US ILC Detector R&D

Jim Brau
UNIVERSITY OF OREGON

June 19, 2007

DOE/NSF Review, Argonne

American Linear Collider Physics Group

US ILC Detector R&D

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- ILC Physics Goals set by the collider parameters and physics goals depend on detector requirements that are beyond the state-of-the-art
- These detector requirements differ in many respects from the LHC (lower rates and radiation - high precision)
- Global community is moving forward to develop capabilities
- US community is integrated with world-wide effort,
  but US effort has been limited by level of resources so far

OUTLINE OF INTRODUCTION

Physics requirements for ILC detectors
History of US LCDRD program
Global coordination of R&D (World Wide Study)
Detector concepts
Roadmap to mature detector designs (engineering)

ILC Physics Goals

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- **EWSB**
  - Higgs
    - Mass (~50 MeV at 120 GeV)
    - Width
    - BRs (at the few% level)
    - Quantum Numbers (spin/parity)
    - Self-coupling
  - Strong coupling (virtual sensitivity to several TeV)
- **SUSY particles**
  - Strong on sleptons and neutralinos/charginos
- **Extra dimensions**
  - Sensitivity through virtual graviton
- **Top**
  - Mass measured to ~ 100 MeV (threshold scan)
  - Yukawa coupling
- **W pairs**
  - W mass

Constrained Initial State & Simple Reactions

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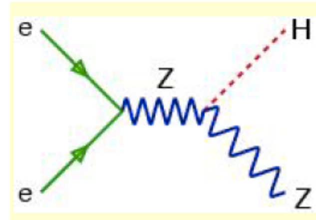
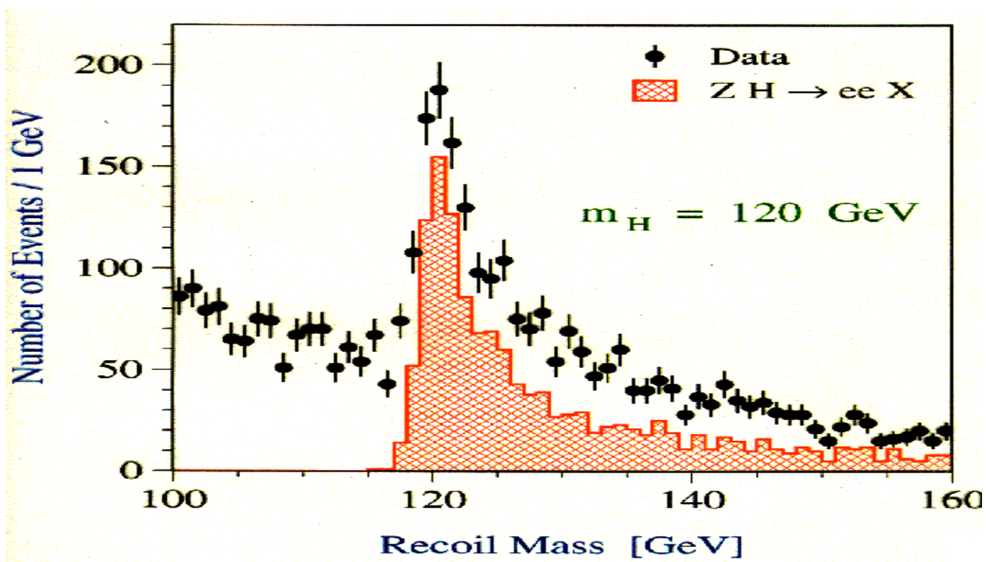
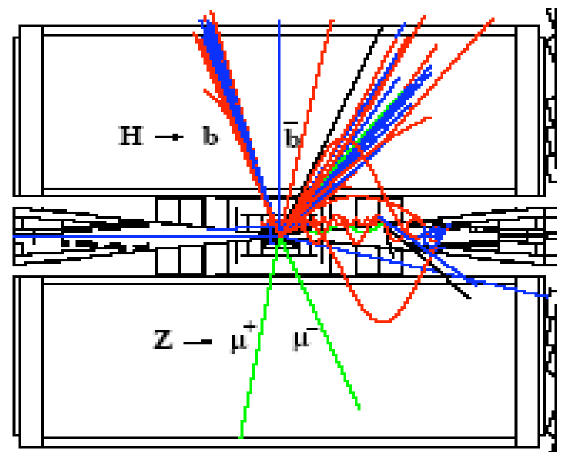
- •Well defined initial state
- •Democratic interactions



Higgs recoiling from a Z, with known CM energy⇓, provides a powerful channel for unbiassed tagging of Higgs events, allowing measurement of <u>even invisible decays</u> (⇓ - some beamstrahlung)





500 fb^{-1} @ 500 GeV, TESLA TDR, Fig 2.1.4

Demands Precise Tracking

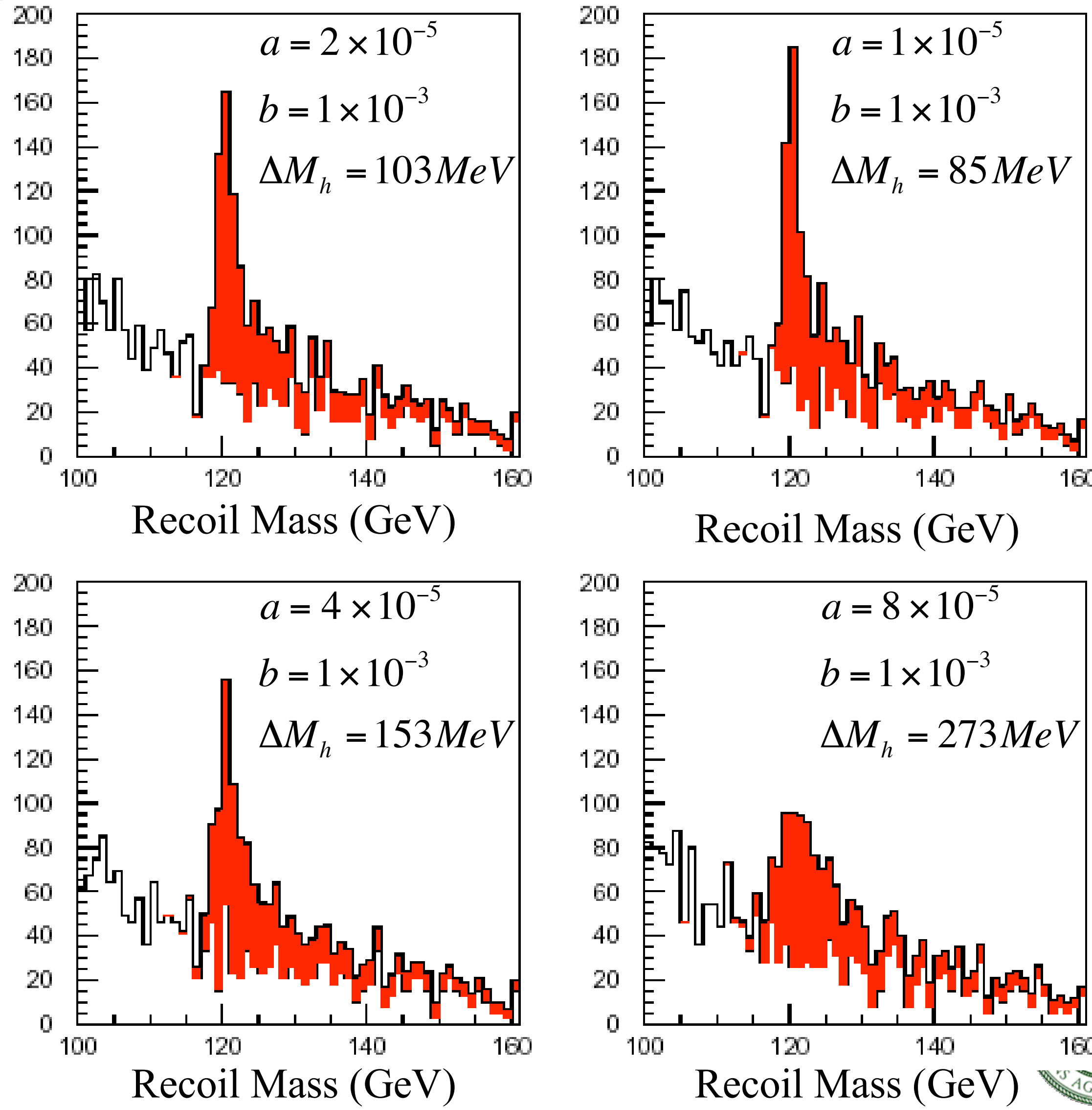
Effect of Tracking Resolution

$$e^+e^- \to Zh \to \mu^+\mu^- X$$

$$\sqrt{s} = 350 GeV$$

$$L = 500\, fb^{-1}$$

$$\frac{\delta p_t}{p_t^2} = a \oplus \frac{b}{p_t \sin\theta}$$



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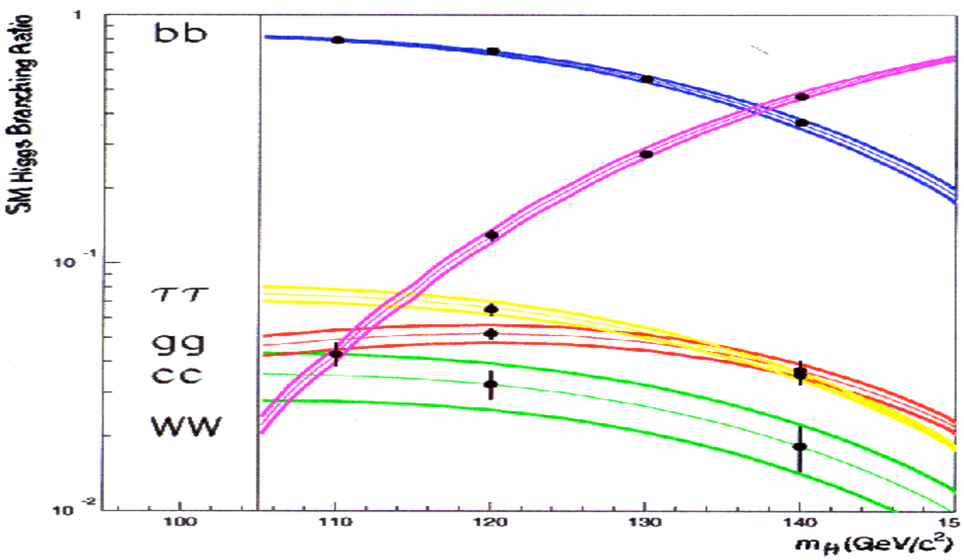
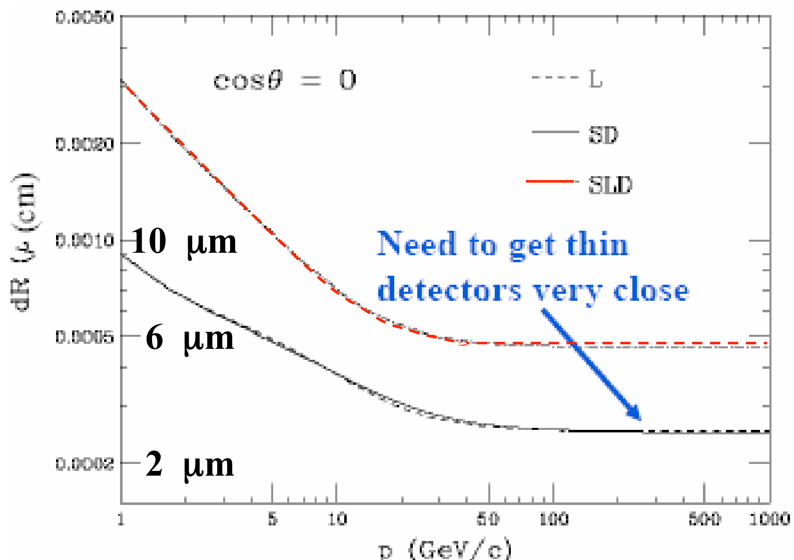
The Electroweak Precision Measurements Anticipate a Light Higgs – Then What?

- Measurement of BR's is powerful indicator of new physics
  e.g. in MSSM, these differ from the SM in a characteristic way.
- Higgs BR must agree with MSSM parameters from many other measurements.



Vertex Detector
Impact Parameter Resolution



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Is This the Standard Model Higgs?

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b vs. W

TESLA TDR, Fig 2.2.6

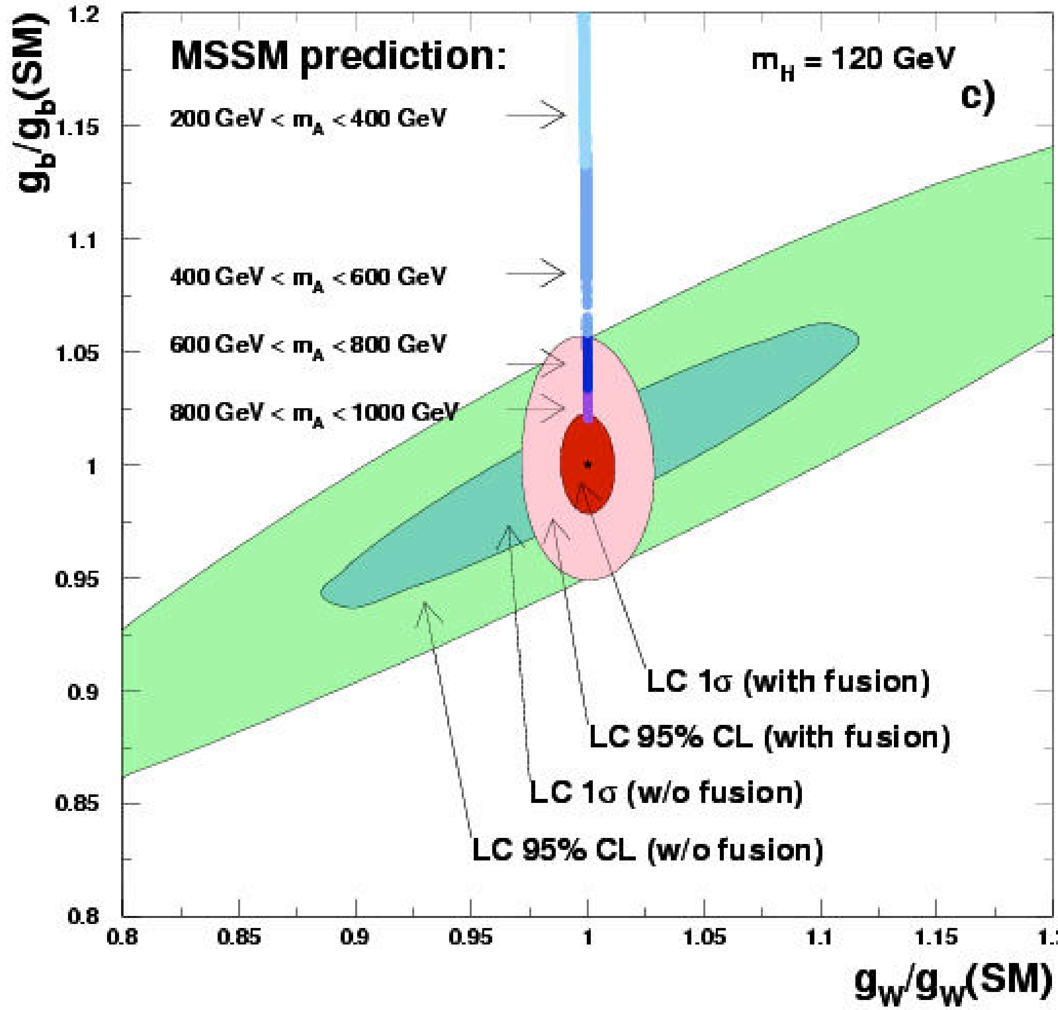
Arrows at:

M_A = 200-400
M_A = 400-600
M_A = 600-800
M_A = 800-1000

HFITTER output

conclusion:

for M_A < 600,
likely to distinguish



Supersymmetry at the Linear Collider

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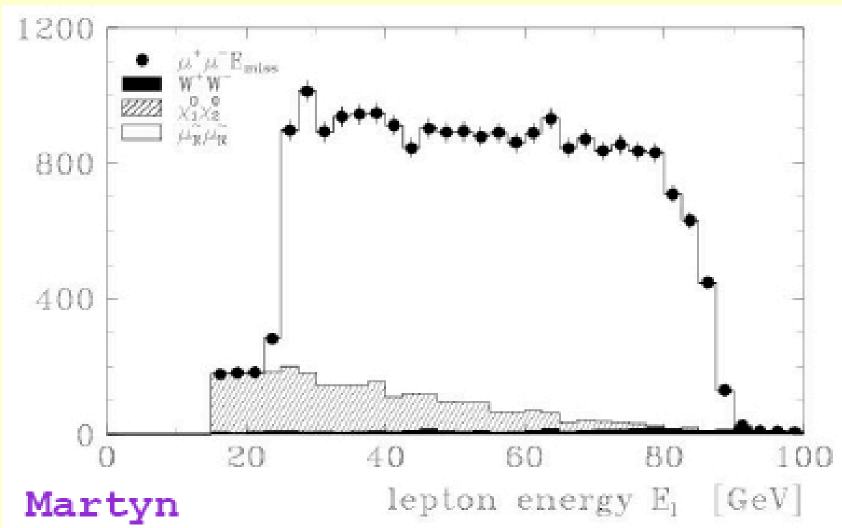
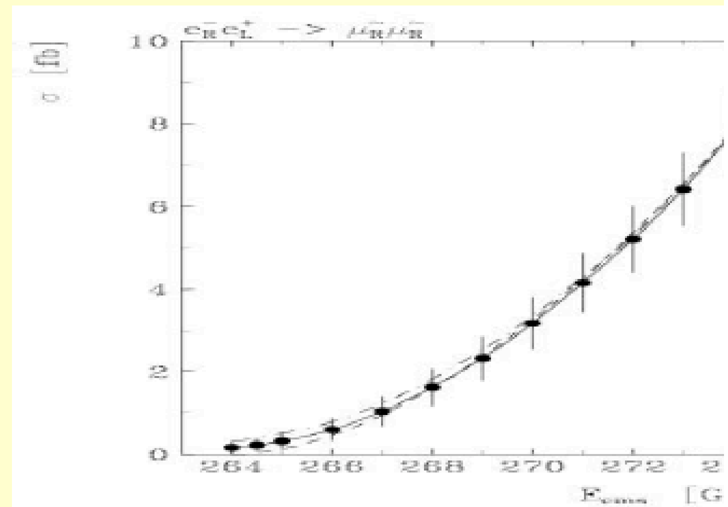
Clean signals from sleptons and charginos/neutralinos

in continuum:



and from threshold scan:



The Linear Collider and the LHC

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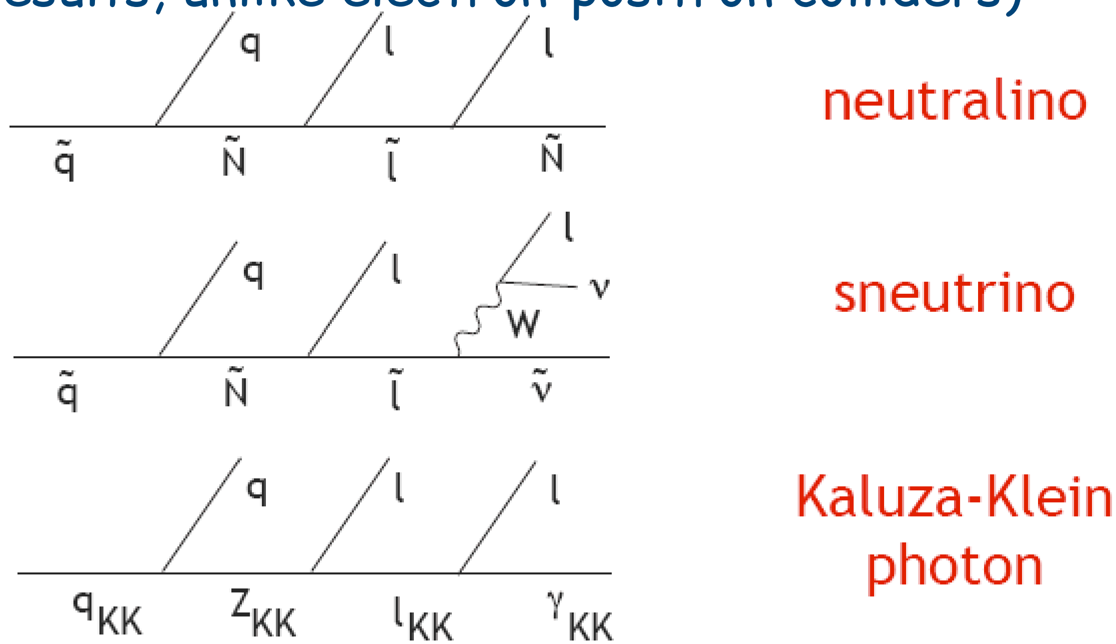
The Linear Collider would be able to distinguish these dark matter candidates, which might be indistinguishable at the LHC

(hadron colliders tend to produce model dependent results, unlike electron-positron colliders)



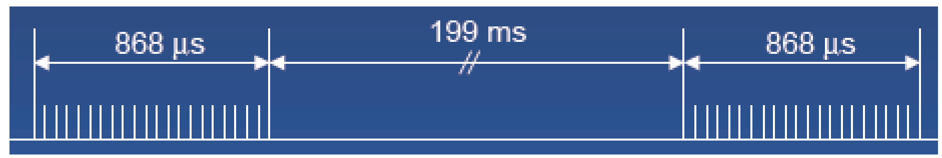
Peskin, Victoria ALCPG Workshop, July, 2004

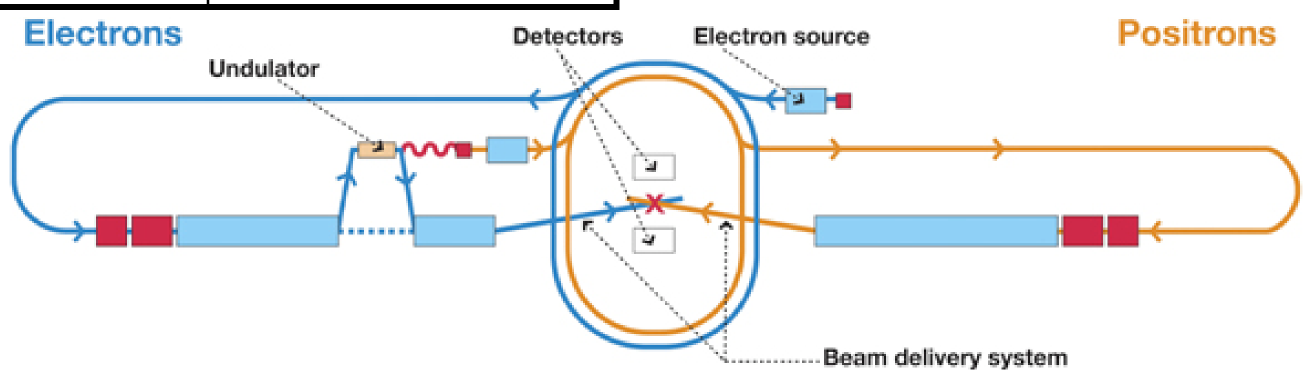
ILC Detector Requirements

- Two-jet mass resolution comparable to the natural widths of W and Z for an unambiguous identification of the final states.
- Excellent flavor-tagging efficiency and purity (for both b- and c-quarks, and hopefully also for s-quarks).
- Momentum resolution capable of reconstructing the recoil-mass to di-muons in Higgs-strahlung with resolution better than beam-energy spread.
- Hermeticity (both crack-less and coverage to very forward angles) to precisely determine the missing momentum.
- Timing resolution capable of separating bunch-crossings to suppress overlapping of events .

Collider Parameters

Machine parameter	value
#bunches/train	2820
#trains/sec	5
bunch spacing	308 nsec
bunches/sec	14100
length of train	868 μsec
train spacing	199 msec
crossing angle	0-20 mrad
Luminosity	2×10^{34} cm^{-2} s^{-1}





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Event Rates and Backgrounds

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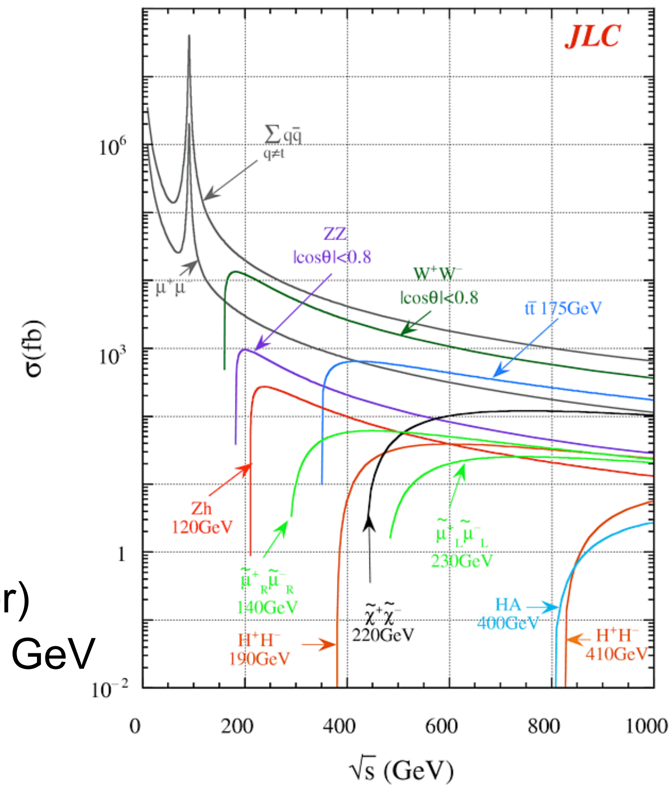
- **Event rates (Luminosity = 2 x 10^{34})**
  - $e^+e^- \rightarrow$ qq, WW, tt, HX
    - **~ 0.1 event / train**
  - $e^+e^- \rightarrow e^+e^- \gamma\gamma \rightarrow e^+e^-$ X
    - **~ 200 /train**



- **Background**
  - 6 x 10^{10} γ / BX (from synchrotron radiation, scatters into central detector)
  - 40,000-250,000 e^+e^- / BX (90-1000 TeV) @ 500 GeV
  - Muons: < 1 Hz/cm^2 (w/ beamline spoilers)
  - Neutrons: ~3 x 10^8 /cm^2/ yr @ 500 GeV

Ref: Maruyama, Snowmass 2005

By LHC standards, these are modest, allowing better detector performance

Collider defined by ILC Scope

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Important step in moving to a final design for the International Linear Collider was to establish the physics motivated Linear Collider Scope

- **BASELINE MACHINE**
  - E_{CM} of operation 200-500 GeV
  - Luminosity and reliability for 500 fb^{-1} in 4 years
  - Energy scan capability with <10% downtime
  - Beam energy precision and stability below about 0.1%
  - Electron polarization of > 80%
  - Two IRs with detectors
  - E_{CM} down to 90 GeV for calibration
- **UPGRADES**
  - E_{CM} about 1 TeV
  - Allow for ~1 ab^{-1} in about 3-4 years
- **OPTIONS**
  - Extend to 1 ab^{-1} at 500 GeV in ~ 2 years
  - e^-e^-, $\gamma\gamma$, $e^-\gamma$, positron-polarization
  - Giga-Z, WW threshold

Parameters for the Linear Collider

September 30, 2003

http://www.fnal.gov/directorate/icfa/LC_parameters.pdf

6.1 List of subcommittee members

Asia: Sachio Komamiya, Dongchul Son
Europe : Rolf Heuer (chair), Francois Richard
North America: Paul Grannis, Mark Oreglia

ILC Experimental Advantages

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Elementary interactions at known E_{cm}*
eg. $e^+e^- \rightarrow$ Z H
* beamstrahlung manageable

Democratic Cross sections
eg. $\sigma(e^+e^- \rightarrow ZH) \sim 1/2\ \sigma(e^+e^- \rightarrow d\bar{d})$

Modest backgrounds and radiation (vis a vis LHC)

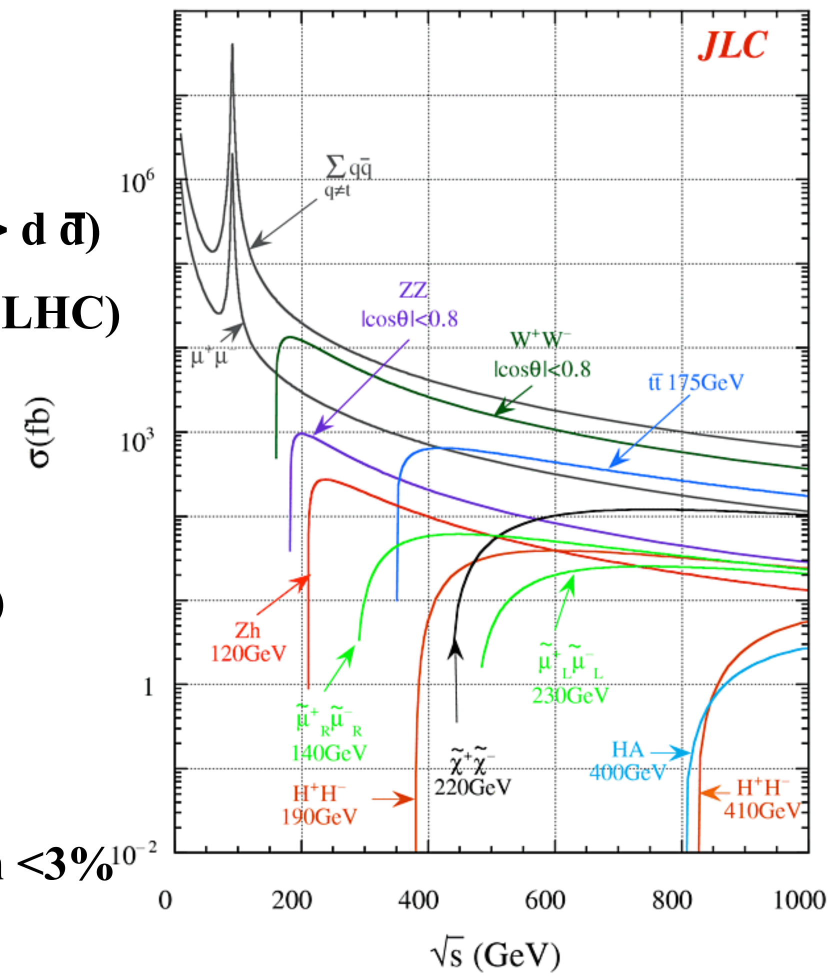
Inclusive Trigger
total cross-section

Highly Polarized Electron Beam
~ 80% (+ positron polar. – R&D)

Exquisite vertex detection
eg. $R_{beampipe} \sim 1$ cm and $\sigma_{hit} \sim 3\ \mu m$

Calorimetry with Jet Energy Precision
$\sigma_E/E \lesssim 30\%/\sqrt{E}$ up to 100 GeV, then <3%

Advantage on precision meas.
eg. $H \rightarrow c\ c$



Detector performance translates directly into effective luminosity

Detector R&D Required

- Performance requirements for ILC Detector exceed state-of-the-art
  - Calorimeters with ~100 million cells
    - Jet resolution goal ~ 30%/ √E
  - Pixel Vertex Detector with ~10^9 ≤ 20 μm pixels
    - Impact parameter resolution 5μm ⊕ 10μm/(p $\sin^{3/2}\theta$)
    - Sensitivity to full 1 msec bunchtrain
  - Tracking resolution
    - TPC
    - Silicon microstrips
    - $\sigma(1/p) \leq 5 \times 10^{-5}$ /GeV
  - High Field Solenoid ~ 5 Tesla
  - High quality forward tracking systems
  - Triggerless readout
- R&D Essential to Optimize Performance and Physics Yield

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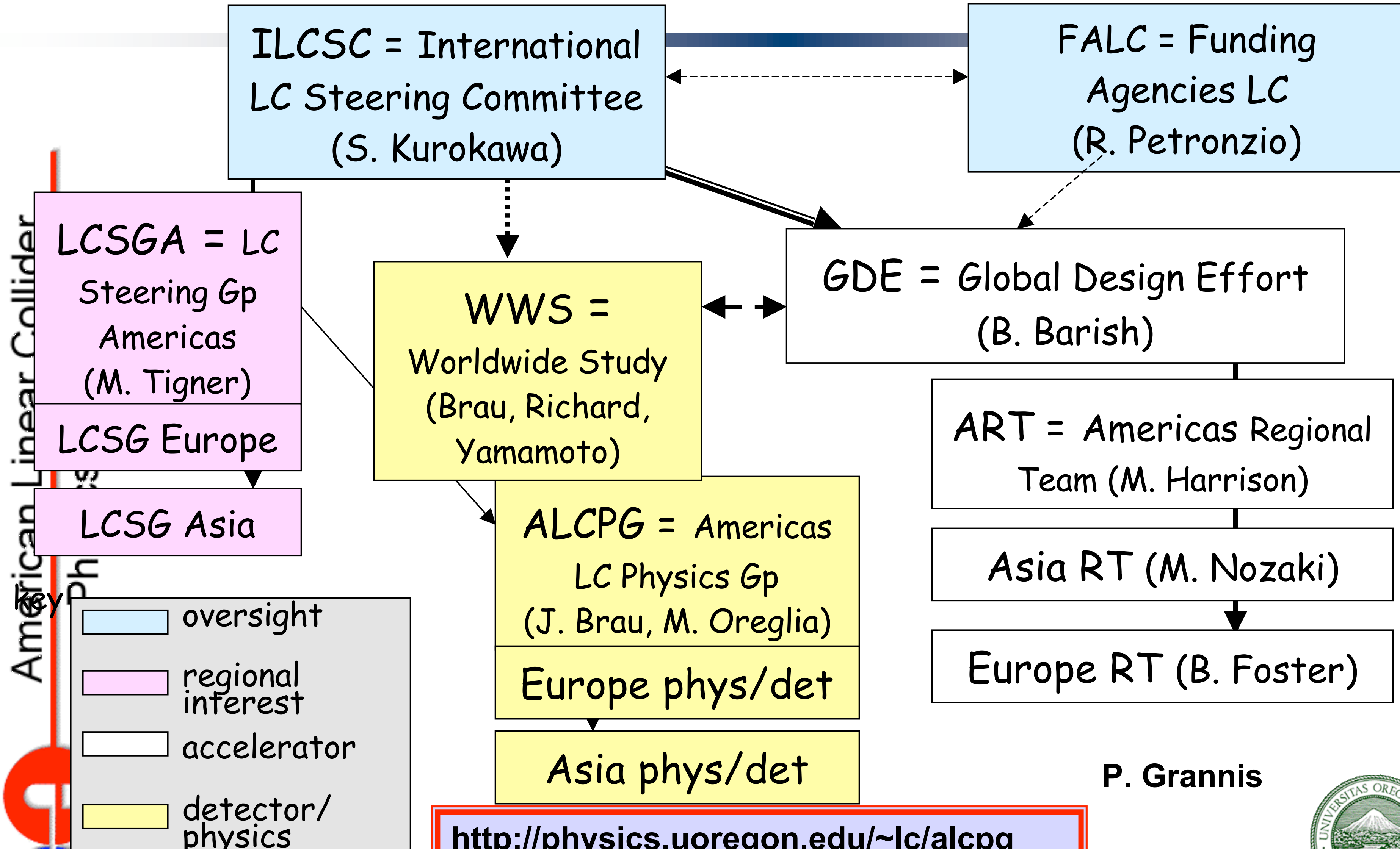
Global Organization



P. Grannis

http://physics.uoregon.edu/~lc/alcpg
http://physics.uoregon.edu/~lc/wwstudy

UNIVERSITY PROGRAM

- Pre-FY03
  - Program to support mostly simulation efforts
- FY03 and FY04
  - Begin funding of detector hardware efforts
  - UCLC/LCRD proposals prepared (univ. and small labs)
  - LCSGA review panel (H. Gordon et al.) recommendations

US Linear Collider Detector R&D

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- FY05
  - US community organized three year proposal
    - Individual PIs proposed projects and budgets
  - LCSGA organized process to recommend awards based on specified total DOE/NSF funding level (integrated process)
  - Joint DOE/NSF review by the agencies
  - 3 year umbrella grant to Oregon (sub-awards)
- FY06
  - US community organized 2nd year project proposals
  - LCSGA process to recommend sub-awards
  - NSF and DOE agree on sub-awards
- FY07
  - Similar process
  - Includes separate supplementary funding for high priorities

LCDRD Program

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Topic	FY05		FY06		FY07	
	$0.817M		$1.348M		$2.175M	
LEP	**5**	**15%**	**6**	**13%**	**6**	**13%**
VXD	**1**	**9%**	**4**	**13%**	**4**	**14%**
TRK	**8**	**32%**	**8**	**22%**	**9**	**18%**
CAL	**9**	**41%**	**13**	**45%**	**11**	**49%**
PID(mu)	**2**	**4%**	**2**	**6%**	**3**	**6%**
projects	25		33		33	
NSF	$0.117M		$0.300M		$0.375M	
DOE	$0.700M		$1.048M		$1.800 M	
UO umbrella	$0.797M		$1.257M		$1.833M	
direct to labs	$0.020M		$0.091M		$0.342M	

Linear Collider Detector R&D – FY05

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Luminosity, Energy, Polarization

3.1 John Hauptman Gas Cerenkov Cal for Lum Measm't
3.4 Eric Torrence Extraction Line Energy Spectrometer
3.5 Mike Hildreth BPM-Based Energy Spectrometer
3.7 William Oliver Compton polarimeter backgrounds
3.8 Giovanni Bonvicini Incoherent and coherent beamstrahlung

Vertex

4.1 Charlie Baltay Pixel Vertex Detector

Tracking

5.2 Lee Sawyer GEM based Forward Tracking
5.7 Dan Peterson MPGD Readout for a TPC
5.8 Keith Riles Tracker Simulation and Alignment Sys.
5.10 Bruce Schumm Long Shaping-Time Silicon Strip
5.13 Stephen Wagner Reconstruction Studies for SiD Trk
5.14 Richard Partridge Simulation Studies for a Silicon Tracker
5.15 Eckhard von Toerne Calor-based Tracking/Long-lived Part.
5.17 Dan. Bortoletto Thin silicon sensors

Linear Collider Detector R&D – FY05 (cont.)

Calorimetry

6.1 Vishnu Zutshi	Scintillator-based Tail-ctchr/Muon Trkr
6.2 Uriel Nauenberg	Calorimetry R&D
6.4 Usha Mallik	Particle Flow Studies
6.5 Raymond Frey	Silicon-tungsten EM calorimeter
6.6 Andy White	Digital Hadron Calorimetry w/ GEMs
6.9 Dhiman Chakraborty	Particle-Flow Algorithms and Sim.
6.10 Graham Wilson	ECAL Concepts for Particle Flow
6.14 José Repond	Had Cal with Digital Readout (RPCs)
6.16 Richard Wigmans	Dual-Readout Calorimetry

Muon

7.2 Paul Karchin	Scintillator Based Muon System
7.5 Robert Wilson	Geiger-Mode APDs for Muon Sys.

Linear Collider Detector R&D – FY06

American Linear Collider Physics Group

Luminosity, Energy, Polarization	
3.1 John Hauptman	Gas Cerenkov Cal for Lum Measm't
3.4 Eric Torrence	Extraction Line Energy Spectrometer
3.5 Mike Hildreth	BPM-Based Energy Spectrometer
3.6 Yasar Onel	Polarimetry
3.7 William Oliver	Compton polarimeter backgrounds
3.8 Gio. Bonvicini	Incoherent and coherent beamstrahlung
Vertex	
4.1 Charlie Baltay	Pixel Vertex Detector
4.2 Marco Battaglia	Monolithic Pixel Detector Module
4.4 Henry Lubatti	Vertex Detector Mech. Structures
4.5 Gary Varner	Pixel-level Sampling CMOS VxDet
Tracking	
5.2 Lee Sawyer	GEM-based Forward Tracking
5.7 Dan Peterson	MPGD Readout for a TPC
5.8 Keith Riles	Tracker Simulation and Alignment Sys.
5.10 Bruce Schumm	Long Shaping-Time Silicon Strip
5.13 Stephen Wagner	Reconstruction Studies for SiD Trk
5.15 Eckh. von Toerne	Calor-based Tracking-Long-lived Part.
5.17 Dan. Bortoletto	Thin silicon sensors
5.19 Dan Peterson	TPC signal digitization

Linear Collider Detector R&D – FY06 (cont.)

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Calorimetry

6.1 Vishnu Zutshi	Scintillator-based Hadron Calorimeter
6.2 Uriel Nauenberg	Scintillator EM/Had Cal and BeamCal
6.4 Usha Mallik	Particle Flow Studies
6.5 Raymond Frey	Silicon-tungsten EM calorimeter
6.6 Andy White	Digital Hadron Calorimetry w/ GEMs
6.9 Dhi. Chakraborty	Particle-Flow Algorithms and Sim.
6.10 Graham Wilson	ECAL Concepts for Particle Flow
6.14 José Repond	Had Cal with Digital Readout (RPCs)
6.18 John Hauptman	New Concept Detector
6.19 A.J.S. Smith	Calorimeter and Muon ID
6.20 Tianchi Zhao	Scint/Cheren Rad Plates Cal w/ SiPMs
6.21 Satish Dhawan	Modular DAQ Development
6.22 Gerry Blazey	Scintillator-based Tail-catcher/Muon Tracker

Muon

7.2 Paul Karchin	Scintillator Based Muon System
7.5 Robert Wilson	Geiger-Mode APDs for Muon Sys.

FY07 LC Detector R&D

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LCDRD organized in anticipation for increased funding in FY07 – discussed $3M for LCDRD

(also, developed 5 year R&D plan)

Developed a proposal early for a few (9) high priority, urgent efforts (~$1M)

followed by annual round for another $2M

Supplemental proposal

1 – call for abstracts (received 22)

2 – selection of highest priorities/urgent needs (9)

http://physics.uoregon.edu/~lc/lcdrd/supplement-06a.html

Supplemental LCDRD Proposal

Process under the auspices of the LCSGA

1 – abstracts (received 22)

totaling about $10M over 2 years

2 – selection of highest priorities/urgent needs (9)

selection made by Oreglia/Weerts/White/Karlen,

chaired by Brau

consensus by four made it unnecessary

for chair to "vote"

Proposal submitted to DOE and NSF

agency review to decide on funding of projects

http://physics.uoregon.edu/~lc/lcdrd/supplement-06a.html

Supplemental LCDRD Proposal

SELECTION CRITERIA

1. **Is the focus of the R&D project addressing a critical need of the ILC detectors?**
   1. critical, very high priority   2. important, priority
   3. useful   4. irrelevant

2. **What does this project provide which is unique to the ILC detector R&D effort?**

3. **How urgent is the planned R&D with the support proposed? Consider a realistic level of support that might come from the supplemental program over 2 years, as well as the base support. Are there urgent steps being taken by this R&D?**
   1. extremely urgent   2. important, but only mildly urgent
   3. needed eventually   4. not needed at all

4. **Deliverables - will the R&D supported with the funding result in significant deliverables?**
   What deliverables?

5. **Rating - overall quality of the research plan and goals, and the strength of the team to carry out the objectives**
   1. excellent   2. good
   3. satisfactory   4. poor

http://physics.uoregon.edu/~lc/lcdrd/supplement-06a.html

Supplemental LCDRD Proposal

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- High Performance Digital Hadron Calorimetry for the International Linear Collider
  PI - J. Repond
- Development of a Silicon-tungsten Test Module fo an Electromagnetic Calorimeter
  PI - R. Frey
- TPC Development
  PI - D. Peterson
- Pixel Vertex Detector R&D for Future High Energy Linear e+e- Colliders
  PI - C. Baltay
- Energy Spectometers for the International Linear Collider
  PI - E. Torrence/M. Hildreth
- Pixel-level Sampling CMOS Vertex Detector for the ILC
  PI - G. Varner
- Detector to Measure the Beam-strahlung Gammas
  PI - W. Morse
- Long Shaping-Time Silicon Microstrip Readout
  PI - B. Schumm
- Scintillator Based Muon System R&D
  PI - P. Karchin

2 VXD
2 TRK
3 CAL
1 Muon
1 LEP

This balanced distribution was not by design

http://physics.uoregon.edu/~lc/lcdrd/supplement-06a.html

FY07 Proposal

http://physics.uoregon.edu/~lc/lcdrd/detector-fy07.html

- For inclusion in proposal to NSF and DOE for 3rd year of umbrella grant

- Areas of Detector R&D included in the scope of the umbrella grants:
  - 1. Luminosity, Energy, and Polarization measurements of the ILC beams at the interaction point
  - 2. Vertex detector development
  - 3. Tracking detectors, including solid state and gaseous devices
  - 4. Calorimeters for measurement of energy of high energy neutral and charged particles, and particle jets
  - 5. Muon detectors and particle ID detectors

FY07 proposals & evaluation

- 40 projects for FY07 from univ. and “small” labs
- $4.843 M – modest requests limited by availability of funds
- 30 continuations of efforts supported in FY05
- 10 requests for new projects.

- Evaluation teams of 2-3 experts looking at each of the specific topics
- Executive committee of eight independently evaluated all of the proposals.

  (J. Alexander, J. Brau, M. Demarteau, D. Karlen, D. MacFarlane, M. Oreglia, R. van Kooten, H. Weerts)
  - Conflict of interest was considered carefully, and dealt with to avoid inappropriate influence in the review process.
- Evaluation of each proposal for the following factors:

  RATING: overall quality of the research plan and goals, and the strength of the team to carry out the objectives (excellent, good, satisfactory, poor)

  RELEVANCE: the relevance of the project to the linear collider detectors (critical, important, useful, irrelevant)

  CONCEPTS: the importance of the work (except for the LEP - luminosity, energy, polarization proposals) to an active linear collider detector concept (critical, important, useful, irrelevant)

critical that project contributes to advancing detector technology for specific sub-detector capabilities of priority for the ILC physics program

Linear Collider Detector R&D – FY07

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Luminosity, Energy, Polarization

3.4 Eric Torrence	Extraction Line Energy Spectrometer } **(also suppl. funding)**
3.5 Mike Hildreth	BPM-Based Energy Spectrometer } **(also suppl. funding)**
3.6 Yasar Onel	Polarimetry
3.7 William Oliver	Compton polarimeter backgrounds
3.8 Gio. Bonvicini	Incoherent and coherent beamstrahlung
3.9 Bill Morse	BeamCal and GamCal

Vertex

4.1 Charlie Baltay	Pixel Vertex Detector **(also suppl. funding)**
4.2 Marco Battaglia	Monolithic Pixel Detector Module
4.4 Henry Lubatti	Vertex Detector Mech. Structures
4.5 Gary Varner	Pixel-level Sampling CMOS VxDet **(also suppl. funding)**

Tracking

5.2 Lee Sawyer	GEM-based Forward Tracking
5.7 Dan Peterson	MPGD Readout for a TPC **(also suppl. funding)**
5.8 Keith Riles	Tracker Simulation and Alignment Sys.
5.10 Bruce Schumm	Long Shaping-Time Silicon Strip **(also suppl. funding)**
5.13 Stephen Wagner	Reconstruction Studies for SiD Trk
5.15 Eckh. von Toerne	Calor-based Tracking-Long-lived Part.
5.17 Dan. Bortoletto	Thin silicon sensors
5.19 Dan Peterson	TPC signal digitization
5.21 Richard Partridge	2-D Readout of Silicon Strip Detectors

Linear Collider Detector R&D – FY07 (cont.)

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Calorimetry	
6.1 Vishnu Zutshi	Scintillator-based Hadron Calorimeter
6.2 Uriel Nauenberg	Scintillator Had Cal w/ SiPDs
6.4 Usha Mallik	Particle Flow Studies
6.5 Raymond Frey	Silicon-tungsten EM calorimeter **(also suppl. funding)**
6.6 Andy White	Digital Hadron Calorimetry w/ GEMs
6.9 Dhi. Chakraborty	Particle-Flow Algorithms and Sim.
6.10 Graham Wilson	ECAL Concepts for Particle Flow
6.14 José Repond	Had Cal with Digital Readout (RPCs) **(also suppl. funding)**
6.18 John Hauptman	4th Concept Detector
6.19 A.J.S. Smith	Calorimeter and Muon ID
6.20 Tianchi Zhao	Scint/Cheren Rad Plates Cal w/ SiPMs
Muon	
7.2 Paul Karchin	Scintillator Based Muon System **(also suppl. funding)**
7.5 Robert Wilson	Geiger-Mode APDs for Muon Sys.
7.8 Henry Band	RPC and Muon System Studies

Linear Collider Detector R&D – FY07 (cont.)

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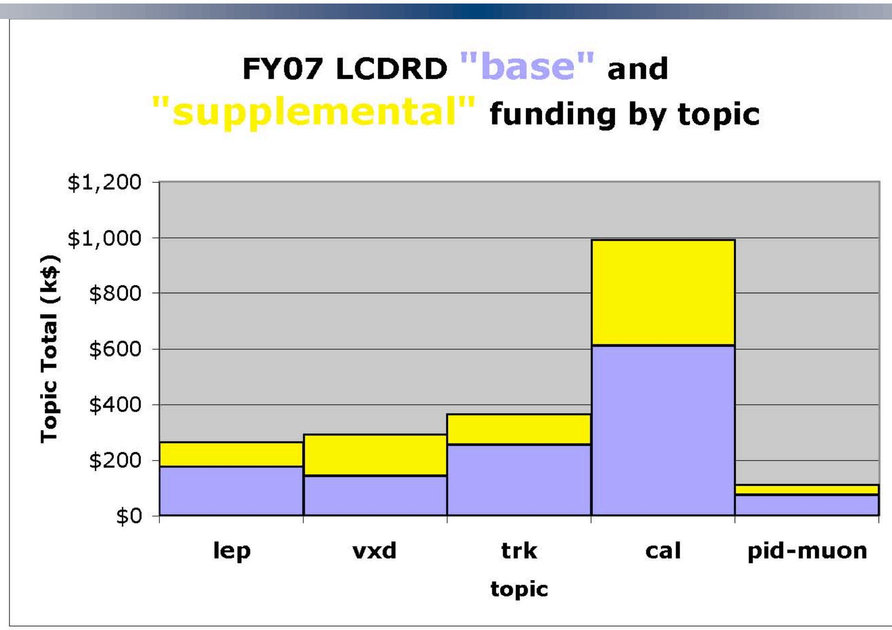

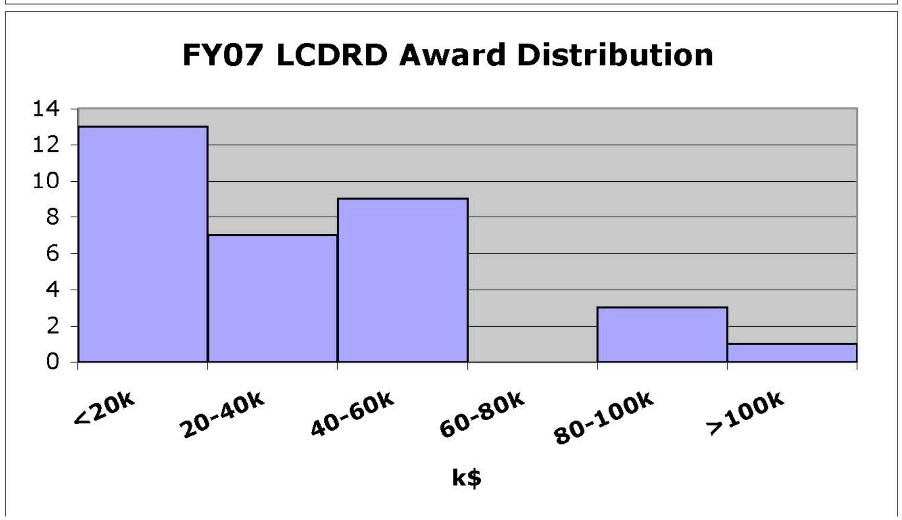

LAB Detector R&D (FY06)

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Estimates of funding prepared at DOE, but **not official**

	physicist FTE	engineer/ tech FTE	compute prof. FTE	admin FTE	total FTE	SWF $K	detector	travel	total M&S	Total K$
SLAC	7.15	0.38	3	0.55	11.08	2,007	427	32	460	2,467
LBNL (1)					2.79	335			145	480
FNAL (2)	4.1	7.1	0.	0.	11.2	1,635	370	50	420	2,055
Pixels	2.8	2.7	0.	0.	5.5	833	309	33	342	
HCAL	0.1	1.6	0.	0.	1.7	237	6	6	12	
Solenoid	0.3	0.4	0.	0.	0.7	100		3	3	
Test Beam	0.1	1.8	0.	0.	1.9	249	14		14	
Muon Syst	0.9	0.7	0.	0.	1.5	216	41	8	49	
ANL (3)					3.25	355	150		150	505
BNL (4)						100				
Lab Total					**28.27**	**4,332**			**1175**	**5,507**

(1) an old estimate from Jim Siegrist; not sure it is accurate
(2) PPD only; hope to increase FTE to 16. There may be <1 FTE not included from CD
(3) assumes get $100K from LDRD; took overhead factor as 1.33 for SWF to convert non-Ohd to Ohd bearing
(4) verbal estimate from Sally Dawson

Labs have independent organization
– but there is coordination and collaboration with LCDRD

WWS Detector R&D Panel

- **WWS Detector R&D Panel**

Charge:

- **Surveys ILC detector R&D**
- **Maintains registry of ongoing ILC detector R&D**
- **Critically reviews the status of ILC detector R&D**
- **Registers the regional review processes**
- **Organizes global reviews of ILC detector R&D**

Panel Membership:

- **Asia: Tohru Takeshita, HonJoo Kim, Yasuhiro Sugimoto**
- **Europe: Chris Damerell (chair), Jean-Claude Brient, Wolfgang Lohmann**
- **North America: Dean Karlen, Harry Weerts, Ray Frey**

D. Peterson was replaced by D. Karlen on R&D Panel after the ILC Detector R&D Report

- **https://wiki.lepp.cornell.edu/wws/bin/view/Projects/WebHome**

WWS Detector R&D Panel

American Linear Collider
Physics Group

- Report: ILC Detector R&D, January, 2006
  - http://physics.uoregon.edu/~lc/wwstudy/R&D Report-final.pdf
  - Survey of global needs and resources
  - Urgent needs require $32M and 1870 man-years over next 3-5 years
  - Established support over 3-5 years $15M and 1160 man-years
  - Translating man-years to dollars ($100k/man-year)
    - $33M/yr established over 4 years, and $22M/yr more required

Subdetector Distribution
(WWS R&D Panel)

Note Calorimetry and Vertexing

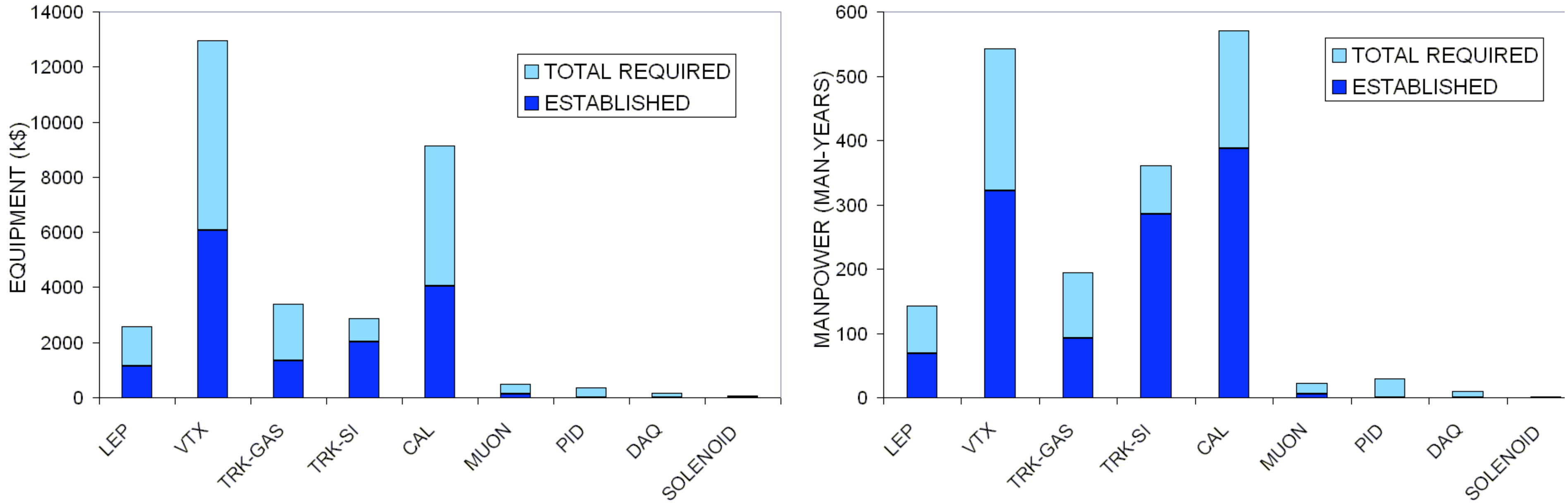


Fig 2. Urgent R&D support levels over the next 3-5 years, by subdetector type. 'Established' levels are what people think they will be able to get under current conditions, and 'total required' are what they would need to establish proof-of-principle for their project.

Global Perspective
(WWS R&D Panel)

US Detector R&D effort lags behind Europe

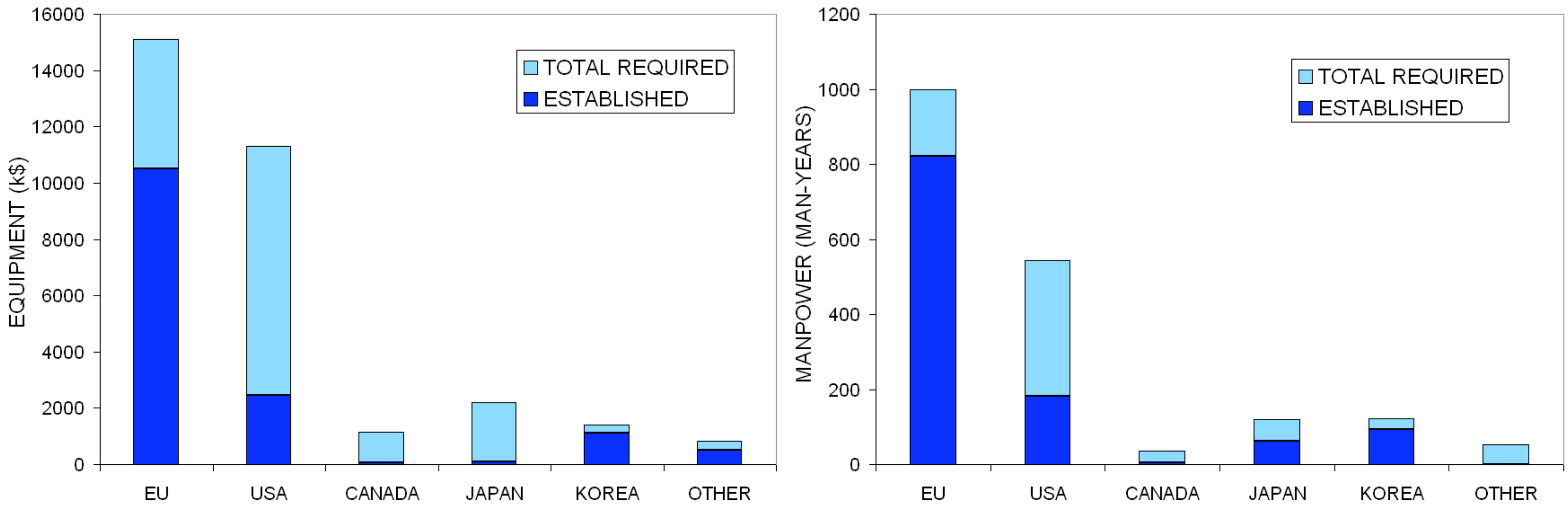


Fig 1. Urgent R&D support levels over the next 3-5 years, by funding country or region. 'Established' levels are what people think they will be able to get under current conditions, and 'total required' are what they would need to establish proof-of-principle for their project.

EUDET

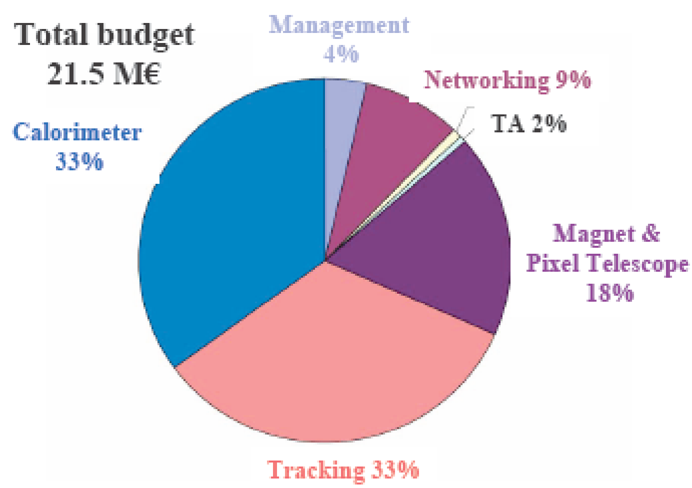
2003 CARE: Coordinated Accelerator Research in Europe
Integrated Infrastructure Initiative (I3)

2004 EUROTeV: European Design Study Towards a Global TeV Collider
Design Study

2005 EUDET: Detector R&D towards the International Linear Collider
Integrated Infrastructure Initiative (I3)

Budget:
- 21.5 million Euro total
- 7.0 million Euro EU

Manpower:
- ≈ 57 FTE total
- ≈ 17 FTE funded by EU



- most of the resources for the development of the infrastrutures
- 4 year program
  1/1/06 – 12/31/09
- Builds on many years of well funded R&D

NOTE – this is infrastructure
THERE IS MORE

ILC Detector R&D Reviews

- Initiated by WWS - place the R&D in global context
- Reviews
  - Beijing (Feb, 2007)--tracking
  - DESY (LCWS) (June 2007)--calorimetry
  - Fermilab (Oct. 2007)--vertexing
  - Asia (March 2008)--particle ID, muon tracking, solenoid, beam diagnostics, and DAQ
- Review teams
  - External reviewers (~8)
  - WWS R&D Panel members
  - GDE RDBoard chair
  - Connection to regional reviews such as DOE/NSF
- Reports
  - http://physics.uoregon.edu/~lc/wwstudy/detrdrev.html

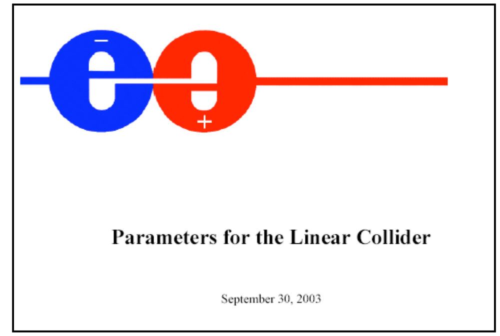
American Linear Collider Physics Group

ILC Designed for Two Contrasting and Complementary Detectors

American Linear Collider Physics Group

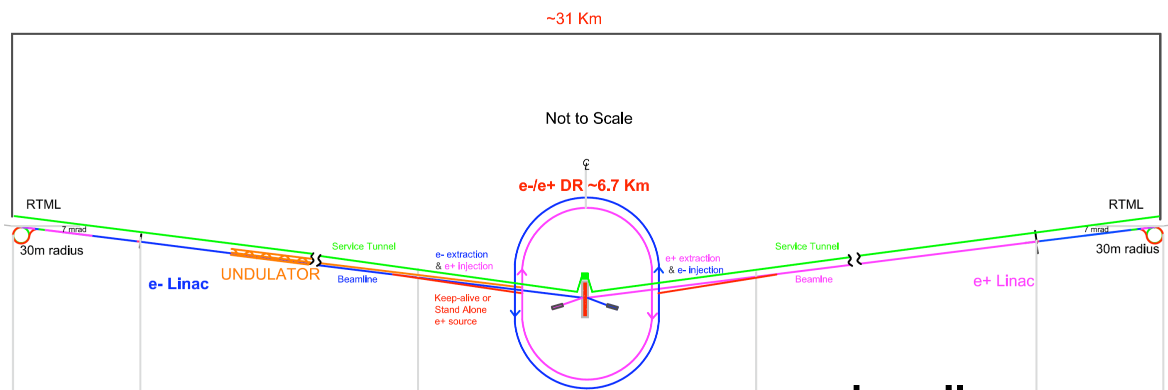
- ILCSC Scope Document

http://www.fnal.gov/directorate/icfa/LC_parameters.pdf


Parameters for the Linear Collider

September 30, 2003

- GDE IR Design

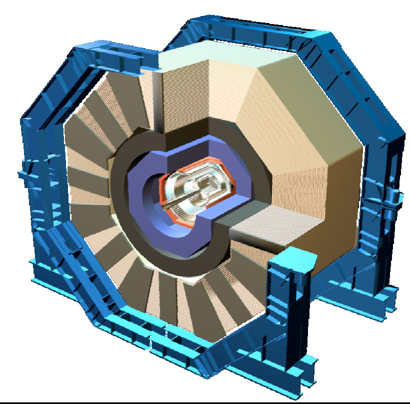


push-pull

Active full detectors being developed:

GLD
LDC
SiD
4th

Referred to as "concepts"



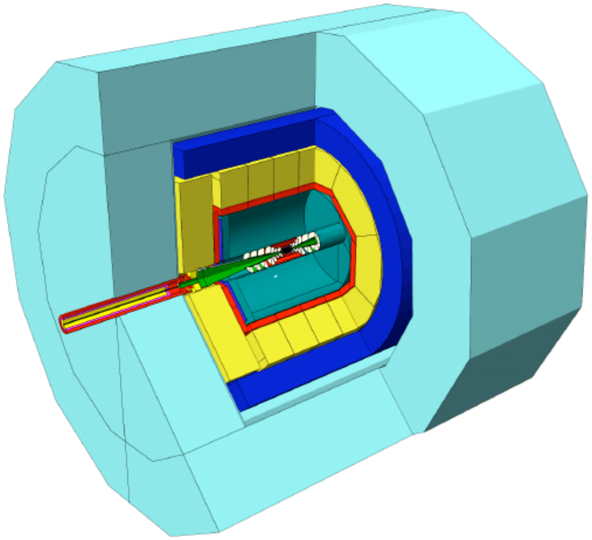
Two Detectors

- Complementarity
  (with contrasting detectors)
- Competition
- Cross check
- Efficiency
- Insurance
- Scientific Opportunity

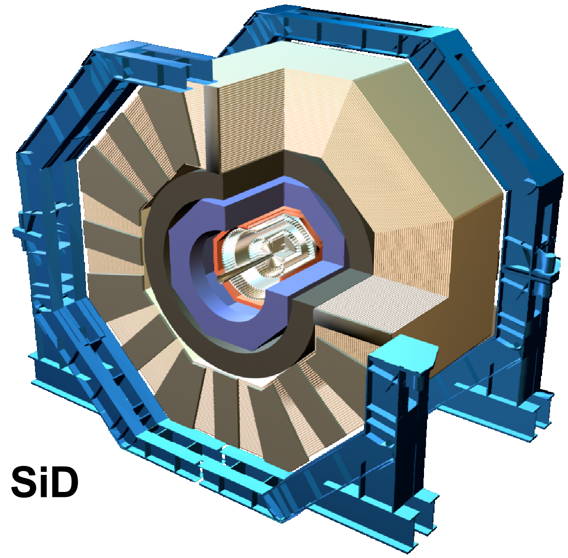
American Linear Collider Physics Group

The Concepts

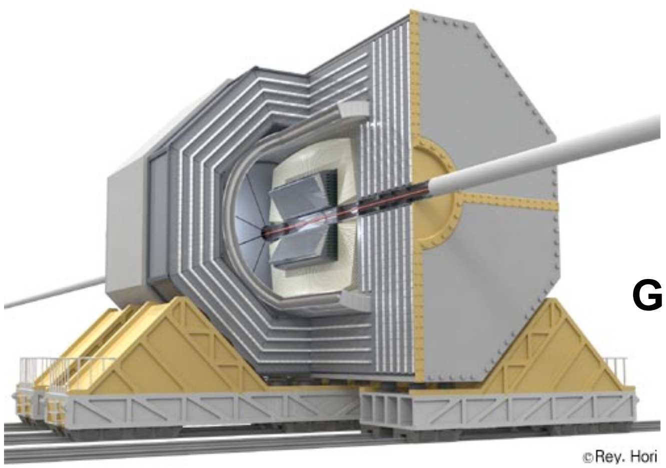
American Linear Collider
Physics Group



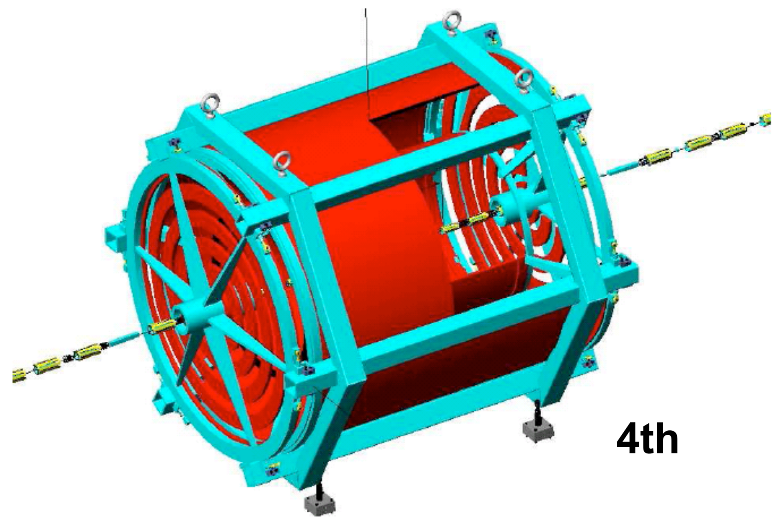
LDC



SiD



GLD



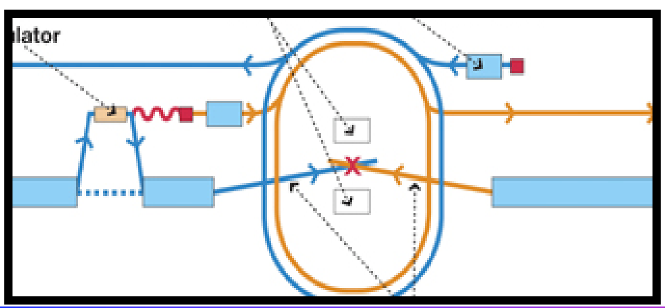
4th

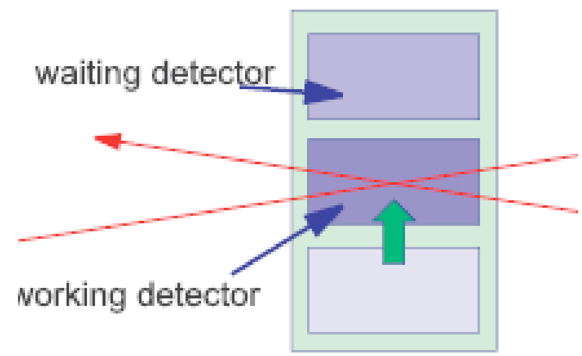
The Concepts

	Tracking	ECal Inner Radius	Solenoid	EM Cal	Hadron Cal	Other
SiD	silicon	1.27 m ↓	5 Tesla ↑	Si/W	Digital (RPC..)	Had cal inside coil
LCD	TPC gaseous	1.68 m ↓	4 Tesla ↑	Si/W	Digital or Analog	Had cal inside coil
GLD	TPC gaseous	2.1 m	3 Tesla	W/ Scin.	Pb/ Scin.	Had cal inside coil
4th	TPC gaseous	1.4 m	3.5/1.5	crystal	Multi-fiber readout	Double Solenoid (open mu)

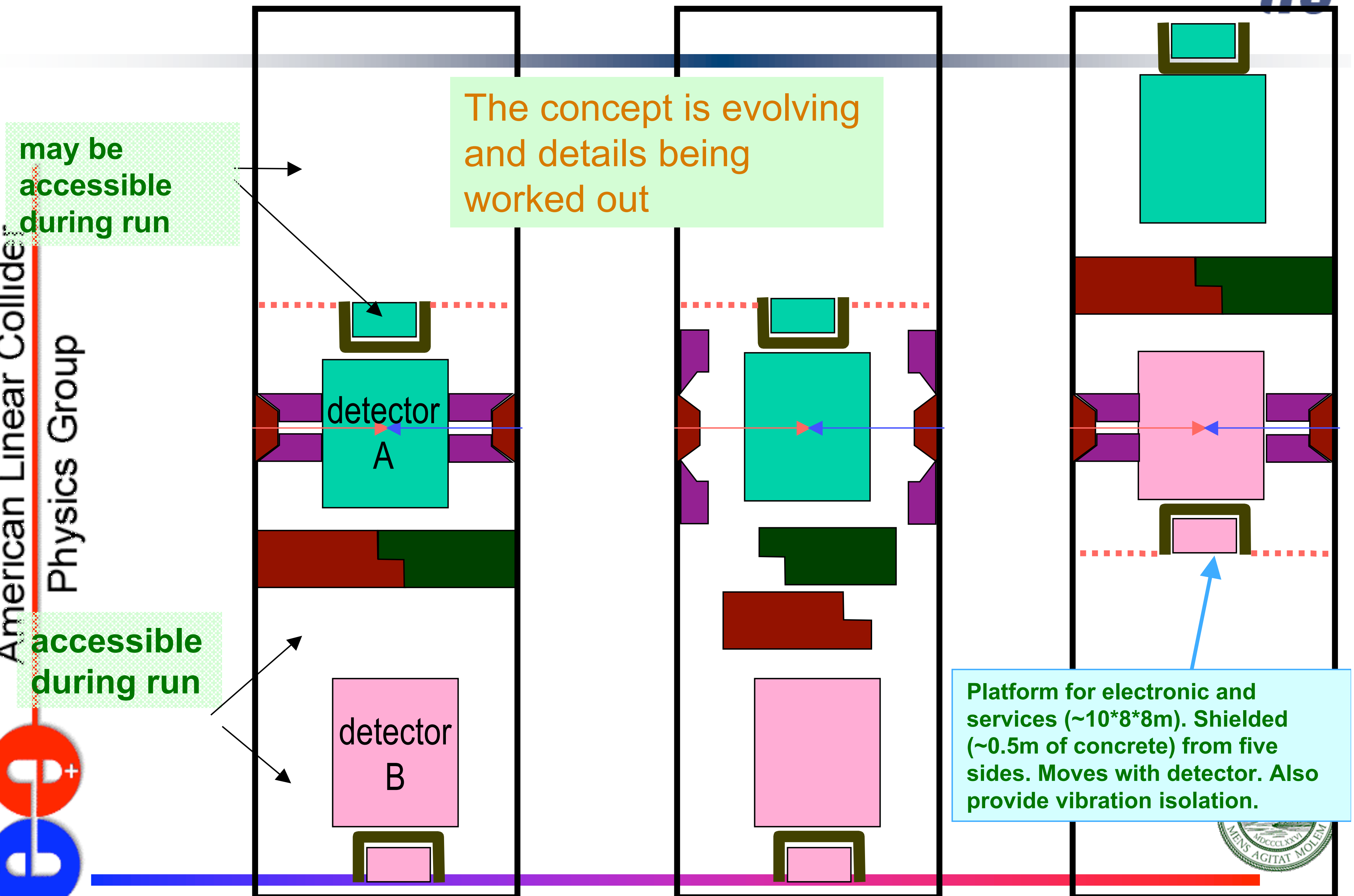
Single IR with Push-Pull Detectors

- Large cost saving compared with 2 IR
  - ~200 M$ compared with 2 IR with crossing angles 14/14 mrad
- Push-pull detectors
  - Task force from WWS and GDE formed
  - Quick conclusion is
    - **No show-stopper**
    - **But need careful design and R&D**
      - **—For example, need quick switch-over**
    - **2 IR should be kept as an 'Alternative'**





Concept of IR hall with two detectors



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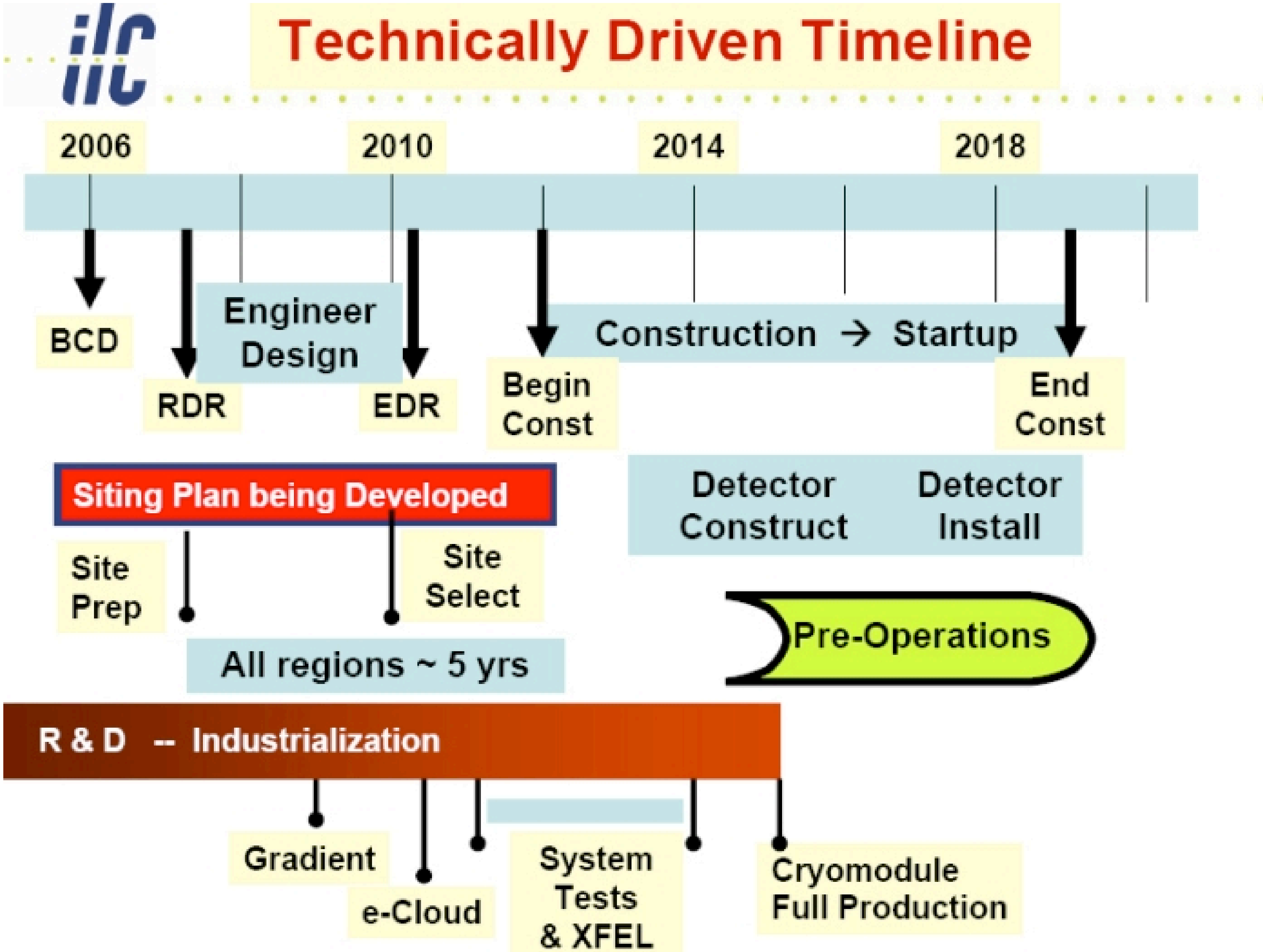
A. Seryi, Feb 4, 2007, Beijing



Technically Driven Timeline
2006
2010
2014
2018
BCD
RDR
Engineer Design
EDR
Construction → Startup
Begin Const
End Const
Siting Plan being Developed
Site Prep
Site Select
All regions ~ 5 yrs
Detector Construct
Detector Install
Pre-Operations
R & D -- Industrialization
Gradient
e-Cloud
System Tests & XFEL
Cryomodule Full Production

Roadmap

- GDE plans an Engineering Design Report in 2010
  - Ready for proposal for construction approval
- Detectors must maintain pace of the machine
  - Synchronize
- Request to World Wide Study from ILCSC

Roadmap

American Linear Collider Physics Group

Shin-ichi Kurokawa, ILCSC Chair
Albrecht Wagner, ICFA Chair

Subject: Letter to WWS Co-Chairs

- 26 February 2007
- To: Co-Chairs of the WWS International Organizing Committee
- From: ILCSC

- **The realization of the International Linear Collider has taken major steps forward in recent years.** This could not have happened without the leadership taken coherently by the particle physics community, within the framework of ICFA. Unprecedented collaborative steps have been necessary, and the community has adapted successfully to what, in some regions, required major redirections of traditional accelerator R&D effort.
- Two major milestones, the selection of the main-linac RF technology and the GDE's announcement of the RDR budget and associated design choices, keep the GDE on pace to **complete a construction-ready engineering design for the ILC accelerator-complex by 2010**.
- Maintaining this momentum requires also that the equivalent strategic decisions and the level of technical maturity for the two ILC detector proposals keep pace with the accelerator schedule. Major progress in this regard is ongoing under the auspices of WWS. In addition, **a definite plan together with milestones is needed to have detector designs of a maturity similar to that of the accelerator by 2010.** This needs an enhanced effort by the community. ILCSC will support the formation of an International Detector Advisory Group to assist this effort. ICFA looks forward to receiving such a plan from WWS at the June 1, 2007 ILCSC meeting at DESY.

Roadmap

March 2006 - **Detector Outline Documents** (4)

http://physics.uoregon.edu/~lc/wwstudy/concepts/

June 2007 - **Detector Concept Report**

(companion to machine Reference Design Report)

The Detector Concept Report

makes the physics case for the ILC,

describes the detector requirements,

presents detector concepts that can achieve the physics goals,

and describes the required detector R&D

http://www.linearcollider.org/wiki/doku.php?id=ilcdcr:ilcdcr_home

http://www.linearcollider.org/wiki/doku.php?id=dcrdet:dcrdet_home

(final editing now)

Roadmap

March 2006 - **Detector Outline Documents** (4)

June 2007 - **Detector Concept Report**

Roadmap

Summer 2007 - ILCSC announces call for Letters of Intent for detector designs for the two engineering designs, due Summer 2008.

- **Research Director (appointed by ILCSC)**
  - ILCSC has created search committee
- **International Detector Advisory Group**

Summer 2008 - Detector design teams submit **Letters of Intent** (backed by design reports) proposing candidates for the two detector designs.

End of 2008 - **Two detector designs** recognized for development to the engineering design phase.

Engineering designs completed for two detectors along with collider EDR. (requires additional resources to R&D)

American Linear Collider Physics Group

WWS response to ILCSC Request

- **The World Wide Study goal to produce two engineering design reports for the two contrasting and complementary detectors synchronized with collider progress**
- **Research Director**
  - work with a review committee to develop procedures that will result in definition of contrasting and complementary detectors suitable for development to engineering design reports,
  - actively engage with global experimental community,
  - facilitate growth of detector collaborations capable of this work,
  - endorse decisions of the detector design teams,
  - help secure the resources which are required,
  - monitor progress toward the engineering designs,
  - guide and coordinate the global detector R&D activities as long as such management is required,
  - work on common issues with the GDE, particularly on the machine-detector interface, and
  - organize outreach activities to the scientific community and government representatives
- **The International Detector Advisory Group (IDAG)**

ILCSC has created a search committee for the Research Director

US 5 Year ILC Detector R&D Funding Profile

American Linear Collider Physics Group

Five Year Project Plan Developed by ALCPG

provide proofs of principle, designs, etc. to be ready to build

- includes labs
- broad participation in developing plan
- task driven, detailed

FY08: $17.4M
FY09: $20.5M
FY10: $20.9M
FY11: $23.5M
FY12: $21.9M

TOTAL FY08-FY12 ~ $104M

SYNCHRONIZED TO GDE 2010 EDR, DETECTOR DESIGN COMPLETE IN 2011

FY07

LCDRD (univ/small lab)	$2.175M
LABS	> $5.5M(fy06)
total	> $8M (est. ~$10M)

Milestones
Priorities
Deliverables

← **MANAGEMENT PLAN**

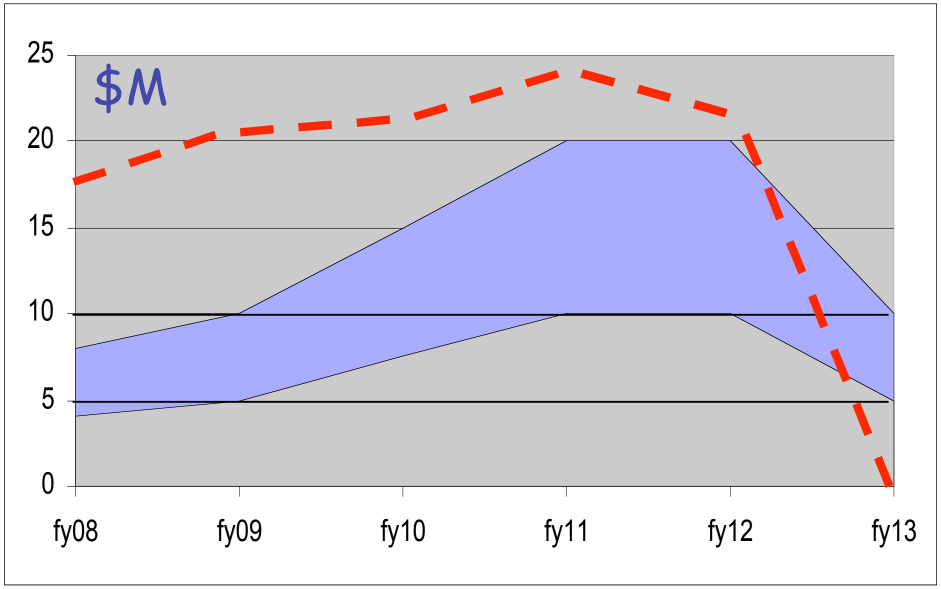
US 5 Year ILC Detector R&D Funding Profile

Five Year Project Plan Developed by ALCPG

TOTAL FY08-FY12 ~ $104M

DOE budget guidance for review.

High	**$82.5M**
Mid	**$62.0M**
Low	**$41.5M**



Resources of labs might reduce gap

NOTE: This is R&D only; EDRs will need additional resources

- - - - ALCPG R&D Plan

Conclusion

- US Detector R&D effort has been developing for several years
- US funding levels have limited progress here - Europeans moving ahead
- GDE will deliver ILC engineering design in 2010, ready for construction start in 2012,
  - it is urgent that detector progress keep pace
- US R&D plan (coordinated globally) should now be supported

to advance the US R&D effort

and to enable US leadership in the ILC experiments