An International Linear Collider
and
What It Might Mean for SLAC

David Burke
SLAC Scenarios Presentation
April 1, 2003
Quarks to the Cosmos

- Unification of Electromagnetic and Weak Forces established with great precision.
  Higgs?

- Unification of EW and Nuclear Forces?
  Can’t be the Higgs!
  Supersymmetry?

- Dark Matter and Dark Energy
  Supersymmetry?
  Extra dimensions?

- Big Bang Inflation
  What drives this tremendous increase in the entropy of the universe?

→ A Mission for the Next Half Century
HEP Goals

- **HEPAP Bagger-Barrish Sub-Panel (2001)**
  - “Initial 500 GeV … expandable to 800-1000 GeV.”

- **ACFA**
  - “Initial capability 500 GeV … expandable to 1 TeV and higher.”

- **ECFA**
  - “A 400 GeV collider.”

- **American Linear Collider Physics Group (2003)**
  - “500 GeV expandable to approximately 1 TeV, and possibly higher.”

<table>
<thead>
<tr>
<th>$\sqrt{s}$ (GeV)</th>
<th>$\sim 500$ fb$^{-1}$</th>
<th>$\sim 1000$-2000 fb$^{-1}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>350-400</td>
<td>low-mass h; production rates, BRs, spin; tt production; low-mass SUSY</td>
<td></td>
</tr>
<tr>
<td>500</td>
<td>WW fusion, hWW; more SUSY states; h → tt for high-mass h</td>
<td>rare h BRs (h → $\gamma\gamma$, h → $\mu^+\mu^-$); low mass h self coupling</td>
</tr>
<tr>
<td>800-1000</td>
<td>possibly H, A, H$^+$ mass; higher mass SUSY; new theories; extra dimensions</td>
<td>rare h decays via WWh; tth, hhZ;</td>
</tr>
<tr>
<td>1000-1500</td>
<td>likely H, A, H$^+$ mass; SUSY model parameters ?; strongly interacting WW ?</td>
<td>H, A, H$^+$ BRs; heavier Higgs self-couplings; strongly interacting WW?</td>
</tr>
</tbody>
</table>
Accelerator Technologies

Room Temperature X-Band
SLAC-KEK Lead
NLCTA

Superconducting
DESY Lead
TTF

Each has demonstrated performance necessary for initial 500 GeV cms collisions.
### NLC/JLC Energy Reach

The JLC/NLC Stage 2 design luminosity is $5 \times 10^{33}$ cm$^{-2}$ s$^{-1}$ at 1.3 TeV cms.

<table>
<thead>
<tr>
<th>High Energy IP Parameters</th>
<th>Stage 1</th>
<th>Stage 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMS Energy (GeV)</td>
<td>500</td>
<td>1000</td>
</tr>
<tr>
<td>Site</td>
<td>US</td>
<td>Japan</td>
</tr>
<tr>
<td>Luminosity ($10^{33}$)</td>
<td>20</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>30</td>
<td>25</td>
</tr>
<tr>
<td>Repetition Rate (Hz)</td>
<td>120</td>
<td>150</td>
</tr>
<tr>
<td></td>
<td>120</td>
<td>100</td>
</tr>
<tr>
<td>Bunch Charge ($10^{10}$)</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>Bunches/RF Pulse</td>
<td>192</td>
<td>192</td>
</tr>
<tr>
<td>Bunch Separation (ns)</td>
<td>1.4</td>
<td>1.4</td>
</tr>
<tr>
<td>Loaded Gradient (MV/m)</td>
<td>50</td>
<td>50</td>
</tr>
<tr>
<td>Injected $\gamma_x / \gamma_y (10^{-8})$</td>
<td>300 / 2</td>
<td>300 / 2</td>
</tr>
<tr>
<td>$\gamma_x$ at IP ($10^{-8}$ m-rad)</td>
<td>360</td>
<td>360</td>
</tr>
<tr>
<td>$\gamma_y$ at IP ($10^{-8}$ m-rad)</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>$\beta_x / \beta_y$ at IP (mm)</td>
<td>8 / 0.11</td>
<td>13 / 0.11</td>
</tr>
<tr>
<td>$\sigma_x / \sigma_y$ at IP (nm)</td>
<td>243 / 3.0</td>
<td>219 / 2.1</td>
</tr>
<tr>
<td>$\theta_x / \theta_y$ at IP (nm)</td>
<td>32 / 28</td>
<td>17 / 20</td>
</tr>
<tr>
<td>$\sigma_x$ at IP (um)</td>
<td>110</td>
<td>110</td>
</tr>
<tr>
<td>$\gamma_{ave}$</td>
<td>0.14</td>
<td>0.29</td>
</tr>
<tr>
<td>Pinch Enhancement</td>
<td>1.51</td>
<td>1.47</td>
</tr>
<tr>
<td>Beamstrahlung $\delta B$ (%)</td>
<td>5.4</td>
<td>8.9</td>
</tr>
<tr>
<td>Photons per e+/e-</td>
<td>1.3</td>
<td>1.3</td>
</tr>
<tr>
<td>Two Linac Length (km)</td>
<td>13.8</td>
<td>27.6</td>
</tr>
</tbody>
</table>

![Graph](image)
• DESY Commitment

Factor 7 increase in accelerating gradient with factor 5 reduction in cost.

At 35 MV/m and 30 km …

• Experience at U.S. Labs

Jeff Lab, Cornell
FNAL, BNL

→ Superconducting cavities and linacs.
→ Large cryogenic systems.
International Linear Collider
Technical Review Committee

- Formed in 1994 by all world-wide laboratories working in HEP.


- Charged in 2001 by ICFA to reassess technical status and establish work that remains to be done to be able to build a TeV linear collider.
• “By the end of 2003, we hopefully should know if TESLA can reach 800 GeV at 35 MV/m.”

• “By the end of 2003, we hopefully should know if JLC/NLC can meet its main linac [1 TeV] RF system specifications.”

• “If yes, then the International Community could make a choice based on the other respective merits of these machines.”
Steers Towards International Steering / Oversight Group

U.S. Steering Group

Asian Steering Group

European Steering Group

Govt. Agencies

Govt. Agencies

Govt. Agencies

International Steering / Oversight Group

Steers Towards

International Organization / Laboratory Charged with Constructing LC

Global Goals

• Technology Selection and International Design Group in 2004.
• International “Project Start” in 2005.
U.S. Linear Collider Steering Committee

Executive Committee
Jonathan Bagger, Jim Brau, Sally Dawson, David Burke, Jonathan Dorfan (Chair), Gerry Dugan, Jerry Friedman, Jim Gates, Steve Holmes, Young-Kee Kim, Dan Marlow, Mark Oreglia, Maury Tigner, Mike Witherell, Harvey Lynch (Exec Secretary)

Accelerator Sub-committee
Chair: Dugan

Detector/Physics Sub-committee
Chairs: Oreglia, Brau

International Affairs Sub-committee
Chair: Tigner
U.S. Technology Evaluation

USLCSG Accelerator Subcommittee

Gerry Dugan (Chair), David Burke, David Finley, Mike Harrison, Steve Holmes, Jay Marx, Hasan Padamsee, and Tor Raubenheimer

Four Task Forces:  
Accelerator Design  
Civil Construction and Site  
Cost and Schedule  
Reliability

• Developing models of U.S. implementation of normal and superconducting LC matching the specifications from the ALCPG.

• Design based on TESLA TDR and JLC/NLC although not identical.

• Studying sites in Illinois and California for both technologies.

• Cost and risk assessments.

Report to USLCSG in September as part of U.S. position in technology down-select.
International Projects and Timelines

Will not say much about organization … but ITER experience may be important …

Design-Build  A single “project” with a planned timeline of phases.
   E.g.  R&D and CDR, PED, Construction, Commissioning
   International agreements up front.
   E.g. When and how to select the site.

Design,  Two distinct “projects” each with deliverables.
then Build  E.g. Agreement to complete R&D → PED.
   New agreement to complete Construction.  Ops, a third?

Where ITER is now after spending ~ 1 B$ world-wide:
   Technical R&D advanced, and Project Engineering Design complete.
      → Work Packages outlined and Cost Estimates understood.
   Candidate sites developed by those who want to bid to host.
      → Canada, France, Japan, and Spain
   Ready to start negotiations on Build phase ---- U.S. back in at ~ 10% of ~ 5 B$. 


### LC Pre-Construction Activities

<table>
<thead>
<tr>
<th>Year</th>
<th>Activity Description</th>
</tr>
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<tbody>
<tr>
<td>FY2004</td>
<td>Continue preconceptual design and R&amp;D (SLAC, FNAL, LBNL, LLNL, and BNL).</td>
</tr>
<tr>
<td>FY2005</td>
<td>Continue to fabricate accelerator structure prototypes at FNAL and KEK.</td>
</tr>
<tr>
<td>FY2006</td>
<td>Compile Conceptual Design Baseline.</td>
</tr>
<tr>
<td>FY2007</td>
<td>Site &amp; Civil Facilities continue to evaluate potential IL and CA sites.</td>
</tr>
<tr>
<td>FY2008</td>
<td>Program continue design &amp; technology evaluation by Intl LC Technical Rev’w Cmtee.</td>
</tr>
</tbody>
</table>

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ETF: 
![ETF Image](image-url)

... ~ 1B$ (out of 6-7 B$ TPC) to get the LC to where ITER is today.
Funding Model for U.S. Share of an International LC Project

- U.S. funds ~ 65% of project. → U.S. share is ~ 4 B$.  
  (Or perhaps, 600 M$ for the B$ Design phase).

- Fraction ~ 30% comes from re-directed Base HEP program.
A Vision of a U.S.-Based LC

• Community can not withstand the cost and conflict of creating a new laboratory. (SSC catastrophe.)

• Labs can not just *take “ownership” of part* of the project, or worse yet, become *contractors to* the project. (SNS difficulties.)

• Labs *will be integral parts* of the project.

• The expertise to design, build, operate, and manage accelerators can not be found on the street – it lives at the labs.

• Every part of SLAC will be integrated into the LC Project
  – Engineers, Scientist, Technicians
  – Computing, Shops, and Labs
  – Information Services, Business Services, Personnel, Publications, Shipping, Receiving, Warehousing, Stock Room
## Model U.S. HEP Appropriations (M$)
First Year of the Construction Phase (ca 2009)

### HEP Base (Non LC Program - HEPAP P5 Committee)

<table>
<thead>
<tr>
<th>Item</th>
<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fermilab (URA Contract)</td>
<td>220</td>
<td>(Tevatron, Neutrinos, etc)</td>
</tr>
<tr>
<td>SLAC (Stanford Contract)</td>
<td>120</td>
<td>(B-Factory, Astro, etc)</td>
</tr>
<tr>
<td>DOE University Program</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>NSF University Program</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>HEP Equipment (Other than LC)</td>
<td>100</td>
<td>(Including GPP, AIP, etc.)</td>
</tr>
<tr>
<td><strong>HEP Base Sub-Total</strong></td>
<td><strong>560</strong></td>
<td></td>
</tr>
</tbody>
</table>

### U.S. LC Project

<table>
<thead>
<tr>
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<th>Amount</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. LC Central Management*</td>
<td>200</td>
<td>* Funds distributed to various labs (e.g. BNL, LBNL, LLNL), universities, other contractors, and industries directly by the U.S. LC Project Management (including funds needed to support work at the construction site, project management, etc).</td>
</tr>
<tr>
<td>FNAL (URA Contract)</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>SLAC (Stanford Contract)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>NSF (Cornell Contract)</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><strong>LC Sub-Total</strong></td>
<td><strong>490</strong></td>
<td></td>
</tr>
</tbody>
</table>

**HEP Total**                                          **1050**
Possible Organization of the U.S. Part of the LC Project

- Agencies of Other Gvmts
  - DOE and NSF
    - FNAL, BNL, ... Cornell, etc

- International Project Management
  - U.S. LC Project Contractor???
  - U.S. LC Project Director (Chair, U.S. LC Project Executive Board)
    - U.S. LC Project Executive Board
      - Management Advisory Committee
      - Financial Advisory Committee
      - Machine Advisory Committee
      - Scientific Advisory Committee?

- Deputy Directors
  - Deputy for LC Project at SLAC
  - Deputy for LC Project at FNAL
  - Deputy for LC Project at Cornell

- Construction Manager(s?)
  - U.S. LC Project Deputy Directors
  - SLAC Deputy Directors
    - Deputy for LC Project at SLAC
    - Deputy for Non-LC Programs

- President Stanford University
  - SLAC Director (Member, LC Project Executive Board)
  - SLAC Associate Directors
LC Project Cost Profile
NLC 2002 Estimate

Major Categories

33%  Main Linac Components*
33%  Conventional Construction*
20%  All Other Components
14%  Other Project Costs

* Initial 500 GeV cms on 1 TeV footprint.

Figures do not include contingency, escalation, or detectors.
Main Linac Activities
NLC 2002 Estimate

Figures do not include contingency, escalation, or detectors.
Other Project Activities
NLC 2002 Estimate

Figures do not include contingency, escalation, or detectors.
What Might This Mean for SLAC?

- A U.S.-hosted LC will provide great opportunities and missions for SLAC (and other HEP institutions) no matter where it is sited and no matter what technologies are used to build it.
  - Accelerator Physics and Operational Experience
  - Accelerator Technologies and Engineering
  - Computing
  - Technical and Business Management
  - Fabrication, Assembly and QC, Labs
  - Beams and R&D Facilities --- S-Band Linac, LINX, FFTB-II, ETF, Tunnel Mock-Up

- There are several decisions coming up that will clarify the details of the path for SLAC.

- Plan now from the perspective of resources (~ 30 - 40 %) – people and facilities – across the Lab integrated into the LC project. Such planning will be robust against site and technology choices.