EXPERIMENTAL FACILITIES

Laboratoire Léon Brillouin

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LIST OF AVAILABLE INSTRUMENTS

Powder diffractometers

3T2 "Thermal neutrons" 2-axis (20 detectors) high resolution, mainly for nuclear structure determination.

G4.1 "Cold neutrons" 2-axis (multidetector 800 cells) high flux, mainly for magnetic structure determination.

G4.2 "Cold neutrons" 2-axis (7x10 detectors) high resolution, for structure determination on polycrystalline samples with large unit cell.

MICRO (G6.1) "Cold neutrons" 2-axis (multidetector 400 cells) with long wavelength (~5Å) and high flux, for the study of very small powder samples (<1mm^3). Very high pressure cell available (40 GPa).

Single crystal diffractometers

5C1 "Hot neutrons" 2-axis with lifting arm, polarized neutrons, magnetic field (8 Tesla) for spin-density maps determination.

5C2 "Hot neutrons" 4-circle for nuclear structure determination.

6T2 "Thermal neutrons" 2-axis, lifting arm and 4-circle, mainly for magnetic structure determination. 8 Tesla magnetic field available.

Diffuse scattering instruments

7C2 "Hot neutrons" 2-axis (multidetector 640 cells) for local order studies in liquid or amorphous systems. Cryostat and furnace available (1.2K to 1300°C).

G4.4 "Cold neutrons" 2-axis (48 detectors, elastic/inelastic discrimination by time-of-flight technique) for local order studies in single crystals. Furnace available (1400°C).

Small-angle scattering instruments

PACE (G1.1) "Cold neutrons" (annular detector, 30 rings) for study of large scale structures in isotropic systems (mainly polymers and colloids).

PAXY (G2.3) "Cold neutrons" (X-Y detector, 128x128 cells) for study of large scale structures (10 to 500 Å) in anisotropic systems (polymers under stress, metallurgical samples, vortex in superconductors…).

PAXE (G5.4) "Cold neutrons" (X-Y detector, 64x64 cells) for multipurpose. Studies of large scale structures.

PAPOL (G5.5) "Cold neutrons" (X-Y detector, 64x64 cells), polarized beam. Large scale magnetic structure ; contrast variation by nuclear polarization of protons.

Diffractometers for material science studies

6T1 "Thermal neutrons" 4-circle for texture determination.

DIANE (G5.2) "Cold neutrons" 2-axis for internal strain determination in bulk samples with spatial resolution ~ 1mm^3.

Reflectometers

EROS (G3 bis) "Cold neutrons" reflectometer operating in time-of-flight mode for multipurpose surface studies.

PRISM (G2.4) "Cold neutrons" reflectometer with polarized neutrons and polarization analysis for the study of magnetic layers.

Triple-axis instruments

1T "Thermal neutrons" high-flux spectrometer with focusing monochromator and analyzer, mainly devoted to phonon dispersion curves measurements.

2T "Thermal neutrons" high-flux 3-axis instrument with focusing monochromator and analyzer, mainly devoted to spin-waves and magnetic excitations studies (1.5 to 80 meV). Very high pressure cell (100 Kbar) available.

4F1 "Cold neutrons" high flux 3-axis instruments with double monochromator and analyzer, mainly devoted

4F2 to the study of low-energy (15µeV to 4meV) magnetic excitations. Polarized neutrons and polarization analysis option available.

G4.3 "Cold neutrons" high resolution and low background 3-axis instrument, mainly devoted to elastic diffuse scattering studies.

Quasi-elastic instruments

MIBEMOL (G6.2) "Cold neutrons" high resolution (~15µeV at 10Å) time-of-flight instrument for the study of low energy excitations, mainly in disordered systems.

MESS (G3.2) "Cold neutrons" small-angle high resolution spin-echo instrument, for the study of slow dynamics (Fourier time ~40 ns) of disordered matter (movement of large molecules in biology or physical chemistry, relaxation of magnetic moments).

MUSE (G1 bis) Cold neutrons, high resolution and high flux spin-echo instrument. It can study, in a large Q range, slow dynamics of large molecules in biology or long relaxation times like in glassy transition (Fourier times ≈ 20ns).

INTRODUCTION

ORPHEE is a nuclear research reactor which has been specially designed to produce intense neutron beams. It is linked to the Laboratoire Léon Brillouin (LLB, managed jointly by the CEA and the CNRS) who is in charge to build and run a set of spectrometers in order to offer the scientific community access to the neutron scattering technique.

The purpose of this booklet is to help the experimentalist when he considers the possibility of performing a neutron scattering experiment and when he writes the proposal.

The first part gives the main characteristics of the reactor and of its different moderators (thermal, hot and cold source).

The second and main part gives the performance of all spectrometers and the available sample environment.

At last, we give some recommendations and main rules to follow when submiting a proposal.

All informations about how to access our facility can be obtained from :

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THE REACTOR AND THE NEUTRON SOURCES

THE REACTOR

ORPHEE is a swimming pool type reactor with a thermal power of 14 MW and a neutron flux of 3.10^{14} neutrons $cm^{-2}s^{-1}$. The main components of the reactor are shown in figure 1.

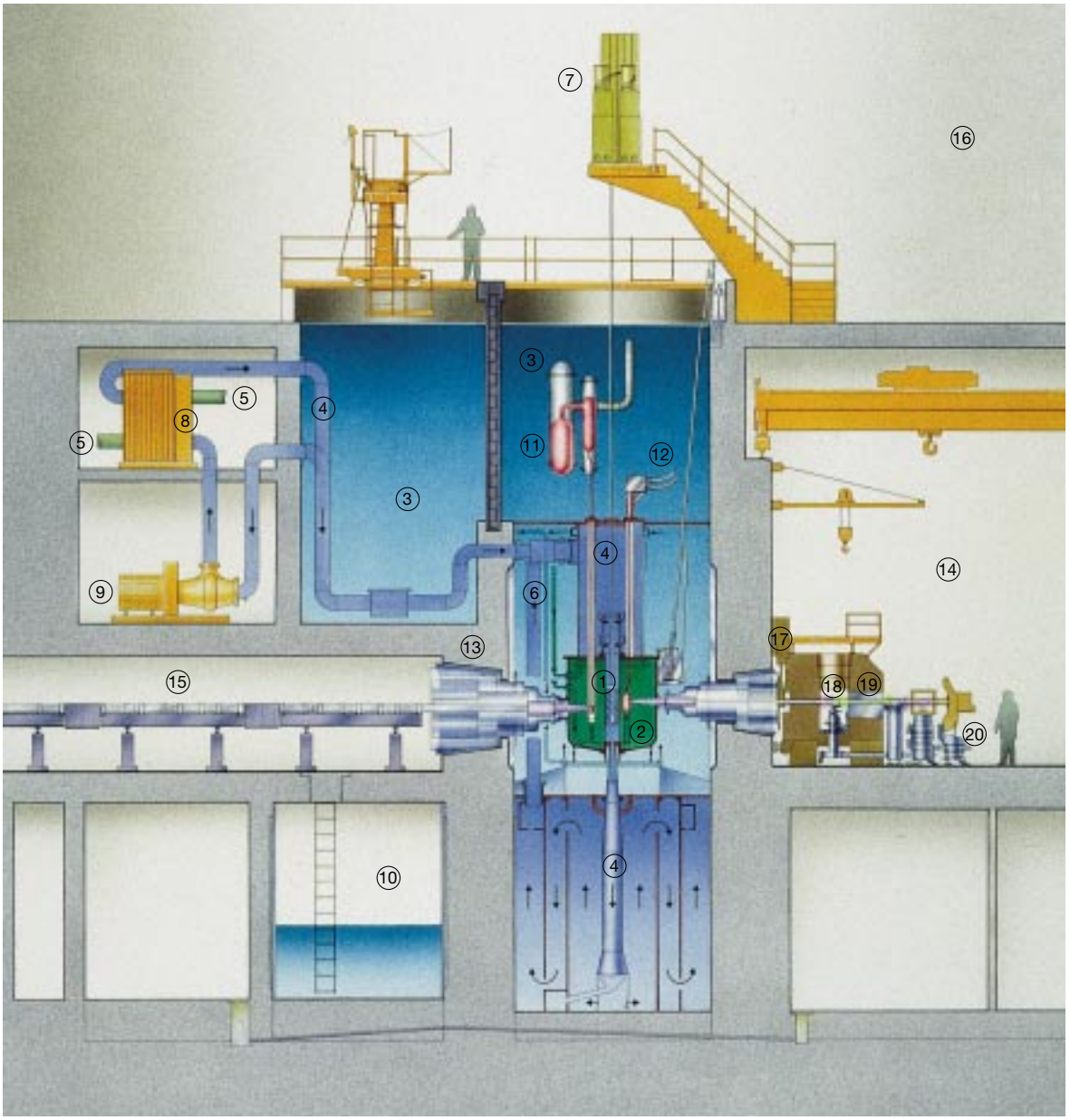


Figure 1: vertical cut of the reactor and its cooling circuit.

1. Core
2. Heavy water reflector
3. Pool and transfer channel
4. Primary circuit
5. Secondary circuit
6. Heavy water circuit
7. Command mechanism of the control rods
8. Exchanger
9. Pump
10. Drainage tank for the pool
11. Cold source
12. Hot source
13. Tangential tubes
14. Experimental hall
15. Neutron guide
16. Hall for access to reactor pool
17. Fixed primary protection
18. Monochromator
19. Protection of the monochromator
20. Spectrometer

THE CORE

The core is very compact. It is housed in a zircaloy parallelepipedic enclosure with a square section (25 x 25 cm^2) and an active height of 90 cm.

It consists of 8 assemblies of parellel plates (fuel elements) made from a fissile material (an aluminium - uranium alloy, the latter enriched in ^{235}U) which are arranged around a central beryllium reflector.

The division of the fuel elements into thin plates (1.27 mm) separated by narrow channels of water (2.1 mm) produces a very large surface for thermal exchange per unit volume (on the order of 0.6 m^2 per dm^3), yielding an elevated specific power. This is the main condition for the production of a significant neutron flux.

The total mass of uranium 235 of the core is less than 6 kg.

The core is renewed every 100 days.

The control of the reactivity is accomplished by means of vertically moving control rods consisting of neutron absorbing plates (Hafnium).

The core is placed in a reflector of heavy water circulating from bottom to top in a stainless steel vat. The biological protection is ensured by light water, contained in a pool measuring 15 m high and 4.5 m diameter. The pool is surrounded by a 1.50 m thick concrete wall. The total diameter of the reactor block is 7.50 m.

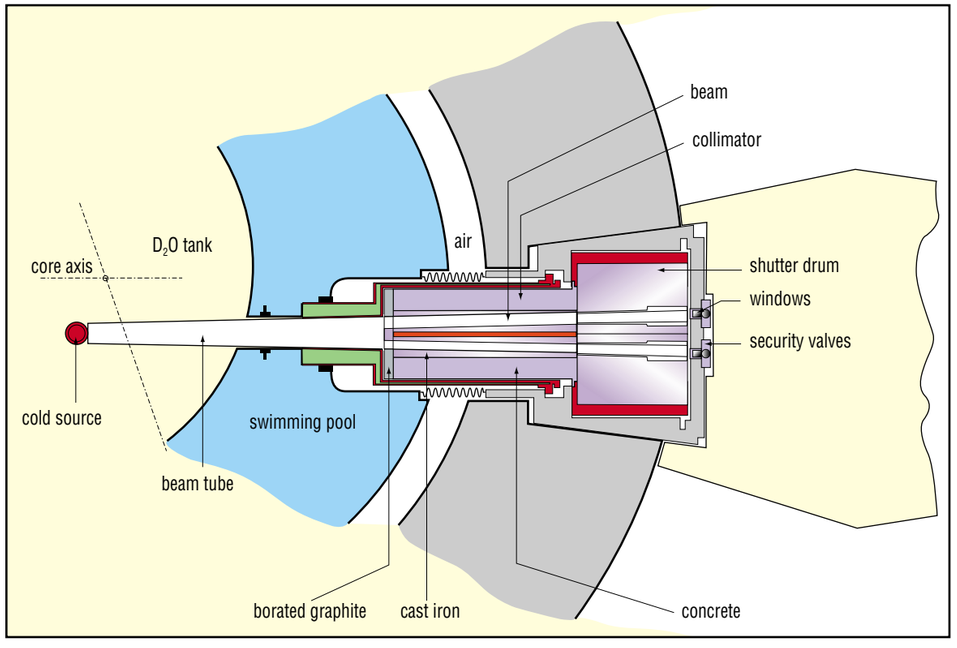


Figure 2: horizontal cut of a beam hole.

THE BEAM TUBES

The reactor is equipped with 9 horizontal tubes, tangential to the core, allowing the use of 20 neutron beams. The "nose" of these tubes is situated in the moderator near the core, where the flux of thermalized neutrons is maximum. Three tubes are viewing the two "cold sources", two other tubes a "hot source".
It is thus possible to select the spectrum of neutrons that is best adapted to the desired use.

Six cold beams are extracted to an adjoining hall (neutron guide hall) by "neutron guides" emerging from the reactor building.

Nine vertical tubes are used to irradiate different samples for activation analysis. The samples are sent by a pneumatic connection to the Pierre Süe Laboratory, a joint facility of the CEA and the CNRS.

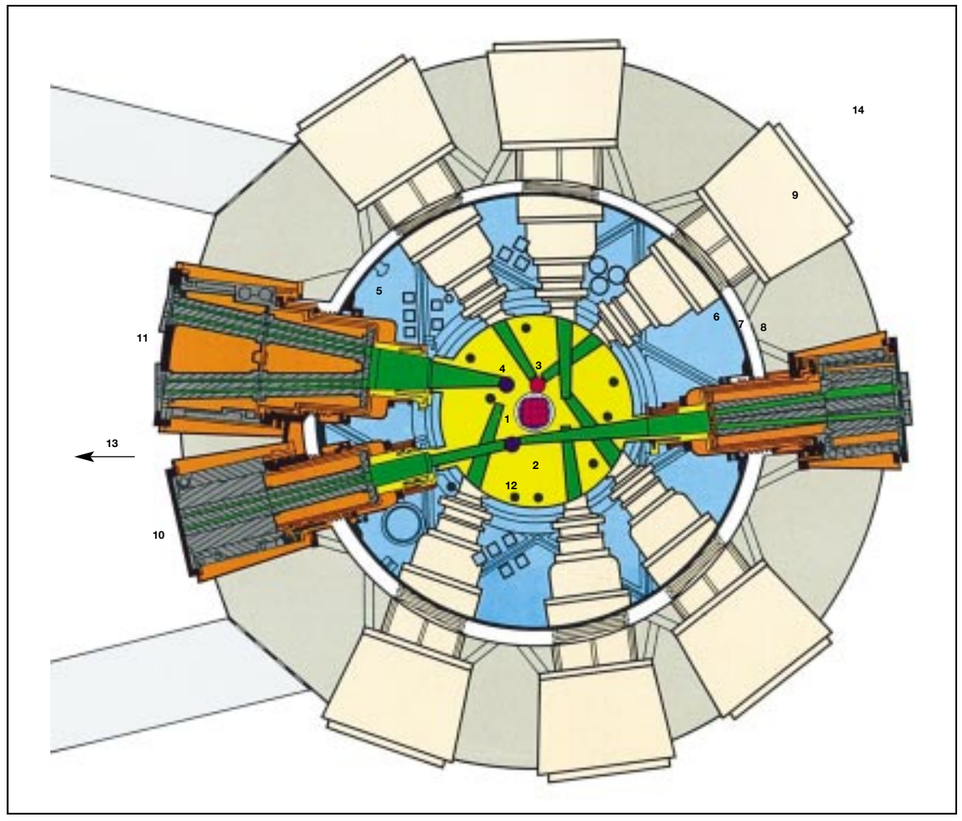


Figure 3: horizontal cut of the reacteur block at the beam hole level.

1. Core
2. Heavy water reflector
3. Hot source
4. Cold source
5. Pool
6. Pool inner wall
7. Annular space
8. Pool outer wall
9. Single tube
10. Single tube
11. Double tube
12. Vertical tube
13. Neutron guide hall
14. Experimental hall

THERMALISATION OF NEUTRONS

ORPHEE has been designed to produce a high thermal neutron flux at neutron energies ~25 meV. Nevertheless, many experiments need higher (~ 100 meV) or lower (~ 5 meV) neutron energies. They may be obtained from secondary moderators, placed inside the principal moderator where they create local conditions which modify the average energy.

1 - The principal moderator :

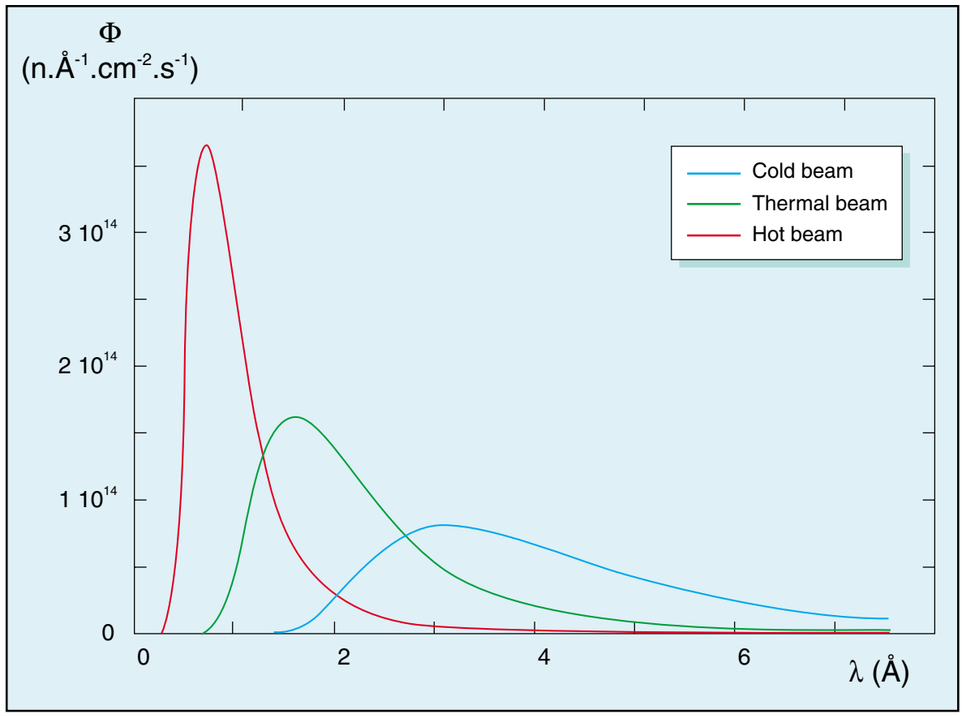
It is a cylindrical heavy water tank, 2 meters high and 2 meters diameter. The mean temperature of the water is kept around 50°C. With such a moderator, the localisation of the maximum of the thermal flux is sufficiently far enough from the core to prevent any overheating of the "nose" of the beam tubes. Also, many beam tubes can be inserted since there is a large volume over which the neutron flux varies only slightly. The distance from the nose of the thermal beam to the core axis is 360 mm.

2 - The cold sources :

The moderator is liquid hydrogen. The hydrogen is entirely confined in a close-loop. In the upper part, the gas is condensed by thermal contact with liquid helium. Thermosiphon phenomena ensure the circulation of the liquid to provide in fresh liquid the hydrogen cell.
Inside the heavy water tank we have two cold sources SF1 and SF2 with closely related geometry : the liquid occupies the volume between two cylinders of 100 and 130 mm diameter. The total height of the internal volume is 200 mm (SF1) and 300 mm (SF2) respectively.

3 The hot source :

It is a cylinder made of graphite, 122 mm diameter and 208 mm high. It is only heated by the γ ray flux produced by the reactor. Thermal isolation is obtained from several thermal screens (of graphite), the whole device being enclosed in a double wall container (in zircaloy). The operating temperature is 1400 K.



Differential flux (per Å) given by local moderators.

		T Y P E	FLUX (10^9 n.cm^{-2}.s^{-1})_
CHANEL	BEAM		
1T	1	Thermal	3.93
4F	2	Cold	17.5
7C	2	Hot	7.52
8F	G1	Cold	0.99
	G 1bis	Cold	0,71
	G2	Cold	1.26
	G3	Cold	1.61
	G 3bis	Cold	1,5
	G4	Cold	0.91
9F	G5	Cold	1.88
	G 5bis	Cold	1.22
	G6	Cold	2.07

**** The measurement has been made by activation of a gold foil. The flux is measured at the monochromator position for 1T, 4F and 7C and at the end of guide position for the 8F and 9F tubes.***

THE NEUTRON GUIDES :

The propagation characteristics of the wave associated with a neutron involves the refractive index "n" of the medium, which depends on its chemical composition. At an interface, the passage from a medium with index "n_1" to a medium with index "n_2" will involve a change in the direction of propagation and, under certain conditions ($n_2<n_1$; incident angle < critical angle), the wave will not be able to pass through : it will undergo total reflection. The critical angle depends on the difference (n_2-n_1) and on the wavelength of the neutron. This phenomenon, well known for electromagnetic waves (optical fibers), is used to transport neutrons without loss over distances covering several tens of meters. The guide is a hollow tube made of thick glass whose internal walls are polished and covered with a layer of nickel. However, the index of this material, although one of the best, is only slightly different from the vacuum index and the critical angle of total reflection is small : $\theta_c = 6 \times \lambda$ (Å) arc min.

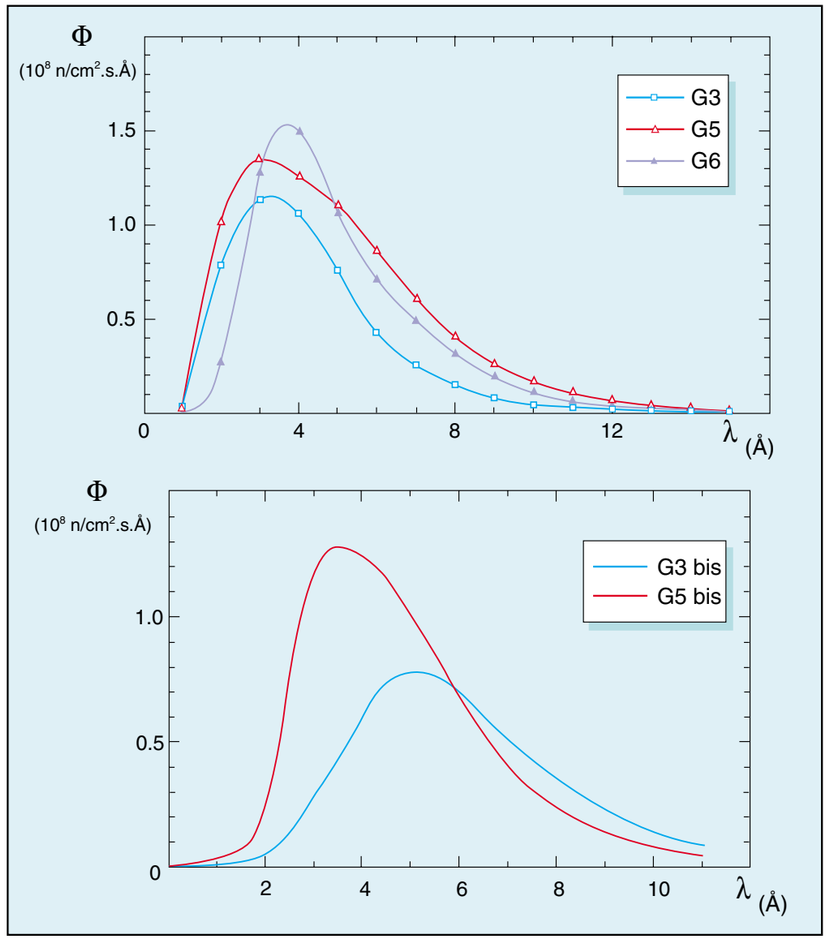


Figure 4: Flux versus wavelength at the end guide position.

In order to increase the performance, one can use constructive interference between the waves reflected by alternating layers of controlled thickness, which creates a succession of diffraction peaks beyond the critical angle. Present day technology allows the deposition of multilayers of nickel-titanium giving guides with an effective critical angle 2 at 3 times that of a simple total reflection guide.

Another possibility given by the neutron guide is to suppress all fast neutrons in the beam. Indeed, with a curved guide (length L, width e, radius of curvature R_c, critical angle of the coating $k\theta_c$(Ni)) only neutrons with wavelength greater than λ_c(Å)=(1146/k) $\sqrt{e/R_c}$ will propagate.

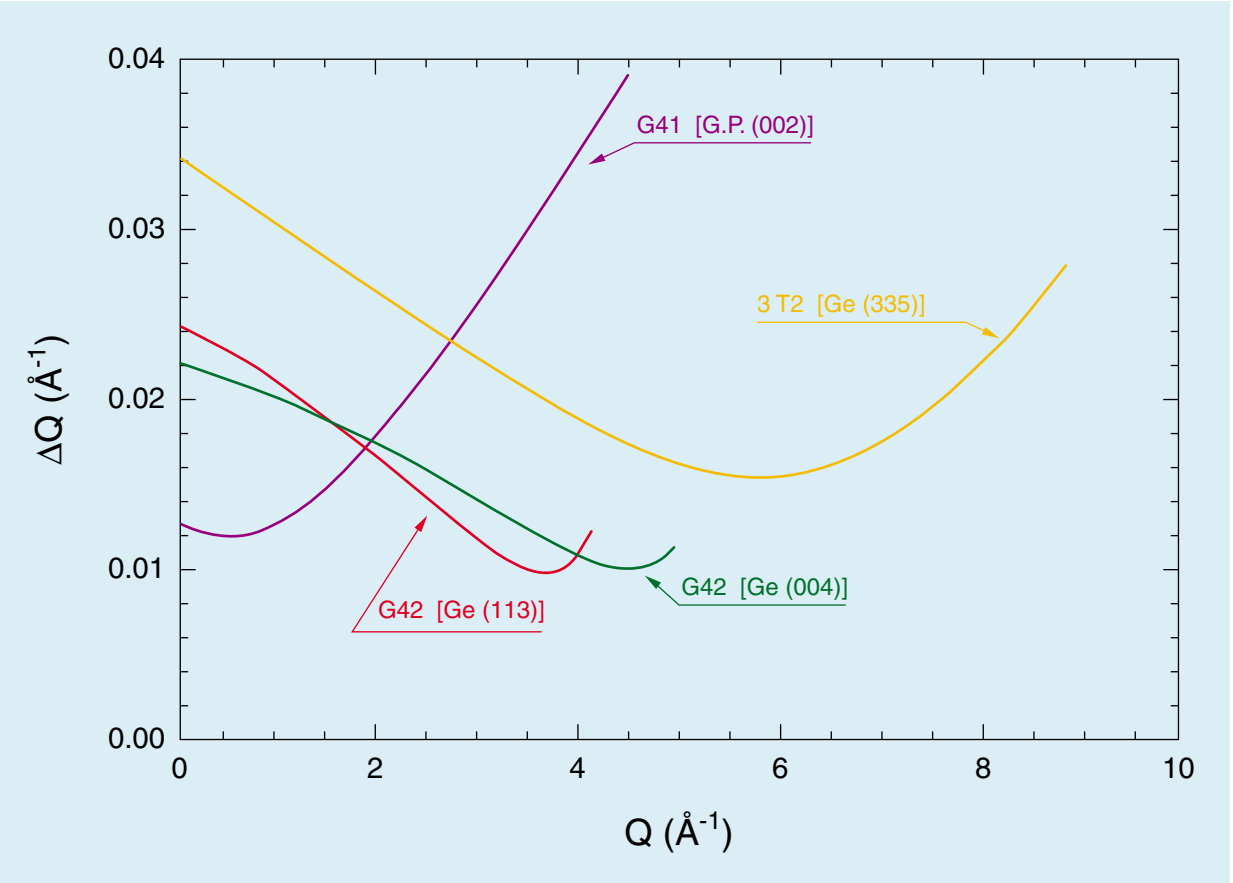
Along each guide, several spectrometers are installed. Each uses only the narrow wavelength band given by a monochromator placed inside a short interruption of the guide. As it is only at the end position of a guide that one can get a broad band or a polychromatic neutron beam, this potential is enhanced with 3 neutron beam deviators.
The following table gives the main characteristics of each guide and deviator. The flux transmited, as a function of wavelength, is shown in figure 4.

One can note that since the previous edition of this book, 2 guides (G1 and G2) have been equipped with supermirrors $2\theta_c$, which increase considerably the available flux at short wavelengths.

MAIN CHARACTERISTICS OF GUIDES

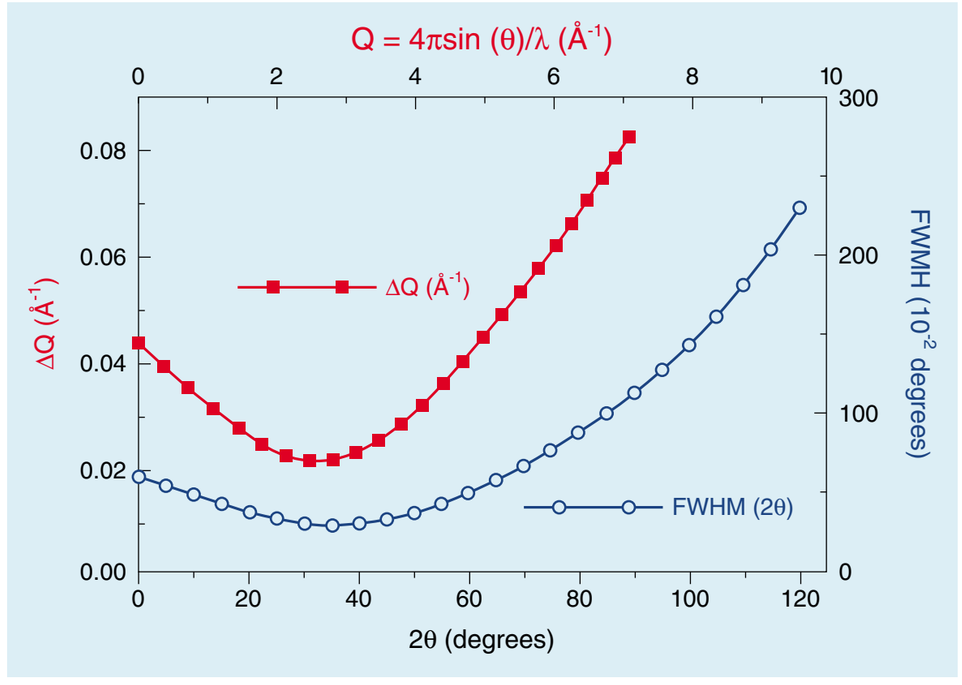
GUIDE	COATING	RADIUS OF CURVATURE (m)	WAVELENGTH CUT-OFF (Å)	WAVELENGTH AT MAXIMUM FLUX (Å)	TOTAL LENGTH (m)	NUMBER OF SPECTROMETERS
G1	Supermirror $2\theta_c$	463	3	4	33,3	1
G2	Supermirror $2\theta_c$	1042	2	3	39,3	2
G3	^{58} Ni	4167	2	4	39,6	1
G4	ordinary Ni	4167	2	4	63,2	5
G5	ordinary Ni	∞	1,7	2,7	56,3	5
G6	ordinary Ni	1042	4	4	39,7	2
DEVIATORS						
G1 bis	Polarizing Supermirror $3\theta_c$	46	4,4	6,2	8,6	1
G3 bis	Supermirror	50	2,3	3,3	9	1
G5 bis	Supermirror	155	3,4	5,3	9,5	1

POWDER DIFFRACTION SPECTROMETERS

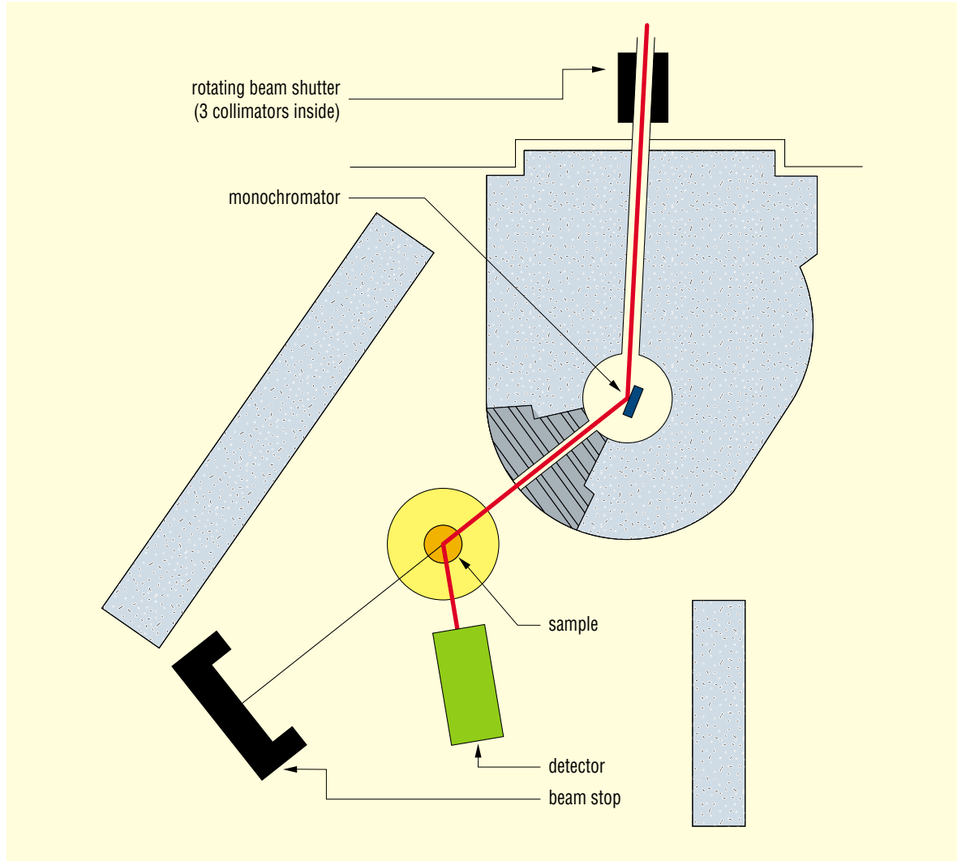


Q domain and resolution for three diffractometer.

Type of instrument	Two-axis diffractometer
Beam tube	Thermal (30 x 80 mm^2)
Monochromators	Cu (111), PG (002),
Maximum flux at specimen	1.5 10^7 n cm^{-2} s^{-1}
Maximum beam size at specimen	20 x 80 mm^2
Incident wavelength	1.5 Å < λ < 2.4 Å λ depends on the choices of monochromator and $2\theta_M$ ($10° \leq 2\theta_M \leq 50°$)
Angular resolution	See figure
Angular range	0° - 120° (2θ)
Collimation	(α_1) : 15', 30', 2°
Detector	^{3}He (α_3= 10' ; 1°)
Minimum step size scan	0.02° (2θ)
Data collection and Instrument control system	PC / SUN
Ancillary equipment	★ Cryostat 1.5 K → 550 K ★ Furnace 100°C → 1000°C



Resolution curves : (○) *Full width at half maximum (FWHM) versus 2θ ;*
(■) *Q variation of the resolution ΔQ (λ_0 = 0.1525 nm).*



General layout of the diffractometer 3 T1.

3 T1 is a two-axis spectrometer dedicated to neutron diffraction studies either on powders or single crystals (a ± 20° rotation of the sample around two orthogonal horizontal axis is available).

The incident monochromatic wavelength is obtained via two reflecting monochromators :
either : Copper (111)
or : Focusing (002) graphite (β = 24')

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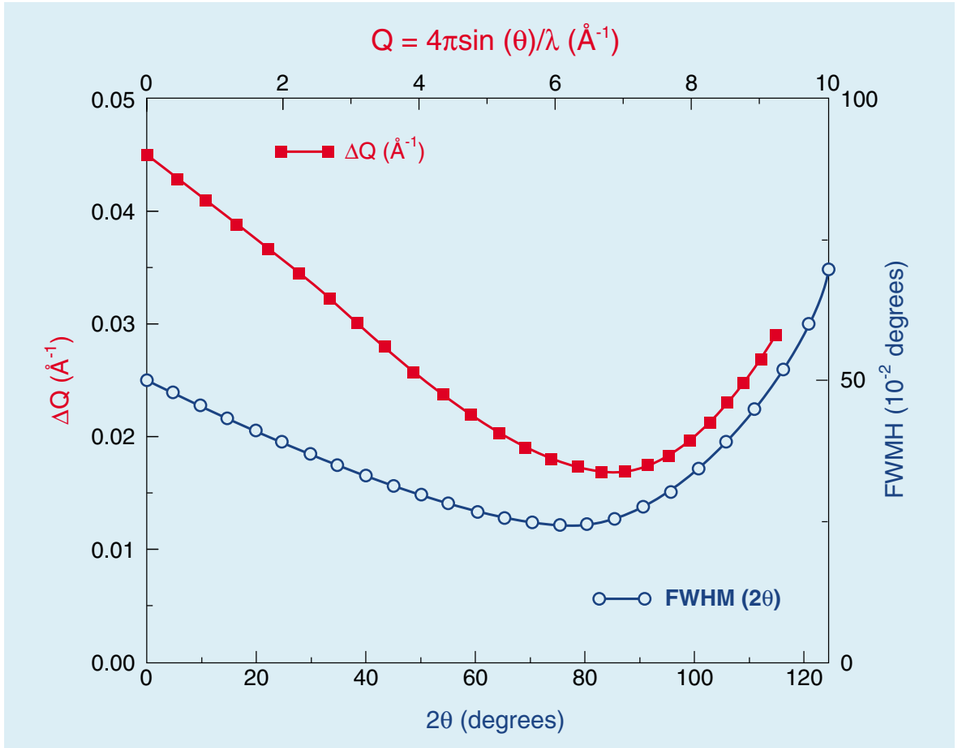
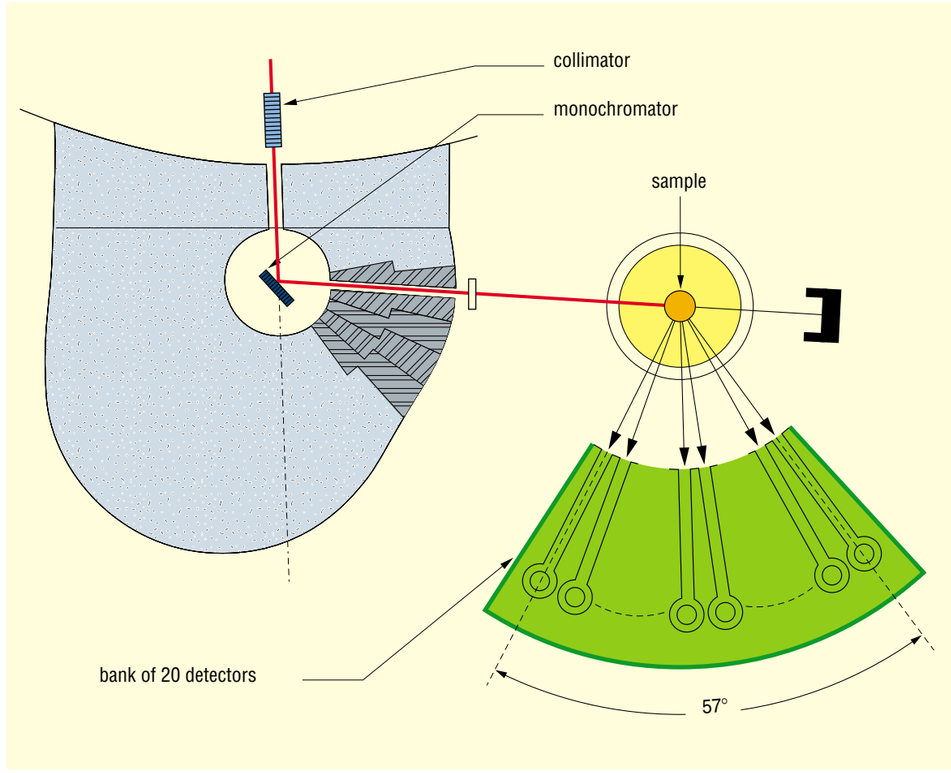
Type of instrument	Two-axis diffractometer
Beam tube	Thermal (30 x 80 mm^2)
Monochromator	Vertically focusing Ge (335)
Maximum flux at specimen	10^6 n cm^{-2} s^{-1} (λ = 1.2 Å ; α_1 = 10')
Maximum beam size at specimen	20 x 50 mm^2
Incident wavelength	1.225 Å ($2\theta_M \approx 90°$)
Angular resolution	See Figure (α_1 = 10')
Angular range	$2\theta < 125°$
Collimation	α_1 variable (10', 14', 21')
	α_3 fixed (10')
Detectors	20 ^{3}He detectors, 3° apart
Minimum step size scan	0.02° (2θ)
Data collection and Instrument control system	PC

Ancillary equipment

★ Cryofurnace (1.5 K - 550 K)
★ Furnace (T ≤ 1000°C)



Resolution curves : (O) *Full width at half maximum (FWHM) versus 2θ ;*
(■) *Q variation of the resolution ΔQ (λ_0 = 0.1225 nm).*



General layout of the diffractometer 3 T2.

3 T2 is a high resolution two-axis diffractometer dedicated to neutron powder diffraction studies in the fields of crystallography, solid state physics, chemistry and material science.

Due to the value of the incident monochromatic wavelength (1.225 Å, thermal neutrons) crystallographic unit cell volumes of the studied samples have to be ≤ 1000 $Å^3$)

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G 4-1 Cold Neutron Two-Axis Diffractometer PYRRHIAS,

Type of instrument	Two-axis diffractometer
Beam tube	Cold neutron guide G 4
Monochromator	Pyrolytic graphite (002), vertical focusing
Take-off-angle	$42 < 2\theta_M (°) < 110$
Incident wavelength	$2.43 < \lambda (Å) < 5.5$
Max. flux at specimen	4.10^6 n cm^{-2} s^{-1} (λ = 2.43 Å)
Max. beam size at specimen	10 x 50 mm^2
Detectors	Linear multidetector 800 cells (BF_3)
Minimum step size scan	0.02° (2θ)
Angular range	$3 < 2\theta (°) < 105$
Angular resolution	See figure
Data collection and Instrument control system	PC computer

Ancillary equipment

★ Cryostat 1.5 K < T < 300 K
★ Cryofurnace 1.5 K < T < 550 K
★ Furnace T < 1000°C
★ High (hydrostatic) pressure cell : P < 23 Kbar
★ Vertical magnetic field : H < 1.5 T

G 4-1 is a two-axis powder diffractometer equipped with a vertical focusing pyrolytic graphite monochromator and a 800-cells multidetector covering a 80° - 2θ range (step 0.1° between 2 cells).

The most frequently used wavelength is 2.43 Å but can occasionaly be varied between 2.43 and 5.5 Å. The accessible 2θ diffusion angle covers the range 3° - 105° ; in that range it is possible to perform diagrams with 0.02° step (2θ).

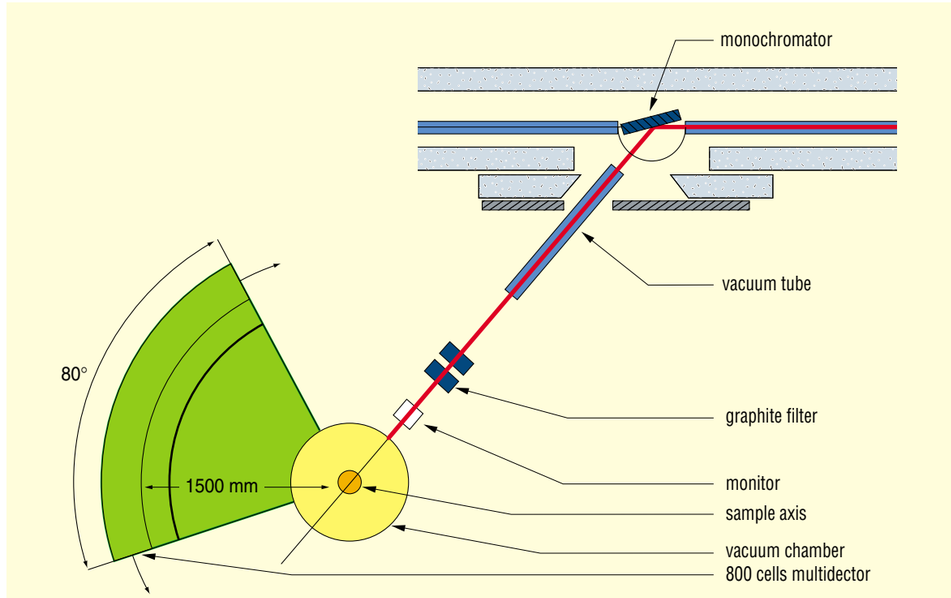
The instrumental resolution of the spectrometer being minimal at low 2θ diffusion angle ($2\theta < 60°$), G 4-1 is particularly well adapted for magnetic structure determination.

The high acquisition rate of the multidetector allows to perform diffraction studies (structural or magnetic) as a function of external parameters (temperature, pressure…) and to follow in situ cinetic reactions or phase transitions ; the minimal acquisition time is of the order of one minute. With longer acquisition time (a few hours) it becomes possible to detect and quantify minority phases present in a multiphase compound, generally down to 0.1% (weight percentage).

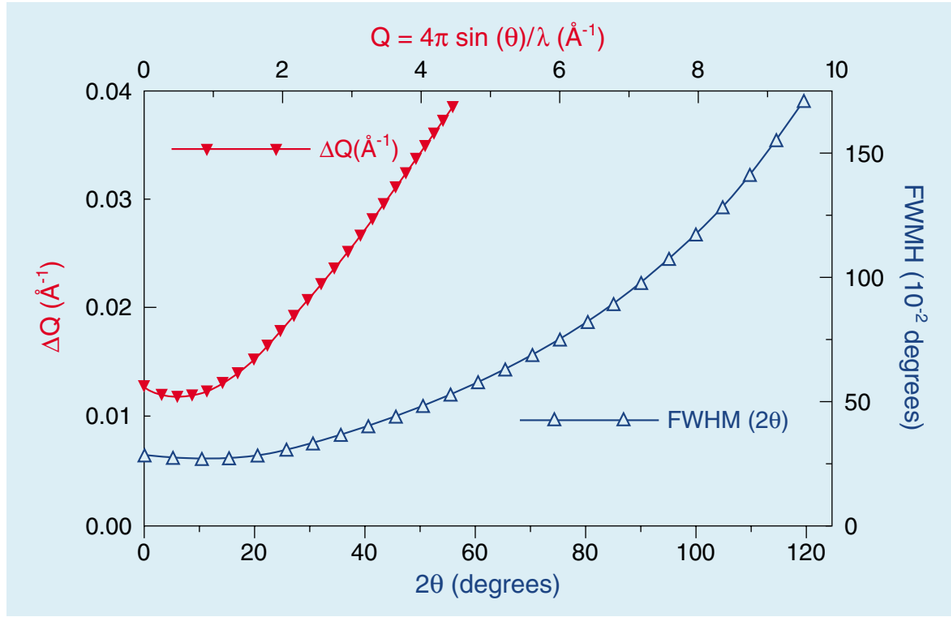
Soon available :

• dilution cryostat down to 50 mK.

Cold Neutron Two-Axis Diffractometer PYRRHIAS, G 4-1



General layout of the cold neutron two axis diffractometer G 4-1.



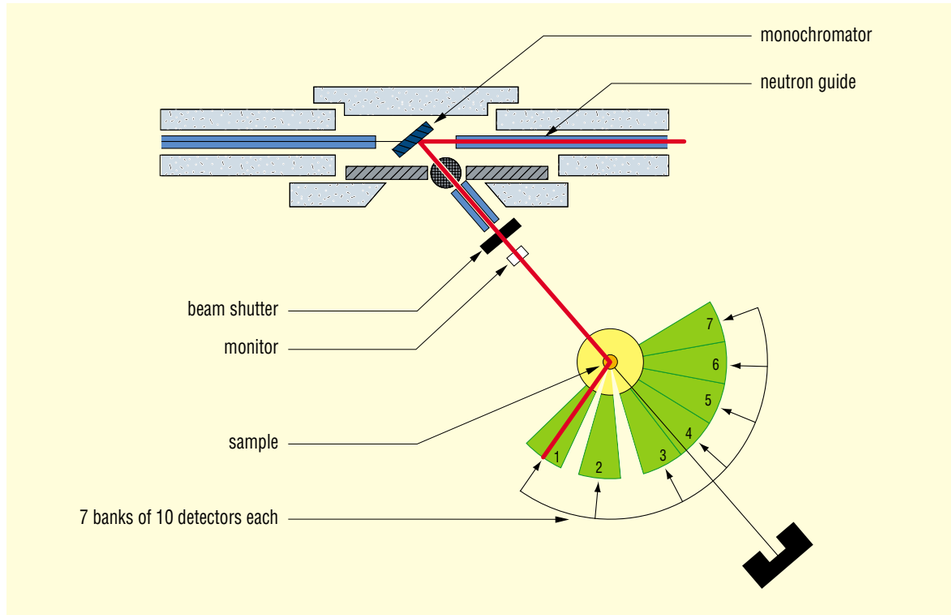
Resolution curves : △ *Full width at half maximum (FWHM) versus 2θ ;*
▼ *Q variation of the resolution ΔQ (λ = 0.245 nm).*

Responsible : G. André **e-mail : gandre@llb.saclay.cea.fr**

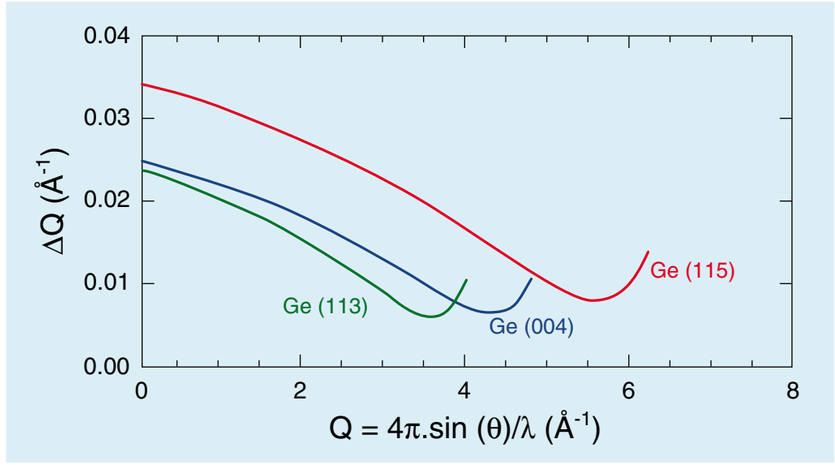
G 4-2 High Resolution Powder Diffractometer

Type of instrument	Two-axis diffractometer
Position	Cold neutron guide G 4, position G 4-2
Monochromator	Focusing Ge ; vertical axis [1 $\bar{1}$ 0] II (115) plane
Take-off angle	$2\theta_M = 112°$
Wavelength	1.80 Å, 2.34 Å, 2.82 Å
Detector system	70 ^{3}He detectors enclosed in 7 sections each containing 10 detectors with a Soller collimator in front of each detector. The angular divergence of the collimators is 13'.
Minimal scanning step (2θ)	0.01°
Working scanning step (2θ)	0.1°
Angular range	$6° < 2\theta < 174°$ ($Q_{max} \approx 7.0$ Å^{-1})
Accessible range of lattice spacing	0.9 Å < d < 27 Å ; 0.12 Å^{-1}< Q < 6.95 Å^{-1}
Best resolution	$\Delta d/d \approx 2.0 \times 10^{-3}$
Data collection and instrument control	PC + CAMAC
Ancillary equipment	★ Cryofurnace : 1.5 K < T < 520 K

This diffractometer was designed and constructed in the Materials Science Research Laboratory of PNPI, Russia. It is installed at the G 4-2 site and has been in operation since january 1997.
The diffractometer is designed for determination and refinement of the crystal and/or magnetic structure of powder materials especially with an elementary cell volume up to 1500 Å^3.
The original feature of the diffractometer consists of the way in which its 70 detectors are arranged, i.e., inside 7 dependent sections (each with a step motor and an absolute position encoder). Each section contains ten neutron detectors with a Soller collimator in front of each detector. The encoder of each section measures the angular position of the first detector in the section with a precision of 18" in the range of 0 - 360°. The other detectors in the section are positioned at 2° from each other. In the stage of preliminary data processing their positions are refined by the angular position of the transmission neutron beam measured by each detector. The sections are set in motion by step motors with the help of three air cushions lifting them over the base surface.
The diffractometer mainly operates in the superposition mode : each part of the neutron diffraction pattern is measured successively by all detectors and the results are added up. The procedure is as follows : the detectors assembly as a whole (all seven sections) starts motion from the initial position at a given step and has the specified monitor counts (or specified exposition time) for each position. At the same time, the smallest technological gap between the sections is preserved. As soon as the first section reaches the specified final position, all sections stop and the transport velocity is switched on, at which the first section moves to the end of the detector assembly. The measuring procedure continues till the second section reaches the final position, then the third, etc… As a result, each detector measures the entire diffraction pattern. In further measurements of the same sample, the movement of the detector assembly can be accomplished in the backward direction. This determines a high luminosity of the diffractometer and considerably simplifies the correction for the efficiency of counting channels and the relative positions of the detectors. Simpler algorithms of operation in the non-superposition mode are also possible. In this case, for calibrating the counting channels and relative positions of the detectors, the efficiency file obtained during measurements in superposition mode is used.
The collimator window is 11 x 110 mm^2, the working length is 200 mm, and the distance between the films is 1 mm ; the collimators are made of a thin polymer film with a gadolinium oxide-based absorber. The mean transmission coefficient measured for all 70 collimators is 85% and the beam divergence is 12 - 13'. The focusing Ge monochromator provides the possibility of using three wavelengths. This allows the diffractometer to be easily adjusted for many physical problems. The neutron monochromator is a set of 11 plates made from a plastically deformed Ge single crystal. The vertical axis is the rotation axis of the monochromator and coincides with the crystallographic direction [1$\bar{1}$0] within an accuracy of several minutes of arc. The plates are arranged one over another in a computer-controlled vertical focusing device which enables precision turning of the plates around the horizontal axis for the monochromator to have the form of a degenerated parabola. Turning of the monochromator as a whole around the vertical axis allows us to use the Ge (115), (004) and (113) reflections in the experiment. At the same time the resolution of the diffractometer changes and the neutron wavelength range changes from 1.8 Å to 2.8 Å. This allows us to optimise the conditions of a particular neutron diffraction experiment.



General layout of the cold diffractometer G 4-2.



Resolution curves.

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J. Rodriguez-Carvajal **e-mail : juan@llb.saclay.cea.fr**

Cold Neutron Two-Axis Diffractometer MICRO

Beam tube ..... Cold neutron guide G 6
Monochromator ..... Pyrolytic graphite, vertical focusing
Type of instrument ..... Two-axis diffractometer (“Tanzboden” type)
Maximum flux at the sample ..... 3 x 10^6 neutrons cm^{-2} sec^{-1} (ambient pressure version)
2 x 10^7 neutrons cm^{-2} sec^{-1} (high pressure version)
Maximum beam size at the sample ..... 10 x 30 mm
Incident wavelength ..... Between 4 and 6 Å
Removal of the λ/2 contamination ..... Beryllium filter
Angular range ..... $0 < 2\theta < 147°$
Detector ..... Linear (BF_3) multidetector (“Banana” 0 type, 80°) with 400 cells

Detector and sample rotations and the data collection are made using a PC computer linked to the central SUN computer for the storage of data. On-line date treatments can be performed by a second PC computer installed near the first one.

Sample environment

Low temperatures ..... Cryostat (ILL type) : $1.5 < T < 300$ K
Closed circle cryogenerator : $10 < T < 300$ K
High temperatures ..... Small furnace which replaces the inner part of the cryogenerator : $T < 300$ C
High temperature furnace $T < 1300$ C
Magnetic fields ..... No

High pressure ..... Sapphire anvil cells $P < 10$ GPa
Diamond anvil cells $P < 50$ GPa

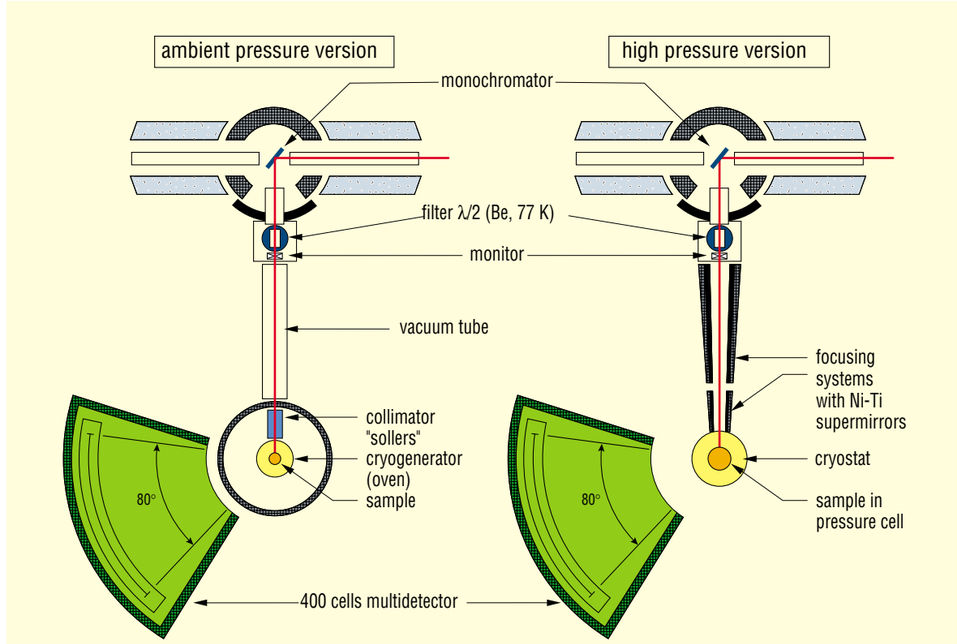
Note : all the pressure cells are compatible with the ILL-type cryostat. Pressure is applied outside of the spectrometer in the neighboring building. Pressure is measured by a ruby fluorescence at room temperature and kept constant during cooling.

G 6-1 is a two-axis powder diffractometer installed on a cold neutron guide. It is a high-intensity long-wavelength ($4 < \lambda < 6$ Å) instrument used to study magnetic structures, long-periodicity mesoscopic structures and diffuse scattering at ambient and high pressures. A monochromatic neutron beam is selected by a graphite monochromator. The typical incident wavelength is 4.74 Å and can be exceptionally changed in the above range. The contamination of the second harmonics (λ/2, λ/3,…) is suppressed by inserting a beryllium filter (cooled down to liquid nitrogen temperature) in the incident beam path. The diffractometer is equipped with a linear (banana-type) 400-cells multidetector covering 80 degrees of scattering angle. The multidetector and its protection can rotate around the sample axis, covering a total angle of 150 degrees.

The spectrometer operates in two different versions :

1) ***ambient pressure version***
In this version, the incident neutron path is under vacuum. The sample, collimator and beam catcher are placed inside a large vacuum chamber. In this vacuum chamber, several types of sample environment may be insered. Namely a cryogenerator ($10 < T < 300$ K), an ILL type cryostat ($1.5 < T < 300$ K), a small furnace ($T < 300$ C) easy to install with the same environment as the cryogenerator, or a more powerful furnace ($T < 1300$ C) similar to that used on 7 C2 diffractometer. An electromagnet could be also installed ($H < 1.5$ Tesla) but the instrument is not currently equipped with it. The option of polarized neutrons is now suppressed.

Cold Neutron Two-Axis Diffractometer MICRO
G 6-1



General layout of the diffractometer G 6-1.

Due to its high flux and resolution, but limited scattering vector range ($0.15 < q < 2.5$ $Å^{-1}$ in the typical configuration), this diffractometer is well adapted to the study of structural and magnetic phase transitions, diffuse scattering in disordered systems, specific features at low q's in amorphous and liquid states, adsorbed layers, etc…

2) ***High pressure version***
In this version the diffractometer is used to study magnetic order, phase transitions, mesoscopic structures (nanomaterials, polymers,…) in wide range of pressures $0 < P < 50$ GPa.
To study small samples at very high pressures a special double-stage focusing system with Ni-Ti supermirrors is installed along the incident beam path. The focusing system allows to increase intensity at the sample place by a factor of 7 (with some reduction of angular resolution). The focusing angle in the horizontal plane can be varied allowing to choose an optimal ratio between intensity and resolution in each experiment. Additional protection is used to decrease background in experiments with small samples.
The diffractometer is equipped with various high-pressure cells with sapphire and diamond anvils. Available sample volume : from several mm^3 (sapphire anvils) down to 0.01 mm^3 (diamond anvils). The maximal pressures are up to 50 GPa (500 Kbar) for strongly scattering samples and 7 - 10 GPa (70 - 100 Kbar) for normal scatterers. A specially modified cryostat generates temperatures in the range $1.5 < T < 300$ K. Currently, there is no high-pressure high-temperature option.

Responsibles :
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High pressure version : I. Goncharenko **e-mail : gonch@llb.saclay.cea.fr**

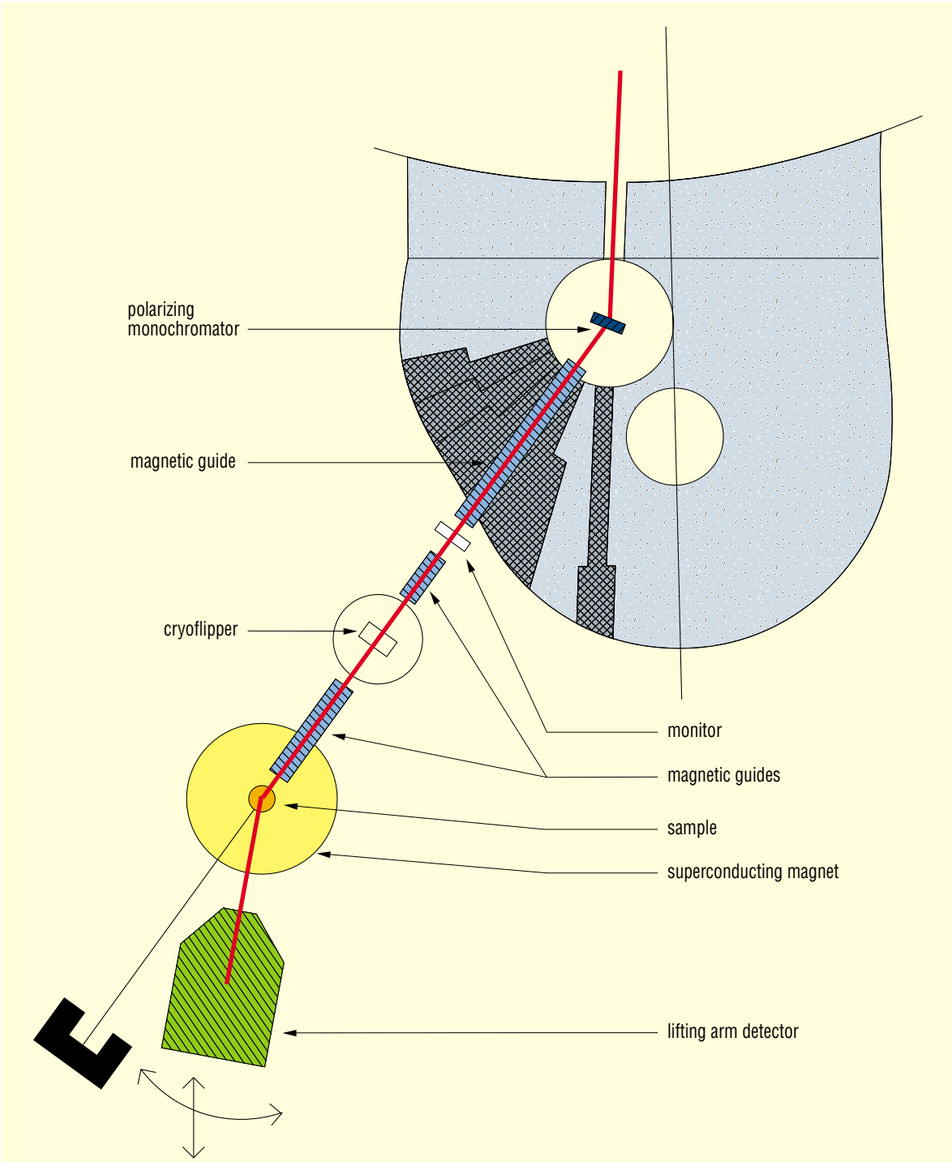
DIFFRACTOMETERS FOR SINGLE CRYSTALS

Beam tube	5 C1 Hot source
Monochromator	Heusler Cu_2MnAl (111)
Collimation	Horizontal divergence before the monochromator 58', 28' or 14'
Type of instrument	two-axis ; lifting arm detector polarized neutrons
Max. beam size at specimen	20 x 20 mm
Incident wavelength	λ = 0.84 Å
Angular ranges	Detector : 0, 120° in the horizontal plane -5, + 18° in the vertical plane
Minimum step size scan	0.01°
Detector	^{3}He counter
Data collection and Instrument control system	PC Data are transfered to a SUN computer for further treatment.
Ancillary equipment	★ Cryostat from 1.5 K → 300 K. ★ Cryomagnet H < 7.8 Tesla

The diffractometer is devoted to the determination of the magnetic structure factors, using an incident polarized neutron beam ; it is utilized for magnetic form factor and magnetization density studies on single crystals.
The polarization direction of the incident neutrons is defined by a magnetic guide field and can be inverted with the help of a cryogenic flipping device. A strong magnetic field is applied to the sample.

The intensities I+ and I-, diffracted by the sample, are measured when the incident neutrons are respectively polarized parallel (+) or antiparallel (-) to the applied magnetic field. The flipping ratio R = I +/I-, is thus measured for each Bragg reflection, and gives access to the magnetic structure factor, knowing previously the nuclear structure factor.
The wavelength is 0.84 Å (maximum of the flux of the hot source). This short wavelength allows the investigation of a large domain of reciprocical space.

Polarized Hot Neutron Two-Axis Spectrometer 5 C1



General layout of the spectrometer 5 C1.

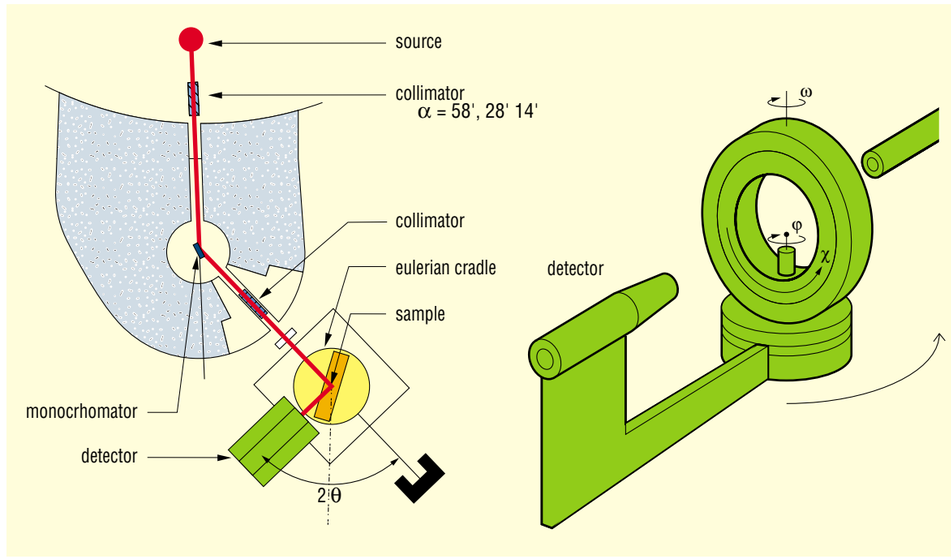
Responsible : B. Gillon **e-mail : gillon@llb.saclay.cea.fr**

Beam tube	5 C2 (hot source)
Monochromators	Cu (220) and GeSi (311), adjustable vertical focusing
Type of instrument	centric Eulerian cradle (Stoe)
Max. flux at specimen (n/cm^2 s)	5.7 x 10^6 (λ = 0.835 Å, α_1 = 58')
	5.0 x 10^6 (λ = 1.112 Å, α_1 = 58')
Max. beamsize at specimen	$\varnothing$ = 15 mm
Incident wavelength	0.835 Å (Cu 220), Erbium filter
	1.112 Å, GeSi (311)
λ/2 contamination	< 0.1% for λ = 0.835 Å
	0 for λ = 1.112 Å
Angular range	-100° ≤ 2Θ ≤ 130°
	-60° ≤ ω ≤ 65°
	-180° ≤ χ ≤ 180°
	-180° ≤ φ ≤ 180°
Collimation α_1	58', 28' or 14'
Resolution	$\Delta\omega$ = 0.12°(FWHM) at 2θ = 40° for λ = 0.835 Å
	$\Delta\omega$ = 0.20°(FWHM) at 2θ = 40° for λ = 1.112 Å
Detectors	^{3}He detector, position sensitive detector under construction
Data collection and instrument control system	PC (LINUX), modified and extended DIF4N software
Ancillary equipment	★ cryostat and furnace (5 K < T < 1400 K)

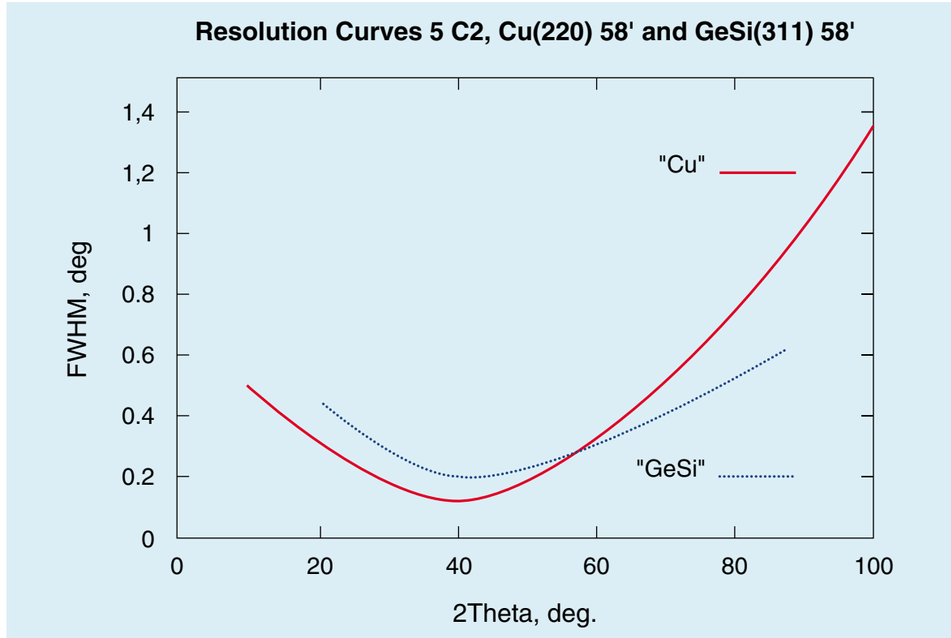
The purpose of this four-circle diffractometer is the measurement of Bragg-reflections for the evaluation of structure factors. It allows to determine crystal structures and magnetic structures of twinned or untwinned single crystals. Typical applications are the localisation of hydrogen in inorganic and organic compounds, the analysis of disordered crystal structures and anharmonic displacement parameters, structural phase transitions, magnetic structures, high-Tc superconductors or related materials, and quasicrystals. The shorter wavelength is used to study small unit cells (V < 2000 Å^3) up to high (sin θ/λ) values, which allows to obtain very precise information on thermal displacement parameters. The longer wavelength is used to collect data of even larger unit cells (V < 8000 Å^3) with a high resolution.

A helium cryostat and a furnace allow temperature dependent structure investigations in the temperature range from 5 K to 300 K and from 300 K to 1400 K. Special sample environments (like uniaxial or hydrostatic pressure, electric or magnetic fields) can be adapted individually.

This diffractometer was built by german scientists in cooperation between the FZ Karlsruhe and the LLB. It is currently operated by the RWTH Aachen and the LLB under the “Verbundforschung” program of the Federal Ministry of Education and Research “BMBF”.



General layout of the diffractometer 5 C2.



Resolution Curves 5 C2, Cu (220) 58’ and GeSi (311) 58’.

Responsibles :
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Beam tube	6 T (thermal source)
Monochromators	Cu 220 P.G. 002
Incident wavelength	0.90 Å, 1.55 Å, 2.35 Å
Collimation	α_1 = 14', 28', 57' α_2, α_3 = 10', 30'
Range of monochromator angles	2θ = 27° or 42°
Ranges of spectrometer angles	-28° < 2θ < 140° -90° < ω < 90° -180° < χ < 180° -180° < φ < 180° - 5° < ν < 26°
Detector	^{3}He
Ancillary equipement	★ Displex 5 K - 300 K ★ ^{4}He cryostat 1.5 K - 300 K ★ Cryomagnet 7.5 T, 12 T ★ Dilution cryostat 30m K ★ High pressure cell

The diffractometer is equipped with two vertically focusing monochromators :

1) Copper (220) λ = 0.90 Å (Er filter)

2) pyrolytique graphite (002) λ = 1.55 and 2.35 Å (PG filter).

Depending on the aim of experiment a high flux configuration (bent monochromator, relaxed collimation) or high resolution configuration (planar monochromator, short wavelength, tight collimation) can be easily used.

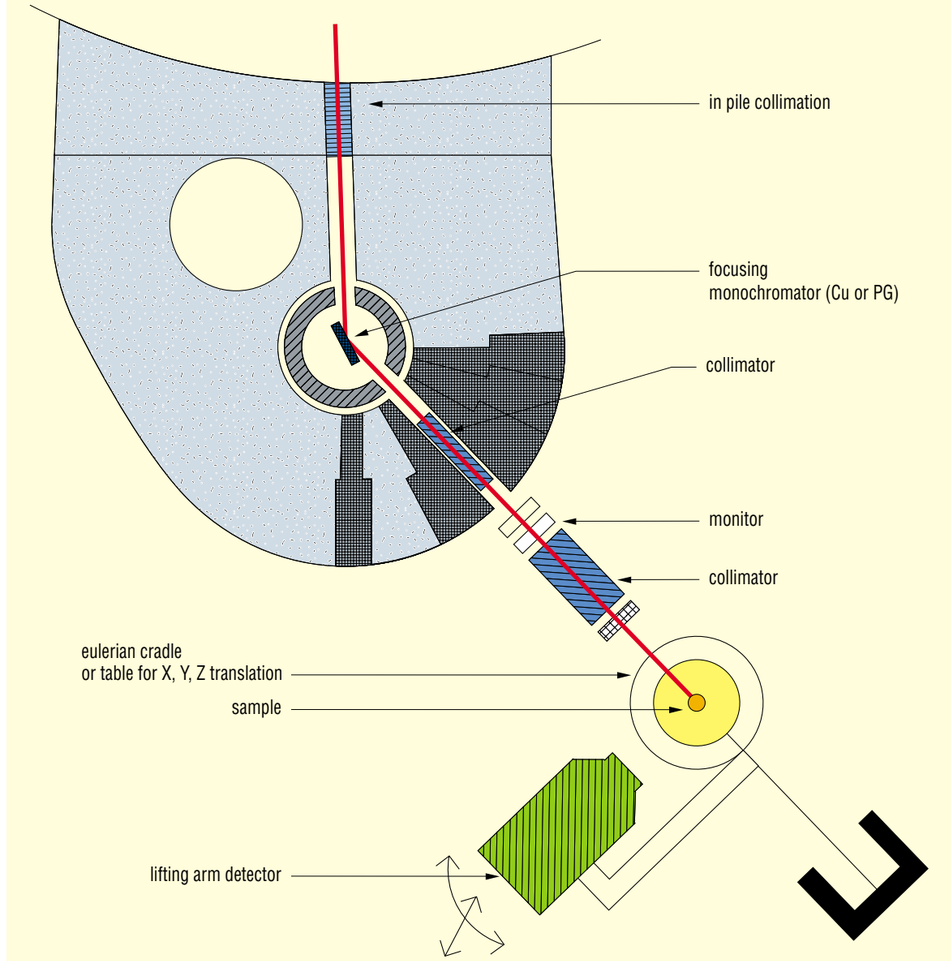
Two types of diffractometer can be mounted :

1) 4-circles geometry : with an Eulerian (deported) cradle for structural studies of large unit cells (cell volumes of more than 1000 Å) and high resolution studies (phase transitions, etc…).

2) Lifting counter geometry using cryomagnet, dilution cryostat and high pressure cell for magnetic studies.

The spectrometer is controlled by a Windows NT PC computer.

Thermal Neutron Four-Circle Diffractometer with Lifting Counter 6 T2



General layout of the diffractometer 6 T2.

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J.-M. Kiat **e-mail : kiat@llb.saclay.cea.fr**

DIFFUSE SCATTERING INSTRUMENTS

Beam tube	7 C - Hot source
Monochromators	Ge (111) , Cu (111) , Ge (311)
Type of instrument	Two-axis (for diffraction from disordered systems).
Max. flux at specimen	10^6 - 2.10^7 n cm^{-2} sec^{-1}
Max. beam size at specimen	5 x 2 cm^2
Incident wavelength	λ = 1.11 Å - 0,7 Å - 0.58 Å
Angular ranges	1.25° < 2θ < 128°
Q range	0.3 $Å^{-1}$ < Q < 20 $Å^{-1}$
Distance sample - detector	1.5 m
Collimation	Vertical : 2°
	Horizontal : 0.6° (0.2° possible)
Detectors	640 cell PSD (height : 70 mm, width 5.2 mm)
	covering 128° (2θ)
	radius of curvature 1.50 m
Data collection and Instrument Control System	PC computer
Ancillary equipment	★ Furnace 320 K < T < 1700 K
	★ Cryostat 1.5 K < T < 300 K
	★ Vacuum tight

The two-axis diffractometer 7 C2 is located on the hot source of the reactor Orphée. It is dedicated to structural investigations of liquids, glasses and amorphous materials.

The characteristics of 7 C2 are detailed in “Position sensitive detection of thermal neutrons” Ed. P. Convert - B. Forsythe, Academic Press - London 1983.

The high energy neutrons provide a wide range of momentum transfer and reduced inelastic scattering. The detector is a curved multidetector filled with $^{10}BF_3$. The 640 cells cover a scattering angle 2θ = 128° (step 0.2°). The sample to detector distance is 1.5 m. Three monochromator crystals (Ge(111), Cu(111) and Ge(311)) allow for the three incident wavelengths : 1.1 Å, 0.7 Å and 0.58 Å. (computerised change of wavelength).

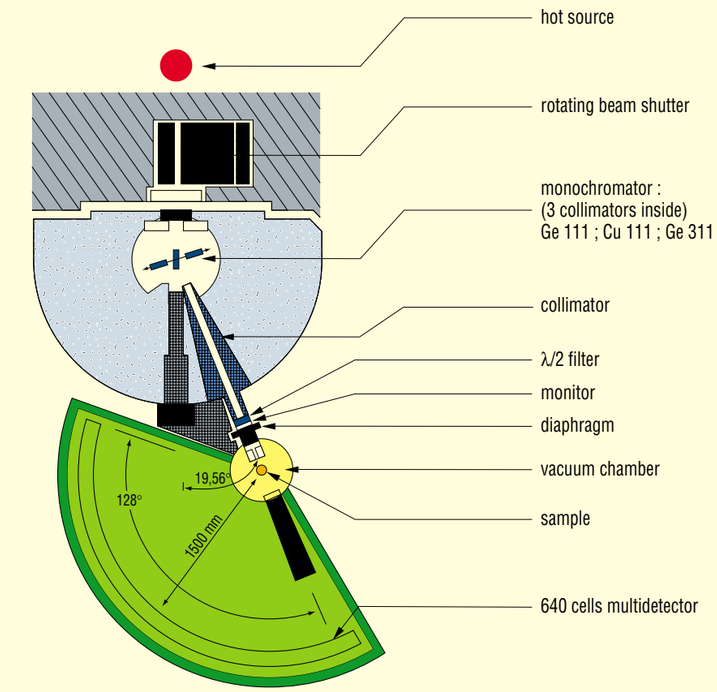
The beam is collimated between the hot source and the monochromator (3 types of collimation), and between the monochromator and the sample (4 types).

The sample is placed in a 600 mm diameter vacuum vessel. In this vessel can be added :

- a sample changer (5 positions) for room temperature experiments
- a furnace with a vanadium or niobium heater, covering a temperature range 300 K - 1700 K
- a similar furnace that can be put upside down (manually), in order to mix liquids
- a thermal bath with a temperature range 200 K - 350 K.

A cryostat is also available for temperatures from 1.5 K to 300 K. The cryostat tail in the beam is made from vanadium.

Hot Neutron Two-Axis Diffractometer 7 C2



General layout of the diffractometer 7 C2.

The 7 C2 spectrometer is controlled via a PC type computer which drives the temperature (furnace, cryostat) and the sample changer at room temperature.

Standard programs for data reduction are available on the computers of the group. Guides are available for these analysis programs (in french and in english) as well as for the driving programme of 7 C2.

Projects :
The BF_3 detector will be replaced by a detection ensemble composed of 12 2D-microstrip detectors filled with 10 bars ^3He. This will result in an increase of the efficiency by a factor 4 at least. Each detector will have its own collimation, which will greatly improve the signal-to-background ratio.
A new thermal bath working from 200 K to 500 K will be available soon.

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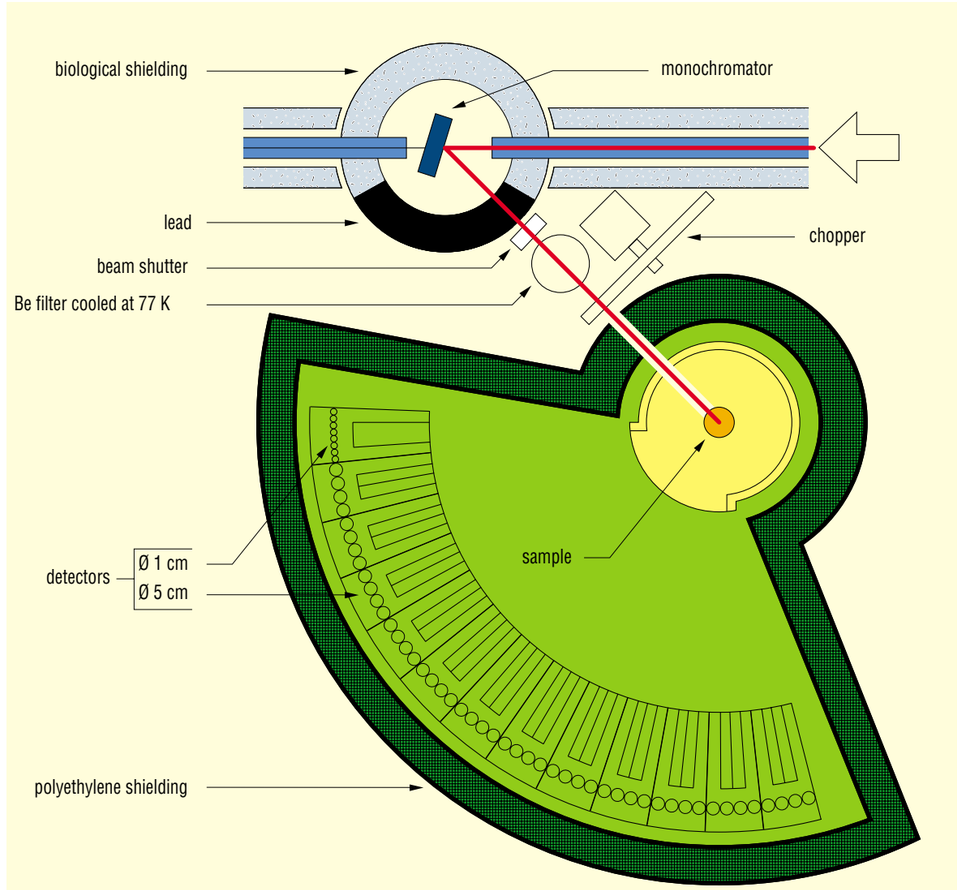
G 4-4 Two-Axis Diffractometer for Elastic Diffuse Scattering

Beam tube	Cold neutron Guide G 4
Monochromators	Graphite, 5 slabs (80 x 30 x 2 mm), vertical focusing Mosaicity 0.8°
Type of instrument	Diffractometer.
Max. flux at specimen (n/cm2.s)	1.3 x 10^6 (λ = 5.6 Å)
Max. beam size at specimen	25 x 50 mm^2
Incident wavelength	2.4 < λ (Å) < 6 $\Delta\lambda/\lambda = 4.10^{-2}$
Incident energy	12 > E (meV) > 2.2
Energy resolution	8 to 0.5 meV
Angular resolution	2.5° or 0.625°
Angular ranges	-5° < 2θ < 140°
Scattering vector ranges	0.1 < Q ($Å^{-1}$) < 5
Collimation	Monochromator-sample distance : 1.8 m (λ = 5.6 Å) Sample-detector distance : 1.5 m
Detectors	64 ^{3}He detectors (48 + 16)
Background	1 c/min detector
Data Collection and Instrument Control System	PC
Ancillary equipment	★ Furnace (T < 1300°C) ★ Cryostat (1.5 < T < 300 K)

This instrument is dedicated to the study of disorder in solids, in particular in metallic alloys : short range order, size effects, impurity effects. The sample is a polycrystal or a single crystal oriented outside the instrument.
The incoming beam is monochromatic (2.4 < λ < 6 Å). The focusing monochromator, made of 5 graphite blades, concentrates the beam on about 6 cm at the sample level, with a flux increase by a factor of 2 or 3. A nitrogen cooled beryllium filter (λ > 3.96 Å) eliminates $\lambda/2$ harmonic of the incident beam.

A vacuum vessel around the sample, 80 cm diameter, minimizes the background due to air scattering and includes a furnace for in situ high temperature experiments. An automatic sample translator enables to compare various samples, including a vanadium standard and a background without sample. For single crystal studies, an automatic rotation of the sample is provided, in order to explore the diffuse scattering in a whole plane of the reciprocal space.
The measuring system is made of 48 ^{3}He detectors, 50 mm in diameter, and a block of 16 (10 mm in diameter), which can be rotated by ± 5° around the sample axis.



General layout of the diffractometer G 4-4.

The experiment is equipped with a PC which enables to position the instrument, collect the data, and to perform some pre-treatments of the spectra while new data are collected.

A time of flight system (with chopper) enables, for each detector, to select the elastically scattered neutrons, which correspond to static disorder. The analysis of the inelastic part of the time of flight spectra yields interesting information about localized excitations (crystal field, optical phonons …).

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(Onera)

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SMALL ANGLE SCATTERING

G 1-2

Small Angle Neutron Scattering facility PACE (isotropic scattering)

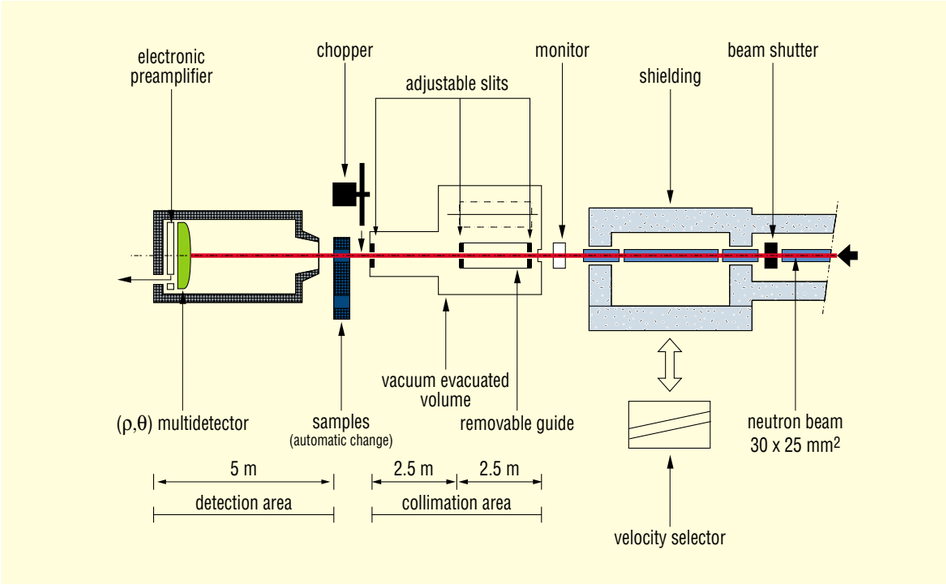
Beam tube	Neutron guide G1 (cold source), supermirror coating $2\theta_c$ (cutoff : 3 Å)
Monochromators	Mechanical selector (DORNIER) 2 Å < λ < 40 Å with Δλ/λ between 5% and 10% (hwhm) depending on the tilt angle (between 0 and 10°).
Max. beam size at specimen	2.5 x 3 cm^2
Typical size	0.7 x 0.7 cm^2
Beam collimation	with 2 diaphragms between 0.7 and 2.5 cm diameter, distant from 2.5 or 5 m depending on the distance between sample and detector.
Detector	BF_3 position sensitive multidetector made of 30 concentric rings of 1 cm width. First ring radius : 3 cm ; last ring radius : 32 cm
Typical range of accessible scattering vectors	2 x 10^{-3} < q ($Å^{-1}$) < 0.5
Available sample surroundings	- automatic sample changer for 16 different samples for temperature between 10 and 80°C - cryostat (2 K) and displex (10 K) - furnace (50 < T(°C) < 300)
Data collection and instrument control System	EURO modules from LLB (independent and intelligent IEEE 488 instruments)
Computer driving :	PC and WINDOWS operating system

PACE is a small angle neutron scattering spectrometer dedicated to the study of isotropic scattering. It is equipped with a position sensitive multidetector made of 30 concentric rings centred around the beam. This is its main feature making treatment and rapid estimation of data specially easy.
The monochromator is provided by Dornier Embh, and has the particularity of being very compact that allows retracting it without substantial handling. The experimentalist can thus easily work on white beam using the time of flight method.

The monochromator also allows to reach small wavelengths (down to 2 Å) that offers the possibility of extending the scattering vector range to high values without shadow due to the sample surroundings.
The spectrometer is equipped with a sample changer that allows to plan the automatic measurement of 16 different samples.
It is computer-driven with a WINDOWS software that allows a complete automatic adjustement of the spectrometer (centring of the beam and samples, attenuator optimisation…) and measurement programming.

Small Angle Neutron Scattering facility PACE (isotropic scattering)

G 1-2



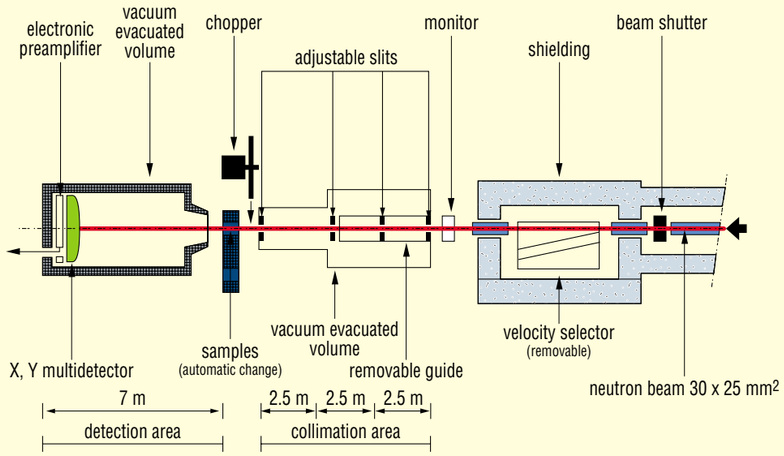
General layout of the spectrometer G 1-2.

Responsibles : L. Auvray **e-mail : auvray@llb.saclay.cea.fr**
D. Lairez **e-mail : lairez@llb.saclay.cea.fr**

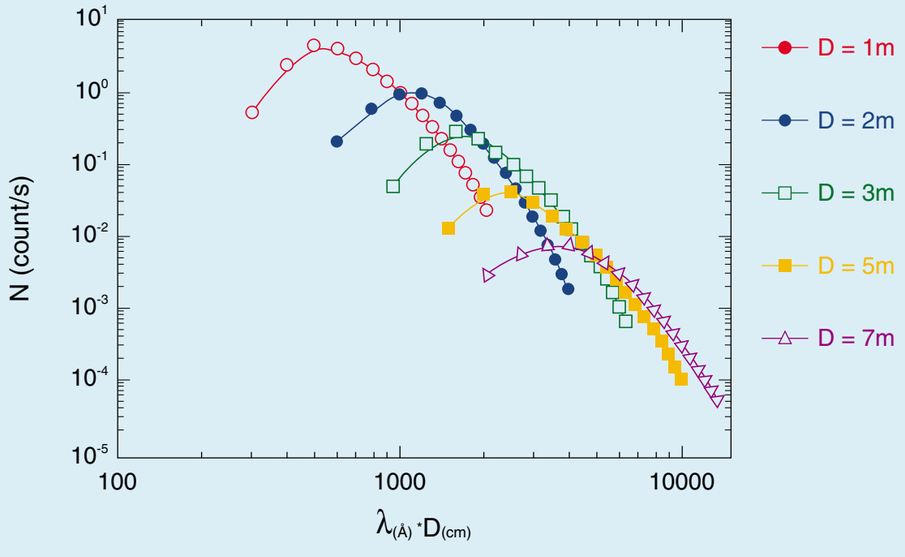
Beam tube	Neutron guide G 2 (cold source), supermirror coating $2\theta_c$ (cutoff : 2.6 Å)
Monochromator	1) Mechanical selector 4 Å < λ < 20 Å Δλ/λ ~ 10%. 2) Neutron guide 4 Å < λ < 20 Å Δλ/λ ~ 30%. 3) Time of flight method
Type of instrument	Small Angle Scattering diffractometer for high resolution (in q-space) studies.
Max. flux at specimen	Strongly dependent on the collimation
Max. Beam size at specimen	2.5 x 3 cm^2 - typical size 1 x 1 cm^2.
Moment transfer range	3 x 10^{-3} $Å^{-1}$ < q < 1 $Å^{-1}$
Distance Sample Detector	1 m to 7 m continuously variable
Scattering angle range (2θ)	0° to 60° (for distance sample detector < 3.5 m)
Collimation	Fitted to the sample detector distance and computer controlled.
Attenuators	Choice between 14 (PMMA) sheets of different transmissions
Detector	BF_3, XY multidetector, 64 x 64 cm^2 15500 cells, each 5 x 5 mm^2.
Data collection	The data treatments are done by using available home made programs on PC and SUN
<u>Ancillary equipment</u>	★ Automatic sample changer (8 positions) with temperature control (-43 < T < 100°C) ★ Furnace (50 < T < 300°C) ★ Cryostat (2 K) and displex (10 K). ★ Magnetic field H < 2 T ★ Computer controlled Couette type viscosimeter ★ Automatic sample changer in electromagnet

PAXY is a small angle neutron scattering instrument designed for experiments requiring a good resolution. It is used for isotropic or anisotropic scattering and for the study of periodical structures. The instrument is installed at the end of the cold neutron guide G 2. Incoming polychromatic neutrons are monochromatized by a mechanical velocity selector ; wavelength may vary from 0.4 nm to 2 nm.
The neutrons are then collimated with two ^{58}Ni guide elements under vacuum. These elements can be moved in (or out) the incident neutron beam. Two circular holes of variable diameter achieve the collimation. The geometry of the incident collimation depends on the beam divergence required.
The sample holder is equipped with a double goniometer (± 20°) and two independent rotating tables, one for heavy charge (~ 800 kg).

Various sample environments can be chosen such an automatic temperature controlled sample changer, cryostat, magnet with or without vertical sample changer, shearing cell (Couette cell or Cone and Plate).
The BF_3 multi-detector, with 128 x 128 cells of 5 x 5 mm^2, can be positioned at any distance between 1 and 7 m from the sample in the horizontal direction in its vacuum tube. This tube can rotate around the vertical axis of the sample to extend the q range.
Smaller q values (down to 10^{-3} $Å^{-1}$) may be reached using the time of flight technique instead of the mechanical selector.
The instrument is operated by a PC computer through a menu-driven interface and an image of the data collected are displayed on a colour monitor.



General layout of the spectrometer G 2-3.



Intensity in a cell of the detector versus incident wavelenth (λ) and for various sample detector distances (D).

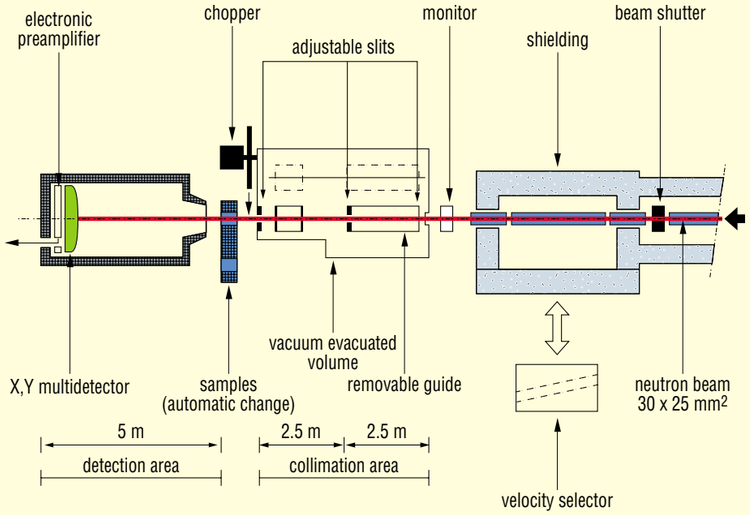
Responsible : A. Lapp **e-mail : lapp@llb.saclay.cea.fr**
Co-Responsible : L. Noirez **e-mail : noirez@llb.saclay.cea.fr**

Beam tube	Neutron Guide G5 (cold source)
Monochromator	Mechanical selector $4 \leq \lambda \leq 25$ Å ; $5\% \leq \Delta\lambda / \lambda \leq 15\%$
Type of instrument	Small angle scattering diffractometer
Typical flux at specimen	7×10^5 n cm^{-2} s^{-1} for $\lambda = 4$ Å and a collimation obtained with two slits of 12 and 7 mm, 2.5 m far apart.
Max. beam size at specimen	2.5 x 3 cm^2 Usually, circular with ∅ = 7 mm
Range of momentum transfer	$2 \times 10^{-3} < Q < 0.5$ Å^{-1} (monochromatic beam) $1 \times 10^{-3} < Q < 0.5$ Å^{-1} (time of flight)
Angular range	6×10^{-3} to 0.8 rad
Distance sample - detector	$0.8 < D < 5$ m
Collimation	Adapted to sample-detector distance, through a movable neutron guide element.
Detector	BF_3, XY multidetector, 64 x 64 cm^2 with 4000 cells, each 1 x 1 cm^2
Data collection and Instrument control system	Microcomputer PC
Ancillary equipment	★ Automatic sample changer (16 positions) with temperature control (-43 < T < 100°C). ★ Cryostat 4 < T < 370 K ★ Magnet H < 2 T ★ Furnace (50 < T < 300°C) ★ Displex (10K)

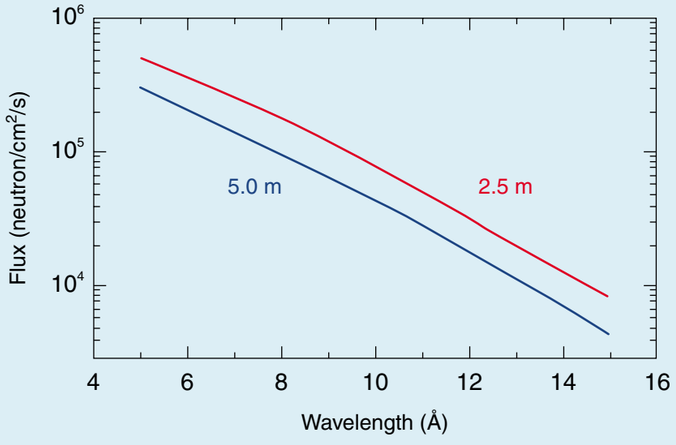
PAXE is a small angle scattering instrument installed at the extremity of the guide G5, which is a straight guide coated with ^{58}Ni. There is a XY position sensitive detector.
Measurements can be performed :
- with a monochromatic beam ($4 < \lambda < 25$ Å), using a velocity selector. The wave-length resolution ($\Delta\lambda/\lambda$) can be chosen between 5 and 15%.
- with a polychromatic beam (time of flight method) using a chopper.

The XY detector, filled with BF_3 contains 64 x 64 cells of 1 x 1 cm^2. It is mounted on a moveable trolley placed within a cylindrical tube kept under vacuum. The sample to detector distance can be chosen between 0.8 and 5 m.

The numerical values on the table above show the ranges of wavelength and distance. They yield a Q range extending from 3.10^{-3} to 0.5 Å^{-1} ; smaller values of Q (down to 10^{-3} Å^{-1}) may be reached using the time of flight technique.
Collimation is achieved by two circular slits at the two extremities of a tube under vacuum. The collimation length is equal to either 2.5 or 5 m. For a collimation of 2.5 m, a neutron guide is inserted before the collimation section, in order to maximise the flux.
The figure below depicts the total neutron flux at sample position for different wavelengths and distances of collimation, assuming $\Delta\lambda/\lambda = 10\%$.
The data acquisition is done by electronic devices controlled by PC computers connected to the network of the laboratory.



General layout of the spectrometer G 5-4.



Incident flux on sample.

Responsibles : J. Teixeira **e-mail : teixeira@llb.saclay.cea.fr**
G. Pepy **e-mail : pepy@llb.saclay.cea.fr**

Small Angle Scattering Diffractometer with Polarized Neutrons PAPOL

Monochromator	Multilayer Ni-Ti on Si Fixed wavelength λ = 8 Å ± 0.5
Polarizer	Flat mirrors in reflection geometry Transmission 45% Polarization 94%
Collimation length	7 m fixed
Sample to detector distance	0.8 m to 3.8 m variable in steps of 1 m
Area detector	64 x 64 cm, resolution 5 mm
Beam intensity	3.10^4 n/cm^2/s at the sample
Data acquisition	Proprietary, PAXY compatible Time resolved acquisition possible
Ancillary equipment	Apparatus for dynamic polarization, with in particular : ★ Superconducting magnet : 3.5 T horizontal split coil with high homogeneity (5 10^{-5}) horizontal access parallel (∅ 89 mm) and perpendicular to the field (∅ 42 mm) ★ Dilution insert to cool the ^{4}He-filled sample holder to T = 0.2 K

PAPOL is mainly dedicated to the development of macromolecular structure studies using the method of contrast variation by dynamic nuclear polarization. Making use of the large spin-dependent scattering length of ^{1}H, this method is an alternative to isotopic substitution H - D in hydrogen-rich samples.

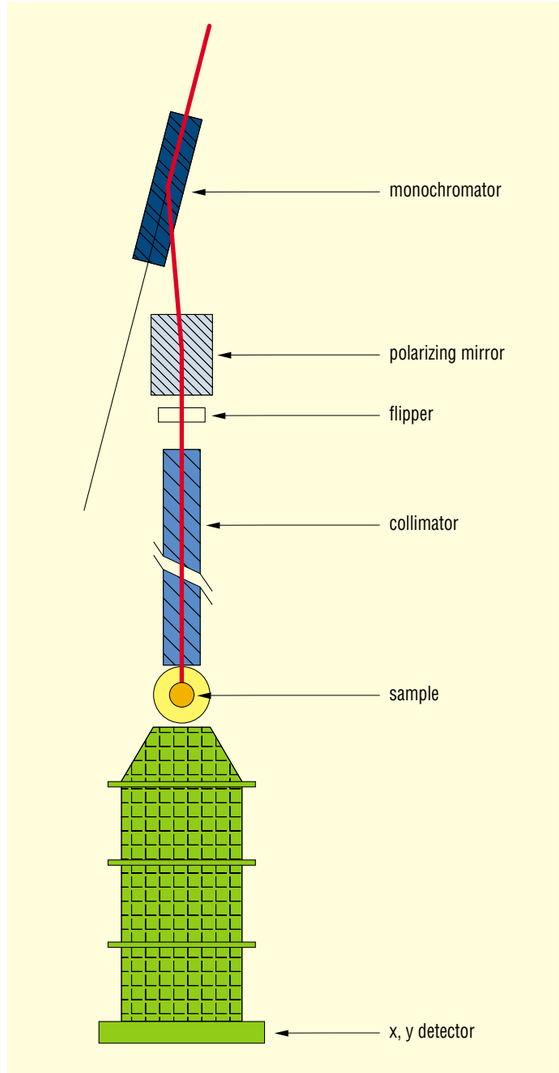
All the equipement necessary to create and to measure the nuclear polarization is available :

- a 3.5 T horizontal field with high homogeneity (5.10^{-5})
- a dilution insert able to cool the sample, inserted in ^{4}He, down to 0.2 K
- microwave sources (70 GHz and 94 GHz) for dynamic nuclear polarisation
- a CW NMR spectrometer to measure and to manipulate the polarization.

PAPOL is also particularly well suited to study magnetic nanoscale objects (Magnetic particles, clusters, vortices, etc…). In addition to the pure magnetic and nuclear contributions, its polarized beam is able to measure with high precision the interference term which is linearly dependent on magnetisation density.

Small Angle Scattering Diffractometer with Polarized Neutrons PAPOL

G 5-5



General layout of the diffractometer G 5-5.

Responsible : H. Glattli

e-mail : glattli@drecam.cea.fr

DIFFRACTOMETERS FOR MATERIAL SCIENCE STUDIES

Beam tube	6T (thermal source)
Monochromator	Cu 111
Incident wavelength	1.159 Å
Maximal beam size	2 x 2 cm^2
Neutron flux at specimen	10^7 n cm^{-2} s^{-1}
Collimation	α_1 = 10', 15', 54'
	α_3 = 10', 60'
Range of monochromator angle	$2\theta_m$ = 32°
Ranges of spectrometer angles	-20° < θ < 80°
	-10° < ω < 40°
	0° < χ < 180°
	0° < φ < 360°
Detector	^{3}He
equipement	Furnace for in situ measurements T < 950°C

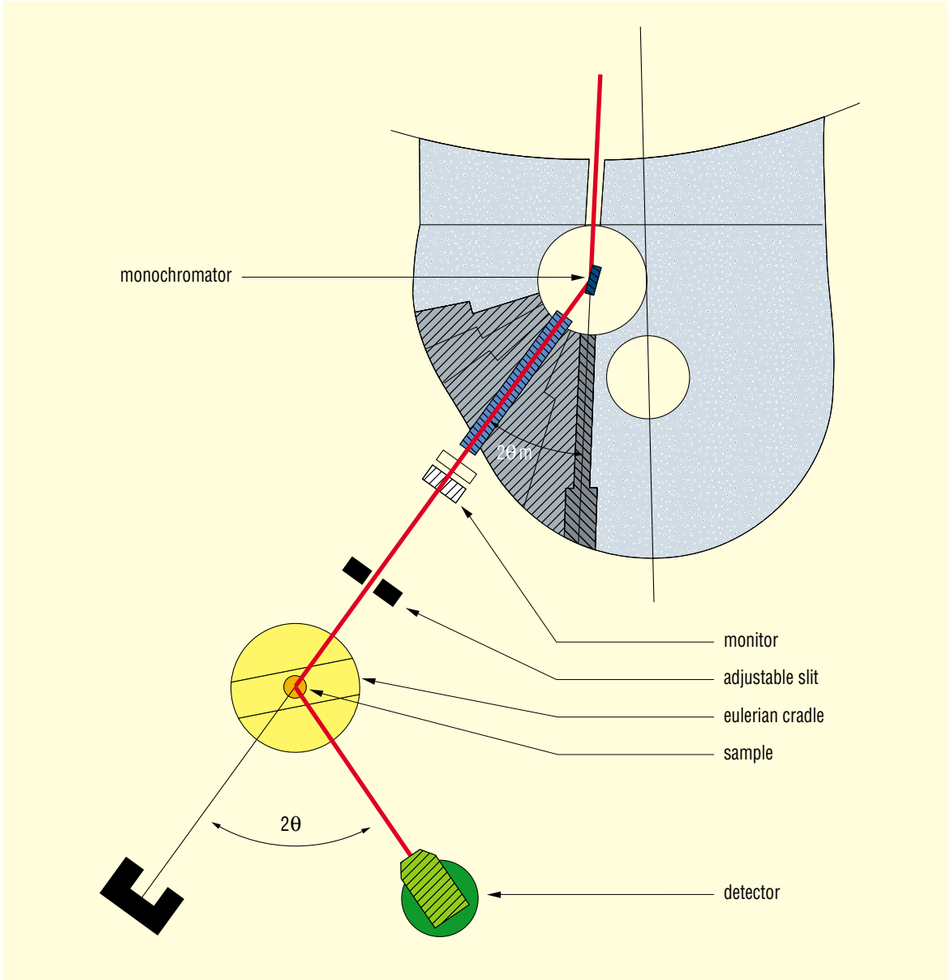
The 6 T1 diffractometer is dedicated to pole figure determination, for crystallographic texture analysis.
Neutron diffraction technique allows to measure complete pole figures in transmission mode and to analyse large volumes up to 1 cm^3. This technique is useful for large grain materials, or heterogeneous materials. It allows characterising the texture of minority phases. Moreover, no surface preparation is required for the sample.

The neutron wavelength is 1.159 Å, selected by a Cu (111) monochromator. The maximal beam size is 2 x 2 cm^2 but a window device can reduce it. The diffractometer is equipped with a deported Eulerian cradle (Frank Heydrich Ø 400 mm) with 0.01° precision. The sample-counter distance can change between 80 and 150 cm.

Depending on the aim of experiment, various collimations of the incident and diffracted beam can be used. The 6 T1 resolution allows determining the energy stored in the grains during the deformation as a function of crystallographic orientation through Bragg peak broadening analysis.

A Windows NT PC computer pilots the diffractometer. The pole figure measurement time is at least 2 or 3 hours (grid 5° x 5°).

Moreover, at the LLB, several programs are available to calculate the Orientation Distribution Function using harmonic or vectorial methods.



General layout of the diffractometer 6 T1.

Responsible : M.H. Mathon **e-mail : mathon@llb.saclay.cea.fr**

Beam tube	Cold Neutron Guide G 5
Monochromator	Pyrolytic graphite (002) or (004)
Incident wavelength	2.3 Å ≤ λ ≤ 6 Å continuously variable
Type of instrument	Two-axis
Detector	100 x 100 mm^2 EMBL (Grenoble outstation) ^{3}He PSD
Neutron flux at specimen	ca. 3.8 x 10^6 n cm^{-2} s^{-1} at 3 Å
Angular ranges	20° < 2θ < 120° 0° < ω < 360°
Resolution	Δd/d = 1.9 x 10^{-3} at d = 2 Å (λ = 2.8 Å, using the (004) monochromator reflection)
Positioning table	with x, y and z movements : +/-75 mm x, y axes travel and 300 mm z-axis travel
Position repeatable	to 1 micron (x, y, z). Samples up to 500 kg in weight can be supported
Gauge dimensions	from 0.3 mm to 25 mm incident and outgoing beams Variable in both dimensions.
Data collection and instrument Control system	Personal computer (PC)

Ancillary equipment

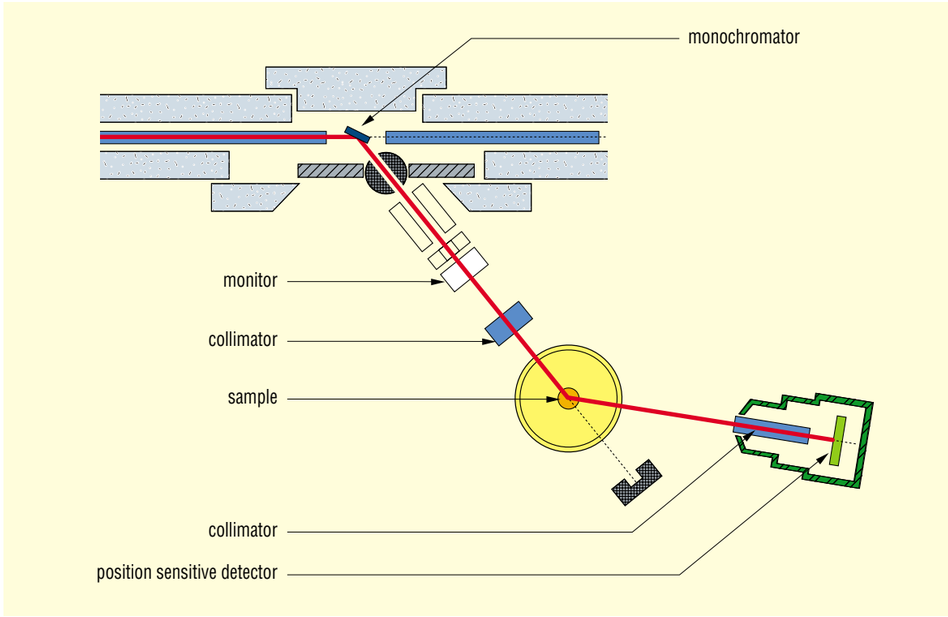
★ Uni-axial loading rig : ± 20 kN dynamic loading for tension, compression and tension-compression. It can be mounted on positioning table
★ Eulerian cradle (inner diameter = 400 mm) 0 < χ < 160° and 0 < ϕ < 360° for complete stress tensor determination
★ Four point bending device
★ Furnace (T < 800°) for high temperature measurements

Internal and residual stresses in materials have a considerable effect on material properties, including fatigue resistance, fracture toughness and strength. Neutron diffraction provides a powerful non-destructive tool for stress analysis deep within a crystalline material. In this way, it does not need specimen preparation and samples with cumbersome geometries can be studied. The principle of the technique, called Neutron Strain Scanning, is to use crystal lattice as an atomic strain gauge to measure strain distributions with a sub-millimeter spatial resolution with an accuracy of better than 50 microstrain (50 x 10^{-6}). The stresses are thus calculated from the measured strains by using elasticity laws.
In the last years, a new diffractometer “DIANE” entirely dedicated to stress analysis was built at the Laboratoire Léon Brillouin in Saclay in collaboration with the Italian INFM (Istituto Nazionale Fisica della Materia). The instrument is a two axis diffractometer, consisting of a monochromator, a sample table and a multidetector. It is situated on the G5 cold guide of the Orphée reactor.

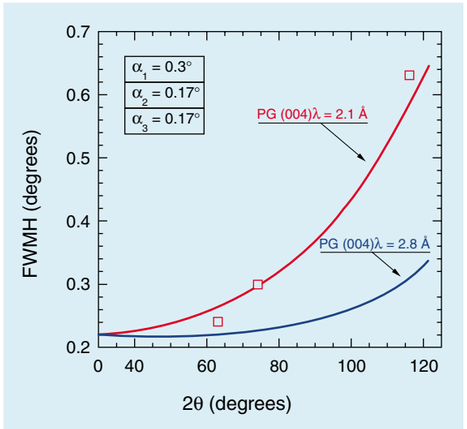
The monochromator is a pyrolytic graphite single crystal, using the (002) or the (004) reflection, providing a continuously variable wavelength spectrum between 2.3 Å and 5 Å. When it is possible, the preferred reflection is the (004), providing a good instrumental resolution.

The sample table has been constructed in order to support very big samples, up to 500 kg in weight. It is equipped with x-y-z translation tables and a ω rotation about the vertical axis. In this way, the residual stress field in real industrial components can be evaluated. For smaller samples (up to 5 kg weight), an Eulerian cradle, equipped with a x-y-z stage, for the determination of complete stress tensor in a point, is also available. Different sized Cd masks, ranging from 0.3 mm to 25 mm in width, just before and after the sample, are available to define the size and the shape of the gauge volume, according to the different experimental requirements. As an example, with a gauge volume of about 1 mm^3, a steel sample of about 30 mm thick can be investigated, whereas aluminum samples may be four times as thick.

Two-Axis Strain Diffractometer “DIANE” G 5-2



General layout of the diffractometer G 5-2.



Instrumental resolution of G 5-2, measured with a standard germanium powder with a neutron incident wavelength of 2.8 Å and of 2.1 Å using the graphite monochromator (004) reflection.

The PSD is actually operating as a linear one dimensional detector system. The advantage of this solution with respect to the classical linear one-dimensional detector is that it has a larger effective detection area. The PSD is positioned at a distance ranging from 900 to 1200 mm from the sample, with an angular aperture of 4°- 6° in 2θ and an electronic resolution of about 0.03°- 0.02°. In this way complete Bragg peaks are recorded in single exposure type measurements, reducing the measuring time with respect to a single detector.

A new device for in situ mechanical loading of test samples during neutron diffraction strain measurements has been installed. It can be mounted on the neutron diffractometer and can be aligned with the loading direction parallel or perpendicular to the scattering direction for measurements of longitudinal and transverse strains. The capacity of the applied load cell is 20 kN and it is controlled by a pneumatic system. Different jaws of grips are available in order to study different specimen geometry.

Responsible : M. CERETTI **e-mail : ceretti@llb.saclay.cea.fr**

REFLECTOMETERS

G 2-4

Two-Axis Polarised Reflectometer with Polarisation Analysis PRISM

Beam tube	Cold neutron guide G2
Monochromator	Multilayer monochromator
Type of instrument	Two-axis.
Typical flux at specimen (Dq = 0.03°)	3 x 10^5 n/cm^2/s
Max. beam size at specimen	Width : 1.5 mm Height : 15 mm
Incident wavelength	0.43 nm
Angular resolution (horizontal)	0.01° to 06° (typical 0.04°)
Vertical divergence	2°
Angular range	$0 \leq 2\theta \leq 120°$
Minimum step size scan	$\Delta\theta$ = 0. 01°
Detectors	^{3}He tube or microstrip PSD

Ancillary equipment

★ Cryomagnet : 2.5 K ≤ T ≤ 300 K
B = 7 T in the sample plane
★ Continuous flow cryostat : 80 K ≤ T ≤ 300 K
B = 1.2 T in the sample plane or
Perpendicular to the sample plane
★ Furnace : 800°C in 10 mT

This spectrometer is suited for the study of magnetic thin films and multilayers with polarisation analysis but can also be used for high resolution large angle diffraction.

We use movements with a precision of 0.01°. Slits are made of single crystal Gallium Gadolinium Garnet to reduce small angle neutron scattering.
The incident beam is produced by a multilayer monochromator mounted in the guide G 2. The wavelength is fixed at 0.43 nm. The wavelength spectrum width $d\lambda/\lambda$ is 5%.
The scattering angle 2θ can be varied up to 120°. The sample table can sustain 350 kg and the beam center is at 270 mm from the top goniometer.
Experiment interface allows complex batching for sweeping field, currents, temperatures, etc… while scanning angles.

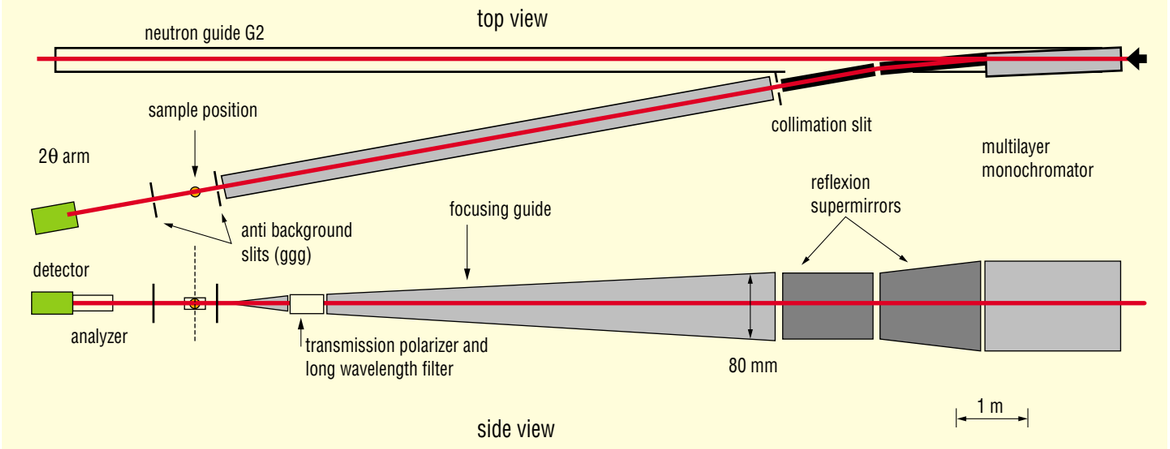
The spectrometer can be equipped with a cryomagnet for low temperature measurements or high field measurements (up to 7 T in the sample plane). It can also be equipped with a more flexible nitrogen continuous flow cryostat that can be fitted into a 1.2 T magnet.
In this latter case, the field can be applied in any direction relative to the sample plane.

Neutrons are polarised with transmission FeCo/Si supermirrors. The polarisation is analysed by reflection supermirrors. The flipping ration is of the order of 35.

In reflectivity, this spectrometer allows to measure reflectivity curves with a dynamic range of 10^5 - 10^6 on a 1 cm^2 sample in 12 hours for all spin states (non spin-flip and spin-flip).

Two-Axis Polarised Reflectometer with Polarisation Analysis PRISM

G 2-4



General view of the G 2-4 spectrometer.

Responsible : F. Ott

e-mail : fott@llb.saclay.cea.fr

G 3 BIS

Time of Flight Reflectometer EROS

Distance chopper to detector ..... 6.25 m
Distance sample to detector ..... 2 m
Wavelength range ..... 3 Å to 25 Å
Wavelength resolution ..... fixed $\Delta\lambda$ from 0.1 Å to 1 Å
Angular range ..... 0.1° to 6°
Angular resolution ..... 0.007° to 0.15°
Position of the surface ..... horizontal
Horizontal beam size at the sample ..... 25 mm
Vertical beam size at the sample ..... 0.5 mm to 10 mm
Detection ..... ^{3}He
Maximum intensity ..... 1000 count.sec^{-1} Å^{-1} at 3.5 Å
Background ..... 1 count.hour^{-1} Å^{-1}
Minimum measurable reflectivity ..... 5.10^{-6}
Typical acquisition time : ..... 4 h - 8 h (soft matter)

Ancillary equipment

★ Multireflections system for samples of 10 cm to 50 cm long
★ Furnace (60°C, 200°C)
★ Magnets with horizontal or vertical field between 0.001 T and 1 Tesla
★ Controlled temperature cells (from -40°C to 60°C) for liquid surface measurements
★ Polarizer and flipper for polarized neutron measurements

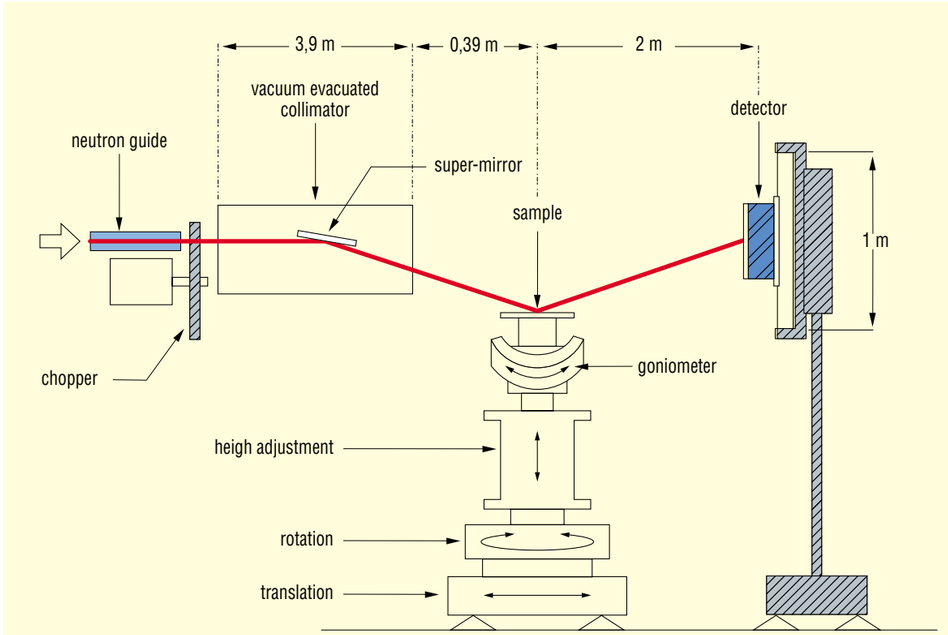
This reflectometer is dedicated to the study of interfaces by neutron reflection. The reflected intensity at grazing angle of a non polarized white neutron beam is measured as a function of wavelength. The variation of this reflection coefficient (reflectivity) with the wavevector is linked to the concentration profile perpendicular to the interface. If this profile is represented by a succession of different layers, the thickness, composition and roughness of each layer may be determined within the range from 2 to 500 nm for thickness and 1 to 20 nm for roughness. All type of interfaces might be studied, including air/liquid interfaces.

The reflectometer is installed at the end of the neutron guide G 3 bis. It is composed first of a chopper that produced the neutron bursts. Then, a 3.9 m evacuated collimator defined a very narrow neutron beam. Inside the collimator, a neutron supermirror enables the deviation of the beam towards liquid surfaces. The samples are installed on a goniometric head for alignment purpose. The reflected intensity is measured at a 2 to 4 m distance by single ^{3}He counter.

A polarizer and a flipper can be installed in order to perform polarized neutron measurements. A multireflections measurement system providing a better precision on the reflection coefficient when this one is close to one is available.

Time of Flight Reflectometer EROS

G 3 BIS



General layout of the spectrometer G 3 BIS.

Responsible : A. Menelle

e-mail : menl@llb.saclay.cea.fr

INELASTIC SCATTERING

I

Triple-axis instruments

"TRIPLE AXIS EQUIPMENT POOL"

The triple axis group has a pool of sample environments available for use on
1T1, 2T1, 4F1, 4F2 and G 4-3.
Request for their use are made to the local contact.

- *Graphite filter*

- *Furnace ➜ 200 - 1800°C*
  Furnace ➜ 20 - 400°C

- *Nitrogen flow cryofurnace ➜ 80 - 600 K*
  He Cryogenerators ➜ 10 - 300 K
  Top loading He cryogenerators ➜ 10 - 300 K
  ^{4}He cryostats ➜ 1.5 - 300 K
  Dilution insert ➜ 100 mK - 6 K

- *Electromagnet horizontal or vertical field 0 - 1.1 Tesla*
  Helmoltz coils vertical field ➜ 0 - 0.17 T
  Cryomagnet vertical field ➜ 0 - 6 T

- *Pressure cryostat ➜ 0 - 300 K with :*
  - *He hydrostatic pressure cell (isotropic) ➜ 0 - 5 Kbar*
  - *Clamp hydrostatic pressure cell (isotropic) ➜ 0 - 16 Kbar*
  - *Clamp hydrostatic pressure cell (windows) ➜ 0 - 25 Kbar*

- *Electric field insert (0 - 4 kV) for top loading cryogenerator*

Beam tube :	Tangential 40 x 80 mm^2
Monochromator :	PG 002, Cu 111, Cu 220
Incident wavelength :	0.6 < λ
Incident energy resolution :	Variable, typical 5 %
Analyzer :	PG 002
Collimations - In pile :	40' , 25' , 15'
Collimations - Mon-sample :	66' , 49' , 31' , 14'
Collimations - Sample-an.:	75', 49', 30', 23', 20', 12'
Collimations -An.-det. :	75', 49', 30', 23', 20', 12'
Range of monochromator take-off angle :	15° < $2\theta_m$ < 80°
Range of scattering angles :	-50° < φ < 125°
Range of detector angle :	-100° < 2θ < 100°
Range of goniometer arcs :	± 20°
Distance goniometer-center of beam :	170 ± 30 mm
Flux at specimen :	Strongly dependent on collimation and energy
Beam size at specimen :	Defined by diaphragm (30 x 40 mm^2)
Momentum transfer :	0.3 - 10 Å^{-1}
Energy transfer :	0.8 - 100 meV
Detector :	^{3}He (upright, area : 50 x 100 mm^2)

Ancillary equipment — ★ **"Triple Axis Equipment Pool" (see on front of this chapter)**

This triple-axis spectrometer is installed on the thermal neutron beamline and is dedicated to the study of inelastic neutron scattering due to collective excitations in condensed matter. The triple-axis geometry allows measurements of the scattering function S(**Q**, ω) in single crystals at well defined values of the reciprocal lattice vector **Q** and the energy, ω. In the past the spectrometer has been successfully utilized for investigations of lattice dynamics (phonons) and magnetic excitations (magnons and more exotic excitations in strongly correlated electron systems) in a wide variety of materials. The spectrometer has vertical and horizontal focusing of both the monochromator and analyzer, which optimizes the observed intensity at the expense of wavevector resolution. This feature allows one to obtain useful results even with relatively small samples.

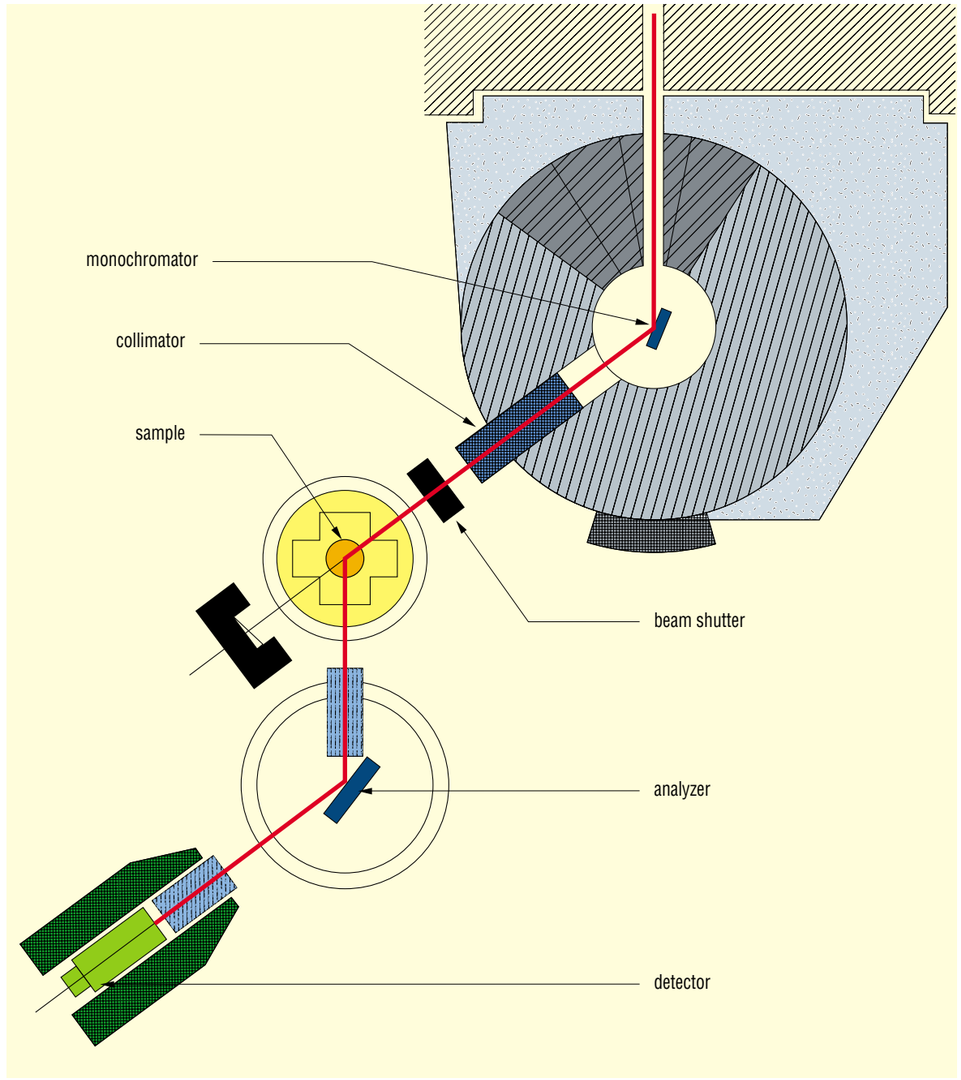
The main components of the instrument are the monochromator stage, the sample stage, and the analyzer stage. Neutron trajectories are defined by Soller collimators. Rutherford collimators with replaceable blades are available as well. The instrument is fully computer-controlled, with the software allowing scans in and out of the scattering plane.

The monochromator stage allows the use of three different monochromators (PG002, Cu111, and Cu220). All are vertically and horizontally focusing in order to increase the neutron flux at the sample position. The horizontal curvature for all monochromators, and the vertical curvature for the PG002 and Cu220 monochromators are fixed. The Cu111 monochromator has a variable vertical curvature, to achieve optimal focusing for a wide range of incident neutron energies. The monochromators, which are mounted inside a mobile concrete drum, can be interchanged by remote control.

The rotating sample stage is equipped with a double goniometer as well as translation stages, which allow one to tilt the sample in any direction as well as to adjust the horizontal and vertical positions of the sample.

The analyzer stage can be used with three different analyzers (flat PG002, focusing PG002). They are mounted on small individual modules that one can install in reproducible orientations. The focusing PG002 monochromator has fixed vertical curvature and variable horizontal curvature. It contains two remote-controlled slits, a vertical one before the analyzer crystal and a horizontal one before the detector. These can be used to optimize the signal to background ratio as well as the analyzer resolution.

Double Focusing Thermal Triple Axis Spectrometer 1 T1



General layout of the spectrometer 1 T1.

This spectrometer has been built by German scientists and is operated in collaboration between the INFP Karlsruhe and the L.L.B

Responsibles : D. Reznik **e-mail : reznik@llb.saclay.cea.fr**

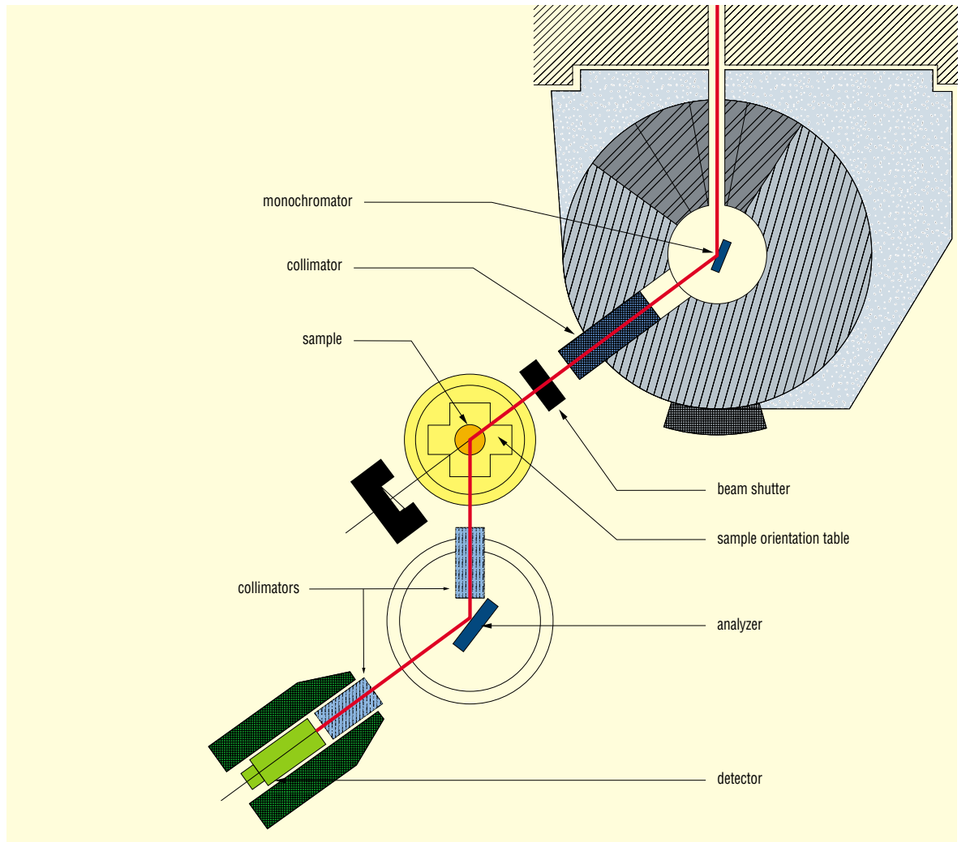
Beam tube	Tangential on thermal source channel 2 T : 5 x 12 cm^2
Monochromator	Option unpolarized neutrons : 1) PG 002, η ~ 0.6° 15 x 13 cm^2 2) Cu 111, η ~ 0.8° 15 x 13 cm^2
Monochromator	Option polarized neutrons : Heusler, η ~ 0.5° 14 x 13 cm^2 All monochromators have a vertical curvature automatically adapted to the incident neutron energy
Analyzer	Option unpolarized neutrons PG 002, η ~ 0.6° 11 x 9 cm^2
Analyzer	Option polarized neutrons Heusler, η ~ 0.5° 11 x 10 cm^2 Both analyzers have an horizontal curvature automatically adapted to the final neutron energy. The PG 002 has additionally a vertical curvature which can be manually changed
Beam size at specimen	3 x 4 cm^2
Incident energy	8 - 140 meV (unpolarized neutrons) 8 - 70 meV (polarized neutrons)
Momentum transfer	0 - 8 $Å^{-1}$
Energy transfer	0 - 100 meV (unpolarized neutrons) 0 - 55 meV (polarized neutrons)
Detector	^{3}He
Typical energy resolution :	$\delta\omega \approx 0.8$ meV at $k_F = 2.662$ $Å^{-1}$ ($E_F = 14.7$ meV) $\delta\omega \approx 3.5$ meV at $k_F = 4.1$ $Å^{-1}$ ($E_F = 35$ meV)
Collimation :	10' to 60'
Range of scattering angle :	$0° \leq 2\theta_s \leq 360°$ (± 20° double goniometer)
Ancillary equipment	★ **"Triple Axis Equipment Pool" (see on front of this chapter)**

This spectrometer has been built to study inelastic scattering from condensed matter. This corresponds to collective excitations either from the lattice (phonons) or from magnetically ordered systems (magnons). The triple axis spectrometer can be also used to study the dynamics in more disordered samples such as amorphous systems and spin-glass as it fully measures the scattering function S(Q, ω) over a wide energy range and at any position in the reciprocal space. For instance, in strongly correlated electron systems such as high-T_c superconductors, one can fully determine the generalized spin susceptibility. By selecting the neutron polarization one can further separate magnetic scattering from lattice contributions. A polarized option can be used on 2 T.
The spectrometer is composed of 3 elements, each rocking around an axis :

1) The first axis is a monochromator to select neutrons with specific incident energy. This part is inside a mobile concrete block (called drum).
2) The second axis is related to the sample to be studied which can be oriented in any direction.
3) The third axis is an analyzer allowing to determine the final neutron energy. After being selected by the analyzer, the neutrons are finally measured by a ^{3}He detector located in a closed block in order to reduce the background level.

With the polarized option, the neutron polarization is selected by a monochromator and an analyzer, both made of an Heusler alloy which allows to select only neutrons with a specific spin state. A coil flipper is used to reverse the neutron spin state and select each component of the neutron cross-section.

Horizontal guide fields are installed in the monochromator drum up to the sample position and vertical guide fields between sample to the analyzer. A small field (~ 15 Oe) of arbitrary orientation can be applied at the sample position using an Helmoltz coils system consisting of three coils on a cylinder surface and two circular coils.



General layout of the spectrometer 2 T1.

On different segments of the neutron path (reactor-monochromator, sample-analyzer, analyzer-detector), Soller collimations can be placed to choose the angular divergence and improve the spectrometer resolution. All equipment of the triple axis pool can be installed at the sample position on the goniometers system (Cryostat (with dilution insert), Close-cycle refrigerator, Vertical Magnetic coil, Furnaces, Pressure cell…).

Due to its implementation on a thermal neutron beam, this spectrometer is well adapted for studying excitations over a wide energy range 1.5 to 100 meV (0.3 to 25 THz) which covers the typical range of phonon and magnon branches in single crystals.
All triple-axis measurements can be fitted on line by an homemade fitting programme. This programme performs a convolution product of all standard neutron cross-sections by the spectrometer resolution function.

Responsible : P. Bourges **e-mail : bourges@llb.saclay.cea.fr**

Areas are given.....Width x height
Beam tube.....Left beam of tangential channel 4F,
aimed to cold source SF2
Radiant surface : 8 x 15 cm^2
Output of the channel : 4 x 7 cm^2
Monochromator.....Double monochromator set-up
M 1 : Pyrolytic graphite η = 0.4° 11 x 8.5 cm^2
allows controlled vertical focussing
M2 : Pyrolytic graphite η = 0.8° 11 x 8.5 cm^2

Analyzer..... Pyrolytic graphite η = 0.4° 6 x 6 cm^2
Horizontally bent pyrolytic graphite 6 x 6 cm^2
Incident wavelength.....1.8 < λ < 6 Å
Incident energy resolution..... 300 > δE > 3 GHz
Collimation (horizontal)..... in pile : 50', 30', 15'
between monochrom.(optional) : 50'
others : 60', 40', 20', 10'
Range of monochromator angle (M2).....31° < 2θ < 149°
Range of scattering angle.....-5° ≤ ϕ ≤ 140°
Range of analyzer angle.....0 < $2\theta_A$ ≤ 150°
Range of crystal orientation.....0 ≤ ψ ≤ 360°
± 20° double goniometer
Detector..... ^{3}He
Beam size at specimen..... 4 x 8 cm^2
Background.....~0.5 count/minute

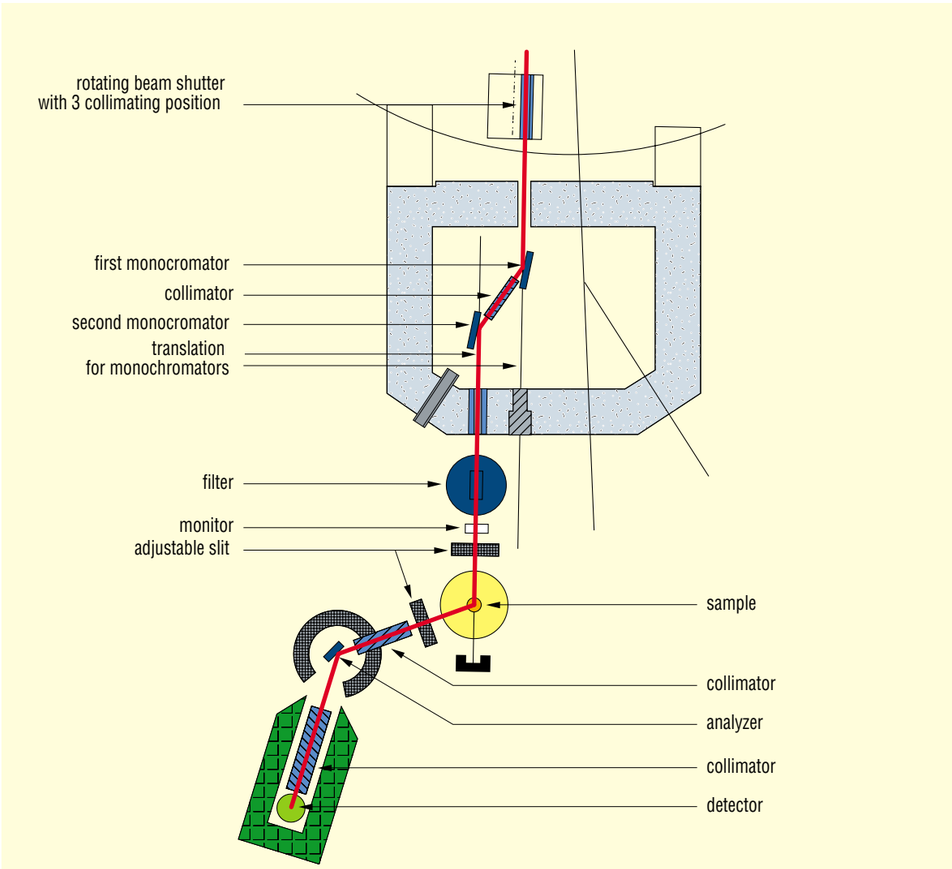
ki ($Å^{-1}$)		1.05	1.55	2.66
Best energy resolution (FWHM at ω = 0)	(GHz)	3.6	20	120
	(microeV)	15	80	500
Best wave-vector resolution (FWHM)	($Å^{-1}$)	3.10^{-3}	5.10^{-3}	9.10^{-3}
Flux at sample (n/cm2 sec)		-	$3.5x10^6$	$14x10^6$

Ancillary equipment
★ Be filter (77 K)
★ Neutron polarization and polarization analyzis
★ **"Triple Axis Equipment Pool"**
(see on front of this chapter)

4F1 and 4F2 are twin 3-axis spectrometers with very similar characteristics which are fed by a liquid-hydrogen cold neutron source
A full description of both spectrometers is given on the 4F2 page.
As an option, 4F1 can be equipped for polarized neutrons with polarization analysis.
The four intensities I^{++}, I^{+-}, I^{-+}, I^{--} corresponding to neutron spin-flip and non–spin-flip processes can be measured sequentially.
This requires the installation of an additional shielded module between the monochromator and the sample, containing a filter, the polarizing supermirror and a Mezei flipper. The supermirror can be rotated to achieve optimal alignment, yielding a polarization efficiency of 98% with a reflectivity of 55% above λ = 3.5 Å.

Vertical and horizontal guide fields are available.
The sample can be subjected to in a magnetic field:
• horizontal field up to 0.7 or 1.4 T (electromagnet), depending on the gap
• vertical field up to 0.14 T (Helmoltz coils) or 1.4 T (electromagnet) or 6T (cryomagnet)
• 3D-inclined guiding field of 1mT (cubic die magnet with 3 orthogonal windings).
The second flipper, made of a superconducting foil and a switched magnetic coil, is placed between the sample and the analyzer.
The horizontally curved Heusler analyzer performs both energy and polarization analyzis.

Cold Neutron Three Axis Spectrometer 4 F 1



General layout of the spectrometer 4F1

Responsibles : **M. Hennion** **e-mail : mhennion@llb.saclay.cea.fr**
JM. Mignot **e-mail : mignot@llb.saclay.cea.fr**

Areas are given..... Width x height
Beam tube..... Right beam of tangential channel 4 F
aimed to cold source SF2
Monochromator..... Double monochromator set-up
M1 : pyrolytic graphite h = 0.4°
11x8.5 cm^2 computer controlled vertical focussing
M2 : pyrolytic graphite h = 0.4° 11x8.5 cm^2
Analyzer..... Flat pyrolytic graphite h = 0.4 ° 7.5x5 cm^2
Horizontally curved pyrolytic graphite 6x6 cm^2
Flat Ge (111)
Collimations..... In pile : 50', 30', 15'
between M1-M2 25' (optional)
others : 60', 40', 20', 10'
Range of monochromator angle..... $31° < 2\theta < 149°$
Range of scattering angle..... $-2° < \phi < 150°$
Range of analyzer angle..... $-150° < 2\theta_A < 150°$
Range of crystal orientation..... $0 < \psi < 350°$
Beam size at sample..... 2 x 4 cm^2
Detector..... ^3He ∅ = 5 cm h = 15 cm
Incident wavelength (wave-vector)..... $2 < \lambda_i$ (Å) < 6.3 $(3.2 > k_i (Å^{-1}) > 1)$
Scattered wavelength (wave-vector)..... $1.6 < \lambda_f$ (Å) < 6 $(4 > k_f (Å^{-1}) > 1.05)$

ki ($Å^{-1}$)	1.05	1.55	2.66
Maximum energy creation (THz)	-	0.75 (3 meV)	3.1 (12 meV)
Best energy resolution (Ghz)	2.3 (9 μeV)	13 (50 μeV)	80 (320 μeV)
Typical energy resolution (Ghz)	7 (30μeV)	56 (220μeV)	300 (1,2 meV)
Maximum wave-vector transfer ($Å^{-1}$)	1.9	3	5.1
Best wave-vector resolution ($Å^{-1}$)	3.10^{-3}	$5\ 10^{-3}$	$.9\ 10^{-3}$
Flux at sample (n/cm2 sec.)	-	$3.5x10^6$	$14x10^6$

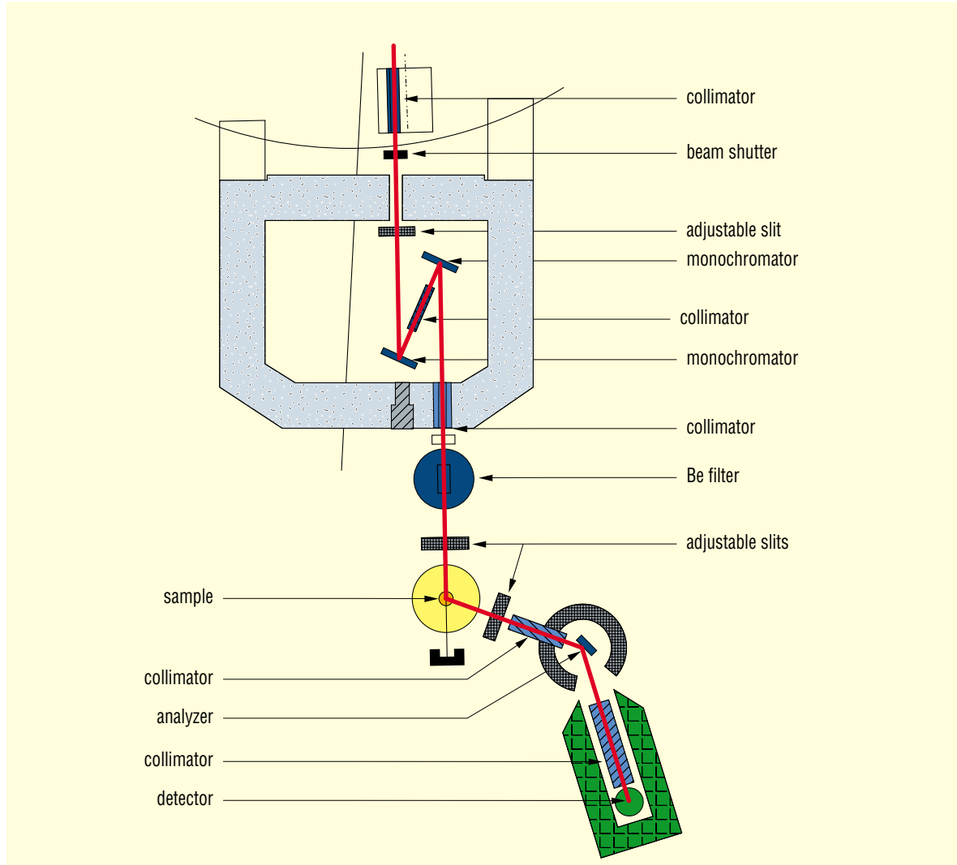
Ancillary equipment

★ Be filter (77 K)
★ **"Triple Axis Equipment Pool"**
(see on front of this chapter)

4F1 and 4F2 are twin 3-axis spectrometers with very similar characteristics (see description below), which are fed by a liquid-hydrogen cold neutron source.
Polarized neutrons are only available on 4F1 (see 4F1 page).
These spectrometers are designed for measuring dispersive excitations with low energy transfers (w < 4 meV, n < 1THz) with a good resolution and a high flux (see Table).
They are well suited for measuring acoustic phonon dispersions, soft phonons, spin waves, quasi-elastic scattering, as well as for fine studies of modulated structures.
They are equipped with a double pyrolytic graphite monochromator, providing wavelengths between 6 and 2 Å (1.05 < ki < 2.7 $Å^{-1}$. Available collimators are (60', 30',15') before and (60', 40', 20', 10') after the monochromators. An optional collimator (25', 15') can be added between the two monochromators. The monochromator has a computer-controlled vertical focusing.
The incident beam can be filtered by a cooled Be or a graphite filter.

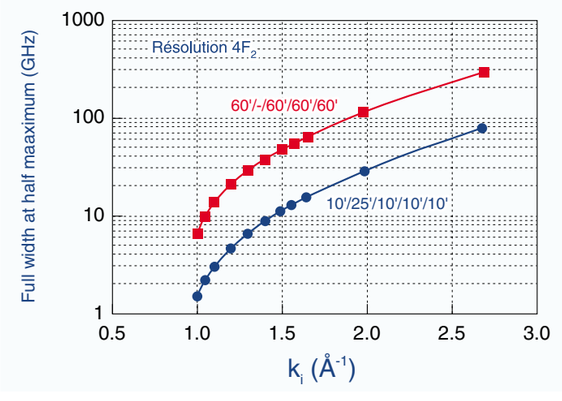
The pyrolytic graphite analyzer is normally used in a horizontally focusing geometry. In this mode, the curvature of the analyzer is controlled by the computer, and the collimators (60', 40', 20', 10') are replaced by wedge-shaped tunnels.
The sample table is equipped with two orthogonal non-magnetic goniometers, allowing tilts of ± 20°. Their upper face (serving as a support for the various sample environments) is located 270 mm below the axis of the beam.
The sample-to-monochromator and sample-to-analyzer distances can be adjusted to accommodate various sample environments.
The spectrometer is controlled by a SUN computer running under Unix/Solaris OS. It allows various data processing softwares, including fit and convolution programs, to be run in real time during the measurements.

Cold Neutron Three Axis Spectrometer 4 F 2



General layout of the diffractometer 4F2

Energy resolution (GHz) as a function of the incident wave-vector ki. Collimations are respectively: in-pile/M1-M2/M2-sample/sample-analyzer/analyzer-counter



Responsibles : **D. Petitgrand** **e-mail : petitg@llb.saclay.cea.fr**

Beam tube	Neutron Guide G4 25 x 150 mm^2
Monochromator	Pyrolytic graphite 75 x 150 mm^2
Analyzer	Pyrolytic graphite 75 x 100 mm^2
	Vertically bent (curvature is adjusted automatically)
Incident wavelength	$0.235 < \lambda < 0.6$ nm
Incident energy resolution	$0.005 < \delta\omega < 0.2$ Thz
Collimations	Interchangeable, 60', 30', 10'
	on each arm after monochromator
Range of monochromator angle	$40° < 2\theta < 140°$
Range of scattering angle	$-140° < \phi < +140°$
Range of analyzer angle	$-155° < 2\theta < +155°$
Range of crystal orientation	$0 < \psi < 360°$
	Eulerian cradle or goniometer
Max. flux at specimen	5.10^5 n/cm^2 sec (k_i = 18.5 nm^{-1})
Beam size ar specimen	Width : 25 mm ; height 50 mm
→ Momentum transfer	0 - 30 nm^{-1}
→ Energy transfer	0 - 3 Thz
Detector	^{3}He

Ancillary equipment

★ Be filter (77 K)
★ Furnace (20 - 1200°C)
★ Multidetector : only in diffraction mode (without analyzer)
★ **Triple Axis Equipment Pool (see on front page of this chapter)**

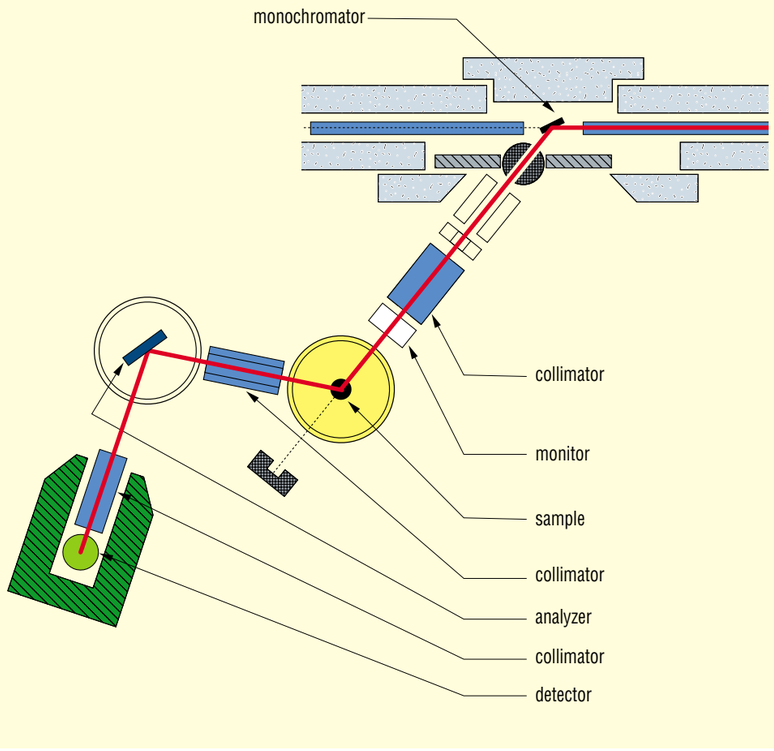
On the one hand this spectrometer is used for the investigation of inelastic scattering at low energies with high resolution like measurements of dispersion curves of phonons and magnons, phonon softening, etc… On the other hand it serves for elastic studies on problems where good peak/background ratio, suppression of inelastic scattering and high resolution of momentum and/or energy transfer are essential.

The neutrons are extracted from the guide by a focusing monochromator of pyrolytic graphite. Wavelengths are available in the range of 0.235 nm to 0.6 nm which allows the use of a pyrolytic graphite (ki = 26.62 nm^{-1}) or a beryllium (ki = 15 nm^{-1}) filter for suppressing second order contributions from the incident beam.

All modules are set on air cushions. The spectrometer is entirely controlled by a Unix computer system and all elements (mechanical, electronical, software and data treatment) are fully compatible with the other triple axis spectrometers of the LLB. Because of its position at a cold guide, the conditions are particularly favourable for investigations requiring low background and excellent resolution.

The goniometers of this spectrometer permit to mount every equipment available through the triple axis pool such as pressure cells, cooling devices and magnets.

Cold Neutron Triple Axis Spectrometer G 4-3



General layout of the spectrometer G 4-3.

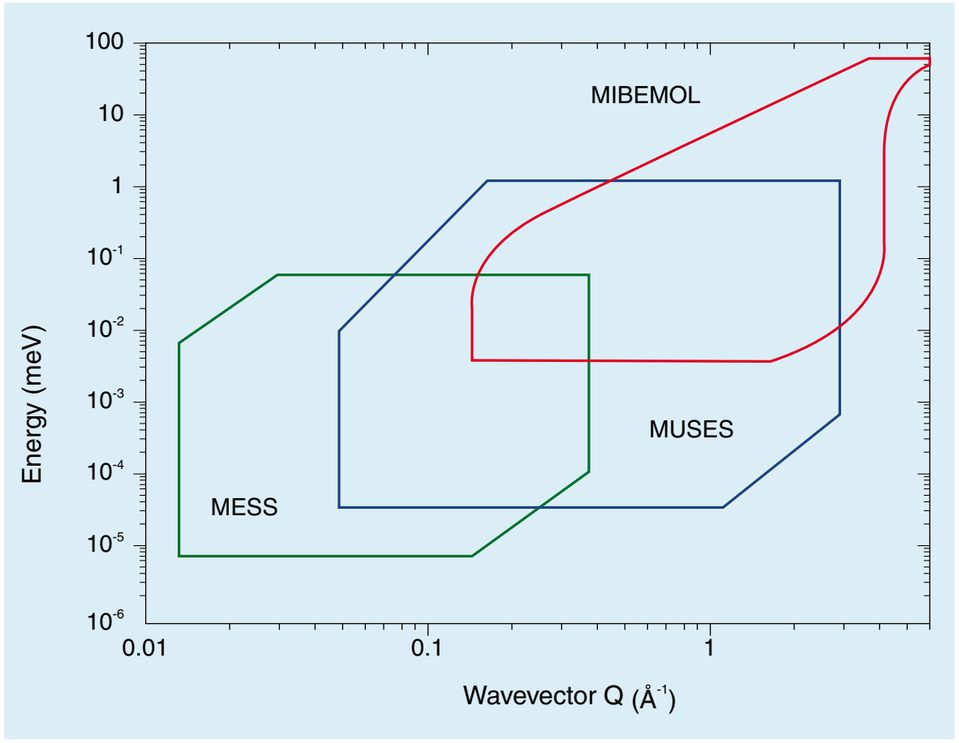
Responsible : M. Prem (University of Vienna) e-mail : prem@llb.saclay.cea.fr

II

Quasi-elastic and high resolution instruments

HIGH RESOLUTION SPECTROMETERS FOR INELASTIC AND QUASIELASTIC NEUTRON SCATTERING

There are 3 different high resolution instruments at the LLB : a time-of-flight spectrometer (Mibémol) and 2 neutron spin-echo spectrometers (Mess and Muses). Each spectrometer cover domain in the energy-wavevector space which is complementary to the others (see figure). It is then possible to measure condensed matter dynamics from microscopic to mesoscopic length scales over more than 6 orders of magnitudes in time (0.1 - 50000 ps). The three spectrometers use cold neutron beams of the Orphée guide hall.



Energy - wavevector domain cover by each spectrometer

In time-of-flight spectroscopy, neutron energy changes are directly measured by differences between incident and scattered neutrons beam energies.

MIBEMOL uses a primary chopper cascade spectrometer to produce roughly monochromatic pulsed beam. Energy analysis is performed by measurement of the time-of-flight from sample to detector. The scattered neutron beam is recorded simultaneously over a wide range of angle. This instrument is very versatile with respect to wavelength and energy resolution which depend on chopper speed and respective phases. This spectrometer is generally used to measure dynamics of sample with a smooth wavevector dependent intensity like incoherent or coherent scattering of non long range ordered systems. The measurements are performed at constant angle, thus **Q** and ω are strongly correlated. Medium energy phenomena (E < 15 meV) can be measured in neutron energy gain and as a particular consequence of the instrument flexibility, measurements can be performed with everything constant but the energy resolution using different configurations.

In neutron spin-echo spectroscopy neutron energy changes are measured via neutron spins. This trick allows a decoupling of incident beam monochromatisation and energy analysis. Hence this technique can use a broad wavelength distribution and the measured quantity (scattered beam polarization) is, to the first order, proportional to the intermediate scattering function I (Q, t).

MESS is a small angle neutron spin echo spectrometer. It get advantage of the strong SANS intensity from coherent scattering length density differences (the use of H-D contrast is particularly important) to compensate for the flux decrease arising from the necessary beam collimation of the SANS measurements. The precession regions are very long (sample to detector distance ~ 6 m) thus the maximum Fourier time is ~ 40 ns.

MUSES is optimized for higher angle measurements with a very high intensity at the sample position and a strong flexibility. It can be used to measure coherent scattering and isotopic incoherent scattering processes over broad wavevector domain and high resolution. Spin incoherent scattering intensity can also be measured (in absence of significant coherent scattering) although the inherent P = -1/3 reduction of the scattered beam polarization. Both spectrometers MESS and MUSES can also be used for polarization analyzis.

	Mibémol	**MUSES**	**MESS**
λ (Å)	2 ... 12	3.5 ... 14	5 ... 10
2θ (°)	37 ... 142°	5 ... 110°	1.5 ... 25°
Max E gain (meV)	30	0.6	0.6
δ E (μev)	20 ... 500	0.030	0.016
Q max (Å^{-1})	4.0	2.75	0.5
Q min (Å^{-1})	0.2	0.05	0.016

Beam tube ..... Cold G6. Neutron guide 2.5 x 5 cm^2
Incident wavelength ..... $2 < \lambda < 12$ Å
Range of incident energies ..... $0.6 < E < 20$ meV
Monochromator = counter rotating choppers .. 20 000 RPM (equivalent)

Elastic energy resolution ..... $1\ \% < \frac{\Delta E}{E} < 8\ \%$

Distance from sample to detectors ..... 3. 58 m
Horizontal divergence ..... ±0.1° per Å on the sample
Vertical divergence ..... ±0.1° per Å on the sample
Flux at specimen ..... 1.2 x 10^4 $n/cm^2/sec$ at 5.0 Å.
Beam size at specimen ..... 2.5 x 5.0 cm^2

Detectors (size and scattering angle at specimen) :

★ 400 ^{3}He detectors (width = 32 mm, height = 370 mm) located at 67 positions ($\Delta\theta = 1.3°$, $\Delta\Omega = 5.6\ 10^{-3}$ sterrad) $35° < 2\theta < 147°$
★ 32 ^{3}He detectors (width = 32 mm, height = 250 mm) located at 4 positions between $12° < 2\theta < 32°$.

Ancillary equipments available

★ Cryostat 1.5 K < T < 300 K
★ Cryogenerator 10 K < T < 300 K
★ Furnace 50°C < T < 400°C
★ Cryofurnace 4 K < T < 600 K
★ Thermo regulated bath -40°C < T < 100°C
★ High Temperature furnace 200°C < T < 1200°C
★ Cryoloop 110 K < T < 700 K

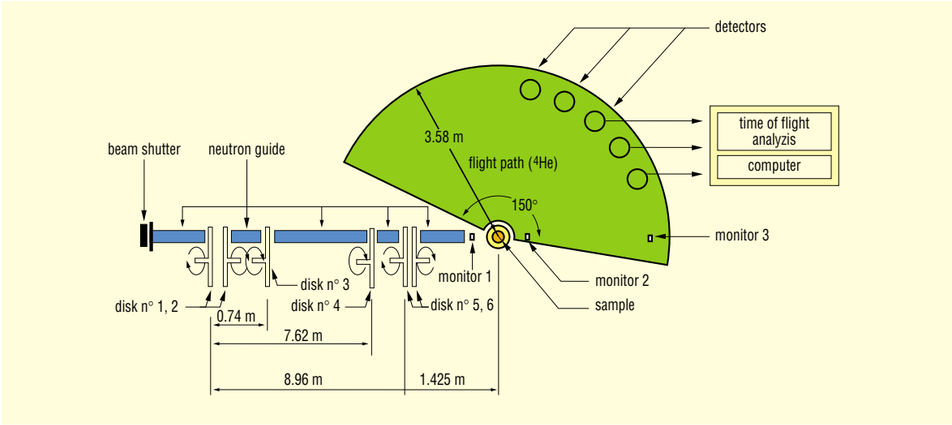
MIBEMOL is an inelastic time-of-flight neutron spectrometer. It is designed to study soft non dispersive excitations in condensed matter between 0.01 and 100 meV (1 meV = 8 cm^{-1} = 0.25 Thz). The corresponding time-scale ranges from 10^{-13} up to 10^{-10} seconds.

Typical study performed on the instrument cover field as different as spin dynamics in high Tc superconductors, tunneling, dynamics of quantum liquids, dynamics of soft matter, biology, local and long range diffusion in disordered systems.

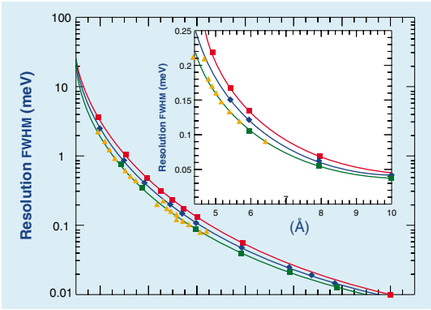
The spectrometer is settled at the end of the G 6 cold guide. The monochromatisation of the incident beam is achieved by a system of six choppers.

The flight path from end of the guide to sample is under primary vacuum. To avoid scattering by atmospheric water the time-of-flight basis is filled with He.

As shown on Fig.1, flux at sample, energy resolution and accessible Q range (not shown) are strongly dependent of incident wavelength on sample. Mibémol is a very versatile instrument that makes possible to set-up those parameters so as to match with the best conditions needed to deal with the excitation under study. Some numerical examples showing large increase of flux upon spectrometer setting are given in table 1.



General layout of the time-of-flight spectrometer G 6-2.



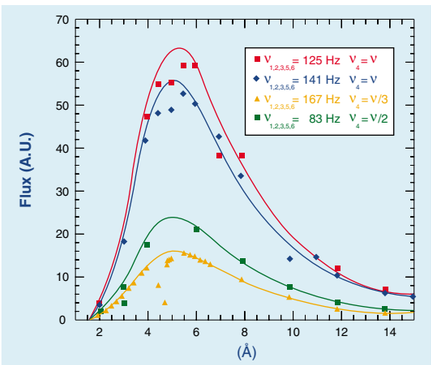


Fig. 1 : *Examples of some achievable instrumental conditions on Mibémol as function of neutron incident wavelength.*
For a given incident wavelength, while the resolution is a slowly varying function of the speed of the choppers, the flux is strongly dependent of this parameter.

Top : Corresponding energy resolution (FWHM). Symbols and colors are the same as for bottom plot. Resolutions achieved for usual wavelength are shown in the inset.

Bottom : Flux at sample as a function of the speed of the choppers. For all curves, frequencies of chopper 1, 2, 3, 5, 6 are equal. The frequency of chopper 4 (anti-overlap chopper is indicated).

Table 1 : *Selected examples showing the increase of flux obtained for two usual energy resolutions (R) by interplay of chopper frequencies (ν) and initial wavelength (λ). For each resolution, calculations have been made by considering $\nu_2 = \nu_1$ and $\nu_2 = \nu_1/3$.*

		$\nu_2 = \nu_1$		$\nu_2 = 0$	
R (μe V)	$\nu_{1,3,5,6}$ (Hz)	λ (Å)	Flux (A.U.)	λ (Å)	Flux (A.U.)
	166	5.8	15.9	5.9	23.5
100	133	6.3	18.4	6.4	26.9
	83	7.3	22.8	7.5	32.7
	166	9.3	6.3	9.5	8.9
24	133	10.0	6.4	10.3	9.0
	83	11.8	6.4	12.0	9.0

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G 1 BIS Neutron resonance spin-echo Spectrometer MUSES

Beam tube	Cold G 1 bis. Neutron guide 2.5 x 5 cm^2, polarizing bender	
Incident wavelength	$3.5 < \lambda < 14$ Å	
Range of incident energies	$0.4 < E < 6.7$ meV	
Monochromator = Dornier velocity selector	max speed 28 000 RPM	$\frac{\Delta\lambda}{\lambda} = 0.1 - 0.15$
Beam area at sample position	4 x 4 cm^2	
Flux at sample position (polarized)	10^7 n/cm^2/sec at 5.0 Å.	
Divergence	± 0.1° per Å on the sample	
Distance sample - Detector	3100 mm	
Field path integral with NSE Option	0.5 - 50 G.m	
Frequency range of the RF coils	40 - 640 kHz	
Distance between RF coils	1800 mm	
Time range	λ = 3.5 Å	1.2 ps ... 1.1 ns
	λ = 6.0 Å	6 ps ... 5.0 ns
	λ = 10 Å	29 ps ... 22.0 ns
Energy range	λ = 3.5 Å	6.0 10^{-4} ... 0.55 mev
	λ = 6.0 Å	1.3 10^{-4} ... 0.11 mev
	λ = 10 Å	3.0 10^{-5} ... 0.02 mev
Angular range	4 - 110°	

Polarizing/analysing devices

★ Polarizing bender R = 76 m, FeCo/TiNi supermirrors m = 2.5 on the concave side and m = 2 on the convex side, the 25 mm beam is divide into 3 channels of 8 mm

★ Analysing device : supermirrors R = 17 m, 5 x 5.6 x 500 mm^3

Ancillary equipments available

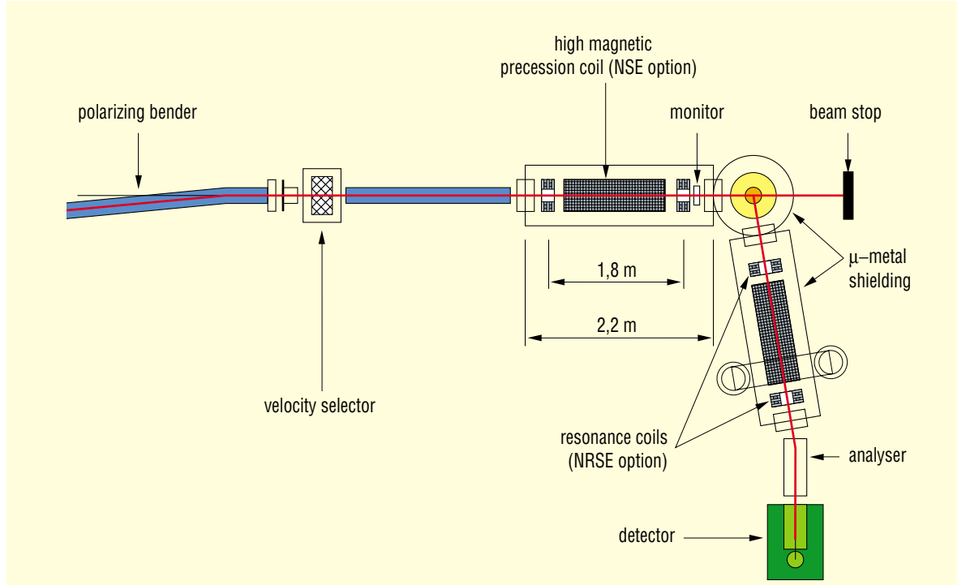
★ 10 K < 800 K

★ 4 K < 600 K

★ 200°C < 1800 °C

MUSES is a mixed resonance-conventional neutron spin echo spectrometer installed on the guide G 1 bis. The aim of this spectrometer is to study high resolution quasielastic scattering in the medium wavevector range (0.05 $Å^{-1} < Q < 2.75$ $Å^{-1}$) bridging the gap between Time-of-flight spectroscopy and SANS Neutron Spin-Echo at the LLB.

The spectrometer is divided into two distinct parts, a conventional NSE spectrometer for measurements at small Fourier times (typically $\tau < 200$ ps for $\lambda \sim 10$ Å) and an NRSE option for measurements at longer times. In resonance spin-echo spectrometry, the two high magnetic precession coils are replaced by four radio-frequency coils ; two in the first arm and two in the second. Only within these coils the spins are submitted to magnetic field and consequently the remaining neutron path has to be shielded from any magnetic contamination (earth magnetic field...). The field geometry in the coils is very similar to the one used in nuclear magnetic resonance : a static high field in the vertical direction B_0, and a horizontal radio-



General set-up of the spin-echo spectrometer G 1 BIS.

frequency field $B_1(t)$ rotating in the horizontal plane. Such a configuration allows measurements at high Fourier times without the need of high magnetic fields. It is particulary interesting for measurements at high angles, because of the difficulty of keeping the field line path in the sample position with conventional NSE option (needs of tunning devices). It allows a very high flexibility with respect to wavevector changes : the resolution function is negligibly angle dependent for a given wavelength.

The neutron beam is polarized by a bender of 4 m length and 76 m radius made out with NiTi super mirrors. A velocity selector roughly monochromizes the incident flux with a wavelength band of $\delta\lambda/\lambda \sim 0.1 - 0.15$. The polarized flux intensity at the wavelength maximum and at the sample position of the spectrometer MUSES is 10^7 n.cm^{-2} s^{-1} for $\lambda \sim 5$ Å, this total integrated flux of the 40 x 40 mm^2 beam at the sample position is ~ 1.6 10^8 n.s^{-1}. Due to the presence of μ-metal shielding, very small Fourier times can be measured (at low current) with NSE option because the depolarization of the beam due to the earth magnetic field or any environmental fields is absent.

Typical studies performed on the instrument are dynamics in liquids and supercooled liquids (in bulk or confined geometries), dynamical studies of soft condensed matter (polymers, colloids...), Biologically relevant systems, critical phenomena, molecular motions in crystals...

Responsible : S. Longeville **e-mail : longevil@llb.saclay.cea.fr**

Beam tube	G3 horizontally bent cold guide
Used wavelengths	5 Å - 10 Å (preferred wavelengths 6 - 8 Å)
Monochromation	Mechanical selector
	$\frac{\Delta\lambda}{\lambda} \cong 18\%$ FWHM
Polarizer, analyzer	Supermirrors
	Polarization $P_0 > 92\%$
Focusing guides of the incident collimation	^{65}Cu guides
	Length : 1.8 m and 2 m
Peak intensity at the sample	0.5×10^6 n cm^{-2} s^{-1}
	(Typical size : 27 x 27 mm^2)
Length of precession fields	L = 4 m
Total number of turns	2 478
Precession current	2 A - 140 A
Maximum field integral	0.4 T.m
Spectral resolution	At 8 Å : $h\omega_{min}$ = 1 neV
	Fourier time ~ 40 ns
Sample to analyzer distance	≈ 6 m
Momentum transfert range	$1.5° \leq 2\theta \leq 90°$
	At 6 Å : 0.0274 Å^{-1} < Q < 1.5 Å^{-1}
	At 8 Å : 0.0205 Å^{-1} < Q < 1.11 Å^{-1}
Detectors	5 ^{3}He detectors
Ancillary equipment	★ Sample box (3 sample positions) Either fluid heater (- 20°C < T < 80°C) or resistive heater (20°C < T < 120°C)
	★ Furnace (1 sample) (T < 500°C)
	★ Orange cryostat 1.5 K

Neutron Spin Echo (NSE) is a particular technique in inelastic neutron scattering : both the incoming and outgoing neutron velocity (rather given components of these) are measured by using the Larmor precession of the neutron's spin. This technique allows to directly determine the intermediate scattering function, S (Q, t) of the studied sample.
The accessible time range is a few ten nanoseconds (energy transfer of a few neV). This technique is peculiarly well suited to measurements of non-dispersive elementary excitations.

The neutron spin echo spectrometry is a method of wavelength focusing, allowing to use a large energy range of incident neutrons ($\frac{\Delta\lambda}{\lambda}$ ~20% FWHM). This advantage compared to the classical inelastic techniques partly compensates the loss of intensity due to the length of the instrument and to the polarization analysis of the neutron spins.

In the quasi-elastic approximation, the measured quantity, the echo amplitude is proportional to :

$$\int S(Q, \omega) \cos \omega t \, d\omega = \check{S}(Q, t)$$

where t, the Fourier time, is expressed as :

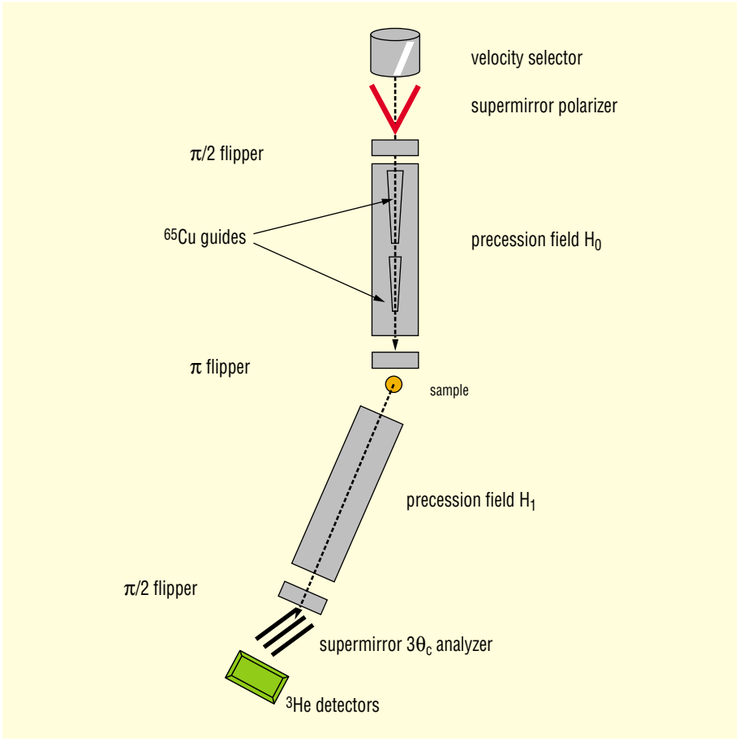
$$t_{(sec)} = 1.863\ 10^{-16}. (\int_0^L H.dl).\ \lambda_0^3$$

H is the field in Oersted and λ_0 (in Å) is the mean incident wavelength. $\int_0^L H.dl$ is the field integral over the length L (in cm) inside the precession solenoids.

Besides the measurement of the echo amplitude, a classical polarisation analysis (three dimensional) can be performed in order to determine the coherent/incoherent contributions in S(Q, ω), to separate magnetic and nuclear signal…
Among the physical phenomena measured with MESS, we can mention :
- internal motion or diffusion of big molecules (biochemistry, polymers, membranes)
- magnetic scattering (paramagnetic, ferromagnetic, spin glass)..

This spectrometer has been built in collaboration with the KFKI (Science Academy Hungary).

Neutron Spin Echo Spectrometer MESS G 3-2



General layout of the spectrometer G 3-2.

The neutron beam is roughly monochromatised by a velocity selector ($\Delta\lambda/\lambda$ ~ 18%), then flipper turns the polarization perpendicular to the magnetic field H_0 of the first precession solenoid, so that the Larmor precession will start. The π flipper reverses the polarization so that the fields H_0 and H_1 (in the second precession arm) are in the same direction. After scattering by the sample, the neutron spin precess in the second precession field H1. At the end of the second solenoid, the neutron spin is turned again by the second π/2 flipper, parallel to the magnetic field in order to be analyzed. The spin-echo signal is recorded by several ^{3}He detectors.
Two guide elements coated with ^{65}Cu can be put in the first precession solenoid. This focusing device allows us to perform lower energy resolution measurements with higher neutron flux.
The whole length of the instrument and the high maximum field integral (0,4 T.m) lead to a high Q and ω resolution spectrometer.

On MESS, the Fourier time is expressed as :

$$t_{(ns)} = 2.341\ 10^{-7}.\ N_{sol}.\ I_p.\ \lambda^3$$

as function of the turn number (N_{sol}), the precession current (I_p) and the incident wavelength (λ).

Data acquisition and treatment are performed on PC computers working with Windows 98 or NT System.

Responsibles : F. Boué **e-mail : boue@llb.saclay.cea.fr**
A. Brulet **e-mail : brulet@llb.saclay.cea.fr**

PROPOSALS
SELECTION COMMITTEES
MISCELLANEOUS

ORGANIZATION OF THE USERS ACCESS

To perform an experiment, the researcher must submit a proposal on a special form where he specifies his scientific interest and describes the proposed experiment.

Deadlines for submission are : 1st April and 1st October of each year.

The proposals are examined and selected by a peer review international Selection Panel composed of experts (in the majority external to LLB) which meets every 6 months. It is divided into 4 subpanels :

- Physical chemistry and biology
- Structural studies and phase transitions
- Magnetism and superconductivity
- Disordered systems and materials science.

Among those selected on the basis of scientific merit, experiments are chosen on the following criteria :

- **new users**
- **experiments involving PhD thesis (or post-docs)**
- **countries with no neutron facilities.**

After the experiment, the user team must send a written experimental report, and reprints of the related publication(s). The experimental reports and list of publications are published in the LLB scientific activity report.

In the LLB, the users obtain the necessary scientific support to prepare, perform and interpret their experiments. The involvement of the local contact depends on a preliminary informal agreement with the users to decide whether there will be a formal collaboration and common publication, or basic instrumental and data analysis support only.

EXPERIMENTAL PROPOSALS

You are request to send a proposal for the experiments you wish to carry out. It can concern equally the submission of a new proposal or a resubmission of a proposal which have obtained “B” grade from a previous Selection Committee. It can be on the dedicated application form or through our web server. This service is available at the following address :

http://www-llb.cea.fr/proposals/

The proposals should be carefully completed and sent to us using either the paper original forms (if you are in need of further copies please contact us by postmail, fax, telephone or e-mail) or the web server. For your convenience, you will find on our laboratory’s web server the list of spectrometers, their main characteristics and the way to join the physicist normally responsible of each instrument.

1. Proposal submission

When completing the form, please indicate whether it is a new proposal, a continuation of a previous experiment or a resubmission. Each demand should be self-contained and presented in a clear and concise manor, written in English of French. For guidance, the contents of a proposition should correspond to the equivalentr of a 5 to 10 minutes oral presentation. In the case of a project continuation, attach the corresponding experimental report if it has not already been previously supplied.
All the proposals should be sent to the “Secrétariat Scientifique du Laboratoire Léon Brillouin”.
To be included in the next selection, the deadlines for reception are :

1st April and 1st October

2. LLB’s web server : http://www-llb.cea.fr

3. Function of the Selection Committee

Proposals are examined by 4 Selection Committees. Each is composed of 10 to 12 senior scientists which are nominated by the management of llb for 3 years. At least half of them do not belong to the LLB and 2 or 3 are coming from foreign institute.
For each spectrometer, LLB gives a beam-time available which is shared out by the committee ; each proposal gets a grade A or B or C

A : means that the experiment must be done and the committee allocates a beam-time,

B : means that the experiment might be done if there is some extra beam-time,

C : means that the experiment is refused on scientific arguments.

Selection Committees are asked to take care of the educational duty of the LLB when proposal comes from new young searcher.

EXPERIMENTAL REPORT

After each experiment done at LLB, you must write an experimental report and send it to the scientific secretary of the LLB at the following address :
Scientific Secretary
Laboratoire Léon Brillouin
CEA- Saclay
F-91191 Gif-sur-Yvette cedex
A Word 97 template file may be obtained on our web site.
Please : **NO MORE THAN 4 PAGES** the other ones will be lost.

Once filled, this file may be sent back to our secretariat by e-mail at the following address :
experience@llb.saclay.cea.fr

LABORATOIRE LEON BRILLOUIN
CEA/SACLAY
91191 Gif-sur-Yvette Cedex
FRANCE

PROPOSITION D'EXPERIENCE
(RESEARCH PROPOSAL)

N° :

Ne pas remplir
(*To be filled by LLB)*

CLASSIFICATION
Thème : ..... Sous thème : .....

A remplir par le participant (cf. classification)
(To be filled by the applicant, see classification list)

Projet dans le cadre d'un contrat ☐

European Access Programme (H.P.R.I.) ☐

Nouvelle proposition ☐ *(New proposal)*

Resoumission ☐ *(Resubmission)*

Continuation ☐ → ☐ N° Expérience précédente *(Last experiment number)*

TITRE DE L'EXPERIENCE : _____
(TITLE OF THE EXPERIMENT) : _____

PREMIER PROPOSANT *(FIRST APPLICANT)*

NOM, PRENOM : _____ **NATIONALITÉ :** _____
(Full name) ***(Nationality)***

STATUT [Chercheur confirmé = C ; Post-doc = P ; Thésard = T ; Autre = A] **:** _____
***(Status** [senior scientist = C; Post-doc = P; Ph D = T; Other= A])*

ORGANISME DE RATTACHEMENT [CNRS ; CEA ; Université ; Autre (préciser)] **:** _____
***(Affiliation Institute** [CNRS; CEA; University; Other (precise, which one)])*

LABORATOIRE (adresse complète) : _____
(Laboratory, Institute, full address) _____ **Code Unité CNRS :** _____

Téléphone : _____ **Fax :** _____ **e.mail :** _____

AUTRES PARTICIPANTS *(OTHERS APPLICANTS)*

Nom, Prénom *(Full name)*	**Nationalité** *(Nationality)*	**Statut** *(Status)*	**Organisme de rattachement** *(Affiliation Institute)*	**Laboratoire** (adresse complète) *(Laboratory, full address)*	**Code Unité CNRS**

Correspondant local *(Local contact)*			
Appareil(s) souhaité(s) *(Proposed instrument(s))*			
Temps d'expérience demandé (jours) *(Estimated measuring time, days)*			

THEMATIC CLASSIFICATION

Theme A : CHEMICAL PHYSICS, BIOLOGY

A.01.....Polymers, liquid crystals
A.02.....Water, aqueous solutions, polyelectrolytes
A.03.....Biology
A.04.....Colloids, surfactants
A.05.....Gels, composite materials
A.06.....Other....

Theme B : STRUCTURAL STUDIES, PHASE TRANSITIONS

B.01.....Mineral crystalline structures : ceramics, zeolites, hydrides, alloys ...
B.02.....Molecular systems
B.03.....Structural studies of phase transitions
B.04.....Dynamical and structural properties of quasiperiodic systems
B.05.....Lattice dynamics
B.06.....Dynamical properties of phase transitions
B.07.....Other....

Theme C : MAGNETISM, SUPERCONDUCTIVITY

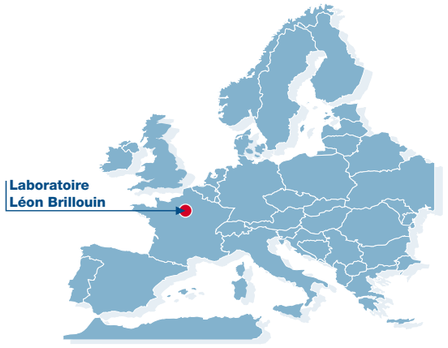
C.01.....Superconductor materials and related compounds
(Structural studies included)
C.02.....4 f Lanthanide systems (heavy fermions)
C.03.....5 f Actinide systems (heavy fermions)
C.04.....3 d Transition systems
C.05.....Low dimensional magnetism
C.06.....Magnetic multi-layers
C.07.....Frustration and magnetic disorder. Small magnetic particles
C.08.....Molecular magnetism
C.09.....Other....

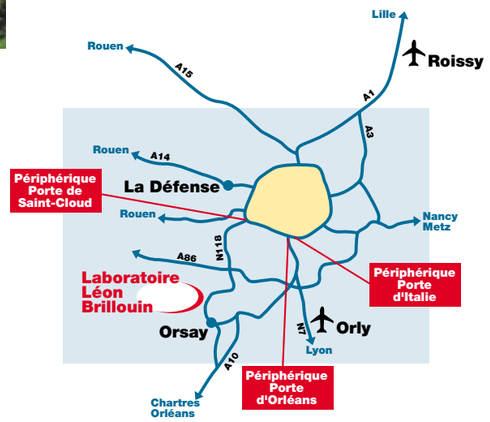
Theme D : DISORDERED SYSTEMS AND MATERIAL SCIENCE

D.01.....Local order in alloys
D.02.....Liquid and amorphous structures
D.03.....Dynamics of disordered systems
D.04.....Glass transition
D.05.....Thin film materials
D.06.....materials : textures
D.07.....materials : stresses
D.08.....materials : clusters, cavities
D.09.....Neutron radiography
D.10.....Other....

GENERAL INFORMATIONS

Access is provided free of charge for the selected user teams. Travel and subsistence up two users are reimbursed by the LLB.





Accommodation and logistic support

The Laboratoire Léon Brillouin is situated within the Research Centre of CEA/Saclay, at 25 km at the south of Paris. The two airports of Paris (Roissy-Charles de Gaulle and Orly) and the town centre are connected directly to the RER line wich serves the CEA/Saclay research centre (station : “Le Guichet”).
The Scientific Secretary of the LLB provides a list of hotels in the neighbourhood of the Centre (Saclay, Orsay, Gif-sur-Yvette).
A few rooms are avaible inside the centre (restricted to E.U. national).

For any further information, please contact :

LABORATOIRE LEON BRILLOUIN
SCENTIFIC SECRETARY
CEA SACLAY
BATIMENT 563
91191 GIF-SUR-YVETTE CEDEX (France)

Tel. 33(0) 1 69 08 60 38 • Fax 33(0) 1 69 08 82 61
e-mail : experience@llb.saclay.cea.fr • internet : http://www-llb.cea.fr

GENERAL LAYOUT OF EXPERIMENTAL HALLS