New Physics of EEE for Opening Subquark Physics

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Abstract: Opening new physics of Electric and Electronics Engineering now is necessary for opening subquark physics, just as the quark physics was opened in 1960s by the new EEE physics the klystron in 1930s, the linac in 1940s, and collider in 1950s.

I. Introduction

Owing to the situation that the project of SSC was abandoned, and the LHC schedule is extended, one has time now to deal with the basic technological physics problems of LC (Linear Collider) and HC (Hadron Collider). Thus, a Collider Detector and Particle Physics Development Chart (CDPPDC) has been designed to improve the Livingston Chart. It has been presented as an equilibrium principle between the Trend of Electric and Electronics Engineering Technologies (TEEET) and the Extraordinary Particle Physics Exploration (EPPE). Because of this objective reality TEEET should be considered as an important factor in CDPPDC as well as physical and political motivation.

In CDPPDC one can see that the energy of electron beam is always lower than that of proton beam. Nevertheless, there is a Panofsky Leap Forward of new TEEET which is klystron linac. It makes the energy of electron beam equal to proton beam firstly, and results in the discovery of the quarks.

One can expect that the subquark physics will derive at the next Panofsky Leap to make the energy of LC match the LHC; Thereby, it is essential to increase the acceleration gradient like S, C, X, K Band Klystron, Relativistic Klystrons, L Band Klystron of TESLA, TBA, even WFA, LPA, TFE, LA, etc.

However, the new TEEET problems of detection to be enhanced for LC as well as
detectors of LHC are emphasized in this paper and will be investigated elaborately in following papers.

The conclusion is that the R&D of LC should expedite to match HC, and the international cooperation or joint venture for developing LC is necessary to open subquark physics. Therefore, we must invent new techniques with new conceptions beyond ANSI/IEEE std. 100-1992 and the existing orthodox quantum theory in standards of ANSI, DIN, JS, GB; as well as IEC, IEEE, ISO etc.

II. Improvement of Livingston Plot

The rising energy fronts of accelerators and colliders of high energy physics are expressed by the Livingston Lines. It encourages people to lay out the HERA [1] and LHC [2], SSC [3], even ELOISARON [5]. Furthermore, TLC [6], JLC [7] CLIC [8,9], TESLA [10], VLEPP [11], etc. are all fitted on the Livingston Plot. The newest Livingston Plot is composed of a couple of parallel straight lines on the dual logarithm plot of energy versus age. One is the electron Livingston Line, another is the proton Livingston Line. The energy gap between these two lines is about one order. It represents the intrinsic technology difference between proton colliders and electron colliders. The Livingston Plot overlooked the luminosity, which was deemed as correct in the past time, as far as the luminosity is no problem when the energy is below 400 Tev for proton colliders or 200 Gev for electron colliders. It can be resolved by the storage rings where a bunch is used to collide again and again after revolutions. Storage rings are available for e+e- colliders of energy below 200 GeV. The recent progresses are the upgrade of famous e+e- collides ANODE, BEPC, PEP, CESR, TRISTAN going to Φ, τ-C, and B Factories.

However, the energy of the next generation electron/positron colliders is greater than 1TeV. Hence the storage ring will fail to work because the energy loss of synchrotron radiation will render the increase of energy. Hence, people have to choose the new projects of Linear Collider [12-14], say LC.

Conversely, in the case of LC, the increase of energy is fundamentally capable, [15] but the increase of luminosity is not easy, because every bunch can merely be used to collide once each time. The repetition rate of the bunch generators can not be anticipated to increase significantly in the near future. In this case the only choice to increase the luminosity is to highly focus the bunch. Thus, a lot of new technical or technological problems of electrical or electronics engineering issues are produced. Of course, the primary one is to improve the Livingston Plot in such a way as to involve the renovation of luminosity. The second is increasing accelerating gradient based on traditional LC.
III. CDPPDC Plot of HEP Collider Projects

CDPPDC means Collider, Detector, and Particle Physics Development Chart. CDPPDC shows the development tendency of HEP (High Energy Physics). It is represented in a (Hilbert) state space, which has three abscissas and three ordinates. Let abscissas are: (1) MeV/GeV/TeV energy scale of collider, (2) ps/μs resolution of electronics, (3) device/channel/processor complexity of detector, and electronics. Let ordinates are: (1) GHz * MW/generation of heavy electronics, (2) luminosity/flux/million of particle physics, (3) annual progress

CDPPDC shows that the above tendency of particle physics is parallel to the development line of pp ep, e⁺e⁻ colliders as storage detectors. The very greatest thing is that they are all parallel to the development lines of SEE (Electronics + Electronics Engine + EE) including heavy-electronics, microelectronics, and photonics.

IV. Equilibrium Principle of TEEET and EPPE in CDPPDC

If one deals with the luminosity line precisely and goes into details, then one can see that it splits into three parallel lines. The inner is the proton/proton (or anti-proton) line, the middle is electron/proton line, and the outer is the electron/positron line. The energy gaps between these three lines are nearly equal.

Furthermore, notice that the proton/proton (or proton/anti-proton) line and the electron/proton line are identical, but the electron/positron line is not so. It is broader and goes downward and then upward. The situation shows that the electron/positron collider is one of the most complicated Livingston Lines.

However, in general, all of the three are in parallel, and they parallel to the development lines of TEEET including the response of electronics and photonics, the transistor density of VLSI, the complexity and the power + frequency of RF devices. It shows that the development of EPPE is in equilibration with TEEET. We call it the equilibrium principle of TEEET and EPPE in CDPPDC.

V. Fifth Technical and Engineering Leaps for Collider Development

One can find that there have been five leaps on the CDPPDC which are the technical basis or opening quark physics:

A. Fermi/Top Forward:

In 1967 the energy of new 20 GeV electron line at SLAC jumped to the energy of 20
Only proton accelerator AGS at BNL in 1962 by the proton beam technique. This big jump was the first, and hitherto, the only leap forward of the accelerator development on the CDPPDC. It resulted in the discovery of quarks and the opening of the deeper level of the particle physics, the quark physics.

B. O’Neil—Rinder Leap;

Storage rings for e+ e- collider has been researched by Princeton—Stanford group at Stanford since 1950s. It was a new method of HEP experiments in that time. This technical and engineering leap resulted in the discovery of charm quark in 1974.

AGS at BNL collaborated with ANGDE at Frascati, and SPEAR at SLAC discovered the 4th quark, the charm which is a new quark suggested by GIM theory. Before GIM theory the quark model of Gellman—Neeman has three quarks only.

C. van de Meer—Rubbia Leap;

In the early 1980s CERN got the important luminosity to avoid the decline of proton/anti-proton collider from proton/proton Livingston line of the CDPPDC by the stochastic cooling. The dispersive anti-proton bunch. This leap led to the discovery of the intermediate bosons. This is the most important confirmation of the Standard Model.

D. Racker—Hees Leap;

In the 1980s SLAC created the new idea of electron/positron collider, the linear collider, and proved by SLC. It directed toward the discovery that merely three generations exist for quarks and leptons which is in concurrence with the Standard Model. This result has been followed, developed and excelled by LEPI immediately. However, the best result is that the NLC (Next generation Linear Collider) was proved to develop by the way of SLC.

E. Wilson—Lederman—Preble Leap;

In the beginning of 1990s FNAL Tevatron a superconductor proton/anti-proton collider is aiming at searching for the top quark, concurrently the last of six quarks of the Standard Model. Now top quark is confirmed by CDF and D0 on Tevatron [16, 17].

F. Next Leap;

According to the equilibrium principle of EPPE and (EEEP) expressed in CDPPDC Plot, we can expect that the subquark physics will arrive at the time of next Panofsky Leap. Hopefully, in that time the energy of LHC at CERN with imaginative, the Pacific Linear Collider suggested by J. M. Paterson[5] will match the Mediterranean Eicronatron suggested by A. Zichichi[5]. One of the most story (EEEP) processes in Next Leap is about a detection either in detectors or in colliders.

Obviously, all of these five leaps hold the same major mechanism of increasing the collider energy. Meanwhile, the importance of luminosity, the precision of colliding and detecting are also increasingly prominent [19, 20]. That means the intensification of detection either in improving the detectors or in improving the colliders are interesting.
VI. The Special Position of LC on CDPPDC

(1) Proton accelerators, proton-antiproton colliders, and proton-proton colliders are developed smoothly on the same development line without any brokenness in last 60 years.

(2) Electron-proton colliders as well as electron accelerators, electron linacs are in the same situation, and are all parallel to the development line of proton-target accelerators, proton-proton, and proton-antiproton colliders.

This situation means that those machines are developed by means of improving or innovating ordinary EEE technologies, but there was no new physics of EEE raised by machine R&D.

(3) Only electron-positron collider development line was broken into two lines at the state point of SLC/LEP. This line broken means electron-positron colliders lag behind proton machine, and the R&D becomes complex.

In point of view of EEE, this special case means that the R&D of LC must spread widely on many fields of EEE. Most of R&D are located on the frontier of EEEET. Hence, LC has strong effect of "Spin Off". Therefore, it is not only the interest of HEP, but also benifits industry. Thus, the R&D of LC has strong vitality, and it will be also the motivation of opening new basic research.

VII. Advanced EEE Problems of LC

Though the detectors of LC should be easier to design and run than that of the detectors of HC, because the events of electron-positron collision are more clear, the colliding rate and the hadron background are much lower than the proton-proton collisions. However, the detection problems of LC still become more difficult than that of the proton-proton colliders, since it comes from the LC itself.

One of the most hard problems of LC is how to increase the luminosity. The difficult problem of increasing the luminosity of LC is how to detect and measure the diameter of the bunch cross section in the dimension of nanometer? And how to measure the bunch length in the dimension of micron? Another is Beamstrahlung and Bunchstrahlung of bunch photon backgrounds. It is resulted from the ultra forcusing and compressing beam interaction.

These kinds of detection and measurement are very important in the real time control for increasing the luminosity and for the precise measurement of short life events. The advanced Shintake spot size monitor with 266 nm wavelength of 4th harmonic Nd-YAG laser can measure [23]1/10 μm spot, and is the best solution by the existing EEE technologies. Further, this approach makes one consider the critical problem of recent EEE which surpass the standard of EEE.
VIII. New Problems of Detection in Detectors

Originally, humans are good at observation with vision, where visual sense, imaging, persistence, impression, as well as intelligence are all parallel in eye and brain. Hence, it is very fast, particle physicists can explain the physical meaning immediately, when he saw an image of event in bubble chamber. Thus, in point of view of understanding event, bubble chamber is the best detector, because it is well matched to human visual perception.

At present, because of extremely huge event rate, which blocks the photo system of bubble chambers either in on-line acquisition or in off-line analyzing. The full electronic detector which has been developed significantly to open subnuclear physics by R. Hofstadter as early in 1950s[21], and has been further developed by G. Charpak as a revolution of detector and high energy experimental methods[22]. Now bubble chambers have already been eliminated by the full electronic detectors. It has the ability of real time triggering decision which can auto select the good events in a rate of one event/s from the great huge background events, and has been used to test the Standard Model of quark lepton physics successfully. However, one can not see events directly in a electronic detector like bubble chamber photos, because all output signals are electronic. It has to be read out by an on-line computer system and interface system.

The coming proton colliders like LHC, are going to open the new physics which is beyond the Standard Model. Meanwhile, the detectors may have data flow of up to the billions bytes/sec with the parallel output of millions channels. Thereby, in comparison with bubble chamber, some shortage of electronic detector will appear as follows:

A. Bottle Neck of Data Flow

The von Neumann architecture of on-line computers are too hard to work, because it is required to have one to ten millions arms (equivalent VAX-11-780).

B. Parallel Output and Serial Read

The detector has about millions channels of parallel output, but the electronic readout are various kinds of serial operation like CCD, Multiplex, Analog bus, ADC, TDC, Waveform Memory, Digital bus, VME/VXI interface, etc. Hence, they are very hard to be included in the data acquisition system without piling up.

C. Vertex Imaging

The resolution of vertex imaging is still worse than that of the bubble chambers in spite of the fact that it has ten millions of pixels or more. However, the vertex imaging is important to open a new physics.

D. Dead Region

The electronic detectors inserted in a collider are good at detecting the large transverse momentum events, but usually hampered by the dead regions for the detection of small
transverse momentum events which may be important to open a new physics. Conversely, there is no dead region in bubble chambers.

E. Priori Triggering

The electronic triggering always require priori, therefore, it is difficult to preset the triggering logic without an explicit subquark model like the Standard Model of quark physics. Even chambers do not need any priori. Theoretically, it can record the unknown events.

The physical results of great detectors are usually exceeding their expectation of orginal physical goal. IMB, Kamiokande II are the typical examples. Their physical goal is to detect the proton decay, but the result is the discovery of Super NOVA SN1987A. However, one of the constant development of the detector is as great as possible. It leads to the production of Gran Sasso project in 1990s.[4]

F. von Neumann Principle

Million channels of detector dataout every triggered good event are parallelly into online computer to do imaging. Unfortunately, all computers are clumsy to do the job of vision, because von Neumann principle of computer is serialism which is extremely good at computing, but very stupid at vision. Thus, the value of LC and HC is limited by the computers between detector and human vision.

G. Reducing Randomness of Photonic Signal[24-1,44]

For the purpose of improving resolutions of PID and calorimetry the randomness of signal photoelectron of TOF, Arogel, DIRC as well as scintillating fiber should should be reduced.

IX. Suggestible EEE Physics on \( R^2 \cdot D \) of Collider Detector[16,24-31,44]

1. Parallelism replaces a mono von Neumann figure host computer as an on-line computer.
2. Feedforward trainable ANN triggering replaces priori logic of triggering.
3. Hillis-Feynman figure of Boolean Cubic connectionism replaces bus (for example VME, VXI bus) and interface.
4. Perception ANN Readout Electronics replaces CCD, Multiplex and analog bus.
5. Systolic VLSI and Systolic Array with Boolean Cubic to be the local processor.
7. Beside ADC, TDC, and Waveform Memory one can research the Analog-Space Convertor (ASC).
8. Dead cone free detector of Photoelectronic or "Photonic Bubble Chamber".
9. Picosecond and micron technique for high resolution vertex imaging.
10. The great detector is envisaged to be a benefit of the high energy astrophysics including the search of monopole. According to Drell and Parker, those detectors have to be huge
in size, at least with a length of several hundreds meters. We investigated the scintillating fibers and films concerned with such large dimension. These very long distance transmitting scintillation signal can also be used in Bjozken's detector.

(11) Reducing the intrinsic (including quantum) randomness of single photon, in photonic imaging, timing and calorimetry.

X. Suggestible EEE Physics on Detection and Accelation of NLC Bunch[6-41]

(1) Resolution technique for measurement of bunch size in femtosecond and nanosecond.
(2) Virtual photon detection technique for bunch signal dynamics.
(3) Mode analysis of virtual photon travelling.
(4) Four dimensional potential photon extends IEEE standard of detection and EEE measurement of electric strength and as the bunch signal carrier.
(5) de Broglie wave phase shift as the bunch signal carrier.
(6) Gauge invariance of EEE measurement.
(7) Causality and probability of EEE measurement.
(8) Virtual photon accelerator.

XI. Conclusions

Some suggestions have been raised since we worked on BES/BEPC.[42-47]

(1) The Standard Model of quark-lepton physics is based on the technical level represented in the Standard Terms of ANSI/IEEE std 100-1992. To open the new physics of subquark we have to invent new techniques with new conceptions beyond ANSI/IEEE std 100-1992.[40,41]

(2) The R&D of LC should be expedited to match HiC. According to Penojsky Leap Forward in CDPPDC which opened the new physics of quark the sub-nucleonic physics, the next new physics of sub-quark will be opened by the next "Penojsky Leap Forward" in which the energy match between proton/proton collider and electron/positron collider will happen.

(3) LC R&D needs: (a) QED conception of EM field beyond ANSI/IEEE std-100-1992, (b) virtual photons in QED, (c) information carrier beyond orthodox quantum theory.

(4) Detector R&D needs non von Neumann computer with full parallel readout electronics. It also needs new quantum theories to improve resolutions.

(5) If high energy physics community pay more attention and more money invested on the EEE photon research to expedite the new TEEET on CDPPDC, then the sub-quark physics will be open more quickly.
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