Search for new light particles at ILC main beam dump

Yasuhito Sakaki[1*], Daiki Ueda[2†] and Mihoko Nojiri[1,3‡]

[1] *High Energy Accelerator Research Organization (KEK), Tsukuba, Ibaraki 305-0801, Japan*
[2] *Department of Physics, Faculty of Science, University of Tokyo, Bunkyo-ku, Tokyo 113-0033, Japan*
[3] *Kavli IPMU (WPI), University of Tokyo, 5-1-5 Kashiwanoha, Kashiwa, Chiba 277-8583, Japan*

Abstract

We propose a beam dump experiment at the International Linear Collider (ILC). We investigate the sensitivity of the beam dump experiment by considering axion-like particles. We show that the detection sensitivity of the beam dump experiment at ILC is almost an order of magnitude higher than other beam dump experiments.

Introduction — ILC is one of the future collider experiments with electron and positron beams. In the ILC experiment, a large number of high energy particles, such as photon, muon, and electrons, is produced in the beam dump. We propose a feasibility study of a beam dump experiment at the ILC, which provides a possibility to search for new light particles. We also provide an estimate for the sensitivity of axion like particles (ALP).

An experimental setup — We consider an experimental setup consisting of the main beam dump, a muon shield, a decay volume, and a detector. The absorber of the main beam dump is water. [1]. It is assumed that lead is placed where muons pass on the shield. The detector's shape is assumed as a cylinder, and its axis was aligned with the beam axis. For ILC-250, the beam energy is $E_{\rm beam} = 125$ GeV, and the number of incident electrons into the beam dump is $N_{\rm EOT} = 4 \times 10^{21}$/year [2].

Axion-like particles — We consider the following effective Lagrangian for ALPs: $\delta\mathcal{L} = -\frac{1}{4} g_{a\gamma\gamma} a F_{\mu\nu} \tilde{F}^{\mu\nu} + \frac{1}{2}(\partial_\mu a)^2 - \frac{1}{2} m_a^2 a^2$, where a is the ALP, which is produced by photons in a water dump. After passing through the muon shield, ALP decays in the decay volume and emits two photons, which reach the detector and are observed as a signal.

In Fig. 1, the red and black curves are the bounds of constraint for ILC-250 at 95% C.L. with 1 year and 20 years statistics. The shaded regions are constraints from other experiments. It can be seen that the ILC beam dump experiment has almost an order of magnitude higher sensitivity than other beam dump experiments in the small coupling region. We also have obtained similar results for a scalar particle coupled to leptons.

Proposal — We would like to discuss or work on the following things:

- Comparison with LHC results
- Considering other searchable new Physics
- Monte Carlo simulation (including background estimation)
- Is there a better design/concept for the experiment? (In particular, what is the optimal length of the sub-tunnel behind the main beam dump?)
- What is a feasible design of detectors and a muon shield?

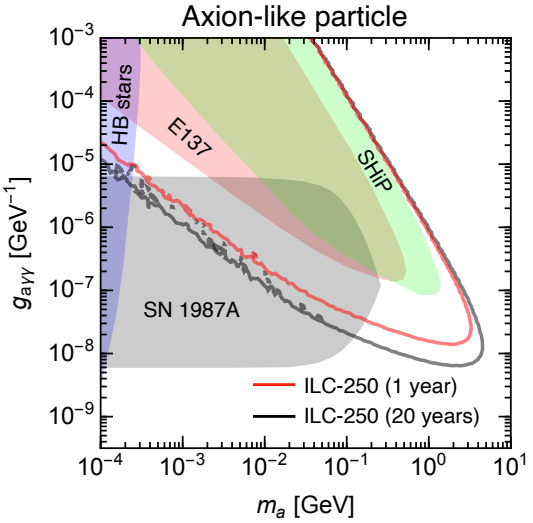

Figure 1: Sensitivity reaches for the ILC beam dump experiment for the axion-like particle. The red and black curves are the bounds of constraint for ILC-250 at 95% C.L. with 1 year and 20 years statistics. The shaded regions are excluded regions or sensitivities from other experiments. Taken from [3].

*sakakiy@post.kek.jp
†ueda@hep-th.phys.s.u-tokyo.ac.jp
‡nojiri@post.kek.jp

References

[1] P. Satyamurthy, P. Rai, V. Tiwari, K. Kulkarni, J. Amann, R. G. Arnold, D. Walz, A. Seryi, T. Davenne, O. Caretta, C. Densham and R. B. Appleby, Nucl. Instrum. Meth. A **679** (2012), 67-81 doi:10.1016/j.nima.2012.01.075

[2] T. Behnke et al., [arXiv:1306.6327 [physics.acc-ph]]; H. Baer et al., [arXiv:1306.6352 [hep-ph]]; C. Adolphsen et al., [arXiv:1306.6353 [physics.acc-ph]]; C. Adolphsen et al., [arXiv:1306.6328 [physics.acc-ph]]; T. Behnke et al., [arXiv:1306.6329 [physics.ins-det]].

[3] In preparation. A first paper on this project will be submitted on arXiv in early September.