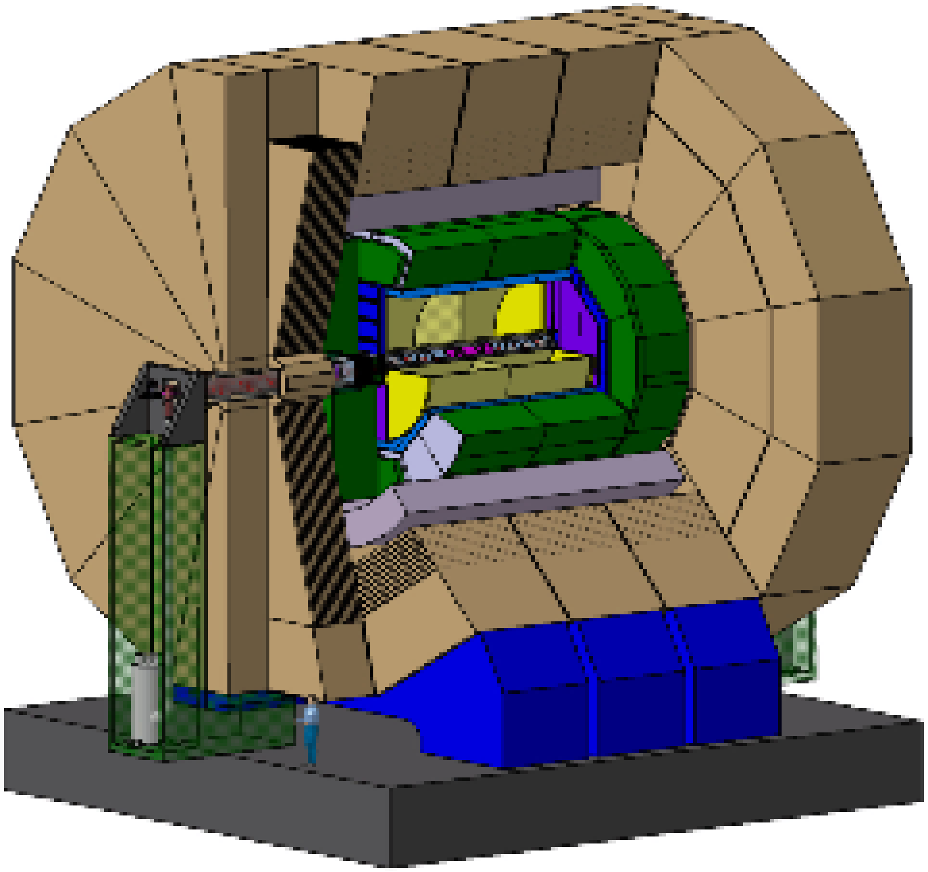
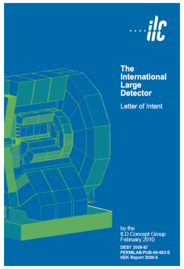
# ILD Concept



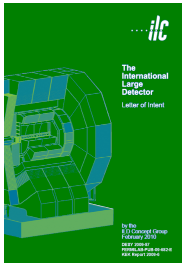
Ties Behnke, DESY,
for the ILD concept group
http://www.ilcild.org




Letter of intent (2009)

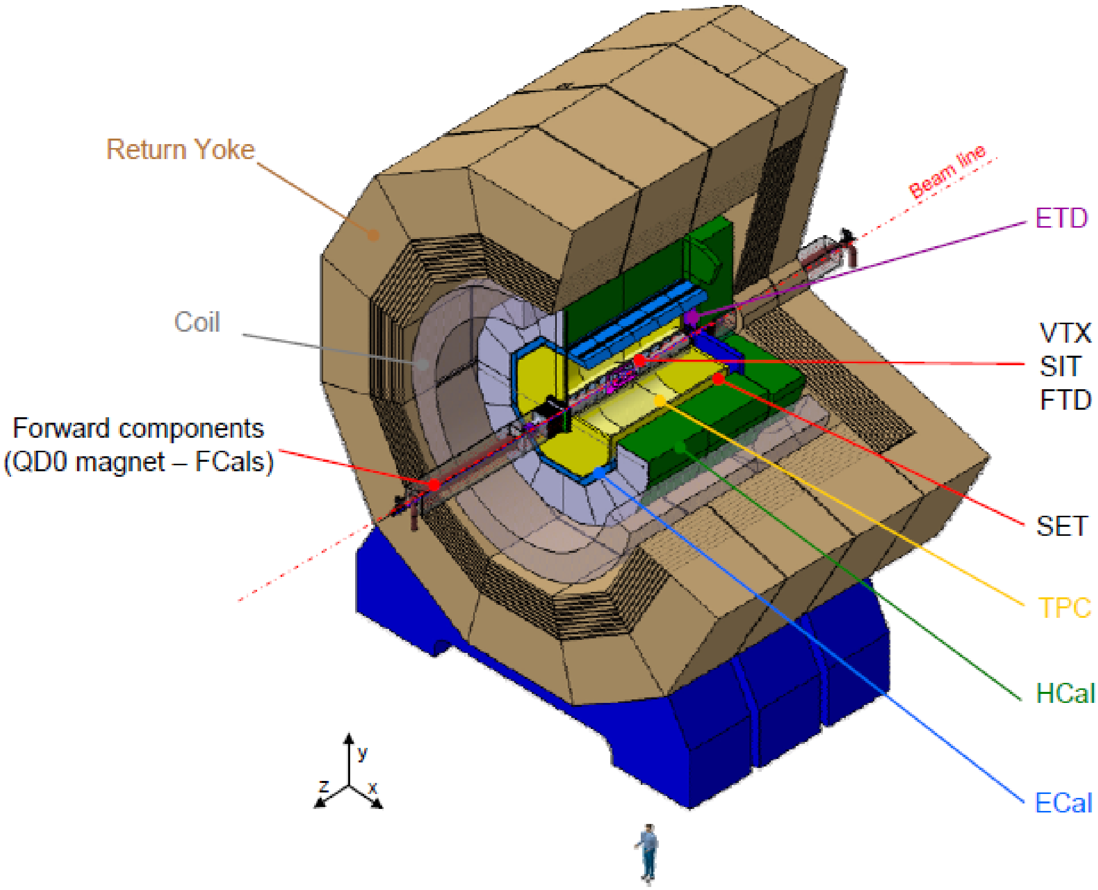
Evaluation
Readiness
Flexibility

Detailed Baseline Document (DBD) 2012




Solid and reliable design

# Detector Layout




Multi-purpose detector

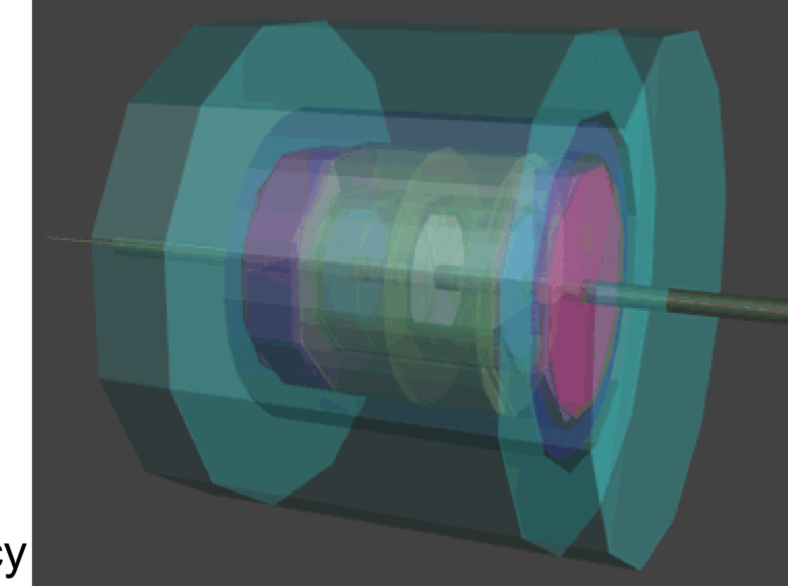
precision tracking
- High efficiency, high precision

precision calorimetry
- granularity

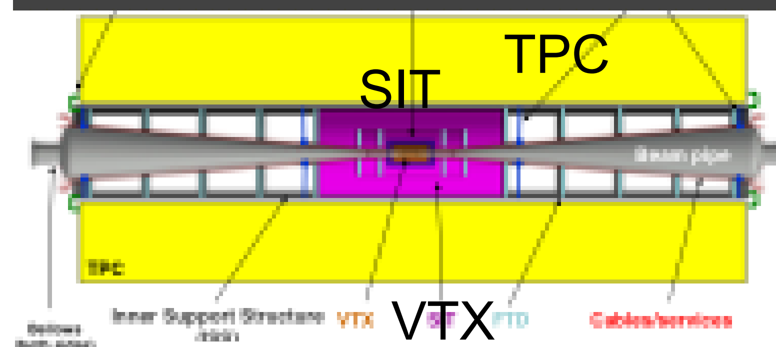
precision muon system

hermetic

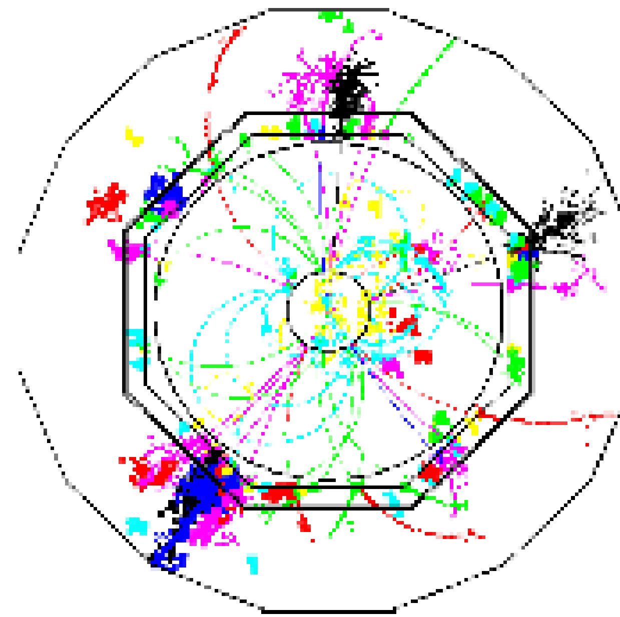
# ILD concept



- Detector optimized for particle flow:
  - Robust tracking (TPC + SI), optimized for efficiency and solid angle coverage
  - Fine-grained calorimetry, optimized for topological reconstruction




- Detector optimized for precision:
  - Excellent vertexing, close to IP
  - Excellent tracking resolution
  - Full solid angle coverage



Strong basis in Europe and Asia, less so in US
LOI: some 600 authors from 130 Institutes

# R&D collaborations

Subdetector R&D in ILD: heavily depend on the R&D collaborations

CALICE/ LC-TPC/ FCAL/ SILC/ …

R&D collaboartions have the resources and manpower

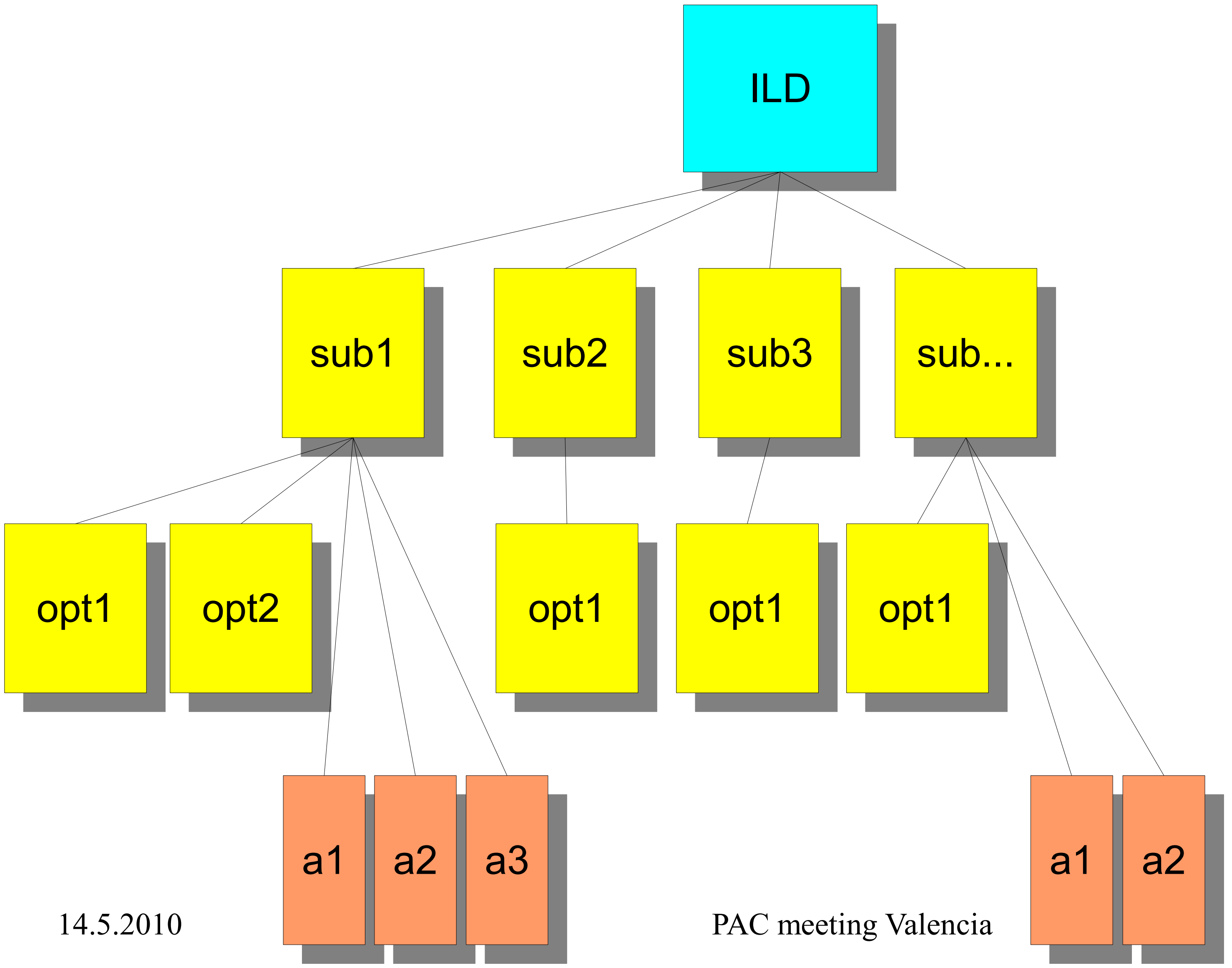
- no explicit support for concept work in many areas
- many third party funds go to R&D collaborations (EUDET, AIDA in Europe)
- many synergies with other projects are more apparent/ easier in R&D then in concepts
- optimize resource sharing among concepts

ILD does not (always) control the planning: planning becomes more difficult

# Goals of ILD until 2012

- Define a detector with options, which are considered "ready" by the R&D groups and ILD
- Include list of alternatives which are less advanced, but are promising candidates
- Improve based on real engineering the integration of the detector and its overall realism
- Improve the integration of the detector into the machine context
- Improve our understanding of costing of these detectors

# ILD baseline

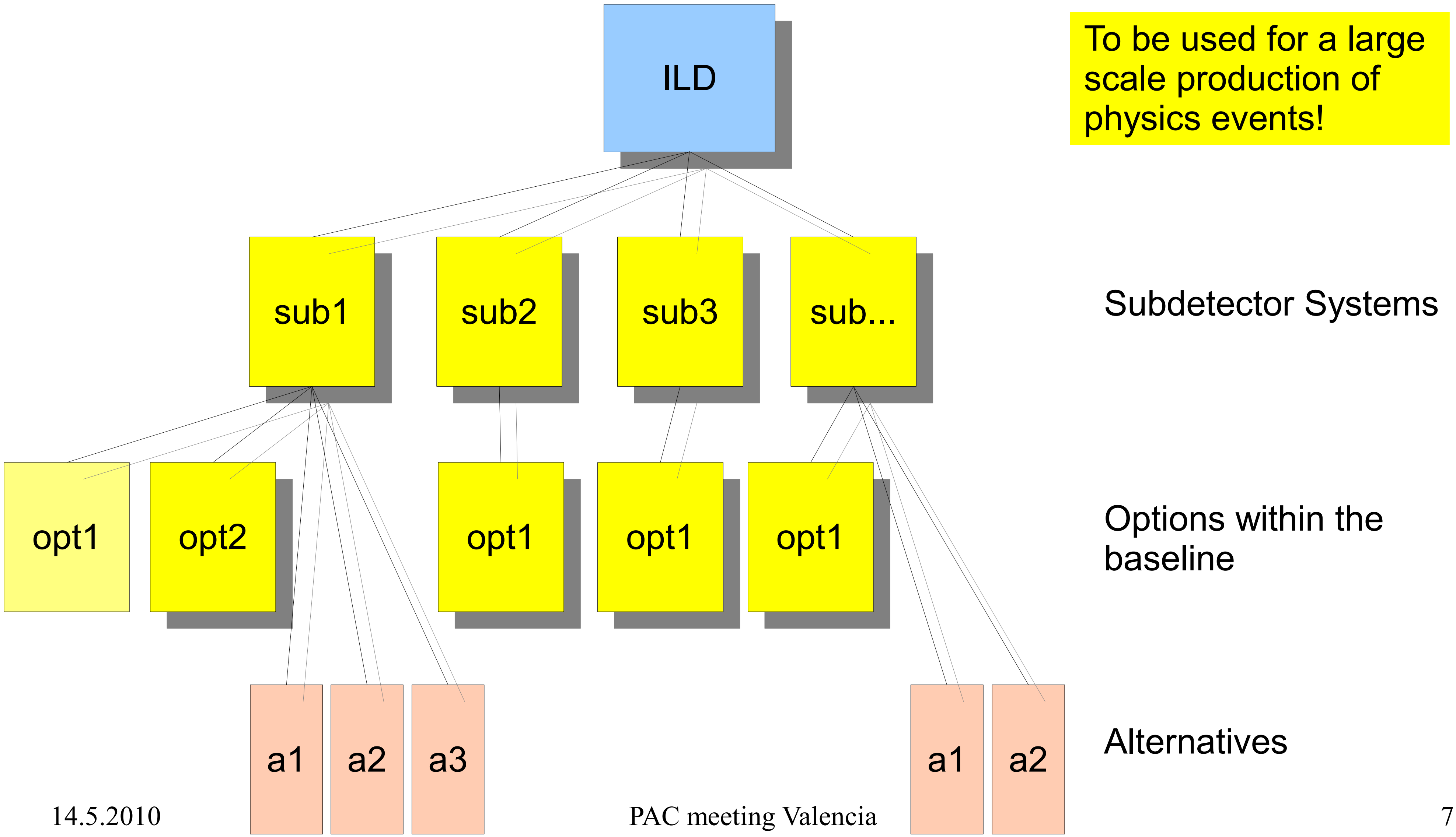



Subdetector Systems

Options within the baseline

Alternatives

# ILD: simulation baseline




To be used for a large scale production of physics events!

# ILD base lines

- Simulation base line SBL
  - a unique set of sub-detectors with reality
  - includes detailed detector model
  - will be defined in 2010/ early 2011

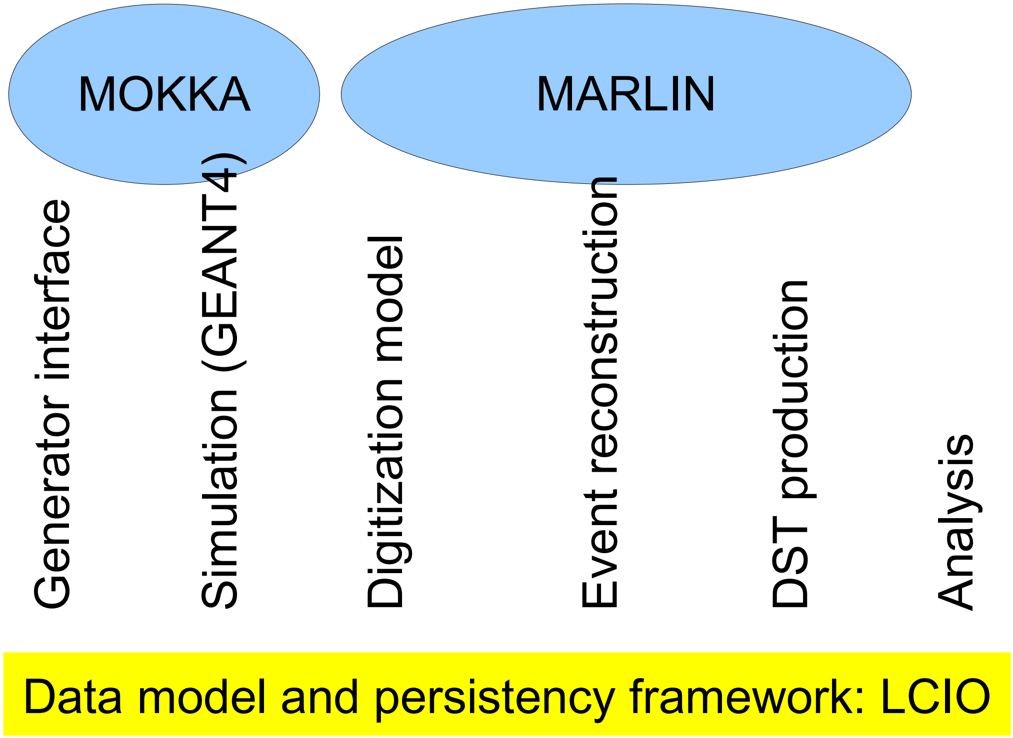
performance

- Detector base line DBL
  - realistic technical solutions for sub-detectors
  - discuss with R&D group
  - will have a readiness review in early 2012

technology

# ILD: simulation

Fairly complete and performant software system is in place



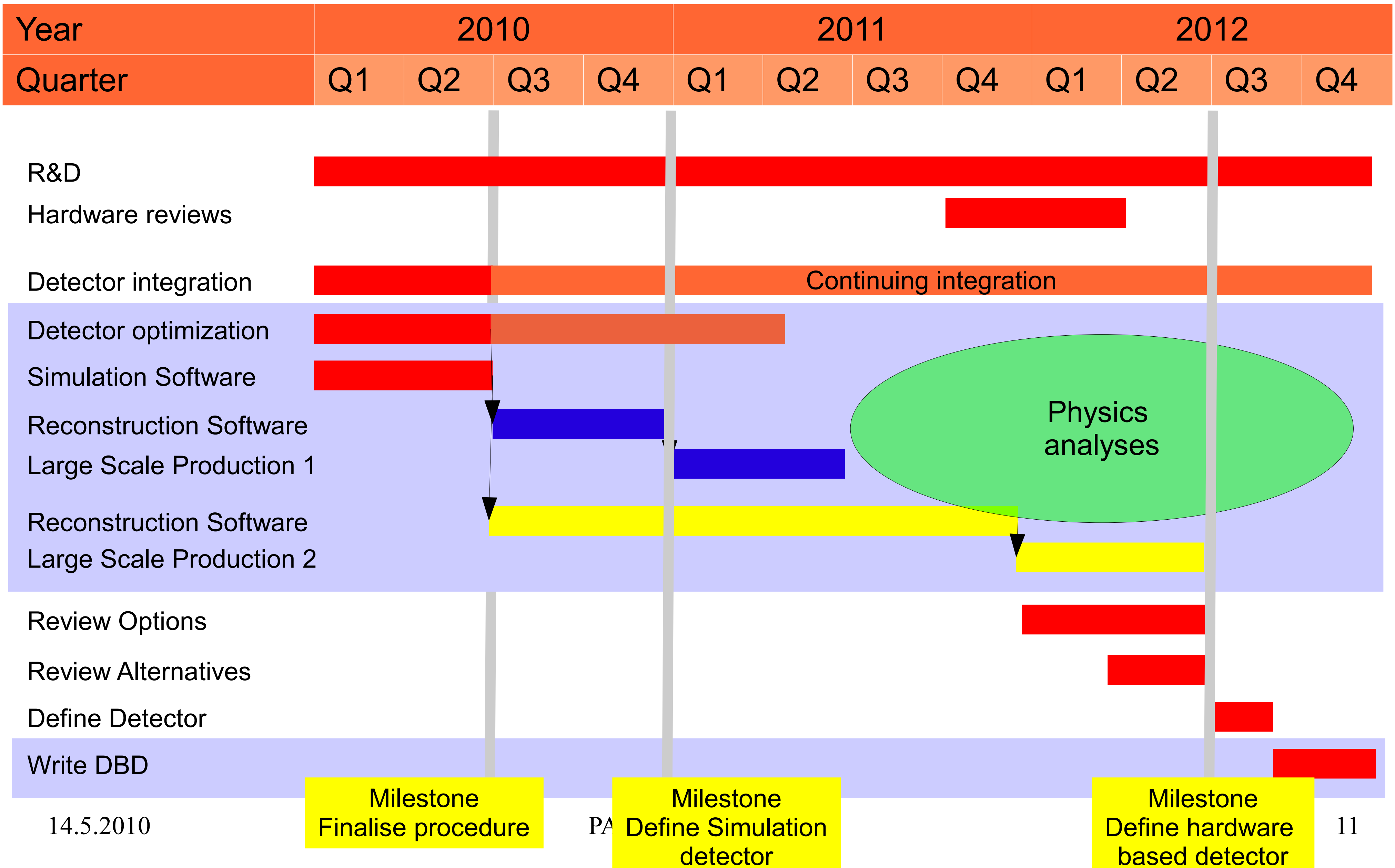

Have produced a few 100 Mio Events for Letter of Intent physics and optimization studies

# ILD Simulation baseline

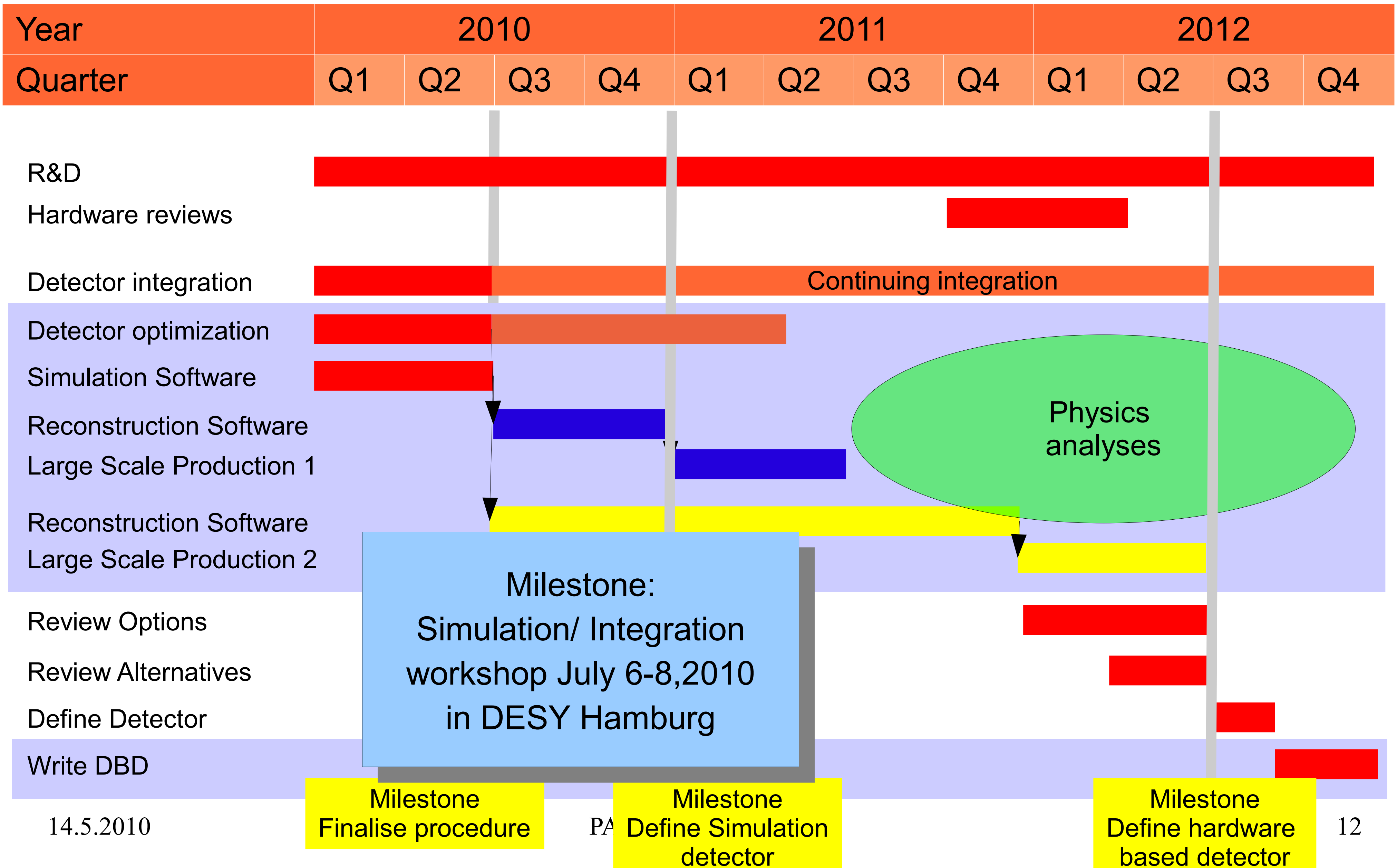
- Major work needed  to improve software
  - tracking code
  - ghost hits in tracker
  - background overlay ( forward)
  - details in sub-detector cables, services,  material, cracks,,,
  - calorimeter difference
- to evaluate physics  performance

Improve level of realism

# Main Milestones



# Main Milestones



# Subdetector Technologies

A global trend: larger and larger segmentation

LHC/ sLHC: deal with large occupations and backgrounds

ILC:

need extreme precision
deal with backgrounds (Vertex Detector)
do "tracking with a calorimeter"

Driven by technology:
price ~ area,
not # of channels

ILD examples of proposed granularity:

- Silicon Tungsten Calorimeter $9 \times 10^{7}$ cells (5x5 mm2)
- Vertex Detector $9 \times 10^{9}$ pixels (20x20 μm2)

Without the technology the physics will suffer

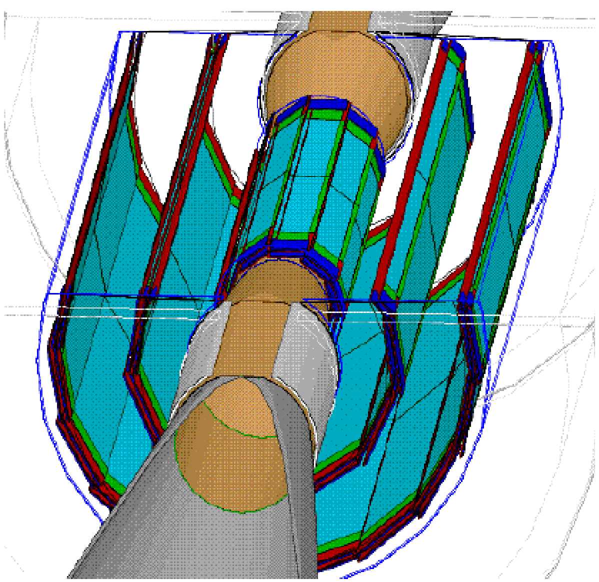
# Vertexing

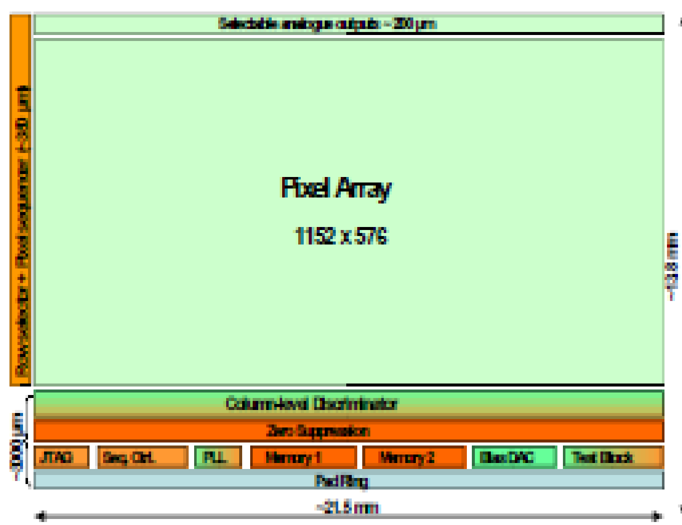
Pixel detector:

Many different technologies under discussion
Resolution – dead area – material – speed
CCD – MAPS – FPCCD – ISIS - others

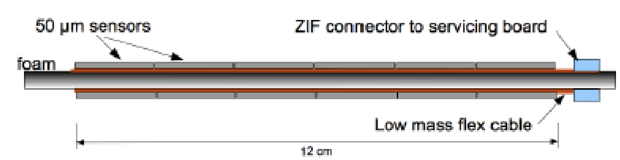
Low mass structure
readout speed

5/ 6 pixel layers, as small inner radius as possible, low material

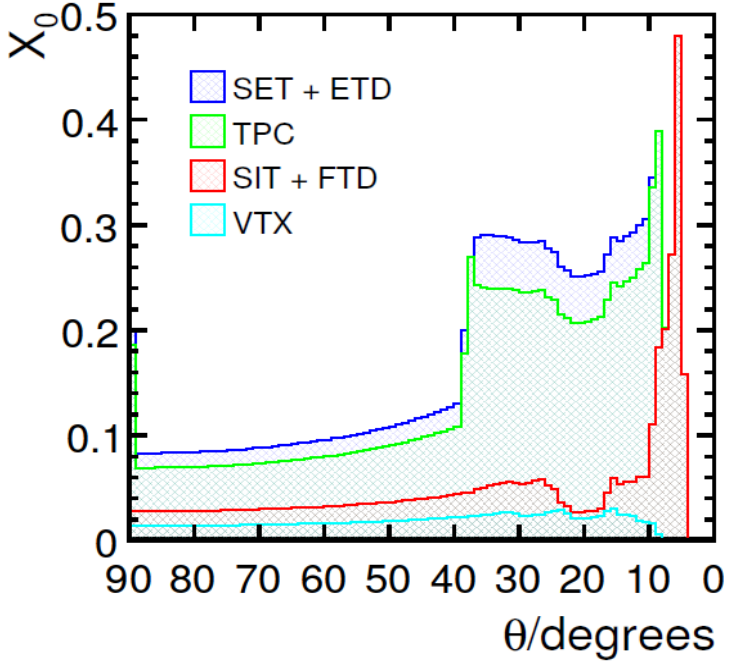





R&D:
Development of low mass ladder prototype (→ 2012)



# Material in the Tracker




Low material tracker is key goal of R&D in the next few years

Goal: very light tracking system:

total material before calorimeter < 10% X0 in the barrel
<30% (or less) in the endcap

including all services, all support structures, cables, etc.

Realistic (but optimistic) estimates make this believable...

# PLUME

## Pixelated Ladder with Ultra-low Material Embedding

*Geometry for an ILD vertex detector, 2009-2012*

Objectives :

- achieve a doublesided ladder prototype for an ILD vertex detector by 2012 (DBD)
- material budget : < 0.3% $X_0$ (final goal for 2012 prototype)
- quantify power pulsing and air-flow cooling effects on final sensor spatial resolution
- evaluate benefits of double-sided concept (mini-vectors)

Baseline :

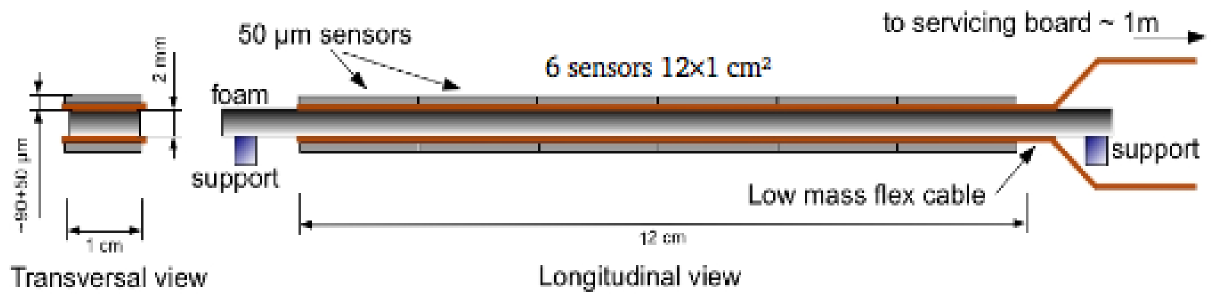
- MIMOSA-26 CMOS sensor (developed for EUDET-Telescope)
- Power pulsing (< 200ms period, ~1/50 duty cycle) and power dissipation (100mW/cm²)
- Air cooling

Current concept :

- 6 x MIMOSA-26 thinned down to 50µm
- Kapton-metal flex cable
- Silicon carbide foam (8% density) stiffener, 2mm thickness
- Wire bonding for flex - outer world connection
- Digital readout

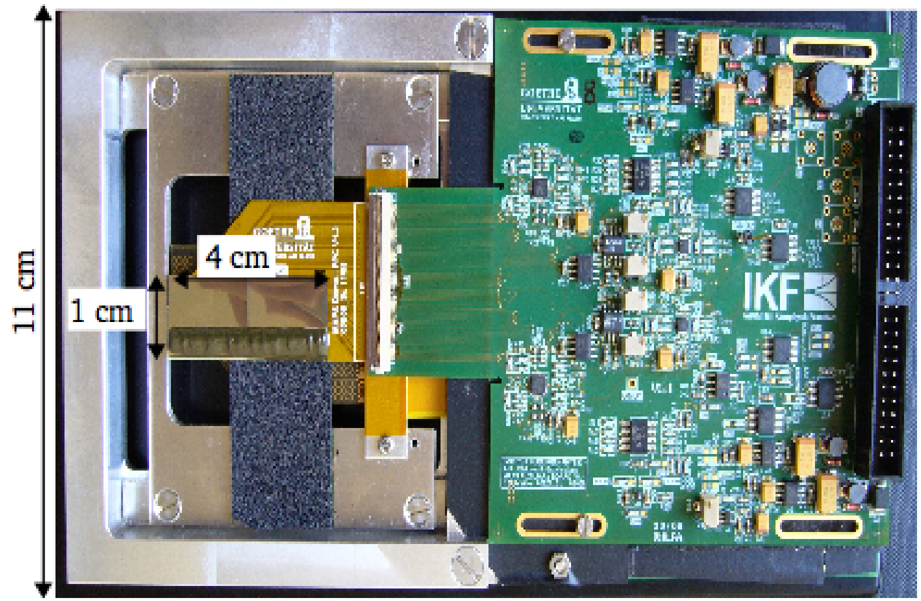
**PLUME collaboration:**

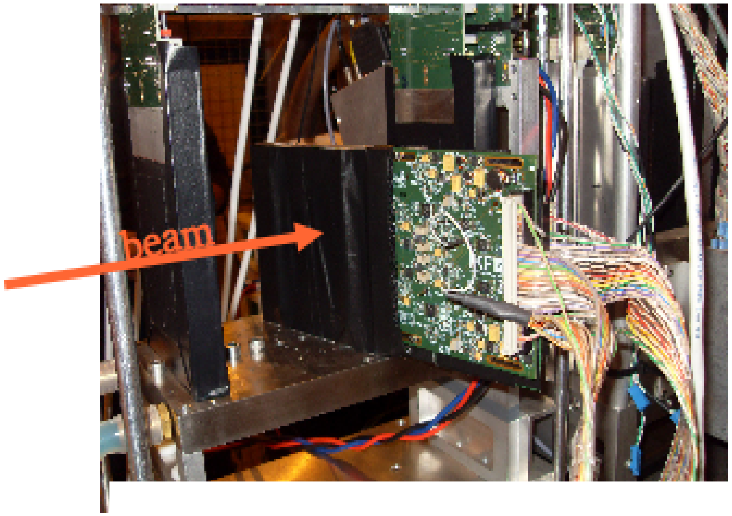
- Bristol University
- Oxford University
- DESY (Hamburg)
- IPHC (Strasbourg)



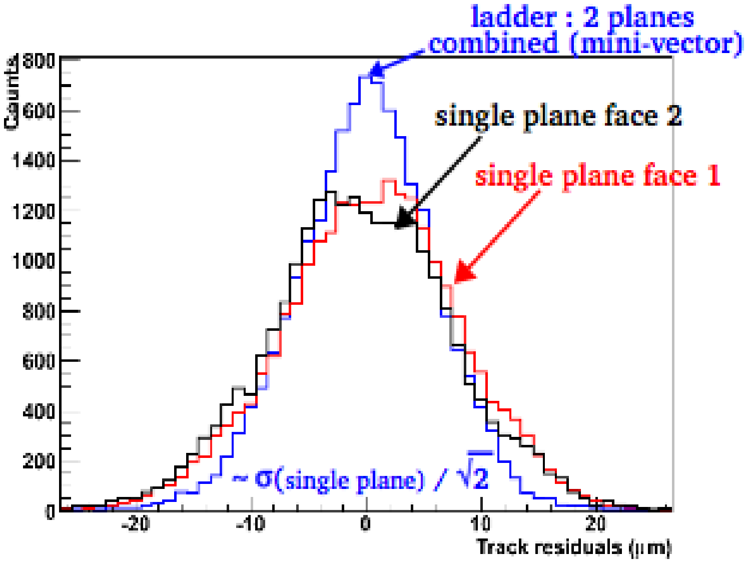
# PLUME status

*Goal : develop technology for ultra-thin VTX detectors*



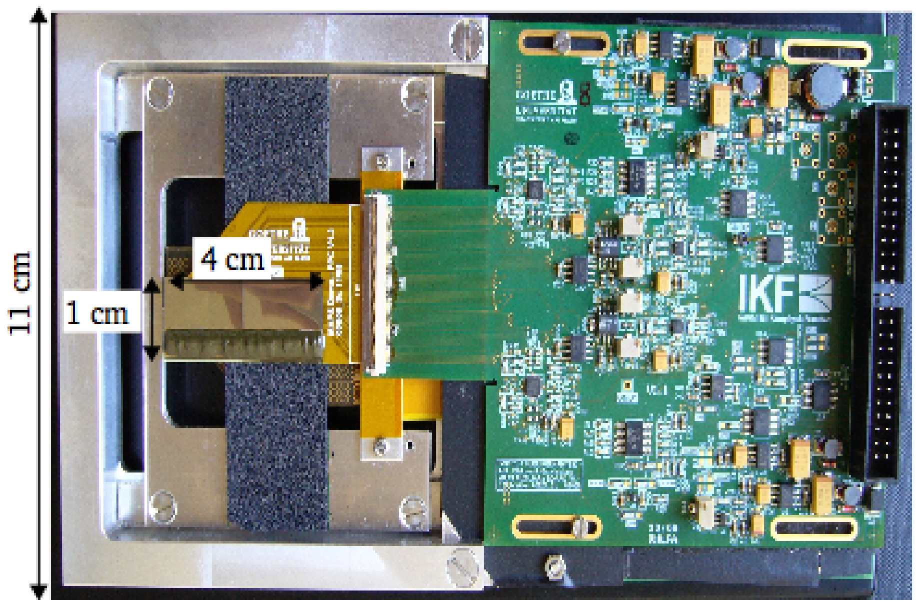

- 2 x MIMOSA-20 analog sensors, thinned down to 50 um with 1 x 4 $cm^2$ sensitive area
- material budget ~ 0.6 % X0 (SiC foam 0.18%, sensors 0.11%, glue 0.2%, flex 0.29 %)
- tested @ SPS-CERN
- preliminary mini-vector study
- Study binary chip (Mimosa26 design)
- Power pulsing studies

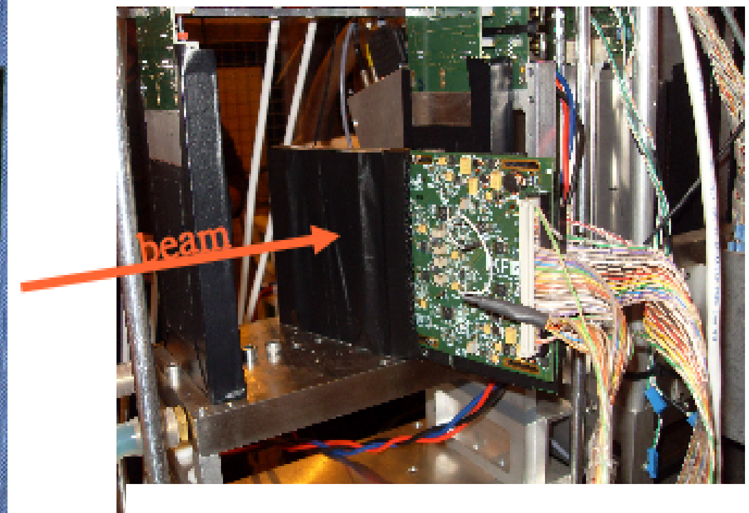



from November 2009 beam test data

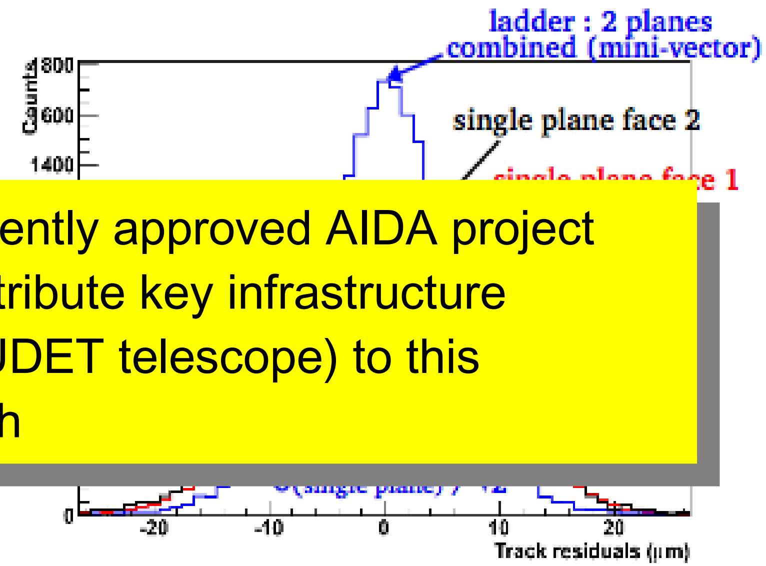
# PLUME status

*Goal : develop technology for ultra-thin VTX detectors*




- 2 x MIMOSA-20 analog sensors, thinned down to 50 um with 1 x 4 cm² sensitive area
- material budget ~ 0.6 % X0 (SiC foam 0.18%, sensors 0.11%, glue 0.2%, flex 0.29 %)
- tested @ SPS-CERN
- preliminary mini-vector study
- Study binary chip (Mimosa26 design)
- Power pulsing studies




from November 2009 beam test data

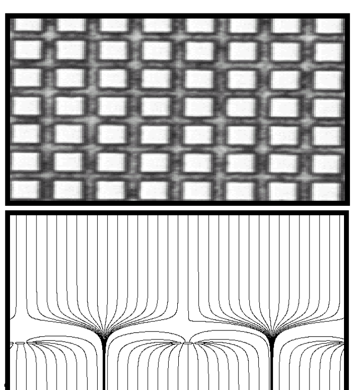
The recently approved AIDA project will contribute key infrastructure (a la EUDET telescope) to this research

# TPC

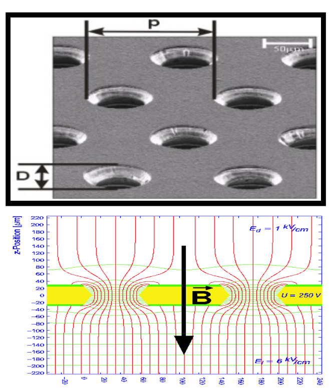
Design (goal) of ILD TPC

- Micro patter gas detector (MPGD) as the TPC endcap detector
- 0.4m<R<1.8m, |Z|=2.15m
- $\sigma_{point}(r\Phi)<100\mu m$
- $\sigma_{point}(z)\sim 0.5mm$
- Two-hit resolution ~ 2mm(rΦ), 6mm(z)
- Material budget ~4%$X_0$ (r), 15%$X_0$ (endplate)
- Momentum resolution:
  - $\delta(1/p_t)\sim$9E-5/GeV/c (TPC only)
  - $\delta(1/p_t)\sim$2E-5/GeV/c (all trackers)

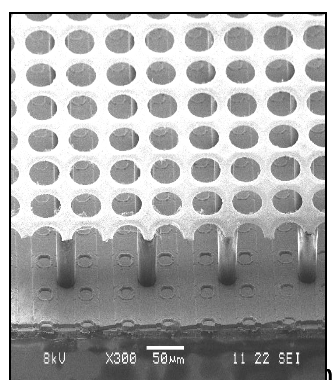
**MicroMEGAS**

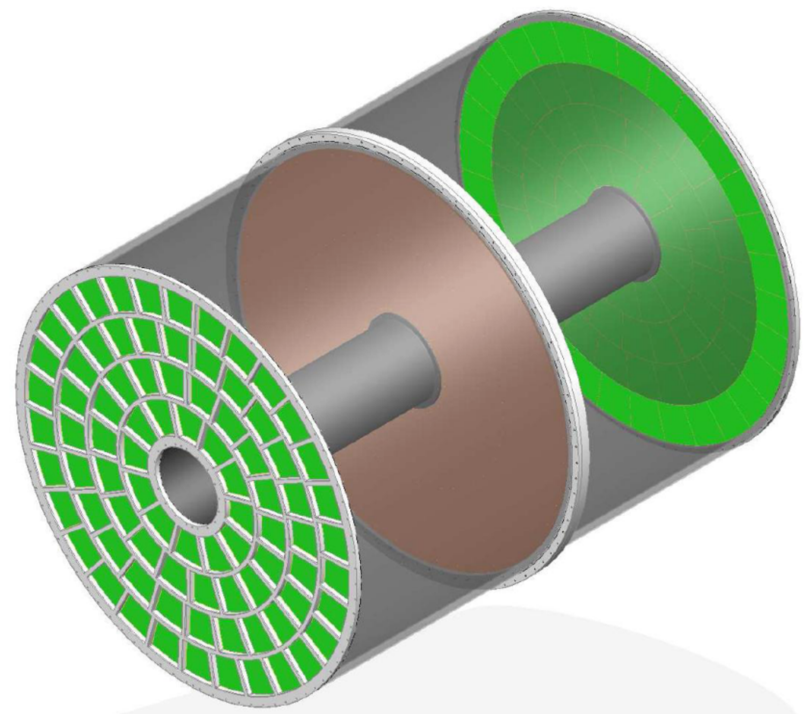


**GEM**




**Ingrid TimePix**



T2K tracker
Neutrinoless double beta decay

# Large area Silicon trackers

Large area Silicon based tracking

- inside the TPC (SIT)

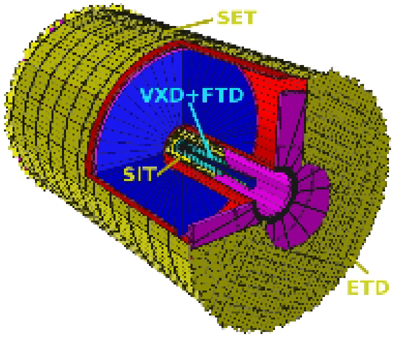
- outside the TPC (external Si tracker)

- forward Silicon disks

**B=3.5 T**

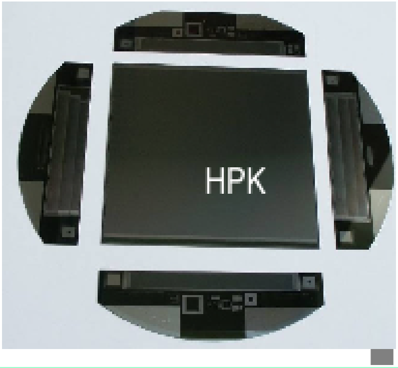
Total area: 180 $m^2$
Total Channels Nb: $10^7$
Based on a unique Si sensor size
(except very forward disks FTD)

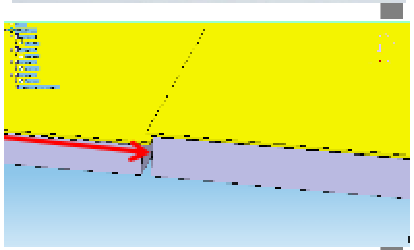
# Silicon tracker status

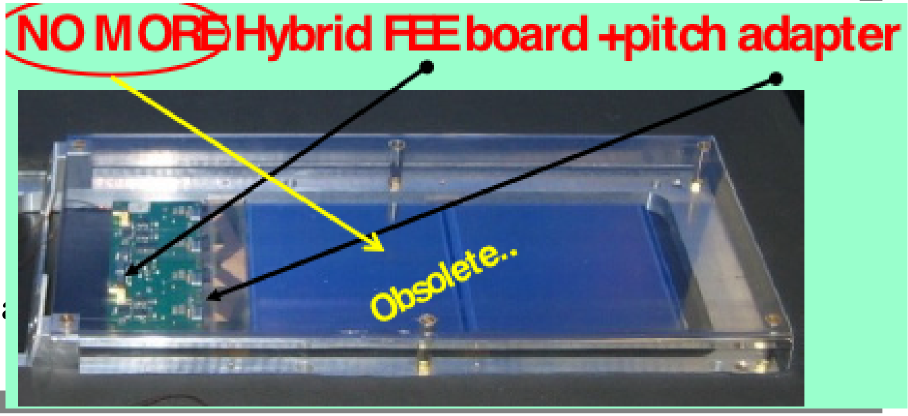



ONE size, 180m$^2$
200 nm 10$^7$ ch

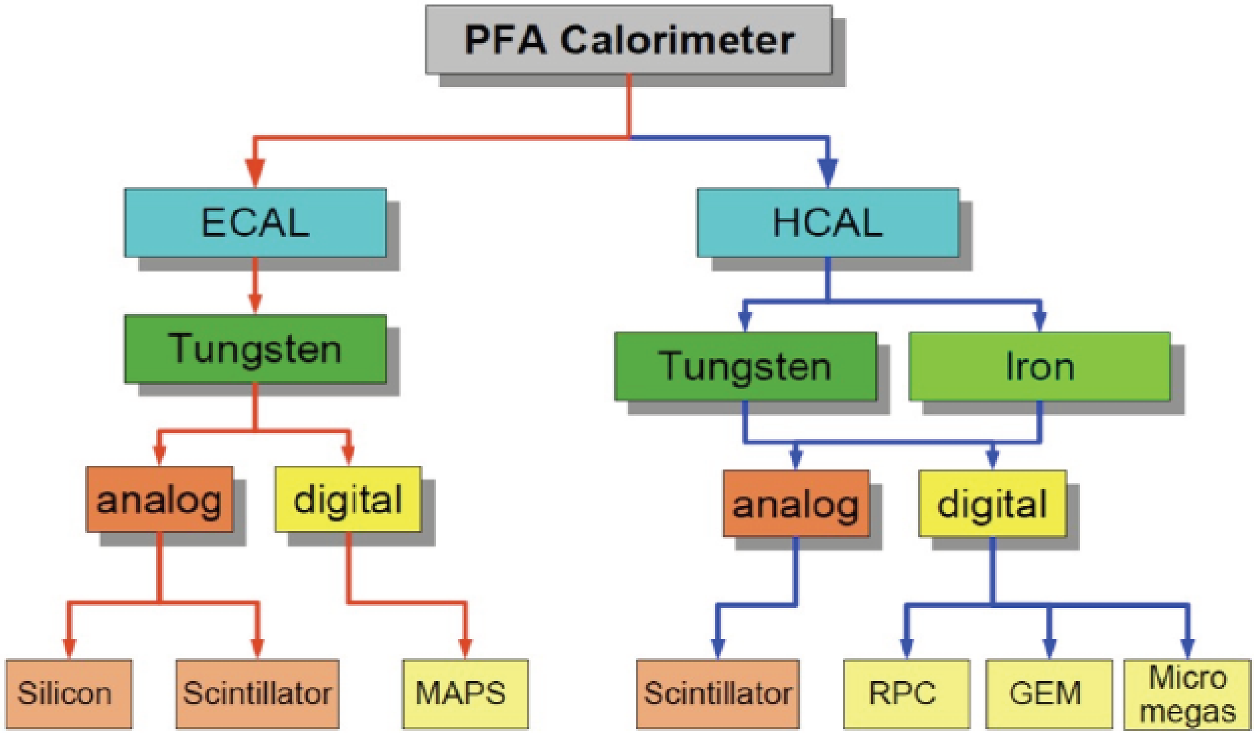
- disk(very forward) & barrel/endcap
- silicon strip sensor : 6' to 8'
- alignment
  - improve laser trans. 20 to 70%
  - new method ready
- edgeless sensor dev.
- FE and RO electronics
- direct connection
- DAQ
- Beam Test processing , synchronization,





# Calorimeter



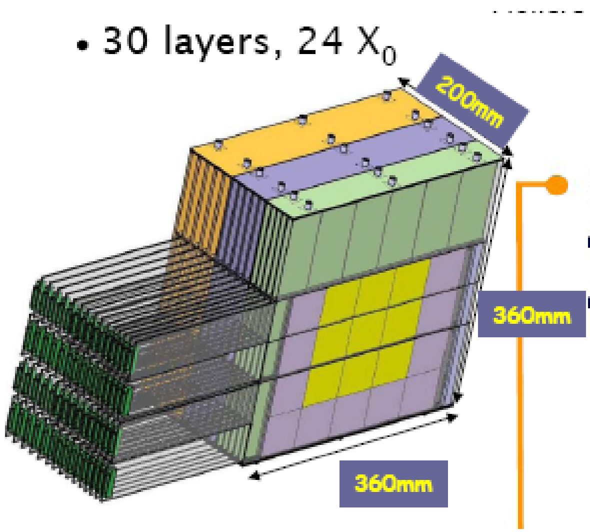

ILD: Calorimetry is done by the CALICE collaboration:

A number of different options are pursued.

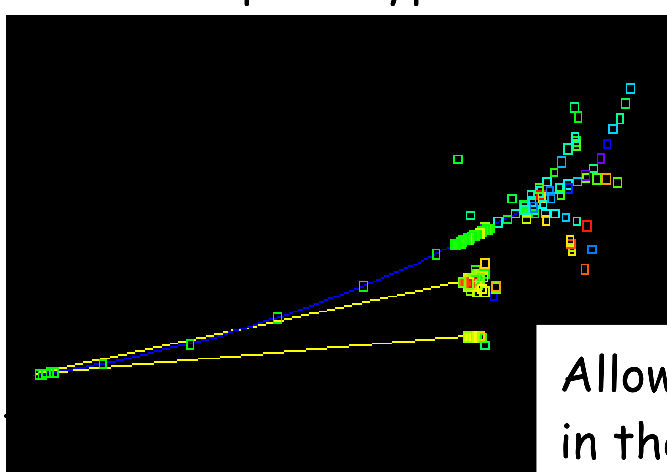
Most CALICE options are also in ILD.

# PFLOW ECAL

Sampling calorimeter, Tungsten – Silicon diode readout
Typical granularity for ECAL: 0.5cmx0.5cm to 1cmx1cm,

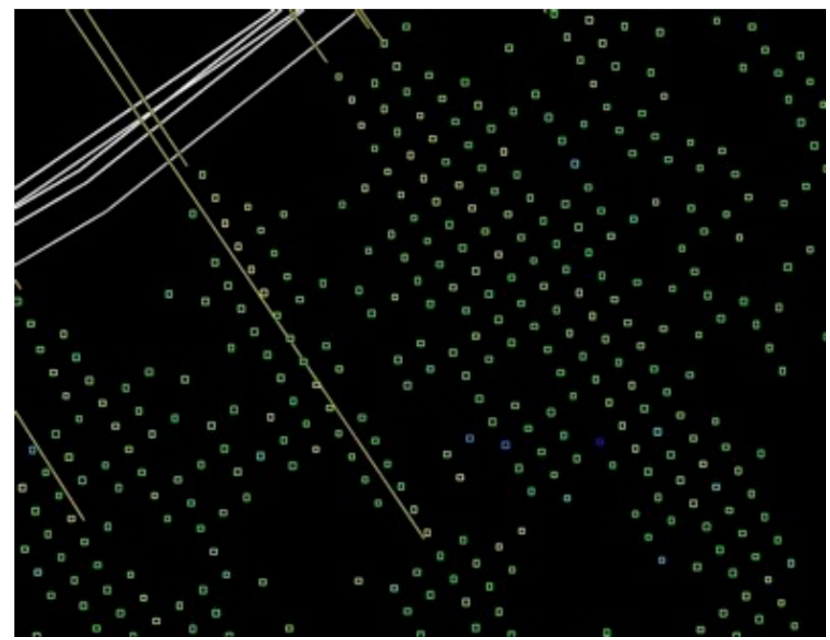



CALICE prototype



Allows "tracking" in the calorimeter

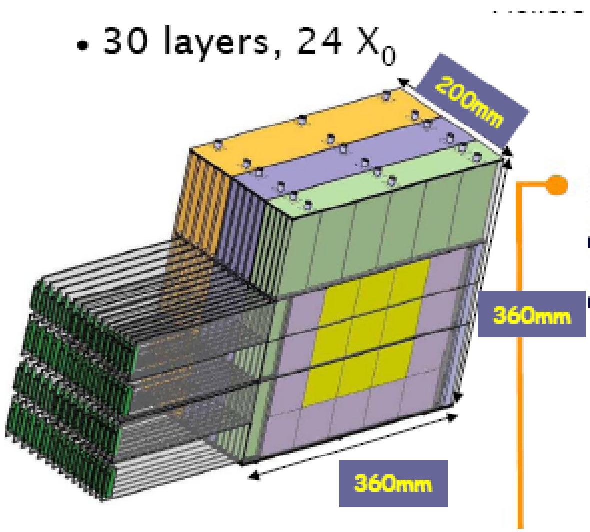
Normal analogue ECAL segmentation:



Very detailed shower images

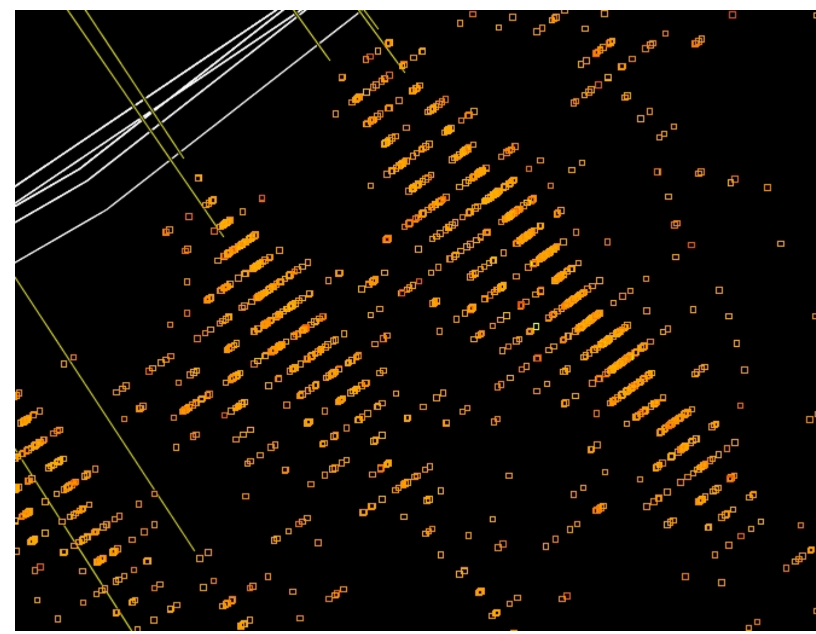
# PFLOW ECAL

Typical granularity for ECAL: 0.5cmx0.5cm to 1cmx1cm,
SI detectors, Tungsten absorbers

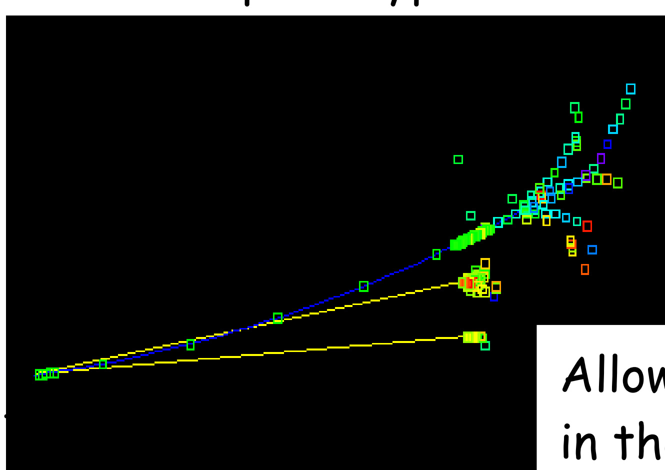



CALICE prototype

Extreme segmentation:
MAPS sensors in the ECAL



Even more detailed shower images



Allows "tracking"
in the calorimeter

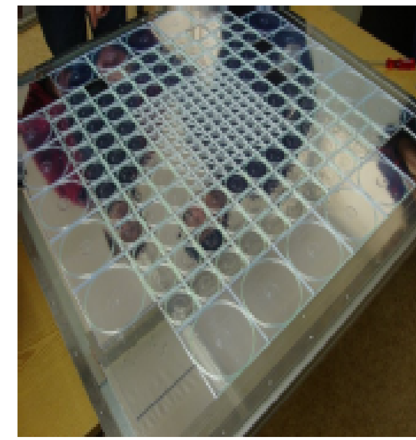
# PFLOW HCAL

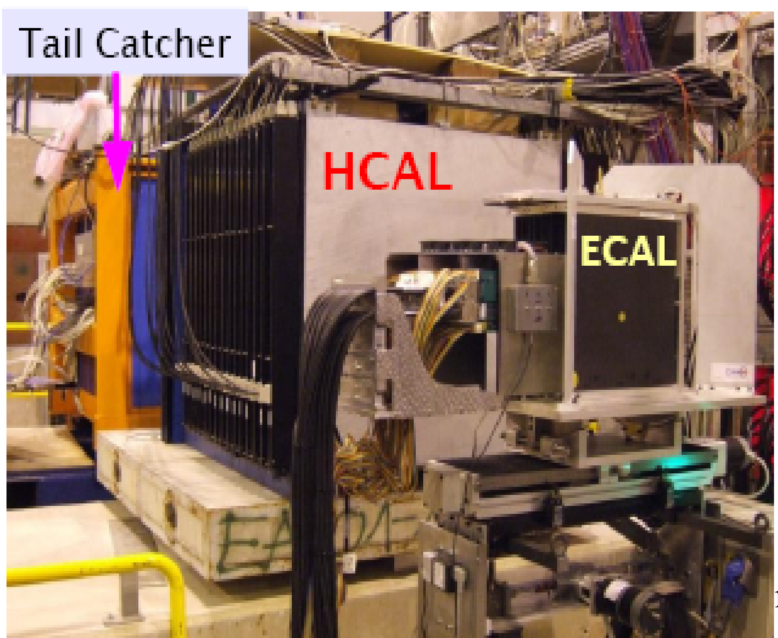
HCAL plays crucial role in a particle flow calorimeter

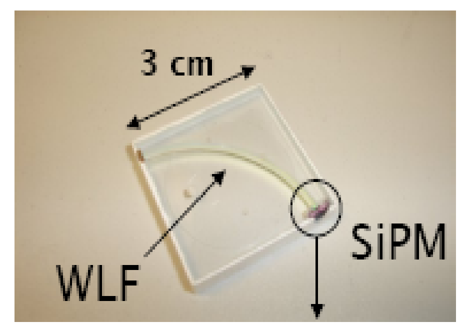
Simulation of hadronic shower is problematic

Typical cell sizes 3x3 $cm^2$ with analogue readout

Digital option investigated (smaller cells, 1bit readout)

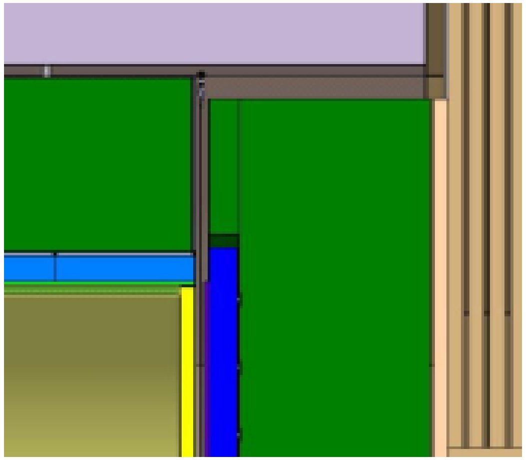





Major effort (CALICE) to protoype such a calorimeter for the ILC

# An Interface example:



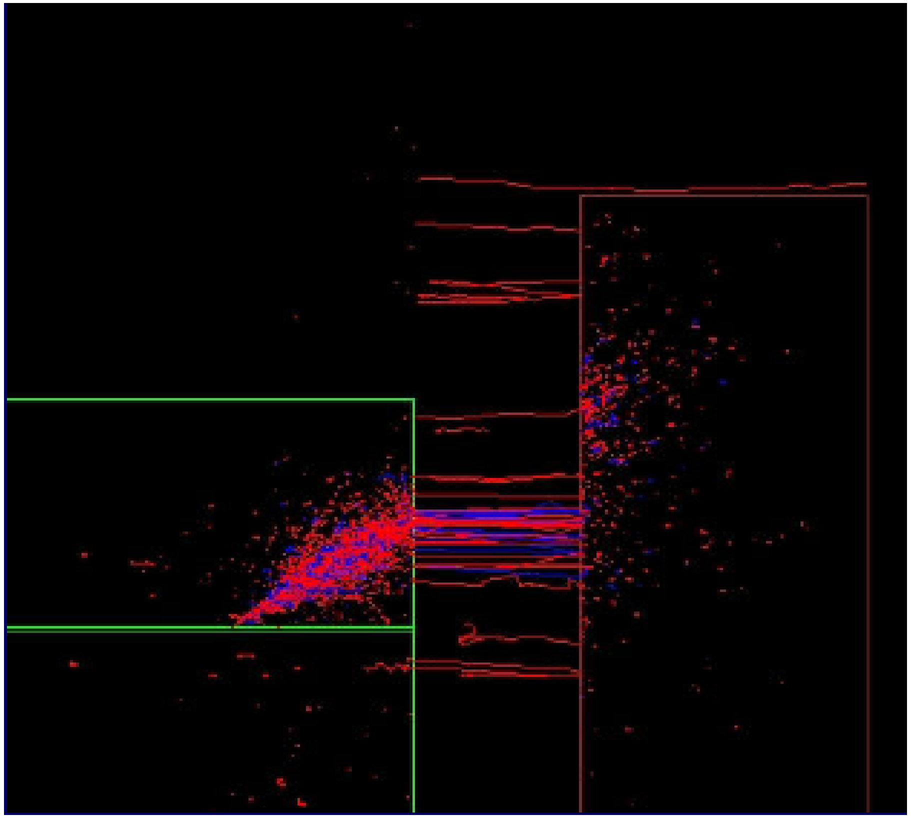
Transition region barrel endcap:

- Distance barrel – endcap?
- How much material?
- Services from other detector?
  - TPC cables and services
  - TPC support
  - ETD services
  - Forward tracking?
  - Others?

Many interfaces between detectors are ill defined:

- Geometrically
- Functionally

# An Interface example:



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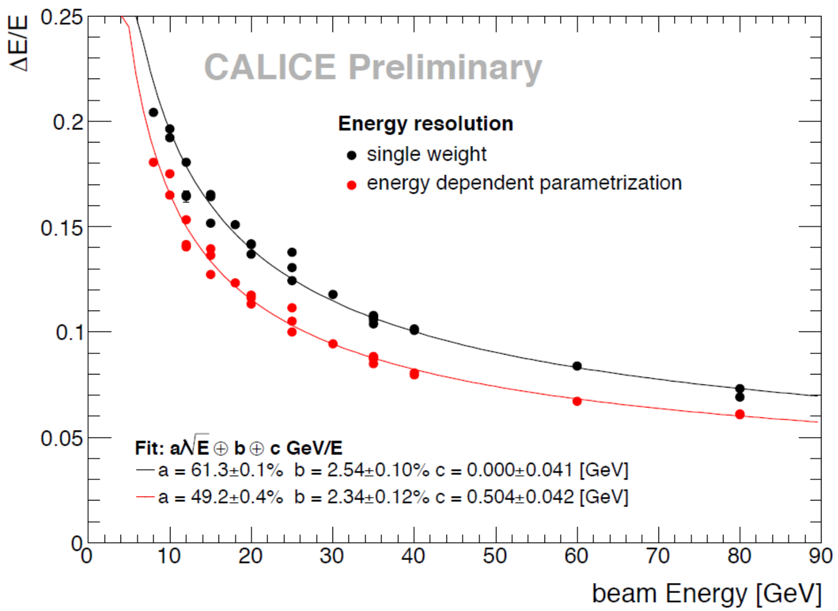
  - Forward tracking?
  - Others?

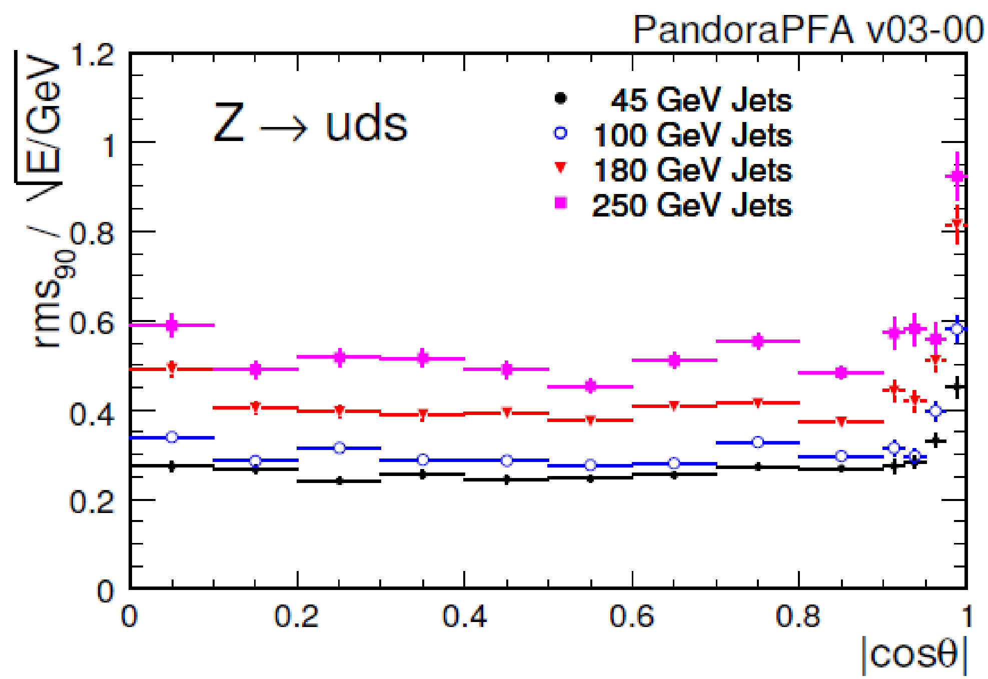
Many interfaces between detectors are ill defined:

- Geometrically
- Functionally

Have setup a small WH
to address these issues
and bring together
integration – physics - technology

# Performance



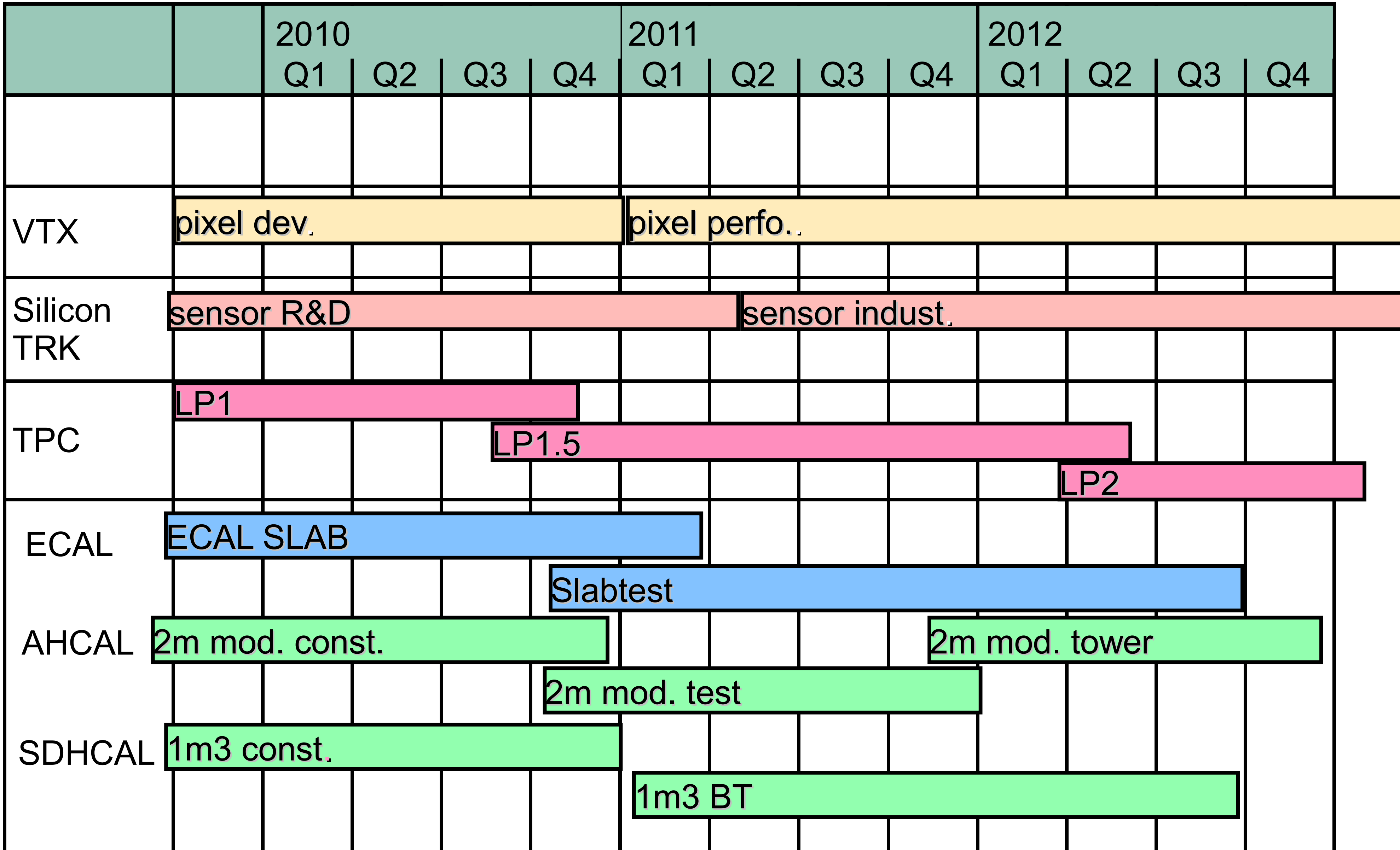




Measured energy resolution
without (black)
with (red) reweighting

Simulated jet-energy resolution for
different energies:
Goal of 30%/√E reached for E(jet)<100 GeV

Proposed detector seems to deliver promised performance

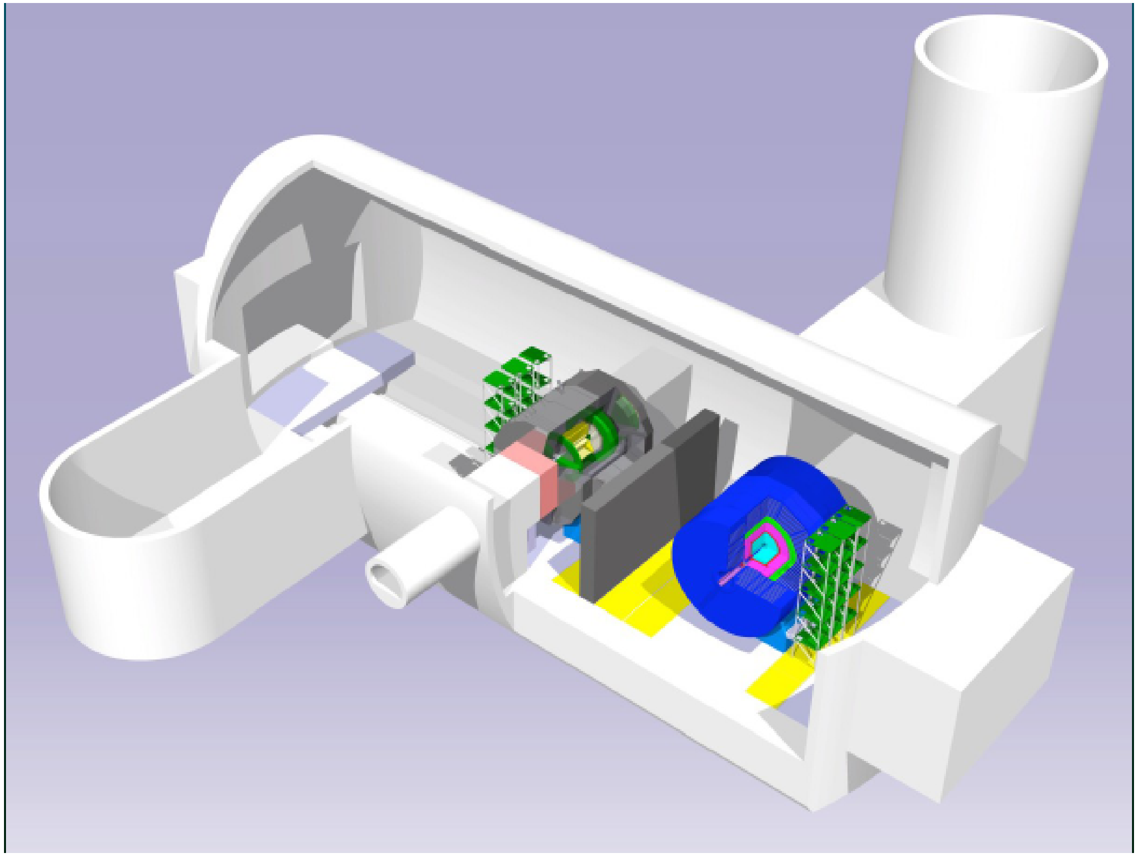
# Sub-detector schedule






Note: not all activites are already funded, schedule is funding driven

# Push-Pull

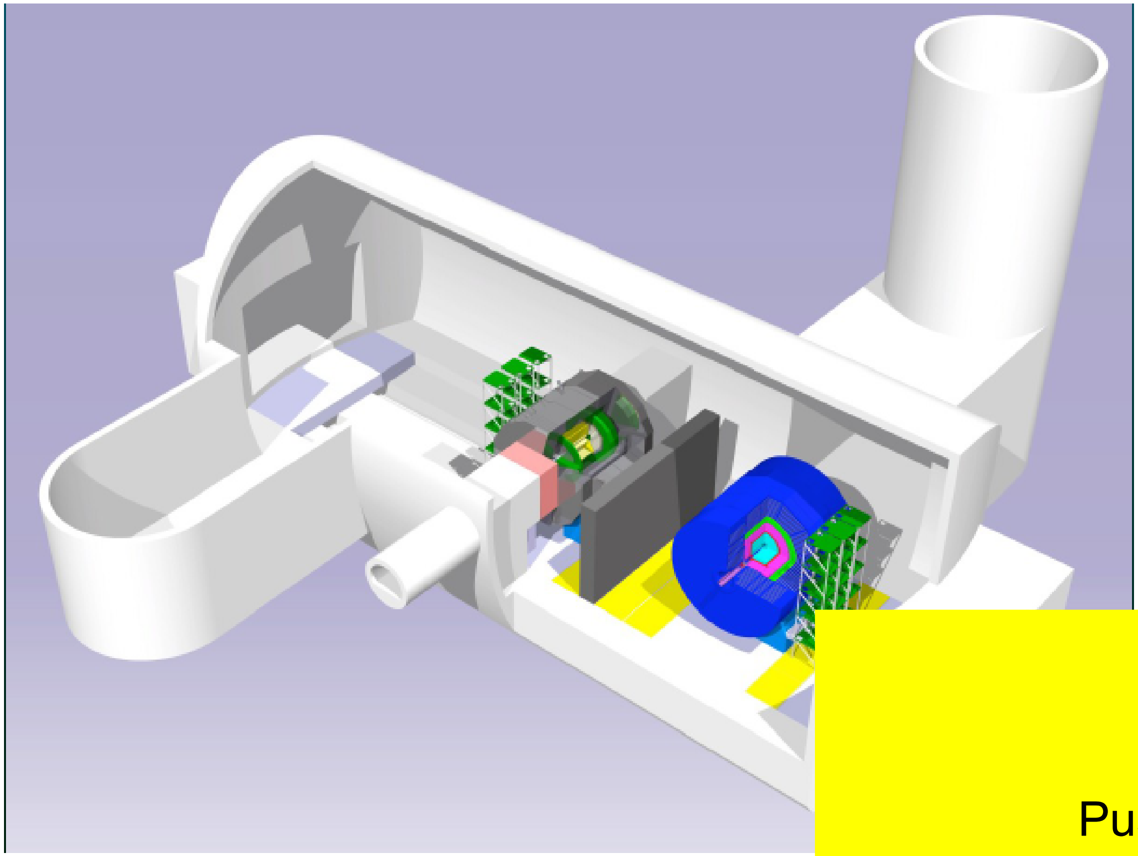


The ILD detector

As proposed inside the hall in push-pull configuration

- Understand implications of push pull on detector design
- Agree with SiD on a common push-pull design
- Coordinate detector activities with the GDE activites
- Add some real engineering

# Push-Pull



The ILD detector

As proposed inside the hall in push-pull configuration

- Understand implica
- Agree with SiD on
- Coordinate detecto
- Add some real engineering

Push pull might have
a major impact on
the detector design!

# Conclusion

ILD has proposed a plan how to advance the detector design towards the DBD

DBD will include

- detector options (have passed readiness review)
- detector alternatives (hold promise, have not advanced enough)

ILD community is still active

R&D on components is done intensely (R&D collaborations)

Funding issues become increasingly important

Increasingly we see synergies between ILC developments and other experiments.