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Instrument Workshop Summary on New Components - Detectors

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The number of formal presentations in this workshop session was deliberately limited in order to allow some time for general discussion of detector-related topics of interest. The five formal presentations corresponding to papers submitted for the proceedings and the discussions specific to them are summarized first. Since the full papers are available in the proceedings, these summaries are very brief. The detection system which was to have been presented by Charlie Bowman is summarized in somewhat greater detail, since there is no other paper on that system in the proceedings. Finally, the topics raised in the general discussion period and the discussions which they gave rise to are presented in summary form.

Dr. Maeda described the development of and initial results obtained with two-dimensional multi-wire gas proportional counters using a ^{3}He-Ar-CO_2 fill gas. Both a 21x21 cm^2 prototype and a 51x51 cm^2 detector were constructed. This latter detector was developed for use on a small-angle scattering instrument at the KUR reactor at Kyoto. These detectors could be encoded by charge-division encoding, delay-line encoding, or by wire-by-wire readout, offering an useful intercomparison of the various encoding techniques. Delay-line encoding resulted in a resolution of ~5 mm fwhm. Details of these detectors are provided in the paper "Area detector for small-angle neutron scattering at KUR" by Y. Maeda, M. Sugiyama, and S. Uehara in these proceedings.

Dr. Shimizu discussed several different scintillation counters which were used in a nuclear-physics experiment on parity non-conservation in neutron-nuclear interactions, being done on one of the neutron beams at KENS. The neutron detectors in this experiment were a 10-micron thick indium foil coupled with a plastic scintillator and used as a beam monitor, and a ^{10}B liquid scintillator used to detect the main neutron beam after its passage through the sample target. The gamma rays produced by interactions in the sample were detected using BaF_2 scintillators. The liquid scintillator has high-data-rate capabilities which may be of interest for some neutron scattering experiments, as it can operate at 10 MHz data rates with no apparent problems. Details of these detectors are included in the paper "Scintillation detector system in neutron-nuclear experiments" by Y. Masuda, H. M. Shimizu, and T. Adachi in these proceedings.

Kent Crawford gave a general overview of the neutron detectors in use at IPNS, with emphasis on the beam monitors and the various types of position-sensitive detectors used there. This detector summary is contained in the paper "Neutron detectors at IPNS" by R. K. Crawford, J. R. Haumann, and G. E. Ostrowski in these proceedings.

Mike Johnson presented Peter Davidson's paper, which brought us up to date on the current status of the ^{6}Li-containing ZnS scintillation detectors being developed and used at ISIS. Three instruments, IRIS, HRPD, and SANDALS now rely heavily on these detectors, and a large position-sensitive detector of this material is currently being fabricated for use on SXD (see "Single crystal diffraction at ISIS" by C. C. Wilson in these proceedings). In all cases coincidence between two or more photomultipliers (PMTs) is required to produce a countable event, and this essentially eliminates problems from intrinsic PMT noise. For the 51-element IRIS detector, the gamma/neutron discrimination is $\sim 10^{-8}$ and the intrinsic background is ~2 counts/element/hour. For the HRPD detectors the corresponding numbers are $\sim 10^{-6}$ gamma/neutron discrimination and ~3 counts/element/hour intrinsic background. The ZnS scintillator is nearly opaque, so the individual scintillator pieces are made thin to allow the light to escape. In most of these detector systems neutrons are incident at an angle to the plane of the ZnS scintillator in order to increase the detection efficiency. In the SANDALS detectors where high efficiency is required down to quite short wavelengths, a number of layers of the scintillator are stacked with space between them for the light to escape. Details of these detectors can be found in the paper "Developments on neutron detectors" by P. L. Davidson in these proceedings.

Nobuo Niimura discussed some of the detectors made with ^{6}Li-glass scintillator material at KENS. These have been made in a variety of geometries with several different types of encoding, using glass from Japanese manufacturers. Particularly heavy use is on the WIT thermal-neutron small-angle diffractometer, which has an area detector with concentric annular segments made of this scintillator, and also has an incident beam monitor utilizing powdered glass scintillator. The annular detector uses pattern discrimination applied to the signals from the various PMTs in order to reduce background noise. A wide-angle detector array of this scintillator is used on the FOX single-crystal diffractometer at KENS as well. More details are available in the paper "Several experiences of using Li-glass scintillators" by N. Niimura, H. Hirai, K. Aizawa, K. Yamada, F. Okamura, and M. Isobe in these proceedings.

Although Charlie Bowman was unable to attend the ICANS meeting and hence could not give his talk scheduled for this session (C. D. Bowman and H. G. Priesmeyer, "Current-mode neutron detection for stroboscopic diffraction studies"), he was kind enough to send some materials describing the Bowman-Priesmeyer detection system used for very-high-instantaneous intensity (up to $\sim 10^{11}$ neutrons/sec) in-beam transmission measurements. This is the detection system used for the single-pulse test experiment reported by Peter Egelstaff above ("Experiments using single neutron pulses" by C. D. Bowman, P. A. Egelstaff, and H. G. Priesmeyer in these proceedings). The material Charlie sent has been presented for publication elsewhere (J. D. Bowmam, J. J. Szymanski, V. W. Yuan, C. D. Bowman, A. Silverman, and X. Zhu. "Current-Mode Detector for Neutron Time-of-Flight Studies"), and so is only summarized briefly here.

This detection system involves current-mode operation of a photomultiplier tube coupled to a thick ^{6}Li-glass scintillator. The detector and data collection system are shown schematically in Fig. 1. Since the system was designed to have high efficiencies at rather high neutron energies, a 1 cm thick NE905 ^{6}Li-glass scintillator was used. This scintillator was 13.3 cm in diameter and optically coupled to a Hamamatsu R1513 12.5 cm photomultiplier. The S20 type photocathode was used to provide the large photocathode currents (up to 1.6 μA) required at the highest instantaneous detection rates (~10^{11}/sec). Each of the last 4 dynodes of the 10-dynode chain in the PMT was connected to its individual high-voltage/high-current power supply in order to keep the last 4 dynode voltages fixed for all photocathode voltages. With this design the maximum allowed instantaneous anode current was 32 mA. A transient digitizer (DSP model 2012S) was used to read out the resulting time-of-flight spectrum from a single pulse (see the Egelstaff presentation cited above). The sampling time interval of this digitizer can be varied between 50 ns and 10 μs. A multipole filter was used to shape the incoming signal with a time constant matched to this sampling time interval. The digital output of the transient digitizer was transferred to the signal-averaging memory (DSP model 4101) after each pulse. Results from a single pulse or a number of pulses could be accumulated there, and this memory could also be used to subtract out spurious signals which were in phase with the 60 Hz line frequency.

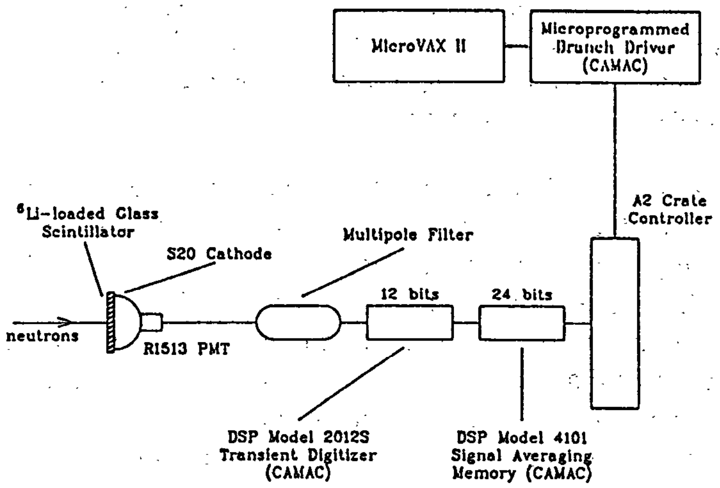

Figure 1. Schematic diagram of the Bowman-Priesmeyer current-mode neutron detection system.

Figure 2 shows the transmission of a ^{238}U sample measured with this detection system. A number of resonance absorption lines can be clearly seen. Also shown in the figure are similar measurements at much lower counting rates made using traditional pulse-counting techniques. The current-mode measurements did not permit discrimination against gamma rays (as is done with pulse-height discrimination in the usual pulse-counting measurements), so there is a significant gamma background in the current-mode measurements. This is seen most clearly for the resonance at 66 eV (near 500 μs) where the transmission goes nearly to zero as measured in the pulse-counting mode but is significantly above zero as measured in the current mode. Such gamma problems would likely be significantly reduced if a 1-2 mm thick ^{6}Li-glass scintillator, which is adequate for neutrons below ~1 eV, were used. Despite these gamma-ray problems, this current-mode measuring technique does offer the capability for collecting neutron time-of-flight data at the extremely high instantaneous rates required to obtain adequate data from a single pulse. As the intensity of pulsed neutron sources continues to increase it is likely that this technique will find more and more uses among the neutron-scattering community.

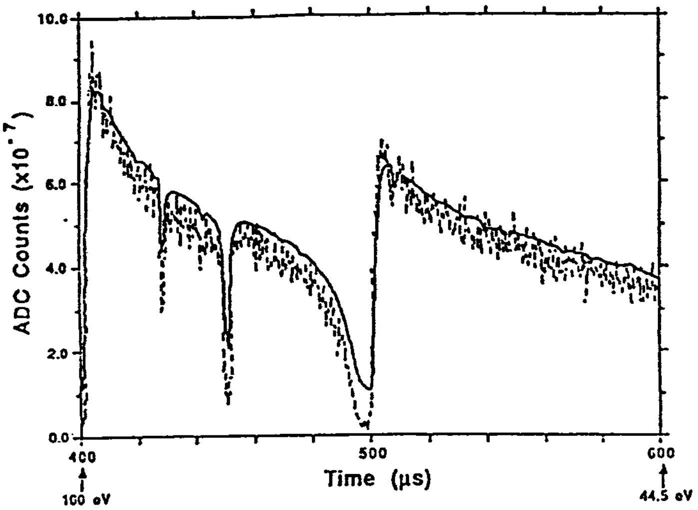

Figure 2. Neutron transmission through a ^{238}U sample. The solid curve is the time-of-flight spectrum collected using the current-mode detection system discussed here. The dashed curve shows transmission through the same sample, measured with traditional pulse-counting techniques. The axis-labels refer to the solid curve, and the dashed curve has been scaled to provide rough correspondence.

In the discussion it was noted that the session co-chairmen were developing a survey of neutron detectors in use or under development at the various steady-state and pulsed neutron sources in the world, and input into this survey was solicited from the workshop participants. Considerable discussion also centered on the need for very small detectors (2-3 mm) for use as transmission beam monitors for small-angle scattering experiments. It was noted, however, by John Hayter and Peter Egelstaff that any direct measurement of transmission in a small-angle-scattering experiment will be contaminated by the sample small-angle-scattering, so care should be exercised when using this means of measuring the sample transmissions. There was some discussion concerning the lack of uniformity in efficiency of the ^{6}Li-glass scintillators. Glass obtained in Europe seems to have varied in efficiency from batch to batch, complicating the fabrication of detectors from this material. Nobuo Niimura stated that no such problems had been detected with ^{6}Li-glass from their Japanese source. General concerns were expressed about the time and temperature stability of detectors and detection electronics, and the effect this might have on absolute intensity measurements. No one had any hard numbers on this for any of the different types of detection system discussed, but there was some feeling that photomultiplier-based systems might suffer the most from such problems.

In conclusion, it was very encouraging to see the large numbers of different types of detectors which were being operated successfully in the various laboratories, and the considerable amount of detector and electronics development which is ongoing. The excellent results obtained with the ZnS scintillator detectors at ISIS are particularly encouraging, and it is likely that the use of such detectors will spread rapidly to other neutron-scattering laboratories.