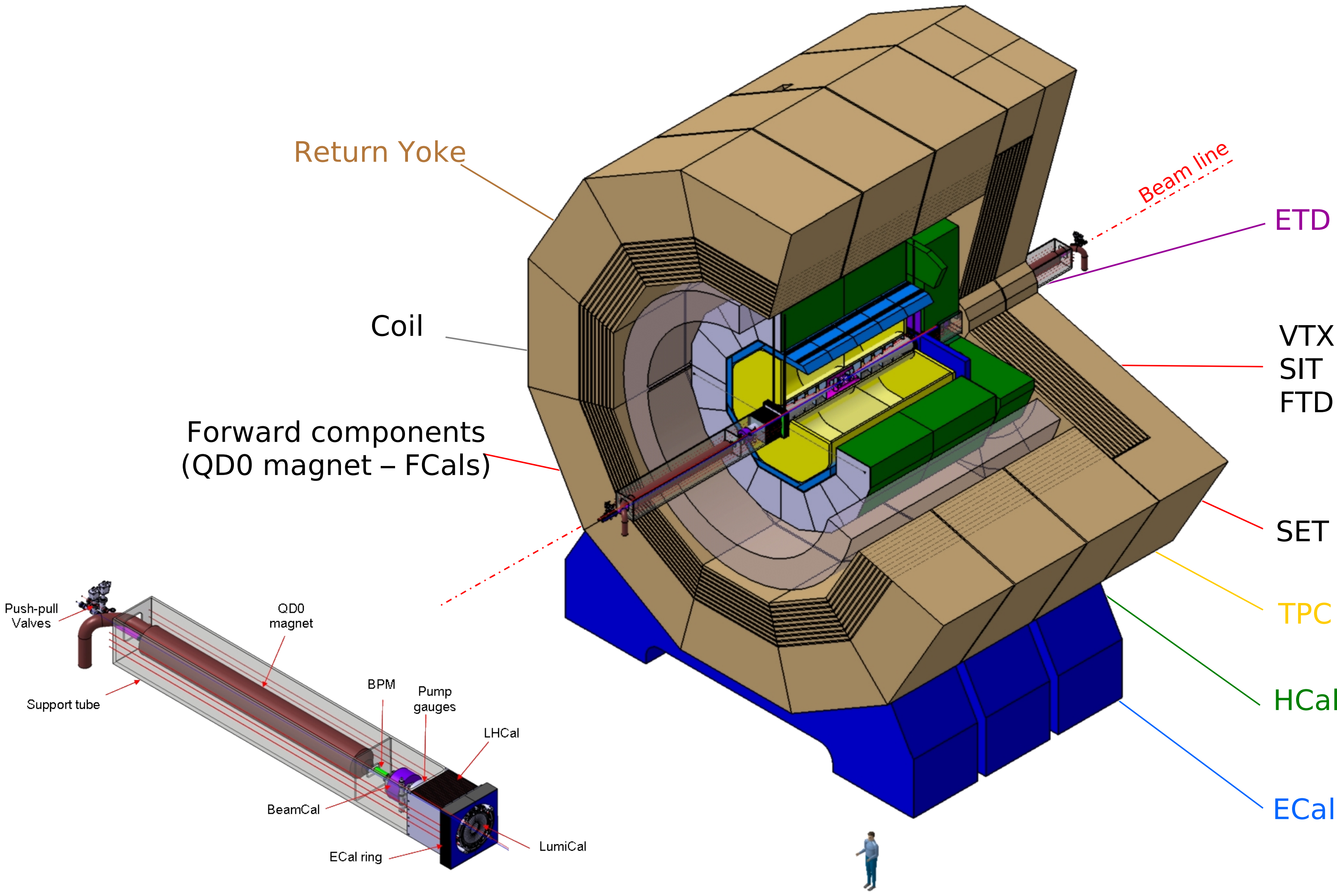
ILD concept status

Roman Pöschl
LAL Orsay

ALCPG Workshop Eugene/OR March 2011

The ILD Proposal



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

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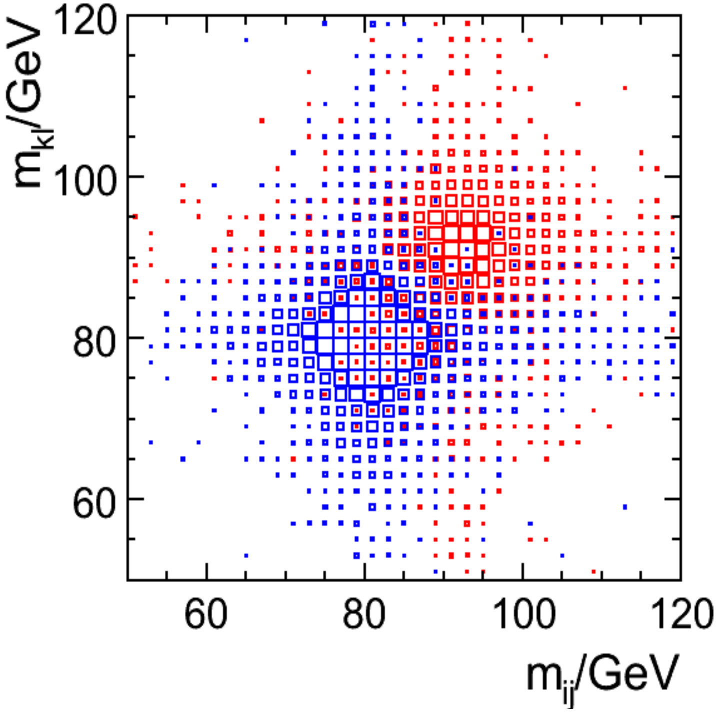
Particle flow detector

W, **Z** pair separation in the ILD detector
in <u>multijet</u> final states



Remember: M_Z-m_W ≈ 10 GeV

The guiding lines

- Interplay of very advanced detector components
- Developped in R&D collaborations

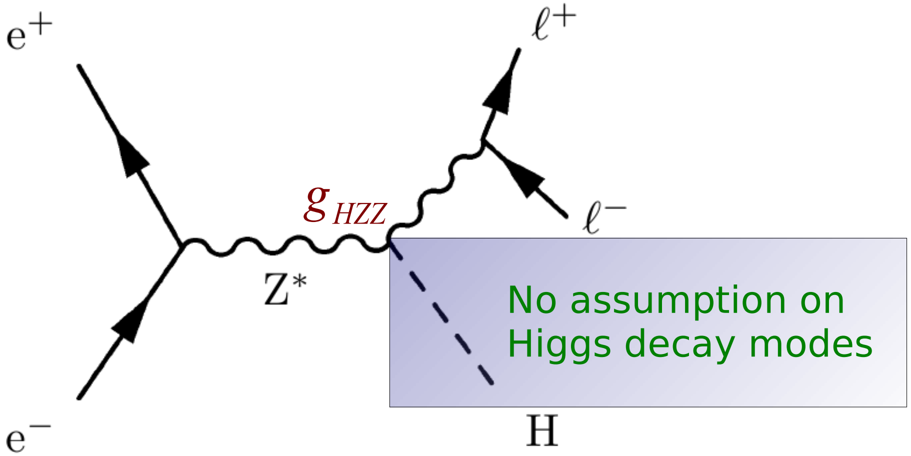
- LOI validated in 2009 by IDAG

- Move towards DBD in 2012
  No technology decision!!!!

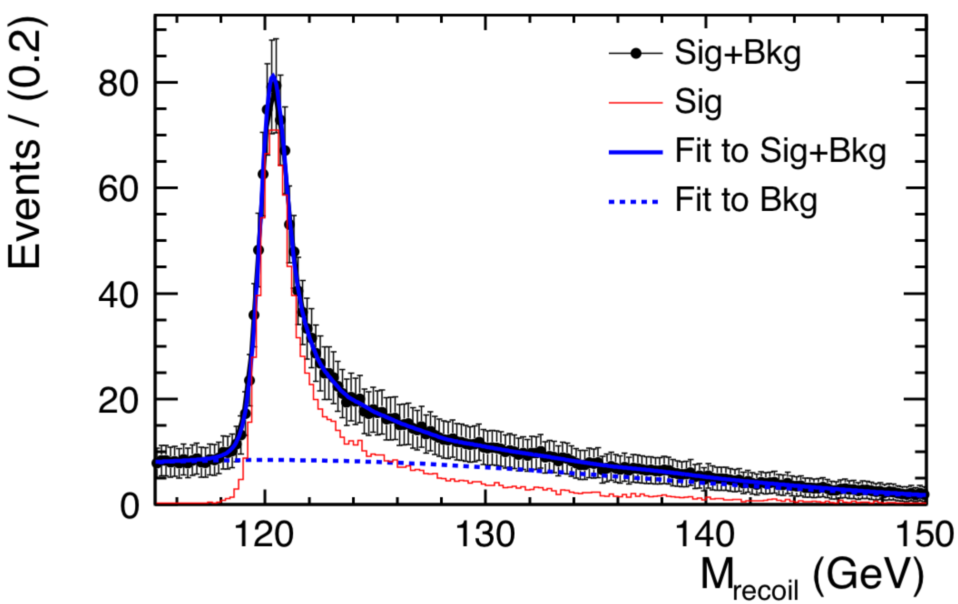
- Integrate **'realism'** in detector simulation

Physics results with ILD

Higgs production at @ 250 and 350 GeV



Recoil Mass: $M_h^2 = M_{recoil}^2 = s + M_Z^2 - 2\,E_Z\sqrt{s}$



Higgs branching ratios

Preliminary results

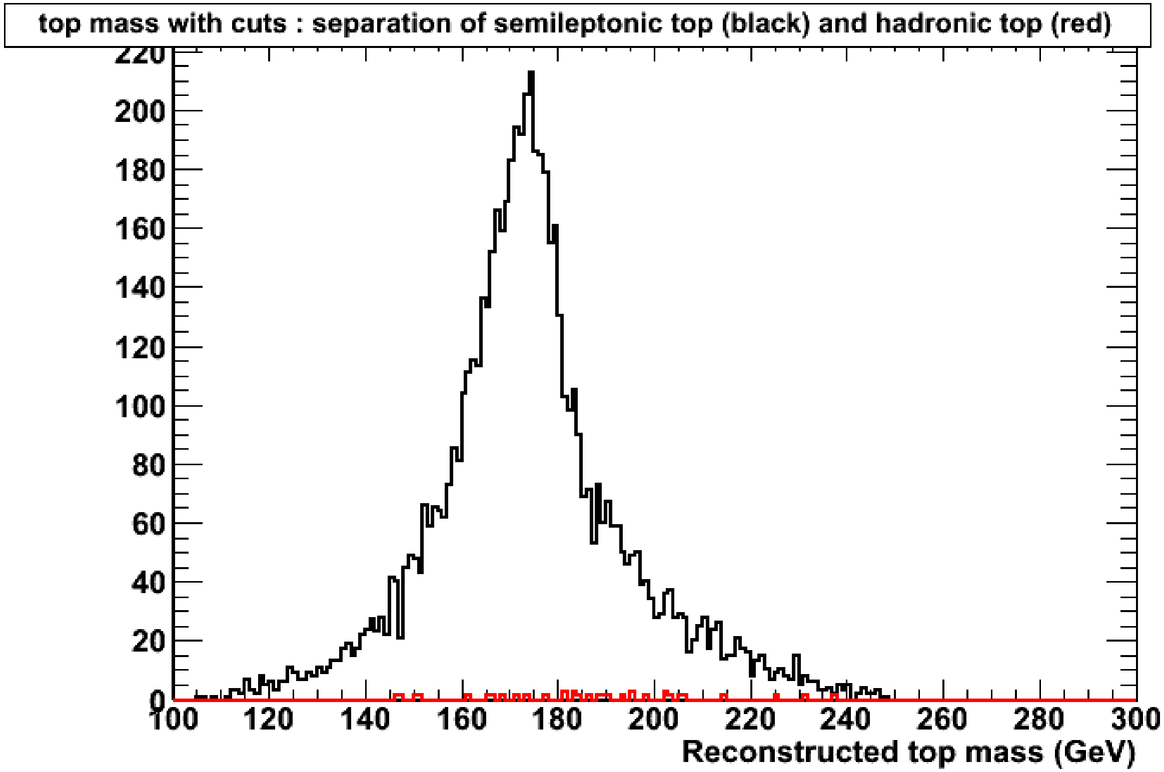
	Ecm	ΔBR(cc)/BR(bb)
Neutrino (nnH)	250	20.7%(28.9%)
	350	14.2%
Hadron (qqH)	250	23.0%→18.7% (31.3%→26.0%)
	350	16.4%→16.6%
Muon (mmH)	250	39.5%(45.3%)
	350	43.9%
Electron (eeH)	250	47.5%(50.9%)
	350	37.8%
Combined	250	13.7%(18.0%)
	350	10.0%

Ongoing analysis

ILD studies as input for communication with machine developers!!!

Example for ongoing analysis

Top quark physics:



- Top quark exists(!!!)
- Large mass hierarchy among fermions
- Compositeness, extra dimensions
- Aim measure AFB, ALR (polarised beams)

Example: Top mass

Towards DBD

Simulation baseline: To react to new benchmark scenarios at 1 TeV
Will be used for mass simulation and reconstruction

Scenarios: $e^+ e^- \to \nu \bar{\nu} h^0$

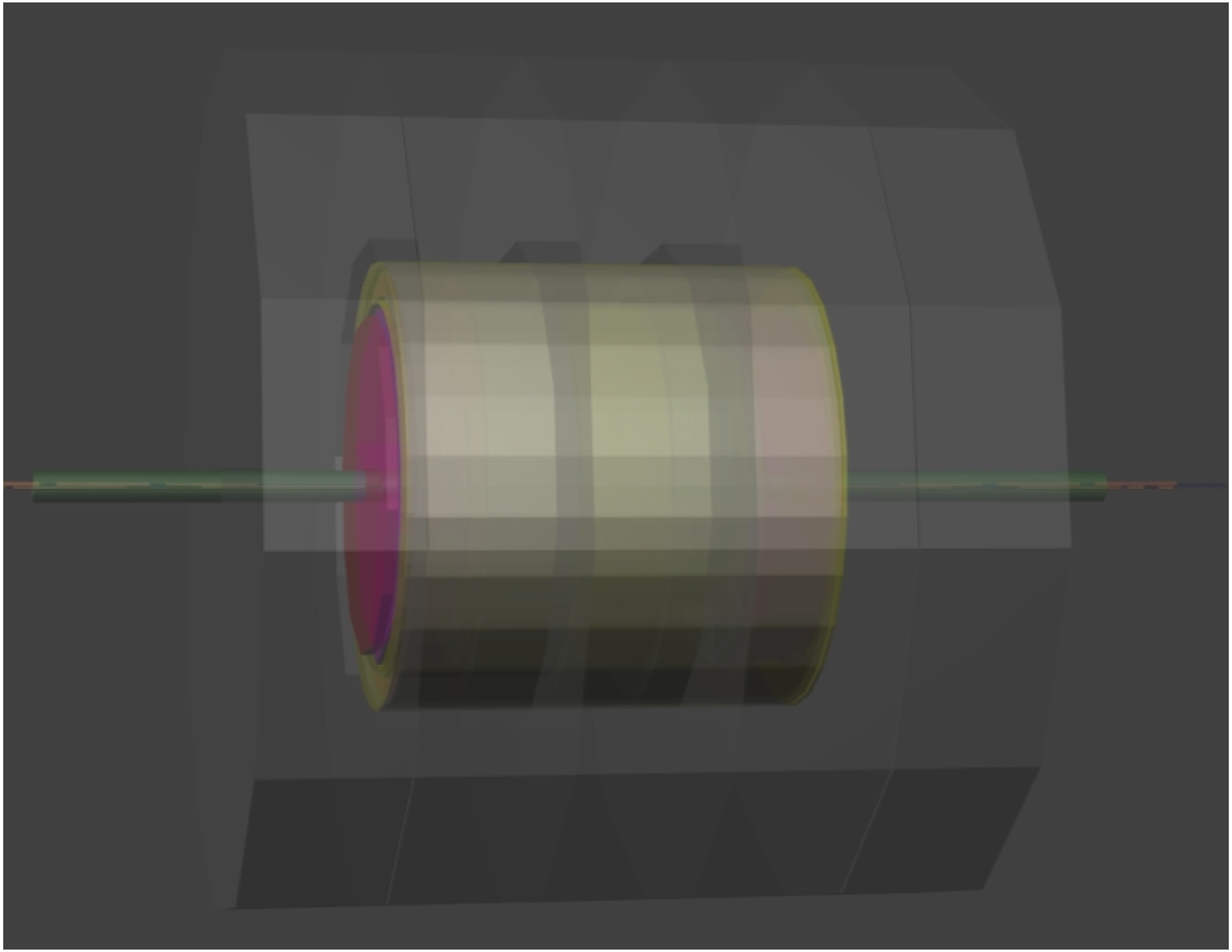
$e^+ e^- \to W^+ W^-$

$e^+ e^- \to t \bar{t} h^0$

Technology baseline: Propose sub-detector technologies options which (in principle could) be used for detector construction
Rely on input from R&D collaborations
No technology decision in DBD
Alternative technologies will be considered, too
Detailed simulation of physics processes?

Timeline: Next iteration at ILD group meeting at KEK
Baseline by LCWS 2011 @ Granada

Preparation of DBD studies - Model ILD01



Detector as implemented in Mokka – ILD simulation software

Different options: ILD_01pre00, ILD_01pre01 and ILD_01pre01fw

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Guiding lines for detector simulation

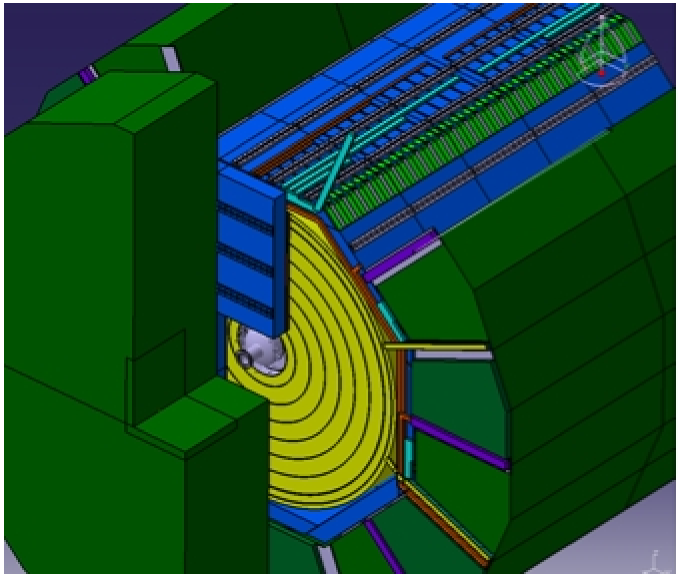
Flexiblity

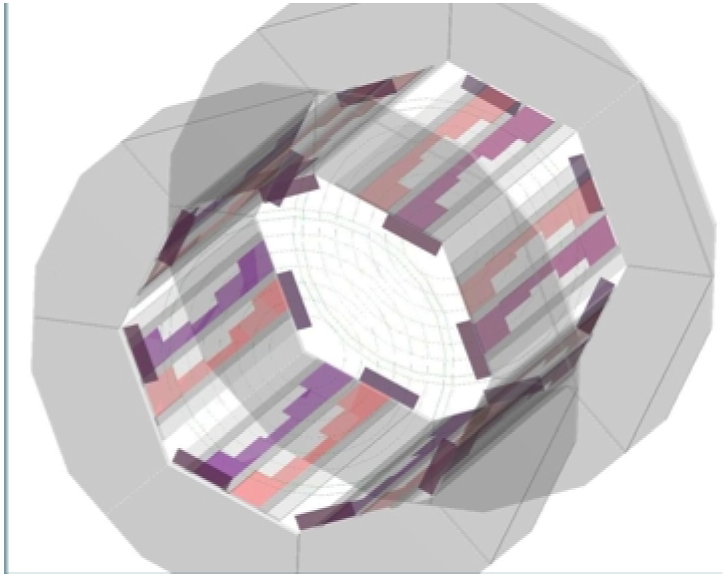
- A scalable Ecal mixing silicon and/or scintillator sensitive layers
- Exchange of AHCAL and SDHCAL in same detector volume

Realism

- Implementation of services and realistic mechanical designs

Engineering model





Corresponding simulation

“Interface” between engineering and simualation by EDMS s/w

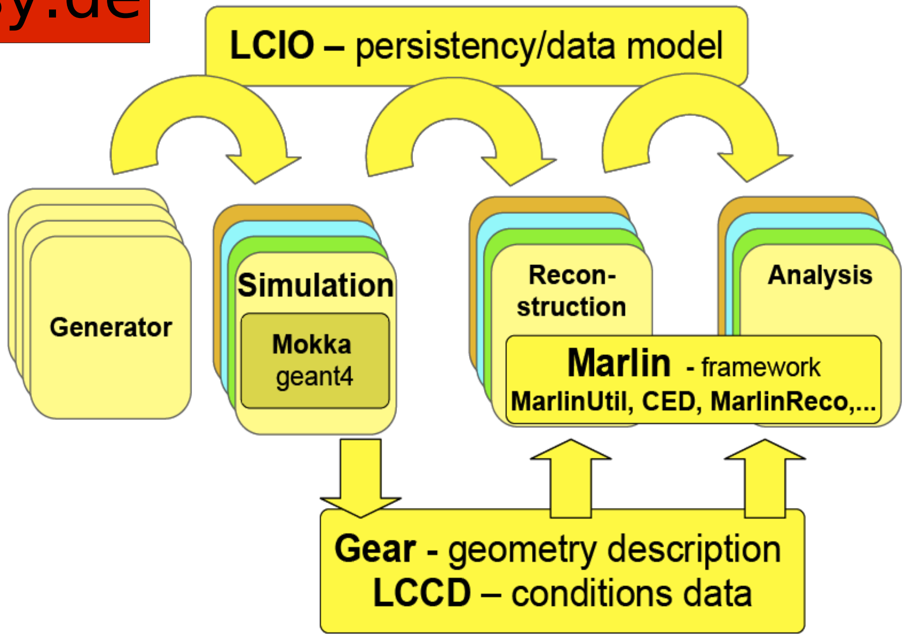
Alternative designs

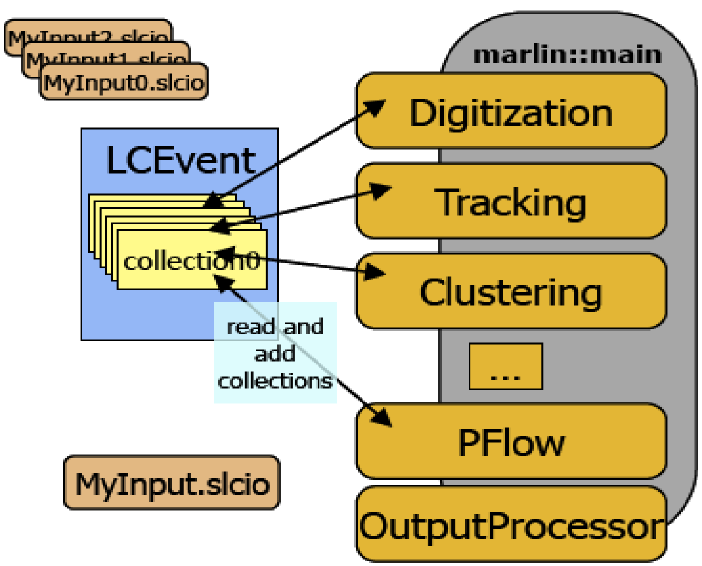
- Available: improved implementation of semi-digital (GRPC) Hcal a la Videau

ILD Core Software Tools

http://ilcsoft.desy.de

- **Mokka** (LLR)
  - geant4 simulation application
- **LCIO** (DESY/SLAC)
  - international standard for persistency format / event data model
- **Marlin**
  - core application framework for reconstruction & data analysis
- **GEAR** geometry package f. reconstruction
- **LCCD**
  - conditions
  - data toolkit (DB)
- **CED**
  - 3d event display





- complete framework used in Monte Carlo & 'real experiments':
- **ILD** **detector concept** studies
- **Calice** calo testbeam
- **LC-TPC** testbeam
- EUDET - **Pixel Telescope**
- **synergies between testbeam and global detector optimization**

Software development

- some improvements in core tools (LCIO, GEAR, CED)

  - many (small) improvements in reconstruction tools (MarlinReco):

  - active work on reconstruction for technology options:
    - FPCCD digitizer
    - SciEcal strip clustering
    - SDHcal reconstruction

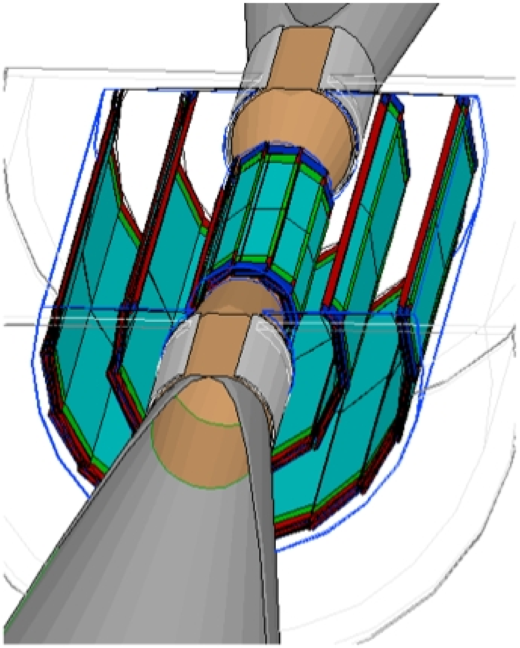
  - started to develop new tracking code (C++, based on KalTest)

DESY: Some progress with the tracking and some bug fixes and improved build tools.

New release v01-11-pre03 (mainly targeted at the CLIC CDR)

Subdetector components I – Vertex detectors

Aim to equip three doubled sided layers

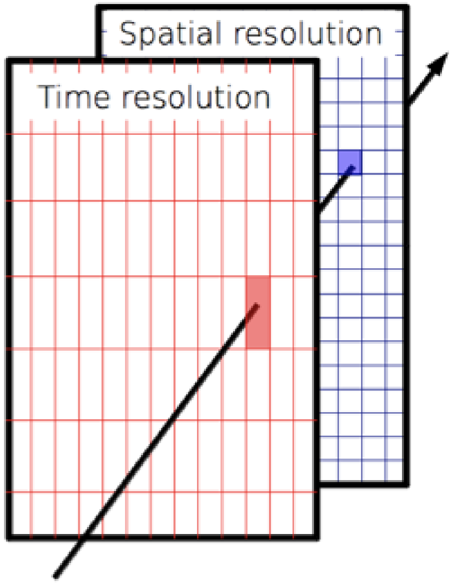


Sensor development

Inner double layer inner radius
- binary charge encoding
- 16x16 μm^2 pitch => < 3µm resol.
- r/o time 40-50 µs

Inner double layer outer radius
- binary charge encoding
- 16x64 μm^2 pitch => 5µm resol.
- r/o time 10-12 µs

Outer layers
- 35x35 μm^2 pitch
- charge encoding with 4 bit ADC
  => expected resolution 3-4 µm
- r/o time < 100 µs



Design of prototypes meeting these specs ongoing
Fabrication in danger due to short funding

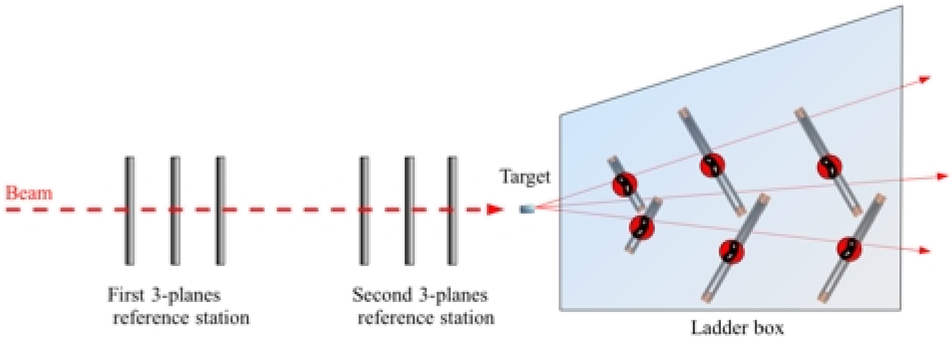
Subdetector components I – Vertex detectors cont'd

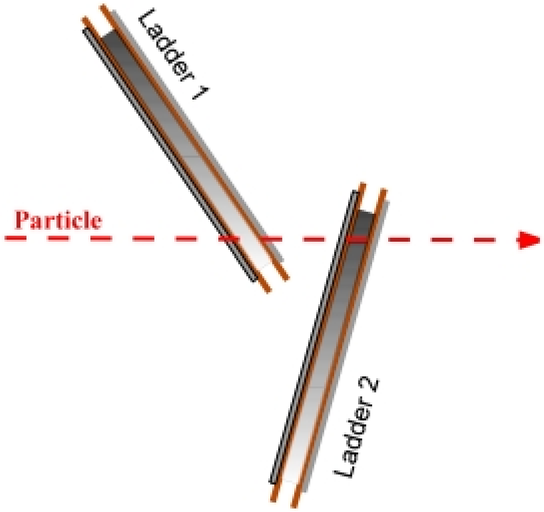
PLUME collaboration:
Development of double sided ladders with MIMOSA 26 sensors

Material budget 0.6%X_0

Further studies to reduce material budget to 0.4% for DBD

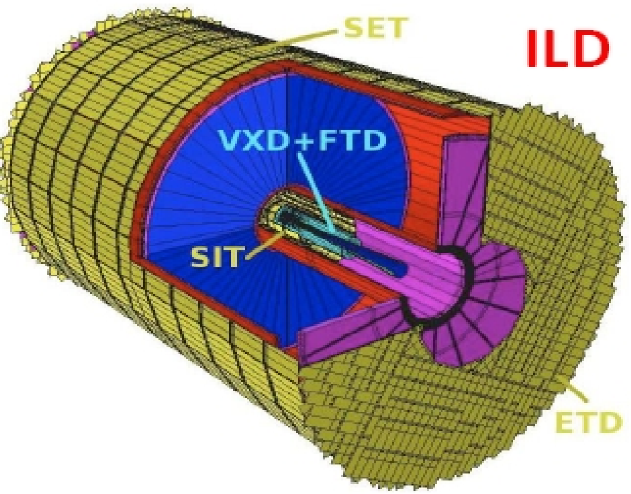
Tentative test beam setup for 2011-2012





R&D has to continue beyond 2012

Subdetector components II – Silicon Inner Tracking



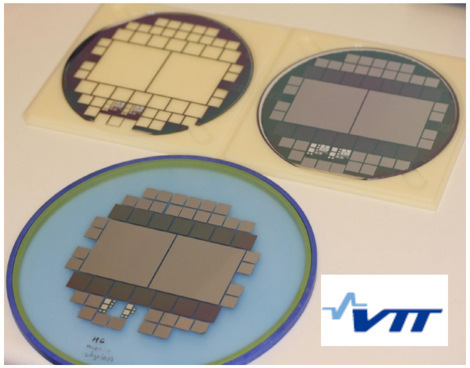
- Developed within SiLC R&D collaboration framework
- Based on 4 Silicon components surrounding the TPC: **SIT, SET, FTD, ETD**
- **Main objectives: high performances & low % X0 =>**
- Main R&D streams: sensors, FE readout, interconnection
- *Baseline sensor technology: Single sided strips for all but 3 FTD disks nearest to Vertex detector (pixels)*
- For DBD:

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

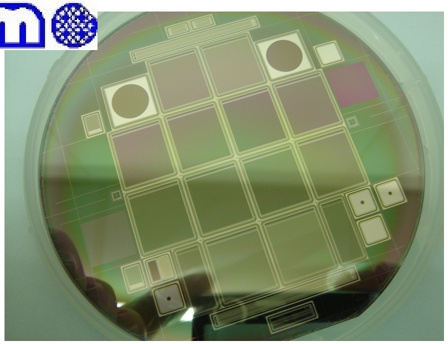
- **SiLC strategy on sensors R&D**:

✓ *Close collab with expert Silicon Labs: CNM-IMB, IRST, VTT, ETRI and with industrial firms: HPK, Micron etc.*

✓ *Performances validated on test beams prototypes*



New edgeless sensors

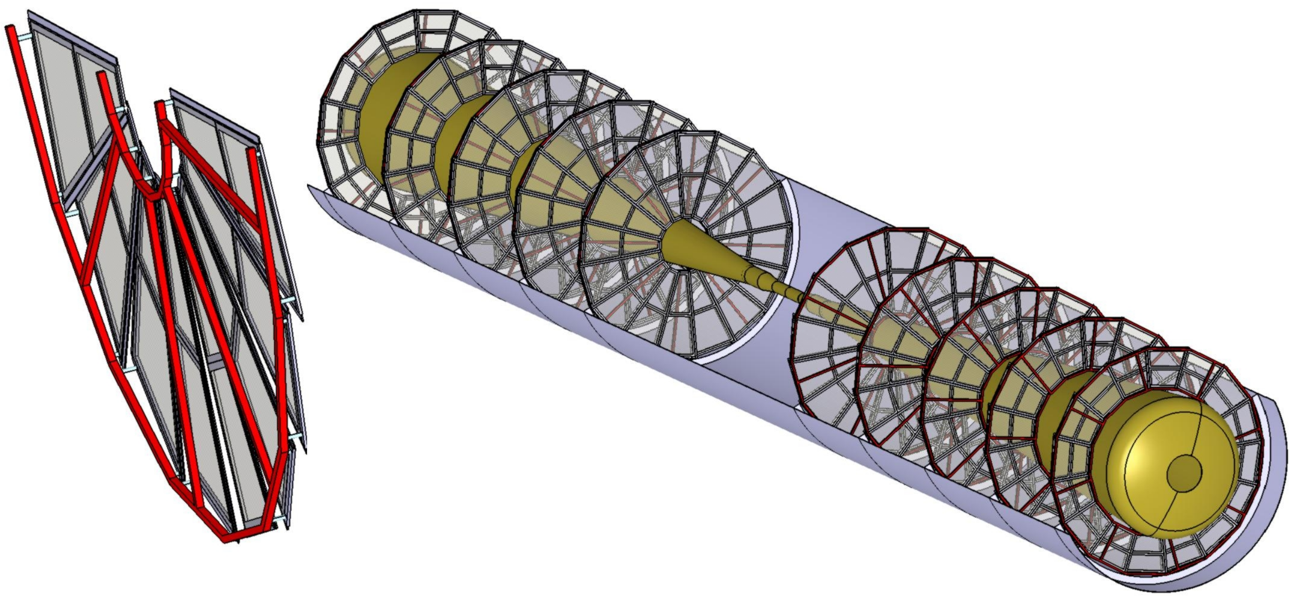


High transmittance sensors
Goal: T~70%; Already now: 50%

From general point of view:
High benefit from involvement in shorter term experiments for keeping/developing expertise & for funding and from synergy with (s)LHC.

Subdetector components II – Silicon Inner Tracking cont'd

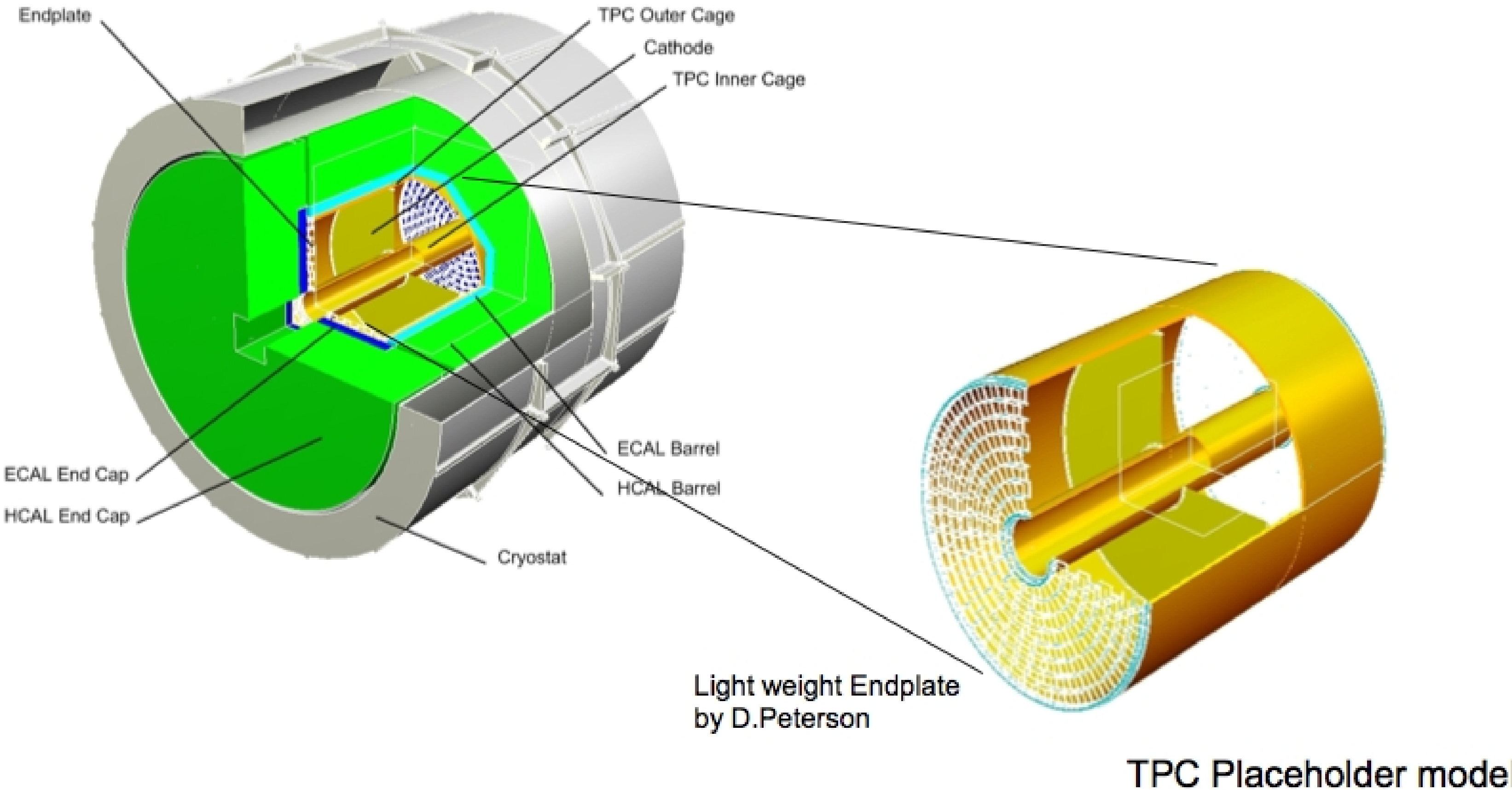
- EU FP7 project AIDA (Advanced European Infrastructures for Detectors at Accelerators)
  - ILD **FTD demonstrator** as AIDA's "advanced deliverable"
- Periodical meetings with ILD inner region integration group (M. Joré), realistic design as much as possible for the DBD.



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

Subdetector components III - TPC

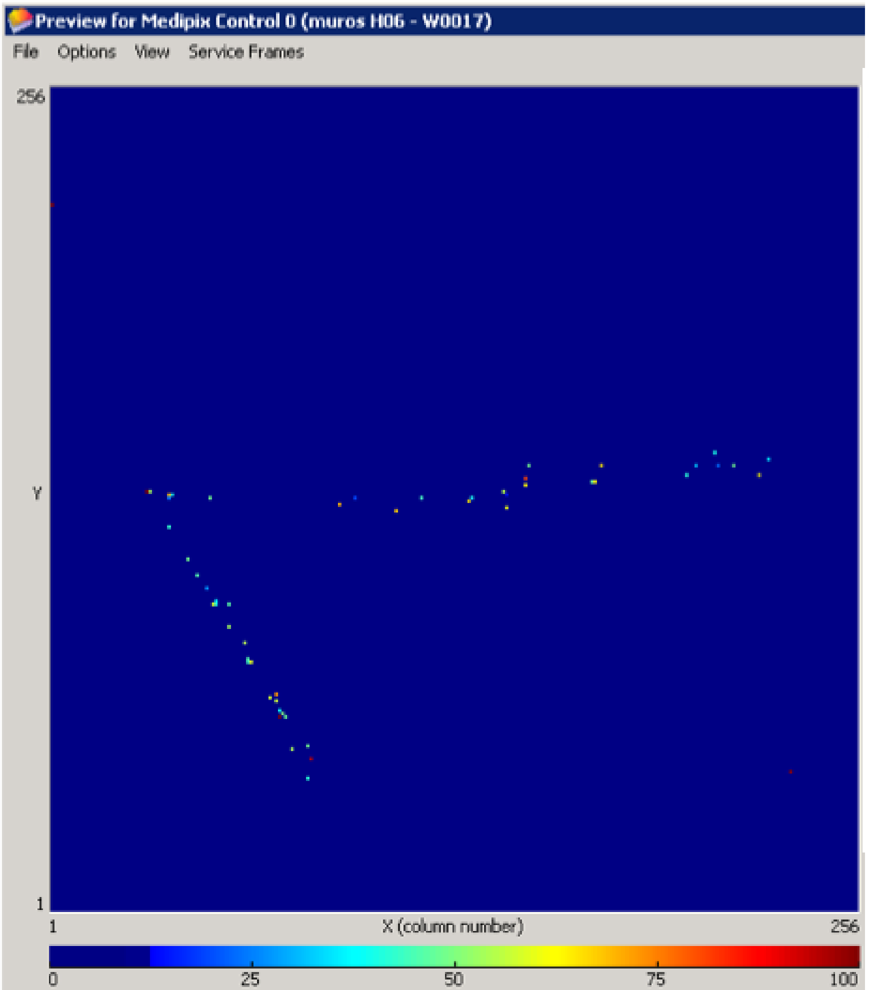
Central tracking in ILD based on TPC

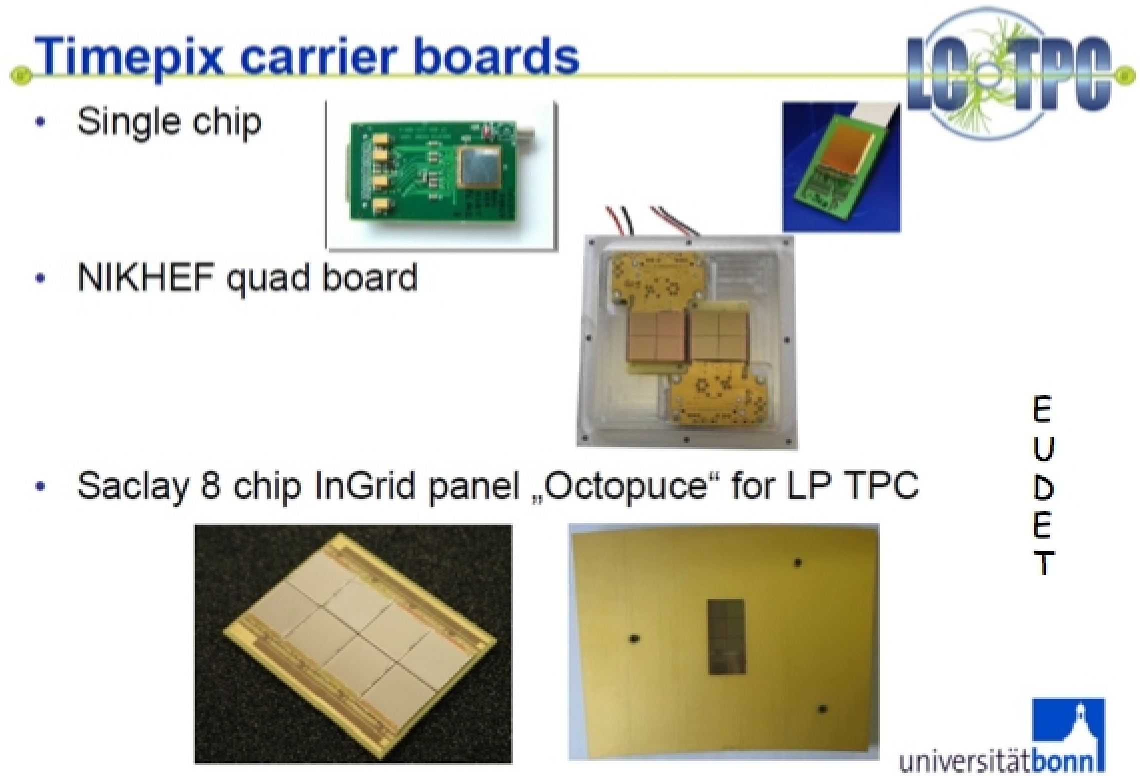


Integration of TPC into full detector is challenging
Close collaboration between R&D groups and (mechanics) integration experts – True also for all other components

Subdetector components III – TPC cont'd

Pixel r/o for Micro Pattern Gas Detectors - GEMs, Micromegas

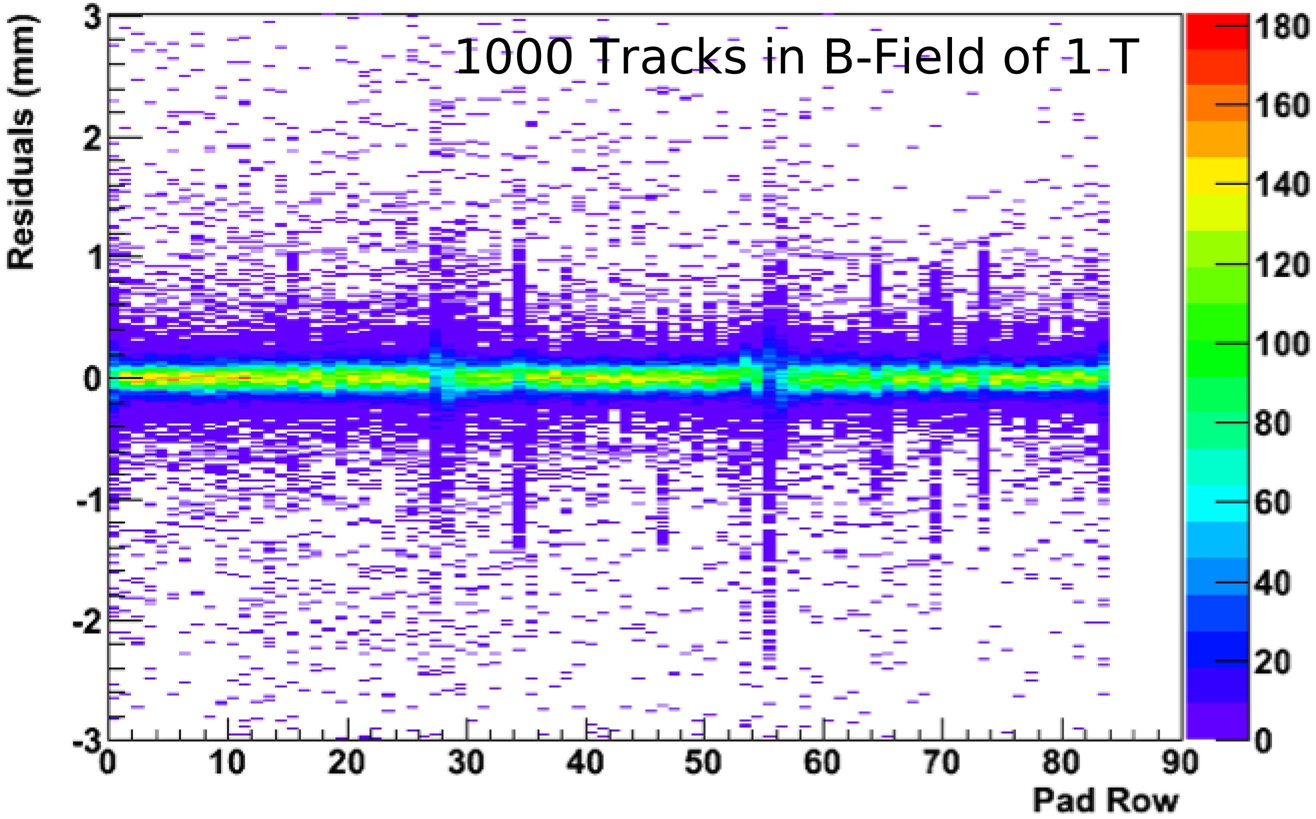




Intensive R&D within LCTPC Collaboration

Subdetector components III – TPC cont'd

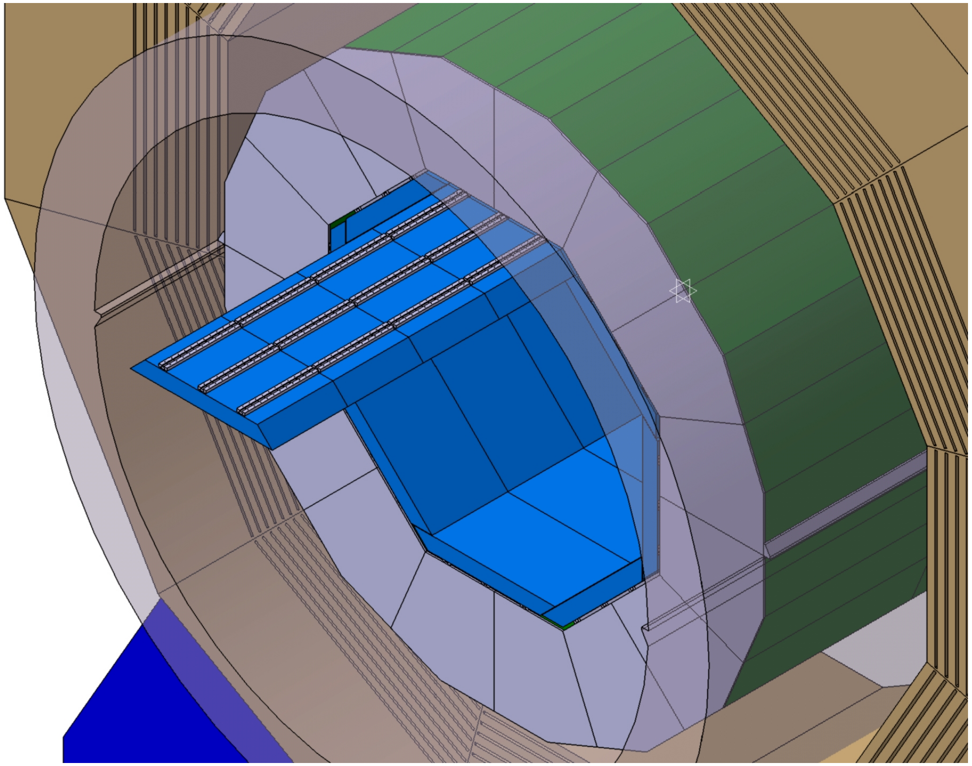
Track reconstruction based on cluster algorithm
Millipede fit to account for misaligned pad rows



- 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

Subdetector components IV - 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. lI=96mm
  - Narrow showers
  - Assures compact design
- Silicon as active material
  - Support compact design
  - Allows for pixelisation
  - High signal/noise ratio

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

Detector Optimisation – Number of Layers/Sensitive Material

Models under study:

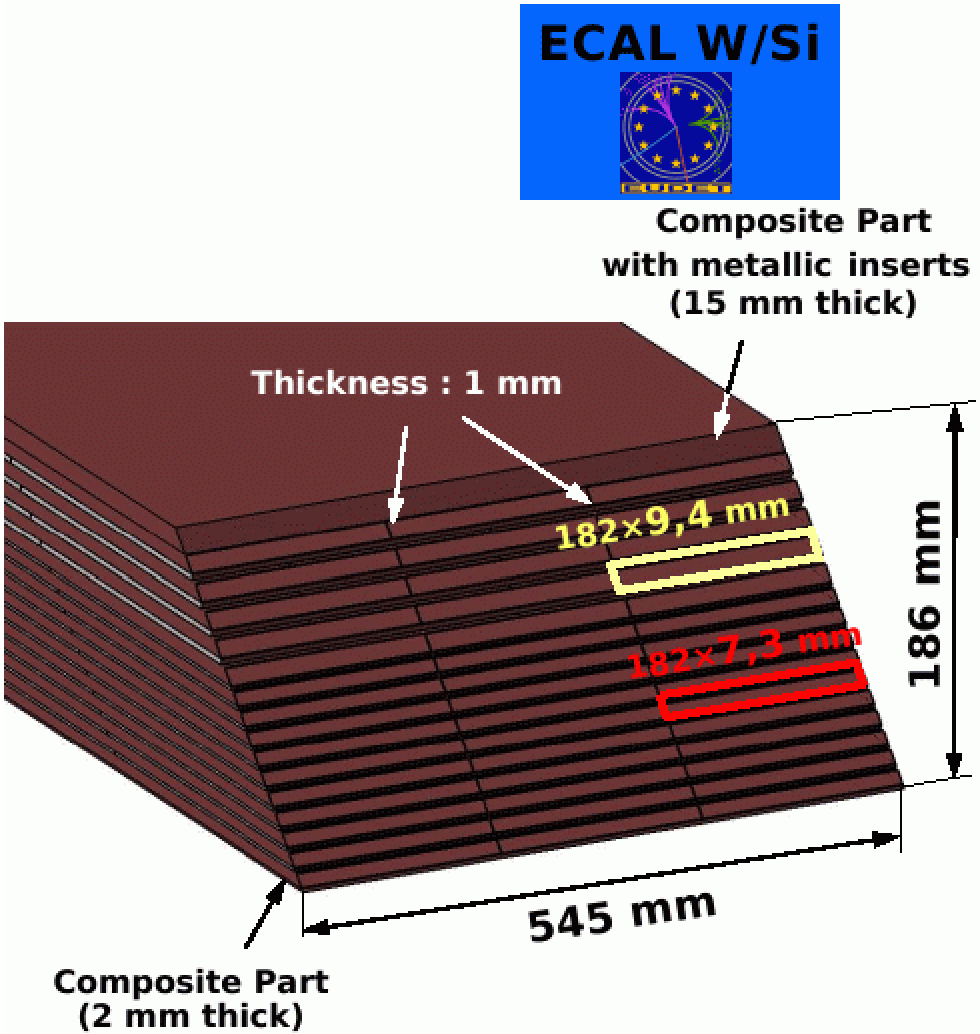
1) A pure SiW Ecal Calorimeter with 20 < N < 30 Layers

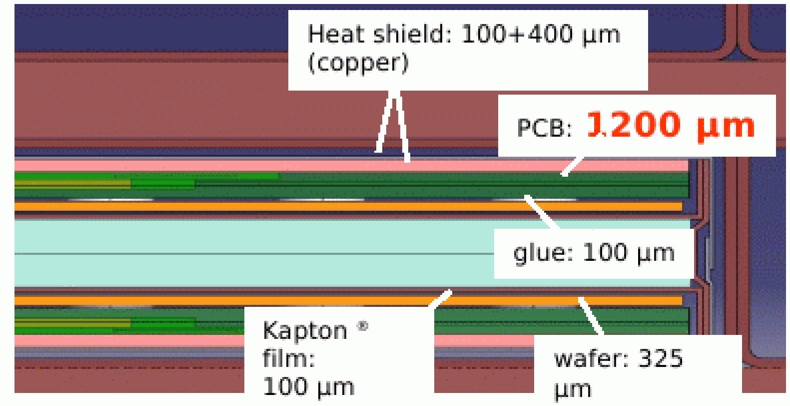
2) A pure Scintillator Ecal

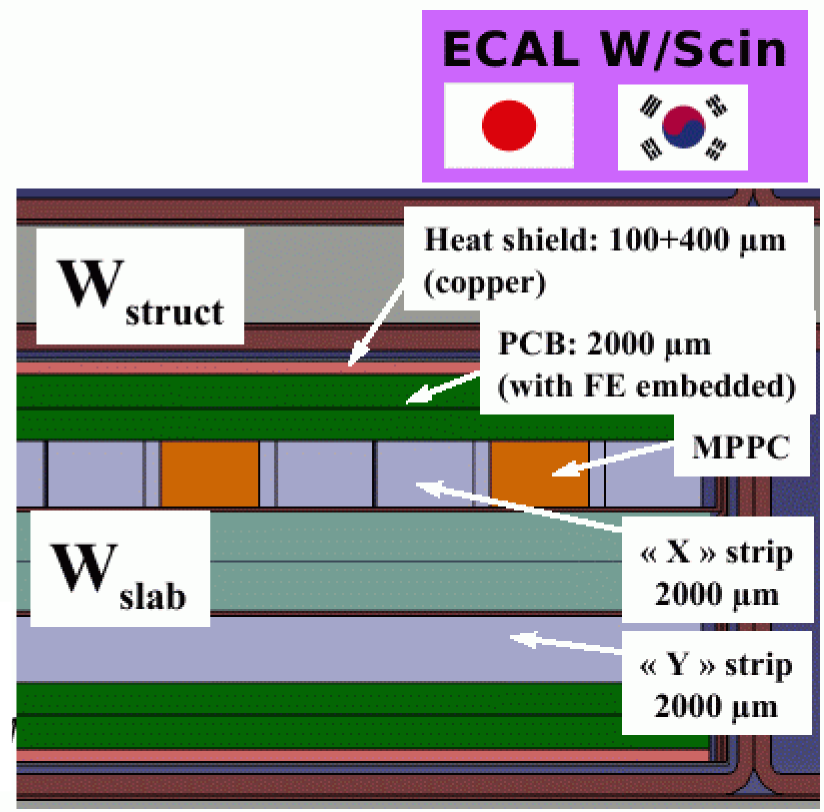
3) A hybrid solution
   e.g. first 20 layers Si with rear part of calorimeter equipped with Scintillator

PFA studies for hybrid calorimeter ongoing

Technological prototypes and alternative Ecal technologies



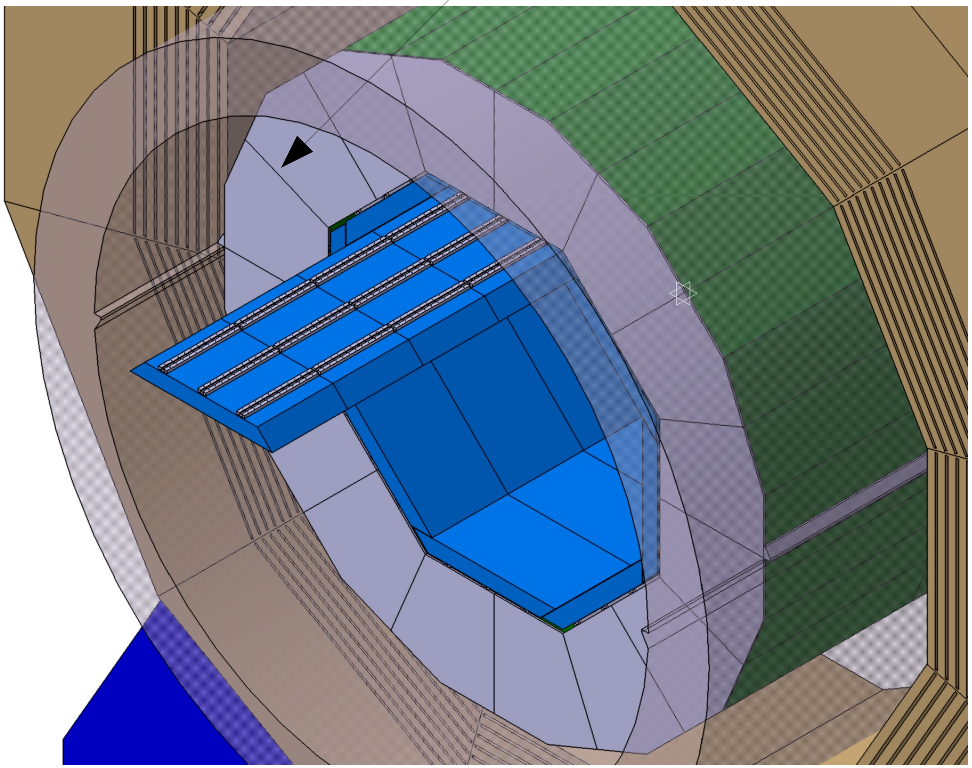




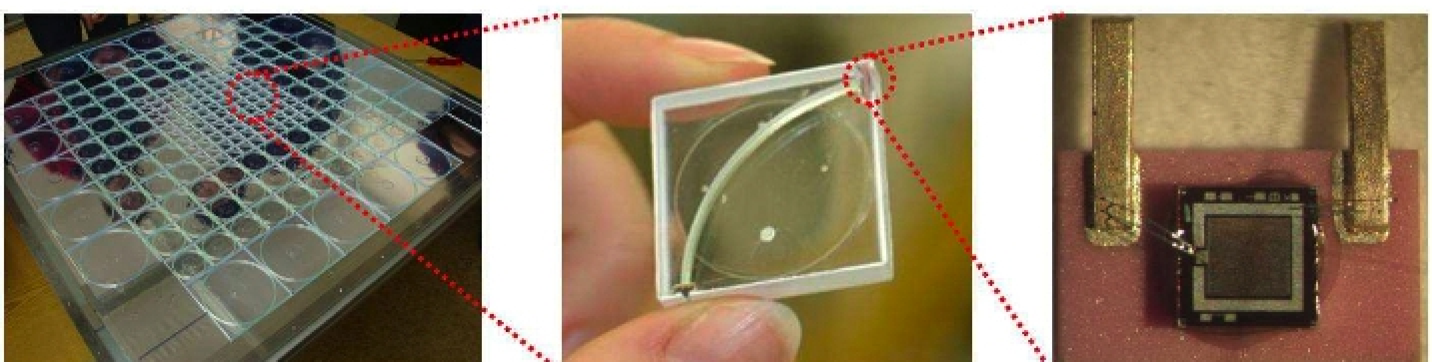
Technological prototype to address engineering challenges of detector construction

Subdetector components V - Hadron calorimeters

(Analogue) Hcal

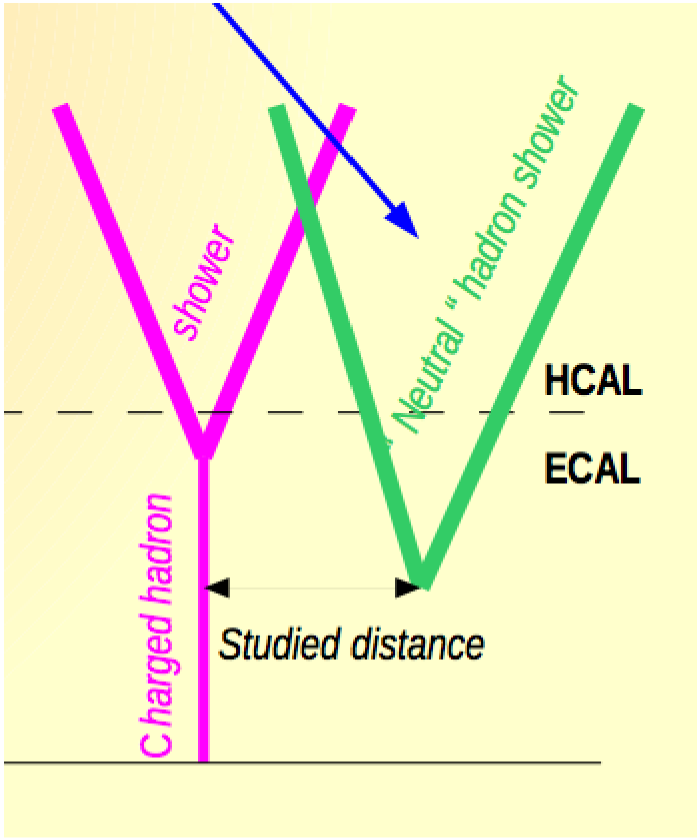


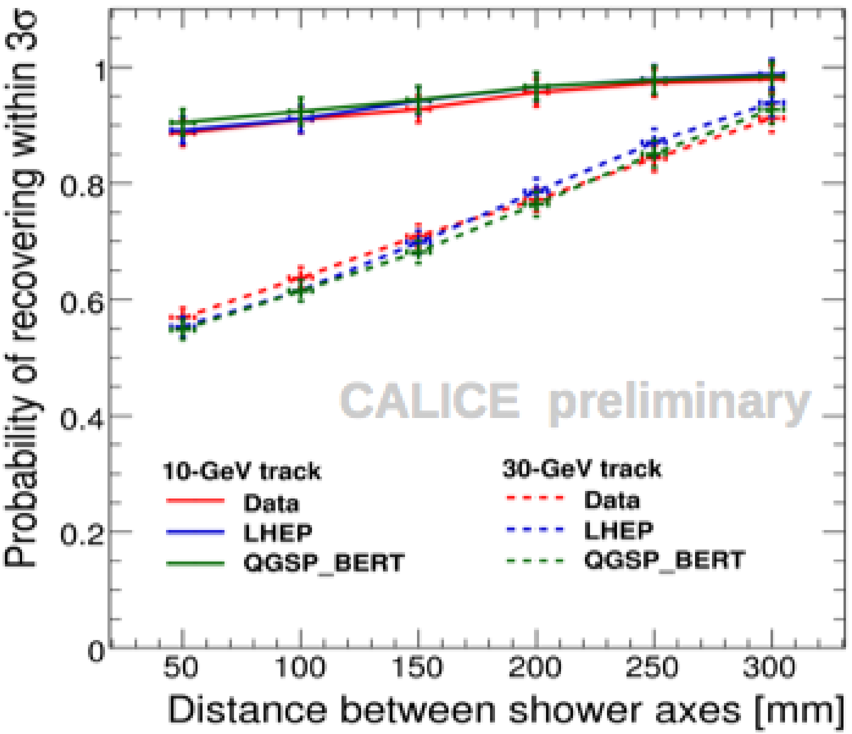
- Steel/scintillating tiles
- Size 3x3 cm^2
- r/o by silicon pms
- Large scale testbeam program within CALICE



Testbeam results

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



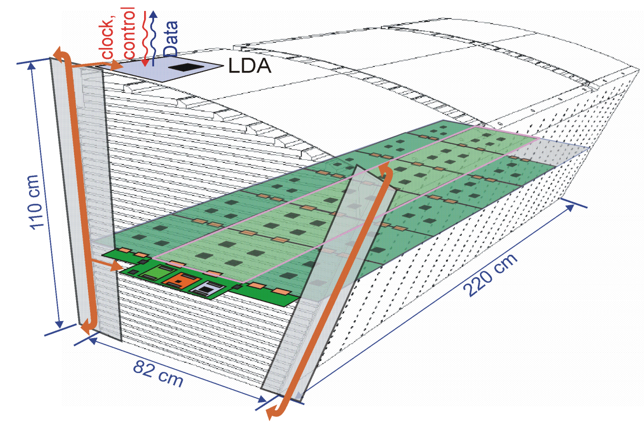


Transport of beam test data into physics studies

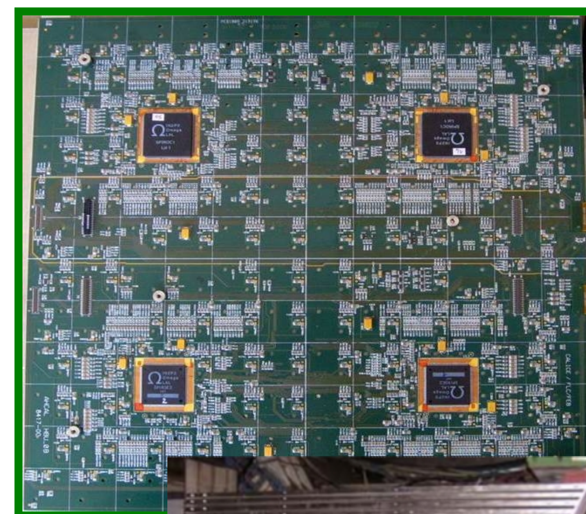
Successful application of PFA to real data with highly granular calorimeters

Technological prototype

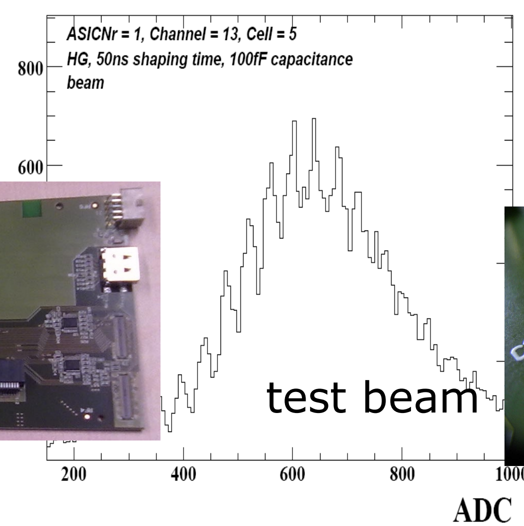
- 2nd generation prototype has integrated readout ASICs and LED system - and time measurement
- Prototype roadmap:
  - 2010: 1st HBU
  - 2011: full layer (2000 ch)
  - 2012: several options
    - instrument part of ILD wedge
    - tungsten HCAL

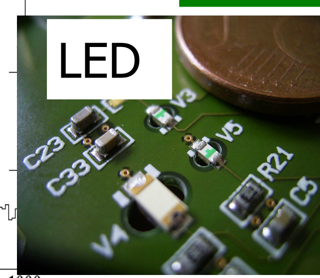


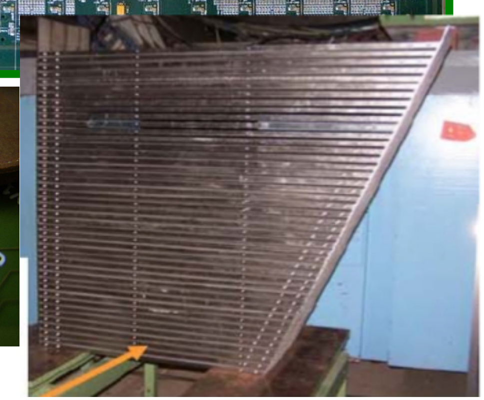
12x12 tiles, $36 \times 36\ cm^2$



10 cm



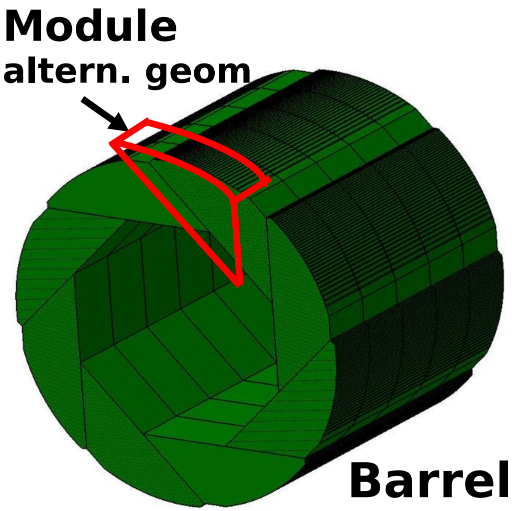


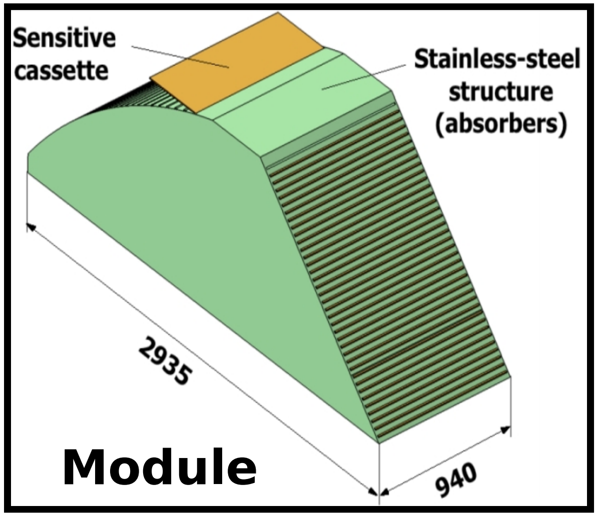


SDHCAL-GRPC

The SDHCAL proposed for ILD ha

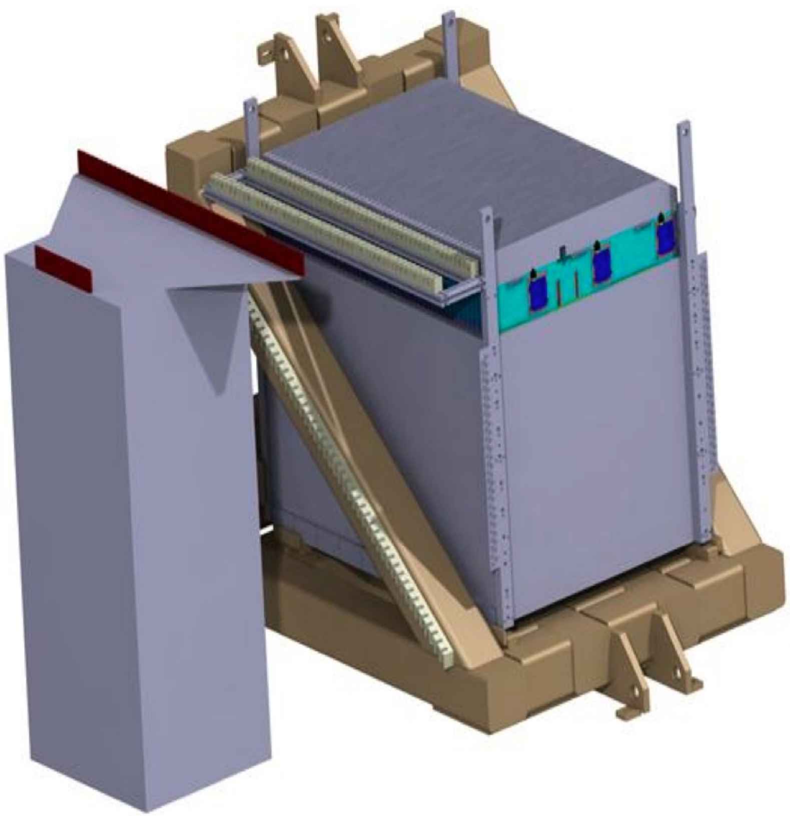
→ Self-supporting mechanics
→ Minimized dead zone
→ Minimized thickness
→ One-side services
→ Power pulsed embedded electronics



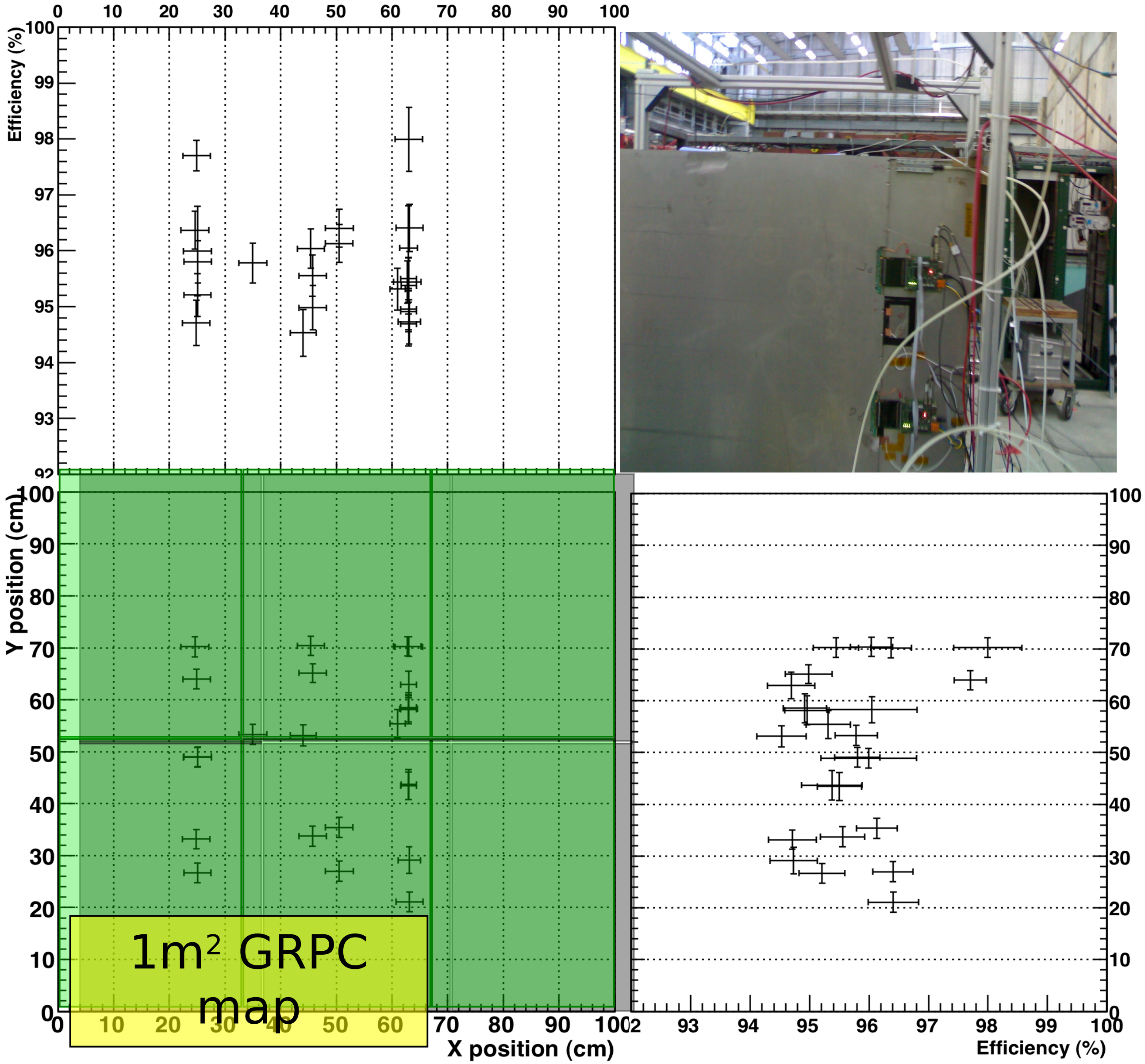


A technological prototype is being built:
It will be made of 48 units.
Each unit is made of :
2 cm absorber
+ **0.6 cm sensitive medium**
1 cm^2 transversal granularity

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



TestBeam Validation



2 full cassettes were successfully tested at T9-PS May 2010 and H4-SPS in September 2010

Towards CALICE input to DBD

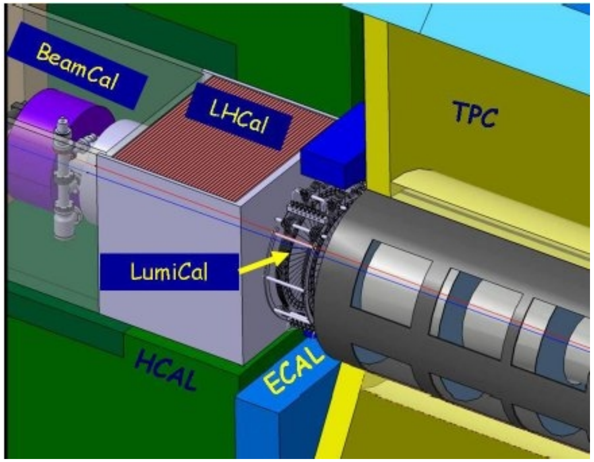
- Considerable experience in operating highly granular calorimters
  Ecals, Ahcal, (S)DHCAL

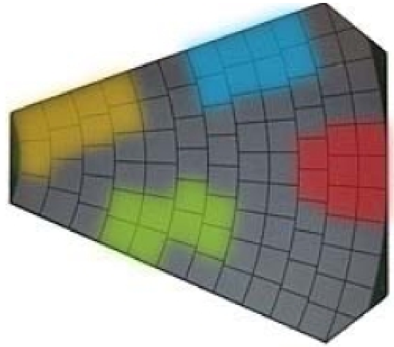
- Feasibility of detector construction
  - First successful power gating in magnetic field - SDHCAL beam tests
  - Embedding of front end electronics w/o compromising
    data precision – SiW Ecal beam tests
  -> see Calo session at ALCPG

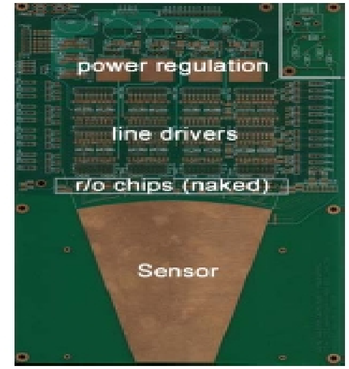
- Definiton of technology readiness criteria until CALICE collaboration meeting in May
  Review by DESY PRC in April

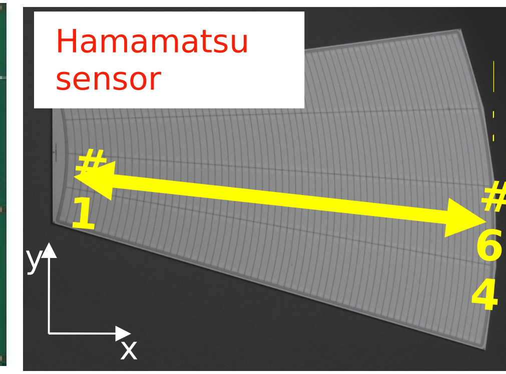
- CALICE report will be prepared until spring 2012

Subdetector components v - Forward calorimeters



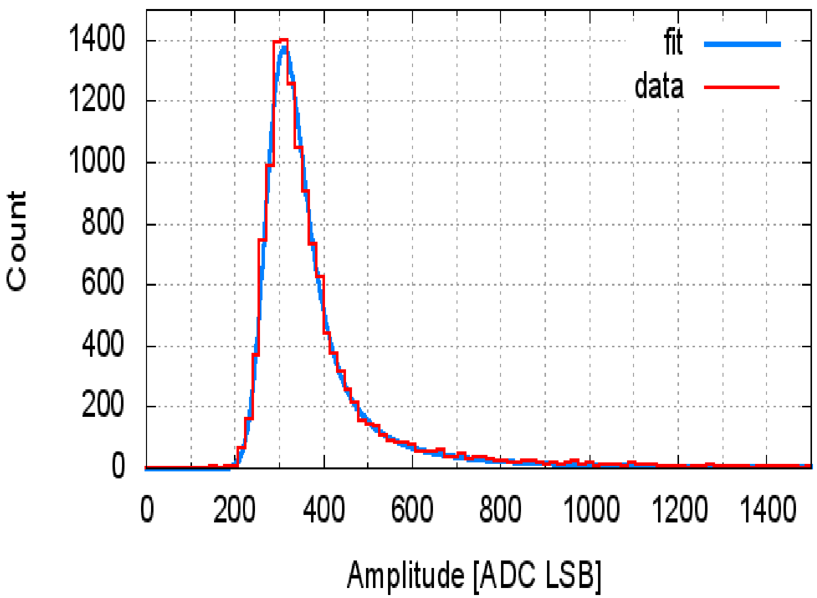






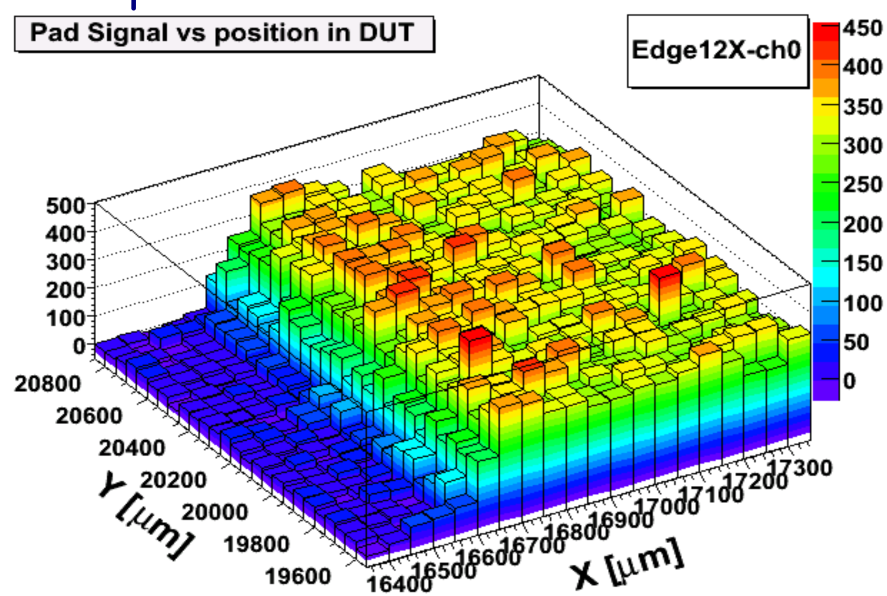
LumiCal

Signal spectrum



Homogeneity of the response

BeamCal



S/N ~ 20

Cross talk: ~ %

In addition: study of stability, edge effects

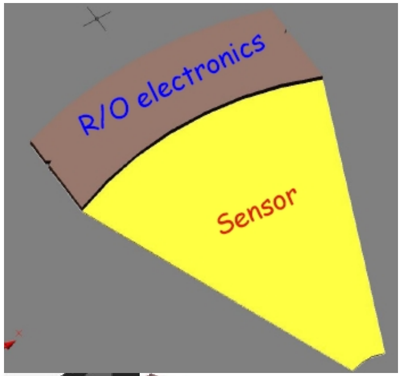
A prototype calorimeter

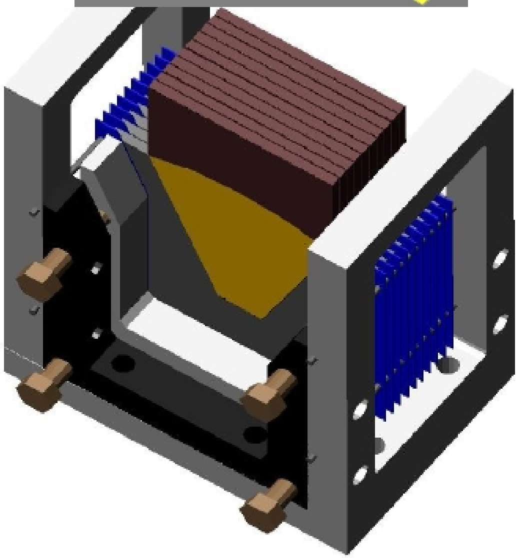
- Flexible, high precision tungsten structure
- Fast FE Readout
- Innovative connectivity scheme
- Position control devices

Infrastructure common with others:

- Power pulsing
- Data acquisition
- Tracking in front of the calorimeter

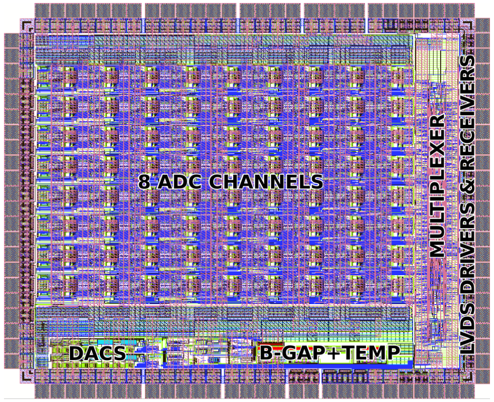
Support within AIDA (as true for other R&D in this talk)



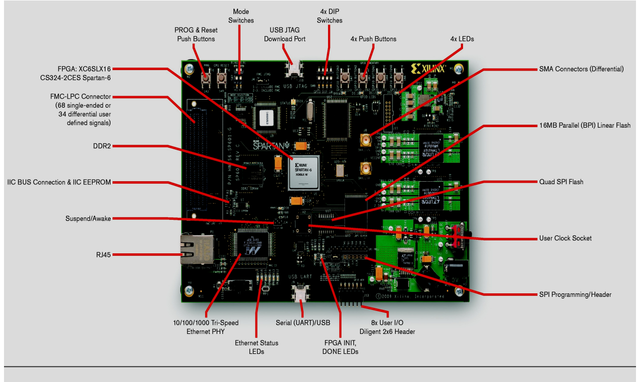


Preceeded by:

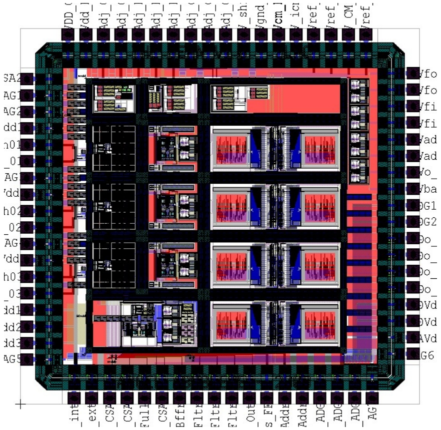
8 channel ADC



DAQ interface

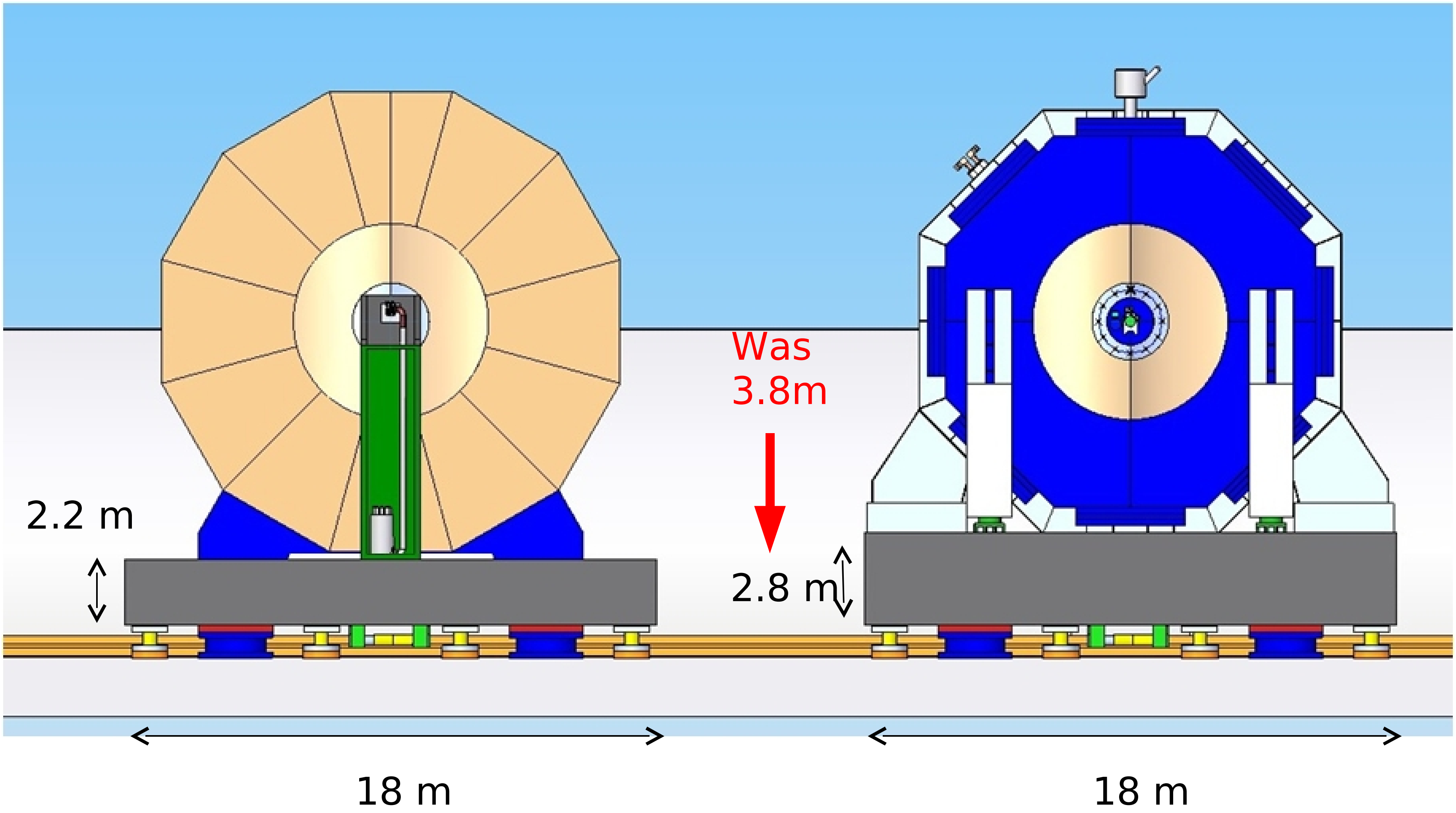


Integrated chip



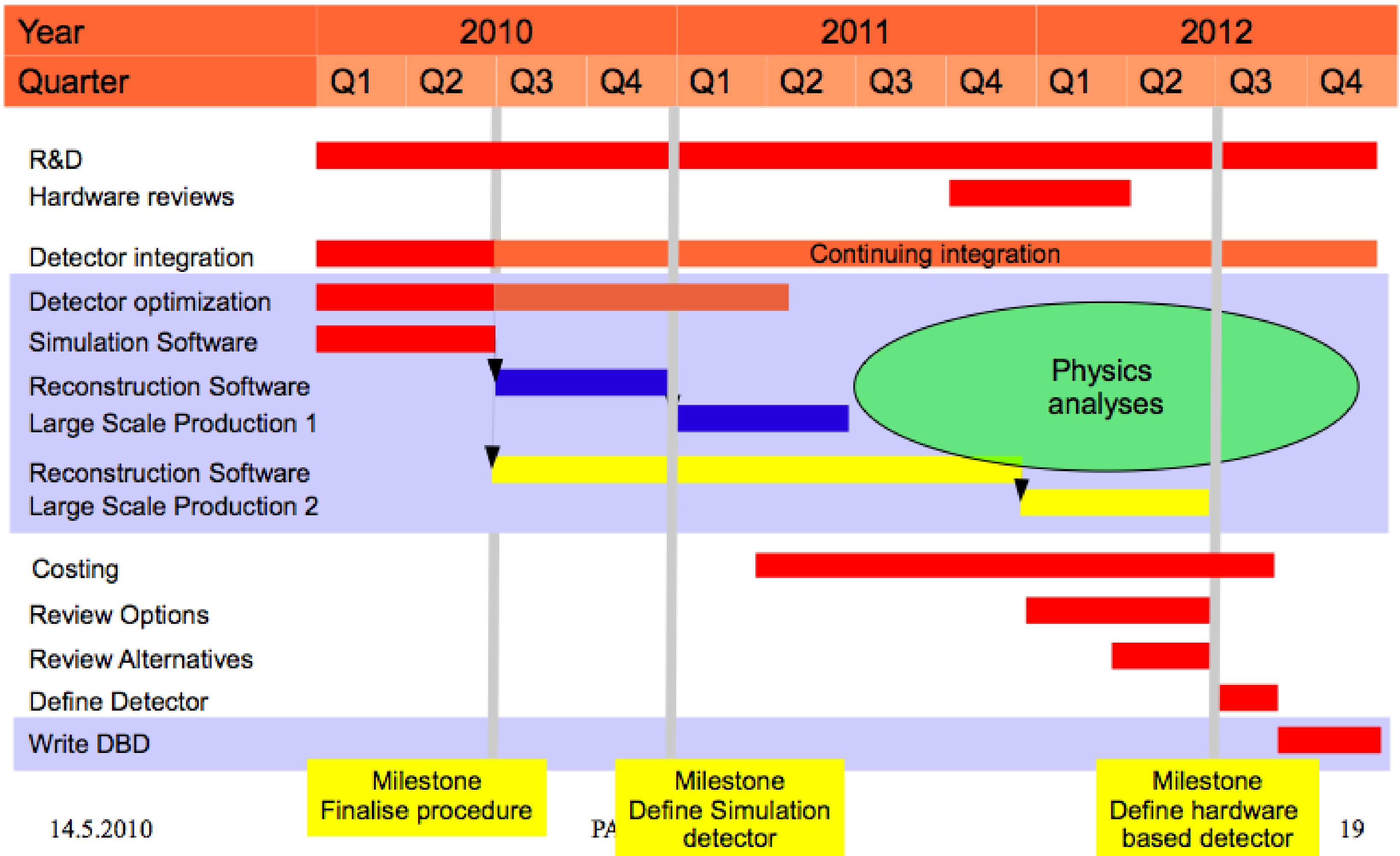
Detector integration " External"

Current proposal - ILD and SiD on a common platform



ILD lowered by 1m due to changes to yoke feets
=> SiD platform less thick
Common beam height of 8m

Main Milestones



Summary and outlook

- ILD is moving towards the DBD phase

- ILD software framework proven to be able to contribute substantially to point out **physics potential of a linear collider**!!!!

  ... and will continue to do so for new benchmarks

- The keywords towards the DBD phase are **realism**

  Close collaboration between engineering and simulation groups

- ... but also **flexibility**

  DBD will contain options and alternatives

- Work by detector R&D groups are the basis for the DBD

  Based on experience with (large scale) prototypes

- First definition of base line at LCWS11

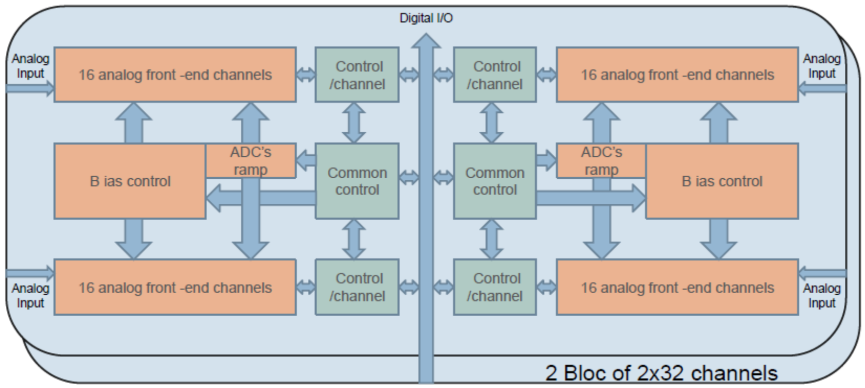
Backup

Important changes in Mokka

- A scalable Ecal mixing silicon and/or scintillator sensitive layers
- Analog Hcal with electronics inside
- Pad-row-based TPC with Endplate of 25 percent X0
- Improved implementation of Sit, SET, ETD by the SiLC Collaboration
- Ftd - First mechanical design with micro-strips (disks 3,4,5,6,7) and pixel (disks 1,2) technologies by Jordi Duarte.
- Coil using Coil Cryostat with detector instrumentation by Valeri Saveliev
- first implementation of services (cables, cooling, etc)
- improvements in implementation of: LumiCal, Tube, Mask, Yoke, BeamCal, Magnetic field,

- Available (but not included by default in the new ILD models): improved implementation of digital (GRPC) Hcal (that follows the design suggested by Henri Videau), and a new implementation that replaces, in the Analog Hcal, the scinillator layers and their associate components with GRPC layers identical to those in the GRPC Hcal, by Ran Han.

Towards DBD on FE readout electronics and interconnect

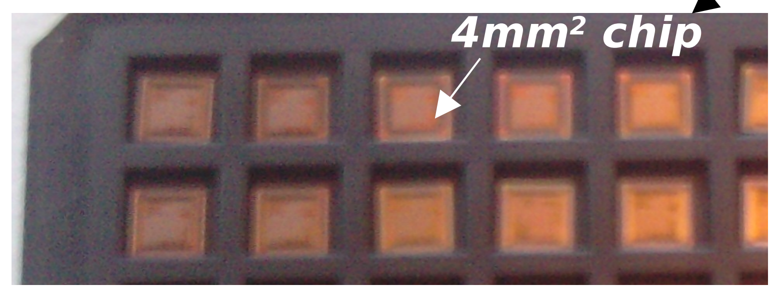


Goal: *mix-mode FE readout, pulse-height reconstruction, zero suppression, digital control (highly fault tolerant, flexible/robust) power cycling, in DSM CMOS*

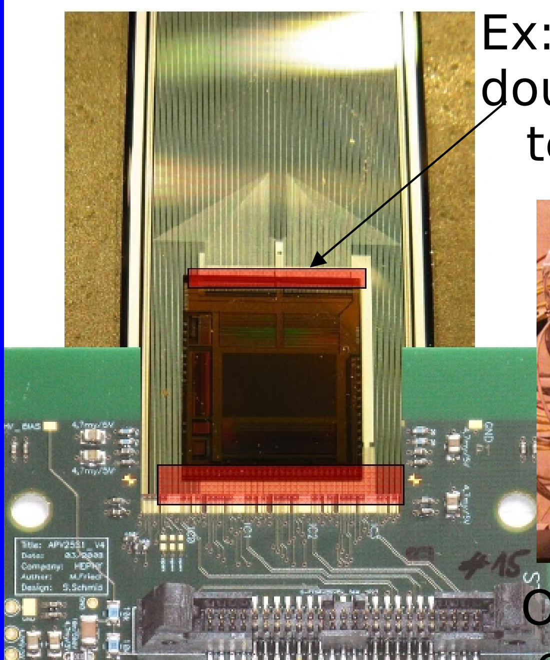
Also a fast VFE version developed for CLIC & for shorter term Muon g-2/EDM project.

Current baseline techno = CMOS IBM 130nm

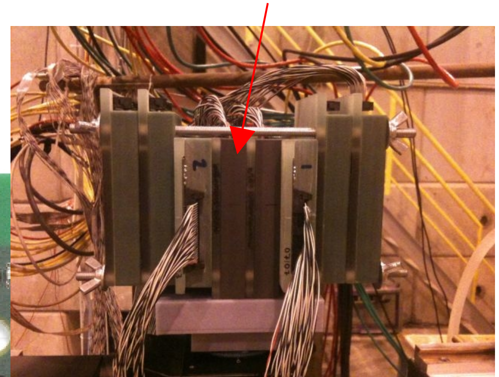
- Lately achieved: optimized VFE, analogue memory and A/D blocks, being tested



Interconnection FE readout/strips

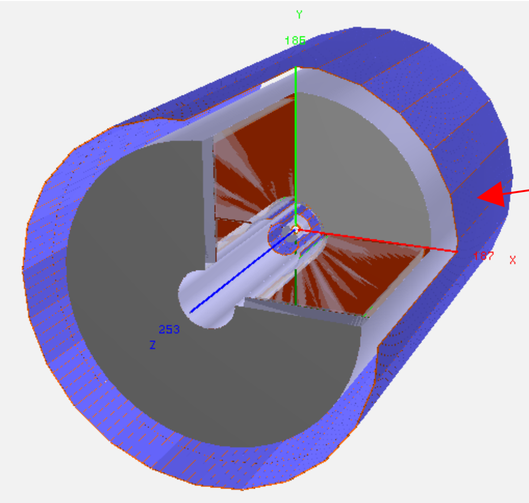


Ex: Inline pitch based on double metal sensors tested at CERN t.b.



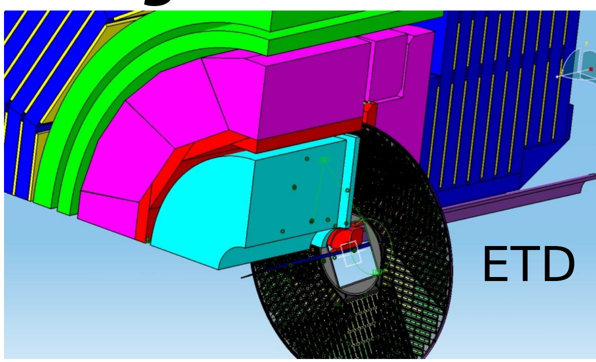
Other studied options: ex: TAB based

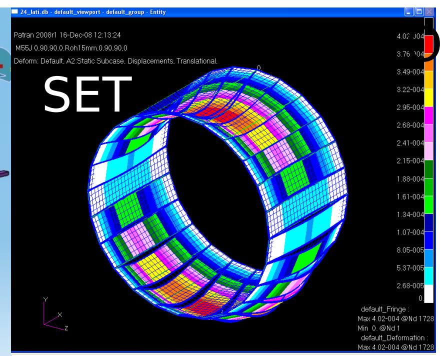
For DBD:
- 128 channels full prototyped & tested FE readout.ASIC
- At least one fully developed direct interconnection FE/strip



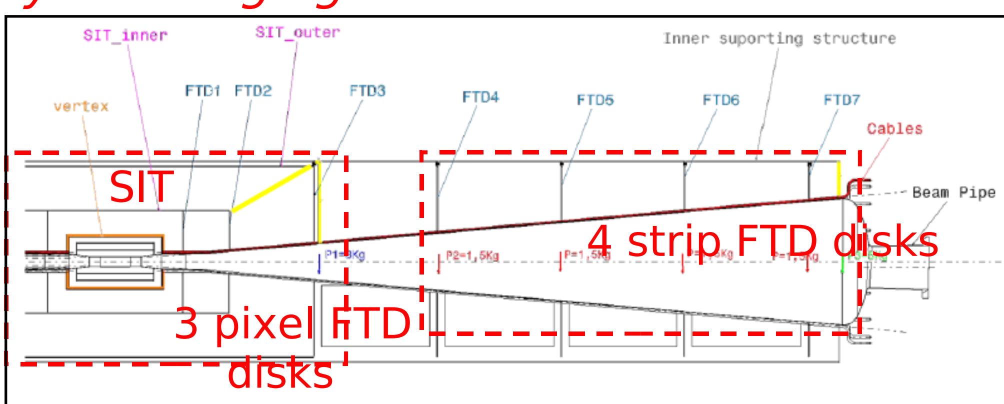
Simulations:
New: Full detailed (more realistic) description of the 4 Silicon components in the MOKKA framework
Next steps: develop full tracking reconstruction and achieve detector optimization and Physics studies.
Special attention to: End Cap tracking performances versus challenging forward Physics cases.

Integration studies on all 4



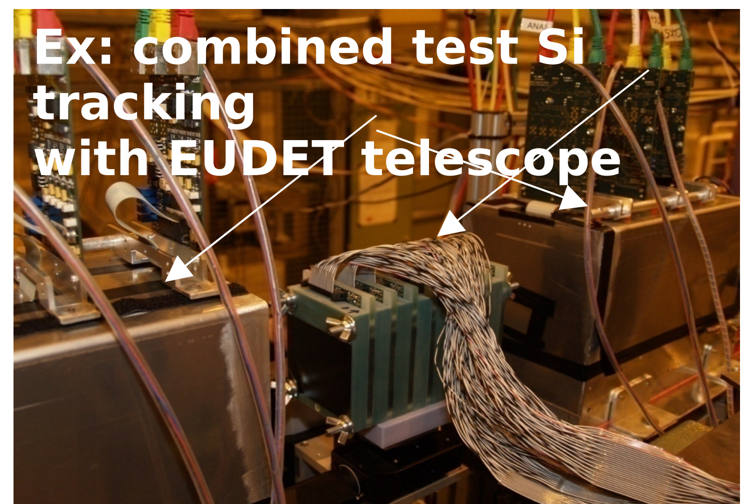


ery challenging because mix Gas & Si tracking



Test beam activities

ngoing since 2007 at DESY & CERN



eveloped expertise and infrastructures
SiLC+EUDET & AIDA) & with involvements
n shorter terms experiments: BELLE II,
Muon g-2/EDM

- Advances in sensors, mechanics and structural and environmental monitoring (see talk from M. Fernandez).
- New FTD mechanical design including electronics and services envelop, currently being produced, to be communicated to the integration group.