HEP Research Statement

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In this statement, I'll focus on my research experience and plans as they relate to high energy physics. I'll discuss my accelerator physics background and plans for Crocker Nuclear Lab in a separate document.

As you can see from my CV, I've been fortunate enough to have had a rather varied career in high energy physics. For my thesis research, I worked on direct photon production at Fermilab. This is a process in which a photon is ejected from a hadronic interaction instead of a gluon, providing a cleaner measure of proton structure than jet studies. After graduate school, I was awarded a CERN Fellowship, during which I worked on the Opal Experiment at CERN, where I studied quark-antiquark asymmetries. From CERN, I went to Princeton University, initially to work on the GEM experiment at the LHC. After the cancelation of the SSC, I worked on the Belle Experiment at KEK, studying CP-violation in the B-meson system, as well as small experiment at SLAC (E-144), which studied high-field QED phenomena in laser-electron interactions.

When I came to Fermilab, I initially worked on the MiniBooNE short baseline neutrino experiment, and remained involved with the analysis through the first oscillation results. Since roughly 2006, I have been focusing entirely on the Mu2e Experiment [1], and this is the project I would like very much to bring to UC Davis.

The Mu2e experiment is designed to search for the conversion to an electron of a muon which has been captured by an atomic nucleus – a process which would violate lepton flavor number. This can in fact occur in the Standard Model through virtual neutrino mixing, but the rate is many orders of magnitude below what we could conceive of observing in an experiment in the foreseeable future.

On the other hand, most proposed theories beyond the Standard Model predict this process will occur at a much higher rate, and indeed the fact that it hasn't been observed yet has already placed constraints on such theories. The Mu2e experiment has a planned sensitivity that is four orders of magnitude better than the previous best experiment, which is unusually large improvement in a single experiment. This gives it a virtual mass reach of several thousand TeV in some channels, making it very complementary to research at the LHC. Again, any signal would be unambiguous evidence of new physics, so it's not overstating things to say that this is perhaps the most important single measurement currently being proposed.

The Mu2e experiment is a key part of Fermilab's near term plans and has recently received its final "CD-3" from the DOE, meaning construction is in full swing. Data taking is scheduled to take place in 2022, so we'll soon be at the point to take graduate students.

The Mu2e Experiment is very similar to the MECO experiment, which was proposed at Brookhaven. When MECO was cancelled, I was part of the team that proposed to mount the experiment at Fermilab,

and Professor Jim Miller of Boston University and I were the initial spokespersons[1]. This was a complicated time in terms of planning at Fermilab, with the ILC still being a high priority at the beginning of our proposal, and this was followed by a struggle for the lab to find direction. I think Jim and I deserve at least some of the credit for positioning Mu2e to become the centerpiece of the lab's near term plans, as endorsed by the Particle Physics Project Prioritization Panel (P5) under all funding scenarios. This was accomplished primarily by focusing on the physics goals of the experiment, rather than the political exigencies of the time.

My main contributions to the experiment have involved beam delivery. The experiment requires short bunches of 8 GeV proton beam, separated by about 1.5 μsec, with nothing between them at less than a 10^{-10} fractional level. It was not possible to generate such a beam in the Tevatron era, but Milorad Popovic, Chuck Ankenbrandt, and I proposed a scheme to use components of the antiproton system, which became available when the Tevatron shut down, and this became the basis of the Fermilab proposal [2].

Since then, I've focused on achieving that 10^{-10} level of "extinction", and monitoring that we have succeeded in doing so. We quickly realized that the system designed for MECO would not have worked, so I designed a system of resonant dipoles and collimators, such that only in time beam is transmitted. This required a detailed theoretical treatment of the beam line, integration into the design, and high statistics simulation. The project passed a technical review in the fall, and will soon begin construction. I am currently writing a paper on the project which will be submitted to PR-STAB soon [3].

My plan for UC Davis would be to start a Mu2 group as part of the ongoing HEP effort. I hope to engage other faculty members at the fractional FTE level. I'm particularly interested working together with the CMS people to explore the complementarity between Mu2e signals or limits and searches at the LHC in the High Luminosity era. I also plan to apply to the DOE for funds to hire a postdoc for the effort.

The extinction effort is already fully funded through the project. Once construction begins, my major responsibilities will be budget and schedule oversight. My position within the experiment is well established, so no further "buy in" would be required; however, there are plenty of opportunities to exploit the expertise at UC Davis. In particular, I'm very excited about numerous instrumentation projects which would benefit from the impressive instrumentation capabilities of the department. In addition to helping with primary physics goals of the experiment, these would facilitate interesting ancillary measurements, including numerous additional thesis topics.

I have discussed these matters with the Mu2e spokespeople and project management, and all are extremely excited about the possibility of getting UC Davis involved in the project.

[1] We used the term "Contact persons" prior to the first formal elections. By that time, I had taken over as head of the US LHC Accelerator Research Program (USLARP), so I did not stand for the spokesman.

References

[1] Mu2e Collaboration (L. Bartoszek *et al*), "Mu2e Technical Design Report", https://arxiv.org/abs/1501.05241 (2015)

[2] The details have changed over time, to save money, to be more synergistic with the g-2 experiment, and to remain compatible with the NOvA neutrino experiment. For the most recent version, see E. Prebys et al, "Modified Running Scenarios for the g-2 and Mu2e Experiments", FNAL-BEAMS-DOC 4854 (2015), http://beamdocs.fnal.gov/AD-public/DocDB/ShowDocument?docid=4854

[3] In the mean time, see, e.g., E. Prebys and S. Werkema, "Out-of-time Beam Extintion in the Mu2e Experiment", THPF121, Proceedings of the 6th International Particle Conference (2015), http://accelconf.web.cern.ch/AccelConf/IPAC2015/papers/thpf121.pdf