DEAR Technical Note IR-20

DEAR Monte Carlo results for the "16 CCD-22" cryogenic target setup

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1 Introduction

The results of the DEAR Monte Carlo simulation for the "16 CCD-22" cryogenic target filled with hydrogen are presented in this Note together with a comparative study of different CCD-detectors configurations.

The setup, as included in the Monte Carlo simulation, is presented in Section 2.

The results, in terms of percentage of kaons stopping inside the target and of X-ray signal detected by CCDs, are presented in Section 3. In Section 4 conclusions are drawn.

2 Cryogenic target setup

The "16 CCD-22" DEAR cryotarget setup is described in detail in ref. [1]. The elements relevant for the simulation are summarized below.

The vacuum jacket is an aluminum cylinder, 10 mm thick, with a radius of 15 cm and a height of 26.5 cm, placed at 4 cm with respect to the DEAR pipe. Inside the vacuum jacket the cryogenic target is placed at 1 cm from the bottom. The target is an aluminum cylinder, 5 mm thick, with a radius of 6.5 cm and a height of 14.3 cm. On the lateral wall of the cylinder 8 windows (sectors of cylinder) are cut, made by Kapton, 50 μm thick, in correspondence with the 16 CCD-22. The windows height is 7 cm, while their length (as circle arcs) is 3.8 cm and are starting 3 cm from the target bottom. CCDs are placed at 6 mm distance with respect to the Kapton

windows. The active area of a CCD-22 is 2.5 $\times$ 2.5 cm^2 with a depletion layer thickness of 40μm. For CCD-05 the active area is 2.6 $\times$ 1.7 cm^2, with a depletion layer thickness of 30μm.

The windows in front on kaons before reaching the hydrogen target are:

- 125μm of aluminum at the entrance of the vacuum jacket, with a diameter of 8 cm;
- 190μm of Hostaphane, at the entrance of the target cell, with a diameter of 10 cm.

The degrader was optimized to have the maximum number of kaons stopped in front of the CCDs.

All other elements (DEAR pipe, DAΦNE pipe, quadrupoles, DEAR platform, etc.) are the same as in all previous simulations, and are presented in [2].

Three different configurations of the CCD detectors were considered in the simulation:

- 8 CCD-22 plus 4 CCD-05;
- 8 CCD-22 plus 8 CCD-05;
- 16 CCD-22.

Figures 1 and 2 show a schematic view of the cryogenic target setup used in the simulation.

3 DEAR Monte Carlo results obtained with the cryogenic target

3.1 Kaons stopping inside the hydrogen target

The work started by optimizing the degrader in order to maximize the percentage of kaons stopping inside the target, as well as requiring that kaons stop in front of the CCDs.

After having performed such an optimization (which gave a degrader thickness of 1.9 mm of plexiglass), 200,000 ϕ-particles were generated. The vertex position of the ϕ-particles had the following spreads [3]:

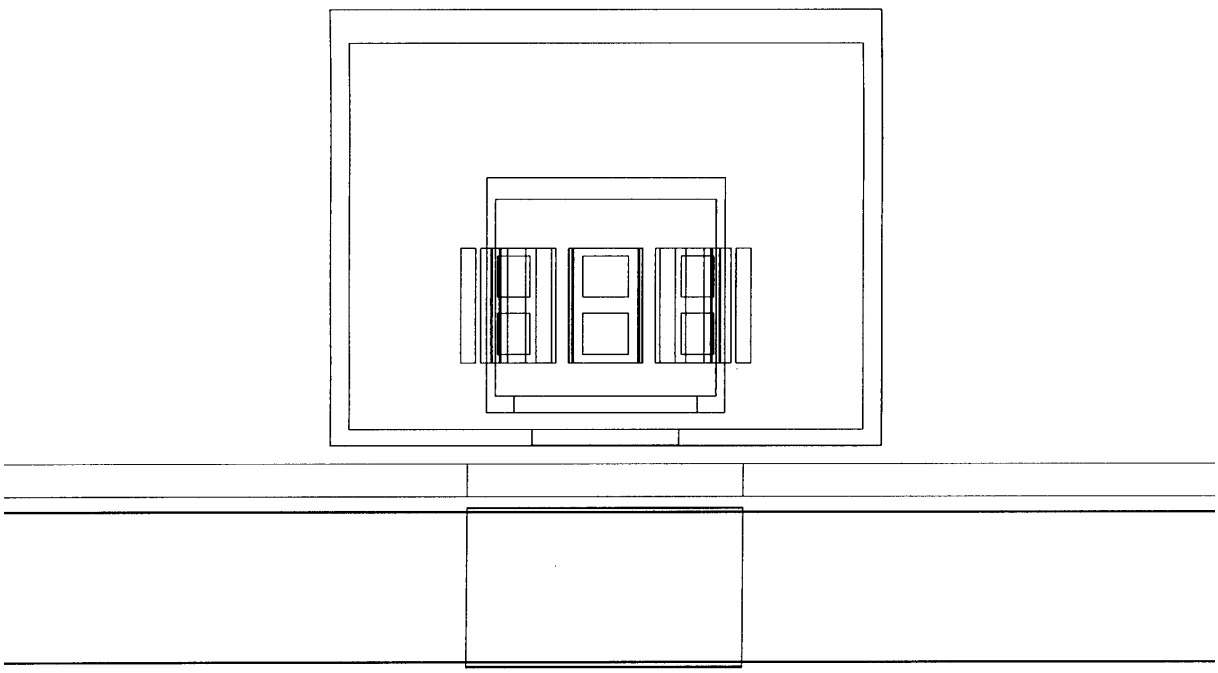

Figure 1: Schematic view of the cryogenic target setup - side view.

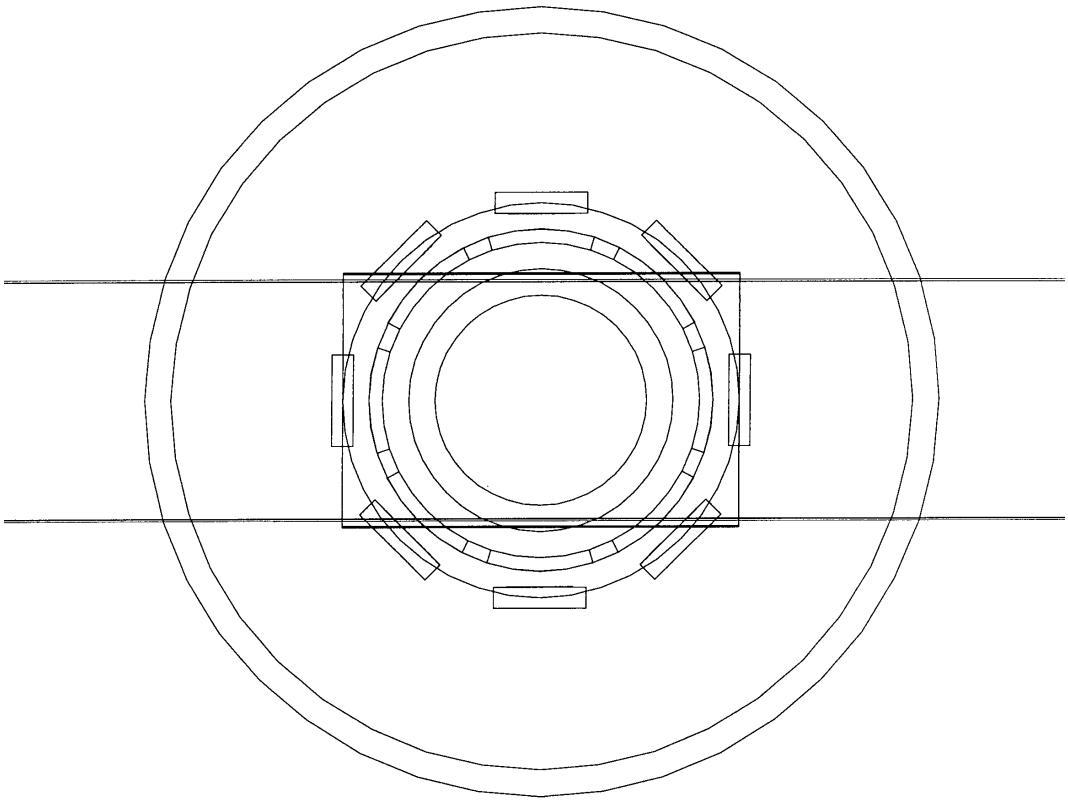

Figure 2: Schematic view of the cryogenic target setup - top view.

- 0.211 cm on the x-axis;

- 0.00211 cm on the y-axis;

- 3.0 cm on the z-axis;

where the z-axis is along the electron and positron beam direction. The energy spread of the electron (positron) beam generating ϕs is of about 200 keV [4].

The bidimensional distributions as well as the y-distribution of the kaons stopping inside the target are presented in Fig. 3.

The total number of kaons stopping inside hydrogen turned out 2,851, which means 2.9% of the overall generated negative kaons from ϕ-decays.

3.2 X-ray signal

The number of X rays detected by the CCDs was studied for each one of the 3 configurations mentioned in the previous Section.

One of the first results which came out from the Monte Carlo simulation was that at 6.5 keV the efficiency of a CCD-22 is about 75% (that of a CCD-05 being about 60%).

The results are presented in Table 1. In order to make a comparison with the previous evaluations of the expected K_α signal, the yield of the $2p \rightarrow 1s$ transition was considered as being 3% and the signal was calculated for a luminosity of 10^{32} cm^{-2}s^{-1}. The results are compared with the value given in the DEAR Proposal [5] and with the evaluation of the expected signal in the first realized cryotarget setup [6].

4 Conclusions

By comparing, in Table 1, the expected yield in the first cryotarget setup with the actual CCD configuration in the new setup, a factor of about 3.4 is gained in the X-ray signal. This factor is obtained as a consequence of:

- a larger number of CCDs, part of those being CCD-22 which have an area larger than that of a CCD-05;

- an efficiency of CCD-22 about 1.3 times larger than that of a CCD-05;

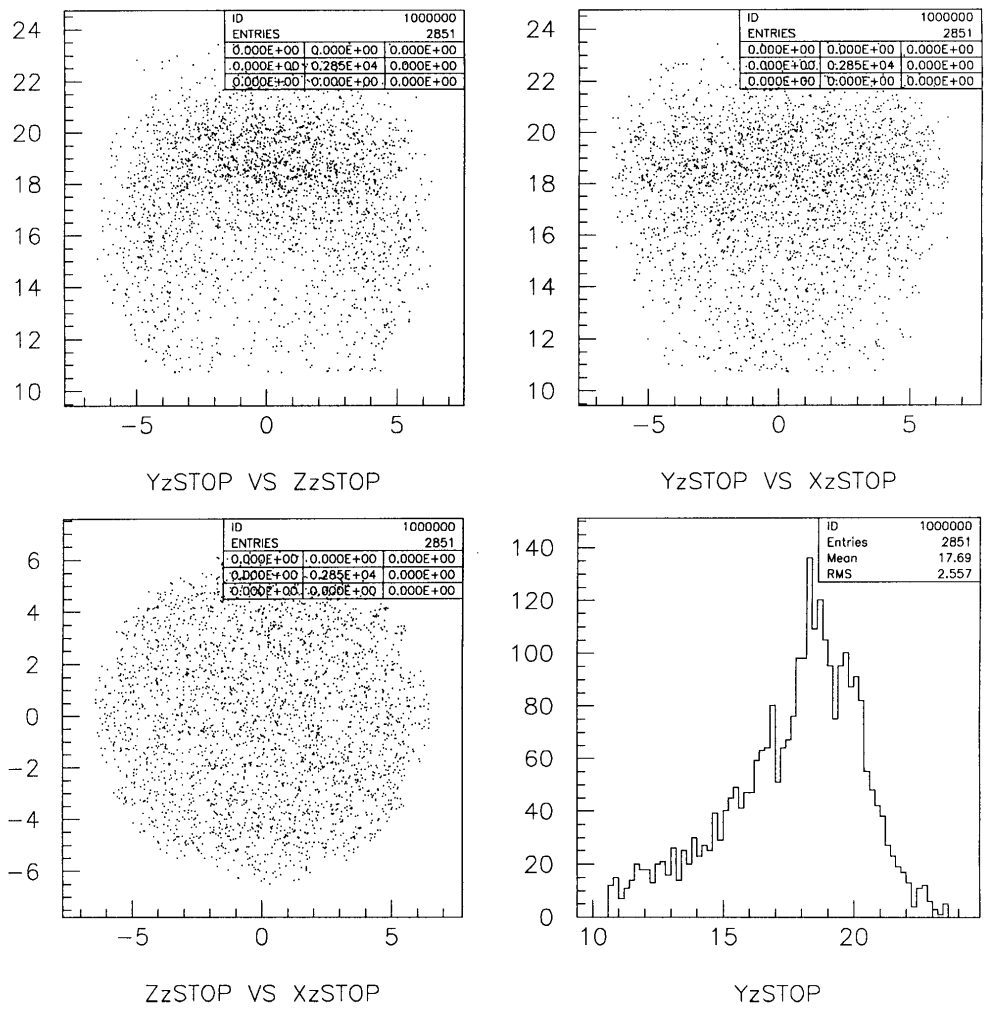

Figure 3: Distributions of kaons stopping inside the hydrogen target. Dimensions are in cm.

Table 1: The predicted K_α rate for various detector combinations compared with the value given in the DEAR Proposal [5] and with the value expected in the first realized cryotarget setup [6]. D_{IP-T} is the distance from the interaction point to the target center; d_{CCD} represents the distance from the target to the CCD-detectors.

Geometry	Type/Number of CCDs	D_{IP-T} (cm)	d_{CCD} (mm)	K_α/hour
Proposal	CCD-05/8	19	2	20.5
I cryotarget	CCD-05/8	20	12.5	12.8
Actual	CCD-22/8 + CCD-05/4	17.5	6	43.1
Future	CCD-22/8 + CCD-05/8	17.5	6	54.2
Option	CCD-22/16	17.5	6	72.3

- an improved geometry - where the factor which plays the most important role was recognized [6] to be the distance between CCDs and target (Kapton window): in the new geometry the distance was reduced by a factor of 2.

From Table 1, it is also apparent that an increase in the rate of about a factor of 6 with respect to the first cryosystem can be gained by using 16 CCD-22.

References

[1] J. Zmeskal *et al.* (DEAR Collaboration), "The DEAR Target and Detector System", Physics and Detectors for DAΦNE, Frascati Physics Series, Vol. XVI, to appear.

[2] S. Bianco *et al.* (DEAR Collaboration), The DEAR case, Rivista del Nuovo Cimento Vol. **22**, N. 11, 1999.

[3] The European Physics Journal, Review of Particle Physics, Vol. 3,*High-Energy Collider Parameters:* e^+e^- *Colliders*, p. 141, 1998.

[4] S. Guiducci, DAΦNE machine staff, private communication.

[5] R. Baldini *et al.*, The DEAR Proposal, LNF-95/055 (IR), 1995.

[6] R. King and J. Zmeskal, "Improved Detectors and Target Geometries for the DEAR Experiment", DEAR Technical Note IR-6, July 1, 1998.