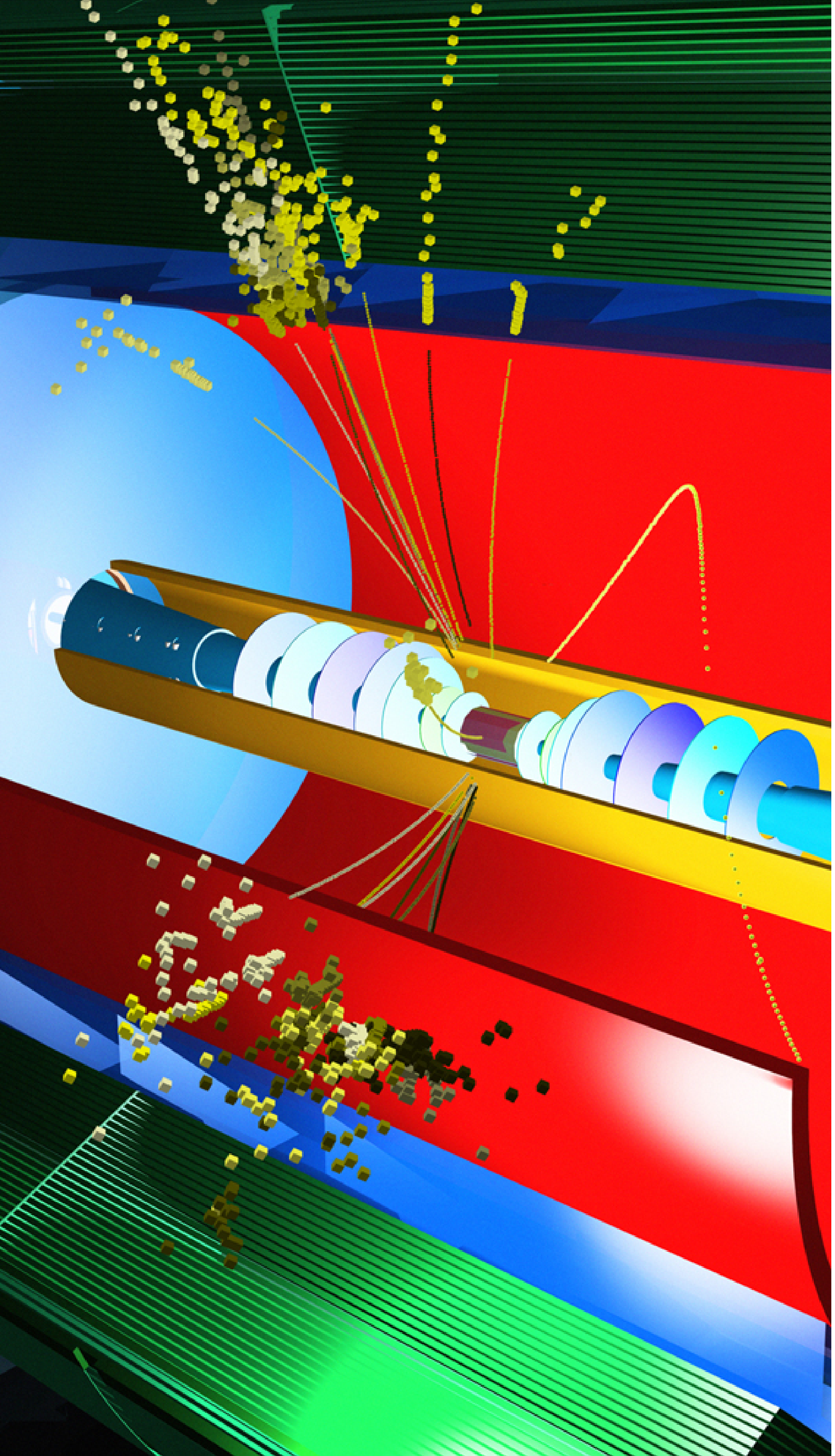
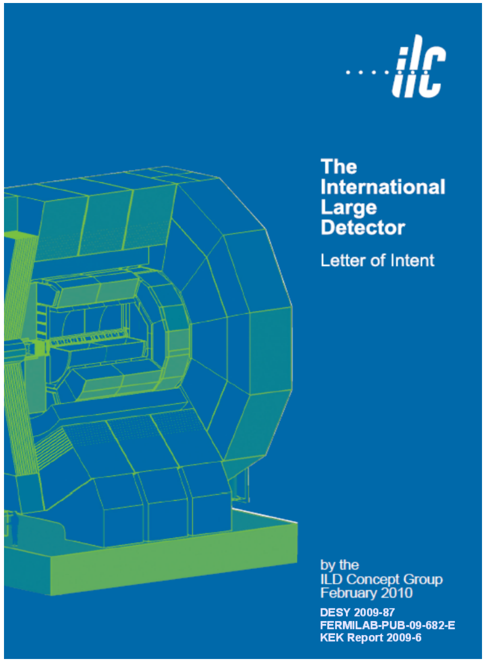


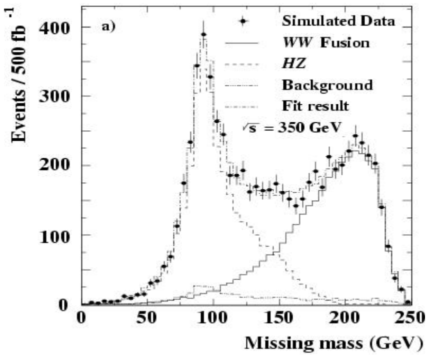
ILD: A detector for the ILC

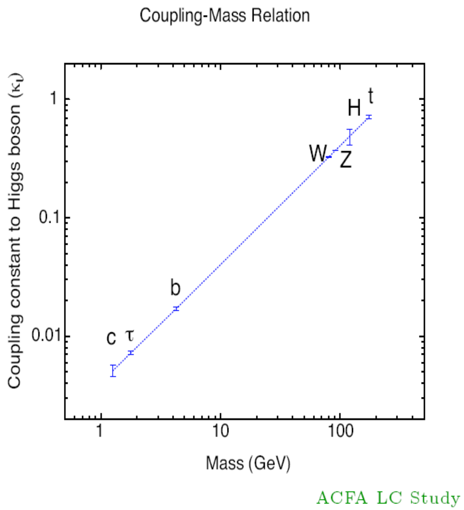
For the
ILD concept group
Ties Behnke, DESY

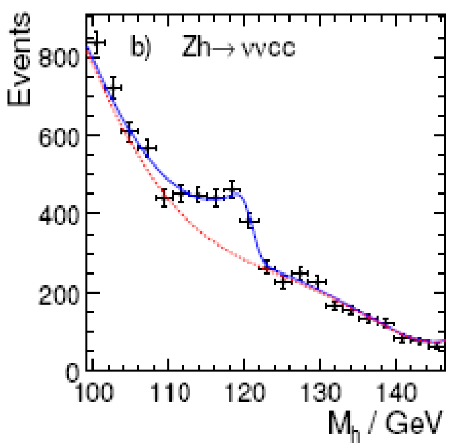


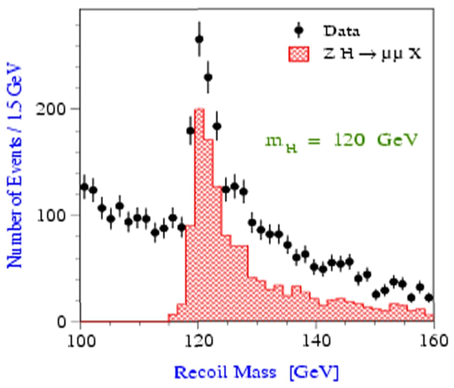
Presentation to the JSPS kickoff
Sendai, Japan, 12.9.2011

Physics at the ILC









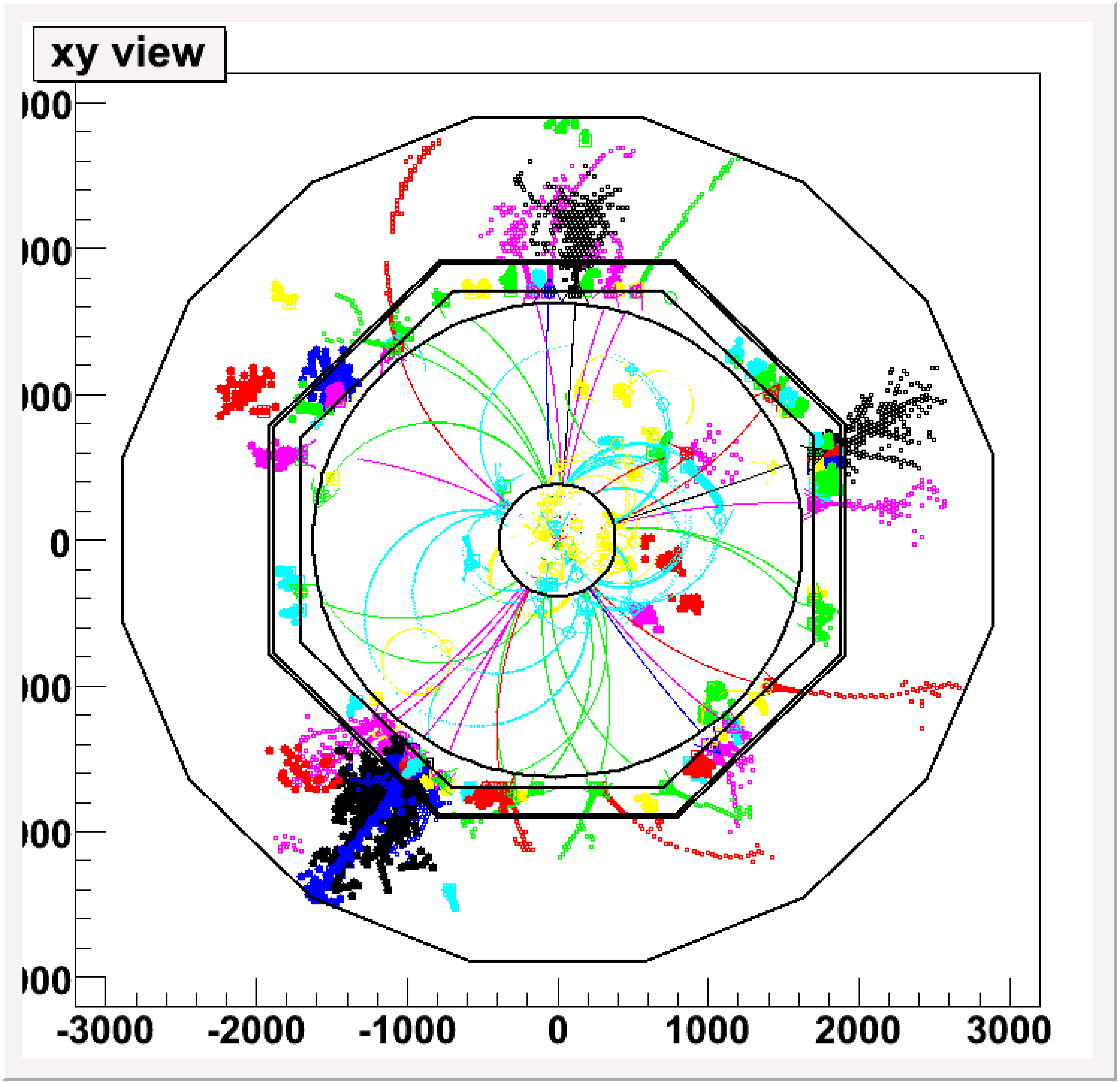
Very broad physics program

Many different final states

Often hadronic final states:
Need to be able to reconstruct multi-jet final states with good precision

Higgs physics
Standard model physics
Searches
etc.

Top event



A Detector at the ILC

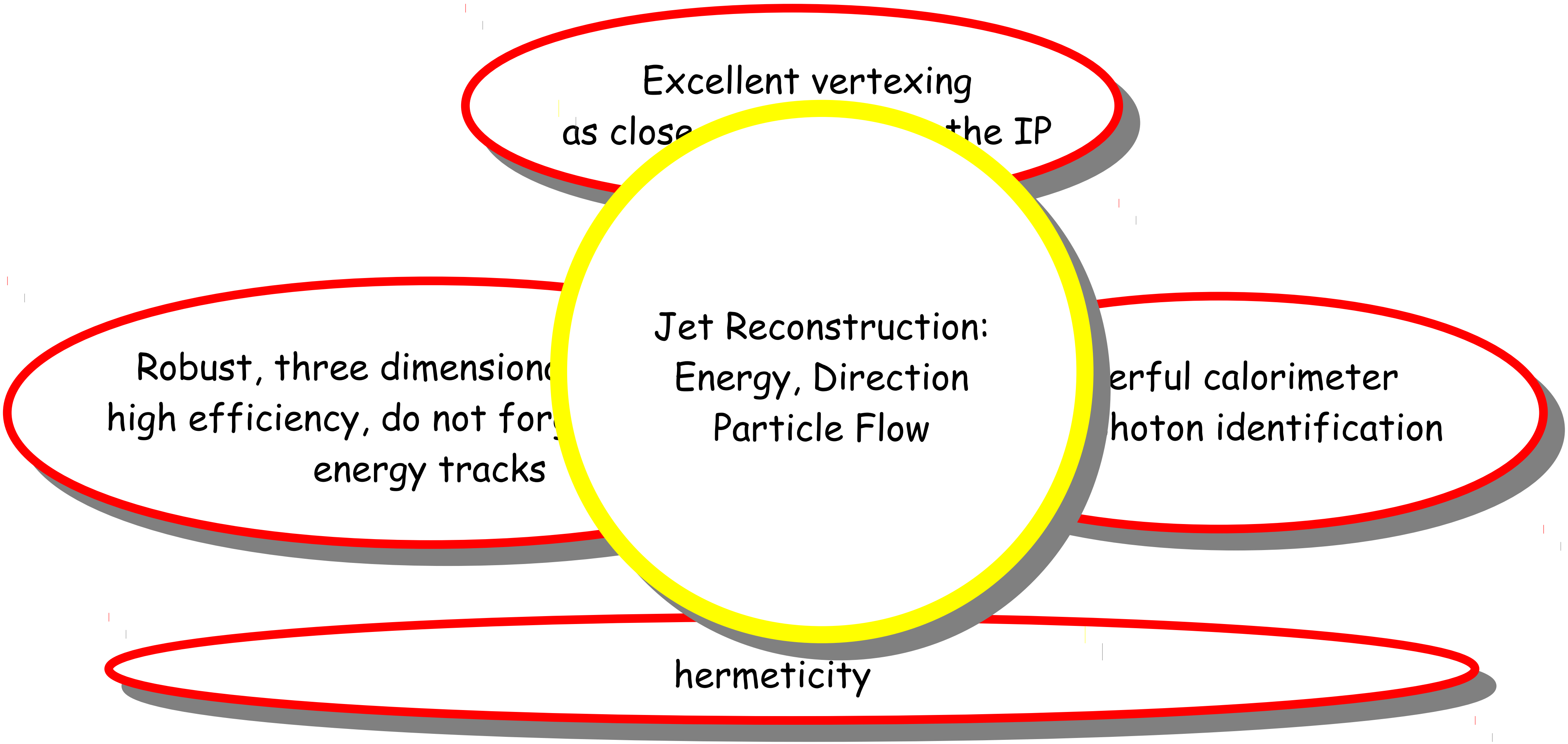
Excellent vertexing
as close as possible to the IP

Robust, three dimensional tracking
high efficiency, do not forget the low energy tracks

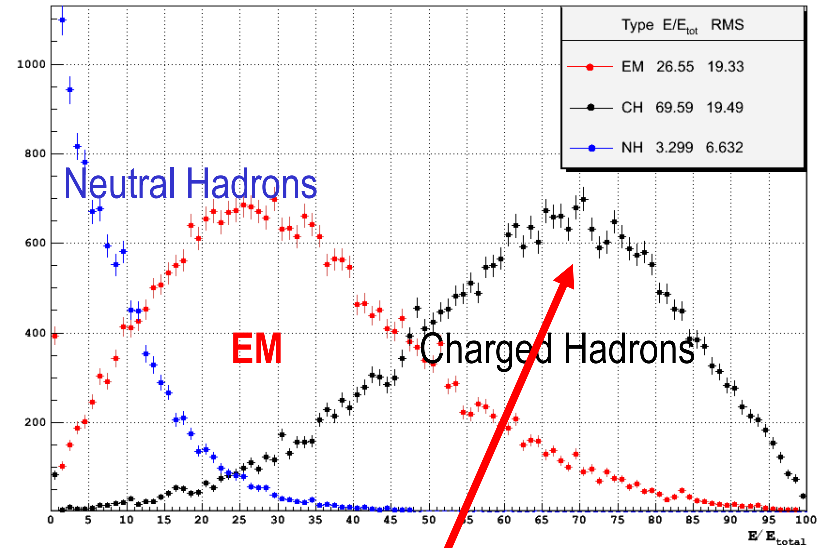
Powerful calorimeter
good photon identification

hermeticity

Detector Requirements



Particle Flow



- Most precise event reconstruction
  (measured e.g. in the jet mass)

- Individual particles are reconstructed:
  charged and neutrals

Fundamental problem: fluctuations in the calorimeter:

<70%>

use tracker as much as possible
replace information in calorimeter by tracker information
only use calorimeter for neutral particles (photons, neutral hadrons)

Pushes requirements for calorimeter:
excellent segmentation
energy resolution is of lesser importance

30%/√E (below 100 GeV)
is the goal

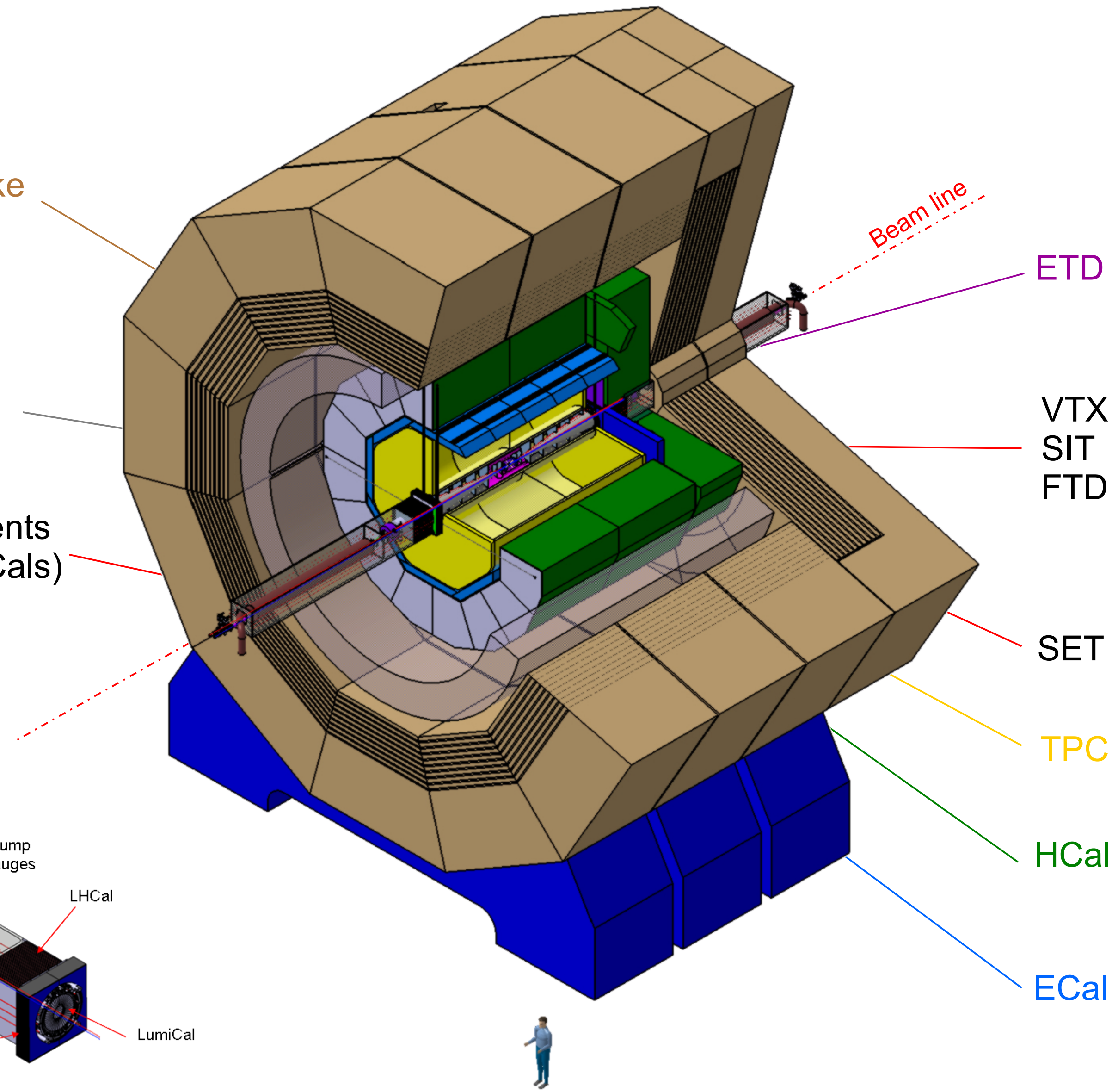
The Detector Philosophy

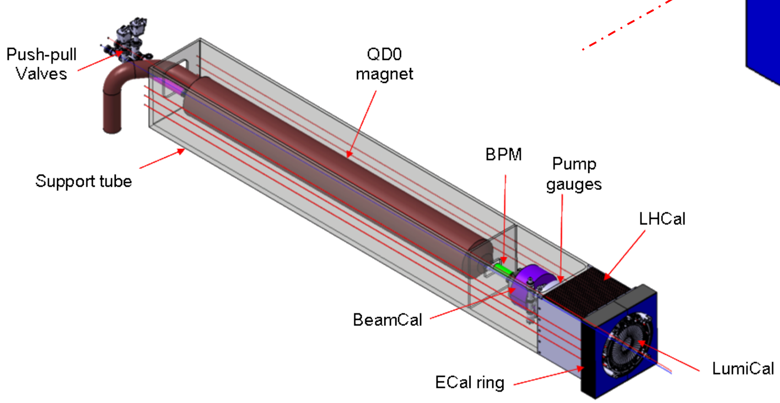
Basic considerations:

- Magnet 3.5T (à la CMS) all up to HCAL inside(reduce background, excellent momentum resolution)
- VTX….. precision on impact parameter, very low material budget including services
- Silicon tracker precision on momentum, linking VTX to TPC, alignment, low material budget
- Tracker: choice based on low material budget and redundancy on tracks and V0 -> **TPC** (endplate micromegas/GEM and reduced services)
- ECAL: density, granularity , high B field, … -> ECAL tungsten-Silicon/scintillator (separate and identify all particles : charged hadron / neutral em/ neutral hadron)
- HCAL: granularity and density -> HCAL Fe – Tile/RPC (separate and identify all particles (charged hadron / neutral hadron/ Muon Id.)
- W-Si/diamond for the forward calorimeter (cope with high level of background, stability for lumi. measurement)

Important for all: services : power distribution, cooling, hanging structures, etc…

The ILD Proposal





Letter of Intent in 2009 – Invited by IDAG to work **towards a DBD for 2012**

ILD's roots

GLD detector concept
Strong base in Asia,
plus US and EU

Late 90's
of last centruy

LDC (TESLA) detector
Strong base in Europe,
plus Asia and US

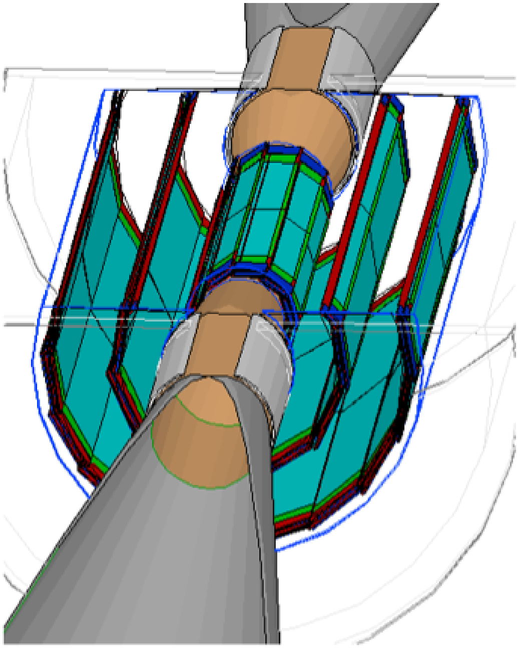
In 2007 during LCWS2007 conference LDC and GLD decided to join forces and prepare a letter of intent together

International Large Detector, ILD

This was the starting point for a very successful collaboration between the different ILC detector groups (with a certain emphasis on Europe and Asia, but with significant contributions from the Americas as well)

Vertex detectors

Baseline design: Three doubled sided layers:

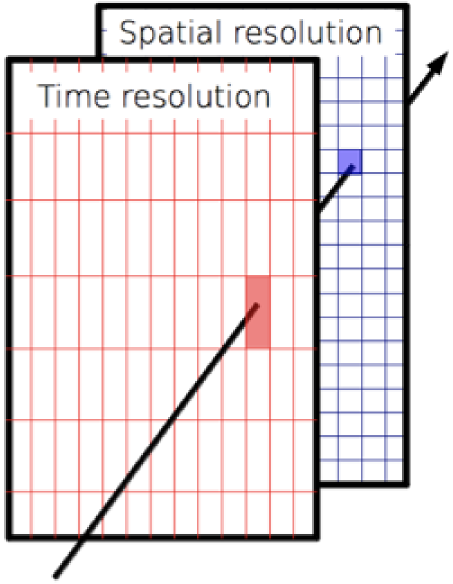


Sensor development

Inner double layer inner radius
- binary charge encoding
- 16x16 μm^2 pitch => < 3μm resol.

Inner double layer outer radius
- binary charge encoding
- 16x64 μm^2 pitch => 5μm resol.

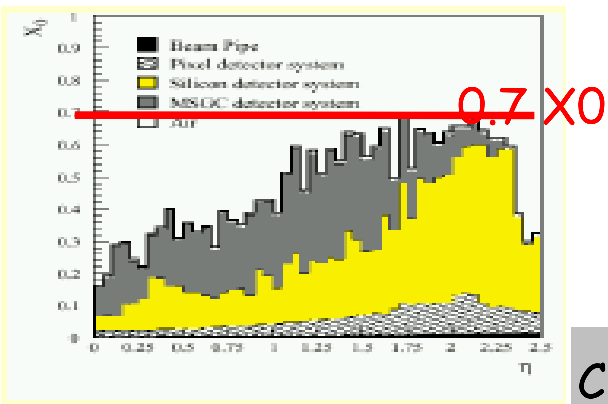
Outer layers
- 35x35 μm^2 pitch
- charge encoding with 4 bit ADC
  => resolution 3-4 μm

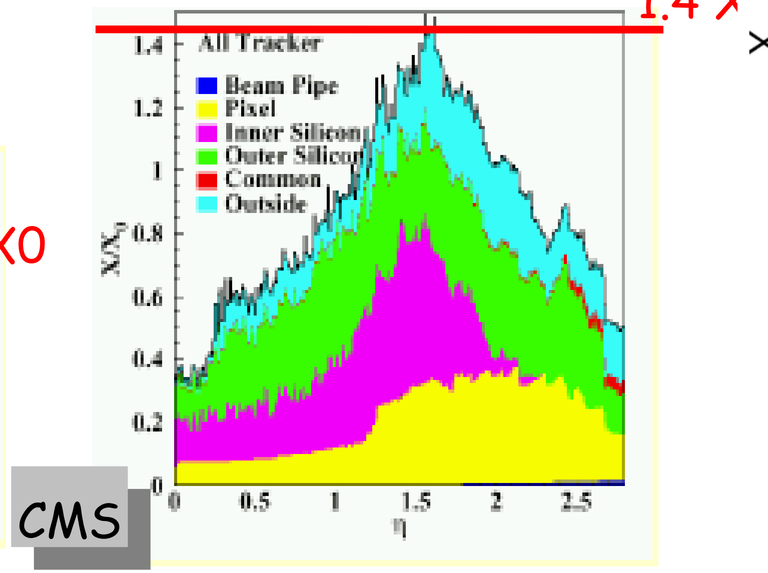


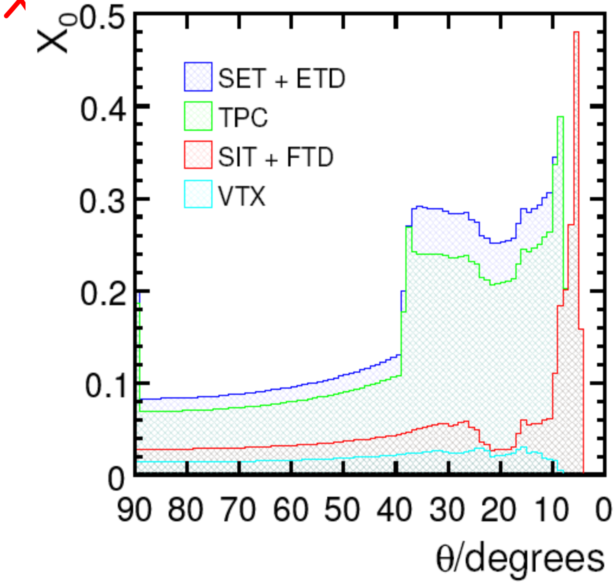
Central role by Japanese group,
principle has been demonstrated, prototyping ongoing

Vertex detectors: Material

... and the reality 10 years later







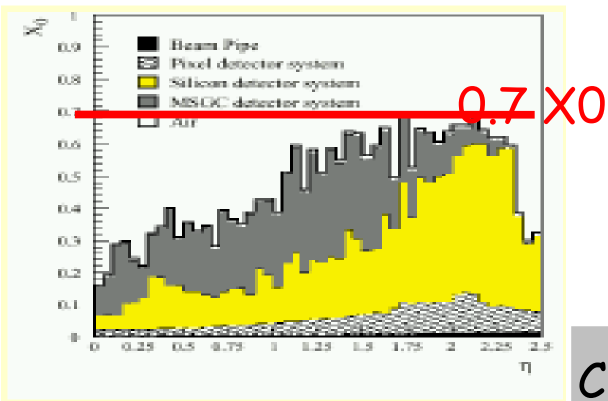
PLUME collaboration:
Development of double sided ladders with MIMOSA 26 sensors

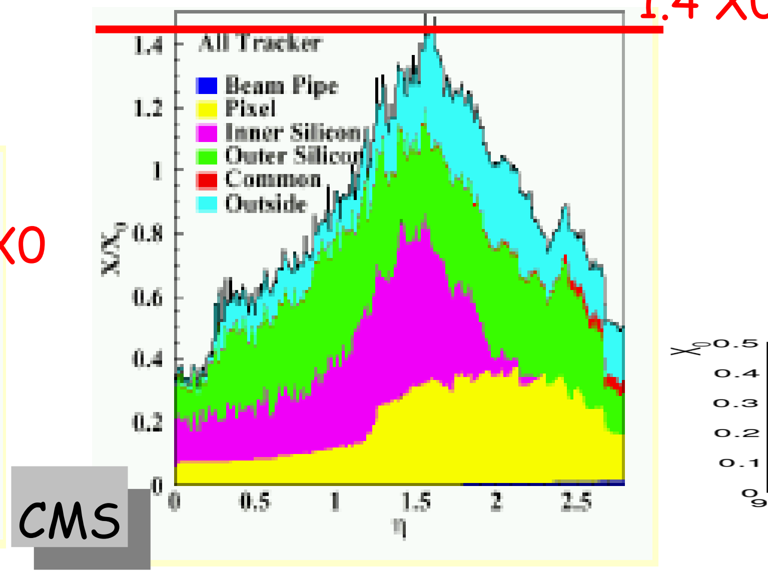
Material budget 0.6%X_0

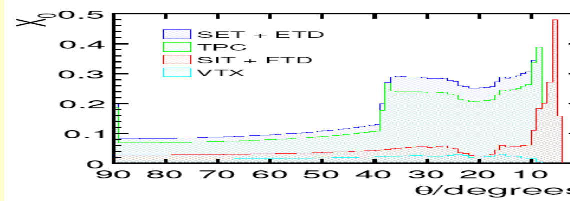
Further studies to reduce material budget to 0.4% for DBD

Vertex detectors: Material

... and the reality 10 years later





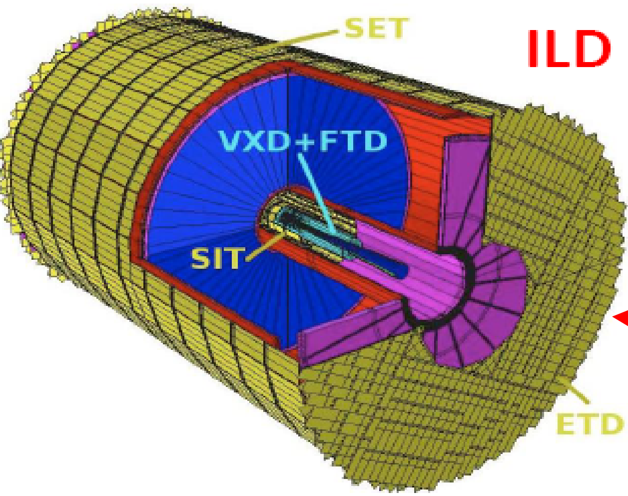


PLUME collaboration:
Development of double sided ladders with MIMOSA 26 sensors

Material budget 0.6%X_0

Further studies to reduce material budget to 0.4% for DBD

Silicon Inner Tracking

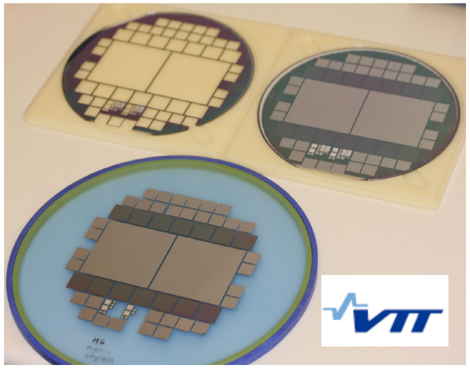


- Based on 4 Silicon components surrounding the TPC:

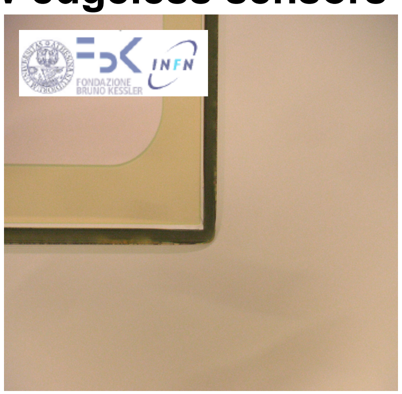
SIT, SET, FTD, ETD

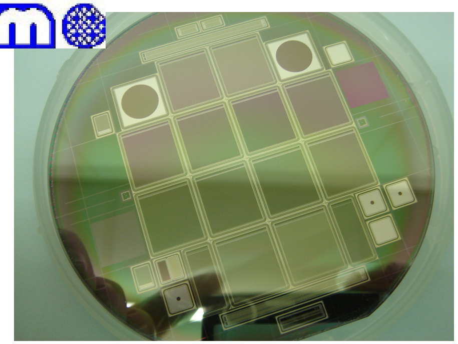
- **Main objectives: high performances & low % X0 =>**
- Main R&D streams: sensors, FE readout, interconnection
- Baseline sensor technology: Single sided strips

- For DBD:
  New planar single sided strips technology, large sensors (6''), edgeless and high transmittance (IR laser alignment) options



New edgeless sensors





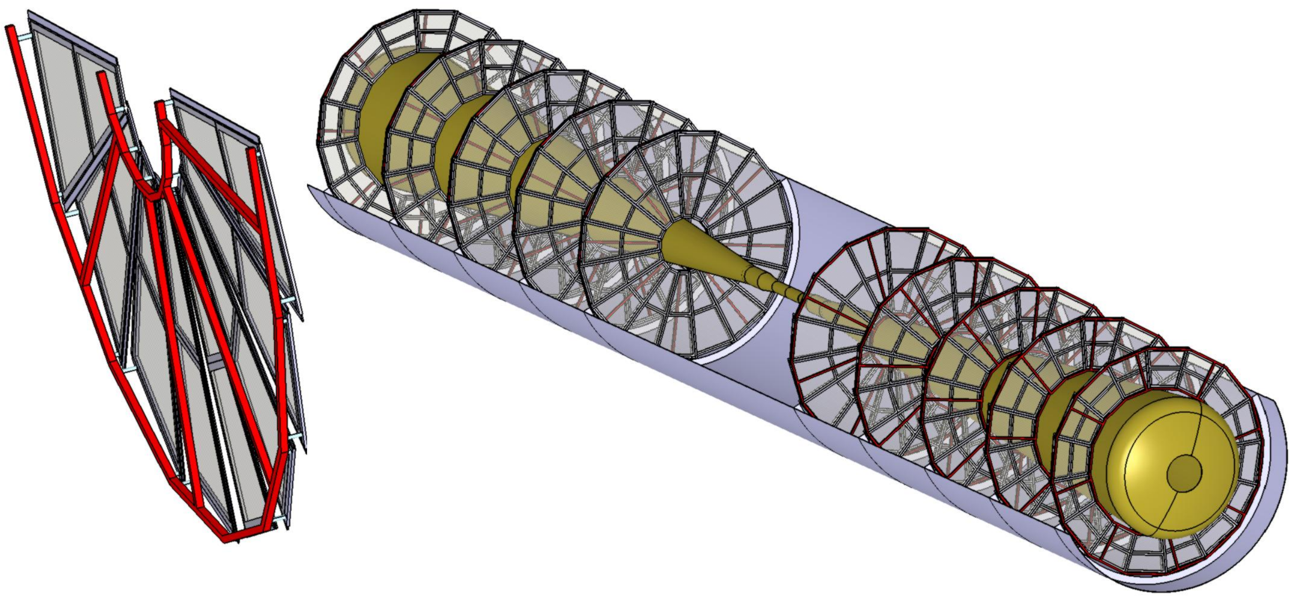
High transmittance sensors
Goal: T~70%; Already now: 50%

High benefit from involvement in shorter term experiments for keeping/developing expertise & for funding and from synergy with (s)LHC.

Korean collaboration

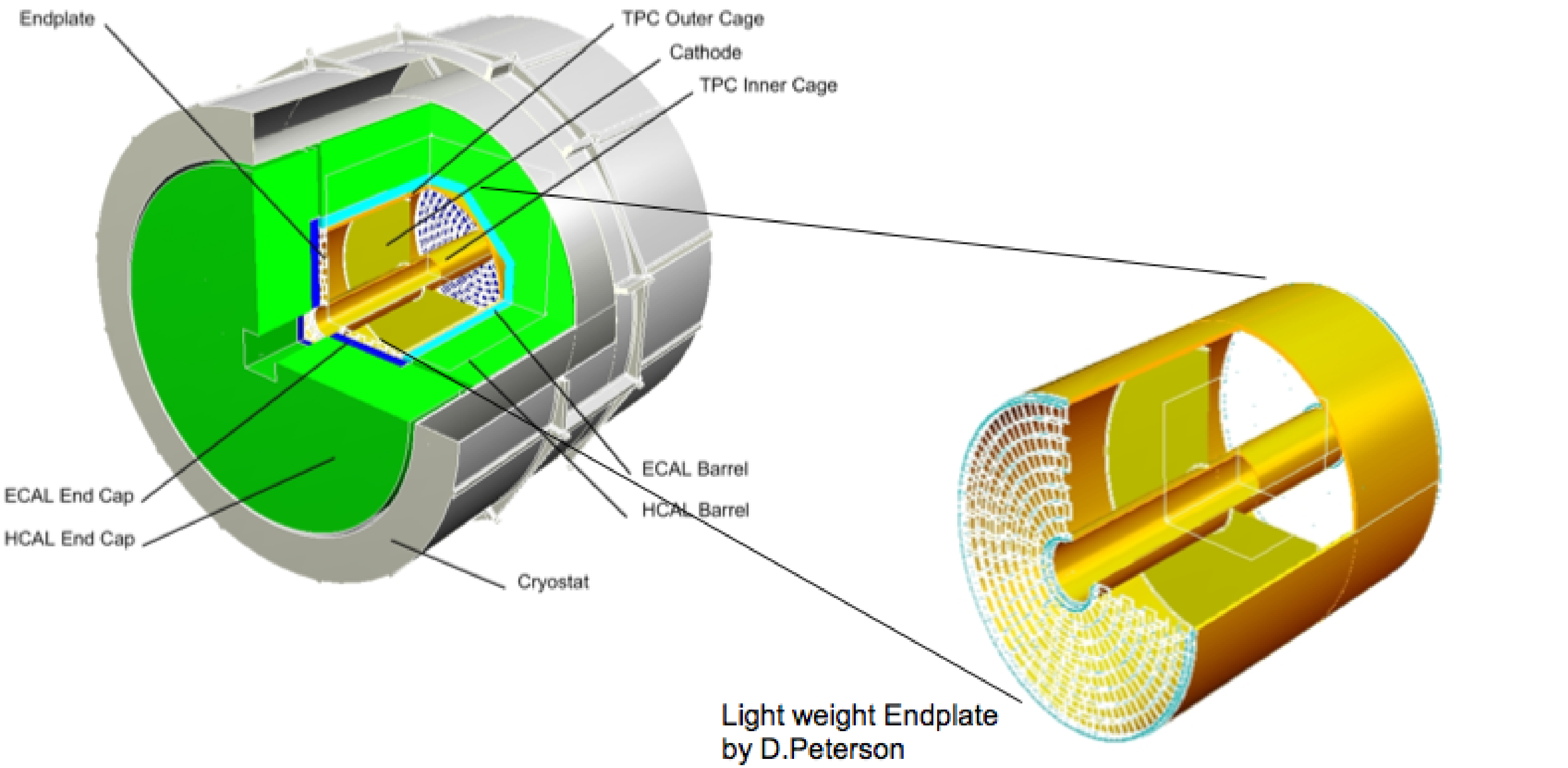
Silicon Forward Tracking

- Forward tracking: 2 (3) pixel disks, rest strips
- High efficiency coverage to low angles
- Periodical meetings with ILD inner region integration group (M. Joré), realistic design as much as possible for the DBD.



- New FTD mechanical design including electronics and services envelop, currently being produced, to be communicated to the integration group.

Time Projection Chamber



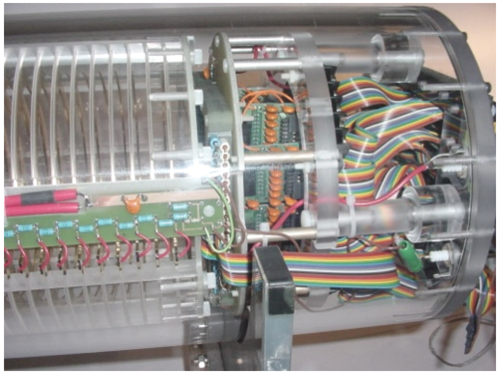
TPC Placeholder model

Large number of space points, good point resolution
- high efficiency tracking and pattern recognition
- Important for particle flow
- Particle identification additional benefit

Strong Japanese and Chinese contributions

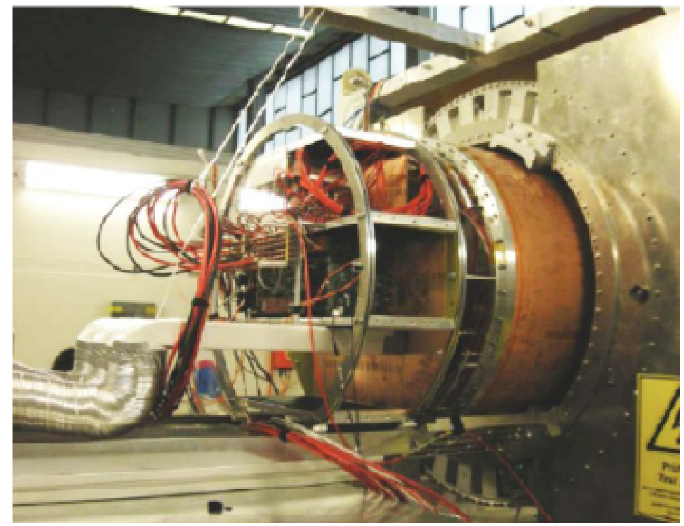
< 2011

Status of TPC work



Small TPC prototypes

2011



Large TPC prototype

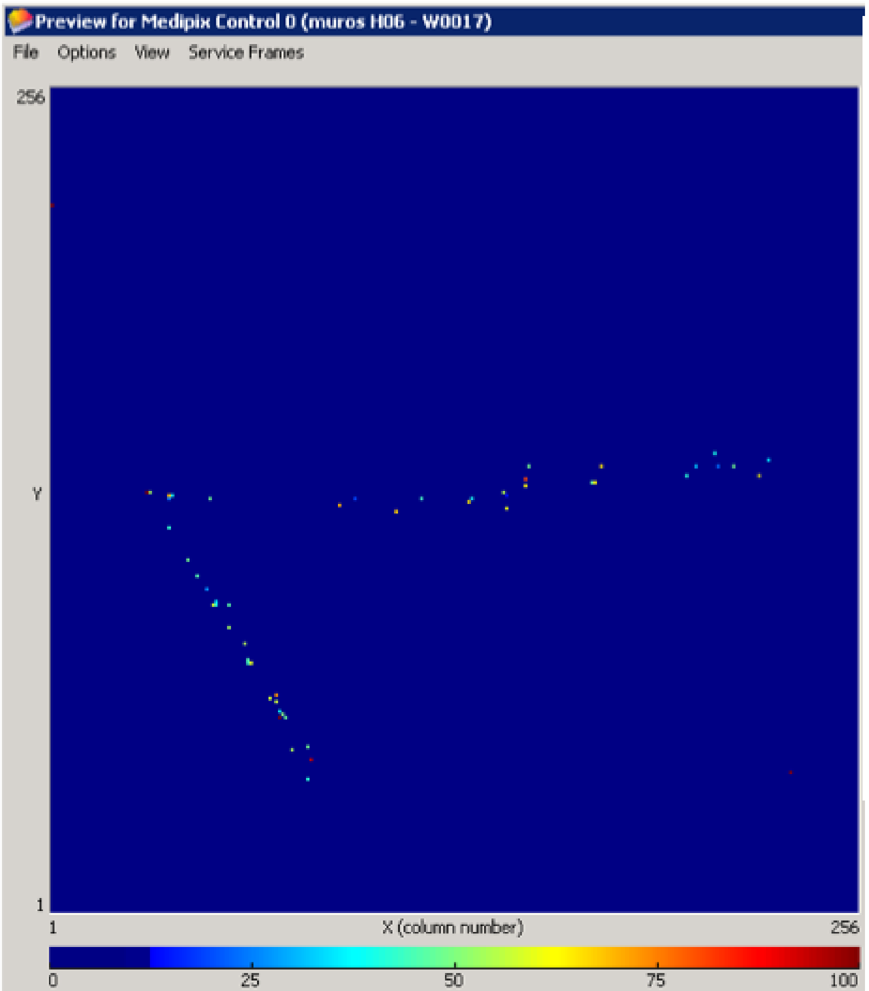
TPC endplate design
TPC material budget
Si material budget

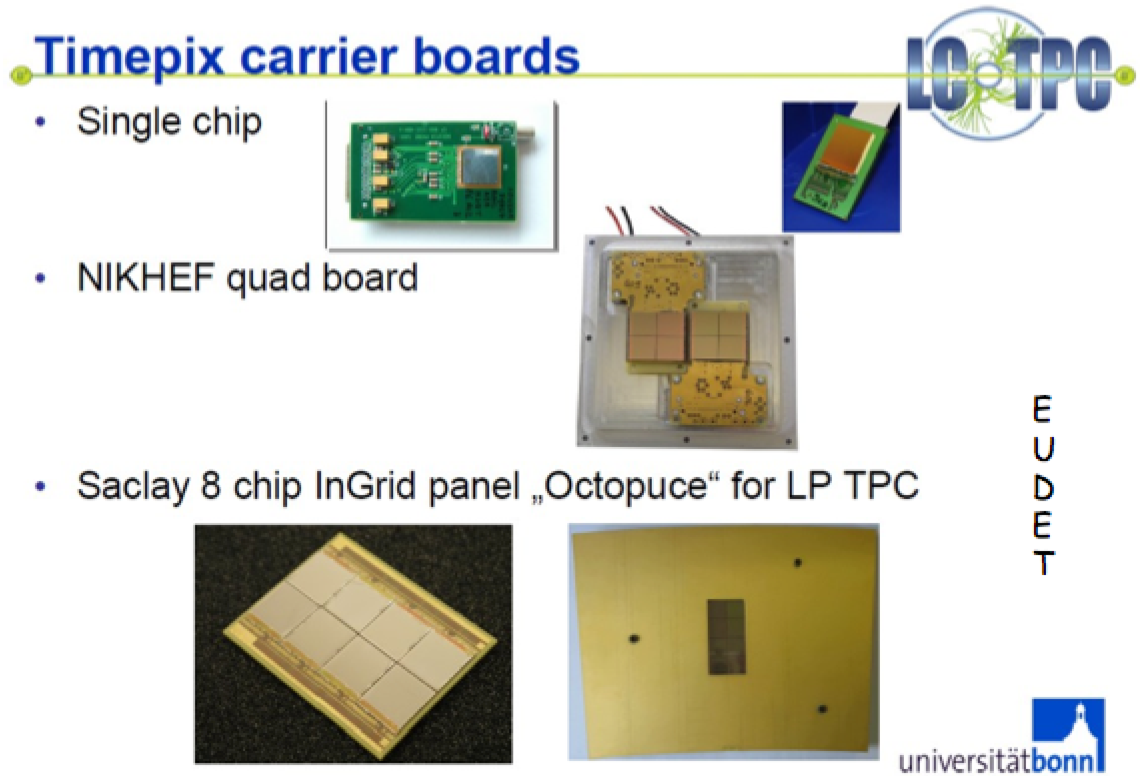
Support structures
Power pulsing
Cabling, services

Different readout technologies
- GEM
- MicroMegas
- Pixel readout (GEM/ micromegas)

Time Projection Chamber

Several readout technologies are under investigation
Pixel r/o for Micro Pattern Gas Detectors - GEMs, Micromegas

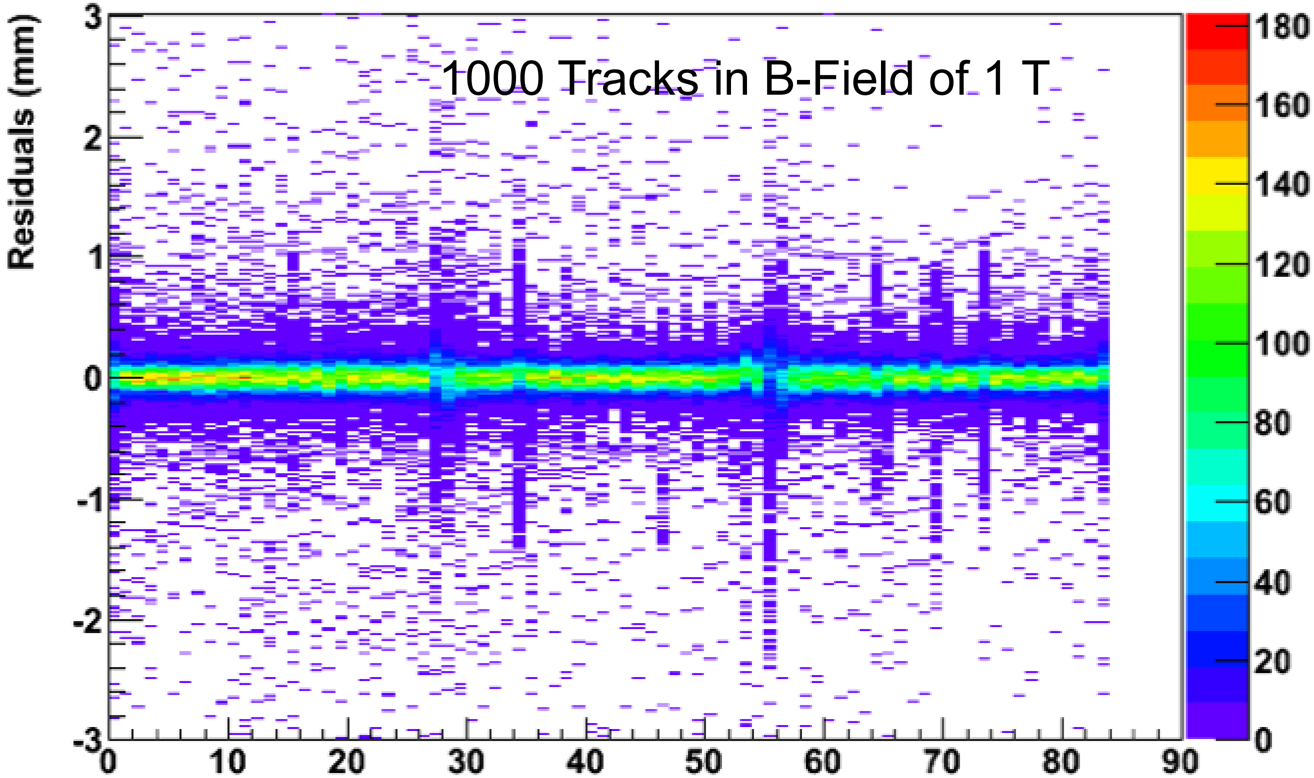




Intensive fundamental R&D
within LCTPC Collaboration.

Time Projection Chamber

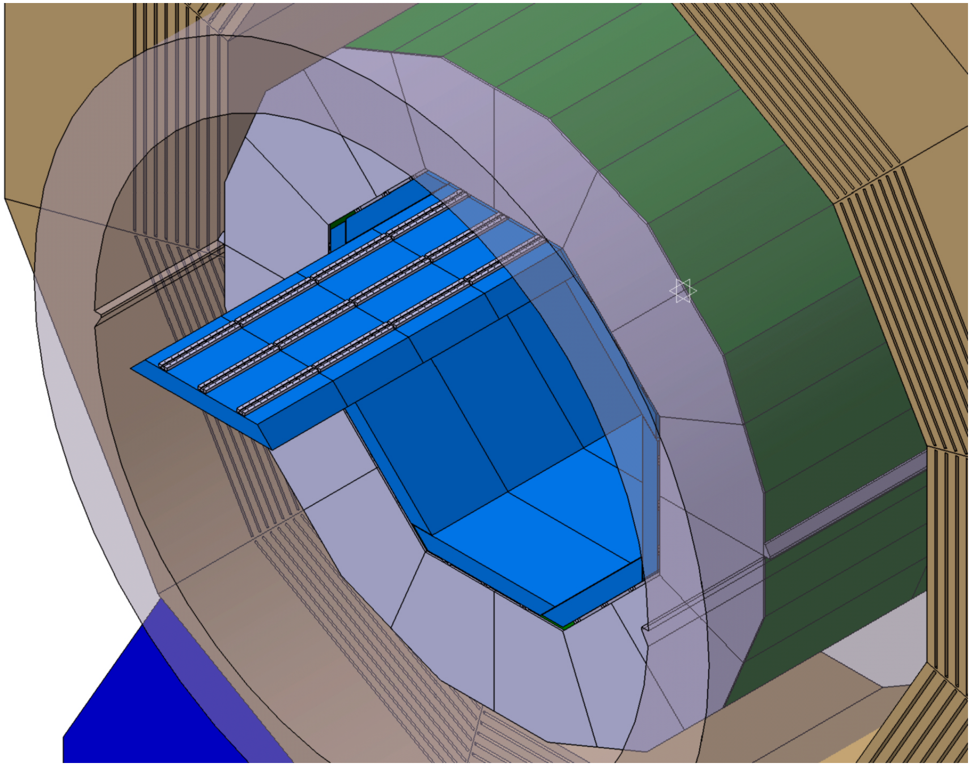
Track reconstruction based on cluster algorithm
Millipede fit to account for misaligned pad rows



- Results on point resolution show that σ_y at zero drift is about 0.0613 ± 0.0006 mm and σ_z at zero drift is about 0.259 ± 0.002mm.
- Result on momentum resolution is $\sigma(1/p_t) \approx 9.2x10^{-3} \pm 0.0002 GeV^{-1}$ at a drift length of 15 cm

Electromagnetic calorimeter

The SiW Ecal in the ILD Detector



Basic Requirements

- Extreme high granularity
- Compact and hermetic

Basic Choices

- Tungsten as absorber material
  - X0=3.5mm, RM=9mm. II=96mm
  - Narrow showers
  - Assures compact design
- Silicon as active material
  - Support compact design
  - Allows for pixelisation
  - High signal/noise ratio
  - Alternative Scintillator readout

SiW Ecal designed as Particle Flow Calorimeter
R&D within CALICE Collaboration

Strong Japanese contribution

ECAL: a Hybrid approach?

Models under study:

1) A pure SiW Ecal Calorimeter with 20 < N < 30 Layers

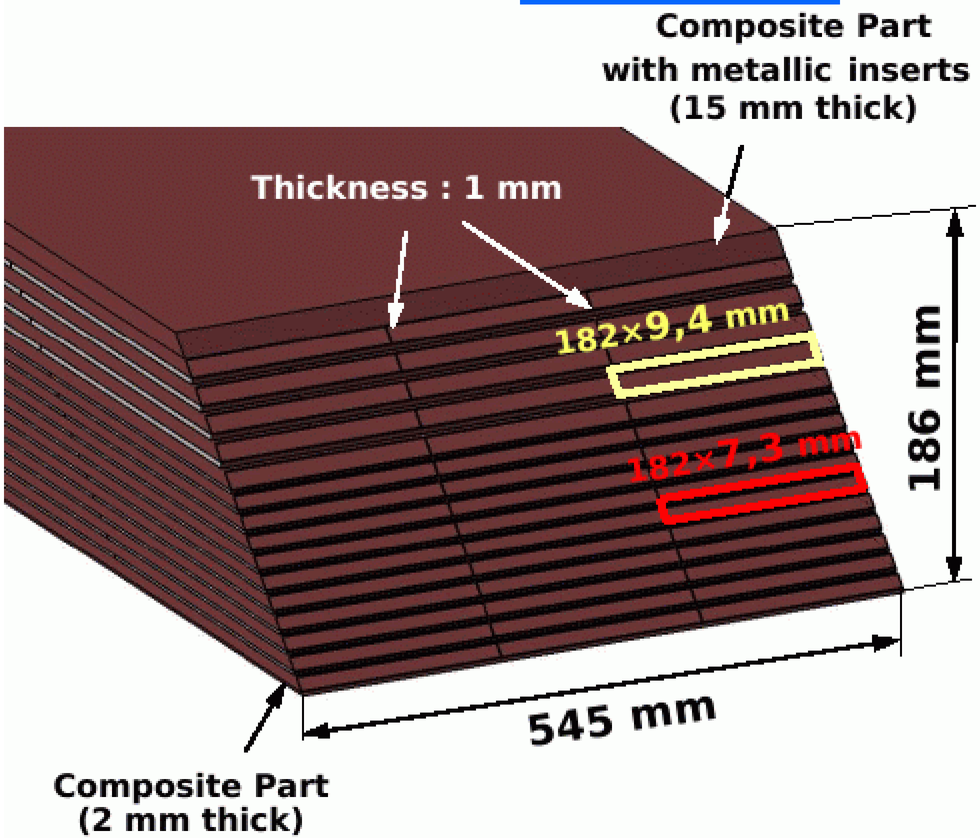
2) A pure Scintillator Ecal

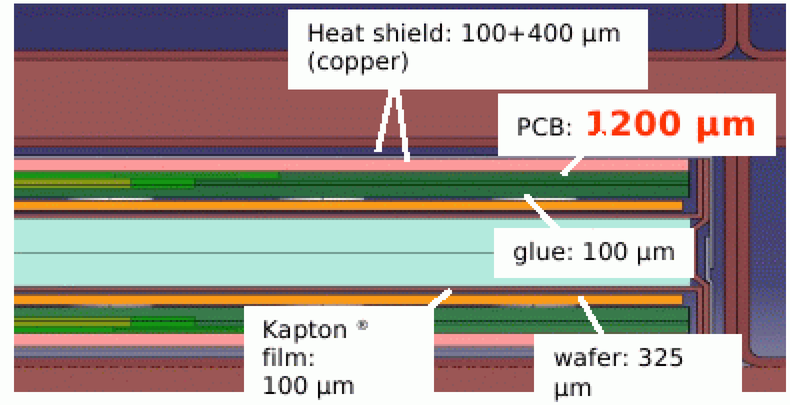
3) A hybrid solution
   e.g. first 20 layers Si with rear part of calorimeter equipped with Scintillator

PFA studies for hybrid calorimeter ongoing

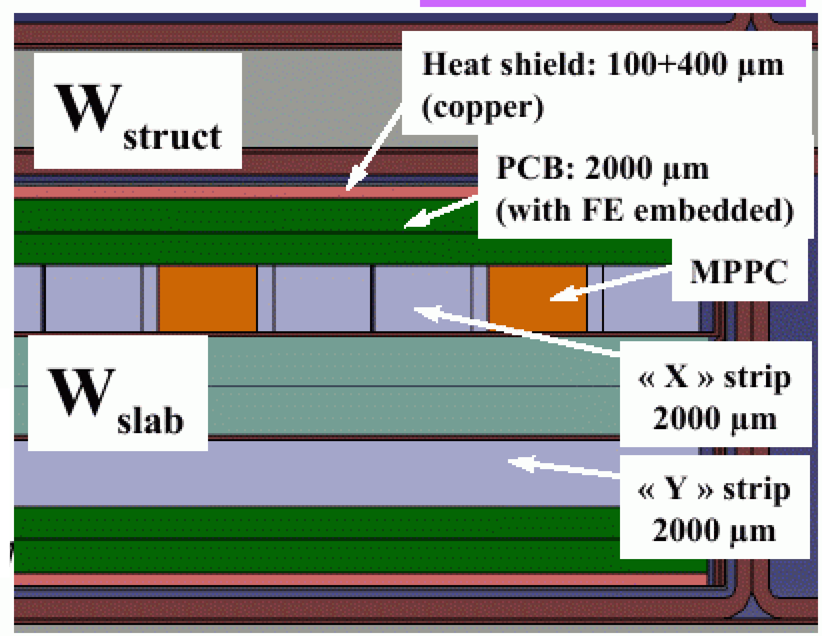
ECAL Prototypes

ECAL W/Si





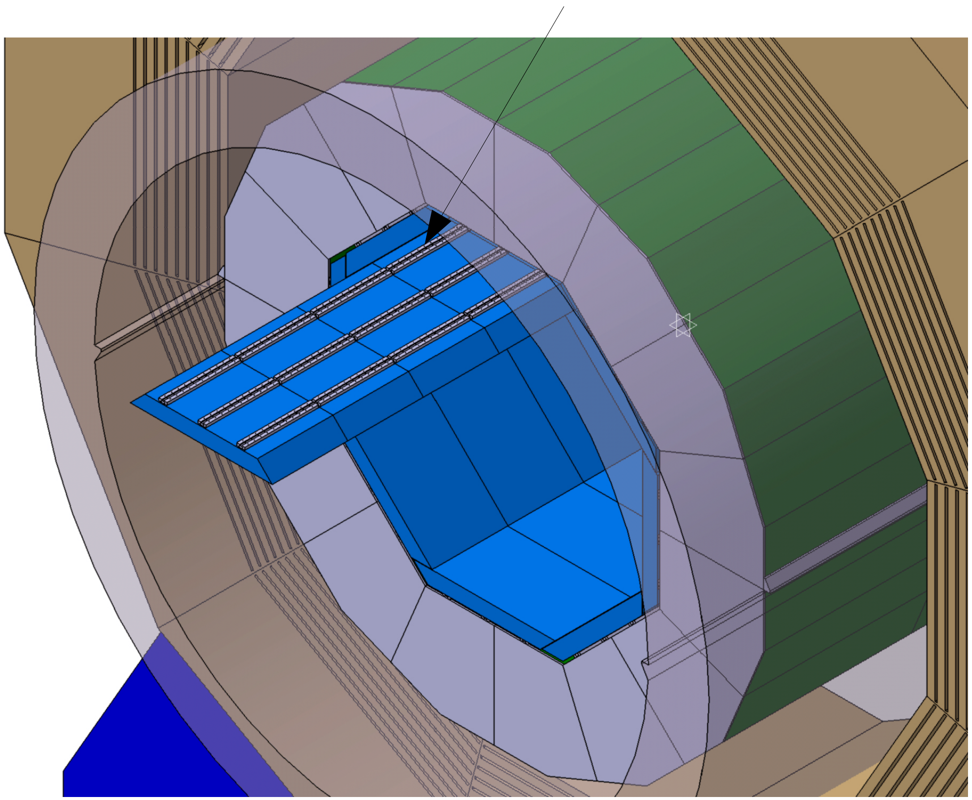
ECAL W/Scin



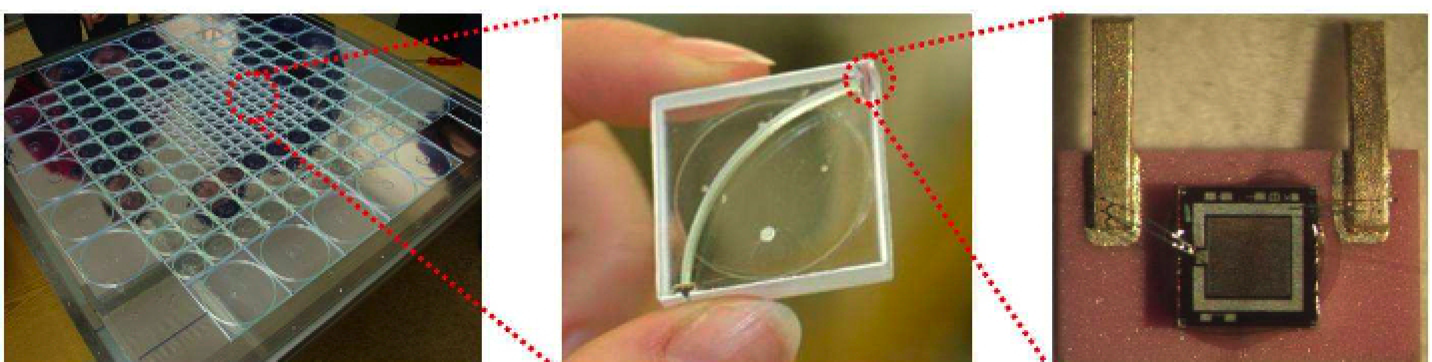
Technological prototype to address engineering challenges of detector construction

Hadron calorimeter: analogue HCAL

(Analogue) Hcal



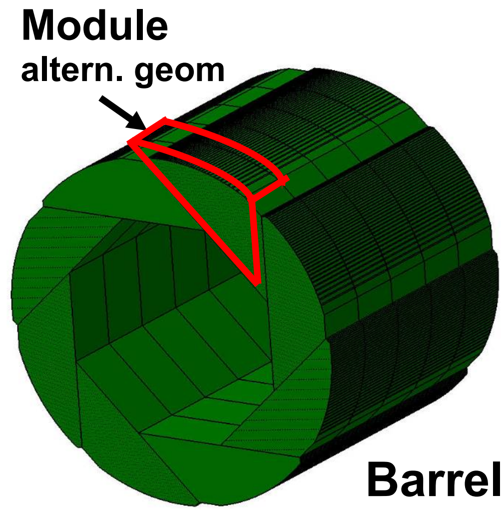
- Steel/scintillating tiles
- Size 3x3 cm^2
- r/o by silicon PM's
- Large scale testbeam program within CALICE
- option with W absorbers under study for CLIC detector

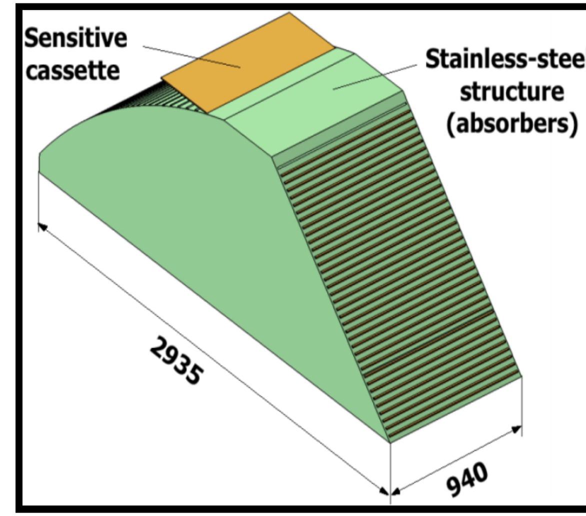


Hadronic Calorimeter: Semi-digital HCAL

Alternative approach:

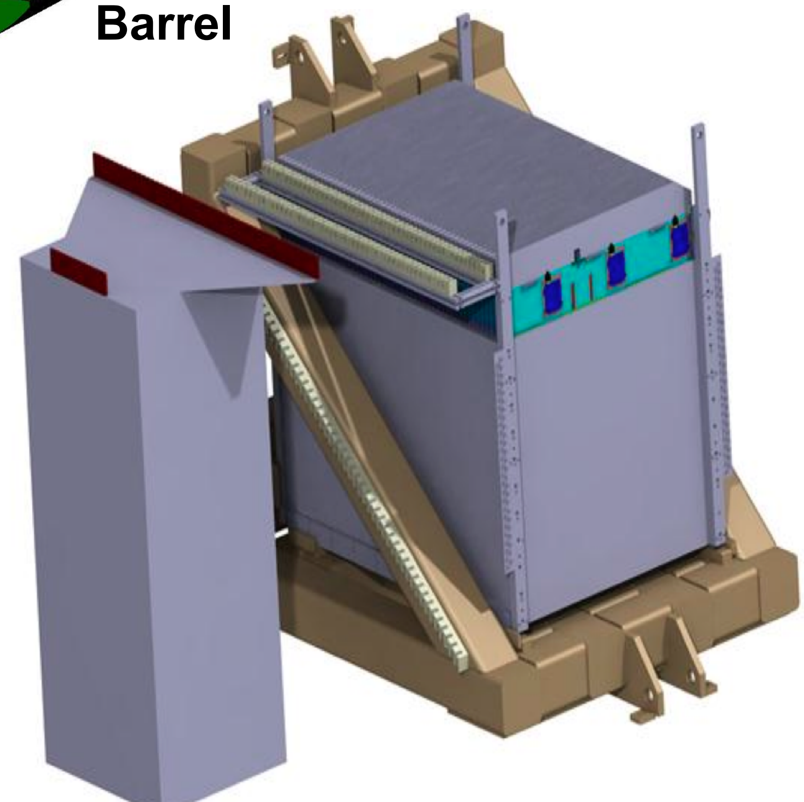
- Digital readout per cell
- Many more cells (1x1 cm2)
- Different sensor technologies are under investigation baseline: RPC technology





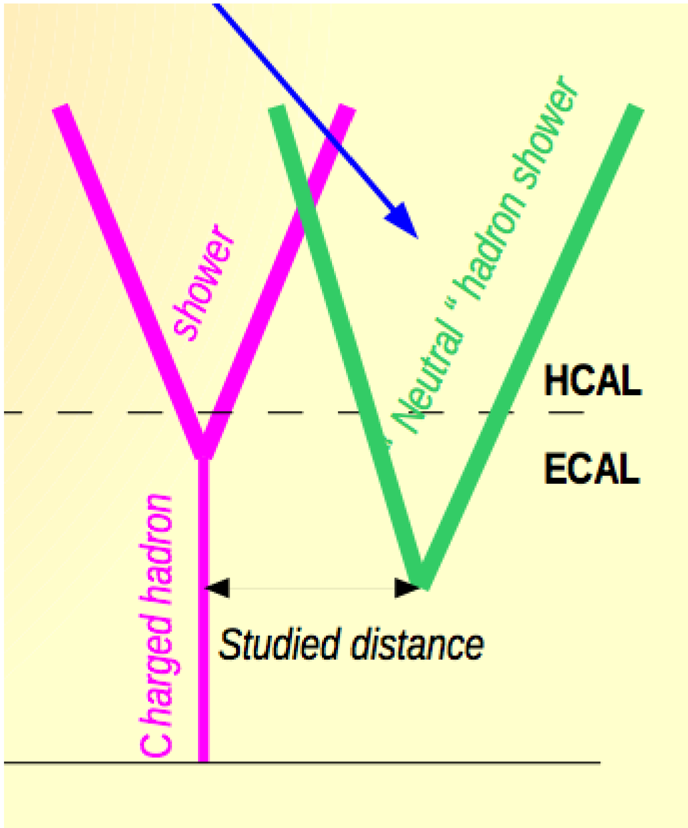
A technological prototype is being built:
It will be made of 48 units.
Each unit is made of :
2 cm absorber
+ 0.6 cm sensitive medium
1 cm^2 transversal granularity

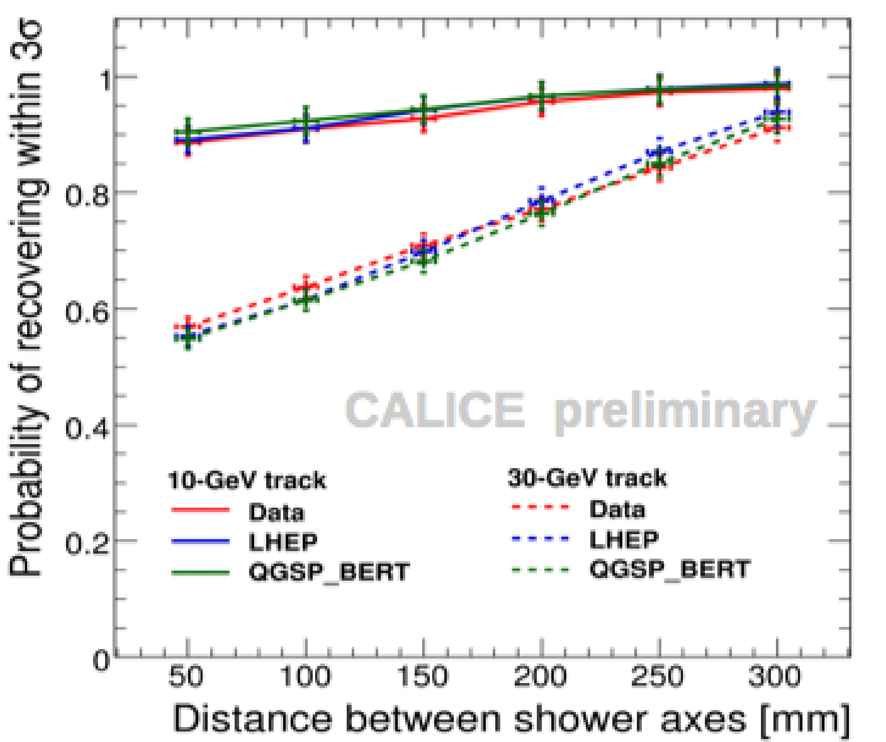
This is about **$6\lambda_I$**
and **442368 channels**



Calorimeter: testbeam results

CALICE **Data** mapped onto ILD detector to test PFA

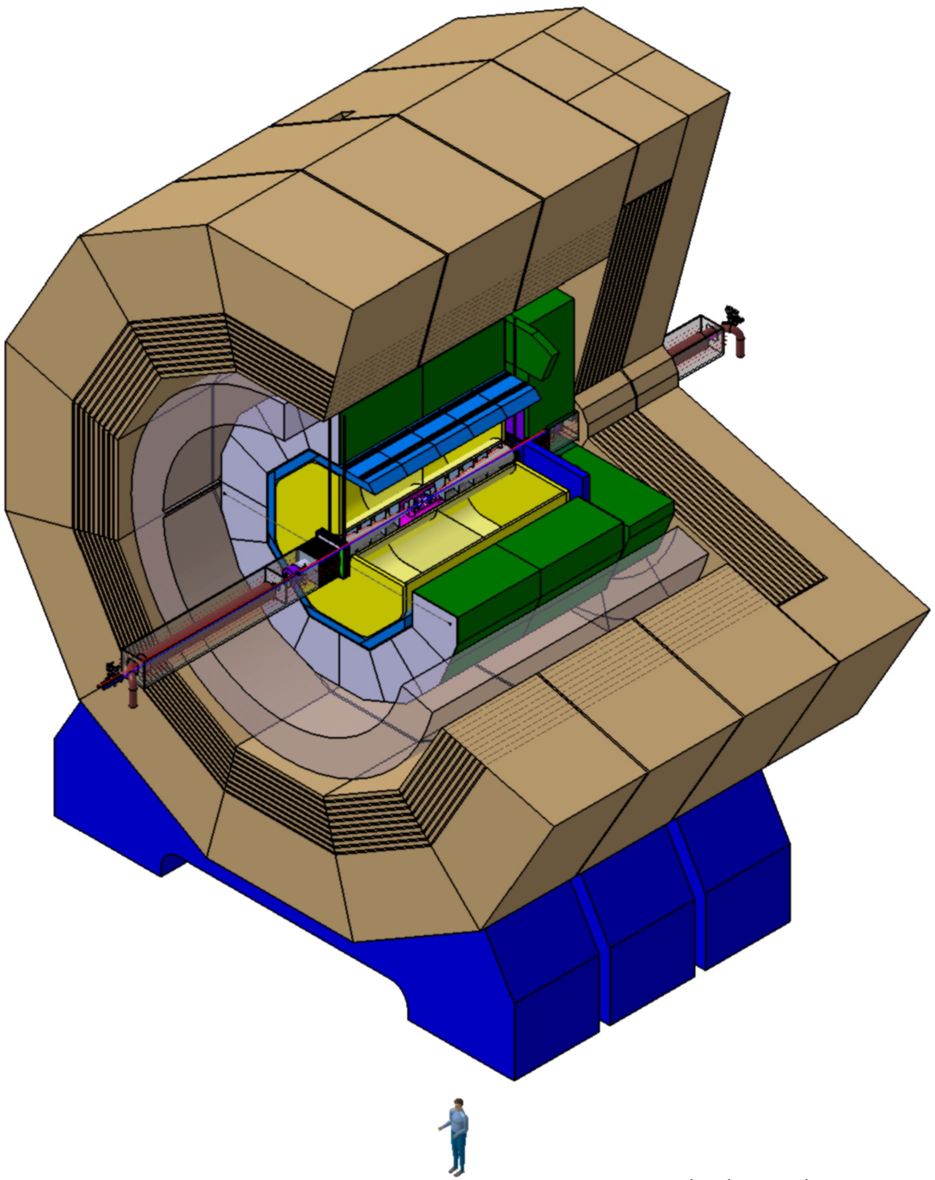




Transport of beam test data into physics studies

Successful application of PFA to real data with highly granular calorimeters

Outer Shell



Instrumented iron return yoke:
Muon System
(RPC or Scintillator)

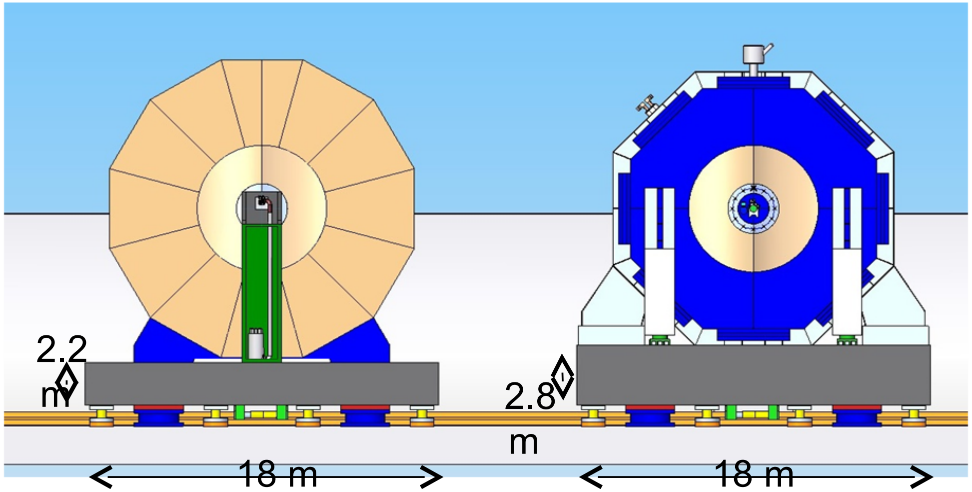
Iron yoke optimized and designed for push pull with two detectors

Machine Detector Integration

Push Pull engineering work

Close cooperation with SiD and CERN (CLIC/ CMS) has been established

- Platform solution has been agreed as a common baseline between ILD and SiD
  - Significant effort at CERN/ ETH/ DESY/ KEK
  - Measurements at CMS proove vital
- ILD hall integration is studied in Europe for a deep site, KEK for a Japanese mountainous site



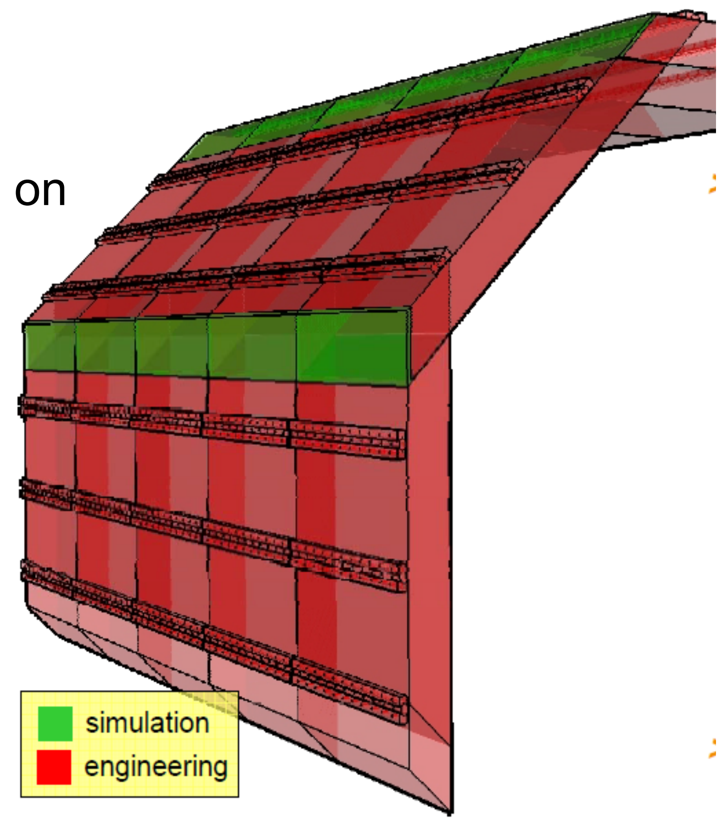
Detector Integration

Central CAD model of ILD has been established at LLR/ LAL

Synchronisation with Simulation model is ongoing

Procedures for documentation in EDMS are being worked on

- Mechanical support of inner detectors – etc
- Rooster of dead material/ cables/ etc is being filled

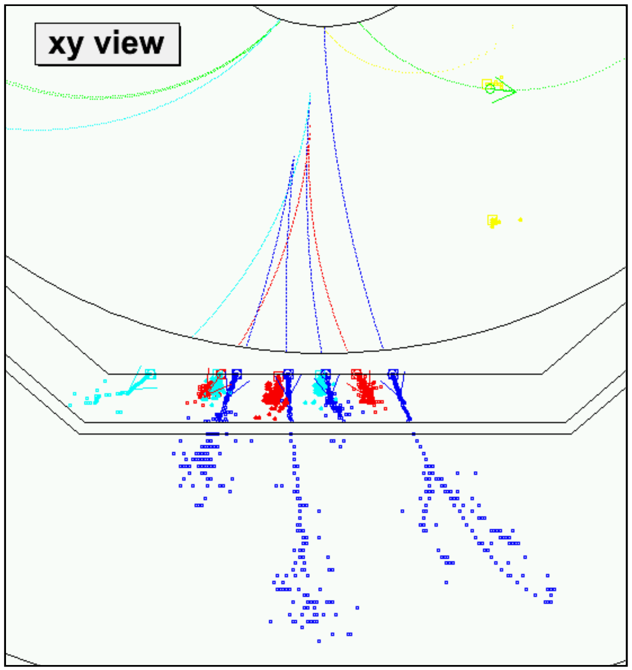


Truly global effort with contributions from all partners

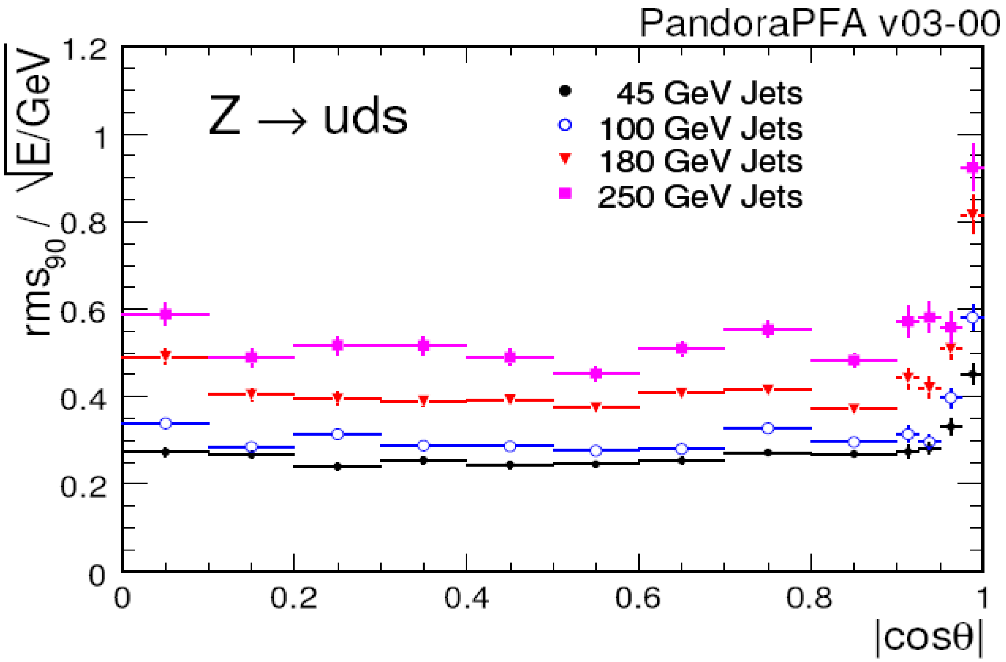
Plans subdetectors

Vertex	Full scale ladder prototype (mechanics) including cooling concept, several chip technologies (FPCCD, DEPFET, MAPS)	PLUME project
Silicon	Single sided Silicon sensor tested edgeless sensors tested Readout chip prototyped	SiLC
TPC	GEM, muMegas readout tested with multi-module in LP, pixel readout demonstrated under realistic conditions Model for advanced end plate demonstrated	LCTPC
ECAL	Extensive test beam data, demonstrate system integration, second generation prototype	CALICE
AHCAL	Extensive test beam results, second generation readout designed and tested, second generation prototype demonstrated	CALICE
DHCAL	Extensive test beam results, feasibility established, readout concept established, second generation prototype demonstrated	CALICE
Muon	Extensive Simulation and optimization, Scintillator readout with SiPM established and prototyped, mechanical design established	
FCAL	Sensor tests and readout chain done, system established	FCAL

How well does it work?



Simulation of an event



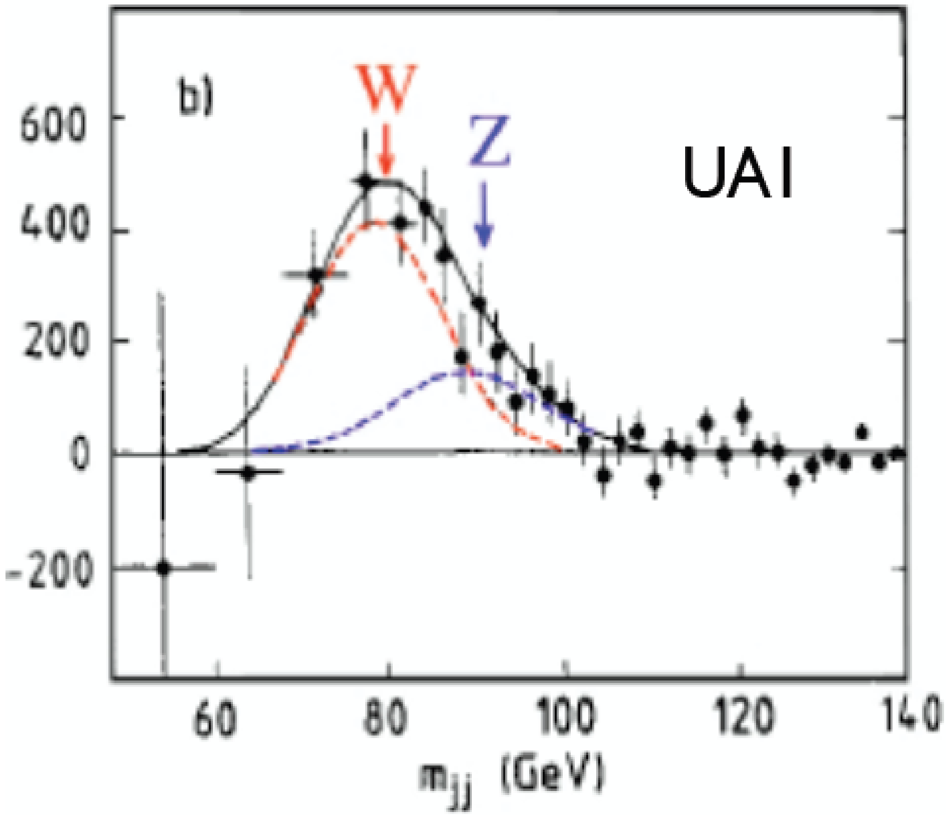
M. Thomson

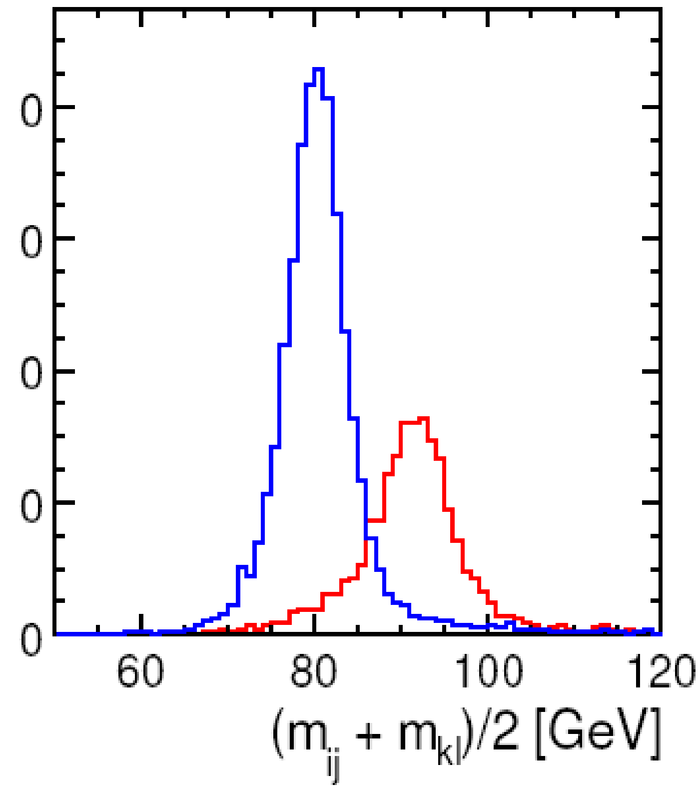
Resolution about 30%/√E for jets below 100 GeV

Particle flow gives ~2x better performance than traditional approach (<100 GeV jets)

Significant achievement over the last few years

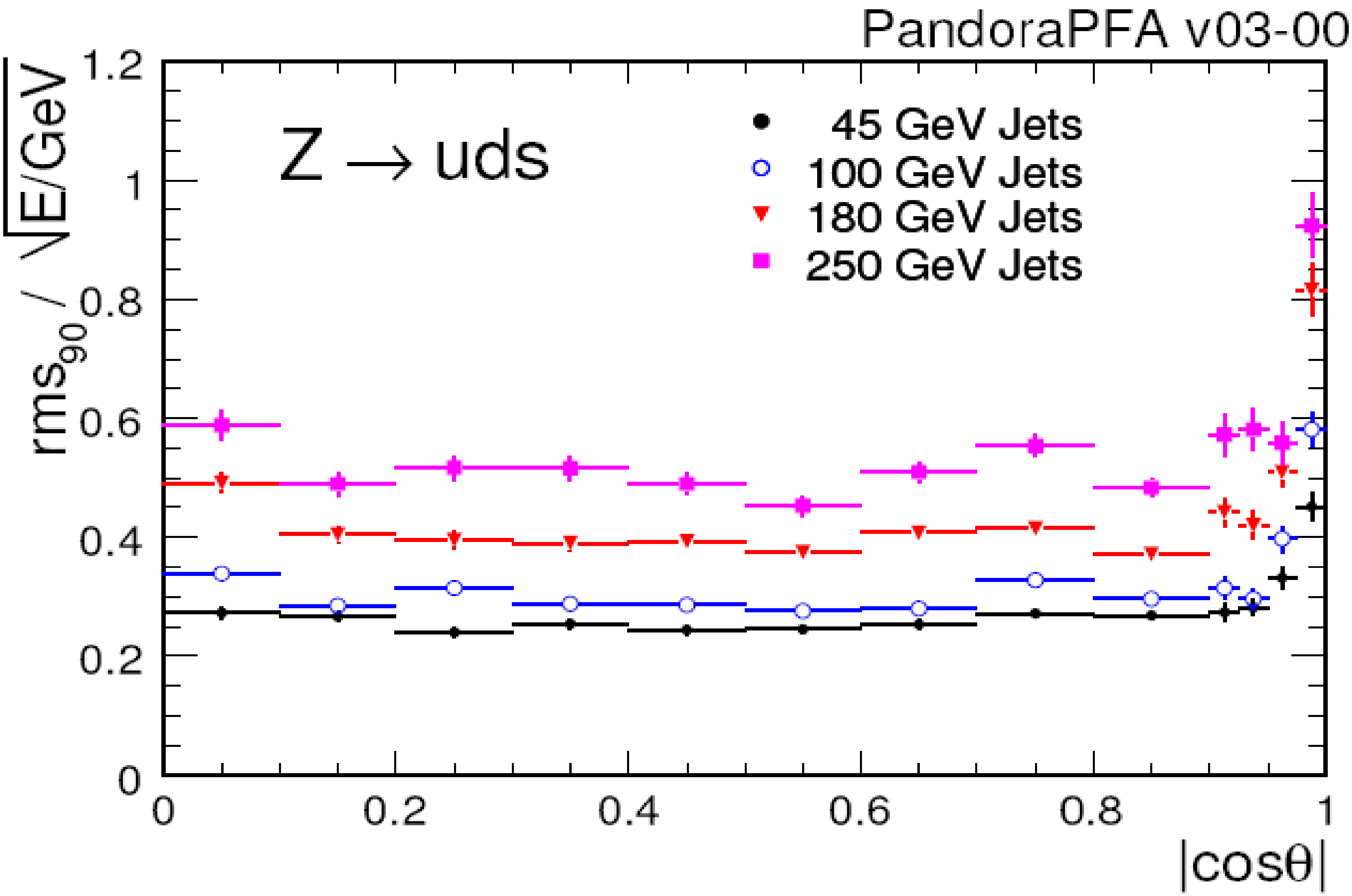
W-Z separation: Comparison





Crucial for many channels (SUSY, others)
Crucial to understand and separate SM from NP

Performance



Analysis

Goals:

Want to sharpen the case for ILD and the ILC

Want to show the performance of ILD at 1TeV

Want to be able to react to the results from the LHC

An encouraging number of analyses is being pursued (strong center in Asia/ Japan)

Please join the monthly analysis meetings via WEBEX!

Analysis	Group	BM
$e^+e^- \to ZH \to l^+ l^- X$	Youssef Khoulaki, Hassan II, Morocco	
$e^+e^- \to ZH \to l^+ l^- X$ (for Vertex detector background/ optimisation)	Georgios Gerasimos Voutsinas, Strassbourg	
BR($H \to$bb/ cc/ gg) in BR(H->bb/ cc/ gg) at 250 GeV and 350 GeV	Hiroaki Ono, Nippon Dental University	
Little Higgs with T- Parity at 1 TeV	Eriko Kato, Tohoku	
Top Physics at 500 GeV	Phillipe Doublet, Roman Poescl, Francois Richard, LAL	
W e nu, ZZ, Z nu nu, nu nu h at 1 TeV	Graham Wilson, Brian van Doren, and Marco Carrasco-Lizaragga, Kansas	
ZHH	i) Tomohiko Tanabe + Taikan Suehara Tokyo ii) Junping Tian, Tsinghua	
ttH	i) Harjah Tabassam, Edinburgh ii) Ryo Yonamine, KEK	
long- lived staus	Wataru Yamaura and Katsushige Kotera, Shinshu, DESY	
Model-independent WIMP searches in e+e-->ngamma + invisible	Christoph Bartels, DESY	
Bi-linear R-parity violating SUSY	Benedikt Vormwald, DESY	
SPS1a' in general, selectrons with small mass-differences (for SB2009-BAW)	Mikael Berggren, DESY	
TGC:s and polarisation (at least for SB2009-BAW)	Ivan Marchesini, DESY	
SUSY "point 5"	Jenny List, DESY	

To be updated

What do we want for the DBD

Subdetector Technologies:

- Demonstrate technology by test beam in a realistic prototype
- Demonstrate basic performance by analysis of test beam data
- Demonstrate ILD performance by integration into simulation with realistic model
- Demonstrate integration into ILD by 1st level engineering solutions
  - Per subdetector
  - Globally for ILD

Note: R&D for ILD is done by the R&D collaborations in close cooperation and coordination with ILD.

What do we not want for the DBD

We do not want to exclude any technology

We do not want to select one baseline, if there is no need to do so

We do not want to define the detector too early

However we want to make sure that we have
at least one working solution for each sub-detector
realistically modeled and prototyped.

ILD: The next steps

2012: technical design report (DBD)

Continue intense R&D program to validate and test technologies

Show the validity of the overall concept by making a fully integrated model of the detector

Validate the model based on a detailed and well understood simulation

Funding:
Detector R&D has some funding (AIDA in Europe, JSPS in Japan, US uncertain)
R&D collaborations leverage funds from other activities
Central ILD funding extremely limited

Series of dedicated ILD meetings before the submission deadline of the DBD
Next one (exact date and venue not yet decided): spring 2012 probably in Asia

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ILD organisation

Central management of the concept group:

Joint steering board:
- Hitoshi Yamamoto
- Yasuhiro Sugimoto (contact person)
- Ties Behnke (contact person)
- Henri Videau
- Graham Wilson
- Dean Karlen

http://www.ilcild.org

Central “parliament” of the concept: ILD EB
- JSB members
- ILD working group members
- contact people to the R&D groups (subdetector contacts)

Lightweight, transparent and democratic organisation to steer the ILD concept

Summary

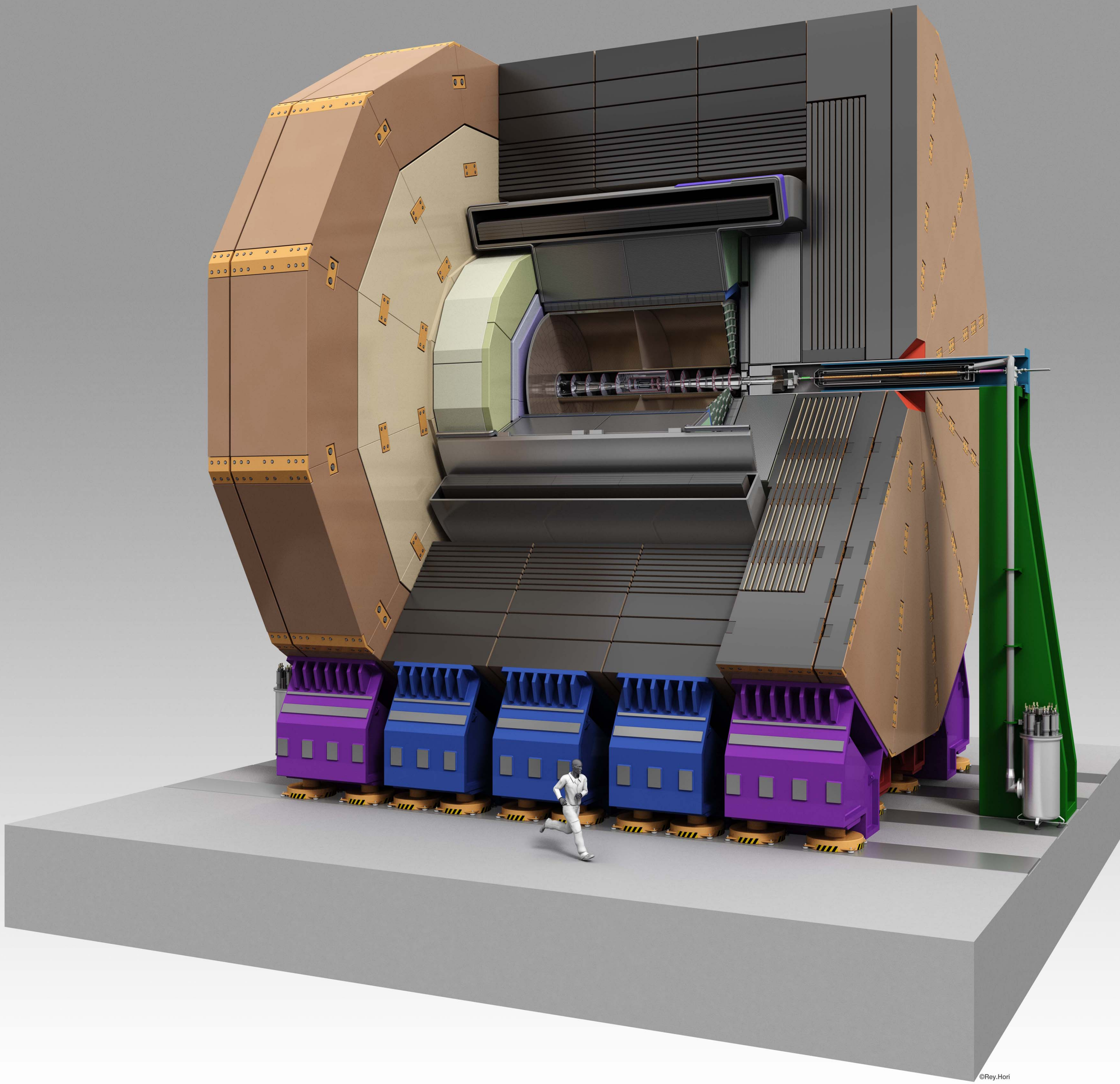
ILD has been a success story of worldwide collaboration

Significant effort in Europe and Asia, less significant in Americas (but very valuable)

Program has been formulated to move towards the technical baseline document

Significant effort exists worldwide to support and develop ILD

A particularly strong contribution to ILD exists in Japan, significantly strengthened now with the new JSBS program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