CHAPTER 1

INTRODUCTION

In experimental particle physics, the study of the smallest known particle using particle accelerator provides the mankind the instrument to understand the fundamental building blocks of deep within the atoms and its relation to the universe as a whole.

In a particle accelerator, the two beams accelerating from the opposite direction collided and interacted at the scale deep within the atom to produce quarks, neutrinos, leptons and fragmentations from the interaction to challenge the theories that form these observed phenomena.

At Hadron Electron Ring Accelerator (HERA), the collision of electron and proton, accelerated 30GeV and 920GeV respectively in the opposite direction has been used to probe the internal structure of proton. In the ZEUS detector at HERA, the energy and the momentum of the particles produced during the electron-proton collision was recorded by the detectors surrounding the interaction point of the ZEUS detector such as the central tracking detector (CTD) and the hadronic and electromagnetic calorimeters.

While charge particles were often used to reconstruct the kinematic variables of the electron-proton collision in the ZEUS detector, the reconstruction of variables of neutral particles using the uncharged tracks in the ZEUS detector has not been extensively explored. In this thesis we explored the methodology of using uncharged tracks in the calorimeter of the ZEUS detector to reconstruct the long-lived neutral hadrons in the final states, i.e. K_L^0 .and neutron *n*, by using the energy deposits of the uncharged ZEUS unidentified energy flow (ZUFOS) objects in the hadronic calorimeter of the ZEUS detector.

The characteristics of K_L^0 .and neutron *n*, which has sufficiently long decay length to reach the hadronic calorimeter (HACs) without decaying were used to differentiate the potential K_L^0 .and neutron *n* candidates. From identification the potential candidates of these long-lived neutral hadrons the source of K_L^0 .and neutron *n* production were narrowed to $\phi(1020)$ and Λ.

The study of strange content of light unflavored meson $\phi(1020)$ $s\bar{s}$ from the mixing of vector meson (ρ, ω, ϕ) and the fragmentation of baryon Λ with quark uds, both as results from the interaction of electron-proton at high energy, carried out with the decay channels $\phi \to K_L^0 K_S^0$ and $\Lambda \to n\pi^0$ respectively, using the measured neutral energy particles deposited in the hadronic calorimeter (HAC) of the ZEUS will give a new information on strangeness conservation and CP (charge conjugate and parity) violation, since both ϕ and Λ decay into neutral particles K_L^0, K_S^0 .and n, π^0 respectively.

It will also give a novel method of data analysis for long-live neutral particle using energy deposits in HAC, conventionally carried out using charge particles detection in the CTD (central tracking detector). The information from the neutral energy deposits by neutral particles

in the HACs then could be backtracked to CTD vertex to provide more information on the neutral particle trajectory and its origin.

The objective of this thesis is to establish methodology for indentifying long-lived neutral hadrons in the final state, using energy deposited by the long-lived neutral hadrons in the calorimeter of the ZEUS detector. The development of readout control of the calorimeter of the ZEUS detector that includes the software controller and hardware implementation, and halomuon analysis of the ZEUS detector are also included in this thesis, as part of Malaysian contribution to the experimental high energy physics especially for ZEUS collaboration.

In Chapter 2 of this thesis, theoretical reviews that form the basis of the research carried out in this thesis is given. In Chapter 3, setup ZEUS of Experiment at HERA and the Monte Carlo simulation performed simultaneously with the on-line ZEUS experiment is discussed.

In Chapter 4, the Readout Control (ROC) simulated for the ZEUS calorimeter data taking and halomuon analysis carried out in the ZEUS detector are discussed. In Chapter 5, event reconstruction and event selections for reconstructing the $\Lambda \to n\pi^0$ and $\phi \to K_L^0 K_S^0$ channels are described. In Chapter 6, result from the $\Lambda \to n\pi^0$ and $\phi \to K_L^0 K_S^0$ decays reconstruction are given and discussed. Finally in Chapter 7, the conclusion of the research and its future outlook are given.