

# **The Linear Collider and the 3<sup>rd</sup> TRIUMF 5YP (2005-2010)**

TRIUMF Town Meeting  
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Dean Karlen  
University of Victoria & TRIUMF

# Outline

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- Answers to the following:
  - Why is it important for your community and for TRIUMF to consider this investment (scientific case and relevance to TRIUMF's mandate)?
  - What is proposed?
  - Who would get involved (define the user community)?
  - What resources are requested?
  - What other funds are requested from other agencies (CFI, NSERC, etc)?
  - When are these resources required (time line)?

# Rationale

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- The scientific case for the Linear Collider is solid
  - Its primary goal: to uncover a detailed understanding of electroweak symmetry breaking and all the other new physics that comes with it
  - directly related to the most fundamental questions in our field: the origin of mass, flavour, mixing, dark energy and dark matter
- Because of the strength of the scientific case and the state of the accelerator technology, a consensus has developed across the world HEP community that this is the next step to take, and that the step should be taken soon...

# Consensus

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- ECFA statement:
  - “...the realisation, in as timely a fashion as possible, of a world-wide collaboration to construct a high-luminosity  $e^+e^-$  linear collider with an energy range up to at least 400 GeV as the next accelerator project in particle physics; decisions concerning the chosen technology and the construction site for such a machine should be made soon”

# Consensus

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- HEPAP statement:
  - “We recommend that the highest priority of the U.S. program be a high-energy, high-luminosity, electron-positron linear collider, wherever it is built in the world.... We recommend that the United States prepare to bid to host the linear collider, in a facility that is international from the inception.”

# Consensus

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- ACFA statement:
  - “ACFA urges the Japanese Government to arrange a preparatory budget for KEK to pursue an engineering design of the collider, to study site and civil engineering, as well as to investigate the process for the globalization.”

# Consensus

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- OECD GSF report:
  - “The Consultative Group concurs with the world-wide consensus of the scientific community that a high-energy electron-positron linear 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.”
  - The cost of the LC will be broadly comparable to that of the LHC, and can be accommodated if the historical pattern of expenditure on particle physics is maintained, taking into account the additional resources that the host country (or countries) will need to provide.

# Science program

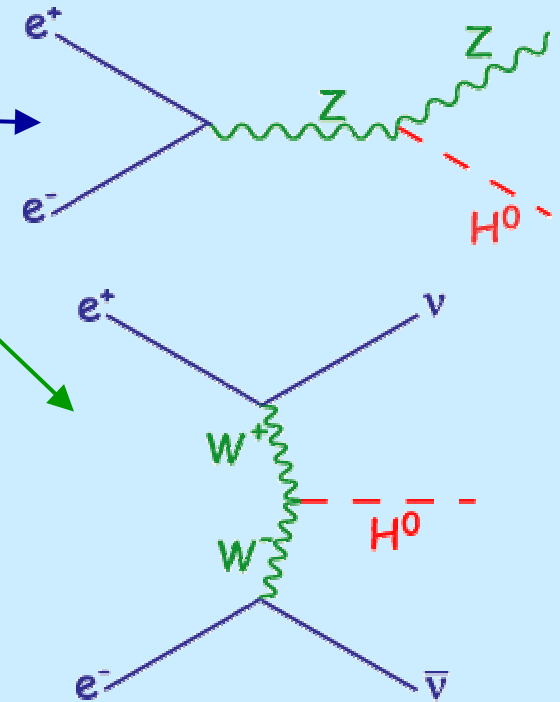
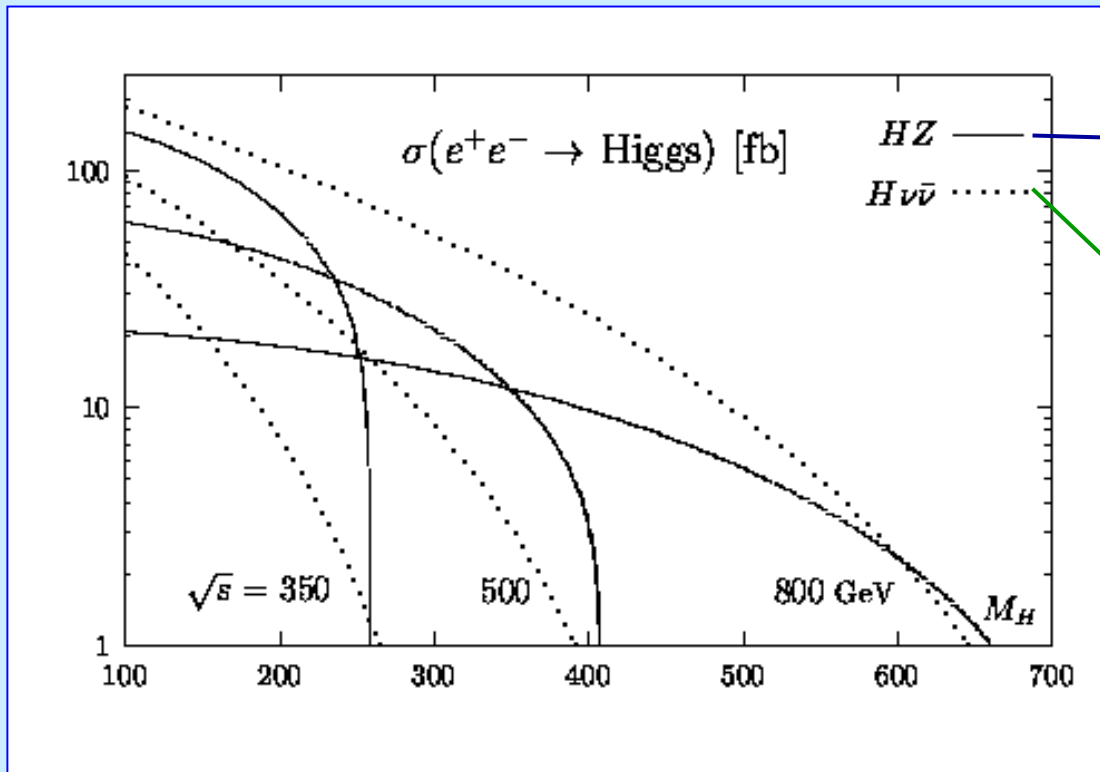
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- Well documented: 3 major reports from 2001:
  - Snowmass resource book
  - TESLA TDR
  - ACFA report
- From precision measurements, we can confidently predict a rich physics program for the first phase linear collider ( $E_{\text{cm}} = 500 \text{ GeV}$ )
  - a Higgs or Higgs-like object responsible for EWSB should be found with mass below  $\sim 200 \text{ GeV}$



# Higgs physics

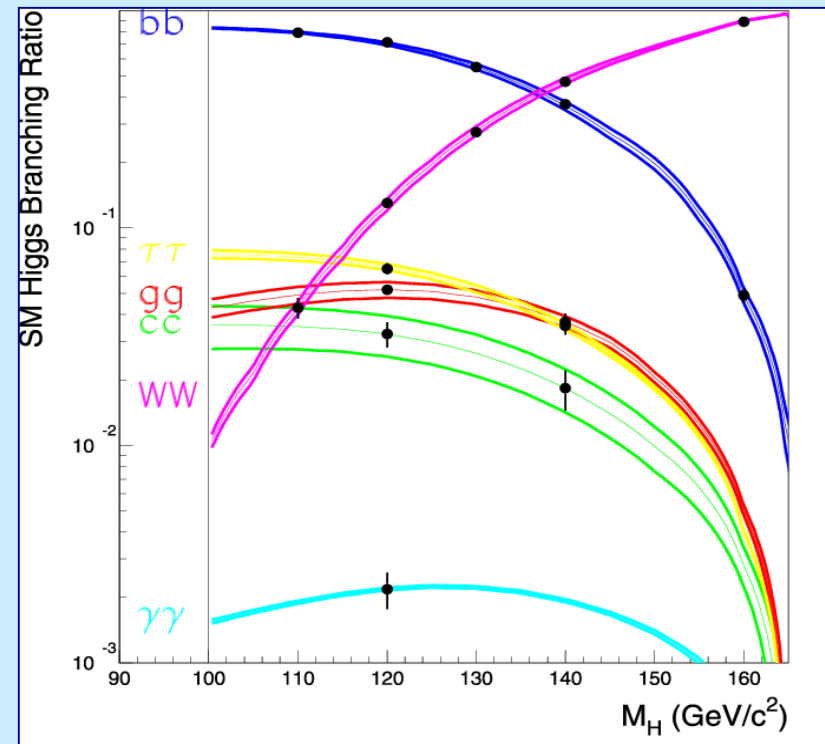
- Higgs production at a Linear Collider



# Higgs physics

- The linear collider experiments will be able to measure the following Higgs properties:

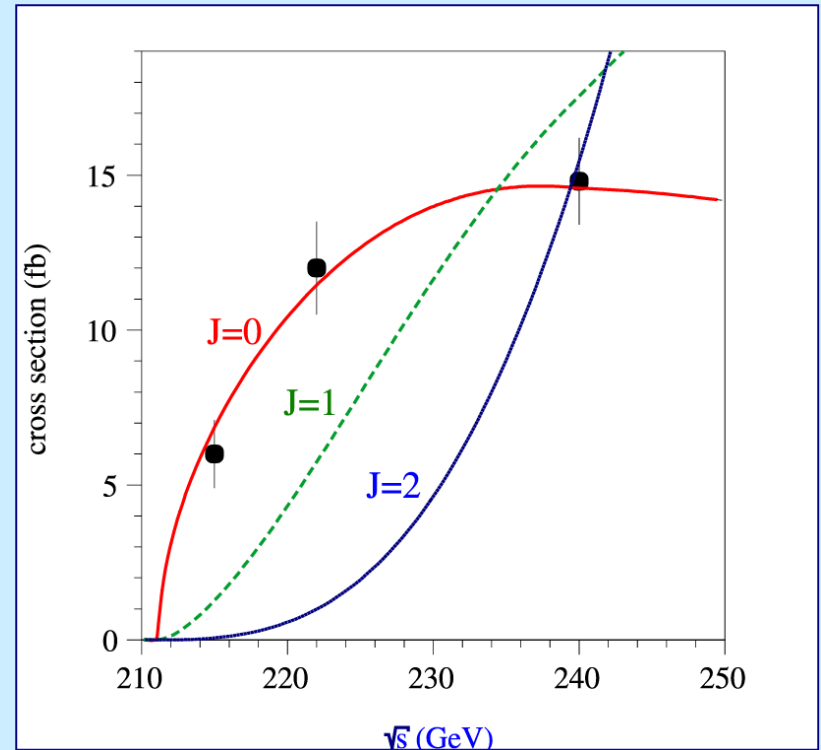
- branching ratios to fermions
  - confirm(?) its role in mass generation
  - distinguish SM from SUSY Higgs (?)
  - model independent measurements, using Z tag



# Higgs physics

- The linear collider experiments will be able to measure the following Higgs properties:

- spin & parity
  - confirm(?) its basic quantum numbers



# Higgs physics

- The linear collider experiments will be able to measure the following Higgs properties:
  - its mass
    - precision of 50 MeV or better
  - its total width: 
$$\Gamma_H^{Total} = \frac{\Gamma(H \rightarrow WW)}{BR(H \rightarrow WW)}$$
  - its couplings to Gauge bosons and to itself:
    - confirm (?) its role in EWSB

# Other new physics

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- The origin of EWSB will likely involve other new physics
  - a single SM Higgs boson without new physics has serious problems
  - some proposals:
    - supersymmetry
    - new gauge interactions
    - extra spatial dimensions
- Information from the LC and LHC will be necessary to disentangle it all...

# Other new physics

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- Concurrent running of the LC and the LHC is important in exploring the new physics
  - relating the measurements of  $m_A, m_h, m_{\tilde{t}}, m_{\tilde{b}}, m_t$
  - improved measurements of LSP masses by LC improves mass measurements of other susy particles by LHC
  - knowledge of decay modes for lower lying susy states from LC will allow LHC to better measure cascades of heavier states
  - LC triggerless detectors may observe topologies that LHC detectors do not trigger on: LHC triggers could then be modified to confirm & study further

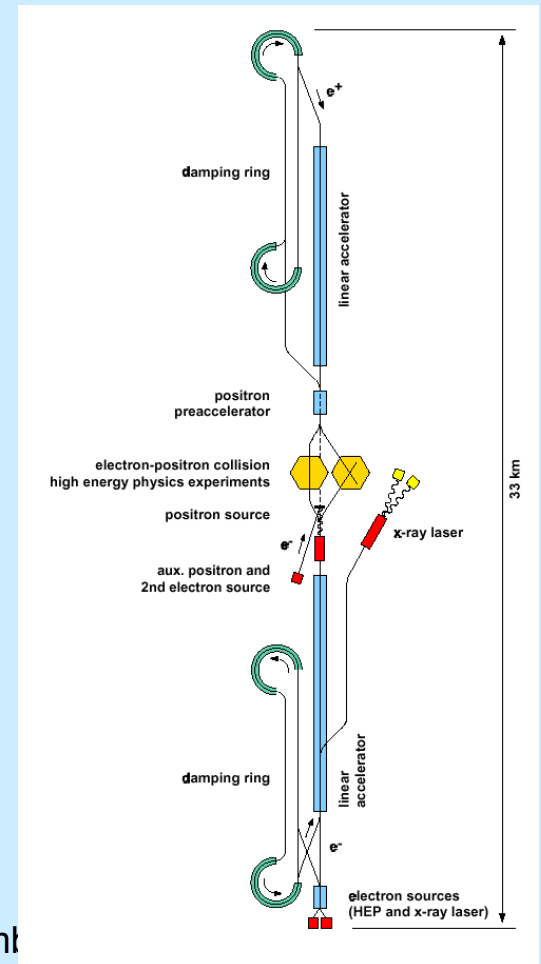
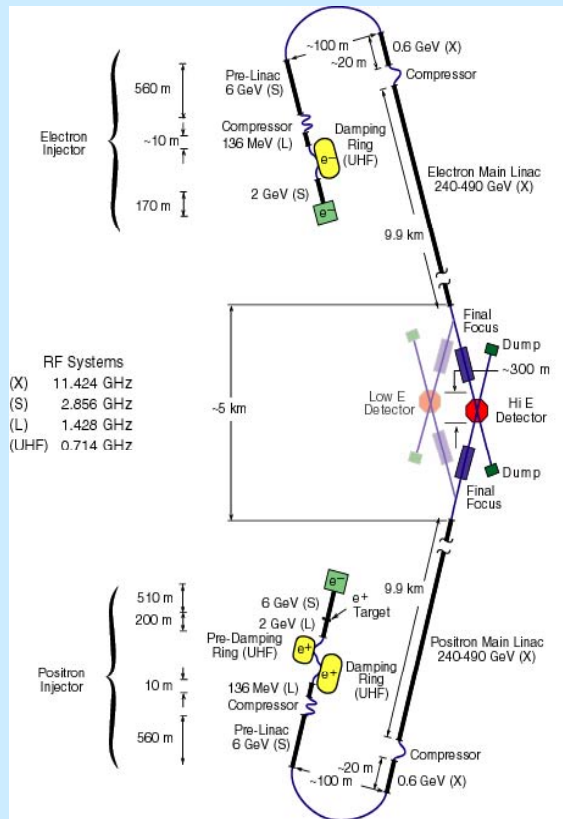
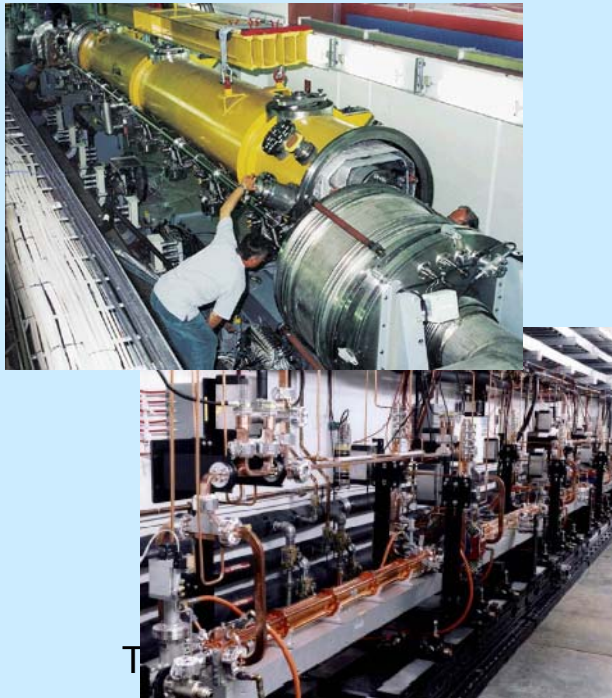
# Importance for community and TRIUMF

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- To retain its stature and excellence in HEP, Canada needs to participate in the forefront international particle physics programs
  - can we afford to not be part of this effort?
- Relevance to TRIUMF's mandate:
  - Since 1995, TRIUMF is the Canadian “gateway to international facilities in subatomic physics”
    - Up until now: LHC contributions, required for access to the physics program: \$40M
    - LC contributions fit naturally into this framework: give access to physics program and provide new technically challenging projects for Canadian industry

# What is proposed?

- Linear colliders have been proposed in:
  - Europe (TESLA)
  - USA (NLC)
  - Asia (JLC)





# Status of proposals

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- TESLA:
  - Technical Design Report submitted to German Science Council in March 2001
  - Total cost: 3.1 B euro
  - Response from Council (July 2002) very positive
  - Expect to have decision from German government in 2003
- NLC:
  - Senate recommendation for \$5M (start Oct. 2002) for US to prepare a detailed design
    - working hard to complete proof of concept in 2003

# Who would get involved?

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- Already a core Canadian group involved:
  - Magnet vibration control system:
    - NSERC operating grant
    - T. Mattison (UBC)
      - studying the feasibility of a 10 m baseline laser interferometer to control the vibration of heavy objects at the nanometer scale
  - TPC readout using micropattern gas detectors:
    - NSERC operating grant
    - Carleton/TRIUMF: R. Carnegie, M. Dixit, H. Mes  
Montreal: J.P. Martin
    - Victoria/TRIUMF: D. Karlen
    - exploring the capabilities of GEM and Micromegas devices to provide high resolution readout in TPCs

# Who would get involved?

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- IOF grant (2002/3):
  - *Carleton University:* R. Carnegie, M. Dixit, S. Godfrey, P. Kalyniak, H. Mes
  - *TRIUMF:* E. Blackmore
  - *McGill University:* F. Corriveau
  - *UBC:* T. Mattison
  - *University of Montreal:* J. P. Martin
  - *University of Toronto:* J. Martin, W. Trischuk
  - *University of Victoria:* D. Karlen, M. Roney
  - *York University:* S. Bhadra
- Once approval comes, expect rapid growth:
  - good match to Canadian expertise (LEP, Babar, ...)
  - new faculty hires in coming years, new TRIUMF & IPP RS
  - could eventually grow to size comparable to ATLAS/Canada

# What resources are requested?

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- Accelerator R&D and construction
  - existing TRIUMF expertise is relevant for a number of projects under consideration:
    - design of kicker magnets for damping rings and the associated fast switches using power semiconductors (IGBTs)
    - beam dynamics, lattice calculations
    - precision magnet systems
    - vibration control systems (Tom Mattison)
    - superconducting cavities
- Detector R&D and construction
  - facilities and personnel

# What resources are requested?

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- Proposal for Accelerator effort:
  - form a small group of accelerator physicists, engineers, and designers to join the TESLA and JLC/NLC collaborations
  - in coordination with TRIUMF management, identify a small set of R&D projects, matched to expertise
  - some of the R&D projects will naturally lead to in-kind contributions to the accelerator during its construction in the latter part of the 5 year plan

# What resources are requested?

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- Proposal for Accelerator effort:
  - The scale of the effort: determined by the eventual size of the Canadian LC group
    - useful precedent: ATLAS/Canada
      - the machine costs for LHC & LC are similar
      - the eventual Canadian fraction would be similar
      - Canada contribution to LHC: \$40 M
      - construction period of LC: 8 years
    - suggests an annual in-kind contribution (capital and salaries) of \$3-4M in the out years of the five year plan
  - need to start with an initial project definition team of around 5 people, and grow as needed

# Funds requested from other agencies?

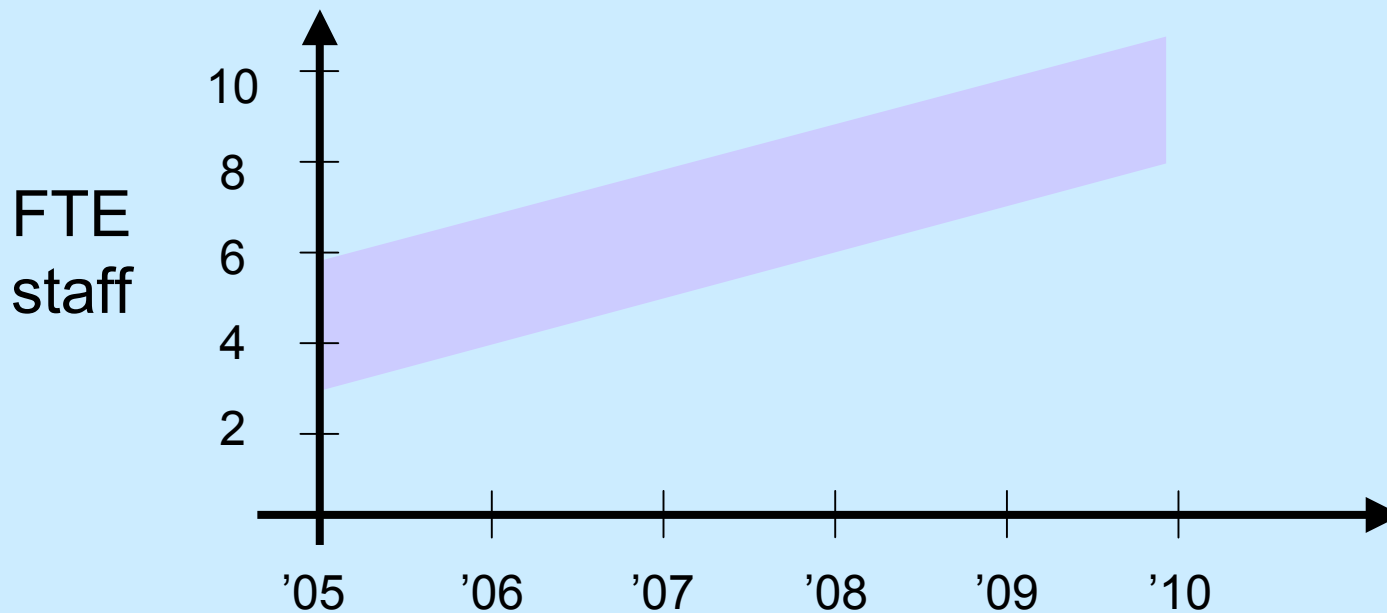
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- NSERC now funds:
  - initial efforts for establishing a Canadian group in a future LC experiment
  - TPC detector R&D
  - magnet vibration control systems
- Funds will be requested from NSERC for:
  - capital costs for detector contributions
  - operating costs for the experimental group

# When are these resources required (time line)?

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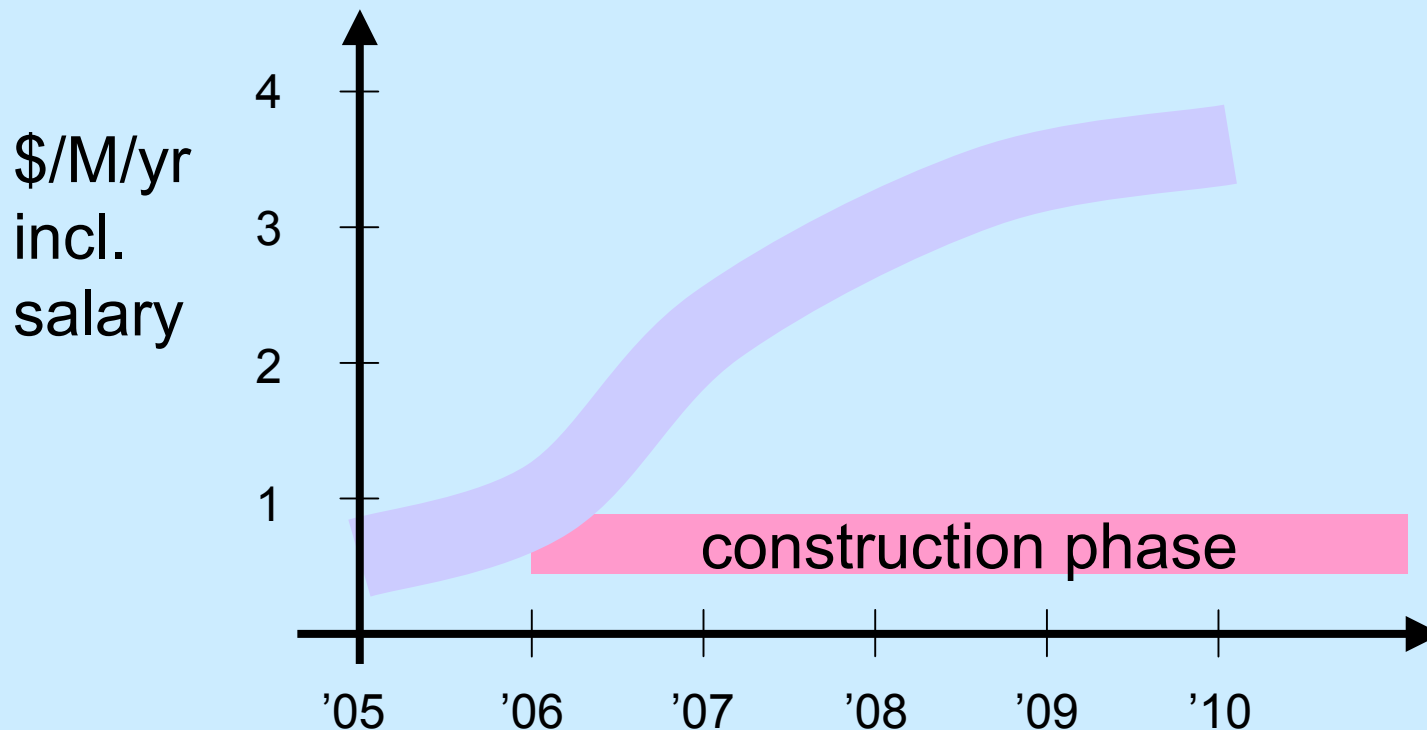
- A rough estimate of the staff requirements:





# When are these resources required (time line)?

- A rough estimate of the total contribution per year.



# Summary

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- The Linear Collider stands to be the next frontier particle physics facility
- For Canada to maintain excellence in HEP research, it will be essential for TRIUMF to devote significant resources to this project
- The Linear Collider provides an opportunity for TRIUMF to increase its stature as a world class accelerator laboratory