

# **The Linear Collider and the Future of Fermilab**

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DOE Annual Program Review

March 24, 2004

# Outline

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- Orientation — Fermilab and the World Beyond
- The Current Fermilab Program
- The Linear Collider and Fermilab's Future: Conclusions and Recommendations

# Orientation

## International Scene

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- Strong endorsement by HEPAP, and corresponding advisory committees in Europe and Asia, of the Linear Collider as the next large HEP facility beyond LHC.
- ILCSC organized and operating under the auspices of ICFA  
[http://www.fnal.gov/directorate/icfa/International\\_ILCSC.html](http://www.fnal.gov/directorate/icfa/International_ILCSC.html)
  - Goal: Promote construction of a linear collider through world-wide collaboration
- Major activities include:
  - Preparation of world-wide “consensus document”  
<http://flc25.desy.de/lcsurvey/>
  - International performance document
  - ITRP convened with recommendation due by 12/04
  - Development of an international framework
    - GDO
    - Host lab/international project governance model

# Orientation

## International Scene

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- Performance Goals

[http://www.fnal.gov/directorate/icfa/LC\\_parameters.pdf](http://www.fnal.gov/directorate/icfa/LC_parameters.pdf)

- Initial maximum energy of 500 GeV, operable over the range 200-500 GeV for physics running.
- Equivalent (scaled by 500 GeV/ $\sqrt{s}$ ) integrated luminosity for the first four years after commissioning of 500 fb<sup>-1</sup>.
- Ability to perform energy scans with minimal changeover times.
- Beam energy stability and precision of 0.1%.
- Capability of 80% electron beam polarization over the range 200-500 GeV.
- Two interaction regions, at least one of which allows for a crossing angle enabling  $\gamma\gamma$  collisions.
- Ability to operate at 90 GeV for calibration running.
- Machine upgradeable to approximately 1 TeV.

# Orientation

## National Scene

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- USLCSG established and functioning
    - <http://www.slac.stanford.edu/~hll/USLCSG/>
    - Development and implementation of a strategy for bringing an international linear collider to reality
    - Coordination of U.S. R&D activities
    - Preparation of the U.S. bid to host
  - (U.S.) machine performance document released
    - <http://www.slac.stanford.edu/~hll/USLCSG/BidToHost/MachineScopeA30323.pdf>
  - Identification of LC as highest mid-term priority in the Office of Science 20-year plan
    - (Orbach comment that on-shore LC will require Presidential initiative)
  - Governance study nearing completion
    - Consistent with European and international views
    - [\(http://committees.web.cern.ch/Committees/ECFA/Cern03KalmusReport.pdf\)](http://committees.web.cern.ch/Committees/ECFA/Cern03KalmusReport.pdf)
  - Warm-cold comparative study released
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# The Current Fermilab LC Program

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- **“We propose to the U.S. and to the international HEP community that we work together to build a linear collider at or near the Fermilab site.”** M. Witherell, HEPAP Subpanel, June 12, 2001
- NLC R&D is centered in the Technical Division
  - Fabrication of accelerating structures
    - For 8-pack test
    - As basis for industrialization strategy
  - Development of girder designs
  - Permanent magnets (with AD)
    - On hold
  - Accelerator Division effort, which became nearly non-existent following diversion of personnel onto Run II, is currently being reconstituted.
  - Damping ring and ETF design studies starting up.

# The Current Fermilab LC Program

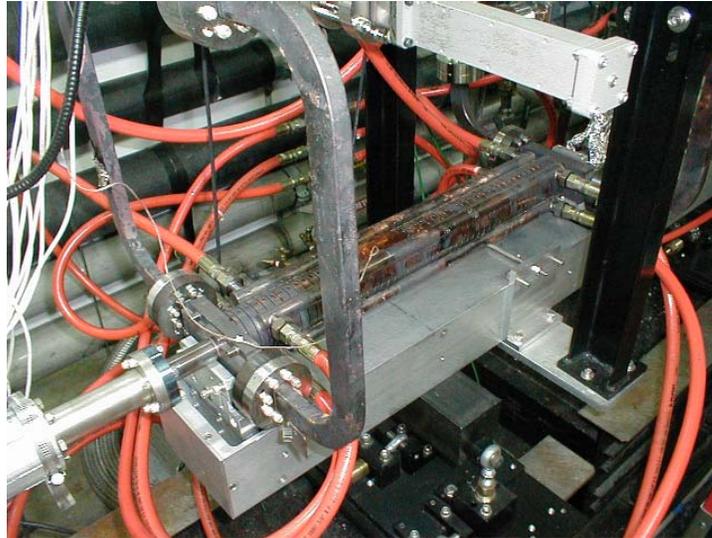
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- Fermilab remains a member of the TESLA collaboration.
    - Modest continuing consultation support for TTF
    - Elements of FNPL program are aimed at both TESLA and LC more generally
  - Siting Studies in FESS
    - Three representative Illinois sites investigated over FY99-FY02
      - Two deep, one shallow; two traversing site, one to the west
    - One Illinois site investigated as part of the USLCSG study
      - Deep; west; warm and cold incarnations.
    - Provide coordination of the entire NLC siting effort (IL and CA)
    - Collaboration formed with NIU Geology Department
  - Total Fermilab effort is ~\$3M; static at this level since FY2001.
    - Represents roughly 15-20% of U.S. effort.
    - Does not include ~\$2M of SCRF R&D, of which 30-50% is LC related.
    - Expect consolidation of NLC and SCRF efforts following technology recommendation.
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# The Current Fermilab LC Program

## X-band Structures

- Three of four structures currently operating at NLCTA were fabricated by Fermilab.
- FXB-006 is the first structure built by anyone to achieve NLC specification for gradient and breakdown rate ( $<0.1$  breakdown/hour @ 60 Hz, 400 nsec, 65MV/m)

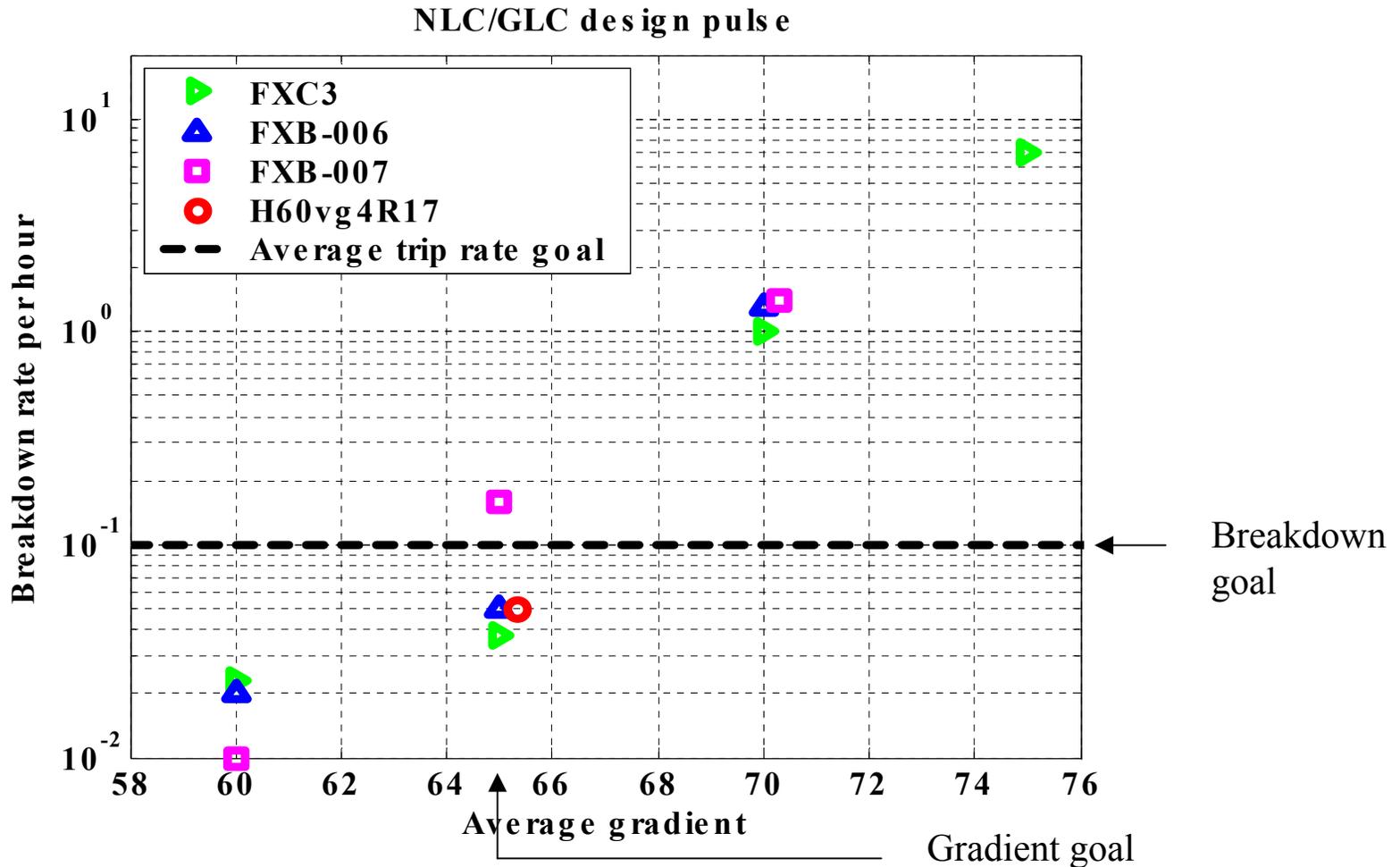


FXB-006

- FXC series are “full feature”, including damping manifold, structures  
⇒FXC003 has also met the NLC gradient/breakdown rate criteria

# The Current Fermilab LC Program

## X-band Structures/Performance



# The Linear Collider and Fermilab's Future

## FLRPC/Linear Collider Subcommittee

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### Subcommittee Members

J. Butler  
M. Carena  
D. Finley  
E. Fisk  
S. Holmes  
R. Kephart  
Y-K. Kim  
A. Kronfeld  
S. Nagaitsev  
R. Patterson  
S. Tkaczyk

### Participants

D. Amidei	V. Kuchler
J. Appel	S. Mishra
G. Blazey	H. Montgomery
J. Brau	M. Oreglia
A. de Gouvea	E. Ramberg
B. Dobrescu	R. Rubinstein
J. Dorfan	M. Tigner
E. Eichten	H. Weerts
A. Freitas	C. White
G. Gollin	M. Witherell
J. Jackson	V. Yarba
K-J. Kim	

# FLRPC/Linear Collider Subcommittee

## Goals

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- The linear collider subcommittee established two goals for discussion:
    - Understand the ramifications of successfully competing to bring the linear collider to northern Illinois and make recommendations on the steps that should be taken to assure the strongest possible Fermilab presentation within the U.S. “bid to host”.
    - Understand Fermilab’s role in gaining approval for an internationally based linear collider. Outline options for Fermilab involvement in construction and operations (for both Illinois and non-Illinois sites), and make recommendations on the scope of laboratory effort that should be devoted to these activities.
- ⇒ As our discussions evolved the subcommittee focused most strongly on understanding what is required to establish Fermilab as the most attractive LC host laboratory on earth. (Figuring element two is a straightforward extrapolation.)

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- The Linear Collider offers an extraordinarily exciting physics program
  - Electro-weak symmetry breaking
  - SUSY
  - Extra dimensions
  - Strong dynamics
  - Dark matter
  - The unknown?
  - **“The opportunities afforded by the Linear Collider are rich, of profound importance, and extremely exciting, addressing central issues common to both particle physics and cosmology. The promise of LC physics is more than strong enough to say that Fermilab should play a leading role, and should put itself in a position to serve as host for the facility when the time comes.”--FLRPC Physics Subcommittee**

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- Fermilab/Northern Illinois/U.S. is a natural host
    - Fermilab
      - Scientific and engineering expertise in forefront accelerator and detector technologies
      - Significant experience in construction and operations of large accelerator based projects.
      - The leadership mantle of U.S. high energy physics
    - Northern Illinois
      - Strong scientific base, including two national laboratories and five major research universities.
      - Geology ideally suited to a linear collider
      - Transportation and utilities infrastructure system that could support LC construction and operations.
    - United States
      - The wealthiest nation in the world with a tradition of undertaking cutting edge scientific projects that challenge the imagination.
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# FLRPC/Linear Collider

## Conclusions & Recommendations

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**Recommendation 1: Fermilab reiterate its desire to serve as the host laboratory for a linear collider.**

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- A successful U.S. bid to host an international LC project must confront issues that are likely to be important to the international community:
  - Secure and reliable funding
  - Access to scientists and their families (visas and work permits)
  - Willingness to divide project benefits equitably among participants
  - Willingness to share decision and policy making positions equitably
- A successful Fermilab bid to host will require:
  - Strong and visible commitment
    - From lab management
    - From the staff
  - Establishment of the necessary credentials, both in reality and in perception
    - Demonstrated capabilities in linear collider technologies, including establishment of an intellectual leadership role
    - Demonstrated organizational and management capabilities
    - Identification of an excellent local site

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- A successful Fermilab bid to host will require (cont.)
  - Outreach to and support from
    - International high energy physics community
    - National (at least) science community
    - National political leaders
    - Local institutions
    - Our neighbors
- Fermilab should develop a siting plan.
  - In collaboration with local institutions, state and local governments, and the surrounding communities.
- Fermilab should strengthen its engagement with the USLCSG and ILCSC
  - Consideration of bid to host the GDO

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- The Fermilab investment needs to grow to ~\$20M/year at the time of ETF construction, and to ~\$100M/year at the time of the LC construction start (~1/3 of the laboratory effort) in the Fermilab as host lab scenario
  - Growth of the Fermilab investment during construction and operations will depend strongly on the international governance model agreed to.
    - Could become ~50%
  - ~2/3 of this if LC is in U.S. but not Fermilab
  - ~1/3 of this if LC is off-shore.
  - Accelerator/detector split should be heavily weighted towards accelerator

# FLRPC/Linear Collider

## Conclusions & Recommendations

**Recommendation 2: Appoint a full time person within the Directorate with responsibility for coordinating and directing all Fermilab LC activities and providing communications to outside institutions on linear collider. This should include both creation and execution of a strategic plan based on visible leadership and enhanced efforts in:**

- Technology R&D
- Site studies
- Public outreach
- Governance models

**and incorporating**

- Establishment of a realistic timeline in consultation with the USLCSG
- Preparation of the Fermilab component of the U.S. bid to host an international linear collider facility.
- Plans for Fermilab participation in the linear collider in the event that the LC is sited elsewhere.

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- Fermilab should act swiftly to develop its capability to provide technical leadership on the LC construction.
  - Engagement in critical accelerator technology issues and demonstration project(s).
    - Suggest identifying a limited number (two) of areas in which to concentrate accelerator physics effort with goal of establishing leadership, e.g. main linac, damping rings, and/or sources
    - Siting the Engineering Test Facility at Fermilab would provide a unique opportunity to develop LC expertise within the Fermilab scientific and engineering staffs
  - Target detector R&D in a limited number of areas deemed critical to detector performance in which the lab has special capabilities, for example
    - Computing/simulations, vertexing & tracking, calorimetry, muons
    - Test beams

# FLRPC/Linear Collider

## Conclusions & Recommendations

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**Recommendation 3: Fermilab initiate efforts to establish performance goals and develop design studies for both warm and cold ETFs, in collaboration with international partners, with a subsequent goal of hosting the ETF for the chosen technology.**

# FLRPC/Linear Collider

## Conclusions & Recommendations

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- Governance models from the three regions of the world are converging on a model in which the international linear collider is organized as an international project with a nearby host laboratory, separately managed and each with its own (independent) organization.

**Recommendation 4: Fermilab planning for a future including the linear collider should be based upon the host laboratory/international project model.**

# Summary

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- The Linear Collider offers an extraordinarily exciting physics program. If constructed near Fermilab it would become the centerpiece of the laboratory's future.
- The possibility for Fermilab to serve as host laboratory represents a unique opportunity that needs to be pursued aggressively.
  - Will require increased focus and effort within the laboratory
  - We believe our recommendations offer a path forward.
- The laboratory is in the process of growing its program into new areas with a goal of expanding funding as recommended above
  - Formation of collaboration on damping rings involving U.S. universities and laboratories
- A linear collider in northern Illinois is not certain
  - ⇒ Fermilab must be prepared for multiple outcomes (here, there; early, late)