

Fast Ramping Proton & Muon Acceleration

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Preliminary 150 Hz 8 GeV Fermilab Proton Booster

	15 Hz Booster	150 Hz Booster
Ring Circumference	468 m	468 m
Rise Frequency	15 Hz	100 Hz
Fall Frequency	15 Hz	300 Hz
No. RF Cavities	17	114
Total RF Power	1.7 MWatt	11.4 MWatt
Ferrite Type	Ni-Zn	Yttrium-Garnet
Ferrite Biasing	Axial	Radial
RF Cavity Length	2.4 m	2.0 m
RF Ring Fraction	8%	50%
Dipole Peak Field	0.7 T	1.1 T
Magnet Ring Fraction	60%	40%
Lamination Thickness	0.64 mm	0.18 mm
Lamination Material	3% Si Steel	3% Si Steel
Chokes	3% Si Steel	Metglas
Magnets/Power Supply	2	1
Turns/Magnet	48 or 56	24 or 28
Maximum AC Voltage	455 Volts	2200 Volts
Maximum Current	1023 Amps	3000 Amps
Copper Wire Size	12 × 12 mm	2 × 2 mm
Total Magnet Power	1.3 MWatt	5 MWatt

150 Hz 8 GeV Fermilab Proton Booster Notes

- 10x more cycles → 10x more protons
- Magnet Formulas : $I = B h / \mu_0 N$, $V = 2\pi B f N w \ell$
- Lower Eddy Current Loss Options
Power Lost = [Volume]($2\pi f B w$)² / (24ρ)
Move magnet coils further away from fringe fields.
Thinner, higher resistance steel: 6% Si NKK Super E-Core
- Higher gradient RF would be useful (Finemet ??).
Allows lower magnetic fields and coil currents.

Muons: 5 to 4000 GeV with one 25 GV 800 MHz LINAC

- 800 MHz RF handles beam loading better than 1.3 GHz RF
- 5 to 100 GeV in a 4 pass dogbone using same 25GV LINAC
- 100 to 4000 GeV in an $R = 2200\text{m}$ tunnel (fits Fermilab)
 - 100 to 550 GeV with 100% 2T magnets
 - 550 to 2000 GeV with 18% 16T and 78% $\pm 2\text{T}$ magnets
 - 2000 to 3100 GeV with 36% 16T and 64% $\pm 2\text{T}$ magnets
 - 3100 to 4000 GeV with 50% 16T and 50% $\pm 2\text{T}$ magnets
 - 16T superconducting magnets are fixed (8T gives 2400 GeV)
 - Interleaved ramping magnets go from -2T to +2T
 - 71% muon survival during 156 orbits which takes 7.2 ms
- Need 34 10MW Klystrons to feed 4×10^{12} orbiting muons
 - Need 8 ms pulse and 12% duty cycle for 15 Hz rep rate
 - 10MW 1.3GHz ILC Klystrons: 1 ms pulse, 2% duty cycle
- Each muon sign has its own ring, because $\Delta p = 25 \text{ GeV}/c$.
Can use harmonic number jumping to keep in phase with RF.