# DESIGN AND CONSTRUCTION OF A TURN-KEY 100 MeV LINAC FOR THE SWISS LIGHT SOURCE

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*Abstract*

The 100 MeV injector for the Swiss Light Source is a turn-key-system consisting of thermionic gun, a prebuncher and buncher system, two S-Band accelerating structures (5.2 m) as well as the complete supplies (RF and DC), control electronics and control software. An overview on the major design, fabrication and installation steps with description of the achieved test results is presented.

## 1 INTRODUCTION

In 1998 the Paul Sherrer Institut (CH) contracted the manufacturing of a 100 MeV injector linac [1] with ACCEL Instruments. Based on customer specifications, ACCEL designed, built, installed and commissioned this system within two years.

## 2 SYSTEM

The main systems of the Linac are:

- Electron Source
- Bunching Section
- Accelerating Structures
- RF Supply
- Control System

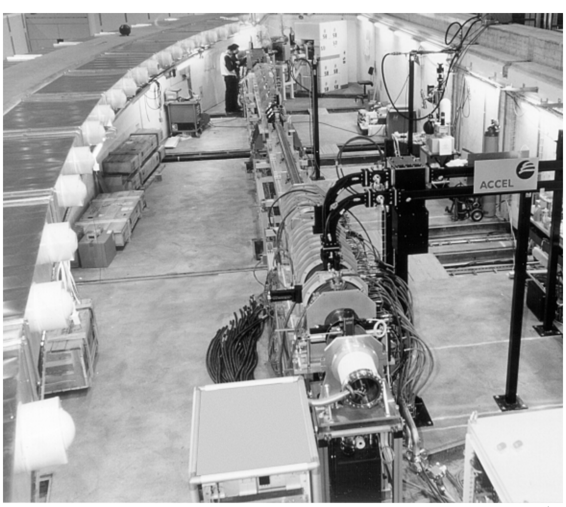


Figure 1: Linac during installation February 2000[1]

### 2.1 Electron Source

The electron source was designed to house a standard cathode and two fulfil the high dynamical range according to the requested charge and pulse pattern. Two modes of operation had been defined by PSI. A single pulse mode (Mode 1) which is allowed to fill only one booster bucket. The booster is operated at 499.652 MHz, this corresponds to a pulse length of 1 ns. Mode two is capable of filling the entire booster, with a single shot. Both modes are specified to produce the same charge. For the measured data refer to table 1.

[1] Source: PSI Pressestelle

Table 1: Electron source Parameters

| Parameter | Value |
|---|---|
| Energy | 90 keV |
| Output pulse current Mode1 | (0.06-3) A |
| Output pulse current Mode2 | (0.1-3) mA |
| Pulse length Mode1 | 1ns FWHM |
| Pulse length Flat Top Mode2 | (0.2 – 1)μs |
| Droop Mode2 | ≈ 6 % |
| Repetition rate | ≤ 10Hz |

A sketch of the electron source is given in figure 2.

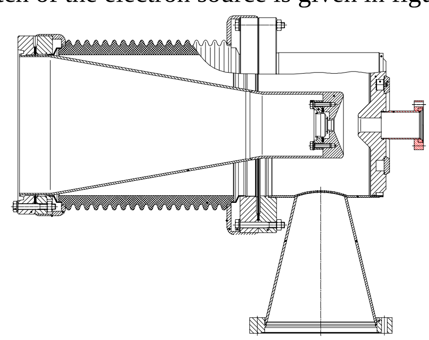

Figure 2: Layout of the Electron Source

The electron source was characterised using a Faraday Cup and a wall current monitor [3]. Figure 3 show the first pulse generated, fulfilling the needs of charge (2.3 nC) and pulse length (1 ns FWHM).

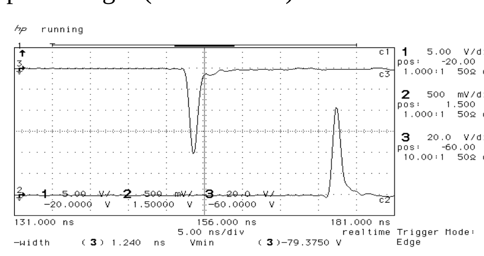


Figure 3: Short Pulse Bunch shape of the electron source

### 2.2 Bunching Section

The bunching section is capable of compressing the beam longitudinal to have more then 80% of the electrons within less then 20° of the 3 GHz system (~20 ps pulse length).

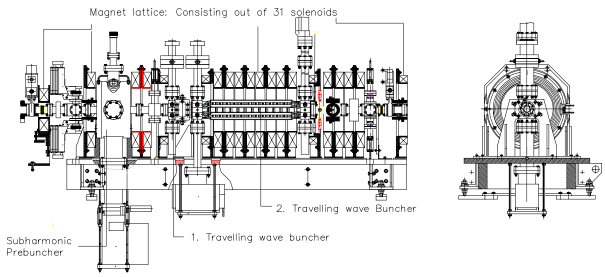


Figure 4: Bunching section, consisting out of a 500 MHz prebuncher and two 3 GHz travelling wave bunchers. The magnet system as well is shown

## 2.3 Accelerating Structures

The travelling wave constant gradient structures accelerate the beam from 3 MeV to 100 MeV. Structure parameters are listed in table 2.

Table 2: Parameters S-Band Structure

| Basic parameters | | |
|---|---|---|
| Length | 5.2 | m |
| Shunt Impedance | 51.5 | MΩ/m |
| Attenuation | 0.5 | Neper |
| Frequency | 2.997912 +/- .03 | GHz |
| Mode | 2 π / 3 | |
| Type | Const. Grad. | |

Figure 5 show the first 5.2 m long accelerating structure produced by ACCEL for the SLS project.

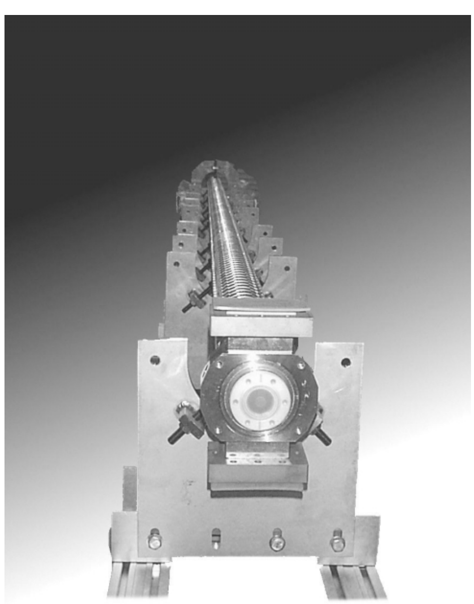

Figure 5: S-Band Structure built following DESY Linac II Design [2]

## 2.4 RF Supply

From the PSI master rf signal (500 MHz), two 500 MHz lines, one for the grid modulation of the gun and the other for the 500 MHz subharmonic prebuncher are generated. Beside that a frequency multiplier is used to produce the 3 GHz. Two 3 GHz branches are used. Each branch feed one Thomson TH 2100 35 MW klystron, the 300 W drive power required by this klystron type is generated by a solid state amplifier. All amplifiers are operated in pulsed mode. Settings for the rf power, as used during commissioning are listed in table 3.

Table 3: Rf power levels used during commissioning

| Component | Power required |
|---|---|
| Electron Source Grid | 500 W |
| 500 MHz prebuncher | 500 W |
| 4 cell buncher | 2.7 MW |
| 16 cell buncher | 3.7 MW |
| Accelerating section 1 | 11.5 MW |
| Accelerating section 2 | 18 MW |

The pulse forming network is charged by a 10 kJ switch mode power supply. The voltage (~290 kV) and current (~290 A) pulses of the first klystron are shown in figure 6.

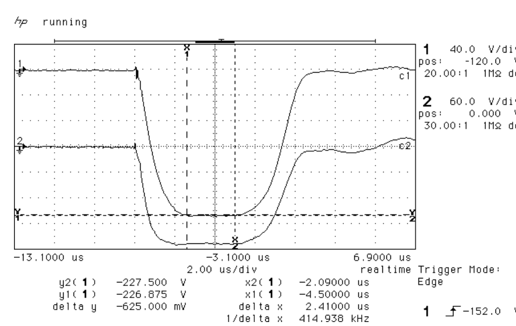


Figure 6: HV Klystron Pulse delivered by a 20 Cell Pulse Forming Network

## 2.5 Control System

The control system of the linac is based on a VME field bus system with VxWorks and a control computer running Linux. According to the requirements of our customer EPICs was chosen as the control system software. Beside EPICs state machines, to control system components, also graphical user interfaces where delivered. These interfaces are programmed using an extended version of Tcl/Tk (EMW[2]). Figure 7 shows the rf panel as an example, it allow phasing and rf power adjustment of all accelerating components.

[2] www.delta.uni-dortmund.de/controls

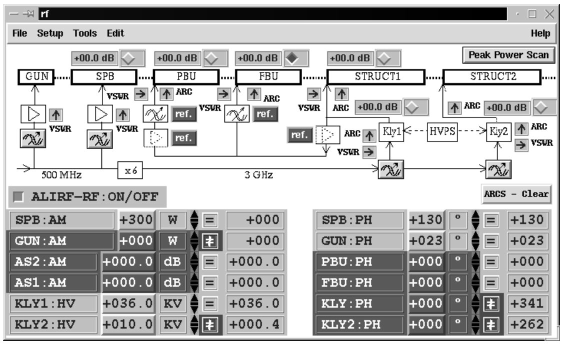


Figure 7: Graphical User Interface for RF control

## 3 COMISSIONING

Commissioning of the injector was finished in April 2000, after showing all defined parameters in a 4 hour run [4] for each mode, without readjusting the system.

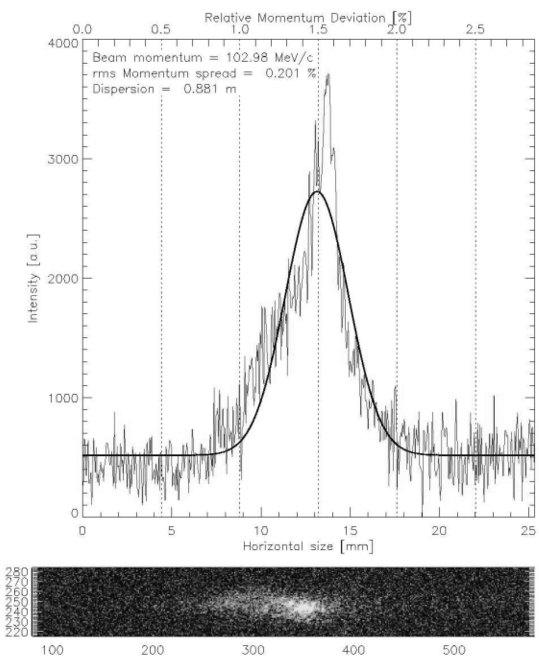


Figure 8: Energy spread measurement in Long Pulse Mode

The results are listed in table 4. The system fulfilled or exceeded all requirements.

Figure 8 show the energy spread as measured after a 15° bending magnet.

Table 4: Commissioning results of the SLS Injector

| Param. | Unit | Long Pulse Mode | | Short Pulse Mode | |
|---|---|---|---|---|---|
| | | Spec | Meas | Spec | Meas |
| Bunch length | ns | 200-900 | 200-2200 | 1 | 1 |
| Charge | nC | 1.5 | 2.1 | 1.5 | 2 |
| Energy | MeV | >100 | 103 | >100 | 102 |
| Energy stability | % | <0.25 | <0.1 | <0.25 | <0.1 |
| Energy spread | | <0.5 (rms) | 0.3 | <0.5 (rms) | 0.4 |
| Emittance (1s), n. | π mm mrad | <50 | 40 | <50 | 50 |
| Repetition rate | Hz | 3.125 | 3.125 / 10 | 3.125 | 3.125 / 10 |

## 4 CONCLUSION

This 100 MeV Linac was designed, built, installed and handed to SLS as a turn-key system based on a set of parameters as charge, emittance, energy and energyspread within about a two year period.

## ACKNOWLEDGEMENTS

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## REFERENCES

[1] Specification for the ELECTRON PRE-INJECTOR LINAC for the SWISS LIGHT SOURCE, SLS SPEC03/RL02

[2] R. Brinkmann, Conceptual Design of a 500 GeV e+e- Linear Collider, DESY 1997-048

[3] M. Dach, et al., “SLS Linac Diagnostics – Commissioning Results”, Beam Instrumentation Workshop Proceedings, Boston, 2000.

[4] M. Pedrozzi, C.Piel, “Commissioning of the SLS-Linac, this conference