


Report from the Vertex Detector Working Group



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Vertex R&D Strategy

- Quantify requirements coming from
 - Machine constraints - warm or cold; make conservative assumptions regarding backgrounds, radiation etc.
 - Physics goals - identify a few benchmark processes that are challenging for the vertex detector and important for LC physics program, eg flavor tagging to measure Higgs branching ratios
- Carry out simulations and paper studies to derive detector requirements from the accelerator/physics requirements
- Pursue hands-on R&D in focused program aimed at most important physics goals, keeping in mind that there is time to make significant technical advances

Requirements for an LC Vertex Detector

- | **Accelerator-related requirements, such as**
 - | **Beam-pipe radius, thickness, machine stayclear**
 - | **Radiation levels & background rates**
 - | **Event rate and time structure of collisions**
 - | **etc.**
- | **Physics requirements, eg vertex flavor tagging, driven by:**
 - | **Impact parameter resolution**
 - | **Two-track/two-hit separation**
 - | **Efficiency, fake track rate**
 - | **Solid angle coverage**
 - | **etc.**

Accelerator Requirements

- **Backgrounds: determine minimum beampipe radius, radiation levels, vertex detector occupancy and readout requirements**
 - Beam pipe radius ~1-1.5 cm, thickness 160 - 250 um Be (.04 - .07% X_0)
 - Inner layers of vertex detector must tolerate 100's kRad ionizing radiation and 10^{10} neutrons/mm²
 - Backgrounds dominate occupancies; at NLC can readout between trains while at Tesla, long train necessitates readout during train and hence higher readout rates
- **Multiple scattering in beampipe sets scale for thickness of first detector layer and for point resolution at low p**
 - Radius and thickness of beampipe are critical inputs for vertex detector; think of beampipe as part of detector
 - Beampipe and background issues are natural area for vertex detector group to contribute to machine design/simulations

Neutron Backgrounds

From D. Asner's talk

Neutron hit density in VXD

	NLC-LD-500 GeV e^+e^-	NLC-LD-500 GeV $\gamma\gamma$
Beam-Beam pairs	1.8×10^9 hits/cm ² /yr	expect similar
Radiative Bhabhas	1.5×10^7 hits/cm ² /yr	expect similar
Beam loss in extraction line	0.1×10^8 hits/cm ² /year	expect similar
Backshine from dump	1.0×10^8 hits/cm ² /yr	1.0×10^{11} hits/cm²/yr
TOTAL	1.9×10^9 hits/cm²/yr	1.0×10^{11} hits/cm²/yr

Figure of merit is 3×10^9 for CCD VXD

**Takashi Maruyama &
Jeff Gronberg**

L1 & L2 cannot use CCD – Active Pixels?

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Physics Requirements

■ Flowdown of requirements:

- y Science requirement: Precision on particular physics quantities, eg error on $\text{Br}(H \rightarrow cc)$
- y Performance requirement: high-level event parameter, eg specified flavor tag purity at a given efficiency
- y Detector requirement, eg impact parameter resolution or tracking efficiency vs fake rate for a given detector subsystem

A number of LC vertex detector studies have already been performed at all 3 levels; work is ongoing and we heard reports showing good progress.

Vertex Detector Parallel Session

- Reports on simulations:
 - Track ionization in CCDs - Su Dong
 - Flavor tagging & Higgs Br - Chris Potter
 - Charm tagging in $e^+e^- \rightarrow W^+W^-$ - Wolfgang Walkowiak
 - Vertex detector backgrounds at a $\gamma\gamma$ collider - David Asner
- Reports on hands-on R&D:
 - UK R&D on CCDs - Philip Burrows
 - Oregon/Yale CCD R&D - Homer Neal
 - FNAL/Universities Interest in Vertex R&D - William Wester
 - Rad-hard CCD development at LBNL - Hakeem Oluseyi

UK CCD R&D Plans

- Bristol, Lancaster, Liverpool, Oxford, Queen Mary, RAL
- Funded for four years
- Ambitious R&D program in several areas
 - Thinned detectors (20 um or even less)
 - Mechanical support of thinned detectors
 - Radiation damage studies
 - Faster CCD readout
 - New CCD design (Marconi) with column-wise readout
 - Off-detector electronics - ASICs & DAQ

Oregon/Yale R&D Proposal

■ From Homer Neal's presentation

University of Oregon:

- | Lead role in the radiation hardness measurements of the VXD3 CCDs
- | Collaborate with the Yale group in developing commercial silicon fabrication houses to partner in the design and fabrication of CCDs
- | Consult with the Yale group in the mechanical engineering designs of the CCD support mechanisms

Yale University:

- | Provide support to the Oregon group in the SLD CCD radiation hardness measurement.
(design and construction of fixtures to support CCDs during irradiation, transportation, and measurements, use of the Yale clean room, etc...)
- | Take the lead role in developing potential silicon fabrication partners for the design and fabrication of the CCDs.
- | The Yale mechanical engineering staff, with CCD detector experience from both the SLD vertex detector and the QUEST project will take the leading role in the preliminary engineering study of the CCD support mechanism.

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FNAL + Universities - EOI

From William Wester's presentation:

Physics, engineering, and technical resources exist at FNAL. A few of us want to help LC effort!

Current commitments include CDF/D0, CMS, and BTeV – natural phases of R&D, prototyping, and production – LC fits in this cycle

We propose to contribute resources on the three identified fronts. A few \$K's for equipment and materials can go a long way.

The LC vertex detector R&D effort can be coordinated with several university groups and Fermilab all contributing

(Interested in radiation testing, thinned detectors, ASIC development/faster readout speed. Interested Universities include Northwestern, Oklahoma, Purdue)

Rad-hard CCD development at LBNL

- p-channel CCD technology originally developed at LBNL for SSC - fully depleted, rad-hard
- Now being optimized for astronomy - high QE, broader wavelength response, cheaper & better than traditional thinned n-channel CCDs
- Has been successfully commercialized at Mytel Semiconductor
- Could provide a rad-hard CCD for LC applications - has been tested up to 10^{11} protons/mm²
- Format, pixel size, output transistor characteristics can all be tailored at LBNL to match desired LC parameters

Summary

- There are interesting vertex detector issues to address both in simulation and in hands-on R&D
- There is one well-established US R&D effort and some nascent efforts
- Should aim to cooperate with one another and on global level with international partners