Linac Test Facility Beam Properties

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Abstract

A new experimental beam area, the Linac-area Test Facility, will be constructed at Fermilab beginning in spring 2001. This area will be used initially for cryogenic tests of liquid-hydrogen absorbers for the MUCOOL R&D program and, later, for high-power beam tests of absorbers and other prototype muon-cooling apparatus with the intense, 400-MeV, FNAL Linac proton beam. A new primary beamline will divert beam from the Linac to the test facility, taking advantage of civil construction left behind from the Linac Upgrade Project. This note specifies the range in beam parameters that will be available: a range intended to match the range in beam properties needed to test the prototype muon-cooling absorbers and structures. The hope is to design sufficient flexibility into control of the beam such that the facility will support not only this, but future technical applications as well.

1 Introduction

A new facility derived from the FNAL Linac is being constructed to perform tests of muon cooling devices and structures. Civil construction will begin on the experimental hall in the spring of 2001, with beneficial occupancy expected in May 2001. Installation of the primary beamline is scheduled to start in spring, 2002. The facility will be located southwest of Wilson Hall between the Linac berm and the parking lot.

The liquid-hydrogen absorbers are designed to cool large beams: $\sigma = 1$ to 5 cm, with a total cooling-channel acceptance of 3σ. Given the small transverse beam size characteristic of the Linac, the beam extracted from the Linac must be blown up. This note specifies the range in beam parameters that will be available and a method by which those parameters can be achieved under current Linac operating conditions.

2 Linac and LTF Beam Parameters

The parameters of the Linac beam are given in Table 1. Since the Linac delivers an H^- beam, the two electrons will need to be stripped upstream of the test stand in a carbon foil in order to provide only protons to the test apparatus.

The liquid-hydrogen absorbers to be tested range in size from 11 to at least 18 cm in radius, with the muon beam filling almost the entire cross-sectional area of the absorber. To simulate realistically the muon beam in a cooling channel, the test beam must then satisfy certain requirements for size, divergence, and intensity, and, also, in the adjustability of these parameters. For example, much smaller “hot” beam spots are desired in order to test the limits of localized heat deposition in the absorbers. The proposed parameter ranges are summarized in Table 2.

Table 1: General Linac beam parameters

Parameter	**Value**	**Unit**
Kinetic Energy	401.5	MeV
Energy Spread	1	MeV
Peak Current	52	mA
RF Structure	201.24	MHz
Bunch Length	0.208	ns
Pulse Length	50	µs
Max Particles Per Bunch	1.6	10^9
Max Particles Per Pulse	1.6	10^{13}
Max Beam Power	15.7	kW
Beam Emittance (95%)*	8	mm·mrad
σ_{max} (rms)	9	mm

* Since $\beta\gamma \approx 1$, normalized and unnormalized emittances are approximately equal.

The magnetic elements needed to produce this large beam require an unusually large aperture of at least 15 cm in radius just upstream of the device under test. (A similar aperture is needed downstream in order to refocus the beam onto the beam dump.) In addition, to avoid unacceptable beam losses on the beamline and test-stand components, tails will need to be scraped at $\pm 3\sigma$ on a primary collimator located upstream of the shielding wall that will separate the Linac enclosure from the Test Facility. A secondary collimator is recommended just after the shielding to shadow downstream components, in particular, the test stand. The secondary collimator represents a final safeguard against activation, thereby guaranteeing levels of residual radioactivity that allow hands-on-maintenance.

Table 2: Beam parameters proposed for the Linac Test Facility

Parameter	**Minimum**	**Maximum**	**Unit**
Beam Size ($\pm 3\sigma$) at D.U.T.*	1	30	cm
Beam Divergence† ($\pm 3\sigma$) at D.U.T.*	±0.5	±14	mr
Number of Pulses per Second		15	
Number of Protons per Pulse	1.6	16	10^{12}
Pulse Duration	5.0	50	µs

* D.U.T. = Device Under Test
†Min. divergence at max. size and vice versa.

Currently, we are exploring the availability at various laboratories of large-aperture quadrupoles suitable for transporting and controlling these large beams. Stripping foils, collimators, and their housings will need to be built. Extraction components, diagnostics, and other beamline devices will be addressed in a later note. However, the devices critical to achieving the large beam size are the quadrupoles. Therefore, we need the above specifications and parameters to be reviewed by the collaboration before proceeding with acquisition of these critical beamline components and finalizing the beamline design.