VERY SMALL ANGLE NEUTRON SCATTERING SPECTROMETER (TPA)

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More and more studies of large-scale objects (> 50 nm) are needed nowadays. The very small angle neutron spectrometer (Très Petits Angles, TPA) will be dedicated to the study of such nanostructures, usually found in branched polymers, organized multi-component systems (such as vesicles), reinforced rubber, cell membranes in biology, clays, porous systems, alloys in metallurgy…

TPA is developed to reach lower scattering vectors than those obtained by classical small angle scattering spectrometers. The scattering vector range will be from 2.10^{-4} to 10^{-1} $Å^{-1}$. The principles of this new spectrometer are the same as for conventional small angle spectrometers: small apertures collimation and two dimensional detector but with a high resolution. In order to achieve the 2.10^{-4} $Å^{-1}$ wave vector and keep a "reasonable" flux, the overall length of the apparatus will be 2 x 6 m. It is installed at the end of a cold neutron bender, G5bis.

The fabrication of a large multi-detector with small pixel size (< mm) is far from easy. There-fore, it has been decided to use a commercial image plate (MAR345), equipped with a neutron converter. Its dimensions (2300 x 2300 pixels of 100 or 150 µm each) give access to high resolution. The drawback is its sensitivity to γ radiations, which imposes special care such as the use of lead and heavy concrete shielding and requires new technical studies on the spectrometer elements.

The wavelength selection will be achieved by a monochromator with double super-mirrors $3\theta_c$ (15% FWHM). The characteristics of these super-mirrors are especially interesting for our purpose: better transmission (+20%) compared to velocity selector, no direct view of the guide and weaker γ production. A mechanical apparatus, now under construction, will allow the monochromatic beam position to be kept constant while changing the wavelength from 4 to 15 Å.

The detector tank in which the detector will be located is under study. Once finished, its fabrication (6 months) and on site installation are foreseen in 2005. Figure 1 is a scheme of the TPA.

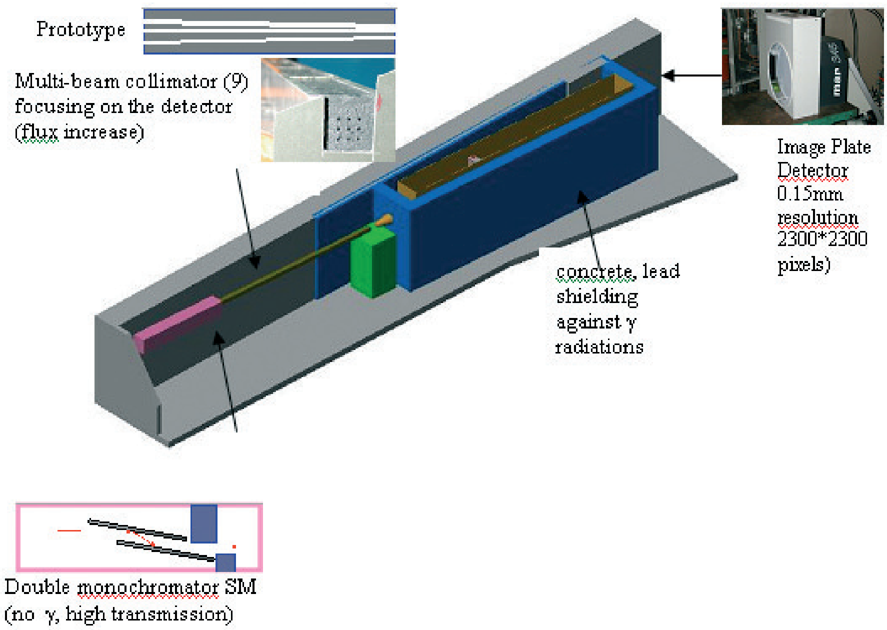

Figure 1. Principle of the Très Petits Angles (TPA) spectrometer. q range :2. 10^{-4}-10^{-1} $Å^{-1}$.

At the present time, the sample-to-detector distance is 4 m and the wavelength is 7.5 Å. This non optimized setup already gives access to the smallest scattering vectors possible at LLB. Data are in good agreement with those from D11 at ILL (40 m collimation, detector at 36 m from the sample). Even if the latter enables lower scattering vectors, TPA has a much better resolution (figure 2).
The weak neutron flux is a limitation of this type of spectrometer. To compensate, different focalisation systems can be implemented: Fresnel lenses, magnetic lenses … At LLB, a multi beam collimator prototype, made of 9 cylindrical holes along a 1 m long boron carbide with a 1 m focalisation length, has been successfully tested. Figure 3 shows the results obtained with this multi-beam collimator compared to equivalent simple collimation and figure 4 shows the spatial distribution of neutrons for various detector positions from the exit of the collimator up to the focal plane. Further multi-beam collimators will be tested and collaboration on this topic has started in 2004 in the frame of the European project NMI3.

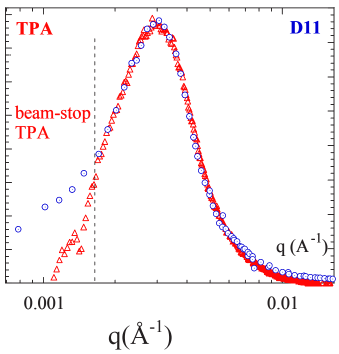

Figure 2. Comparison of resolution between D11 ILL in its very small angle configuration (blue points) and TPA in a non optimised configuration (red points) .

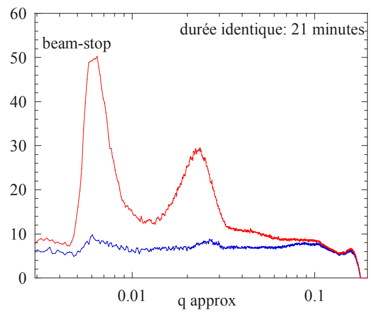

Figure 3. Scattering intensity by a lamellar phase with the 9 multi-beam collimation prototype (red curve) and with simple collimation (blue curve) on TPA.

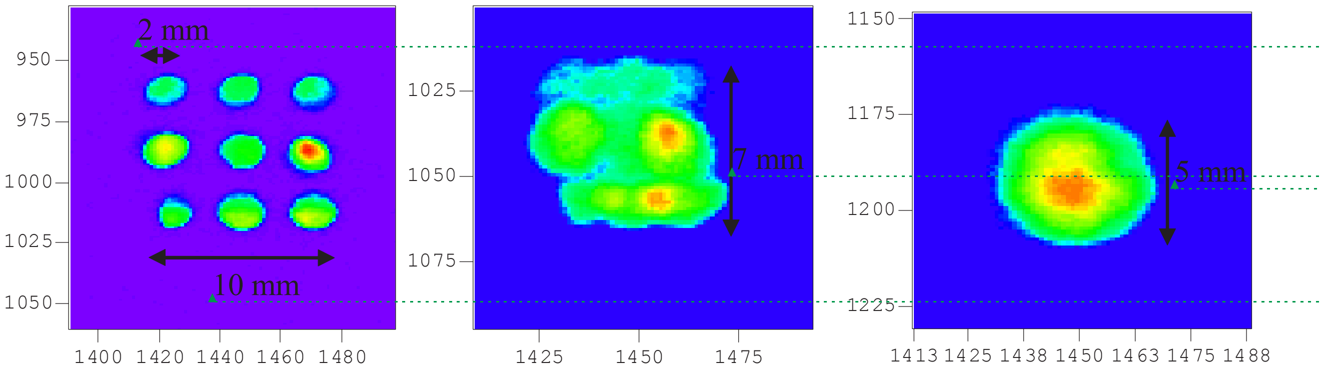

Figure 4. Spatial distribution of neutron flux after the multi-beam collimator for various detector positions: (A) at the exit of the collimator, (B) at 50 cm and (C) at the focal plane (100 cm).