Utilizing the Open Science Grid to Improve the DØ Measurement of the $W \rightarrow e\nu$ Charge Asymmetry Near the Calorimeter Gap

Julie Torborg

Abstract

The DØCollaboration at Fermilab is scheduled to present a first result of the asymmetry measured in the electron decay channel in spring of 2006. I have been the primary investigator to this analysis, which utilizes only 300 pb^{-1} of the approximately 1 fb^{-1} the collaboration has stored to tape. Updating the analysis to include the additional data will require studies of software and detector performance.

In this paper, I propose a plan to continue my analysis of the charge asymmetry as a professor at Hamline University. Emphasis is placed on maintenance and study of the Inter-Cryostat Detector (ICD) to improve the measurement, and connecting to the Open Science Grid (OSG) for data processing. Throughout this proposal, I place special emphasis on how the undergraduate student can assist in this research.

I finish with an estimate of budget requirements and a look past DØ to possible future research in experimental high energy physics.

My current responsibilities as a Post-doctoral Fellow on the DØ experiment are, as may be guessed from the preceding abstract, study of the $W \rightarrow e\nu$charge asymmetry and study and maintenence of the ICD. These are not unrelated tasks, as the ICD is designed to detect EM objects.

The DØ detector is built concentrically around the beampipe, (Figure 1) trending from fine to coarse position resolution. The liquid argon calorimeter that encloses the central tracking system is broken into three parts, each within its own cryostat. The ICD is mounted between the central and end cryostats to provide coverage in the gap. Because it is a "stopgap" detector, interest in the ICD's maintenance and improvement has been slim. Because the group is so small, any assistance in these tasks will be welcomed. Two distinct opportunities appropriate for an undergraduate researcher (or sequence of undergraduate researchers, for the life of the experiment) working 1-5 hours/week are analyzing calibration data and collision data.

Special data-taking runs exercise the ICD during beam downtimes by injecting signal directly into the readout system (light into photomultipliers, charge into amplifiers). ADC counts are plotted and compared to historic norms. Deviations are reported to the writers of the experiment's reconstruction software so that they can be accounted for.

Separately, a student may look at physics objects (electrons, photons) taken during colliding. One simple study is to reconstruct the mass peak for Z bosons that decay to electrons separately for events where one of the electrons is in the ICD and events where both electrons are well within the calorimeter.

Proper characterization of the ICD is necessary to the $W \rightarrow e\nu$charge asymmetry both because it contributes electron coverage and missing energy (MET) resolution. The $W \rightarrow e\nu$asymmetry is the result of a relativistic boost and thus measured in bins of the Lorentz-invariant coordinate "rapidity". Take away the ICD, and some rapidity bins are uninstrumented, and there are statistical holes in the analysis.

While this affects some subset of the data, the effect of the ICD on MET resolution is apparent in every event. Since neutrinos interact only weakly, they pass through the detector without depositing any energy. The only signal they leave is the absence of the energy that they took with them. To extract this signal, the energy in the transverse plane is vector summed. The vector needed to make this sum equal zero is the "missing energy" in the event, and assumed to be a neutrino. Gaps in the hermeticity of the detector skew both the value and position of this vector. Imagine a $Z \rightarrow ee$ event where one of the electrons escapes through an uninstrumented part of the detector. The electron is identified as a neutrino, and now instead of an "ee" signal, an "$e\nu$" is seen an the originating particle is classified as a W.

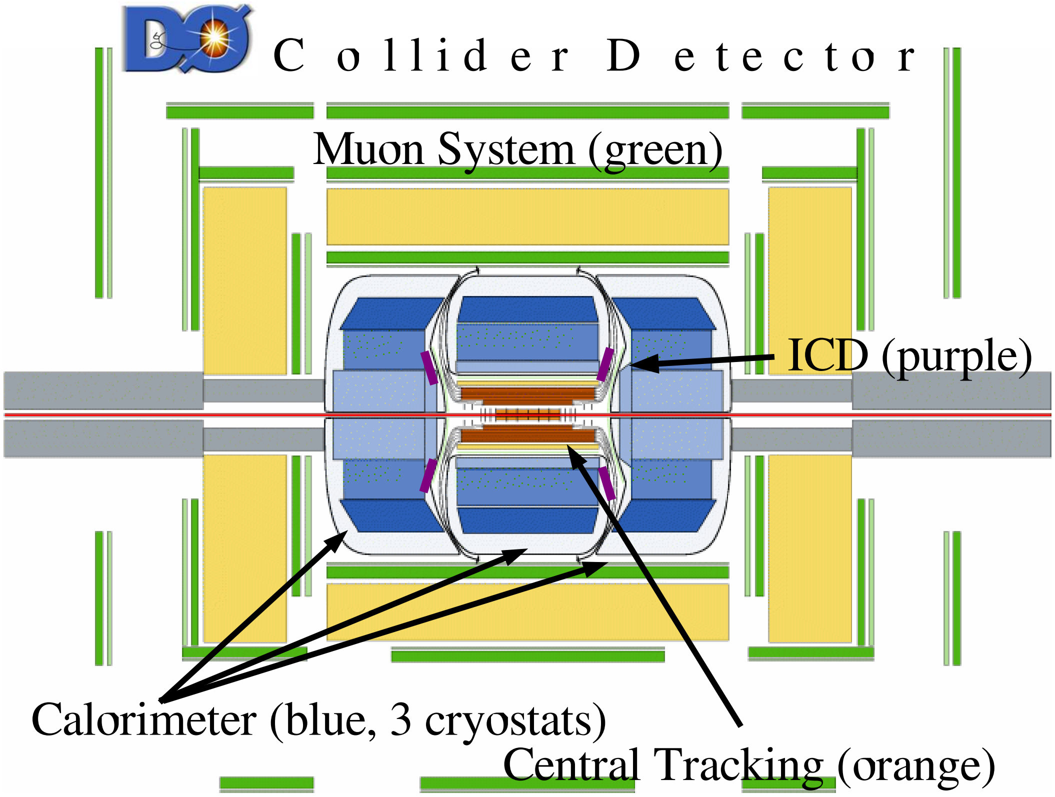

Figure 1: Longitudinal cross section of the DØ Collider Detector. The ICD is indicated in purple. In the transverse plane, the ICD is a ring.

The analysis of this and other $W \rightarrow e\nu$backgrounds is another opening for student involvement. $Z \rightarrow ee$ and $W \rightarrow \tau\nu$ are both small backgrounds that need to be accounted for by either a correction factor or systematic error. These studies are well within the scope of an undergraduate research project.

Moving to include the entire 1 fb^{-1} of data will provide challenges of its own. Currently my 130 million pre-selected W-like events take about 4 hours to process when divided among 40 2 GHz dual-processor CPUs. I don't expect Hamline to have this kind of processing power in the near future, much less 3 times this much processing power. Luckily, this summer the Open Science Grid opened for business.

Similar in concept to "SETI at Home," the purpose of the OSG is to utilize dormant CPU cycles. Still in its infancy, the OSG already links over 15,000 CPUs whose resources are sourced out in batch requests. In return for access to these vast computing resources, users provide additional computing or software development.

I can imagine an undergraduate making a research project out of connecting a Hamline subcluster to the grid. Another grid project that requires attention is being able to access and analyze DØ data from the grid.

The current data management paradigm at DØ is SAM. Physical storage of the DØ data is on magnetic tapes, with robots to mount and dismount requested tapes to the tape drives for data retrieval. The SAM data access software has traditionally been run on dedicated UNIX clusters or desktop Linux clusters local to the experiment. Users interface to this software to perform analysis.

Some traditional SAM operations have been moved to the OSG through the SAMGrid project. There are SAM servers on the OSG that can access the SAM tape drives, but the interface to perform analysis is still in the testing stages. The level of technical expertise required for actual development of the interface is probably beyond that of an undergraduate. However, a student could develop a project around beta testing such software when it does become available.

Connecting to the OSG also serves as an investment in the next generation of high energy experiments. The Main Injector Neutrino Oscillation Search (MINOS) experiment is planning to use the OSG to analyze its data. The experiment began taking data in spring of 2005 and is expected to run some 5 years. I am encouraged by Hamline's proximity to the detector (which is in Soudan, MN, near Duluth) and the major collaborators (University of Minnesota, Twin Cities and Duluth) to consider joining the project as the DØ experiment draws to an end over the next 2-3 years.

Alternatively, the University of Minnesota Twin Cities group is involved in CMS, one of the two large experiments on the Large Hadron Collider (LHC) at CERN. Analysis of any number of particle physics topics could be pursued through a collaboration with their group, but all of them will require access to the OSG, since CMS data will be available exclusively on the Grid.

The beautiful thing about large high energy physics experiments is that researchers can provide services according to their resources. I expect that as a new teacher at Hamline, my most important resource would be time, and I would have precious little of it to dedicate to research beyond getting students involved. I would expect that over the next few years, I would become more comfortable in my role as teacher and be well on my way to being a publishing researcher.