

Research Statement

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My research interests lie in the frontier of fundamental physics. High Energy Physics(HEP) offers some of the most interesting experimental opportunities to expand our knowledge of fundamental physics and discover new physics phenomena. I am primarily interested in studying the predictions of theories that pose solutions to the fundamental questions not answered by the Standard Model of particle physics. These questions include, but are not limited to: how to unify gravity with the other fundamental forces, baryogenesis and the prevalence of matter over antimatter in the universe, understanding the values of the large number of parameters in the Standard Model and an explanation for dark matter. An example of a theory that poses answers to some of these questions is the minimal Supergravity Unification Model(mSUGRA). mSUGRA offers a solution which unifies the ideas of Supersymmetry(SUSY) and gravity. Also in the mSUGRA variant of SUSY a small subset of the model's parameters describes a large part of the behavior of the model which gives the theory considerable predictive power. These predictions can be tested by collider physics experiments, which can either constrain the possible parameter space of the model or discover new physics predicted by the model.

I am currently working on a search for the decay $B_s \rightarrow \mu^+ \mu^-$. The probability for this decay occurring by Standard Model processes is extremely small. This decay indirectly probes for new physics since the branching ratio could be considerably larger in SUSY models such as mSUGRA. More recently, the prospect of observing $B_s \rightarrow \mu^+ \mu^-$ has received additional attention because part of the mSUGRA parameter space which predicts large enhancements in the branching ratio of $B_s \rightarrow \mu^+ \mu^-$ overlaps with that which predicts deviations in $(g-2)_\mu$ roughly consistent with recent experimental determinations. This decay mode is considered one of the most likely avenues for discovering new physics at the Tevatron. Currently we have published a limit on this branching ratio which is more than a factor of three better than previously published limits. In addition, we have submitted an updated analysis for publication which improves the limit by another factor of three. This limit provides constraints in models such as mSUGRA and significantly reduces the allowed parameter space of R-parity violating and S0(10) SUSY models.

With the data sample collected over the next few years of operation at the Tevatron and at the LHC, direct searches for new phenomena become more interesting. At the Tevatron the production of combinations of neutralinos and charginos from valance quark annihilation will be interesting. These particles have decay modes involving multiple leptons that offer a distinct signal. Direct searches for SUSY particles and indirect constraints such as those gained from $B_s \rightarrow \mu^+ \mu^-$ can complement each other. Whereas $B_s \rightarrow \mu^+ \mu^-$ is enhanced at large $\tan \beta$, direct production of new phenomena, such as chargino neutralino pairs decaying into three leptons plus missing energy, is enhanced if $\tan \beta$ is small. Together, searches such as these probe and constrain large regions of SUSY parameter space.

I am also interested in pursuing searches for other new physics decays involving high transverse momentum leptons. Lepton signatures are an excellent way to search for new physics at CDF and at the LHC. Possible new physics signatures involving leptons can come from sources as diverse as SUSY gauginos, Higgs, and excited bosons such as W and Z primes. These types of signatures will probably be the first to be understood during the early running period of the LHC making them a likely discovery channel. To improve the prospects for these types of analysis I am initiating a project to improve the performance of the forward track finding using the CDF silicon micro-vertex detector. Finding tracks in this region of the detector with high efficiency will allow the identification of forward leptons and significantly enhance the sensitivity of lepton based searches for new physics. Tracking using a silicon micro-vertex detector will also be the primacy method of finding tracks and leptons in the CMS detector and the ideas developed and tested at CDF will be applicable to at that experiment as well.

SUSY models such as mSUGRA offer a possible solution to some of the fundamental questions of particle physics that are not answered by the otherwise successful Standard Model. The results of direct and indirect searches inspired by these models will either reveal new physics or lead us to the development of new models and experimental ideas for exploring these fundamental questions. I intend to pursue a research program that combines these two methods of searching for new physics and I look forward to continuing to collaborate with other High Energy physicists in building and analyzing the results of current and future experiments.

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