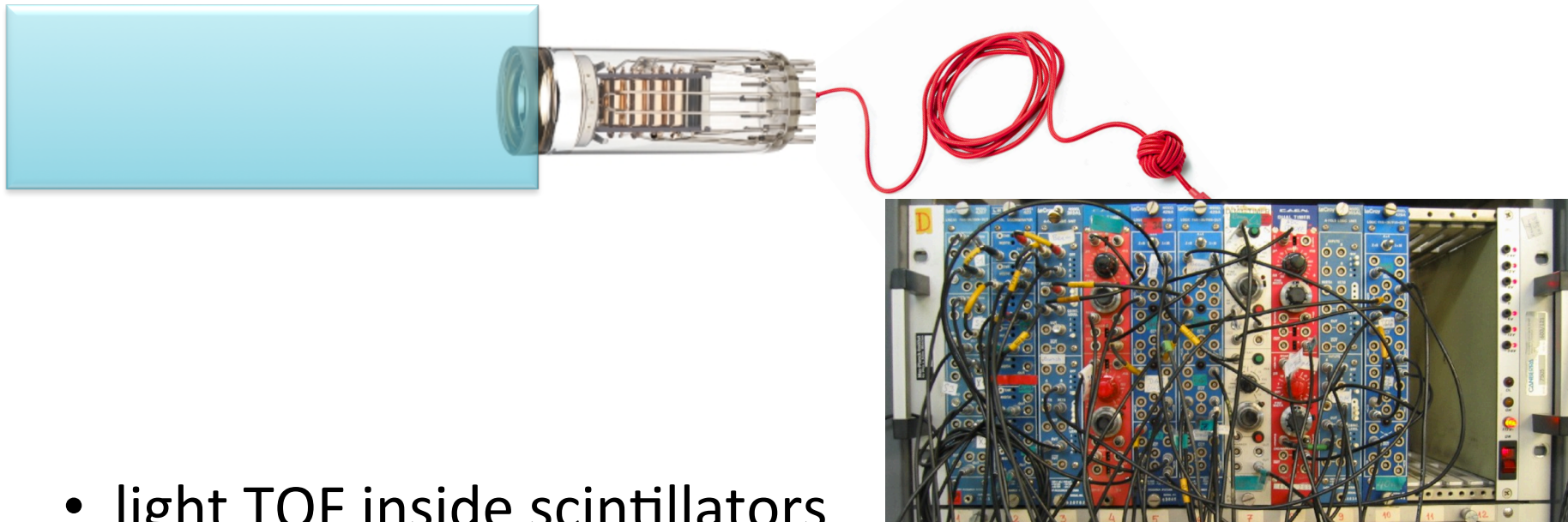


Trigger Setup



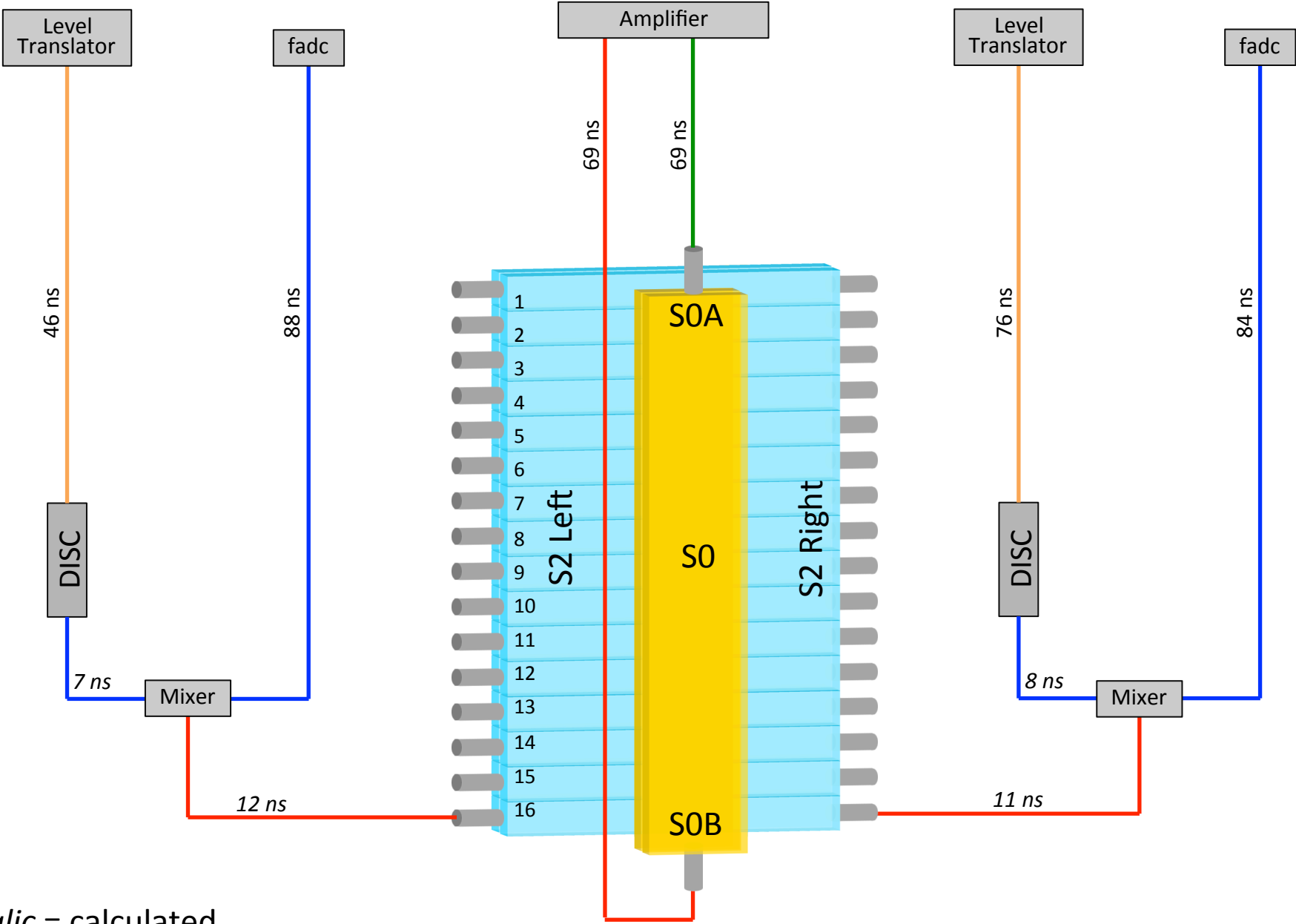
Reynier Cruz Torres

Elements to take into account for trigger setup



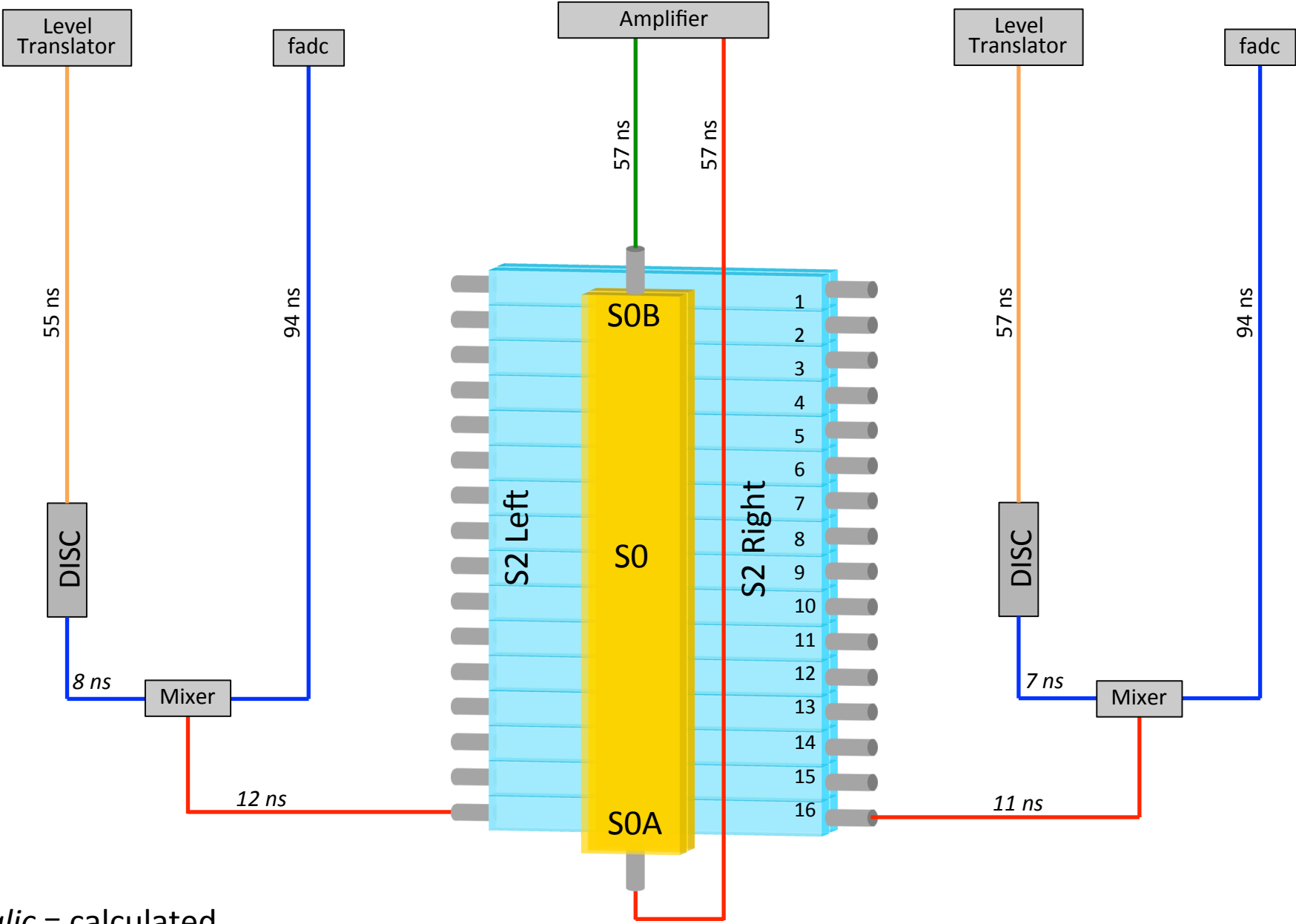
- light TOF inside scintillators
- PMT output delays
- cables to electronics
- electronics delay

LHRS

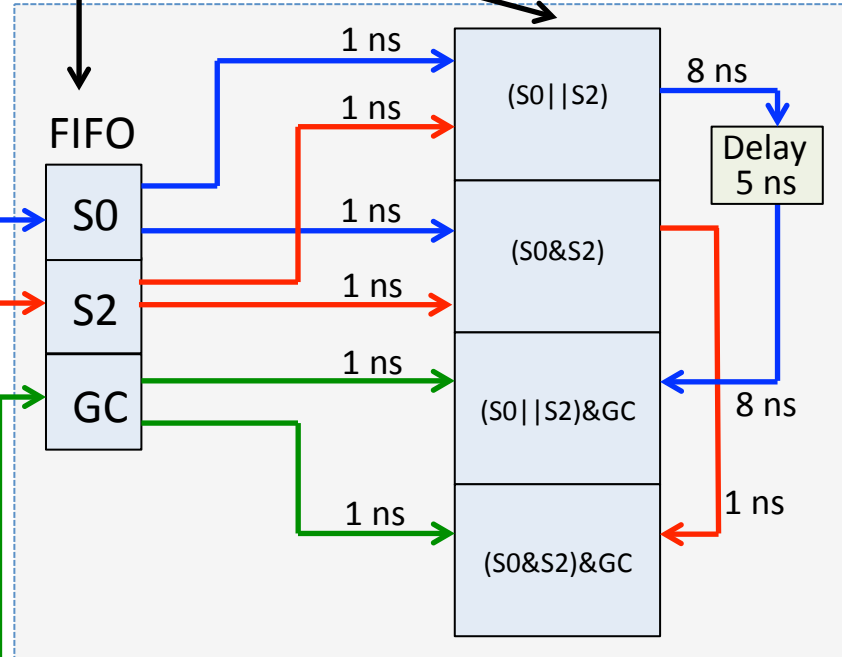
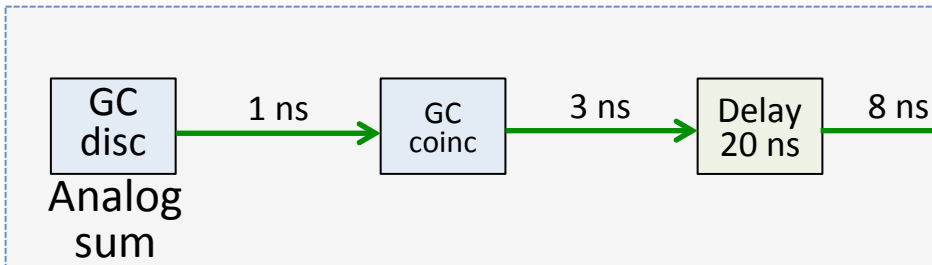
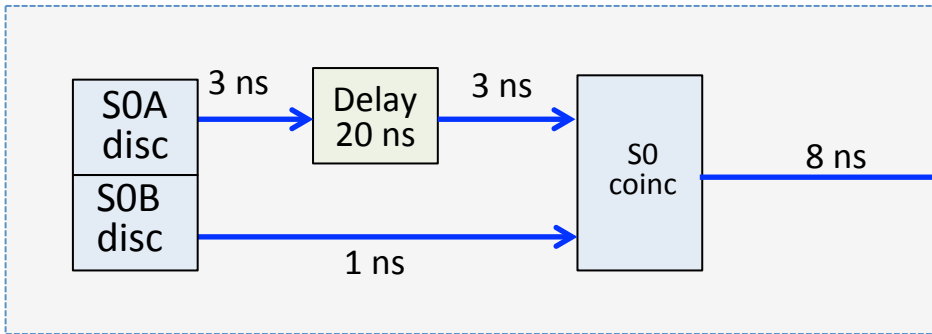
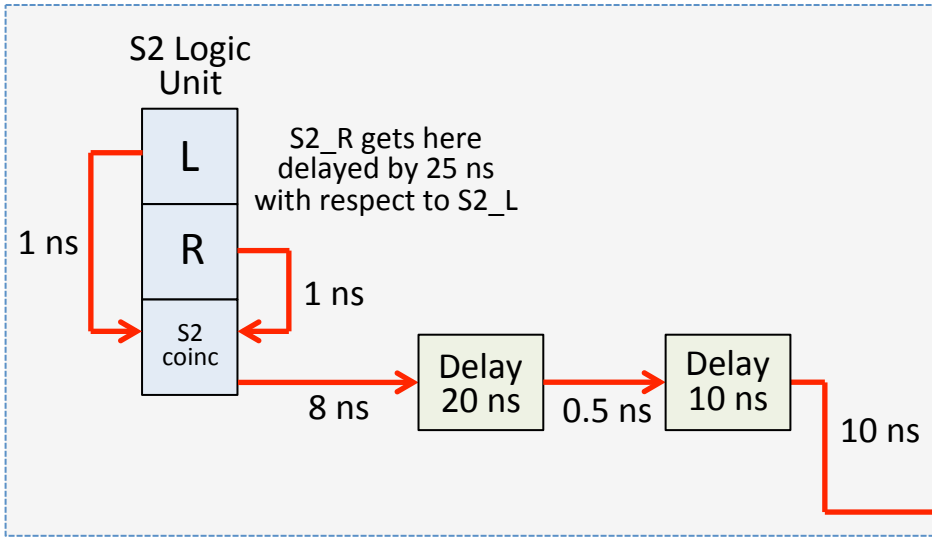


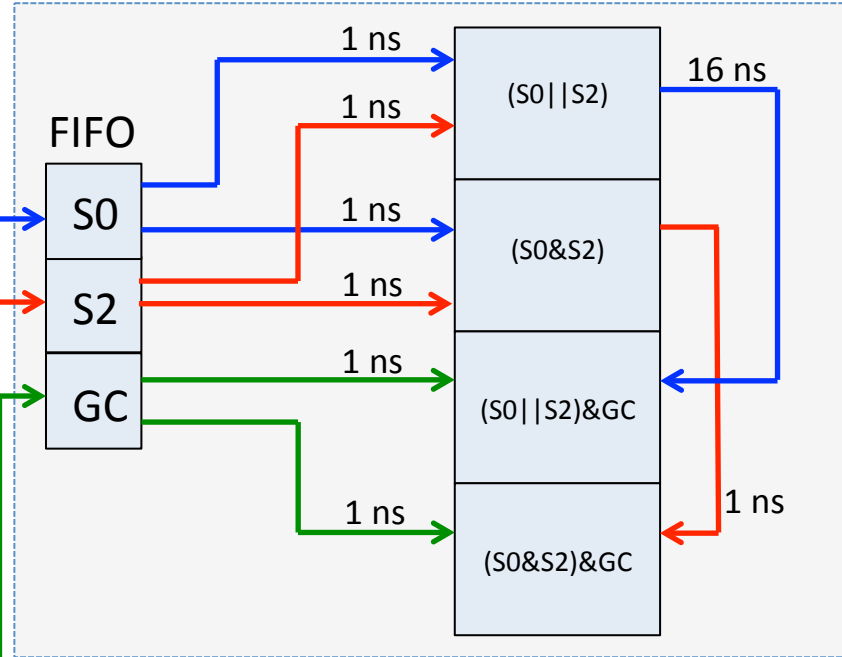
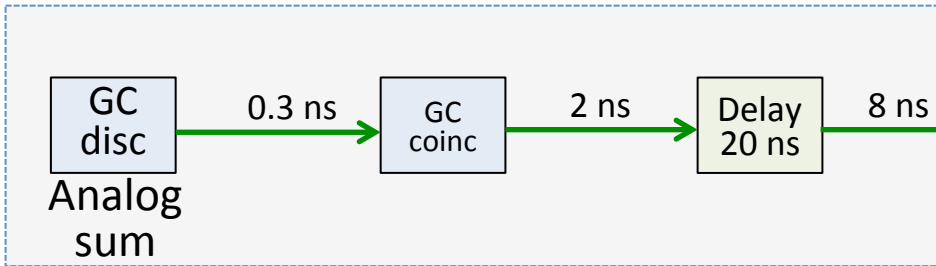
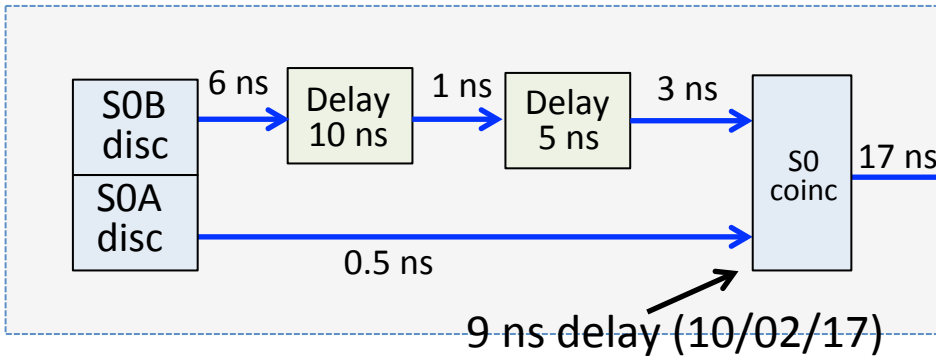
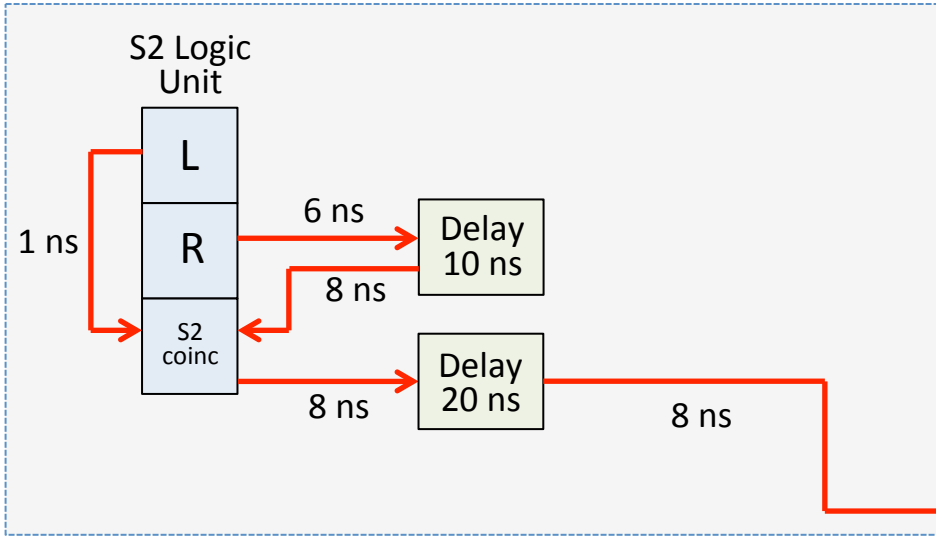
Italic = calculated

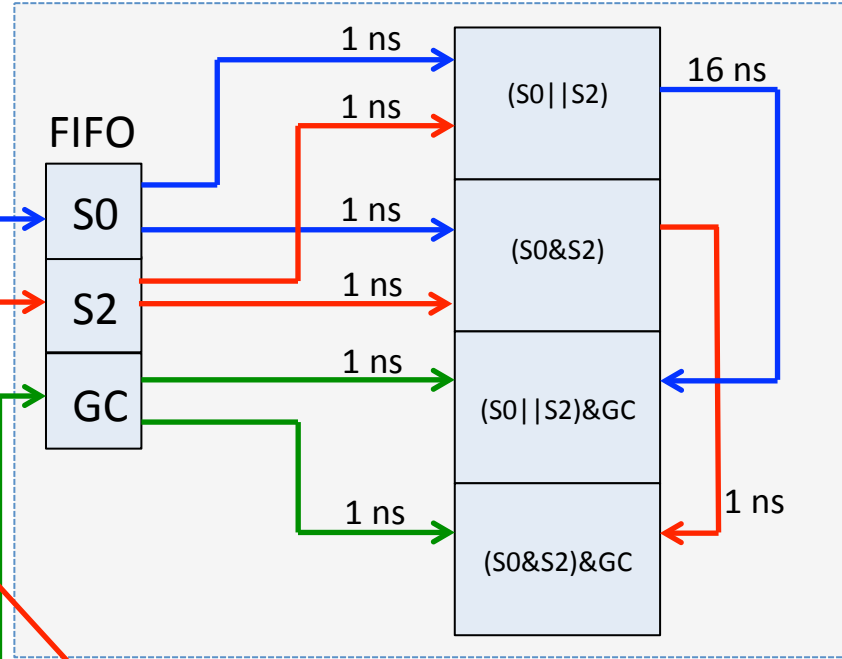
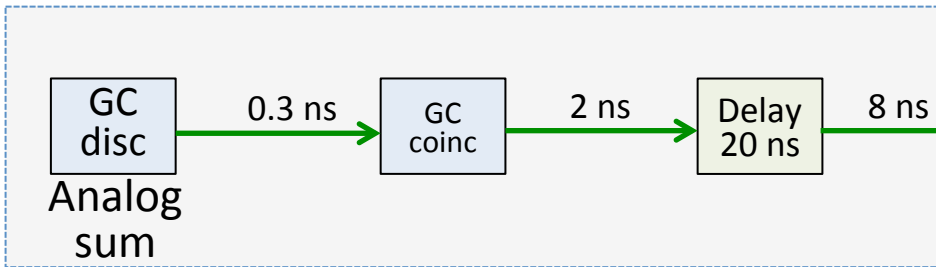
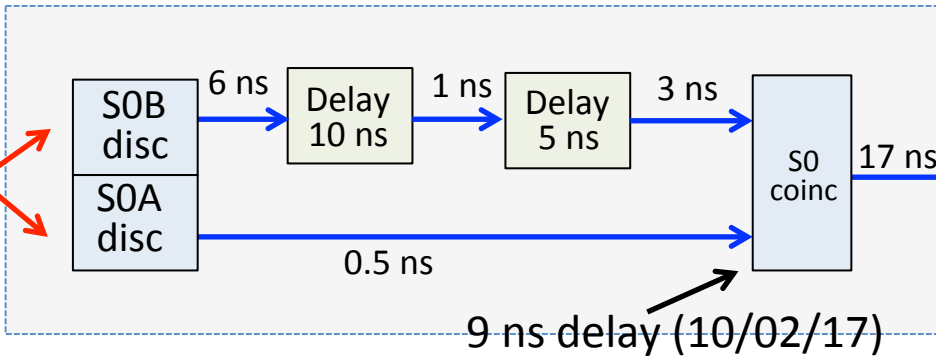
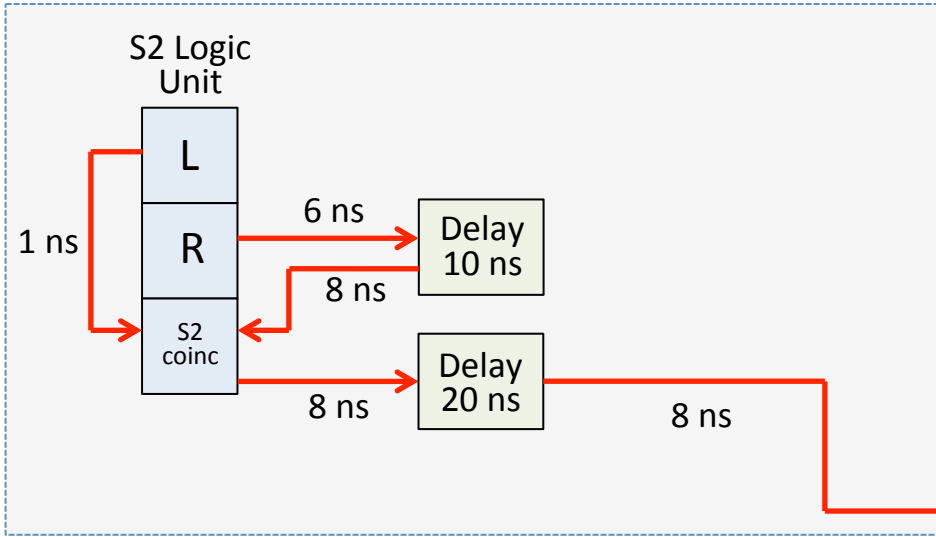
RHRS



10 ns delay (09/26/17)



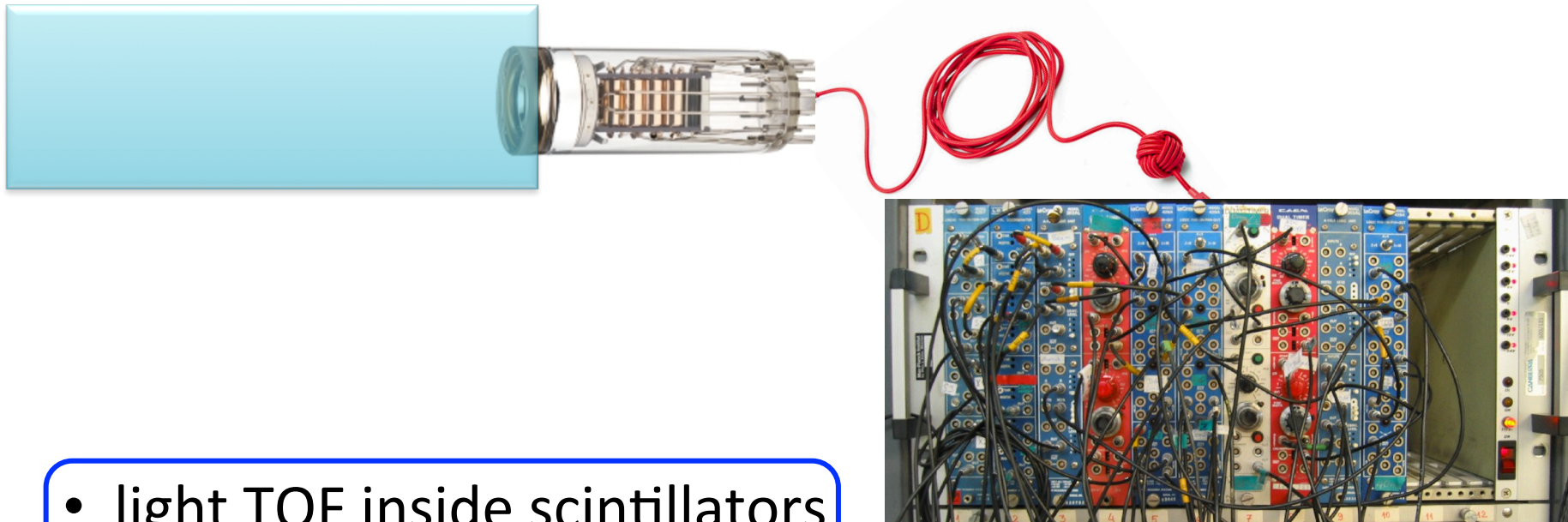




This delay was adjusted

A and B delays were swapped since my last presentation (on Sept 27, 2017)

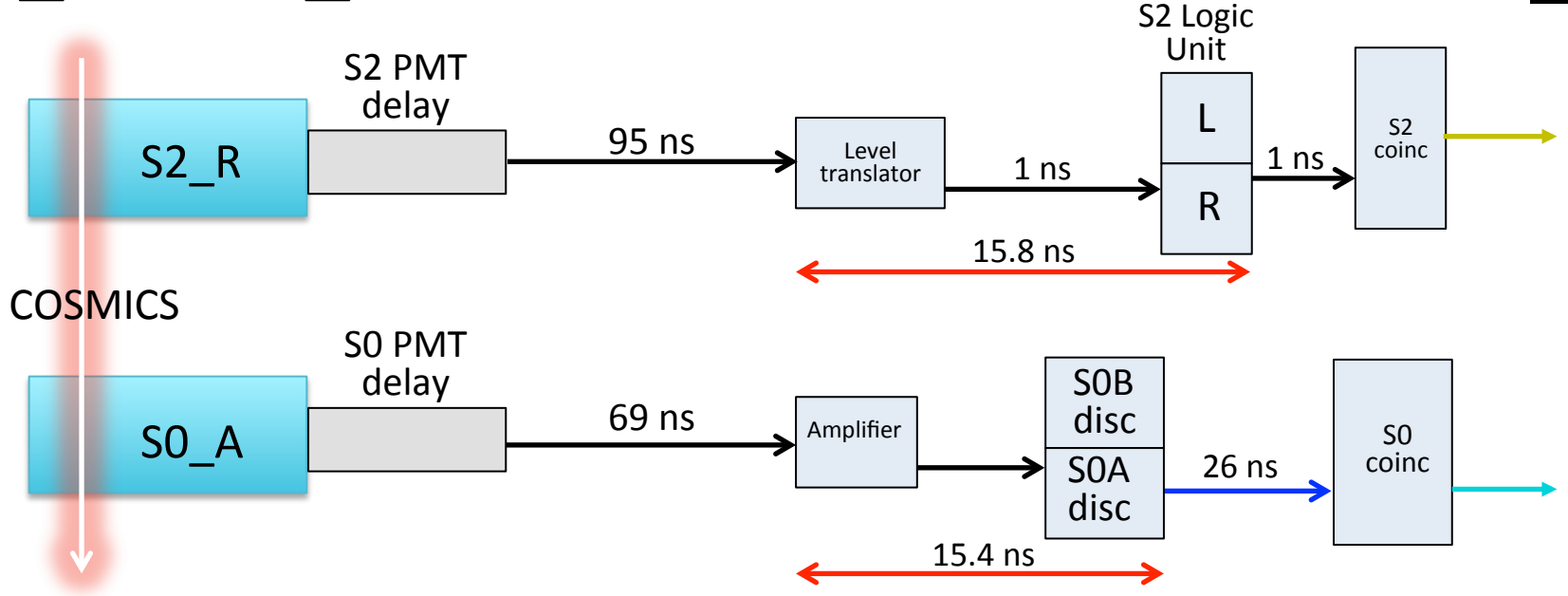
Elements to take into account for trigger setup



- light TOF inside scintillators
- PMT output delays
- cables to electronics
- electronics delay

LHRS

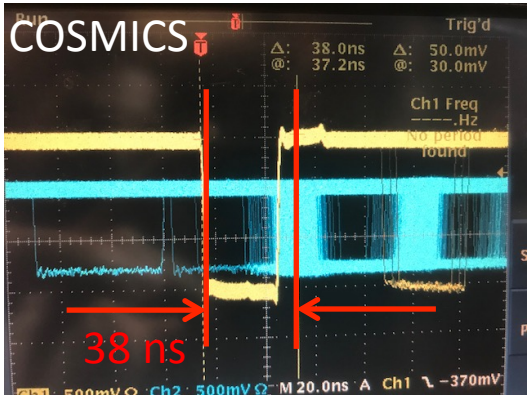
S2_R & S0_A



$$(S0_A \text{ PMT delay}) + 69 + 15.4 + 26 + 8 + \text{TOF} - [(S2_R \text{ PMT delay}) + 95 + 15.8 + 1 + 8] = 38$$

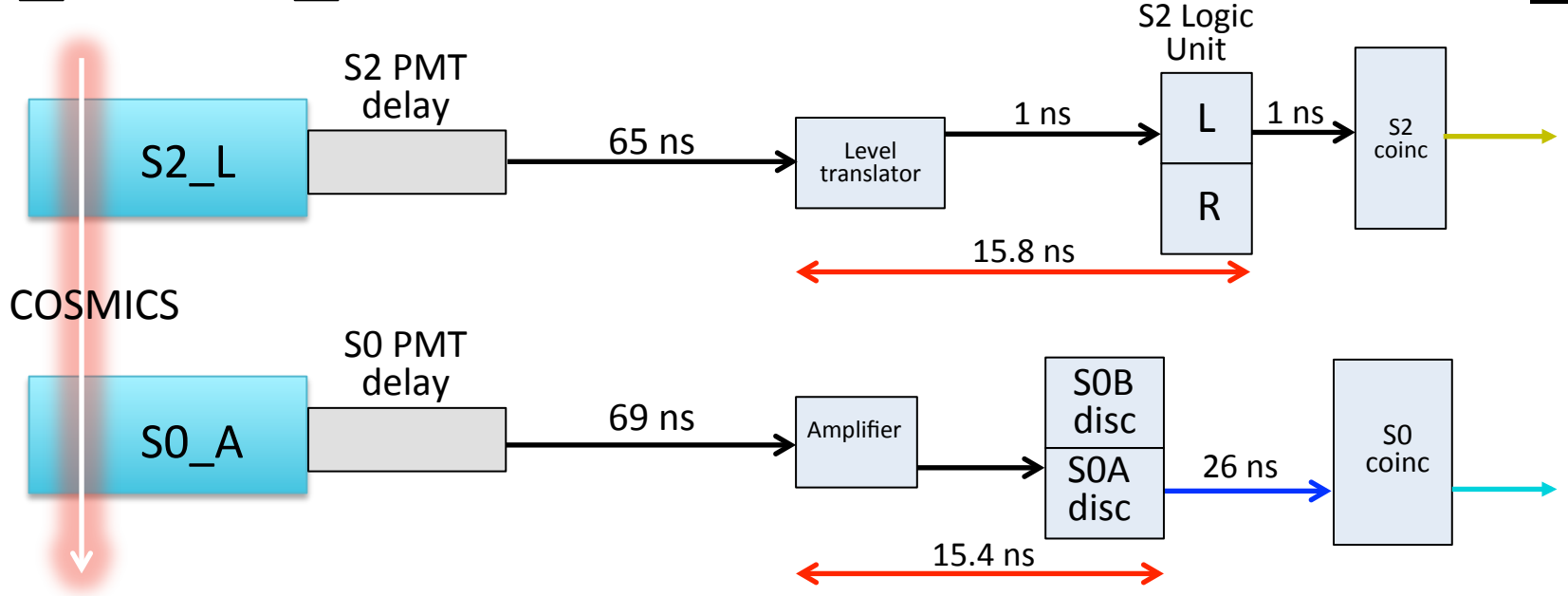
$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 38 - 3.6 = 34.4$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 34.4 \text{ ns}$$

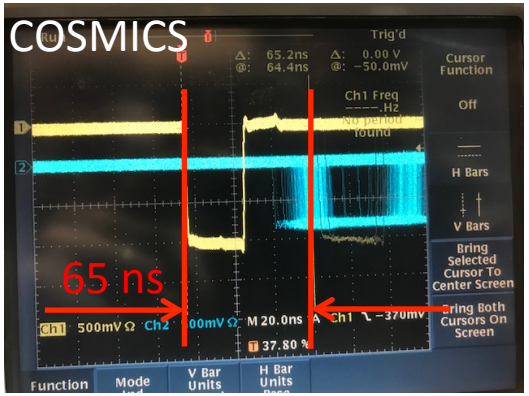
S2_L & S0_A



$$(S0_A \text{ PMT delay}) + 69 + 15.4 + 26 + 8 + \text{TOF} - [(S2_L \text{ PMT delay}) + 65 + 15.8 + 1 + 8] = 65$$

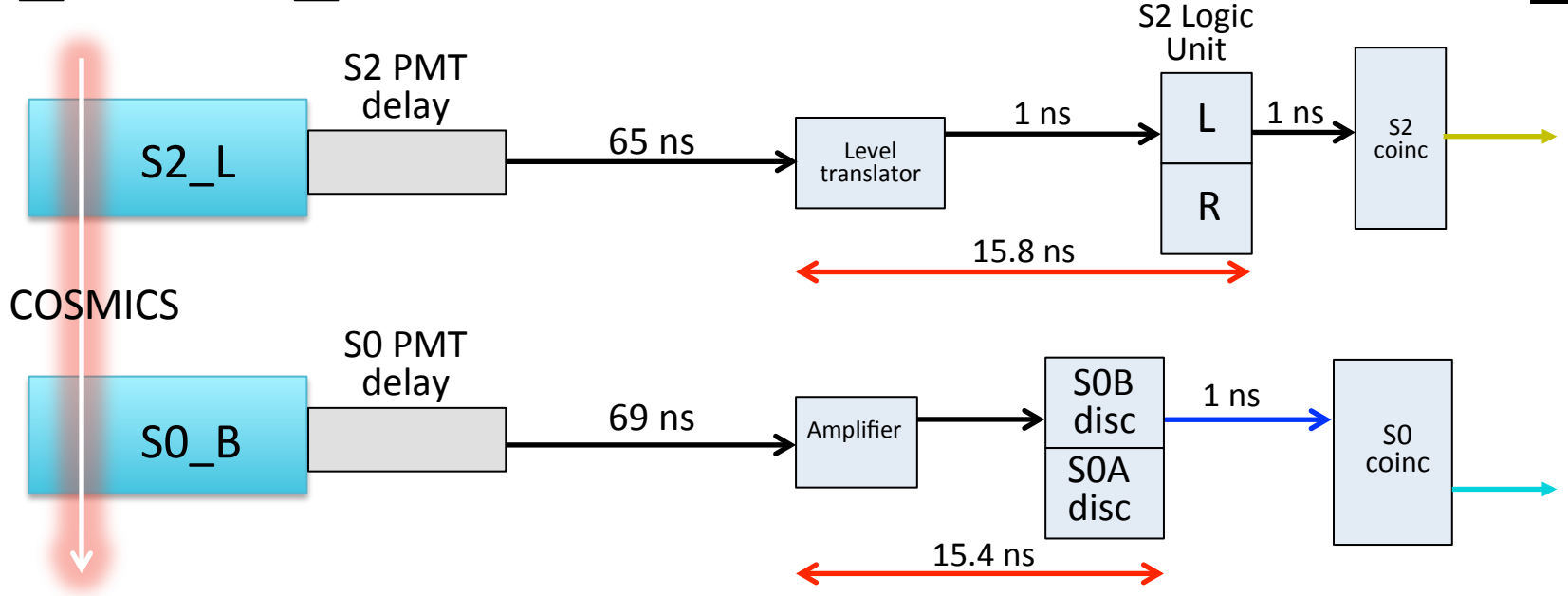
$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 65 - 33.6 = 31.4$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 31.4 \text{ ns}$$

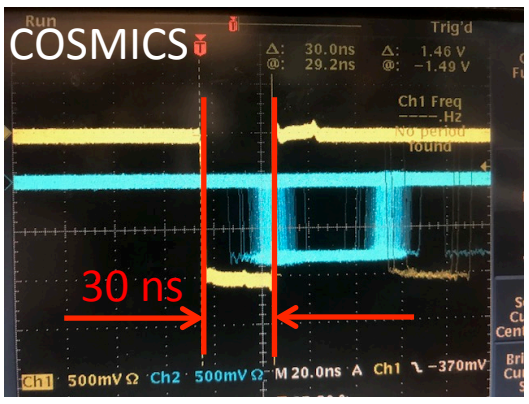
S2_L & S0_B



$$(S0_B \text{ PMT delay}) + 69 + 15.4 + 1 + 8 + \text{TOF} - [(S2_L \text{ PMT delay}) + 65 + 15.8 + 1 + 8] = 30$$

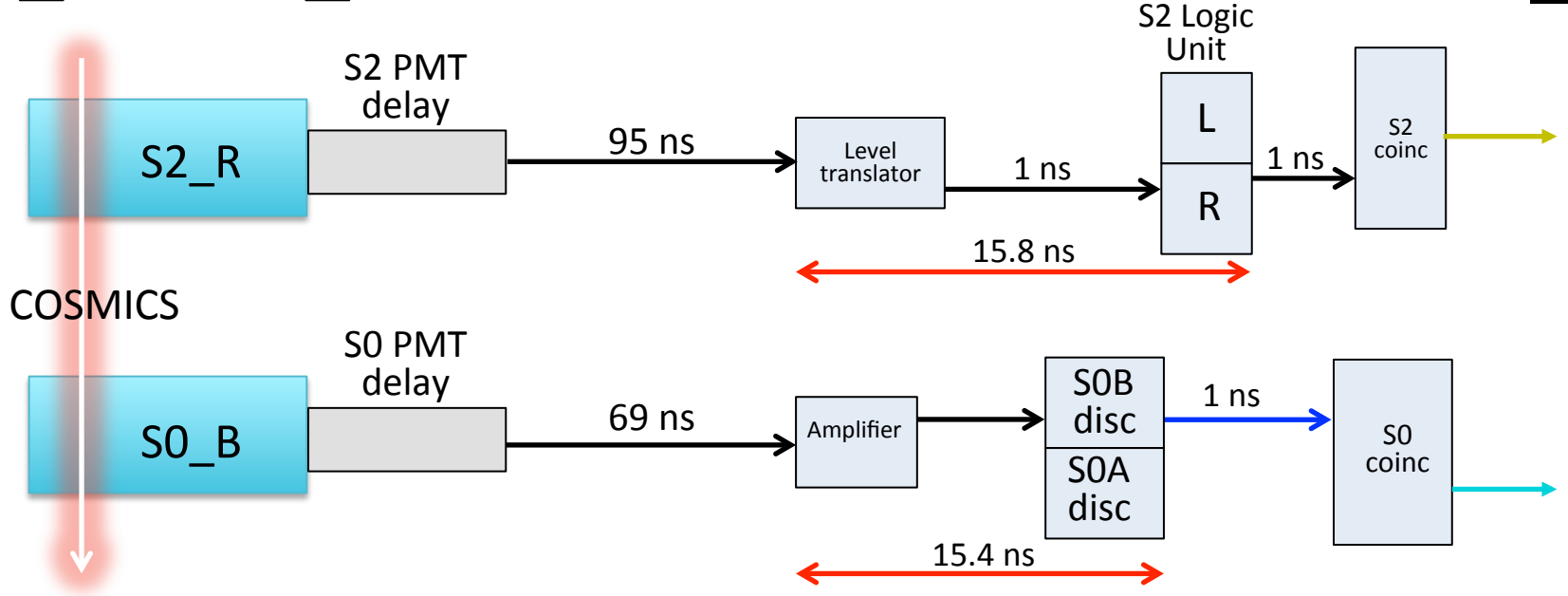
$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 30 - 8.6 = 21.4$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 21.4 \text{ ns}$$

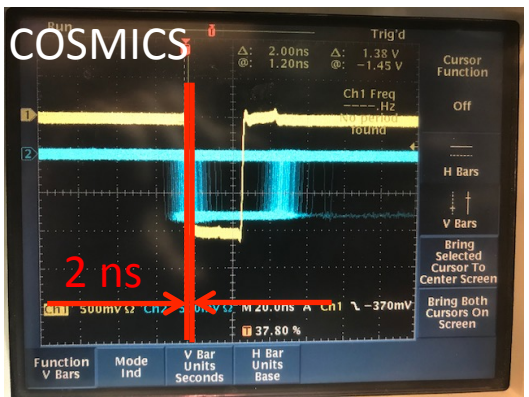
S2_R & S0_B



$$(S0_B \text{ PMT delay}) + 69 + 15.4 + 1 + 8 + \text{TOF} - [(S2_R \text{ PMT delay}) + 95 + 15.8 + 1 + 8] = 2$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 2 + 21.4 = 23.4$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 23.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 34.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 31.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 21.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 23.4 \text{ ns}$$

$$S2_R \text{ delay} = I_0$$

$$S2_L \text{ delay} = I_0 + 3 \text{ ns}$$

$$S0_A \text{ delay} = I_0 + 34.4 \text{ ns}$$

$$S0_B \text{ delay} = I_0 + 23.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 34.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 31.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 21.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 23.4 \text{ ns}$$

$$S2_R \text{ delay} = l_0$$

$$S2_L \text{ delay} = l_0 + 3 \text{ ns}$$

$$S0_A \text{ delay} = l_0 + 34.4 \text{ ns}$$

$$S0_B \text{ delay} = l_0 + 23.4 \text{ ns}$$

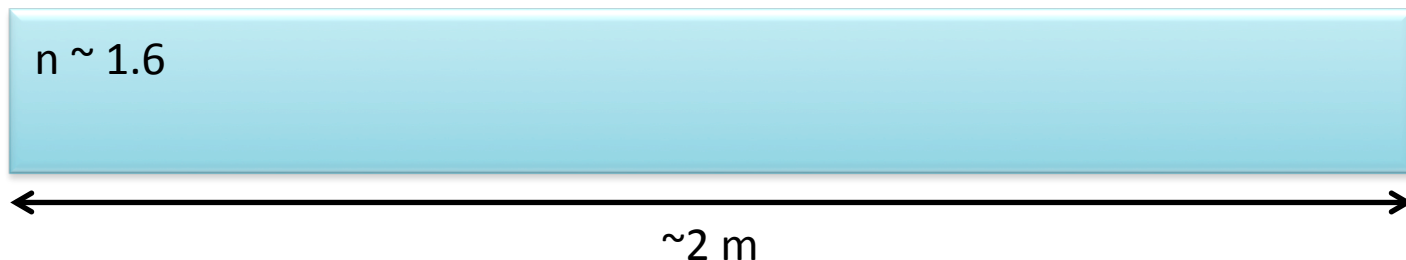
This could be: only PMT delay, only light TOF delay, or both. Which one is it?

Estimation: Light TOF in S0

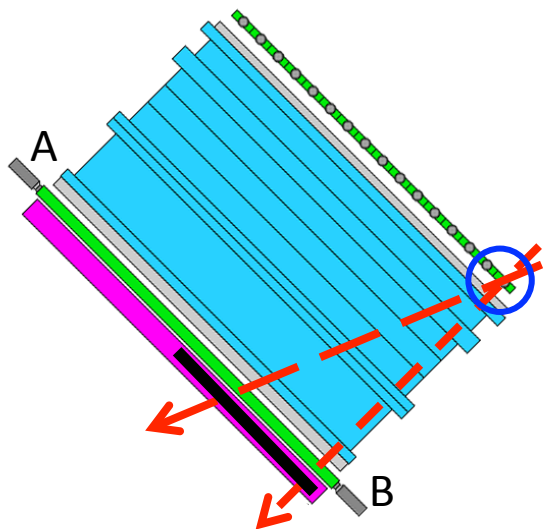
S0 scintillators $\sim 2\text{m}$ long

Speed of light in scintillator $\sim (3 \times 10^8 \text{ m/s}) / (1.6)$

Light TOF: $\sim (2 \text{ m} \times 1.6) / (3 \times 10^8 \text{ m/s}) \sim 10 \text{ ns}$

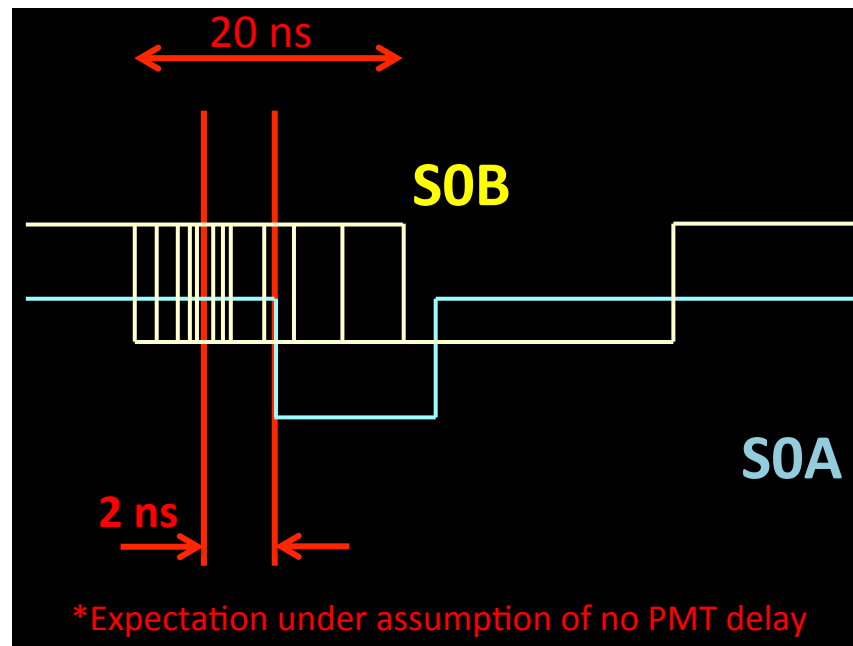
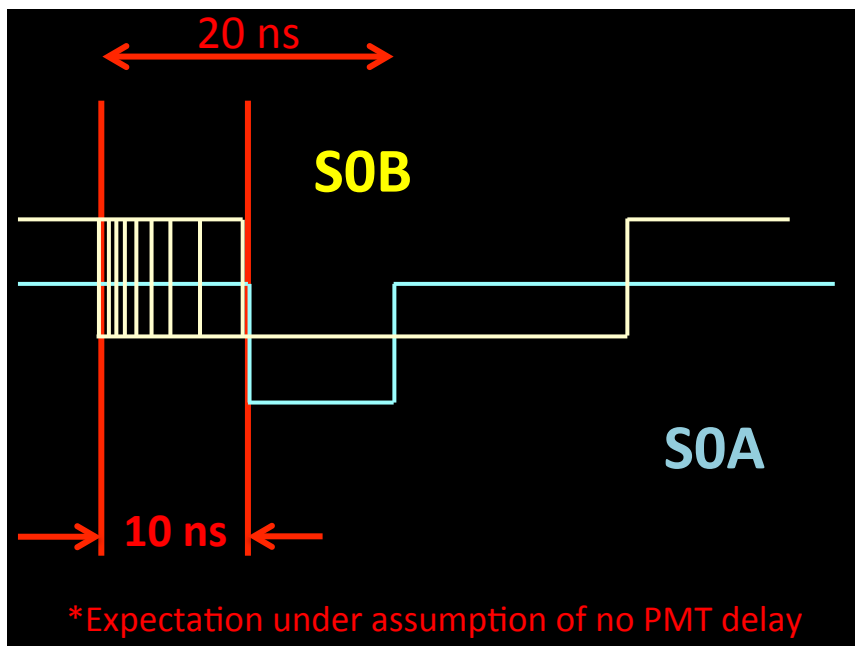
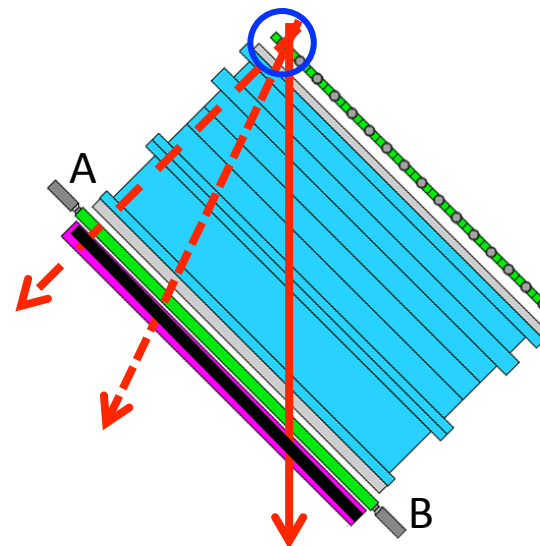


Triggering externally on
S2_L(16) & S2_R(16) & SOA &
SOB

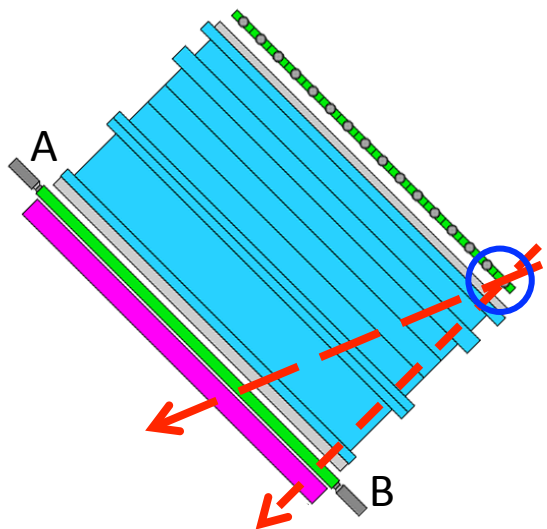


LHRS

Triggering externally on
S2_L(1) & S2_R(1) & SOA &
SOB

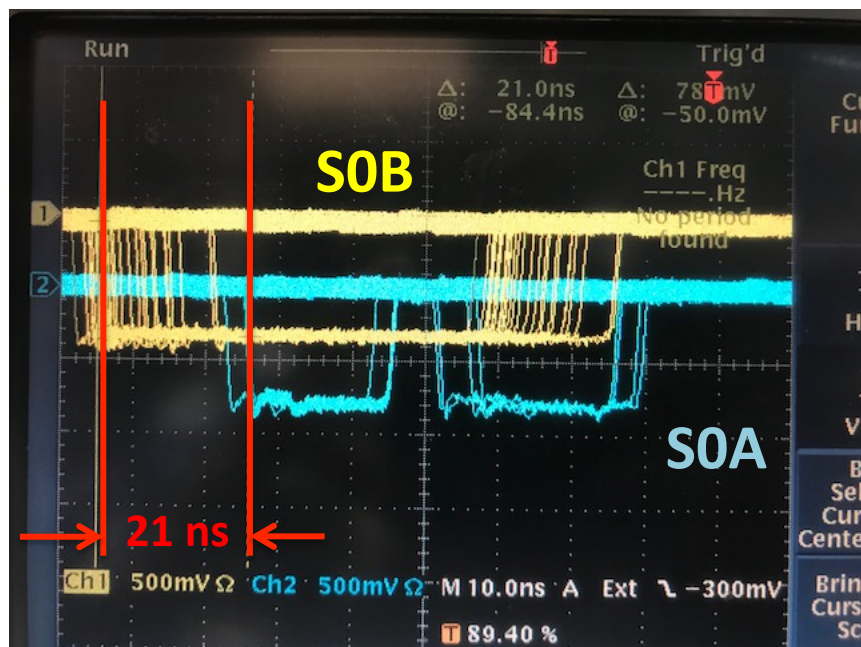
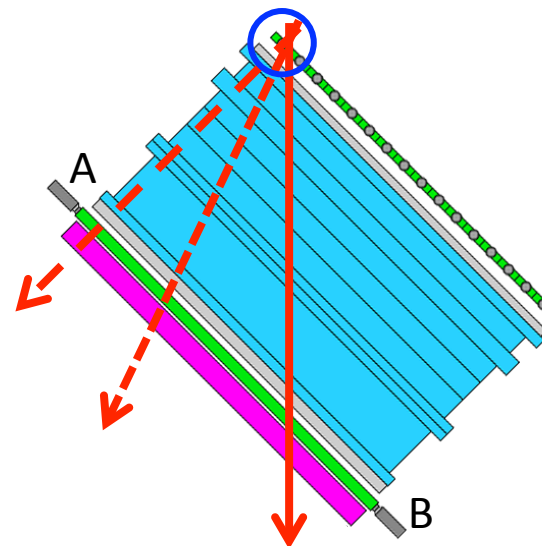


Triggering externally on
S2_L(16) & S2_R(16) & SOA &
SOB



LHRS

Triggering externally on
S2_L(1) & S2_R(1) & SOA &
SOB



$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 34.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 31.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 21.4 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 23.4 \text{ ns}$$

$$S2_R \text{ delay} = l_0$$

$$S2_L \text{ delay} = l_0 + 3 \text{ ns}$$

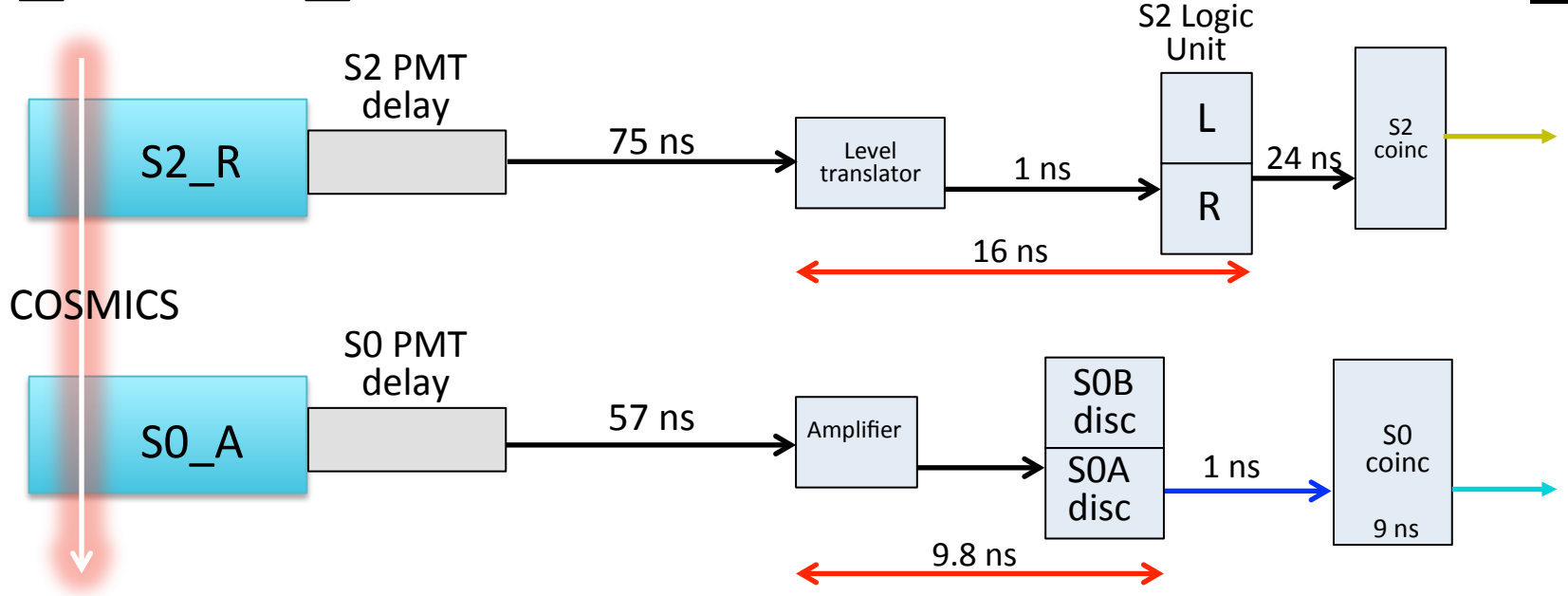
$$S0_A \text{ delay} = l_0 + 34.4 \text{ ns}$$

$$S0_B \text{ delay} = l_0 + 23.4 \text{ ns}$$

This difference is due to PMT delay!

RHRS

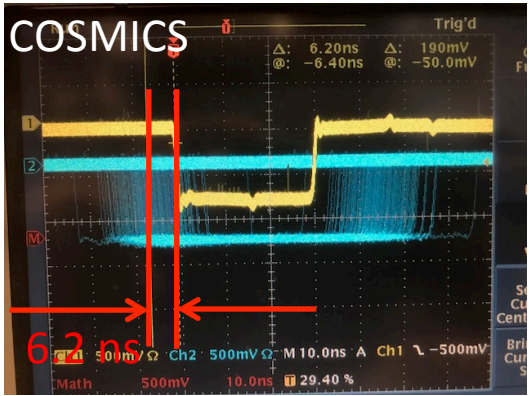
S2_R & S0_A



$$(S0_A \text{ PMT delay}) + 57 + 9.8 + 1 + 8 + \text{TOF} - [(S2_R \text{ PMT delay}) + 75 + 16 + 24 + 8] = -6.2$$

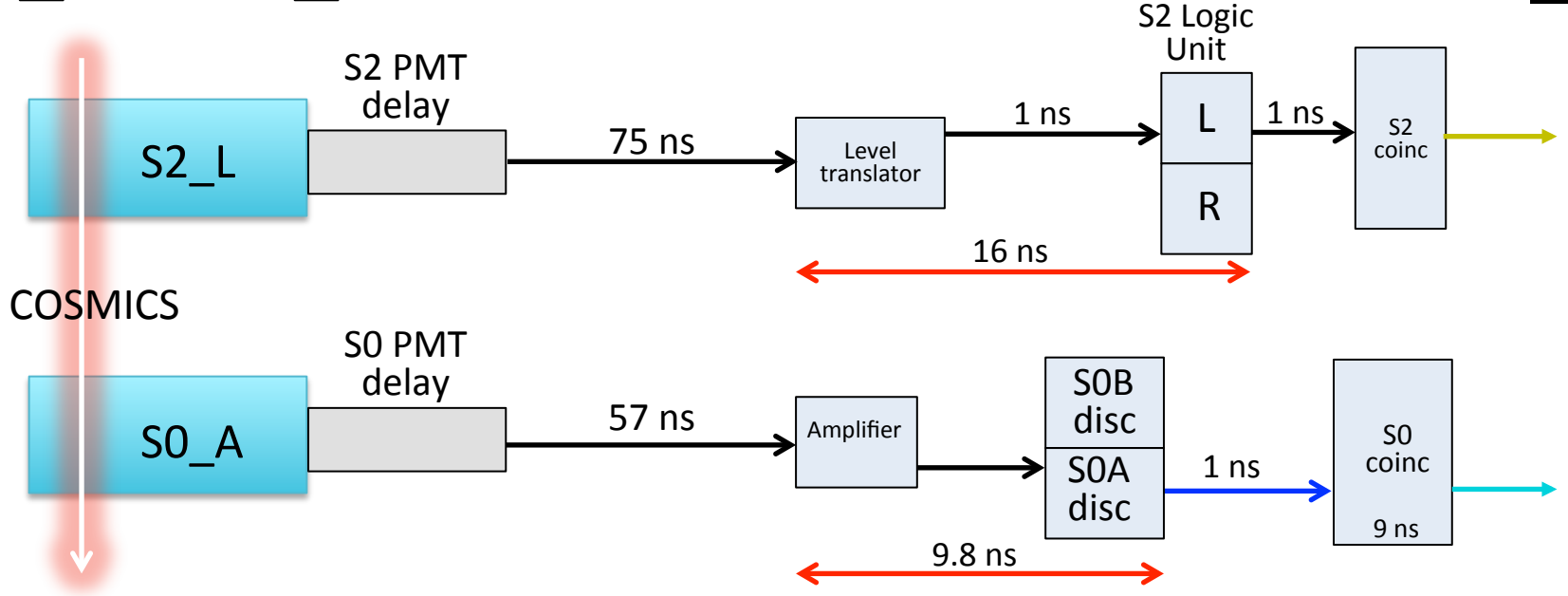
$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = -6.2 + 42.2 = 36$$

* where we assumed TOF = 5 ns
 * all numbers in nano-seconds



$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 36 \text{ ns}$$

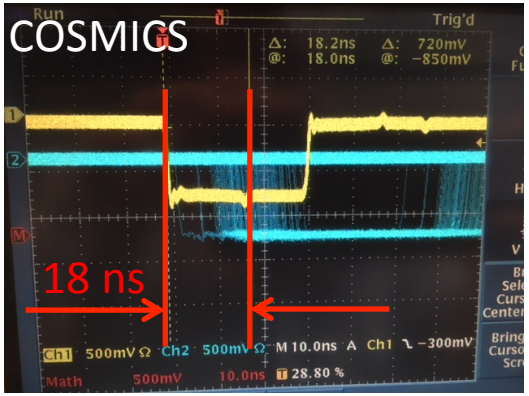
S2_L & S0_A



$$(S0_A \text{ PMT delay}) + 57 + 9.8 + 1 + 8 + \text{TOF} - [(S2_L \text{ PMT delay}) + 75 + 16 + 1 + 8] = 18$$

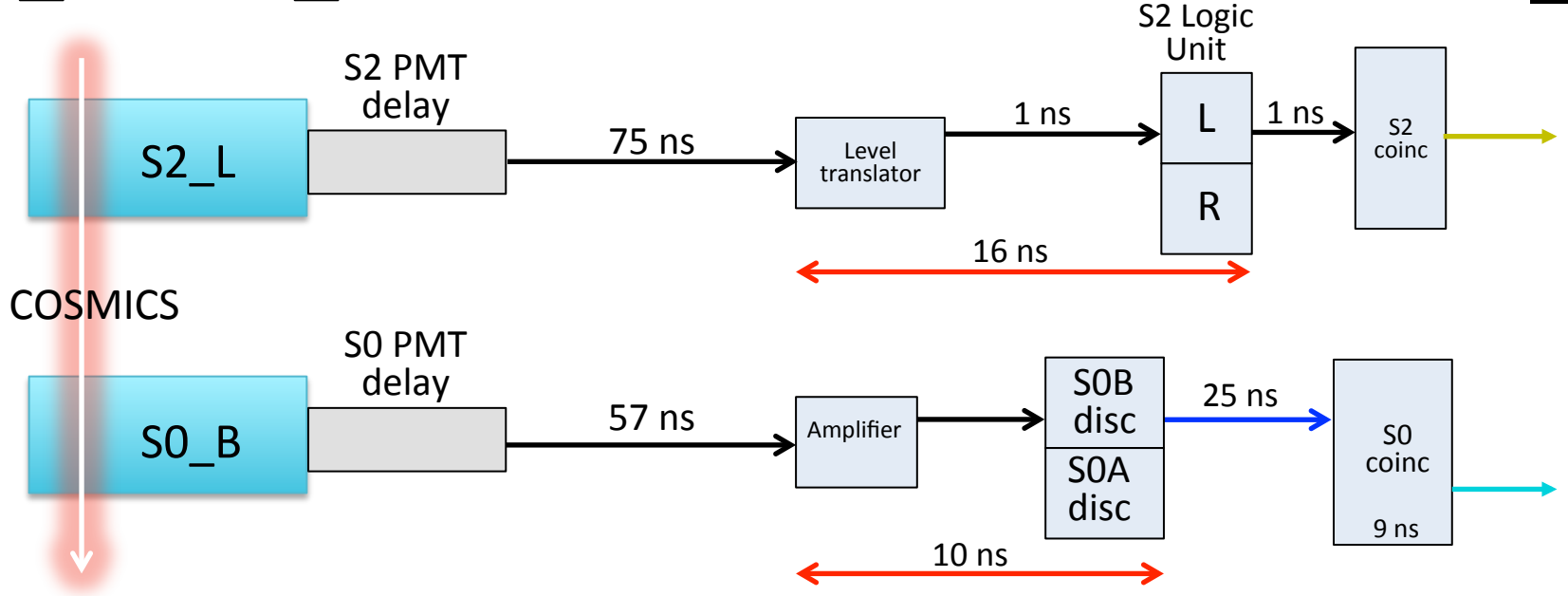
$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 18 + 19.2 = 37.2$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 37.2 \text{ ns}$$

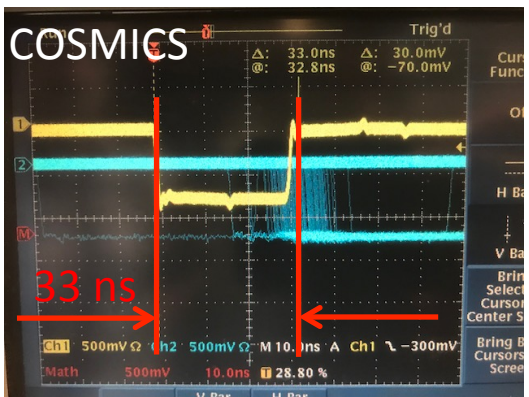
S2_L & S0_B



$$(S0_B \text{ PMT delay}) + 57 + 10 + 25 + 8 + \text{TOF} - [(S2_L \text{ PMT delay}) + 75 + 16 + 1 + 8] = 33$$

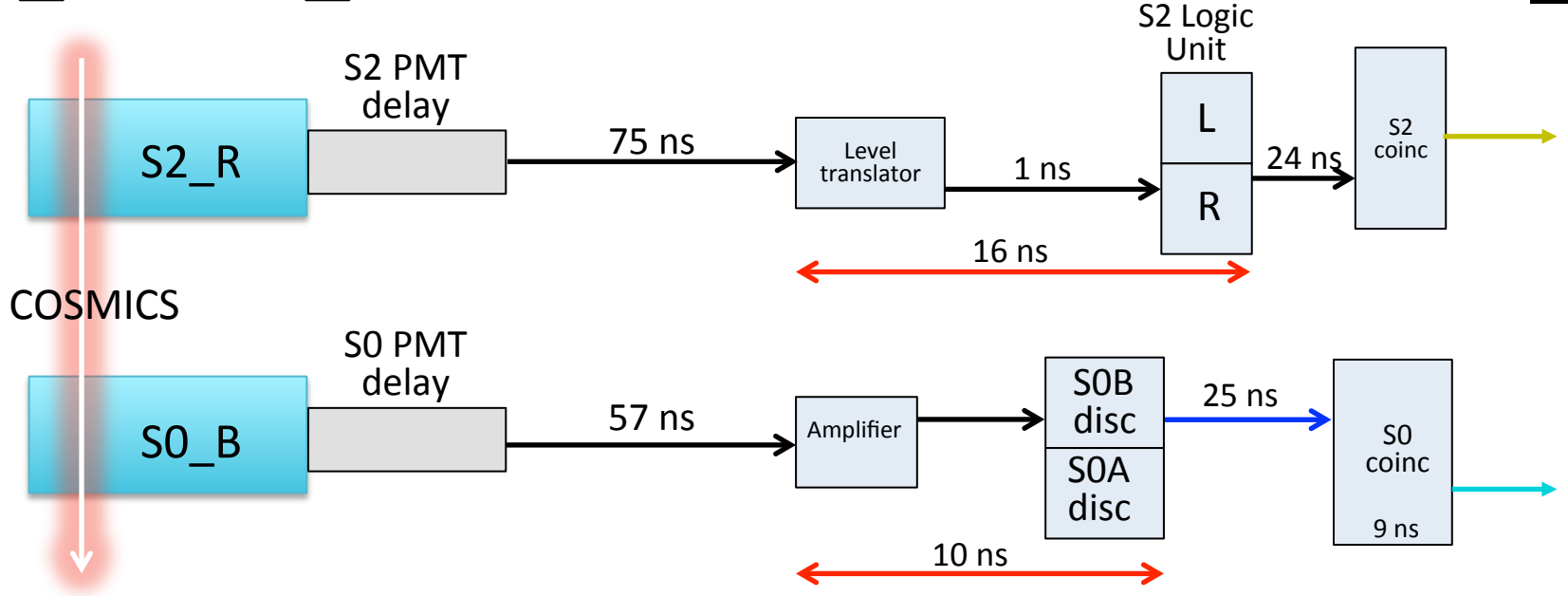
$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = -5 + 33 = 28$$

* where we assumed TOF = 5 ns
 * all numbers in nano-seconds



$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 28 \text{ ns}$$

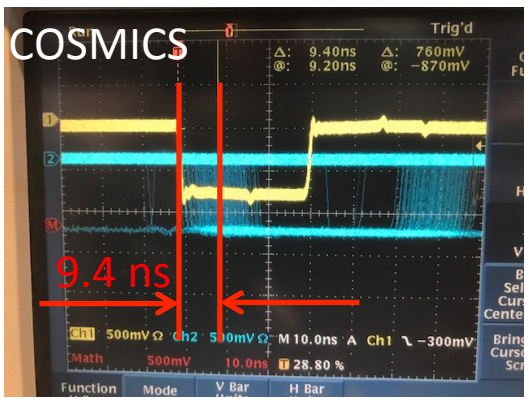
S2_R & S0_B



$$(S0_B \text{ PMT delay}) + 57 + 10 + 25 + 8 + \text{TOF} - [(S2_R \text{ PMT delay}) + 75 + 16 + 24 + 8] = 9.4$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 9.4 + 18 = 27.4$$

- * where we assumed TOF = 5 ns
- * all numbers in nano-seconds



$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 27.4 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 36 \text{ ns}$$

$$(S0_A \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 37.2 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_L \text{ PMT delay}) = 28 \text{ ns}$$

$$(S0_B \text{ PMT delay}) - (S2_R \text{ PMT delay}) = 27.4 \text{ ns}$$

$$S2_L \text{ delay} = l_1$$

$$S2_R \text{ delay} = l_1 + 1 \text{ ns}$$

$$S0_A \text{ delay} = l_1 + 37 \text{ ns}$$

$$S0_B \text{ delay} = l_1 + 28 \text{ ns}$$

**Fake signal for
coincidence
trigger**

$t_0 + t_{PMT} + 1ns + 20ns + 5ns + 75ns$

$t_0 + t_{PMT} + 5ns + 95ns$

$t_0 + t_{PMT} + 34ns + 69ns$

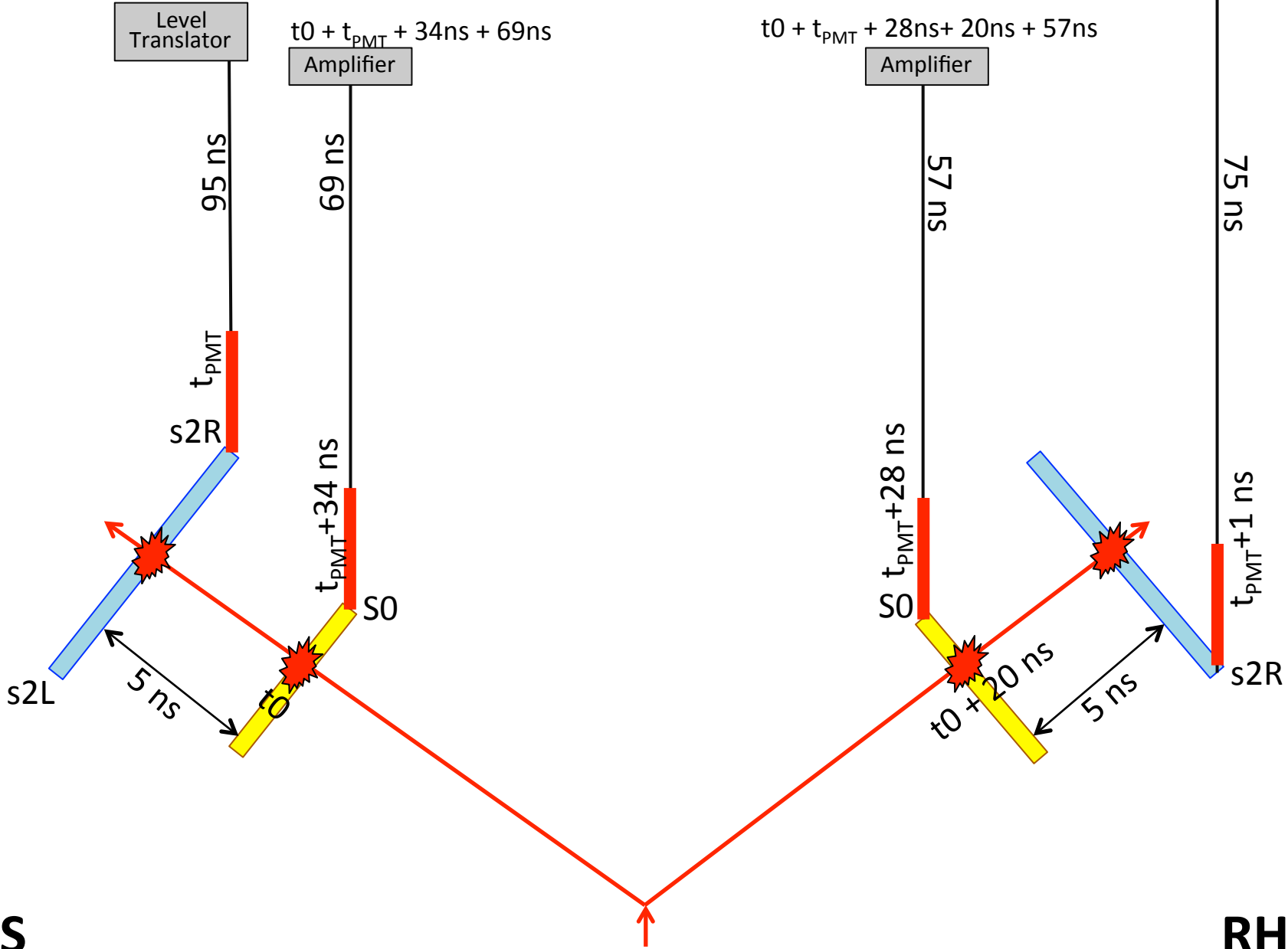
$t_0 + t_{PMT} + 28ns + 20ns + 57ns$

Level Translator

Level Translator

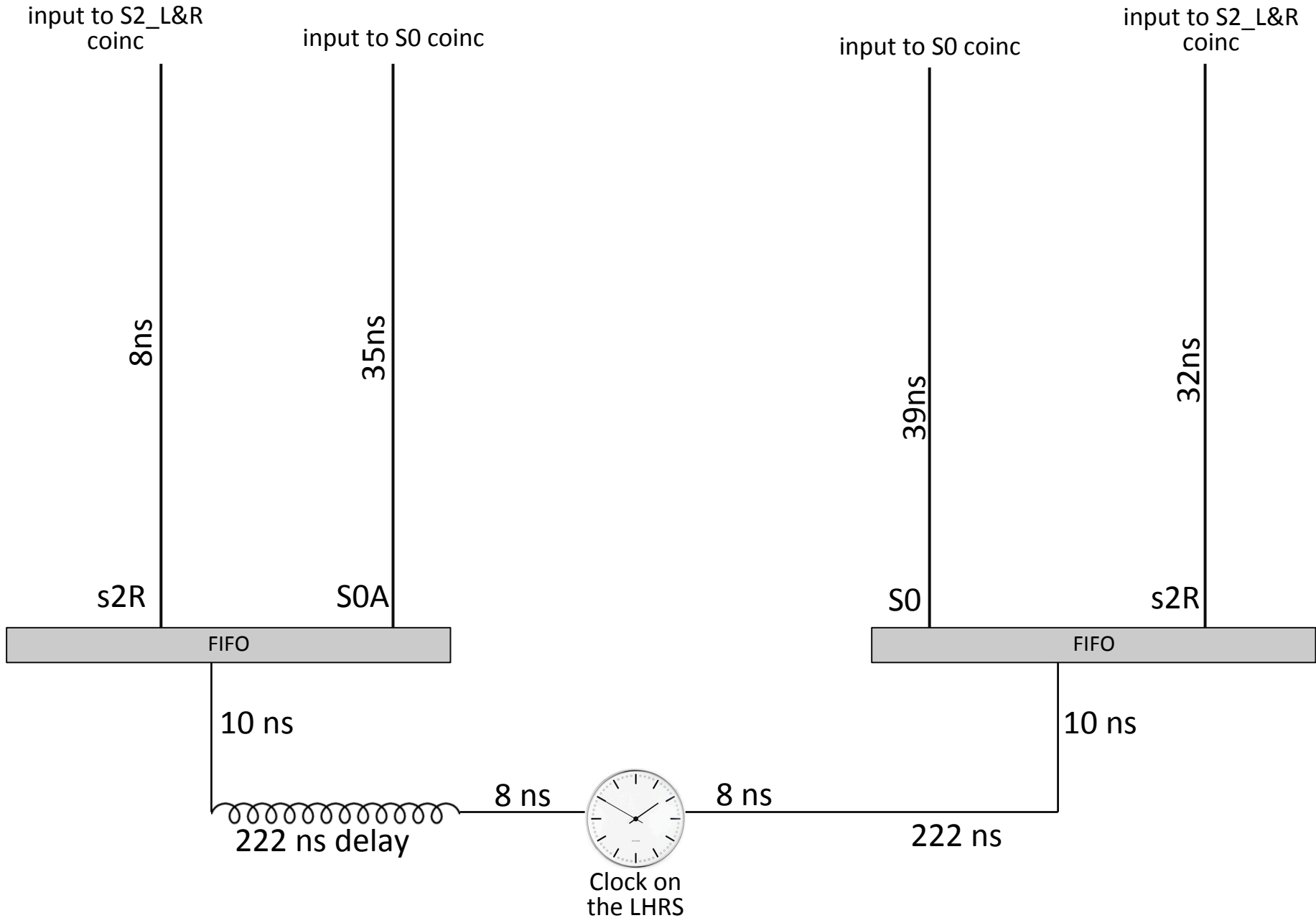
Amplifier

Amplifier



LHRs

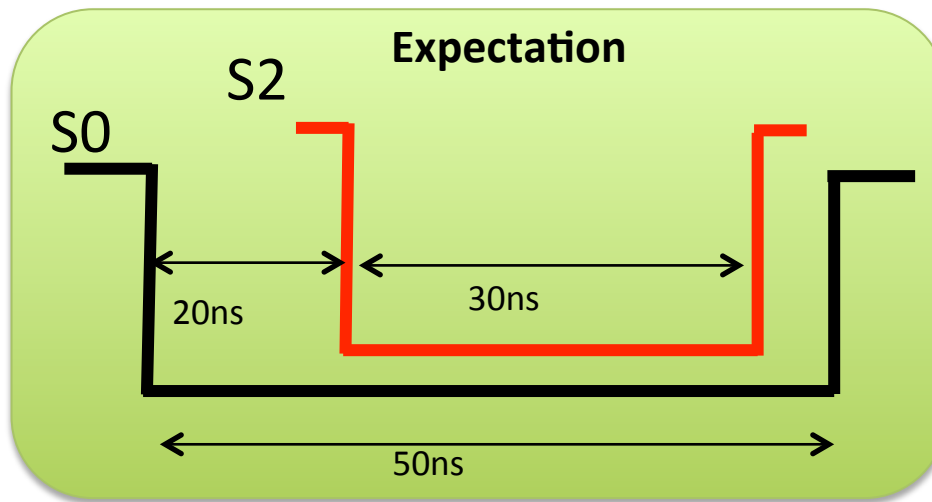
RHRS



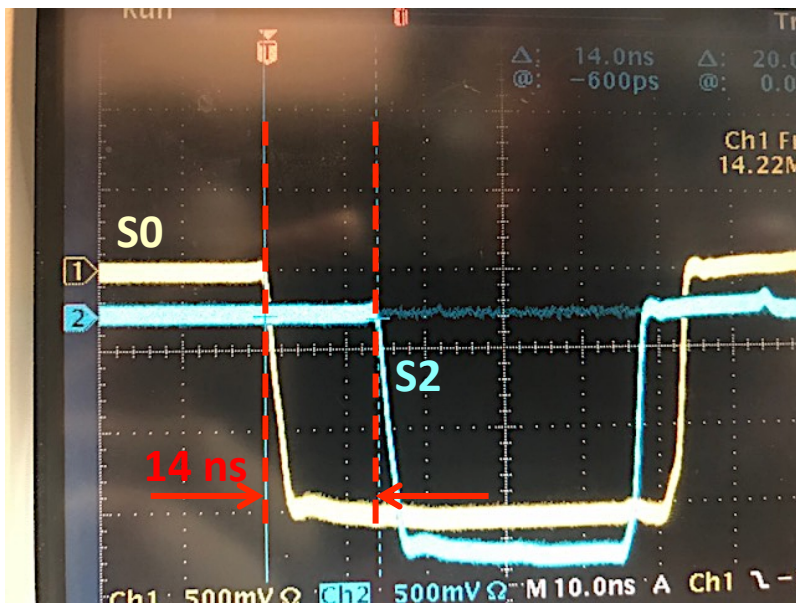
LHRs

RHRs

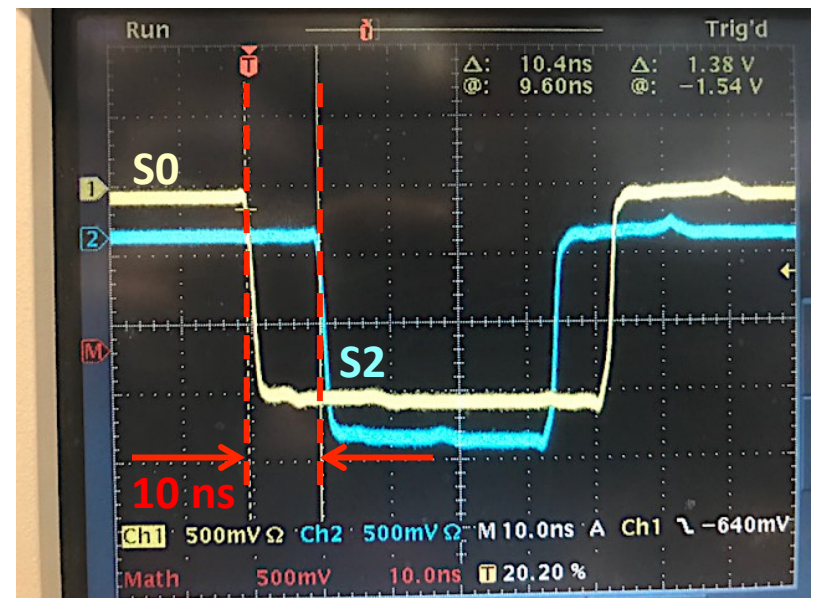
**Single arm
triggers with
fake signal**



LHRS



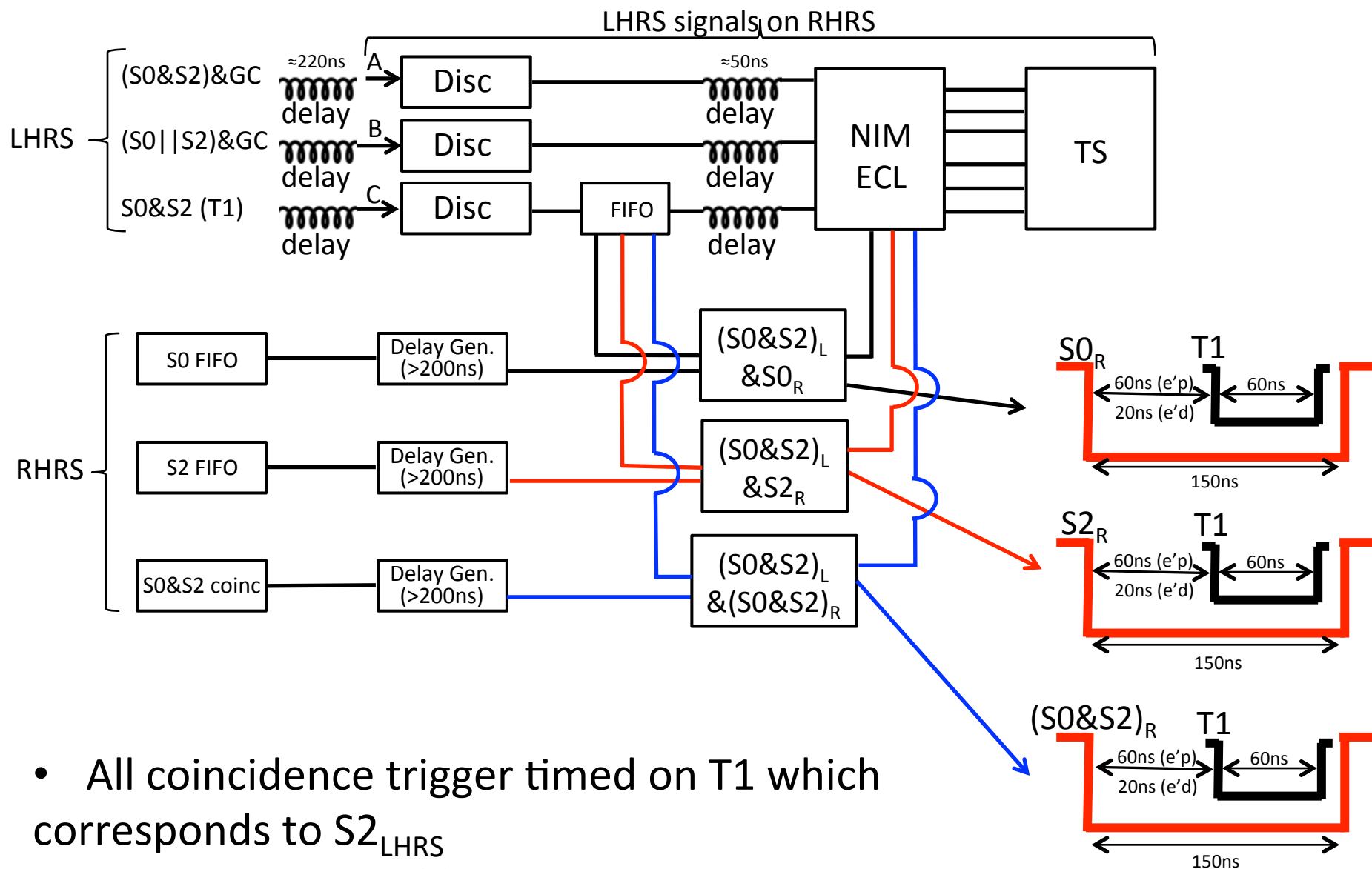
RHRS



* (S0-S2 delay should be ~20ns) Might need adjustment for real electrons

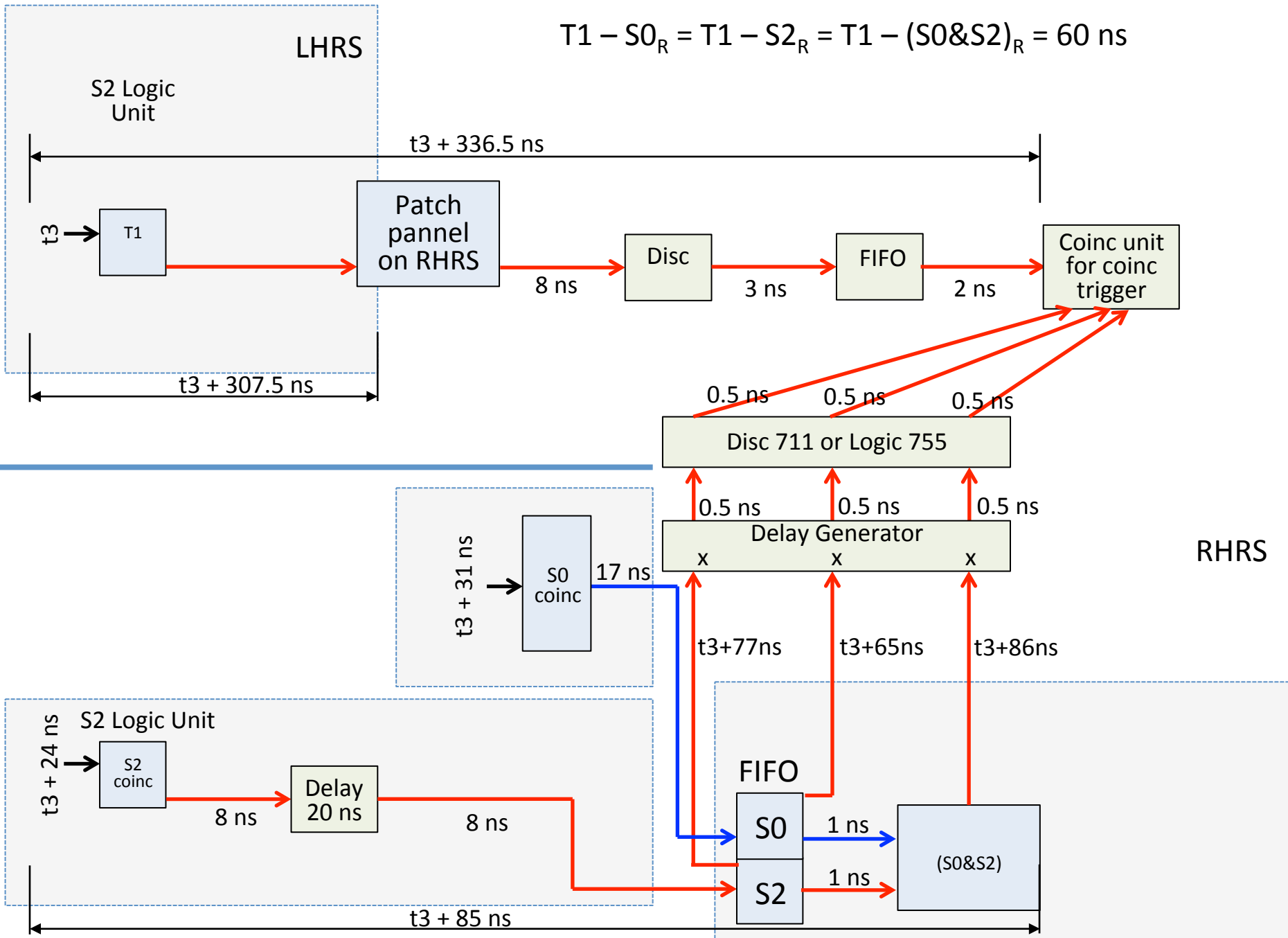
**Coincidence
trigger with
fake signal**

Coincidence triggers



- All coincidence trigger timed on T1 which corresponds to $S2_{LHRs}$
- > all trigger but $(S0 \mid \mid S2) \& GC_{LHRs}$ timed on $S2_{LHRs}$
- $(S0 \mid \mid S2) \& GC_{LHRs}$ timed on $S0_{LHRs}$ if S0 fires

$$T1 - S0_R = T1 - S2_R = T1 - (S0\&S2)_R = 60 \text{ ns}$$



Prediction for the delays on RHRS for coinc trigger

Need to set delay in RHRS delay generator for S2 (RHRS) to:

$$t_3 + 336.5 - (t_3 + 77 + x + 0.5 + 8 + 0.5) \text{ ns} = 60 \text{ ns}$$

$$x = 190.5 \text{ ns}$$

Need to set delay in RHRS delay generator for S0 (RHRS) to:

$$t_3 + 336.5 - (t_3 + 65 + x + 0.5 + 8 + 0.5) \text{ ns} = 60 \text{ ns}$$

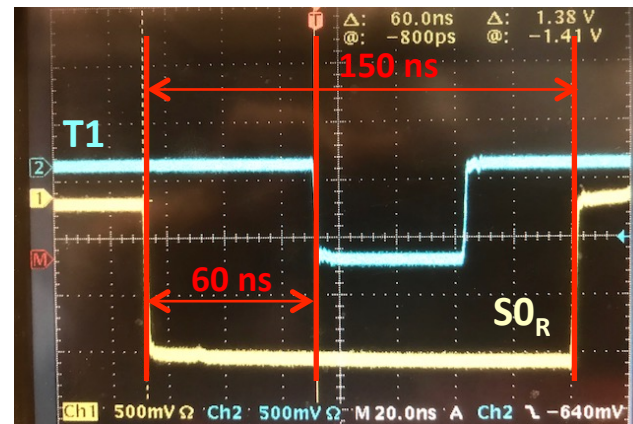
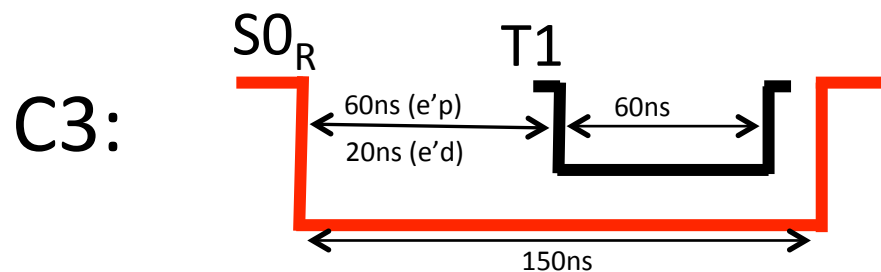
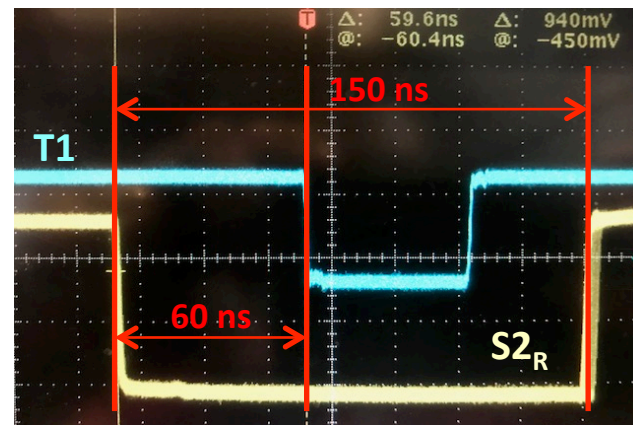
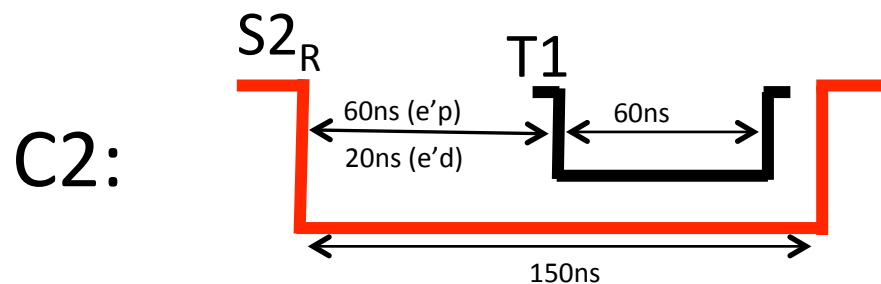
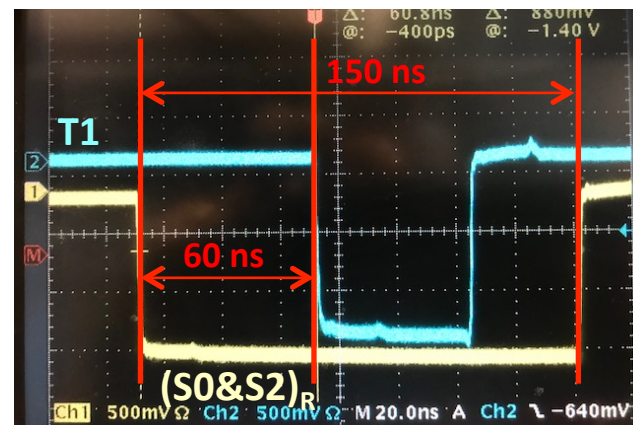
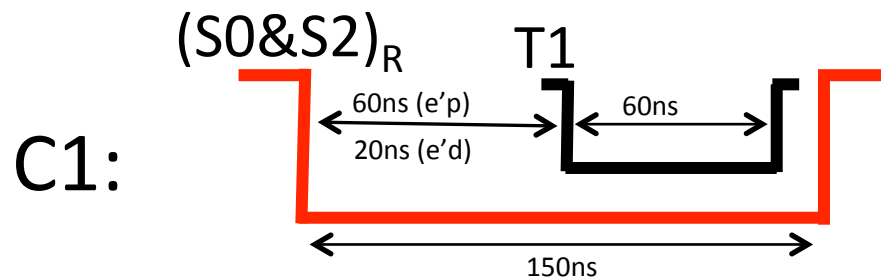
$$x = 202.5 \text{ ns}$$

Need to set delay in RHRS delay generator for S0&S2 (RHRS) to:

$$t_3 + 336.5 - (t_3 + 86 + x + 0.5 + 8 + 0.5) \text{ ns} = 60 \text{ ns}$$

$$x = 181.5 \text{ ns}$$

Coincidence triggers



To-do list

- Trigger delays for coincidence setup
- Test switching between single arm and coincidence
- Plug all connections between spectrometers
- Update schematics and labeling in the hall

Summary

- Both, single and coincidence triggers are finished. Please, do not modify anything. See handout!