THE 500 MeV INJECTOR FOR MAX-LAB USING A RECIRCULATED LINAC

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Abstract

Two linac structures equipped with SLED cavities [1] producing 125 MeV each will be installed at MAX-lab. The electron beam, supplied by an RF-gun, will be recirculated once through the linacs and reach a final energy of 500 MeV.

The recirculator is isochronous and achromatic which conserves a low energy spread and emittance. All magnets are machined out of two double iron plates allowing an easy production and installation.

First operation at 125 MeV is foreseen to Christmas 2000.

1 INTRODUCTION

The national laboratory MAX-lab is currently replacing its old injector (a 100 MeV Racetrack Microtron) for the storage rings. The injector will produce electrons for injection at 250 MeV into the MAX I storage ring, 500 MeV into the storage rings MAX II and MAX III, which is in production. The MAX I storage ring is also operated as a pulse stretcher and will raise its energy from 100 to 250 MeV. The source should also provide electrons for future possible installations of FELs in the Infrared and/or VUV.

2 CONCEPT

The basic principle of the new injector is to create a compact machine at a moderate cost which can operate for multiple purposes (tab 4.). Despite the long tradition at MAX-lab of Racetrack Mikrotrons the choice has fallen on a linac solution. On a traditional linac two concepts have been attached. First the linacs are equipped with SLED cavities. They allow an increase of roughly 80% of the extracted energy. Second the electron beam is recirculated once through the linacs. By this method a 15 m section with two 75 MeV linacs can be boosted to a final energy of 500 MeV.

2.1 Operation modes

The linac and recirculator system will operate in a number of modes (tab. 1). These include both modes to replace the old accelerators, and modes that are expansions of the current system. Finally there are modes which are for development, and not actually funded at the moment.

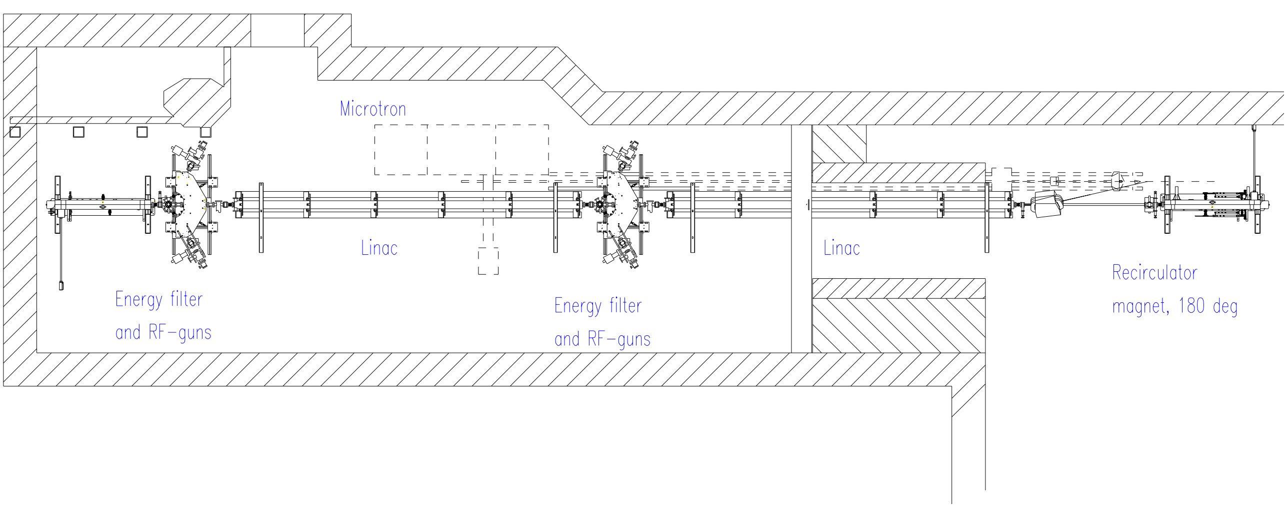

Figure 1: Layout of the recirculator.

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Table 1 Operation modes

Energy	Mode	
100-125	SLED	Inject MAX I and MAX II (stage 1)
250	SLED	Injector for MAX I, SR and pulse strecher. (stage 2)
500	SLED	Injector for MAX II and the new ring. (stage 3)
30- 75	Classical	Driver for IR-FEL.
200-500	SLED	UV-FEL.

2.2 Layout

The complete new injector is designed to fit into the existing microtron cave (fig. 1), which is directly underneath the MAX I storage ring.

Some additional radiation shielding will be added to ensure safe conditions even with a more powerful source. The two linac structures will hang from the ceiling and the recirculation line will follow close to the floor level. The overall length of the system is 15 m.

Table 2. The LINAC system

Type	TWT	
Length	5.2	m
Q	10.000	
Frequency	3	GHz
Klystron power	35	MW
Energy gain (no SLED, 0 A)	77.35	MeV
Energy gain (SLED, 0 A)	138.7	MeV
Energy gain (SLED, 50 mA)	136.5	MeV
Peak gradient increase by SLED	x 2.63	
Peak integrated gradient increase by SLED	x 1.793	

3 THE LINAC SYSTEM

The two linac sections (tab. 2 and fig. 3) are produced by Accel, tuned at DESY and already delivered to MAX. These structures are identical to the ones delivered to the 100 MeV injector for SLS (PSI, Switzerland). In standard configuration using one 35 MW klystron per linac an electron energy fo 75 MeV can be achieved. In the MAX-lab set up a system with SLED cavities (tab. 3) boost this energy to above 125 MeV.

3.1 SLED system

The idea of energy doubling is developed by Stanford [1] and uses additional storage cavities into which energy is accumulated and rapidly released to the linacs. (a similar technique is developed by CERN called LIPS). There is of course a cost for this energy boost: the pulse to the linacs is considerably shorter than in the ordinary case. By recirculation the extracted electron pulse will be maximum half of the linac pulse. In our case we will extract a 100 ns pulse at 500 MeV. As our storage rings are 100, 100 and 300 ns each this is a very convenient number.

Table 3. Parameters of the SLED cavities

MODE	TE015
Q	100.000
Frequency	3 GHz
β	6.7
Diameter	200 mm
Length	300 mm

3.2 RF-system

Two new 35 MW klystrons are ordered to supply the linacs. These can conveniently be placed in an adjacent room.

4 THE RECIRCULATOR

The recirculator (fig. 3) is to recycle the electron beam after the first transit of the linacs back to the first linac for the second linac transit under isochronous conditions. The system is thus designed to work at 250 MeV.

Each 180^0 bend should be close to a drift section matrix. They are also achromats to first and second order of energy. The 180^0 bend consists of three bending magnets and five quadrupole magnets. The first order momentum compaction is adjusted to zero and the contribution from energy errors to second order for the length coordinate are adjusted to zero.

Table 4. The linac design and performance.

		MAX I	MAX II	MAX III
Target	Electron energy (MeV)	250	500	500
	Pulse length (ns)	100	100	100
	Pulse current (mA)	40	40	40
	Rep rate (Hz)	10	10	10
	Emittance (nmrad) rms	20	10	10
	Energy spread(%) rms	+-0.5	+-0.2	+-0.2
Simulated	Emittance,norm (rms, mm mRad)	14 @ 50 mA		
		3.4 @ 5 mA		
	Energy, per section	273 MeV @ 50 mA, 35 MW		
	$\sigma E/E$ (rms, %)	0.033		
	ΔL (rms)	3 ps		

4.3 Magnets

The magnets of the recirculator are machined out of two solid plates of 70 mm iron (fig.2). The two plates are arranged such that they form a "door". The coils and the vacuum chamber are mounted for the magnets and the "door closed". The whole 180 degree bend thus forms one package.

4.4 Chicane

The circumference of the recirculator must be precisely a multiple of the linac wavelength 99.974 mm (frequency 2.9987 GHz). Therefore the circumference is chosen to be 1 mm shorter than such a multiple and a chicane is added in the recirculator return path. This chicane can add up to 2 mm length. It consists of three magnets with a spacing of 1.0 m center-to-center. The beam in the central magnet is displaced 45 mm relative the straight beam at maximum deflection.

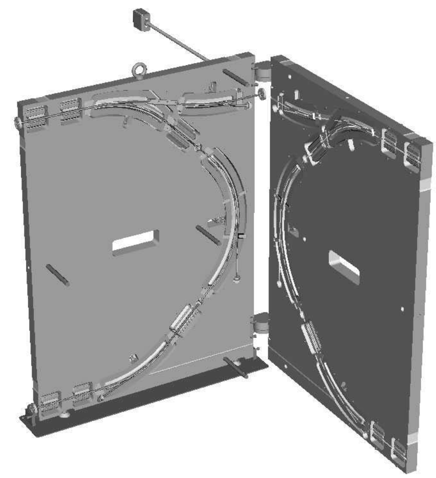

Figure 2. The reciruclator magnets fare machine out of one solid iron plate forming a door.

5 SUMMARY

A cost effective and compact solution for a 500 MeV linac based injector has been elaborated. The performance is expected to well fulfil the current needs at MAX-lab. At the same time the machines provides excellent opportunities for new developments, especially as a driver for different FEL solutions [2]. Today (June 2000) the two linac sections, one klystron and injection magnets are delivered to MAX. The recirculator magnets and the gun are in production. First installations are planned for this summer and first beam half a year later.

REFERENCES

1 Z.D. Farkas; SLAC-PUB-1453 (1974)
2 S. Werin et. al. FEL 99

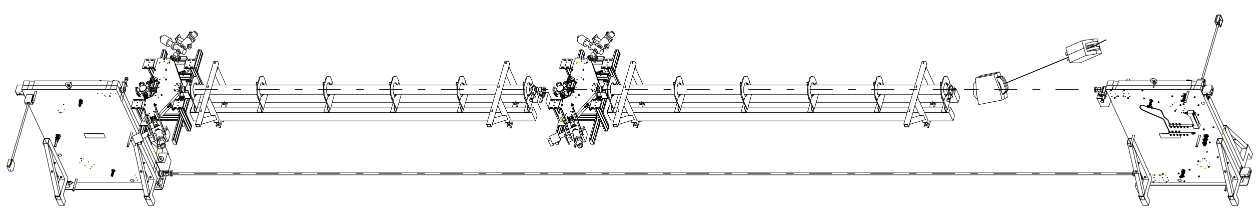

Figure 3. The injector system