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SUMMARY OF X-RAY RING PERFORMANCE BEFORE THE 1987 SHUTDOWN

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I. Introduction

On February 28, 1987, the X-ray ring was shut down for major modifications. 627 Ampere hours of time integrated current had been accumulated and lifetimes of 25 and 9 hours had been routinely achieved at 50 and 200 mA, respectively. In this paper, I will summarize pressure and lifetime behavior since the first bakeout¹ in March 1984, when the lifetime at 20 mA was about 20 minutes. More information can be found in References 1-5.

II. Pressure

From the first bakeout, the pressure in the bending magnets, where most of photon stimulated desorption takes place, decreased by a factor of ~40. The CO/CO₂ ratio which is significant in beam gas interaction, was lowered by a factor of 5. Most improvement was due to synchrotron radiation clean-up of the vacuum chamber, but some improvement was observed in the pumping speed of distribution pumps (DIP). The pressure in the straight sections was always low, with little influence on the lifetime. After about 60 A-hours, the pressure in the machine became low compared to the rf cavities due to vacuum leaks in the copper seals, rf windows, and welds. The effects on the lifetime became obvious, and after ~120 A-hours, rf cavity's pressures ($>3 \times 10^{-8}$ Torr) became dominant. Various fixes, i.e., cooling the copper seal, vacuum sealant spraying of windows and welds, brought the pressure to an acceptable level (Table I). One remaining problem was a leak in the pump penetration weld of cavity number three, which opened every two to three weeks and lowered the lifetime by 50%. Luckily, it could always be fixed by vacuum sealant and good lifetime was restored. All problems will be eliminated during the shutdown. Selected pressures in various parts of the ring are tabulated in Table I. The following partial pressures in nTorr were calculated for 202 mA at 620 A-hours:

$$\text{H}_2 (2) = 1.3$$

$$\text{CO} (28) = 0.7$$

$$\text{A} (40) = 0.1$$

$$\text{CO}_2 (44) = 0.1$$

TABLE I

	Straight Sections		Magnets	Cavity	Average
	I	1 = 114 m	44 m	12 m	Pressure
Amp-hours	mA	Torr	Torr	Torr	Torr
220	110	3×10^{-10}	1.7×10^{-9}	2.5×10^{-8}	2.4×10^{-9}
400	133	2×10^{-10}	1.5×10^{-9}	1.2×10^{-8}	1.5×10^{-9}
620	0	7×10^{-11}	3×10^{-10}	6×10^{-9}	4×10^{-10}
620	202	3×10^{-10}	2×10^{-9}	8×10^{-9}	1.3×10^{-9}

III. Beam Lifetime

Knowledge of the partial pressures of residual gas components permits us to calculate the beam lifetime which then can be compared with the measured value shown in Fig. 1. The circulating beam electrons interact both with the nuclei and the electrons of the residual gas atoms, but the total cross sections for nuclear interactions, i.e., Bremsstrahlung and coulomb scattering, dominate the lifetime. Assuming rf acceptance of 1% (Ref. 2), the Bremsstrahlung lifetime,

$$T_B = \frac{3.2 \times 10^{-8} X_0}{MP} \text{ hours,} \quad (1)$$

where

$$X_0 = \text{gas radiation length}^6 (\text{g cm}^{-2})$$

M = mass number

P = pressure (Torr)

Coulomb scattering lifetime⁷, T_{cs} , for 2.53 GeV electrons assuming vertical aperture $\frac{d}{2} = 1 \text{ cm}$, $\langle \beta v \rangle = 10 \text{ m}$ and $\beta \text{ max} = 28 \text{ m}$

$$T_{cs} = \frac{5.1 \times 10^{-6}}{Z^2 P} \text{ hours} \quad (2)$$

Figure 1

where Z = atomic number.

For the scattering on electrons⁷, only the inelastic scattering is of any significance and the resulting lifetime

$$T_{1S} = \frac{2 \times 10^{-6} \text{ hours}}{ZP} \quad (3)$$

The lifetimes calculated from partial pressure given in II for beam current of 200 mA are:

$$T_B = 36 \text{ hours}$$

$$T_{CS} = 38 \text{ hours}$$

$$T_{1S} = 117 \text{ hours.}$$

The resulting total calculated lifetime of 16 hours can be compared with 8.3 hours measured at 200 mA.

The factor of two discrepancy can be due to the following:

- a. inaccuracy in measured total and partial pressures
- b. different limiting aperture than 2 cm used in (2)
- c. presence of positive ions⁸ trapped in the potential well of the beam chamber in the vacuum.

The ionized residual gas molecules or atoms interact with the beam in the same way as neutral molecules, but are not collected by either the BA gauges or RGAs.

A few selected lifetimes are tabulated in Table II.

TABLE II
Selected Lifetime

<u>A hours</u>	<u>I(mA)</u>	<u>T(min)</u>
11	60	60
26	90	150
70	80	300
220	110	380
400	130	600
620	200	500
620	50	1500

IV. Distributed Ion Pumps (DIP)

It is a well-known fact that the pumping speed of ion pumps decreases drastically below the 10^{-9} Torr range. Since measurement of DIPs dynamic pumping speed is difficult, we have checked their effectiveness by selectively switching off 6, 8, and 16 DIPs and observed the change in lifetime. Table II shows the resulting decrease in lifetime per pump, ΔT , at different stages of X-ray ring operation (A-hours). In early stages 10-20 A-hours, little change in lifetime was observed even when all 16 DIPs were switched off. After 620 A-hours, a significant improvement in pumping speed in 10^{-9} Torr range was observed.

TABLE III
DIP Performance

<u>A-hours</u>	<u>I(mA)</u>	<u>DIP - off</u>	<u>$\Delta T\%$</u>	<u>Reference</u>
10	50	8	<1%	1
	40	16	0	1
80	70	8	1%	3
		16	1.1%	3
620	150	6	3.4%	

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