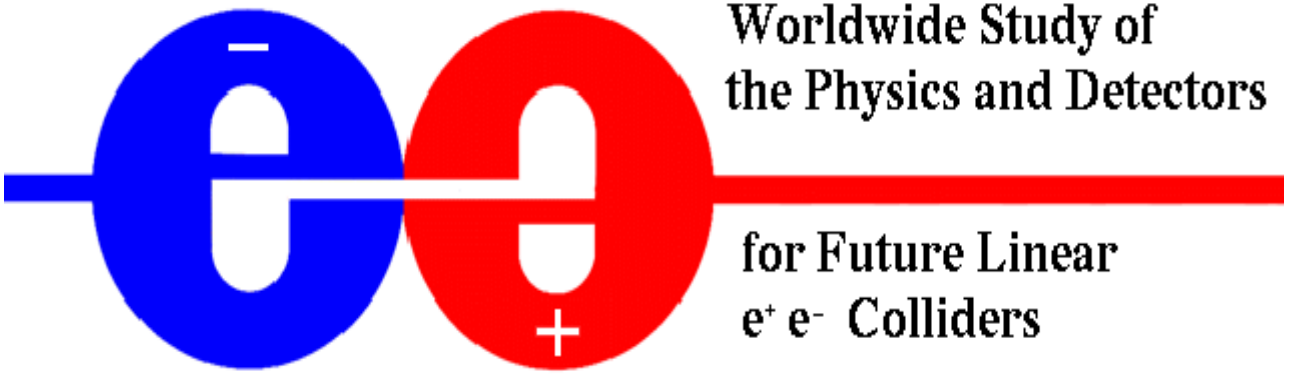
# Report from Worldwide Study




H. Park (Kyungpook Nat'l Univ.)

**For ILC Korea Meeting at PAL**

# WorldWide Study OC Members

- **Started in 1998 (Vancouver ICHEP)**
- **6 committee members from each of 3 regions**
- **3 co-chairs are now members of GDE**

| Asia | Europe | America |
|---|---|---|
| Atul Gurtu | Tiziano Camporesi | Jim Brau* |
| Wei-Shu Hou | Michael Danilov | John Jaros |
| Hwanbae Park | Rolf Heuer | Dean Karlen |
| Akiya Miyamoto | David Miller | Andreas Kronfeld |
| Hitoshi Yamamoto* | Fransois Richard* | Lark Oreglia |
| Chang-Gehn Yang | Ron Settles | Richie Patterson |

# Tasks of WWS

- **Organizes/coordinates international activities on LC Physics/ Detector studies as endorsed by ICFA/ILCSC in summer 2004, in particular,**

  - **recognize and coordinate studies on whole detector concepts and work toward interregional detector TDRs**
  - **interface with GDI, especially on MDI issues**
  - **keep a register of R&Ds relevant to LC experimental programs, identify those that are vital or missing, and ensure peer review of R&D proposals**
  - **organize interregional meetings and workshops**
  - **organize LCWS (1 per year now)**

# LCWS History

- **International activities on ILC physics/detectors**

  - Saariselka, Finland : Sept. 9-14, 1991
  - Hawaii, USA : April 26-30, 1993
  - Morioka, Japan : Sept. 8-12, 1995
  - Sitges, Spain : April 28-May 5, 1999
  - Fermilab, USA : Oct. 24-28, 2000
  - Jeju Island, Korea : Aug. 26-30, 2002
  - Paris, France : April 19-23, 2004
  - Stanford, USA : March 17-23, 2005
  - Snowmass, USA (ALCPG with WWS) : Aug 14-27, 20005
    held together with the ILC workshop
  - Bangalore, India : March 9-13, 2006
    (http://www.tifr.res.in/lcws06/index.php)

**are intensifying**:

Every 2 years → Every 1.5 years → Every < 1 year

# Regional LC Detector/Physics Workshops in the last year

- **ACFA8, Daegu, Korea : Jul. 11-14, 2005**
  **(>85 participants, 25 plenary talks, 27 plenary talks)**
- **ALCPG, Snowmass, USA : Aug. 14-27, 2005**
- **ECFA, Vienna, Austria : Nov. 14-17, 2005**
  **:**
  **:**
  **:**

# Since superconducting RF technology is chosen by ITRP(Aug., 2004)

- **The name is officially decided to be**
  **International Linear Collider (ILC)**

- **GDE (Global Design Effort) – the first stage of GDI (Global Design Initiative) is being formed**
  - **1st ILC Workshop at KEK, Nov. 13-15, 2004**
  - **2nd ILC Workshop at Snowmass, Aug. 2005**

- **The choice is fully supported by the whole LC community**
  - **LC machine efforts are being re-organized around cold technology**
  - **demonstrates the ability of our community to unite behind an important project**

# International Consensus...

- Up to 2002, ACFA, ECFA, HEPAP reached the common conclusion that the next accelerator should be an e+e- linear collider with an initial energy of 500 GeV, running in parallel with LHC, and later upgradeable to higher energies
- 2003/11, US DOE Office of Science Future Facilities Plan: LC is first priority mid-term new facility for all US Office of Science
- 2004/1, ACFA, ECFA, HEPAP chairs reaffirmed their community's priorities for a 500 GeV linear collider operated in parallel with the LHC
- 2004/1, OECD Science Ministerial Statement endorsed the plan for global collaborative development of a linear collider
- 2004/2, ICFA reaffirmed that the highest priority for a new machine for particle physics is a linear e+e- collider with an initial energy of 500 GeV, extendible up to about 1 TeV, with a significant period of concurrent running with the LHC

...is overwhelming

# ILC Parameters

**Operating simultaneously with LHC**
**(to start ~2015 : not in the "scope document")**
**http://www.fnal.gov/directorate/icfa/LC_parameters.pdf**

- **1st stage**
  - **Energy 200 → 500 GeV, scannable**
  - **500 $fb^{-1}$ in first 4 years**
    **+ 500 $fb^{-1}$ in next 2 years**
- **2nd stage**
  - **Energy upgrade to ~ 1 TeV**
  - **~1000 $fb^{-1}$ in 3-4 years**
- **Energy Scan + e- polarization**
- **Options**
  - **$\gamma\gamma$, $\gamma$e-, e-e-, Giga-Z**

# Tasks for LC Physics/Detector Studies

- **Inputs to machine design (GDE)**
  - **Options ($\gamma\gamma$, $\gamma$e-, e-e-, Giga-Z..)**
  - **Number of IRs : a task force team formed**
  - **MDI issues (crossing angle, constraints from detector designs)**

- **Design and Build Detectors**
  - **Establish detector concepts**
  - **Perform necessary R&Ds**
  - **Study physics/detector bench marks**

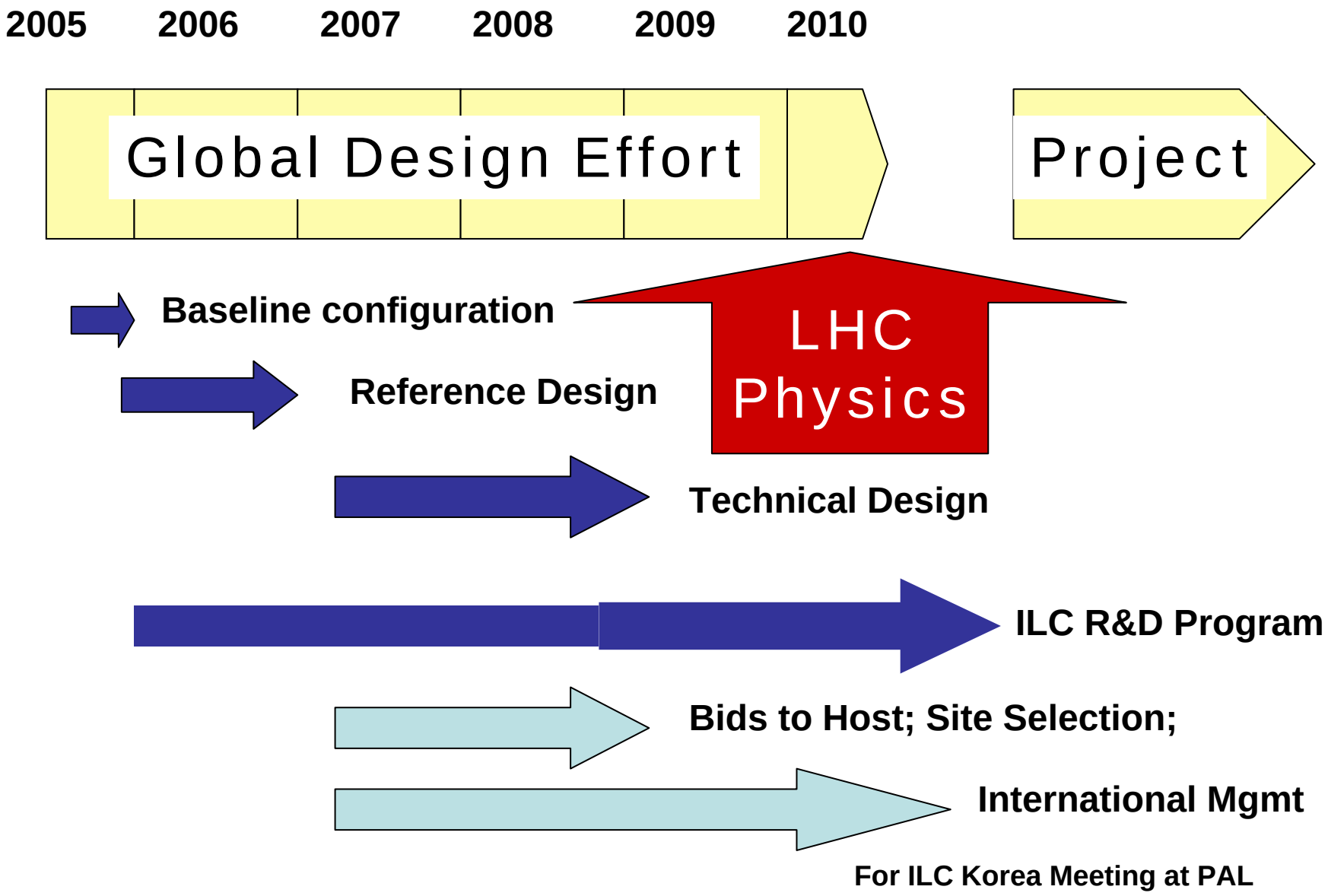
- **Sharpen LC Physics Cases**
  - **New physics models**
  - **LHC and LC**
  - **Cosmology and LC**

# Detector Timeline by WWS

**Timed to machine benchmarks**

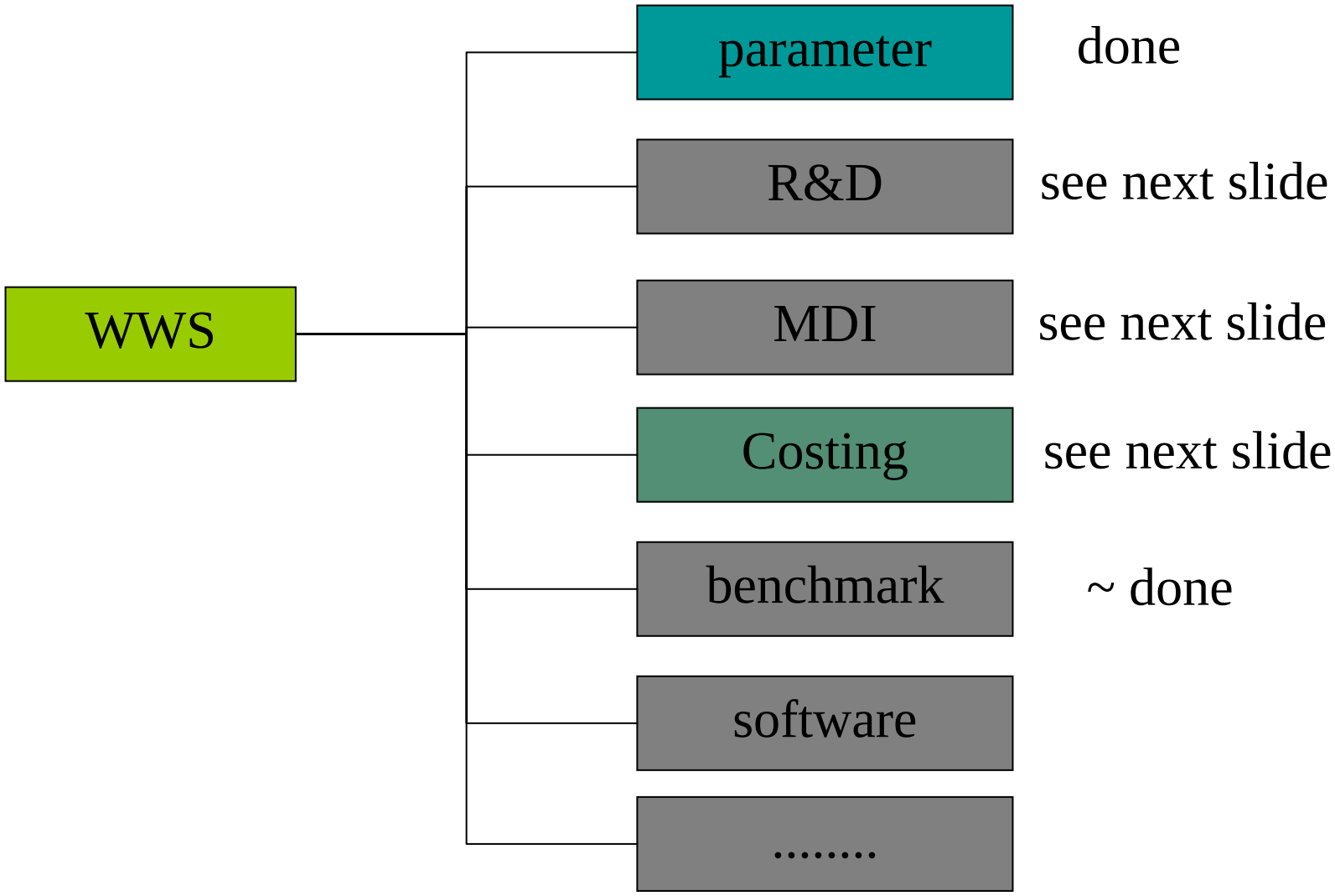
| | | |
|---|---|---|
| 2004 | ITRP recommended superconducting RF technology (not a design choice) | Setup 3 panels (detector R&D, MDI, costing) |
| 2005 | December: Accelerator Baseline Configuration Document | *Individuals are encouraged to participate in multiple concept studies* |
| 2006 | December: Accelerator Reference Design Report | March: DOD submitted to WWS by concept teams |
| 2007 | | WWS receives a detector CDR (one document) |
| 2008 | LC site selection December: TDR | Collaborations form and submit LOIs for proposal to the global lab |
| 2009 | | Global lab selects experiments |

# The GDE Plan and Schedule




For ILC Korea Meeting at PAL

# WWW Panels


WWS
parameter
done
R&D
see next slide
MDI
see next slide
Costing
see next slide
benchmark
~ done
software
.....

# 3 Panels by WWS

- Detector R&D Review Panel
  - Survey and prioritize R&Ds (NOT individual proposals)
  - Inputs are from R&D collaborations and concept studies
  - Register and facilitate regional review processes
  - 3 members from each region, balanced over expertise and launched LCWS2005
    (C. Damerell, J.-C. Brient, W. Lohmann, H.J. Kim, T. Takeshita, Y. Sugimoto, D. Peterson, R. Frey, H. Weerts)
    http://wiki.lepp.cornell.edu/wws/bin/view/Projects/WebHome
  - Detector R&D report (December 2005)
- MDI Panel
  - Liase with machine efforts(.i.e. GDE)
  - Existing LCWS/WWS leadership of MDI acts as this panel for now (P. Bambade, T, Tauchi, M. Woods)
- Costing Panel
  - ensure the same costing basis
  - edit into a single document to be included with the machine RDR

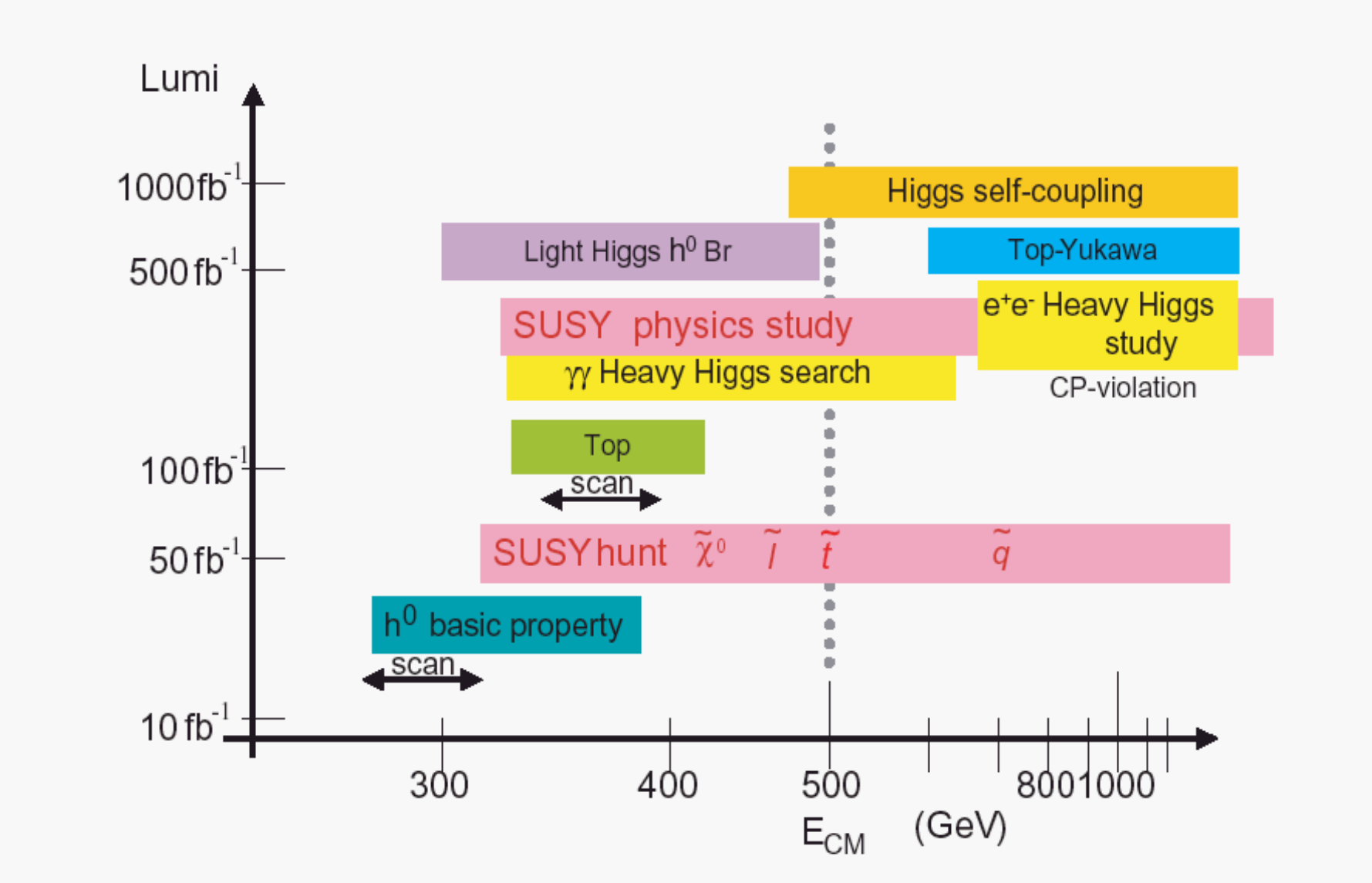
# Detector Outline Documents

- To be completed in March 2006 by each detector concept team, and submitted to WWS

- Contents (~100 pages in total)
  - Introduction
  - Description of the detector concept
  - Expected performances for benchmark modes
  - Subsystem technology selections
  - Status of on-going studies
  - List of R&Ds needed
  - Costing
  - Conclusion

- Real detector CDR  in 2007 (not far away)

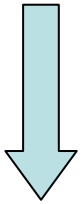
# LC Physics




For ILC Korea Meeting at PAL

# LC Physics

- Just one example of LC physics:
  - $5\sigma$ discovery of SM Higgs
    1 year LHC = 1 day LC
    LC can discover Higgs-like particle even if rate is 1/100 of SM
- Power of precision and sensitivity
  - WMAP → dark matter/energy
  - precision measurements on Z → # $\nu$, Higgs mass, ….
  - Direct/indirect CPV in B decays by B factories
  - …….



- LC is a precision machine
- LC is a high-sensitivity machine
- LC is a discovery machine

# Detector Performance Goals

http://blueox.uoregon.edu/~lc/randd.pdf

- Vertexing for flavour tagging, etc

$$\sigma_{ip} = 5\mu m \oplus 10\mu m/p \sin^{3/2}\theta$$

  - ~1/5 in beampipe and ~1/30 in pixel size wrt LHC

- Tracking for tagged Higgs, etc

$$\sigma(1/p) = 5 \times 10^{-5}$$

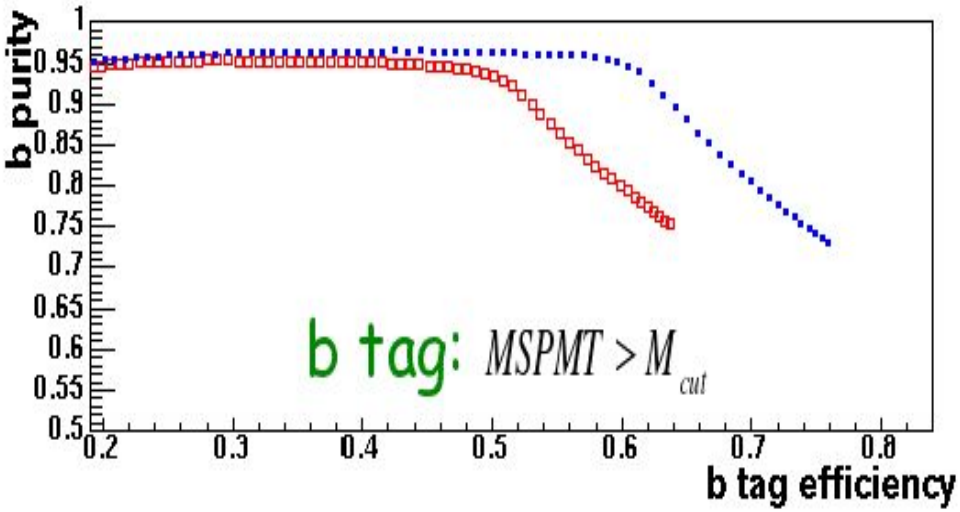
  - ~1/6 in material and ~1/10 resolution wrt LHC

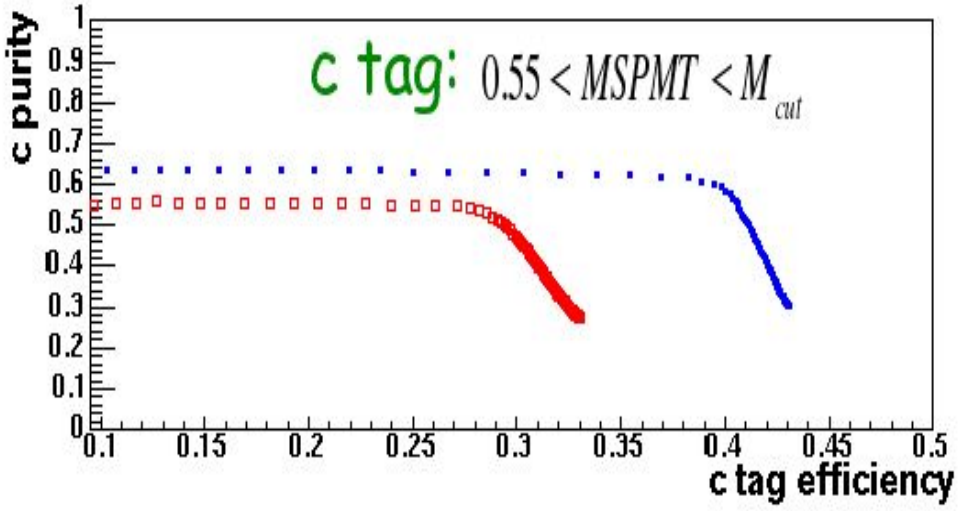
- Jet energy for quark, W, Z reconstruction/separation, etc

$$\sigma_E/E = 0.3/\sqrt{E}$$

  - ~1/2 in resolution wrt LHC

# Flavour Tagging by Vertexing

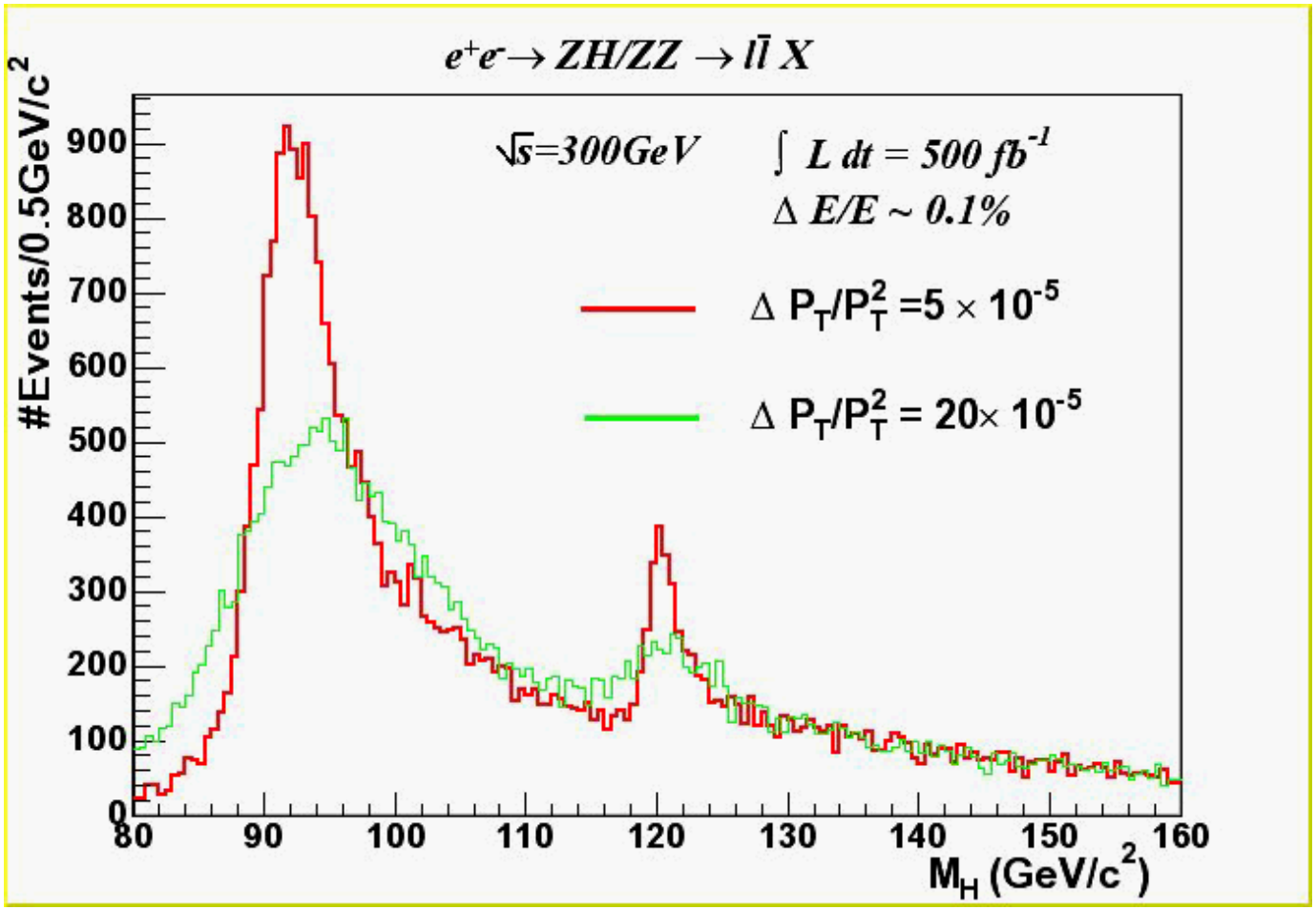



Pixel vertex detector

- 4-layer
  0.3 % $X_0$/ layer
  $r_{bp}$ = 2 cm
  conservative design
- 5-layer
  0.1 % $X_0$/ layer
  $r_{bp}$ = 1 cm
  agressive design
  (~goal resolution)

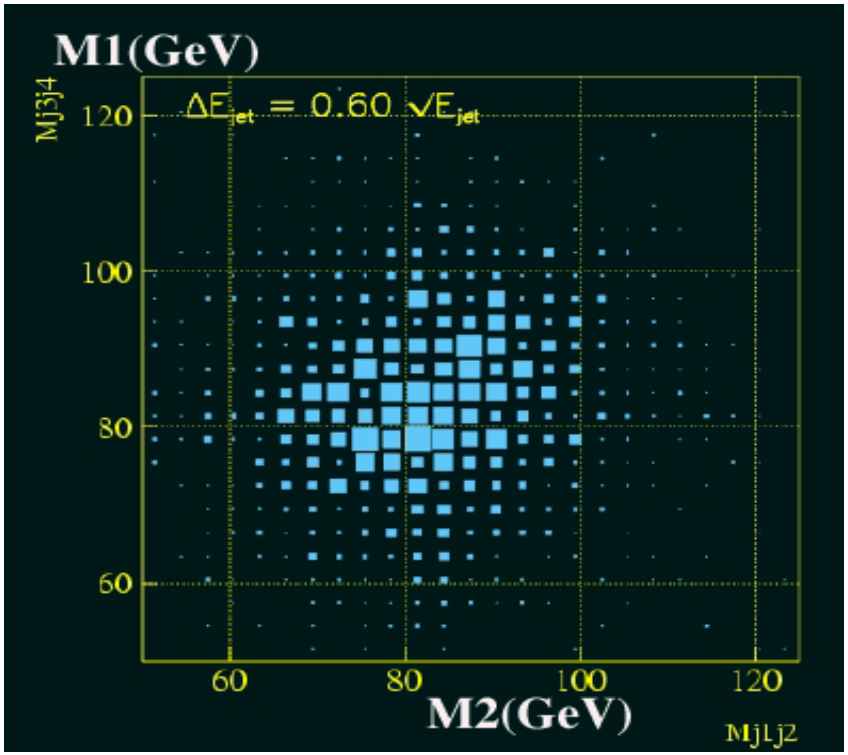
# Recoil Mass Reconstruction with Tracker

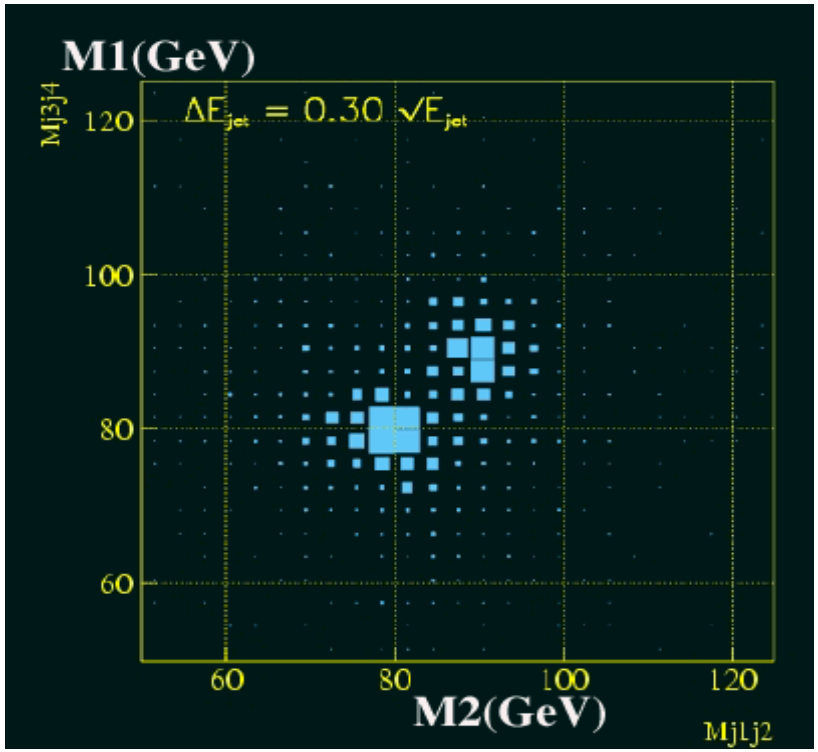



- **Good momentum resolution of ~5x10$^{-5}$ is required (not a luxury). Not limited by the beam energy spread.**

# Jet(Quark) Reconstruction

$$e^+e^- \to \nu\bar{\nu}WW, \nu\bar{\nu}ZZ$$




$$\sigma_E / E = 0.6/\sqrt{E(\mathrm{GeV})}$$

$$\sigma_E / E = 0.3/\sqrt{E(\mathrm{GeV})}$$

# PFA(Particle Flow Algorithm)

- **Many other important modes have 4 or more jets : e.g.**
  - **Higgs self-coupling : 6 jets**

$$e^+e^- \to Zhh \to (q\bar{q})(q\bar{q})(q\bar{q})$$

  - **Top Yukawa coupling : 8 jets**

$$e^+e^- \to t\bar{t}h \to (bq\bar{q})(\bar{b}q\bar{q})$$

  - **WW* branching fraction of Higgs : 4 jets+missing neutrino**

$$e^+e^- \to Zh \to (q\bar{q})(q\bar{q})(\ell\nu)$$

- **How to achieve** $\sigma_E / E = 0.3/\sqrt{E}$ **for jet ?**
- **Basic idea : PFA**
  - **Use trackers for charged particles**
  - **Use ECAL for photon**
  - **The rest is assumed to be neutral hadrons (ECAL+HCAL)**

# Strategy for Detector Design

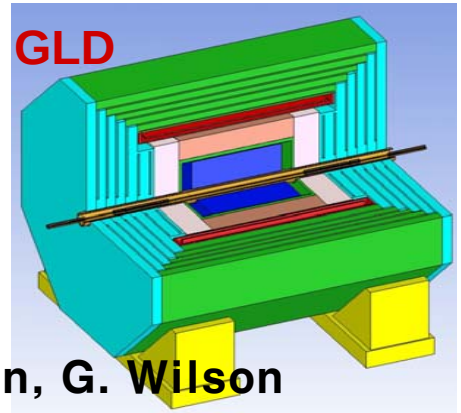
## Where is the optimum?

- Larger beampipe radius for stay-clear from e+e- pair background
  → larger ECAL radius
  → larger solenoid radius
  → worse vertexing

$$\sigma^2_{jet} = \sigma^2_{ch} + \sigma^2_{\gamma} + \sigma^2_{nh} + \sigma^2_{confusion}$$

- PFA:Confusion is dominant even for the goal of $\sigma_E / E = 30\% / \sqrt{E}$
  → fine segmentation , large radius

# Major Detector Concept Studies

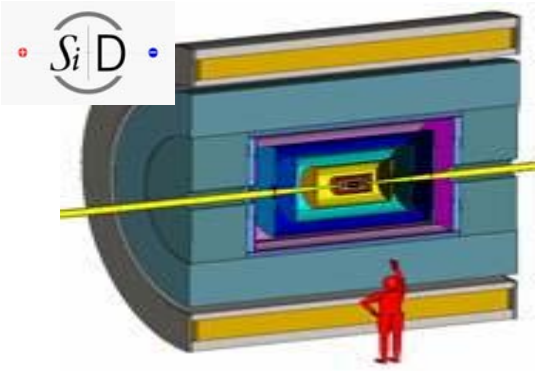



- **G**lobal **L**arge **D**etector (Asian origin)
  - TPC(+Silicon IT), 3T field
  - W/Scintillator ECAL ("large" radius)
  - 6 "contact person":

    H. Park, H. Yamamoto, R. Settles, M. Thomson, M. Ronan, G. Wilson
- **L**arge **D**etector **C**oncept (European origin)
  - TPC, 4T field
  - Si/W ECAL ("medium" radius)
  - 6 "contact person"

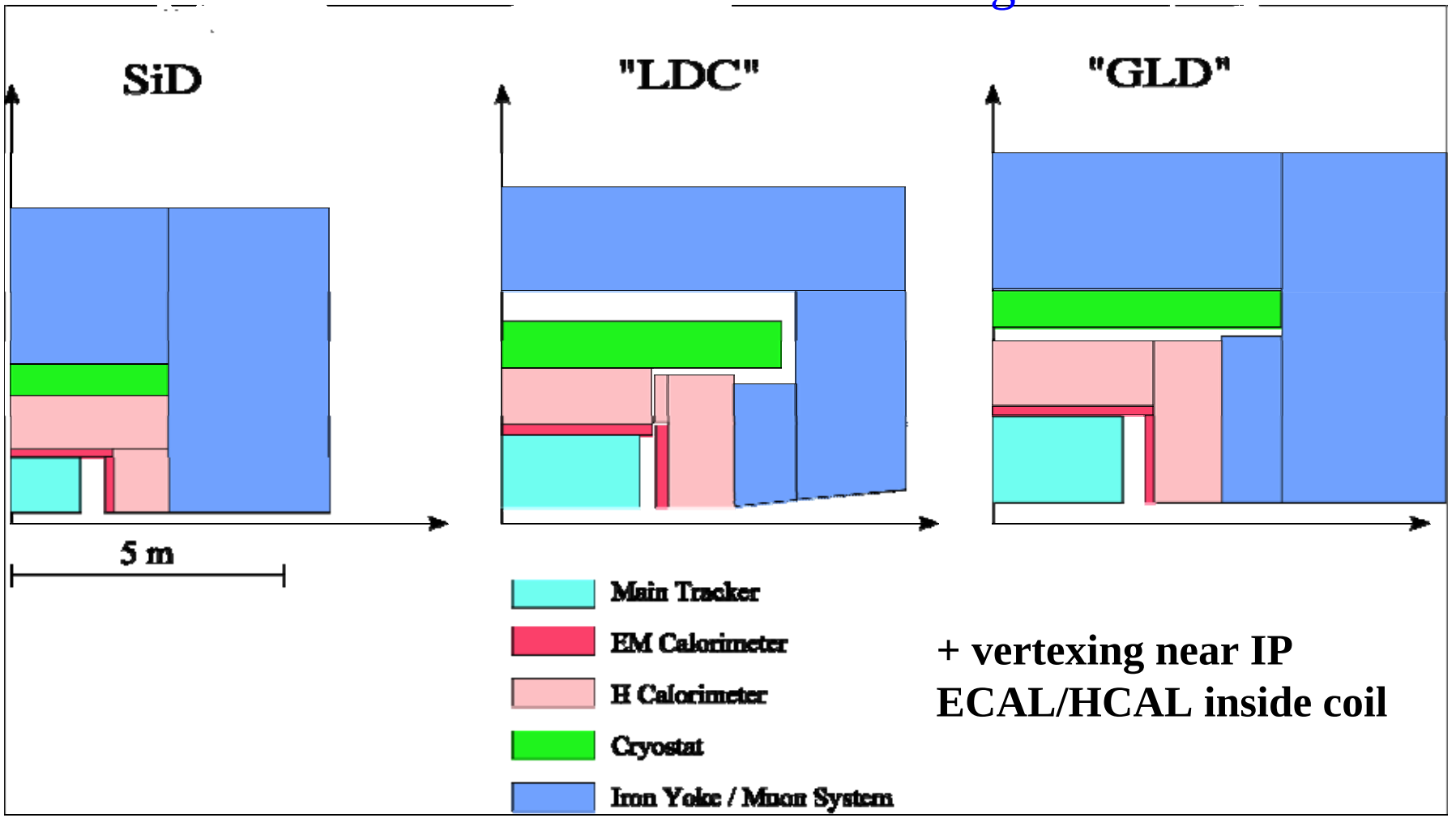
    M. Battaglia, T. Behnke, D. Karlen, H. Videau,Y. Sugimoto, Y. Hsiung
- **S**ilicon **D**etector (American origin)
  - Silicon tracker, 5T field
  - Si/W ECAL ("small" radius)
  - 4 "coordinator"

    J. Jaros, H. Weerts, H. Aihara, Y. Karyotakis



# Major Detector Concept Studies

Main Tracker drives detector configuration



# On Detector Concept Studies

- They are inclusive, not exclusive
  - An individual can sign multiple concept studies
    GLD: http://ilcphysics.kek.jp/gld/
    LDC: http://www-flc.desy.de/ilc/ldc
    SiD: http://www-sid.slac.stanford.edu

- The parameters of 3 detector concepts are not final
  - Optimization – bench marks

- New ideas for detector concepts not excluded
  - J. Hauptman at snowmass, http://www.phys.ttu.edu/dream
  - based on dual-readout compensating calorimetry
    Spatial(fine fibers),EM fraction(Cerenkov scintillation),
    binding energy losses/neutrons(time readout, third fiber)

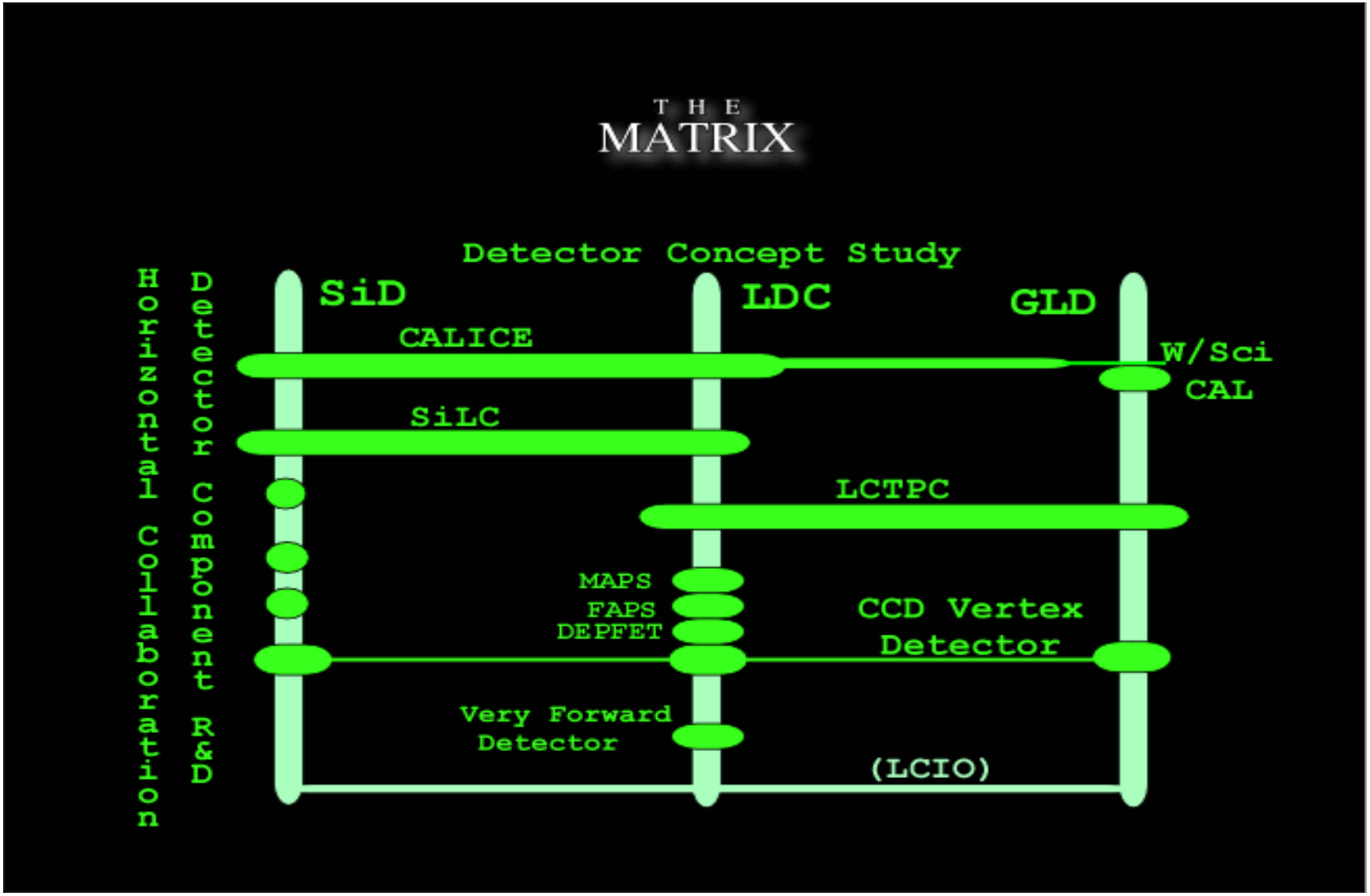
- Many studies are common to concept studies
  - "Horizontal collaborations" on subdetectors are already strong and encouraged
  - simulation tools and bench mark studies also

# Requests from WWS for new concept

As of Sept. 2005

- Contact person(s)
- Provide representatives for panels:
  (R&D panel, MDI panel, Costing panel)
- Produce “detector outline document” by end of Feb. 2006

# Horizontal and Vertical Collaborations




For ILC Korea Meeting at PAL

# Other Issues

- # of IR, #of Detectors
  - # of detector panel of WWS (chair: J. Brau)
    (http://blueox.uoregon.edu/~lc/wwstudy)

- # of BDS and cross angles
  - MDI panel

Hope to see all of you in Bangalore LCWS2006, 9-13 March