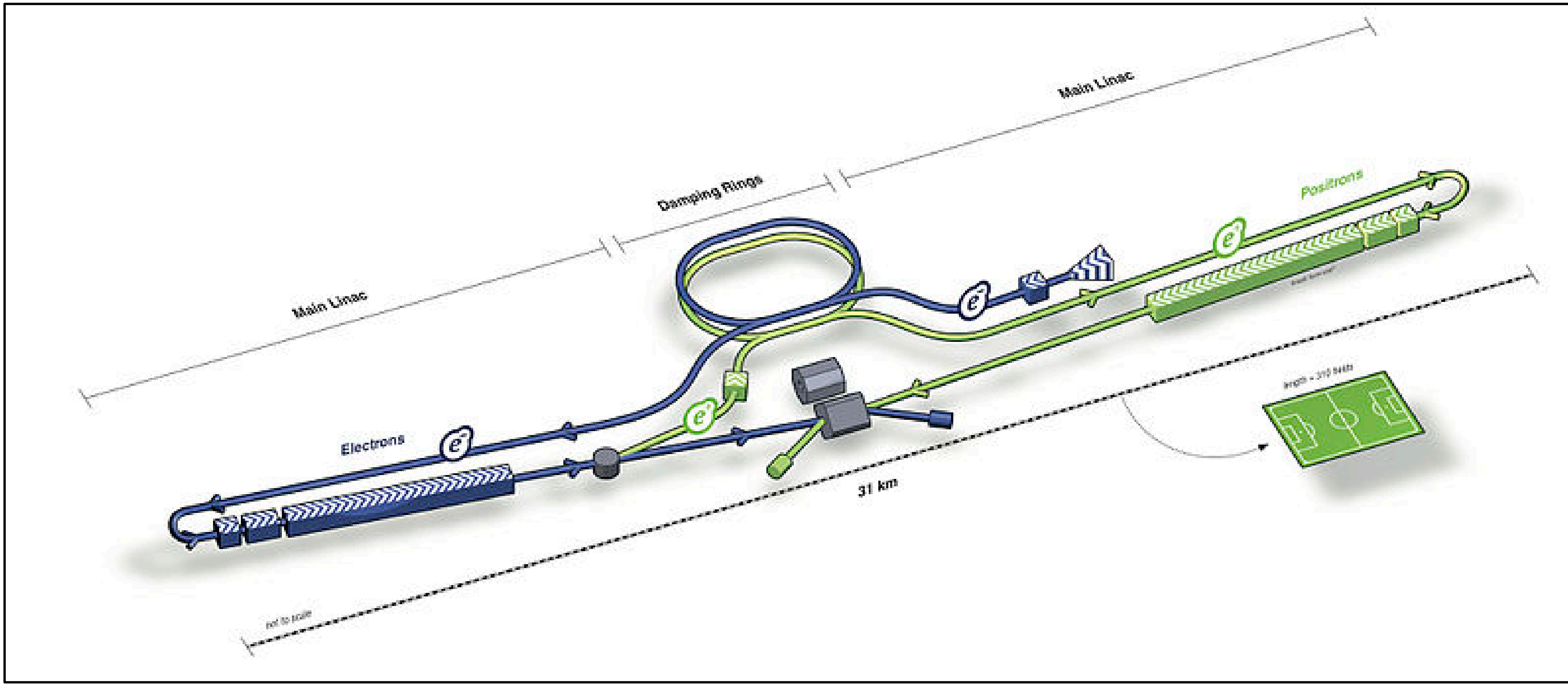
ILC Status

Dmitri Denisov, Fermilab

Fermilab Users Meeting June 11 2014

International Linear Collider



- ILC or International Linear Collider is e^+e^- linear collider with the following main parameters
  - Center of mass energy ~500 GeV
  - Luminosity >10^{34} $cm^{-2}s^{-1}$
- No synchrotron radiation, but long tunnel to accelerate to ~250 GeV/beam
  - Colliding point-like particles

Brief History

- After success of SLAC's linear e^+e^- collider in 1990's (SLC) many proposals developed to go to even higher colliding energy
  - Among them NLC(SLAC), TESLA(DESY), "ILC at Fermilab"
- Since ~2008 Global Design Effort (GDE) was progressing developing
  - Technical design of an ILC
  - Cost estimate and international cooperation plan
- GDE concluded in 2012
  - Including TDRs for the accelerator and detectors
  - Physics case strengthened with a Higgs discovery
- In 2012 Japan expressed strong interest to host the ILC
  - Part of Prime Minister Abe plan
- Over last two years
  - Substantial progress in technical developments
  - Development of cooperation between participants on "Governments level"
- P5 strongly supported US participation in the ILC

P5 – Global Vision/Science Drivers

- The United States and major players in other regions can together address the full breadth of the field's most urgent scientific questions if each hosts a unique world-class facility at home and partners in high-priority facilities hosted elsewhere.
  - Hosting world-class facilities and joining partnerships in facilities hosted elsewhere are both essential components of a global vision.

The Science Drivers:

– Use the Higgs boson as a new tool for discovery
– Pursue the physics associated with neutrino mass
– Identify the new physics of dark matter
– Understand cosmic acceleration: dark energy and inflation
– Explore the unknown: new particles, interactions, and physical principles

- **Recommendation 1:** Pursue the most important opportunities wherever they are, and host unique, world-class facilities that engage the global scientific community
- **Recommendation 2:** Pursue a program to address the five science Drivers

P5 Recommendation on ILC

- As the physics case is extremely strong, we plan in all Scenarios for ILC support at some level through a decision point within the next five years.
  – If the ILC proceeds, there is a high-priority option in Scenario C to enable the U.S. to play world-leading roles.
  – Even if there are no additional funds available, some hardware contributions may be possible in Scenario B, depending on the status of international agreements at that time.
  – If the ILC does not proceed, then ILC work would terminate and those resources could be applied to accelerator R&D and advanced detector technology R&D.

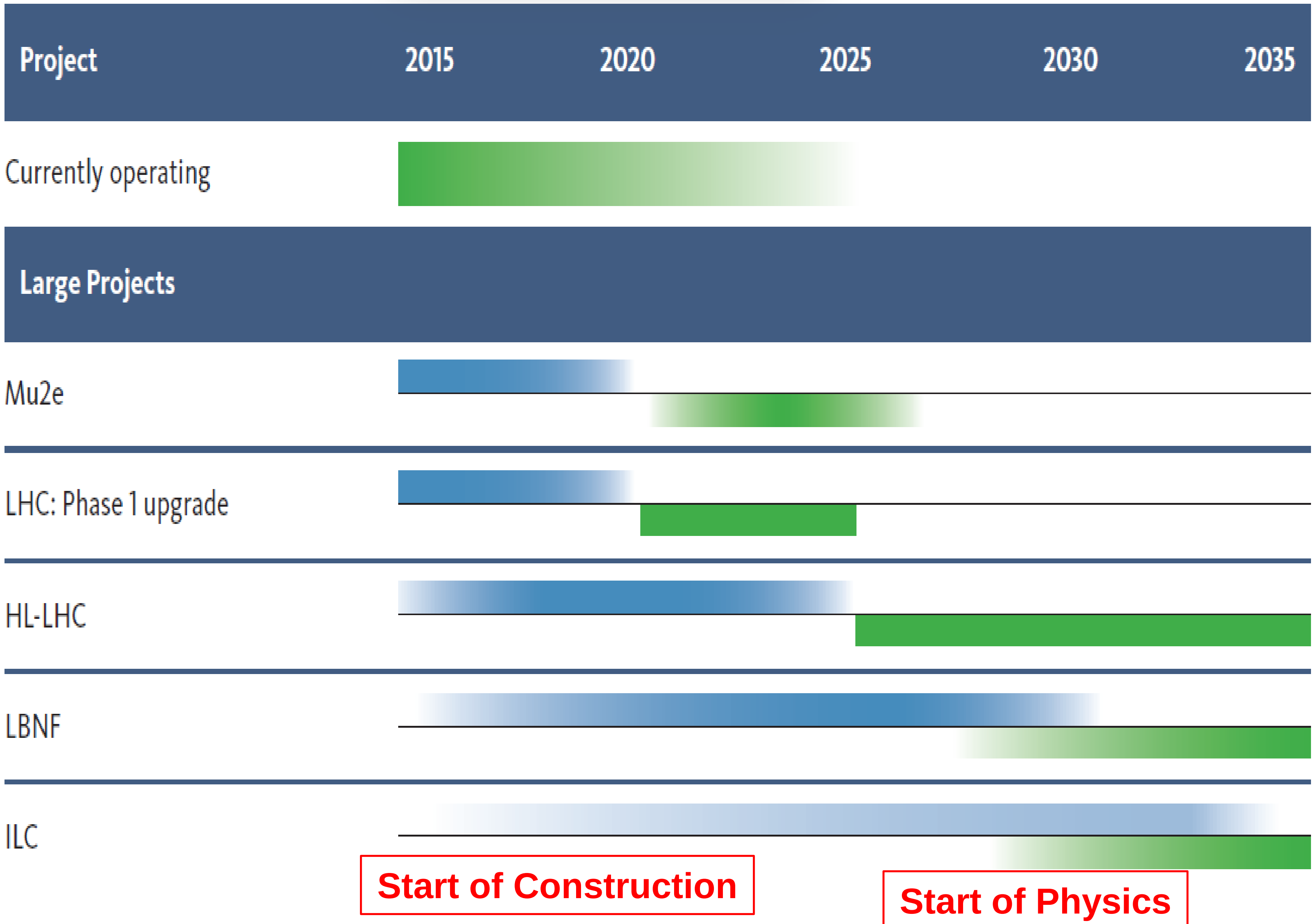
- **Recommendation 11:** Motivated by the strong scientific importance of the ILC and the recent initiative in Japan to host it, the U.S. should engage in modest and appropriate levels of ILC accelerator and detector design in areas where the U.S. can contribute critical expertise. Consider higher levels of collaboration if ILC proceeds.

P5 Scenarios for Large Projects

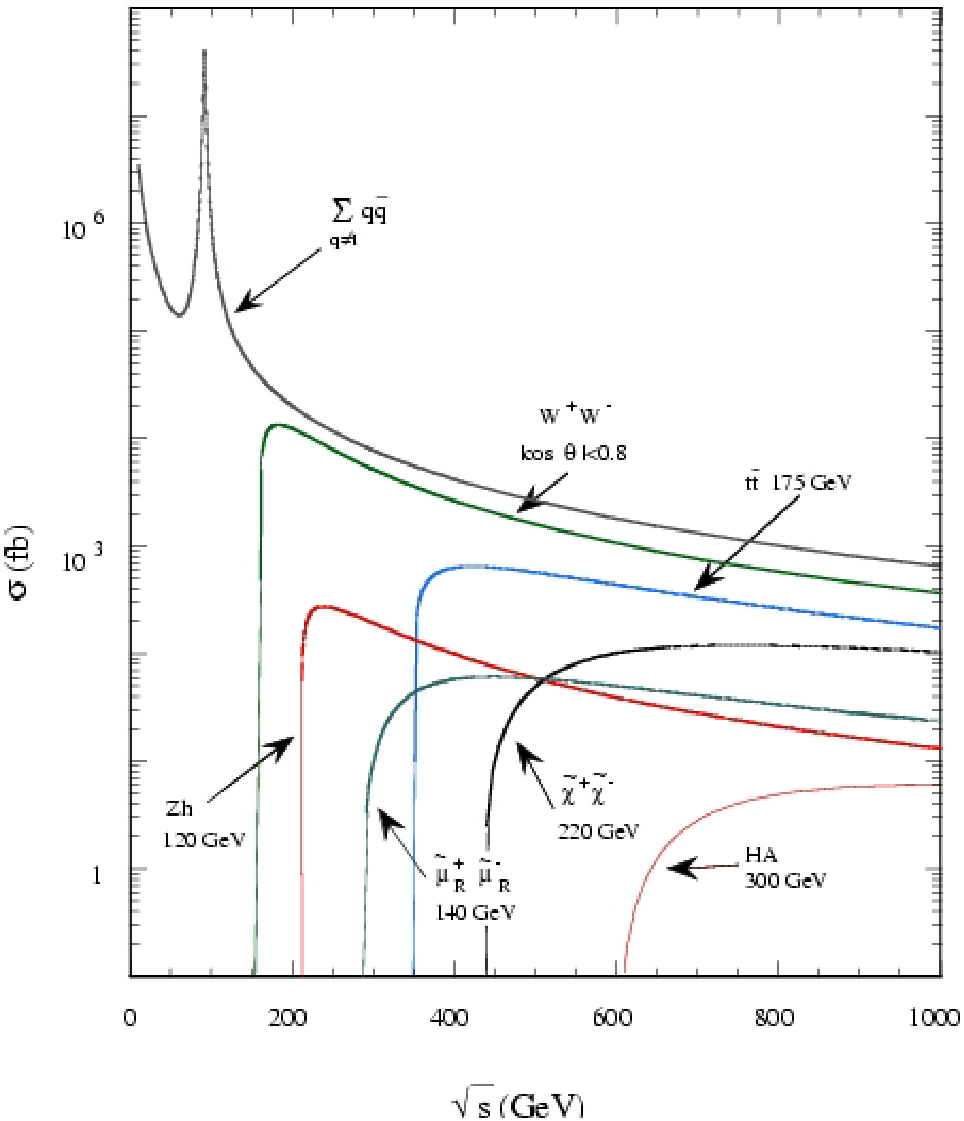
Table 1
Summary of Scenarios

Project/Activity	Scenarios: Scenario A	Scenario B	Senario C	Science Drivers: Higgs	Neutrinos	Dark Matter	Cosm. Accel.	The Unknown	Technique (Frontier)
Large Projects									
Muon program: Mu2e, Muon g-2	Y, Mu2e small reprofile needed	Y	Y					✓	I
HL-LHC	Y	Y	Y	✓		✓		✓	E
LBNF + PIP-II	Y, LBNF components delayed relative to Scenario B.	Y	Y, enhanced		✓			✓	I,C
ILC	R&D only	R&D, possibly small hardware contri-butions. See text.	Y	✓		✓		✓	E

P5 Timeline for Large Projects

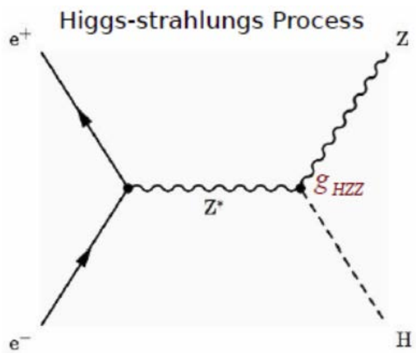


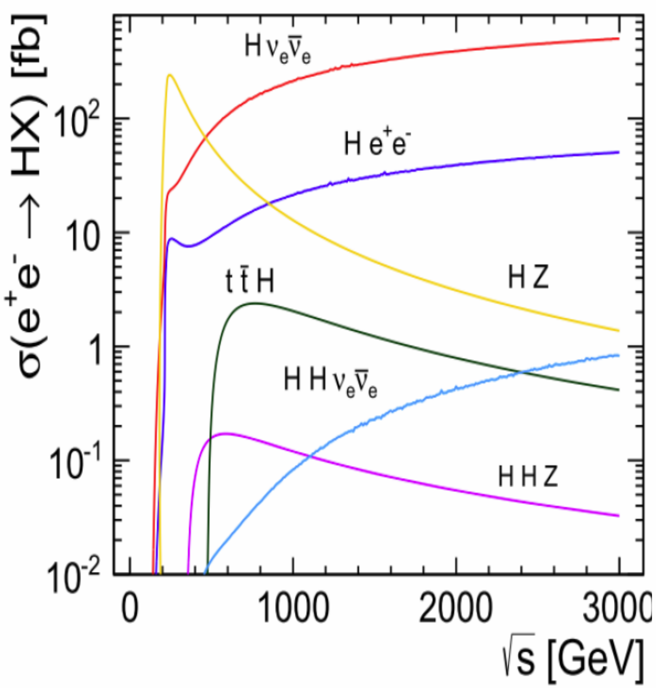
ILC Physics and Experiments



- **Low cross sections**
  - **High luminosity needed**
- **Low rate of interactions**
  - **Collect all events**
  - **High efficiency required**
- **Point like particles colliding**
  - **Sharp thresholds**
  - **Can be used for precision measurements including top mass**
- **Large number of different production/decay channels**
  - **Have to detect all “standard objects” well**
  - **Jets/photons, leptons, charged tracks, missing energy**

Higgs Studies at the ILC





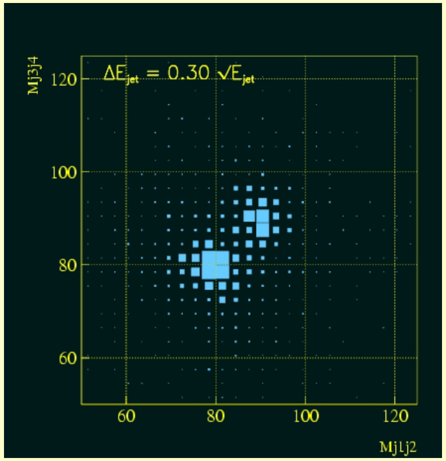
Summary of expected accuracies $\Delta g_i/g_i$ and Γ_T for model independent determinations of the Higgs boson couplings

Mode	ILC(250)	ILC(500)	ILC(1000)	ILC(LumUp)
$\sqrt{s}$ (GeV)	250	250+500	250+500+1000	250+500+1000
L (fb^{-1})	250	250+500	250+500+1000	1150+1600+2500
$\gamma\gamma$	18 %	8.4 %	4.0 %	2.4 %
gg	6.4 %	2.3 %	1.6 %	0.9 %
WW	4.9 %	1.2 %	1.1 %	0.6 %
ZZ	1.3 %	1.0 %	1.0 %	0.5 %
$t\bar{t}$	–	14 %	3.2 %	2.0 %
$b\bar{b}$	5.3 %	1.7 %	1.3 %	0.8 %
$\tau^+\tau^-$	5.8 %	2.4 %	1.8 %	1.0 %
$c\bar{c}$	6.8 %	2.8 %	1.8 %	1.1 %
$\mu^+\mu^-$	91 %	91 %	16 %	10 %
Γ_T	12 %	5.0 %	4.6 %	2.5 %
hhh	–	83 %	21 %	13 %
BR(invis.)	< 0.9 %	< 0.9 %	< 0.9 %	< 0.4 %

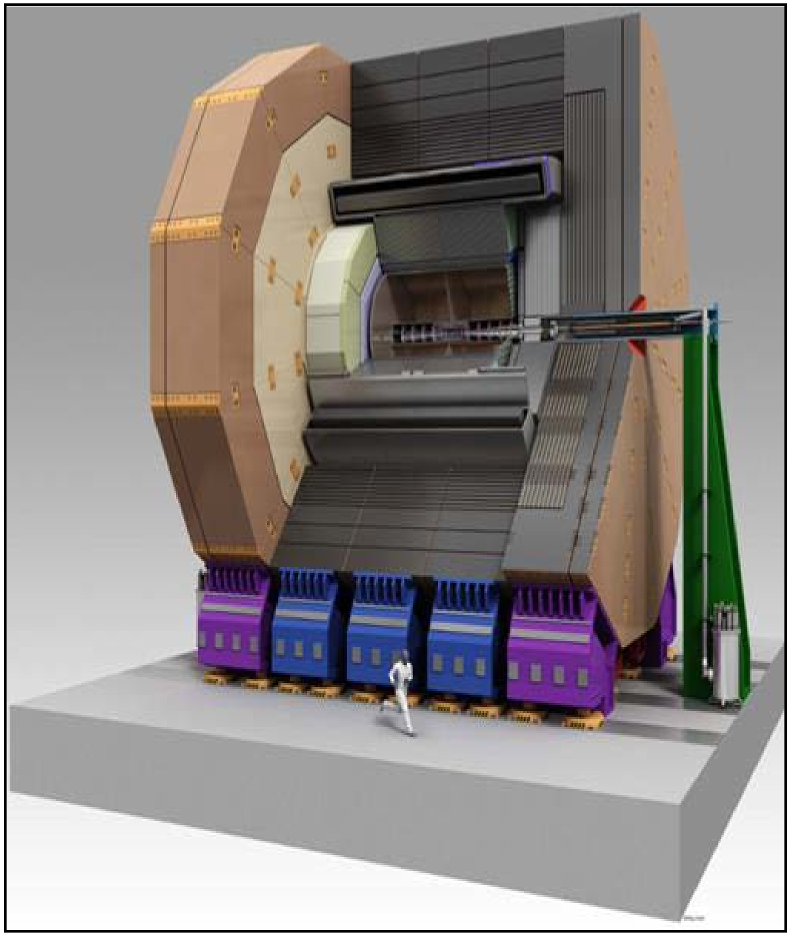
The precision couplings measurements at LHC in the 2—10% range can be potentially reduced at the ILC by an order of magnitude, while providing a model independent determination of Higgs partial widths

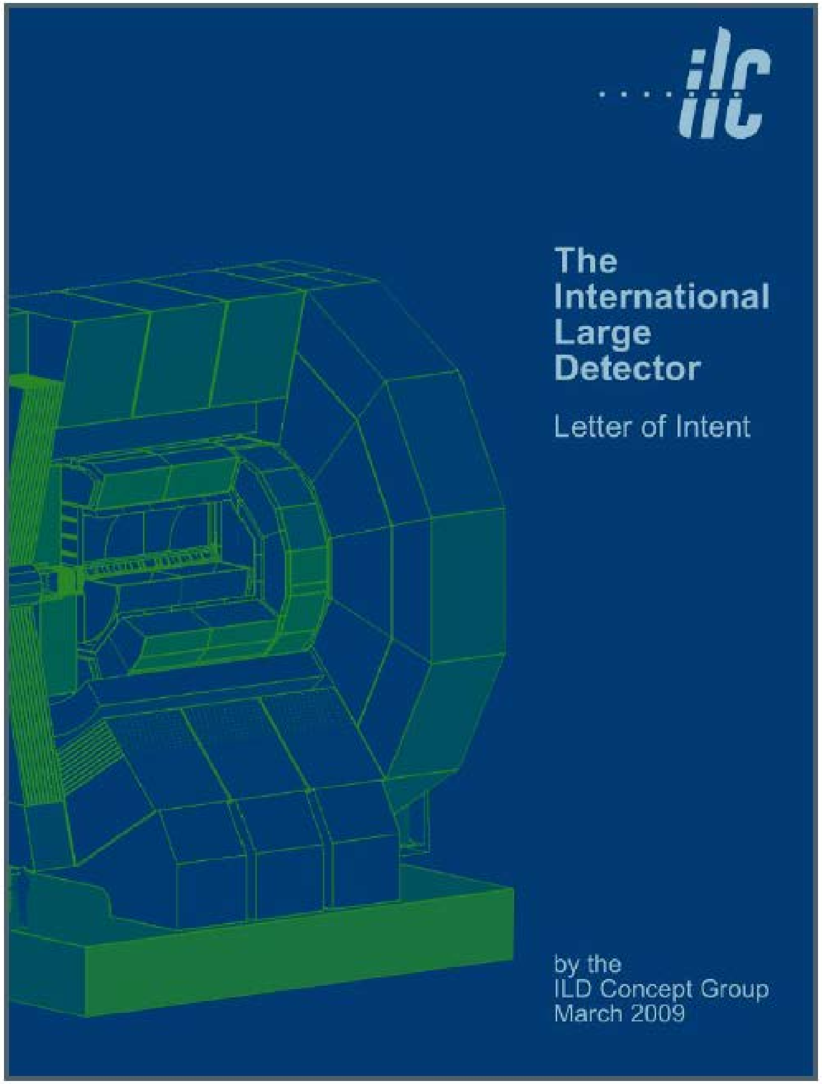
ILC Detectors

- Two detectors are planned: ILD and SiD
- "Push-pull" operation
  - One experiment collects data at a time
- General purpose collider detectors for wide range of physics studies
  - Similar to the Tevatron or LHC
- Excellent tracking, calorimetry and muon systems
  - Separate W/Z in hadronic decays to a pair of jets – excellent jet resolution
  - Charged tracks momentum resolution
    - Silicon tracker for SiD
    - TPC for ILD
- Substantial R&D efforts during GDE initiative
  - TDRs available for both detectors
  - While detectors will benefit from an optimization
    - There are no technical show-stoppers



ILD - International Large Detector



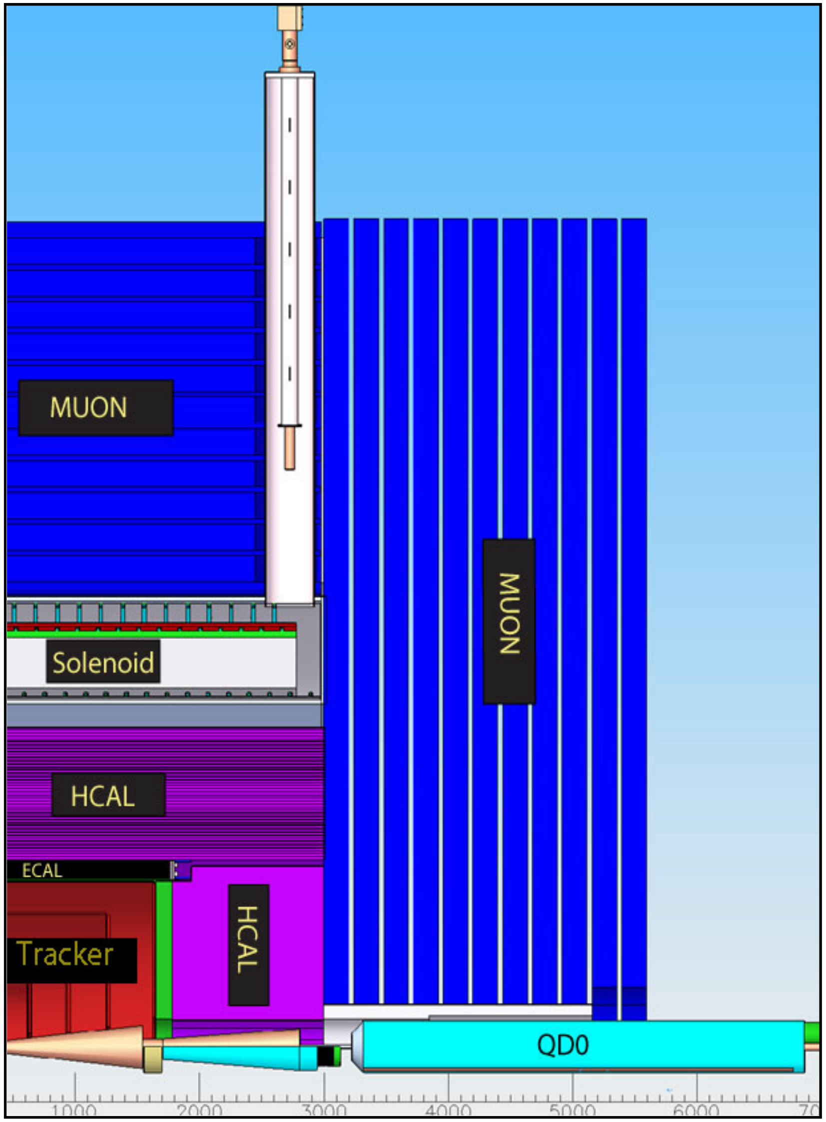


- A modern detector designed for ILC. Similar size to CMS.
- ILC: higher energy (x 5), higher luminosity (x 500), much better detectors than LEP

http://ilcild.org/documents/ild-letter-of-intent

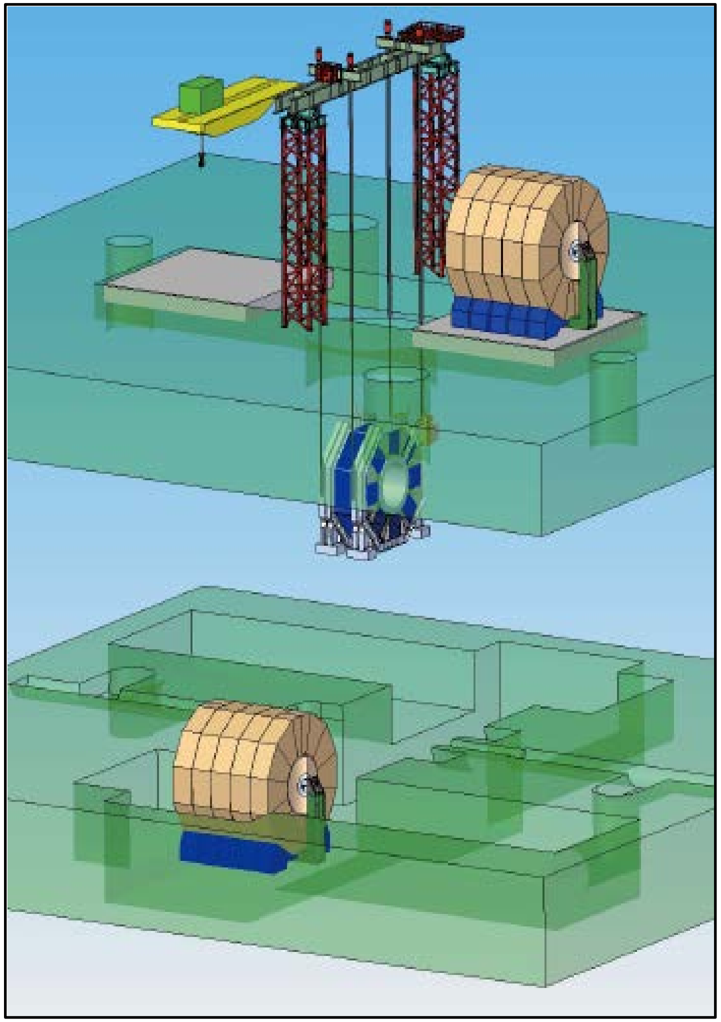
695 signatories, 32 countries, 148 institutions

SiD Detector

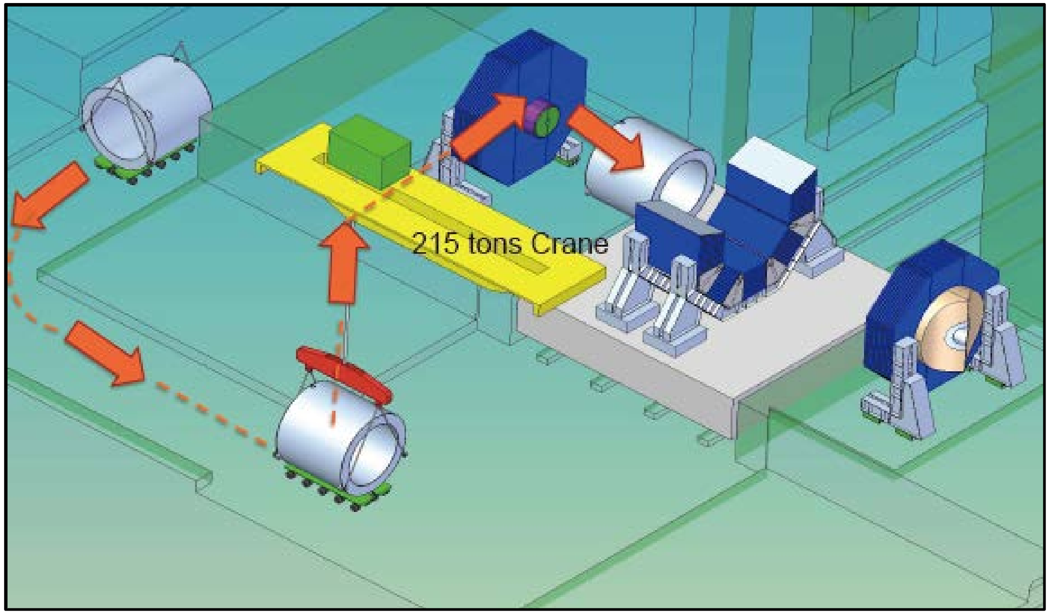


- **SiD rationale**
  - A compact detector designed to make precision measurements, with sensitivity to a wide range of new phenomena
- **Design choices**
  - Compact design with 5 T field
  - Robust silicon vertexing and tracking system with excellent momentum resolution
  - Time-stamping for single bunch crossings
  - Highly granular Calorimetry for Particle Flow
  - Iron flux return/muon identifier is part of the SiD self-shielding

Detectors Assembly

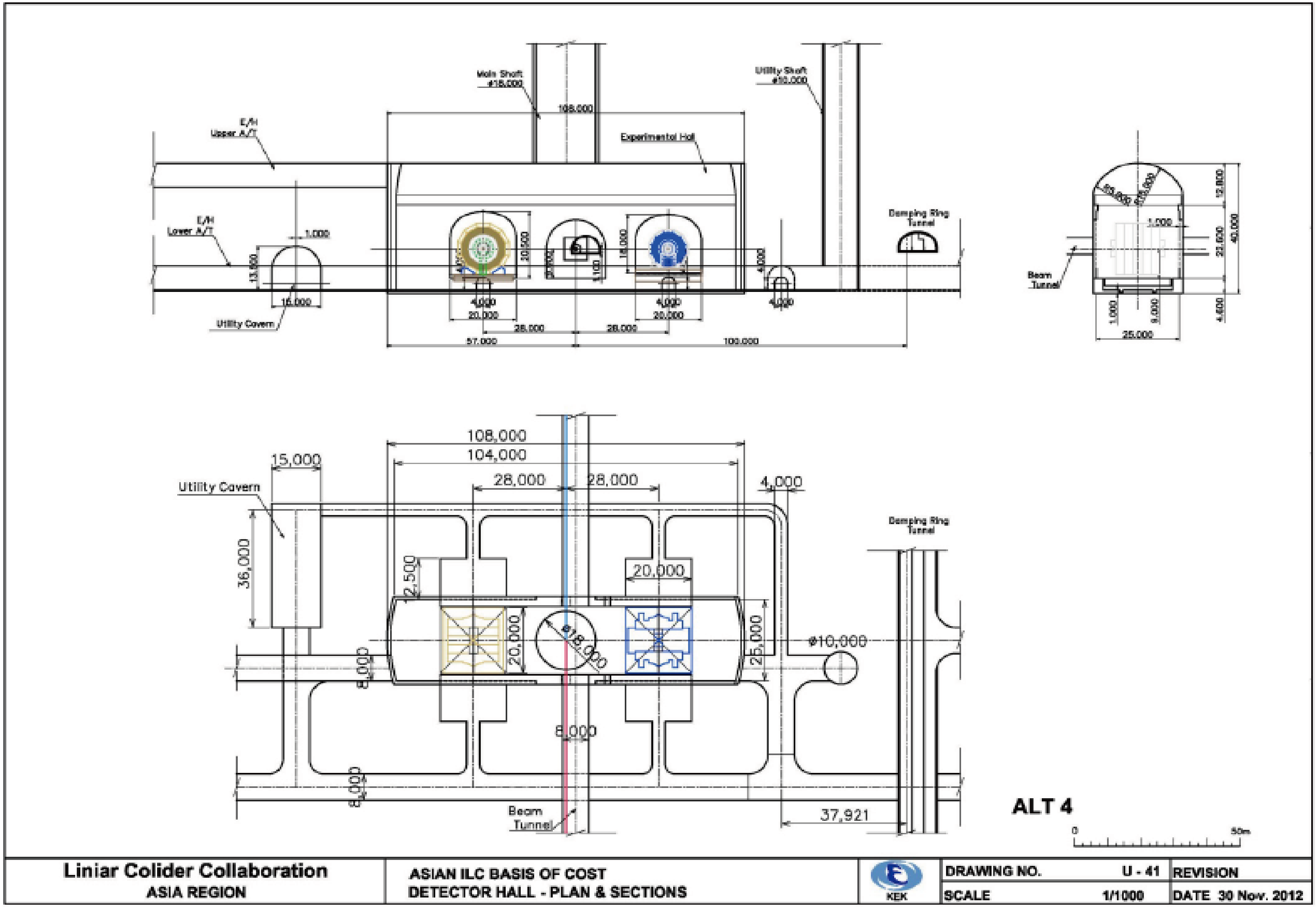


Vertical Access
"CMS-like"



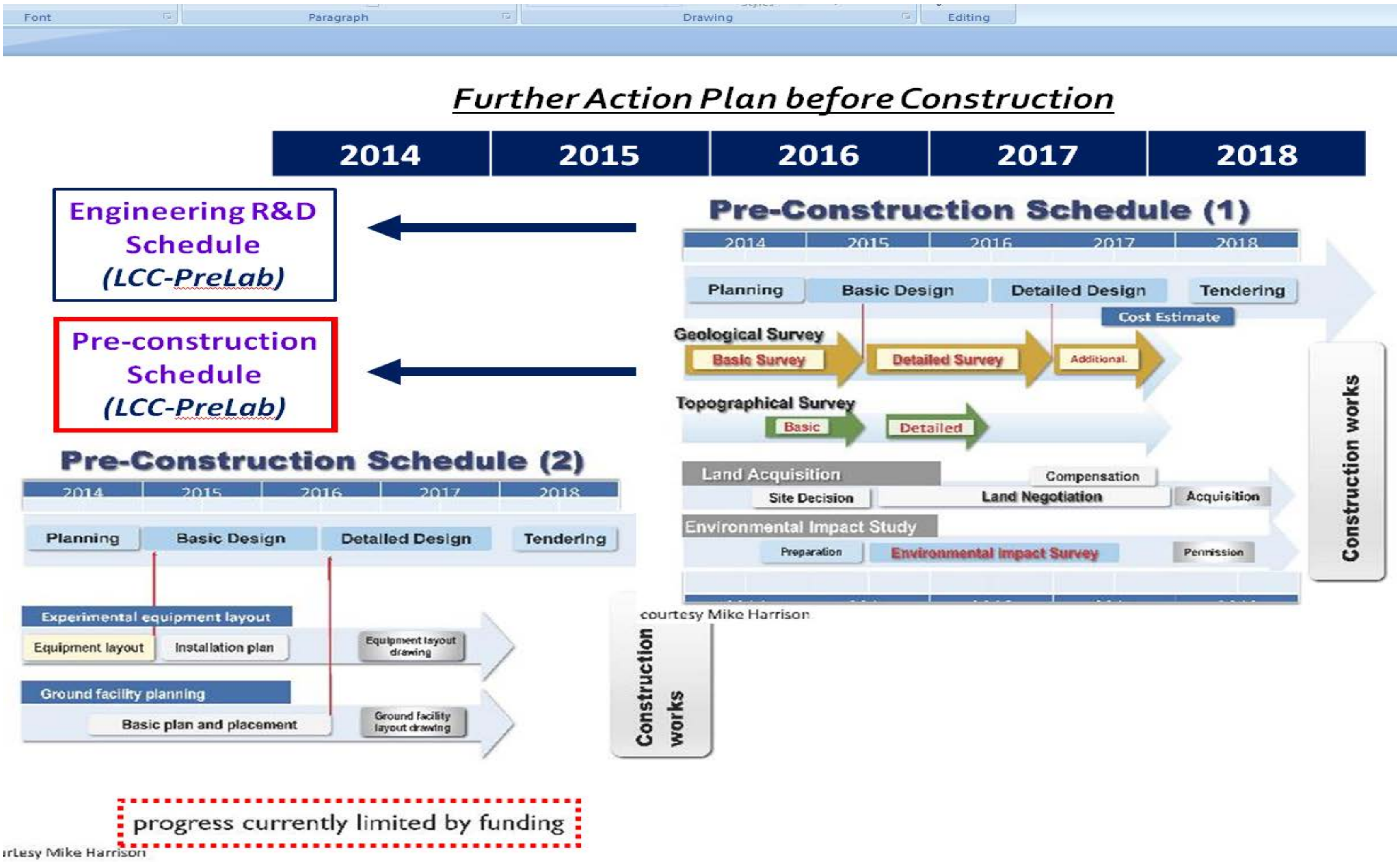
Horizontal Access
TDR baseline

Technical Drawings



Two detectors in "push-pull" geometry

KEK is Actively Developing Construction Plans



Construction starts around 2018

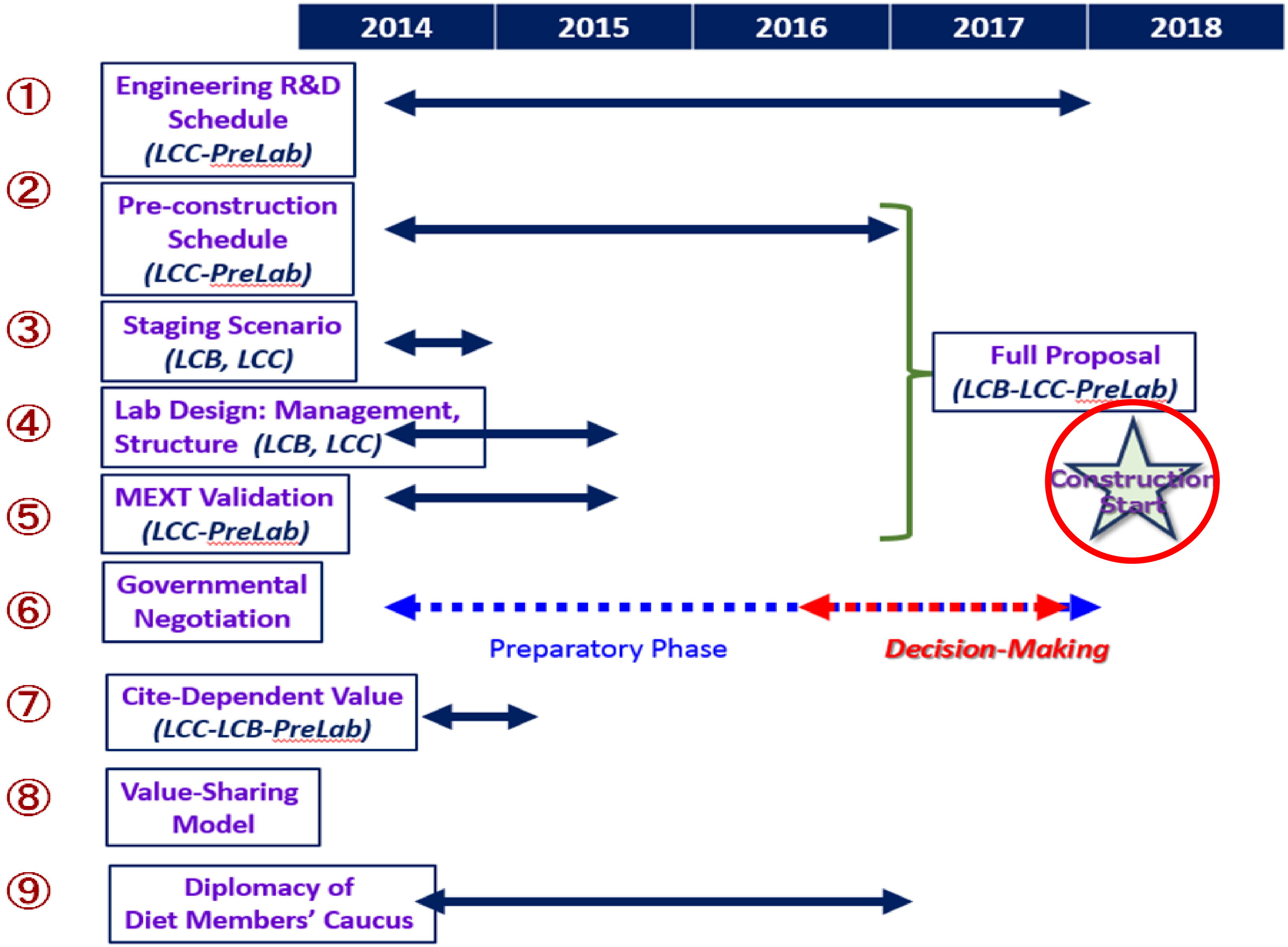
A site chosen by the Japanese HEP community

In August 2013, the Japanese site evaluation committee by scientists and experts in Japan recommended the Kitakami-site as a candidate for ILC. Internal Review Committee concluded that the proposed site is in good geological conditions.

2012 Science Council of Japan Comments

- A more precise research strategy for the ILC in view of the LHC upgrade path;
- The funding framework that does not affect the broader field of science or other critical national priorities;
- Detailed plan of international cost-sharing;
- A domestic organization to implement the project consisting of the High Energy Accelerator Research Organization (KEK) and universities;
- Human resources required during construction and operation, in particular, for leadership positions.

Steps Toward Construction (A. Suzuki)



Active Political Efforts to Establish ILC Cooperation

Meeting of the U.S. – Japan
Science and Technology
Joint High Level Committee

April 30, 2013
Washington, D.C.

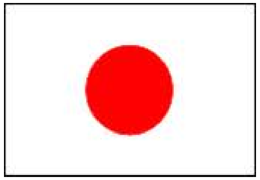
Next Meeting in July

US-Japan Advanced Science and Technology Symposium

This symposium gathers US and Japanese leaders from policy makers for the field of science and innovation, academia and industry. With the International Linear Collider (ILC) as an example, the discussion will cover the US-Japan co-operation in science and technology, working together for innovation and the realization of economic growth as well as methods and policies for the development of scientific and technical human resources.

Building ILC was among main elections themes of the current Japan's Prime Minister Abe

ILC Cooperation Efforts in Europe


October 2012


March 2013


March 2013

April 2014

May 2014

Letter from

MEXT MINISTRY OF EDUCATION, CULTURE, SPORTS, SCIENCE AND TECHNOLOGY-JAPAN

Federation of Diet Members for the ILC
Room 302 (Office of Takeo Kawamura)
Second Members' Office Building of the House of Representatives
2-1-2 Nagata-cho, Chiyoda-ku, Tokyo 100-8982, Japan

to

CERN DG

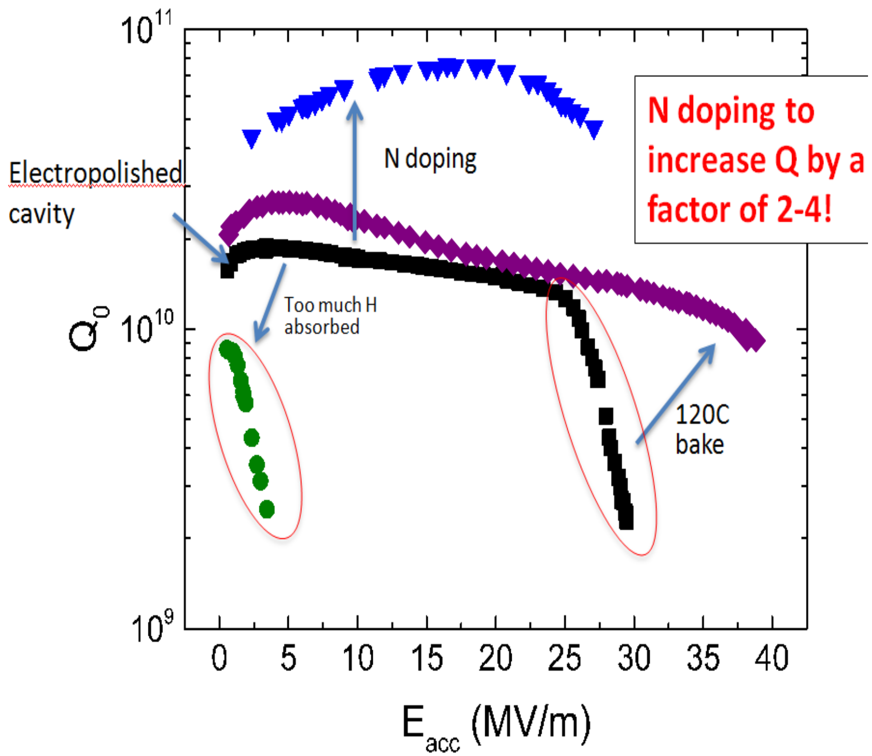
EU Government

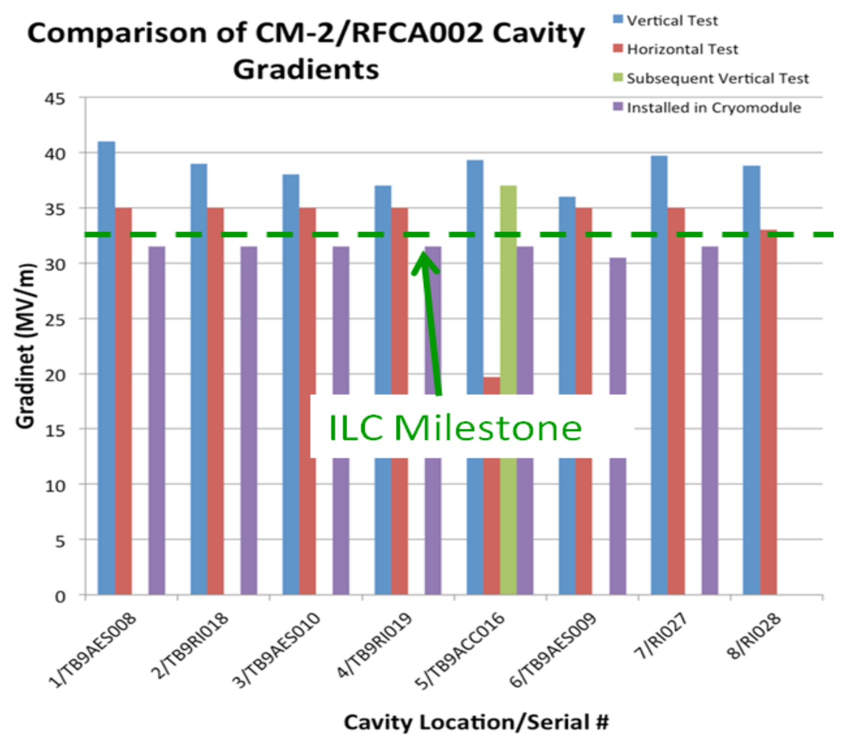
June 2014

Meeting : France-Japan Friendship Diet Members' Caucus

Fermilab's Potential ILC Contributions

- **SCRF accelerating cavities**
  - **Synergy with PIP-II and LCLS accelerating cryomodules**
- **R&D in accelerator systems, including controls**
- **Design of the ILC detector(s)**





- **Two excellent results for SCRF cavities obtained at Fermilab recently**
  - **Substantial Q factor increase of the cavities**
  - **At ASTA cavities reached ILC specification of 32.5 MV/m**

Americas Workshop on Linear Colliders

- Last month 200 scientists from around the world met at Fermilab
- To continue development of the physics case, and advancing detector and accelerator designs for a high energy linear electron-positron collider
- ILC hosted in Japan was main topic of the workshop

Organization of ILC Activities in America

American Linear Collider Committee (ALCC) is coordinating efforts in America

ALCC tasks:

- Be advocate for & enable LC case especially towards funding agencies
- Coordinate activities.
- Cover both ILC and CLIC.
- Provide connection/conduit to LCC
- Organize regional workshops

There is a charge/charter

Membership:

Jonathan Bagger	*TRIUMF*	Graham Wilson	*Kansas*
Nigel Lockyer	*Fermilab*	Mike Harrison	*BNL*
David MacFarlane	*SLAC*	Marc Ross	*SLAC*
Lia Merminga	*TRIUMF*	David Rubin	*Cornell*
Hugh Montgomery	*JLab*	Joe Lykken	*Fermilab*
Director	*TRIUMF*	Andy White	*UT Arlington*
Harry Weerts	*ANL chair*	Paul Grannis	*Stony Brook*
Jim Brau	*Oregon*	Dmitri Denisov	*Fermilab*

Concluding Remarks

- GDE developed technical design for e^+e^- linear collider with energy ~500 GeV and luminosity ~ 10^{34} $cm^{-2}s^{-1}$
  - Collider of point-like particles to study all Standard Model particles with unprecedented precision and to look for the effects beyond those known
- Such machine addresses 3 out of 5 P5 science drivers
  - And fosters international cooperation
- Japan is strongly considering hosting ILC
  - US and Europe are interested to participate
- Fermilab has unique capabilities to play leading role in this project
  - SCRF cavities design/construction
  - Detectors and analysis
- Construction can be started as early as 2018
  - Depends mainly on the agreements between countries involved
- Site to locate ILC is recommended in North Japan
  - Site-specific activities/developments are starting
- ALCC committee is working with DOE/NSF to develop R&D program for the next few years
  - Both accelerator and detectors – let us know if you are interested!

P5 about ILC

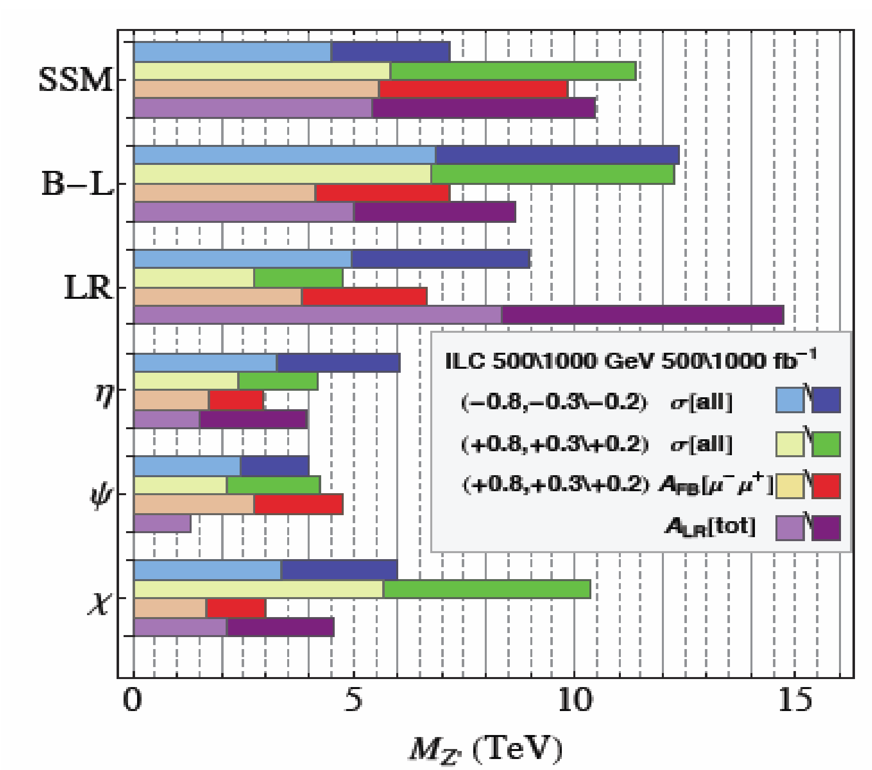
- **The interest expressed in Japan in hosting the International Linear Collider (ILC), a 500 GeV e^+e^- accelerator upgradable to 1 TeV, is an exciting development.**

- Following substantial running of the HL-LHC, the cleanliness of the e^+e^- collisions and the nature of particle production at the ILC would result in significantly extended discovery potential as described in the Drivers sections, mainly through increased precision o measurements...

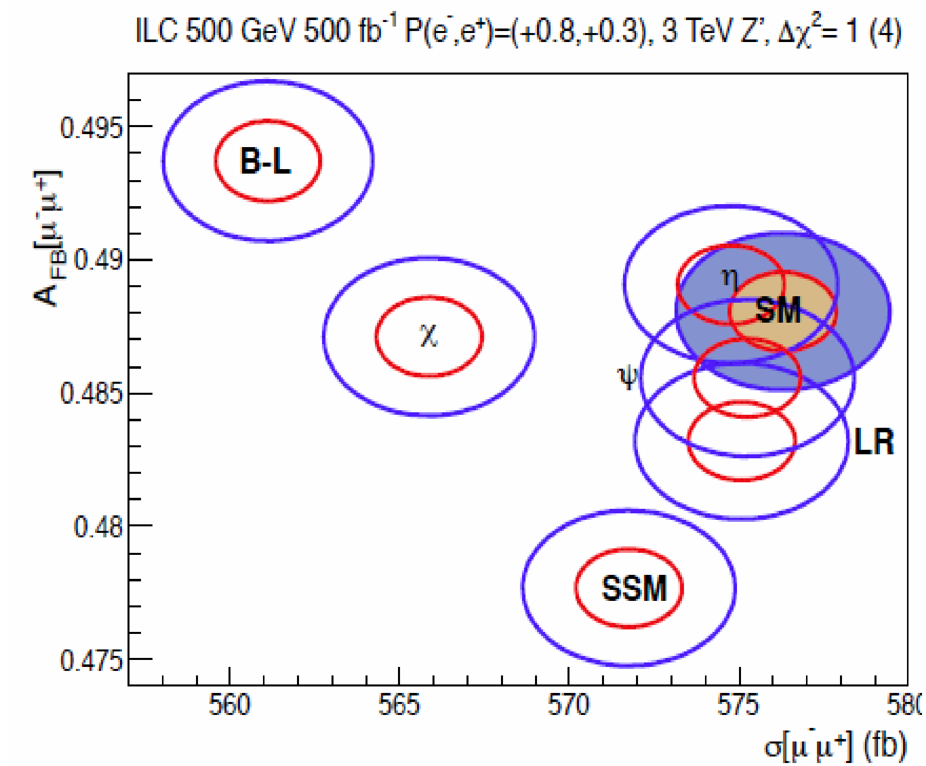
- The U.S. has played key roles in the design of the ILC accelerator, including leadership in the Global Design Effort. Continued intellectual contributions to the accelerator and detector design are still necessary to enable a site-specific bid proposal, which would take advantage of unique U.S. accelerator physics expertise such as positron source design, beam delivery, superconducting RF, and the accelerator-detector interface. Particle physics groups in the U.S. also led the design of one of the two ILC detector concepts.

Unique ILC Precision Measurements

ILC Z' mass reach



Understanding Z'



- Precision studies of all known Standard Model particles
  - Top quark mass measurement to ~10 MeV
  - Is our universe stable?
- Sensitivity to new particles, like Z', with masses well above energy of the lepton collider