Proposal to the
University Consortium for a Linear Collider

August 23, 2002

Proposal Name

Straw Tube Wire Chambers for Forward Tracking in the Linear Collider Detector

Classification

Detector: Forward Tracking

Personnel and Institution(s) requesting funding

O. K. Baker, Hampton University K. McFarlane, Hampton University V. Vassilakopoulos, Hampton University

Add more lines for additional institutions, if needed.

Collaborators

Hampton University: O.K. Baker, K. McFarlane, V. Vassilakopoulos

Other HBCU's and personnel will be added as part of the Center for the Study of the Origin and Structure of Matter (COSM), a NSF-funded Physics Frontiers Center.

Contact Person

O. Keith Baker
baker@jlab.org
757-727-5820

Project Overview Hampton University proposes to perform research and development of a straw-tube based wire chamber for charged particle tracking in the Linear Collider Detector. One proposed detector layout would use straw tubes for forward tracking at large radii. Such a layout is necessary (forward tracking) in order to ensure hermiticity and for luminosity measurement. The Forward Chamber (FCH) would extend radially from the Time Projection Chamber inner radius to just below the outer radius of a suggested Time Projection Chamber (TPC) field cage. There would be several layers of straw tubes with several different wire orientations, including stereo wires.

Hampton University, a member of the ATLAS Collaboration at the LHC, is part of the US group constructing the barrel Transition Radiation Tracker (TRT) for the Inner Detector. The TRT is a straw-tube based gaseous wire chamber capable of handling event rates as high as 18 MHz per 0.75-meter long (half-) straw. This system will be a charged particle tracking device as well as a particle identification detector, especially for electron-hadron separation. There will be strong overlap and synergy between the current LHC activity and the proposed NLC research and development. The tools and techniques used in one case will benefit the other. The Hampton University group will continue to work on LHC detectors and simulations during the time of this NLC activity.

Hampton University proposes to apply the experience and technical knowledge gained from this project to the tracking working group of the Liner Collider community. We will extend the work done for the LHC detector to tracking in the forward direction where the TPC and the LC vertex detectors performance would either not exist or be degraded compared to the central region. The use of CF_4 gas in tracking chambers serves two purposes: (1) It is a fast gas, that is the charged particle drift velocity in a gaseous mixture containg this compound is approximately 100 μm/ns. Fast gas recovery times in tracking chambers means higher rates can be handled. (2) It acts as a cleaning agent under certain conditions. Chambers may be effectively regenerated by flushing with a mixture including CF_4 without having to physically remove the chamber to clean it of silicon deposits (silicon deposits on wires degrade the chamber performance over time in a high rate environment).

In contrast to the benefits, there can be rather severe ageing effects on chambers that use CF_4 in a high rate environment; this has been seen in our development of LHC wire chambers. Recognizing that the LC charged particle event rate will be a small fraction of that expected (and planned for) at the LHC, there are still several outstanding tracking issues that need to be addressed for gaseous detectors. The Hampton group proposes to study the following issues for LC tracking:

FY2003 Project Activities and Deliverables

1. The effect of CF_4 gas on detector components in the LC environment. These components include (i) gold-plated tungsten wire, (ii) straw walls, and (iii) electronics boards that come into contact with this gas This will have two phases. In Phase One (FY2003) we will bring the proposed system (gas, irradiation, electronics, DAQ, test chamber) into operation and get results from short-term tests. We will build a gas system capable of handling a two or three component mixture. The group will also deliver a report on our experience (from ATLAS TRT development) with CF_4 in a high radiation environment. Although the rates at the LC will be lower than at the LHC, the work should be useful to this collaboration for long term stability and efficiency issues for the LC.

2. The use of thin-walled straw-tube wire chambers for charged particle tracking, including an analysis of the requirements on a drift tube system for forward tracking. This would include estimates of occupancy, and ionization current. Additionally, we will build and test a small straw-tube wire chamber to be used with this gas system. It is expected that this work will carry over into the next fiscal year. In order to carry out this work, the Hampton group will need to build an irradiation system providing high ionization currents, since the deleterious effects from CF_4 show up only when high ionization is present. The straw tube wire chambers that Hampton is helping to build for the LHC can handle rates in excess of 10 MHz per one meter long straw. An X-ray system capable of providing this ionization current will be purchased and assembled. (The reason for high ionization is so that a 10-year or so LC run could be simulated in a six-month test run, for example.)

3. Detector simulations of forward charged particle tracking at the LC. The code will be a modification of the LHC detector simulation software.

FY2004 Project Activities and Deliverables

1. Improved tracking algorithms for LC events. We will improve upon code already being used for tracking using straw-tube based gaseous detectors.

2. Phase Two (FY2004) referenced above will be implemented. We will complete long-term testing of the gas system and components under irradiation and report on the results. This activity will make use of the Hampton University experience with the ATLAS TRT straw-tube modules.

FY2005 Project Activities and Deliverables

1. Define an initial detector geometry for a straw tube forward tracker;

2. Continue detector simulations of charged particle tracking at the LC. The code will be a modification of the LHC detector simulation software. LC tracking code based upon the initial forward tracker design that can be used in physics studies will be developed.

Budget justification

In order to carry out this research and development program, we request funds to partially support a single postdoctoral researcher for years FY004 and FY005. The postdoc will use facilities on the Hampton University campus, in conjunction with the group of PhD-level researchers and students already in the LHC group. The equipment and materials/supplies needed for this study are shown below; the equipment and materials/supplies request is included in the FY003 request. The requested budget for a three year period is shown below in thousands of US dollars:

Equipment: X-ray source: $7k X-ray enclosure: $4k Chamber HV supply and test/measurement equipment: $4k Data Acquisition Equipment: $10k

Supplies: Gases: $3k Plumbing parts, etc. $2k.

The postdoctoral researcher will assist with detector research and development, detector simulation, and code development for straw tube wire chamber tracking. There will be two undergraduate student workers for the duration of the research and development project.

The indirect cost is 49% of all items except equipment. Student support for this project will come from the Hampton University Center for the Study of the Origin and Structure of Matter (COSM), an NSF-supported Physics Frontiers Center.

Three-year budget, in then-year K$

Institution: Hampton University

Item	FY2003	FY2004	FY2005	Total
Other Professionals	0	50.0	52.5	102.5
Graduate Students	0	0	0	0
Undergraduate Students	0	0	0	0
Total Salaries and Wages	0	50	52.5	102.5
Fringe Benefits	0	9.2	9.7	18.9
Total Salaries, Wages and Fringe Benefits	0	59.2	62.2	121.4
Equipment	25.0	0	0	25.0
Travel	0	0	0	0
Materials and Supplies	5.0	5.0	5.0	15.0
Other direct costs	0	0	0	0
Total direct costs	30.0	64.2	67.2	161.4
Indirect costs	2.5	31.5	32.9	66.9
Total direct and indirect costs	32.5	95.7	100.1	228.3