DEAR Technical Note IR-8

Monte Carlo calculation for Touschek lost positrons hitting a simplified DEAR setup

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1 DEAR "no-target" 2CCDs setup

A simple DEAR setup was installed at the $DA\Phi NE$ machine, in the FINUDA pit, on 14 October 1998, in order to perform background measurements with and without beams circulating in $DA\Phi NE$.

The setup consists of 2 CCDs, with their readout boxes, with an Aluminium window of 50 μm, placed in the interaction region (IR) at a distance from the pipe of about 60 cm in the horizontal plane and of about 10 cm in the vertical plane. This setup stays in an asymmetrical position with respect to the Interaction Point (IP), namely is located in front of the flanges between the central quadrupole and the first quadrupole of the DAY-ONE IR - shifted of about 36 cm towards the electrons-coming-in direction.

2 Background from beam losses

In the present commissioning phase of the machine, the circulating beams are of the order of few mA and the dynamical vacuum, consequently, does not exceed $3 \cdot 10^{-9}$ torr. In these working conditions, the dominant cause for particle losses from the primary beams is the so-called Touschek effect.

The Touschek effect is an elastic Coulomb scattering between a pair of particles within the same 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 magnetic acceptance of the ring the particle is lost.

In Table 1 (from ref. [1]) the rates of lost particles due to Touschek scattering are reported.

Table 1: Particles lost due to Touscheck scattering in the DEAR interaction region (N=$8.9 \cdot 10^{10}$ particles per bunch).

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

Particles with negative deviation ($\delta < 0$) are lost in the last quadrupole before the interaction point. Those with positive δ are lost in the quadrupole after the interaction point.

3 Experimental results with a positron beam

In the night of 21 October '98 a measurement of the beam lifetime of a positron beam was performed at $DA\Phi NE$. A positron beam with an initial intensity of about 2 mA was injected and then left to decay.

We performed measurements with the "no-target 2 CCDs" setup during a time of 3.75 hours with runs of 15 minutes each. In Fig. 1 the number of clusters versus time is presented (a cluster of hit pixels occurs whenever a charged or a neutral particle deposits energy in the CCD).

Analyzing Figure 1 one deduce that, for a current of about 1.6 mA (the mean value of the current during our 15 minutes data taking), the total number of clusters for 2 CCDs in 15 minutes was about 600; 290 clusters were generated by the "non-machine background", the remaining 310 by the lost particles from the primary positron beam.

Concerning the X-ray background, the statistics was too poor to have an analogous figure. However, a ratio of about 60 between the total number of clusters and the number of X rays (in the 2-18 keV dynamical range) was observed. This would result in a total number of X rays, observed in 15 minutes as accompanying the 600 clusters, of about 10. About 5 of these X

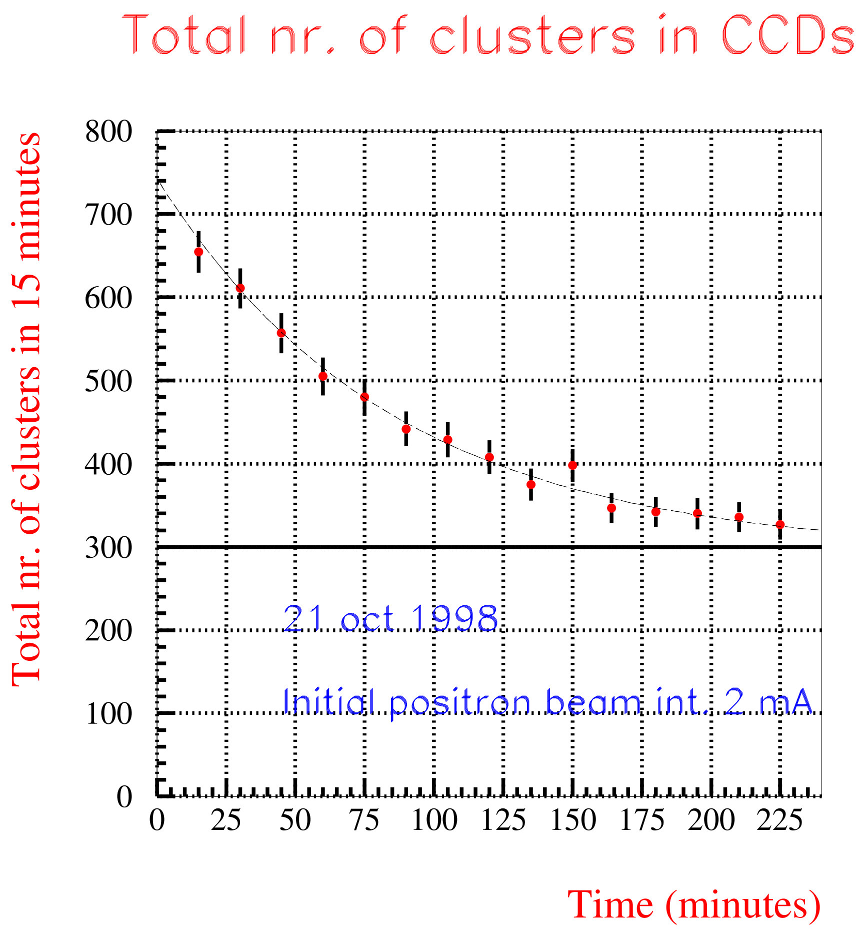

Figure 1: Total number of clusters for Runs of 15 minutes as a function of time, with the 2CCDs setup, in the night of 21 October 1998.

rays are generated by the “non-machine background’, the remaining 5 can be attributed to the machine background.

Normalizing to 1 hour the experimental results we obtain:

- Total number of clusters for 2 CCDs: (2400 ± 100) hour^{-1};
- Total number of clusters after subtracting the ”non-machine” background: (1240 ± 70) hour^{-1};
- Total number of X rays for 2 CCDs (in the range 2-18 keV): (40 ± 10) hour^{-1};
- Total number of X rays for 2 CCDs after subtracting the “non-machine” background (in the range 2-18 keV): (20 ± 5) hour^{-1}.

4 DEAR Monte Carlo for the “no-target 2 CCDs setup”

The elements considered in the DEAR Monte Carlo [2] were:

- Day-One interaction region, with the central quadrupole included;
- pipe: $DA\Phi NE$ pipe in the central region - Aluminium, 2 mm;
- CCDs placed at the distances of the pipe above mentioned and surrounded by an aluminium box of 1 cm thickness.

As input for the calculation the values reported in Table 1 were used. In the Table, the particles lost are referred to a number of particles per bunch of $8.9 \cdot 10^{10}$, which gives a single bunch current of 45 mA (Project value). The machine was working without scrapers, with a 1.6 mA average current during the 15 minutes of our data taking. The beam measured lifetime in this period was about 130 minutes to be compared with the lifetime at full current, reported in Table 1, equal to 97 minutes. Therefore the rate of lost particles, input of the Monte Carlo, is about $1 \cdot 10^5 \cdot 1.6/45 \cdot 97/130 \simeq 2.6$ kHz.

Lost positrons were generated with the kinematics corresponding to the Touschek scattering (ref [3]).

The preliminary results are reported in the next Section.

An example of the way in which the Monte Carlo works is shown in Figure 2, where all particles generated by 10 positrons lost, due to Touschek scattering ($\delta < 0$), are reported.

Fig:2 10 positrons lost before IP

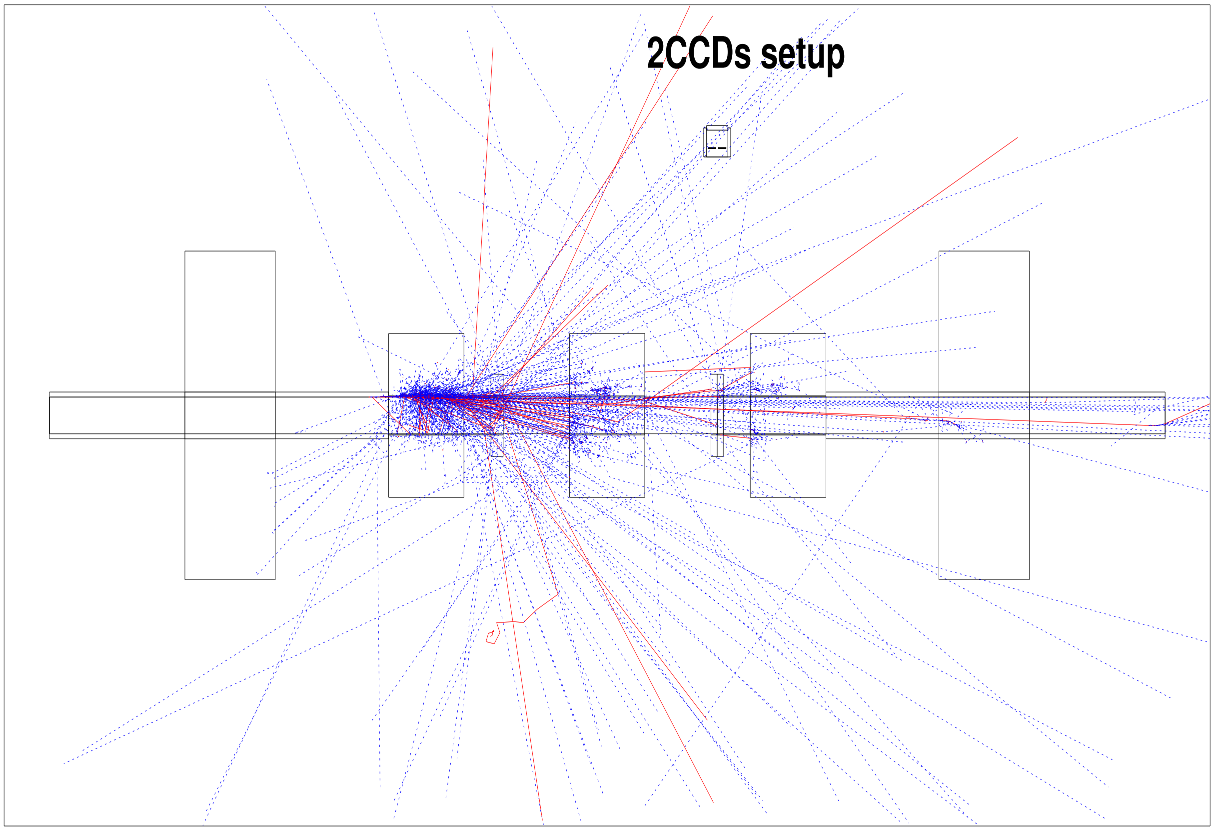

Figure 2: Result of the cascades produced by 10 positrons lost from the primary beam, due to Touschek scattering, before the IP

5 Results of the Monte Carlo calculations

A total number of 1.420.000 positrons lost from the primary beam were generated. Being the rate of lost particles due to the Touschek effect equal to about 2.6 kHz, this corresponds to about 546 s of beam time. The obtained results at the level of CCDs were:

- total number of particles depositing energy in CCDs: 178 particles (positrons and electrons);
- X rays with energy below 18 keV: 3 X rays

This gives the following results:

- Total number of clusters generated by a 1.6 mA positron beam circulating in $DA\Phi NE$: (1173 ± 86) hour^{-1};
- Total number of X rays in the range 2-18 keV generated by a 1.6 mA positron beam circulating in $DA\Phi NE$: (20 ± 12) hour^{-1}.

6 Conclusions

The comparison between the experimental results of background measurements with circulating beams in the $DA\Phi$NE machine, using a simplified version of the DEAR experimental setup, with a calculation performed with the DEAR Monte Carlo shows a fairly good agreement.

This makes us confident - within the limits of a comparison done for a simplified setup and machine conditions - in the reliability of the background evaluations performed for the DEAR setup at full luminosity and, specifically, in the results obtained in background suppression using different shielding configurations.

References

[1] S. Guiducci, *Background calculation for the DAΦNE experiments*, Proceedings of the *5th European Particle Accelerator Conference (EPAC'96),* Sitges (Barcelona), Eds. S. Myres *et al.*, Institute of Physics Publishing, Bristol and Philadelphia, 1996, pag. 1365.

[2] S. Bianco *et. al*, "The DEAR case", to be published.

[3] S. Guiducci (DAΦNE Machine staff), private communication.