TWIST: A High-Precision Study of Normal Muon Decay

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During the past year, TWIST, the TRIUMF Weak Interaction Symmetry Test, has been building and testing the magnet and detector system and developing the software needed for the muon decay study. Early in the year, the design of the wire chambers and their mounting cradle were finalized. Since then, work has proceeded on their construction at TRIUMF, University of Alberta, Texas A&M, Valparaiso, and elsewhere.

Nearly all the wire planes and cathode foils needed for the detector have now been completed and inspected. The tolerances that we have been able to maintain on wire plane construction are quite high. For example, the drift chamber wire positioning precision has been found to be ±2.6 :m from measurements of the actual locations of the each wire in every plane after they have been epoxied and soldered in place. The wire tension has been found to be uniform to ±0.6 gm. Meanwhile, TAMU personnel have carried the primary responsibility for the production of the cathode foils.

The wire planes and cathode foils are now being assembled into modules, each of which contains 1, 2 or 4 U wire planes, together with an equal number of V wire planes. After each module is assembled, it is tested to verify that it is leak tight. Then it is subjected to a series of electrical tests — including plateau studies to verify operation at standard high voltage levels, ^{55}Fe source scans to verify uniformity of the response, and cosmic ray measurements to verify tracking response. In particular, we have done detailed cosmic ray bench studies with two different configurations, one consisting of 3 independent U-V modules offset from each other by vertical spacers and the other consisting of 8 drift chamber planes, 4 U and 4 V, assembled into a single module we refer to as the "dense stack". These tests have been done using both Ar-C_4H_{10} and DME chamber gases. The latter yielded a spatial resolution of 63 :m rms during early studies with the dense stack, meeting our design criterion of better than 100 :m and approaching our target resolution of 50 :m. We anticipate that the resolution will improve further as we continue to improve our tracking and alignment software. It is important to note that these bench tests have also exercised all of our electronic modules - preamplifiers, postamplifier/ discriminators, FASTBUS TDC's — in systems with several hundred channels operating simultaneously without oscillation problems. At present, we are about to start installing somewhat more than half of the final wire chamber modules in the mounting cradle for an engineering run at TRIUMF this summer.

The mechanical drawings for the magnet yoke were sent out for bids last summer. The yoke was delivered to TRIUMF in December, 2000. Since then it has been assembled and aligned in M13. The solenoid has been surveyed into place inside it, and power and cryogenic leads have been installed. The magnet will be powered up in April.

Substantial effort has gone into software development over the past year. Several modifications and upgrades have been made to the Monte Carlo code in order to improve both its physics simulation abilities and its coupling to the analysis programs. Notably, we have investigated the physics assumptions underlying the simulation of energy loss and multiple scattering of low-energy particles passing through thin media in order to be certain that they are adequate for our needs. We've also performed a detailed study of the stopping distribution of the muon beam to minimize muon depolarization during the stopping process and to optimize the design of our gas beam degrader system (a short, isolated section of beam line that will contain a mixture of He and CO_2, with the relative composition adjusted to center the stopping distribution within the target).

Our group has continued to devote considerable effort to the development of the pattern recognition code to be used by the analysis programs. The final output from the pattern recognition codes is a set of candidate hit cells to form a helical track, together with a "first guess" for the parameters of that track. The hit list and first guess parameters will then be passed to a subsequent Kalman filter routine, which is being developed by collaborators from TRIUMF and Alberta, that will perform the detailed tracking, including resolving left-right ambiguities in the drift chamber hits. Considerable effort recently has gone into obtaining the best possible estimate for the number of turns that a particle (either an incident muon or a decay positron) makes along its helix within the wire chamber, because the Kalman filter code is rather inefficient when it is asked to make discrete changes in the track parameters. The pattern recognition codes now succeed in finding a large number of Monte Carlo generated events, though considerable work is still needed, especially to handle complex event topologies.

The current schedule calls for an in-beam engineering run with approximately half the final detector system this coming summer, to be followed by the first run with the full detector system late this year. Our goal is to obtain our first physics results, focusing on the Michel parameters Δ and ∗, during the fall run.