DAΦNE TECHNICAL NOTE

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Note: **IR-6**

BACKGROUND EVALUATION IN DAΦNE

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1. Introduction

In Ref. [1] the calculations of the background in the KLOE Interaction Region (IR) coming from particles lost by Touschek scattering in the DAΦNE rings have been presented. The same analysis has been performed for the Fi.Nu.Da. IR and the results for KLOE have been updated with the new version of the lattice and the detailed design of the vacuum chamber.

The rate of particle losses, due to different processes, in the DAΦNE main rings is listed below for the maximum value of the number of particles per bunch:

$$N = 8.9\ 10^{10}\ \text{part/bunch/beam.}$$

	$\dot{N}$ (s^{-1}/bunch/beam)
Touschek scattering	4.4 10^6
Coulomb scattering	1.0 10^6
gas bremsstrahlung	6.3 10^5
beam-beam bremsstrahlung (2 cross.)	1.7 10^6
total loss rate	7.8 10^6

The losses due to different processes have a different distribution along the ring. In the following we evaluate the rate of particles lost in the two interaction regions due to Touschek scattering, which is the main contribution. For the KLOE experiment the losses in the IR due to gas scattering and gas bremsstrahlung have been calculated and are reported in Ref. [2].

The particles which undergo a Touschek scattering in the straight sections, where the dispersion function is zero, get lost in the arcs, and therefore they are not a source of background for the detectors. Those scattered in the arcs gain a large horizontal betatron and synchrotron amplitude and get lost when they reach the vacuum chamber aperture. The main source of background for each IR comes from those particles which have got a Touschek scattering in the arc upstream.

In Ref. [1] a solution to strongly reduce the number of particles which hit the vacuum chamber inside the KLOE IR has been presented:

a) increase of the vacuum chamber aperture inside the detector;

b) install two beam scrapers upstream the splitter magnet of the KLOE IR in both rings.

The scrapers are thick targets which can be moved in the horizontal plane, independently on both sides of the beam, in order to reduce the aperture and cut all large amplitude particles upstream the IR.

During DAΦNE operation the aperture of the scrapers has to be optimized as a compromise between background rejection and good beam lifetime. The target thickness is 5 cm tungsten (15 radiation lengths) in order to absorb all the electromagnetic shower of the 500 MeV particles. The splitter magnet helps in clearing the charged particles which lose energy in the scraper.

The insertion of the scrapers helps also in reducing the background coming from particles which make gas bremsstrahlung in the arcs, because they follow the same trajectories as the Touschek scattered ones.

The scrapers are foreseen also for the Fi.Nu.Da. experiment upstream the splitter magnet of the SHORT arc.

Moreover a scraper in the vertical plane to cut particles coming from Coulomb gas scattering will be installed in each ring.

2. Fi.Nu.Da. IR

The trajectories of the Touschek scattered particles in the Fi.Nu.Da. IR are shown in **Figs. 1a,b** for a positive and negative relative energy deviation ε respectively. The radius of the particle trajectory in the transverse plane is shown in the figure and compared with the vacuum chamber aperture, all the tracks being inside the scrapers aperture $A_{sc}=10\sigma_x$. The figures show the situation for one beam, the other one is symmetric respect to the IP.

A Montecarlo program described in Ref. [1] has been used to calculate the rate of particles per bunch which undergo a Touschek scattering in the arc upstream and hit the vacuum chamber inside the Fi.Nu.Da. IR. The results are shown in **Table I** for the design value of the half crossing angle θ=12.5mrad and for the maximum value of the circulating particles per bunch N=8.9 10^{10}.

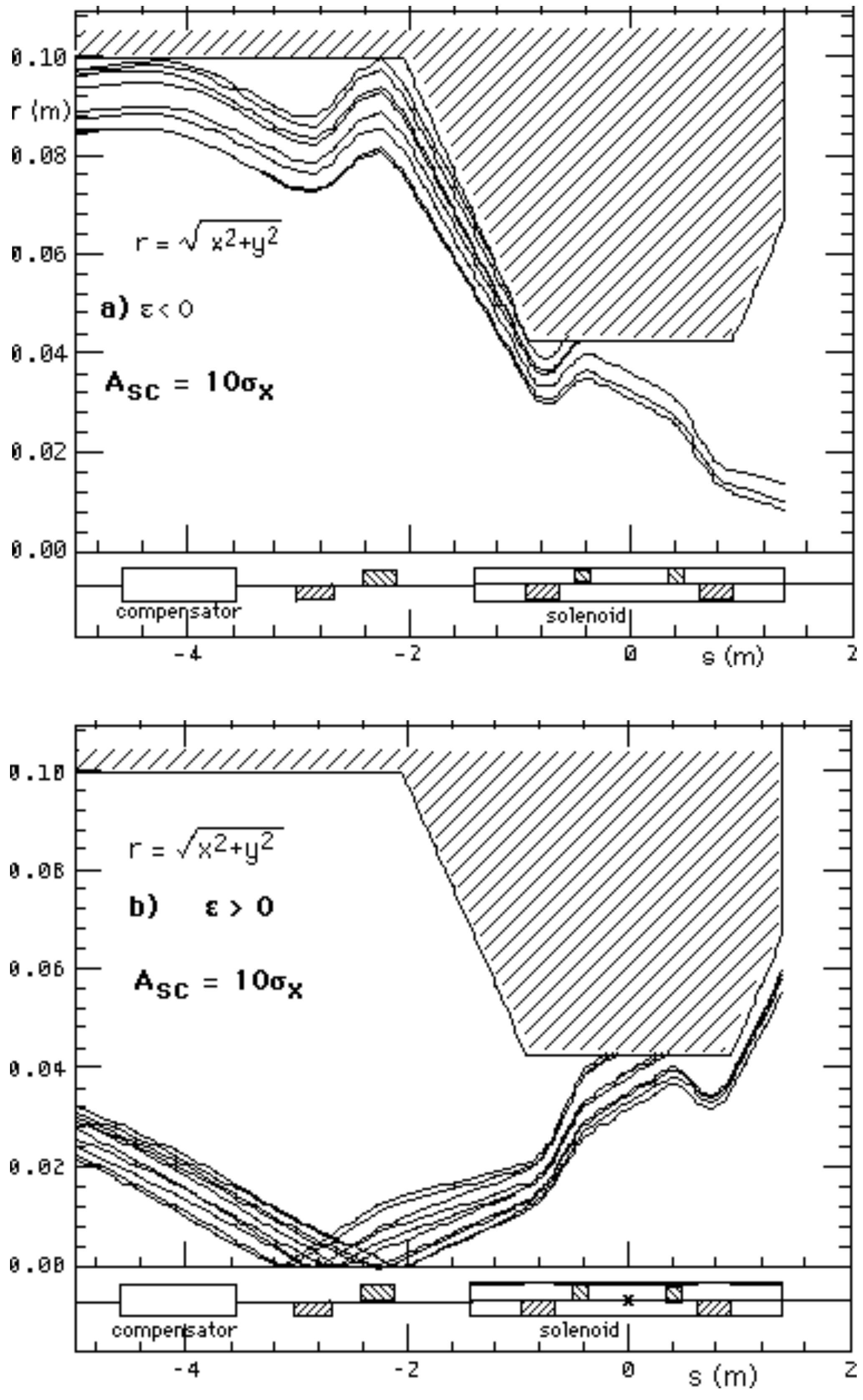

Fig. 1 - Trajectories in the Fi.Nu.Da. IR of particles which make Touschek scattering in the arc upstream: $A_{SC}=10\sigma_x$, **a)** $\varepsilon < 0$, **b)** $\varepsilon > 0$.

The rate of particle losses for a positive or negative relative energy deviation and the total rate are given in the table as a function of the scrapers aperture A_{sc}. The last column shows the value of the total beam lifetime, corresponding to the scrapers aperture, calculated at the maximum bunch current in the colliding beams configuration.

The vacuum chamber aperture is shown in Fig. 1: in the region near to the IP the radius is A_{IP}=43 mm.

For the phase I configuration of DAΦNE (30 bunches, luminosity L=1.5 10^{32} cm^{-2} s^{-1}), without scrapers, the rate of particles lost on the chamber inside Fi.Nu.Da. is of the order of 12 MHz.

Table I - Fi.Nu.Da. IR - A_{IP} = 43 mm

A_{sc}/σ_x	A_{sc} (mm)	$\dot{N}_Q(\varepsilon>0)$ (s^{-1})	$\dot{N}_Q(\varepsilon<0)$ (s^{-1})	$\dot{N}_Q$ (s^{-1})	τ_{tot} (min)
8	23.5	1.2 10^4	3.0 10^3	1.5 10^4	141
9	26.5	3.4 10^4	1.5 10^4	5.0 10^4	161
10	29.4	5.8 10^4	3.6 10^4	9.4 10^4	184
no scrap.	43.0	1.1 10^5	9.1 10^4	2.0 10^5	184

Figures 2a,b show the distribution in the longitudinal coordinate of the particles hitting the vacuum chamber in the region between the splitter magnet and the end of the Fi.Nu.Da. detector: all the losses are concentrated in between the two quadrupoles nearest to the IP.

These losses give a high background rate for the Fi.Nu.Da. experiment. The solution to reduce it, without affecting the beam lifetime, is to increase the aperture of the quadrupoles nearest to the IP. The same quantities as in Table I have been calculated for a larger value of the vacuum chamber internal aperture (A_{IP}=53 mm) and are listed in **Table II**.

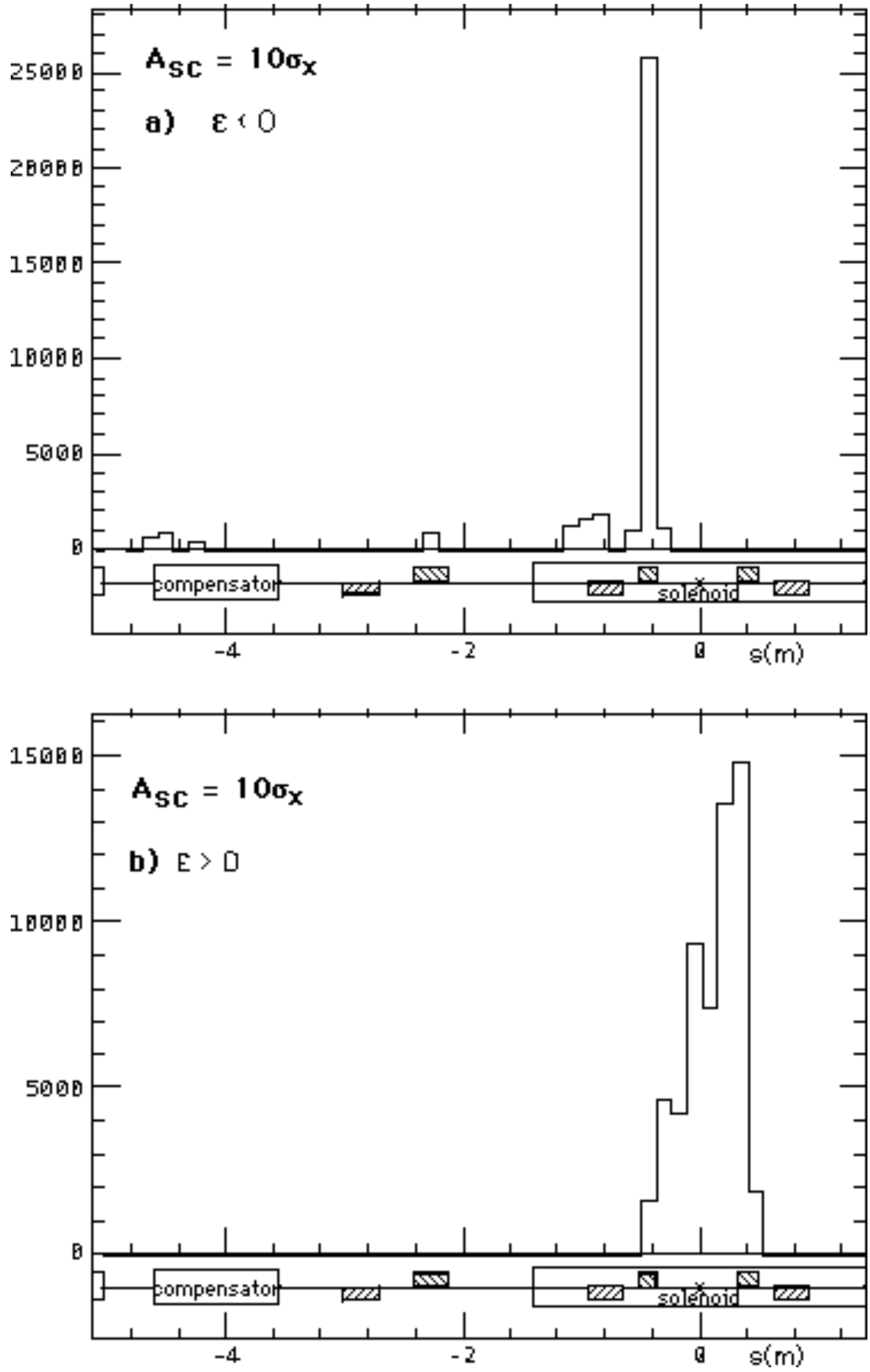

Fig. 2 - Distribution in the longitudinal coordinate of the particles hitting the vacuum chamber in the region between the splitter magnet and the end of the Fi.Nu.Da. detector. $A_{SC}=10\sigma_x$, **a)** $\varepsilon < 0$, **b)** $\varepsilon > 0$.

Table II - Fi.Nu.Da. IR - A_{IP} = 53 mm

A_{sc}/σ_x	A_{sc} (mm)	$\dot{N}_{Q(\varepsilon>0)}$ (s^{-1})	$\dot{N}_{Q(\varepsilon<0)}$ (s^{-1})	$\dot{N}_Q$ (s^{-1})	τ_{tot} (min)
8	23.5	225.	0.	225.	141
9	26.5	$1.7\ 10^3$	52.	$1.7\ 10^3$	161
10	29.4	$6.5\ 10^3$	$2.2\ 10^3$	$8.7\ 10^3$	184
no scrap.	43.0	$5.1\ 10^4$	$5.2\ 10^4$	$1.0\ 10^5$	184

The data of tables I and II are summarized in **Fig. 3** as a function of the scrapers aperture.

Increasing the vacuum chamber aperture around the IP the scrapers became more efficient and the particles losses are strongly reduced.

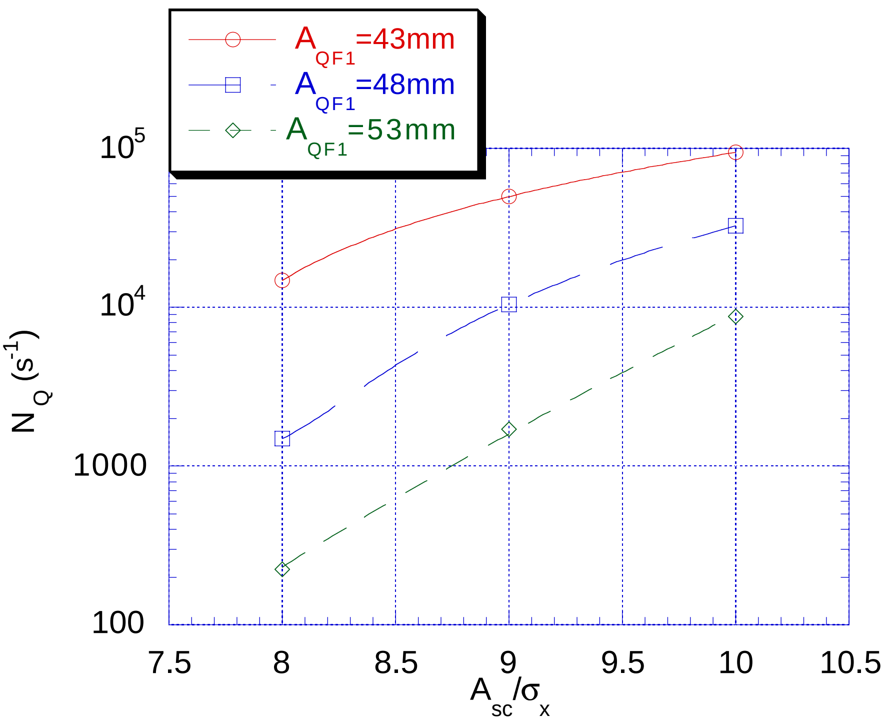

Fig. 3 - Rate of particle losses due to Touschek scattering for the Fi.Nu.Da. IR as a function of the scrapers aperture A_{sc}/σ_x, for different apertures of the vacuum chamber.

3. KLOE IR

The rate of particle losses due to Touschek scattering for the KLOE IR has been updated with the latest version of the lattice and the detailed design of the vacuum chamber aperture. The results are shown in **Table III** for θ=12.5mrad and N=8.9 10^{10} particles per bunch.

Table III - KLOE IR

A_{sc}/σ_x	A_{sc} (mm)	$\dot{N}_Q(\varepsilon>0)$ (s^{-1})	$\dot{N}_Q(\varepsilon<0)$ (s^{-1})	$\dot{N}_Q$ (s^{-1})	τ_{tot} (min)
9	25.0	0.	0.	0.	161
10	27.8	6.98 10^3	467	7.5 10^3	184
no scrap.	43.	1.50 10^5	7.44 10^4	2.2 10^5	184

The results do not differ very much from those given in ref.[1] for the largest aperture of the QF2 quadrupole.

4. Conclusions

It is proposed to install a beam scraper upstream the splitter magnet for each ring for both the experiments to cut the large amplitude particles which otherwise would be lost on the vacuum chamber inside the IRs.

For KLOE the increase of the vacuum chamber aperture has reduced the back-ground rate to an acceptable level. The same solution is suggested for Fi.Nu.Da.: the vacuum chamber radius in the IP region has to be enlarged by one centimeter.

The evaluation of the background rates presented here may vary according to lattice or machine parameters (as emittance or bunch length) modifications . The choice of the DAΦNE operating parameters will be done in order to optimize the average luminosity (i.e. peak luminosity and beam lifetime) taking into account the experimental requirements on the background level. To do this it is very useful to make background measurements during commissioning on the day-one lattice. A detector can be installed near to the IP to measure background and beam lifetime as a function of the scrapers position and machine configuration.

References

[1] S. Guiducci: "Background in the KLOE IR due to Touschek scattering", Technical note IR-5 (1994).

[2] E. Gero: "Beam-gas Background Calculations for DAΦNE", KLOE note 102 (1994).