

**Thomas Jefferson National Accelerator Facility** Newport News, Virginia, USA, Managed by the Jefferson Science Associates, LLC for the U.S. Department of Energy Office of Science

#### **INTRODUCTION**

The purpose of the charge calorimeter is to measure the electron beam current with 1% absolute accuracy. The current in hall-A is determined by using a non-invasive cavity monitor (BCM) calibrated by another device, the Unser monitor. The Unser monitor can achieve about 0.2 % accuracy of calibration around 50A [1], but at low current it is difficult to reach 1 % accuracy because the Unser monitor has noise levels of order of 0.2-0.3A[2]. Therefore, a Tungsten calorimeter has been built to calibrate the BCM at beam currents below the range of the Unser monitor. The energy deposited in the calorimeter is given by

 $E_{cal}(Joules) = E_{beam}(MeV) \times I_{beam}(A) \times t (sec)$ 

where  $E_{cal}$  is the energy absorbed by the calorimeter,  $E_{\text{beam}}$  is the beam energy,  $I_{\text{beam}}$  is the average beam current and t is the

exposure time. The calorimeter temperature will change after the beam exposure and is given by

(1)

$$T = E_{cal} / C_m$$

where C<sub>m</sub> is the heat capacity of the slug. The calorimeter is designed to operate between 0.8 GeV to 12 GeV of beam power, and between 0.1A to 5A for beam currents [3].



# **Precision Absolute Beam Current Measurement of Low Power Electron Beam**<sup>\*</sup>

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## ABSTRACT

Precision measurement of low power CW electron beam current for the Jefferson Lab Nuclear Physics program have been performed using a Tungsten calorimeter. This paper describes the rationale for choice of the calorimeter technique as well as the design and calibration of the device. The calorimeter is in use presently to provide a 1 % absolute current measurement of CW electron beam with 50 to 500 nA of average beam current and 1-3 GeV beam energy. Results from these recent measurement will also be presented.



The Calorimeter Experiment in Hall-A



Histogram For C<sub>m</sub> Values

Calibration of Calorimeter as Faraday Cup

To simulate the real beam effect a heater has been embedded inside the slug and its resistance has been measured and found to be 6.9  $\Omega$ . A fixed Current and Volt have been applied for a fixed time using "Agilent 3458" multimeter. Current and Voltage calibrations are performed at values that match the expected beam exposure values for incident beam power and exposure time. The Current and Voltage values can be determined form equation(3) and the time of exposure can be determined form equation(4).  $E_{\text{beam}}(\text{MeV}) I_{\text{beam}}(A) = I^2 / R = V^2 \times R$ T = 86000(Joules) /  $E_{\text{beam}}$ (MeV)  $I_{\text{beam}}$ (A) (4)

The average heat capacity has been calculated and found to be 8555.5 J/K with a standard deviation value equal to 13.92 The calorimeter can be used as a Faraday cup, therefore a bleed-off wire is connected to the back face of the slug to remove the accumulated charges. In order to do the calibration with 1% accuracy, a 50 A current should be used. A resistance has been measured with high accuracy and found to be  $22.79 \pm 0.01$  M $\Omega$  then it connected to "Exitron" multimeter. A set of data has been taken between the input current (V/R) and the output current. The relation between the input and output currents found to be linear with slope =  $1.14253 \pm 0.00038$  and offset =  $-0.04368 \pm 0.00015$ 

The Unser monitor used to calibrate the Hall-A BCM has 0.2% accuracy for beam currents around 50  $\mu$ A. The Unser monitor is not designed to provide absolute calibrations for beam currents below 5 µA. A calorimeter has been designed and fabricated with a mechanical and thermal design to minimize the heat losses. All the measurements are consistent with 1% absolute precision.

Accelerator Conference, Chicago USA. operations, JLAB internal document. beam, Proceedings of DIPAC 2005, Lyon, France



Government purposes.



## **EXPERIMENTAL WORK**

## SUMMARY

## REFERENCES

[1] J.C.Denard et.al, High accuracy beam current monitor system for CEBAF's experimental Hall A, Proceedings of the 2001 Particle

R.Gilman, Hall A beam calorimeter: overview, specification,

[3] A.Freyberger et.al. Absolute current calibration of 1 A CW electron



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