ITRP

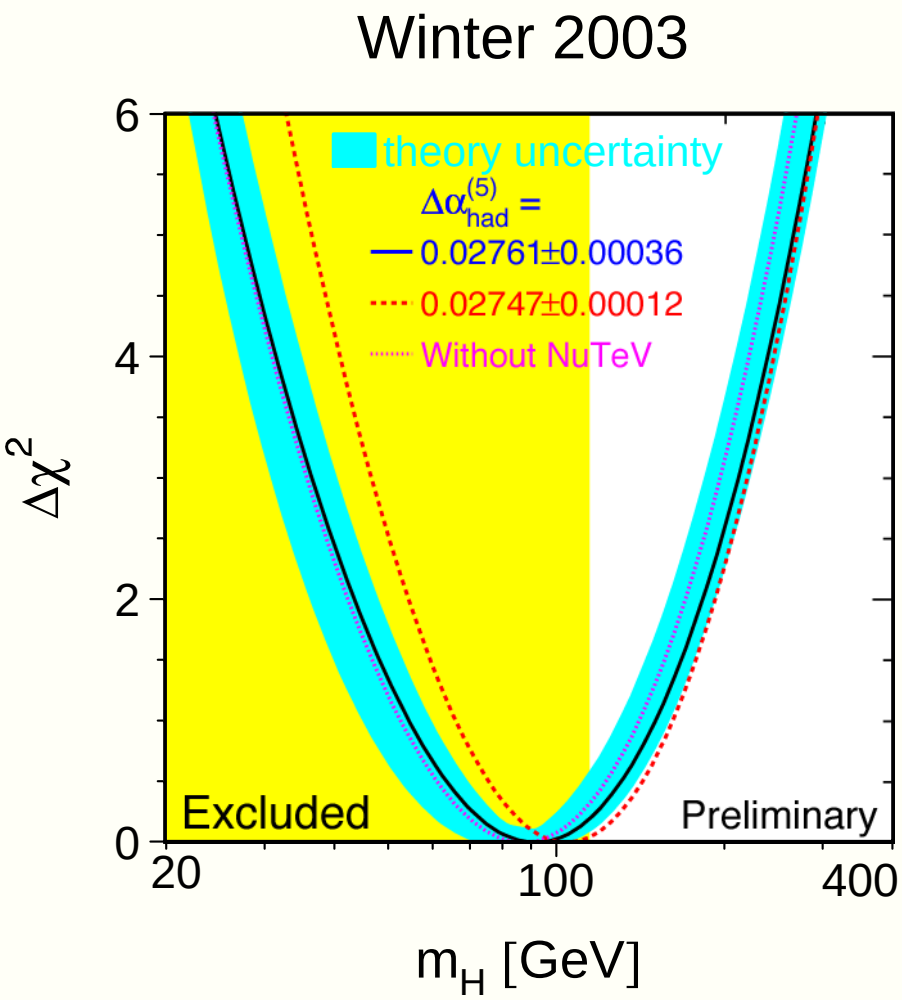
Linear Collider Technology Recommendation

Barry Barish
APS DPF Meeting
UC Riverside
30-Aug-04

Why ITRP?

- **Two parallel developments over the past few years (the science & the technology)**
  - **The precision information from LEP and other data have pointed to a low mass Higgs; Understanding electroweak symmetry breaking, whether supersymmetry or an alternative, will require precision measurements.**
  - **There are strong arguments for the complementarity between a ~0.5-1.0 TeV LC and the LHC science.**
  - **Designs and technology demonstrations have matured on two technical approaches for an e^+e^- collider that are well matched to our present understanding of the physics. (We note that a C-band option could have been adequate for a 500 GeV machine, if NLC/GLC and TESLA were not deemed mature designs).**

Electroweak Precision Measurements



LEP results strongly point to a low mass Higgs and an energy scale for new physics < 1TeV

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LHC/LC Complementarity

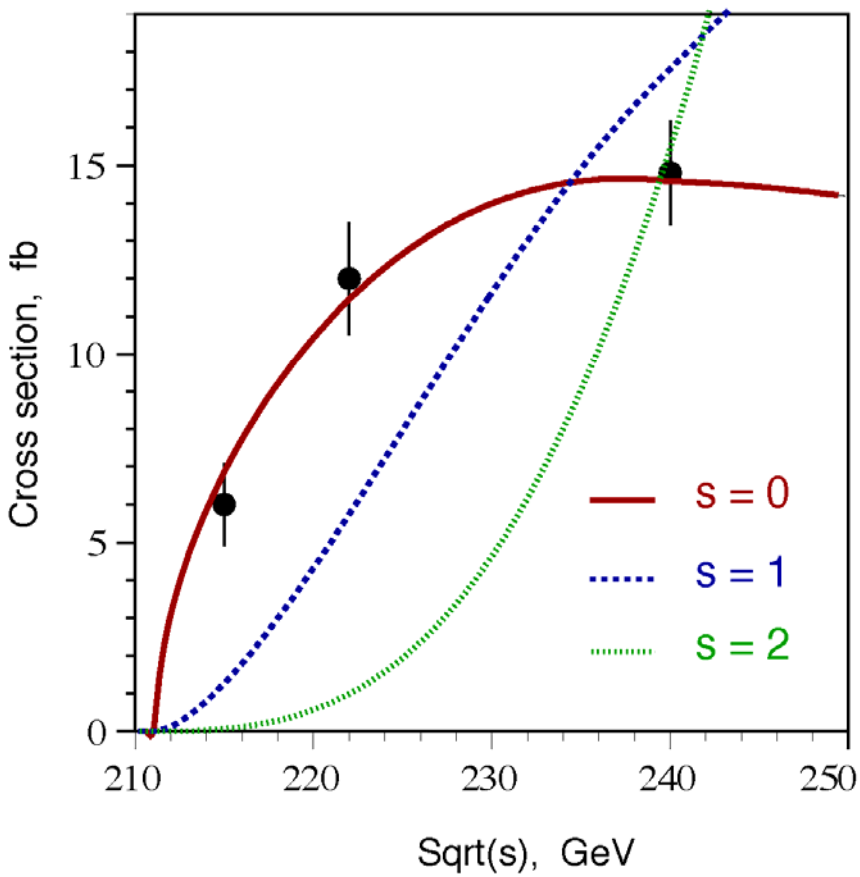
The 500 GeV Linear Collider Spin Measurement

LHC should discover the Higgs

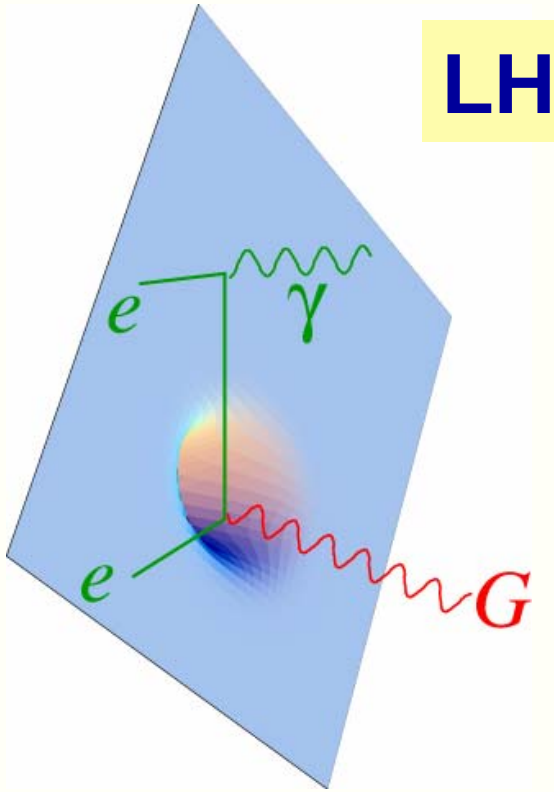
The linear collider will measure the spin of any Higgs it can produce.

The process $e^+e^- \rightarrow HZ$ can be used to measure the spin of a 120 GeV Higgs particle. The error bars are based on 20 fb^{-1} of luminosity at each point.

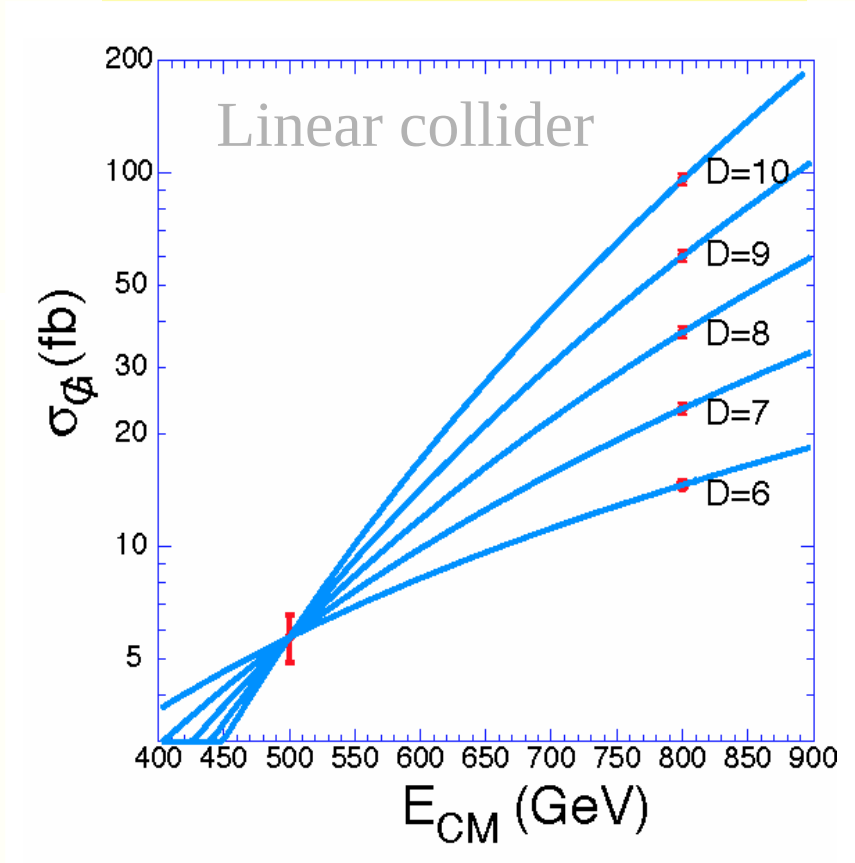
The Higgs must have spin zero



LHC/LC Complementarity



Extra Dimensions



New space-time dimensions can be mapped by studying the emission of gravitons into the extra dimensions, together with a photon or jets emitted into the normal dimensions.

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What has the Accelerator R&D Produced?

INTERNATIONAL LINEAR COLLIDER

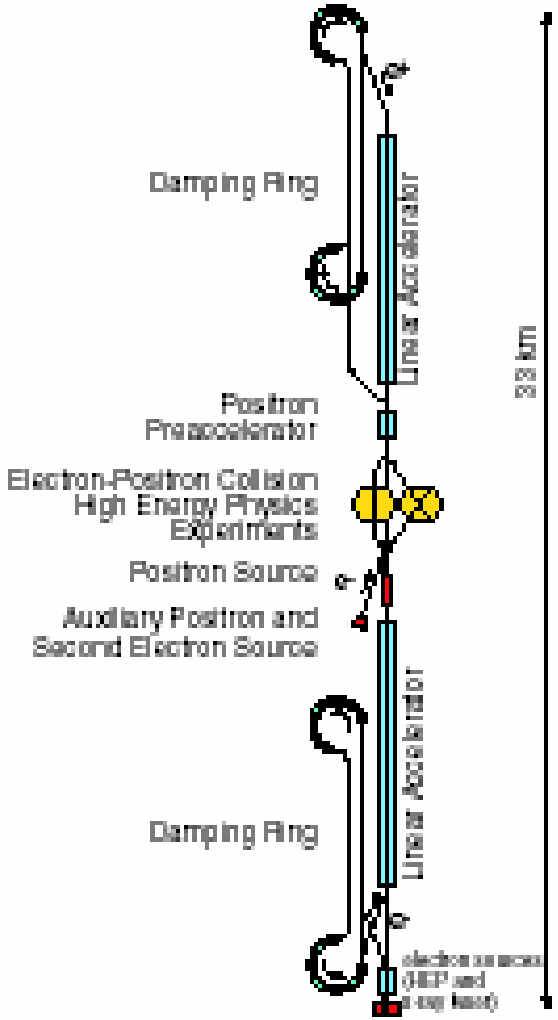
TECHNICAL REVIEW COMMITTEE

SECOND REPORT

2003

The Report Validates the Readiness of L-band and X-band Concepts

TESLA L-band Linear Collider



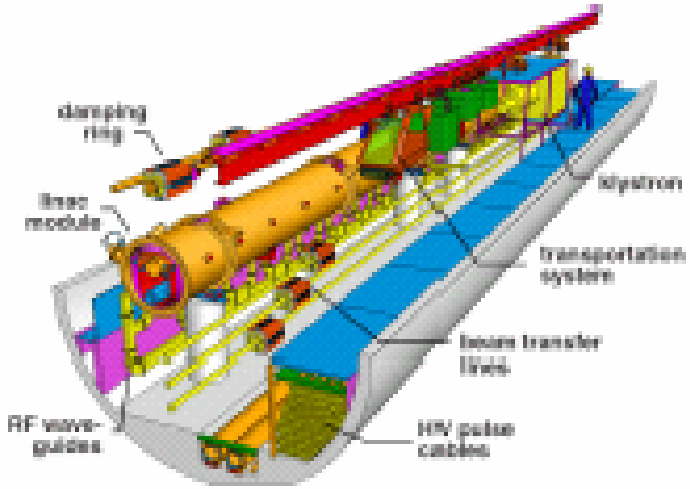
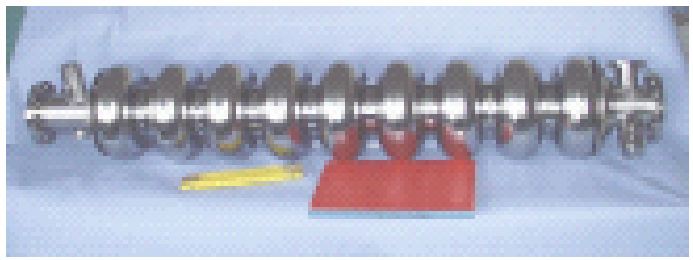
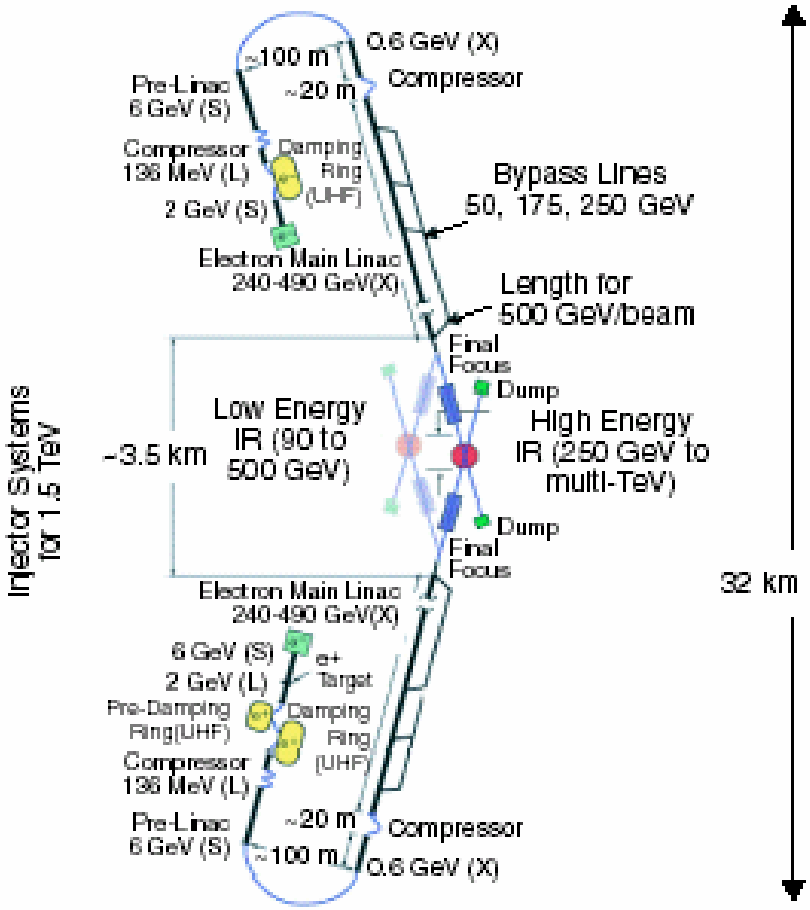


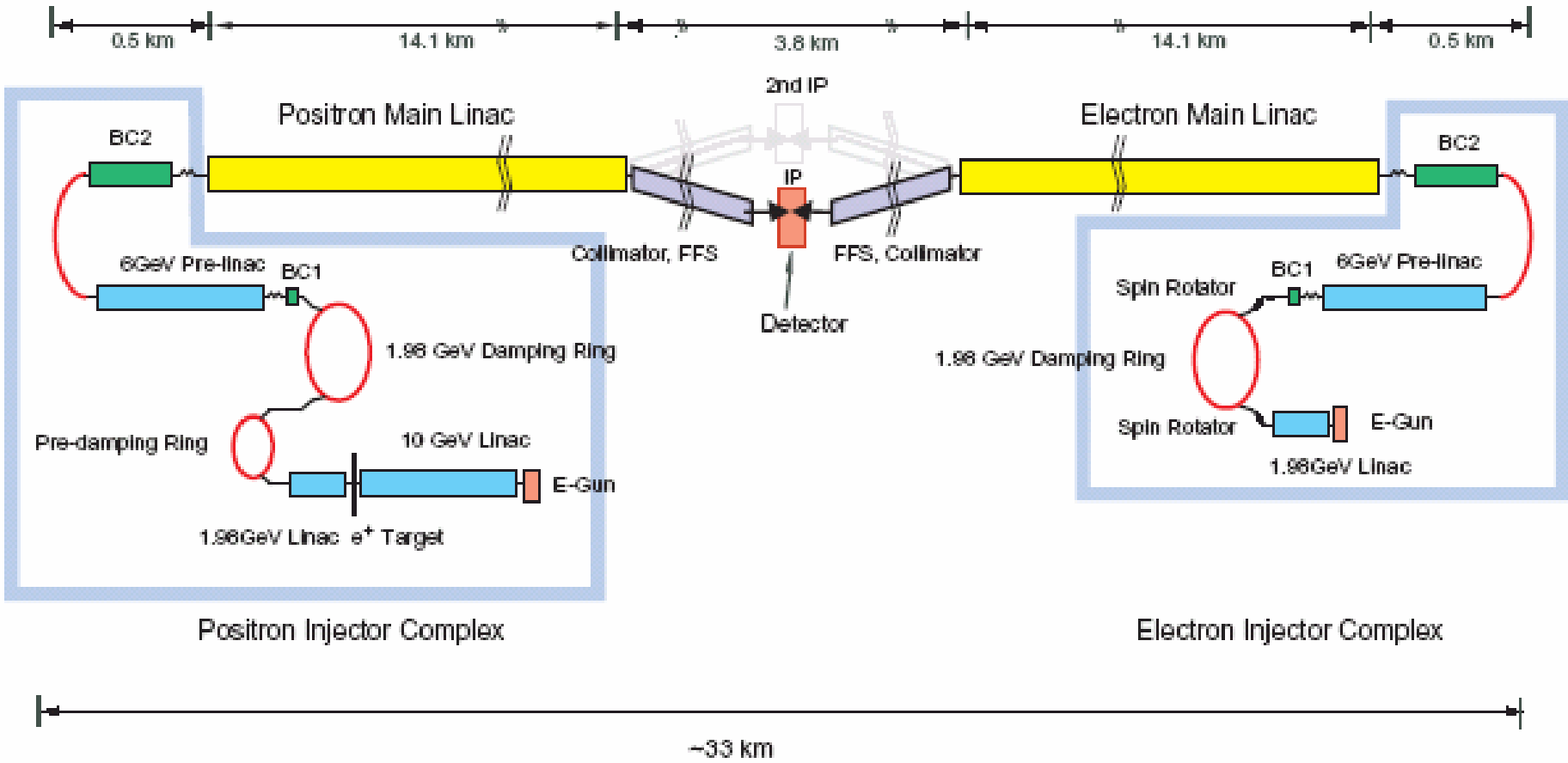
FIGURE 2. Sketch of the 5 m diameter TESLA linac tunnel



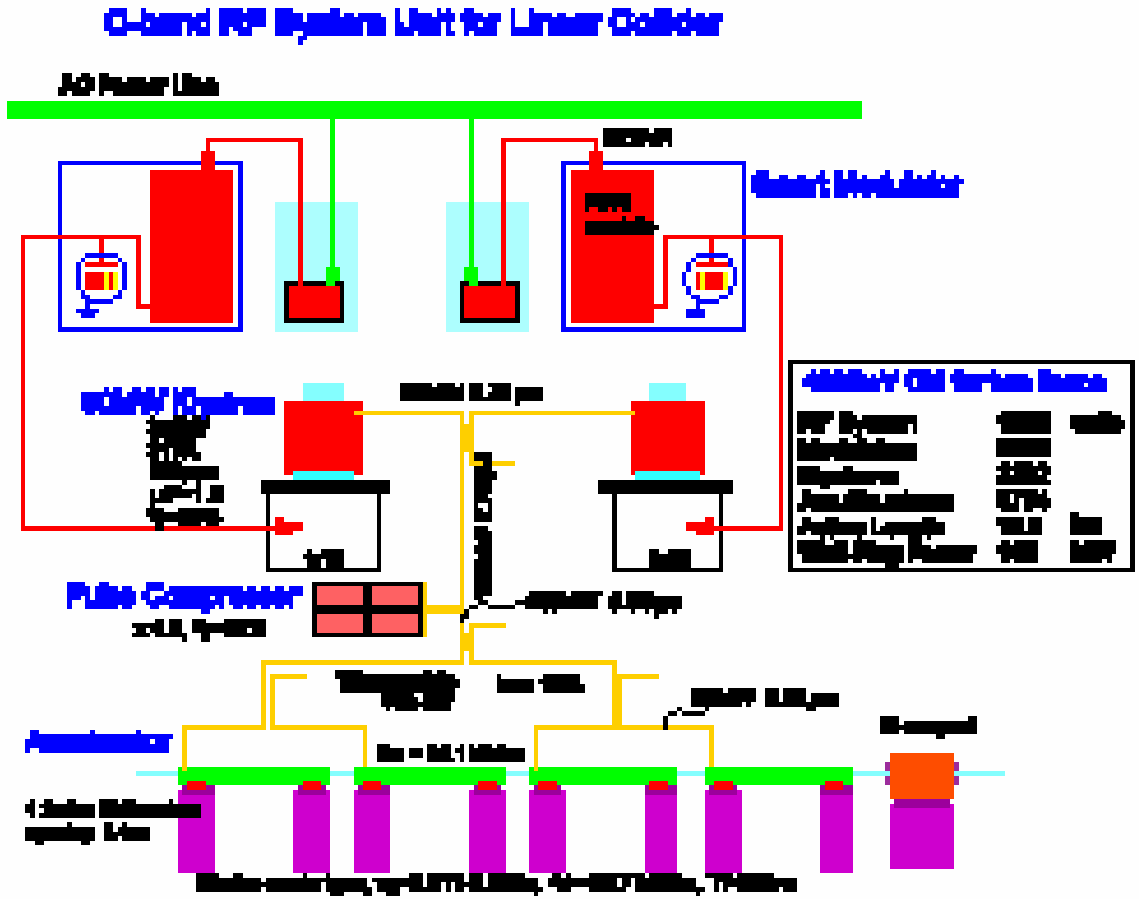
SLAC X-Band NLC



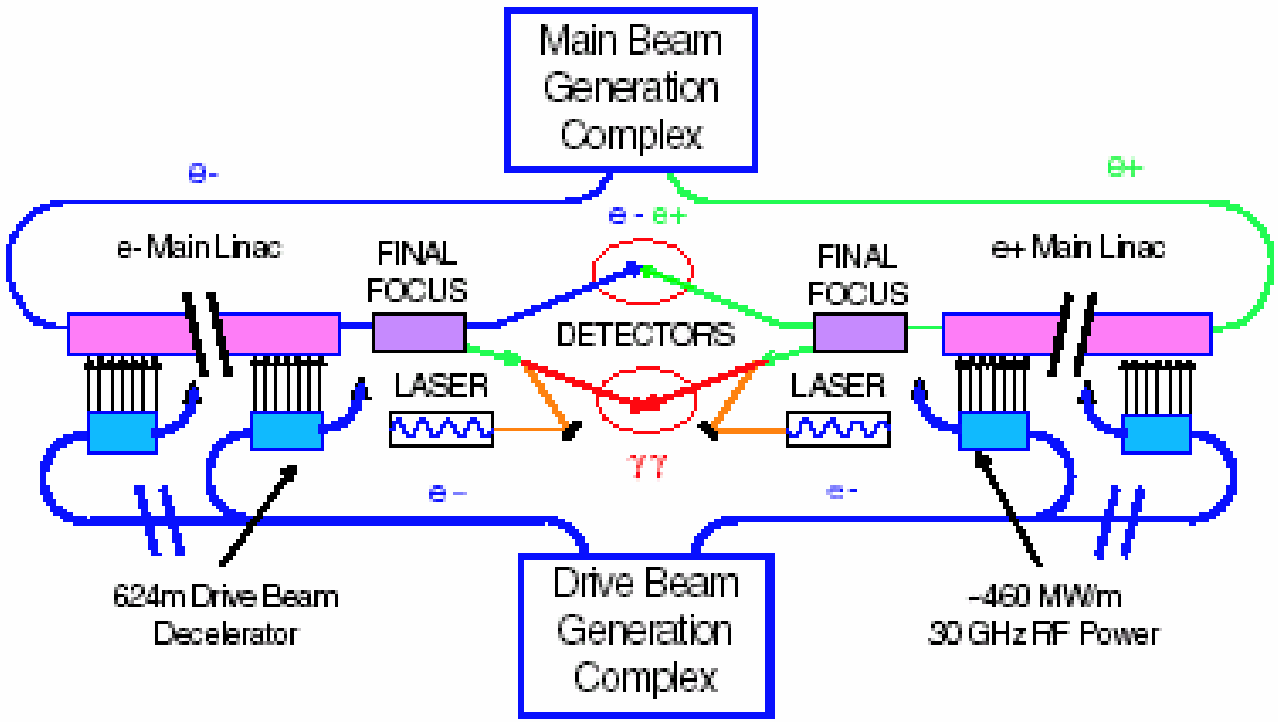
KEK X-Band GLC



C-Band JLC


C-band RF System Unit for Linear Collider
AC Power Line
Klystron
Klystron Modulator
Pulse Compressor
Accelerator

CLIC


Main Beam
Generation
Complex
e-
e+
e - e+
e- Main Linac
FINAL
FOCUS
DETECTORS
FINAL
FOCUS
e+ Main Linac
LASER
LASER
γγ
e –
e-
624m Drive Beam
Decelerator
Drive Beam
Generation
Complex
~460 MW/m
30 GHz RF Power

Why Decide Technology Now?

- **We have an embarrassment of riches !!!!**
  - **Two alternate designs -- “warm” and “cold” have come to the stage where the show stoppers have been eliminated and the concepts are well understood.**
  - **R & D is very expensive (especially D) and to move to the “next step” (being ready to construct such a machine within about 5 years) will require more money and a concentration of resources, organization and a worldwide effort.**
  - **It is too expensive and too wasteful to try to do this for both technologies.**
  - **A major step toward a decision to construct a new machine will be enabled by uniting behind one technology, followed by a making a final global design based on the recommended technology.**
  - **The final construction decision in ~5 years will be able to fully take into account early LHC and other physics developments.**

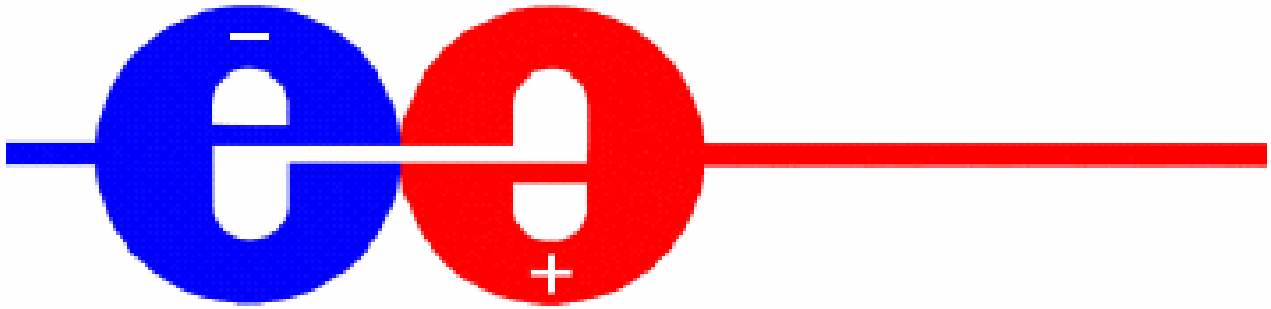
The Charge to the International Technology Recommendation Panel

General Considerations

The International Technology Recommendation Panel (the Panel) should recommend a Linear Collider (LC) technology to the International Linear Collider Steering Committee (ILCSC).

On the assumption that a linear collider construction commences before 2010 and given the assessment by the ITRC that both TESLA and JLC-X/NLC have rather mature conceptual designs, the choice should be between these two designs. If necessary, a solution incorporating C-band technology should be evaluated.

Note -- We have interpreted our charge as being to recommend a technology, rather than choose a design



Parameters for the Linear Collider

September 30, 2003

Preamble to the List of Parameters

Over the past decade, studies in Asia, Europe and North America have described the scientific case for a future electron-positron linear collider [1,2,3,4]. A world-wide consensus has formed for a baseline LC project with centre-of-mass energies up to 500 GeV and with luminosity above 10^{34} $cm^{-2}s^{-1}$ [5].

Beyond this firm baseline machine, several upgrades and options are envisaged whose weight, priority and realization will depend upon the results obtained at the LHC and the baseline LC.

This document, prepared by the Parameters Subcommittee of the International Linear Collider Steering Committee, provides a set of parameters for the future Linear Collider and the corresponding values needed to achieve the anticipated physics program.

The ITRP Members

Jean-Eudes Augustin (FRANCE)
Jonathan Bagger (USA)
Barry Barish (USA) - Chair
Giorgio Bellettini (ITALY)
Paul Grannis (USA)
Norbert Holtkamp (USA)
George Kalmus (UK)
Gyung-Su Lee (KOREA)
Akira Masaike (JAPAN)
Katsunobu Oide (JAPAN)
Volker Soergel (Germany)
Hirotaka Sugawara (JAPAN)

David Plane - Scientific Secretary

How ITRP has Approached its Task

- **Six Meetings scheduled**
  - **RAL (Jan 27,28 2004)** → **Tutorial and organization**
  - **DESY (April 5,6 2004)**
  - **SLAC (April 26,27 2004)** → **Site Visits**
  - **KEK (May 25,26 2004)**
  - **Caltech (June 28,29,30 2004)** → **Deliberations Began**
  - **Korea (August 11,12,13)**
  - **More meetings as needed**

Arriving in Korea

Deliberating in Korea

Departing from Korea

International Technology Recommendation Panel Meeting
August 11 ~ 13, 2004. Republic of Korea

Evaluating the Criteria Matrix

- **We analyzed the technology choice through studying a matrix having six general categories with specific items under each:**
  - **the scope and parameters specified by the ILCSC;**
  - **technical issues;**
  - **cost issues;**
  - **schedule issues;**
  - **physics operation issues;**
  - **and more general considerations that reflect the impact of the LC on science, technology and society**

- **We evaluated each of these categories with the help of answers to our "questions to the proponents," internal assignments and reviews, plus our own discussions**

Our Process

- We studied and evaluated a large amount of available materials
- We made site visits to DESY, KEK and SLAC to listen to presentations on the competing technologies and to see the test facilities first-hand.
- We have also heard presentations on both C-band and CLIC technologies
- We interacted with the community at LC workshops, individually and through various communications we received
- We developed a set of evaluation criteria (a matrix) and had each proponent answer a related set of questions to facilitate our evaluations.
- We assigned lots of internal homework to help guide our discussions and evaluations

The Recommendation

- **We recommend that the linear collider be based on superconducting rf technology (from Exec. Summary)**
  - **This recommendation is made with the understanding that we are recommending a technology, not a design. We expect the final design to be developed by a team drawn from the combined warm and cold linear collider communities, taking full advantage of the experience and expertise of both (from the Executive Summary).**
  - **Details of the assessment will be presented in the body of the ITRP report to be published around mid September**
  - **The superconducting technology has several very nice features for application to a linear collider. They follow in part from the low rf frequency.**

Some of the Features of SC Technology

- **The large cavity aperture and long bunch interval reduce the complexity of operations, reduce the sensitivity to ground motion, permit inter-bunch feedback and may enable increased beam current.**
- **The main linac rf systems, the single largest technical cost elements, are of comparatively lower risk.**
- **The construction of the superconducting XFEL free electron laser will provide prototypes and test many aspects of the linac.**
- **The industrialization of most major components of the linac is underway.**
- **The use of superconducting cavities significantly reduces power consumption.**

Remarks

- **CLIC, C-Band, GLC/NLC and TESLA researchers have done a fantastic job bringing these technologies to the point where we can move forward toward making a next generation linear collider a reality.**

- **We especially want to note the importance of the the work that has been done on the warm technology. We need to fully capitalize on the experience from SLC, FFTB, ATF and TTF as we move forward. The range of systems from sources to beam delivery in a LC is so broad that an optimized design can only emerge by pooling the expertise of all participants.**

The Next Steps

- **We endorse the effort now underway to establish an international model for the design, engineering, industrialization and construction of the linear collider. Formulating that model in consultation with governments is an immediate priority. Strong central management will be critical from the beginning.**

International Linear Collider (ILC)

- **On August 21st 2004, ICFA unanimously endorsed the ITRP's recommendation to adopt superconducting technology as the basis for the main linacs**
  - **The consortium has agreed to officially retire the names GLC, NLC and TESLA in favor of the International Linear Collider (ILC).**

- **ICFA envisages a compact structure, called the Global Design Effort (GDE), to coordinate the work of the consortium partners.**
  - **Most of the work of the GDE will go on at the laboratories, and most of the human and financial resources will be provided by those laboratories.**
  - **A process for selecting a Director for the GDE is now in place and a Director could be selected as early as the end of CY 2004.**

Getting Started

- **Establishing roles and responsibilities for the ILC design and R&D will be a process overseen by the Central Design Team.**
- **The guiding principle needs to be: "Make choices that facilitate and maximally advantage the best design, and assure the best chances of success with construction and operation of the ILC."**
- **As a first step, an ILC Workshop is being planned to be held at KEK in November.**
- **The efforts in the U.S will be optimized to fit with the best overall plan for ILC.**

The U.S. Effort on the ILC

- **Coordination of the distributed design effort is envisaged to proceed via three regional coordinators, who will be chosen by the regional steering committees in consultation with their respective funding agencies and the GDE Director.**
- **This is a major and exciting step forward taken by the international community to realize a TeV e+e- collider.**
- **Strong regional coordination is anticipated:**
  - **In North America, SLAC and FNAL are offering to act as co-coordinating centers for the regional effort.**

SLAC - Looking Forward

- **The SLAC linear collider team has embraced the ITRP process from the beginning, and is joining in the worldwide effort for R&D and design of the ILC.**

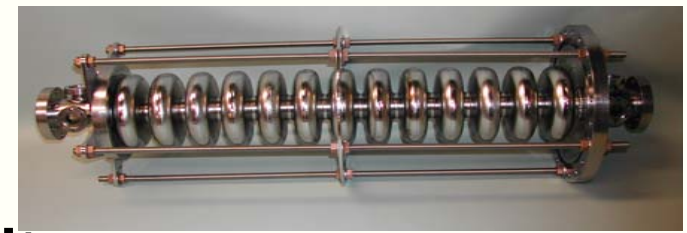
- **SLAC has been the center of the U.S. linear collider R&D effort. They bring critical skills, experience and insights essential to the U.S. effort to design the ILC.**

- **Much of the design and R&D carried out for the "warm" machine directly applies to the ILC "cold" technology design - including the Main Linac, and ranging from Beam Sources to the Interaction Region and Detector**

- **SLAC was committed to playing a leadership role for the NLC, and remains so for the ILC. They are already forming plans their technical roles in the ILC design effort**

Fermilab ILC Efforts to Date

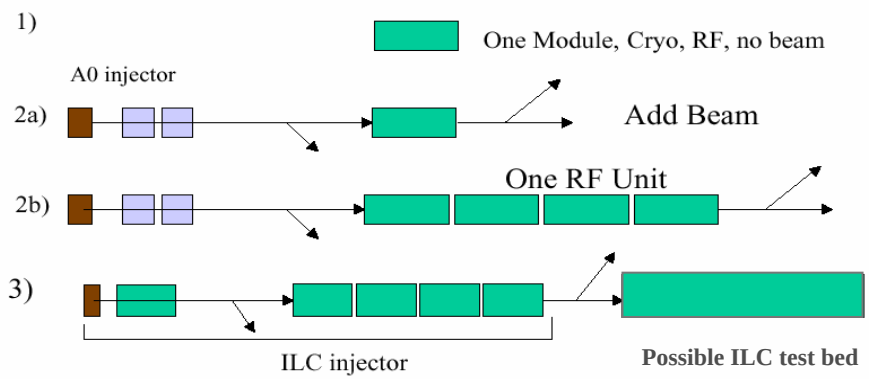
- **NLC**
  - **X-band structures fabrication**
    - **5 of the 8 structures at successful NLCTA test were built by Fermilab**
  - **Civil/siting studies**
- **SCRF**
  - **Operation of 15 MeV photoinjector (identical to TTF injector)**
  - **SCRF cavity development for FNPL and CKM (now defunct)**
- **Extremely talented scientific & engineering group in place with ability to work on warm or cold structures**



⇒ Bottom line: By redirecting X-band and focusing SCRF more strongly on ILC, Fermilab can effectively double resources in FY05.

Fermilab Plan

- **It is essential to establish U.S. capability in the fabrication of high gradient SRF structures.**
  - **Fermilab commitment to provide U.S. leadership following cold decision**
- **Focus has been on a test facility at Fermilab (aka SMTF—Superconducting Module Test Facility).**
  - **Interested partners: ANL, BNL, Cornell, FNAL, JLab, LANL, LBNL, MIT, MSU, ORNL, SLAC**
- **Concept of a possible evolution:**



2005-06

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Remarks and Next Steps

- **The linear collider will be designed to begin operation at 500 GeV, with a capability for an upgrade to about 1 TeV, as the physics requires. This capability is an essential feature of the design. Therefore we urge that part of the global R&D and design effort be focused on increasing the ultimate collider energy to the maximum extent feasible. (from ITRP Exec Summary)**

- **A TeV scale electron-positron linear collider is an essential part of a grand adventure that will provide new insights into the structure of space, time, matter and energy. We believe that the technology for achieving this goal is now in hand, and that the prospects for its success are extraordinarily bright. (from ITRP Exec Summary)**