2. The international setting surrounding the project. What is the schedule for other competing experiments? By what date must the project start? What is the minimum number of years of running that the proponents would consider adequate? What is the projection for available manpower for construction and then detector operation and physics exploitation?

What is the schedule for other competing experiments?

The lab has provided a plan for its operation between now and 2012.

BTeV is undertaken in the context of a long program of B physics explorations, which began in 1977 with the discovery of the Upsilon. Enormous contributions were made by CLEO, ARGUS, CDF and groups at PEP, PETRA and LEP. At present, the two asymmetric e^+e^- collider facilities, PEP II/BaBar and KEK/BELLE, have established CP violation in $B \rightarrow J\backslash\psi\ K_S$ decays and have shown that, viewed within the context of the Standard Model, it is consistent with other measurements in B and K decays**,** providing there are no surprises due to discreet ambiguities. These two storage rings will gradually improve their luminosities, perhaps reaching 10^{34} /cm^2-s over the next few years and their experiments will continue to produce new results. These experiments can observe B_d and B_u decays but will not be able to contribute meaningfully to the knowledge of B_s decays. The two high P_t Tevatron experiments, CDF and D0, are now running and over the next few years should contribute to the study of CP violation in B_d and B_u decays, and observe B_s mixing. However, the experiments at the asymmetric colliders and the Tevatron will not address many critical issues that remain in the study of B decays: whether all CP violation is a result of the CKM mechanism or whether there are other contributions that appear as departures from the very specific predictions of the Standard Model. In the answer to question 1, we have explained how BTeV continues the B physics program and extends it to unprecedented sensitivity for New Physics beyond the Standard Model**, and how BTeV is crucial to interpret any New Physics found at the LHC.**

On the relevant timescale, the only competing experiment is LHCb, a B physics experiment at the LHC. The schedule for both LHCb and BTeV have uncertainties. LHCb depends on the completion date of the LHC, the length of the commissioning period, the initial luminosity, and the funding profile and priority of the experiment. The current schedule calls for a machine commissioning run in 2007 followed by a 4 month physics run starting in the late summer of '07. This is based on schedules that certainly have to be viewed as extrapolations at this point in time since only a tiny fraction of the crucial components have been fabricated and funding remains a concern. Moreover, the schedule as published has no contingency. The lab plan notes that if this project were managed by DOE, there would be a schedule contingency estimated at around 18 months. Some expectation of schedule slippage is therefore built into the Fermilab plan. On the other hand, it would be unwise to formulate a plan that depends on excessively long delays in the current LHC schedule.

For BTeV, the main issues are 1) when the detector can be ready, which depends both on funding issues and overcoming technical challenges; and 2) when the appropriate transition to BTeV operation from CDF/D0 operation can be accomplished, which is a programmatic issue for Fermilab management.

The current detector funding profile for BTeV calls for completion of R&D in FY04, ramp up of funding for construction in FY05, peak funding in FY06, 07, and FY08 and completion of the detector in FY09. The spending profile permits the installation of all infrastructure components – the analysis dipole, the RICH vessel, the muon toroids, the EMCAL support structure, and the superstructure for all other tracking chambers – in the shutdown scheduled for 2006 to replace the Run 2 silicon detectors. Most of the design work to accomplish this is complete. After that, because of the open geometry of the detector, installation of most components can occur a little at a time on down days and the occasional longer shutdowns that occur. Commissioning can proceed immediately as each piece is installed, using interactions of the beam halo on a wire target and occasional periods of collisions obtained by turning the separators off at the very end of collider stores. This will provide an important head start to BTeV for commissioning its detector relative to LHCb, while permitting both RUN 2 experiments to continue for as long as possible. The Fermilab schedule shows this commissioning activity as an official activity of the program beginning in 2008, although some limited work could start as early as 2007. Fermilab management supports this model.

The original BTeV proposal in May of 2000 included the construction of a new set of IR magnets specifically for producing collisions at C0. This plan would have provided the ability to run any two of the three experiments, BTEV, CDF, and D0, simultaneously, although CDF/BTeV or D0/BTeV both could not both run at the highest luminosity. As part of the descoping of the detector in 2002, Fermilab management decided that the IR quadrupoles from one of the existing experiments will be moved to C0 to form the low β^* collision region. Under this plan, one of the two high P_t experiments would have to stop running forever at when this occurs.

It is estimated that the installation of the IR components will require 3 months. The Fermilab schedule, presented in its documentation to P5, shows the installation occurring in the middle of 2009. As explained above, Fermilab management believes that, even though this would nominally place BTeV two years behind LHCb, a more realistic assessment of the situation is that BTeV would start no more than 6 months to a year behind. Moreover, BTeV will, when it starts to run, be nearly fully commissioned under the current plan. Because of the character of the BTeV detector, and given the current spending profile, a significant portion of BTeV can be installed parasitically before this shutdown. The current funding profile is consistent with this schedule. The last portion of the spending, the part that occurs in 2009, is for mainly for trigger and electronics components that are in the counting room and do not require access to the experimental hall to install.

A protracted delay, relative to the startup of LHCb, puts BTeV at a disadvantage. However, there are a few factors that make it possible for BTeV to start a bit behind

LHCb and then overtake it. First, these types of experiments are trying to achieve statistical precision and it will take quite a bit of time to accumulate enough data to have a useful result. Since BTeV has significant advantages over LHCb, even in this circumstance it remains competitive. Secondly, these experiments are fairly complicated and require significant commissioning periods. BTeV's ability to run with a partial detector in parasitic mode can give it a head start even before its IR is installed. However, it is important that a realistic plan be developed and followed, that allows BTeV to come into operation in a timely and competitive manner.

Fermilab also retains the option of building a separate set of IR quadrupoles if it were to turn out that it made physics sense to prolong the running for CDF and D0 or to keep both B0 and D0 viable as interaction regions. It should be noted that because there is significant lead time required to build new IR components, certain procurements, such as superconducting wire, must be started, and supported by adequate funding, relatively soon.

Finally, one might ask what would happen if the LHC were significantly delayed. From the standpoint of competition with LHCb, one could simply delay BTeV startup. This strategy might not, however, produce the best physics. We are assured by Fermilab management that decisions about running will be based on considerations such as doubling times for the running experiments, physics opportunities, and performance of the detectors. There is a commitment to get BTeV significant running in 2009, even if the LHC were to slip significantly. Again, the option exists to build a third set of IR quadrupoles and to attempt to run two out of three interaction regions together, if there is a long delay in the LHC schedule or if a period of overlap of (One) Run 2 detector and LHC operation is desirable.

What is the minimum number of years of running that the proponents would consider adequate?

We envision the experiment lasting on the order of 3 years in its current form. We expect to bring the detector on quickly due to partial commissioning activities discussed above. During the three year data-taking period, we hope for some improvements in efficiency and perhaps incremental improvements in luminosity throughout this period. We use the measurement of the angle χ to set the statistical goal for BTeV. The error on χ over this period, neglecting any possible efficiency or luminosity improvements, will be about 0.4^o, compared to the value expected in the Standard Model of about 2^o. This permits a reasonable test of the consistency of the Standard Model.

The doubling time beyond this period is prohibitively long. If, however, it turned out to be desirable to proceed to push the sensitivity of these measurements, presumably based on their connection with New Physics observed either in BTeV or at the LHC, it is possible to reduce the doubling time to two years by adding a second arm to BTeV. This second arm would double the number of tagged B events per year without requiring any increase in machine luminosity. It is also possible that there could be increases in machine luminosity that we could efficiently utilize. Reducing the time between crossings would also allow more luminosity to be accumulated quickly.

What is the projection for available manpower for construction and then detector operation and physics exploitation?

The current size of the BTeV collaboration is 160 Physicists. Several of the groups are "below strength," mainly because they cannot build up until BTeV is approved for construction. Moreover, in this stage of the experiment, it is not appropriate to recruit large number of physicists who do not have permanent positions. When these considerations are taken into account, the projected size of BTeV, based only on the existing groups, is about 275. However, we expect that additional collaborators will join if BTeV is approved for construction soon. We project a collaboration size of 250-350.

The needs for various human resources for the construction project are given in Table 1 below. Approximately 350 FTE-years of physicist effort is required over the 5-6 years of the construction projects. This includes commissioning. We estimate another 200 fte-years of effort to complete the offline analysis from where we are today. The total of 550 fte-years should be well within the capabilities of the collaboration since about 2000 people-years of effort will be available (or perhaps more realistically, 1500 people-years given a ramp-up). This gives a required duty factor of 25% to 33%. Members of this experiment have worked together on large projects before and an average duty factor of 50% has been typical.

Our model of operations assumes that experimenters on shift will carry out many routine maintenance functions, as we have done in our many experiments at Fermilab and elsewhere. We see this as a crucial component of successful experiment operation and student training. Given the technical complexity of the experiment and the difficulties of working in the limited space at C0, we have included a modest technical staff to provide expertise and assistance in operation. The staff is available only during regular hours on weekdays, but is, of course, also available for emergency call-in. We see no problem maintaining operations with an experiment of this size. We estimate that 30-50 physicist FTE-year/year will be required for operations and maintenance. Similarly, we believe that we will have plenty of people to analyze the data based on our previous experiences. There will certainly be more than 100 FTE-year/year of effort available for the analysis.

Table 1: A breakdown of the labor required for BTeV construction, based on information from the Temple Review of October 2002.

resource	Project Total (person-years)
Physicist (incl RA)	285
Graduate Student	53
Mechanical Engineer	44
Electronics Engineer and designers	108
Software Engineer	55
Senior Technician	36
Technician	110
Drafter	11