Research and Education:

A Proposal by Aaron Dominguez for the University of Nebraska, Lincoln

As I explained in my "Statement of Research and Professional Interest," my research in high energy physics has centered around an experimental understanding of one of the most outstanding questions in the field: the Higgs mechanism. I will continue to exploit the window of opportunity available at the Tevatron to explore the Higgs sector of the standard model and minimal supersymmetric standard model, first by completing the publication of recent results of these searches at CDF, and then by joining the D0 experiment to continue these efforts over the next couple of years. The LHC should give us vast possibilities to discover new physics, including a very thorough search for the Higgs boson. I would like to join CMS immediately, and to transition my efforts over the next three years from the Tevatron to the LHC full time. Lastly, I would like to build upon my experience with educational outreach in the communities around the University, and to add leadership and organizational support as the CROP program grows throughout Nebraska in the next few years. I will briefly discuss the motivation for such endeavors, and a rough timeline and outline of resources necessary for success.

Verification of the Higgs mechanism as the origin of the particle masses begins with the observation the scalar particles predicted by the model. The standard model requires one physical scalar boson, and the minimal supersymmetric standard model (MSSM) requires five physical scalars, with one having properties much like the standard model's. Because of large backgrounds and small signal cross sections, discovery of the standard model Higgs boson at the Tevatron during RunII will be challenging, whereas the large amount of data offered by the upcoming CMS experiment should make discovery possible over a wide range of Higgs masses. However, there is a window of Higgs masses between the current experimental limits from the

LEP experiments of 115 GeV and $\sim$120 GeV where D0 and CDF can either extend this lower limit or observe a $\sim 3\sigma$ excess of events after collecting about 3-4 fb^{-1} of data. In this relatively light Higgs mass region, the scalar particle would decay predominantly into b-quarks and would be at least as challenging to observe at the LHC. The Tevatron would thus be able to close an experimental window in the Higgs search with the next three years of data. Discovery of the standard model Higgs at the LHC beyond about 120 GeV should be easier.

The MSSM presents us with a more complex Higgs sector which can only be completely explored at future experiments such as CMS and beyond. However, in contrast to the standard model, unexcluded regions of parameter space in the MSSM predict production cross sections large enough for a 5σ discovery over a broad range of Higgs masses. Such discoveries should be possible at CDF and D0 in the next three years of data taking.

This sets the stage for my research at the Tevatron for the next two to three years, and my transition to CMS. I would first finish the publication of the result of CDF's search for the MSSM Higgs boson over the next several months. By the end of 2004, I would expect to be fully involved with D0 and ending my contributions to CDF. For the following one to two years, I would help lead D0's search for the Higgs boson in both the standard model and its extensions. Studies of the experimental issues of searches for evidence of supersymmetry and the Higgs boson at the LHC would begin immediately as a part time effort. Over the next two to three years, I would foresee a more or less gradual transition of my research time from D0 to CMS.

There are several key resources which would be necessary to successfully carry out such a research plan in the next two years, before I would be receiving support from external funding agencies. The first, and most important resource is graduate students and postdoctoral researchers. I see the need for at least three graduate students and at least one postdoc. There are a broad range of topics related to searches for new physics and the Higgs boson at D0 which would make it quite natural to have a unified group of students and one or two postdocs carrying out original research and studies needed for individual theses and publications. The students could also devote the first part of their research activities to physics studies and UNL's responsibilities, such as the luminosity measurement, for the CMS experiment. After the two year mark, it would be more natural for beginning students and postdocs to

remain on CMS activities full time, with the expected start of data taking in 2007.

There are three other classes of resources needed for this research program: computing, my summer salary, and travel. Computing is a resource that could be naturally shared among the three high energy experimentalists and with the physics department as a whole, but is essential for the analysis of the large and complex datasets from D0 and for computer-intensive physics studies for CMS. A reasonable system for a group our size would be a 20-30 node rack mounted system, including an external disk array of a few terabytes. Currently, a 20 node system of dual CPU 3 GHz processors, which includes the necessary gigabit network backbone and local disks for caching the data during processing, can be purchased for about $45k. The external disk array of 4TB, including a controller node, costs about $10k. Such a system could be administered quite easily part time by an undergraduate or graduate student. A budget for travel would include yearly conferences, monthly trips to Fermilab for myself, and possibly one or two students during the summers before they finish their classes. Travel to CERN would be less frequent during the first two years of my time at UNL, probably every other month. With trips to Fermilab costing about $500 and trips to CERN about $1000 during the winter and $1500 during the summer, this would amount to about $25-30k for two years. In addition, I would need funds to pay for my summer salary for these first two years.

Finally, educational outreach will play a large role in my life at the University of Nebraska. I see two main areas of interest over the next few years: 1) establishing a version of the BEST program in Lincoln, then implementing a mentorship program at UNL for under-represented undergraduate and high school students; and 2) growing the already successful CROP program. BEST tutoring is an after school homework program that pairs up Latino and other under-represented high school students with elementary school students of similar backgrounds. In a similar vein, I would like to begin a mentorship program at UNL that pairs upper-level undergrad, and possibly grad students, with local high school students and younger undergrads from under-represented sectors of today's America. My experience with founding the BEST program in Illinois is that it takes about a year of one-on-one contact with local leaders, educators, and politicians to understand the needs of the community and to form a lasting coalition. I would supply the impetus

and direction for these programs, but would need funds to pay a stipend to someone to be the liaison between the university and the community and take care of some of the day-to-day operations in the early stages of development. After this initial period of about a year, funding should come from separate proposals to the university, funding agencies and grass roots charities.

The CROP program is set to grow to a new level involving about one hundred high schools throughout Nebraska. I would like to contribute to this effort with leadership, organization, and some technical expertise. A program of this size will require a new organizational structure, and I would contribute to the grant writing, and implementation of such changes. I would also make myself available to organize and run some of the training sessions and summer workshops for the teachers and students in Lincoln, and at other regional sites in Nebraska. Finally, with the help of an undergrad or grad student, I would like to implement a framework that allows for easy network access and analysis of data from all the various high school sites.

In conclusion, the next several years will be an exciting time in high energy physics, and I very much look forward to working with the University and my colleagues on these research and educational programs.