INTERLABORATORY COLLABORATION FOR R&D TOWARD TeV-SCALE ELECTRON-POSITRON LINEAR COLLIDERS

Member Institutions and their Representatives as of June 1994

Asia

IHEP	S. Wang	WANGSH@BEPC2.IHEP.AC.CN
KEK	K. Takata	TAKATA@JPNKEKVX
POSTECH	W. Namkung	NAMKUNG@VISION.POSTECH.AC.KR

FSU

BINP	V. Balakin	BALAKIN@VLEPP.SERPUKHOV.SU
DUBNA	V.Sarantsev	SARANCEV@SSD.JINR.DUBNA.SU

Europe

Aachen	K. Lubelsmeyer	
Berlin	H. Henke	HENKE@TU-BERLIN.DE
CEA	J. Haissinski	
CERN	K. Hubner	HUBNER@CERNVM.CERN.CH
Darmstadt	T. Weiland	DD2E@TEMF00.TEMF.E-TECHNIK.TH-DAMSTADT.DE
DESY	B. Wiik	F35BLU@DHHDESY3
Frankfurt	H. Klein	UF14@DDAGS13
Frascati	S. Tazzari	TAZZARI@IRMLNF
LAL (Orsay)	J. Lefrancois	LEFRANCOIS@LALCLS.CERN.CH
SEFT	R. Orava	SEFT@PHCU.HELSINKI.FI

America

BNL	R. Palmer	PALMER@BNL
CEBAF	Ch. Leemann	SOLTYS@CEBAF.GOV
Cornell	M. Tigner	TIGNER@LNS62.LNS.CORNELL.EDU
Fermilab	S. Holmes	HOLMES@FNAL
LBL	W. Barletta	BARLETTA@LBL.GOV
Maryland	A. Dragt	DRAGT@QUARK.UMD.EDU
SLAC	D. Burke	DAVEB@SLAC.STANFORD.EDU
UCLA	C. Pellegrini	PELLEGRINI@UCLAHEP

CHARGE TO THE 1994/1995 TECHNICAL REVIEW COMMITTEE

The Technical Review Committee is to consider the goal to design, build, and operate a TeV-scale linear electron-positron collider capable of satisfying the need to explore the particle physics of this energy range. Specifically the Committee is

to examine accelerator designs and technologies suitable for a collider that will initially have center of mass energy of 500 GeV and luminosity in excess of 10**+33cm**-2s**-1, and be built so that it can be expanded in energy and luminosity to reach 1 TeV center of mass energy with luminosity of 10**+34cm**-2s**-1.

The Committee is also asked to comment on the potential of technologies to reach higher energies and luminosities, and to provide alternative physics capabilities, for example gamma-gamma collisions.

The Technical Review Committee is to identify the accelerator physics issues and technological requirements for each approach to provide particle physics opportunities at the energy and luminosity goals stated above. The report of the Committee should contain a brief summary of the status of and expected progress toward understanding and achieving the most important of these requirements. The Committee should attempt to identify areas of possible further collaboration in the world-wide linear collider R&D program.

A draft of the Committee report should be submitted to the Collaboration Council shortly after the LC95 meeting scheduled for March 1995 in Japan.

EXPERIMENTATION

Members

R. Settles (MPI, Chairman)

T. Markiewicz(SLAC, Deputy Chairman)

S. Bertolucci(INFN-Laboratori Nazionali di Frascati)

S. Kawabata(KEK)

D. Miller(University College London)

R. Orava(Univ. Helsinki)

F. Richard(LAL, Universite de Paris-Sud)

T. Tauchi(KEK)

A. Wagner(DESY)

Content of the report for TRC

1. Experimentation (Draft #6   23.5.95)
   - 1.1 Introduction
   - 1.2 Physics
2. Experimentation Aspects
3. IR and Detector Issues
4. Detector Options
5. Tabulation of What's been Done
6. Other Things Left to Do
7. Summary and Recommendations

1. Experimentation

1.1 Introduction

Principal Purposes

(1) Physics goals and related experimental issues

(2) Requirements for machine designs

(3) Issues with a close collaboration between exp. and machine

(4) Generic detector possibilities

1.2 Physics

3 main facets of the physics potential of the e^+e^- collider

(1) Standard Physics

top quark properties

trilinear gauge couplings

QCD

photon structure, minijets

(2) New Physics

Higgs

Beyond the standard model- SUSY

(3) A potential for the heavy higgs scenario at the highest energy.

2. Experimentation Aspects

First stage

Ecm=500GeV

Mh up to 350GeV, ΔMtop =0.5GeV, 1% accuracy of trilinear gauge couplings, and NLSP of SUSY for 10 fb^{-1}

If advantageous commissions at lower energies,

Ecm=250GeV to discover a Higgs up to Mh=150GeV as definite test of SUSY (it may be a SUSY killer.). 1/2 fb^{-1}

Ecm=350GeV for a scan for toponium (Mtop~170GeV). Mtop to 0.5 GeV with 1fb^{-1}/point for 8 to 10 energy points.

Second stage

Ecm=1 TeV, 100 fb^{-1}

Mh up to 0.6 TeV, and SUSY particles (H,A,$H^{+(-)}$, colored superpartners)

Further stage

Ecm=1.5 TeV, 200 fb^{-1}

Mh=0.7-0.8 TeV or new strong interaction through $W_L W_L$ (re)scattering. A question "Ecm=1.5TeV is enough?" to be addressed at a future workshop.

Two IR's

scientific redundancy:

complementary: one for $\gamma\gamma$, $e^-\gamma$, e^-e^- collisions

competition:

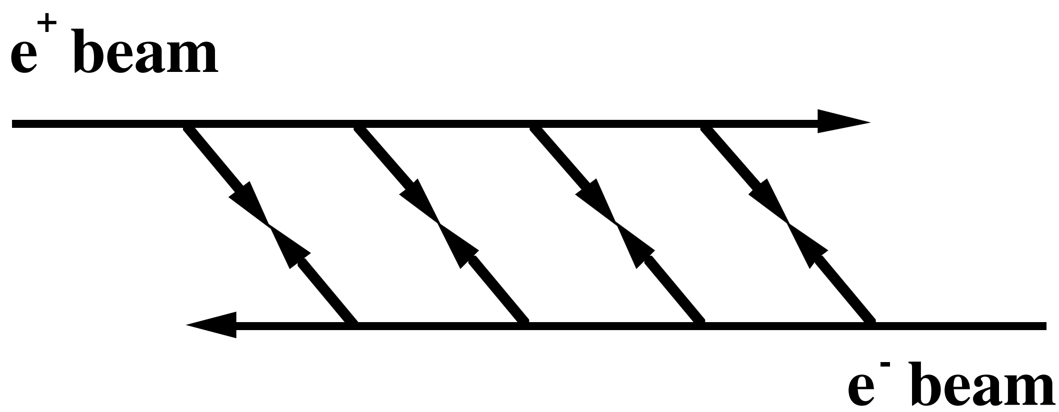
sociology: large society of e^+e^- physics

reliability:

Machine study for

switch between two IR's within a matter of hours ?

even multiple IR's ?



Z^o-pole running for physics

If no Higgs is found up to Ecm=1TeV,

5×10^{31} $cm^{-2}s^{-1}$ for $\Delta\sin\Theta_W$=0.0001 with 90% pol.,

a few $\times 10^{33}$ $cm^{-2}s^{-1}$ for CP violation, for Z^o running.

Polarized beams

for disentangling the trilinear couplings

for the g-2 measurement of the top quark

SUSY studies

$\gamma\gamma$, $e^-\gamma$, e^-e^- collider implications

Complimentary measurement to those at the e^+e^- collider

Higgs production, $\gamma\gamma \to W^+W^-$, e^-e^- resonances, single scalar electron production in γe^- collision, etc. .

Luminosity as a function of Ecm

Minimization of machine-beam energy spread and beamstrahlung

for the top threshold scan, a M_{Higgs} measurement(Mh~Mz) and precise measurements of trilinear gauge couplings.

Need a narrow machine-energy-spread mode >> 0.2% spread

For the detector, good endcap tracking for 0.1% measurement.

Z^o-peak running for calibration

highly desirable, but about 3pb^{-1} of data is enough for 3 or 4 calibrations per year. luminosity=10^{31} cm^{-2}s^{-1}

3. IR and Detector Issues

Background calculations in tables were done by D.Schulte (DESY), which are consistent with ours.

Backgrounds

From upstream,

shynchrotron radiations from beam-tails at QC's

<- beam collimation

muons created at a collimation section to scrape the beam tails

<- big-bend, spoiler magnets and muon-attenuators

machine parameters: aperture of QC1, beam crossing angle, beam-tails

At IP,

minijets from bremmstrahlung and beamstrahlung photons

e^+e^- pairs (incoherent processes)

<- a conical mask defining a dead cone(machine parameters)

<- e^+e^- pair monitor for beam-spot sizes etc.

machine parameters: beam intensity, spot sizes(σ_x,σ_y,σ_z)

Vibrations

Beam stability at the sub-10 nm level in a final focus system

ground vibration of either seismic or cultural origin

Mechanical means

active devices for a beam-based feedback at $f < f_o$

by measuring absolute or relative quad motion

passive devices at $f > f_o$

a support tube linking the quads on either side of the IP

<- detector and FF quad cooling and gas system

Beam diagnostics near the IP

measurement of the beam parameters at the IP separately for each beam at the full beam intensity

-> needs R&D of optical wires etc. located at 20% distance from the IP to QC1 requiring close cooperation between detector and machine physicists

Extracted beam diagnostics

Initial design should begin for an energy spectrometer, a Compton polarimeter and a beamstrahlung photon monitor.

$\gamma\gamma$-collider implications

Conceptual engineering works should begin for laser beam and recoiled electrons, mask, vertex detector....

Trigger rate and Data volume

At the SLC/SLD the trigger rate and data volume can vary enormously from pulse-to-pulse.

-> the trigger and data acquisition system with sufficient dynamic range

trigger rate: trains/sec (<100Hz) or bunches/sec (3~16KHz) depending on the bunch separation; 1.4~16nsec for normal cavity, 1~2 μsec for TESLA

The ability to easily correlate its data (including noise, dark current, e^- or e^+ side) with that of the machine should be a design consideration.

Detector timing

While sub-nanosecond timing has been achieved in various detectors, it is typically not trivial and not available in real-time. Complete realistic conceptual designs for detectors which address this issue must begin.

4. Detector Options

Earlier studies have shown that the performance of existing e^+e^- detectors would be good enough to do much of the physics in the early phase of the machine at low energy.

High performance detectors

JLC detector requiring

(a) hermetic calorimetry in $|\cos\theta| < 0.98$

(b) jet invariant mass resolution comparable with the natural widths of the W and the Z.

(c) a lepton pair recoil mass resolution for $e^+e^- \to Z\,H$ comparable with the beam energy spread of ~200 MeV.

1.5 TeV detector (Europe) similar to the JLC detector.

An alternative would be a small high-field detector. The performance figures of such a detector have not yet been worked out in detail.

6. Other Things Left to do Vibrations

Measurements of Ground Motion

The power spectrum $S(f,k)$, frequency f and wave number k, should be measured at a quiet, a moderate, and a noisy site, tabulated, and made generally available. Current tolerance estimates use semi-empirical formulae to relate frequency and wave number. Also effects on the depth and the tunnel should be carried out.

Engineering of Supports

The concept of the support tube linking both ends of the final focus needs to be more adequately developed.

Active and Passive Vibration Suppression

Devices, which accurately measure the relative motion of the two magnets more in terms of the change in field, need to be developed.

at least a factor of ten safety margin in $f > f_o$

Beam Based Feedback as a Vibration Suppression Tool

Estimates based on actual SLC performance should be carried out. $f < f_o$

Analysis of the Spent Beam

the energy spectrometer and Compton polarimeter under a condition of increased photon background from SLC experience

Pre- and post-collision polarimeters may be required.

Depolarization during a collision

0.4% (Y=0.14) at Ecm=500GeV

5% (Y=0.7) at Ecm = 1 TeV

Practical design for e+e- pair monitor (radiation hardness and multi-bunch collisions)

Background Studies

More elaborate simulations which model realistic detectors, and which allow events from the physics generators to be overlaid, must begin. <- JIM for JLC-I

7. Summary and Recommendations

(1) The lowest energy of the machine should overlap with the highest energy of LEP so that no e^+e^- "discovery gap" exists;

(2) the first stage of the collider is Ecm=0.5 TeV, which opens much of the physics potential, precision measurements of the SM and perhaps discovery of the higgs and/or SUSY;

(3) the machine design energy should encompass Ecm ~ 1 TeV in order to match the discovery reach of LHC and to realize fully the potential for standard and new physics;

(4) it should be upgradable to Ecm ~ O(1.5-2TeV) to realize fully the potential for understanding electroweak symmetry breaking in the no-higgs-particle case;

(5) the luminosity required is up to $100fb^{-1}$/year for precision measurements;

(6) polarized beams are necessary: polarized e^- are essential, polarized e^+ very important;

(7) Z^o -peak running with polarized beams offers the possibility for sensitive new tests of the internal consistency of the SM.

The series of physics milestones between LEP energies and Ecm =1 TeV show that a convincing physics program can consist of commissioning the machine at Ecm=0.25 TeV to 0.35 TeV before reaching the first stage energy of Ecm = 0.5 TeV, and a continuation of the step-wise energy increase up to Ecm =1 TeV.

The strategy of increasing the energy, of pursuing the complementary options of $\gamma\gamma$, γe^-, or e^-e^- collider modes, or of running at the Z^o -pole can be decided after the physics results have been extracted from the 0.5 TeV e^+e^- running.

The detectors are challenging. There seems to be no critical aspect of the detectors which would tell us that any one of machine designs would not allow to achieve the physics goals set forth. Clearly the larger the bunch-time spacing, the easier it will be to do the experiments and extract the physics. The backgrounds will be larger than at LEP, but not so large as to spoil the cleanliness of e^+e^- experimentation we have experienced in the past.

There is quite a lot of R&D work related to IR issues to be done, as discussed in Subsection 6 above; it is mainly related to elimination of vibrations and to a better understanding of backgrounds.