Coincidence Trigger, GMn Run Group

Sebastian Seeds

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1 Overview

The signal paths beginning with a single scattering event in the target chamber, propagating through both detector paths (electron arm and hadron arm), and returning in coincidence at data acquisition (DAQ) is detailed here.

2 Layout

Three essential sections are needed to describe the time delay expected from scattering events across all proposed kinematics for GMn and GEn-RP. The first details the time-of-flight (TOF) calculations for each kinematic setting for scattered protons and electrons. The second details the signal propagation through the detector, front-end electronics, and cables to the trigger supervisor (TS) at the DAQ bunker of the hadron arm. The third details the signal propagation through the detector, front-end electronics, and cables to the TS at the DAQ of the electron arm.

2.1 Particle TOF

Elastic scattering is presumed as a first order approximation of the TOF for scattered products through each arm of the apparatus. The TOF for each particle are estimated as follows.
Neglecting the rest mass energy of the electron (M_e), the energy of the scattered electron is fully described by the scattering angle and beam energy:

$$E'_e = \frac{M_p E_e}{M_p + E_e(1 - \cos\theta)}$$

The energy transferred to the proton ν from the electron to the proton is energy lost by the electron after scattering:

$$\nu = E_e - E'_e$$

The four-momentum transfer imparted to the proton is described by these quantities:

$$Q^2 = 2E_e E'_e(1 - \cos\theta)$$

The invariant mass transfer W^2 can be calculated from these:

$$W^2 = M_p^2 + 2M_p\nu - Q^2$$

Finally, the momentum of the proton is obtained with the above quantities:

$$p_p = \sqrt{(\nu + M_p)^2 + W^2}$$

With the usual definitions of γ and β:

$$\gamma_{e,p} = \frac{E'_{e,p}}{M_{e,p}} \quad ; \quad \beta_{e,p} = \sqrt{1 - \left(\frac{1}{\gamma_{e,p}}\right)^2}$$

The velocities as a fraction of the speed of light (β) of the electron passing through the electron arm and the proton passing through the hadron arm are obtained. With the additional distances to the hadronic calorimeter (HCal) and BigBite calorimeter (BBCal), the time of flight for both scattered products are calculated. Table 1 contains this TOF information for all kinematics.

2.2 Hadron Arm

A schematic of the signal path through the hadron arm is depicted in Figure 1. The sum of all signal delays through hardware is estimated to be **725** ns.

2.3 Electron Arm

A schematic of the signal path through the electron arm is depicted in Figure 2. The sum of all signal delays through hardware is estimated to be **750** ns.

2.4 DAQ

A logic signal is configured for both arms at **60** ns width. Noting a maximum difference from the total delays between the arms over all kinematics of $\Delta t \approx \mathbf{35}$ ns, this estimate confirms the plan and layout of the coincidence trigger as presented here.

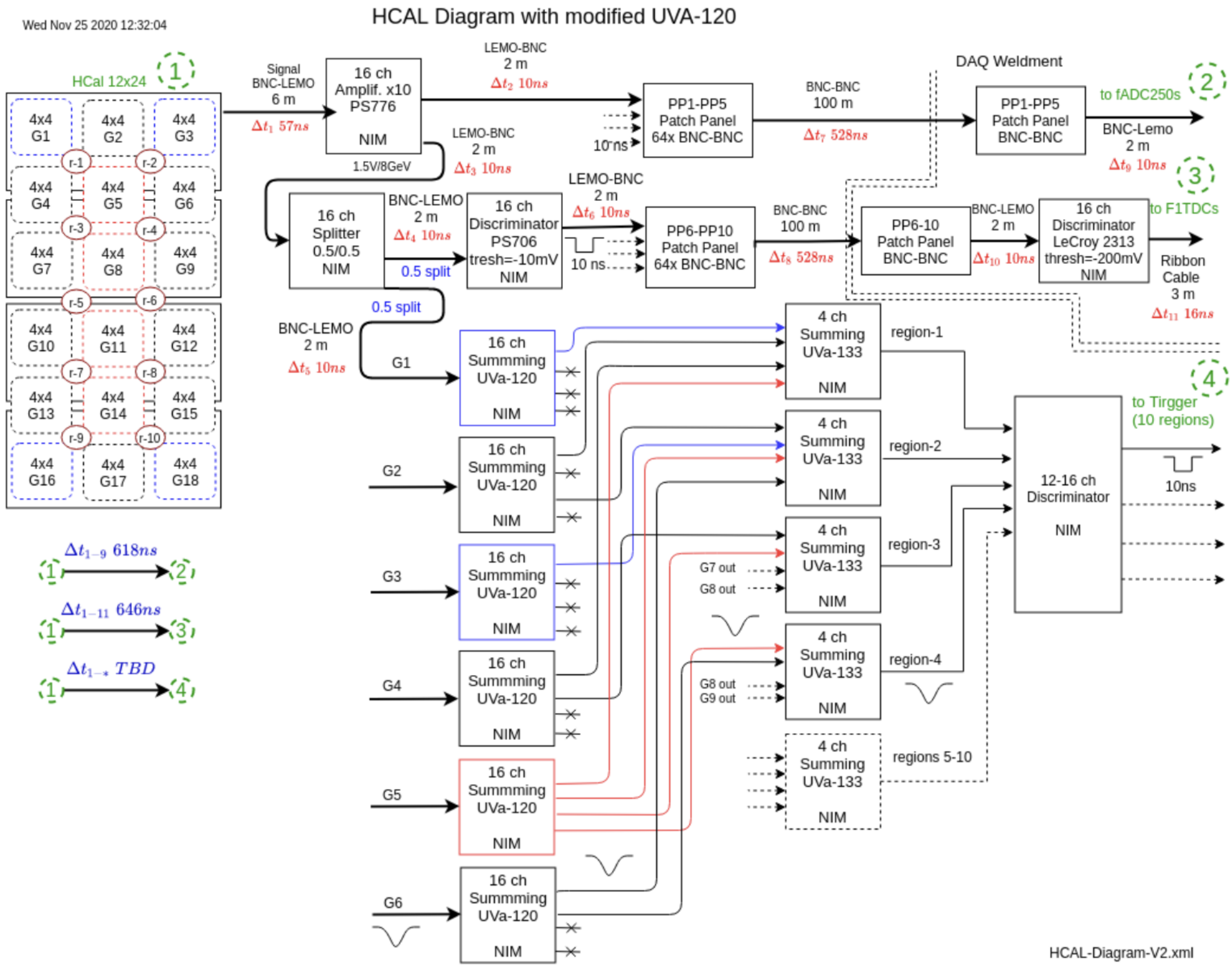

Figure 1: Hadron Arm Timing Schematic

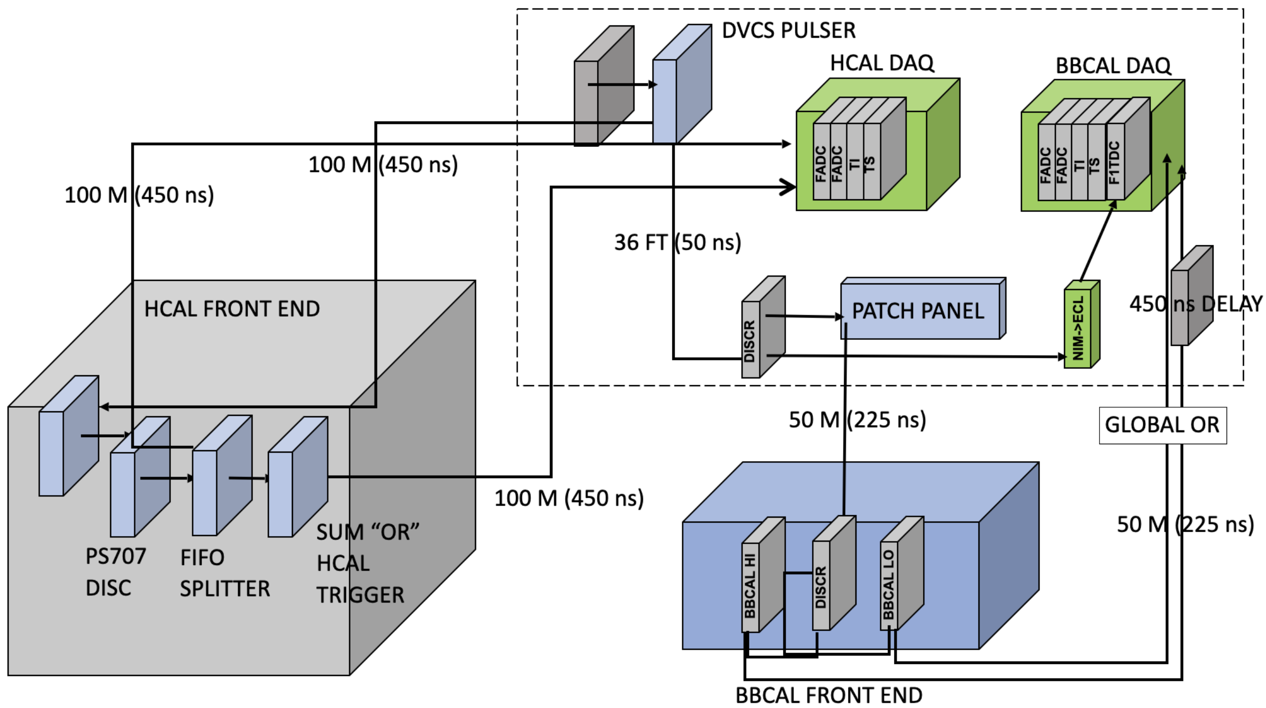

Figure 2: Electron Arm Timing Schematic

Table 1: Signal Delay by Kinematic

Name	Energy	Program	TOF e (ns)	TOF p (ns)	H.Arm Delay	E.Arm Delay	Coincidence Δt
SBS-1	1.92	Comm. 1	6.17	39.28	763.58	756.17	8.11
SBS-2	5.56	Comm. 2	6.17	42.71	761.83	756.17	11.54
SBS-3	5.56	GMn 5.0	6.00	42.28	761.79	756.00	11.27
SBS-4	3.70	GMn 3.0	6.34	42.69	762.09	756.00	11.68
SBS-5	7.38	GMn 6.5	5.84	42.36	761.73	756.34	11.02
SBS-6	7.38	GMn 8.0	5.17	41.67	761.71	755.84	10.83
SBS-7	7.38	GMn 10	6.67	52.18	771.71	755.17	22.01
SBS-8	5.56	nTPE 4.0	5.17	35.20	755.16	756.67	3.53
SBS-9	4.03	GMn 4.0	6.67	34.35	755.17	755.17	4.18
SBS-10	9.91	GMn 12.2	5.17	63.79	781.71	756.67	32.12
SBS-11	9.91	GMn 13.6	5.17	63.32	781.71	755.17	33.15
SBS-12	4.03	Gen-RP	5.17	34.32	755.17	755.17	4.15
SBS-13	6.00	PionKLL	5.17	34.04	755.05	755.17	3.87