POW7— Glasses/Liquids Diffractometer —Reference Instrument WBS 1.7.6
Technical Note ANL/SNS/98-3
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1 Instrument Description

1.1 Overview

POW7 is designed for structural measurements on glasses and liquids. Figure 1 provides a schematic representation of POW7, and Table 1 gives the parameters for this instrument. The short incident flight path maintains the highest possible flux on sample to allow the counting statistics needed to effectively use isotope substitution in cases where the contrast is low. Emphasis is placed on using the shortest wavelengths practical to measure each Q in order to minimize inelasticity effects.

Fig. 1. Schematic plan view of the glasses/liquids diffractometer POW7.

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Table 1. Parameters for the glasses/liquids diffractometer POW7

Component	Parameter	Value
Moderator	Beam line Moderator	7BU liquid-H ₂ O, decoup, pois
Geometry	Source-sample distance Sample-detector distance near 0° Sample-detector distance at 90°	9.0 m 5.0 m 1.0 m
T ₀ chopper	Type Radius to beam center Length Distance from moderator Frequency Beam width at chopper Wavelength range to open or close	Horizontal-axis T ₀ , 1-blade 250 mm 300 mm 7.0 m 60 to 120 Hz 30 mm 0.18 Å @ 60 Hz
Guide system		no guides
Collimation and beam line	Upstream Before sample Before sample (option) Beam line, distances <4.5 m Beam line, distances >4.5 m	standard apertures variable aperture converging Soller helium-filled beam tube evacuated to <10 ⁻² torr
Beam-line shielding		none required
Beam stop	Steel Paraffin radial thickness around steel re-entrant hole in steel	1.6 m × 1.6 m × 2.6 m 0.2 m 0.2 m × 0.2 m × 0.5 m
Sample	Width Height	10 to 20 mm 20 to 50 mm
Detector angular coverage		~1.5° to 90°
Linear position sensitive detectors	Type Diameter Encoded length Position resolution Distance from sample Number Solid angle coverage	³ He proportional 12 mm 600 mm 10 to 20 mm 1.0 to 5.0 m 700 ~0.4 sr
Data acquisition		Standard system

Table 6.3-3 (continued)

Component	Parameter	Value
Scattering chamber	Geometry	Irregular shape
	Length	~5.5 m
	Width	~2.2 m
	Height	~0.7 m
	Filling	Evacuated to $<10^{-2}$ torr
	Shielding, top and bottom	Fixed
	Shielding, sides	Removable
	Shielding thickness and composition	TBD
Sample chamber	Depth	~1.2 m
	Diameter	~0.6 m
	Filling	Evacuated to 10^{-6} torr
Resolution	$\delta Q/Q$, 90° scattering	7×10^{-3} fwhm
	$\delta Q/Q$, 2° scattering	0.1 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 POW7 because of its high intensities at short and intermediate wavelengths, coupled with adequate timing resolution. Beamline 7BU was chosen for this instrument because this beamline views the poisoned ambient temperature water moderator BU which provides these characteristics

1.3 Choppers

A T_0 chopper is used to cut out the prompt pulse to reduce background. This chopper rotates at 60-120 Hz to allow it to open and close sufficiently fast for the short wavelengths. This T_0 chopper has a single blade so there are no problems with beam blockages between pulses at these higher rotation speeds.

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

Table 2. Assumed chopper parameters for POW7.

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)	30.00
distance to detectors (m)	14.00

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

Table 3a. Opening and closing times for different chopper settings for POW7.*

frame	1	2	1	2
$t_{\max}$ (μ s)	16667	33333	16667	33333
T_0 freq (Hz)	60.0	60.0	120.0	120.0
$T_0 \Delta t$ (μ s)	318	318	159	159
$t_{\min}$ (μ s)	318	16985	159	16826
$T_0 t_c$ (μ s)	0	16667	0	8333
$T_0 t_{eo}$ (μ s))	159	16985	159	8492
$T_0 t_{sc}$ (μ s)	8174	33015	8174	16508

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 POW7.*

frame	1	2	1	2
$t_{\max}$ (μ s)	16667	33333	16667	33333
T_0 freq (Hz)	60.0	60.0	120.0	120.0
$T_0 \Delta \lambda$ ($\text{\AA}$)	0.18	0.18	0.09	0.09
$\lambda_{inc-max}$ ($\text{\AA}$)	4.71	9.42	4.71	9.42
$\lambda_{inc-min}$ ($\text{\AA}$)	0.18	4.89	0.09	4.80
$T_0 \lambda_c$ ($\text{\AA}$)	0.00	9.42	0.00	4.71
$T_0 \lambda_{eo}$ ($\text{\AA}$))	0.18	9.60	0.09	4.80
$T_0 \lambda_{sc}$ ($\text{\AA}$)	9.24	18.66	4.62	9.33

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 Detectors

The detectors are placed on appropriate loci on both sides of the sample, at distances from the sample ranging from ~1.0 m at 90° to ~5 m in the forward direction. These provide continuous coverage of scattering angles from ~1.5° to 90°.

2 Performance

2.1 Resolution

The parameter of interest for this instrument is the wave-vector transfer Q given by

$$Q = \frac{4\pi \sin \theta}{\lambda} = \frac{4\pi L \sin \theta}{3955.4 t} \quad (1)$$

The resolution in this variable is given approximately by

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

Table 4 shows the resolution calculated at different scattering angles for this instrument.

Table 4. Resolution and dynamic range for POW7.

2θ	Frames 1-4		
	$\delta Q/Q$ (fwhm)	$Q_{\min}$ ($\text{\AA}^{-1}$)	$Q_{\max}$ ($\text{\AA}^{-1}$)
90°	6×10^{-3}	1.9	98.7
2°	0.07	0.05	2.4

2.2 Dynamic Range

Running the T_0 chopper at 120 Hz allows operation with a wavelength range of 0.09-4.62 Å.

A bandwidth chopper may be necessary to eliminate frame overlap problems for the low-angle detectors. The necessity for this chopper will be evaluated in future studies.

2.3 Data Rate

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