Commissioning of the 100 MeV Swiss Light Source Injector Linac

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Abstract

The 100 MeV injector for the Swiss Light Source, designed and delivered as turnkey system by ACCEL Instruments, was commissioned in April 2000 [1]. A description of the system consisting of electron source, buncher section, accelerating structures, rf power plant and control system will be given. Specified and measured beam parameters will be compared to show the performance of the entire system.

1 INTRODUCTION

Since April 2000 the injector Linac for the Swiss Light Source SLS is under operation. Meanwhile the booster commissioning started successful.

2 LINAC

The main systems of the Linac as electron source, bunching section, accelerating structures, RF supply and control system will be described according to their performance in the following paragraphs. More information can be found in former publications [2][3][4][5].

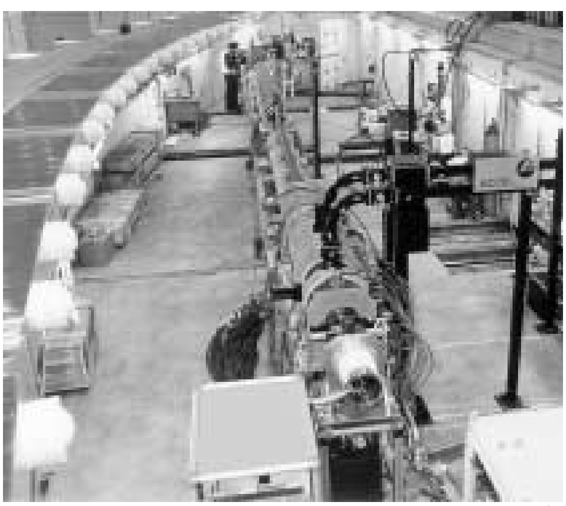

Figure 1: Linac during installation February 2000[1]

2.1 Electron Source

The electron source is operated in two modes, allowing to fill the storage ring with single bunches and with 500 MHz modulated multi bunch trains. The electron source parameters are listed in table 1.

Beside these two operation modes for single and multi bunch filling of the storage ring, SLS requires variable pulse charge. This option will be used to keep the stored current in the synchrotron light source constant within 0.1% by injecting just low charged pulses into the storage ring.

All operation modes and the amount of emitted current as well are under remote control[2]. The electron source current is varried either by changing the pulser voltage or the grid voltage of the cathode.

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

Figure 2 shows the bunch shape right after the source for different settings. After reducing the charge, no further adjustments are necessary to accelerate the beam to 100 MeV.

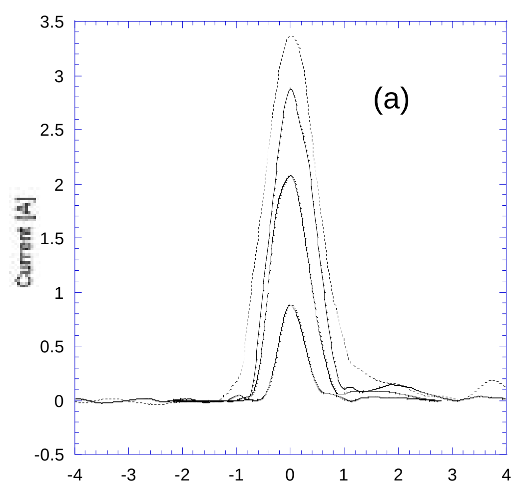

Figure 2: Wall Current Monitor signals for different charges right after the electron source

2.2 Bunching Section

Requirements as low energy spread and emittance ask for a high efficient bunching. The bunching system is

[1] Courtesy PSI Pressestelle

[2] All needed control system software based on the SLS EPICs and VxWorks installation. All graphical user interfaces supplied had been written using an extendent version of Tcl/Tk

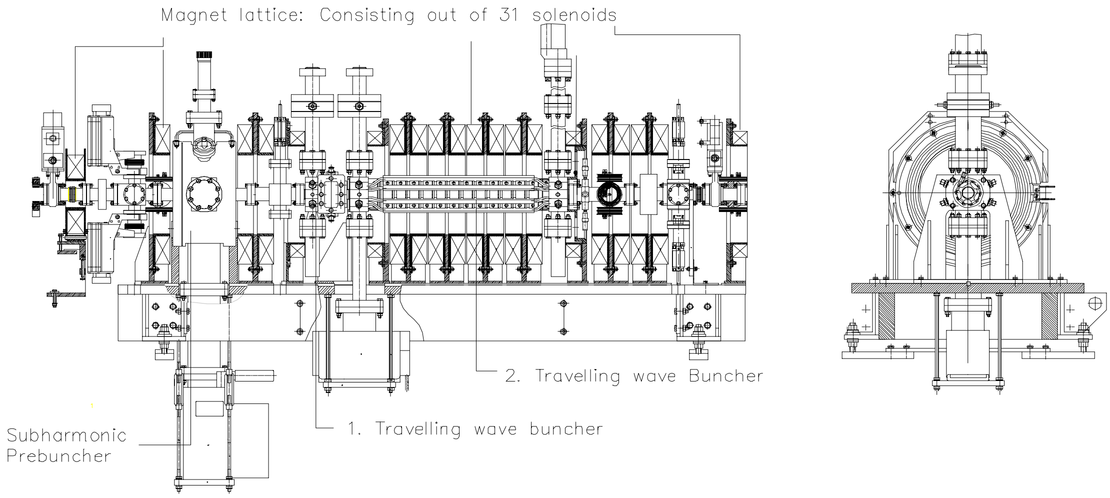

Figure 3: Bunching section, consisting of a 500 MHz prebuncher, two 3 GHz travelling wave bunchers and magnet system

shown in figure 3. The drift spaces between bunching components had been optimised to find an effective compromise for all operation modes using Parmela[6]. The values simulated and achieved are listed in table 2.

Both travelling wave bunchers, the 4 cell pre buncher and the 16 cell final buncher, are based on designs developed for the DESY S-band linear collider test facility[7].

Table 2: Longitudinal beam parameters

Value	Unit	Specified	Simulated	Achieved
Energy spread	%	0.5 rms	0.7	0.4
Trans-mission	%	-	90	80

The two 3 GHz bunchers are very effective. The energy spread within a micro bunch is below 0.1 %, as it can be seen in figure 4. This corresponds to a micro bunch length of 5° in the 3 GHz frame. The image is taken after the transfer dipol magnet. The dispersion here is ~0.8 m therefore the micro bunches seperated by beam loading in the accelerating structures can nicely be seen.

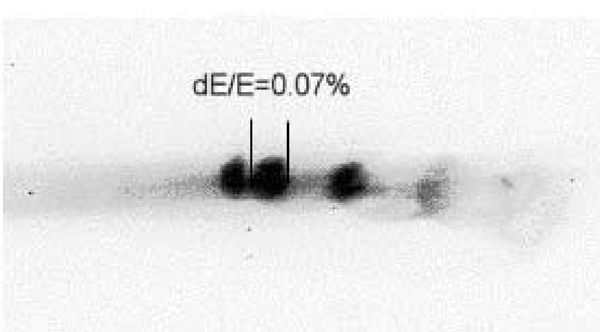

Figure 4: Micro bunch energy spectrum, separated by beam loading

The image as shown in figure 4 can only be observed when the 500 MHz sub harmonic pre buncher is not operating. The 500 MHz pre buncher can catch over 80% of the particles emitted from the electron source in single bunch mode, in multi bunch mode even more, and merge them into one 3 GHz bucket.

2.3 Accelerating structures

The mean energy of the beam after the bunching section is 4 MeV. To reach the specified energy of 100 MeV two 5.2 m long traveling wave structures are used. Basic and operational parameters are given in table 3.

Table 3: Parameters S-Band Structure under operation

Basic parameters			
Frequency	2.997912 +/- .03		GHz
Shunt Impedance	51.5		MΩ/m
Length	5		m
Operation			
	Section 1	Section 2	
Input power	12	19	MW
Gradient	9	11	MV/m
Energy gain	44	55	MeV

Figure 5 shows the energy reached and the over all energy spread of the particle beam.

2.4 Magnet lattice

Due to space charge and longitudinal compression the beam needs strong focusing. This is realised from 90 keV up to 11 MeV by 31 solenoids. The following focus elements are quadrupols. The solenoids are of three different types. One air cooled high impedance coil is used right after the gun, all others are water cooled. This setup of magnets can produce a peak magnetic field of

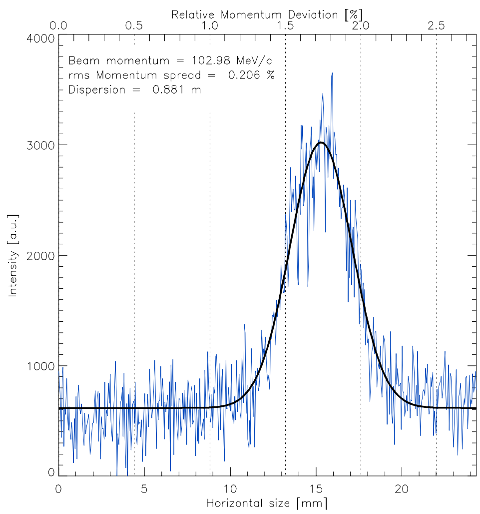

Figure 5: Energy (102 MeV) and energy spread (0.2% rms) measurement in Short Pulse Mode (@1.9 nC)

1900 Gauss. 16 independent power supplies are used to shape the magnetic field.

To avoid steering effects of the solenoids three pairs of steerers are installed as well. With this flexible optics it was possible to achieve the emittance which is required to insure efficient injection into the SLS booster. The emittance measurement was done by variing the transfer line quadrupoles while observing the beam size by using an optical screen. The emittance program written by A. Streun, uses IDL built in functions to analyse the beam image taken from a frame grabber card [4].

2.5 RF power plant

The main rf power is generated by two 3 GHz power plants equipped with Thomson TH2100 tubes. Each pulse forming network is charged by a switch mode power supply and can be operated up to 10 Hz.

Besides energy stabilisation of all accelerating structures and a stable low level rf system, the precision of the charging units is responsible for the excellent energy stability of the entire linac. As shown in figure 6 the stability is much better than the required 0.25%.

Table 4: Comissioning results

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
Stability	%	<0.25	<0.1	<0.25	<0.1
dE/E rms	%	<0.5	0.3	<0.5	0.4
Emittance (1σ), n.	π mm mrad	<50	40	<50	50
Rep. Rate	Hz	3.125	3.1/10	3.125	3.1/10

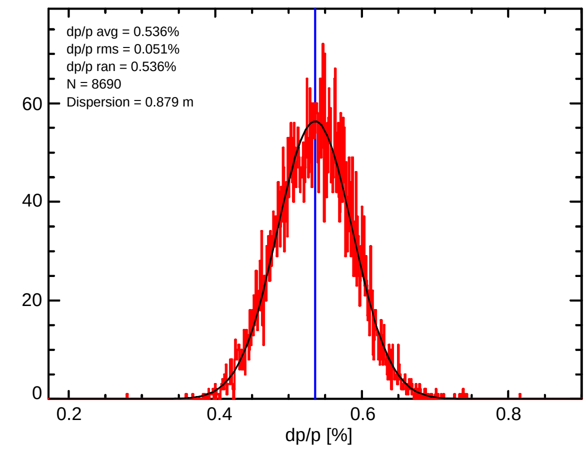

Figure 6: Long term energy stability of the linac: No. of pulses: 8890, energy spread: 0.536%, jitter: 0.05%

3 SUMMARY

Commissioning of the injector was finished in April 2000, after showing all defined parameters in a 4 hour run [3] for each mode, without readjusting the system.

Design, installation, commissioning and operator training was done within a two year period. The major measured parameters are listed in table 4.

4 REFERENCES

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