CDF Run 2b Silicon Report
Executive Summary

The CDF Run 2b Working Group
For the CDF Collaboration

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The CDF Run 2b Silicon Working Group Report[1]: Executive Summary

We have studied the lifetimes of all components of the CDF Run 2a silicon detectors. We have established integrated luminosity levels which we believe can be attained with reasonable detector performance. We cannot guarantee that these safe limits, which are listed in Table 1, can be exceeded. As a result, we have seriously considered the possibility that a substantial portion of the Run 2a detector will not survive Run 2b (15 fb^{-1}). In particular, there is a significant likelihood that L00, the innermost 3 layers of SVX-II, and all SVX-II port-cards will need to be replaced.

In order to minimize lost running time, CDF should be prepared to install new silicon detector components during the shutdown for accelerator luminosity upgrades. This is currently scheduled for late 2003 or early 2004. An alternative later date, while allowing more time for detector design and production, is not in the interest of CDF physics goals and should be avoided.

A major renovation, on such a short time scale, that retains or improves the CDF detector performance, requires the use of simple components, designs, and streamlined construction techniques. To that end, the Run 2b Silicon Working Group has carefully studied the Run 2a detector experience and many new technological developments in the field - such as those now being used for LHC silicon trackers. The Working Group then developed and studied detailed examples for several replacement scenarios.

The conclusion that we draw from our studies is that a full replacement of the L00 and SVX-II detectors would have the greatest likelihood of achieving our schedule, performance, and luminosity goals. There are many reasons why this is true. First of all, a careful analysis of partial SVX-II replacement scenarios indicates that the shutdown period required would be a minimum of 9.5 months and possibly as much as 14 months. This is an unacceptably long time to be off the air. In addition, partial SVX-II replacement scenarios were found to involve more risk and a potential loss of performance. Alternatively, an example of a full replacement scenario was developed by the Working Group that would have lower risk and potentially improved performance over the Run 2a detector. Unfortunately, in either case the replacement project would be of substantial scale. Initial estimates for the resources required for full and partial SVX-II replacement scenarios are presented in Table 2 and Table 3, respectively.

With an accumulation of as little as 0.5 fb^{-1}, (but preferably 1 - 2 fb^{-1}), of data on tape, the Working Group expects that the longevity of Run 2a components will be much better understood. This will occur in the first year of running and will allow us to greatly refine our plans. For example, we may determine with good confidence that only L00 and L0 will not survive to 15 fb^{-1}. In this case, we will only need to replace L00. This could be done with either a replica of the Run 2a device using more rad-hard components, or pixels. The latter have the potential to greatly enhance the overall performance of the tracker. At the other extreme, it is possible that the majority of SVX-II layers need to be replaced. In this case, as mentioned above, we must be prepared to make a timely but major replacement

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in the shortest possible shutdown period. The Working Group finds that this can only be achieved if all of SVX-II and L00 are replaced by a new system that is constructed, tested, and ready to install in ISL at the start of the shutdown.

To be prepared to start building the right replacement components at the right time, we need R&D to be carried out in FY01. We have prepared a proposal for an R&D program that would focus on the design of a new sub-micron readout chip starting as soon as possible. For either a partial or a full SVX-II replacement, production readout chips will be needed in quantity in just over 2 years. Our FY01 R&D program would also have as its goal the development of robust new hybrids and port-cards, and a well developed and prototyped mechanical design for a new silicon tracker. We would continue our studies of pixels which we believe could provide major benefits to the CDF physics program.

We foresee the following time line for the CDF Run 2b Silicon tracker. In FY01 we would hope to get half way to the completion of a new readout chip to replace the SVX3D. We would also produce prototypes of our new hybrid and port-card concepts as well as prototypes of modules and module support and cooling systems. For pixels we would prototype cooling and mechanics and refine our understanding of new DAQ components. R&D would continue on the chip and sensor within the already existing FNAL pixel development project. By the end of FY01 we would prepare refined designs of potential replacement systems and also refine our cost estimates and schedules. By that time or shortly thereafter, we would expect to have enough collider data to greatly refine our lifetime estimates of the Run 2a system. From these new estimates we would make a decision about the scale of the Run 2b replacements and would choose a system design based upon the knowledge gained in our FY01 R&D program. The design would be adjusted to have a scope that matches the time available before the replacement shutdown. The final system choice and proposal would be presented to the PAC and FNAL directorate as early as possible in FY02.

The Working Group believes that the plan just outlined is the most reasonable one available to us at this time. The FY01 R&D program is the most critical element of this plan. We strongly recommend that the FNAL PAC and Directorate support this effort immediately. The resources we need for FY01 R&D programs for micro-strips and pixels are summarized in Table 4 and Table 5, respectively. While not negligible, the Working Group feels that the M&S costs and manpower needs are not large and represent our only insurance for continued operation in Run 2b. We strongly recommend that there be a decision to support this program at the FNAL PAC meeting held at FNAL in November of 2000.

Layer	Safe Lifetime (fb^{-1})	Cause of Death
L00	7.4	V_{dep}
L0	4.3 (5.6)	S/N (V_{dep})
L1	8.5 (10.9)	S/N (V_{dep})
L2	10.7	V_{dep}
L3	23 (30)	S/N (V_{dep})
L4	14	V_{dep}
L6	> 40	n/a
L7	> 40	n/a
L8	> 40	n/a
SVX-II port-cards	5.7	DOIM
ISL & L00 port-cards	14.6	DOIM

Table 1: Safe lifetimes for each layer of SVX-II as defined in the text. In the "Cause of Death" column S/N stands for signal to noise and V_{dep} for depletion voltage.

Item	Estimated Cost k$	Contingency	Total Costs
0.25 μm Chip submissions	300	150	450
Silicon	800	300	1,100
Fine-pitch Cables	200	200	400
Hybrids & Pig-tails	600	200	800
Power Supplies	200	100	300
Port cards	500	350	850
Mechanics & Cooling	400	400	800
Be beam pipe	150	50	200
Total M&S	3,150	1,750	4,900
Manpower	Estimated (FTE-years)	Contingency	Total
IC Engineers	2.5	1.5	4.0
Mech. Engineers	6.0	3.0	9.0
Module Labor	8.0	4.0	12.0
Final Assembly Labor	4.0	2.0	6.0

Table 2: Costs involved in making a full SVX-II replacement.

Item	Estimated Cost k$	Contingency	Total Costs
Chip submissions	300	150	450
Silicon	700	350	1,050
Hybrids & Pig-tails	300	150	450
Fine-pitch Cables	200	200	400
Power Supplies	200	100	300
Port cards	350	175	525
Mechanics & Cooling	350	175	525
Be beam pipe	150	50	200
Assembly fixtures	100	50	150
Total M&S	2650	1,400	4,050
Manpower	Estimated (FTE-years)	Contingency	Total
IC Engineers	2.5	1.5	4.0
Mech. Engineers	4.0	2.0	6.0
Module Labor	11.0	6.0	17.0
Final Assembly Labor	6.0	3.0	9.0

Table 3: Costs involved in making a partial SVX-II replacement.

Item	Estimated Cost k$	Contingency	Total Costs
FE Chips submissions	60	30	90
Hybrids (LBNL)	55	25	80
Port cards	20	10	30
Module Mechanics	20	10	30
Support Mechanics & Cooling	100	50	150
Total M&S	255	125	380
Manpower	Estimated (FTE-years)	Contingency	Total
IC Engineers	1.5	0.5	2.0
Port-card Engineering	0.5	0.25	0.75
Technicians	2.0	1.0	3.0
Mech. Engineering	1.5	0.75	2.25

Table 4: Resources required for micro-strip R&D in FY01.

Item	Estimated Cost k$	Contingency	Total Costs
DAQ Test stand	15	7.5	22.5
System Mechanics	20	10	30
Staves prototypes	20	10	30
Cooling	15	7.5	22.5
Total M&S	70	35	105
Manpower	Estimated (FTE-years)	Contingency	Total
Mech. Engineering	1.0	0.5	1.5
ESE	0.5	0.25	0.75
Design	1.0	0.5	1.5
Technician	1.0	0.5	1.5

Table 5: Resources required for Pixel R&D in FY01.