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COMPILATION OF RESOLUTIONS AND INTENSITIES OF SLOW
NEUTRON, INELASTIC SCATTERING, TIME-OF-FLIGHT INSTRUMENTS

R. M. Brugger and Y. D. Harker

PHILLIPS
PETROLEUM
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ATOMIC ENERGY DIVISION

NATIONAL REACTOR TESTING STATION
US ATOMIC ENERGY COMMISSION

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BY

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CONTENTS

I. INTRODUCTION	1
II. EQUATIONS	4
III. DEFINITIONS	5
IV. REFERENCE	7

TABLES

I. Cold Neutron Chopper -- Harwell	9
II. Cold Neutron Chopper -- Birmingham University	10
III. Cold Neutron Chopper -- Brookhaven National Laboratory	11
IV. Cold Neutron Chopper -- Argonne National Laboratory	12
V. Cold Neutron Chopper -- Picatinny Arsenal	13
VI. Cold Neutron Chopper -- Studsvik	14
VII. Cold Neutron Chopper -- Stockholm	15
VIII. Cold Neutron Chopper -- Stockholm	18
IX. Cold Neutron Chopper -- ISPRA	17
X. Phased Chopper Velocity Selector -- ISPRA	19
IX. Rotating Crystal Spectrometer -- ISPRA	21
XII. Rotating Crystal Spectrometer -- Chalk River	23
XIII. Rotating Crystal Spectrometer -- Karlsruhe	24
XIV. Phased Rotor Neutron Spectrometer -- Chalk River	26
XV. Phased Chopper Velocity Selector (Equal Slot Choppers) -- Materials Testing Reactor	29
XVI. Phased Chopper Velocity Selector (Unequal Slot Choppers) -- Materials Testing Reactor	30
XVII. Rotating Crystal Spectrometer -- Battelle-Northwest Laboratory . .	31
XVIII. Linac Neutron Velocity Selector -- General Atomics	33
XIX. Linac Neutron Velocity Selector -- General Atomics	35

XX.	Linac Neutron Velocity Selector -- Rensselaer Polytechnic Institute	36
XXI.	Phased Chopper Velocity Selector -- Rensselaer Polytechnic Institute	37
XXII.	Cold Neutron Chopper -- Bucharest	38
XXIII.	Neutron Chopper -- MOL	39

FIGURES

1.	The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_o/t_o$, versus the beam intensity, $I(n/min)$ for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point	40
2.	The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity, $I(n/min)$, for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV	40
3.	The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, $I(n/min)$, for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV	40
4.	The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_o/t_o$, versus the beam intensity, $I(n/min)$, for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point	40
5.	The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity, $I(n/min)$, for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the final mean energy of the inelastically scattered neutrons was chosen to be 25 meV	41

6. The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, $I(n/min)$, for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV 41
7. The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_0/t_0$, versus the beam intensity, $I(n/min)$, for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point 41
8. The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity $I(n/min)$, for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV 41
9. The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, $I(n/min)$, for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV 42

COMPILATION OF RESOLUTIONS AND INTENSITIES OF SLOW NEUTRON, INELASTIC SCATTERING, TIME-OF-FLIGHT INSTRUMENTS

I. INTRODUCTION

This compilation is an attempt to present intensities and resolutions of all slow neutron, inelastic scattering instruments that use time-of-flight methods. The theory of resolution of phased choppers as presented by Royston[1] is the basis for the analysis. However, since full widths at half maximum of bursts are more widely used than standard deviations, Royston's equations have been converted from standard deviations to half widths. The authors know that this is not exact, but they felt that it was necessary to encourage a response from other scientists. So long as the shapes of the time-of-flight and time distributions can be approximated by a triangle, this change does not introduce large errors.

Using the definitions of this compilation, the scientists actually using the instruments were asked to supply their intensities and resolution. In some cases these definitions do not exactly fit a scientist's instrument; or his interpretation of the resolutions and intensities has been somewhat different from those of the authors. In the tables the difference^[a] in interpretations by the scientists is indicated wherever it occurs. The equations of Royston that are used are for a phased chopper system in which both choppers have equal burst times. Thus, for rotating crystal spectrometers, filter choppers, and linear accelerators plus choppers, the equations are only approximations.

To determine resolution, Equation (1) was obtained by the following arguments. Start with Royston's Equation (7)

$$\sigma_{tR}^2(X_R) = X_R^2 \sigma_{\tau R}^2 + \sigma_{tR}^2(0)$$

(where the subscript R refers to parameters as defined by Royston and no subscript refers to the definitions in this compilation). To convert Royston's Equation (7) to the notation of this compilation the following conversions were used:

$$(a) \ x + d = X_R$$

[a] In the requests to the scientists for information, Equations (1) and (2) were misstated as

$$\Delta t_o^2 = \Delta \tau^2 + (x+d)^2 \left(\frac{\Delta E_o}{E_o} \right)^2 \left(\frac{1.3 \times 10^3}{E_o} \right)$$

$$\text{and} \quad \Delta t_f^2 = \Delta \tau^2 + \left[x + \left(\frac{E_o}{E_f} \right)^{3/2} d \right]^2 \left(\frac{\Delta E_o}{E_o} \right)^2 \left(\frac{1.3 \times 10^3}{E_o} \right).$$

Corrections have been made for this error so that the tables are consistent with Equations (1) and (2).

$$(b) \ 2\Delta t = \Delta t_R$$

Using Royston's Equation (22) where $\sigma_{tR}(0) = \frac{\Delta t_R}{4\sqrt{3}}$ one gets

$$(c) \ \frac{\Delta\tau}{2\sqrt{3}} = \sigma_{tR}(0)$$

(d₁) For any triangular distribution (0.8) (full width at half maximum) ≈ 2 (standard deviation)

(d₂) For the energy distribution in particular, full width at half maximum for time of flight/time of flight = (1/2) ($\Delta E/E$)

$$(d_3) \ \text{Time of flight } (\mu\text{sec/m}) = \frac{72.3}{\sqrt{E_0}(\text{eV})}$$

In combining d₁, d₂, and d₃ one gets

$$2\sigma_{tR} = (0.8) (1/2) \left(\frac{\Delta E}{E}\right) \frac{72.3}{\sqrt{E_0}}$$

and finally

$$(d_4) \quad 2\sigma_{tR} = (0.8) \left(\frac{\Delta E}{E}\right) \sqrt{\frac{1310}{E}}$$

Substituting in Royston's Equation (7) the relations found in a, b, c, and d₄, one obtains

$$(0.4)^2 \Delta t^2 = (x + d)^2 (0.4)^2 \left(\frac{\Delta E_0}{E_0}\right)^2 \left(\frac{1310}{E_0}\right) + \frac{\Delta\tau}{(4)(3)}$$

which reduces to

$$\Delta t^2 = (x + d)^2 \left(\frac{\Delta E_0}{E_0}\right)^2 \left(\frac{1310}{E_0}\right) + \frac{\Delta\tau^2}{1.92}$$

which approximates

$$\Delta t_0^2 \sim \frac{1}{2} \Delta^2 + (x + d)^2 \left(\frac{\Delta E_0}{E_0}\right)^2 \left(\frac{1.3 \times 10^3}{E_0}\right)$$

Equation (2) can be obtained in a similar manner from Equation (47) of Royston.

In Tables I through XXIII, intensities and resolutions are given for each instrument at a set of incident energies that cover their normal range of operation. Whenever possible, measured values are used. The "Resolution (elastic)" represents the resolution for elastic scattering, while "Resolution (inelastic)" is an attempt to show the resolution when neutrons are inelastically scattered by the sample. In the latter case, 0.025 eV was arbitrarily selected as the mean final neutron energy in all cases. In this case $\Delta t_f/t_f$ represents the error in timing the burst of neutrons that are inelastically scattered while $\Delta E/E$ was selected to represent the error in measuring the change in energy

when both the incident energy and the final energy must be determined by time of flight and when these measurements are uncorrelated.

The intensities and resolutions for each instrument are given in a separate table, and a standard format is used to aid in comparing one instrument to another. Figures 1 through 9 are an attempt to present data for several instruments in one display. The attempt is only partially successful since the graphs cannot show the dependence of intensity on such parameters as angular resolution; they show but do not compensate for different incident energies.

II. EQUATIONS

$$(1) \quad \Delta t_o^2 = \frac{1}{2} \Delta \tau^2 + (x + d)^2 \left(\frac{\Delta E_o}{E_o} \right)^2 \left(\frac{1.31 \times 10^3}{E_o} \right)$$

$$(2) \quad \Delta t_f^2 = \frac{1}{2} \Delta \tau^2 + \left[x + \left(\frac{E_o}{E_f} \right)^{3/2} d \right]^2 \left(\frac{\Delta E_o}{E_o} \right)^2 \left(\frac{1.31 \times 10^3}{E_o} \right)$$

$$(3) \quad \Delta \epsilon^2 = 4 \left[E_f^2 \left(\frac{\Delta t_f}{t_f} \right)^2 + E_o^2 \left(\frac{\Delta t_o}{t_o} \right)^2 \right]$$

III. DEFINITIONS

<u>Flight Path:</u>	The distance d in meters from the sample to the detectors.
<u>Source Flux:</u>	The thermal neutron flux/cm ² sec at the bottom of the beam hole.
<u>$I(n/cm^2 min)$:</u>	The intensity of monoenergetic thermal neutrons/cm ² min at the sample position.
<u>$I(n/min)$:</u>	The intensity of monoenergetic thermal neutrons/min over the complete beam area at the sample position.
<u>Resolution:</u>	The energy, time resolution, and combined energy-time resolution for scattering neutrons.
<u>E_o:</u>	The mean energy in eV of the incident monoenergetic beam.
<u>ΔE_o:</u>	The full width at half maximum of the energy spread in eV in the monoenergetic beam.
<u>$\Delta \tau$:</u>	The full width at half maximum in μ sec of only the time spread in the monoenergetic beam. (In the MTR Velocity Selector this is the full width at half maximum of the burst when measured right after the last chopper.)
<u>t_o:</u>	The time of flight in μ sec of the elastically scattered neutrons to travel from the sample to the detector.
<u>Δt_o:</u>	The full width at half maximum in μ sec of the burst of elastically scattered neutrons as measured in time at the detectors.
<u>E_f:</u>	The mean energy in eV of the neutrons inelastically scattered with a discrete energy change.
<u>t_f:</u>	The time of flight in μ sec of the inelastically scattered neutrons to travel from the sample to the detectors.
<u>Δt_f:</u>	The full width at half maximum in μ sec. of the burst of inelastically scattered neutrons as measured in time at the detectors.
<u>x:</u>	The distance in meters from the "effective chopping point" (see Royston) to the sample position. (For a system consisting of two identical choppers rotating at the same speed, the effective chopping point is midway between choppers.)
<u>ϵ:</u>	The discrete energy change in eV of the neutrons involved in an inelastic scattering process when the final mean energy of the neutrons is 0.025 eV.
<u>$\Delta \epsilon$:</u>	The uncertainty in measuring ϵ in eV due to the finite widths

in time of the incident and scattered bursts for the inelastic case. $\Delta\epsilon$ is computed using Equation (3).

Signal/background: The ratio of the total number of counts in the time interval spanned by the vanadium elastic scattering peak to the background counts in the same interval.

Sample Thickness: The thickness parallel to the incident beam in centimeters of the vanadium sample.

Scattering Angle: Angle of scattering relative to the incident beam in degrees at which the signal/background was measured.

Range: The normal range of the scattering angles of the instrument.

No. of Detector Banks: Number of detector banks at different scattering angles used simultaneously.

Solid Angle per Detector Bank: The solid angle subtended by each detector bank.

Kind of Detector: The kind of detector normally used in the detector banks (ie, 1 in. x 18 in. 167-cm BF_3 detector or 5 in. diameter Li loaded glass scintillation detector, etc.).

IV. REFERENCE

1. R. J. Royston, "The Resolution Function of a Two-Rotor Neutron Velocity Selector", Nuclear Instruments and Methods, 30 (1964) pp 184-202.

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TABLE I
COLD NEUTRON CHOPPER -- HARWELL

<u>Instrument:</u>	Cold Neutron Chopper
<u>Location:</u>	DIDO Reactor, Atomic Energy Research Establishment, Harwell
<u>Reference:</u>	Harris, Cocking, Egelstaff, and Webb, Proceedings of the Chalk River Conference on "Inelastic Scattering of Neutrons in Solids and Liquids", Vol. 1, p 107, I.A.E.A., Vienna (1963).
<u>Beam Size:</u>	5.08 cm x 2.54 cm
<u>Flight Path:</u>	1.3 m
<u>Source Flux:</u>	5×10^{13} thermal neutrons/cm ² -sec (liquid H ₂ source increases this by X4 at 0.005 eV)
<u>Intensity Determination:</u>	Measured
<u>Intensity:</u>	

E_0 (eV)	I (n/min)	I (n/cm ² -min)
0.005 eV (37,500 rpm[a])	2.0×10^6 [b]	1.6×10^5 [b]
0.005 eV (28,300 rpm[a])	2.4×10^6 [b]	1.9×10^5 [b]
0.005 eV (18,700 rpm[a])	4.4×10^6 [b]	3.4×10^5 [b]

Resolution (elastic):

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)	$\Delta t_0/t_0$
0.005 eV (28,300 rpm[a])	0.0005	0.10	16	0.012	100	0.074

Resolution (inelastic):

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	t_f/t_f		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005 eV (28,300 rpm[a])	0.025	44[c]	0.073	0.020	0.0037[d]	0.19

[a] Angular velocity of chopper.

[b] Intensities recorded are with liquid hydrogen source.

[c] Computed from Equation (2) with $x = 0.64$ computed from Equation (1).

[d] Computed from Equation (3).

TABLE II

COLD NEUTRON CHOPPER -- BIRMINGHAM UNIVERSITY

<u>Instrument:</u>	Cold Neutron Chopper
<u>Location:</u>	HERALD Reactor, A.W.R.E., Aldermaston
<u>Reference:</u>	Ph.D. Thesis, F. P. Szabo, 1965.
<u>Beam Size:</u>	4.5 cm x 2.5 cm at the rotor axis (also at sample position)
<u>Flight Path:</u>	1.6 meters
<u>Source Flux:</u>	2×10^{12} thermal neutrons/cm ² -sec. The experiment makes use of a 15 cm tangential beam tube. The quoted flux is that measured at the source position, with the tube filled with water.

Intensity Determination:Intensity:

E_o (eV)	I (n/min)	I (n/cm ² -min)
0.005	2.2×10^5	1.94×10^4

NOTE: These intensities will be considerably increased when a cold source is installed toward the end of 1965.

Resolution (elastic):

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	$\Delta \tau$ (μsec)	$\Delta \tau/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.005	0.00125	0.25	11.5	0.0072	242	0.15

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	57 [a]	0.078	0.02	0.0042	0.21

Signal/Background:

E_o (eV)	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.005	0.28	50	40

Scattering Angles:

Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
20 to 90	8	1.6	0.0078	Proportional Counter Enriched BF ₃ 5 cm diameter 40 cm active length 70 cm pressure

[a] Computed from Equation (2) with $x = 0.3$ calculated from Equation (1).

TABLE III

COLD NEUTRON CHOPPER -- BROOKHAVEN NATIONAL LABORATORY

<u>Instrument:</u>	Cold Neutron Chopper
<u>Location:</u>	HFBR, Brookhaven National Laboratory
<u>Reference:</u>	K. Otnes and H. Palevsky, Proceedings of the Chalk River Conference on "Inelastic Scattering of Neutrons in Solids and Liquids", Vol. 1, p 95, I.A.E.A., Vienna (1963).
<u>Beam Size:</u>	1.25 cm x 5 cm
<u>Flight Path:</u>	1.6 m
<u>Source Flux:</u>	5×10^{14} thermal neutrons/cm ² -sec

Intensity Determination: Calculated

Intensity:

E_0 (eV)	I (n/min)	I (n/cm ² -min)
0.005 (one rotor system)	4.8×10^8	7.7×10^7
0.005 (two rotor system)	2.4×10^8	3.8×10^7
0.005 (three rotor system)	3.0×10^7	4.8×10^6

Resolution (elastic):

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (sec)	$\Delta t_0/t_0$
0.005 (one rotor system)	0.00065	0.125	25.0	0.016	128 ^[a]	0.08
0.005 (two rotor system)	0.00033	0.0625	12.5	0.008	64 ^[a]	0.04
0.005 (three rotor system)	0.00016	0.0315	12.5	0.008	40 ^[a]	0.025

Resolution (inelastic):

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005 (one rotor system)	0.025	39 ^[b]	0.053	0.02	0.0028 ^[c]	0.14
0.005 (two rotor system)	0.025	19 ^[b]	0.027	0.02	0.0014 ^[c]	0.072
0.005 (three rotor system)	0.025	18 ^[b]	0.024	0.02	0.0012 ^[c]	0.061

[a] Assuming $x = 0.4, 0.4, \text{ and } 0.8$ for the three cases.

[b] Assuming sample immediately after last chopper.

[c] Computed from Equation (3).

TABLE IV

COLD NEUTRON CHOPPER -- ARGONNE NATIONAL LABORATORY

<u>Instrument:</u>	New Cold Neutron Chopper (completion November 1, 1965)				
<u>Location:</u>	CP-5 Reactor, Argonne National Laboratory				
<u>Reference:</u>	D. Connor (private communication).				
<u>Beam Size:</u>	3 cm x 1 cm				
<u>Flight Path:</u>	4.0 meters				
<u>Source Flux:</u>	Approximately 5×10^{12} thermal neutrons/cm ² -sec (cold source, $T_n \approx 50^\circ\text{K}$)				
<u>Intensity Determination:</u>	Estimated (duty cycle included)				
<u>Intensity:</u>					
<u>$E_0(\text{eV})$</u>	<u>$I(\text{n/min})$</u>	<u>$I(\text{n/cm}^2\text{-min})$</u>			
0.00495	1.5×10^6	5.0×10^5			
<u>Resolution (elastic):</u>					
	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>
<u>$E_0(\text{eV})$</u>	<u>$\Delta E_0(\text{eV})$</u>	<u>$\Delta E_0/E_0$</u>	<u>$\Delta\tau(\mu\text{sec})$</u>	<u>$\Delta\tau/t_0$</u>	<u>$\Delta t_0(\mu\text{sec})$</u>
0.00495	0.0005	0.1	5	0.00125	$212[\text{a}]$
					<u>$\Delta t_0/t_0$</u>
					0.053
<u>Resolution (inelastic):</u>					
		<u>Burst Width at Detector</u>		<u>Uncertainty in Energy Change</u>	
<u>$E_0(\text{eV})$</u>	<u>$E_f(\text{eV})$</u>	<u>$\Delta t_f(\mu\text{sec})$</u>	<u>$\Delta t_f/t_f$</u>	<u>$\epsilon(\text{eV})$</u>	<u>$\Delta\epsilon(\text{eV})$</u>
0.00495	0.025	18.5[b]	0.01	0.020	$0.0005[\text{c}]$
					<u>$\Delta\epsilon/\epsilon$</u>
					0.025
<u>Signal/Background:</u>					
<u>$E_0(\text{eV})$</u>	<u>V. Sample Thickness (cm)</u>	<u>Scattering Angle (degrees)</u>		<u>Signal/Background</u>	
<u>Scattering Angles:</u>					
<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>	
15 to 120	81	4	0.0087	RF ₃ (160 cm pressure)	
[a] Calculated from Equation (1).					
[b] Calculated from Equation (2).					
[c] Calculated from Equation (3).					

TABLE V
COLD NEUTRON CHOPPER -- PICATINNY ARSENAL

<u>Instrument:</u>	Cold Neutron Chopper				
<u>Location:</u>	AMRA Reactor, Watertown, Massachusetts				
<u>Reference:</u>	Boutin, Prask, and Trevino (private communication).				
<u>Beam Size:</u>	7.5 cm x 7.5 cm				
<u>Flight Path:</u>	5.03 meters				
<u>Source Flux:</u>	10^{12} thermal neutrons/cm ² -sec				
<u>Intensity Determination:</u>	Measured				
<u>Intensity:</u>					
<u>E_o (eV)</u>	<u>I (n/min)</u>		<u>I (n/cm²-min)</u>		
0.005	1.5×10^9 ^[a]		2.4×10^7 ^[a]		
<u>Resolution (elastic):</u>					
	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		
<u>E_o (eV)</u>	<u>E_o (eV)</u>	<u>E_o/E_o</u>	<u>Δt (μsec)</u>	<u>Δt/t_o</u>	<u>Δt_o (μsec)</u> <u>Δt_o/t_o</u>
0.005	0.0015	0.30			1008 0.195
					128 ^[b] 0.025 ^[b]
<u>Resolution (inelastic):</u>					
<u>Scattering Angles:</u>					
<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>		<u>Kind of Detector</u>
Fixed 90	3	5.03	0.0002		BF ₃
					190 cm pressure
					2 in. diameter
					20 in. long

[a] Chopper after sample, so that chopper transmission and duty cycle not included.

[b] Resolution as measured by the slope of the Be cutoff.

TABLE VI
COLD NEUTRON CHOPPER -- STUDSVIK

<u>Instrument:</u>	Cold Neutron Chopper				
<u>Location:</u>	R2 Reactor Studsvik				
<u>Reference:</u>	Dahlborg, Larsson, and Sköld, Proceedings of the Bombay Conference on "Inelastic Scattering of Neutrons in Solids and Liquids", I.A.E.A. (1964).				
<u>Beam Size:</u>	5 cm x 8 cm				
<u>Flight Path:</u>	4.5 meters				
<u>Source Flux:</u>	6×10^{13} thermal neutrons/cm ² -sec				
<u>Intensity Determination:</u>	Measured				
<u>Intensity:</u>					
E_0 (eV)	I (n/min)		I (n/cm ² -min)		
0.005	4.8×10^6 (With Chopper)		1.3×10^5 (With Chopper)		
<u>Resolution (elastic):</u>					
	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>
E_0 (eV)	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)
0.005	0.0007	0.15			53[a]
					0.012[a]
<u>Resolution (inelastic):</u>					
		<u>Burst Width at Detector</u>		<u>Uncertainty in Energy Change</u>	
E_0 (eV)	E_f (eV)	Δt_f (μsec)	$\Delta t_f/t_f$	ϵ (eV)	$\Delta \epsilon$ (eV)
0.005	0.025	45	0.0225	0.020	0.0009
					0.045
<u>Signal/Background:</u>					
E_0 (eV)	<u>V Sample Thickness (cm)</u>	<u>Scattering Angle (degrees)</u>		<u>Signal/Background</u>	
0.005	1	90		30	
<u>Scattering Angles:</u>					
<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradians)</u>	<u>Kind of Detector</u>	
0 to 130	2	4.5	8.0×10^{-3}	3 cm x 30 cm	
				150 cm BF ₃	

[a] Resolution as measured by the slope of the Be cutoff.

TABLE VII
COLD NEUTRON CHOPPER -- STOCKHOLM

<u>Instrument:</u>	Cold Neutron Chopper No. 1
<u>Location:</u>	R1 Reactor, Stockholm
<u>Reference:</u>	Dahlborg, Larsson, and Sköld, Proceedings of the Bombay Conference on "Inelastic Scattering of Neutrons in Solids and Liquids", I.A.E.A. (1964).
<u>Beam Size:</u>	5 cm x 10 cm
<u>Flight Path:</u>	3.0 meters
<u>Source Flux:</u>	6×10^{11} thermal neutrons/cm ² -sec

Intensity Determination: Measured

<u>Intensity:</u>		
E_o (eV)	$I(n/min)$	$I(n/cm^2-min)$
0.005	6.0×10^9 ^[a]	1.1×10^8 ^[a]

Resolution (elastic):

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	Δt_o (μsec)	$\Delta t_o/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.005	0.0025	0.5			60 ^[b]	0.02 ^[b]

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	80	0.057	0.021	0.0027	0.13

Signal/Background:

E_o (eV)	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.005	0.7	30	20

Scattering Angles:

Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradians)	Kind of Detector
0 to 90	1	3	6.0×10^{-3}	BF ₃ 1140 mm Hg 15 mm diameter (3 layers)

[a] Chopper after sample so those numbers do not include duty cycle or transmission of chopper. Duty cycle $\approx 3.0 \times 10^{-3}$.

[b] Resolution as measured by the slope of the Be cutoff.

TABLE VIII
COLD NEUTRON CHOPPER -- STOCKHOLM

Instrument: Cold Neutron Chopper No. 2
Location: R1 Reactor, Stockholm
Reference: Dahlborg, Larsson, and Sköld, Proceedings of the Bombay Conference on "Inelastic Scattering of Neutrons in Solids and Liquids", I.A.E.A. (1964).
Beam Size: 5 cm x 10 cm
Flight Path: 3.5 meters
Source Flux: 3×10^{11} thermal neutrons/cm²-sec

Intensity Determination: Measured

Intensity:

<u>E_0 (eV)</u>	<u>I (n/min)</u>	<u>I (n/cm²-min)</u>
0.005	4.0×10^6	8.0×10^4

Resolution (elastic):

<u>E_0 (eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>ΔE_0 (eV)</u>	<u>$\Delta E_0/E_0$</u>	<u>$\Delta \tau$ (μsec)</u>	<u>$\Delta \tau/t_0$</u>	<u>Δt_0 (μsec)</u>	<u>$\Delta t_0/t_0$</u>
0.005	0.0015	0.3	96	0.028	490 [a]	0.14 [a]

Resolution (inelastic):

<u>E_0 (eV)</u>	<u>E_f (eV)</u>	<u>Burst Width at Detector</u>		<u>ϵ (eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f (μsec)</u>	<u>$\Delta t_f/t_f$</u>		<u>$\Delta \epsilon$ (eV)</u>	<u>$\Delta \epsilon/\epsilon$</u>
0.005	0.025					

Signal/Background:

<u>E_0 (eV)</u>	<u>V Sample Thickness (cm)</u>	<u>Scattering Angle (degrees)</u>	<u>Signal/Background</u>
0.005	0.5	60	7

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradians)</u>	<u>Kind of Detector</u>
0 to 115	4	3.5	6.0×10^{-3}	BF ₃ 1500 mm Hg 30 mm diameter

[a] Resolution as measured by the slope of the Be cutoff.

TABLE IX
COLD NEUTRON CHOPPER -- ISPRA

Instrument: Cold Neutron Chopper
Location: Ispra-I Reactor, EURATOM C.C.R. Ispra, Italy
Reference: Haas, Kley, Krebs, and Rubin (private communication).
Beam Size: 5 cm x 10 cm
Flight Path: 2.9 m/4.5 m
Source Flux: 0.8×10^{13} thermal neutrons/cm²-sec

Intensity Determination: Measured

Intensity:

<u>E_0 (eV)</u>	<u>I (n/min)</u>	<u>I (n/cm²-min)</u>
0.005 (11,000 rpm[a])	3.5×10^7	7×10^5

Resolution (elastic):

<u>E_0 (eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>ΔE_0 (eV)</u>	<u>$\Delta E_0/E_0$</u>	<u>$\Delta \tau$ (μsec)</u>	<u>$\Delta \tau/t_0$</u>	<u>Δt_0 (μsec)</u>	<u>$\Delta t_0/t_0$</u>
0.005 (11,000 rpm[a])	0.00154	0.31	60	0.02	624	0.21

Resolution (inelastic)[b]:

<u>E_0 (eV)</u>	<u>E_f (eV)</u>	<u>Burst Width at Detector</u>		<u>ϵ (eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f (μsec)</u>	<u>$\Delta t_f/t_f$</u>		<u>$\Delta \epsilon$ (eV)</u>	<u>$\Delta \epsilon/\epsilon$</u>
0.005	0.025	230[c]	0.17	0.020	0.0088[d]	0.44

Signal/Background (2.9 m flight path -- no data for the 4.5 m flight path):

<u>E_0 (eV)</u>	<u>V Sample Thickness (cm)</u>	<u>Scattering Angle (degrees)</u>	<u>Signal/Background</u>
0.005	0.28	90	11

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>
90	1	2.9	0.0143	BF ₃
30 to 90	2	4.5	0.00593	BF ₃

TABLE IX (Cont.)

COLD NEUTRON CHOPPER -- ISPRA

Comments: The data given for ΔE_0 , $\Delta \tau$ and Δt_0 refer to the following system:

It is assumed that the calculated resolutions approximately represent this system.

- [a] Angular velocity of chopper.
- [b] Resolution for the 2.9 m flight path.
- [c] Computed using Equation (2), with $x = 1.04$ given by Equation (1).
- [d] Computed using Equation (3).

TABLE X

PHASED CHOPPER VELOCITY SELECTOR -- ISPRA

<u>Instrument:</u>	Two Rotor Velocity Selector					
<u>Location:</u>	Ispra-I Reactor, EURATOM C.C.R. Ispra, Italy					
<u>Reference:</u>	K. H. Krebs (private communication).					
<u>Beam Size:</u>	1.2 cm x 2 cm					
<u>Flight Path:</u>	1.5 m					
<u>Source Flux:</u>	2×10^{13} thermal neutrons/cm ² -sec					
<u>Intensity Determination:</u>	Calculated					
<u>Intensity:</u>						
<u>E₀ (eV)</u>	<u>I (n/min)</u>	<u>I (n/cm²-min)</u>				
0.005 (13,300 rpm)	3.6×10^5	1.5×10^5				
0.0136 (22,000 rpm)	1.8×10^6	7.5×10^5				
<u>Resolution (elastic)[a]:</u>						
<u>E₀ (eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>ΔE₀ (eV)</u>	<u>ΔE₀/E₀</u>	<u>Δτ (μsec)</u>	<u>Δτ/t₀</u>	<u>Δt₀ (μsec)</u>	<u>Δt₀/t₀</u>
0.005 (13,300 rpm)	0.00036	0.071	58	0.04	120	0.078
0.0136 (22,000 rpm)	0.00097	0.071	35	0.04	73	0.079
<u>Resolution (inelastic)[a]:</u>						
<u>E₀ (eV)</u>	<u>E_f (eV)</u>	<u>Burst Width at Detector</u>		<u>ε (eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f (μsec)</u>	<u>Δt_f/t_f</u>		<u>Δε (eV)</u>	<u>Δε/ε</u>
0.005	0.025	74 ^[b]	0.11	0.020	0.0055 ^[c]	0.27
0.0136	0.025	55 ^[b]	0.080	0.0114	0.0047 ^[c]	0.41
<u>Signal/Background:</u>						
<u>Scattering Angles:</u>						
<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>		
0 to 90	4	1 to 2	0.003 to 0.06	BF ₃ Counters		
				70 cm pressure		
				5 cm OD x 40 cm effective length		
				Li ⁶ I Crystals		
				7.5 cm diameter		

TABLE X (Cont.)

PHASED CHOPPER VELOCITY SELECTOR -- ISPRA

Comments: The data given for ΔE_0 , $\Delta \tau$, and Δt_0 refer to the following systems:

The following equations were used:

$$\Delta \tau = \frac{a}{\omega r}$$

$$\frac{\Delta E_0}{E_0} = 2\sqrt{2} \frac{\Delta \tau v_0}{D}$$

[a] Assumed $x = 1.15 + 0.5 = 1.65$ where $s = 0.5$ (see comments above).

[b] Computed using Equation (2).

[c] Computed using Equation (3).

TABLE XI
ROTATING CRYSTAL SPECTROMETER -- ISPRA

<u>Instrument:</u>	Rotating Crystal Spectrometer
<u>Location:</u>	Ispra-I Reactor, EURATOM C.C.R. Ispra, Italy
<u>Reference:</u>	Meister, Haas, and Kley (private communication).
<u>Beam Size:</u>	8 cm x 4.5 cm
<u>Flight Path:</u>	3.07 m
<u>Source Flux:</u>	2×10^{13} thermal neutrons/cm ² -sec
<u>Intensity Determination:</u>	The intensities are deduced from the peak fluxes measured by gold activation in the stationary reflected neutron beam (higher order neutrons subtracted).

Intensity[a]:

E_o (eV)	$I(n/min)$	$I(n/cm^2\text{-sec})$
0.005	2.5×10^4	7.0×10^2
0.025	2.5×10^5	7.0×10^3
0.060	4.5×10^5	1.2×10^4
0.125	1.5×10^5	4.0×10^3

Resolution (elastic)[a,b]:

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	$\Delta \tau$ (μsec)	$\Delta \tau/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.005	0.00010	0.020	36	0.012	50	0.016
0.025	0.0004	0.016	35	0.023	36	0.026
0.060	0.0013	0.021	26	0.028	34	0.038
0.125	0.0035	0.028	20	0.032	28	0.045

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	29[c]	0.021	0.020	0.0011[d]	0.055
0.060	0.025	57[c]	0.041	0.035	0.0050[d]	0.14
0.125	0.025	100[c]	0.072	0.100	0.012[d]	0.12

Signal/Background:

Scattering Angles:

Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
0 to 110	1	3.07	0.012	BF ₃ 700 mm Hg pressure 5 cm diameter x 40 cm active length

TABLE XI (Cont.)

ROTATING CRYSTAL SPECTROMETER -- ISPRA

Comments: The data given refer to the following (preliminary) experimental layout:

[a] For crystal 1-1/2 in. $\varnothing$ turning with 6000 rpm.

[b] Scattering angle $\theta = 0$.

[c] Computed using Equation (2), with $x = 1.0, 6.1$, and 5.4 given by Equation (1).

[d] Computed using Equation (3).

TABLE XII
ROTATING CRYSTAL SPECTROMETER -- CHALK RIVER

<u>Instrument:</u>	Rotating Crystal Spectrometer
<u>Location:</u>	NRU Reactor, Chalk River
<u>Reference:</u>	B. N. Brockhouse in Inelastic Scattering of Neutrons in Solids and Liquids, p 113, I.A.E.A., Vienna (1961), also A. D. B. Woods (private communication).
<u>Beam Size:</u>	2.5 cm x 5 cm
<u>Flight Path:</u>	3.3 m
<u>Source Flux:</u>	2×10^{14} thermal neutrons/cm ² -sec

Intensity Determination: Measured

Intensity:

E_o (eV)	I (n/min)	I (n/cm ² -min)
0.005	2.5×10^5	2×10^4
0.013	7.5×10^5	6×10^4
0.032	5×10^5	4×10^4
0.044	2.5×10^5	2×10^4

Resolution (elastic):

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	$\Delta \tau$ (μsec)	$\Delta \tau/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.005		≈ 0.01 [a]	28	0.0083	56	0.017
0.013		≈ 0.01 [a]	20	0.010	36	0.017
0.032		≈ 0.01 [a]	18	0.013	24	0.018
0.044		≈ 0.01 [a]	16	0.014	22	0.020

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Burst Width at Detector	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	43 [b]	0.028	0.020	0.0014 [c]	0.01
0.013	0.025	28 [b]	0.019	0.012	0.0010 [c]	0.083
0.032	0.025	22 [b]	0.015	0.007	0.0010 [c]	0.14
0.044	0.025	29 [b]	0.019	0.019	0.0020 [c]	0.10

[a] Calculated.

[b] Calculated from Equation (2) with $x = 7.4, 6.3, 6.8$, and 7.9 computed from Equation (1).

[c] Calculated from Equation (3).

TABLE XIII
ROTATING CRYSTAL SPECTROMETER -- KARLSRUHE

Instrument: Rotating Crystal Spectrometer
Location: FR2 Reactor, Kerforschungszenrum Karlsruhe
Reference: W. Glaser, I.A.E.A. Study Group Meeting on Research Reactor Experimental Techniques, October 1964, Bucharest; KFK-Report 263.

I. Beam Size: 3 cm x 7 cm

Flight Path: 2 meters

II. Beam Size: 4 cm x 5 cm

Flight Path: 3.5 meters

Source Flux: 8×10^{12} thermal neutrons/cm²-sec^[a]

Intensity Determination: Measured

Intensity:

	E_0 (eV)	$2\theta_{\text{BRAGG}}$ (degrees) ^[b]	I (n/min)	I (n/cm ² -min)
I.	0.085	24	3.4×10^5	1.6×10^4
	0.040	36	4.8×10^5	2.3×10^4
	0.020	52	3.4×10^5	1.6×10^4
II.	0.008	86	5.0×10^4	1.2×10^3

Resolution (elastic):

	E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
		ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)	$\Delta t_0/t_0$
I. [c]	0.085	0.0070	0.092	20	0.04	40	0.083
	0.040	0.0024	0.060	20	0.03	40	0.057
	0.020	0.0008	0.040	20	0.02	40	0.037
II. [d]	0.008	0.00008	0.01	20	0.007	40	0.015

Resolution (inelastic):

	E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Changes	
			Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
I.	0.085	0.025	40 [e]	0.10	0.060	0.03 [e]	≈ 0.05
	0.040	0.025	40 [e]	0.10	0.015	0.03 [e]	≈ 0.2
	0.020	0.025	40 [e]	0.10	0.005	0.03 [e]	≈ 0.6
II.	0.008	0.025	40 [e]	0.10	0.017	0.03 [e]	≈ 0.2

Signal/Background:

E_0 (eV)	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.085	0.2	135	10
0.040	0.2	135	20
0.040	0.2	145	33
0.020	0.2	145	9
0.020	0.2	135	10

TABLE XIII (Cont.)

ROTATING CRYSTAL SPECTROMETER -- KARLSRUHE

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>
20 to 150	9	2	0.003	He ³ & Li ⁶ -ZnS

[a] To be increased X7 late 1965.

[b] Al crystal (111).

[c] One collimator before the crystal (15 minutes of angle): crystal at 14,000 rpm.

[d] Second collimator behind the crystal.

[e] Extracted from experimental values.

TABLE XIV

PHASED ROTOR NEUTRON SPECTROMETER -- CHALK RIVER

<u>Instrument:</u>	Phased Rotor Neutron Spectrometer (to be dismantled 1966).		
<u>Location:</u>	A.E.C.L. Chalk River		
<u>Reference:</u>	D. I. Page (private communication).		
<u>Beam Size:</u>	2.5 cm x 5.0 cm		
<u>Flight Path:</u>	1.7 m for 1st Quadrant Detectors 1.3 m for 3rd Quadrant Detectors 3.0 m for 4th Quadrant Detectors (narrow angle array)		
<u>Source Flux:</u>	1.2×10^{14} thermal neutrons/cm ² -sec		
<u>Intensity Determination:</u>	Measured		
<u>Intensity:</u>			
E_0 (eV)	I (n/min)	I (n/cm ² -sec)	
0.10	6.3×10^5	4.9×10^4	
0.055	7.2×10^5	5.6×10^4	
0.025	2.6×10^5	2.0×10^4	

Resolution (elastic)[a]:

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)	$\Delta t_0/t_0$
0.10[b]	0.00195	0.195	6	0.009[c]	12.26[c]	0.018[c]
0.055[b]	0.00076	0.0138	6	0.0065[c]	11.65[c]	0.0125[c]
0.025[b]	0.00026	0.0104	6	0.0044[c]	12.35[c]	0.009[c]
0.10[b]	0.00195	0.0195	6	0.016[d]	10.0[d]	0.026[d]
0.055[b]	0.00076	0.0138	6	0.012[d]	8.96[d]	0.017[d]
0.025[b]	0.00026	0.104	6	0.0078[d]	9.32[d]	0.12[d]
0.10[b]	0.00195	0.0195	6	0.021[e]	9.3[e]	0.0315[e]
0.055[b]	0.00076	0.0138	6	0.015[e]	8.68[e]	0.0215[e]
0.025[b]	0.00026	0.0104	6	0.010[e]	9.5[e]	0.016[e]

Resolution (inelastic)[a]:

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.10[b]	0.025	57.8[c]	0.042[c]	0.075	0.00415[c]	0.055[c]
0.055[b]	0.025	19.3[c]	0.0207[c]	0.030	0.0027[c]	0.09[c]
0.10[b]	0.025	34.9[d]	0.045[d]	0.075	0.00568[d]	0.075[d]
0.055[b]	0.025	13.1[d]	0.0249[d]	0.030	0.0035[d]	0.117[d]
0.10[b]	0.025	27.8[e]	0.047[e]	0.075	0.0068[e]	0.089[e]
0.055[b]	0.025	11.3[e]	0.0279[e]	0.030	0.00453[e]	0.151[e]

Signal/Background:

E_0 (eV)	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.1	0.36	10 to 90	≈ 50
0.1	0.36	90 to 160	≈ 25
0.017	0.36	4 to 22	≈ 10

TABLE XIV (Cont.)

PHASED ROTOR NEUTRON SPECTROMETER -- CHALK RIVER

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>
10 to 90	15	1.7	0.00383	LiF-ZnS Scintillation
90. to 160	9	1.3	0.00872	
4 to 22	10	3.0	0.00129	

[a] Assuming $x = 1.85$.

[b] Rotors at 30,000 rpm.

[c] 3 m flight path.

[d] 1.7 m flight path.

[e] 1.3 m flight path.

TABLE XV
PHASED CHOPPER VELOCITY SELECTOR
(EQUAL SLOT CHOPPERS) -- MATERIALS TESTING REACTOR

<u>Instrument:</u>	Phased Chopper Velocity Selector[a]					
<u>Location:</u>	Materials Testing Reactor, NRTS, Idaho Falls, Idaho					
<u>Reference:</u>	Gavin, Harker, and Brugger (private communication).					
<u>Beam Size:</u>	3.38 cm x 10.16 cm					
<u>Flight Path:</u>	2 meters					
<u>Source Flux:</u>	2×10^{14} thermal neutrons/cm ² -sec					
<u>Intensity Determination:</u>	Measured					
<u>Intensity:</u>						
<u>E₀(eV)</u>	<u>I(n/min)</u>	<u>I(n/cm²-min)</u>				
0.10[b]	2.9×10^6	8.5×10^4				
0.076[c]	1.2×10^6	3.5×10^4				
0.055[c]	2.4×10^6	7.0×10^4				
0.042[c]	1.7×10^6	5.0×10^4				
<u>Resolution (elastic):</u>						
<u>E₀(eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>ΔE₀(eV)</u>	<u>ΔE₀/E₀</u>	<u>Δτ(μsec)</u>	<u>Δτ/t₀</u>	<u>Δt₀(μsec)</u>	<u>Δt₀/t₀</u>
0.10[b]	0.0027[d]	0.026	6.5	0.014	14.7[e]	0.032
0.076[c]	0.0018[d]	0.024	6.5	0.012	14.7[e]	0.028
0.055[c]	0.0011[d]	0.020	6.5	0.010	14.7[e]	0.024
0.042[c]	0.0007[d]	0.017	6.5	0.009	14.7[e]	0.021
<u>Resolution (inelastic):</u>						
<u>E₀(eV)</u>	<u>E_f(eV)</u>	<u>Burst Width at Detector</u>		<u>ε(eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f(sec)</u>	<u>Δt_f/t_f</u>		<u>Δε(eV)</u>	<u>Δε/ε</u>
0.10	0.025	56[f]	0.061	0.075	0.0071[g]	0.095
0.076	0.025	40[f]	0.044	0.051	0.0048[g]	0.094
0.055	0.025	28[f]	0.031	0.030	0.0031[g]	0.10
0.042	0.025	21[f]	0.023	0.017	0.0021[g]	0.12
<u>Signal/Background:</u>						
<u>Scattering Angles:</u>						
<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank</u>	<u>Kind of Detector</u>		
15 to 145	15	2 to 2.25	0.007 to 0.029	BF ₃ 167 cm pressure 1 in. ID, 18 in. long		
2.8 to 20	15	2.5	0.0004 to 0.0008	BF ₃ 167 cm pressure 1 in. ID, 4 in. long		
2.0 to 10	15	2.25	0.0006 to 0.0012	He ³ 10 Atm 1 in. ID, 6 in. long		

[a] Both choppers have equal speeds and slot widths.

[b] 83 in. radius of curvature curved slits in rotors. Choppers at 12,000 rpm.

TABLE XV (Cont.)

PHASED CHOPPER VELOCITY SELECTOR
(EQUAL SLOT CHOPPERS) -- MATERIALS TESTING REACTOR

[c] 42 in. radius of curvature curved slits in rotors. Choppers at 12,000 rpm.

[d] Computed from Equation (1) using Δt_0 values at two distances from the chopper (2 beam monitors).

[e] Measured.

[f] Computed from Equation (2) with $x = 2.6$ computed from Equation (1).

[g] Computed from Equation (3).

TABLE XVI
PHASED CHOPPER VELOCITY SELECTOR
(UNEQUAL SLOT CHOPPERS) -- MATERIALS TESTING REACTOR

<u>Instrument:</u>	Phased Chopper Velocity Selector ^[a]					
<u>Location:</u>	Materials Testing Reactor, NRTS, Idaho Falls, Idaho					
<u>Reference:</u>	R. M. Brugger (private communication).					
<u>Beam Size:</u>	3.38 cm x 10.16 cm					
<u>Flight Path:</u>	2.25 meters					
<u>Source Flux:</u>	2×10^{14} thermal neutrons/cm ² -sec					
<u>Intensity Determination:</u>	Measured					
<u>Intensity:</u>						
<u>E₀(eV)</u>	<u>I(n/min)</u>	<u>I(n/cm²-min)</u>				
0.07 ^[b]	2.9×10^6	1.0×10^5				
0.05 ^[b]	3.1×10^6	1.1×10^5				
0.03 ^[b]	1.4×10^6	4.8×10^4				
<u>Resolution (elastic)^[c]:</u>						
<u>E₀(eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>E₀(eV)</u>	<u>ΔE₀/E₀</u>	<u>Δτ(μsec)</u>	<u>Δτ/t₀</u>	<u>Δt₀(μsec)</u>	<u>Δt₀/t₀</u>
0.07	0.0020	0.038	6.5	0.010	19.4	0.031
0.05	0.0012	0.032	6.5	0.009	19.4	0.027
0.03	0.0006	0.025	6.5	0.007	19.4	0.020
<u>Resolution (inelastic)^[c]:</u>						
<u>E₀(eV)</u>	<u>E_f(eV)</u>	<u>Burst Width at Detector</u>		<u>ε(eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f(μsec)</u>	<u>Δt_f/t_f</u>		<u>Δε(eV)</u>	<u>Δε/ε</u>
0.07	0.025	62	0.0602	0.045	0.0053	0.12
0.05	0.025	35	0.034	0.025	0.0032	0.13
0.03	0.025	24	0.023	0.005	0.0017	0.34

[a] Both choppers have equal speeds. Slot width of first chopper is 2x that of second chopper.

[b] 42 in. radius of curvature curved slits in rotors. Choppers at 12,000 rpm.

[c] Assumed x = 1.34.

TABLE XVII

ROTATING CRYSTAL SPECTROMETER -- BATTELLE-NORTHWEST LABORATORY

Instrument: Rotating Crystal Spectrometer with Phased Chopper
Location: Battelle-Northwest Laboratory, Richland, Washington
Reference: O. K. Harling (private communication).
Beam Size: $2.5 \times 10.16 \text{ cm}^{[a]}$
Flight Path: $1.5 \text{ m}^{[b]}$
Source Flux:

Intensity
Determination: Measured and Calculated

Intensity:

$E_o \text{ (eV)}$	$I (\text{n/min})$	$I (\text{n/cm}^2\text{-min})$
I. $0.300^{[c]}$	12.0×10^5	4.64×10^4
II. $0.300^{[c]}$	3.0×10^5	1.16×10^4
III. $0.300^{[c]}$	0.75×10^5	0.29×10^4

Resolution (elastic):

$E_o \text{ (eV)}$	Energy Distribution of Burst		Time Distribution of Burst ^[d]		Burst Width at Detector ^[e]	
	$\Delta E_o \text{ (eV)}$	$\Delta E_o/E_o$	$\Delta \tau \text{ (}\mu\text{sec)}$	$\Delta \tau/t_o$	$\Delta t_o \text{ (}\mu\text{sec)}$	$\Delta t_o/t_o$
I. $0.3^{[c]}$	0.0132	0.044	7.0	0.035	13.3	0.066
II. $0.3^{[c]}$	0.0066	0.022	6.0	0.031	7.3	0.037
III. $0.3^{[c]}$	0.0029	0.0097	4.7	0.024	4.9	0.025
IV. $0.1^{[c]}$	0.0009	0.009	6.5	0.019	7.5	0.022
V. $0.5^{[c]}$	0.013	0.026	5.0	0.033	5.5	0.036

Resolution (inelastic):

$E_o \text{ (eV)}$	$E_f \text{ (eV)}$	Burst Width at Detector		$\epsilon \text{ (eV)}$	Uncertainty in Energy Change ^[f]	
		$\Delta t_f \text{ (}\mu\text{sec)}$	$\Delta t_f/t_f$		$\Delta \epsilon \text{ (eV)}$	$\Delta \epsilon/\epsilon$
I. $0.3^{[c]}$	0.025	180	0.26	0.275	0.0186	0.068
II. $0.3^{[c]}$	0.025	93	0.14	0.275	0.0093	0.034
III. $0.3^{[c]}$	0.025	43	0.060	0.275	0.0041	0.015
IV. $0.1^{[c]}$	0.025	21	0.03	0.075	0.001	0.013
V. $0.5^{[c]}$	0.025	190	0.28	0.475	0.015	0.032

Signal/Background:

$E_o \text{ (eV)}$	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.017	0.225	90	17.5

TABLE XVII (Cont.)

ROTATING CRYSTAL SPECTROMETER -- BATTELLE-NORTHWEST LABORATORY

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>
15 to 165	11	1.0 and 1.5	0.0065 to 0.033	BF ₃ 1 in. ID, 10 in. long, 2 Atm
		1.0 and 1.5	0.0043 to 0.030	He ³ 1 in. ID, 15 in. long, 8 Atm

[a] Can be increased to 5 cm in width.

[b] Can be decreased to 1.0 meter.

[c] With Cu[220] planes in transmission mode. Crystal rotating at 12,000 rpm

I. Collimator 0.36° II., IV., V. Collimator 0.18° III. Collimator 0.079°

[d] Burst measured at sample.

[e] Δt_0 given is for a 15° scattering angle.

[f] $\Delta \epsilon$ was calculated from $\Delta \epsilon^2 = \left(\frac{2\Delta t_f}{t_f} \right)^2 + \Delta E_0^2$, where ΔE_0 is the Bragg energy uncertainty in the incident beam. This method of calculating $\Delta \epsilon$ differs from that used in Equation 3 of this compilation. For the Battelle Rotating Crystal Spectrometer the contribution of the energy spread is small compared to the total time spread in the incident neutron pulse, ie, $\frac{\Delta E_0}{E_0} < \frac{2\Delta t_0}{t_0}$ under normal operating conditions. Therefore use of Equation 3 would overestimate the error in $\Delta \epsilon$.

TABLE XVIII

LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

<u>Instrument:</u>	General Atomic Neutron Velocity Selector (10,800 rpm) (in operation)					
<u>Location:</u>	General Atomic Electron LINAC					
<u>Reference:</u>	W. L. Whittemore (private communication).					
<u>Beam Size:</u>	7.0 cm x 25.4 cm					
<u>Flight Path:</u>	2.0 meters					
<u>Source Flux:</u>	Not Determined Directly					
<u>Intensity Determination:</u>	Measured					
<u>Intensity:</u>						
<u>E_o (eV)</u>	<u>I (n/min)</u>	<u>I (n/cm²-min)</u>				
0.167[a]	6.7×10^5 [b]	3.8×10^3 [b]				
0.233[a]	5.5×10^5 [b]	3.1×10^3 [b]				
0.41[a]	5.5×10^5 [b]	3.1×10^3 [b]				
<u>Resolution (elastic):</u>						
<u>E_o (eV)</u>	<u>Energy Distribution of Burst</u>		<u>Time Distribution of Burst</u>		<u>Burst Width at Detector</u>	
	<u>ΔE_o (eV)</u>	<u>$\Delta E_o/E_o$</u>	<u>$\Delta \tau$ (μsec)</u>	<u>$\Delta \tau/t_o$</u>	<u>Δt_o (μsec)</u>	<u>$\Delta t_o/t_o$</u>
0.167[a]	0.0062	0.370	19	0.0539	26	0.0743
0.233[a]	0.0101	0.0436	19	0.0634	26	0.0861
0.410[a]	0.0238	0.0580	19	0.0841	26	0.1150
<u>Resolution (inelastic):</u>						
<u>E_o (eV)</u>	<u>E_f (eV)</u>	<u>Burst Width at Detector</u>		<u>ϵ (eV)</u>	<u>Uncertainty in Energy Change</u>	
		<u>Δt_f (μsec)</u>	<u>$\Delta t_f/t_f$</u>		<u>$\Delta \epsilon$ (eV)</u>	<u>$\Delta \epsilon/\epsilon$</u>
0.167	0.025	125[c]	0.148	0.142	0.0259[d]	0.182
0.233	0.025	198[c]	0.218	0.208	0.0417[d]	0.200
0.410	0.025	450[c]	0.495	0.385	0.0971[d]	0.251
<u>Signal/Background:</u>						
<u>E_o (eV)</u>	<u>V Sample Thickness (cm)</u>	<u>Scattering Angle (degrees)</u>			<u>Signal/Background</u>	
0.167	0.19	60			3.6 (8.0)[e]	
0.233	0.19	60			5.4 (9.5)[e]	
0.410	0.19	60			3.5 (6.6)[e]	

TABLE XVIII (Cont.)

LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

Scattering Angles:

<u>Range (degrees)</u>	<u>Number of Detector Banks</u>	<u>Flight Path (m)</u>	<u>Solid Angle per Detector Bank (steradian)</u>	<u>Kind of Detector</u>
30 $\pm$ 1.75 ^[f]	1	2.0 ^[g]	0.0032 to 0.016	He ³ 1 in. ID, 20 in. long, 10 Atm
60 $\pm$ 3.5 ^[f]	1	2.0 ^[g]	0.0032 to 0.032	BF ₃ 1 in. ID, 20 in. long, 167 cm
90 $\pm$ 3.5 ^[f]	1	2.0 ^[g]	0.0064 to 0.032	BF ₃ 2 in. ID, 20 in. long, 90 cm
120 $\pm$ 3.5 ^[f]	1	2.0 ^[g]	0.0064 to 0.032	BF ₃ 2 in. ID, 20 in. long, 90 cm
150 $\pm$ 3.5 ^[f]	1	2.0 ^[g]	0.0064 to 0.032	BF ₃ 2 in. ID, 20 in. long, 90 cm

[a] 120 in. radius of curvature.

[b] Output for LINAC with 400 mA and 28 MeV electrons, Tungsten target, and a 1.5-in. H₂O moderator; uranium target gives an increase by a factor of 2; improvements in GA LINAC expected by January 1966 will increase neutron output by another factor of 2.

[c] Computed from Equation (2), with $x = 4.8$ computed from Equation (1).

[d] Computed from Equation (3).

[e] Parentheses indicate signal at peak to background.

[f] The angular range can be reduced if circumstances require this improved angular resolution.

[g] This flight path can be increased to ≈ 3.0 m, if necessary.

TABLE XIX

LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

Instrument: General Atomic Neutron Velocity Selector (14,400 rpm) (expected)
Location: General Atomic Electron LINAC
Reference: W. L. Whittemore (private communication).
Beam Size: 7.0 cm x 25.4 cm
Flight Path: 2.0 meters
Source Flux: Not Determined Directly

Intensity Determination: Measured.

Intensity:

E_o (eV)	I (n/min)	I (n/cm ² -min)
0.167[a]	6.7×10^5 [b]	3.8×10^3 [b]
0.233[a]	5.5×10^5 [b]	3.1×10^3 [b]
0.41[a]	5.5×10^5 [b]	3.1×10^3 [b]

Resolution (elastic):

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	$\Delta \tau$ (μsec)	$\Delta \tau/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.167[a]	0.00456	0.0273	14	0.0395	19	0.0539
0.233[a]	0.00749	0.0321	14	0.0467	19	0.0631
0.410[a]	0.01741	0.0426	14	0.0630	19	0.0840

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.167	0.025	93[c]	0.101	0.142	0.0187[d]	0.132
0.233	0.025	146[c]	0.161	0.208	0.0306[d]	0.148
0.410	0.025	328[c]	0.360	0.385	0.0700[d]	0.182

[a] 120 in. radius of curvature.

[b] Output for LINAC with 400 mA and 28 MeV electrons, Tungsten target, and a 1.5-in. H₂O moderator; uranium target gives an increase by a factor of 2; improvements in GA LINAC expected by January 1966 will increase neutron output by another factor of 2.

[c] Computed from Equation (2), with $x = 4.5$ computed from Equation (1).

[d] Computed from Equation (3).

TABLE XX

LINAC NEUTRON VELOCITY SELECTOR -- RENSSELAER POLYTECHNIC INSTITUTE

<u>Instrument:</u>	Phased Linac-Chopper Velocity Selector (old 14,400 rpm chopper)
<u>Location:</u>	Linear Accelerator Laboratory, Rensselaer Polytechnic Institute, Troy, New York
<u>Reference:</u>	Seemann, Moore, and Kirouac (private communication).
<u>Beam Size:</u>	2.54 cm x 3.80 cm
<u>Flight Path:</u>	1.87 m
<u>Source Flux:</u>	1.1×10^{11} neutrons/sec eV into 4π steradians at 25 KW average electron beam power

Intensity Determination: Measured

Intensity:

E_o (eV)	I (n/min)	I (n/cm ² -min)
0.20	0.7×10^5	5.4×10^3
0.50	1.2×10^5	9.3×10^3
1.00	2.5×10^5	1.9×10^4

Resolution (elastic):

E_o (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_o (eV)	$\Delta E_o/E_o$	Δt (μsec)	$\Delta t/t_o$	Δt_o (μsec)	$\Delta t_o/t_o$
0.20	0.011	0.055	15.5	0.051	28	0.093
0.50	0.040	0.080	15.5	0.082	28	0.15
1.00	0.115	0.115	15.5	0.11	27	0.20

Resolution (inelastic):

E_o (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.20	0.025	200[a]	0.23	0.175	0.038[b]	0.22
0.50	0.025	700[a]	0.82	0.475	0.14[b]	0.30
1.00	0.025	1985[a]	2.32	0.975	0.42[b]	0.43

[a] Computed from Equation (2), with $x = 4.0$, 4.5, and 4.1 computed from Equation (1).

[b] Computed from Equation (3).

TABLE XXI

PHASED CHOPPER VELOCITY SELECTOR -- RENSSELAER POLYTECHNIC INSTITUTE

<u>Instrument:</u>	Phased Linac-Chopper Velocity Selector ^[a] (new 30,000 rpm chopper)
<u>Location:</u>	Linear Accelerator Laboratory, Rensselaer Polytechnic Institute, Troy, New York
<u>Reference:</u>	Seeman, Moore, and Kirouac (private communication).
<u>Beam Size:</u>	5.08 cm x 10.16 cm
<u>Flight Path:</u>	2.37 m
<u>Source Flux:</u>	1.1×10^{11} neutrons/sec eV at 0.5 eV into 4π steradians at 25 kW average electron beam power

Intensity Determination: Calculated from source flux

Intensity:

E_0 (eV)	I (n/min)	I (n/cm ² -min)
0.20[b]	4.3×10^5	8.3×10^3
0.50[c]	3.6×10^5	7.0×10^3
1.00[d]	2.9×10^6	5.7×10^4

Resolution (elastic):

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μ sec)	$\Delta \tau/t_0$	Δt_0 (sec)	$\Delta t_0/t_0$
0.20[b]	0.006	0.030	15.7	0.041	23	0.060
0.50[c]	0.015	0.030	11.8	0.048	14	0.058
1.00[d]	0.042	0.042	7.8	0.043	12	0.067

Resolution (inelastic):

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μ sec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.20[b]	0.025	140[e]	0.13	0.175	0.024[f]	0.14
0.50[c]	0.025	330[e]	0.31	0.475	0.069[f]	0.13
1.00[d]	0.025	920[e]	0.85	0.975	0.14[f]	0.14

[a] Operation scheduled for August 1965.

[b] 85 in. radius of curvature for chopper slits, chopper at 15,000 rpm.

[c] 85 in. radius of curvature for chopper slits, chopper at 20,000 rpm.

[d] 85 in. radius of curvature for chopper slits, chopper at 30,000 rpm.

[e] Computed from Equation (2), with $x = 6.0, 5.0$, and 4.6 computed from Equation (1).

[f] Computed from Equation (3).

TABLE XXII
COLD NEUTRON CHOPPER -- BUCHAREST

<u>Instrument:</u>	Cold Neutron Chopper
<u>Location:</u>	VVR-S Reactor, Bucharest
<u>Reference:</u>	Teutsch, Mateescu, Nahorniak, Diaconescu and Timis, Revue Roumaine de Physique 9, p 737 (1964)[a].
<u>Beam Size:</u>	4 cm x 4 cm
<u>Flight Path:</u>	2.4 m
<u>Source Flux:</u>	2×10^{12} thermal neutrons/cm ² -sec
<u>Intensity Determination:</u>	Calculated

Intensity:

E_0 (eV)	I (n/min)	I (n/cm ² -min)
0.005	4.5×10^5 [b]	3.0×10^4 [b]

Resolution (elastic):

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)	$\Delta t_0/t_0$
0.005	0.0014	0.28	90[c]	0.033[c]	445	0.17
					90[d]	0.033[d]

Resolution (inelastic):

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	118	0.11	0.020	0.0055	0.28

Signal/Background:

E_0 (eV)	V Sample Thickness (cm)	Scattering Angle (degrees)	Signal/Background
0.005	0.35	90	30

Scattering Angles:

Range (degree)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
15 to 90	1	2.4	0.024	10 B-10F ₃ 300 mm Hg 4 cm diameter 35 cm long

[a] A new Be filter, 34 cm long, is used and the chopper was placed in front of the sample.

[b] To be increased by cooling the filter.

[c] Total error including sweep-time, channel width, etc.

[d] Error for the Be cutoff ($\Delta E_0 = 0$), characteristic for elastic and quasi-elastic measurements with the filter-method.

TABLE XXIII
NEUTRON CHOPPER -- MOL

<u>Instrument:</u>	Cold and Thermal Neutron Chopper
<u>Location:</u>	BR2, Mol (Belgium), Beam Tube R2
<u>Reference:</u>	W. Van Dingenen (private communication). Paper in preparation (Nuclear Instruments and Methods).
<u>Beam Size:</u>	6 cm x 6 cm
<u>Flight Path:</u>	4.5 meters
<u>Source Flux:</u>	9×10^{13} thermal neutrons/cm ² -sec
<u>Intensity Determination:</u>	Measured
<u>Intensity:</u>	

	E_0 (eV)	I (n/min)	I (n/cm ² -min)
Be-filtered cold neutron beam:	0.005 to 0.004	1.5×10^8	5.5×10^6
Monochromatic cold neutron beam:	0.005	1.3×10^7 (with chopper)	4.6×10^5 (with chopper)
Monochromatic thermal beams are provided:	No data yet		

Resolution (elastic) (at 5000 rpm):

E_0 (eV)	Energy Distribution of Burst		Time Distribution of Burst		Burst Width at Detector	
	ΔE_0 (eV)	$\Delta E_0/E_0$	$\Delta \tau$ (μsec)	$\Delta \tau/t_0$	Δt_0 (μsec)	$\Delta t_0/t_0$
0.005	0.00015	0.025	100		93	0.02

Resolution (inelastic) (at 5000 rpm):

E_0 (eV)	E_f (eV)	Burst Width at Detector		ϵ (eV)	Uncertainty in Energy Change	
		Δt_f (μsec)	$\Delta t_f/t_f$		$\Delta \epsilon$ (eV)	$\Delta \epsilon/\epsilon$
0.005	0.025	71 [a]	0.03	0.020	0.0015	0.075

Signal/Background:

E_0 (eV)	V Sample Thickness (cm)	Scattering Angles (degrees)	Signal/Background
0.005	0.3	90	66

Scattering Angles:

Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
0 to 120	1 [b]	4.5	0.00033	2 layers of 2 in. enriched BF ₃ detectors (20th Century), 18 in. long, 70 cm pressure

[a] Computed from Equation (2) with $x = 0.28$ calculated from Equation (1).

[b] Eight banks are under project.

Fig. 1 The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_0/t_0$, versus the beam intensity, $I(n/min)$ for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point.

Fig. 2 The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity, $I(n/min)$, for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

Fig. 3 The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, $I(n/min)$, for incident energies less than 10 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

Fig. 4 The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_0/t_0$, versus the beam intensity, $I(n/min)$, for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point.

Fig. 5 The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity, I (n/min), for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the final mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

Fig. 6 The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, I (n/min), for incident energies between 10 and 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

Fig. 7 The full width at half maximum of a burst of elastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_0/t_0$, versus the beam intensity, I (n/min), for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point.

Fig. 8 The full width at half maximum of a burst of inelastically scattered neutrons as measured at the detector divided by their mean time of flight from the sample to the detector, $\Delta t_f/t_f$, versus the beam intensity, I (n/min), for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

Fig. 9 The uncertainty in measuring the energy change divided by the energy change, $\Delta\epsilon/\epsilon$, versus the beam intensity, I (n/min), for incident energies greater than 100 meV. The number next to each symbol denotes the incident energy in meV associated with that point. For this compilation, the mean energy of the inelastically scattered neutrons was chosen to be 25 meV.

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