

Linear Collider Detector Efforts in Germany

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HEP Detector Development in Germany

General situation

Long tradition of significant detector contributions to collider-based HEP experiments

Very strong involvement in HL-LHC detector upgrades (ATLAS, CMS, LHC-b)

→ highest priority in German HEP

Strong involvement in Belle-II (DEPFET vertex detector)

LC-related R&D active since „TESLA“ days – centered around DESY with significant university involvement (supported by EUDET, AIDA, Helmholtz-Alliance)

very limited funding for universities funding for LC detectors currently

Statement on a Linear Collider Project in Japan by KET (German Committee for Particle Physics)

1. The successful running of the LHC and its experiments continues to be the recommendation with highest priority. This includes in particular the high luminosity upgrades of the LHC and the Phase-2 upgrades of the experiments, which currently constitute the only way to directly explore the multi-TeV energy regime.
2. The proposal of the Japanese community to host the ILC as an international project finds enthusiastic support in the German community. In view of the unique capabilities of such a facility for precision measurements of the newly discovered particle, the foreseen expandability to higher energies and the technical readiness of the project as documented in the Global Design Effort ⁴⁾ we strongly recommend to contribute actively to the realisation of this project.

justified hope that this statement + European Strategy for Particle Physics will allow for somewhat increased and more targeted R&D funding in next university funding period (2015-2018)

LC Detector R&D in Germany ...

Calorimetry

DESY
Hamburg University
Heidelberg University
Mainz University
MPI Munich
Wuppertal University

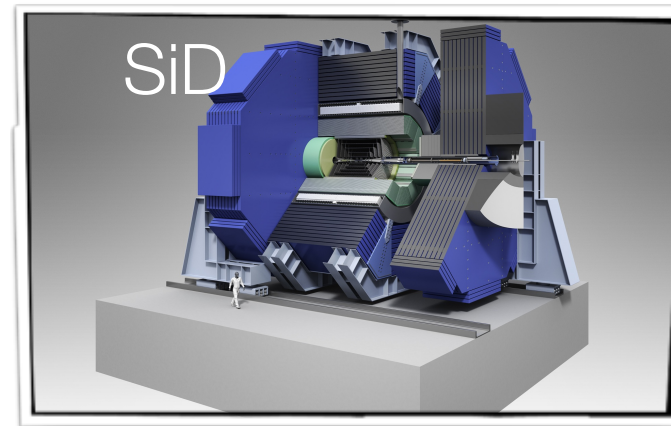
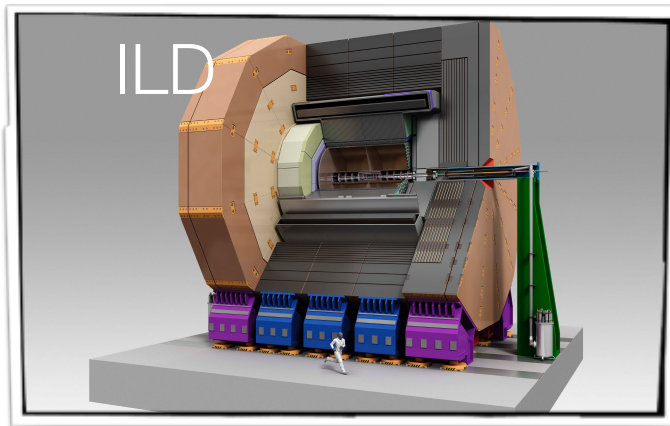
Tracking

DESY
Bonn University
Siegen University

Vertexing

various
rather busy elsewhere
(ATLAS,CMS,Belle-II,mu3e,...)

International Involvement ...



ILC Detector Concept

[Particle Flow Detector]
[e.g. ILD]

TPC

Momentum resolution:
 $\delta(1/p_t) \sim 9 \times 10^{-5} \text{ GeV}^{-1}$
Spatial resolution:
 $\sigma_{r\phi} < 100 \mu\text{m}$, $\sigma_z < 0.5 \text{ mm}$
 dE/dx resolution: $\sim 5 \%$
Efficiency: $> 97 \%$
[for $p_t > 1 \text{ GeV}/c$]

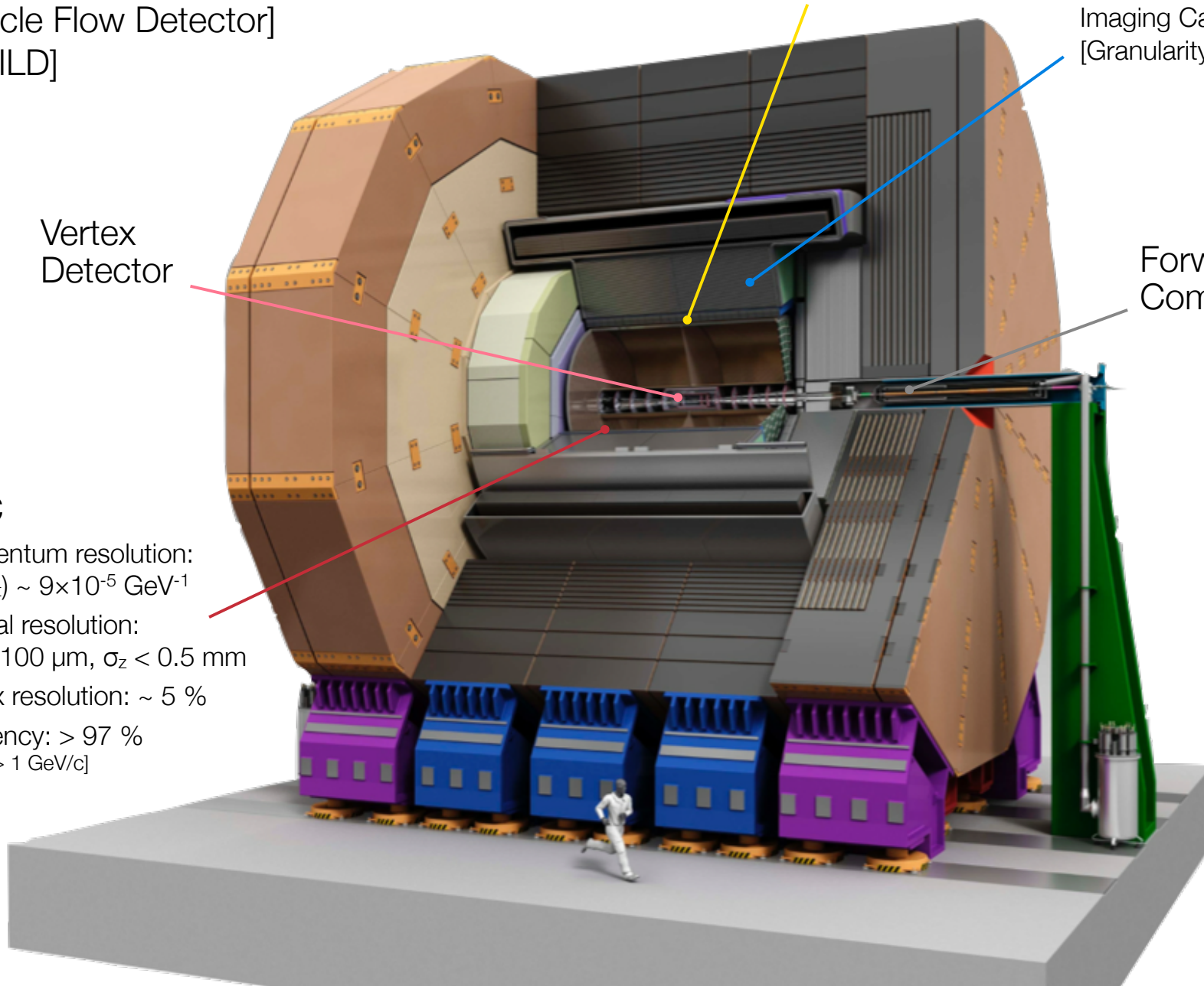
Vertex
Detector

ECAL

HCAL

Energy resolution:
 $\sigma/E \sim 50\%/\sqrt{E \text{ GeV}^{1/2}}$
Imaging Capability
[Granularity: $1\text{-}3 \text{ cm}^2$]

Forward
Components



Calorimetry

Significant German effort on calorimeter R&D ...

[as much as limited funding allows ...]

DESY HH

DESY Zeuthen

Univ. Hamburg

Univ. Heidelberg

Univ. Mainz

MPI Munich

Univ. Wuppertal

LS integration; electronics ...

Forward calorimeter development

SiPM & tile optimization ...

ASICs; SiPM simulation; tile tester

Data acquisition; HBU production

SiPM & tile optimization ...

LED calibration system

+ Analysis, Simulation, Reconstruction

Main emphasis: Analogue Hadron Calorimeter

also: exploitation of synergies for scintillator ECAL research ...

research on forward calorimetry ...

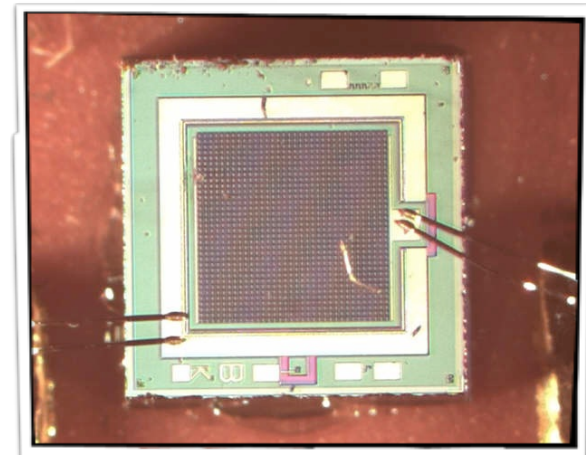
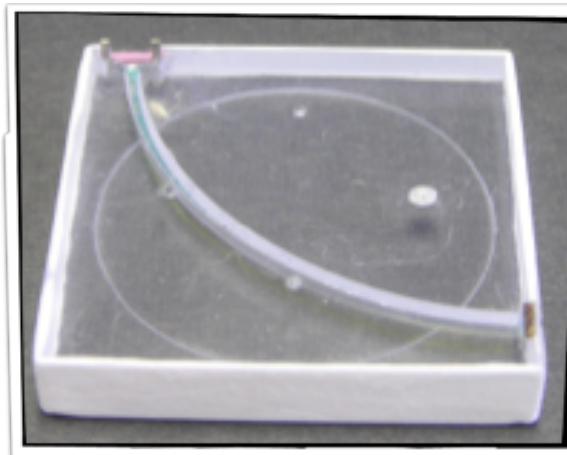
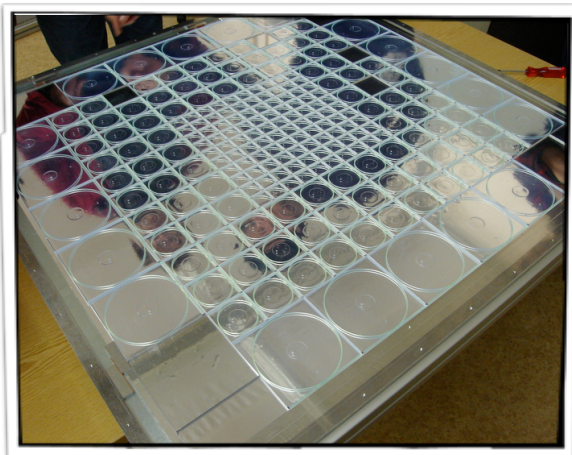
The Analog HCAL

Analog HCAL: 1 m³ Prototype
Steel/Tungsten-Scintillator sampling structure

Approx. 8000 channels
Light detection with SiPMs

Calibration/Monitoring
using MIPs and integrated LED system ...

Test beam operation since 2006



Prototype Performance

Many results from physics prototypes based on a wealth of high-granular shower data ...

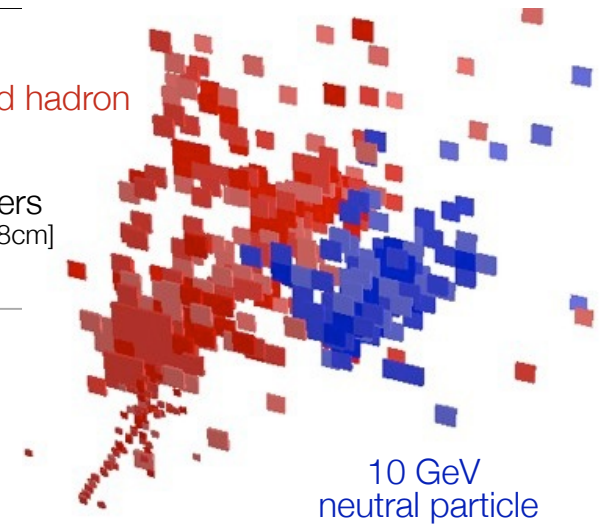
Investigations of test beam data yield ...

- Operation experience
- Response validation
- Calibration performance
- Energy resolution
- Imaging performance
- PFA validation
- MC Validation
- ...

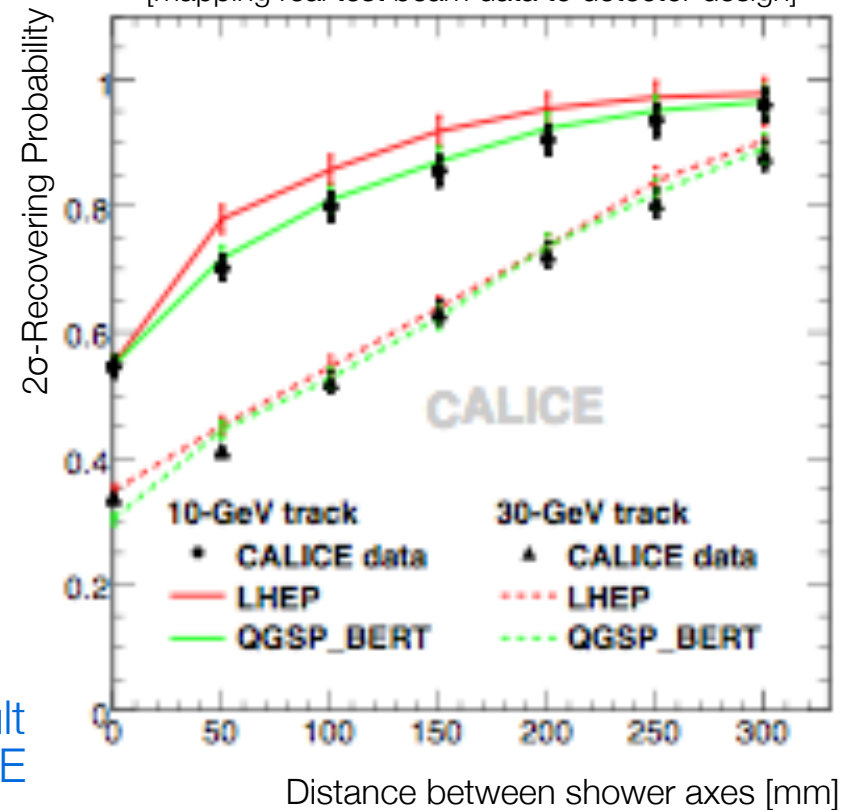
Example result from CALICE

30 GeV charged hadron

Two showers
[Separation: 18cm]



ILD performance study
[mapping real test beam data to detector design]



[JINST 6, P07005 (2011)]

Ongoing R&D work: example Heidelberg

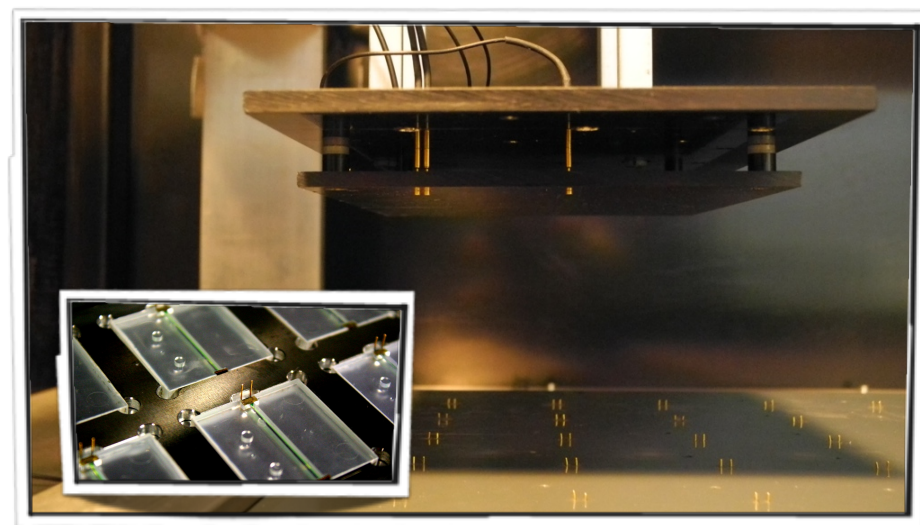
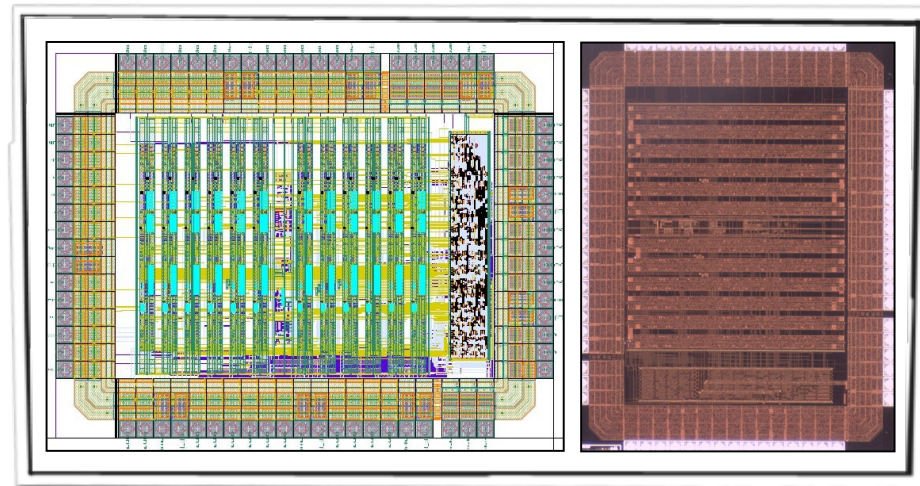
Front-end ASIC design
[optimized for low gain SiPMs]

Tile/SiPM characterization
Large scale tile testing

SiPM Simulation
[Program: Gossip]

...

KLauS ASIC [Version 2.0]



Large Tile Tester Prototype
[with Klaus readout]

Next Step: Scalable HCAL Prototype

Status:

Concept for mechanics and electronics integration exists ...
Detailed detector R&D ongoing ...

To Do:

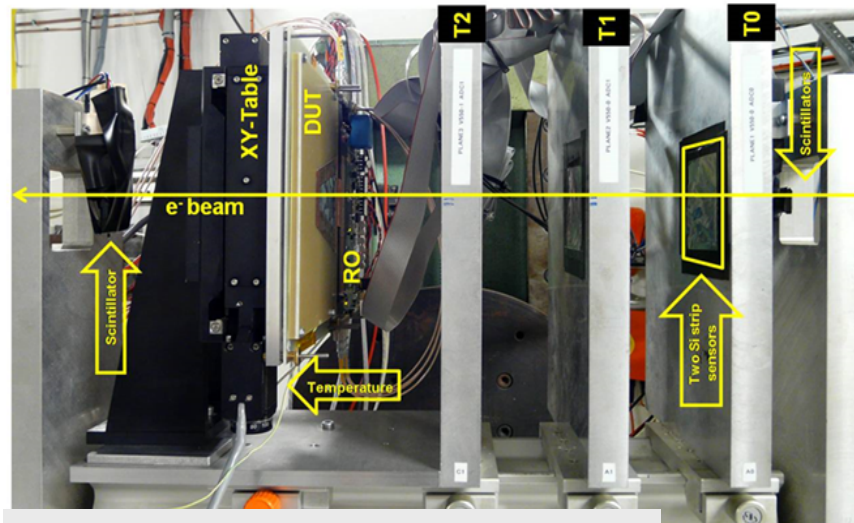
Detailed module integration planing ...
Mass production and quality control ...
[yields feedback to design considerations ...]
System level performance studies ...
[includes studies on timing in Fe and W]

Goal: Competitive proposal ...

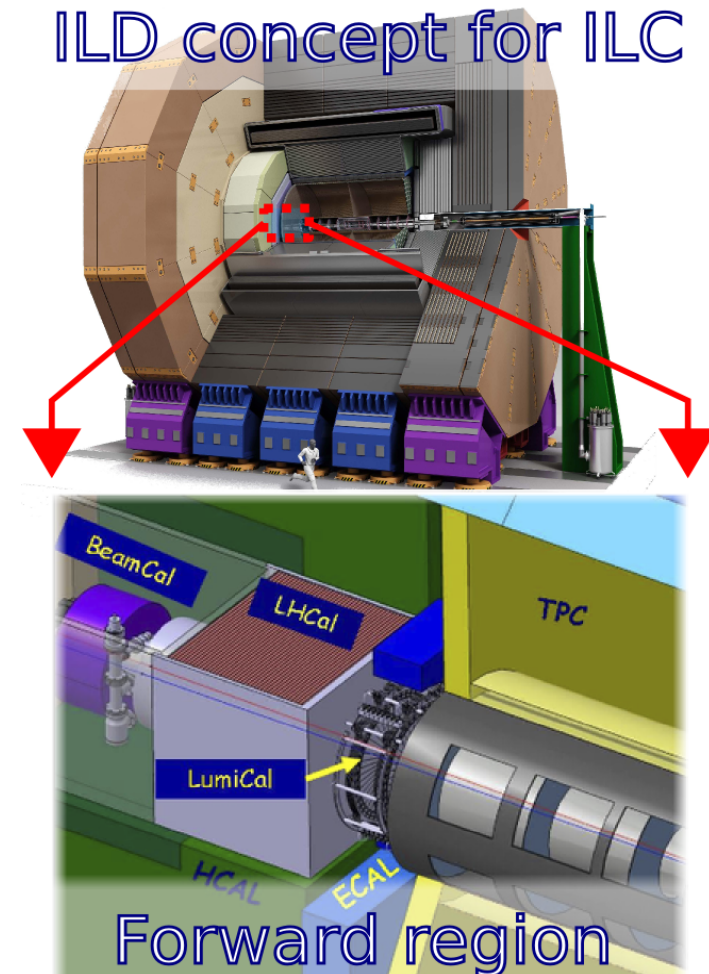
Forward Calorimetry: FCAL collaboration

Goals: design very forward region of ILC detectors
fast luminosity measurement
develop prototype detectors

DESY is the “HUB” for FCAL
Major partner: CERN, INPPAS and UST Cracow,
TAU Tel Aviv, JINR Dubna, several universities
(Chile, Rumania, Serbia, USA, Japan)



Testbeam setup at DESY II electron beam



Tracking

Substantial involvement within Germany ...

[as much as limited funding allows ...]

DESY HH

Univ. Bonn

Univ. Siegen

LS infrastructure; GEM modules ...

Pixel modules (InGrid, Timepix) ...

Pixel readout tests (GEM, Timepix)...

+ Analysis, Simulation, Reconstruction

Former (hibernating?) contributors:

RWTH Aachen, MPI Munich, Univ. Freiburg,

Univ. Karlsruhe, Univ. Rostock

Main emphasis: Time Projection Chamber

in particular: exploitation of different TPC readout technologies ...

TPC Prototype & Test Infrastructure

TPC test system
developed for DESY test beam ...

Magnet
with TPC prototype

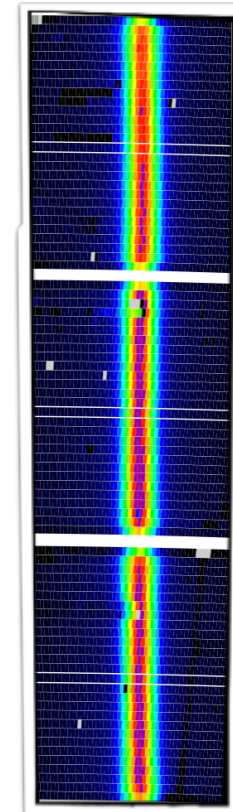
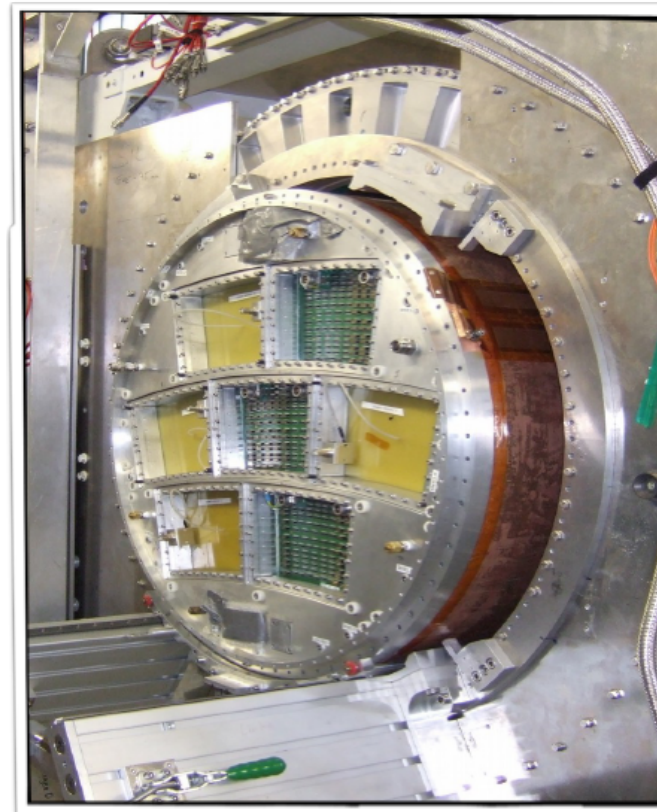
Track
inside TPC

Infrastructure at DESY

- 1T test magnet ...
- Moveable stage ...
- Control equipment ...

Scientific goals:

- Test of different technologies ...
- Investigate alignment issues ...
- Calibration studies
- Performance studies ...



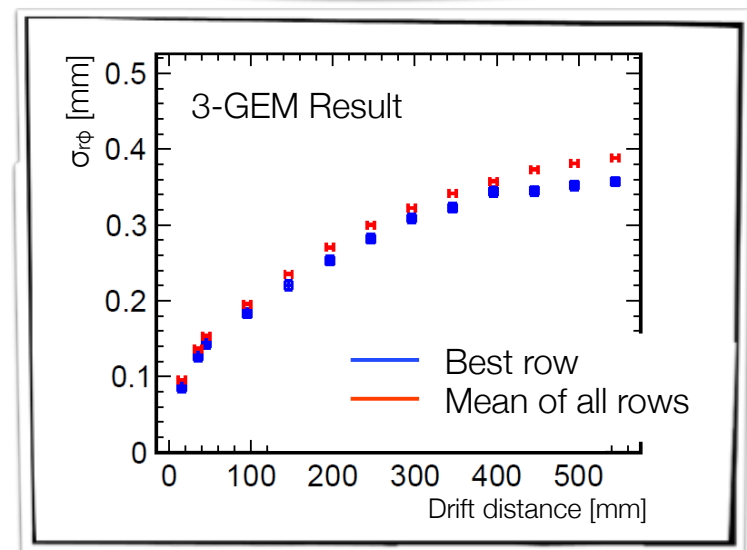
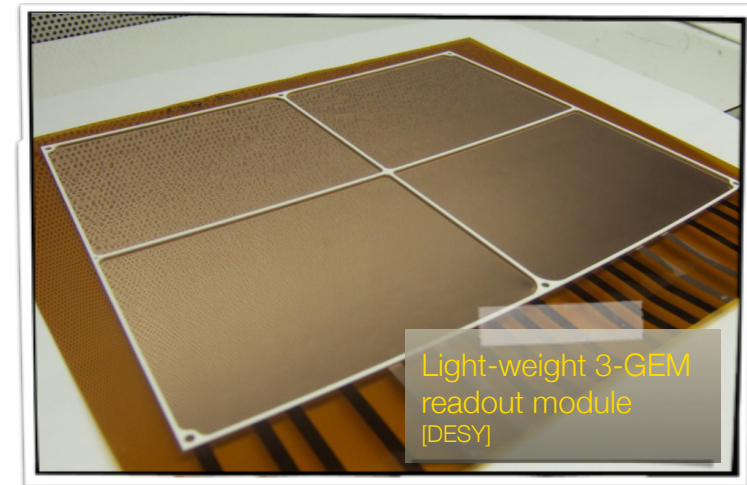
TPC Endplate Technologies

GEM studies:

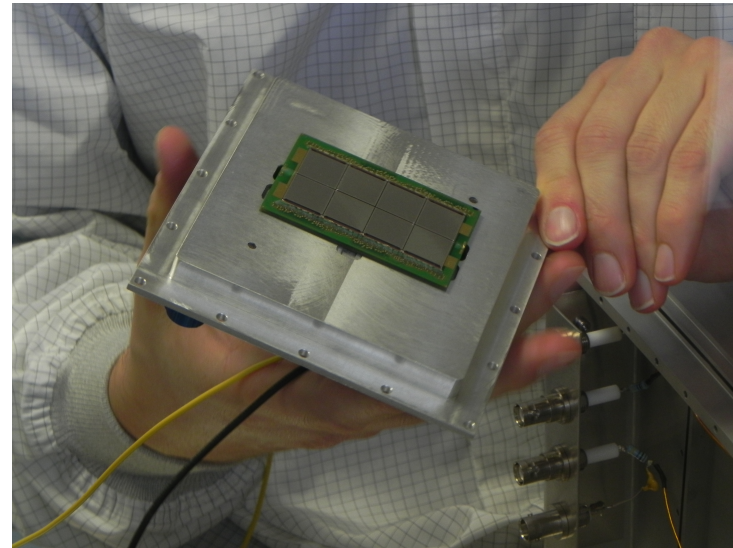
Spatial resolution: $60\ \mu\text{m}$...
[at zero drift distance]

Study of field distortion effects
and alignment issues started ...

Alternative technologies:
2-GEMs; micromegas, pixels ...

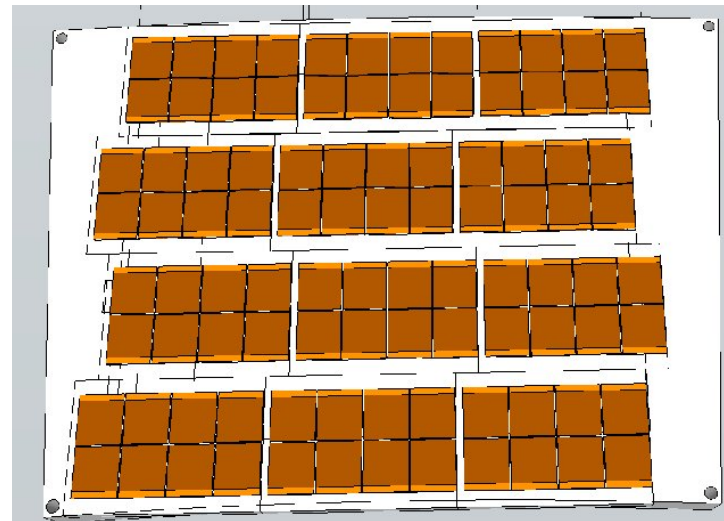


TPC Endplate Technologies: PixelTPC



8-InGrid Module

InGrid production on wafer scale
Contribution to Timepix3 (ready)
Next goal „100 chip“-module



TPC – Future Challenges

Scalability:

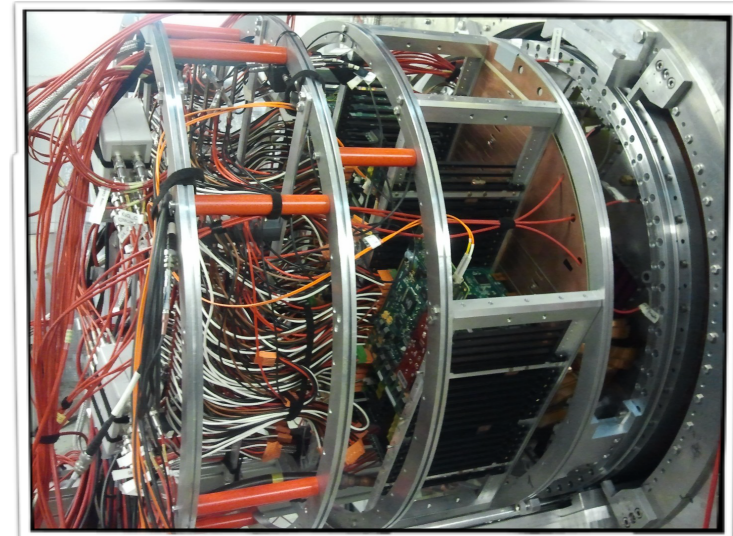
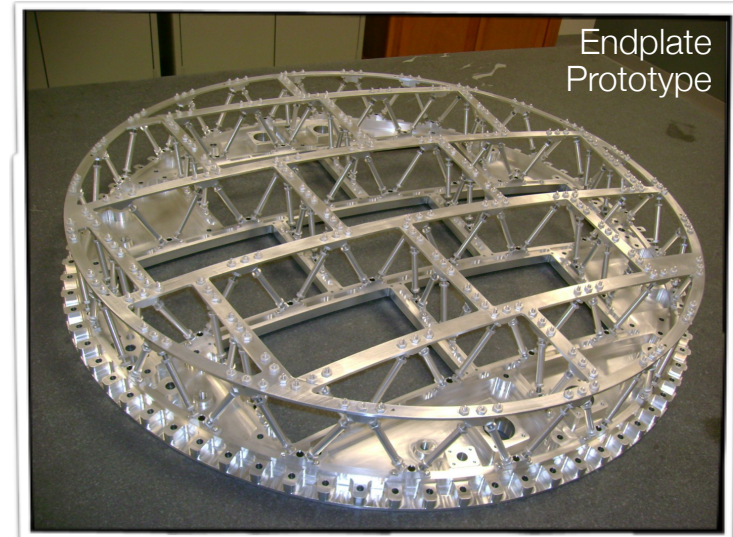
Develop large scale system ...
Demonstrate technical feasibility ...

Integration:

Establish overall system design ...
Prove integrability into ILD ...

Readout:

Improve readout system ...
Compact design necessary ...
[Extra factor 10 needed]



Final Remarks

Proposal from Japan + TDR puts ILC much closer to real axis
Visible interest + preparation from Physics+Detector community
in Europe vital (both at country and EU level)

Comprehensive detector R&D by German research groups
concerning calorimetry and tracking, in particular ...

Time Projection Chamber Development

Imaging Hadron Calorimeter Research

[Further involvements & interests: FCAL, Pixel Detector, ...]

Preparing for leading contributions to an ILC detector