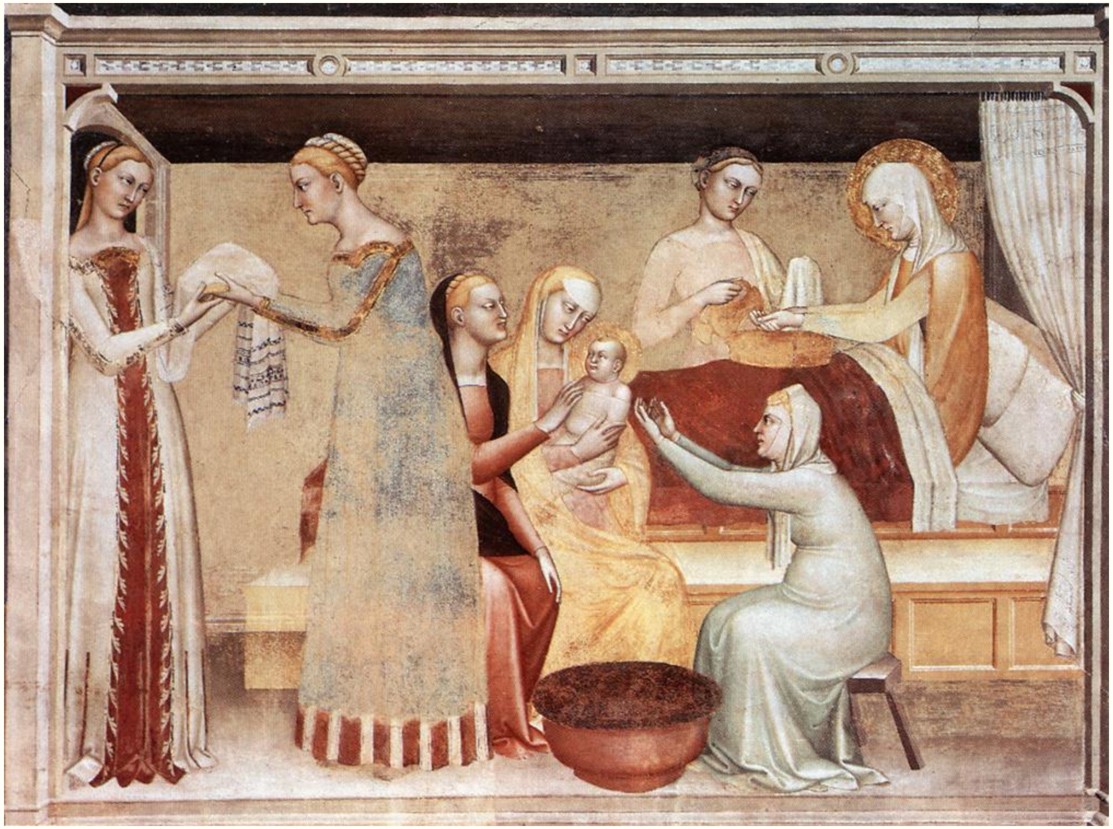
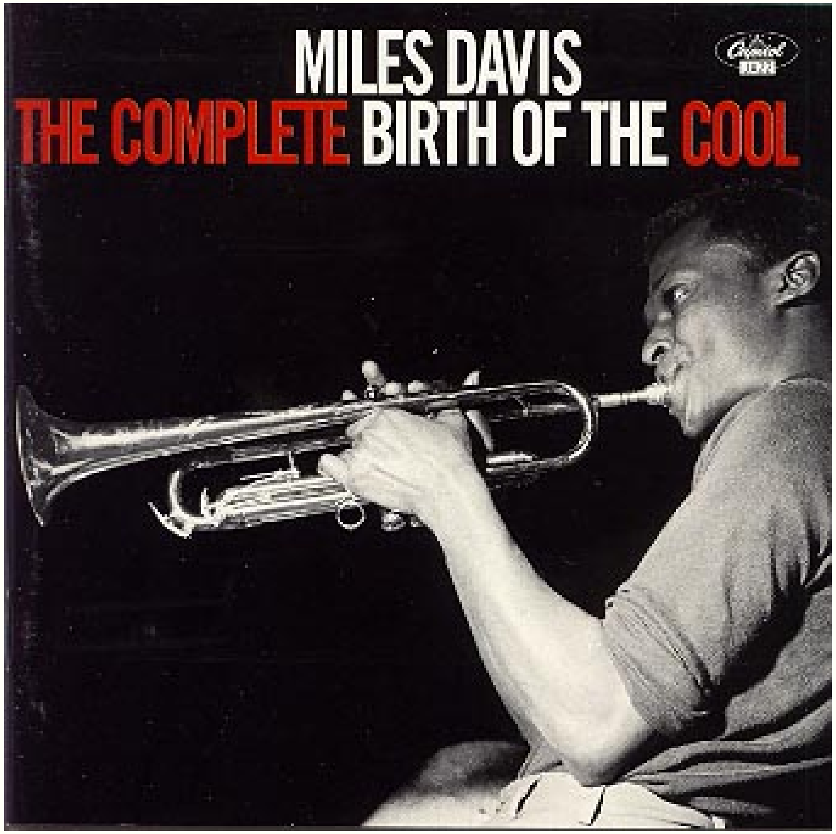
The Birth of the GDE



Barry Barish
TESLA Collab Mtg
31-March-05

The Birth of the GDE



Barry Barish
TESLA Collab Mtg
31-March-05

The Linear Collider

2001: The Snowmass Workshop participants produced the statement recommending construction of a Linear Collider to overlap LHC running.

2001: HEPAP, ECFA, ACFA all issued reports endorsing the LC as the next major world project, to be international from the start

2002: The Consultative Group on High-Energy Physics of the OECD Global Science Forum executive summary stated as the first of its Principal Conclusions:

"The Consultative Group concurs with the world-wide consensus of the scientific community that a high-energy electron-positron collider is the next facility on the Road Map.

"There should be a significant period of concurrent running of the LHC and the LC, requiring the LC to start operating before 2015. Given the long lead times for decision-making and for construction, consultations among interested countries should begin at a suitably-chosen time in the near future."

“Consensus Document”

April 2003: signed now by ~2700 physicists worldwide.:

Worldwide Study of
the Physics and Detectors
for Future Linear
$e^+ e^-$ Colliders

Understanding Matter, Energy, Space and Time:
The Case for the Linear Collider

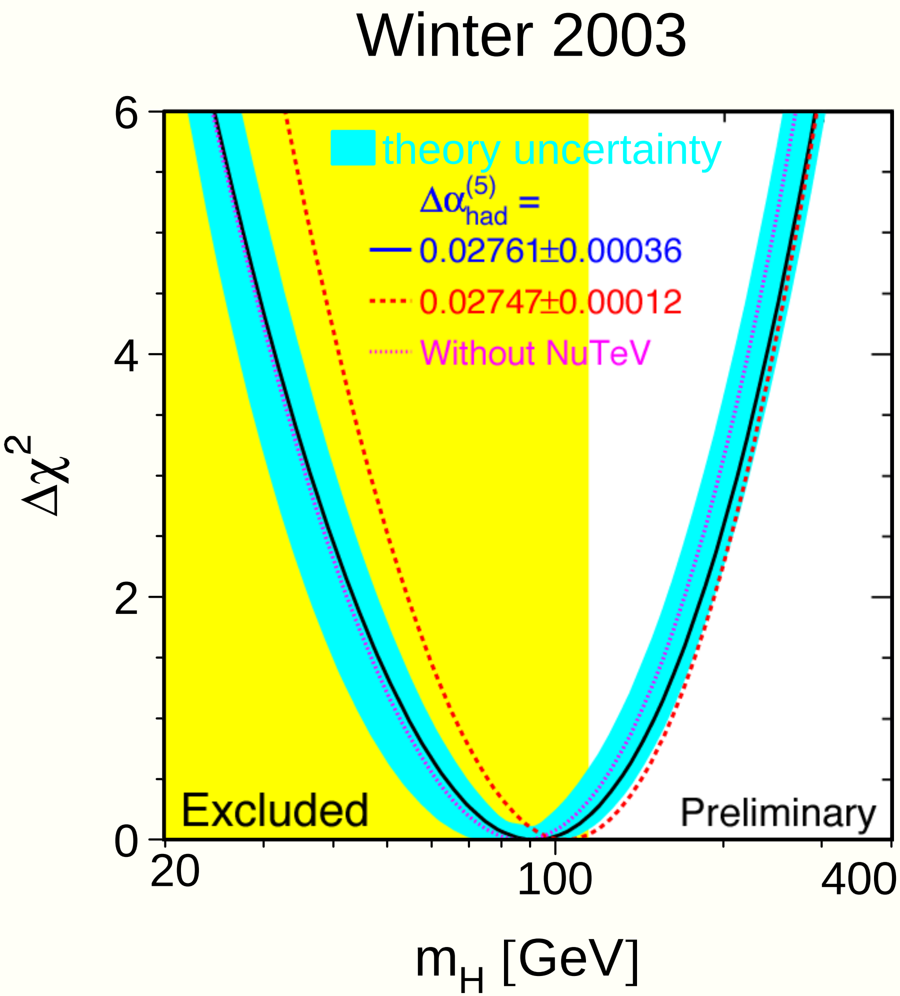
A summary of the scientific case for the e+ e- Linear Collider, representing a broad consensus of the particle physics community.

http://sbhepnt.physics.sunysb.edu/~grannis/ilcsc/lc_consensus.pdf)
(To join this list, go to http://blueox.uoregon.edu/~lc/wwstudy/)

Why a Linear Collider?

- 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

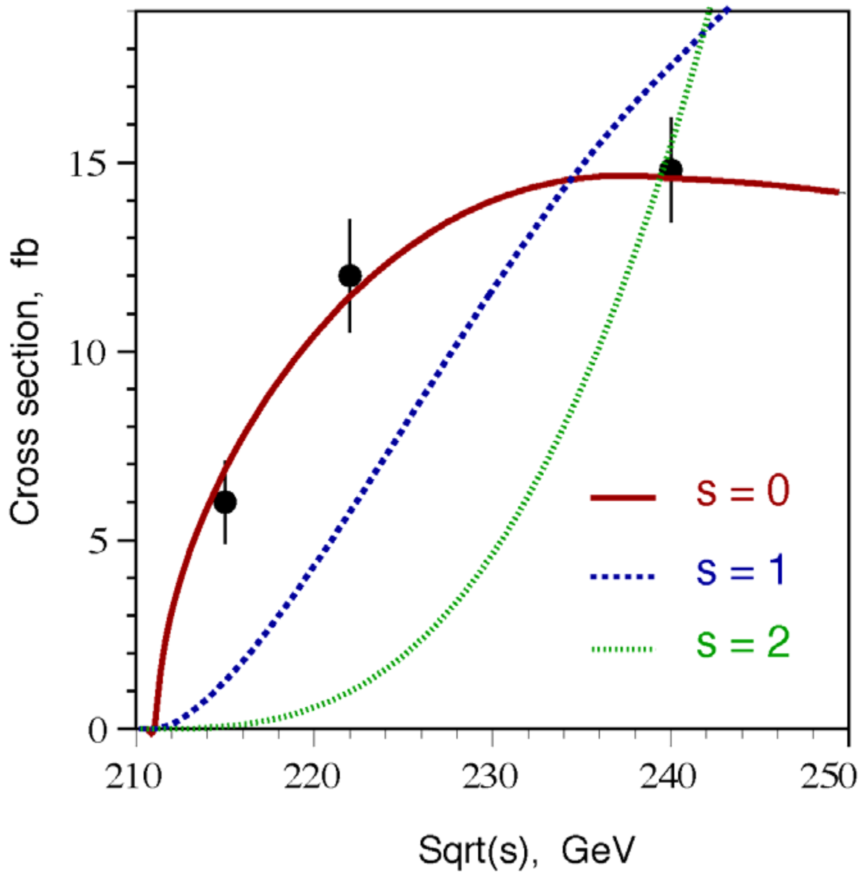
The 500 GeV Linear Collider Spin Measurement

LHC should discover the Higgs

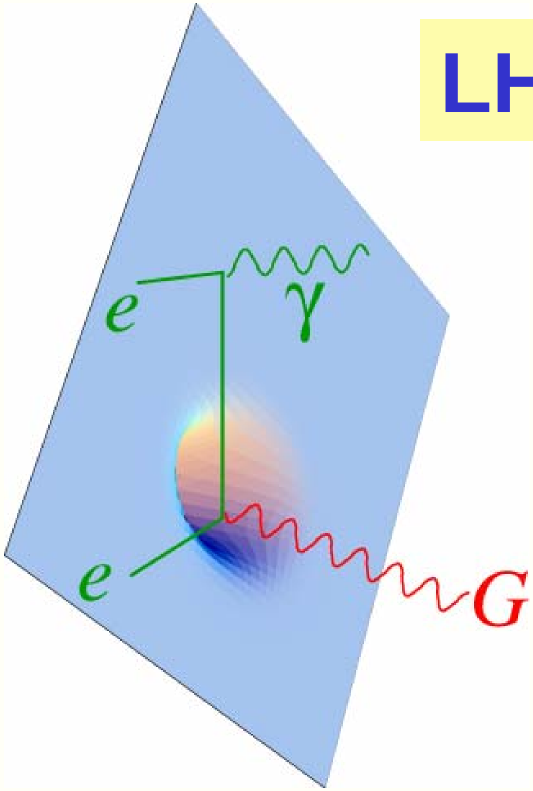
The linear collider will measure the spin of any Higgs it can produce.

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.

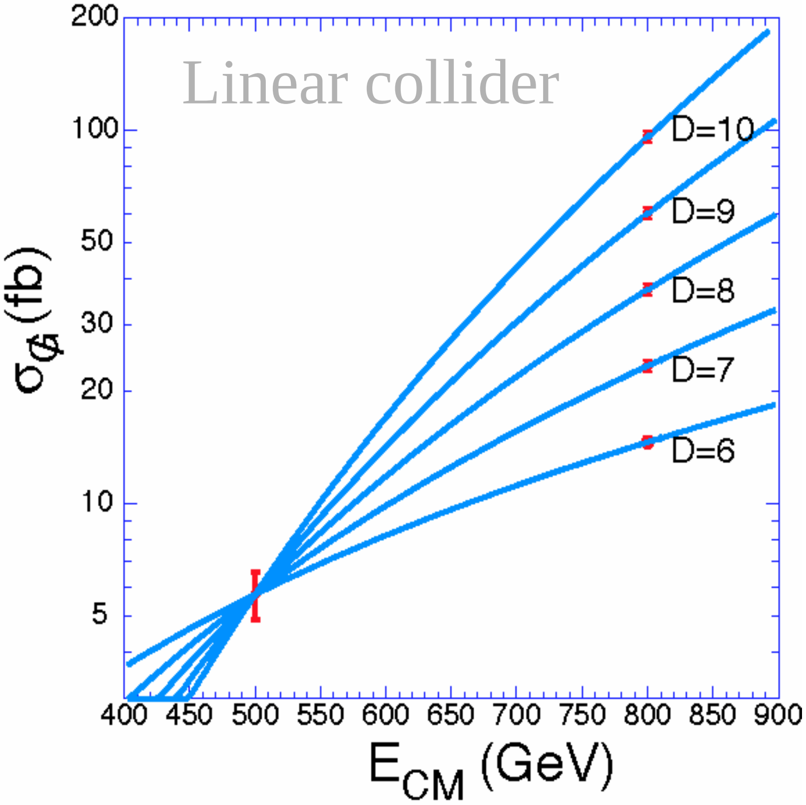
The Higgs must have spin zero



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.

Convergence of Science and Technology

- **Two parallel developments over the past few years (the science & the technology)**
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Worldwide Study of the Physics and Detectors for Future Linear $e^+ e^-$ Colliders

Parameters for the Linear Collider
September 30, 2003

Parameters for the Linear Collider

Baseline machine

- E_{cm} continuously adjustable from 200 - 500 GeV
- Luminosity and reliability to allow $\int L dt$ = 500 fb^{-1} in 4 years following the initial year of commissioning
- Ability to scan at any energy between 200 and 500 GeV; downtime to set up not to exceed 10% of actual data-taking time
- Energy stability and precision below 0.1%; machine interface must allow energy, differential luminosity spectrum with that precision
- Electron polarization of at least 80%
- 2 intersection regions for experiments; one with crossing angle to enable $\gamma\gamma$ collisions
- Allow calibration at the Z, but with lower luminosity and emittance

ICFA/ILCSC Evaluation of the Technologies

INTERNATIONAL LINEAR COLLIDER

TECHNICAL REVIEW COMMITTEE

SECOND REPORT

2003

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

Technical Review Committee

In Feb. 2001, ICFA charged a Technology Review Committee, chaired by Greg Loew of SLAC to review the critical R&D readiness issues.

The TRC report in 2003 gave a series of R&D issues for L-band (superconducting rf TESLA), X-band (NLC and GLC), C-band and CLIC. The most important were the R1's: those issues needing resolution for design feasibility.

- R1 issues pretty much satisfied by mid-2004

ITRP in Korea

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

TRC R1 Issues

<u>L-Band</u>: Feasibility for 500 GeV operation had been demonstrated, but 800 GeV with gradient of 35 MV/m requires a full cryomodule (9 or 12 cavities) and shown to have acceptable quench and breakdown rates with acceptable dark currents.

<u>X-band</u>: Demonstrate low group velocity accelerating structures with acceptable gradient, breakdown and trip rates, tuning manifolds and input couplers. Demonstrate the modulator, klystron, SLED-II pulse compressors at the full power required.

R1 issues pretty much satisfied by mid-2004

ITRP Schedule of Events

- **Six Meetings**
  - RAL (Jan 27,28 2004) → Tutorial & Planning
  - DESY (April 5,6 2004)
  - SLAC (April 26,27 2004) → Site Visits
  - KEK (May 25,26 2004)
  - Caltech (June 28,29,30 2004) → Deliberations
  - Korea (August 11,12,13) → Recommendation
  - ILCSC / ICFA (Aug 19) → Exec. Summary
  - ILCSC (Sept 20) → Final Report

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 interpreted our charge as being to recommend a technology, rather than choose a design

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

What that Entailed

- We each traveled at least 75,000 miles
- We read approximately 3000 pages
- We had constant interactions with the community and with each other
- We gave up a good part of our “normal day jobs” for six months
- We had almost 100% attendance by all members at all meetings
- We worked incredibly hard to “turn over every rock” we could find.

from Norbert Holtkamp

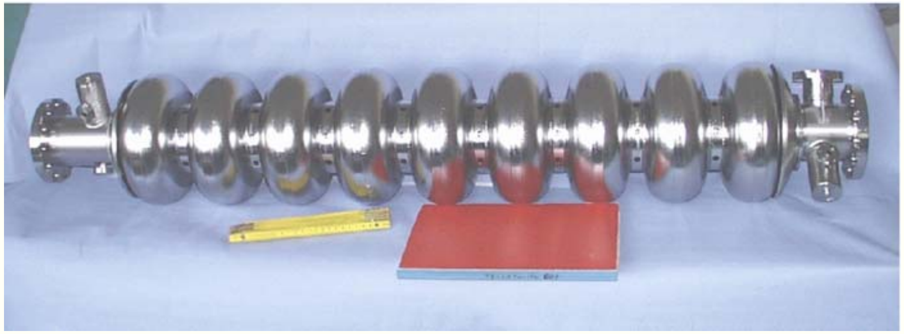
Evaluating the Criteria Matrix

- 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

The Recommendation

- **We recommend that the linear collider be based on superconducting rf technology**



  - **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).**
  - **The superconducting technology has several very nice features for application to a linear collider. They follow in part from the low rf frequency.**

What Comes Next?

- **ILCSC initiated a Global Design Effort (GDE)**

The plan they put forward:

o **A Central Team located at a National Laboratory Site, with Director, Chief Accelerator Scientist, Chief Engineer and staff initially of 10-15.**

o **Three regional teams sited in Asia, Europe and North America as determined by the regions. Each to have a Regional Director who join with the Central Team Director, Accel. Scientist and Engineer to form an overall directorate.**

o **Central Team to direct the work and design choices.**

o **Actual design of subsystems to be done in the Regional Teams**

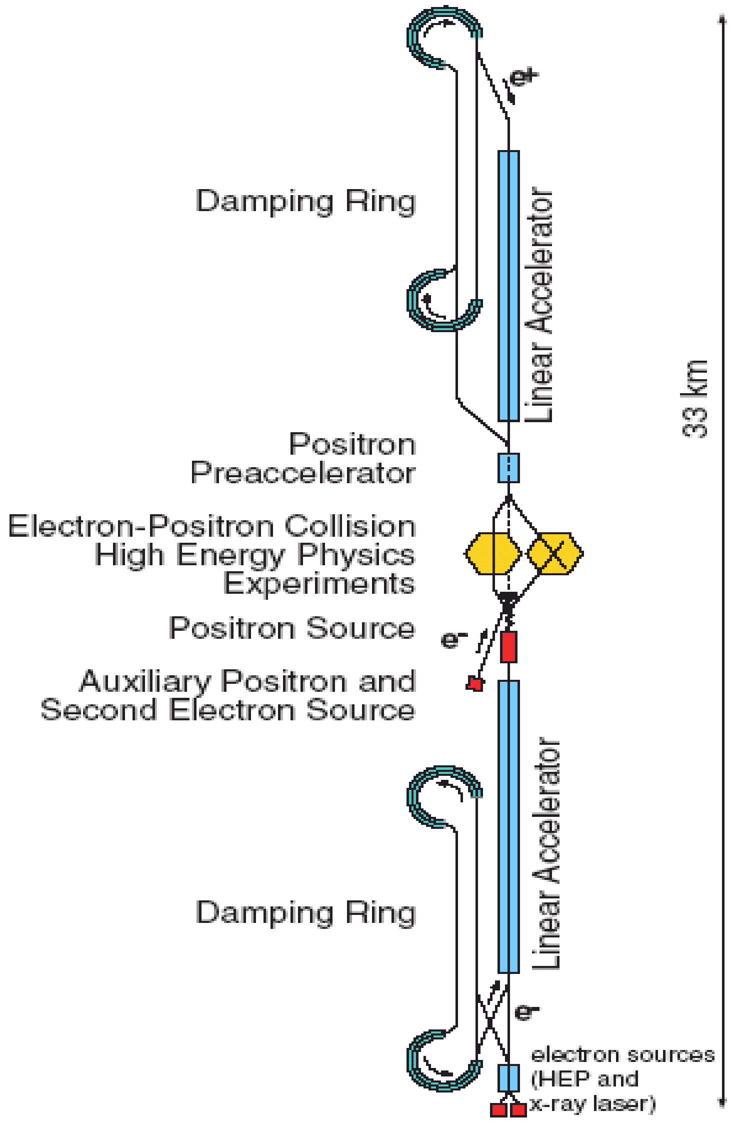


FIGURE 1. TESLA layout

TESLA Concept

- **The main linacs are based on 1.3 GHz superconducting technology operating at 2 K. The cryoplant, of a size comparable to that of the LHC, consists of seven subsystems strung along the machines every 5 km.**

TESLA Cavity

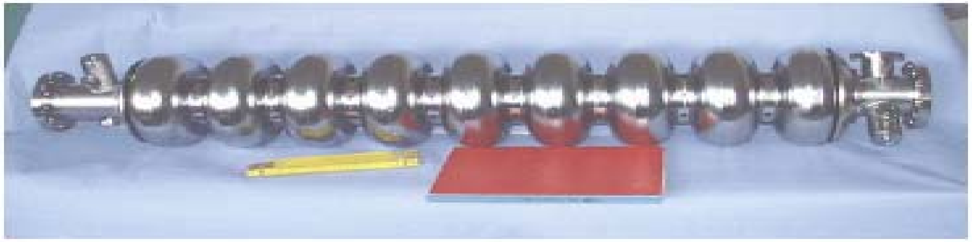


FIGURE 3. The 9-cell niobium cavity for TESLA

- **RF accelerator structures consist of close to 21,000 9-cell niobium cavities operating at gradients of 23.8 MV/m (unloaded as well as beam loaded) for 500 GeV c.m. operation.**
- **The rf pulse length is 1370 μs and the repetition rate is 5 Hz. At a later stage, the machine energy may be upgraded to 800 GeV c.m. by raising the gradient to 35 MV/m.**

TESLA Single Tunnel Layout

- **The TESLA cavities are supplied with rf power in groups of 36 by 572 10 MW klystrons and modulators.**

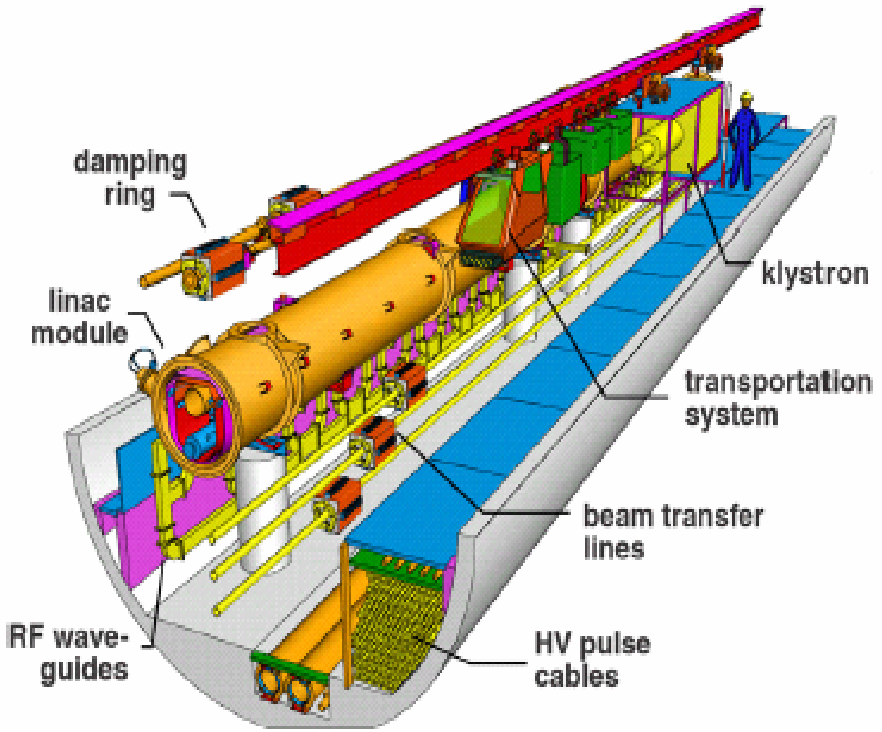


FIGURE 2. Sketch of the 5 m diameter TESLA linac tunnel

Experimental Test Facility - KEK

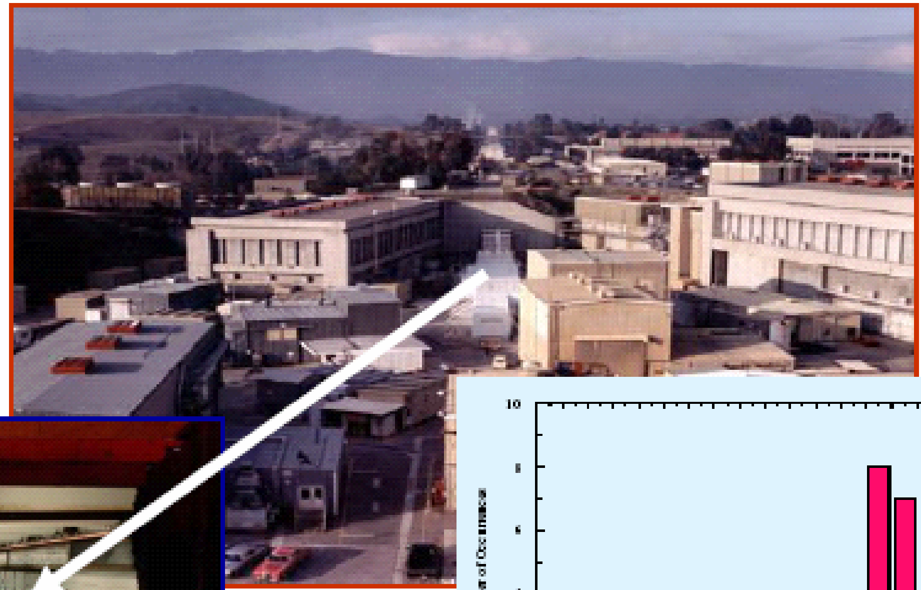
- **Prototype Damping Ring for X-band Linear Collider**
- **Development of Beam Instrumentation and Control**

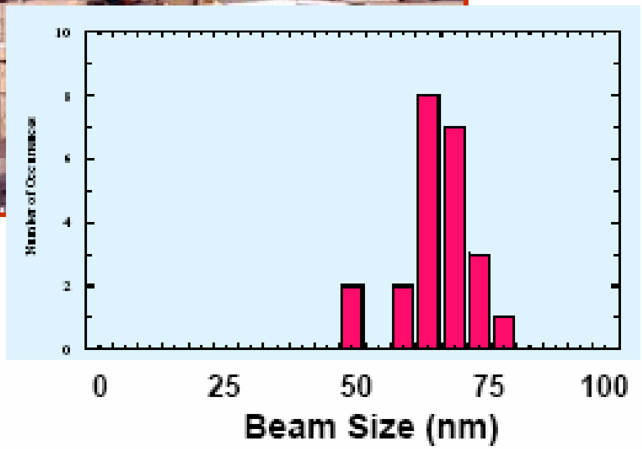
	ATF	GLC/NLC-DR	
E_b	1.28 (1.54 max)	1.98	GeV
N_e	~ 10^{10}	0.75 10^{10}	e-/bunch
S_b	2.8	1.4	ns
N_b	20	192	/pulse
$\gamma\varepsilon_x$	~4	3	µm.rad
$\gamma\varepsilon_y$	~0.015	0.02	µm.rad

Evaluation: Technical Issues

Final Focus Test Beam Collaboration

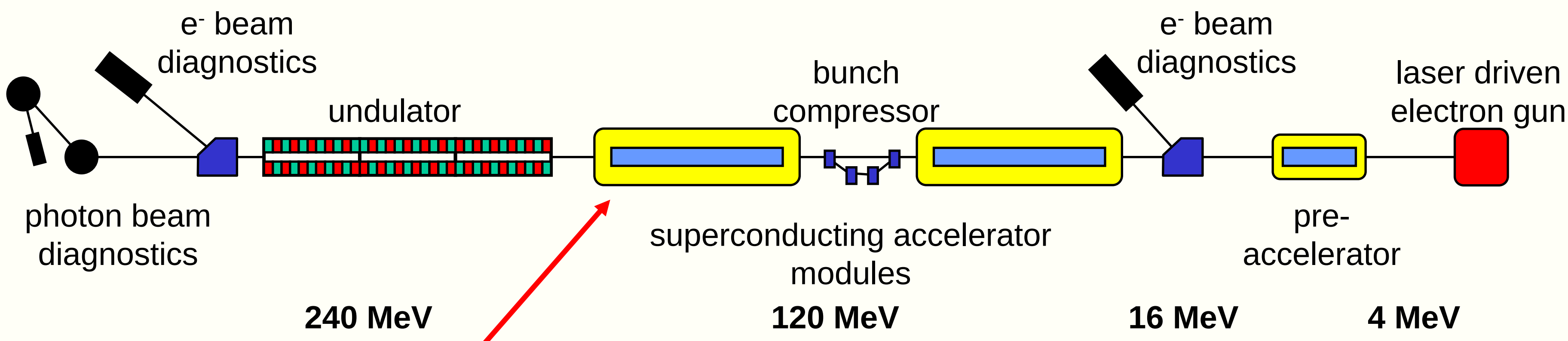
BINP (Novosibirsk)
DESY
Fermilab
IBM
Kawasaki
KEK
LAL (Orsay)
MPI(Munich)
Rochester
SLAC

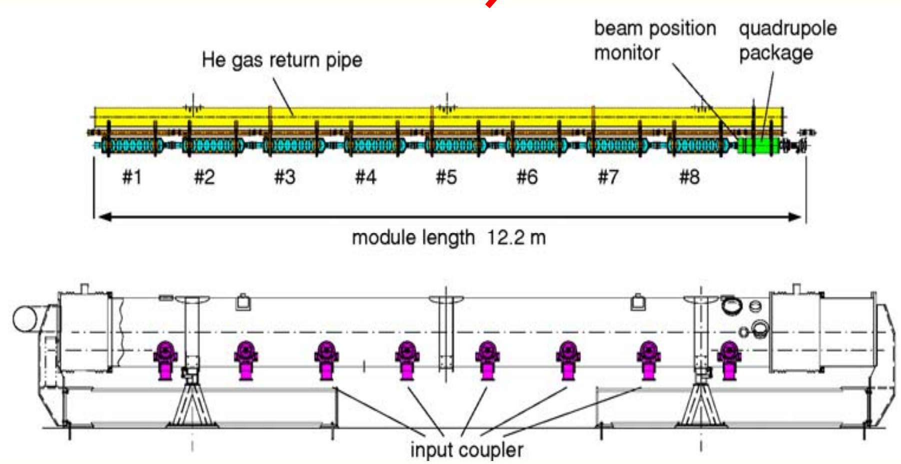




Vertical beam size of 60-70 nm … the needed demagnification.

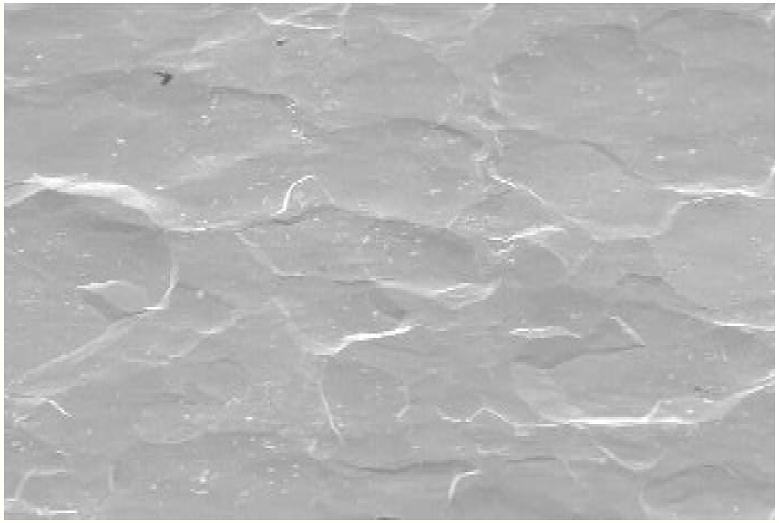
TESLA Test Facility Linac





Electro-polishing

(Improve surface quality -- pioneering work done at KEK)

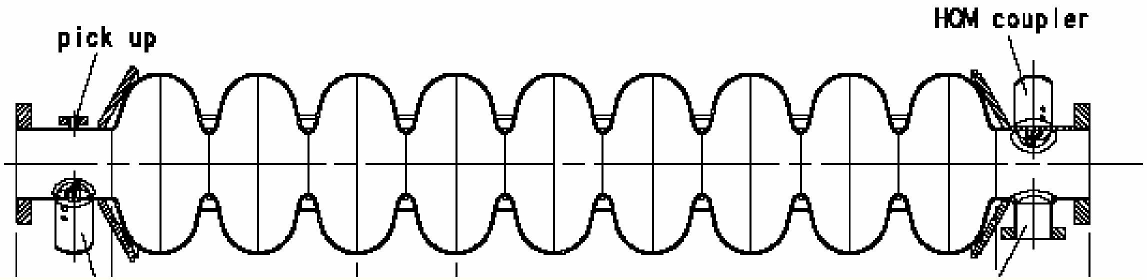


BCP

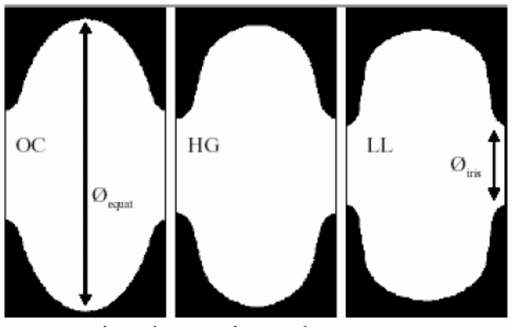
EP

- Several single cell cavities at g > 40 MV/m
- 4 nine-cell cavities at ~35 MV/m, one at 40 MV/m
- Theoretical Limit 50 MV/m

New Cavity Shape for Higher Gradient?



TESLA Cavity

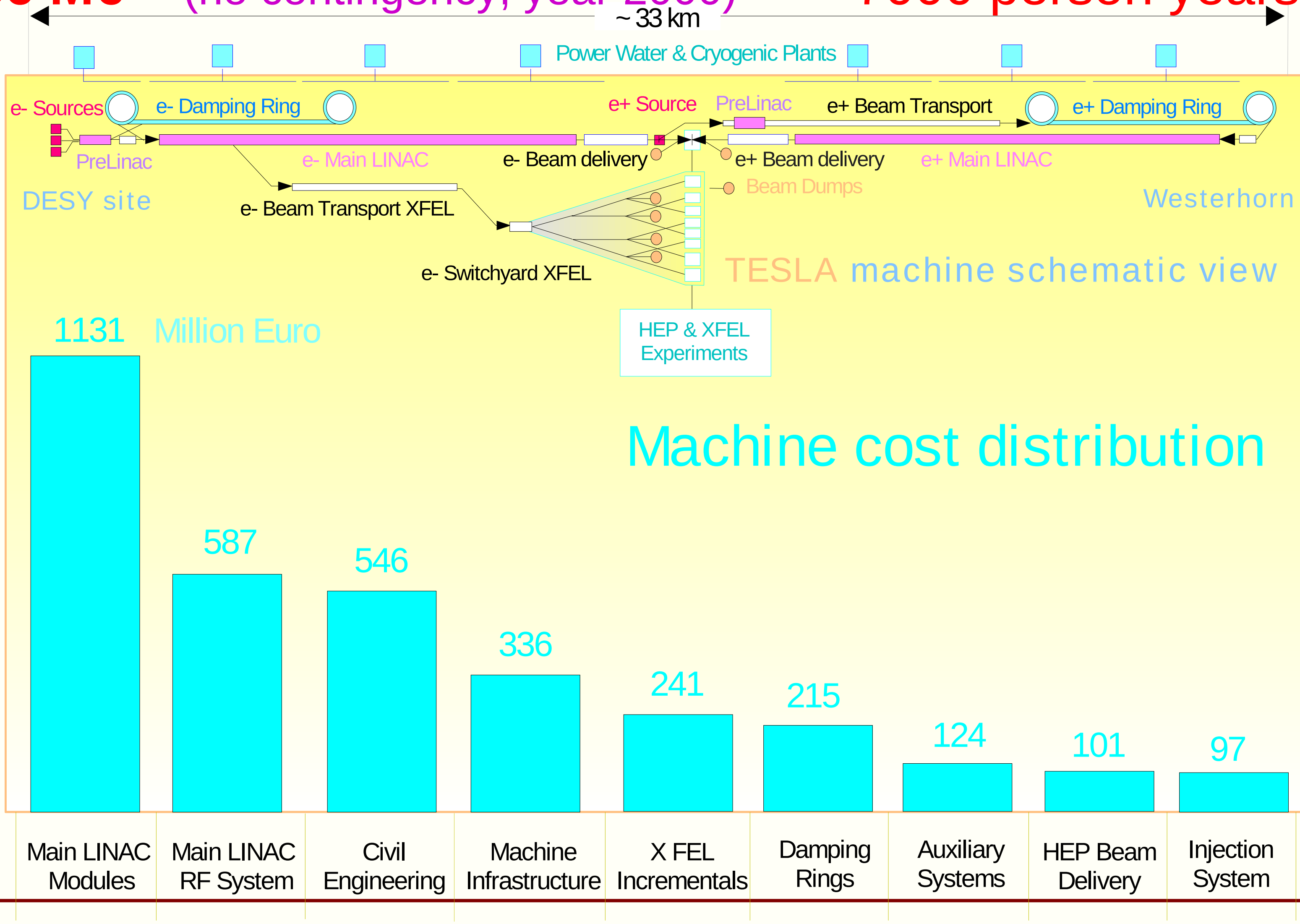


Alternate Shapes

- **A new cavity shape with a small Hp/Eacc ratio around 35Oe/(MV/m) must be designed.**
  - Hp is a surface peak magnetic field and Eacc is the electric field gradient on the beam axis.
  - For such a low field ratio, the volume occupied by magnetic field in the cell must be increased and the magnetic density must be reduced.
  - This generally means a smaller bore radius.
  - There are trade-offs (eg. Electropolishing, weak cell-to-cell coupling, etc)

TESLA Cost estimate500GeV LC, one e+e- IP

3,136 M€ (no contingency, year 2000) + ~7000 person years



Statement of Funding Agency (FALC) Mtg

17-Sept-04 @ CERN

Attendees: Son (Korea); Yamauchi (Japan); Koepke (Germany); Aymar (CERN); Iarocci (CERN Council); Ogawa (Japan); Kim (Korea); Turner (NSF - US); Trischuk (Canada); Halliday (PPARC); Staffin (DoE – US); Gurtu (India)

Guests: Barish (ITRP); Witherell (Fermilab Director,)

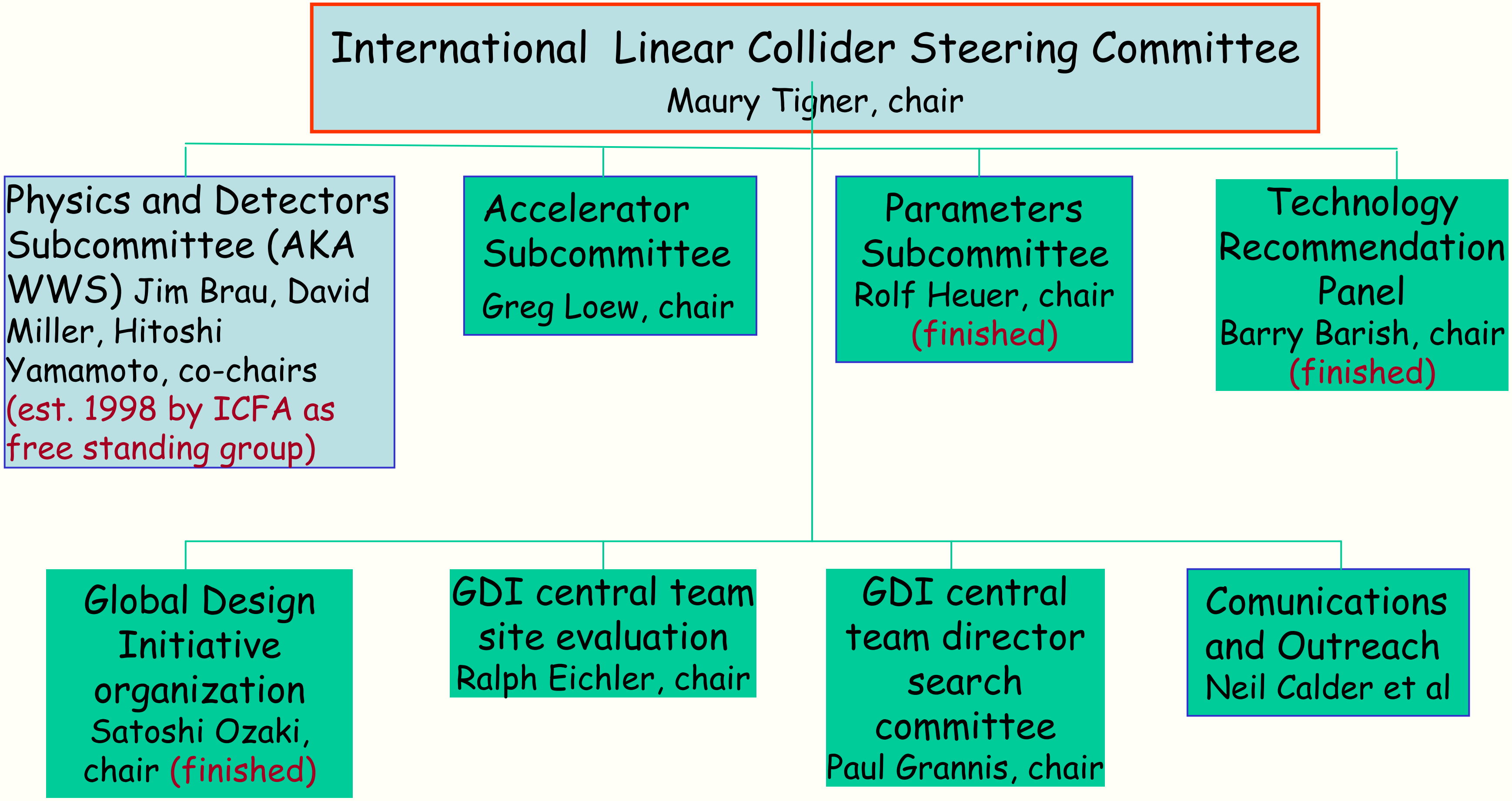
"The Funding Agencies praise the clear choice by ICFA. This recommendation will lead to focusing of the global R&D effort for the linear collider and the Funding Agencies look forward to assisting in this process.

The Funding Agencies see this recommendation to use superconducting rf technology as a critical step in moving forward to the design of a linear collider."

FALC is setting up a working group to keep a close liaison with the Global Design Initiative with regard to funding resources.

The cooperative engagement of the Funding Agencies on organization, technology choice, timetable is a very strong signal and encouragement.

Fall 2002: ICFA created the International Linear Collider Steering Committee (ILCSC) to guide the process for building a Linear Collider. Asia, Europe and North America each formed their own regional Steering Groups (Jonathan Dorfan chairs the North America steering group).



GDE – The first step

- Define first baseline configuration (end of 2005)
- CDR (end of 2006)

How to get from here to there??????

Test facilities

Costs

R&D program

Conclusion

Remarkable progress in the past two years toward realizing an international linear collider:

important R&D on accelerator systems

definition of parameters for physics

choice of technology

start the global design effort

funding agencies are engaged

❖ **Many major hurdles remain before the ILC becomes a reality (funding, site, international organization, detailed design, …), but there is increasing momentum toward the ultimate goal --- An International Linear Collider.**