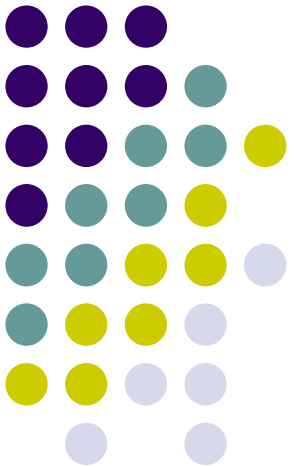
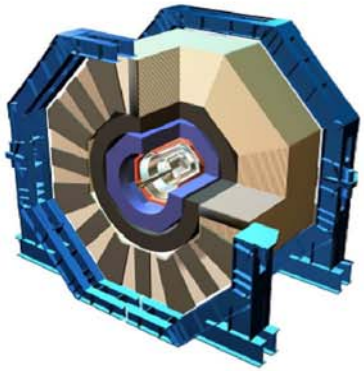
ILD – A Large Detector for ILC

Mar. 3, 2008
Yasuhiro Sugimoto
KEK

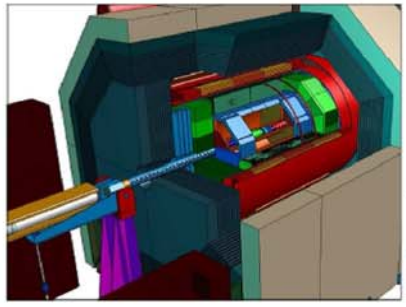


Detector concepts for ILC

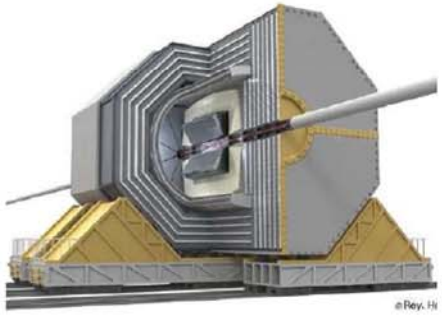
- Four Detector Concepts (GLD, LDC, SiD, 4th) published Detector Outline Documents (DODs) in 2006
- Three of them (GLD, LDC, SiD) are optimized for “PFA”
  - PFA: Particle Flow Algorithm is a method to get the best jet-energy resolution
  - In PFA, energy of each particle in a jet is measured **separately**: Charged particles by tracker, γs by ECAL, and neutral hadrons by HCAL+ECAL
    - Larger BR^2 is preferable to separate charged tracks in the calorimeter
    - Calorimeter should have fine granularity



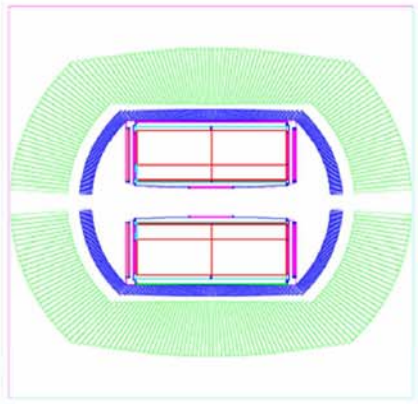
SiD



LDC

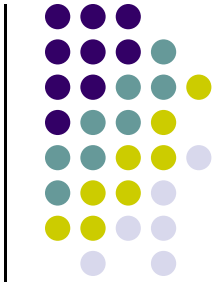


GLD



4th

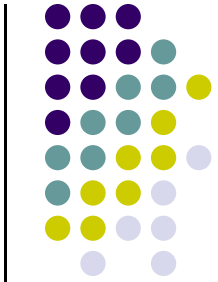
Detector features



	GLD	LDC	SiD	4-th
Tracker	TPC + Si-strip	TPC + Si-strip	Si-strip	TPC or DC
Calorimeter	PFA Rin=2.1m	PFA Rin=1.6m	PFA Rin=1.27m	Compensating Rin=1.5m
B	3T	4T	5T	3.5T No return yoke
BR^2	13.2 Tm^2	10.2 Tm^2	8.1 Tm^2	(non-PFA)
E_{store}	1.6 GJ	1.7 GJ	1.4 GJ	2.7 GJ Dual solenoid
Size	R=7.2m |Z|=7.5m	R=6.0m |Z|=5.6m	R=6.45m |Z|=6.45m	R=5.5m |Z|=6.4m

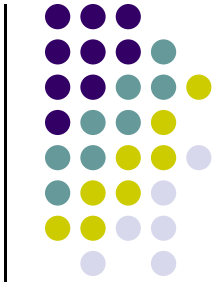
ILD

History of ILD (1)



- Feb.2007: At ACFA WS at Beijing, serious discussion on the ILC detector roadmap has started
- Feb.26.2007: A letter was sent from ILCSC to WWS co-chairs requiring to draw a roadmap to produce two detector EDRs by 2010 keeping pace with the accelerator schedule
- Mar.2007~: Detector roadmap working group is formed and several phone meetings have been held
- Apr.2007: Proposal of the “LOI process” to the roadmap W.G.
- Apr.27.2007: The 1st joint meeting of GLD-LDC contact persons
- May 29.2007: GLD-LDC joint meeting at LCWS2007 and agreement on the joint effort towards a common LOI

History of ILD (2)

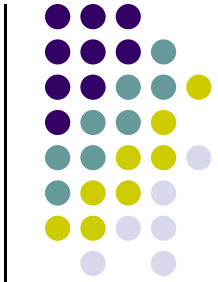


- Jul.2007: GLD/LDC joint steering board (JSB) members are selected
- Aug.22.2007: The 1st JSB meeting and agreement on organizing working groups
- Sep.13.2007: The name of the detector is decided as “ILD” (until formation of real collaboration) at the 3rd JSB meeting
- Oct.1,2007: LOI call by ILCSC (due Oct.2008)
- Oct.2007: ILD meeting at ALCPG2007
- Dec.2007: Black December (Budget crisis in UK and US)
- Jan.2008: ILD Workshop at DESY Zeuthen (2.5 days)
- Feb.2008: EDR → Technical Design / deadline of LOI:Oct.2008→Mar.2009
- Mar.2008: ILD meeting at TILC08

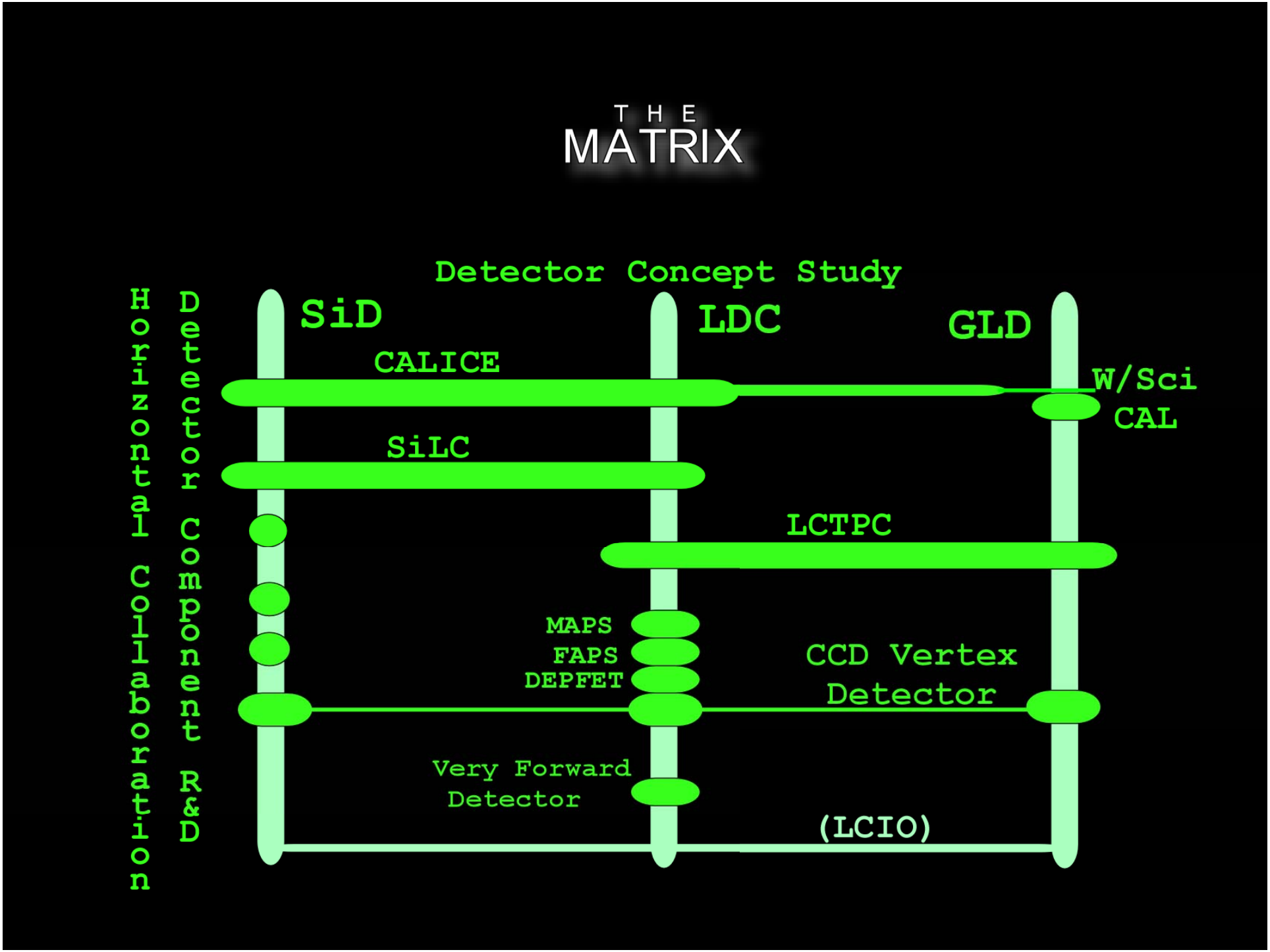
ILD Workshop at Zeuthen

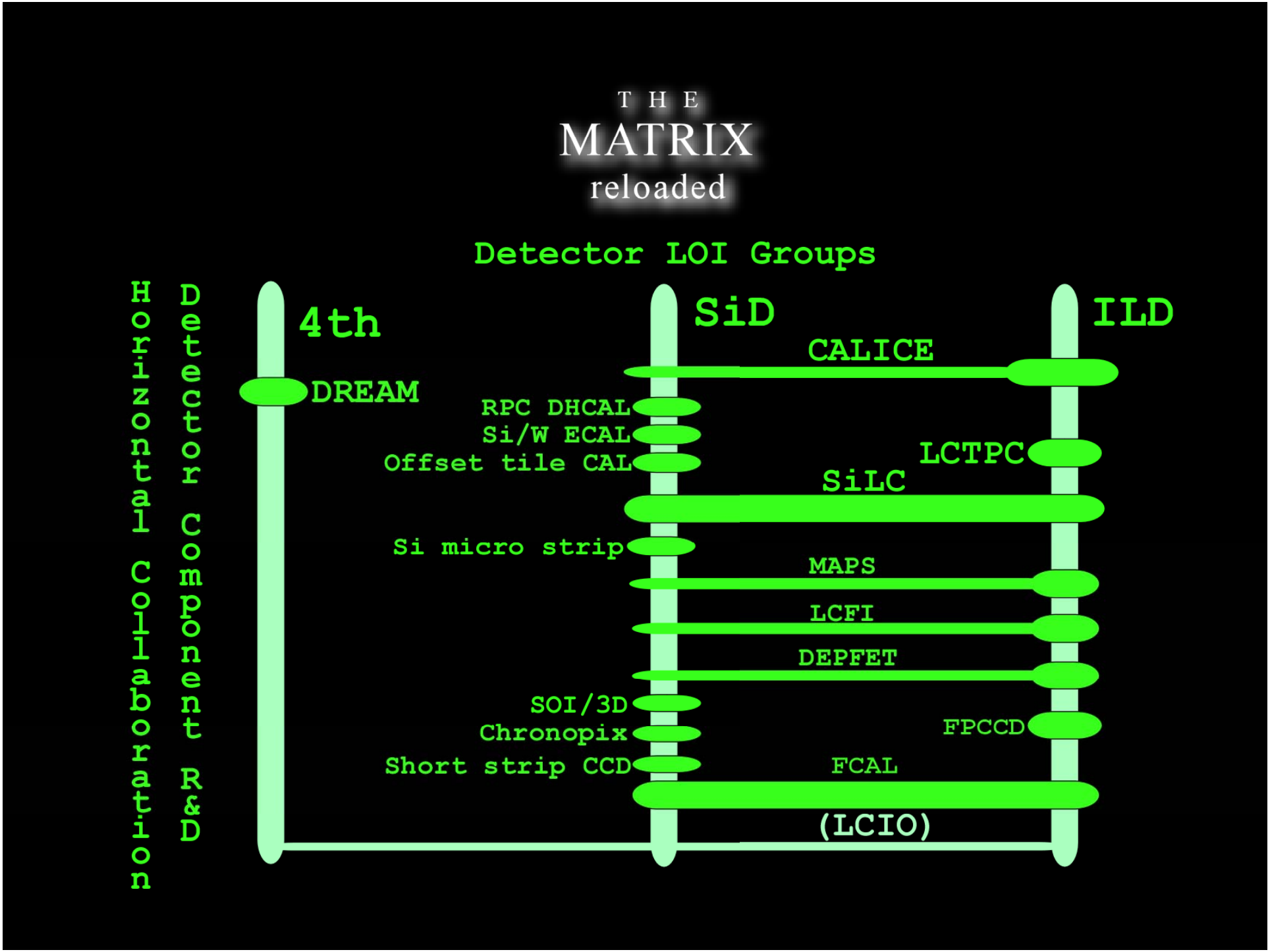
- 2.5 days workshop
  with ~120 participants

ILD organization

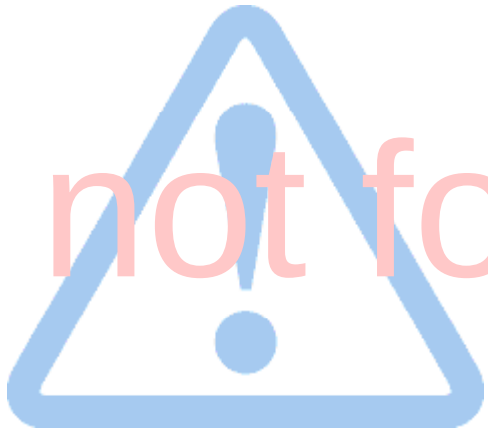


- Joint Steering Board members selected in July 2007
  - T.Behnke, D.Karlen, Y.Sugimoto, H.Videau, G.Wilson, H.Yamamoto
- At present, we don't have sub-groups for sub-detectors specific to ILD
- Information on sub-detectors will be obtained from existing horizontal collaborations (LCTPC, CALICE, SiLC, etc.), and contact persons of each detector R&D group are nominated
- For the design study of ILD, three working groups have been organized
  - Detector optimization W.G. (M.Thomson, T.Yoshioka)
  - MDI/Integration W.G. (K.Busser, T.Tauchi)
  - Costing W.G. (A.Maki, H.Videau)


THE
MATRIX
Detector Concept Study
SiD
LDC
GLD
Horizontal Collaboration
Detector Component R&D
CALICE
W/Sci
CAL
SiLC
LCTPC
MAPS
FAPS
DEPFET
CCD Vertex
Detector
Very Forward
Detector
(LCIO)

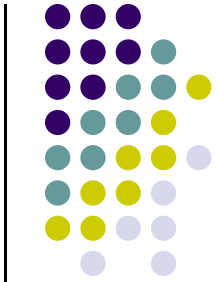

THE
MATRIX
reloaded
Detector LOI Groups
Horizontal Collaboration
Detector Component R&D
4th
SiD
ILD
DREAM
CALICE
RPC DHCAL
Si/W ECAL
Offset tile CAL
LCTPC
SiLC
Si micro strip
MAPS
LCFI
DEPFET
SOI/3D
Chronopix
Short strip CCD
FPCCD
FCAL
(LCIO)

ILD baseline design



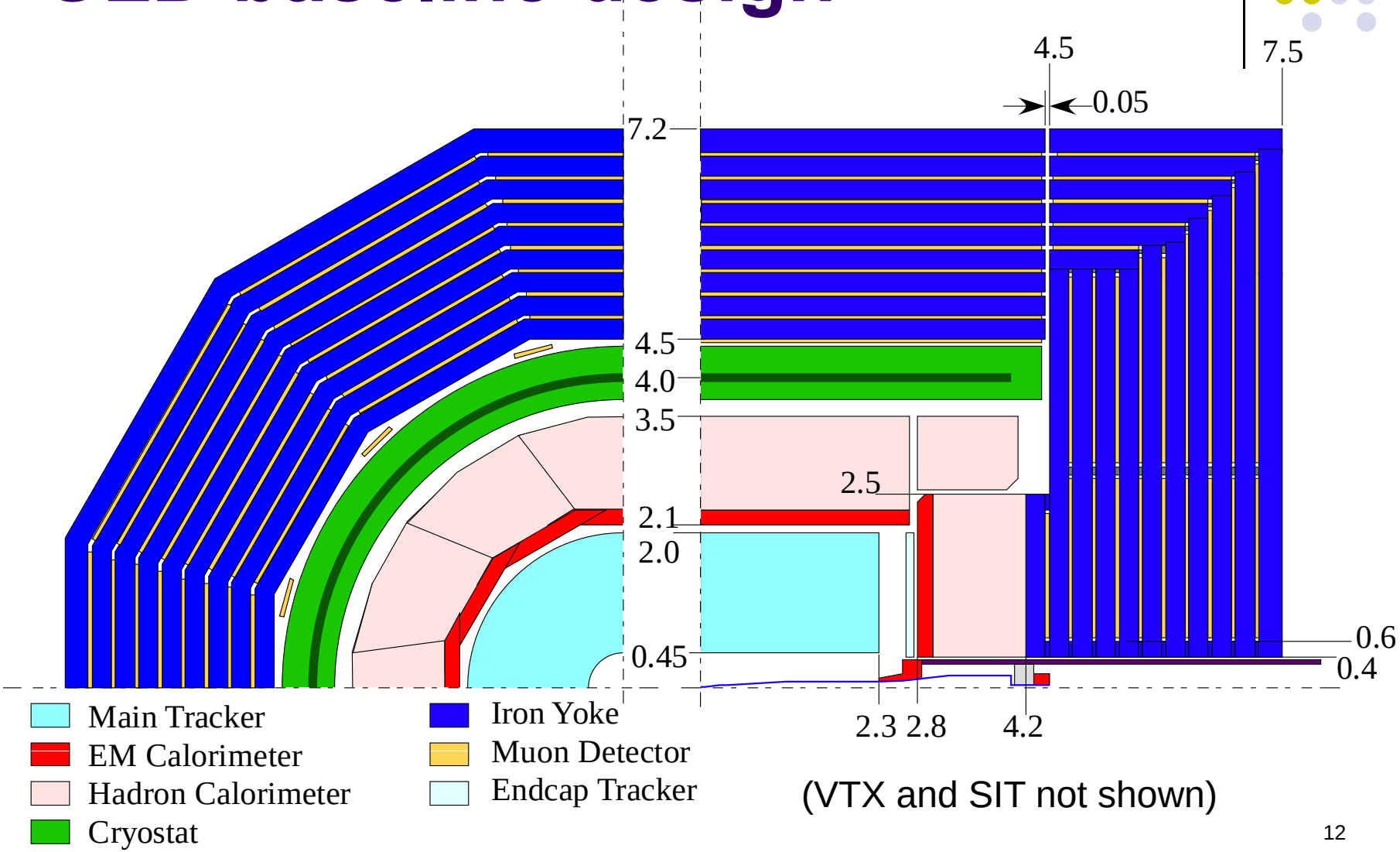
Our first priority task is to get the unified design of the “ILD”

ILD study activity



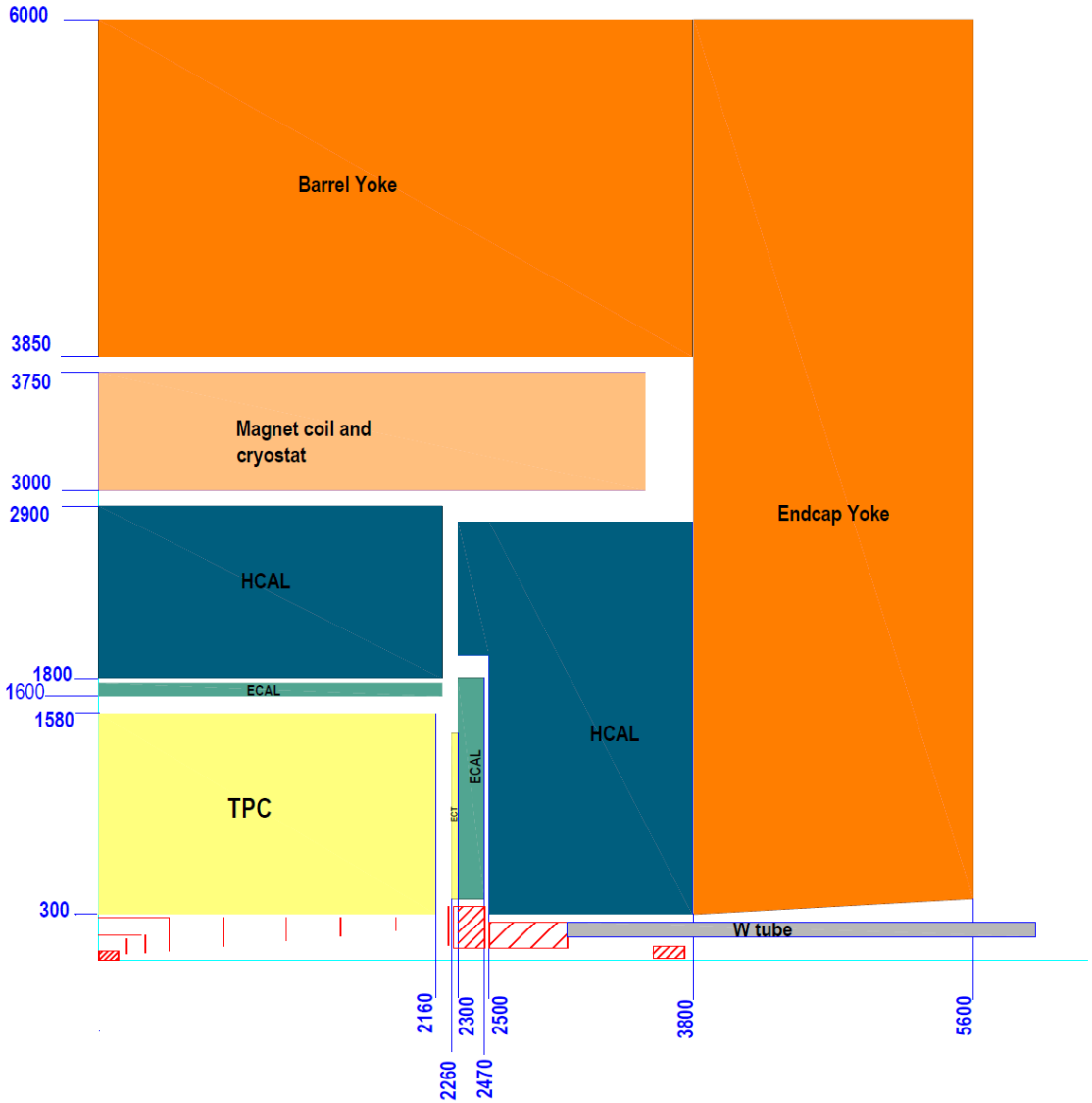
- Mandate
  - To write a Letter of Intent (LOI) to make a technical design of the detector
- Milestones
  - Mar. 31, 2008: Submit EOI
  - Summer 2008: Define the baseline parameter set for the unified detector
  - Mar.31,2009: Submit LOI
- Goal for LOI
  - Define unified and optimized parameters (size, shape, sub-detectors)
  - Demonstrate physics performance of the unified detector
  - Final technology choice for each sub-detector will not be done ➔Several technology options will be preserved for each sub-detector
  - R&D of sub-detectors will not be completed by LOI submission, but we should identify R&D items needed for ILD in LOI

GLD baseline design



(VTX and SIT not shown)

LDC baseline design

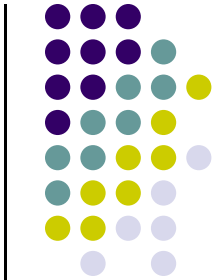


GLD/LDC baseline design

Sub-detector	GLD	LDC
Vertex det.	FP CCD	CPCCD/CMOS/DEPFET/ISIS/SOI/…
Si inner tracker	Si strip (4-layers)	Si strip (2-layers)
Si forward trk.	Si strip/pixel (?)	Si strip/pixel (?)
Main trk.	TPC	TPC
Additional trk.	Si endcap/outer trk. (option)	Si endcap/external trk.
EM CAL	W-Scintillator	W-Si
HCAL	Fe(Pb)-Scintillator	Fe-Sci./RPC*/GEM*
Solenoid	3T	4T
Muon det.	Scintillator strip	Sci strip/PST/RPC
Iron yoke	(25cm + 5cm) x 9/10	(10cm+4cm) x 10 + 1m
Forward CAL	W-Si/Diamond	W-Si/Diamond

* Digital HCAL

Performance goal



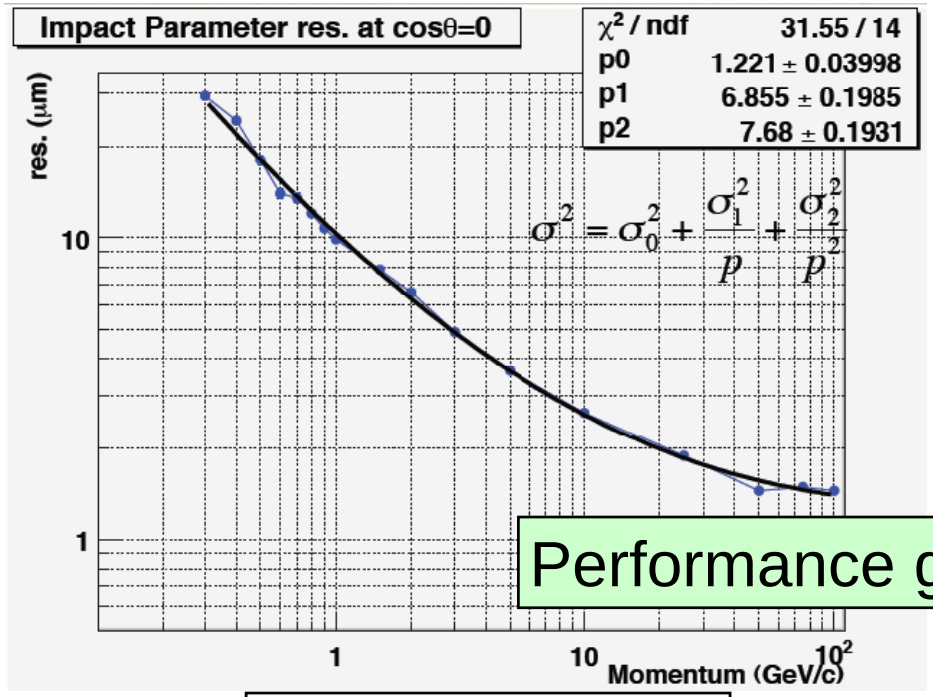
- Vertex Detector
  - Impact param. res. : $\sigma_b = 5 \oplus 10/(p\beta\sin^{3/2}\theta)$ μm
    - Charm and τ ID is important : cτ ~ 100 μm >> σ_b
- Tracker
  - $\delta p_t/p_t^2 = 5\text{x}10^{-5}$ /GeV
- Calorimeter
  - Jet energy resolution : $\sigma_E/E = 30\%/E^{1/2}$

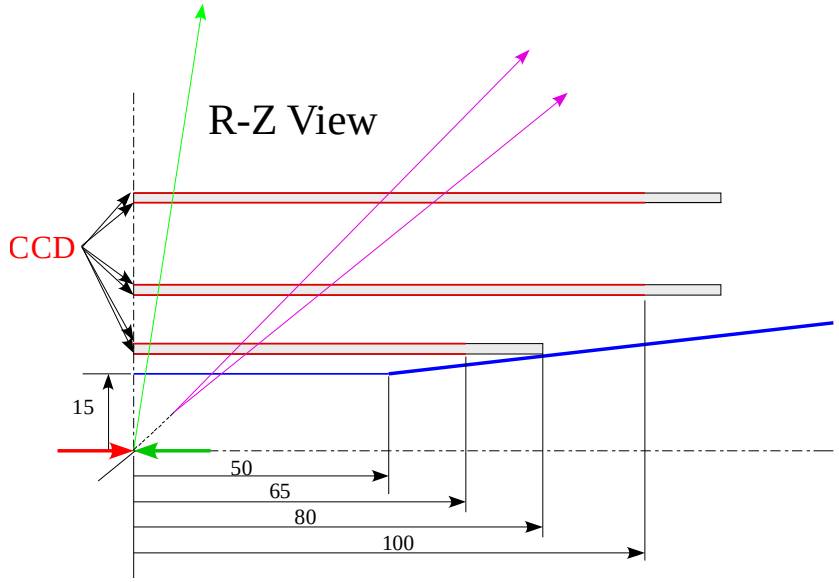
    or $\sigma_E/E = 3 - 4$ %
- Hermeticity
  - Forward coverage down to ~5 mrad

Expected performance

- Impact parameter resolution

GLD study





Performance goal achieved

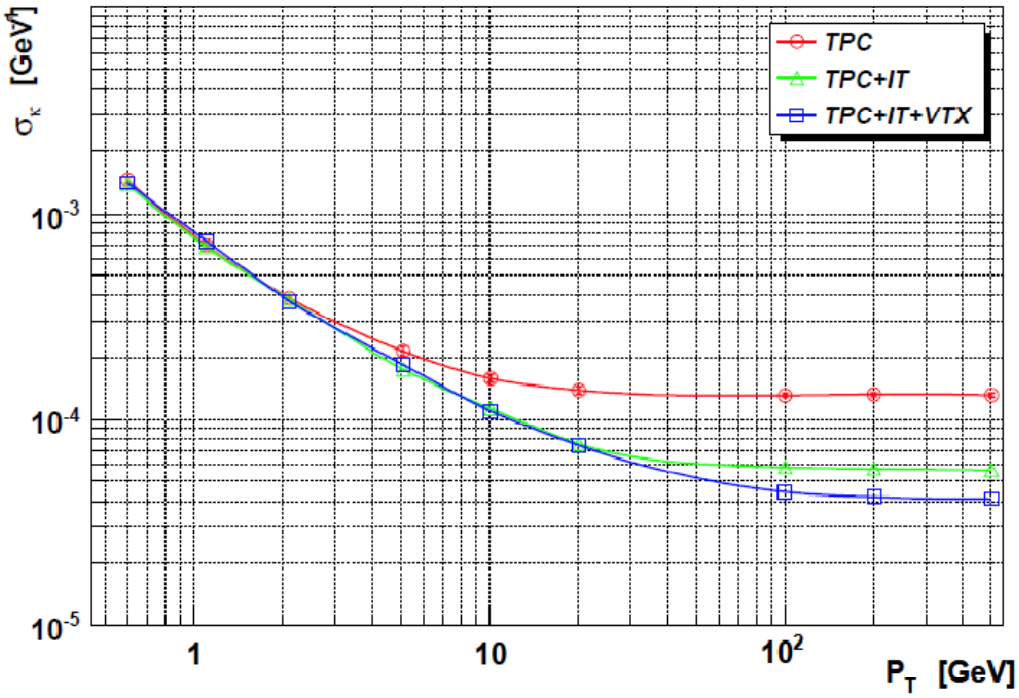
80μm Si-equivalent per layer is assumed

Layer	R (mm)
1	20
2	22
3	32
4	34
5	48
6	50

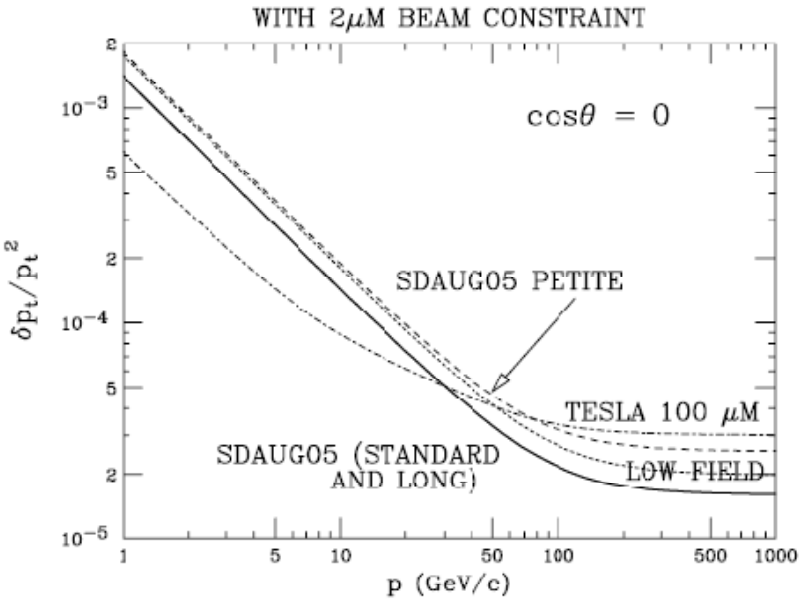
Expected performance

- Momentum resolution

GLD study



SiD study



Performance goal achieved

Expected performance

- PFA performance

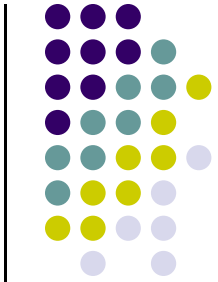
  Jet-energy resolution study by M.Thomson for LDC00 (BR^2=11.6 : Larger than latest LDC) using Pandora PFA

  - uds only
  - cosθ<0.7
  - Full tracking

E (GeV)	$\sigma_E / E(\%)$	$\alpha\ (\sigma_E / E = \alpha / \sqrt{E})$
45	3.5	0.235
100	3.1	0.306
180	3.2	0.427
250	3.6	0.565

Performance goal achieved

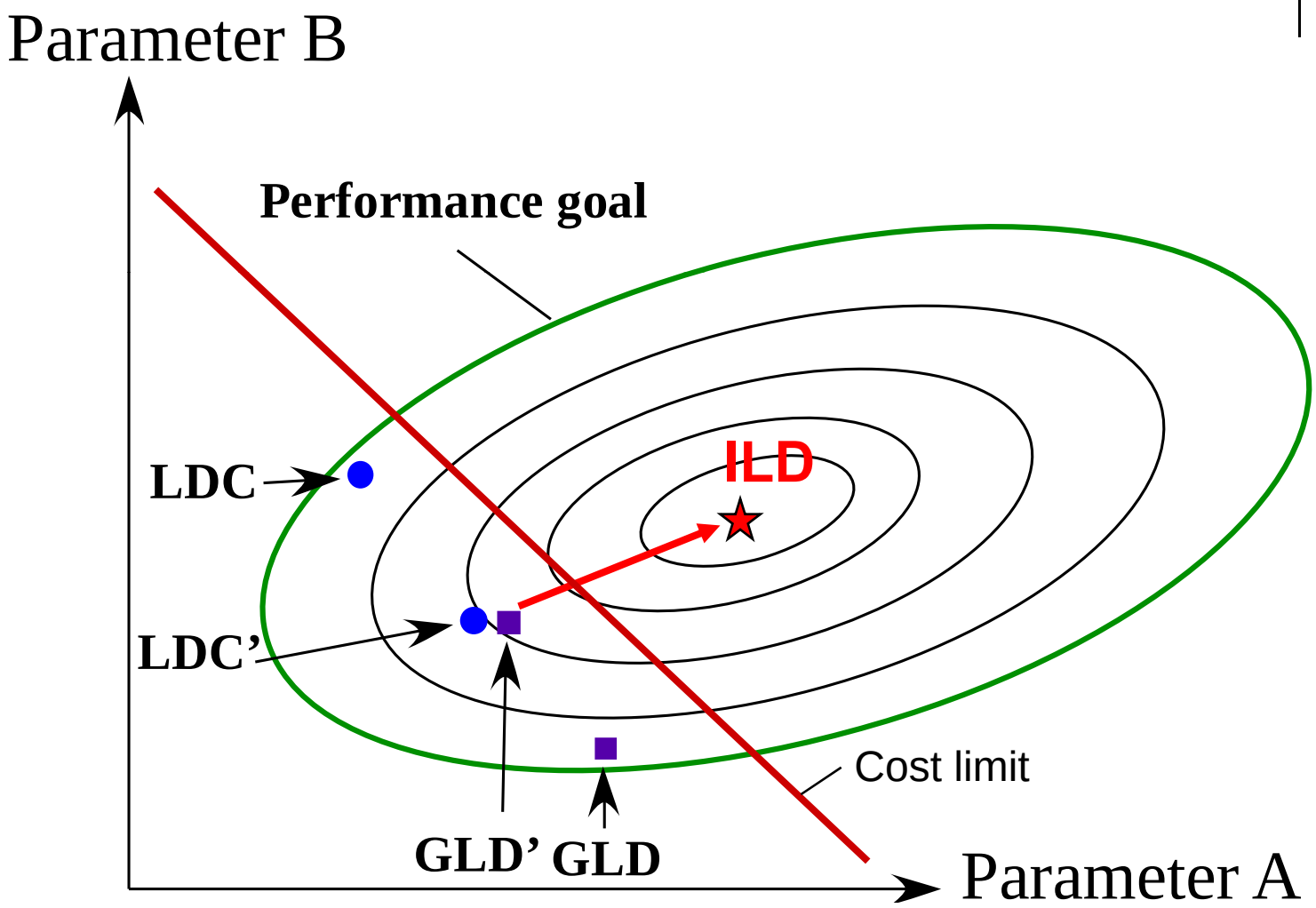
Optimization procedure



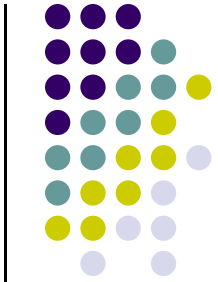
- Estimate physics performance for selected benchmark processes as a function of detector parameters
- At first, we define the mesh-points in multi-dimensional phase space of detector parameters: i.e., GLD, GLD', LDC', LDC, and simulation study will be done at these mesh-points

Sub-detector	Parameter	GLD	GLD'	LDC'	LDC
TPC	Rout (m)	2.0	1.8	1.8	1.58
Barrel ECAL	Rin (m)	2.1	1.85	1.82	1.6
	Material	Sci/W	Sci/W	Si/W	Si/W
Barrel HCAL	Material	Sci/Fe	Sci/Fe	Sci/Fe	Sci/Fe
Solenoid	B field (T)	3.0	3.5	3.5	4

Optimization procedure

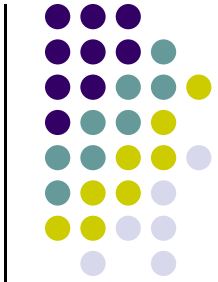


Benchmark processes



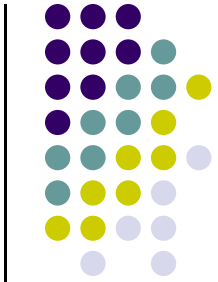
- Three sets of benchmark processes for ILD
  - A) Few selected processes for detector optimization
    ➔ Define ILD baseline design
  - B) Several (7?) processes common to all LOI groups (Compulsory)
    ➔ Show ILD baseline performance
  - C) (A) + (B) + Other processes which utilize advantages of ILD such as pattern recognition and dE/dx measurement in TPC
    ➔ Demonstrate superiority of ILD

Engineering challenge of ILD



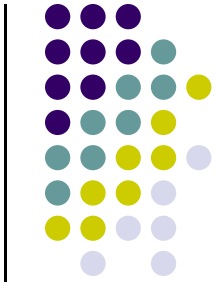
- Optimization W.G. does not discuss about “real world”
- A lot of realistic engineering issues will be studied/discussed in the MDI/Integration W.G., such as
  - How to support sub-detectors
  - How to integrate sub-detectors into a detector system
  - Surface assembly scheme (CMS style?)
  - Detector alignment
  - Power consumption and cooling method
  - Amount of cables and pipes coming out from the detector
  - Location and size of electronics-hut
  - Design of back-end electronics and DAQ system
  - Design of detector solenoid with anti-DID (Detector Integrated Dipole) and flux-return yoke
  - How to open and maintain the detector
  - How to make it compatible with the push-pull scheme
  - …
  - …

How to join ILD



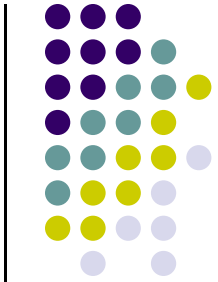
- Join Working Groups
  - Mailing list subscription from
    - https://lists.desy.de/sympa/info/ild-detector-optimisation/
    - https://lists.desy.de/sympa/info/ild-detector-mdi/
  - Join working group meetings
    - http://ilcagenda.linearcollider.org/categoryDisplay.py?categId=129
- Join sub-detector R&D relevant to ILD
  - https://wiki.lepp.cornell.edu/ilc/bin/view/Public/WWS/

Summary



- ICFA/ILCSC called for LOI to be submitted by March 2009
- LOI groups validated by IDAG will make technical design phase-I by 2010, and technical design phase-II by 2012
- GLD and LDC spontaneously merged into ILD and will write a common LOI
- There are so many issues to be studied towards LOI and Technical Design Phase
  - Optimization study for the common detector parameters
  - Simulation studies to demonstrate ILD performance
  - Engineering studies for MDI/detector integration
  - Sub-detector R&D
- A lot of works on ILD study will be presented at this workshop, and discussions on optimization and design of ILD will be done at ILD meeting on March 5th, 6th, and 7th

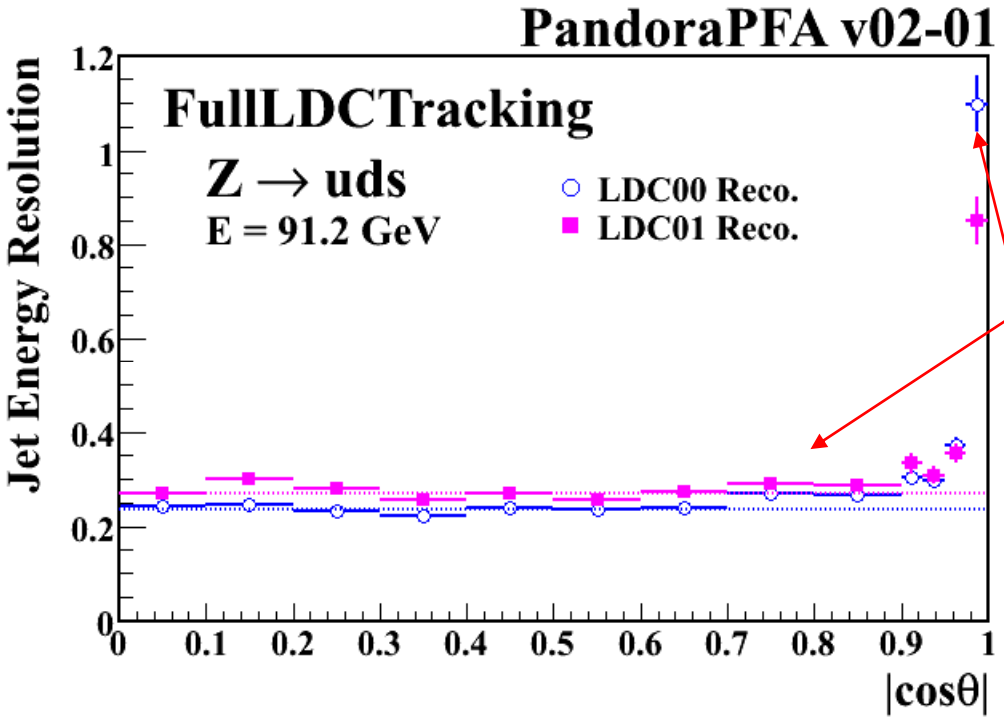
Backup slides



(from a talk by M.Thomson at Zeuthen WS)

PandoraPFA : LDC00 vs LDC01_05Sc

★ NOTE: so far mostly looked at 91.1 GeV



Comments

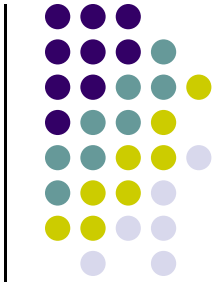
★ Barrel performance worse
23.5%/√E ➞ 27.0 %/√E

★ Less degradation in Barrel/Endcap overlap region for LDC01
HCAL RING ?

★ Far Endcap region LDC01 better !
LCAL/ECAL Plug

★ For the moment concentrate on degraded performance in barrel
potential implications for detector design…

Charge of W.G.s



- Detector Optimization
  - Investigate the dependence of the physics performance of the ILD detector on basic parameters such as TPC radius and B-field. On the basis of these studies and the understanding of any differences observed the WG will make recommendations for the optimal choice of parameters for the ILD detector
- MDI/Integration
  - The MDI/working group is charged to produce a self-consistent design of the structure of the ILD detector from the viewpoint of machine-detector interface (MDI) and detector integration for the LOI that is to be submitted by October 1, 2008. Specifically, it covers the design of the beam pipes, magnets, iron return yoke, beam instrumentations, and their supports that require works by the detector group. Also, it should address general detector structure and assembly issues, where the aspects that affect the machine design will have initial priority. Beam background studies should be performed when necessary. The group should work closely with the machine people and the groups working on subdetectors that affect the structure of the ILD detector.