The Run IIb CDF Detector Project

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Fermilab

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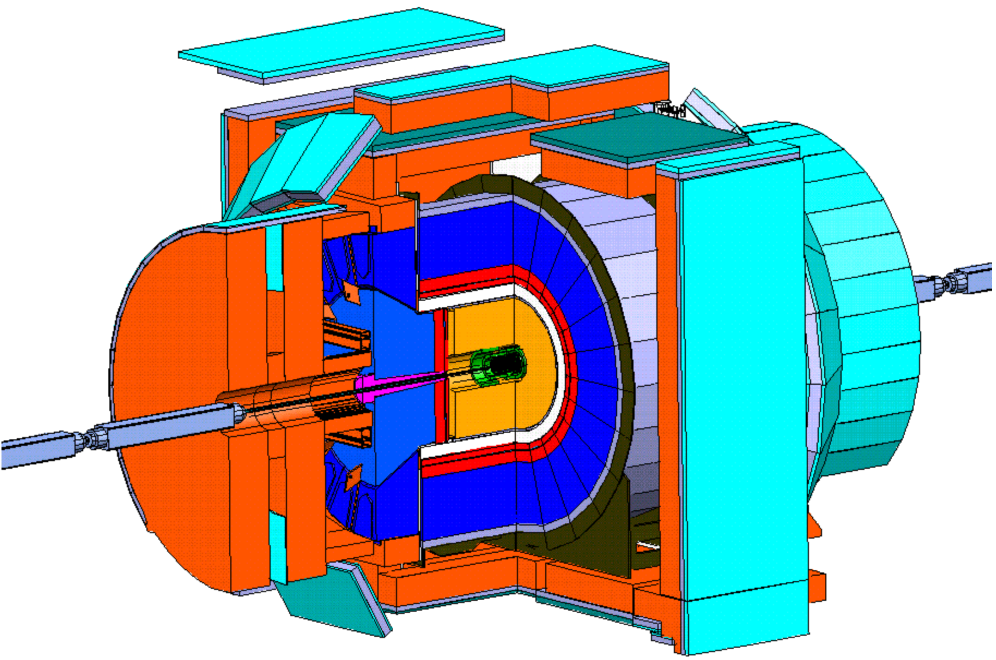
CDF for Run II



- The current detector was designed/built based on Run IIa specifications:
  - Maximum instantaneous luminosity of $2\times10^{32}cm^{-2}s^{-1}$.
  - Integrated luminosity of 2 fb^{-1}.
  - Operation with 396 ns and 132 ns bunch spacing.
- As in Run I, CDF's strength lies in its tracking system
  - Good momentum precision
  - Good vertex precision – b hadron identification

The Run IIb Specifications

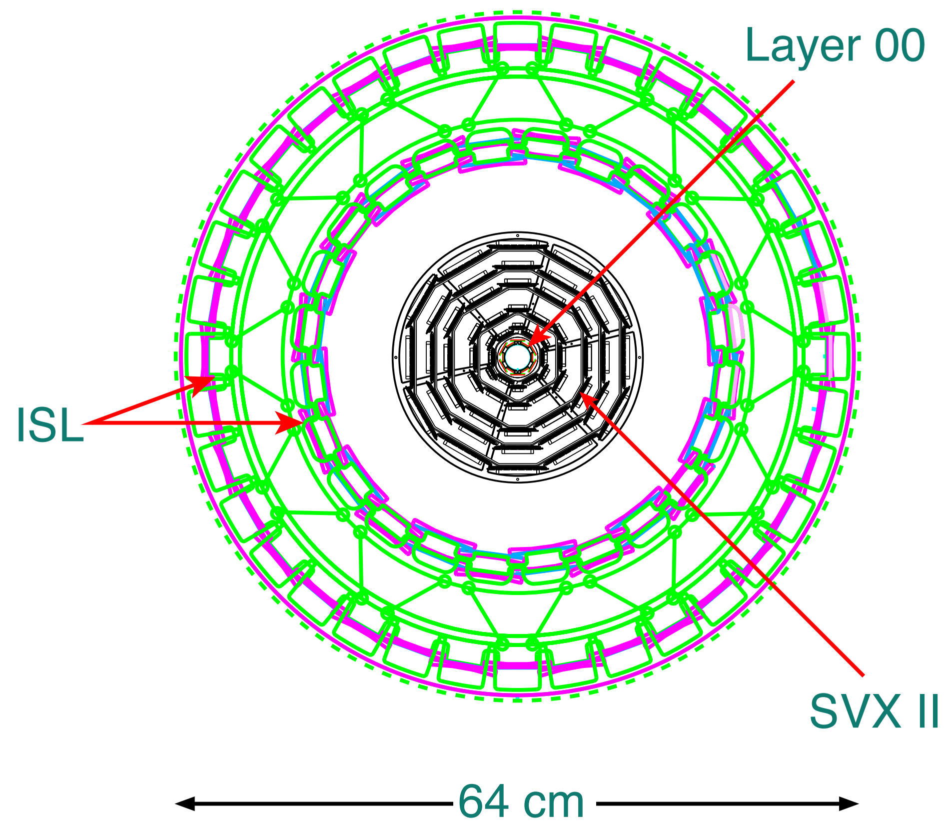
- Operating conditions for Run IIb:
  - Maximum instantaneous luminosity of $4\text{-}5\times10^{32}cm^{-2}s^{-1}$.
  - Integrated luminosity of 15 fb^{-1}.
- Not all portions of the detector can operate effectively in these conditions
  - Integrated luminosity results in radiation damage of the tracking system.
  - Instantaneous luminosity results in high occupancy events and requires increase data acquisition bandwidth.
- The Run IIb project consists of replacements for key elements needed for the Higgs search and maintenance of the high P_T program.

Run IIa silicon system

- Radiation damage tests and rate measurements allow us to predict the lifetime of the SVXII.

Layer	Lifetime (fb^{-1})
00	7.4
0	4.3
1	8.5
2	10.7
3	23
4	14

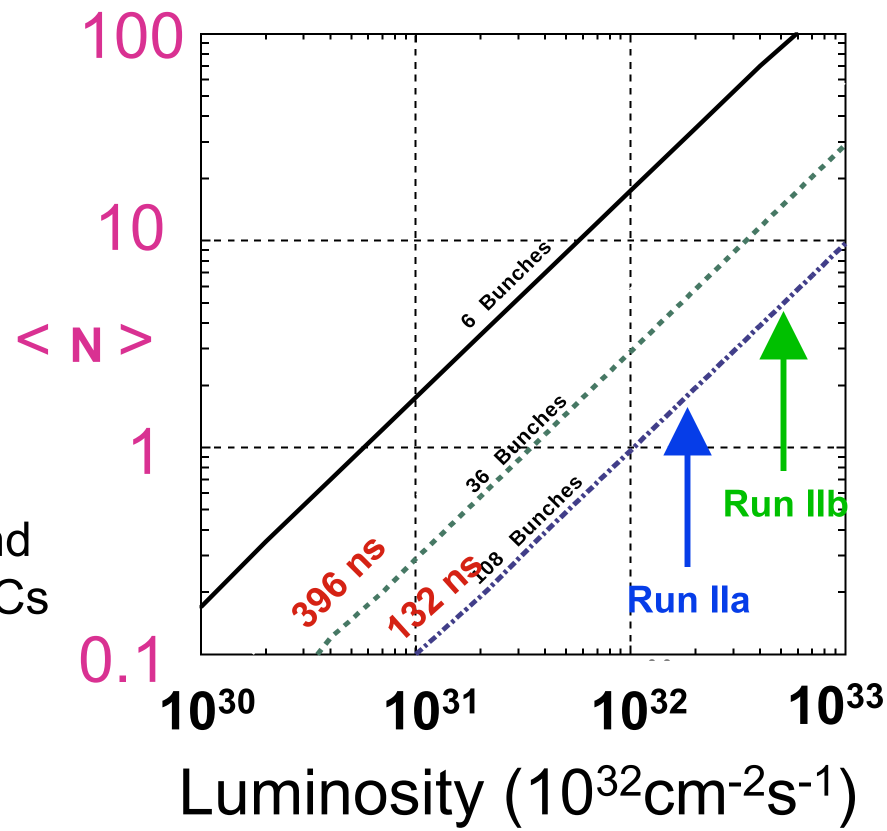
- We are forced to replace the inner layers.



Silicon detector end view

Instantaneous Luminosity

- The instantaneous luminosity of run IIb produces
  - Occupancy problems - fake triggers and overlapping events
    - An issue for the preshower and track trigger
  - Data collection rate problems - handling the data volume/rate
    - Impacts the data acquisition, and exceeds the capacity of our TDCs

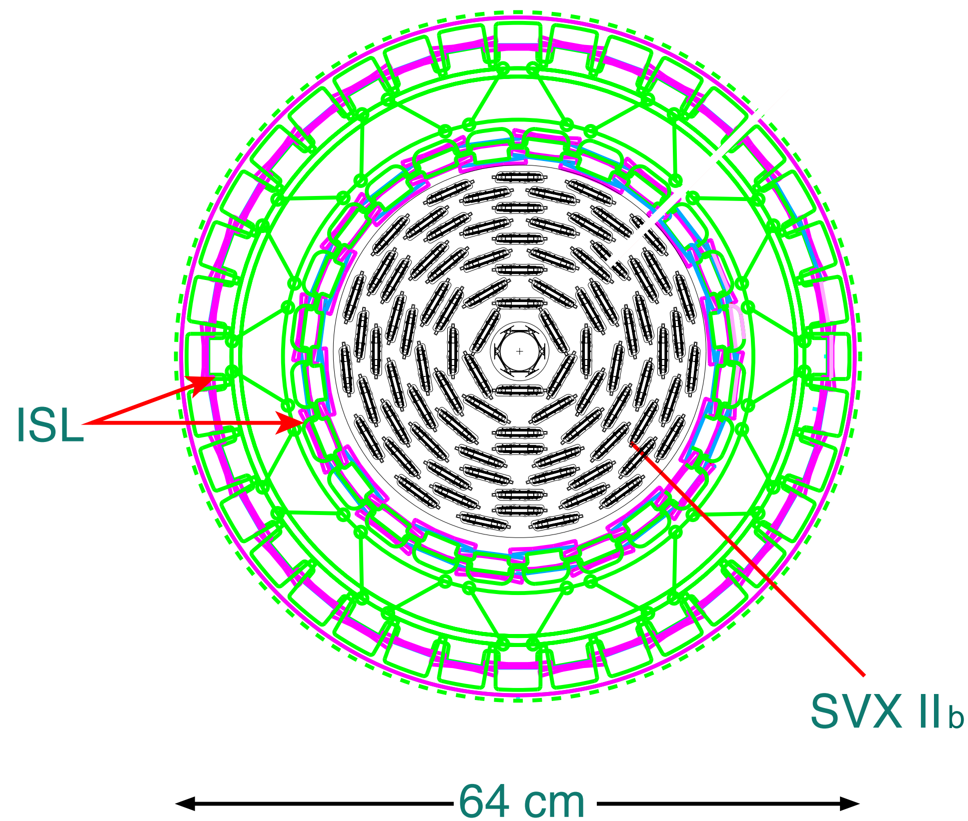


CDF's Run IIb Projects

- We have developed a program of upgrades to the current system that is required to maintain CDF as a viable Higgs search experiment for Run IIb:
  - Replacement Silicon Detector
  - Upgrades to the Calorimeter
  - Upgrades to the Data Acquisition and Trigger system
- This program has been presented to the Physics Advisory Committee and received its approval.

Run IIb silicon system

- All inners layers will be replaced.
  - Partial replacement is risky.
- New detector is designed for quick construction
- A basic module - the “stave” will be built
- This structure will populate most of the detector volume
- This gives the advantage of fewer different parts than the current detector



Silicon detector end view

Calorimeter Upgrades

- The new preshower will replace the existing CPR.
- One of the last pieces of gas calorimetry (most replaced for Run IIa)
  - Replacement uses scintillator
  - Optical fiber readout, with 16 channel phototubes
    - Not a new technology for CDF
- Also, timing capability will be added to the electromagnetic calorimeter

A CPR2 prototype

Data Acquisition

- Our current data acquisition is specified to operate at a level 2 trigger accept rate of 300 Hz.
- The Run IIb high P_T program requires at least 750 Hz capability.
- Upgrades are needed to
  - Event builder switch – collects data from many sources, forms an event, and moves it to the level 3 computers
  - Time to digital converters – TDCs used for the COT have an inherent readout limit at about 300 Hz.

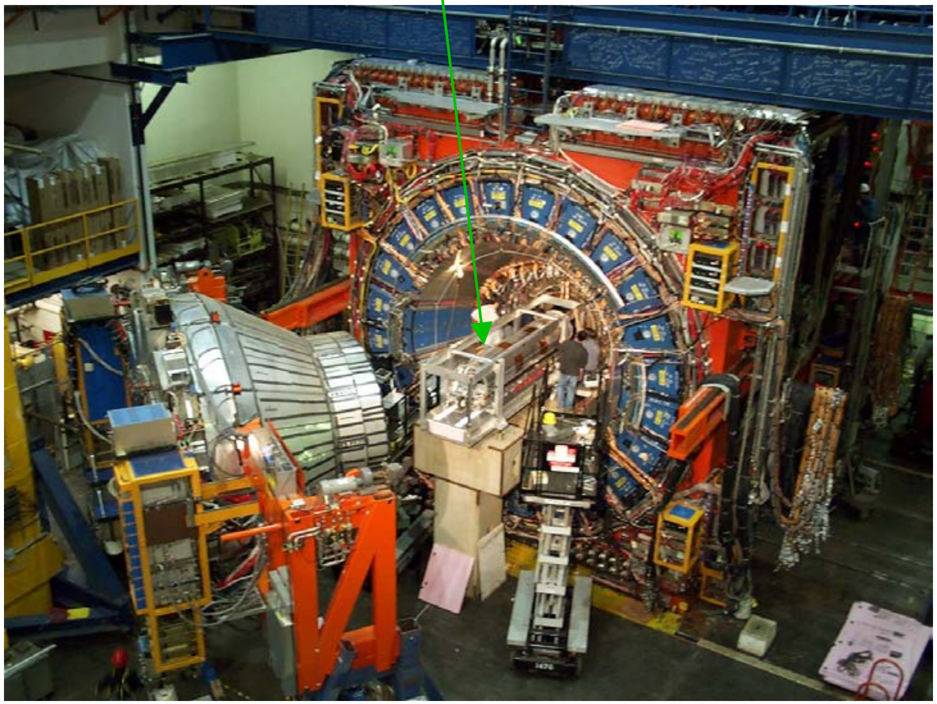
Triggers

- The high event occupancy for Run IIb drives up the rate of fake triggers in the tracking system
  - Fast track trigger (XFT) requires upgrading
- The duration of the run motivates the need for maintenance of processors that will become obsolete, and uneconomical to maintain
  - Level 2 decision crate
  - Level 3 processors (PCs)
    - High occupancy will also drives a need for greater processing power

Silicon Installation

- Silicon detector replacement
  - Space constraints require removal of the central detector from the collision hall
  - This requires 14 weeks (round trip).
- Time constraints force a complete replacement of SVXII.
  - Partial replacement would also be very risky.

ISL and SVXII positioned for installation (Jan. 2001)



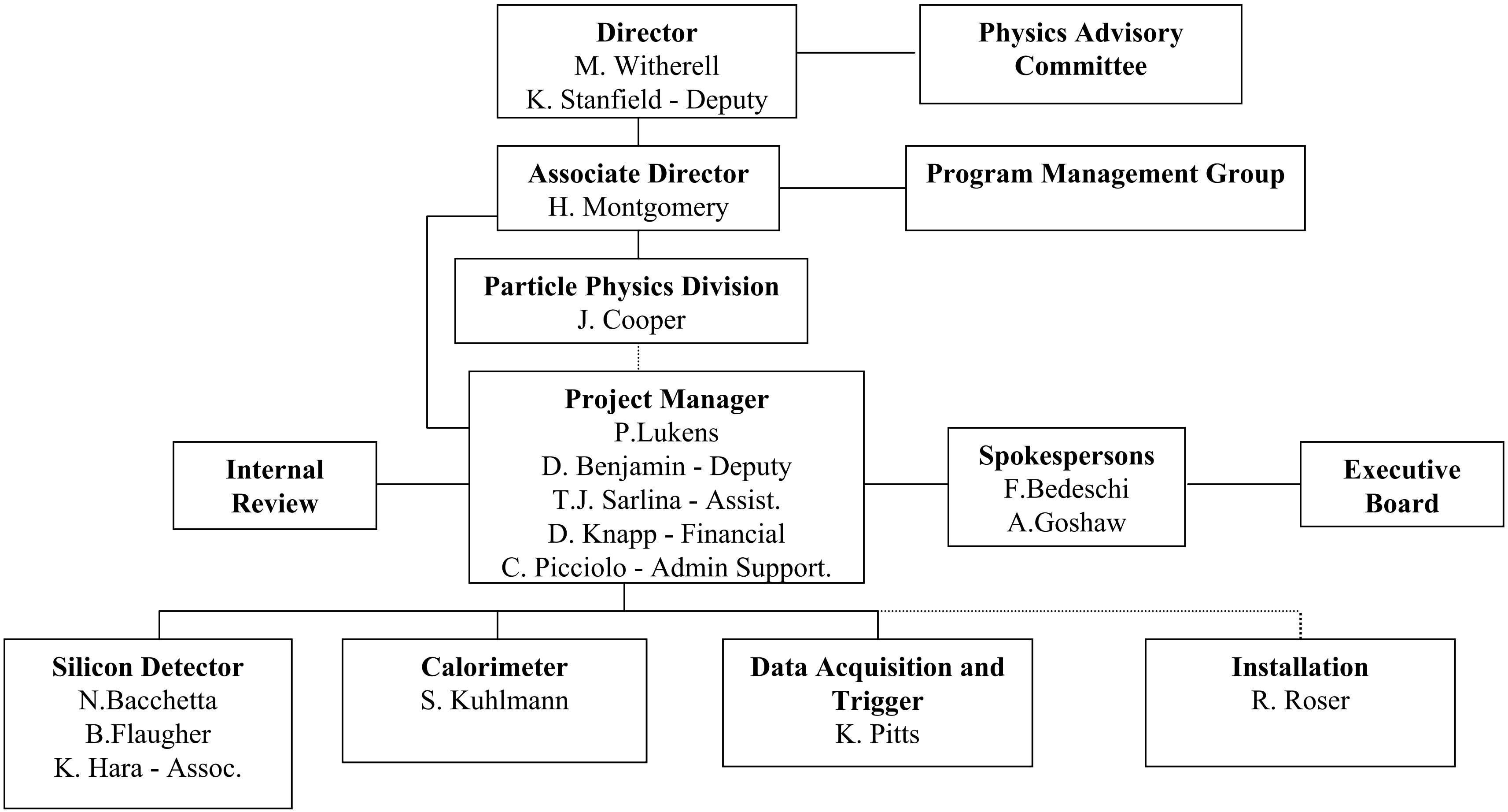
Installation

- The project does not include installation of the detector components in its scope.
  - Project completion is decoupled from Tevatron operations.
  - In this strategy, project completion can be independent of Run IIa operations.
- However, we will manage the installation activities.
  - Resource loaded schedule will be maintained for it.
- We currently plan a 34 week shutdown for the silicon replacement.
  - Installations for preshower and the various cabling tasks occur within that period.

Installation Milestones

Task	Date Completed	Delta (wks) (WRT Silicon complete)
Drop Interlocks, Access to Collision Hall	3/04/05	-7
Central Detector Ready to Roll Out	4/06/05	-2
Install Silicon Interlock Hardware	3/31/05	-3
Silicon Detector Reqd. at Si Det	5/20/05	----
Silicon Detector Ready for Installation	7/15/05	+8
Central Detector Ready to Roll In	8/5/05	+11
Central Detector Moved	8/12/05	+12
Silicon Ready to be powered	8/26/05	+14
Ready for Collisions	11/18/05	+26

Run IIb Organization



Resource Loaded Schedules

- Resource loaded schedules have been created for each subproject.
- All M&S, R&D, and labor costs have been derived from the schedules.
- Labor rates originate from Particle Physics Division
  - Special category created for Silicon Facility labor
- Some labor is contained in M&S costs
  - Silicon work at LBL
  - Preshower construction at Argonne

Schedules

- The silicon detector sets the critical path for the project.
- A base estimate schedule has been written, which the Level 2 managers feel accurately reflects the length of time it will take to build the detector
  - No explicit contingency is included in this base schedule.
  - This is the schedule used to manage the project
- Milestones are placed at the end of significant tasks in the resource loaded schedules.

Schedule Contingency

- A hierarchy of milestones has been established and implemented in the silicon schedule.
  - Level 4 - ~100, used by the project managers
    - Reportable to CDF Run IIb Project Manager
  - Level 3 - A subset corresponding to significant events
  - Level 2 - Copies of the Level 3 milestones, with schedule contingency added.
    - Reportable to the Directorate and DOE Run II Project Manager
  - Level 1 - A subset of the Level 2 milestones, with additional contingency added.
    - Reportable to DOE headquarters

Schedule

- This approach to the schedule strategy gives us a schedule to use for project management
  - Defined by the Level 3/4 milestones.
  - Silicon complete May, 2005
- Schedule contingency is then explicitly inserted before the Level 1 and 2 milestones.
  - Level 2 completion – Dec. 2005
  - Level 1 completion – Nov. 2006
- We plan to treat schedule contingency as we do cost contingency
  - Use will require a formal change control process.

Cost Contingency

- Our cost contingency is calculated for the lowest level tasks in the schedules.
- Guidelines are as follows:

Description	Level
Item is Complete	0%
Purchase order has been placed	10%
Engineering estimate, based on vendor information	30%
Physicist estimate, based on conceptual design	50%
Estimate based on experience	100%

Risk Analysis

- Risk is minimized in the basic design of the subprojects in every way possible
  - Reuse of familiar technologies and techniques
  - Conservatism in the designs - no aggressive performance specifications
  - Ample cost and schedule allocated - contingency added where appropriate.
- Analysis of risk to the current plan has been performed along the lines of a formalism described in the Project Management Body of Knowledge.

Risk Analysis

- Two factors are estimated in the risk analysis
  - Impact factor - severity of impact of an item’s substandard performance on the project (cost overrun, schedule slip, technical performance, etc.)
  - Probability of occurrence - the likelihood that substandard performance will occur
- The product of these gives a risk factor.
- Mitigation is considered for items with a high risk factor (> 0.15).

Risk Analysis

- The impact table is adapted to reflect meaningful situations with respect to the subprojects.
- Risk analyses are performed by the Level 2 managers
  - An separate analysis of our riskiest project (silicon) has also been written by the Run IIa silicon manager.
- High risk items are mitigated
  - Cost or schedule contingency
  - Alternative strategies (additional vendors, preproduction pieces, etc.).

Cost Estimates

- Currently, all cost estimates are obtained by extracting the resource loaded schedule information into a spreadsheet.
- Indirect costs and escalation are then applied to obtain total cost estimates.
- We are working towards a more sophisticated approach - direct loading of the schedule resources into the Cobra financial package.

Project Tracking

- The Cobra financial package will provide a more precise estimator for total costs
  - Indirect charges, labor rates, handled better
  - Timing changes handled correctly (i.e., purchase slips into another year and indirects are adjusted)
- Most importantly, it also takes input from the general ledger for comparison to our schedules.
- This is the tool which will be used to calculate earned value, for tracking the project progress.
  - Currently used by NUMI for their tracking.

Tracking Status

- We have successfully loaded the silicon detector schedule (our largest by far) into Cobra.
  - Sample reports are available
- Other schedules will follow soon.
  - Technical issues for incorporating schedules are understood.
- Interface with the general ledger is in progress.

Total Cost by Subproject

	2002	2003	2004	2005	2006	Contingency	Totals
Silicon	$ 1,418	$ 5,282	$ 5,660	$ 2,023	$ -	$ 7,189	$ 21,573
Calorimeter	$ 67	$ 816	$ 250	$ -	$ -	$ 363	$ 1,496
DAQ/Trigger	$ 43	$ 1,078	$ 2,472	$ 1,509	$ -	$ 2,802	$ 7,904
Administration	$ 201	$ 325	$ 341	$ 343	$ 6	$ 608	$ 1,825
Total	$ 1,728	$ 7,502	$ 8,723	$ 3,875	$ 6	$ 10,962	$ 32,798

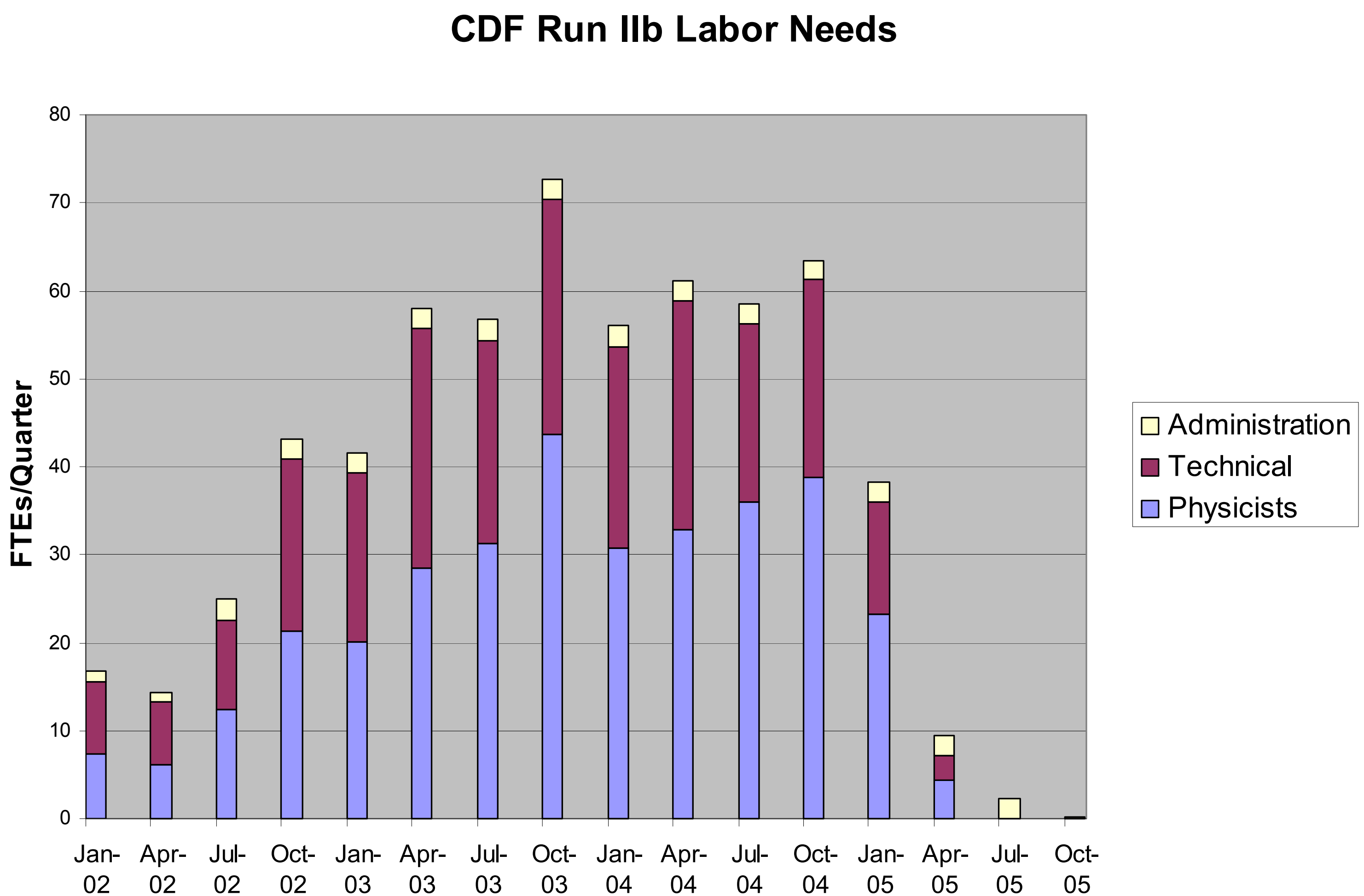
Total costs (with G&A) in AY $K

- Our overall contingency is 50%.
- Additional resources are required in the form of contributed labor.
  - Physicists are not considered part of the project cost.
  - This labor is included in the schedules.

Foreign Contributions

- Substantial foreign funding is anticipated
- Japan
  - Sensors and analog cables for layer 0
  - Phototubes and bases
- Italy
  - Chip engineering, power supplies for silicon
  - ASDs, fibers, scintillator for calorimeter
- Discussion are underway with Taiwan, Korea, and Canada for contributions to silicon.

Labor Required



Funding Required

Cost (AY $K)	2002	2003	2004	2005	2006	Totals
Silicon	$ 709	$ 4,843	$ 6,670	$ 5,056	$ 1,702	$ 18,981
Calorimeter	$ 63	$ 830	$ 307	$ 154	$ 86	$ 1,439
DAQ/Trigger	$ 141	$ 887	$ 2,784	$ 2,698	$ 663	$ 7,173
Administration	$ 163	$ 407	$ 437	$ 601	$ 150	$ 1,758
Total Equ. Cost	$ 1,076	$ 6,967	$ 10,197	$ 8,509	$ 2,602	$ 29,352
R&D Cost	$ 1,179	$ 2,008	$ 242	$ 17	$ -	$ 3,446
Total Project Cost	$ 2,255	$ 8,975	$ 10,439	$ 8,527	$ 2,602	$ 32,798
Funding (AY $K)						
DOE - Equip. Total	$ 3,500	$ 3,469	$ 9,401	$ 8,508	$ 2,602	$ 27,480
DOE - R&D	$ 1,670	$ 480	$ -	$ -	$ -	$ 2,150
Japan	$ 235	$ 1,171	$ 786	$ -	$ -	$ 2,193
Italy	$ 65	$ 374	$ 168	$ -	$ -	$ 606
University base	$ 19	$ 248	$ 83	$ 19	$ -	$ 369
Total Funding	$ 5,488	$ 5,742	$ 10,439	$ 8,527	$ 2,602	$ 32,798

- Costs include G&A and Contingency
- All costs/funds are in AY $K

Upcoming large (> $50K) critical procurements

- FY 1st quarter
  - Production sensors (11/25) $363K – Japanese purchase
- FY 2nd quarter
  - Hybrid test stands (2/21) $200K
- FY 3rd quarter
  - Production SVX4 chips (5/20) $325K
  - Production sensors (5/22) $300K

Summary

- We have developed a well focused program to upgrade CDF for the Run IIb era.
- This project will maintain the high P_T physics program, and enable CDF to continue as a Higgs search experiment until the LHC era begins.
- The window of opportunity for Run IIb requires the detector upgrades to begin soon.
  - Major purchases for silicon are scheduled for November.

Conclusion

- The CDF collaboration has a strong history of supporting the experiment, and has made good use of the data.
  - Recent Spokesmen's poll indicated ample scientific manpower will be available for the project.
- We are fully committed to proceeding with the Run IIb CDF detector project, and we are eager to get going.

Impact Factors

	Very Low Risk 0.05	**Low Risk 0.1**	**Moderate Risk 0.2**	**High Risk 0.4**	**Very High Risk 0.8**
Cost Objective	Insignificant cost increase	< 5% Cost increase	5-10% Cost increase	10-20% Cost increase	> 20% Cost increase
Schedule Objective	Insignificant schedule slippage	Schedule slippage < 5%	Overall Project slippage 5-10%	Overall Project slippage 10-20%	Overall Project slippage > 20%
Scope Objective	Scope decrease barely noticeable	Minor areas of scope affected	Major areas of scope affected	Project scope reduction unacceptable for physics objectives	Scope of project effectively useless for mission
Technical Objective	Technical degradation of project barely noticeable	Technical performance of final product minimally affected	Technical performance of final product moderately affected	Degradation of technical performance unacceptable for physics objectives	Technical performance of end item effectively useless for mission