**Monte-Carlo integration** Bill’s idea: Dumber alternative approach of estimating the parameters of the two multivariate normal distributions and then simply random sampling from them (e.g., using Matlab's mvnrnd) and computing log likelihood ratios.  From large numbers of such samples (which should be fast to obtain) one could compute histograms of the log likelihood ratios for the two categories. These two histograms could be fitted to estimate the 1D probability density functions for the likelihood ratios.  They could then be integrated using a single scalar criterion (LLR=0) to determine the accuracy (hits and correct rejections). A weakness in this is specifying the family of 1D distributions to fit.  However, I poked around on the web and it seems these log likelihood ratios should have a "generalized chi-squared distribution" that is determined by the means and covariance matrices of the underlying multivariate normals.  It is a messy distribution, but there appear to be some algorithms (software) for computing the 1D integrals.  Not sure how robust, fast or general these numerical integrations are.  But if possible, you can simply write down the generalized chi-squared distribution of the LLR of two gaussians with given parameters, and numerically integrate it in 1D. Then it would not require sampling from the multivariate distributions.  (See wikipedia page on generalized chi-squared distribution.)