Tile Multiple Readout and Beyond

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Introduction

Dual Readout Calorimetry measures scintillation light and Cherenkov light on the same hadron shower to correct the jet energy in order to compensate hadron and jet energy measurements.

Dual Readout with parallel plastic scintillator and quartz fibers shows promise, but limitations exist including but not limited to radiation damage of the plastic scintillators and high costs.

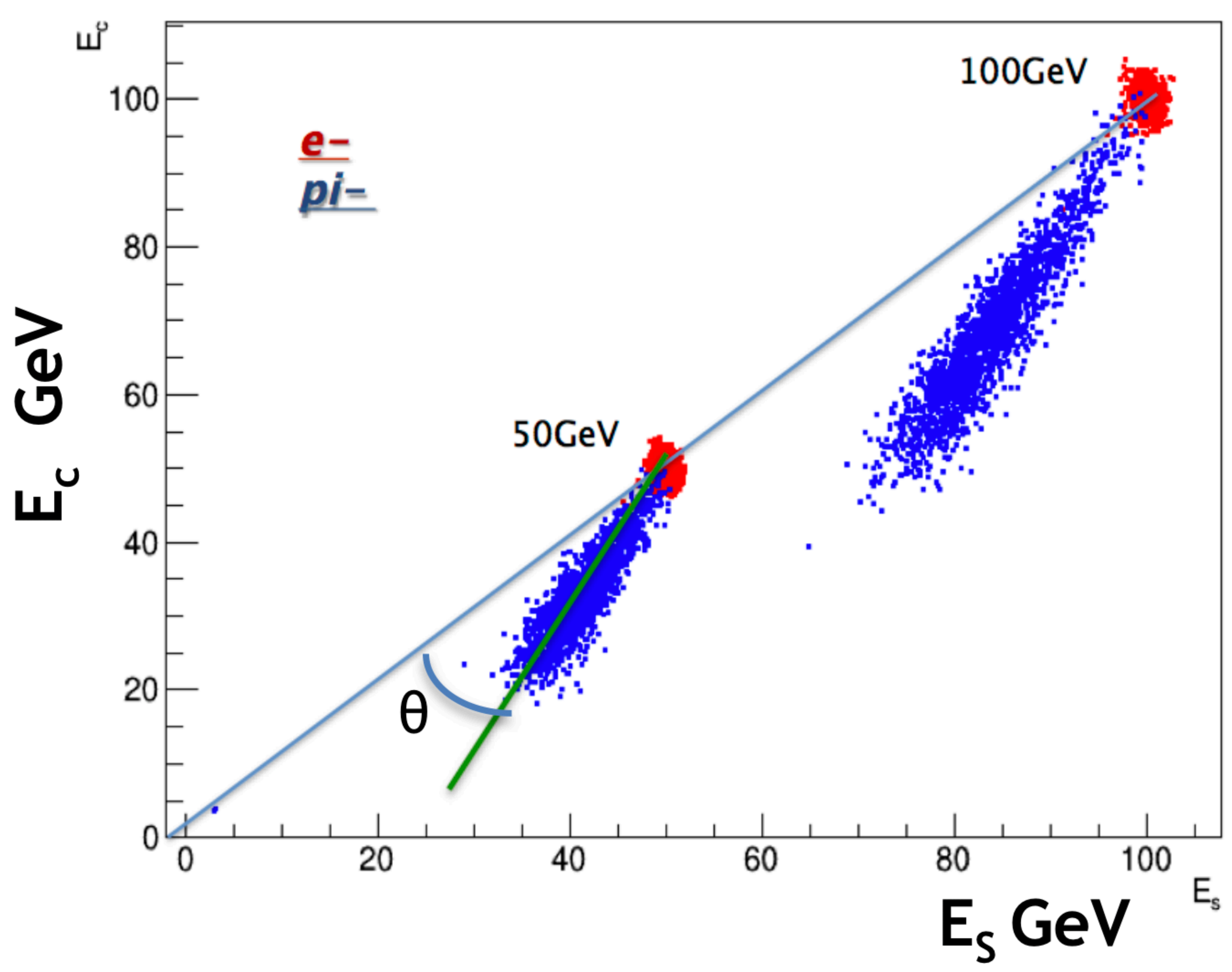
We present dual readout calorimetry with scintillator and Cherenkov tile readout and beyond to multiple tile readout, with superior energy resolution, and radiation resistant ionization sensors in the form of tiles (inorganic scintillators, Si, LArgon).

Monte Carlo (MC) studies were used to design prototype tile dual calorimeters using Fe or Cu absorbers, Cherenkov and plastic scintillator tiles, including an integral Cherenkov-compensated e-m frontend using Pb tiles. The MC studies are extended to other tile type appropriate for dual readout and extend to multiple readout with 3 or more types of tile radiation sensors – sensors with different responses and/or higher contrast to component signals to e-m or hadron showers, neutrons and ions. Sensors include tiles with low refractive indices (aerogel, others), transition radiation "tiles", secondary emission tiles sensitive to ions and low energy protons, hydrogenous vs non-hydrogenous ionization-sensing tiles, and neutron sensing tiles. Multiple readout improves dual readout by extending to triple or more readout. Of special interest is application of tile dual or multiple tile readout to high granularity particle/energy flow calorimeters, not possible with parallel fibers.

Tile Multiple Readout Monte Carlo

GEANT4 Simulation:
0.5 cm thick Cu Absorber, Quartz, and Plastic Scintillator. 0.5 m x 0.5 m x 3.6 m overall size.

Only photons in 325-650nm range were counted. Plot of $E_{scintillator}$ vs. $E_{Cherenkov}$ for electrons and pions.



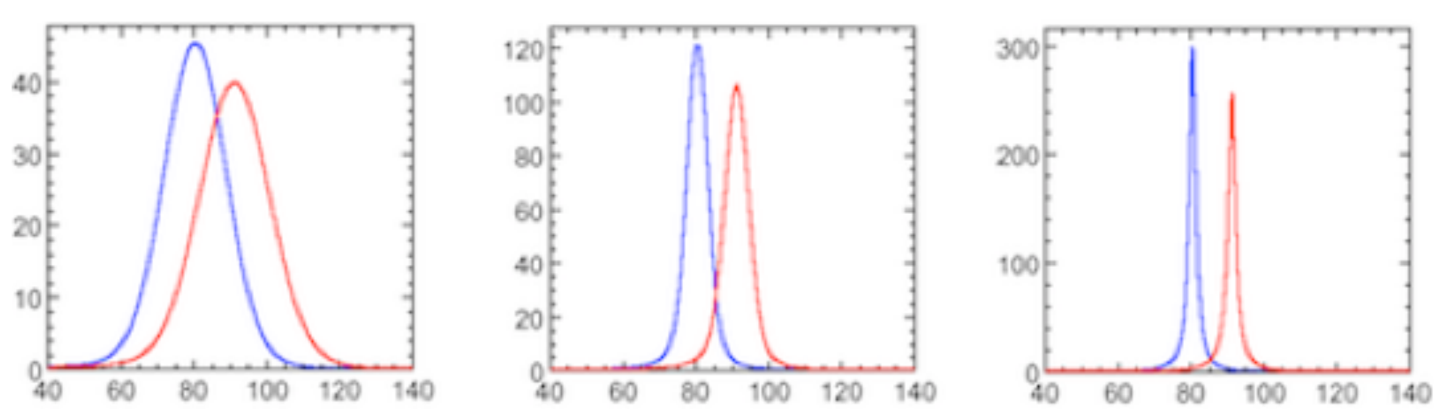
A Simple analysis: Linear fit to hadron scatter points (Green line), with slope R, corrects the energy: Project the scatter points as a histogram perpendicular to the linear correlation, the energy distribution becomes Gaussian & narrower.

One Physics Example: Precision jets

Jet-Jet masses: Goal for future experiments: SM Z->jet jet; W->jetjet; Ratio W,Z->jj to W,Z->leptons ~ 6-7

Reconstruct AND Separate (+SM, ETmiss, jet tags, V-V scattering, BSM, W', Z'…)

Separation of W from Z: σEjet/Ejet ~3% necessary at 100 GeV, with typical single particle energies ~10 GeV. A 3%-4% jet energy resolution from 50-500 GeV gives 2.6-2.3σ W/Z separation. J-J mass resolution is very important In searches for heavy W'/Z', vector boson scattering, triple VVV.



W/Z->jet-jet separation: Left - calorimeter σE/E=60%/√E; Middle σE/E 22%/√E (3% @ 50 GeV) ~2.6σ separation; Right -perfect resolution: ~4.5σ separation.