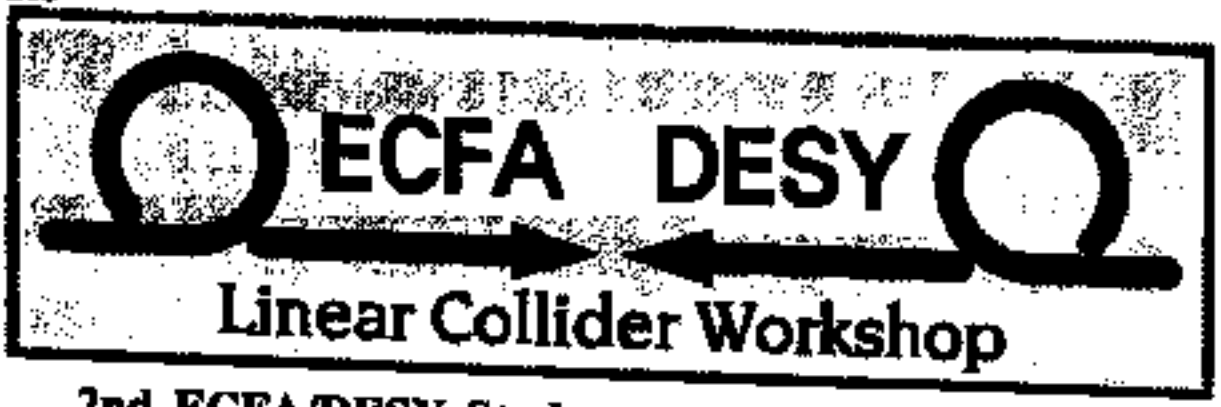
S18



2nd ECFA/DESY Study on Physics and Detectors for a Linear Electron-Positron Collider

LAL - Orsay - France, April 5-7, 1998

Date : April 7, 1998 - 09:00

Leaders of groups 1a to 1f

REFERENCE REACTIONS ?

(FIRST SUGGESTIONS) D. Miller

QCD

$F_2^\gamma(x, Q^2)$?

ℓ to 0.1%

+

+

HIGGS

$e^+e^- \to HZ$

$e^+e^- \to H\nu\nu$

$e^+e^- \to Hee$

$\gamma\gamma \to$ HEAVY H

+

+

ALTERNATIVE

$e^+e^- \to \nu\bar{\nu}\gamma$

$?\gamma e \to e^*$ (HOW MONOCHROMATIC)

TOP

$e^+e^- \to t\bar{t}$ AT THRESHOLD

$\to t\bar{t}H$ AT 700 – 800 GeV

top decay in continuum

ELECTROWEAK

$e^+e^- \to Z\gamma$?

$\to WW$] 4f

$\to ZZ$]

$\to c\bar{c}$

$b\bar{b}$

$\to e^+e^-$

SUSY

$e^+e^- \to \tilde{\chi}_1^+\tilde{\chi}_2^-$? | + POLARISATION

$\tilde{\chi}_1^0\tilde{\chi}_2^0$. |

$\to \tilde{t}\bar{t}$, $\tilde{\mu}^+\tilde{\mu}^-$

$\to$ finite decay lengths

$e^-e^- \to \tilde{e}^-\tilde{e}^-$?

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QCD + $\gamma\gamma$ Working Group

P.N. Burrows, A. de Roeck

QCD + $\gamma\gamma$ Working Group

P.N. Burrows
A. de Roeck

+

H. Spiesberger
L. Jönsson
T. Sjöstrand
U. Carina Müller
W. Bernreuther
F. Kapusta
W. Da Silva
C. Carimalo
M. Cacciari
F. Jérôme
D. Miller
H. Kühn
M. Greco
E. Elsen

WANTED: Theoretician convenor(s)!

Usual disclaimer:

QCD / $\gamma\gamma$ studies part of the broad programme @ a high energy e^+e^- collider

- Check that QCD works @ $\sqrt{s} \gtrsim 500$ GeV!

  TESLA $\mathcal{L} \sim 5 \times 10^{34}\ cm^{-2}s^{-1}$

  $\Rightarrow$ O(1M) $q\bar{q}$ events / year

  $\Rightarrow$ rich programme of "Z^0-style" QCD studies

- Check Q^2-evolution of QCD observables,

  eg. 3-jet rate R_3

Running of QCD Observables

Recall 3-jet rate:

$$R_3(y_c) \;=\; A(y_c)\alpha_s \;+\; B(y_c)\alpha_s^2 \;+\; \ldots$$

For fixed y_c (= 0.08 'E0' scheme):

$$R_3(Q^2) \;\leftrightarrow\; \alpha_s(Q^2)$$

Recall:

$$\alpha_s(Q^2) \;=\; \frac{4\pi}{\beta_0 \ln(Q^2/\Lambda^2_{\overline{MS}})}\left(1 - \frac{2\beta_1}{\beta_0^2}\frac{\ln(\ln(Q^2/\Lambda^2_{\overline{MS}}))}{\ln(Q^2/\Lambda^2_{\overline{MS}})} + \ldots\right)$$

where: $\beta_0 = 11 - 2N_f/3$

$\beta_1 = 51 - 19N_f/3$

Strategy:

Measure R_3 at as many Q^2's as possible!

Already have data: $14 \le Q \le$ ~~135~~ 172 GeV,

soon up to 190 GeV

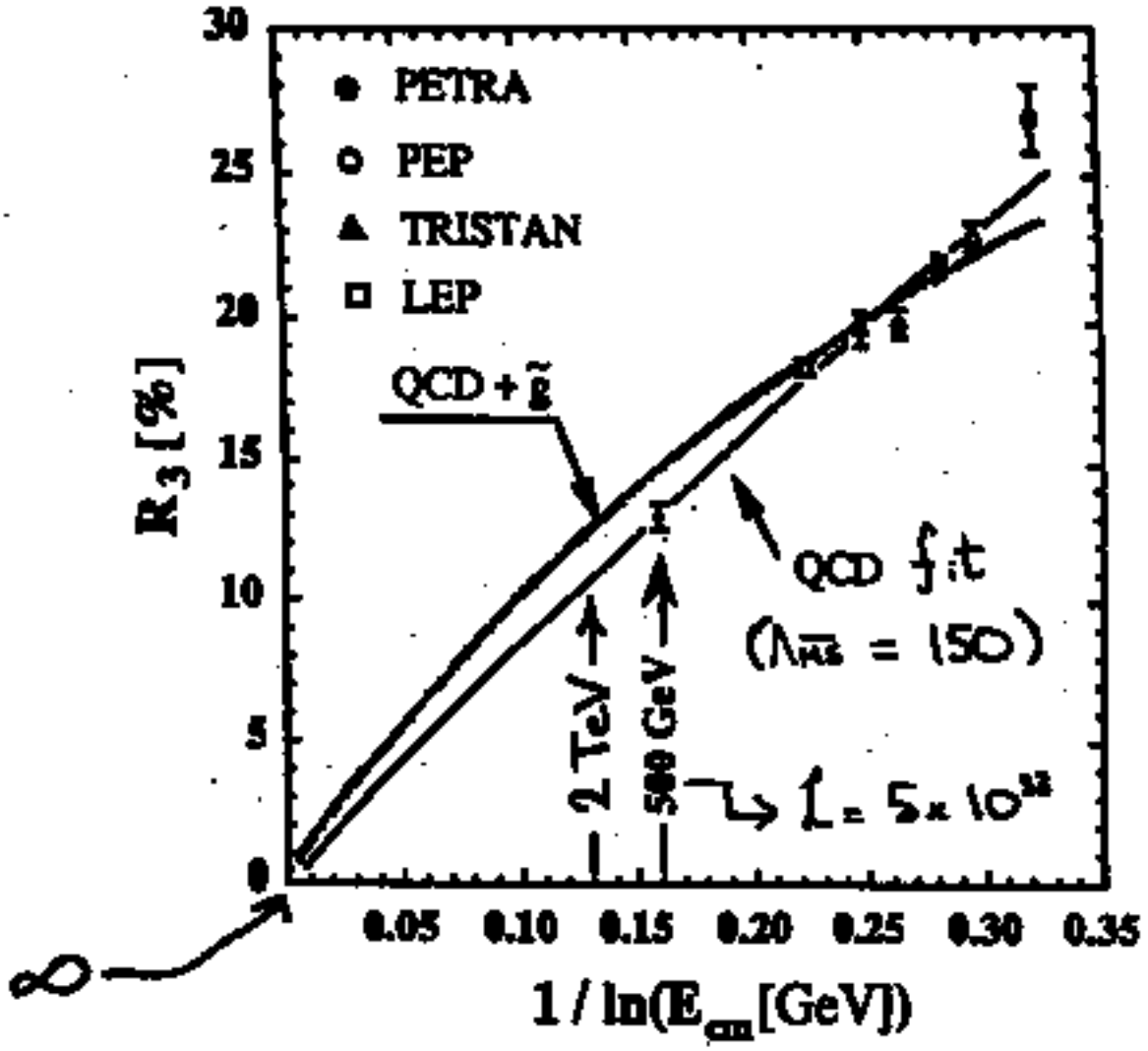


Fig. 4. Three-jet event production rates as a function of $1/\ln(E_{cm})$, measured with the JADE jet finder for a constant jet resolution of $y_{cut} = 0.06$.

Light gluinos: $N_f \longrightarrow N_f + 3N_{\tilde{g}}$

Precision (probably) limited by LOWER ENERGY DATA!

QCD running $\Rightarrow$

capability to vary $\sqrt{s}$ desirable

in particular,

high-precision data point @ $\sqrt{s} = M_Z$

$\Rightarrow$ large lever-arm in Q^2,
common detector systematics

not to mention:

calibration of detector

precision EW physics
→ eg. $\sin^2\theta_W$ via A_{LR}

$\Rightarrow$ ability to produce Z^0 events
in c.m.s. via asymmetric
beam E v. exciting!

α_s Measurements

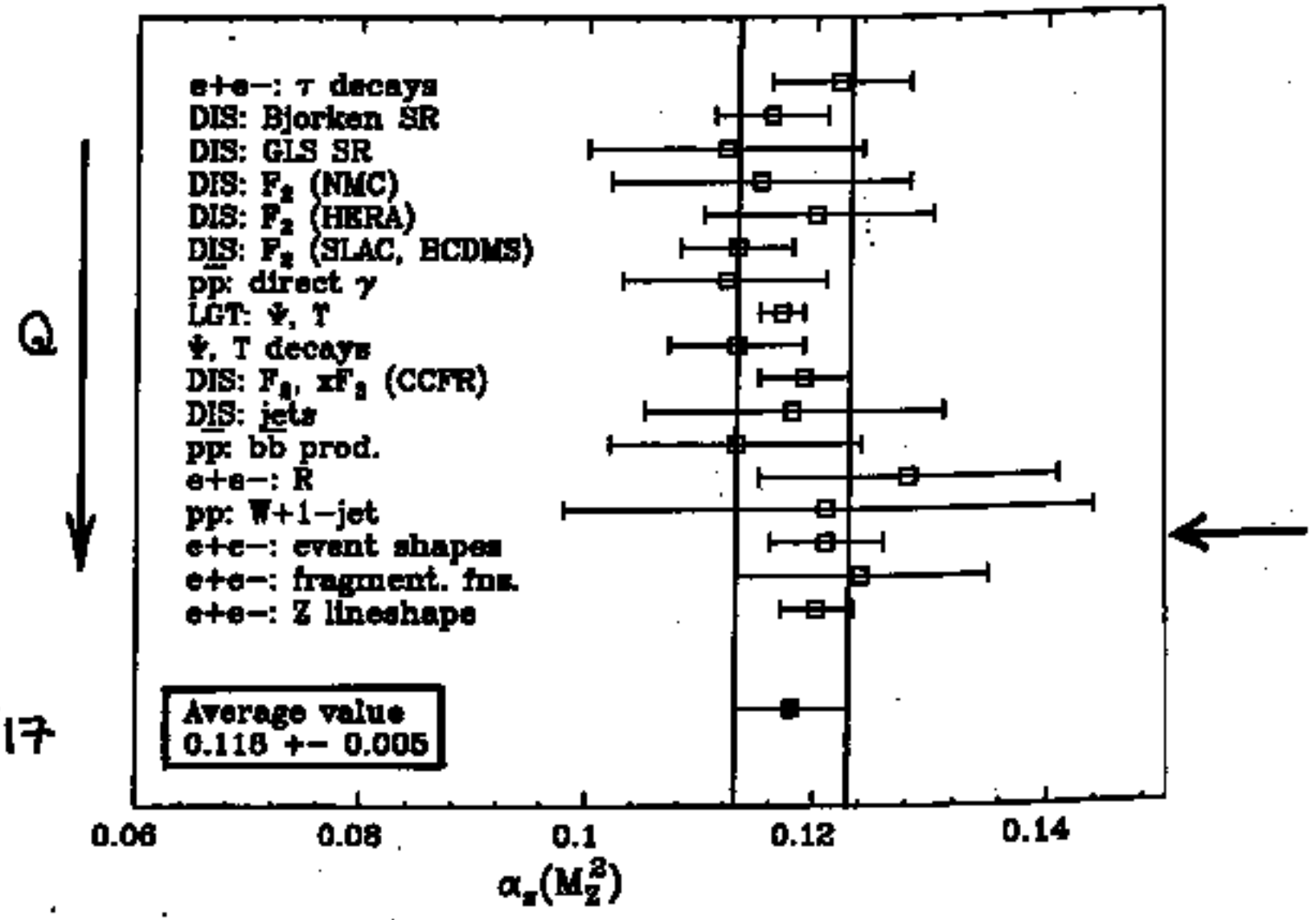
- α_s not measured precisely today!
  => FIG
- Better meas. possible @
  high energy e^+e^- collider:
  Event shapes:
  Hadronisation corrections $\sim 1/Q$
  $\sqrt{s} = 500$ GeV => 5x smaller than Z^0
  CAUTION: $O(\alpha_s^2)$ calcs. needed

Theoretically more attractive: $R = \frac{\sigma_{had}}{\sigma_{\mu^+\mu^-}}$

$\mathcal{L} \sim 5 \times 10^{34} \equiv 1$ Mevs/yr => $\Delta R \sim 0.1\%$ possible

=> $\Delta\alpha_s(500\text{GeV}) \approx 0.003$

SUMMARY OF MEASUREMENTS June 1997



$\chi^2 \simeq 6/17$

QCD + top-quark physics

- $\sigma_{t\bar{t}}(m_t, \alpha_s)$ well known

  input of precise α_s => reduce Δm_t

- study of hard-gluon E distn. in $t\bar{t}g$ events

  => set limits on anomalous chromoelectric + chromomagnetic moments

[NLO calcs. of $b\bar{b}g$ jet cross-sections completed recently: Bernreuther et al
Rodrigo et al

→ extend to $t\bar{t}g$ system ...]

- ... complicated by Γ_t

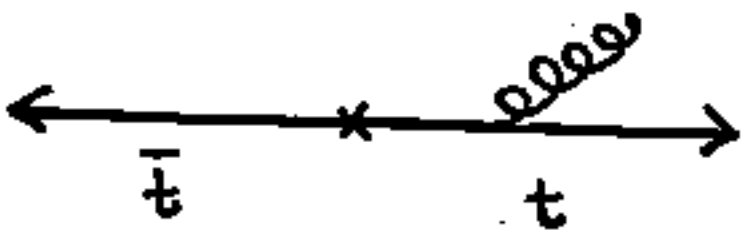
  => interesting soft-gluon radiation patterns

  => FIG

Interplay: $\Gamma_t \leftrightarrow$ top fragmentation

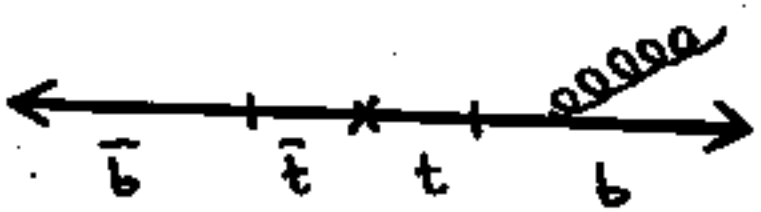
Gluon radiation: limiting cases

$\Gamma_t = 0$:



(A)

$\Gamma_t = \infty$:



(B)

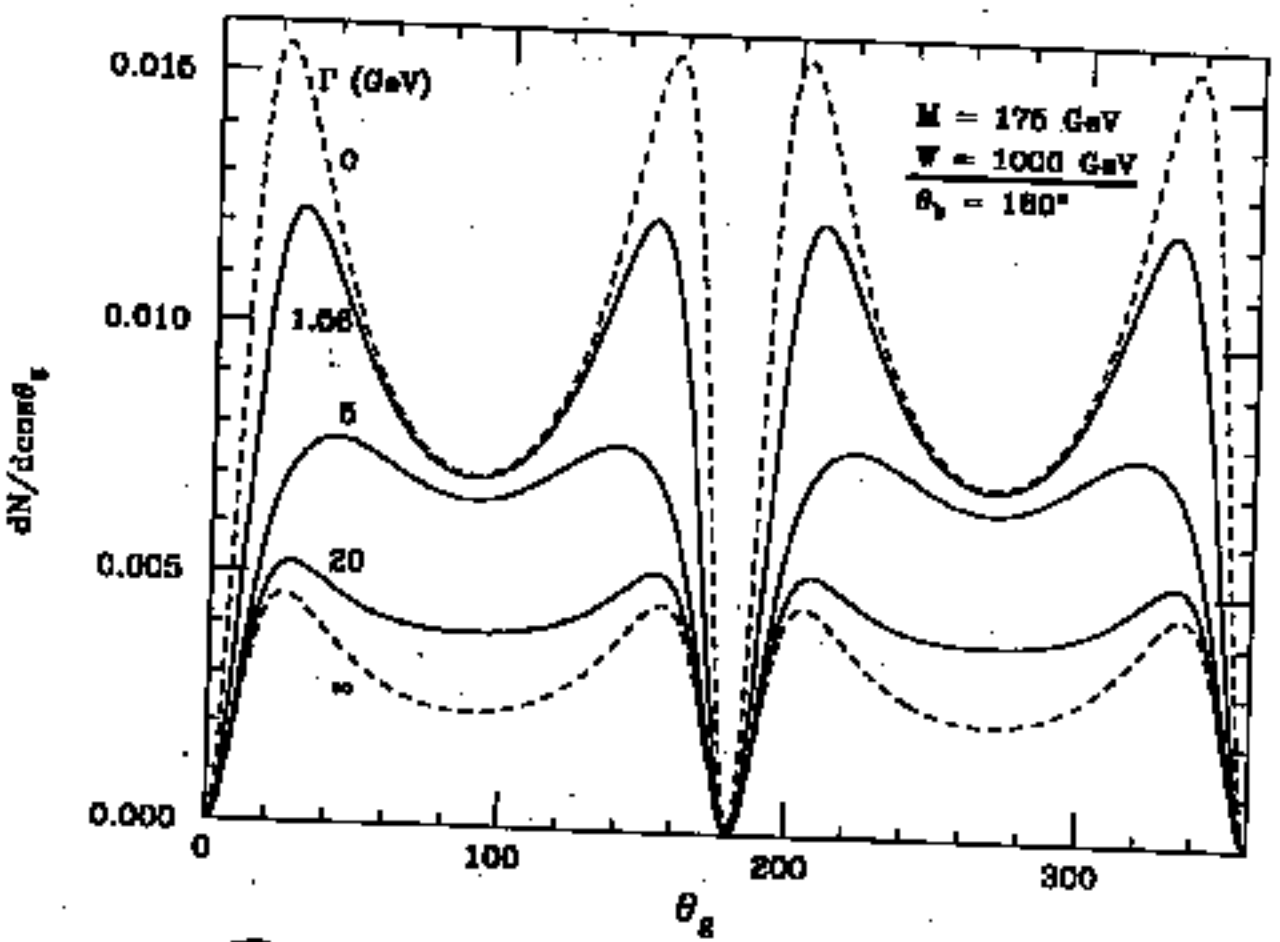
$0 < \Gamma_t < \infty$:

(A) $\oplus$ (B)

L. Orr et al

Update : $m_t = 175$ GeV

$\theta_b = 180°$



Emission Δ of 5 GeV gluons

Realistic simulation needed !

$\Rightarrow \Delta\Gamma_t$

Summary

New high-$\mathcal{L}$ scenario very attractive for QCD!

Warrants updated study of:

- Precise α_s meas: R or event shapes
- Q^2-evolution of observables (data points @ Z^0)
- Limits on anomalous strong t moments ($t\bar{t}g$)
- Meas. of Γ_t from soft gluon radiation (?)

Also:

"QCD events" as backgrounds,

event selection ϵ, π

⋮

$\gamma\gamma$ PHYSICS AT THE LC

A DE ROCK

PACT OF INCREASED LUMI

ETECTOR "SIMULATION" → TRUE ACCEPTANCE/

SIMULATORS PHOJET ✓ PYTHIA/HERWIG? SYSTEMATICS/NEW REQUIREMENTS ?

BACKGROUND ISSUES ↔ MACHINE

QUANTITATIVE RESULTS (E.G. $x g^{\gamma}(x,Q^2)$ FROM JETS)

USEFULLNESS OF LOWER ENERGIES?

OTHER INTERACTIONS γe, $\gamma\gamma$! (HIGHER E_{CM} ?)

NEW TOPICS ASYMMETRIC BEAMS ?

S]

OTON STRUCTURE $F_2(x,Q^2)$, $F_2^{\gamma}(x,Q^2)$, CC $F_L(x,Q^2)$, $F_2(x,Q^2,P^2)$

LUTION ? LOW x ?

CTRON STRUCTURE ? → INVITE THEORIST

STUDIES

FKL EFFECT (LOW x PHENOMENON)

RAGMENTATION/ JET & PARTICLE PRODUCTION/

ROMPT PHOTON / ... α_S ?

PHYSICS

TOTAL CROSS SECTION ; $\sigma_{\gamma\gamma}^{TOT}$

RACTIVE PHENOMENA

Y POMERON (ODDERON)

M PRODUCTION ONIUM - PRODUCTION

UARK PRODUCTION $\gamma\gamma \to$ RES.

PHYSICS (OTHER GROUPS) / $\gamma\gamma \to$ TOP

→ MANPOWER NEEDED

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HIGGS Working Group

A. Djouadi

HIGGS walking group:

DJOUADI [redacted]

* Update of constraints on MSSM Higgs sector:
  - Knowledge from LEP2 / Tevatron
  - Two-loop RCD corrections — Hollik ...
  - New developpements: IPP, mb/susy... — Espinosa...
  - constraints from REWSB, CCB.... — Le Mouel, Moultaka
  - XMSSM: bounds, no-loss theorem.. — Espinosa...
* Update of cross sections: still a chance at EE500 ($\frac{500}{500}$)
  for: $e^+e^- \to hA, HA, H^+H^-, H\nu\bar{\nu}$ .... — RC, ISR, Beamstr...
* Update of BR's: $h \to b\bar{b}$ (SUSY-RCD)
  $h \to gg, \gamma\gamma$ ($\tilde{q}$ loops) — Kalinowski
  3 body decays (WWZ...) + SUSY, GZ...
  Program HDECAY — ⋮
* Cross sections for higher order processes: $\int \mathcal{L} = 500\ fb^{-1}$!

$e^+e^- \to$	$\phi\phi Z, \phi\phi\nu\bar{\nu}$	Mühlleitner, Hilliam, ... Oslandi ....
$\to$	$\gamma\phi$	Illana, Hollik, ...
$\to$	$H^\pm W^\mp$	Arhib, ...
$\to$	$\tilde{t}\tilde{t}h$	Kneus, Moultaka, ...
$\to$	$t\bar{t}H + g$	Spira ....

* $\gamma\gamma \to \phi \to t\bar{t} + X$ interference — Krämer ....
  $e\gamma \to eH$ dim 6 operators — Mele ....

Any other contribution is welcome !!
Especially experimental contributions ....

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HIGGS Working Group

E. Gross

Higgs WG - NLC ORSAY

S: De-Jong, A. Djouadi, E. Gross, A. Read
↳ theoretical presentations: next

As newcomers (E.G. + A.R.) we came as experts in Higgs discovery and found out that the Higgs has already been discovered...

$m_H \sim 70 \div 80 \Leftrightarrow m_H > 90$

[or in the worst case as A.D. puts it:
the relevant question is
How many minutes it will take to discover it...]

Q. Why revising the May 97 CDR ?

A. Most (not all) of the work on which the '97 CDR is based on, was assuming $\int \mathcal{L} = 50\ fb^{-1}$ with a Non-Realistic (LEP-type) detector simulation

Now we are talking of

$\int \mathcal{L} = 500\ fb^{-1}$ for $\sqrt{s} = 500$ GeV (350, 800)

↘ NEW GAME RULES

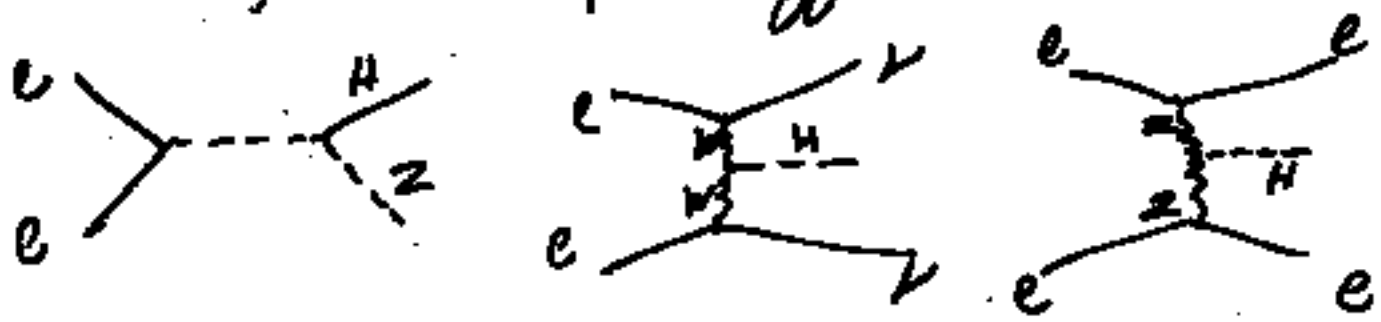
for $m_H \sim 150$

$\sigma(e^+e^- \to HZ) \sim \sigma(e^+e^- \xrightarrow{WW} H\nu\bar{\nu}) \sim 50\ fb \Rightarrow$

25K HZ, 25K $H\nu\bar{\nu}$, 3K Hee (ZZ fusion)

There are many physics subjects, we cannot cover them all, try to point out some minimum subjects we would like to cover:

for SM(susy) Higgs



(*) From $HZ \to H\mu\mu + He\varphi$

$m_H^2 = s - 2\sqrt{s}\,E_{ll} + m_{ll}^2$

$\int \mathcal{L} = 50\ fb^{-1}$ @ $\sqrt{s} = 500$ GeV

$\Delta m_H = 180$ MeV with LEP det simulation

Mass resolution affected by tracking resolution

(*) Cross Section ($HZ \to H\mu\mu$ → (Schriber) $(\sigma \to HZ)$ measurement

(*) Separation into channels requires hermetic detector ($\nu\bar{\nu}$ final states)

↳ Energy Flow, calorimetry

(*) BR ($H \to b\bar{b}$, $c\bar{c}$ (+ gluons)) ↔ Vertex Det performance

Can we separate $c\bar{c}$ from gluons?

There is already (M. Battaglia, R. Voopionpen DESY 97-123E) work based on

$\int \mathcal{L} = 50\ fb^{-1}$ @ $\sqrt{s} = 360, 500$ GeV

with > SIM DET

CDR '97 results

$\Delta\left(\sigma_{ZH}\cdot BR(H\to b\bar{b})\right)$ 6.2 % for $m_H=140$

$\Delta\left(\sigma_{ZH}\cdot BR(H\to c\bar{c}+gg)\right)$ 47%

$\Delta\dfrac{BR(H\to c\bar{c}+gg)}{BR(H\to b\bar{b})}$ 48 %

Work should be revised
(higher Lum, better det sim and
maybe improve analysis)

[this work is an improvement over
Hildreth, Barklow, Burke
and is based on Λ'+Delphi inspired b-tag]

(*) Measuring $H\to b\bar{b}, c\bar{c}, \tau^+\tau^-$ ...
$\Rightarrow$ $Hf\bar{f}$ Yukawa Couplings

(*) Fusion (ZZ, WW) processes
$\Rightarrow$ HZZ, HWW couplings

(*) $\sigma(ee\to HZ\to H\mu\mu)\to$ HZZ coupling

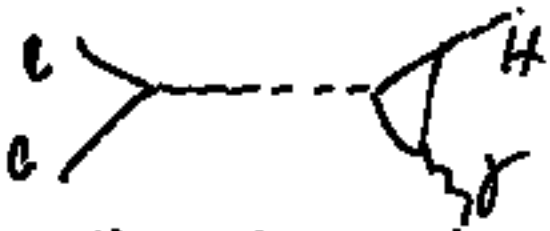
(*) $e^+e^-\to Ht\bar{t}$ (top group?)

(*) Partial Widths

$BR_S \rightarrow$ partial widths

$H\gamma\gamma$ best via $\gamma\gamma \rightarrow H$

(*) With $\int L = 500\ fb^{-1}$ one might start looking at direct $H \rightarrow \gamma\gamma$ ($BR \sim 3 \cdot 10^{-3}$ for $m_H \sim 130$) and construct $\gamma\gamma$ (difficult)

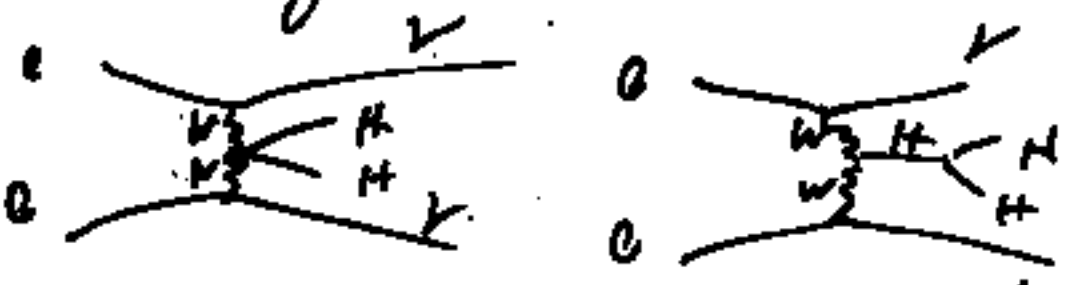
(*) 

(A.D et. al ...)

Monochromatic γ

(lots of returned γ bg)

(*) Trilinear & Quartic self couplings



provides a direct look into the SSB Lagrangian

SUSY $e^+e^- \to HA$

(*) There is already a very mature analysis $e^+e^- \to HA$ based on $\int L = 200\ fb^{-1}$ @ $\sqrt{s} = 500$ GeV
(C. Troncon & A. Andreazza DESY 97-038)

$m_{A,H} = 260, 340 \to m_l \sim 110$ GeV SM like

$\Delta m_{A,H} \sim 1\text{-}5$ GeV

$\Delta l\ (e^+e^- \to HA) \times BR(H \to bb) \times BR(h \to bb) \sim 5\text{-}11\%$

(*) Hopefully this analysis will be improved, revised for higher $\int L$ and with improved det simulation and more detailed SUSY-Higgs interpretation

(*) $e^+e^- \to H^+H^-$

(*) XMSSM

(*) $\gamma\gamma$, $e^-\gamma$, e^-e^-

(theoretical contributions → A. L

Monte Carlos

HZ , WW→H, ZZ→H

HZHA ?

BG processes

ee→qq̄ , WW, ZZ

We forgot ee→W(e)ν (bg to Hνν

Det Simulation

4½ years old SIMDET (Schmitz)

A more realistic simulation will not be available before X(?) months; we should continue with the existing fast simulation

Central MC production etc...

.... Maybe by 2008...

How many Indians?

Virtually 32

Theoreticians	11
Expressed interest	15
Expressed agreement to work with C-band det	1
Expressed interest in Phys-Det feedback	3
Did not express specific interest (but would like to get minutes proj	2
Total	32

If 50% will spend 30% of their time

$$16 \times 50\% \times 30\% \sim 3$$

PLEASE RESPOND TO e-mail

JUNE is TOO CLOSE!!!

Not much progress is expected from any point of view!

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Alternative Theories

G. Wilson

ALTERNATIVE THEORIES

CONVENERS:

REINHOLD RÜCKL (T

GRAHAM WILSON (E

SUBJECT MATTER ?

BROADLY (ANTI) DEFINED AS NON-SUSY, NON-HIGGS THEORIES / MODELS TESTABLE AT LC ENERGIES.

→ FORUM FOR NEW THEORETICAL IDEAS APPLIED TO LC AND EVALUATING FEASIBILITY OF "ALTERNATIVE" MODEL PHYSICS AT A LC.

AS AN EXPERIMENTALIST, A MAJOR GOAL IS TO IDENTIFY ALTERNATIVE EXPERIMENTAL SIGNATURES MAYBE / MAYBE NOT MOTIVATED BY ALTERNATIVE MODELS OF NEW PHYSI

AND MOST IMPORTANTLY

WE ALL SHOULD DEFINE

THE PHYSICS GOALS OF THIS GROUP

"ALTERNATIVE THEORIES"

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• R. Rückl	
• H. Spiesberger	
F. Boudjema	
• J. Kalinowski	

YOU SHOULD RECEIVE MINUTES NEXT WEEK.

PLEASE SEND E-mail and

"OBVIOUS TOPICS"

COMPOSITENESS

CONTACT INTERACTIONS ✓ S.R. C.S.

EXCITED FERMIONS

HEAVY FERMIONS

LFV ($e^-e^- \to W^-W^-$) ✓ C.H. P.M. JI

LEPTOQUARKS / R_p / $\tilde{\nu}$ ✓ C.S. HS, JK, RR

W', Z' ✓ A.L. S.R. N.P. S.I. HIGGS ✓ A.D. GAUGE BOSONS

GENERAL ISSUES

SCALING LAWS $\mathcal{L}$, E AL FOR W', Z'

e^-e^- C.H.

$\gamma\gamma$, γe, ...

$p\bar{p}$

Möller scattering at high $\sqrt{s}$ → TEST e^- COMPOSITENESS

$\mathcal{L}$ measurement

ALTERNATIVE TOPICS

M. RAIDAL
- EXOTIC HIGGS
- non-standard SUSY models
- doubly charged particles
- LR models . . . .

J. MAALAMPI
- LR models
- Majoron model . . .
- $e^-e^- \to W^-W^-$, $e^-e^- \to \mu^-\mu^-$
- ν_μ H^-

A. DEANDREA & collaborators
- STRONGLY INTERACTING EW sector
- pseudo goldstone bosons
- new vector resonance $\to \pi^+\pi^-$

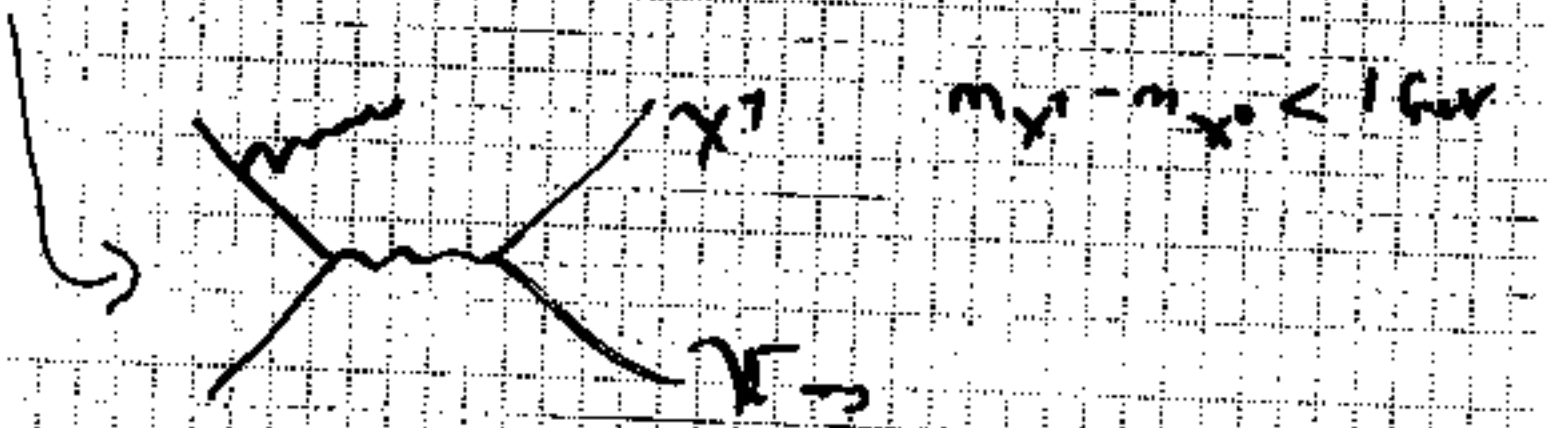
"ALTERNATIVE" EXPERIMENTAL SIGNATURES

- LONG LIVED PARTICLE PRODUCTION
- FRACTIONALLY CHARGED PARTICLES
- DOUBLY CHARGED ..
- MACROSCOPIC LIFETIMES
- ISR TAGGING OF (QUASI) INVISIBLE PARTICLES
- MONOPOLES

trigger

$\frac{dE}{dx}$ etc

dE/dx vs p



Z' limits at a LC with high Luminosity

A. Leike, LMU Munich

1. $e^+e^- \to f\bar{f}$, no signal at normal L_{int}

- Scaling: $M_{Z'}^{lim} \sim \sqrt[4]{\frac{5L_{int}}{1+r^2}}$, $r = \frac{\Delta^{syst}O}{\Delta^{stat}O}$
- At a LC with normal L_{int}:

  $r \approx 1$ for observables O with final Leptons
  $r > 1$ for observables O demanding flavour tagging ($\varepsilon \approx 2\%$ for b quarks)

- $L_{int} \to 10 \cdot L_{int}$ and $\Delta^{syst}O = const.$

$$\Rightarrow M_{Z'}^{lim} \to \sqrt[4]{\frac{5 \cdot 10 L_{int}}{1+10r^2}} = M_{Z'}^{lim} \sqrt[4]{\frac{10(1+r^2)}{1+10r^2}} \approx 1.16\, M_{Z'}^{lim}$$

- $L_{int} \to 10 \cdot L_{int}$ and $\Delta^{syst}O / \Delta^{stat}O = const.$

$$\Rightarrow M_{Z'}^{lim} \to \sqrt[4]{\frac{5 \cdot 10 L_{int}}{1+r^2}} = M_{Z'}^{lim} \sqrt[4]{10} \approx 1.78\, M_{Z'}^{lim}$$

➡ The gain in $M_{Z'}^{lim}$ for $L_{int} \to 10\, L_{int}$ depends crucially on the syst. errors.

2. $e^+e^- \to f\bar{f}$, Z' signal at normal L_{int}

- Scaling: $\frac{\Delta M_{Z'}}{M_{Z'}}, \frac{\Delta \text{coupling}}{\text{coupling}} \sim \sqrt{\frac{1+r^2}{s L_{int}}}$

- $L_{int} \to 10 \cdot L_{int}$ and $\Delta^{syst} = \text{const.}$

$$\Rightarrow \frac{\Delta M_{Z'}}{M_{Z'}} \to \sqrt{\frac{1+10r^2}{s \cdot 10 L}} = \frac{\Delta M_{Z'}}{M_{Z'}} \cdot \sqrt{\frac{1+10r^2}{10(1+r^2)}} \approx \begin{cases} 0.74 \frac{\Delta M_{Z'}}{M_{Z'}} & \text{lept} \\ 0.91 \frac{\Delta M_{Z'}}{M_{Z'}} & \text{b-qu} \end{cases}$$

- $L_{int} \to 10\, L_{int}$ and $\Delta^{syst} 0 / \Delta^{stat} 0 = \text{const.}$

$$\Rightarrow \frac{\Delta M_{Z'}}{M_{Z'}} \to \sqrt{\frac{1+r^2}{s \cdot 10 L}} \approx \frac{\Delta M_{Z'}}{M_{Z'}} \cdot \frac{1}{\sqrt{10}} \approx 0.31 \frac{\Delta M_{Z'}}{M_{Z'}}$$

$\Rightarrow$ The increase of the precision of a Z' model measurement depends even more on the systematic errors than $M_{Z'}^{min}$.

3. Other processes

- Processes with smaller σ don't suffer from systematics

⇒ Processes with $\sigma \gtrsim \frac{1}{10}\sigma(e^+e^- \to \nu\bar{\nu}\gamma)$ could give interesting information

- Examples: $e^+e^- \to \nu\bar{\nu}\gamma$

  $\gamma e \to (\nu W) \to f_1 \bar{f}_2 \nu$

  $\gamma e \to (e Z') \to f \bar{f} e$

- Can these (or other) processes help to improve M_Z^{eim} or M_W^{eim} for high L_{int} ?

- What can they contribute to a model measurement?

4. $e^+e^- \to \nu\bar{\nu}\gamma$

- Proposal to measure the # of generations:
  A.D. Dolgov, L.B. Okun, V.I. Zakharov, Nucl. Phys. B41 (1972) 197
  E. Ma, J. Okada, Phys. Rev. Lett. 41 (1978) 287
  K.J.F. Gaemers, R. Gastmans, F.M. Renard, Phys. Rev. D19 (1979) 16
- SM calculation with 1-loop QED corr.:
  F.A. Berends, G.J.H. Burgers, C. Mana, M. Martinez, W.L. van Neerven, Nucl. Phys. B301 (1988) 583
- Higher order RC's:
  G. Montagna,
- Well studied background for neutralino production
- ∃ preliminary study (J.A. Hewett, Snowmass 97) on the sensitivity to W' in the point interation approximation of the W and the W'.
  result: $M_{W'}^{lim} \approx (1-2)\sqrt{s}$ seems to be acheavable for $\sqrt{s} = 500$ GeV and $L_{int} = 50 fb^{-1}$.
- Point interaction approximation is known to break down for the W at $\sqrt{s} > M_W$.

If there exists a light W', most model predict a light Z' too.

⇒ Process is under investigation by
S. Godfrey, P. Kalyniak and A. L...

SUMMARY

* EXPECTED EXPERIMENTAL UNCERTAINTIES ON $\frac{d\sigma}{d\cos\theta_f}$ for $e^+e^- \to f\bar{f}$ NEEDED FOR W', Z', CI, LQ etc.

* NEED ALSO TO KNOW $\left(\frac{\Delta\mathcal{L}}{\mathcal{L}}\right)_{expt}$ AND $\left(\frac{\Delta\mathcal{L}}{\mathcal{L}}\right)_{theory}$

NEED TO KNOW γ ENERGY SPECTRA, $\mathcal{L}$

* TO EVALUATE $\gamma\gamma$, γe OPTIONS

(E.G. $\gamma e \to e^*$ USEFUL IFF GOOD γ MONOCHROMATICITY (IF e^* ALREADY DISCOVERED).

* WG SEEMS "THEORETICALLY" VIABLE
  → DESIRABLE TO COVER NEW FERMION SECTOR TOO (f^*, $L^\pm$, L^0, ...
  (PLEA FOR HELP HERE)

* EXPT^L INTEREST SO FAR OVERLAPS DIRECTLY WITH "SM PROCESS" MEASUREMENT

REFERENCE REACTION : $e^+e^- \to \nu\bar{\nu}\gamma$ SUGGESTED

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2nd ECFA/DESY Study on Physics and Detectors for a Linear Electron-Positron Collider

LAL - Orsay - France, April 5-7, 1998

Date : April 7, 1998 - 09:00

Electroweak Gauge Theories

K. Moenig, T. Ohl

2nd ECFA/DESY Study on e^+e^- LCs

Orsay, Apr 6, '98

Electroweak Gauge Theories

- SM Physics
- Gauge Boson Properties (SM & beyond)

http://crunch.ikp.physik.tu-darmstadt.de/ilc

Ohl@hep.tu-darmstadt.de, ohl@ifh.de

- announcements
- Contacts
- etc.

T George Zoumakis, Thessaloniki

E Klaus Mönig, DESY Zeuthen

T Thorsten Ohl, TH Darmstadt

Electroweak Gauge Theories

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+ commitments from
Perugia & Torino

Physics program

1) TGV higher precision @ 500 fb^{-1} yr$_{eff}^{-1}$

2) QGV

3) EWSB
   ⇒ strongly interacting weak sector [SUSY]

4) Background for Higgs searches & Higgs precision measurements

5) Background for top precision meas.

6) EW radiative corrections on the gauge boson sector

   500 fb^{-1} yr$_{eff}^{-1}$

7) Radiative return $e^+e^- \to \gamma Z$

Calculational program

1) $e^+e^- \to 2f$ @ high energies

2) $e^+e^- \to 4f + \gamma$
@ better precision

3) $e^+e^- \to 4f + g$
@ good precision

4) $\gamma\gamma \to 4f$ complete [Boos/Ohl]

5) $\gamma e^- \to 3f + \gamma + g$

6) $e^+e^- \to 6f$ ← ie. $3V \to 6f$ or $2V + 2f \to 6f$

7) Polarisation initial and final states

8) $e^+e^- \to 2\gamma\gamma$, $2\gamma\gamma\gamma$?

Reference Reactions

1) $e^+e^- \to \begin{pmatrix} W^+W^- \\ Z\,Z \end{pmatrix} \to 4f \begin{cases} l\nu\,jj \\ jjjj \\ l^+e^-jj \end{cases}$

∵ "bread & butter"

∵ TGV

∵ M_W, $\frac{M_W}{M_Z}$

Christoph Burgard
Hywel Phillips
[Tim Barklow]
Jan Timmermans

2) $e^+e^- \to Z\gamma + n\gamma$

∵ calibration

∵ luminosity ($\frac{\Gamma}{M}$)

Klaus Mönig
Thorsten Ohl

3) $e^+e^- \to \begin{matrix} c\bar{c} \\ b\bar{b} \end{matrix}$

∵ flavor tagging

∵ R_b, R_c

Tim Behnke
Richard Hawkings

4) $e^+e^- \to e^+e^-$ $\begin{cases} \text{large angles} \\ \text{small angles} \end{cases}$

∵ luminosity

∵ compositeness, etc.

Available Tools

Reference reactions w/ "reasonable" accuracy implemented in HERWIG/PYTHIA.

* dedicated $e^+e^- \to VV \to 4f$ generators available from LEP2 studies

* radiative return rather poor (1γ: 10%, 2γ: 30%, ...)
  $\Rightarrow$ calculate $e^+e^- \to Z\gamma\gamma$

Apr. 7, 1998

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LEP I (sic!) revisited?

Can we do A_{LR} on the Z?

[Francois Richard]

$\boxed{\text{MAYBE}}$ $\boxed{\sin\theta_W \text{ @ } 10^{-5}}$

Problems: *) Luminosity limited by e^+-source @ low energies. $\mathcal{L} \lesssim 10^{32}\,cm^{-2}s^{-1}$

not a real problem

*) Polarization measurement? Blondel-scheme not obvious ∵ no symmetry

∵ no stabilization

∴ Klaus Honig will look at it (before Lund)

→ Alain says that it works!

Specific Projects

1) Beam spectra for $5 \cdot 10^{34}\,cm^{-2}s^{-1}$
   ⇒ Generator group [Th.O., Daniel Schulte]

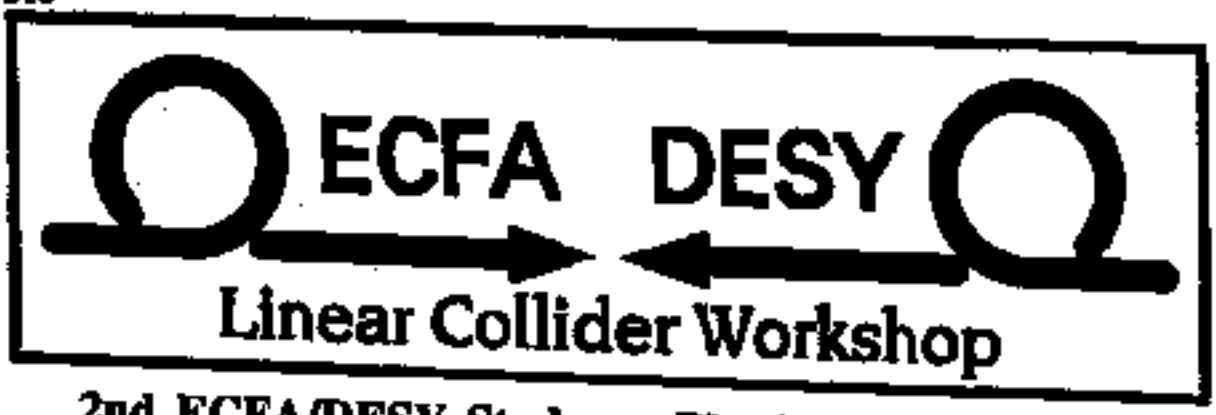
2) Radiative Corrections for $e^+e^- \to Z\gamma$ ⇒ Lumi?
   $e^+e^- \to Z\gamma\gamma$ vs. $\int dx_1 dx_2 D(x_1)D(x_2)\sigma_{Z\gamma}(s x_1 x_2)$

3) Energy calibration using asymmetric beams
   $20\,GeV \times 500\,GeV \Rightarrow m_Z$
   $500\,GeV \times 500\,GeV \Rightarrow$ asymmetry

4) ZFITTER @ TESLA [Dmitri Bardin, Tord Riemann et al.]

5)

S18



2nd ECFA/DESY Study on Physics and Detectors for a Linear Electron-Positron Collider

LAL - Orsay - France, April 5-7, 1998

Date : April 7, 1998 - 09:00

SUSY Working Group

W. Majerotto

W. Majerotto
ECFA - DESY
Lin. Coll. Workshop
5-7 April 1998
LAL - Orsay

SUSY Working Group

Conveners: Exp: G. Blair, U. Martyn, Y. Sirois
Th.: A. Bartl, W. Majerotto

$\geq$ 30 participants

lively discussion

Short presentations:

F. Richard: Some new aspects
S. Ambrosiano (prepared): GMSB
W. M.: Some suggestions
C. Heusch: e^-e^-

General agreement :

- **GREAT DISCOVERY POTENTIAL:**

already in the 1st phase ($\sqrt{s} = 500$ GeV) :

- charginos $\tilde{\chi}_1^+$
- neutralinos $\tilde{\chi}_1^0$, $\tilde{\chi}_2^0$
- sleptons : $\tilde{e}$, $\tilde{\mu}$, $\tilde{\tau}$, $\tilde{m} \lesssim 250$ GeV
- Stop $\tilde{t}_1$, if squark mixing large
- h : if nonstandard decay modes (invisible decays, ...)

at higher energies ($\rightarrow$ 1 - 2 TeV) :

most likely better than LHC!

$\tilde{\chi}_2^\pm$
$\tilde{\chi}_3^0$, $\tilde{\chi}_4^0$
sleptons $\tilde{m} > 250$ GeV
squarks $\tilde{u}$, $\tilde{d}$, $\tilde{s}$, ..

$\rightarrow$ heavier Higgs bosons H, A, $H^\pm$

• PRECISION MEASUREMENTS POSSIBLE

Previous studies :

$\delta m_{\tilde{\chi}_1^+} = 100\,\text{MeV}$

$\delta m_{\tilde{\chi}_1^0} = 600\,\text{MeV}$

$\delta m_{\tilde{e}} = 1.8\,\text{GeV}$

$\delta m_{\tilde{t}_1} = 7\,\text{GeV}$

Can be improved by the high $\mathcal{L}$ available
→ Scanning possible !

→ • DETERMINATION of SUSY PARAMETERS

- Chargino/neutralino production & decays :
  → M', M, μ, $\tan\beta$
- Stop / sbottom production & decays :
  → A, $M_{\tilde{Q}}$, $M_{\tilde{U}}$, $M_{\tilde{D}}$
  (soft SUSY breaking parameters)

Even if h and SUSY will already be discovered at the start of the LC

→ TEST of SUSY model only possible by the LC :
  → Test of MSSM (supergravity)
  → Test of universality ass.
  → SUSY-breaking mechanism

• SUBJECTS PROPOSED FOR THIS WORKSHOP:

- $e^+e^- \to \tilde{\chi}_k^+ \tilde{\chi}_l^-$
  $\tilde{\chi}_i^0 \tilde{\chi}_k^0$

  - with spin correlations (between production and decay) taken into account
    → angular distr., asymmetries
    → additional information
  - include radiative corrections (espec. Yukawa intr.)

  Goal: more precise determination of SUSY parameters

  New: M, M', μ complex!

- $e^+e^- \to \tilde{t}_1 \bar{\tilde{t}}_1, \ \tilde{b}_k \bar{\tilde{b}}_k$ $\quad \tilde{t}_i \to \tilde{\chi}^+ b, \ldots$

  - include SUSY-QCD corrections to production and decays
  - include three-body decays:
    $\tilde{t} \to b \ell \tilde{\nu}, \ b \tilde{e}_L, \ b W \tilde{\chi}_i^0, \ldots$

- **GMSB - Models:**

(Gauge mediated SUSY breaking)

$\tilde{G}$ (gravitino) lightest SUSY particle LSP

NLSP: $\tilde{\chi}_1^0$ or $\tilde{\tau}$

Example: $e^+e^- \to \tilde{\chi}_1^0 \tilde{\chi}_1^0$

$\tilde{\chi}_1^0 \to \gamma \tilde{G}$ $\quad$ $\tilde{\chi}_1^0 \to \gamma \tilde{G}$

$e^+e^- \to \tilde{e}_1 \tilde{e}_1$, $\tilde{e}_1 \to \gamma \tilde{G}$

Decay length L:

$10^{-4}\,\text{mm} < L < 100\,\text{m}$

$\text{few } 10^{-6}\,\text{keV} < L < 1\,\text{keV}$

→ new signatures, implications for detectors

- **$\not{R}$ models:**

$$W \sim \lambda_{ijk} (L_i L_j) \bar{E}_k + \lambda'_{ijk} (L_i Q_j) \bar{D}_k + \lambda''_{ijk} \bar{U}_i \bar{D}_j \bar{D}_k + \mu_i L_i H_2$$

Lepton number or baryon number violation

→ Impact on phenomenology is substantial

- **$\not{CP}$: SUSY-parameters complex: M, M', μ, A**

$e^+e^- \to t\bar{t}$

$\tilde{\chi}^+ \tilde{\chi}^-$ and decays

$\tilde{\chi}^0_i \tilde{\chi}^0_j$

- Studies in Non-minimal SUSY models

- e^-e^-:

  For example $e^-e^- \to \tilde{e}^-\tilde{e}^-$

  $\tilde{\chi}^0_i$: exchange in t-channel
  (Fermion number violating)

  → Precise measurement of mass, mixing, tanβ

  due to low background
  (no W^-W^-)

  $\delta m_{\tilde{e}} \sim 100$ MeV

Participant Name	Preferred e-mail	SUSY Sub-topic of Particular Interest
G. Blair*	blair@ppu1.ph.rhbac.ac.uk	MSSM Standard Parameter Extraction
Ch. Thiebaux	thiebaux@polhp6.in2p3.fr	R-parity Violation
E. Norrbin	emanuel@thep.lu.se	Event Generators
P. Checchia	Checchia@cern.ch	$\chi \to \gamma\tilde{G}$; $e^+e^- \to \tilde{G}\tilde{G}\gamma$
A. Read	Alex.read@fys.uio.no	MSSM Higgs Parameters
C. Troncon	Clara.Troncon@cern.ch	MSSM Higgs Parameters (HA, hA produ
S. Komamiya	Komamiya@cern.ch	SUSY Breaking
		Detector Issues
M. Raidal	raidal@mail.desy.de	$SO(10)$ Motivated MSSM
		New Signals Beyond SUGRA
K. Huitu	katri.huitu@helsinki.fi	Extended Models, R-parity Violation
		SUSY Breaking (+ Singlet Higgs)

Participant Name	Preferred e-mail	SUSY Sub-topic of Particular Interest
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M. Gruwé	magali.gruwé@cern.ch	Experimental Issues; $\chi^+\chi^0$
		Gauge Mediated SUSY Breaking ...
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R. Nahnhauer	nahnhauer@ifh.de	Event Topology, Detector Scenarios

Participant Name	Preferred e-mail	SUSY Sub-topic of Particular Interest
Y. Sirois*	sirois@in2p3.fr	SUSY-GUT mass relations
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A. Sopczak	andre.sopczak@cern.ch	SUSY parameters
		STOP
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		Fully Hadronic Final States
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		Production Mechanism
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G. Wilson	graham.wilson@cern.ch	$\pi\gamma E_{T,miss}$; $l^+l^- E_{T,miss}$
		Gauge Mediated SUSY Breaking ---

Participant Name	Preferred e-mail	SUSY Sub-topic of Particular Interest
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S. Shulzalov	shulzalov@mail.desy.de	R-Parity Violation, CP-Violation ...
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H. Eberl	helmut@hephy.oeun.acat	Theoretical/Phenomenology Issues
E. Elsen	elsen@desy.de	$\tilde{q}$'s in MSSM
		Experimental Signatures