Updates for 2021 DAQ, Triggers and MC

T. Cao

University of New Hampshire

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Outline

- 2021 hardware DAQ and trigger updates
- Software updates for hps-java
 - DAQ management system
 - Trigger diagnostic system
 - Readout system
- Status of 2021 MC
- Summary

2021 Hardware DAQ and Trigger Updates

- Since Moller trigger is applied into the 2021 HPS experiment, format of 2021 DAQ configuration somewhat changes comparing to format of 2019 DAQ configuration.
 - Format for single0/single1 triggers changes:
 - One-pass beam: both single0 and single1 triggers are applied for Moller single trigger, so format changes for both of them.
 - Two-pass beam: Only single1 trigger is applied for Moller single trigger, so format changes only for single1.
 - ✦ Format for other triggers has no change.
- Since no format change for VTP and TS banks, 2019 software codes for these two banks are still available for 2021.

What Changes for Format of single0/single1?

- 1. Add a new line for Moller mode:
 - VTP_HPS_SINGLE_MOLLER_MO DE_EN <trig_bit_inst> <en>
 - Set <en> as 1 to let PDE for upper limit, instead of lower limit for ap single triggers.
- 2. Change XMIN for ap single trigger into XYMINMAX for Moller single trigger
 - VTP_HPS_SINGLE_XMIN
 <trig_bit_inst> <xmin> <en> ->
 VTP_HPS_SINGLE_XYMINMAX
 <trig_bit_inst> <xmin> <xmax>
 <ymin> <ymax> <en>

######################################	######################################	oller: (660-1410) MeV	,
#	singles trigger b	it number	
#	Seccings	enable	cut
#			
#	i i	ĺ	
# Enchlo trianon			
# Enable trigger	1	1	
VIF_HFS_SINGLE_EN	1	1	
# Minimum cluster energy: 1 to 8191, units MeV			
VTP_HPS_SINGLE_EMIN	1 660	1	
VTP_HPS_SINGLE_EMAX	1 1410	1	
VTP_HPS_SINGLE_NMIN	1 1	1	
UTD UDC CINCLE NOLL	ED NODE EN 1 1		
# Minimum cluster x coordinate: $(-13, -10)$ and X $(-1, 1)$			
VTP HPS SINGLE XYMINMAX $1 -13 -10 -11 1$			
(
# Cluster position	dependent energy th	reshold coefficients	
<pre># Cluster Energy <</pre>	C0 + C1*X + C2	*X*X+C3*X*X*X	
# 3 sigma VTP_HPS_	SINGLE_PDE 1 2252	.66 103.169 1.28530	0.000 1
# 4 sigma VTP_HPS_	SINGLE_PDE 1 2676	.83 154.409 3.03128	0.000 1
# Use 2 signs out			
# USE 3 SIGMA CUL #VTP HPS SINCLE PDF	1 2252 66 103 1	69 1.2853 0.0000	1
"VII_HED_DINGLE_FDE	1 2252.00 105.1		-

Updates for hps-java

- Changes for DAQ configuration format look not big, but codes related to DAQ and triggers need to be comprehensively updated.
- To let hps-java available for 2021, updates includes:
 - DAQ configuration management system
 - Trigger diagnostic system
 - Readout system

Updates for DAQ Configuration Management System

- The system is applied to access DAQ configuration. To access 2021 DAQ configuration,
 - Update DAQ configuration parser EvioDAQParser2019
 - + Update DAQConfig2019 and related support classes to hold parameters from DAQ configuration
 - Update DAQConfig2019Driver: associated with DAQ configuration manager
 ConfigurationManager2019 to access DAQ configuration
 - DAQ configuration version is mapped with run number. Through run number in hps-java command, a corresponding DAQ configuration version is accessed.
 - There are two optional modes to read DAQ configuration:
 - 1. Directly read DAQ configuration bank from the first evio file of a run (Only the first file of each run includes DAQ configuration bank). This mode is applied for the trigger diagnostic system.
 - 2. Read DAQ configuration from text files which are stored in a resource of hps-java Maven package. All DAQ configuration versions for 2021 two-pass and one-pass experiments are added into the resource. This mode is applied for the readout system.
- All above updated parser, classes and drivers are compatible for both 2019 and 2021.

Updates for Trigger Diagnostic System

- The trigger diagnostics system is designed to provide a robust check on the performance of the HPS trigger.
- The package in hps-java emulates the trigger processing in hardware: pulse integration, cluster construction and trigger generation. Then, It performs extensive cross-comparison of clustering and triggering results as reported in run data by the hardware versus the expected results defined by software simulation.
- Since DAQ configuration changes and Moller trigger is added, the system is updated to be available for 2021 experiment.
- During 2021 experiment, run scan was taken by the system. For each run, a corresponding DAQ configuration version is accessed by the DAQ configuration management system. So DAQ parameters used by emulation is completely consistent with configuration in hardware.

2021 Run Scan: Cluster Efficiency

Cluster efficiency vs. run number



2021 Run Scan: Trigger Efficiency - Single3 Top

Software cluster simulated trigger efficiency vs run number for Singles 3 Top



2021 Run Scan: Trigger Efficiency - Single3 Bot

Software cluster simulated trigger efficiency vs run number for Singles 3 Bot



Issue for Runs 14439 to 14457



triggerValidationAna_x_y_ecalCluster_hh trippervisidationAna.x.x.acalCluster.3M Entries 22617 Y of recon ecal cluste Mean x 0.67 Mean y -0.09117 Std Dev x 14.94 Std Dev y 1.855 -20-15-10 -5 10 15 20 0 -5 X of recon ecal cluster



Run 14441



Run 14439 Reco. Ecal Cluster

Explanation for Issue

- Some channels at X = -7 and -8 are missed in hardware cluster distribution, while reconstructed cluster distribution looks fine. Therefore, the issue should take place at the firmware stage.
- Ben suggested that parameters are not set right for the missing channels.
- The issue was found in time and immediately fixed by roc_reboot during DAQ.
- XMIN = 5 for single2&single3 triggers and X = [-13, -10] for Moller trigger, so these triggers are not affected. Therefore, the issue just has very slight effect on these production runs 14439 to 14457.

Updates of Readout System: Application of DAQ Configuration Management system

- Since early this year, the DAQ management system has been applied into the readout system.
 - ✦ With this update, the DAQ parameters can be accessed.
 - Gains and pedestals, applied in the software trigger system, are from DAQ configuration, instead of database, which is applied before update.
 - Other parameters, such as parameters for pulse integration (NSB, NSA, window), parameters for GTP clustering and Hodoscope pattern building, and parameters for cuts of triggers, etc, are from DAQ configuration, instead of setup in steering files.
 - With this update, the readout system is conveniently updated to be available for new experiments.

Updates of Readout System: Readout Steering Files

- Since the DAQ configuration management system is applied, and DAQ configuration version is mapped with run number, all readout steering files for 2019 MC are available for 2021 MC.
- Since Moller single trigger is applied for the 2021 experiment, the 2019 single trigger driver SinglesTrigger2019ReadoutDriver is updated to be available for both ap single and Moller single triggers.
- Since no specified steering files for Moller triggers, two new steering files, OptionalTriggerTypeSingles.lcsim and OptionalTriggerTypePairs.lcsim, are developed to optionally choose any type of single and pair triggers, respectively. To apply them, an option -DtriggerType=<trigger type> needs to be included in hps-java command. A trigger type needs to be specified in the option:
 - singles0, singles1, singles2 or singles3 for the steering file
 OptionalTriggerTypeSingles.lcsim
 - pair0, pair1, pair2 or pair3 for the steering file OptionalTriggerTypePairs.lcsim

Updates of Readout System: Processing of Multi-type Triggers

- Previously, we process one type of trigger in readout per job. With update, readout is able to process multi-type of triggers simultaneously.
- Like experiments, we use TS bank to record status of trigger list. For experiments, we have a TS system to set prescales for multi-triggers and send triggers based on pre-scales. For MC, we check if there is/are one or multitrigger(s) sent by trigger readout driver(s) every input event (2 ns). If multi-triggers are sent, we only read out MC data one time to avoid the same events are read out repeatly, while all fired triggers are recorded by TS bank.
- We can arbitrarily add available triggers into a readout steering file. Like experiments, TS bank will tell us what triggers are fired. During analysis, we can handle MC TS bank in the same way of experiments. The steering file PhysicsRun2019TrigMultiSingles.lcsim processes single2 and single3 triggers.



Count for single3 is larger than count for single2 since Emin and PDE cuts for single2 are tighter.

Status of 2021 MC

- With the above updates, software is ready for 2021 MC.
- In recent months, MC production is mainly for preparation of 2021 experiment, especially for analysis of trigger tuning.

MC for Trigger Tuning of 2021 Experiment

- For preparation of 2021 experiment, MC samples for both one-pass and twopass beams were produced, including pure ap, rad, tritrig, wab, Moller and beam samples as well as tritrig-wab-beam, Moller-wab-beam and wab-beam samples.
- These samples were produced with ideal detectors and random trigger.
- Information about these samples is in confluence pages:
 - Two-pass beam: <u>https://confluence.slac.stanford.edu/display/hpsg/</u> <u>future+3.7+GeV+Beam</u>
 - One-pass beam: <u>https://confluence.slac.stanford.edu/display/hpsg/</u> <u>future+1.92+GeV+beam</u>
- These samples helped to successfully extract trigger conditions to construct DAQ configuration for 2021 experiment.

Trigger Tuning for 2021 Experiment by MC Samples

- A comprehensive set of cods based on hpstr was developed to take trigger tuning analysis.
 - Similar to 2019 trigger tuning analysis by Sam, ap single/pair triggers and FEE trigger were determined.
 - ♦ New Moller triggers were extracted.
- During analysis, there are some findings, which should also be taken care of in future experiments.
 - ✦ Effects of decay angle of e+e- pair from ap on ap triggers
 - Difference of GTP cluster energy between software/readout and hardware

Effects of Decay Angle of e+e- Pair on ap Triggers

 As beam energy decreases and ap mass increases, more tracks are out of SVT/Ecal acceptance, and more clusters appear at low |X| and/or high |Y|. Such clusters might lose energy so that distributions of PDE and energy slope are not stable.



PDE Cut

PDE cut is not applied for one-pass beam.





PDE cut is applied for two-pass beam.

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triggerParameterExtractionAna_energy_vs_x_index_pos_hh



Energy Slope Cut

Energy slope cut is not applied for one-pass beam.





Energy slope cut is applied for two-pass beam.





Difference of GTP Cluster Energy between Software and Hardware



- Through comparison between experimental and MC FEE data of 2019, ratio of data to MC for GTP cluster energy is 0.93.
- 2021 trigger conditions, extracted by MC, are scaled by the ratio.

Discussion for Moller Triggers

- As beam increases, detection of electrons from Moller becomes harder and harder for the HPS facility.
- 3.7 GeV is close to the critical point that SVT can detect both outgoing electrons from Moller. But it is rare that both of such electrons hit Ecal. So we applied single trigger for experiment with two-pass beam.
- For 2021 data, it is harder to extract clean Moller events from two-pass beam than one-pass beam. For two-pass beam, extra cuts based on kinematic calculations of two-body system are strongly suggested.



Summary

- Based on DAQ and trigger updates for 2021 experiment, hps-java has been updated for DAQ configuration management system, trigger diagnostic system, and readout system. After updates, related drivers for 2019 are compatible with both 2019 and 2021.
- With updates, software is ready for 2021 MC production.
- 2021 triggers, extracted by MC, were successfully applied into 2021 experiment.