Operational Experience with the CDF Run II Silicon Detector

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Abstract

The CDF Run II Silicon Detector is the largest operating silicon detector in High Energy Physics. Its 722,000 channels spread over 7 m^2 of silicon micro-strip sensors allow precision tracking and vertexing. The CDF silicon detector played a critical role in the discovery of B_s mixing and is used extensively for the current Higgs Boson searches. Over the last 7 years, the detector efficiency has remained stable at 95% after the Run II commissioning period. The infrastructure (cooling, power supplies) problems dealt with are discussed.

Key words: silicon detector, vertex detector, tracker, CDF, cooling
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1. The CDF Silicon Detector in Run II

The CDF Silicon Detector is located in the proximity of the interaction point of the multipurpose detector CDF [1]. It is composed by three subdetectors. Vertexing and tracking depends mainly on the SVX-II subdetector [2], which comprises the majority of sensors. The second subdetector, L00 [3] is mounted on the beam pipe and improves the vertex precision. The third subdetector, ISL [4], is the outermost and is designed to extend the forward and backward coverage.

2. Corrosion in Cooling Lines

In 2007 the ISL cooling system failed due to a substantial leakage in the aluminum piping. The investigation indicated that the coolant fluid had turned highly acidic (pH ≈ 2, the equivalent of lemon juice). The presence of formic acid accounted for the acidity. This acid was formed out of the ethylene glycol present in the coolant (originally a solution at 10%). The previous year the cooling temperature ran at relatively warm temperatures (up to 15° C compared against the regular 6° C) during a 2-3 months Tevatron shutdown period; the detector had been switched off. It is believed that this long warm running favored the chemical reactions.

Using specialized instruments (mainly boroscopes and catheters) the inner surface of the cooling rings surrounding ISL was explored. The instruments penetrated about 1 m depth inside the CDF detector through a cilran tube. This tubing connects to an aluminum structure welded to cooling pipe rings surrounding ISL (along the radial axis). Seemingly affected spots were localized in the welding; those areas were coated with epoxy.

Prevention was implemented at CDF; pH and conductivity are monitored and controlled by means of deinonizer filters. The coolant solution in ISL was replaced by deionized water.

3. Automation of Operations

Keeping the full detector working during collisions has been a major concern at CDF. Thus, the most common high voltage problems have been addressed through automated systems [6]. One common problem is a failure whereby a power supply module either switches off spontaneously or its communication with the control system is lost. It is believed that radiation in collision hall induces these failures; the design of the power supplies (based on CAEN SY527) was not radiation tolerant.

To deal with these failures a system was implemented to recognize the error conditions and reset the modules. Another system identifies sensors which have been left unpowered and recovers the normal operations by switching on the high voltage and reinitializing the sensor chips. In this way the power supply failures, as well as high voltage trips, are fixed in minimum time, and human intervention has been significantly reduced. During collisions, the full Silicon Detector is taking data 98% of the time on average (relative to the time the CDF detector is running).

4. Aging of Power Supplies, "Dropping Voltage"

After six years of operation, an aging phenomenon was observed in some power supply modules. The voltage delivered by one or more low voltage channels dropped 10-15% within

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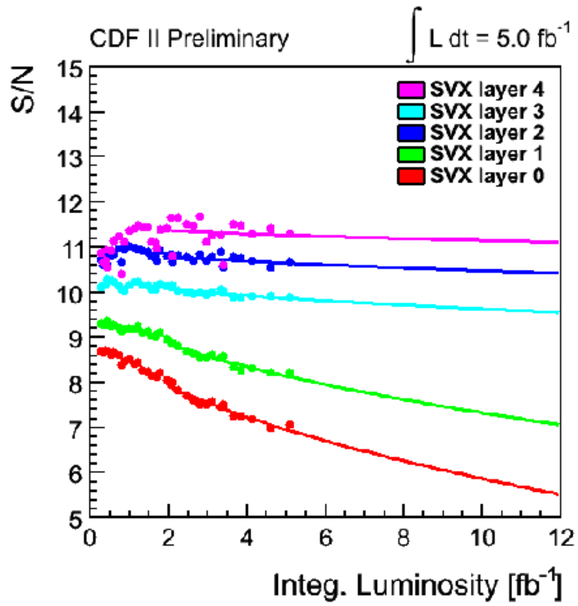

Figure 1: Signal-to-Noise ratio for the SVX layers of sensors as a function of the integrated luminosity. Fits to data have been extrapolated to 12 fb^{-1}. The estimations are based on strips for longitudinal positioning.

the period of a few months. The readout performance was sometimes affected. The electrical aging of a sort of capacitors (10 μF) in the voltage regulator circuit accounted for the phenomenon [7]. The capacitors on the majority of the modules have been replaced since then. The manufacturer of power supplies was notified about these failures.

5. Lorentz Induced Resonances

The generation of potentially hazardous Lorentz forces as a result of the interplay of the position of the sensor wires, the magnetic field and the trigger rates was investigated in detail [5]. An innovative system was implemented which interrupts the data taking before a resonance condition is reached; thus, preventing the fatigue of wire bonds and permanent loss of connections.

Bench tests revealed that this risk can be mitigated or eliminated at the phase of detector construction if the bonds would be covered by encapsulant drops (such as sylgard 186 silicon elastomer).

6. Performance: Present and Future

The possibility to run the Tevatron until 2011 is presently under discussion. It has been estimated that the delivered luminosity would be then 12 fb^{-1}.

In Figure 1 it can be seen that the projection of the Signal-to-Noise ratio is still good enough at that year; since b-tagging is still possible at S/N $\approx$ 3 with the use of efficient algorithms.

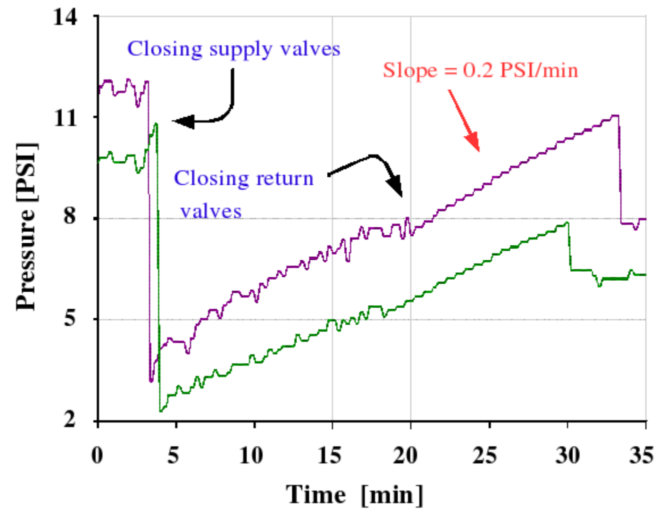

Figure 2: Rate-of-Rise tests for portcard lines of ISL (East and West sides). The rate (slope) in both cases is 0.2 PSI/min.

Another point of interest is the hermeticity of the cooling lines. We have performed Rate-of-Rise (RoR) tests to estimate it. In a RoR test vacuum is drawn, then supply valves are first closed and while vaccumm is still being drawn, the return valves are also closed. As a result the pressure rises at a rate proportional to the leakage. The results have been satisfactory, an example is shown in Figure 2. Further testing and maintenance is scheduled in Summer 2009 *.

7. Conclusions

Over the years the CDF Silicon Detector has accumulated valuable experience. Design and operation of newer and future detectors can benefit from it. It is imperative to consider prevention and control of corrosion in cooling systems; this should be done as early as in the design phase. Lorenz forces may affect High Energy Physics detectors and its effects must be considered and kept safe. At CDF, automatation of the recovery from high voltage issues has remarkably improved the operations. The silicon detector is in good shape to continue running until the end of the Tevatron operations.

References

[1] D. Acosta *et. al.*, Phys. Rev. **D71**, 032001 (2005)
[2] A. Sil *et. al.*, Nucl. Instrum. Meth. A **447**, 1 (2000)
[3] C.S. Hill *et. al.*, Nucl. Instrum. Meth. A **511**, 118 (2003)
[4] A. Affolder *et. al.*, Nucl. Instrum. Meth. A **453**, 84 (2000)
[5] G. Bolla *et. al.*, Nucl. Instrum. Meth. A **518**, 277 (2004)
[6] U. Husemann *et. al.* , FERMILAB-CONF-08-521-E (2008)
[7] R. Eusebi *et. al.*, Nucl. Instrum. Meth. A **598**, 50 (2009).

*See also, R. Martinez-Ballarin, "The CDF Run II Silicon Detector: Longevity Studies", these proceedings