CLAS12 Trigger Commissioning Plan

Valery Kubarovsky

November 21, 2017

The CLAS12 trigger system will use the following detectors:

1. High Threshold Cherenkov Counter (HTCC)
2. Preshower Calorimeter (PCAL)
3. Electromagnetic calorimeter (EC)
4. Forward time of flight counters (FTOF)
5. Forward electromagnetic calorimeter (FTcal) with hodoscope (FThodo)
6. Central Neutron Detector (CND)
7. Central Time of Flight (CTOF)

All trigger detectors have to be calibrated. The trigger parameters will be set as the energy deposition in the calorimeters (PCAL, EC, FTcal), hodoscopes (FTOF, FThodo, CND, CTOF) or number of photoelectrons in HTCC. The calibration of the detectors is the responsibility of the experimental groups. The preliminary detector calibration has to be done during cosmic runs if possible.

The FADC pedestals depend on the detector?s occupancy. The correct setting of pedestals affects the trigger rate. The experimental groups have to develop the software tools for analyzing the pedestal runs with the goal to create pedestal tables that will be used in the trigger setting file. These tables have to be available before the study of the trigger rates as a function of the beam current. The low intensity pedestal tables can be taken from cosmic runs.

1 Random trigger

The random trigger (generator and Faradey cup, prescaled) will be used for the trigger efficiency test and for the trigger parameters tuning off-line. It is very convenient and powerful tool because it doesn?t require numerous special runs with different trigger parameters, like energy thresholds in the calorimeters or HTCC cuts. The random trigger will be used for the evaluation of the absolute trigger efficiency. The DAQ time window has to be around 400 ns during data taking with this trigger. The random trigger rate depends on the DAQ performance. 10-20 kHz is the acceptable rate for these measurements.

2 MIP trigger

This trigger will be set in the beginning of the run. The MIP trigger will select events with at least one particle with MIP signal in the PCAL and EC calorimeters. This trigger is supposed to be used for the calibration of the CLAS12 detectors as well. It is not biased by HTCC cuts as in the electron trigger. The suggested trigger cuts are as follows:

- PCAL cluster energy $>$ 5 MeV (MIP is at 30 MeV)
- ECtotal cluster energy $>$ 60 MeV (MIP is at 78 MeV)
- PCAL+ECtotal $>$ 80 MeV (MIP is at 108 MeV)

We are going to keep the MIP trigger ON during trigger study even at high beam current with sufficient prescale factor.

The MIP trigger will give all other groups the possibility to start tuning the CLAS12 detectors. At the same time trigger group will analyze data off-line with the goal to determine the electron trigger cuts in HTCC and calorimeters. At this stage we will need tracks reconstructed in DC. We want to tune trigger parameters using events that are completely reconstructed in CLAS12.

3 Electron Trigger

Electron trigger will select events with the electrons hitting the forward detectors. The trigger cuts will be tuned using events fully reconstructed in DC and hitting HTCC, PCAL and EC. The minimum electron momentum for the 100% torus current is supposed to be more than 1.5 GeV. The trigger parameters will be tuned first at low beam current. To kill the MIP particles we need to set the calorimeter cuts at least at these levels:

- PCAL cluster energy ¿ 50 MeV (MIP is at 30 MeV)
- ECtotal cluster energy ¿ 110 MeV (MIP is at 78 MeV)
- PCAL+ECtotal ¿ 160 MeV (MIP is at 108 MeV)

This minimum biased trigger will be used for the tuning trigger parameters off-line and for testing the trigger logic. The runs with several energy and HTCC cuts have to be taken at lower beam current for the trigger parameters tuning as well.

4 Photoproduction Trigger

The MesonX experiment aims at studying meson spectroscopy in the light-quark sector, searching for evidence of exotic and rare mesons. For this purpose, small-angle electron scattering on proton target will be used to produce meson resonances decaying to multi-particle final states. The meson decay products will be measured in Forward Detectors, while the small angle scattered electron will be measured in the Forward Tagger (FT). CLAS12 detectors information will be used to select events with multiple hadrons (three or more) in the final state and FT information will be used to impose the condition that an electron in the energy range of interest (0.5-4.5 GeV) is detected in this device. For the trigger commissioning we will use several special triggers.

4.1 Forward Tagger Trigger

The FT trigger will be built based on the coincidence of a cluster in the FT-Cal with energy in a selected range and of matching hits in the two layers of the FT-Hodo. The FT-Cal cluster is built using algorithms similar to the ones developed for the HPS ECAL. The main adjustable parameters are the crystal threshold, the minimum number of crystals in the cluster and the minimum and maximum cluster energy. The FT-Hodo hits are defined requiring the signal in a tile of the detector being above a selectable threshold. A coincidence between hits in the two layers should be defined based on the geometrical and time match of the hits. The coincidence between the FT-Cal cluster and the FT-Hodo hits is defined based on geometrical and time matching. The geometry constraint will be applied using a predefined table defining the correspondence between the cluster seed ID and the hodoscope tile IDs. The time coincidence should be defined with an adjustable window.
The FT trigger conditions:

A One cluster in the FTcal

B One cluster in the FTcal in coincidence with FTcalo

C Two clusters in the FTcal (to identify one electron and one gamma/electron)

D Three clusters in the FTcal (to identify one electron and two gammas/electrons)

4.2 CLAS12 Triggers

The CLAS12 trigger algorithm should allow to ?count? the number of final state particles, distinguishing charged from neutrals particles. In the forward detector, charged particles can be identified at the first level simply requiring a coincidence between hits in the FTOF panel 1A paddles, FTOF panel 1B paddles and PCAL clusters. For FTOF paddles, a ?hit? can be defined based on the coincidence of signals above adjustable thresholds in the left and right PMTs. The coincidence of these three detectors could be built based on a rather simple geometrical and time matching. Geometrical matching can be defined using lookup tables. The time matching should use an adjustable time window that will be of the order of tens of nanoseconds. Neutral particles and in particular photons can be identified looking for clusters in the EC and PCAL. For both charge and neutral particles, the trigger algorithm should be able to detect more than one particle per sector. The trigger algorithm for charged particles could evolve to include also information from DC segments.

Once forward and central detector information will be processed to identify particles, the total number of charged and neutral particles within a time window of tens of nanoseconds should be computed. A trigger should be issued when the numbers of charged and neutral particles are larger than chosen values. Since the physics events of interest involve several topologies that could have different combination of charge and neutral particles, multiple trigger conditions should be defined, including low multiplicity triggers (one or two particles) that would be used for trigger algorithm debugging and to select simple final states (single or double pions) used to check the analysis procedure. Because of the very high rates, these low multiplicity triggers will have to be prescaled.
The CLAS12 forward detectors trigger conditions:

a One charged particle in the FD (defined as a coincidence of PCAL and FTOF-1b)

b Two charged particles in the FD (defined as a coincidence of PCAL and FTOF1b)

c One cluster in the calorimeters PCAL+ECAL or PCAL only. The cluster can be neutral (gamma) or charged (e^+/e^-)

d Two clusters in the calorimeters PCAL+ECAL or PCAL only. The clusters can be neutral (gamma) or charged (e^+/e^-)

e One charged particle in the Center Detector (CD) defined as the coincidence between CND and CTOF.

4.3 CLAS12 and FT matching

The final trigger will be built requiring a coincidence between the CLAS12 and FT triggers within an adjustable time window. The window width should be similar to the time windows used to build the CLAS12 trigger, i.e. of the order of tens of nanoseconds, to account for the jitter coming from the dependence of particle time of flights from path length and beta as well as the jitter due to for example the hit position on the FTOF counters.
MesonEx triggers (in order of priority):

B+b Electron in the FT + two hadrons in the FD

B+d Electron in FT + two gammas (e^+/e^-) in the FD

C+c Electron in the FT + one gamma (e^+/e^-) in the FD

D Electron in the FT + two gammas (e^+/e^-) in the FD

4.4 Triggers to be tested for the future usage

B+e Electron in the FT + one hadron in the CD, elastic electron in the FT + one hadron in the CD

B+A+e Electron in the FT + one hadron in the CD + one hadron in the FD

5 Trigger Commisioning Schedule

Table 1: Day 1

	Beam Current	Events or Time	Trigger	Purpose	Tools
1	5 nA	10K	Random	Pedestals	Fit pedestals
2	1-100 nA	1 hour	Scalers ONLY	Record detector's rates as a function of current	Detector's Scalers
3	5 nA	30 mins	HTCC only	Timing of all detectors	FADC timimg distributions
4	5 nA	1 hour	MIP trigger	PCAL, EC and HTCC tr. parameters	Expert monitoring
5	5 nA	1 hour	Random	Test trigger logic, choose tr. parameters	Off-line trigger analysis
6	5 nA	1 hour	Electron	Test trigger logic, trigger rate at low current	Off-line trigger analysis

Table 2: Day 2

	Beam Current	Events or Time	Trigger	Purpose	Tools
1	1-100 nA	1 hour	Random	Pedestals at diff. currents	Expert monitoring
2	1-100 nA	1 hour	Electron	Study tr. rates at diff. currents	Off-line analysis
3	80 nA	2 hours	Electron	Scan trigger parameters for HTCC, PCAL, EC	Trigger scalers , Expert monitoring
4	<5 nA	30 mins	FTcal only	FTCal tr. parameters	Monitoring off-line analysis
5	<5 nA	30 mins	FTCal+ FTHodo	FTHodo tr. parameters and FTHodo matching	Monitoring off-line analysis
6	5 nA	1 hour	2 FT clusters	Multiple clusters parameters	Monitoring off-line analysis
7	5 -10 nA	1 hour	3 FT clusters	Multiple clusters parameters	Monitoring off-line analysis
8	<5 nA	1 hour	FTOF-1b	FTOF parameters Coincidence with PCAL	Monitoring off-line analysis off-line analysis
9	<5 nA	1 hour	PCAL	PCAL parameters Coincidence with FTOF-1b	Monitoring off-line analysis off-line analysis
10	<5 nA	1 hour	FTOF-1b+ PCAL	Hadron trigger parameters	Monitoring off-line analysis

Table 3: Day 3

	Beam Current	Events or Time	Trigger	Purpose	Tools
1	5 nA	1 hour	2 hadrons	Hadron coincidence	Monitoring and off-line analysis
2	1-100 nA	2 hours	2 hadrons	Hadron trigger rate and accidentals	Monitoring and off-line analysis
3	<5 nA	1 hour	1 hadron + 1 FT cluster	Coincidence between FT and FD	Monitoring and off-line analysis
3	5 nA	1 hour	2 hadrons + 1 FT cluster	Coincidence between FT and FD	Monitoring and off-line analysis
4	1-100 nA	2 hours	2 hadrons + 1 FT cluster	Coincidence between FT and FD Rates and accidentals	Monitoring and off-line analysis off-line analysis