Does the ILC need Physics Results from the LHC?

Sven Heinemeyer, CERN

Snowmass, 08/2005

Does the ILC need Physics Results from the LHC?

Sven Heinemeyer, CERN

Snowmass, 08/2005

NO!

One has to distinguish:

1. Political aspect

2. Sociological/political aspect

3. Physics aspect

Political aspect: (not the real issue here!)

Start of ILC construction and possible first LHC results are close in time

Argument: we will never get the money from the politicians without a major discovery at the LHC!

Q: Is there a way out?

A: possibly not, **but we must not give up!**
We must try to reverse this way! (Many seem to have given up . . .)

Several aspects:

- dangerous way! Possible: LHC sees something inconclusive
  $\Rightarrow$ ILC is needed even more
  (but in the "current" position this will be hard to defend!)

- What is a major discovery ? (Preferred redefinitions possible)

- why are we in this position?
  To some extent because delay was appreciated . . .

Sociological/political aspect: (not the real issue here!)

Albrecht Wagner: "We have to show our ability to the politicians to build and run a large international facility. Otherwise we will not get the money."

Q: Is there a way out?

A: possibly not, **but we must not give up!**
We must try to reverse this way! (Many seem to have given up . . .)

– Haven't we shown this ability already
(though on somewhat smaller scale)?

– What about other branches of science?

Physics aspect:

$\Rightarrow$ This is the real question here!

Q: Do we need LHC data to have a good physics case for the ILC?

Physics aspect:

$\Rightarrow$ This is the real question here!

Q: Do we need LHC data to have a good physics case for the ILC?

A: The case has been made many^n times! ($n \gg 2$)

There are many documents that all make the case:

TESLA TDR, Snowmass 2001 resource book, ACFA report, ECFA/DESY workshop summary (Amsterdam), LHC/ILC report, . . .

Holes have been filled, loopholes have been filled, . . .

$\Rightarrow$ The case has been made again and again and again . . .

$\Rightarrow$ The case has been made again and again and again . . .

my (very) personal impression:
(mostly) in the USA there is panel after panel after panel . . .

each asks again for the case to be made

$\Rightarrow$ The case has been made again and again and again . . .

my (very) personal impression:
(mostly) in the USA there is panel after panel after panel . . .

each asks again for the case to be made

. . . and frankly I am tired of it!

⇒ The case has been made again and again and again . . .

my (very) personal impression:
(mostly) in the USA there is panel after panel after panel . . .

each asks again for the case to be made

. . . and frankly I am tired of it!

RTFM!

Let's look at the physics case(s):

Approach I: Guaranteed discovery

Basic principle: unitarity

$\Rightarrow$ something has to show up at $\sqrt{s} \lesssim 1$ TeV

Many^n models have been invented.

$\Rightarrow$ the ILC can do interesting physics in all the cases

(check the documents!)

Two possible avenues:

Higgs vs. no Higgs

Avenue # 1: Higgs

⇒ the case is crystal clear!

The ILC will measure mass(es), couplings, quantum numbers with unprecedented accuracy

This ILC precision will be needed to disentangle different models

⇒ the ILC is crucial to verify the Higgs mechanism itself

We may have more than the Higgs itself . . .

Many extended models have been invented (more/less motivated)

⇒ in nearly all of them the ILC can see something else than the LHC (and measure it with unprecedented accuracy)

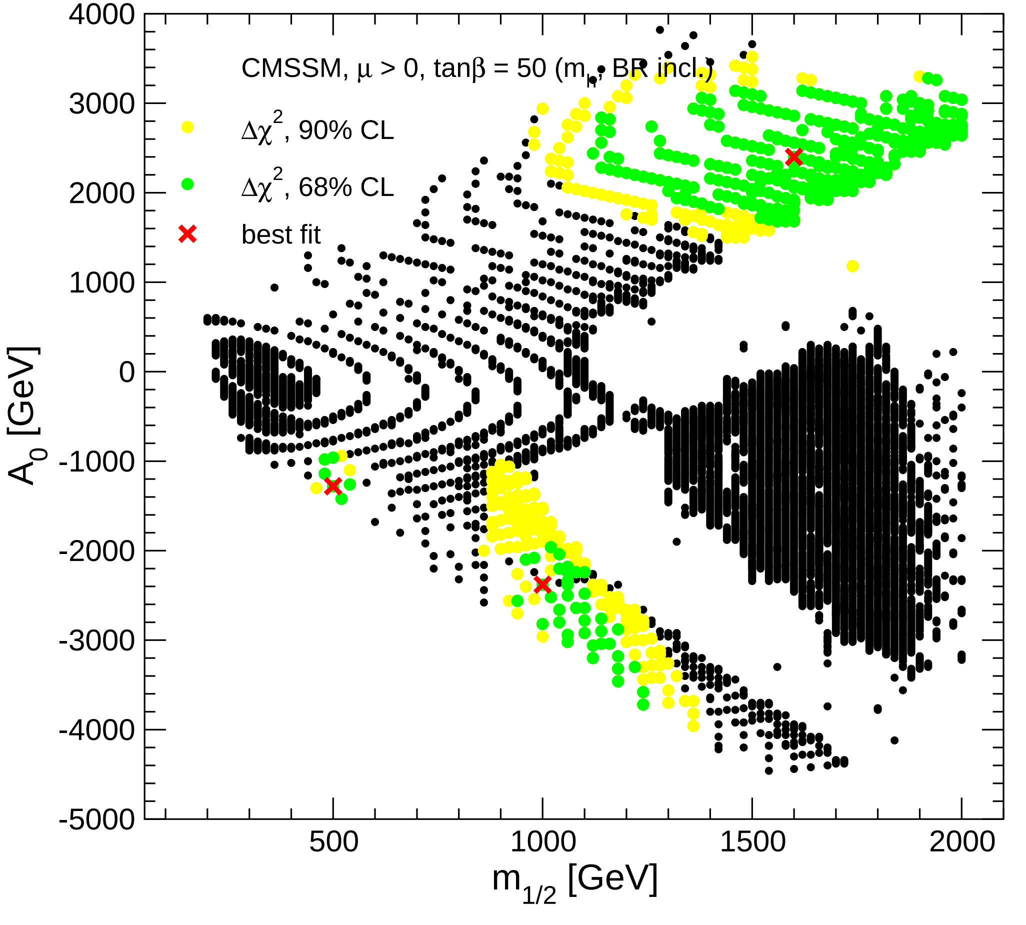
⇒ ILC precision is crucial to determine model parameters
(the LHC is simply not precise enough)

In all these cases one should keep in mind:

the ILC is flexible! $e\gamma$, $\gamma\gamma$, GigaZ

The indirect reach can cover scales beyond the direct reach of LHC/ILC

Example: CMSSM with very high mass scales: [*J. Ellis et al. '04*]



In all these cases one should keep in mind:

Very important question: electroweak symmetry breaking

$\Rightarrow$ the ILC will definitely measure the top-quark properties with highest precision

Example:

$$\delta m_t^{\text{LHC}} \lesssim 1 - 2 \text{ GeV}, \qquad \delta m_t^{\text{ILC}} \lesssim 0.1 \text{ GeV}$$

Due to its high mass the top quark can give valuable hints for EWSB!

δm_t^{exp} crucial for indirect determinations of high scales

Avenue # 2: no Higgs

⇒ the case is also clear!

⇒ Extra dimensions, strong EWSB, compositeness, . . .

The ILC can:

– discover gravitons
– see indirect effects of gravitons/KK towers in SM processes
– measure the number of new large extra dimensions (M_D vs. δ)
– detect strong EWSB scales beyond 3 GeV
– strong EWSB (effective) couplings can be measured
– has a higher reach for compositeness than the LHC

⇒ just look up the existing documents!

⇒ just look up the existing documents!

Alternative	TESLA	LHC
KK graviton radiation	$M_D \lesssim 8\,\mathrm{TeV}$	$M_D \lesssim 7.5\,\mathrm{TeV}$
KK graviton exchange	$M_D \lesssim 8\,\mathrm{TeV}$	?
strong WW interactions	$\Lambda_* \gtrsim \Lambda_{\mathrm{EWSB}}$ (3 TeV)	$\Lambda_* \lesssim \Lambda_{\mathrm{EWSB}}$
vector resonance couplings	$\mathcal{O}(0.1 - 1\%)$	$\mathcal{O}(1 - 10\%)$
Goldstone couplings	$\mathcal{O}$ (1%)	$\mathcal{O}$ (10%)
leptoquark Yukawa couplings	$\mathcal{O}(5\%)$	upper bounds $\mathcal{O}(0.2e)$
compositeness scale	$\Lambda \lesssim 110\,\mathrm{TeV}$	$\Lambda \lesssim 35\,\mathrm{TeV}$

[*TESLA TDR*]

⇒ if there is a case for the LHC, there is one for the ILC

Approach II: Three extreme scenarios

Scenario I:

$\longrightarrow$ the LHC sees nothing

$\Rightarrow$ then we need the ILC even more!

(however: difficult to sell since we brought ourselves in this strange position)

Scenario II:

$\longrightarrow$ the LHC sees many things (inconclusive?)

Can we then really understand it without the ILC precision?

$\Rightarrow$ most probably not. We need the ILC!

Scenario III (worst case for the ILC):

$\longrightarrow$ the LHC sees only very heavy states beyond the ILC reach

$\Rightarrow$ the ILC is flexible:

ILC/GigaZ has indirect sensitivity to extremely heavy states!

Also possible: LHC has overlooked something $\Rightarrow$ ILC will find it

Approach II: Three extreme scenarios

Scenario I:

→ the LHC sees nothing

⇒ then we need the ILC even more!

(however: difficult to sell since we brought ourselves in this strange position)

Scenario II:

→ the LHC sees many things (inconclusive?)

Can we then really understand it without the ILC precision?

⇒ most probably not. We need the ILC!

Scenario III (worst case for the ILC):

→ the LHC sees only very heavy states beyond the ILC reach

⇒ the ILC is flexible:

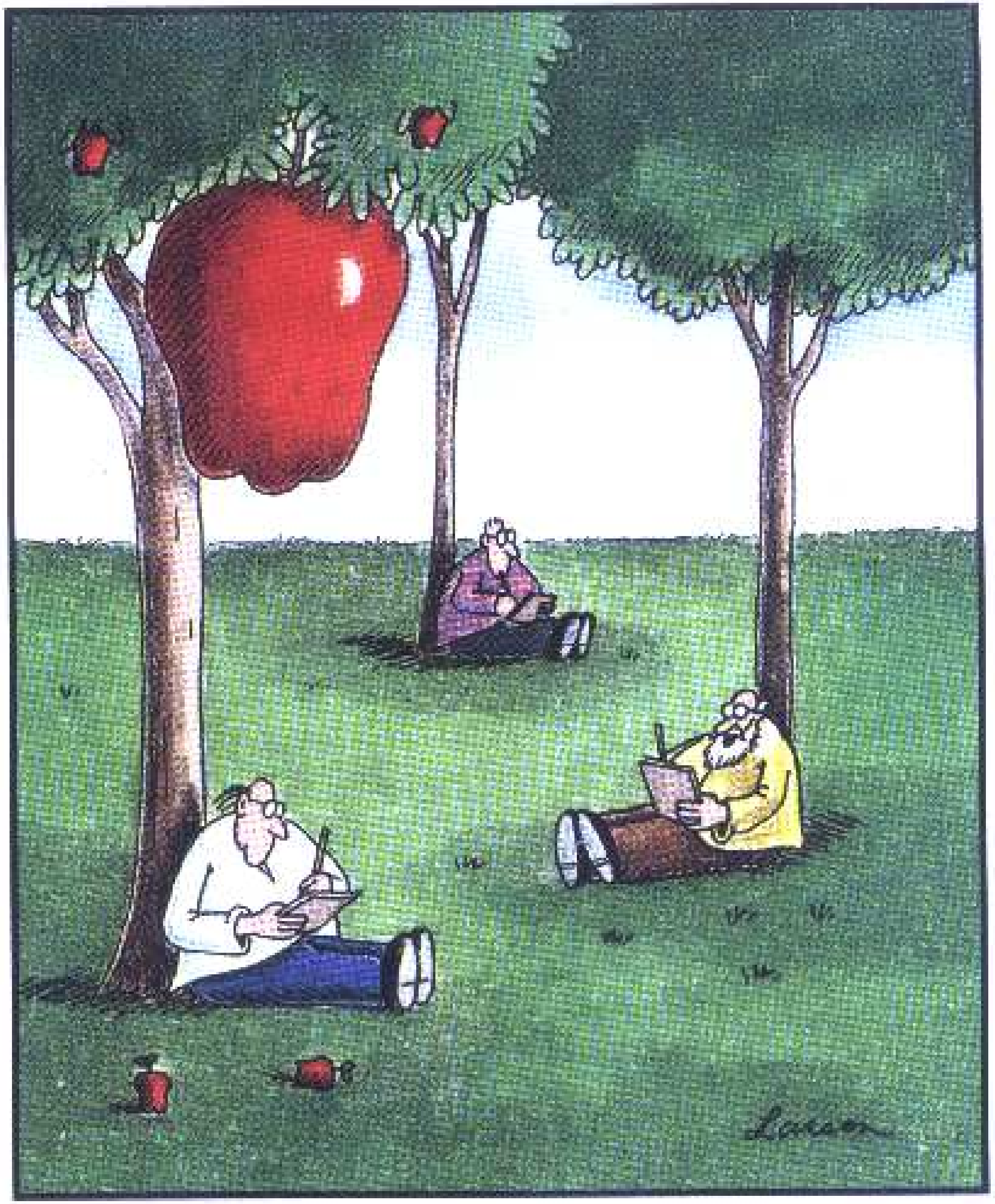
ILC/GigaZ has indirect sensitivity to extremely heavy states!

Also possible: LHC has overlooked something ⇒ ILC will find it

⇒ always the ILC has a compelling physics case independent of the LHC

To finish on a bit lighter note:

Sometimes we have to wait for new discoveries, triggered by . . .



"Nothing yet. ... How about you, Newton?"