DEAR Technical Note IR-12

Monte Carlo calculation for the new NTP DEAR setup

C. Petrascu
February 3rd 1999

1 The new NTP DEAR setup

After the successful operation of the 2-CCD setup during the period of background measurements, in the period October-November 1998, a new NTP setup was designed in which two 2-CCD setup are used together with a new target cell design. In such a way, cooling of CCDs by liquid nitrogen is eliminated, since the cryotiger system of the 2-CCD setup is used. The big advantage of using this new setup consists in the fact that it is no longer necessary to enter each 36 hours in the DAΦNE hall to fill-up the nitrogen dewar, operation which might be rather complicated, taking into account the working regime of $DA\Phi NE$. Just to be mentioned in this regard, during the beam-test period previously mentioned we had access only three times in the experimental area!

The new NTP target is an aluminium box, $30 \times 30 \times 30$ cm^3, with an entrance window for kaons made of aluminium ($\sim 100\mu m$), of circular shape, 15 cm diameter. The target will be placed on the DEAR platform - the one which will be used for the final cryogenic setup as well - rotated 45^0 with respect to the beam axis.

The target has 2 circular windows (7 cm diameter) towards the vacuum chambers of the two 2-CCD setup, made in kapton, 50 μm width, positioned in the middle of the target wall. The windows are positioned on two adjacent faces of the target.

The CCDs are placed horizontally and are distant about 1 cm from the target window.

The new NTP setup is shown in Fig. 1 (side view) and Fig. 2 (top view).

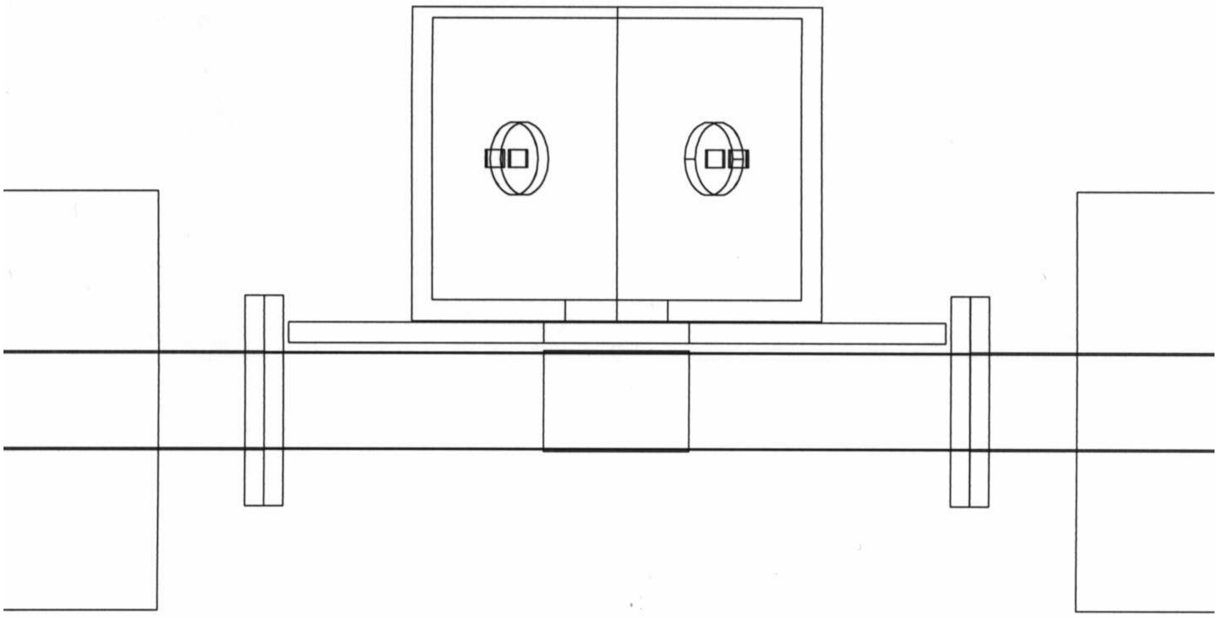

Figure 1: The NTP setup - side view

The aluminium target cell is filled with nitrogen at NTP conditions.

In the next sections we shall present the results - in terms of percentage of stopped kaons and X-ray signal- of the Monte Carlo simulation.

2 Kaons stopping in the NTP target

An optimization of the degrader (scintillator, in the simulation) in terms of a maximum number of stopped kaons in the target, gave a value of 2.8 mm. With this value for the degrader width we proceeded to perform a Monte Carlo run, generating 200.000 ϕ-particles and studying the kaons stopping in the target (nitrogen).

The electron and positron beam energy spread considered in the simulation was 0.04%, while the spread of the interaction point (source of ϕ

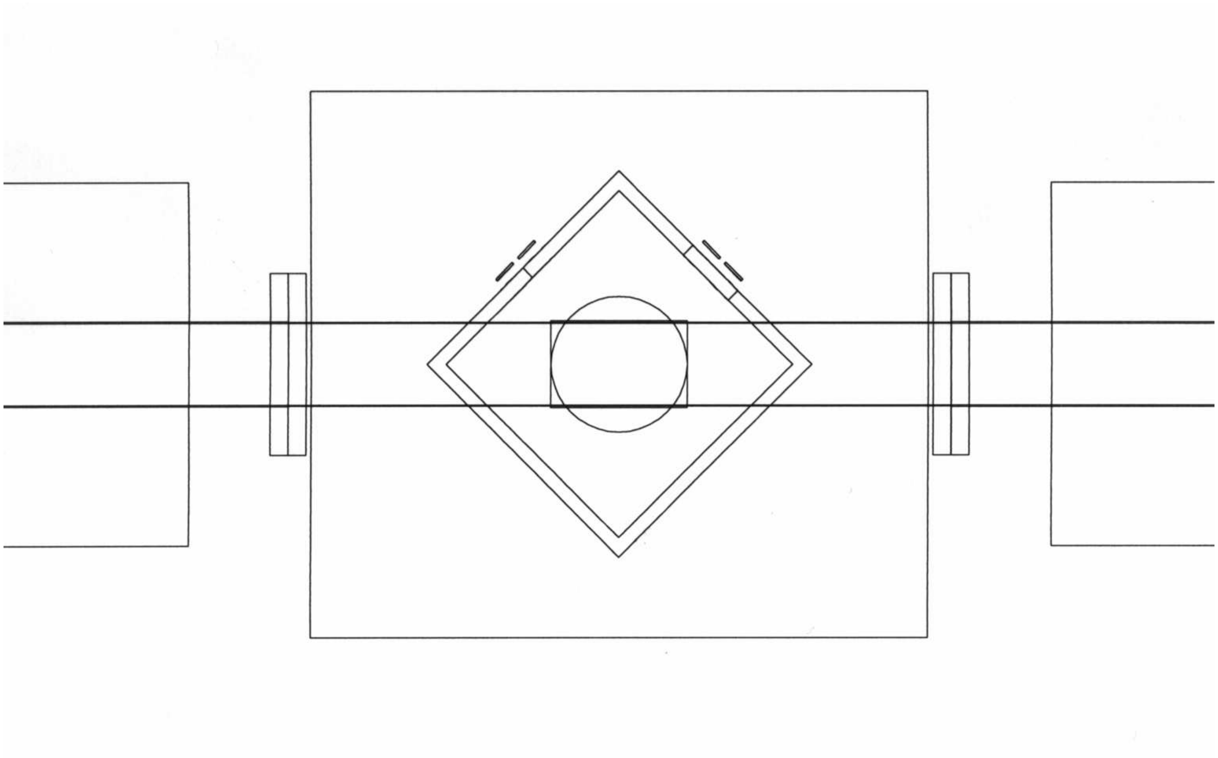

Figure 2: The NTP setup - top view

particles) were: $\sigma_x = 2$ mm; $\sigma_y = 0.02$ mm; $\sigma_x = 3$ cm.

The percentage of kaons stopping in the target with respect to the overall number of generated kaons was:

$$K_{stop} = (2.4 \pm 0.2)\% \tag{1}$$

The one-dimensional distributions of the kaons stopped in the target are presented in Fig. 3, while the bi-dimensional ones are shown in Fig.4.

The y-distribution of the stopped kaons shows a decreasing behavior as going farther and farther with respect to the interaction point; this trend is a combined effect between the stopping power of N_2 at NTP and the decay of kaons.

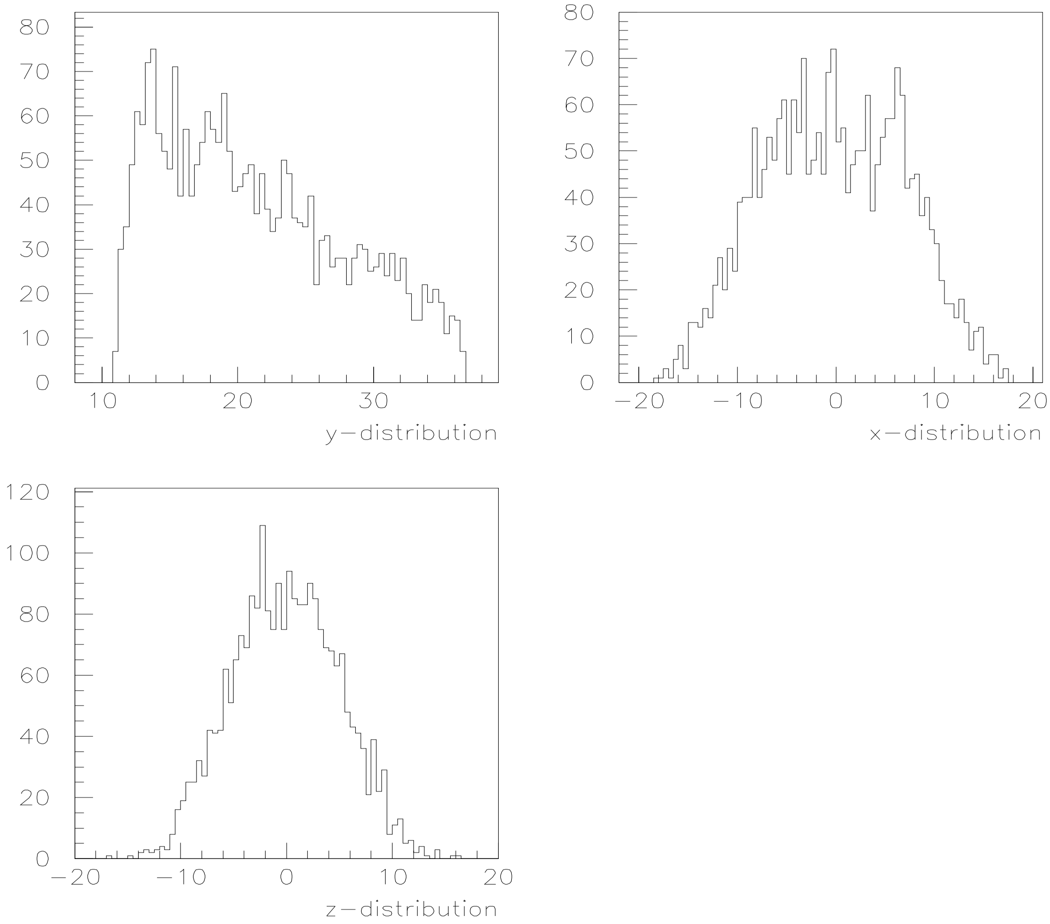

Figure 3: The one-dimensional distributions of kaons stopping in nitrogen target at NTP (200.000 ϕs generated)

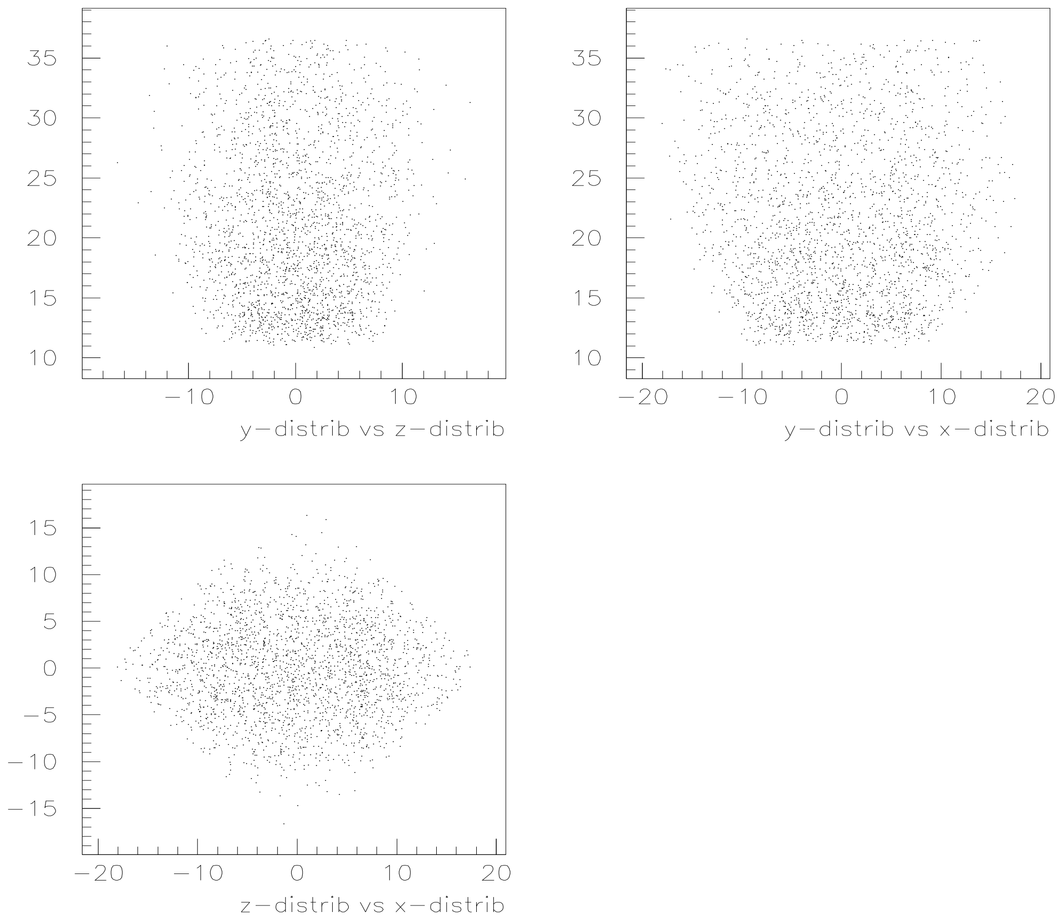

Figure 4: The bi-dimensional distributions of kaons stopping in nitrogen target at NTP (200.000 ϕs generated)

3 X-ray signal

DEAR Monte Carlo works with modified subroutines, in order to take properly into account the particle interactions below 10 keV. Each time when a kaon is stopped (energy less than 10 keV) in the nitrogen target, an X ray of 4.57 keV ($7 \rightarrow 6$ transition of kaonic nitrogen) is emitted. The X rays reaching the 4 CCDs are recorded and studied. CCD efficiency is properly taken into account by the Monte Carlo program (for this energy is $\sim 90\%$), while the yield of the transition (80% in this case) is considered off-line.

Generating 200.000 ϕ decays, the total number of X rays recorded by CCDs were 6. This means that for an integrated luminosity of 1 pb^{-1}/day the signal will be:

$$X_{signal}(4.57\ keV) = (91 \pm 37)\ X/day \tag{2}$$

4 Further studies

With the "old" NTP target the X-ray signal registered by the CCDs, as given by Monte Carlo, was about 200 counts/day, at the integrated luminosity of 1 pb^{-1}/day, to be compared with a signal of about 100 counts/day of the new setup. In order to check whether the latter can be eventually increased additional studies were performed.

Below, there some results from these studies are reported.

4.1 CCD windows lowering

Having checked (see Fig. 1 and 2) that the kaon stopping distribution is more dense at the bottom of the nitrogen target, a possibility of increasing the signal would be to shift down the CCDs, with respect to the center of the target. However, due to the fact that just after the entrance window the distribution of stopping kaons is more shrinked with respect to the more spread one farther on, the X-ray signal registered by CCDs (smaller acceptance) does not significantly increase.

4.2 Nitrogen at 2 bar

Increasing the density of nitrogen (by increasing the pressure at 2 bar) the stopping distributions are accordingly modified. They are reported in Fig. 5 and 6 (one- and bi-dimensional).

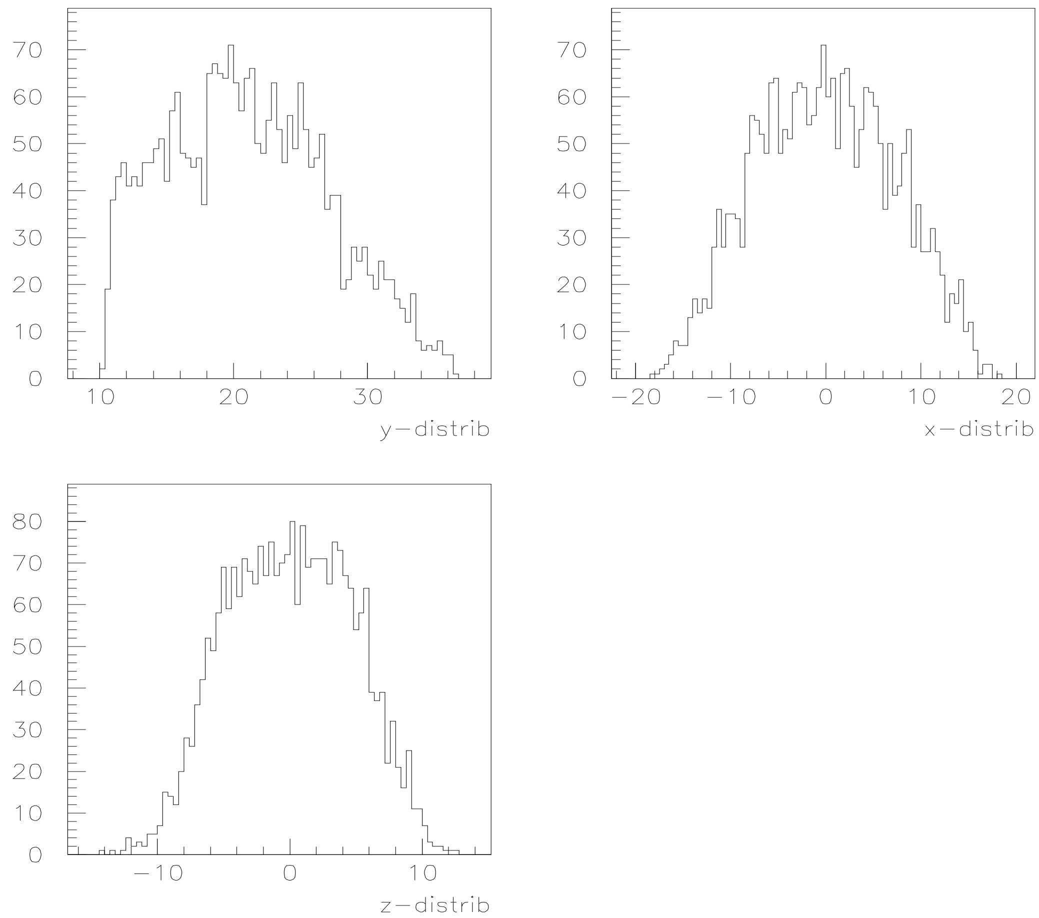

Figure 5: The one-dimensional distributions of kaons stopping in nitrogen target at 2 bar pressure (200.000 ϕs generated)

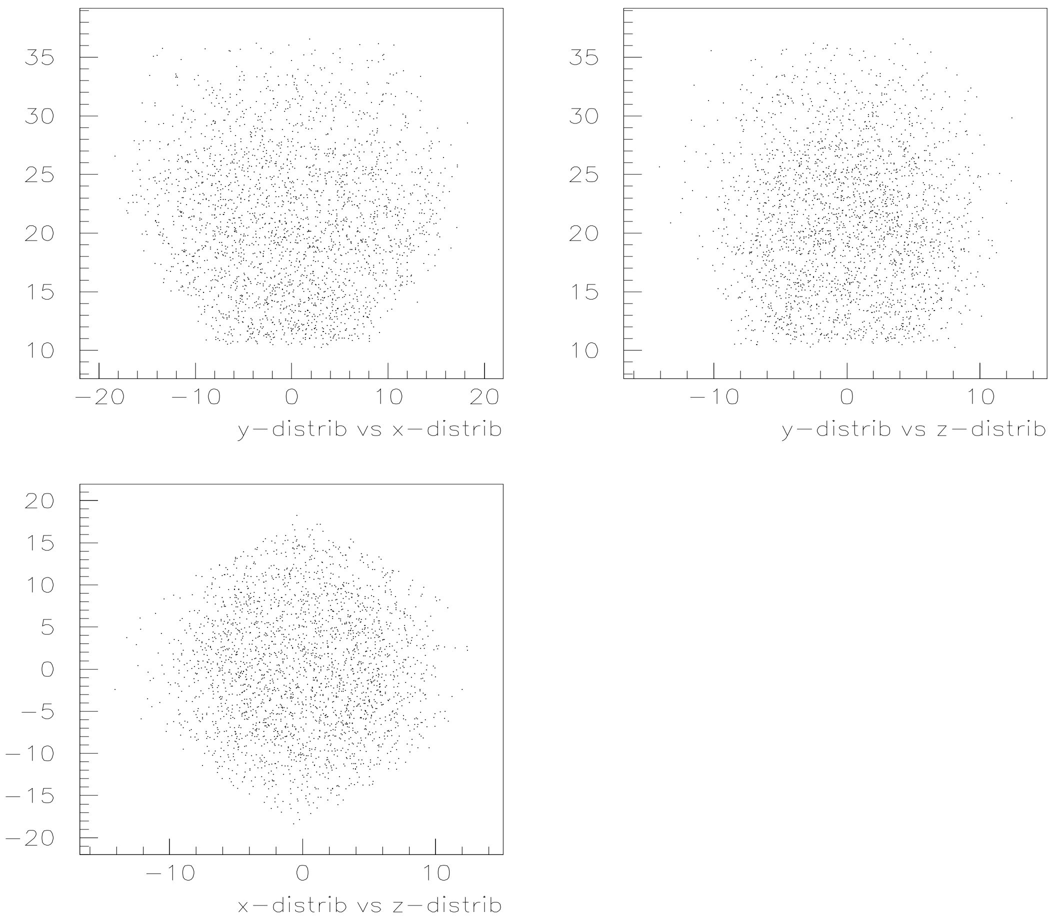

Figure 6: The bi-dimensional distributions of kaons stopping in nitrogen target at 2 bar pressure (200.000 ϕs generated)

Optimal degrader width in this case was 2.7 mm of scintillator. In this case the percentage of kaons stopping inside the target is $(5.2 \pm 0.2)\%$, while the X-ray signal is (110 ± 31)/day, for an integrated luminosity of 1 pb^{-1}/day.

4.3 Smaller target

If, instead of a $30 \times 30 \times 30$ cm^3 target cell one would use for example a target of $15 \times 15 \times 30$ cm^3 (where 30 cm is the height), with the CCDs placed right after the entrance window, the kaons stopped inside the target are $(1.8 \pm 0.2)\%$, while the X-ray signal is (150 ± 45)/day, for an integrated luminosity of 1 pb^{-1}/day.

Finally, since the z-spread of the originating point for the ϕs, for different beam dynamics, can vary between 1 and 3 cm, simulations have been performed changing the z-beam spread from 3 to 1 cm, but results did not change significantly.

5 Conclusions

Although there is an apparent loss of signal with respect to the rate obtainable with the "old" NTP setup, the advantage of avoiding a problematic access to DAΦNE for refilling the nitrogen dewar, definitely supports the present choice.