K0TO Raw Binary Run Data: File Format 6

A unification of file layout and packet information with stored binary data structure.
Mandolin node assignment information is described by MandolinFor2013Apr.pdf.
File layout described by Nikola Whallon, K0TO Run File Format 6.pdf.
Packet layout described by Monica Tecchio, payload_v2.pdf.

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The Files

File Format 6 was first used in March 2013. Run data was written to a series of binary data files by L3 Mandolin nodes. Each file is labeled according to run, file number, and source node: run_____node___file_.bin

Mandolin nodes were labeled as follows:

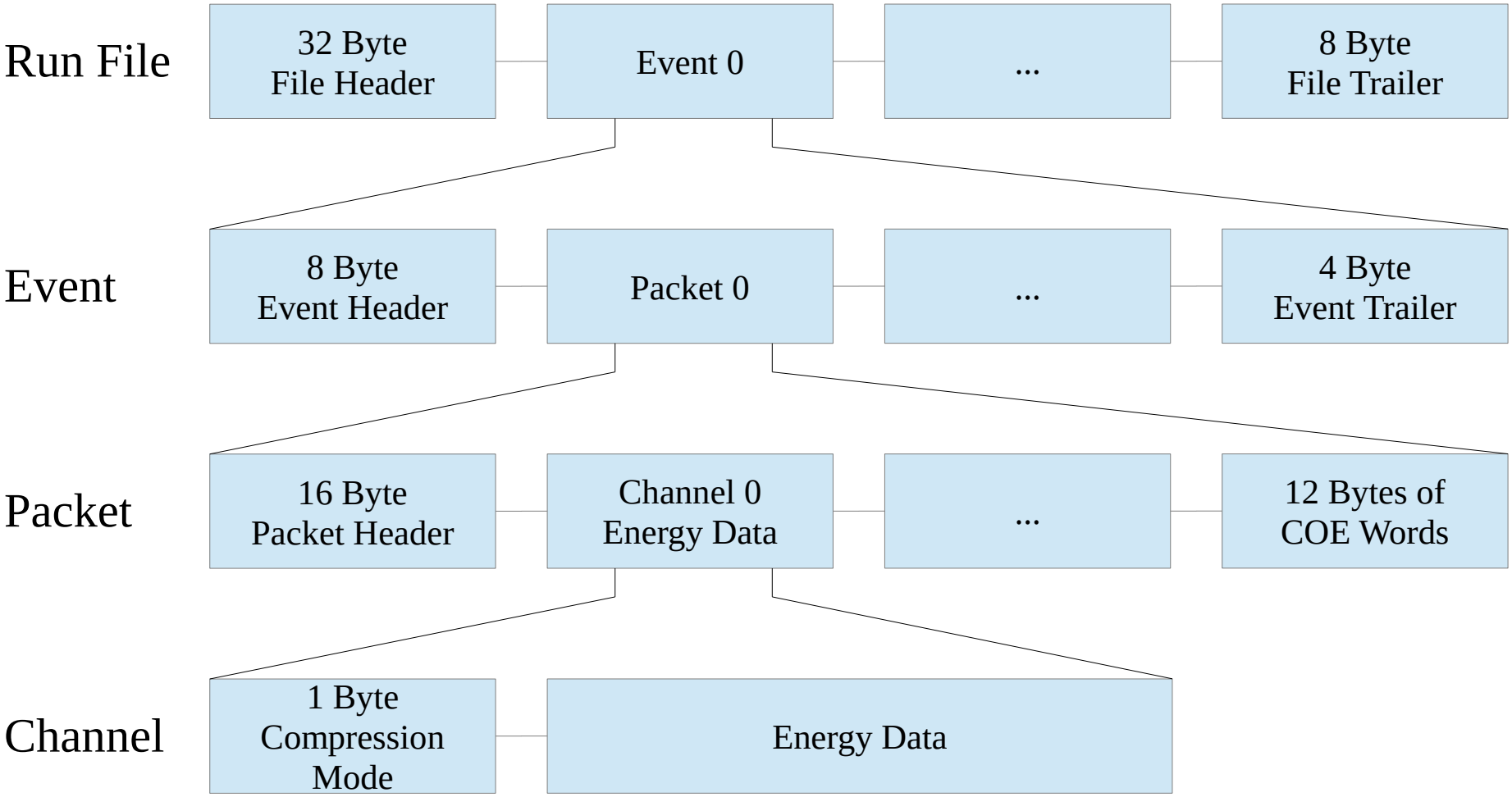
compute-x-y | x = 0 or 1 and y ranges from 0 to 18

File names contain node number labels of the format “xy”. For example, node0 = compute-0-0, and node110 = compute-1-10. Not all Mandolin nodes were assigned to L3. As a result, there are gaps in sequential node number.

Events were distributed in sequential order across 29 mandolin L3 nodes for processing and storage. The first node received Event 1, the second node received Event 2, etc., until returning to the first node which receives Event 30, and so on. When a file size limit of about 4 GB was reached, a new file was started. Thus there are typically multiple files per node per run.

File Structure Overview

Diagram by Nikola Whallon – K0TO Run File Format 6.pdf



File Header/Trailer

Each file begins with a File Header.
The File Header consists of 8 Words * 4 Bytes/Word - Little Endian format:

Header	0x12341234
File Format Version	6
Run ID	Should match file name.
Node Number	Should match file name.
Timestamp	Chronological
Number of Samples/Channel	64
Total Channels, All ADCs	245
Trailer	0x12121212

Each file ends with a File Trailer.
The File Trailer consists of 2 Words * 4 Bytes/Word - Little Endian format:

nEvents	Number of events in the file.
Trailer	0x43214321

Events

There are nEvents (see File Trailer) events.
Each event starts with an Event Header
consisting of 2 Words*4 Bytes/Word - Little Endian Format:

Header	0xaaaaaaaa
Event Bytes	Number of bytes in event.

Each Event contains 245 Packets of varying length.
Each contain the following:

L2 Header	2 Words * 2 Bytes/Word - Big Endian
ADC Header	6 Words * 2 Bytes/Word - Big Endian
16 Channels of Energy Data	Varying bit length – bit packed.
COE Words	6 Words * 2 Bytes/Word - Big Endian

Each event is followed by a 4 Byte Little Endian Trailer word:

Trailer	0xffffffff

The final event in a run may be truncated and incomplete.

L2 Header

An L2 header consists of 2 Words * 2 Bytes/Word - Big Endian format.
These words contain the following bit-packed information:

Word\Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
L2-1	1	1	E_{17}	E_{16}	E_{15}	E_{14}	E_{13}	E_{12}	E_{11}	E_{10}	L2a	S_4	S_3	S_2	S_1	S_0
L2-2	1	1	E_9	E_8	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0	I_3	I_2	I_1	I_0

E[17:0] = Event/trigger number within spill.
S[4:0] = L2 Trigger module slot number within trigger crate (from 4 to 21).
I[3:0] = Input fiber number within L2 Trigger module (corresponds to one ADC module).
L2a = 1 if L2 trigger accept, 0 if L2 reject.

ADC Header

An ADC header consists of 6 Words * 2 Bytes/Word - Big Endian format.
These words contain the following bit-packed information:

Word\Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
ADC-1	1	1	N_5	N_4	N_3	N_2	N_1	N_0	K_{15}	K_{14}	K_{13}	K_{12}	K_{11}	K_{10}	K_9	K_8
ADC-2	1	1	LOS	T_{28}	N_9	N_8	N_7	N_6	K_7	K_6	K_5	K_4	K_3	K_2	K_1	K_0
ADC-3	1	1	T_{27}	T_{26}	T_{25}	T_{24}	T_{23}	T_{22}	T_{21}	T_{20}	T_{19}	T_{18}	T_{17}	T_{16}	T_{15}	T_{14}
ADC-4	1	1	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	T_7	T_6	T_5	T_4	T_3	T_2	T_1	T_0
ADC-5	1	1	L_7	L_6	L_5	L_4	L_3	L_2	L_1	L_0	COE	A_4	A_3	A_2	A_1	A_0
ADC-6	1	1	E_{13}	E_{12}	E_{11}	E_{10}	E_9	E_8	E_7	E_6	E_5	E_4	E_3	E_2	E_1	E_0

N[9:0] = (Number of samples/event)/8 = 64/8 = 8
K[15:0] = Number of header + energy words saved for event.
T[28:0] = Timestamp in multiples of 8ns clock cycles.
LOS = 1 if compression used, 0 else. (Does not refer to File Format 6 specific compression.)
L[7:0] = Spill Number
A[4:0] = ADC VME slot number
COE = 1 if COE is calculated, else 0.
E[13:0] = Event number within spill.

Energy Data

Energy data is compressed and written in a different format than that of a compressed ADC packet. Rather than the first sample from each of 16 channels being written, followed by all 16 second samples, and so on, all samples from a single channel are stored sequentially. These samples are written in a compressed, bit packed format. Data for each of the 16 channels contains the following:

First byte: nBits, the number of bits used to store each sample in the current channel.

If nBits is not 16, the following 2 bytes contain a Big Endian format unsigned integer representing the minimum energy of the current channel.
If nBits = 16, these 2 bytes are not written.

The following nBits*8 bytes contain the 64 bit-packed energy values, each of length nBits, representing the original ADC sample values - minimum channel energy.

This pattern is repeated for each of the 16 ADC channels.

COE Words

COE words consist of 6 Words * 2 Bytes/Word - Big Endian format.
These words contain the following bit-packed information:

Word\Bit	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0
COE-1	0	1	1	0	0	0	COE	0	0	0	0	OVFL	T_3	T_2	T_1	T_0
COE-2	0	1	1	0	T_{15}	T_{14}	T_{13}	T_{12}	T_{11}	T_{10}	T_9	T_8	T_7	T_6	T_5	T_4
COE-3	0	1	1	0	X_{11}	X_{10}	X_9	X_8	X_7	X_6	X_5	X_4	X_3	X_2	X_1	X_0
COE-4	0	1	1	0	X_{23}	X_{22}	X_{21}	X_{20}	X_{19}	X_{18}	X_{17}	X_{16}	X_{15}	X_{14}	X_{13}	X_{12}
COE-5	0	1	1	0	Y_{11}	Y_{10}	Y_9	Y_8	Y_7	Y_6	Y_5	Y_4	Y_3	Y_2	Y_1	Y_0
COE-6	0	1	1	0	Y_{23}	Y_{22}	Y_{21}	Y_{20}	Y_{19}	Y_{18}	Y_{17}	Y_{16}	Y_{15}	Y_{14}	Y_{13}	Y_{12}

T[15:0] = Total energy summed over all ADC channels.
X[23:0] = x-coordinate energy weighted sum over all ADC channels: $\sum E_i x_i$
Y[23:0] = y-coordinate energy weighted sum over all ADC channels: $\sum E_i y_i$