ESRF	**Experiment title:** Nanochannels in track etched membranes	**Experiment number:** ME-626
Beamline: ID01	**Date of experiment:** from: December 10 to: December 16, 2003	**Date of report:**
Shifts:	**Local contact(s):** P. Boesecke	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

G. Pepy*, LLB, CEA Saclay, 91191 Gif sur Yvette CEDEX, France
A. Kuklin*, FLNP, JINR, 141980 Dubna, Russia
M. Toulemonde*, CIRIL, GANIL, BP 5133, 14070 Caen Cedex 5, France
B. Schiedt*, GSI, Planckstr. 1, 64291 Darmstadt, Germany
C. Trautmann*, GSI, Planckstr. 1, 64291 Darmstadt, Germany

Report:

Track membranes are thin polymer foils irradiated by energetic heavy ions (MeV-GeV) [1,2]. Ion tracks consist of defects created along the ion trajectories. By etching the track in a suitable chemical agent open channels can be created with diameters between tens of nm up to several µm. The pores have cylindrical geometry and are very uniform in size. Therefore these membranes can readily be used for filtration. They are also more and more used as templates for metallic wires replica prepared by electrochemistry.

As the pores in ion track membranes are strictly parallel, an excellent sample orientation is required to obtain interpretable SAXS spectra. Then oscillations of the Bessel function (radial part of the channel scattering function) are easily seen in the scattered intensity [3] (figure 1).

Previous experiments (ME419 and SC934) had brought interesting information about the quality of various samples, namely the channel radius and the radius dispersion. In particular we found that pores in polycarbonate had a much more uniform size than in polyethyleneterephtalate. However, at that time, the large number of different materials irradiated with different heavy ions, at different fluences and etched differently prevented us to obtain a thorough determination of the influence of each parameter.

Therefore the main goal of experiment ME-626 (ID01) was to compare
3 types of polycarbonates foils,
irradiated with one type of ion beam, Xe ions (11.1 MeV/u) of GSI, Darmsdadt
and 3 fluences, ($3x10^8$, $5x10^8$,10^9 ions/cm^2)
the irradiated foils were UV treated or not
and etched with the same solution (5N NaOH at 60C), with times 3 min, 5 min, 8 min.

The more systematic selection of sample parameters was extremely successful: we observed as many as 32 oscillations of the radial scattering function, showing that some samples exhibited an exceptional degree of perfection.

The off-line analysis of the large number of different measurements was extremely difficult: for instance significant details were so tiny that it was impossible to bin the data as was done in previous experiments. The

data treatment program had to take care of several hundred thousands pixels for each file. Finally it was necessary to introduce additional parameters such as beam line resolution and radius dispersion to describe the data in full detail. This is the reason why only now we can write a successful report; we apologize for the long delay.

The main results are:
- the tracks in **polycarbonate foils always provide better channels** than in polyethylenterephtalate, Different types of polycarbonate show not only a difference in quality but also in the absolute value of the channel diameters,
- there is a systematic effect of **the UV sensitization, which decreases very significantly the radius dispersion,**
- depending of the channel diameter, large pore densities leads to pore overlapping destroying the uniformity of the channels. We calculated how many channels interact for a given diameter and fluence. It seems that the interaction between close channels takes place more often than the calculation tells,
- the radius dispersion of the smaller channels is larger than that of the bigger pores.

It might be possible that a large halo around the original track makes the etching rougher and eases the connection between neighbouring channels.

These results were partly presented at the PIANO school in September 2005. They will be presented in detail at the SAS2006 conference and published in the proceedings (a special issue of Journal of Applied Crystallography, after normal reviewing process).
The data treatment code can be given costfree to any interested user. It will also be presented and published in the SAS2006 conference.

References :
[1] R. Spohr, Nuclear Instruments and methods, 173 (1980) 229-236
[2] D. Albrecht thesis, (1983), GSI report 83-13
[3] G. Pépy, A. Kuklin, Nuclear Instruments and methods in Physics Research B 185 (2001) 198-203

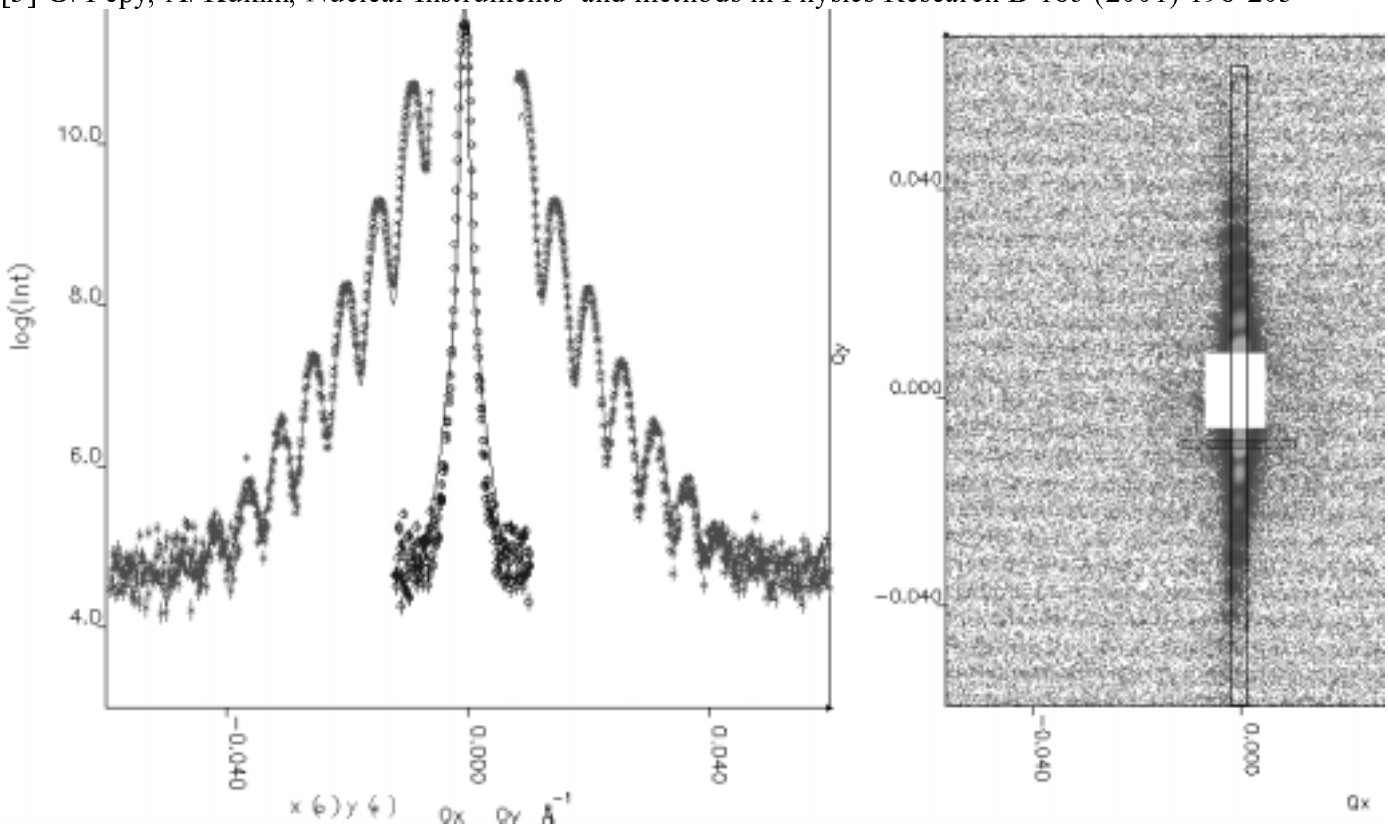

Fig 1. Right, the SAXS pattern of 5.10^8 pores/cm^2 in polycarbonate. The tracks were UV sensitized, and etched for 5 min. Left, the scattered intensity in a vertical and a horizontal cut, as a function of the scattering vector. The line corresponds to a fit with the newly delopped code.