TWIST: measuring the space-time structure of muon decay

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This past year, TWIST completed the blind analysis of final data sets, which were recorded in 2006 and 2007. The results were revealed when the "black box" was opened on Jan. 29, 2010. We found $\rho = 0.74991 \pm 0.00009(\text{stat.}) \pm 0.00028(\text{syst.})$, $\delta = 0.75072 \pm 0.00016(\text{stat.}) \pm 0.00029(\text{syst.})$, and $P_\mu\xi = 1.00084 \pm 0.00035(\text{stat.}) +0.00165 -0.00063(\text{syst.})$. The ρ and δ results have a large, positive correlation (+0.69). The δ and $P_\mu\xi$ results have a significant, negative correlation (-0.43) when $P_\mu\xi$ is below the central value. All other parameter correlations are relatively small.

These results can be combined to find $P_\mu\xi\delta/\rho = 1.00192 +0.00167 -0.00066$. This was a surprise. $P_\mu\xi\delta/\rho$ represents the asymmetry at the endpoint, and thus must be ≤ 1. Since the unblinding, the collaboration has focused on trying to identify a possible source for this 2.9σ discrepancy. In nearly all cases, the new cross-checks have validated the original blind analysis results, but one issue has been identified. It appears that the energy calibration procedure did not compensate fully for differences in the mean muon stopping location between the data and Monte Carlo. It also appears that the 2006 data that were recorded with a Ag target are substantially more sensitive to this issue than the data that were recorded using an Al target. At present, it is not yet clear whether this issue is the cause of the $P_\mu\xi\delta/\rho$ discrepancy or not.

Prior to the unblinding, our group was responsible for the evaluation of the correlations among the various muon decay parameters. This task is complicated by the fact that both statistical and systematic effects contribute. We were also responsible for updating the final ρ and δ results from the 2004 data [1] to account for some small biases that had existed in the previous analysis and were revealed during the analysis of the 2006 and 2007 data. Since the unblinding, we have played a significant role in the cross-checking effort. Once the cross-checks are completed, we will perform a final global analysis of all muon decay parameter measurements in order to obtain the most precise, model-independent limits on the space-time structure of muon decay.

[1] R.P. MacDonald *et al*. (TWIST Collaboration), Phys. Rev. D **78**, 032010 (2008).