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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



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

BY

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PHILLIPS PETROLEUM COMPANY



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#### 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 defininitions 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<sup>[a]</sup> 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)

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

(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

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

and

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

- (d<sub>1</sub>) For any triangular distribution (0.8) (full width at half maximum)  $\approx 2$  (standard deviation)
- (d<sub>2</sub>) For the energy distribution in particular, full width at half maximum for time of flight/time of flight = (1/2) ( $\Delta E/E$ )

(d<sub>3</sub>) Time of flight (
$$\mu$$
sec/m) =  $\sqrt{\frac{72.3}{E_{o}(eV)}}$ 

In combining d1, d2, and d3 one gets

$$2\sigma_{\tau R} = (0.8) (1/2) \left(\frac{\Delta E}{E}\right) \frac{72.3}{\sqrt{E_o}}$$

and finally

(d4) 
$$2\sigma_{\tau R} = (0.8) \left(\frac{\Delta E}{E}\right) \sqrt{\frac{1310}{E}}$$

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

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

which approximates

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$$\Delta t_o^2 \approx \frac{1}{2} \Delta^2 + (x + d)^2 \left(\frac{\Delta E_o}{E_o}\right)^2 \left(\frac{1.3 \times 10^3}{E_o}\right)$$

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  $\Delta e/\epsilon$  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 resultion; they show but do not compensate for different incident energies.

### II. EQUATIONS

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

(2) 
$$\Delta t_{f}^{2} = \frac{1}{2} \Delta \tau^{2} + \left[ x + \left( \frac{E_{o}}{E_{f}} \right)^{3/2} d \right]^{2} \left( \frac{\Delta E_{o}}{E_{o}} \right)^{2} \left( \frac{1 \cdot 31 \times 10^{3}}{E_{o}} \right)$$

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

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### III. DEFINITIONS

Flight Path:	The distance d in meters from the sample to the detectors.
Source Flux:	The thermal neutron $flux/cm^2$ sec at the bottom of the beam hole.
<u>I(n/cm<sup>2</sup>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.
Resolution:	The energy, time resolution, and combined energy-time resolution for scattering neutrons.
E <sub>o</sub> :	The mean energy in eV of the incident monoenergetic beam.
△E <sub>o</sub> :	The full width at half maximum of the energy spread in eV in the monoenergetic beam.
<u>Δτ:</u>	The full width at half maximum in $\mu$ 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.)
t <sub>o</sub> :	The time of flight in $\mu$ sec of the elastically scattered neutrons to travel from the sample to the detector.
	The full width at half maximum in $\mu$ sec of the burst of elastically scattered neutrons as measured in time at the detectors.
E <sub>f</sub> :	The mean energy in eV of the neutrons inelastically scattered with a discrete energy change.
	The time of flight in $\mu$ sec of the inelastically scattered neutrons to travel from the sample to the detectors.
$\Delta t_{\underline{f}}$ :	The full width at half maximum in $\mu$ 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 con- sisting of two identical choppers rotating at the same speed, the effective chopping point is midway between choppers.)
<u>e:</u>	The discrete energy change in eV of the neutrons involved in an inelastic scattering process when the final mean energy of the neutrons in 0.025 eV.
<u>∆</u> €:	The uncertainty in measuring $\epsilon$ 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.

<u>Scattering Angle:</u> 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.

<u>Kind of Detector:</u> The kind of detector normally used in the detector banks (ie, 1 in. x 18 in. 167-cm BF3 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", <u>Nuclear Instruments and Methods</u>, <u>30</u> (1964) pp 184-202.

# TABLE I

### COLD NEUTRON CHOPPER -- HARWELL

Instrument:	Cold Neutron Choppe	er							
Location:	DIDO Reactor, Atom	ic Energy I	Research Estab	ishment, Ha	rwell				
Reference:	eference: 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).								
Beam Size:	<u>eam_Size</u> : 5.08 cm x 2.54 cm								
Flight Path: 1.3 m									
Source Flux:	5 x 10 <sup>13</sup> thermal ne	utrons/cm <sup>2</sup>	-sec (liquid H.	, source ind	reases this	by X4 at 0.0	05 eV)		
Intensity Determination:	Measured		·				-		
Intensity:									
E	o(eV)		I(n,	'min)		<u>I(n/c</u>	m <sup>2</sup> -min)		
0.005 eV (	37,500 rpm[a])		$2.0 \times 10^{6[b]}$			$1.6 \times 10^{5[b]}$			
0.005 eV (	28,300 rpm[a])		$2.4 \times 10^{6LbJ}$			1.9 x 10 <sup>5[b]</sup>			
0.005 eV (	18,700 rpm <sup>Laj</sup> )		$4.4 \times 10^{6LbJ}$			3.4 x 10 <sup>5[b]</sup>			
Resolution (ela	<u>stic)</u> :								
		Ener Distril of Bu	rgy pution urst	Time Distribu of Bur	e ition st	Burst W at Dete	idth ctor		
E	o(eV)	∆E <sub>o</sub> (eV)	ΔE <sub>O</sub> /E <sub>O</sub>		$\Delta \tau / t_{o}$	At (usec)	At /t		
0.005 eV (	28 300 rpm[a])	0.0005	0.10	16	0.012	100	0 074		
0.005 21 (	20,000 1 pm2=17	0.0005	0.10	10	0.012	100	0.0/4		
Resolution (ine	<u>lastic)</u> :								
			Burst N at Dete	lidth ctor		Uncerta Energy	inty in Change		
E	o(eV)	E <sub>f</sub> (eV)	Δt <sub>f</sub> (µsec)	t <sub>f</sub> /t <sub>f</sub>	€(eV)	∆ε(eV)	Δε/ε		
0.005 eV (	28,300 rpm <sup>[a]</sup> )	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

Instrument:	Cold Neutron Chopper							
Location:	HERALD Reactor, A	IERALD Reactor, A.W.R.E., Aldermaston						
Reference:	Ph.D. Thesis, F.	P. Szabo, 1965.						
<u>Beam_Size</u> :	4.5 cm x 2.5 cm	at the rotor axis	s (also, at s	sample position)				
Flight Path:	1.6 meters							
Source Flux:	2 x 10 <sup>12</sup> thermal tube. The quote water.	neutrons/cm <sup>2</sup> -se d flux is that me	c. The exp asured at t	periment makes us he source positio	e of a 15 cm tan n, with the tube	gential bear filled with		
Intensity Determination:								
Intensity:								
E_(eV)		I(n/m	in)		I(n/cm	2 <sub>-min</sub> )		
0.005		2.2 x	105		1.94	× 10 <sup>4</sup>		
<u>NOTE</u> : toward th	These intensities e end of 1965.	will be consider	ably increa	sed when a cold s	ource is install	ed		
Resolution (ela	<u>stic):</u>							
	Energy Distribut of Burs	ion t	Tim Distrib of Bu	e ution rst	Burst Wi at Detec	dth tor		
E <sub>o</sub> (eV)	ΔE <sub>o</sub> (eV) Δ		(usec)	Δτ/t <sub>o</sub>	Δt <sub>o</sub> (usec)	∆t <sub>o</sub> /t <sub>o</sub>		
0.005	0.00125	0.25	11.5	0.0072	242	0.15		
Resolution (ine	lastic):							
		Burst W at Dete	idth ctor		Uncerta Energy	intyin Change		
E <sub>c</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	c(eV)	∆ε(eV)	Δε/ε		
0.005	0.025	57[a]	0.078	0.02	0.0042	0.21		
Signal/Backgrou	<u>nd</u> :					s.		
F (eV)	V Sa Thịc	imple :kness	Scatt Ang	ering le				
<u>-0(017</u>		<u>m)</u>	(degr	rees)	Signal/Bac	kground		
0.005	0.	.28	5	0	40			
Scattering Angl	es:		Sol-	id Angle per				
Range <u>(degrees)</u>	Number of Detector Ban	Flight_Pat ks(m)_	:h Det (!	tector Bank steradian)	Kind of Deter	tor		
20 to 90	8	1.6		0.0078	Proportional Co Enriched BF3	ounter		
					5 cm diameter 40 cm active 10 70 cm pressure	ength		

[a] Computed from Equation (2) with x = D.3 calculated from Equation (1).

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### TABLE III

### COLD NEUTRON CHOPPER -- BROOKHAVEN NATIONAL LABORATORY

Instrument:	Cold Neutron Chop	per					
Location:	HFBR, Brookhaven	National Labora	tory				
<u>Reference</u> :	K. Otnes and H. P Scattering of	alevsky, Procee Neutrons in Sc	dings of th lids and Li	e Chalk Rive quids", Vol	r Conferen . 1, p 95,	ice on "Inelast I.A.E.A., Vie	ic nna (1963).
<u>Beam Size</u> :	1.25 cm x 5 cm						
Flight Path:	1.6 m						
Source Flux:	5 x 10 <sup>14</sup> thermal	neutrons/cm <sup>2</sup> -se	ec				
Intensity Determination:	Calculated						
Intensity:							
	E <sub>o</sub> (eV)		I	n/min)		I(n/c	m <sup>2</sup> -min)
0.005 (one	rotor system)		4.	8 x 10 <sup>8</sup>		7.7	x 10 <sup>7</sup>
0.005 (two	rotor system)		2.	4 x 10 <sup>8</sup>		3.8	x 10 <sup>7</sup>
0.005 (thr	ee rotor system)		3.	0 x 10 <sup>7</sup>		4.8	x 10 <sup>6</sup>
<u>Resolution (ela</u>	<u>stic)</u> :						
		Ener Distrib of Bu	gy oution irst	Tim Distribu of_Bu	≘ ution rst	6urst W at Dete	'idth ctor
- <u></u>	E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	∆E <sub>o</sub> ∕E <sub>o</sub>	AT (USEC)	∆t/t <sub>o</sub>	∆t <sub>o</sub> ( sec)	Δt <sub>o</sub> /t <sub>o</sub>
0.005 (one	rotor system)	0.00065	0.125	25.0	0.016	128 <sup>[a]</sup>	0.08
0.005 (two	rotor system)	0.00033	0.0625	12.5	0.008	64 <sup>[a]</sup>	0.04
0.005 (thr	ee rotor system)	0.00016	0.0315	12.5	800.0	40 <sup>[a]</sup>	0.025
Resolution (ine	lastic):						
			Burst at_Det	Width ector		Uncertain Energy_C	ty in hange
*	E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	<sup>∆t</sup> f <sup>/t</sup> f	<u>ε(eV)</u>	Δε(eV)	Δε/ε
0.005 (one	rotor system)	0.025	39[p]	0.053	0.02	0.0028[c]	0.14
0.005 (two	rotor system)	0.025	19[b]	0.027	0.02	0.0014 <sup>[c]</sup>	0.072
0.005 (thr	ee rotor system)	0.025	18 <sup>[b]</sup>	0,024	0.02	0.0012[c]	0.061

[a] Assuming x = 0.4, 0.4, 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

Instrument:	New Cold Neutron Chop	per (compl	etion Nove	mber 1, 1965)			
Location:	CP-5 Reactor, Argonne National Laboratory						
Reference:	D. Connor (private co	mmunication	).				
Beam Size:	3 cm x 1 cm						
Flight Path:	4.0 meters						
Source Flux:	Approximately 5 x	10 <sup>12</sup> therm	nal neut	rons/cm <sup>2</sup> -sec (co	ld source,	T <sub>n</sub> ≈ 50°K)	
Intensity Determination:	Estimated (duty cycle	included)					
Intensity:							
E <sub>o</sub> (eV)		I(n/m	in)		I(n/c	m <sup>2</sup> -min)	
0.00495		1.5 x	106		5.0	x 10 <sup>5</sup>	
Resolution (ela	<u>stic):</u>						
	Energy Distribution of Burst		Ti Distri of B	me bution urst	Burst Wi at Detec	dth tor	
E_(eV)	$\Delta E_{o}(eV) \Delta E_{o}/$	E_	A=(usec)	Δτ/t	Δt <sub>o</sub> (µsec)	Δt <sub>2</sub> /t <sub>2</sub>	
0.00495	0.0005 0.1	<u>.</u>	5	0.00125	212 <sup>[a]</sup>	0.053	
Resolution (ine	lastic):						
		Burst W at Deter	idth ctor		Uncertai Energy C	nty in hange	
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	ε(eV)	∆∈(eV)	Δε/ε	
0.00495	0.025	18.5[b]	0.01	0.020	0.0005[c]	0.025	
Signal/Backgrou	nd:						
	V Sample		Scatte	ring			
E <sub>o</sub> (eV)	Thickness (cm)		Angl (deare	e es)	Signal/Bac	karound	
			<u>1.acgr.c.</u>	<u> </u>	<u></u>	Agr ound	
Scattering Angl	<u>es</u> :						
Range (degrees)	Number of Detector Banks	Flight (m	Path )	Detector Bank (steradian)	Kind of [	etector	
15 to 120	81	4		0.0087	BF <sub>3</sub> (16	0 cm	
[a] Calculated	from Equation (1).				p. 635	/	
[b] Calculated	from Equation (2).				-		
[c] Calculated	from Equation (3).						

### TABLE V

COLD NEUTRON CHOPPER -- PICATINNY ARSENAL

Instrument:	Cold Neutron Chopper							
Location:	AMRA Reactor, Watertown, Massachusetts							
Reference:	Boutin, Pra	sk, and Tr	evino (priva	te communi	cation).			
Beam Size:	7.5 cm x 7.	5 <b>cm</b>						
Flight Path:	5.03 meters		_					
Source Flux:	-10 <sup>12</sup> therma	l neutrons,	/c# <sup>2</sup> -sec					
Intensity Determination:	Measured					-		
Intensity:								
E <sub>o</sub> (eV)		1	(n/min)		<u>I(r</u>	<u>/cm<sup>2</sup>-min)</u>		
0.005		1.5	x 10 <sup>9[a]</sup>		2.4	x 10 <sup>7[a]</sup>		
Resolution (ela	<u>stic)</u> :							
	Energ Distribu of_Bur	y tion st	Time Distribu of Bur	tion st				
E <sub>o</sub> (eV)	E <sub>o</sub> (eV)	Eo/Eo	$\Delta t(\mu sec)$	∆t/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>		
0.005	0.0015	0.30			1008 128 <sup>[b]</sup>	0.195 0.025 <sup>[b]</sup>		
Resolution (inelastic):								
Scattering Angles:								

Range <u>(degrees)</u> Fixed 90	Number of <u>Detector Banks</u> 3	Flight Path (m) 5.03	Solid Angle per Detector Bank (steradian) 0.0002	Kind of Detector BF3 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.

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# T'ABLE VI

### COLD NEUTRON CHOPPER -- STUDSVIK

Instrument:	Cold Neutron Chopper			
Location:	R2 Reactor Studsvik			
Reference:	Dahlborg, Larsson, and Sk of Neutrons in Solids a	öld, Proceedings of nd Liquids", I.A.E.	f the Bombay Conferen .A.(1964).	ce on "Inelastic Scattering
Beam Size:	5 cm x 8 cm			
<u>Flight Path</u> :	4.5 meters			
Source Flux:	6 x 10 <sup>13</sup> thermal neutrons	/cm <sup>2</sup> -sec		
Intensity Determination:	Measured			
Intensity:				
E <sub>o</sub> (eV)		I(n/min)		I(n/cm <sup>2</sup> -min)
0.005		4.8 x 10 <sup>6</sup> (With Chopper)		$1.3 \times 10^5$ (With Chopper)
Resolution (ela	stic):			
	Energy Distribution of Burst	Dist. of	Time ribution Burst	Burst Width at Detector
E <sub>o</sub> (eV)	ΔE <sub>o</sub> (eV) ΔE <sub>o</sub> /E <sub>o</sub>	Δτ(µse	c) $\Delta \tau / t_0$	$\Delta t_0(\mu sec) \Delta t_0/t_0$
0.005	0.0007 0.15			53 <sup>[a]</sup> 0.012 <sup>[a]</sup>
Resolution (ine	lastic):			
		Burst Width at Detector		Uncertainty in Energy Change
E_(eV)	E <sub>r</sub> (eV)	$\Delta t_e(usec) \Delta t_e/t_e$	- ( - )( )	
0.005	0.025	45 0.0225	<u>e(ev)</u>	$\frac{\Delta \varepsilon(ev)}{\Delta c e e} = \frac{\Delta \varepsilon}{2}$
Signal/Backgrou	<u>nd</u> :		0.020	0.0003 0.045
	V Sample	Sca	ttering	
E <sub>o</sub> (eV)	Thickness (cm)	Al (de	ngle arees)	Signal/Background
0.005	1	<u></u>	90	30
Scattening Angl	<b>AC 1</b>			
Statter nig Angi	<u>c.</u> .		Solid Angle per	
Range (degrees)	Number of Detector Banks	Flight Path (m)	Detector Bank (steradians)	Kind of Detector
0  to  130	2	4.5	$8.0 \times 10^{-3}$	3 cm x 30 cm
	-			150 cm BF <sub>2</sub>
<u> </u>				

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

# TABLE VII

COLD NE 😚 - CHOPPER -- STOCKHOLM

Instrument:	Cold Neutron Chopper No.	I			
Location:	R1 Reactor, Stockholm				
<u>Reference</u> :	Dahlborg, Larsson, and S of Neutrons in Solids	köld, Proce and Liquids	edings of ", I.A.E./	the Bombay Conferen A. (1964).	ce on "InelasticScattering
Beam Size:	5 cm x 10 cm				
Flight Path:	3.0 meters				
Source Flux:	6 x 10 <sup>11</sup> thermal neutron	is/cm <sup>2</sup> -sec			
Intensity <u>Determination</u> :	Measured				
Intensity:					
E <sub>o</sub> (eV)		I(n/m	in)		$I(n/cm^2-min)$
0.005		6.0 x 1	09[a]		$1.1 \times 108^{[a]}$
			-		
Resolution (ela	<u>istic)</u> :				
	Energy		T <sup>.</sup>	ime	During the states
	of Bursi		of l	Burst	at Detector
E_(eV)	$\Delta E$ (eV) $\Delta E_{-}/E_{-}$	-		Δτ/t.	At (usec) At /t
0.005		<u>)</u>	AT (USEC	<u> </u>	
0.005	0.0025 0.5				00243 0.024 4
Resolution (ine	elastic):				
		Burst W <u>at Dete</u>	idth <u>ctor</u>		Uncertaintyin <u>Energy Change</u>
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	c(eV)	δε(eV) δε/ε
0.005	0.025	80	0.057	0.021	0.0027 0.13
Signal/Backgrou	ind:				
	V Sample		Scatt	ering	
E <sub>o</sub> (eV)	(cm)		Ang (dear)	le ees)	Signal/Background
0.005	0.7		3	0	20
Scattering Angl	les:				
Range	Number of	Flight	Path	Solid Angle per Detector Bank	
(degrees)	Detector Banks	<u>(m)</u>		(steradians)	Kind of Detector
0 to 90	1	3		6.0 x 10 <sup>-3</sup>	BF3
					1140 mm Hg
					15 mm diameter (3 layers)
[a] Chopper aft	ter sample so those number	rs do not in	clude dut	v cvcle or transmiss	ion of chopper. Duty

[a] Chopper after sample so those numbers do not include duty cycle or transmission of chopper. Duty cycle  $\,\approx$  3.0 x 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			
<u>Reference</u> :	Dahlborg, Larsson, and Ski of Neutrons in Solids an	öld, Proceedings of t nd Liquids", I.A.E.A.	he Bombay Conferenc (1964).	e on "Inelastic Scattering
Beam Size:	5 cm x 10 cm			
Flight Path:	3.5 meters	•		
Source Flux:	3 x 10 <sup>11</sup> thermal neutrons,	/cm <sup>2</sup> -sec		
Intensity Determination:	Measured			
Intensity:				
E <sub>o</sub> (eV)		l(n/min)		I(n/cm <sup>2</sup> -min)
0.005		4.0 x 10 <sup>6</sup>		$8.0 \times 10^4$
Resolution (ela	astic):			
	Energy Distribution of Burst	Tim Distrib of Bu	e oution Irst	Burst Width at Detector
E_(eV)	$\Delta E_{eV}$ $\Delta E_{eV}$		Δτ/t	$\Delta t_{a}(\mu sec) \Delta t_{a}/t_{a}$
0.005		<u>AT(1)Sec)</u>	0.028	$\frac{0}{490[a]}$ $\frac{0}{0}$ $\frac{1}{14[a]}$
0.005	0.0015 0.5	50	0.020	.50 0.14
Resolution (ine	<u>elastic)</u> :			
		Burst Width at Detector		Uncertainty in Energy Change
E (eV)	E <sub>c</sub> (eV)	$\Delta t_c(\mu sec) \Delta t_c/t_c$	( - )( )	
0.005		<u><u><u></u></u><u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u><u></u></u></u>	<u>e(ev)</u>	$\Delta \epsilon (ev) = \Delta \epsilon / \epsilon$
0.005	0.025			
Signal/Backgrou	und:			
	V Sample Thickness	Scatt	tering le	
$E_{o}(eV)$	<u>(cm)</u>	(degr	rees)	Signal/Background
0.005	0.5	6	50	7
Scattering Ang	les:			
Range	Number of	Flight Path	Solid Angle per Detector Bank	Kind of Detector
(degrees)	Detector Banks	<u>    (m)                                </u>	(steradians)	Kind of Detector
	4	3.3	0.U X IU	0r3 1500 mm Ha
				30 mm diameter

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

# TABLE IX

### COLD NEUTRON CHOPPER -- ISPRA

· · · · · · · · · · · · · · · · · · ·									
Instrument:	Cold Neutron Ch	opper							
Location:	Ispra-I Reactor	spra-I Reactor, EURATOM C.C.R. Ispra, Italy							
Reference:	Haas, Kley, Kre	aas, Kley, Krebs, and Rubin (private communication).							
Beam Size:	5 cm x 10 cm	cm x 10 cm							
<u>Flight Path</u> :	2.9 m/4.5 m								
Source Flux:	0.8 x 10 <sup>13</sup> ther	mal neutrons	/cm <sup>2</sup> -sec						
Intensity Determination:	Measured								
Intensity:									
E <sub>o</sub> (eV)		T	(n/min)		I(n/c	$m^2$ -min)			
0.005			$5 \times 10^7$		7	x 10 <sup>5</sup>			
(11,000 rp	m[a])				•	~ 10			
Resolution (ela	<u>stic)</u> :								
	E Dist	nergy	Tim Distrib	le	Burst Wi	dth			
		Burst	of Bu	<u>rst</u>	at Detec	tor			
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV	) $\Delta E_0/E_0$	Δτ(µsec)	Δτ/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>			
0.005 (11,000 rp	m[a]) 0.0015	4 0.31	60	0.02	624	0.21			
Resolution (ine	<pre>lastic)[b];</pre>								
		Burst Wi at Detec	dth tor		Uncertain Energy C	ty in hange			
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	ε(eV)	Ac(eV)	Δε/ε			
0.005	0.025	230[c]	0.17	0.020	0.0088 <sup>[d]</sup>	0.44			
Signal/Backgrou	nd (2.9 m flighd	path no	data for the	4.5 m fligh	<u>it path)</u> :				
E <sub>o</sub> (eV)	V Sample Thicknes (cm)	S	Scattering Angle (degrees)		Signal/Bac	kground			
0.005	0.28		90		11				
Scattering Angl	- 20								
Searcer ing Angr	<u>cs</u> .		Sol	id Angle per	r				
Range (degrees)	Number of Detector Ban	Flight uks (m	Path De	etector Bank Steradian)	Kind of D	etector			
90	]	2.	د 9	0.0143	BF-				
30 to 90	2	4.	5	0,00593	BF2				
					v				

### TABLE IX (Cont.)



### COLD NEUTRON CHOPPER -- ISPRA

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

the second se	and the second se							
Instrument:	Two Rotor Ve	locity Sel	lector					
Location:	Ispra-I Reac	tor, EURAT	OM C.C.R. Isp	ora, Italy				
Reference:	K. H. Krebs	(private d	communication)					
Beam Size:	1.2 cm x 2 c	m						
Flight Path:	1.5 m							
Source Flux:	$2 \times 10^{13}$ the	rmal neut:	rons/cm <sup>2</sup> -sec					
Intensity Determination:	Calculated							
Intensity:								
E <sub>c</sub> (eV)			τ/,	(min)			T/n/a	2
0.005			111	<u>105</u>			<u>1(n/c</u>	<u></u>
(13,300 rpi	n)		5.0	5 X 10°			1.5	X 105
0.0136 (22,000 rpm	n)		1.8	3 x 10 <sup>6</sup>			7.5	x 10 <sup>5</sup>
Resolution (ela	stic)[a]:							
		Ener Distrit of Bu	rgy pution Irst	Di	Time stribu of Bur	tion	Burst Wi at Detec	idth tor
E <sub>c</sub> (eV)		∆E_(eV)	AE /E		c.o.c.)	Δτ/t	Δt (µsec)	Δt /t
0.005		0.00036	0 071		sec)	0.04	120	0 070
(13,300 rpi	n)	0.00030	0.0/1	5	Ū.	0.04	120	0.076
0.0136 (22,000 rp	n)	0.00097	0.071	3	5	0.04	73	0.079
Resolution (ine	lastic)[a]:							
			Burst W at Detec	idth :tor			Uncerta Energy (	inty in Change
E <sub>c</sub> (eV)	E <sub>f</sub> (eV	)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>		e(eV)	Δε(eV)	AE/E
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
Signal/Backgrou	nd: es:							••••
Range (degrees)	Numb Detect	er of or Banks	Flight ( (m)	Path	Solid Dete (ste	l Angle per ctor Bank radian)	_Kind of D	etector
0 to 90		4	l to a	2 .	0.00	3 to 0.06	BF3 Cour	ters
							70 cm press 5 cm OD x effective	sure 40 cm e length

Li<sup>6</sup>I Crystals 7.5 cm diameter

### TABLE X (Cont.)

### PHASED CHOPPER VELOCITY SELECTOR -- ISPRA

<u>Comments</u>: The data given for  $\Delta E_0$ ,  $\Delta \tau$ , and  $\Delta t_0$  refer to the following systems:



The following equations were used:

.

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

$$\frac{\Delta E_{o}}{E_{o}} = 2\sqrt{2} \frac{\Delta \tau v_{o}}{D}$$

[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

Instrument:	Rotating Crystal Spec	trometer			·		
Location:	Ispra-I Reactor, EURATOM C.C.R. Ispra, Italy						
Reference:	Meister, Haas, and Kley (private communication).						
Beam Size:	8 cm x 4.5 cm	3 cm x 4.5 cm					
Flight Path:	3.07 m	J.07 m					
Source Flux:	2 x 10 <sup>13</sup> thermal neut	rons/cm <sup>2</sup> -sec					
Intensity <u>Determination</u> :	The intensities are stationary reflected	deduced fr d neutron bea	om the pea m (higher or	k fluxes measured der neutrons subt	by gold activa racted).	ition in the	
Intensity[a]:					•		
E <sub>o</sub> (eV)		1 (n/m	in)		l(n/c		
0.005		2.5 ×	104		7.0	$\times 10^2$	
0.025		2.5 x	10 <sup>5</sup>		7.0	$\times 10^{3}$	
0.060		4.5 x	10 <sup>5</sup>		1.2	x 10 <sup>4</sup>	
0.125		1.5 x	10 <sup>5</sup>		4.0	x 10 <sup>3</sup>	
Resolution (ela	<pre>stic)[a,b];</pre>						
	Energy Distributi of Burst	on	T <sup>+</sup> Distr <sup>+</sup> of E	me bution Jurst	Burst Wi at Detec	idth :tor	
E <sub>o</sub> (eV)	ΔΕ <sub>0</sub> (eV) ΔΕ		Δτ (µsec)	Δτ/t <sub>o</sub>	$\Delta t_0(\mu sec)$	Δt <sub>o</sub> /t <sub>o</sub>	
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 (ine	<u>lastic)</u> :						
		Burst Wi <u>at_Detec</u>	dth tor		Uncertain Energy (	nty in <u>Change</u>	
E_(eV)	E <sub>€</sub> (eV)	∆t <sub>f</sub> (µsec)	$\Delta t_f / t_f$	c(eV)	Ar (eV)	AE/E	
0.005	0.025	29[0]	0.021	0.020	$\frac{0.0011[d]}{0.0011[d]}$	0.055	
0.060	0.025	57[c]	0.041	0.035	0.0050 <sup>[d]</sup>	0.14	
0.125	0.025	100[¢]	0.072	0.100	0.012 <sup>[d]</sup>	0.12	
Signa1/Backgrou	<u>nd</u> :						
Scattering Angl	es:						
		Eliab+	D-+6	Solid Angle per			
(degrees)	Detector Banks	(m)		(steradian)	Kind of D	etector	
0 to 110	1	3.07	1	0.012	BF3		
					700 mm Hg	pressure	
					5 cm dia x 40 cm length	meter 1 active	

# TABLE XI (Cont.)

### ROTATING CRYSTAL SPECTROMETER -- ISPRA

<u>Comments</u>: The data given refer to the following (preliminary) experimental layout:



- [a] For crystal 1-1/2 in. Ø turning with 6000 rpm.
- [b] Scattering angle e = 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

Instrument:	Rotating Crystal S	Spectrometer				
Location:	NRU Reactor, Chall	k River				
<u>Reference</u> :	B. N. Brockhouse Vienna (1961), a	in Inelastic Scat also A. D. B. Woo	tering of Neut ds (private co	trons in Solids au mmunication).	nd Liquids, p	113,I.A.E.A.,
Beam Size:	2.5 cm x 5 cm					
Flight Path:	3.3 m	_				
Source Flux:	2 x 10 <sup>14</sup> thermal a	neutrons/cm <sup>2</sup> -sec				
Intensity Determination:	Measured					
Intensity:						
E <sub>o</sub> (eV)		I(n/	min)		I(n/c	m <sup>2</sup> -min)
0.005		2.5	x 10 <sup>5</sup>		2	x 10 <sup>4</sup>
0.013		7.5	x 10 <sup>5</sup>		6	x 10 <sup>4</sup>
0.032		5	x 10 <sup>5</sup>		4	× 10 <sup>4</sup>
0.044		2.5	x 10 <sup>5</sup>		2	× 10 <sup>4</sup>
Resolution (ela	<u>stic)</u> :					
	En Distr of 1	ergy ibution Burst	Time Distribu of Bur	e ution rst_	Burst W at Dete	idth ctor
E <sub>0</sub> (eV)	∆E <sub>o</sub> (eV)	△E <sub>o</sub> /E <sub>o</sub>	Δτ(µSec)	Δτ/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	Δt <sub>o</sub> /t <sub>o</sub>
0.005		≈ 0.01[a]	28	0.0083	56	0.017
0.005 0.013		≈ 0.01 <sup>[a]</sup> ≈ 0.01 <sup>[a]</sup>	28 20	0.0083 0.010	56 36	0.017 0.017
0.005 0.013 0.032		$\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$	28 20 18	0.0083 0.010 0.013	56 36 24	0.017 0.017 0.018
0.005 0.013 0.032 0.044		$\approx 0.01^{[a]} \\ \approx 0.01^{[a]} \\ \approx 0.01^{[a]} \\ \approx 0.01^{[a]} \\ \approx 0.01^{[a]}$	28 20 18 16	0.0083 0.010 0.013 0.014	56 36 24 22	0.017 0.017 0.018 0.020
0.005 0.013 0.032 0.044 <u>Resolution (ine</u>	lastic):	$\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]}$	28 20 18 16	0.0083 0.010 0.013 0.014	56 36 24 22	0.017 0.017 0.018 0.020
0.005 0.013 0.032 0.044 <u>Resolution (ine</u>	<u>lastic)</u> :	$\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ Burst Wi <u>at Detec</u>	28 20 18 16 dth <u>tor</u>	0.0083 0.010 0.013 0.014	56 36 24 22 Burst W <u>at Dete</u>	0.017 0.017 0.018 0.020 lidth ctor
0.005 0.013 0.032 0.044 <u>Resolution (ine</u> E <sub>0</sub> (eV)	E <sub>f</sub> (eV)	$\approx 0.01[a]$ $\approx 0.01[a]$ $\approx 0.01[a]$ $\approx 0.01[a]$ Burst Wi <u>at Detec</u> $\Delta t_{f}(\mu sec)$	$\frac{28}{20}$ 18 16 16 16 16 16	0.0083 0.010 0.013 0.014 <u>ε(eV)</u>	56 36 24 22 Burst W <u>at Dete</u> _∆∈(eV)	0.017 0.017 0.018 0.020
0.005 0.013 0.032 0.044 <u>Resolution (ine</u> <u>E<sub>0</sub>(eV)</u> 0.005	<u>lastic)</u> : E <sub>f</sub> (eV) 0.025	$\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ Burst With the set of t	$\frac{28}{20}$ 18 16 $\frac{dth}{tor}$ $\frac{\Delta t_f / t_f}{0.028}$	0.0083 0.010 0.013 0.014 <u>ε(eV)</u> 0.020	56 36 24 22 <u>Burst W at Dete</u> <u>Δε(eV)</u> 0.0014[C]	0.017 0.017 0.018 0.020 hidth ctor <u>Ac/c</u> 0.01
0.005 0.013 0.032 0.044 <u>Resolution (ine</u> <u>E<sub>0</sub>(eV)</u> 0.005 0.013	<u>lastic)</u> : E <sub>f</sub> (eV) 0.025 0.025	$\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ Burst With the set of t	$\frac{28}{20}$ 18 16 $\frac{dth}{tor}$ $\frac{\Delta t_f / t_f}{0.028}$ 0.019	0.0083 0.010 0.013 0.014 <u>c(eV)</u> 0.020 0.012	56 36 24 22 Burst W <u>at Dete</u> <u>Δε(eV)</u> 0.0014[c] 0.0010[c]	0.017 0.017 0.018 0.020 Hidth <u>ctor</u> 0.01 0.083
0.005 0.013 0.032 0.044 <u>Resolution (ine</u> <u>E<sub>0</sub>(eV)</u> 0.005 0.013 0.032	<u>lastic)</u> : E <sub>f</sub> (eV) 0.025 0.025 0.025 0.025	$\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\approx 0.01^{[a]}$ $\frac{\text{Burst Wi}}{\text{at Detect}}$ $\frac{\Delta t_{f}(\mu \text{sec})}{43^{[b]}}$ $28^{[b]}$ $22^{[b]}$	28     20     18     16     dth     tor $ $	0.0083 0.010 0.013 0.014 <u>ε(eV)</u> 0.020 0.012 0.007	56 36 24 22 Burst W <u>at Dete</u> $\Delta \varepsilon (eV)$ 0.0014[c] 0.0010[c] 0.0010[c]	0.017 0.017 0.018 0.020 Hidth <u><math>\Delta \varepsilon / c</math></u> 0.01 0.083 0.14
0.005 0.013 0.032 0.044 <u>Resolution (ine</u> <u>E<sub>0</sub>(eV)</u> 0.005 0.013 0.032 0.044	Elastic): E <sub>f</sub> (eV) 0.025 0.025 0.025 0.025 0.025	$\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\approx 0.01^{[a]} \\\frac{Burst Wi}{at Detec} \\\frac{\Delta t_{f}(usec)}{43^{[b]}} \\28^{[b]} \\22^{[b]} \\29^{[b]} \end{bmatrix}$	$     28     20     18     16     dth     tor              \frac{\Delta t_{f}/t_{f}}{0.028}     0.019     0.015     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019     0.019 $	0.0083 0.010 0.013 0.014 <u>ε(eV)</u> 0.020 0.012 0.007 0.019	56 36 24 22 <u>Burst W</u> <u>at Dete</u> <u>Δε(eV)</u> 0.0014[c] 0.0010[c] 0.0010[c] 0.0020[c]	0.017 0.017 0.018 0.020 hidth <u>ctor</u> 0.01 0.083 0.14 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).

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# TABLE XIII

ROTATING	CRYSTAL	SPECTROMETER	 KARI SRIIHE
NO IM ING	UNISTAL	JILGINOPEILK	 NANESNORE

Instrument:	Rota	ting Crystal Spe	ctrometer						
Location:	FR2	Reactor, Kerfors	chungszentrum Ka	ırlsruhe					
<u>Reference</u> :	W. G Oc	W. Glaser, I.A.E.A. Study Group Meeting on Research Reactor Experimental Techniques, October 1964, Bucharest; KFK-Report 263.							
I. <u>Beam Siz</u>	<u>e:</u> 3 cm	3 cm x 7 cm							
<u>Flight</u> F	<u>ath</u> : 2 me	ters							
II. <u>Beam Siz</u>	<u>:e</u> : 4 cm	x 5 cm							
Flight F	ath: 3.5	meters							
Source Flux:	8 x	1012 thermal neu	trons/cm <sup>2</sup> ~sec <sup>[a]</sup>						
Intensity Determinatio	on: Meas	ured							
Intensity:		20	Гы						
	E <sub>c</sub> (eV)	20 (d)	BRAGG	I(n	(min)	ting			
Ι.	0.085	70	24	3.4	<u>v 10<sup>5</sup></u>	1.6	$x 10^4$		
	0.040		36	4.8	x 10 <sup>5</sup>	2.3	x 10 <sup>4</sup>		
	0.020		52	3.4	x 10 <sup>5</sup>	1.6	x 10 <sup>4</sup>		
11.	0.008		86	5.0	x 10 <sup>4</sup>	1.2	x 10 <sup>3</sup>		
Resolution (	elastic):								
		Ene	rgy	Tim	e				
		Distri of B	bution urst	Distrib of Bu	ution <u>rst</u>	Burst W at Detec	idth tor		
	E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	∆E <sub>o</sub> ∕E <sub>o</sub>	Δτ(µsec)	∆⊤/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	<sup>∆t</sup> o <sup>/t</sup> o		
1.[c]	0.085	0.0078	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		
11.[d]	0.008	0.00008	0.01	20	0.007	40	0.015		
Resolution (	<u>inelastic)</u>	:							
			Burst W at Dete	lidth ctor		Uncertai Energy (	inty in Changes		
	E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	ε(eV)	∆c(eV)	Δε/ε		
Ι.	0.085	0.025	40[e]	0.10	0.060	0.03 <sup>[e]</sup>	≈ 0.05		
	0.040	0.025	40 <sup>[e]</sup>	0.10	0.015	0.03 <sup>[e]</sup>	≈ 0.2		
	0.020	0.025	40[e]	0.10	0.005	0.03[e]	≈ 0.6		
11.	0.008	0.025	40[e]	0.10	0.017	0.03[e]	≈ 0.2		
Signal/Backg	round:								
		V Si	ample	Scatter	ing				
	E <sub>o</sub> (eV)	Thi: ()	ckness cm)	Angle (dearee	5)	Signal/Ba	karound		
	0.085	<del>کر ۔ ۱</del>	0.2	135	<u> </u>	10	<u></u>		
	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:				
Range (degrees) 20 to 150	Number of Detector Banks 9	Flight Path (m) 2	Solid Angle per Detector Bank (steradian) 0.003	<u>Kind of Detector</u> He <sup>3</sup> & Li <sup>6</sup> -ZnS
[a] To be increased	X7 late 1965.			
[b] Al crystal (111)	•			
[c] One collimator b	efore the crystal (15	minutes of angle):	crystal at 14,000 rpm	
[d] Second collimato	r behind the crystal.			
[e] Extracted from e	xperimental values.			

# TABLE XIV

# PHASED ROTOR NEUTRON SPECTROMETER -- CHALK RIVER

Instrument:	Phased Rotor Neu	tron Spectrome	ter (to be d	ismantled 1966).		
Location:	A.E.C.L. Chalk Ri	iver				
Reference:	D. I. Page (priva	ite communicati	on).			
Beam Size:	2.5 cm x 5.0 cm					
<u>Flight Path</u> :	1.7 m for 1st Qua 1.3 m for 3rd Qua 3.0 m for 4th Qua	drant Detector drant Detector drant Detector	s s s (narrow ang	gle array)		
Source Flux:	1.2 x 10 <sup>14</sup> therma	1 neutrons/cm <sup>2</sup>	-sec			
Intensity Determination:	Measured					
Intensity:						
E <sub>o</sub> (eV)		I	(n/min)		1(	n/cm <sup>2</sup> -sec)
0.10		6	.3 x 10 <sup>5</sup>		 /	$1.9 \times 10^4$
0.055		7	.2 x 10 <sup>5</sup>		Ę	5.6 x 10 <sup>4</sup>
0.025		2	.6 x 10 <sup>5</sup>		2	2.0 x 10 <sup>4</sup>
Resolution (ela	stic)[a].					
Resolucion (cita	<u></u> . Fuer	av	т	ime		
	Distrit of_Bu	ution rst	Distr Of [	ibution Burst	Burst W at Dete	lidth ector
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	ΔE <sub>O</sub> /E <sub>O</sub>	AT (USEC)	Δτ/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>
0.10[b]	0.00195	0.195	6	0.009[c]	12.26[c]	0.018[c]
0.055 <sup>[b]</sup>	0.00076	0.0138	6	0.0065 <sup>[c]</sup>	11.65[¢]	0.0125 <sup>[c]</sup>
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[0]	וח טנקן	0.026[d]
0.10 0.055[b]	0.00135	0.0138	6	0.012 <sup>[d]</sup>	8 96[d]	0.017[d]
0.025[b]	0.00026	0.104	6	0.0078[d]	9.32[d]	0.12[d]
	0.000105	0.0205	c c	o. ooj[e]	 []	0.0015[0]
	0.00195	0.0195	6		9.3C <sup>1</sup>	
0.055[0]	0.00076	0.0138	6	0.015[0]	8.68 <sup></sup>	0.02150-4
0.025	0.00020	0.0104	0	0.0102-3	9.52	0.0102-3
Resolution (ine	lastic)Lal:					
		Burst at_De	Width tector		Uncerta Energy (	inty in Change
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	Δt <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	<u>ε(eV)</u>	$\Delta \epsilon (eV)$	Δε/ε
0.10[b]	0.025	57.8[c]	0.042[c]	0.075	0.00415 <sup>[c]</sup>	0.055[c]
0.055 <sup>[b]</sup>	0.025	19.3 <sup>[c]</sup>	0.0207[c]	0.030	0.0027 <sup>[c]</sup>	0.09 <sup>[c]</sup>
0.10 <sup>[b]</sup>	0.025	<sub>34.9</sub> [d]	0.045[d]	0.075	0.00568 <sup>[d]</sup>	0.075 <sup>[d]</sup>
0.055[b]	0.025	13.1[d]	0.0249[d]	0.030	0.0035 <sup>[d]</sup>	0.117 <sup>[d]</sup>
[م]مد م	0 025	27 e[e]	0 047[e]	0.075	0 0068[e]	0 089[e]
0.055[b]	0.025	27.85 -	0.0472 P	0.075	0.0000- 0.00453[e]	0.151[e]
Signal/Backgrou	0.025	11.02 5	0.0279- 2	0.000	0.00455	0.151
Signaly backgrou	<u>1110</u> . V S:		500	ttoning		
E (eV)	Thịc	kņess	A	ngle		
<u>-0,2,7</u>		<u>.m)</u>	<u>(de</u>	grees)	Signal/	Background
0.1	0.	. JD	10	to 90	~	50
0.17	0.	. 30 26	90	to 160	~	25
0.017	0.	. 30	4	LO 22	*	18

# TABLE XIV (Cont.)

# PHASED ROTOR NEUTRON SPECTROMETER -- CHALK RIVER

Scattering Angles:				
Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
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 = 1.8	35.			
[b] Rotors at 30,000	D rpm.			
[c] 3 m flight path				
[d] 1.7 m flight pat	th.			
[e] 1.3 m flight pat	th.			

### TABLE XV

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

Instrument:	Phased Chopper Veloc	ity Selector <sup>[4</sup>	3]				
Location:	Materials Testing Rea	actor, NRTS,	Idaho Fa	lls, Ida	ho		
Reference:	Gavin, Harker, and Bi	rugger (privat	te commu	nication	).		
Beam Size:	3.38 cm x 10.16 cm						
Flight Path:	2 meters						
Source Flux:	2 x 10 <sup>14</sup> thermal neu	trons/cm <sup>2</sup> -sec					
Intensity Determination:	Measured						
Intensity:							
E <sub>o</sub> (eV)		IG	n/min)			I(n/c	m <sup>2</sup> -min)
0.10[6]		2.9	9 x 10 <sup>6</sup>			8.5	$\times 10^4$
0.076[c]		, 1.4	$2 \times 10^{6}$			3.5	x 10 <sup>4</sup>
0.055[c]		2.4	4 x 10 <sup>5</sup>			7.0	x 10 <sup>4</sup>
0.042[c]		1.1	7 x 10 <sup>6</sup>			5.0	x 10 <sup>4</sup>
Pecolution (ela	etic):						
Resolucion (ela:	<u>SCICJ</u> . Eneri	<b>1</b>		Tim	0		
	Distrib of Bu	ution rst		Distrib of Bu	ution rst	Burst Wi at Detec	dth tor
E <sub>c</sub> (eV)	۵E <sub>o</sub> (eV)	∆E /E	٨	t(usec)	Δτ/t <sub>o</sub>	Δt <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>
0.10[b]	0,0027[d]	0.026	-	6.5	0.014	14.7[e]	0.032
0.076[c]	0,0018 <sup>[d]</sup>	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 <sup>[d]</sup>	0.017		6.5	0.009	14.7[e]	0.021
Pocolution (inc	lactic).						
Resolucion (The	<u>Idst(c)</u> :	Burst W	idth			Uncertair	ity in
F (aV)	F (aV)	at Deter	ctor	-		Energy Cr	ange
E <sub>O</sub> (ev)	$\frac{E_{f}(ev)}{e}$	$\Delta t_{f}(sec)$	$\frac{\Delta t}{f' t}$		<u>∈(eV)</u>	Δε(eV)	Δε/ε
0.10	0.025	56[1]	0.061		0.075	0.0071193	0.095
0.076	0.025	40 <sup>[†]</sup>	0.044		0.051	0.0048[9]	0.094
0.055	0.025	28Lf]	0.031		0.030	0.0031[9]	0.10
0.042	0.025	21[1]	0.023		0.017	0.0021[3]	0.12
<u>Signal/Backgrou</u>	<u>nd</u> :						
Scattering Angl	<u>es</u> :						
Range (degrees)	Number of	Flight Pa	ath	Solid A	ngle per	Kind of Dota	eton
$\frac{16}{16} \pm 0.145$	JECECCOT BAIKS	2 to 2	26	0 007			
10 00 145	15	2 00 2.0	20	4.007	CG 0.025	167 cm press	1110
						1 in. ID, 18 in	. long
2.8 to 20	15	2.5		0.0004	to 0.0008	BF2	
	•-					167 cm press	ure
						1 in. ID, 4 in.	long
2.0 to 10	15	2.25		0.0006	to 0.0012	He <sup>3</sup>	
						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  $\Delta t_0$  values at two distances from the chopper (2 beam nuclitors).

[e] Measured.

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

[g] Computed from Equation (3).

# TABLE XV1

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

Instrument:	Phased Chopper Ve	locity Selector <sup>[a]</sup>						
Location:	Materials Testing	laterials Testing Reactor, NRTS, Idaho Falls, Idaho						
Reference:	R. M. Brugger (pr	ivate communicatio	n).					
Beam Size:	3.38 cm x 10.16 cm	Π						
Flight Path:	2.25 meters							
Source Flux:	2 x 10 <sup>14</sup> thermal 1	neutrons/cm <sup>2</sup> -sec						
Intensity Determination:	Measured							
Intensity:								
E <sub>o</sub> (eV)		I(n/m	in)		t (n/	(m <sup>2</sup> -min)		
0.07[b]		2.9 x	106		1.0	x 10 <sup>5</sup>		
0.05[b]		3.1 x	10 <sup>6</sup>		],]	x 10 <sup>5</sup>		
0.03[b]		1.4 x	10 <sup>6</sup>		4.8	x 10 <sup>4</sup>		
Resolution (ela	<pre>stic)[c];</pre>							
	Ener Distril of Bu	rgy Dution urst	Time Distribu of Bur	e ution rst	Burst W at Dete	idth ctor		
E <sub>o</sub> (eV)	E <sub>0</sub> (eV)	ΔE <sub>o</sub> /E <sub>o</sub>	Δτ(µsec)	Δτ/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>		
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		
Resolution (ine	lastic)[c]:							
		Burst W at Dete	idth ctor		Uncer <u>Energ</u>	taintyin <u>y Change</u>		
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	$\Delta t_{f}(\mu sec)$	<sup>∆t</sup> f <sup>/t</sup> f	<u>ɛ(eV)</u>	Δε(eV	<u>) Δε/ε</u>		
0.07	0.025	62	0.0602	0.045	0.005	3 0.12		
0.05	0.025	35	0.034	0.025	0.003	2 0.13		
0.03	0.025	24	0.023	0.005	0.001	7 0.34		
[a] Both choppe	rs have equal spee	ds. Slot width of	first choppe	r is 2x that of	second chopper	•		
LbJ 42 in. radi	us of curvature cu	rved slits in roto	rs. Choppers	at 12,000 rpm.				

[c] Assumed x = 1.34.

# TABLE XVII

# ROTATING CRYSTAL SPECTROMETER -- BATTELLE-NORTHWEST LABORATORY

Instrument:	Rotating Crystal Spectromete	lotating Crystal Spectrometer with Phased Chopper							
Location:	Battelle-Northwest Laborator	attelle-Northwest Laboratory, Richland, Washington							
Reference:	O. K. Harling (private commu	). K. Harling (private communication).							
<u>Beam Size</u> :	2.5 x 10.16 cm[a]								
Flight Path:	1.5 m <sup>[b]</sup>								
Source Flux:									
Intensity Determination:	Measured and Calculated								
Intensity:									
$E_0(\epsilon)$	20)	<u>1(n/min)</u>	$1(n/cm^2-min)$						
1. 0.300	[-]	12.0 × 10 <sup>3</sup>	$4.64 \times 10^4$						
11. 0.300		$3.0 \times 10^{2}$	1.16 x 10 <sup>4</sup>						
III. 0 <b>.</b> 300	lc]	0.75 x 10 <sup>5</sup>	$0.29 \times 10^4$						
Resolution (ela	<u>stic)</u> :								
	Energy Distribution	Time Distribuțion	Burst Width						

	of Bu	irst	of BurstLd] at Detec		tor[e]	
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	<sup>∆E</sup> o/Eo	<u>Δτ(µsec)</u>	Δτ/t <sub>o</sub>	∆t <sub>o</sub> (µsec)	Δt <sub>o</sub> /t <sub>o</sub>
1. 0.3[c]	0.0132	0.044	7.0	0.035	13.3	0.066
11. 0.3[¢]	0.0066	0.022	6.0	0.031	7.3	0.037
111. 0.3[c]	0.0029	0.0097	4.7	0.024	4.9	0.025
1V. 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):

		Burst Width <u>at Detector</u>			Uncertainty in _Energy ChangeL <sup>f</sup> ]	
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	€(eV)	Δε(eV)	
1. 0.3[c]	0.025	180	0.26	0.275	0.0186	0.068
11. 0.3[c]	0.025	93	0.14	0.275	0.0093	0.034
111. 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:						
	V.Sam	ple	Scatterin	a		

E <sub>o</sub> (eV)	Thickness (cm)	Angle (degrees)	Signal/Background
0.017	0.225	90	17.5

### TABLE XVII (Cont.)

#### ROTATING CRYSTAL SPECTROMETER -- BATTELLE-NORTHWEST LABORATORY

Scattering Angles: Solid Angle per Detector Bank Flight Path Range Number of Kind of Detector (degrees) Detector Banks (m) \_\_\_\_\_ (steradian) 11 15 to 165 1.0 and 1.3 0.0065 to 0.033 BF<sub>3</sub> 1 in. ID, 10 in. long, 2 Atm He<sup>3</sup> 1.0 and 1.5 0.0043 to 0.030 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]  $\Delta t_o$  given is for a 15° scattering angle.

[f]  $\Delta \varepsilon$  was calculated from  $\Delta \varepsilon^2 = \left(\frac{2\Delta t_f}{t_f}\right)^2 + \Delta E_o^2$ , where  $\Delta E_o$  is the Bragg energy uncertainty in the incident beam. This method of calculating  $\Delta \varepsilon$  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,  $\frac{\Delta E_o}{E_o} < \frac{2\Delta t_o}{t_o}$  under normal operating conditions. Therefore use of Equation 3 would overestimate the error in  $\Delta \varepsilon$ .

# TABLE XVIII

# LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

Instrument:	General Atomic N	eutron Velocit	y Selector (	10,800 rpm)	(in open	ation)	
Location:	General Atomic Ele	ctron LINAC					
Reference:	W. L. Whittemore (	orivate communi	cation).				
Beam Size:	7.0 cm x 25.4 cm						
Flight Path:	2.0 meters						
Source Flux:	Not Determined Dire	ectly					
Intensity Determination:	Measured						
Intensity:							
E <sub>o</sub> (eV)		I (	n/min)			I(n/cr	m <sup>2</sup> -min)
0.167[a]		6.7	x 105[b]			3.8 x	103[b]
0.233[a]		5.5	x 10 <sup>5[b]</sup>			3.1 x	10 <sup>3[b]</sup>
0.41[a]		5.5	x 10 <sup>5[b]</sup>			3.1 x	10 <sup>3[b]</sup>
Resolution (ela	<u>stic)</u> :						
	Ene Distril of B	rgy bution urst	Tim Distrib of Bu	e ution rst		Burst Wid at Detect	dth tor
E_(eV)	ΔE <sub>o</sub> (eV)	ΔE <sub>O</sub> /E <sub>O</sub>	Ar(usec)	Δτ/t	۵t	(µsec)	Δt /t
$\frac{1}{0.167[a]}$	0.0062	0.370	19	0.0539		26	0 0743
0.233[a]	0.0002	0.0436	19	0.0634		26	0.0861
$0.410^{[a]}$	0.0238	0.0580	19	0.0841		26	0.1150
Resolution (ine	elastic):						
····		Burst W	idth		· ι	Incertain	ty in
	· .	at Dete	<u>ctor</u>		_	Energy Cl	hange
$E_{o}(eV)$	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	$\Delta t_{f}/t_{f}$	<u>ɛ(eV)</u>		ic(eV)	$\Delta \varepsilon / \varepsilon$
0.167	0.025	125[c]	0.148	0.142	0.	0259 <sup>[d]</sup>	0.182
0.233	0.025	198 <sup>LCJ</sup>	0.218	0.208	0.	0417 <sup>[d]</sup>	0.200
0.410	0.025	450[c]	0.495	0.385	0.	097][d]	0.251
Signal/Backgrou	<u>ind</u> :						
	V Sam	ple	Scatter	ing			
E <sub>o</sub> (eV)	l hicki (cm	ness )	Angle (dearee	5)	Si	ional/Bacl	karound
0.167	0.1	<u>,                                    </u>	60	<u></u>	<u>-</u>	3.6 (8.0	)[e]
0.233	0.1	9	60			5.4 (9.5	,[e]
0.410	0.1	9	60			3.5 (6.6	,[e]
						• -•	-

### TABLE XVIII (Cont.)

#### LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

Scattering Angles:			<u> </u>	
Range (degrees)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector
30 ± 1.75[f]	1	2.0[9]	0.0032 to 0.016	He <sup>3</sup>
				1 in. ID, 20 in. long 10 Atm
60 ±3.5[f]	1	2.0 <sup>[g]</sup>	0.0032 to 0.032	BF3
				l in. ID, 20 in. long 167 cm
90 ±3.5[f]	1	2.0[9]	0.0064 to 0.032	BFa
				2 in. ID, 20 in. long 90 cm
120 ± 3.5[f]	1	2.0[g]	0.0064 to 0.032	BFa
				2 in. ID, 20 in. long 90 cm
150 ±3.5 <sup>[f]</sup>	1	2.0[a]	0.0064 to 0.032	BF3
				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. H<sub>2</sub>O 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  $\approx$  3.0 m, if necessary.

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# TABLE XIX

### LINAC NEUTRON VELOCITY SELECTOR -- GENERAL ATOMICS

Instrument:	General Atomic Neutron Velocity Selector (14,400 rpm) (expected)	
Location:	General Atomic Electron LINAC	
<u>Reference</u> :	W. L. Whittemore (private communication).	
Beam Size:	7.0 cm x 25.4 cm	
<u>Flight Path</u> :	2.0 meters	
Source Flux:	Not Determined Directly	
Intensity Determination:	Measured	
Intensity:		
$\frac{E_{o}(eV)}{0.167[a]}$	$\frac{1(n/min)}{6.7 \times 10^{5}[b]}$	<u>I(n/cm<sup>2</sup>-min)</u> 3 a x 103 <sup>[b]</sup>
0.233[a]	5.5 × 105[b]	3.1 x 10 <sup>3[b]</sup>
0.41[a]	5.5 x 10 <sup>5LDJ</sup>	3.1 x 10 <sup>3[b]</sup>

Resolution (elastic):

	Ener Distril of_Bu	rgy Dution urst	Tim Distrib of Bu	e ution rst	Burst W at Deter	idth ctor
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	∆E <sub>o</sub> /C <sub>o</sub>	Δτ(usec)	Ar/to	st <sub>o</sub> (usec)	sto/to
0.167[a]	0.00456	0.0273	14	0.0395	19	0.0539
0.233 <sup>[a]</sup>	0.00749	0.0321	14	0.0467	19	0.0631
0.410 <sup>[a]</sup>	0.01741	0.0426	14	0.0630	19	0.0840

#### Resolution (inelastic):

		Burst W <u>at Dete</u>	idth ctor		Uncertaint Energy Ci	ty in Nange
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (usec)	∆t <sub>f</sub> /t <sub>f</sub>	<u>c(eV)</u>	Ac(eV)	Δε/ε
0.167	0.025	93[c]	0.101	0.142	0.0187[d]	0.132
0.233	0.025	146[¢]	0.161	0.208	0.0306 <sup>[d]</sup>	0.148
0.410	0.025	328[c]	0.360	0.385	0.0700 <sup>[d]</sup>	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.  $H_20$  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).

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[d] Computed from Equation (3).

# TABLE XX

### LINAC NEUTRON VELOCITY SELECTOR -- RENSSELAER POLYTECHNIC INSTITUTE

the state of the s					The second se	
Instrument:	Phased Linac-Chopp	er Velocity Selecto	or (old 14,4	100 rpm chopper)		
Location:	Linear Accelerato	er Laboratory, Rei	nsselaer Po	lytechnic Insti	itute, Troy,	New York
Reference:	Seemann, Moore, an	id Kirouac (private	communicat	ion).		
Beam Size:	2.54 cm x 3.80 cm					
Flight Path:	1.87 m					
Source Flux:	1.1 x 10 <sup>11</sup> neutror	ns/sec eV into 4m	steradians	at 25 KW ave	erage electror	beam power
Intensity Determination:	Measured					
Intensity:						
£ <sub>o</sub> (eV)		I(n/mi)	n)		I (n/c	:m <sup>2</sup> -min)
0.20		0.7 x	10 <sup>5</sup>		5.4	x 10 <sup>3</sup>
0.50		1.2 x	10 <sup>5</sup>		9.3	× 10 <sup>3</sup>
1.00		2.5 x	10 <sup>5</sup>		1.9	x 10 <sup>4</sup>
Resolution (ela	stic):					
	Ener Distrib	gy Dution	Time Distribu	e Ation	Burst Wi	ldth
- ( ))	of Bu	irst	Of Bui	<u>rst</u>	at Detec	tor
E <sub>o</sub> (eV)	$\Delta E_{o}(eV)$	ΔE <sub>O</sub> /E <sub>O</sub>	Δτ(usec)	$\Delta \tau / t_0$	∆t <sub>o</sub> (µsec)	$\Delta t_0 / t_0$
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 (ine	elastic):					
		Burst Wi at Detec	dth <u>tor</u>		Uncerta Energy	inty in Change
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	ε(eV)	∆c(eV)	Δε/ε
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 <sup>[b]</sup>	0.30
1.00	0.025	1985[a]	2.32	0.975	0.42 <sup>[b]</sup>	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

Instrument:	Phased Linac-Chopper Velocit	y Selector[a]	(new 30,000 rpm chop	oper)
Location:	Linear Accelerator Laborator	y, Rensselaer I	Polytechnic Institut	ce, Troy, New York
Reference:	Seeman, Moore, and Kirouac (	private commun	ication).	
Beam Size:	5.08 cm x 10.16 cm			
Flight Path:	2.37 m			
Source Flux:	1.1 x 10 <sup>11</sup> neutrons/sec eV a beam power	at 0.5 eV int	o 4π steradians a	it 25 kW average electron
Intensity Determination:	Calculated from source flux			
Intensity:				
E <sub>o</sub> (eV)		l(n/min)		I(n/cm <sup>2</sup> -min)
0,20[b]		$4.3 \times 10^{5}$		$8.3 \times 10^3$
0.50[c]		3.6 x 10 <sup>5</sup>		$7.0 \times 10^3$
1.00 <sup>[d]</sup>		2.9 x 10 <sup>6</sup>		5.7 x 10 <sup>4</sup>
Resolution (ela	<u>stic)</u> :			
	Energy		Time	

	Distribution of_Burst		Distribution of_Burst		Burst Width at Detector	
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	ΔE <sub>0</sub> /E <sub>0</sub>	Δτ(usec)	Δτ/t <sub>o</sub>	∆t <sub>o</sub> ( sec)	∆t <sub>o</sub> /t <sub>o</sub>
0.20 <sup>[b]</sup>	0.006	0.030	15.7	0.041	23	0.060 •
0.50 <sup>[C]</sup>	0.015	0.030	11.8	0.048	14	0.058
1.00 <sup>[d]</sup>	0.042	0.042	7.8	0,043	12	0.067

#### Resolution (inelastic):

		Burst Width at Detector			Uncertainty in Energy Change	
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	$\Delta t_{f}(\mu sec)$	∆t <sub>f</sub> /t <sub>f</sub>	ε(eV)	Δε(eV)	Δε/ε
0.20 <sup>[b]</sup>	0.025	]40[e]	0.13	0.175	0.024[f]	0.14
0.50 <sup>[c]</sup>	0.025	330[e]	0.31	0.475	0.069[f]	0.13
1.00 <sup>[d]</sup>	0.025	920 <sup>[e]</sup>	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
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Instrument:	Cold Neutron Chopper	······································			
<u>ocation</u> :	VVR-S Reactor, Bucharest				
leference:	Teutsch, Mateescu, Nahorr	niak, Diaconescu and	Timis, Revue Roumaine de	e Physique <u>9</u> , p 737 (1964)	
<u>Beam Size</u> :	4 cm x 4 cm				
Flight Path:	2.4 m				
Source Flux:	2 x 10 <sup>12</sup> thermal neutrons/	′cm <sup>2</sup> -sec			
Intensity Determination:	Calculated				
intensity:					
$E_{o}(eV)$		I(n/min)		I(n/cm <sup>2</sup> -min)	
0.005		4.5 x 10 <sup>5[b]</sup>		3.0 x 104[b]	
<u>Resolution (ela</u>	<u>istic)</u> :				
	Energy Distribution <u>of Burst</u>	Di	Time stribution of Burst	Burst Width at Detector	
E <sub>o</sub> (eV)	ΔE <sub>o</sub> (eV) ΔE <sub>o</sub> /E <sub>o</sub>	Δτ(μs	ec) ∆τ/t <sub>o</sub>	∆t <sub>o</sub> (µsec) ∆t <sub>o</sub> /t <sub>o</sub>	
0.005	0.0014 0.28		] 0.033[c]	445 0.17	
				90[d] 0.033[d]	
Resolution (ine	elastic):				
		Burst Width at Detector		Uncertainty in <u>Energy Change</u>	
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (usec) ∆t <sub>f</sub> /	<sup>t</sup> f ε(eV)	AE(PV) AE/E	
0.005	0.025	118 0.1	1 0.020	0.0055 0.28	
Signal/Backgrou	und:				
	V Sample		Scattering		
E <sub>0</sub> (eV)	(cm)_	(cm) (degrees)		Signal/Background	
0.005	0.35		90	30	
Scattering Ang	es:				
Range (degree)	Number of Detector Banks	Flight Path (m)	Solid Angle per Detector Bank (steradian)	Kind of Detector	
		2.4	0.024	10 B-10F <sub>3</sub>	
15 to 90				J	

[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 guasi-elastic measurements with the filter-method.

# TABLE XXIII

### NEUTRON CHOPPER -- MOL

instrument:	Cold and Thermal	Neutron Choppen	r				
ocation:	BR2, Mol (Belgiu	m), Beam Tube R	2				
Reference:	W. Van Dingene Methods).	n (private con	munication). Paper	in prepar	ation (Nuclea	r Instruments a	
<u>Beam Size</u> :	6 cm x 6 cm		*				
light Path:	4.5 meters						
Source Flux:	9 x 10 <sup>13</sup> thermal	neutrons/cm <sup>2</sup> -so	ec				
Intensity Determination:	Measured						
Intensity:							
			E <sub>o</sub> (eV)	I (n/	min) I	(n/cm <sup>2</sup> -min)	
Be-filtere	d cold neutron be	0.005 to 0.004	1.5 x	$1.5 \times 10^8$ $5.5 \times 10^6$			
Monochromatic cold neutron beam:		0.005	1.3 x (with c	$1.3 \times 10^7$ $4.6 \times 10^5$ (with chopper) (with chopp			
Monochroma	tic thermal beams	are provided:	No data yet				
Resolution (ela	stic) (at 5000 rp	<u>m):</u>					
	Energ Distribu of Bur	y ition st	Time Distribution of Burst		Burst at De	: Width tector	
E <sub>o</sub> (eV)	∆E <sub>o</sub> (eV)	ΔE <sub>o</sub> /E <sub>o</sub>	Δτ(µsec)	τ/t <sub>o</sub>	Δt <sub>o</sub> (µsec)	∆t <sub>o</sub> /t <sub>o</sub>	
0.005	0.00015	0.025	100		93	0.02	
Resolution (ine	lastic) (at 5000	rpm):					
		Burst at Det	Width ector		Uncer Ener	tainty in Tay Change	
E <sub>o</sub> (eV)	E <sub>f</sub> (eV)	∆t <sub>f</sub> (µsec)	∆t <sub>f</sub> /t <sub>f</sub>	e(eV)	Ac(eV)	Δε/ε	
0.005	0.025	7][a]	0.03	0.020	0.0015	0.075	
ignal/Backgrou	nd:						
E (eV)	V S Thi	ample ckness	Scattering Angles	l			
0.005	<u>(cm)</u>		(degrees)	(degrees)		STYNAT/ BACKYROUND 66	
0.005		0.3	90			00	
Scattering Angl	es:						
Range (degrees)	Number of Detector Bank	Flight Pat	Solid Angle pe h Detector Bank (steradian)	er C	Kind of Det	ector	
0 to 120	1[b]	4.5	0.00033	2 lay	ers of 2 in.	enriched BF3	

[b] Eight banks are under project.

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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,  $\Delta \varepsilon / \varepsilon$ , 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,  $\Delta \varepsilon / \varepsilon$ , 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, l(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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Fig. 9 The uncertainty in measuring the energy change divided by the energy change,  $\Lambda\varepsilon/\varepsilon$ , 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.



