The new chopper spectrometer at LANSCE, PHAROS

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ABSTRACT: We describe the new chopper spectrometer PHAROS under design at Los Alamos. It is intended to provide 0.5% incident energy resolution for incident energies between 50 meV and 2 eV. This will be achieved with a methane moderator and a 20-m incident flight path on Flight Path 16 of the Los Alamos Neutron Scattering Center. The secondary flight path will be 4 m for scattering angles between 10° and 140°. For small scattering angles (down to 0.5°), the secondary flight path can be extended to 10 m. We include results of preliminary tests on phasing a prototype chopper and the Proton Storage Ring. These show that phasing can be achieved and that the width of the transmitted neutron pulse is in reasonable agreement with calculation.

1. Description of the proposed spectrometer

A new chopper spectrometer is currently under design at the Los Alamos Neutron Scattering Center. In March 1987, a workshop was held at the Argonne National Laboratory to define the parameters of the spectrometer, and the present design does not differ greatly from the thinking expressed in the report[1] of that workshop. The configuration of the spectrometer is shown schematically in Fig.1 and the proposed instrument parameters are given in Table 1. A more detailed scale drawing showing chopper positions and building constraints is shown in Fig. 2.

TABLE 1

Moderator-Chopper Distance	18.5 m
Chopper-Sample Distance	1.5 m
Sample-Detector Distance	4 m between 10° and 140°
	up to 10 m between -10° and + 10°
Moderator	12.5 x 12.5 cm^2 liquid methane
Source Repetition Frequency	12 or 24 Hz
Chopper Frequency	600 Hz
Chopper Diameter	10 cm
Chopper Slit Spacing	1 mm or more
Sample Size	up to 5 cm x 7.5 cm

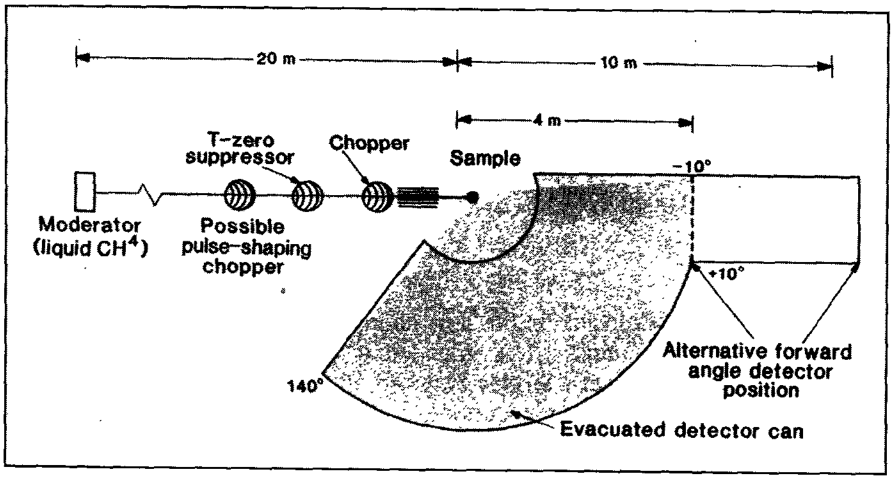

Fig. 1 A schematic diagram of the proposed LANSCE chopper spectrometer

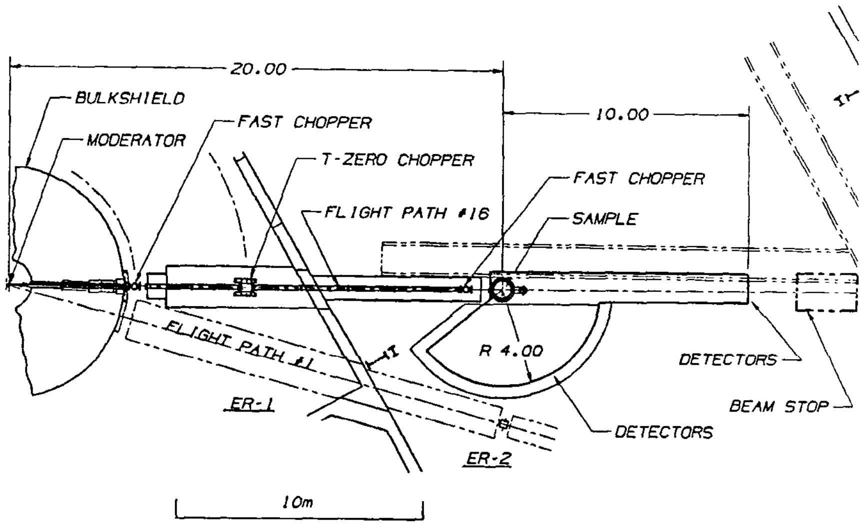

Fig. 2 A scale drawing showing the position of the choppers and the spectrometer footprint in the LANSCE facility. The primary chopper sample and secondary flight path will all be in the new Experimental Hall ER-2, while the T-zero chopper and a possible pulse-shaping chopper will be in the old experimental hall ER-1.

The spectrometer will be installed on Flight Path 16, which currently views a water moderator (in the flux-trap geometry) at 15° from the normal to its surface. This will be replaced by a liquid methane moderator by 1992. Up to three choppers will be placed in the incident beam. The most important of these is the primary chopper, which is closest to the sample position. It is an aluminium-bodied chopper mounted on a magnetic-bearing system, which has been described previously[2], with a borated slit package. Secondly, there will be a T-zero supressor, which is intended to block the beam line when protons hit the target, but be completely removed from the beam by the time 2eV neutrons (the highest energy we currently envisage using) reach it. While it would be best, from a background point of view, to place the T-zero suppressor as close to the source as possible, it will be 10 m from the source to have the beam fully open in time for 2eV neutrons. Thirdly, there will be provision for yet another chopper to be placed, at some later date, close to the bulk shield. This will be a fast chopper, similar to the primary chopper, and its purpose will be to clean up the spectrometer resolution function and/or to improve the time resolution beyond that of the moderation time. As the beam size in this position is larger than at the sample position, it would be best if this chopper could contain an aperture significantly larger than the sample size.

Our philosophy is very similar to that which has been employed at ISIS, namely that we will have a fast magnetic-bearing chopper for monochromation purposes, with a slower nickel-alloy T-zero suppressing device upstream to reduce backgrounds. In contrast, the practice to date at IPNS has been to employ one Be-bodied chopper, on mechanical bearings, for both purposes.

The secondary flight path will be evacuated, with the detectors placed outside the vacuum behind thin aluminium alloy windows. It will extend to 4 m for scattering angles between 10° and 140° and can be extended to a maximum of 10m in the forward direction. The purpose is for experiments at small momentum transfers (and, hence, small scattering angles), like neutron Brillouin scattering[3,4]. We plan to reach scattering angles as low as 0.5°, although we will need additional collimation between sample and chopper to achieve this cleanly. In all probability, the low-angle option will be ready before the wide-angle flight path, and we plan to build it in such a way that the spectrometer can be used solely in that mode at first.

The spectrometer will use 10 atmosphere ^{3}He proportional counters throughout, most probably 2.5-cm-diam., 90-cm active-length linear position-sensitive detectors. We are currently working on window designs for the vacuum vessel, which are compatible with this detector configuration, while minimising the dead angle due to structural window panes.

The incident beam profile and chopper apertures are such that samples of size up to 5 cm x 7.5 cm may be used. This is significantly larger than beam sizes at ISIS, but significantly smaller than those on LRMECS and HRMECS at IPNS.

2. Preliminary tests of the chopper system

Figure 3 shows the components of our rotor immediately prior to assembly. We have run the primary chopper at 8 m from the moderator on a test beam line, Flight Path 5, at LANSCE. This flight path is considerably shorter than that proposed for the final spectrometer and it views a low-resolution ambient water moderator. The results are shown in Fig. 4. Figure 4(a) shows the relative phasing of the LAMPF accelerator to our chopper, without phasing the Proton Storage Ring (PSR)[5] to the chopper. This distribution is very broad, with the tails clearly extending to ± 150 μs. We believe that this is mainly due to inaccuracies introduced in the zero-crossing

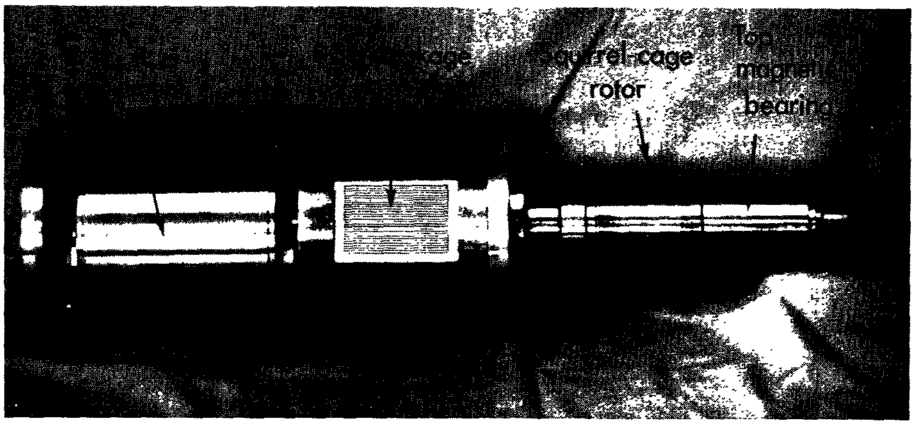

Fig. 3 Components of the 600-Hz rotor prior to assembly. The slit package consists of 0.71-mm-thick boron-fibre epoxy resin slats with 0.76-mm open slits between, all on a 1.5-m radius.

circuitry that triggers LAMPF. However, the proton beam can be held in the PSR for up to 150 μs, with extraction on a trigger from the chopper. Results in this mode are shown in Figs. 4(b) through (d). Figure 4(b) shows the signal from a magnetic pick-up on the rotor; these data are directly comparable with Fig. 4(a). There is a small tail on the distribution, which we believe is due to the 150-μs window being insufficient in some cases. Figures 4(c) and (d) show transmitted neutron signals in two downstream monitors: the first of which is immediately after the chopper and the second is 3.1 m further downstream. The peak in Figure 4(c) has a standard deviation of 3.60 μs. If one calculates the width one should observe, based on the chopper parameters, the result in Fig. 4(b), and the monitor thickness, one arrives at a standard deviation of 3.2 μs. Given the imprecision of the measurement in Fig. 4(b), this is reasonable agreement. The width of the peak in the downstream monitor is dominated by dispersion of the neutron pulse, which is mainly due to the moderator pulse width.

These results show definitively that we can phase the chopper and the PSR.

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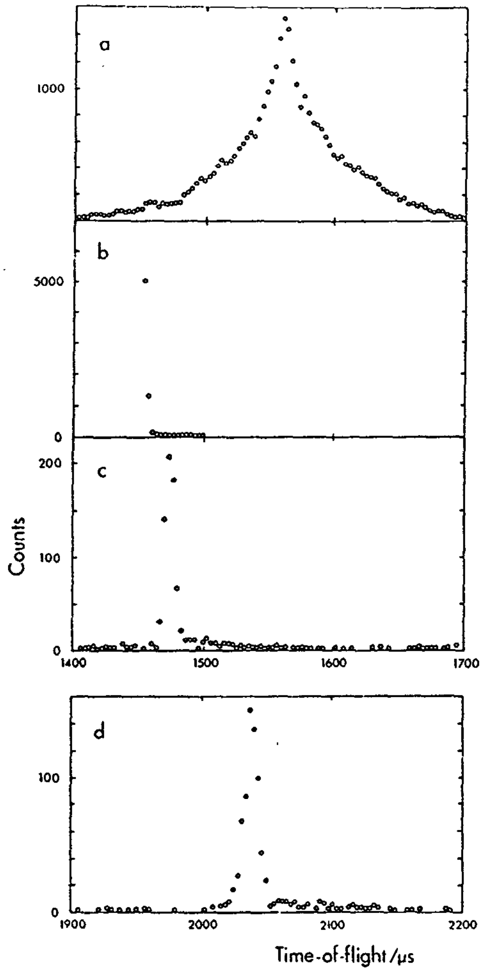

Fig. 4 Time-of-flight spectra for the chopper system on flight path 5 at LANSCE.

(a) The magnetic pick-up signal on the rotor, with the chopper following the LAMPF accelerator trigger signal. This represents the time jitter in the accelerator trigger signal. The FWHM is approximately 42 μs, but with very substantial tails to the distribution.

(b) Magnetic pick-up signal as in (a), but with the proton beam held in the PSR until kicked out on a trigger from the chopper control signal. The standard deviation of this distribution is approximately 1.9 μs, the time bin-width (3.2 μs) being insufficient to determine this quantity accurately.

(c) Signal in a beam monitor immediately after the chopper, with extraction from the PSR triggered by the chopper. The standard deviation of this distribution is 3.60 ± 0.12 μs.

(d) Signal in a downstream monitor, with extraction from the PSR triggered by the chopper. The standard deviation of this distribution is 5.50 ± 0.22 μs.

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