# Analysis Needs for a Parity-Violation Experiment

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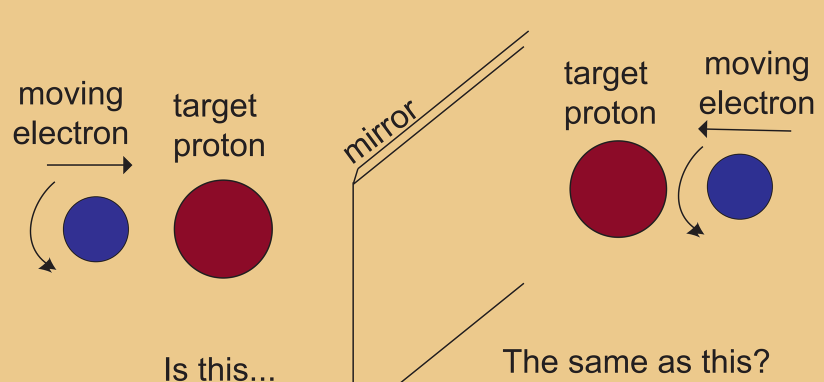
## Abstract

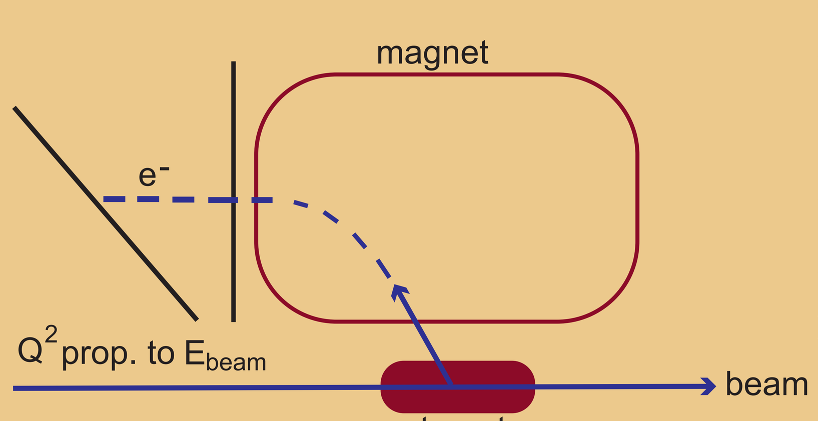
The G0 experiment at Jefferson Lab measures parity violating asymmetries in elastic electron-nucleon scattering to separately determine the electric and magnetic strange form factors over a broad range of momentum transfers. The next phase of the G0 experiment, performed at backward angles, will use two arrays of plastic scintillators and aerogel Cherenkov counters to detect elastically scattered electrons. Two arrays are required in order to perform tracking and hence to differentiate between elastic and inelastic electrons. Fast scalers counting coincidences are read and cleared at the helicity reversal rate, giving rise to *helicity-reversal events*. In addition, *detector-checkout events* are acquired periodically to digitize pulse heights and timing spectra from the detectors. The detector-checkout events are essential for monitoring the performance of the detectors as well as individual photomultiplier tube (PMT) rates. For example, efficiency for electron detection and contaminations from backgrounds can be estimated using these events. In addition, aging of the detectors due to radiation damage is monitored. The most important aspect of the detector-checkout events will be that they will allow characterizing the success of the detectors to reject backgrounds. A custom C++ code converts raw data files into data summary files. The data summary files are analyzed using custom analysis tools (developed using the ROOT toolkit).


## Parity Violation




The electromagnetic and strong interactions obey parity, or "mirror symmetry." The weak interaction, on the other hand, does not. Because electrons interact through both the electromagnetic and weak interactions, the parity violation that arises out of the weak interaction can be exploited in scattering experiments involving electron beams to determine the neutral weak form factors of the proton. By comparing these with known electromagnetic form factors, it is possible to get information about the contribution of strange quark-antiquark pairs to these observables. In such experiments, parity transformation is equivalent to reversing the helicity of the electron beam. It is therefore possible to quantify parity violation by measuring the cross-section asymmetry under helicity reversals.

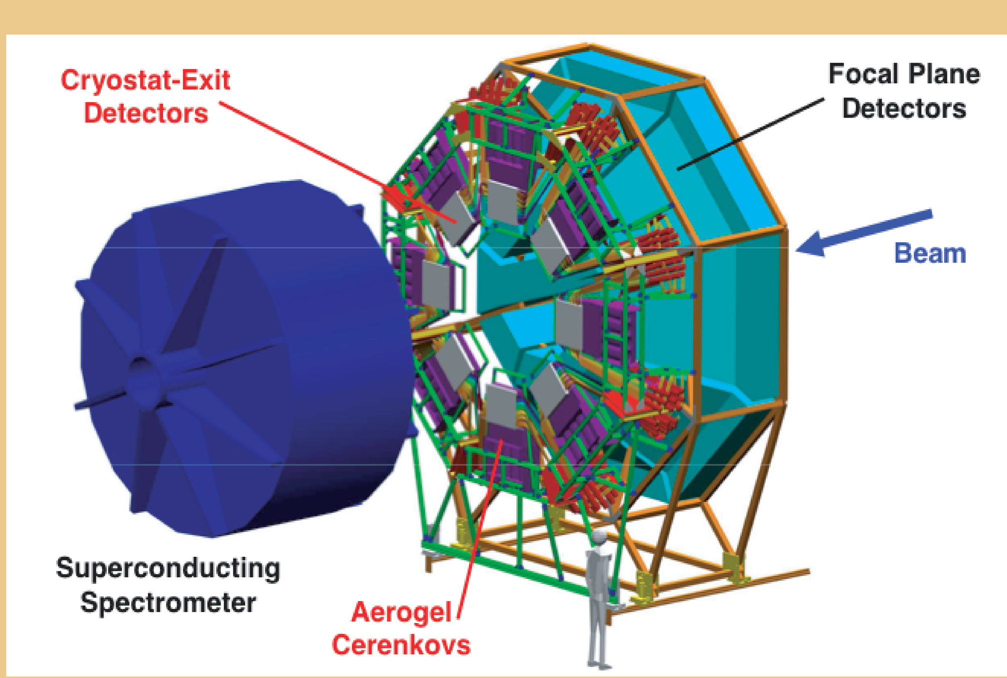
### The G0Experiment




*Backward Angle Schematic*

The G0 experiment at Jefferson Lab measures parity violating asymmetries in elastic electron-nucleon scattering to separately determine the electric and magnetic strange form factors over a broad range of momentum transfers ($Q^2$). The next phase of the G0 experiment, performed at backward angles, will use two arrays of plastic scintillators and aerogel Cherenkov counters to detect elastically scattered electrons. Two arrays are required in order to perform tracking and hence to differentiate between elastic and inelastic collisions.

The detector system for G0 is divided into 8 separate octants (see figure). Each octant contains two arrays of plastic scintillators and an aerogel Cherenkov detector. The scintillator arrays are: a Focal Plane Detector (FPD) array of 16 detectors and a Cryostat Exit Detector (CED) array of 9 detectors. These two scintillator arrays will be paired together to detect and separate elastic and inelastic electrons. The Cherenkov detector will be used to reject pions across the full G0 momentum range.

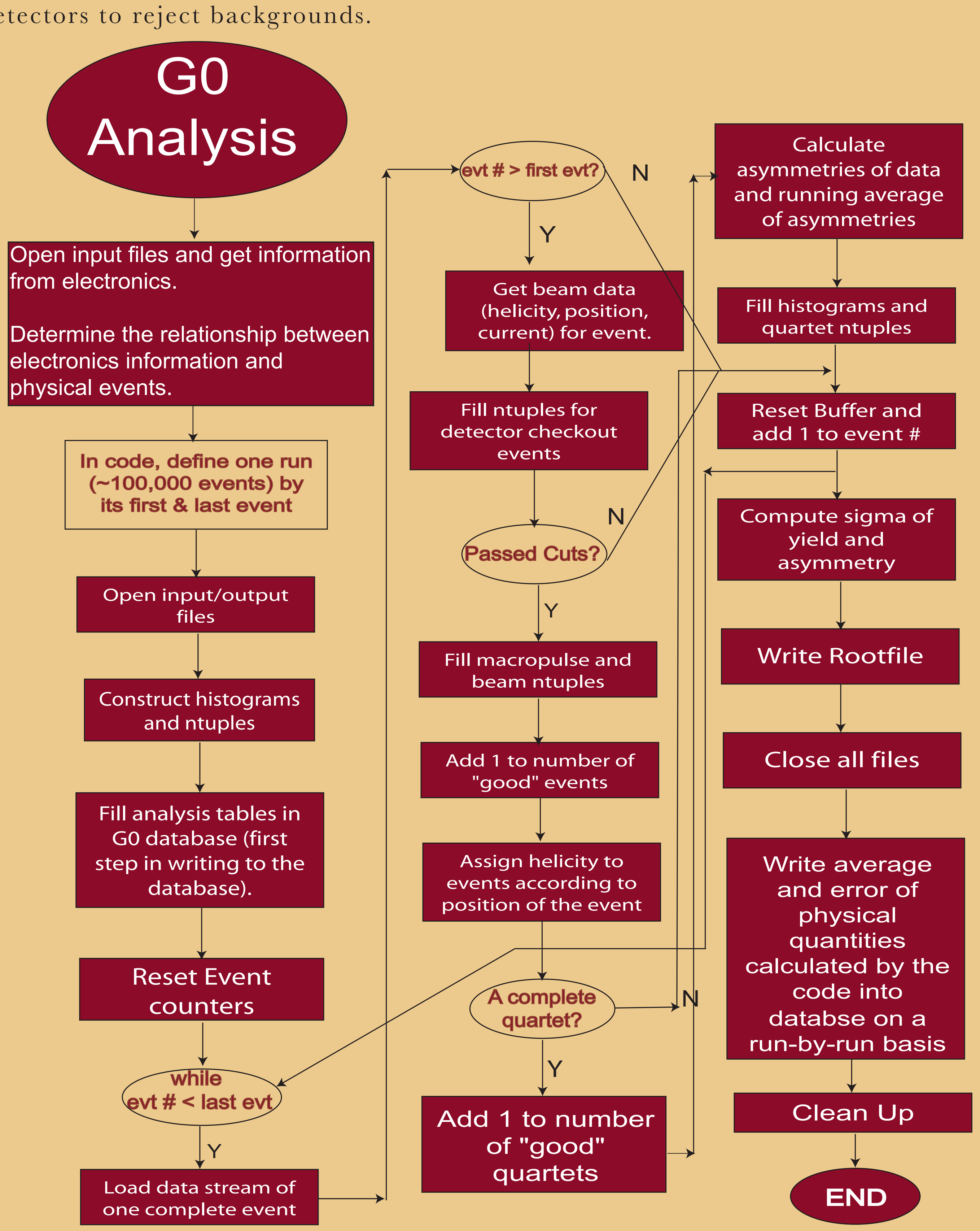



*G0 Backward Angle Configuration*

## Data Aquisition (DAQ) and Analysis

In order to determine the asymmetry in the scattering events, electron scattering events are converted to electronic signals by the detectors. The signals are then converted from analog to digital in the frontend electronics. The digital information is stored as raw data, and a custom C++ code, called the "analyzer" is used to convert these raw data files into data summary files. The data summary files are then analyzed with more custom code which uses the ROOT toolkit [2]. The flow of logic in the analyzer code is outlined below.

This analysis is based on two different types of events: Fast scalers counting coincidences are read and cleared at the helicity reversal rate, or *macro-pulse* rate, giving rise to ***helicity-reversal events***. Helicity reversal events are the core events in the G0 experiment and are read during the helicity flips. In addition to this, ***detector-checkout events*** are acquired periodically to digitize pulse heights and timing spectra from the detectors. These events allow for the monitoring of the performance of the detectors as well as individual photomultiplier tube (PMT) rates. The most important aspect of the detector-checkout events will be that they will allow characterizing the success of the detectors to reject backgrounds.




*Analysis Procedure - adapted from [3]*

- One event in the DAQ is one ***macro-pulse*** of 1/30 s.
- A ***micro-pulse*** is a 32 ns beam electron pulse.
- One ***run*** consists of approximately 1 hour of data taking or 100,000 events.
- The ***helicity*** of the beam is changed with every macro-pulse, which ensures that measured asymmetries are indeed the result of parity violation and not because of changes in, for example, beam quality or apparatus over longer periods of time.
- One ***quartet*** is a collection of four events with either helicity (-++-) or (+- -+).
- Two types of data are recorded: ***Beam data*** is the data that records the helicity, beam position, and beam current. It also records quartet-wise helicity flip patterns and delayed helicity reporting. ***Time encoding electronics data*** record coinicidence between CED's and FPD's.
- If a coincidence is recorded for one FPD/CED pair and is accepted by the Cherenkov detector, then it is kept as a ***"good" event*** and will be used in the analysis code.

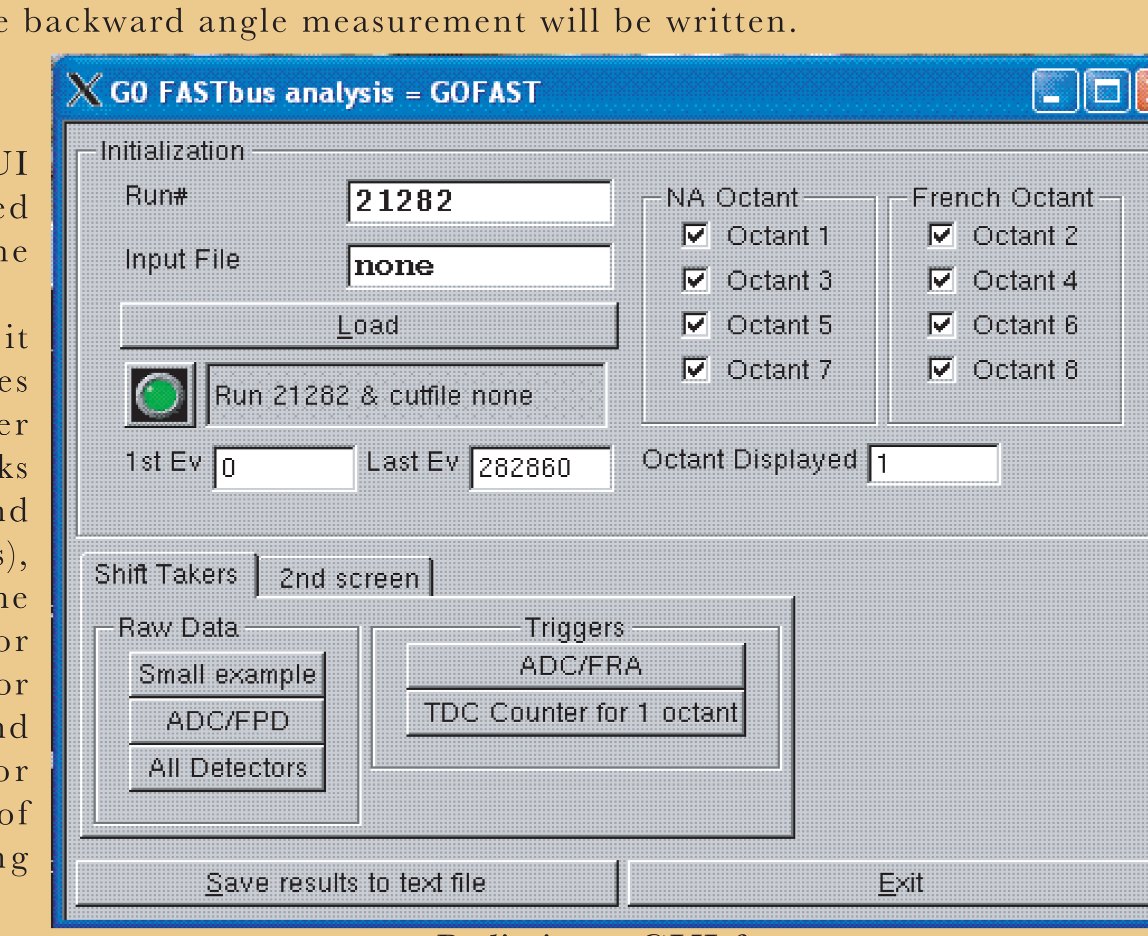
## Preparing Software for Detector Checkout Events

The backward-angle experiment will begin in December 2005, and it is crucial to have detector-checkout software available for initial testing. Although a similar software scheme was used for the previous run of the G0 experiment conducted at forward angles, significant modifications to that code are required considering the large number of new detectors. This software will be used for monitoring anode currents on photomultiplier tubes in the experiment, a change in which would signify radiation damage, and for adjusting photomultiplier high-voltages to account for gain shifts.

In order to prepare the software for the backward angle measurement, it was necessary to modify existing code from the forward angle experiment. Most significantly, the detector checkout event classes and ntuples had to be modified. The writing of new histograms was also necessary. The most important part of these modifications was the addition of new detectors: additional scintillator and Cherenkov counters.

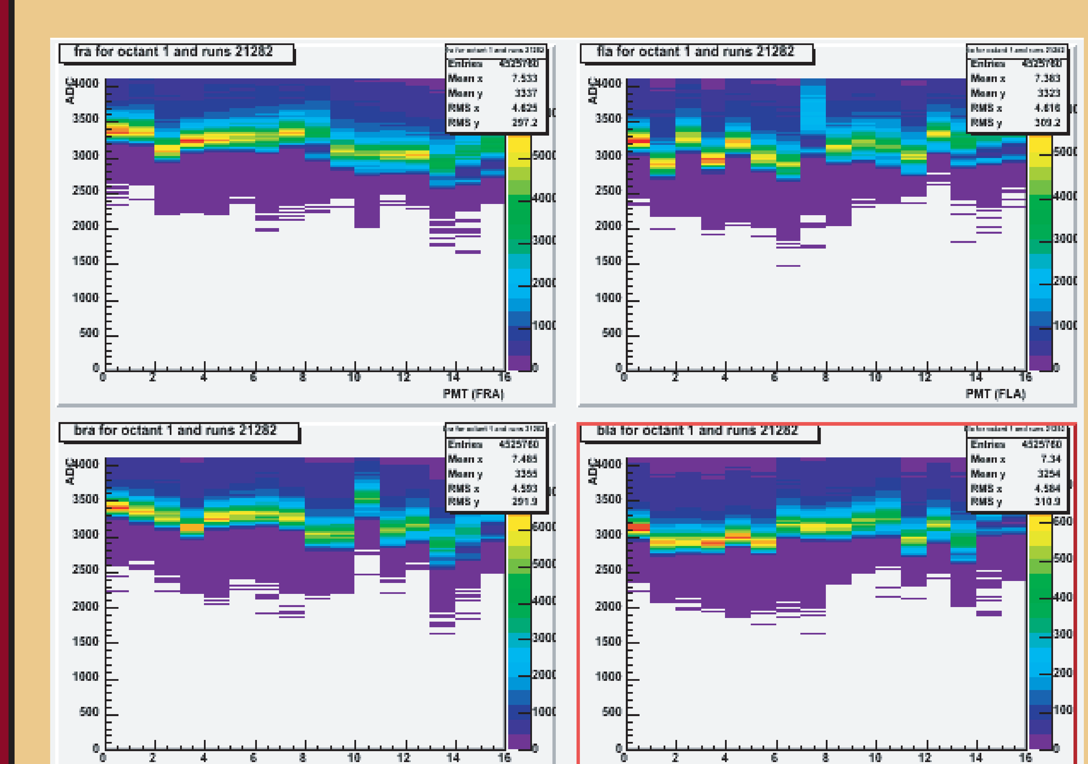
A new C++ code to generate Monte Carlo events in data summary files was written in order to test the modifications to the checkout event codes. In addition to this, the GUI used to facilitate the use of compiled ROOT scripts was modified, and appropriate ROOT scripts for the backward angle measurement will be written.

The preliminaty GUI format is a stripped down version of the forward angle GUI. When completed, it will have three types of plots: shift taker plots (for basic checks of the apparatus and trigger configuations), expert plots (to define and check cuts for more detailed detector checkout events), and GMS plots (for detailed analysis of Gain Monitoring System events).




*Preliminary GUI format*

### Status & Outlook



*Sample plot with forward angle data (ADC/FPD button)*

The detector checkout event classes and ntuples have been appropriately modified. The Monte Carlo simulation code has been written and will be integrated into the new classes. The preliminary GUI is ready and scripts will be written and incorporated into it on an as need basis. A variety of useful detector checkout tools are under development since the basic framework is complete.

Detector checkout event analysis is important because it allows for the assessment of the ability of the detectors to reject backgrounds

## References


[1]A. Biselli, J.Liu, D. Marchand, K. Nakahara, P. King, J. Roche, D. Spayde, g0analysis: The engine replay for G0. http://g0web.jlab.org/manual/Analysis_manuals.html.
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[4] J. Roche, P. King and J. Liu, Booklet of the G0 fastbus data. *(unpublished)*.
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