

DHCAL Construction Status



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CALICE Meeting, September 16 – 18, 2009
Université Claude Bernard Lyon I, France

1 m³ – Physics Prototype

Description

40 layers each ~ 1 x 1 m²

Each layer with 3 RPCs, each 32 x 96 cm²

Readout of 1 x 1 cm² pads with one threshold (1-bit)

~400,000 readout channels

Layers to be inserted into the existing AHCAL structure

Purpose

Validate DHCAL concept

Gain experience running large RPC system

Measure hadronic showers in great detail

Validate hadronic shower models

Status

Started construction in fall 2008



RPC Construction

Not yet on critical path

RPC design

- 2 – glass RPCs
- 1 – glass RPCs (developed by Argonne)

Chambers needed

114 + spares

Material



- Glass in hand for 300 chambers
- Kilometers worth of channels for rim in hand
- Kilometers worth of fishing line in hand
- ~50% of resistive paint in hand

Assembly steps

- Spraying of glass plates with resistive paint
- Cutting of frame pieces
- Assembly of chamber
- Gluing of glass plates
- Mounting of HV cable



Spraying of the glass sheets

Challenge

Produce a uniform layer with $R_{\square} = 1 - 5 \text{ M}\Omega$
(value only critical for thin plate, large plate can be lower)

Previously used paint (LICRON)

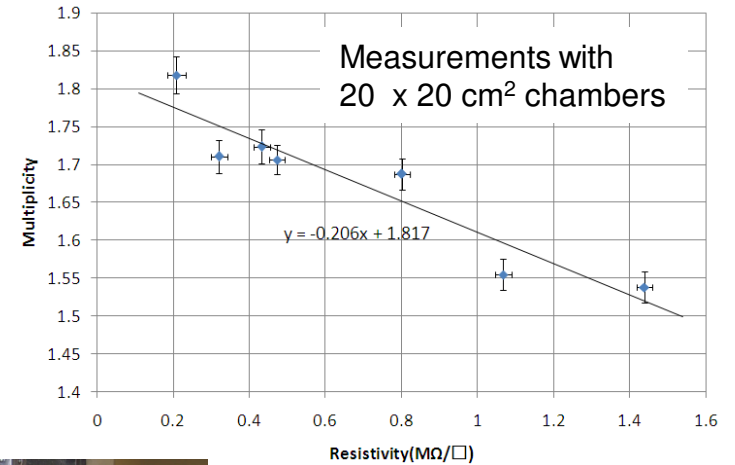
Not useful anymore

New paint (artist paint) identified

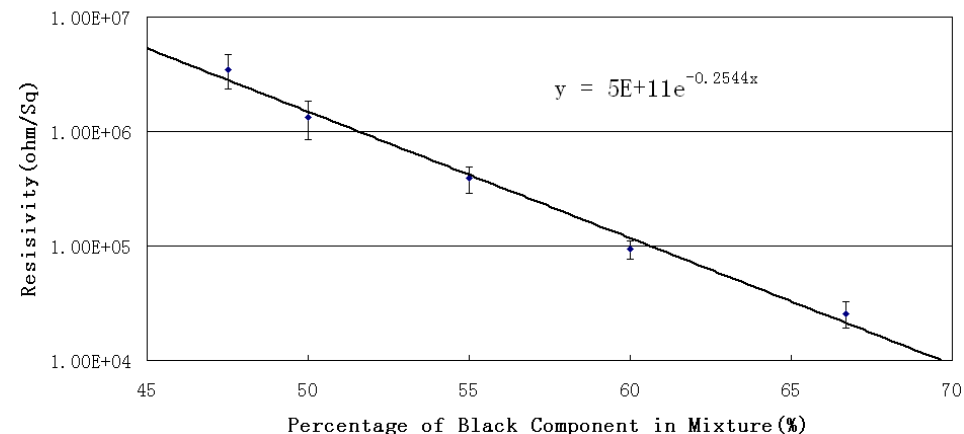
Reasonably cheap
Non toxic
2 component mixture
Needs to be sprayed

→ **Provided proof of principal**

Multiplicity@90%eff Vs. Paint Resistivity on Readout Side



Resistivity Vs. Percentage of Black Component in mixture

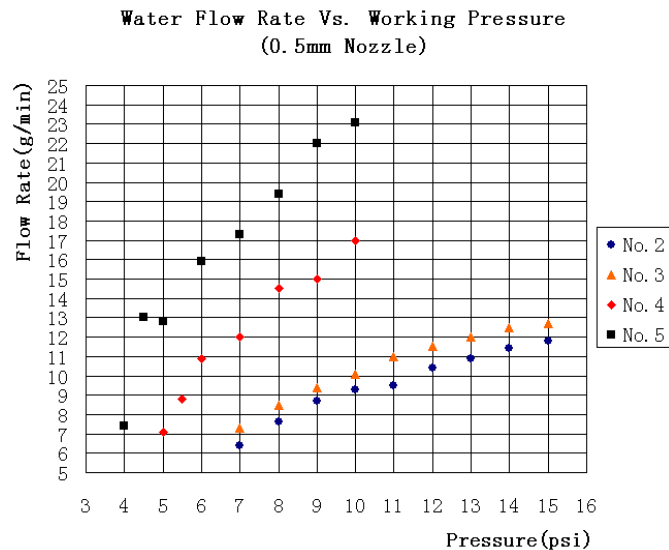


Professional spraying booth

Being assembled
Fully automatic
Fumes being vented outside

Flow rate versus pressure

Depends critically on nozzle
Needs to be measured before
spraying glass
Can be measured with H₂O



Uniformity

Excellent

Time dependence

Cures very quickly
(Better than the old LICRON)

Dependence on the environment

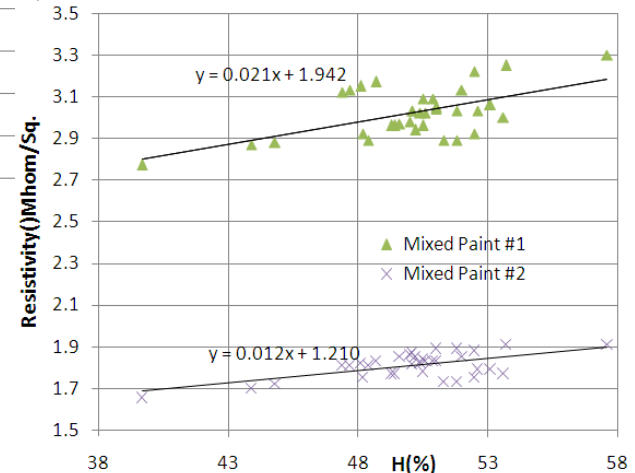
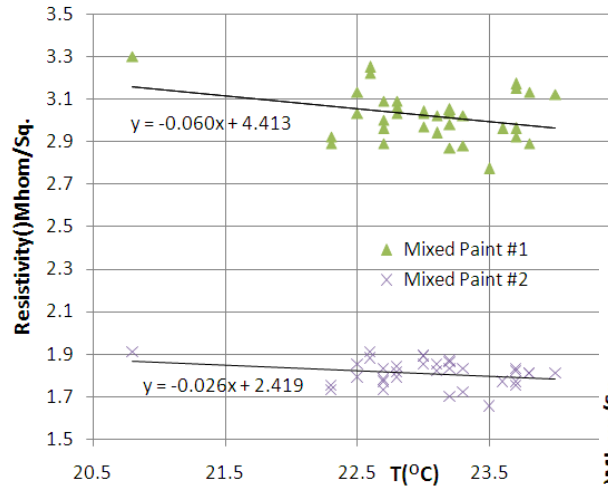
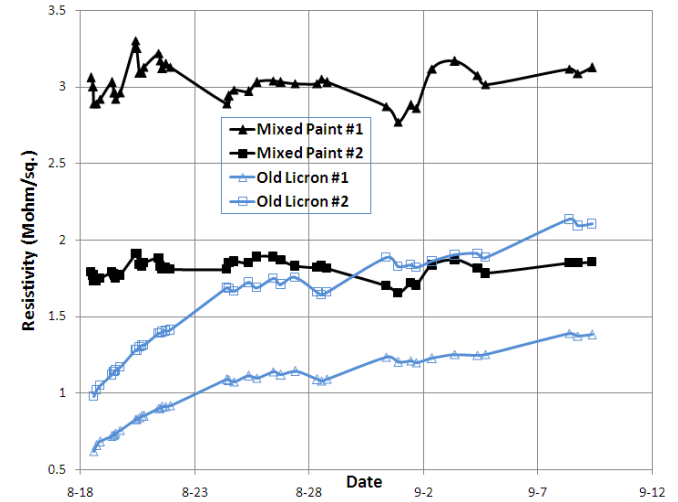
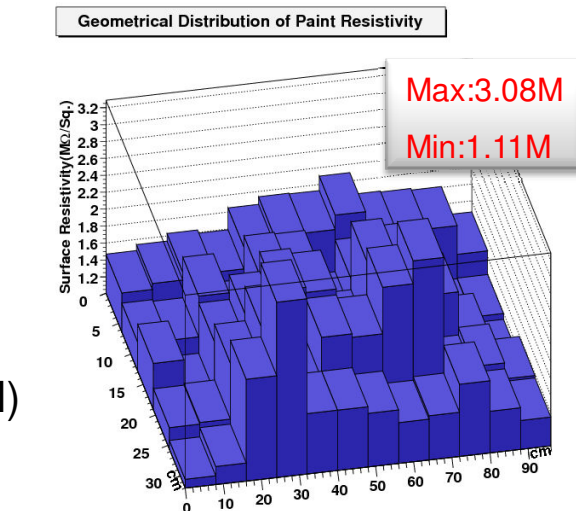
Temperature < 2%/ΔT=1°C
(Old LICRON ~ 14%/ ΔT=1°C)
Humidity < 1%/ΔH=1%
(old LICRON ~ 0.3%/ΔH=1%)

Long term stability

Old LICRON: R goes up with time, after been exposed to air

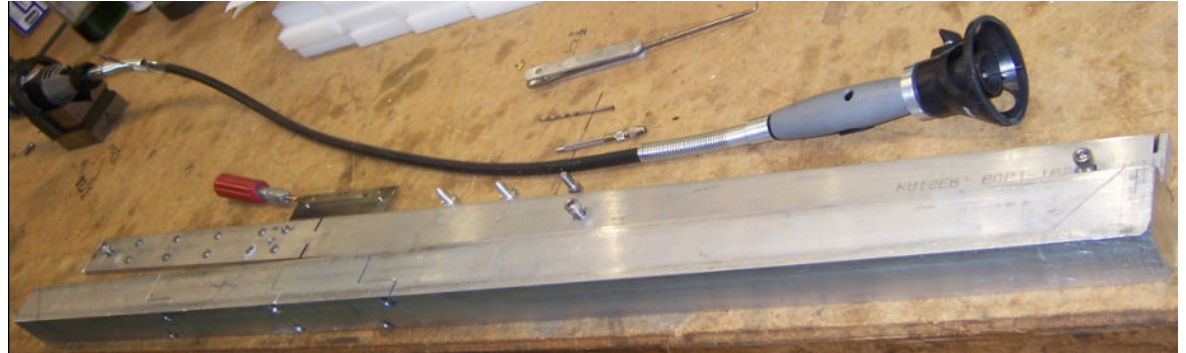
Time needed

Preparation ~ 25 min
Spraying ~ 10 min/plate
Cleanup ~ 10 min



Can do several plates in one go...

Cutting of frame pieces



Challenge

Need to cut pieces with a precision of 0.2 mm
Need to drill holes with a precision of 0.2 mm

Fixture

Assembled and tested

Time needed

~ 15 minutes/frame

Assembly of Chambers

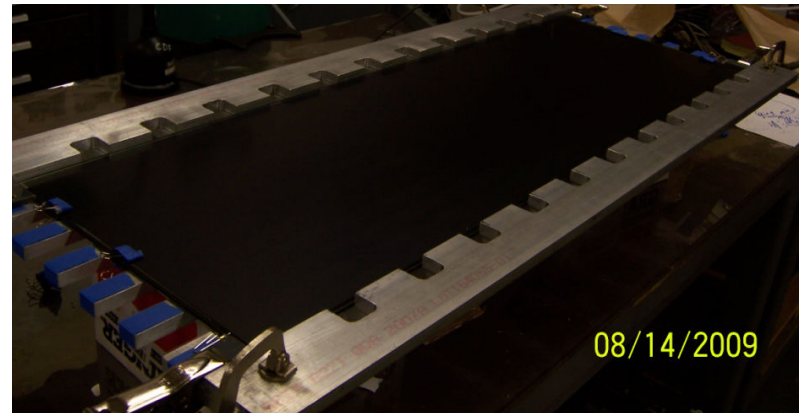
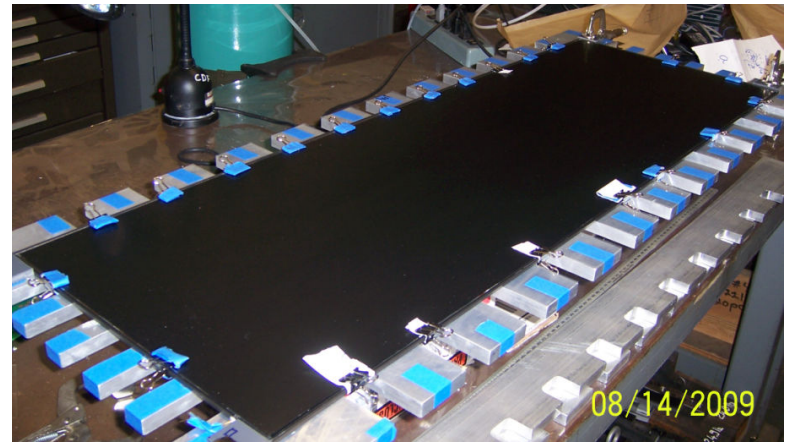
Jig for gluing glass and frame

Jig designed and built
2nd jig (different design) being built

Time needed

Approximately 4 - 8 hours/chamber
(not counting curing time)

1.5 technicians trained for assembly



Assembly Status

# of RPCs	Label	# of glass plates	Glass thickness [mm]	Size [cm]	Conductive Paint	Status	Tests	Problems
~15		2	1.1	20 x 20	Old licron	built	2 years	None
1		1	1.1	20 x 20	Old licron	built	2 years	None
1+3		2	1.2/1.2	32 x 96	Old licron	built	10+ month	High pad multiplicity ~2.1 (mainly due to lower resistivity)
3		1	1.1	20 x 20	Old licron	built	4 months	None
8	LR001	2	0.85/1.10	32 x 96	White paint (brushed)	built	6+ months	None
	LR002				Black Paint (brushed)	built	6+months	None
	LR003				Black Paint (Sprayed)	built	~ 2 months	None
	LR004					built	~ 2 months	None
	LR005					Built with Jig	1 month	None
	LR006					Built with Jig		None
	LR007				being built with Jig			

Quality Assurance

Currently

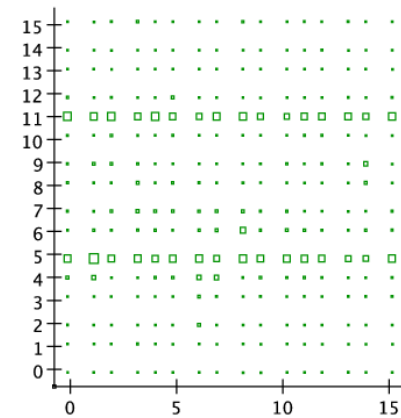
Use old electronics to check out chambers

Future

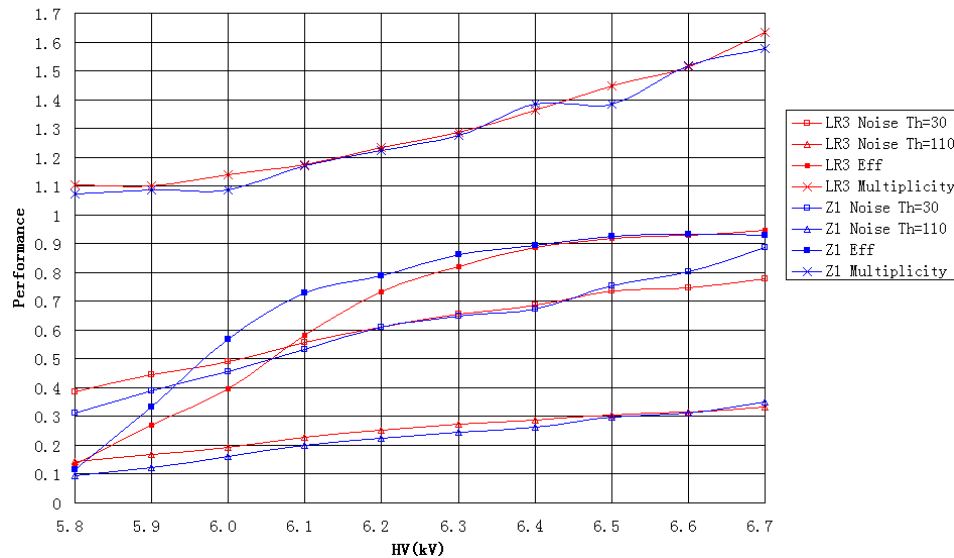
A) Will measure each chamber with new electronics and VST (for tracking)

B) Will measure cosmic rays with completed cassettes in hanging file structure

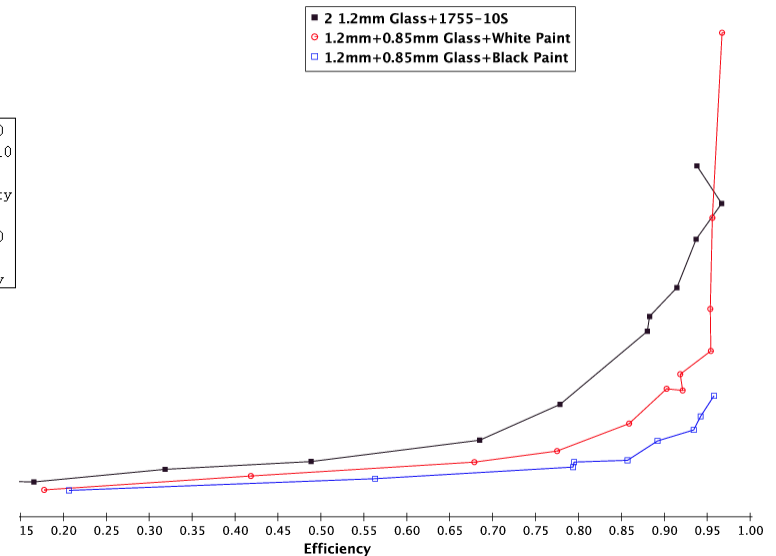
Noise Distribution of Z1



Performance Vs. HV



Multiplicity Vs. Efficiency (Th=110@Variable HVs)



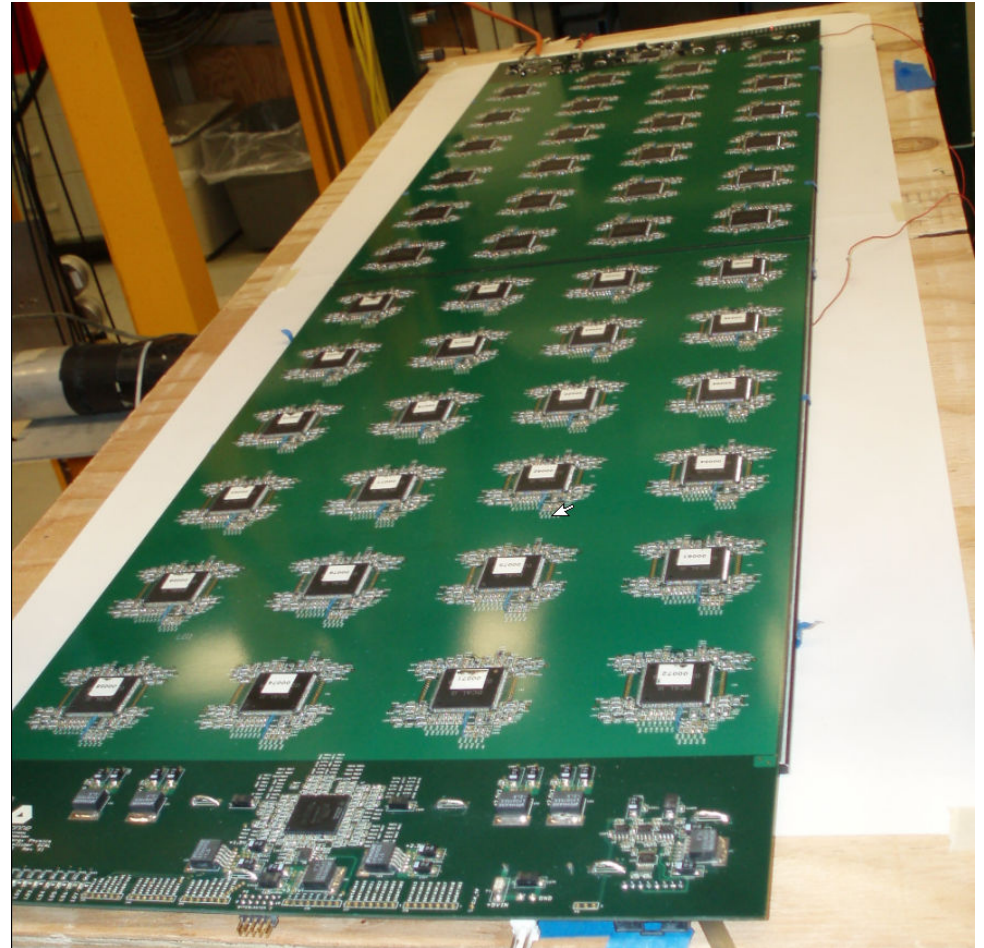
First cosmics with new board

Setup

Uses 7 chambers from VST
1 large chamber with 1 board

Data taking

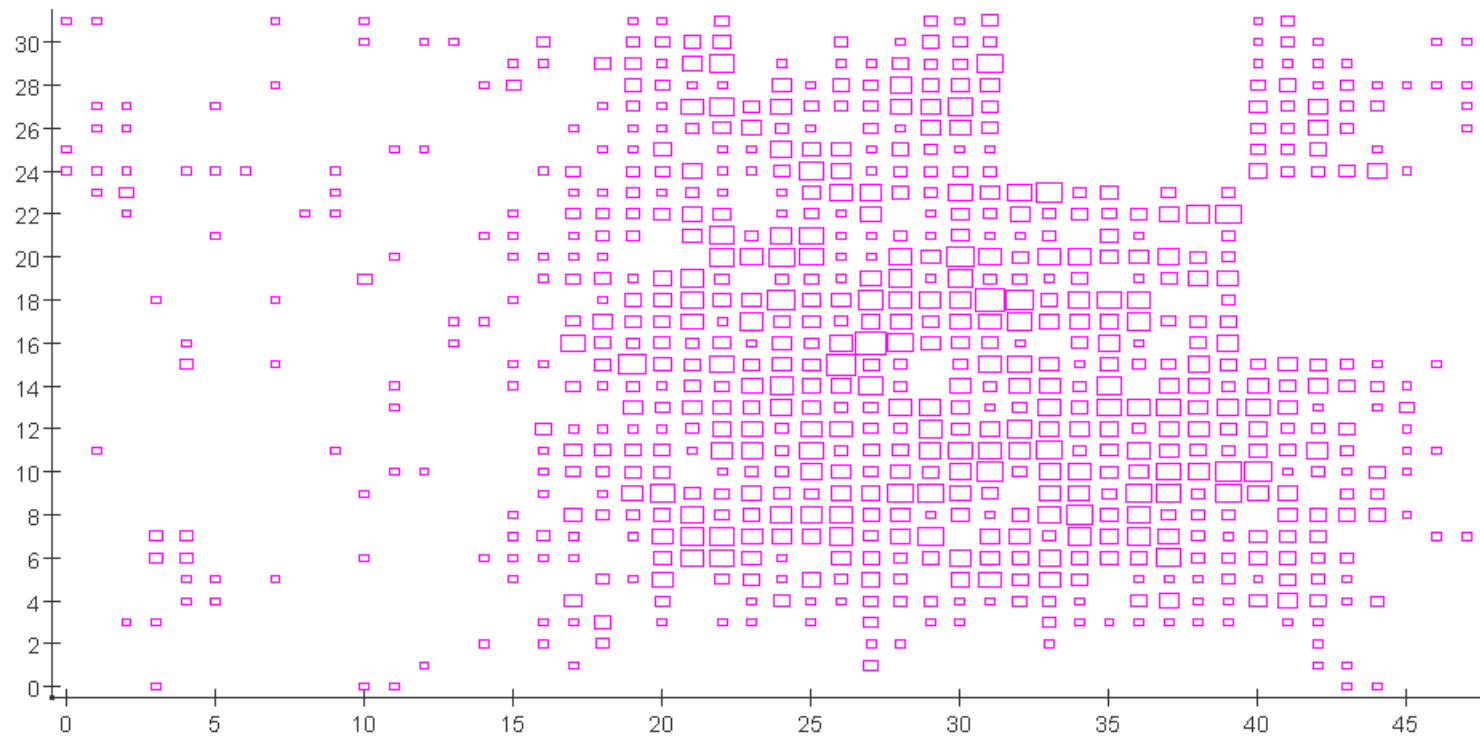
First events on 9/11/2009



First Run of Large FEB(Noise Run)



All Hits(First Run of FEB, Cosmic-ray Run)



file #0 16-bite data with timestamp out of range (without DCON errors): 2
file #0 16-bite data with wrong timestamp (in range, without DCON errors): 7
file #0 16-bite data with time matching problem (ambiguity in event building): 0
Events built out of data: 3471 Events with building error: 0
Selected Events: 2252 Events with building error: 0

Layer 8

projected hits from good tracks: 509
found matching clusters: 352
efficiency = 0.6915520628683693
multiplicity = 1.2954545454545454
68.9(1.26) 67.3(1.38) 75.5(1.28)
66.7(1.39) 77.6(1.21) 68.8(1.32)
60.8(1.19) 73.5(1.36) 66.0(1.20)

Cassettes

Purpose

Protect RPCs, cool front-end ASICs, compress RPCs

Design

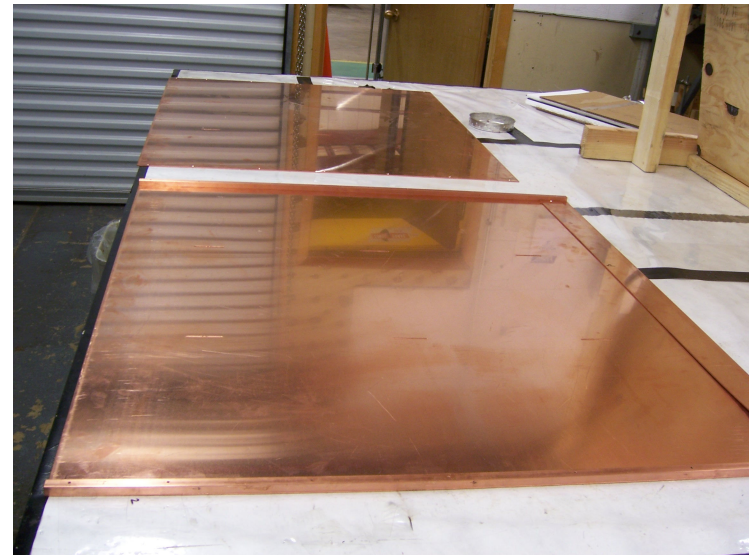
2 x 2 mm² copper sheets + cooling tube on top
Will fit into CALICE AHGAL structure

Prototypes

First one built some time ago
2nd prototype to be built shortly (material in hand)

Assembly

Not expected to be labor-intensive



Gluing fixture for Pad- and FE-boards

1536 glue dots in less than 3 hours

Fixture

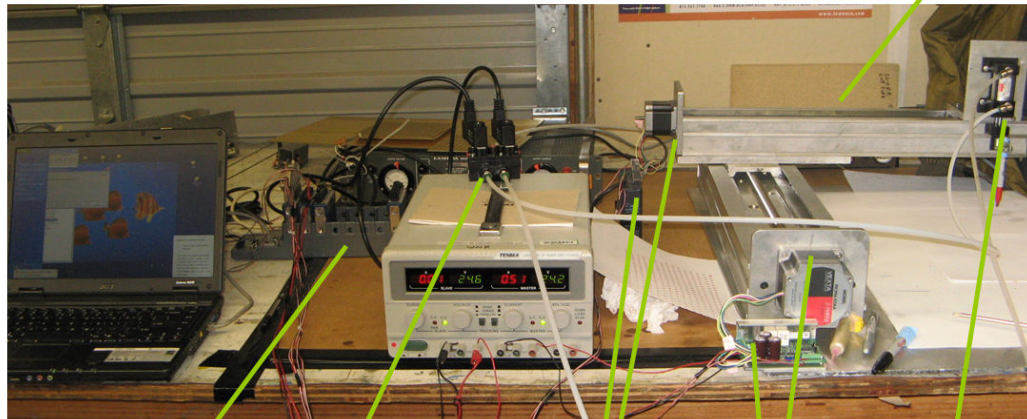
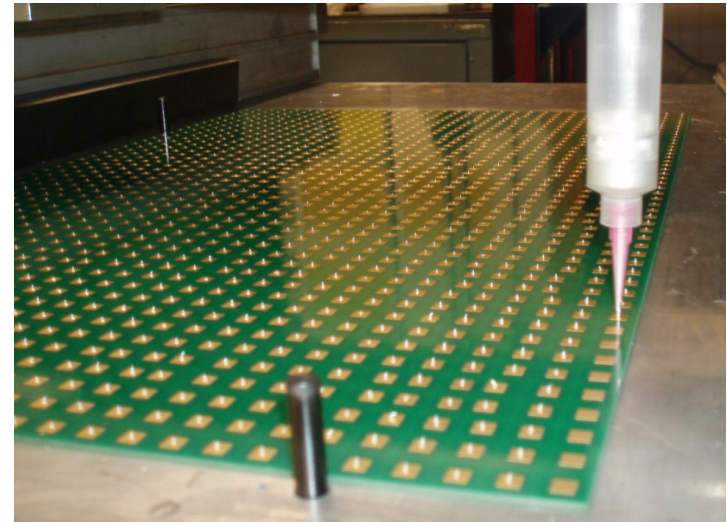
Designed, built and commissioned

Practise

Glued a few 16 x 16 cm² boards

New front-end boards

First board successfully glued
~55 minutes needed/board



Controller

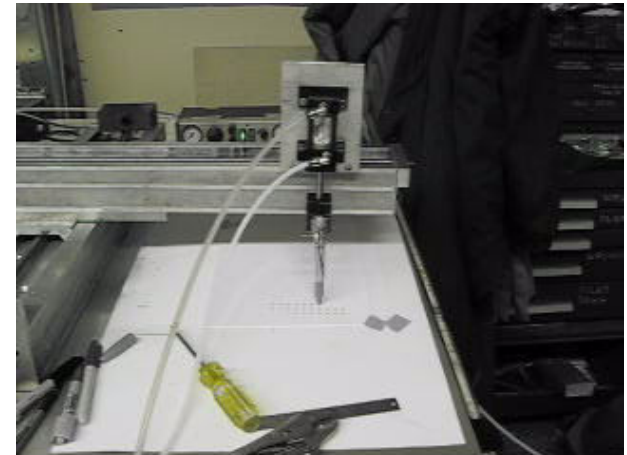
Solenoid valve

x axis motor and driver

y axis motor and driver

z slider

Glue Dispenser



Gas and HV systems

Gas mixing system

Provides flow for entire 1 m³
Designed, assembled and tested
RPC performance very similar to pre-mixed gas



Gas distribution system

Re-use system from Vertical Slice Test
Need to add 12 outputs (scheduled for October 10 – 20)

Chamber leak tester

Useful for testing completed RPCs
Will be provided by September 29

HV system

Two full systems available
Control software written
System currently in use



DAQ software

Not on critical path

Implemented into CALICE DAQ framework

New readout architecture and geometry implemented

Readout of mixed system (VST + new boards) debugged

Remaining issue with maximum record size to be sorted out

OFFLINE software

Not on critical path

Working on event builder (Jacob Smith)

Agreement to use standard LCIO – Marlin – LCCD – Mokka chain

Low Voltage System

Need +5 Volts for front-end boards

System

Consists of power supplies and distribution boxes
Fits into one rack

Wiener power supplies

7 units in hand

Distribution boxes

Design finalized: individual switches for each front-end board
Parts for 1 unit ordered
To be assembled first week of October

Cables

To be cut later



Test Beam with 10 Planes?

Preceding tests

All **RPCs** will be tested individually with cosmic rays in horizontal stack

measurement of operating point, non-uniformity, noise rate

All assembled **cassettes** will be tested with cosmic rays in vertical hanging file structure

either tests in self-triggered mode or in triggered mode (identical to the test beam)
use of gas mixer and HV system (as at the test beam)

First cassette will be inserted into CALICE AHCAL **structure**

mechanical tests

Material list for test beam

Gas mixer (to be taken from hanging file tests)
HV system (to be taken from hanging file tests)
VME readout (to be taken from hanging file tests)
LV system (part of hanging file tests)



Incompatible with
hanging file tests at
Argonne

Estimated effort

Move of equipment	1 man week
Set-up in test beam	2 man weeks
Data taking	5 man x 3 weeks
Data analysis (minimal)	2 man x 3 weeks
Disassembly and move back	1 man week
Set-up into hanging file structure	2 man weeks

Total	27 man weeks
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Benefits

We will certainly learn something

Cable length
Beam characteristics
Data taking

Data will not be published

The benefits do not justify the effort. The group is in general not in favor of such a test.

Preliminary plan to test 1 plane + TCMT in February

Test Beam Plans

Start with standalone DHCAL program (including TCMT!)

Broadband muons for calibration

Positrons 1 – 16 GeV

Pions 1 – 66 GeV

Protons 120 GeV

Followed by data taking with Silicon-Tungsten in front

Time scale still uncertain

Realistic goal of data taking starting in spring 2010

DHCAL Construction Overview

Item	Status	Outstanding problems/tasks	Critical path
RPC construction	Several chambers built	Test of full-scale 1-glass chambers (requires final front-end board) Develop production procedure	(November - ?)
DCAL chips	Being tested	Yield?	Until ~ October 1
Front-end boards	Final design	1 additional round of prototyping?	~May - November
Back-end	DCOL being tested TTM being re-designed	None	No
Gas system	Being assembled	None	No
HV system	Completed	None	No
DAQ software	Being modified	Record length limitation	No
OFFLINE software	Being developed	None	No