RawCOPPER data format

June. 23, 2014 (svn rev. 11234)

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Revision History of this document

- Jan.5, 2014 rev. 8376 : Add definition of tentative subsysID format
- Dec. 16, 2013 rev.7974 :
  - Add B2linkFEE header format
  - Add comments about handling StoreArray when unpacking Raw*** data.
- Oct.21, 2013 :rev.7133
  - Add instruction about Rawdata unpacking program
- Oct. 18, 2013 :rev. 7095
  - 1st draft
- Jun. 23, 2014 : rev. 11234
  - Online (header/trailer) reduction scheme on readout PC is introduced
    - RawHeader format is changed
    - COPPER header/trailer format is changed
  - Nakao-san updated B2LFEE/HSLB header/trailer format
    - See [b2link_ml:0144] Re: Belle2link version 0.01 - SVN update

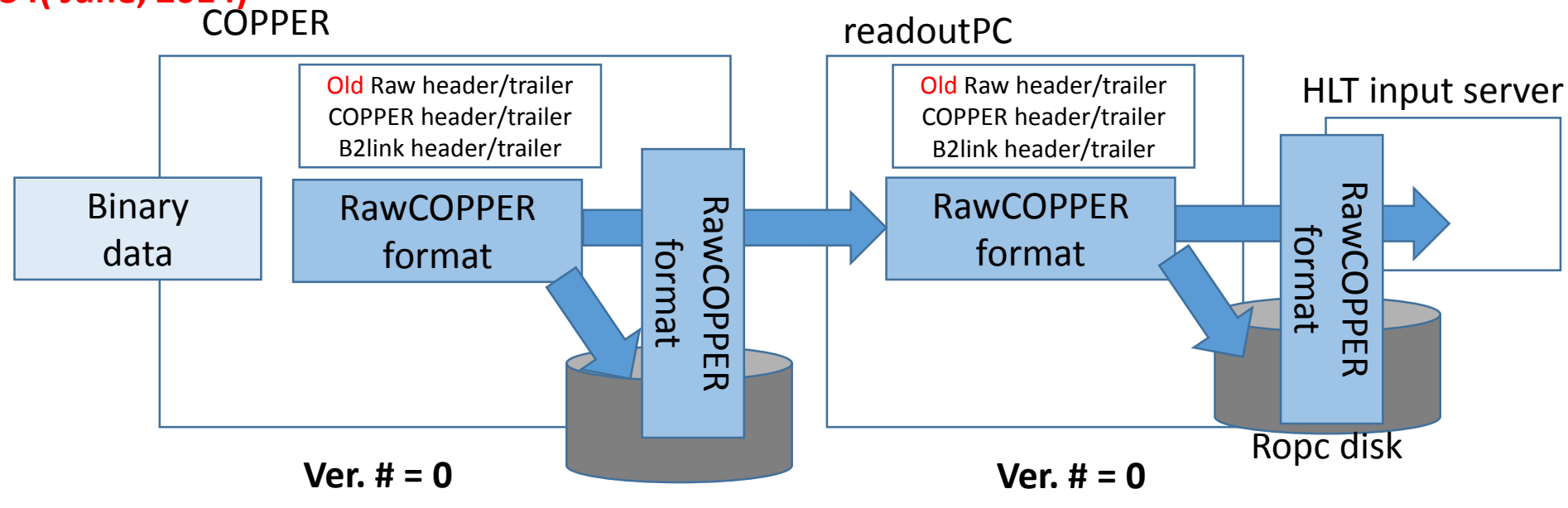
1, Overview of RawCOPPER format (one data block from a COPPER board)

- RawCOPPER header
  - COPPER header
    - B2link HSLB header (slot A FINNESSE)
      - B2link FEE header(slot A FINNESSE)
        - Data contents(Detector buffer) (slot A FINNESSE)
      - B2link FEE trailer (slot A FINNESSE)
    - B2link HSLB trailer (slot A FINNESSE)
    - B2link HSLB header (slot B FINNESSE)
      - B2link FEE header(slot B FINNESSE)
        - Data contents(Detector buffer) (slot B FINNESSE)
      - B2link FEE trailer (slot B FINNESSE)
    - B2link HSLB trailer (slot B FINNESSE)
    - B2link HSLB header (slot C FINNESSE)
      - B2link FEE header(slot C FINNESSE)
        - Data contents(Detector buffer) (slot C FINNESSE)
      - B2link FEE trailer (slot C FINNESSE)
    - B2link HSLB trailer (slot C FINNESSE)
    - B2link HSLB header (slot D FINNESSE)
      - B2link FEE header(slot D FINNESSE)
        - Data contents(Detector buffer) (slot D FINNESSE)
      - B2link FEE trailer (slot D FINNESSE)
    - B2link HSLB trailer (slot D FINNESSE)
  - COPPER trailer
- RawCOPPER trailer

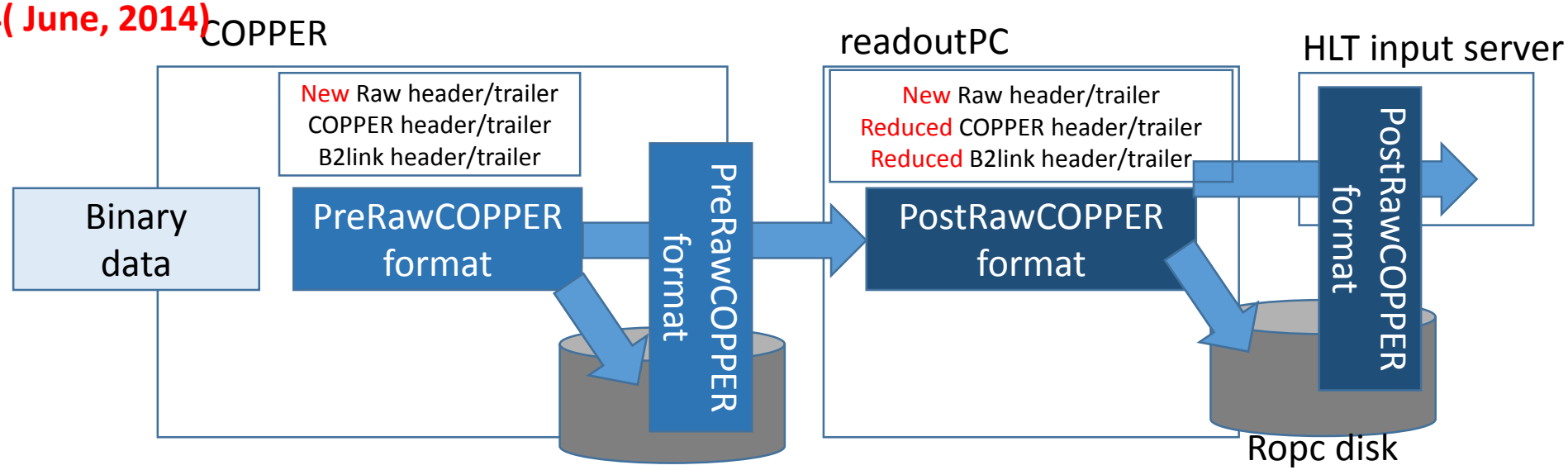
RawCOPPER header/trailer
-> See Sec. 2
COPPER header/trailer
-> See Sec.3
B2link(FEE+HSLB) header/trailer
-> See Sec.4
Detector buffer
-> Untouched by DAQ

1-1, Online header/trailer reduction

Before rev. 11234(June, 2014)



After rev. 11234(June, 2014)



PreRawCOPPER format : Ver # = 1 + 0x80 = 129

PostRawCOPPER format : Ver # = 1

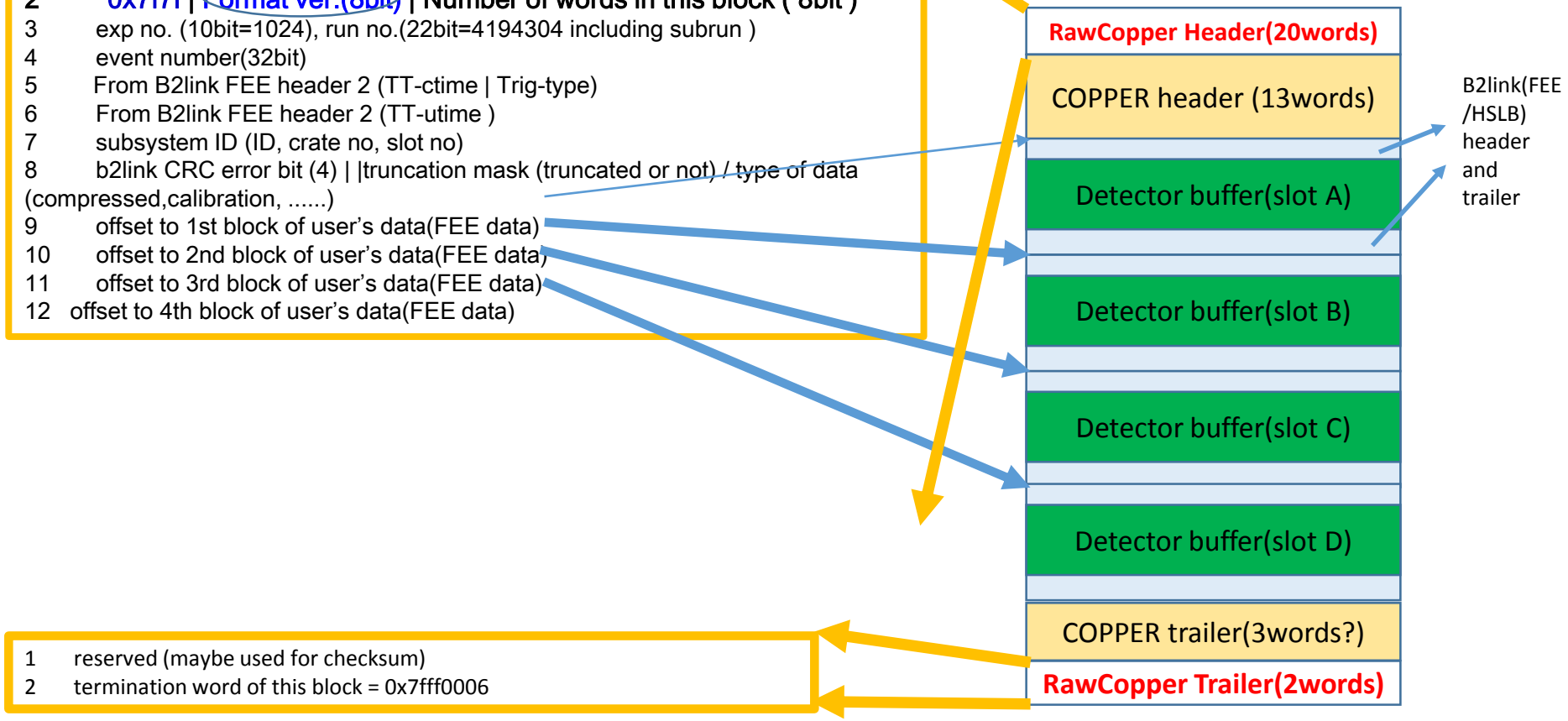
- PreRawCOPPER format
  - If you store data by COPPER CPU, then output data will be in Pre(reduction)RawCOPPER format.

- PostRawCOPPER format
  - Store the data downstream from readout PC, the output data will be in Post(reduction)RawCOPPERFormat

2-1, "RawCOPPER header/trailer" format in PreRawCOPPER format (ver. 1+0x80)

Use this version number to distinguish
Different data format.
Ver.0 : to 2014. June(including DESY test)
ver.1 : from June.2014

1 Number of total words
2 0x7f7f | Format ver.(8bit) | Number of words in this block (8bit)
3 exp no. (10bit=1024), run no.(22bit=4194304 including subrun)
4 event number(32bit)
5 From B2link FEE header 2 (TT-ctime | Trig-type)
6 From B2link FEE header 2 (TT-utime)
7 subsystem ID (ID, crate no, slot no)
8 b2link CRC error bit (4) | |truncation mask (truncated or not) / type of data (compressed,calibration, ...)
9 offset to 1st block of user's data(FEE data)
10 offset to 2nd block of user's data(FEE data)
11 offset to 3rd block of user's data(FEE data)
12 offset to 4th block of user's data(FEE data)



1 reserved (maybe used for checksum)
2 termination word of this block = 0x7fff0006

2-2, “RawCOPPER header” and trailer format in PostRawCOPPER format (ver.1)

Same as PreRawCOPPER format

2-3, 32bit Subsystem ID (A.K.A. node ID)

(31-24) Detector ID : 8bit=256 : detector & DAQ nodes
(23-17) CRATE ID : 7bit=128 :
(16-12) SLOT ID : 5bit=32 :
(11-0) N.A. : 12bit (4096) COPPER S/N?

SubsystemID = “TTD ” = 0x54544420 and is reserved by FTSW ID now.

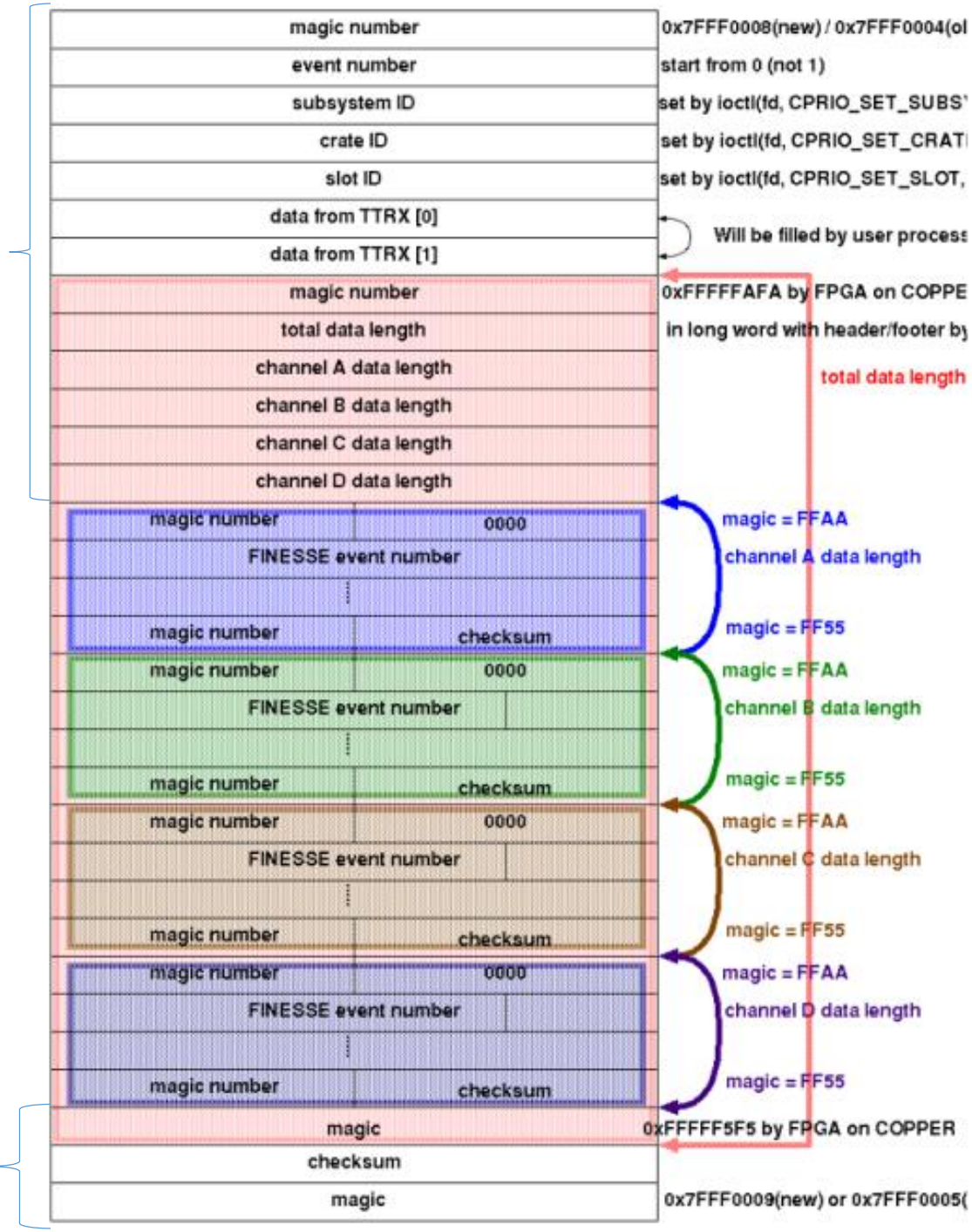
Detector ID (Defined in release/rawdata/dataobjects/include/RawCOPPER.h)

- #define SVD_ID 0x01000000 // tentative
- #define CDC_ID 0x02000000 // tentative
- #define BPID_ID 0x03000000 // tentative
- #define EPID_ID 0x04000000 // tentative
- #define BECL_ID 0x05000000 // tentative
- #define EECL_ID 0x06000000 // tentative
- #define BKLM_ID 0x07000000 // tentative
- #define EKLM_ID 0x08000000 // tentative

3-1, COPPER header and trailer in PreRawCOPPER format (ver. 1 + 0x80)

COPPER header

COPPER Trailer



3-2, COPPER header and trailer in PostRawCOPPER format (ver.1)

No COPEPR header and trailer in Post reduction rawcopper format.

4-1, B2link FEE header/Trailer, B2link HSLB header/Trailer in PreRawCOPPERFormat (ver. 1+0x80)

From Nakao-san's Belle2link User guide (June 10, 2014):
You can download from 18th B2GM indico page
http://kds.kek.jp/getFile.py/access?contribId=132&sessionId=28&resId=0&materialId=0&confId=15329

```
-----------------------------------------------
HSL: 0xFFAA(16) -- B2L header  |   HSLB-tag(16)
-----------------------------------------------
B2L: '0'(1) | TT-ctime(27)          | TT-type(4)
B2L: TT-tag(32)
B2L: TT-utime(32)
B2L: TT-exprun(32)
B2L: '0' | B2L-ctime(27)          |  reserved(4)
-----------------------------------------------
FEE: Data #0 (32)
FEE: Data #1 (32)
FEE:    ....
FEE: Data #n (32)
-----------------------------------------------
B2L: '0'(1) | TT-ctime(27)          | TT-type(4)
B2L: TT-tag(16)           |       B2L-CRC16(16)
-----------------------------------------------
HSL: 0xFF55(16)           | CRC error count(16)
-----------------------------------------------
```

B2link HSLB header

B2link FEE header

B2link FEE trailer

B2link HSLB trailer

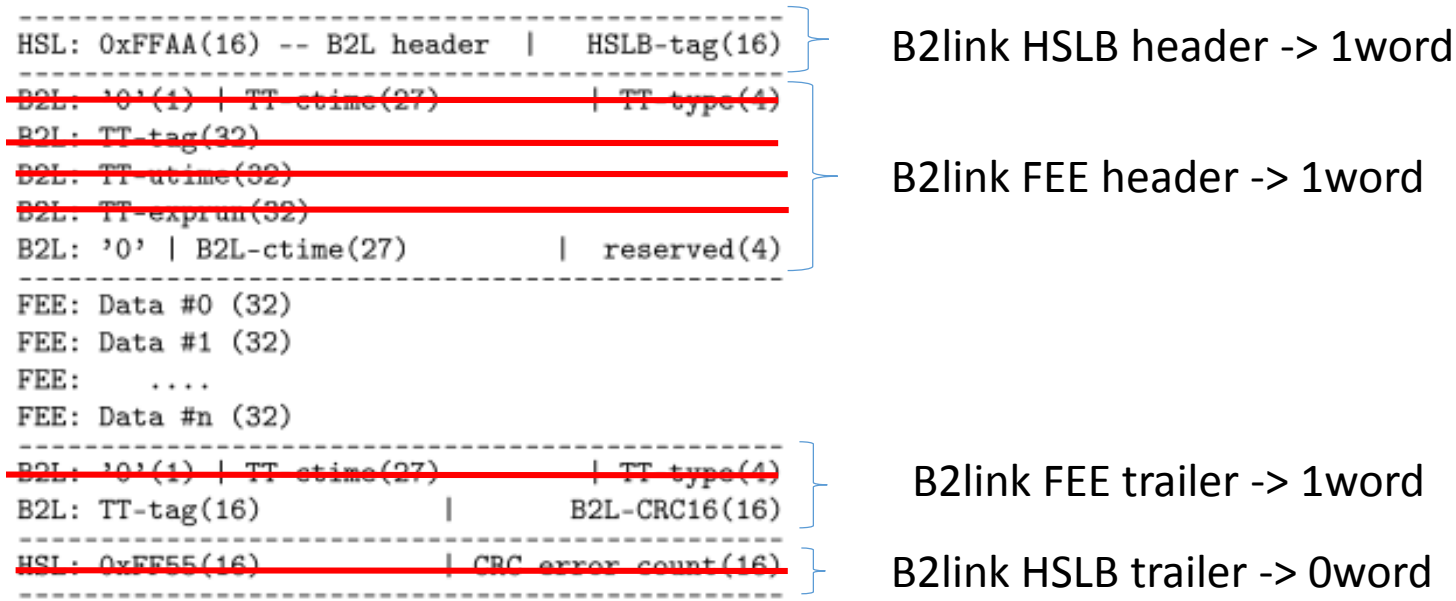
*Figure 5: Data format as read out by the COPPER. The header and trailer words labelled with **HSL** are attached by HSLB, the words with **B2L** are attached by the belle2link component, and the words with FEE are those written into the belle2link component by the frontend firmware.*

NOTICE :
To produce this format, the b2tt core used in the FEE firmware should be the latest.

Please see Nakao-san's following e-mails :
[b2link_ml:0143] Belle2link version 0.01 - SVN update
And
[b2link_ml:0144] Re: Belle2link version 0.01 - SVN update .

4-2, B2link FEE header/Trailer, B2link HSLB header/Trailer in PostRawCOPPERFormat (ver. 1)

From Nakao-san's Belle2link User guide (June 10, 2014):
You can download from 18th B2GM indico page
http://kds.kek.jp/getFile.py/access?contribId=132&sessionId=28&resId=0&materialId=0&confId=15329



B2link HSLB header -> 1word

B2link FEE header -> 1word

B2link FEE trailer -> 1word

B2link HSLB trailer -> 0word

Figure 5: Data format as read out by the COPPER. The header and trailer words labelled with **HSL** *are attached by HSLB, the words with* **B2L** *are attached by the belle2link component, and the words with FEE are those written into the belle2link component by the frontend firmware.*

4-3, Older B2link header/trailer formats

At DESY test in January of 2014

From Nakao-san's B2GM slides:
http://kds.kek.jp/getFile.py/access?contribId=143&sessionId=38&resId=0&materialId=slides&confId=13911

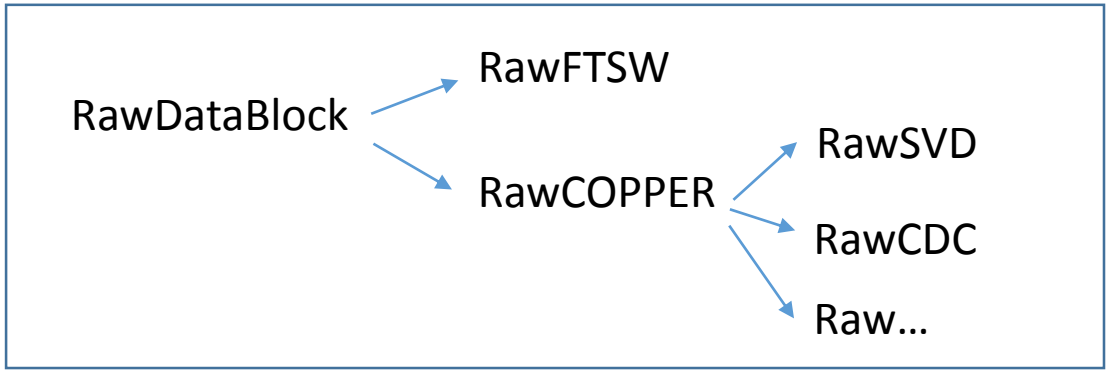
Data format (Final?)

The format used at the telescope test

```
-------------------------------------------------
HSL: 0xFFAA(16) --- B2L header  |      HSLB-tag(16)
-------------------------------------------------
B2L: '0'(1) | TT-ctime(27)              | TT-type(4)
B2L: TT-tag(32)
B2L: TT-utime(32)
B2L: TT-exprun(32)
B2L: '0' | B2L-ctime(27)         |     debug-flag(4)
-------------------------------------------------
FEE: Data #0 (32)
FEE: Data #1 (32)
FEE:    ....
FEE: Data #n (32)
-------------------------------------------------
B2L: TT-tag(16)                 |  B2L-checksum(16)
-------------------------------------------------
HSL: 0xFF55(16)                 | HSLB checksum(16)
-------------------------------------------------
```

- tag (event number) and utime to be increased to 32-bit (done), HSLB-checksum, B2L-checksum to be added

5-1, RawDataBlock object (to handle Raw data from COPPER board)



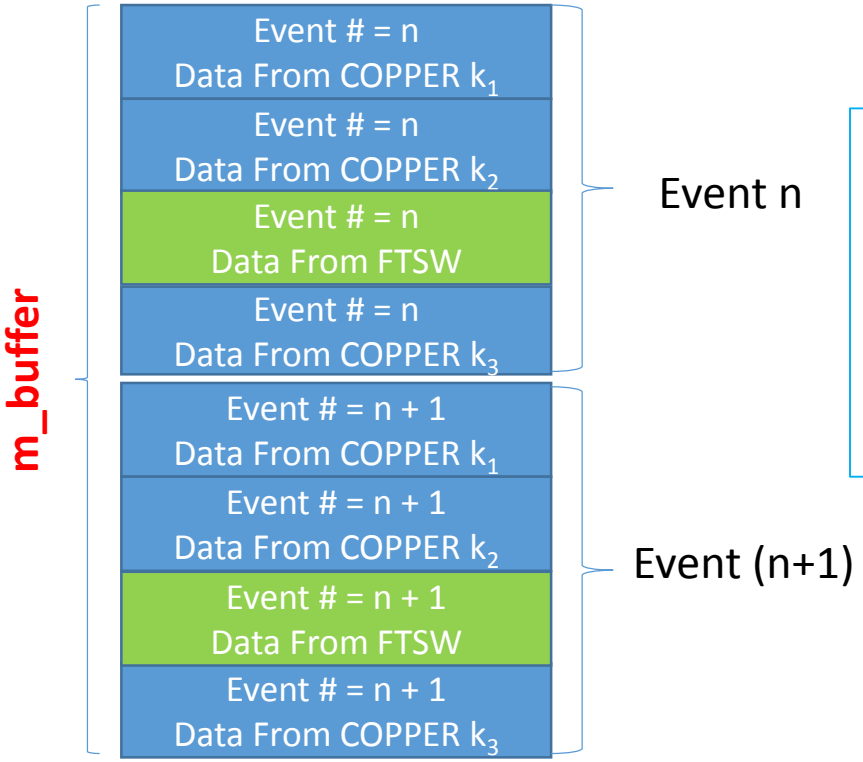
Source code :

https://belle2.cc.kek.jp/svn/trunk/software/rawdata/dataobjects/

```
RawDataBlock{
        methods to access data;
        int m_num_nodes; // # of nodes
        int m_num_events;// # of events

        int* m_buffer;  -> buffer for data
}
```

Example of data structure



In this example,
M_num_nodes = 4
M_num_events = 2.

# of data blocks = 4 * 2 = 8

5-2, RawCOPPER class select proper “format class” depending on Pre/Post formats

Data taken at the DESY beam test(old format) can be read with the latest rawdata package
-> by checking data ver. In header.

New RawCOPPER class

- No change in style of the member functions -> No effect on derived class
- Does not have a format information in itself
  - Format class contains format information
    - RawCOPPERformat.cc -> the latest format
      - RawHeader.cc
    - RawCOPPERformat_v0.cc -> an old format
      - RawHeader_v0.cc
  - Assign format class to m_access in CheckVersionSetBuffer()
  - Use m_access to access buffer contents

```
inline int RawCOPPER::GetExpNo(int n)
{
  CheckVersionSetBuffer();
  return m_access->GetExpNo(n);
}

inline int RawCOPPER::GetRunNo(int n)
{
  CheckVersionSetBuffer();
  return m_access->GetRunNo(n);
}
```

Notice :

- **RawCOPPER class supports both formats for a while (0.5-1 year after the format becomes stable?).**
  - **In that case, the latest RawCOPPER class cannot be used to read old format**
  - **Of course, you can use old rawdata repository to read old format**
  - **For ver.0 format, use rawdata repository before 11228**

6, Example : how to get information of RawCOPPER header

You can get event # info from RawCOPPER object like this;

```
StoreArray<RawCOPPER> raw_cprarray;                                  } When StoreArray is used
 for (int i = 0; i < raw_cprarray.getEntries(); i++) {
                for ( int j = 0; j < raw_cprarray[ i ].GetNumEntries(); j++) {
//              Get Event number
                        unsigned int event_no = raw_cprarray[ i ].GetEveNo( j );
//              Get RawCOPPER data block
                        int* buf = raw_cprarray[ i ].GetBuffer( j );
//              See contents of a data block (from RawCOPPER header to RawCOPPER trailer)
                        for( int k = 0; k < raw_cprarray[ i ] .GetBlockNwords( j ); k++ ){
                                printf("%d¥n", buf[ k ] );                }
//              Get Detector Buffer (raw data from detector electronics)
                        int* buf_slot_a = raw_cprarray[ i ].Get1stDetectorBuffer( j );
                        int* buf_slot_b = raw_cprarray[ i ].Get2ndDetectorBuffer( j );
                        int* buf_slot_c = raw_cprarray[ i ].Get3rdDetectorBuffer( j );
                        int* buf_slot_d = raw_cprarray[ i ].Get4thDetectorBuffer( j );
                        int* buf_slot[4]; for( int k = 0; k < 4;k++){ buf_slot[ k ] = raw_cprarray[ i ].GetDetectorBuffer(j,k) }
//              See contents of raw data from detector
                        for( int k = 0; j < raw_cprarray[ i ].Get1stDetectorNwords( j ); k++ ){
                                printf("%d¥n", buf_slot_a[ k ] );       }
                        for( int k = 0; j < raw_cprarray [ i ].Get2ndDetectorNwords( j ); k++ ){
                                printf("%d¥n", buf_slot_b[ k ] );       }
                        …..
                }
}
```

Test program to read RawCOPPER(RawCDC) data

1, Get dummy data file (data from two CDC FEE boards connected to FINESSE A and C.)
login.cc.kek.jp : ~yamadas/rawdata/root_output_RawCDC_rev7133.root

2, See contents of the data
% cd ${BELLE2_LOCAL_DIR}/daq/; svn update
% cd ${BELLE2_LOCAL_DIR}/daq/rawdata/examples/
% basf2 **ReadStoreTemplate.py** -i ./root_output_RawCDC_rev7133.root | less

```
[INFO] Steering file: ReadStoreTemplate.py
>>> basf2 Python environment set
>>> Framework object created: fw

===== DataBlock(RawCDC) : Block # 0 : Event # 0 : node ID 0x00000000 : block size 224 bytes
== Detector Buffer(FINESSE A)
0x0094c13a 0x91000001
== Detector Buffer(FINESSE C)
0x0094c13a 0x91000001

===== DataBlock(RawCDC) : Block # 1 : Event # 1 : node ID 0x00000000 : block size 224 bytes
== Detector Buffer(FINESSE A)
0x0094c23f 0xf1000001
== Detector Buffer(FINESSE C)
0x0094c23f 0xf1000001

===== DataBlock(RawCDC) : Block # 2 : Event # 2 : node ID 0x00000000 : block size 224 bytes
== Detector Buffer(FINESSE A)
0x0094c30d 0x69000001
== Detector Buffer(FINESSE C)
0x0094c30d 0x69000001
....
```

In this data,
Detector buffer contains only 2words(=8bytes) per/FINESSE/event.

Note that block # is a number used by DAQ software for handling data and not related with Event #.

rawdata class diagram on rev. 11234

Green : unchanged
Sunlight yellow : mdified
Blue : added

Arrow -> inheritance