Cluster separability with alternative Hcal designs:

RPC vs scintillator

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Outline

• Performance quantification for two-particle separation: recap from LCWS ’05.
• Comparison of performance for alternative Hcals.
• Tests of the results.
• Summary.
Two-particle quality: D09

- Goal: to distinguish charged clusters from neutral clusters in calorimeters.
- Proposed a figure of merit to gauge performance of algorithm:
  \[ \text{Quality} = \text{fraction of event energy that maps in a 1:1 ratio between reconstructed and true clusters}. \]
- Higher quality \( \Leftrightarrow \) less “confusion”.
- Showed this plot (right) at LCWS ’05 for simulation of (analog) Si/W Ecal with (digital) rpc/Fe Hcal (the “D09” model in Mokka).
- Quality improves with separation (naturally).
  \[ \forall \pi^+\gamma \text{ separation at 5 GeV pretty good; } \pi^+n \text{ somewhat tougher (n showers typically not well connected geometrically)}. \]
- Question: how does the scintillator/Fe Hcal compare?
Two-particle quality: D09 vs D09Scint

- rpc/Fe curves updated from LCWS ’05 (N.B blue circles on p3 have become red triangles here):
  - upgraded from Mokka v.03-02 to Mokka v.04-00 (no discernable effect);
  - tuned clustering cuts (reason for improvement).
- scint./Fe curves added (the “D09Scint” model in Mokka).
- Significantly better cluster separation apparently achieved with rpc/Fe Hcal (stat. error bars ∼ marker size).
- Advantage particularly pronounced for $\pi^+n$ separation.
- Can this be believed and understood?
- Has important consequences if so.
- Appears to be due to more isolated, disconnected hits in $n$ showers in the scintillator/Fe Hcal…
Energy calibrated (D09 model) according to:

\[ E = \alpha [(E_{\text{Ecal}; 1-30} + 3E_{\text{Ecal}; 31-40})/E_{\text{Ecal mip}} + 20N_{\text{Hcal}}] \text{ GeV}. \]

- Hits map mostly **black ↔ black** (π⁺) and **red ↔ red** (n) between reconstructed and true clusters.
- Fraction of event energy in 1:1 correspondence = 62.1 + 24.8 + 0.1 = 87.0 %.
• Energy calibrated (D09Scint model) according to:

\[ E = \alpha \left[ \left( E_{\text{Ecal}; 1-30} + 3E_{\text{Ecal}; 31-40} \right) / E_{\text{Ecal mip}} + 5E_{\text{Hcal}/E_{\text{Hcal mip}}} \right] \text{GeV}. \]

• Hits map mostly black \( \leftrightarrow \text{red} (\pi^+) \) and red \( \leftrightarrow \text{black} (n) \) between reconstructed and true clusters.

• Fraction of event energy in 1:1 correspondence = 46.8 + 32.1 + 0.6 + 0.3 + 0.1 = 79.9 %.
Two-particle quality: D09 vs D09Scint

- Test: switch off the Hcal (i.e. just use the Ecal hits).
- Respective curves are consistent with each other (stat. error bars ~ marker size).
- (Probably) not a bug in the samples!
• Test: change the scint./Fe Hcal cell-energy threshold cut about the default (1/3 Mip) and reoptimise clustering cuts.

• Lowering threshold ⇒ more isolated hits accepted ⇒ hard to assign to correct clusters ⇒ lower quality.

• Raising threshold ⇒ lose mip tracks ⇒ previously connected hits become isolated ⇒ lower quality.

• Conclusion: can’t achieve same quality as rpc/Fe Hcal by adjusting threshold cut.
• Hcal cell-energy threshold lowered to zero.
• Low-energy halo of isolated hits (from both particles) accepted.
• Correct hit-to-cluster assignment harder to achieve.
\( \pi^+ n \) event at 10 cm separation: D09Scint

- Hcal cell-energy threshold raised to 2 Mip.
- Mip track disappears and remaining hits are less well connected.
- Correct hit-to-cluster assignment harder to achieve.
Calibration of 5 GeV $\pi^+$

- $E(D09) = \alpha[(E_{\text{Ecal}; 1-30} + 3E_{\text{Ecal}; 31-40})/E_{\text{Ecal\ mip}} + 20N_{\text{Hcal}}]$ GeV.
- $E(D09\text{Scint}) = \alpha[(E_{\text{Ecal}; 1-30} + 3E_{\text{Ecal}; 31-40})/E_{\text{Ecal\ mip}} + 5E_{\text{Hcal}}/E_{\text{Hcal\ mip}}]$ GeV.
- Test: vary the relative weighting of the Hcal contribution (up to a factor 2 in either direction) and repeat quality studies; also swap D09 and D09Scint calibrations.
- Difference in calibrations doesn’t impact on quality difference between Hcal types.
(Does the shape difference in the calibrated Hcal energy distributions matter though?)
Summary

- Preliminary study suggest that **rpc/Fe is favoured over scintillator/Fe for the Hcal** in charged-neutral cluster separation (when neutrons are involved, at least).
- Conclusion not dependent upon action of treating cells in an analogue way or digitally; rather on intrinsic properties of tile or gaseous detector.
- Could be part-biased by the tracking-based approach to clustering adopted by *this* algorithm? Nice to check predictions with alternative strategies.
- Demonstrated with “quality” – somewhat contrived measure: does it really propagate to the ultimate goal of particle flow?
- Don’t know for sure, but probably is a good indication of what to expect.