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Calorimeter e/h Effects on Reconstructing High Pt W/Z →Hadrons

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The effect of different calorimeter intrinsic e/h values is investigated for reconstructing high Pt W/Z → hadrons. The boson's width is found, to first order, to be independent of e/h but a systematic shift is found in the reconstructed mass. this shift is Pt (Z°) dependent and is comparable to cone size effects.

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[1]To appear in the proceedings of Particles and Fields '91. Vancouver, British Columbia. August 18 - 22, 1991

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Previous studies[1,2] have shown that some high Pt jet physics processes at the SSC are insensitive to the calorimeter linearity, as parameterized by the relative electromagnetic and hadronic (e/h) response. This presumably depended on the "slowly falling" QCD cross section $d\sigma/dp_t$. It seems, at least *a priori*, possible that there are other interesting jet physics topics which might be more sensitive to the calorimeter linearity. This paper reports on the effect on reconstructing high Pt W/Z→ hadrons for a range of intrinsic e/h calorimeters. This decay channel is of interest in processes such as $H \rightarrow l^+l^-$ jet jet.

The recent publication of the GFLASH[3] routines for quickly simulating both hadronic and electromagnetic showers has provided a useful tool in investigating e/h effects. Figure 1 shows the distribution of the fractional energy deposited by secondary π^0 during a charged pion's shower as a function of incident energy. This distribution, including its fluctuations has been tuned to reproduce test beam results on a high Z absorber. This π^0 fraction, f_π, was then used on a shower by shower basis to determine the calorimeter response to hadrons via the relation

$$E_{obs} = K\left\{f_\pi + \left(1 - f_\pi\right)\left(\frac{e}{h}\right)^{-1}\right\} E_{inc}$$

Einc is the hadron's incident energy and K is a calibration constant, determined for 100 GeV/c² incident hadrons. The resolution for a single

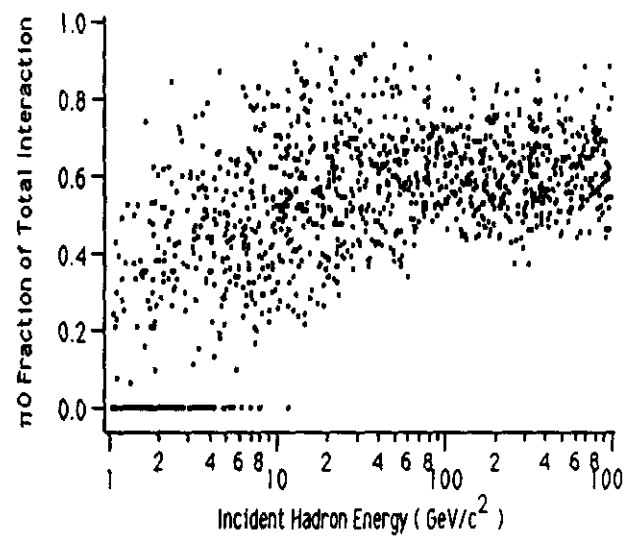

Figure 1. Fraction of shower energy deposited by secondary π^0's

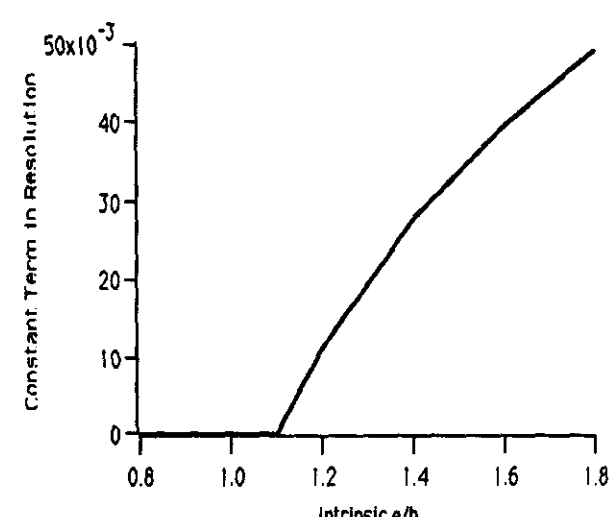

Figure 2. Constant term in calorimeter resolution predicted by the model.

hadron is determined using

$$\sigma^2 = \{f_\pi^2(0.21)^2 + (1 - f_\pi)^2(0.60)^2\} E_{inc}$$

The electromagnetic term was determined for a DØ hadronic calorimeter response[4] to electrons. The hadronic component was calculated for the same calorimeter using this formula and $\sigma_{hadrons}=0.45\sqrt{E}$. It appears, however, that this simple model for the resolution fails at low energies (E< 3 GeV/c²) by predicting a larger width then has been observed[5]. Another consequence of this simple model is a prediction for the constant term as a function of e/h, as shown in Fig. 2. The total hadronic resolution is shown in Fig. 3. This does not include a noise term which is technology dependent and can not be simply related to e/h. The average response to hadrons for various values of e/h is shown in Fig. 4. The nonlinearity caused by the varying π^0 fraction is most significant for energies below 20 GeV/c².

This model for the calorimeter response was used to estimate the effects of various e/h values in the simplest calibration scheme, i.e. no corrections for a known low energy response. Single Z^0 bosons were generated with a range of P_t and forced to decay into hadrons. Figure 5 shows the spectrum for the final state hadrons.

The reconstructed Z^0 mass, ignoring calorimeter granularity, is shown in Figure 6 as a function of e/h for various Z^0 P_t's. All final state decay products except neutrinos were used in reconstructing the invariant mass. Photons (and electrons) were smeared with a response of $\sigma_{EM}=0.16\sqrt{E}$. Muons contributed either their energy of 3 GeV/c², which ever was less. Figure 7 shows the fitted Z^0 width as a function of e/h. There is no evidence for a correlation with calorimeter nonlinearity.

The low energy response problems are exacerbated by including the soft, large angle particles. For comparison, Figure 8 shows the fitted widths requiring two and only two ΔR = 0.7 jets. There is still a significant shift in reconstructed mass in going from e/h=1.00 to

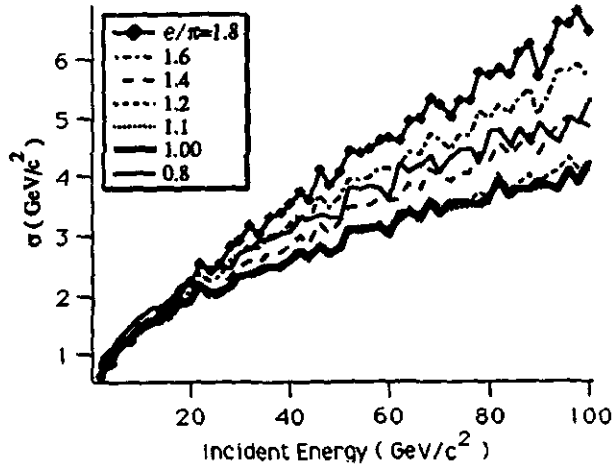

Figure 3. Hadron resolution, as predicted by the model, as a function of incident energy.

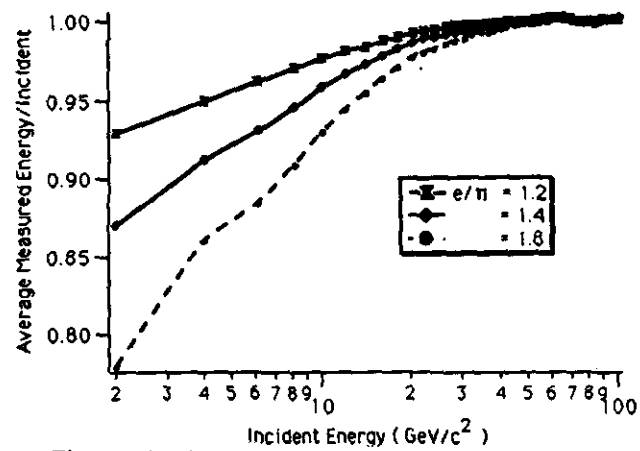

Figure 4. Average response of calorimeter to hadrons as predicted by model.

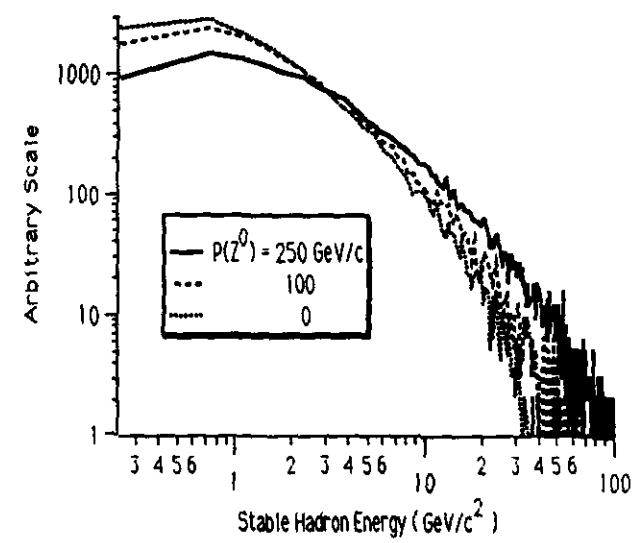

Figure 5. The final state hadron spectrum from Z^0 decay.

e/h=1.4. This e/h correction is comparable to the cone correction. The fragmentation of Z^0's (and by extension W's) is well understood from LEP and it can be expected that both these corrections will be known. Those technologies which have worse sampling terms will, of course, have wider mass distributions. It is troubling, however, that this nonlinearity is so Z^0 energy dependent. A complete analysis for the Higgs decay channel, $H \rightarrow l^+ l^-$ jet jet, must still be done to prove that a correction algorithm can be found.

References

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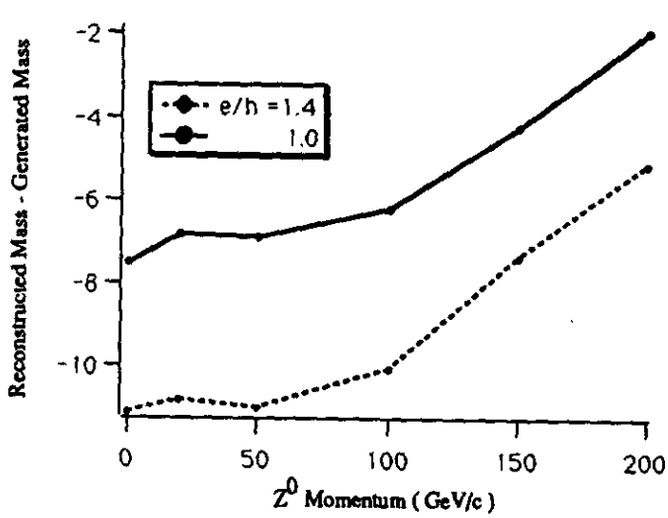
5. H. Gordon, Private communication.



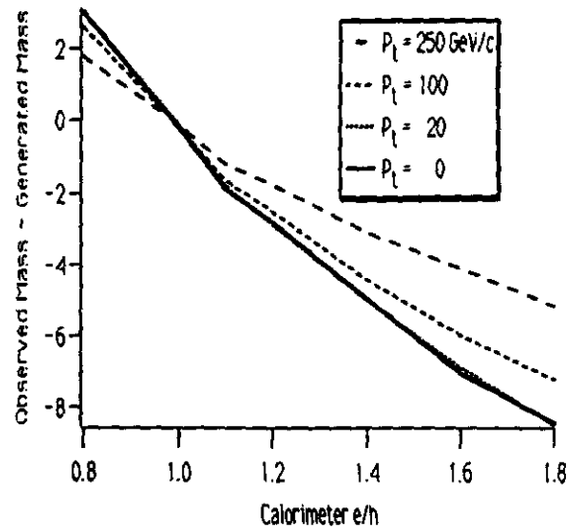


Figure 6. Average error in reconstructing the Z^0 mass vs. e/h.

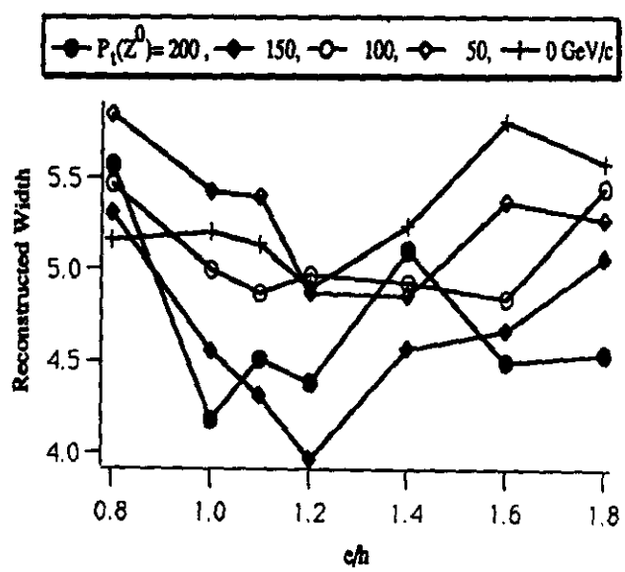


Figure 7. Reconstructed width of Z^0 (generated with zero width) as a function of calorimter e/h.

Figure 8. Average error in reconstructed Z^0 mass using two and only two jet events (cones with ΔR =0.7) events. Neutrinos have been removed from generated mass.