The CDF and D0 detectors as laboratories for students

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The idea is to allow students to use the existing CDF and D0 detectors to collect cosmic ray data. We discuss the educational benefits to students (and Fermilab), and some complications and difficulties of this idea, but we do not discuss costs or logistical problems.

1 Educational aspects

Fermilab is a special place, a fact more obvious to those who bring students to Fermilab. One only needs to watch their faces. This psychological aspect, combined with the use of an actual detector to collect events, could be a powerful part of Fermilab's mission to enhance and promote scientific education over a broad range of ages and capabilities and, hopefully, over more than the Chicago-land area.

1.1 Data possibilities

The potential data set is huge due to the size of these detectors: predominantly cosmic ray muons, a percent or so of electrons and protons, and some muon rate at the horizontal. One scientific goal would be to search for up-going muons. There would be 'zoons', events with no apparent explanation.

The D0 and CDF detectors are complicated, and their respective software structures would not be accessible to these students. In spite of that, keeping the existing detectors unchanged and keeping the existing software would probably be the best and (for Fermilab staff) the easiest route to take. The CPU farms would 'age', but that wouldn't matter: even with failing CPUs there would be sufficient computing resources to manage the basic data reductions.

1.2 Physics problems

The most obvious are the angular and energy distributions of muons. This enterprise could result in the best such measurements in existence. The nuclear interaction rate, $\mu^{\pm}U$ in D0 and $\mu^{\pm}Fe$ in CDF, could be measured by counting. The muon rate could be used to measure the density of the atmosphere, changing hourly with temperature and annually with the seasons. Up-going muons would be a serious and most pleasant observation, opening a window for neutrino physics. The non-muon content of the stuff coming down might be interesting, too.

2 Who would be interested?

Clearly, university students studying physics would find that analyzing actual data is interesting. One could think of a 3 credit lab course something like the credits given to students at accelerator schools. After some 'shift taking', the students would return to their universities for analysis with full use of the web for communications with other students.

We think that even high school students would like this, but the logistics would probably require Fermilab residency (in the Village dorms) for a week or two, parental permissions, accompaniment by a teacher, etc. It might be best to mix high school students with university students as 'experienced mentors'.

The Chicago area would be easy to access, but something this good must be made available to the nation. It is not yet clear how students from far away could easily access this program, except perhaps as a special event in the summer.

The program should not be Fermilab's recruitment for the next generation of high energy physicists. In fact, detectors used in hospitals and oil exploration wells, for example, could also be discussed as uses for these same instruments.

2.1 Would students be lost?

Some would not get it. Some would love it. The atmosphere should be cooperative among the students as they gather data and decide what to do with it, and competitive with respect to the other detector. An essential aspect would be conversations with experienced D0 and CDF physicists over lunch, in the evenings, etc., just like now. It's how we learned.

Most of the scientific enterprise as we know it would be felt by these students. There would be groups of 2-3 working on particular problems, the CDF and D0 groups would compete for results, there would be notes written with attributions and acknowledgements, and there would be the first exercising of the scientific method and data-integrity checking by these students. There would also be failures in problem solving, analysis, and in the interactions of students with others.

It might be a good idea to allow physical access to the detector insides so that students could actually interact with and touch the parts of the detector that appear in the computer-reconstructions. (This would be more education than some PhDs have had.)

3 Summary

It is well known that young people adapt to new environments and learn by doing, and injecting students directly into a real detector at a real lab, with real people to talk to about the data and the problems that arise, will have a galvanizing effect on many students. In conversation with Fermilab physicists, these students would easily be directed to the fundamentals of particles and their interactions: ionization energy loss, multiple scattering, the concept of a cross section, statistical fluctuations, and aspects of the technologies in the respective detectors of CDF and D0.