Linear Collider Detector R&D

Proposal to NSF/DOE for US Universities

J. Brau

LCDRD Program

US University LC Detector R&D
(FY05-FY08, extended to FY10)

Topic	FY05		FY06		FY07		(suppl. only) FY08*	
	$0.817M		$1.348M		$2.175M		$0.8M	
LEP	**5**	**15%**	**6**	**13%**	**6**	**13%**	**1**	**3%**
VXD	**1**	**9%**	**4**	**13%**	**4**	**14%**	**2**	**18%**
TRK	**8**	**32%**	**8**	**22%**	**9**	**18%**	**2**	**16%**
CAL	**9**	**41%**	**13**	**45%**	**11**	**49%**	**2**	**54%**
PID(mu)	**2**	**4%**	**2**	**6%**	**3**	**6%**	**1**	**8%**
projects	25		33		33		8	
NSF	$0.117M		$0.300M		$0.375M		($0.300M)	
DOE	$0.700M		$1.048M		$1.800M		$0.500M	
UO umbrella	$0.797M		$1.257M		$1.833M		$0.260M	
direct to labs	$0.020M		$0.091M		$0.342M		$0.240M	
							$0.300M to come	

* DOE FY08, NSF was to come early in FY09 - soon!

Preparing for next phase

- Spring 2007 - Review at Argonne
- Fall 2007 - LCDRD coming to end of 3 year grant
  – Discussions with DOE/NSF on how to proceed
- DOE-HEP leadership change
  – Meeting at DOE (Kovar, Brau, Weerts, Nicholson, Blazey) - Nov 16, 2007
- Omnibus Bill - 2007
  – Is ILC Detector R&D relevant?
  – Generic vs. SiD (or XD) specific?

Preparing for next phase (cont.)

- Jan-Aug 2008 - many discussions
- Sep 2008 - Boulder SiD Workshop
  - M. Goldberg and H. Nicholson - agency views
- Oct 2008 - Yamada meets with Kovar
  - Explains purpose of LoIs
  - Positive reaction regarding 2008 proposals for support of LoI defined program
- Nov 2008 - Agencies want a few joint proposals, not many individual proposals
  - Proposals from US LoI groups supported by individual project descriptions

FY09 Timelime

- Nov 16, 2008 - message to community
  - US LoI groups to submit proposals to both agencies for prioritized projects
- Dec 16, 2008 - guidelines posted on web
- Jan 9, 2009 - Andy asks SiD project info by Jan 12
- Jan 14, 2009 - SiD adhoc (AW, MD, HW, JJ, MB, JB)
  - met at SLAC to discuss SiD R&D proposal. Contact SiD collaborators with guidance.
- Jan 23, 2009 - Proj. des. submitted to George Gollin
  - George produced the collected set (Big Doc)
- Feb 18, 2009 - SiD proposal submitted to DOE and NSF from Univ of Oregon
  - PIs - Jim Brau and Marcel Demarteau

SiD US Univ. Detector R&D – FY09 Proposed Projects

Vertex

4.1 Charlie Baltay (Yale-Oregon)	Pixel Vertex Detector (Chornopix)
4.4 Henry Lubatti (Washington)	Vertex Detector Mech. Structures
4.5 Gary Varner (Hawaii)	Pixel-level Sampling CMOS VxDet
4.6 Julia Thom (Cornell)	3D Sensor Simulation

Tracking

5.8 Keith Riles (Michigan)	Tracker Simulation and Alignment Sys.
5.10 Bruce Schumm (Santa Cruz)	Sensor QA, Rad-hard sensors
5.22 Satish Dhawan (Yale)	DC-DC Converters
5.23 Sally Seidel (New Mexico)	Sensor QA, cables

SiD US Univ. Detector R&D – FY09 Proposed Projects (cont.)

Calorimetry	
6.1 Vishnu Zutshi (NIU)	Scintillator-based Hadron Calorimeter
6.2 Uriel Nauenberg (Colorado)	Scintillator Had Cal w/ SiPDs
6.4 Usha Mallik (Iowa)	Particle Flow Studies
6.5 Raymond Frey (Oregon)	Silicon-tungsten EM calorimeter
6.6 Jae Yu (UT Arlington)	Digital Hadron Calorimetry w/ GEMs
6.19 A.J.S. Smith (Princeton)	RPC Calorimeter and Muon ID
6.25 Peter Fisher (MIT)	PFA-GEMs
6.26 Ren-yuan Zhu (Caltech)	Crystal Dual-readout
6.27 J. Butler, Y. Onel (BU-Iowas)	RPC HCal
Muon	
7.2 Paul Karchin (Wayne St., Indiana, ND, NIU)	Scintillator Based Muon System
7.8 Henry Band (Wisconsin)	RPC and Muon System Studies
Luminosity, Energy, Polarization	
3.4 Eric Torrence (Oregon)	Extraction Line Energy Spectrometer
3.5 Mike Hildreth (Notre Dame)	BPM-Based Energy Spectrometer
3.6 Yasar Onel (Iowa)	Polarimetry
3.8 Gio. Bonvicini (Wayne State)	Incoherent and coherent beamstrahlung

February 18, 2009

SiD Detector R&D

Boston University, Caltech, Cornell University, Indiana University,
Massachusetts Institute of Technology, Northern Illinois University, Princeton University, University of California at Davis,
University of California at Santa Cruz, University of Colorado, University of Hawaii, University of Iowa, University of Michigan,
University of New Mexico, University of Notre Dame,
University of Oregon, University of Texas at Arlington,
University of Washington, University of Wisconsin,
Wayne State University, and Yale University

in collaboration with

Argonne National Laboratory,
Brookhaven National Laboratory,
Fermi National Accelerator Laboratory,
and SLAC National Accelerator Laboratory

Critical R&D for the SiD Detector Concept

Members of the SiD detector concept have been engaged in R&D for detector components and software systems at the International Linear Collider (ILC) for a number of years. This activity includes U.S. university HEP groups, U.S. national laboratories, and equivalent non-U.S. entities. In this section we summarize the critical R&D tasks for each area of SiD[2]. University groups are involved in many of these areas, but not all, and overall it engages the worldwide SiD collaboration.

1) General

For the overall performance of the SiD detector, we need to demonstrate that the detector can adequately address the full spectrum of the physics at a 500GeV ILC, with extension to 1 TeV. This includes a full simulation of the detector, track reconstruction code, and development of a fully functional Particle Flow Algorithm (PFA). While we have working versions of the simulation, reconstruction, and the PFA, we anticipate significant further developments, which will provide the critical tools to optimize and finalize the detector design.

2) Vertex Detector.

No ILC ready vertex detector sensor yet exists. The main needs are to develop one or more solutions for the sensors, a demonstrably stable and low mass mechanical support, and pulsed power/cooling solutions. Sensor technologies are being developed, as well as mechanical support materials, designs, pulsed power, and cooling.

3) Tracking Detector.

The priorities for tracking are testing a multi-sensor prototype in the absence of a magnetic field and at 5T, refining the track finding and fitting performance, understanding the optimal forward sensor configuration, and developing more detailed understanding of the mechanical stability and required alignment. Work is underway in all of these areas, some by members of the SiLC Collaboration.

Critical R&D for the SiD Detector Concept

4) Electromagnetic Calorimetry.

For the baseline silicon-tungsten Ecal design, the operability of a fully integrated active layer inside the projected 1.25mm gap between absorber plates must be demonstrated. Sufficient S/N, successful signal extraction, pulse powering, and adequate cooling must be shown as well. Mechanical prototypes with steel rather than tungsten will first be built, followed by a full depth tower appropriate for beam tests. For the alternative MAPS technology being investigated in the U.K., a key need is production of large sensors with sufficient yield.

5) Hadronic Calorimetry.

The priority for hadronic calorimetry is to demonstrate the feasibility of assembling a fully integrated, full-size active layer within a ~8mm gap between absorber plates. Several technologies are being investigated: RPC's, GEM's, and scintillating tiles/SiPM's. A European project studies micromegas layers. All of this work is being carried in conjunction with the CALICE Collaboration, and the results will form a critical component of SiD's future technology selection. An alternative approach, using homogeneous crystal calorimetry with dual readout, is also being studied. This effort needs to demonstrate good hadronic energy linearity and resolution in a test beam, to develop suitable crystals, to produce a realistic conceptual design, and to simulate physics performance.

6) Electronics.

One critical item on electronics is a demonstration of the operation of 1024 channel version of the baseline KPiX chip. Another is to develop power distribution schemes for the vertex detector and tracker with DC-DC conversion or serial powering. Adapting and testing KPiX readout to the tracker, calorimeters, and muon systems must also be continued and perfected.

Critical R&D for the SiD Detector Concept

7) Magnet.

For the superconducting solenoid, it is required to demonstrate that a 5T field can be achieved with acceptable reliability and cost, and with acceptable forces. To address cost reduction, a new conductor is being studied. R&D for the Detector Integrated “anti-” Dipole coils is also required.

8) Engineering Issues.

A credible scheme for push-pull operation is required that achieves acceptable repositioning of the detector, preserving internal alignment, in an acceptably short cycle time. Equally important is achieving the required mechanical stability of the quadrupole focusing lenses.

9) Forward Calorimetry.

A sensor that can survive the radiation environment in the forward region is required, along with suitable readout electronics. Some of this work is collaborative with the FCAL Collaboration.

10) Muon system.

Emphasis is placed on development of reliable, and robust RPCs. SiPMs for scintillator strips are a new technology of interest, also under development.

Prioritization of SiD R&D

- The critical R&D areas for the SiD detector concept have been enumerated
- Prioritization of R&D is a complicated undertaking
  - Many considerations need to be balanced in setting priorities:
  - the importance of the R&D for the viability of the detector concept;
  - the expected return on investment;
  - facilitating collaboration growth;
  - accounting for developments outside the U.S;
  - etc.
- Each individual project reviewed and evaluated for SiD priorities by a six-person ad hoc SiD committee.
- Some modification by interaction with project leaders.

Project Descriptions

The project numbers refer to those in the document of US university project descriptions, prepared by the ALCPG, and known as the BigDoc:

http://www.hep.uiuc.edu/LCRD/LCRD_UCLC_proposal_FY09/LittleBigDoc_2009.pdf

Vertex Detector

Chronopixel [project 4.1] Yale-Oregon

Continuous Acquisition Pixel [project 4.5] Hawaii

Modeling of 3D Pixel Detector Technology [project 4.6] Cornell

Vertex Detector Mechanical Structures [project 4.4] U. Washington

Project Descriptions (cont.)

<u>Tracker</u>

SiD Tracker Alignment System [project 5.8] Michigan

Applications of Silicon Sensors [project 5.10] Santa Cruz

Development and Testing of Silicon Sensors and Cable Interconnects [project 5.23] New Mexico

Powering of ILC Detector Front End Chips by DC-DC Converters & HV RF [project 5.22] Yale

<u>Calorimeters</u>

Electromagnetic Calorimeter R&D [project 6.5] Oregon-Davis

Hadron Calorimeter R&D - Resistive Plate Chambers [project 6.27b] Boston-Iowa

Hadron Calorimeter R&D - GEM chambers [project 6.6] UT Arlington

Hadron Calorimeter R&D - Scintillator tiles with SiPM readout [project 6.1] NIU

Homogeneous Crystal Calorimetry with Dual Readout [project 6.26] Caltech

Particle Flow Algorithm and Simulation
[project 6.4] Iowa
[project 6.25] MIT

Project Descriptions (cont.)

Muons

Resistive Plate Chambers
[project 6.19] Princeton
[project 7.8] Wisconsin

Scintillator with SiPMs [project 7.2] Indiana, NIU, Notre Dame, and Wayne State

Forward Calorimetry

[project 6.2] Colorado
[project 5.10] Santa Cruz

Beamline Instrumentation

Four projects have been submitted for beamline instrumentation. SiD is interested in these, particularly work on energy spectrometry and polarimetry. There is a possibility that these could be supported under the US accelerator R&D program, so we are not proposing them within this framework.

Second and Third Year Developments

Reduced R&D at the $1M level

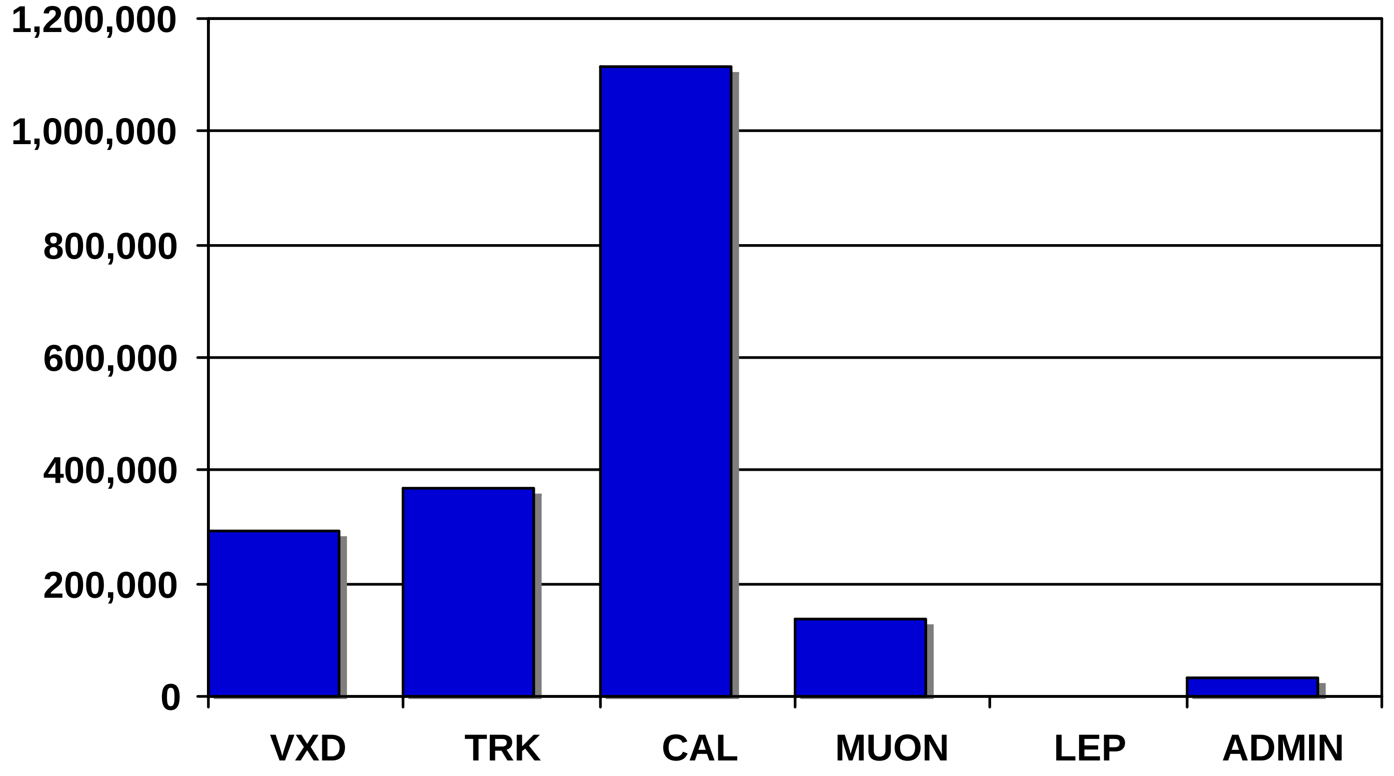
- Given the wide range of funding possibilities, a funding scenario of $1M was also considered.
- This corresponds to a funding at about 50% of the proposed level.
- In this scenario, all budget levels were set at half of our proposed budget with selected exceptions.

Management

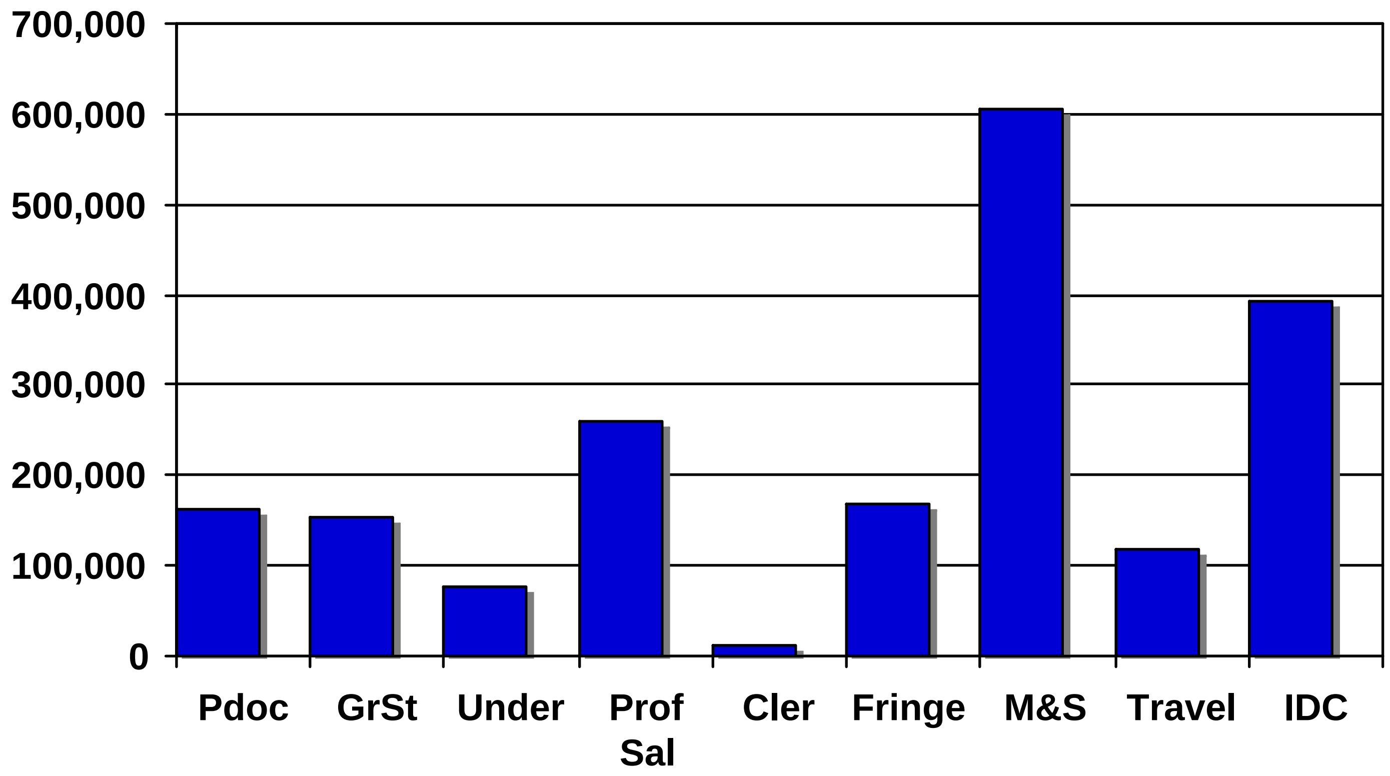
SiD leadership will monitor progress on all projects that are supported from this proposal. Semi-annual progress reports will be requested by the PIs from each of the individual project leaders.

Broader Impacts

Subsystem Distribution (year 1)



Category Distributions (year 1)



3 year Budget

• Year 1	$ 1,949,439
• Year 2	$ 3,004,030
• Year 3	$ 4,001,842
• Total	$ 8,955,311

The specific distribution between project needs in years 2 and 3 are not detailed in the proposal.

Summary

- Proposal submitted Feb 18
- Both agencies have acknowledged receipt
- Expect review in coming months