New projects of e^+e^- colliders – challenges for the computing system

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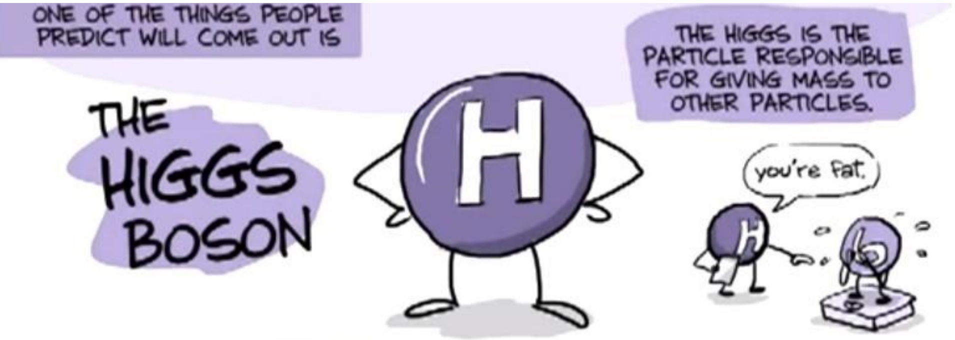
FCAL Collaboration
High precision design

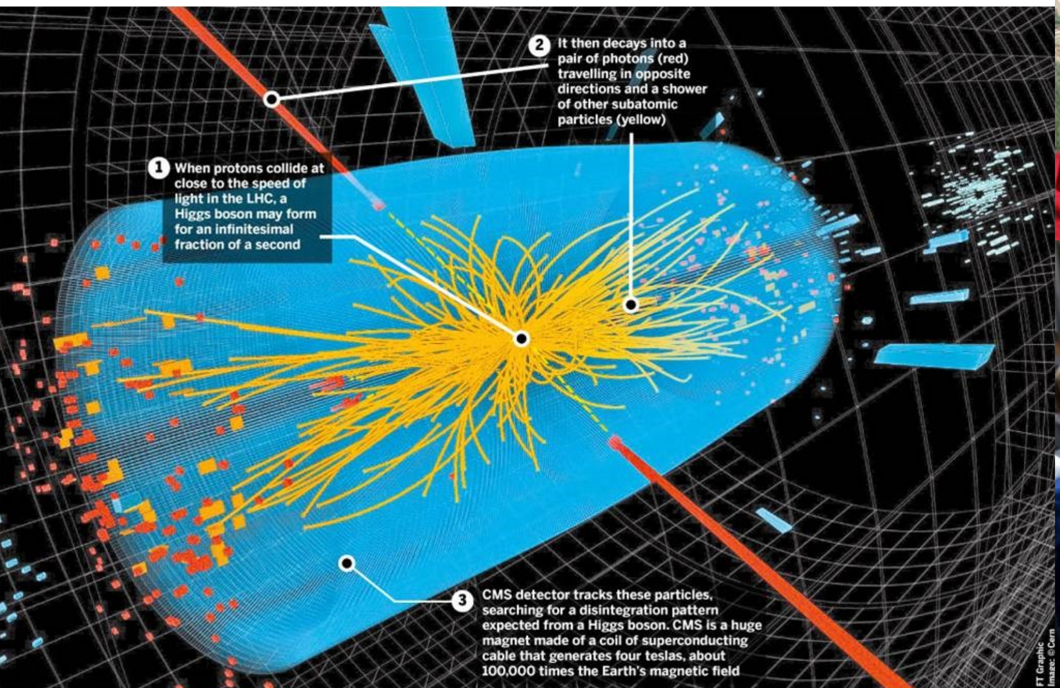
KU KDM 2015
Zakopane, 11 – 13 March 2015

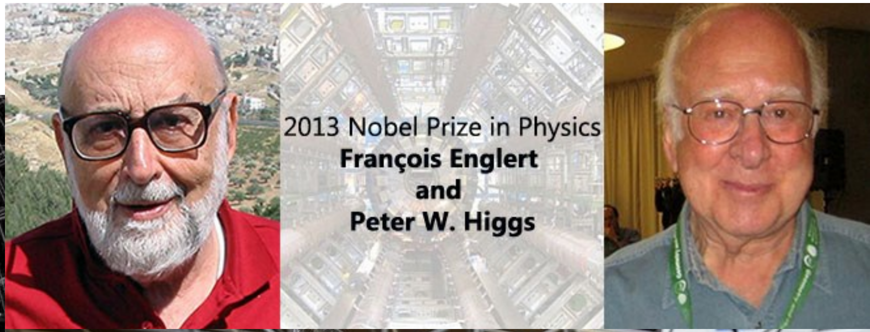
Higgs boson discovery



Prediction in 1964

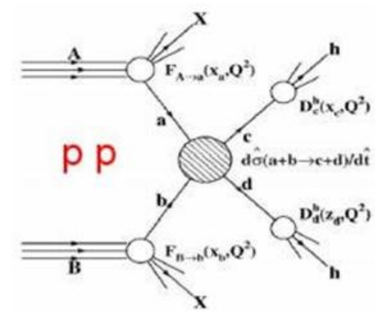
Discovery 4 July 2012



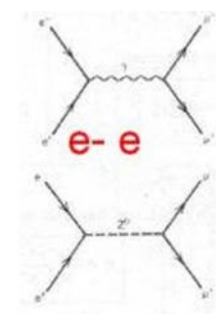


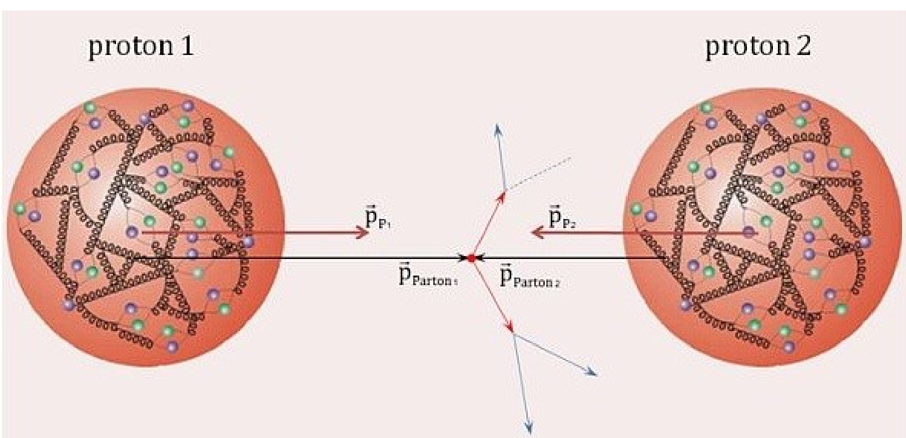
Why e^+e^- colliders?

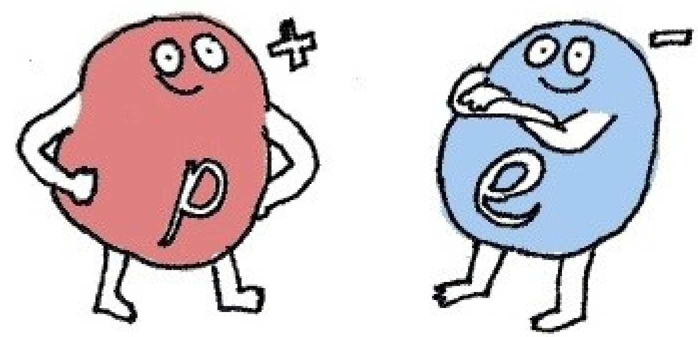
- Hadron collisions: compound particles
  - Mix of quarks, anti-quarks and gluons: variety of processes
  - Parton energy spread
  - QCD processes large background sources
  - Hadron collisions $\Rightarrow$ large discovery range



- Lepton collisions: elementary particles
  - Collision process known
  - Well defined energy
  - Other physics background limited
  - Lepton collisions $\Rightarrow$ precision measurements

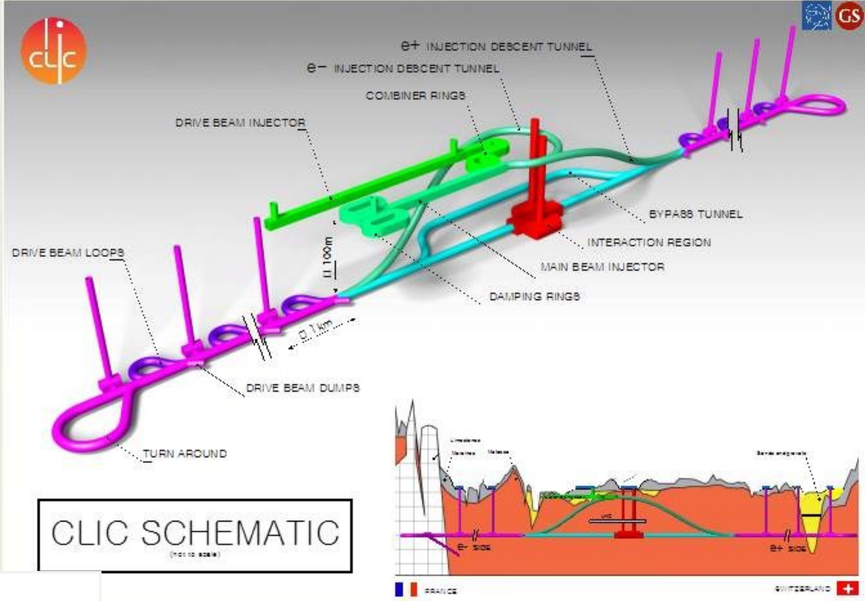


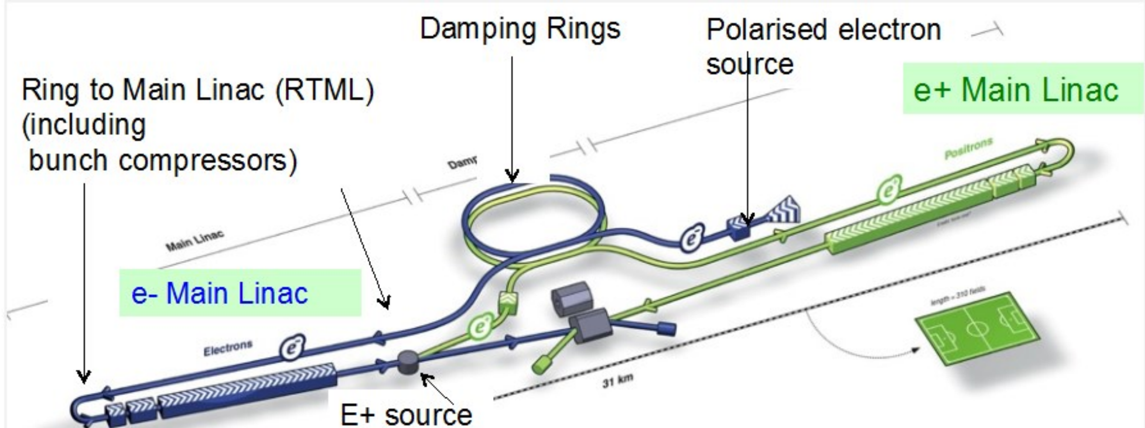


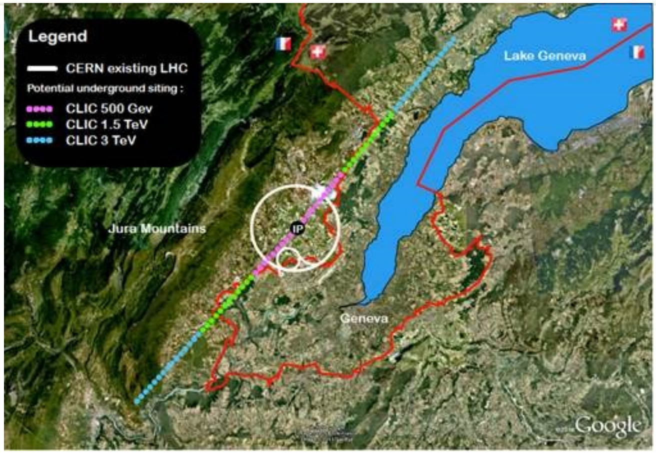


Projects of future

e^+e^- colliders

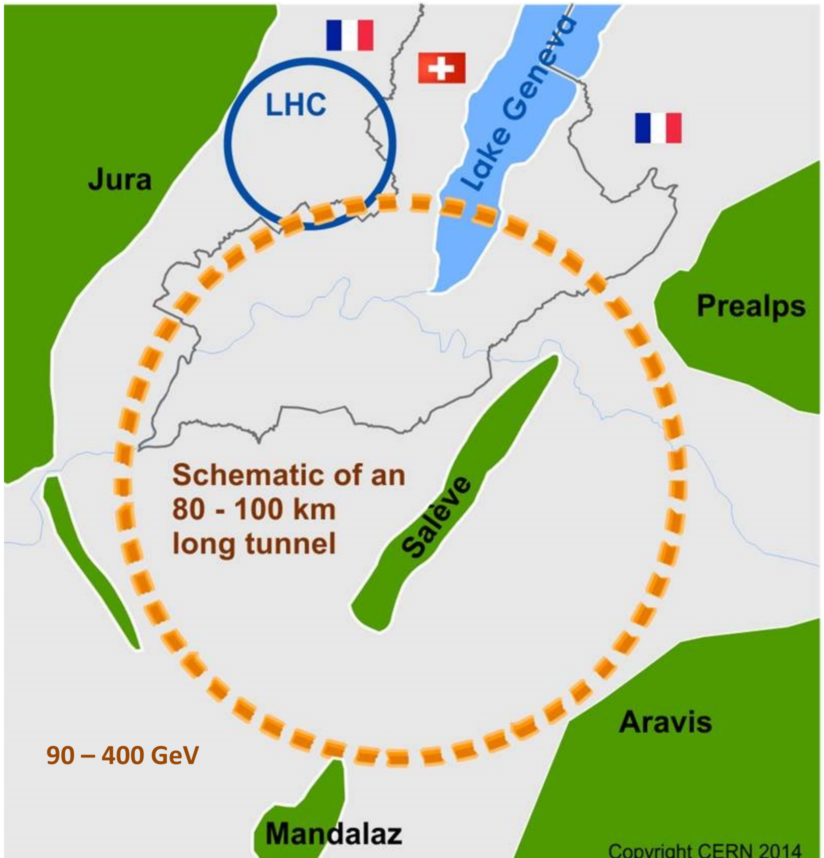






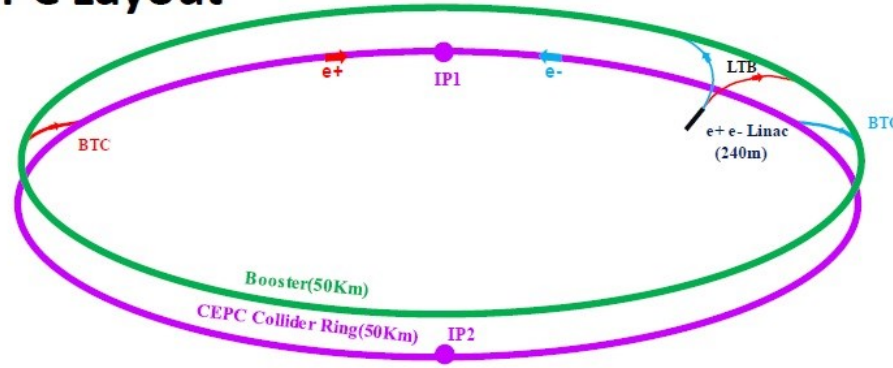
Linear colliders

Projects of future e^+e^- colliders



FCC-ee

CEPC Layout



240 GeV

LTB : Linac to Booster

BTC : Booster to Collider Ring

Circular colliders

Challenges for the computing system

In order to explore the opportunities which would be provided by the future e^+e^- colliders in the context of planed physics researches large scale Monte Carlo studies are necessary.

Monte Carlo simulations are performed for:

→ physics benchmark studies – consume the largest share of the CPU resources,

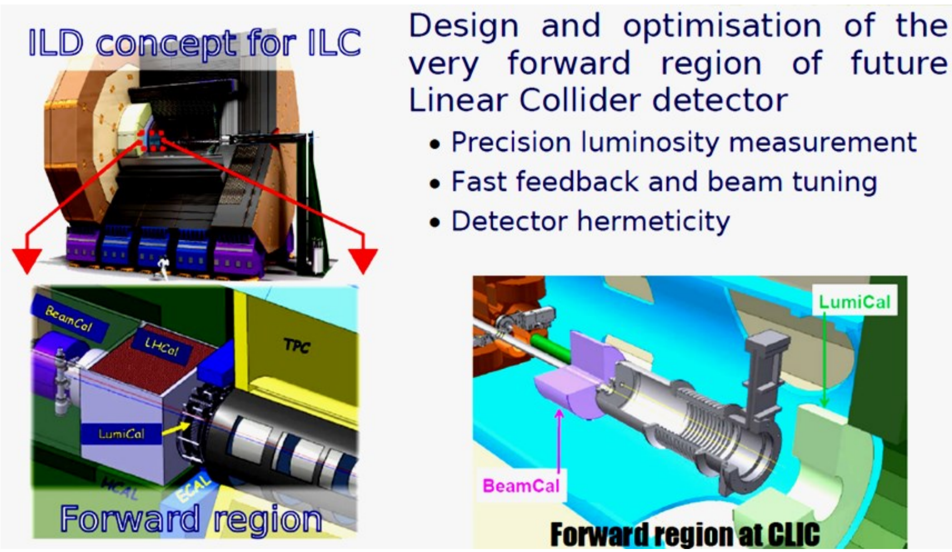
→ detector optimisation studies – full simulations for variation of individual detector parameters ,

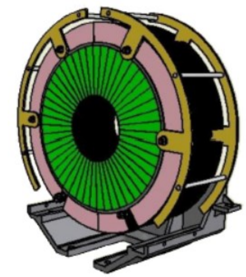
→ test beam data analyses.

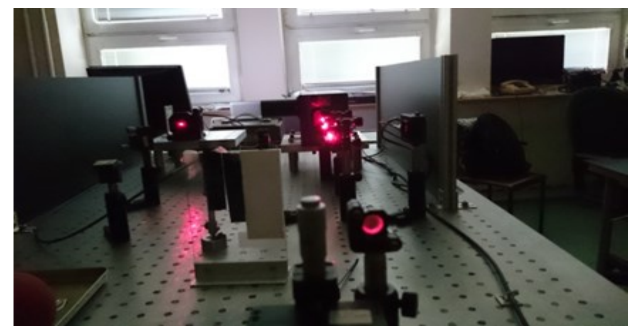
In 2014 overall about 1200 years of CPU time was consumed by the linear collider detector groups. For 2015 it is estimated that computing resources in the order of 2000 CPU years will be required for the ILC VO.

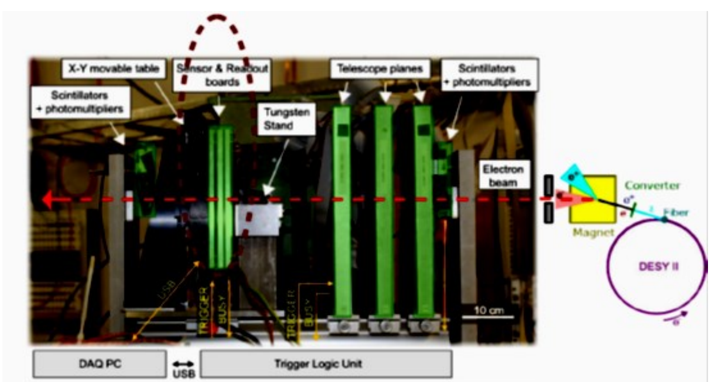
Cracovian group's participation (1)

- As part of the FCAL Collaboration – R&D work on the technologies of special calorimeters in the very forward region of future detectors at an e+e- collider (prototype of the LumiCal detector)

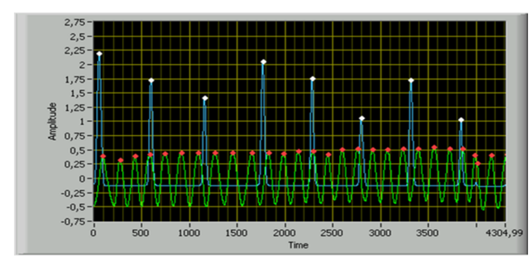








Example test-beam setup at DESY



Cracovian group's participation (2)

- Physics studies and detector description:
  - exotic Higgs decays,
  - forward – backward asymmetries for b and t quarks,
  - two-photon interactions – photon structure functions
  - detector simulation: geometry, reconstruction
  - optimisation of the detector response – granularity of the internal detector structure
  - background from physical and accelerator related processes

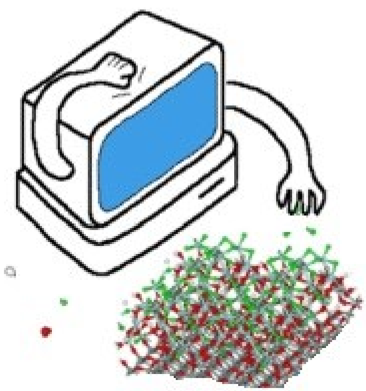
The assumed requirements in 2015:

1.5 million of CPU hours

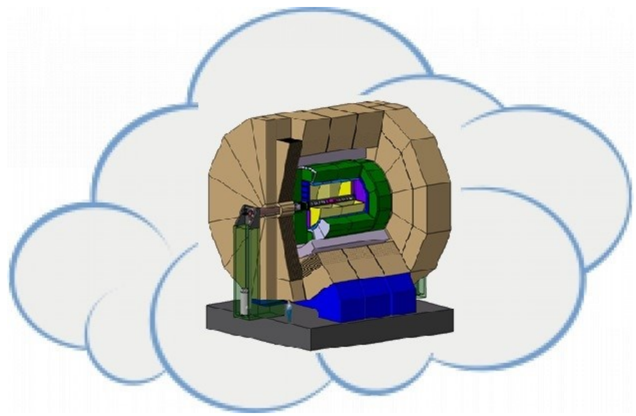
15 TB of storage

How we do it?

Generation



Simulation in
detector's geometry

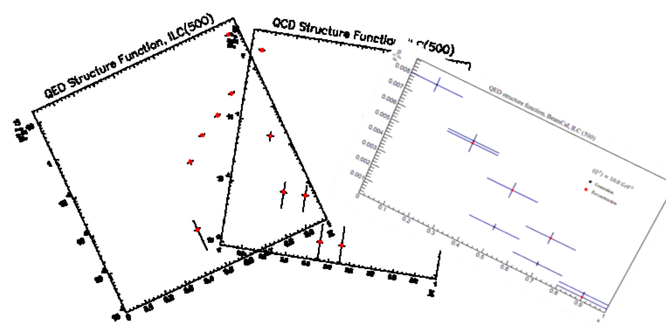


Analysis

For 1000 events of $\gamma\gamma$ interactions :

	CPU hours
Generation	0.25
Simulation	16.68
Reconstruction	2.46
Total	**19.39**

Results



Summary

- Even though a Higgs particle has been discovered at the LHC, we need to examine all of its properties to verify its full identity.
- The elucidation of new phenomena predicted by New Physics models as well as a detailed knowledge of the Standard Model at high energies are also still important.
- So the construction of a new e^+e^- collider is much anticipated. The new projects are currently under the phase of intense studies.
- In order to explore the opportunities which would be provided by the future collider large scale Monte Carlo studies are necessary – large amounts of CPU hours and storage are required.

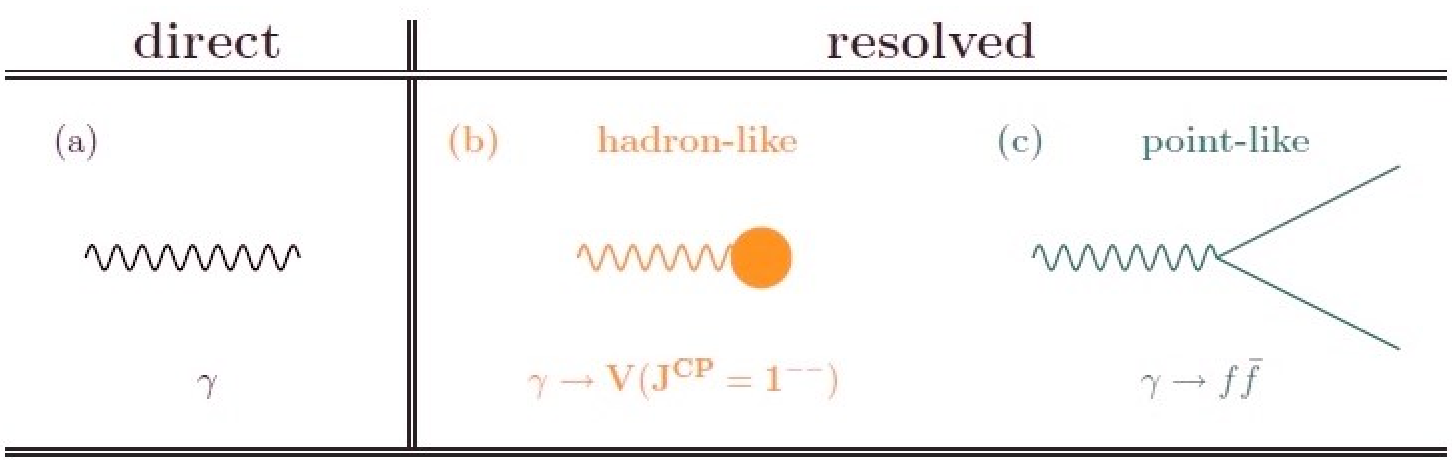
Backup

Estimated time dimension of the ILC project

- 2013 - 2016
  - Negotiations among governments
  - Accelerator detailed design, R&Ds for cost-effective production, site study, CFS designs etc.
  - Prepare for the international lab.
- 2016 – 2018
  - 'Green-sign' for the ILC construction to be given (in early 2016)
  - International agreement reached to go ahead with the ILC
  - Formation of the ILC lab.
  - Preparation for biddings etc.
- **2018**
  - Construction start (9 yrs)
- **2027**
  - Construction (500 GeV) complete, (and commissioning start)
    (250 GeV is slightly shorter)

Photons & their interactions

- As a gauge boson of QED photon is a massless ($m < 2 \cdot 10^{-16}$eV) and chargeless ($q < 5 \cdot 10^{-30}$e) particle, which has no internal structure.
- According to the QFT the existence of interactions means that the intermediate boson can develop a structure. Photon can fluctuate into a charged fermion – antifermion pair.
- It can interact directly as a point particle (*direct photon*) or by fermions produced in a quantum fluctuation (*resolved photon*).
- Anomalous photons (*point-like*) - when the quantum fluctuation leads to a pair of quarks, one of which then takes part in the strong interaction. Fluctuation to a pair of leptons always gives anomalous contribution to the structure of the photon.
- Hadron-like photons - when the quantum fluctuation leads to a hadronic final state with the same quantum numbers as the photon.



Photon structure functions

Deep inelastic eγ scattering

Analogy with studies of the proton structure functions at HERA

HERA LC