Hadron Calorimeter Readout Electronics Calibration, Hadron Calorimeter Scintillator Upgrade, and Missing Transverse Momentum Resolution due to Pileup

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Final Presentation for the UM-CERN REU Summer Program

HCAL Electronics Readout Calibration

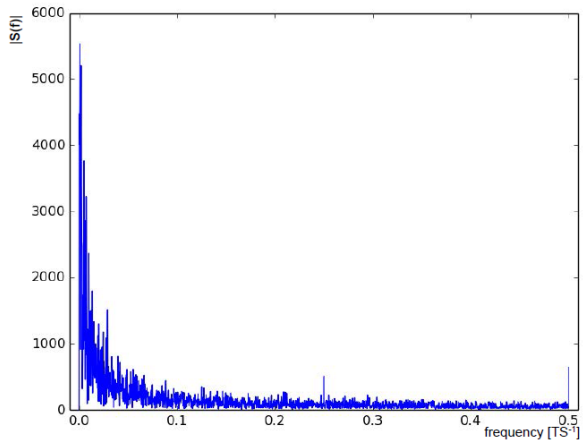
- The CMS hadron calorimeter (HCAL) will have **QIE10 readout boards** newly installed this year.
- QIE stands for Charge Integrator and Encoder. The chip integrates charge signals from a photodetector over 25 ns periods and encodes the signals into non-linear digital output, while maintaining good sensitivity in both high and low energy regions (wide dynamic range).
- QIE10 chips have wider dynamic range (from 3 fC to 330 pC), finer process technology, and increased channel density than the previous generation.

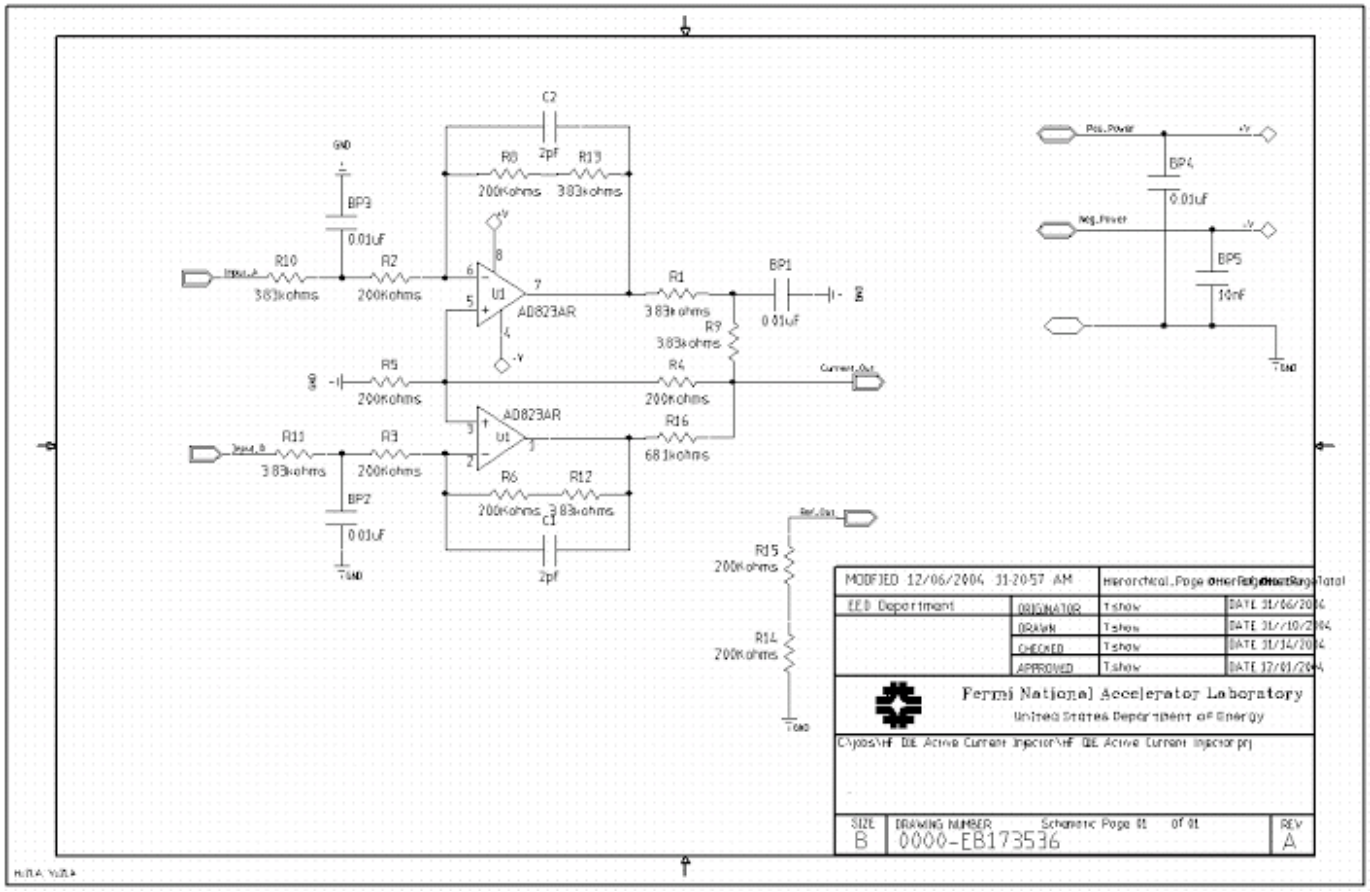
HCAL Electronics Readout Calibration

(Advisor: Richard Kellogg)

- To calibrate the QIE10 boards, we modify a **charge injector circuit** shown on the right.
- Used HCAL DAQ system to take data (40MHz): charge injector -> QIE -> trigger + readout
- Using Fourier analysis, we identified the noise of our circuit to be **1/f mode** from an op-amp. So we modified the circuit with additional load impedance, which suppresses the noise **by a factor of 2**.

w/ Eric Gonzalez:



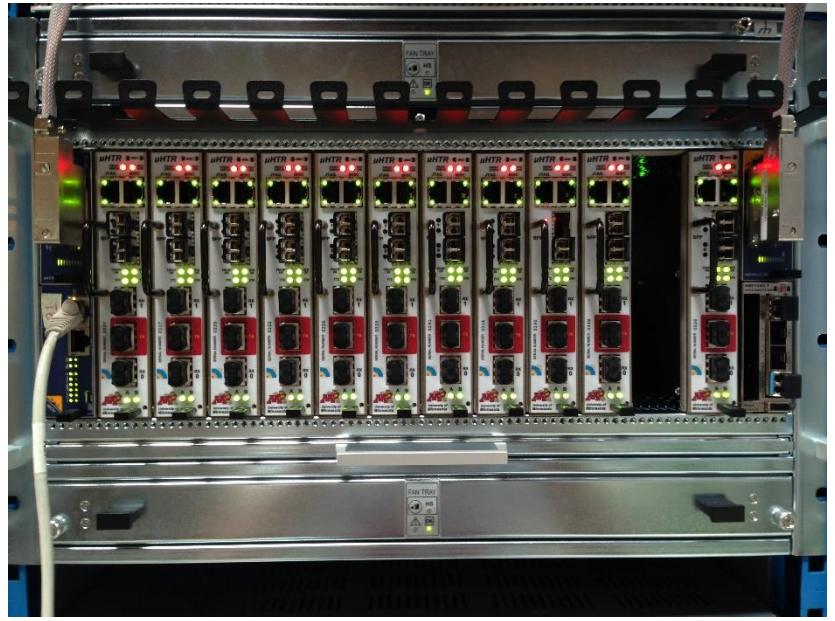


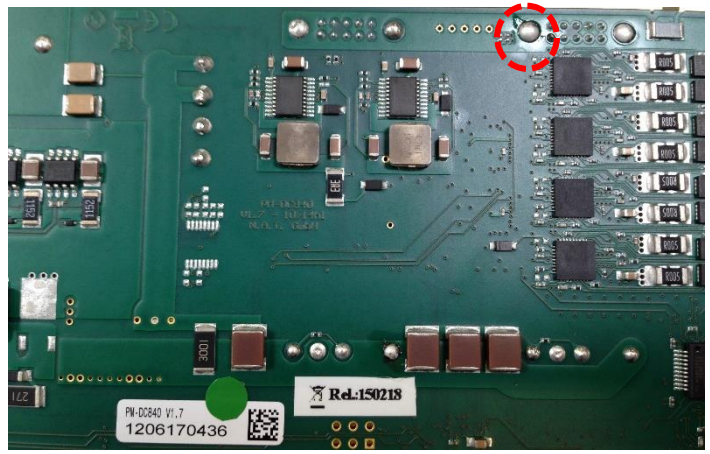
HCAL Readout Electronics Testing

Tests and set up crates for electronics boards

- MicroTCA is a crate system for the next generation of electronics boards in CMS.
- We're testing and installing these new crates for HCAL DAQ in the underground service cavern.
- Set up and test two different uTCA crates (hardware + local area network).

- Test 20+ new uTCA power modules before installation in the underground service cavern.

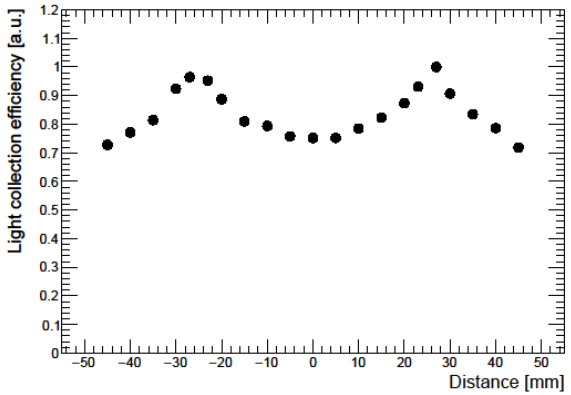




HCAL Scintillator Upgrade

(Advisors: Sarah Eno, Alberto Belloni)

- The CMS hadron calorimeter needs significant upgrade for the High-Luminosity LHC.
- Extreme radiation hardness makes liquid-scintillator tile a candidate for CMS Phase-2 Upgrade on the HCAL Endcap.
- Finished writing and submitting a CMS detector note reporting results from my GEANT4 Monte Carlo simulation for liquid-scintillator tiles. (The simulation was done before summer.)



Available on CMS information server

CMS DN -2015/009

The Compact Muon Solenoid Experiment

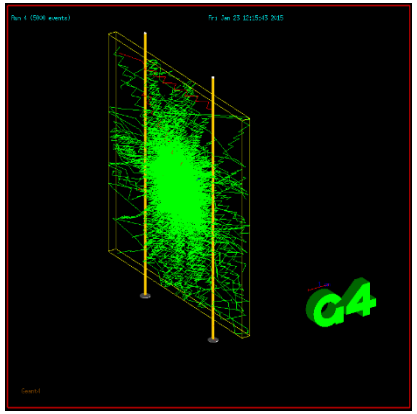
Detector Note

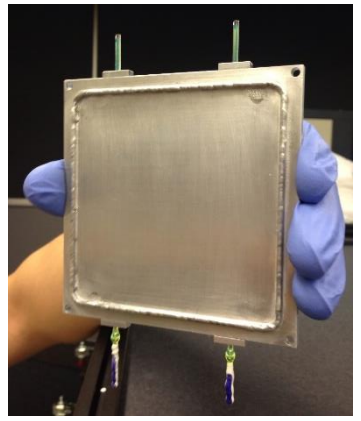
The content of this note is intended for CMS internal use and distribution only

27 February 2015 (v2, 23 June 2015)

Optimizations of light-collection efficiency and uniformity for liquid scintillator tile

Zishuo Yang, Young Ho Shin, Sarah Eno, Alberto Belloni, Joshua Samuel



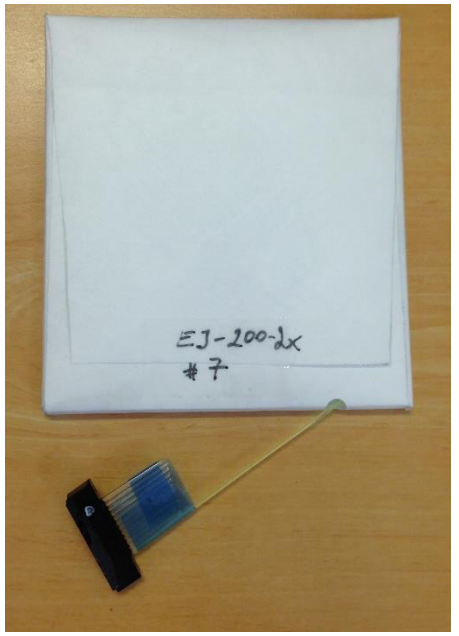


HCAL Scintillator Upgrade

Test beam preparation for scintillator tiles

- Maryland group is conducting test beam studies for our plastic and liquid-scintillator tile prototypes.
- Help to assemble and prepare scintillator tiles before installation onto the test beam stand.

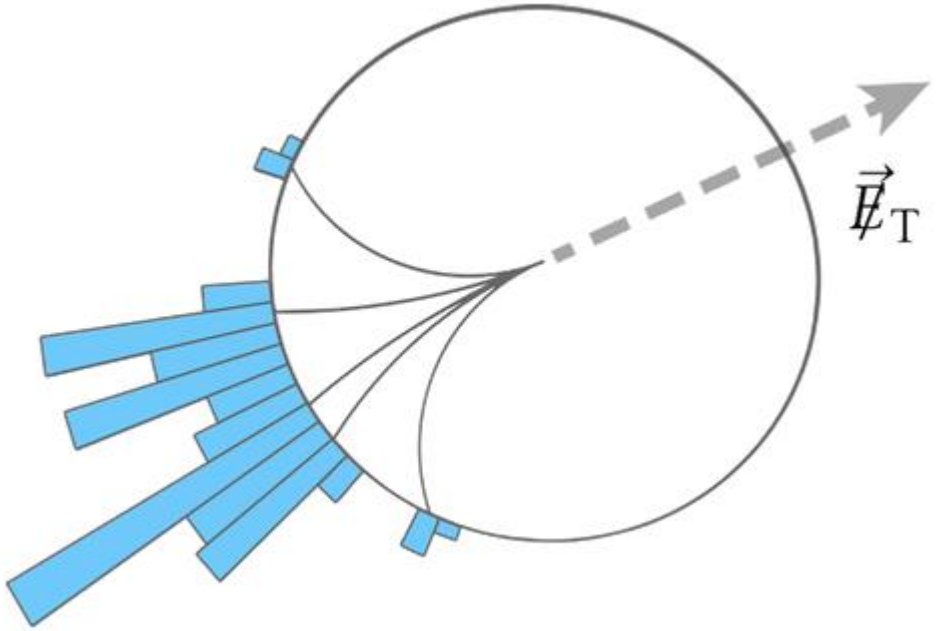
150 GeV muon beam!



Plastic (left) and liquid (right) scintillator tiles

Missing Transverse Momentum

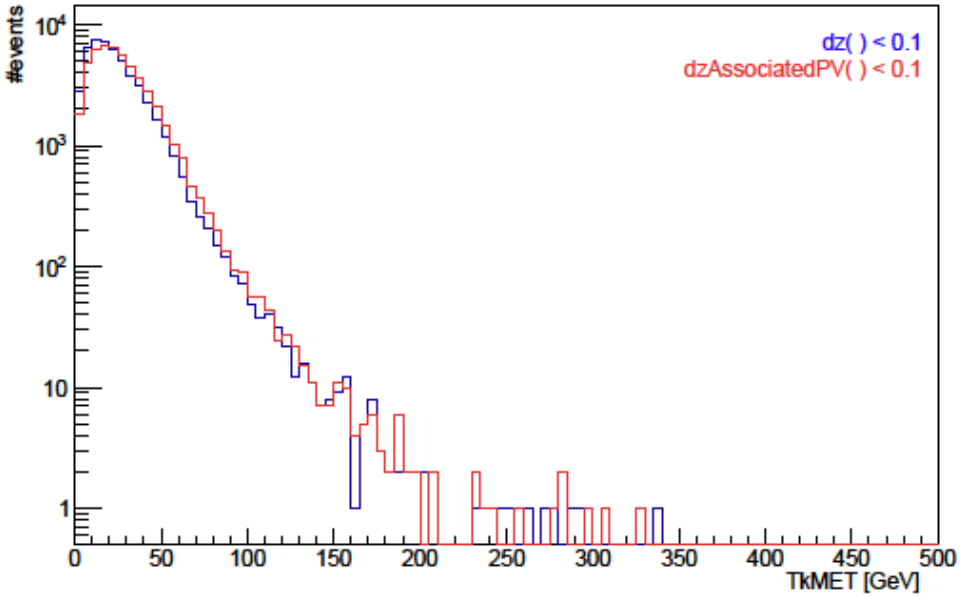
- Missing transverse momentum (MET) is the imbalance in the transverse momentum of all observed particles in the final state of collisions: $\vec{\not{E}}_{\mathrm{T}} \equiv -\sum \vec{p}_{\mathrm{T}}$
- By momentum conservation, MET is the total transverse momentum of all unobserved particles, such as neutrinos or other weakly interacting objects.
- MET is a key variable in SUSY, extra dimensions, as well as dark matter searches. It also played an important role in studies contributing to the discovery of the Higgs boson.



Tracker MET Resolution Study on Track and Vertex Reconstruction

(Advisor: Mariarosaria D'Alfonso
with Young H. Shin)

- Tracker MET (TkMET) is the transverse missing momentum of charged particles only. CMS tracker gives detailed information about charged particles, which is used to reconstruct the primary vertices (PV) candidates.
- With Run2's growing Pileup, the choice of the right PV and the separation between charged particles originating from Pileup is less trivial than in Run1.
- I'm comparing alternative definitions of TkMET to improve TkMET resolution, which can later be used for improving Pileup rejection and PV assignment.
- In order to study MET coming only from tracks of hard-scatter primary vertices, we take the longer path to match MC-truth vertices with reconstructed vertices and get various information on the matched vertices.
- To be continued in fall and eventually measure MET resolution of different reconstruction algorithms.



Thanks a lot!