INJECTOR LINAC OF SPRING-8

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Abstract

The linac that is SPring-8 injector was completed and started operation from August 1. A beam was able to be transported to the final beam dumping at a tail end on August 8. From now on this linac carries out beam adjustment and be scheduled to do a beam injection to a synchrotron in October.Å@The construction and fundamental performance of the linac are described.

Introduction

SPring-8 is the synchrotron radiation facility of 8GeV in Japan. The storage ring operation will begin next February in 1997, and common use of the light is scheduled from the autumn of the year. The number of beam lines begin from 10, and 60 beam lines will be constructed finally. The buildings of this facility is already completed (fig.1). This linac is built as the injector for the booster synchrotron which accelerates the beam from 1 to 8 GeV[1].

Fig.1 Birds view of the site.

Configuration

This injector linac is 140m long, and maximum energy of electron beam is 1.15GeV. Positron beam can be generated optionally and used properly the demands of the storage ring to reduce ion trapping and stretch the life time.

The electron gun has three types of grid pulsers. One is called single pulser for 1 nano-second width[2], short pulser can generate 10 to 40 nano-seconds pulse, and long pulser of 1 micro-second for beam commissioning and full-fill operation of the storage ring. The cathode assembly is used Y-796 of IMAC. Beam current of 20 amps is derived by 200 kV in the emission stability of 1.5%.

Bunching section has two single cell prebunchers and a 13 cells buncher of standing wave type. Transport efficiency of 64% corresponding to a simulation is established without sub-harmonic bunchers. Specifications of bunching section was searched in Tokai establishment of JAERI before moving to the site two years ago. According to the result of the search, the bunching section rearranged and drift space between the electron gun and first prebuncher was cut short to adapt a high current mode operation by removing the profile monitor just behind the gun.

Main region consists of 26 accelerator sections and 13 klystron of 80MW. Accelerator sections are 3m long of 81 cells, constant gradient type of 2856MHz. Accurate phase deviations of the accelerator sections are shown in Fig.2. Auto squeeze machine of MHI and detailed comparison of measurement with calculations established this accuracy in spite of low cost.

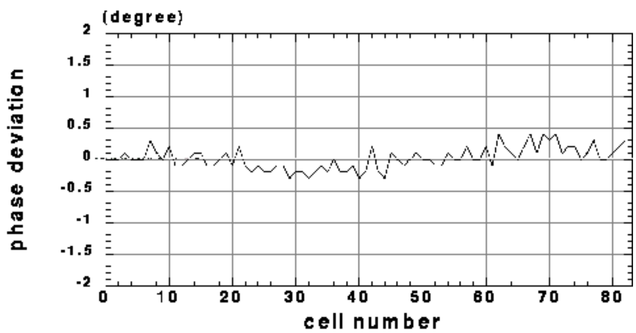

Fig.2 Phase deviations of accelerator section

13 klystrons of 80MW type are used. Flatness of modulators is less than 0.5% in 2 micro-seconds (modulator pulse width is 5 micro-seconds). Drive power for the klystrons are distributed by a ladder consists of a phasing device and WF-H-50 coaxial cables[3]. Phase of micro-wave for each accelerator sections are controlled by comparison of phase of beam wake field with the phase of a reference line of high stability coaxial cable.

QT magnets are regularly placed each two accelerator sections. Bending magnets are placed at 60 MeV point, 250 MeV point and 1 GeV point for energy analyzing and latter two bending magnets can be used for beam extractors.

Profile monitors, which are placed with each QT in regular sections, are mainly used for alignment of beam transport. Ordinary CT for long pulse and tuned fast CT for single pulse are set at eight points. The fast CT can observe the modulation of 2856MHz. Wire grid monitors are set for emmittance measurement, and the lines of cherenkov monitors are prepared for measurement of micro-structure on time base.

Construction

Set up of this linac at the site began in August 1995, and finished in March 1996 including test of each devices and alignment. Factory fabrication excepting a gun and bunching section takes about two years over rapped setting up.

Devices are aligned by the laser referenced position pointer[4]. Under the very quiet condition of stopping air conditioner in midnight, the position of center of QT, flange of accelerator sections and profile monitors are measured 5 minutes intervals from downstream. Temperature fluctuations is under 0.1 degree during the measurement due to the insulating effect of shield 3m thickness. Three times measurement a night and the average of data uses for positioning the next day. It takes two weeks for first alignment in December 1995, and we measured the positions again just before starting beam operation for confirmation of alignment and estimation of deformation of the building in July 1996. At last displacement of these positions are suppressed in 0.1 mm (Fig.3) without using a vacuum chamber for the laser beam.

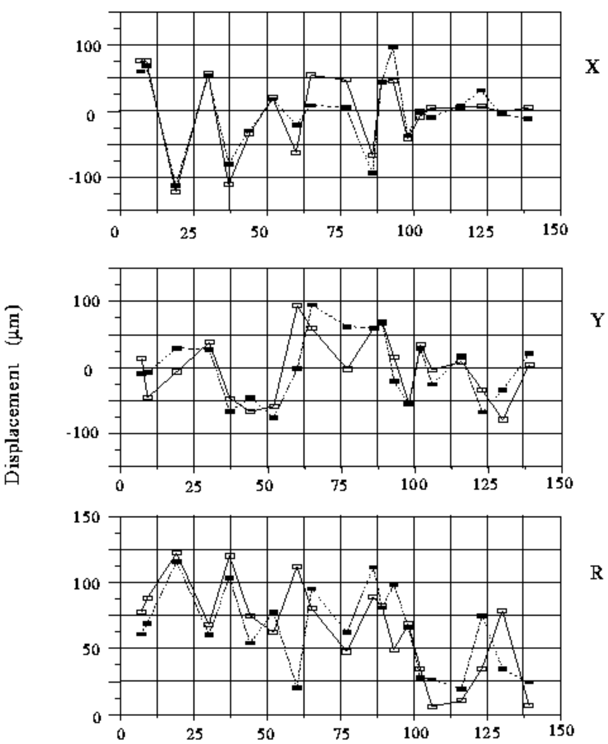

Fig.3 Distance from the laser reference point.

Operation

Before the beam commissioning, aging of microwave components was done. It was expected that aging of whole system takes long time caused of experience in factory conditioning of the one unit of klystron and wave guide. We prepared automatic aging system by computers. Aging process is explained in qualitative analysis and experience, but actual parameters like a vacuum threshold are depends on the configuration of each system, microwave power and surface history. In this condition, we consider fazzy logic is suitable for aging process. For the definition of membership functions, standard PD control process using temporary thresholds are made (Fig.4). Consequence of the trial of this PD control process, it is observed that the temporary thresholds suit for this system, and the initial aging of all sections were done by this process. We expected it might taken 1500 hours but it took only 500 hours for the aging of all sections. Then each klystron generates 80MW, 2 micro-seconds, 60 pps. And each accelerator section is supplied 34MW maximum. At the ordinary operation, klystrons are drove in 60MW.

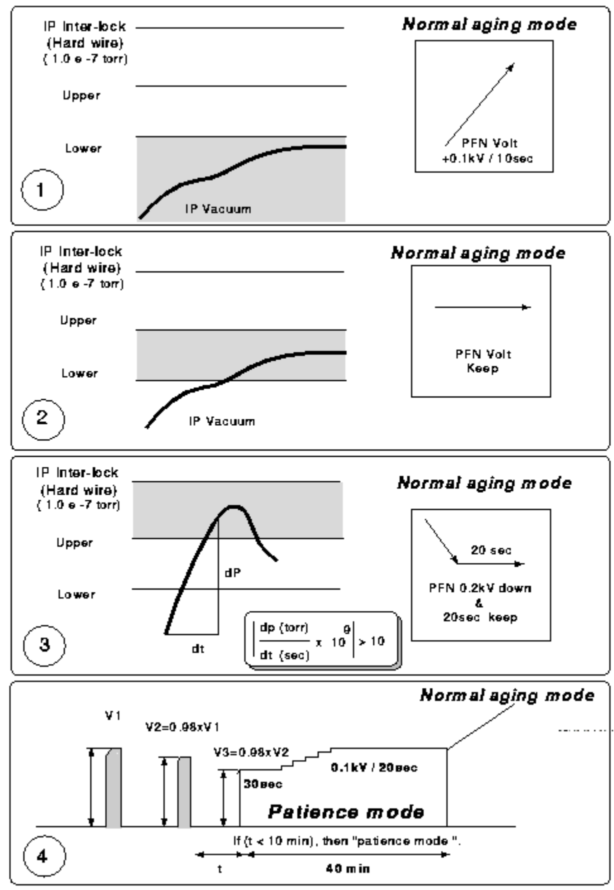

Fig.4 Logic of aging process

In the aging term, the relation of out gas ratio versus input microwave power of this system is observed. Lower power than 5MW activates surface molecules of impurities, and around 25MW power derives sinking impurities in copper material (Fig.5). In this region, out gas volume balances with pumping ability of this system and vacuum response becomes dull without break down. Gradual long aging in this region is effective for the shortening the time of conditioning after machine intervals.

After the term of summer maintenance, Two aging processes of a PD control and a Fazzy logic control are compared. Necessary microwave power can be fed to the wave guides and accelerator sections, but copper surface is not enough clean and a rapid aging process needs when the operation re-starts.

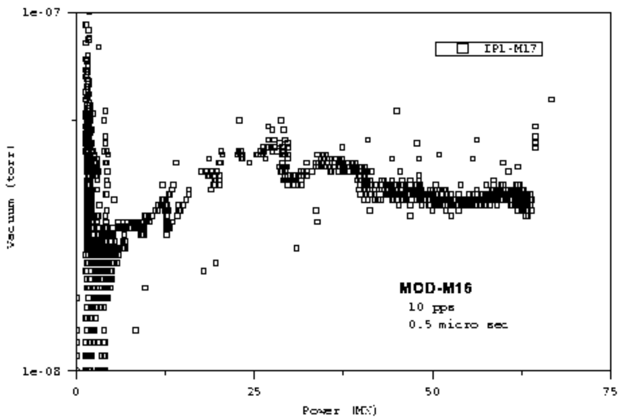

Fig.5 Out gas vs micro wave power at typical section

First beam of this linac was successfully established on August 1 just after raw admission is given. The gun operated in 2 amps, 10 nano-seconds, 5 pps under the radiation survey. Beam transport efficiency from the bunching section to the beam dump is over 95%. But we are not allowed to send a beam to the synchrotron area yet. The bending magnet at 1GeV can not actuate and energy specter could not measured. At the point of just after the buncher, HWFM of energy spectrum is 2%, and normalized emittance is 130 mmmrad.

Before starting injection to the synchrotron in October, accurate phase control will be done in long pulse mode.

Modification Plan

This linac will be operate full time as a injector until the end of commissioning of the storage ring. And another beam transport line adds for the use of other purpose. We design a RF photo-cathode electron gun[5]. Low power model of cavities are tested now, and single cell type is the first candidate. Cathode material is copper, and titanium is coated to suppress secondary emission with controlling thickness. The first target is 1nC and 1ps, and a isochronous transport line is designed for Self Amplitude Spontaneous Emission[6]. As a first R&D, we prepare 3 or 5 m undulator to prove the gain and the assumptions of initial spontaneous emission. For this SASE, modification of alignment system of active feedback is required, and several methods are estimated.

We have an extraction line at 250 MeV point. At this place, we plan several experiments under the collaborations with other sections. One is to generate gamma lay for the excitation of nucleus by the interaction with high power lasers. The design of laser system of the photo-cathode electron gun and this high power laser are combined to minimize a timing jitters. Another plan is high flux slow positron generation. A bending magnet at 250 MeV is used for 45 degree transport line.

From the summer in 1997, local government of Hyogo prefecture start the construction of New-SUBARU which is 1 GeV storage ring for synchrotron radiation. This ring is used for special industrial purpose and ring physics itself. SPring-8 linac is used as the injector of New-SUBARU too. Higher reliability, higher rate of operation and flexibility are required to this linac.

Conclusion

SPring-8 injector linac started operation. First beam was observed at 11:10 the day of official admission as a radiation device was given. Detailed tuning up and machine study will be done in this year, and routine operation for injection starts from next February. After commissioning of the storage ring, modification for many other purpose of SASE, gamma source and injection to medium energy ring of New SUBARU project.

References

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