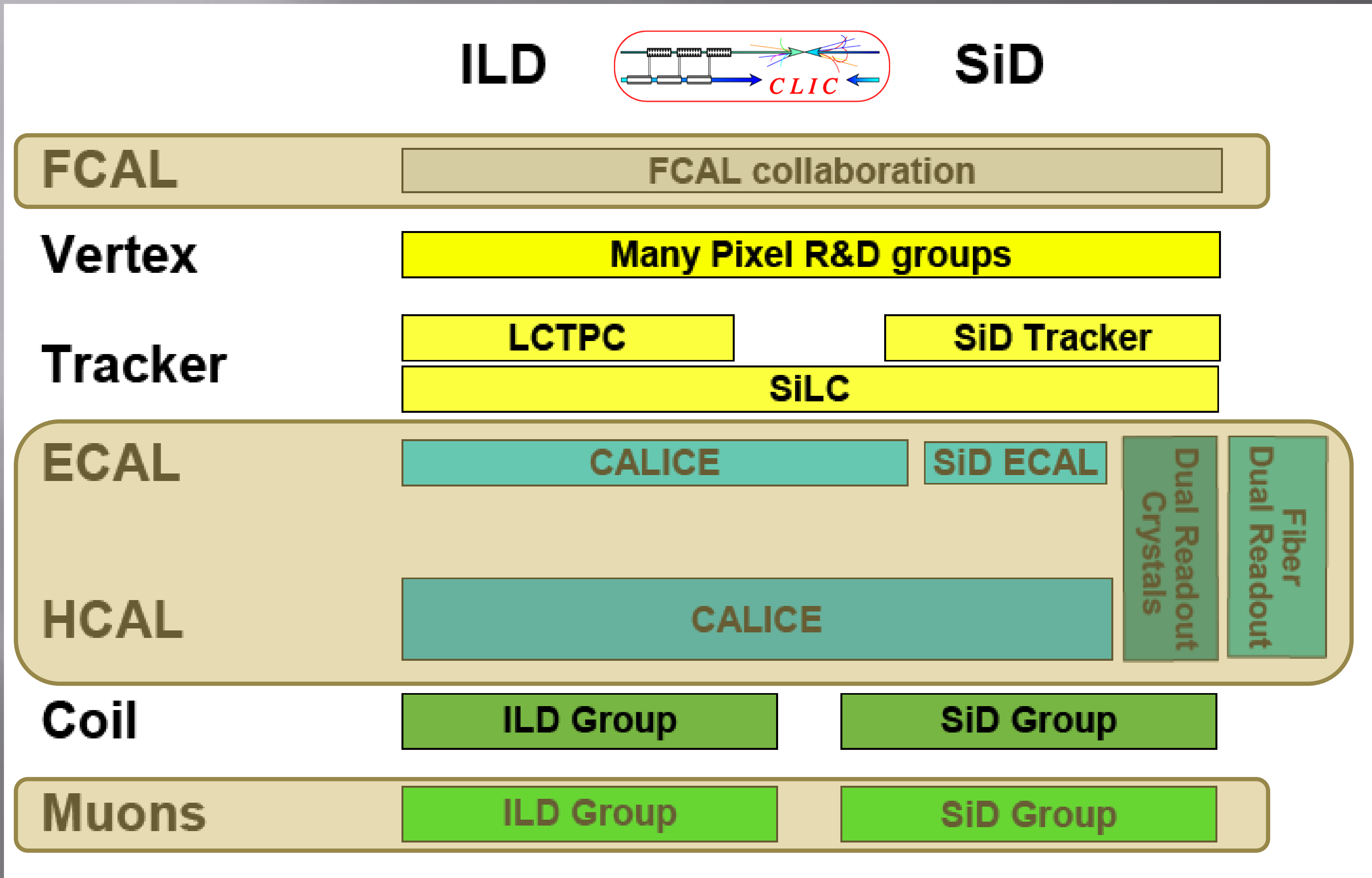
SUMMARY OF CALORIMETER AND MUON SESSIONS

18-22 Oct 2010, IWLC2010 in Geneva

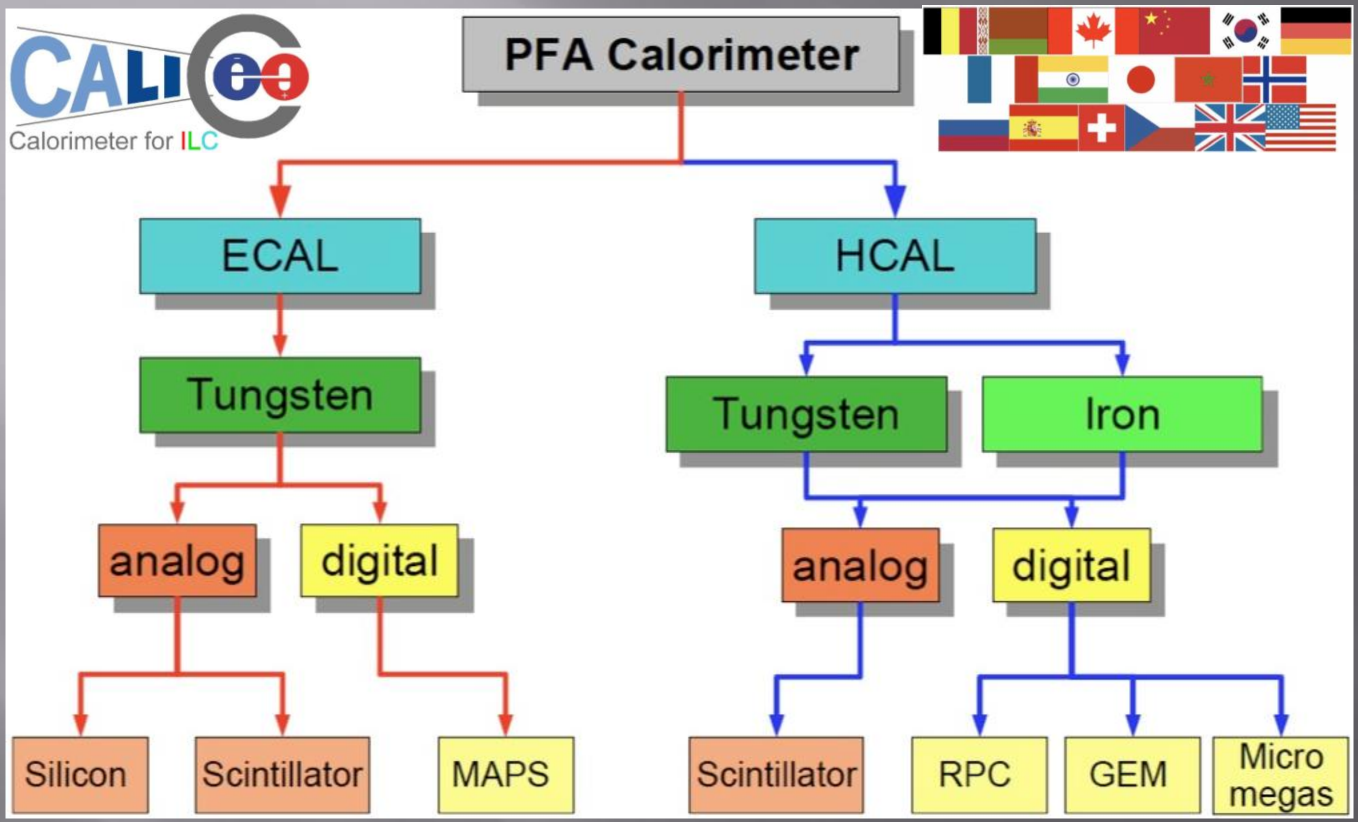
K. Kawagoe / Kobe University

Disclaimer: 27 presentations in 5 sessions on Wednesday/Thursday
& Workshop dinner on Wednesday and OPAL dinner on Thursday
Impossible to cover everything…

Structure of R&D Groups



CAL/Muon R&D groups



FCAL

Muon system

Dual Readout Calorimeter (Crystal/Glass/Fiber)

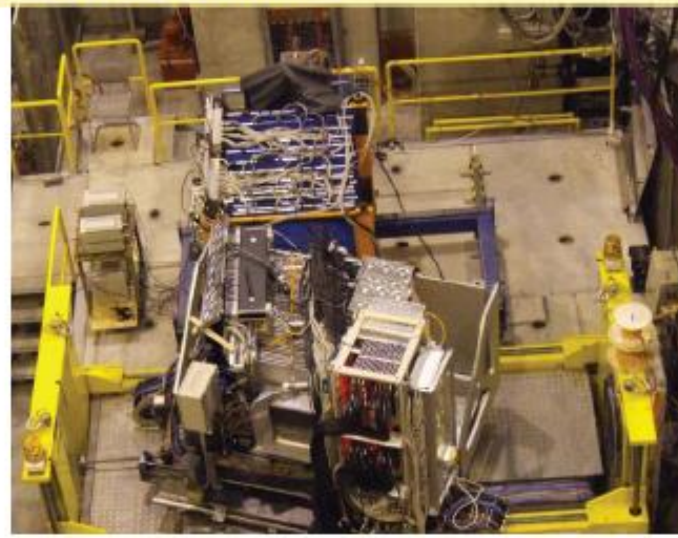
CAlorimeter for LInear Collider Experiments

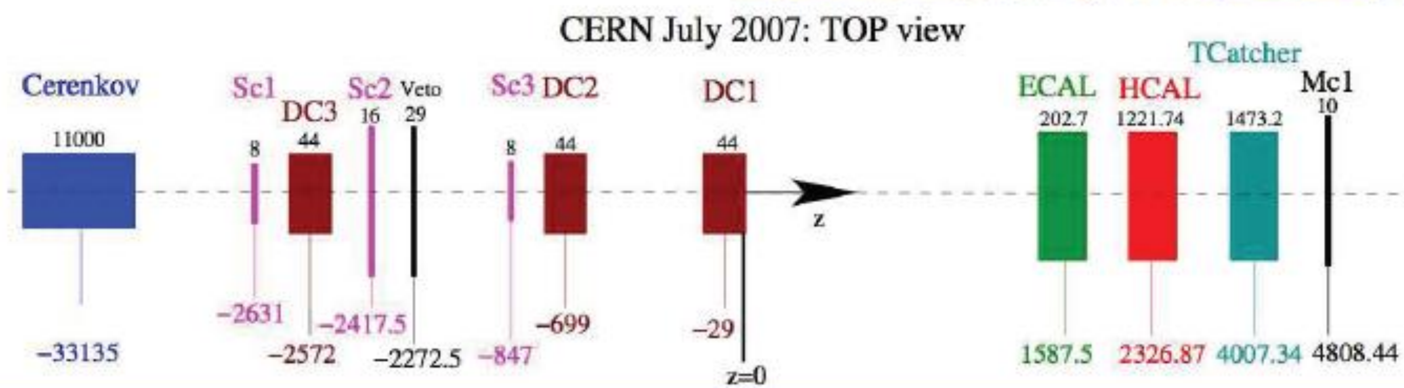
- R&D of highly granular calorimeter for Particle Flow ILC detectors (e.g. ILD and SiD): See also the slides of plenary talks on Monday:
  - R&D on detectors (Jean-Claude Brient)
  - SiD (Andy White)
  - ILD (Henri Videau)
- 17 talks from CALICE in parallel sessions
  - Analysis results of TB data
  - Report on current/future TB activities
  - Technological prototype
  - Study of Tungsten AHCAL

CALICE test beams

CALICE test beams

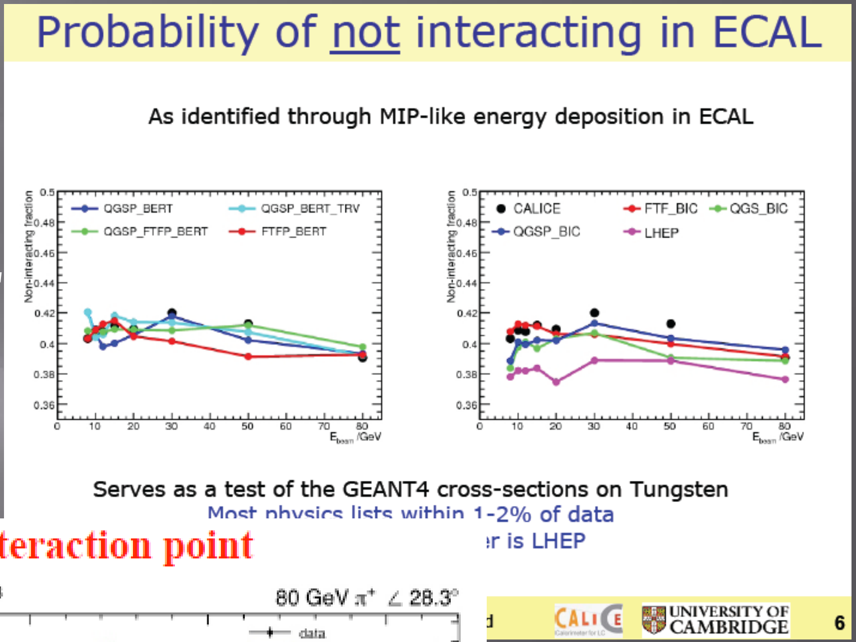
- 2006-2007
  - SiW ECAL+AHCAL+TCMT @ CERN
- 2007
  - Small DHCAL test @ Fermilab
- 2008-2009
  - (SiW/ScW) ECAL + AHCAL + TCMT @ Fermilab

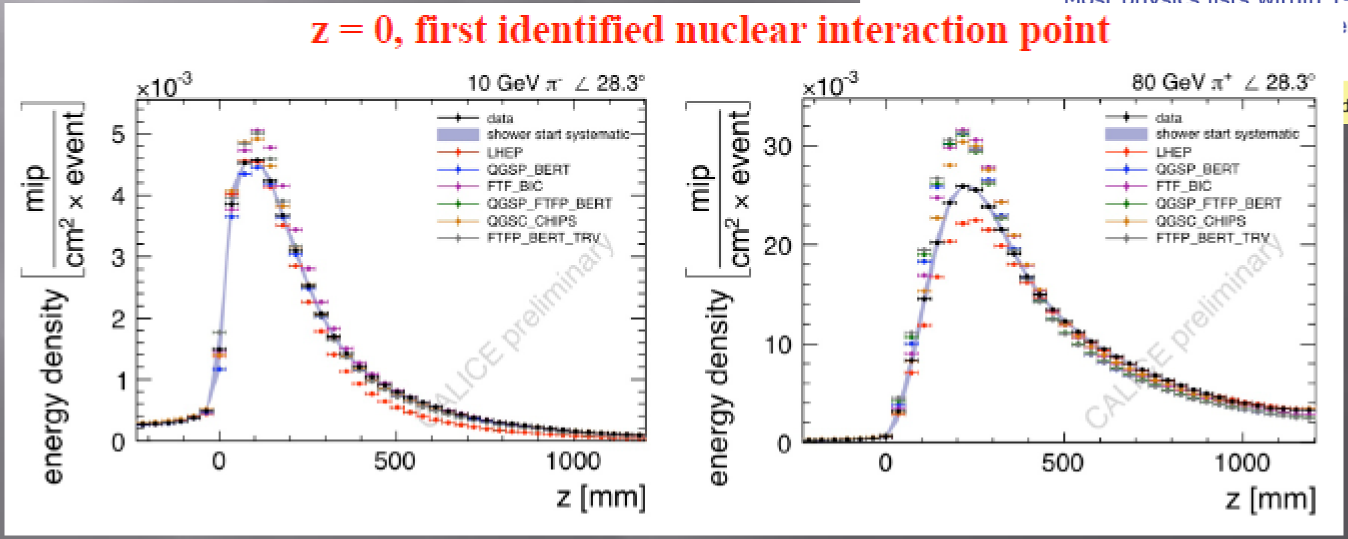




TB results → MC physics models

- Shower profiles are measured and compared with MC of various physics models.
  - Pion interactions in SiW ECAL
  - Pion interactions in AHCAL

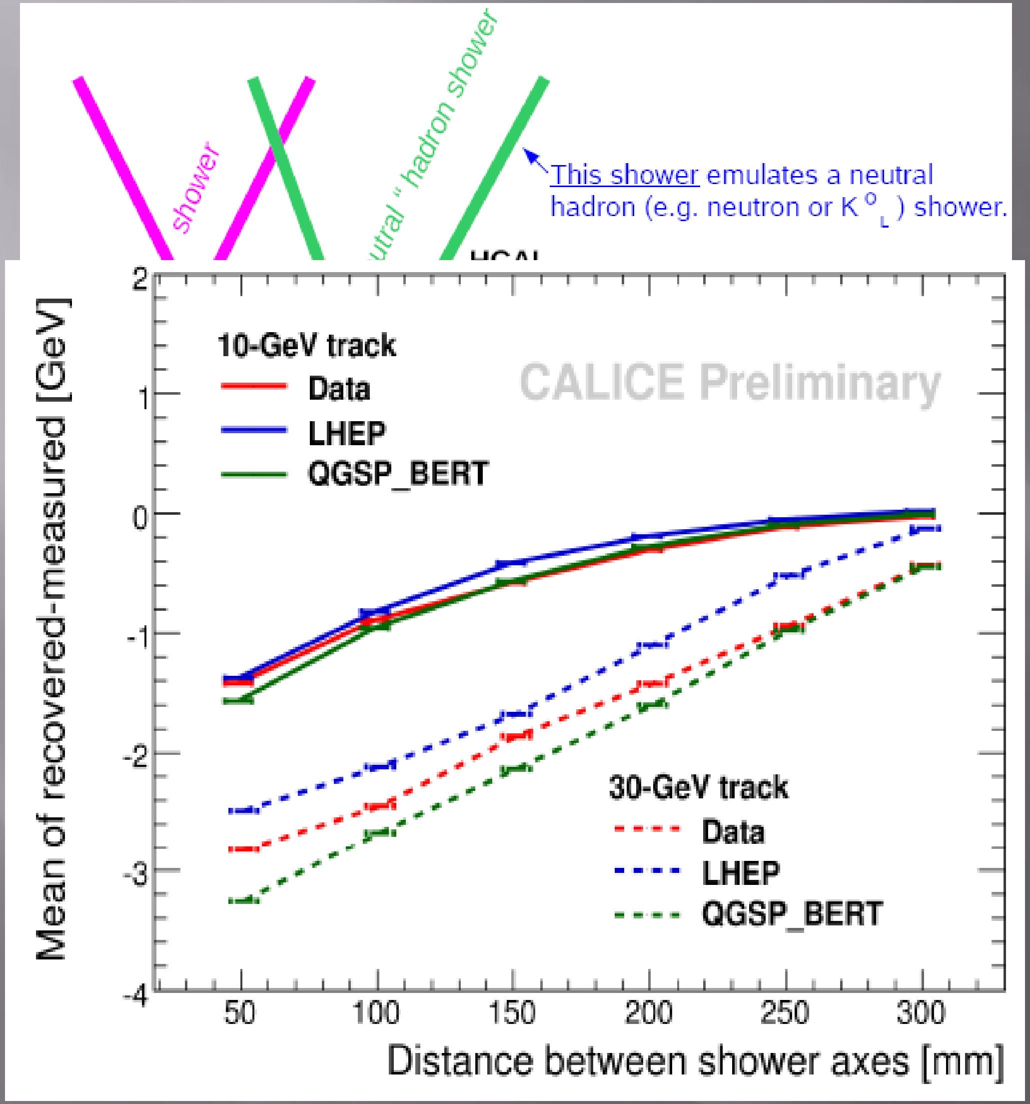




David Ward, Shaujun Lu

CALICE Calorimeter for ILC

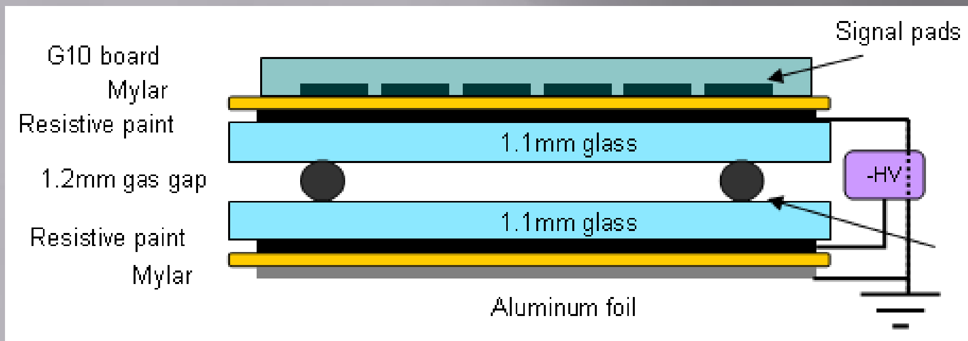
First test of PandraPFA with AHCAL TB data

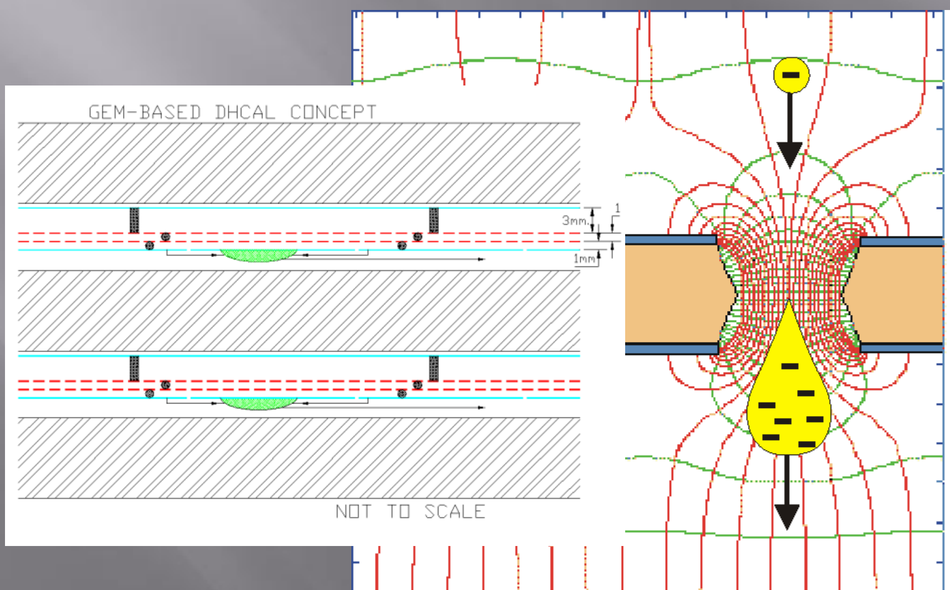


- Two overlaid TB pions are used to test PandraPFA.
- Difference of measured and recovered energies, RMS deviation, and recovery probability are consistent with Geant4 MC.

Oreg Markin

US DHCAL





- RPC DHCAL
  - DHCAL with 38 RPC layers are being tested NOW at MTBF (Fermilab)
  - 2nd round TB scheduled in Jan/Feb 2011.
- GEM DHCAL
  - 30cm x 30cm prototype
  - 30cm x 100cm prototype
  - THGEM/KPiX tested at CERN (RD51)
  - 5 GEM layers of 100cm x 100cm will be tested together with layers of other technology

Harry Weerts, Andy White

DHCAL

CALICE Calorimeter for ILC

Staged Approach--- it took a long time, lot of work

2005- 2006

R&D – RPCs
Measurement of basic performance criteria
Development of specific designs

R&D – Electronic readout
Development of front-end ASIC (DCAL chip)
Development of digital readout system

2007

2008

Vertical Slice Test
Test of concept with small scale calorimeter

0.4 m^2
2560 channels

2009

R&D – RPCs
Design of larger chambers
Gas mixing rack

R&D – Electronic readout
Next iteration of DCAL chip
Improved front-end boards

2010

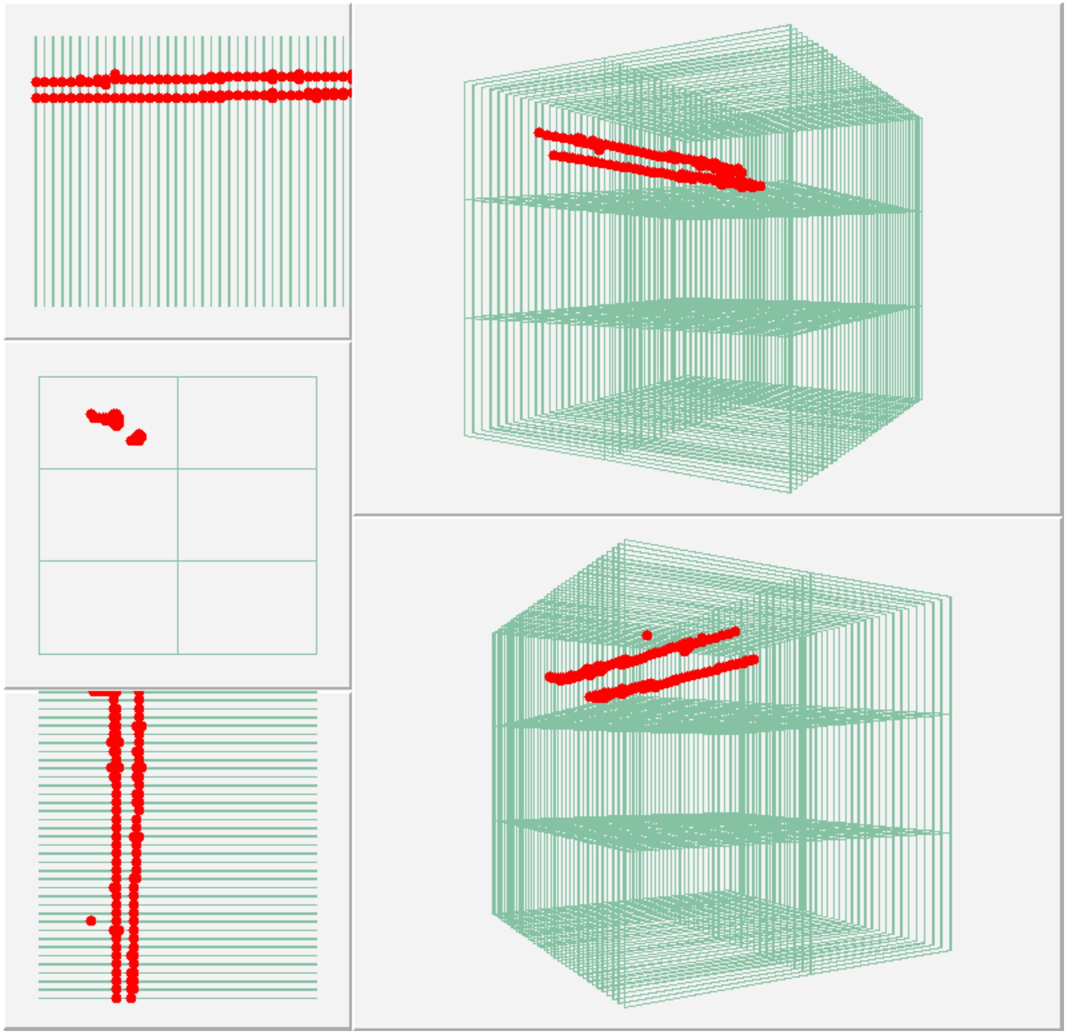
Construct/test
40 m^2
350,000 channels

Physics prototype
Proof of DHCAL concept
Measurement of hadronic showers

Current activity

IWLC2010, October 2010, CERN, H.Weerts 5

32 GeV secondary beam with 3 m beam blocker = muons
NO event selection



4 October start moving hardware to Fermilab

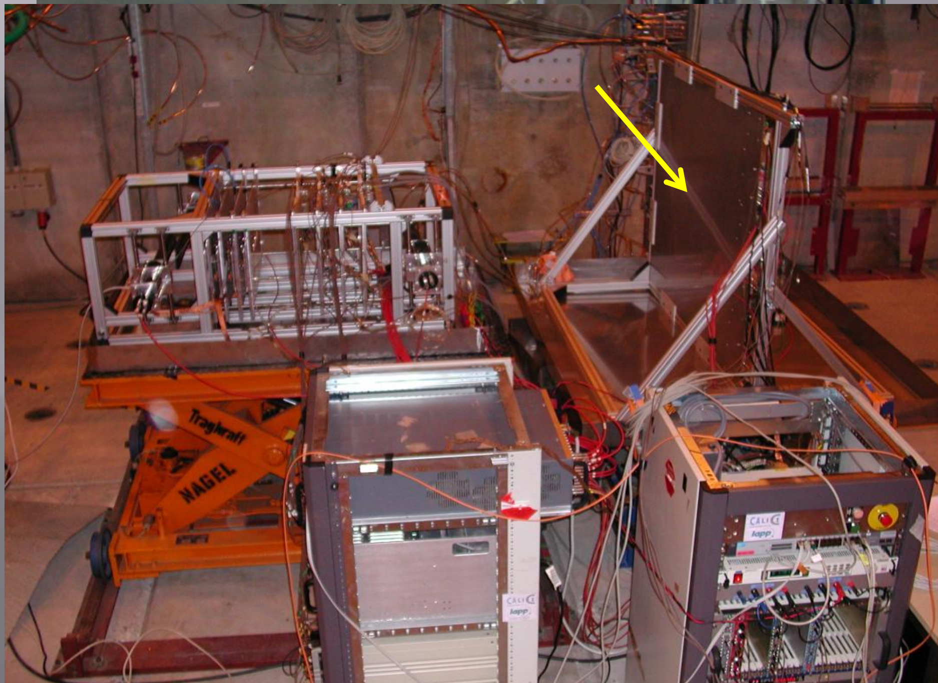
8 October RPCs installed, hook up gas, HV, get permits, start cabling

15 October all cabled up, ready for beam

16 October first noise runs and muons from beam

20 October (today) waiting for hadrons

European DHCAL



- Glass RPC SDHCAL
  - A unit tested at CERN PS T9.
  - Power pulsing readout was tested in 3T B field.
  - 40 layers will be ready in March 2011.
- Micromeagas DHCAL
  - A $1m^2$ prototype produced and tested at CERN PS T9.
  - Several layers will be made with new FE.

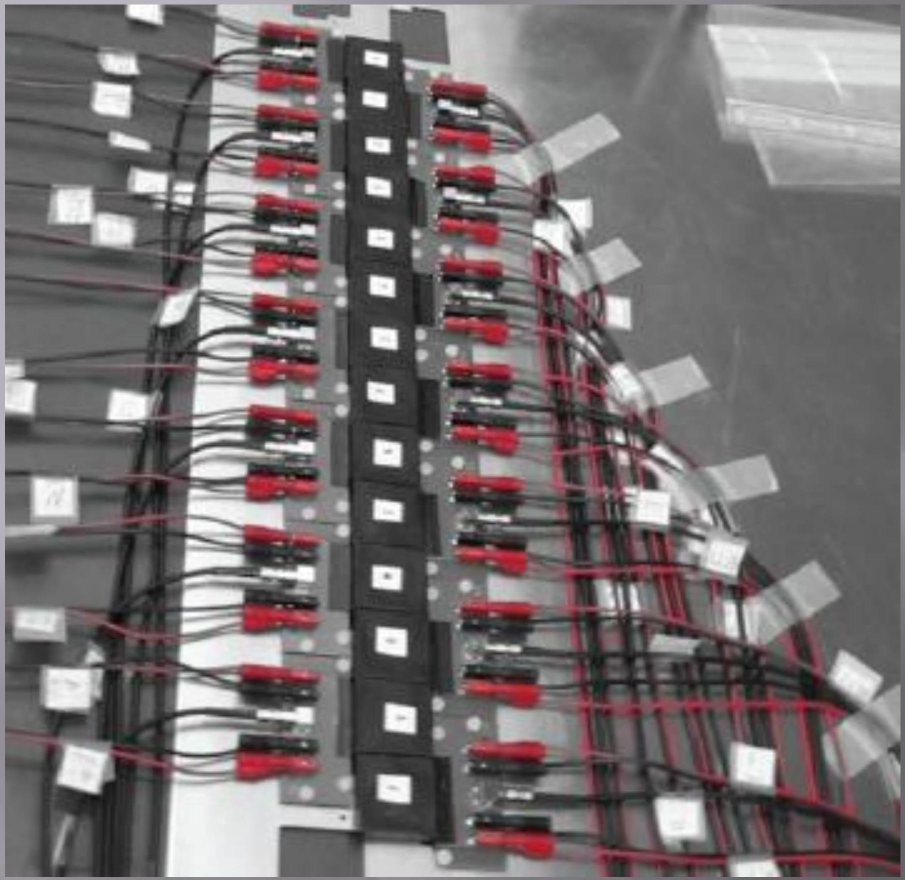
Muriel Vander Donckt
Catherin Juliette Adloff

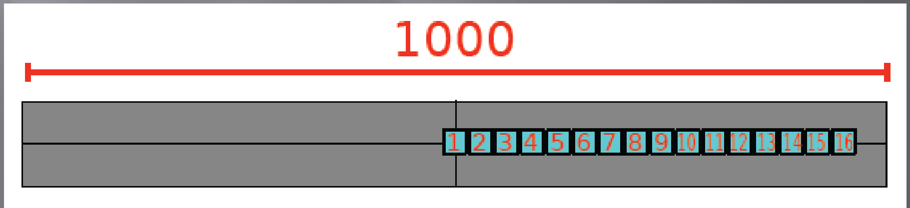
TB of W-AHCAL

Peter Speckmayer, Angela Timoce, Erik van Der Kraaij

- Tungsten is more advantageous absorber than iron at higher energies (e.g. CLIC) .
- Commissioning at CERN-PS from 30th Aug.
  - Existing 30 AHCAL modules inserted in W structure
  - Test of LED system
  - Repair a few modules
- Move to T9 on 3rd Nov.
- TB starts on 6th Nov.

Tungsten Timing Test Beam (T3B)





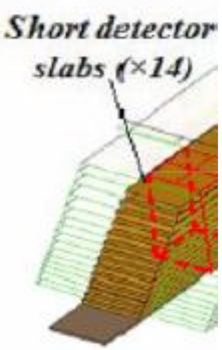
- Time resolution may be important at CLIC: High hadron background combined with 2 GHz bunch crossing frequency
- Goal: Measure the time structure of the signal within hadron showers in a Tungsten calorimeter with scintillator readout
- Use a (very) small number of scintillator cells, read those out with high time resolution
- Record signal over long time window: ~ 2 µs to sample the full shower development

Next generation prototypes

The technological AHCAL prototype

Devel

Tec
P



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Mark

Daniel Jeans

IW

Integration tests

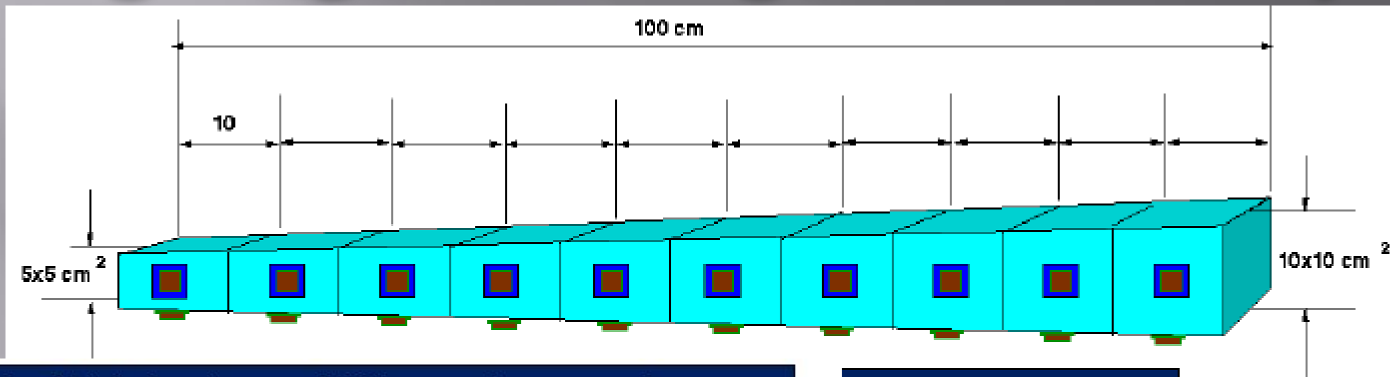
- Systems available @ UCL, LLR and now Cambridge
- Whole chain established :
  DAQ PC with ODR ⇔ LDA ⇔ DIF and CCC source
- Multiple 10 DIF ⇔ LDA links established
- FastTrig and Busy signals functional.

Vincent.Boudry@in2p3.fr 2nd gen CALICE DAQ | IWLC2010 | CICG, Geneva, 29/09/2010 16/24

Dual Readout Calorimeters

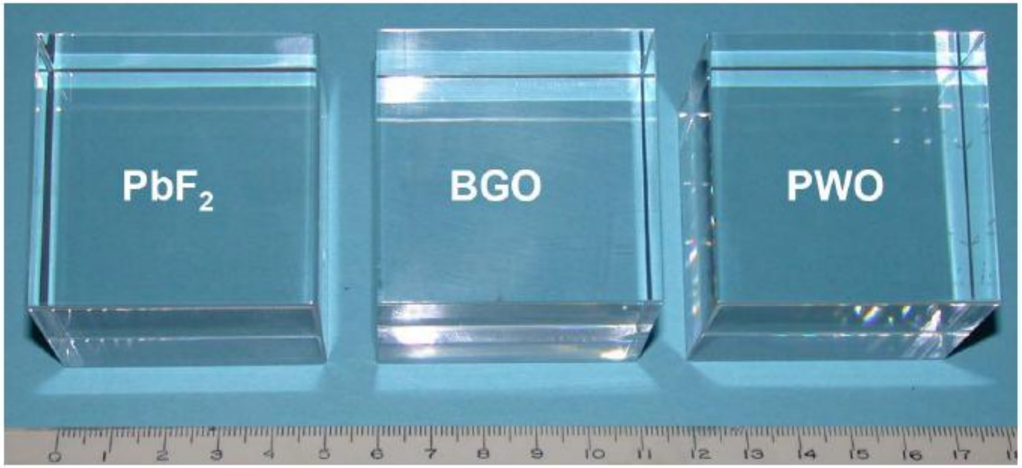
- Completely different approach from PFA, to aim for excellent jet energy resolution.
- Measure scintillation and Cherenkov lights individually to evaluate the electromagnetic component in hadronic shower.
- Several groups working on this idea
  - DREAM Calorimeter (4^{th} detector concept)
  - Homogeneous HCAL with Crystal
  - Dual Readout with Meta-crystal
  - ADRIANO in TWICE Collaboration (cancelled)

Homogeneous HCAL with longituginal-segmented crystal

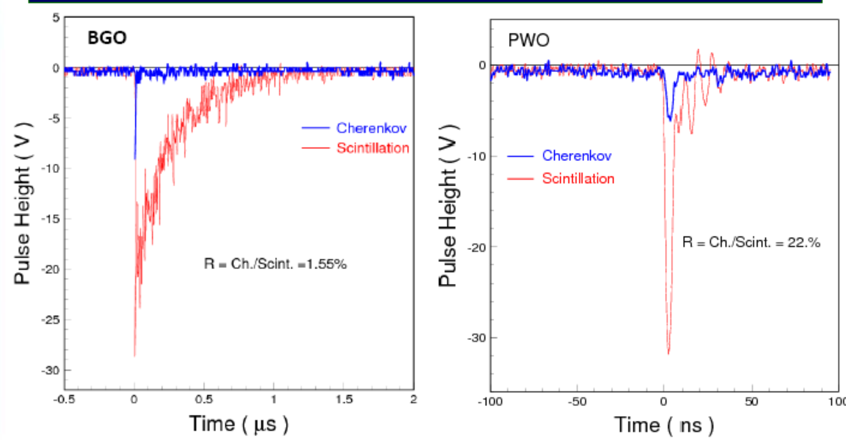


ith pointing geometry

Crystals of high density, good UV transmittance and some scintillation light, not necessary bright and fast, are required. The volume needed is 70 to 100 m^3: cost-effective material. Following 2/19/08 workshop at SICCAS, 5 x 5 x 5 cm samples evaluated.



1.6% for BGO and 22% for PWO with UG11/GG400 filter and R2059 PMT, which is configuration dependent.



Ren-yuan Zhu

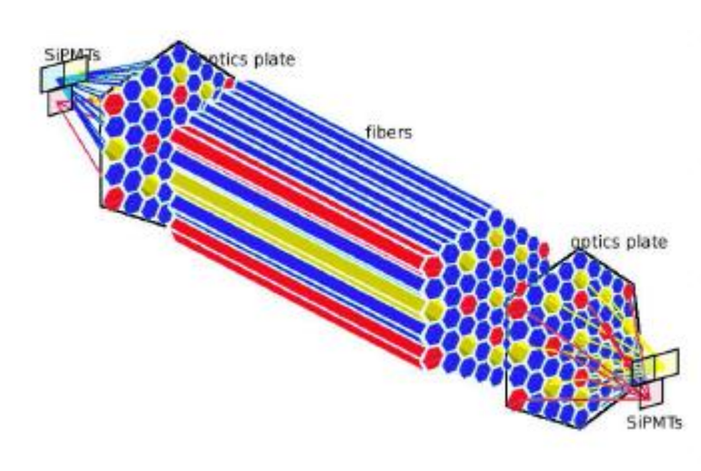
Dual readout with metacrystals

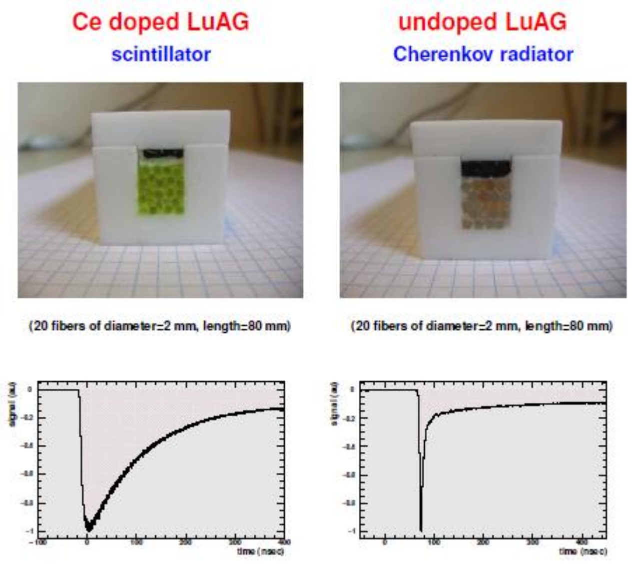
► · **the meta-crystals concept**

: use of both **undoped** and ***Ce doped*** heavy crystal fibers of identical material. The undoped crystals behave as **Cherenkov radiators** while the doped crystals behave as ***scintillators***

: a candidate material is the Lutetium Aluminium Garnet (LuAG) crystal ($Lu_3Al_5O_{12}$)

Physical properties		Optical properties	
Density	6.73 gr/cm^3	Light yield (Ce doped)	25000 ph/MeV (50% of NaI)
Zeff	62.9	Emission wavelength	535 nm (Ce doped)
Radiation length X_0	1.41 cm	Decay time	60 nsec (Ce doped)
Interaction length λ_I	23.3 cm	Refractive index	1.842 at 633 nm
Melting point	2260 °C	Cherenkov threshold	97 keV
Thermal expansion	8.8 10^{-6}/°C	Max Cherenkov angle	57 °
Thermal conductivity	31 W/m°C	Total reflection angle	33 °



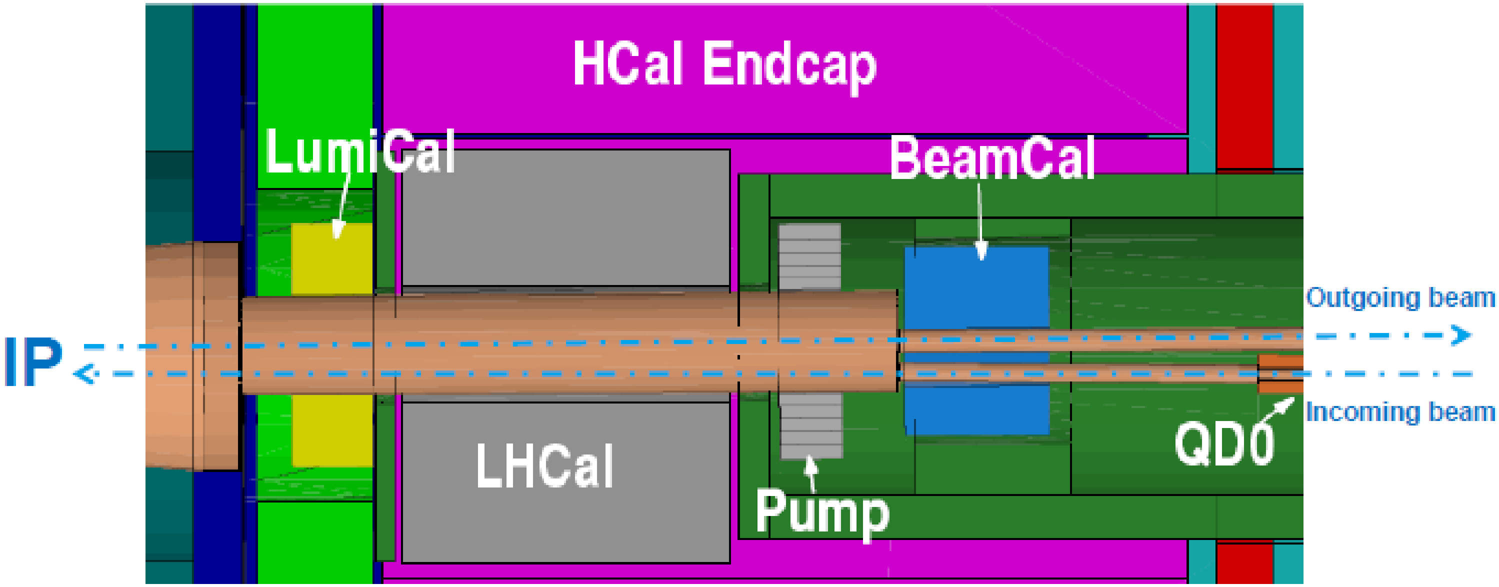


- Material development
- Test beam of small prototype
- Simulation studies

Georgios Mavromanolakis

Forward Calorimeters

Forward Region

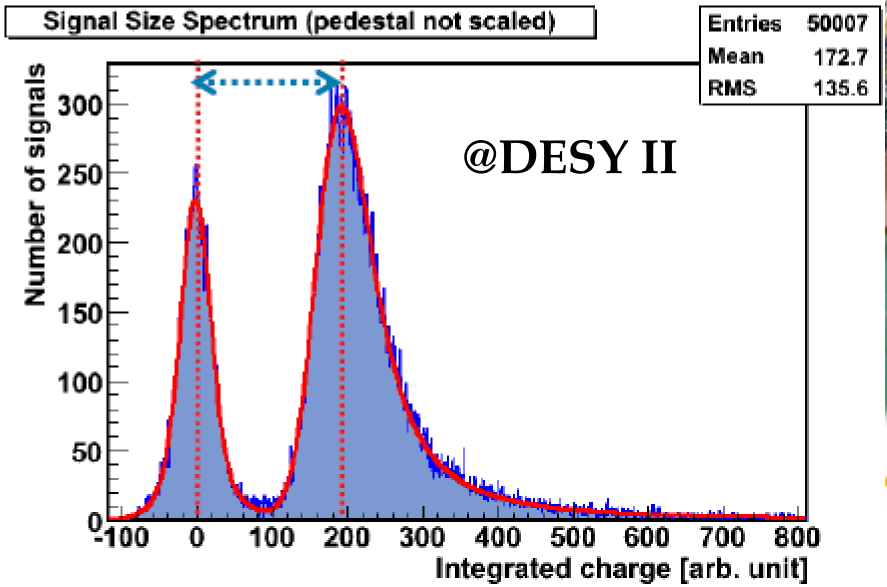


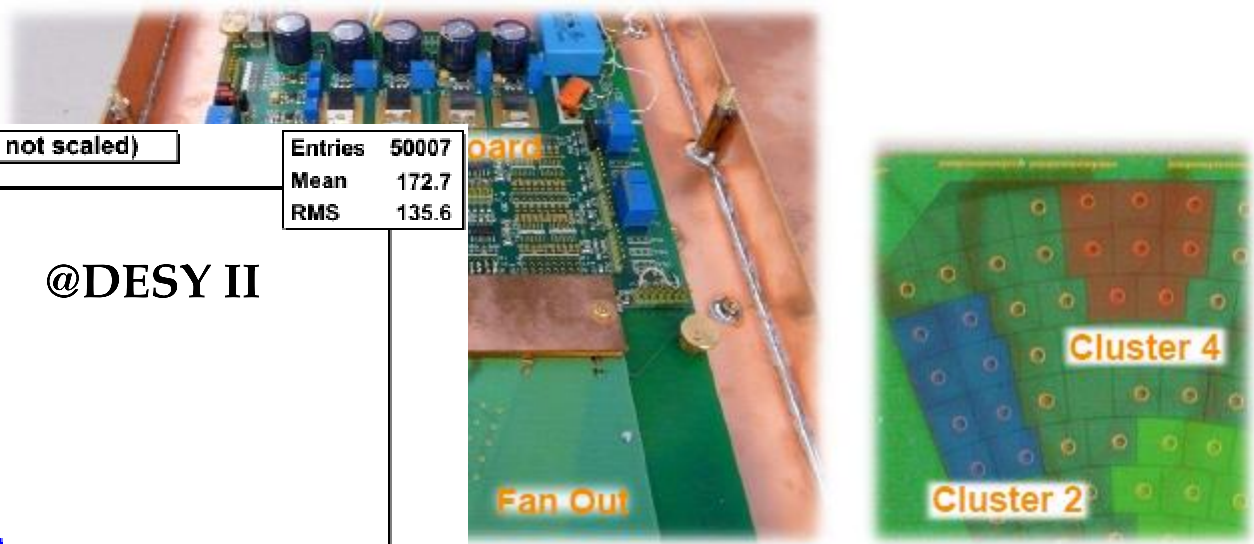
Precise luminosity measurement,
Hermeticity (electron detection at low polar angles),
Assisting beam tuning (fast feedback of BeamCal data to machine)

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

Olga Novgorodova | IWLC2010 | Geneva, 18-22 October 2010 | Page 3

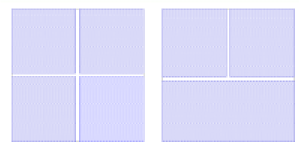
First TB studies of GaAs sensor for Beamcal



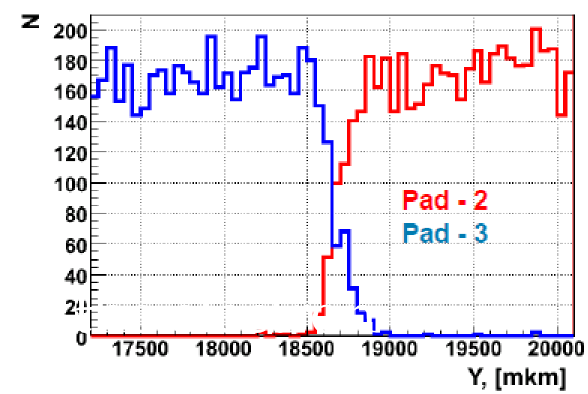


Al window

	All Channels
CCE	23-34%
S/N	6-12
HV	60V



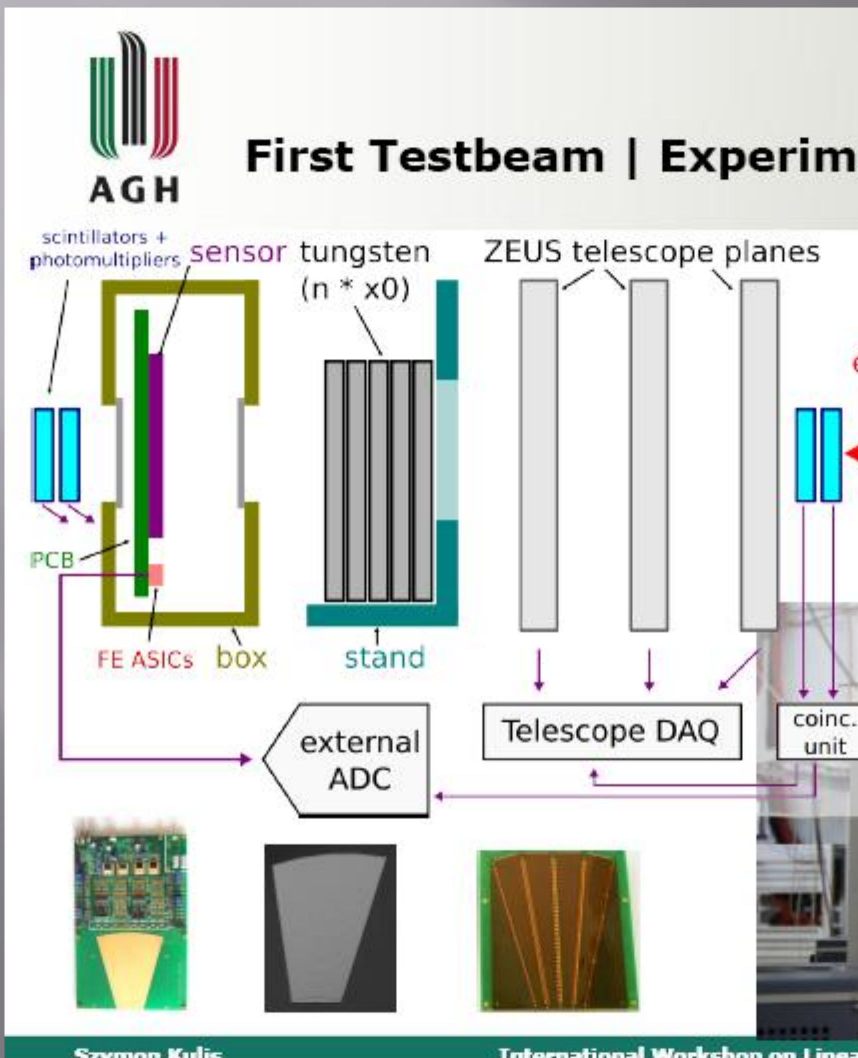
- Pad's gaps 0.2 mm
- 50 µm bin
- Charge Sharing in 4 Edge case

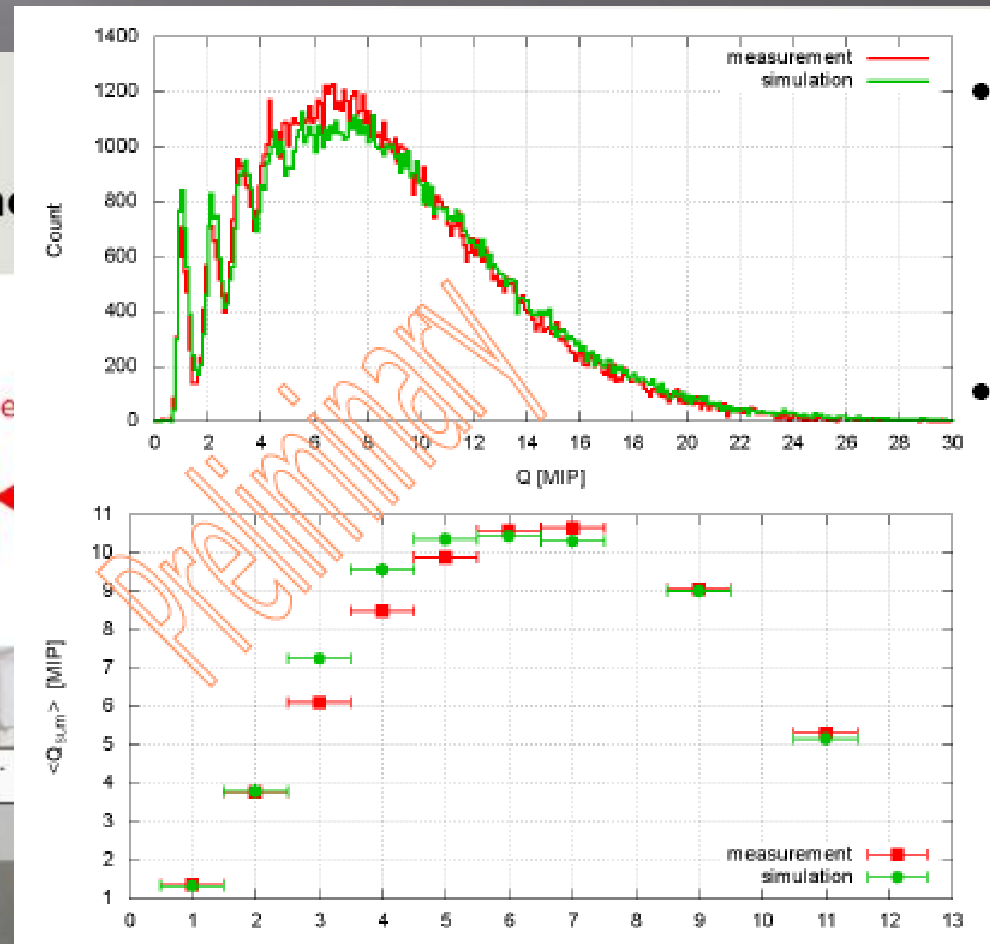


Olga Novgorodova | IWLC2010 | Geneva, 18-22 October 2010 | Page 11

Orga Novgorodova

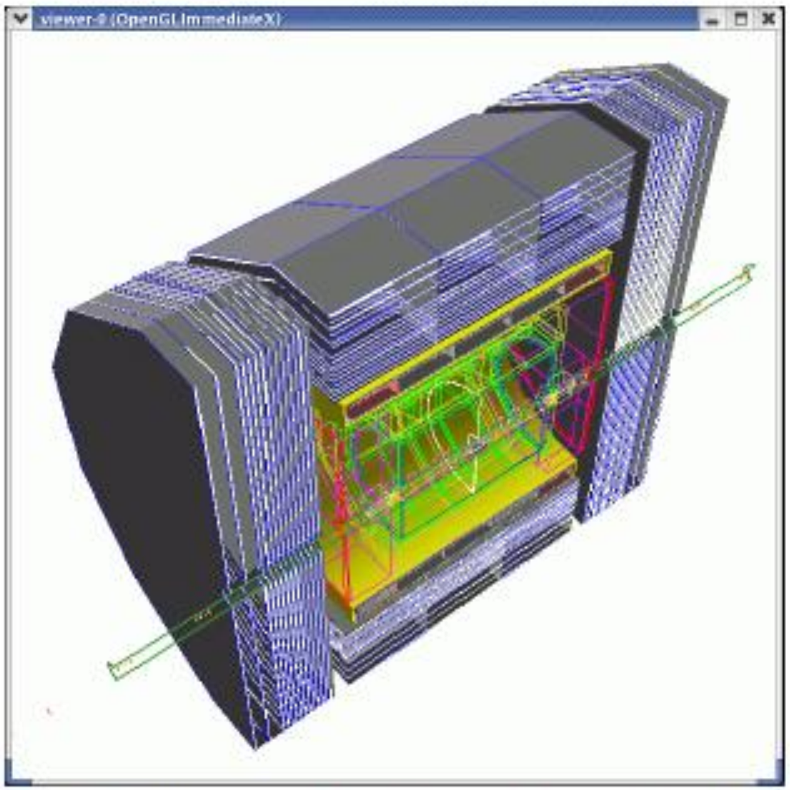
First TB of Si sensors for Lumical



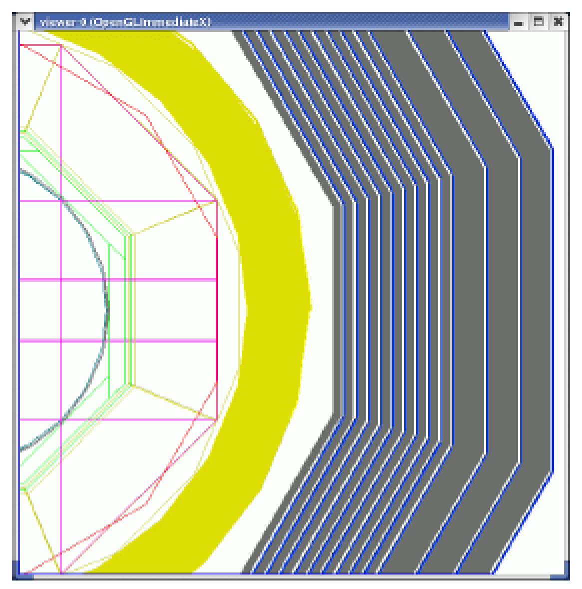


Szymon Kulis

Muon system

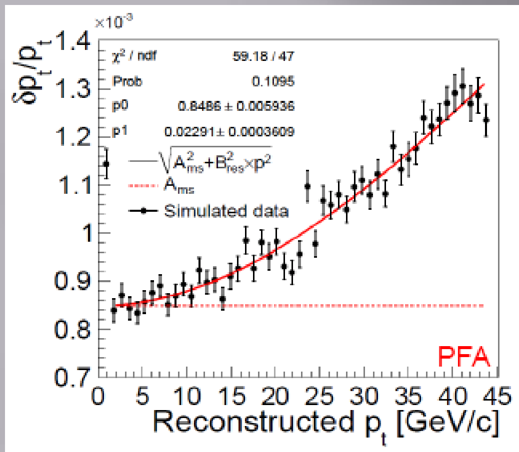


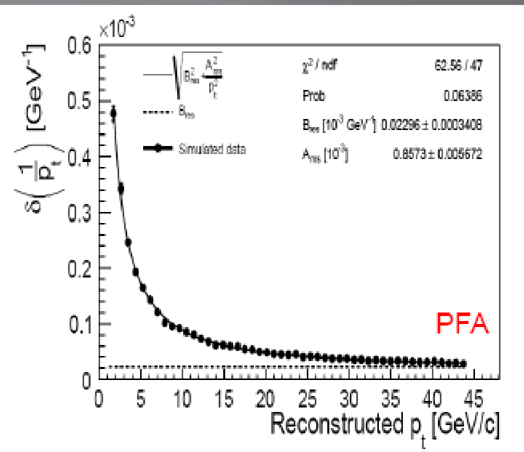
View of the muon detector, magnet and Yoke of the ILD detector as described in MOKKA



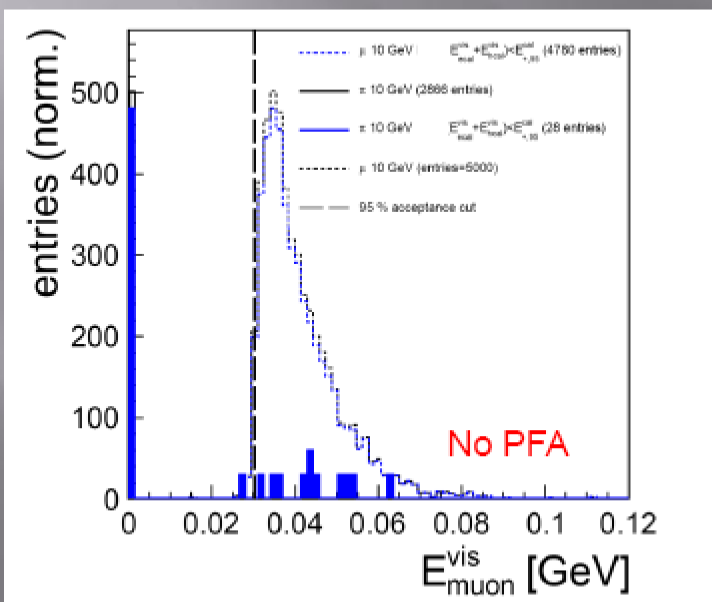
- 3 talks based on simulation studies (ILD, CLIC)
  - Momentum and d0 resolution in ILD
  - Muon/pion identification
  - Performance as the tail catcher of HCAL

Performance study of ILD muon system





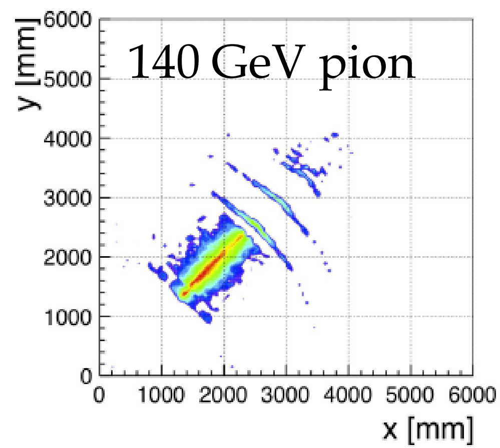
$\delta(1/pt) = 2.3\ 10^{-5}\ GeV^{-1}$
$\delta(D_0) = 2.5\ \mu m$

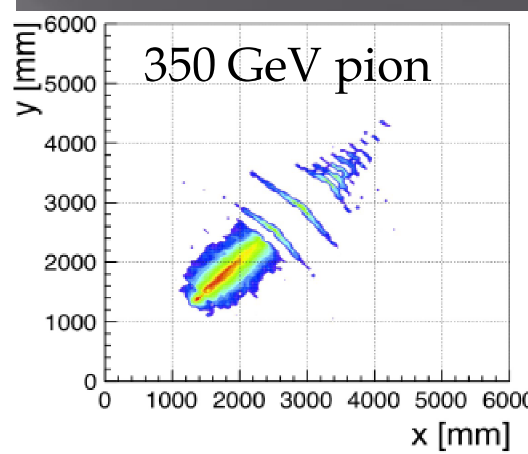


95 % efficiency acceptance

(99.62 0.12)% pion purity

Study of Muon system as HCAL tail catcher





Nicola D'Ascenzo
Valeri Saveliev

Muon finding in PandraPFA

Reconstruction of muons in a particle shower

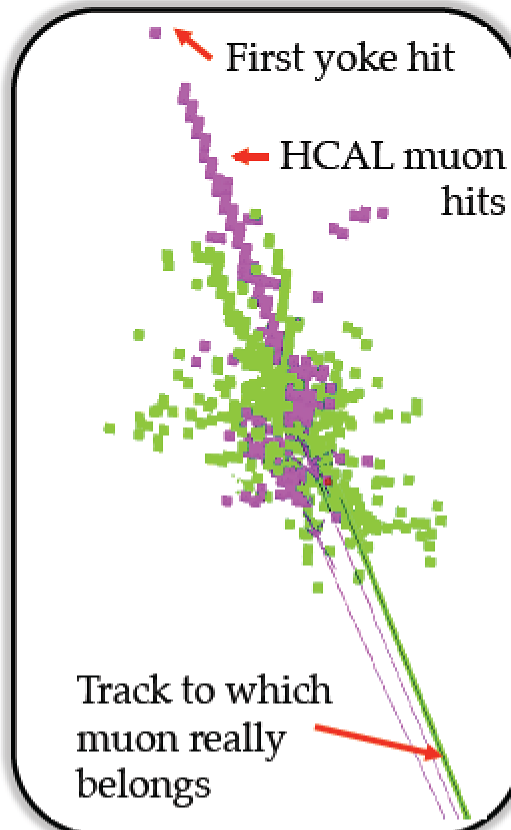
Green and purple are two reconstructed PFOs.

Pandora clusters the hits outwards

- In a dense environment it occasionally has wrong hit assignment for muon hits in the HCAL.

To prevent this:

- start with a new algorithm that matches Inner Detector tracks to tracks in the yoke.
- Then use fine granularity of the HCAL to pick up HCAL hits along this newly defined muon track



IWLC - October 20, 2010 Erik van der Kraaij, CERN LCD 7

Erik Van Der Kraaij

Summary

- Various technologies have been proposed and tested for ECAL/HCAL/FCAL/Muon
- Physics prototypes of ECAL and AHCAL have demonstrated their performance at the test beams.

  ➔Moving on to technological prototypes
  - Close to size of detector modules
  - Integrated electronics, services
- Physics prototypes of DHCAL with various technologies are being developed/tested.
- Calorimeter studies motivated by CLIC started:
  - Tungsten HCAL / T3B
  - Dual Readout Calorimeter
- New ideas are still to come.

Backup slides

Future TB plans

Calo Summary Table

Calorimeter	Date	Type	Requirements	Projected TB facility (option
RPC DHCAL m^3 (φ)	$\geq$ mid 2010	All types High E (in combined TB)	$<$ 100 Hz	FNAL
GEM DHCAL (φ)	$\geq$ 2011	low E e, μ, π	—	FNAL
µMegas, RPC layers SDHCAL m^3 (τ)	2009 $\rightarrow$ end 2010 $\geq$ end 2010	low E e, μ, π All types	 $<$ 100 Hz or ILC like	CERN CERN (FNAL)
W HCAL structure (φ)	$\geq$ '10	All types	—	CERN
DECAL	$\geq$ 2011	e (all E)	Large XY table	CERN & DESY
CALICE AHCAL (τ)	$\geq$ 2012	e (all E), low E π	$\leq$ 1 kHz or ILC like	CERN (FNAL)
CALICE ECALs (τ)	$\geq$ 2011	e (all E), low E π	$\leq$ 1 kHz or ILC like	CERN (FNAL)
Combined CALICE (τ)	$\geq$ 2011-2012	All types	$\leq 0.1 - 1$ kHz or ILC like $>$ 3 T magnet, telescope	CERN & FNAL
SiD ECAL	$\geq$ 2011	e 5–10+ GeV low E e, π (FNAL)	Beam localisation ILC like, low rate (0,1,2 e/Bunch)	SLAC (DESY) FNAL
SiD Muons	$\geq$ 2011	High E had. Combined test	—	FNAL FNAL
FCAL	2010–2013 $\geq$ 2012	low E e High E electrons Irradiation with e	Telescope Telescope	DESY CERN FZD, TU Darmstadt
DREAM	2010–2013	High E had.	—	CERN

Table 3: *Prototypes (φ and τ refer respectively to Physics and Technological CALICE prototypes), date of first test beam operations, run type & constrains, estimated time.*

See also: Summary of testbeam workshop LCTW09: http://arxiv.org/abs/1010.1337

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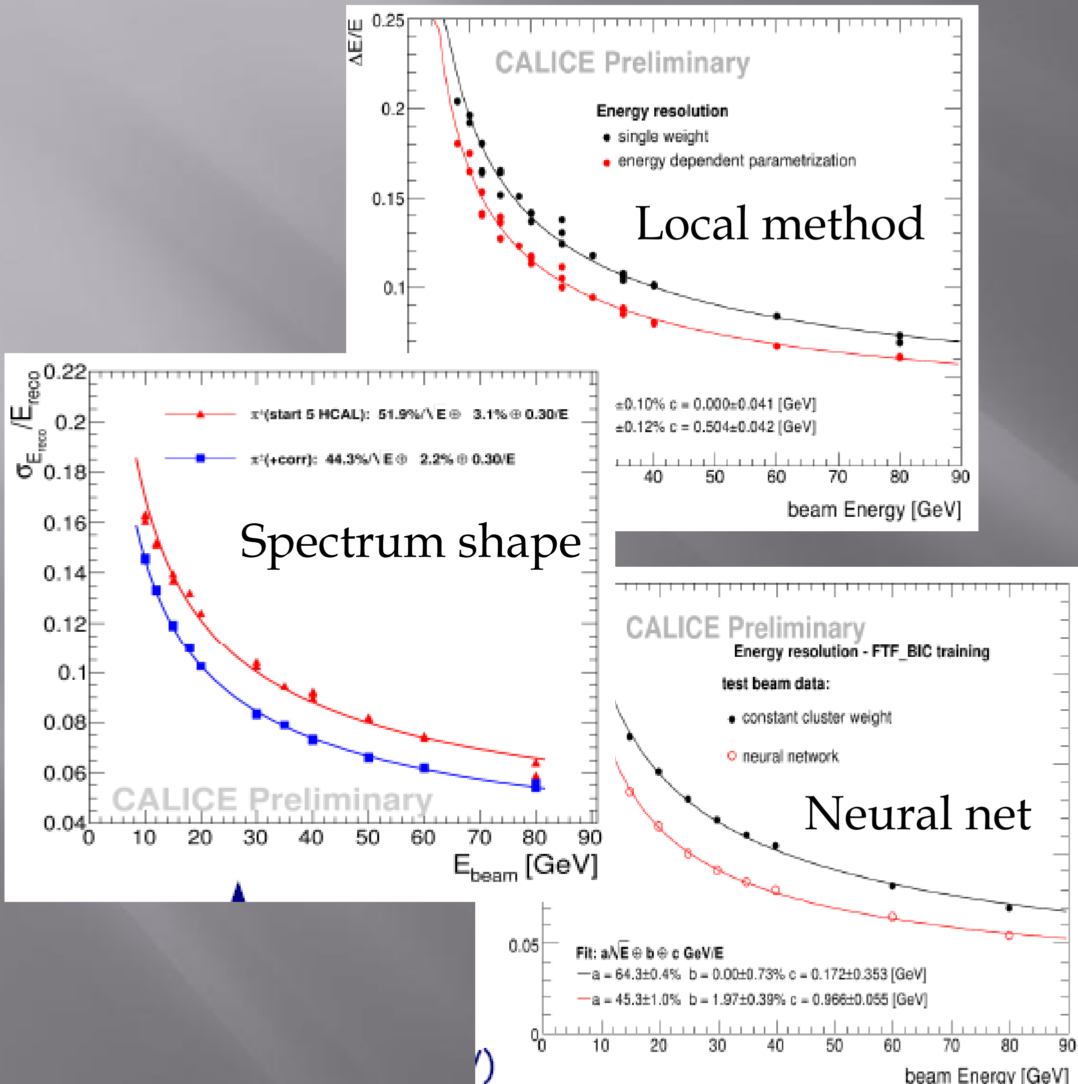
IWLC10 CERN/Geneva October 2010

Roman Poeschl

Software compensation with AHCAL TB data

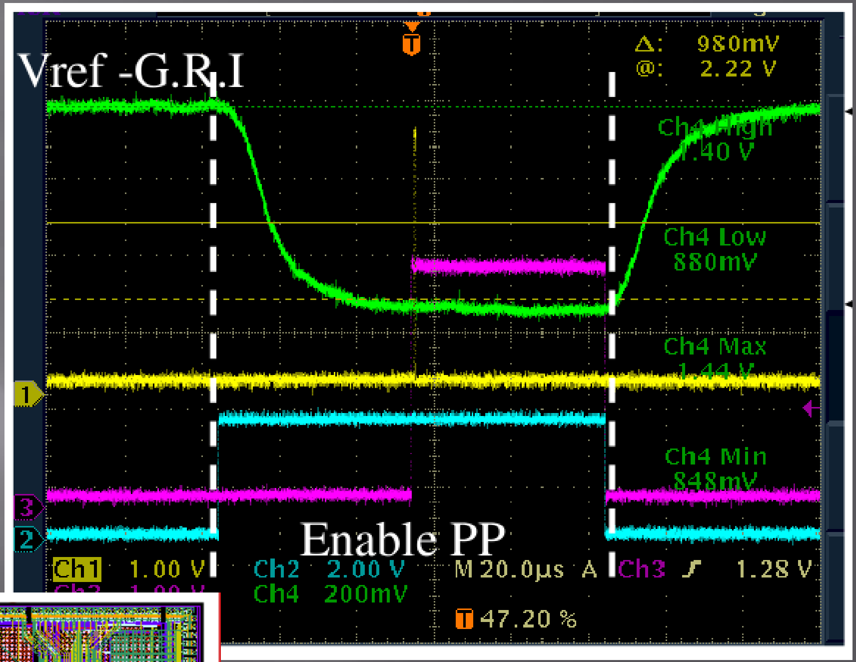


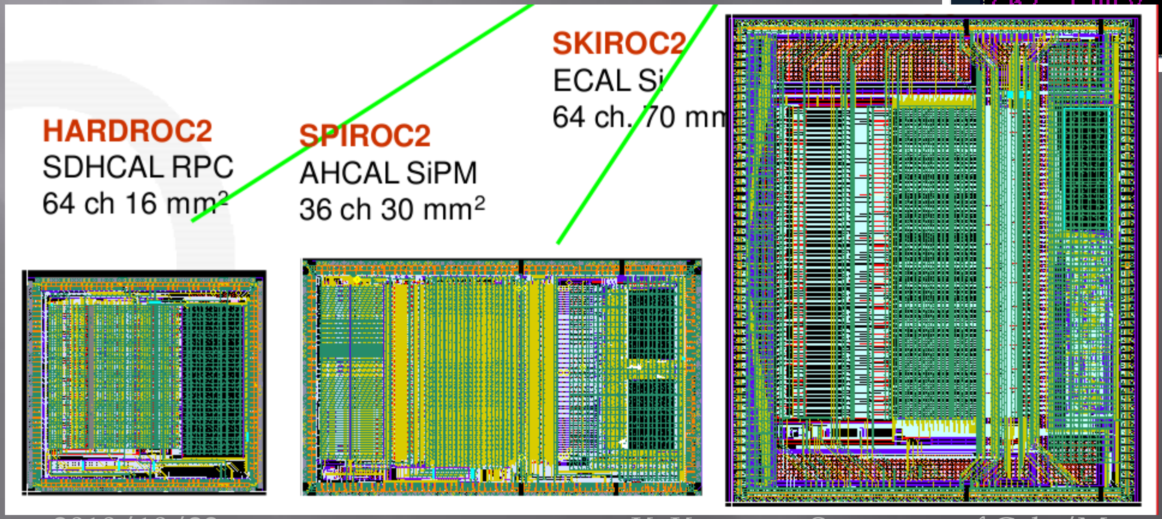
- CALICE AHCAL is NOT compensating: $e/\pi>1$.
- Local method
  - Weights determined by the energy density of hit cells
- Global methods
  - Spectrum shape
  - Neural Network using six observables
- 10~25% improvement in pion energy resolution

Marina Chadeeva

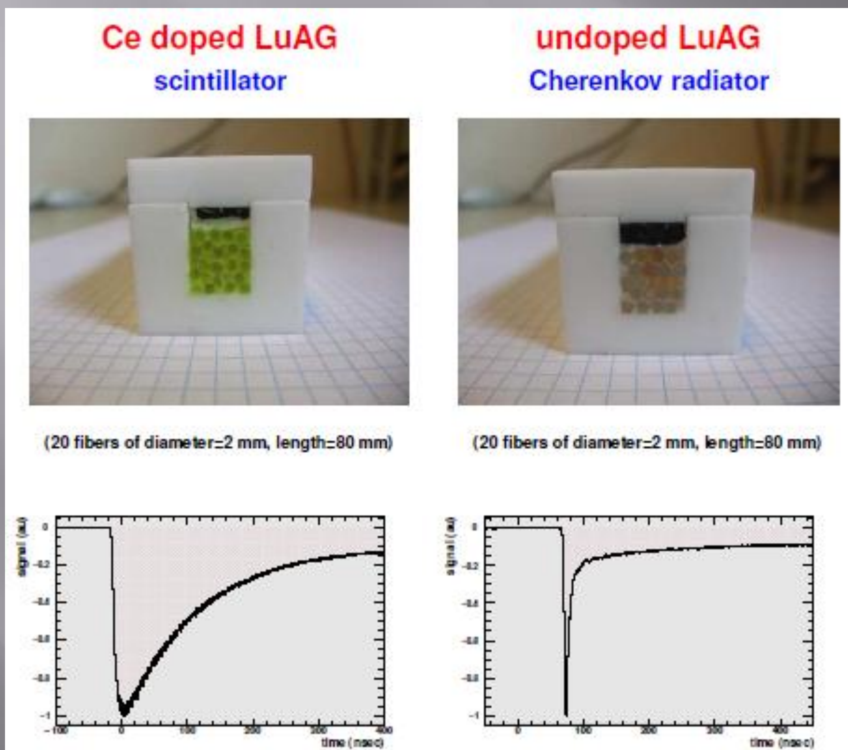
Front-end ASICs

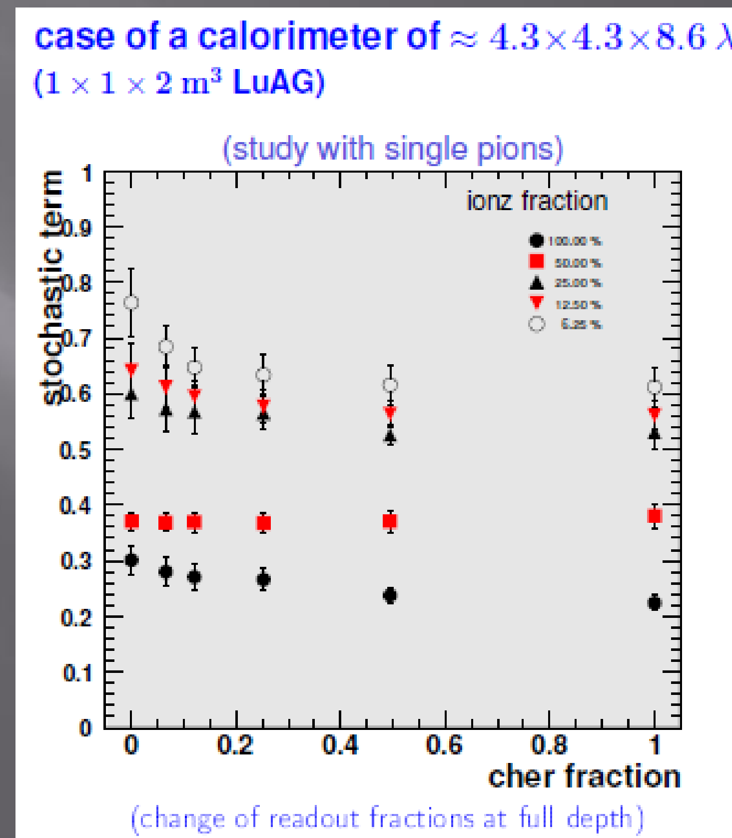
- First tests of power pulsing underway
- Typically integrated into detector volume



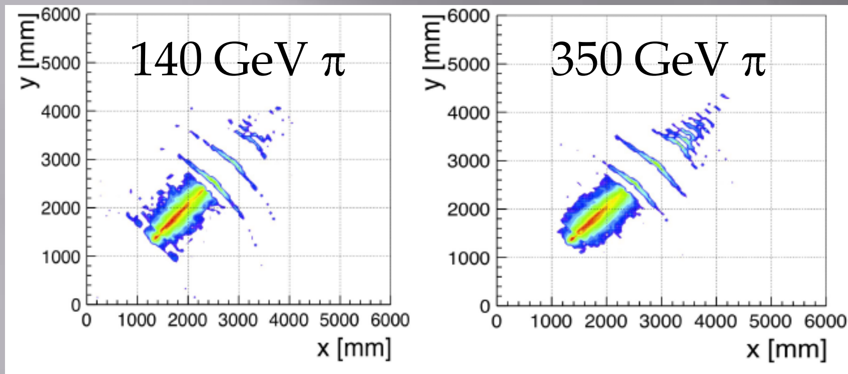


Material development, testbeam study and simulation study underway

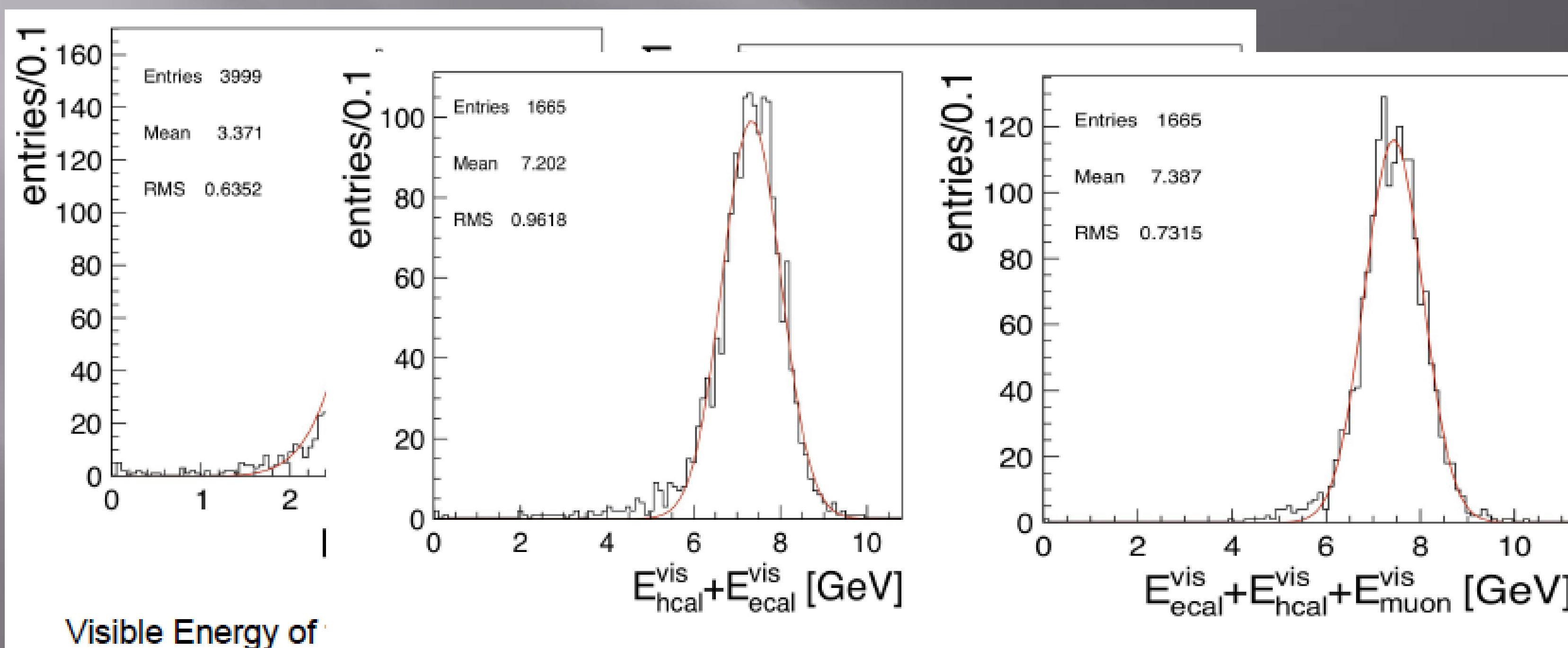




ILD muon system as the tail catcher



- Improvement for high-energy pions by including energy deposit in the muon system



Visible Energy of the pion showers in ILD, energy 350 GeV

Valeri Saveliev