CLIC PHYSICS STUDY GROUP

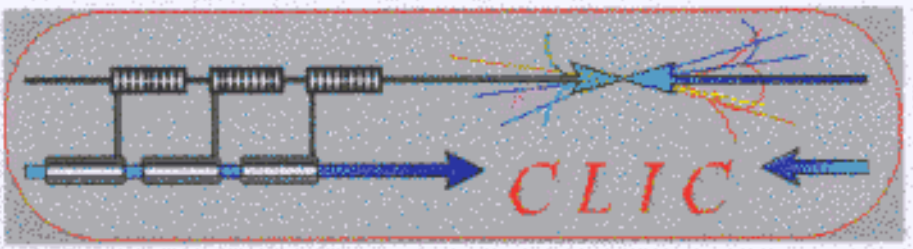
ALBERT DE ROECK, CERN

DESY, 22 SEPTEMBER

CONTENTS

- Introduction
- Short & long term aims
- Activities

e^+e^- COLLIDER $\sqrt{s} = 3$ TEV



Info:
http://clicphysics.web.cern.ch/CLICphysics/

HISTORY

- CLIC machine study group exists for some years.
  Aim: Multi-TeV machine (1–5 TeV)
  High Luminosity (10^{35}cm^{-2}s^{-1})
  Challenging parameters
  Can one do (precision) Physics with such a machine?
  ⇒ PHYSICS STUDY GROUP
- February '00: Memo to CERN authorities.
  March '00: Start of the PWG
- PHASE I: now
  PHASE II: in preparation
- Meetings:
  - "Regular" meetings at CERN → every 2-3 weeks
  - General Meetings:
  - 25/26 May
  - 28 June (SUSY workshop)
  - 5/6 October !
- Statistics:
  Regular meetings: 10-20 people
  Total subscribed: ∼ 100 people

PLAN

PHASE I ($\rightarrow$ NOW)

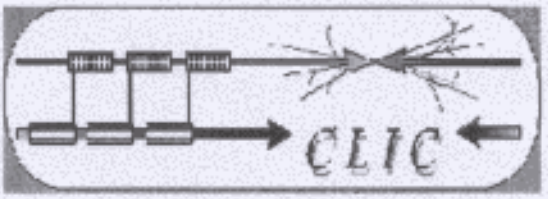
- Q: IS A PROCESS OBSERVABLE?
  Q: ACCURACY OF THE MEASUREMENT?
  $\Rightarrow$ REFERENCE REACTIONS
  $\rightarrow$ FEEDBACK TO MACHINE
  - FINAL FOCUS, MACHINE PARAMETERS,...
  - LUMI SPECTRUM, BEAM ENERGY LOSS, BACKGROUND, PILE-UP,...
- PREPARATION OF TOOLS
  (CALYPSO FOR LUMINOSITY SPECTRUM, PANDORA, SIMDET BASED PACKAGE WITH CLIC ENERGY SPECTRUM AND HADRONIC BACKGROUND; DIFFERENT LUMINOSITY SPECTRA; GEANT BASED IP SIMULATION PROGRAM)
  - STUDIES OF PHYSICS CHANNELS
  - IMPACT ON THE DETECTOR DESIGN
  $\rightarrow$ TRACKER: TPC? SILICON? OTHER?
  $\rightarrow$ 4T OR 6T FIELD?
  $\rightarrow$ PIXEL DETECTOR: 3 CM BEAMPIPE
  $\rightarrow$ SMALL ANGLE TAGGER: $\theta_{min} = 40$ MRAD
  $\rightarrow$ MASK $\Rightarrow$ 120 MRAD
- TIMESCALE: RESULTS FOR LCWS2000

CERN — European Organization for Nuclear Research

Compact e+e- Linear Collider (CLIC) - Physics Study Group

CERN

Organisers/steering:
M. Battaglia
A. De Roeck (convener)
C. Detraz
J. Ellis
D. Schulte
R. Settles
G. Wilson



A high energy linear e+e- collider has been considered as a possible option for CERN as a post-LHC machine, see e.g. the report "Options for Future Colliders at CERN" by J. Ellis, E. Keil, G. Rolandi, (CERN-SL-98-004).
A general open meeting took place on May 25/26. The agenda and talks can be found "here"

The next open meeting is planned for October 5/6.

Within the framework of the "world-wide collaboration on Linear Colliders", the CLIC study explores the technical feasibility of beam acceleration by travelling wave structures at room temperature and high frequency (30 GHz) powered from a drive beam, the so-called Two Beam Acceleration scheme. The design luminosity for e+/e- collisions at a centre of mass of 3 TeV is 10^35 cm-2 sec-1. Polarisation, e-e- and gamma-gamma collisions are also considered as an option. The CLIC machine study home page can be found here

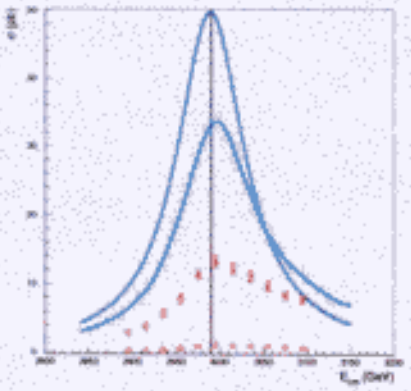
In February 2000 the Proposal for a Physics Study Group for the CLIC Multi-TeV Linear Collider was endorsed by the CERN management. The aim of

Physics Signatures

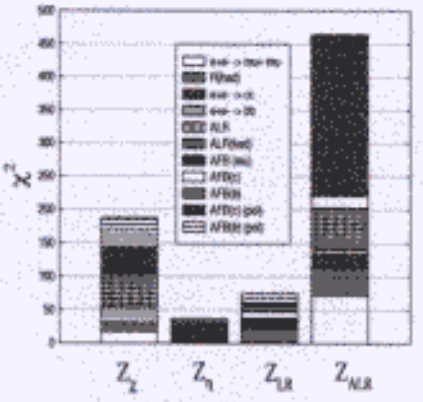
Optimisation of CLIC reference parameters
first goal of the present CLIC Physics Study

- Useful to define a set of **Physics Signatures**
  - motivated by interesting physics scenario(s)
  - relevant to specific aspects of accelerator performance and detector response.

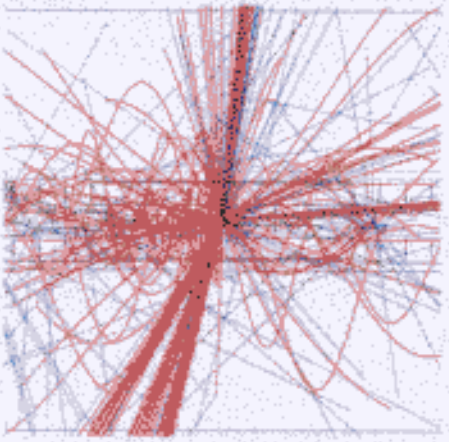
Resonance Scan



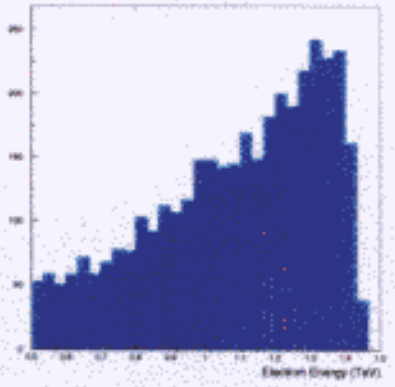
Electro-weak Fits



Multi-Jets Final States



E_{miss} and Fwd Processes



Physics Signatures and CLIC Physics Program

Physics Signatures	Higgs Sector	SUSY	SSB	New Gauge Bosons	Extra Dimensions
Resonance Scan				Z'	KK
EW Fits				A_{LR}, A_{FB}	$A_{FB}^{b\bar{b}}$
Multi-Jets	H^+H^- $t\bar{t}H$ $HH\nu\bar{\nu}$ HHZ		Techni-ρ		
E_{miss}, Fwd	He^+e^-	$\tilde{\ell}^+\tilde{\ell}^-$ $\tilde{\chi}^+\tilde{\chi}^-$			

TRESHOLD SCAN *

Physics Signatures and CLIC Parameters

Physics Signatures	Beam-Strahlung	Beam E Spread	Beam Polarization	Pairs	$\gamma\gamma$ Bkg.
Resonance Scan	Stat. Shape Syst.	Shape Syst.	Couplings	$\Gamma_{bb,cc,tt}$	$\Gamma_{bb,cc,tt}$
EW Fits	Unfold Boost		Polar. Meas.	$b\bar{b}$, $c\bar{c}$ Tags	$\cos\theta$ Bkg Flavour
Multi-Jets	5-C Fit			Tags for Jet pairing	Fake Jets
E_{miss} Fwd	θ_{miss}			Fwd Tracking	E_{hem} E_T

REFERENCE REACTIONS FOR THE CLIC

PHYSICS STUDY GROUP

Contents

Planned investigations

Subject	Persons
An S-channel resonance, E.g. Z'	D. Schulte, M. Battaglia P. Heikkinen, A. Ferrari
S-Wave threshold/no missing energy (E.g. Heavy Lepton pairs)	---
S-Wave threshold/ missing energy (E.g. chargino pairs)	---
P-Wave threshold /no missing energy (E.g. Charged Higgs, hA)	---
P-Wave threshold / missing energy (E.g. smuons, stop)	G. Wilson, A.Sopczak, A. Nowak
Z+H+H...	---
WW Scattering, Heavy Higgs	A. De Roeck +
EW, Precision Tests	M. Battaglia+
BFKL (QCD) effects Jets	C. Royon, De Roeck, T. Wengler

Details on the list of planned investigations can be found here

Albert de Roeck

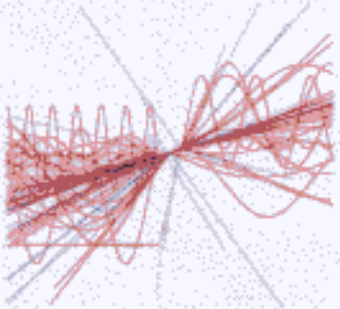
TASK LIST FOR THE CLIC PHYSICS STUDY GROUP

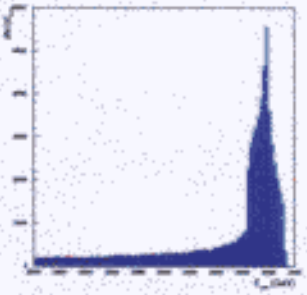
Subject	Persons
Luminosity Spectrum	D. Schulte +
Measurment of the Luminosity spectrum	K. Moenig, M. Battaglia, D. Schulte
Optimization of the Luminosity spectrum	Machine Group
Hadron Background	D. Schulte, A. De Roeck
Pair Background	---
IP simulation	D. Schulte, M. Battaglia
Impact on the Detector (crossing angle/ spent beam...)	Machine Group
Detector Simulation Programs	A. De Roeck, M. Battaglia, M. Berggren
Detector Issues	R. Settles, A. Frey, G. Wilson, M. Battaglia

For more details see detailed task list
Albert de Roeck

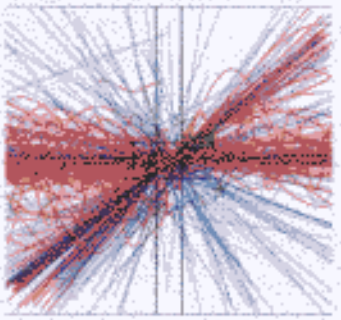
Analysis Tools

Physics Generator ((CompHep +) Pythia 6)
+ CLIC Beamstralhung Spectrum (Calypso)



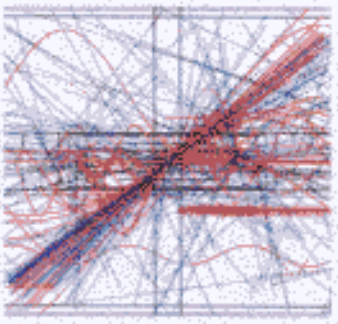


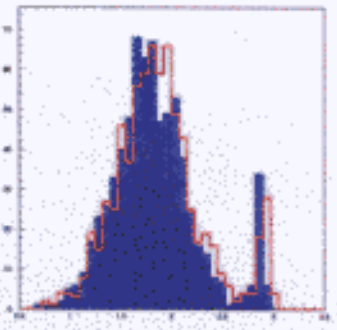
+ $\gamma\gamma \rightarrow$ hadron Background (Hades)



$\rightarrow$ Hepevt File

Geant **Full Sim**	Simdet **Par. Smear**
(TESLA CDR Det.)	**(TESLA CDR Det.)**
(Brahms **v.1**)	**B = 4-6 T**

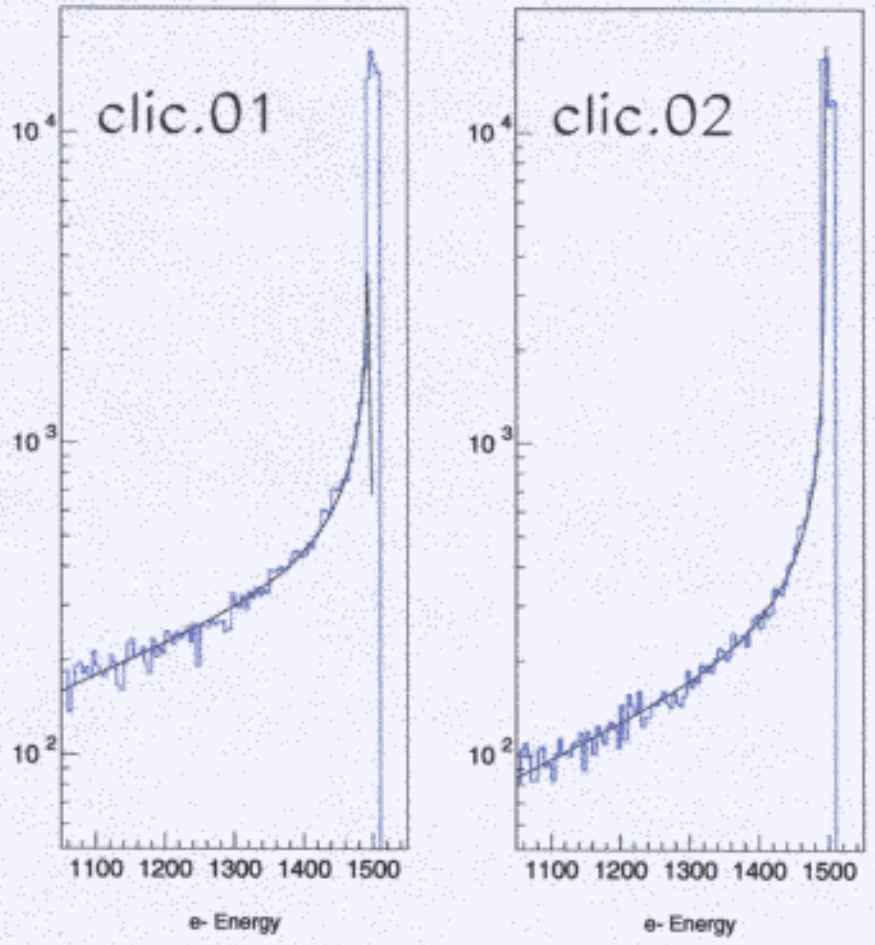




SIMDET

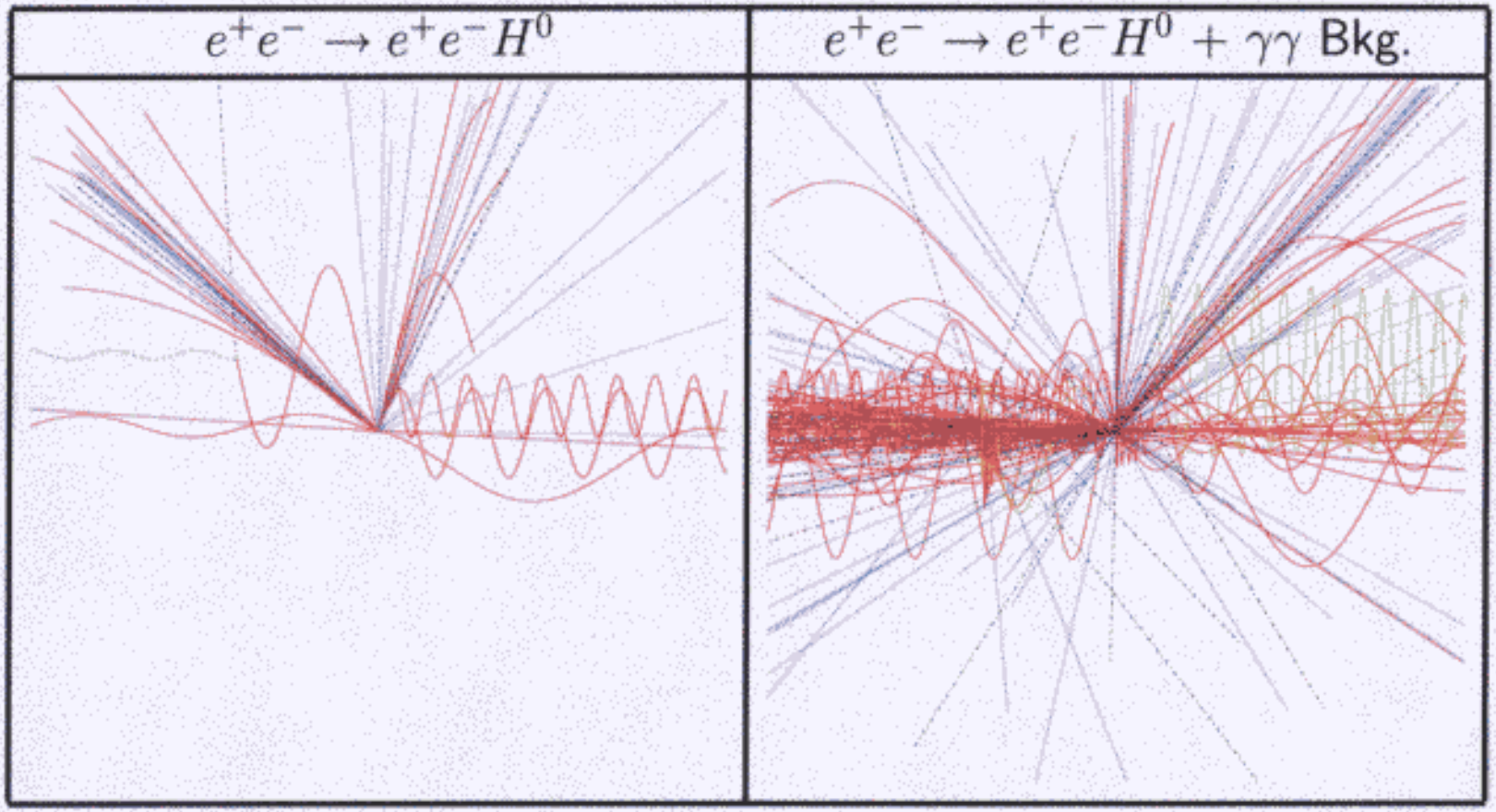
Summary of Tentative Detector Performances

Detector	ECFA 1997 CDR Design	CLIC Studies
Vertexing	$\delta(IP_{r\phi}) = 10\mu m \oplus \frac{30\mu m GeV/c}{p\sin^{3/2}\theta}$ $\delta(IP_z) = 7\mu m \oplus \frac{30\mu m GeV/c}{p\sin^{5/2}\theta}$	$15\mu m \oplus \frac{35\mu m GeV/c}{p\sin^{3/2}\theta}$ $7\mu m \oplus \frac{35\mu m GeV/c}{p\sin^{5/2}\theta}$
Solenoidal Field	B = 3 T	B = 4 T/(6 T)
Tracking	$\frac{\delta p_t}{p_t^2} = 7. \times 10^{-5}(\frac{GeV}{c})^{-1}$	$\frac{\delta p_t}{p_t^2} = 5. \times 10^{-5}(\frac{GeV}{c})^{-1}$
E.m. Calorimeter	$\frac{\delta E}{E\ (GeV)} = 0.10\frac{1}{\sqrt{E}} \oplus 0.01$	$\frac{\delta E}{E(GeV)} = 0.10\frac{1}{\sqrt{E}} \oplus 0.01$
Had. Calorimeter	$\frac{\delta E}{E\ (GeV)} = 0.50\frac{1}{\sqrt{E}} \oplus 0.04$	$\frac{\delta E}{E\ (GeV)} = 0.50\frac{1}{\sqrt{E}} \oplus 0.04$
μ Detector	Instrumented Fe yoke $\frac{\delta p}{p} \simeq 30\%$ at 100 GeV/c.	Instrumented Fe yoke $\frac{\delta p}{p} \simeq 30\%$ at 100 GeV/c.
Energy Flow	$\frac{\delta E}{E\ (GeV)} \simeq 0.3\frac{1}{\sqrt{E}}$	$\frac{\delta E}{E\ (GeV)} \simeq 0.3\frac{1}{\sqrt{E}}$
Coverage	$\lvert\cos\theta\rvert < 0.99$	$\lvert\cos\theta\rvert < 0.99$


clic.01
clic.02
10^4
10^3
10^2
1100 1200 1300 1400 1500
e- Energy

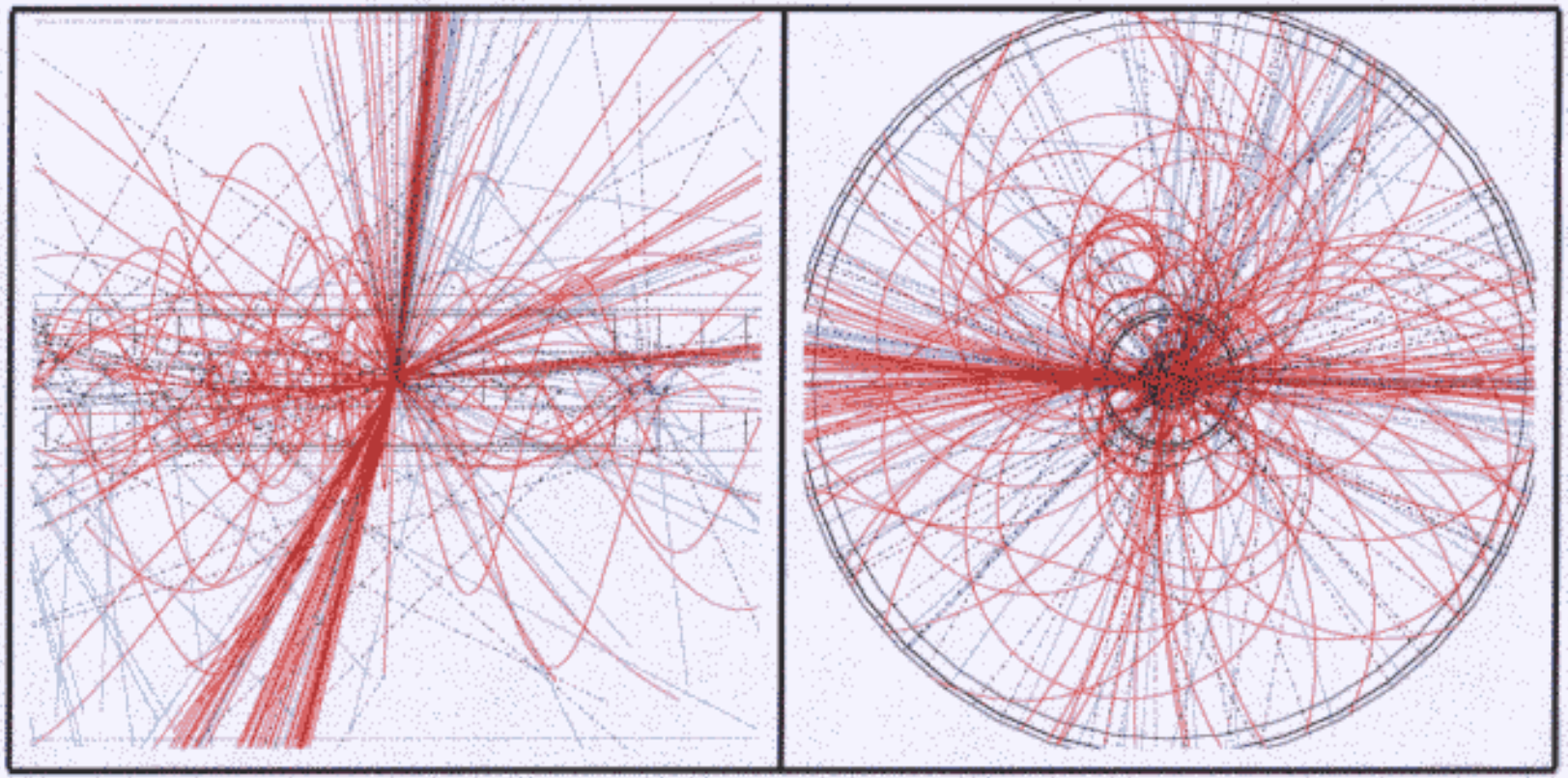
$e^+e^- \to e^+e^- H^0 \to X$

for $\sqrt{s} = 3$ TeV, $M(H^0) = 600$ GeV, $B = 6$ T



$$e^+e^- \to H^+H^- \to t\bar{b}\,\bar{t}b$$

for $\sqrt{s} = 3$ TeV, $M(H^\pm) = 900$ GeV, $B = 4$ T



Jet Flavour Tagging

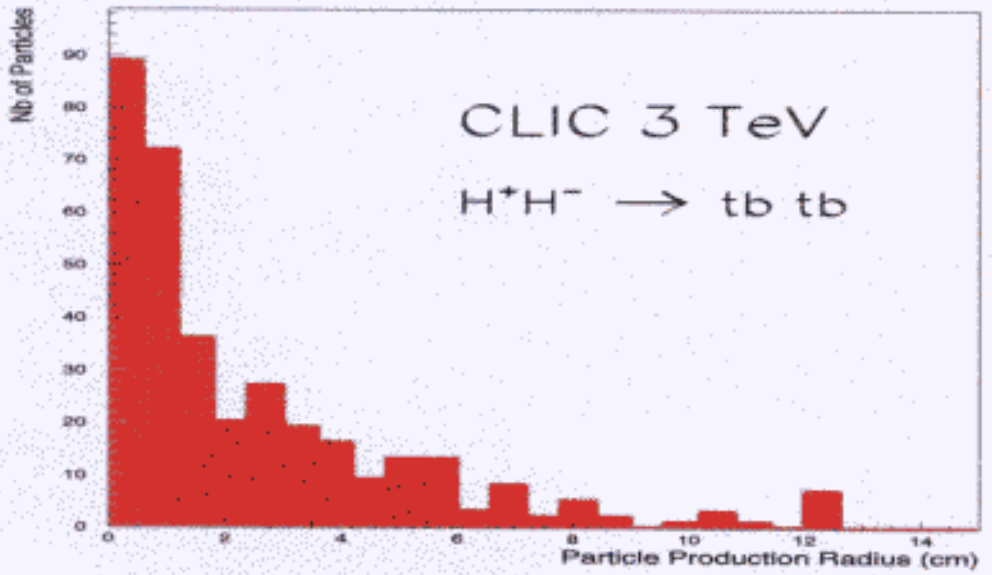
$e^+e^- \to b\bar{b}$ Production

$\sqrt{s}$ (TeV)	0.09	0.5	0.8	**3.0**
$\sigma_{b\bar{b}}$ (pb)	9160	0.4	0.15	**0.01**
$\int L$		500 pb^{-1}	500 pb^{-1}	**5000 pb^{-1}**
$N_{b\bar{b}}$	900k	200k	75k	**50k**

- **Topological tagging** of short-lived hadrons

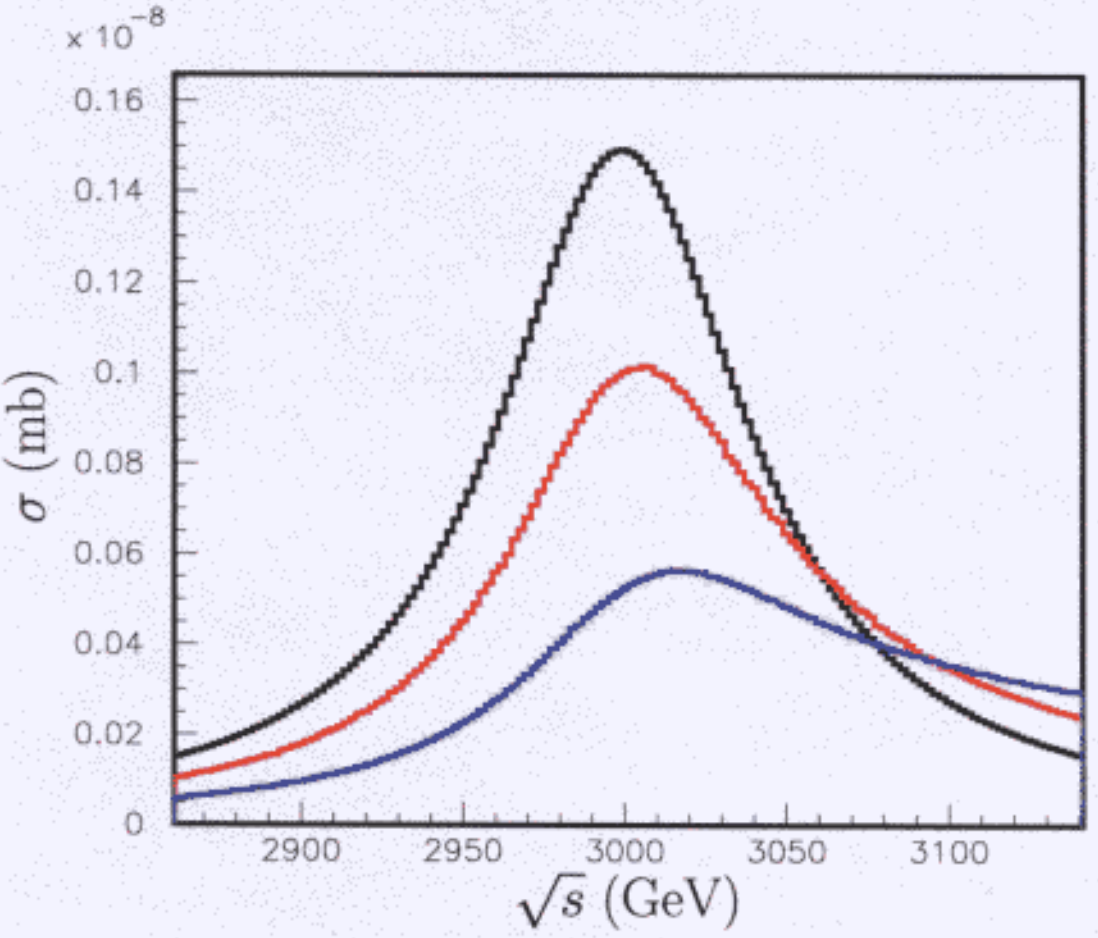
$B \to X$ Decay Length

$\sqrt{s}$ (TeV)	0.09	0.2	0.35	0.5	**3.0**	
	Z^0	HZ	HZ	HZ	H^+H^-	$b\bar{b}$
d_{space} (cm)	0.3	0.3	0.7	0.85	**2.5**	**9.0**



Obtained cross sections

This is a comparison of the different cross sections generated during the analysis. Here we have a plot showing three cross sections:



–Born cross section
–w/ISR
–w/ISR and CLIC luminosity spectrum

Preliminary results

3 point scan at $\sqrt{s} = 2936$ GeV, 3016 GeV, and 3096 GeV; sharing 50%, 30 % and 20 %.

	`clic.01`	`clic.02`
$M_{Z'} \pm \delta M_{Z'}$ (GeV/c^2)	3000.1 ± 0.3	3000.1 ± 0.5
$(\Gamma_{Z'} \pm \delta\Gamma_{Z'})/\Gamma_{\mathrm{SM}}$	1.002 ± 0.005	1.000 ± 0.006
$\sigma_{\mathrm{peak}} \pm \delta\sigma_{\mathrm{peak}}$ (fb)	562 ± 1	668 ± 2

PLAN

Phase II

- physics potential of CLIC
- polarization
- $\gamma\gamma$, $e\gamma$ and e^-e^- options
- Detector details
- Comparison with other machines ($\mu\mu$...)

- Advanced tools
  Generators, Geant4 Detector program

- $\Rightarrow$ Startup of a long term workshop spring/summer 2001 (Working groups...)
  $\longrightarrow$ Coordination with the ECFA workshop...?

- However: already now theorist can use

$$e^+e^-\text{: } \sqrt{s} = 3 \text{ TeV}, \mathcal{L} = 10^{35} cm^{-2} s^{-1}$$