RADIATION FROM THE SDTL OF J-PARC

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Abstract

X-ray radiation from the SDTL of J-PARC linac has been observed with the beam loss monitor by the tank. The results show that the X-ray intensity depends not only on the RF power level of the tank but also on the RF structure of the tank. In the paper we will show the status of the investigation for the origin of the X-ray radiation from the tank.

INTRODUCTION

Japan Proton Accelerator Research Complex (J-PARC) is a high-intensity proton accelerator facility constructed in the Tokai campus of Japan Atomic Energy Agency (JAEA) under the collaboration between KEK and JAEA. The accelerator consists of a 181-MeV linac, a 3-GeV rapid cycle synchrotron and a synchrotron main ring. The 181-MeV injection linac comprised of the an H^- ion source, RFQ linac, DTLs, and separated type DTLs (SDTLs).

The SDTL is a short DTL which has 5 gaps in a tank. Drift tubes in the SDTL do not accommodate the quadrupole magnet but the quadrupole doublet is set between the tanks. J-PARC has 32 SDTL tanks. One klystron supplies the RF power to two adjacent SDTL tanks. Moreover SDTL-31 and SDTL-32 are used as the debuncher. (Thus these two tanks are neglected in the following section.)

The beam loss monitor (BLM) is set on the base of the magnet as shown in Fig 1.

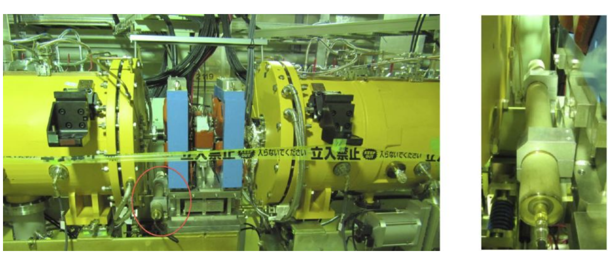

Figure 1: SDTLs and Q-doublet and BLM.
(Left) Yellow: SDTL, Blue: Q-doublet, Red circle: BLM.
(Right) Extended photo of the BLM

The main purpose of the BLM is to protect the tank from the radiation damage by the beam. While it detects also the X-ray radiation from the tank induced by the RF field. As the result, it is found that the BLM is very useful for the RF conditioning of the SDTL because the radiation level of the tank depends on the progress of the RF conditioning of the tank. Namely the radiation level is a good measure of the tank status.

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As the initial RF conditioning had been done for SDTL of J-PARC, the radiation level from the SDTL tanks has no time dependence during the practical beam operation period with the constant RF power. Naturally it depends on the input RF power. Furthermore the radiation level from the tank probably depends on the structure of the tank. In the following section we describe the status of the study for the radiation from the tank induced by the high-power RF field.

BEAM LOSS MONITOR

The beam loss monitor (BLM) is a cylindrical proportional counter [1, 2] made by Toshiba (model:E6876-600) [3]. The effective volume size of the BLM is 27mm in diameter and 500mm in length. It is filled with the mixed gas (Ar + CO_2(<1%) , 10^5Pa). Applied voltage is 2kV on the anode cylinder which is covered by a outer cylinder. (The right-side photo of the Fig 1 shows the outer cover of BLM.)

The cosmic ray induced signal in the BLM is shown in Fig 2 as an example. There is a small second peak which is delayed about 700ns from the first peak. It is probably caused by the miss impedance matching between the cable and signal processing circuit.

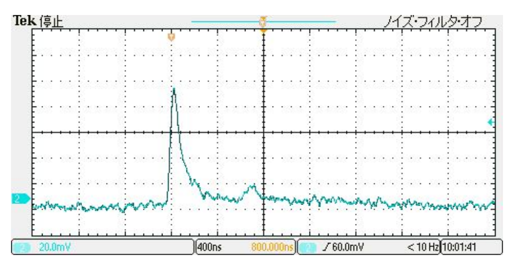

Figure 2: Cosmic ray signal detected by BLM.

THE SDTL INDUCED SIGNAL

The examples of the detected signal of the BLM for the SDTL-12 are shown in the Fig 3. At the practical operating power level, the base line of the signal is piled up by the high counting rate of the radiation. It also shows that the radiation during RF pulse rising part is lager than that of RF pulse plateau. (The signal induced by the lost beam overlaps the offset signal induced by the constant radiation from the tank.)

RADIATION LEVEL

The pulse height of the signal plateau for almost BLM in the SDTL section has been measured with the practical

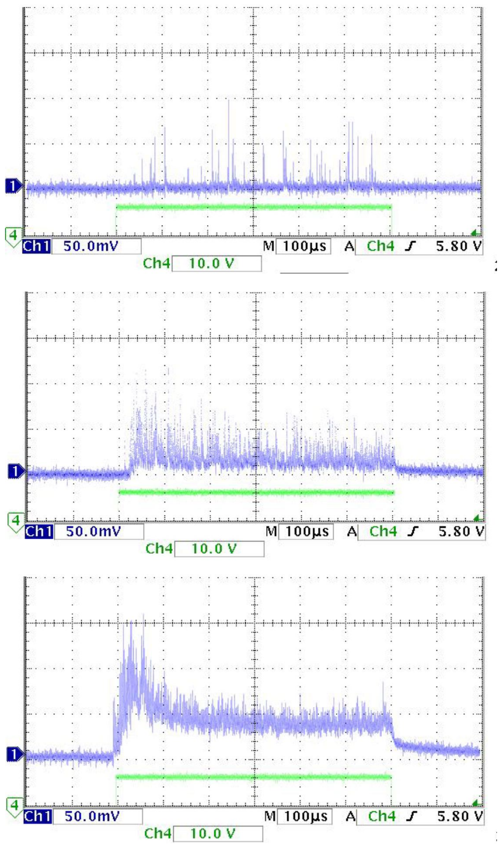

Figure 3: Output signal from SDTL-12 BLM.
Top: P_{RF}=0.2 MW/tank
Middle: P_{RF}=0.3 MW/tank
Bottom: P_{RF}=0.4 MW/tank
Green line: Gate pulse for RF switch.

operating level of the RF power. The nearest neighboring pair of the SDTL was turned off during the measurement if the radiation from the tank which is not a target of measurement is not negligible. Furthermore the observed pulse height is decreased by half if the BLM is located between two tanks which are supplied the RF power from the same klystron. (The radiation from the second nearest tank by RF field is negligible small.)

Finally the correlation between the RF power level in the tank and the height of BLM signal is obtained as shown in Fig 6. In the figure the blue dots are the data for SDTL-01 to SDTL-12. While the red dots show the data for SDTL-13 to SDTL-30. It shows that the latter data is smaller than the former one.

It is discussed in the next section what can make the difference for the pulse height with the same power level.

DISCUSSION

The output signal from the BLM shows the radiation from SDTLs. Thus the difference of signal pulse height must be caused by the difference of the SDTL structure.

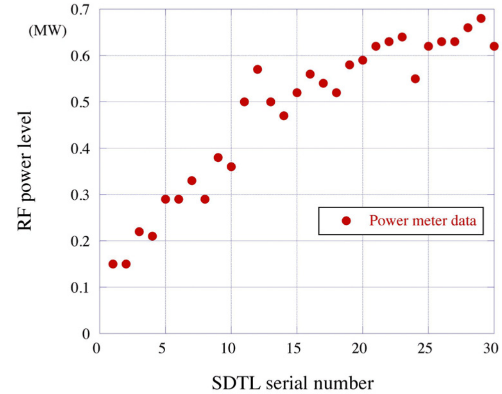

Figure 4: RF power level of SDTLs.

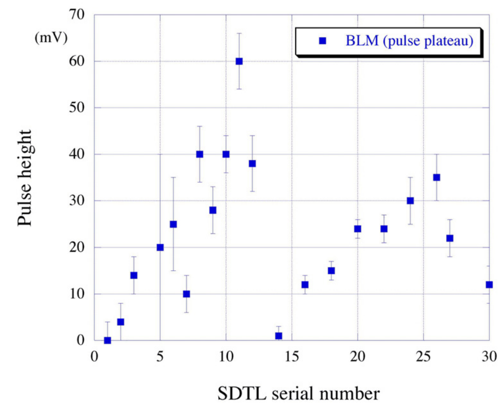

Figure 5: Pulse height of BLM.

However the RF structure of the whole SDTL tanks is same except for the position of the moveable tuner [4].

Auto-tuner Position

The auto-tuner position along the tank is the center of the tank from SDTL-01 to SDTL-12. It is standard layout of the single auto-tuner because the perturbation effect by the tuner for the field distribution on the beam axis is min-

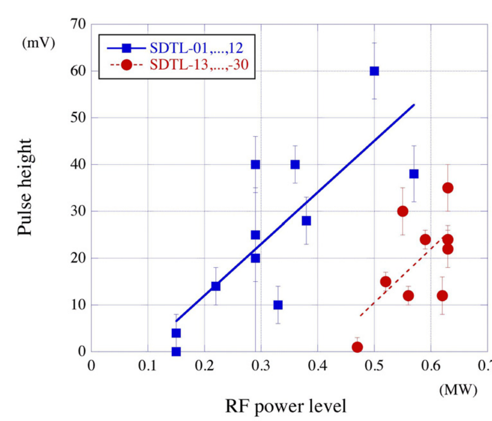

Figure 6: RF power dependence of BLM.

imum. As the SDTL of J-PARC has 5 gaps in the tank, the center of the tank is the gap center. The electric field in the gap spread out in transverse direction when the gap size is long. It means that the tuner interacts the electric field when the length is long enough. In that case, the trend of the frequency shift by the tuner changes. In particular, the effect of the electric field on the tuner is not negligible for the high-energy part of the SDTL because the gap length is much longer than that of the lower energy part. Therefore the auto-tuner position along the tank moved from the center of the tank to the side of the nearest drift tube shown in Fig 7 for the SDTL-13 to SDTL-32. The observed frequency shift is shown as shown in Fig 8. It shows the saturation of the frequency shift for SDTL-12 but it is almost linear for the SDTL-13.

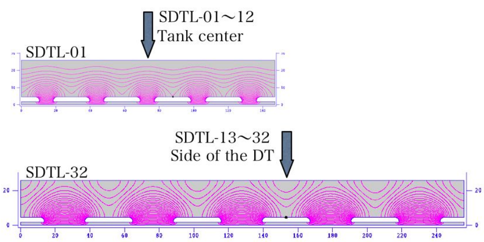

Figure 7: Example of the auto-tuner position.

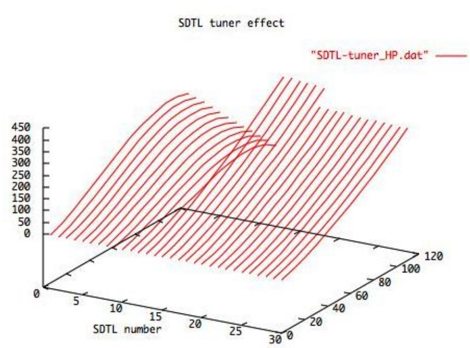

Figure 8: Frequency shift by the auto-tuner.

Particle Tracking Simulation

The multipactor around the tuner has been considered at first as the candidate of the origin of the radiation from the tank described before. In order to investigate the maltipactor phenomenon, the simulation code of Particle Studio of Computer Simulation Technology (CST-PS) has been used. The simulation has been done with the models around the tuner shown in the left side of Fig 9. For SDTL-12 the tuner is located at the center of the gap (Top of 9) . While the tuner is side of the drift tube for SDTL-13 shown in the bottom of 9. The simulation has been done by changing the power in the tank. As the result, we did not find any multipactor zone for both structures near the power level for the practical use. Thus it is planed to evaluate the energy distribution of the secondary electron which collides the tank surface. The simulation study is still on going.

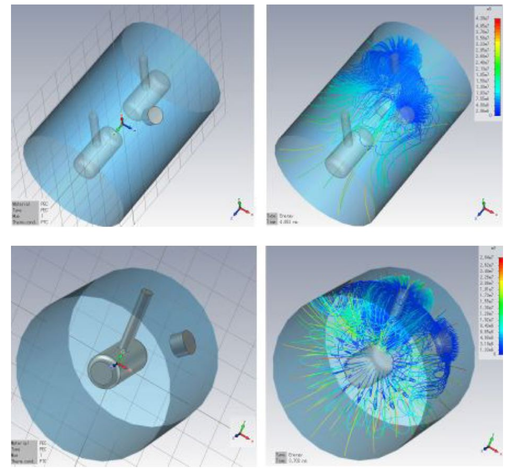

Figure 9: CST-PS simulation
Top left: Model of SDTL-12,
Top right: Electron trace example of SDTL-12
Bottom left: Model of SDTL-13,
Bottom right: Electron trace example of SDTL-13

SUMMARY

We have observed the X-ray radiation from the SDTL of J-PARC linac with the BLM by the cavity. The results show that the X-ray intensity depends not only on the RF power level of the tank but also on the RF structure of the tank. We have started the simulation study in order to find the origin of the X-ray in the tank. The study is still being continued.

Furthermore the signal of BLM will be measured more precisely because the quality of the data is not fine now.

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