Magnet vacuum chamber problems changed implementation (NuMI Review Feb 02)
AND
Beamline review increased nominal kick by approximately 50% (Directors Review April 02)

Accelerator Physics Specifications

Kick Angle (120 Gev Protons)	900 µrad (3.6 kG-m), to radial inside of MI, nominal
Magnet Vacuum Flange Location	1.687 m DS of center of Q602 in Main Injector

(Requires moving horizontal Schottky, transverse wideband detector, DCCT and pinger. Above includes transition piece)

Physical and field aperture	33 mm V x 81 mm H elliptical shape, minimum clear aperture
Field Rise Time (1% to 99%)	1.30 µs maximum (588 – 519 = 69 buckets @ 120 Gev)
Field Flattop time	9.78 µs minimum (6 x 84 + 5 x 3 = 519 buckets @ 120 Gev)
Field Fall time	NA
Flattop during pulse	+/- 1%
Flattop pulse to pulse	+/- 1%

Mechanical Requirements (Derived from Physics Specifications and Other constraints)

Physical beam line space	7.09 m upstream magnet flange to downstream magnet flange

(Does NOT include ion pumps, transition pieces or bellows. Additional 0.44 m are required for transitions and bellows)

Vacuum	$< 10^{-7}$ Torr, 6" Conflat flange, install bellows down stream end, new 300 l/s pump and move existing 300 l/s pump downstream
~~Copy of MI-52 Kicker Magnet~~	~~9510 ME 359987 (x 2)~~
Similar to MI-52 Kicker Magnet	New assembly drawings, new design for ends of magnet, new design for loads
Power Supply Location	MI-60 South Power Supply Room
Water cooling required for magnet	1200 W total (600 W / magnet, 300 W / load)

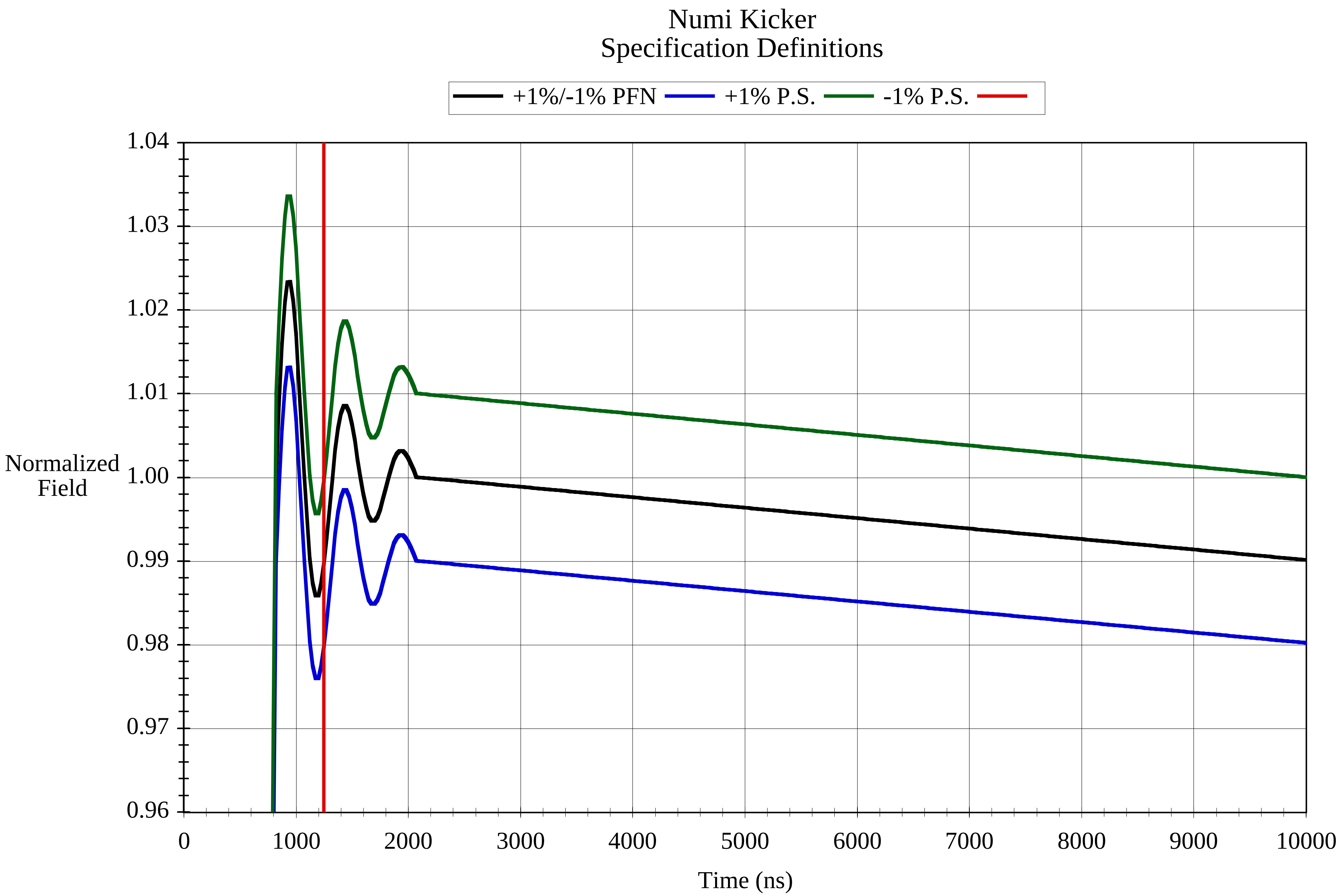
Electrical Requirements (Derived from Physics Specifications and Other constraints)

Total nominal integrated field	3.6 kG-m (2460 A/magnet, 1.98 m magnetic length)
Maximum integrated field (110%)	4.0 kG-m (2730 A/magnet, 2 x 600 ns propagation time)

(Above integrated field numbers do not include the 2.6% electric field kick)

Pulse Forming Network Length	11.5 µs minimum (=9.78 µs + 2 x 0.60 µs + 0.50 µs)
Two Magnets in Series	Rise Time of PFN must be shorter and pulse with slightly longer
MI reset to transfer/next MI reset	1.25 seconds/1.83 seconds

________	________	________	________	________
Chris Jensen (EE)	Terry Anderson (ME)	Nancy Grossman (L3M Power Supply)	Sam Childress (L3M Magnet)	Shekhar Mishra (MI Dept Head)


Numi Kicker
Specification Definitions
+1%/-1% PFN
+1% P.S.
-1% P.S.
Normalized Field
1.04
1.03
1.02
1.01
1.00
0.99
0.98
0.97
0.96
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Time (ns)

Magnets
(One magnet string and two magnets string, strings parallel, loads end of each string)

- No commercial manufacturer of 86” long ceramic vacuum chamber

- Mechanical Support Department (BD) is investigating alternative materials
  - This investigation is limited by budget and manpower
  - Transition from Pyrex tube to Kovar metal flange needs greater strength
  - PEEK has been installed in MI under vacuum and with radiation

- Recycled vacuum chambers will be used
  - Three needed for project and three recovered from old systems
  - Have one good long chamber “dedicated” to NuMI
  - One spare long chamber and one spare magnet remain from Main Injector project

- The Fluorinert used for high voltage insulation has degraded in the MI kickers
  - A filtration system was installed in MI May 01 to combat the problem
  - This solution has visibly cleared up particulates in the Fluorinert
  - An additional filter is required for the magnet load cooling system – separate Fluorinert volumes

- There is considerable daily tunnel temperature variation near Q602, +/- 3 C
  - Is this due to the major vehicle access? Can it be reliably controlled?
  - The extremes at Q520 are similar, but the variation is seasonal, not daily
  - Capacitance has temperature coefficient of approximately –0.47%/C
  - Magnet temperature variations lead to an impedance mismatch and a step in the flattop
  - The new load cooling system has a variable temperature set point (manual or remote?)
  - Thermal insulation around the magnet body is another possibility

Magnet Load Cooling (This was covered under separate review in June 02)

– Each load resistor for NuMI extraction kicker has a higher average power
  - 1.5 times rated MI-10 load power (~ 200 W), 3 x current MI-10 load power (~ 100 W)

– Higher dissipation would result in larger temperature extremes
  - The load resistors have a temperature coefficient of approximately –0.1%/C
  - Change in resistance is equivalent to mismatch step in flattop and to power supply variation
  - Add forced cooling with temperature regulation

– The cooling system design and specification are 90% complete
  - Regulation to be better than +/- 3 F
  - Set point adjustable between 80 F and 120 F

– Construction will begin ASAP to dovetail with load testing

Magnet Loads

– 2 loads per magnet, each magnet current flow in parallel, cooling flow in series

– Original Load problems
  - There is a reliability problem with the high power loads at MI-10 that is related to the fluid and radiation; Filters have been added at MI-10 which seem to take care of the decomposition products; A filter will be installed in cooling system

– A new design for the loads has begun
  - Original design was for convective flow at very little pressure to outside (5 psig)
  - New design will be for forced flow and 50 psig
  - Prototype testing will be necessary; (High power testing and high voltage testing)

Power Supply

Thyratron and Thyratron Enclosure

– To get long life from thyratron (CX1592C) use of double triggering
  - Design is 50% complete

– Mechanical design of the thyratron enclosure with a designer/drafter
  - Mechanical and electrical design of the tube enclosure is 100% complete
  - Mechanical and electrical drawings of the tube enclosure are 95% complete
  - Manufacturing of mechanical and electrical components is 95% complete
  - Only stand design and procure are outstanding. Depends upon PFN enclosure

– Monitoring of CX1592 used at MI-52 done to estimate pre-fire rates
  - Most problems at MI–52 are time line related
  - NuMI thyratron runs at one operating voltage so this should not be a large problem

Charging and Termination Enclosure

– Mechanical design was begun with PPD in June 02
  - Uses same high voltage feed–through as PFN enclosure
  - All electrical parts specified
  - Most long lead time electrical components are received

Pulse Forming Network and Enclosure

– Previous capacitor contract was cancelled (non–performance)
  - This was fortunate; The design changed substantially and old capacitors wouldn't work

– New specification was written and capacitors have been ordered
  - Due end of September 02

– Inspection of MI-52 PFN has shown some problems which must be addressed
  - High current connections to thyratron and between inductors show damage after 10^6 pulses
  - Effective coupling of ~ -1% due to large series inductance
  - Large series inductance between PFN and output cables of thyratron

– New design for longer required lifetimes and to meet new requirements
  - Eliminate many high current connections
  - Increase effective coupling to ~ 5% by winding on single form
  - New requirement of two magnets in series but same field rise time so faster PFN rise time

– Mechanical design was begun with PPD in April 02
  - Design of PFN and tank is at feasibility stage

– High Voltage Feed–through Design
  - Ceramic feed–through with mounting flanges received
  - Non magnetic parts for low inductance
  - Center conductor and outer conductor with bellows to reduce tolerances on interfaces
  - Outer conductor concept complete
  - Inner conductor at feasibility stage

Charging Power Supply

– Regulation achieved with existing MI-52 supply and load was measured
  - Over several hours, when load temperature is stable, regulation is better than +/- 0.25%
  - Over sixteen hours, when load temperature is stable, regulation is worse than +/- 1%
  - Source of regulation problem was found to be humidity in the building. The air insulated power supply had varying leakage current on the feedback resistor which caused regulation errors
  - No air insulated supplies will be used

– A possible second source for charging supply was found
  - It is considerably cheaper if water cooling is available
  - Taps have been added in the drawing for the magnet load cooling system
  - This supply may be available in February 03
  - The vendor has been promising this supply for two years

Controls

– Controls for power supply were started early because of initial schedule
  - NIM bin based controls system.
  - Modules are copies of existing kicker controls for MI
  - Some modules require modifications

– Design of controls has to incorporate new magnet temperature control system
  - Some new NIM modules are required

– Fault identification and action plan has been done
  - One or two new trips required for load cooling system
  - One sum fault bit for before triggering faults
  - C204 card (MADC Monitor) for power supply voltage, magnet current and load temperature

Manpower

- A detailed list or remaining tasks and there dependence has been started
- Electrical Engineer/Design and Oversight
  - Chris Jensen
- Electrical Technician for Controls and PFN electrical assembly
  - Dirong Chen OR Ken Kellogg
- Electrical Drafting
  - EE Support drafting department
- Mechanical Engineering/Design and Oversight
  - Power Supply Mechanical Design – Andrew Szymulanski, PPD/MD
  - PFN Assembly Oversight – Chris Jensen, BD/EES AND/OR Andrew Szymulanski, PPD/MD
  - Magnet load and magnet cooling – Scott Reeves, BD/MSD
  - Magnet – Jim Walton, BD/Tev
  - Vacuum chamber – Rob Reilly, BD/MSD
- Mechanical Technician
  - PFN assembly ? High Rise or MAB?
  - Magnet assembly – Cliff Foster, BD/MSD is only experienced technician
  - Magnet load assembly – Cliff Foster, BD/MSD is only experienced technician
  - Magnet cooling assembly – To be determined, BD/MSD
- Mechanical Drafting
  - PFN, Termination Box and Thyratron Stand – To be determined, PPD/MS
  - Thyratron Enclosure (Revisions) and PFN Prototype Coil – Tim Hamerla, BD/MSD

List of Remaining Tasks for Power Supply

1. Design of PFN Coil	Started
2. Design of PFN Tank and Other Internals	Started
3. Design of HV Feed–through	Started
4. Capacitor Order	Started
5. Manufacture Prototype PFN Coil and Shield	After 1
6. Final Adjustment on PFN Coil and Tank	After 3, 4
7. Design of Termination Tank	After 2
8. Design of Thyratron Enclosure Stand	After 2,7
9. Order Remaining PFN Parts	After 6
10. Order HV Feed–through	After 3
11. Order Termination Parts	After 7
12. Order and Assem Thyratron Stand	After 8
13. Thyratron Trigger	Started
14. Assembly Termination Box	After 11
15. Connect Term Box and Thyratron Enclosure	After 12,14
16. High Voltage Test of all but PFN	After 15
17. Assembly PFN	After 4
18. Testing of PFN Only	After 7
19. Installation of PFN, Thy and Term	After 18
20. Electrical Controls	After Magnet Cooling
21. Installation of Controls	After 20
22. Commissioning	After 21

List of Remaining Tasks for Magnet

1. Order Magnet Internal Parts	7.22.02
2. Box Redesign for Shorter Beam Tube	After 10
3. Design of Unique Internal Parts	After 2
4. Design of Unique External Parts	Anytime
5. High Voltage test w/o Fluorinert in magnet	Anytime
6. Order Magnet Internal Parts	After 3
7. Order Magnet External Parts	After 2
8. Inspection of Incoming Parts	Continuous
9. Design Review of Ceramic Joints	ASAP
10. Sample Weld of Monel-Kovar-Stainless Steel	ASAP
11. Design of Special Chill Blocks	After 9
12. Final Weld of beam tubes w/vacuum flanges	After 11
13. Assembly of 3 magnet boxes w/ beam tubes	After 6,7
14. Assembly of 1st magnet w/ internal parts	After 1, 13
15. Assembly of 2nd and 3rd magnets w/ internal parts	After 14
16. Design Load Cooling System	Started
17. Order Load Cooling System Parts	After 16
18. Testing of Cooling System	Concurrent 23
19. Install Piping infrastructure	Long Shutdown
20. Design of Magnet Load	Started
21. Order Load Parts for Prototype	After 20
22. Assembly of Prototype Load	After 21
23. Burn-in test of prototype Load	Concurrent 18
24. Order Load Parts for Final	After 23
25. Assembly of final loads	After 24
26. High Voltage Test of Magnets w/ Fluorinert	After 15,25
27. Tunnel Installation	After 26

Simulations and Calculations

- Full electrical model of PFN
  - Model is done based on calculations.
  - Need a prototype coil to verify model
  - Only limited changes available (coil form diameter and coil shielding diameter)
- Detailed model of magnet and load
  - Made detailed measurements of old magnet design and new magnet design
  - Verified old magnet design against pulse measurements
  - Using detailed model of magnet and PFN to predict performance with three magnet system
- Complete simulation of new PFN and magnet
  - Some adjustments still required

Installation

- Cable tunnel pulls for all but the instrumentation are complete
  - Small number of cables
  - Do all at the same time
- Pulse forming network and switch enclosure
  - Assembled in tech areas and delivered to MI-60
  - Installation 3rd Quarter 2004
- Magnets, Magnet Loads and Magnet Cooling
  - Assembled in High Rise tech area and Mechanical Tech are and delivered to MI-60
  - Installation 4th Quarter 2003