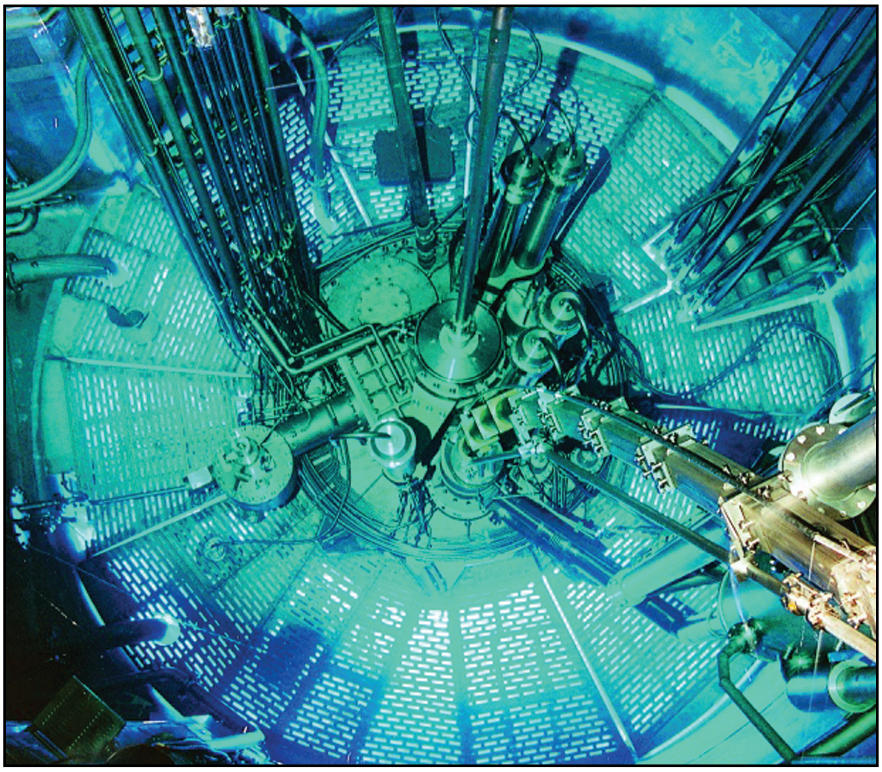
The high flux reactor



Reactor core

Refurbished between 1993 and 1995, the ILL High Flux Reactor produces the most intense neutron flux in the world: 1.5×10^{15} neutrons per second per cm^2, with a thermal power of 58.3 MW.

The single fuel element sits in the centre of a tank of 2.5 m diameter containing the heavy water moderator. Cooling and moderation is by heavy water circulation passing through heat exchangers. The moderator partly reflects thermalised neutrons back towards the fuel element.

Biological shielding is provided by a light water swimming pool surrounding the reflector tank encased in dense concrete.

The reactor operates continuously for 50-day cycles, followed by a shut-down for changing the fuel element. In addition, there is an annual longer shut-down to enable necessary maintenance of equipment to be carried out. Normally there are 4.5 cycles a year, providing 225 days for science.

ESSENTIAL DATA OF THE HFR	
Thermal power	58.3 MW
Max. unperturbed thermal flux in the reflector	1.5×10^{15} neutrons $cm^{-2}s^{-1}$
Max. perturbed thermal flux at the beam tubes	1.2×10^{15} neutrons $cm^{-2}s^{-1}$
Coolant flow in fuel element	2400 m^3/h
Coolant velocity	17 m/s
Coolant pressure (outlet)	4 bar
Coolant temperature (outlet)	50 °C
Reactor cycle	50 days
Average consumption of ^{235}U	36 %

Table 1 - *Essential data of the high flux reactor*

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Reactor hall

There are in total:

- 13 horizontal beam tubes
- 4 inclined beam tubes
- 2 neutron guide halls
- 5 guides for thermal neutrons
- 8 guides for cold neutrons
- 1 vertical guide for very cold and ultra-cold neutrons

Neutron fluxes available

The thermal neutron flux, in equilibrium with the heavy water moderator (300 K), has a peak in the Maxwellian distribution at 1.2 Å. For certain beams and guide tubes this is modified by the inclusion of special moderators:

Hot source (10 litres of graphite at 2400 K):
It enhances the neutron flux at wavelengths below 0.8 Å.

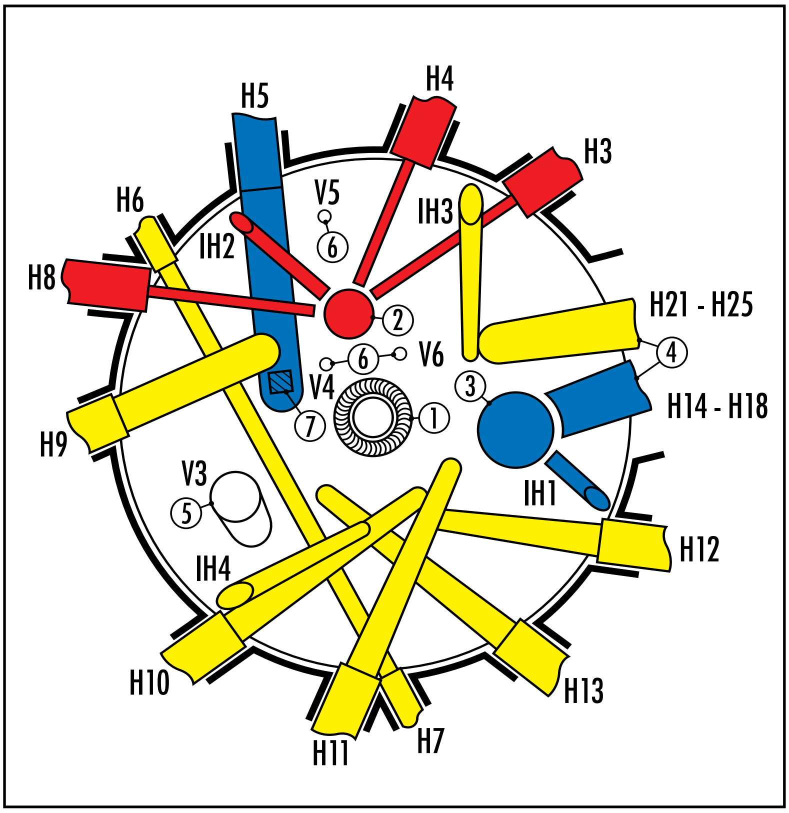
Vertical cold source (20 litres of liquid deuterium at 25 K): It enhances the neutron flux at wavelengths above 3 Å (4.5 x 10^{14} /cm^2 sec).

Horizontal cold source (6 litres of liquid deuterium at 25 K): It enhances the neutron flux at wavelengths above 3 Å (8.0 x 10^{14} /cm^2 sec).

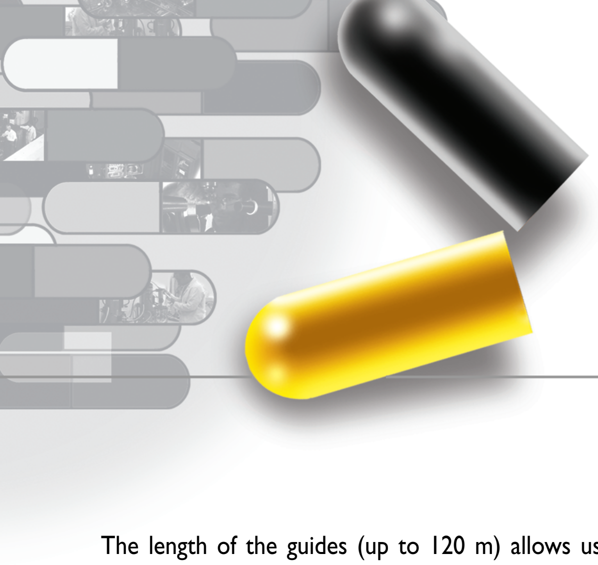
In the **reactor hall**, neutron beams are available from thermal, hot and cold beam ports and from one cold neutron guide connected with the horizontal cold source.

In the **neutron guide hall 1**, neutron beams are available from four thermal and six cold neutron guide tubes.

In the **neutron guide hall 2** neutron beams are available from two cold neutron guide tubes.



Beam-tube arrangement at the ILL-HFR



The high flux reactor

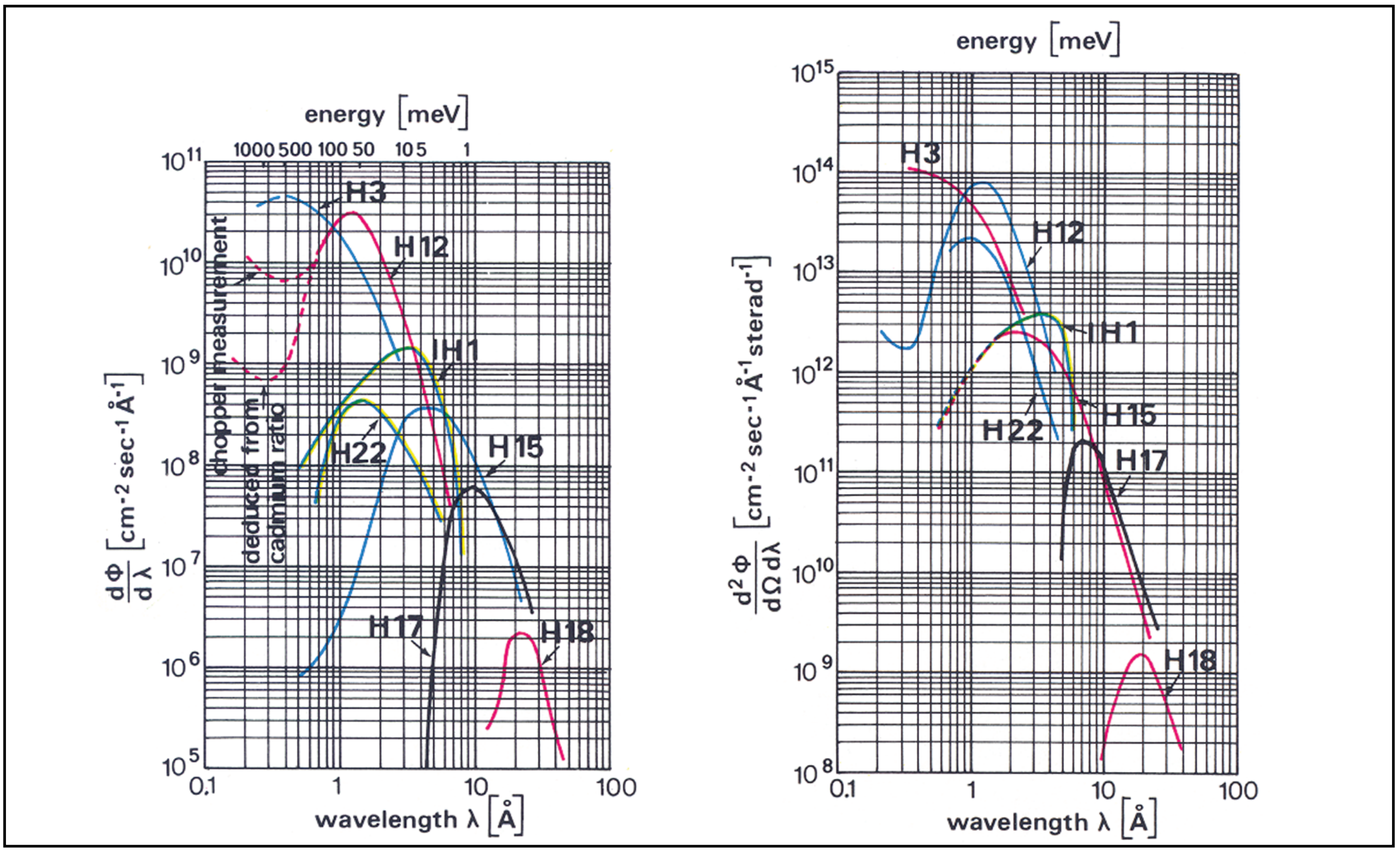
The length of the guides (up to 120 m) allows us to install a great number of instruments benefiting from a high thermal or cold neutron flux and low background.

Table 2 gives the characteristic fluxes of some beam tubes and neutron guides at the ILL-HFR.

Beam number	Type	Radius of curvature	Type of neutrons	Capture flux ϕ_c /cm²s	Flux ϕ /cm²s
H3	Beam tube		Hot	2×10^{10}	3.3×10^{10}
H12	Beam tube		Thermal	2.6×10^{10}	2.9×10^{10}
IH1	Beam tube		Cold	10^{10}	4.7×10^{9}
H22	Guide	27000 m	Thermal	1.4×10^{9}	7.8×10^{8}
H15	Guide	2700 m	Cold	1.1×10^{10}	2×10^{9}
H17	Guide	2700 m	Cold	1.2×10^{10}	2.4×10^{9}
H53	Guide	2700 m	Cold	10^{10}	2×10^{9}

Table 2 *- The capture flux ϕ_c = U ($d\phi(\lambda)/d\lambda$)(λ/1.8 Å) $d\lambda$ is measured with the activation of a gold foil at the outlet of the reactor shielding in the case of the beam tubes, and after one line of sight in the case of the guides (September 2003).*

Flux distributions



NEUTRONS
FOR SCIENCE

Hot source (HS)

The HS is a double zircaloy cylinder of 29 cm diameter filled with a graphite block surrounded by carbon felt insulation at 2400 K. This hot source feeds three main beam tubes: H3, H4 and H8.

Vertical cold source (VCS)

The VCS is an aluminium sphere of 38 cm diameter filled with boiling liquid deuterium at 25 K. Its design features are:

- A sphere incorporating a re-entrant cavity 10 cm wide and 20 cm high with a penetration depth of 25 cm. The cavity is a magnesium vessel, filled with gaseous deuterium. Its design is optimised with respect to the six horizontal cold guides (3 x 20 cm).

- A vertical service tube, sufficiently large to incorporate a vertical neutron guide of 7 cm diameter constructed of aluminium and lined with a thin (0.15 mm) nickel tube. This is followed by a curved square guide (7 x 7 cm^2) with a radius of 13 m and length of 13 m. The guide supplies very cold neutrons (VCN) to the "neutron turbine". The turbine provides ultra-cold neutrons (UCN) to a number of experiments (see description of instrument PF2 p.112).

Horizontal cold source (HCS)

The HCS has the shape of an orthocylinder of 21 cm diameter filled with liquid deuterium. It is housed in a 23 cm diameter horizontal beam tube. This cold source feeds two main neutron guides:

- The first guide (H53 - instrument IN14 in the reactor hall, instruments IN16, EVA and PF1 in guide hall 2) has a width of 6 cm giving an enhanced flexibility for horizontal focusing.

- The other guide (H51) is divided into two parts: the upper part of 4 x 5.5 cm^2 is used as H512 for D22. The lower part is split two guides by a beam splitter which consists of a 2 m long assembly of TiNi supermirrors deposited on a Si-substrate into: H513 (4 x 5.5 cm^2) is the transmitted beam, and H511 is the reflected beam which is fed into a polarising guide (4 x 5.5 cm^2 - instrument project IN15).

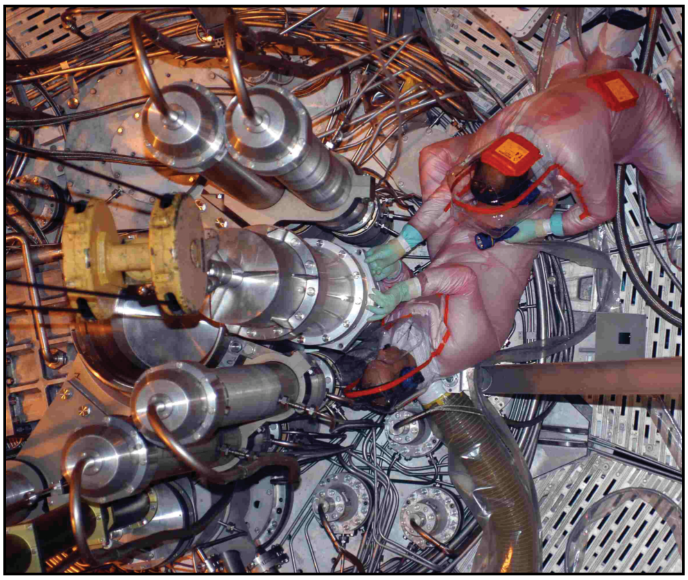
These guides differ from the guides on the vertical cold source in the following ways:

- A ^{58}Ni coating increases the solid angle by a factor 2 as compared to natural Ni coating

- The spectrum is extended to shorter wavelengths due to a more direct view in the first part of the guide H53 up to the three-axis spectrometer IN14

- The spectrum is extended to longer wavelengths due both to the elimination of the metal walls and the D_2O gap between the moderator and the guides present in the VCS.

References:
Commissariat a l'Energie Atomique, Bulletin d'Informations Scientifiques et Techniques (BIST), ***165*** *(December 1971) and* ***166*** *(January 1971). P. Ageron, "Cold Neutron Sources at ILL", Nucl. Instr. and Meth. A**284**(1989)197199.*



Hot source