JAPAN ATOMIC ENERGY RESEARCH INSTITUTE

TOKAI RESEARCH ESTABLISHMENT

TOKAI-MURA, NAKA-GUN, IBARAKI-KEN

Nuclear Data Measuring Fascilities in Japan

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November, 1963

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I. Crystal spectrometer

JAERI Crystal spectrometer

Organization:

Japan Atomic Energy Research Institute.

Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

Researches on slow neutron physics.

Status:

Being used since 1962.

Scientist in charge of experimental programme:

Y. Ohno

Number of staff employed:

4

Available reference for more detailed description:

Y. Ohno et al.; "The JAERI Neutron Crystal Spectrometer", Pile neutron research in physics, P.585, IAEA, 1962.

Y. Ohno et al.; "The Construction and Performance of the JAERI Neutron Crystal Spectrometer", JAERI 1030, (1962), (In Japanese).

Reactor at which it is installed:

JRR-2,(a CP-5 type reactor of 10-MW maximum).

Type:

SINGLE and PLANE Crystal spectrometer

Collimator:

Cross section area: 30 × 35 mm.

Angular divergency: 20' and 2' of arc prepared.

Crystal available:

LiF (200), LiF (111), Be (0002) and Calcite.

Useful neutron energy range:

Up to	3 eV	LiF (200)
"	5 eV	with LiF (111).
"	20 eV	Be (0002)

Sample specifications:

Useful area: 35 mm × 30 mm

Distance from crystal and detector: 160 cm.

Possibility of activation measurements: Possible.

Accuracy in angular positioning for the crystal-sample coupling:

Less than ± 5 sec. of arc.

Energy resolution at some typical angles:

$\Delta E/E$ = 3 % at 0.025 eV of the neutron energy using LiF (200) plane and a collimater of 20' angular divergency.

II. Mechanical monochromator

JAERI Mechanical monochromator

Organization:

Japan Atomic Energy Research Institute.

Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

1) Neutron cross sections measurements for the cold neutron energy region.

2) To remove the higher order contaminations of the neutron

from the JAERI neutron crystal spectrometer.

Status:

First operation at the JRR-1 reactor on 1963.

Scientist in charge of experimental programme:

Y. Ohno

Number of staff employed:

2.

Available reference for more detailed description:

In preparation.

Important characteristics not included in the list:

To be inserted into a horizaontal hole of JRR-2 when this monochromator is to be coupled with the crystal spectrometer.

Reactor at which it is installed:

JRR-1 (a Water-boiler-type reactor of 50 kW) or JRR-2 (a CP-5 type reactor of 10-MW maximum).

Rotor:

Type: Cylindrical rotor with helical slots.

Diameter: 19.5 cm.

Materials of rotor body and slits: AR Monel, cadmium lined.

Type and number of slits: 80 helical slits of 1.5 mm × 4 cm with a pitch of 10 meter.

Maximum rotational speed and stability: 15,000 rpm with a stability better than 0.1 %.

Transmission efficiency:

75 %.

Neutron energy range:

0.00033 eV to 0.033 eV.

Beam cross-sectional area:

35 × 30 mm.

Typical resolution:

25 % .

III. Pile oscillator

JAERI Pile oscillator

Organization:

Japan Atomic Energy Research Institute.

Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

Measurements of thermal-neutron absorption cross sections.

Status:

Operated since 1958.

Scientist in charge of experimental programme:

T. Fuketa

Number of staff employed:

1

Available references for more detailed descriptions:

T. Fuketa, Paired-chamber type pile oscillator, Nucl. Inst. and Meth., 13 35 (1961).

T. Fuketa and S. Otomo, Paired-chamber type pile oscillator, Pile neutron research in physics P. 633 IAEA, (1962).

Reactor at which it is installed:

JRR-1 (a water- boiler-type reactor of 50 kW).

Principle of oscillation:

Local flux perturbation.

Location in the reactor:

Reflector.

Medium surrounding the oscillator:

Graphite.

Nature of neutron flux at oscillator position:

Spectrum: Thermal, Cadmium to Indium ratio; 10

Intensity: 3×10^{11} n/cm^2.sec.

Gradient along oscillator direction: Less than 5 %.

Sample used as reference:

Boron-10 or gold foil.

Maximum size and dimensions of the tested sample:

17 mm in diameter and about 100 mm in length.

Oscillator wave:

Shape: Sine wave.

Period: 0.5 c/ sec ~ 2 c/ sec variable.

Stroke: ± 75 mm ~ ± 200 mm variable.

Sencitivity or minimum absorption detectable:

Less than 0.5×10^{-3} cm^2 in the whole macroscopic cross section $\Sigma_a V$ of the sample.

IV. Particle accelerators

JAERI Electron linear accelerator

Organization:

Japan Atomic Energy Research Institute.

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Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

X-ray production, neutron production.

Status:

Operated since Dec. 1960.

Scientist in charge of experimental programme:

H. Takekoshi

Number of staff employed:

5

Manufacturer:

High Voltage Eng. Corp. USA.

Nature of accelerated particles:

Electrons.

Minimum and maximum energy of acceleration:

2 $\sim$ 20 MeV.

Maximum beam current:

100 mA (4μsec width) at 20 MeV.

Target:

Pb

Neutron Yield: 2.4×10^{12} sec^{-1}

Pulse length:

4 $\sim$ 0.04 microsec.

Pulse repetition rate:

50 $\sim$ 300 cps.

Peak neutron yield per second during the pulse:

2×10^{15}

Neutron flight path:

Number of neutron beams: 2

Maximum length: 50 m, 10m.

Intermediate stations: None.

Useful diameter: 30 cm, 8 cm.

Transmitting medium: Vacuum.

Neutron detector:

BF_3 counters, Li glass scintillation counter.

Time analyzer:

Number of channels: 256

Minimum channel width: 0.25 microsec.

Counting capacity per channel: 2^{16}.

JAERI 5.5 MV Van de Graaff acceleratos

Organization:

Japan Atomic Energy Research Institute.

Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

Fast neutron physics.

Status:

Installed since 1962, now under repair.

Scientist in charge of experimental programme:

K. Tsukada

Number of staff employed:

5

Type of accelerator:

Model CN, High Voltage Engineering Corporation, USA.

Nature of accelerated particles:

H^+, D^+, T^+, He^{3+}, He^{3++}, He^{4+}, He^{4++}

Minimum and maximum energy of acceleration:

1.0 ~ 5.5 MeV.

Energy stabilization:

$< \pm 5$ KV (for analyzed protons)

Maximum beam current:

20 μA (1.0 ~ 5.0 MV)

10 μA (> 5.0 MV)

Targets and reactions available:

a) Neutron yield in 4π geometry obtained by using a double foil gas target of 1 atm, 3 cm long.

10^9 neutrons/10μA	$D(d,n)He^3$ at 3 MeV
2.5×10^9 "	$T(p,n)He^3$ at 3 MeV
5.5×10^9 "	$T(d,n)He^4$ at 1 MeV
5×10^9 "	Li(p,n)Be at 2.2 MeV

b) Neutron energy:

1.6 ~ 8.7 MeV	$D(d,n)He^3$
0 ~ 4.7 MeV	$T(p,n)He^3$
11.6 ~ 22.5 MeV	$T(d,n)He^4$
0 ~ 3.8 MeV	Li(p,n)Be

Pulsation system:

Terminal pulsing system.

Beam bunching system: Mobley type.

Pulse length:

10 ns (half width) before the bunching.

$\sim$ 1.3 ns (half width) after the bunching.

Pulse repetition rate:

10^6 p.p.s.

Peak neutron yield per second during the pulse:

5.5×10^{11} neutrons/ 1 mA, 1 atm, 3 cm length.

5.5×10^{12} neutrons/10 mA, 1 atm, 3 cm, length.

(with the pulsed ion beam bunching system)

Neutron detector:

Plastic scintillator (5" Ø x 2") with three phototubes.

(RCA 6810A).

Time analyzer:

Number of channels: 256

Minimum channel width: 0.25 ns

Counting capacity per channel: 2^{20}.

Devices to measure angular distributions:

Rotating table (flight path; 1$\sim$4 m).

JAERI 2 MV Van de Graaff accelerator

Organization:

Japan Atomic Energy Research Institute.

Location:

Tokai-mura, Ibaraki-ken, Japan.

Main purpose of the apparatus:

Fast neutron physics.

Status:

Operated since 1957.

Scientist in charge of experimental programme:

K. Tsukada

Number of staff employed:

2

Type of accelerator: Model AK, High Voltage Engineering Corporation, USA.

Nature of accelerated particles:

H^+, D^+, T^+, e^-

Minimum and maximum energy of acceleration:

0.2 ~ 2.0 MeV.

Energy stabilization:

$< \pm$ 2 KeV (for analyzed protons).

Maximum beam current:

50 μA for positive ions.

Targets and reactions available:

a) Neutron yield in 4π geometry by using double foil gas target.

1×10^9	neutrons/10 μA,	1atm,	3 cm length	$D(d,n)He^3$ at 2 MeV
2.5×10^9	"	"	"	$T(d,n)He^4$ at 1 MeV
4.0×10^9	"	"	"	$T(p,n)He^3$ at 2 MeV

b) Neutron energy

1.65 ~ 5.2 MeV	$D(d,n)He^3$	
12 ~ 18.2 MeV	$T(D,n)He^4$	
0 ~ 1.2 MeV	$T(p,n)He^3$	

Pulsation system:

Terminal pulsing system.

Beam bunching system: None.

Pulse length:

3 ns (half width).

Pulse repetition rate:

5×10^6 p.p.s.

Peak neutron yield per second during the pulse:

6×10^{10} neutrons/150μA, 1 atm, 3 cm length. $T(p,n)He^3$ at 2 MeV

Electrostatic accelerator

(Electrotech. Lab.)

Organization:

Electrotechnical Laboratory, Ministry of International Trade and Industry.

Location:

Tanashi-machi, Kitatama-gun, Tokyo.

Main purpose:

Neutron physics research.

Status:

First operation; 1958.

Scientist:

O. Yura

Number of staff:

4

References for more detailed description:

1) E. Teranishi, Researches of the Electrotechnical Laboratory, No. 617 (1961).

2) S. Furubayashi et al., Jour. Phys. Soc. of Japan 18, 1235 (1963)

Manufacturer:

Toshiba Electric Co..

Nature of accelerated particles:

Protons and deuterons.

Minimum and maximum energy:

0.7 MeV ~ 2.7 MeV.

Energy stabilization:

± 0.1 %

Maximum beam current:

25 μA on target.

Targets and reactions available:

$Li(p,n)Be$, $T(p,n)He^3$, $D(d,n)He^3$, $T(D,n)He^4$

(admissible current on target: Less than 10 μA).

Neutron yield: $< 10^8$ n/4π.

Neutron energy: 1 keV ~ 5.5 MeV

14 MeV ~ 17 MeV

Cockcroft-Walton accelerator

(Kyushu Univ.)

Organization:

Institute of Applied Nuclear Physics,

Faculty of Engineering, Kyushu University.

Location:

Hakozaki-machi, Fukuoka City, Japan.

Main purpose of the apparatus:

Research of neutron-induced reactions and neutron source for reactor physics.

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Status:

Operated since 1959.

Scientist in charge of experimental programme:

Prof. M. Sonoda.

Number of staff employed:

6

Available references for more detailed description:

Jour. Phys. Soc. Japan 15, 1680 (1960).

Memo. Coll. Eng. Kyushu Univ. 20, 367 (1961).

Type of accelerator:

Cockcroft-Walton Type (home made).

Nature of accelerated particles:

Protons or deuterons.

Minimum and maximum energy of acceleration:

$\lesssim$500 kV.

Energy stabilization:

0.130 kV/mA.

Maximum beam current:

$\sim$1 mA.

Targets and reactions available (admissible current on target).

Ti-D or Ti-T 200 μA

Neutron yield in 4π geometry 5×10^9

Neutron energy $\sim$3- and 14-MeV.

The machine is not operated pulsatively, but time-of-flight experiments are carried out by associated α-particle method.

Neutron flight path:

1 $\sim$ 2 m

Neutron detector:

Plastic scintillator.

Time analyzer:

Number of channels; 128

Minimum channel width

Counting capacity per channel; 99,999

Cockcroft-Walton accelerator

(Konan Univ.)

Organization:

Department of Physics, Faculty of Science, Konan University.

Location:

Motoyama, Higashi-nada-ku, Kobe, Japan

Main purpose of the apparatus:

Experimental study of nuclear physics.

Scientist in charge of experimental programme:

K. Yuasa

Type of accelerator:

Cockcroft-Walton, (home made).

Minimum and maximum energy of acceleration:

100 to 400 keV.

Cockcroft-Walton accelerator

(Kyoto Univ.)

Organization:

Department of Physics, Faculty of Science, Kyoto University.

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Location:

Kitashirakawa-Oiwake-cho, Sakyo-ku, Kyoto, Japan.

Main purpose of the apparatus:

Production of T-D and D-D neutrons.

Production of Li-p and F-p gamma rays.

Status:

Year of first operation; 1958.

Scientist in charge of experimental programme:

S. Yasumi

Number of staff employed:

8

Type of accelerator:

Cockcroft-Walton type (home made).

Minimum and maximum energy of acceleration:

0 ~ 600 kV.

Cockcroft-Walton accelerator

(Kyoto Univ.)

Organization:

Department of Nuclear Engineering, Faculty of Engineering,

Kyoto University.

Location:

Uji-shi, Kyoto-fu, Japan.

Main purpose:

Neutron Production.

Status:

Completed 1963

Scientist in charge of experimental programme:

M. Sakisaka

Manufacturer:

Nisshin Electric Works Co. Ltd..

Minimum and maximum energy of acceleration:

150 ~ 600 kV.

V. Mass separators

Electrotechnical Lab. mass separator

Organization:

Electrotechnical Laboratory, Ministry of International Trade and Industry.

Location:

2-chome, Chiyoda-ku, Tokyo, Japan.

Main purpose:

Source production for radioisotope standard and target preparation for monochromatic neutron generation.

Status:

Completed on 1956.

Scientist in charge of experimental programme:

O. Yura

Number of staff employed:

1

Available reference for more detailed description:

I. Kohno, Bull. ETL 26 777 (1962).

"Isotope separation with ETL mass separator and purity of some collected isotopes."

Ion source::

Ion density; 10 mA/cm^2

Extraction voltage; 50 kV (maximum)

Ion current in the beam; 10 mA (Ion source output)

Throughput per week; 30 hours (machine time)

Deflection magnet:

Weight; 5.5 ton

Power supply; 17.5 kW

Stabilization; 0.05 % /day

Maximum magnetic field; 6000 gauss (maximum)

Vacuum:

$5 \sim 10 \times 10^{-6}$ Torr. (in operation)

Curvature radius of ion path:

70 cm

Angular deflection of the ion beam

60^{o}

Collector efficiency:

1 % defined as collected isotope/consumed material

Resolution:

$(M/\Delta M)$ 250

Kyoto Univ. mass separator

Organization:

Department of Physics, Faculty of Science, Kyoto, Japan.

Location:

Kitashirakawa, Oiwake-cho, Sakyo-ku, Kyoto, Japan.

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Main purpose of the apparatus:

Production of enriched stable isotopes which are used in scientific research, especially, in nuclear physics.

Status:

Year of first operation or date scheduled for completion; 1956.

Scientist in charge of experimental programme:

J. Muto

Number of staff employed:

4

Available references for more detailed description:

J. Muto and K. Okano: Mem. Coll. Sci. Univ. Kyoto 28A 337 (1956).

Ion source:

Ion density; 0.2 ~ 1 A

Extraction voltage; 5 ~ 50 kV (acceleration voltage)

Ion current in the beam: 0 ~ 5 mA

Throughout per week:

Deflection magnet:

Weight: 7 tons

Power supply: 10 kW DC motor generator

Stabilization: High current regulator having 400 cycle chopper-converter, stability: 1/4000.

Maximum magnetic field: 8000 gauss.

Vacuum:

Two sets of evacuating pumps are used. Each set of pumps consists of an 8 inch oil diffusion pump with the pumping speed of 1250 litre/sec at 2×10^{-6} mm Hg and a Kinney type rotary pump with pumping speed of 680 litre/min at 1 mm Hg.

Curvature radius of ion path:

60 cm.

Angular deflection of the ion beam:

60°.

Collector efficiency:

10 ~ 30 %

Resolution:

($M/\Delta M$) 150 in normal operation.

250 in favourable conditions.

INS mass separator

Organization:

Institute for Nuclear Study, University of Tokyo.

Location:

Tanashi-machi, Kitatama-gun, Tokyo, Japan.

Main purpose of the apparatus:

Production of separated or enriched isotopes as the target for the nuclear studies.

Status:

Year of first operation; 1957.

Scientist in charge of experimental programme:

M. Sakai and K. Kaneko

Number of staff employed:

3

Available reference for more detailed description:

M. Sakai, Mass Spectroscopy, No. 14, 27, (1960), (In Japanese).

Ion source:

Extraction voltage: - 20 kV maximum

Acceleration voltage: + 50 kV maximum

Ion current in the beam: up to 10 mA

Deflection magnet:

Weight: 17 tons

Power supply: 20 kW

Stabilization: 1/3000 ~ 1/10000

Maximum magnetic field: 7000 gauss

Vacuum:

1×10^{-5} mm Hg

Curvature radius of ion path:

90 cm

Angular deflection of the ion beam:

60°

Collector efficiency:

0.02 ~ 0.6 (collection/consumption)

Resolution:

100 ~ 150

VI. Special mass spectrometer

Hitachi mass spectrometer

Organization:

Ozenji Division of Hitachi Central Research Laboratory, Hitachi Ltd..

Location:

1099, Ozenji, Kawasaki-si, Kanagawa-ken, Japan.

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Main purpose of the apparatus:

Measurement of isotopic ratio of Uranium,

Status:

Year of first operation; 1958.

Scientist in charge of experimental programme:

K. Taniguchi

Number of staff employed:

2

Ion source:

Electron bombardment, surface ionization.

Extraction voltage: greater than 20 V.

Ion current: $10^{-10} \sim 10^{-15}$ amp.

Deflection magnet:

Weight: 1350 kg.

Power supply: 38 Watt . Stabilization ; 1 ~ 2 /10.000

Maximum magnetic field: 5500 gauss.

Vacuum:

$10^{-6} \sim 10^{-7}$ mm Hg.

Curvature radius of ion path:

335 mm

Angular deflection of the ion beam:

90°

Resolution ($M/\Delta M$):

Maximum; 3000

ordinary use; 350

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VII. Research reactors

JRR-1

Name: Japan Research Reactor No. 1 (JRR-1).

Situated: Tokai-mura, Ibaraki-ken, Japan.

Critical: Aug., 1957.

Type: Water-boiler type (Light water homogenous reactor)

Owner: Japan Atomic Energy Research Institute

Operator: Y. Ohno, T. Fuketa

Designer: Atomics International USA

Use:
1) Measurements of thermal neutron absorption cross sections using the pile oscillator inserted into a virtical experimental hole.
2) Measurements of total and partial cross sections for the cold neutron using the mechanical neutron monochromator installed at the thermal column.

Power: 50 kW maximum

Fuel: Average thermal neutron flux; $\sim 8 \times 10^{11}$ n/cm^2 sec

Peak thermal neutron flux; 1.2×10^{12} n/cm^2 sec

Average fast neutron flux; $\sim 9 \times 10^{11}$ n/cm^2 sec

Peak fast neutron flux; 1.2×10^{12} n/cm^2 sec

by gold foil activation method with β-γ coincidence counting.

Experimental facilities:

Pile oscillator, mechanical monochromator.

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JRR-2

Name: Japan Research Reactor No. 2 (JRR-2)

Situated: Tokai-mura, Ibaraki-ken, Japan.

Critical: April, 1962.

Type: CP-5 type (D_2O-Enriched Uranium Reactor)

Owner: Japan Atomic Energy Research Institute

Operator: Y. Ohno

Designer: American Machine and Foundry, USA

Use: 1) Measurements of the slow neutron cross sections of the various elements using the neutron crystal spectrometer.

2) Inelastic scattering measurements for the thermal neutrons using a phased chopper and time-of-flight technique.

Power: 10 MW maximum

Fuel: 90 enriched U-Al alloy plate with Al cladding.

Flux: Average thermal flux in the center of the core:

1.62×10^7 n/cm^{2}sec·W

Peak thermal flux in the center of the core:

2.18×10^7 n/cm^2·sec·W

by gold foil activation method.

Experimental facilities:

Crystal spectrometer, phased chopper for inelastic scattering measurements.

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JRR-3

Name: Japan Research Reactor No. 3 (JRR-3)

Situated: Tokai-mura, Ibaraki-ken, Japan.

Critical: September, 1962.

Type: Natural Uranium - Heavy water type

Owner: Japan Atomic Energy Research Institute

Operator: H. Takekoshi

Designer: Japan Atomic Energy Research Institute

Use: Neutron-capture gamma-ray spectroscopy using a high-resolution Compton-electron spectrometer (under construction) installed at the tangential beam hole.

Power: 10 MW maximum

Fuel: Metalic uranium rod with Al cladding.

Flux: Average thermal neutron flux; 9×10^{12} n/cm^2 sec

Peak thermal neutron flux; 2×10^{13} n/cm^2 sec

Peak fast neutron flux; 3.7×10^{12} n/cm^2 sec

by the design calculations.

Experimental facilities:

Compton-spectrometer for capture γ study.

Kyoto Univ. research reactor

Name:	Kyoto University Research Reactor
Situated:	Kumatori-cho, Sennan-gun, Osaka-fu, Japan.
Critical:	To be critical on April, 1964.
Type:	Tank type with pool (Light water-enriched uranium reactor)
Owner:	Kyoto University
Power:	1 KW
Use:	under planning

Supplement to "Nuclear data measuring fascilities in Japan"
(INDSWG-21)

(To be inserted between the cover and page 1)

O. Phased-chopper neutron spectrometer

JAERI Neutron spectrometer

Organization: Japan Atomic Energy Research Institute

Location: Tokai-mura, Ibaraki-ken, Japan.

Main purpose: Inelastic scattering of neutrons by solids and liquids; mainly phonon and magnon scattering.

Status: Will be completed by June 1964.

Number of staff employed: 4

Scientist in charge: N. Kunitomi

Available reference:

Specification JAERI - memo 532-624 (in Japanese)
Hazard Report-1 JAERI-memo 1032. (in Japanese)
Hazard Report-2 JAERI-memo 1421 (in Japanese)

Literature of Neutron Research:

1) Neutron Deffraction and Scattering Studies at JAERI. JAERI-memo 1315
2) Reflectivity of Collimated Neutrons by a Mosaic Single Crystal JAERI-memo 1434

Future Program:

1) From July to September, 1964.
   Instrumental alignment and calibration
2) From October, 1964.
   a) Inelastic scattering by several hydrides, at various temperatures, e.g. ZrHx, TiHx, VHx, TaHx, etc.
   b) Critical magnetic scattering.

Reactor at which the spectrometer is installed: JRR-2

Type: Tripple phased-rotor type, distance between the 1st and the 3rd rotor being 3m.

Rotors: Type: Disc with two windows; axis horizontal.
Diameter: 50 cm
Material of the rotor body: precipitation type aluminum alloy
Window: 3 cm x 3 cm
Maximum speed: 12,000 rpm
Stability: 0.5 %

Minimum neutron pulse length:
1.13×10^{-4} sec

Flight path: 2 m in maximum; medium: air

Location of the detectors:
Surrounding specimen for the scattering angle of $0^{\circ} \sim 90^{\circ}$

Type and number of neutron detectors:
Ten BF_3 counters are assembled in a unit.

Time analyzer:
Number of channels: 256
Minimum channel width: 5 microsec
Counting capacity per channel: 16,384
Special devices for automatic operation: None

Resultant specifications:
Wavelength range: 1 Å~10 Å
Beam cross sectional area: 3 x 3 cm
Typical resolving power: $\Delta\lambda/\lambda$ = 7.5 % at 2 Å