Updates on EICROC0 testing at BNL

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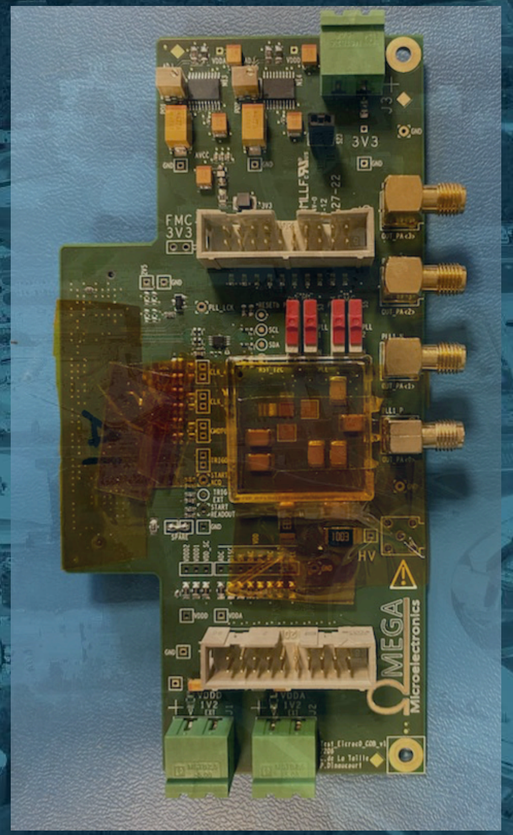
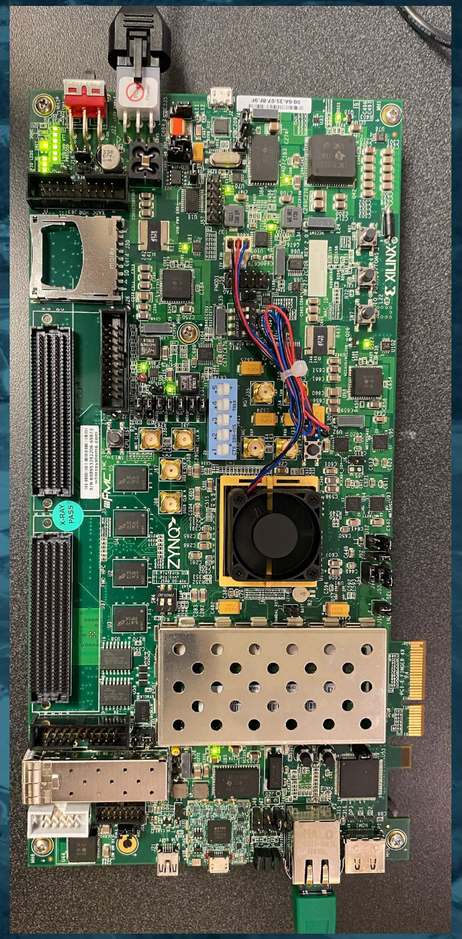
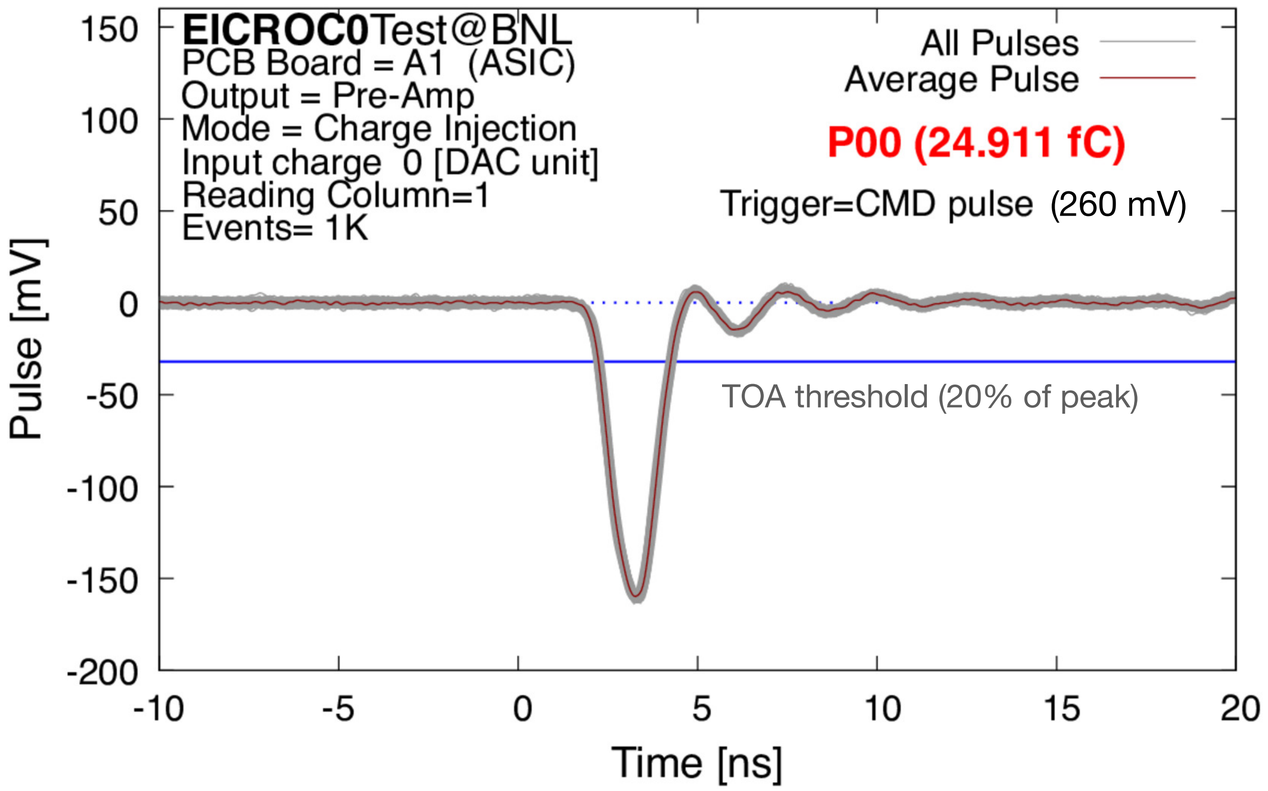


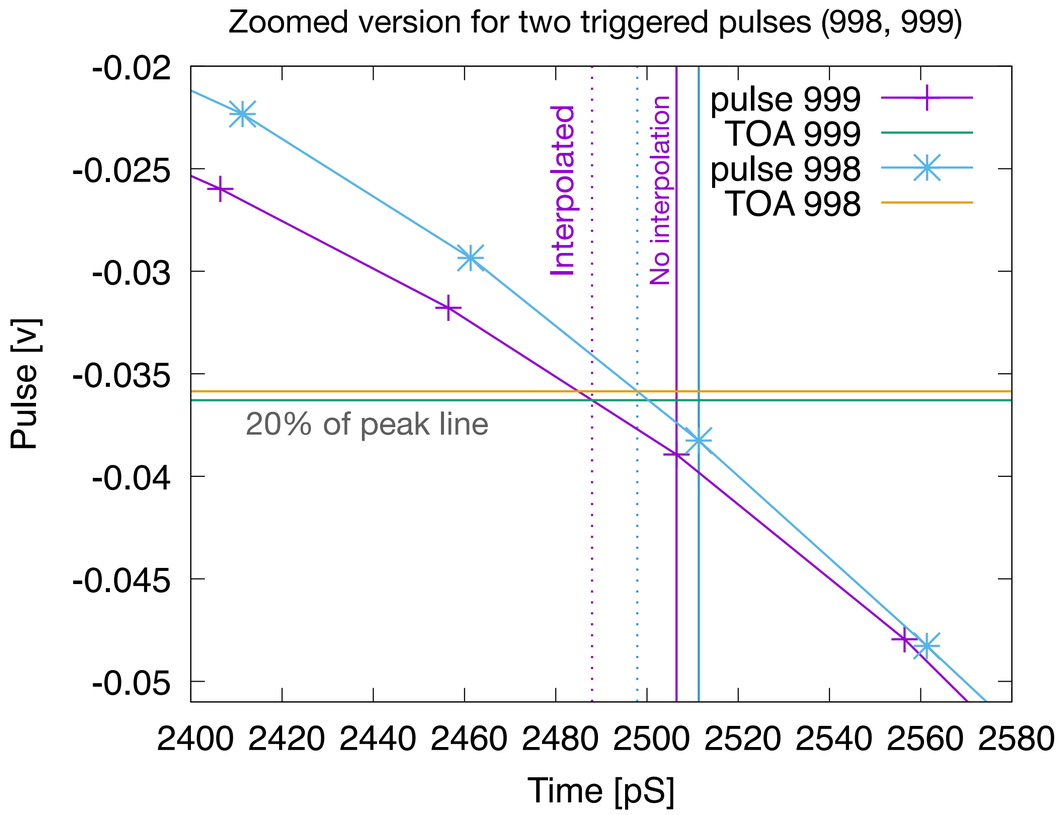


Updates on Dec 05, 2023
Group meeting with developers

Jitter determination method -1

TOA determination & interpolation

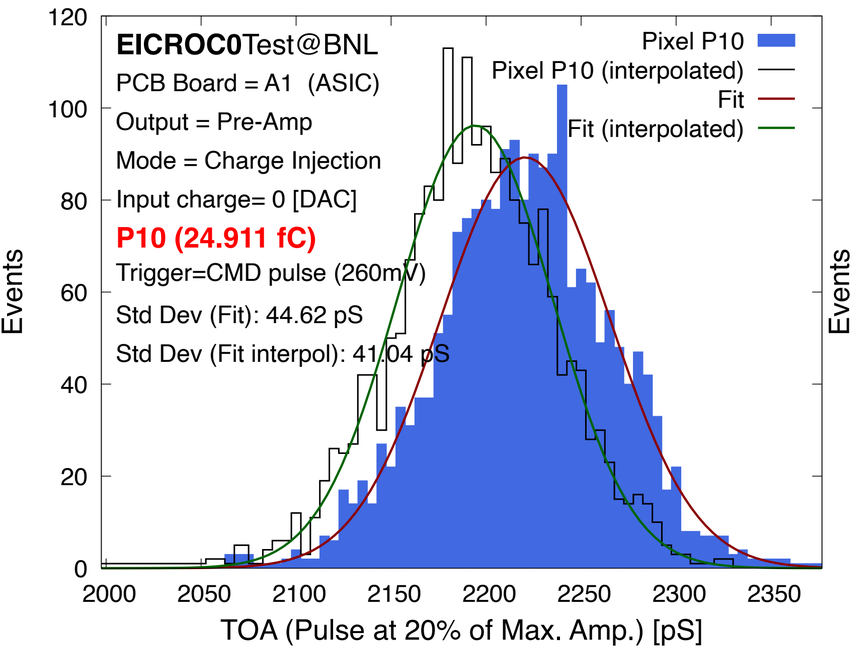


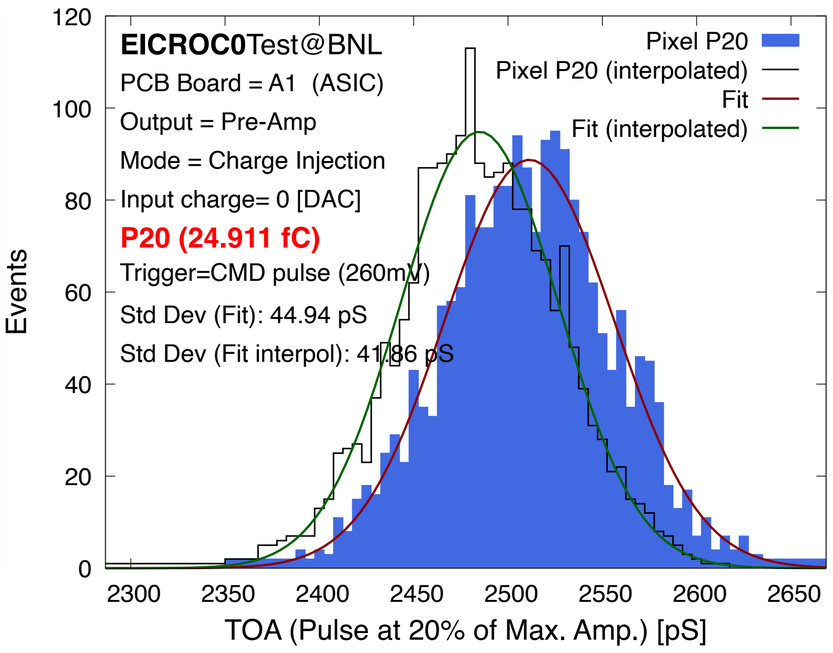


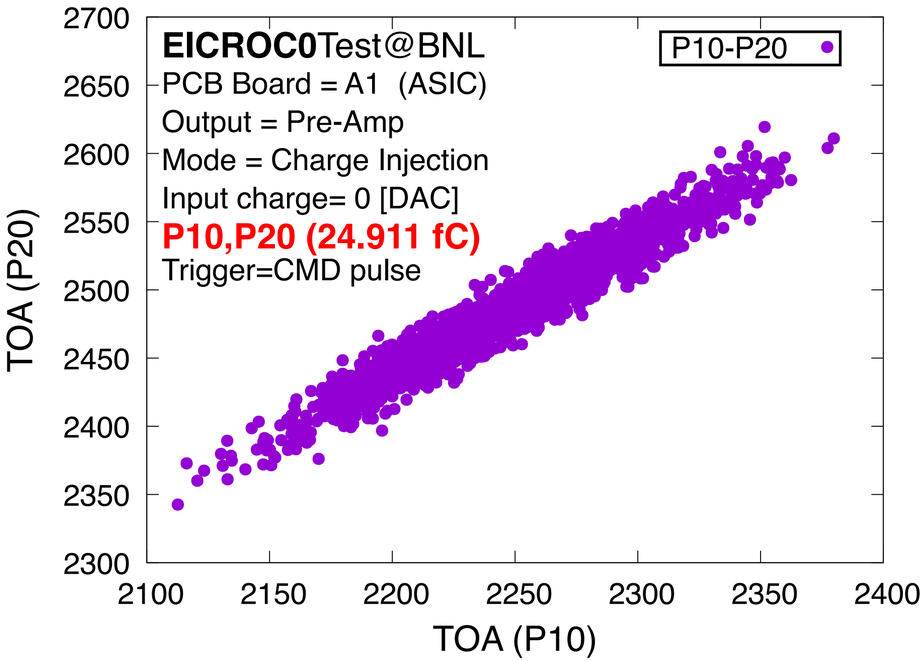
Charge injected in three channels
at the same time P00, P10, P20
1K times to extract the TOA

0,0	1,0	2,0	3,0
0,1	1,1	2,1	3,1
0,2	1,2	2,2	3,2
0,3	1,3	2,3	3,3

TOA distributions in 1D and 2D (correlation)



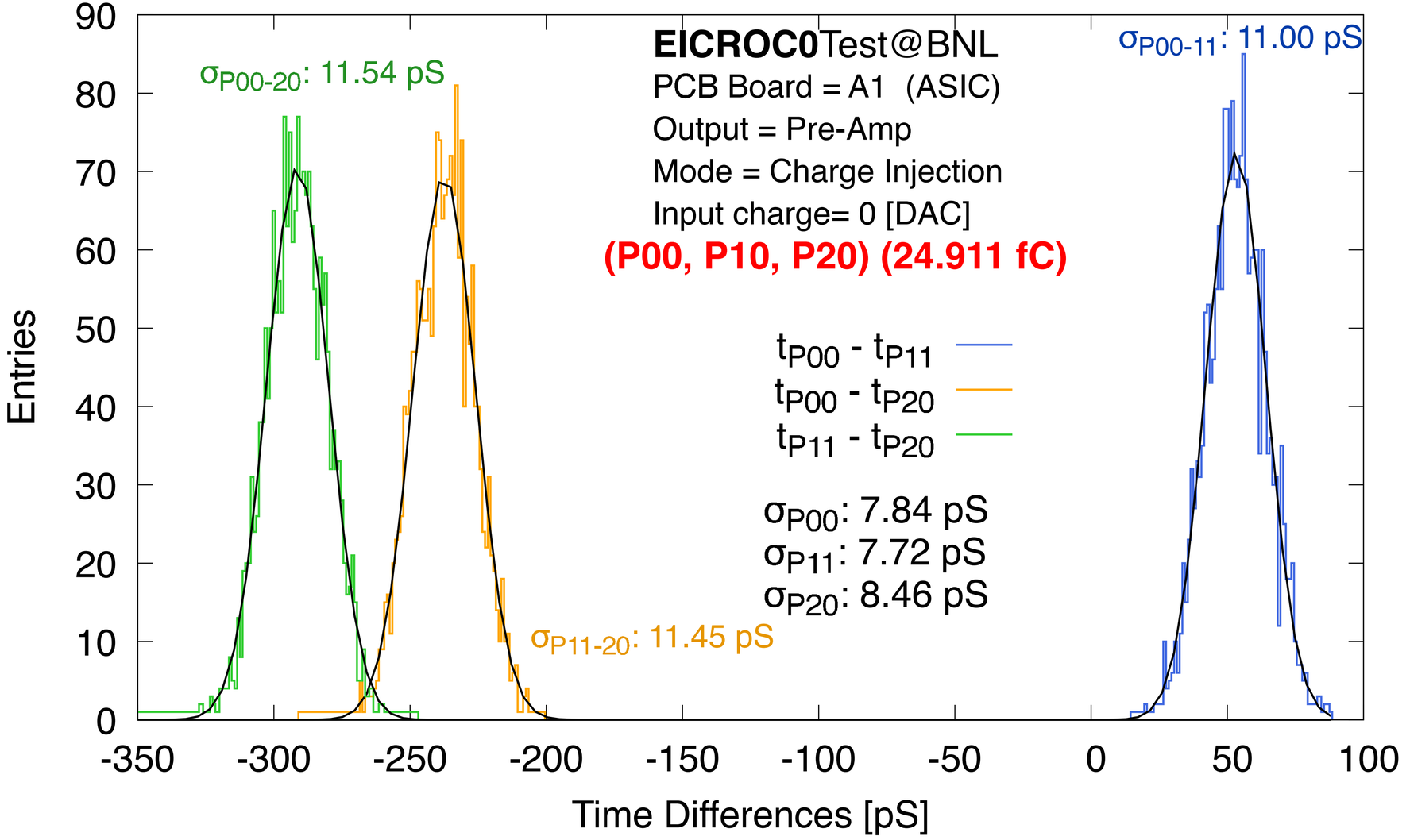




We look at the correlation of TOA between pixels

0,0	1,0	2,0	3,0
0,1	1,1	2,1	3,1
0,2	1,2	2,2	3,2
0,3	1,3	2,3	3,3

Jitter determination using timing difference



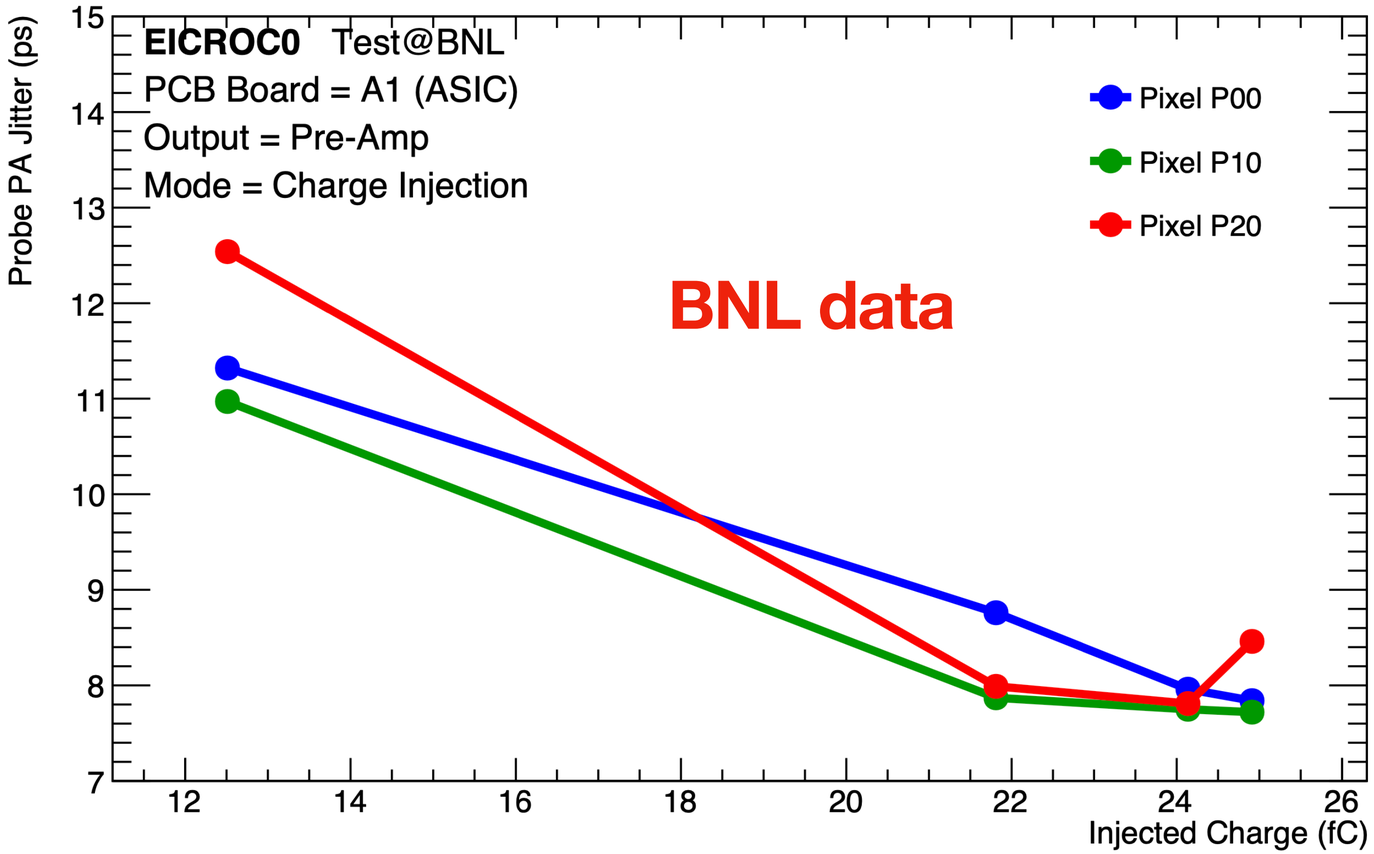
0,0	1,0	2,0	3,0
0,1	1,1	2,1	3,1
0,2	1,2	2,2	3,2
0,3	1,3	2,3	3,3

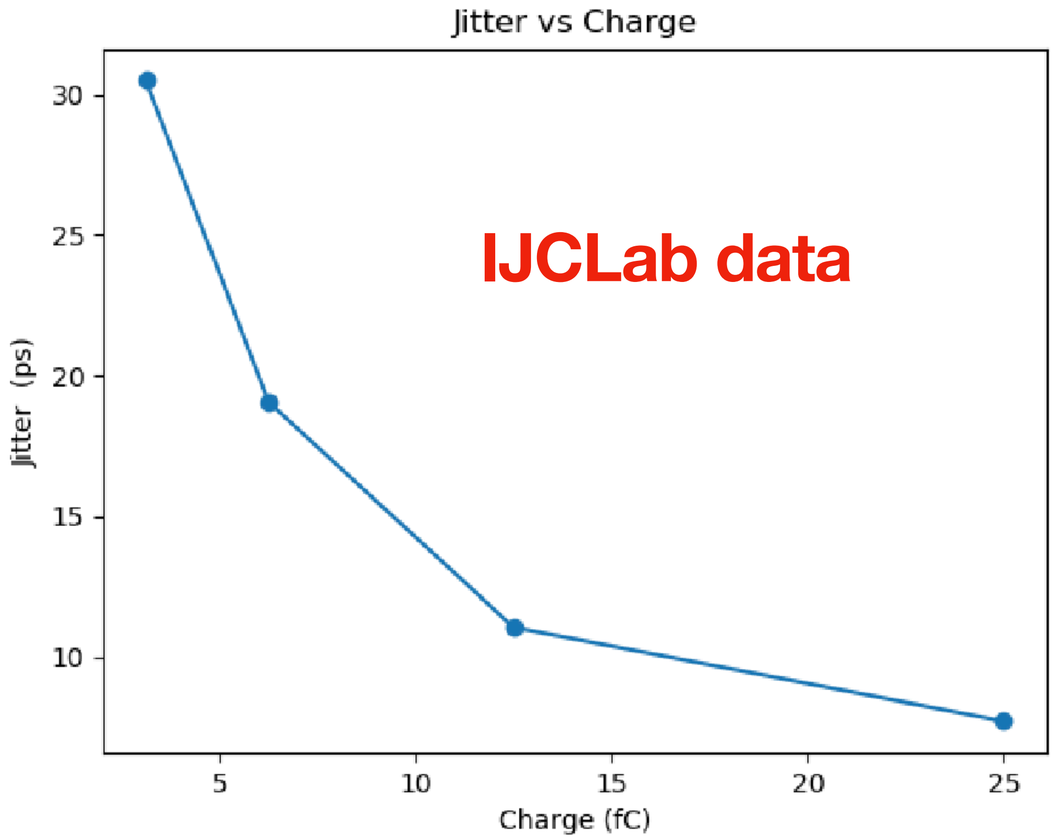
$$\sigma^2_{00-10} = \sigma^2_{00} + \sigma^2_{10}$$
$$\sigma^2_{00-20} = \sigma^2_{00} + \sigma^2_{20}$$
$$\sigma^2_{10-20} = \sigma^2_{10} + \sigma^2_{20}$$

Three equations, three unknowns. Solve to get jitter in each pixel

Individual pixels have 7-8 pS jitter using this method

Jitter with charge injection: Comparison





Jitter reduces with the amount of charge injection

Questions about TDC data

Configuration File

ProbeDiscri-ch0.txt

```
#indirect_register_addr, value            , # Comment
0x20C                  , B'0-1-110110     , # Bit7   :
                                            # Bit6   :
                                            # Bit5-0 :
0x022                  , B'1-001-0-1-11, # Pixel (0,0)
0x027                  , B'0-000-1-0-11, # Pixel (0,1)
0x02C                  , B'0-000-1-0-11, # Pixel (0,2)
0x031                  , B'0-000-1-0-11, # Pixel (0,3)
0x042                  , B'0-000-1-0-11, # Pixel (1,0)
0x047                  , B'0-000-1-0-11, # Pixel (1,1)
0x04C                  , B'0-000-1-0-11, # Pixel (1,2)
0x051                  , B'0-000-1-0-11, # Pixel (1,3)
0x082                  , B'0-000-1-0-11, # Pixel (2,0)
0x087                  , B'0-000-1-0-11, # Pixel (2,1)
0x08C                  , B'0-000-1-0-11, # Pixel (2,2)
0x091                  , B'0-000-1-0-11, # Pixel (2,3)
0x102                  , B'0-000-1-0-11, # Pixel (3,0)
0x107                  , B'0-000-1-0-11, # Pixel (3,1)
0x10C                  , B'0-000-1-0-11, # Pixel (3,2)
0x111                  , B'0-000-1-0-11, # Pixel (3,3)
```

LoopEvent-LS.py

```
    eic.set_shift_cmdpulse(100)        # 0..1023
    # eic.set_shift_trigger(150)        # 0..1023
    eic.set_shift_trigger(180)
    eic.wr_asic_reg(0x20A,180)
    # eic.clk40_en(1) # 40 Mhz clock ## When switching off the clock comment out the lines 100 and 101
    eic.lpgbtclk_en(1) # 160 Mhz clock
#   eic.cmdpulse(1000)
    for j in range(1000):
        eic.cmdpulse()
#           eic.cmdtrigger()
        time.sleep(.1)   #to make sure enough time to send signal to the oscilloscope
#         eic.set_shift_trigger(i*10)
#        eic.cmdtrigger()
        print ("trigger :",j)
    time.sleep(0.5)
    eic.lpgbtclk_en(1)
    #Comment out it when clock is swtiched off
    eic.extract_data_2_csv(outfilename_without_ext)
    eic.extract_data_2_txt(outfilename_without_ext)

eic.exit()
```

```
0x20A                  , B'1010-0000        , # Bit7-0 : 10bitDAC[7:0]

0x20B                  , B'000011-10      , # Bit7-2 : dac_biaspa[5:0]
                                            # Bit1-0 : 10bitDAC[9:8]
```

We get sensible data only when the most significant bits in the 10bitDAC are 10 or 11 (Last 2 bits in 0x20B are set to 10 in this case)

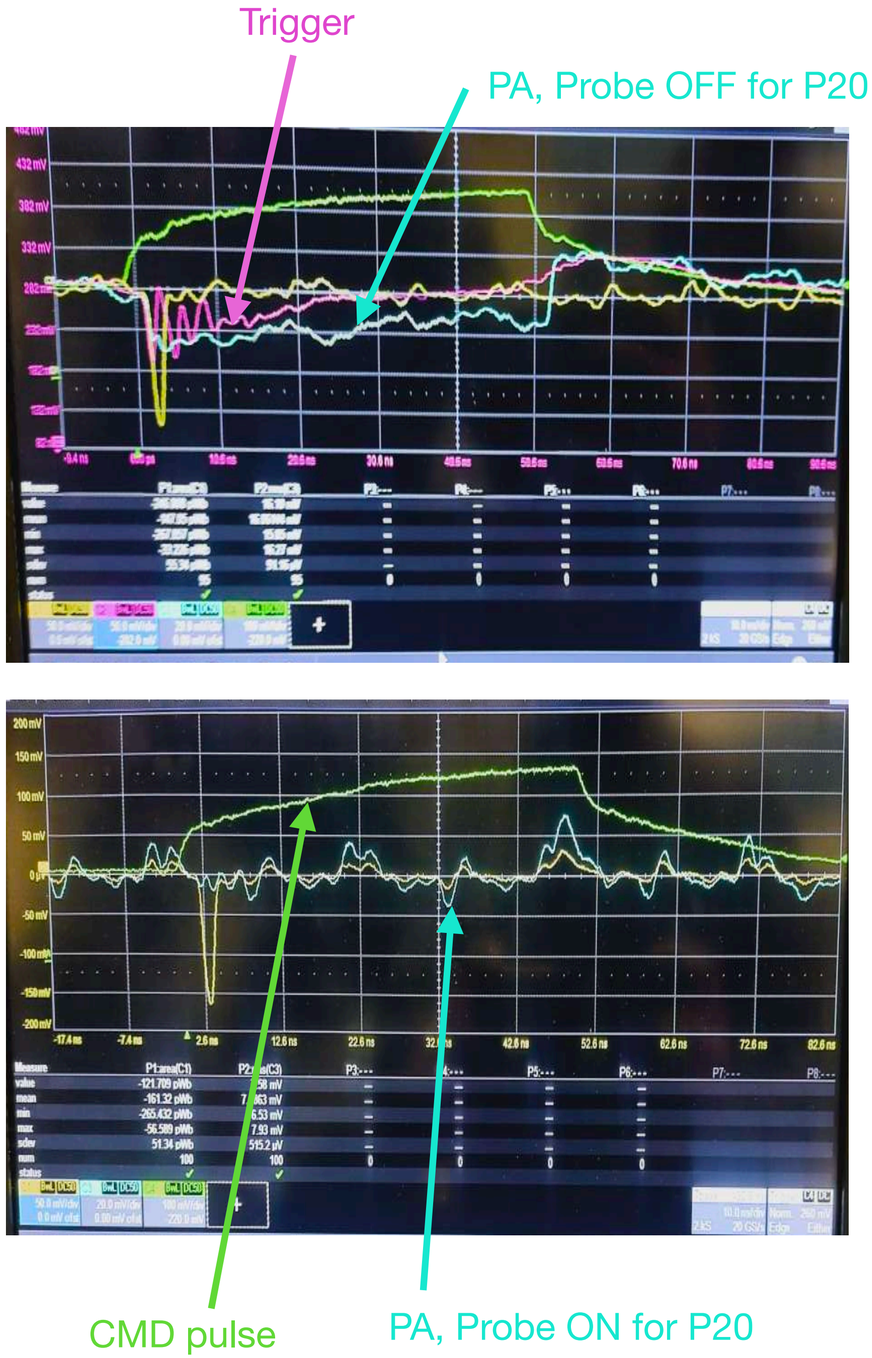
Question 1

Event Number	TDC0	ADC0	HB1	TDC1	ADC1	HB2	TDC2	ADC2	HB3	TDC3	ADC3	HB4	TDC4	ADC4	HB5	TDC5	ADC5	HB6	TDC6	ADC6	HB7	TDC7	ADC7	HB8
157795913352	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1
157795913352	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0
157795913352	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0
157795913352	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0
157795913352	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0
157795913352	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0
157795913352	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0
157795913352	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0
157795913352	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	98	237	0	0	237	0	0	237	1
157795913352	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0	0	199	0
157795913352	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0
157795913352	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0	0	208	0
157795913352	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0	0	181	0
157795913352	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0	0	205	0
157795913352	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0	0	204	0
157795913352	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0	0	206	0
157806236320	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1

P00

P20

P00



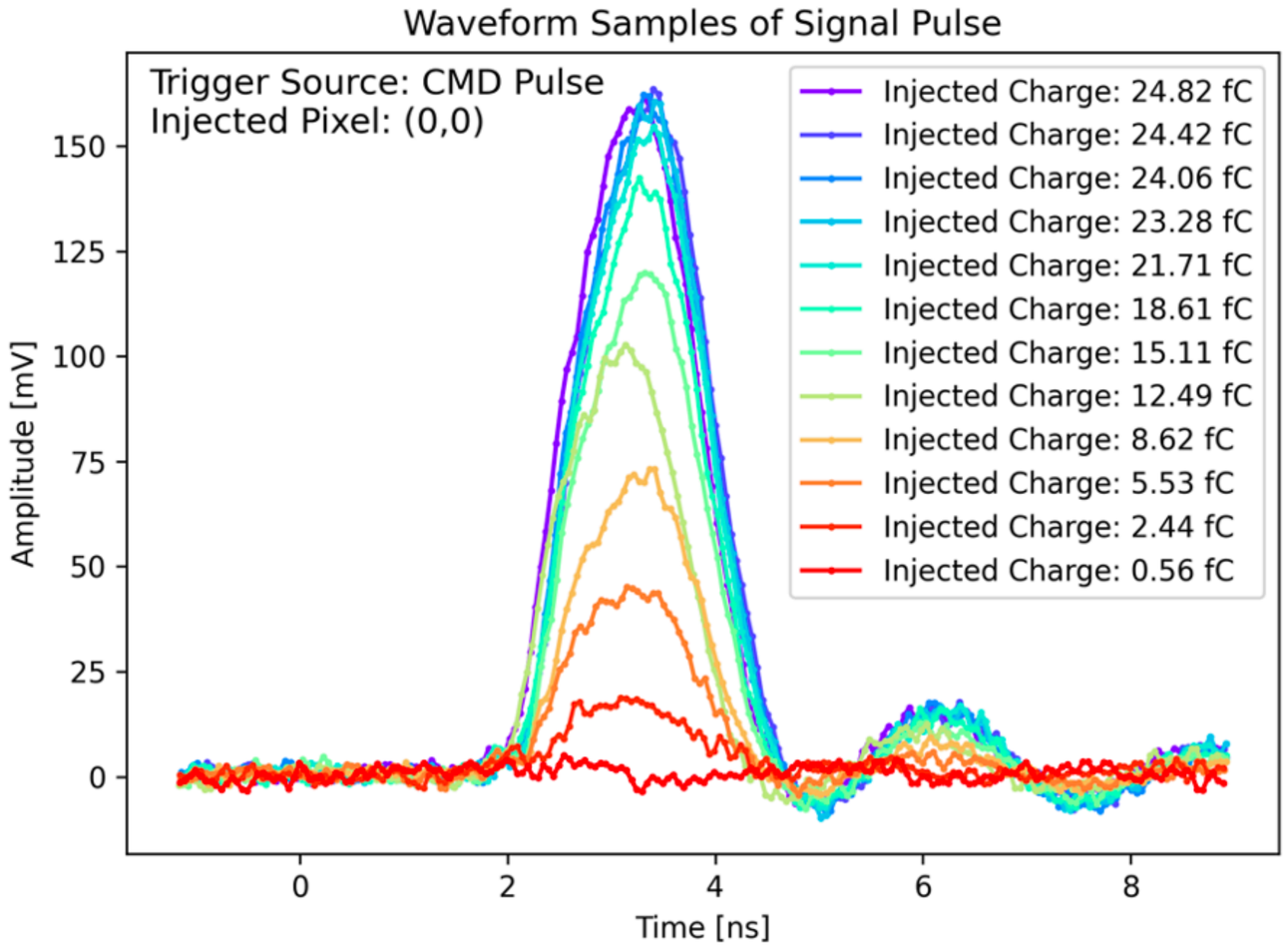
Why does P20 show a hit when charge is injected only in P00?

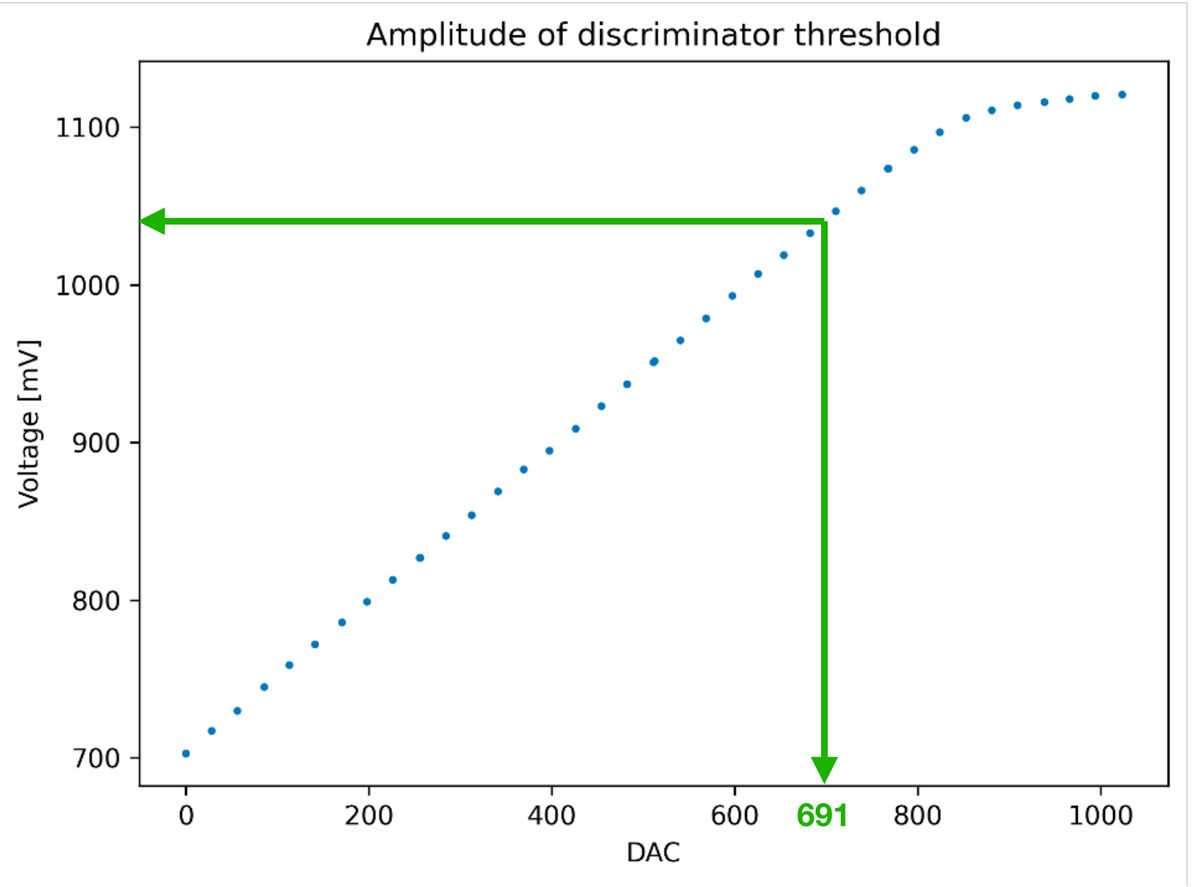
Question 2

Event Number	TDC0	ADC0	HB1	TDC1	ADC1	HB2	TDC2	ADC2	HB3	TDC3	ADC3	HB4	TDC4	ADC4	HB5	TDC5	ADC5	HB6	TDC6	ADC6	HB7	TDC7	ADC7	HB8
157795913352	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1
157806236320	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1
157817176335	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	100	237	0	0	237	0	0	237	1
157828015761	0	237	0	0	237	0	0	237	0	0	237	0	999	237	0	106	237	0	0	237	1	0	237	1
157838156384	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1
157848549940	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	108	237	0	0	237	0	0	237	1
157859213312	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	109	237	0	0	237	0	0	237	1
157869119187	0	237	0	0	237	0	0	237	0	0	237	0	1003	237	0	100	237	0	0	237	1	0	237	1
157879533714	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	105	237	0	0	237	0	0	237	1
157889622742	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	104	237	0	0	237	0	0	237	1
157899789152	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	109	237	0	0	237	0	0	237	1
157910334654	0	237	0	0	237	0	0	237	0	0	237	0	993	237	0	103	237	0	0	237	1	0	237	1
157920163796	0	237	0	0	237	0	0	237	0	0	237	0	0	237	0	110	237	0	0	237	0	0	237	1

Why are 2 hit bits and 2 TDC values recorded in multiple events when injecting into P00?

Question 2 (contd.)





Are multiple hit bits related to the discriminator threshold set by registers 0x20A and 0x20B?

Discriminator thresholds are set based on amplitudes of the analog waveform. Then, why are calibration voltages so high compared to waveform amplitudes?

Question 3

DAC62																
	Event_number	TDC0	HB0	TDC1	HB1	TDC2	HB2	TDC3	HB3	TDC4	HB4	TDC5	HB5	TDC6	HB6	TDC7	HB7
112	196430901194	0	0	0	0	0	0	0	0	230	0	0	0	0	1	0	0
304	196555690632	0	0	0	0	0	0	0	0	230	0	0	0	0	1	0	0
400	196621915728	243	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
496	196685227759	0	0	0	0	0	0	0	0	226	0	0	0	0	1	0	0
880	196937760056	0	0	0	0	0	0	0	0	222	0	0	0	0	1	0	0
1072	197065864803	0	0	0	0	0	0	0	0	233	0	0	0	0	1	0	0
1136	197107069123	0	0	0	0	0	0	0	0	246	0	0	0	0	1	0	0
1328	197233310464	0	0	0	0	0	0	0	0	235	0	0	0	0	1	0	0
1520	197365236924	0	0	0	0	0	0	0	0	219	0	0	0	0	1	0	0
1648	197449975772	0	0	0	0	0	0	0	0	217	0	0	0	0	1	0	0
1968	197663066343	0	0	0	0	0	0	0	0	234	0	0	0	0	1	0	0
2032	197704892621	0	0	0	0	0	0	0	0	233	0	0	0	0	1	0	0
2160	197793080546	0	0	0	0	0	0	0	0	236	0	0	0	0	1	0	0
2224	197836022346	0	0	0	0	0	0	0	0	230	0	0	0	0	1	0	0
2352	197923428693	0	0	0	0	0	0	0	0	226	0	0	0	0	1	0	0
2480	198011359644	0	0	0	0	0	0	0	0	235	0	0	0	0	1	0	0
2544	198055883515	0	0	0	0	0	0	0	0	243	0	0	0	0	1	0	0
2640	198119298600	242	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
2736	198184547262	0	0	0	0	0	0	0	0	234	0	0	0	0	1	0	0
2864	198267259200	0	0	0	0	0	0	0	0	223	0	0	0	0	1	0	0
3184	198481320498	0	0	0	0	0	0	0	0	235	0	0	0	0	1	0	0
3696	198825335716	0	0	0	0	0	0	0	0	230	0	0	0	0	1	0	0
3888	198950280464	0	0	0	0	0	0	0	0	235	0	0	0	0	1	0	0
4496	199357417503	242	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0
4784	199553534656	0	0	0	0	0	0	0	0	234	0	0	0	0	1	0	0
4848	199597429950	0	0	0	0	0	0	0	0	239	0	0	0	0	1	0	0
4912	199639123006	0	0	0	0	0	0	0	0	221	0	0	0	0	1	0	0
5104	199767524144	0	0	0	0	0	0	0	0	229	0	0	0	0	1	0	0

How to calibrate so as to get hit bit and TDC value in the same column for all events?

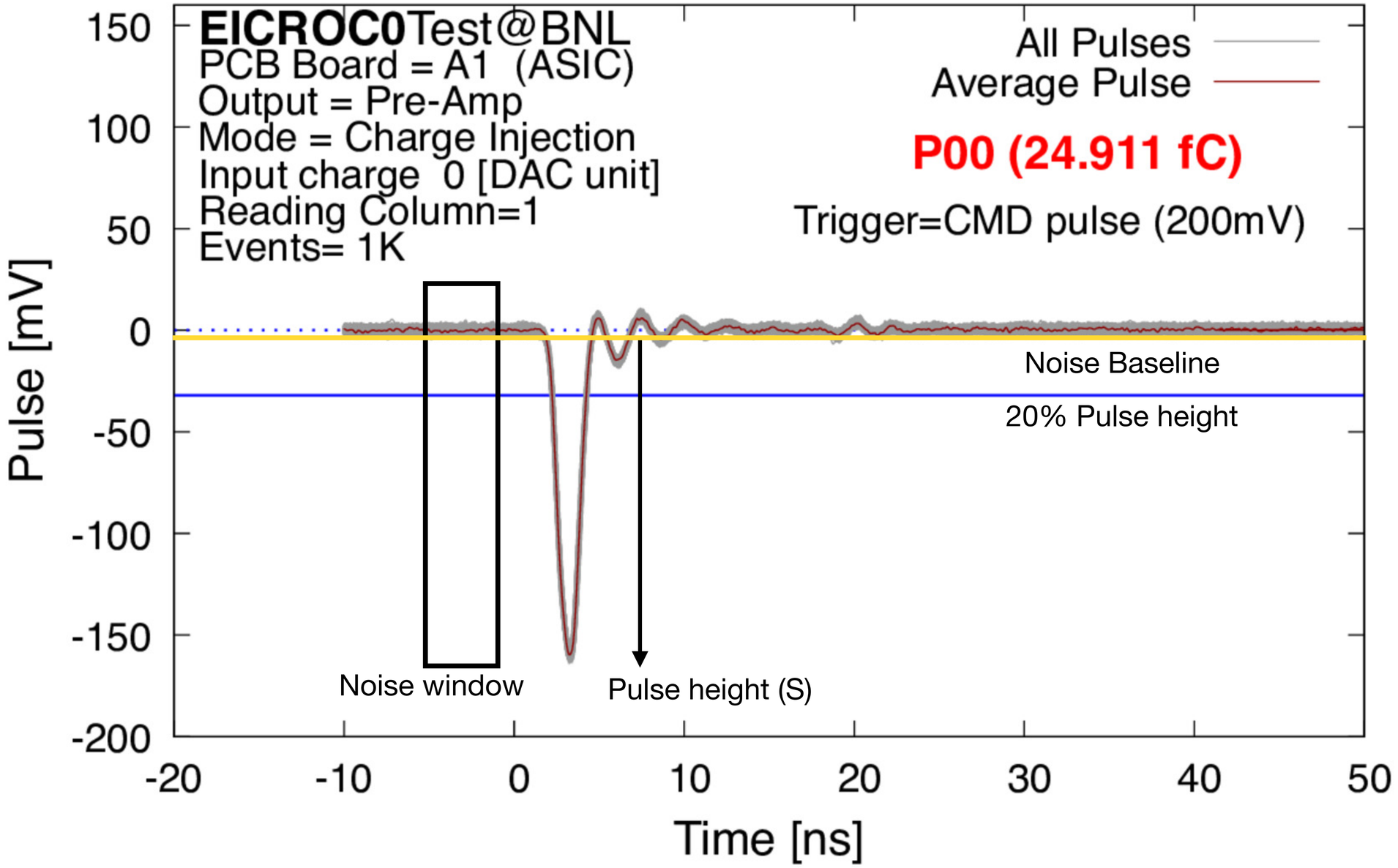
Consistency check of Python Event Code

```
if args.cfg:
    eic.wr_asic_cfg (args.cfg)
    #time.sleep(1)
    #eic.set_cmdpulse_period(1000)    # 200us

    eic.set_cmdpulse_timeout(5)     # Cmdpulse Timeout
    eic.set_trigger_timeout(5)      # Cmdtrigger Timeout
    eic.cmdpulse_sig(1)              # negative Cmdpulse
    eic.trigger_sig(1)               # positive TrigExt 1 needed for discri studies
    eic.trigout_sig(1)               # invert
    eic.set_width_trigger(2)

    eic.set_delay_startacq_pulse(2)       # Delay Rising Edge Start_Acq -> TrigExt(0)
    eic.set_delay_trigout_end_startacq(4)  # Delay Trigout -> Falling Edge of Start_Acq
    eic.set_delay_startacq_startreadout(10) # Delay Start_Acq -> Start_Readout
    eic.set_startreadout_width(5)          # Start_Readout Width
    eic.set_startacq_width(10)          # Start_Acq Width

    eic.set_shift_cmdpulse(100)        # 0..1023
    eic.set_shift_trigger(150)        # 0..1023
    # eic.set_shift_trigger(180)
    eic.wr_asic_reg(0x20A,180)
```

BACKUP

Jitter determination method -2

Signal and noise estimations



Jitter=t_{rise}/(S/N)