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S. Leone
The CDF ISL Group

Istituto Nazionale di Fisica Nucleare
Sezione di Pisa, I-56010 Pisa, Italy

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

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The Intermediate Silicon Layers (ISL) Detector for the Collider Detector at Fermilab

Sandra Leone[†]

Istituto Nazionale di Fisica Nucleare, Sezione di Pisa, I-56010 Pisa, Italy

[†] for the CDF ISL group*

E-mail: sandra.leone@pi.infn.it

Abstract

The Intermediate Silicon Layers detector is part of the CDF upgrade for Run II. The ISL is a large radius (29 cm) silicon tracker with a total active area of about 3.5 m^2. The conceptual design and the status of the project are reviewed.

1. Introduction

In the year 2000 the Tevatron $p\bar{p}$ Collider will provide collisions at a center of mass energy $\sqrt{s}$ = 2.0 TeV. The instantaneous luminosity will reach a maximum of 1 - 2 $\cdot$ 10^{32} cm^{-2} s^{-1} with an interbunch separation of 396 ns and later of 132 ns. In order to match the physics capabilities of such a machine, the CDF detector is undergoing a large upgrade program which includes the complete rebuilding of its tracking system[1].

CDF will have two silicon detectors, the Silicon Vertex detector (SVXII) and the Intermediate Silicon Layers detector (ISL). SVXII will have five layers, located at radial distances between 2.5 and 10.6 cm. The ISL will be located between SVXII and the Central Outer Tracker (COT) with one central layer (6 C) at $\approx$ 23 cm from the beamline and two forward–backward layers (6 and 7 F/B) at $\approx$ 20 and $\approx$ 29 cm from the beamline respectively. Layer 6 C covers the region $|\eta| < 1$, layers 6 and 7 F/B cover the region $1 < |\eta| < 2$. The total length of the ISL is about 2 m (Fig. 1). The ISL detector will strengthen the overall tracking capabilities in the region $|\eta| < 1$ and allow tracking in the forward ($1< |\eta| < 2$) region. In the forward region, silicon–only tracking will be possible, using the SVXII and ISL measurements. Simulation studies have shown that the geometrical acceptance of the SVXII-ISL detectors is over 95% up to $|\eta| \approx 1.7$ and is still 50% at $|\eta| \approx 2.0$ with a momentum resolution σ_{P_t} $\approx 0.04 \cdot P_t^2$ (where P_t is in GeV/c).

Figure 1. The ISL detector. Only half of the sensors are displayed.

2. ISL components

The ISL detector is composed of 296 basic units, the *ladders* (see Fig. 2). Each ladder is made of three silicon sensors bonded together to form one electrical unit, and glued on a carbon fiber support. The readout hybrid is mounted off the silicon and glued on the edge of the support. Two ladders form a module. The modules are mounted on the carbon fiber support structure, the *space frame*.

2.1. Ladders

The silicon sensors are double–sided AC coupled microstrip detectors from high resistivity n–type silicon bulk material. They have 512 strips/side (112 μm pitch). Strips on the $r-\phi$ side run parallel to the beamline while those on the $r-z$

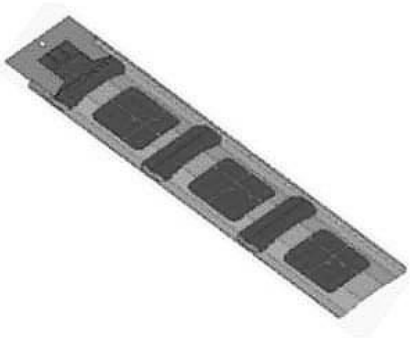

Figure 2. Scheme of the ISL ladder.

Figure 3. Picture of half ISL space frame

side are at a small stereo angle (1.2^o). Layer 7 will have 7.4×5.5 cm^2 sensors produced by Micron Semiconductors from $6''$ wafers. A slightly shorter version (6.7×5.7 cm^2) of similar detectors is manufactured by Hamamatsu from $4''$ technology and installed on the inner layer. All together the active area is ≈ 3.5 m^2. Signals from the silicon sensors are read out by rad–hard SVX3 chips, which perform signal integration, analog pipelining, digital conversion and data sparsification for each of the 128 channels per chip [2]. The SVX3 chip continuously performs the analog data acquisition during digitalization and readout. This feature allows operation for Level 1 acceptance rates up to 50 kHz. Each ISL hybrid hosts 4 SVX3 chips on each side, for a total of 8 chips per hybrid. The total number of readout channels is $\approx$ 300,000.

The lightweight yet stiff carbon fiber ladder support is designed to allow an easy assembly and microbonding.

2.2. Space Frame

The modules will be kept in the final position by a lightweight carbon fiber structure, the space frame. The space frame is made of eight hollow carbon fiber rings (flanges) connected by carbon fiber rods, for a total weight of ≈ 7 kg before mounting the modules. It is ≈ 2 m long and it will also support the SVXII detector (see Fig. 3). The design also incorporates a carbon fiber outer screen which will give enormous rigidity to the whole structure. Finite element analysis predicts a maximum gravitational sag $< 30\ \mu m$ in the center. Carbon fiber was chosen to minimize material and maximise rigidity. 4 plies of carbon fiber (each 125 μm thick) are used for flange construction. Thin layers of beryllium (*ledges*) are precision–glued on the flanges. They support the ISL modules and precision–locate the silicon sensors with an accuracy of 50 μm[3].

The ISL space frame was built in Pisa and shipped to Fermilab in July 1999.

3. Conclusion

The ISL detector is a challenging project for position tolerance, number of readout channels and engineering design. The space frame has been completed. Several working pre-production ladders have been built and tested. Ladder production is expected to start in Fall 1999.

References

[1] CDF II Collaboration, *Technical Design Report*, FERMILAB-Pub-96/390-E 1996.

[2] A. Munar for the ISL group, "*The CDF ISL Detector*", to appear in: "*Il Nuovo Cimento*" as proceedings of "*RD99 Conference*", Florence, June 1999.

[3] F. Palmonari for the ISL group, "*The ISL Spaceframe*", ibid.

* The CDF ISL group:
A. Affolder, P. Azzi–Bacchetta, N. Bacchetta, A. Barbaro–Galtieri, G. Barker, A. Basti, F. Bedeschi, D. Bisello, S. Blusk, W. Caskey, G. Chiarelli, A. Connolly, R. Demina, R. Ely, R. Field, M. Garcia–Sciveres, K. Giolo, D. Goldstein, J. Goldstein, G. Grim, M. Guerzoni, R. Haas, C. Haber, K. Hara, F. Hartmann, A. Heiss, C. Hill, M. Hrycyk, J. Incandela, Y. Kato, D. Knoblauch, M. Kruse, R. Lander, C.M. Lei, G. Leonardi, S. Leone, G. Martignon, Y. Miyazaky, A. Moggi, T. Muller, A. Munar, T. Okusawa, F. Palmonari, M. Paulini, D. Pellett, G. Piacentino, F. Raffaelli, F. Roederer, D. Saltzberg, M. Schilling, M. Shimojima, D. Stuart, T. Takano, K. Takikawa, M. Tanaka, P. Tipton, N. Turini, I. Volobouev, W. Yao, T. Yoshida, H. Wenzel, T. Wilkes, F. Zetti, S. Zucchelli.