Proposal to the
University Consortium for a Linear Collider

August 14, 2002

Proposal Name

R&D towards a Silicon drift detector based main tracker for the NLC-SD option

Classification (accelerator/detector: subsystem)

Detector: Tracking

Personnel and Institution(s) requesting funding

Rene Bellwied, David Cinabro, Vladimir Rykov, Wayne State University

Collaborators

David Lissauer, Francesco Lanni, Vivek Jain, Brookhaven Physics Department

Veljko Radeka, Zheng Li, Wei Chen, Brookhaven Instrumentation Division

Contact Person

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Project Overview

During the past two years our group was partially funded by Fermilab Director's funds and the NSF, in order to develop a scheme in which Silicon drift detectors could be used for the main tracking device in the NLC-SD option. We participated in the design study which led to the SD layout as described in the Snowmass Resource Book. Our main effort during the past two years was two-fold:

a.) to perform simulations that show the physics capabilities of a Silicon based main tracker and compare its performance to the gaseous tracker as proposed for the L-detector option.

b.) to further develop the necessary hardware in terms of the wafers themselves, the mechanical support structure and the front-end/readout electronics based on our original design for the STAR-SVT at RHIC

With respect to a.) Vladimir Rykov has worked with us for the past 18 months on simulations and software development. He was partially funded by the linear collider R&D funds. His work's main emphasis was on comparative performance simulations in the existing software framework and a study of the track timing performance of SDD's which can be used in order to distinguish between pile-up events in the detector.

With respect to b.) Rene Bellwied and David Cinabro have mostly worked on a new detector layout for the SD main tracker based on the successful STAR Silicon Vertex Tracker, which was constructed and is operated under the leadership of Rene Bellwied. Based on these projects of the past two years we propose the following steps for the future:

FY2003 Project Activities and Deliverables

We propose to continue our comparative study of the performance of a main tracker based on Silicon drift detectors. We believe that the existing tracking and pattern recognition code, originally developed for the Large detector (LD) TPC option, can be optimized and used for the 3d SD option. First encouraging results by Vladimir were shown at the Chicago and Santa Cruz LC meetings. We have an agreement with Norman Graf's group that we will provide a full GEANT based geometry definition of our proposed tracker before the fall of 2002. We also intend to port a detector response code from STAR into the LC simulation framework. Finally we would like to adapt a code recently written by a WSU led software group for STAR which allows track matching between the two main tracking detectors in STAR and the electro-magnetic calorimeter in STAR. We believe that this integrated tracking code (IT) can be applied to the SD design in order to simultaneously analyze the information from the vertex detector, the main tracker and the calorimeter in order to optimize and test the energy flow paradigm.

Regarding hardware we propose to layout a first LC specific wafer design in collaboration with the BNL Instrumentation division. In the second half of the year we will submit a prototype design for production to the BNL production lab. Proposed initial changes to the existing SDD design will include:

a.) increase the detector size by using six inch rather than four inch wafers

b.) operate wafers at higher voltage (up to 2500 V) in order to accommodate longer drift length

The first year deliverable would be a version of the LC tracking code fully optimized for an SD style detector and a design and prototype of a LC specific wafer layout

FY2004 Project Activities and Deliverables

We intend to continue our simulation activity and add a testing component to the ongoing hardware effort in order to produce a next generation of Silicon drift detectors. The testing will be performed at WSU and BNL with the postdoc funded through this proposal and graduates students funded by WSU. We propose to further optimize the design and produce a larger prototype batch ($\sim$20) of new Silicon drift detectors. The new iteration will address issues based on the following improvements:

a.) increase the readout pitch in order to reduce the channel count

b.) thin the wafer from 300 microns to 150 microns

The second year deliverables would be a new integrated tracking code for the SD detector option (ITSD) and a second iteration on the LC specific Silicon drift detector prototypes.

FY2005 Project Activities and Deliverables

Our simulation effort and production of prototype improved detectors will continue. In collaboration with the Instrumentation division at Brookhaven National Laboratory we propose to design and produce a new prototype of a CMOS based front-end chip. The major changes compared to the old STAR design are:

a.) use deep sub-micron technology to improve radiation hardness

b.) reduce power consumption to allow air-cooling of the detector

c.) potentially include the ADC stage into the PASA/SCA design

d.) test tape automated bonding of the front-end to the detector rather than wire-bonding

We also propose to begin a design for the mechanical support of the Silicon ladders based on a design used for the Silicon Strip detector layer in STAR.

The third year deliverables would be a final set of prototype detectors, some prototype front-end chips, a conceptual design of a Silicon drift detector main tracker for an LC SD style detector (including support structure and electronics integration), and simulation and reconstruction code for it.

Budget justification

Throughout the three years the budget contains a sub-contract allocation in order to purchase specific component orders produced by the BNL Instrumentation division. For some of these orders the initial materials and supplies will be provided by WSU, and those items are listed under the appropriate category. The collaboration with the BNL Physics department is not supported through this proposal. BNL Physics provides manpower to the simulation and testing effort without financial support from this grant. The WSU overhead rate is 49% for onsite manpower, material and supplies and the first 25 K of a multi-year subcontract (i.e. the contract provision for BNL).

The first year budget emphasises the continuation of our simulation and reconstruction effort. Continuing salary for 50% of a postdoctoral fellow and some travel money is requested. We also initiate the subcontract with BNL for the development of a new wafer layout and electronics design.

In the second year the software and testing effort is increased by raising the postdoc contribution from 50% to 100%. In addition money is required for the purchase of Silicon starting material ($25K) at WSU, continuing mask design ($10K) and the production of a large batch of prototype detectors ($40K) at BNL. More travel money is requested for trips between BNL and WSU related to prototype production and testing as well as participation in LC workshops.

In the third year the software effort continues and additional funding is required for a second round of mask design ($10K), production of the final batch of prototype detectors ($30K), and design and production of prototype front-end chips ($50K) at BNL . More travel money is requested for trips related to prototype production and testing.

Three-year budget, in then-year K$

Institution: Wayne State University

Item	FY2003	FY2004	FY2005	Total
Other Professionals	21	42	44	107
Graduate Students	0	0	0	0
Undergraduate Students	0	0	0	0
Total Salaries and Wages	21	42	44	107
Fringe Benefits (23.7%)	5	10	11	26
Total Salaries, Wages and Fringe Benefits	26	52	55	133
Indirect cost on Salaries	13	26	27	66
Equipment	0	0	0	0
Travel	4	6	10	20
Materials and Supplies	0	25	10	35
Total Equipment, Materials, and Travel	4	31	20	55
Indirect Cost on Equipment etc.	2	15	10	27
Subcontracts	25	50	90	165
Indirect Cost on Subcontracts	12	0	0	12
Total direct costs	55	133	165	353
Indirect costs	27	41	37	105
Total direct and indirect costs	82	174	202	458