**Project name**

Development of a silicon-tungsten test module for an electromagnetic calorimeter

**Classification (accelerator/detector:subsystem)**

Detector:calorimetry

**Institution(s) and personnel**

University of Oregon, Department of Physics and Oregon Center for HEP:
Raymond Frey (professor), David Strom (professor)

Stanford Linear Accelerator Center:
M. Breidenbach (faculty), D. Freytag, N. Graf, G. Haller, J. Jaros (faculty), M. Huffer, J.J. Russell

**Contact person**

Raymond Frey
rayfrey@cosmic.uoregon.edu
(541) 346-5873

**Project Overview**

The TESLA and SD detector designs call for a silicon-tungsten electromagnetic calorimeter (ECal) as the best option for providing the necessary segmentation to implement the energy flow method for jet reconstruction at the LC. The number of detector pixels is on order 50 million. One of the outstanding technical questions is how to integrate a silicon detector wafer with its readout electronics. Along with the cost of the silicon detectors themselves, a solution to the integration issue is likely to determine the overall viability of the silicon-tungsten approach. We have, in fact, proposed[1,2] a possible solution to the integration issue. We propose to implement this idea in stages, starting with component feasibility assessments (year 1) and engineering prototypes (year 2). If successful, we plan to develop a full ECal module (year 3) for testing in a beam.

Briefly, we propose to start with the largest commercially feasible silicon wafer, which for a 6 inch wafer for SD would include about 1000 pixels. One readout chip for each wafer would be bump bonded to the wafer. The chip would include the analog and digitization elements for the 1000 pixels. In this way, the channel count is effectively reduced by 1000. We take advantage of the low beam duty cycle ($5\times10^{-5}$ for NLC) to reduce the heat load using power cycling. At least for the first stages, we break up the project into two categories:

1. Silicon detector design, procurement, and characterization (Oregon)

2. Readout chip design, procurement, and design (SLAC)

The description above is the main thrust of this proposal. However, several of us (Frey and Strom, Graf and Jaros) also plan to be involved in closely related activities for which we are not requesting funding here, namely technical simulations, detector modeling simulations, algorithm development, and physics simulations. The technical simulations include EGS and GEANT4 studies of dynamic range, sampling structure, segmentation, etc; modeling of test beam module configuration options; and SPICE simulations of silicon crosstalk, etc. Modeling simulations include issues such as tracker-ECal integration, photon and tau reconstruction, pion rejection, etc; algorithms for energy flow would be developed in conjunction with the modeling studies; physics simulations are to include development of multi-jet and other benchmark processes for energy flow evaluation, and studies of the limits of jet resolution (QCD, 2-photon, etc).

**Description of first year project activities**

Design and procure first round of detector prototypes. Design and discussions with vendors is in progress. We do not yet know the prototype costs, but based on past experience we hope to purchase about 5 detector wafers with the indicated budget line. These are to be full 6 inch wafers with pixels, traces, bump bond pads, biasing, etc. These are to be received at Oregon and will undergo initial testing, including basic QA and crosstalk measurements (using an IR laser system). In parallel, SLAC will develop the first readout chip. No funds are requested for this part. Goal is to have wafers and readout chip ready to be bonded together for testing by end of year one. Year one is to include a silicon detector test in a 5 T magnetic field.

**Budget**

Year 1

| Institution | Item | Cost |
|---|---|---|
| Oregon | Custom silicon detector prototypes (about 5) | $25,000 |
| Oregon | Probe and test equipment for detectors | $10,000 |
| Oregon | Oregon total | $35,000 |
| SLAC | SLAC total | $0 |

**Description of second year project activities (guesstimates)**

Test first round prototypes using various particle sources on the bench. Most likely will need a second round of detector (and readout chip) prototypes. Start to prepare a system for a full test beam experiment.

Year 2

| Institution | Item | Cost |
|---|---|---|
| Oregon | Custom silicon detector prototypes – round 2 | $25,000 |
| Oregon | Data acquisition equipment | $10,000 |
| Oregon | Test equipment | $ 5,000 |
| Oregon | Oregon total | $40,000 |
| SLAC | SLAC total | $0 |

**Description of third year project activities (guesstimates)**

Procure a “final” set of detectors. At this point, the cost/detector will be reduced, based on past experience. Goal is to build a full-depth ECal module of 30 layers (wafers), one wafer wide. The tungsten radiator plates to be procured and fabricated by method to be determined. Test beam to include both EM particles and hadrons. Other detector modules hopefully to be included (i.e. HCal, tracker) if possible, to be determined.

Year 3

| Institution | Item | Cost |
|---|---|---|
| Oregon | Custom silicon detector prototypes (25-30) | $40,000 |
| Oregon | Tungsten, material and machining | $40,000 |
| Oregon | Oregon total | $80,000 |
| SLAC | SLAC total | $0 |

**References**

1. M. Breidenbach, talk at Chicago LC Workshop, Jan. 2002.
2. R. Frey, talk and conference paper presented at Calorimeter 2002, Pasadena, CA, March 2002.

(both available at http://www.slac.stanford.edu/xorg/lcd/calorimeter/ )