AN EXPERIMENTAL TEST OF CHARGE SYMMETRY IN n-p SCATTERING

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The scientific motivation and basic measurement plan for experiment #80, "A Search for Charge Symmetry Violation in n-p Scattering," have been summarized in the 1978 IUCF Technical and Scientific Report. We propose a significant experimental test for the presence (at a level expected theoretically[1]) of class IV charge-symmetry-breaking (CSB) forces, which have spin- and isospin-dependences antisymmetric under interchange of two nucleons. Such CSB nuclear forces are expected to arise from various indirect electromagnetic effects on meson exchange,[1] and possibly from intrinsic SU(2)-symmetry breaking in the strong interaction associated with quark mass differences.[2] The experiment requires measurement of left-right asymmetries, to a precision of $\sim \pm 5\times10^{-4}$, in the scattering of 200 MeV polarized neutrons from polarized protons. Measurements will be carried out simultaneously over a broad range of angles $[75^\circ \leq \theta_{c.m.}(n) \leq 120^\circ]$.

Much of the large-scale equipment development needed for this experiment is presently under way. The liquid helium cryostat, with built-in superconducting magnet, needed for the "spin refrigerator" polarized hydrogen target[3] is under construction at the University of Wisconsin. Progress on the layout and component design for the polarized-neutron beam line is summarized in the Technical Section of the present Report. We report below on the design status of the detector arrays and electronics for the CSB experiment.

There are a number of critical experimental considerations which constrain the detector design.

Scattered neutrons and recoil protons must be detected in coincidence, over similar laboratory angular ranges The left and right detectors must thus each serve to detect either protons or neutrons with high efficiency. (This constraint also ensures that we can carry out a null $\vec{p}$-$\vec{p}$ scattering experiment with the same equipment, using a secondary beam of polarized protons, rather than neutrons, from the liquid deuterium production target.) Events from quasi-free (n,np) reactions initiated on "heavy" nuclei present in the polarized target (e.g., C, O, S, Y) must be distinguished from free n-p scattering events via high-resolution measurements of the opening angle and coplanarity of the detected n-p pair. Proton position measurements at several distances from the target are needed to allow "ray-tracing" of the point of origin of the observed particles. We do not require very good energy resolution in either the proton or neutron detection, but reasonable timing performance (e.g., ∿1 ns FWHM resolution with respect to the cyclotron RF) is needed to hold down random coincidence rates and to pick out events initiated by neutrons in the high-energy charge-exchange peak of the neutron spectrum from the liquid deuterium pro-

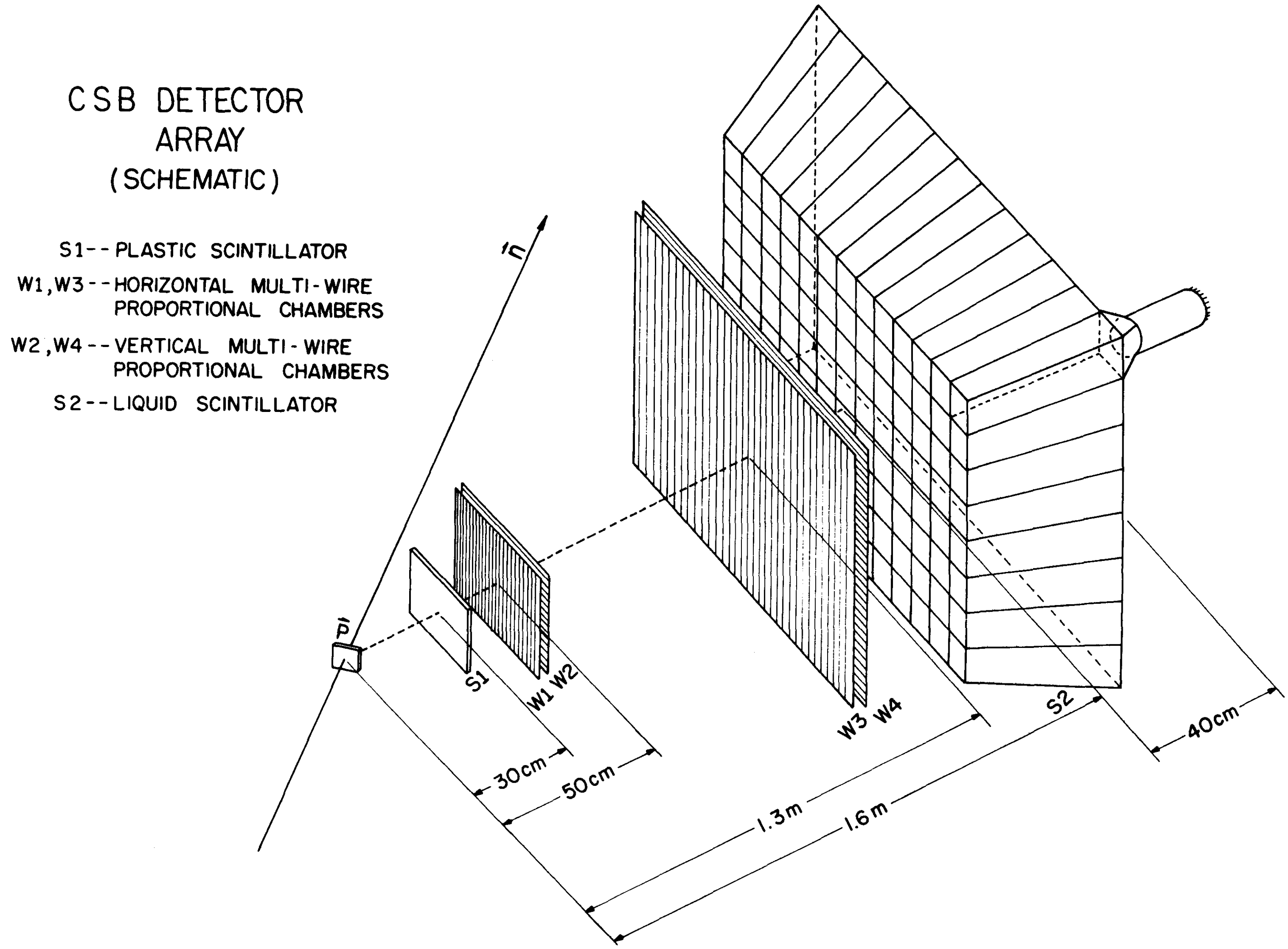

Figure 1. *Schematic illustration of one arm of the detection apparatus planned for the CSB experiment. Only the active areas of detectors are indicated. The outline of the corner sub-cell of the large-volume liquid scintillator is indicated by dashed lines. A separate phototube will be mounted at the rear of each of the ∿100 sub-cells.*

duction target.

A schematic illustration of the detector array planned is given in Fig. 1. A completely symmetric arrangement will be placed to the left of the incident beam direction. Protons will be identified by a six-fold coincidence among the two scintillators S1 and S2 and the four multi-wire proportional chamber (MWPC) planes on one side of the beam, and they can be distinguished from other charged particles by the relative energies deposited in S1 and S2. Neutrons will give signals only in the large-volume liquid scintillator S2. Polar and azimuthal angle information will be obtained from S2 by sub-dividing the large liquid scintillator vat into ∿100 optically isolated cells, each tapered and aimed toward the target, and having an individual photomultiplier tube mounted at the rear. This scheme, in comparison with others considered, has the advantage of logical simplicity, reducing the position information for the neutron to digital information, analogous to that provided for charged particles by multi-wire chambers. The overall efficiency for detection of 100 MeV neutrons is expected to be ∿40%.

Construction of the MWPC's will begin shortly at IUCF. Readout of the wire chambers will be accomplished by a combination of commercial (LeCroy) boards and a home-built controller. We are presently in the process of testing various prototype liquid-scintillator cells, in order to determine the combination of liquid, cell wall covering, and phototube which represent the optimum compromise between performance (timing, neutron detection efficiency, light attenuation, chemical stability, etc.) and cost. Design of an optimum electronics scheme for processing events from the large-volume, multi-celled neutron detector requires writing a sophisticated Monte-Carlo code to simulate the detector response, including treatment of polarization effects in the neutron interactions and detailed tracing of the paths of the neutron and recoil particle(s) through the detector subsequent to an initial interaction. In its present conception, the electronics scheme includes a separate (CAMAC) TDC and ADC to digitize the timing and energy signals from each of the 200 liquid-scintillator sub-cells, along with coincidence latches whose bit pattern indicates which TDC's and ADC's should be read out for a particular valid n-p coincidence event.

We aim to complete construction and initial testing of the above detectors and electronics by the summer of 1981, by which time both the polarized neutron beam and polarized hydrogen target should also be available.

1) E.M. Henley and G.A. Miller, in Mesons in Nuclei, ed. M. Rho and D. Wilkinson (North-Holland, Amsterdam, 1979), Vol. 1, p. 405; C.Y. Cheung, E.M. Henley, and G.A. Miller, Nucl. Phys. A305, 342 (1978); A. Gersten, Phys. Rev. C 18, 2252 (1978); C. Yalcin, M. Halil, and E. Aksahin, Phys. Scripta 20, 36 (1979).

2) P. Langacker and D.A. Sparrow, Phys. Rev. Lett. 43, 1559 (1979).

3) J. Button-Shafer, R.L. Lichti, and W.H. Potter, Phys. Rev. Lett. 39, 677 (1977).