PDS Validation Updates

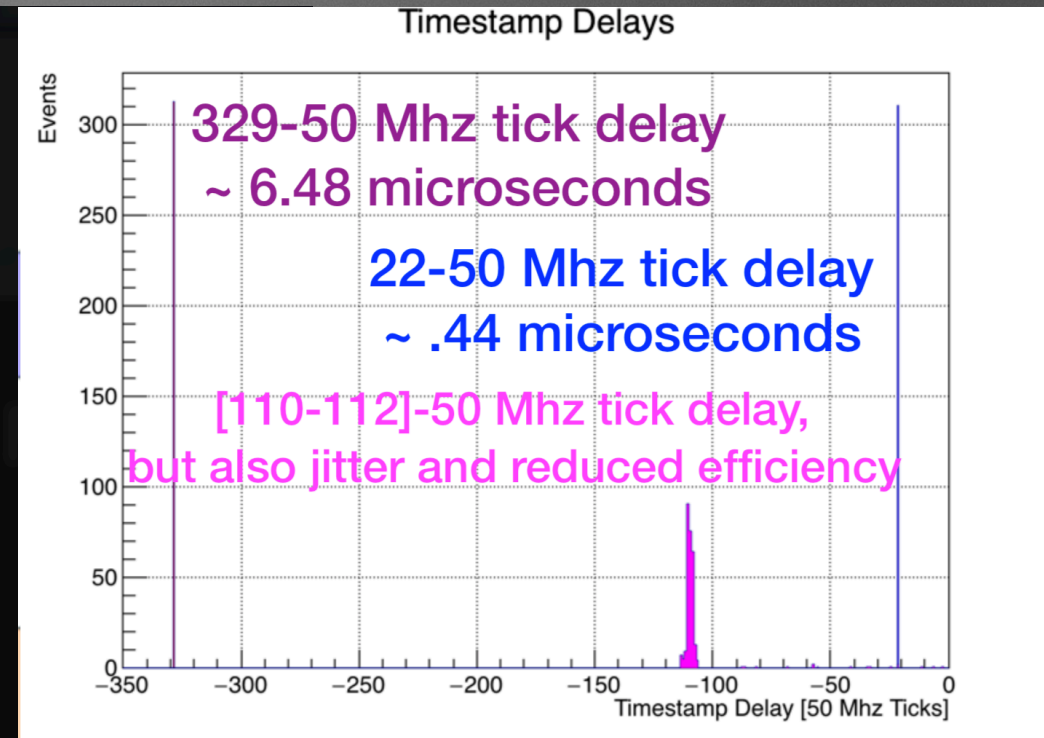March 14, 2019
Bryan Ramson, Kyle Spurgeon

Introduction

- Technology comparisons underway but need a sample of events to compare!

- Only beam right detectors see beam (only one ARAPUCA to compare).

- To get full coverage we need access to cosmics.

- PDS+TPC would be fine, but neither of these systems trigger on cosmics! We must do PDS+CRT+TPC

PDS+CRT Matching

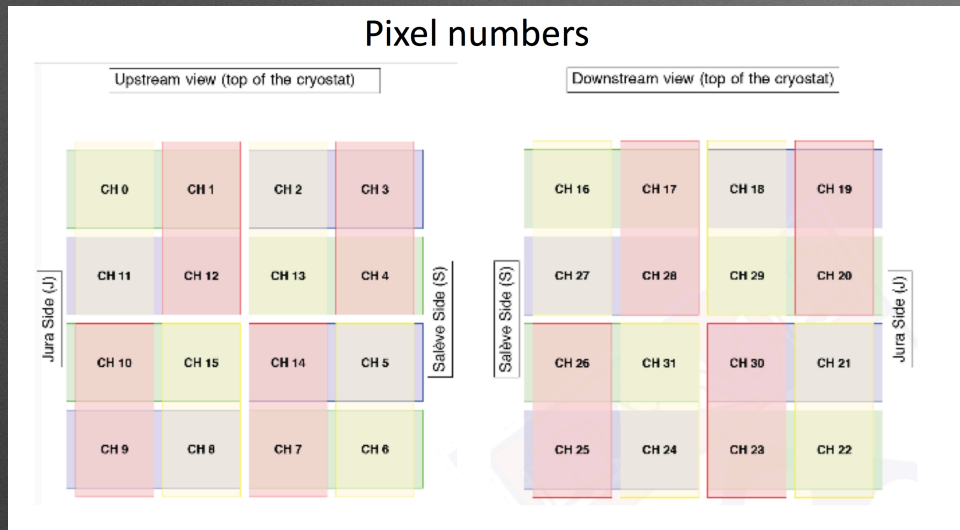- Have attempted to match PDS and CRT with timing differences:

```
Begin processing the 38th record. run: 5786 subRun: 1 event: 282 at 14-Mar-2019 13:33:37 CET
Begin processing the 39th record. run: 5786 subRun: 1 event: 284 at 14-Mar-2019 13:33:37 CET
ctb Timestamp: 77072379239569764 Channel 33554432
crt Timestamp: 77072379239569675 Channel 21
crt Timestamp: 77072379239569677 Channel 22
crt Timestamp: 77072379239569676 Channel 2
crt Timestamp: 77072379239569675 Channel 0
Begin processing the 40th record. run: 5786 subRun: 1 event: 291 at 14-Mar-2019 13:33:38 CET
ctb Timestamp: 77072379356172958 Channel 1612464355
crt Timestamp: 77072379356172869 Channel 28
crt Timestamp: 77072379356172869 Channel 31
crt Timestamp: 77072379356172873 Channel 8
crt Timestamp: 77072379356172873 Channel 9
crt Timestamp: 77072379356172873 Channel 10
crt Timestamp: 77072379356172873 Channel 11
crt Timestamp: 77072379356172869 Channel 24
crt Timestamp: 77072379356172869 Channel 27
crt Timestamp: 77072379356172871 Channel 2
crt Timestamp: 77072379356172872 Channel 1
Begin processing the 41st record. run: 5786 subRun: 1 event: 441 at 14-Mar-2019 13:33:38 CET
Begin processing the 42nd record. run: 5786 subRun: 1 event: 444 at 14-Mar-2019 13:33:38 CET
Begin processing the 43rd record. run: 5786 subRun: 1 event: 450 at 14-Mar-2019 13:33:38 CET
ctb Timestamp: 77072380937032620 Channel 2147485696
crt Timestamp: 77072380937032533 Channel 4
crt Timestamp: 77072380937032533 Channel 3
crt Timestamp: 77072380937032534 Channel 1
crt Timestamp: 77072380937032529 Channel 20
crt Timestamp: 77072380937032531 Channel 23
Begin processing the 44th record. run: 5786 subRun: 1 event: 452 at 14-Mar-2019 13:33:39 CET
Begin processing the 45th record. run: 5786 subRun: 1 event: 454 at 14-Mar-2019 13:33:39 CET
ctb Timestamp: 77072381008811366 Channel 67108864
crt Timestamp: 77072381008811277 Channel 20
crt Timestamp: 77072381008811279 Channel 22
crt Timestamp: 77072381008811278 Channel 2
crt Timestamp: 77072381008811277 Channel 1
Begin processing the 46th record. run: 5786 subRun: 1 event: 457 at 14-Mar-2019 13:33:39 CET
ctb Timestamp: 77072381065996829 Channel 33554432
crt Timestamp: 77072381065996740 Channel 21
crt Timestamp: 77072381065996742 Channel 22
crt Timestamp: 77072381065996741 Channel 2
crt Timestamp: 77072381065996740 Channel 0
Begin processing the 47th record. run: 5786 subRun: 1 event: 461 at 14-Mar-2019 13:33:39 CET
ctb Timestamp: 77072381127572164 Channel 786688
crt Timestamp: 77072381127572076 Channel 5
crt Timestamp: 77072381127572075 Channel 7
crt Timestamp: 77072381127572076 Channel 29
crt Timestamp: 77072381127572076 Channel 30
crt Timestamp: 77072381127572076 Channel 31
Begin processing the 48th record. run: 5786 subRun: 1 event: 465 at 14-Mar-2019 13:33:40 CET
ctb Timestamp: 77072381172465205 Channel 33554432
crt Timestamp: 77072381172465116 Channel 21
crt Timestamp: 77072381172465118 Channel 22
crt Timestamp: 77072381172465116 Channel 2
crt Timestamp: 77072381172465116 Channel 1
Begin processing the 49th record. run: 5786 subRun: 1 event: 467 at 14-Mar-2019 13:33:40 CET
ctb Timestamp: 77072381211733933 Channel 2
crt Timestamp: 77072381211733843 Channel 24
crt Timestamp: 77072381211733843 Channel 27
```

Timestamp Delays

329-50 Mhz tick delay
~ 6.48 microseconds

22-50 Mhz tick delay
~ .44 microseconds

[110-112]-50 Mhz tick delay,
but also jitter and reduced efficiency

Events

Timestamp Delay [50 Mhz Ticks]

To wit: matching
requires understanding
of relative times

PDS+CRT Matching

- Time matching is fine, but need to understand *where* things are:

Pixel numbers

Upstream view (top of the cryostat)

CH 0	CH 1	CH 2	CH 3
CH 11	CH 12	CH 13	CH 4
CH 10	CH 15	CH 14	CH 5
CH 9	CH 8	CH 7	CH 6

Jura Side (JU) — Salève Side (S)

Downstream view (top of the cryostat)

CH 16	CH 17	CH 18	CH 19
CH 27	CH 28	CH 29	CH 20
CH 26	CH 31	CH 30	CH 21
CH 25	CH 24	CH 23	CH 22

Salève Side (S) — Jura Side (JU)

Front

28		29	
20	21	22	23
16	17		
12		13	
4	5	6	7
0		1	

Back

30		31	
26	27	24	25
		18	19
15		14	
8	9	10	11
	3		2

x (cm) / y (cm)

Upstream

| CTB Pixel	CRT Hard Module	CRT Soft Module	GDML Center X (cm)	GDML Center Y (cm)	GDML Center Z (cm)
9	(6,5)	(4,0)	-111.494	65.2494	-972.204
8	(7,5)	(5,0)	58.5057	65.2494	-972.204
10	(6,4)	(4,12)	-111.494	235.249	-972.204
15	(7,4)	(5,12)	58.5057	235.249	-972.204
11	(1,3)	(20,16)	-111.494	410.249	-972.204
0	(1,2)	(20,28)	-111.494	580.249	-972.204
1	(0,3)	(21,28)	58.5057	580.249	-972.204
12	(0,2)	(21,16)	58.5057	410.249	-972.204
7	(5,10)	(6,1)	307.506	65.2494	-267.204
14	(8,11)	(6,13)	307.506	235.249	-267.204
6	(9,10)	(7,1)	477.506	65.2494	-267.204
5	(9,11)	(7,13)	477.506	235.249	-267.204
13	(15,12)	(22,17)	307.506	410.249	-267.204
4	(15,13)	(23,17)	477.506	410.249	-267.204
2	(14,12)	(22,29)	307.506	580.249	-267.204
3	(14,13)	(23,29)	477.506	580.249	-267.204
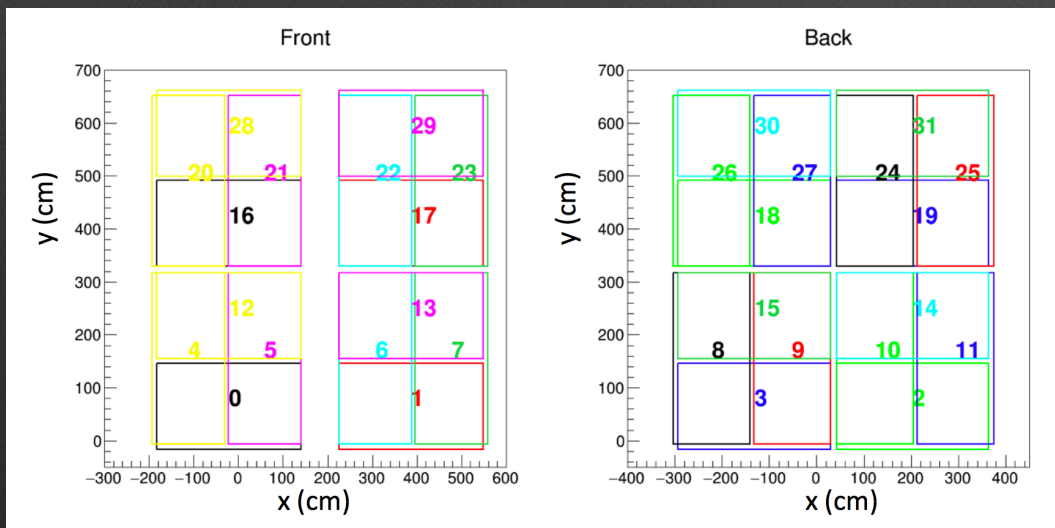
Downstream

CTB Pixel	CRT Hard Module	CRT Soft Module	GDML Center X (cm)	GDML Center Y (cm)	GDML Center Z (cm)
22	(22,21)	(8,3)	-221.494	65.2494	1085.55
21	(22,20)	(8,15)	-221.494	235.249	1085.55
23	(23,21)	(9,3)	-51.4943	65.2494	1085.55
30	(23,20)	(9,15)	-51.4943	235.249	1085.55
20	(17,19)	(26,18)	-221.494	410.249	1085.55
19	(17,18)	(26,30)	-221.494	580.249	1085.55
29	(16,19)	(27,18)	-51.4993	410.249	1085.55
18	(16,18)	(27,30)	-51.4993	580.249	1085.55
24	(24,26)	(10,2)	123.506	65.2494	1085.55
31	(24,27)	(10,14)	123.506	235.249	1085.55
25	(25,26)	(11,2)	293.506	65.2494	1085.55
26	(25,27)	(11,14)	293.506	235.249	1085.55
28	(31,28)	(24,19)	123.506	410.249	1085.55
17	(31,29)	(24,31)	123.506	580.249	1085.55
27	(30,28)	(25,19)	293.506	410.249	1085.55
16	(31,29)	(25,31)	293.506	580.249	1085.55

Toy Monte Carlo Comparisons

Toy Monte Carlo

Data Run 5875
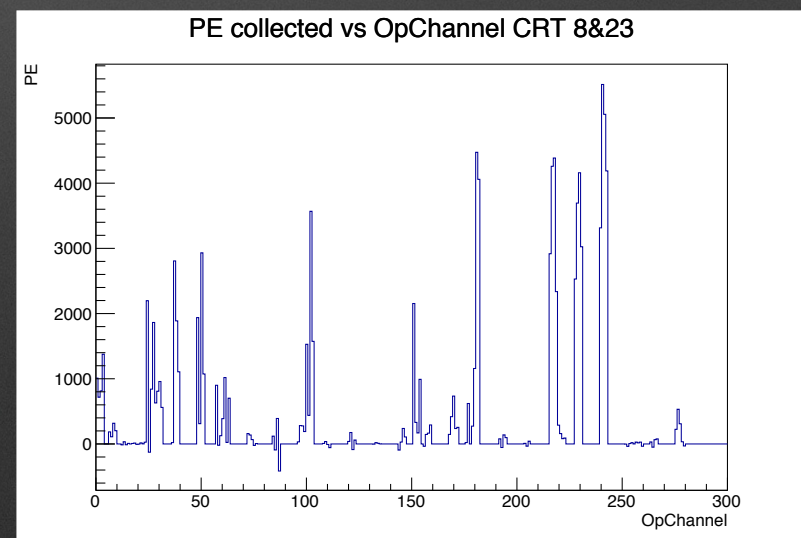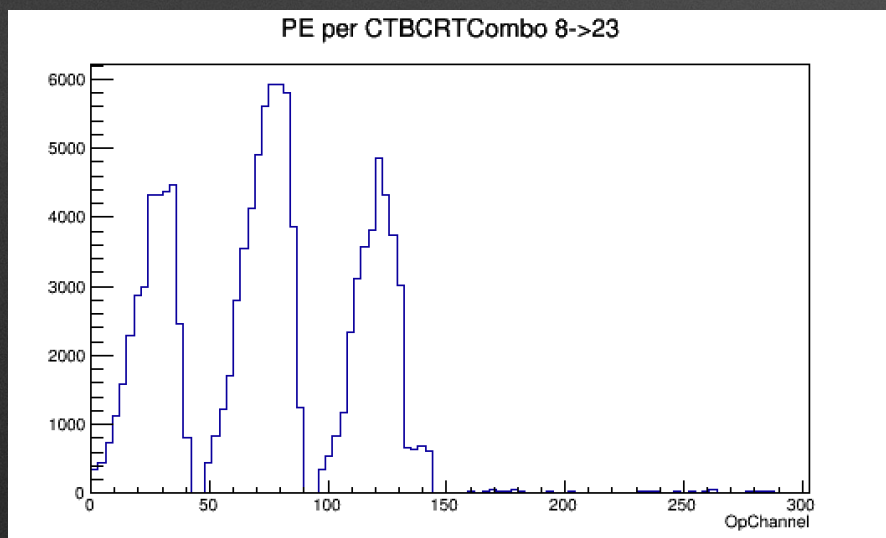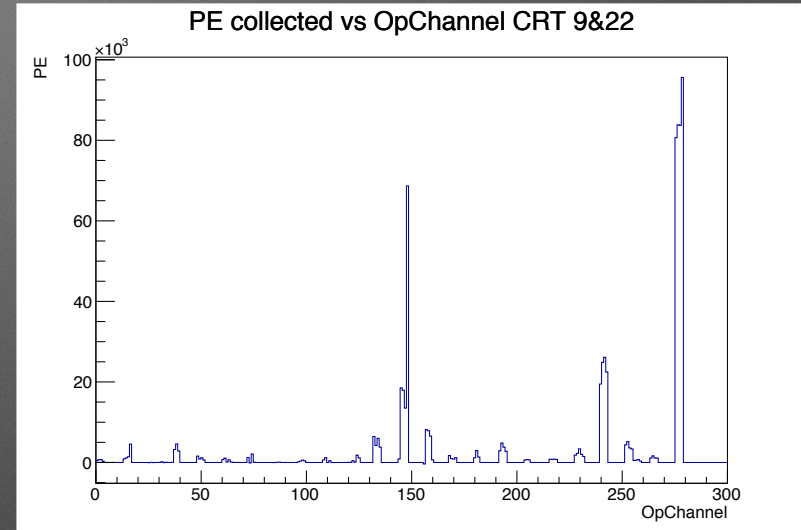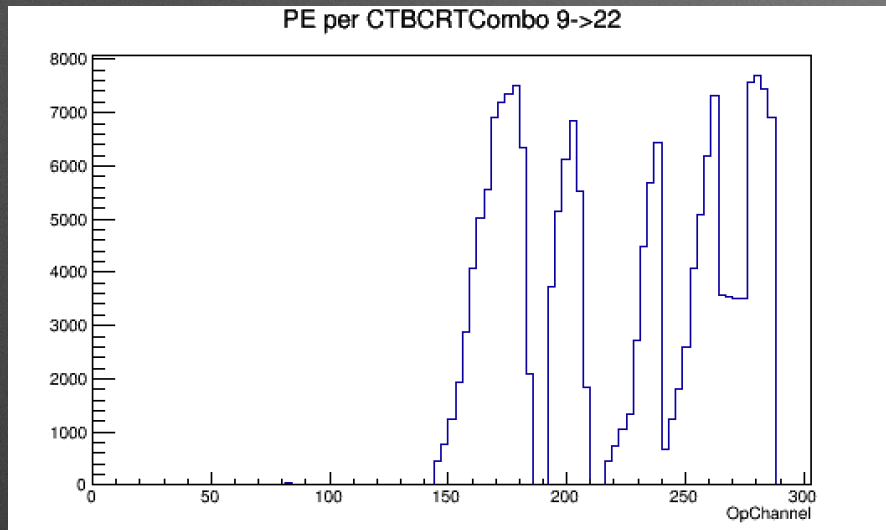
Interim Conclusions

- Sample selection and matching is difficult with large CRT size, but we haven't begun to use the TPC yet.

- Approach seems promising

- Still fine tuning actual CRT locations w.r.t. PDS+TPC

- Have yet to track CTB vs. CRT efficiency (CTB triggers but doesn't record pixels) but we get about ~30k horizontal triggers per hour(?)