Calorimeter analysis for jet reconstruction

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Abstract. In order to reconstruct particle mass using its jet decay, killing calorimeter clusters made by charged particles are essentially important. Precise association of charged tracks and calorimeter clusters requires fine granularity of calorimters and fine-tuned algorism. In this study, tuning of conventional algorism with a calorimeter of reasonably fine granularity is tried.

OUTLINE OF THE JLC DETECTOR

JLC detector is a large-volume general-purpose detector with a medium magnetic field of 2Tesla. Whole calorimter system is designed to be located inside of a solenoid for the best performance and hermeticity. Detailed study on physics capability of this detector has been carried out so far.

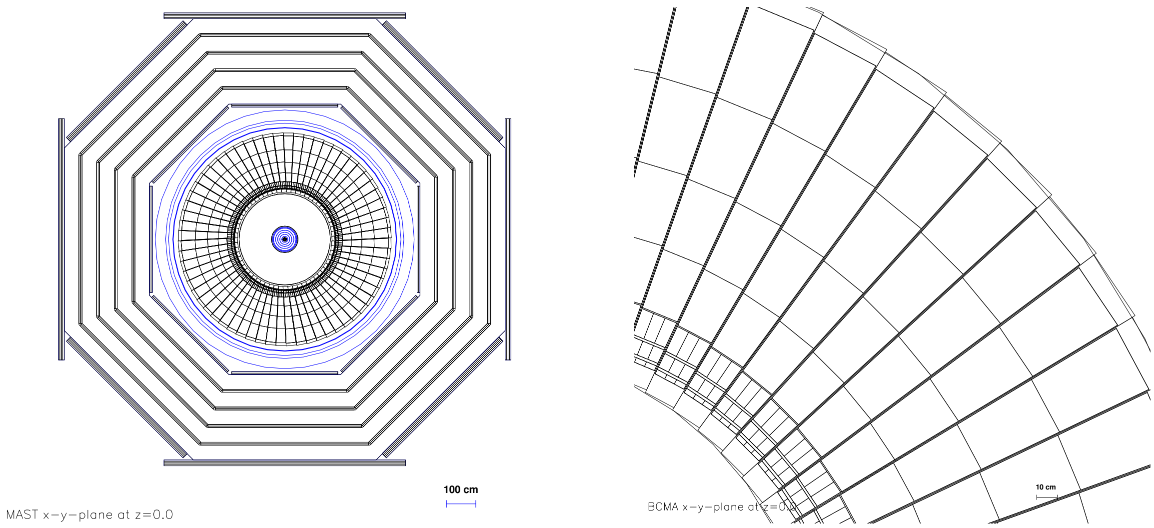

FIGURE 1. Configuration of 3Tesla Detector. Right is a close-up of calorimeter part.

Recent study on the background showed that 2Tesla is a little too weak to suppress beam-beam background to the VTX/CDC. We have therefore made a new detector design with 3Tesla magnetic field and smaller sizes, and started its physics capability study. In the following study, full simulation was done for the 3Tesla detector. The layout of the detector is shown in Fig.1.

CALORIMETER DESIGN IN THE SIMULATOR

The required energy resolution is

$\sigma_E/E = 15\%/\sqrt{E} \oplus 1\%$ for EM particles, and

$\sigma_E/E = 40\%/\sqrt{E} \oplus 2\%$ for hadrons.

In order to achieve this hadron resolution, the calorimeter is designed with hardware-compensated composition. It has a tile/fiber structure with lead absorber and plastic scintillator tiles with acryl plates for fiber routing. The thicknesses are 4mm and 1mm for lead and scintillator of EM section, respectively, and 8mm and 2mm for hadron section. The configuration of the calorimeter implemented in the simulator is also shown in Fig.1. The EM section is divided in to three longitudinal sections, and scintillator-strip shower position detectors [1] are inserted between EM sections. Transverse segment size is 24mrad (4cm). The hadron section has four longitudinal sections, and transverse segment size of 72mrad (12cm).

ANALYSIS

Final goal of the analysis is 2-jet mass reconstruction of W decay. For the reaction $e^+e^- \to W^+W^-$ at 400GeV, quick simulation analysis achieved mass resolution of 3.3GeV without kinematical fit. This is regarded as the target resolution of full simulation analysis.

What were actually studied, however, are as follows;

- Energy measurement mapping with single-particle sample.
- Tower-boundary response mapping with single-particle sample.
- Calorimeter clustering with single-particle and dummy-jet samples.
- Cluster-track association with dummy-jet samples

Analysis with W-decay events has not yet been carried out due to difficulty on cluster-track association at the dummy-jet stage.

Algorism

In order to achieve the best jet energy reconstruction, tracking momentum must be used for charged particles, and calorimeter energy must be used for neutral particles. For this purpose, one needs to identify clusters generated by charged particles and delete them from the list so as not to count them in the jet-clustering process. This is straightforward for isolated clusters, but very sophisticated algorism is needed for overlapping clusters.

In the following analysis, conventional energy-momentum balance is tried to judge the existense of overlapping neutral clusters. The EFLOW analysis [2], which reconstructs neutral clusters with their spatial shower structure, has not been tried since it requires finer granularity than the present JLC calorimeter design for its best performance.

EM cell clustering is done by conventional Jade algorism. Parameters are tuned so that only one particle is responsible to one cluster. Hadron cell clustering is done by contiguous-cell algorism ; all the contiguous cells make one cluser. Thus plural particles can be associated to this cluster. This algorism gives better result than Jade algorism, which tends to devide one hadron cluster into several clusters.

Cluster-track association is done as follows to find overlapping neutral clusters. Here track are assumed to be non-muons. Muons are treated separately.

1. Do EM cell clustering and make a cluster list in order of energy.
2. Pick up a cluster from the list and find out a track which position matches to the cluster.
3. Cluster energy and track momentum are compared.
    - If they match, delete the cluster from the list.
    - If $E > P$, judge that a photon is overlapped. Track contribution is subtracted and the remnant is treated as a photon cluster.
    - If $E < P$, judged that this cluster is non-EM, and trasfer this cluster to the hadron cell clustering.
4. Do hadron cell clustering and make a cluster list in order of energy.
5. Pick up a cluster from the list and find out a track which position matches to the cluster.
6. Cluster energy and track momentum are compared.
    - If they match, delete the cluster from the list.
    - If $E > P$, judge that a neutral hadron is overlapped. Track contribution is subtracted and the remnant is treated as a neutral hadron cluster.
    - If $E < P$, delete the cluster.

Single-particle Response

By injecting single electrons and single pions over calorimeter surface, energy response mapping was done. Detailed mapping was done around the boundary region between barrel and endcap, and around tower boundaries. About 4% lower response was found at the barrel-endcap boundary, and 2.3% lower response at the tower boundaries for both electrons and for pions.

Energy resolution for pions was obtained to be about $\sigma_E/E = 66\%/\sqrt{E}$. More tuning is needed to reproduce beam test results [3].

Dummy Jet Analysis

Before trying the W decay analysis, 'dummy jet' events were analysed for parameter tuning. 19GeV e^-, γ, π^+ were generated in the same direction, and four triplets were generated as shown in Fig.2. Two-'jet' mass of 80GeV should be obtained by appropriate analysis. However present analysis has not yet been well tuned; reconstructed mass and width are about 81GeV and 4.4GeV, respectively, while analysis using calorimetric information only gives much better width of 2.4GeV. More parameter tuning is needed to resolve overlapping neutral cluster from charged cluster precisely.

CONCLUSION

A full simulator is constructed for the JLC detector. Response mapping is done for the calorimter system. Conventional neutral cluster isolation algorism using energy-momentum balance, which was very successful for the analysis of quick simulation results, has been tried for the JLC calorimeter analysis. The results, however is not yet very successful, and much more tuning should be needed.

REFERENCES

1. K.Kawagoe, in theis proceedings.
2. P.Gay, V.Morgunov, in theis proceedings.
3. T.Takeshita, in theis proceedings.

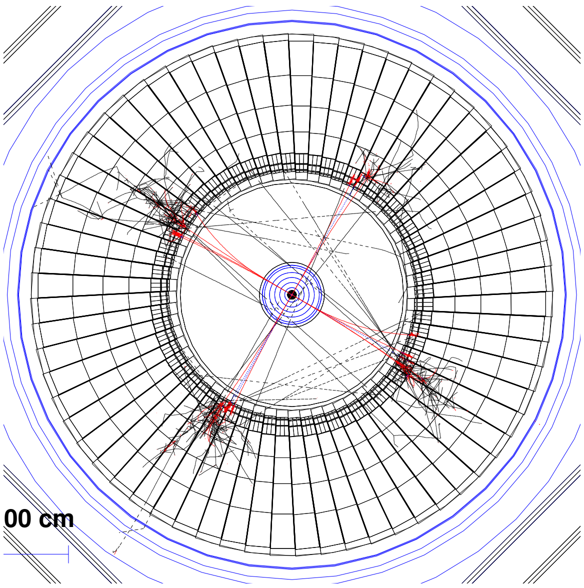

FIGURE 2. 'Dummy jet' event used for analysis tuning.