Coincidence Trigger Setup for GEn Experiment in Hall-A

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1 Time of Flight Calculation

Four different kinematic setup for GEn experiment will have different time of flight for both leptons and hadrons in two different arms. Time of flight is calculated using the relation:

$$T = \frac{\text{distance}}{c}\sqrt{1 + \left(\frac{m}{|\vec{p}|}\right)^2} \tag{1}$$

where c is velocity of light, m is mass of the particle and $|\vec{p}|$ is the momentum of the particle.

A. Beam energy: 2.1 GeV, Q^2: 1.7 GeV^2, Bigbite angle: 47.5°

B. Beam energy: 4.2 GeV, Q^2: 2.9 GeV^2, Bigbite angle: 29.5°

C. Beam energy: 6.3 GeV, Q^2: 6.6 GeV^2, Bigbite angle: 35.9°

D. Beam energy: 8.4 GeV, Q^2: 9.7 GeV^2, Bigbite angle: 35.0°

Considering the beam electron along z axis and the e-N scattering as elastic scattering, we could write

$$p_e \approx (E_1, 0, 0, E_1) \tag{2}$$
$$p_p = (M_p, 0, 0, 0) \tag{3}$$
$$p'_e \approx (E_3, 0, E_3 sin\theta, E_3 cos\theta) \tag{4}$$
$$p'_p = (E_4, \vec{p_p}) \tag{5}$$

where prime represents four momentum after scattering and $p'_p = p_p + p_e - p'_e$.

For each kinematic region, E_3 could be calculated using the relation

$$Q^2 \approx 2E_1E_3(1 - cos\theta) \tag{6}$$

and

$$|\vec{p'_p}|^2 \approx (-E_3 sin\theta)^2 + (E_1 - E_3 cos\theta)^2 \tag{7}$$

Hence we have,

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A. $\implies E_3 = 1.2477$ GeV and $|\vec{p_p'}| = 1.5577$ GeV

B. $\implies E_3 = 2.6630$ GeV and $|\vec{p_p'}| = 2.2940$ GeV

C. $\implies E_3 = 2.7575$ GeV and $|\vec{p_p'}| = 4.3760$ GeV

D. $\implies E_3 = 3.1926$ GeV and $|\vec{p_p'}| = 6.0677$ GeV

With these momentum of final-state electron and proton, the time of flight of electron (T_e) to bigbite shower (1.63 +1.9 = 3.53 meters[1]) and time of flight of proton (T_p) to HCal (17 m from pivot) are

A. $\implies T_e = 11.77$ ns and $T_p = 66.15$ ns

B. $\implies T_e = 11.77$ ns and $T_p = 60.60$ ns

C. $\implies T_e = 11.77$ ns and $T_p = 57.95$ ns

D. $\implies T_e = 11.77$ ns and $T_p = 57.34$ ns

[1]BigBite magnet is 1.63 m from pivot and Provakar mentioned that preshower is 1.7 m and shower is 1.9 m from Bigbite magnet

2 Coincidence Trigger set-up (HCAL and BBCAL triggers in Trigger Supervisor (TS) Rack)

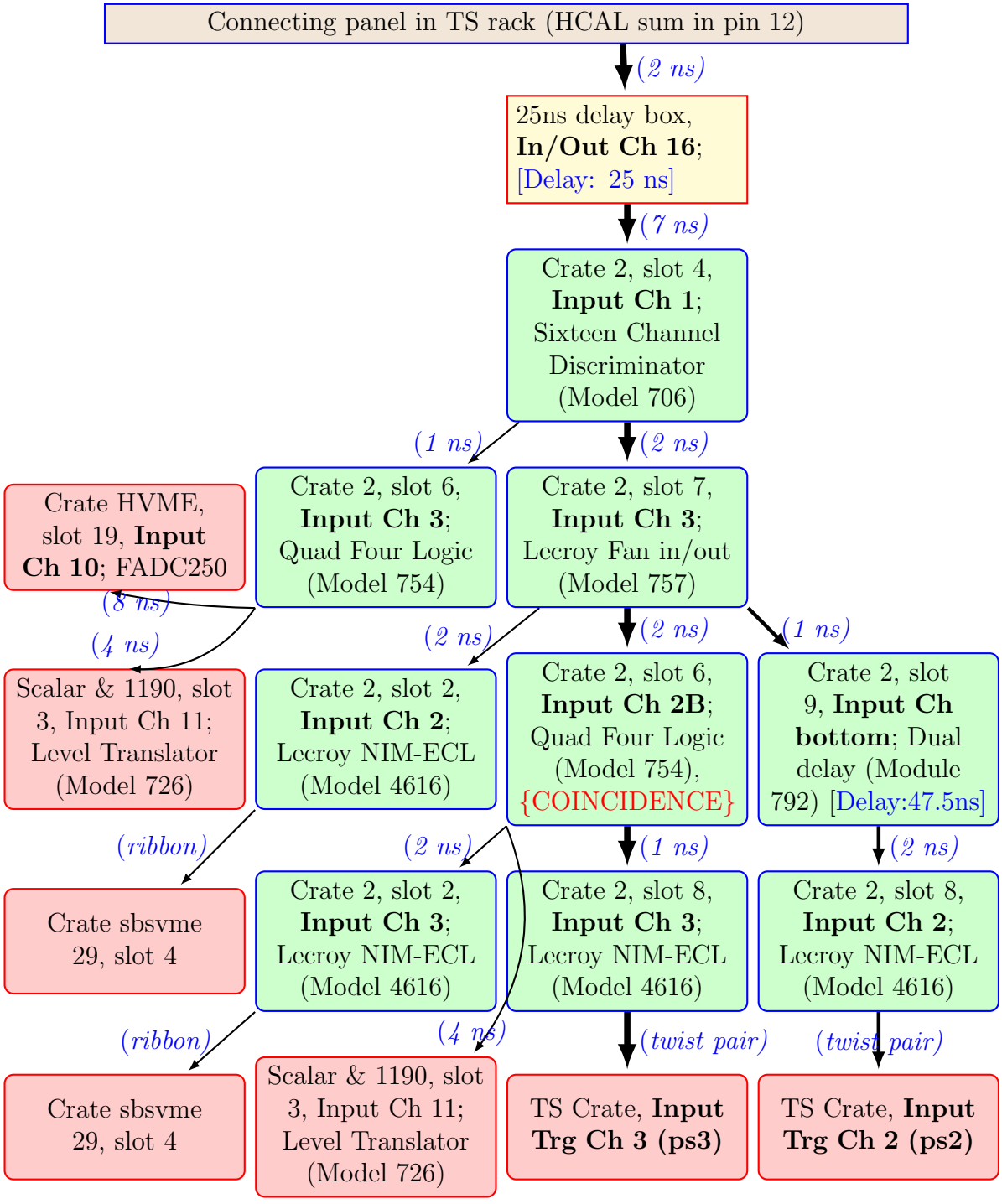
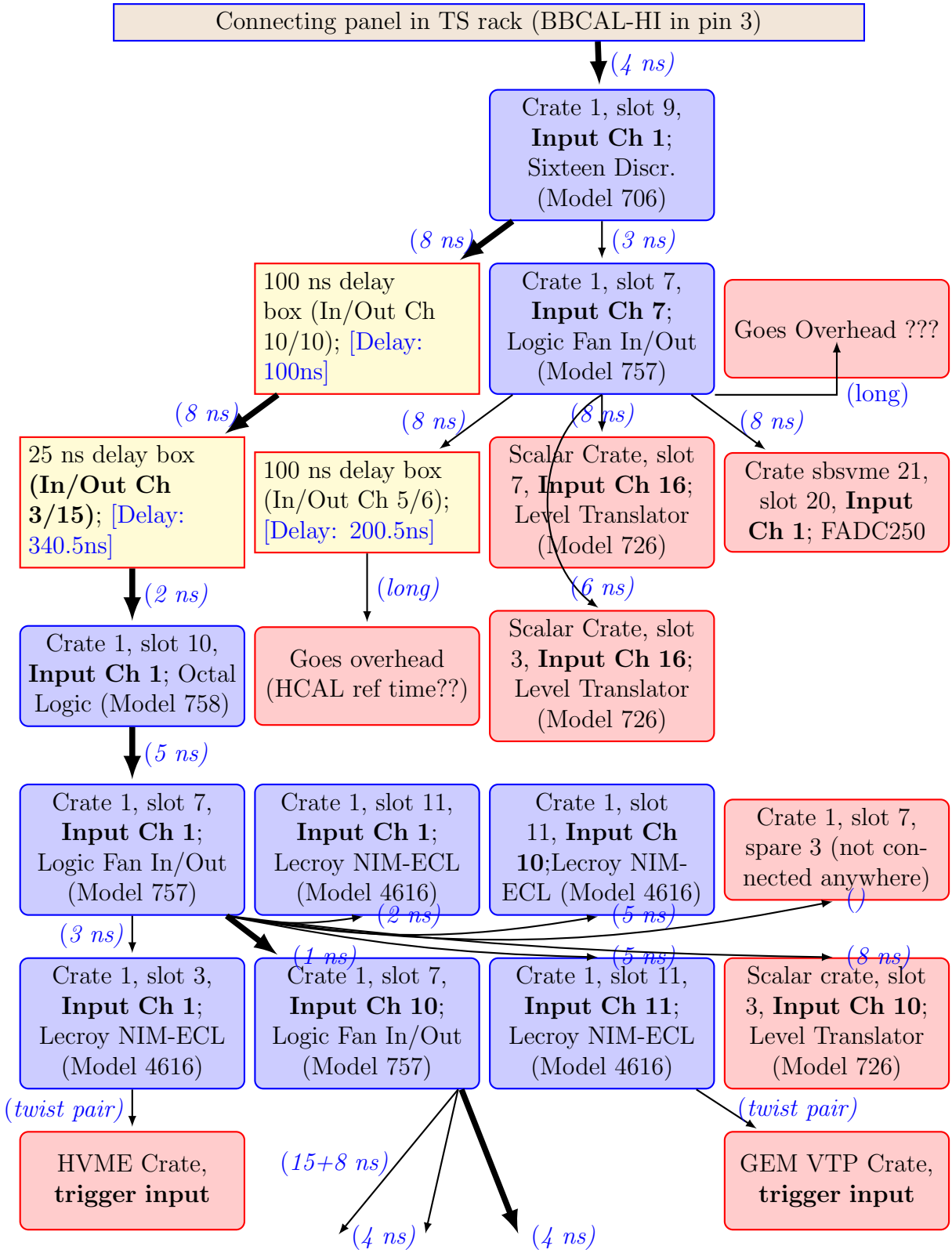


Figure 1: HCAL (ps2) and Coincidence (ps3) trigger setup in SBS collaboration (Most are NIM components except mentioned otherwise)


Connecting panel in TS rack (BBCAL-HI in pin 3)
(4 ns)
Crate 1, slot 9, Input Ch 1; Sixteen Discr. (Model 706)
(8 ns)
(3 ns)
100 ns delay box (In/Out Ch 10/10); [Delay: 100ns]
Crate 1, slot 7, Input Ch 7; Logic Fan In/Out (Model 757)
Goes Overhead ???
(long)
(8 ns)
(8 ns)
(8 ns)
(8 ns)
25 ns delay box (In/Out Ch 3/15); [Delay: 340.5ns]
100 ns delay box (In/Out Ch 5/6); [Delay: 200.5ns]
Scalar Crate, slot 7, Input Ch 16; Level Translator (Model 726)
Crate sbsvme 21, slot 20, Input Ch 1; FADC250
(2 ns)
(long)
(6 ns)
Crate 1, slot 10, Input Ch 1; Octal Logic (Model 758)
Goes overhead (HCAL ref time??)
Scalar Crate, slot 3, Input Ch 16; Level Translator (Model 726)
(5 ns)
Crate 1, slot 7, Input Ch 1; Logic Fan In/Out (Model 757)
Crate 1, slot 11, Input Ch 1; Lecroy NIM-ECL (Model 4616)
Crate 1, slot 11, Input Ch 10;Lecroy NIM-ECL (Model 4616)
Crate 1, slot 7, spare 3 (not connected anywhere)
(3 ns)
(2 ns)
(5 ns)
(1 ns)
(5 ns)
(8 ns)
Crate 1, slot 3, Input Ch 1; Lecroy NIM-ECL (Model 4616)
Crate 1, slot 7, Input Ch 10; Logic Fan In/Out (Model 757)
Crate 1, slot 11, Input Ch 11; Lecroy NIM-ECL (Model 4616)
Scalar crate, slot 3, Input Ch 10; Level Translator (Model 726)
(twist pair)
(twist pair)
HVME Crate, trigger input
(15+8 ns)
(4 ns)
(4 ns)
GEM VTP Crate, trigger input

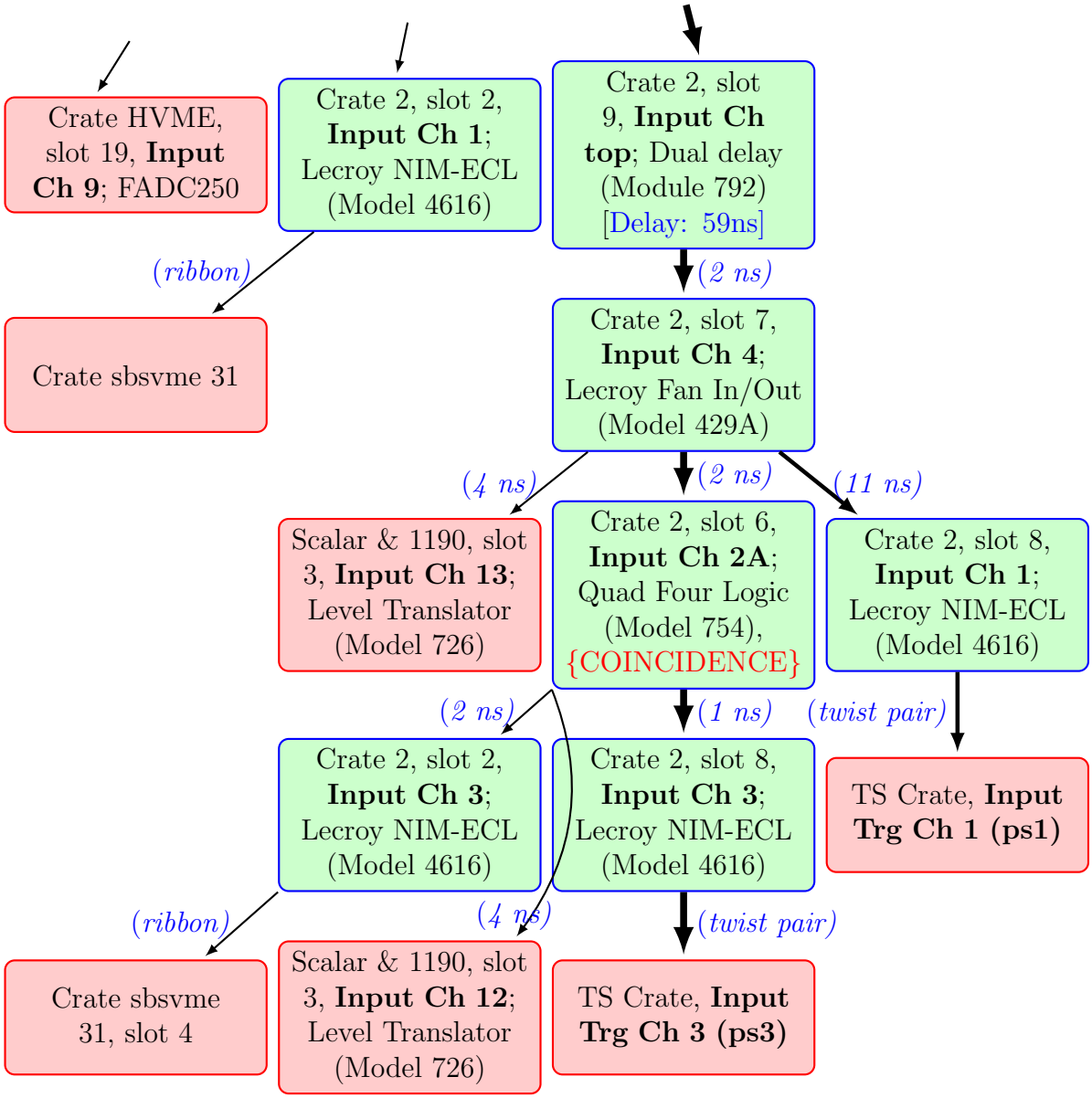


Figure 2: BBCAL (ps1) and Coincidence (ps3) trigger setup in SBS collaboration (Most are NIM components except mentioned otherwise)

3 Coincidence trigger timing

At the connecting panel which is at the top of Trigger Supervisor (TS) rack, the time delay of HCAL trigger (pin 12) w.r.t. BBCAL HI trigger (pin 3) is ∼492 ns, if trigger starts at the same time on both BBCAL and HCAL [checked with a pulser connected, so excluded PMT delay during this measurement].

After passing through various electronics and delay boxes, HCAL and BBCAL triggers are ready for the coincidence in the coincidence module with the following configuration

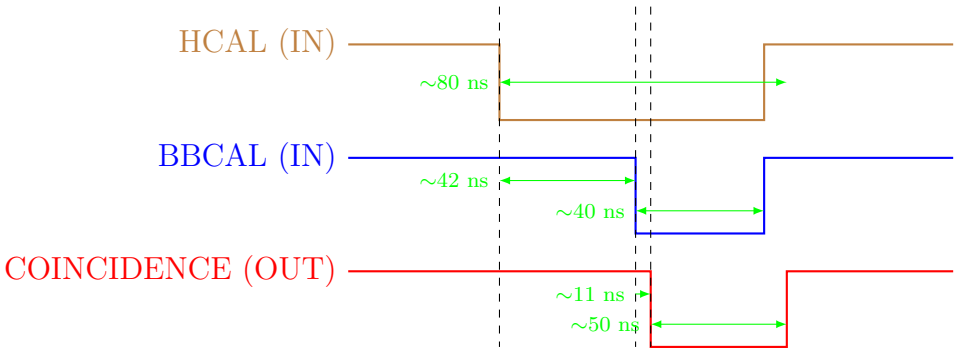


Figure 3: Delay and coincidence trigger setup in Quad Four Logic unit (model 754 at crate 2 slot 6)

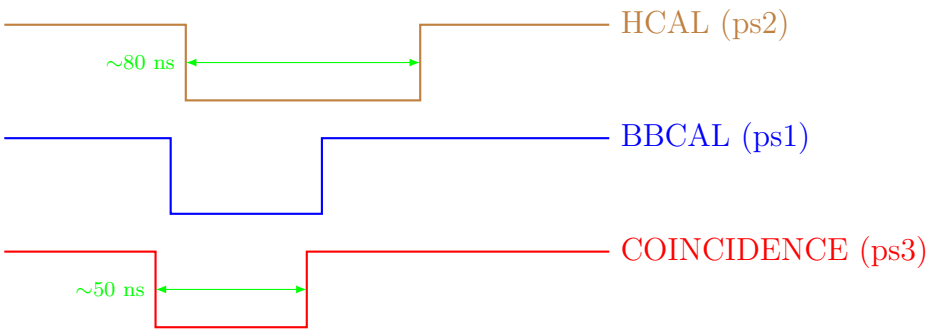


Figure 4: Delay and coincidence trigger in Lecroy NIM-ECL unit (model 4616 at crate 2 slot 8). HCAL is delayed by ∼51.5 ns and BBCAL by ∼11ns in parallel to coincidence generation, ultimately making coincidence trigger coming at first to the TS compared to BBCAL and HCAL triggers. Because of this we could pre-scale singles without loosing coincidences. [Note: BBCAL declares coincidence timing, so prepared this setup in such a way that COINCIDENCE/BBCAL timing to TS matches with the previous set-up BBCAL timing in TS.]