TRIGGER SIMULATION ON MICRO-DST

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A new routine which allows to simulate exactly the full trigger using only micro-DST information is presented. It allows to apply on any real data set the trigger conditions corresponding to all periods prior to the one in which the data were actually collected. It also allows to apply on Monte Carlo events produced with T23 conditions the trigger of any period of CPLEAR data taking. It verifies that a given offline $K\pi$ *pair satisfies any of these trigger conditions. The information provided by the routine and the results of high statistics checks are presented.*

1. Introduction

Experience with the analysis of CPLEAR data has proven the importance of the exact and detailed knowledge of if and why each offline selected event satisfies the trigger under which it was collected. Moreover, in order to understand the differences between periods and to extract the maximum information from our available Monte Carlo statistics we need the tools to simulate many trigger conditions on the same data.

On the other hand, the information available on miniDSTs (and copied to microDSTs) did not give up to now that flexibility. Furthermore, the extensive tests carried out in August 1995 demonstrated that the widely used MHKSYM variables were not exact for a small but important percentage of events (false kaons, non-primary tracks in the first positions of the CONFIG track list). Finally, the 'best' trigger information was not the the same for real data and Monte Carlo.

2. The input data

The analysis of tens of millions of events from the 1995 data taking and Monte Carlo being produced prohibits the use of the full NHPLIB software on raw data in the day to day work for reasons of processing time and storage (staging). Thus some information was added to the micro DST format (1.5M events in 1Gb) which provide the required level of flexibility and redundancy. The already existing information was also improved after fixing all known bugs and changing the way some variables were defined. On this occasion micro DSTs are being recreated for all periods and T23 Monte Carlo, so that all data are treated the same and valid comparisons can be made. The available information (micro version 9503 or higher), described in detail in a separate write-up under preparation, are :

- Hitmaps of EDL(S1,S2, $S\overline{C}S$), $P_T$cut, IDL(K,primary,track) . This new information allows 'matching' to be done even at these early trigger stages.
- A list of valid tracks at the CONFIG level (up to a maximum of 6) with their primary and kaon bits. Up to this stage all full trigger configurations used since 1992 are identical. The parametrisation output for each track is duplicated to allow simulation before/after run 260968, when the erroneous twist correction was removed from the trigger.

- The PKPπ output and HWP2 bits (Nphe, dE/dx, TOF) for each track. This is duplicated for the two parametrisations mentioned above and a third set of HWP2 bits exists to allow for the removal of the multiple kaon bits at this stage after run 271183.
- The 'best' trigger that the event would pass for EDL, P_T, IDL, CONF and REG. Note that up to now this was not done in the same way for real data and MC and there was no provision for register type '1' as used in 1995.

For P28,P29 real data and T23 MC the tracks filling the REGISTER slots and the register word for the last track are copied when the actual trigger simulation runs on the raw data of each event.

This high redundancy (detailed track bits, 'best' trigger and exact register) allows for the first time to cross-check the correctness and self consistency of all this information on millions of events. This allowed to fully debug the new version of the software in a few days. The multiple HWP2 information will allow to use the high statistics of P28 and P29 in addition to MC to reproduce the effects observed in previous (fragmented in terms of trigger) periods.

3. Functionality of the routine

The routine takes as input parameters the track numbers of the primary Kπ pair (IHK and IHP, numbers in the CONFIG valid track order) and checks first the following conditions :

a) The EDL satisfies condition 3 (at least 1 $S\overline{C}S$ and at least one more S1) and IHK corresponds to one of the $S\overline{C}S$.
b) The P_T cut satisfies condition 2 and IHK corresponds to one of the P_T-good sectors.
c) The IDL satisfies conditions 2 or 3 with IHK corresponding to a kaon and IHP corresponding to a primary track.
d) The CONFIG satisfies conditions 2 or 3 with IHK, IHP primaries and valid and IHK kaon.

Then the register routine is called. This is the H1SRC1 subroutine of NHPLIB where a few lines are added to also return the 'best' register number that the event satisfies (0..5). This allows to check if the event would pass the register control before introduction of the 'J.Derre' trigger, in P24 (4th register slot not a kaon), in P25-P27, and P28-P29 (released trigger, reg=1). For all periods the 'best' register number calculated is checked against the same information directly written on the micro. For micros of version 9504 or higher the last register word, where all the register decisions are contained, is compared bit by bit to the same information copied on the micro when the full NHPLIB software was run on the raw data , at the time of production of the micro. The same is done for the tracks which enter each of the four register slots. This allows to verify that the available information is self consistent and that any simulation of a different trigger type can be fully trusted.

For events where : **i)** the register does not return 0 (at least the two first slots filled) **ii)** IHK is in slot 1 **iii)** IHP is in slot 2 or 3 **iv)** there are more than two valid tracks (to exclude events that would pass HWP2.5) , the following information is combined with the register answer :

- the IDL and CONFIG number as appropriate for each period or sub-period,
- the PKPπ cut for IHP for all periods,
- the dE/dx and N_{PHE} cuts on the kaon for all periods,
- the dE/dx cut on IHP using the parametrisations, cut LUTs and kaon bits of each period
- the TOF on IHP, for all periods after P24 on MC and only if it was present in the trigger for real data,

in order to define a series of logical variables which give for each of the main CPLEAR trigger periods if the event would pass the trigger due to the track pair IHK, IHP.

A separate variable describes if there exist in the register slots one (or more) false kaons and if this was IHP, of opposite charge to the real kaon but not IHP, or with the same charge as the real kaon.

Finally, for real data, the detailed information is combined in one variable which, if true, signals that the event passed in the proper way the trigger under which it was collected. In its definition it is not allowed that IHP was considered as a kaon for all periods before the beginning of P27, when the kaon bit for slots 2 and 3 was disabled at the input of HWP2. The EDL and P_T-cut is checked again to take into account the possible presence of PC0 and a higher value for P_T-cut during data taking. For P24 and earlier the presence of any second kaon track in the register is not allowed.

4. Results of high statistics checks

A) Internal crosschecks

- The 'best' register level pass was checked for 27 million events of periods 25,26,27 and no single event was found to give a dissagreement between the number recalculated and the one written on the micro.
- The 'best' register level pass, the register slots filling *and* the register word were checked bit by bit on 1,200,000 events of P28. Only 15 events (1.25×10^{-5}) gave a dissagreement and in all cases it was due to track number 7 being present in a slot of the real (NHPLIB on raw data) register. This is not a problem of the software described here, but is due to the limitation of the micro arrays to a maximum of 6 valid tracks at the CONFIG level. In periods 27 and earlier this case does not exist because events with more than 4 valid tracks were not allowed by the trigger conditions actually used. For periods 28 and later only those events where track 7 corresponds to our offline primary pion will be wrongly rejected.

We can conclude that the validity of this routine for periods before P28 is 100% and for periods 28 and later only less than 10^{-5} of events will be wrongly rejected. Even if these events are assymetric, they would not have any detectable impact on our measurements. It should be mentioned that always the simulation (NHPLIB) as it runs on raw data is the reference; no comment can be made here on the agreement between this and the real hardware.

B) Rare and interesting cases observed

- In 2×10^{-3} of real data events with open pion dE/dx LUTs the offline pion fails the pion dE/dx cut.
- In 2.5×10^{-4} of events the offline primary pion is seen as a primary valid track in the CONFIG but is is not primary in the IDL level (it is only track).
- 4×10^{-3} of events which pass the trigger and matching fail the new (V6.001) MHKSYM matching. In all cases this is due to a non primary track in position 1 of the CONFIG valid track sequence.

C) Events passing the trigger simulation and matching

P25.1 : 82.9%
P25.2 : 85.9%
P26 and P27 : 88.6%

5. Calling arguments and output variables description

The routine can be found on /afs/cern.ch/user/t/touraman/public/trigger/trig.f. Inside the first routine one can find the lines with the variables to add to the micro.incl file. The call to the routine is : CALL TRIG(IHK,IHP) where ihk, ihp are the numbers of the primary kaon and pion in the numbering scheme of valid config tracks (mhktra notation in MINI and MICRO). The logical variables defined in the routine are :

- lt23 : pass trigger 23
- lidl2, lidl3 : pass IDL with 'Jack Derre'conditions (3) or earlier (2)
- lcon2, lcon3 : same as above for CONFIG
- lregxx , xx=22,24,25,28 : pass the REGISTER CONTROL with conditions of P17-P23, P23-P24 (after 'J. Derre' introduction), P25-P28 (new KK logic), P28 and later (reg=1)

- lpasxxx , xxx=220,240,251,252,260,270,280 : pass the full trigger of various subperiods, including KIN and HWP2, as these evoluted in time. For details see the comments at the beginning of the routine.
- lpasrea : for real data this is the combination of all the above information in such a way that the real trigger used, as written in the MHWTRI variable, is satisfied. It is enough to use ONLY THIS VARIABLE on all real data, unless detailed checks are to be made.

In all variables the matching of the pair ihk, ihp is included. In lhkrea the KK logic is taken into acount and ihp is required not to be Kaon in HWP2. More detailed information about Kaon bits in the register is given in the integer variable IKKTRI, which has the values :

- 0 : only ihk is kaon at the register
- 1 : ihp is kaon at the register
- 2 : a kaon exists in the register slots 2 or 3 but it is not ihp
- 3 : a kaon exists in register slot 4

For problems with the routine or questions you can send mail to christos.touramanis@cern.ch

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