DEAR Technical Note IR-31

Monte Carlo simulation based on GEANT for the study of the DAΦNE scrapers *Preliminary results*

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1 Introduction

The aim of the present Note is to present the preliminary results of a GEANT 3.21 based Monte Carlo simulation for the scrapers used by DAΦNE in order to reduce the background (Touschek).

A simple geometry (paralelipiped) was considered; the tracking parameters were optimized and a study of different configurations was done.

The results, in terms of tracking, importance of different effects (energy loss, multiple scattering, and Bremsstrahlung) and a study of the background reduction in terms of impact point and angles are presented.

Section 2 is dedicated to the presentation of the setup and to the study of tracking parameters. In Section 3 results in terms of various effects, for a given kinematics, are presented, and the results of the simulation - with all effects included - as depending on hitting point and hitting angle are discussed. Section 4 is dedicated to a Summary of the results and Conclusions.

2 Setup and tracking optimization by GEANT

The geometry considered for the Scraper, done in Tungsten (W), is very simple: they are modelated as being paralelipipeds with the following dimensions:

- 3.5 cm along the beam direction (z-axis), representing 10 radiation lengths;
- 4.5 cm in the x-direction;
- 2.5 cm in the y-direction - the vertical one.

To be mentioned that only the first dimension is relevant for the results of the simulations, the last 2 being not relevant.

Special care was dedicated to the tracking parameters. Trying to work with AUTO = 1 parameter in the input data card, the result was that the steps were far too “big”, in the sense that in the first step the energy loss (starting with an energy of the particles ob about 510 MeV) was already at the order of 100 MeV!!! This proved that one needs to provide the tracking parameters in such a way that in the end one should find the optimal solution between: a tracking as accurate as possible and the running time of the program as small as possible. Trying different sets of parameters the one which proved to satisfy in a first approximation the previous requirements was:

STEMAX = 100.0
DEEMAX = 0.0005
EPSIL = 0.0001
STMIN = 0.001

where DEEMAX represent the maximum fractional energy lost in one step while STMIN the maximum length of one step (10 microns in this case). Further reducing these parameters did not bring a difference in the results.

The result is presented in NTUPLES containing the energy and positions of the outcoming particles at the plan soon after the scraper - which, presumably, have some possibility to be further tracked and arrive to give background for experiments in the Interaction Regions. The NTUPLE contains as well the vertices of the particles arriving to the mentioned plan. An energy cut of 490 MeV was applied for the outcoming particles, which represents a variation of about 4% with respect to initial value.

3 Simulation results

Before starting the “real” simulations a study of the relative importance of different effects was performed. To do this simulations in which the energy cut was imposed at 350 MeV (to have more statistics) and the lost particles (electrons) of 511 MeV energy were hitting at an angle of about 14 mrad in the horizontal plane the surface of the scraper, all along the 3.5 cm of length was performed.

The results for 10000 particles generated in each case, were:

- when all effects, energy loss, multiple scattering and Bremsstrahlung were set to 0, all 10000 were registered - as expected - at the out-plane;
- when energy loss was set to 0 and all other effects were present, 6630 particles were in the Ntuple;
- when energy loss and multiple scattering were set to 1 and Bremsstrahlung at 0 (absent) the particles in the Ntuple were 1592;
- when energy loss and Bremsstrahlung were set to 1 and multiple scattering at 0 (absent) the particles in the Ntuple were 510;
- finally, when all effects were present the number of particles in the Ntuple was 1630.

This proves that, apart from energy loss, which, of course, is important, the role of multiple scattering (at least for these small angles) is much more important than the role of Bremsstrahlung - as expected. There are differences in angles of the outcoming particles for the situation presented above - but their study was not the aim of this work.

To be mentioned that the multiple scattering is calculated using Gaussian approximation (but results are almost the same using Moliere Approximation or Coulomb scattering), while for energy loss the GLANDO GEANT subroutine is used.

From now on we worked with all 3 effects present in the data card and an energy cut for particles present in the Ntuple of 490 MeV. The results of the Monte Carlo simulations are presented in what follows for the following situations: particles hitting the scraper on the side (almost perpendicular) and particles hitting the scraper on the surface (almost parallel to the surface). The hitting particles were always simulated to be in the horizontal plane (reason for which the x and y dimensions of the scrapers are not relevant).

3.1 Particles hitting the scraper on the side

The result of the simulation in which particles (electrons of about 510 MeV0 hit the scraper on the side is very simple - practically not even one particle was present in the Ntuple registering particles after scraper for 10^5 generated hits. This result was independent of angle and height. In fact it is what we were expecting: 10 radiation lengths of tungsten do not allow to particles to pass through if the cut in energy is at a level of 96% of the incident one.

3.2 Particles hitting the scraper on the surface

This case is not trivial. The result strongly depends on the angle with which particles are impinging on the scraper. The multiple scattering proves to be the dominant effect for small angles, as it will be further proved.

In Table 1 the results of various simulations are presented, for 10^5 particles generated in each case in the horizontal plane for all 3.5 cm length of the scraper (with z-coordinate between -1.75 and 1.75 in the Monte Carlo program).

As one can see from Table 1 shielding factors between 2 and 300 can be obtained, function of the angles of the incoming particles.

Let's examine closer the two extreme situations, namely 1 and 20 mrad incident particles. In Figure 1 there is shown the z-vertex position of the particles in the Ntuple, while in Figures 2 and 3 the x- and y-positions of the particles just after the scraper are shown. The same information are shown in Figures 4,5 and 6 for an incident angle of 20 mrad.

A study of Figure 4 brings to the conclusion that the 334 particles which are in the Ntuple - are generated in the last 1 mm (or so) corner of the scraper. These particles are loosing very few energy and are passing further. Figure 1 proves the fact that when angle is small (smaller than 5-7 mrad) the dominant effect is the multiple scattering.

4 Summary of the results and Conclusions

The present Note deals with a Monte Carlo study, based on GEANT 3.21, of the effect that paralelipipedic-shaped scrapers, built on tungsten, might have for different kinematics (angles and impact point) in the reduction of

Table 1: The results of Monte Carlo simulations for different angles of electrons; 10^5 particles of 511 MeV energy were simulated for each case

Angle (mrad)	$\cos(\theta)$	Number of particles in the NTU	Shielding factor
1	0.9999995	46202	2.16
3	0.9999955	16781	5.96
5	0.9999875	4691	21.32
10	0.9999500	361	277.
15	0.9998875	334	299.
20	0.9998000	334	299.

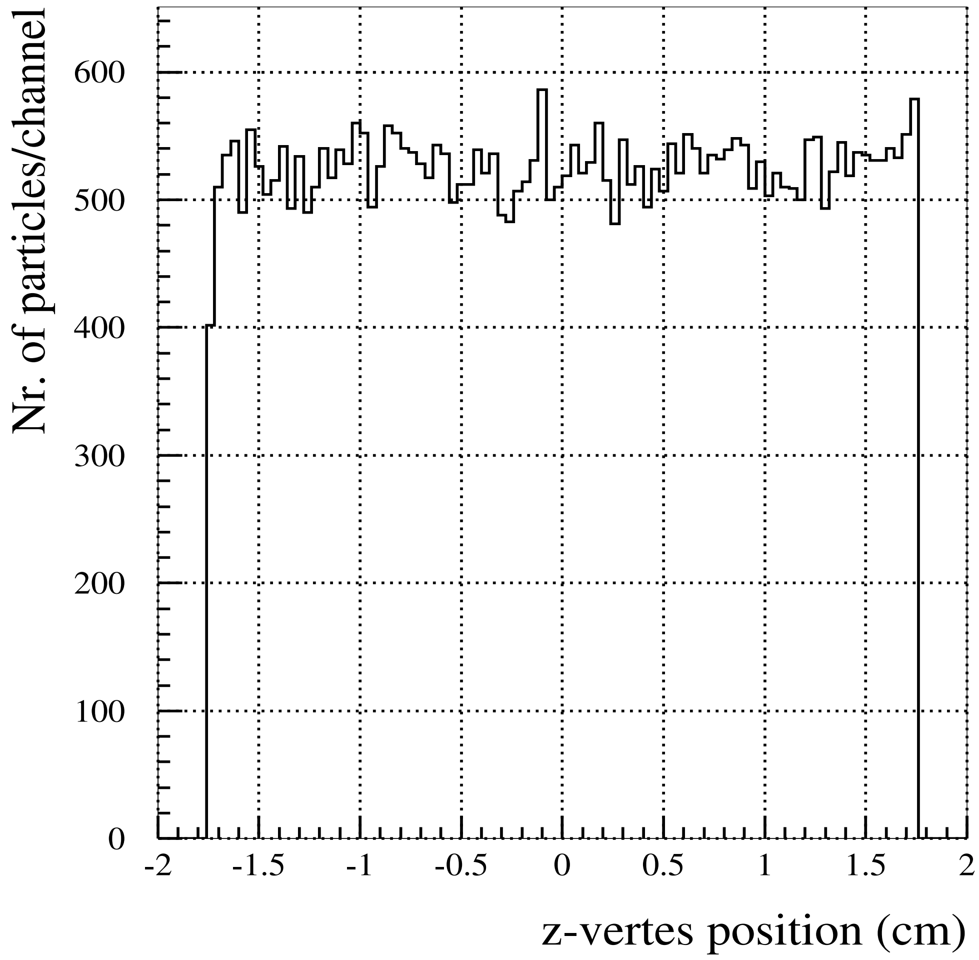

Figure 1: The z-vertex positions for particles registered in the Ntuple for an incident angle of 1 mrad.

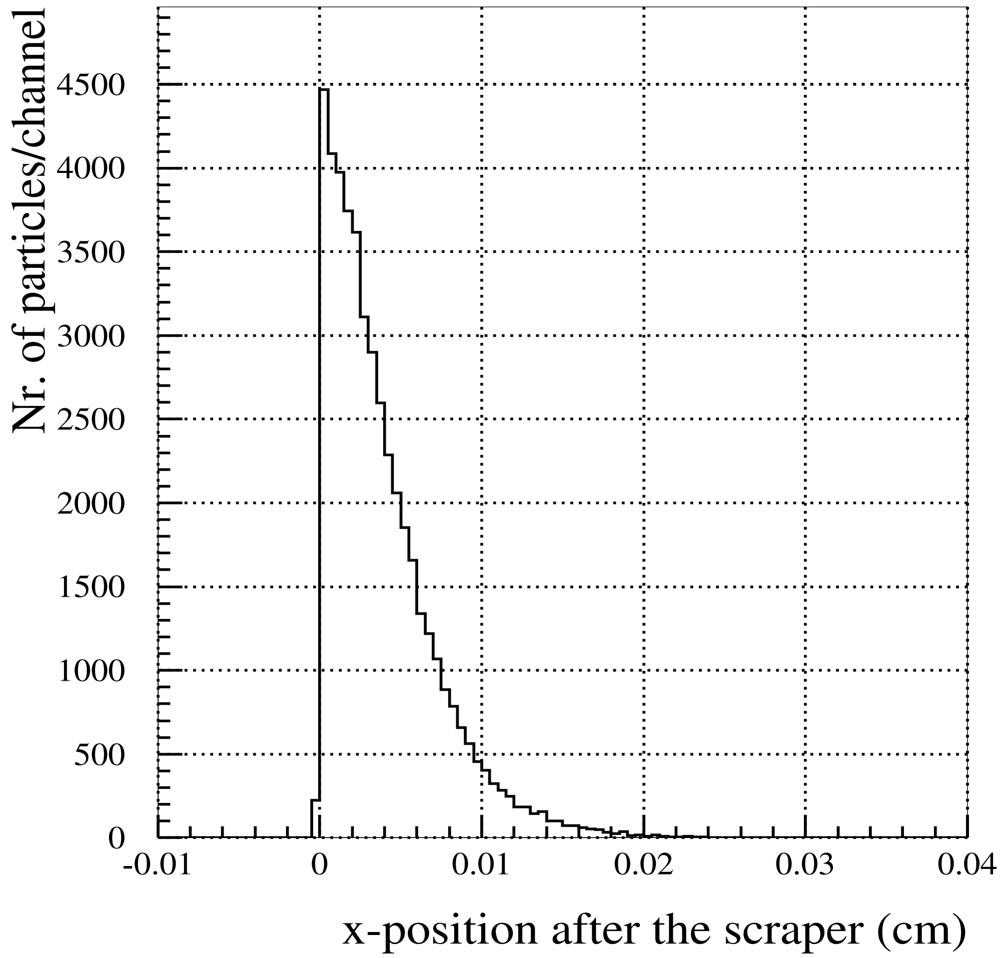

Figure 2: The x-coordinates for particles registered in the Ntuple for an incident angle of 1 mrad.

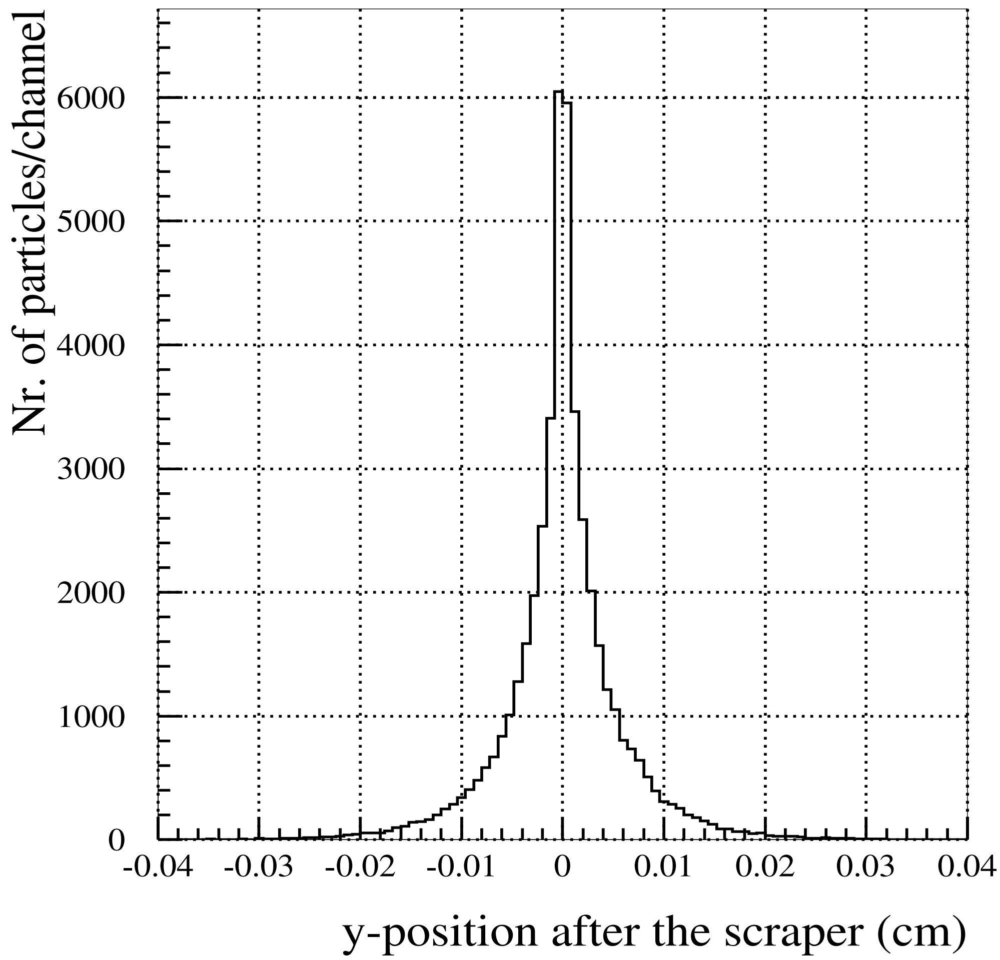

Figure 3: The y-coordinates for particles registered in the Ntuple for an incident angle of 1 mrad.

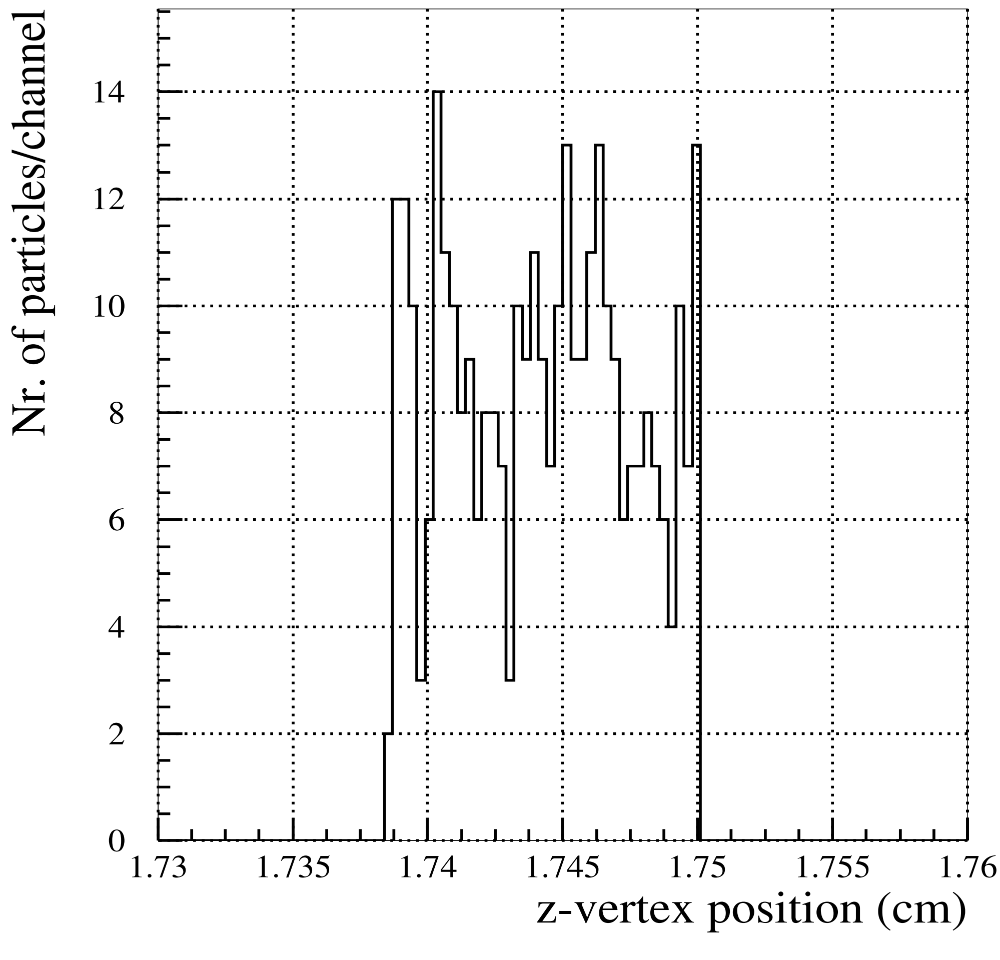

Figure 4: The z-vertex positions for particles registered in the Ntuple for an incident angle of 20 mrad.

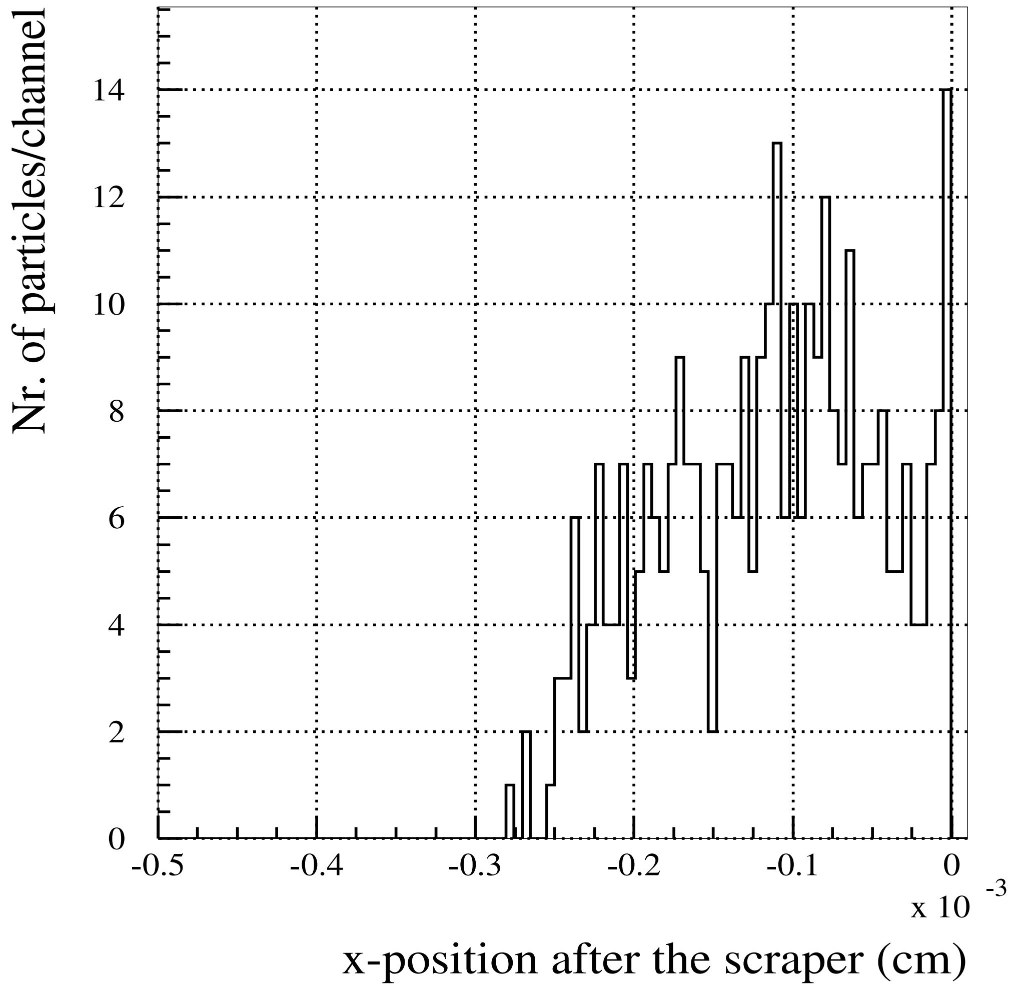

Figure 5: The x-coordinates for particles registered in the Ntuple for an incident angle of 20 mrad.

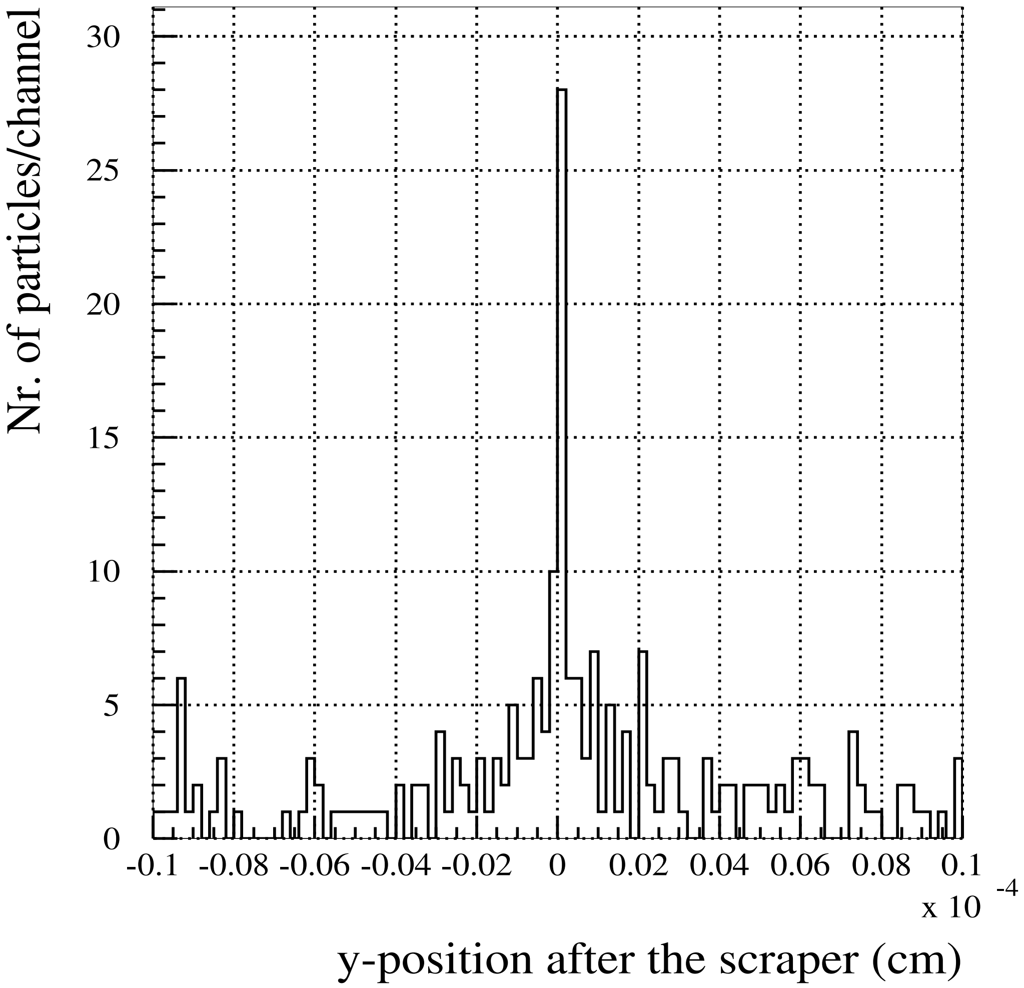

Figure 6: The y-coordinates for particles registered in the Ntuple for an incident angle of 20 mrad.

the background supposed to come from Touschek effect. No magnetic field is included.

The partial contribution of different effects (multiple scattering, energy loss and Bremsstrahlung) was studied. It was shown that for the energy range of interest (energy not smaller than 96% of the initial one) the dominant effect is the multiple scattering - as expected.

Two situations were studied:

a) lost particles hitting almost *perpendicular* the scraper;

b) lost particles hitting almost *parallel the surface* of the scraper with a given angle.

In case a) the absorption is complete.

In case b) the dominant effect is the *multiple scattering for small angles* ($< 5 - 7$ mrad) and the result strongly depend on the incident angle; for large angles (> 10 mrad) energy loss is responsible for the particles crossing the last millimeter at the corner of the scraper.

Analyzing the results presented in Table 1 in the present Report one obtains a reduction factor of the background of a factor about 30 for angles between 0 and 15 mrad (mean value). Measurements give a factor of about 3. Therefore, one (or few) of the following facts occurred:

- the Touschek cone is about 1-2 mrad;
- the momentum acceptance is higher than 2%;
- the losses are not Touscheck-limited to the horizontal plane but occurr in a region where scrapers are not acting.

Proposed therapy:

1. Eliminate the effect of multiple scattering by making - through a cut of the scraper - the particles hit the surface at an angle of ≥ 20 mrad (bigger is, safer is);
2. Eliminate the residual effect of energy loss in the corner by shaping the corner properly.

The Monte Carlo study of this geometry will be the object of a coming study.