Hexacolor Problem of Electron Beam from the Linac at LNS

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Abstract

The beams from the pulse stretcher ring have 6 different time structure repeated with 50 pps when operated with 300 pps. This structure is thought as come from different energies of the incident pulsed beam from the Linac. We measured the energy spectra of the Linac beam by pulse to pulse, and found 6 different energies. Also we found differences in accelerating RF voltages which repeat every 6 pulses.

1 Introduction

Laboratory of Nuclear Science of Tohoku University is the laboratory which equip a 300 MeV electron Linac, and study many kinds of works from RI production to photonuclear physics. Recently the experiments, which measure scattered electron and nuclear products in coincidence, are normally made in nuclear physics, and we have constructed a stretcher ring which stretch the duty factor of the electron beam. The construction of the ring was completed in 1998, and experiments using this ring were started in Jun. 1999.

When a 300pps pulsed beam was injected to the stretcher ring, the extracted beam from the ring had a peculiar time structure, though the duty factor was stretched from 0.001to 0.7 . This structure is repeated with 50 pps, that is with every 6 pulses. This is clearly the effect of converting the frequency from 50 to 300pps. We call it as a hexacolor problem.

This paper describes the position and energy spectrum of each 6 pulses from the Linac which are thought to be most effective to the hexacolor problem.

2 Hexacolor problem

A picture of the extracted beam from the pulse stretcher ring is shown in Fig. 1.You can see from the picture that a hexacolor is divided into 2 patterns, one the stretched beam is concentrated in advance and other concentrated behind. The energy spread of the incident beam is 1 percent. These 2 patterns are explained as the result of the difference of energy spectrum in the incident beam pulses. In order to make sure of this idea we measure the energy spectrum of 6 pulses in the incident beam from the Linac.

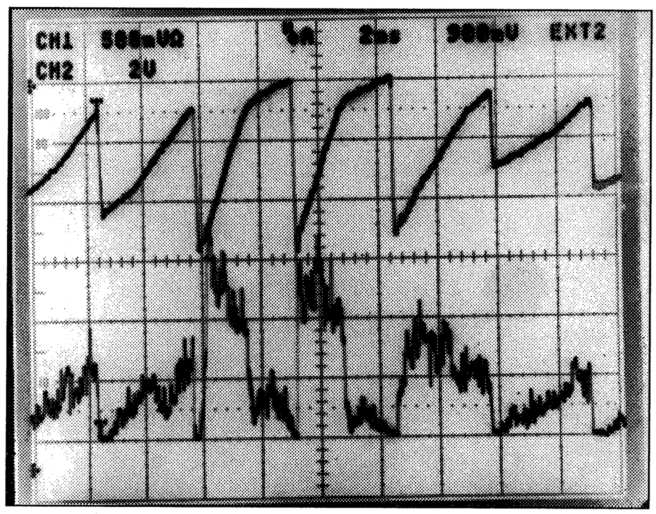

Fig. 1 Hexacolor beams in stretcher ring that measured by DCCT current monitor (top), and extracted beam that measured by spill monitor plastic scintillator (bottom).

3 Measurement of the energy spectrum

The energy spectrum of the beam from the Linac was measured using the energy analyzing system of the low energy section of the Linac. The system composed of 2 magnets, a Q-magnet and a slit. We set the slit width to 1 percent and vary the current of the magnet. Intensity of the beam which passes through the system was measured by a core monitor behind the analyzer. In order to distinguish 6 pulses, we have made a special trigger generator. The measured energy spectrum for each pulse is shown in Fig.2. One can see the 6 energy spectra are divided into 2 groups, one is high energy group (pulses 3, 4 and 5) and the other is low energy group (pulses 6, 1,and 2). The numbers of pulses are only relative. The difference of energies of 2 groups is about 1 percent (500 keV).

The energy spectrum of the high energy section of the Linac was also measured using the energy analyzing system located at the excit of the Linac. Results were similar to that measured at low energy section. However because these measurements were made for 6 pulses separately, the time needed for the 6 measurements takes about one hour. The energy spectrum can change within one hour when the whole measurements finish. Then we have made a measuring system which can get 6 spectra in 1 scan. A preliminary spectra obtained with the new system is shown in Fig.3. Though the statistics is poor, the similar tendency that 6 pulses are divided into 2 groups can be seen in the spectra.

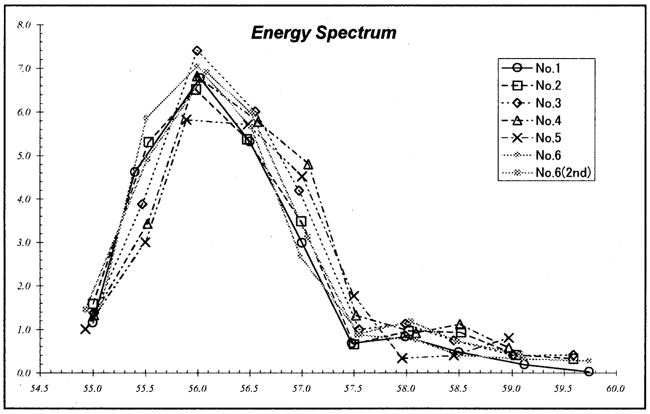

Fig. 2 The measured energy spectra for each pulse in 6 scans. Spectrum No.6(2nd) is measured in order to confirm reappearance of spectrum for long time interval.

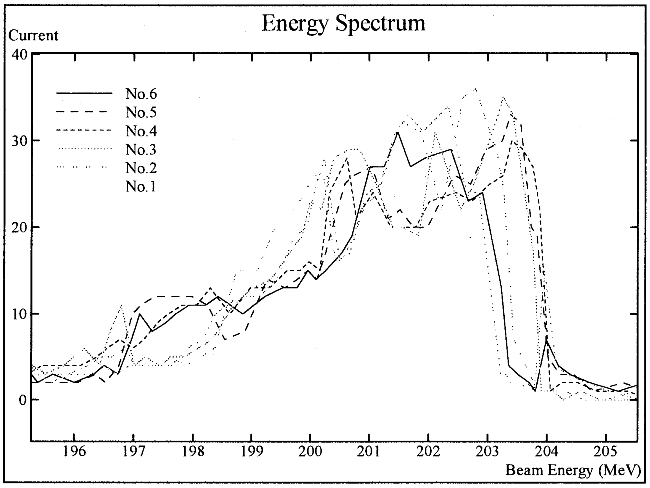

Fig. 3 Energy spectra in 1 scan. However pulse numbers are only relative, and the pulse number of Fig.3 don't correspond to numbers of Fig.2. We needed only 5minutes to measure 6 spectra.

4 RF power

These energy differences are most easily come from the variation of RF power and phase for each pulses. We have measured the RF power and phase at the excits of the accelerating tubes. We used a pulse stretcher circuit and the trigger generator, and measured the RF voltages by a oscilloscope. A picture in Fig.4 shows RF pulses at the exit of the B11 accelerating tube. The pulse heights clearly show the hexacolor phenomenon. The values of the RF voltages change pulse to pulse, and this change repeat every 6 pulses. The ratio of maximum to minimum pulses is 1.018 for this case. We measured also RF from other Klystrons and found similar effects though the ratios are about a half of the B11 case.

A pulse to pulse differences of RF phases were also measured, however no prominent differences can be seen for the 6 pulses.

Fig. 4 Powers of RF pulse at exit of accelerating tube 'B11'. The maximum pulse height is 1.8% larger than minimum pulse.

5 Beam course

At the exit of the stretcher ring, beam sometimes divided into 6 portions spatially. Also sometimes the beam from the stretcher ring have two centers. In order to measure whether these effects correlate with the directions of the incident beam pulses, we observe the beam shapes from the Linac, being divided into 6 colors, by a screen monitor. There are no difference in shapes among 6 colors was found.

6 Conclusion

A hexacolor problem is found in the beam from the newly constructed pulse stretcher ring, where the beam has 6 different time structures when operated with 300pps. This difference comes from the effect of converting the frequency from 50 to 300pps. The different structure shows a difference in energy spectrum of the incident beam. We measure the energy spectrum of the beam from the Linac and found reasonable differences among 6 colors. Also we found that these energy differences are consistence with the variations of the RF voltages.