UPGRADING OF TARN-II VACUUM SYSTEM

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Abstract

Ion pumps and titanium getter pumps have been increased nearly twice in the TARN-II. The pumping speed per unit length is now improved up to 2/3 times that of TARN-I. An average vacuum pressure of 10^{-11}Torr order has been achieved at beam time. Performance of the system after the upgrading is reported.

Introduction

TARN-II is an storage, cooling and acceleration ring of light heavy ions with electron cooling device[1,2]. The ring has been used for study of accelerator technology and atomic physics. An ultra-high vacuum of 10^{-11}Torr order is required to obtain long beam lifetime for the experiments of atomic physics. The ring has a circumference of 78 m, which is 2.5 times as long as that of TARN-I[3]. At the beginning, however, only vacuum pumps of TARN-I were used to evacuate the ring chamber of this system. Upgrading of the pump system of TARN-II was performed by adding titanium getter pumps and sputter ion pumps in 1991. The present status of the vacuum in TARN-II is reported.

Pumping system

The vacuum system of TARN-II based on that one of the TARN-I. Sputter ion pumps, titanium getter pumps and turbo-molecular pumps are used for main pumps. The pump system of the ring is shown in Fig.1. The symbol 'OLD' indicates pumps used at TARN-I. The turbo-molecular pumps of 500 l/s are used in the long straight section S1, S3 and S5. Roots pumps equipped to S3 and S5 are used only at the time of pumping down from atomospheric pressure.

An upgrading of the vacuum system was performed by adding titanium getter pumps (TGP) and sputter ion pumps (IP) in 1991. The numbers of pumps and pumping speed at the TARN-I, and those of TARN-II, before and after the improvement are compared in Table 1.

Performance

Attention has been paid that the ring chamber must be kept in vacuum as long as posible. After the improvement of pump system, there was once the chamber was exposed to atomospheric pressure for 5 day while undertaking work to equip beam current transformer in 1992. After the exposure, baking process of 100°-200°C at ring chamber, 250°C at ion pumps and 350°C at titanium getter pumps were performed. Baking temperatures of some parts were limited lower than 50°C for protection of electric characteristics. This problem is very important to get an ultra-high vacuum. An average vacuum pressure of 8 x 10^{-11}mbar have been achieved. The pressure measurements were performed by Bayard-Alpert

Table 1: Comparison of the pump speed before and after the upgrade of TARN-II

	TARN-I (l/s)	TARN-II Previous (l/s)	TARN-II Present (l/s)
TGP	1500 x8	1500 x7	1500 x8 1000 3 700 4 400 11
Ip	800 x4 400 4	800 x5 400 3 160 2	800 x6 400 5 160 6
Total pump speed	16800	16000	30000

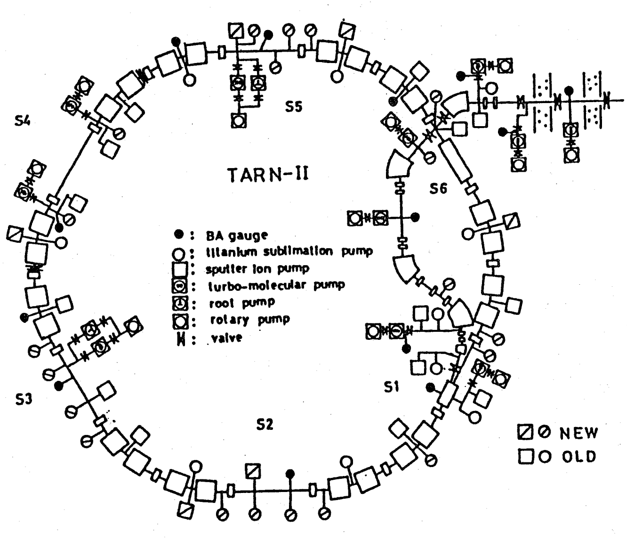

Fig. 1 Schematic layout of the vacuum system at TARN-II.

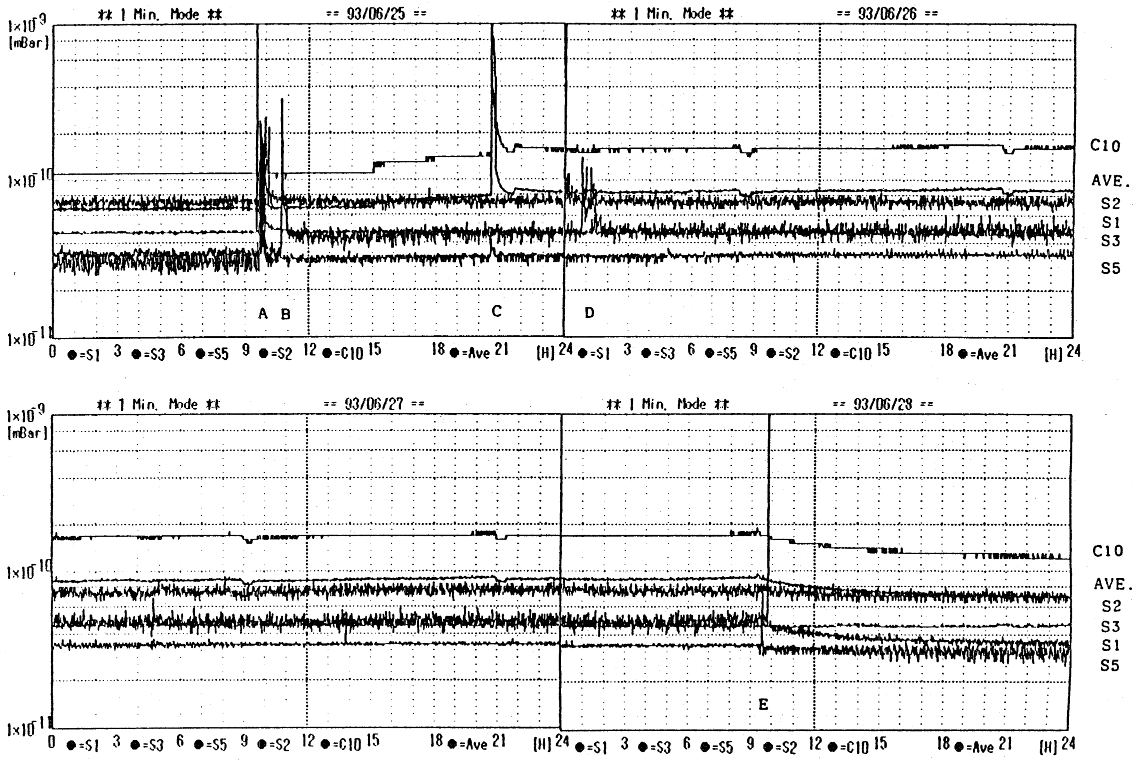

Fig. 2 An example of vacuum pressure data as a function of time which were measured at five positions of the ring at the beam time. Symbols S1-S5 and C10 indicate the pressures at long straight sections and chamber of dipole magnet. Symbol of Ave represents the average pressure which is about 8 x 10^{-11}mbar(6x10^{-11}Torr). A; titanium getter pupms of the ring were flashed, B; injection valve was opened, C; titanium getter pump of transport was flashed, D; ion beam of HeH^+ 9.5 MeV was injected into the inflector chamber and E; injection and transport valve were closed.

gauges. An example of vacuum pressure data at beam time which were recorded by the data taking system is shown in Fig. 2. In the figure, vacuum pressures at S1, S2, S3 and S5 indicate 10^{-11}mbar order, but vacuum pressure at C10 which is located at the dipole magnet chamber near the transport line and RF cavity rised at beam time. The reasons of the pressure rise are considered as follows: 1) Out gassing from chamber wall by temperature rise of dipole magnet. 2) Influence from out gassing of RF cavity. Temperature of cooling water of the RF cavity was very high 30°C at entrance and 40°C at exit. 3) Gas flow from the transport line. This is indicated by pressure variation at 9 and 21 H when transport valve was closed while liquid nitrogen was feed and titanium getter pump was flashed at getter chamber of transport line.

Many kinds of ions were injected and circurated in the ring. The energies, mean pressures and lifetimes of ion beams circulated in the ring so far are listed in Table 2.

Build up test of the ring was performed. Measured points were S1, S3 and S5 where automatic range change vacuum gauge were located. Result of the test is shown in Fig.3. Residual gas spectra before and after the build up are shown in Fig. 4. Variation of partial pressures are shown in Fig. 5.
Ion currents of H_2 and CO/N_2 are not changed before and after of the build up. CH_4 peak saturate after the first rise up. He and Ar peaks rise up with time, but Ar peak gradualy saturate. We suppose that these are He and Ar captured by ion pumps.

Table 2. Lifetimes of ion beams circulated in TARN-II

Ion	Energy (MeV)	Mean pressure (Torr)	lifetime (sec)
p	20	2.2 x 10^{-9}	12
p	20	1.1 x 10^{-10}	320
H_2^+	20	2.0 x 10^{-9}	0.1
H_3^+	13	1.2 x 10^{-10}	0.8
$^3He^+$	13	5.4 x 10^{-10}	0.7
$^4He^{2+}$	40	1.3 x 10^{-10}	400
	40	2.1 x 10^{-10}	110
	40	3.2 x 10^{-10}	100
HD_2^+	9.5	1.2 x 10^{-10}	1.1
HeH^+	9.5	1.2 x 10^{-10}	1.3
HeD^+	7.9	1.1 x 10^{-10}	1.5
$^{14}N^{5+}$	85	1.4 x 10^{-10}	12
$^{14}N^{7+}$	85	1.9 x 10^{-10}	40
	85	3.6 x 10^{-10}	35
	85	1.0 x 10^{-9}	18

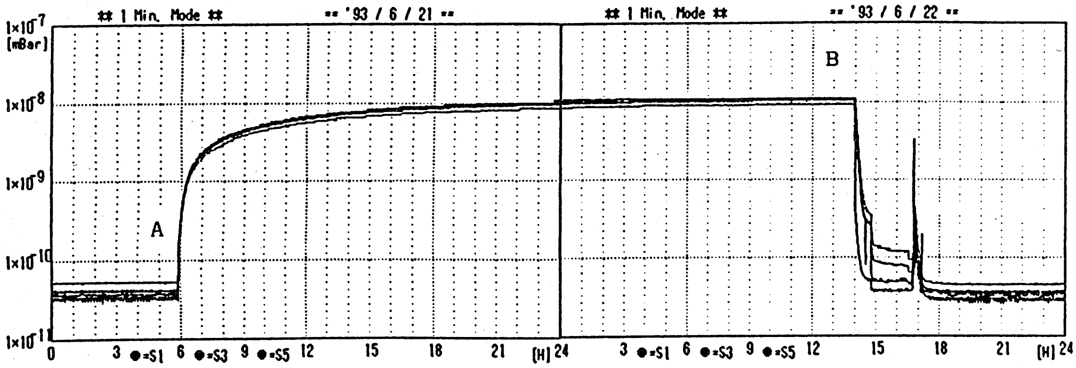

Fig. 3 Build up test of the ring. A and B are measured points of residual gas spectra.

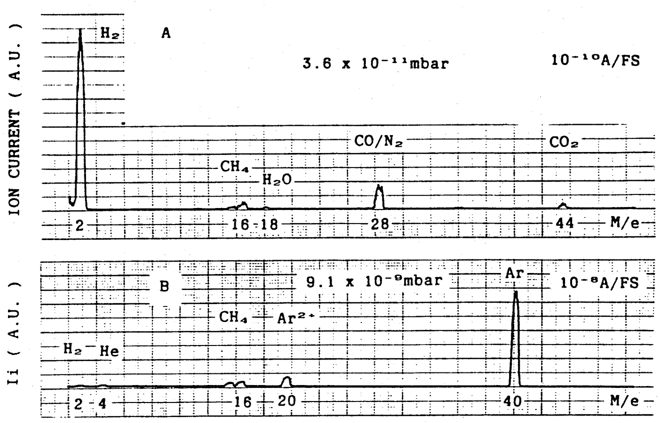

Fig. 4 Residual gas spectra of the ring.
A) Spectrum before build up test.
B) Spectrum at end point of build up.

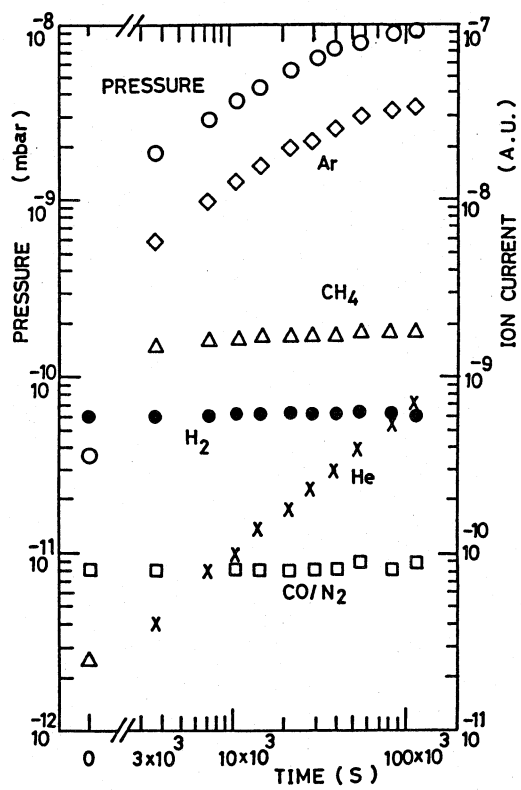

Fig. 5 Total pressure and residual gas as a function of time.

Conclusion

Pump speed of unit length through the ring was improved to 2/3 that of TARN-I.

An average pressure of 10^{-11}mbar order has been achieved with beam.

For further improvement of vacuum system, problems listed below must be considered;

1) Improvement of the vacuum in the transport line.
2) High temperature baking of possible parts.
3) Improvement of pumping speed.
4) Development of vacuum pressure measurements.

Acknowledgements

The authors would like to express their thanks to the members of Accelerator Research Division, Institute for Nuclear Study, University of Tokyo.

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