ILC at DESY

Experimental activities

Ties Behnke

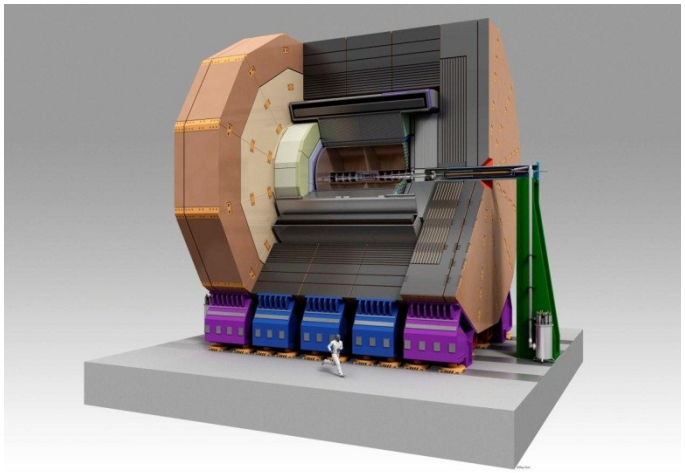
PRC 8.11.2012

Linear Collider Detector Activities

Driving force: development of a precision detector for the ILC (LC)

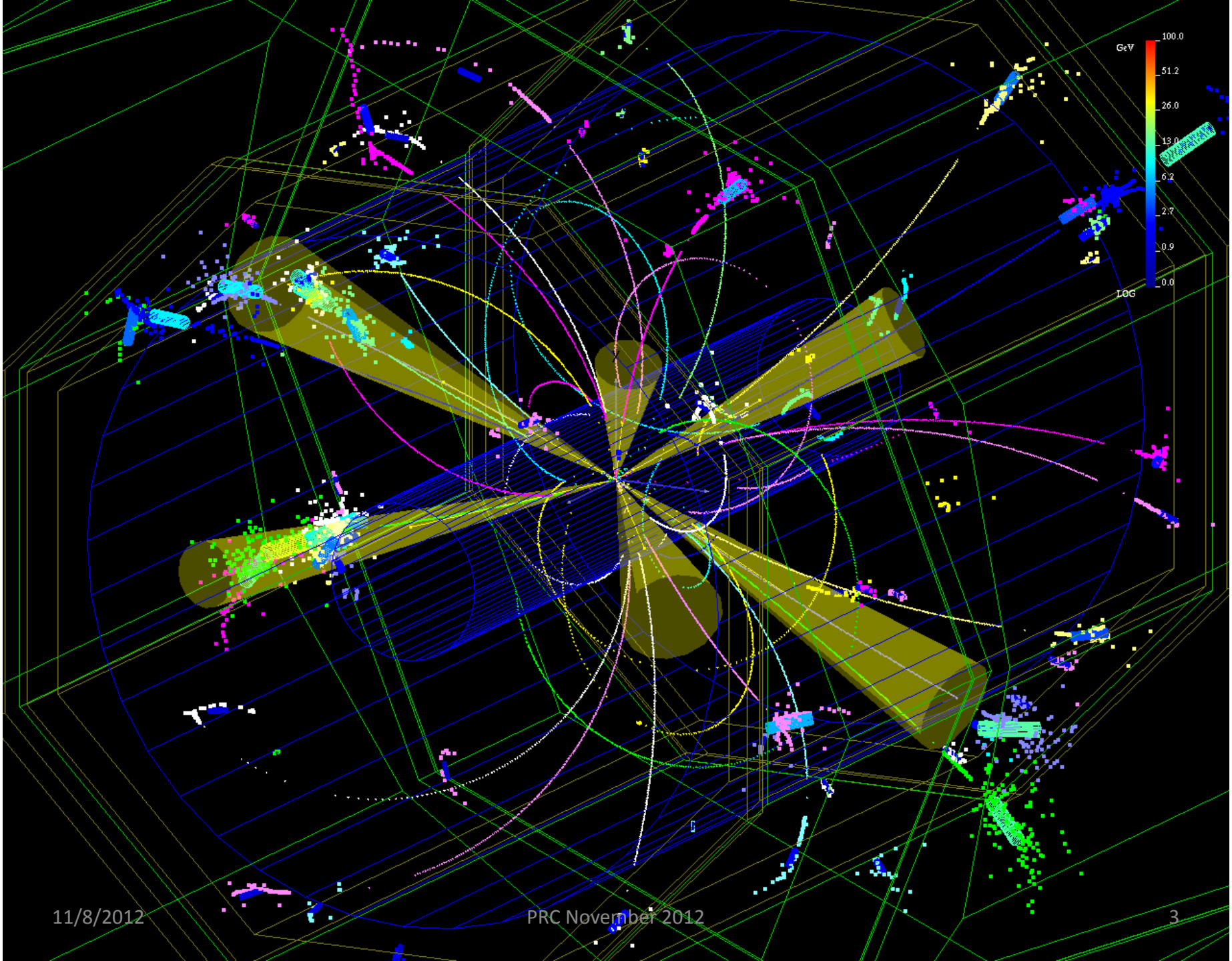
The ILD detector concept
Letter of Intent 2009, detailed design report 2012,
main editors from DESY

Ca 700 physicist from ca 30 countries



Precision detector, optimized for particle flow

- Precision vertexing and tracking, stress efficiency in the tracking
- Granular calorimetry
- Excellent hermeticity


GeV
100.0
51.2
26.0
13.0
6.2
2.7
0.9
0.0
LOG

Activities

Development of an integrated detector concept
- overall optimization and layout
- physics capabilities
- Tools

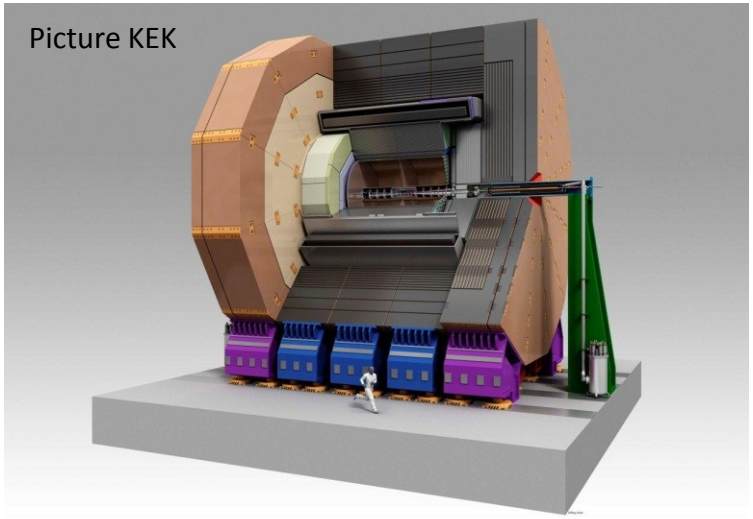
Development of selected technologies

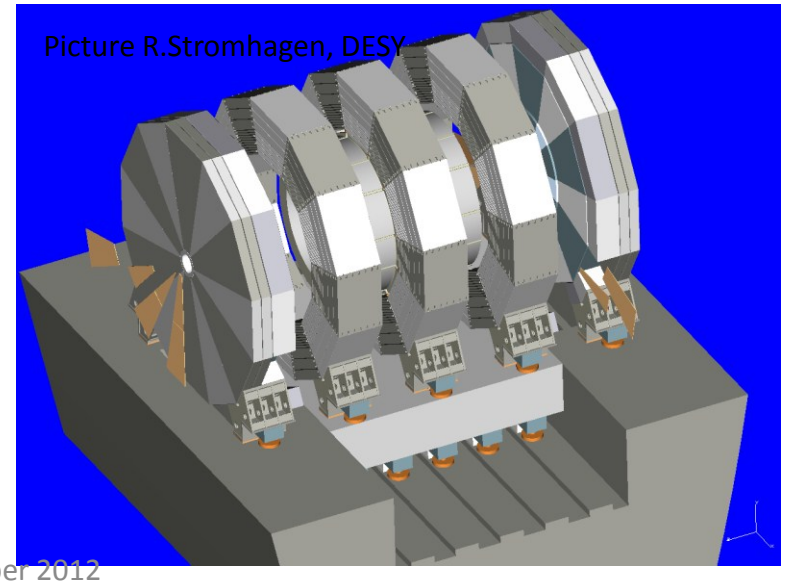
- Tracking/ vertexing system
- Calorimeter: hadronic calorimetry, forward calorimetry
- Beam instrumentation: polarisation

Activities not covered in this talk:
- Accelerator developments
- Positron source developments

Overall Detector Integration

- Interface of the ILD detector with the accelerator
- Contribute to the development of a common push-pull system
- Overall mechanical integration of the detector.
- Provide a central instance for documentation and project tracking (EDMS) for ILD.





Conceptual study of the operation and design of the Iron Yoke in ILD

Linear Collider Physics

Study LHC physics in detail

- Precision probe in clean, low background environment reveals underlying physics. Example Higgs

Direct Discoveries

- Color neutral states
- Higgs sector

Discovery through precision

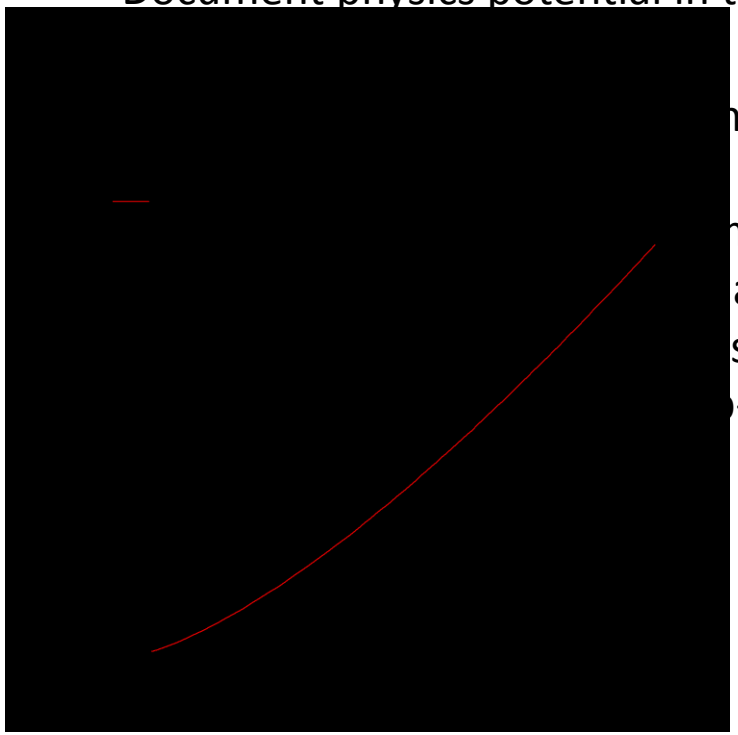
- Precision tests of SM particles highly sensitive to new physics

(slide from Jim Brau, LCWS 2012)

Physics studies

Make the physics case for the linear collider

- React to LHC discoveries and results
- React to new developments and improvements in theory and tools
- Document physics potential in the TDR



ne example studied at DESY

nuon threshold scan
a scenario compatible with
smo, electroweak precision & LHC,
-to-date ILC parameters

Outlook – underway:

- comprehensive study of „natural SUSY“ / „Higgsino world“ scenarios
- Higgs quartic coupling

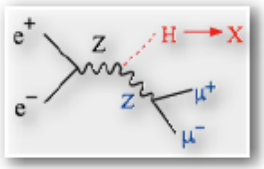
Higgs Physics

After the CERN discovery: understand how well the LC can do in more detail.

ZH @ 250 GeV (~mZ+mH+20GeV) :

- Higgs mass, width, J^{PC}
- Gauge quantum numbers
- Absolute measrement of HZZ coupling (recoil mass)
- BR(h->VV,qq,ll,invisible) : V=W/Z(direct), g, γ (loop)

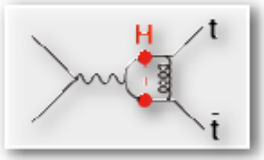
-> couplings to H (other than top)



ttbar @ 340-350GeV (~2mt) : ZH meas. Is also possible

- Threshold scan --> indirect meas. of top Yukawa coupling
- A_{FB}, Top momentum measurements
- Form factor measurements

γ γ → HH @ 350GeV possibility



vvH @ 350 - 500GeV :

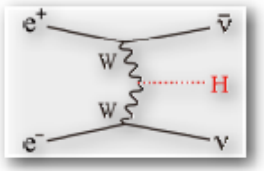
- HWW coupling -> total width --> absolute normalization of couplings

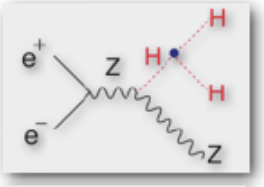
ZHH @ 500GeV (~mZ+2mH+170GeV) :

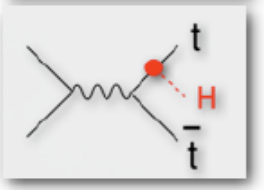
- Prod. cross section attains its maximum at around 500GeV -> Higgs self-coupling

ttbarH @ 500GeV (~2mt+mH+30GeV) :

- Prod. cross section becomes maximum at around 700GeV.
- QCD threshold correction enhances the cross section -> top Yukawa measurable at 500GeV concurrently with the self-coupling







We can complete the mass-coupling plot at ~500GeV!

Higgs Physics

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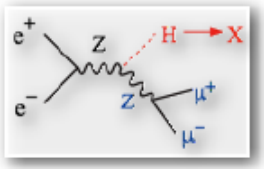

ttbar @ 340-350GeV (~2mt) : ZH meas. Is also possible

- Threshold scan --> indirect meas. of top Yukawa coupling
- A_{FB}, Top momentum measurements
- Form factor measurements γ γ → HH @ 350GeV possibility

Central measurement: Higgs self coupling. Intense study ongoing in KEK, DESY will join this in the near future

vvH @ 350 - 500GeV :

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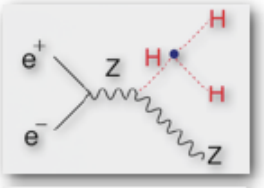

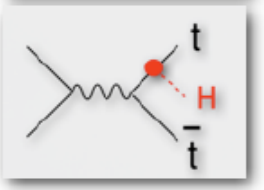

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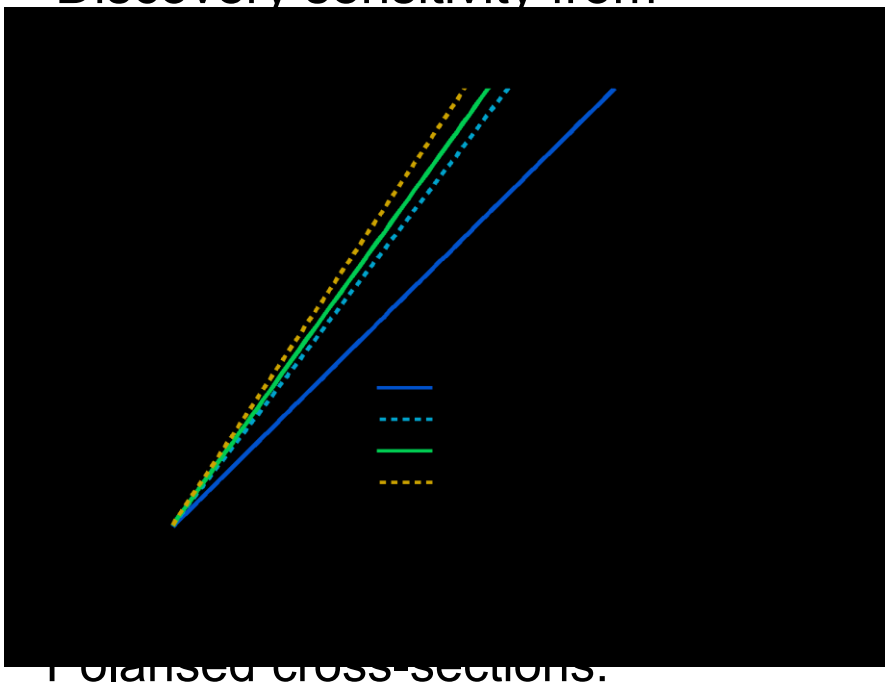
Characterisation of WIMPs [arxiv:1206.6639, accepted by EPJC]

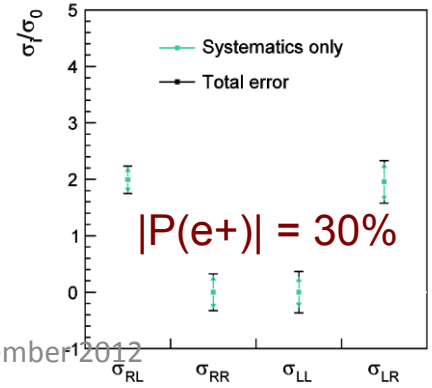
Pair creation of WIMPs+ ISR phot

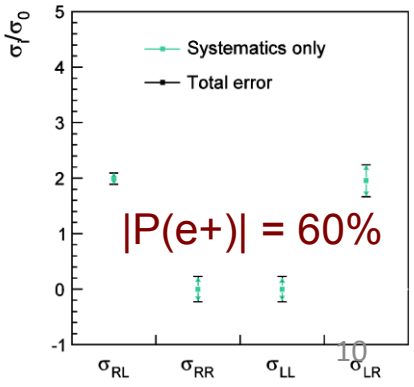
Discovery sensitivity from



- Predict from relic density
  $\sigma(e^+e^- \rightarrow \chi\chi\gamma) \approx O(100\ fb)$
  $\times\ BR(\chi\chi \rightarrow e^+e^-)$
- Main background: $e^+e^- \rightarrow \nu\nu\gamma$
  suppress with polarisation!
- Full detector simulation,
  incl. systematic uncertainties
- Mass to %-level from γ recoil
- Discriminate s- vs p-wave
  product'n

Polarised cross-sections:
determine chiral structure of WIMPs

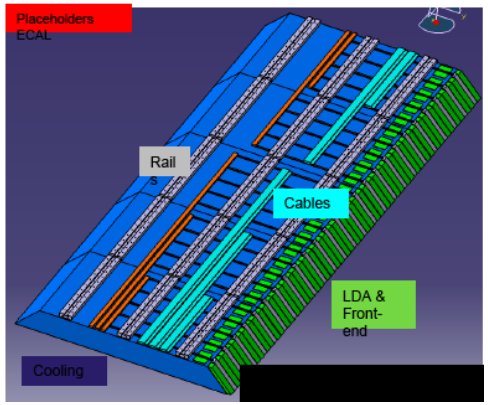




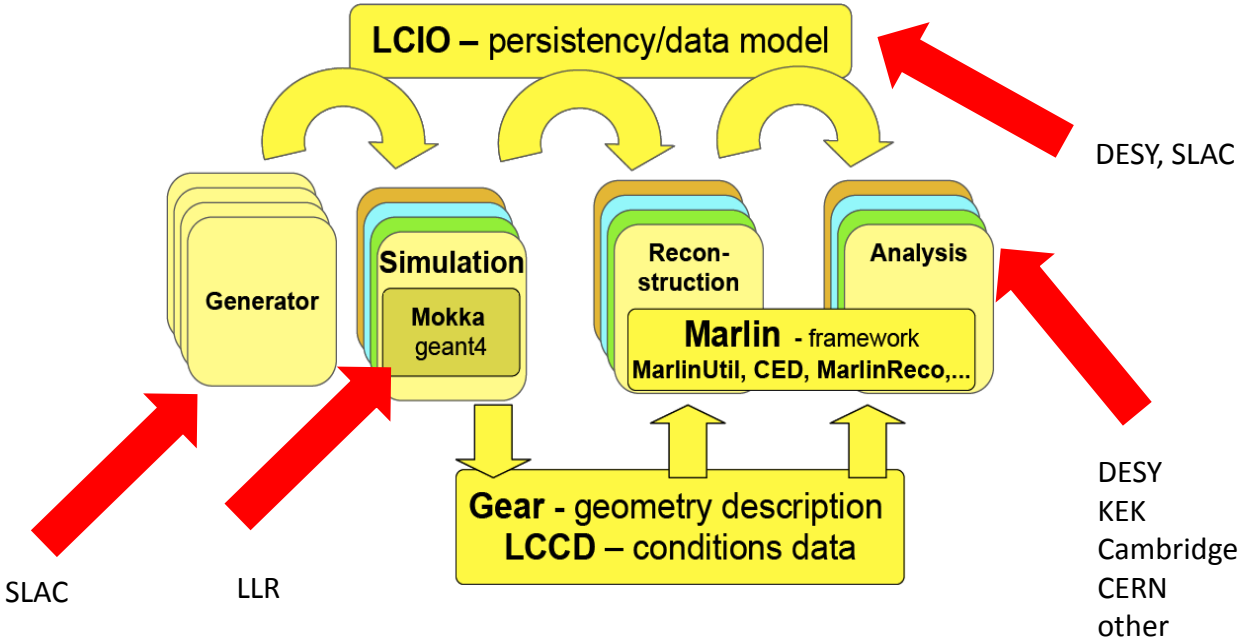
Software tools

Goal:

- Develop “easy to use” software framework for LC studies



Detailed simulation model of ECAL module

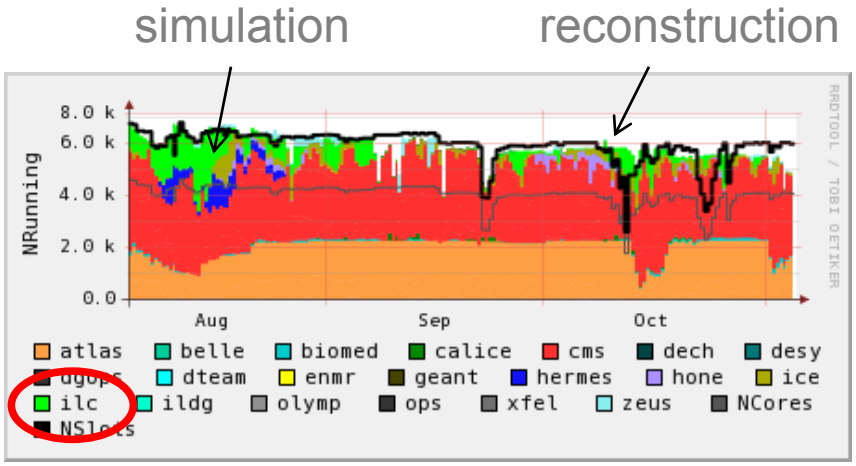


(Boxes without affiliation; DESY)

DESY plays a central role in the development, Maintenance, and application of the LC software suite.

Event production for LC studies

- simulated and fully reconstructed
- **>10M** events with ILD_O1_v05
- 50k simulation and 10k reconstruction jobs
- **large fraction done at DESY**



- some benchmarks:
  - sim: 5-9 min / event
  - rec: 30-60 sec / event * (w/o background)
  - rec: 45-210 sec / event * (w/ background)

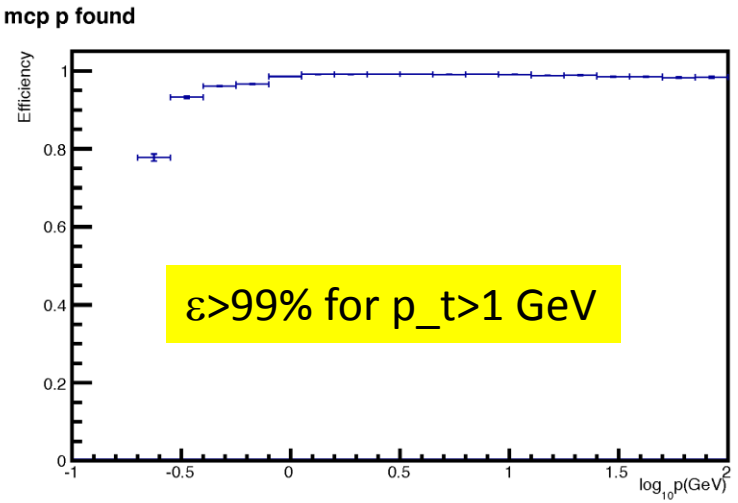
ILC GRID usage small compared to the LHC.

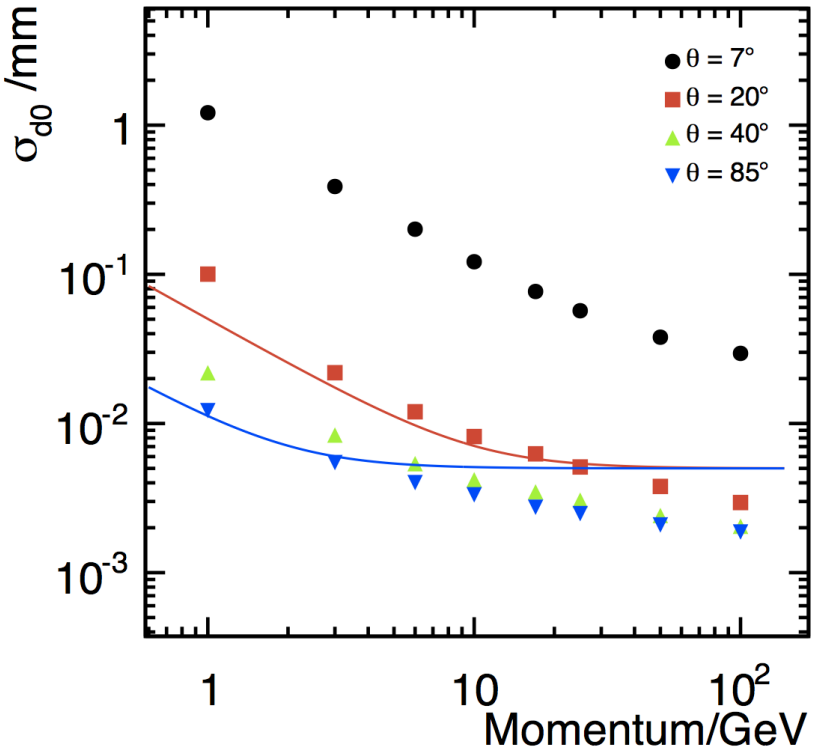
Essential service to enable the in-depth Linear Collider studies for the technical design report (DBD)

New Tracking Code

Major new development project:

Tracking code for ILD detector





Complete re-write of a very complex piece of code for

- Improved performance
- Long term maintainablility

TPC tracking
VTX tracking
Combined tracking

Technologies

- Do fundamental technology developments
- Develop solutions for the concrete case of an ILC detector
- Prototype the technologies
- Develop integration strategies

Done integrated into
AIDA
Helmholtz Alliance “Physics at the Terascale”
Helmholtz detector portfolio

Vertex Detector

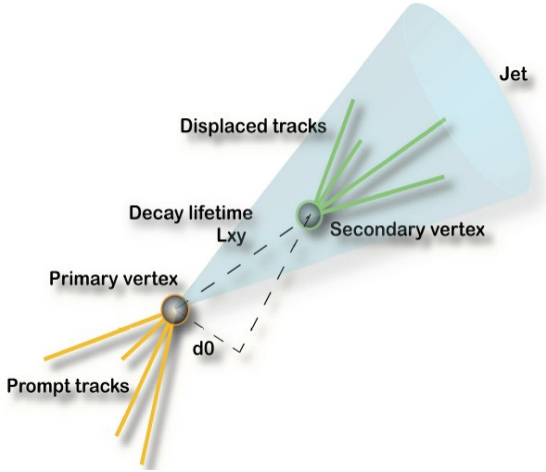
Vertex detector

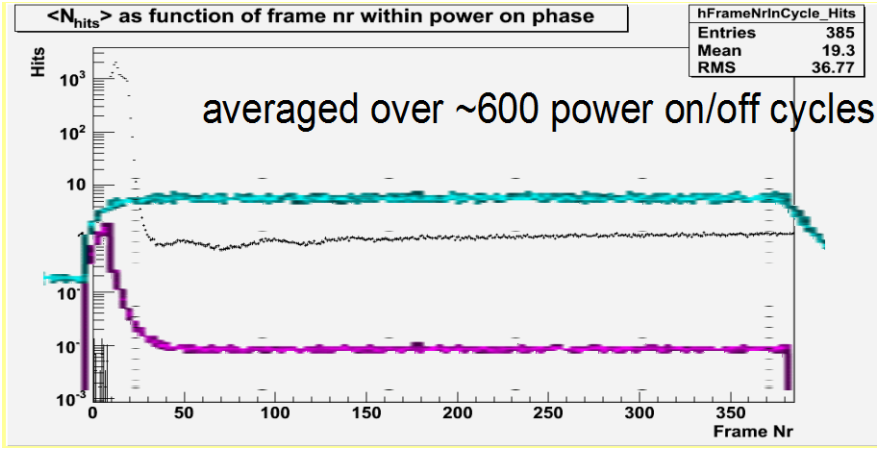
Many technologies are under study worldwide

One of the key challenges: material budget

Goal: <0.3% X0 per double layer
Prototype ladder 2011: 0.6% X0 achieved

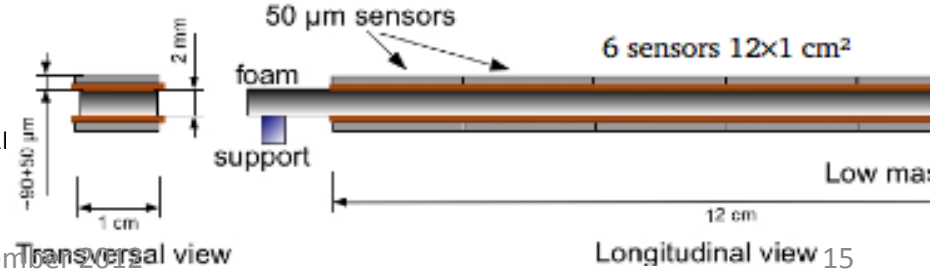
DESY “testing” center, using our infrastructure and know how to establish the operation of the new sensors and new materials.





Baseline :

- 6 x MIMOSA26 thinned down to 50µm (developed for EUDET Telescope)
- Kaptonmetal flex cable
- Silicon carbide foam (8% density) stiffener, 2mm thick
- Wire bonding for flex - outer world connection
- Digital readout

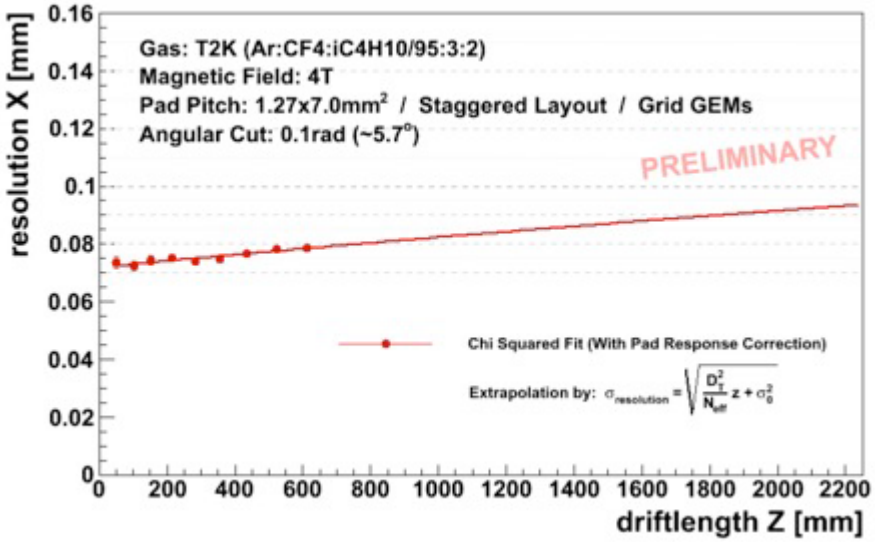


Time projection chamber

TPC is part of central tracking in ILD.

Proof of principle for a GEM based TPC in high fields done at DESY

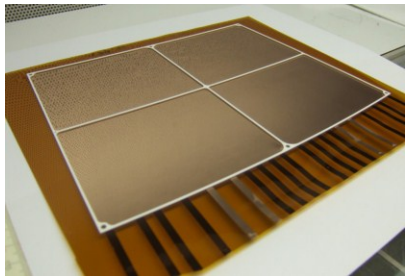
(see also reviews of LC-TPC by the PRC in recent years)

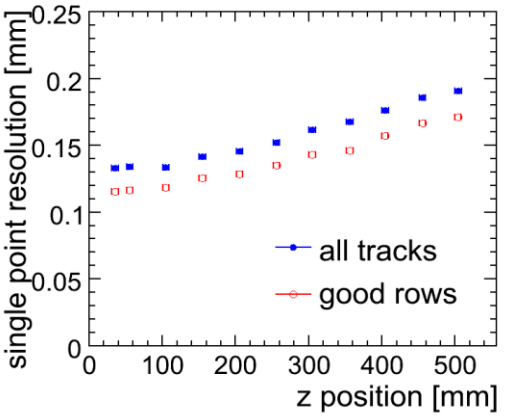


Focus at DESY

- Development of an compact GEM based readout module (hardware, software)
- Operation and improvement of the LC-TPC test facility at DESY
- Support to non-DESY groups in the use of the LC-TPC test facility

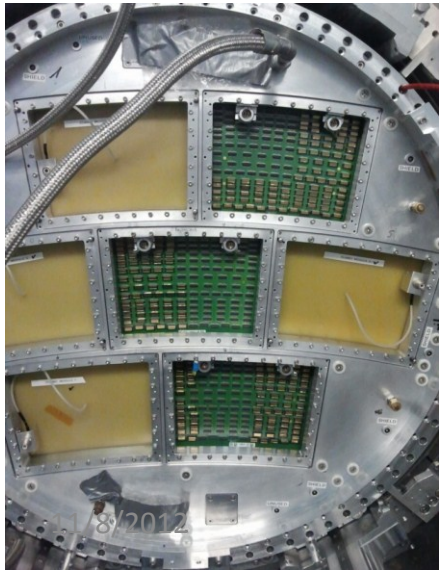
DESY GridGEM module



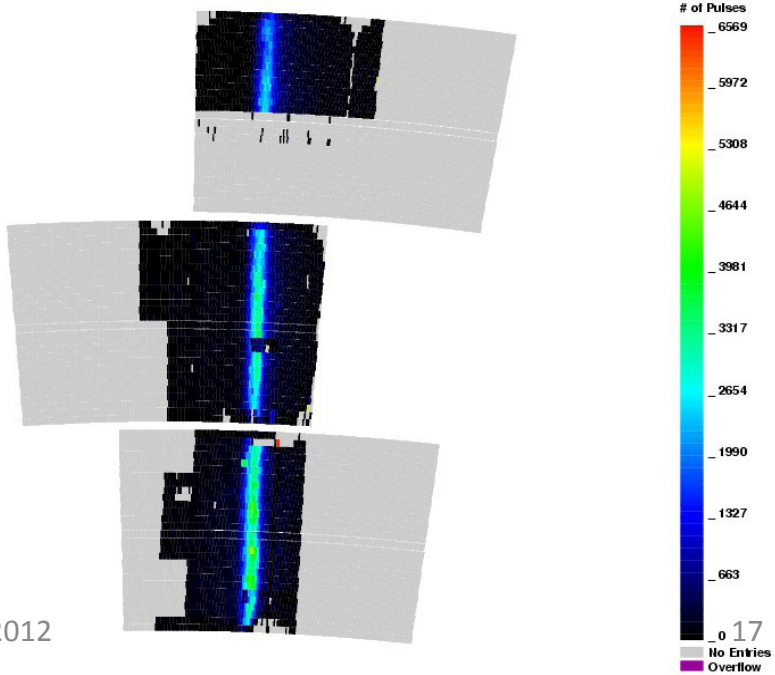


Measured single point resolution.

Light weight, self-supporting GEM structure with minimal dead zones.



Test beam 2012:
Operate sucessfully
Three modules in large prototype with 1T B-field



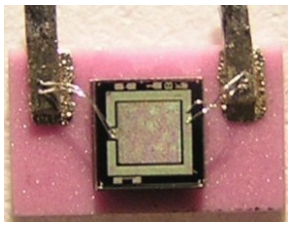
Hadronic Calorimeter

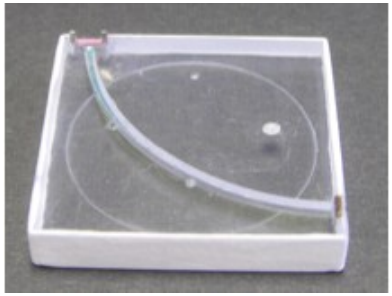
- Hadronic calorimeter plays central role in a particle flow detector:
  - Final resolution for fully hadronic states is dominated by HCAL and confusion.

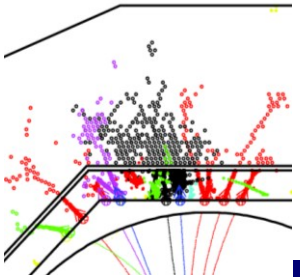
Hadronic tile calorimeter

- Close cooperation with Russian groups on SiPM readout
- Pioneered SiPM usage in HEP projects
- Excellent cooperation within Germany within Terascale Alliance
- Collaboration with many other groups within CALICE, synergy e.g. with ECAL in Japan

Last years: very successful test beam campaign with “physics prototype” to study and establish performance.



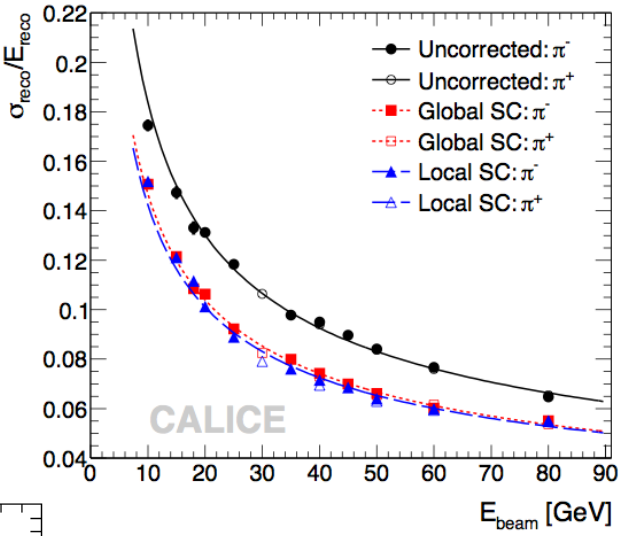




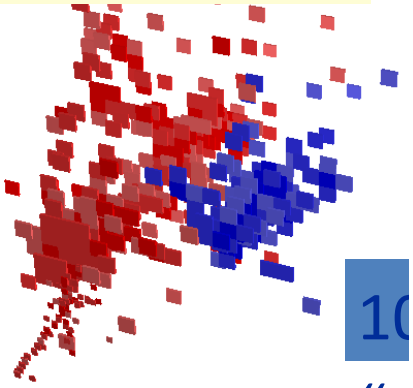
Analysis highlights

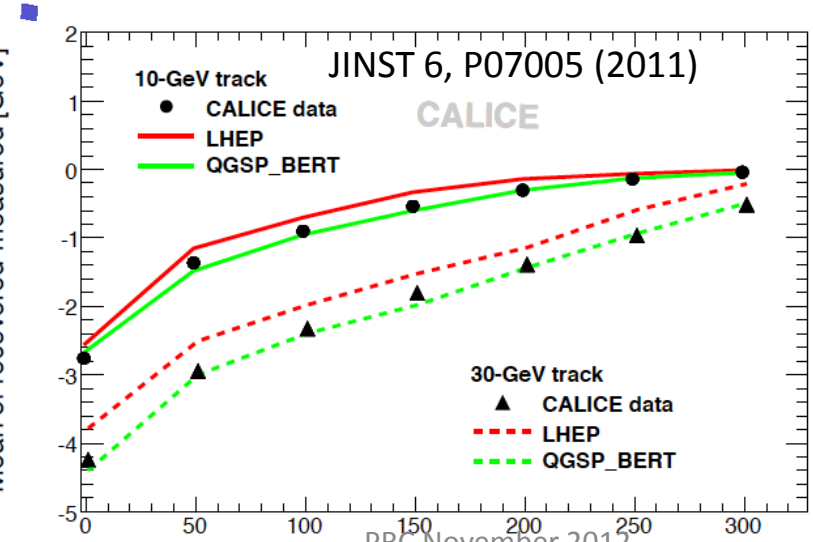
$\sigma/E = 45.1\%/\sqrt{E} \oplus 1.7\% \oplus 0.18/E$

- Analysis of scintillator HCAL data nearly complete
- major role in establishing particle flow experimentally
- excellent calorimetry perfromance, too
- precise validation of Geant 4 models



data and MC agree on two particle separation





software compensation

JINST 7, P09017 (2012)

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PRC November 2012

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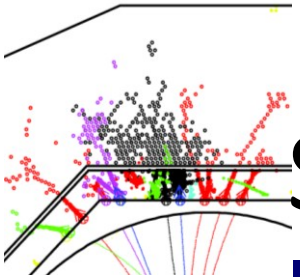
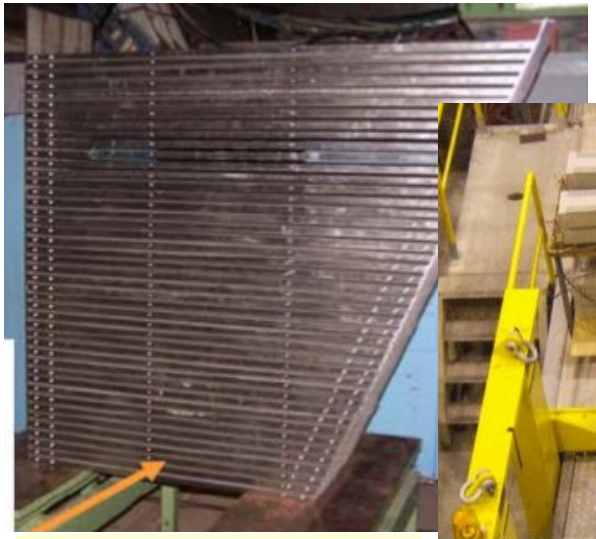
CALICE Calorimeter for ILC



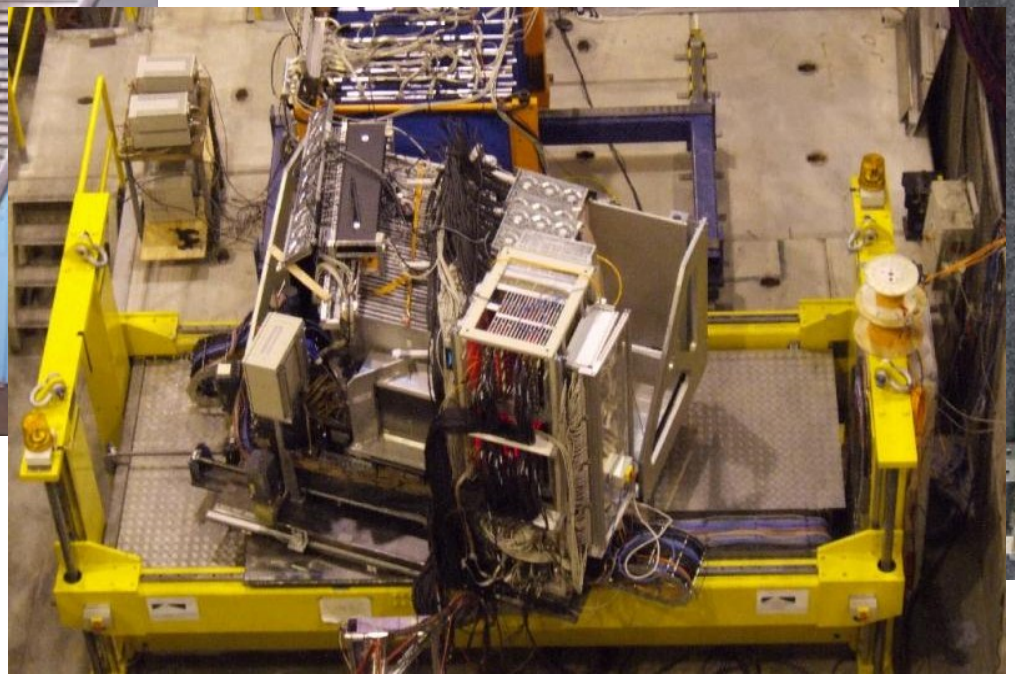
Scintillator HCAL at DESY

- DESY active in mechanics, electronics and system integration, test beam support, software, analysis

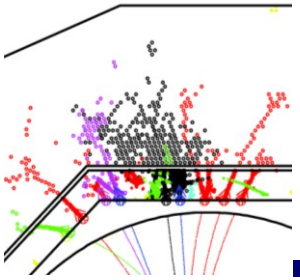
test beam infrastructure:
ECAL HCAL TCMT



ILD absorber: achieving tight tolerances in cost-effective way

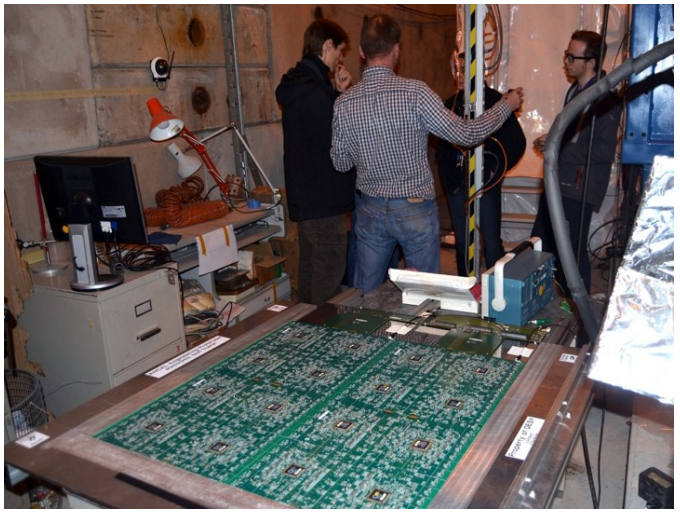


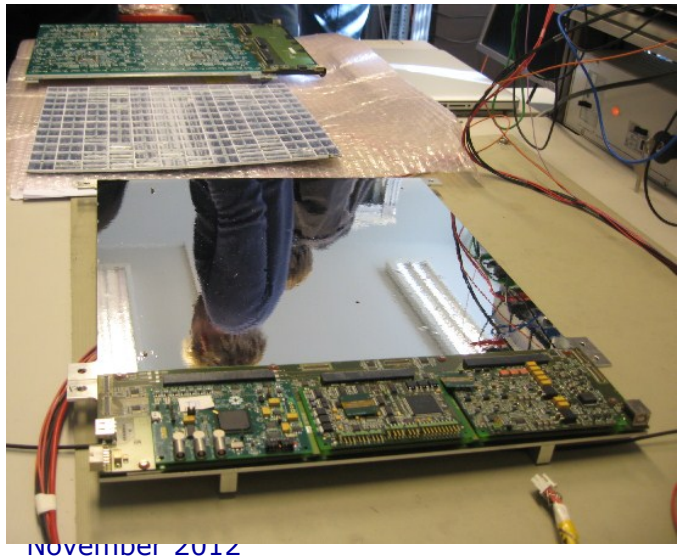
integrated electronics



Future plans

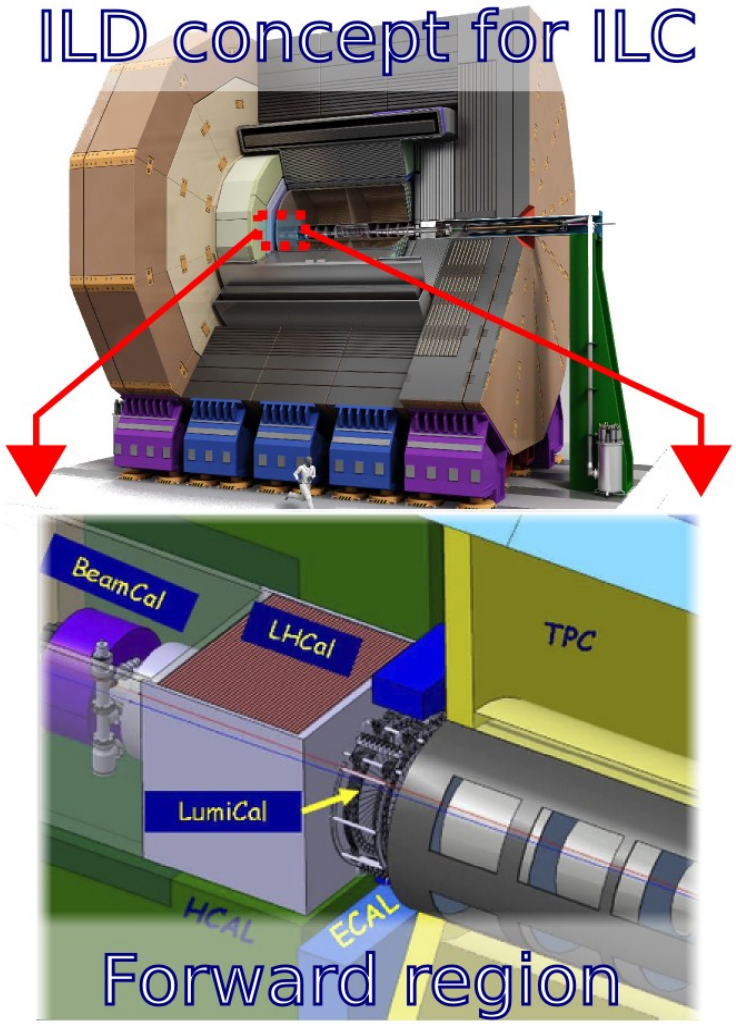
- First layer of 2nd prototype under test this week at CERN - so far successfully!
- Next: instrument one tower of ILD stack for electron test beam at DESY
- Then: “grow” a hadronic prototype, using same active parts for ILD and tungsten stacks
- Prove integration concept and study shower time structure
- Mechanics, readout ASICs and DAQ at hand - EUDET heritage
- Test bench for different sensor - SiPM and tile - options





Forward Calorimeter

Zeuthen



LumiCal:

- precise luminosity measurement, 10^{-3} at ILC , 10^{-2} at 3 TeV

BeamCal (and Pair Monitor):

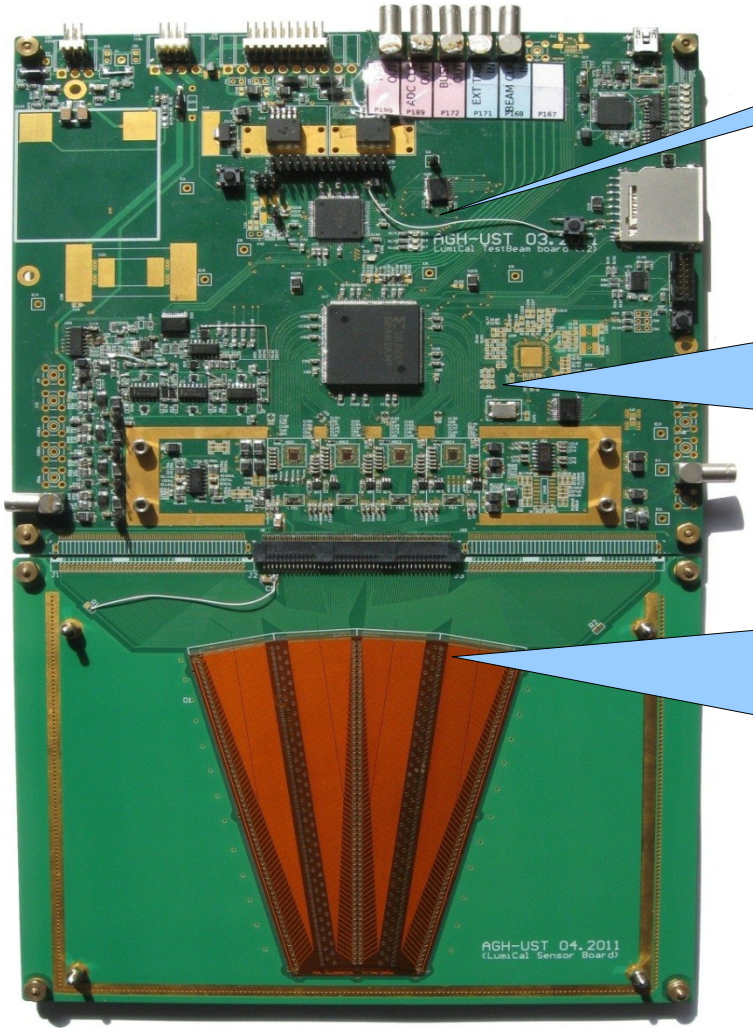
- hermeticity (electron detection at low polar angles),
- assisting beam tuning (fast feedback from BeamCal and pair monitor data to machine)

Challenges:

- radiation hardness (BeamCal),
- high precision (LumiCal) and
- fast readout (both)

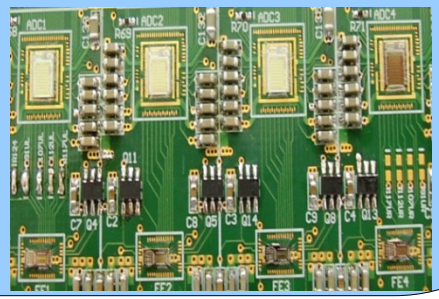
Module Design

AGH-UST and DESY



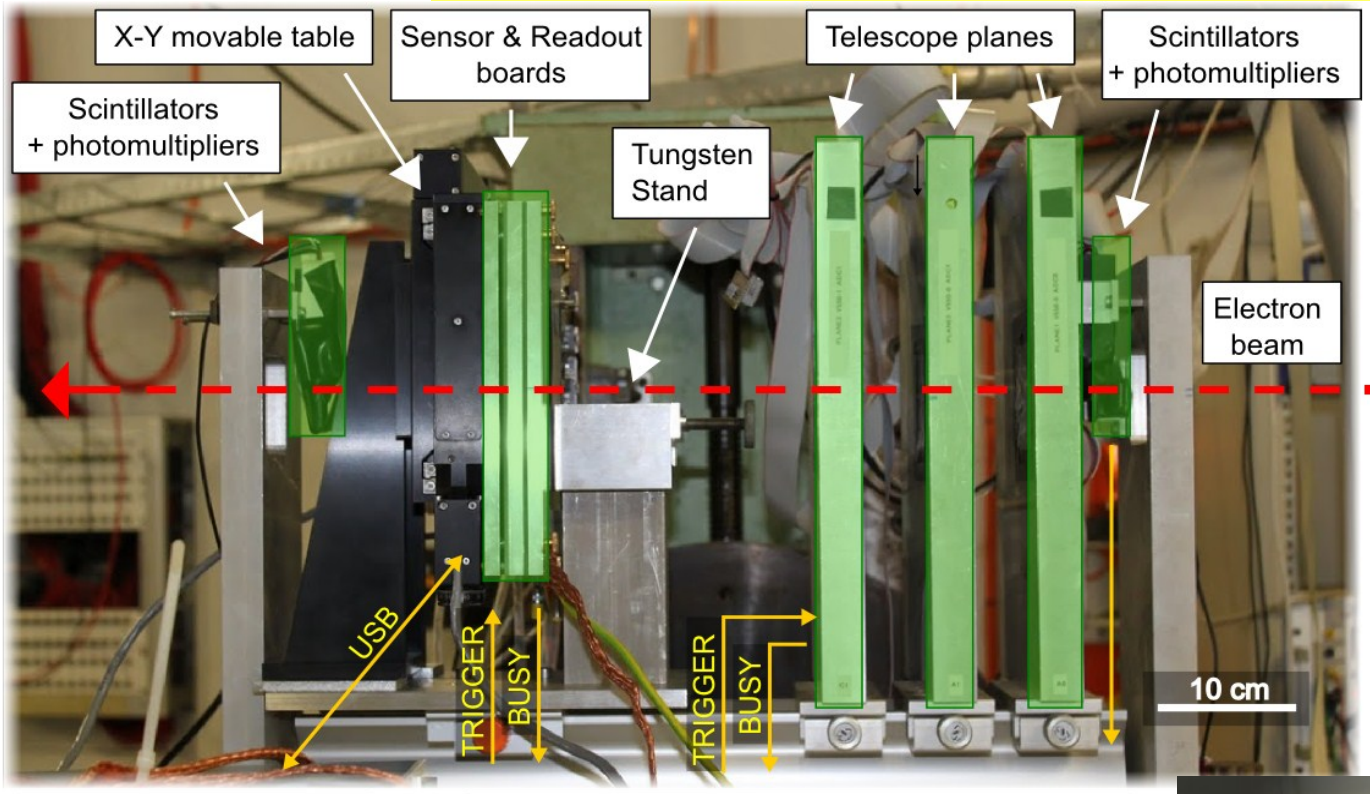
Data concentrator
Xilinx Spartan 3E

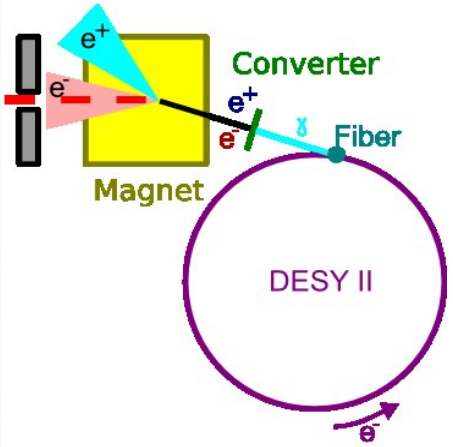
4 pairs of Front-end + ADC



LumiCal / BeamCal sensors

Test-beam Setup

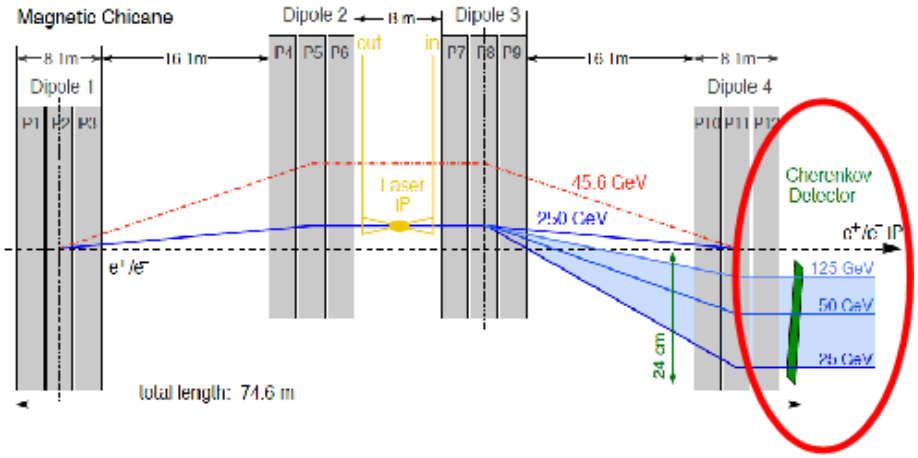




- 50×10^6 events recorded
- different areas of the sensor
- different FE settings
- data with FE and external ADC

Internationally highly recognised activity, strong synergy and spinoff to LHC (Beam monitoring)

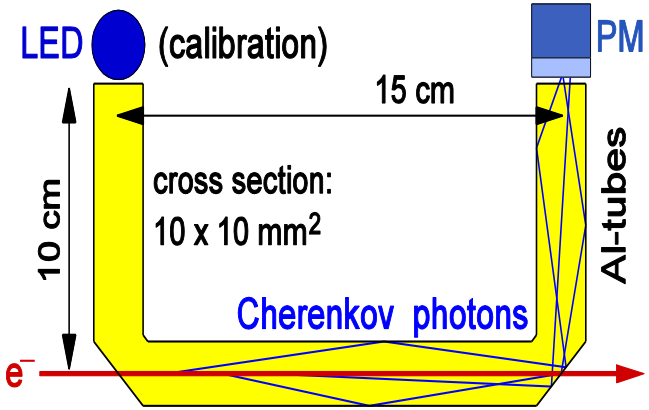
Polarisation

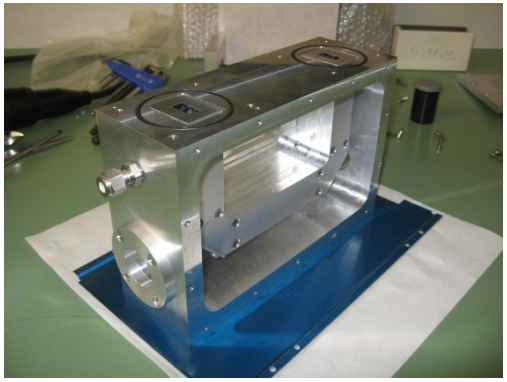


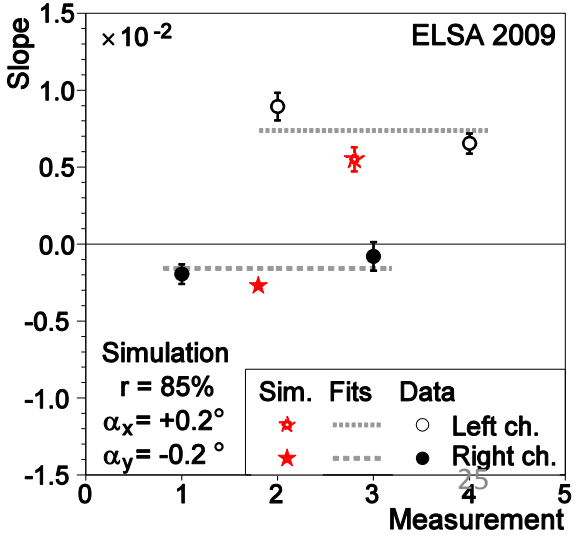
Polarised beams:
Improtant asset of the linear collider.

Need precision determination of the degree of polarisation:
O(0.1%)

Development of precision calorimeters for the scattered electrons (positrons)





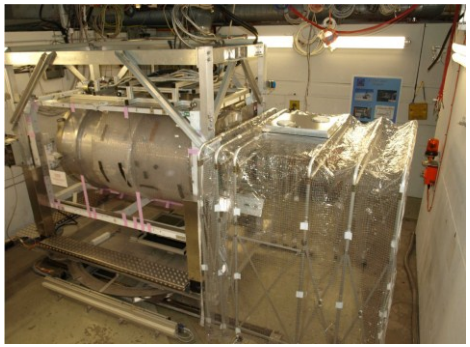


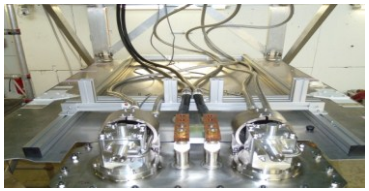
Summary

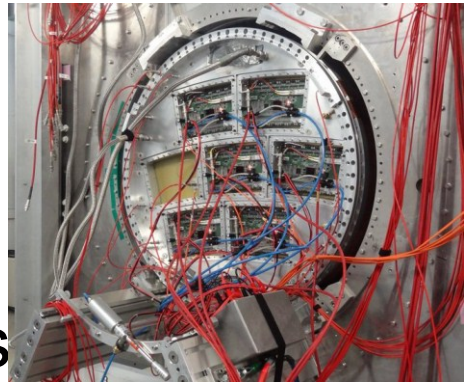
- Detector development for the linear collider is an active area of research at DESY at both sites (Hamburg and Zeuthen)
- Central contributions to the design of an integrated detector concept
- Strong role in “core tools” for the international linear collider community
- Active contributions to a number of key technological challenges at the LC
- Closely integrated into the LC community but also more generically into the Helmholtz detector initiative

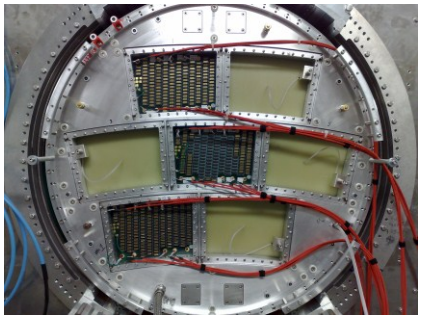
Testbeam setup

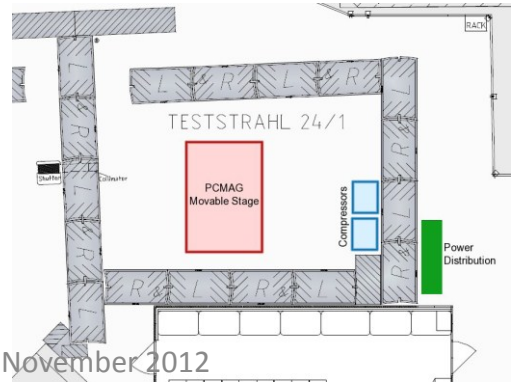
- Complete TPC test infrastructure
- Recent magnet upgrade within AIDA
- Service for other groups
- Lots of measurements campaigns (booked solid until march'13)





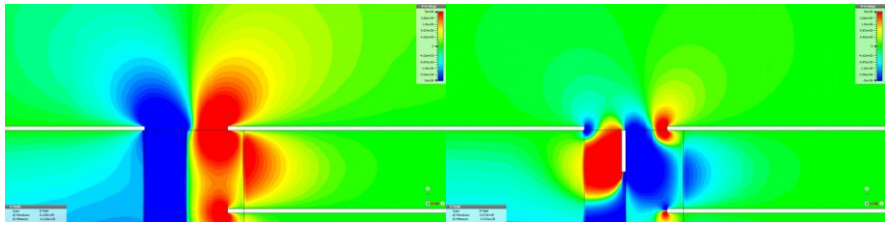


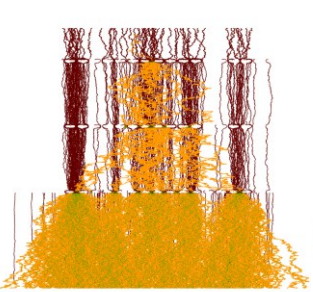


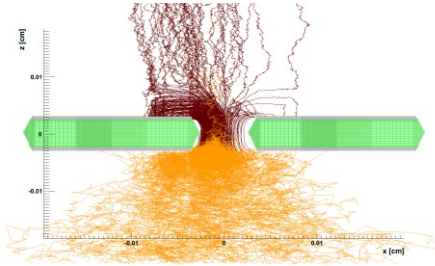


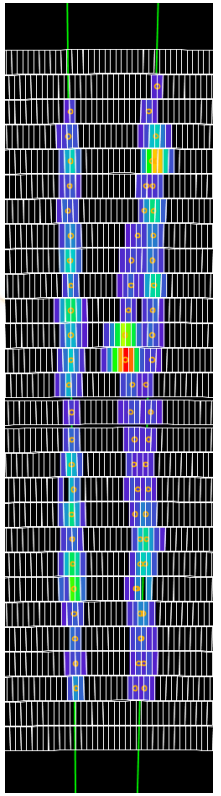
Simulation activities

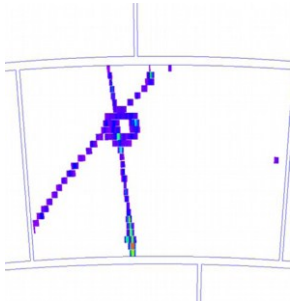
- Simulation:
  - Electrostatics
  - GEM amplification
  - Ion back drift
- Track finding package
- Track Fitting implementatic
- Central Services for LCTPC:
  - Coordination of SW activities
  - Conditions database
  - Data storage coordination
  - Test beam data analysis packages

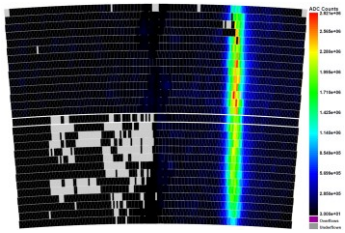












LC activities at DESY and Hamburg University

- LC Forum to support LC activities in Germany (see http://lcforum.desy.de)
- Contributions to ILC TDR
- Polarised positrons for future colliders
  - Future collider projects require intense e+ beams
  - Polarised e+ enhance substantially the physics potential (ILC, CLIC)
  - Topic 1: Optimization of e+ source components
    - Positron production target ⇔ extreme material stress (stress waves, damage)
    - Polarised photons create polarised e+: collimate the photon beam to increase the e+ polarisation ⇔ high stress and radiation load in collimator material
  - Topic 2: Spin manipulation and transport
    - Source optimization to achieve high e+ polarisation
    - Simulation of spin transport from start to end
    - Spin manipulation to preserve the polarisation