## ***Excerpt from the June 2002 PAC Recommendations***

## *Run II*

Run II is the most important component of the Fermilab research program, and much of the Aspen meeting was devoted to reviewing the status and plans for the accelerator complex and the D0 and CDF detectors. In preparation for the meeting the Committee reviewed updates from the collaborations on their current operations and their Run IIb upgrade plans, including answers to questions posed in the April PAC report. Additionally, the Committee received reports from the Technical Review Committee (TRC), chaired by Jim Pilcher, and the Director's Review Committee (DRC), chaired by Ed Temple. During the Aspen meeting the Committee heard reports from the Beams Division on Run IIa accelerator performance and the Run IIa and Run IIb luminosity-improvement programs, and from the "132-ns" committee, chaired by David Finley, on bunch-spacing options for future Tevatron running. Status and planning for Run II computing were described in a written report received from the Run II Computing Review Committee, chaired by Ian Bird, and a summary presentation in Aspen from the Computing Division.

The Committee congratulates the Beams Division for the recent improvement in Tevatron luminosity and for the sharpened focus on the challenge of meeting Run II luminosity goals. This is the single most critical ingredient for the success of the Laboratory's program, and the Committee looks forward to hearing of continuing rapid progress in the near future.

Maintaining the capabilities of the CDF and D0 detectors throughout the run is also essential for the success of Run II. The development of upgrade plans that will ensure adequate performance, while meeting the rigorous schedule and fiscal constraints that the Laboratory faces, has been a major challenge. While the Committee believes that this challenge has not yet been completely met, it also recognizes the necessity to proceed toward a full baseline review of the projects by late summer. On this basis, the Committee recommends Stage I approval for the CDF and D0 Run IIb upgrade projects.

Because of the complexity of the projects and the schedule and budgetary challenges, it is necessary to explain exactly what the recommendation of Stage I approval signifies in this case. The Committee enthusiastically endorses the physics goals of Run IIb and acknowledges the necessity of maintaining the capabilities of all of the detector subsystems included in the upgrade projects. It is not possible at this time, however, to approve a specific and detailed plan for every one of these upgrades. In the sections that follow we have classified each upgrade component in one of three ways. The silicon detectors for both experiments are clearly essential and have sufficiently well-defined scopes, budgets and schedules to proceed to a baseline review. Some other systems are judged not yet to be in this state, but are sufficiently close that they can be ready for a baseline review on the late-summer timescale. A few upgrade components are simply not well enough defined for detailed baseline review at this time. This is either because the scope of the upgrade has not yet been convincingly and quantitatively established, or because the collaboration has not yet made all of the necessary technical decisions to present a fully defined project. This third category poses a special challenge. Since the success of Run IIb may depend on these items, they cannot be excluded from the overall upgrade projects. Since they are not completely defined, however, they cannot yet be baselined in the traditional sense. The Committee encourages the Laboratory to work with the collaborations to include all of these upgrade components in the project baseline, but with specific conditions to be met before they can proceed to construction. The Committee proposes that the Laboratory include these items on an "authorize-as-required" basis, with funding held in a "trust fund" until determination is made that the scope of the project satisfies the requirements, and that the project is ready to proceed and is compatible with available resources and schedule.

With this somewhat unconventional recommendation, the Committee highlights the continuing importance of the TRC and the DRC. These panels have already provided essential guidance to the collaborations. They will play critical roles in the preparation for the baseline review during the next few months. Once projects are authorized, these bodies and the Laboratory's Project Management Group should provide continuing oversight and monitoring of progress relative to milestones. Upgrade components identified as not yet ready for authorization to proceed should be subjected to technical, cost and schedule reviews equivalent to full baseline reviews before authorization is granted.

In this report, the Committee endorses the recommendations of the TRC and DRC. No independent technical review has been attempted. The Committee's comments should be seen as highlighting observations and recommendations made by those panels and suggesting steps that can be taken to prepare for upcoming reviews.

The remainder of this report provides (A) a brief discussion of the physics opportunities that establish Run II as the Laboratory's top priority; (B) specific comments on the CDF and D0 Run IIb silicon upgrades; (C) assessments of the non-silicon upgrade components; (D) comments on the Run IIa and Run IIb luminosity programs and the related issue of Tevatron bunch spacing; and (E) brief comments about Run II Off-Line Computing.

## (A) <u>Physics of Run IIb</u>

The Tevatron will be the world's energy frontier collider until the advent of the LHC. Run II will be the first comprehensive search for the new physics of the TeV energy scale. Strong theoretical arguments and experimental hints point towards new physics associated with electroweak symmetry breaking and the Higgs boson. This new physics could take the form of supersymmetry, new dynamics, or even extra dimensions of space. Understanding the new physics of the TeV scale is the key step towards attacking the most interesting and profound questions of our field, including the unification of forces, the "DNA of matter" that explains its rich flavor structure, the nature of dark matter and dark energy, and the evolution and origin of the universe.

Run IIb offers the extraordinary opportunity to discover the Higgs boson predicted by the Standard Model or its minimal supersymmetric extensions (MSSM). As shown in Figure 1, precision electroweak data, which are sensitive to virtual effects of the Higgs, strongly favor a Higgs boson lighter than about 200 GeV. Indeed the best fit mass is somewhat less than the current lower bound of 114 GeV obtained by the Higgs searches at LEP. The LEP experiments themselves reported several candidate Higgs events with masses close to 115 GeV. Furthermore, in the MSSM extension of the Standard Model, there is a hard theoretical upper bound of 135 GeV on the mass of the lightest Higgs. All of these considerations make the Higgs mass range 115 GeV < $M_H$ < 200 GeV of extreme interest.

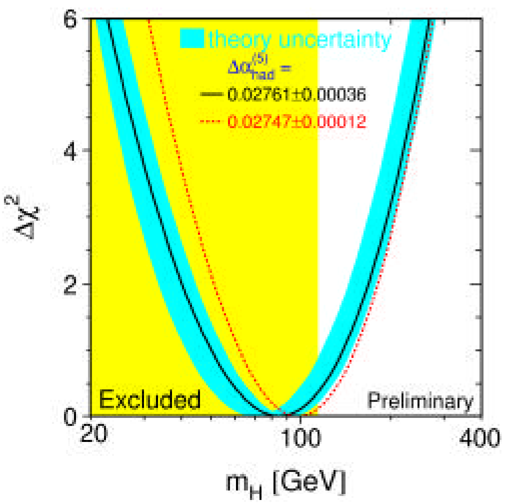


Figure 1

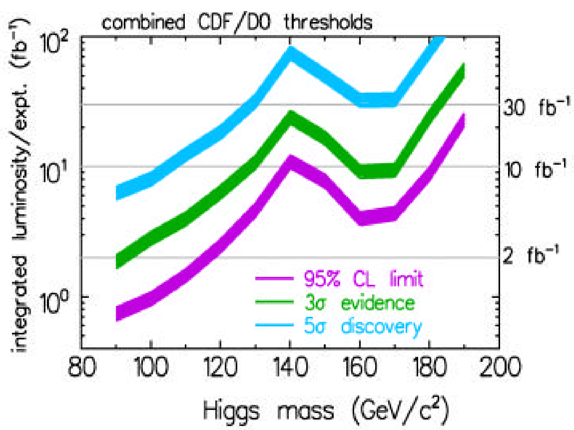


Figure 2

Figure 2 shows the projected combined sensitivity of the CDF and D0 Run II detectors for a Standard Model Higgs boson (M. Carena *et al.*, "Report of the Tevatron Higgs Working Group," (arXiv:hep-ph/0010338). With 10 $fb^{-1}$ of integrated luminosity per detector, almost the entire Higgs mass range from 115 GeV to 200 GeV can be excluded at the 95% confidence level. With the same 10 $fb^{-1}$, a Higgs boson can be discovered at the 3-sigma level for the mass range 115 to 130 GeV, and in a higher mass window of 160 to 170 GeV. With 15 $fb^{-1}$ of integrated luminosity, 5 sigma discovery and study of the Higgs boson properties become possible in the mass range near the LEP bound.

As noted by the recent HEPAP subpanel: "Discovery of the Higgs would be a revolutionary step for particle physics." In the lower part of Higgs mass range, the Tevatron experiments would observe the Higgs in *WH* and *ZH* associated production, channels which are very challenging for the LHC experiments.

Even non-observation of the Higgs in Run IIb would be a result of extreme importance. If the Higgs is not observed, 95% CL exclusion over the mass range required by the electroweak precision data would put the Standard Model in crisis. This is especially so since the Run II measurements of the *W* and top masses may tighten the precision electroweak constraints. If the Higgs is not observed, supersymmetry in the form of the MSSM will be excluded at the 95% CL or better over all but a tiny sliver of its parameter space.

While the Higgs search is not the only important physics opportunity for Run IIb, it is the one for which high-luminosity running is absolutely essential, since Higgs sensitivity begins for integrated luminosities above about 2 $fb^{-1}$ per experiment, and requires a minimum of 10-15 $fb^{-1}$ to accomplish the goals outlined above.

A Higgs search also makes stringent requirements on the performance of the D0 and CDF detectors. The Higgs search relies on the associated production channels *WH* and *ZH*, with the *W* decaying leptonically and the *Z* decaying to neutrinos. For Higgs mass less than 135 GeV, a Standard Model Higgs decays predominantly to $b\bar{b}$. The corresponding discovery signatures suffer from large backgrounds as a result of a variety of Standard Model processes. The detectors will need excellent *b*-tagging efficiencies (since the Higgs decays mostly to $b\bar{b}$), excellent $b\bar{b}$ dijet mass resolution (since the Higgs signal is on top of a large Standard Model background), excellent tracking capabilities (needed for the dijet mass resolution and to trigger on *WH* associated production), and excellent missing energy resolution (to detect *ZH* associated production where the *Z* decays to neutrinos). For Higgs mass greater than 135 GeV, the Higgs decays predominantly to $WW^*$, requiring sensitivity to dilepton channels.

All of these capabilities must be maintained in the context of the challenges of running at high luminosities. Triggering poses special challenges. The triggers must be highly efficient for the signal events, while maintaining strong rejection power against backgrounds and fakes, despite the high rates and high occupancies. In addition to a number of Higgs signal channels, the trigger menus must also allow the collection of data samples for calibration and for study of the irreducible Standard Model background processes.

The Committee notes that these same capabilities will allow CDF and D0 to explore other new physics targets that may be discovered in Run II. This is especially true for possible discoveries of super-partner particles, of new physics associated with top, and of evidence for extra spatial dimensions. While 2-4 $fb^{-1}$ may well be enough integrated luminosity to make such discoveries, Run IIb will be essential to follow up and study the new physics, and to search for other new physics in related channels.

## (B) Run IIb Silicon Upgrades

1. Introduction

The silicon upgrades are driven by the dominance of the $b\bar{b}$ decay mode of the Higgs in the mass range to be probed and the expectation that the current silicon detectors cannot survive beyond the first 4-5 $fb^{-1}$ integrated luminosity of Run II. The preeminent role of *b*-vertex reconstruction for Higgs discovery puts a heavy burden of performance and reliability on the silicon vertex detectors for Run IIb, and this in turn has led to ambitious designs that dominate the cost and schedule of the Run IIb upgrades.

2. Key Issues

The DRC met in April and the TRC reconvened by phone in May to review schedule, budget, and technical issues. The Committee has received all reports and responses from these meetings, as well as detailed responses from each collaboration to the Committee's April report. The Committee has not attempted to repeat the technical evaluations but takes this opportunity to call attention to the key issues.

a) Procurement

- The Committee notes with great pleasure the report of SVX4 arrival and encouraging initial results. This is a very significant milestone.

- Both CDF and D0 have achieved significant reductions in the sensor price.

- D0 has experienced delay in obtaining sensors, apparently due in part to procurement delays at Fermilab and production delay at Hamamatsu. Delays in sensor procurement will delay the critical milestone of building and testing the first full stave.

- Both collaborations are planning for the vendors to do the initial testing of sensors, a move the Committee commends.

b) Mechanical

- CDF and D0 do not yet have assembly fixtures in hand and D0 is investigating the possibility of using CDF fixtures. The Committee commends this simplifying approach and urges rapid convergence to a decision on this issue and start up of prototype assembly.

c) Design Issues and Pending Studies

- The design of cooling tubes is not advanced and basic questions remain unanswered. The Committee notes the need for rapid convergence on this issue.

Design options that require long-term studies, such as of the aging properties of potential materials, appear to be inconsistent with this requirement.

- The TRC made special mention of the CDF radiation incident and the need to reevaluate electronics designs for protection against current or voltage spikes. The Committee takes this issue very seriously and would have appreciated reports from the collaborations. Detailed responses to the TRC concerns should be presented to the upcoming joint review.

- It is not clear that the collaborations have yet conducted sufficient radiation damage studies on all of the components that will be in the radiation field. The collaborations should present to the joint review any test results and plans for further studies.

d) Milestones

- Both collaborations provided detailed milestone charts as requested. The milestones are hard to compare and the collaborations should provide at least a concordance, if not a common format, for the review committees.

- The Committee joins with the TRC and the DRC in emphasizing the great importance of achieving the first prototype test involving a full stave and readout. The Committee is very pleased to see that CDF is close to this milestone and that they have given it prominence in their planning. The Committee recommends full effort be applied to reach this milestone before the Lehman review. D0 is in the process of adding a similar milestone. Full stave testing should address diverse issues including readout, cooling, assembly techniques, and radiation damage.

- A timely start of stave production is a key milestone.

- System integration before installation was emphasized by both the TRC and the DRC and this Committee concurs in that emphasis.

e) Schedule

- The DRC emphasized the tightness of the schedule, and noted that the plan lacked sufficient contingency. They also called attention to specific issues such as the lack of an adequate installation plan and schedule, and the need to plan for a period in 2003-2004 when SiDet facilities will be at saturation. The importance of adhering to schedule cannot be overemphasized.

3. Descoping Issues

The silicon detectors dominate the cost and schedule for both the CDF and D0 upgrade projects and as such have been the focus of considerable scrutiny by both collaborations, this Committee, the TRC, and the DRC over the last year and a half.

During this time the detector designs have been simplified and streamlined. Significant design options have been evaluated in terms of the "Higgs metric" in which the figure of merit is the square of the *b*-vertex tagging efficiency. At this stage the Committee and the collaborations recognize that the remaining possibility for further streamlining is to descope by omitting Layer 4. The collaborations have provided the Committee with quantitative evaluations of the impact of such a descope. As there are both costs (to physics) and benefits (to schedule and budget) in such a descope, the Committee has examined the tradeoffs carefully.

The collaborations' evaluation of the physics cost reach qualitatively and quantitatively similar conclusions. Despite some slight differences in the simulation inputs, the collaborations find that the omission of Layer 4 from an otherwise fully functioning detector will reduce the double *b*-tag efficiency by 8% (CDF) or 10% (D0). This is equivalent to a loss of three to four months of Run IIb operation. With inefficiencies in the central tracker the losses can worsen to 12% (D0 - scattered inefficiencies) or 26% (CDF - total loss of inner COT layers), or even in the worst case, 38% (D0 - no CFT information at all). The Committee concludes, therefore, that the contribution of Layer 4 is significant enough that under optimistic assumptions it will affect the Higgs metric by at least 10% and that in plausible high occupancy scenarios the impact could exceed 20%.

As pointed out by both collaborations, omission of Layer 4 would also bring with it other costs that are less quantifiable, such as the loss of redundancy and "robustness" in the tracking systems. These qualities may be important in the later parts of Run IIb.

On the other hand, the Committee notes that omission of Layer 4 would bring quantifiable benefits in the form of schedule and budget relief. CDF estimates the construction time saved by not building the staves for Layer 4 is three to four months, and both collaborations' budgets indicate that the financial savings would be about $1M if the decision to descope were made now. If the decision were made late in the construction period, the money would have been mostly spent, but some schedule relief could still be obtained.

The Committee finds the physics consequences severe enough to make the descoping of either silicon detector at this time inadvisable. The collaborations are encouraged to make every effort to adhere to schedule and budget constraints so that descoping can be avoided.

## 4. Conclusions and Recommendations

While there are still outstanding issues, as noted above and addressed below in the recommendations, the Committee recognizes the urgent schedule pressures and recommends proceeding to the baseline review. The Committee sees the upcoming joint review of the TRC and the DRC as a critical milestone for the collaborations to target.

The Committee reiterates its endorsement of the recommendations of the TRC and DRC. In the recommendations below we call out specific items that should be addressed in preparation for the joint review.

Recommendations for both collaborations:

1. Move expeditiously towards prototype stave testing.

2. Plan and perform appropriate radiation tests on electrically working prototype staves and/or individual components.

3. Address the issue of short-pulse radiation damage as recently observed by CDF, and modify designs to reduce or eliminate susceptibility.

4. Develop detailed plans and schedule for full system testing prior to installation.

5. Develop detailed plans and schedule for installation so that the shutdown time can be minimized.

## (C) <u>Non-Silicon Upgrades</u>

1. CDF Electromagnetic Calorimeter Timing Upgrade

CDF proposes to provide timing measurements for their electromagnetic calorimeter. This would allow rejection of cosmic rays that might otherwise fake energetic photons. The Committee accepts the justification that this would reduce potential background in searches for exotic particles and recommends approval of this upgrade. It is the view of the Committee, however, that it should be given lower priority than the other proposed upgrades. The Committee also notes that the cost of this upgrade to the Laboratory is small because substantial contributions are expected from other sources.

CDF has decided to base this upgrade on inductive pickup off the existing anode output. This decision obviates the need to dismount, modify, and remount the bases. The Committee supports this decision and encourages that the planned prototype measurements of this technique be completed, if possible, prior to the upcoming joint TRC/DRC review in order to reduce the level of contingency needed for this upgrade.

2. Trigger and Data Acquisition Upgrades

Run IIb will provide CDF and D0 with increased luminosity that will result in increased trigger rates. It will also bring increased detector occupancy from increased multiple interactions per beam crossing which will cause further increase in trigger rates. Upgrades of trigger capabilities and/or data acquisition bandwidth will be required to cope with the increased trigger rates. In addition, due to constrained resources, the experiments will need to tighten their trigger menus in order to select the highest priority physics from the wealth of interesting physics accessible in Run IIb.

CDF and D0 have proposed a set of upgrades to provide increased trigger and data acquisition capabilities for Run IIb. The specific upgrade proposals of each experiment are appropriate to the existing trigger and data acquisition architecture of the experiment. For instance, D0 upgrades are primarily trigger upgrades, focusing particularly on their Level-1 trigger; whereas CDF upgrades center somewhat more on upgrades of data acquisition bandwidth, and on the Level-2 and Level-3 triggers.

The Committee agrees with the collaborations that the physics of Run IIb demands upgrades in each of the areas proposed. The Committee was not able to provide a detailed review of all the proposed technical solutions, cost estimates, and schedules. It relies upon the upcoming joint TRC/DRC Review organized by the Laboratory to provide this scrutiny. The subsequent sections contain comments and suggestions relating to some of the proposed trigger and data acquisition upgrades. A table summarizes the status of planning for each of the proposed upgrades and some suggested actions related to the upgrades.

a) D0 Level-1 Calorimeter Trigger

The Committee believes that the D0 Level-1 Calorimeter Trigger is ready to proceed to baseline review. The D0 Level-1 Calorimeter-Track Matching trigger is discussed below.

b) Level-1 Track Trigger Upgrades

Both CDF and D0 propose upgrades of their Level-1 charged-track triggers, which are referred to as XFT and L1CTT, respectively. These upgrades are intended to reduce the number of fake (trigger) tracks arising from increased occupancy, particularly when multiple interactions per crossing occur.

The Committee is concerned that understanding of requirements upon Level-1 tracking triggers in the hostile environment of multiple interactions is not yet sufficient. The impact of Level-1 tracking triggers on physics sensitivity is complicated because these triggers are components of more complex Level-1 triggers, and because their outputs play a role in Level-2 triggers. Furthermore, projected detector occupancies are so much higher than current occupancies that uncertainties in simulation and extrapolation are significant. On one hand, the collaborations have not yet adequately justified their proposed Level-1 tracking trigger upgrades in terms of the Higgs sensitivity metric requested by the Committee. On the other hand, the upgrades, as proposed, may not be adequate. These comments also apply to the D0 Level-1 Calorimeter-Track Match upgrade because of its close relation to the Level-1 tracking trigger. Further study of Level-1 tracking triggers is required.

In order to evaluate what upgrades to the Level-1 tracking triggers are required to cope with increased occupancy, it is necessary to understand what requirements are placed upon Level-1 tracking triggers by the principal physics goals of Run IIb, such as the Higgs search.

- What are the quantitative requirements on efficiency, fake rate, and $p_T$ and $\phi$ resolutions? These requirements should be quantitatively justified in terms of Higgs sensitivity. They should include requirements derived from the requirements of Level-2 silicon triggers for tracks found by Level-1.

- Do the proposed Level-1 tracking trigger upgrades satisfy these requirements? Can alternative trigger criteria (*e.g.*, higher track $p_T$ threshold, higher lepton $p_T$ threshold, tighter spatial match, shower-shape cuts) be used to satisfy the trigger requirements?

- How does the performance of the existing tracking triggers and the proposed tracking triggers compare to the requirements, as a function of the number of multiple interactions per crossing? How well do simulated occupancies compare with data?

Answers to these questions should be prepared for the upcoming joint TRC/DRC review. If this work cannot be completed in time for the review, then a conservative technical solution that is guaranteed to meet requirements should be specified as the baseline. Meanwhile, studies should be continued until an appropriate technical solution is validated and subsequently launched.

c) CDF DAQ Bandwidth Upgrades

Three proposed CDF upgrades are related to upgrading the rate capability of the data acquisition and Level-3 trigger: the upgrade of the Event Builder Switch, TDC replacement, and the Level-3 Trigger PC Farm Upgrade. With present hardware, data acquisition bandwidth will be limited to ~300 Hz. CDF proposes to increase this bandwidth to 1 kHz.

CDF presented a sample Level-1 trigger menu that totals to a rate of 676 Hz at $5\times10^{32}$. This was based on linearly extrapolating measurements made during Run I to the much higher luminosities of Run II. In light of the uncertainties inherent in such an extrapolation, the Committee feels that a more thorough assessment of the trigger rate and the bandwidth goal should be made before technical plans are finalized. The Committee suggests a study that compares three or four choices for the total bandwidth in the range between 300 Hz and 1.5 kHz. For each case an optimal trigger configuration should be constructed, and quantitative comparison of the resulting Higgs sensitivities will establish the bandwidth goal that satisfies the requirements of necessity and adequacy.

A new DAQ bandwidth (Level-2 rate) goal should be justified prior to the upcoming joint TRC/DRC review. The scope of the Event Builder Switch upgrade and Level-3 PC Farm upgrade should be consistent with this goal.

d) Online Computing and Level-3 Farm Upgrades

The sustained operation of the online computing and Level-3 farm systems of both experiments will require a program of ongoing maintenance as well as upgrades in the capabilities of the systems related to higher luminosity. Ongoing maintenance requires such items as software licensing, equipment repair and replacement (including obsolete equipment), and system administration. It includes periodic replacement of processors. New processors are also needed to provide increased processing capabilities for Level-2 and Level-3 triggers. Some portion, or perhaps all, of required increases in processing capabilities can be provided via periodic replacement. Consequently, the upgrades of the CDF Online Data Acquisition Computing, the CDF Level-3 PC Farm, the D0 Online Computing, and the CDF Level-2 Trigger Decision Crate, include the costs both of routine operations and of expanded capabilities. The Laboratory should decide what portion of each of these proposed upgrades is to be attributed to operations budgets and what portion is to be included in the Run IIb upgrade budget. This guidance should be provided in time for the collaborations to develop feasible baseline plans for the upcoming joint TRC/DRC Review.

e) D0 Level-2 Silicon Tracking Trigger Upgrade

D0 has recently completed a study of whether to include five silicon layers or six in their Level-2 Silicon Tracking Trigger (STT). This study led to the determination that five layers are adequate. The Committee concurs with this decision. The use of five layers, instead of six, results in a cost savings of approximately $300K. A previous study indicated the need for more than the four layers used in Run IIa.

f) Summary for Non-Silicon Upgrades

The findings, comments, and conclusions of the Committee regarding the proposed non-silicon upgrades of CDF and D0 are each summarized in two tables. One table summarizes the current status of technical choices, justification, definition of scope, prior reviews, etc., for each proposed upgrade. The other table summarizes actions to be taken for each upgrade. Notes are provided to help with interpretation of the table. These tables are intended to help the collaborations to prepare for the upcoming TRC/DRC and Lehman reviews.

A few further notes are provided here:

- <u>Documentation for baseline review:</u>

In preparation for the upcoming joint TRC/DRC Review, the collaborations should complete all documentation of proposed technical solutions that will be required for baselining. The Committee believes that the existing D0 Trigger TDR provides the necessary documentation for the D0 upgrades, although some sections of the TDR need to be updated to reflect recent progress. The existing CDF IIb Detector Technical Design Report does not provide adequate technical description of many of the proposed CDF upgrades and options.

- Remaining technical decisions:

The table of actions designates a small number of CDF upgrade projects that require selection of a technical solution. CDF should designate a decision date for the selection of the technical solution for each of these upgrades.

- Project launches:

Several upgrade projects require further elucidation of the scope of the proposed upgrade relative to requirements. Intensive engineering, fabrication, and procurement activities for these upgrade projects should not be launched until elucidation has been provided and the scope of the proposed upgrades is known to be appropriate. Some upgrade projects also require selection of a technical solution before launching significant activities on these upgrades. The collaborations should accomplish as much of the elucidation of scope, and as many technical selections, as possible before the upcoming reviews. Those upgrade projects whose technical solutions and scope are fully justified at the time of the baseline review can be launched after the Run IIb Detector Upgrade Project is baselined. Budgets for upgrades with open technical choices or with incomplete definition and justification of scope should be placed in a "trust fund" until the upgrade is ready for launch.

Upgrade projects that are expected to be ready for launch at the time of the baseline review are designated in the table of actions, with notes indicating what choices or elucidation is needed before launch. Upgrade projects that are not ready for launch are also designated, with notes indicating the reason. The collaborations should designate dates by which these upgrade projects must be ready for launch in order to ensure timely completion.

Note that, in speaking of launching upgrades at the time the overall detector upgrade project is baselined, the Committee is not recommending that production and procurements start immediately. Procurements, particularly of commercial processors, should be done an appropriate moment relative to experimental need and to evolution of prices.

| CDF STATUS | Reviewed by TRC | Reviewed by DRC | Reviewed in prior PAC meetings | Adequate definition of scope | Adequate justification of scope | Technical solution chosen | Ready to develop feasible baseline |
|---|---|---|---|---|---|---|---|
| *Calorimeter Upgrades* | | | | | | | |
| Central Preradiator Replacement | Y | Y | Y | Y | Y | Y | Y |
| Electromagnetic Calorimeter Timing | N | Y | Y | N[4] | Y[6] | N | N[13] |
| *Data Acquisition & Trigger Upgrades* | | | | | | | |
| Online DAQ Computing for Run IIb | N | N | N | Y | Y | Y | Y |
| Level 2 Trigger Decision Crate | N | N | Y | N[2,4] | N[2] | N | N[14] |
| Level-3 Trigger PC Farm Upgrade | Y | N | Y | Y[2] | N[2] | Y | N[13] |
| Upgrade of Event Builder Switch | Y | Y | Y | Y[5] | N[5] | Y | N[13] |
| Addition of Stereo Data to XFT | N | N | Y | Y[1] | N[3] | Y | N[11] |
| TDC Replacement | N | N | N | N[4,5] | N[5] | N | N[14] |

| CDF ACTIONS | Ready to develop feasible baseline | Choose final technical solution before baseline review | Complete evaluation in order to develop feasible baseline before baseline review | Specify an adequate solution to use to establish baseline in absence of final technical solution | Joint TRC-DRC Review should pay special attention to scope definition of this project (note[10]) | Launch project with baselining (note[9]) |
|---|---|---|---|---|---|---|
| *Calorimeter Upgrades* | | | | | | |
| Central Preradiator Replacement | **Y** | tech soln set | eval done | not needed | std attn | **Y** |
| Electromagnetic Calorimeter Timing | **N[13]** | **Y** | **Y[4]** | not needed | std attn | **Y[7]** |
| *Data Acquisition & Trigger Upgrades* | | | | | | |
| Online DAQ Computing for Run IIb | **Y** | tech soln set | eval done | not needed | std attn | **Y[8]** |
| Level 2 Trigger Decision Crate | **N[14]** | **N[21]** | **N[22]** | **Y** | **Y[2]** | **N[19]** |
| Level-3 Trigger PC Farm Upgrade | **N[13]** | tech soln set | **Y[2]** | not needed | **Y[2]** | **Y[18]** |
| Upgrade of Event Builder Switch | **N[13]** | tech soln set | **Y[5]** | not needed | std attn | **Y[20,18]** |
| Addition of Stereo Data to XFT | **N[11]** | tech soln set | **Y[11]** | **Y[12]** | **Y** | **Y[20,18]** |
| TDC Replacement | **N[14]** | **N[21]** | **N[22]** | **Y** | std attn | **N[19]** |

| D0 STATUS | Reviewed by TRC | Reviewed by DRC | Reviewed in prior PAC meetings | Adequate definition of scope | Adequate justification of scope | Technical solution chosen | Ready to develop feasible baseline |
|---|---|---|---|---|---|---|---|
| *Level 1 Trigger Upgrades* | | | | | | | |
| Level 1 Tracking Trigger | Y | Y | Y | Y[1] | N[3] | Y | N[11] |
| Level 1 Calorimeter Trigger | Y | Y | Y | Y | Y | Y | Y |
| Level 1 Calorimeter-Track Matching | Y | N | Y | Y[1] | N[3] | Y | N[11] |
| *Level 2 Trigger Upgrades* | | | | | | | |
| Level 2 Beta Trigger | Y | N | Y | Y[2] | N[2] | Y | N[13] |
| Level 2 Silicon Track Trigger | Y | N | Y | Y | Y | Y | Y |
| *Online Computing* | N | N | N | Y[2] | N[2] | Y | N[13] |

| D0 ACTIONS | Ready to develop feasible baseline | Choose final technical solution before baseline review | Complete evaluation in order to develop feasible baseline before baseline review | Specify an adequate solution to use to establish baseline in absence of final technical solution | Joint TRC-DRC Review should pay special attention to scope definition of this project (note[10]) | Launch project with baselining (note[9]) |
|---|---|---|---|---|---|---|
| *Level 1 Trigger Upgrades* | | | | | | |
| Level 1 Tracking Trigger | **N[11]** | tech soln set | **Y[11]** | **Y[12]** | **Y** | **Y[20,18]** |
| Level 1 Calorimeter Trigger | **Y** | tech soln set | eval done | not needed | std attn | **Y** |
| Level 1 Calorimeter-Track Matching | **N[11]** | tech soln set | **Y[11]** | **Y[12]** | **Y** | **Y[20,18]** |
| *Level 2 Trigger Upgrades* | | | | | | |
| Level 2 Beta Trigger | **N[13]** | tech soln set | **Y[2]** | not needed | **Y[2]** | **Y[18]** |
| Level 2 Silicon Track Trigger | **Y** | tech soln set | eval done | not needed | std attn | **Y** |
| *Online Computing* | **N[13]** | tech soln set | **Y[2]** | not needed | **Y[2]** | **Y[8,16]** |

## Table Footnotes and Abbreviations

Footnotes:

1. Scope may change when physics studies completed.
2. Required processing power needs justification.
3. Necessity and adequacy of scope needs physics justification.
4. Technical solution not chosen.
5. Required bandwidth needs justification.
6. Low priority.
7. If definition of scope completed for baseline review.
8. Refers only to Upgrade Project portion.
9. "baselining" refers to successful completion of Aug 2002 Lehman Review.
10. Attention should be paid to necessity and/or adequacy of defined solution and scope.
11. Complete evaluation if possible; otherwise, specify an adequate solution to use to establish baseline.
12. Specify an adequate solution to use to establish baseline if impossible to complete evaluation.
13. Complete evaluation for baseline review then develop feasible baseline for review.
14. Specify an adequate solution to use to establish baseline.
15. Requires update.
16. Launch L3 filter farm upgrade portion only after requirements presented and justified.
17. Level 3 filter farm portion.
18. Put funding in Trust Fund until requirements presented and justified.
19. Put funding in Trust Fund until requirements presented and justified and technical solution chosen.
20. Launch if physics justification provided for necessity and adequacy of scope.
21. It is not practical to choose technical solution before Aug 2002 Lehman Review.
22. Final technical solution not expected for baseline review.

Abbreviations:

"tech soln set" Final technical solution has already been chosen.

"eval done" Evaluation of necessity and adequacy of chosen technical solution is complete.

"not needed" Final technical solution has already been specified.

"std attn" The joint TRC/DRC review does not need to pay special attention during its review of this upgrade. The standard amount of attention will be adequate.

## (D) Comments on the Run IIa and Run IIb Luminosity Programs and the Related Issue of Tevatron Bunch Spacing

1. Run IIa Progress and Plans

The Committee heard an update of progress and plans for accelerator operations in Run IIa. The Committee was encouraged by the substantial luminosity increases since its April meeting, and by recent improvements to reduce the antiproton emittance in the Accumulator. These include a new dual lattice, and a core cooling upgrade installed during the recent shutdown. The Committee commends the Beams Division for its aggressive response to the difficult Run IIa startup. The team now includes over 100 physicists and engineers.

Many challenges remain to meet the ambitious luminosity goals of Run IIa. The Committee heard plans for a sustained campaign, which will attack a number of accelerator performance issues in parallel. As part of this strategy, additional modifications of the Recycler, the Main Injector, and the Tevatron are planned for this year. The plan also includes integrating the Recycler into collider operations next year, with the goal of making antiproton recycling with electron cooling operational in 2004.

2. Run IIb Accelerator Upgrades

The Committee heard an update on the Run IIb accelerator upgrade project. Substantial progress has been made on electron cooling, to the extent that, as mentioned above, commissioning may occur during Run IIa. Progress has also been made on the antiproton target lithium lens, including a new collaboration with the University of Illinois. Other Run IIb projects are being delayed due to the diversion of key personnel to Run IIa activities. These delays jeopardize the Run IIb accelerator upgrades; this problem needs to be addressed as soon as possible.

In this regard, the Committee was encouraged by several recent examples of both Fermilab and outside physicists being recruited and integrated into Run IIa activities. The Committee encourages the Laboratory management to continue these efforts, and to expand them, where appropriate, to Run IIb projects.

3. Operation with 132 ns Bunch Spacing

The Committee received and heard a report concerning Tevatron operation with a bunch spacing of 132 ns. The Committee thanks David Finley and his panel for their report, which outlines a number of challenges of accelerator operation with a bunch spacing of 132 ns. An attractive alternative scheme of luminosity leveling with a bunch spacing of 396 ns was presented. If it works, the commissioning of the machine for Run IIb could be made simpler and faster.

The ultimate goal of Run II is to obtain the highest possible integrated luminosity under event pileup conditions that are acceptable to the experiments. The Run IIb detectors have been designed for a bunch spacing of 132 ns, and the decision on whether or not to operate in that mode does not need to taken immediately. In the meantime, the Beams Division and the two collaborations are encouraged to establish whether luminosity leveling and 396 ns operation can provide conditions that are acceptable to the experiments and maximize the integrated luminosity for Run IIb. Luminosity leveling should be tested during Run IIa.

### (E) Run II Off-Line Computing

The Committee received the written report of the recent Run II Computing Review Committee and heard a summary presentation by Stephen Wolbers of the Computing Division (CD). The Committee congratulates the collaborations and CD on the successful completion of the Run IIa off-line computing project and the establishment of effective and timely processing of current data. The Committee notes the Review Committee's conclusion that the experiments' processing and storage needs can be met, at least initially, within the budgetary guidance of $2.5M per year per experiment. Periodic reviews of off-line requirements by the Run II Computing Review Committee will be an important component of the Laboratory's continuing project management.