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DEVELOPMENT OF COMPACT SYNCHROTRON LIGHT SOURCE "LUNA"

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Abstract Ishikawajima-Harima Heavy Industries Co.,Ltd(IHI) has developed a prototype compact synchrotron light source "LUNA". This machine has been completed by the end of 1988 and is scheduled to be used synchrotron radiation in 1989.

INTRODUCTION

Synchrotron radiation is expected to be used for various industrial need, especially for LSI lithography. IHI has developed LUNA to use synchrotron radiation for various research. LUNA* was installed at IHI Synchrotron Radiation Facility(ISRF) in Dejima-mura, Ibaraki prefecture.

*Lithography Use New Accelerator

INJECTOR

An injector of LUNA is a 45MeV linear accelerator. We chose injection energy considering two points. First is electron life time by scattering with residual gas. It is desirable to choose the higher energy in order to accumulate higher beam current. Electron life time is neccesary to be much more than injection pulse interval. Second is compactness and cost. It is preferable to choose lower energy and shorter accelerating tube.

Linear accelerator consists of electron gun, 50cm buncher section, 1.5m regular section and 2×2m regular sections. Power supply use 8MW klystron and 21MW klystron. RF frequency is 2856 MHz. Accelerating tube is constant impedance type. IHI has manufactured almost components of linear accelerator at own shop. Basic parameter of linear accelerator is shown in Table 1.

SYNCHROTRON

Synchrotron radiation is extracted from normal bending magnet of 800MeV synchrotron (storage ring).

Basic parameter of synchrotron

We chose energy and magnetic field so as to set peak wavelength of SR around 10A.

Basic parameter is shown in Table 2. Synchrotron radiation spectrum is shown in Fig.1.

Lattice of synchrotron

Lattice of LUNA is very simple. It has four normal cells including 90 degree sector bending magnet, horizontal focusing quadrupole magnets and vertical focusing quadrupole magnets. Also, we set sextupole magnets for correcting chromaticity, skew quadrupole magnet for changing coupling constant, horizontal and vertical steering magnets for correcting closed orbit distortion. Layout of synchrotron is shown in Fig.2.

Magnet

Bending magnet is made of 0.5mm thickness silicon steel considering synchrotron operation during injection. 90 degree sector yoke consists of 3 blocks (30 degree sector). Orbit radius is 1955m, pole gap is 50mm and maximum field is 1.5 tesla for 900MeV operation.

Quarupole magnet is also made of silicon steel plate. Bore radius is 48mm, yoke length is 200mm and maximum field gradient is 13 Tesla/m.

RF system

RF frequency (178.5MHz) was selected considering availability and reliability of power supply, reguirement from bunch length, size of RF cavity, influence to beam instability and control system. So, we judged lower frequency is preferable. RF cavity is a re-entrant type made of OCFC. Inner diameter is 520mm and length is 480mm. Power supply is terode. RF voltage at 800MeV is about 70KV so as to keep enough quantum lifetime. But Touschek lifetime is dominant at injection energy. 10KV is neccesary to keep touschek life more than 1 hour.

Vacuum system

Pressure is neccesary to keep less than 10^{-9}torr. So, we could get electron beam life time more than 10 hour at 800MeV. Vacuum pumps consist of 200ℓ/s ion pumps at bending section and 150ℓ/s NEG pumps at bending section and straight sections. Ti sublimation pumps are also set to assist ion pump and NEG pump. There are no DIP at bending chamber.

One bending vacuum chamber correspond to 90 degree bending magnet and cross section is rectangular. Vacuum chamber at straight section has ion clearing electrode to avoid ion trapping.

All vacuum chamber is made of SUS 316L

STATUS of LUNA

Building of ISRF was completed by the end of 1988. Also, all component test was finished and installed at March of this year. Now, we are doing preoperation test. It is scheduled to extract synchrotron radiation in 1989.

Reference

(1) S. Mandai et al: "Development of Compact Synchrotron Light Source for X-ray Lithography", the 3rd International Conference on Synchrotron Radiation Instrumentation (SRI-88), Tsukuba, JAPAN, 1988.

Table 1 Basic parameter of linear accelerator

Energy	45MeV
RF Frequency	S band (2856MHz)
Peak Current	100mA
Pulse width	1 μs
Repetition rate	1Hz
Energy spread	±2%
Emittance	10^{-5}m·rad

Table 2 Basic parameter of synchrotron

Energy	800MeV
Critical wave length	21.8A (peak 9.2A)
Beam current	50mA
Beam lifetime	30min
Circumference	23.5m
Vacuum pressure	10^{-9} torr
Bending magnet	90 degree sector 1.33 Tesla
RF frequency	178.5MHz

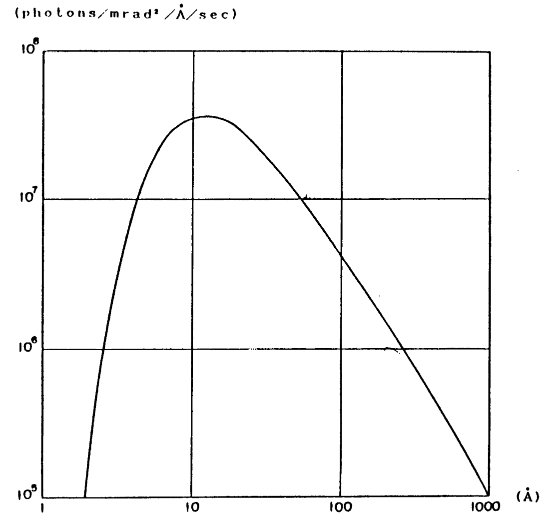

Fig. 1 Synchrotron radiation spectrum

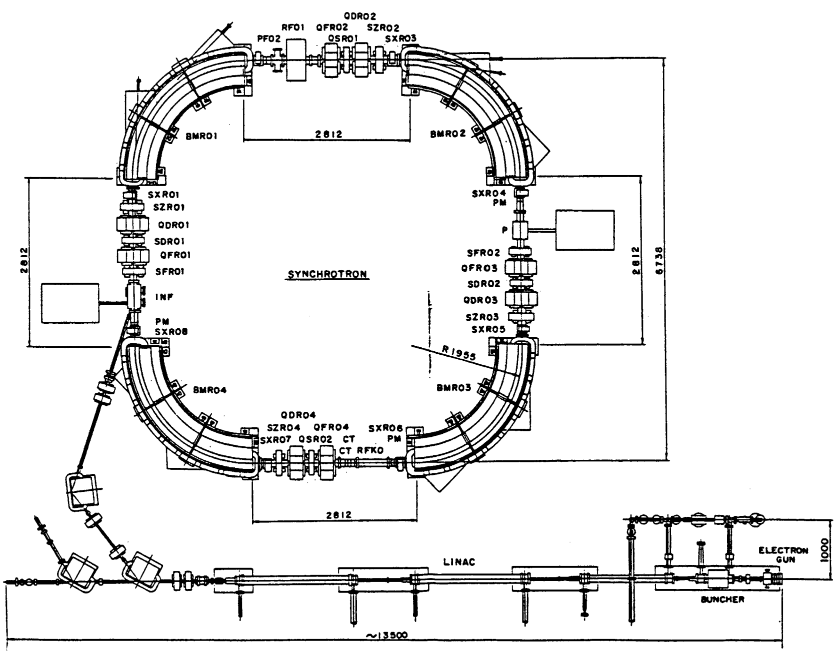

Fig. 2 Layout of LUNA