How to perform event building in a MINIBALL experiment

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Abstract

This document describes how to perform event building and to generate ROOT trees from med data in a Miniball experiment.

Contents

1 Online data acquisition

Any data in a MINIBALL experiment will be produced by connecting to the `MBS` subsystem and reading raw data from the harware modules in `VME` and `CAMAC` crates [1]. Online data are then written to disk using the `MED` format (`MBS` event data) [2].
Fig. 1 shows data flow as well as software components used to acquire experimental data.

Following files are needed for this step:

- `DgfReadout.c`
  user's readout function given by hardware definitions in `Config.C`,
  auto-generated during config step
- `DgfAnalyze.cxx`
  methods and functions to setup the `ROOT` system and to decode raw data from `MBS`,
  auto-generated during the config step
- `udef/ProcessEvent.cxx`
  consistency checks and accumulation of diagnostic histograms,
  has to be provided by user

2 Filling hitBuffers from raw data

2.1 Extracting hits from DGF-4C data

2.2 Extracting hits from CAEN ADC/TDC data

3 Event building

In a second step one may create meaningful events from raw data read from `MED` files. These events may then be written to `ROOT` trees and used in replay sessions afterwards. Fig. 2 shows how to do the event building.
Steps to be performed for the event building process:

- in `SetCppIfdefs.C`: activate event building

  ```
  dgf->MakeDefined("__EVENT_BUILDING_ON__", kTRUE, "Start event building");
  ```

- in `Config.C`: define an event class to be used for event building

  ```
  dgf->IncludeUserClass("udef", "MbEvent.cxx", kTRUE);
  ```

  when doing the config step for the first time this will generate a template class `MbEvent`;
  you then have to modify this class according to your needs

- provide an event building algorithm: `TUsrEvtReadout::BuildEvent()` in `udef/BuildEvent.cxx` (table 2, fig. 3)
- in `.rootrc` file: add an entry `TMrbAnalyze.CoincWindow:  N`
- perform config, compile and link the whole stuff, run `C_analyze`

3.1 Inserting time stamps in ADC/TDC data

3.2 Event building algorithm

4 Replay session

Once events have been built and tree data have been written to `ROOT` file one may start a replay session by reading these pre-sorted data. Fig. 4 shows the data flow for such a replay session. The gain in speed is about a factor of 10 as compared to replaying raw data from `MED` files.
User has to provide a method `MbEvent::Analyze()` containing his analysis. A wrapper class `MbExp` may be used to establish pointer arrays pointing to different event components such as cores, segments, channels, etc (table 3).

References

[1] See also: "Instructions how to use the DAQ in a MINIBALL experiment", `http://www.bl.physik.uni-muenchen.de/marabou/html/doc/DaqInstructions.pdf`

[2] For details see: "MED Data Structure", `http://www.bl.physik.uni-muenchen.de/marabou/html/doc/MedStructure.pdf`

Figure 1: Online data acquisition

Figure 2: Event building

```
Bool_t TUsrEvtReadout::InsertTimeStamp(Int_t TsIdx, Int_t TsChannel, Int_t StartIdx, Int_t NofHbx) {
//________________________________________________________________[C++ METHOD]
//////////////////////////////////////////////////////////////////////////////
// Name:         TUsrEvtReadout::InsertTimeStamp
// Purpose:      Insert time stamps into adc data
// Arguments:    Int_t TsIdx       -- index of timestamping buffer
//               Int_t TsChannel   -- number of timestamping channel
//               Int_t StartIdx    -- index of adc buffer to start with
//               Int_t NofHbx      -- number of buffers to process
// Results:      kTRUE/kFALSE
// Description:  Inserts time stamps from timestamping dgf into adc buffers.
//               Time stamps in dgf buffer are sorted by time,
//               adc/tdc buffers contain single channel data grouped by event number.
//               This algorithm inserts time stamps one by one in adc channel data;
//               channels belonging to one event (i.e. having the same event number)
//               will be marked with same time stamp.
// Keywords:
//////////////////////////////////////////////////////////////////////////////

  TUsrHBX *tsHbx = this->GetHBX(TsIdx);                  // connect to hitbuffer of time stamping dgf

  for (Int_t i = StartIdx; i < StartIdx + NofHbx; i++) {  // loop over adcs/tdcs
    tsHbx->ResetIndex();                                 // reset to first item in ts-dgf buffer
    TUsrHit * tsHit = tsHbx->FindHit(TsChannel);         // fetch first item (= time stamp)
    if(!tsHit) break;                                    // no time stamps in this buffer (should never be)
    TUsrHBX * cHbx = this->GetHBX(i);                    // connect to current adc/tdc buffer
    cHbx->ResetIndex();                                  // reset to first item in buffer
    TUsrHit * cHit = cHbx->NextHit();                    // fetch first adc/tdc hit (= channel data)
    while(tsHit && cHit) {                               // step thru buffers
      Int_t evtNo = cHit->GetEventNumber();              // save current event number from adc/tdc hit
      while(cHit->GetEventNumber() == evtNo) {           // as long as event number doesn't change:
        cHit->SetChannelTime(tsHit);                     //    insert current time stamp in adc hit
        cHit = cHbx->NextHit();
        if (!cHit) break;                                // end of adc/tdc buffer reached
      }
      tsHit = tsHbx->FindHit(TsChannel);                 // event number in adc/tdc buffer has changed:
    }                                                    //    get next time stamp from ts-dgf buffer
  }
  return(kTRUE);
}
```

Table 1: Algorithm used for time stamp insertion

Figure 3: Event builder: schematic diagram

Figure 4: Offline replay session

```
Bool_t TUsrEvtReadout::BuildEvent() {
//________________________________________________________________[C++ METHOD]
//////////////////////////////////////////////////////////////////////////////
// Name:        TUsrEvtReadout::BuildEvent
// Purpose:     Event building
// Arguments:   --
// Results:     kTRUE/kFALSE
// Exceptions:
// Description: Loops over all hit buffers,
//              collects hits within window 'coincWindow'
//              stores hits in events of type MbEvent
//              then calls method MbEvent::WriteToTree() for each event
//              Strategy:
//                a binary tree TBtree is used to compare events
//                method TBtree::FindObject() calls MbEvent::Compare()
//                MbEvent::IsEqual() then tests if time stamps are 'equal' within 'coincWindow'
//                hits belonging to an event are stored in a hit buffer of type TClonesArray,
//                to get the benefits of TClonesArray these hit buffers have to be static
//                they will be allocated only once and reused afterwards.
// Keywords:
//////////////////////////////////////////////////////////////////////////////

  TBtree evtsS;
  TBtree * evts = &evtsS;

// reset hit buffers
  TObjArrayIter epI(&poolOfMbEvents);
  while(MbEvent * evt = (MbEvent *) epI.Next()) evt->Reset();

// fill binary tree, create events if necessary
  Int_t evtCount = 0;
  for (Int_t i = kIdxCluster1; i < kIdxCluster1 + kNofSevts; i++) {    // loop over all hit buffers
    if (i == kIdxTSCluster) continue;           // discard time stamper
    TUsrHBX *hbx = this->GetHBX(i);             // pointer to current hit buffer
    if (hbx) {
      Int_t hitNo = 0;
      hbx->ResetIndex();                        // reset buffer index to first hit
      while (TUsrHit *hit = hbx->NextHit()) {   // loop over hits of this buffer
        if (hit->GetChannelTime() == 0) continue;              // time stamp = 0 -> junk data
        tmpEvent.SetEventTime(hit->GetChannelTime());          // insert time stamp into temp event
        MbEvent * evt = (MbEvent *) evts->FindObject(&tmpEvent);   // compare it with events already there
        if (evt == NULL) {                                     // no match
          if (evtCount < poolOfMbEvents.GetEntriesFast()) {    // try to get a event from pool
            evt = (MbEvent *) poolOfMbEvents[evtCount];
          } else {
            evt = new MbEvent();                // create a new one
            poolOfMbEvents.Add(evt);            // add it to pool
          }
          evt->Reset();                         // reset event time, hit buffer etc
          evt->SetEventTime(hit->GetChannelTime());  // insert time stamp
          evt->SetCoincWindow(coincWdw);        // should know about time window
          evts->Add(evt);                       // add new event to binary tree
          evtCount++;
        }
        evt->AddHit(hit);                       // append current hit to event
        hitNo++;
      }
    }
  }

// call method MbEvent::WriteToTree() for all events
 TBtreeIter evI(evts);
 while(MbEvent * evt = (MbEvent *) evI.Next()) evt->WriteToTree();  // write event data to tree
 evtsS.Clear();                                // clear entries in binary tree
 return(kTRUE);
}
```

Table 2: Algorithm used for the event building process

```
//_______________________________________________________[C++ CLASS DEFINITION]
////////////////////////////////////////////////////////////////////////////////
// Name:           MbExp
// Purpose:        Wrapper class to access MbEvent data
// Description:    Organizes MbEvent data in a more "experiment-oriented" way.
//                 Data may be accessed via cluster, core, and segment numbers (dgf),
//                 via adc and channel numbers, resp.
//                 Performs boundary check if requested.
//                 Indices start with 0.
// Keywords:
////////////////////////////////////////////////////////////////////////////////

class MbExp {

  public:
    MbExp(MbEvent * Event = NULL) { Init(Event); };    // default ctor
    virtual ~MbExp() {};                // default dtor

    TUsrHit * Core(Int_t Cluster, Int_t Core, Bool_t BoundaryCheck = kFALSE);
    TUsrHit * Segment(Int_t Cluster, Int_t Core, Int_t Seg, Bool_t BoundaryCheck = kFALSE);
    TUsrHit * Particle(Int_t Dgf, Int_t Channel, Bool_t BoundaryCheck = kFALSE);
    TUsrHit * Time(Int_t Tdc, Int_t Channel, Bool_t BoundaryCheck = kFALSE);

    void Init(MbEvent * Event = NULL); // initialize ptr arrays with data from MbEvent

  protected:
    TUsrHit * fCores[kNofDgfClusters][kNofDgfCoresPerCluster];
    TUsrHit * fSegs[kNofDgfClusters][kNofDgfCoresPerCluster][kNofDgfSegsPerCore];
    TUsrHit * fPart[kNofAdcs][kNofChannelsPerAdc];
    TUsrHit * fTime[kNofTdcs][kNofChannelsPerTdc];

  protected:
    TUsrHit fEmptyHit;
};
```

Table 3: Wrapper class to access event components