# BACKGROUND CALCULATION FOR THE DAΦNE EXPERIMENTS

S. Guiducci, INFN-LNF, Frascati, Italy

*Abstract*

DAΦNE is an $e^+e^-$ Φ-factory under construction at the Frascati National Laboratories. The project status is well advanced and commissioning of the main rings is foreseen for beginning of 1997 [1]. The beams will circulate in a double ring collider and cross, with a small horizontal angle, in two Interaction Points (IPs). A careful study of the loss rates due to Touschek scattering, which are the main source of background for the detectors, has been performed for both Interaction Regions (IRs) and a solution to strongly reduce them has been adopted.

## 1 INTRODUCTION

The IR1 interaction region is dedicated to the KLOE detector, mainly to study CP violation in neutral K decays [2]. The other one, IR2, will house the FINUDA detector for hypernuclei decays study [3]. A third experiment, DEAR, for exotic nuclear physics [4], will run at an early stage of machine operation.

In order to get the high luminosity required for the CP violation experiment ($L = 5\cdot10^{32}$ $cm^{-2}$ $s^{-1}$) DAΦNE will operate with high current and many bunches: from 30 for initial operation up to a maximum of 120. Due to the low energy of the machine (.51 GeV) and the high current there will be a high rate of particle losses, mainly from Touschek scattering, which dominates the beam lifetime.

The different contributions to the DAΦNE single beam lifetime and the related design parameters are listed in Table I.

Table I - Single beam lifetime and related parameters

| | |
|---|---|
| Particles/bunch | 8.9 $10^{10}$ |
| Emittance | $10^{-6}$ m rad |
| Coupling factor | .01 |
| Bunch length | .03 m |
| Relative energy spread | 5.5 $10^{-4}$ |
| RF Voltage | 254 kV |
| Gas pressure (biatomic gas Z=8) | $10^{-9}$ Torr |
| Quantum lifetime | 4.5 $10^{31}$ hours |
| Gas bremsstrahlung | 2.0 $10^3$ min |
| Coulomb gas scattering | 1.9 $10^3$ min |
| Touschek scatterimg | 160 min |
| Single beam total lifetime | 135 min |

For the three experiments the loss rates due to Touschek scattering have been computed. The results and a solution adopted to reduce the background rates are presented in the following.

An evaluation of the rates of particle losses due to Coulomb gas scattering and bremsstrahlung has been done for KLOE [5], [6] and is in progress for DEAR and FINUDA. The expected background level is low because special care has been taken in the design of the interacion regions vacuum system in order to get a low local gas pressure and to reduce the beam gas interactions.

## 2 TOUSCHEK SCATTERING BACKGROUND

Touschek scattering is an elastic Coulomb scattering between pairs of particles within a bunch. The result is a change of the longitudinal momentum of the two particles: one loses and the other gains the same fraction δ of momentum. If the momentum deviation exceeds the acceptance of the ring the particle is lost.

In the DAΦNE rings we distinguish two regions: straight sections with vanishing dispersion and arcs with high dispersion.

The particles scattered in the straigth sections undergo a momentum deviation but no betatron oscillation, and therefore cannot be lost in the IRs, where the dispersion is zero.

The particles scattered in the arcs gain an horizontal oscillation amplitude and can be lost on the vacuum chamber inside the IRs producing background for the experiments.

These particles follow similar trajectories, i.e. with the same phase of the betatron oscillation and an amplitude proportional to the momentum deviation δ. An example is given in Fig. 1

The number of particles hitting the vacuum chamber has been evaluated by tracking the Touschek scattered particles from the arc upstream to the end of each IR.

## 3 RESULTS

### 3.1 KLOE and FINUDA

After a detailed study of the particle losses in the KLOE and FINUDA IRs [7], [8], the following solution has been adopted to reduce the background rates:

- increase the vacuum chamber aperture inside the detectors
- insert two beam scrapers upstream the splitter magnet of each IR.

The scrapers are thick targets (3.5 cm tungsten ~ 10 radiation lengths) which can be inserted independently on both sides of the vacuum chamber reducing the horizontal aperture to cut the large amplitude particles upstream the IR.

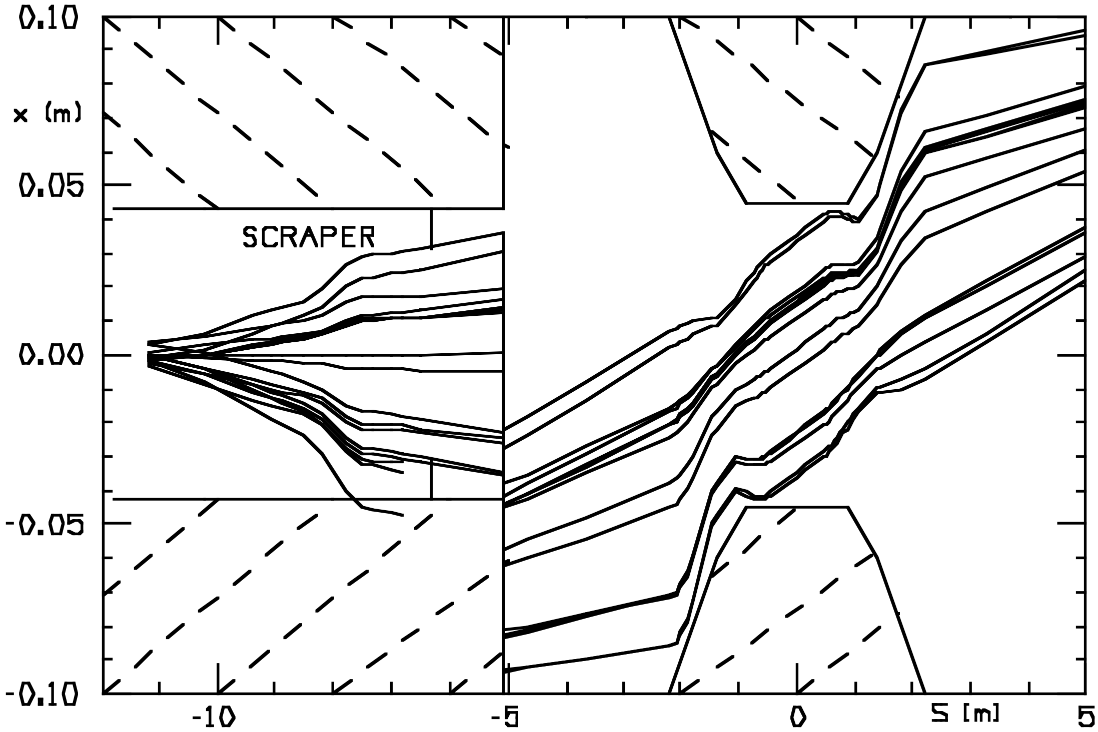


Figure **:** Horizontal trajectories of Touschek scattered particles from the last bending of the arc to the end of the DEAR IR2. The vacuum chamber apertures are shown in the picture. At the ends of the IR there is a change of the reference system, which is centered on the quadrupole axis.

TABLE II - Particles lost due to Touschek scattering in the KLOE and FI.NU.DA. detectors
N=8.9 $10^{10}$ part./s/bunch/beam – θ = 12.5mrad

| $A_{sc}/\sigma_x$ | $N_{KLOE}$ ($s^{-1}$/bunch/beam) | $N_{FI.NU.DA.}$ ($s^{-1}$/bunch/beam) | $\tau_{tot}$ (min) |
|---|---|---|---|
| no scrapers | 1.47 $10^5$ | 1.76 $10^5$ | 135. |
| 10 | 695. | 1.55 $10^4$ | 117. |
| 9 | 0. | 4.10 $10^3$ | 101. |
| 8 | 0. | 756. | 84. |

The results are shown in Table II for the nominal value of the half crossing angle θ and the maximum number of particles per bunch foreseen in DAΦNE.

The number of particles per bunch lost on the vacuum chamber inside the KLOE and FINUDA detectors is listed in the table for different values of $A_{sc}$, the scrapers' aperture in units of the horizontal beam size. The beam lifetime corresponding to different scrapers' apertures is shown in the last column. The calculations have been performed for the updated version of the DAΦNE lattices.

Due to the horizontal crossing angle, the layout of the machine is not symmetric with respect to the Interaction Point (IP). In the KLOE IR the beams come from the external (LONG) ring, while in the FINUDA IR come from the internal (SHORT) one.

The number of particles lost in the FINUDA IR is higher, anyway the rate calculated with a scrapers' aperture of $10\sigma_x$ is already acceptable for the detector.

## *3.2 DEAR*

DEAR has more stringent requirements than the other experiments on the background rates because it uses a CCD camera and has no trigger. This experiment does not have a dedicated IR design but will be installed in one of the two IRs in the configuration designed for machine commissioning.

DAΦNE has a special IR design for commissioning with electromagnetic quadrupoles and no solenoids, while the KLOE and FINUDA IRs have permanent magnet quadrupoles and solenoids.

Table III - Particles lost due to Touschek scattering in the DEAR (IR1) detector
N=8.9 $10^{10}$ part./s/bunch/beam – $\theta$ = 12.5mrad

| $A_{sc}/\sigma_x$ | $A_{sc}$ (mm) | $N_{DEAR}$ (IR1) ($s^{-1}$/bunch/beam) | | | $\tau_{tot}$ (min) |
|---|---|---|---|---|---|
| | | $\delta$<0. | $\delta$>0. | total | |
| no scrapers | 43 | 7.73 $10^5$ | 6.03 $10^4$ | 8.33 $10^5$ | 139 |
| 11 | 31 | 0. | 323. | 323. | 138 |
| 10 | 28 | 0. | 0. | 0. | 124 |

Table IV - Particles lost due to Touschek scattering in the DEAR (IR2) detector
N=8.9 $10^{10}$ part./s/bunch/beam – $\theta$ = 12.5mrad

| $A_{sc}/\sigma_x$ | $A_{sc}$ (mm) | $N_{DEAR}$ (IR2) ($s^{-1}$/bunch/beam) | | | $\tau_{tot}$ (min) |
|---|---|---|---|---|---|
| | | $\delta$<0. | $\delta$>0. | total | |
| no scrapers | 43 | 8.77 $10^4$ | 1.10 $10^5$ | 1.97 $10^5$ | 97 |
| 10 | 31 | 7.45 $10^3$ | 2.71 $10^4$ | 3.46 $10^4$ | 96 |
| 9 | 28 | 725. | 7.38 $10^3$ | 8.11 $10^3$ | 90 |
| 8 | 25 | 35. | 1.01 $10^3$ | 1.05 $10^3$ | 77 |
| 7 | 22 | 0. | 55. | 55. | 63 |

The two IRs are different and therefore the calculation has been performed for both, using different lattices to reduce the background.

The same quantities as in Table II are shown in Tables III and IV together with the rates for the positive and negative energy deviation. These are listed separately in the tables because the particles with negative energy deviation $\delta$ are lost in the quadrupole before the IP, and are the main source of background, while those with positive $\delta$ are lost in the quadrupole after the IP and have a very small probability of reaching the detector.

The DEAR experiment is compatible with both the IRs but will be most probably installed into IR1, which has a lower background rate.

The DEAR group is preparing a version of the experiment dedicated to background measurements to take data in a very preliminary stage of machine operation. This will be useful to have a precise estimate of background rates for all the experiments and to adjust the machine parameters in order to reduce the background.

## 4 CONCLUSIONS

To reduce the background rates due to Touschek scattered particles in the DAΦNE interaction regions the following solutions have been adopted: to increase the vacuum chamber aperture in the interaction regions and to install three beam scrapers in proper locations for each ring.

Two horizontal scrapers will be installed upstream the splitter magnet in both the IRs and a vertical one downstream the splitter in the FINUDA IR.

The horizontal scrapers help also in reducing the background coming from gas bremsstrahlung in the arcs; the vertical one reduces the number of lost particles generated by Coulomb gas scattering.

At a very early stage of machine operation it will be possible to measure the rate of particle losses in the DEAR IR. This will be very useful to improve the machine performance for all the experiments by adjusting the machine parameters to get a high average luminosity with low background rates.

## REFERENCES


[1] ‘DAΦNE: the first Φ-Factory', G. Vignola and DAΦNE Team, these proceedings.

[2] ‘KLOE’, KLOE Collaboration, LNF-92/019(IR), Apr. 1992.

[3] ‘FINUDA’, FINUDA Collaboration, LNF-93/021 (IR), May. 1993 .

[4] ‘The DEAR Proposal’, DEAR Collaboration, LNF-95/055(IR), Oct. 1995.

[5] ‘Preliminary background calculations for DAΦNE’, M. K. Sullivan, DAΦNE technical note IR-2, 1993.

[6] ‘Beam-gas background calculations for DAΦNE’, E. Gero, KLOE note 102, 1994.

[7] ‘Background in the KLOE IR due to Touschek scattering’, S. Guiducci, DAΦNE technical note IR-5, 1994.

[8] ‘Background evaluation in DAΦNE’, S. Guiducci, DAΦNE technical note IR-6, 1995.