Language: 英語 /English

KEK 物理セミナー Physics Seminar

6 月 21 日 (月) June 21 (Mon)
13:30 ~ 14:30

4 号館 セミナーホール Seminar Hall in the 4th Building

＊ いつもと場所と時間が異なります ＊

The Linear Collider Discussion

Ronald Settles
(Max Plank Institute)

- Abstract:
An overview of physics and detector issues for the sub-TeV linear will be given. I shall dwell some on the European point of view, since I am a member of the ECFA LC organizing committee, specifically on the large detector option, being one of the builders of the Aleph TPC. And I also want to outline world happenings, being also a member of the 'World-Wide-Study' organizing committee. In particular I shall emphasize reasons why a multi-TeV LC cannot be considered for the next machine, and why a sub-TeV machine is the only sensible option. I would like to close with a discussion with the audience, in an attempt to understand the present (slightly turbulent) political situation with regards to achieving our linear collider project.

Past presentations are archived at our home page, `http://seminar.kek.jp/physics/` .

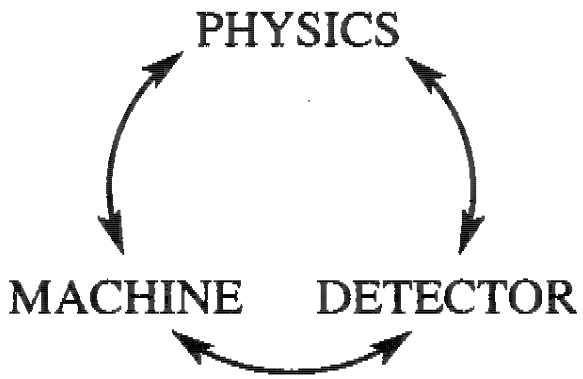
Organizers: K. Yoshimura and I. Adachi

2004.6.17

The International e^+e^- Linear Collider

Status Report by Ron Settles

- Experimentation



- LC Detector
- World Activities
- Politics

KEK June 2004

Ron Settles – Desy/MPI-Munich

Brief History

e^+e^- Linear Collider

- $\sqrt{s} = 90 - 161 - 350 - 500 - 1000$ GeV
- $\sim 10^2$ Physics workshops over last 14 years
- $\sim 10^2$ Machine workshops over last 14 years
- Latest: LCWS 1999 Sitges Apr. 1999
  LCWS 2000 Fermilab Oct. 2001
  LCWS 2002 Korea Aug. 2002
  LCWS 2003 Paris April 2003
  $\cdots$ int'l physics/detector w.s.

  LC99 Frascati Oct. 1999
  LC02 SLAC Feb. 2002
  $\cdots$ int'l LC machine w.s.

Ron Settles

WHY LC?

TWO-PRONG ATTACK at LC on PHYSICS beyond the SM

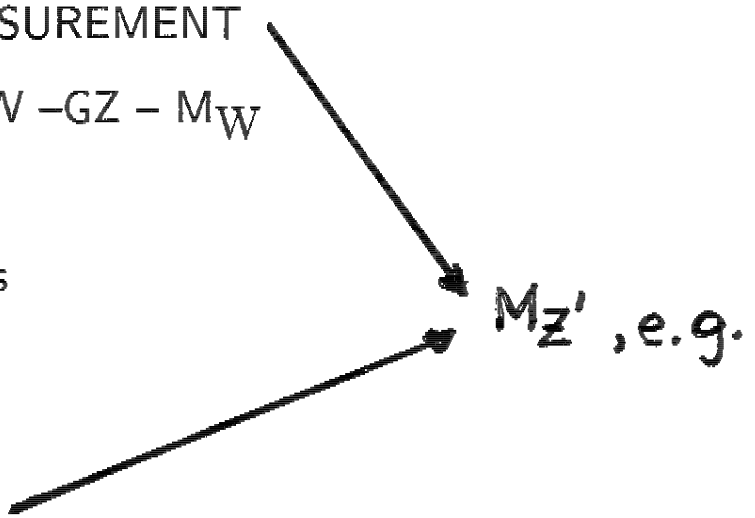
→ INDIRECT

PRECISION MEASUREMENT

Higgs – Top – WW –GZ – M_W

⇒ High statistics

⇒ Polarized beams



→ DIRECT

DISCOVERY

Susy – Alternative Theories

→ NECESSARY COMPLEMENT to LHC

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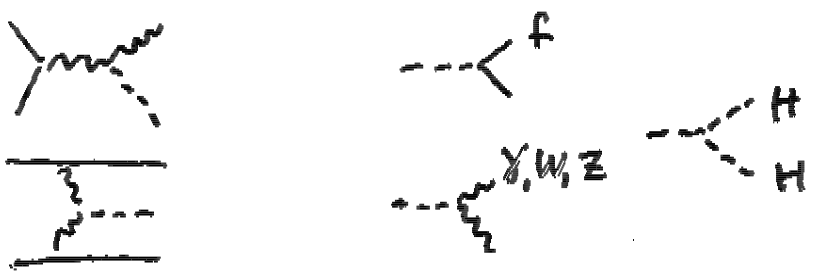
PHYSICS ⟶ MACHINE
Executive Summary

HIGGS

DISCOVERY & PRECISION MEAS. of
PRODUCTION, COUPLINGS



10^5 Higgs few % 20%

→ 500 fb^{-1} @ $\sqrt{s} \sim m_Z + m_W + 25$ GeV
$\sim$ 230 GeV acc. to EW fits

TOP

PRECISION MEASUREMENT
Mass $\delta m_t \sim 100$ Mev

Z charges $\begin{matrix} v_t = 1 - \frac{8}{3} \cdot s_W{}^2 \\ a_t = +1 \end{matrix}$ $\sim 1\%$

Mag., El. dip. mom. $\sim 1\%$, $\sim 10^{-18}$
Yukawa Coupling $g^2_{ttH} \sim 5\%$
→ 300 fb^{-1}, 1000 fb^{-1} @ 400 GeV, 700 GeV
polarized beams

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WW

PRECISION MEAS.
Mag.dip., El.quad. mom.

$$\left.\begin{aligned} \mu_{\gamma,Z} &= -\frac{e}{M_W}[z + \delta\kappa_{\gamma,Z} + \lambda_{\gamma,Z}] \\ Q_{\gamma,Z} &= -\frac{e}{M_W^2}[1 + \delta\kappa_{\gamma,Z} + \lambda_{\gamma,Z}] \end{aligned}\right\} \quad \delta\kappa, \delta\lambda \sim 10^{-3}$$

$\rightarrow$ few 100 fb^{-1} @ 500 GeV
polarized beams

SUSY

DISCOVERY & PRECISION MEAS.
Meas. all Susy parameters
$\rightarrow$ many 100 fb^{-1} up to highest energy
polarized beams

BEYOND E–W

PRECISION MEAS. & DISCOVERY
Z′, f*, H^{ns}, LQ, TC, $n_D > 4 \ldots$
$\rightarrow$ few 100 fb^{-1} up to highest energy
polarized beams

Z – PEAK

PRECISION MEAS.
$\delta \sin^2\theta_W \sim 10^{-5}, \delta M_W \sim 6$ MeV
$\rightarrow$ 1 Giga Z
polarized beams

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POLARISATION

"JEWEL of the LC"

$\mathcal{P}_{e-} \sim 80\%$ $\mathcal{P}_{e+} \sim 60\%$

HIGGS (+ strong WW)	increase S/N	$\mathcal{P}_{e-}$
SUSY (Spectroscopy)	"	$\mathcal{P}_{e-}$ & $\mathcal{P}_{e+}$
E–W Couplings	sep. γ & Z	$\mathcal{P}_{e-}$
Giga Z $\delta s^2_W \sim 10^{-5}$	meas. pol.	$\mathcal{P}_{e-}$ & $\mathcal{P}_{e+}$
QCD	increase S/N	$\mathcal{P}_{e-}$
TOP	"	$\mathcal{P}_{e-}$
BEYOND E–W	"	$\mathcal{P}_{e-}$ & $\mathcal{P}_{e+}$

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Example of Experimental Programme

- World LC

$\sqrt{s} =$	91	500	800/1000	GeV
$\mathcal{L}$	$= 6 \times 10^{33}$	3×10^{34}	5×10^{34}	$cm^2 s^{-1}$

- PHYSICS

Year	Physics	$\sqrt{s}$ Gev	$\int \mathcal{L}dt$ fb^{-1}	Years Running
2015	Commissioning			1
2016	Higgs	250	200	2
2018	Top	350	200	1
2019	WW, HHH	500	500	2
+y	Susy			
2020	Yukawa ttH	750	1000	2
+y	New Physics			
y	GZ	91	50	1
y	M_W	161	100	1

$\Sigma \sim 15-20$

- ENGINEERING READY!

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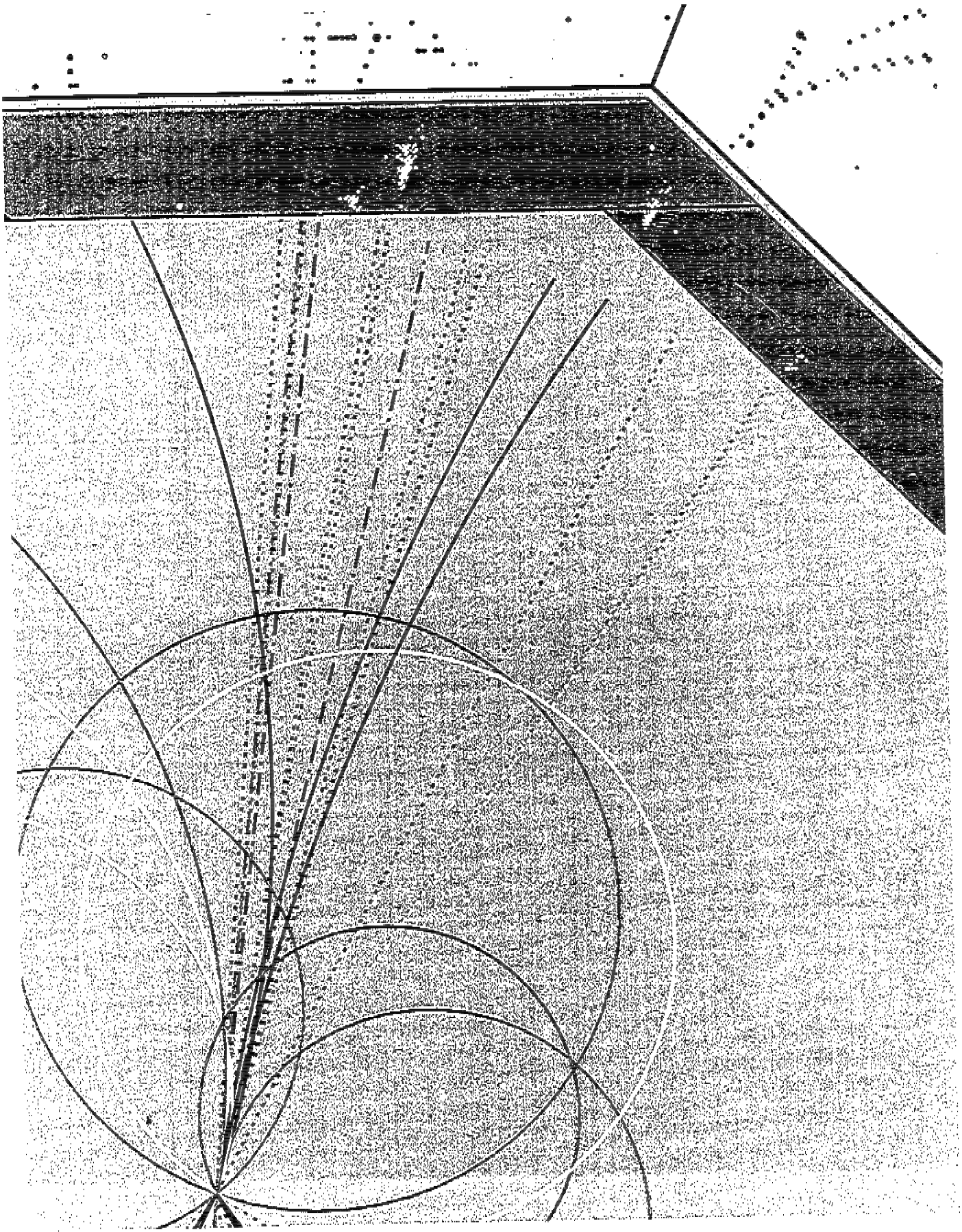
PHYSICS $\longrightarrow$ DETECTOR
Executive Summary

Part of a $q\bar{q}$-event at $\sqrt{s} = 91\,\mathrm{GeV}$



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Crucial Points for LC Detector Concept

Require excellent performance for

- Energy flow
  - * E+H Cal inside coil
  - * min. material "in front of" Ecal
  - * high 3–D granularity
- Tracking momentum measurement
- Vertex resolution
- Hermeticity + forward direction

- Larger backgrounds
  - High $\vec{B}$ field
  - min. material inside Ecal

➡ 3 to 3^2 x better than at LEP/SLC

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Detector Goals

• vertexing e.g. $t\bar{t}$	$\delta(\mathrm{IP}_{\phi,z}) \lesssim 5\mu\mathrm{m} \bigoplus \frac{10\mu\mathrm{m}\mathrm{GeV}/c}{\mathrm{p}\sin^{3/2}\theta}$
• tracking e.g. Higgs	$\delta(1/\mathrm{p_t}) \lesssim 6\times10^{-5}$ GeV/c^{-1}
• fwd. dirn e.g. lumi, t–ch.phys.	$\delta(1/\mathrm{p_t}) \lesssim 3\times10^{4}$GeV/c^{-1}, $\delta(\theta) \lesssim 2\times10^{-5}, \cos\theta \lesssim 0.99$
• jet energy from energy flow	$\delta(\mathrm{E}/\mathrm{E}) \lesssim \frac{0.30\mathrm{GeV}^{1/2}}{\sqrt{\mathrm{E}}}$
• hermeticity for $\not{E}$ meas.	$\sim$ 5 – 10 mrad for beampipe, only hole
• backgrounds robustness	min. material inside Ecal, $\vec{B} \gtrsim 3$T, granularity

R & D, prototyping to shoot for these goals

- Desy PRC
- USLC SG ↗ LC RD ↘ UCLC
- acfahep.kek.jp

from TDR

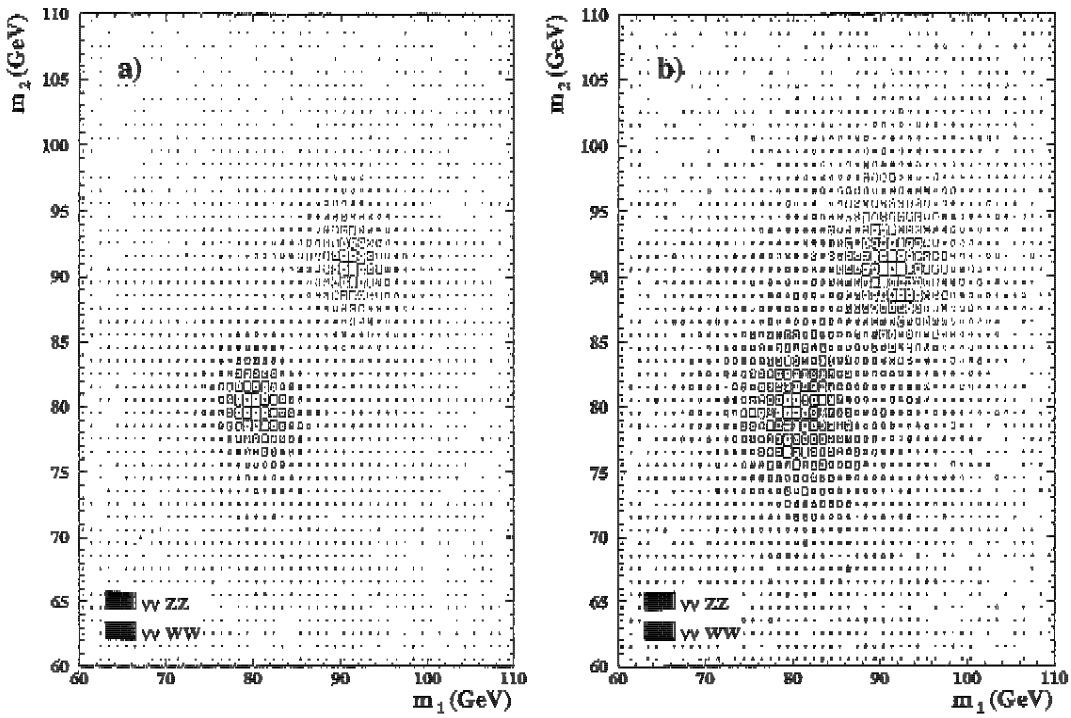

Figure 9.4.4: *Reconstructed masses for* $e^+e^- \to \nu\bar{\nu}WW$ *events and* $e^+e^- \to \nu\bar{\nu}ZZ$ *events for a)* $\Delta E/\sqrt{E} = 30\%$ *and b)* $\Delta E/\sqrt{E} = 60\%$.

for electrons can be brought down from 83 mrad to 25 mrad with the help of the LAT.

Another important task of the LAT is the measurement of the absolute luminosity. The luminosity at an e^+e^--collider is most conveniently measured from Bhabha scattering in the forward region which is a high cross section QED process. Due to the steep angular dependence ($d\sigma/d\theta \propto 1/\theta^3$) the most important requirement for a precise luminosity measurement is an excellent position resolution to define the inner acceptance border. Using SiW calorimeters at LEP a precision of $< 0.1\%$ has been reached and there is no reason why this should not also be possible with the LAT [12].

9.6 Other Topics

For many analyses like threshold scans or high precision measurements in the continuum a good knowledge of the luminosity spectrum is required. This spectrum can be measured from the acolinearity of Bhabha events in the forward region [13]. In the same analysis also the beam energy spread can be measured.

Figure 9.6.1 shows the differential luminosity reconstructed from Bhabha events in the FTD [14]. Without including the beam energy spread a small dilution due to detector resolution can be seen, however the smearing due to the beam energy spread is much larger than detector effects. Already with $3\,\mathrm{fb}^{-1}$ the average fractional centre of mass energy after beamstrahlung, $\sqrt{s'/s}$, can be measured to $5 \cdot 10^{-5}$, better than

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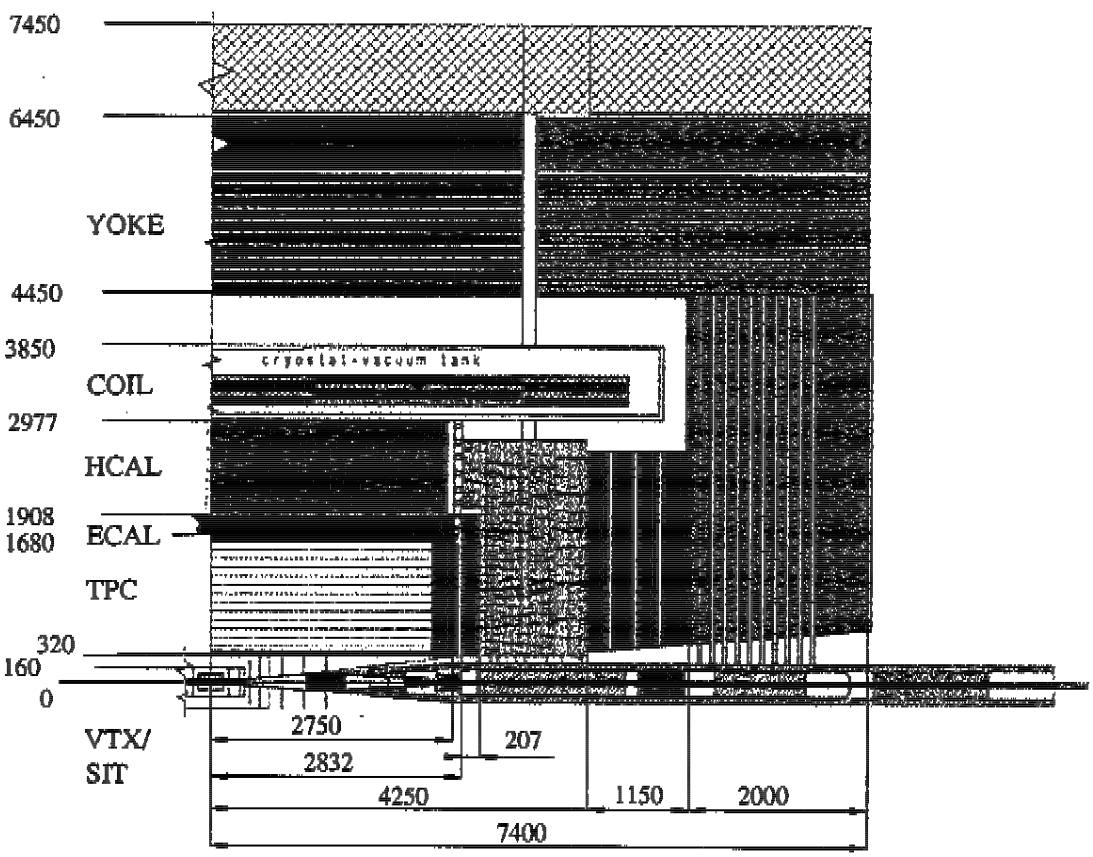
TDR TESLA DETECTOR

- Flavor tag $\delta(\mathrm{IP}) \sim 5\mu\mathrm{m} \oplus \frac{10\mu m\ \mathrm{GeV/c}}{\mathrm{p}\sin^{3/2}\theta}$
- Track momentum $\delta(1/\mathrm{p}_t) \sim 6 \cdot 10^{-5}\ \mathrm{GeV/c}^{-1}$
- Energy flow $\delta\mathrm{E}/\mathrm{E} \sim 0.30/\sqrt{\mathrm{E}}$



- granularity
- hermeticity
- min. material inside calos
- calos inside 4 T coil

Linear Collider Detector R&D

August 28, 2002
http://blueox.uoregon.edu/~lc/randd.ps(pdf) ⇒ create websites for rapidly developing projects to link into...

Editors
Jim Brau (jimbrau@faraday.uoregon.edu)
Chris Damerell (C.J.S.Damerell@rl.ac.uk)
Gene Fisk (hefisk@fnal.gov)
Yoshiaki Fujii (yoshiaki.fujii@kek.jp)
Rolf-Dieter Heuer (rheuer@mail.desy.de)
Hwanbae Park (sunshine@knu.ac.kr)
Keith Riles (kriles@umich.edu)
Ron Settles (settles@mppmu.mpg.de)
Hitoshi Yamamoto (yhitoshi@awa.tohoku.ac.jp)

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⇒ shall see few pages

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⇒ [Ref]

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Scientific-Political Situation

- Worldwide . . .
  - Activities
- Regional . . .
  - America
  - Asia
  - Europe
- Global Accelerator Network
  - G.A.N.

⋮

- Discussion of latest developments at end of talk

Worldwide activity (up to 1 year ago)

Detetor R&D Panel

- overview being compiled... Feb. 02

ICFA

- GAN study
  - global
  - technical

  } working groups... report "soon"

- Technical Review Comm.
  "ILC Loew panel"
  - energy
  - luminosity

  } working groups

  Tesla
  JLC(c)
  JLC(x)/NLC(x)
  CLIC

  1st draft summer 2002

OECD - Global Science Forum

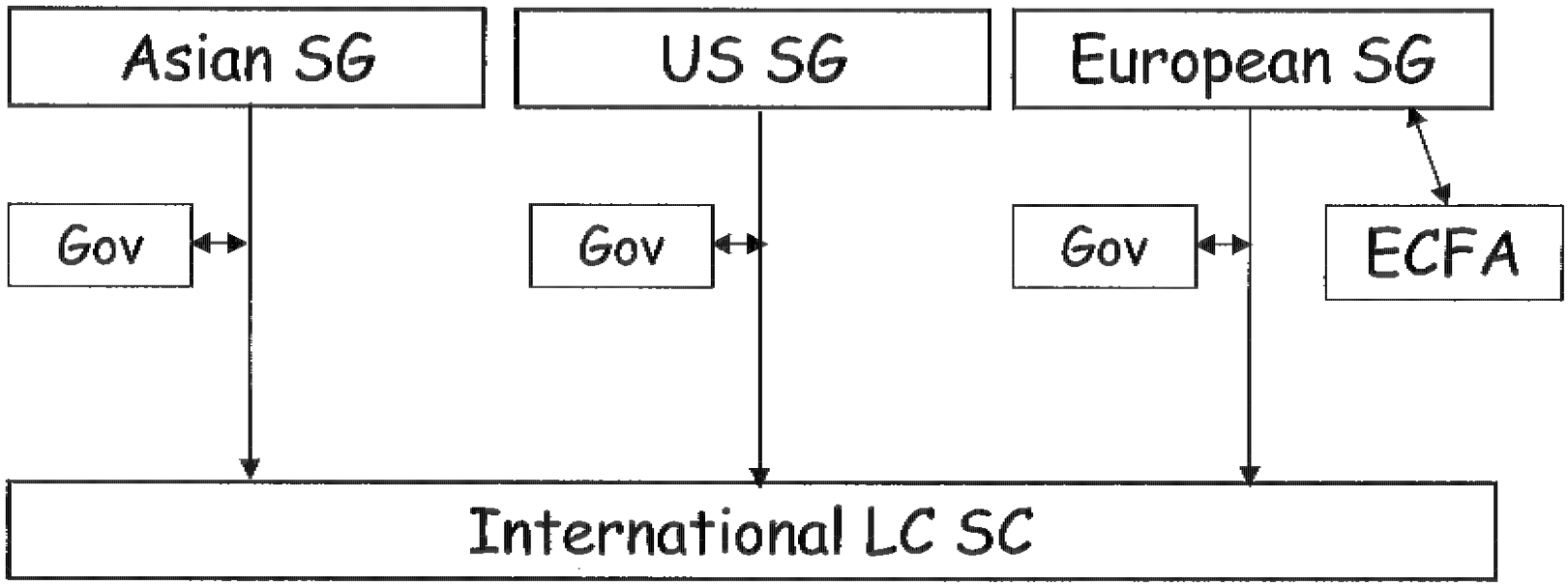
Consultative group on HEP
- roadmap of HEP
- formal aspects of GAN
- Legal " - -

} working groups

report June 2002

LC Steering Groups

ICFA initiative:



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01- 8-26; 8:30AM;BELLE GROUP
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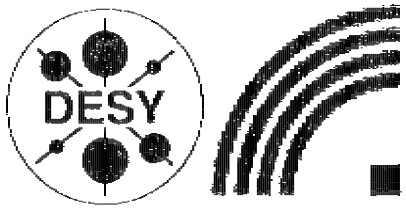
;+81-298-64-5340
18/ 50



ILCSC Members

Current Members

Category	Current incumbent
Directors	
KEK	Hirotaka Sugawara
SLAC	Jonathan Dorfan
DESY	Albrecht Wagner
CERN	Luciano Maiani
FNAL	Michael Witherell
LC Steering Group Chairs	
Asian	Won Namkung
European	Brian Foster
N. American	Jonathan Dorfan
Other	
Chair	Maury Tigner
China (IHEP Director)	Hesheng Chen
Russia (BINP Director)	Alexander Skrinsky
ICFA outside LC regions	Carlos Garcia Canal
Asia Rep.	Sachio Komamiya
Europe Rep.	David Miller
N. American Rep.	Paul Grannis

Ron Settles,Dec

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GAN

Remote operation will very likely be of key importance for the future operation of large facilities.

Key issues:

- social aspects

Tests in this area are ongoing or planned (TTF, A0, LINX, PI3...)

ICFA is considering to sponsor future GAN workshops

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20/ 50

OECD Consultative Group

- The Consultative Group concurs with the world-wide consensus of the scientific community that a high-energy electron-positron linear collider is the next facility on the Road Map.
- There should be a significant period of concurrent running of the LHC and the LC, requiring the LC to start operating before 2015. Given the long lead times for decision-making and for construction, the process of consultation among interested countries should begin at a suitably-chosen time in the near future.

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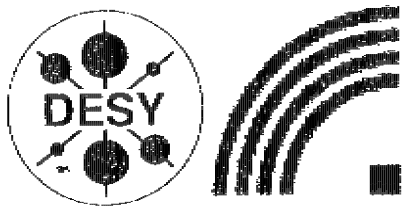

OECD Consultative Group

- The cost of the LC will be broadly comparable to that of the LHC, and can be accommodated if the historical pattern of expenditure on particle physics is maintained, taking into account the additional resources that the host country (or countries) will need to provide.

... Discussion on organisational issues etc

It was decided to continue these OECD discussions.....

Ron Settles,Dec.2002 (from A.W.@ BadHonnef)

01- 8-26; 8:30AM;BELLE GROUP ;+81-298-64-5340 # 22/ 50
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Regional

Europe

- Tesla TDR — March 2001
  - Hamburg site — 4 GE incl. FEL+Manpower
  - German Science Council — mid 2002
- ECFA Report — July 2001

  rec: "> 400 GeV LC as timely a.p."
- Ecfa/Desy WS
  - Cracow Sept. 2001
  - St. Malo April 2002
  - Prague Nov. 2002
  - Amsterdam April 2003
  - Montpellier Nov 2003
  - Durham Sept 2004
- KET Germany
  - Support Tesla/Desy Nov. 2001
  - "Next 15 yrs Ptcl. Phys D"
  - Dec 01, May 02, Nov 02

Regional

America

- Snowmass — July 2001
  rec: "LC complementary to LHC"
- HEPAP Report — Nov 2001, Feb 2002
  rec: "LC next accel., US host"
  6 GeV, "20yr Plan",
- LC Studies Mtg — 7-8 Jan. 2002
  Chicago, ~200 attendees
- LC / Det R&D Mtg — 5 April 2002
  Fermilab
- "LC Consortium Org. Mtg." — 19 April 2002
  Cornell
- LC Studies Mtg. — Santa Cruz, Cornell, SLAC, Victoria ...

Asia

- ACFA Report
  acfa.hep.kek.jp — Fall 2001
  rec: "500GeV LC+FEL, Asian site"
- ACFA Meetings — Taiwan, Beijing, Tokyo, Mumbai, Taiwan ...

(Historical Transparencies...)

LC MACHINE

- SEVERAL DESIGNS ...

	DESY		KEK	SLAC	~~BINP~~	CERN
	TESLA	~~S-BAND~~	JLC(~~X~~,C,X)	NLC.	~~VLEPP~~	CLIC
GHz:	1.3	~~3~~	~~X~~,6,11	11	~~14~~	30

- WORLD COOPERATION

WORKSHOP SERIES LC88 → LC02
SLAC Feb 4-8, 2002

→ SHARING OF R&D

- R&D PROJECTS / TEST FACILITIES

DESY	KEK	SLAC	~~BINP~~	CERN
TTF, ~~SLTF~~	ATF, Damp. Ring, Many others	SLC, FFTB, NLCTA	~~[illegible]~~	CTF I, DBF, CTF II, CTF III

→ HUGE EFFORT HAS ESTABLISHED MACHINE CULTURE TO MAKE IT WORK

(~~X~~ ≡ "bit the dust"..)

e^+e^- LINEAR COLLIDER MACHINE PROGRESS

- YEARLY WORKSHOPS

LC88	SLAC
LC90	KEK
LC91	PROTVINO
LC92	GARMISCH-PARTENKIRCHEN
LC93	SLAC
LC95	KEK
LC97	ZVENIGOROD
LC99	FRASCATI
LC02	SLAC

- THE INTERNATIONAL COLLABORATION, THEN FORMED TO COORDINATE R&D, REQUESTED THE REPORT AT LC95 BY A

  TECHNICAL REVIEW COMMITTEE

  ➡ TO DOCUMENT THE STATE OF THE ART. FOR ~YEARLY UPDATES, SEE http://www.slac.stanford.edu/xorg/ilc-trc/ilc-trchome.htm

- DESIGN REPORTS

  JLC DESIGN STUDY
  KEK REPORT 92-16

  ZEROTH DESIGN REPORT for NLC
  SLAC REPORT 96-

  CONCEPTUAL DESIGN REPORT DESY LC
  DESY 97-048/ECFA97-18

Structure and Members of the Technical Review Committee

Steering Group:

G. Loew, Chairman
T. Weiland, Secretariat

Reading Committee:

B. Aune, V. Balakin, H. Edwards, K. Hübner, E. Paterson, A. Sessler, K. Takata, G. Vignola, G. Voss, B. Wiik

Working Groups:

1) Injection Systems and Pre-Accelerators
M. Yoshioka, Chair
A. Mikhailichenko, Deputy Chair
H. Braun, J.P. Delahaye (CLIC), K. Flöttmann, J. Frisch, R. Miller, C. Pagani, L. Rinolfi, J. Rosenzweig, H. Tang, C. Travier, D.A. Yeremian

2) Damping and Compression Systems
J. Rossbach (SBLC), Chair
J. Urakawa,Deputy Chair
S. Chattopadyhay, A. Mikhailichenko, J.P. Potier, T. Raubenheimer

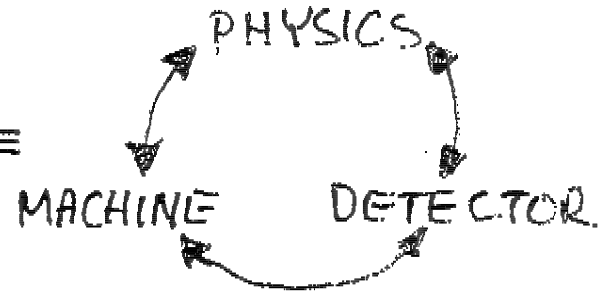
3) Linac Technology
P. Wilson (NLC),Chair
D. Proch, Deputy Chair
N. Holtkamp, Deputy Chair
G. Caryotakis, T. Higo, H. Mizuno, W. Namkung, H. Padamsee, R. Palmer, N. Solyak (VLEPP), G. Westenskow, I. Wilson

4) Beam Dynamics
K. Yokoya (JLC), Chair
A. Mosnier, Deputy Chair
G. Guignard, R. Ruth, R. Wanzenberg

5) Beam Delivery
R. Brinkmann (TESLA),Chair
V. Telnov, Deputy Chair
A. Dragt, J. Irwin, O. Napoly, K. Oide, A. Sery, B. Zotter

6) Experimentation
R. Settles, Chair
T. Markiewicz, Deputy Chair
S. Bertolucci, S. Kawabata, D. Miller, R. Orava, F. Richard, T. Tauchi, A. Wagner

EXPERIMENTATION REQUIREMENTS ≡



TRC 95: "GREEN LOEW REPORT"

Table 1: Some e^+e^- experiments and the corresponding performance quality needed for machine and detector.
Quality key: from "-" not important, to "***" very important (LEP/SLC detectors ~ **).

PHYSICS	MACHINE[a]				DETECTOR[b]						
	$\int \mathcal{L}dt$ fb^{-1}/y	$\sqrt{s}$ TeV	Narrow $\mathcal{L}(\sqrt{s})$	Pol. beams	Hermeticity	Tracking	Calorimetry	3-Dim. Granul.	Lepton I.D.	Vertex Tag	pi/K I.D.
•HIGGS											
Light Higgs	1-10	.2									
Higgs spin-parity	20	to	**[c]		**	***	**	**	**	***	*
SM/Susy B.R.	100	~.5									
Interm. Higgs	200	~1									
•HEAVY, STRONGLY-INTERACTING HIGGS											
W_LW_L-scatt.	200	~1.5			***	***	**	***	**	-	-
•ELECTROWEAK GAUGE BOSONS											
WWV-coupl.	10	.3									
Unfold γ, Z-coupl.	50	to	***	**	***	***	**	**	***	-	-
WWVV-coupl.	100	1									
•SUSY											
Light $\tilde{t}$	10	.2									
$\tilde{\chi}_j^{\pm}, \tilde{\chi}_i^0, \tilde{\ell}$	10										
Susy spectroscopy	20	to		*[d]	***	**	**	**[d]	**	-	-
Susy parameters	100										
$\tilde{q}, \tilde{g}$	100	~1-2									
•EXTENDED GAUGE											
New particles	200	~2			***	***	**	***	**	**	
•TOP QUARK											
Thr. scan	10	~.35	***		**	**	**	**	**	***	*
g-2,hel.anal.,V+A	50	.4									
Rare decays	50	to		**	***	**	**	**	**	***	**
Yukawa coupl.	100	1									
•QCD											
Hadronization	1	For									
Heavy flavors	10	all			**	**	**	*	*	**	*
$\alpha_s(s)$	10	$\sqrt{s}$									
•(Virtual)$\gamma\gamma$											
Minijets	1										
$F_2^{\gamma}(x, Q^2)$	10		*		***[e]	**	**	**	**	*	*
Heavy flavors	10										
Overall			***	**[d]	***	***	**	***	**	***	**
$\mathcal{L}(\sqrt{s})$ Det.[a]					**	***	**	**	**	-	-

[a] Narrow c.m.s. energy spread arising from machine and beamstrahlung effects. *** means the energy spread from the machine must be small ($\sigma \simeq \mathcal{O}(0.2\%)$); the luminosity spectrum must be well-measured (to the $\pm 0.1\%$ level); the last row of the Table describes the performance quality of the detector for measuring the luminosity spectrum.

[b] By "Tracking" and "Calorimetry" is meant the measuring accuracy for momentum and energy, respectively.

[c] If $M_{Higgs} \simeq M_{Z^0}$, upgrade to ***.

[d] If supersymmetry is discovered, upgrade to ***.

[e] Small angle tagger would allow low-x studies and high Q^2.

http://www.slac.stanford.edu/xorg/ilc-trc/ilc-trc.html

2nd ILC-TRC Report 2001-02

- ICFA July 2001 → New charge to Loew panel
- Update comparison for 500 GeV LC

  TESLA
  JLC (C)
  JLC (X)/NLC(X)
  CLIC

- Working groups
  - Technology RF Power, Energy Performance
  - Luminosity Performance...

    ... Sources
    Damping Rings
    Beam Transport
    Detector Interface
    Reliability/Operability

- Plans

  - Interim reports Feb'02 (LCO2 Sitges) - Apr.02
  - 1st draft Jun'02 (EPAC Paris)
  - Final report Oct'02

Report From The International Linear Collider Technical Review Committee

Gregory A. Loew

ICFA Seminar

CERN

October 8-11, 2002

TRC Working Group Members

Technology, RF Power & Energy Performance Group	Luminosity Performance Group
Daniel Boussard (Retired from CERN)	**Gerry Dugan** (Cornell)
Adolphsen, Chris - SLAC	Assmann, Ralph - CERN
Braun, Hans H. -CERN	Decking, Winfried - DESY
Chin, YongHo - KEK	Gareyte, Jacques - CERN
Edwards, Helen - FNAL	Kozanecki, Witold - SACLAY
Hübner, Kurt - CERN	Kubo, Kiyoshi - KEK
Lilje, Lutz - DESY	Phinney, Nan - SLAC
Logatchov, Pavel - BINP	Rogers, Joe - Cornell
Pasquinelli, Ralph - FNAL	Schulte, Daniel - CERN
Ross, Marc - SLAC	Seryi, Andrei - SLAC
Shintake, Tsumoru - KEK	Settles, Ronald - MPI
Toge, Nobu - KEK	Tenenbaum, Peter - SLAC
Weise, Hans - DESY	Wolski, Andy - LBNL
Wilson, Perry - SLAC	Walker, Nick - DESY

Tab_ 1.1 Overall Parameters

_ 9/18/02

	TESLA		JLC (C)		JLC/NLC* (X)		CLIC	
Center of mass energy	500 GeV	800 GeV	500 GeV	1000 GeV	500 GeV	1000 GeV	500 GeV	3000 GeV
RF frequency of main linac (GHz)	1.3		5.7	5.7/11.4¶	11.4		30	
DEsign luminosity ($10^{33}cm^{-2}s^{-1}$)	34.0	58.0	14.1	25.0	25.0 (20.0)	25.0 (30.0)	21.0	80.0
Linac repetition rate (Hz)	5	4	100		150 (120)	100 (120)	200	100
No. of particles/bunch at IP (10^{10})	2	1.4	0.75		0.75		0.4	
No. of bunches/pulse	2820	4886	192		192		154	
Bunch separation (nsec)	337	176	1.4		1.4		0.67	
Bunch train length (μsec)	950	860	0.267		0.267		0.102	
Beam power/beam (MW)	11.3	17.5	5.8	11.5	8.7 (6.9)	11.5 (13.8)	4.9	14.8
Unloaded/loaded gradient† (MV/m)	23.4 / 23.4	35 / 35	41.8/31.5	41.8/31.5 / 70/55	65 / 50		172 / 150	
Total two-linac length (km)	30	30	17.1	29.2	13.8	27.6	5.0	28.0
Total beam delivery length (km)	3		3.7		3.7		5.2	
Proposed site length (km)	33		33		32		10.2	33.2
Total site AC power‡ (MW)	140	200	235	310	243 (195)	292 (350)	175	410
Tunnel configuration‖	Single		Separate		Separate		Two-Beam	

* Numbers in ( ) for the JLC/NLC correspond to the NLC design with 120 Hz repetition rate.

¶ The 1 TeV JLC-C collider uses a C-band rf system for the first 200 GeV of each linac followed by an X-band rf system for the remaining 300 GeV of acceleration – the X-band rf system would be identical to that described for the JLC-X band collider.

† The main linac loaded gradient includes the effect of single-bunch (all modes) and multibunch beam loading, assuming that the bunches ride on crest. Beam loading is based on bunch charges in the linacs, which are slightly higher than at the IP.

‡ Total site power includes AC for linac rf and cooling systems as well as power for all other beam lines and site facilties.

‖ The single tunnel layout has both the klystrons and accelerator structures in the main linac tunnel while the separate tunnel layout places the klystrons and modulators in a separate enclosure. The Two-Beam scheme uses the separate tunnel layout for the drive linac–there are no klystrons and modulators associated with the main linac.

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Assessments

The Broad Picture

- In the last 15 years, progress on LC designs and technologies has been remarkable. Innovations for both cold and warm machines have been equally impressive
- Beam dynamics computer simulations have also made enormous progress and can be used to great advantage
  - The TRC believes that there are no discernable show stoppers or insurmountable obstacles to build TESLA, JLC (C) or JLC/NLC (X) in the next few years
  - While these three approaches differ in their relative degree of technical readiness and their upgrade potentials, any of these machines could probably start construction in the next 3-5 years
- Having said this, much important R&D remains to be done in a number of technical areas. Global funding support is insufficient
  - Several of the Test Facilities are underutilized or used for other purposes
  - Linear colliders of the proposed size and complexity require much greater attention to reliability, availability and operability, and substantial R&D needs to be done to ensure that commissioning and reaching design specs does not take too long
  - Realizing a linear collider in a timely way requires enhanced collaboration between all laboratories and joining of all forces behind a unified design and a single technology

Ranking Criteria for R&D

R1

R&D needed for feasibility demonstration of the machine

R2

R&D needed to finalize design choices and ensure reliability of the machine

R3

R&D needed before starting production of systems and components

R4

R&D desirable for technical or cost optimization

R&D Rankings Common to All Machines

R1 None

R2

All Damping Rings

- Further simulations and experiments to understand magnitude and possible means of suppression of electron cloud effects
- Further simulations of fast ion instability and experiments at ATF and elsewhere to verify predictions
- Extraction kicker stability studies to below 10^{-3} level
- Further simulations of emittance correction algorithms with validation at ATF and elsewhere

All Low Emittance Transport

- Completion of static tuning studies using beam-based alignment techniques, with corrections made in the presence of low and high frequency mechanical vibrations, rf variations, instrument imperfections
- Development of a sufficiently detailed prototype of the main linac girder, or cryomodule with quadrupole to provide information about sources of vibration
- Development of most critical beam instrumentation including intra-train and/or train-to-train luminosity monitors and laser-wire monitors

Reliability, Availability and Operability

- Detailed evaluation of critical sub-systems reliability

Common R&D Rankings
(cont.)

R3 (cont.)

All Machine/Detector Interface

- If collimator wakefields are found to be large, experimental validation of the octupole tail-folding scheme
- Development of new simulation tools, and better machine models, for improved tracking of primary and secondary particles
- Evaluation of the mechanical stability of the solenoid coil and/or iron yoke
- Demonstration of final doublet (SC, PM or iron) stabilization in anticipation of large vibrations
- Evaluation of IP feedbacks
- Development of beam polarization and energy diagnostics

Reliability, Availability and Operability

- Detailed design of Machine Protection System with study of failure modes
- Better assessment of MTBF and MTBO of critical subsystems
- Critical evaluation of recovery time after machine access

TESLA (500 GeV c.m.)
R&D Rankings

R1 None

R2

- Test of a complete main linac RF sub-unit (as identified in machine description) with beam
- Testing of several cryomodules at nominal field (23.4 MV/m) over long enough periods to verify breakdown and quench rates, and measure dark current
- Detailed analysis of the tradeoffs between one and two-tunnel layouts
- Inclusion of systematic and random multipole and wiggler errors for particle loss simulations and dynamic aperture optimization
- Development of damping ring kicker
- Optimization of damping ring dynamic aperture to eliminate calculated beam losses at injection
- Review of trade-offs between head-on and crossing-angle collisions at IP and implications for present extraction line design

JLC(X)/NLC (500 GeV c.m.) R&D Rankings

R1

- Test of complete accelerator structure at design gradient with detuning and damping, including study of breakdown and dark current
- Demonstration of SLED II pulse compression system at design power level

R2

- Test of a complete X-band main linac RF sub-unit (as identified in machine description) with beam
- Full test of KEK 75 MW, 1.6 μs PPM klystron at 150 or 120 Hz
- Full test of SLAC induction modulator

CLIC (500 GeV c.m.)
R&D Rankings

R1

- Test of existing structures at 130 ns pulse length and design gradient
- High power test of structures with wakefield damping
- Design and test of "switchable" power extraction transfer structures
- Validation of drive beam generation with fully loaded linac
- Full test of a basic hardware unit (at reduced length)

R2

- Test of a complete main linac RF subunit (at reduced length) with beam
- Further structure tests with tungsten or other materials
- Validation of drive beam stability
- Validation of a multibeam klystron (16.7 microsecond pulse) for drive beam accelerator
- Study of a more efficient modulator
- Design of damping ring

Chair's Conclusions

- The final written report should come out in early 2003. It may yet contain some changes in the R&D Rankings
- In any case, crucial R&D remains to be done between now and the end of 2003
- If one had to "launch" a project today for 500 GeV, TESLA would be the only one having "essentially" proven performance specs for the main linac RF system
- By the end of 2003, we should hopefully know if TESLA can reach 800 GeV at 35 MV/m (with the addition of RF power and cryogenics)
- By the end of 2003, we should also hopefully know if JLC(X)/NLC (500 GeV) can meet its main linac RF system specifications
- If yes, then the International Community could make a choice based on the other respective merits of these machines

LATEST DEVELOPMENTS

Discussion :

I would like tell you
how I see the situation,
and you tell me what's
wrong with my picture...

ITRP

INTERNATIONAL TECHNICAL REVIEW PANEL

- ICFA initiative Nov. 2003

- "wise men" to choose technology warm/cold

ASIA	AMERICA	EUROPE
G.S. Lee	J. Bagger	J.-E. Augustin
A. Masaike	B. Barish	G. Belletini
K. Oide	P. Grannis	G. Kalmus
H. Sugawara	N. Holtkamp	V. Soergel

- Meetings 2004

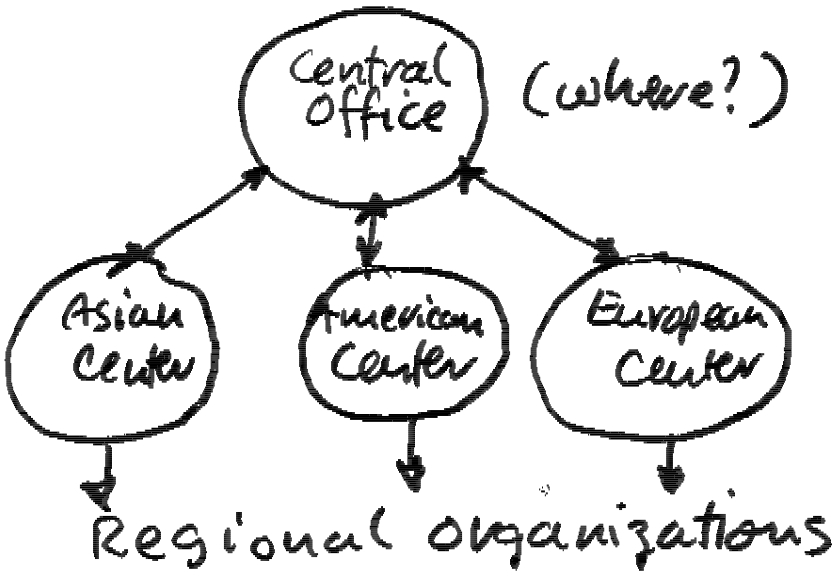
London	Jan.
Desy	Apr. 5-6
Slac	Apr. 26-27
KEK	May 25-26
CalTech	Next week
?	August

↳ DECISION!
??

GLOBAL DESIGN INITIATIVE

(organization?)

GDI for LC machine



After ITRP decision, CDR for machine end 2005
TDR " 2007
Final design " 2009

For detectors, it is proposed that we follow:

CDR	2006
TDR	2008
Final Design	2010

WHAT ABOUT CLIC?

The problem:

- Two meetings of funding agencies to discuss funding prospects for 0.5-1.0 TeV LC

CANADA (NSERC)
FRANCE (CRNS)
GERMANY (BMBF)
ITALY (INFN)
JAPAN (MEXT)
UK (PPARC)
US (DOE, NSF)
CERN (PRC, DG)

paraphrased

⇓

- 1st meeting 20 July 2003

:

5. "... concurrent running LC/LHC from 2015 ... maintain viable community of physicists and engineers to ensure vitality of field in future."
6. "... choice of technology by end 2004 ..."
8. "... site choice a.s.a.p (→ Y. Totsuka does not agree)."

→ everything looked o.k., more or less

paraphrased

↓ - 2nd meeting 6 April 2004

3. "... decision to construct 2010, commission 2015 ... 5 years concurrent running with LHC..."

4. "... CLIC technology shown feasible by 2010... TRC issues R1 & R2 addressed by CTF 3 ... CLIC multi TeV possible 2021..."

5. "... if LHC finds nothing (no Higgs, no SUSY)... sub TeV LC would give minimal output... therefore next energy range should be multi TeV... it would be logical to proceed directly to multi TeV CLIC ..."

6. "... sub TeV LC design ready 2010... assuming evidence from LHC, physics criteria would be needed and agreed on to form basis for decision to confirm construction of sub TeV LC in 2010."

7. "... R1 and R2 issues addressed so that CLIC demonstrates feasibility by 2010 so that if LHC finds nothing, sub TeV know how can be used for CLIC..."

FIRST : THE CASE HAS BEEN MADE

Ron Settles – Desy/MPI-Munich

for example, **Europe**

PHYSICS and DETECTOR for the LC

- PREL. WORKSHOPS 1991 – 95

- FIRST ECFA/DESY STUDY 1996 – 97

  Frascati, UC London, MPI-Munich, DESY
  → LC CONCEPTUAL DESIGN REPORT
  DESY 1997-048/ECFA 1997-182
  DESY 97-123E
  PHYS.REP. 299(1998)1

- SECOND ECFA/DESY STUDY 1998 – 2000

  Orsay, Lund, Frascati, Oxford, Obernai, Padua, Desy
  → TDR FOR DETECTOR
  → PROPOSAL for MACHINE
  } March 2001
  DESY 2001-011/ECFA 2001-209

- EXTENDED ECFA/DESY STUDY 2001 – 03

  Cracow, St. Malo, Prague, Amsterdan ···

- ECFA STUDY 2003 – 05

SECOND: sub TeV LC necessary,
"NO MATTER WHAT"

- PHYSICS

LHC finds:	Sub TeV LC:
SUSY	SUSY "forest" & Higgs precision measurement
Higgs, no SUSY	prec. meas. Higgs, prec. meas. EW, ⇒ indirect $\delta M_{Higgs} \sim 5$GeV stringent test of SM
Nothing	Prec. EW meas: GigaZ ($\delta \sin^2\theta \sim 10^{-5}$) M_W ($\delta M \sim 7$MeV), M_{top} ($\delta M \sim 100$ MeV) sensitive to new physics in 10 TeV range (Z', Strong EWSB, contact int, etc.

- ENGINEERING

to maintain machine culture, know how, viability, must learn how to build this machine starting at low energy

THIRD: if LHC sees nothing, you don't know energy range for LC without prec. meas at sub TeV LC.
Maybe the next energy range is >10 TeV, then physics output from CLIC "minimal"...

FOURTH: by 2010, CLIC addresses R1 & R2 issues from TRC Loew panel

➡ THESE ISSUES ARE FOR 500 GeV CLIC !

➡ THE 3 TeV CLIC HAS NOT EVEN BEEN EVALUATED !!

Therefore the only sensible solution is to start with sub TeV LC

➡ PHYSICS, ENGINEERING ARE READY...

Ron Settles – Desy/MPI-Munich

Summary

- The physics case has been accepted by the worldwide community: European, American and Asian HEP authorities declare "LC should be the next machine"
  $\gtrsim 400$ GeV
- The ILC-TRC rankings are flowing into R&D projects (e.g. ESGARD)
- The HEP community is organizing itself towards the world project
- The political discussions are well underway

  ...the time is ripe to start the International LC project...