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Position sensitive CZT detectors for the COBRA neutrinoless double beta decay project

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When Pauli first postulated the existence of the neutrino, he suggested that it would have no charge and no mass. This view held for almost 70 years, but a few years ago results from solar and atmospheric neutrino studies, now confirmed by terrestrial accelerator and reactor measurements, revealed the phenomenon of neutrino oscillations. This is the changing of one type of neutrino to another as they propagate through space, so that a beam of pure electron-neutrinos can evolve into a mixture of electron-, muon- and tau-neutrinos, with the ratios changing with distance. One consequence of the oscillation phenomenon is that it implies that neutrinos cannot have zero mass. Unfortunately, while the oscillation measurements can reveal the differences between the three neutrino masses (or more correctly the mass-squared differences) they cannot tell us what the absolute mass scale is. Given the enormous consequences of a finite neutrino mass there is great interest in determining this quantity.

Conventional approaches to measuring the neutrino mass involve measurements of the end point of beta decays. A number of new measurements are in progress and the view is that these will reach a sensitivity of around 0.5 eV. However, theorists favour a mass between 10-50 meV, which will be beyond the reach of this type of measurement. The only approach known which might achieve this sensitivity is neutrinoless double beta decay (0⊠⊠⊠). Neutrino accompanied double beta decay (2⊠⊠⊠⊠) is a rare decay process with a lifetime > 1020 years. There are 36 known isotopes where this decay can occur and it has been observed in about a dozen of these. 0⊠⊠⊠ ⊠ decay, if it occurs, will be even rarer and estimates put the lifetime in the region of 1026 years. Experiments to record this process will require large target masses (tonnes) and will need to be operated in low background underground laboratories.

The COBRA project uses a novel approach in using CZT (Cadmium Zinc Telluride) detectors both as the target and the detector. CZT is a room temperature semiconductor, so offering high resolution for the decay. The neat aspect is that the detector is also the source of the decay particles, because there are 9 isotopes of Cd, Zn and Te which are candidates for 0⊠⊠⊠⊠ decay. The signal of the decay is then two beta particles which are emitted from the same point in the detector and whose energies sum to the energy release in the decay.

At present the test setup employs an array of 1x1x1 cm cubic crystals supplied by eV Products. The main problem with CZT detectors is the poor hole mobility, which leads to excessive hole

trapping and a consequent position dependence on the signal depending on the interactions depth in the crystal. The detectors we use employ the “gridded cathode”approach to remove this position dependency. However, as with any experiment of this type, the key is to reduce signals from background processes. One of the ways in which we hope to improve this is by employing pixellated detectors, by using digital pulse shape readout to record signal risetimes and by exploiting induced charge sharing between readout electrodes to determine event positions within the detector volume. These ideas will be explored in the talk.

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