CCD Vertex Detector R&D for Linear Collider and Radiation Damage Study

By Nick Sinev (University of Oregon) for the Oregon and Yale groups

Oregon: Jim Brau, David Strom, Nick Sinev
Yale: Charles Baltay, Homer Neal, David Rabinowitz

Presented for DOE review 01/30/03
Plan

- Introduction – LC Vertex Detector Challenge
  - Readout speed
  - Thickness
  - Radiation Hardness
- US CCD Vertex Detector R&D group
  - Goal and plans
- Radiation Damage Study
  - Goal
  - Spare CCD test
  - Plans for VXD3 postmortem study and current status
LC Vertex Detector challenge

- Compare to SLD VXD3 detector:
  - Readout time: need to be \(\sim 10\) times faster for NLC/JLC or \(\sim 1000\) faster for TESLA.
  - Impact parameter resolution – limited by multiple scattering in detector – need to push to the lowest possible thickness.
  - Radiation damage – backgrounds at new LC will be about \(100\) times higher. This is the sensitive issue for CCD based detector.
**Plans of U of O/Yale CCD R&D group**

**The goal of joint R&D group:** Advance in the CCD detector design to meet LC challenges.

**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.
Radiation damage study

- The goal is to understand all details of radiation damage effects and develop the way to minimize impact of such effect on detector operation
- Use the VXD3 spare CCDs to study effects caused by neutrons and other particles.
- Use CCDs which operated in VXD3 and sustained radiation damage to verify our knowledge of background conditions in SLD and in general.
- Test CCDs from different vendors made with different technologies to understand technology impact on radiation hardness
- Test CCD prototypes, developed on the basis of our understanding of radiation damage reduction technique.
VXD3 experience

- During VXD3 commissioning there was fire in dumping ring. During dumping ring repair we decided to continue using undumped beam for the VXD3 hardware and software debugging. At that time we had sometime very high background levels in CCDs. Later it was found, that innermost CCDs sustained radiation damage:
Test of radiation damage performed on spare CCD in 1998
Plan for VXD3 postmortem study

Extraction
- VXD3 will be extracted from SLD together with cryostat
- Cryostat will be opened and VXD3 split into two half-barrels
- Beam pipe will be replaced with special fixture to provide illumination of inner CCDs
- Half-barrel with CCDs will be placed in the test stand cryostat and cooled to operational temperature

Examination
- The measurements, using developed algorithm will be done
- The distribution of number of traps/pixel and distribution of damaged pixels in azimuth and Z co-ordinate will be analyzed
Status

- Test Stand, used for 1998 measurements, has been moved to collider hall (the only place where SLD VAXes still running)
- Fastbus crate is connected to SLD VAX.
- CCD readout electronics has been tested
- Test stand software has been tested
- Currently preparing for measurements with irradiated spare CCD (to check if damages seen in 1998 has not annealed)
- Team is working on extraction of VXD3.