the beginning of runs. In order to get a sample of minimum biased events, a small fraction of events at each level are accepted randomly. In 1993, the CTD track reconstruction at the TLT was still preliminary, with resolution in momentum far below that achieved in offline reconstruction, because calibration constants were not available online and more studies were needed in the first year of the CTD operation.

3.4 ZEUS detector simulation

When measuring a cross section, one tabulates the number of events in each bin of selected kinematic variables. In general, the observed number of events in each bin differs from the true distribution due to several reasons: (1) errors in bin assignment resulted from poor resolution in kinematic variables and energy loss in dead materials in front of the detector, (2) limited acceptance of the detector and and inefficiency of the triggers and filters, and (3) unwanted background events. A straightforward way to test whether an observed distribution has evolved from an assumed distribution is to compare real data and Monte Carlo data. One generates a sample of events according to the assumed distribution and pass the events through a simulated detector and triggers. Then the same set of programs used for reconstruction, event selection and analysis can be applied to the simulated events as if they were real data. The Monte Carlo method is extensively used in every stage of the experiment, from the detector and trigger design and event selection, to acceptance correction and error analysis. It also serves as an efficient and economical analysis and learning tool. In fact, more human and computer time are spent on simulated experiments than on real data in today's HEP experiments.

An observed event comes from a long and complicated series of reactions(for example, particle shower development in the calorimeter). If we can model the various elementary processes, the computer can build complex reaction chains for us. Simulation of the event production according to theoretical models is done by event generators which will be described in Chapter VI. More challenging and important is the detector and trigger simulation. An accurate simulation of the detector and triggers is required for studies of the detector acceptance and resolution. Comparison of theoretical models with the data is undermined if the detector and trigger system are not truthfully simulated.

The ZEUS detector is simulated by a large Fortran program package called MOZART.[48,49] MOZART contains description of the detector materials(wires, uranium plates, scintillators etc.) and their geometry, with routines to track particles through the materials taking into account the physics processes such as particle decay, energy loss, electromagnetic and nuclear interactions and multiple scatterings. Much of the necessary framework has been provided by the CERN GEANT program package.[50] Although MC(Monte Carlo) is helpful, it is not to be trusted blindly. The reliability of the MC depends on the accuracy of the description of the wire positions, dead materials in front of the CTD and the calorimeter, and shower development processes.

The readout electronics and triggers were simulated by ZGANA.[49] The input data could be either real raw data or Monte Carlo raw data(output of MOZART). Since the ZEUS detector and trigger system were under continuous development, MOZART and ZGANA have many versions. In the version for the 1993 data analysis, ZGANA simulated the FLT and the TLT. The SLT in 1993 only rejected bad events due to PMT malfunction and beam halo and beam-gas background. Simulation of the SLT is not important for most purposes since this trigger had little effect on signal acceptance. The TLT is a software trigger written in Fortran77, hence the same code can be used for both real data and Monte Carlo events. Simulation of the FLT involves simulation of the electronics of the component FLTs and the logic operations of the GFLT. In simulation of the electronics, one needs calibration constants such as PMT charge to particle energy conversion factors. The calibration constants were updated frequently online. But the CAL-FLT online readout electronics did not use these updated calibrations during the 1993 runs. This can cause a difference between online and MC trigger efficiencies if a significant fraction of events were triggered near the thresholds.