Research Interests and Plans

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I have been a member of the DØ collaboration at Fermilab since 1989 and of the ATLAS collaboration at CERN since 2007. I have also been deeply involved in detector R&D, simulation and algorithm development for the International Linear Collider (ILC) since 2001. Physicswise, my main interest is in searches for new phenomena in production and decays of the top quark. In the area of instrumentation, my primary focus is on calorimetry and detector simulation.

Top Quark Physics

The large mass of the top quark makes it an important testing ground for the Standard Model (SM). It is expected to decay, before hadronization, to a W boson and a b quark, giving us the unique opportunity to study the properties of a bare quark free from the long-distance effects of QCD, such as color-confinement. The W-t-b coupling can be studied at the Tevatron through measurements of the single top production cross section, $t \to Wb$ branching fraction, polarization of W in top decay, and spin correlation between pair-produced top quarks. The top quark is also very important to searches for physics beyond the SM. While it is generally accepted that any non-SM particle is heavier than all other fermions within the SM, phase space is still open for several non-SM decays of top quark resulting in on-shell production of yet-unobserved particles. It is also possible that a particle as massive as the top quark plays a special role in generation of mass through gauge interactions (e.g. in technicolor-inspired models). I have been involved in studies of the top quark for a long time. I served as a convenor of the top physics group at DØ in Run 1 for 3 years and co-authored an article for the 2003 issue of *Annual Review of Nuclear and Particle Physics* on the present and future of top quark physics at hadron colliders.

Careful studies of the top quark at the Tevatron and the LHC is most likely to lead us to fascinating revelations of the working of Nature. I am particularly interested in searching for a charged Higgs boson either in the production or the decay of top quarks. The fundamental scalar sector of the SM consists of a single physical Higgs boson, which is electrically neutral. Therefore, observation of a fundamental charged scalar will immediately signal new physics. Because the charged Higgs couplings to fermions is proportional to the latter's mass, fermions of the third generation, especially the t quark and the τ lepton, play a special role in such searches. I have been active in top physics and τ identification at the Tevatron for more than a decade and have continued in that vein at the LHC. Presently I am working with one student on DØ on the measurement of top pair production cross section in the τ+jets final state and with two on ATLAS to understand the SM processes contributing to the lepton+jets final states in both single- and pair-produced top quarks. The study at DØ will subsequently be extended for a direct search for $t \to H^+b$, while at ATLAS we intend to carry out a global fit between data and SM predictions and interpret the result in the context of new physics scenarios.

Beyond the LHC, much more can be learned about the top quark at an e^+e^-

collider, e.g. ILC or CLIC, where top quarks will be produced via electroweak interactions. Fine controls over collision energy and beam polarization, together with high-precision detectors operating in a very-low-background environment, will allow us to make several crucial precision measurements of top-quark properties that are not possible at hadron colliders.

Calorimetry

In the new millenium, a worldwide consensus has emerged that the High Energy Particle Collider facility to follow the LHC must be an e^+e^- collider with a center-of-mass energy reach around 1 TeV or more. A high-energy, high-luminosity lepton collider is essential for precision studies of many processes within the SM as well as some beyond it that may be discovered at the LHC. To fully exploit the physics potential of the such a machine, detectors must employ novel technologies and algorithms that yield unprecedented resolution in position and energy-momenta measurements of particles and jets. from 2001 to 2007, I was deeply involved in ILC calorimetry, which was challenged to achieve a di-jet mass resolution of 3% without any external constraint. The most promising means to achieve such an ambitious goal is the so-called "particle-flow" algorithms (PFA), which require fine 3-d granularity in the calorimeter for the energy clusters initiated by neutral particles to be separated from those initiated by charged ones, so the latter can be substituted by more precise track momentum measurements. Although the DØ and ATLAS calorimeters are not optimized for PFA's, the proposition of using track information to improve jet energy measurements is a promising one. A part of the ATLAS team at NIU, which I lead, is engaged in online and offline data quality monitoring for the ATLAS tile calorimeter. We believe that a good understanding of the calorimeter data at the cell level is essential in minimizing jet-related systematic uncertainties, which will soon become the dominant component of the total uncertainty in many a physics measurement at the LHC.

Detector simulation

The rest of the NIU ATLAS team is participating in detector simulation. This too has its roots in our prior involvement in this area for the ILC, where we developed programs and tools for simulating the energy deposition (using GEANT4) and its transformation to persistent data (a.k.a. "digitization"). Proper accounting of pile-up, noise, and non-linearities in transfer functions are crucial for estimating the detector performance. My colleagues and I are contributing to digitization modeling for the tile calorimeter as well as core simulation support (GEANT4 and validation of digitization for the entire detector) with the goal of making ATLAS simulation as accurate and precise as possible.

We are also involved in simulation of and pattern recognition for the pixel disk detectors for the ATLAS upgrade, which is still in the conceptual design phase. Participation in tile calorimeter upgrade, contingent upon an anticipated growth of the group, is being mooted.