

Status of ETM firmware

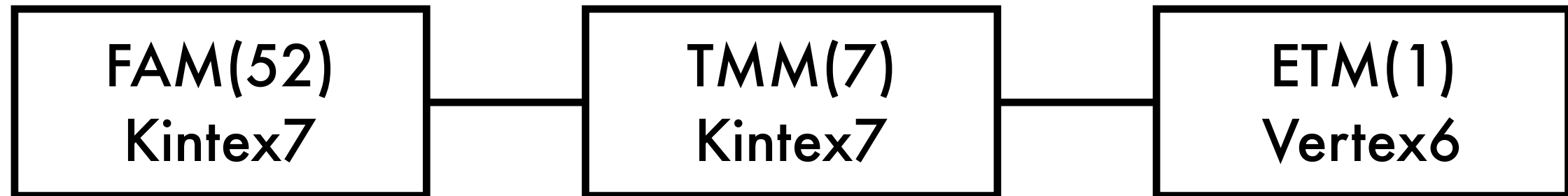
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TRG/DAQ Workshop
Sep 05. 2016

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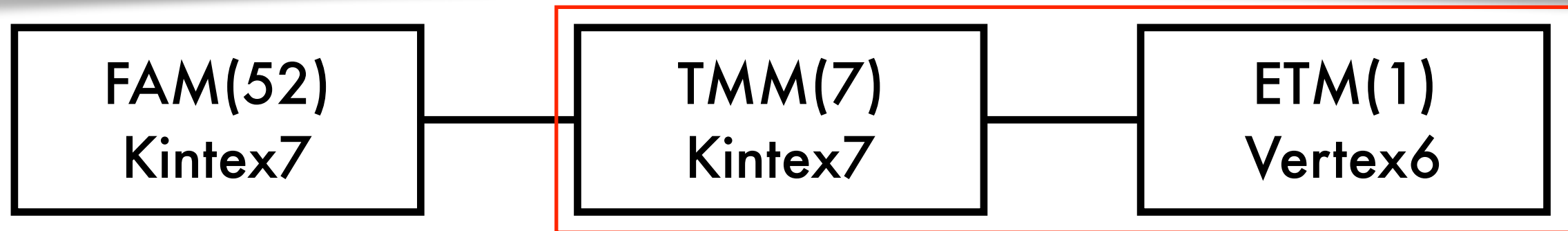
Optical Link Status

Optical Link Issues



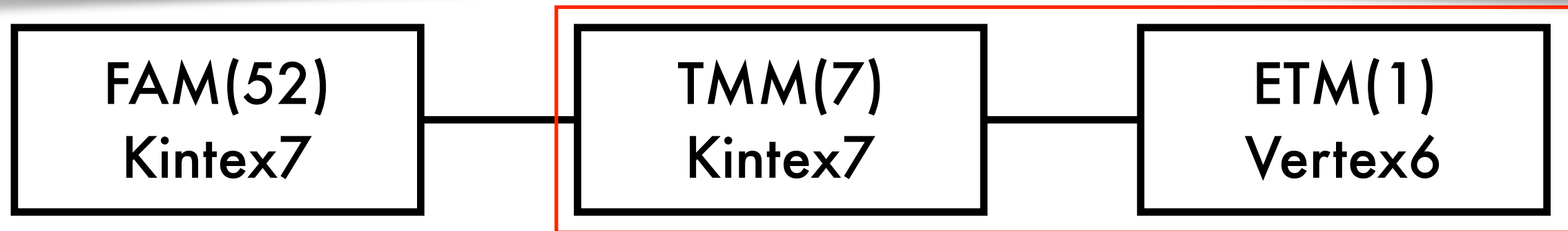
- (1) Data alignment problem
 - FAM → TMM, TMM → ETM
 - Unno san kindly solve this problem.
- (2) Instability at Link start up
 - TMM → ETM

Link Instability Problem



- Many Links didn't go to up state after reboot or power-up
 - There was a bug to do gtxtxreset & gtxrxreset.
 - Some of links were still down.
- ECL-TRG GTX Link protocol (TMM → ETM)
 - (t=0) TMM send Sync-Pattern(0xB5) with TMM(ascii) + K-char (0x3C) to ETM.
 - (t=0) ETM send Sync-Pattern(0xB5) with ETM(ascii) + **Not-ready** + K-char (0x3C) to TMM.
 - (t=1) TMM try **bitslip** operation to match Sync-Pattern and ETM(ascii).
 - (t=1) ETM try **bitslip** operation to match Sync-Pattern and TMM(ascii).
 - (t=2) After ETM match Sync-Pattern and TMM(ascii) (**Link-up**), ETM send Sync-Pattern(0xB5) with ETM(ascii) + **Ready** + K-char (0x3C) to TMM.
 - (t=3) TMM receive "Ready" from ETM, send FAM data to ETM.

Link Instability Problem



- We found the reason of TMM-ETM Link Instability problem.
- FAM-TMM Link : 20bit ($16\text{bit} \times 10\text{bit} / 8\text{bit}$)
 - To match sync-pattern maximum 20 times bit slip is needed.
- TMM-ETM Link : 40bit ($32\text{bit} \times 10\text{bit} / 8\text{bit}$)
 - To match sync-pattern maximum 40 times bit slip is needed.

Kintex7 vs Vertex 6

- Kintex7 support maximum 40 bitslip for 4byte datawidth mode.

Kintex7 GTX manual

ALIGN_COMMA_WORD setting of 2, the slide position returns to 0 after the 19th slide operation. Thus in RXSLIDE_MODE = PCS, a maximum of 40 bits of sliding is possible when RX_INT_DATAWIDTH= 1 (4-byte) and ALIGN_COMMA_WORD = 4.

we use these options

RX_DATA_WIDTH	RX_INT_DATAWIDTH	ALIGN_COMMA_WORD	Possible RX Alignments (Grey = Comma Can Appear on Byte)
32/40 (4-byte)	1 (4-byte)	1	Byte3 Byte2 Byte1 Byte0
32/40 (4-byte)	1 (4-byte)	2	Byte3 Byte2 Byte1 Byte0
32/40 (4-byte)	1 (4-byte)	4	Byte3 Byte2 Byte1 Byte0

- Vertex6 support maximum 20 bitslip for 4byte datawidth mode.

RX_DATA_WIDTH	ALIGN_COMMA_WORD	Possible RX Alignments (Grey = Comma Can Appear on Byte)
32/40 (4-byte)	1 (Any Boundariy)	RXDATA Byte 3 RXDATA Byte 2 RXDATA Byte 1 RXDATA Byte 0
32/40 (4-byte)	2 (Even Boundaries Only)	RXDATA Byte 3 RXDATA Byte 2 RXDATA Byte 1 RXDATA Byte 0

ETM Firmware modification

- Since insufficient maximum bitslip support, link instability appear.

- Our sync pattern : 4D4D543C (MMT + k-character) + B5B5B5B5

- Sync stage, we can get several patterns by bitslip

- Kintex 7 case

B5B5B5B5 + 4D4DB5B5 + B5B5543C =>

(10 bitslip) B5B5B5B5 + 4DB5B5B5 + B54D543C =>

(10 bitslip) B5B5B5B5 + 4D4D543C + B5B5B5B5 (O)

- But Vertex 6 case

B5B5B5B5 + 4D4DB5B5 + B5B5543C =>

(10 bitslip) B5B5B5B5 + 4DB5B5B5 + B54D543C =>

(10 bitslip) B5B5B5B5 + 4D4DB5B5 + B5B5543C =>

(10 bitslip) B5B5B5B5 + 4DB5B5B5 + B54D543C => ... (X)

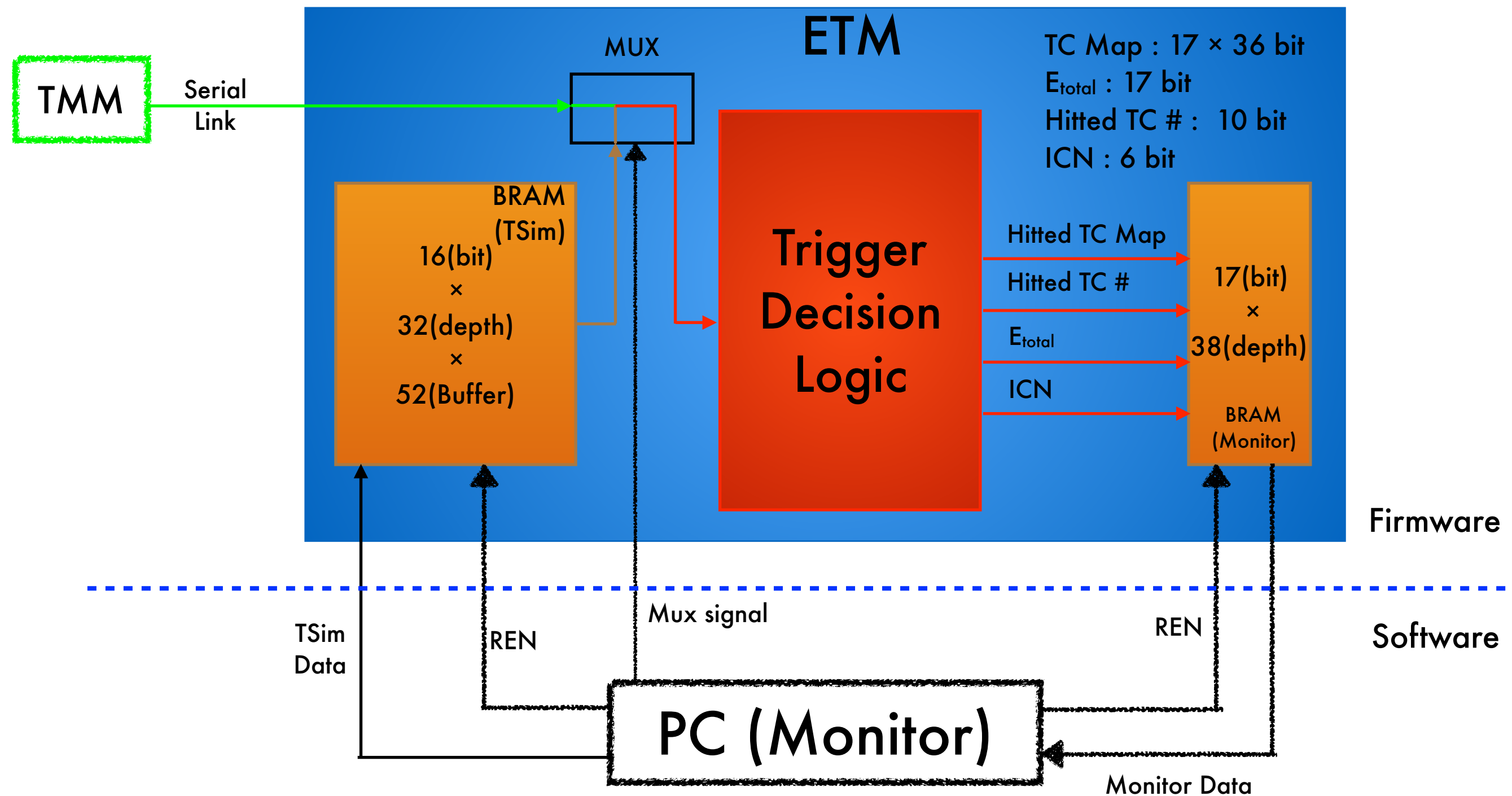
Solution

- Count # of bitflip : bitflip_cnt
 - If bitflip_cnt : 0 ~ 19 => mux = 0
 - If bitflip_cnt : 20 ~ => mux = 1
- If mux = 0 => new_gtx_rxd <= gtx_rxd
- If mux = 1 => new_gtx_rxd <= gtx_rxd(15 downto 0) & dgtx_rxd(31 downto 16)
where, dgtx_rxd is 1 clock delayed from gtx_rxd.
- Result => **All Links are Up-state, automatically** after reboot/power-up.
- New variable : gtx_rxd, gtx_rxc, gtx_disperr, gtx_notintable

```
if(bitflip_mux = '0') then
  new_gtx_rxd <= gtx_rxd;
  new_gtx_rxc <= gtx_rxc;
  new_gtx_disperr <= gtx_disperr;
  new_gtx_notintable <= gtx_notintable;
else
  new_gtx_rxd <= gtx_rxd(15 downto 0) & dgtx_rxd(31 downto 16);
  new_gtx_rxc <= gtx_rxc( 1 downto 0) & dgtx_rxc( 3 downto  2);
  new_gtx_disperr <= gtx_disperr(1 downto 0) & dgtx_disperr(3 downto 2);
  new_gtx_notintable <= gtx_notintable(1 downto 0) & dgtx_notintable(3 downto 2);
end if;
```

TSim Buffer

TSim Monitor Diagram



TSim Data Converter

- In order to make 1 TRG signal, we check 2 events window.

- $126 \text{ ns} \times 2 = 32 \text{ clk}$ (127MHz)

- TSim data is kinds of TC-like data.

- Although ETM generate TRG using TC information, Real ETM receive FAM-like data.

- TSim data must be converted to FAM-like data.

- Timing Setting

- Total Timing = counter * 126 + timing (ns)
- I set arbitrary number (25 ns) as a boundary (red colored box).

- Energy Setting

- Roughly, 1 FADC count = 5 MeV

- Header setting (FB, FD, F7 : K-character)

- FB(251) : 1(or more) TC fired, Odd FAM #.
- FD(253) : 1(or more) TC fired, Even FAM #.
- F7(247) : No TC fired.

TSim Data

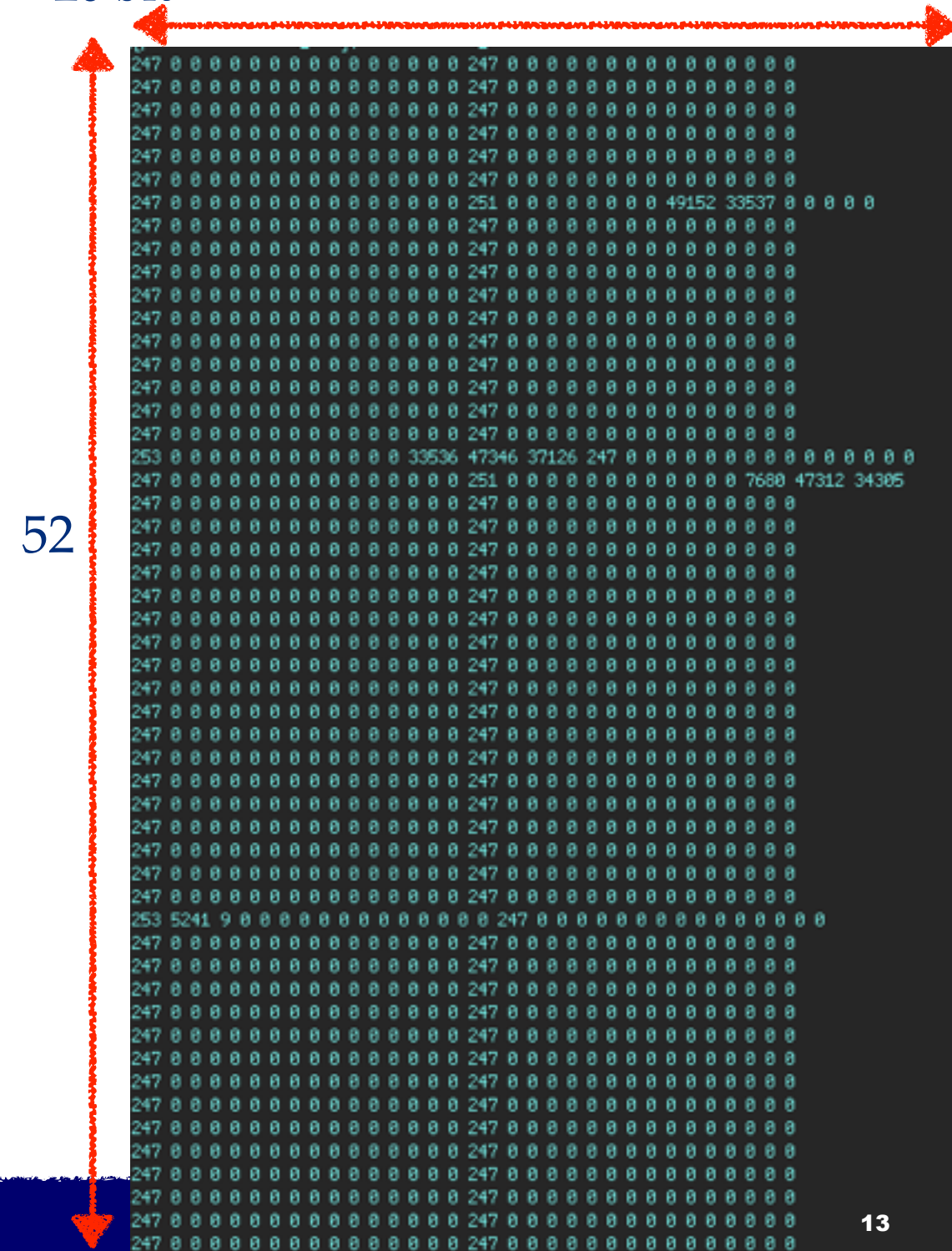
68	27.772	0.140
199	15.008	3.214
200	17.280	0.533
211	37.967	0.148
212	31.374	0.134
429	17.406	5.727

tc id timing (ns) energy (GeV)

TSim Data Converter

- Data Setting
 - 1 TC information = 1(fire) + 7(timing) + 12(energy) = 20 bit
 - Serial Link width = 16 bit
 - So FAM/TMM slice a data and send to ETM, then ETM reconstruct data.
 - => Slice TSim data like a TMM data.
 - Fill 0 for others.

2 events window



TSim Monitoring Program

- Update monitoring program

```
=====
0   : Quit
-----
1   : ETM Status
2   : Reset mon general
3   : TMM GTX Reset (99 : loop)
4   : Read TMM RxD
5   : Read TMM Link Error Count
6   : Reset TMM Link Error Count
7   : TRG Summary
8   : Set Data Type
-----
20  : Read ETM to HSLB Data
30  : TMM Channel Monitor Data
40  : B2L Related Monitor
50  : TSim Related Monitor
=====
```

```
Select action?
[50]
=====
0   : Quit
1   : Reset Buffer
2   : Set data mux
3   : Write data
4   : Send read enable
5   : Read TRG Logic Output
6   : Read TRG Logic Output (Root)
=====
Select action?
█
```

- Reset : Fill all buffer as 0.
- Set data mux : We can choose ETM input data, TMM or TSim.
- Send read enable : “REN” signal
- Read TRG Logic (5, 6) : ETM Logic output

TSim Monitoring Program

- Command (5)

TSim ETM output

```
Select action?
5

=====
BE|  B  | FE
01 : 00|000000000000|000
02 : 00|000000000000|00
03 : 00|000000000000|000
04 : 00|000000000000|00
05 : 00|000000000000|000
06 : 00|000000000000|00
07 : 00|000000000000|000
08 : 00|000000000000|00
09 : 00|000000000000|000
10 : 00|110000000000|00
11 : 00|110000000000|000
12 : 00|000000000000|00
13 : 00|000000000000|000
14 : 00|000000000000|00
15 : 00|000000000000|000
16 : 00|000000000000|00
17 : 00|000000000000|000
18 : 00|000000000000|00
19 : 00|000000000000|000
20 : 00|000000000000|00
21 : 00|000000000000|000
22 : 00|000000000000|00
23 : 00|000000000000|000
24 : 00|000000000000|00
25 : 00|000000000000|000
26 : 00|000000000000|00
27 : 00|000000000000|100
28 : 00|000000000000|00
29 : 00|000000000000|000
30 : 00|000000000000|00
31 : 00|000000000000|000
32 : 00|000000000000|00
33 :  |000000000000|
34 :  |000000000000|
35 :  |000000000000|
36 :  |000000000000|

=====
ICN = 3, # of hit TC = 6
E(tot) = 1980 (FADC) : 9.900(GeV)
```

```
[shkim@b2ec1trgpc02 tsim_conv]$ more bhabha_2_etm.txt
9.896 3
```

TSim FAM output

TSim Data

tc id	timing (ns)	energy (GeV)
68	27.772	0.140
199	15.008	3.214
200	17.280	0.533
211	37.967	0.148
212	31.374	0.134
429	17.406	5.727

- Command (6)

TC Map

TC Map																		← TC θ ID				
		18		16		14		12		10		8		6		4		2		0		
← TC φ ID																						
		0		2		4		6		8		10		12		14		16		18		
0		516	515	92	91	90	89	88	87	86	85	84	83	82	81	3	2	1				
2		513	514	104	103	102	101	100	99	98	97	96	95	94	93	4	5					
4		520	519	116	115	114	113	112	111	110	109	108	107	106	105	8	7	6				
6		517	518	128	127	126	125	124	123	122	121	120	119	118	117	9	10					
8		524	523	140	139	138	137	136	135	134	133	132	131	130	129	13	12	11				
10		521	522	152	151	150	149	148	147	146	145	144	143	142	141	14	15					
12		528	527	164	163	162	161	160	159	158	157	156	155	154	153	18	17	16				
14		525	526	176	175	174	173	172	171	170	169	168	167	166	165	19	20					
16		532	531	188	187	186	185	184	183	182	181	180	179	178	177	23	22	21				
18		529	530	200	199	198	197	196	195	194	193	192	191	190	189	24	25					
20		536	535	212	211	210	209	208	207	206	205	204	203	202	201	28	27	26				
22		533	534	224	223	222	221	220	219	218	217	216	215	214	213	29	30					
24		540	539	236	235	234	233	232	231	230	229	228	227	226	225	33	32	31				
26		537	538	248	247	246	245	244	243	242	241	240	239	238	237	34	35					
28		544	543	260	259	258	257	256	255	254	253	252	251	250	249	38	37	36				
30		541	542	272	271	270	269	268	267	266	265	264	263	262	261	39	40					
32		548	547	284	283	282	281	280	279	278	277	276	275	274	273	43	42	41				
34		545	546	296	295	294	293	292	291	290	289	288	287	286	285	44	45					
36		552	551	308	307	306	305	304	303	302	301	300	299	298	297	48	47	46				
38		549	550	320	319	318	317	316	315	314	313	312	311	310	309	49	50					
40		556	555	332	331	330	329	328	327	326	325	324	323	322	321	53	52	51				
42		553	554	344	343	342	341	340	339	338	337	336	335	334	333	54	55					
44		560	559	356	355	354	353	352	351	350	349	348	347	346	345	58	57	56				
46		557	558	368	367	366	365	364	363	362	361	360	359	358	357	59	60					
48		564	563	380	379	378	377	376	375	374	373	372	371	370	369	63	62	61				
50		561	562	392	391	390	389	388	387	386	385	384	383	382	381	64	65					
52		568	567	404	403	402	401	400	399	398	397	396	395	394	393	68	67	66				
54		565	566	416	415	414	413	412	411	410	409	408	407	406	405	69	70					
56		572	571	428	427	426	425	424	423	422	421	420	419	418	417	73	72	71				
58		569	570	440	439	438	437	436	435	434	433	432	431	430	429	74	75					
60		576	575	452	451	450	449	448	447	446	445	444	443	442	441	78	77	76				
62		573	574	464	463	462	461	460	459	458	457	456	455	454	453	79	80					
64				476	475	474	473	472	471	470	469	468	467	466	465							
66				488	487	486	485	484	483	482	481	480	479	478	477							
68				500	499	498	497	496	495	494	493	492	491	490	489							
70				512	511	510	509	508	507	506	505	504	503	502	501							

ETM Logic monitor result

Result

- TSim data : 3 Bhabha events, 1 physics event
 - Monitoring results are consist with TSim-ETM output.
 - Total Energy discrepancy : ~few MeV level (~1 FADC count)
 - Test with more TSim events is needed.
 - First version of ETM Logic is ready.

B2L Status

B2Link Bug

- B2Link header/trailer include many “FFFFFFFF” in some events.
- Condition : High TRG Rate (~25KHz)

```
statft version 20150409 FISA 1045 / FE2071b - 2016.02.23 14:04:19.358
— RUNNING about 26951.5Hz since 1970.01.07 16:07:12 for 1595s —
16 exprun=0002600 exp 0 run 38 sub 0
18 omask=00000000 s3e=0 selx/o=0/0 x/o=0/00 xor=00
20 reset=c0000000 no-FIFO auto-reset
28 seltrg=00000001 aux
2a/2b trig=03969f13 02b7030e (in:60202771 -> out:45548302)
00/01 last=ffffffff ffffffff (limit 1 / > last 1)
```

Header

```
cea8aaff ffffffff ffffffff f2ffffff 00020000 0025bd21 08670009 00000000 00000000 00000000 00000000 00000000
00000000 00000000 003d0000 003da000 000000fa 0000fa00 00000000 00000000 00000000 00000000 023d0000 00000000
00000000 00000000 00000000 00000000 00000000 00000000 013d0000 00000000 0ca00800 70090000 08e7008e d7008e70
008e7008 8b7008e7 003de700 ffffffff 53d6ffff 000055ff
```

Trailer

HSL: 0xFFAA(16) -- B2L header		HSLB-tag(16)	}	B2link HSLB header
B2L: '0'(1) TT-ctime(27)		TT-type(4)		
B2L: TT-tag(32)			}	B2link FEE header
B2L: TT-utime(32)				
B2L: TT-exprun(32)				
B2L: '0' B2L-ctime(27)		reserved(4)		

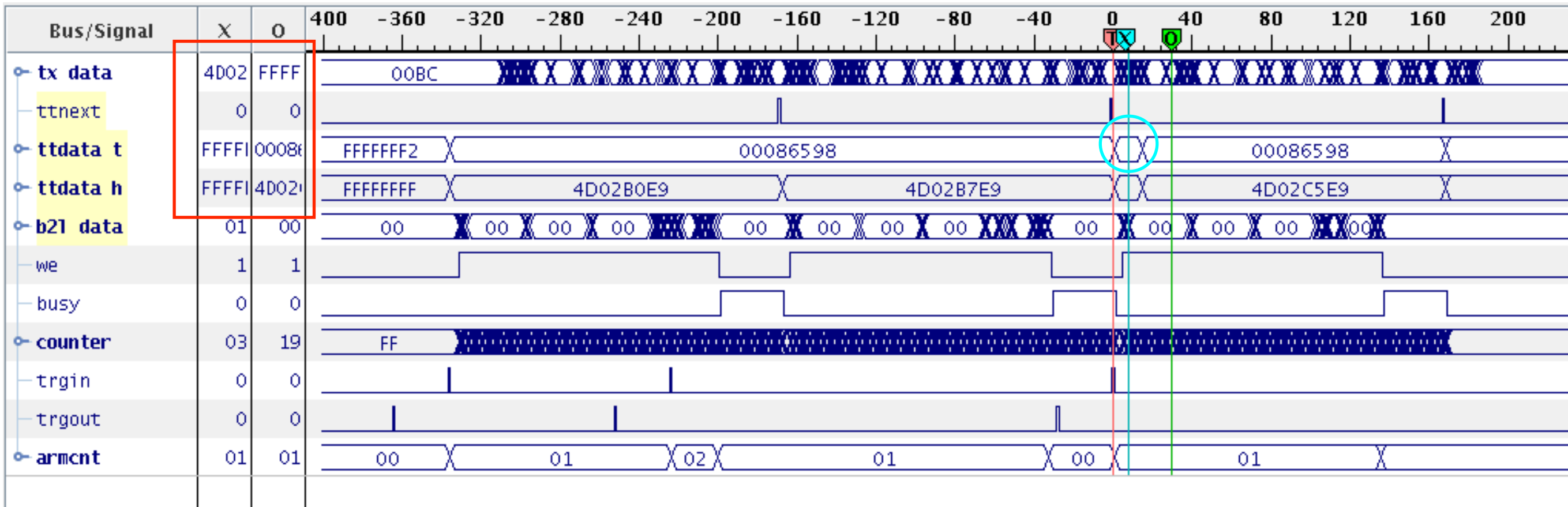
FEE: Data #0 (32)				
FEE: Data #1 (32)				
FEE:				
FEE: Data #n (32)				

B2L: '0'(1) TT-ctime(27)		TT-type(4)	}	B2link FEE trailer
B2L: TT-tag(16)		B2L-CRC16(16)		

HSL: 0xFF55(16)		CRC error count(16)	}	B2link HSLB trailer

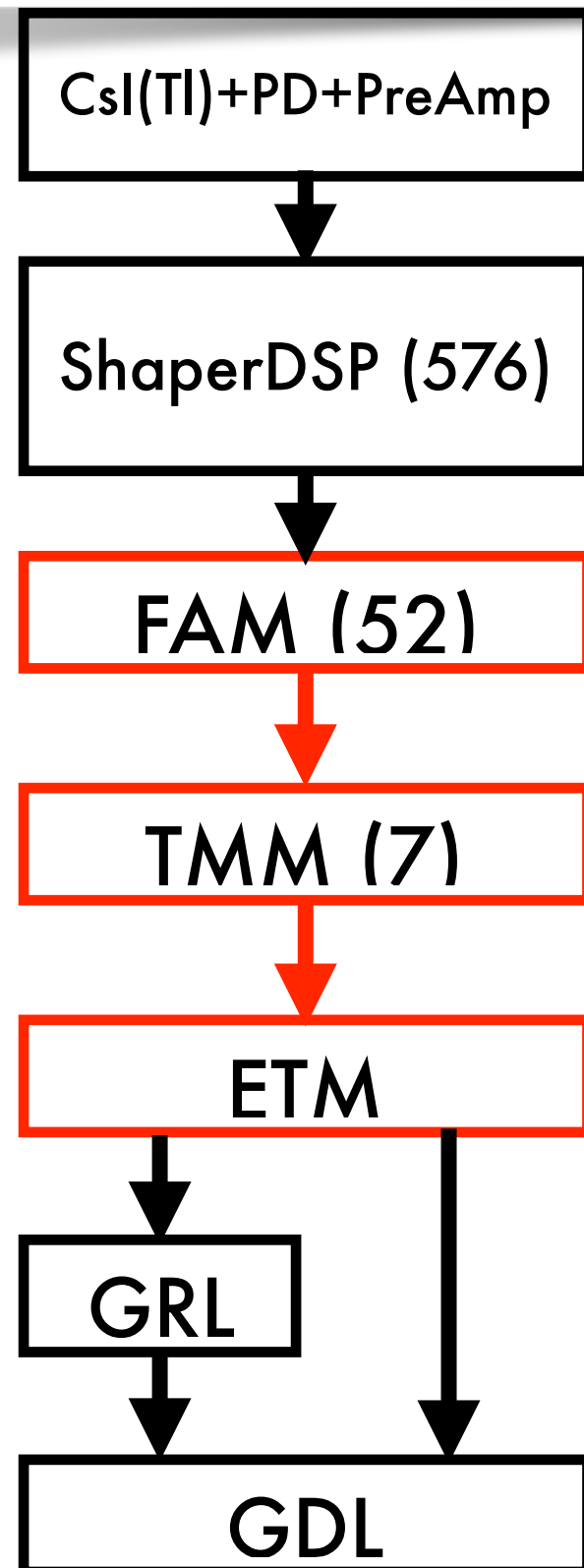
Problematic Situation

- When “F...F” included ttdata overlaped “b2l we”, txdata includes “FFFF”s.

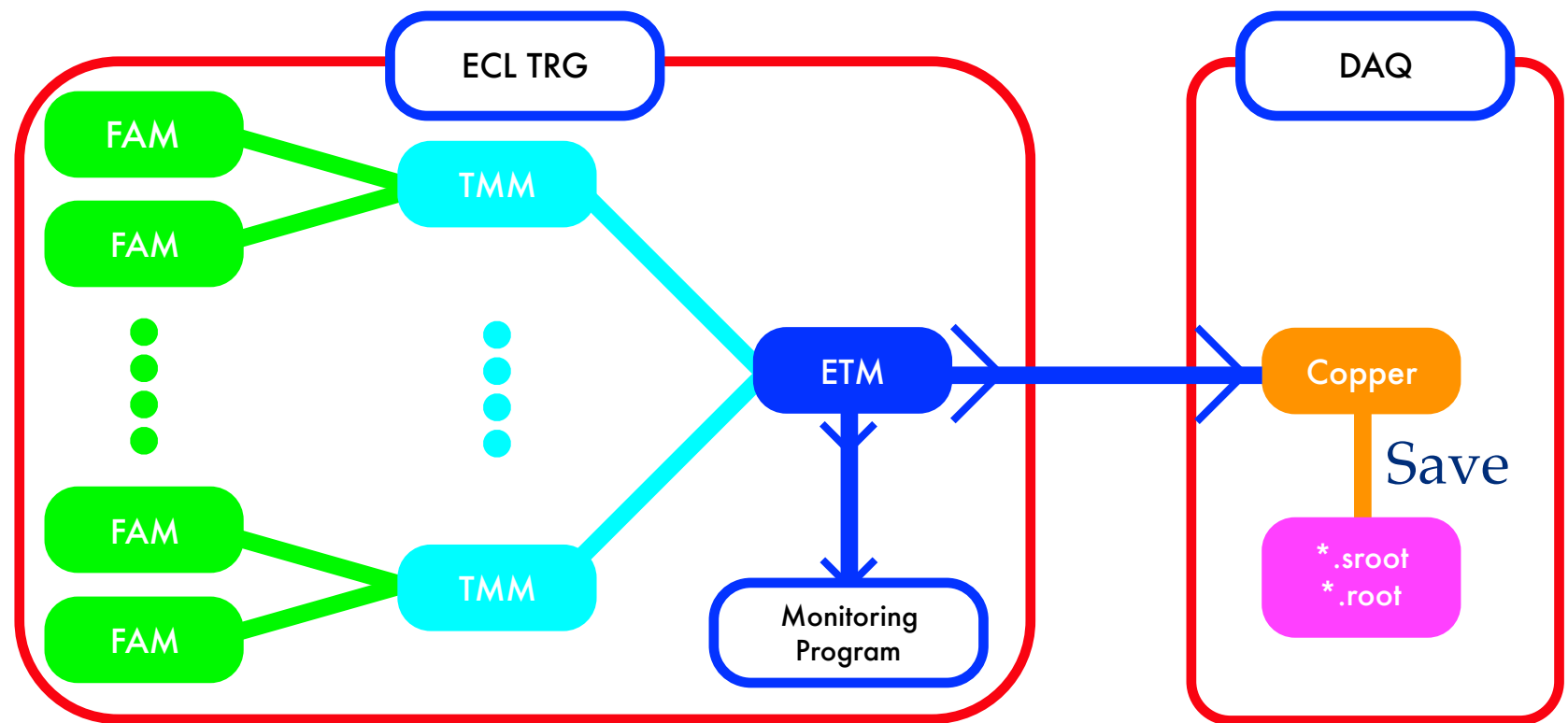


- June 2016, Nakao-san debug this problem. (Belle2Link version-0.17)

ECL-TRG Data flow diagram

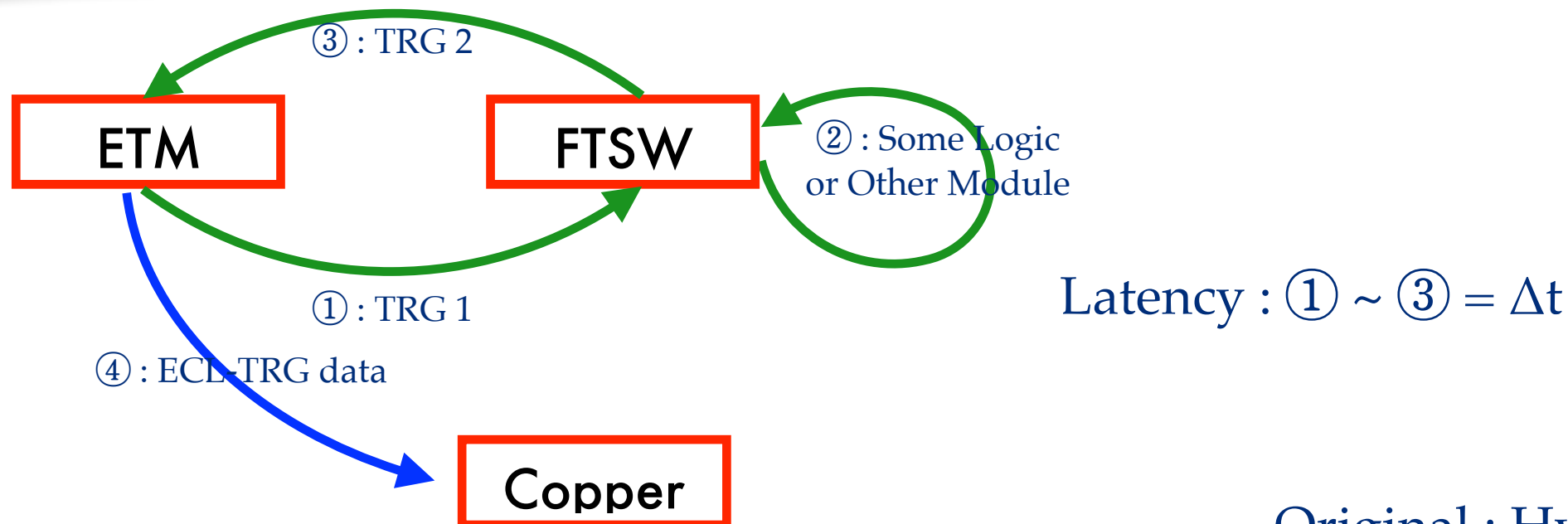


- ECL-TRG Data Flow

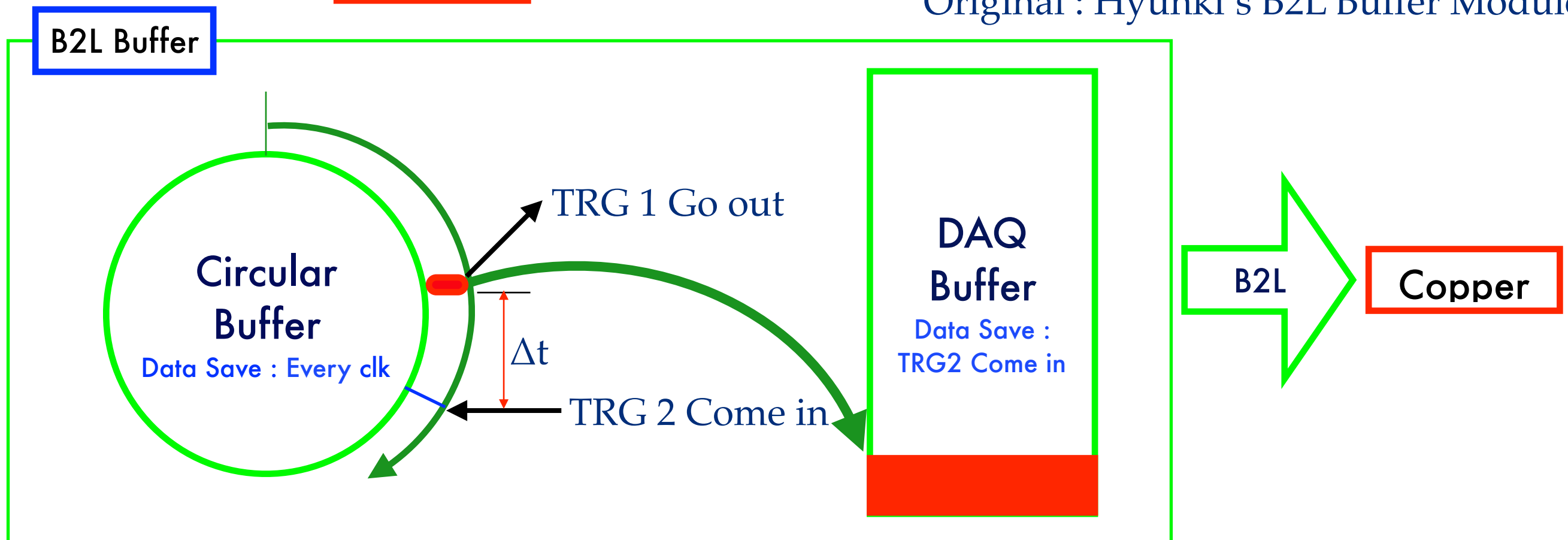


- 52 FAM → 7 TMM → 1 ETM
- ETM sends ECL-TRG data to Copper through B2Link.
- We can check data using our monitoring program.

B2Link Buffer Update(Diagram)



Original : Hyunki's B2L Buffer Module



Cosmic Run (Aug / 2016)

Cosmic Run (Aug / 2016)

- Cosmic(?) data taking
 - B2L data contents : $576 \text{ TC} \times 21\text{bit} = 12\text{K bit}$
 - 1bit flag, 1bit revo (0 or 1), 7 bit time, 12 bit energy
 - Compile time (w/o any logic) :
 - Normal) Timing constraint fit fail.

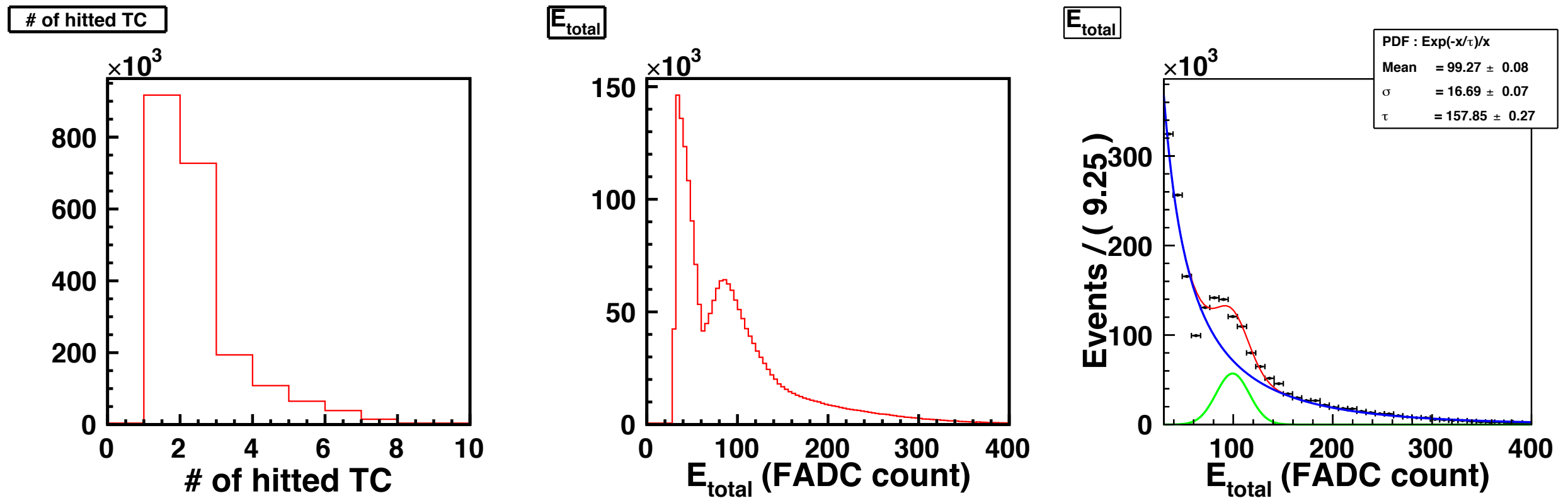
Ictm Project Status (08/21/2016 - 23:01:25)	
Parser Errors:	No Errors
Implementation State:	Placed and Routed
• Errors:	No Errors
• Warnings:	8888 Warnings (2612 new)
• Routing Results:	X 8117 Signals Not Completely Routed
• Timing Constraints:	X 1 Failing Constraint
• Final Timing Score:	89086634

- SmartXplorer) 11h 25min for “Map” & “Place & Route”

SmartXplorer Results									
MapIOReg implementation results were copied to current project, and implementation properties updated to reflect the strategy. MapIOReg is the best strategy.									
	Strategy	Host	Output	Status	Timing Score	Run Time	LUTs	Slice Registers	WorstCaseSlack
☐	MapRunTime	None	None	None	None	None	None	None	None
☒	MapIOReg	panic-desktop	run2	Done	1.0045e+06	11h 25m 35s	54,913 (22%)	116,119 (24%)	-1.565ns
☐	MapRegDup	panic-desktop	run3	Failed Par	None	12h 52m 14s	56,869 (23%)	116,120 (24%)	-6.496ns
☐	MapExtraEffortIOReg	None	None	None	None	None	None	None	None
☐	MapLogOptRegDup	None	None	None	None	None	None	None	None
☐	MapExtraEffort2	panic-desktop	run6	Aborted	None	04h 36m 18s	54,653 (22%)	116,120 (24%)	None
☐	MapLogicOpt	None	None	None	None	None	None	None	None

Cosmic Run (Aug&Sep / 2016)

- So I just prepare Dummy data (w/ counter)
 - Take data ~30 min (Data size : 2 GByte, 2M events, TRG Rate ~ 1K Hz)
 - No data corruption found.
- Also take cosmic data. (~ 2M events, TRG Rate ~ 1K Hz)



- Assume cosmic energy = 200 MeV $\Rightarrow$ 1 FADC count = 2 MeV
- Assume cosmic energy = 300 MeV $\Rightarrow$ 1 FADC count = 3 MeV

ETM Firmware Status

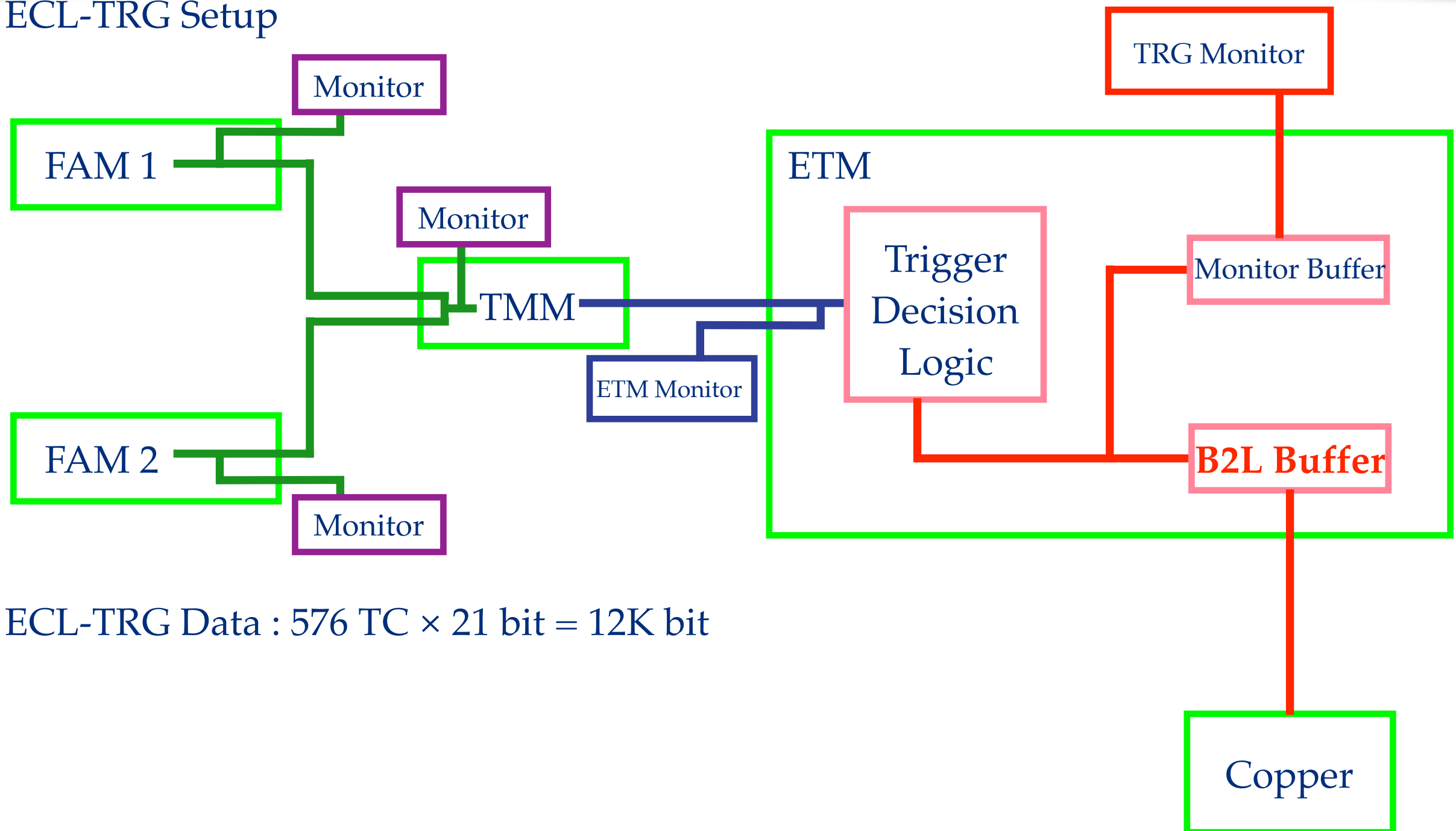
New B2Link Data

- Now we work on to reduce B2Link data size.
 - Send only hitted TC information w/ TRG output.
 - Final B2Link data size will be flexible based on # of hitted TC.
 - Totally, all variables are depended on TSim result.
 - # of Max. hitted TC = 30 (based on TSim), so I set 7 bit (0 ~ 127)
 - 1 TC hit information = TC number (10 bit) + Time (7 bit) + Energy (12 bit) = 29 bit
 - Increase event window : 250 ns $\rightarrow$ 375 ns
- Final B2Link Data
 - Revo(0)(8bit) + Max TC#(10 bit) + Max time(7bit) + Max energy(12bit) + ntc(6bit) + Energy weighted timing (7 or 8 bit) + Etotal (17bit) + ICN (?? bit) + etc(not decided)
 - ntc(0) + ntc(1) + ntc(2) +
Data(29bit data $\times$ ntc(0)) + Data(29bit data $\times$ ntc(1)) + Data(29bit data $\times$ ntc(2))
 - Max data size = ~3K bit

Backup

ECL-TRG Setup & Data Flow

- ECL-TRG Setup



- ECL-TRG Data : $576 \text{ TC} \times 21 \text{ bit} = 12\text{K bit}$