WWS Calorimetry R&D Review: Overview of CALICE

Paul Dauncey, Imperial College London

On behalf of the CALICE Calorimeter for ILC Collaboration

The CALICE Collaboration

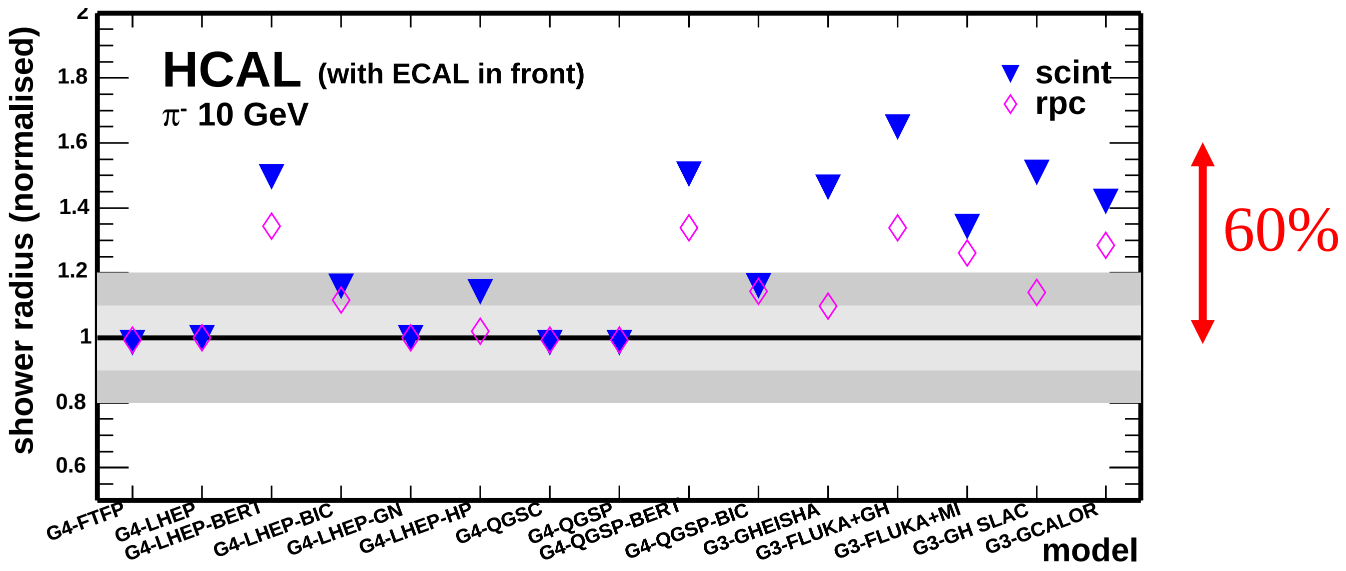
- CALICE is undertaking a major program of calorimetry R&D
  - More than 200 people, 41 institutes, all 3 ILC regions
- The work is directed towards calorimetry optimised for:
  - Particle flow algorithms (PFA)
  - Software compensation (mainly)
  - We consider this the most promising approach
- This choice sets the basics of the calorimeters
  - Requires separation of hadronic jets into individual particle components
  - Optimised calorimetry will have high granularity in transverse and longitudinal directions
  - Need to consider ECAL, HCAL and (outside the solenoid) the “tail catcher” (TCMT) together as an integrated system

CALICE goals

- The aim is to find the "best" calorimeter to deliver the ILC physics requirements
  - Where "best" is in a performance/cost/operability multi-dimension space
  - The space metric is not yet defined; all these variables need to be studied
- The work is not for any specific detector concept group
  - The "best" may be different for each concept
  - Many CALICE members are members of concept groups
  - Our results will be relevant to all groups
  - We have given talks to all three concept groups interested in PFA
  - This is likely to increase now we have beam test results
- Given the limited ILC R&D resources worldwide, we consider it important to make the findings of such a large amount of R&D available to all parts of the ILC community

Simulation uncertainties

- We would like to design optimised calorimeters right now
  - Using simulation of full ILC detectors with physics benchmark channels
  - But simulations of hadronic interactions have significant uncertainties



- An issue for any design optimised using simulation
  - Must compare simulation to real data and find most usable model(s)
  - Must be done with calorimeters close in material terms to proposals

Two major R&D efforts

- Physics prototypes; aims are
  - Use similar converter and sensitive layer technology to proposed calorimeters
  - High statistics beam test data to do detailed comparison with simulation models
  - Get experience of operation and performance
  - Keep as much as possible in common to ease comparison of technologies and reduce R&D cost
- Technical prototypes; aims are
  - Use similar sensitive layer technology, mechanics, readout electronics, cooling, DAQ, etc, to proposed calorimeters
  - Get experience of integration and technical issues of building a full-size, ILC-like module; many such issues are independent of a specific detector concept
  - Run in beam test to understand operation and performance of full module
  - Keep as much as possible in common to ease comparison of technologies and reduce R&D cost
- Outcome will be a reliable simulation and the required information on cost, performance and operational issues
  - This will allow us to proceed with the calorimeter optimisation

Physics prototypes

- Compare two ECALs
  - Silicon-tungsten; analogue diode pads
  - Scintillator-tungsten; analogue, ±WSF, MPPC

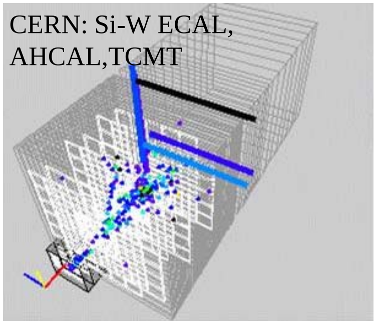
Compare two HCALs (plus variants)

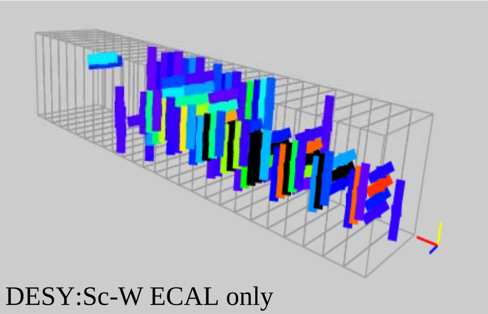
- Scintillator-steel; analogue, WSF, SiPM
- Gas-steel; digital, RPCs/GEMs/Micromegas

- Measure performance of TCMT
  - Scintillator-steel; analogue, WSF, SiPM

Physics prototype common readout

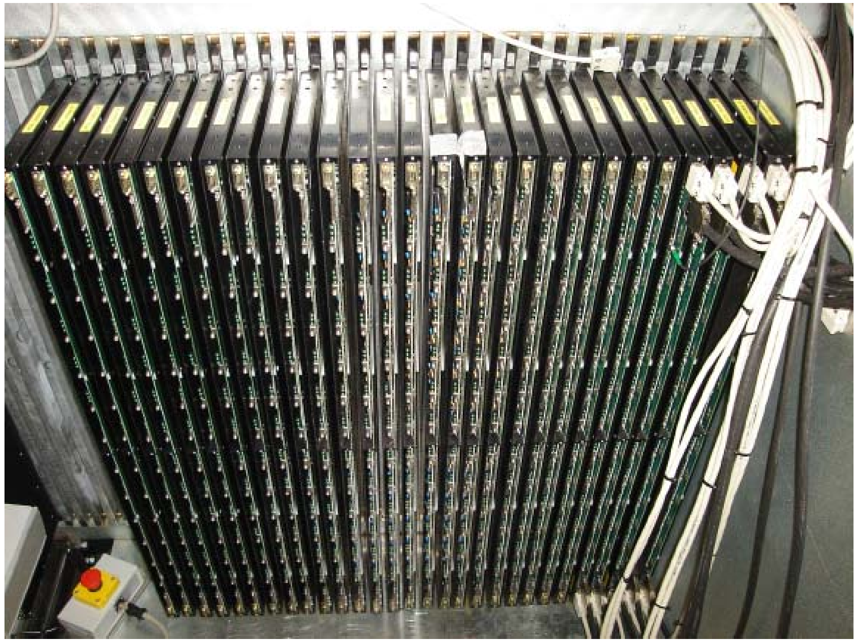
- On-detector readout board
  - Used for all SiPM detectors
- VME readout electronics common in all beam tests so far
  - VME custom boards adaptable to different channel counts





- Online DAQ software system common to all
  - Single format for raw data output
- Offline event reconstruction and analysis format common to all
  - Conversion to LCIO and reconstruction all centralised
  - Grid tools widely used for ease of data distribution and handling over widely dispersed collaboration

Physics prototype common mechanics

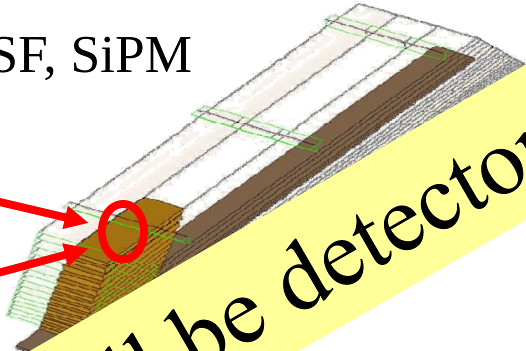


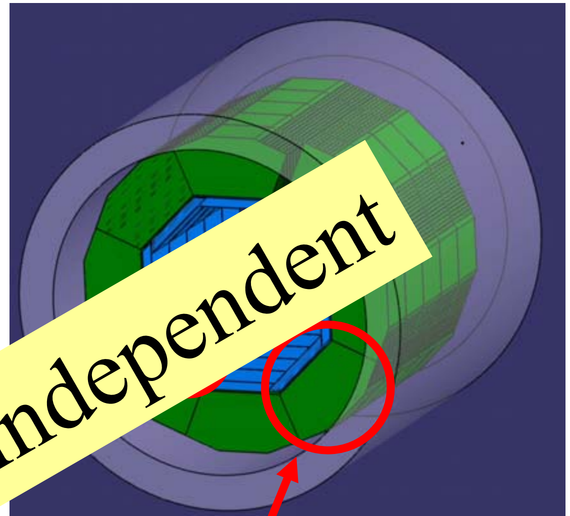
- Converter stack; 38 steel layers
  - Usable by scintillator and all gas HCALs
  - Removes material difference uncertainty in HCAL comparisons

- Movable stage
  - Holds HCAL converter planes and ECAL
  - Manual and computer 3D motion control
  - Allows scan of beam over calorimeter surface for studies of cracks, etc.

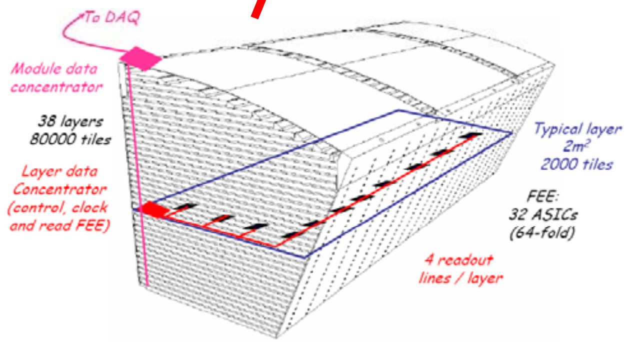
Technical prototypes

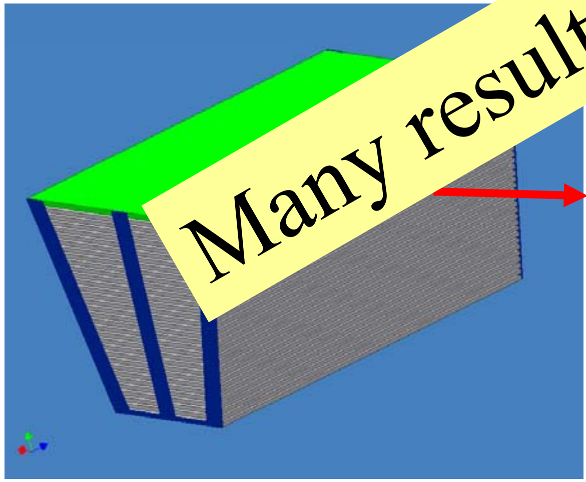
- “LDC-like” modules
  - ECAL; silicon-tungsten; analogue, diode pads and digital, MAPS
  - HCAL; analogue, WLSF, SiPM

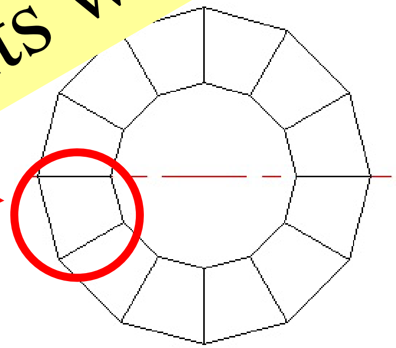




Many results will be detector independent



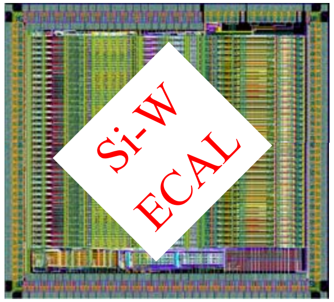


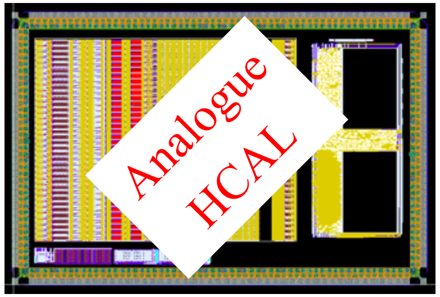


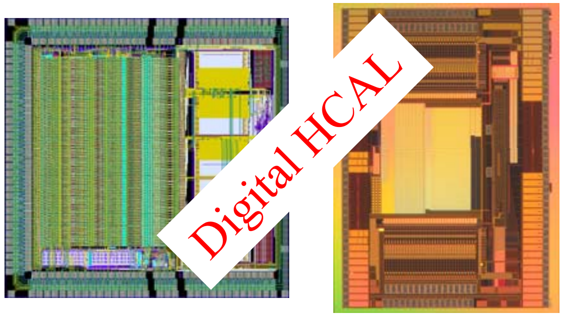
- “SiD-like” module
  - HCAL; digital, RPC/GEMs/micromegas

Technological prototype common items

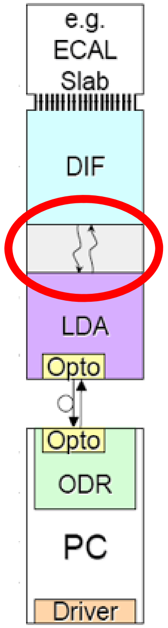
- On-detector readout ASICs; second-generation, ILC-like
  - Being designed with common concept for downstream DAQ







- DAQ and online system
  - Common to all detectors
  - Crateless, non-custom, ILC-like system with readout directly into PCs
  - System-dependences isolated to single interface (LDA-DIF)
- Offline software
  - Again, common and based on LCIO, Grid



The usual questions

- Electromagnetic simulations are accurate; why test ECAL?
  - PFA needs an integrated calorimeter
  - Study performance and operation of ECAL
  - 1/3 of hadronic showers start in the ECAL
- Gas HCALs have a long history; why is R&D needed?
  - Large differences seen in simulation of both scintillator and gas HCALs
  - Recent advances in RPCs; not a matured technology
  - Fine granularity, digital RPCs not used on large scale; PFAs are a new twist
  - GEMs and micromegas are novel for calorimetry
- Muon chambers are "easy"; why test TCMT?
  - Main function is tail catcher rather than muon tagger
  - Exploring and measuring tails is part of calorimeter optimisation
  - Test of application of AHCAL technology to different detector

Stay tuned…

- The following talks will cover all aspects of the CALICE program in more detail
- Physics and/or technical prototypes for each technology
  - Status, results, performance and schedule for each
- Common items used across all technology prototypes
  - Readout electronics
  - Off-detector DAQ and software
- Physics prototype test beam
  - Installation and run performance
  - Preliminary results and comparisons with simulation
- And then…

I'll be back