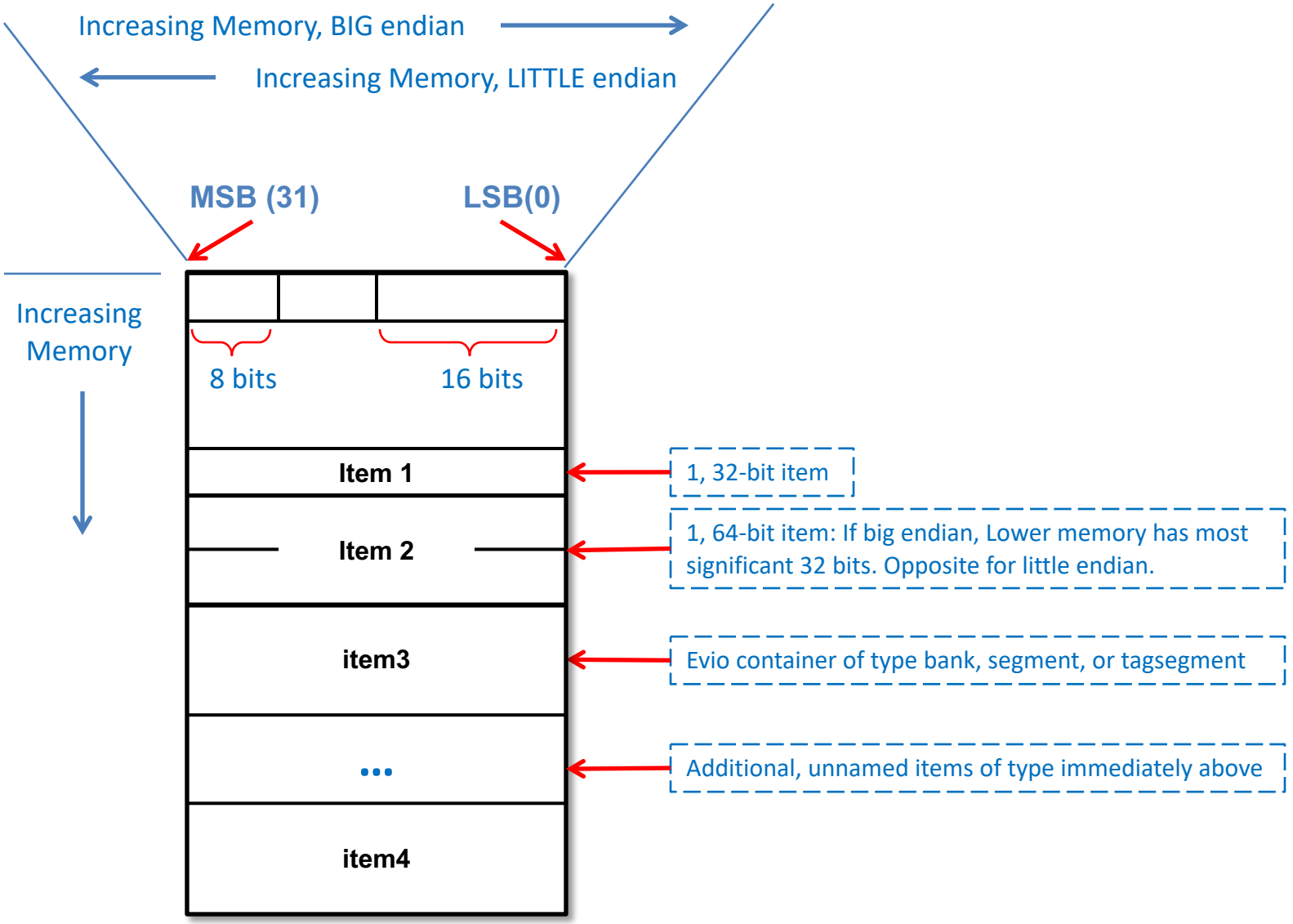
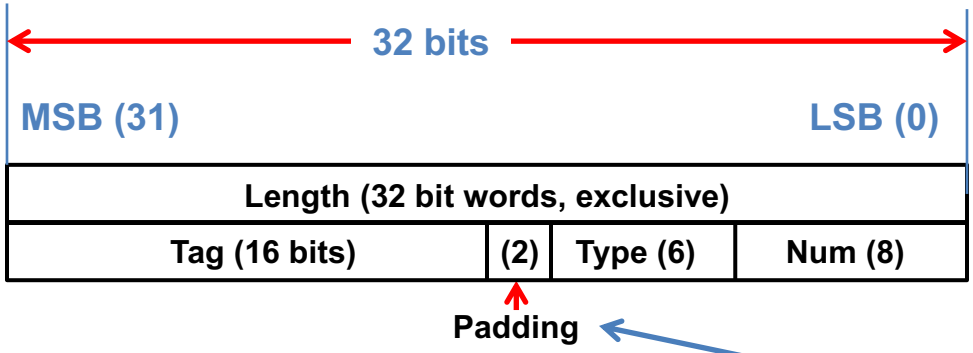
# CODA Online Data Formats

# Key to Reading Data Layouts



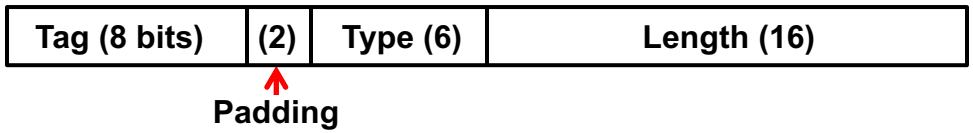
# Evio Header Formats

## Bank :

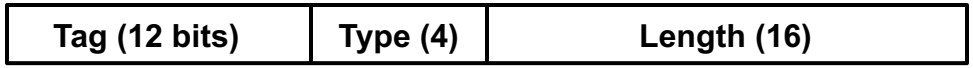



Number of unused bytes at end of following data if not a multiple of 32 bits.
For shorts, it is 0 or 2.
For chars (not strings), it is 0, 1, 2, or 3

## Segment :




## Tag Segment :



# Evio Content Type Codes

| Content Type | Primitive Data Type | Content Type | Primitive Data Type |
|---|---|---|---|
| 0x0 | 32 bit unknown (not swapped) | 0x21 | Hollerit (Composite data internal) |
| 0x1 | 32 bit unsigned int | 0x22 | N value (32 bit int, Composite data internal) |
| 0x2 | 32 bit float | 0x23 | n value (16 bit int, Composite data internal) |
| 0x3 | 8 bit char* (string) | 0x24 | m value (8 bit int, Composite data internal) |
| 0x4 | 16 bit signed int | | |
| 0x5 | 16 bit unsigned int | | |
| 0x6 | 8 bit signed int | | |
| 0x7 | 8 bit unsigned int | | |
| 0x8 | 64 bit double | | |
| 0x9 | 64 bit signed int | | |
| 0xa | 64 bit unsigned int | | |
| 0xb | 32 bit signed int | | |
| 0xc | Tag Segment | | |
| 0xd | Segment | | |
| 0xe | Bank | | |
| 0xf | Composite | | |
| 0x10 | Bank | | |
| 0x20 | Segment | | |

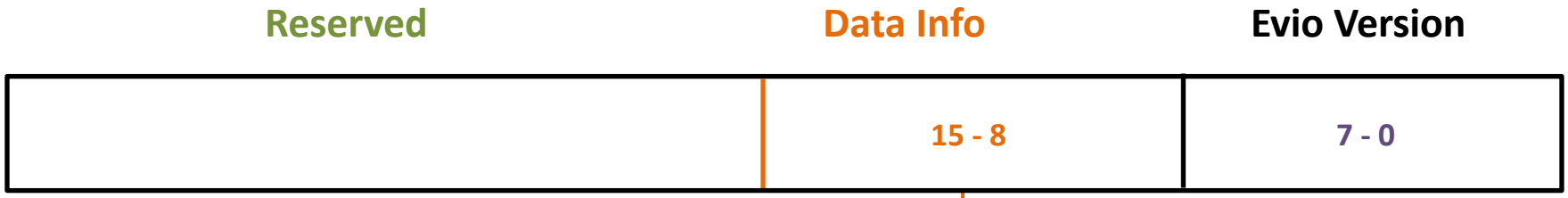
# Block Header (evio format versions 1-3)

| | | |
|---|---|---|
| 1 | Block Length | Length of block in 32-bit words, inclusive |
| 2 | Block Number | Record id starting at 0 |
| 3 | Header Length | Length of block header in 32-bit words (8) |
| 4 | Start | Offset in words to first event header in block relative to start of block |
| 5 | End | Number of valid words in block (header + data). Same as block length except for the last block. |
| 6 | Version | Evio format version |
| 7 | Reserved | Reserved |
| 8 | Magic Number | Number for endianness tracking (0xc0da0100) |

# Block Header (evio format version 4)

| | | | |
|---|---|---|---|
| 1 | Block Length | | Length of block in 32-bit words, inclusive |
| 2 | Block Number | | Order of block in network transfer (record id) starting at 1. From ROC: -1 if payload banks not being built. |
| 3 | Header Length | | Length of block header in 32-bit words (8) |
| 4 | Event Count | | Number of evio events (payload banks) in block, not including dictionary. |
| 5 | Reserved 1 | | If content is being built (eg ROC Raw type), = source CODA id, else reserved |
| 6 | Bit Info | Version | Evio format version in low 8 bits. Bit Info in high 24 bits See next slide. |
| 7 | Reserved 2 | | Reserved |
| 8 | Magic Number | | Number for endianness tracking (0xc0da0100) |

# Block Header, Bit Info / Version Word

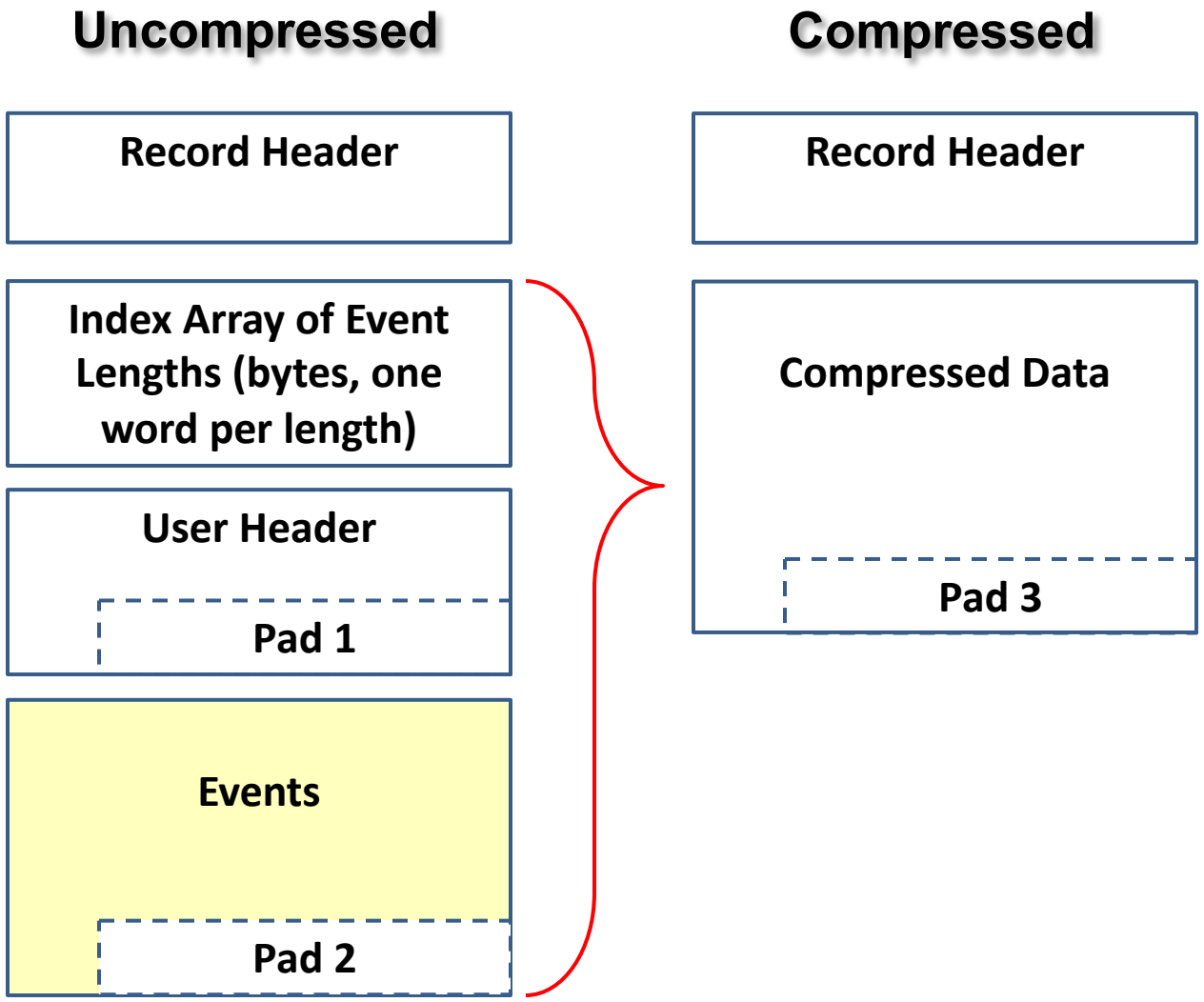



| BIT | FUNCTION (if bit set) |
|---|---|
| 8 | Dictionary exists |
| 9 | Is last record in stream or file |
| 10-13 | Data content type for CODA online only: ROC Raw = 0, Physics = 1, Partial Physics = 2, Disentangled = 3, User = 4, Control = 5, Mixed = 6, Other = 15 |
| 14 | Has ”first event” (in every split file) which is first USER type event in this block |
| 15 | Streaming data (not triggered) |
| 16-31 | Reserved |

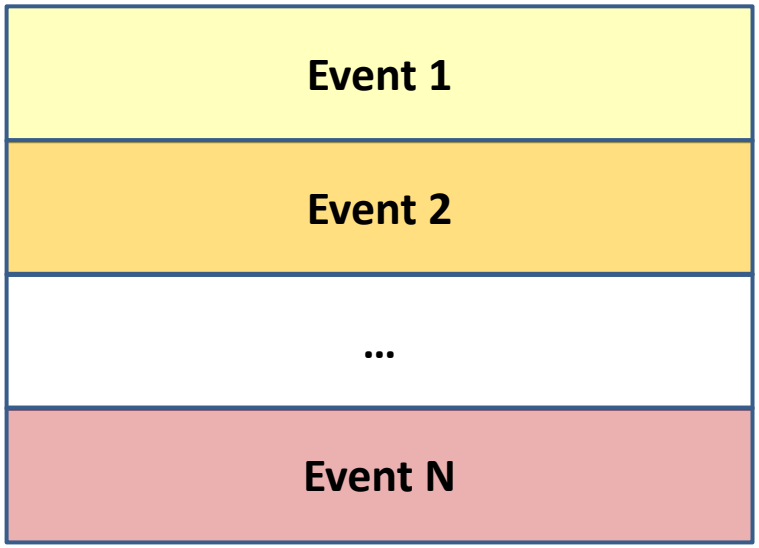
NOTE: User events from ROC are typed as ROC Raw (EB handles this).

# HIPO/EVIO FORMAT VERSION 6

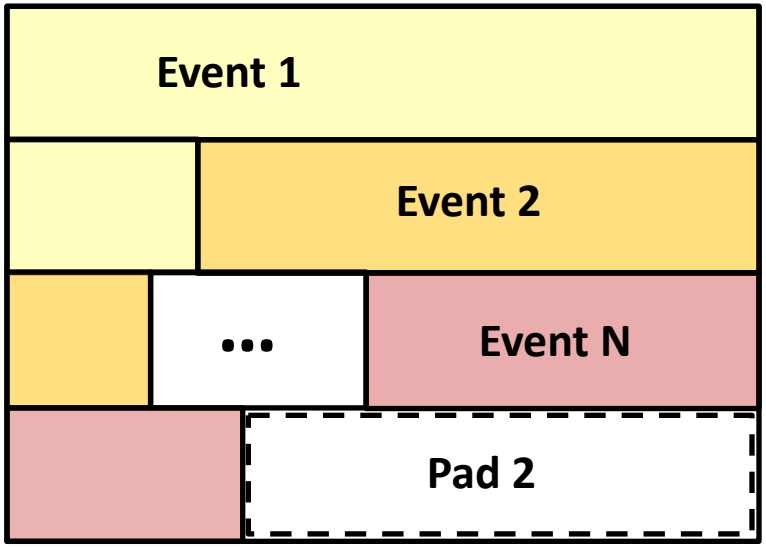
# Record


Uncompressed
Compressed
Record Header
Index Array of Event Lengths (bytes, one word per length)
User Header
Pad 1
Events
Pad 2
Record Header
Compressed Data
Pad 3

## Evio Events




## HIPO Events



# File Trailer

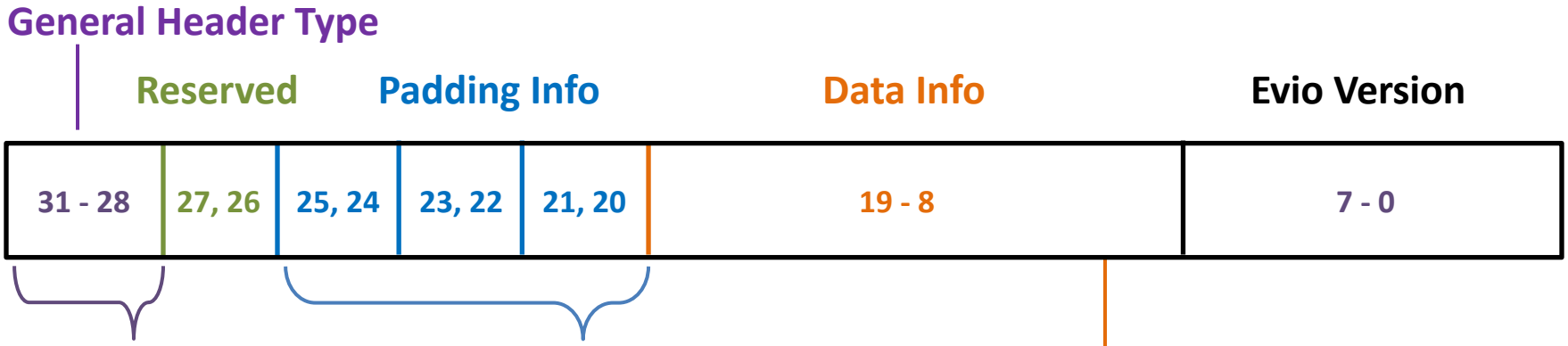
Record Header

Optional Uncompressed Array:
record length in bytes,
followed by its event count
(2 words / record)
(all records except this trailer)

# Record Header

| | | | |
|---|---|---|---|
| 1 | Record Length | | Length of record in 32-bit words, inclusive |
| 2 | Record Number | | Record id from 1. From ROC: -1 if payload banks not being built |
| 3 | Header Length | | Length of this header in 32-bit words (always 14) |
| 4 | Event Index Count | | Number of events contained (Evio: not including dictionary). Same as index array length in 32-bit words if array exists. |
| 5 | Index Array Length | | Length of index array in bytes. Each array word is an event length in bytes. |
| 6 | Bit Info | Version | Evio format version in low 8 bits. Bit Info in high 24 bits |
| 7 | User Header Length | | Optional user header length in bytes |
| 8 | Magic Number | | Number for endianness tracking (0xc0da0100) |
| 9 | Uncompressed Data Length | | Length of uncompressed record, without this header, in bytes |
| 10 | Type | Compressed Data Length | Compression type in high 4 bits (0=none, 1 = LZ4, 2 = LZ4 Best, 3 = GZIP). Length of compressed data in 32-bit words (low 28 bits). |
| 11<br>12 | User Register 1 | | User defined long word (64 bits) |
| 13<br>14 | User Register 2 | | User defined long word (64 bits) |

# File/Record Headers, Bit Info / Version Word




| Value | Header Type |
|---|---|
| 0 | Evio record |
| 1 | Evio file |
| 2 | Evio extended file |
| 3 | Evio file trailer |
| 4 | HIPO record |
| 5 | HIPO file |
| 6 | HIPO extended file |
| 7 | HIPO file trailer |

| Bits | Padding |
|---|---|
| 25-24 | Pad 3 |
| 23-22 | Pad 2 |
| 21-20 | Pad 1 |

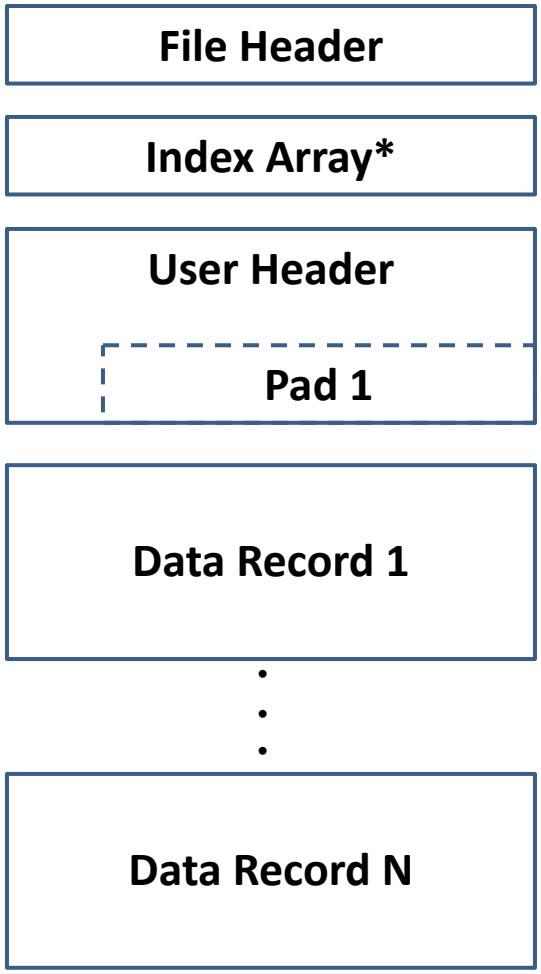
Bit uses depend on header type

# Data Info Bits for Headers

| BIT (from 0) | FILE HEADER (if bit on) |
|---|---|
| 8 | Dictionary exists |
| 9 | Has “first event” (in every split file) |
| 10 | File trailer with index array exists |
| 11-19 | Reserved |

| BIT (from 0) | RECORD HEADER (if bit on) |
|---|---|
| 8 | Dictionary exists (first record only) |
| 9 | Has “first event” (first record only, in every split file) |
| 10 | Is last record in stream or file |
| 11-14 | Data content type for CODA online only: ROC Raw = 0, Physics = 1, Partial Physics = 2, Disentangled = 3, User = 4, Control = 5, Mixed = 6, ROC Raw Streaming = 8, Physics streaming = 9, Other = 15 |
| 16-19 | Reserved |

# File




* Same format as file trailer index:
1 word of record length in bytes,
followed by 1word of event count

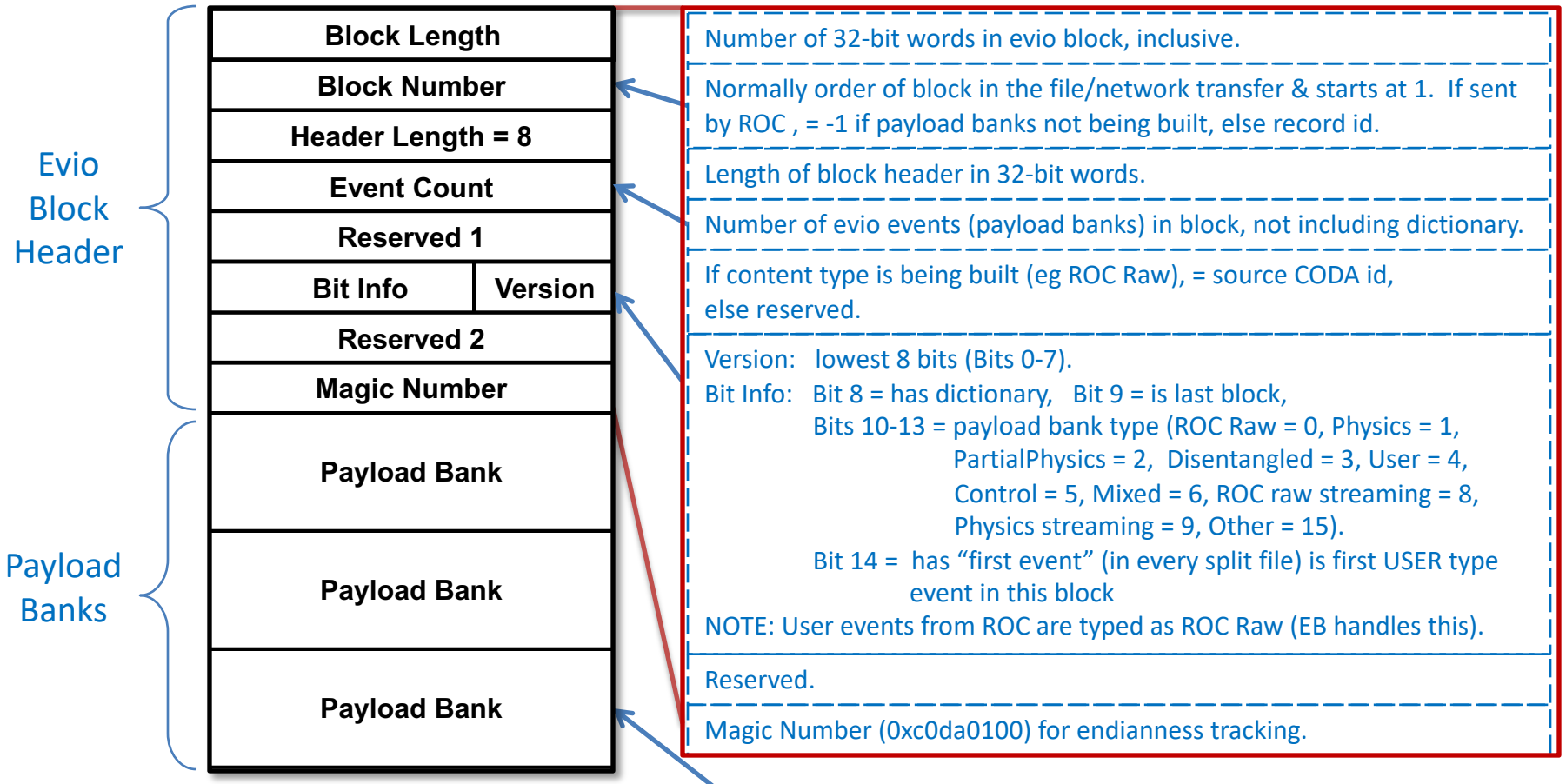
# File Header

| | | | |
|---|---|---|---|
| 1 | ID | | Identification word. For Evio = 0x4556494F (EVIO in ascii).<br>For HIPO = 0x43455248 (CERH in ascii). |
| 2 | File Number | | If file being split, the split number (starting at 1) |
| 3 | Header Length | | Length of this header in 32-bit words (always 14) |
| 4 | Record Count | | Number of records contained. Same as index array length in 32-bit words if array exists. |
| 5 | Index Array Length | | Length of index array in bytes |
| 6 | Bit Info | Version | Evio format version in low 8 bits. Bit Info in high 24 bits |
| 7 | User Header Length | | Optional user header length in bytes |
| 8 | Magic Number | | Number for endianness tracking (0xc0da0100) |
| 9<br>10 | User Register | | 64 bit register available for user |
| 11<br>12 | Trailer Position | | Number of bytes from beginning of file to beginning of trailer (ending general record header). Value of 0 means either no trailer exists or its position is unavailable |
| 13 | User Integer 1 | | Integer available for user |
| 14 | User Integer 2 | | Integer available for user |

# EXTENDED File Header (Differences)

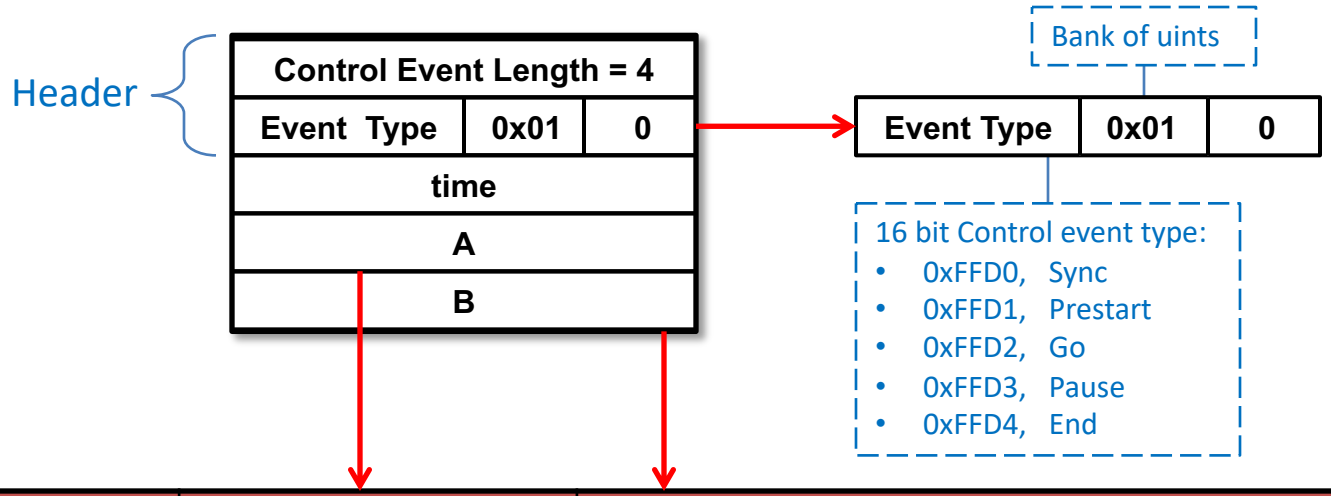
| | | |
|---|---|---|
| 3 | Header Length | Length of this header in 32-bit words GREATER THAN 14 |
| 15 + | User Integers 3+ | Additional integers available for user beyond the regular general file header. |

# Network Transfer (Evio Output) Format




Format used when sending all types of online CODA data over the network. They are in standard evio buffer/file output format with block headers.

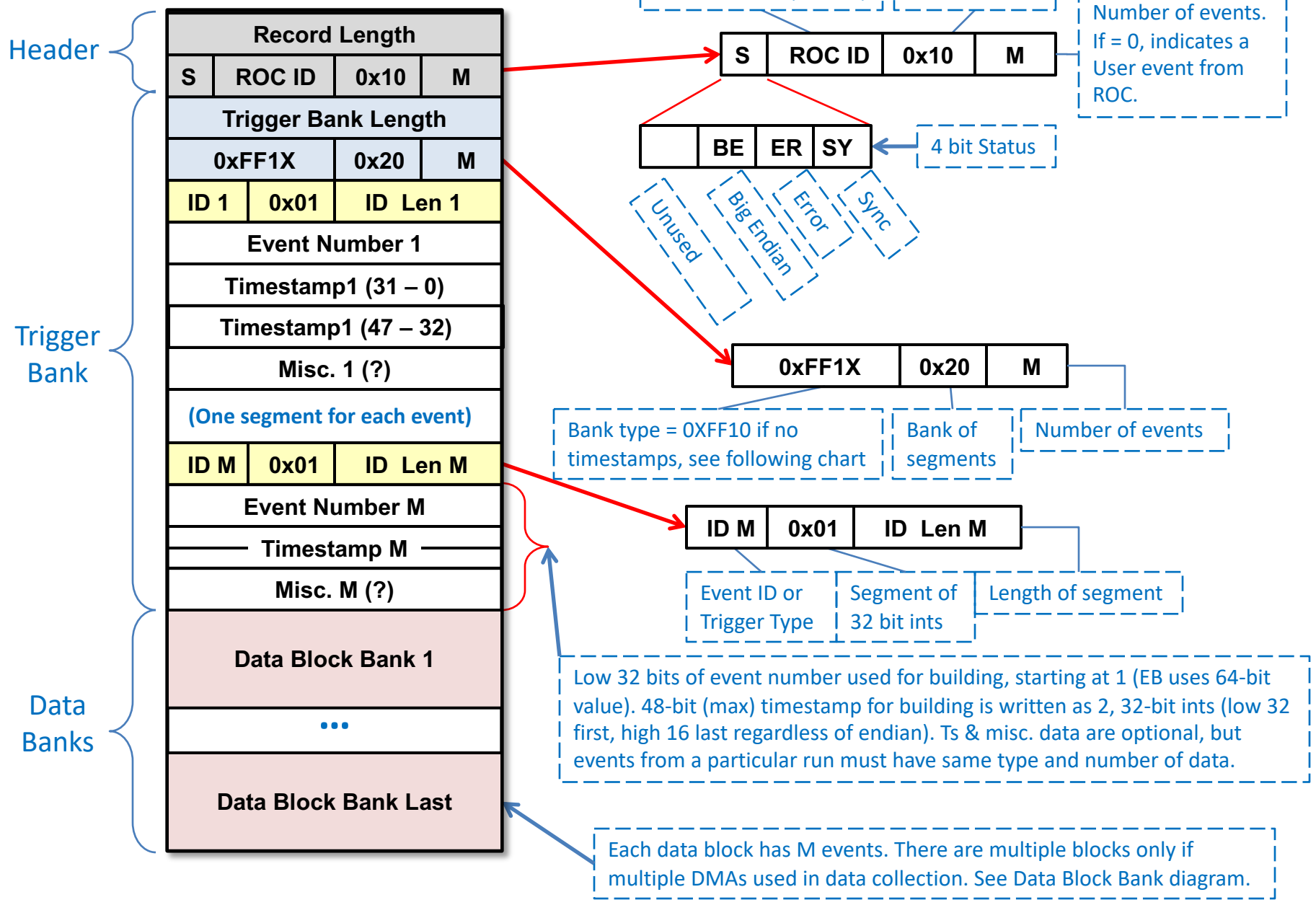
# Control Event

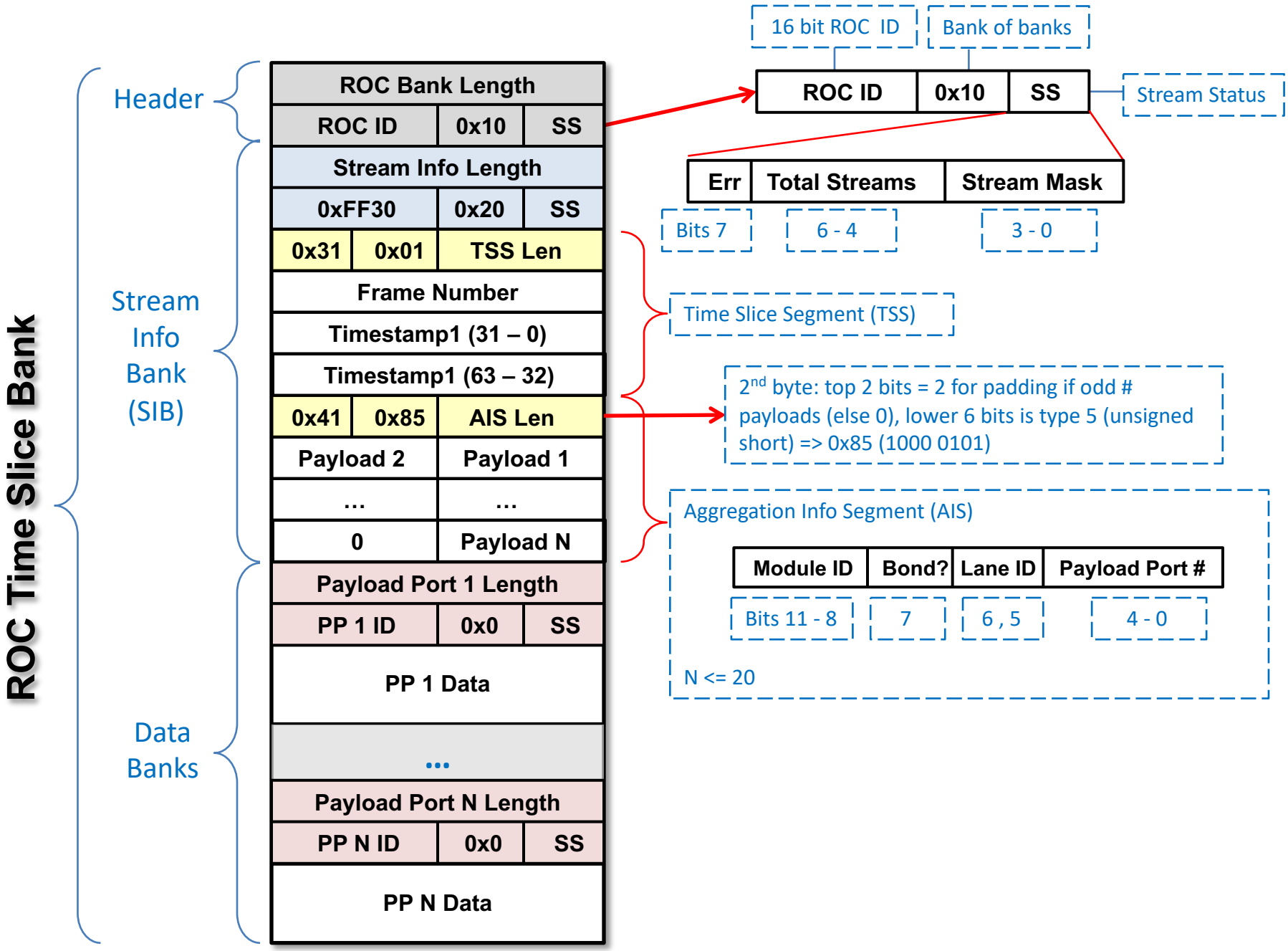



| Event Type | A | B |
|---|---|---|
| Sync | # events since last sync | # events in run |
| Prestart | run number | run type |
| Go | (reserved) | # events (or frames if streaming) in run so far* |
| Pause | (reserved) | # events (or frames if streaming) in run so far* |
| End | (reserved) | # events (or frames if streaming) in run so far* |

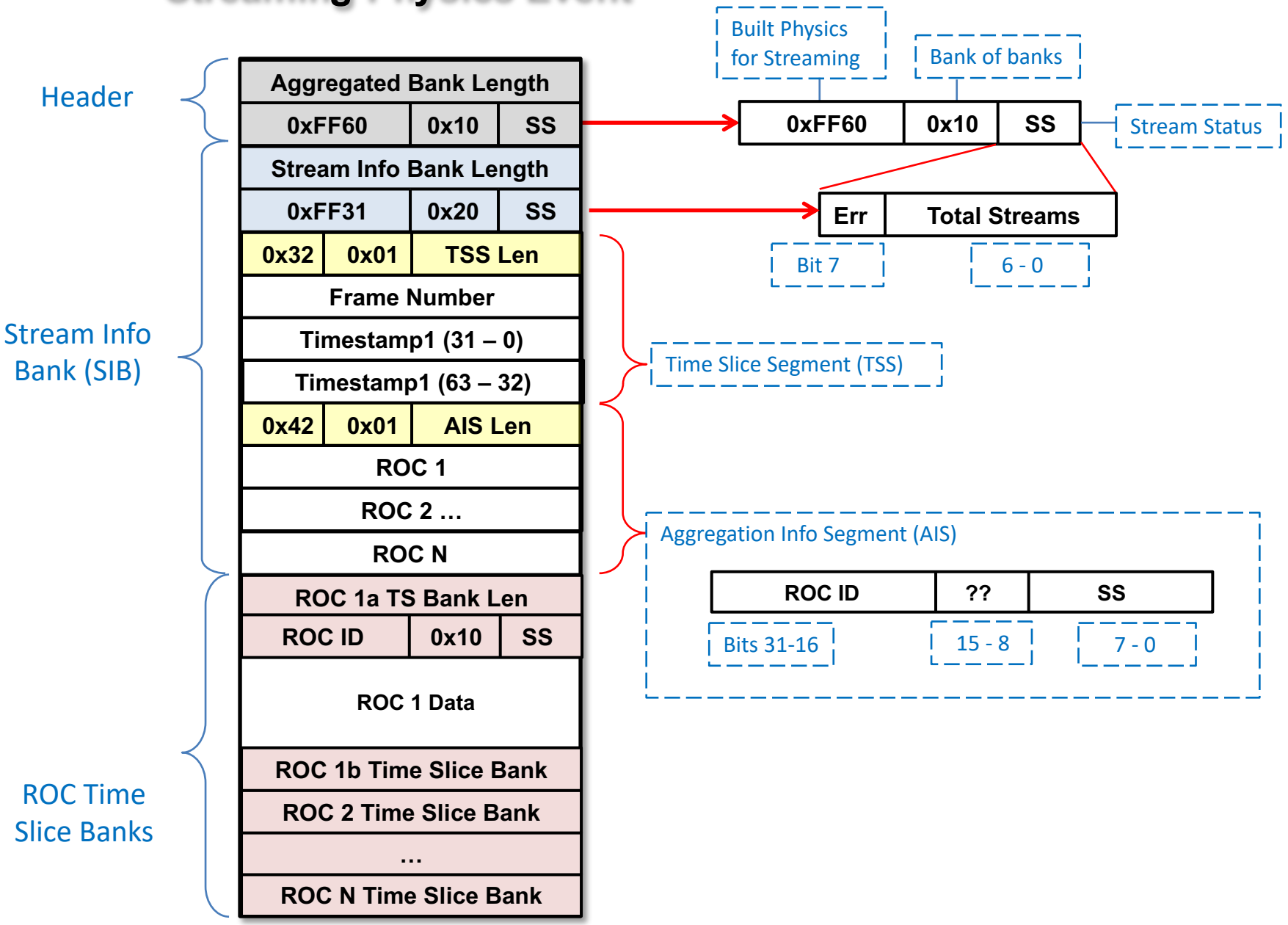
*Control events included in event count but not in frame count

# ROC Raw Data Record

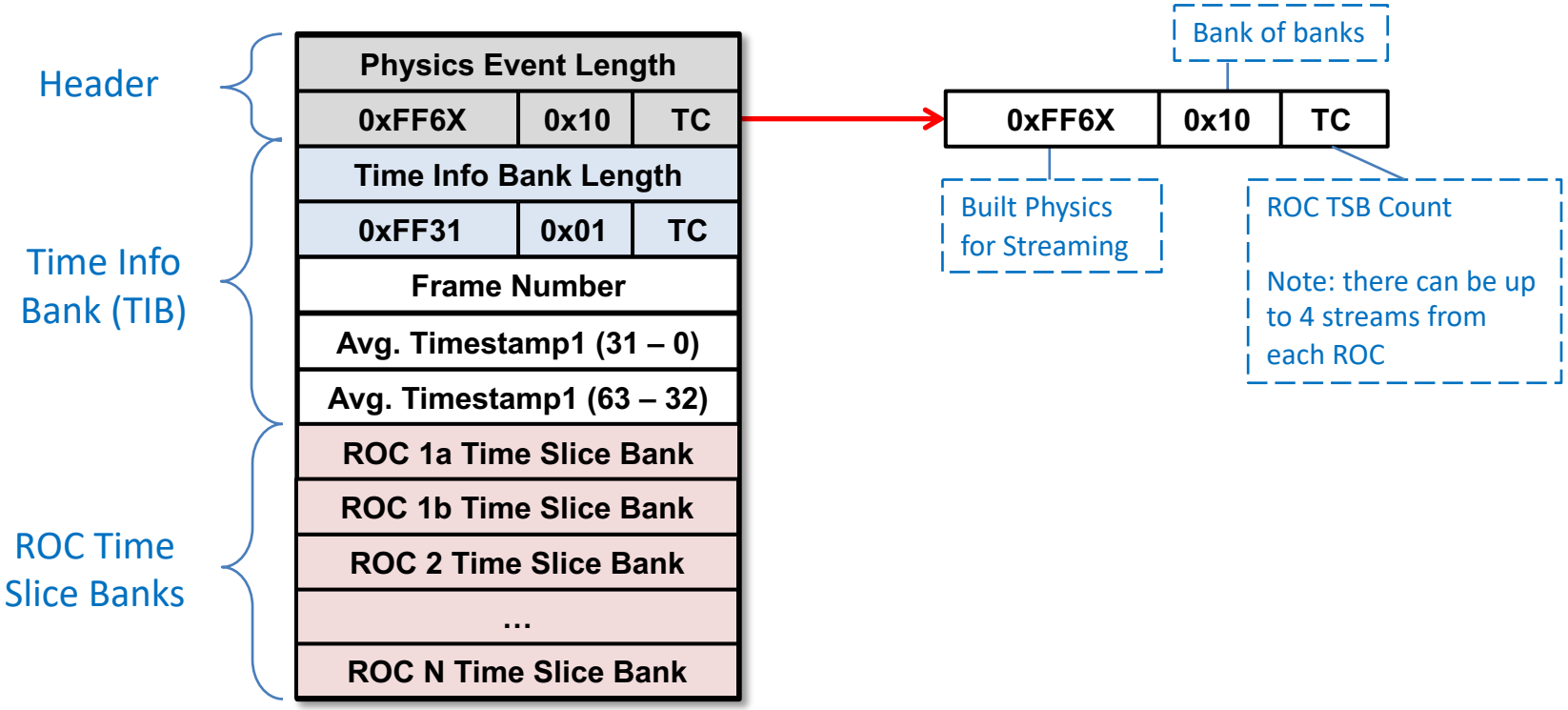



ROC Time Slice Bank
Header
Stream Info Bank (SIB)
Data Banks
ROC Bank Length
ROC ID
0x10
SS
Stream Info Length
0xFF30
0x20
SS
0x31
0x01
TSS Len
Frame Number
Timestamp1 (31 – 0)
Timestamp1 (63 – 32)
0x41
0x85
AIS Len
Payload 2
Payload 1
…
…
0
Payload N
Payload Port 1 Length
PP 1 ID
0x0
SS
PP 1 Data
…
Payload Port N Length
PP N ID
0x0
SS
PP N Data
16 bit ROC ID
Bank of banks
ROC ID
0x10
SS
Stream Status
Err
Total Streams
Stream Mask
Bits 7
6 - 4
3 - 0
Time Slice Segment (TSS)
2nd byte: top 2 bits = 2 for padding if odd # payloads (else 0), lower 6 bits is type 5 (unsigned short) => 0x85 (1000 0101)
Aggregation Info Segment (AIS)
Module ID
Bond?
Lane ID
Payload Port #
Bits 11 - 8
7
6 , 5
4 - 0
N <= 20

# Streaming Physics Event



# Streaming Physics Event (OLD)



# TRIGGER BANK TAGS

| Tag Value | Purpose |
|---|---|
| 0xFF10 | Raw trigger, no timestamps |
| 0xFF11 | Raw trigger, w/ timestamps |
| 0xFF20 | Built trigger, **no** timestamps, **no** run # & run type, includes run specific data |
| 0xFF21 | Built trigger, w/ timestamps, but **no** run # & run type, includes run specific data |
| 0xFF22 | Built trigger w/ run # & run type, but **no** timestamps, includes run specific data |
| 0xFF23 | Built trigger with timestamps and run # & run type, includes run specific data |
| 0xFF24 | Built trigger, **no** timestamps, **no** run # & run type, **no** run specific data |
| 0xFF25 | Built trigger, w/ timestamps, but **no** run # & run type, **no** run specific data |
| 0xFF26 | Built trigger w/ run # & run type, but **no** timestamps, **no** run specific data |
| 0xFF27 | Built trigger with timestamps and run # & run type, **no** run specific data |
| 0xFF4F | Built trigger using at least one ROC with bad or nonexistent trigger bank |

# PHYSICS EVENT TAGS

| Tag Value | Purpose |
|---|---|
| 0xFF50 | Event built by primary event builder |
| 0xFF58 | Event built by primary event builder with sync bit set |
| 0xFF70 | Event built by secondary event builder |
| 0xFF78 | Event built by secondary event builder with sync bit set |

# STREAMING TAGS

| Tag Value | Purpose |
|---|---|
| 0xFF30 | Stream Info Bank (SIB) containing frame # followed by timestamp |
| 0xFF31 | Time Info Bank (TIB) containing frame # followed by timestamp |
| 0xFF32 | Time Info Bank (TIB) containing frame # followed by timestamp with non-fatal error |
| 0x31 | Time Slice Segment (TSS) containing frame # followed by timestamp |
| 0x41 | Aggregation Info Segment (AIS) |
| 0xFF60 | Built from ROC Raw Data streamed from ROC / VTP |
| 0xFF61 | Built from ROC Raw Data streamed from ROC / VTP with non-fatal error |
| 0xFF62 | ***Possibly:*** event built by DC event builder in streaming mode |
| 0xFF64 | ***Possibly:*** event built by secondary event builder in streaming mode |
| 0xFF66 | ***Possibly:*** event built by primary event builder in streaming mode |

## CODA RESERVED BANK TAGS

| Tag Value Range | Purpose |
|---|---|
| 0xFF00 - 0xFFFF | Complete range of reserved values |
| 0xFFE0 - 0xFFFF | Undetermined |
| 0xFFD0 - 0xFFDF | Control events |
| 0xFF90 - 0xFFCF | Undetermined |
| 0xFF50 - 0xFF8F | Physics events |
| 0xFF10 - 0xFF4F | Trigger banks |
| 0xFF00 - 0xFF0F | Undetermined |

## CONTROL EVENT TAGS

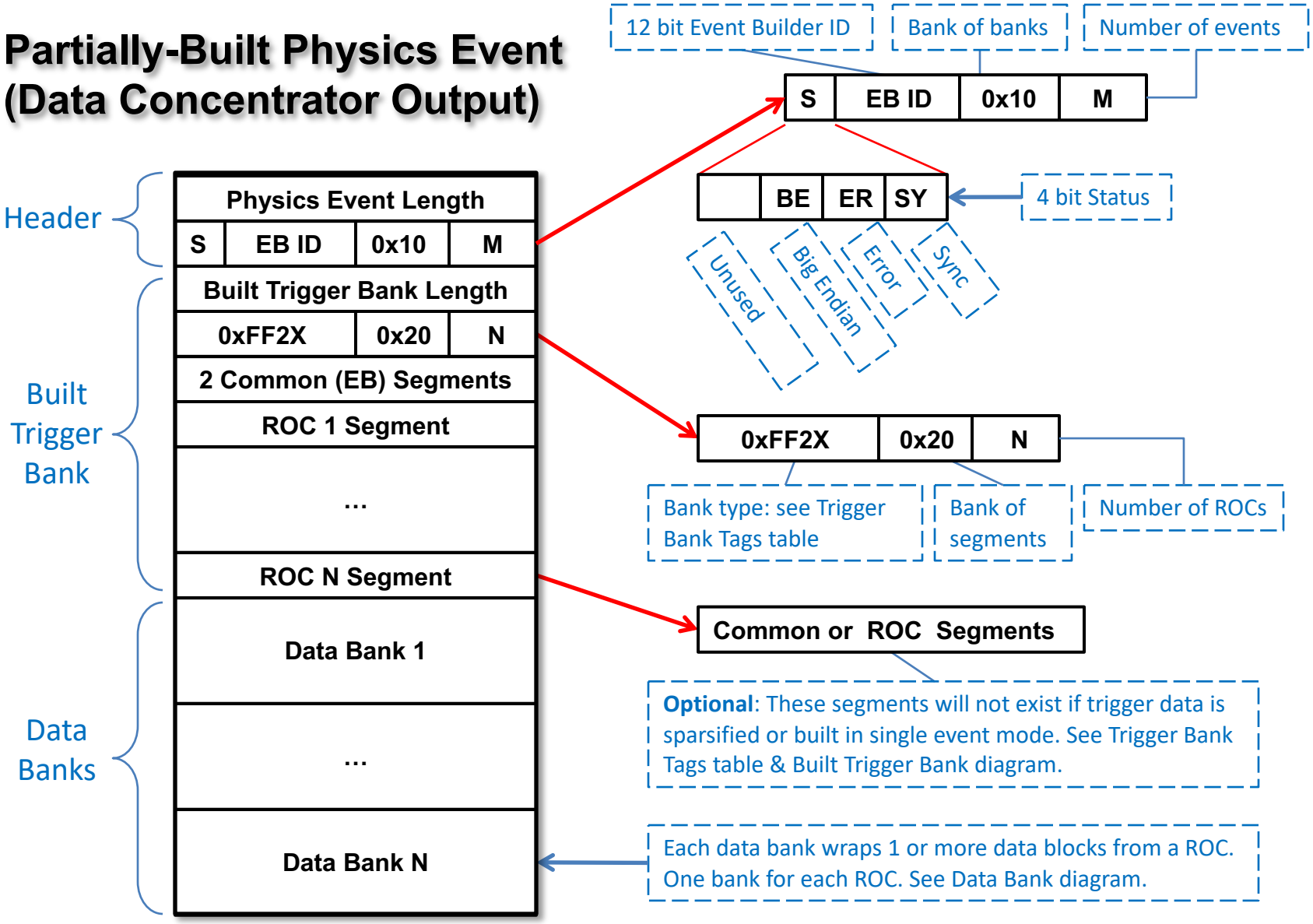
| Tag Value | Control Event |
|---|---|
| 0xFFD0 | Sync |
| 0xFFD1 | Prestart |
| 0xFFD2 | Go |
| 0xFFD3 | Pause |
| 0xFFD4 | End |

## PHYSICS EVENT TAGS

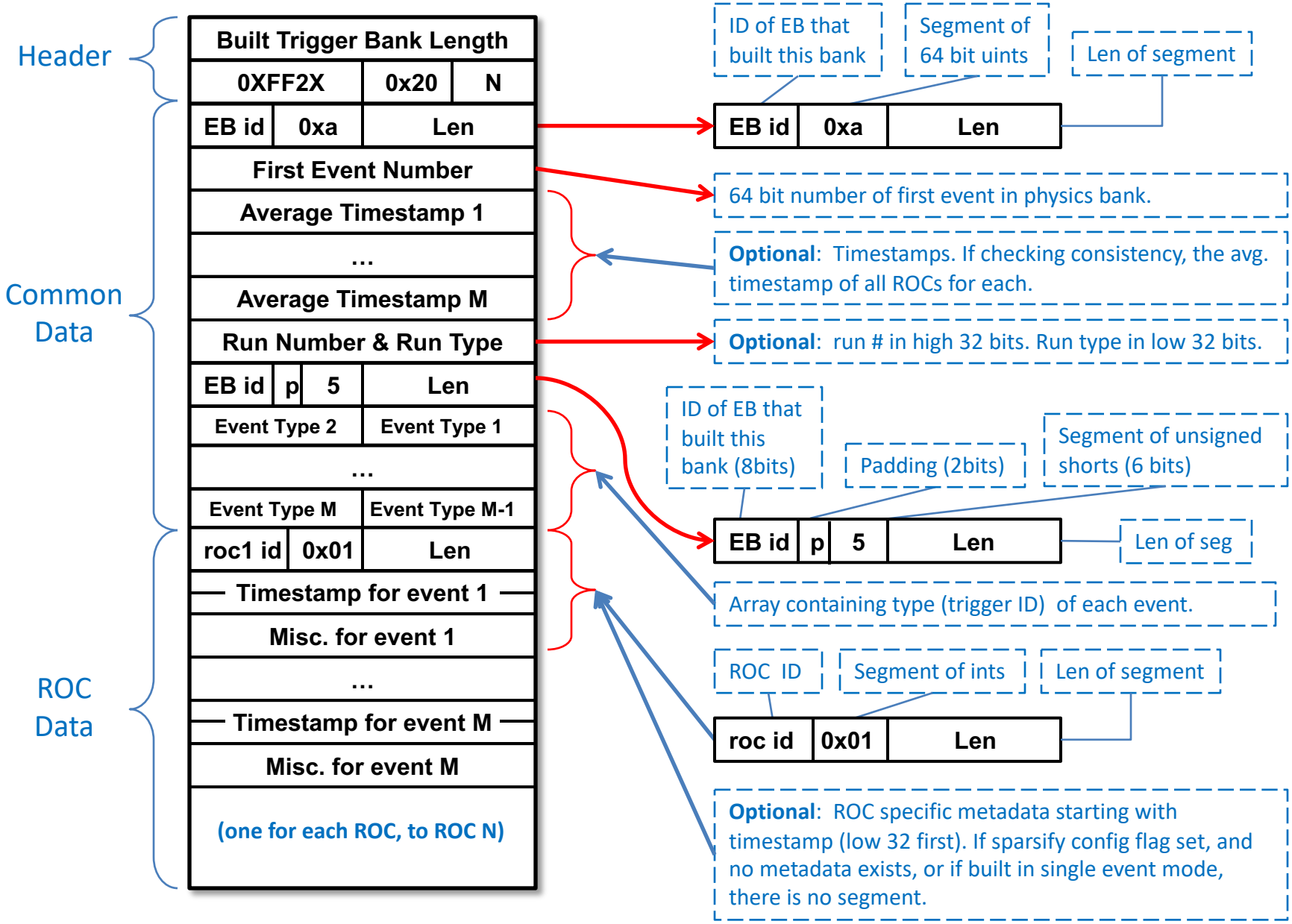
| Tag Value | Event Made by |
|---|---|
| 0xFF50 | PEB |
| 0xFF58 | PEB with sync set |
| 0xFF70 | SEB |
| 0xFF78 | SEB with sync set |
| 0xFF60 | Streaming ROC Raw |
| 0xFF62 | Streaming DC |
| 0xFF64 | Streaming SEB |
| 0xFF66 | Streaming PEB |

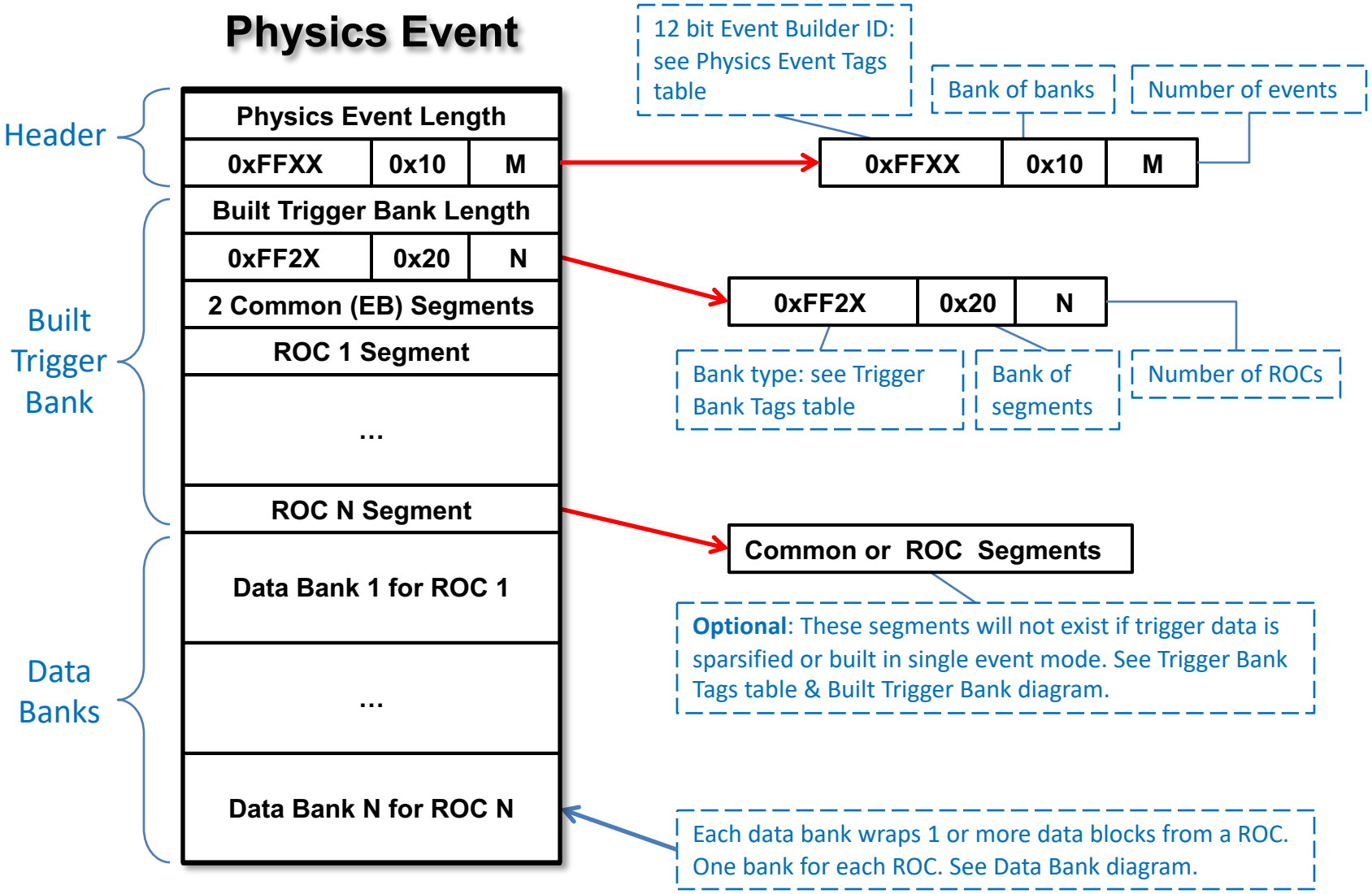
$4^{th}$ bit set indicates that the last event in the entangled block is a sync event

# Partially-Built Physics Event (Data Concentrator Output)

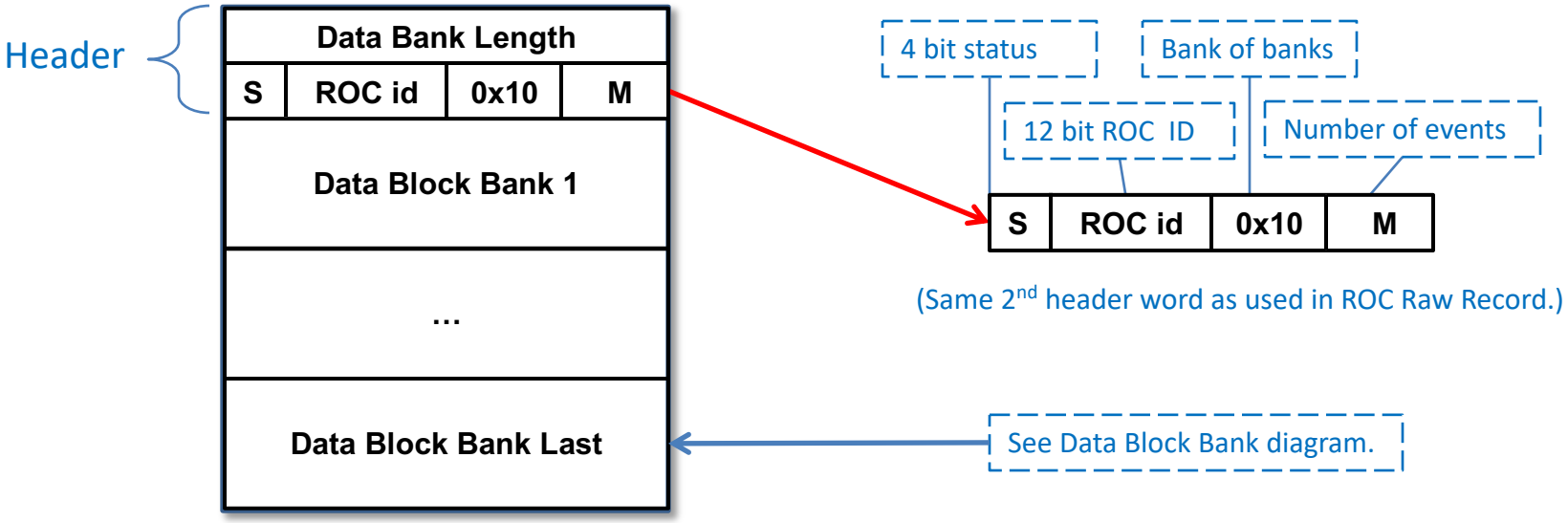


# Physics Event's Built Trigger Bank

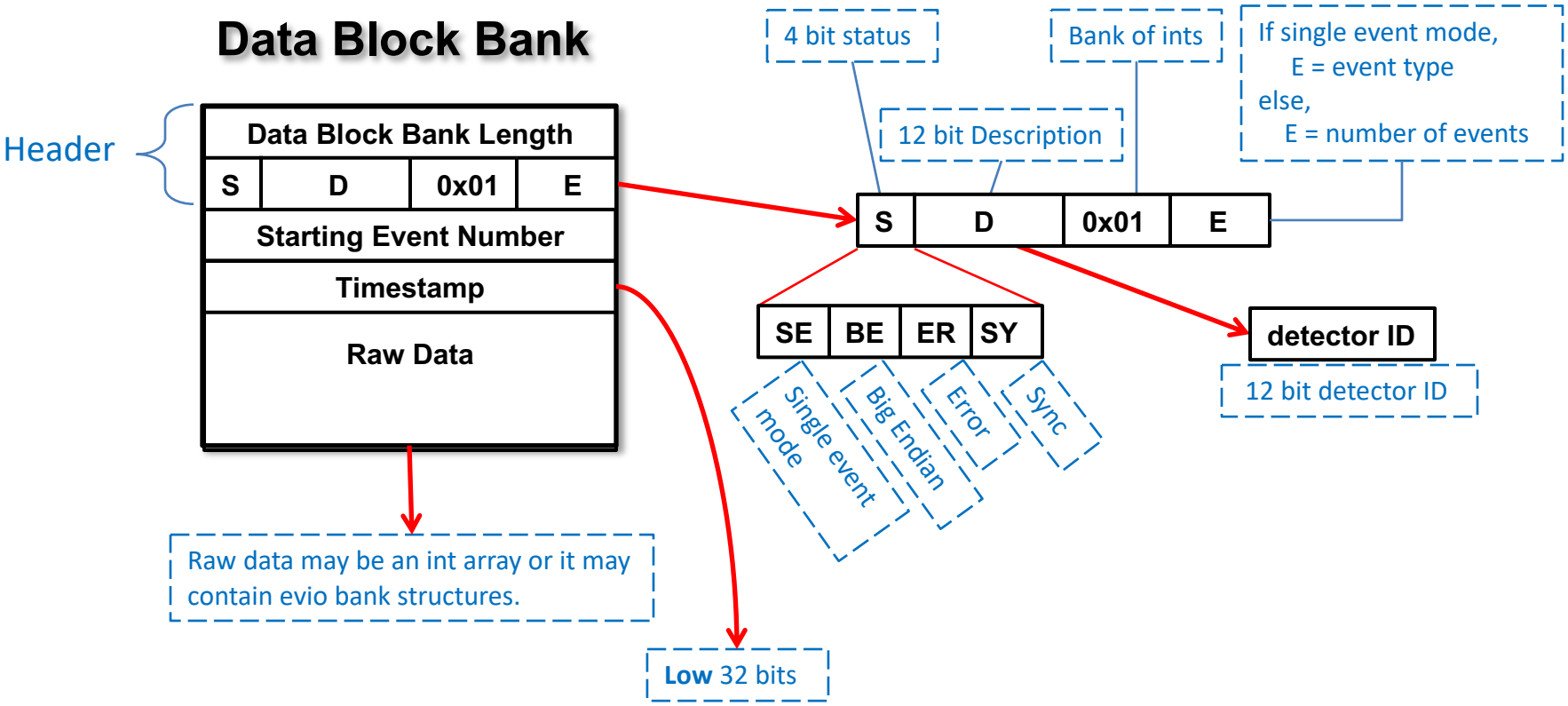



Physics Event
Header
Built Trigger Bank
Data Banks
Physics Event Length
0xFFXX
0x10
M
Built Trigger Bank Length
0xFF2X
0x20
N
2 Common (EB) Segments
ROC 1 Segment
...
ROC N Segment
Data Bank 1 for ROC 1
...
Data Bank N for ROC N
12 bit Event Builder ID: see Physics Event Tags table
Bank of banks
Number of events
0xFFXX
0x10
M
0xFF2X
0x20
N
Bank type: see Trigger Bank Tags table
Bank of segments
Number of ROCs
Common or ROC Segments
Optional: These segments will not exist if trigger data is sparsified or built in single event mode. See Trigger Bank Tags table & Built Trigger Bank diagram.
Each data bank wraps 1 or more data blocks from a ROC. One bank for each ROC. See Data Bank diagram.

# Physics Event's Data Bank

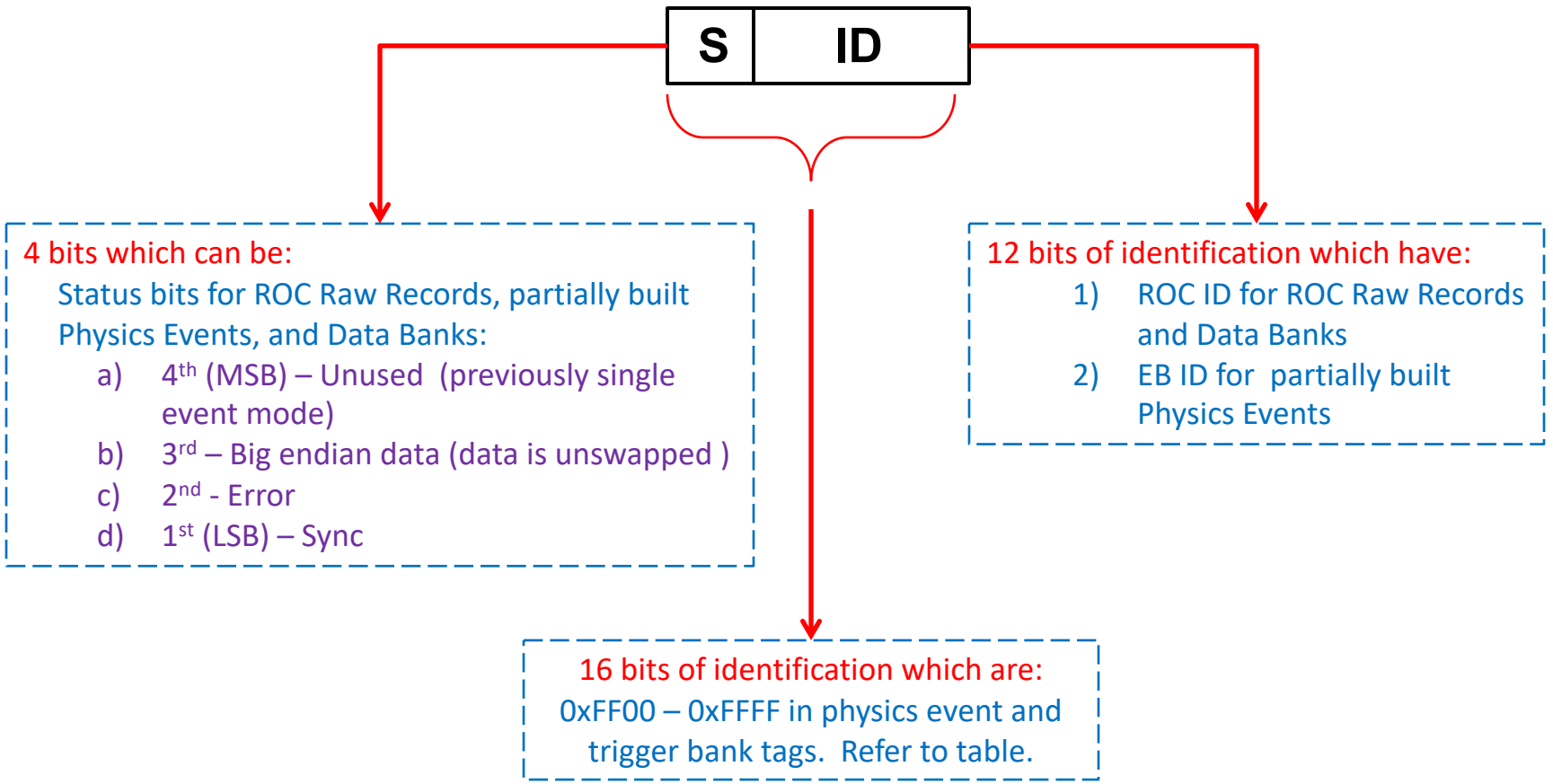



Data blocks from a single ROC are wrapped in this data bank. There should be at least one data block and there may be more if more than one DMA is used in acquiring data for this ROC. If more than one block, each contains a fragment for every one of the M events and from unique modules. In addition, the last block may have data associated only with the last event (such as scalar data).

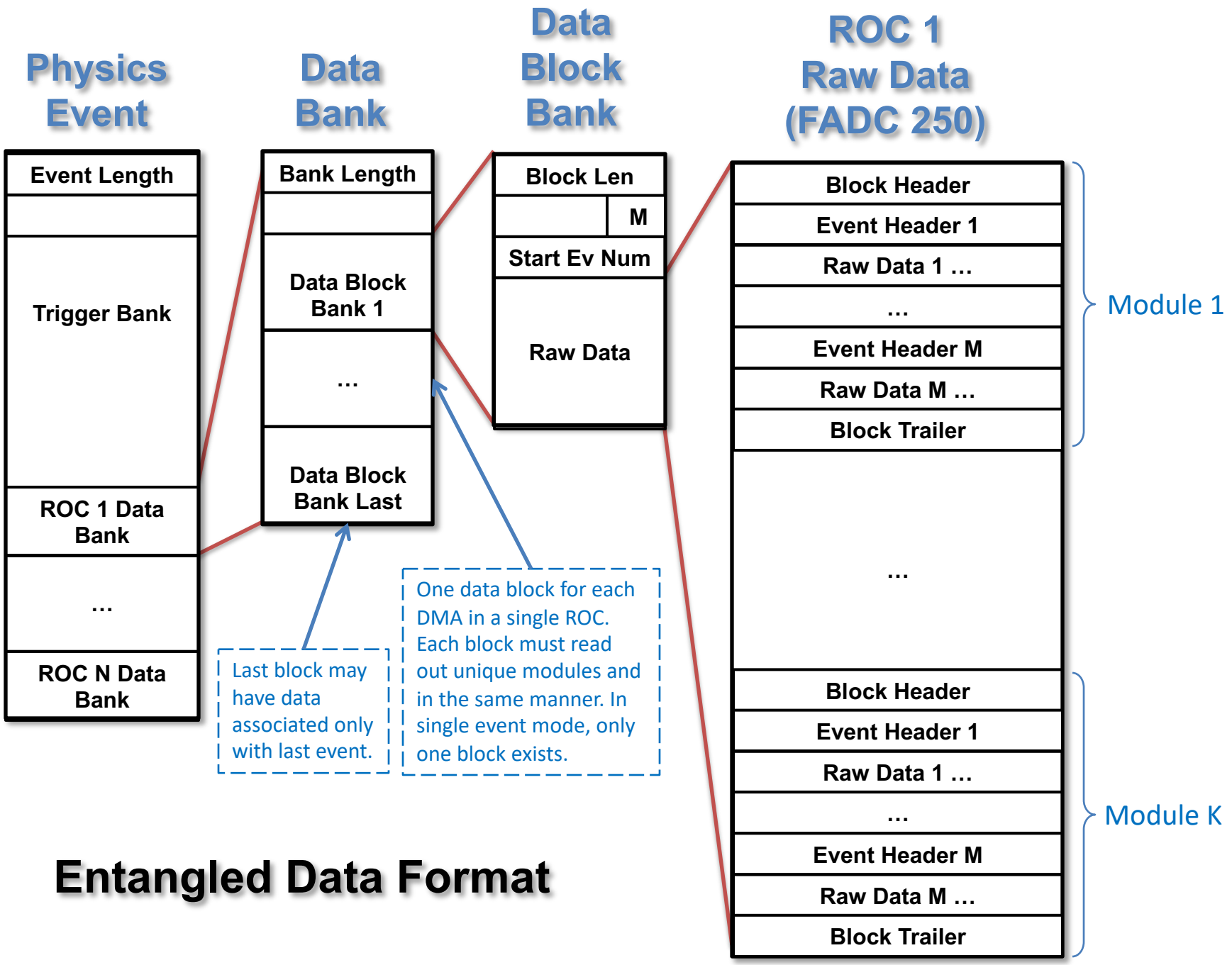


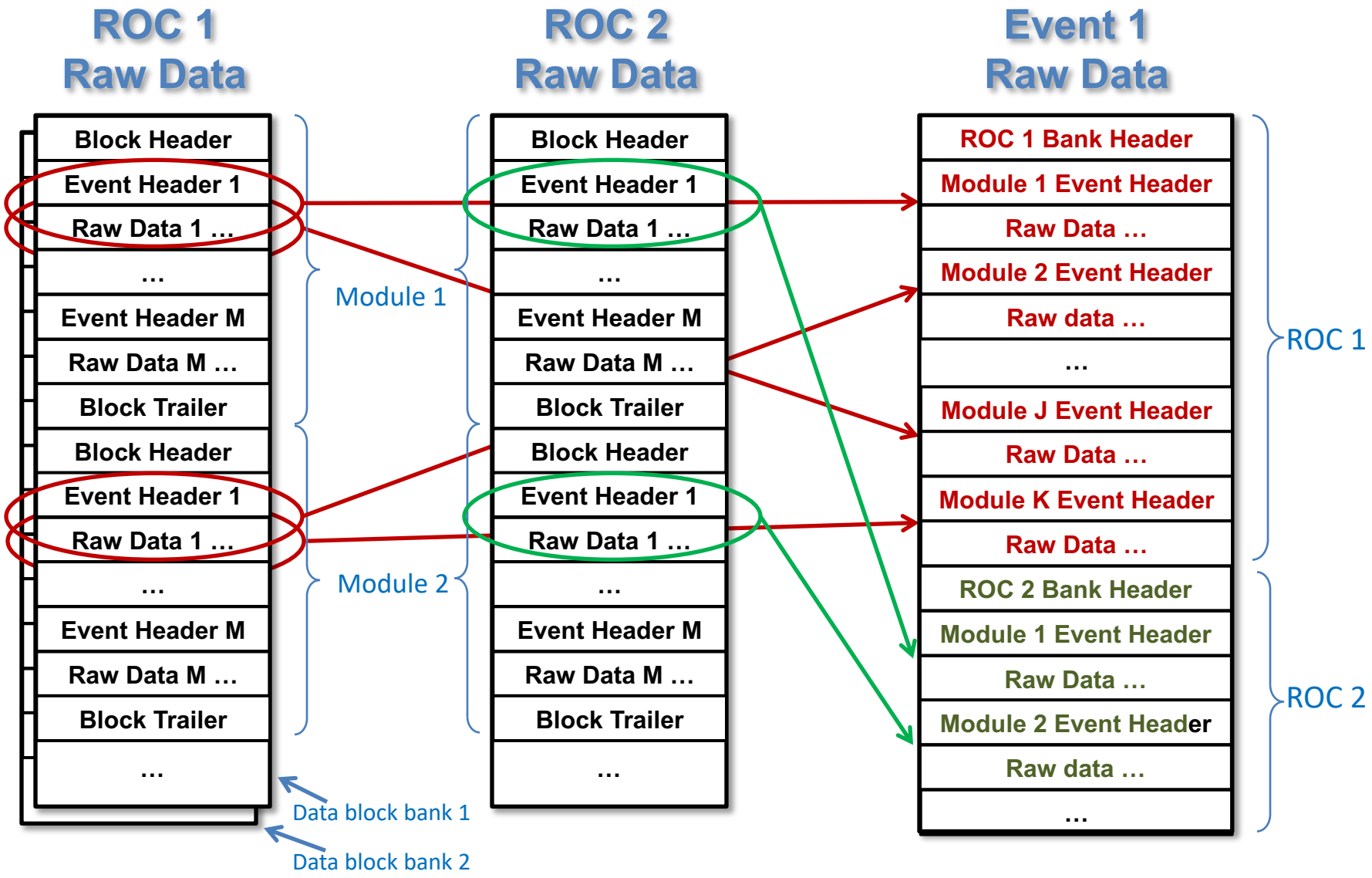

Contains raw data from a single ROC containing one or more events. If this block is the last in a data bank, and there are multiple events, and E = 1, then this data is associated only with the last event (e.g. scalar readout).

# 16-bit EVIO CODA-Format Tag



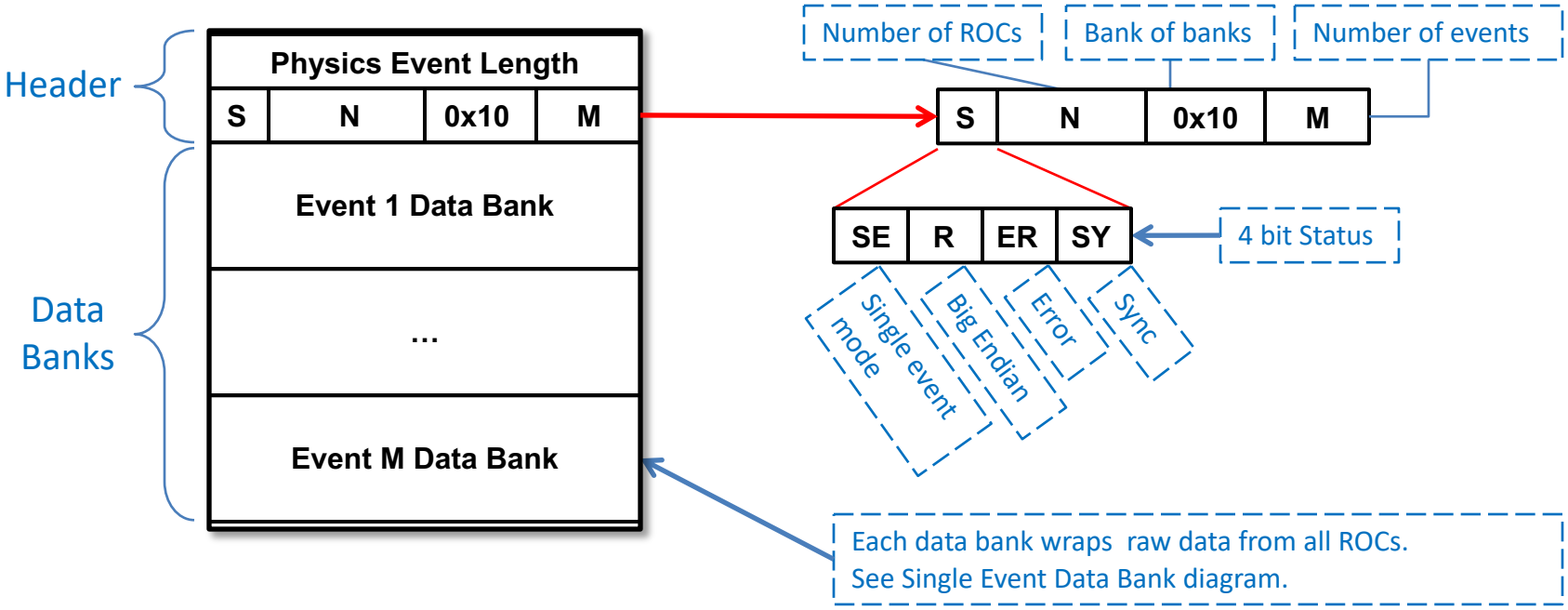
# Disentangling Built Physics Event


Physics Event
Data Bank
Data Block Bank
ROC 1 Raw Data (FADC 250)
Event Length
Trigger Bank
ROC 1 Data Bank
...
ROC N Data Bank
Bank Length
Data Block Bank 1
...
Data Block Bank Last
Block Len
M
Start Ev Num
Raw Data
Block Header
Event Header 1
Raw Data 1 ...
...
Event Header M
Raw Data M ...
Block Trailer
...
Block Header
Event Header 1
Raw Data 1 ...
...
Event Header M
Raw Data M ...
Block Trailer
Module 1
Module K
Last block may have data associated only with last event.
One data block for each DMA in a single ROC. Each block must read out unique modules and in the same manner. In single event mode, only one block exists.
Entangled Data Format

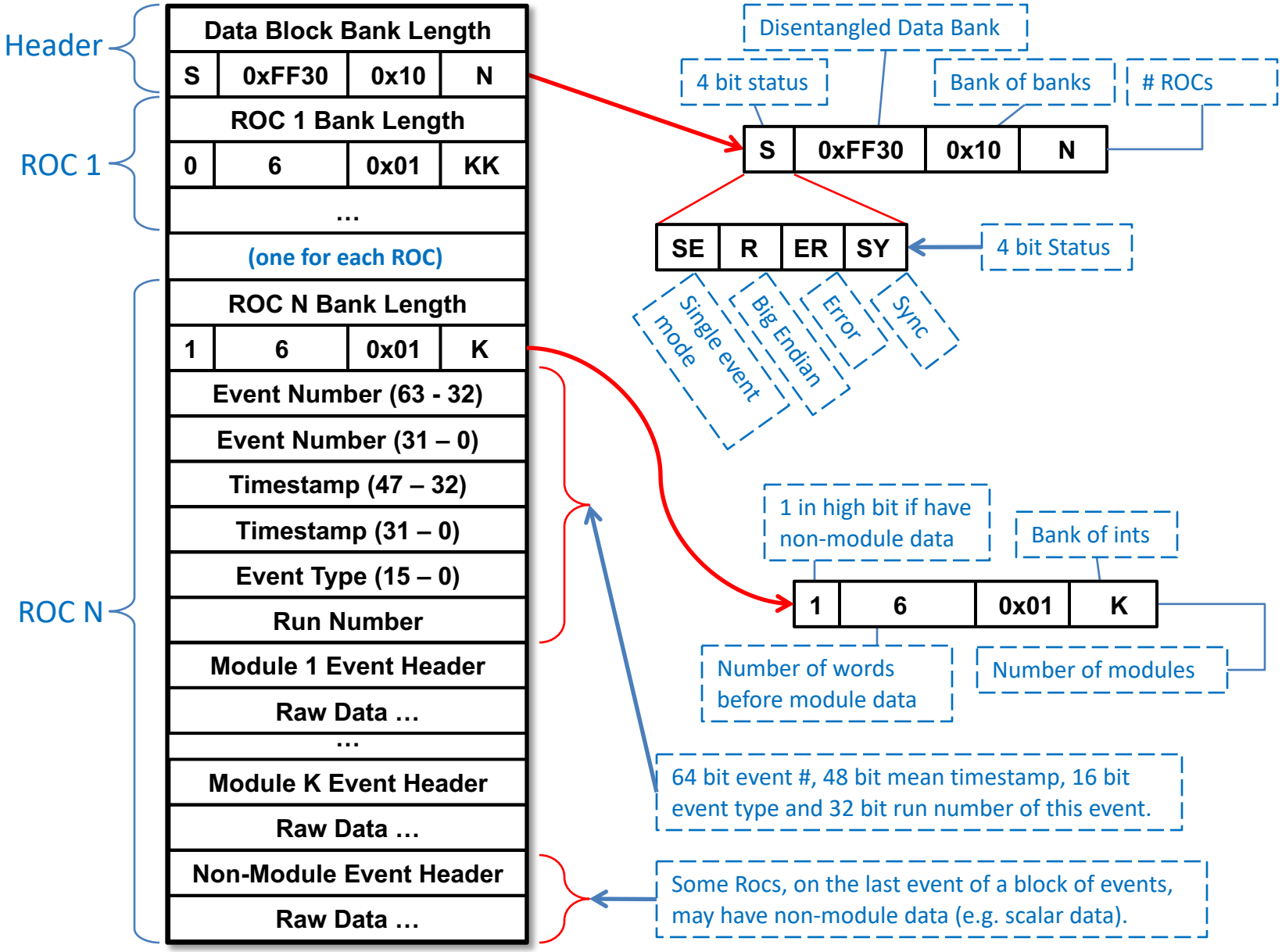



# Entangled To Disentangled FADC 250 Raw Data

# Disentangled Physics Event



# Single Event (Disentangled) Data Bank



# FADC 250

| Data Type Values | |
|---|---|
| 0 – block header | 7 – pulse integral |
| 1 – block trailer | 8 – pulse time |
| 2 – event header | 9 – streaming raw data |
| 3 – trigger time | 10 – 12 user defined |
| 4 – window raw data | 13 – event trailer (debug only) |
| 5 – window sum | 14 – data not valid (empty module) |
| 6 – pulse raw data | 15 – filler (non-data) word |

## Block Header Word Format

| Bits | Value | Comment |
|---|---|---|
| 31 | 1 | This is a type defining word |
| 30 – 27 | 0 | Data type = block header |
| 26 – 22 | Slot ID | Set by VME64 backplane |
| 21 – 14 | Event # | Number of events in block |
| 13 – 12 | Module Type | 0=FADC250, etc. |
| 11 – 0 | Event block # | Used to align block when building events |

## General Data Word Format

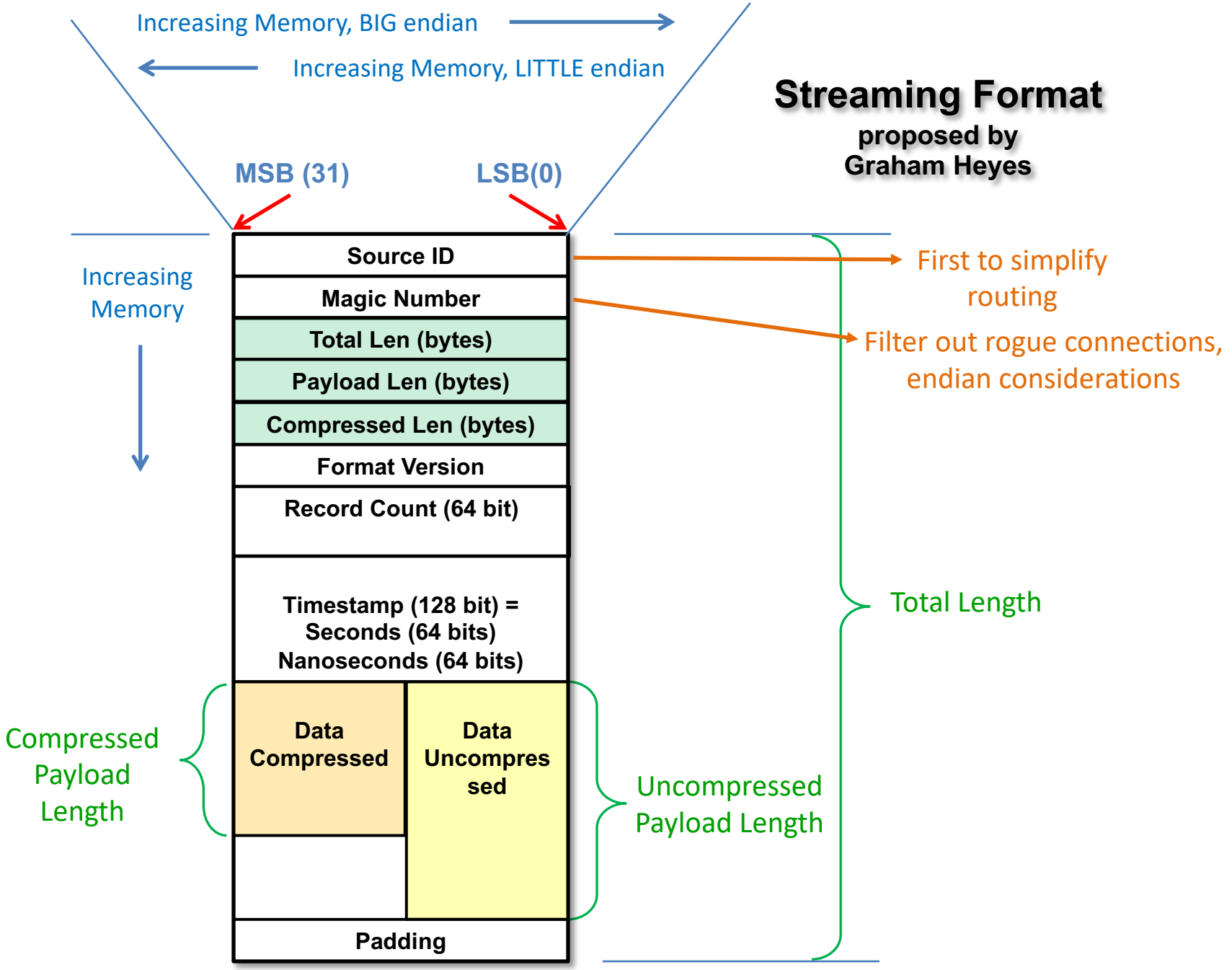
| 31st bit | Bits | Usage |
|---|---|---|
| 1 | 30 - 27 | 4-bit data type (see chart) |
| 1 | 26 - 0 | Data type dependent data payload |
| 0 | 3 0 - 0 | Data payload using last defined data type |

## Block Trailer Word Format

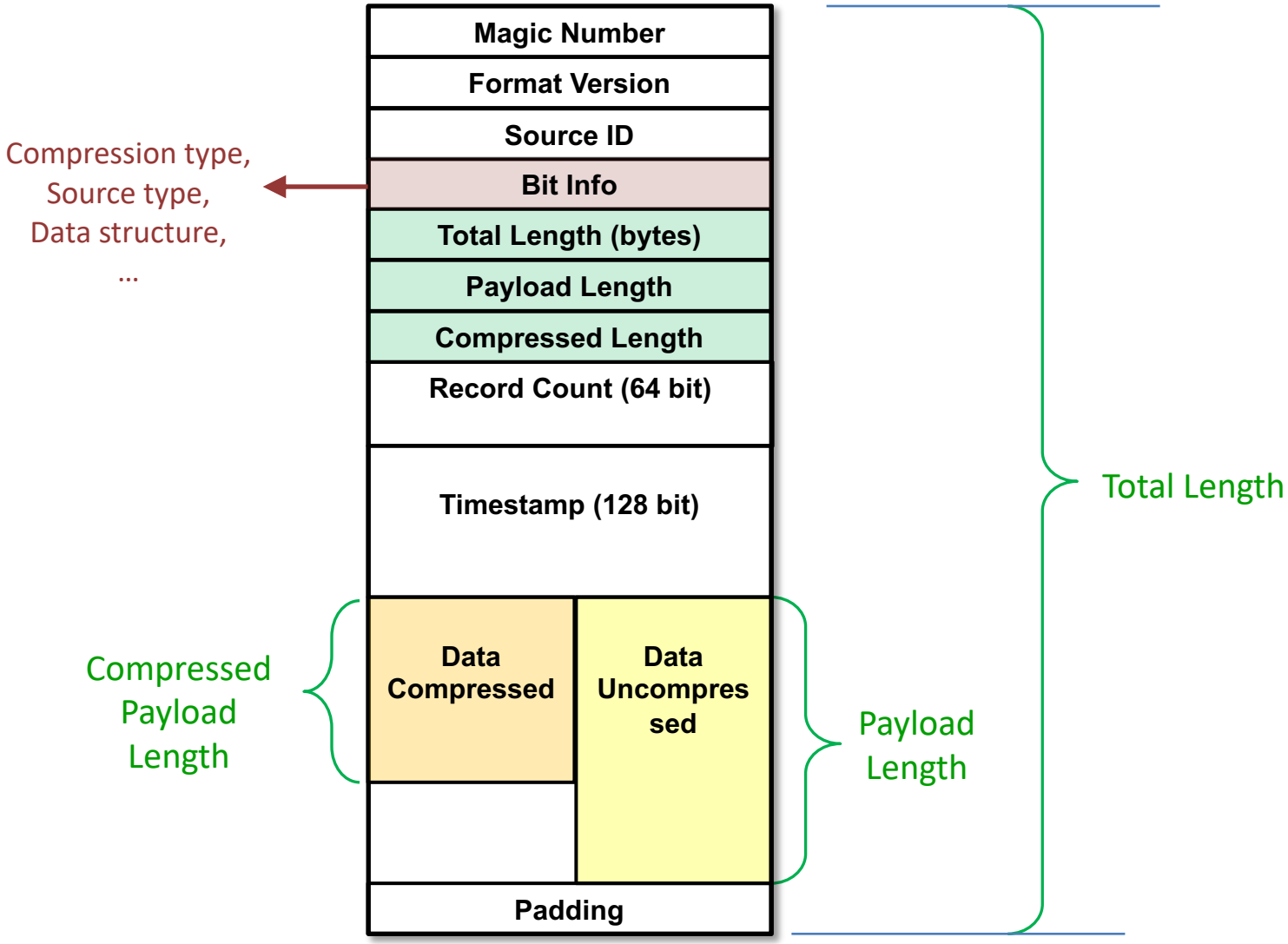
| Bits | Value | Comment |
|---|---|---|
| 31 | 1 | This is a type defining word |
| 30 – 27 | 1 | Data type = block trailer |
| 26 – 22 | Slot ID | Set by VME64 backplane |
| 21 – 0 | Total # of words in block of events | Number of 32 bit words in block |

## Event Header Word Format

| Bits | Value | Comment |
|---|---|---|
| 31 | 1 | This is a type defining word |
| 30 – 27 | 2 | Data type = event header |
| 26 – 22 | Slot ID | Set by VME64 backplane |
| 21 – 20 | Module type | 0=FADC250, etc. |
| 19 – 0 | Trigger number | ADC processing chip # |


Increasing Memory, BIG endian
Increasing Memory, LITTLE endian
Streaming Format
proposed by
Graham Heyes
MSB (31)
LSB(0)
Increasing
Memory
Source ID
Magic Number
Total Len (bytes)
Payload Len (bytes)
Compressed Len (bytes)
Format Version
Record Count (64 bit)
Timestamp (128 bit) =
Seconds (64 bits)
Nanoseconds (64 bits)
Data
Compressed
Data
Uncompres
sed
Padding
First to simplify
routing
Filter out rogue connections,
endian considerations
Total Length
Compressed
Payload
Length
Uncompressed
Payload Length

# Streaming Format



# Questions:

- Do we pick a fixed endian for simplicity?  (and skip the magic #)
- Pick an endian just for the header?
- What if data / record have mixed endian values?
- Could we always ensure all data is 1 particular endian?

- Merge fields like format version and compression type that may not require 32 bits each?

- Record count to ensure sequential records made obsolete by timestamp?
- Send time window size?  so we know if data is missing.
- Is time slice window fixed?

- Don’t allow fields that require the writer to go back and change it after writing data?