Updates of the Readout System for Beam Background Merging

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Overview

- To take into account of beam background effects on MC samples, signal events are required to be merged with beam background.

- To significantly speed up MC production and improve quality of MC samples, we attempt to merge pulser data with MC signal samples.

- After pulser data and MC data are overlaid, events include two groups of collections:

  - Pulser data: ADC samples for Ecal, hodoscope, and SVT
    - Ecal: 48 samples, 192 ns time window (4 ns clock-cycle for FADC250)
    - Hodo: 32 samples, 128 ns time window (4 ns clock-cycle for FADC250)
    - SVT: 6 samples, 144 ns time window (24 ns clock-cycle for APV25)

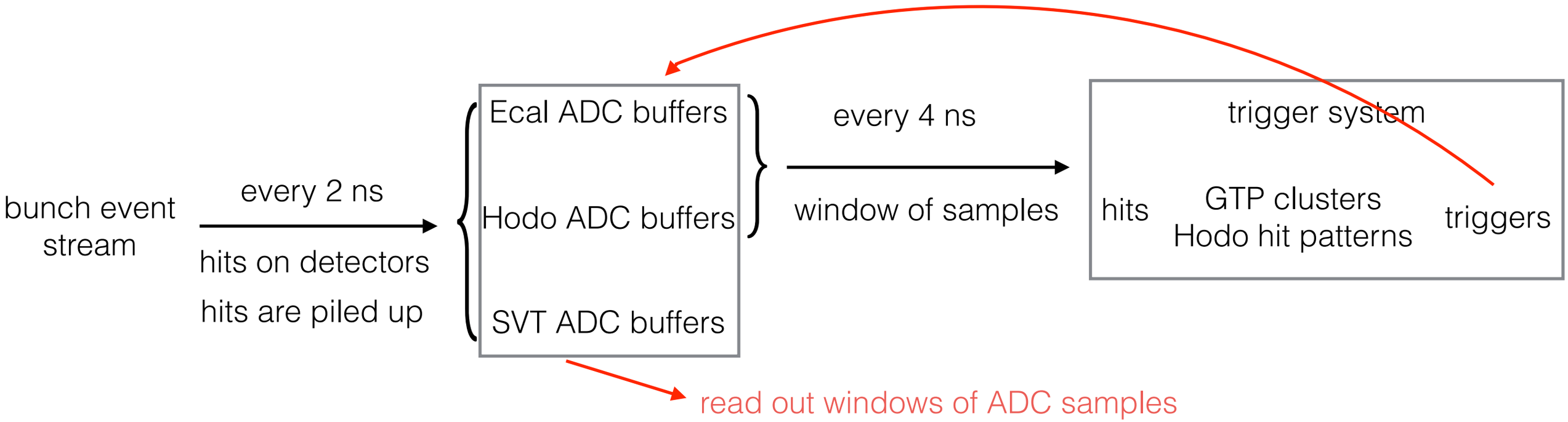
    Ecal:
    01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48
    Hodo:
    01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
    SVT:
    01 02 03 04 05 06

  - MC data: MC particles, hits for Ecal, hodoscope and SVT

- To apply overlaid data, the readout system needs to be updated.

How to Update Readout?

The readout system is emulation of the DAQ system



For an overlaid event, ADC samples from pulser data are merged with digitized MC hits. Merged samples are buffered for usage of the trigger system and readout of triggered events.

How to Merge?

- Three different cases are handled separately:
  - If pulser data does not have a channel in MC data,
    - directly buffer samples
  - If MC data does not have a channel in pulser data,
    - add noise into MC hits
    - convert MC hits into a window of ADC samples
    - add pedestal
    - buffer samples
  - If MC data has a channel that is also in pulser data,
    - convert MC hits into a window of ADC samples
    - merge with samples of pulser data
    - buffer merged samples
- Note: if a ADC sample is (or merged with) a sample from pulser data, noise and pedestal should not be added; if a ADC sample is produced from MC data, noise and pedestal should be added

Software updates: Input for readout with beam background merging

- Original data are MC signal events from SLIC, and experimental events from pulser data

    1. Evio to LCIO for pulser data

    2. Event overlay: Overlay MC events from SLIC and experimental events from pulser data with application of the tool DataOverlayDriver developed by Jeremy

    3. Spacing: Space overlaid events with interval of 250. Although loops of drivers are actually time basis, we use process(EventHeader event) for loop, which is event basis. After digitization, samples of one overlaid events will be handled in a time window and the trigger system handles ADC sample buffers clock-cycle by clock-cycle, so empty events need to inserted into neighbored overlaid events to provide enough space for the time window.

- After merging and spacing, we obtain overlaid events with collections for MC hits and ADC samples of pulser data, and there are 249 empty events between neighbored overlaid events

Software updates: steering file for Readout

```
<execute>
    <!-- SLiC Data Drivers -->
    <driver name="EcalHitsOutputDriver"/>
    <driver name="MCParticleOutputDriver"/>
    <driver name="HodoscopeHitsOutputDriver"/>
    <driver name="TrackerHitsSVTOutputDriver"/>
    <driver name="TrackerHitsEcalOutputDriver"/>

    <!-- Pulser Data Drivers -->
    <driver name="EcalPulserDataInjectDriver"/>      // New driver to globally buffer Ecal ADC samples
    <driver name="HodoPulserDataInjectDriver"/>    // New driver to globally buffer hodoscope ADC samples

    <!-- SVT Readout Drivers -->
    <driver name="SVTReadoutDriver" />             // Need to be updated to handle pulser data

    <!-- Hodoscope Readout Simulation Drivers -->
    <driver name="HodoscopePreprocessingDriver"/>
    <driver name="HodoscopeDigitizationDriver"/>
    <driver name="HodoscopeRawConverterDriver"/>
    <driver name="HodoscopePatternDriver"/>

    <!-- Calorimeter Readout Simulation Drivers -->
    <driver name="EcalDigitizationDriver"/>
    <driver name="EcalRawConverterDriver"/>
    <driver name="GTPReadoutDriver"/>

    <!-- Trigger Simulation -->
    <driver name="SinglesTrigger"/>

    <!-- LCIO Output and Data Management Driver -->
    <driver name="ReadoutManagerDriver"/>

    <driver name="CleanupDriver" />
</execute>
```

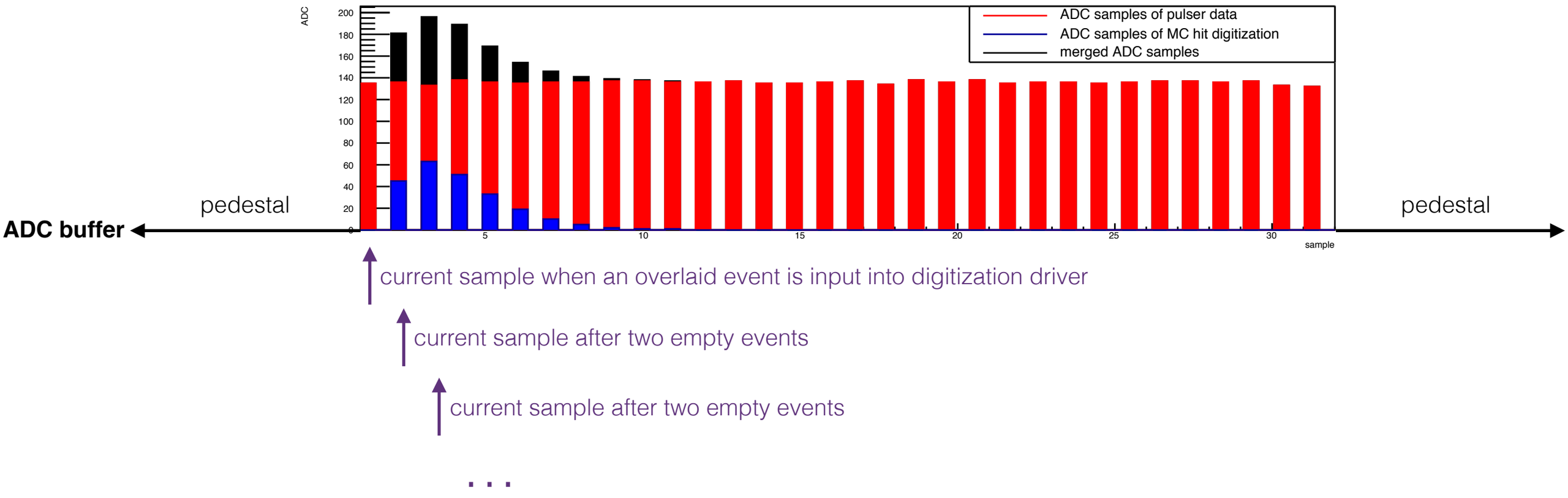
Both of hodoscope and Ecal digitization drivers are based on DigitizationReadoutDriver. DigitizationReadoutDriver needs to be updated to handle pulser data

Software updates: new drivers in the readout system

- PulserDataReadoutDriver: a base driver to take in collections of pulser data
- RawTrackerHitReadoutDriver: a driver to take in collections of pulser data with type of RawTrackerHit (ADC sample collections for Ecal, hodo and SVT)
- DigitizationWithPulserDataMergingReadoutDriver: developed based on DigitizationReadoutDriver; a base class to obtain MC hits and pulser samples, digitize MC hits and merge with pulser samples, apply pulse integration algorithm to construct raw hits for usage of the trigger system
- EcalDigitizationWithPulserDataMergingReadoutDriver: a digitization driver for Ecal
- HodoscopeDigitizationWithPulserDataMergingReadoutDriver: a digitization driver for hodoscope

Software updates: demonstration

ADC samples for a hodoscope channel



After MC data is merged with pulser data, ADC samples are buffered. Then, ADC buffers are used for the pulse integration algorithm, while the current sample in each ADC buffer moves one step every two empty events (i.e. one clock-cycle).

Summary

- The readout system is updated for beam background merging.
  - Updates for Ecal and hodoscope have been done.
  - Merged ADC samples for the new system can be applied like digitized ADC samples in the old system so that the trigger system does not need to be changed.
    - Updates for SVT need to be supported by SVT experts.
- All new drivers are developed in a new package org.hps.digi so that the old readout system keeps available.
- hps-java branch: iss225
- Preliminary tests show the new system works well. Further analysis for effects of beam background on signal events is ongoing.