Chapter 6

Cost Estimate

We present here the revised costs for the BTeV detector. The detector has only one arm and there are no costs for interaction region magnets as they are assumed to come from either B0 or D0. We have absorbed part of the software development costs and all of the offline computing hardware costs into the trigger project, as we explain below.

6.1 "Single Arm" Detector Definition

The detector we costed consists of the full pixel vertex detector, one set of foward tracking chambers, one Ring Imaging Cherenkov counter, one electromagnetic calorimeter, and one muon detector.

We retain the full vertex detector because we need it to cover the full interaction region. It is also advantageous in determining the primary vertex to be able to detect tracks in the pixel detector which go into both hemispheres.

We also retain the full bandwidth capability of the trigger and data acquisition systems. The savings from reducing in these areas is small and the gains in extra efficiency from the extra bandwidth are non-negligible. We also now have the ability to use any excess capacity, even during running, to do offline reconstuction, analysis, and simulation so this may be seen as absorbing the offline computing farm into the trigger farm. This is discussed more below,

We also retained the toroid steel on the uninstrumented side of the detector. One reason for this is that we will probably need it as a shield from machine backgrounds. A second reason is that we have to support the compensating dipole and shield the detector from spray coming from it. Finally, if we ever do find the funds to implement the second arm, we would not want to change the floor loading by introducing such a heavy object in the midst of a running experiment. Since the steel for the two toroids is coming from an existing magnet (SM12 in MEast) the cost of doing this is only about $200K.

6.2 Components for the IR

The May 2000 estimate for a new Interaction Region was \$36M. The plan is now to use components reclaimed from one of the two existing collider experiments, CDF and D0. The Beams Division is working out some of the details of this plan at low priority. The fully loaded cost is estimated to be less than \$11M, half of which is work on the C0 infrastructure. It is agreed that these expenses will be handled on operating and plant budgets.

6.3 Offline Software and Computing Hardware for Reconstruction and Analysis

We have included funding for software and computing professionals in the trigger project. We assume that their effort, together with the database activities in the DAQ project, work being performed by computing professionals in the NSF-funded (\$5M) RTES project, and software obtained from the datagrid development efforts will provide enough "professionally engineered software" to support the physicists in the collaboration who will be writing the reconstruction, analysis, and simulation software. The RTES project provides the tools to partition "on the fly" the trigger farm, which is only heavily used at the beginning of stores and is fully available for "offline" reconstruction and analysis between stores and during accelerator downtime. As explained above, we did not reduce the trigger farm to account for the reduced load when there is only one arm. This leaves significant capability, even while collisions are occuring, for offline reconstruction, etc. It is worth noting the delay in the start of the experiment due to the new IR plan results in a substantial reduction in costs for computing hardware due to Moore's law.

6.4 Changes in costing assumptions, methodologies

We note that some changes have occured in the rules by which fringe benefits are handled for Fermilab labor. We have applied what we believe are the most recent rates for fringe benefits, vacations, and other paid time off. In particular, we have included a new 29.4% cost for Fermilab employees, assigned to the project, over and above their normal salaries and 28.5% fringe benefits, that we were not required to enter before. We note that this results in an increase of about \$5 M in cost over our May 2000 estimate.

6.5 Overhead (G&A)

The estimates in the table below do not include G&A. These are real costs but the rules differ from institution to institution and are therefore hard to compute. Also, considerable ingenuity can be applied to reduce these costs. All of our university groups waive G&A on equipment purchases associated with a construction project but some may charge it on various types of labor. Fermilab charges it on all labor and on equipment purchases but has a cap on large purchases over $500K. Our best estimate currently is that this will add about $10.5M to the project cost, composed of

- Overhead (or G&A) on Fermilab at a rate of 29.4% and on the American University groups of 25%. The later rate is an estimate of an average that may be charged. Most BTeV University groups are likely to be overhead exempt. We estimate the overhead cost for the project as 8 M$.

- A procurement cost due to Fermilab for writing purchase orders of 16.6% on any item for the first 0.5 M$. For a contract to a University for example, we would need pay this on the first 0.5 M$ but not on any costs over that amount. We estimate this cost to be 2.5 M$.

6.6 Contingency

In our May 2000 cost estimate, we had a contingency of only about 29.6%. We emphasize that we have another 18 months of R&D funding before we could become a construction project and we will, during this period, build a prototype of each detector and key components of the trigger and DAQ. This will result in substantially reduced risk, which has not been possible on other large experiments. In addition, many of our technologies are being used elsewhere. Nevertheless, we have large contingencies for the highest risk items: the pixel detector and the trigger. The total contingency is 31.5%.

6.7 The High Level Rollup of the Costs

The cost estimate is based on the reviewed estimate submitted with the May 2000 proposal. We have revised costs on the basis of new information and a careful consideration of the reduction in scope to a single arm. The actual cost estimate is based on a detailed, task-oriented Work Breakdown Structure containing over 50,000 items. It is summarized here at WBS Level 2.

In Table 6.1 we list the itemized costs for each detector subsystem or category. We also show for each category the cost of labor and materials and the assigned contingency.

The total cost is $103.8 M, without overhead. If one adds our G&A estimate, the total becomes $114.3M. This may be compared to the previous estimate of $138.1M for the detector and $16.5M for the offline computing, or $154.6M. The savings, without the IR, are $40.3M. If one includes the full IR cost of $33.8M, then the total cost reduction is $74.1M. We recall that this also includes a higher percentage contingency (31.5% vs 29.6%) than we had in the May 2000 estimate and the negative impact of recent accounting changes.

Table 6.1: One Arm Cost Estimate for BTeV

WBS #	Item	Labor (M$)	Parts (M$)	Contingency (%)	Total (M$)
1.1	Dipole, Toroids & Beam Pipe	0.2	1.0	31	1.7
1.2	Pixel Detector	5.4	7.0	40	17.3
1.3	RICH Detector	1.9	8.3	23	12.5
1.4	EM Calorimeter	2.3	8.0	33	13.7
1.5	Muon Detector	1.2	3.9	37	7.0
1.6	Straw Tracker	2.7	3.3	28	7.6
1.7	Silicon Tracker	1.2	1.6	26	3.5
1.8	Trigger Electronics & Software	3.6	6.2	42	14.0
1.9	Event Readout & Controls	5.9	6.3	24	15.1
1.10	Installation & Commissioning	2.9	1.7	33	6.1
1.11	Project Management	3.9	0.3	25	5.3
	Sum	31.0	47.5	32	103.8

6.8 Continuing Work to Reduce Costs

Every Level 2 project within BTeV has been reviewed for completeness and, to the extent possible, for accuracy. We still believe that some cost reductions are possible and that some double counting may exist. For example, items may appear both in individual projects and in the "installation and integration" section. Some opportunities for reuse of existing equipment may also have been overlooked. We will be examining this is the next few weeks. However, we do not expect to find huge gains.

6.9 Opportunities for further Cost Reductions to the US HEP budget

There are three good possibilities for reducing the amount of funding needed:

- BTeV physicists have joined with computer scientists to form a collaboration to research the design and implementation of high-performance, heterogenous, fault-tolerant and fault-adaptive real-time systems that are an integral part of the hardware they serve (embedded). This group has been funded with a 5 M$ grant from the ITR program of the NSF. Some of the work done here contributes to the development of the trigger software, but we have not reduced actual costs here to fully reflect this new source of funds.

- The Italian groups in BTeV have requested funds for parts of the experiment that they are interested in constructing. These include the Forward Silicon Tracker, the

Forward Straw Detector and the RICH Detector. We believe it likely that they will get substantial funding that will subtract from the costs above. Accounted using our rules, their request exceeds 7 M$. We also hope for various contributions of labor and/or “in kind” contributions of materials from our other foreign collaborators. We also will seek support from funding agencies other than DOE.

- DOE arranged that all foreign purchases for BABAR entered the U. S. duty free. We estimate savings in BTeV $\sim$1M$ if this can be done in this case.