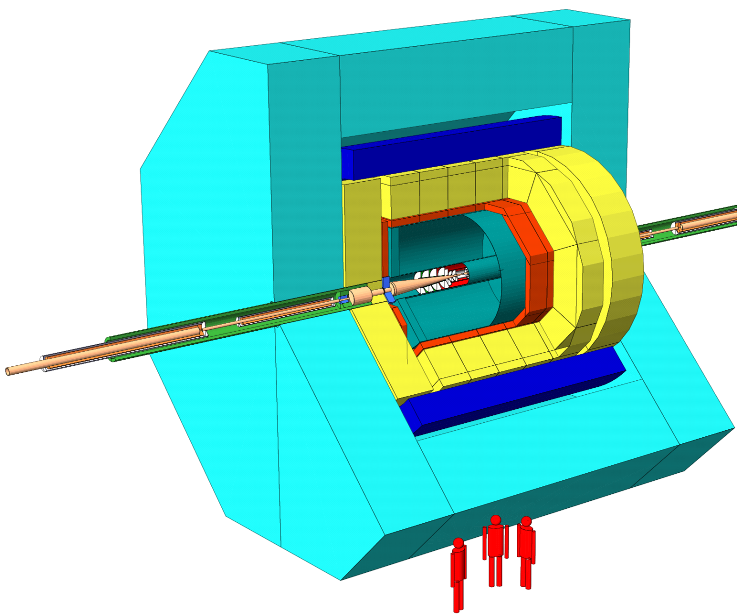
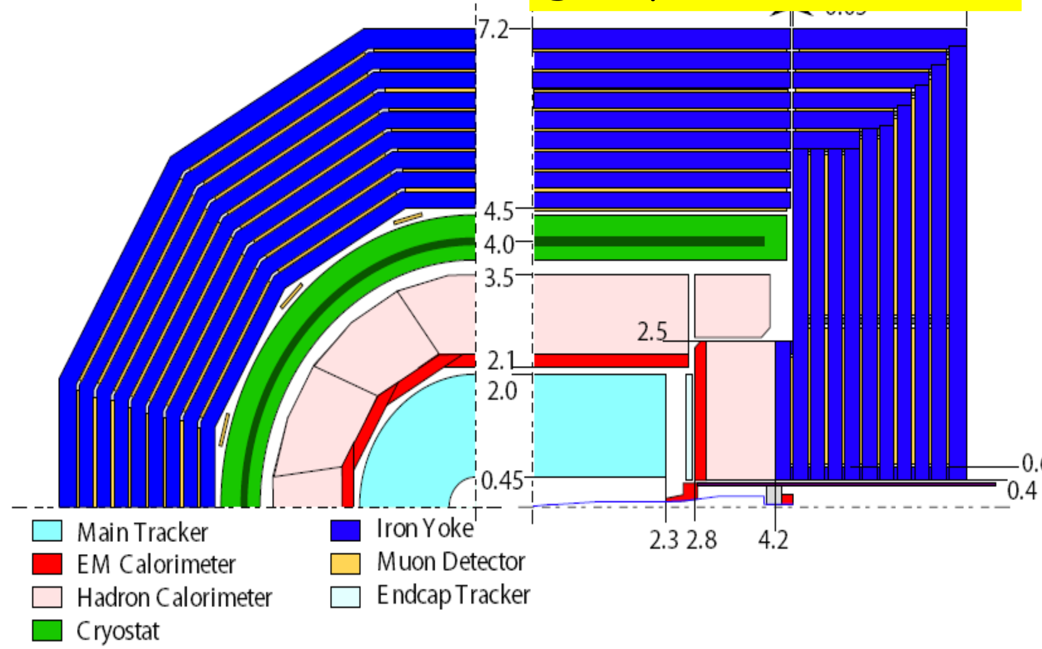
# The ILD:
# a large detector for the ILC

Ties Behnke, DESY
for the ILD concept group






LDC DOD:
see http://www.ilcldc.org

GLD DOD
see arXiv:physics/0607154v1

Large Detector Concept

Global Detector Concept

# The concept behind the concept

The Design Motivation behind ILD

- Precision detectors
- High reliability/ redundancy to enable precision physics

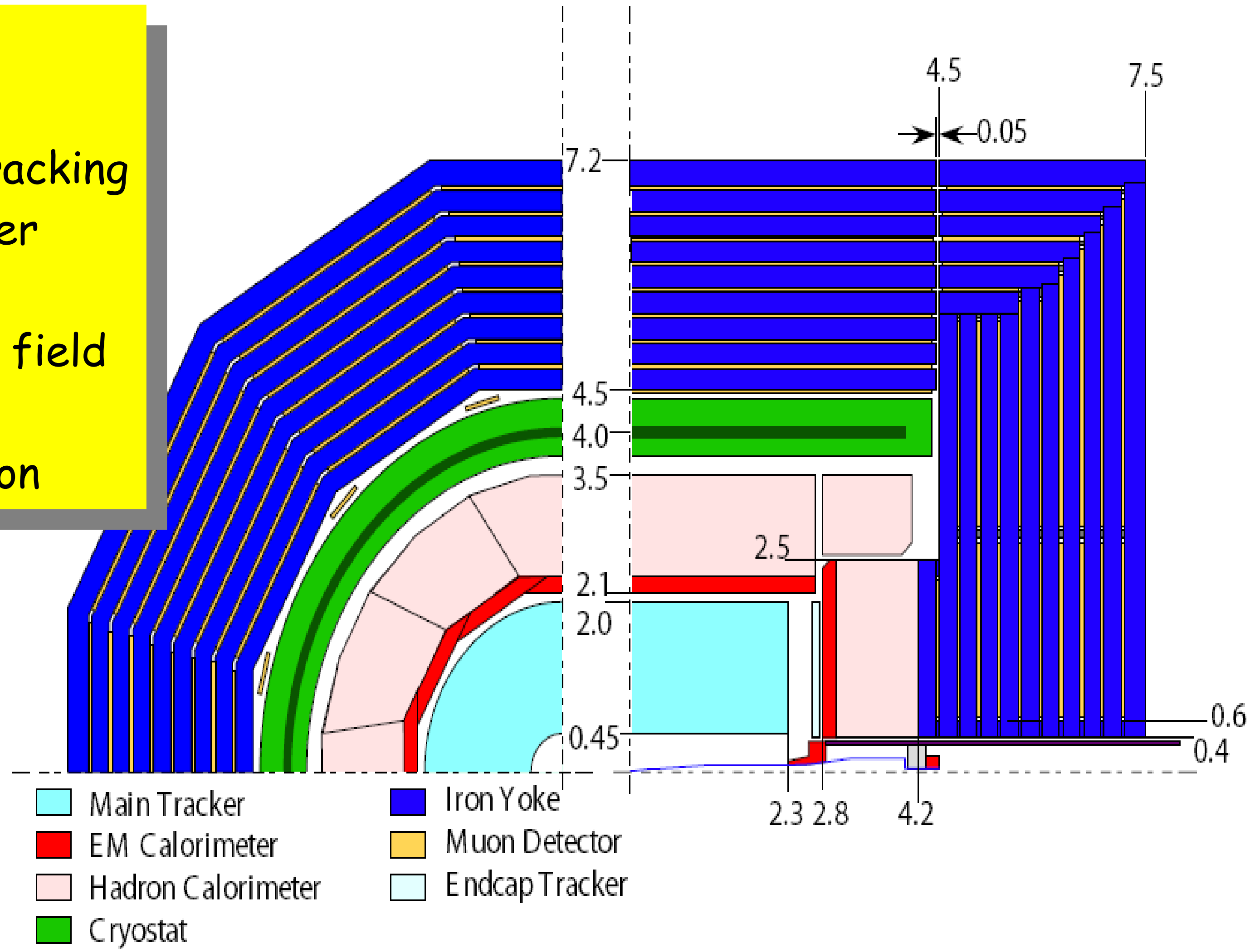
Reliable, redundant tracking system

High precision calorimetry based on particle flow for best jet energy reconstruction and excellent particle ID

Hermeticity

# Basic Layout

- High precision Vertex
- Large Volume TPC
- (nearly) complete SI tracking
- Particle Flow calorimeter
- Excellent hermeticity
- 3-4T central solenoidal field
- Iron Return Yoke with
  Muon instrumentation



# ILD History: International Large Linear Collider Detector

Roots are in the former JLC and TESLA projects

First conceptual reports in the late 90ies

RDR 2007: JLD and LDC separate reports

LCWS2007: plan to merge LDC and GLD has been formulated

September 2007: Joint Steering Board for ILD established

November 2007: ILD meeting at ALCPG in Chicago

January 2008: ILD workshop in DESY Zeuthen

March 2008: ILD meeting in Sendai, Japan

# Structure of ILD

General Assembly: all groups who consider themselves members of ILD

Executive board:
JSB + contact people

Subdetector contacts

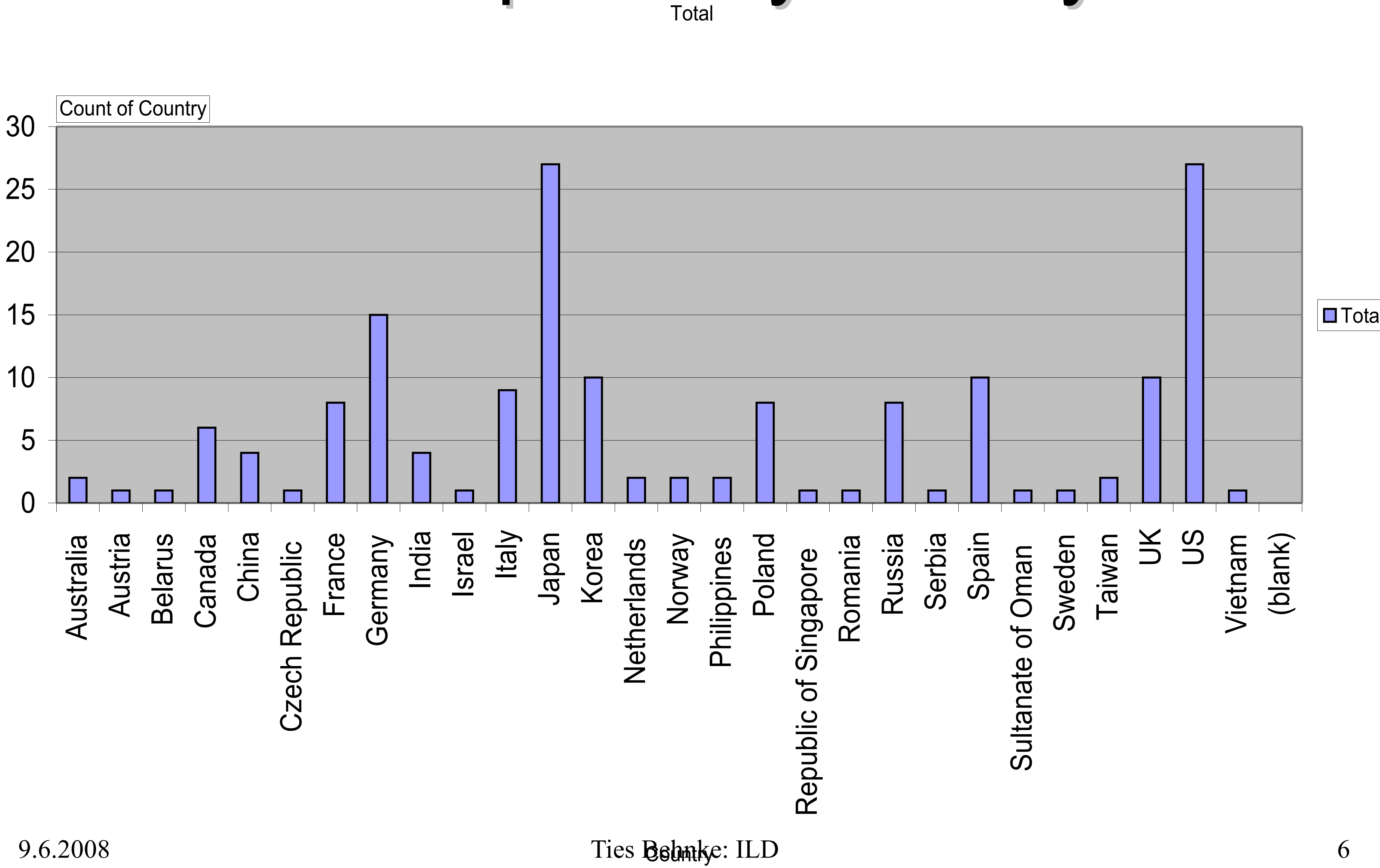
- VTX
- SI
- TPC
- CALO
- Muon
- FCAL
- DAQ
- ...

Working groups

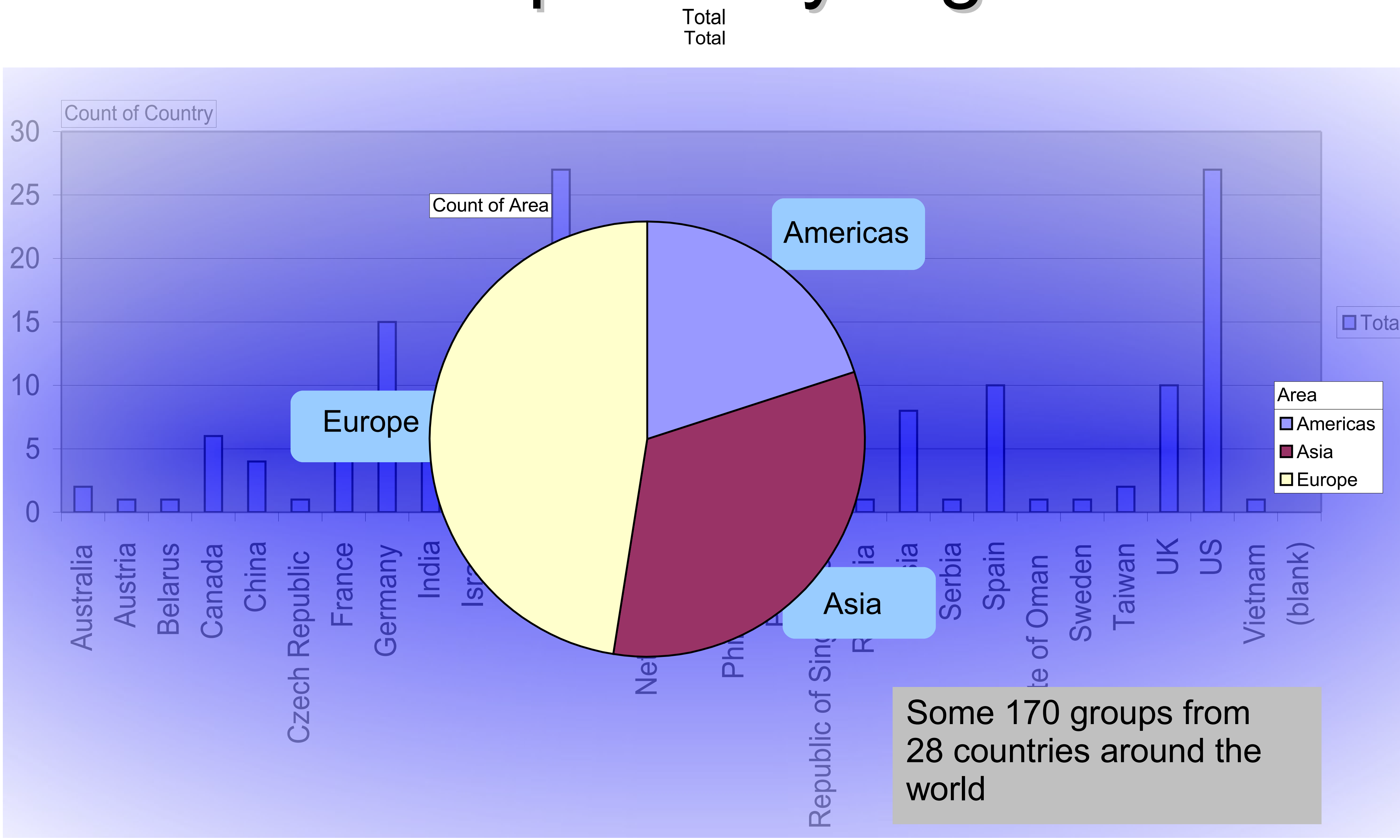
- Optimization
- MDI
- cost

Joint Steering Board

# Participants by country



# Participants by region




Some 170 groups from 28 countries around the world

# ILD structure

- **Joint Steering Group**
  - Ties Behnke, Dean Karlen, Yasuhiro Sugimoto, Henri Videau, Graham Wilson, Hitoshi Yamamoto
- **Working groups:**
  - Optimization (Thomson, Tamaki)
  - MDI (Büsser, Tauchi)
  - Cost (Videau, Maki)
- **Subdetector contacts:**
  - VTX Winter, Sugimoto
  - SI tracking Park, Savoy-Navarro
  - TPC Settles, Fujii
  - Calorimeter Brient, Laktineh, Sefkow, Kawagoe
  - DAQ Eckerlin

This structure is a starting point, and will be adjusted as needs arise

We are lacking US involvement at this stage.

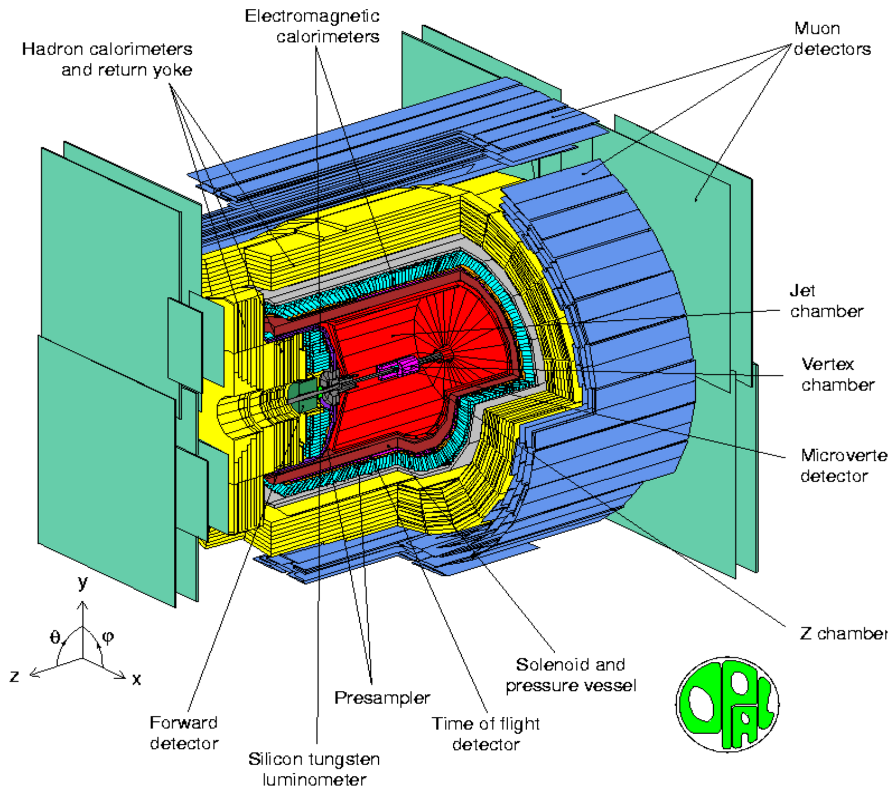
# Review of ILD Design

- 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 >> $\sigma_b$
- Tracker
  - $\delta p_t / p_t^2 = 5 \times 10^{-5}$ /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

# Lessons learned

- Last generation of e+e- detectors: LEP detectors/ SLD
- Enormous experience in building the LHC detectors
- Be prepared for the unexpected (lifetime measurements, ultimate precision)
- Material hurts and is very important
  (example: vertexing at LEP, luminosity m
- Three dimensional event reconstruction
  is very important for precision
- For ultimate precision:
  - need good hadronic calorimetry
- Reality will be different than simulation..



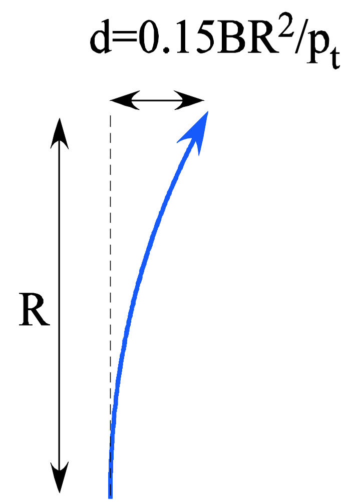
# PFLOW and DETOPT

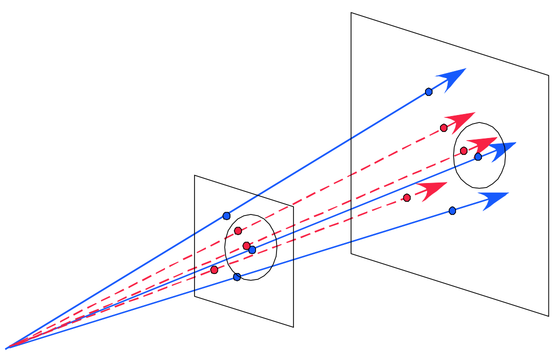
**Concept of particle flow is central to the ILD concept**

Separation of particles:

But only applicable in the barrel!

- Charged track separation ∝ $\mathbf{B\ R_{in}^2}$
- Neutral separation ∝ $\mathbf{R_{in}}$



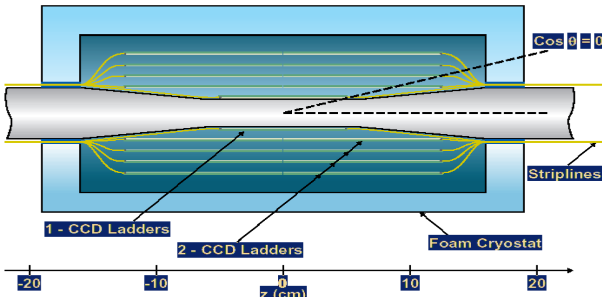
But other issues enter as well:

- Moliere radius (= material)
- Segmentation of CALO

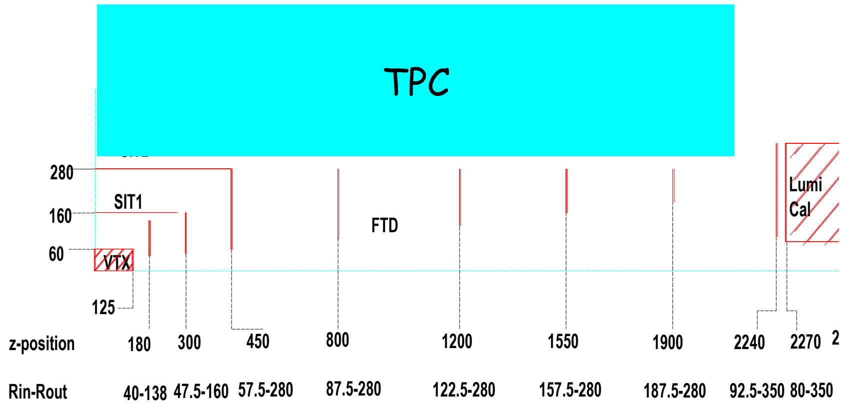
Questions: what is the optimal size? (including aspect ratio)
What is the optimal B-field

# The inner detector

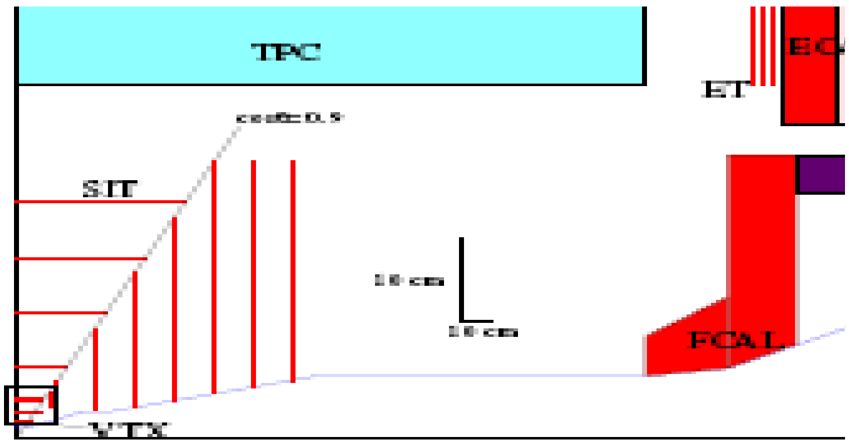
Basic layout:




- high precision VTX detector
- auxiliary SI tracking to bridge the gap between VTX and TPC
- high precision many point TPC



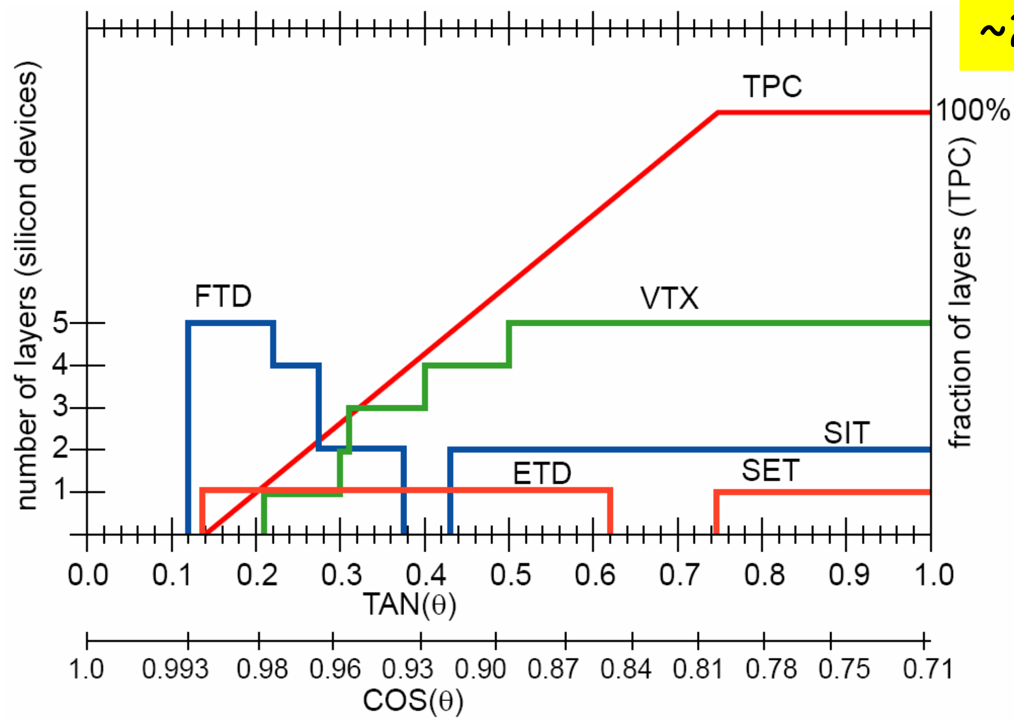

2 SIT layers




4 SIT layers

# Tracking Configuration

Coverage of subdetectors:




~200 hits

Open Questions:

- Role of additional detectors?
- External Si tracker?
- SI detector behind the TPC endplate?

LDC coverage

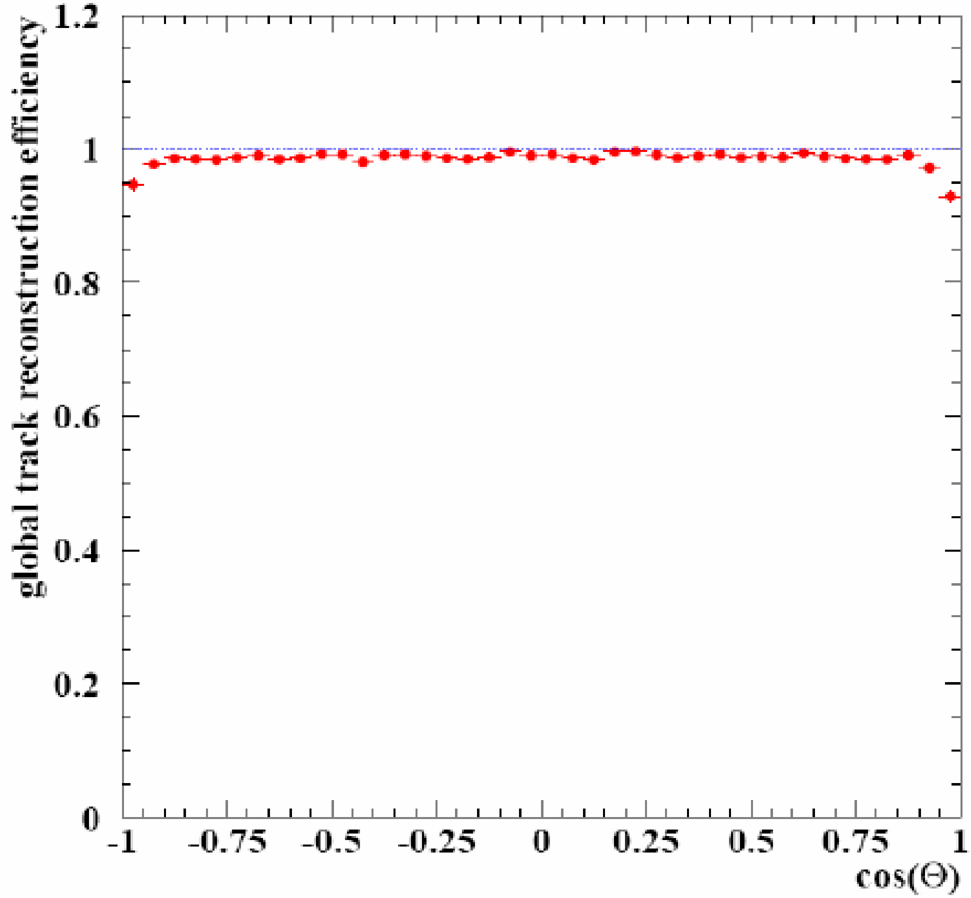
# Tracker Performance

Large number of 3D track hits in TPC + SI detectors

Very high redundancy and excellent efficiency

Excellent precision

High efficiency is extremely important for particle flow!



# Calorimetry: Layout

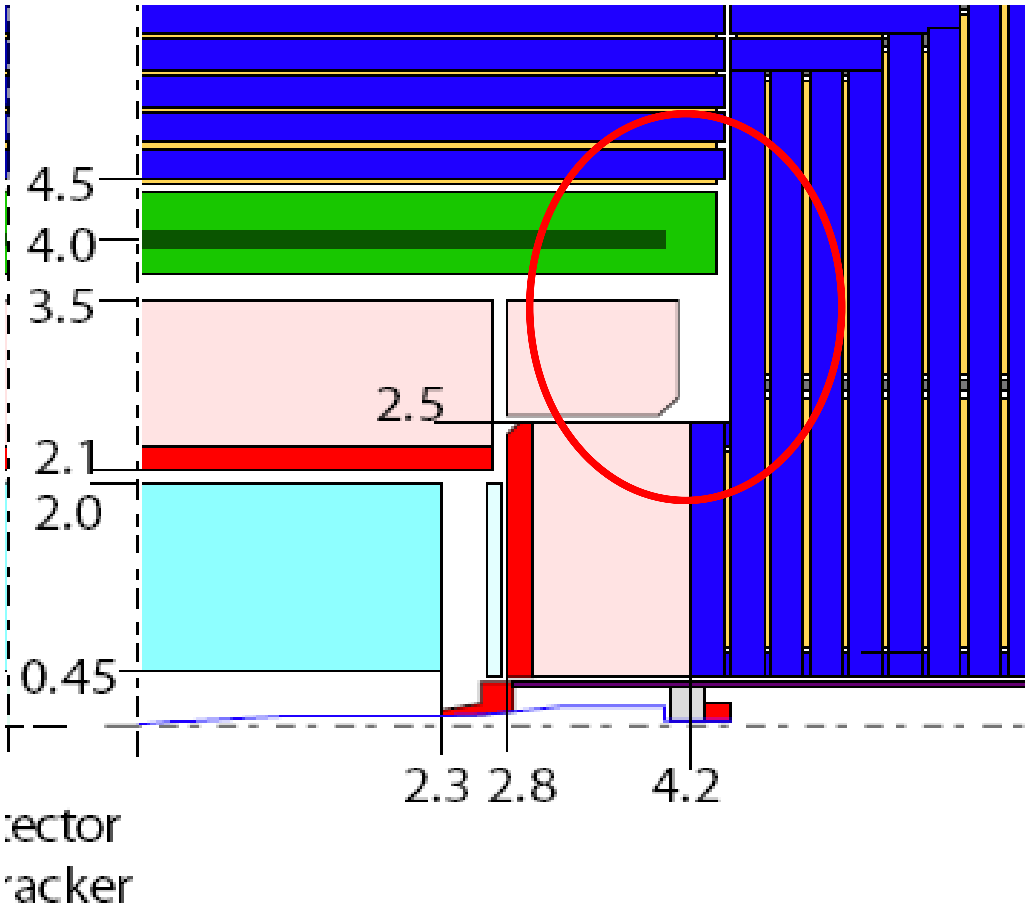
Calorimeter System is
inside the coil

hermetic design
details are being
worked out

Major design input:

optimisation for particle flow

GLD design

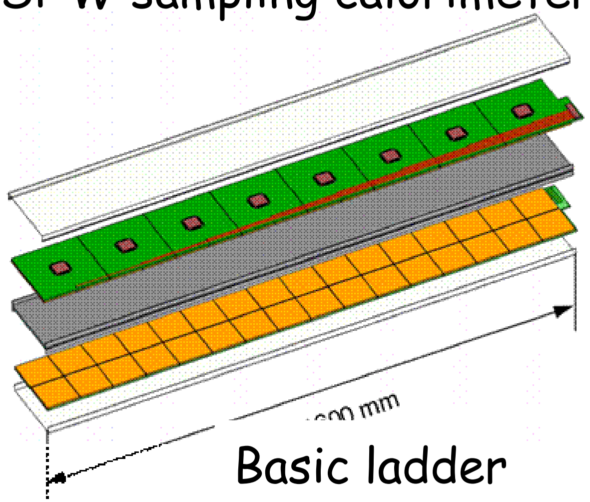


# ECAL: technology

Particle flow calorimetry:

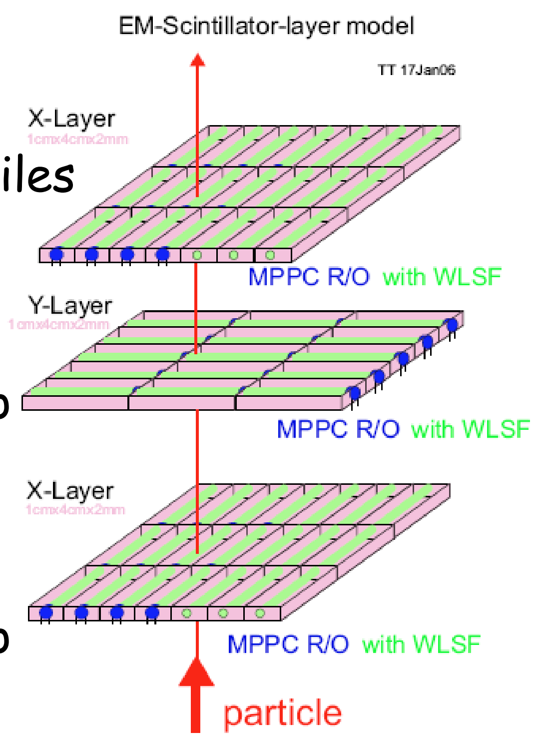
small cells, small Moliere radius

LDC: Si-W sampling calorimeter



Basic ladder design

Strip or tiles




strip

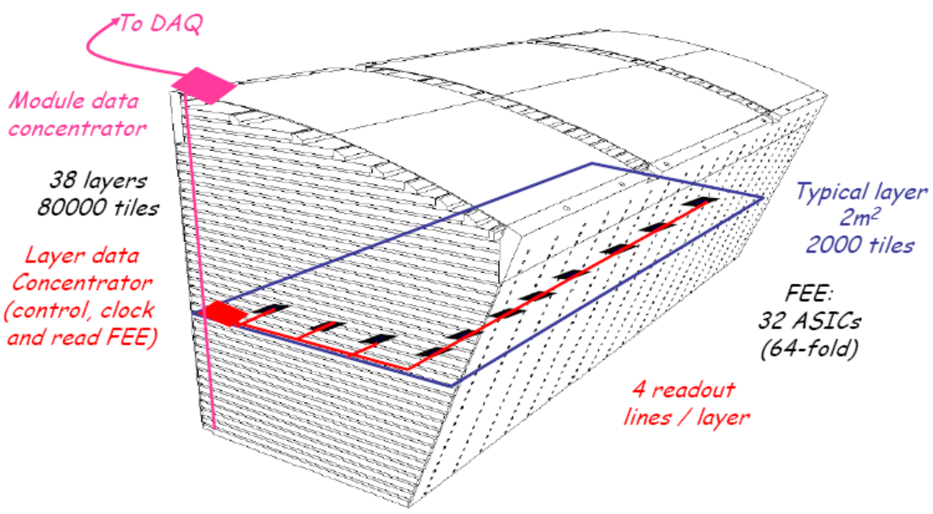
strip

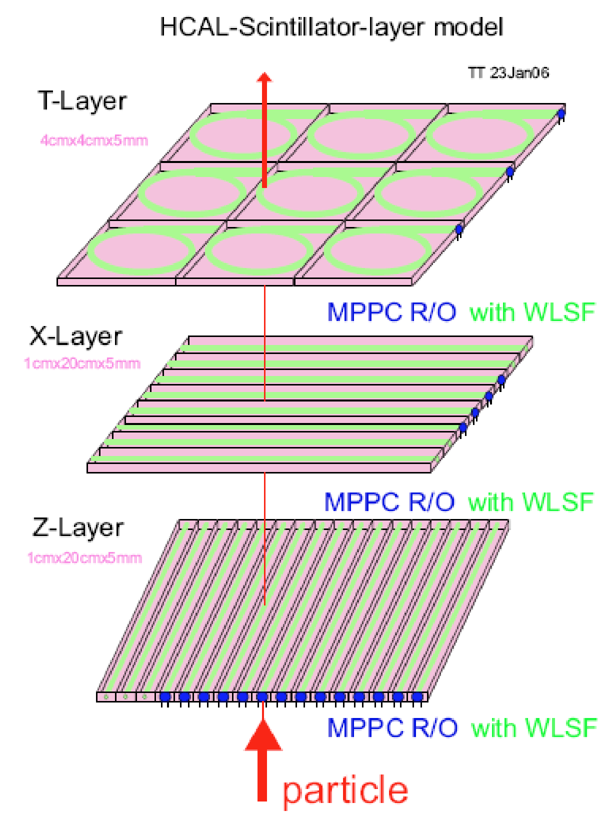
GLD: Scintillator-Pb sampling calorimeter

# HCAL

Two options are under investigation:

Analogue Scintillator tile – Fe sampling
digital Fe-sampling

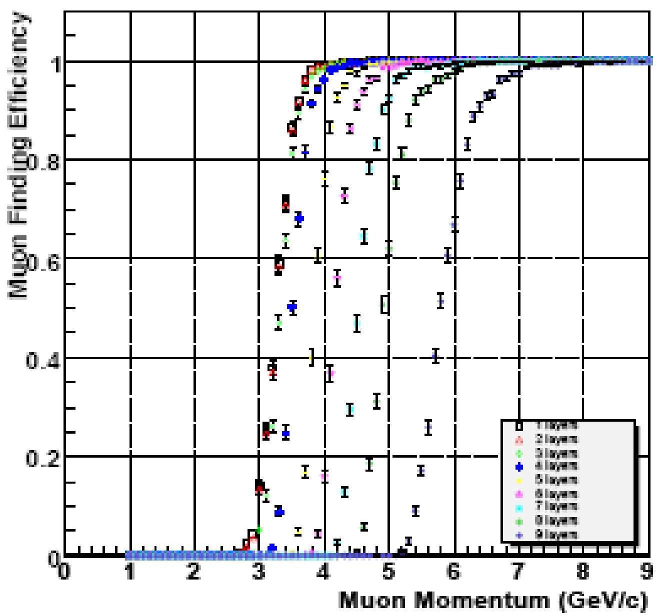


# Outer Detectors

Muon system: instrumented iron return yoke

Options are Scintillator strip or large area RPC




Number and spacing of layers need to be optimized

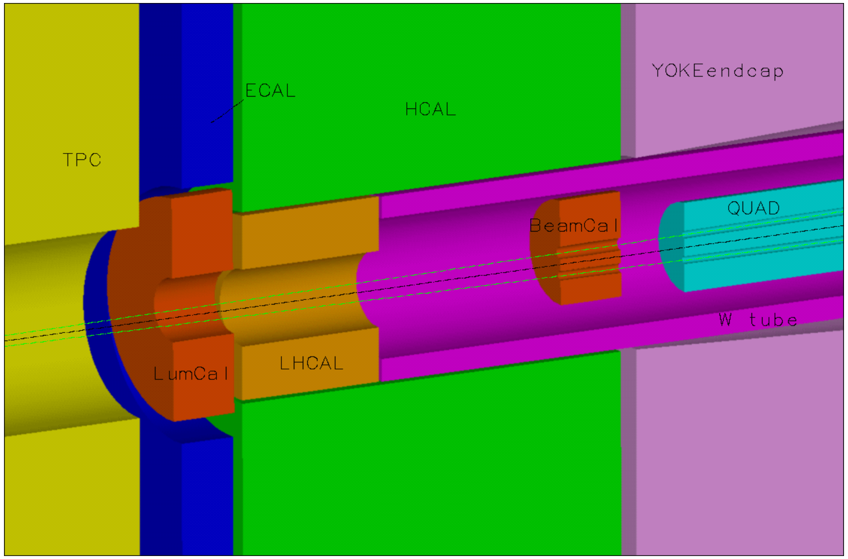
Role of Muon detector in a PFLOW detector needs to be understood

# Very forward detectors

Ambitious instrumentation to

- Measure backgrounds
- Tag physics particles
- Monitor the beams
- Shield the inner detectors

Close interaction with machine groups is essential




MDI working group is already studying this in detail

expect progress very soon

This has far-reaching consequences for the overall detector design: high priority!

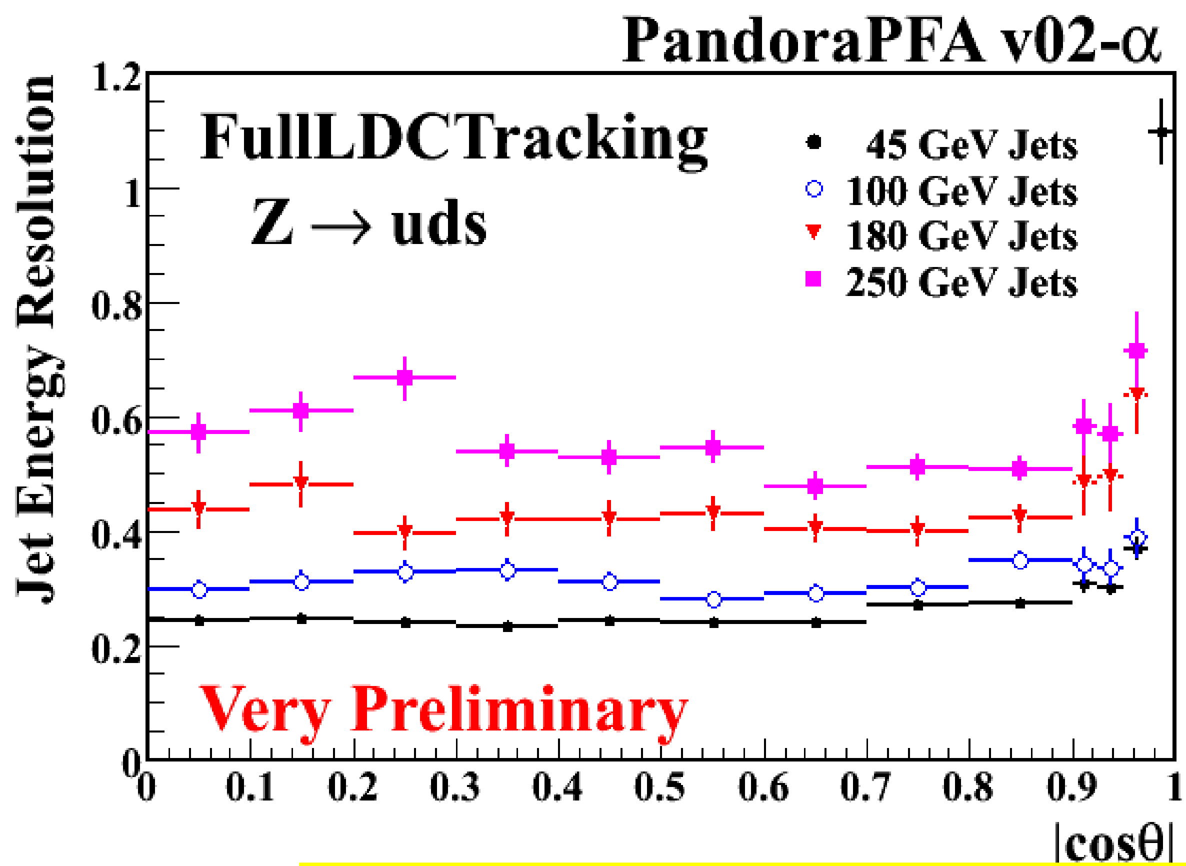
# Particle Flow: Performance

Particle flow (PandoraPFA)
including full realistic tracking

Mark Thomson, Cambridge
see talk later in this conference
more up-to-date performance

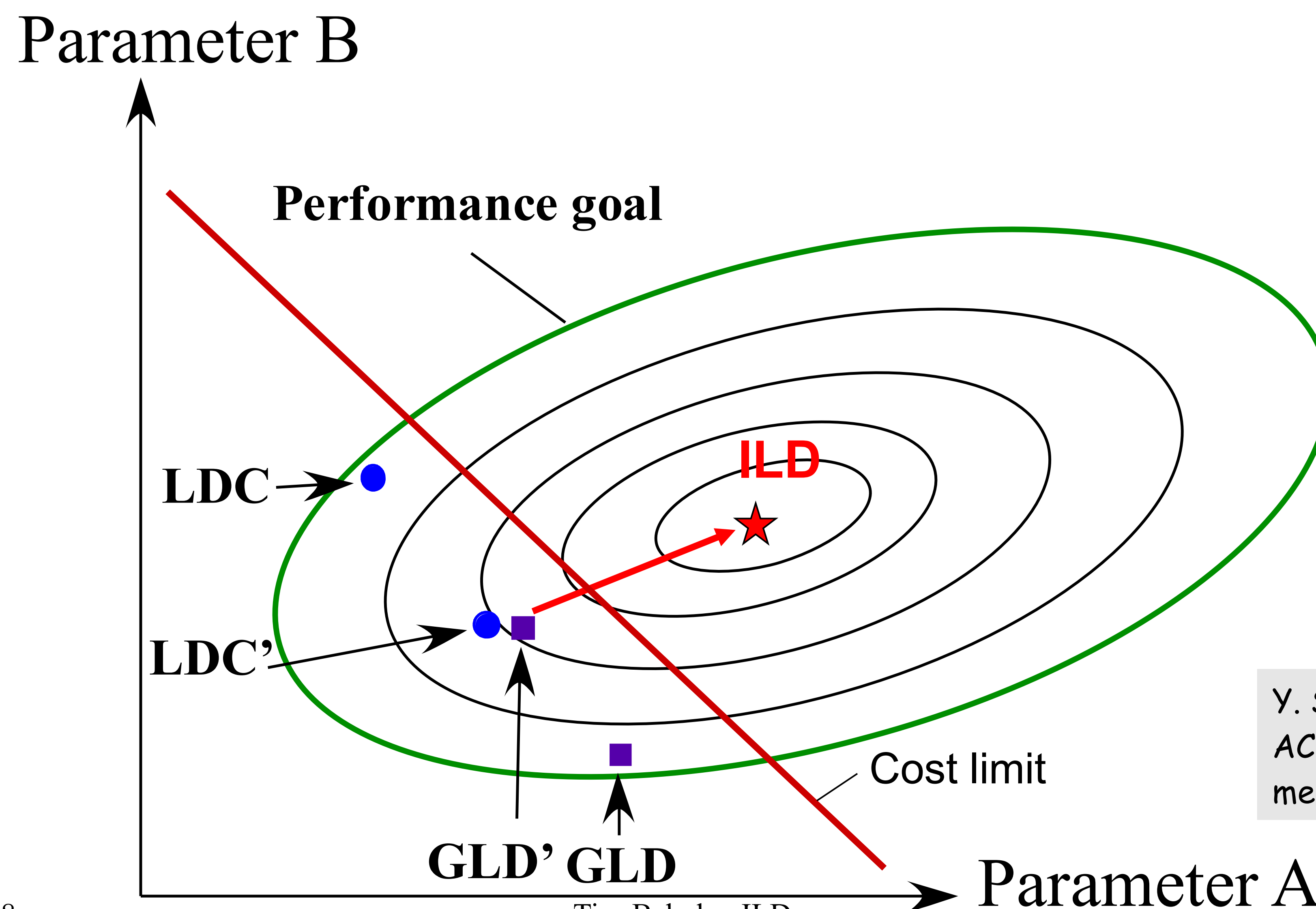
There is still room
for significant improvement

but performance is
good enough to
start real physics analyses




25%/sqrt(E) at 45 GeV at the moment
including realistic LDC tracking!

# Optimization procedure




Y. Sugimoto, ACFA Sendai meeting

# How to continue

Optimization working group:

prepares for large scale production of simulated events based on intermediate versions of the detector

actual detector optimization will be done more on dedicated samples

time scale: see Marks presentation

Early fall: will define the ILD layout

Fall: review analyses, start forming the LOI editorial board

Deliver LOI Spring 2009

# Engineering challenge for 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
  - ...



Y. Sugimoto at TILC08

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  - ...
  - ...

# ILD and Detector R&D

ILD maintains very close relations to the horizontal R&D collaborations

Most of the R&D is done by the R&D collaborations.
They have the expertise and people.
ILD does not have its own R&D program.

CALICE/ LC-TPC/ FCAL/ LCFI/ MAPS/ DEPFET/ others

A remark:

ILD is not a formal collaboration.
ILD does not intend to become a formal collaboration any time soon

This is pre-mature also in view of recent setbacks of the ILC program

# Scope of LOI, or what is the LOI and what not?

- Make a convincing case for the ILD detector:

  Demonstrate the needed performance based on the agreed reference reactions (and more, if possible).

- Demonstrate that the proposed detector has been optimized

  Show on key examples why the detector looks as it does: needs detailed and full simulation studies

- Show that the proposed ILD detector is feasible

  no complete engineering, but show a path towards this
  illustrate that an integration into a complete detector is possible
  Keep costs under control!

This is a very ambitious program, which will need the support from everyone!

# Summary and Conclusion

ILD: an exciting exercise in global detector development

Integration of LDC and GLD into one concept is proceeding

Optimization studies have started, but present many and huge challenges: see discussions this meeting

ILD is relatively well positioned to meet the challenge
(but recent events in UK and US hurt)

ILD biggest strength is its strong ties to the R&D collaborations
and their know-how
and its broad constituency in all three regions of the world.