Update of the TRISTAN Superconducting RF System

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Abstract

The TRISTAN superconducting RF system has been operated since 1988. The remaining operational problem is the trip of the cavity caused by synchrotron radiation. In order to reduce the trip rate, we made realignment of Q-magnets in the straight section and put a movable radiation mask near the end of the arc section. The effect of these improvement, operating status and long term performance are reported.

I. INTRODUCTION

The TRISTAN superconducting RF system continues to provide 40% of the total ring accelerating voltage. The history of the operating condition is summarized in Table 1. Once in 1992, the number of operating cavities was decreased to 23, because of many troubles such as vacuum leak at beam pipe indium joints and water leak at outer water jackets of input coupler ceramic windows [1]. Three water leaked pairs of cavities were electro-polished again, and four leaked pairs were simply reassembled. In the last winter shutdown, the last cavity pair, one of which was never operated since its installation, was replaced by a repaired pair. But unfortunately, one of HOM coupler connectors was found to be sputtered probably by excessive fundamental power due to HOM coupler quench during horizontal test. After exchange of the connector, the cryostat was installed again and full 32 cavities came into operation from April, for the first time since the commissioning in 1988.

Also in the last summer shutdown, the following 3 counterplans were performed in order to reduce trip rate.

1) Correction of Q-magnet alignment near the collision point.
2) Installation of a movable radiation mask at the place 7 m arc side from the outermost cavity (10D#4).
3) Improvement of the orbit control scheme during acceleration and replacement of beam position monitors around the sc cavities.

The effect of these on the trip is discussed later.

II. CAVITY PERFORMANCE IN THE RING

After the last report [2], the cavity performance was measured three times. Figure 1 shows the distribution of the maximum accelerating gradient, where "First 16" means that cavities were installed in 1988 and never electro-polished afterwards. One of the worst cavities (11B#4) was degraded after reassembling. "Last 16" are those installed in 1989, and "Spare & Repair" are those installed in 1991 (4 cavities) and those reelectro-polished after 1991 because of contamination or degradation. As a whole, the cavities are keeping the initial gradient, but a few cavities show degradation during operation (Fig. 1 b). The limitation of these cavities (11D#3,#4) is coupler arc [2]. Since the gradient recovers after warm up and the input couplers can handle enough power if the cavities are detuned, we think the limiting mechanism is multipacting around the coupling port due to gas adsorption from the arc side and by so many trips (discharge).

Table 1: Summary of the operation of SC Cavities in TRISTAN-MR

Period		Number of cav. (at 4K)	(operated)	Total Vc (MV)	Eacc(ave.) (MV/m)	Energy (GeV)	Current (mA)	Physics Run (days)
1988	Nov-Dec	16	16	105-109	4.4-4.6	30.0	10	18
1989	Jan-Mar	16	14	82-88	4.0-4.2	30.4	9	49
	May-Jun	14	14	87	4.2	30.4	10	17
	Jun-Jul	16	16	105	4.4	30.7	10	37
	Oct-Dec	30	28-29	190-200	4.6-4.7	32.0	12	25
1990	Feb-Mar	32	31	160	3.5	29.0	12	37
	Apr-May	32	30-31	160	3.5-3.6	29.0	12	25
	May-Jun	32	28-30	150-160	3.6	29.0	13	39
	Jul	30	25	130	3.5	29.0	13	31
1991	Jan-Jul	32	29-30	140-145	3.3	29.0	9	36
	Oct-Dec	30	26	140	3.6	29.0	13	35
1992	Feb-Mar	26	23	125	3.6	29.0	12	31
	Apr-Jun	28	23-25	135-140	3.8	29.0	13	77
	Oct-Dec	32	25-31	150-170	3.3-4.1	28.8-29.9	13	66
1993	Feb-Apr	30-32	28-32	145	3.2	29.0	13	48

Total accumulated time of cavities at 4.4 K : 23300 hours

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Figure 2 shows the result of Q measurement by liquid He consumption. The worst data point at 5 MV/m is that of the degraded cavity, 11B#4.

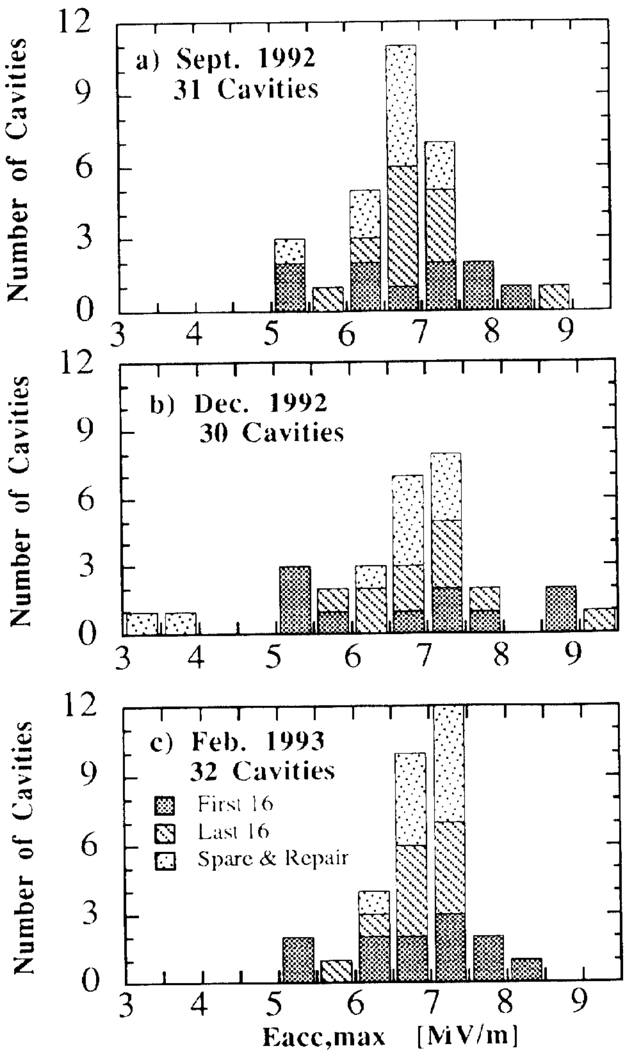

Fig. 1 Distribution of the maximum accelerating gradients.

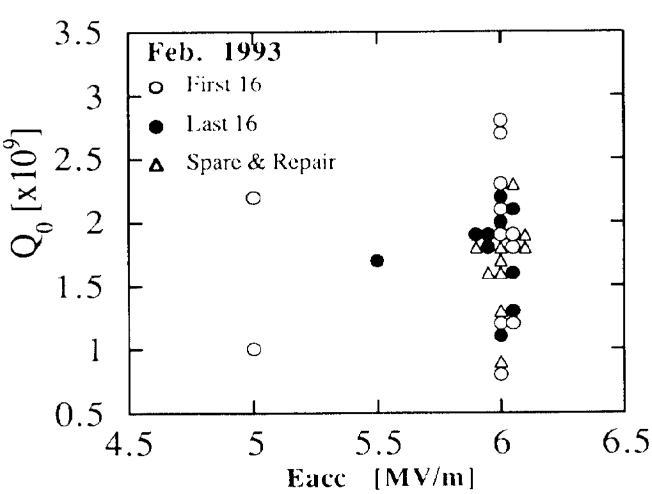

Fig. 2 Distribution of the unloaded Q values.

III. TRIP

A. General Feature

There have been many types of trips and reports. Here we summarize the present our understanding. In some cases, the trips were caused by troubles of input couplers [3], but in the other most cases, they are not related to hardware performance, they happen from the beginning of a running period. The general features of these trips are summarized as follows.

1) They are concentrated on some location, both arc sides (10D and 11D) and around 10B. Once the cavities at 10B#1,#2 and 11D#3,#4 were exchanged to other cavities, but the trip rate was not reduced. Figure 3 shows the distribution of the trips in the last two running period.
2) The trip rate changes day by day, which is more remarkable for the trips at Flat Top [2]. Figure 4 shows the recent Fill by Fill trip rate of 11D#4 and 10D#2,#4 at Flat Top. Very high trip rates of 10D#4 and 11D#4 in Fig. 3 a) were due to heavier bunching of the trips.
3) Trips during acceleration are sometimes concentrated around some energy corresponding to each cavity [3].
4) Trips during acceleration are liable to happen with higher beam current [2]. But on the other hand, trips at Flat Top do not strongly depend on the beam current, they happen also with lower current at the end of fills.
5) Most of trips seem to be discharge in the cavity or around the coupling ports of input couplers and monitor couplers.

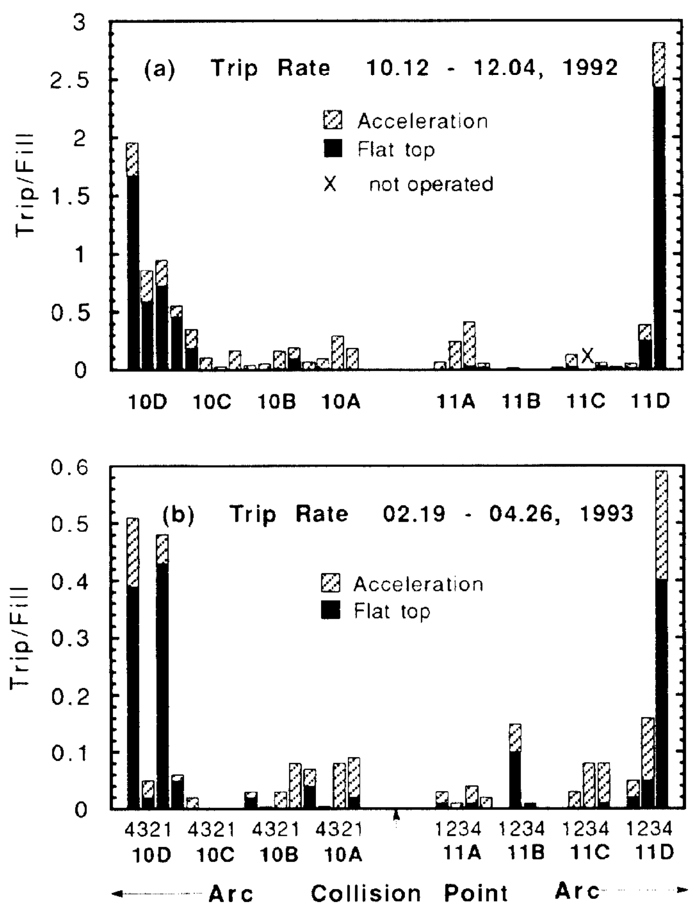

Fig. 3 Distribution of the trips.

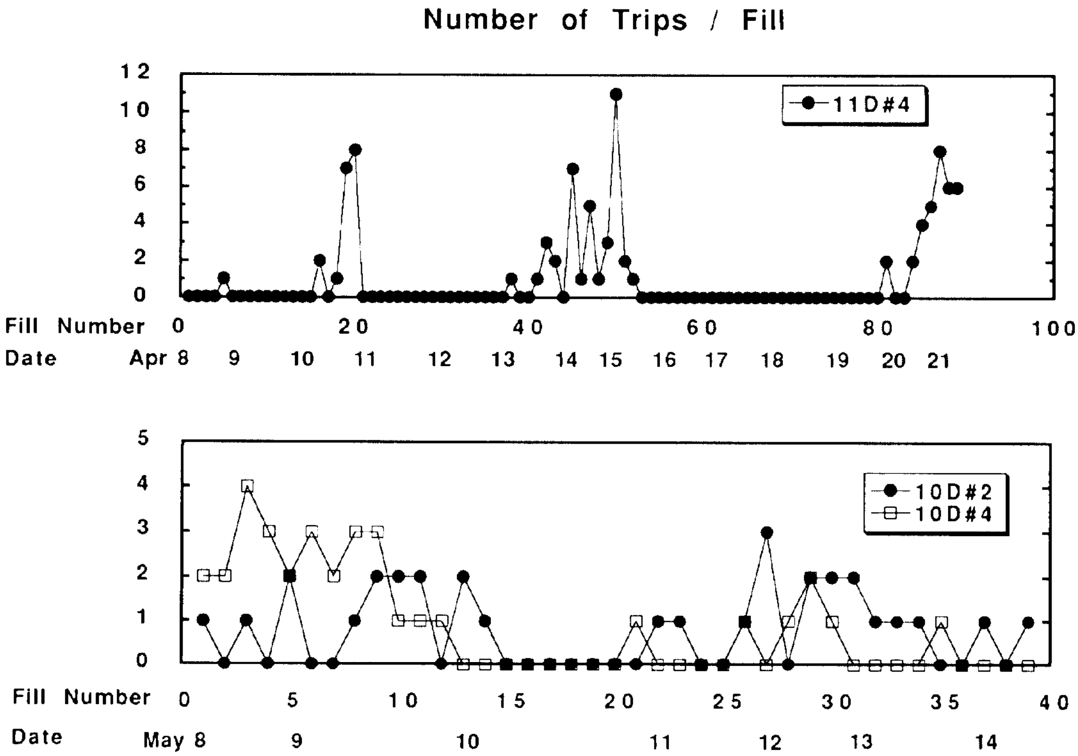

Fig. 4 Fill by Fill trip rate at Flat Top.

B. Counterplans

We have supposed that the main trigger is the synchrotron radiation. In 1990, we moved fixed radiation masks of both outermost cryostats into the ring center by 1 mm. The effect was very drastic for the trip of 11D#3 during acceleration but was not seen for the other trips [3]. The mask of the cryostat containing 10D#3,#4 was moved by another 1 mm in the summer of 1991, and then the trip of 10D#3 during acceleration became quiet. So the trips of these cavities during acceleration are supposed to be due to the synchrotron radiation from bending magnets.

The trips of the cavities from 10A#3 to 10B#2 were prominent in 1991 and the first half of 1992 [1,2]. Since they became prominent after installation of the superconducting quardrupole magnets, we doubted the alignment of the magnets. In the summer of 1992, the correction of horizontal alignment for the superconducting and the neighboring normal conducting Q-magnets, which are located at the same side as 10A, was done by 1 mm and 1.6 mm respectively to the direction of the outer side of the ring. The effect is striking, the trips around 10A and 10B have become quiet as is seen in Fig. 3. This means that COD of mm order at superconducting Q-magnets can produce enough radiation to cause the trips.

The remaining frequent trips are those of 10D#2,#4 and 11D#4 at the Flat Top. They are all arc side cavities in cryostats and are completely hidden by the masks from the radiation coming from arc side. But, we thought that the scattered radiation at the masks might be a trigger and installed a new movable mask which can hide the fixed masks of three arc side cryostats. This movable mask came into operation in the last December, but we can not find the effect on the trip rate. This might be reasonable, since the trip rate of these cavities depends strongly on the time, but it is hard to imagine that the situation of the radiation changes strongly with the time. Now, we doubt the fluctuating synchrotron radiation from Q-magnets around the collision point and schedule the beam test in the next week.

IV. REFERENCES

[1] T. Shishido et al., "Operating Status of the TRISTAN Superconducting RF System", *Proc. of the 3rd Euro. Part. Acc. Conf.*, Berlin, Germany, Mar. 1992, pp. 57-59.

[2] K. Kubo et al., "Four Years of Operation of the TRISTAN Superconducting RF System", *Proc. of the 15th Int. Conf. on High Energy Accelerators*, Hamburg, Germany, July 1992, pp. 691-693.

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