Hitoshi's role in the ILC Physics

Hitoshi-Fest@Kavli IPMU
19 December 2024

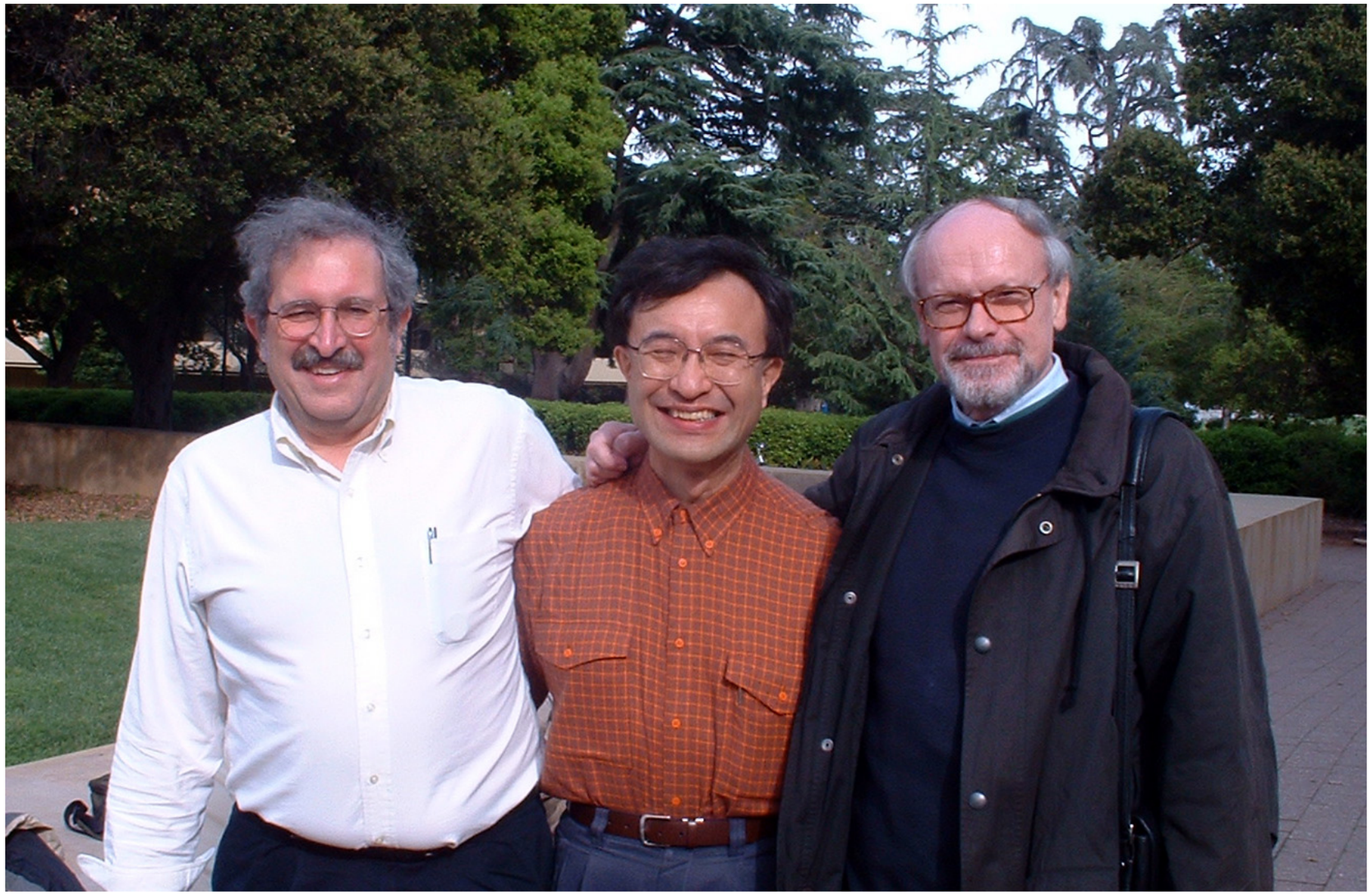
Hitoshi has been involved in Linear Collider physics for a long time

— actually, since before most of you were born.

Our collaboration on this subject goes back to 1990.

This is me in 1990.

The SLC and LEP had started taking data in the summer of 1989.



In the fall of 1989, Peter Zerwas, Kaoru Hagiwara, and I — quite independently — gave the same seminar at DESY, KEK, and SLAC. We argued that the next step in e+e- physics would be a linear collider to study the Higgs, the W, top, and SUSY.

SLAC-329

SLAC-329

OPPORTUNITIES AND REQUIREMENTS FOR EXPERIMENTATION AT HIGH ENERGY e^+e^- COLLIDER

C. Ahn, C. Baltay, T. L. Barklow, P. R. Burchat, D. L. Burke,
A. R. Cooper, C. Dib, G. J. Feldman, J. F. Gunion, H. E. Haber,
T. M. Himel, B. W. Lynn, S. Komamiya, M. E. Peskin,
A. Petersen and R. J. Van Kooten

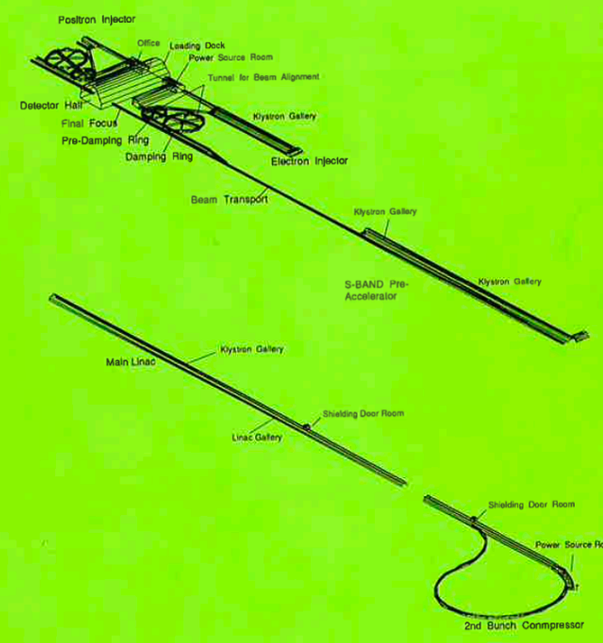
SLAC-Report-329
May 1988

Prepared for the Department of Energy
under contract number DE-AC03-76SF00515

STANFORD LINEAR ACCELERATOR CENTER
Stanford University · Stanford, California

KEK Report 92-16
December 1992
A/H/M

JLC-I



JLC Group

NATIONAL LABORATORY FOR
HIGH ENERGY PHYSICS

JLC Group

The JLC group consists of particle and accelerator physicists who have been involved in the feasibility studies for the realization of the JLC project, and those who intend to join forces to further promote the project. This group always welcoms everybody who shares the same goal. The following are the group members as of December, 1992.

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T. Higo, H. Hirayama, H. Ida, H. Ike[illegible], [illegible] Itoh, K. Itoga, S. Iwata, S. Kamada,
[illegible] Kanzaki, S. Kawabata, T. Kawamoto, M. Kikuchi, Y. Kimura, H. Kitamura,
M. Kobayashi, T. Kobayashi, S. Koike, S. Koizumi, K. Kubo, T. Kubo, T. Kubo, Y. Kurihara,
S. Kuroda, Y. Makida, K. Manabe, T. Matsui, H. Matsumoto, T. Mimashi, A. Miura,
A. Miyamoto, H. Mizuno, T. Naitou, M. Nakai, H. Nakayama, Y. Namito, Y. Nemoto,
J. Odagiri, T. Ohama, K. Oide, Y. Okada, T. Omori, Y. [illegible], H. Sakai, [illegible]. Sakamoto,
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Tokyo Management College, Ichikawa 272, Japan

T. Nakazato, M. Yamaguchi, M. Oyamada, T. Yamakawa, K. Abe, K. Hikasa, H. Murayama
Faculty of Science, Tohoku University, Sendai 980, Japan

K. Anraku, S. Asai, K. Kawagoe, T. Kawamoto, T. Kobayashi, S. Komamiya, T. Mashimo,
H. Matsunaga, T. Mitsui, T. Mori, M. Morii, S. Orito, T. Saeki, T. Sanuki, K. Shigekuni,
T. Tsukamoto, I. Ueda, T. Yoshida, K. Yoshimura
Department of Physics and International Center for Elementary Particle Physics, University of Tokyo, Tokyo 113, Japan

In the fall of 1990, I was invited to attend the Nishinomiya Conference and, as an add-on, the 2nd JLC Workshop.

This was one of the great experiences of my life. I met my now-longtime collaborators Keisuke Fujii and Akiya Miyamoto and began a 35-year relationship with KEK.

I also met two young but promising graduate students — Mihoko Nojiri and Hitoshi Murayama.

2nd JLC Workshop

Nov. 6 - 8 , 1990
at Seminar Hall (3rd building), KEK

Program

Nov. 6, 1990

9:00 - 9:10	Openning address		
9:10 - 9:20	JLC Accelerator	Chairman	S.Iwata(KEK)
9:20 - 10:00	Status of JLC R&D		H.Sugawara(KEK)
10:00 - 10:40	JLC Physics		Y.Kimura(KEK)
	---------- Coffee break ----------		S.Takeda(KEK)
			H.Murayama(Tokyo)
10:50 - 11:10	Top and Higgs hunting before JLC	Chairman	K.Kato(Kogakuin)
11:10 - 11:50	Standard physics at JLC		K.Hikasa(KEK)
11:50 - 12:05	Radiative correction to top production		I.Watanabe(Hiroshima)
12:05 - 12:20	Higgs search at JLC		J.Fujimoto(KEK)
	---------- Lunch ----------		M.Biyajima(Shinshu)
		Chairman	K.Hagiwara(KEK)
13:30 - 13:50	The uses of polarization in Linear Collider Experiments		M.Peskin(SLAC)
13:50 - 14:20	SUSY at TeV energy scale		M.Jimbo(FujitaGakuen)
14:20 - 14:50	Compositeness at TeV energy scale		Y.Kikukawa(Nagoya)
14:50 - 15:00	Comment on strong WW interactions		K.Hikasa(KEK)
15:00 - 15:15	Interacting Instantons for TeV Physics		N.Kikuchi(Kyoto)
	---------- Coffee break ----------		
		Chairman	Y.Shimizu(KEK)
15:30 - 16:10	Measurements of W and Z at JLC		A.Miyamoto(KEK)
16:10 - 16:40	Physics in the $t\bar{t}$ threshold region		K.Fujii(KEK)
18:30 - 21:00	Get-together (Party at restaurant Zen)		

(note) Three lectures on the Physics of the NLC by M.Peskin(SLAC) are scheduled during the workshop period : Nov. 5 to 7, 17:00 - 18:00 at the Seminar Hall.

Nov. 7, 1990		Chairman	H.Nakayama(KEK
9:00 - 9:40	Accelerator Test Facility (ATF)		J.Urakawa(KEK)
9:40 - 10:05	Damping ring of ATF		S.Kuroda(KEK)
10:05 - 10:30	Beam transport and bunch compressor of ATF		M.Kikuchi(KEK)
	---------- Coffee break ----------		
		Chairman	T.Shidara(KEK)
10:40 - 11:00	X-band klystron		H.Mizuno(KEK)
11:00 - 11:20	Klystron modulator		M.Akemoto(KEK)
11:20 - 11:40	X-band accelerating structure		T.Higo(KEK)
11:40 - 12:00	High power RF technology		H.Matsumoto(KEK
12:00 - 12:20	Status of JLC active alignment studies		N.Ishihara(KEK)
	---------- Lunch ----------		
		Chairman	N.Nakazawa(Koga
13:30 - 13:55	Higgs search - 1 WWZ/ZZZ production		J.Kanzaki(KEK)
13:55 - 14:20	Higgs search - 2 W fusion processes		Y.Kurihara(KEK)
14:20 - 14:45	Study of the Yukawa coupling via $t\bar{t}Z$ and $\nu\bar{\nu}\,t\bar{t}$		T.Tsukamoto(KEK
14:45 - 15:00	Physics on the Z pole		T.Omori(KEK)
15:00 - 15:10	A brief comment on $\gamma\gamma$ collision		I.Endo(Hiroshima)
	---------- Coffee break ----------		
		Chairman	K.Hikasa(KEK)
15:20 - 15:50	Problems in Feynman diagram evaluation		Y.Shimizu(KEK)
15:50 - 16:10	Monte Carlo event generation		S.Kawabata(KEK)
16:10 - 16:30	GRACE-CHANNEL		H.Tanaka(ICRRTo
16:30 - 16:50	Summary of physics discussions		M.Kobayashi(KEK
Nov. 8, 1990			
		Chairma	K.Takata(KEK)
9:00 - 9:40	Wakefield effects in Linac		K.Bane(SLAC)
9:40 - 10:05	Beam dynamics in accelerating structures		K.Kubo(KEK)
10:05 - 10:30	Beam dynamics in final focus		K.Oide(KEK)
	---------- Coffee break ----------		
		Chairman	S.Takeda(KEK)
10:40 - 11:20	Recent developments in ultra-precision machining		S.Koizumi(KEK)
11:20 - 11:40	Polarized electron sources		T.Omori(KEK)
11:40 - 12:00	Positron sources		Y.Takeuchi(KEK)
12:00 - 12:20	Review of coherent synchrotron radiation		T.Nakazato(Tohok
	---------- Lunch ----------		
		Chairman	T.Matsui(KEK)
13:30 - 14:00	Review of solenoidal magnet		S.Terada(KEK)
14:00 - 14:30	Review of tracking device		S.Uno(KEK)
14:30 - 15:00	Review of electromagnetic calorimeter		H.Hayashii(Nara)
	---------- Coffee break ----------		
		Chairman	R.Kajikawa(Nagoy
15:10 - 15:40	Review of hadron calorimeter		S.Suzuki(Nagoya)
15:40 - 16:00	Concluding remarks		S.Iwata(KEK)
16:00 - 17:00	Open discussions		

I was fascinated by many beautiful simulation results on W and Z bosons at high energy.

I found out that these had all been produced by one of Hagawara's graduate students, Hitoshi Murayama.

Hagiwara had brought an early version of MADGRAPH back from Wisconsin. He and Hitoshi built up a library of helicity amplitudes — HELAS — to study W's at high energy.

Hitoshi added simplifications to implement the unitarity cancellations among Feynman diagrams in these processes.

UT-580
March, 1991

Ph. D. Thesis

Study of the Symmetry-Breaking Physics at JLC

Hitoshi Murayama*

Department of Physics, University of Tokyo
Bunkyo-ku, Tokyo 113, Japan

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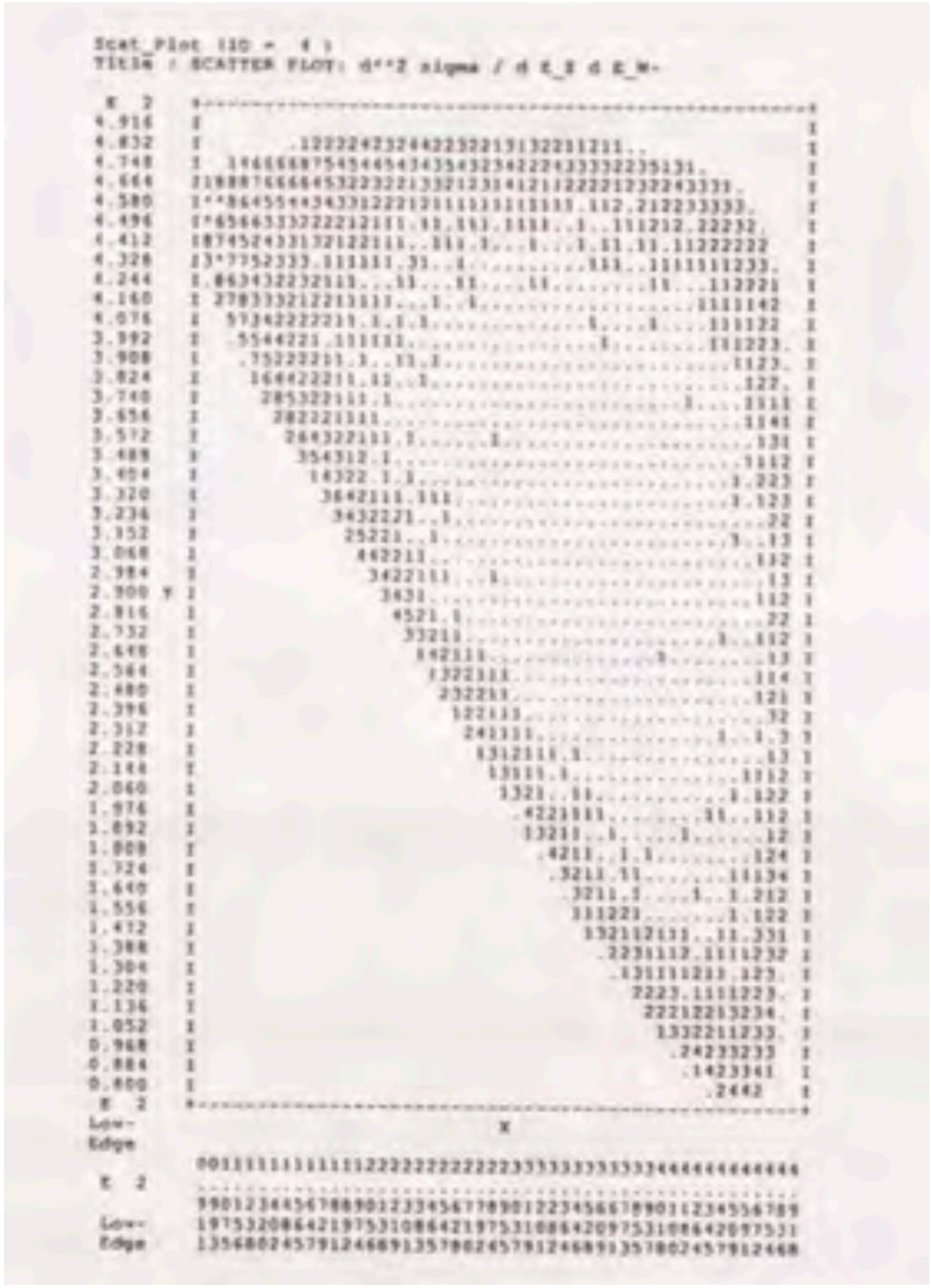
*Adress after Apr., 1991: Dept. of Physics, Tohoku Univ., Sendai, 980 Japan

Dalitz plot of

$$e^+e^- \to W^+W^-Z^0$$

from Hitoshi's thesis



KEK Report 91-11
January 1992

HELAS: HELicity Amplitude Subroutines for Feynman Diagram Evaluations

H. Murayama[1], I. Watanabe[2] and K. Hagiwara[3]

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Sendai 980, Japan
[2] *Department of Physics, Hiroshima University*
Higashi-Hiroshima 724, Japan
[3] *Theory Group, KEK, Tsukuba, Ibaraki 305, Japan*

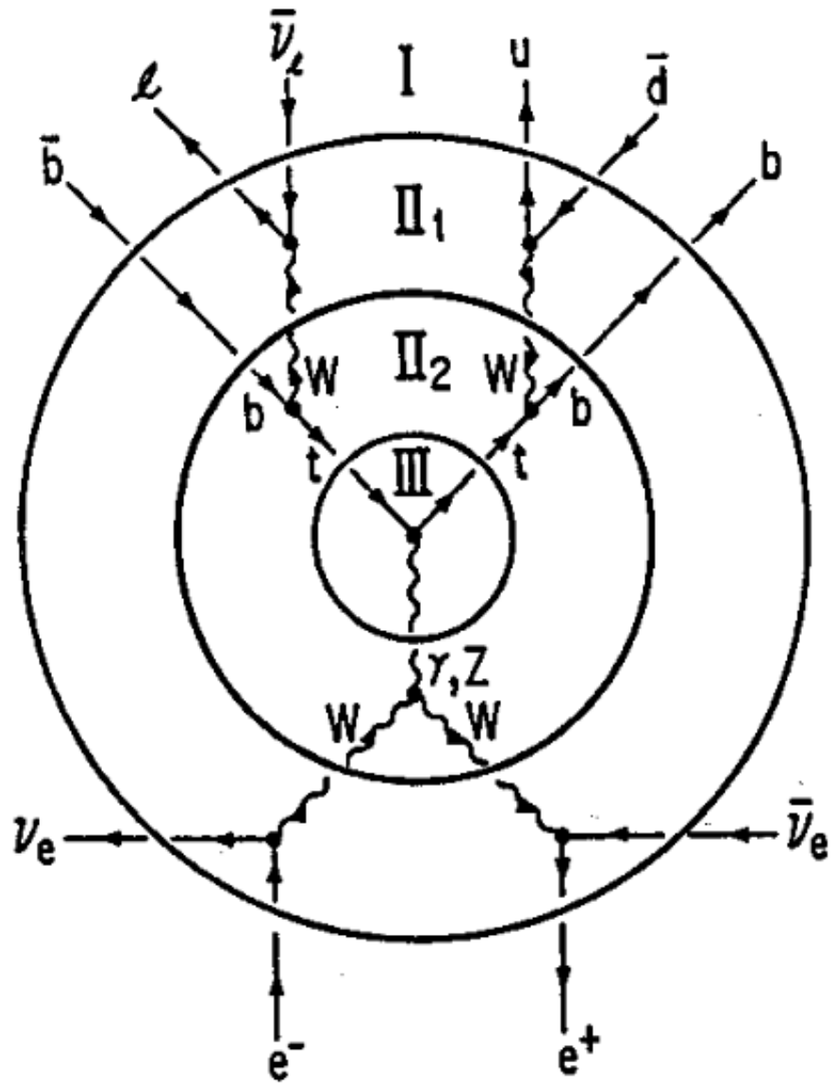

Figure 5: The steps you follow when coding with HELAS . The shown example is an extended version of Fig. 4(a), where the final W^+ decays into $u\bar{d}$, and W^- into $l\bar{\nu}_l$.

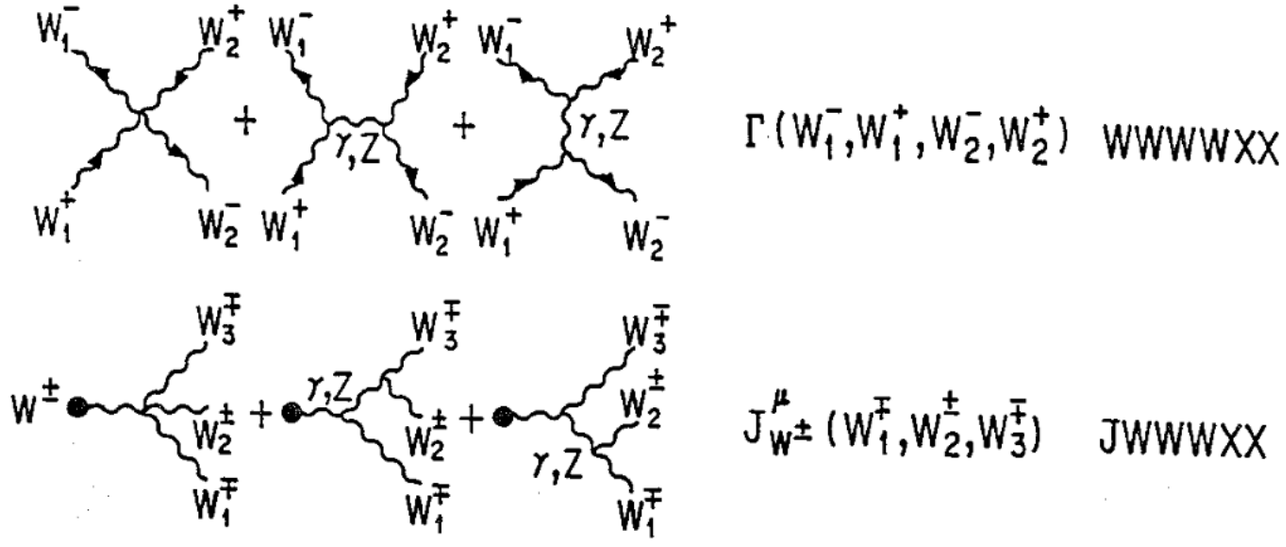

Figure 9: The HELAS subroutines for the $VVVV$ vertex. WWWWXX and W3W3XX give the T-matrix elements, while JWWWXX and JW3WXX give off-shell vector currents. Note that four-point contact term as well as vector boson exchange diagrams are included. These subroutines are written in double precision.

Over the next few years, Hitoshi became the leading theorist of the JLC group.

Here are a few things that he did, and that we did together.

PHYSICAL REVIEW D VOLUME 51, NUMBER 7 1 APRIL 1995

Precision study of supersymmetry at future linear e^+e^- colliders

Toshifumi Tsukamoto,[1] Keisuke Fujii,[1] Hitoshi Murayama,[2,3] Masahiro Yamaguchi,[3] and Yasuhiro Okada[1]
[1] *National Laboratory for High Energy Physics (KEK), Tsukuba 305, Japan*
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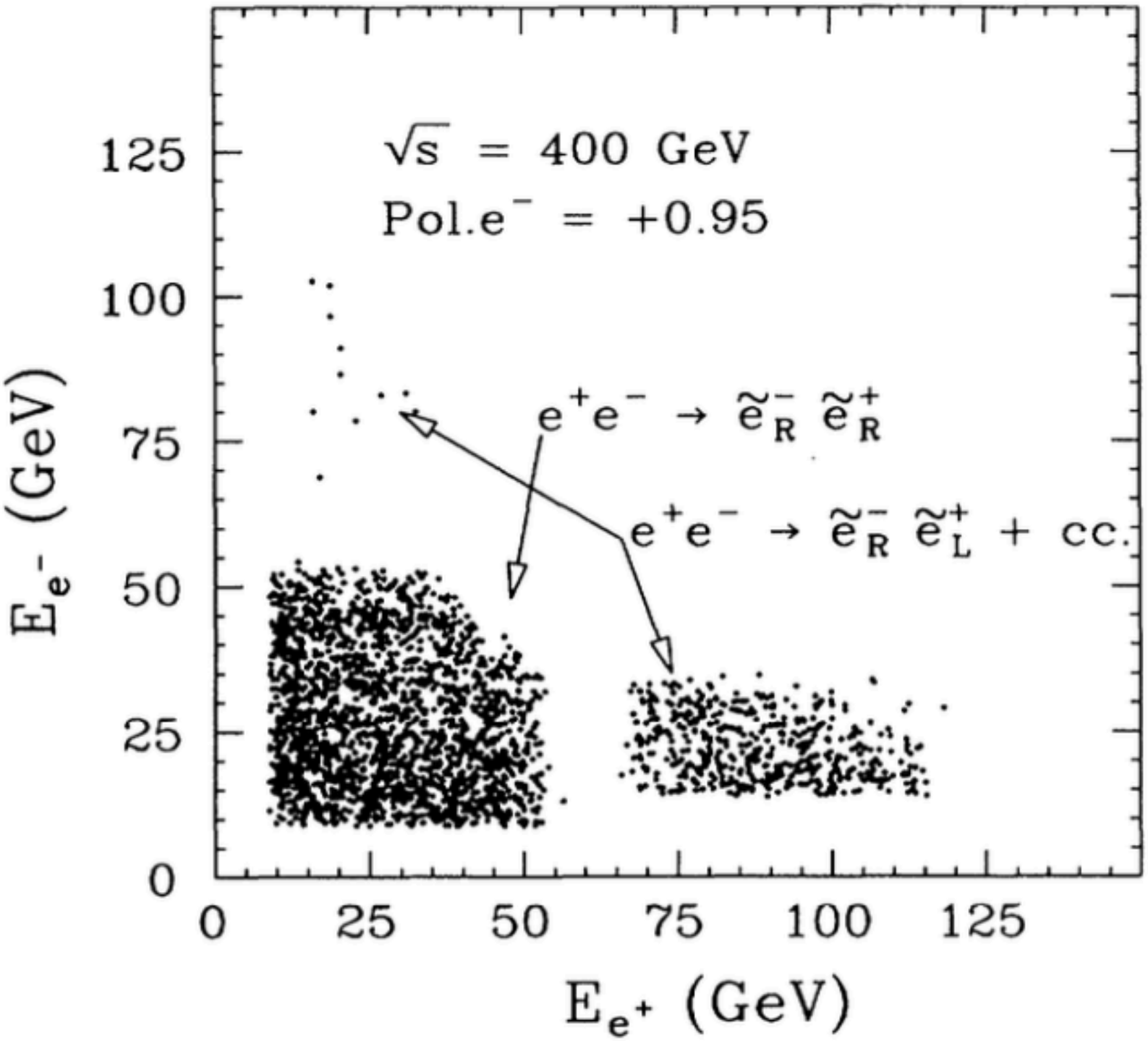
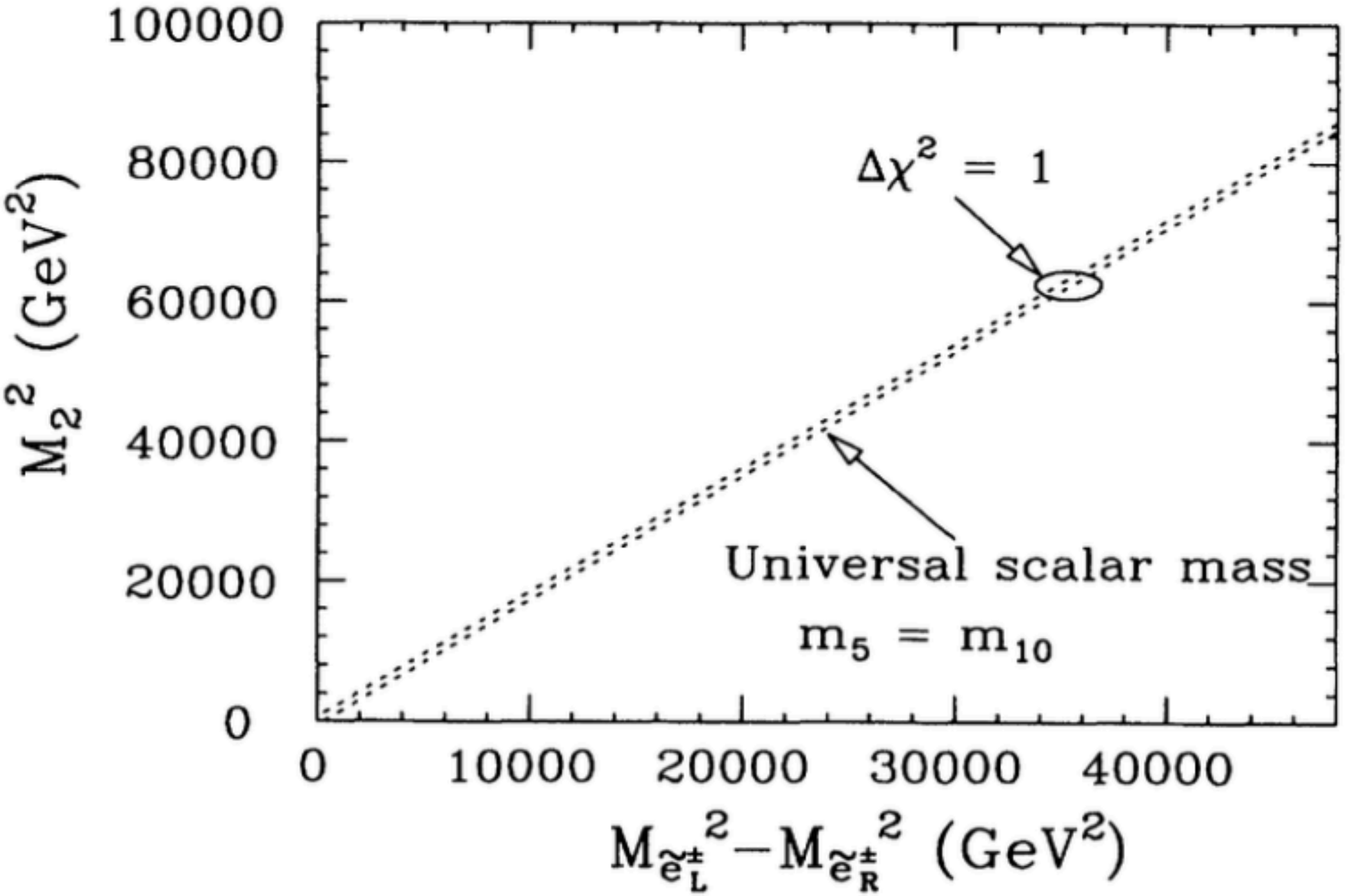
[3] *Department of Physics, Tohoku University, Sendai 980, Japan*
(Received 29 October 1993; revised manuscript received 27 September 1994)


√s = 400 GeV
Pol.e⁻ = +0.95
e⁺e⁻ → ẽ⁻R ẽ⁺R
e⁺e⁻ → ẽ⁻R ẽ⁺L + cc.
E_e⁻ (GeV)
E_e⁺ (GeV)
0
25
50
75
100
125


100000
80000
60000
40000
20000
0
M_2^2 (GeV^2)
$\Delta\chi^2 = 1$
Universal scalar mass
$m_5 = m_{10}$
0
10000
20000
30000
40000
$M_{\tilde{e}_L^\pm}^2 - M_{\tilde{e}_R^\pm}^2$ (GeV^2)

Many years later, we at SLAC applied these methods to connect collider data to properties of dark matter in SUSY models.

Determination of dark matter properties at high-energy colliders

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Marco Battaglia
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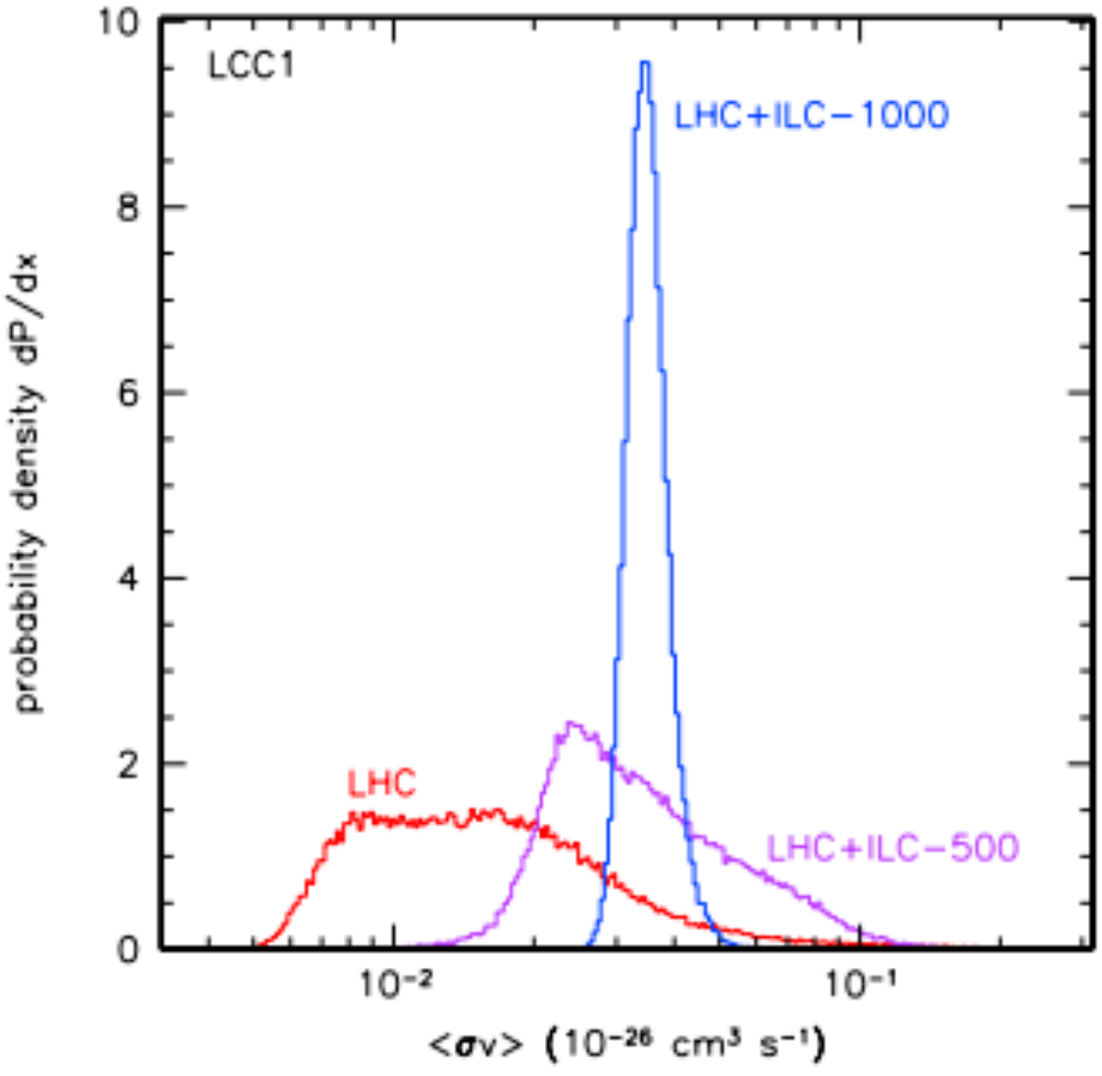
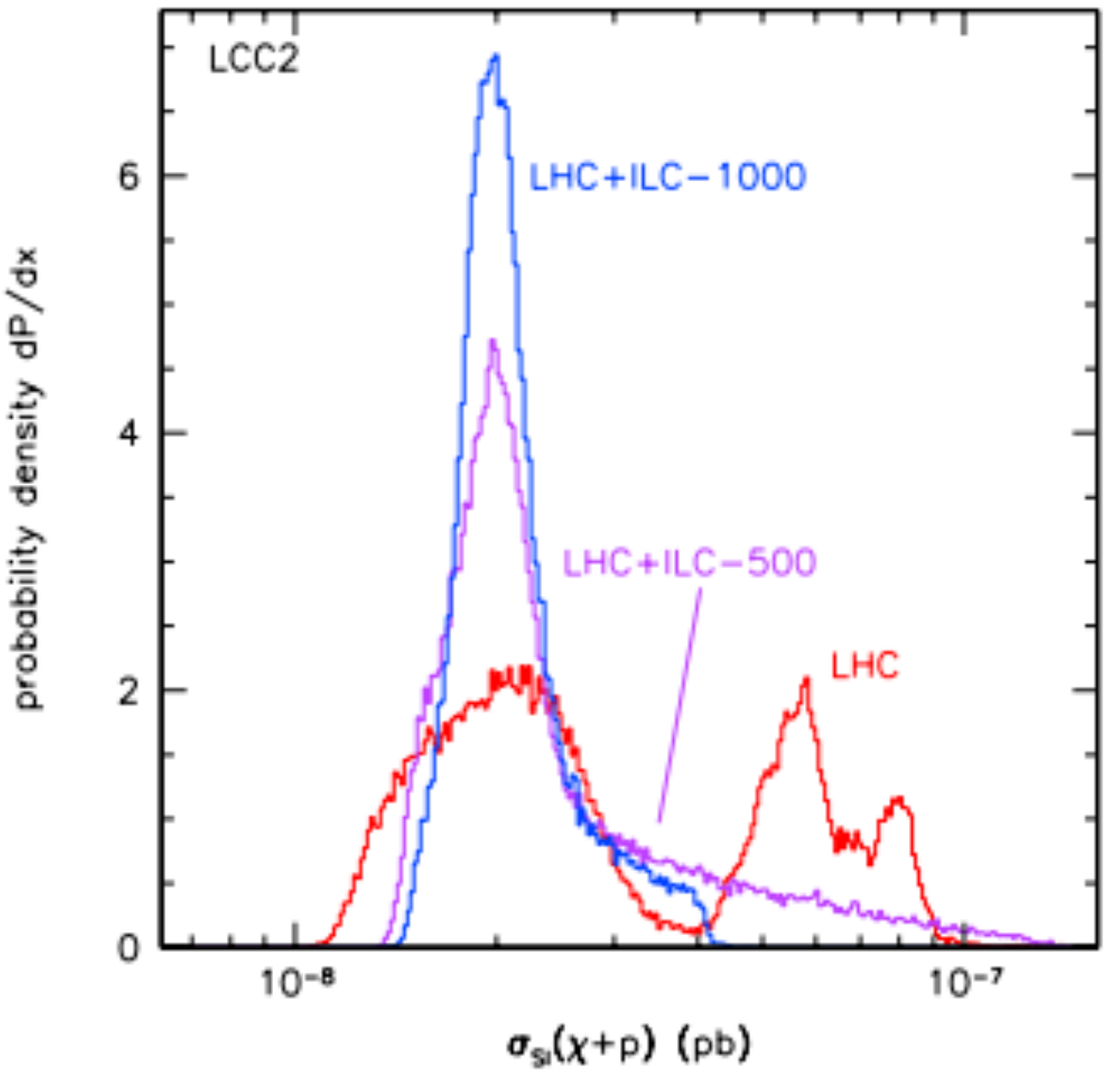
Michael E. Peskin and Tommer Wizansky
Stanford Linear Accelerator Center, Stanford University, Stanford, California 94309, USA
(Received 2 March 2006; published 30 November 2006)

predictions from collider data:



relic density



direct detection cross section

PHYSICAL REVIEW D VOLUME 52, NUMBER 3 1 AUGUST 1995

Testing supersymmetry at the Next Linear Collider

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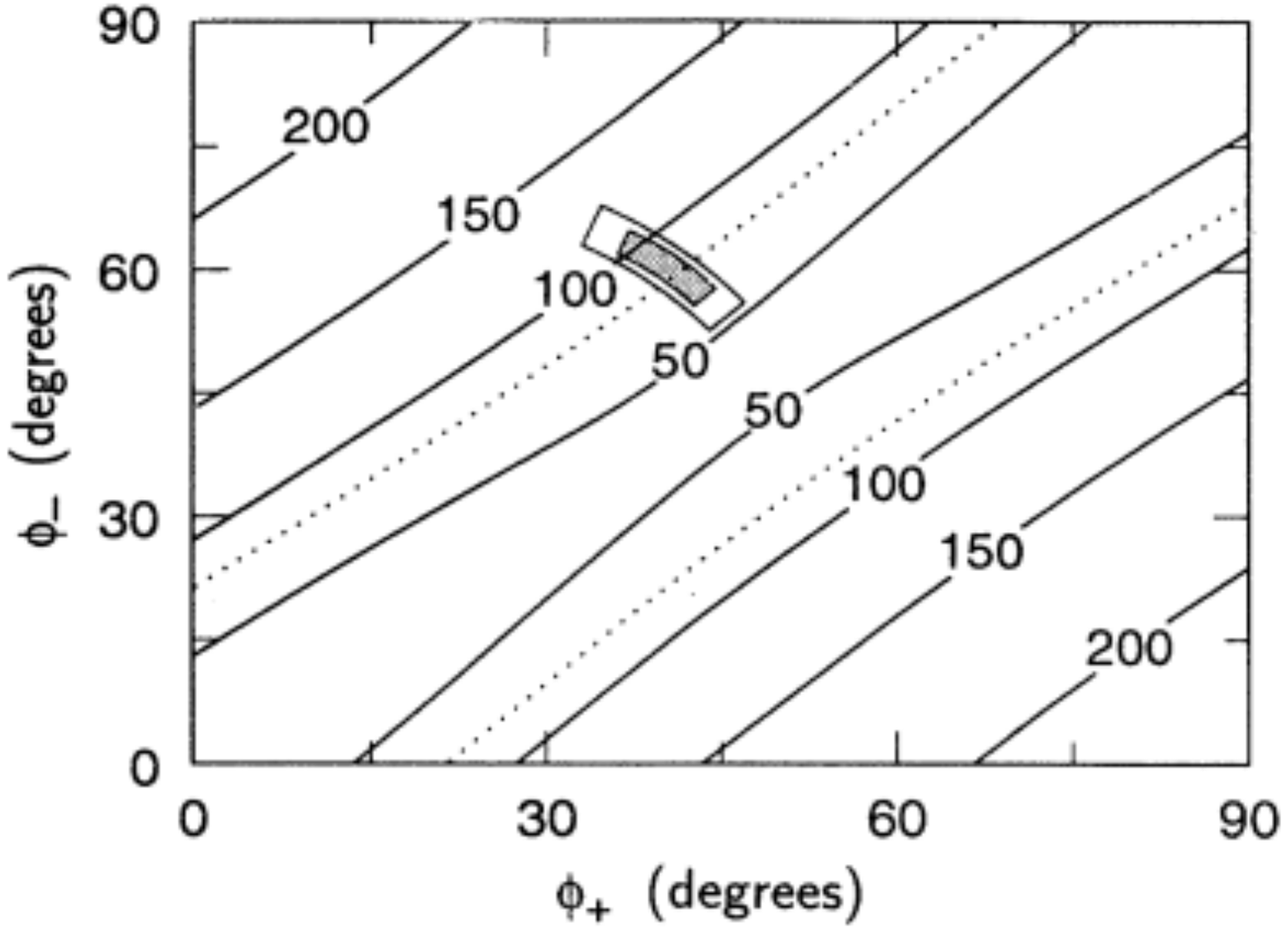
(Received 27 February 1995)

Up to now, almost all discussion of supersymmetry at future colliders has been concerned with particle searches. However, if candidates for supersymmetric particles are found, there is much more that we will want to know about them. Supersymmetry predicts quantitative relations among the couplings and masses of supersymmetric particles. We discuss the prospects for testing such relations at a future e^+e^- linear collider, using measurements that exploit the availability of polarized beams. Precision tests from chargino production are investigated in two representative cases, and sfermion and neutralino processes are also discussed.

PACS number(s): 11.30.Pb, 12.60.Jv, 13.88.+e, 14.80.Ly



"On the dotted contours, the SUSY relation $M_W^\chi = M_W$ holds."

PHYSICS OPPORTUNITIES OF e^+e^- LINEAR COLLIDERS

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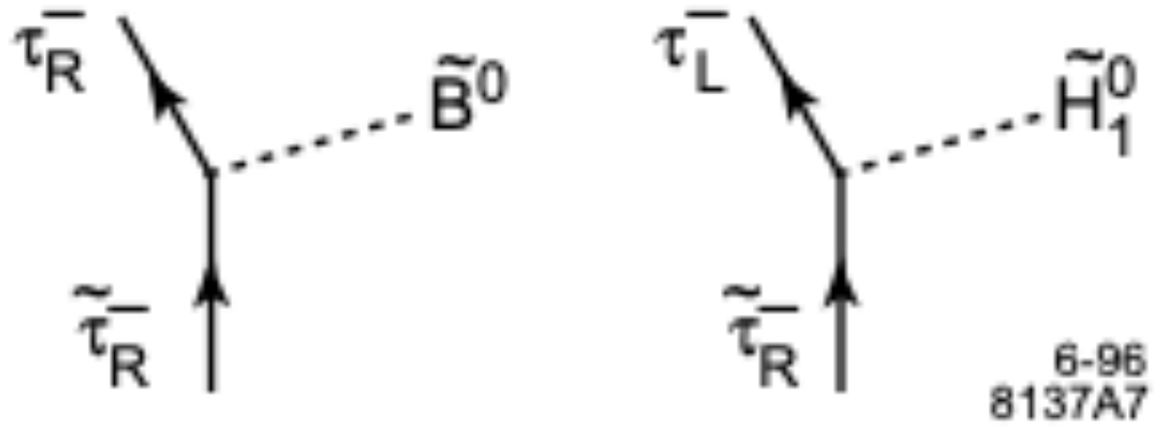
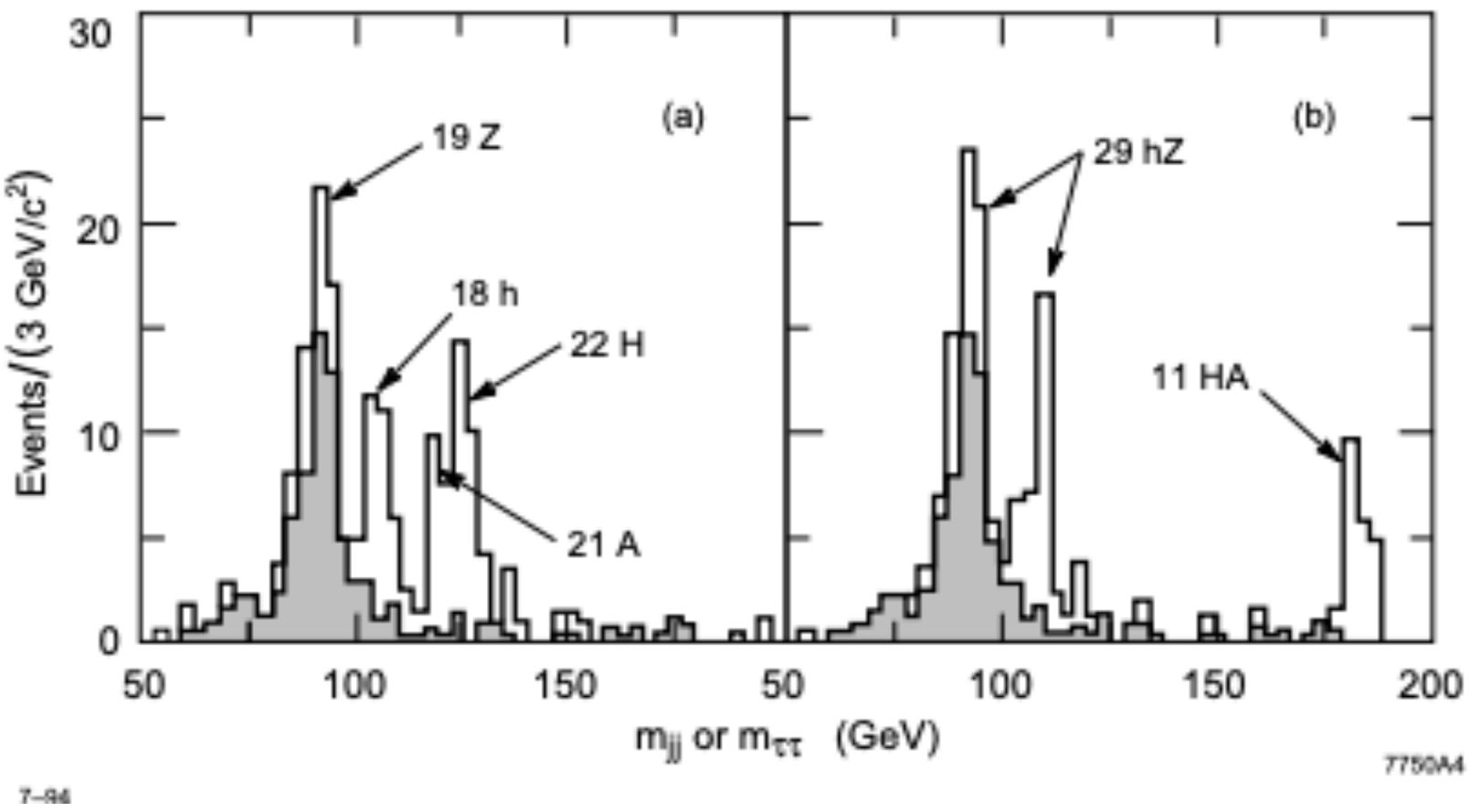
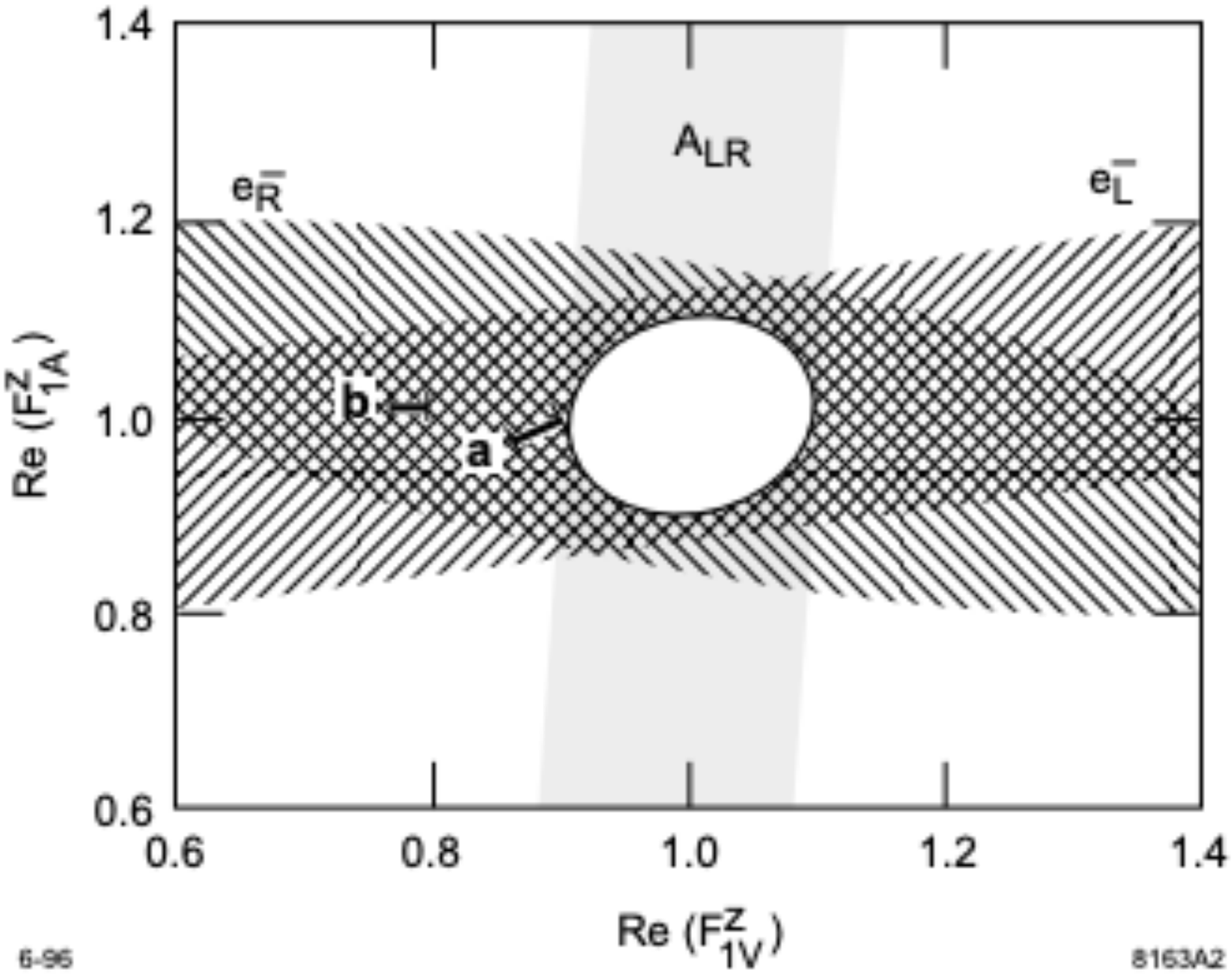
KEY WORDS: electron-positron annihilation, W boson, Higgs particles, top quark, supersymmetry

ABSTRACT

We describe the anticipated experimental program of an e^+e^- linear collider in the energy region 500 GeV–1.5 TeV, emphasizing topics relevant to the mystery of electroweak symmetry breaking.


τ_R^-
$\tilde{B}^0$
$\tilde{\tau}_R^-$
τ_L^-
$\tilde{H}_1^0$
$\tilde{\tau}_R^-$
6-96
8137A7


30
20
10
0
Events/(3 GeV/c²)
(a)
19 Z
18 h
22 H
21 A
(b)
29 hZ
11 HA
50
100
150
50
100
150
200
m_{jj} or $m_{\tau\tau}$ (GeV)
7750A4



The ttA and ttZ form factors enter the production amplitude for $e^+e^- \to t\bar{t}$.

(Thanks to Tim Barklow.)

After this followed 30 years of struggle and persuasion to make this physics available, first at Fermilab and then in Japan. In 2025, we will try to bring this vision to CERN.

But, by Asian tradition, at 60 years old, one is reborn.

Hitoshi, you are now

ex-IPMU Director

ex-Linear Collider Collaboration Deputy Director

ex-P5 chair

Now it is time to go back to Physics and have fun !

I wish you a very happy 60th !