Study of Warm Liquid Calorimeter(Abstracts of Doctral Dissertations)

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Abstract

Chapter 1. Introduction

In SSC(Superconducting Super Collider) project that was going to run at Texas state in USA at the late of this century, we were going to study Higgs boson, which is origin of mass in the standard model of particle physics, top quark, SUSY particles, and so on. To study such physics, warm(room temperature) liquid calorimeter seems to be more suitable detector than other candidates for SDC, which was one of the detectors in SSC, because it had good hermeticity, ease of segmentation, uniformity of response, and so forth. We, however, have to study it in its use, because its technology is not yet established. The critical issues for its development are purification of liquid, material compatibility with liquid and radiation resistance as liquid properties itself and linearity, resolution and compensation of energy as a calorimetry performance.

Chapter 2. Measurements of liquid properties

For use of warm liquid as a medium of ionization chamber, we have to remove electronegative impurities, O_2, H_2O, CO_2, in liquid. The liquid is purified using vacuum distillation and molecular sieves to remove those impurities and purity of the order of 10^{-9} is achieved. The chambers used in following measurements are mainly made of stainless steel and have two plate structure with 0.7 or 0.5cm gap that ^{207}Bi is deposited on the center of the cathode plate for ionization source. The liquid used is TMG(tetramethylgermanium). The measurements of several material compatibilities with TMG were performed by observing deterioration of purity of liquid as a function of time immersing materials in TMG. The material we tested mainly was lead because it was most promising material used for absorbers in calorimetry. The result shows that the purity of liquid immersing *Pb* is not deteriorated for more than 1 year. Furthermore, from measurements about other materials we found these materials could be used with TMG unless they include electronegative components. The measurements of the radiation resistivity of TMG were performed by exposing ^{60}Co γ ray to TMG and observing decrease of signal as a function

of dose absorbed in TMG. The result shows that signal is almost constant up to about $10krad$ of absorbed dose, but after that value the signal gradually decreases and finally disappears at about $100krad$. The magnitude of the signal is reduced to 40% at $100krad$. But if we convert our results to the case of general calorimeter with $0.2cm$ gap, then we can show that the magnitude of the signal falls into 3% only of the first signal at $100krad$.

Chapter 3. Beam test experiment of warm liquid calorimeter

The beam test experiment of the warm liquid calorimeter was done at MT beam line in Fermilab in USA. In the experiment energies deposited in calorimeter were measured varying incident energies of e, π and μ. The liquid used is TMP(tetramethylpantane) and the calorimeter is constructed by inserting energy detector between lead and iron absorber. following five configurations were prepared: $Pb(0.65cm)/TMP(0.25cm) = 2.5/1\times 140$ *layers*, $Fe(0.6cm)/TMP = 2.5/1\times 140$, $Fe/TMP = 15/1\times 38$, $Pb\cdot Al(0.2cm)\cdot Al\cdot Pb\cdot TMP\times 70$ and $Al\cdot Pb\cdot Pb\cdot Al\cdot TMP\times 70$. In the first three configurations, calorimetry performances by difference of absorber are measured and last two ones are prepared to measure transition effect in calorimeter. From these measurements of energy deposited in TMP calorimeter, we can analyze linearity of deposited energy to incident energy, resolution of energy and ratio of deposited energy of e to that of π, e/π which determine the performance of calorimeter. These results are as follows. The non linearity is less than 3%. For relative energy resolution σ/E to incident energy $E[GeV]$, $0.15/E$ for e and $0.57/E$ for π are achieved after sampling correction. For e/π measurement(it is desirable that e/π is equal to 1 and the compensation of energy is expected in warm liquid since it is hydrogenous liquid), we obtained $e/\pi = 1.17$ at $100GeV$ with lead absorber. This value shows that TMP calorimeter can get e/π approximately equal to 1 without using uranium absorber. From these measurements, we can show that TMP calorimeter can compete with other existing calorimeters in performance.

Chapter 4. Search for Higgs boson using warm liquid calorimeter

We tried to search Higgs boson (H^0) in Monte Carlo simulation using value of energy resolution obtained in previous chapter. The clearest mode observed in calorimeter is $H^0 \longrightarrow Z^0Z^0 \longrightarrow e^+e^-e^+e^-$. The main background to this mode is $q\bar{q} \longrightarrow Z^0Z^0 \longrightarrow e^+e^-e^+e^-$. H^0 search simulation was done with unknown H^0 mass parameters, that was, different production cross sections, in luminosity $10^{33}cm^{-2}s^{-1}$. The result shows that H^0 in this mode is clearly detectable in our warm liquid calorimeter.

Chapter 5. Summary

The warm liquid calorimeter is usable in future high energy physics experiment if remaining problems are solved.