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BEAM-GAS BACKGROUND CALCULATION FOR DEAR

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Abstract

The present paper describes the results obtained from a Monte Carlo simulation of the particles lost in the DAY-ONE Interaction Region (IR) of the DAΦNE machine. Coulomb scattering on the nuclei of residual gas and beam-gas Bremsstrahlung, which are the main sources of background in the initial phase of machine operation, were considered. A ray-tracking program (TURTLE) was used to follow the trajectories of the particles in the rings and to evaluate the number of particles that hit the vacuum chamber in the interaction region.

1. INTRODUCTION

DEAR [1] is an experiment which will measure, with a suitable soft X-ray detector, a Charge-Coupled Device (CCD), the last X-ray transition in kaonic hydrogen, allowing one to obtain the shift of the 1s level and its width caused by the KN strong interaction, and therefore to measure, without any extrapolation, as it occurs in scattering experiments, the S-wave K^-p scattering length a_{K^-p}.

This will definitively solve the "kaonic hydrogen puzzle", and will clarify the behaviour with energy around threshold of the scattering amplitude f_{K^-p}. The measurement will also allow understanding the nature of the Λ (1405) and to test the quark model predictions.

The DEAR experiment will be installed in the initial stage of DAΦNE operation, in one of the interaction regions designed for the machine commissioning (DAY-ONE IR), after removing the central quadrupole situated on the interaction point (I.P.) and inserting a thin Carbon fiber reinforced Aluminium vacuum chamber.

In Fig. 1, a layout of DAΦNE is shown: the two colliding beams run in two separated rings, which have in common the interaction regions, KLOE and FINUDA. Each ring is made of an internal part (SHORT) and an external one (LONG). As the final decision on where DEAR will be installed has not yet been taken, the background calculations have been performed for both the IRs.

To obtain a high luminosity ($5 \cdot 10^{32} cm^{-2} s^{-1}$) it is required a high current: for DAΦNE the design value of the number of particles per bunch is $N = 9 \cdot 10^{10}$ and the number of bunches varies from 30 for phase I up to 120 for the maximum luminosity.

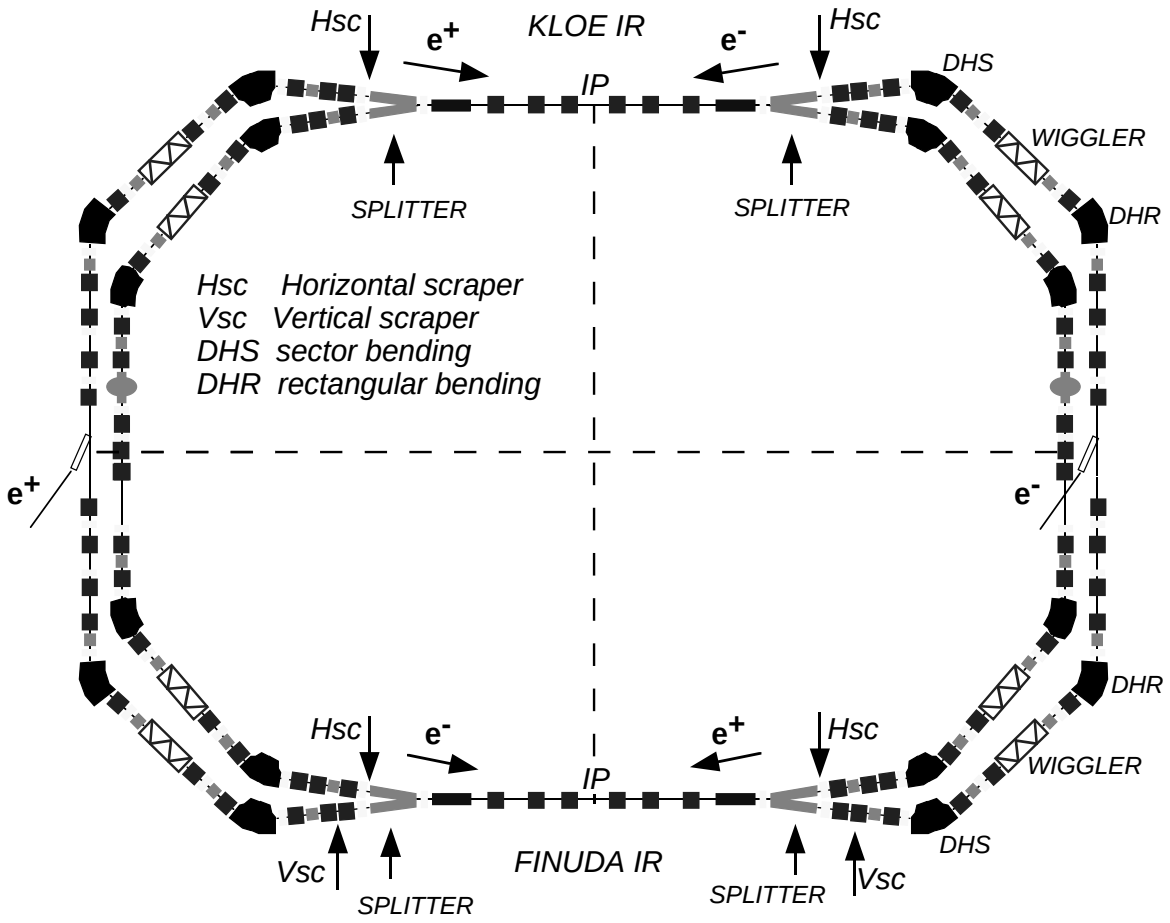

Figure 1 - DAΦNE general layout with the DAY-ONE IRs in the DEAR configuration. Scrapers and splitters are also indicated.

The estimated beam lifetime is of the order of two hours and therefore the number of particles per bunch per beam lost all along the ring is of the order of 13 MHz. The percentage of these particles which are lost in the interaction regions has to be calculated for the various causes of beam losses: Toushek effect, Coulomb scattering, beam-gas Bremsstrahlung. These results will then be used as input for the Monte Carlo of the DEAR experiment to evaluate the background level on the detector.

The evaluation of the background rate is in particular important to determine the operating conditions for the detector: CCD's cannot tolerate to have more than 5% of the overall number of pixels hit by background particles.

The particles lost due to Touschek effect have been already calculated for the DAΦNE IRs in the KLOE, FINUDA and DEAR configurations [2].

The rates of particles, which hit the vacuum chamber in the DAΦNE IRs after beam-gas interaction were previously evaluated for the DAY-ONE [3] and KLOE [4] configurations in simulations which took, however, into account only a small fraction of the ring.

This paper reports the first simulation, along the entire ring (98 m and 400 elements), of the rates of particles which hit the vacuum chamber after beam-gas interaction in the DAY-ONE IRs for the DEAR configuration.

The beam-gas interaction is the main source of background for DEAR, because in the initial stage of machine operation the synchrotron radiation produces desorption of gas molecules from the vacuum chamber and gives therefore a high residual gas pressure.

2. PROGRAM DESCRIPTION

The main tool used to simulate the machine beam-gas background is the TURTLE program (Trace Unlimited Rays Through Lumped Elements).

It was created for accomplishing the task of tracking charged particles through magnetic elements [5] and then adapted to include in-flight decay and subsequently tracking of both parent and daughter (neutral and/or charged) particles (DECAY_TURTLE) [6]. The current version includes beam-gas Bremsstrahlung, Coulomb scattering in gas and the electromagnetic showers produced in the slits along the beam line [7].

For the daughter particles coming from beam-gas interaction on the nuclei of residual gas, the program takes into account the probabilities given by the cross sections of each process, and the proper kinematic distributions.

The matrices included in the program allow to handle the transport of particles through drift spaces, sector and rectangular bending magnets with fringing field effect and pole-face rotation, quadrupoles, sextupoles, and solenoids with fringing field. All the magnetic elements have aperture limitations and slits can be inserted in the beam line in order to study the distribution of the stopped particles in different positions along the pipe.

There is the possibility to introduce shifts in coordinates and angles, and beam rotations in order to handle misalignments of the pipe and changes in the reference orbit.

The input of the program consists of a file containing the accelerator lattice, the geometrical limitations, the initial phase space of the beam, the parameters of the histograms that the program will create on request, and the physical parameters necessary to calculate the probabilities of the various processes.

2.1 *Tracking*

The tracking is performed independently for each particle, characterized by a six coordinate vector:

$$X= (x,x',y,y',l,\delta)$$

where x and y represent the coordinates in the plane orthogonal to the central trajectory, chosen as z axis, x' and y' are the angles that the ray makes relative to the z axis in the xz and yz planes, respectively, l is the longitudinal coordinate relative to a particle travelling along the reference orbit with the design momentum, and δ represent the relative momentum deviation.

The effect of each magnetic element is calculated through its transfer matrix R:

$$X(t) = RX(0)$$

In those cases where second order effects have to be calculated, a second order matrix T is also used. The matrix elements can then be written, in the second order approximation, as

$$X_i(t)=\Sigma_j\ R_{ij}*X_j(0) + \Sigma_{j,k}\ T_{ijk}*X_j(0)*X_k(0)$$

This gives the possibility to extract at any point the beam parameters and to study the effects of the aberrations for each magnetic element.

The second order approximation is automatically enabled when one introduces the beam-gas interaction or it is requested by the input commands.

2.2 *Beam-gas interaction simulation*

The two main processes which characterize the interaction of the circulating beams of electrons and positrons with the atoms of residual gas in the machine pipe are the Coulomb scattering and the Bremsstrahlung on gas.

The Coulomb scattering cross section for relativistic electrons is [8]:

$$\frac{d\sigma}{d\Omega} = \frac{4Z^2 r_e^2}{\gamma^2} \frac{1}{\left(\theta^2 + \theta_1^2\right)^2}$$

where:

$$\theta_1 = \alpha Z^{1/3} \frac{1}{\gamma}$$

Z is the atomic number, r_e the classical electron radius, γ the electron energy in units of rest mass and α is the fine structure constant.

The cross section for beam-gas Bremsstrahlung is [8]:

$$\frac{d\sigma}{dk} = \frac{1}{n_a X_0 k}\left[1 + (1-\nu)\left(1 - \nu + \frac{1}{9\ln\left(183/Z^{1/3}\right)} - \frac{2}{3}\right)\right]$$

where $\nu = k/E_0$ is the energy of the emitted photon relative to the electron energy and the radiation length X_0 is given by the following expression, which takes into account both the scattering on the nucleus and on the electrons of the residual gas atoms:

$$\frac{1}{X_0} = 4\alpha r_e^2 n_a Z(Z+1.3)\ln\frac{183}{Z^{1/3}}$$

n_a is the number of atoms per unit volume at atmospheric pressure.

In order to increase the efficiency of the simulation for beam-gas interaction, all the generated particles are randomly made to interact along the beam-line and then TURTLE calculates a normalization factor which gives the fraction of beam particles affected by the interaction processes.

The normalization factor is calculated per bunch per generated ray. One has to multiply the number of lost particles by the normalization factor and the bunch frequency in order to obtain the rate. The normalization factor depends on the cross section of the process integrated on the given range (minimum and maximum scattering angle for Coulomb scattering, energy limits for Bremsstrahlung), the number of electrons per bunch N_e, and the length of the trajectory l , as follows:

$f_{norm} = \frac{N_e}{N_{rays}} \frac{p}{760} n_a \sigma(\theta_1, \theta_2) l$ for Coulomb scattering, and

$f_{norm} = \frac{N_e}{N_{rays}} \frac{p}{760} n_a \sigma(\nu_1, \nu_2) l$ for beam gas Bremsstrahlung

with p=pressure in torr.

Coulomb scattering does not change the energy of the electrons, only the direction is modified, therefore the angular deviation is chosen randomly for ϕ (polar angle) and also randomly, but weighted with the cross section, for θ (azimuth).

Bremsstrahlung process does not change the direction of the electrons, only the momentum is modified: the momentun variation is performed by using a random procedure weighted with the corresponding cross section.

3. HANDLING THE DAΦNE PARAMETERS

3.1 *Histograms and input-output*

The TURTLE input file for the present simulation contains about 400 elements (entire ring simulation) for each of the two interaction regions. The magnetic elements considered in the simulation are dipoles, both rectangular and sector type, quadrupoles and sextupoles. The edges of the non-sector bending magnets and the wigglers, which are composed by many dipoles, had to be modelled in order to have the same transfer matrix used in the DAΦNE design.

Geometrical limitations (slits) were used in order to simulate the apertures in the case of scrapers and the vacuum pipe profile. Beam phase space and gas parameters were taken into account.

In addition, in this input one has to introduce the output requests, consisting in histograms for lost particle distributions (angle, position, momentum, origin).

In order to fasten and simplify the task, a program which creates the command input file for TURTLE was written *ad hoc* . This program is able to recreate quickly the modified lattice, to introduce the new model for magnets, and to formulate the output request according to a control card, in which only the physical parameters of interest are specified. All the subsequent calculations are done automatically, giving the possibility to make a faster simulation and reducing the risk of mistakes.

Other two programs were written, for converting the output in graphic files (HBOOK) and for taking into account the pressure variation along the vacuum pipe.

The capacity of tracking and histogramming of TURTLE was enlarged in order to increase the statistics and to control a larger number of segments in the same run.

The output consists of distributions of particles which are lost near the interaction point and become sources of background, and tables with the loss rates at different positions in the IR.

3.2 *Gas pressure*

The gas pressure is the most important factor, depending the beam-gas interaction on the number of nuclei of the residual gas and therefore on the local gas pressure.

At the accelerator start-up, the vacuum chamber pressure is high due to the residual molecules extracted by the synchrotron radiation. Then, the pressure decreases following the decreasing of the desorption coefficient with the integrated dose, given by the product of the circulating current by the time of operation.

The input of the simulation contains a set of commands which extract the origin (interacting points distribution) of the lost particles for each requested output in the IR. The rates of particles lost in the IR, calculated at a constant pressure, are equivalent to the result of a numerical integration of the distribution of their origins. The numerical integration of the distribution of the origins, weighted with the pressure at their interacting point, gives the pressure normalization factors which are used to calculate the real loss rates, according to a given pressure map.

This gives the possibility to formulate vacuum requirements for those sectors which eventually have a high density of background sources.

3.3 *Tests of the simulation*

To check the beam optics the transfer matrix for the entire ring calculated by TURTLE was printed out. The comparison between the DAΦNE design matrix and the TURTLE one is given in Appendix A, Table A1, for the entire ring and for the wiggler magnet. It shows indeed a good agreement, also if the model for the magnet edges is slightly different in the two cases.

As a further check of the beam optics, a comparison between the design central beam trajectory in the DEAR IR and the TURTLE one was performed (see Fig. A1 of Appendix A). The crossing angle of the beam at the I.P. corresponds to the design value of 12.5 mrad.

Finally, as a global test of the simulation, the total number of particles lost for Coulomb scattering all along the ring was calculated. The frequency of lost electrons for a gas pressure of 10^{-9} torr (N_2 gas), consistent with beam lifetime calculations, is of the order of 1 MHz/bunch/beam.

In the present simulation, a frequency of lost electrons equal to 0.88 MHz/bunch/beam was obtained, in fair agreement with the other independent simulation.

4. RESULTS

In Fig. 1, the layout of the DAΦNE machine with the position of the four splitters and of two horizontal scrapers and a vertical one for each ring, are shown. The scrapers are thick targets with an adjustable aperture, in order to cut the particles trajectories which are far from the central one. For both the IRs, the simulation was performed for one complete turn in the machine, starting at the end of the splitter magnet "downstream" an IR, i.e. following the sense of one circulating beam, and ending 0.45 m after the I.P., at the end of the DEAR beam pipe.

In Fig. 2, a layout of one quarter of the ring is shown, with a detail of the IR with the DEAR beam pipe. A qualitative example of the distributions of the particles inside the pipe, in the region near the I.P., after Coulomb scattering and gas Bremsstrahlung is also shown. The distribution of Bremsstrahlung particles is in the horizontal plane, because the momentum variation produces a spread of amplitudes in the horizontal plane when the particles pass through the bending magnets. The Coulomb scattered particles are distributed around the beam, because their momenta do not change and the scattering angle is uniformly distributed in ϕ.

The simulation was performed in the conditions reported in Table 1.

Table 1 - Parameters used in the simulation

number of bunches per beam	30
number of electrons per bunch	$9 \cdot 10^{10}$
constant gas pressure	10^{-9} torr (biatomic gas, Z = 7)
electrons momentum	510 MeV/c
sextupoles	on
scrapers aperture	$9\ \sigma_{x,y}$ ($\sigma_{x,y}$ are the beam sizes)
half crossing angle at I.P.	±12.5 mrad
number of tracks simulated:	$24 \cdot 10^6$ for Coulomb scattering
	$3 \cdot 10^6$ for Bremsstrahlung

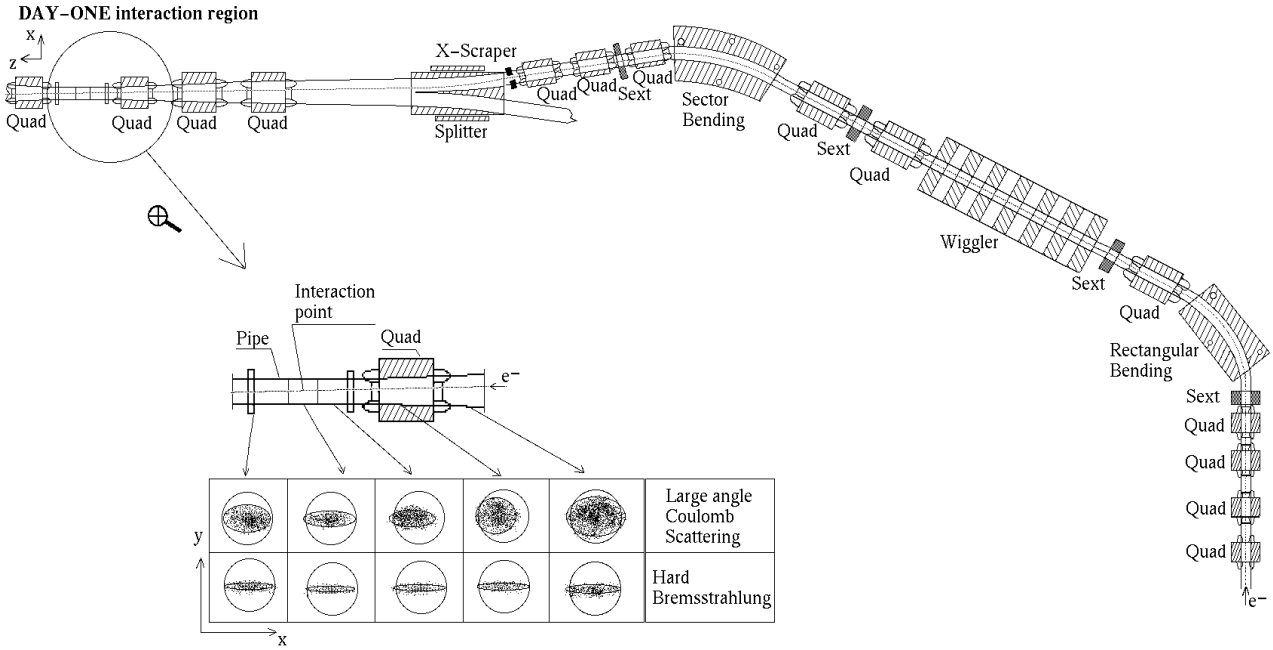

Fig. 2 - Layout of one quarter of the ring and qualitative distributions of the particles in the DEAR IR after beam-gas interaction.

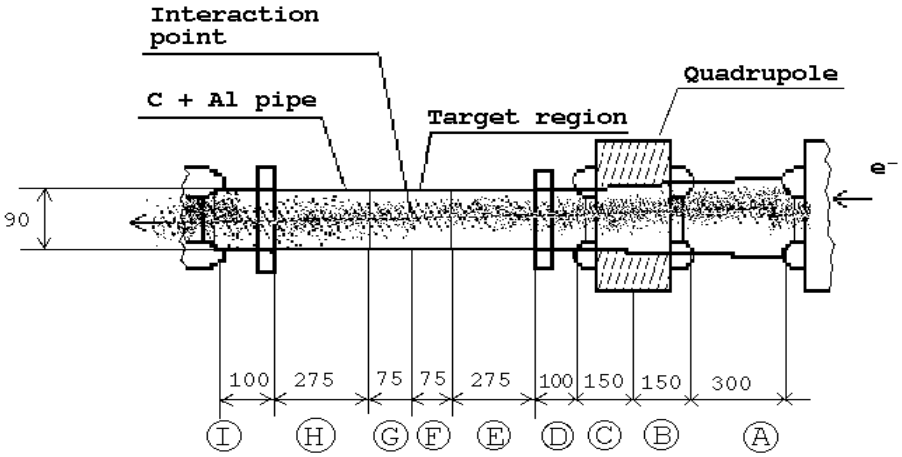

Figure 3 - Sections in the DAY-ONE DEAR IR considered in counting the lost particles. (all sizes are in millimeters)

The region of the IR near the I.P. was divided into 9 segments (see Fig. 3) in order to get the longitudinal distribution of the lost particles, which is required as an input for the DEAR Montecarlo.

The Coulomb scattering was simulated for the angular interval given below, and the Bremsstrahlung process simulation was performed for two ranges of momentum variation (the intervals were chosen taking into account the cross section variation).

Coulomb Scattering (C.S.)	[1 mrad - 500 mrad]
Hard Bremsstrahlung (H.Br.)	[$\Delta p/p$ 20 % - 90%]
Soft Bremsstrahlung (S.Br.)	[$\Delta p/p$ 0.2 % - 20%]

For C.S. angles below 1mrad and for S.Br. momentum variation below .2% there are no particles lost in the interaction regions, because they are inside the machine acceptance.

In Table 2a and 2b the loss rates in the different segments are listed for the KLOE and FINUDA IRs, respectively, for the machine configuration given in Table 1.

Table 2a - KLOE IR - Rates of lost particles (electrons, photons) per beam in sectors of the DEAR IR (Machine parameters of Table 1)

Losses	A (KHz)	B (KHz)	C (KHz)	D (KHz)	E (KHz)	F (KHz)	G (KHz)	H (KHz)	I (KHz)
C.S. el.	40.2	9.9	6.0	4.0	12.1	4.7	5.4	26.1	11.8
H.Br. el.	28.0	8.4	4.9	2.0	7.2	1.8	2.0	9.3	3.8
H.Br. ph.	1.5	0.4	0.5	0.25	0.6	0.13	0.2	0.6	0.2
S.Br. el.	64.6	9.9	0	0	0	0	0	0	0
S.Br. ph.	5.9	2.4	1.4	0.9	2.4	0.5	0.7	2.2	36.5

Table 2b - FINUDA IR - Rates of lost particles (electrons, photons) per beam in sectors of the DEAR IR (Machine parameters of Table 1)

Losses	A (KHz)	B (KHz)	C (KHz)	D (KHz)	E (KHz)	F (KHz)	G (KHz)	H (KHz)	I (KHz)
C.S. el.	53.7	11.3	8.8	4.7	15.3	6.4	9.1	45.6	21.9
H.Br. el.	28.3	8.4	4.6	2.3	6.9	2.2	2.2	9.1	3.7
H.Br. ph.	1.5	0.4	0.4	0.25	0.7	0.15	0.15	0.6	0.2
S.Br. el.	107.	17.5	0	0	0	0	0	0.02	0.17
S.Br. ph.	6.1	2.1	1.5	0.85	2.1	0.4	0.5	2.2	33.7

The effect of different machine configurations on the total rates of lost particles in the DEAR IRs (sectors from A to I) is reported in Table 3 for Coulomb scattering and hard Bremsstrahlung.

Table 3 - Total rates of lost particles per beam in the DEAR IRs for different machine configurations ($p=10^{-9}$ torr - 30 bunches - $9 \cdot 10^{10}$ part/bunch)

Losses	Scrapers	Sextupoles	Cros. mrad	KLOE KHz	FINUDA KHz
C.S. - el.	9 Sigma	Yes	12.5	120.2	176.8
C.S. - el.	No	Yes	12.5	148.6	215.1
C.S. - el.	9 Sigma	No	12.5	120.4	166.7
C.S. - el.	9 Sigma	Yes	10	114.2	164.7
H.Br. - el.	9 Sigma	Yes	12.5	67.4	67.7
H.Br. - el.	No	Yes	12.5	67.4	67.7
H.Br. - el.	9 Sigma	Yes	10	57.3	57.3

As shown in the table, the effect of scrapers, sextupoles and crossing angle on the total rate of lost particles at most to a factor ~ 1.2 both for the KLOE and the FINUDA IRs. Also the difference between the KLOE and FINUDA IRs is at most a factor ~ 1.5, and therefore the two IRs can be considered equivalent.

The angular distributions of the electrons lost near the I.P. (the F segment in Fig. 3), as a function of ξ (impact angle between the pipe and the direction of the particle momentum) and of ψ (polar angle, between the radius of the pipe passing through the hitting and the horizontal axis), are given in Fig. 4 for Coulomb scattering.

In Fig. 5 the electrons angular distributions, together with the momentum distribution, are given for hard Bremsstrahlung.

Due to the crossing angle, the beam trajectory passes off axis in the IR quadrupoles, and therefore, in both processes, the particles are lost mainly on one "side" of the the pipe (see ψ distributions). This side changes from one IR to the other: on the interior of the ring, $\psi \sim 0$ deg, for the FINUDA IR and outside, $\psi \sim 180$ deg, for the KLOE IR, because the beams are entering in the two IRs from the inner and outer arc, respectively.

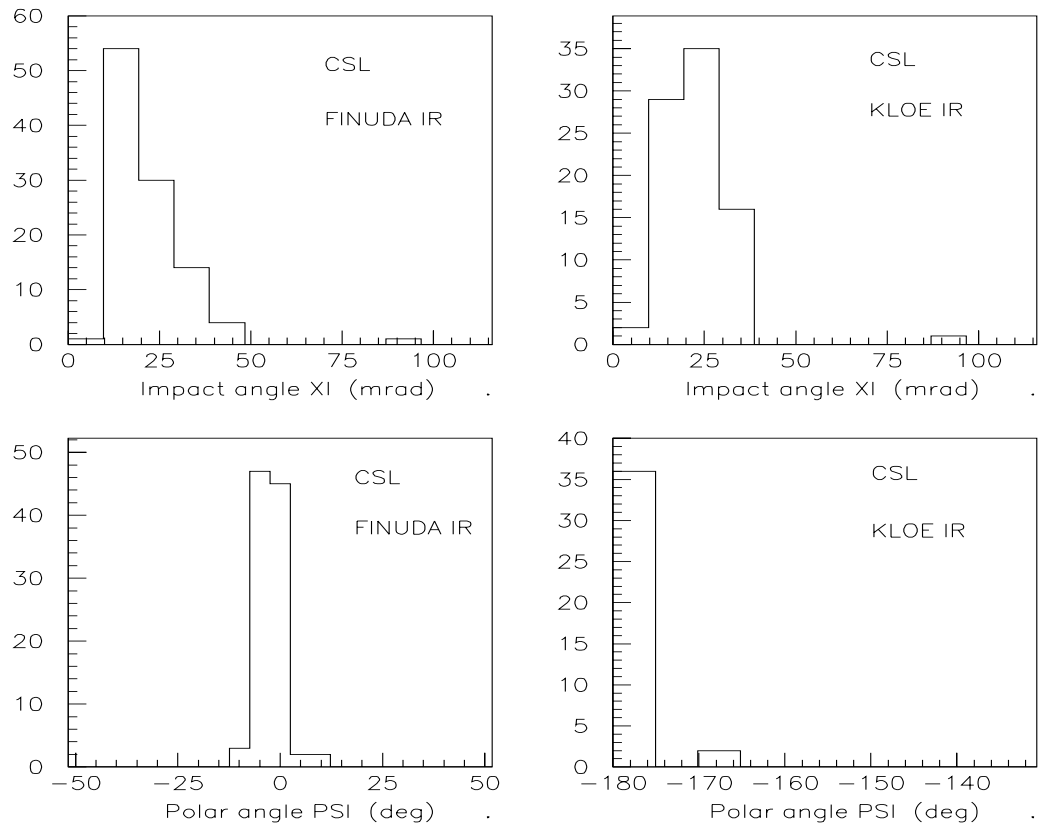

Figure 4 - Coulomb scattering. Angular distributions of the electrons lost in the pipe near the DEAR target (sector F on Fig. 3) as a function of the azimutal angle (ξ) and polar angle (ψ).

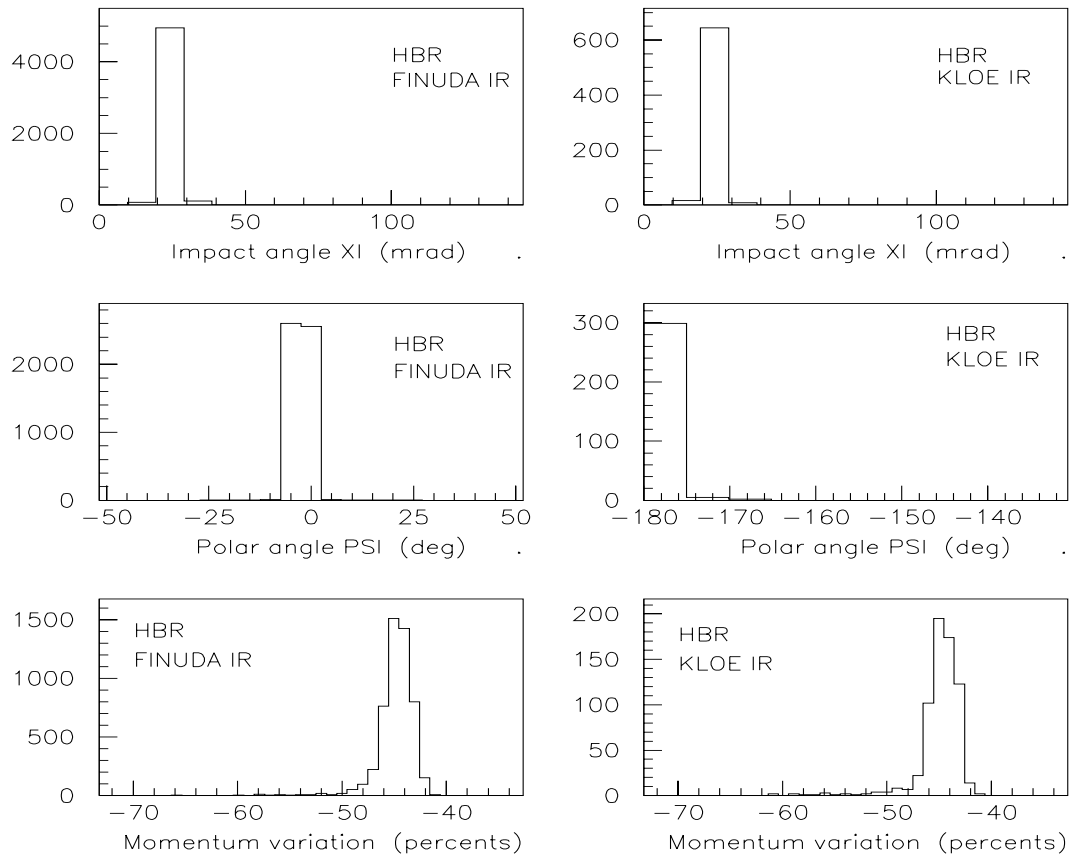

Figure 5 - Bremsstrahlung. Angular distributions of the electrons lost in the pipe near the DEAR target (sector F on Fig. 4) as a function of the azimutal (ξ) and polar angle (ψ), together with momentum variation distribution.

The distribution of the origins (beam-gas interaction points) of the particles lost near the I.P. (section F) is shown in Fig.6 (KLOE IR) for Coulomb scattering and hard Bremsstrahlung. The simulation is done for the entire ring but, with the scrapers at $9\sigma_{x,y}$, all the particles lost near the I.P. are originated in the half ring upstream.

From Fig. 6 one can see that the origin of the Coulomb scattered electrons is distributed in a region 20 m upstream the I.P., which corresponds to about one quarter of the ring.

The origins of the electrons which had hard Bremsstrahlung, lost near the I.P., are concentrated between the splitter and the interaction point (86.1 ÷ 91.2 m in the figure), because these electrons, having a large momentum variation, are quickly lost after passing through a bending magnet.

This shows the importance of the pressure map for H.Br., in fact all the origins are concentrated in the IR itself, where the pressure is lower than in the arcs.

In Fig. 7, the distribution of the longitudinal coordinate of the position where the particles get lost is plotted versus their origins: the different behaviour of Coulomb scattering and Bremsstrahlung is evident. One can see that the hitting points for Bremsstrahlung interacting particles are concentrated near their origins, since these particles are lost in the nearest bending magnet. On the contrary, the hitting points for Coulomb scattered particles are spread all along the ring, many of them being located in the scrapers.

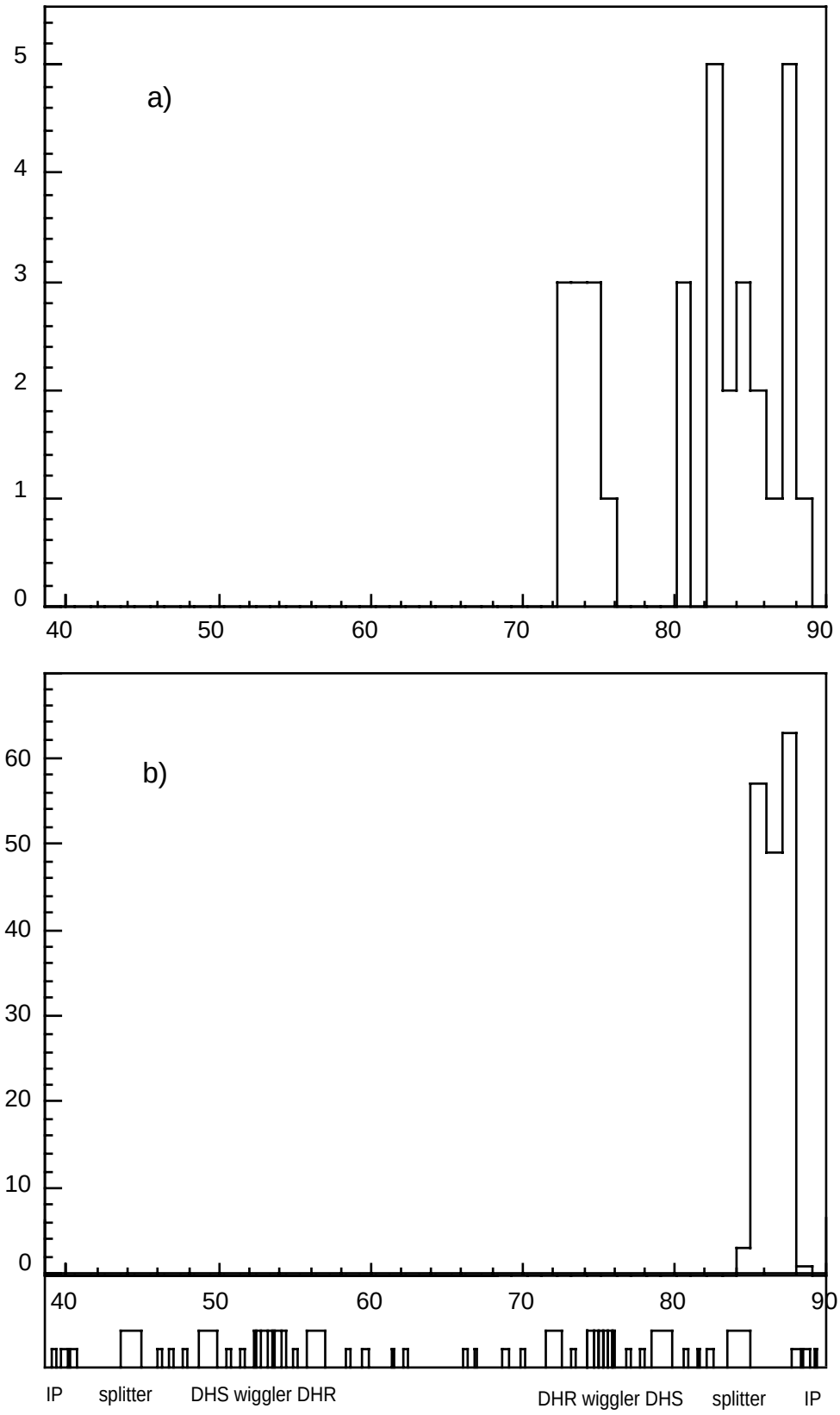

Figure 6 - Distribution of the origins of the electrons lost near the DEAR target (sector F on Fig. 3): for Coulomb scattering a) and hard Bremsstrahlung b). The horizontal axis is the longitudinal coordinate along the ring (in meters) from the FINUDA I.P. to the KLOE I.P.

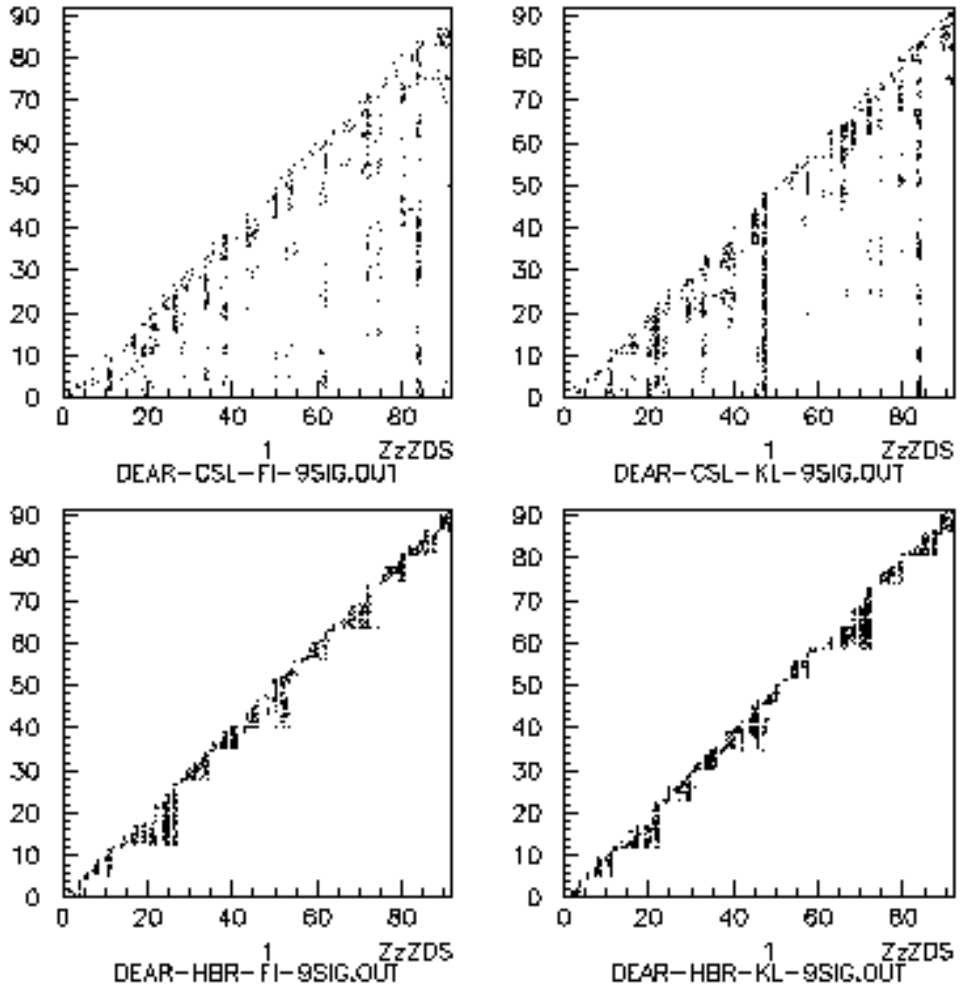

Figure 7 - Distribution of longitudinal coordinate of the position where the particles get lost versus longitudinal coordinate of their origin: for Coulomb scattering and hard Bremsstrahlung.The high density vertical lines in Coulomb scattering distributions correspond to the position of the scrapers.

Tables 2a,b were calculated for a constant gas pressure of 10^{-9} torr. In Fig. 8 the expected behaviour of the gas pressure in the DEAR IR [9] is shown for a total circulating current I_{tot} = 1.3 A and for two different values of beam conditioning: after 100 Ah, and after 1000 Ah. In the I.P., after 1000 Ah of conditioning, the expected value is 10^{-10} torr. In the arcs, where the synchrotron radiation is higher, the gas pressure is larger: after 1000 Ah of conditioning the expected value is 10^{-9} torr.

To take into account the variation of the pressure along the DAΦNE rings, the rates of Tables 2 have to be multiplied by the corresponding pressure normalization factors, listed in Table B1 of Appendix B, calculated by integrating the distribution of the lost particles, weighted with the local pressure at the beam-gas interaction point. Table B1 has been calculated for 1000 Ah, assuming a complete pressure map, for a total circulating current I_{tot} = 1.3 A. Finally, the normalized rates of lost particles are given in Table 4.

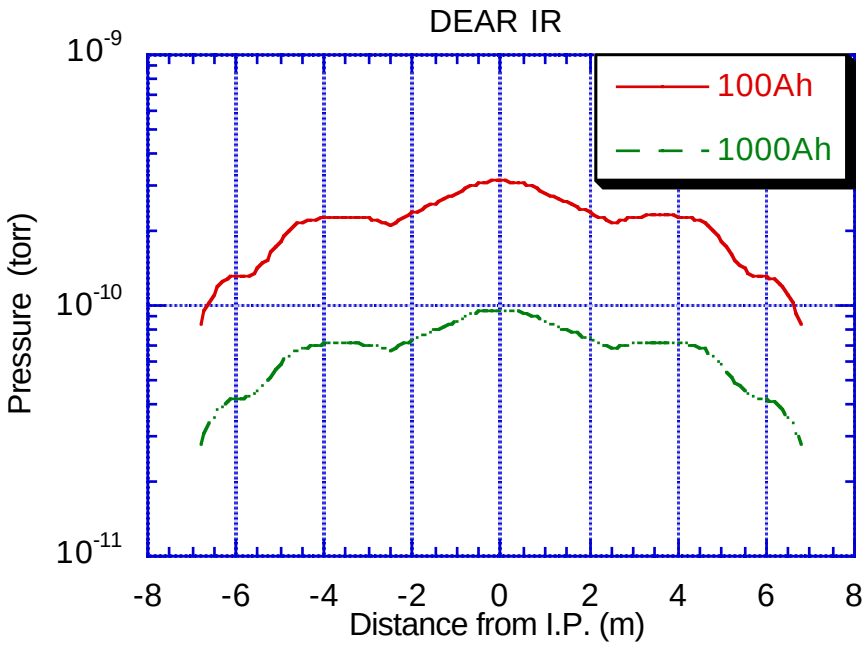

Figure 8 - Pressure map in the DEAR IR after 100 Ah and 1000 Ah for I_{tot} = 1.3 A.

Table 4. Normalized rates of lost particles after 1000 Ah of conditioning.
(30 bunches - $9 \cdot 10^{10}$ part/bunch)

Inter.Reg.	Losses	A (KHz)	B (KHz)	C (KHz)	D (KHz)	E (KHz)	F (KHz)	G (KHz)	H (KHz)	I (KHz)
KLOE	C.S.el	23.3	5.45	3.2	2.04	6.41	2.6	2.92	14.6	7.2
	H.Br.el	6.72	2.02	1.18	0.5	1.73	0.43	0.5	2.23	0.91
	H.Br.ph	0.225	0.06	0.09	0.04	0.1	0.03	0.04	0.12	0.05
FINUDA	C.S.el	41.3	8.7	6.1	3.57	10.9	3.78	5.9	31.5	16.2
	H.Br.el	6.79	2.02	1.1	0.55	1.66	0.53	0.53	2.2	0.89
	H.Br.ph	.225	0.06	0.07	0.04	0.1	0.03	0.03	0.12	0.05

Since the gas pressure in the straigth sections, and specially in the IRs, is lower than 10^{-9} torr (see Fig. 8), all the rates in Table 4 turn out reduced with respect to those given in Table 2. In particular, electrons lost for H.Br., originating in the IRs, are strongly reduced and the contribution of the H.Br. photons becomes negligible. Therefore the main effect for particle losses due to beam-gas interaction eventually turns out to be the Coulomb scattering.

5. CONCLUSIONS

The rates and the distributions of the particles lost due to Coulomb scattering and gas Bremsstrahlung, in the KLOE and in the FINUDA IRs have been calculated for the DEAR configuration. The origins of Coulomb scattered particles is located in one quarter of the ring upstream the I.P., whilst those of Bremsstrahlung particles are located in the IR itself. The two IRs are nearly equivalent from the point of view of particle losses due to beam-gas interaction.

The dependence of the rates of lost particles on gas pressure, scrapers, sextupoles and crossing angle of the colliding beams was studied.

The obtained results constitute the input for the Monte Carlo of the DEAR experiment, in order to evaluate the background level on the CCD detector.

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Appendix A

Table A1. Transfer matrix comparison.

DAPHNE design transfer matrix for 1 ring transport

0.8444*10+00	0.2411*10+01	0.1851*10-04	0.0000*10+00	0.0000*10+00
-0.1191*10+00	0.8444*10+00	-0.8973*10-05	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.1000*10+01	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.0000*10+00	0.9053*10+00	0.1912*10-01
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.9441*10+01	0.9053*10+00

TURTLE transfer matrix for 1 ring transport

0.8437*10+00	0.2412*10+01	-0.5080*10-04	0.0000*10+00	0.0000*10+00
-0.1192*10+00	0.8449*10+00	0.3709*10-04	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.1000*10+01	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.0000*10+00	0.9052*10+00	0.1913*10-01
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.9436*10+01	0.9053*10+00

DAPHNE design transfer matrix for a wiggler

0.1345*10+01	0.2241*10+01	0.4022*10-02	0.0000*10+00	0.0000*10+00
0.3613*10+00	0.1345*10+01	0.4209*10-02	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.1000*10+01	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.2400*10+00	0.1029*10+01
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.9158*10+00	-0.2400*10+00

TURTLE transfer matrix for a wiggler

0.1345*10+01	0.2240*10+01	0.3997*10-02	0.0000*10+00	0.0000*10+00
0.3605*10+00	0.1345*10+01	0.4182*10-02	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.1000*10+01	0.0000*10+00	0.0000*10+00
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.2387*10+00	0.1030*10+01
0.0000*10+00	0.0000*10+00	0.0000*10+00	-0.9152*10+00	-0.2387*10+00

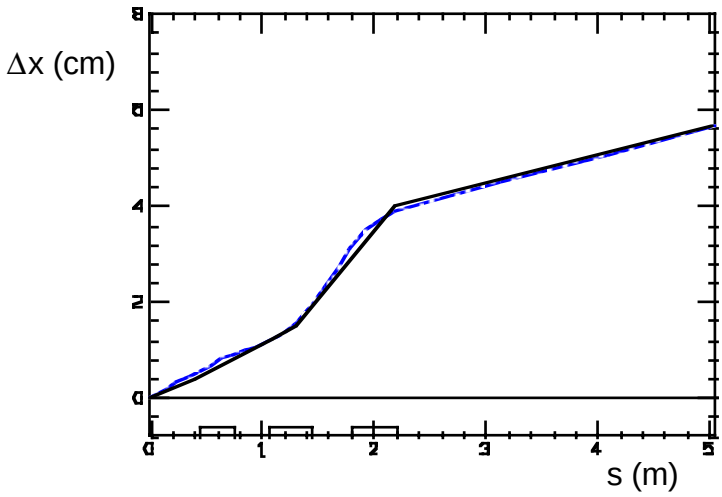

Figure A1 - Comparison between the design central trajectory in the DEAR IR (dashed line), and that calculated by TURTLE (solid line).

Appendix B

Table B1. Pressure normalization factors after 1000 Ah of conditioning
(Scrapers at $9\sigma_x$, sextupoles on, crossing angle 12.5 mrad,
$p = 10^{-9}$ torr, 30 bunches , $9 \cdot 10^{10}$ part/bunch)

Inter.Reg. (part. lost)	Losses	A (KHz)	B (KHz)	C (KHz)	D (KHz)	E (KHz)	F (KHz)	G (KHz)	H (KHz)	I (KHz)
KLOE el.	C.S.L.	0.58	0.55	0.53	0.51	0.53	0.55	0.54	0.56	0.61
KLOE el.	H.Br.	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
KLOE ph.	H.Br.	0.15	0.16	0.17	0.17	0.18	0.2	0.19	0.2	0.26
FINUDA el.	C.S.L.	0.77	0.77	0.75	0.76	0.71	0.59	0.65	0.69	0.74
FINUDA el	H.Br.	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.25
FINUDA ph	H.Br.	0.15	0.16	0.17	0.17	0.18	0.2	0.19	0.2	0.26