KOPIO TN068

Predigitization in KOPIO GEANT MC

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Abstract

The concept and implementation of predigitization in the KOPIO GEANT Monte Carlo is described.

This document assumes some familiarity with the concepts and definitions used in GEANT3.

1 Plan

The goals are

1. Collect all GEANT hits for each detector element to provide realistic 'raw' hit info. Specifically, combine all GEANT hits for each detector element and put them in time bins with energy summed in each bin.
2. This binned information is stored in an ntuple to facilitate analysis.
3. This scheme should allow true 'digitization' at a later stage to form ADC, TDC and/or WFD output. (WFD = WaveForm Digitizer)

Define the following

1. JHIT = a GEANT 'hit'
2. SD = Signal Detector = photomultiplier tube, amplifier, etc.
3. 'detector element' = a single slab of scintillator, a single wire chamber cell, etc.

Every JHIT has the position(local and global), time, deposited energy, distance to the wire (for chambers) and number of photoelectrons (for the catcher).

For each detector element, we specify

1. Attenuation length
2. Propagation velocity
3. Element dimensions

Variable	Definition	Type
`EVENTP`	Event number	Integer
`RUNP`	Run number	Integer
`LASTP`	GEANT track number of last parent (see below)	Integer
`Exxxx`	Total energy in xxxx (MeV)	Real
`Nxxxx`	Total number of hits in xxxx	Integer
`Dxxxx`(i)	Detector number in set xxxx for i^{th} hit	Integer
`ELxxxx`(i)	Element number in detector Dxxxx in set xxxx for i^{th} hit	Integer
`Txxxx`(i)	Binned time(ns) of i^{th} hit	Real
`Axxxx`(i)	Energy(MeV), distance to wire(cm) or NPE of i^{th} hit	Real
`P1xxxx`(i)	$P1 + (\mathtt{LASTP} + 1) \times P2$ for i^{th} hit, where	Integer
	$P1 =$ first parent of hit	
	$P2 =$ second parent of hit	
	$P2 = 0$ if no second parent	
`Lxxxx`	Number of detectors in set xxxx	Integer
`NAMExxxx`(j)	Name of j^{th} detector in set xxxx	Character

Symbol	Definition
i	$1,$ `Nxxxx`
j	$1,$ `Lxxxx`
`xxxx`	set name (Table 2)
NPE	number of photoelectrons

Table 1: Ntuple variable names and definitions. We store the energy for scintillators, the distance of the closest hit to the wire for wire chambers and the number of photoelectrons for the catcher.

4. Location(s) of SD

5. Time bin width and time zero

For each signal detector, we then calculate the arrival times and energies of all hits. For detectors with double-ended readout, the deposited energy is divided by two before propagation to each SD. These hits are then sorted in ascending order of element number and in ascending order of arrival time for each element and binned. The packing and unpacking of the element of each hit is formalized.

The ntuple contents are described in Table 1.

2 Packing and unpacking the element of each hit

The relevant details of the definition of a sensitive detector in GEANT manual are reproduced here:

```
CALL GSDET (CHSET,CHDET,NV,CHNMSV,NBITSV,IDTYP,NWHI,NWDI,ISET*,IDET*)
```

Set name	Definition
PRSC	preradiator scintillator
VETO	outer PR veto scintillator
BAVE	barrel veto
DSVE	DS veto
DSHV	far DS horizontal veto
DSVV	far DS vertical veto
CHVE	charged veto
PRWC	preradiator wire chamber
CALO	calorimeter
BCAT	beam catcher
PRIL	preradiator inner liner
CAIL	calorimeter inner liner

Table 2: Current detector set names

Variable	Type	Definition
CHSET	CHAR*4	set identifier, user defined
CHDET	CHAR*4	detector identifier, has to be the name of an existing volume
NV	INTEGER	number of volume descriptors
CHNMSV	CHAR*4	array of NV volume descriptors
NBITSV	INTEGER	array of NV, NBITSV(I) (I=1,...,NV) is the number of bits in which to pack the copy number of volume CHNMSV(I)
IDTYP	INTEGER	detector type, user defined
NWHI	INTEGER	initial size of HITS banks
NWDI	INTEGER	initial size of DIGI banks
ISET	INTEGER	position of set in bank JSET
IDET	INTEGER	position of detector in bank JS=LQ(JSET-ISET).

Assigns detector CHDET to the set CHSET and defines its basic parameters.

Note: The vector CHNMSV (length NV) contains the list of volume names which permit unambiguous identification of all copies of volume CHDET. Each element of the vector NBITSV (length NV) is the number of bits used for packing the number of the corresponding volume, when building the packed identifier of a given physical detector.

The detector type IDTYP is not used internally by GEANT and can be used to distinguish quickly between various kinds of detectors, in the routine GUSTEP for example.

The array NBITSV(NV) is used to pack the volume copy numbers of a particular JHIT along with an additional bit when there is double-ended readout. The volume copy numbers of a particular JHIT are given in NUMBV(NV). The packing algorithm can be summarized as

$$p = \sum_{j=1}^{n} \left((h_j - 1) \prod_{k=1}^{j-1} 2^{b_k} \right)$$

IDTYP	Detector type
1	Scintillator
2	Wire chamber
3	Beam catcher (aerogel)
4	PR inner liner (crystals and wavelength-shifter)
5	CAL inner liner (crystals and wavelength-shifter)

Table 3: Correspondance between detector type and IDTYP

where

- p is the packed hit element `ELxxxx`,
- $n \equiv$ NV or NV $+ 1$ for single- or double-ended readout, respectively,
- h_j corresponds to `NUMBV(n-j+1)`
- b_k corresponds to `NBITSV(n-j+1)` and
- the product is unity when $j = 1$.

3 Comments

For shashlyk detectors (CALO and VETO), there can be a predigitized hit for *each* scintillator plate within a module. In practice all scintillator plates in a module are summed via wavelength-shifting fibers. An additional step (post-predigitization(?)) could be applied to sum predigitized hits appropriately.

Similar comments probably apply for other detectors as well, where individual slabs of scintillator will be collected into a single readout.