"Calculations of Fundamental Processes at Hadron Colliders involving Joint Students, Postdocs, and Visitors"

Edmond L. Berger (berger@anl.gov), High Energy Physics (HEP) Division, Argonne; and
Jonathan L. Rosner (rosner@hep.uchicago.edu), Enrico Fermi Institute, University of Chicago

Progress to Date. During this first year of the effort, project funds supported a very productive collaborative visit by Professor Jianwei Qiu of Iowa State University. Professor Qiu arrived in March 2007 for a six month sabbatical appointment. He has submitted 2 research papers for publication based on research done since his arrival in March. These are:

1. "Factorization is violated in production of high-transverse-momentum particles in hadron-hadron collisions", May 2007. Archives reference arXiv:0705.2141.
2. "Single Transverse-Spin Asymmetry in Hadronic Dijet Production", June 2007. Archives reference arXiv:0706.1196.
3. "Angular distribution of leptons from the decay of massive vector bosons", July 2007 Edmond L. Berger (ANL), Jian-Wei Qiu (Iowa State/ANL), Ricardo A. Rodriguez-Pedraza (Iowa State) particle physics archives as arXiv:0707.3150

Very considerable further progress has been made by Berger and Qiu during this visit, with the expectation of a publication to be released before the end of this summer, on a calculation of the transverse momentum dependence of each component of the full angular distribution of the decay products of the spin-1 intermediate W and Z bosons produced in hadron collisions. This result is necessary in order to improve the determination of the mass of the W boson produced in hadron collisions at the Fermilab Tevatron and at the LHC, an improved determination that will, in turn, lead to better precision in the prediction of the mass of the Higgs boson. Until now, calculations of the transverse momentum distribution of the W and Z bosons have dealt only with the distribution averaged over the expected angular distribution in the decay of the W and Z bosons. However, normal experimental limitations on angular acceptance inevitably bias the angular coverage, and a more differential calculation has been desirable for a long time. The uncertainty in the transverse momentum distribution of the W boson is now the single most important source of systematic uncertainty in the mass determination.

A reliable calculation of the transverse momentum distribution requires that the leading effects of soft gluon radiation be summed to all orders in coupling strength of perturbative quantum chromodynamics. There are techniques for handling this problem for the spin-averaged situation. For spin-dependence, it is

necessary to develop a new method for all-orders resummation applicable for the several spin-flip components of the angular distribution, components that are suppressed by one or more powers of the typical momentum scale. This is the technical challenge that Berger and Qiu have been addressing. Their results will lead to a publication before the end of Qiu's visit in August and most likely to an ongoing collaboration and series of papers during the coming year.

These results will have immediate impact on the analyses of data from the Fermilab Tevatron, RHIC (Relativistic Heavy Ion Collider) at Brookhaven, and the LHC.