SBS-offline for SBSGenericDetector and BBShower

June 18, 2021

1 Introduction

For the SBSGenericDetector , a detector can be classified as using ADC and/or TDC information. The ADC can be different modes: kNone (no ADC), kADCSimple (like a 792 or fastbus), kADC (F250 in mode 7) and kWaveform (F250 in mode 1). ADC data from a F250 in mode 7 can have up three pulses recorded per channel per event. ADC data from a F250 in mode 1 is a vector of 4ns samples. The size of the vector is fixed in the configuration of the FADC readout list. The size of the vector is determined by the FADC250 module decoder.

The TDC can be in modes: kNone (no TDC for detector), kTDCSimple (only leading edge), kTDC (leading and trailing edge).

2 SBSGenericDetector ReadDatabase

A detector is defined as a grouping of elements which are arranged in rows, cols and layers. There are two numbering schemes for vectors of the elements. Either by element number and like a 2-d array with row and col. The element number is incremented by looping through number of columns inside the looping through rows. The BB Preshower is 26 rows of 2 columns in one layer. The BB SHower is 27 rows of 7 columns in one layer.

The detmap gives the crate, slot, start channel , end channel that are used by the detector. One can also specify the reference channel in the detmap. The chanmap is array of the element index for the slot and channel. Detailed documentation on detmap and chanmap in the main SBS-offline software documentation. For the BB Preshower, the left side was put in slot 3 and slot 4 (chan 9) and the right side slot 3 (chan 10) to slot 6 (chan 3). The left side is column 0 , so all the even element indices. The right side is column 1, so all the odd element indices. For BB Shower, the signals are in slot 6 (chan 4) to slot 20 (chan 0). As an example, row 0 and col 0-6 is in slot 6 and channels 4 to 10.

For processing the waveform data to extract the pulse information , there are the following parameters that can be set in the database. Those that are arrays can have all elements set individually or have one value which is used for all elements.

Parameter nam	Description	Global variable
adc.pedestal	Array of Pedestals (not used for waveform)	adc_ped
adc.gain	Array of gain to convert to GeV	adc_gain
adc.conv	Array of conversion factors (waveform is mV/chan)	adc_conv
adc.thres	Array of threshold (mV)	adc_thres
adc.FixThresBin	Array of fixed threshold crossing bin	adc_FixThresBin
adc.NSB	Array of # of integration samples before threshold crossing	adc_NSB
adc.NSA	Array of # of integration samples after threshold crossing	adc_NSA
adc.NPedBin	Array of # of samples for pedestal determination	adc_NPedBin

3 SBSGenericDetector Decode

The total number of ADC and TDC channels hit in the Decode method is fNhits. The ADC and TDC channels are not counted separately. When ADC is in waveform mode, a sample vector is filled with ADC value for each 4ns bin. The SBSData::Waveform::Process is called. A vector with the raw ADC converted to mV is filled. The pedestal (in mV) is determined by averaging the first NPedBin ADC values. A vector with the pedestal subtracted ADC is filled. The threshold crossing bin is found by looping through the sample raw ADC vector and finding the first bin which has a raw ADC value larger than the pedestal plus the threshold. If a threshold crossing bin, TC, is found, then the ADC samples are integrated from TC-NSB to TC+NSA-1. If no threshold crossing bin, TC, is found, then the ADC samples are integrated from FixThresBin-NSB to FixThresBin+NSA-1. The ADC integration is converted to pC using the 4ns bin width and 50 ohm resistance.

If a threshold crossing bin is found, then the peak amplitude is found within the integration region. The peak, Vpeak, is the ADC value in the sample which within the integration window (starting from the threshold crossing) the following bin has a smaller ADC value than previous sample. To calculate the pulse time, first $V-Mid = (V_{peak} + \text{pedestal})/2$ is calculated. Then loops through the integration region and finds the sample, i, with which has value greater than Vmid and the next sample, i+1, is less than Vmid. The time is 4ns $* [(i + (V_{Mid} - V_i)/(V_{i+1} - V_i)]$. If no threshold crossing bin is found, then the time and amplitude are set to zero. For now the code only find the first pulse that is above threshold.

For each element that has a hit, then method SBSBBShower::FindGoodHit is called. For now this is used to just increment a counter of ngoodhits if the element has a time greater than 0. In principal , it can be used to select the good hit when there are multiple hits in an ADC or TDC for a detector element. Presently there for the waveform data there is no selection of good hits.

3.1 SBSGenericDetector Tree variables

For the tree variables, most are arrays of variable size depending on the number of hits. The total number of ADC and TDC channels hit in the Decode method is fNhits. The ADC and TDC channels are not counted separately.

Tree name	Description	Global variable
nhits	Number of total hits	fNHits
ngoodhits	Number of total good hits	fNGoodhits

If fStorerawHits is set true, then the ADC/TDC raw info is stored.

Tree name	Description	Global variable
hits.t	Array of all hit's Calibrated Leading edge TDC	fRaw.t
hits.t_te	Array of all hit's Calibrated Trailing edge TDC	fRaw.t_te
hits.t_tot	Array of all hit's TDC Time Over Threshold	fRaw.t_ToT

Tree name	Description	Global variable
hits.a	Array of all ADC integral of the all hits (units pC)	fRaw.a
hits.a_amp	Array of all ADC peaks of the all hits (units mV)	fRaw.a_amp
hits.a_time	Array of all ADC time of the all hits (units mV)	fRaw.a_time

The good hit information is the following variables.

Tree name	Description	Global variable
nhits	Number of total hits	fNHits
ngoodhits	Number of total good hits	fNGoodhits
row	Row of the detector element	fGood.row
col	Column of the detector element	fGood.col
layer	Layer of the detector element	fGood.layer
ped	Pedestal of the good hit (units mV)	fGood.ped

Tree name	Description	Glo
a	ADC integral of the good hit (units pC)	
a_p	Pedestal subtracted ADC integral of the good hit (units pC)	f
a_c	Energy Calibrated Pedestal subtracted ADC integral of the good hit (units GeV)	f

Tree name	Description	Global variable
a_amp	ADC peak of the good hit(units mV)	fGood.a_amp
a_amp_p	Pedestal subtracted ADC peak of the good hit (units mV)	fGood.a_amp_p
a_time	ADC time of the good hit (units ns)	fGood.a_time
a_amp	ADC peak of the good hit (units mV)	fGood.a_amp

Tree name	Description	Global variable
tdc	Calibrated Good hit Leading edge TDC	fGood.t
tdc_te	Calibrated Good hit Trailing Edge TDC	fGood.t_te
tdc_tot	Calibrated Good hit Time over Threshold	fGood.t_Tot

Tree name	Description	Global variab
samp_idx	Index in the samples vector for given row-col element	fGood.sidx
samp_nsamps	Number of samples for a given row-col element	fGood.nsamp
samp	Calibrated Pedestal subtracted ADC samples (units mV) in 4ns bins	fGood.samp

4 Short description of FADC250

The FADC250 is a fast data acquisition electronics module which is able to sample a signal pulse at 250MHz (i.e. 4ns time sample). It has two main data acquisition modes:

- Mode 1: all samples within a defined time window are recorded; this allows to perform the waveform reconstruction offline.
- Mode 7: if the recorded pulse passes a defined threshold, the following quantities are recorded: the pedestal, the pulse time, the pulse amplitude, and the pulse integral over a defined time window; Up to 3 pulses can be recorded the trigger window

For the SBS hadron calorimeter (HCal) and SBS BBShower/PreSHower, the FADC will be used with acquisition mode 1.

Details on the algorithm of the FADC is given in the manual. Here is a short description. In mode 7, a threshold is defined in the ROL FADC configuration file for each channel in the FADC. When a pulse has one sample that passes the threshold, then that sample is marked as the threshold crossing sample, TC. The pulse is integrated from NSB samples before the TC and NSA samples after the TC. NSB and NSA are programmed in the ROL FADC configuration file. The average of first four samples in the trigger window are used to determine the pedestal or VMIN. The peak amplitude (VPEAK) is determined by finding a sample beyond TC for which the sample value first decreases. The fine time, TF, is determined in bins of 62.5ps. First the time bin is roughly determined by the time bin of the half amplitude (VMID = (VPEAK + VMIN) / 2)). Then the fine time is determined as TF = 64*(VMID – V(N1)) / (V(N1+1) – V(N1)). The sample number N1 is found on the leading edge of the pulse that satisfies V(N1) $\leq$ VMID $<$ V(N1+1).