45 MeV Linac for the 800 MeV Synchrotron Radiation Light Source

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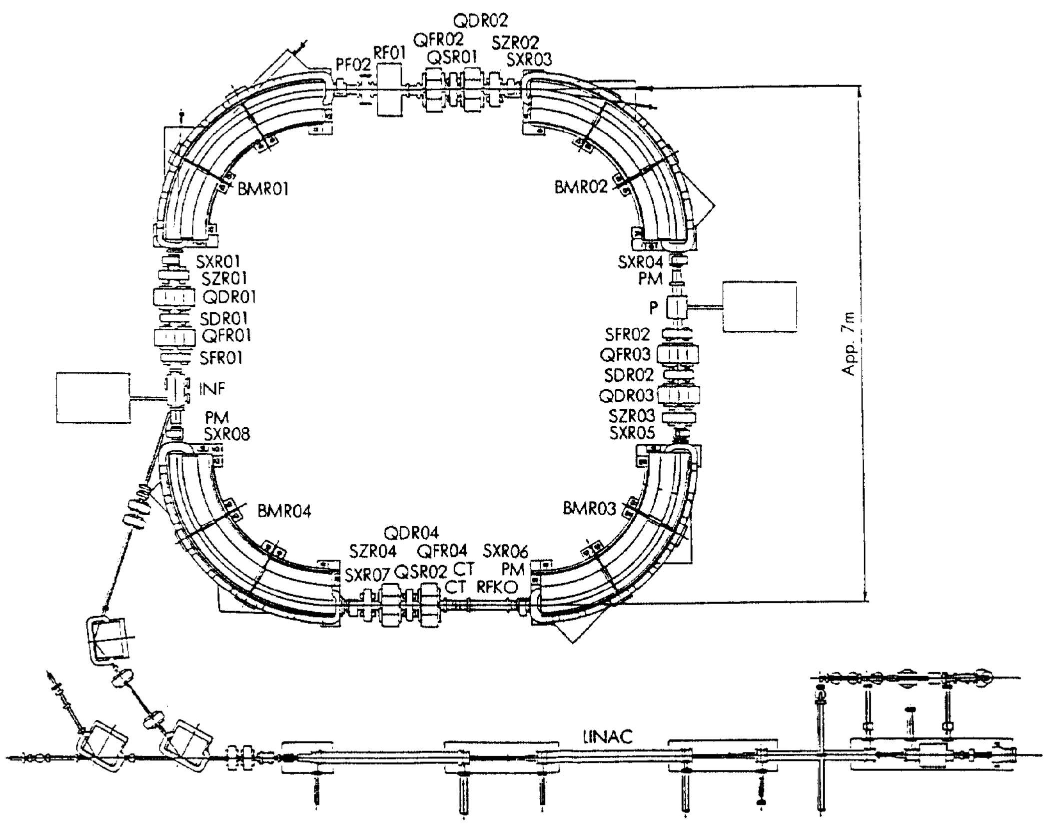
Abstract

A 45 MeV linac has been developed by Ishikawajima-harima Heavy Industries Co.,Ltd (IHI) as an injector of the compact synchrotron radiation light source. The construction of SR system, called LUNA, was completed in 1989 at Tsuchiura facility of IHI, and now several experiments for X-ray lithography are in progress. The linac is now being operated successfully. The detailed descriptions and the beam performances of the linac are described.

INTRODUCTION

Synchrotron radiation is expected to be used in various industrial applications, especially for the X-ray lithography in LSI production. The LUNA system was developed for our own use for various researches, including X-ray lithography[1].

The LUNA specifications were decided to develop "a low - cost, stable light source" in a short time. As a result, we selected the "low energy injection" method and a square ring with



(Note)

RF:	RF cavity	*P:	Purturbator (Pulse magnet for injection)
SXR:	Steering magnet for horizontal direction	PM:	Position monitor
SZR:	Steering magnet for vertical direction	CT:	Current monitor
SFR, SDR:	Sextupole magnet	RFKO:	RF knock-out electrode
QSR:	Skew magnet	BMR:	Bending magnet
INF:	Inflector (Palse magnet for injection)	QFR:	Focusing quadrupole magnet
		QDR:	Defocusing quadrupole magnet

Fig. 1 Layout of Synchrotron

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normal conducting magnets. The ring is used both as a booster and a storage ring. The injector of LUNA is a 45 MeV linear accelerator. We choose this injection energy, for the following two points. The first one is the electron life time problem, scattering with residual gas. It is desirable to choose the higher injection energy in order to accumulate the higher beam current. The second one is compactness and cost. It is preferable to choose the lower injection energy and the shorter accelerating structure. The installation of LUNA was completed in April, 1989. Synchrotron radiation at 800MeV was observed in December, 1989. Now a days, 50mA beam current at 800MeV is obtained, and its lifetime is longer than 30 minutes. The layout of synchrotron is shown in Fig. 1.

DESCRIPTIONS OF LINAC

A. Overall configulation

Fig. 2 shows configulations of linac.The system consists of an electron gun, a 50cm buncher section, a 1.5m regular section and two 2m regular sections. Two S-band klystrons with a frequency of 2,856 MHz are used as RF sources.

B. Electron gun

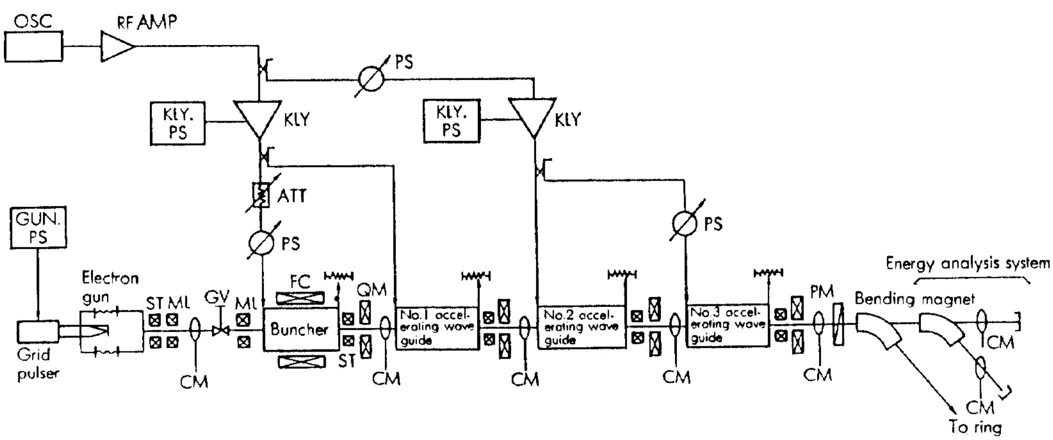
The electron gun is the triode type with grid control. The cathode is the impregnated dispenser type. Electrons are emitted by the pulse voltage 100 kV. Two type of grid pulsers are installed to produce short pulse, 40ns, and long pulse, 1.0μ s.

C. Accelerating wave guides

Fig. 3 shows a cross-section of a regular accelerating wave guide. The specifications are shown below.

Length	1,500mm (1 wave guides)
	2,000mm (2 wave guides)
Type	2/3 π mode
	constant impedance
Shunt impedance	50 MΩ/m
Att. constant	0.28 1/m
Group velocity	0.88c
Q value	12,000
RF frequency	2,856 MHz
RF source	8 MW(peak)
	22MW(peak)

IHI has manufactured the accelerating structured at own shop. The electroforming method was used to construct them.



(Note)

PS:	Phase shifter
ST:	Steering magnet
ML:	Magnetic lens
CM:	Current monitor
CM:	Current monitor
GV:	Gate valve
FC:	Focusing magnet
QM:	Quadrupole magnet
PM:	Profile monitor
OSC:	Synthesizer
RF AMP:	RF Amplifier
KLY:	Klystron
KLY. PS:	Klystron power supply
GUN. PS:	Gun power supply
ATT:	Attenuator

Fig. 2 Configulations of Linac

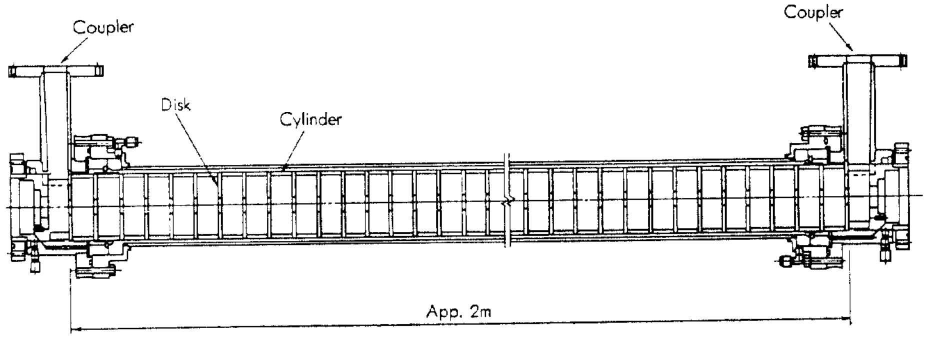


Fig. 3 Cross Section of Regular Tube

D. RF system

S-band (2856 MHz) klystron is employed because it is popular as a high power pulse klystron. The reference RF signal oscillated by a synthesizer is amplified to 2 kW by a low power pulse klystron. It is then amplified to 8 MW and 22 MW by two main klystrons.

E. Vacuum system

The vacuum system of the accelerating wave guides is designed to meet the value of 1.33 x 10 - 4 Pa (10 - 6 Torr) or less. A turbo molecular pump performs rough pumping, after which four ion pumps evacuate the accelerating wave guides with the pumping speed of 60 l/sec each.

EXPERIMENTAL PERFORMANCES

The beam energy and energy spread were measured using an energy analyzing section, which consists of a bending magnet, a slit and a current monitor. Beam energy vs. beam current curve is shown in Fig. 4. Current transformers are used as beam current monitor. They are located at each end of the accelerating wave guides. A fluorescence type screen monitor is located at the end of the linac. Emittance was also measured, following the method used at KEK (National Laboratory for High Energy Physics)[2]. Measurement was carried out by varying the focal length of the quadrupole magnet and recording the diameter of beam profile. The specifications and the performances of the linac system are summarized in Table 1. Performances satisfy the design specifications.

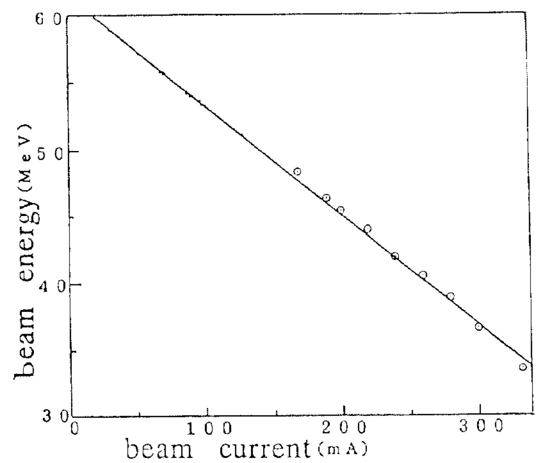


Fig.4 Beam Energy vs. Beam Current

Table 1 Specifications and Performances

	specification	result
Energy	45MeV	45MeV
Beam Current	100mA ($\Delta E/E$ <±2%)	100mA
Pulse Length	Long pulse 1μsec Short pulse 40nsec	~ 1μsec ~ 40nsec
Reptition Rate	1~20pps	1~20pps
Energy Spread	±2%	±1%
Emittance	10^{-5}m · rad	10^{-5}m · rad

CONCLUSION

We have successfully developed the injector for our synchrotron light source. The measured performances fit well with the designed specifications. On the basis of this linac, we are developing the higher electrical field accelerator structure.

REFERENCES

[1]S.Mandai et al.,"Development of Compact Synchrotron Light Source for X-ray Lithography", The 3rd International Conf. on Synchrotron Radiation Instr.,Tsukuba,Japan,1988
[2]S.Ohsawa et al.,"Beam emittance measurement of the positron generator at KEK",Proc.6th Symposium on Acc.Sci. .and Tech.,Tokyo,Japan,Oct.1987