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Analysis of ATF LINAC stabilization

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Abstract

The Accelerator Test Facility (ATF) at KEK is a test accelerator for future linear colliders (LC). Its purpose is to develop the technology that can be stable supply main linac with an extremely low transverse emittance multi-bunch beam. This beam must be very stable, because the future LC must have extremely big luminosity, but on the other hand the additional stabilization increases cost of LC. In this paper, the system of measurement of instability at ATF, and the proposal to reduce it are described. From the analysis result we did modification at ATF to improve stability. We discuss experimental data also

Introduction

The ATF is a test accelerator for studying techniques needed to build a linear collider [1]. It consists of 1.32 GeV injector linac, beam transport line (BT) and damping ring (DR). ATF use mainly three-phase AC line 200V. Many parameters of the accelerator depend on stability of this voltage. Now instability of a AC line consist of two parts, first is connected to loading of a AC line from the proton accelerator taking place near to ATF it makes size 1% and period 2 seconds. Second parts is random it have the amplitude for +/-3%.

Main linac consists from 16 accelerator structures (AC) which are supplied by multipliers of power from 8 klystrons. The beam in the main linac comes from injector. The quality and stability of beam after injector basically determines target parameters of beam after linac.

Injector of ATF (80 MeV) consists of pulse high-voltage station, thermionic gun, two amplifiers for the power to 357 MHz subharmonic bunchers (SHB) and klystron feeds power to S-band buncher and 3-m accelerator structure and many solenoids which ensuring support beam. The basic reasons of instability in ATF can be such as for example, small malfunction in some elements, unsufficient accuracy in some elements of the accelerator, insufficient stability of target parameters of some systems. Phase moving and timing jitter in an elements and influence of external fields such as, change of a magnetic field of earth, difference sort of vibration and temperature changes also.

System setup

For measurement of instability we use 28 channels fast 14 bit ADC. From them 18 channels for measurements in injection part others are intended for measurements a high voltage of klystrons. Besides the managing program ATF allows to receive the synchronized data with BPM and also with integration current transformer (ICT), and do the correlation of one of parameters from another. On Fig.1 the dependence of a horizontal beam position in one

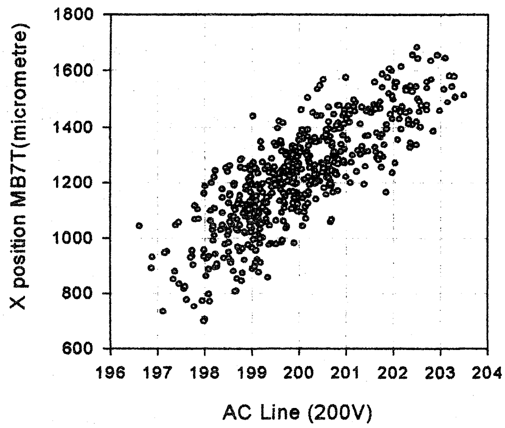

Figure 1. X beam position in Beam transport line

of BPM's in BT from an AC line voltage is submitted. Analyzing half-scientific dependence it is possible to assume, that the stability of high voltage klystron is not enough, as X position, which means beam energy depends on a voltage of an AC line. For the operative control of a condition of stability lengthwise linac and search of places were begun by using intensity monitor fluctuation (see figure 2.), with help of this monitor it is very easily to find klystron number which has changed his parameters.

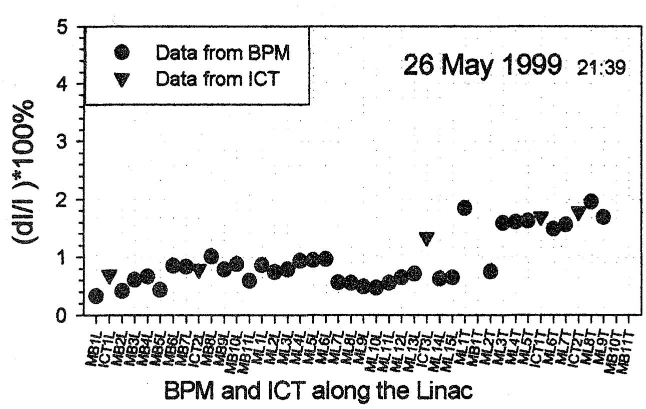

Figure2. Stability of Intensyty along the linac

Injector and Gun

The analysis shows that the accuracy of existing system of stabilization in high voltage is not sufficient, besides is present jitter of start thyratron of the modulator is + /- 25 nSec, and also that at voltage 180 kV the corona currents essential influence on energy of beam. We did modification of thyratron trigger system and reduce jitter to +/-7 nSec, install additional stabilization for AC line and reduce corona currents also. At figure 3. One can see the difference between Gun high voltage before and

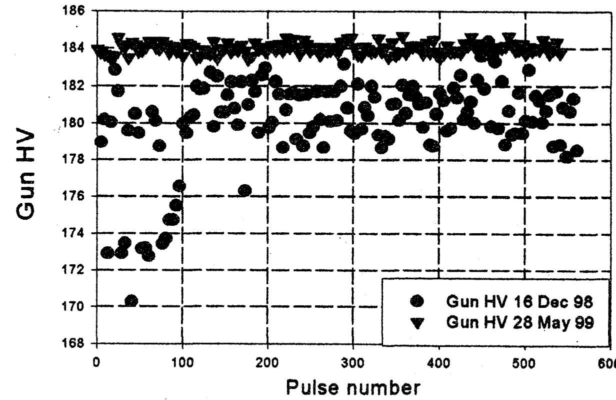

Figure 3. Gun High Voltage

after modification. The large contribution to instability of injector part of the accelerator gives jitter between a pulse of a current from the cathode and phase of an accelerating voltage in SHB. These timing jitter results to instability on energy, bunch length and beam position also, as in this part beam is going through magnetic field. The Helmholtz coil which provide this magnetic fields have small error as for X and for Y coordinate (see figure 4).

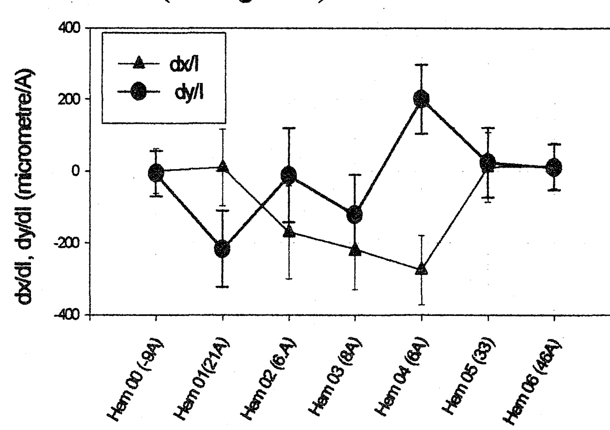

Figure 4. Beam position sensetivity versus current in Helmholtz coil

The temperature of cooling water of this coil has stability +/-2 degree. It results in changes of relative position of these coils and that most unpleasant to changes of their angular inclination (see figure 5) for time with period about 1 hour.

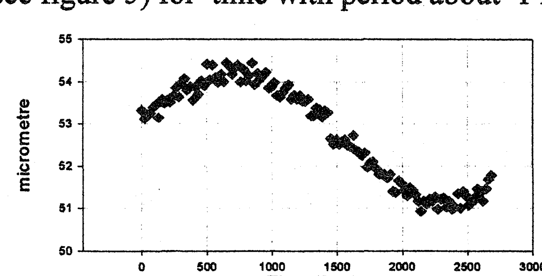

Figure 5. Displacement Helmholtz coil #5.

Bunch length monitor

One of the basic parameters of injector is the stability of bunch length which is at important parameters of the accelerator at full energy affected on energy spread. In [2] it is offered to measure bunch length with the help of two additional cavity setup in beam line. The measurements of width of a spectrum with bottun BPM's established on ATF have shown, that the spectrum is wide enough and there is an opportunity to measure bunch length using signal from this BPM's. In Figure 6. the circuit of such measurements is shown. A signal from two bottuns located opposite each other move on the hybrid, in such circuit the output signal does not depend from beam position in the BPM.

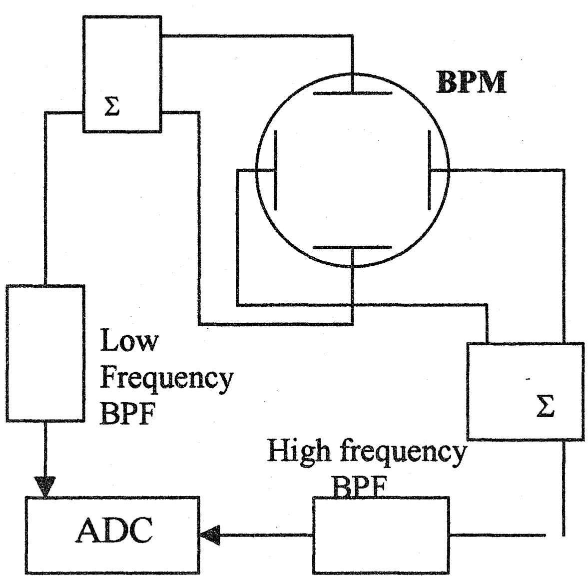

Figure 6. The block diagram of Bunch length measurement.

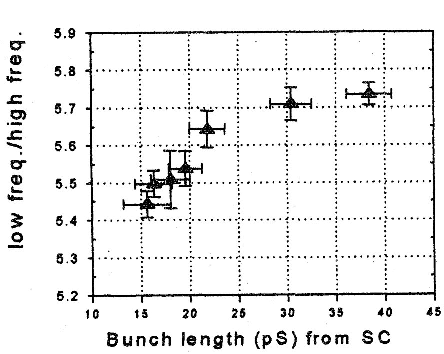

Figure 7. Relation between amplitude of low and high frequency from bottun type BPM.

After band pass filter and diode the signal comes to ADC. Each BPF has band 200MHz and central frequency as: low 2.86GHz and high 6.5 GHz. The calibration results of this type bunch length monitor are shown in Figure 7.

Klystron phase stabilize circuit

At figure 8. we propose one beam based klystron phase stabilize system. After AC in beam line add additional cavity with some frequency like main ATF frequency. In the phase detector we can compare cavity phase which corresponds to beam phase and phase after AC which corresponds to klystron phase.

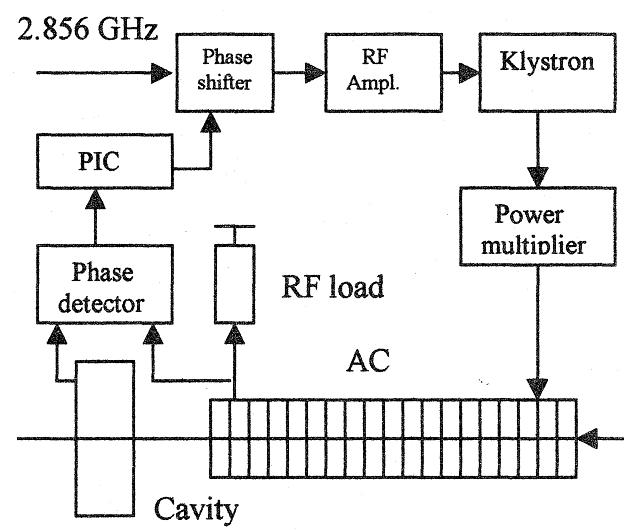

Figure 8. Beam based phase stabilize system

Summary

A analysis of present stability situation at ATF was done and as a result some modification have been made. After this, transmission through linac has achieved 90%.

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1. ATF Design and Study Report. KEK Report 1995-4. Ed. By F. Hinde, S. Kawabata, H. Matsumoto, H. Oide, K. Takata, Seishi Takeda and J. Urakava
2. E.Babenko, R.K.Jobe at all. Length Monitor for 1 mm SLC Buncher, Proc. Of the 1993 PAC, 1993 V.3,p.2423-2426