The International Linear Collider
a physics project
at an electron-positron collider
in an energy range from Z to TeV

ILC

For a detailed study of the electroweak breaking

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What is ILC ?

A brief historical survey

The previous frontier electron-positron collider was the LEP at CERN, a circular collider from Z to W pairs.
First beams summer 89, end in 2000
The first linear collider was at the same time running at SLAC (SLC), with polarised beams.

The first meetings I know about what is now ILC were in 1991 for physics and detector, 1992 for accelerator.

The lepton community was already considering the next step to come in parallel with LHC.

TESLA, NLC, GLC

Under the leadership of DESY
a project of superconducting accelerator (S band) to be built at DESY Hamburg in the energy range Z to TeV (TDR in 2000) in parallel with a synchrotron light source, the EXFEL.
At the same time two warm projects were considered
the Next Linear Collider in the US (Xband)
the Global Linear Collider in Japan.

Germany accepted EXFEL and turned down TESLA.

The world community joined then efforts in a unique project when the superconducting technology was chosen (2004).
That was ILC which under the control of ICFA developped a TDR in 2012. Today the only site under consideration is in Japan (Kitakami).

ICFA created by IUPAP in 1976, in regions : ECFA, ACFA, APS DPB

Introduction

At the time of letters of intent for ILC experiments
there were 4 proposals,
the committee turned down the 4th concept,
two of them, GLD and LDC, merged into ILD
SiD remained.

Today remain SiD, silicon detector,
and ILD international large detector

Introduction

Another approach to the same questions
but at higher energies : the CLIC

developped at CERN on the double accelerator scheme
to reach 3 TeV.
A lot of synergies with ILC, in particular for the detector

Why electrons?

What else?

stable or quasi stable particles: electrons, protons, ions
with their antiparticles
photons (an option)
muons?

A well defined initial state

parton
monokinetic beam
CM = laboratory
interaction point
spin state

Angular distributions → detector
but!

An initial state properly coupled to what we intend to study

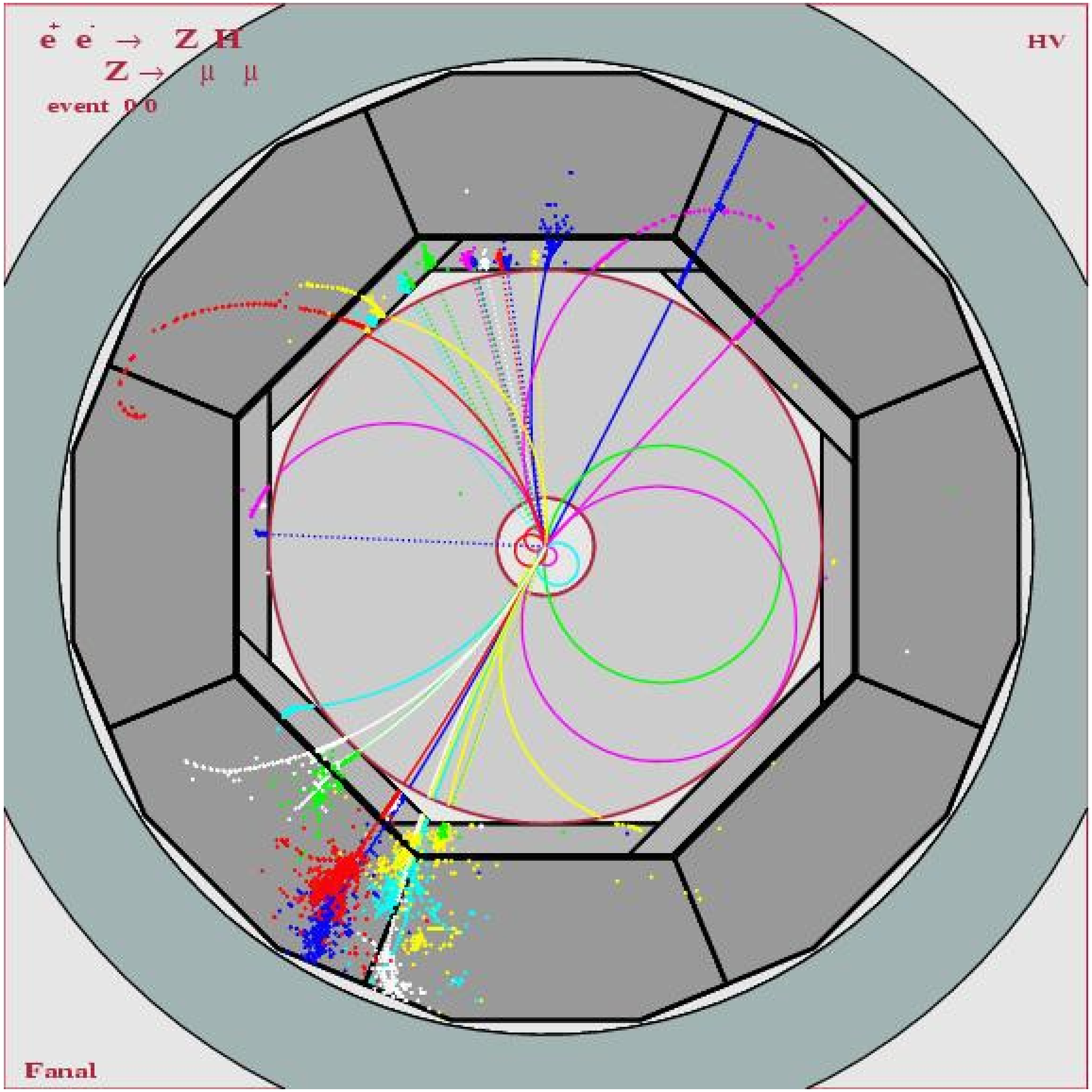
Introduction

A clean collider

The proton-proton
cross section grows with s

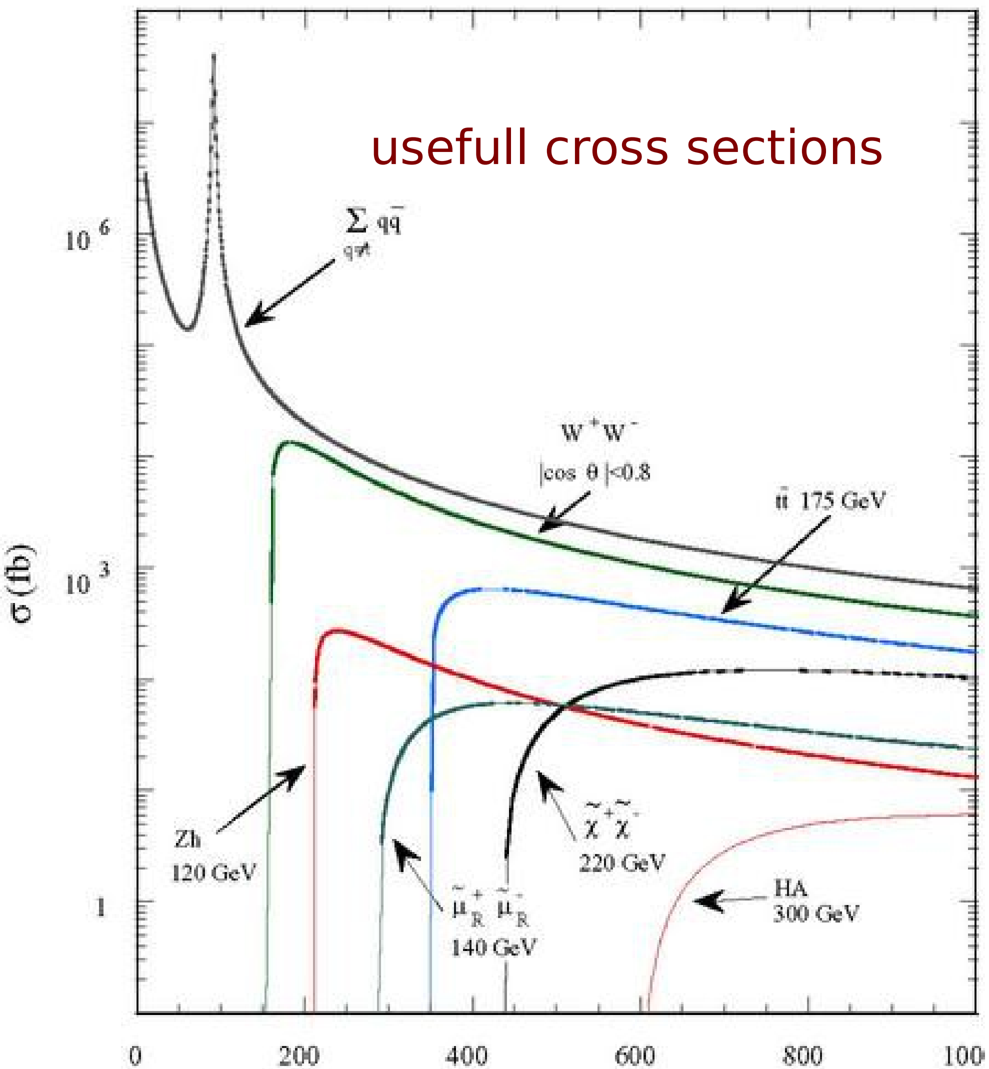
The e^+e^- cross section
for a given final state
far from the threshold
goes like 1/s (why ?)
low backgrounds →
no pile-up,
no trigger,
no bias

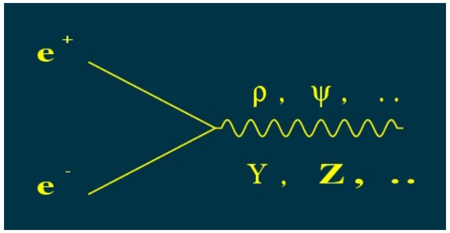
except γγ (including beamstrahlung)
which is at low p_t hence
low angle



Introduction

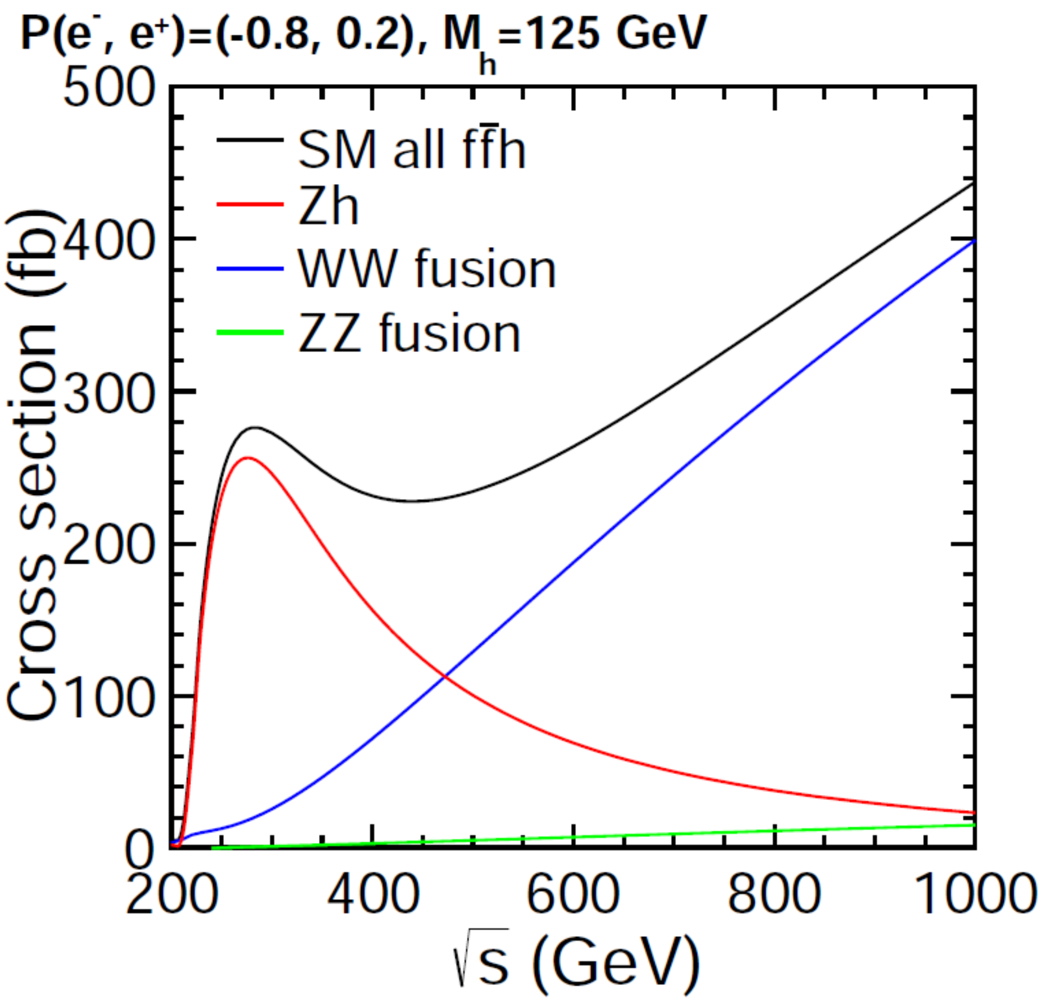
usefull cross sections





GeV

H f $\bar{f}$ production



What accelerator?

Do we know how

to make an electrons-positrons collider
going to the adequate energy (~ TeV)
with an adequate luminosity ?

For cross-sections σ ~ 100 fb
we will need
integrated luminosities above few 100 fb^{-1} per year
(10000 events detected)
counting on a year of 10^7 s to take into account efficiency
this means intantaneous luminosities of 10^{34} cm^{-2} s^{-1}.

What physics?

All what may appear
in the range of energy we can dream of today, from Z to TeV.

is there a physics
to invest the price of
the collider (8 G€)
with 2 (?!) detector(s)(10 %)?

What detector?

Do we know how to make a detector
to collect fully,
in a reasonable time,
the physics present at these energies?

Measurement precision, efficiency
are equivalent to luminosity

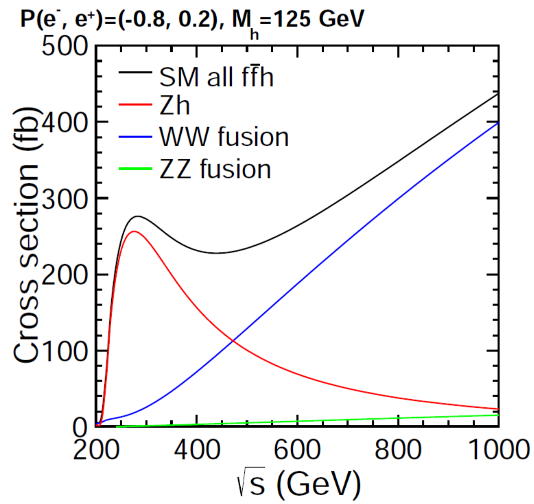
Example:
in the study of
$e^+ e^- \rightarrow ZH, \; Z \rightarrow q\bar{q}, \; H \rightarrow W W^x$
improve the jet resolution by a factor 2
~ gain of a factor 1.5 on $\mathscr{L}$

Control the systematics
at the detector level
as well as accelerator

Introduction

Remark

The way an e^+e^- collects physics is strongly different from a proton machine.



The proton machine covers a wide band of parton-parton collisions energy and the machine will always run at its maximal energy.

The electron collider has optimal energies for given studies, thresholds (many), peak of cross sections.

As a consequence, the time needed to fully explore an energy domain for example GigaZ, W threshold, top threshold, Higgs, high energy, may be considerable.

The choice of a running programme is strategic

Introduction

Socio-scientific remark :

A scientific result has to be reproducible
but should it be reproduced ?

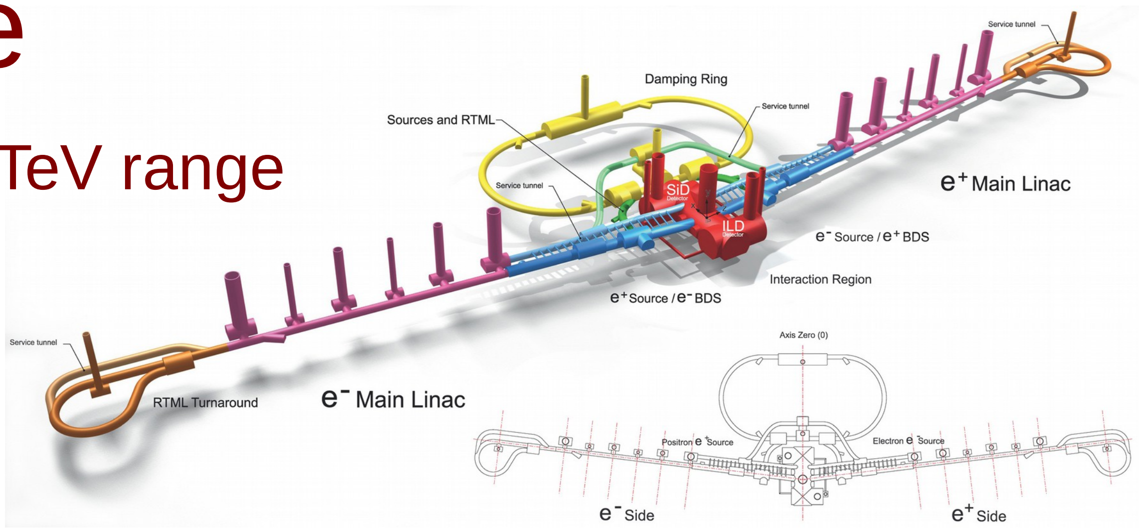
Should we then draw one, two or three experiments?

A circular collider offers space for few experiments easily
LEP had 4, a slight overkill
with an almost equivalent luminosity
a linear one shares at best its luminosity
between the experiments

with rather ugly constraints.

The funny game of push-pull

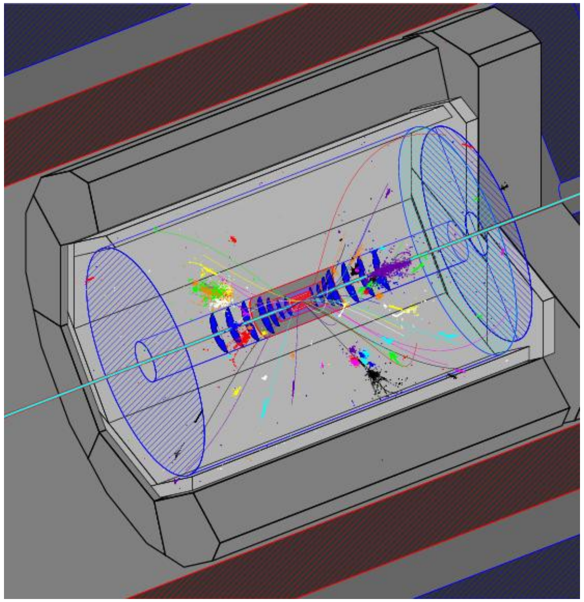
Lectures outline



Making an electron collider in the TeV range

What physics is in front of us ?

A detector to collect it



as well as what is beyond
what we already know

Unit prefixes

milli	m	- 3	latin	kilo	k	3	greek
micro	µ	- 6	greek	mega	M	6	greek
nano	n	- 9	greek	giga	G	9	greek
pico	p	- 12	italian	tera	T	12	greek
femto	f	- 15	danish	peta	P	15	greek
atto	a	- 18	danish	exa	E	18	greek

A question of units

Even though we may use SI units
for some numerical applications
we favour, as it is customary in HEP,
using one unit only to be chosen as « eV ».
this is reached by defining $c=1$, $\hbar=1$, $\varepsilon_0= 1$ $\mu_0=1$

mass, momentum and energy are in eV, or MeV, or GeV

time and length are in the same unit E^{-1} $E=\hbar\omega$

the metre is indeed defined from the second

energy and wavelength

Exercise : knowing that the earth-moon distance is about 300000km or 1s and that $\hbar c=200 MeV\ fm$ give this distance in eV.
or what is the energy of a photon with a wavelength equal to the earth-moon distance ?

writing the field energy, what is the dimension of E field, B field, charge ?

To remember : eV and μm^{-1} are of the same order of magnitude

Exercise

$$\hbar c = 200\, MeV\ fm$$

$$1 = 0{,}2\, eV\, \mu m$$

$$1\, \mu m = 5\, eV^{-1}$$

$$300000\, km = 3\, 10^{14}\, \mu m = 3 \times 5\, 10^{14}\, eV^{-1} = 1{,}5\, (feV)^{-1}$$

END