K_L flux in KLF experiment in Hall D at JLab

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Below, we discuss the flux of the secondary beam of the K_L on the cryogenic targets of the KLF experiment.

In the K-long Faciliyty (KLF) proposal [1] we expected about $10^4 K_L/s$ on cryogenic targets. In the modified setup with the GlueX detector in Hall D we need to change some parameters and see if we can still meet expected yield of neutral kaons on the cryogenic targets. Briefly, the electron beam with $5\mu A$ current will impinge on a 20% radiation length copper radiator, creating the flux of photons, which then interact with 40 cm Be target 24 m upstream of liquid hydrogen (deuterium) target with 6 cm diameter and 40 cm of length. Intensive Monte Carlo studies with GEANT4 program show that 10cm tungsten plug installed after the Be target, so called kaon production target (KPT) to dump the non-interacted photons may not be sufficient and the plug should be 14 cm long instead of 10 cm, also the 6 cm diameter should be reduced to about 5cm to avoid the beam directly shining on the drift chambers of the GlueX detector. This means that the flux will be reduced by 1.4 times due to the tungsen plug and $(6/5)^2 = 1.44$ due to the reduction of the radius of the Be target, so in total the flux will be reduced by factor of two. This rises the question to estimate more rigorously the flux of K_L beam on a target.

In Fig. 1 the yield of K_L is presented from the SLAC measurements [2] for 10 GeV electrons scattering at $2°$. The total integrated yield in the range of $P(K_L)$ = 1-7 GeV/c is bout 10 events/10^4 electrons $\cdot$ sr.

For our case with KLF then we will have the solid angle of $\Delta\Omega = \pi r^2/\mathrm{L}^2 = \pi \times 2.5^2/2400^2 = 3.4\ \times 10^{-6}$ sr. The number of electrons for 5 μA current is $5\times10^{-6}/1.6\times10^{-19} = 3.1\times10^{13}$. The length of Be target in SLAC experiment was 1.75 r.l. which is 33 cm, compared to 40 cm in KLF which leads to the increase of the yield by 40/33 = 1.2. Then in SLAC they used 7 cm tungsten plug compared to 14 cm in our case, the reduction of the flux by factor of two. The radiation length in our case we assume 20% of the copper radiator.

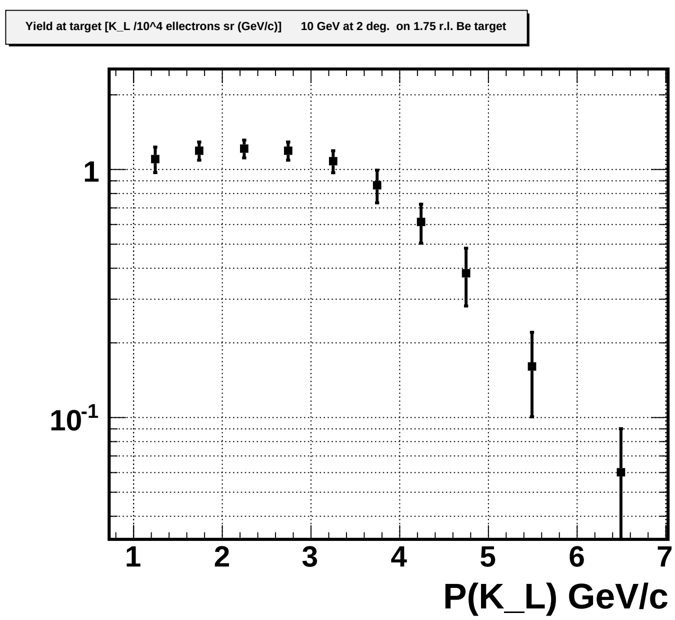

FIG. 1. The K_L yield measured at SLAC for 10 GeV electrons scattering at $2°$.

Putting all these numbers together we will have the following yield of K_L on physics target:
$N(K_L) = 10 \times 10^{-4} \times 3.1 \times 10^{13} \times 1.2 \times 0.5 \times 0.2 \times 3.4 \times 10^{-6} = 1.2 \times 10^{-3+13-6} = 1.2 \times 10^4 K_L/s.$

In conclusion the following parameters of the secondary beam line will lead to about 10^4 K_L/s:

- electron beam current I=5 μA
- copper radiator 20% r.l.

- diameter of the Be target 5 cm, the length 40 cm
- length of the tungsten plug 14 cm

[1] M. Amaryan *et al.* [KLF], "Strange Hadron Spectroscopy with Secondary KL Beam in Hall D," [arXiv:2008.08215 [nucl-ex]].
[2] G. W. Brandenburg, A. D. Brody, W. B. Johnson, D. W. G. S. Leith, J. S. Loos, G. Luste, J. A. J. Matthews, K. Moriyasu, B. C. Shen and W. M. Smart, *et al.* Phys. Rev. D **7** (1973), 708 doi:10.1103/PhysRevD.7.708