SiW ECAL

CALICE input for DBD

Daniel Jeans LLR Ecole polytechnique
for the SiW ECAL group

CALICE week – Shinshu University – March 2012

<u>List of criteria</u> (as defined in last CALICE report to PRC)
to form basis of CALICE input to the DBD writers

- 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

Inputs from two sources:

“physics” prototype experience

Performance, validation of simulation, operational experience

“technological” prototype development

Scalable technologies, open issues

Two upcoming beam test periods (March and July)
will provide further input for this section

• Established performance:

energy resolution, linearity, uniformity, two particle separation

• Validated simulation:

longitudinal and transverse shower profiles, response, linearity and resolution, for electrons and hadrons

Input from physics prototype

Linearity and resolution of response to electrons established in test beams

Consistent with predictions of simulation

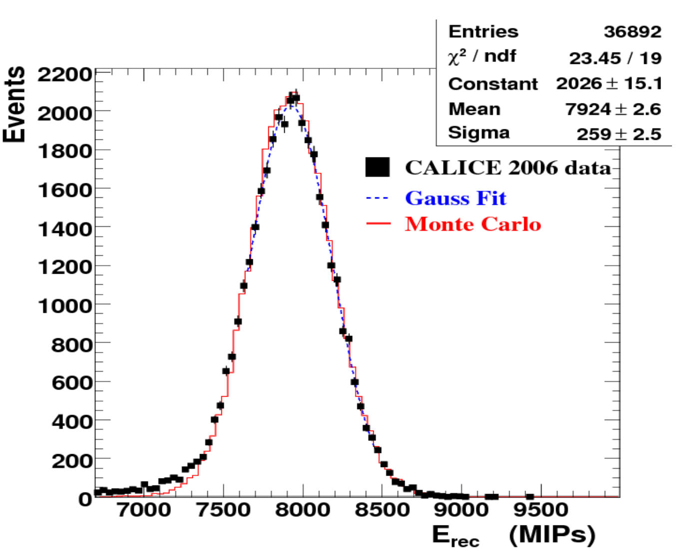
Longitudinal profiles and Molière radius also well described in simulation

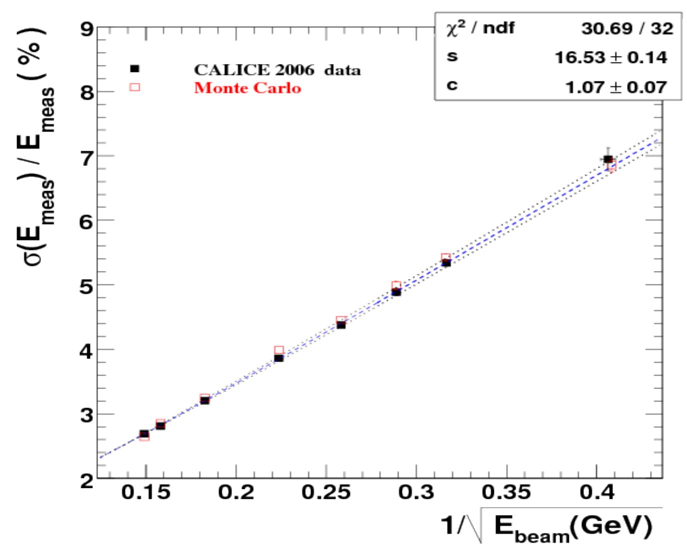
Detailed studies of hadronic interactions in ECAL:

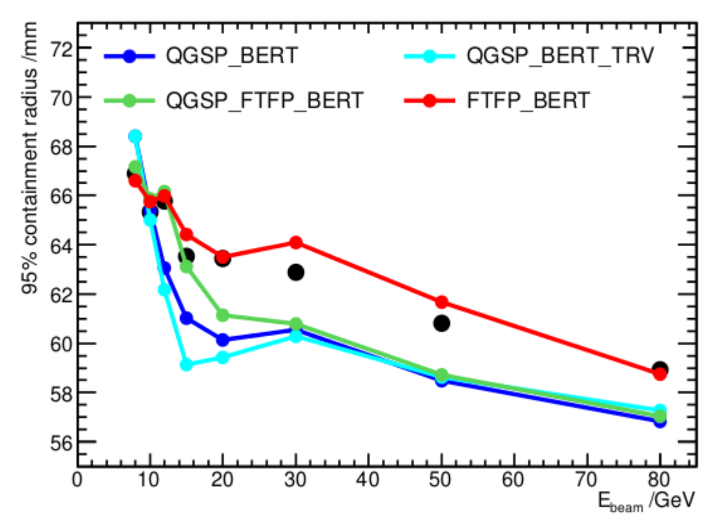
Some GEANT4 models clearly preferred over others,

none describes data perfectly

Overlaying of TB events has tested two-particle separation (ECAL + AHCAL)







• Operational experience:

dead channels, noise, stability, monitoring and calibration

5 years of Physics prototype operation, DESY/CERN/FNAL

Some connectors degrade after many (un)pluggings

No major problems from other sources (e.g. sensor gluing)

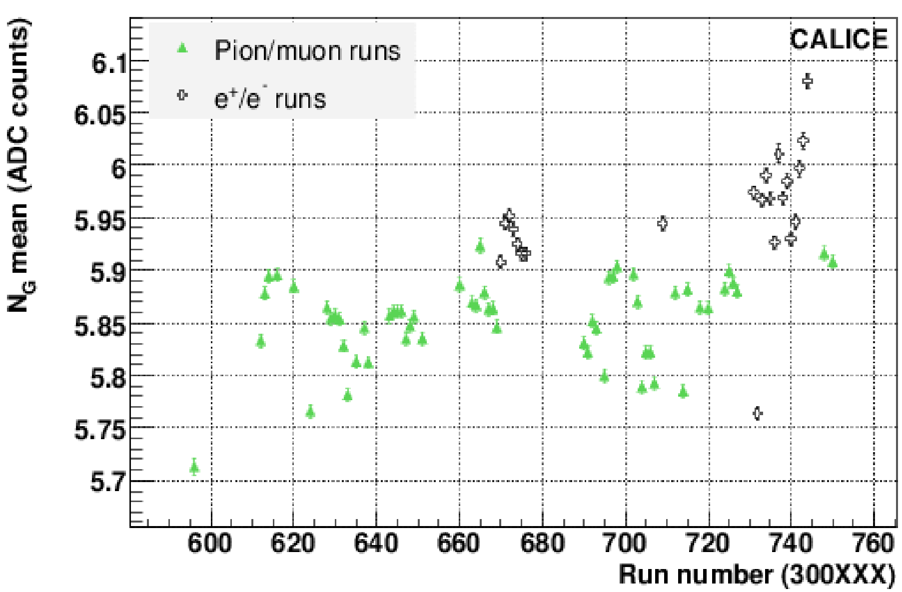
dead channels at per-mille level (not due to known broken connectors etc)

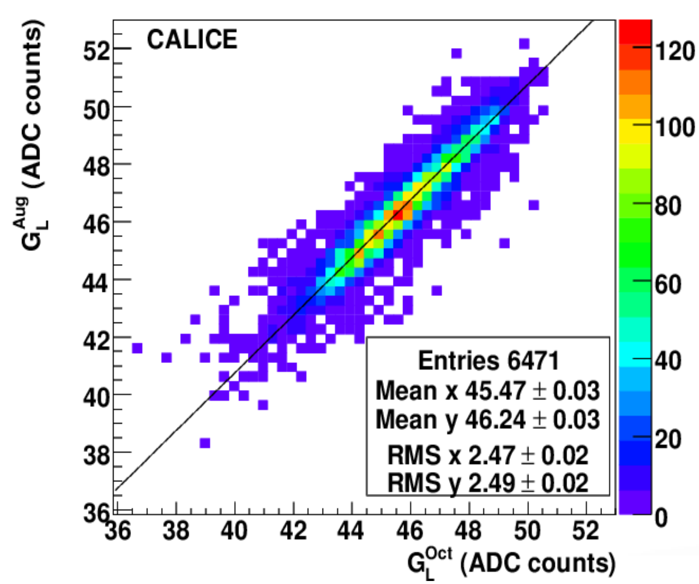
Instrumental effects: guard ring x-talk

Noise manageable: typical Signal/Noise @ MIP ~ 7.5

Some effects due to coherent pedestal shifts

detector calibrations stable over period of years





Documentation for performance, MC validation, operational experience

Published papers

Design and Electronics Commissioning of the Physics Prototype of a Si-W Electromagnetic Calorimeter for the International Linear Collider 2008_JINST_3_P08001

Response of the CALICE Si-W Electromagnetic Calorimeter Physics Prototype to Electrons NIM A608 (2009) 372

Study of the interactions of pions in the CALICE silicon-tungsten calorimeter prototype 2010_JINST_5_P05007

Effects of high-energy particle showers on the embedded front-end electronics of an electromagnetic calorimeter for a future lepton collider NIM A 654 (2011), 97

Additional Calice Analysis Notes

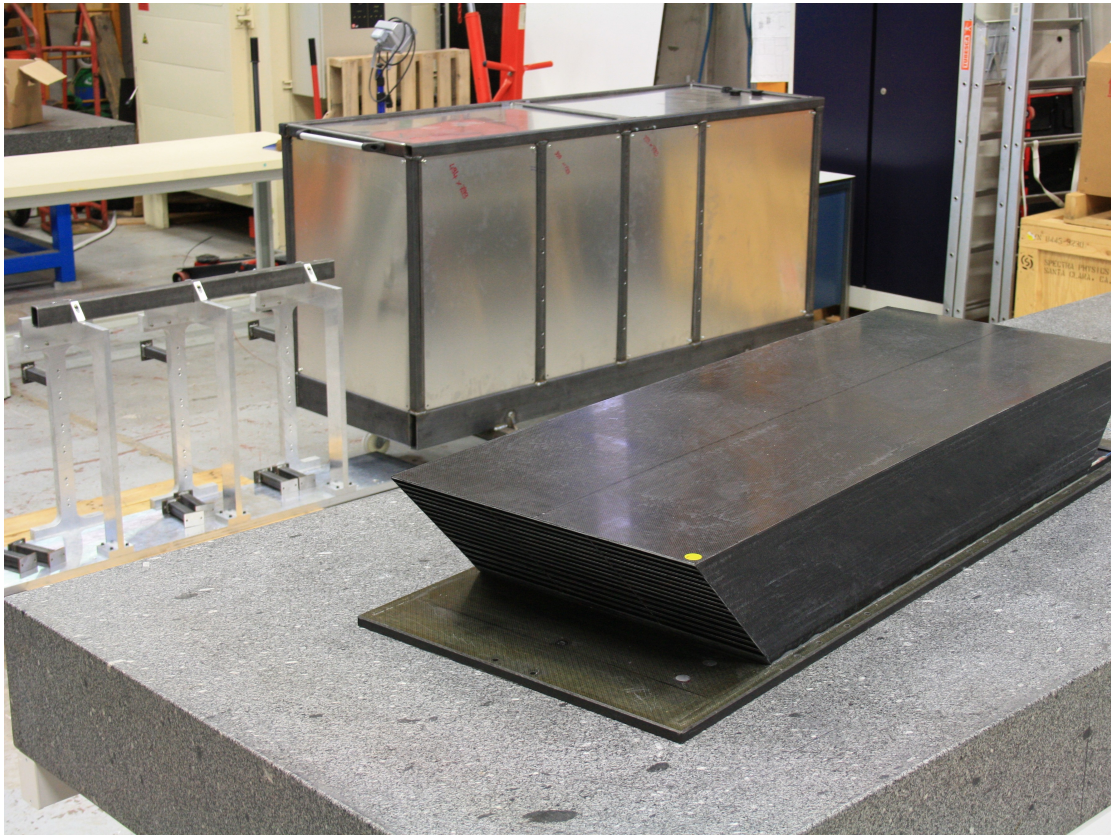
CAN-017.pdf: Study of position and angular resolution for electron showers measured with the electromagnetic SiW prototype

CAN-023a.pdf: Tracking with the CALICE Si-W electromagnetic calorimeter prototype using the Hough transform

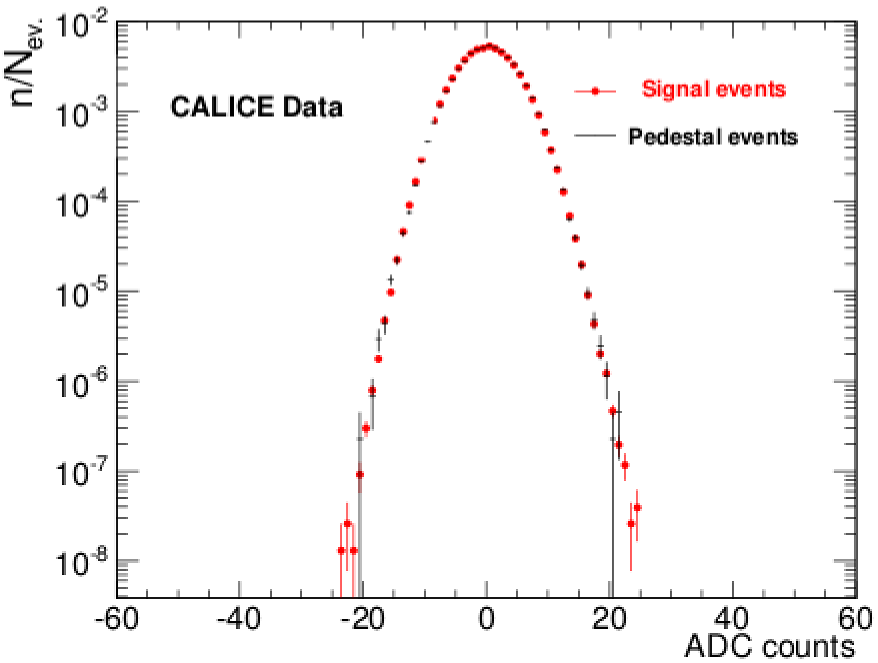
CAN-025.pdf: Interactions of hadrons in the CALICE SiW ECAL prototype

Scalable technologies

being developed for technological prototype,
keeping an eye on industrialisibility



Mechanical composite/W structure,
- suitable for mass production
- First structure completed ~ 2/3 barrel module
- Progress on long endcap structures



Low power FEE
- SKIROC2 available, tested in lab
  - beam-tests March and July
- Power-pulsing not yet tested in SKIROC2
  - power budget not yet verified
  - should have some first results by time of DBD (July tests)
- Insensitivity of FEE to EM showers demonstrated

Silicon sensors

current generation:
- 5mm pixels
- Mitigation of guard ring x-talk
- Understand large-scale production issues

In close contact with Hamamatsu PK on sensor design
- discussions on both technical design (sensor edge, guard ring)
  - and aspects of large-scale production (price, time)

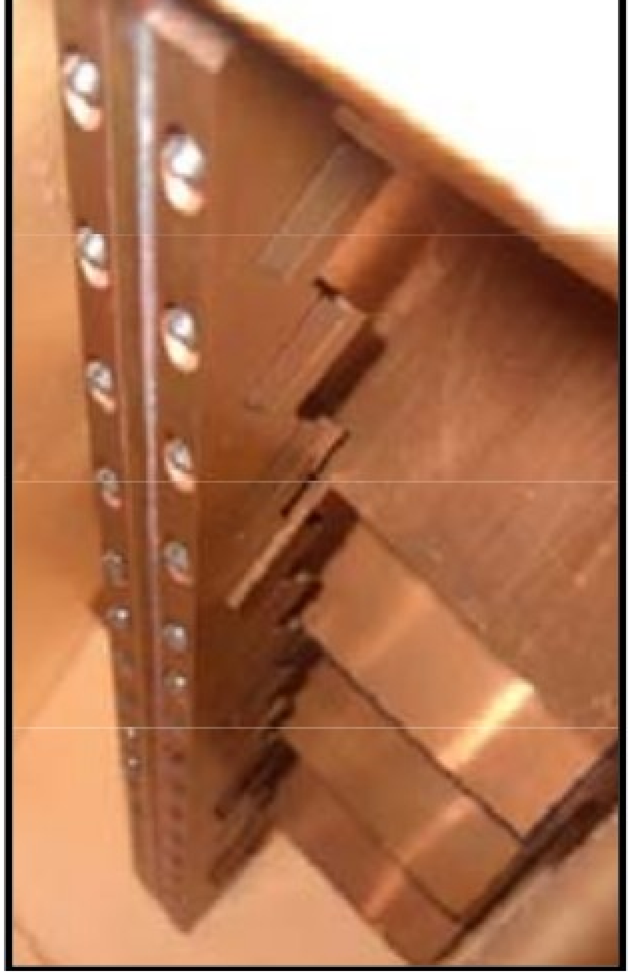
Plan to develop “open” design with technological partner (LETI)
- Will allow use of more generic companies
  - (price advantage?, production capability)

Also small-scale studies on more innovative technology
- e.g. edge-less

Sensors we have OK for basic electrical characteristics
- Tests of particle detection will come this year

Cooling

- Water-based cooling system designed and constructed
- Tests performed on demonstrator module
  - matching simulations developed
- Well developed ideas for extension to ILD

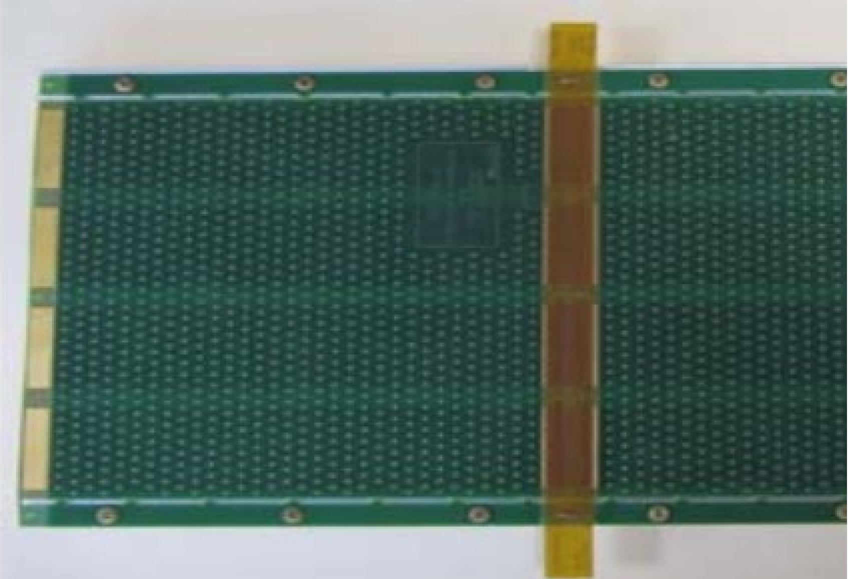


DAQ

- Small-scale (2-ASU) system running stably on test-bench
- Small-/Mid-scale system tested by DBD (March/July tests)

Integration

- Thin, flat ASU (still problematic)
- ASIC wire bonding
- Semi-automised procedure for sensor gluing designed:
  - will be used during 2012
- ASU interconnections well studied and under control



Open issues

Cost
- First cost estimate from HPK for large scale sensor production
- Can move to smaller number of Si layers
  - for a performance penalty → to be quantified for DBD
- Si-scint hybrid studies underway

Power pulsing: operation and power budget

Noise level with dc coupling

Major remaining technological issues
- Sensor guard-ring design
  - - minimise dead zone (simulations suggest not too critical)
  - - reduce x-talk
- Thin, flat PCB
- Endcap mechanics (in particular horizontal alveola)

Operational experience and long term behaviour of new technologies

Keep conservative/back-up options in mind
- less layers
  - thicker PCB
    - packaged asics

fine