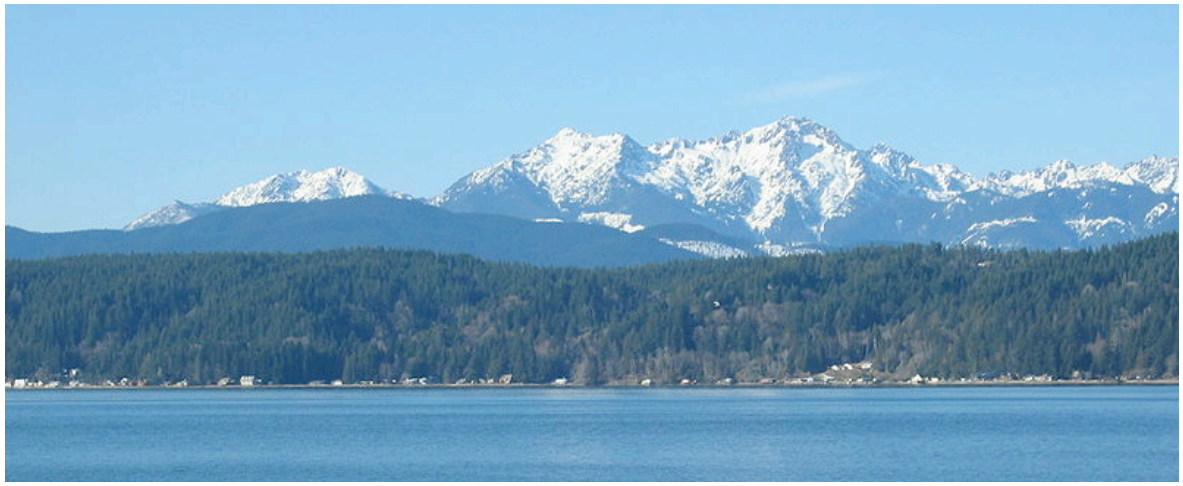
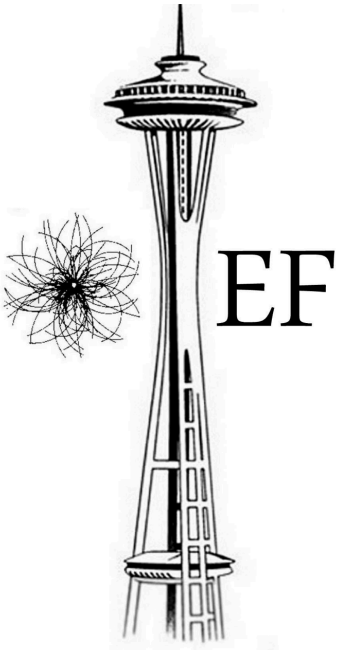
Energy Frontier

Personal opinion of what should be the highest level conclusions of the Energy Frontier report





Discovery Goals at the Energy Frontier

A Higgs boson exists! Does it fully explain how ALL particles acquire mass, or are new laws of physics required?

Are there extra dimensions of space?

What is the nature of new particles and new principles beyond the Standard Model?

What is the dark matter that makes up about one quarter of the contents of the universe?

What is the nature of the dark energy that makes up almost three quarters of the universe?

Do all the forces of nature become one at high energies?

Why is the universe as we know it made of matter? What is the origin of this matter-antimatter asymmetry?

How did the universe form?

Based on list of Nine Questions expressed by P5, 2008 .

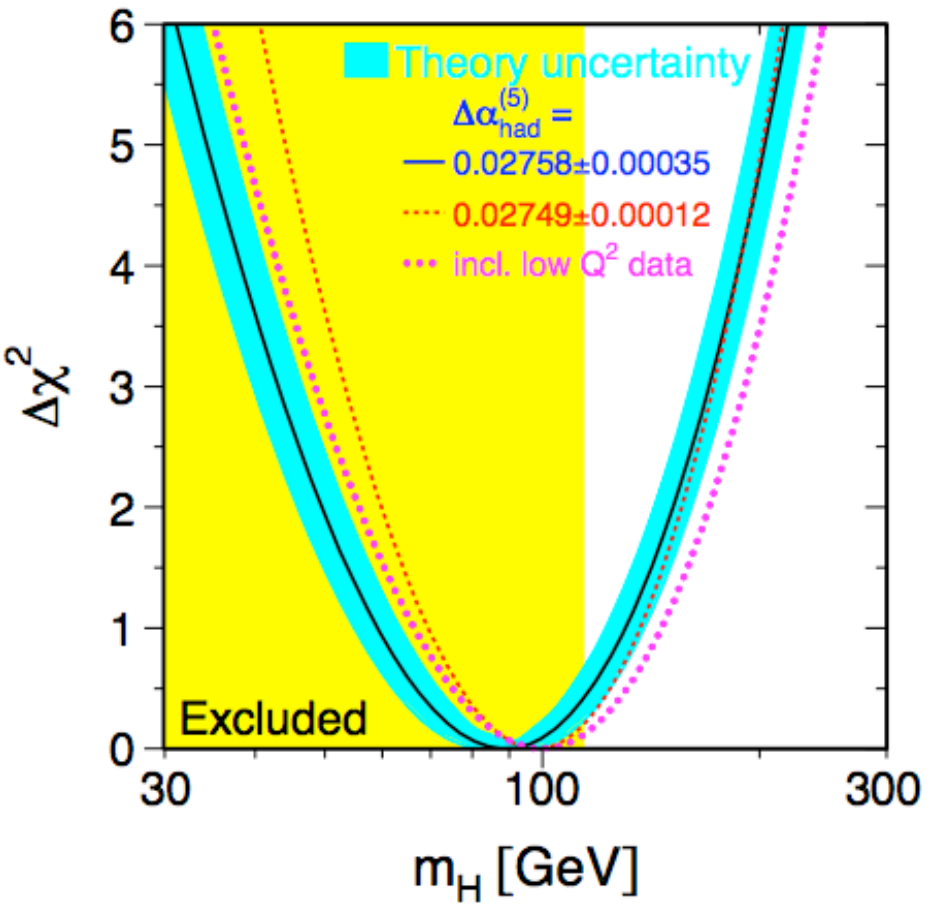
Where are we today?

- Discovery of a Higgs boson at the LHC launches a new era in particle physics
  - first fundamental scalar
    - it appears to be a scalar
    - is it fundamental?
    - this particle is so unique and significant, we need to determine all its properties in great detail
  - motivation for additional new particles and new physics
    - solve Hierarchy problem
    - solve Dark Matter problem
    - complete unification
  - can the Higgs help understand Dark Energy?

LEP & SLC and the Higgs

- LEP/SLC Z-pole measurements
  plus m_t, m_W, and Γ_W from Tevatron run-I and LEP-II
- LEWWG, Winter 2006 -

	Measurement	Fit	$\lvert O^{meas} - O^{fit} \rvert / \sigma^{meas}$
$\Delta\alpha^{(5)}_{had}(m_Z)$	0.02758 ± 0.00035	0.02767	
m_Z [GeV]	91.1875 ± 0.0021	91.1874	
Γ_Z [GeV]	2.4952 ± 0.0023	2.4959	
σ^0_{had} [nb]	41.540 ± 0.037	41.478	
R_l	20.767 ± 0.025	20.743	
$A^{0,l}_{fb}$	0.01714 ± 0.00095	0.01643	
$A_l(P_\tau)$	0.1465 ± 0.0032	0.1480	
R_b	0.21629 ± 0.00066	0.21581	
R_c	0.1721 ± 0.0030	0.1722	
$A^{0,b}_{fb}$	0.0992 ± 0.0016	0.1037	
$A^{0,c}_{fb}$	0.0707 ± 0.0035	0.0742	
A_b	0.923 ± 0.020	0.935	
A_c	0.670 ± 0.027	0.668	
A_l(SLD)	0.1513 ± 0.0021	0.1480	
$\sin^2\theta^{lept}_{eff}(Q_{fb})$	0.2324 ± 0.0012	0.2314	
m_W [GeV]	80.404 ± 0.030	80.376	
Γ_W [GeV]	2.115 ± 0.058	2.092	
m_t [GeV]	172.5 ± 2.3	172.9	



2015 and beyond

- LHC will improve Higgs measurements and extend reach of searches for new physics

  running resumes in ~2015

  studies of Higgs resume

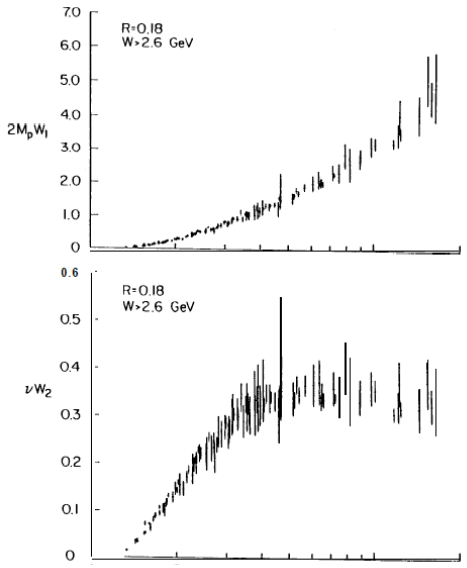
  searches for new physics continue

  expect significant advances in understanding

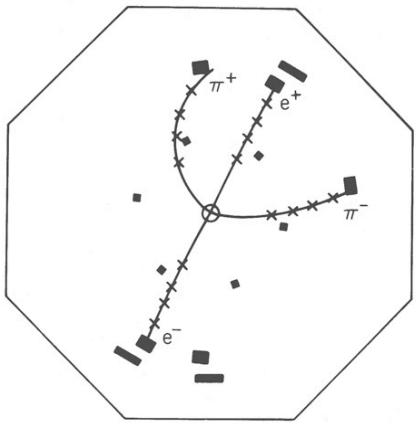
- ...and the LHC (machine and detectors) will be upgraded to capitalize on the investment and scientific opportunity
- Can we / should we / complement the LHC with a lepton collider? - YES

Complementarity

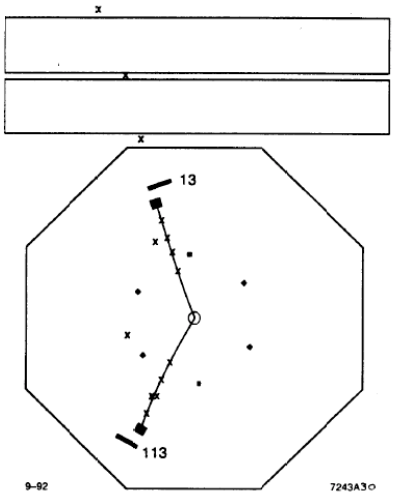
- Long history in HEP of e^+e^- and hadron colliders working in parallel
  - leptons certainly provided precision measurements
    - anticipated SM Higgs mass (earlier slide)
  - but also have good history of **discovery**



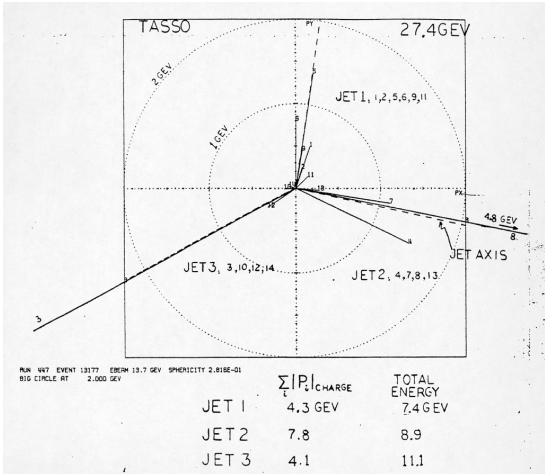
partons



charm



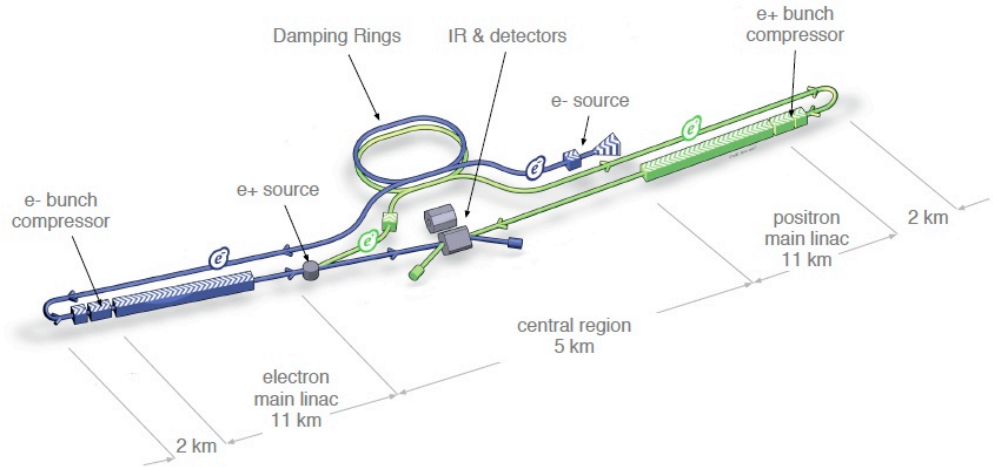
tau-lepton



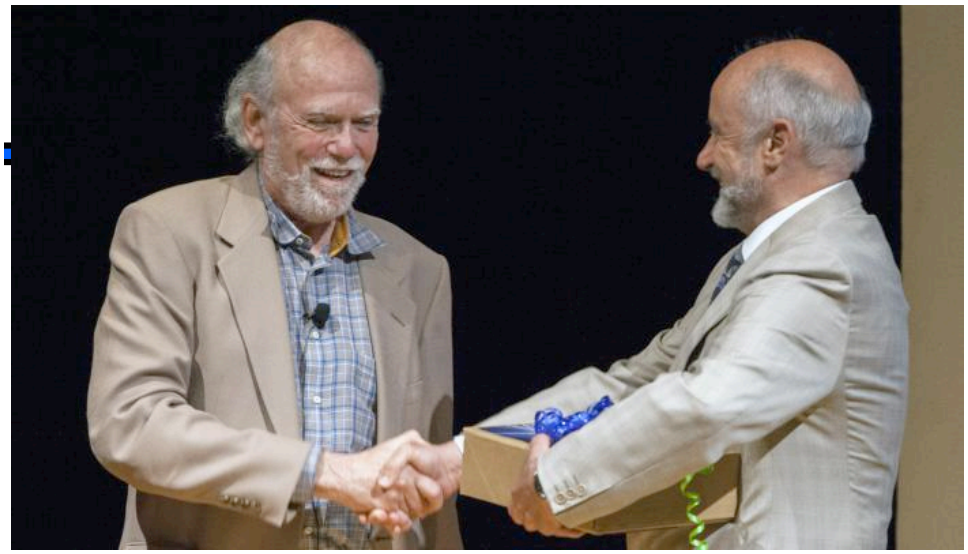
gluon

and LEP-II just missed discovering the Higgs

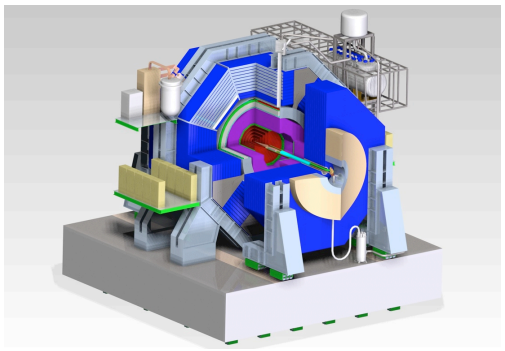
WE NEED SUCH COMPLEMENTARITY IN THE FUTURE

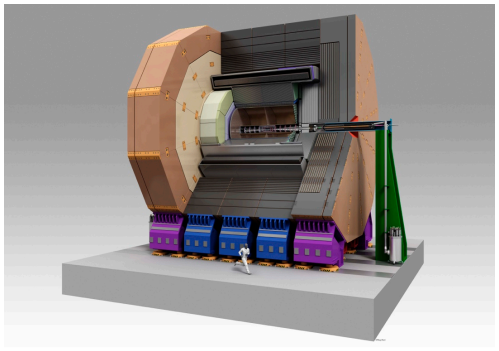


20 year R&D program concluded in 2013 with publication of the ILC TDR
http://arxiv.org/abs/1306.6327



ILC Global Design Effort Director Barry Barish presents ILC TDR to ICFA Chair Pier Oddone





Detector technologies have been developed in global R&D effort

Performance of ILC detectors and ILC physics reach have been studied with detailed, full simulations

Linear Collider Director Lyn Evans discusses ILC with Japanese PM Shinzō Abe

International Linear Collider

- Just as in the past, e^+e^- can again be a powerful complement
  - Precision measurements (Higgs, top, W, ...)
  - Search for weakly coupled new particles
  - ...
- ILC is the tool to provide this complementarity
  - More than 20 years of intense R&D by all major accelerator labs in the world (guided by ICFA) led to the completion of the TDR in 2013
    - XFEL at DESY is 1/10 of ILC
  - ILC is now ready for project start
    - enables the urgently needed 250 GeV - 1 TeV lepton collider
  - Very serious initiative in Japan for hosting a global project
    - This is a very special opportunity for a new facility
    - High level discussions between US and Japanese governments
      - could lead to increased HEP funding
    - Needs expression of interest from US HEP community from Snowmass!
  - US has played critical/leading role in developing this opportunity, and
  - US should now play a leading role in realizing the ILC - collider, detectors, and physics

Personal opinion of what should be the highest level conclusions of the Energy Frontier report

- A strong program at the energy frontier is essential for the US to continue its tradition of an exciting program of discovery in particle physics
- The importance and breadth of the compelling questions which can be addressed at the energy frontier require experimental programs with both hadron and lepton colliders
- The US should continue its leading role at the LHC, including major contributions to the LHC upgrades
- The ILC is now ready to provide the needed complementarity to the LHC
- The US should play a leading role in the ILC proposed as a global project in Japan
- New accelerator & detector technologies will be essential to exploit energy frontier physics opportunities in the future; vigorous R&D to advance both must continue, such as technologies for warm linear collider concepts, very high energy hadron colliders, and the muon collider.