Update from the DØ Collaboration on the Run IIb Upgrade Project

August 22, 2003*

EXECUTIVE SUMMARY

We summarize our current understanding of the DØ Run IIb silicon detector upgrade and present updated information that has become available since the Fermilab PAC meeting in June.

The silicon detector project is on time and on budget. By the end of July, we had obligated or spent $7.5M, which is 47% of the $16.0M base cost of the project. This includes $1.7M from an NSF MRI grant, and significant university and foreign matching contributions.

We have made a serious effort to re-optimize and reduce the time spent installing and commissioning the silicon detector. A full project planning exercise indicates that, given sufficient support from the collaboration and laboratory, DØ can be ready for beam after 14 weeks of downtime. This shutdown roughly shadows the time needed for Beams Division activities and so has minimal impact on delivered luminosity. It is possible because the DØ silicon upgrade is installed in two halves, inside the collision hall, without a time consuming roll-out and roll-in of the detector. We believe we can be recording physics quality data after an additional 14 weeks of commissioning time with beam. A commissioning period of roughly this duration would be required in any event, in order to commission the trigger upgrades.

The physics potential of Run II remains exciting. The DØ and CDF collaborations have worked together to re-evaluate the sensitivity of Run II to a Standard Model Higgs. A new, critical and more detailed evaluation was undertaken, and the original conclusions proved quite robust. The luminosity required to discover or exclude the Higgs may even be less than originally thought. We believe that all the physics which originally motivated Run IIb remains within reach, and is well worth pursuing.

Under all scenarios, the silicon upgrade delivers a large, well-quantified boost in physics sensitivity. Using GEANT together with full pattern recognition, track finding and a realistic b-tagging algorithm, we have simulated the double b-tagging efficiency for the current detector with and without radiation damage, and for the upgraded detector. We find that the double tagging efficiency is degraded by 40-70% in the current detector after radiation damage. In contrast it is increased by 70% in the upgrade, thanks to greater acceptance, additional layers, and improved impact parameter resolution. Following the paradigm introduced by the PAC, we quantify the impact of the upgrade in terms of the integrated, double-b-tag weighted luminosity (a measure of physics sensitivity for such processes as Higgs, top, technicolor and supersymmetry). We find that this physics sensitivity measure is effectively doubled for the Tevatron design luminosity by the silicon detector upgrade, and it is increased by a factor 1.5 in the base scenario. Such gains are very significant — surely such an increase in accelerator luminosity would be judged well worth the investment. Moreover, the gain from the upgrade is robust: for example, it drops by only 4% if the total commissioning time ends up being 50% longer than assumed.

The DØ Collaboration agrees that the decision on whether to proceed with the silicon detector upgrade should be taken with the goal of maximizing the physics potential of the Tevatron. The cost is modest, and the benefit real, under any scenario. On this basis, **the only defensible conclusion is to proceed with the upgrade.** The collaboration is committed and eager to do so.

* Typographically corrected version

Introduction

This document summarizes our current understanding of the Run IIb silicon upgrade and includes information that has become available since the Fermilab PAC meeting in June.

The DØ Collaboration supports the stated policy of the Fermilab Director, that the decision on whether to proceed with the silicon detector upgrade should be taken with the **goal of maximizing the physics potential of the Tevatron.** On this basis, we believe that **the only defensible conclusion is to proceed with the upgrade.** The project is on schedule and on-budget, with 47% of the base project funds having been obligated or spent. The sensitivity gains from the upgraded detector are real and demonstrable and significantly increase the effective luminosity of the Tevatron complex. The upgraded silicon can be installed within the time constraints of the planned accelerator down-time, thus having minimal effect on delivered luminosity. The silicon upgrade maximizes the physics output of the Tevatron no matter what the accelerator performance turns out to be. The physics case remains broad and compelling.

Proceeding with the upgrade now, after so much discussion and uncertainty, will require a measure of boldness and determination. The decision will be scrutinized, even attacked, and will need to be staunchly defended. But we strongly believe that any other course of action will significantly reduce the physics from the Tevatron and will be detrimental to the vitality of the whole US high energy physics program.

1 Sensitivity Gains and Impact of Radiation Damage

The Fermilab PAC chose to measure the physics sensitivity of the Tevatron detectors using delivered luminosity weighted by double b-tag efficiency. We concur with this technique, because double b-tagging is critical for standard model and SUSY Higgs searches, for the collection of a pure top-antitop sample for precise mass measurements, and the pursuit of many other interesting processes.

We have studied the probability to tag two b-quark jets in Higgs events using a full GEANT simulation of the silicon detector with full pattern recognition, track finding, and a secondary vertex tagging algorithm[1]. The algorithm is based on counting tracks with significant signed impact parameter. We tuned the performance so as to achieve the same mistag rate (probability to tag a light quark jet as a b-jet) under all conditions. We studied the impact of three models for the effect of radiation damage on the detector:

- Damage Model A: total loss of the innermost layer detectors, but no impact on the other detectors.
- Damage Model B: loss of a random 50% of the innermost layer detectors, 50% of the disk detectors, and 10% of the outer layers (layers 2-4). (This 10% loss is consistent with current operating conditions[2].)

[1] http://d0server1.fnal.gov/projects/run2b/meetings/DOEReviews/Aug03_Update/run2a_irrad.pdf
[2] http://d0server1.fnal.gov/projects/run2b/meetings/PAC/June03/smtlongevity.pdf

- Damage Model C: total loss of the innermost layer detectors, plus loss of a random 50% of the disk detectors, and 10% of the outer layers (layers 2-4).

The results of our studies are summarized in the table below:

Detector configuration	**Double b-tagging efficiency**	
	Higgs Signal + 0 minimum bias events (low luminosity)	Higgs Signal + average 7.5 minimum bias events (luminosity $2\times10^{32}cm^{-2}s^{-1}$)
Current Detector		
- No radiation damage	0.23 ± 0.01	0.19
- Radiation damage model A	0.14 ± 0.01	
- Radiation damage model B	0.14 ± 0.01	
- Radiation damage model C	0.069 ± 0.004	
Upgraded Detector		0.32

Several observations can be drawn from the table:

- The additional overlaid minimum bias collisions at high luminosity reduce the tagging efficiency.
- Radiation damage, if the current detector is not upgraded, reduces the double-tagging efficiency by an amount of order 40% (0.23 to 0.14), and maybe as much as 70% (0.23 to 0.07).
- The new detector offers substantially (a factor of 1.7) improved performance over the current detector.

The latter improvement stems from three changes: increased acceptance owing to the elimination of gaps and cracks in the present geometry, improved impact parameter resolution due to a smaller beam pipe with new layer 0 and 1 detectors close to the collision point, and improved pattern recognition thanks to six silicon barrel layers rather than the four in the current detector.

Still following the example of the PAC, we convoluted the above double tagging efficiency estimates with the "base" and "design" accelerator profiles to obtain a measure of the relative physics impact of the silicon upgrade. To do this, we recalculated the luminosity profile with a shutdown shortened to 14 weeks but leaving all other assumptions unchanged. Excluding the luminosity delivered during the physics commissioning period leads to a base of 4.7 fb^{-1} by the end of FY09 and a design projection of 9.4 fb^{-1} (These numbers are larger than those in the Beams Division plan because the shutdown period is reduced compared with that plan).

The conclusion incorporates the following assumptions:

(a) Radiation damage causes a linear decrease in our double-tagging efficiency from nominal to 0.6×nominal. This corresponds to damage models A or B above; obviously model C would introduce a more dramatic effect. Using our central values for radiation lifetime, the efficiency loss starts at 3.6 fb^{-1} and reaches its asymptotic value at 4.9 fb^{-1}.

(b) There is a 14 week shutdown in either scenario, during which the upgrade would be installed.

(c) This is followed by 14 weeks of commissioning for the new device, in the scenario where the upgrade takes place. The loss of luminosity in this physics commissioning period is tallied and is modest (0.2 fb^{-1} for the base goal and 0.5 fb^{-1} for design).

(d) As enumerated in the table above the new detector delivers 1.7 times the nominal double b-tagging efficiency after commissioning.

One obtains the result shown in Figure 1. It is also instructive to take the ratio of upgraded to non-upgraded scenarios in order to quantify the gain from the upgrade. This is shown in Figure 2.

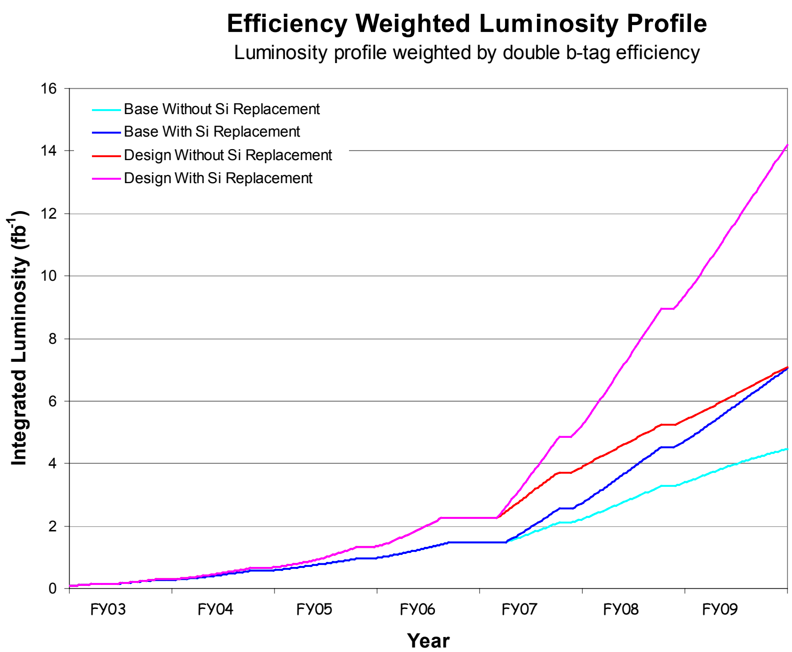

Figure 1. Efficiency-weighted luminosity profile for Run II, showing "base" and "design" luminosities with shortened shutdown, weighted by double b-tagging efficiency with and without a silicon upgrade. The vertical scale corresponds to the equivalent luminosity accumulated with the undamaged, current silicon detector.

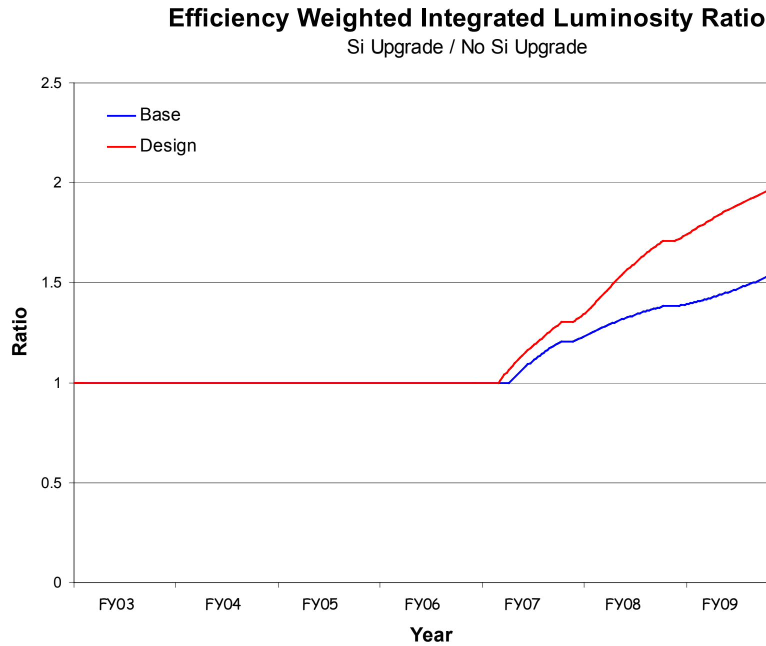

Figure 2. As above, but showing the ratio of efficiency weighted luminosity for the upgraded to the non-upgraded detector.

Whether the accelerator achieves the "base" or the "design" luminosity, there is a significant gain from the upgrade. DØ gains a factor of 1.5 to 2 in effective luminosity or physics sensitivity. These are large relative improvements, and can be compared to taking the base luminosity up to the design level, or the design level to more than the original goal of 15fb^{-1}. Such improvements are well worth accomplishing. The overall program gains 25-50%. Surely a virtually guaranteed 25% increase in accelerator luminosity would be considered to be worth the relatively modest investment required to complete the silicon detector upgrade.

1.1 Radiation Lifetime and Uncertainties

The DØ detector is substantially less radiation-hard than the CDF detector, due to the use of Micron sensors on the innermost layer of the DØ detector. We expect that the lifetime of the silicon tracker will be limited by micro-discharge breakdown of the junction in the Micron-supplied detectors in the inner four barrels[3]. This will begin to occur at bias values of ~150 volts and all channels will fail at bias values of ~200 volts. This means that we will start to lose significant numbers of channels at an integrated luminosity of 3.6 ± 1.8 fb^{-1} and that 100% of the channels on the inner layer will be dead by 4.9 ± 2.5 fb^{-1}. These estimates have not changed since the PAC meeting. They are central values, not "safe lifetime" numbers. The uncertainties reflect how well we can estimate the micro-discharge formation and dose accumulation. As demonstrated in Figure 3, varying the radiation lifetime impacts the integrated, double b-tag weighted luminosity.

[3]http://d0server1.fnal.gov/projects/run2b/meetings/PAC/June03/smtlifetime.pdf

The ratio at the end of 2009 varies from 1.8* to 2.2 for the design profile and from 1.5 to 2.0 for the base, if the radiation lifetime is varied by $\pm 1\sigma$. We believe that this only strengthens the case for silicon detector replacement.

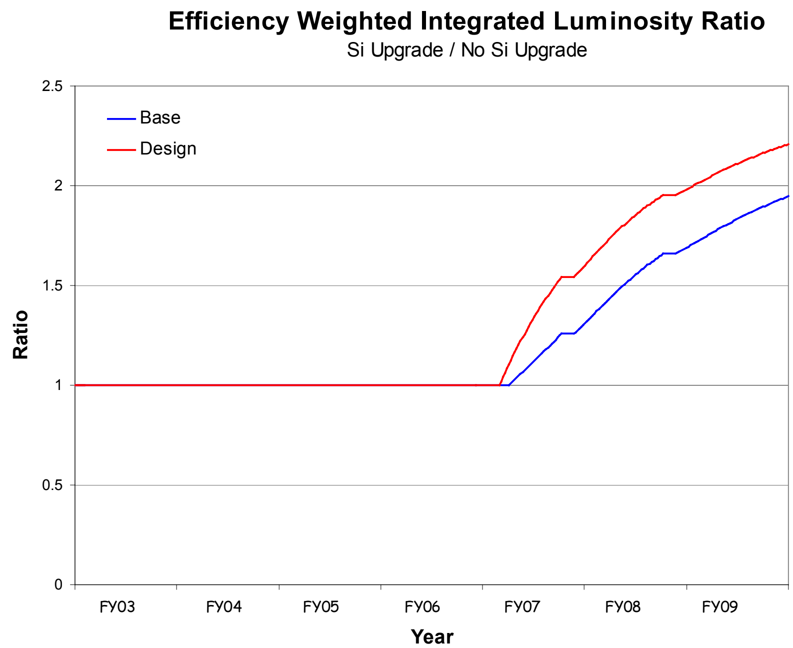

Figure 3: As Fig.2 but assuming a one standard deviation faster onset of radiation damage.

* Mistakenly quoted as 1.6 in the August 15 version of this document.

2 Physics Motivation

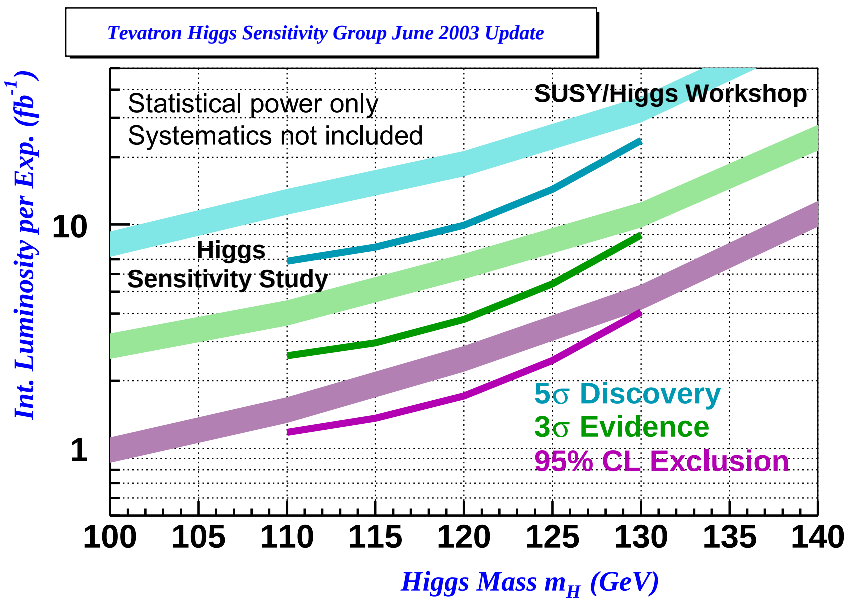

Figure 4. Update on the Higgs Sensitivity Study. The broad bands show the range of prediction from the 1998 Run II SUSY/Higgs workshop; the narrower lines are the new predictions.

As has been widely reported, the CDF and DØ collaborations have undertaken to revisit the Standard Model Higgs reach and to update the standard luminosity reach plot[4]. The result is shown in Fig. 4 (which assumes the tagging efficiency of the upgraded detector.) The most important lesson to be drawn from this study is that when a new, critical and more detailed evaluation was undertaken the original study's conclusions proved quite robust. The luminosity required to discover or exclude the Higgs may even be less than originally assumed. The physics which originally motivated Run IIb still remains important and it still remains within reach — and we should be willing to pursue it.

Of course, there is much more to the physics of Run II than just the Higgs. The broad program of searches and standard model physics argues for the silicon upgrade. For example:

- The sensitivity to B_s mixing critically depends on the innermost silicon layer. Our proper time resolution will be significantly improved with the new inner layers in the upgraded silicon detector. Without it, radiation damage will eventually make this measurement impossible and prematurely curtail an otherwise very promising b-physics program.
- In many SUSY models, the stop or sbottom squarks are significantly lighter than the other squarks and have heavy flavor signatures. SUSY cascade decays of gluinos can produce copious heavy flavor. The supersymmetric Higgs sector can be constrained or discovered through associated production of a Higgs plus two b-jets, an analysis that requires three b-tagged jets in the final state.

[4] http://flywheel.princeton.edu/~wfisher/docs/HSGnote.pdf

- Many non-SUSY physics models such as topcolor and technicolor yield heavy flavor signatures that require b-tagging.
- The top mass measurement is the single most critical precision measurement in Run II. It strongly depends on having a pure sample with minimal jet combinatorics in order to get the best resolution, and on $Z \rightarrow b\bar{b}$ calibration samples. All this requires efficient double b-tagging.

3 Silicon Technical & Cost Status

3.1 Technical Status

The silicon upgrade continues to make excellent technical progress on all fronts[5]. The table below enumerates the status of the major components. Details are provided in the following text.

The development of the SVX4 chip has been an unqualified success. The second prototype version of the chip was received in May and appears to meet our requirements, eliminating the need for an additional design iteration. Sign off for final chip production is expected to occur within the next month.

Component	Vendor	Design	First Prototype Ordered	First Prototype Delivered	Second Prototype Ordered	Second Prototype Delivered	Final Order	Delivered
L0 Sensors	ELMA	✓	✓	✓				
	HPK	✓						
L1 Sensors	ELMA	✓	✓	✓				
	HPK	✓	✓	✓				
L2 Sensors	HPK	✓	✓	✓			✓	in progress
Analogue Cable	Dycx	✓	✓	✓	✓	✓		
L0 Hybrid	Amitr.	✓	✓	✓	✓			
L1 Hybrid		✓	✓	✓				
L2A Hybrid	CPT	✓	✓	✓	✓			
	others	✓	✓	✓	✓			
L2S Hybrid		✓	✓	✓	✓			
Digital Cable	Honey	✓	✓	✓	✓	✓		
	Basic	✓	✓	✓	✓	✓		
Junction Card		✓	✓	✓	✓			
Twisted Pr. Cable		✓	✓	✓	✓	✓		
Adapter Card		✓	✓	✓	✓	partial		
Purple Card		✓	✓	✓	✓	✓	✓	✓
Test Stand Elctr.		✓	✓	✓			✓	✓

Table 2: Major component status summary for the DZero Silicon Detector

5 http://d0server1.fnal.gov/projects/run2b/meetings/DOEReviews/Aug03_Update/RunIIb_technical_status_Aug03.pdf

Prototype versions of the three silicon sensor types were specified, designed, ordered, produced, probed, and tested during 2002 and through early 2003. Some of the prototype sensors were also subjected to detailed irradiation tests to ensure that they will withstand the anticipated radiation doses. The full production order for the outer layer sensors was placed in April 2003, and the first installment of 130 sensors was received on August 1. This $1.5M order represents the largest single procurement in the upgrade project. Initial characterization tests of these production sensors have shown no measurable difficulties thus far.

Prototypes of all four versions of the ceramic hybrids have been designed, fabricated, and tested, and SVX4 chips have been surface-mounted on all four versions. The hybrids also were mounted on sensors to study readout performance. All four types of hybrids have been successfully read out, and the noise performance was found to be excellent. Pre-production versions of all the hybrid types have been designed, and the outer-layer pre-production hybrids are currently being fabricated.

The analog cables which carry the analog signals from the Layer 0 sensors to the readout hybrids are technically very challenging; we are therefore quite pleased with the success of our prototyping efforts. The last set of prototype cables received was both mechanically and electrically flawless. The cables were used in the construction of full-scale Layer 0 modules, equipped with the pre-production version of the Layer 0 hybrid, and the modules met all our electrical and noise requirements.

Development of the other primary readout elements – junction cards, adapter cards, purple card, digital jumper cables, twisted pair cables – have also progressed very well, and are either at the prototype or pre-production fabrication or testing phase. In addition, prototypes of the temperature monitoring and radiation monitoring systems are under development and testing has begun. Monitoring software also is being written in preparation for the full-scale testing effort. Database development for detector production, commissioning, and operation is also underway.

A prototype version of the carbon-fiber support structures for the Layer 0 and 1 sensors has been designed and tests of the performance of prototype modules on those support structures were performed to evaluate details of the grounding to minimize noise. Results were excellent. All mechanical and thermal finite element analyses of these support structures are complete, and fabrication of a pre-production support structure with co-bonded flex-circuits for good grounding is in progress. A mechanical version of the stave has also been produced and evaluated. The first electrical-grade stave has just been completed – a major sub-project milestone - and the sensors on the axial side of the stave have been read out. The carbon-fiber support structures for the staves are also currently being prototyped.

All burn-in test stands needed for hybrid and module burn-in have been erected at the Silicon Detector Facility, have been reviewed for 24-hour operation, and are fully functional. Long-term tests of hybrids have begun. A laser test stand and debugging stations also have been set up and are operational. The hardware necessary to perform a full system test in the readout configuration, identical to the one employed at DZero during collider operation, is installed at the Silicon Detector Facility and is being debugged. The software needed to support this test system and to integrate the upgraded detector into the DZero system is under development.

3.2 Cost Status

Fermilab, other funding agencies, and DØ institutions have made a significant investment in developing the Run IIb silicon upgrade. A substantial fraction of the tracker cost has already been committed: of the $16.0M estimated base cost, we have either obligated or spent $7.5M, or 47%, through July 2003. (An additional $4.9M in contingency is provided for in the project plan.) These numbers include funds from all sources - DOE R&D and equipment money, and in-kind contributions. The following is the obligation/spending breakdown as of July 2003, and is summarized in Table 3 below:

- All of the approximately $3.7M provided in DOE R&D funds has been spent, with most of the associated work having been completed.
- Most of the in-kind contributions for the silicon sub-project are contained in a $2.4M National Science Foundation Major Research Initiative (MRI), which was awarded in July 2001. Approximately $1.7M, or 71%, has been spent to date. This includes significant university and foreign matching funds.
- In the DOE equipment category, $2.1M in both labor and M&S has been obligated or spent to date. This represents 21% of the $10M base equipment allocation for the silicon. The contingency on the DOE equipment portion is 46%, or $4.6M for the silicon sub-project.

	DOE R&D	**Total In-kind**	**DOE Equipment**		**Total**
	M&S+Labor		M&S	Labor	
Baseline estimate	$3.7M	$2.4M	$5.5M	$4.4M	$16.0
Funds (fraction) obligated or spent	$3.7M (1.00)	$1.7M (0.71)	$1.7M (0.31)	$0.4M (0.09)	$7.5M (0.47)
Funds remaining	$0	$0.7M	$3.8M	$4.0M	$8.5M

Table 3: Base estimates for the silicon sub-project broken out by funding type, and commitments incurred through July 2003. An additional total sub-project contingency of $4.9M is not included.

We note that $1.7M, or 31%, of the $5.5M in base M&S equipment funds for the silicon have been obligated or spent through July, with $3.8M remaining. We consider the remaining cost of this upgrade to be well worth the remaining investment: completion of the silicon will allow us to fully capitalize on the time, effort, and money that has already been invested by the Laboratory, DZero collaborators (both U.S. and non-U.S.), DOE, and NSF. When considered in terms of the overall scientific reach, including the discovery potential that exists at the world's energy frontier, and the continued vitality of the Fermilab collider program and, more generally, the US HEP program, the dollar value seems small indeed.

We note that all numbers quoted above are in actual year dollars and include G&A, with labor, M&S, and contingency broken out separately, as noted.

4 Installation and Commissioning of the Run IIb Upgrade

There has been increased awareness and concern about the impact on the Tevatron physics program of a long shutdown for the installation of the Run IIb upgrades. We have made a serious effort to re-optimize our installation schedule to minimize the length of the shutdown. We are also in the process of developing a detailed physics commissioning plan in MS Project to better understand the steps required before we can record "physics-quality" data. These studies indicate that, with the support of the Laboratory and collaboration, the Run IIb upgrades can be completed during a 14 week accelerator shutdown, and that we will be taking physics quality data 14 weeks after the end of the shutdown.

As before, a fully resource-loaded MS Project file describing the installation plan was developed. In particular, the following items were considered in detail:

- the amount of time required to perform each of the tasks, and the order in which they are performed;
- the resources required to realize task durations;
- consideration of less labor-intensive technical approaches for a few key tasks, and study of the associated impact to both the detector performance and the schedule;
- practical limitations associated with space. This included the creation of a separate resource for each of the regions of most concern (north and south ends of the tracker, east and west sides of the calorimeters, etc.) in order to precisely track manpower flow in these areas;
- preparatory work, mock-ups, and staging work that might be done ahead of time in order to streamline the work during the shutdown and relieve the pressure during this period;
- the availability of general technical and physicist manpower, as well as supervisory and other specialized personnel. This consisted in some cases of having developed lists of people by skill type, training, and, in many instances, by name, who we believe we will need to have at our disposal in order to successfully mount this effort.

We have introduced double-shifts wherever possible and sensible, particularly in the silicon portions, remaining cognizant of the above issues. A five day work week has been assumed; we have reserved the weekends in order to provide us with some time contingency during peak periods, and to deal with unforeseen difficulties or other problems.

We outline below some of the salient features of this new schedule:

- **We have sought to limit the amount of downtime for the accelerator associated with our work in the Collision Hall**. We remind the reader that DZero has designed its silicon detector in two halves, which allows for its installation in the inter-calorimeter gaps while the detector proper remains in the Collision Hall: **no rollout of the platform is required**. This reduces greatly the time, effort, and technical risk associated with the silicon installation.

- **The installation phase is driven entirely by silicon work, and requires a 14 week shutdown.** (Most of the trigger work takes place outside the Collision Hall, . At this stage, the silicon electrical connections will have been checked using local PCs connected directly to the interface cards in the "cathedral" area (next to the calorimeters) in the Collision Hall, and the new beryllium beam tube will have been installed, connected, and leak checked. The detector will remain open to allow access to all connections as the beam comes up, should they be needed. This procedure was used to advantage in Run IIa. Since much of the trigger installation is staged and the hardware debugged in independent racks near the Movable Counting House in the DZero Assembly Building prior to the shutdown, and in any case does not require CH access**,** the readiness for beam for the trigger elements occurs three weeks into the shutdown.

- **We estimate that an initial four weeks after the conclusion of the shutdown will be required for the completion of technical commissioning.** While most of the work is software-related and is therefore expected to be done outside the Collision Hall, we consider this period as providing some contingency for the debugging of detector connections as well. We believe that access time provided from either intended or unintended accelerator downtimes, and those scheduled directly with the BD and CDF, will allow us the necessary integrated access time during early machine commissioning, should it be needed. This, too, is similar to the actual Run IIa experience.

- The transition to physics commissioning will likely occur adiabatically after delivery of first beam, melding naturally with the technical commissioning. For reasons similar to those mentioned in the previous bullet, however, it is assumed to follow immediately after the technical commissioning. **The estimated duration of this physics commissioning time is expected to be 10 weeks**, which reflects a more aggressive approach than was assumed in our previous estimate of three months. It is based on a more detailed understanding of the process, including an MS Project plan that is currently under development. We are not claiming that we will have full understanding of offline b-tagging at this point; our measure is when we start recording physics quality data. The as-built alignment process used in Run IIa allowed this to happen relatively rapidly after technical commissioning was complete, and will be followed again.

- The above yields a total of 14 weeks installation time, in which the Collision Hall is open for access, and 14 weeks total commissioning time (technical + physics), during which increasingly limited access is expected to be required. **This gives a total "physics-to-physics" downtime of 28 weeks**, which is to be compared with our original estimate of 10 months.

- **It is important to note that increasing the total commissioning time from 14 to 21 weeks in the scenario in which the silicon is upgraded, while keeping the non-upgraded commissioning duration at the nominal 14 weeks, results in only a 4% decrease in the integrated, double-b-tag weighted luminosity ratios for both the base and design luminosity profile**.

Independent of whether the silicon upgrades ultimately go forward, the trigger and DAQ/online upgrades will be completed. While the installation needs are reduced, we estimate that the 14 week total commissioning time discussed above will be required to establish the physics readiness of the trigger. Assuming the accelerator needs 14 weeks of downtime for maintenance and its own Run IIb upgrade work, **the total physics downtime for DZero will be more or less independent of whether the silicon is upgraded or not.**

Finally, we emphasize that the silicon installation has been done before by many of the same people who will be devising and executing the current plan. The approach is also the same as that in Run IIa, and we have designed the silicon detector with an eye toward retaining as much of the infrastructure as possible, limiting the amount of work required. Installation and technical commissioning of this new infrastructure consumed a large portion of the word load and time spent during the Run IIa silicon installation.

The table below contains a summary of the most relevant installation and commissioning milestones from our current schedule.

Milestone Name	**Current Forecast Date**
Tevatron Shutdown Begins	10/28/05
Silicon Ready to Move to DAB	12/05/05
Detector Ready for Resumption of Tevatron	02/09/06
Ready for Physics Commissioning	03/06/06
Accumulation of Physics Data Begins	05/19/06

5 Collaboration Commitment to the Run IIb Upgrade

Both in action and word the DØ collaboration has repeatedly and unanimously expressed a desire to upgrade the silicon detector and trigger system. One measure of this support is that in 2002 every collaborating institution completed a Memorandum of Understanding in support of the upgrade. In these memorandums the institutions explicitly consented to redirection of effort to the silicon and trigger upgrades. Such a commitment will ensure timely completion of detector installation and commissioning.

The collaboration's willingness to invest time in pursuit of non-DOE funding for the upgrades is another indication of support for the projects. To be specific, the collaboration has been awarded two NSF Major Research Instrumentation Grants and two CAREER grants in support of the upgrades. The first MRI proposal, consisting of $1.7M plus $0.7M in university matching funds, was awarded in 2001 for *"Development of a Silicon Vertex Detector for the Higgs Search at the Tevatron Collider."* The second MRI, for $0.46M plus $0.11M in university matching, was awarded in 2002 and is titled "*Development of Trigger Systems for the Higgs Search by the DØ Experiment."* The experimenters involved clearly have a professional stake in the success of the two projects.

During the spring and summer the DØ spokespersons and project manager have kept the collaboration advised of the external deliberations involving the upgrade. Based on these meetings, most recently an "all-hands" meeting July 31, 2003 and a question-and-answer period with the Director August 1, 2003 it is clear the experiment is strongly and unanimously behind the silicon and trigger upgrades. The collaboration continues to grow since the prospect for large data sets with improved sensitivity is attractive. In the past year one French and one Canadian group jouned the experiment and we are discussing with two other groups that have expressed an interest. The flip-side of this statement has been expressed by a letter from the European contingent to the Director which describes the difficulty the European groups will have attracting funding should the silicon upgrade be cancelled[6].

In summary the collaboration has historically and consistently expressed support for the upgrade both through their involvement and in their planning for the future. The DØ Collaboration, through both pledges and participation, is solidly committed to meet the demands of the project and schedule.

6 Conclusions

In any scenario the Run II integrated sensitivity for DØ is greatly increased with a robust and improved detector coupled with a short shutdown. The sensitivity for Higgs or SUSY discovery and for top studies is strongly correlated with the double tagging efficiency. Studies have shown that the upgraded silicon tracker with a greater number of layers, closer proximity of the inner layers to the beam pipe, and increased acceptance will

[6] http://d0server1.fnal.gov/projects/run2b/meetings/DOEReviews/Aug03_Update/European_Position.pdf

improve double b-tagging sensitivity threefold relative to the current detector. A reformulation of the silicon installation schedule shows that the associated shutdown will shadow the summer accelerator shutdown. The overall Run II program (both CDF and DØ) will see an effective 25-50% increase in luminosity from the DØ silicon upgrade.

The remaining cost to achieve this effective luminosity increase is modest. Nearly half of the base silicon project funds have already be spent or obligated. Surely for a 25% or greater increase in accelerator luminosity such a cost would be considered a bargain. The collaboration is solidly behind the upgrade and wishes to move forward. **We urge the Directorate to support the completion of the DØ silicon and trigger upgrades in order to maximize the discovery reach and physics of Run II, and to carry this case to the broader HEP community.**