2.2 Simulation and analysis activities for the MAJORANA DEMONSTRATOR

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The UW MAJORANA group leads the simulations and analysis effort within the MAJORANA collaboration. Much of the low-level software for data I/O, event building, data processing, and simulation were written by CENPA personnel. Members of our group have played a central role in the building and validation of the background model for the MAJORANA DEMONSTRATOR, which informs the radiopurity criteria upon which the experimental design is evaluated. We also participate in the development and implementation of data analysis techniques, geometrical models for Monte Carlo simulations, and data handling, storage, and database technologies. Our efforts over the past year have focused on workflow management, improvements to data processiong and cleaning, the development and use of analysis tools for data from the MAJORANA DEMONSTRATOR Prototype Module, and preparation for data taking with enriched Ge detectors.

In her role as head of the Data Cleaning and Run Selection working group, Dr. Clara Cuesta has continued to oversee the implementation and evaluation of the Data Cleaning and Run Selection framework for MAJORANA. Her work in this regard is detailed in section ??.

Dr. Cuesta has also led the development of a pulse-shape based background suppression technique called A/E which analyzes the ratio of the max current in a pulse to the energy collected. Events that produce a single localized energy deposit – such as most $0\nu\beta\beta$decays – will have a smaller value of A/E than events that deposit energy in multiple locations inside the same detector. We have shown using ^{228}Th calibration data that we are able to reduce our backgrounds using this technique by more than 50% (see Fig. 2.2-1).

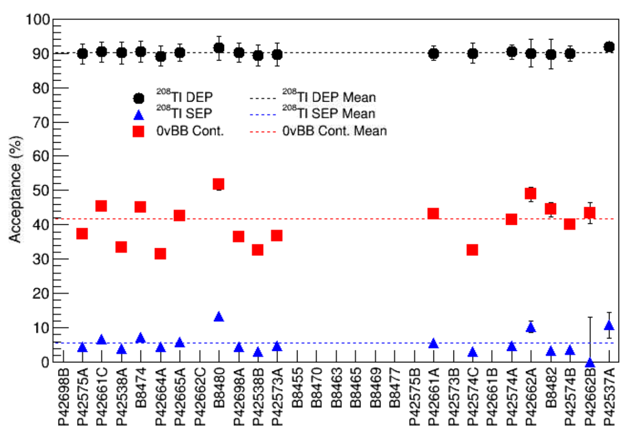

Figure 2.2-1. A/E acceptances for all detectors in Module 1. The black circles show the acceptance in the ^{208}Tl double-escape peak, which is dominated by single-site interactions. We tune the acceptance there to the expected fraction of $0\nu\beta\beta$events that are single-site, which is 90%. The technique is very successful at rejecting events in the ^{208}Tl single-escape peak (blue triangles), which is dominated by multi-site interactions. The effect of the cut on backgrounds in the ^{76}Ge $0\nu\beta\beta$-decay region-of-interest is given for each detector by the red squares.

Micah Buuck has primarily focused this year on two simulations- and analysis-related activities: a pulse-shape based technique for identifying multi-site backgrounds complementary to A/E, and upgrading the simulations software to produce results on the detector level.

The pulse-shape technique requires the generation of a "basis library" of single-site event pulses, which is then used to accept or reject incoming pulses based on a χ^2 fit. He has successfully implemented the software necessary to generate the basis, and has done so on selected sets of calibration data. He is now in the process of quantifying the acceptance of the technique for various kinds of pulse shapes, and tuning input parameters to achieve optimal distinction between single- and multi-site pulses.

Buuck has also modified and upgraded the MAJORANA simulations code to allow for the analysis of simulation results on a detector-level basis. Additionally, he worked to bring old code up-to-date that can determine which simulated interactions happened in the detector dead layers, and if an event is likely to be distinguishable as multi-site.

Julieta Gruszko has collaborated in the development and largely herself implemented a new technique to tag events that occur near the passivated surface of the MAJORANA detectors. These events, which could be due to degraded α-particles, create some electron-hole pairs in the passivated layer. The holes are collected relatively quickly at the point-contact, but the electrons drift slowly out of the passivated layer, causing a small amount of delayed charge to be collected after the primary rising edge. The technique compares the decay of waveforms after the rising edge, looking for that extra charge to appear as a different effective decay constant. Preliminary results are presented in ??

Our attention is now turning toward completing preparations for the first data to come from the full array of Ge detectors. We have recently begun a test of our data-blinding scheme, which will be used once we finish commissioning the system and begin normal data taking. New assay results have improved the predicted background rate in the 4-keV region of interest surrounding the 2039 keV Q-value for double-beta decay of ^{76}Ge to 3.1 counts/ton-year. Major simulation campaigns are underway to provide up-to-date predictions for the full spectrum we expect to see with enriched detector data. Fig. 2.2-**??** shows the full simulated spectrum, including the effect of analysis cuts. Other major activities include software quality assurance tests, database implementation of run information recording and automatic data workflow management, refinement of event building routines, optimization of energy estimation and pulse-shape parameter extraction algorithms, and data monitoring and cleaning routines.