## Area System: Acceleration MAP L2 Manager: J. Scott Berg[[1]](#footnote-1) Sub-System: Acceleration from 63 to ≈3000 GeV Revision Date: February 28, 2014

## Introduction

This subsystem accelerates the muon beam from 63 GeV to the maximum energy that will fit on the Fermilab site given the technology described in this specification. The systems will be able to deliver beam to a collider ring at the intermediate energies of 750 GeV and 1500 GeV.

## Design Requirements

The accelerators will be synchrotrons, where magnet fields are all pulsed with fields approximately proportional to beam momentum, or hybrid synchrotrons, where fixed-field superconducting dipoles are interleaved with bipolar pulsed dipoles, while other magnets are pulsed with fields approximately proportional to beam momentum. The lattices will maintain a constant time of flight and tune through the acceleration process. The acceleration rate will be constant. Sextupoles will be included to correct chromaticity while cancelling their lowest-order resonant driving terms. The energy breakpoint between the first two stages will be chosen to give the first two stages the same circumference. The final stage will attempt to reach the highest energy possible while staying within the Fermilab site boundaries and maintaining a reasonable level of decay (no particular level of decay, or equivalently average acceleration rate, is specified). Table 1 gives the stages and performance requirements.

Table 1: Design requirements for acceleration from 63 to ≈3000 GeV

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Units | Value | | | |
| Input total energy | GeV | 63 | ≈375 | 750 | 1500 |
| Output total energy | GeV | ≈375 | 750 | 1500 | ≈3000 |
| Maximum circumference | km |  |  |  | 15 |
| Machine type |  | Synchrotron | Hybrid Synchrotron | Hybrid Synchrotron | Hybrid Synchrotron |
| Normalized transverse emittance | µm | 25 | | | |
| Normalized longitudinal emittance | mm | 70 | | | |
| Muons per sign |  | 2 × 1012 | | | |
| Repetition rate | Hz | 15 | 15 | 12 | 6 |
| Minimum average acceleration rate | MeV/m | 3.5 | | |  |
| Maximum transverse emittance growth per stage | % | 3 | | | |
| Maximum longitudinal emittance growth per stage | % | 3 | | | |
| Minimum amplitude transmitted | σ | 4.5 | | | |

## Sub-System Parameters

Table 2: Magnet parameters for acceleration from 63 to ≈3000 GeV

|  |  |  |
| --- | --- | --- |
| Parameter | Units | Value |
| Maximum fixed dipole field | T | 10 |
| Maximum ramped dipole field | T | 1.5 |
| Maximum ramped quadrupole field at beam | T | 0.7 |
| Maximum ramped sextupole field at beam | T | 0.5 |
| Maximum kicker field | T | 0.2 |
| Maximum septum field | T | 1.0 |
| Inter-magnet spacing | m | 0.5 |

Table 3: RF parameters for acceleration from 63 to ≈3000 GeV. The highest RF frequency that meets the design requirements will be used.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Parameter | Units | Value | | | |
| Frequency | MHz | 325 | 650 | 975 | 1300 |
| Gradient | MV/m | 20 | 25 | 30 | 35 |
| Maximum energy gain per cell | MeV | 9.22 | 5.77 | 4.61 | 4.04 |
| Maximum cells per cavity |  | 4 | 5 | 7 | 9 |
| Additional length at each end | cells | 1.5 | | | |
| Maximum input power per cavity | MW | 1.2 | | | |

## Technology Requirements

Table 4: List of required sub-system technologies and their Feasibility Ranking

|  |  |
| --- | --- |
| Technology | Feasibility Rank |
| Superconducting RF cavity systems | 1 |
| Detailed Description:  Pulsed superconducting RF cavities, their power supplies, and other associated systems. Stored energy extracted on each pass will be restored. | |
| Rapid cycling magnets | 3 |
| Detailed Description:  Pulsed dipoles, quadrupoles, and sextupoles. Only dipoles are bipolar. Dipole field ramp rates could reach 12000 T/s with a maximum field of 1.5 T. Steel laminate construction. Poles and return yoke may be different materials. Includes power supply which should control current to ramp the field as specified (expected to be nearly linear; may drive the magnet beyond saturation before and after beam is present to achieve this). | |
| Superconducting dipoles | 1 |
| Detailed Description:  Needed for hybrid synchrotrons. Nb3Sn assumed for these fields. | |
| Injection/extraction magnets and systems | 1 |
| Detailed Description:  Kickers, septa, and their power supplies. Kicker fields based on the work of E. Nakamura. | |

1. This manuscript has been authored by employees of Brookhaven Science Associates, LLC under Contract No. DE-AC02-98CH10886 with the U.S. Department of Energy. The United States Government retains a non-exclusive, paid-up, irrevocable, world-wide license to publish or reproduce the published form of this manuscript, or allow others to do so, for United States Government purposes. [↑](#footnote-ref-1)