May 17, 2000

To: Hank Crawford
From: Leo Greiner
Re: STAR Trigger timing block diagram

Hank,
As per your request last week, I have put together a pass at the trigger timing block diagram with explanations of the various delays, adjustments, and timing blocks. In addition I have outlined the commissioning procedure for the baseline trigger and future added trigger detectors.

STAR Trigger timing block diagram

The purpose of this diagram is to show the timing flow of the trigger through the boards and cables that make up the trigger as well as the places for adjustment in each. Each box representing a board has an attendant delay and phase adjust (delay range) associated with each output (in some cases either or both of these may be zero). In general, the timing blocks operate synchronously with respect to the RHIC strobe that they receive, and the delay and phase adjust are taken with respect to that input. The connection and other delays are shown with letter designations, generally these are the cables connecting the boards. Connections shown without letter designations are made through the P1/P2/P3 connectors directly or are a daughter type card connection. For simplicity, only the basic flow for one detector of each trigger detector type through the Trigger system is shown, the timing for the rest of the detectors through the system is identical to the one shown. Once each timing block has been time characterized with respect to delay and phase adjustment, one can use this diagram and the measured cable / etc. delays to generate a complete trigger timing diagram for any arbitrary set of trigger conditions and delays. This will be particularly important when we wish to determine which RHIC interaction corresponded to a particular trigger (trigger latency) and to determine the phase of the RHIC strobe anywhere in the system with respect to the actual collision time (or rather, beam overlap time). This will be necessary as a guide to allow future trigger detectors to be added without impacting the internal timing of the installed system.

Before we begin to install the trigger system at STAR, the components in box outline 2 will be need to already be timed in during the testing at LBL with the cables that we will actually use at BNL. Thus, for all practical purposes, box outline 2 can be treated as a working block when we consider the commissioning of the trigger. Box outline 3 is the asynchronous communication path with the L1 controller and DAQ.

Setup at LBL

The idea here is to get as complete a system working at LBL as possible before we ship everything to BNL. The majority of the baseline trigger (everything in box outline 2) can be functioning and timed in before it is shipped to BNL This will save access and setup time when we arrive. Before we begin setting up the trigger at LBL we need to measure the time characteristics of each timing block and cable delay.

1. Setup the RCC-RCF running from an oscillator.
2. Using the cables that we will use at BNL, connect the DSMIs and TCUI to the RCF and adjust delays on the RCF such that they are passing data correctly. (data valid when strobed)
3. Connect the PDC, TCD and TCD cable driver to the TCUI.
4. Connect the TCD cable driver to the CDB DIB and use the built in phase adjust delays in the TCD to set the timing of the CDB such that it is passing data correctly to the first DSM.
5. The system now contained in box outline 2 is now internally timed in with respect to the RCC.

Setup of the CTB at BNL

The components in box outline 2 are then shipped to BNL with the CDB and DIB boards. We can then adjust the timing of the trigger such that we are running from the RHIC strobe and fixing the phase relationship between the actual interaction and the RS clock that we receive.

1. Re-establish the box outline 2 that one had at LBL.
2. Set up the RCC to run off of the RHIC strobe signal provided by RHIC.

3. Bring out the signals (drivers and measured delays) that one needs to determine that the PMT pulses are falling into the ADC gate along measured cables so that one knows when the ADC signals will fall into the ADC gate.
4. Use the signals that one has routed out of the area and adjust the timing on the whole trigger using the phase delay adjustments in the RCC to put the analog PMT signals into the ADC gate.
5. The basic CTB trigger is now timed in and a timing diagram can be confirmed by measuring the various outputs in the system and comparing them to what is generated by examination of the timing blocks. The phase between the received RCC RHIC strobe and the basic trigger system is now fixed. When new trigger detector systems are added, they will use the timing block diagram to determine the cable lengths and offsets that they will need to correctly integrate into the existing trigger.

Setup of the ZDC at BNL

The ZDC CDB board is located in the CTB CDB crate and receives it's clock at the same time as the other boards in the crate. There is some minor adjustment possible in the gate timing on a board basis but it is easier to carefully adjust the cable length timing such that the relationship shown on the timing block diagram follows

12ns + (PMT CTB 9 ns) + 162 + nRS = ZDC flt time + (PMT ZDC) + ZDC cable run

where nRS refers to an integer number of RHIC strobe periods. This can be done by calculation of the flight paths, cable delays, etc. When this is done to the necessary level of precision we can then use the limited range of gate adjustment built in to the ZDC CDB board to trim the final delay needed.

1. Begin with the basic CTB trigger system timed in and running.
2. Use the same drivers and cables that were used to time in the CTB and attach them to the gate and analog outputs of the ZDC CDB.
3. Check the location of the analog signals with respect to the gate. Adjust the gate position / width as necessary.
4. The ZDC is now timed in.

Setup of the MWC at BNL

The setup of the MWC system will happen after the basic trigger system is installed. It is basically the same procedure that any other trigger level detector will need to follow in order to be added to the trigger. Note that this procedure can be done with the TDC running from the oscillator on the RCC, not necessarily the RHIC strobe. Initially one should have the MWC system together and timed internally on the (spare) TCD using the cables that will actually be used at BNL.

1. Begin with the basic CTB trigger system timed in and running.
2. A calculation must be done to get the relative phasing of the TPC and CTB TCDs. The TPC TCD should be adjusted such that the signal from the interaction will be correct in time to the MWC SCB with respect to the CTB.
3. Using the timing block delays and cable delays, calculate the MWC TCD setting that brings the MWC data into the DSMs at the correct time.
4. Install the MWC and set it running from the RCC on RHIC strobe or internal oscillator.
5. Check that the data is arriving at the DSMs correctly. Adjust using only the MWC TCD module as necessary.
6. The MWC is now timed in.

These procedures should leave us with the STAR trigger fully timed in.

The following table of delays will need to be filled as the system develops.

Timing block delays

Timing Block	Delay	Output phase adjusts
PMT CTB	9 ns (transit time)	none
PMT ZDC	45 ns	none

	(transit time)	
CDB	1 RS	The ADC gate width and position is settable inside each RHIC strobe. The digitized data from each strobe is latched out at the end of that RHIC strobe.
DIB	~12 ns	None
DSMI	~12 ns	None
DSM	1 RS	Fifo output depth selectable in units of nRS
TCUI	~12 ns	None
TCU	1 RS	None
PDC	~12 ns	None
TCD		Delay phasing adjust over a range larger than 1 RS
Cable driver	~12 ns	None
RCC		Don’t care, but phase adjusts on 12 outputs over entire RS range.
RCF	~12 ns	None
MWC FEE	~1 RS	Read out on RS, shaping gives 50 ns transition window
MWC SCB	RS40 ns	40 ns on a RS period
MWC REC		Latency = 120 ns but latches out every RS. Depends on phasing of TPC and MWC TCDs.