STATUS OF THE NEW INJECTOR FOR MAX-LAB

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Abstract

The new injector for MAX-lab is built around two 125 MeV linacs [1] equipped with SLED cavities [2]. The electron beam is recirculated once to reach 500 MeV. A 2.3 MeV thermionic RF gun [3] injects into the system.

The RF-gun is put into operation and commissioning of the first linac is proceeding. Results from the thermionic RF-gun operation, linac commissioning and first beam operations are presented.

1 BACKGROUND

MAX-lab is operating two electron storage rings, MAX I at 550 MeV and MAX II at 1.5 GeV. Currently the injection into MAX I is done by a 100 MeV Racetrack Microtron (RTM). The MAX II is also fed by the RTM but the MAX I is used as a booster to reach the injection energy of 500 MeV. The MAX I storage ring is further used as a pulse stretcher for nuclear physics at energies up to 100 MeV.

To increase the performance of the overall system and to improve reliability as the RTM has been in operation for more than 20 years a new injector system has been designed, constructed and is now partly under commissioning.

2 OVERVIEW

The new injector system is built around two normal conducting 3 GHz linac sections. Both these linacs are equipped with SLED cavities and powered by one 35 MW klystron each and can thus deliver up to 137 MeV at zero current. The linacs are placed in a recirculator and the electron beam passes twice through the system which gives a theoretical energy of 4 x 137 MeV, of which we intend to extract 4 x 125 = 500 MeV.

The electron source for the linacs is a 2.3 MeV RF-gun, which removes the demands for a pre-accelerator and buncher.

2.1 Step 1

The project will run in steps, and the first will be to extract 100 MeV electrons from one linac for the injection into MAX I in a similar pattern as today. When this is achieved the old RTM can be removed and there will be space to install the recirculator system.

2.2 Step 2

In the second step the second linac structure will be installed and the recirculator system. The linacs now has to be conditioned up to full energy and injections into the MAX II ring at 500 MeV will take place.

2.3 Step 3

The last step is operation of the injector for injection into MAX I at 250 MeV to raise the energy of the pulse stretcher mode. At this time 500 MeV injection into the third storage ring at MAX-lab, the MAX II, which is in production will also take place.

3 RF-GUN AND ENERGY FILTER

The gun is a newly designed 3 GHz RF-structure built by MAX-lab [3]. It accelerates the electrons up to 2.3 MeV which removes the demands for a pre accelerator linac. The gun is equipped with a thermionic BaO cathode and a current up to 600 mA is anticipated.

As thermionic guns suffer from a long low energy tail the electron beam is treated in an energy filter. It is a DBA-structure (Q Q B Q B Q Q) bending 120 degrees

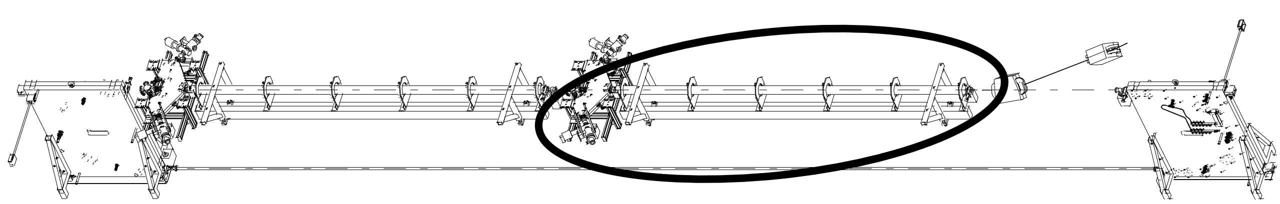

Fig. 1. The injector system. The marked area are the components put into operation.

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with dispersion present in the middle to allow for filtering of low energy particles by a moveable scraper placed in the middle quadrupole. Roughly 50% of the gun output will be removed.

4 LINAC

The two linacs are commercial systems supplied by the ACCEL company. They are 5.5 m long of the travelling wave type, identical to the ones at the SLS. They are fed by one 35 MW klystron each, which would bring us up to 77 MeV at zero current.

A SLED system using high Q storage cavities, designed and built in house, will produce a more powerful, but shorter pulse. The resulting SLED pulse is only 800 ns long. As the linac filling time is 700 ns one can accelerate during 100 ns, which is 1.5 turn in the recirculator.

5 OPERATIONS

First operations and final conditioning of the first linac structure is just underway these days (May 2002). Improvements are seen every day, and what is reported here will be slightly out of date when you read it.

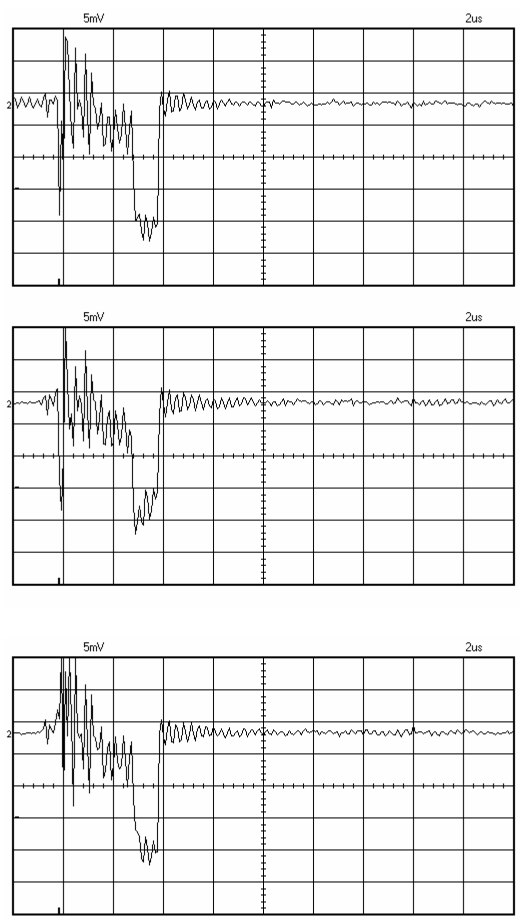

Fig 1 a-c. The electron pulse after the energy filter.
a) optimised b) decreased magnetic field c) increased magnetic field.

5.1 Gun and energy filter operation

The gun is fully commissioned up to maximum energy. The current and emittance of the electron beam has not yet been measured though.

RF commissioning of the gun was straight forward and in principle the main time was spent on two thresholds while raising the input power. The fields in the gun are around 80 MV/m maximum on axis and just below 100 MV/m on the surface.

The BaO cathode was conditioned at around 1100 C. The operation temperature will be lower, but after an interruption of operation over a couple of weeks a quick reconditioning was necessary. Measuring the temperature was done by an IR-thermometer (pyrometer) but this proved to be a little bit tricky, and the precision was not very good.

Emittance and absolute current measurements proved to be difficult in the present set up due to the always present low energy electrons. Adequate focusing of the main beam causes the low energy photons to disturb many measurements. These measurements thus have to be done after energy filtering of the electron beam, and thus some modifications have to be made.

The gun is now operated routinely, and only a few minutes are needed to raise the cathode temperature from stand-by to operation, before full current is extracted.

The electron pulse after the energy filter is, without engaging the scraper, 1 us long (fig 1). The pulse only passes at full energy and by decreasing the magnetic field of the energy filter the earlier part of the macro pulse can be enhanced (fig 1b) and by increasing the field the earlier part of the macro pulse is suppressed (fig 1c).

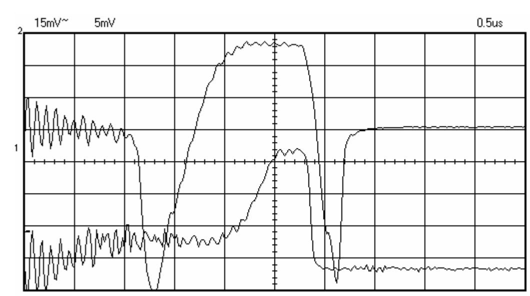

Fig 2. The pulse at the gun exit (top) and after the energy filter (bottom) with the scraper put in.

The conversion efficiency of the energy filter is roughly 30% (amount of particles from the gun that remain in the beam) (fig 2). This is slightly less than simulations predict (50%) which indicates that further optimisation of the electron optics needs to be done.

By introducing the scraper the pulse length can be reduced to 500 ns (fig 2), without changing the RF-pulse length. A further reduction will be possible be shortening of the RF-pulse.

Figure 2 also clearly shows that the scraper removes electrons in the beginning of the macro pulse and leaves the end untouched.

5.2 Linac operation

The first linac is conditioned up to 10 MW at 1.5 us pulses. This was achieved very quickly, within a few hours. Longer pulses are still possible only at lower power levels. Conditioning is now proceeding with short pulses (< 0.5 us) up to full klystron power, 35 MW. The pulse will then be prolonged to > 0.8 us, which is the length of the pulses from the SLED cavities. The following step will be to engage the SLED cavities.

6 SUMMARY

Operation up until the current level has been fairly easy from the side of the accelerator. The main problems lie on the detector side: Lack of detectors and/or detectors that do not perform as expected. In most cases an assumed malfunctioning of the accelerator has proved to be inappropriate detector systems.

Right now the focus is to raise the linac power to be able to accelerate 100 MeV electrons. This needs commissioning of the linac system with the SLED cavities.

REFERENCES

[1] B. Anderberg, Å. Andersson, M. Demirkan, M. Eriksson M. Georgsson, G. LeBlanc, L-J Lindgren and S. Werin, THE 500 MeV INJECTOR FOR MAX-LAB
USING A RECIRCULATED LINAC, EPAC 2000, Vienna

[2] Z.D. Farkas; SLAC-PUB-1453 (1974)

[3] B. Anderberg, Å. Andersson, M. Demirkan, M. Eriksson and S. Werin, A NEW 3 GHz RF-GUN STRUCTURE FOR MAX-LAB, EPAC 2000, Vienna