Beryllium Filter Spectrometer

This instrument is designed primarily for chemical spectroscopy from about 80 cm^{-1} to well over 1600 cm^{-1}. It has been purpose built to capture as many inelastically scattered neutrons as possible. It is ideally suited for studying incoherent inelastic scattering from hydrogenous materials such as organic materials, inorganic hydrides or hydrogen dissolved in metals. Experiments have also been carried out on absorbed hydrogenous materials. Density of state measurements are also possible for incoherent scattering and studies have been carried out on heavy atom-light atom systems where the optical phonons have been clearly visible.

Special features include:

(1) two filter units each subtending a $48° \times 48°$ angle at the sample position,

(2) monochromator which can be cooled to 77°K,

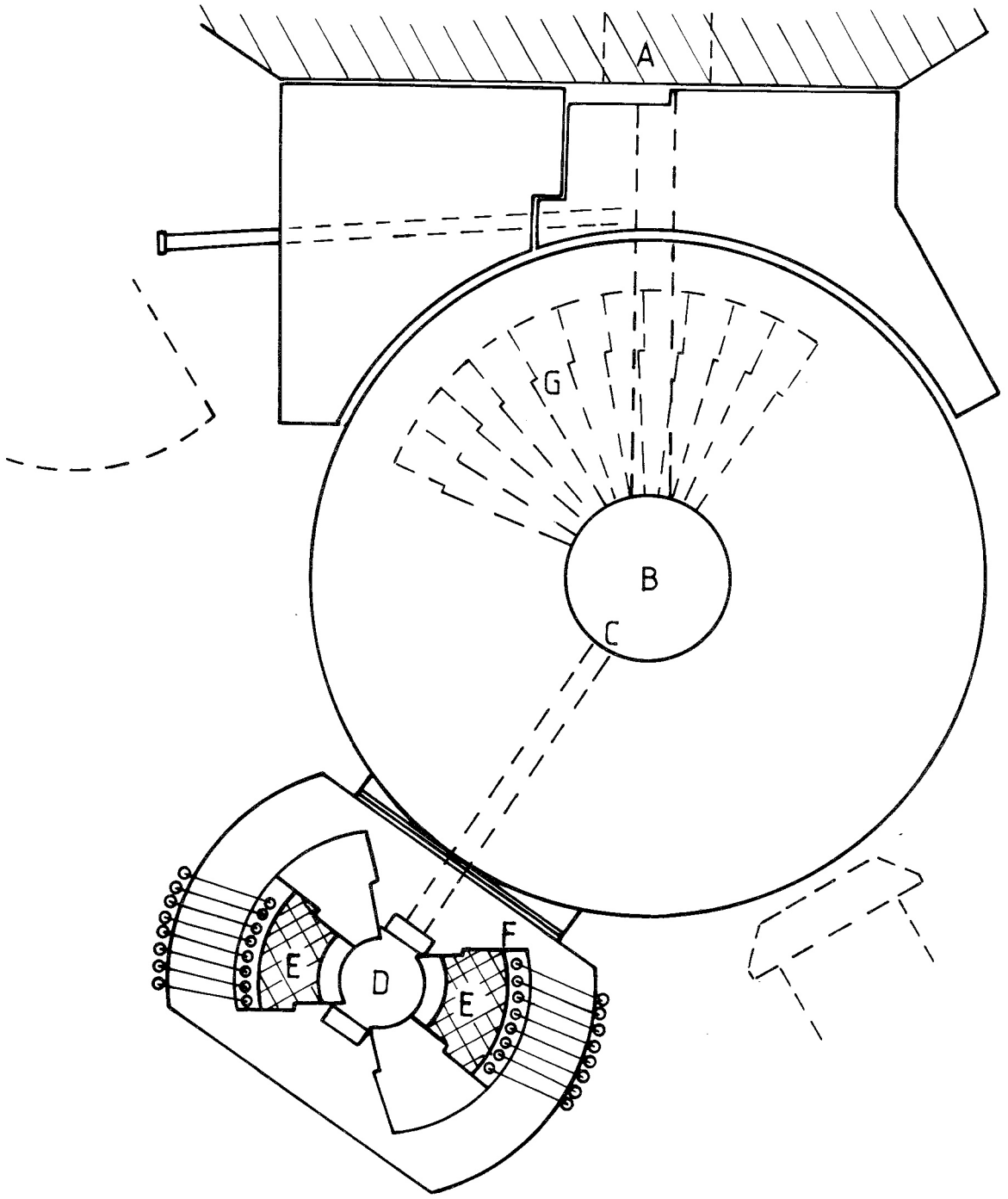
(3) distributed microprocessor control system which allows independent parallel positioning of shafts. Currently three intel 8085 microprocessors are used.

Physical Description

The instrument is shown in plan view in the accompanying drawing. The incident energy is selected by an ω rotation of the monochromator at B which has a vertical (110) axis. The large shielding drum with the attached filter assemblies is then rotated by 2θ. The shielding segments G lift to clear the incident flight tube. The Bragg reflected neutrons of the appropriate incident energy are scattered from the sample at D. Those with less than 5 meV pass through the Be filter blocks E into the detector F. Data is collected on punched tape. At present the input of incident energy settings is via paper tape.

Beryllium Filter Spectrometer Instrument Details

Beam hole	10H DIDO
Monochromator	Aluminium (can be cooled to 77 K)
Wave length range	.6 Å to 2.7 Å
Incident energy range	11 meV to 250 meV
Angular range	$0° < \omega < 370°$ monochromator
	$10° < 2\theta < 70°$ DRUM (two filter units)
	$10° < 2\theta < 85°$ DRUM (one filter unit)
	The lower limit depends on the TAS position.
	The upper limit depends on the diffractometer wall.
Beam size at sample	60×60 mm (maximum)
Collimation	α_1 Flight tube taper
	α_2 Variable (usually 30' sollers)
Flux at sample	1.1×10^6 n cm^{-2} s^{-1} with $\Delta E/E$ of 4% at 50 meV (aluminium crystal)
Detectors	Two banks of 8 BF_3 counters,
	50 mm diameter, 40 cm active length, 70 cm Hg pressure.
Filters	Two units independently cooled to 77 K
	Length 20 cm of Beryllium
	tapered blocks with Cd slats
	each subtends angle of $48° \times 48°$ at sample position.
Ancillary equipment	Purpose built 100 mm bore cryostat capable of operating at
	temperatures down to 10 K.



A In-pile collimators
B Monochromator
C Beam shutter
D Sample position
E Be filter blocks (cooled)
F BF_3 detector arrays
G Shielding segments

AERE - R.9278 Fig. 11
Schematic layout of DIDO beryllium filter spectrometer

MARX Spectrometer

Uses

The MARX spectrometer has two principal modes of operation which combine the speed of data collection of a time-of-flight spectrometer with the positional versatility of a triple-axis. In the first of these the use is in the investigation of quasielastic scattering (inelastic scattering centred on zero energy transfer) to determine diffusion rates and relaxation times. The scans in $(\underline{Q},\omega)$ space are similar to but not so restricted as those made by time-of-flight spectrometers, and can be arranged to give almost constant $|\underline{Q}|$. The best resolution attainable is $\sim 130 - 150\ \mu V$ and scattering at wavevectors out to 2.3 $\mathring{A}^{-1}$ can be examined. The resolution may be broadened and wavevector range increased by simple changes. The second mode of operation is to use the spectrometer to investigate excitations in materials in a similar way to a triple-axis spectrometer. Because of the large range of $\underline{Q}$ and ω examined at one setting of the machine, the data collection rate is higher, and a scan of only five or so points should enable a phonon to be accurately located along a desired direction of $\underline{Q}$. The sample background is measured simultaneously and can therefore be accurately subtracted.

The Position Sensitive Detector (P.S.D.) may be used to examine diffraction from a sample, if the analyser is removed. The spectrometer may also be converted to a conventional triple-axis machine with uses listed under the PLUTO or DIDO triple-axis.

Description

The MARX spectrometer is similar in construction to a triple-axis spectrometer but the use of a large dimension analyser crystal, no soller collimation between sample and detector, and a long position-sensitive detector, enables neutrons with a range of final wavevector and energies to be detected simultaneously. Two such rays from the sample are shown in the figure, and the locus of wavevector transfer $\underline{Q}$ lies on the perpendicular bisector of the negative analyser tau vector.

The incident neutron energy is constant, but its value is manually variable by changing the take-off angle $2\theta_M$ from the monochromator, or by changing the monochromator crystal which is readily accessible via an insertable "coffin". It is intended to automate the monochromator ω-angle in the near future. The sample table, analyser and detector move on air bearings over a resin base floor. The distance between the sample and analyser can be varied manually to change the resolution of the instrument. Surrounding the sample and analyser is a system of shielding which automatically adjusts with the movement of the machine. [An improved shield which allows greater movement and the use of larger cryostats will replace the present system in the near future.] The spectrometer can be converted to a conventional triple-axis by the use of an end-on He^3 counter, additional shielding in front of the P.S.D., and the addition of soller collimators before and after the analyser.

MARX Instrument Details

Angular Ranges and Distances

Monochromator take-off angle	$-32° - 84.5°$; manually variable in 1.0° steps	
Specimen – analyser angle	$-100°$ to $+100°$	dependent on configuration
Analyser – detector angle	$-100°$ to $+100°$	dependent on configuration
M, S, A crystal setting angles	$-320°$ to $+320°$	
Specimen – analyser distance	470 - 850 mm manually variable	
Analyser – detector distance	780 mm	

Mechanical and software limits may be used to define angular range used.

Collimation

In-pile	MARX MODE	Open
Monochromator – sample		0.37°, 0.74° (with Be filter); 0.18°, 0.37°, 0.5° etc. (no Be filter)
Sample – analyser		Open
Analyser – detector		Open

(NB. S-A 0.33° or 0.66° etc. and A-D 1.0°, 2.0° etc. in CONVENTIONAL 3-AXIS MODE).

Max. Beam Size 50 mm × 50 mm

Detector 50 mm diameter × 500 mm active length
4 atmos. He^3 position-sensitive.

Analogue to digital conversion of signal.

Typically at 4 Å and 6 channels/cm, each channel subtends 3.5' at S and corresponds to 10 μV in energy.

Monitor Low efficiency fission chamber.

Monochromators (R = Reflection; T = Transmission).

Pyrolytic Graphite: (002)R, (004)R etc.

Aluminium: Planes $\perp$ to $[1\bar{1}0]$T.

(It is hoped to supply Germanium (111)T in the near future).

(NB. Monochromators must have high transmission to avoid affecting the long-wavelength diffractometer beam).

Analysers 14" × 2" × 1/16" Pyrolytic Graphite (002)R, (004)R etc. – MARX MODE

3.5" × 2" × 1/16" Pyrolytic Graphite (002)R – CONVENTIONAL 3-AXIS MODE

Other crystals are available 'on loan' if required.

Filters

Cooled 150 mm beryllium filter before sample.

Pyrolytic Graphite ($1\frac{3}{4}$" × 2" × 2"), 3.5 ± 1.5° mosaic, before sample.

Absorbers/Masks

Polythene absorbers of various thicknesses available.

Cadmium masks define beam size between ½" - 2", vertically and horizontally.

Flux at Specimen

2.8×10^5 n cm^{-2} s^{-1} at ~4 Å. (Be-filtered beam).

Background

~25 cts/min – no sample, summed over all channels P.S.D., MARX-MODE.

1.5 cts/min – 3-axis counter in CONVENTIONAL 3-axis MODE.

Range of λ_i,Q,ω

MARX Quasielastic: Typically at λ_i = 4.1 Å, Resolution ~ 150 μV, Momentum transfer ~0.3 Å to 2.3 $Å^{-1}$

Inelastic: Energy transfer 0.3 to ~60 meV (neutron energy loss)

Momentum transfer 0.5 $Å^{-1}$ to 7 $Å^{-1}$

Energy resolution ~3%.

CONVENTIONAL 3-Axis mode – see PLUTO 3-axis for comparable figures.

Specimen Height

25 cm or 18.6 cm above table.

Motors

Printed circuit D.C. motors (simultaneous positioning).

Digitisers

Moore-Reid Contact Digitisers.

Control System

PDP8E computer

CAMAC interface.

Software Programs

Real space or reciprocal space scan input parameters.

Scan mode (MARX) up to 2 points per scan.

up to 84 scans.

(3-AXIS) up to 64 points per scan.

Input: Keyboard or teletype, paper tape or buffered on DEC tape.

User Programs: MARX, DAIS, DAID, DAIT, SIRS, LIM, LINT, PRIN, MANU.

Data Output

High speed printer or teletype.

DEC tape.

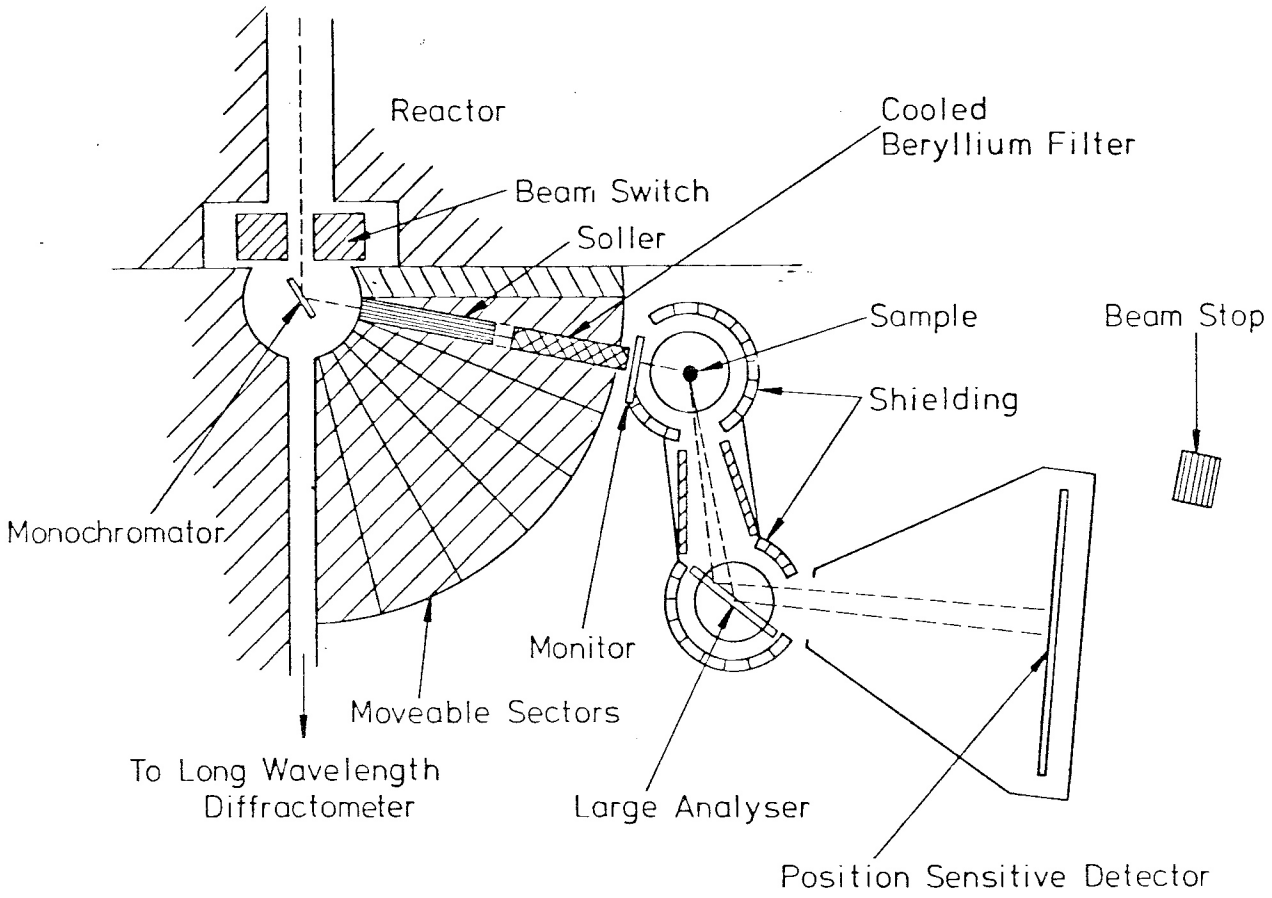
VDU for visual display of P.S.D.

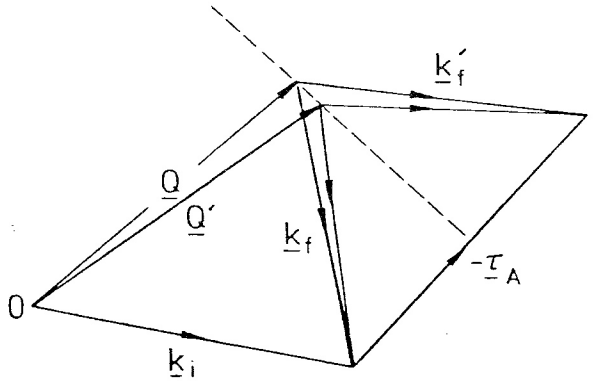
Harwell 6000 Series Units for visual display of total counts.

Ancillary Equipment

Cryostats 4.5 K - 293 K

Furnaces 293 K - 1300 K





AERE - R.9278 Fig. 12
Schematic diagram of PLUTO MARX spectrometer

The Harwell Small-Angle Scattering Spectrometer

Design

The joint Harwell/SRC funded small-angle scattering (S.A.S.) spectrometer is designed to be installed on the 7H2 hole at the PLUTO reactor. The constraint of accommodating the instrument inside the reactor shell means that the overall length is limited to 5m, giving a maximum specimen-detector distance of 2m and a separation of 2m between the collimating aperture plates. A helical slot neutron-velocity selector occupies about 0.7m.

The detector is being manufactured by LETI with 128 × 128 grid elements with 0.5cm spacing as on the D17 instrument at ILL. The counter assembly can be rotated around the specimen position to a maximum of 30°. The neutron beam passes through a cooled beryllium and bismuth filter situated inside the reactor shield thus reducing the fast neutron and γ-ray fluxes. Calculations of the fluxes of the emergent beam ($\lambda > 4$ Å) and of the resolution of the instrument have been made using a basic collimation divergence of 1cm in 2m, a specimen size of 1 cm^2 and assuming the transmission of the filters to be 0.5 and that of the velocity selector 0.33 with a velocity spread of 10%. The calculated figures and comparable ones for D11 with similar resolution are:

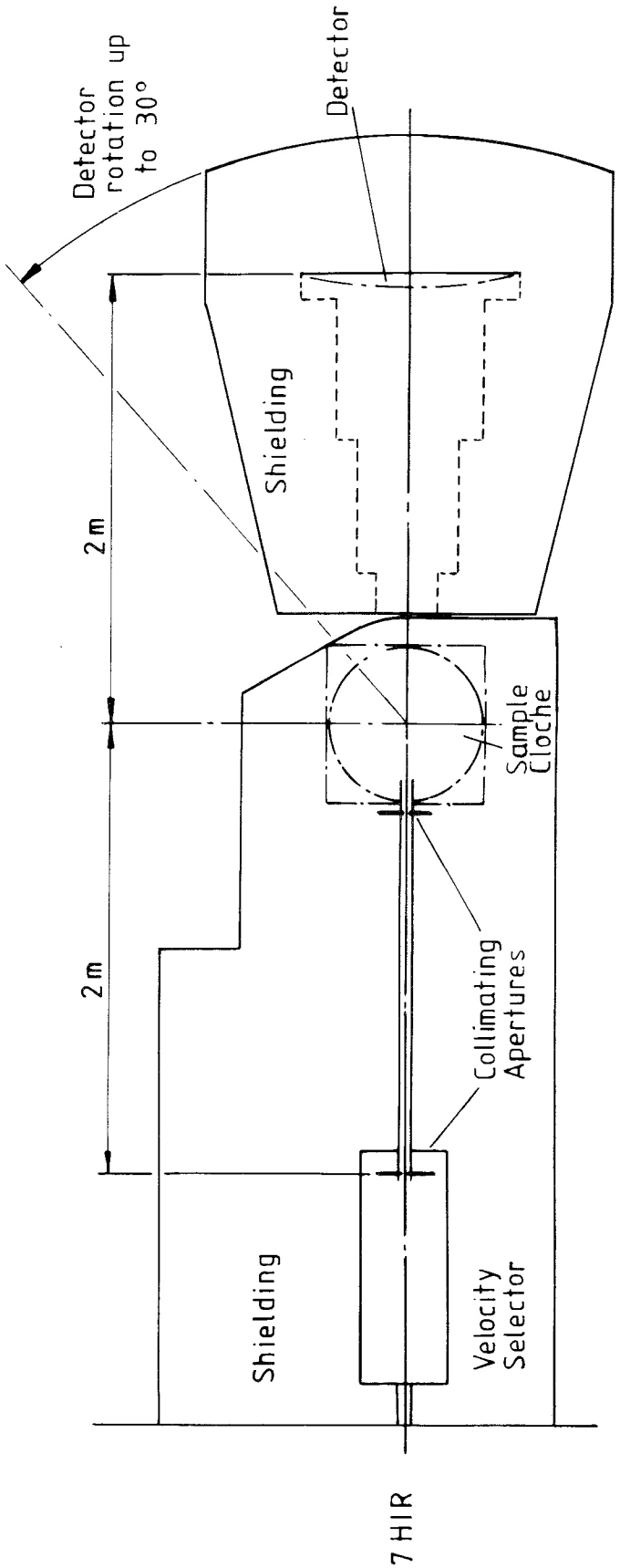
	Flux (n $cm^2 s^{-1}$)		Resolution ($Å^{-1}$)	Q min	Q max ($Å^{-1}$)
λ (Å)	Harwell	Grenoble	Harwell	Harwell	
6	2.8×10^4	4×10^6	7×10^{-3}	2.6×10^{-2}	0.26
10	3.5×10^3	5×10^5	4.4×10^{-3}	1.5×10^{-2}	0.16

Data Collection

It is proposed to use a GT42 display system with 32K words of stores and a 1.2M word disc for data collection from the spectrometer. This will enable some existing software written for the GT44 system at Grenoble to be used directly.

Sample Mounting

The sample chamber is designed to be the same as those on D11 at ILL Grenoble an upright cylinder 350 mm diameter × 850 mm long. It will have a variety of "lids" for holding simple stick samples, cryostats and furnaces.



AERE - R.9278 Fig. 13
Schematic layout of small angle scattering spectrometer plan view

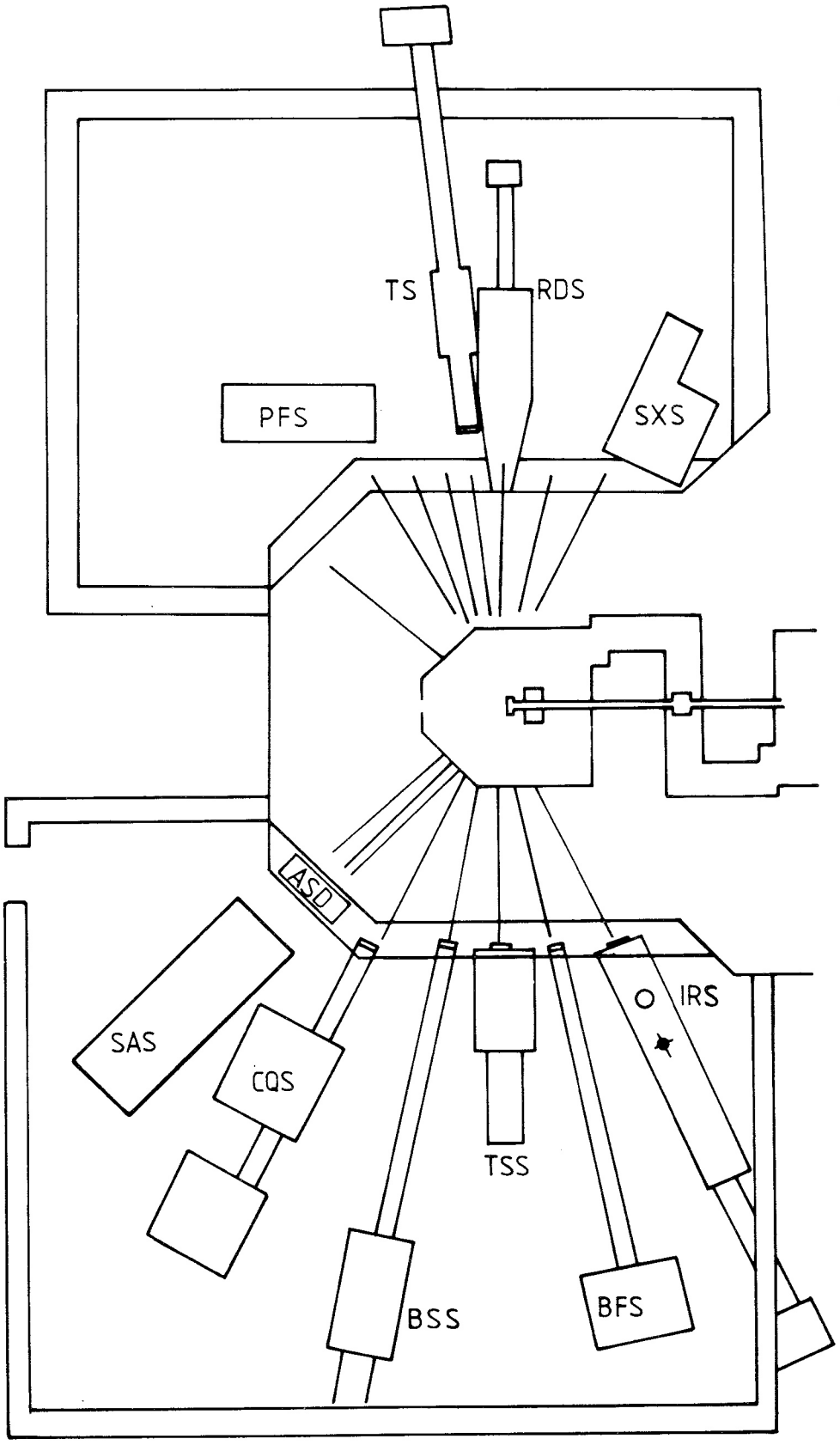
3. LINAC INSTRUMENTS

The Harwell 136 MeV linear accelerator feeds pulses of electrons on to a water cooled heavy metal target in the condensed matter cell. The electrons generate photon bremstrahlung which itself interacts with the target to produce fast neutrons which are then moderated in blankets of hydrogenous material surrounding the target. The mean thermal flux produced at source is estimated at 5×10^{10} n cm^2 s^{-1} and the peak flux is estimated to be 1×10^{13} n cm^2 s^{-1} at a p.r.f. of 150 Hz.

Neutrons from the target pass through any one of 17 beam tubes set in the concrete shield to reach the spectrometers housed in two experimental enclosures (see diagram overleaf). All the instruments operate on the time of flight principle.

The electron beam is time shared with nuclear physics experiments on other cells normally on an alternate pulse basis.

Full operation of the condensed matter cell is expected to commence in April 1979.



AERE - R.9278 Fig. 14
Schematic layout of Harwell linac condensed matter cell

Applications of the Instrument

This instrument is used to measure the structure factor S(Q), or more strictly the differential scattering cross-section $\frac{d\sigma}{d\Omega}(\theta,\lambda)$, for liquids, gases and amorphous solids over a wide Q-range. It can also be used for powder diffraction particularly in the backward angle bank when a high count rate is required.

The downstream fission monitor can be analysed on a time-of-flight scaler to give the energy dependence of the removal cross-section $\sigma_R(E) = \sigma_{ABS}(E) + \sigma_{COH}(E) + \sigma_{INCOH}(E)$ which can be used to aid multiple-scattering and self-shielding corrections and as a cross-check on the sample number density.

Description of the Instrument

The spectrometer consists of a steel detector shield filled with borated wax with a central sample area or well ~0.3 m in diameter.

There are detectors placed symmetrically on each side of the incident beam at angles of 10°, 20°, 35°, 58° and 90°. These detectors have boron-resin defining slits curved to lie on the Debye-Scherrer cone to optimize resolution. The left-hand 90° detector (looking up the beam towards the moderator) has a variable second or scattered flight path but at present the proximity of the TSS to the back-scattering spectrometer makes this a redundant feature.

There is a bank of 7 detectors at the 150° scattering angle. These are arranged in a Q-focussing geometry at an angle of 60.5° to the scattered beam. In addition there are two fission monitors placed at the entrance and exit to the spectrometer. The exit monitor can be time-of-flight analysed to provide additional cross section data.

An evacuable six-position sample changer with vanadium foil windows is available and can be controlled by the PDP-11 computer. Ducting is available for furnace pipes etc. and a removable base plate now permits access from underneath the spectrometer. This feature should permit variable second flight path experiments using a vertically-scattered beam and provide space for the possible future construction of larger sample changers, cryostats and furnaces.

The dimensions of the incoming neutron beam can be defined using boron resin slits available in a range of sizes. Further information concerning the data collection, reduction and archiving programs and the spectrometer is available.

For further information see:

R.N. Sinclair, D.A.G. Johnson, J.C. Dore, J.H. Clarke and A.C. Wright, Nuc. Instr. Meth. 117, 445 (1974).

J.C. Dore and J.H. Clarke, Nuc. Instr. and Meth. 136, 79 (1976).

P.A.V. Johnson, A.C. Wright, R.N. Sinclair, AERE - R 8925 (1978).

D.A.G. Johnson, AERE - M 2757.

J.H. Clarke, AERE - R 8121.

J.H. Clarke, AERE - M 2902.

Total Scattering Spectrometer Instrument Details

Initial flight path = 5.6 m

Second flight path = 0.46 m, variable for 90° left detector

Detector angles = ± 10°, ± 20°, ± 35°, ± 58°, ± 90°, 150°

Monitors Fission detectors before and after sample

Detectors 5 atmosphere ^{3}He, 25 mm diameter

Efficiency $\eta(\lambda) = 1 - \exp(-0.693\lambda)$

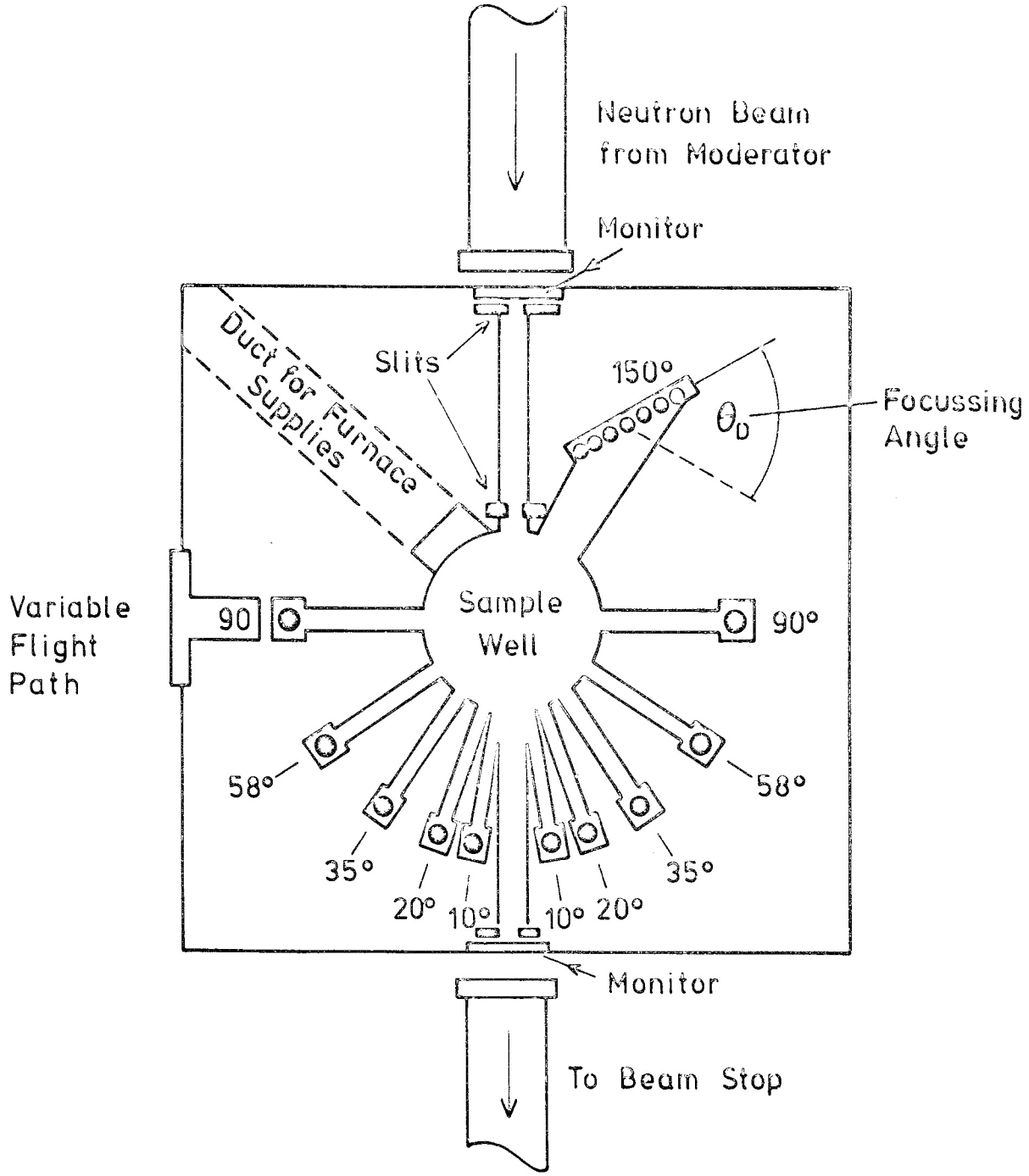
Angle	Detector Aperture Width	Height	Solid Angle	ΔQ/Q Measured	Q min λ = 1.5 Å	Q max λ = 0.2 Å
10	5 mm	85 mm	0.0036 sr	0.2	0.73	5.48
20	5 mm	85 mm	0.0034 sr	0.07	1.45	10.9
35	5 mm	145 mm	0.0056 sr	0.05	2.52	18.9
58	8 mm	250 mm	0.016 sr	0.03	4.06	30.5
90	10 mm	300 mm	0.024 sr	0.015	5.92	44.4
150		300 mm	0.122 sr	0.012	8.09	60.7

150° detector bank

7 detectors, diameter 25 mm, height 300 mm focussing angle

60.5° to radius vector

The parameters listed above relate to the instrument as it was in November 1976. The resolution ΔQ/Q is expected to improve due to the increase in flight path from 4.784 m to 6.06 m. The detector solid angles describe the symmetrical pair of detectors for all angles except 150°.



AERE - R.9278 Fig. 15
Schematic layout of linac total scattering spectrometer Mk.II

The Back Scattering Spectrometer (BSS)

This spectrometer is designed to measure diffraction spectra at a resolution $\Delta Q/Q \simeq 0.003$ at high scattering vectors Q in the range 10 to 30 $\mathring{A}^{-1}$ ($\sin\theta/\lambda \simeq 0.8$ to 2.5 $\mathring{A}^{-1}$). This scattering vector range exceeds that possible by conventional reactor high resolution spectrometers, and is appreciably beyond that practicable by X ray diffraction which is limited by the electronic form factor. The instrument is appropriate for:

(a) Structural parameter refinements from powder samples. The information from the high order peaks enables structural parameters to be obtained by profile fitting techniques to high spatial resolution.

(b) Thermal parameters, including anharmonic contributions. The detailed shape of the Debye-Waller factor at high Q and its temperature dependence enable information to be obtained on the anharmonic coefficients of the atomic potential in which the atoms vibrate.

(c) Crystallite size and strain broadening in alloys. The wide range of scattering vector over which diffraction peak widths may be measured enables estimates to be made of those two contributions. Measurements can be made on minority phases in alloys.

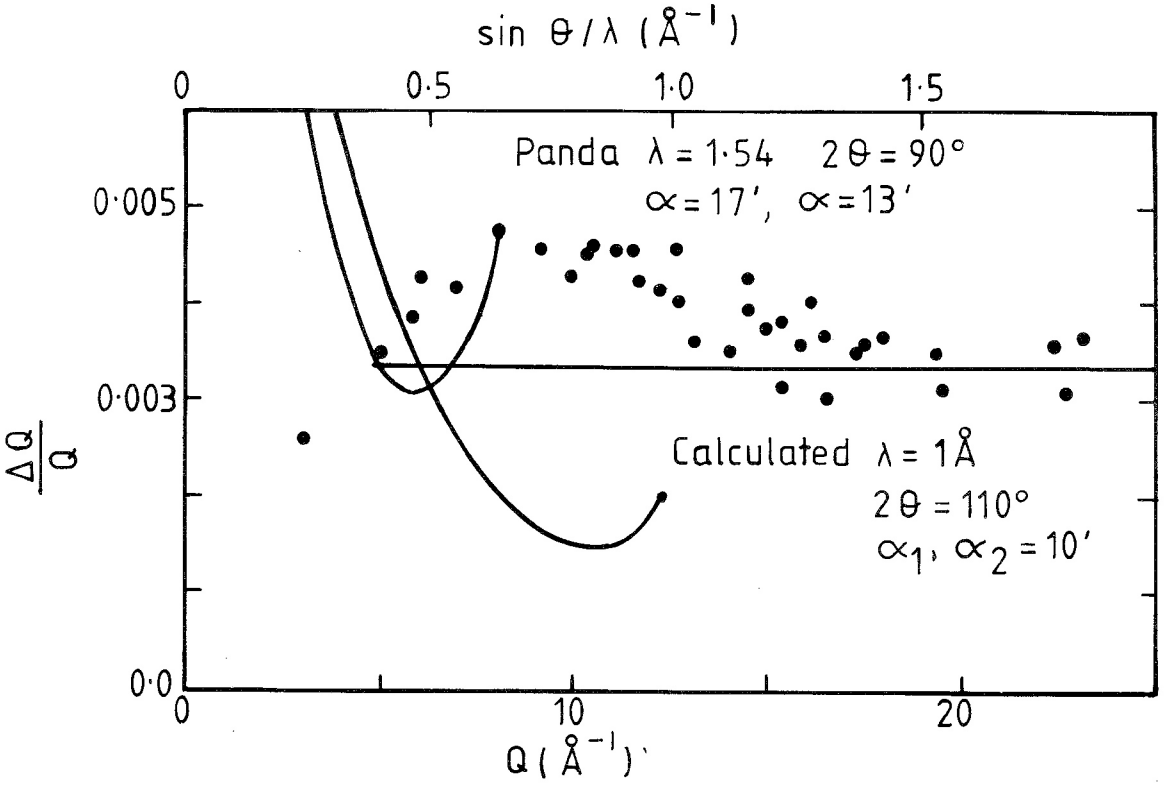
(d) Structure factors S(Q) from liquids and glasses at very high Q.

The instrument has been described in detail in Nuclear Instruments and Method 140 (1977) 241-250. The spectrometer operates by time-of-flight analysis of the pulsed white beam from the LINAC. Time focussing is used so that all neutrons counted may be recorded in a single time-of-flight scan.

A typical sample is a 50×50 mm^2 square plate of thickness calculated to give a 20% scattering power. Good statistics will generally be obtained in about 10 hours counting. For each set of samples, can, background, vanadium, and void runs are required if normalised or absolute cross-sections are required. There is a five position sample changer to facilitate cycling of two samples, can, vanadium and void runs at intervals of 30 min. or so. This can operate at ambient or 77°K temperatures. A furnace to temperatures of order 1000°K is also available. Other sample environments are possible within a 0.5 m diameter only if the vacuum normally around the sample area is dispensed with.

The Back Scattering Spectrometer Instrument Details

Flux at specimen	$\sim 5000/\lambda$ neutrons s^{-1} cm^{-2} $Å^{-1}$
Pulse frequency (variable)	150 Hz
Resolution (see below) ($\Delta Q/Q$)	~ 0.003
Initial flight path	12 m
Scattered flight path	2 m
Scattering angle range (2θ)	165 - 175°
Beam size at specimen	50×50 mm^2



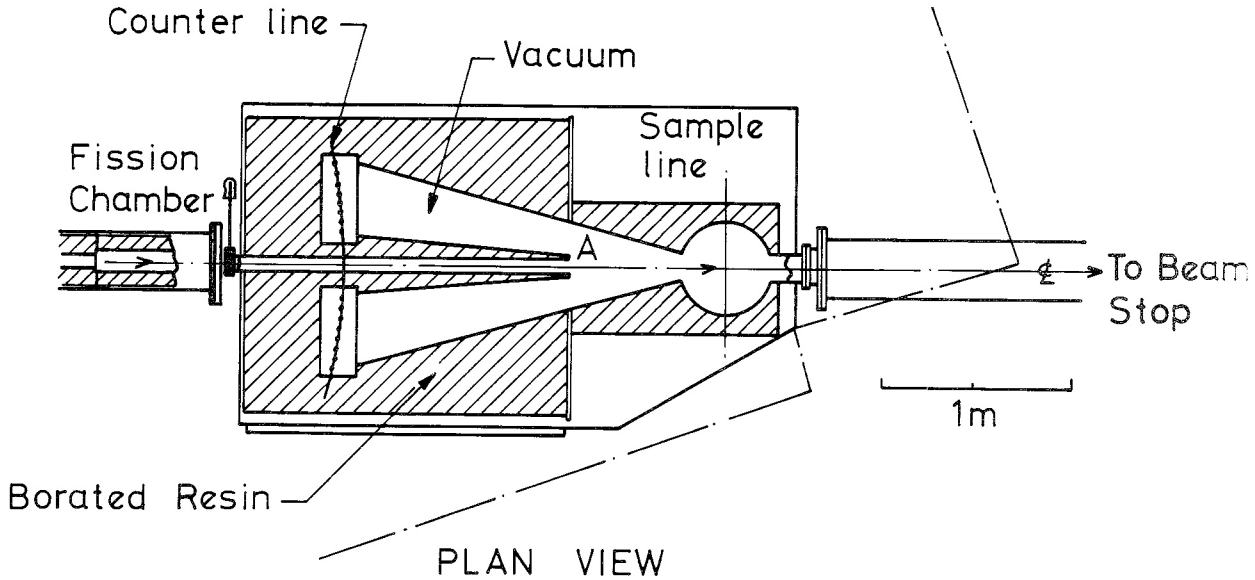
AERE - R.9278 Fig. 16

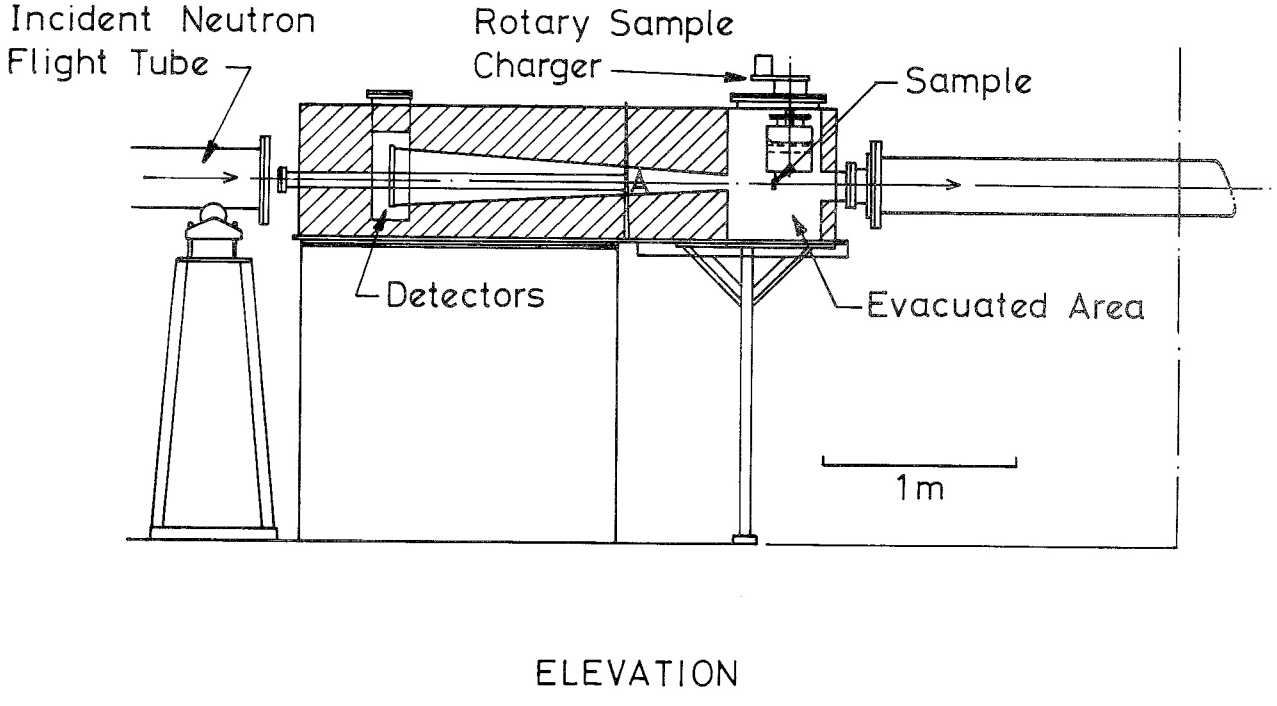
Fig. 16 The points show the resolution of the spectrometer evaluated from the widths of a nickel powder spectrum compared with its calculated resolution $\Delta d/d = 0.0033$. The two parabolas show the experimental resolution from a typical conventional spectrometer, PANDA, at Harwell and the calculated spectrum from a high resolution spectrometer operating at short wavelengths

Warnings

(a) Frame overlap is always a problem. Overlap peaks ($Q < 6$ $Å^{-1}$) can be suppressed by use of an appropriate filter, or profile analysis including overlapped peaks can be employed.

(b) "Soft" molecular crystals often have large thermal parameters and so give a poor signal at high Q.





AERE - R.9278 Fig. 17
Schematic layout of backscattering spectrometer

Active Sample Diffractometer

This instrument is designed as a low resolution inverted time of flight powder/liquids diffractometer. Its main use will be to study active samples either isotopically labelled or containing fissile materials. As the sample sits inside the biological shielding of the target cell it can be used to study samples labelled with tritium (e.g. T_2O). Powder diffraction patterns from gamma active materials (e.g. spent fuel elements) are also possible. Because a time of flight measurement is made the inverted geometry of the diffractometer allows one to observe neutron diffraction patterns of fissile materials. In this respect this diffractometer is unique. The basic principle of operation is shown in Fig. 1a. The white spectrum from the target has a velocity distribution which leads to a time spread of arrivals between t_{min} and t_{max} at the He^3 detector. By placing the sample sufficiently near the target it is possible to separate the band of fission neutrons from the sample which arrive at times t_{F1} to t_{F2} from the elastically scattered neutrons which arrive later. Delayed fission neutrons will still contribute to the background. Frame overlap will also be a problem for very large t_{max}.

A schematic layout of the apparatus is shown in Fig. 1b. One He^3 detector is situated at the end of a shielded secondary flight path which penetrates the biological shielding of the target cell. The sample position is approximately one metre from the target assembly. Although there is some shielding around the sample position it will still receive a high dose of both gamma radiation and fast neutrons.

Active Sample Diffractometer Instrument Details

Initial flight path	1.6 m
Second flight path	5.0 m
Detector angle	155°
Detector	5 atmos. ^{3}He, 25 mm dia.
Flux at specimen	To be measured
Background	To be measured

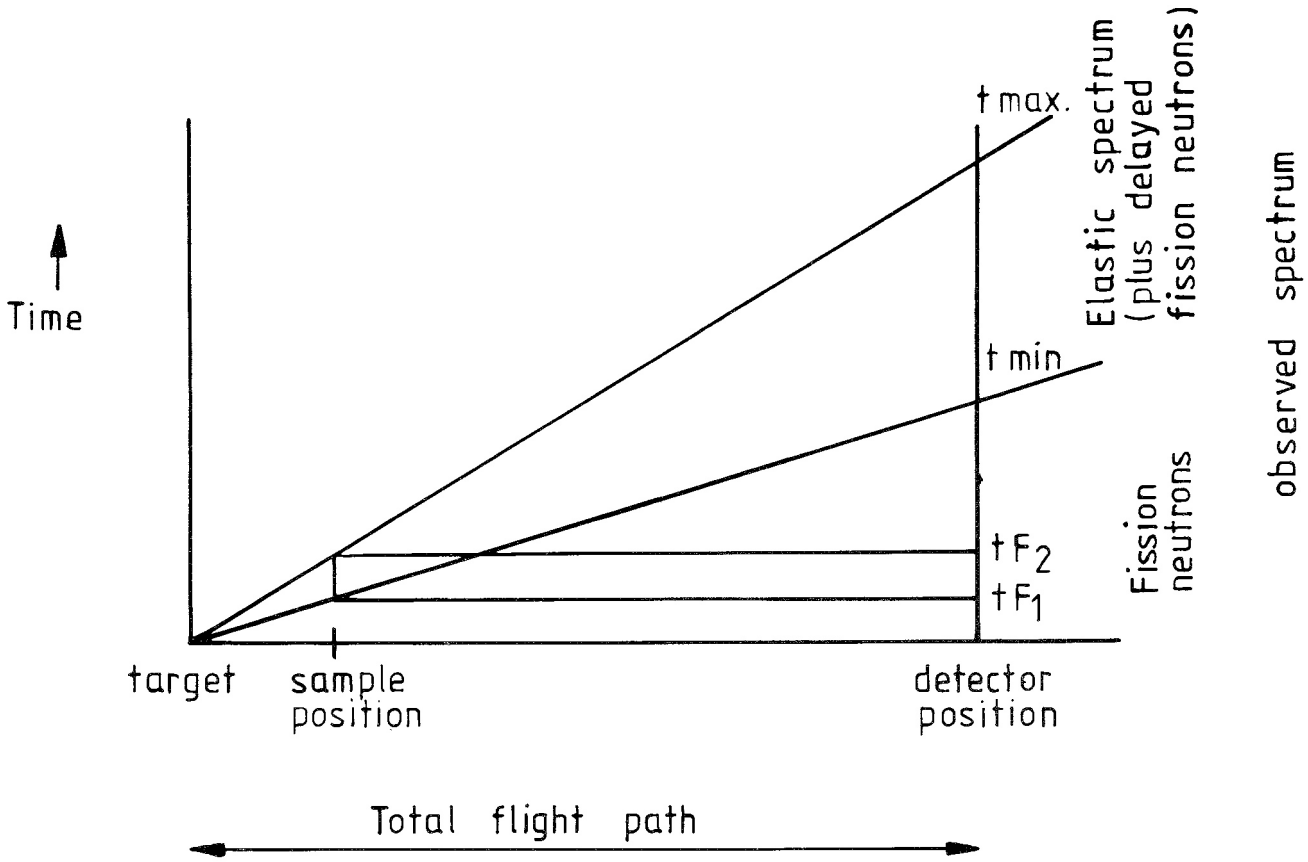


FIG. 1a. TIME OF FLIGHT SPECTRUM FOR FISSILES SAMPLES

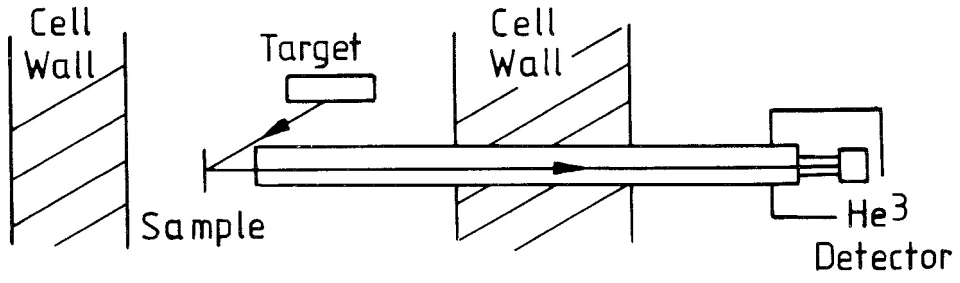


FIG. 1b. SCHEMATIC LAYOUT

AERE - R.9278 Fig. 18
Active sample diffractometer

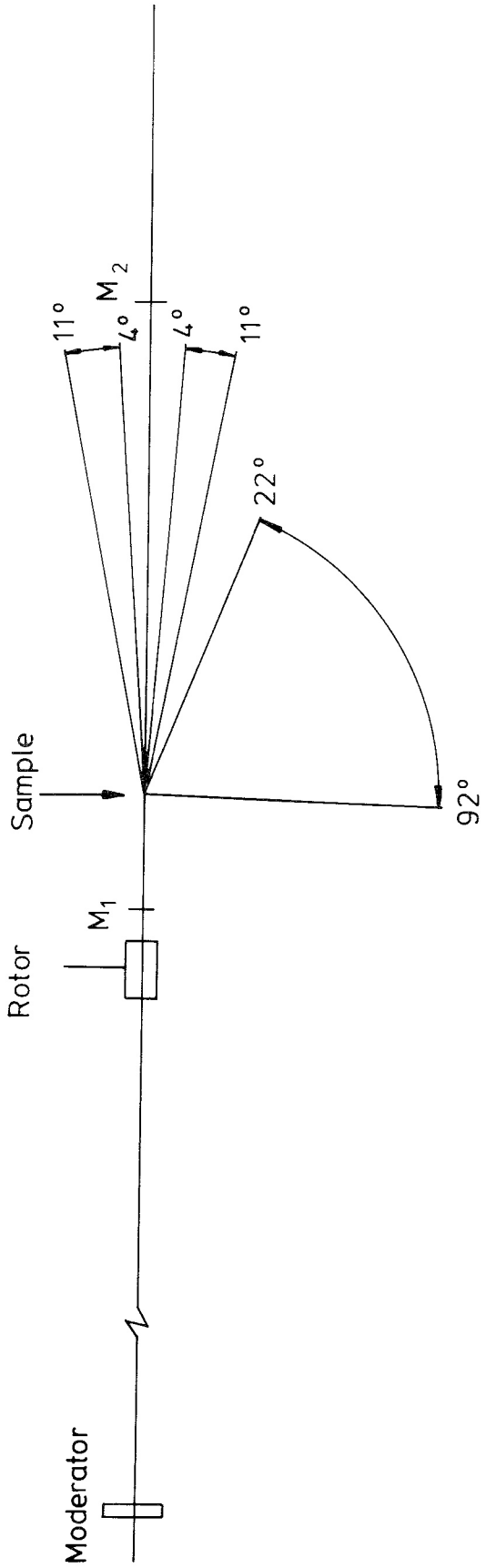
Inelastic Rotor Spectrometer (I.R.S.)

The inelastic rotor spectrometer at the Harwell LINAC is primarily designed to measure $S(Q,\omega)$ in the region of high energy transfer and low momentum transfer to study the atomic motions in liquids, internal vibrational modes in molecular systems and high frequency magnetic excitations. In addition counter banks will be installed to allow medium and high momentum transfer measurements at high energy transfer to be made.

The spectrometer views the moderator through an evacuated flight tube at an angle of 25° to the moderator normal. It comprises a Nimonic rotor placed at 6 metres from the moderator, an evacuated sample chamber 1 metre beyond the rotor and a detector assembly. Initially this assembly will consist of banks of 2 He^3 counters placed at 22° - 92° scattering angle in steps of 10° below the sample at 1.6 m. It is proposed to add a low angle counter bank spanning 4° - 11° during 1979. Fission chambers placed along the direct beam after the rotor enable the incident energy and energy transfer resolution to be determined. The instrument is linked to the LINAC data accumulation system where the data are time analysed and stored on disc and magnetic tape.

Inelastic Rotor Spectrometer Instrument Details

Source of neutrons	$\sim 200\ cm^2 \times 4$ cm thick polyethylene moderator
Rotors	12 slot Nimonic
	(1) $\frac{NS}{TS}$ = 20 Peak Transmission 0.28 eV
	(2) $\frac{NS}{TS}$ = 27 Peak Transmission 0.50 eV
Moderator – Rotor distance	6m
Rotor – Sample distance	1m
Sample – Detector distances	2.5m (4°-11°), 1.6m (22°-92°) 2.6m (140°)
Detectors	He^3 proportional counters of 4 atmospheres and 5 atmospheres pressure
Beam size of sample	5 cm × 2.5 cm
Flux at sample	To be measured
Background	To be measured
Momentum Transfer Q for 0.14 eV energy transfer and 0.28 eV incident energy at 5° scattering angle	$3.5\ \mathring{A}^{-1}$
Scattered neutron energy resolution for 0.14 eV energy transfer at 0.28 eV incident energy	5.7% (8.0 meV)



AERE - R.9278 Fig. 19
Schematic layout of inelastic rotor spectrometer

The Constant Q Spectrometer (CQS)

This spectrometer is designed for measuring excitations in a single crystal sample by providing a closely spaced energy scan at a fixed scattering vector $\underline{Q}$. (Additionally, it provides full $S(\underline{Q},\omega)$ information along a line in reciprocal space.)

The instrument is appropriate for

(a) Phonon and vibrational spectroscopy studies in the energy range 20 to 350 meV. The higher energy range is particularly favoured because of the relatively high epithermal pulsed flux, and the absence of a monochromator crystal.

(b) Magnetic excitation studied in the energy range 20 to 200 meV. The range here is determined by the minimum scattering angle (ϕ = 15°), and a restriction $Q < 5$ Å^{-1} caused by the form-factor.

The principles of the spectrometer have been described (Nucl. Inst. Meth. 1978). The constant Q scan is possible over only a limited energy range determined by the minimum and maximum scattering angle ϕ, and the analyser spacing d

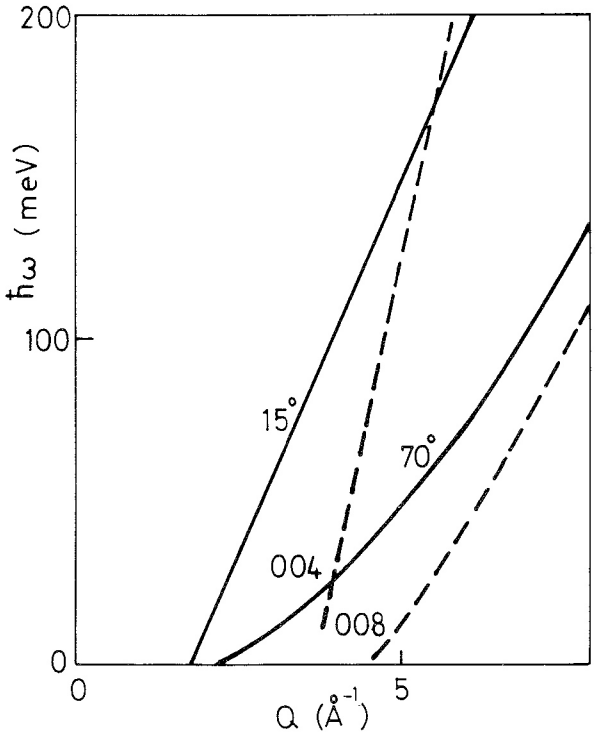
$$\hbar\omega = \frac{\hbar^2}{2m}\left[Q^2 - \frac{2\pi^2}{d^2} + \frac{2\pi}{d} \cdot \sqrt{Q^2 - \frac{\pi^2}{d^2}} \cdot \cot\phi\right]$$

Figure 1 sketches this range for pyrolytic graphite 004 and 008 planes. The spectrometer designed for the Harwell Linac has a counter every ½° allowing 9 energy points between each line shown. The use of a Germanium crystal in transmission geometry allows rapid change of analyser d spacings. The spectrometer well is designed to contain a CT14 cryostat.

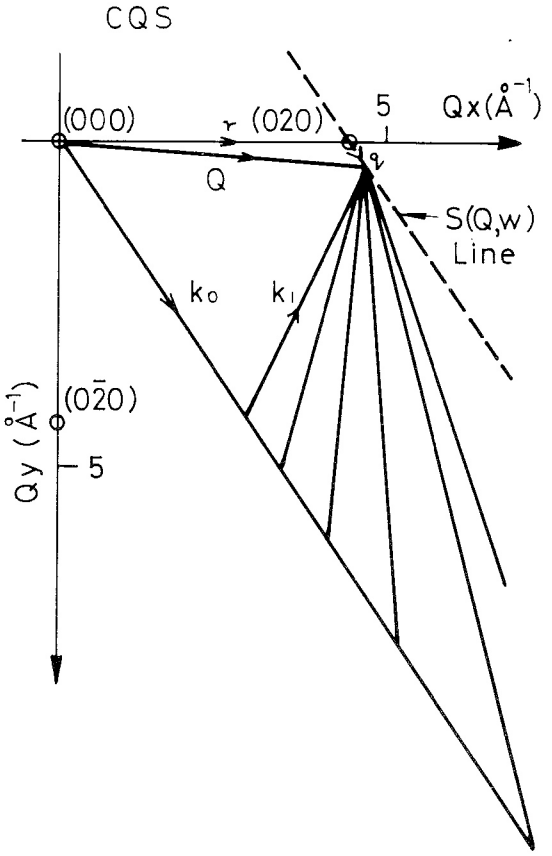
The resolution function of the spectrometer has been evaluated in detail. (Nucl. Inst. Meth., to be submitted). With an 8 m incident flight path and moderate scattering angles, energy resolution is comparable with a triple axis spectrometer. For example $\Delta\hbar\omega \simeq 4$ meV for $\hbar\omega = 120$ meV. The Q resolution ellipsoid is orientated so that it lies in practice almost parallel to k_o.

The Constant Q Spectrometer Instrument Details

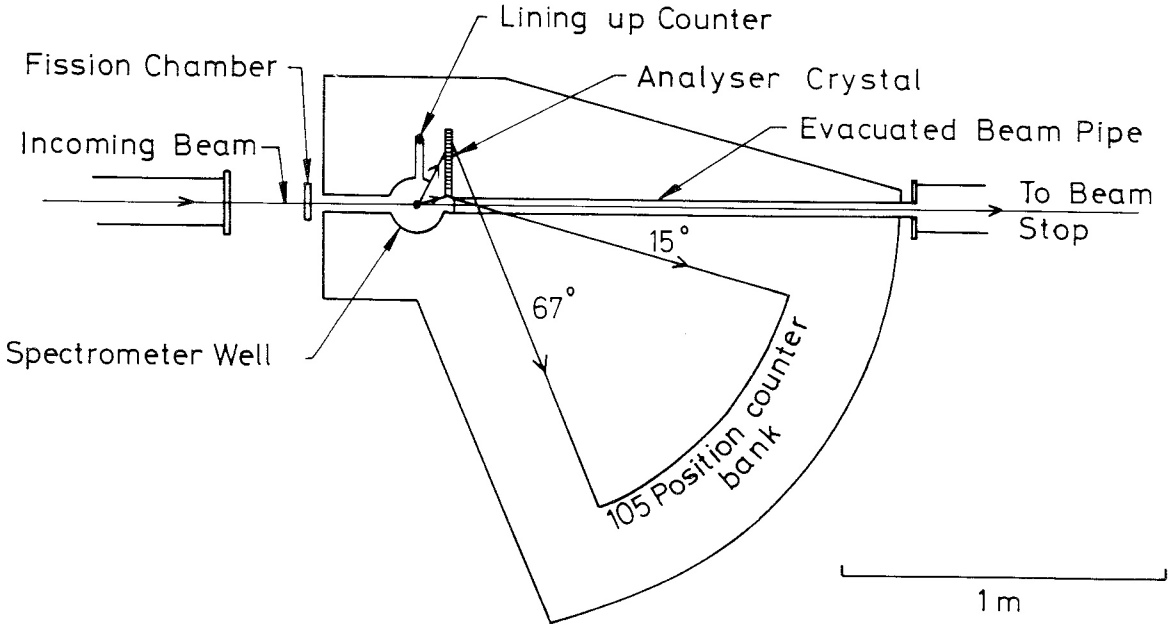
Incident flight path	8 m
Scattered flight path	1.29 m 15° minimum scattering angle
	1.56 m 67° maximum scattering angle
Counter bank	50 element scintillator bank (½° spacing)
	20 element ^{3}He detector array
Beam size at specimen	30×60 mm^2
Optimum sample area	10×40 mm^2
Sample well diameter	160 mm
Sample orientation	± 15° (by motorised arcs)
Intensity at sample	$2300/E_o$ ns^{-1} cm^{-2} (eV)$^{-1}$ Harwell (exp)



AERE - R.9278 Fig. 20
The allowed regions of (Q,ω) space for graphite spacings



AERE - R.9278 Fig. 21
Typical scattering triangles iron (100) plane: $q_{110} = 0.5 Å^{-1}$



AERE - R.9278 Fig. 22
Spectrometer layout

The constant Q spectrometer

Future Instruments on LINAC

Additional instruments for the LINAC are being considered for installation in 1979 and 1980. These are:

(i) A Resonance Detector Spectrometer (RDS) to measure inelastic neutron spectra in the range 0.5 to 1.5 eV over a Q vector range 3 $\mathring{A}^{-1}$ to 8 $\mathring{A}^{-1}$.

(ii) A Transmission Spectrometer (TS) for the measurement of scattering cross sections.

(iii) A Small Angle Scattering (SAS) Instrument.

(iv) A Beryllium Filter Spectrometer (BFS) to measure high energy molecular modes (0.08 to 0.3 eV) at approx. 10% energy resolution.

In addition the following two spectrometers will be installed by the Rutherford Laboratory.

(v) A Single Crystal Spectrometer (SXS) for structural studies.

(vi) A Polarisation Filter Spectrometer (PFS) employing the polarised filter technique.

4. ANCILLARY EQUIPMENT

(a) Cryostats

Title	Size	Tail Material	Temp. Range	Remarks
C.T.14 No. 1 No. 2 No. 3 No. 4	1¾" dia. × 2"	Aluminium	4.2°K - 300°K Variable	Single Crystal or Powder
C.T.18	1¾" dia. × 2"	Aluminium	77°K - 300°K Variable	Single Crystal or Powder
Oxford Inst. No. 1 No. 2	1" dia. × 2"	Vanadium	4.2°K - 300°K Variable	To be used with Vanadium Sample Cans for Powder Work
Thor Cryogenics	1" dia. × 2"	Vanadium	4.2°K - 300°K Variable	To be used with Vanadium Sample Cans
Oxford Instr. 4 Circle	10 mm dia. × 20 mm	Aluminium	10.0°K - 300°K	Used on 4 circle Diffractometer only
Oxford Instr. Cold Finger	2" dia. × 2"	Aluminium	10°K - 300°K Variable	Used on 4H5 Facility
Be Filter MK I	100 mm dia.	Aluminium	10°K - 300°K Variable	Used on MARX Spectro-meter
Be Filter MK II	100 mm dia.	Aluminium	10°K - 300°K Variable	Used on Be Filter DIDO
BOC "PANDA"	1" dia. × 3"	Vanadium	Fixed 4.2°K	Used on Powder Diffractometers
BOC No. 1 Closed Top	2" dia. × 2"	Vanadium	Fixed 4.2°K	Used on Powder Diffractometers
BOC No. 2 Closed Top	1¾" dia. × 3"	Aluminium	Fixed 4.2°K	Used on Powder Diffractometers
BOC Open Top	1¾" dia. × 3"	Aluminium	Fixed 4.2°K	Used on Powder Diffractometers
TBT Van. Tail	¾" dia. × 3"	Vanadium	Fixed 4.2°K	Used on Powder Diffractometers with Van. Cans
TBT	½" dia. × 4"	Aluminium	Fixed 4.2°K	Used on MK VI Diffractometers
HOFFMAN	Gas Deposition	Aluminium	Fixed 4.2°K	Used for Gas Deposition Experiments

(b) **Superconducting Magnets**

Title	Dimension of Specimen Volume	Specimen Temperature	Remarks
Thor Cryogenics 60 KOe Vertical Field	22 mm dia. × 30 mm	Variable 4.2-300°K	Used on Powder Diffractometers (Top Loading)
Oxford Instr. 40 KOe Vertical Field	20 mm bore	Fixed 4.2°K	
Oxford Instr. 10 KOe Horizontal Field	1½" dia. × 2"	Fixed 4.2°K	

(d) **Electromagnets**

1. Vertical or horizontal field ~3 KOe up to 3 × 3 cm giving a wide range of scattering angles.
2. Vertical field 12 KOe 1½" high sample.
3. Horizontal field 15 KOe 1½".
4. Vertical field 16 KOe 1" sample.

(d) **Furnaces**

1. Two 500°K furnaces with 3 position sample alternation for use on the DIDO time of flight spectrometer.
2. 1800°K furnace for use on the PANDA powder diffractometer.
3. 1200°K furnace for single crystal studies on the DIDO time of flight spectrometer.
4. 1200°K furnace for use on triple axis instruments.
5. 2 Standard Harwell 1300°K furnaces with Al bodies for use on most instruments.
6. 1000°K stainless steel furnace for use on the PLUTO triple axis spectrometer.
7. Small 500°K furnace with arcs. Mainly for use on the CURRAN instrument.