Studies of the DØ Hadronic Calorimeter Response Using Single Pions

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The measurement of the response of the D0 calorimeter to isolated charged hadrons (single particle response, "SPR") is important for the hadronic calorimeter calibration. In addition, SPR measurements can be used as input in an improved algorithm to reconstruct the energies of hadronic jets, using information both from the calorimeter and from the tracking system.

The D0 detector has a magnetic central-tracking system, comprised of a silicon microstrip tracker (SMT) and a central fiber tracker (CFT), located within a 2 T superconducting solenoidal magnet [2]. The calorimeter consists of three separate liquid-argon/uranium cryostats: a central section (CC) covering $|\eta|$ up to ≈ 1.1, and two end caps (EC) extending coverage to $|\eta| \approx 4.2$ [1]. Each cryostat is divided into three regions: electro-magnetic (em), fine-hadronic (fh) and coarse-hadronic (ch), in order of increasing radius and decreasing granularity.

The single particle response is defined as the ratio of the measured calorimeter energy E_{cal} over the track energy E_{trk}. The track momentum is converted into track energy assuming the pion mass. As the track momentum can be measured accurately (especially at low momenta) it is a good approximation to the real particle momentum.

For the SPR studies different Monte-Carlo (MC) samples were produced to optimize isolation and data quality cuts, understand influences of particle admixtures (e.g. protons, kaons) to pion samples, deduce the impact of dead material in front of the calorimeter and study implications of different integration times in D0 RunI and RunII. On the data side, Minimum Bias samples were used as a starting point, leading to the development of a dedicated single pion trigger.

To obtain clean samples two groups of cuts are applied: Isolation cuts to ensure "single" pions, not overlapping with calorimeter energy from other particles, and quality cuts to extract tracks measurable with high accuracy. The isolation cuts have the strongest impact on the final statistics as they have to be rather hard not to show any influence from neighbouring particles. As shown in Fig. 1, top, the lateral energy distribution of (low-energetic) pions is

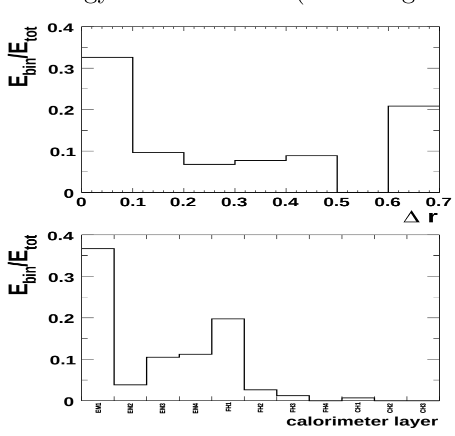

Fig. 1: Single particle shower profiles. Top: lateral profile, bottom: longitudinal profile. Fraction of energy in one calorimeter bin over the total integrated energy is given.

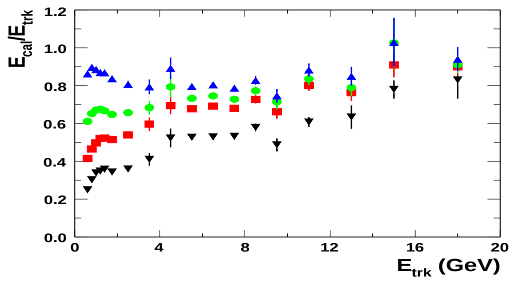

Fig. 2: Single particle response vs. track energy for single pion trigger data below $|\eta| = 0.5$. Calorimeter cone size $\Delta r = \sqrt{\Delta\eta^2 + \Delta\phi^2}$ varies between 0.1 (black), 0.3 (red), 0.5 (green) and 0.7 (blue).

very broad, so that the distances between neighbouring particles have to be high to remove overlaps, leaving only few events in the sample. To enlarge statistics - especially at high energies - a single pion trigger was developed requiring track isolation and a minimum track energy of 5 GeV. As isolation cuts are solely based on tracking information due to the broad calorimeter energy distributions only isolation to charged particles can be obtained. Overlap with "neutral" energy from the decay of neutral pions to photons or stemmimg from other uncharged particles can only be studied and subtracted by MC comparisons.

In Fig. 1, bottom, the longitudinal shower profile of the triggered data sample is shown. Division into energy subranges shows that low energetic particles mainly shower in the first electro-magnetic calorimeter layers whereas contributions in the hadronic calorimeter stem from more energetic pions above 5 GeV. Thus, to obtain the full response energy integration must be performed over all layers.

The result of response distributions for different calorimeter cone sizes can be found in Fig. 2. Towards low energies and small cone sizes a strong cut-off can be seen. This is due to dead material in front of the calorimeter, hindering low-energetic pions to reach the calorimeter surface, and due to the so-called zero-suppression subtracting the average calorimeter noise level. At higher energies this effect vanishes as the energy-loss in the dead material and the noise corrections become negligible. The response reaches a plateau region above 10 GeV whose height only depends on the cone size. With larger cone sizes more of the broad pion energy showers but also more overlapping energy from other particles is picked up and the response increases.

Further studies are planned for the subtraction of neutral energy overlap. The deduction of different response functions for several pseudo-rapidity regions with enhanced statistics at higher energies is aspired. This improved response function will be used as input for a jet energy algorithm using both tracking and calorimeter information.

References

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