# The Low Q Spectrometer for the Rutherford Laboratory Spallation Neutron Source

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## 1 Introduction

Small angle neutron scattering (SANS) is used to study a wide variety of phenomena in many different disciplines (eg biology, polymer science, metallurgy; materials physics etc). The terminus technicus SANS does not only apply to small scattering angles but to small values of the magnitude Q of the scattering vector $\underline{Q} = \underline{k} - \underline{k}_o$ (where $\underline{k}_o$ and $\underline{k}$ are the wave vectors of the incident and scattered neutrons). For elastic scattering $|\underline{Q}| = 4\pi \text{Sin}\theta/\lambda$ where $2\theta$ is the scattering angle and $\lambda$ the neutron wavelength. In materials studies the SANS range is usually defined by $0 < Q < \pi/d$ where d is the interatomic distance in the sample, typically $\sim 3Å$ in condensed matter, giving an upper limit for $Q \sim 1Å^{-1}$. The observed small angle scattering is produced by inhomogeneities of different scattering length density to their immediate environment. In biology the range $0 < Q < 1Å^{-1}$ is also an important area but with even higher Q values also being of interest.

A typical small angle scattering curve is shown in Figure 1. This curve was obtained using three different sample-detector distances on the D11 spectrometer at the Institut Laue Langevin. Many experiments necessitate measurements on D11 using several different detector positions in order to cover a large enough Q range to enable a complete analysis of the data to be accomplished. Hence beam time is lost in moving the detector. In many experiments where the scattering from the sample changes as a function of time, experiments have to be restricted to a single detector position and thus limited Q range with the consequent loss of experimental information. The wide wavelength range available from the cold moderator of the SNS when coupled with a suitable multidetector will permit a large Q range to be simultaneously accessible in one experiment.



In addition to the possibility of simultaneously accessing a large continuous Q range the use of a pulsed beam has two other advantages compared to a continuous beam experiment:

a) Separation of elastic and inelastic scattering if the wavelength spread is limited. This is particularly important if one is interested in the elastic scattering from samples at high temperatures when the separation of the inelastic contribution is important. For example, if one is studying some temperature dependent transition at high temperatures one has to be able to discriminate the origin of changes observed as the temperature is varied (eg elastic or inelastic).

b) Possibility of synchronising a perturbation of a sample with the neutron pulse and thus investigating the response of the sample by collecting the scattered neutrons from many such cycles. In cases where the sample response is slower than the pulse repetition rate, the response over several neutron pulses could be studied, for example, the response of a rubber to stretching, a muscle to stretching, or cyclic deformation of a metal (fatigue, internal friction). In some experiments the pulse width at the sample may have to be limited by selection of a smaller band of wavelength in order to match the response time of the sample.

## 2 Specification

The low Q spectometer will use the 20K moderator in order to give a good intensity of neutrons up to 10Å. In order to obtain a large continuous and yet easily variable Q range a one meter diameter area telescopic detector has been designed. (Figure 2). The detector will be based on the Rutherford type of design (See P Davidson and H Wroe report at this meeting) and will be made of lithium glass scintillator. It will consist of 6048 individual cells arranged in annuli about the beam centre at radii between 5 cm and 50 cm. The spatial resolution in the radial direction will be 3.5% for radii from 10 to 50 cm. The annuli between 5 and 38 cm will be arranged as one miltidetector which can be positioned as a whole at any distance between 2.5 m and 20 m from the sample position. (Figure 3). If the outer rings are positioned at sample-detector distances of 70, 200, 500 and 1000 cm with the main detector at 2000 cm, a Q range of 0.003 to $1Å^{-1}$

would be continuously accessible using a band of incident neutrons between 4 and 10A$^{o}$, assuming that the 10 cm ring is the minimum used. If the wavelength range were extended to 1A$^{o}$ the maximum Q would increase to 4A$^{o-1}$ and there would be considerable overlap of the Q ranges of the various sectors with a consequent increase in the statistical accuracy of the data obtained.

The entire detector will be housed in an evacuated square tube (1.1 m x 1.1 m by 20 m long). The detector will be capable of movement without letting the housing up to air. The lowest achievable vacuum will be $10^{-5}$ torr so that furnaces and liquid nitrogen cryostats can be used without problems of small angle scattering from window materials when measurements at low Q are required. Usually the vacuum will be $\sim 10^{-2}$ torr. A low efficiency two dimensional detector consisting of 137 elements, arranged in a rectangle 6 cm high by 5 cm wide will be mounted at the centre of the main detector but 10 cm behind it. This will be used to determine the gravity corrected beam centre for each wavelength, when large sample detector distances coupled with large wavelengths spreads need to be used.

## 3 Beam Limiting Choppers

These will be described briefly in their beam order. A more detailed description is in preparation (Dusic and Stewart, unpublished).

a) Chopper to produce a band of neutrons 1 to 10A$^{o}$. This chopper is situated within the biological shield 4.3 m from the cold moderator. The frequency of revolution of the chopper will be phase locked with source. It will be manufactured from a nickel superalloy with 30 cm of the alloy in the beam path when in the closed position. The transmission for neutrons of wavelengths less than 0.5A$^{o}$ will be $\sim 10^{-7}$. On the input and output sides of the nickel chopper, simple MgCd alloy disc choppers will be mounted to limit the longest wavelength transmitted to 10A$^{o}$. The removal of neutrons with wavelength shorter than 0.5A$^{o}$ is important since all choppers downstream use cadmium as the neutron absorbing medium; this elimination is particularly important when submultiples of the pulse repetition frequency of the source are used in the experiment. The lowest harmonic wavelength to be transmitted is 18.5A$^{o}$ which can be removed by suitable phasing of the subsequent choppers.



b) Tail cutting chopper

This is a simple MgCd disc chopper situated 4.8 m from the cold moderator. It is used to limit the lowest or highest wavelength transmitted. For example a beam spread from xÅ to 10Å can be obtained with x chosen to exceed the Bragg cut off of the sample under study. Thus contamination of the observed SANS pattern with single and multiple Bragg events can be avoided. In addition when run at a submultiple of the source frequency a beam from the first chopper of 1-10A neutrons, can be obtained at a pulse repetition rate of 25 or 16.6c/s by suitable adjustments of the frequency and phase of the chopper.

c) Velocity selecting choppers

These are again two simple MgCd disc choppers, rotating in opposite directions which enable a band of wavelengths of variable width ($\Delta\lambda$) to be selected. A pseudo monochromatic pulse beam of down to at least 5% ($\Delta\lambda/\lambda$) can also be obtained by suitable phasing of these choppers when the separation of elastic and inelastic scattering is necessary. These choppers are situated outside the biological shield at 7 m and 8 m from the cold moderator. When not in use they can be stopped in the open position. In addition a chopper for reducing the pulse repetition rate by $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, $\frac{1}{5}$, and $\frac{1}{6}$ when necessary will be situated outside the biological shield.

## 4 Collimation

The initial collimation will be flexible with the possibilities of

(a) apertures at a fixed distance (as used on D11 at the ILL)

(b) soller collimators of the Rutherford type,

(c) and possibly eventually focussing collimators

## 5 Sample Area

The sample area will be housed in a cubic aluminium alloy box separated from the main detector vessel by a large vacuum valve. There will be sufficient space to mount a multiposition sample changer, cryostat or furnace and/or a magnet within the sample box. The maximum beam size at the specimen will be 3 x 3 cm, but usually a beam size of $\sim 1$ cm$^2$ will be used.

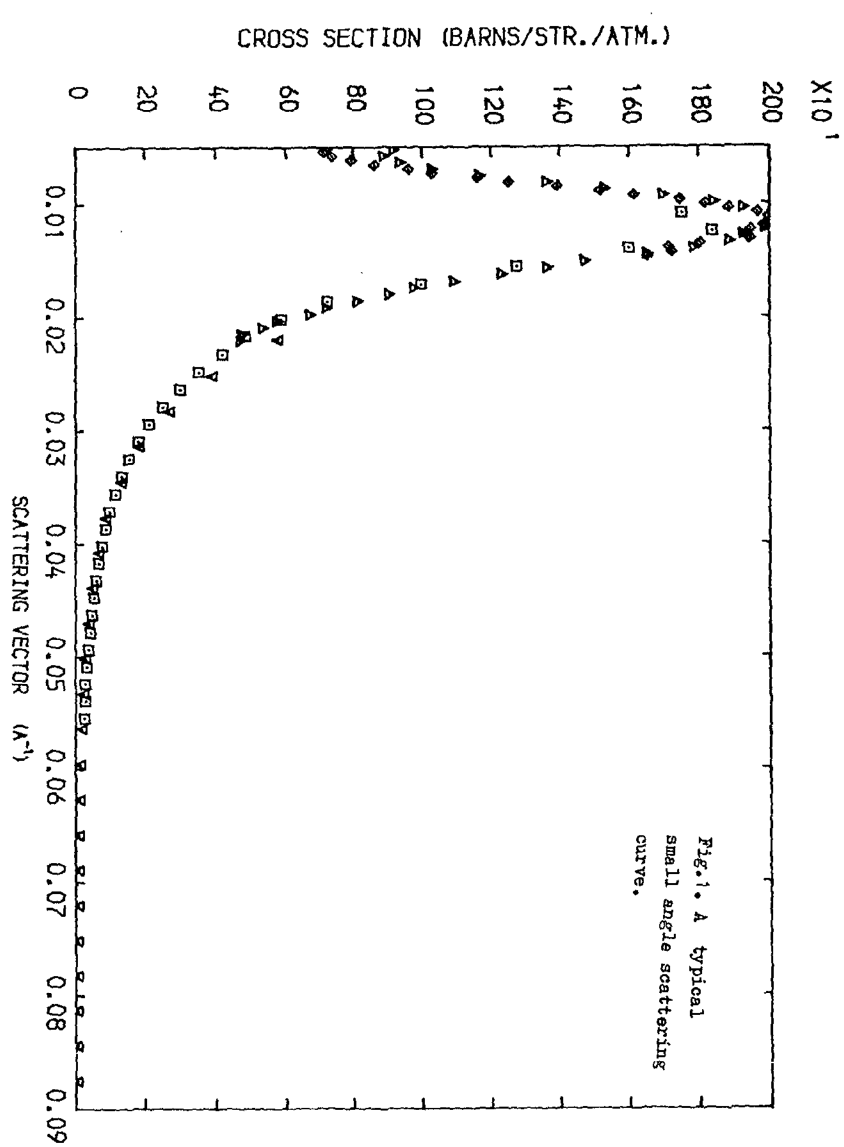


Fig.1. A typical small angle scattering curve.



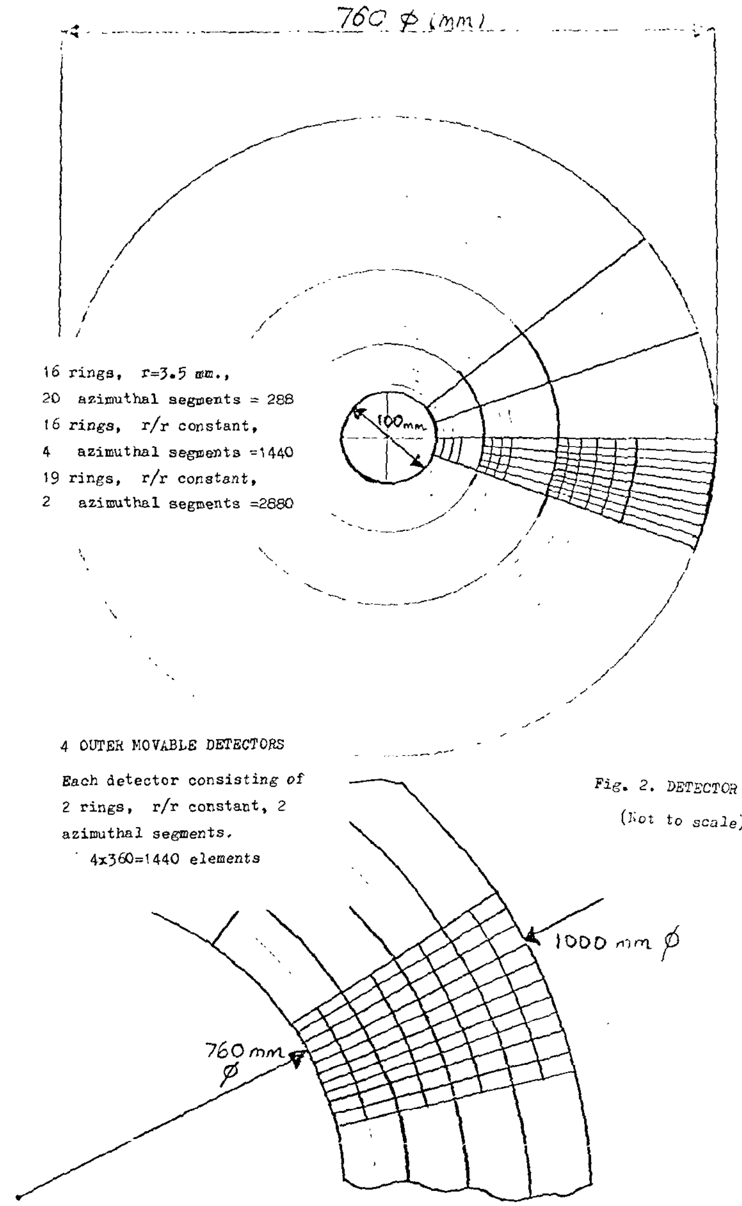


Fig. 2. DETECTOR
(Not to scale)

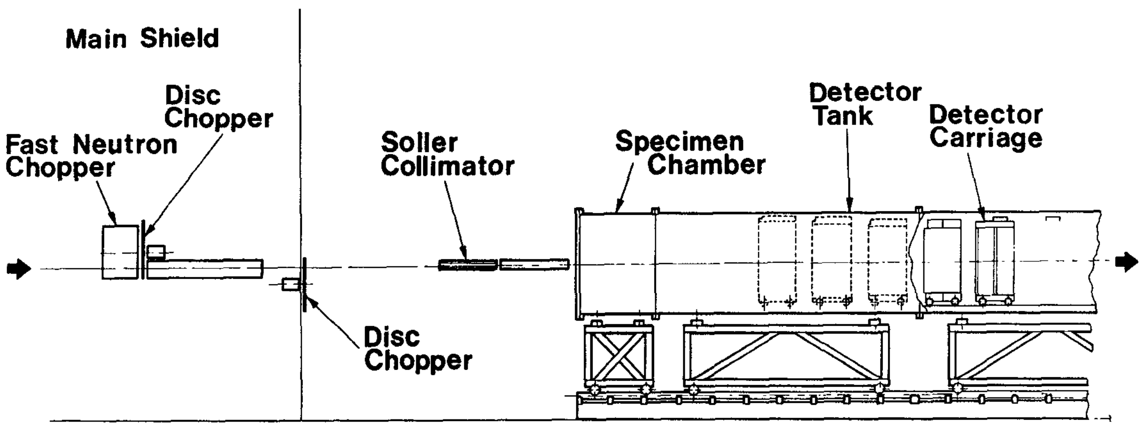


Fig.3. Low Q Spect.