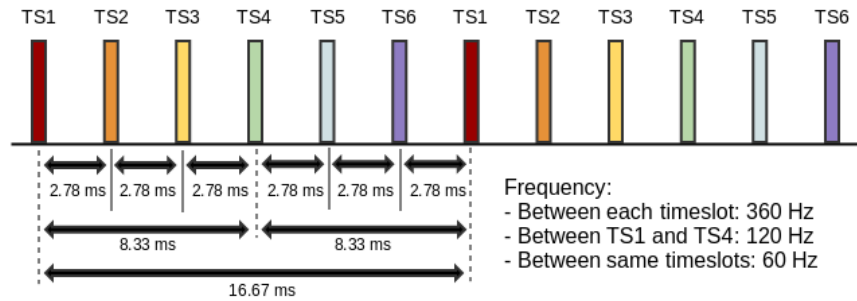


Sequencer and LCLS timing

Brief discussion on the LCLS timing

A great and detailed explanation can be found here: [LCLS 1 Event Generator for Dummies](#)

In summary, the main LCLS-I timing is based on a 360 Hz frequency, which is divided in 6 time slots (TS), each running at 60 Hz, but with a different phase. The 120 Hz beam is a combination of slots TS1 and TS4, while the other ones are "empty".



As shown below, event codes are generated for each time slots, from 60 Hz down to 0.5 Hz. Special event codes combining multiple time slots are also generated. For example, event codes 10 and 40 combine TS1 and TS4, giving a marker for the nominal 120 Hz beam.

IN20 TS 1 to 6 Events											
IN20 EVG Time Slot Events Development											EXIT
Name	Event Code	Delay (Clock Ticks)	Delay (nsec)	Rate (Hz)	Mask Setup	Name	Event Code	Delay (Clock Ticks)	Delay (nsec)	Rate (Hz)	Mask Setup
TS1&4 120Hz	10	13001	109135	120.0	Masks	TS1&4 120Hz	40	13004	109160	120.0	Masks
TS1 60Hz	11	13011	109219	60.0	Masks	TS4 60Hz	41	13014	109244	60.0	Masks
TS1 30Hz	12	13021	109303	30.0	Masks	TS4 30Hz Klys Standby	42	13024	109328	30.0	Masks
TS1 10Hz	13	13031	109387	10.0	Masks	TS4 10Hz	43	13034	109412	10.0	Masks
TS1 5Hz	14	13041	109471	5.0	Masks	TS4 5Hz	44	13044	109496	5.0	Masks
TS1 1Hz	15	13051	109555	1.0	Masks	TS4 1Hz	45	13054	109580	1.0	Masks
TS1 0.5Hz	16	13061	109639	0.5	Masks	TS4 0.5Hz	46	13064	109664	0.5	Masks
TS2&5 120Hz	20	13002	109143	120.0	Masks	TS2&5 120Hz	50	13005	109168	120.0	Masks
TS2 60Hz	21	13012	109227	60.0	Masks	TS5 60Hz	51	13015	109252	60.0	Masks
TS2 30Hz	22	13022	109311	30.0	Masks	TS5 30Hz	52	13025	109336	30.0	Masks
TS2 10Hz	23	13032	109395	10.0	Masks	TS5 10Hz	53	13035	109420	10.0	Masks
TS2 5Hz	24	13042	109479	5.0	Masks	TS5 5Hz	54	13045	109504	5.0	Masks
TS2 1Hz	25	13052	109563	1.0	Masks	TS5 1Hz	55	13055	109588	1.0	Masks
TS2 0.5Hz	26	13062	109647	0.5	Masks	TS5 0.5Hz	56	13065	109672	0.5	Masks
TS3&6 120Hz	30	13003	109151	120.0	Masks	TS3&6 120Hz	60	13006	109177	120.0	Masks
TS3 60Hz	31	13013	109235	60.0	Masks	TS6 60Hz	61	13016	109261	60.0	Masks
TS3 30Hz	32	13023	109319	30.0	Masks	TS6 30Hz	62	13026	109345	30.0	Masks
TS3 10Hz	33	13033	109403	10.0	Masks	TS6 10Hz	63	13036	109429	10.0	Masks
TS3 5Hz	34	13043	109487	5.0	Masks	TS6 5Hz	64	13046	109513	5.0	Masks
TS3 1Hz	35	13053	109572	1.0	Masks	TS6 1Hz	65	13056	109597	1.0	Masks
TS3 0.5Hz	36	13063	109656	0.5	Masks	TS6 0.5Hz	66	13066	109681	0.5	Masks

When multiplexing with SXR as the secondary branch, the SXR line gets their shots on TS1. For a 10 Hz secondary beam to SXR (event code 13), this means that HXR gets the full 60 Hz of TS4, but only 50Hz on TS1 (110 Hz total). When using the sequencer, one needs to be mindful of that, as detailed below.

To be verified: when HXR is secondary, HXR is put on TS4.

Event sequencer

Sync marker

The sync marker defines on which phase the sequence can be started. For HXR, the sync marker follow the event codes 4X. A sync marker of 120 Hz thus means that the sequence will start on the next 120 Hz tick (TS1 or TS4). With a sync marker of 60 Hz or below, the sequence is guaranteed to start on TS4. This is important to ensure a deterministic start of the sequence when multiplexing.

When running a sequence in a loop (N times or repeat forever), the sync marker determines the start for each loop. This means that it will limit the frequency at which the sequence will run. For example, if a sequences that could run at 30 Hz (4 delta beams total, see below) is run with a 10 Hz sync marker, it will only start on a 10 Hz frequency and thus run at 10 Hz.

Lower rate operation

When using the sequencer to operate at lower rep rate (60 Hz and below) or on a custom sequence of beam, one wants to make sure that the DAQ is not synchronized with the 10 Hz shot sent to SXR. That means DAQ must be triggered only on TS4.

To do so, the sync marker should be put on 60 Hz and the DAQ / detector trigger event code generated after an EVEN number of Beam.

Event Sequence Configuration@mf-x-daq

Event Code Sequence 7

Sequence Owner 7 MFX

Photon Beam Owner 7 MFX

Once

Repeat N Times

Repeat Forever

Start

Stop

Status

Beam Rate 120.0

Play Count 526728

Total Play Cnt 526728

Play Status Playing

Current Step 0

Synchronization Settings

Sync Marker 60Hz

Next Sync Immediate

Run using Timeslot

Spare Sequences

Define Sequence 7

Valid Sequence at step 0

Stop at Step: 5

Event Code Allocation

Load spreadsheet

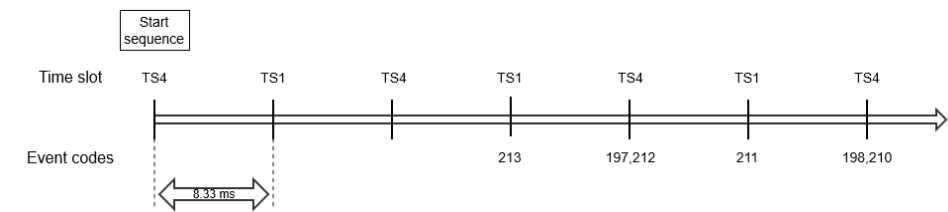
Save spreadsheet

Step	Event Code	Δ Beam	Δ Fiducial	Burst Count	Device/Function
0	213	3	0	0	
1	197	1	0	0	
2	212	0	0	0	
3	211	1	0	0	
4	210	1	0	0	
5	198	0	0	0	
	0	0	0	0	

Working example

In the above figure, the sequencer is used to run at 20 Hz with the pulse picker. The total number of Beam is thus 6 (120 Hz/20 Hz=6) and can't be changed without changing the repetition rate of the loop. In addition, one must allow for 2 Beam after triggering the pulse picker to get the beam through.

The corresponding sequence is executed as follow:



Here, event code 197 triggers the pulse picker and event code 198 the DAQ readout. Note how if the sequence were to start on TS1, the DAQ read out would also end up on TS1. In this case (20 Hz), this means that every second shot falls on the dropped shots that are sent to SXR.