Project name

Study of Energy-Flow Algorithms for Linear Collider Calorimetry

Classification (accelerator/detector:subsystem)

Calorimeter: Hadron Calorimeter

Institution(s) and personnel

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Project Overview

Many of the most important measurements to be made at the Linear Collider are ultimately limited by jet energy resolution. A prime example of the required capability is the need to separate W and Z bosons that decay hadronically. The physics program pushes us to achieve a jet resolution of $\sigma(E)/E \approx 30\%/\sqrt{E}$. Given that a very good existing calorimeter, such as in the DØ detector, has a jet energy resolution of only $\sim 80\%/\sqrt{E}$, it will be a challenge to achieve the desired performance. It is clear that new techniques and technologies are called for. We propose to study the jet reconstruction technique based on the most promising of the new ideas for calorimetry: the Energy-Flow algorithm.

Description of first year project activities

In an Energy-Flow calorimeter, the jet energy is determined by combining several individual measurements: charged particle energies are measured by the tracker, electromagnetic energy is measured in the EM calorimeter, and neutral hadronic energy is measured in the hadron calorimeter. This technique requires an excellent tracker and highly segmented calorimetry. The calorimeter must have fine segmentation in both the transverse and longitudinal dimensions to accurately characterize the shower shape. The necessary granularity results in very high channel counts, of order several million cells, which will prove to be a major cost driver.

We will perform Monte Carlo simulations of the Energy-Flow jet energy reconstruction algorithm. Our initial goal will be to demonstrate the specified jet energy resolution. We will then proceed to studies of an optimized design where the available “knobs” include transverse and longitudinal segmentation, absorber material, and digital vs. analog readout. The performance of the optimized design will be balanced against the estimated total cost and practicality of construction. We plan to use the $WW\nu\nu$, $ZZ\nu\nu$, and top-quark pair-production processes as benchmarks.

Our group has extensive experience in collider physics as members of the DØ collaboration. Butler has been a leader of the Muon System for Run 1, the Muon System upgrade for Run2, and the Level 1 Muon Trigger. Narain has been a leader in calorimeter reconstruction software and electron ID algorithms in Run 1 and the Silicon Track Trigger for Run 2. We have made significant contributions to DØ physics in the areas of top physics, Higgs searches, and searches for new phenomena. Nonetheless, we are new to Energy-Flow calorimetry and we therefore plan to work in conjunction with the groups from NIU and UIC that already have experience in this field. All of these groups have contributed to the DØ calorimeter hardware calibration and algorithms.

This is an excellent project for graduate students to gain experience with state-of-the-art detectors. We are requesting funding for one graduate student for this year. One student will provide sufficient manpower to meet our goals for the first year of the project. We are also requesting a nominal amount of travel funds in order to attend Linear Collider workshops and meetings.

Future work will continue to pursue more detailed and complete simulation studies. While we are initially concentrating on simulation, we are also interested in the design and construction of the calorimeter itself. The Boston University Department of Physics features excellent mechanical and electronics shops, we would like to take advantage of our infrastructure by participating in calorimeter prototype work.

Budget

Item	Cost
Graduate student salary (1 year)	$22,188
Travel	$2000
Indirect costs @ 63%	$15,238
Total	$39,426