

ALCOR simulations

F. Cossio, G. Dellacasa, C. Ferrero

14.11.2025

Time-inverted data

$T_{\text{coarse}} = \text{clk counter (2.5 ns)} = \text{coarse ToA}$

$T_{\text{fine}} = \text{TDC output} = \text{TDC conversion time}$

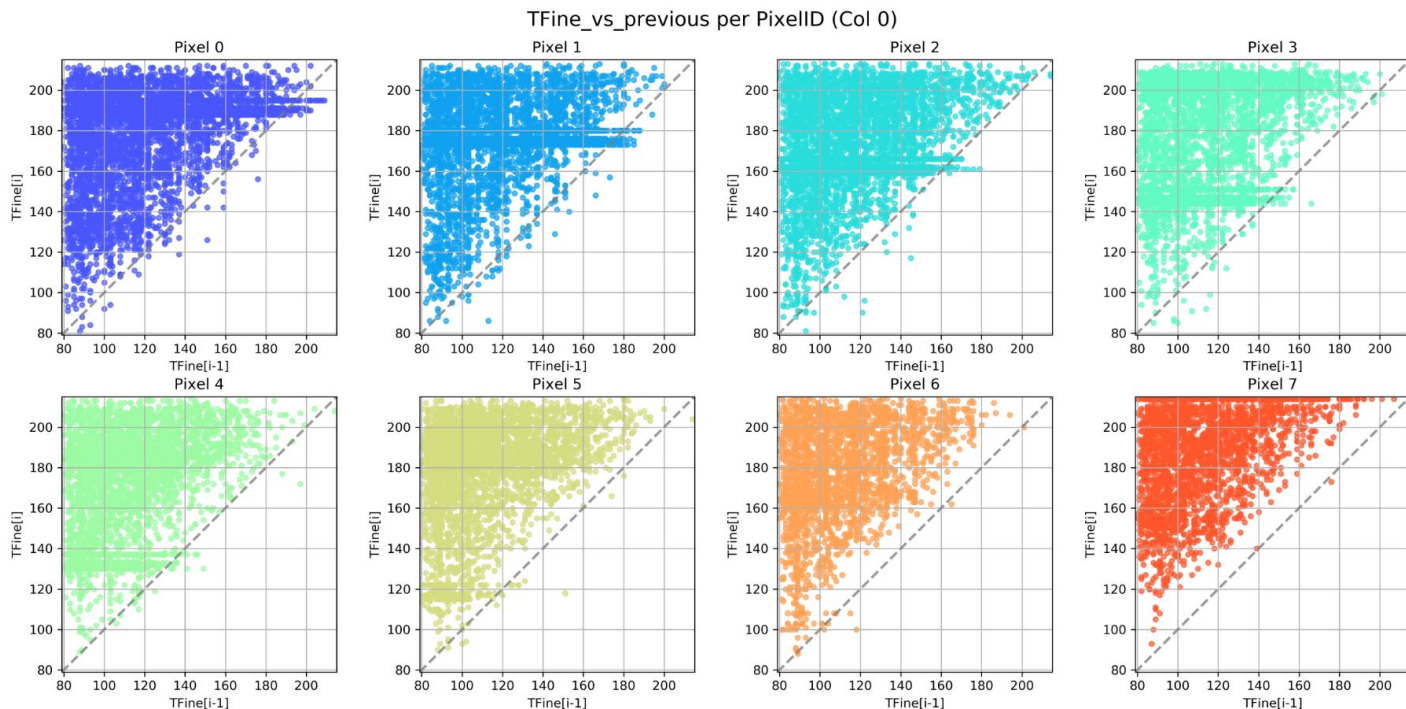
Select time-inverted data outputs $\rightarrow T_{\text{coarse}}[i] < T_{\text{coarse}}[i-1]$ (14% events)

Plot $T_{\text{fine}}[i]$ vs $T_{\text{fine}}[i-1]$

Almost all points have:

$$T_{\text{fine}}[i] > T_{\text{fine}}[i-1]$$

- Longer conversion time explains time-inverted data outputs



Time-inverted data

$T_{\text{coarse}} = \text{clk counter (2.5 ns)} = \text{coarse ToA}$

$T_{\text{fine}} = \text{TDC output} = \text{TDC conversion time}$

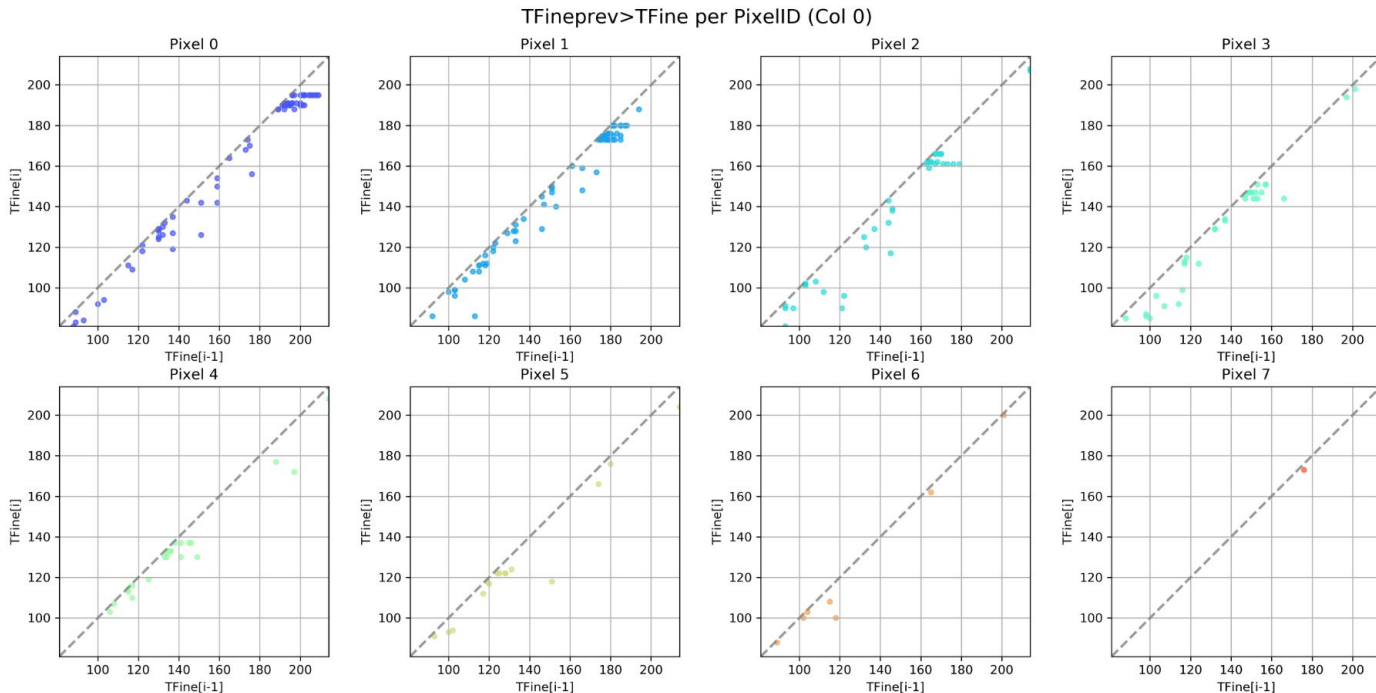
Select time-inverted data outputs $\rightarrow T_{\text{coarse}}[i] < T_{\text{coarse}}[i-1]$ (14% events)

Plot $T_{\text{fine}}[i]$ vs $T_{\text{fine}}[i-1]$

Check rare cases when:

$T_{\text{fine}}[i] < T_{\text{fine}}[i-1]$

- Pixel 0-1-2 have more entries w.r.t. pixel 5-6-7
- This is due to **pixel readout priority** when more than one pixel has one data ready to be transmitted to the EoC



Time-inverted data

$T_{\text{coarse}} = \text{clk counter (2.5 ns)} = \text{coarse ToA}$

$T_{\text{fine}} = \text{TDC output} = \text{TDC conversion time}$

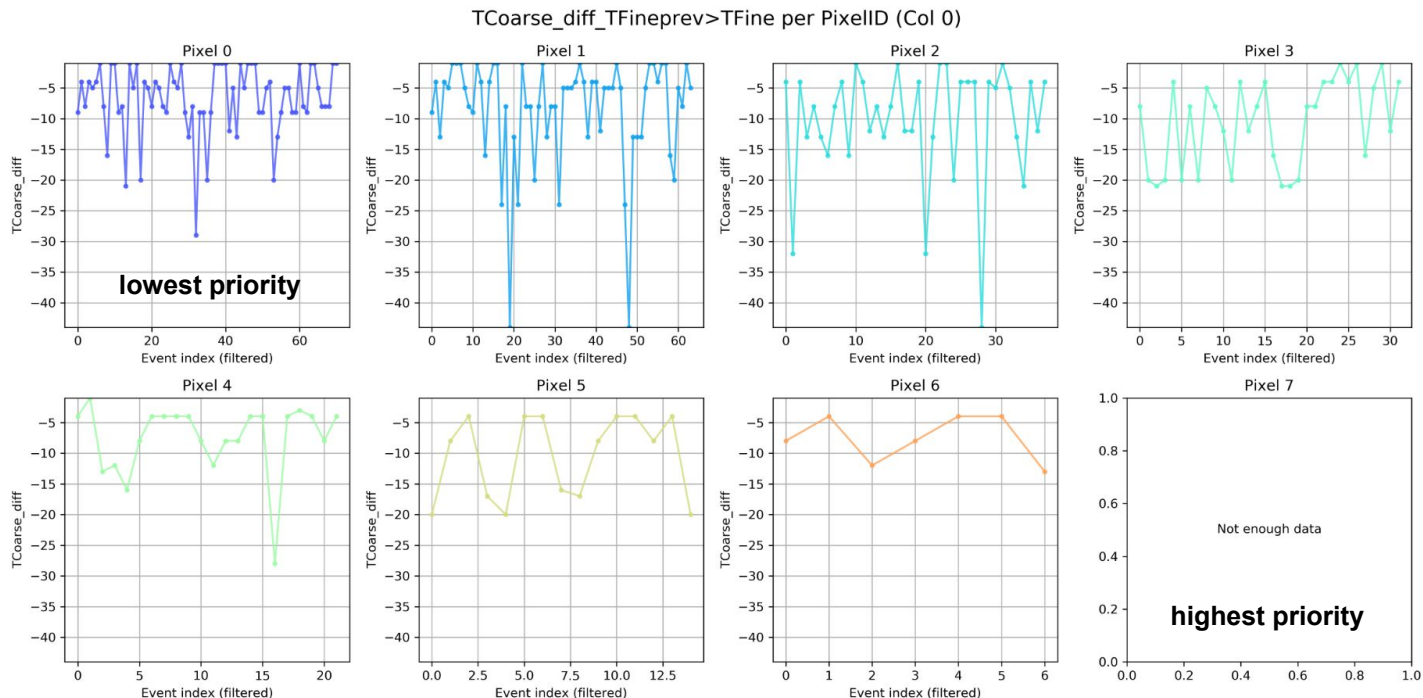
Select time-inverted data outputs $\rightarrow T_{\text{coarse}}[i] < T_{\text{coarse}}[i-1]$ (14% events)

Plot $T_{\text{fine}}[i]$ vs $T_{\text{fine}}[i-1]$

Check rare cases when:

$T_{\text{fine}}[i] < T_{\text{fine}}[i-1]$

- Pixel 0-1-2 have more entries w.r.t. pixel 5-6-7
- This is due to **pixel readout priority** when more than one pixel has one data ready to be transmitted to the EoC



```

export -f /etc/ld.so.conf.d/users/ferretorc/total_sim/data_files/optimize_sim_delay_optmode_3_more_statistics > /data/output_color_notsorted.csv > /data
1 HexWord,ColID,PixelID,tdcID,TCoarse,TCoarse_diff,TFine,ToA,FrameNum,ToA_corrected,CoarseCounter
168925 0E1A6C77,0,3,2,3382,71,119,8454.21875,3371,43089834.21875,5110
168926 0719ECAD,0,1,3,3318,-64,173,8293.1640625,3371,43089673.1640625,5110
168927 011AEA6C,0,0,1,3445,127,108,8611.93359375,3371,43089991.93359375,5110
168928 121ACCB3,0,4,2,3430,-15,179,8573.046875,3371,43089953.046875,5110
168929 191DB49A,0,6,1,3802,372,154,9503.53515625,3371,43090883.53515625,5110
168930 131E9470,0,4,3,3914,112,112,9784.35546875,3371,43091164.35546875,5110
168931 1F1E5ED1,0,7,3,3887,-27,209,9714.9609375,3371,43091094.9609375,5110
168932 161FAC65,0,5,2,4054,167,101,10134.5703125,3371,43091514.5703125,5110
168933 151EFEBF,0,5,1,3967,-87,191,9915.3125,3371,43091295.3125,5110
168934 1A1FDC99,0,6,2,4078,111,153,10193.5546875,3371,43091573.5546875,5110
168935 10202C89,0,4,0,4118,40,137,10293.8671875,3371,43091673.8671875,5110
168936 172256BD,0,5,3,4395,277,189,10985.3515625,3371,43092365.3515625,5110
168937 04225CB4,0,1,0,4398,3,180,10993.02734375,3371,43092373.02734375,5110
168938 14242452,0,5,0,4626,228,82,11564.94140625,3371,43092944.94140625,5110
168939 05239CB0,0,1,1,4558,-68,176,11393.10546875,3371,43092773.10546875,5110
168940 1C246C5B,0,7,0,4662,104,91,11654.765625,3371,43093034.765625,5110
168941 0624A480,0,1,2,4690,28,128,11724.04296875,3371,43093104.04296875,5110
168942 0724DC88,0,1,3,4718,28,136,11793.88671875,3371,43093173.88671875,5110
168943 0225BA7D,0,0,2,4829,111,125,12071.6015625,3371,43093451.6015625,5110
168944 05261A5A,0,1,1,4877,48,90,12192.28515625,3371,43093572.28515625,5110
168945 08263481,0,2,0,4890,13,129,12224.0234375,3371,43093604.0234375,5110
168946 0425DC7F,0,1,0,4846,-44,127,12114.0625,3371,43093494.0625,5110
168947 0F270C90,0,3,3,4998,152,144,12493.73046875,3371,43093873.73046875,5110
168948 0C27D472,0,3,0,5098,100,114,12744.31640625,3371,43094124.31640625,5110
168949 06274CB6,0,1,2,5030,-68,182,12572.98828125,3371,43093952.98828125,5110
168950 1102DC85,0,4,1,366,-4664,133,913.9453125,3372,43095073.9453125,5110
168951 1D02EEBC,0,7,1,375,9,188,935.37109375,3372,43095095.37109375,5110
168952 120354A1,0,4,2,426,51,161,1063.3984375,3372,43095223.3984375,5110
168953 1503CC76,0,5,1,486,60,118,1214.23828125,3372,43095374.23828125,5110
168954 0D046C5B,0,3,1,566,80,91,1414.765625,3372,43095574.765625,5110
168955 1304BC82,0,4,3,606,40,130,1514.00390625,3372,43095674.00390625,5110
168956 1E05AC58,0,7,2,726,120,88,1814.82421875,3372,43095974.82421875,5110
168957 03071C95,0,0,3,910,184,149,2273.6328125,3372,43096433.6328125,5110
168958 0E08C45A,0,3,2,1122,212,90,2804.78515625,3372,43096964.78515625,5110
168959 160A04A2,0,5,2,1282,160,162,3203.37890625,3372,43097363.37890625,5110
168960 170B6487,0,5,3,1458,176,135,3643.90625,3372,43097803.90625,5110
168961 0F0B3CA8,0,3,3,1438,-20,168,3593.26171875,3372,43097753.26171875,5110
168962 1F0B9ED6,0,7,3,1487,49,214,3714.86328125,3372,43097874.86328125,5110
168963 000C8CC1,0,0,0,1606,119,193,4012.7734375,3372,43098172.7734375,5110

```

Pixel 1 has several hits close in time (also time-inverted) and lower priority w.r.t. pixel 2

This effect occurs when we have several hits with similar timestamp, so it depends on event rate

Time-inverted data

$T_{\text{coarse}} = \text{clk counter (2.5 ns)} = \text{coarse ToA}$

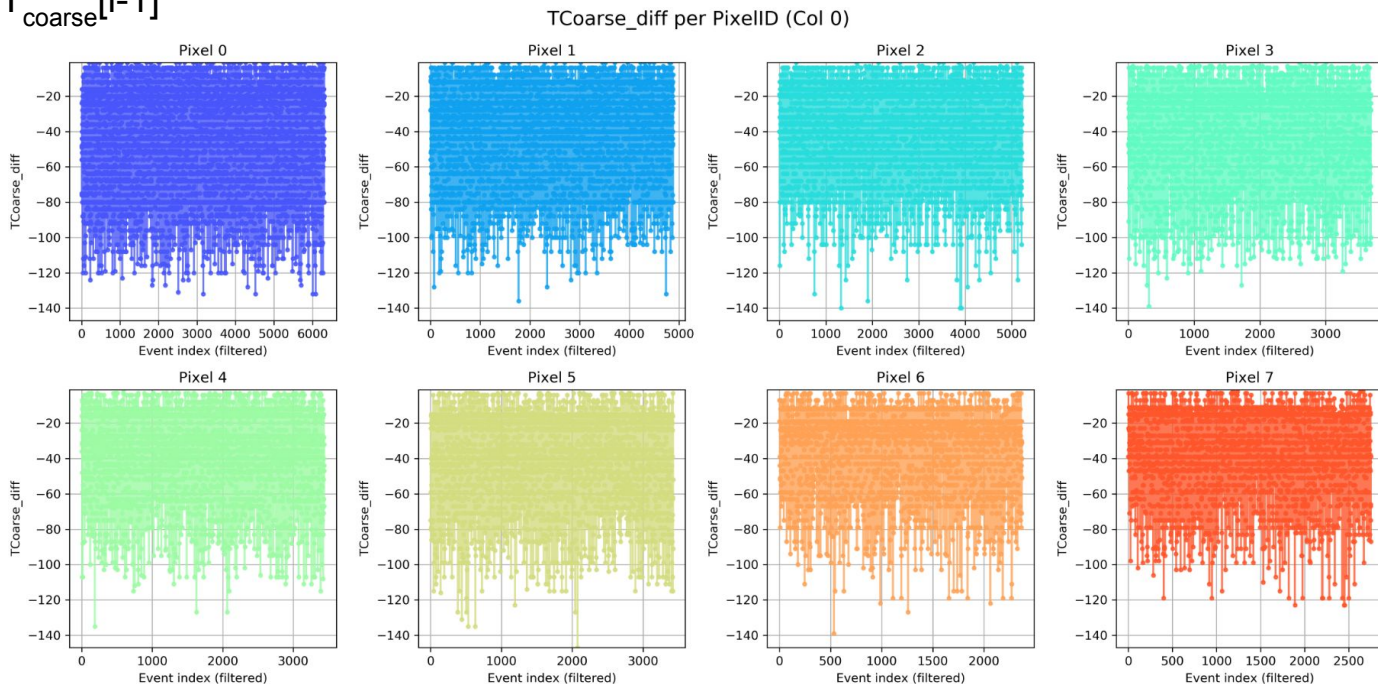
$T_{\text{fine}} = \text{TDC output} = \text{TDC conversion time}$

Select time-inverted data outputs $\rightarrow T_{\text{coarse}}[i] < T_{\text{coarse}}[i-1]$ (14% events)

Plot $T_{\text{coarse_diff}} = T_{\text{coarse}}[i] - T_{\text{coarse}}[i-1]$

MAX negative difference is
about 128 (= MAX TDC
conversion time)

Still some points have:
 $\text{abs}(T_{\text{coarse_diff}}) > 128$



export > elt150xl > disk0 > users > ferreroc > local_sim > data_files > optimize_shut_delay_opmode_3_more_statistics > output_Col0_notsorted.csv > data

1	HexWord	ColID	PixelID	tdcID	Tcoarse	Tcoarse_diff	TFine	ToA	FrameNum	ToA_corrected	CoarseCounter
57802	112184A6	0,4,1	4290	-16,166	10723	30078125	1153	14746063	30078125	5110	
57803	1B22AEB0	0,6,3	4439	149,176	11095	60546875	1153	14746435	60546875	5110	
57804	0F22EC96	0,3,3	4470	31,150	11173	61328125	1153	14746513	61328125	5110	
57805	122404A3	0,4,2	4610	140,163	11523	359375	1153	14746863	359375	5110	
57806	0A24C461	0,2,2	4706	96,97	11764	6484375	1153	14747104	6484375	5110	
57807	1B24ACA3	0,6,0	4694	-12,163	11733	359375	1153	14747073	359375	5110	
57808	132514B0	0,4,3	4746	52,176	11863	10546875	1153	14747203	10546875	5110	
57809	03268CBC	0,0,3	4934	188,188	12332	87109375	1153	14747672	87109375	5110	
57810	0C002C97	0,3,0	22	-4912,151	53	59375	1154	14748173	59375	5110	
57811	100076C1	0,4,0	59	37,193	145	2734375	1154	14748265	2734375	5110	
57812	0B00DCA2	0,2,3	110	51,162	273	37890625	1154	14748393	37890625	5110	
57813	16016C75	0,5,2	182	72,117	454	2578125	1154	14748574	2578125	5110	
57814	0D01BC93	0,3,1	222	40,147	553	671875	1154	14748673	671875	5110	
57815	1701DCA4	0,5,3	238	16,170	593	22265625	1154	14748713	22265625	5110	
57816	14027CB3	0,5,0	318	80,179	793	046875	1154	14748913	046875	5110	
57817	15052C76	0,5,1	662	344,118	1654	23828125	1154	14749774	23828125	5110	
57818	1904EEBF	0,6,1	631	-31,191	1575	3125	1154	14749695	3125	5110	
57819	08058C7A	0,2,0	710	79,122	1774	16015625	1154	14749894	16015625	5110	
57820	1605EC5A	0,5,2	758	48,90	1894	78515625	1154	14750014	78515625	5110	
57821	0A077C86	0,2,2	958	200,134	2393	92578125	1154	14750513	92578125	5110	
57822	17080C5E	0,5,3	1030	72,94	2574	70703125	1154	14750694	70703125	5110	
57823	0906F4CD	0,2,1	890	-140,205	2222	5390625	1154	14750342	5390625	5110	
57824	1A0796B0	0,6,2	971	81,176	2425	60546875	1154	14750545	60546875	5110	
57825	0E09348F	0,3,2	1178	207,143	2943	75	1154	14751063	75	5110	
57826	110B6C85	0,4,1	1462	284,133	3653	9453125	1154	14751773	9453125	5110	
57827	0F0CA46E	0,3,3	1618	156,110	4044	39453125	1154	14752164	39453125	5110	
57828	120C5CBA	0,4,2	1582	-36,186	3952	91015625	1154	14752072	91015625	5110	
57829	1B0D1C7E	0,6,3	1678	96,126	4194	08203125	1154	14752314	08203125	5110	
57830	0C0D4CA0	0,3,0	1702	24,160	4253	41796875	1154	14752373	41796875	5110	
57831	130E5C62	0,4,3	1838	136,98	4594	62890625	1154	14752714	62890625	5110	
57832	0B110C9F	0,2,3	2182	344,159	5453	4375	1154	14753573	4375	5110	
57833	0B115CA6	0,2,0	2222	40,166	5553	30078125	1154	14753673	30078125	5110	
57834	10129C89	0,4,0	2382	160,137	5953	8671875	1154	14754073	8671875	5110	
57835	1114447D	0,4,1	2594	212,125	6484	1015625	1154	14754604	1015625	5110	
57836	12151C84	0,4,2	2702	108,132	6753	96484375	1154	14754873	96484375	5110	
57837	1816CC84	0,6,0	2918	216,132	7293	96484375	1154	14755413	96484375	5110	
57838	1316FC82	0,4,3	2942	24,130	7354	00390625	1154	14755474	00390625	5110	
57839	0D181C66	0,3,1	3086	144,102	7714	55078125	1154	14755834	55078125	5110	
57840	1417EEB7	0,5,0	3063	-23,183	7655	46875	1154	14755775	46875	5110	

0906F4CD Aa ab .* 1 of 1 ↑ ↓ ≡ ×

$T_{coarse_diff} = -140$

Pixel 2 has several hits close in time (also time-inverted) and lower priority w.r.t. pixel 5

This effect occurs when we have several hits with similar timestamp, so it depends on event rate

Summary

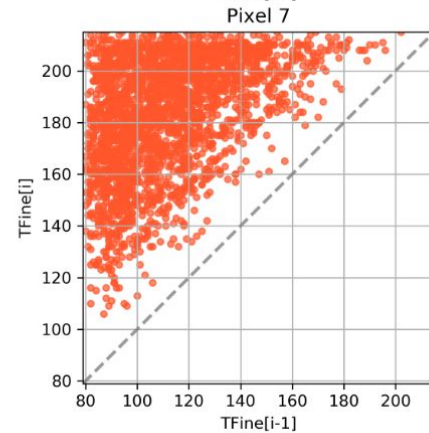
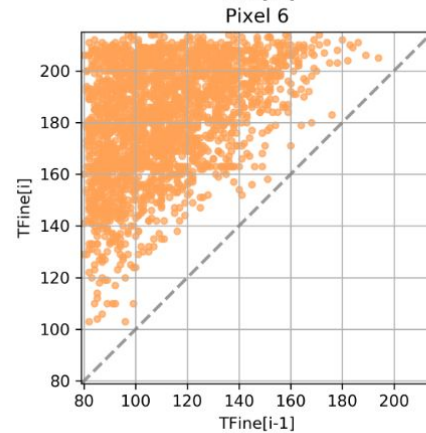
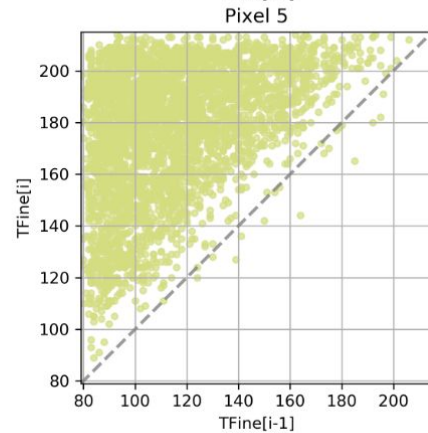
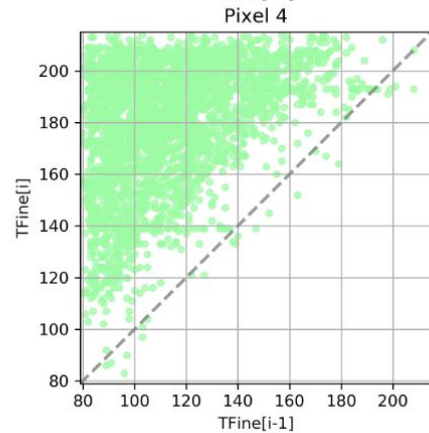
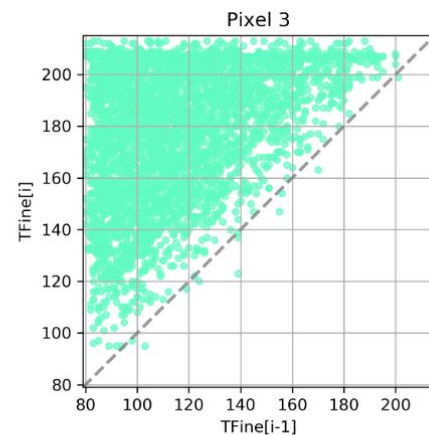
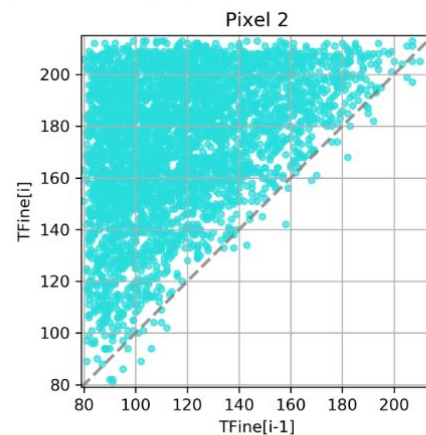
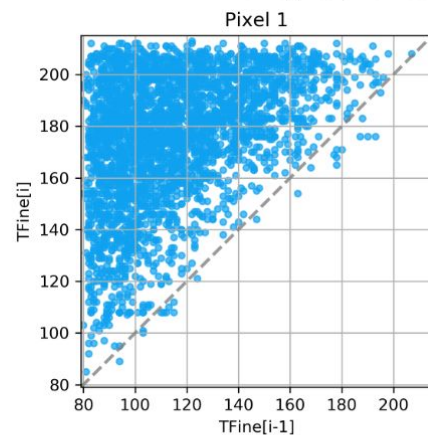
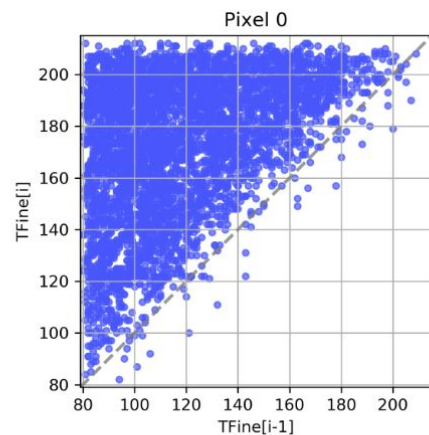
Simulation settings:

- LE mode
 - DCR = 16 MHz/column = 2 MHz/ch $\rightarrow$ real DCR = 1.25 MHz/ch
 - PHY rate = 1 MHz/column
 - Shutter width = 2.5 ns
- In this simulation we have 14% events with time-inverted data output
- Same simulation in SR mode gives 21% events

New simulation in SR mode with:

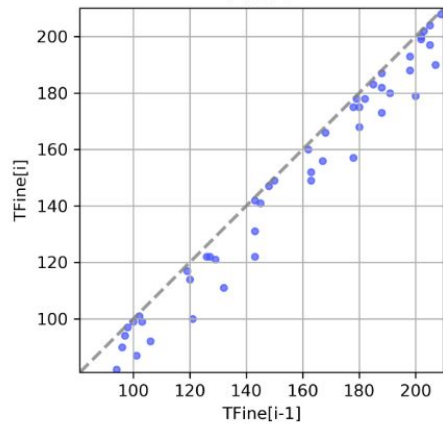
- DCR = 4 MHz/column = 500 kHz/ch $\rightarrow$ real DCR = 450 kHz/ch
- PHY rate = 100 kHz/column
- Shutter width = 7.5 ns

TFine_vs_previous per PixelID (Col 0)

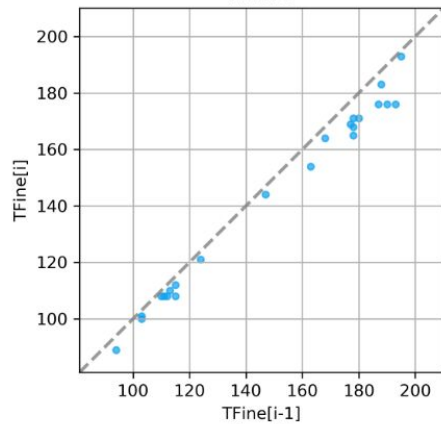


TFineprev>TFine per PixelID (Col 0)

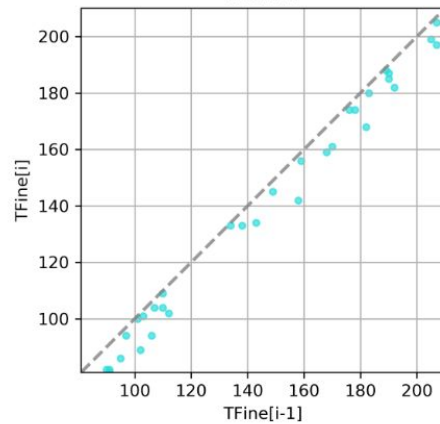
Pixel 0



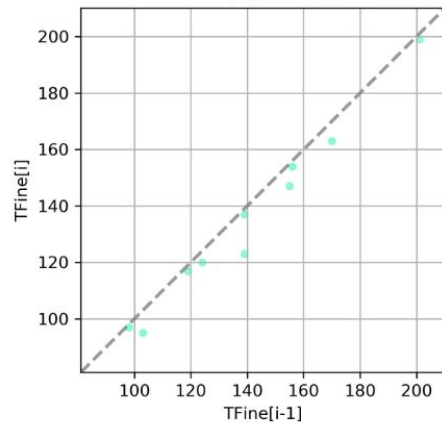
Pixel 1



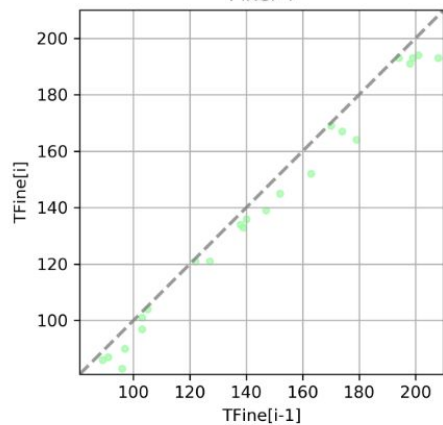
Pixel 2



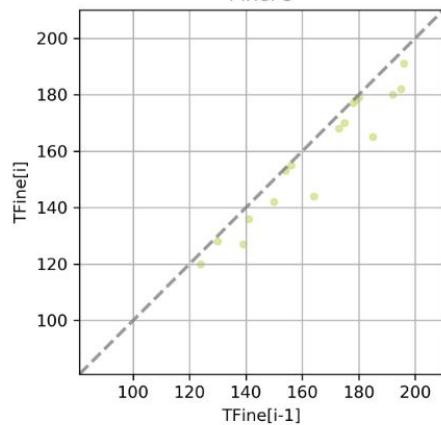
Pixel 3



Pixel 4

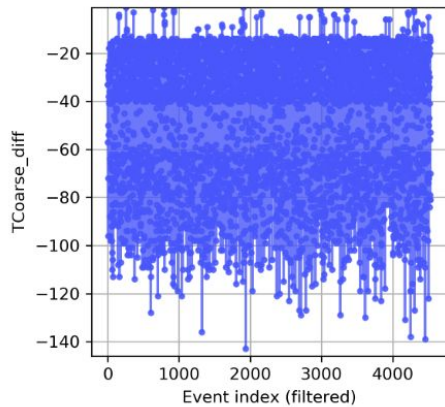


Pixel 5

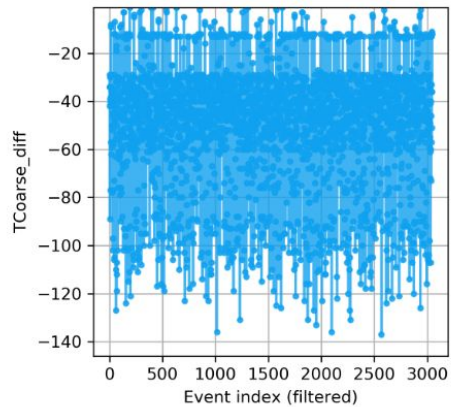


TCoarse_diff per PixelID (Col 0)

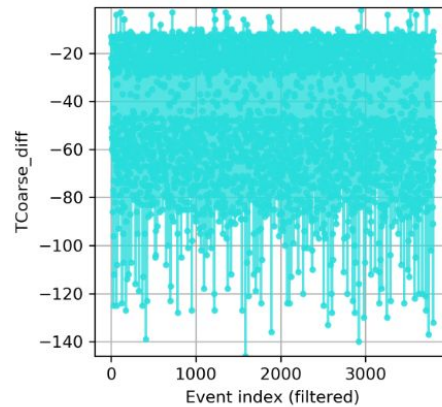
Pixel 0



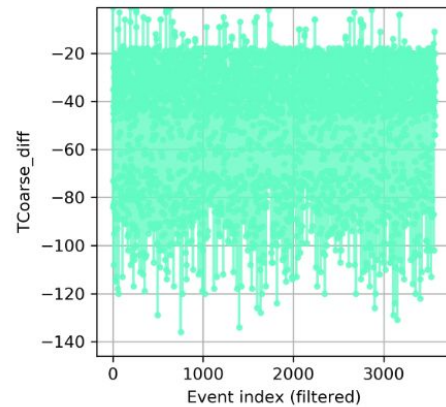
Pixel 1



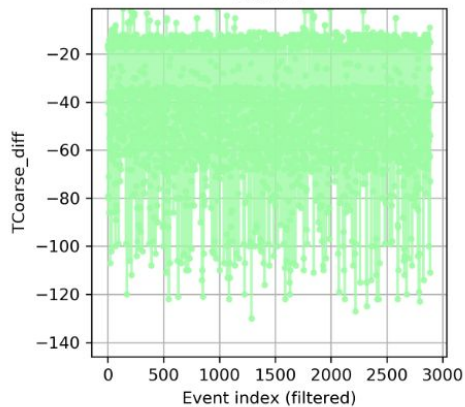
Pixel 2



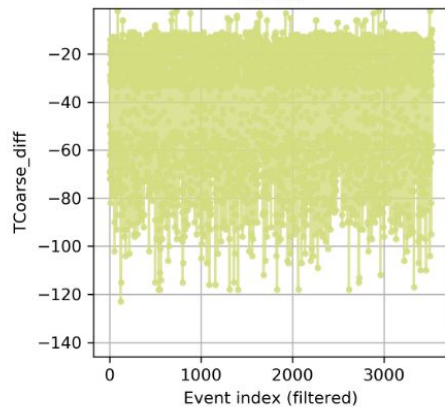
Pixel 3



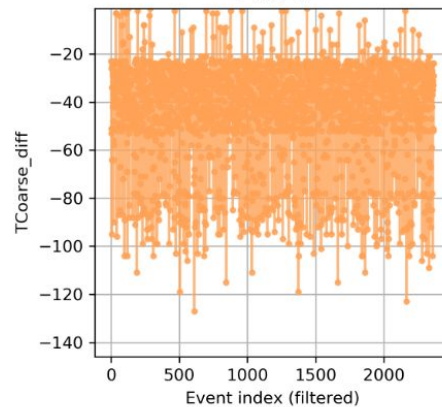
Pixel 4



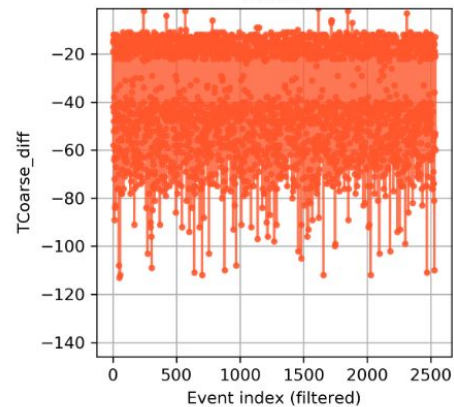
Pixel 5



Pixel 6



Pixel 7



TCoarse_diff_TFineprev>TFine per PixelID (Col 0)

