SPring-8 Linac

Hideaki YOKOMIZO

1. Introduction

The 1GeV linac consists of a 250MeV high current linac and electron/positron converter, and a 900MeV main linac. In order to avoid the ion trapping in the storage ring, SPring-8 linac is able to provide the positron beam with the energy of 900MeV. The electron beam is also able to be accelerated up to 1.15GeV by means of extracting the target of the electron/positron converter from the beam line. The linac is able to produce various kind of the pulse width from 1nsec to 1μsec, which are requested by the storage ring operation modes; multi-banch operation and a single bunch operation. The linac rf-frequency is 2856MHz and its operation rate is 60Hz at the maximum. The main parameters of the linac is shown in Table. 1. The fabrication of the linac components was started in 1990. Installation of the linac in site was started in April, 1995.

Table. 1 Linac Design Parameters

Energy	Positron	0.9GeV
	Electron	1.15GeV
Repetition rate		60Hz
RF frequency		2856MHz
Total length		140m
Beam Current	Positron	10mA
	Electron (1μsec)	100mA
	Electron (1nsec)	300mA
Emittance	Positron	$< \pm$ 1.0%
	Electron	$< \pm$ 1.5%
Electron gun	Cathode assembly	Y796
	Voltage	200kV
Accelerator column	Number	26
	Structure	Traveling wave
	Mode	$2\pi/3$
	Cell number	81
	Length	2.835m
	Input power	26MW
	Energy gain	45MeV
Converter	Target	Tungsten
	Thickness	7mm
	Electron energy	250MeV
LSBT	Length	39m
	Deflection angle	15 degree

2. Preinjector

The preinjector of the linac consists of the electron gun, prebuncher, buncher, beam monitors. This was fabricated in 1992 and temporarily installed in Tokai site to examine its performances. The performances of a thermionic cathode assemble were obtained in the case of changing parameters of the high-voltage, grid-voltage, heater power. The maximum beam current was achieved 22A at the condition of the high voltage of 200kV. The stability of the beam current was obtained to be less than $\pm$ 1.5%. The pulse shape was adjusted by changing the three different types of the grid pulsers. The pulse width of less than 1nsec was achieved by means of using a 4kV rapid rise-time pulser with a short cirtuit. The pulse transfer line between grid pulser and the gun was designed to have an impedance matched with the grid pulser and the gun to prevent the pulse shape deformation. The bunching efficiency of the prebuncher and buncher were 65% which is agreed with the calculation The beam energy is 9MeV at the exit of the buncher and its spread was obtaine to be less than $\pm$ 2%. The normalized emittance was measured to be about 130mm · mrad at the exit of the buncher.

3. Accelerator Column

The linac has 26 accelerator columns. One accelerator column is 2.835m long containing 81 cells, and $2\pi/3$ traveling-wave constant-gradient type. They have three different type in a borediameter of an exit iris, which are 20.0mm, 20.5mm and 20.95mm, respectively. They are arranged in a manner to prevent multisection beam-breakup. The rf power is designed to be fed 26MW to each column at the normal operation, so that the average accelerating field is ~16MV/m, and the energy gain per each column becomes ~45MeV. The accelerator columns are designed to operate in the constant temperature of 30 ℃. The water cooling system is planned to have a capability of adjusting the temperature of the accelerator columns within an accuracy of ± 0.1 ℃. The disks and cylinders of the accelerator column are carefully machined with high precision and brazed in the vacuum furnace. The phase deviations of each cell were obtained to be low enough within the specification of 2 degrees.

4. Magnets

The beam focusing magnets are composed of triplet-quadrupole magnets, which are placed in between accelerator columns. The steering magnets are utilized for beam position adjustment, which are used with the combination of the beam position monitors.

5. Alignment

The precise alignment of the magnets and accelerator columns were carried out using the laser system. The tolerance of the precise alignment of the linac is expected to be less than 0.1 mm along the straight line through the total length of 140m. The laser is set on the axis of the beam. The laser is expended to 12 mm diameter just after the laser head and focused to 2.4mm diameter at the end of the linac. Its pointing stability is less than 1 arc-sec. The laser beam was measured by the position sensitive detector with the resolution of ±15 μm, which was installed in the center of the quadrupole magnets. The precise alignment of each magnet was achieved to be less than 0.1 mm of the deviation from the designed location. After the precise alignment on axis of quadrupole magnets, off-axis measurement of the top of each magnet was carried out to obtain data of the initial location for the future reference.

6. Klystron

The high power klystron used has the capability of the maximum output-power of 80MW with 4msec pulse-width and 60pps repetition-rate. The klystron operates with the beam condition of 391kV and 474A at the maximum output power. One klystron feeds the microwave to two accelerator columns. Totally 13 sets of klystrons are used for the normal sections. One low power klystron is used in the microwave master system for driving high power klystrons. Another medium power klystron is also used at the positron converter section.

7. Modulator

The 190MW pulse modulator designed for high power klystron has 4 parallel and 14 series line type PFN. The ratio of the pulse transformer is 1:16, so that this modulator is required to produce the high-voltage pulse with 49kV. The voltage fluctuation was achieved to be less than ±0.5% during the flat-top of 2μsec among the full width of 5μsec. The reproducibility of the pulse output voltage was obtained to be good within ±0.5%. The thyratron was selected F351; peak voltage 55kV and peak current 10,000A after the careful examination of several candidates. To reduce the effect of the leakage inductance in the PFN condensers, pairs of the PFN coils were designed to have the mutual inductance between the neighboring coils. The new type of De'Qing circuit, which regulates the PFN voltage, was designed to save the De'Qing circuit energy.