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ANL Flexible Linear Collider

------ A 3TeV Linear Collider Using Short rf Pulse (~20ns) Two Beam Accelerator Concept

Proposed by AWA, HEP & Euclid Techlabs, LLC

Identification and Significance of the Issue:

Ongoing efforts toward a TeV scale electron-positron linear collider from the International Linear Collider (ILC) and Compact Linear Collider (CLIC) teams have been well established. Both proposed machines work at frequencies within microwave range. The ILC, which uses superconducting cavities, is designed to operate with the rf pulse length of 1.5ms and according gradient ~35MV/m. And the CLIC, which is based on the room temperature Two-Beam Accelerator (TBA) scheme, chooses the rf pulse length of 240ns and the loaded gradient of ~100MV/m. Meanwhile, schemes using plasma or laser based wakefield acceleration schemes are emerging, where the accelerating gradient in GV/m level has been demonstrated in various experiments, but issues with efficient acceleration, staging and positron accelerations are yet to be demonstrated. Therefore, an alternative design of the high energy machine beyond the Large Hadron Collider (LHC) era still attractive and meaningful, in particular, because history has shown that a good design may not lead to a practical machine due to its cost and other factors. We propose a new scheme that uses high gradient, short pulse and a modular design that capable of achieving 3 TeV with beam power of ~ 15 MW and efficiency of 7%. Higher gradient is desirable for a TeV class linear collider design because it can reduce the length of total linacs. Also, the efficiency and the cost to sustain such a gradient should be considered as well in the optimization process of an overall design.

Technical Approach:

We propose a 3TeV high energy linear collider based on a short rf pulse (~22ns flat top), high gradient (~267MV/m of the loaded gradient), high frequency (26GHz) dielectric two beam accelerator scheme (Figure 1). This scheme is a modular design and its unique locally repetitive drive beam structure allows a flexible configuration to meet different needs (see Fig.1). Preliminary study shows an efficiently (~7% overall efficiency) short pulse collider may be achievable. Major components are:

1. High current drive beam accelerator, inccluidng Klystrons (already commerical available) and Standing Wave Linac.
2. High gradient accelerating structures to sustain 300 MV/m at 20 ns pulse length
3. High poweer extraction devices that capable of > 1 GW at 20 ns pulse length.
4. Beam transport and others.

Research and Development Plan (5 Years):

Argonne National Laboratory is developing a high current accelerator that will be able to provide high quality, high charge, and short bunch length beams using a 1.3 GHz photoinjector RF gun. The facility will be able to generate a 75 MeV bunch train with up to 50 nC charge in each bunch by using a new 1.3GHz rf photoinjector that comprises a high QE CsTe cathode, six standing wave linac tanks, and four Lband 25 MW klystrons. It will provide a unique platform to test GW level power extraction and >250MV/m accelerating gradient. Major milestones related to the LC development are:

1. *75MeV high current drive beamline construction.*
2. *Demonstration of the 40~50A high current beam----generation and transportation.*
3. *Demonstration of ~500MW short pulse 26GHz rf extraction.*
4. *Demonstration of a ~200MV/m, 200MHz bandwidth, short pulse accelerating structure.*
5. *A Two-Beam Acceleration Experiment.*

Required Resources:

1. *ANL support for the bldg.366 expansion in order to house the new AWA 75MeV beamline and necessary experimental area.*
2. *Continued DoE funding for the AWA facility operation and upgrade.*
3. *Continued DoE funding support for the development of short pulse high power rf extractor and high gradient accelerating structure (both ANL and Euclid Techlabs).*

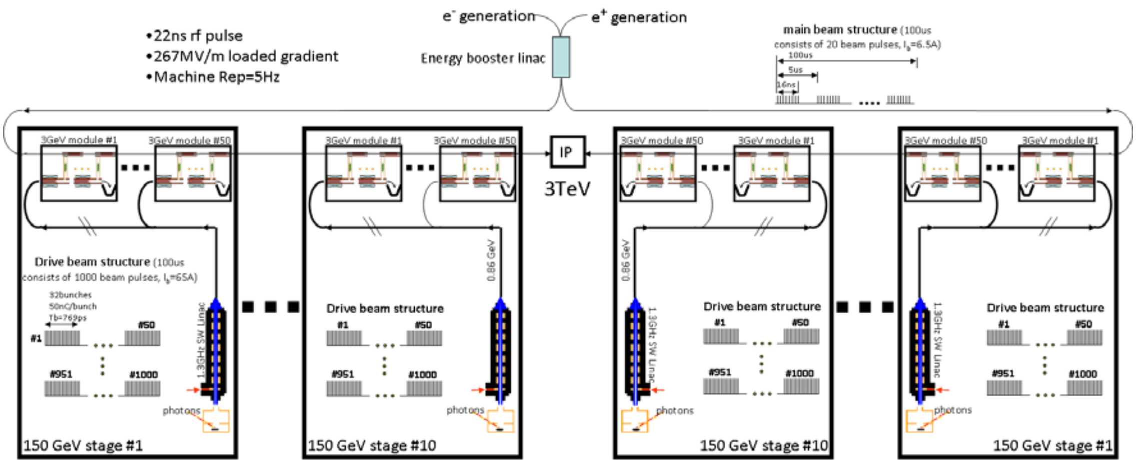

Fig.1. Conceptual layout of one side of Argonne 26GHz 3TeV Dielectric-based Short Pulse TBA Linear Collider . It consists of ten 150GeV stages in one side of machine. Each 150GeV stage is made up of fifty discrete 3GeV modules sharing with one drive beam source, which makes it look like the CLIC scheme except for a few critical differences. Firstly, in each 150GeV stage of the proposed short pulse TBA scheme, 1000 (=50×20) short (~24ns) micro drive pulses go through 50 modules with a local beam pulse repetition rate of 20 (it represents 20 5μs-long macro bunch train as well). Each module provides 3GeV gain, which adds up to 150GeV after 50 modules. Overall, these 1000 micro drive beam pulses, which is organized by 20 repetitive macro 5μs long macro bunches, form a 100μs giant beam pulse. On top of it, machine repetition rate is 5Hz. Secondly, to match the local beam pulse repetition rate of 20, the main beam consists 20 short beam pulses in the same 100μs period of time. Another obvious difference from the CLIC scheme is that the drive beam in this short pulse scheme is generated by a 1.3GHz rf photoinjector in each 150GeV stage with a high QE cathode, which can provide 50nC/bunch with a bunch separation of 769ps (32 sequential bunches form a ~24ns micro drive pulse). At last, to achieve a high rf-to-beam efficiency in the main linacs under the short rf pulse condition, we choose a high frequency (26GHz), high group velocity (~11%c), and dielectric based structure (broadband rf coupling), which in turns provide ~270MV/m of gradient (with assumption of no breakdowns at this level in a 20ns pulse duration), ~9ns filling time, and ~3ns rise time.