ABSTRACT

Magneto-Optic Kerr Effect in a Magnetized Electron Gun. BENJAMIN HARDY (Bowling Green State University, Bowling Green, OH 43402) JOSEPH GRAMES (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Direct current high voltage photoguns like that of the Gun Test Stand at Jefferson Lab, successfully generate electron beams in order to advance studies in Nuclear physics. Magnetized electron beams result from electron production via photoemission within a solenoid magnetic field. As opposed to non-magnetized electron beam sources, magnetized sources have the potential to improve ion beam cooling efficiency significantly. The beam magnetization depends critically on the applied magnetic field. At the Gun Test Stand at Jefferson Lab, a solenoid magnet will be installed adjacent to the photogun to magnetize the electron beam. Due to the photocathode operating in a vacuum chamber, measuring and monitoring the magnetic field at the beam source location with conventional probes is impractical. The Magneto-Optical Kerr effect (MOKE) describes the change on polarized light by reflection from a magnetized surface. The reflection from the magnetized surface may alter the polarization direction, ellipticity, or intensity, and depends linearly upon the surface magnetization of the sample. By replacing the photocathode with a magnetized sample such as pure iron and reflecting polarized light from the sample surface we infer the magnetic field at the beam source location. A controlled MOKE system has been assembled on an optical bench to test the magnetic field on site. It consists of a low power laser, polarizers to define and analyze polarized light, a photo-elastic modulator that supplies a high frequency modulation of the laser polarization to improve the signal to noise ratio of the measurements, and a polished iron foil. Control tests using strong rare earth magnets to imitate the intended 0.15 Tesla solenoid field. Calibration of the solenoid magnet is performed at the Magnetic Measurement Facility at Jefferson Lab, by comparing the MOKE signal with magnetic field measurements. Once calibrated the “Kerr-mometer” will be available as an in-situ diagnostic of the magnetic field strength and uniformity of the photocathode within a vacuum chamber, providing an adequate description of the field at electron beam source. The report summarizes the method and results of controlled tests and calibration of the MOKE sample with the solenoid magnet field measurements.

ABSTRACT

Two-Photon Exchange in Electron-Nucleon Scattering. JESSE ASHWORTH (University of Washington, Seattle, WA 98195) WALLY MELNITCHOUK (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Researchers are working to determine in-depth information about the substructure of the proton. This includes the proton's fundamental charge and current distributions, described by functions called electric and magnetic form factors. These form factors have traditionally been determined by computing elastic electron-nucleon scattering cross sections, to first-order expansion in the electromagnetic fine structure constant, α_e---encompassing a process called one-photon exchange. Experimental discrepancies in the proton's electric-to-magnetic form factor ratio have prompted a need to compute cross sections to second order expansion in α_e, involving two-photon exchange (TPE) interactions. Two methods for calculating TPE cross section contributions exist: one based on hadronic degrees of freedom (suitable at low Q^2) and the other on partonic degrees of freedom (applicable at high Q^2). Both methods have been claimed to principally account for the form factor discrepancy. However, ambiguities exist in the separation of the soft and hard parts of the partonic cross sections. This work aims to resolve such ambiguities and ultimately pave the way toward a unified description of TPE effects at all Q^2 values. Achieving this goal will further pin down the nature of the proton's interior, and the results in turn can be used to better understand the neutron and other hadrons.

ABSTRACT

Error Analysis of CEBAF Emittance Measurements. DEEPSANA SHAHI (Adelphi University at Garden City, NY 11530) TODD SATOGATA (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Particle beams have many relevant properties, including particle type, energy, beam size, and intensity. In the Continuous Electron Beam Accelerator Facility at Jefferson Lab, the electron beam moves through a beamline which consists of drift spaces and quadrupole magnets and the motion of the electrons is expanded around a design trajectory. When the beams are delivered into the experimental halls, the electron beam sizes are measured. From beam size measurements, the electron beam sizes are analyzed by computing the emittance and Twiss parameters, which describes an area of the beam and beam sizes, respectively. Since all measurements have errors, the main focus of this project is to analyze those errors in the measurements. When the electron beam moves through quadrupole magnets, giving transverse coordinates in the direction of the beam's motion, the intensity of the beam is measured using wire scanners (or harp). The Gaussian distribution of particles in phase space (x,x') fits the beam intensity and measures the square beam sizes by using the fit parameters. The measurements in emittance and Twiss parameters are computed along with the errors by analyzing the beam size data based on transverse beam profile measurements. By propagating measurement errors in the square beam sizes, the error bars for emittance measurements and Twiss parameters are calculated. The values for emittance ranges from 7.08×10^{-10} to 2.69×10^{-9} [m] with 10^{-11} error.

ABSTRACT

Analysis of the neutron structure function from A = 3 nuclei. ANTHONY TROPIANO (Michigan State University, East Lansing, MI 48824) WALLY MELNITCHOUK (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

According to Quantum Chromodynamics (QCD), nucleons are made up of quarks and gluons. Experiments scatter high energy leptons from nuclear targets to determine the quark structure of nucleons. In particular, the structure of the neutron is not well understood due to the lack of free neutron targets. Light nuclei provide effective neutron targets; consequently, experiments utilize light nuclei targets, such as deuteron, helium-3, or tritium, in order to extract information on the neutron structure function. Knowledge of the quark structure of the neutron is necessary in order to obtain a complete description of the nucleon's flavor structure. This study focuses on the calculation of the helium-3 and tritium structure functions along with testing the sensitivity in extracting the free neutron structure function, F_2^n. In the weak binding approximation (WBA), nuclear structure functions are convolutions of smearing functions and nucleon structure functions, which essentially reduces the calculation to the evaluation of an integral. The smearing functions are calculated analytically, while parametrizations are used for the nucleon structure functions. We determine the structure functions of sister nuclei, helium-3 and tritium, and their respective European Muon Collaboration (EMC) ratios. Information on the neutron structure function is extracted from the aforementioned EMC ratios of the sister nuclei with the calculation of F_2^n/ F_2^p at several values of Bjorken x. Several experiments at Jefferson Lab will use helium-3 or tritium targets. This study provides a background understanding of the nuclear structure in order to reliably interpret the data from these experiments. The resulting calculations of this study are not in exact agreement with previous experimental data. These results suggest the need to apply nuclear corrections.

ABSTRACT

Calibrating a new polarimetry, pulse NMR, with NMR for the polarized ^{3}He target. CALEB P. FOGLER (Old Dominion University, Norfolk, VA 23529) JIAN-PING CHEN (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

One of the main goals of the Thomas Jefferson National Accelerator Facility (JLab) is the study of the proton and neutron structures. A polarized ^{3}He target provides an effective polarized neutron target to study the neutron spin structure. The target polarization is measured with nuclear magnetic resonance (NMR) and electron paramagnetic resonance (EPR). New experiments for the JLab 12 GeV program require upgrades to the ^{3}He target which needs a new type of polarimetry – pulse NMR (PNMR). PNMR uses a radio frequency (RF) field to perturb the ^{3}He spins which then undergo free induction decay (FID). The amplitude of this oscillating decay is proportional to the ^{3}He polarization. The PNMR needs to be calibrated with regular NMR. This project is to perform these calibrations and to study the systemic effects of PNMR. NMR and PNMR measurements were performed sequentially multiple times. ROOT was used to analyze the data and extract the amplitudes of the measurements which are proportional to the polarizations. These amplitudes were plotted to study the PNMR against the established NMR measurements. PNMR appears to have a linear relationship with NMR. The step remaining is to study the systematic uncertainties of the PNMR. When the study is completed, the new polarimetry, PNMR, will be established.

ABSTRACT

The Building, Testing, and Implementing a Thermocouple In The Hall C Gas Shed. JOHN GONZALEZ (Northeastern Illinois University, Chicago, IL 60634) BRAD SAWATZKY (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

The gas shed in hall c has various instruments that need to stay at constant temperature ranges, such as the gas mixing systems for the wire chamber detectors. There were occasions where the temperature fluctuation caused errors to appear. The temperature was not being recorded at the time, thus there were problems correcting for temperature related issues. An AD595 (Analogue Device) and a thermocouple were used because they are precise enough to get a feel for the temperature in the gas shed, and durable enough to last in the environment. A thermocouple is made up of two dissimilar metals that create a voltage when there is a change in temperature. The project entailed building a circuit based on the AD595 device to calculate the temperature, and used the thermocouple to get a reading. Once one circuit was able to reliably measure known temperatures such as room temperature, three more circuits were made on the same perfboard. The four circuits were tested against a kitchen thermometer in various known temperatures, such as a 0°C ice bath, boiling water, and room temperature. The temperature range between the four circuits were noted to be between two to four degrees Celsius and were within two or so degrees from the kitchen thermometer. The thermocouple circuits were recently installed into the hall c gas shed and connected to the JLab EPICS slow-controls data acquisition system. This new hardware will become a permanent part of the hall c infrastructure, used to ensure proper operation of the hall c gas system for the 12 GeV era.

Modeling Compton Scattering in the Linear Regime

Compton scattering is the collision of photons and electrons. This collision causes the photons to be scattered with increased energy and therefore can produce high-energy photons. These high-energy photons can be used in many other fields including phase contrast medical imaging and x-ray structure determination. Compton scattering is currently well understood for low-energy collisions; however, in order to accurately compute spectra of backscattered photons at higher energies relativistic considerations must be included in the calculations. The focus of this work is to adapt a current program for calculating Compton backscattered radiation spectra to improve its efficiency. This was done by first translating the program from Matlab to python. The next step was to implement a more efficient adaptive integration to replace the trapezoidal method. A new program was produced that operates at less than a half of the speed of the original. This is important because it allows for quicker analysis, and sets the stage for further optimization. The programs were developed using just one particle, while in reality there are thousands of particles involved in these collisions. This means that a more efficient program is essential to running these simulations. The development of this new and efficient program will lead to accurate modeling of Compton sources as well as their improved performance.

ABSTRACT

Electron Beam Dynamics, Astra Modeling and Measurement. ROBERT PARKER-MASON (Morehouse College, Atlanta, GA 30314) FAY HANNON (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Jefferson Lab uses a particle-tracking algorithm called Astra in their Gun Test Stand (GTS). The GTS contains a direct current (DC) gun that uses high voltage with a multi alkali photocathode to accelerate electrons down a beam line. This photocathode was chosen because it has a high quantum efficiency (QE) and it is thought to have long lifetime. The beam line at the GTS comprises of solenoids, viewers and a faraday-cup. The purpose of the GTS is to study how electron beams behave and eventually, run the electron beam at 5 mA without a fluctuation in vacuum. The focus of this project was to simulate the electron beam in the GTS using Astra and confirm those results with measurements. Simulations were then validated with beam measurements. The measurements and simulations agreed well at low current. However, at high current halo was introduced. Halo is unwanted electrons caused by illuminated parts in the photocathode from the multiple reflections of the laser beam. Simulations were then run to determine at which cathode radius the halo would become a problem.