Cap 2010

Recent progresses in the neutron spectrometry as well as the evolution of scientific topics prevail on the LLB to propose major improvements of several spectrometers both in the guide hall and reactor hall. Beside of this project named CAP2010, the upgrades in progress in the laboratory will continue: MUSES, 7C2 , TPA… (see the introduction of this chapter).

Increasing research in new materials for technical applications has brought new needs of structure determination. In condensed matter physics and chemistry, the role of high resolution powder neutron diffraction becomes more and more important. One priority of LLB is to rebuilt the detection system of the **3T2 diffractometer** in order to achieve both better resolution and higher counting rates. The last upgrade of this spectometer was done in 1997, a new focusing Ge (335) monochromator, which gave an increase of the neutron flux by a factor 4.5. The present project concerns the change of the collimators in front of the detectors to increase the resolution by a factor 2, and the installation of 50 (instead of 20) ^{3}He detectors to cover an angular range of 120° (instead of 57°). Figure 1 shows the schema of the new high resolution powder diffractometer 3T2.

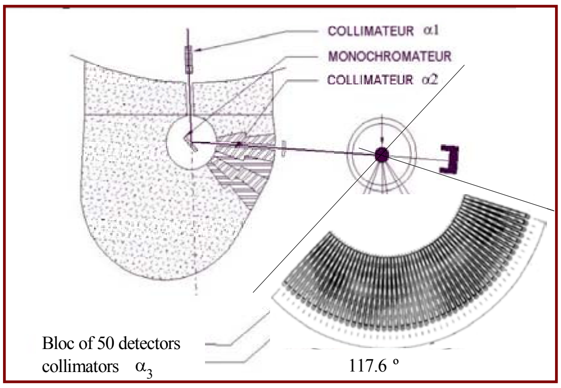

Figure 1. Schema of the project for the high resolution powder diffractometer 3T2.

We also plan to complete the renewal of the **high pressure diffractometer MICRO** on the G6.1 guide, which was recently partly rebuilt to realized original experiments under pressure as high as 100GPa (1Mbar). Pressures up to 51 GPa (510 kbar) are already reached. The replacement of its detector (an old 400 cells banana filled with BF_3 gaz with an angular range of 80°) by a curved linear detector filled with ^{3}He gaz covering a larger solid angle has been decided several years ago. Development of this new detector is still in progress. Increase the pressure up to 1Mbar will require a sample volume reduction. To compensate the intensity loss inherent to this reduction, we will increase the incident beam divergence, i.e. the flux, by changing the nickel coating of the main guide G6 with new $2\theta_c$ super-mirrors, till the monochromator of G6.1. We can then use a better focusing graphite monochromator, especially adapted to the divergence of the new $2\theta_c$ super-mirrors guide.

The **4-circles spectrometer 6T2** (on thermal neutron beam) is actually used at LLB for two kinds of experiments: in its “lifting detector” mode, it is devoted to studies of magnetic structures whereas in its 4-circles configuration, it allows to study the structure of compounds of large unit cell. We would like to shift the 4-circles experiments on the **3T1** channel equipped with an Eulerian cradle. Indeed, as it exists an important demand of single crystal studies, the 3T1 spectrometer could be definitely transformed in 4-circles diffractometer, fully dedicated to single crystal measurements. It could also be equipped in the future with a big two dimentionnal detector.

Another priority is the major modification of the **reflectometer EROS**, spectrometer especially adapted to surface and interface studies in liquid systems. A multi-disc chopper has just been installed instead of the old single chopper : a gain of a factor 2 of the neutron flux is obtained. Still the present limit of the neutron flux on EROS arises from the small beam divergence due to the length of the spectrometer required to obtain a high resolution. Recently, experiments requiring this high resolution have disappeared to the benefit of low reflectivity measurements at large angle, studying small distance. Indeed, the scientific community is now more interested in studies of thin interfaces, from 2 to 10nm. If we compare EROS to the other reflectometers in the world, it appears that to be competitive, it needs to gain a factor 10 to 100 in the neutron flux on the sample. Our solution is to shorten the spectrometer, and first its collimator (see Figure 2).

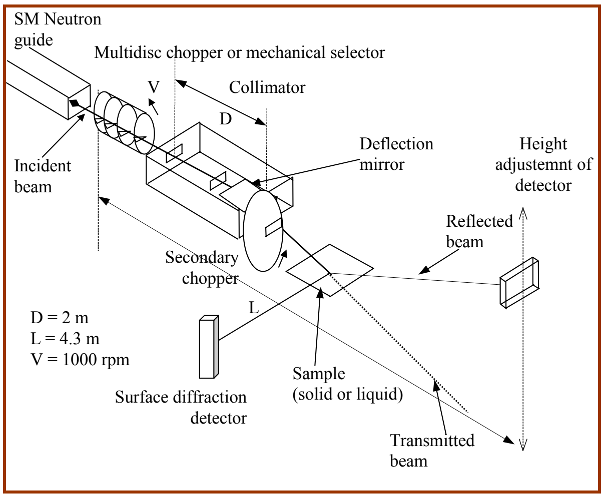

Figure 2. Scheme of the modified reflectometer EROS.

An optimized collimator of 2m length will give an important gain by a factor 10 of the neutron intensity at large angle. More, by putting the detector tube under vacuum, we will gain a new factor 2 on the neutron flux. In the future, a second change should be envisaged: that of the guide. At the moment, EROS is located at the end of a multi-layer guide, G3bis, and thus has few short wavelengths. On a main guide coated with super-mirrors, we would expect an additional neutron flux gain of 4! Two end guide positions are possible: G3 and G6. Whatever the future decisions concerning the new position of EROS in the guide hall, the modifications will keep the options already available on EROS : surface diffraction and off-specular measurements.

Concerning the **time of flight spectrometer MIBEMOL,** the high resolution inelastic scattering spectrometer (in the range 10µeV to 100meV), the comparison of its performances with those of other spectrometers recently built at ILL (Grenoble) or at HMI (Berlin) shows that we shall be soon no more competitive. Then in order to answer to the demand in TOF measurements, we are faced to an alternative. The first solution is the **renewal of MIBEMOL**. It will imply super-mirrors guides associated with vertical focusing method. The disc-choppers will be replaced by choppers with magnetic bearings (in order to increase the rotation velocity of choppers). Such a solution would increase the ratio neutron flux/resolution by a factor 5 or 8. To achieve such a technical solution, another end of guide position instead of that of G6 is necessary. MIBEMOL will have to move on another super-mirror guide to benefit from the whole guide height (15cm) available for focusing. The second possibility is the construction of a **new time of flight spectrometer, named TDV2**, with a **higher flux and a medium resolution.** This spectrometer could work in two modes, time focusing or energy focusing, as FOCUS spectrometer [1] at PSI (Villigen, Switzerland). The two main elements of such spectrometer are a focusing monochromator (crystals) and a Fermi chopper (see figure 3).

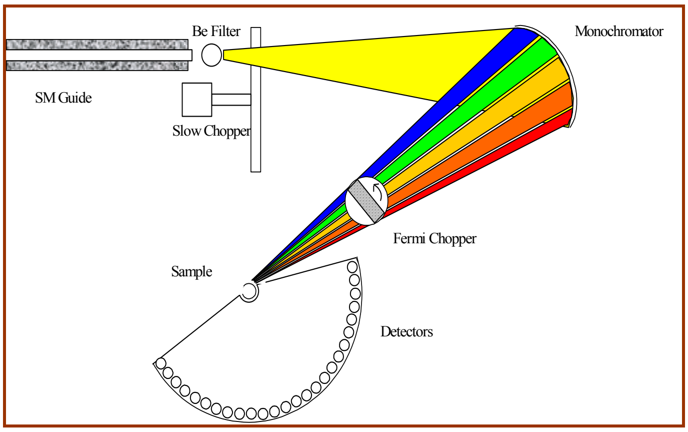

Figure 3. Principles of the project for a new mixte time of flight spectrometer TdV2.

The wavelength distribution of the beam delivered by the monochromator is directly function of the distances guide to monochromator and monochromator to sample. When these distances are equal, the wavelength dispersion is minimum. This mode gives access to a high energy resolution. When they are not equal, the wavelength distribution is large, but the neutron flux is very high and time focusing is possible. The latter technique increases the flux by one order of magnitude compared to multi-chopper spectrometers as MIBEMOL with a comparable energy transfer range, 40µeV to 100meV. This kind of spectrometer is attractive since it offers two possibilities, either a high flux with a low resolution or a low flux with a high resolution. The estimated ratio flux/resolution of TDV2 will be 10 to 15 times higher than that of MIBEMOL (present). For the TDV2 project, the location could be the end of guide position G3, coated with super-mirrors.

Another instrument that we plan to rebuilt is the **polarised neutron diffractometer** (PND) **5C1**. This diffractometer allows to study inter-atomic or inter-molecular magnetic interactions and gives a direct access to the spin density distribution in the unit cell. At present, the only places in the world properly equipped for performing PND (“flipping ratio measurements") are: ILL (Grenoble) with an instrument D3 (hot neutrons) and D23 (thermal neutrons), and LLB with a dedicated instrument 5C1 (hot neutrons). The measurements of polarised neutron flipping ratios on all these instruments are done by a single counter reflection after reflection, which is quite time consuming. Therefore, any improvement of the instrument which can may decrease the total time of the experiment and improve the accuracy, is of a great interest. The aim of the project concerning the instrument 5C1 is to multiply by a factor 5 (20 for large unit cells) the data collection rate. This diffractometer is characterized by a relatively broad wavelength band $\Delta\lambda/\lambda \approx 10\text{-}20\%$, which could make possible simultaneous measurements of a large number of reflections for each sample orientation if a 2D position sensitive detector (PSD) was available. The procedure of measurements will be slightly different from that of the recent Laue-type diffractometers at ILL, LADI and VIVALDI. The sample will be rotated about the vertical axis and the diffraction images will be recorded for each polarisation state. Moreover, the image plate technique used on Laue-type diffractometers, which provides a large detector area combined with a high spatial resolution, is not suitable in the case of PND, since its electronics can not be switched rapidly to ensure the intensity measurements in two polarization states. Our solution is to use an array of one dimensional position sensitive (resistive) detectors or a two dimensional PSD, with an appropriate electronics allowing to separate the two polarisation channels. In our project of very intense precession (VIP) diffractometer (see figure 4), we rely on the collaboration with ILL, where a new multi-tube detector technology has been developed. Such a technique allows to cover a quite large detection area with a resolution of 1.5x10 mm. Preliminary measurements performed at the 6T2 diffractometer in LLB using a multi-tube detector of dimension 320x320 mm made in ILL show that the spatial resolution of the detector is sufficient for our purpose (see figure 5).

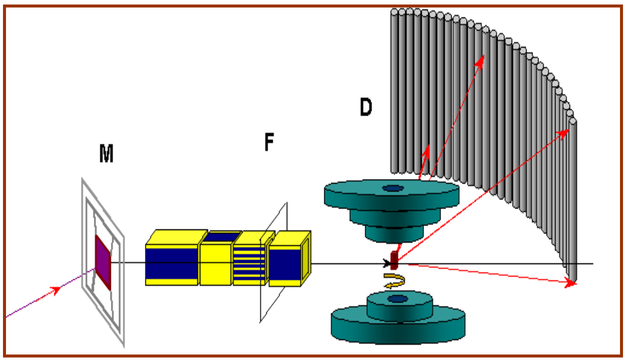

Figure 4. Schema of the polarised neutron diffractometer project on 5C1 , « **V**ery **I**ntense **P**recession diffractometer (VIP diffractometer) ». (M) is the polarizing monochromator (Heusler crystal), (F) is the flipper. Instead of a single detector (D), a new arrangement of 2D multi-tube vertical position sensitive detectors is envisaged.

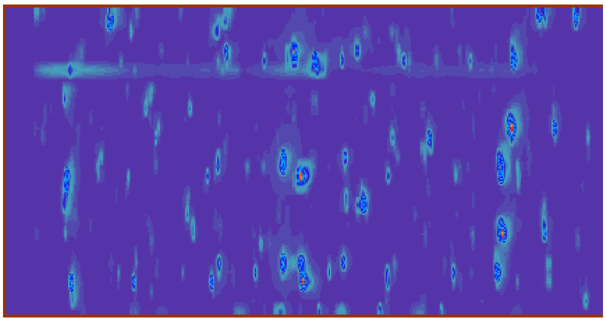

Figure 5. Precession image of the diffraction from the $Sr_{14}Cu_{24}O_4$ single crystal. The image is constructed using 900 frames measured with a step of 0.1°, with the exposition time of 10 seconds. The data collection rate is one order of magnitude higher than with a simple detector.

As a conclusion, all these developments show the will of LLB to enlarge the possibilities of neutron scattering, a tool already useful and determinant to a large research area at the microscopic level (structure and dynamics) in physics, chemistry, biology and materials science.

Reference

[1] J. Mesot, S. Janssen, L. Holitzner and R. Hempelmann, *J. Neutron Research*, **3** , 293 (1996).