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ABSTRACT

Multi-Objective Optimization of Heat Load and Run Time for CEBAF Linacs Using Genetic Algorithms. CODY J. REEVES (University of Florida, Gainesville, FL, 32611) BALŠA TERZIĆ (Old Dominion University, Norfolk, VA, 23529) ALICIA HOFLER (Thomas Jefferson National Accelerator Facility, Newport News, VA, 23606).

The Continuous Electron Beam Accelerator Facility (CEBAF) consists of two linear accelerators (Linacs). Each Linac consists of 200 niobium cavities that use superconducting radio frequency (SRF) to accelerate the electrons. The gradients for the cavities are selected to optimize two competing objectives: heat load (the amount of energy required to cool the cavities) and trip rate (how often the beam turns off within an hour). The resulting system is a multidimensional, multi-objective, nonlinear system of equations that is not readily solved by analytical methods. The study employed a genetic algorithm (GA), which applies the concept of natural selection, to solve this system of equations. This paper enumerates several methods to significantly reduce computation time without degrading solution quality. It also demonstrates ability to employ GA for operational use for any Linac-based facility.

ABSTRACT

Simulation of the Hall C High Momentum Spectrometer Drift Chambers. JONATHAN E. STELZLENI (Purdue University, West Lafayette, IN 47906) MARK JONES (Thomas Jefferson National Accelerator Facility, Newport News, VA, 23606).

The drift chambers of the High Momentum Spectrometer (HMS), in Hall C of Jefferson Lab, are used to determine the trajectory of particles. The main focus of this project was to simulate the drift chambers, obtain their properties, and compare to the HMS drift chambers. Garfield++, a simulation toolkit derived from ROOT, was used to simulate the drift chamber. Using this toolkit, a cell of the drift chambers was successfully simulated with properties comparable to the drift chambers of the HMS. The electric fields surrounding the sense wires, in both the simulation and the HMS chambers, were found to be slightly different. Drift velocities were also compared, which showed similar values, but because the different electric fields and accidentals in the HMS data they were not exact. Garfield++ provides many additional functions, such as the simulation of electron avalanches and high energy electron tracks, which are explored. These simulations help to provide insight into how drift chambers function in practical use.

ABSTRACT

Automatic Surface Defect Detection in Superconducting Radio Frequency Cavities using C++ and OpenCV. DANIEL IRIKS (Santa Rosa Junior College, Santa Rosa, CA 95401 / Sonoma State University, Rohnert Park, CA 94928) GRIGORY EREMEEV (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Thomas Jefferson National Accelerator Facility conducts research, development, and production of superconducting radio frequency cavities for particle accelerators. In cavity production, serious albeit tiny surface defects can remain after polishing and cleaning, and these defects limit accelerator efficiency and performance capabilities. The manual inspection process for these defects is very time-consuming. The purpose of this project was to further develop and test an approach to automating defect detection, which could increase cavity production efficiency by decreasing the time and labor

necessary for inspection and testing. This approach was to use the programming library OpenCV and the language C++ to write a computer program that would inspect pictures of cavity surfaces and detect defects. In this project, the features of automatic application to multiple pictures, name recording of pictures with detected defects, and defect sizing were added to the program. Also, the program was trained to detect a different type of defect, and its performance detecting this type was tested. Testing showed the program had a detection rate of 53% and a false positive rate of 29%, that the average calculated size was 5 times larger than the actual value with a percent relative average deviation of 30%, and that the average program run time was 2.1 seconds per image. These results are inconclusive as to the feasibility of this program's use for automatic cavity inspection. While sufficient detection and false positive rates were not attained in this project, it may be possible to do so by implementing certain improvements in the training procedure and making changes to certain program parameters.

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ABSTRACT

Extracting Free Neutron Data from Electron Deuteron Scattering in an Electron Ion Collider. OZ AMRAM (Carnegie Mellon University, Pittsburgh, PA 15213) DOUGLAS HIGGINBOTHAM (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

The lack of free neutron targets has made it very difficult to study the internal structure of the neutron with high precision. The construction of a new Medium-energy Electron Ion Collider (MEIC) would allow us to use electron-deuteron scattering to obtain free neutron data by tagging the spectator proton. The focus of this project was to test a new model independent method of extracting the neutron structure function (F2N) from simulated cross section data. It was shown that the model independent method converges to a single value of F2N reliably for cross section data with limited random error. A model dependent modification of the method was shown to reduce error in the extracted F2N. This result demonstrates the proof of concept for a model-independent way of extracting F2N from cross section data. A better extraction of F2N from electron-deuteron scattering would fill in one of the major longstanding gaps in our knowledge of nuclear structure.

ABSTRACT

Comparing and Improving Quality Factor (Q_0) Data Collected from Testing in the VTA, CMTF and Tunnel. Mowafeg E. Abdelwhab (Morehouse College Atlanta, Georgia 30314) EDWARD F. DALY (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

The Superconducting Radio Frequency (SRF) Institute at Jlab uses three methods to test RF cavities for quality factors (Q_0): Vertical Test Area (VTA), Cryomodule Test Facility (CMTF), and in the tunnel. The VTA uses an electrical method to calculate Q_0 and the CMTF and tunnel use calorimitry. Participation in each of the three test methods was completed to attain data that can be analyzed to possibly find improvements in the testing techniques and the instrumentation. Since the VTA provides the best environment for the niobium cavities, it is expected that the higher Q_0 values be found using the VTA. However, if the environment and conditions for attaining higher Q_0 values are met in the cryomodule design and the tunnel, it is possible to improve the values in the CMTF and tunnel.

ABSTRACT

Analytic Solutions for Compton Scattering in the High Energy Regime. TODD HODGES (Arizona State University, Tempe, AZ 85004) WALLY MELNITCHOUK (Thomas Jefferson National Accelerator Facility, Newport News, VA 23606).

Thomson sources of electromagnetic radiation utilizing relativistic electrons have seen increased use in fundamental physics research in the past several years. The small frequency range, or bandwidth, of the emitted radiation is highly desirable for applications in nuclear physics, medicine, and homeland security. As the intensity of the incident laser pulse involved in the scattering event increases, the bandwidth of the emitted radiation increases. In accelerators, this increase in bandwidth may be negated through frequency modulation of the laser pulse. However, current analytic solutions governing this frequency modulation are only applicable when the energies of the individual photons in the laser pulse are within the Thomson limit. We derive analytic solutions applicable to laser pulse frequency modulation both within, and outside, the Thomson limit through the use of Quantum Electrodynamics (QED). Specifically, an expression for the differential cross section pertaining to Compton scattering is derived for a reference frame in which both the electron and incident photon are moving. Additionally, an approximation for the differential cross section is derived including first and second order corrections. Progress towards altering the derived expression to include the contribution from multiple photon emitting processes and allowance for specification of incident photon polarization is discussed.

ABSTRACT

Computing Emittance for Non-Gaussian Beam Distributions. CHARLES MCINTYRE (Reed College, Portland, OR 97202) TODD SATOGATA (Thomas Jeerson National Accelerator Facility, Newport News, VA 23606).

We analyze recent data to compute the emittance and Twiss parameters forthe electron beam at Jefferson Lab's Continuous Electron Beam Accelerator Faciliity (CEBAF). The beam is sent through a focusing quadrupole; after focusing, the beam's intensity as a function of transverse position is measured using wire scanners. We develop tools to fit intensity data with both Gaussian and skew-Gaussian distributions, and use the fit parameters to extract mean-square beam size. Analysis of beam size data as a function of quadrupole strength yields the emittance and Twiss parameters. Parameter values are computed in the horizontal plane at 9 points in the accelerator, and in the vertical plane at 6 points. Values for emittance range between $1x10^{-9}$ and $6x10^{-9}$. Values for Twiss parameters are found to deviate from design values by up to 2000%, indicating a poorly tuned beam at the time of measurement.

ABSTRACT

Automatic Wire Scanner Fitting Algorithms, VICTORIA GABRIELLE, (University of Virginia, Charlottesville, VA 22094), ALICIA HOFLER & BALSA TERZIC, Thomas Jefferson National Accelrator Laboratory, Newport New, VA 23606

The Continuous Electron Beam Accelerator Facility (CEBAF), uses harp wire scanners to characterize the electron beam as it passes through the entire beamline. Harps operate by scanning through cross sections of the beam while recording position and induced wire current. The operational tool used in the control room is the harpAnalyzer fitting algorithm, which identifes intensity peaks and fits each peak to a Gaussian distribution using the Levenberg-Marquardt (LM) numerical method. The harpAnalyzer toolis useful over a wide range of harp data scans, but occasionally fails to fit harp data or misinterprets peak location entirely, leading to an erroneous computation of beam emittance. This study details an automation system for a new analyzer tool, harpFit which contains a reimplementation of the harpAnalyzer algorithm with added functionality and alternative, Nature-Inspired Methods (NIM) for

increased robustness. The criterion for comparison of the tools was the ability to identify the correct number of intensity peaks. Once peaks have been identified, the tools must generate a Gaussian that accurately fits each intensity peak location, width, and amplitude against hand-tabulated predictions. A final test was a comparison of error and non-normalized chi-square measurement. Testing of 160 scans chosen in both systematic and at random batches showed that harpFit produced output to higher precision, even for problematic data sets. For peak data that had an approximately constant noise oor, reasonably spaced peaks, and peaks with ample data points, the new tool and old tool preformed with the same level of accuracy. In sets that held more noise, sharper peaks and shorter distances between peaks harpFit still produced reasonable output while harpAnalyzer did not. In those cases, the harpAnalyzer algorithm would either crash or fit noise instead of a peak. Across each metric, harpFit used in conjunction with the new peak finding routine and automation system has higher reliability and trouble-shooting abilities than the old tool. By having a more reliable algorithm, the data provided can now give a quantitative measure of beam merit as the beam travels, which is imperative for the design and execution of accelerator experiments.