Comments on a Review of Specifications for NuMI Magnet Power Supply
June 28, 2001

Responses by Bruce Baller
May 6, 2004

Beam Loss Limits
Presenter: S. Childress

1. (Reviewer: C. Moore) The one comment I would make in addition to the ones already made is about how one measures in a quantitative manner losses at the10^{-4} or even 10^{-6} level. Sam indicated that we have done this in the past and I should have asked him to elaborate.

One calibrates the loss monitors using known loss points such as the profile monitors or the calibration target.

2. (Reviewer: R. Trendler) I was left with the impression (perhaps incorrectly) that the radiation issues resulting from misdirected beam were not yet completely understood. I suggest that this analysis continue and any subsequent results be presented at another review. A more definitive statement (how much radiation, how long will the beam have to be off, etc.) would be valuable to helping the lab understand the impact of misdirected beam.

Done

Alignment Requirements
Presenter: W. Smart

3. (Reviewer: G. Jackson) The collaboration did a good job of explaining the error tolerances of the transverse placement of the magnets. What they missed was the longitudinal positioning along the beamline. For example, while the Recycler transverse magnet placement tolerance was 10 mils, the tolerance for longitudinal magnet placement was almost 10 times bigger. Error calculations should be expanded to include longitudinal placement errors.

The precision of magnet placement is much smaller than needed.

Beam Transport
Presenter: P. Lucas

1. (Reviewer: D. Edwards) Missing from yesterday's discussion was the essential interplay between beam optics and specification. I realize that cost considerations may prohibit a single series-powered transport line, but when I see that the tightest tolerance is associated with V110 and see some space downstream, I have to wonder if another quadrupole or two might help.

The beamline was re-designed with many more quads.

2. (Reviewer: D. Edwards) Why is the design dispersion function not equal to zero on target? Nor did I receive an answer to my question about the derivative of the disperson function.

The re-designed beam has zero dispersion at the target.

3. (Reviewer: E. Harms) There seems to be great reliance placed on AutoTune for MuMI operation. There were no details provided about it despite the fact that I was led to believe in this review that it will play a significant role in compensating for power supply variation as well as provide for ground water protection. AutoTune deserves special scrutiny because of the multi-faceted role it appears to be playing. In my 20+ years of operational experience with the accelerators and beam lines at Fermilab I have reservations about AutoTune based on the little information I have of it. In general, 'automatic' beam line tuning programs in use at Fermilab have not run with 100% reliability and, in fact, most tuning applications require a fair amount of human intervention. I know there has been talk of running AutoTune on an existing beam line, such as AP1, prior to using it for NuMI. What is the status of such an effort? AutoTune needs to be demonstrated to work as advertised on a primary beam line well before it is put to use for NuMI. In addition AutoTune will need to interface to the power supplies through a controls system - ACNET? Are there specifications for the controls system in terms of resolution both for settings and readbacks?

There are inadequate resources to demonstrate auto-tune performance in the P1 line, however it is used in the MiniBooNE line. Instrumentation specs have been defined.

4. (Reviewer: G. Jackson) It was stated that the 5 Booster batches destined for the NUMI target are extracted 90 degrees in longitudinal phase space rotation after the batch aimed at the antiproton production target is extracted. The goal is to obtain the absolute smallest momentum spread possible in the NUMI primary beamline.

   The problem is that the beam distribution during bunch rotation is not rigid, but in fact deforms the longitudinal beam distribution into an S-shaped phase space shape. By knowing the initial longitudinal bunch emittance and the RF voltages during the rotation, it is possible to precisely simulate this shape. This is a straightforward calculation which would give you MUCH better estimates of the particle losses in the transfer line.

   It was stated that a fractional momentum spread was between 100 and 400 ppm. What is the longitudinal emittances before bunch rotation which achieves these momentum spreads?

The concern about the knowledge of the MI emittance and momentum spread has been obviated by the re-designed NuMI beamline that matches the admittance of the Main Injector.

5. (Reviewer: P. Martin) The issue of whether all errors add in quadrature should be addressed. If there is some cancellation, for example the upbend errors canceling the downbend, then the regulation requirements could be relaxed. I would also recommend examining regulation errors in the P1 and P2 line in detail to see the degree of line-locking presently observable.

Done.

6. (Reviewer: P. Martin) The speakers presented results we could not follow in as much detail as I would have liked. There was often confusion as to exactly what was being plotted…what beam size definition, both transverse and in momentum spread, and how they were being summed. Without the exact information, it is difficult to assess the situation. I would recommend that all this information be gathered into one note, with some additional explanation along these lines. Also, the issues of tails on the momentum spread should be examined further.

Addressed in subsequent reviews.

Targeting Characteristics and Requirements
Presenter: P. Lucas

1. (Reviewer: G. Jackson) During the review two facts were stated which were quite troubling. First, it was stated that if the transverse beam size were to be reduced by a factor of two that the target would be damaged. In other words, the target has only a factor of four energy density safety factor. I was not aware that the science/art of targetry had evolved to error bars down to the size of pi.

   Second, it was stated that the tolerance for random transverse beam size changes is 20%, which corresponds to an emittance variation of 40%. Beam instabilities, especially around transition crossing time and during flattop, make such variations of this magnitude quite common. It is not clear to me that any of the present emittance measurement devices in existence can determine transverse emittance accurately or fast enough to be an input in any kind of beam permit system.

Specifications for NuMI Power Supply Regulation
Presenter: N. Grossman

1. (Reviewer: P. Czarapata) The power supply upgrade should provide configurable monitoring that can be used for the power supply interlock. If a number of supplies are going to be monitored for the NuMI beam permit, it would be far better to signal condition and provide a single signal to the monitoring system indicating if the supply is in tolerance or not. This again allows immediate processing of the signal locally without having to transmit it long distances.

OK

2. (Reviewer: E. Harms) The regulation of trim magnet supplies is noted for maximum current (0.1%). One hopes that these devices will not routinely run at the maximum current. There should be a specification for their operation at low current as well.

NuMI is using the standard corrector power supply.

3. (Reviewer: E. Harms) For the quadrupole supplies there is a difference in regulation spec of (0.05% for the maximum current and (0.44% for the operating current – is this really good enough - has some modeling been performed? Why is there a difference in regulation between the two modes?

Quadrupole PS specs were determined and presented in subsequent reviews.

4. (Reviewer: E. Harms) This was advertised to be a review of the power supply specifications. What was presented focused on power supply regulation. Have the supplies themselves already been purchased? Have issues such as water requirements, controls interfaces, manufacturer, etc. already been addressed? Such issues, and probably others that I haven't thought of, should be part of a power supply review.

NuMI is using existing power supplies.

5. (Reviewer: P. Martin) The power supply regulation requirements for most of the NuMI beamline magnet power supplies (four dipole and all quad supplies) appear to be easily achievable. The remaining three dipole supplies are more challenging and require some development and additional cost to the project. It appears the requirements are entirely physics motivated, as opposed to the other issues that were also raised, namely groundwater protection and use of Autotune. It would be useful for future reviews to tabulate the requirements separately for each supply according to these various issues.

OK

6. (Reviewer: R. Trendler) Since it is likely that there could be some surprises, I suggest that all the considered design techniques be implemented to improve power supply performance. Improvements done later are always much more difficult to make. It would be valuable to remove the power supply regulation issue from the list of potential difficulties in operating this beamline.

OK