

NPDGamma CsI(Tl) Current Mode Gamma Array

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We have developed a low-noise current mode detector array for gamma asymmetry measurements [1]. This array will be used in the NPDGamma experiment at LANSCE and can also be used for subsequent parity violation measurements in n-p and n-d capture at HFIR and the SNS. Its construction was supported by a NSF MRI grant in addition to NPE support.

The detector array shown in Fig. 1 is coarsely segmented into 48 CsI(Tl) cubes 15 cm on a side arranged in a roughly cylindrical pattern in 4 rings of 12 detectors each around a cylindrical 20 liter liquid hydrogen target. The liquid hydrogen target stops about 60% of the incident cold neutrons with most of the remainder absorbed in 6Li-rich plastic with negligible gamma yield so that the current-mode signal is indeed dominated by 2.2 MeV n-p capture gammas. The $\sim 3\pi$ solid angle collects $\sim 87\%$ of the parity-odd component of the gamma asymmetry, which is maximized along the (transverse) polarization direction of the neutron beam. Each cube contains $\sim 85\%$ of the 2.2 MeV gamma energy. The ~ 100 MHz rate expected in each detector induced us to employ current mode detection, performed by converting the scintillation light from the CsI(Tl) detectors to current signals using vacuum photo diodes (VPD) with $\sim 10^{-3}$ linearity and low gain sensitivity to DC ($10^{-4}/G$ at 10G) and AC ($10^{-5}/G^2$ at 10G) external magnetic fields. The photocurrents are converted to voltages and amplified by low-noise solid-state electronics. The electronic noise in this detector was measured to be a factor of 70 smaller than the expected gamma shot noise in the asymmetry experiment.

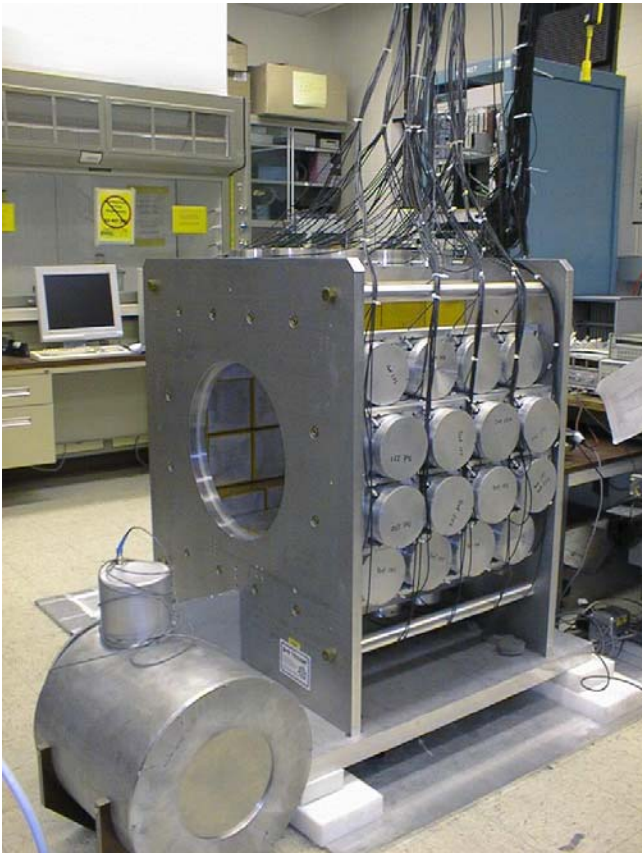


Figure 1: *Picture of the CsI array and the RF neutron spin flipper on the test stand. Bench tests show that the array signals are insensitive to the operation of the neutron spin flipper at the 10^{-9} level.*

Within each 12-detector ring in the array the gamma intensities in each of the 8 near detectors and each of the 4 corner detectors are nearly equal. Spatial nonuniformities in the array efficiency can couple to spin-dependent parity-conserving asymmetries and potentially produce systematic effects. We therefore chose to equalize the signals from near and corner detectors which enter the DAQ by a combination of hardware and software gain adjustments and sample only (1) the average signal in a ring, (2) the differences in each detector from the average signal in a ring. This strategy allows one to exploit the increased dynamic range to increase the gain of the system and minimize the effects of noise in the sampling electronics.

Since the experiment intends to determine an asymmetry with a precision of $5 \cdot 10^{-9}$, any systematic effect resulting in a false asymmetry has to be measured to at least this level of accuracy in a short period of time. For the detector array the two most serious potential instrumental systematic effects may be caused by the radio frequency spin flipper (RFSF) which is used to reverse the spin of the neutrons. Any magnetic fields leaking into the VPDs can produce a systematic effect through a multiplication of the overall detector gain. In addition, any electronic pickup could add a false signal on top of the real signal. If these signals are correlated with the spin state of the neutrons, through the spin flipper, this could lead to false asymmetries. Asymmetries correlated with on-off signals in the radio-frequency neutron spin flipper were shown in bench tests to be less than 10^{-9} and can be measured in a few hours, which is very short compared to the running time of the experiment. This array was successfully tested at LANSCE in the spring 2004 test run in which the parity-odd asymmetries were measured.

1. Z. Chowdhuri, Ph.D. thesis, Indiana University (2000); M. Gericke, Ph.D. thesis, Indiana University (2004).