VI-4   PROBLEMS OF APPLYING PICOSECOND SINGLE ELECTRON PULSE TO PULSE RADIOLYSIS

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There are many important problems when picosecond single pulse is applied to our pulse radiolysis system.   Some of them arises from the characteristics of the linac. It is important to know the characteristics of the linac in order to use the picosecond single pulse radiolysis system effectively. This paper describes some of these problems.

[Satellites]

If the pulse width of injected electron beam from the gun is broad or phase of injection parts are not optimum, satellite pulses occur. For example, Fig. 1 shows satellite pulses located after the main pulse when phase of injected electron beam is delayed about 250 ps from the optimum phase. These satellite pulses complicate the analysis of experimental data.

[Jitter]

External pre-trigger is necessary to use measuring systems with very fast response, such as a streak camera and a sampling oscilloscope. The trigger pulse synchronized with microwave is devided into two pulses at a fast pulse generator. One of them is used for the trigger of the grid pulser of the gun. The other is used for the pre-trigger of measuring systems.

Fig. 2 shows main jitters occurring in components of picosecond single pulse radiolysis system. Microwave is employed as standard.

Three jitters from Δt_1 to Δt_3 are very important for total jitter of picosecond single pulse.

Six jitters from Δt_4 to Δt_9 are not important if $\sqrt{(\Delta t_1)^2 + (\Delta t_4)^2 + (\Delta t_5)^2}$ is less than 70 ps because of the following reasons. If the jitter between microwave and the injected beam from the gun $\left(\sqrt{(\Delta t_1)^2 + (\Delta t_4)^2 + (\Delta t_5)^2} \right)$ exists, the injected timing of beam from the gun is different from the optimum phase of microwave of S.H.B.. But S.H.B. collects and shortens the injected beam into the almost same phase of prebuncher even if the timing of injected beam from the gun is different within small range. And the beam is accelerated on the same phase of prebuncher, ACC-I. and ACC-II. As a result, jitter between microwave and output beam (Δt_9) is considered to be negligibly small.

Therefore, total jitter of picosecond single pulse radiolysis system (Δt: jitter

between output beam and the measuring system) is approximately equal to $\sqrt{(\Delta t_1)^2+(\Delta t_2)^2+(\Delta t_3)^2}$.

When a streak camera is used, total jitter is about 40 ps and when a sampling oscilloscope is used, total jitter is about 30 ps.

Time resolution of picosecond single pulse radiolysis system depends on the total jitter when signal-averaging technique is used.

[Stability]

Problems of beam stabily are devided into two cases. One is the beam stability in short time and the other is the beam stability in long time. Short time means the duration of acquisition of experimental data for signal-averaging. (Several minutes) Long time means the duration to obtain time resolved spectra (Several hours).

Problem of beam stabitity in short time arises mainly from the above-mentioned jitter.

Problem of beam stability in long time arises mainly from microwave drift due to the variation of temperature and thermal expansion of microwave guide tube and cables.

However, if it takes enough time to warm up the linac and the frequency of the microwave is often adjusted, reproducible time resolved optical spectra can be obtained.

For example, Fig. 3 shows three time resolved spectra. All of them are considered to be mainly the fluorescence of PPO.

[Beam monitors]

There are good non-destructive beam monitor for the adjustment of the linac in microsecond time region. However, there is no good non-destructive beam monitor in picosecond time region. Satellite pulses can be clearly distinguished from the main pulse by using a streak camera. Except for a streak camera, satellite pulse located before the main pulse can be clearly distinguished by using the sampling oscilloscope and fast detector heads such as co-axial line target. But satellite pulses located after the main pulse cannot be distinguished easily except for using a streak camera.

Now non-destructive detectors in picosecond time region are developing in our laboratory in collaboration with researchers in KEK.

[Jitter of S.H.B.]

Jitter of S.H.B.(Δt_{10}) in Fig. 2 influences satellites, stability, and total jitter (Δt). Small value of Δt_{10} produces mainly satellites and beam instability. In addition to satellites and beam instability, large value of Δt_{10} produces total jitter of a period of microwave.
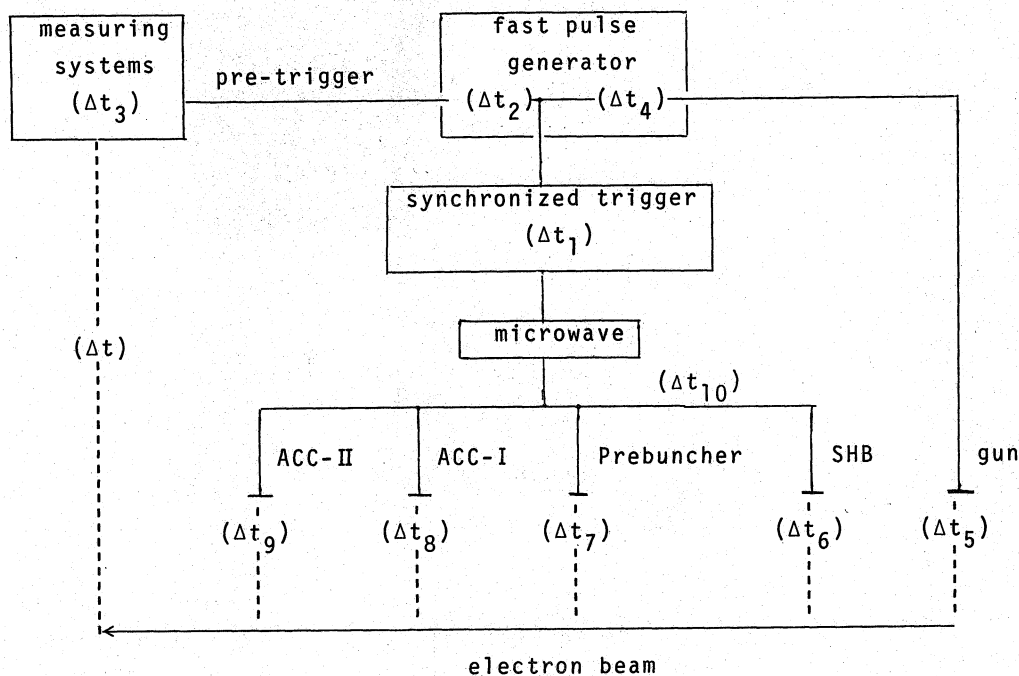
Fig. 2 Main jitters occurring in important components of picosecond single pulse radiolysis system.

(Δt) : total jitter of picosecond single pulse radiolysis (jitter between output electron beam and the measuring system)

(Δt_1): jitter between microwave and the synchronized trigger

(Δt_2): jitter between the synchronized trigger and the pre-trigger

(Δt_3): jitter of the measuring systems (a streak camera)

(Δt_4): jitter between the synchronized trigger and the trigger of the grid pulser of the gun.

(Δt_5): jitter between the trigger of the grid pulse of the gun and injected electron beam from the gun.

(Δt_6): jitter between S.H.B. and electron beam at the subharmonic buncher

(Δt_7): jitter between microwave and electron beam at the prebuncher

(Δt_8): jitter between microwave and electron beam at the accelerator tube I.

(Δt_9): jitter between microwave and electron beam at the accelerator tube II.

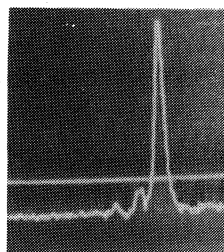(Δt_{10}):jitter between microwave and S.H.B.

Fig. 1 Picosecond single electron pulse with satellite located after the main pulse measured by a streak camera system.
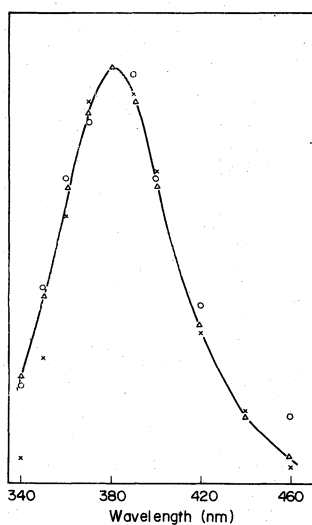

Fig. 3 Time Resolved Spectra observed for 2 mM PPO-Toluene solutions at 260 ps after pulses (Δ), 2 mM PPO-Toluene solutions at 50ps after pulses (o), and 2 mM PPO-Toluene solutions containint 100 mM CCl_4 at 50 ps after pulses (×). These spectra are normarized at the absorption peak at 380 nm.