DEAR Technical Note IR-22

DEAR Monte Carlo results: X-ray signals from different kaonic atoms and different setups

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1 Introduction

In the present Note a summary of DEAR Monte Carlo results, for differents kaonic atoms and different setup configurations is reported with the aim of having gathered all together the different expected results.

NTP target and the cryogenic one, with different number of CCDs-05 or -22 type, the latter, have been simulated; kaons stopping in the target and X-ray signals arriving to the CCDs were registered.

Section 2 presents the studied configurations and kaonic atoms; in Section 3 the results of simulations are reported, while in Section 4 brief Conclusions are drawn.

2 Presentation of the kaonic atoms and setup configurations studied with the DEAR Monte Carlo program

With the DEAR Monte Carlo simulation program the following kaonic atoms and setup configurations have been studied:

1. **kaonic nitrogen** atom with:

- NTP-target with 4 CCDs 05 - presented in more detail in [1], actually installed on DAΦNE;
- CRYOGENIC target - presented in more detail in [2], with:
  - with 4 CCDs 05 at 1 and 2 bar pressure;
  - with 8 CCDs 22 and 4 CCDs 05 at 1 and 2 bar pressure.

2. **kaonic hydrogen atom** with CRYOGENIC target:
   - 8 CCDs 22 and 4 CCDs 05, actually under test in laboratory;
   - 8 CCDs 22 and 8 CCDs 05;
   - 16 CCDs 22.

3. **kaonic helium** atom with:
   - NTP-target with 4 CCDs 05;
   - CRYOGENIC target with 8 CCDs 22 and 4 CCDs 05.

For each one of the mentioned configurations the degrader was optimized such as to maximize the number of kaons stopping inside target and, in the same time, the X-ray signal detected by CCDs.

The results of the simulations are reported in the next Section.

3 DEAR Monte Carlo results

For each one of the configurations presented in the previous Section at least 500.000 ϕs (which corresponds to ~18 minutes of beam at a luminosity of $10^{32} cm^{-2} s^{-1}$) were generated.

The results - in terms of kaons stopping inside target and X rays detected by the CCDs - were recorded and are presented in Table 1. In Table 1 are given the following informations:

- type of kaonic atom considered in the simulation;
- type of target;
- pressure of the target;

- energy of the X-ray transition of interest;
- yield of the transition;
- number of CCD-22 (together with the efficiency for the X-ray energy considered);
- number of CCD-05 (together with the efficiency for the X-ray energy considered);
- percentage of kaons stopped inside target;
- X-ray signal for an integrated luminosity of 1 pb^{-1};
- X-ray signal/hour for a peak luminosity of 10^{32} $cm^{-2}s^{-1}$.

4 Conclusions

Comparing the results presented in Table 1 for different kaonic atoms and different DEAR setups, one arrives to the following conclusions:

1. **Kaonic nitrogen:**
   - ***at 1 bar***
   - a factor of 1.74 is gained going form the NTP target to the CRYO target (with the same number of CCD-05: 4), due to "geometrical effects" (CCDs are closer to the kapton window and closer to the interaction point);
   - a factor up to 8 can be gained going from NTP target with 4 CCD-05 to the actual CRYO target with 8 CCD-22 and 4 CCD-05;
   - ***at 2 bar***
   - an additional factor of about 2 can be gained in the X-ray signal detected by the CCDs going from 1 to 2 bar in all the considered targets and setup configurations.

Table 1: Summary of Monte Carlo results for different setups and different kaonic atoms. N as target means NTP target; C as target means CRYOGENIC target.

K atom	Targ	Press. (bar)	X-ray energy (keV)	Yield of trans. (%)	CCD22 (+effic)	CCD05 (+effic)	Kaons stop in targ. (%)	X-ray for $L_{int} =$ 1 pb^{-1}	X/hour for $L_{peak} = 10^{32}$ $cm^{-2}s^{-1}$
KN	N	1	$\sim$7.5	$\sim$80	-	4($\sim$ 40%)	1.92	65	23.4
KN	N	2	$\sim$7.5	$\sim$80	-	4($\sim$ 40%)	3.41	104	36.5
KN	C	1	$\sim$7.5	$\sim$80	-	4($\sim$ 40%)	0.65	113	40.7
KN	C	2	$\sim$7.5	$\sim$80	-	4($\sim$ 40%)	1.28	200	72.0
KN	C	1	$\sim$7.5	$\sim$80	8($\sim$ 60%)	4($\sim$ 40%)	0.65	527	189.8
KN	C	2	$\sim$7.5	$\sim$80	8($\sim$ 60%)	4($\sim$ 40%)	1.28	1087	391
KH	C	3 (25K)	$\sim$6.5	$\sim$3	8($\sim$ 75%)	4($\sim$ 60%)	2.9	120	43.2
KH	C	3 (25K)	$\sim$6.5	$\sim$3	8($\sim$ 75%)	8($\sim$ 60%)	2.9	150	54.2
KH	C	3 (25K)	$\sim$6.5	$\sim$3	16($\sim$ 75%)	-	2.9	210	72.3
KHe	N	1	$\sim$6	$\sim$10	-	4($\sim$ 60%)	0.3	3.2	1.15
KHe	C	1	$\sim$6	$\sim$10	8($\sim$ 80%)	4($\sim$ 60%)	0.07	9.3	3.35

In conclusion, in studying kaonic nitrogen, going from the present NTP target with 4 CCD-05 to the actual CRYO one with 8 CCD-22 and 4 CCD-05 one might gain a factor of about 8 in the number of counts; a factor of about 16 increasing the pressure up to 2 bar.

2. **Kaonic hydrogen:** a factor of about 1.7 is gained in the X-ray signal going from the cryotarget with 8 CCDs22 and 4 CCDs 05 to a configuration with 16 CCDs22. 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;

   To be mentioned that the improvement with respect to the "old configuration" ("old" target with 8 CCD-05) is a factor 3.4 - for details see ref. [2].

3. **Kaonic helium:**

   The yield of transition for kaonic helium is not well known; tentatively in Table 1 was taken the value of 10%, corresponding to the value for $3d \rightarrow 2p$ transition in kaonic helium reported in [3].

   As seen in Table 1, going from the NTP target with 4 CCD-05 to the CRYO target with 8 CCD-22 and 4 CCD-05, a factor of about 3 can be gained in the X-ray signal.

   To be mentioned here the fact that the gain in X-ray signal passing from one configuration to the other is much less than in the case of kaonic nitrogen (only 3 instead of 8) due to the fact that in Helium at NTP the decay of kaons plays a major role.

References

[1] C. Petrascu, "Monte Carlo Calculation for the new NTP DEAR setup", DEAR Technical Note, IR-12, February 3, 1999.

[2] C. Petrascu, “DEAR Monte Carlo results for the ”16 CCD-22” cryogenic target setup, DEAR Technical Note, IR-20”, April 10, 2000.

[3] S. Baird *et al.*, Nucl. Phys. **A392** (1983)297-310.