Comments from the Review of Specs for Primary Beamline
July 13, 2001

Responses by Bruce Baller
May 6, 2004

Specifications Driven by Physics, MI Parameters
Presenter: P. Lucas

1. (Reviewer: D. Michael) The issue of 4 or 5 of 6 batches should be pursued aggressively and not simply accepted as inevitable.

The NuMI baseline is for 5 batches with pbar operating and 6 batches without pbar.

2. (Reviewer: D. Michael) Technical issues and solutions to assure a 1.9 s (rather than 2.5s?) cycle time should be identified and personnel and resources assigned to do the necessary work.

The NuMI baseline design is for a 1.87 sec cycle time.

3. (Reviewer: D. Michael) Technical issues and solutions necessary to go from 2x10**13 ppp to 4*10**13 ppp must be identified soon and manpower and resources assigned to make this possible.

Significant work needs to be done in the Booster and possibly the Main Injector to achieve 4E13 ppp. This work is outside the scope of the NuMI project.

4. (Reviewer: D. Michael) The assumption of 40pi emittance for 95% of the beam with no non-Gaussian tails appears optimistic and could have a serious impact on ground-water irradiation. It is important to invest effort to gain a better understanding of what we can expect.

The NuMI beamline has been re-designed to match the Main Injector admittance (500 pi mm-mrad). There is no issue with ground water.

5. (Reviewer: D. Michael) The momentum spread may be worse than planned, perhaps as much as 10**-3 pulse-to-pulse variation? Likely to get worse under beam loading conditions. This requires further study on the design impacts it may present and better characterization of the likely quantities to be delivered.

This issue was addressed by the re-design of the beamline.

6. (Reviewer: D. Michael) Quantitative ranges should be specified for the allowed variation in the beam spot size.

Specified in the TDH.

7. (Reviewer: D. Michael) Aperture plots which show 10**-2, 10**-3 and 10**-4 contours for beam should be produced. Better understanding and quantization of tails is essential. The possibility of adding addtional, stragic upstream scrapers should be pursued.

Plots were produced. The beamline re-design obviates the need for scrapers.

8. (Reviewer: D. McGinnis) The beam will have a halo (tails) - count on it! You need to have 2 scrapers per plane on the upstream end of the beam line.

The beamline re-design obviates the need for scrapers.

9. (Reviewer: D. McGinnis) With such a huge dispersion in the beamline near tight apertures, you need to understand the longitudinal phase space of the Main Injector much better.

Addressed by the beamline re-design.

10. (Reviewer: S. Mishra) The beam line being designed will have much more demand on its performance as compared to any standard beam line we are used to. This is mainly due to the beam loss requirement. I think the attention paid to the details in designing this beam line is at least minimal. Beam comes close to aperture at several location. Magnet quality, alignment etc. has not been taken into account

Addressed by the beamline re-design.

11. (Reviewer: S. Mishra) There are a lot of misgiving about the Main Injector performance in this design. For example it was mentioned that the beam will have no or small tails. To date there has not been any beam without tails unless you put a scraper in front of the beam line. We have no clue how the beam will look when the intensity will be close to 2.5e13 ppp. We also do not know about dp/p of the beam at this intensity. I think NUMI designer needs to work with MI staff to get these parameters straight. Donor assume what is in the MI design report, we have real data or a data can/should be taken. Dispersion in the NUMI line is one concern.

Addressed by the beamline re-design.

12. (Reviewer: S. Mishra) One general comment is that NUMI beam line designer needs to work on P1/P2 line on a daily basis to understand the details of the extraction line operation and problem.

There are insufficient resources to devote to a separate project.

13. (Reviewer: A. Para) I am sure that better minds than mine have been working on this, but nevertheless I would like to hear the pros an cons. Given our geometry and sensitivities, is it possible to design a set of collimators to cut the tails and reduce the beam size to such a level that no losses in the carrier tunnel are possible? (It is not a trivial problem as improperly designed collimators may produce more background than reduce it).

Addressed by the beamline re-design.

14. (Reviewer: A. Para) Very long drift space makes us sensitive to a momentum dispersion of the proton beam. Again, it seems that the Main Injector people are far less optimistic here. Is there anything one could do to reduce our sensitivity? I suppose it is maximal at the downstream end of the drift region. Can one have large aperture quadrupoles there to reduce the beam size?

Parameters from Facility Construction, Radiation Control, Instrumentation
Presenter: S. Childress

1. (Reviewer: D. Capista) Auto tuning for this beam line will require significant effort to make it work. In the 18 years I have been involved in operations, I have NEVER seen an auto tune program work completely correctly even under human control. These programs will diverge on solutions in some cases, range control devices, get bad detector data and steer the beam into a beam pipe, and various other problems. There have been many attempts at such programs in the past but when I look at the list of operational programs I believe many of the auto tune programs have been deleted.

2. (Reviewer: D. Capista) Since beam losses need to be kept very low in this beam line, the BPM system needs to be connected the beam permit system. BPMs will tell the permit system something is going wrong before beam loss occurs. It is true that BPM permits have been removed form the accelerators due to reliability issues, but the accelerators do not have the loss issues this beam line has.

3. (Reviewer: D. Michael) A vacuum window should not be placed between the MI and the NuMI beamline. However, an additional vacuum window at the upstream end of the transfer pipe region could help to avoid trouble and accelerate commissioning.

4. (Reviewer: D. Michael) It is likely that BPM monitoring as proposed will need improvement to provide sufficiently reliable information (on the location of the beam in the pipe). Design requirements for beam position measurement are appropriate.

5. (Reviewer: P. Martin) The beam position monitor system has to work reliably both during commissioning and operations. It must also work at both low

intensity for commissioning and at high intensity for operations. Switchable amplifiers or attenuators may be required.

6. (Reviewer: P. Martin) For the physical layout of the NuMI beamline, I would recommend the addition of two vacuum valves (these could be hand-valves), one on each side of the beampipe that otherwise blocks vehicular access to the A1 line or NuMI stub. This would allow removal of the beampipe without letting up the section of NuMI beamline closest to the Main Injector. This will minimize the impact on MI vacuum following the need for access. Because there is no vacuum window separating the beamline from the MI vacuum system, the design goal should be substantially better than 10^{-7} Torr, not the 10^{-6} Torr presented at the review. Further, the NuMI management should make a strong case for getting that section of beamline completely installed and under vacuum at least a year before first beam, along with taking the necessary steps before and during installation to achieve the higher vacuum levels desired. I realize that the installation cannot be completed right now, due to the interference with the Recycler, but that should be able to corrected sometime in the year or so following the fall shutdown. A reasonable goal would be to get your beamline under vacuum in 2003. This would be an appropriate time for the Lambertsons to be installed as well. On a somewhat related matter, the placement of kickers, needs to be firmed up with the Main Injector department, both in the case of two long kickers or three shorter kickers.

7. (Reviewer: P. Martin) Finally, although this isn't directly a NuMI project concern, it certainly is for the MINOS experiment. That is, understanding the losses in the Main Injector for NuMI operations. As I pointed out in one viewgraph, the losses associated with a multiwire being in the beam bring residual radiation levels in the nearly component up to over 1 R/hr. Extrapolating that to the Main Injector, beam losses of 1% would result in over 100 R/hr. The machine becomes unserviceable. The present ~90% efficiency needs to be improved. Just as the MiniBooNE people have worked with the Proton Source to help understand and reduce losses, the NuMI people need to look at the same issues in the MI.

8. (Reviewer: D. McGinnis) You need to have a way of making sure the BPM system is alive from the tunnel. The typical BPM system in the beams division is notoriously unreliable. I suggest that each BPM is connected to calibration system in the tunnel that measures offset and gain.

9. (Reviewer: D. McGinnis) The BPM system needs to work accurately at low (3e9/bunch) and high intensity (6e10/bunch) which is about 30 dB of dynamic range - tough but do-able.

10. (Reviewer: D. McGinnis) You need to re-think your strategy on the auto-tune program and how the loop is closed (by a program or a human), how you commission such a system, and how robust the system is (BPMs, TRIMs, singular matrix, etc...).

11. (Reviewer: S. Mishra) Instrumentation of the beam line need more and clear thoughts. We heard hand waving arguments during the director's review and we did not get any answer to our questions raised during that review on BPM range etc. Instrumentation is a key for the commissioning and operation of this beam line.

12. (Reviewer: S. Mishra) Power supply regulation and its control needs to be specified in great detail with beam stability in mind. You need to do simulations with beam size and several power supply errors together to understand its effect on the beam position and quality. MI's P1 and P2 line can be good place to study this.

13. (Reviewer: S. Mishra) Need application programs for the operation of this line. NUMI needs to develop a clear plan for that.

14. (Reviewer: A. Para) Delivering protons to the NuMI target seems to be more complicated than one could naively expect. This is due to the fact that we are transporting high intensity proton beam through a water table therefore raising a possibility of groundwater contamination. For financial reasons beam is designed to have a very long drift distance with no active elements. Such a design makes us sensitive to beam losses at the level of 10**-6 - 10**-4, well beyond the range of usual concern.

15. (Reviewer: A. Para) Detailed radiation calculations were performed using MARS and the results were presented in a form of limits on the stability of V105 and V104 magnets. It wasn't clear if these were truly the worst cases, or rather the examples.

16. (Reviewer: A. Para) Great deal of discussion was devoted to the 'Auto-tune' program. Opinions on different sides seem to be divided. I would like to understand better the expected role of this tool: is it just a convenience tool enabling to speed up the tuning and perhaps improve the efficiency of the running, or is it expected to be a critical part of our beam control system?

Groundwater Requirements
Presenter: N. Grossman

1. (Reviewer: D. Capista) Review the ground water radiation issue. Clearly we have to stick to what was presented but it would be interesting to know how much beam we really believe we can lose without causing well contamination. It may be a better position to say we can lose the larger amount of beam without a problem but will operate at this lower value.

2. (Reviewer: D. Michael) Groundwater irradiation simulations need to be updated with more complete beam conditions and more complete environmental conditions.

3. (Reviewer: D. Michael) The allowed regulatory conditions for groundwater protection must continue to be pursued to avoid over-simplified, and over-zealous enforcement.

4. Additional local strageic shielding in the carrier tunnel should be considered. Additional strategic water inflow should be considered.

Test Program/P150
Presenter: A. Marchionni

1. (Reviewer: D. Michael) Additional beam extraction and characterization tests should be pursued.

2. (Reviewer: P. Martin) The beam loss budget is of course the most challenging aspect here. To this end, the studies discussed by A. Marchionni are extremely important. In addition to some of the items he discussed, measurements of the beam momentum spread are necessary. Along with the ACNET parameter for the bunch length, I:BLMON, the actual beam signal from which this is derived should be looked at. While this cannot be datalogged or fast-time-plotted, it contains much pertinent information on tails in E-t space, and bunch-to-bunch fluctuations. As I mentioned during the review, using 3-bumps in the P1 and P2 line to study tails and calibrate the BLMs will prove to be a useful tool, I suspect. I would be happy to meet with the NuMI people who will be working on these studies to help plan things further. As mentioned during the review, the Main Injector Dept. is extremely busy, and therefore NuMI personnel are going to have to take responsibility for these studies with minimal support from MID. But it is important to carry these studies out soon, to help set the specs on momentum stability, pulse to pulse and bunch to bunch.

3. (Reviewer: P. Martin) Apart from the studies with the MI beam and beamlines, design studies should continue for the NuMI beamline to verify that there are not combinations of mistunings of several power supplies that can in fact strike the beampipe in the carrier tunnel. Also, pursue a design of two scrapers per plane to clean up any beam tails or halo at a location where losses of a few percent can be tolerated. If the tails are already there coming out of the Booster, could they be cleaned up in the MI-8 line? Or would they grow again during acceleration? More studies!

4. (Reviewer: A. Para) A requirement of very low level of (average) beam losses leads to a very stringent requirements on power supplies stability and their monitoring. It also requires the knowledge of beam profiles and tails beyond our ability to measure them. It is worrisome that we (i.e. NuMI) seem to be far more optimistic about the proton beam properties than people from the Main Injector are. Our test program at P-150 is of great importance and interest, but this beam

line is sufficiently different from the NuMI line that probably no conclusive results can be obtained.

Addressed by the beamline re-design.