A SIMPLE WAY FOR COMPARING EXPECTED AND MEASURED BEAM GAS LIFETIMES IN ELECTRON STORAGE RINGS*

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Abstract

The comparison of measured and expected beam gas lifetimes in electron storage rings is confronted with many problems for evaluating the average partial pressures. In the case of a multitype pumping (ion pumping, Ti sublimators, NEG), a very simple situation can be reached by switching off the ion pumps. Argon realease soon provides a dominant and uniform pressure over the whole vacuum system, thus allowing an accurate evaluation and mesurement of the beam gas lifetime. Experimental results from Super-ACO are presented which justify the assumptions and yield an accurate comparison. Several outcomes of this very simple idea are proposed.

One can draw up a long list of the difficulties encountered in the proper assessment of the beam gas lifetime in a storage ring such as Super-ACO. These arise mostly from :

- Uncertainties on the model for the Photon Stimulated Desorption both from the primary photon beam and from secondary photons. Each of these depend on the wall materials, the angle of incidence of the photons, their energy spectrum, etc. The difference in the dependance of each contribution with the accumulated photon dose which is proportional to $\int_0^T$ Idt, complicates even more the picture.

- Uncertainties in the evaluation of the individual pumping speeds and of the proper conductance of each vacuum chamber vessel.

Both of these uncertainties combine their effect in the averaging, over the ring circumference of the contribution of each partial pressure to the beam gas lifetime due to (elastic and inelastic scattering).

One has to include also the uncertainties on the relative calibration of the Mass Analyser Spectrometers and of the B.A. gauges for the different gas species and finally on the absolute calibration of the B.A. gauges themselves.

Previous attempts at comparing expected and measured beam gas lifetimes in usual running conditions at high current resulted in a ratio as bad as 3 to 1 [1]. Such a difference could also arise from other reasons than the ones stated above, for instance, reduced vertical dynamic aperture or to a smaller extent, lower energy acceptance of the machine. So it is important to devise a test which can check the assumptions on the parameters deduced from the machine optics and relevant to the beam gas lifetime computations. The so-called "Argon Method" developped at LURE is describe below.

Like in many other storage rings, the design of the vacuum system of Super-ACO has made use of several types of pumps : diode and triode pumps, Ti sublimators and long NEG strips distributed over the whole circumference, see **Fig. 1**. After switching off the ion pumps, one observes during many hours the following behavior. The partial pressures of gas species such as H_2, CO and CO_2 are maintained to a very low level due to the pumping speed of the Ti sublimators and of the NEG strips. CH_4 rises, but then saturates after a short while, whereas Argon keeps going up linearly with time for hours and even for days. This is shown by **Fig. 2**. Moreover, since the still active pumps have indeed zero pumping speed for Argon and CH_4, the pressure soon gets uniform over the ring circumference. This is confirmed by the plot of **Fig. 3** which shows the ratio of the pressure reading of a B.A. gauge in each of the machine octants normalized to the reading of another gauge, up to a pressure of 10^{-8} Torr. The constancy of the ratios is unlikely due to a uniform release of Argon and CH_4 over the ring circumference, but is rather an obvious consequence of the absence of pumping speed mentionned above.

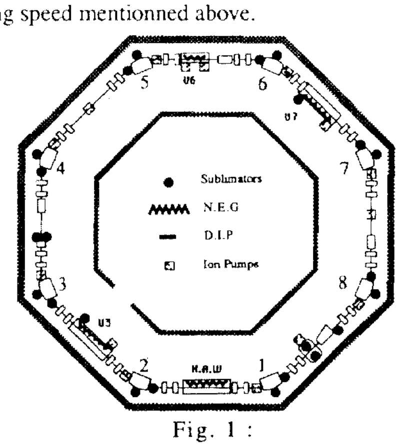

Fig. 1 :
Schematic of the pumping system of Super-ACO.

The uniform pressure obtained allows one to make a relative calibration of the 8 B.A. gauges, after taking into account the effect of stray magnetic fields which can be measured with the machine "on" and "off", see **Table 1**. The calibration of the gauges spreads over ± 20 %.

	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	$\bar{P}$
x 10^{-8} Torr	1.2	1.1	1.2	1.5	1.4	1.0	1.0	1.5	1.24
$P_n/\bar{P}$	.97	.89	.97	1.21	1.13	.81	.81	1.21	

Table 1

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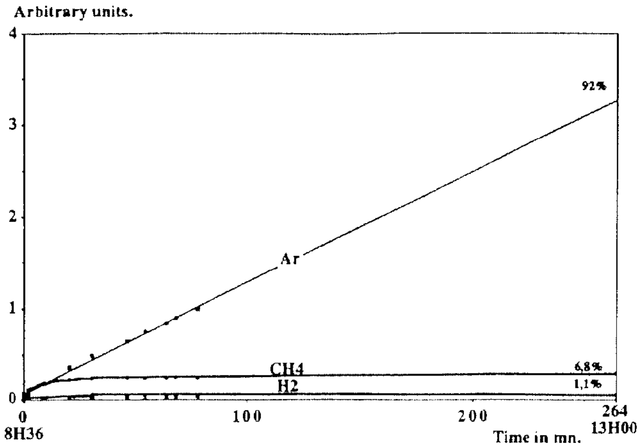

Fig. 2 :

Pressure rise of Argon and CH_4 after switching off all the ion pumps (currents from MAS before absolute pressure evaluation).

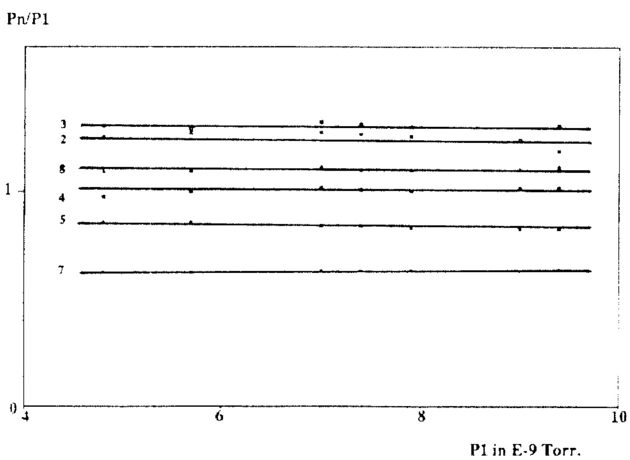

Fig. 3 :

Plot of normalized pressure in the 8 octants versus pressure P_1 after switching off all the ion pumps.

Partial Pressures, Total Pressure, and Lifetime Computation

At time 13 h 00, corresponding to **Fig. 2**, the beam lifetime for an intensity of 15 mA distributed over 24 bunches, at the normal operating point of the machine, $Q_x = 3.697$, $Q_z = 1.720$ and for an average pressure of 2.31 10^{-8} Torr of the 8 B.A. gauges was found to be $\tau = 7.6$ mn. The value of the pressure is corrected for the stray magnetic field effects as mentionned above. Note that the Touschek lifetime contribution can be totally neglected. Furthermore, due to the operation of Super-ACO with a positron beam, ion trapping does not occur.

Fig. 2 shows that Argon, CH_4 and H_2 contribute in terms of current signal to respectively 92, 6.8 and 1.1 % of the total. These signals are then corrected for the MAS calibration factor of each species. The relative pressures obtained are corrected, using B.A. gauge coefficients to obtain their N_2 equivalent values. The total pressure is then normalized to the above quoted value. One finally gets the following partial pressures :

Argon	2.00 10^{-8}	Torr
CH_4	2.31 10^{-9}	Torr
H_2	7.6 10^{-10}	Torr

The cross section for the positron-gas interaction for the elastic and inelastic (Bremsstrahlung) scattering on the nucleons and on the atomic electrons were evaluated, according to J. Haissinski [2]. The following parameters have been used : E = 800 MeV, $\bar{\beta} = 9$ m $\beta_{critical} = 13$ m, vacuum chamber height at critical point 2x1.5 cm, $E/\varepsilon_{RF} = 10^2$.

One finds, with the above mentionned partial pressures, that the Argon contribution to the lifetime is $\tau_{Ar} = 9.3$ mn and that of CH_4 is $\tau_{CH_4} = 584$ mn. The expected beam gas lifetime is therefore 9.2 mn, a value only 20 % higher than the measured one. The contribution of methane to the measured beam gas lifetime is very small, but amounts to about 10 % of the expected lifetime through the pressure evaluation.

Applications of the Argon Method

As mentionned above, the Argon method can be used to get an intercalibration of the vacuum gauges of the entire storage ring. As a result, only one single gauge needs to be absolutely calibrated. In the pressure range of 10^{-8} Torr or more, the correct assessment of stray magnetic field effects can also be made.

The method was found extremely useful in Super-ACO for performing fast and precise measurements of the beam gas lifetime as a function of the machine tune. In 6 hours, more than 60 measurements were taken, each with an accuracy of a few percent, using a beam intensity of 15 mA in 24 bunches, see ref. [3].

Finally, in rings operated with electron beams, ion trapping effects could be measured in ideal conditions of a single gas species filling namely Argon and compared to theoretical expectations.

References

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[2] J. Haissinski. Expériences sur l'anneau AdA, Thèse Doctorat d'Etat, Orsay, Série A, n° 81, 1965.

[3] "Super-ACO Status Report", H. Zyngier, J.C. Besson, M. Bordessoule, P. Brunelle, P. Juan, M.P. Level, P.C. Marin, P. Nghiem, E.M. Sommer, LURE, Orsay, this Conference.