GDE - ILC

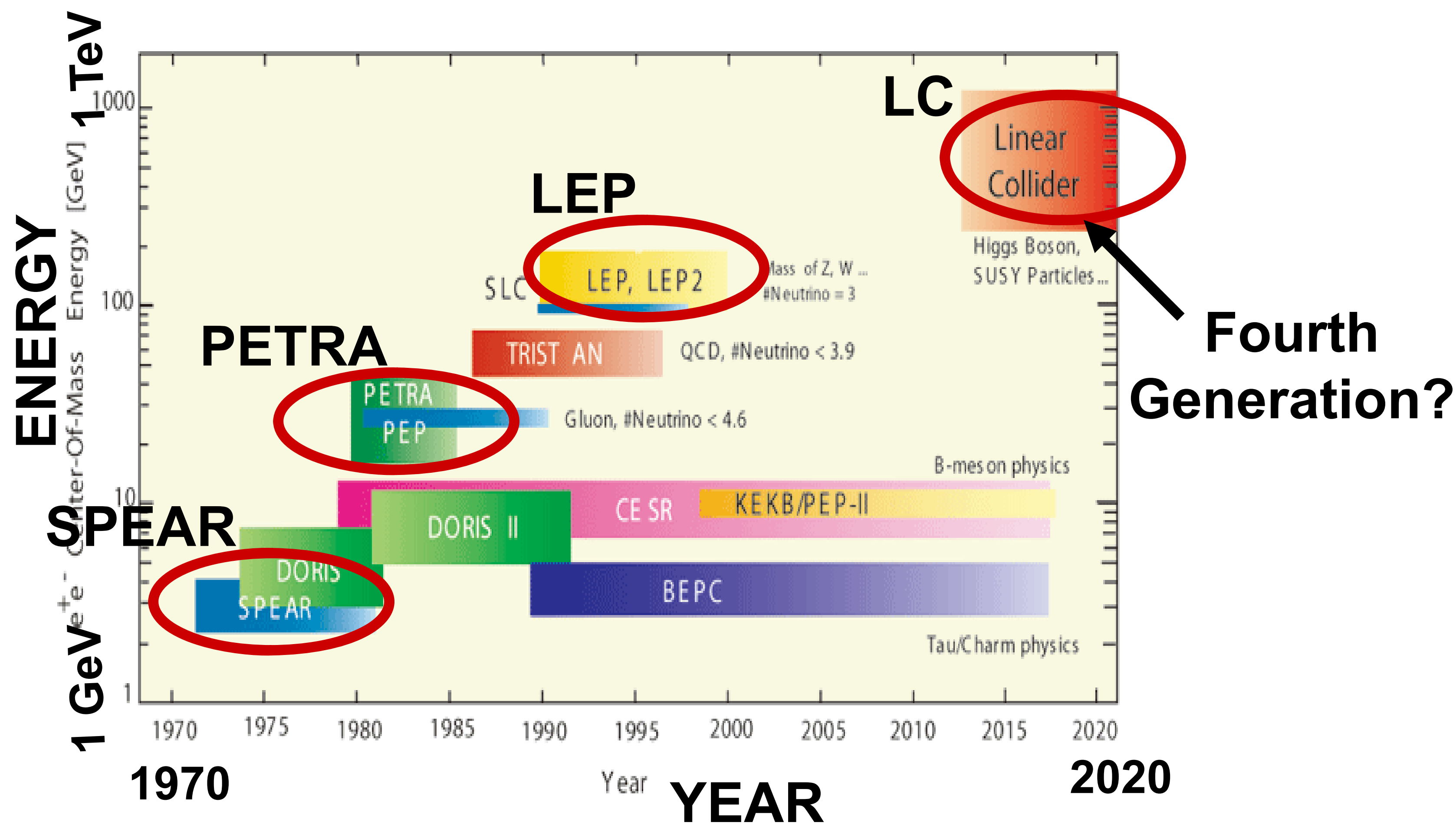
Barry Barish

P5 Meeting - Fermilab

1-Feb-08

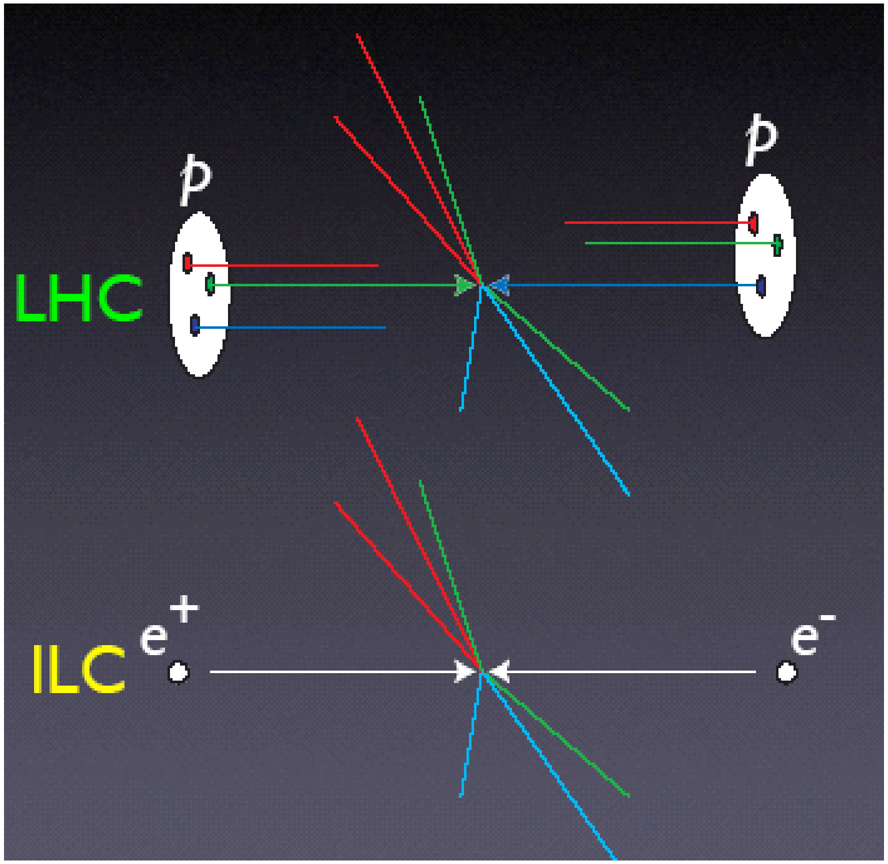
Three Generations of Lepton Colliders

The Energy Frontier



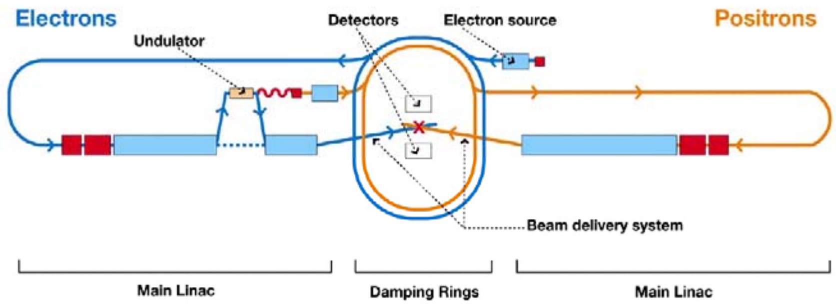
Why a Lepton Collider?

- **elementary particles**
- **well-defined**
  - energy,
  - angular momentum
- **uses full COM energy**
- **produces particles democratically**
- **can mostly fully reconstruct events**

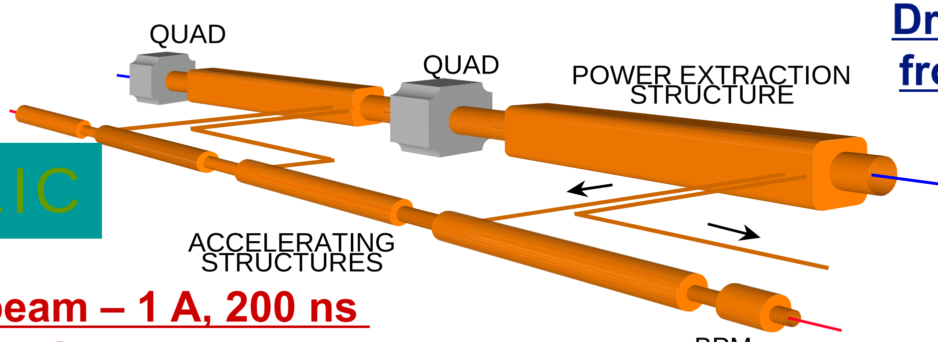


Possible TeV Scale Lepton Colliders

ILC



ILC < 1 TeV
Technically possible
~ 2019



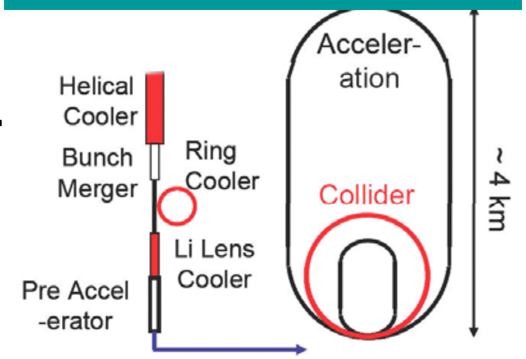
CLIC

Drive beam - 95 A, 300 ns
from 2.4 GeV to 240 MeV

Main beam – 1 A, 200 ns
from 9 GeV to 1.5 TeV

CLIC < 3 TeV
Feasibility?
ILC + 5-10 yrs

Muon Collider



Much R&D Needed
- **Neutrino Factory R&D +**
- **bunch merging**
- **much more cooling**
- **etc**

Muon Collider
< 4 TeV
FEASIBILITY??
ILC + 15 yrs?

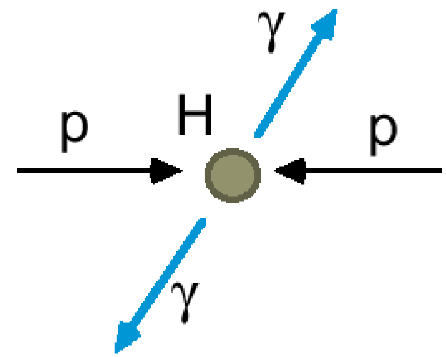
Strategies
TeV Scale Lepton Collider

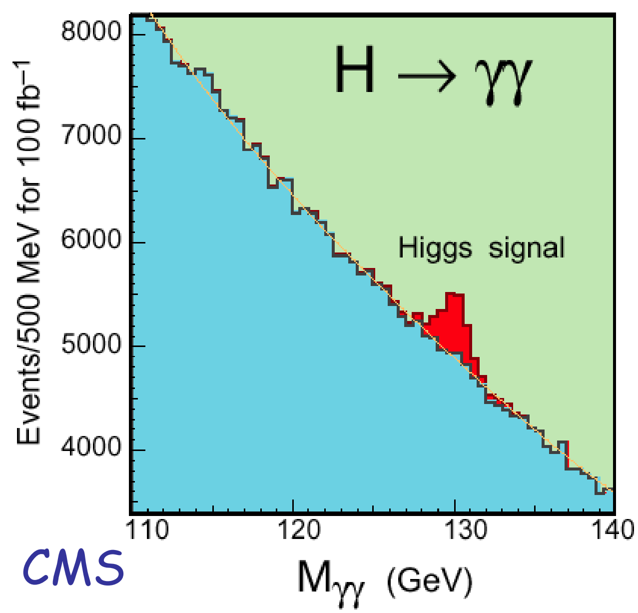
- Assuming LHC reveals the new physics we all anticipate,
  - **We will want complementary lepton collider for precision measurements**

- Time scales dictate vigorously investing toward that goal now
  - **If LHC physics justifies a < 1 TeV machine, ILC can be ready to become construction project as the next big HEP machine (GDE)**
  - **If LHC physics demands a > 1 TeV machine, CLIC may be the answer with a longer time scale, depending on "feasibility" (Tor)**
  - **The alternative muon collider is also a long term possibility, if "FEASIBLE" (Neutrino Sessions)**

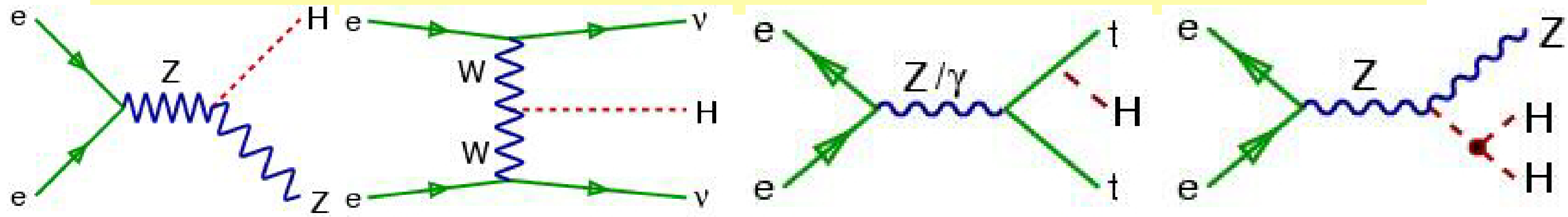
LHC: Low mass Higgs: $H \to \gamma\gamma$
$M_H < 150\ GeV/c^2$

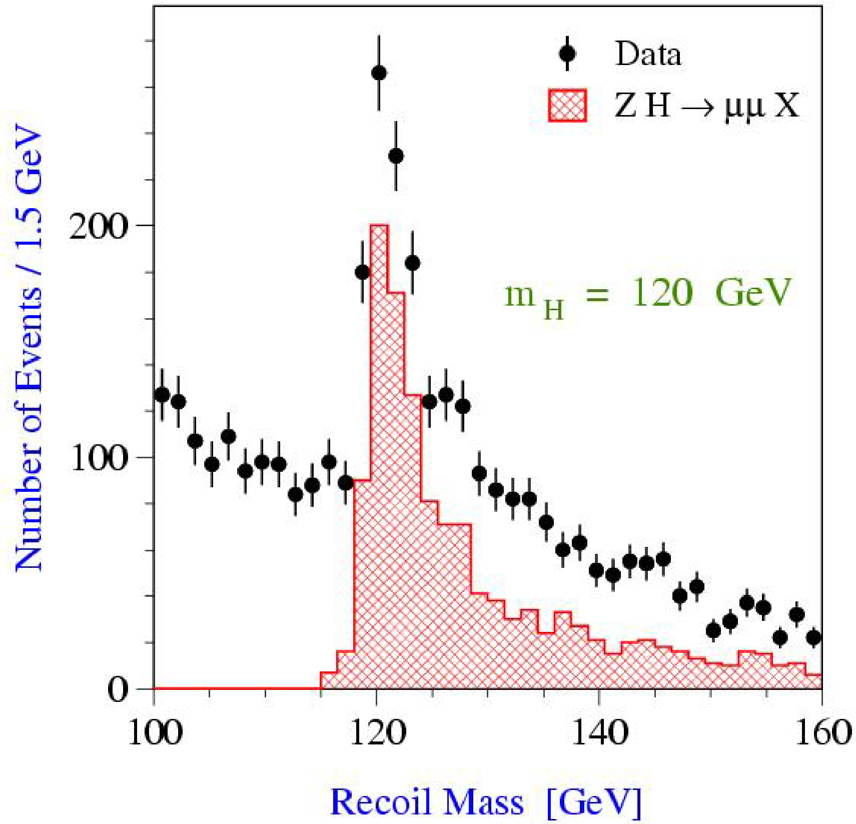
- Rare decay channel: BR ~ 10^{-3}
- Requires excellent electromagnetic calorimeter performance
  - acceptance, energy and angle resolution,
  - γ/jet and γ/π^0 separation
  - Motivation for LAr/$PbWO_4$ calorimeters for CMS
- Resolution at 100 GeV: $\sigma \approx 1$ GeV
- Background large: S/B ≈ 1:20, but can estimate from non signal areas





ILC: Precision Higgs physics

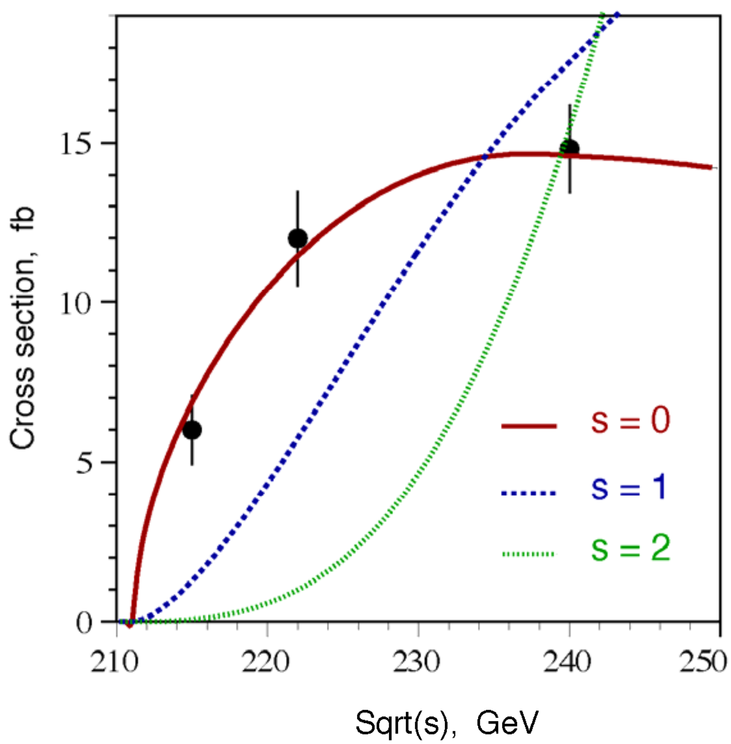




Garcia-Abia et al

- **Model-independent Studies**
  - **mass**
  - **absolute branching ratios**
  - **total width**
  - **spin**
  - **top Yukawa coupling**
  - **self coupling**
- **Precision Measurements**

How do you know you have discovered the Higgs ?

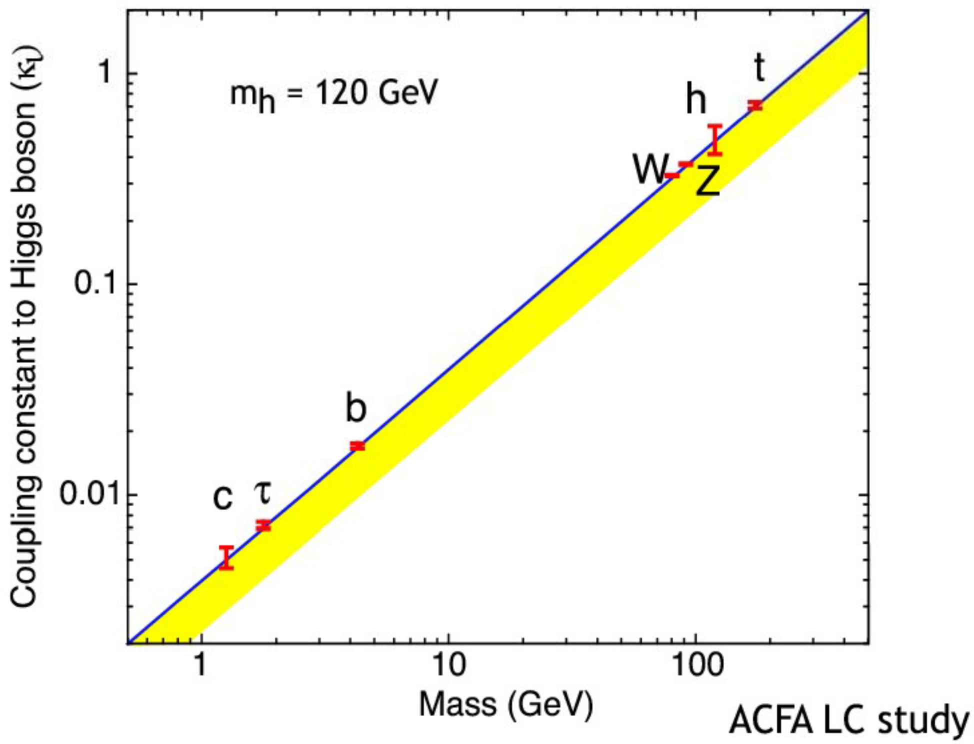


Measure the quantum numbers. The Higgs must have spin zero !

The linear collider will measure the spin of any Higgs it can produce by measuring the energy dependence from threshold

What can we learn from the Higgs?

Precision measurements of Higgs coupling



Higgs Coupling strength is proportional to Mass

Impacts – US / UK Funding

- **UK ILC R&D Program**
  - About 40 FTEs. Leadership roles in Damping Rings and Positron Source, as well as in the Beam Delivery System and Beam Dumps.
  - All of this program is generic accelerator R&D, some of which may be continued outside the specific ILC project.

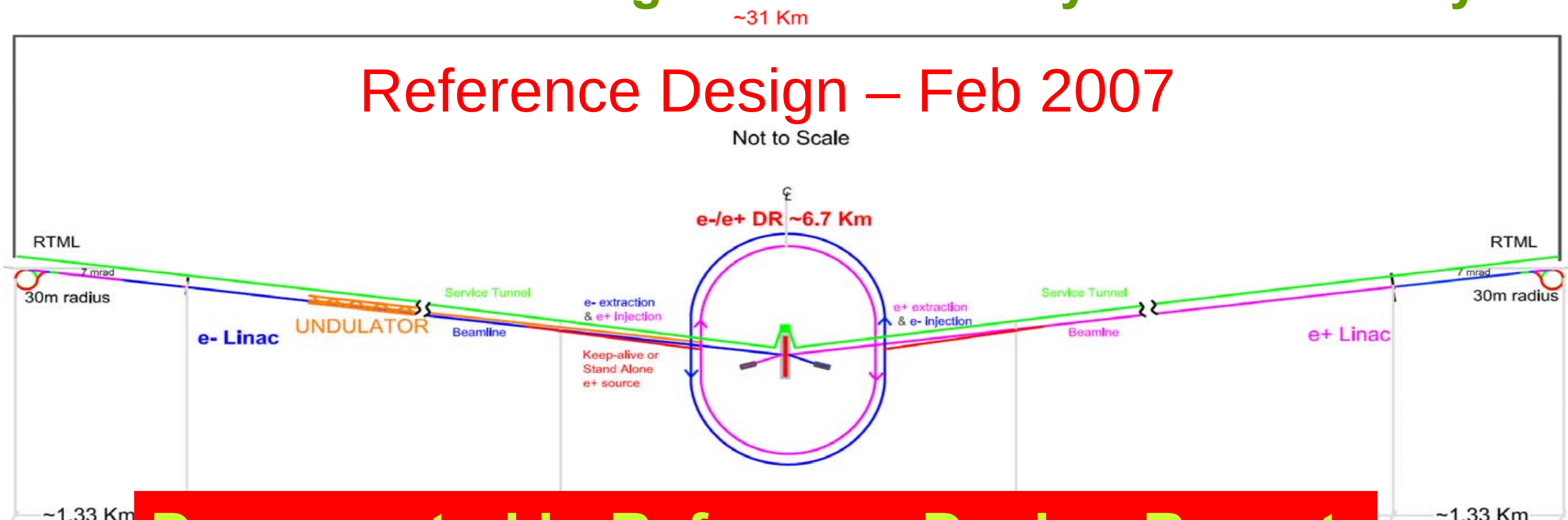
- **US Program**
  - ILC R&D is basically terminated for FY08, but we are planning for a reduced level restored program in FY09.   Presently a broad based program. Future??
  - Generic SCRF also terminated in FY08, but is expected to be revived in FY09, separated from ILC R&D. Primary focus builds US SCRF capability

How should we respond?

- **Original charge of the GDE (from ILCSC, ICFA and FALC) was to develop a "global" design. We have succeeded!**
  - Established a baseline for the ILC (0.5 years) This required ~40 critical decisions to agree globally on the key features of a linear collider
  - Developed a reference design, including international reviews of design, R&D program and costs (1.5 years)
- We have reached the original goals !!
- **We are at a crossroads. Best strategy for future efforts toward a linear collider?**

ILC Reference Design

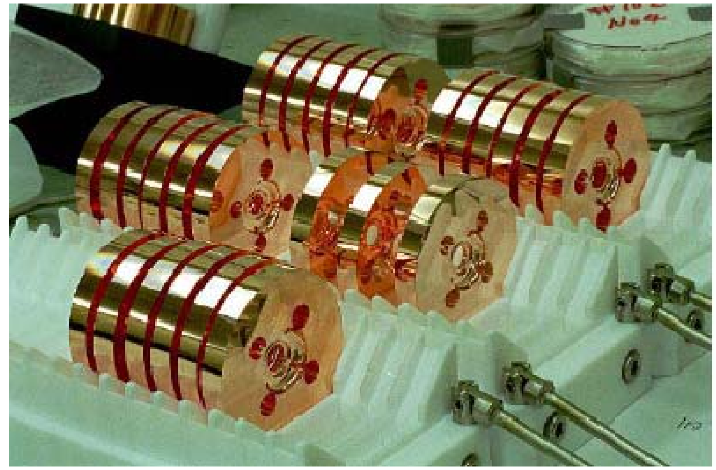
- 11km SC linacs operating at 31.5 MV/m for 500 GeV
- Centralized injector
  - Circular damping rings for electrons and positrons
  - Undulator-based positron source
- Single IR with 14 mrad crossing angle
- Dual tunnel configuration for safety and availability



Documented in Reference Design Report

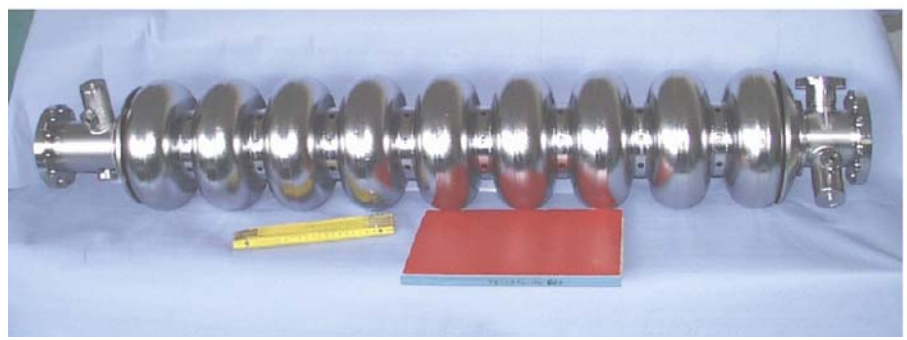
ILC – Underlying Technology

- Room temperature copper structures



OR

- Superconducting RF cavities



Parameters for the ILC

- E_{cm} adjustable from 200 – 500 GeV
- Luminosity → $\int L dt$ = 500 fb^{-1} in 4 years
- Ability to scan between 200 and 500 GeV
- Energy stability and precision below 0.1%
- Electron polarization of at least 80%

- **Machine must be upgradeable to 1 TeV**

RDR Design Parameters

Max. Center-of-mass energy	500	GeV
Peak Luminosity	~$2x10^{34}$	$1/cm^2s$
Beam Current	9.0	mA
Repetition rate	5	Hz
Average accelerating gradient	31.5	MV/m
Beam pulse length	0.95	ms
Total Site Length	31	km
Total AC Power Consumption	~230	MW

RDR Design & “Value” Costs

The reference design was “frozen” as of 1-Dec-06 for the purpose of producing the RDR, including costs.

It is important to recognize this is a snapshot and the design will continue to evolve, due to results of the R&D, accelerator studies and value engineering

The value costs have already been reviewed twice

- 3 day “internal review” in Dec
- ILCSC MAC review in Jan

Σ Value = 6.62 B ILC Units

Summary
RDR “Value” Costs

Total Value Cost (FY07)

4.80 B ILC Units Shared

+

1.82 B Units Site Specific

+

14.1 K person-years

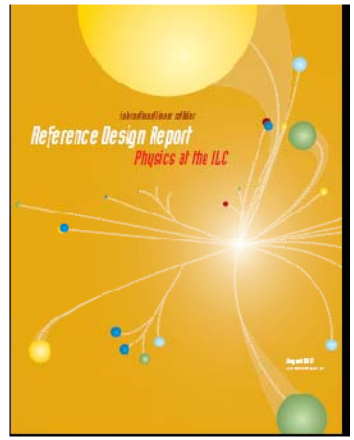
(“explicit” labor = 24.0 M person-hrs @ 1,700 hrs/yr)

1 ILC Unit = $ 1 (2007)

RDR Reports

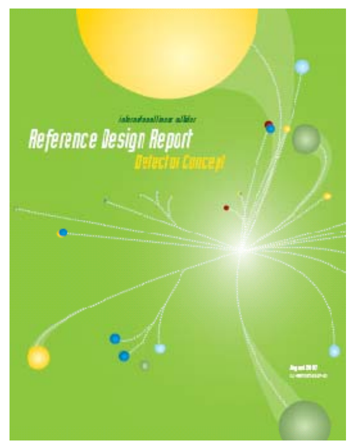
- **Reference Design Report (4 volumes)**

Executive Summary



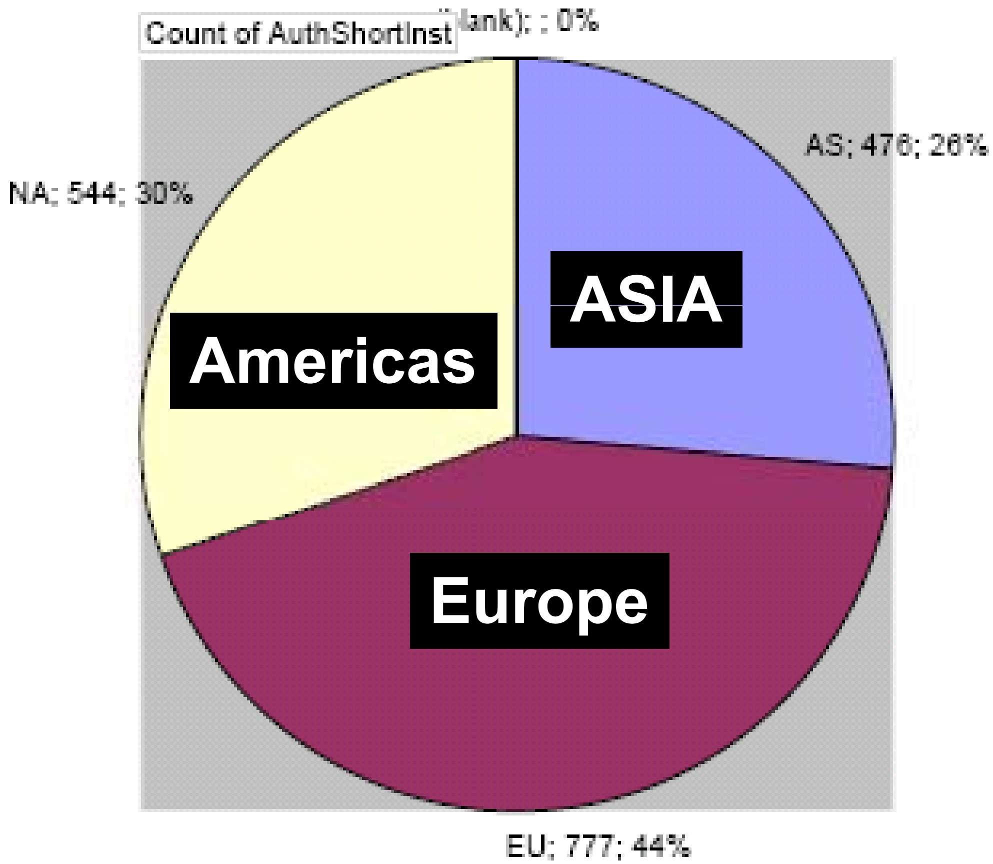
Physics at the ILC

Accelerator



Detectors

RDR Author List



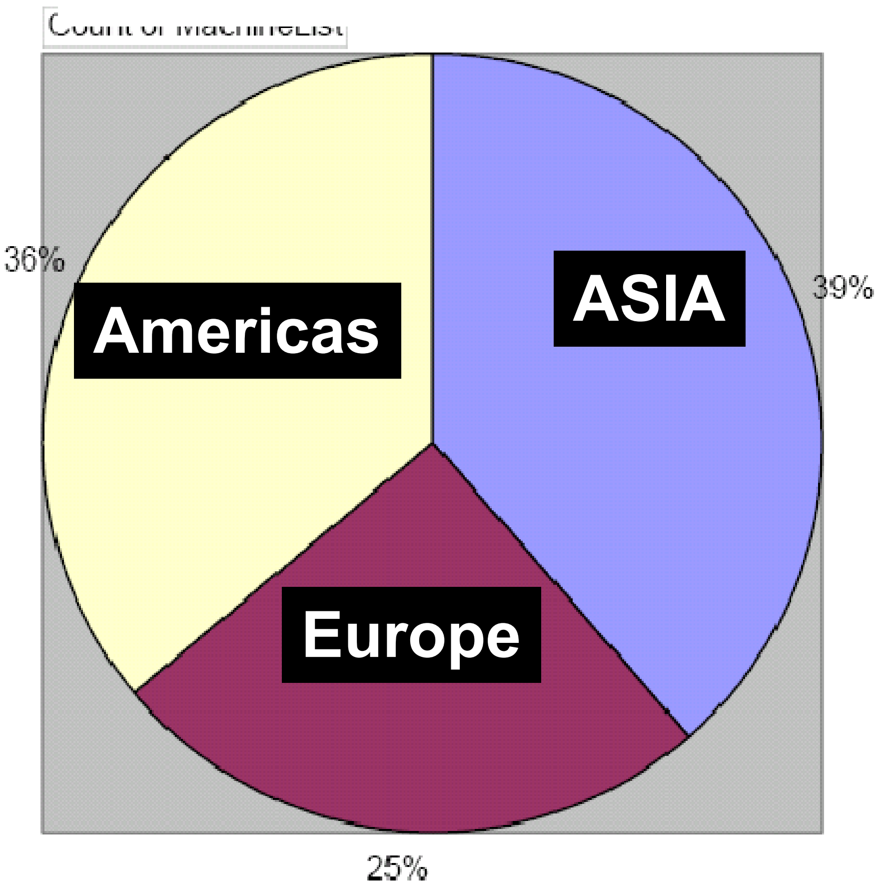
- Asia 476
- Americas 544
- Europe 777

- TOTAL 1797

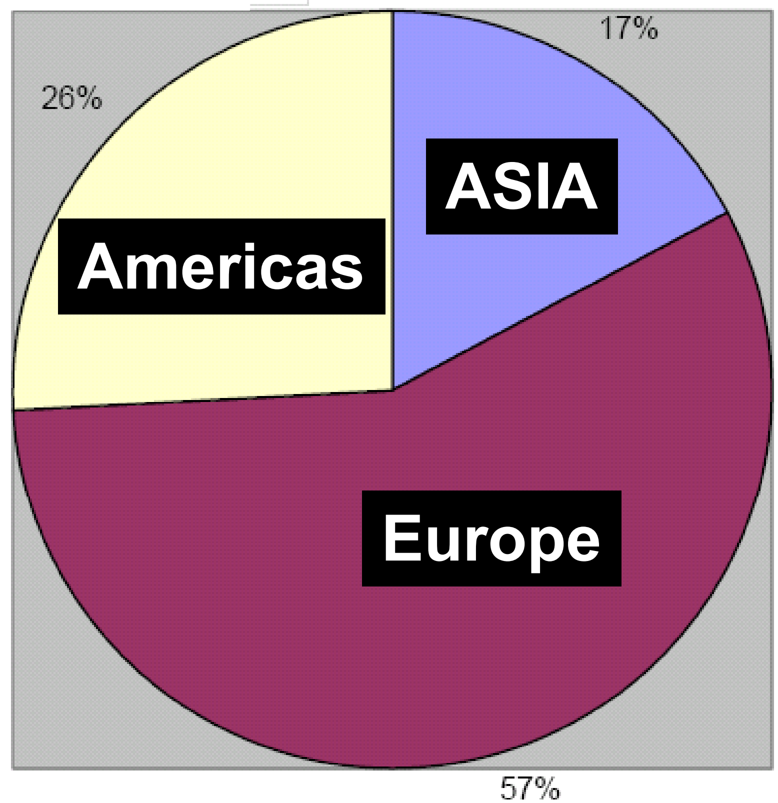
Ties Behnke

RDR Author List

Accelerator



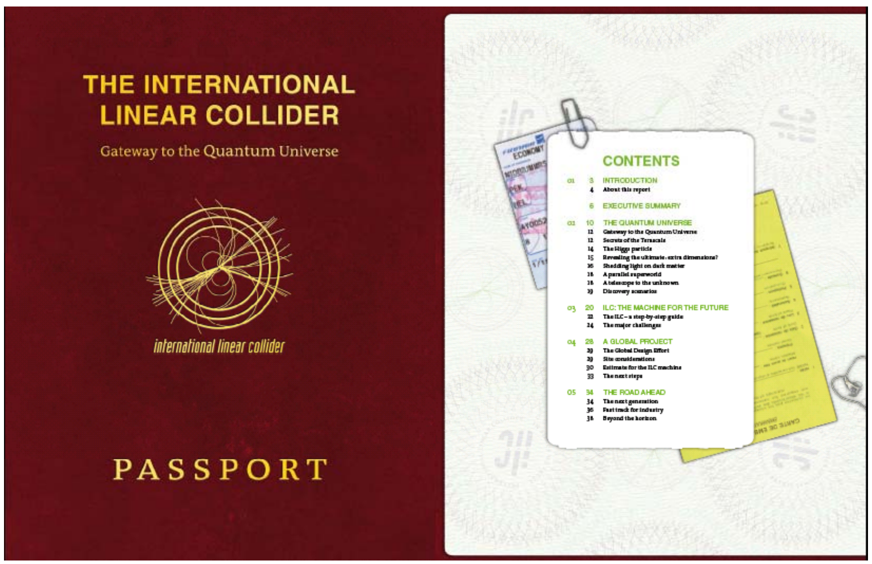
Detector

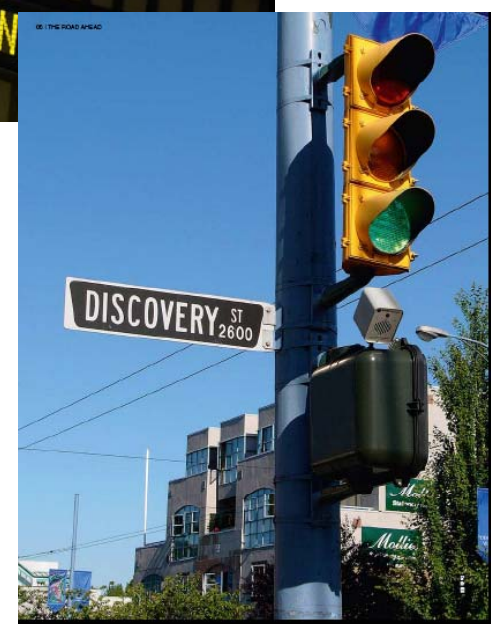


Ties Behnke

Gateway to Quantum Universe

Last piece: Companion Document for broad circulation, including translations to eight languages over the coming year.





http://www.linearcollider.org/gateway/

What's next and why?

- **THE SCIENCE !!!**
  - **Nothing has changed.** A linear collider remains the consensus choice as the highest priority long term investment for particle physics
- **The Technology**
  - **Key technical, design & cost issues must be resolved before a serious project can be proposed**
- **Strong Global encouragement**
  - Strong response urging us to forge ahead and find ways to help or replace US and UK efforts.
  - Global commitment to the Common Fund (Spain)
  - Offers - visiting appointments, equipment help, travel, etc

The Elements of a New Plan

- ILC R&D program must be more focused and strictly prioritized to achieve critical R&D, so project can be proposed, once LHC results justify.
- Build a close collaboration with XFEL. It will provide all SCRF development, except high gradient and ILC scale mass production, including a full systems test in 2013, industrialization, etc.
- Undertake steps to integrate linear collider (ILC and CLIC) R&D efforts, where beneficial to both efforts (meeting on 8-Feb). Examples – sources, damping rings, beam delivery, conventional facilities, detectors, maybe X Band RF R&D (Tor), etc.
- Develop analysis of siting considerations (GDE) and process for siting <u>after</u> 2010 (ILCSC/GDE)

TDP I -- 2010

- **Technical risk reduction**:
  - **Gradient**
    - Results based on re-processed cavities
    - Reduced number 540 → 390 (reduced US program)
  - **Electron Cloud (CesrTA)**
- **Cost risks (reductions) – Main Cost Drivers**
  - **Conventional Facilities (water, etc)**
  - **Main Linac Technology**
- **Technical progress (global design)**
  - **Cryomodule baseline design is a being developed (e.g. plug compatible parts)**

TDP II - 2012

- RF unit test – 3 CM + beam (KEK)
- Complete the technical design and R&D needed for project proposal (exceptions*)
  - Documented design
  - Complete and reliable cost roll up
- Project plan developed by consensus
  - Cryomodule Global Manufacturing Scenario
  - Siting Plan or Process

TDP II 2012
what won't be done?

- **Detailed Engineering Design (final engineering, drawings, industry, etc) will follow before construction.**
- **Global CM industrial plant construction**
- **Some other unresolved issues**
  - **Positron Source ???**
  - **Damping Ring Design work?**

Conclusions

- Central coordination by the GDE is even more essential, if we want to prepare to propose a construction project
- The will is there!
- A plan to recover from UK and US actions appears possible with reduced goals, strict prioritization and stretched out timescale
- A two stage ILC Technical Design Phase (TDP I 2010 and TDP II 2012 is proposed)
- We must have strong support of FALC, P5, ILCSC and ICFA to continue with this plan