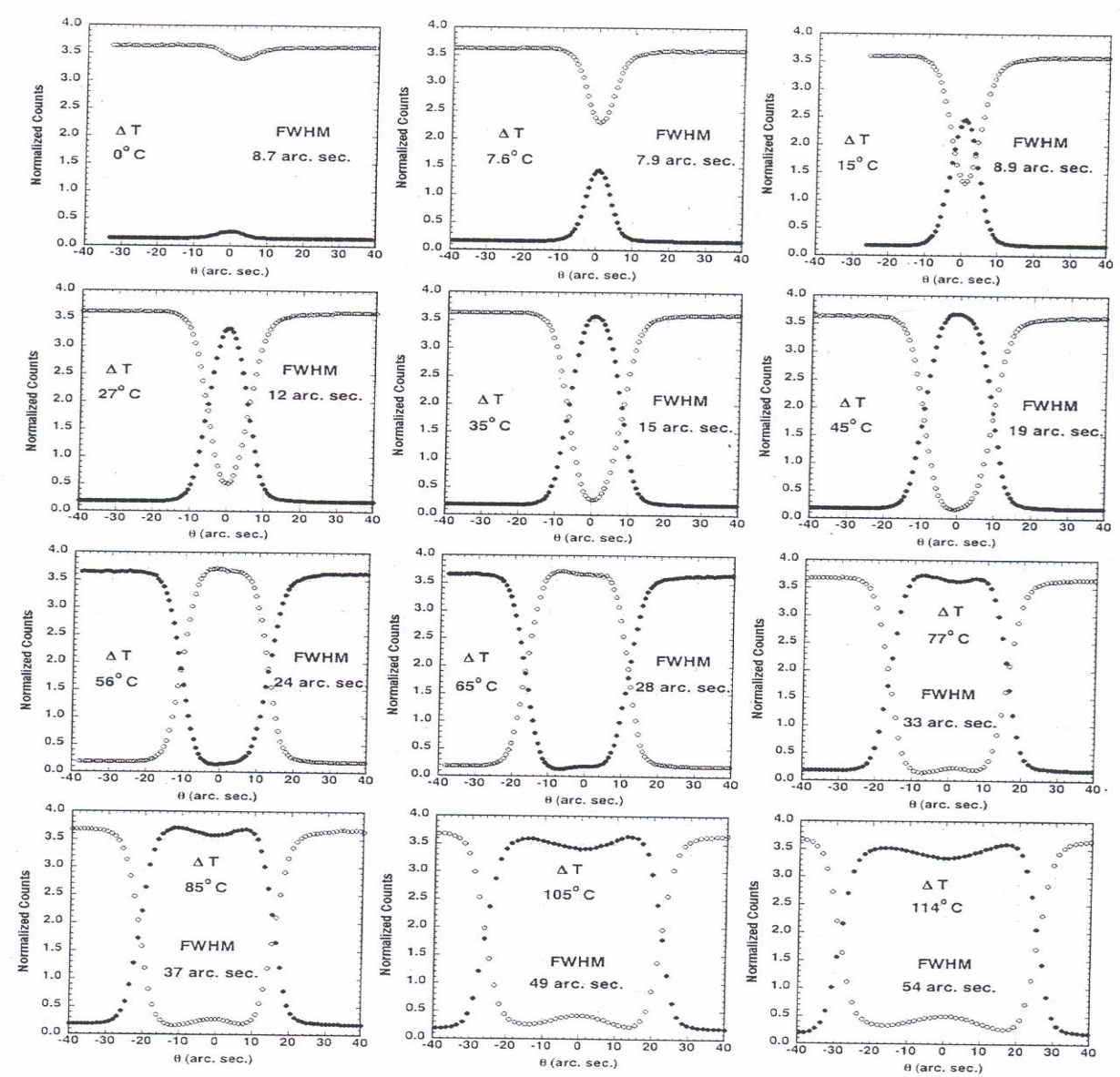

Figure 5. Data taken with a pure silicon crystal using the [111] planes with the hot top geometry and a 96.6 keV x-ray beam. The thermal gradients, ΔT, are in units of °C/cm.

BENT SILICON CRYSTALS

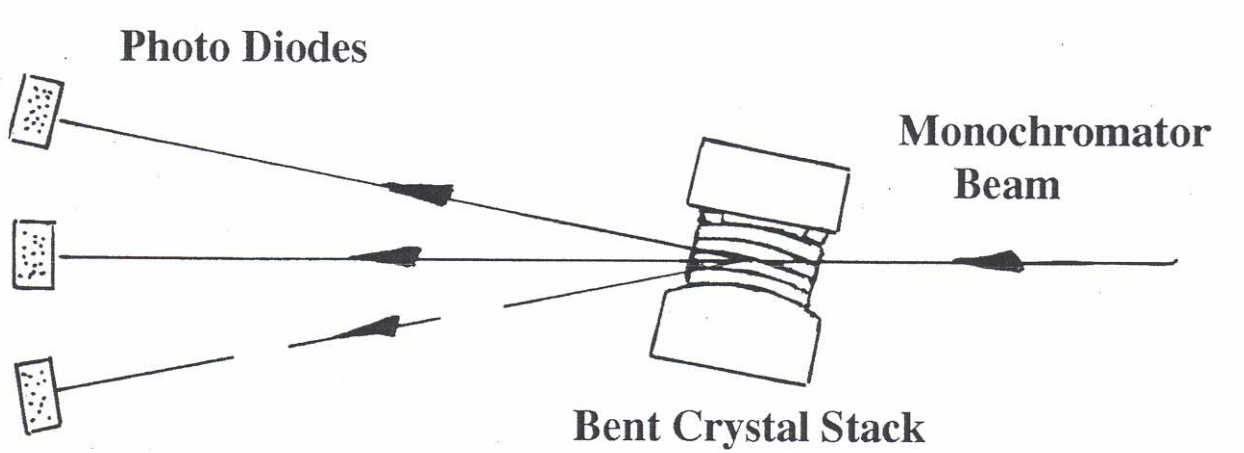

Figure 6. is a schematic of the experimental set up.

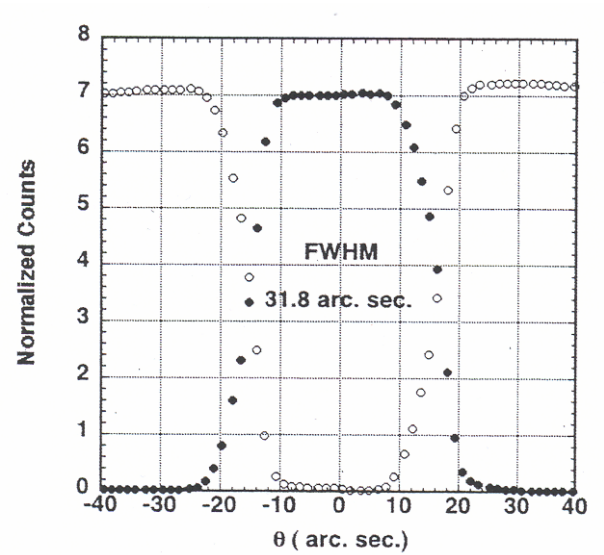

Figure 7. shows a typical rocking curve for a bent silicon crystal using the [111] crystalline planes To diffract a 93 keV x-ray beam.

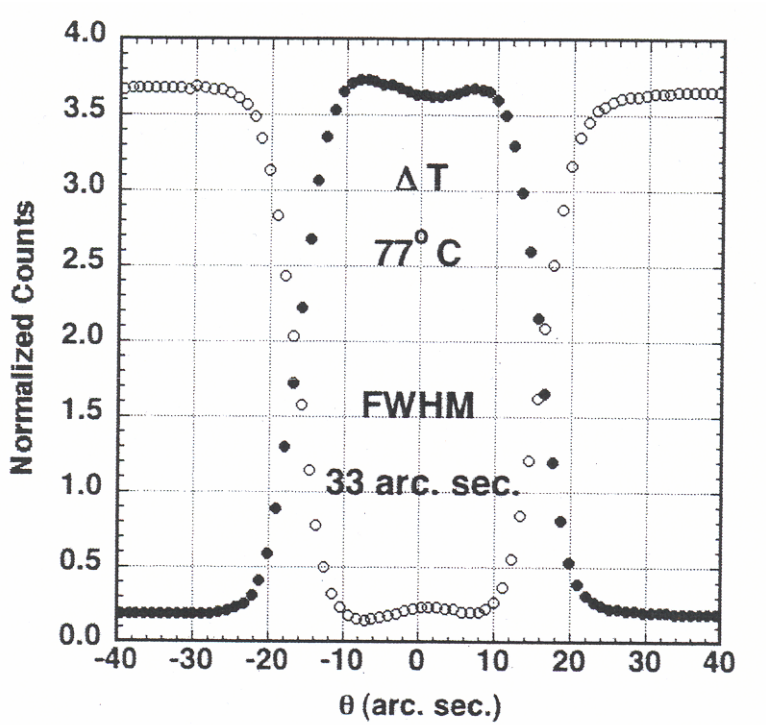

Figure 8. Typical rocking curve for a Si [111] thermal gradient crystal diffracting 93 keV x-rays.

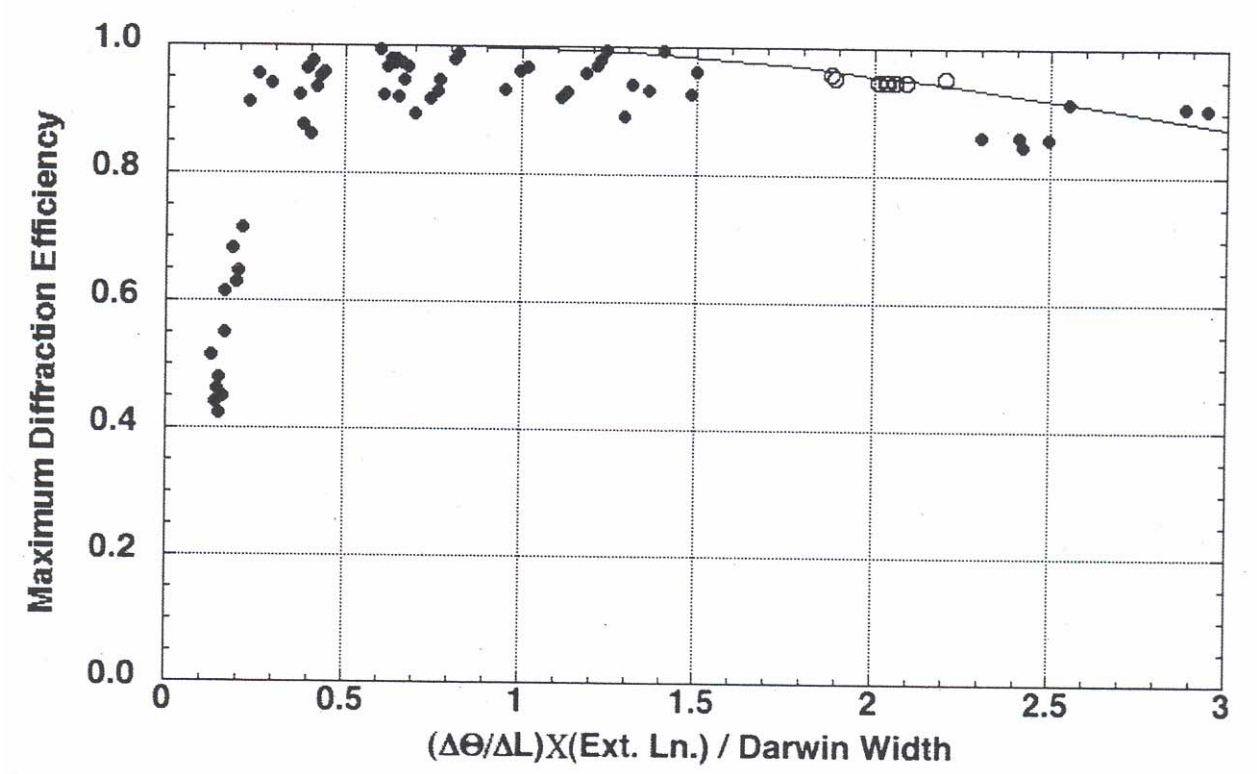

Figure 9. A plot of maximum diffraction efficiency verses the parameter α, defined as the ratio of the extinction length x the curvature per unit lenght, divided by the Darwin width, for the bent crystal data. The solid circles are the Si [111] data and the open circles are the Si [220] data. The solid line is the theoretical limit for the reflectivity of a silicon [111] crystal.

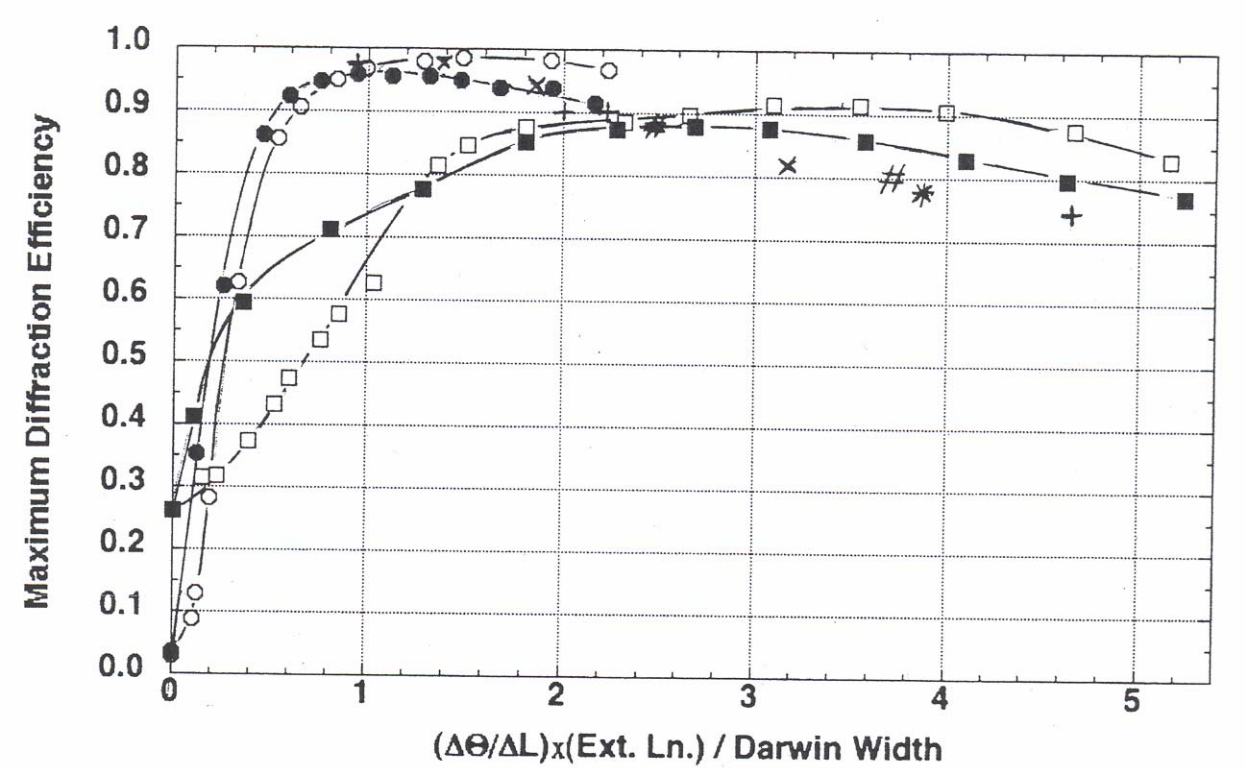

Figure 11. Graph of the measured diffraction efficiency as a function of the curvature,Δθ / ΔL, times the extinction length divided by the Darwin width for a perfect Si crystal. The filled circles and the open circles are for the CT and HT cases, respectively, for the92.6 keV Si data. The filled squares and open squares are for the CT and HT cases for the 153 keV data. The plus signs and the crosses are data points for Keitel's thesis for the 100 keV and 120 keV data, respectively, and the ''#'' and '' symbols are data points for the 160 keV and 200 keV data, respectively.

COMPARISON OF THE DIFFERENT METHODS

Length mm	(Δq / ΔL) arc sec/mm	Diff. Eff.	Trans.	Signal γ's 10^6 sec	BG γ' 10^6 sec	Δq arc sec	ΔE keV
20	1.0	0.572	0.628	709	253	20	7.86
30	1.0	0.572	0.498	831	253	30	11.79
40	1.0	0.572	0.394	876	253	40	15.72
40	1.2	0.507	0.394	947	253	48	18.86
40	1.4	0.454	0.394	991	253	56	22.01
40	1.4	0.411	0.394	1025	253	64	25.15

TABLE I Calculation of count rates diffraction of 400 keV gamma ray as a function of the length and curvature Si crystals using the [111] planes. Source = 4 x 10^{-7} gammas/cm^2/sec.

Length mm	(Δq / ΔL) arc sec/mm	Diff. Eff.	Trans.	Signal γ's 10^6 sec	BG γ' 10^6 sec	Δq arc sec	ΔE keV
30	0.5	0.529	0.557	655	257	15	13.26
40	0.5	0.529	0.459	720	257	20	17.68
40	0.6	0.467	0.459	760	257	24	21.2
40	0.7	0.467	0.459	791	257	28	24.57
40	0.8	0.467	0.459	815	257	32	28.29

TABLE II Calculation of count rates diffraction of 600 keV gamma ray as a function of the length and curvature Si crystals using the [111] planes. Source = 4 x 10-7 gammas/cm2/sec.

Length mm	(Δq / ΔL) arc sec/mm	Diff. Eff.	Trans.	Signal γ's 10^6 sec	BG γ' 10^6 sec	Δq arc sec	ΔE keV
30	0.2	0.654	0.598	463	253	6	9.43
30	0.3	0.507	0.598	539	253	9	14.14
40	0.3	0.507	0.504	605	253	12	18.85
50	0.3	0.507	0.426	613	253	15	23.57
50	0.4	0.412	0.426	664	253	20	31.42
50	0.5	0.346	0.426	667	253	25	39.28

TABLE III Calculation of count rates diffraction of 800 keV gamma ray as a function of the length and curvature Si crystals using the [111] planes. Source = 4 x 10-7 gammas/cm2/sec.

Length mm	(Δq / ΔL) arc sec/mm	Diff. Eff.	Trans.	Signal γ's 10^6 sec	BG γ' 10^6 sec	Δq arc sec	ΔE keV
30	0.2	0.572	0.628	460	200	20	14.73
40	0.2	0.572	0.498	525	200	30	19.64
50	0.2	0.572	0.394	563	200	40	24.55
60	0.2	0.507	0.394	579	200	48	29.46
60	0.3	0.454	0.394	641	200	56	44.19
60	0.4	0.411	0.394	676	200	64	58.92

TABLE IV Calculation of count rates diffraction of 1000 keV gamma ray as a function of the length and curvature Si crystals using the [111] planes. Source = 4 x 10-7 gammas/cm2/sec.