Subcritical Fission Reactor Based on Linear Collider

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Abstract

The beams of Linear Collider after main collision can be utilized to build an accelerator–driven sub–critical reactor.

■ The project of Linear Collider (LC) contains one essential element that is not present in other colliders. Here each electron (or positron or photon) bunch will be used only once, and physical collision leave two very dense and strongly collimated beams of high energy electrons or/and photons with precisely known time structure. We consider, for definiteness, electron beam parameters of the TESLA project [1]

$$\begin{array}{c} particle\ \ energy\ \ E_e = 250\,GeV, \\ number\ \ of\ \ electrons\ \ per\ \ second\ \ N_e = 2.7\cdot 10^{14}/s, \\ mean\ \ beam\ \ power\ \ P_b \approx 11\ MWt, \\ transverse\ \ size\ \ and\ \ angular\ \ spread\ \ negligible. \end{array} \qquad (1)$$

In the Photon Collider mode the used beams contain photons, electrons and positrons. They are not monochromatic but have the same characteristic particle energy (with large low energy tail) and the same mean power.

The problem, how to deal with this powerful beam dump, is under intensive discussion.

Main discussed variant is to destruct these used beams with minimal radioactive pollution (see e. g. [1]). It looks natural also to use these once–used beams for fixed target experiments with unprecedented precision.

Recently we suggested to utilize these used beams to initiate work of subcritical fission reactor and to construct neutrino factory [2]. Here we present estimates for one of these options. Real choice and optimization of parameters should be the subject of detail subsequent studies.

■ The idea to work with sub–critical nuclear reactor, initiated by proton or electron beam, for foolproof production of energy and/or cleaning of nuclear pollution is well known (see e. g. [3]). Here proton or electron beam with particle energy of about 1 GeV is supposed to produce neutrons in the cascades within body of reactor. The problem here is in obtaining necessary beam power $P_b \geq 5$ MW.

According to (1), each used beam of LC is two times more powerful than necessary for this reactor but electron energies are two orders larger. In the suitable target this particle energy can be transmitted to low energy particles to initiate fission process in reactor.

Qualitative description

• The first redistribution of beam energy to a large number of "working" electrons and photons can be realized in special *degrader* – e.g., 0.5 m water pipe with the radius of a few cm. (Water should rotate to prevent vapour explosion.) After passing the degrader, particles with mean energy in hundreds MeV penetrate into the main body of reactor filled with uranium or thorium. After the photons reach the energy of about 10 MeV in the electromagnetic cascades, they get absorbed by nuclei (in giant resonance), producing neutrons.

The scheme of proper reactor is a subject of separate study of reactor specialists.

• To realize this reactor, the crab crossing scheme for main collision may be preferable to place the reactor away from accelerator beam. We assume for definiteness the crab crossing angle of 15 mrad.

One or two sub–critical reactors can be situated at about 500 m from collision point, at about 7 m from accelerating channel providing good protection of collider beam pipe. (Considered used beam should move towards the reactor through low pressure gas after it passes some window protecting high vacuum of collider.)

• The obtained accelerator–driven foolproof sub–critical reactor can be used for energy generation and extra nuclear pollution cleaning. The economical problems are beyond this proposal.

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