COMMISSIONING OF THE 500 MEV INJECTOR FOR MAX-LAB

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Abstract

A 500 MeV new injector system for the storage rings MAX I, II and III have been installed during the winter 2003-4 at MAX-lab. The system consists of two linacs at 125 MeV each, using SLED, and a recirculating system such that the electrons pass the linacs twice, thus reaching a final energy of 500 MeV. The system is injected by a thermionic RF-gun.

The complete system was put into operation in June 2004.

INTRODUCTION

The MAX-laboratory has replaced its 100 MeV Racetrack Microtron (RTM) by a 500 MeV linac injector [1,2]. The reasons for this change are:

- the RTM was growing old (20+ years of operation) with heavy radiation damage on the interior components.
- the MAX I storage ring has been used as a booster, but only been able to operate at 0.03 Hz maximum.
- A new ring, MAX III, is coming into operation and additional flexibility on the injector was needed.
- The MAX I storage ring is used not only as a synchrotron radiation source, but also as a pulse stretcher ring and the new injector will allow an increase of the stretched beam energy to 250 MeV.

The first 100 MeV has been in operation since 1.5 years for injection into the MAX I and II storage rings.

OVERVIEW OF THE MACHINE

The new injector is built as a recirculator where the linac structures are passed twice (fig 1). A thermionic RF-gun is injecting the beam into the linac structures. These are equipped with SLED cavities [3] to increase the energy gain to 125 MeV per passage.

Table 1. Parameters of the injector

Gun	energy	2 MeV
	ε_n	15 mm mRad
	Freq	3 GHz
	Current	>100 mA
	Pulse length	3 ps (simulation)
Linac	energy	125 MeV (w sled)
	Length	5.2 m
	Freq	3 GHz
	Gradient	25 MV/m

The recirculator system consists of two "blocks" including all the lattice elements. The overall size is 15 x 2 m. A chicane along the floor assures the fine tuning of phasing between the turns. A compensation of earth

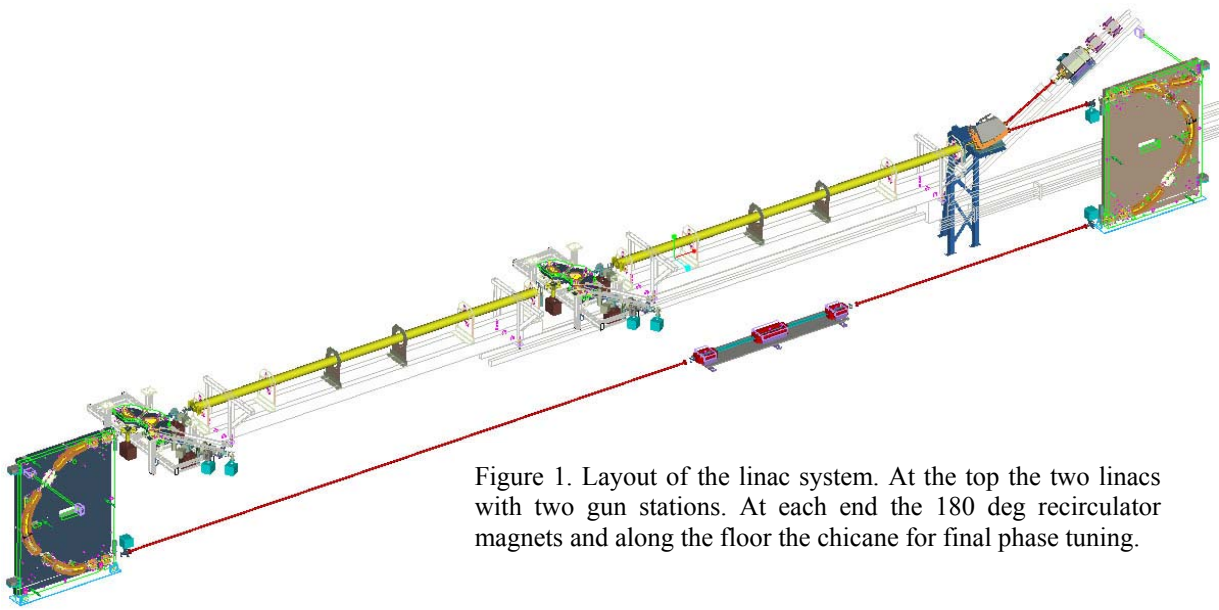

Figure 1. Layout of the linac system. At the top the two linacs with two gun stations. At each end the 180 deg recirculator magnets and along the floor the chicane for final phase tuning.

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magnetic field had to be done in the return path of the recirculator.

CONDITIONING OF THE RF SYSTEMS

Gun

The RF gun is the second structure produced at MAX-lab and put into operation. The first one has been used routinely for 1.5 years without any problems. The conditioning of the second structure was undramatic and went smooothly up to the same level as the first gun. The extracted energy is only around 1.6 MeV (kinetic) but as the operation performs well at this level we have not forced the process further at the moment. The available klystron power is in principle available for kinetic energies above 2 MeV, but we will then lie on the limit for the two recirculators on the waveguide.

SLED cavities

The SLED cavities are also produced by MAX-lab and a first set is in operation since 1.5 years. We have experienced with this second set some minor discharges possibly due to an inbalance in the resonance frequency of the two cavities. This has not hampered the operation and the SLED systems perform on the overall excellently.

Linac structures

The first installed linac (in 2002) was conditioned rather "brutally" and we decided to go ahead more carefully the second time. Conditioning was first done not using the SLED cavities up to full power on the klystron (35 MW). When the SLED system is engaged the pulse length is shortened and the maximum power is immediately increased. When an increase in pressure is detected the power is backed off for a while.

The conditioning has proven to take more time than expected and full power has not been reached by this conference (June 2004).

START-UP AND OPERATION

In December 2002 the first gun and linac was put into operation at 110 MeV. At this time the removal of the RTM and the old electron gun system could begin. After installation of the second linac system a second gun and the recirculator system first beams through the complete system were seen in June this year. (see fig 2 and 3).

Running an electron beam through the gun, energy filter and linac was undramatic as this part is a copy of the part put into operation 1.5 years ago. The main challenge has been in passing the recirculator system and the new injection line for MAX II. The conditioning of the linac's has been slower than expected and we are thus extracting 310 MeV from the injector. The linacs though are conditioned to around 380 MeV.

The start up of a new system is normally done by letting the beam pass element by element and adjust the position and current along the way. This was also initially done in this case. The main result was that one can find magnets which are not properly wired. This is always present and especially in a construction as the MAX recirculator the wiring is a critical task.

The injector is not a forgiving machine in the sense that a beam only close to the desired parameters will not pass. The optics can not allow for more than a few percent of deviation in the quadrupole settings to not destroy the beam completely. On the other hand all components are precisely machined and by a proper knowledge of the quadrupole magnet iron length the theoretical lattice works right from start.

This also proved to be the case. After pinning down errors in the electrical & mechanical installations the beam fairly easy passed the system on theoretical settings.

The first extracted beam only reaches 15 mA (best measured to date) at 310 MeV energy and 60 ns pulse length. This will be improved during the very next days.

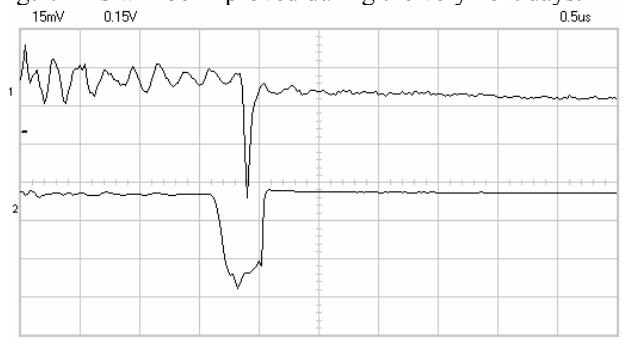

Figure 2. Current pulses. Lower curve shows the current inside the recirculator. The first turn pulse (90 mA, 155 MeV) as a large pulse and on top of it the small second turn (10 mA, 310 MeV). The top curve shows the pulse exiting the injector (5 mA, 310 MeV).

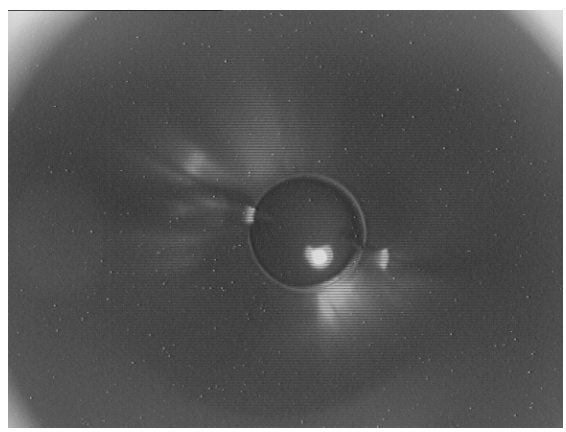

Figure 3. The electron pulse exiting the injector detected on a fluorescent screen.

SUMMARY

A compact flexible linac injector has been put into operation. The system uses the novel MAX-lab technique of integrated magnet lattices and a thermionic RF-gun

also built by MAX-lab. The full design performance has not yet been reached but first passage of the beam was made only two weeks ago. The immediate goal is to operate the injections of the MAX II via the new injector.

REFERENCES

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