A Digital EndCap Calorimeter For CMS?

Burak Bilki

University of Iowa

Why Digital Calorimetry?

- Idea emerged from the need of high segmentation calorimetry for the application of Particle Flow Algorithms[1] (PFAs) at International Linear Collider[2] (ILC). An analog readout solution would result in unrealistic data sizes.
- Simple digital readout with a threshold set well below the signal given by one minimum ionizing particle traversing the active medium.
- Comparable resolution with the analog readout.[3]
- A perfect EndCap solution where the non-uniformity of the magnetic field is precisely mapped. [4]

[1] Session on PFAs in XII International Conference on Calorimetry in High Energy Physics, Chicago, AIP Conf. Proc. 867 (2006) N. Graf et al., 523; L. Xia, 531; P. Krstonosic, 538; D. Chakraborty et al., 546.

[2] http://www.linearcollider.org.

[3] J. Repond, NIM A 572 (2007) 211–214; J. Repond, NIM A 518 (2004) 54–58.

[4] CMS DP-2009/008

Options for Digital Calorimetry

MicroMEGAS[1]

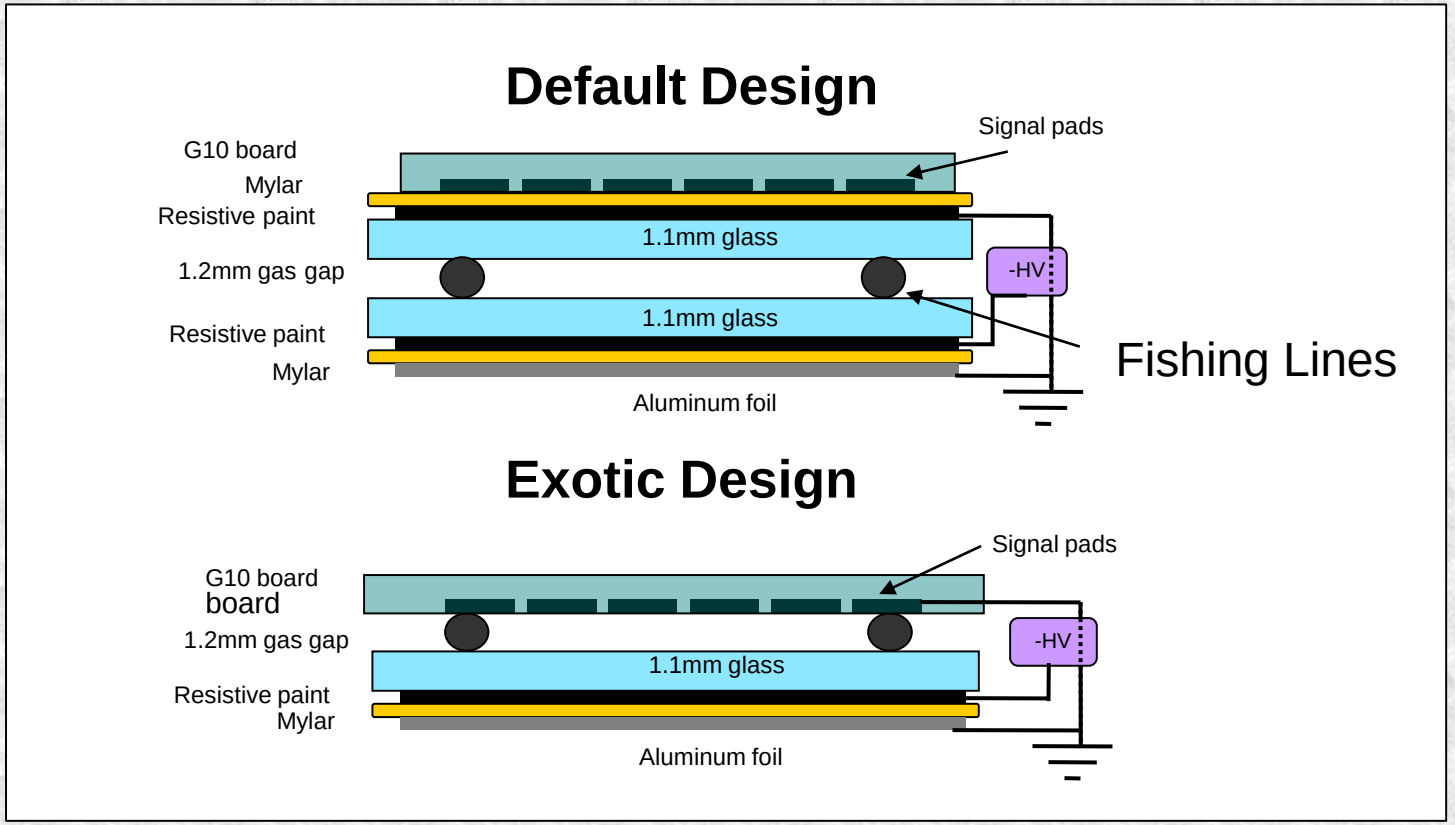
Si, GaAs, Diamond (?) /W[2]

GEMs[3]

RPCs[3]

[1] MicroMEsh GAseous Structure, I.Giomataris et al, Nucl. Instr. Meth. A 376 (1996) 29-35.
[2] BeamCal Forward Calorimeter for ILC
[3] Digital Hadron Calorimeter for SiD, ILC

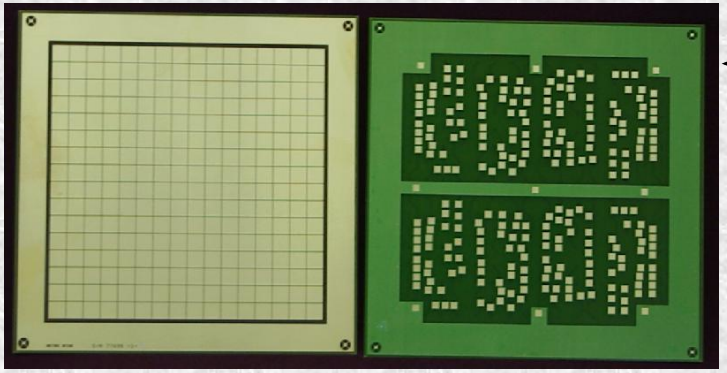
Description of the Calorimeter Stack



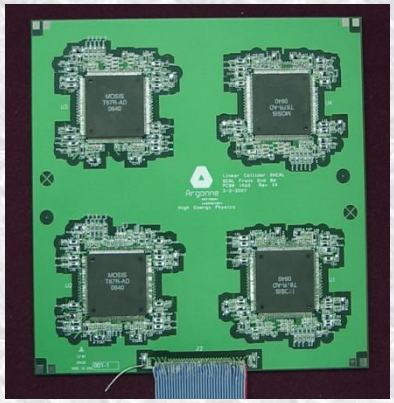
The calorimeter stack consisted of nine chambers interleaved with the combination of a steel (16 mm) and a copper (4 mm) absorber plates, corresponding to approximately 1.2 radiation length. Not all layers were used for all measurements.

The chambers measured 20 x 20 cm^2. They were operated in avalanche mode with an average high voltage setting around 6.1 kV. The gas consisted of a mixture of three components: R134A (94.5%), isobutane (5.0%) and sulfur-hexafluoride (0.5%).

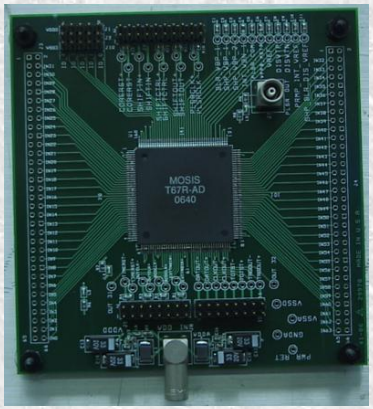
Electronic Readout System



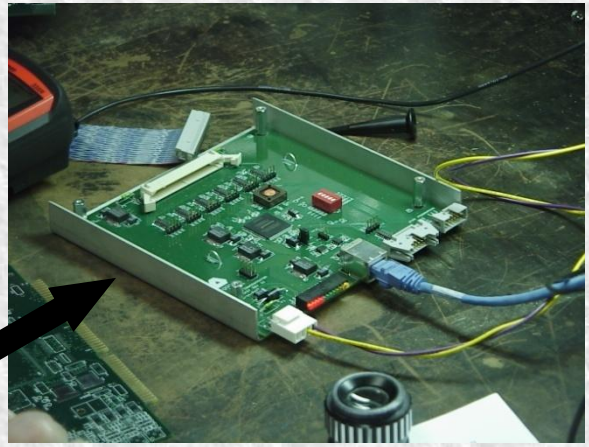
Pad Board



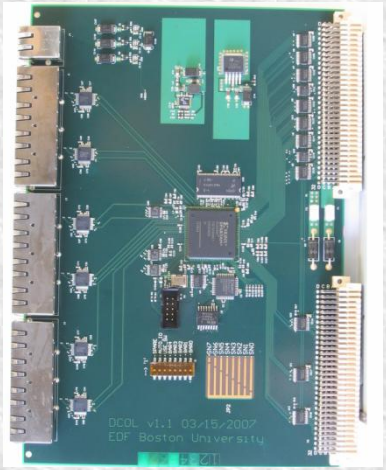
Front-End Board



DCAL Chip

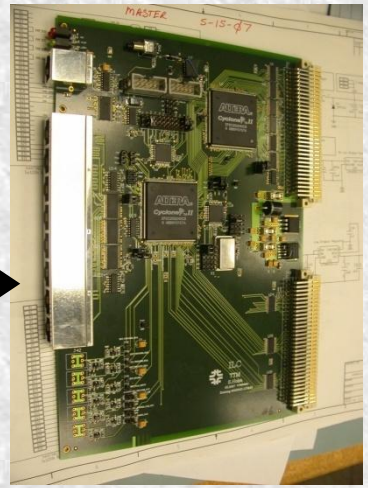


Data Concentrator



Data Collector

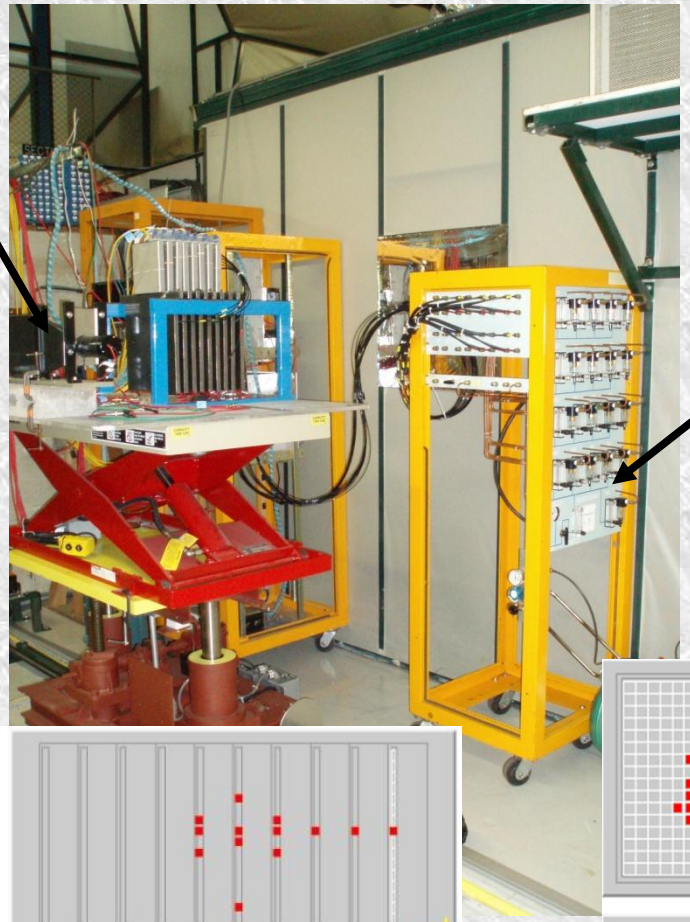
Trigger and Timing Module



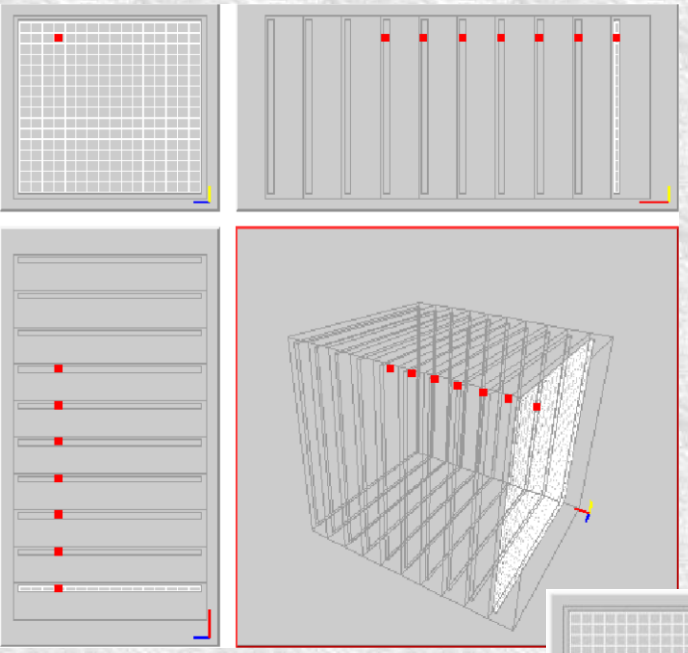
The total number of readout channels was up to 2,304 for nine layers.

Test Beam Setup and Data Collection

The stack containing nine layers within the blue hanging file structure

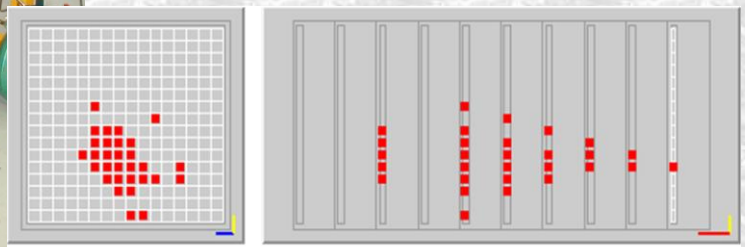


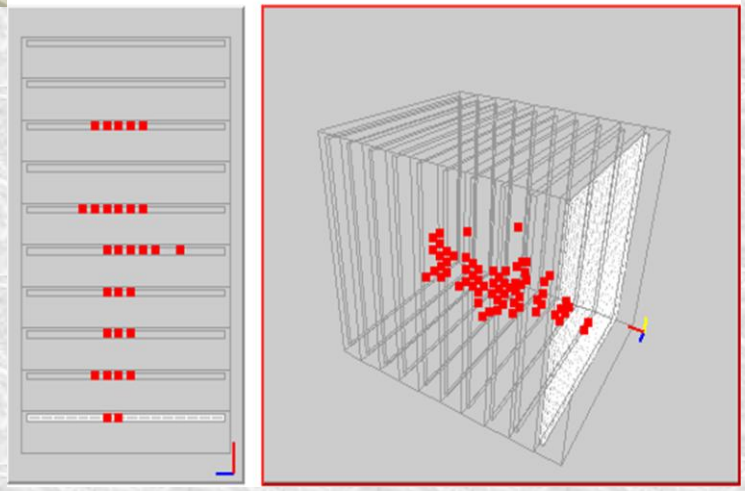
The gas distribution rack

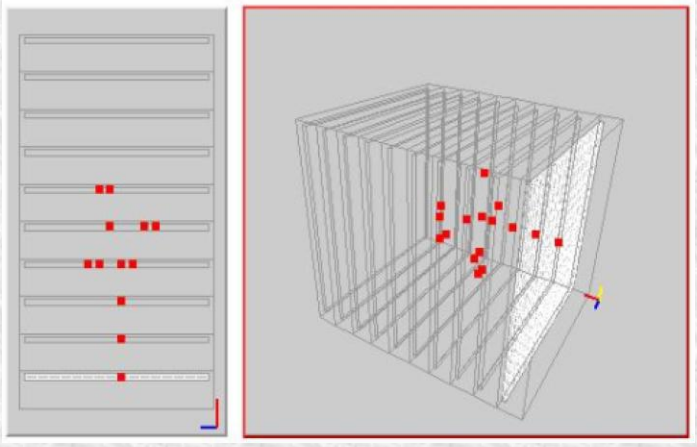


muon

8 GeV e^+





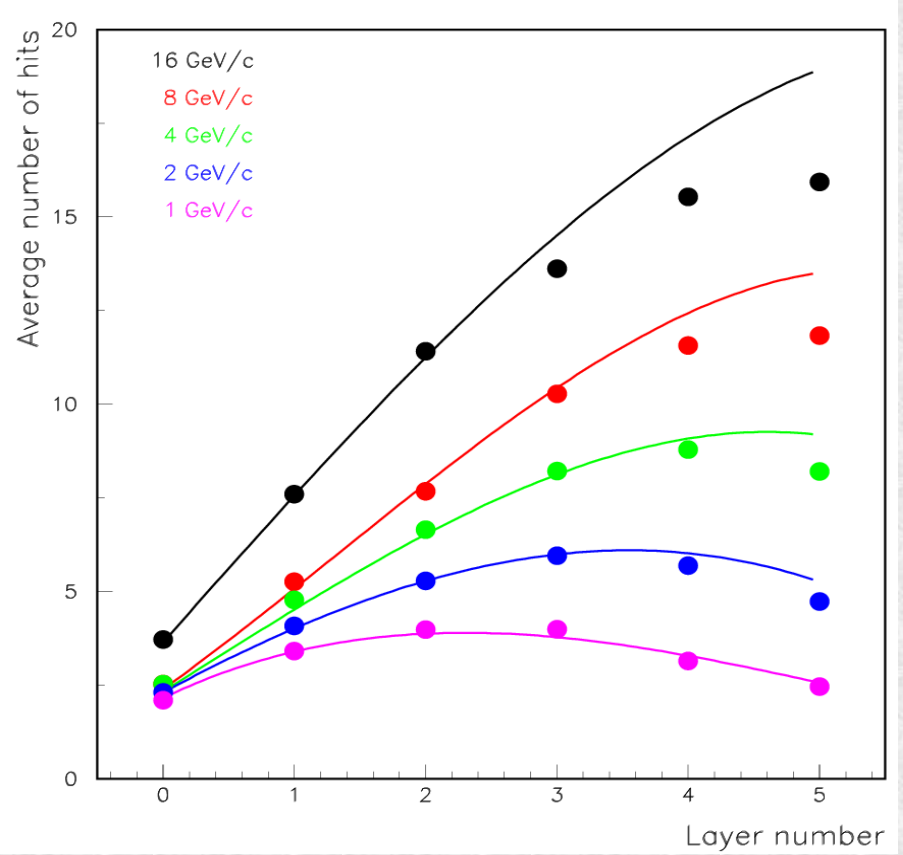


8 GeV pi-

Analysis Procedures

Different analysis procedures were applied for

- calibration with muons[1],
- positron[2] and pion[3] shower measurements and
- rate measurements[4].



Measurement of Positron Showers

Average number of hits as a function of layer number for the various beam energies. The lines represent the results of a GEANT4 simulation of the set-up together with the simulation of the response of RPCs with a standalone program (RPCSIM by J. Repond).

[1] B. Bilki et. al., JINST 3 P05001, 2008.

[2] B. Bilki et. al., JINST 4 P04006, 2009.

[3] B. Bilki et. al., JINST 4 P10008, 2009.

[4] B. Bilki et. al., JINST 4 P06003, 2009.

Conclusions

- **Background Noise:** Typically 0.15 Hz/cm^2.

- **MIP Detection Efficiency:** Depending on the high voltage and threshold settings, efficiencies in the range between 80% and 96% were measured.

- **Pad Multiplicities:** Depending on the high voltage and threshold settings pad multiplicities between 1.2 and 2.2 were measured. With the 'exotic' chamber pad multiplicities around 1.1 were obtained, independent of the operational conditions.

The physics of the Digital Hadron Calorimeter with Resistive Plate Chambers has been understood to a very satisfactory level.

We are now in the progress of building a 1 m^3 DHCAL with 40 layers of RPCs and ~ 400,000 readout channels.

Could be considered as an EndCap Calorimeter alternative for CMS.