Work is continuing on the iron cross section project, principally in the area of experiment design and optimization. Further work has been done on the design of the shell transmission experiment for which the neutron sources are positioned at the center of the spherical shell. We are in the process of studying the neutron energy and the angular distribution of the neutrons, in the laboratory system, produced by charged-particle reactions which may be useful for these experiments. Kinematic calculations of the neutron energies have been made for a wide range of reactions, and we have observed that more massive targets are preferred since the neutron energy range throughout the full angular range is less. Also it is better to use the lighter particle as the projectile. For very massive targets, however, the first excited state of the residual nucleus (and possibly higher excited states, also) tends to be at a low energy. This limits the neutron energy that can be used, when monoenergetic neutrons are required. One could use high-energy charged particles for such reactions and allow the additional energy group associated with the first excited state (or even higher excited states) to be present. This complication would then be handled in the calculational model used to describe the experiment. Not allowing the additional groups would provide a cleaner experiment with the analysis having more sensitivity to the basic nuclear cross section data. We are presently conducting a literature search to obtain laboratory angular distributions for reactions which appear to be promising for this experiment. The $^{15}\text{N}(p,n)^{15}\text{O}$ is one of these reactions. Although there are significant deviations from monoenergetic and isotropic distributions with this reaction, overall it remains the most favorable of those studied. The next step is to run calculations to determine the sensitivities of the nuclear cross section data to an experiment using this source. For many of the reactions very little data on the angular distribution are available. At Ohio University, work is being done to improve the efficiency determinations of detectors that could be used to measure these angular distributions where the data are lacking.
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The detectors used in the portion of the experimental phase, where the neutron sources are positioned at the center of the spherical shell, must have good timing characteristics, and we are studying the most appropriate types of detectors that should be used. One will be based on proton-recoil detection, which is appropriate for the higher neutron energies. The second type of detector will be sensitive to low-energy neutrons. For this phase, time-of-flight spectroscopy techniques will be used to determine the spherical shell transmission, which is directly related to the non-elastic cross section. The neutron energies will also be obtained from these data. These measurements will also allow us to obtain information about inelastically scattered neutrons.

An experiment will also be performed with the detector located in the center of the iron sphere, as opposed to the neutron source. Under these circumstances, the properties of the source should not be a problem. By proper placement of the sphere with respect to the source, the range in neutron energies over the dimensions of the sphere can be quite small. Work is underway determining the types of detectors for use in this experiment. (Time-of-flight techniques cannot be used for this phase.) The spherical shell transmission data obtained from this experiment, which gives the non-elastic cross section, requires a detector that can be biased or whose response can be unfolded to remove neutrons that have had non-elastic interactions. This eliminates many commonly used detectors such as those based on the $^6$Li(n,t), $^{16}$B(n,α) and $^{235}$U(n,f) reactions, which have large positive Q values. Some reactions commonly used in neutron dosimetry, such as the $^{238}$U(n,f) and $^{237}$Np(n,f), with negative Q values may be useful. The most useful detectors will be those based on proton recoil detection. Unfolding techniques could be used at low energies with proportional counters containing methane or hydrogen, and at higher energies hydrogen-based scintillators could be used. At high enough energies, detectors based on the $^3$He(n,p) reaction could be used since its Q value is not too large (although it is not clear that they would perform better than the hydrogen based detectors).

The European community recently completed a new cross section evaluation for $^{56}$Fe, which incorporates many data sets not included in the ENDF/B-VI evaluation. Although this work will not be released as an official JEF (Joint European File) evaluation until the next major JEF release, it was made available to us through the Nuclear Data Bank in Paris. These improved cross section data will be used in the three-dimensional model of the experiment that we are developing using the Automated Adjoint Accelerated MCNP Monte Carlo computer code.

In addition, an unpublished report on the effects of cross section fluctuations and self-shielding effects in the unresolved resonance region, authored by Fritz Froehner, was recently made available by the Working Party on International Evaluation Cooperation of the Nuclear Energy Agency Nuclear Science Committee. This report focuses its emphasis on the effects produced with iron. Though a detailed analysis must be done for the NIST sphere, it is clear that the inclusion of these effects will improve the agreement between the experiment and the ENDF/B-VI results.