Approximately 7,500 tons of purified light water will encase the bottle and phototubes. That light-water jacket is needed to shield the detector from radioactive emissions emanating from the rock surrounding SNO.

The Charged-Current Spectrum in SNO. Measuring the Cerenkov spectrum due to the charged-current interaction of ^{8}B electron neutrinos shown in Reaction (4) is one of the primary goals of SNO. Should the neutral- to charged-current ratio indicate neutrino oscillations, the shape of the charged-current spectrum could be used to probe different solutions to the solar-neutrino problem. For example, the MSW effect predicts a depletion in the flux of lower-energy ^{8}B neutrinos, and this reduced flux would be mostly evident as a change in the shape of the spectrum between about 5 and 8 MeV, as shown in Figure 7. SNO's detection ability and sensitivity to the charged-current signal have been assessed with computer simulations that predict the response of the detector to that signal and various anticipated background signals.

An example of such a simulation is shown in Figure 8. Below about 4 MeV, the detector is recording Cerenkov light that is due mostly to background processes (the "Cerenkov background wall"). Uranium and thorium atoms, which will unavoidably contaminate the heavy water and the detector materials, decay and produce energetic beta particles and gamma rays. These emissions create Cerenkov light when they streak through the heavy water. Signals due to neutrino events cannot be discerned beneath this wall of background light, and thus SNO is only expected to be sensitive to neutrinos with energies greater than about 5 MeV.

It is also evident from Figure 8 that between about 5 and 8 MeV, the summed Cerenkov spectrum derives from a complex overlap of different signals. The charged-current spectrum, which extends all the way to about 14 MeV, peaks in that region. But the neutral-current spectrum and neutrino elastic-scattering spectrum are also present. Whereas detecting these latter signals is one of the design goals for SNO, in the context of isolating and measuring the charged-current spectrum, the signals represent complicating backgrounds.

The simulation shows the importance of maintaining an ultraclean detector environment in order to minimize the Cerenkov wall, especially in the critical region between 5 and 8 MeV. (See the box "Nothing to Dust: The Meaning of Clean" on page 149.) Although ensuring the radiopurity of construction materials has been a major focus in this project, the background levels in the light-water jacket and in the heavy water will be monitored by a variety of techniques. In addition, several calibration sources will establish the optical properties of the SNO detector and its response to electrons, gamma rays, and neutrons. These sources will be inserted in the

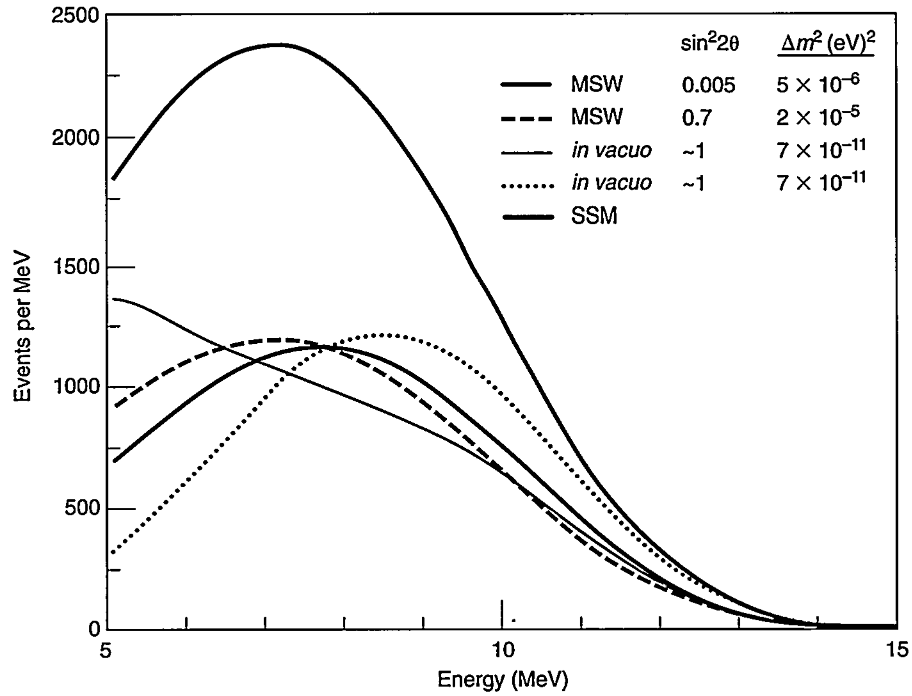

Figure 7. Theoretical Distortions in the Charged-Current Spectrum
By assuming a ^{8}B neutrino spectrum, one can simulate what SNO would record for the charged-current (electron neutrino) Cerenkov spectrum. The black curve results from the standard-solar-model (SSM) spectrum, whereas the other curves are the result of distorting the ^{8}B spectrum either through *in vacuo* neutrino oscillations (red curves) or the MSW effect (blue curves). The amount of distortion depends on the amplitude and wavelength of the oscillations, which are characterized by the amount of mixing between neutrino flavors (the parameter $\sin^2 2\theta$) and the mass difference between neutrino mass states (the parameter Δm^2), respectively. The red curves reflect two of the five "just so" solutions for *in vacuo* neutrino oscillations, labeled as such because the large mixing angles and tiny mass differences are just right to make the oscillation length match the earth's orbit. The two blue curves derive from two different MSW solutions that are consistent with the existing data. The solid curve results when one assumes that electron neutrinos become muon neutrinos over a density range that is short compared with the neutrino oscillation length (nonadiabatic MSW solution), whereas the dashed curve results from a theory that assumes essentially the opposite (adiabatic, or large-angle, solution). The most favored solution to the solar-neutrino problem is the nonadiabatic MSW solution.