**POW6—High-Resolution/Strain Powder Diffractometer—Reference Instrument WBS
1.7.11**Technical Note ANL/SNS/98-2
R. K. Crawford – 12/10/98**1 Instrument Description****1.1 Overview**

POW6 is optimized to provide the best possible resolution at 90° scattering angle for diffraction from materials in special environments (cryostats, furnaces, pressure cells, etc.) and for precision strain distribution and deformation measurements. Figure 1 provides a schematic representation of POW6, and Table 1 gives the parameters for this instrument. The instrument also provides very good resolution in backscattering.

Work supported in part by the U. S. Department of Energy, BES, contract No. W-31-109-ENG-38.

The submitted manuscript has been created by the University of Chicago as Operator of Argonne National Laboratory ("Argonne") under Contract No. W-31-109-ENG-38 with the U.S. Department of Energy. The U.S. Government retains for itself, and others acting on its behalf, a paid-up, nonexclusive, irrevocable worldwide license in said article to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the Government.

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, make any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

Fig. 1. Schematic plan view of the high-resolution powder diffractometer POW6.**Table 1. Parameters for the powder diffractometer POW6**

Component	Parameter	Value
Moderator	Beam line	17BU
	Moderator	Liquid-H ₂ O, decoup, pois
Geometry	Source-sample distance	60.0 m
	Sample-detector distance at 150°	5.0 m
	Sample-detector distance at 90°	5.0 m
T ₀ chopper	Type	Horizontal-axis T ₀
	Radius to beam center	250 mm
	Length	300 mm
	Distance from moderator	7.0 m
	Frequency	30 Hz
	Beam width at chopper	15 mm
	Wavelength range to open or close	0.18 Å @ 30 Hz
Bandwidth chopper #1	Type	Disk
	Radius to beam center	250 mm
	Length	10 mm
	Distance from moderator	7.5 m
	Frequency	10 to 60 Hz
	Beam width at chopper	15 mm
	Wavelength range to open or close	0.08 Å @ 60 Hz
Bandwidth chopper #2	Type	Disk
	Radius to beam center	250 mm
	Length	10 mm
	Distance from moderator	20.0 m
	Frequency	10 to 60 Hz
	Beam width at chopper	15 mm
	Wavelength range to open or close	0.03 Å @ 60 Hz
Guide	Type	Curved
	Radius of curvature	10,809 m
	Coating, sides	natural Ni
	Coating, top and bottom	3 × θ_c supermirror
	Channel width	15 mm
	Channel height	60 mm
	Moderator-to-guide distance	8.0 m
	Moderator to end of guide sides	51.0 m
	Moderator to end of guide top and bottom	59.0 m
	Filling	Evacuated to <10 ⁻² torr
Collimation	Near sample	Variable aperture
Beamline shielding	Steel radial thickness around beam	0.7 m
	Paraffin radial thickness around steel	0.2 m
	Channel for guide	0.2 m × 0.2 m
	Length	46.5 m

Table 6.3-2 (continued)

Component	Parameter	Value
Beam stop	Steel	1.6 m × 1.6 m × 2.6 m
	Paraffin radial thickness around steel	0.2 m
	Re-entrant hole in steel	0.2 m × 0.2 m × 0.5 m
Sample	Width (maximum beam size)	10 mm
	Height (maximum beam size)	50 mm
Detector angular coverage		Grouped in banks
Linear position sensitive detectors	Type	³ He proportional
	Diameter	12 mm
	Encoded length	600 mm
	Position resolution	15 mm
	Distance from sample	5.0 m
	Number	550
	Solid angle coverage	0.16 sr
Data acquisition		standard system
Scattering chamber	Geometry	Individual arms
	Length of arm, excluding shielding	5.2 m
	Height, excluding shielding	0.7 m
	Filling, direct beam portion	evacuated to <10 ⁻² torr
	Filling, remainder	Helium
	Shielding	Some removable
	Shielding thickness and composition	TBD
Sample chamber	Open area in which various chambers or large specimens can be installed	
	Filling	Various, incl. 10 ⁻⁶ torr
Resolution	$\delta d/d$, backscattering	7×10^{-4} fwhm
	$\delta d/d$, 90° scattering	1.2×10^{-3} fwhm

1.2 Source

A poisoned decoupled ambient temperature water moderator provides a polychromatic beam of neutrons to the instrument. The design documented here assumes a fwhm pulse width of $\delta t \approx 25 \mu\text{s}$ at $10 \text{ \AA}$, $\delta t \approx 24 \mu\text{s}$ at $5 \text{ \AA}$, $\delta t \approx 22 \mu\text{s}$ at $3 \text{ \AA}$, and $\delta t \approx 10 \mu\text{s}$ at $1 \text{ \AA}$.¹ This moderator was selected for POW6 because of its sharp pulses and high intensities at intermediate d-spacings.

Beamline 17BU was chosen for this instrument because this beamline views the poisoned ambient temperature water BU moderator normal to its surface, thus providing the best possible timing resolution for the instrument.

1.3 Choppers

A T_0 chopper is used to cut out the prompt pulse to reduce background, and a series of bandwidth-limiting choppers is required to limit the incident bandwidth to prevent frame overlap, the condition in which fast neutrons from one pulse catch up with slow neutrons from the preceding pulse. To provide maximum flexibility, this series of choppers must be able to select different bandwidths as well as to vary the wavelength at which the incident bandwidth is centered. The requirement to vary the selected bandwidth can be satisfied by using two choppers. This bandwidth can be centered at any wavelength simply by adjusting the phase of the bandwidth choppers. The second chopper, when properly positioned, can also help to cut out additional neutrons that could contaminate the data.

Preliminary optimization of the chopper locations and speeds was done using a spreadsheet to evaluate the wavelengths for which the chopper system is fully open and the wavelengths for which one or more of the choppers is opening or closing. Table 2 shows the parameters assumed for the choppers, and Tables 3a and 3b show the opening and closing times and wavelengths for each of these choppers for several different choices of chopper phases. Appendix A of Reference 2 gives the equations used for these calculations.

Figure 2 shows a time-distance diagram for POW6 based on the data in Tables 2-3 for several different choices of chopper phasing. It is evident that for some of these phasing choices the second bandwidth chopper is needed to block unwanted wavelengths (e.g., neutrons from the wrong pulse) that can pass through the first chopper.

Table 2. Assumed chopper parameters for POW6.

source frequency (Hz)	60.00
T_0 chopper diameter (mm)	500.00
T_0 chopper distance (m) *	7.00
beam width at T_0 chopper (mm)	15.00
bandwidth chopper #1 diameter (mm)	500.00
bandwidth chopper #1 distance (m) *	7.50
beam width at bandwidth chopper #1 (mm)	15.00
bandwidth chopper #2 diameter (mm)	500.00
bandwidth chopper #2 distance (m) *	20.00
beam width at bandwidth chopper #2 (mm)	15.00
distance to detectors (m)	65.00

* Distances are measured from the moderator along the neutron path.

Fig. 2a

Fig 2b

Fig. 2c

Fig. 2d

Fig. 2e

Fig. 2f

Fig. 2g

Figure 2. Timing diagram for POW6. a) frames 1-6. (0.18 to 6.09 Å); b) frame 1. (0.18 to 1.01 Å); c) frame 2. (1.05 to 2.03 Å); d) frame 3. (2.06 to 3.04 Å); e) frame 4. (3.07 to 4.06 Å); f) frame 5. (4.09 to 5.07 Å); g) frame 6. (5.10 to 6.09 Å). Heavy dashed horizontal lines indicate the chopper-closed periods. In all cases the bandwidth lines indicate the boundaries of both the fully-open and fully-closed chopper conditions.

Table 3a. Opening and closing times for different chopper settings for POW6.*

frame	1	2	3	4	5	6	1-2	1-3	1-4	1-5	1-6	4-6
$t_{\max}$ (μ s)	16667	33333	50000	66667	83333	100000	33333	50000	66667	83333	100000	100000
T_0 freq (Hz)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
$T_0 \Delta t$ (μ s)	318	318	318	318	318	318	318	318	318	318	318	318
BW1 freq (Hz)	60.0	60.0	60.0	60.0	60.0	60.0	30.0	20.0	15.0	12.0	10.0	20.0
BW1 Δt (μ s)	159	159	159	159	159	159	318	477	637	796	955	477
BW2 freq (Hz)	60.0	60.0	60.0	60.0	60.0	60.0	30.0	20.0	15.0	12.0	10.0	20.0
BW2 Δt (μ s)	159	159	159	159	159	159	318	477	637	796	955	477
$t_{\min}$ (μ s)	2956	17184	33851	50517	67184	83851	2956	2956	2956	2956	2956	51552
$T_0 t_c$ (μ s)	0	16667	33333	50000	66667	83333						
$T_0 t_{eo}$ (μ s)	318	16985	33652	50318	66985	83652						
$T_0 t_{sc}$ (μ s)	16348	33015	49682	66348	83015							
BW1 t_{so} (μ s)	182	1824	3747	5670	7593	9516	23	-136	-296	-455	-614	5471
BW1 t_{eo} (μ s)	341	1983	3906	5829	7752	9675	341	341	341	341	341	5948
BW1 t_{sc} (μ s)	1923	3846	5769	7692	9615	11538	3846	5769	17692	9615	11538	11538
BW1 t_{ec} (μ s)	2082	4005	5928	7851	9775	11698	4164	6247	18329	10411	12493	12016
BW2 t_{so} (μ s)	750	5128	10256	15385	20513	25641	591	432	273	114	-45	15385
BW2 t_{eo} (μ s)	909	5287	10416	15544	20672	25800	909	909	909	909	909	15862
BW2 t_{sc} (μ s)	5128	10256	15385	20513	25641	30769	10256	15385	20513	25641	30769	30769
BW2 t_{ec} (μ s)	5287	10416	15544	20672	25800	30928	10575	15862	21149	26437	31724	31247

T_0 = t-zero chopper, BW1 = first bandwidth chopper, BW2 = second bandwidth chopper

f = frequency, Δt = time for chopper edge to sweep thru beam

so = start open; eo = end open; c = fully closed; sc = start close; ec = end close

This table assumes $\Delta t_{cl}=0$ for the T_0 chopper.

* See Appendix A of Ref. 2 for definitions and equations.

Table 3b. Accessible wavelengths for different chopper settings for POW6.*

Frame N	1	2	3	4	5	6	1-2	1-3	1-4	1-5	1-6	4-6
$t_{\max}$ (μ s)	16667	33333	50000	66667	83333	100000	33333	50000	66667	83333	100000	100000
T_0 freq (Hz)	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
$T_0 \Delta\lambda$ ($\text{\AA}$)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18	0.18
BW1 freq (Hz)	60.0	60.0	60.0	60.0	60.0	60.0	30.0	20.0	15.0	12.0	10.0	20.0
BW1 $\Delta\lambda$ ($\text{\AA}$)	0.08	0.08	0.08	0.08	0.08	0.08	0.17	0.25	0.34	0.42	0.50	0.25
BW2 freq (Hz)	60.0	60.0	60.0	60.0	60.0	60.0	30.0	20.0	15.0	12.0	10.0	20.0
BW2 $\Delta\lambda$ ($\text{\AA}$)	0.03	0.03	0.03	0.03	0.03	0.03	0.06	0.09	0.13	0.16	0.19	0.09
$\lambda_{\text{inc-max}}$ ($\text{\AA}$)	1.01	2.03	3.04	4.06	5.07	6.09	2.03	3.04	4.06	5.07	6.09	6.09
$\lambda_{\text{inc-min}}$ ($\text{\AA}$)	0.18	1.05	2.06	3.07	4.09	5.10	0.18	0.18	0.18	0.18	0.18	3.14
$T_0 \lambda_c$ ($\text{\AA}$)	0.00	9.42	18.84	28.25	37.67	47.09						
$T_0 \lambda_{eo}$ ($\text{\AA}$)	0.18	9.60	19.02	28.43	37.85	47.27						
$T_0 \lambda_{sc}$ ($\text{\AA}$)	9.24	18.66	28.07	37.49	46.91							
BW1 λ_{so} ($\text{\AA}$)	0.10	0.96	1.98	2.99	4.00	5.02	0.01	-0.07	-0.16	-0.24	-0.32	2.89
BW1 λ_{eo} ($\text{\AA}$)	0.18	1.05	2.06	3.07	4.09	5.10	0.18	0.18	0.18	0.18	0.18	3.14
BW1 λ_{sc} ($\text{\AA}$)	1.01	2.03	3.04	4.06	5.07	6.09	2.03	3.04	4.06	5.07	6.09	6.09
BW1 λ_{ec} ($\text{\AA}$)	1.10	2.11	3.13	4.14	5.15	6.17	2.20	3.29	4.39	5.49	6.59	6.34
BW2 λ_{so} ($\text{\AA}$)	0.15	1.01	2.03	3.04	4.06	5.07	0.12	0.09	0.05	0.02	-0.01	3.04
BW2 λ_{eo} ($\text{\AA}$)	0.18	1.05	2.06	3.07	4.09	5.10	0.18	0.18	0.18	0.18	0.18	3.14
BW2 λ_{sc} ($\text{\AA}$)	1.01	2.03	3.04	4.06	5.07	6.09	2.03	3.04	4.06	5.07	6.09	6.09
BW2 λ_{ec} ($\text{\AA}$)	1.05	2.06	3.07	4.09	5.10	6.12	2.09	3.14	4.18	5.23	6.27	6.18

T_0 = t-zero chopper, BW1 = first bandwidth chopper, BW2 = second bandwidth chopper

f = frequency, Δt = time for chopper edge to sweep thru beam

so = start open; eo = end open; c = fully closed; sc = start close; ec = end close

This table assumes $\Delta t_{cl}=0$ for the T_0 chopper.

* See Appendix A of Ref. 2 for definitions and equations.

1.4 Guide

1.4.1 Guide Gain

The intensity on the sample is given by the intensity with no guide multiplied by the gain from the guide. Appendix B of Ref. 2 provides the equations used to estimate guide gain. These were used to establish the preliminary set of guide parameters shown in Table 4 for POW6. The gains calculated using these parameters with the guide starting 2.5 m from the moderator and 8 m from the moderator are shown respectively in Tables 5a and 5b.

The neutron guide system for POW6 was designed to meet the constraint that the incident beam divergence must be no worse than that from natural collimation (i.e., horizontal collimation given by the ratio of the moderator size to the incident path length). This may not have been the optimum constraint for such a diffractometer, as it is very conservative, but it illustrates the principles involved.

The collimation constraint imposed here means that the horizontal gain of the guide can be at most unity. Under these conditions the intensity at the sample is independent of the guide width, provided the guide width and incident and exit path lengths satisfy the requirements for full illumination given in Appendix B of Ref. 2. The width of the guide for POW6 was chosen to satisfy these requirements with physically reasonable values for L_{inc} and L_{exit} . Parameters for the vertical guide were chosen to give a physically reasonable guide size with reasonable values for L_{inc} and L_{exit} . Even for these constraints the guide is not yet fully optimized. Further optimization or optimization with different constraints would result in different guide parameters, so the constraints must be carefully considered.

The main advantage of the horizontal guide in this case is that it allows a much narrower beam to be used than would otherwise have been the case. This improves the characteristics of the T_0 and bandwidth choppers, and also results in a lower background of fast neutrons. It may also permit the splitting off of a second guide to operate more than one instrument from this beam port.

Table 4. Preliminary guide parameters for POW6.

Parameter	Meaning	Value
M_h	moderator width (mm)	100.00
M_v	moderator height (mm)	120.00
L_{inc}	moderator-guide distance (m)	2.50 8.00
g_h	guide width (mm)	15.00
g_v	guide height (mm)	60.00
m_h	horizontal supermirror "m"	1.00
m_v	vertical supermirror "m"	3.00
λ^*	characteristic wavelength (Angstroms)	0.98
R	radius of curvature (m)	10808.65
L_{sight}	line-of sight distance (m)	36.01
L	source-sample distance (m)	60.00
L_{exit-h}	horizontal guide-sample distance (m)	9.00
L_{exit-v}	vertical guide-sample distance (m)	1.00
S_h	sample width (mm)	10.00
S_v	sample height (mm)	50.00
M_h/L	no-guide collimation horizontal (rad)	0.00167
M_v/L	no-guide collimation vertical (rad)	0.00200
g_h/L_{exit-h}	exit collimation horizontal (rad)	0.00167
g_v/L_{exit-v}	exit collimation vertical (rad)	0.06000
	(M-g)/2 (horizontal) (mm)	42.50
	(M+g)/2 (horizontal) (mm)	57.50
	(M-g)/2 (vertical) (mm)	30.00
	(M+g)/2 (vertical) (mm)	90.00
	(g-S)/2 (horizontal) (mm)	2.50
	(g+S)/2 (horizontal) (mm)	12.50
	(g-S)/2 (vertical) (mm)	5.00
	(g+S)/2 (vertical) (mm)	55.00

λ	0.5	1	2	3	4	5	6	7	8	9	10
$2\theta_{c-eff-h}$ (rad)	0.00170	0.00340	0.00680	0.01020	0.01360	0.01700	0.02040	0.02380	0.02720	0.03060	0.03400
$2\theta_{c-eff-v}$ (rad)	0.00510	0.01020	0.02040	0.03060	0.04080	0.05100	0.06120	0.07140	0.08160	0.09180	0.10200
$L_{inc-full-h}$ (m)	50.00	25.00	12.50	8.33	6.25	5.00	4.17	3.57	3.13	2.78	2.50
$L_{inc-full-v}$ (m)	11.76	5.88	2.94	1.96	1.47	1.18	0.98	0.84	0.74	0.65	0.59
F_{inc-h}	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
F_{inc-v}	1.00	1.00	1.00	0.99	0.93	0.85	0.76	0.67	0.59	0.52	0.47
F_{exit-h}	0.83	0.49	0.25	0.16	0.12	0.10	0.08	0.07	0.06	0.05	0.05
F_{exit-v}	1.00	1.00	0.97	0.93	0.90	0.87	0.86	0.85	0.85	0.85	0.85
$G_{ideal-h}$	1.02	2.04	4.08	6.12	8.16	10.20	12.24	14.28	16.32	18.36	20.40
$G_{ideal-v}$	2.55	5.10	10.20	15.30	20.40	25.50	30.60	35.70	40.80	45.90	51.00
$G_{actual-h}$	0.84	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
$G_{actual-v}$	2.55	5.10	9.93	14.06	16.99	18.91	20.01	20.39	20.39	20.39	20.39
G_{ideal}	2.60	10.40	41.62	93.64	166.46	260.10	374.54	509.80	665.86	842.72	1040.40
G_{actual}	2.15	5.10	9.93	14.06	16.99	18.91	20.01	20.39	20.39	20.39	20.39

[illegible]

1.4.2 Guide Curvature

This guide is curved to minimize the transmission of fast neutrons from the prompt pulses. The effect of this curvature on the guide gain is discussed in Appendix B of Reference 2. The guide curvature can introduce a wavelength-dependence of the effective beam position at the sample. Further studies will be required to determine the magnitude of this effect and to determine whether it can be reduced sufficiently by the introduction of a straight guide section after the curved section.

1.4.3 Monte Carlo Simulations

Monte Carlo simulations were used to obtain a more accurate estimate of the performance of the POW6 guide system. Parameters were the same as in Tables 1 and 4 except as noted. For the simulations, neutrons were assumed to be emitted with equal probability from the entire moderator surface, and with equal probability within the angular range ± 0.06 radians about the nominal beam direction. Since the critical angle for natural Ni at 10 Å is only 0.017 radians, this range of angular divergence was more than enough to include all neutrons that could be accepted by the POW6 guides. The same number of randomly generated initial neutron paths (1,000,000) was used for each 1-dimensional simulation, and total guide performance was obtained by comparing neutrons on sample with and without the guide for the corresponding simulations for the horizontal and vertical direction. For these simulations, the guides were assumed to have reflectivity of 1.0 up to the critical angle θ_c for natural Ni, and a reflectivity of 0.95 from θ_c to $m\theta_c$, where m takes on the appropriate supermirror value for the particular set of guide surfaces. Table 6 shows the results of these simulations.

Table 6a. Simulated guide gains for POW6 ($L_{inc} = 2.5$ m with 0.4 m gap).

λ	1	3	6	10
$G_{actual-h}$	0.75	0.93	0.93	0.97
$G_{actual-v}$	4.41	10.11	13.20	15.48
G_{actual}	3.33	9.35	12.31	15.02

Table 6b. Simulated guide gains for POW6 ($L_{inc} = 2.5$ m with no gap).

λ	1	3	6	10
$G_{actual-h}$	0.75	0.94	0.95	0.99
$G_{actual-v}$	4.47	10.50	14.35	16.92
G_{actual}	3.35	9.87	13.67	16.80

Table 6c. Simulated guide gains for POW6 ($L_{inc} = 8.0$ m with no gap).

λ	1	3	6	10
$G_{actual-h}$	0.86	0.99	0.99	0.99
$G_{actual-v}$	4.41	6.72	7.39	7.41
G_{actual}	3.77	6.68	7.32	7.33

For the case where the guide starts at 8 m from the moderator, the values from the simulation (Table 6c) agree very well with those from the analytical calculation (Table 5b) except at the shortest wavelengths. This reduced guide transmission at short wavelengths is a well-known effect due to the guide curvature. When the guide starts at 2.5 m from the moderator the simulation values (Table 6b) fall well below those calculated analytically (Table 5a). These differences can be ascribed to the fact that the additional gains in the 2.5 m case result entirely from the supermirror guides used in the vertical direction. The simulation used an average reflectivity of 0.95 for the supermirror while the analytical calculation assumed a reflectivity of 1.00. The higher gains are achieved by having several reflections from the supermirror surfaces, in which case the less-than-perfect reflectivity results in significant losses.

Including a gap for a T_0 chopper reduces the gain from 16.8 to 15.0 at 10 Å, with somewhat smaller effects at the shorter wavelengths. Truncation of the guide sides at 9 m from the sample limits the maximum horizontal divergence to that which would be obtained with natural collimation (sample viewing the entire moderator) so that the guide will not impact the resolution. Under these conditions the sides of the guide provide little or no gain but do allow a smaller beam to be brought out from the biological shield, resulting in shorter chopping times and reduced background.

1.5 Detectors

These detectors are grouped in banks on both sides of the sample, primarily around backscattering and around 90°, with some groups at other angles. The backscattering and 90° banks are at 5 m from the sample. The linear position sensitive detectors are used to provide a large-solid-angle array for backscattering without compromising the angular resolution. They also permit two-dimensional spatial resolution at 90°, which, together with a suitable collimation system, provides the ability to measure strains simultaneously in different gage volumes.

1.6 Sample area

The large open area allows strain and deformation measurements on large engineering specimens. Appropriate shielding and vacuum spaces will fill this area at other times.

2 Performance

2.1 Resolution

The parameter of interest for powder diffraction is the inter-plane spacing d given by

$$d = \frac{\lambda}{2 \sin \theta} = \frac{3955.4 \text{ t}}{2L \sin \theta} \quad (1)$$

The resolution in this variable is given approximately by

$$\frac{\delta d}{d} = \left\{ \left(\frac{\delta t}{t} \right)^2 + \left(\frac{\delta L}{L} \right)^2 + (\cot \theta \delta \theta)^2 \right\}^{1/2} \quad (2)$$

Table 7 shows the resolution calculated at different scattering angles for this instrument.

Table 7. Resolution and dynamic range for POW6.

2 θ	Frames 1-4		
	$\delta d/d$	$d_{\min}$ (Å)	$d_{\max}$ (Å)
150°	6.8×10^{-4}	0.09	0.96
90°	1.1×10^{-3}	0.13	1.41
30°	3.6×10^{-3}	0.26	7.84
15°	7.3×10^{-3}	0.69	15.55

2.2 Bandwidth and Dynamic Range

Running the bandwidth-limiting choppers at 30 Hz, 20 Hz, 15 Hz, 12 Hz, or 10 Hz allows reasonable operation using one pulse in two, one pulse in three, one pulse in four, one pulse in five, or one pulse in six, with corresponding maximum wavelength of 2.03 Å, 3.04 Å, 4.06 Å, 5.07 Å or 6.09 Å. In these modes, some portions of the wavelength range starting at 1.01 Å, 2.03 Å, 3.04 Å, 4.06 Å, and 5.07 Å may be contaminated by the intervening prompt pulses. Figure 2a shows an example of the 10 Hz operation.

An alternate mode of operation is to run the bandwidth-limiting choppers at 60 Hz, phased to select a wavelength range that falls between various of the prompt pulses. This wavelength range can be in the first frame (before the following pulse), the second frame (one intervening prompt pulse), and so forth. This chopper scheme provides clean operation in the first, second, third, fourth, fifth, and sixth frames for this instrument, giving access to wavelength ranges ~0.18 to 1.01 Å, ~1.05 to 2.03 Å, ~2.06 to 3.04 Å, ~3.07 to 4.06 Å, ~4.09 to 5.07 Å, and ~5.10 to 6.09 Å, respectively. These choppers cannot handle all the potential frame overlap problems when trying to work beyond the sixth frame at 60 Hz. Accessing some higher wavelengths may be possible by reducing the bandwidth-limiting chopper frequency to 30 Hz or less to eliminate some of the pulses, but this will give, at best, only spotty coverage at wavelengths above 6.09 Å.

2.4 Data Rates

Data rate estimates for this instrument will be provided in a later Technical Note.

References

1. SNS Conceptual Design Report values for decoupled poisoned ambient water moderator.
2. Technical Note ANL/SNS/98-1