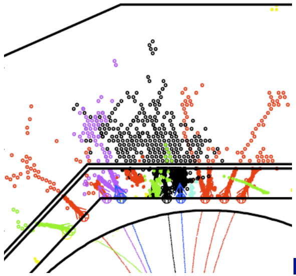
Calorimetry in ILD

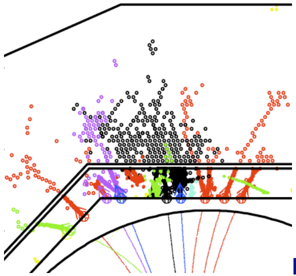
Felix Sefkow

ILD workshop in Kyushu
May 25, 2012

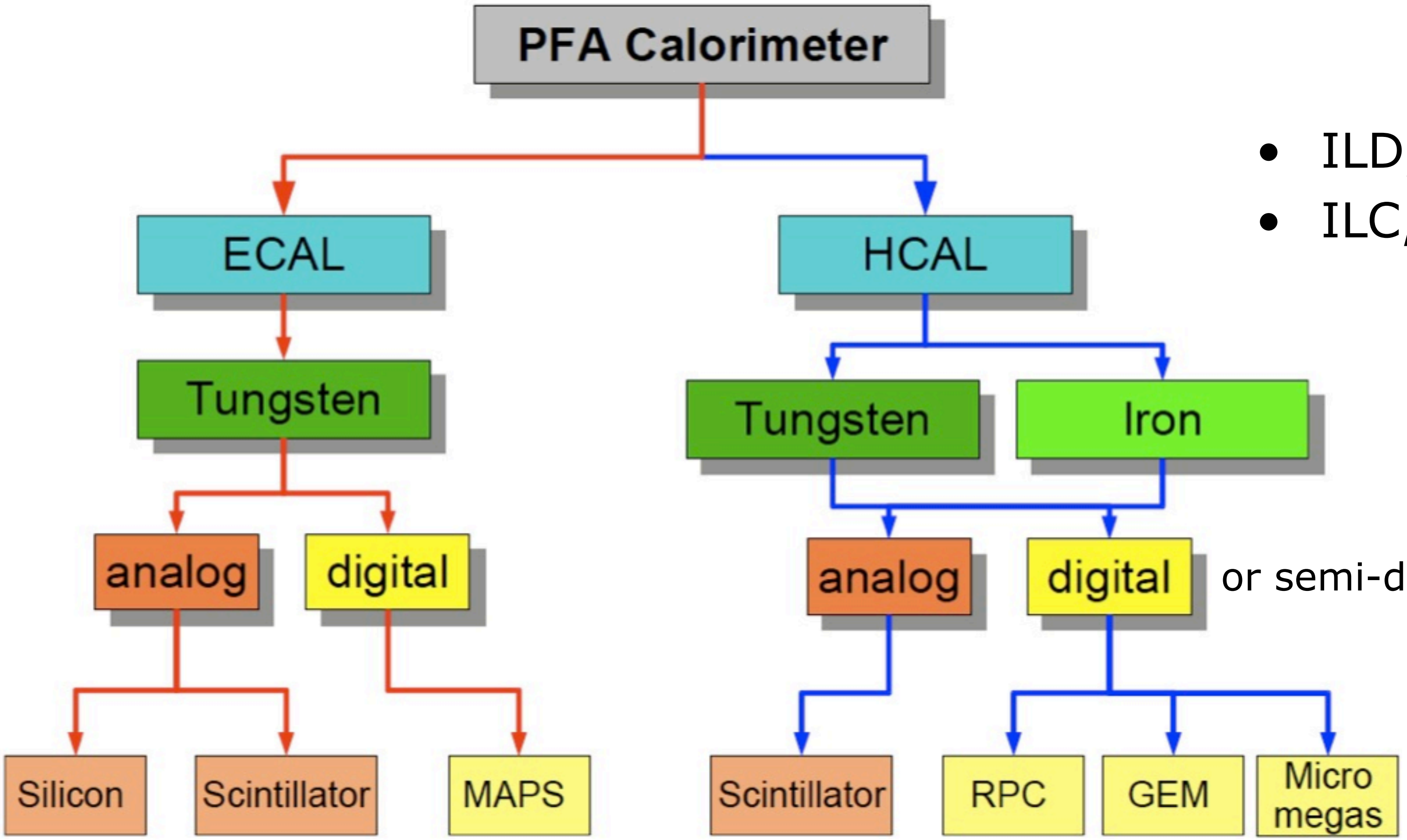


Outline

- Detector technology overview
- Common issues
- DBD structure
- Readiness criteria
- Future plans

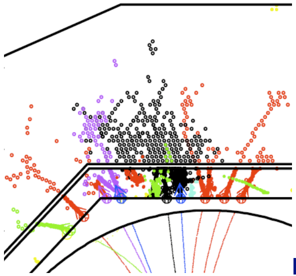


Calorimeter technology tree



or semi-digital

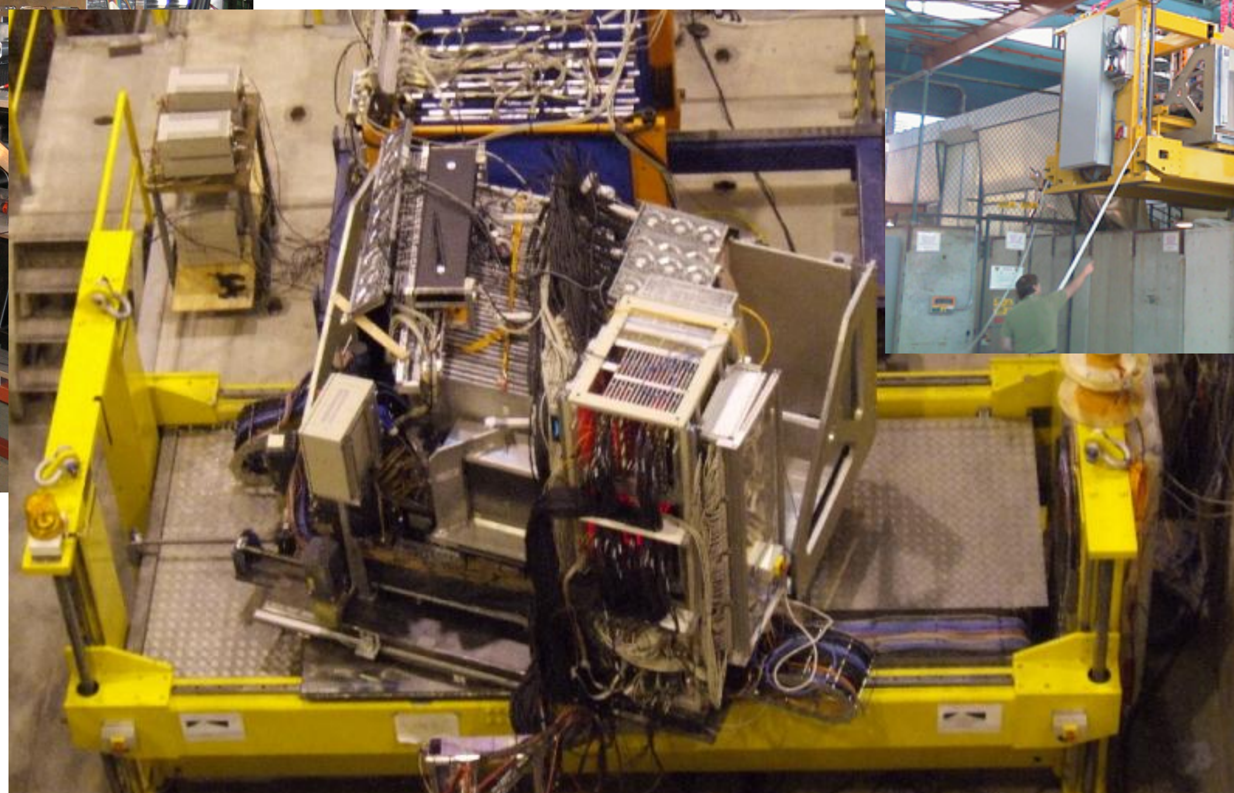
- ILD, SiD
- ILC, CLIC



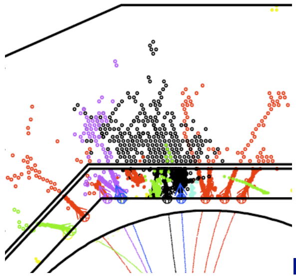
Test beam experiments

DESY 2005
SiECAL

CERN 2006-2007
add Scint HCAL



FNAL 2008-09
Si -> Sci ECAL

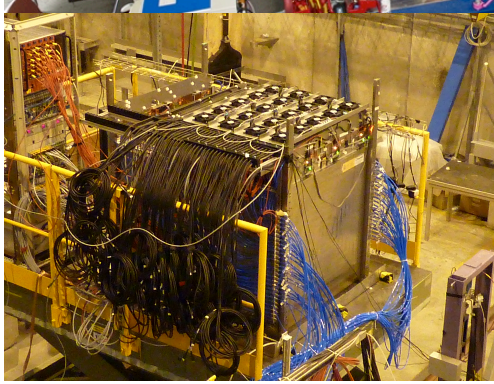


Test beam experiments 2010+

CERN
2010-11
W abs.
AHCAL

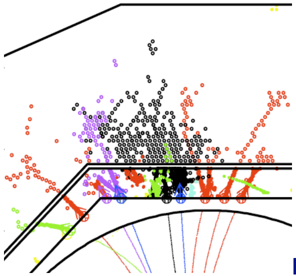
2012:
DHCAL

FNAL2010-11:
Scint AHCAL → RPC DHCAL

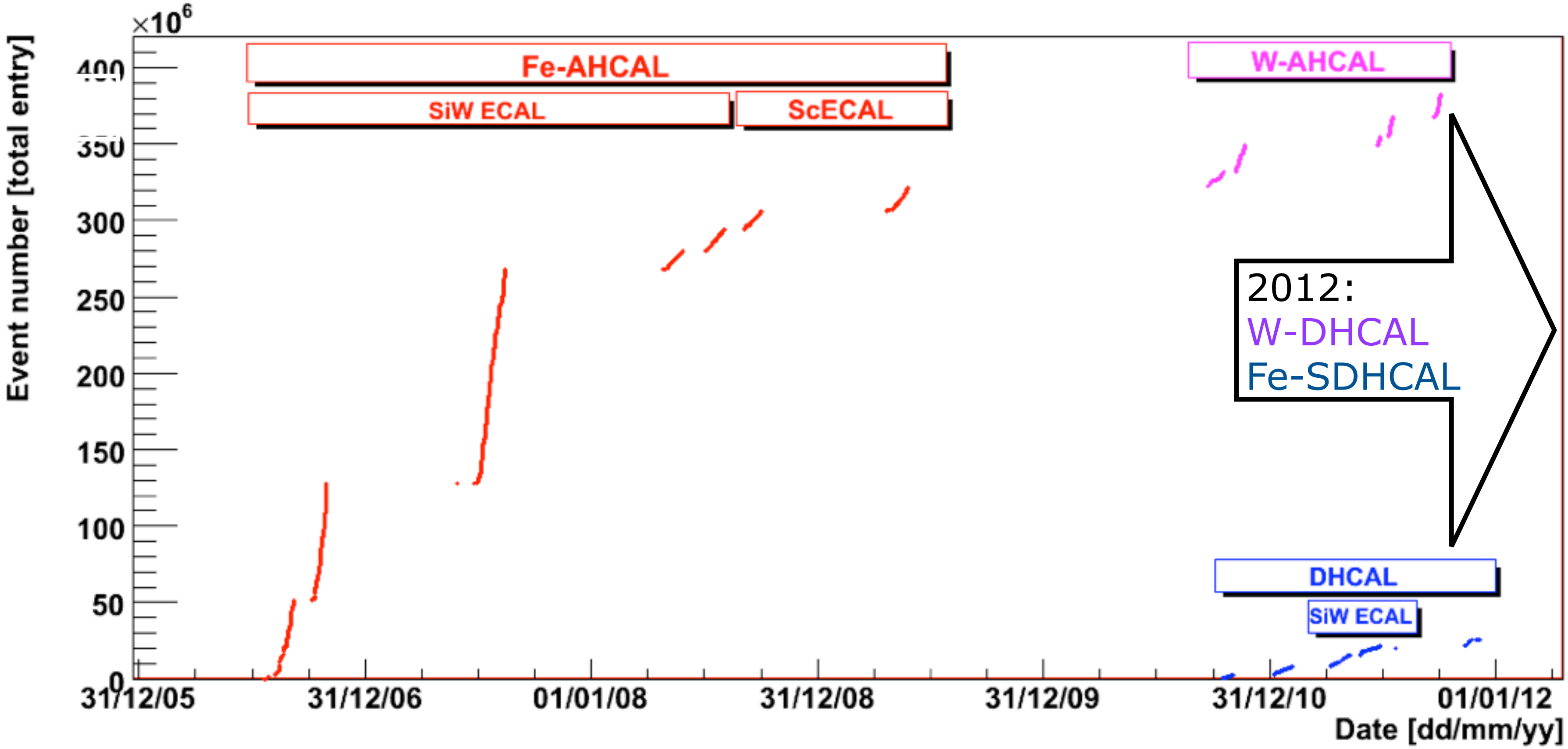


2012: m^3 SDHCAL

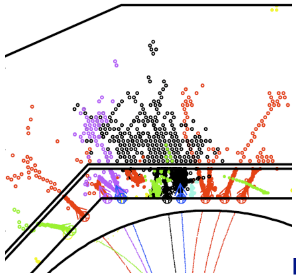
DESY
2nd generation
scint HCAL



Summary of data taken

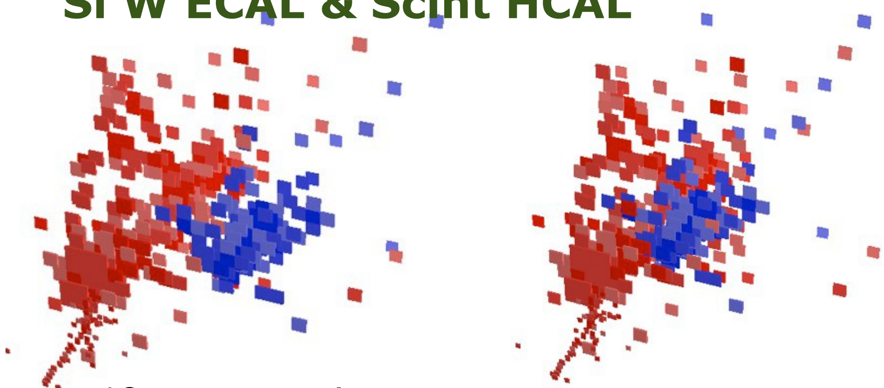


- Muon, LED and noise runs not included
- event size ~ 50kB -> 20 TB of physics data on the GRID



PFLOW with test beam data

Si W ECAL & Scint HCAL

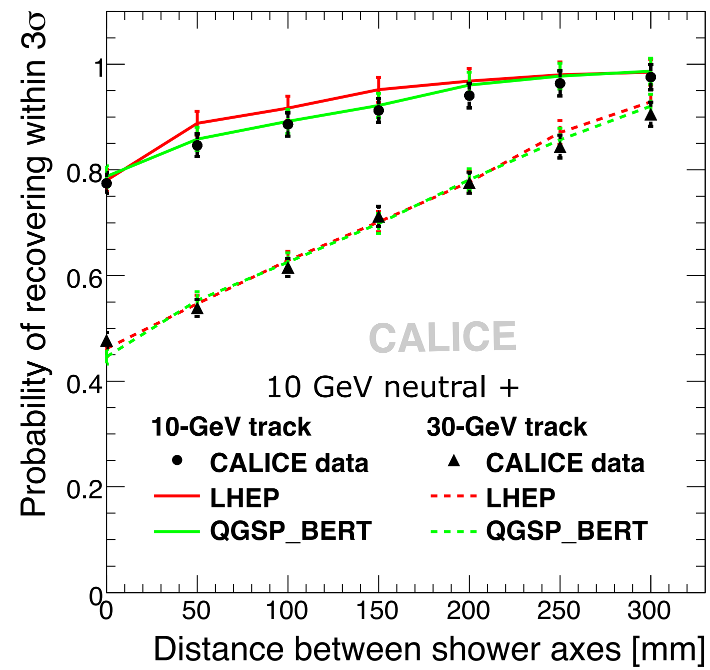


~18 cm separation of shower

~7 cm separation of shower

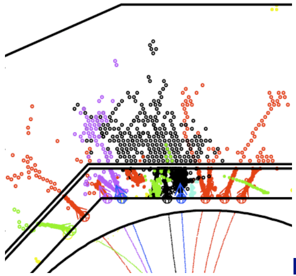
30 GeV charged hadron

10 GeV 'neutral' hadron

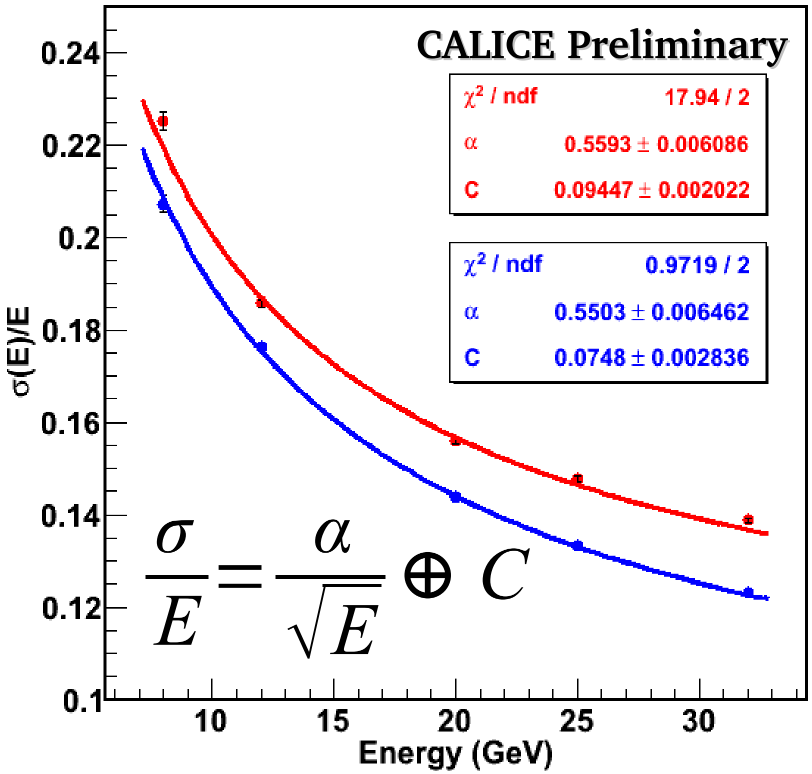


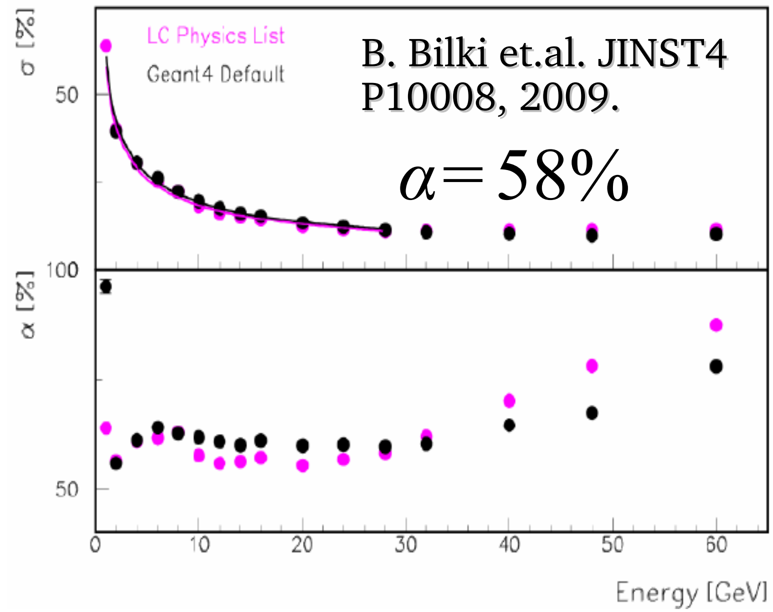
- The "double-track resolution" of an imaging calorimeter
- Small occupancy: use of event mixing technique possible
- test resolution degradation if second particle comes closer
- Important: agreement data - simulation

JINST 6 (2011) P07005



DHCAL first results: pions





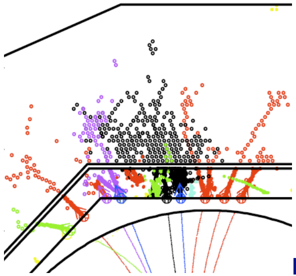
32 GeV data point is not included in the fit.

MC predictions for a large-size DHCAL based on the small-size prototype results.

Standard pion selection

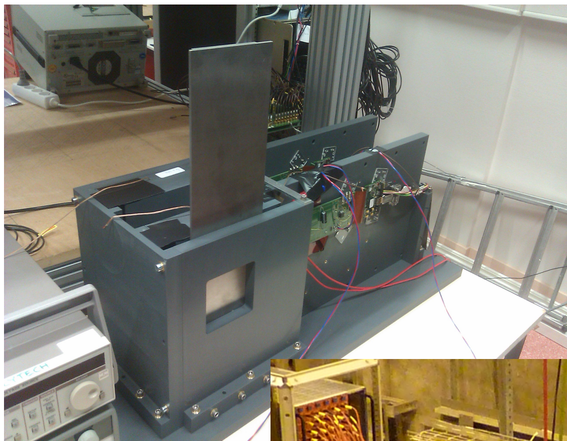
+ No hits in last two layers

16

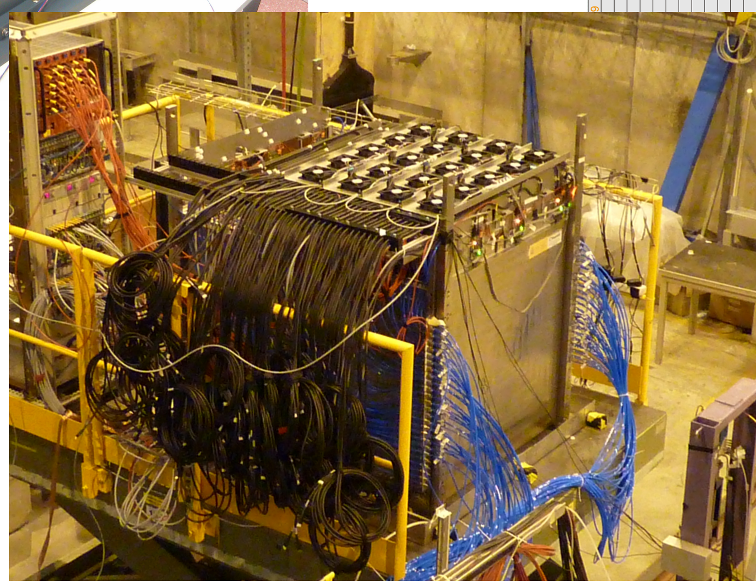


Technological demonstrators

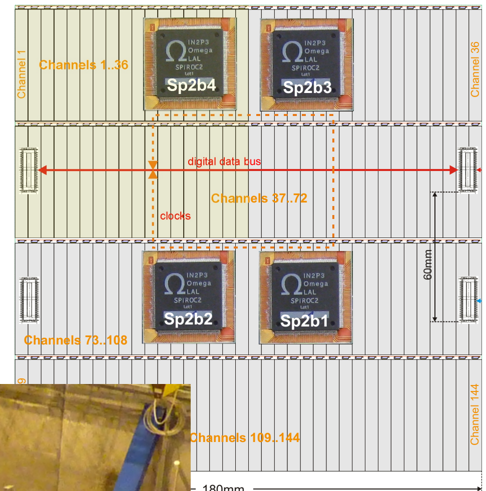
- Solutions found, tests started, different status



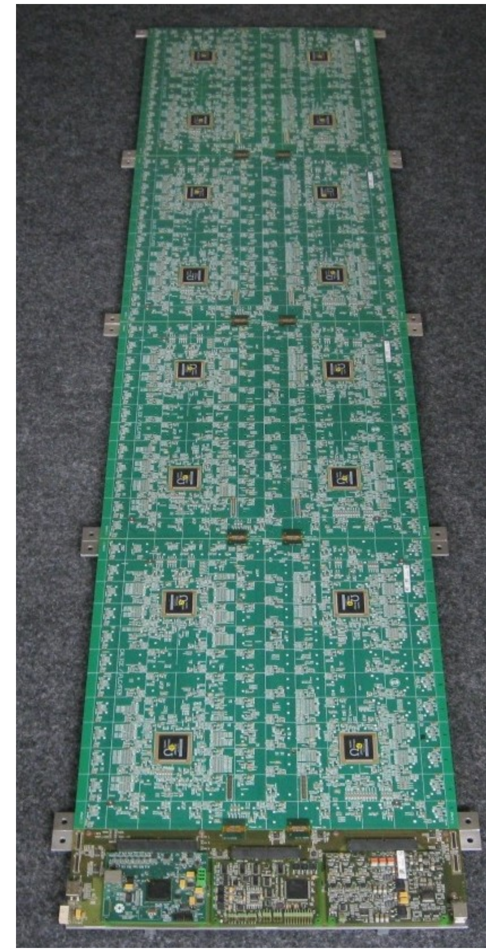
Si ECAL



SDHCAL

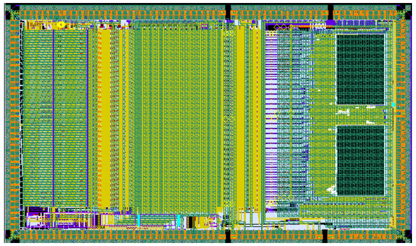


Scint ECAL

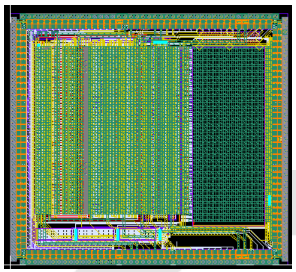


AHCAL

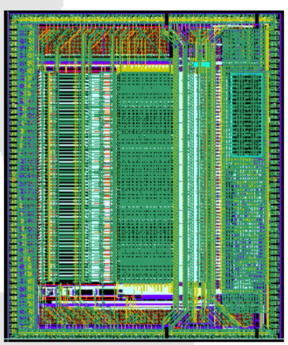
ASICs for ILC prototypes



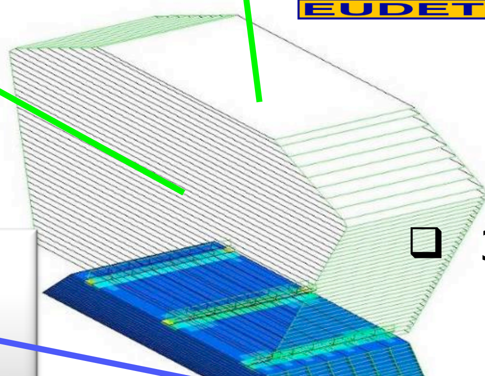
SPIROC2
Analog HCAL (AHCAL)
(SiPM)
36 ch. 32mm²
June 07, June 08, March 10



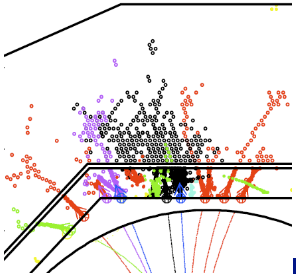
HARDROC2 and MICROROC
Digital HCAL (DHCAL)
(RPC, µmegas or GEMs)
64 ch. 16mm²
Sept 06, June 08, March 10



SKIROC2
ECAL
(Si PIN diode)
64 ch. 70mm²
March 10

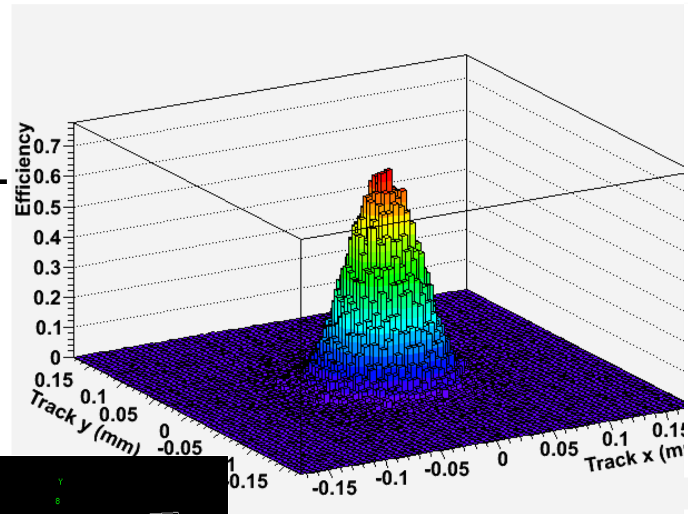


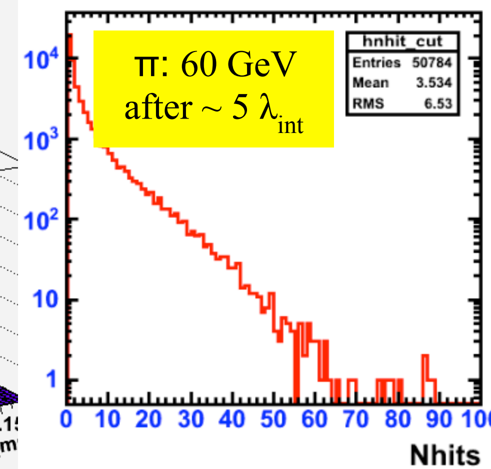
- 1st generation ASICs: FLC-PHY3 and FLC_SiPM (2003) for **physics prototype**
- 2nd generation ASICs: ROC chips for **technological prototypes**
  - ✓ Address integration issues
  - ✓ Auto-trigger, analog storage, internal digitization and token-ring readout
  - ✓ Include power pulsing : <1 % duty cycle
  - ✓ Optimize commonalities within CALICE (readout, DAQ…)
- 3rd generation ASICs (AIDA funded):
  - ✓ **Independent channels to perform Zer suppress**

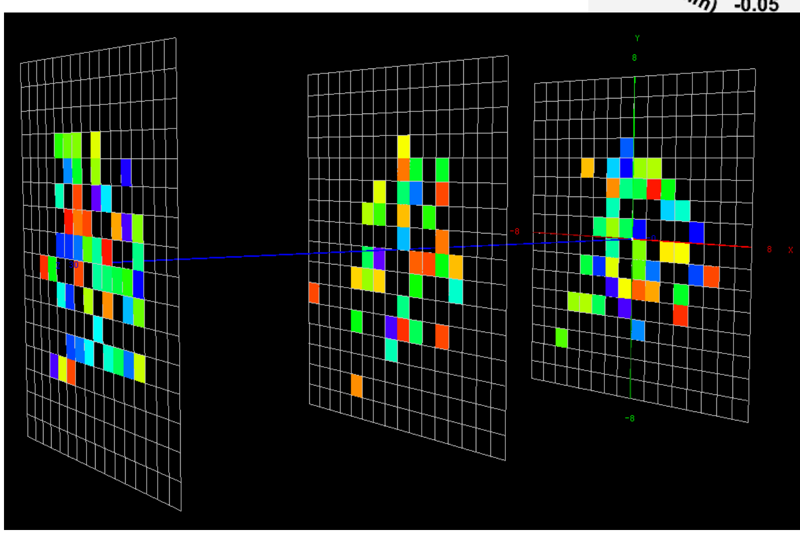


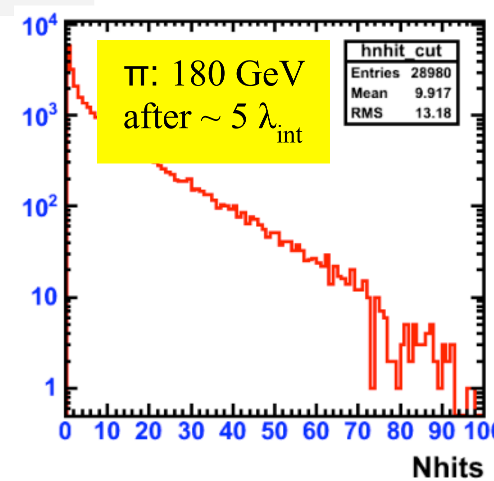
Alternatives

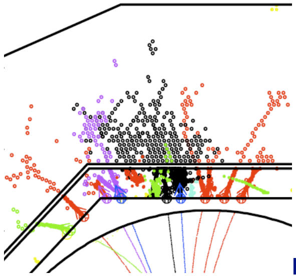
- MAPS DECAL
- GEM DHCAL
- Micromegas SDHCAL
- ongoing beam tests









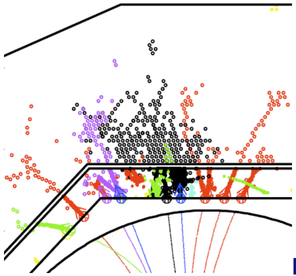


Technologies

- High granularity needs spur the use of novel detection techniques in calorimetry
  - Si pads at large scale, SiPMs, pad RPCs, MPGDs
  - ultra-low power mixed-circuit ASICs are key

- All major technologies have undergone or are undergoing extensive full-scale beam tests
- Si W ECAL and Sci Fe AHCAL analysis nearly complete
- Analysis of the more recent tests has just begun, but all results so far are encouraging and confirm the expectation

- Technological demonstrators of scalable systems start to provide first results
- No show stoppers seen, but more tests are necessary

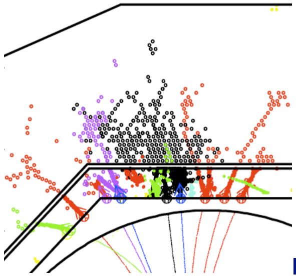


Structure of the DBD

- Extended common calorimeter section (in ILD part)
  - PFA implications on calo design (granularity), roles of ECAL, HCAL
  - ECAL and HCAL system and technology overview
    - explain AHCAL SDHCAL, T and V structure compatibility
    - mention alternatives
  - challenges from high granularity: electronics and integration, readout and DAQ architecture, example ROC schematics
  - explain how results support each other, e.g. power pulsing
  - overview of test beam campaigns, common results (2 particle)

- Si ECAL, Scint ECAL

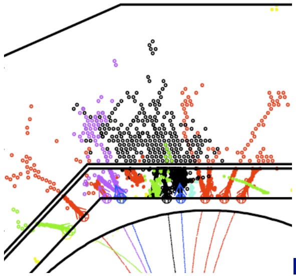
- AHCAL, SDHCAL



Readiness criteria

- **Established performance:** energy resolution, linearity, uniformity, two particle separation
- **Validated simulation:** longitudinal and transverse shower profiles, response, linearity and resolution, for electrons and hadrons
- **Operational experience:** dead channels, noise, stability, monitoring and calibration
- **Scalable technology solutions:** power and heat reduction, low volume interfaces, data reduction, mechanical structures, dead spaces, services and supplies
- **Open R&D issues:** analysis and R&D to be completed before a first pre/production prototype can be built, cost reduction and industrialization issues

- Internal document ready, plan to make public before DBD to IDAG
- **incomplete; remains valid after DBD**
  - e.g.: which features are needed in simulation for reproduction of data
  - hope for some key answers in 2012, but tough
- goal: compare energy and topological performance of candidate technologies for different energy and detector regions



Future plans

- We must fully exploit the existing prototypes
  - more data taking after LS1
- We must fully exploit the existing data
  - physics analysis is involved, but rewarding

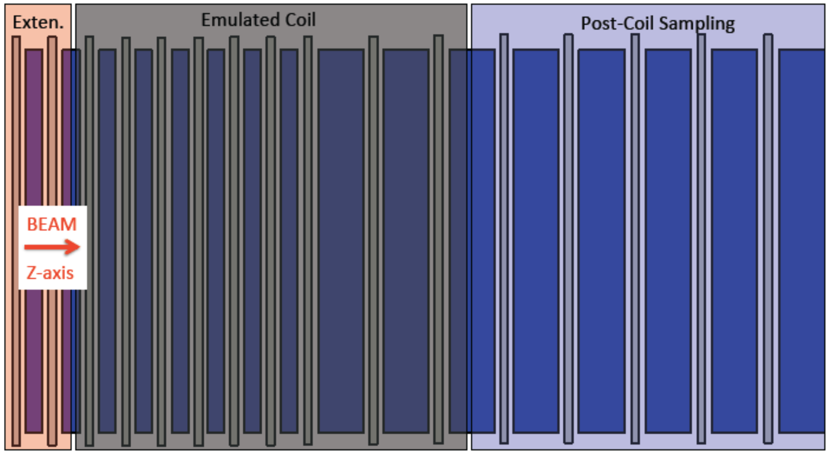
- We must proceed from single or few layer demonstrators to full-scale tests of the integration concepts
- New physics possibilities: 4x finer ECAL, timing in AHCAL

- There is lots to do on system level - powering, cooling, data concentration - before we can proceed to pre-production prototypes (module 0)

Back-up
slides

Containment – use of Tail Catcher

- Tail catcher gives us information about tails of hadronic showers.
- Use ECAL+HCAL+TCMT to emulate the effect of coil by omitting layers in software, assuming shower after coil can be sampled.
- Significant improvement in resolution, especially at higher energies.



2012_JINST_7_P04015

arxiv:1201.1653 (accepted by JINST)