Fast Monte Carlo Program
for the CLAS Detector
Update # 1

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1 Updates to Fast

The FAST Monte Carlo program has been upgraded to include the latest geometry of the CLAS detector and simulate the hardware triggers. This version has been prepared so that the first round of proposals to the PAC can include realistic estimates of acceptance, trigger rates and resolution consistent with the description of the instrumentation for Hall B described in the Conceptual Design Report.

The original description of the FAST Monte Carlo [1] remains a useful document because the general features of the program are unchanged. However, the implementation of specific details has changed and information on hit information in scintillators, cerenkov and shower counters is returned to help simulate detector design and implement the hardware triggers.

The upgrades to the parametric Monte Carlo may be classified into three categories as follows:

- Geometry
- Hit information in detectors
- Simulation of Trigger
- Output Files

2 Geometry

There have been two major changes in the geometry of the CLAS detector since the presentation to TAP II [2]. There are illustrated in Figs 1 and 2. The first is the addition of the “mini-toroid.” This magnet serves to shield the drift chambers from backgrounds spraying from the target and allows detectors to be placed in the region of the target (region I). This required a modification to the shape of the main coil to allow extraction of the mini-toroid and drift chamber package in region I. Thus the drift chamber system now consists of three packages corresponding to the target region (CH1 in region I), the region inside the magnetic field (CH2 in region II) and surrounding the large toroid (CH3 in region III). Due to the change in the shape of the coil, the integral field has been reduced primarily in the
Figure 1: Side view of the CLAS detector, which now includes the mini-toroid, drift chamber planes in region I and cerenkov counters backing up the shower counters.
Figure 2: Front view of the CLAS detector, which now includes the mini-toroid, drift chamber planes in region I and cerenkov counters backing up the shower counters.
forward direction. There have been corresponding changes in the resolution functions and acceptance functions which are shown in Figs 3-10

The second major change in geometry has moved the scintillator plane about 50cm further away from the target to allow room to install cerenkov counters between the last layer of drift chambers (CH3) and the scintillators. This change has slightly modified the acceptance functions of the scintillator plane and shower counters, as well as added another detector element. The specification of the geometry, which was previously scattered among various source files, has been extracted and placed in the new source file GEOMETRY.FOR.

3 Hit Information

The response of the detectors in the original version of FAST was summarized by computing an average efficiency for detection. For applications where cuts are imposed on the detector response, which is the case for example in simulating the trigger, such a description is not adequate. We have therefore modified the code to compute hits in the scintillator, cerenkov and shower counters. For each detector, three variables are filled which specify the response and which counter was hit (the sector and module numbers). The variables are

hit.cer - hit in cerenkov counter (0 or 1)
hit.sci - hit in scintillator counter (0 or 1)
hit.shw - hit in shower counter (visible energy in GeV)
isecl.cer - cerenkov counter sector (1-6)
isecl.sci - scintillator counter sector (1-6)
isecl.shw - shower counter sector (1-6)
imod.cer - cerenkov counter module (1-5)
imod.sci - scintillator counter module (1-48)
imod.shw - shower counter module (1)

The sector and module numbers are zero if there is no acceptance for the track in question. The hit value is filled regardless.

The shower counter response to electrons, pions, protons and neutrons is shown in Fig 11 The response in the cerenkov counter is 1 if a charged
Fractional Momentum Resolution

Figure 3: The parametrization of the fractional momentum resolution (FWHM) is shown for the case when the vertex is specified (solid) and for long targets (dashes). The contributions due to multiple scattering and position resolution are shown separately.
Angular Resolution $p = 1\text{GeV/c}$

Scattering Angle ($\theta$)

Figure 4: The parametrization of the angular resolution $\theta$ (FWHM) is shown for the case when the vertex is specified (solid) and for long targets (dashes). The contributions due to multiple scattering and position resolution are shown separately.
Figure 5: The parametrization of the angular resolution $\phi$ (FWHM) is shown for the case when the vertex is specified (solid) and for long targets (dashes). The contributions due to multiple scattering and position resolution are shown separately.
Figure 6: The parametrization of the vertex resolution (FWHM) is shown for the case when the vertex is specified (solid) and for long targets (dashes). The contributions due to multiple scattering and position resolution are shown separately.
Scintillation Counters

Figure 7: The parametrization of the timing resolution (r.m.s.) is shown on the right scale (dotted curve). The length of the scintillator counters is given by the scale on the left (solid curve).
CLAS Acceptance
DCs – Region II

Scattering Angle (θ)

Figure 8: The parametrization of the minimum momentum required to reach drift chambers in region II for the two magnet polarities.
Figure 9: The parametrization of the minimum momentum required to reach the trigger counters for the two magnet polarities. The acceptance to hit the drift chambers in region III is quite similar.
Figure 10: The parametrization of the minimum momentum required to reach the shower counters for the two magnet polarities. Note that the acceptance is defined by both a minimum and maximum momentum.
Calorimeter Response to $e$, $\pi$, $p$, $n$

Figure 11: Visible energy in the shower counter deposited by electrons, pions, protons and neutrons of fixed momentum.
particle has velocity which is greater than 0.9989211c and 0 otherwise. All charged tracks produce hits in the scintillators. Neutrons produce a hit 5% of the time and photons produce a hit 10% of the time. The efficiency for detection is then 1 if the hit in a particular counter is above a preset threshold.

In order to determine which counter was hit by a charged track, the bending in the magnetic field is approximated in first order by

\[ \Delta = 0.15 \int \frac{Bdl}{p} \]

\( \Delta \) is the bending due to the magnetic field relative to the distance from the target to the detector and \( p \) is the particle momentum. \( \int Bdl \) is the total integral magnetic field at a given scattering angle. This approximation is quite adequate at large angles. In the forward direction the derivative of the field is so large that precise estimates of the bending require a much more sophisticated treatment of the problem.

**Note and Warning:** Due to all these upgrades, some of the calling sequences have been modified, so existing code must be made compatible by noting the changes in the examples distributed with the new sources.

4 Simulation of the Trigger

The simulation of trigger levels 1, 2 and 3 within the FAST Monte Carlo has been implemented and is described in [3]. The trigger requirements are specified in a trigger specification file which is read in at initialization time. To change a trigger configuration one need only change the input file, not the actual FORTRAN code. The trigger specification is checked event by event and three logical variables are set which indicate whether the event would have passed a given trigger:

```
LEVEL.1.TRIGGER
LEVEL.2.TRIGGER
LEVEL.3.TRIGGER
```
These variables are available in the `TRIG_COMMON.INC` Common Block and may be accessed during analysis. A summary of the number of events satisfying each trigger is given in a table in the list file.

Example #5 of the FAST Monte Carlo shows an implementation of a one-prong and a two-prong trigger applied to the file `ALL_EVENTS.DAT`, which is a file of deep inelastic events. For example, 12 events satisfy level 1, 11 events satisfy level 2 and 10 events satisfy level 3 of the two-prong trigger. The batch file to run the program `FAST5.BAT` is shown in Table 1. The subroutine which actually implements the trigger is `TRIG_ANAL`, which also fills a variety of useful histograms defined in `TRIG_HSTDEF`. These histograms may be used to determine the requirements in the trigger which will maximize the signal to background for a particular process. The trigger file specification in the example was written to enhance the detection of the Delta (1232).

5 Output File

We have added the capability of writing an output file with the FAST Monte Carlo. The format of the file is referred to as the "Fast Data" format and includes all the information contained in the CELEGS input file as well as trigger information and calculated variables stored in the Common `/fsmear/` (specified in `FAST_COMMON.INC`). To write an output file one must define the logical variable `FAST_DATOUT` and set the logical switch in the last line of `SYS$INPUT` to `T` (see Table 1). A file in this same format may be read by the program by defining the logical variable `FAST_DATIN` and setting the switch in the next-to-last line of `SYS$INPUT` to `T` (see Table 1). When FAST reads a file in this new format, preprocessing of the event is bypassed as all the relevant information is read from the file. Note that in this case the input specifications of polarity, vertex definition and resolution terms are ignored and taken from `FAST_DATIN`. 
Table 1: DCL Command procedure FAST5.BAT, the one-prong trigger for example #5. The actual example runs a second time using a two-prong trigger file. Note the last two input lines to SYS$INPUT specify the type of input file and whether an output file is to be written.

$!
$! Procedure to run CLAS Fast Monte Carlo Program $!
$! This procedure is setup to execute Example #5. $!
$ define Fast_input SYS$INPUT
$ define Fast_lst FAST.LIS
$ define Fast_hbk FAST.HBK
$ define LUND ALL_EVENTS.DAT
$ define Trigspec Trigger_delta_1prong.dat
$!
$ run fastmc:Fast
'Example 5: Deep Inelastic File – One prong Trigger' /Title
10000 /event limit
1 /magnet polarity (+1 = neg bend toward axis, -1 neg away)
'vertex' /'vertex' defined, 'novertex' for long targets
'both' /'pos', 'mul', 'both' - pos or mult scat terms only, or both
'nolist' /'list' or 'nolist' print events read from file
'example5' /'example1', 'example2', 'example3', 'other' analysis options
F /T = Input File is in "Fast Data" format (F=LUND Format)
F /T = Write Output file in "Fast Data" format (F=no output File)
$ eod
$ exit
References

