Timing Patterns & Operation Modes

Lars Fröhlich
Travemünde, 2018-02-21

Overview

Timing Patterns

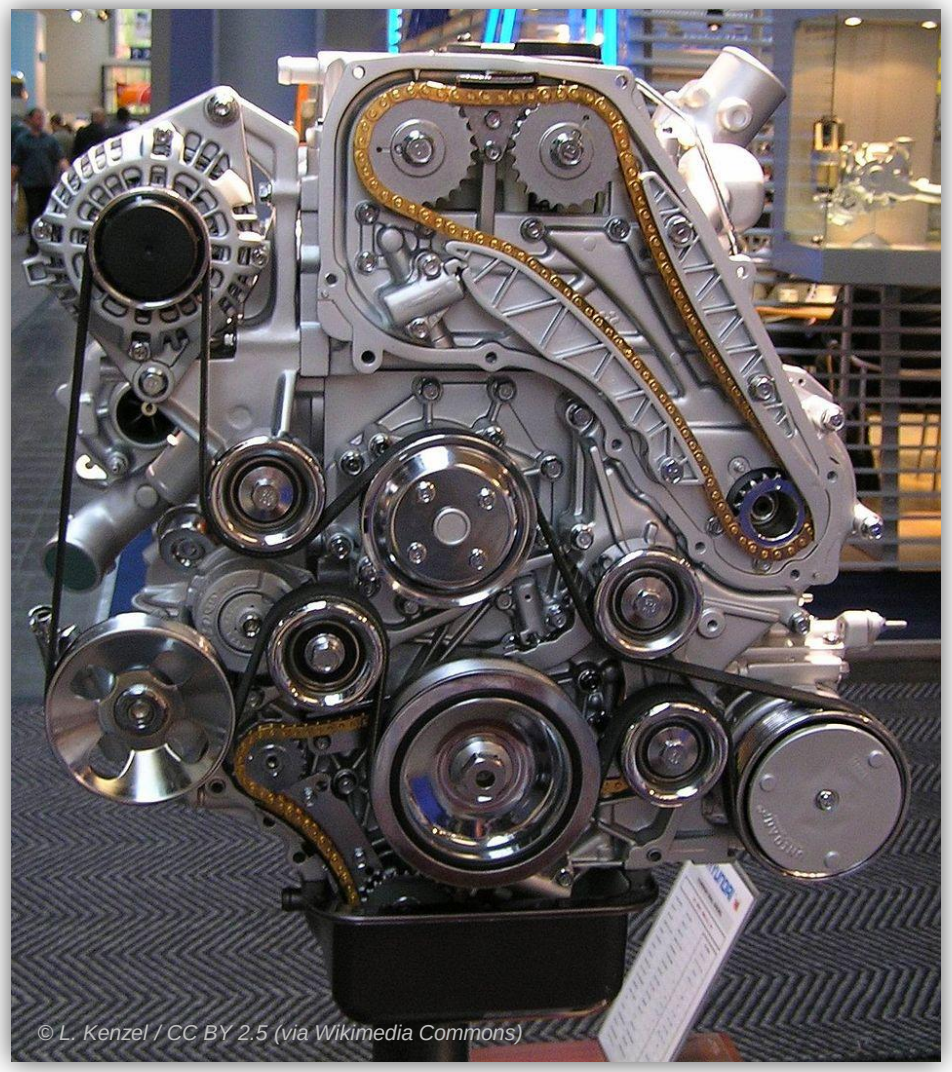
- Legacy Mode
- User-Defined Mode
- The Timing Pattern in Detail
- A Typical Pattern for User Operation
- Subtrains

MPS Operation Modes

- Operation Mode Detection
- Bunch Destination vs. Operation Mode

Live Demo

- Building a User-Defined Pattern



Timing Patterns

Or: What we never wanted to know about the timing system but were forced to find out.

Two Modes for the Timing System

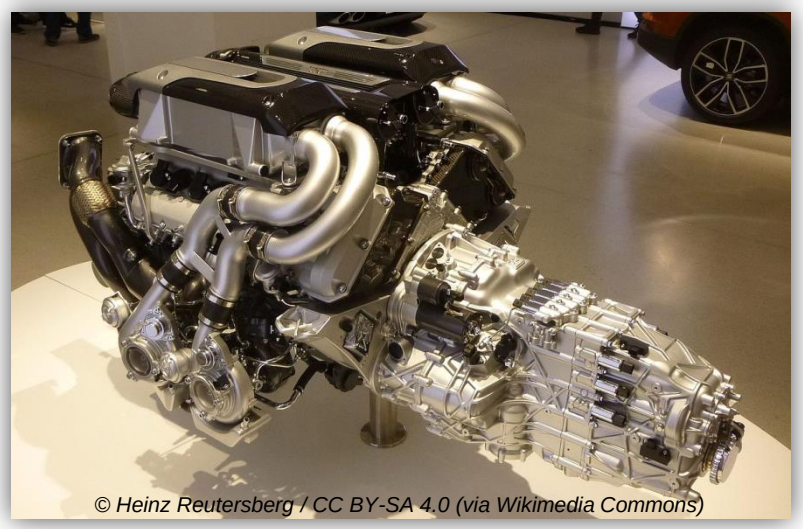
Or: Two Ways to Generate Bunches

Legacy Mode (“Old Mode”)

- We have been using it for a long time.
- Robust.
- Easy to understand.

User-defined Mode (“New Mode”)

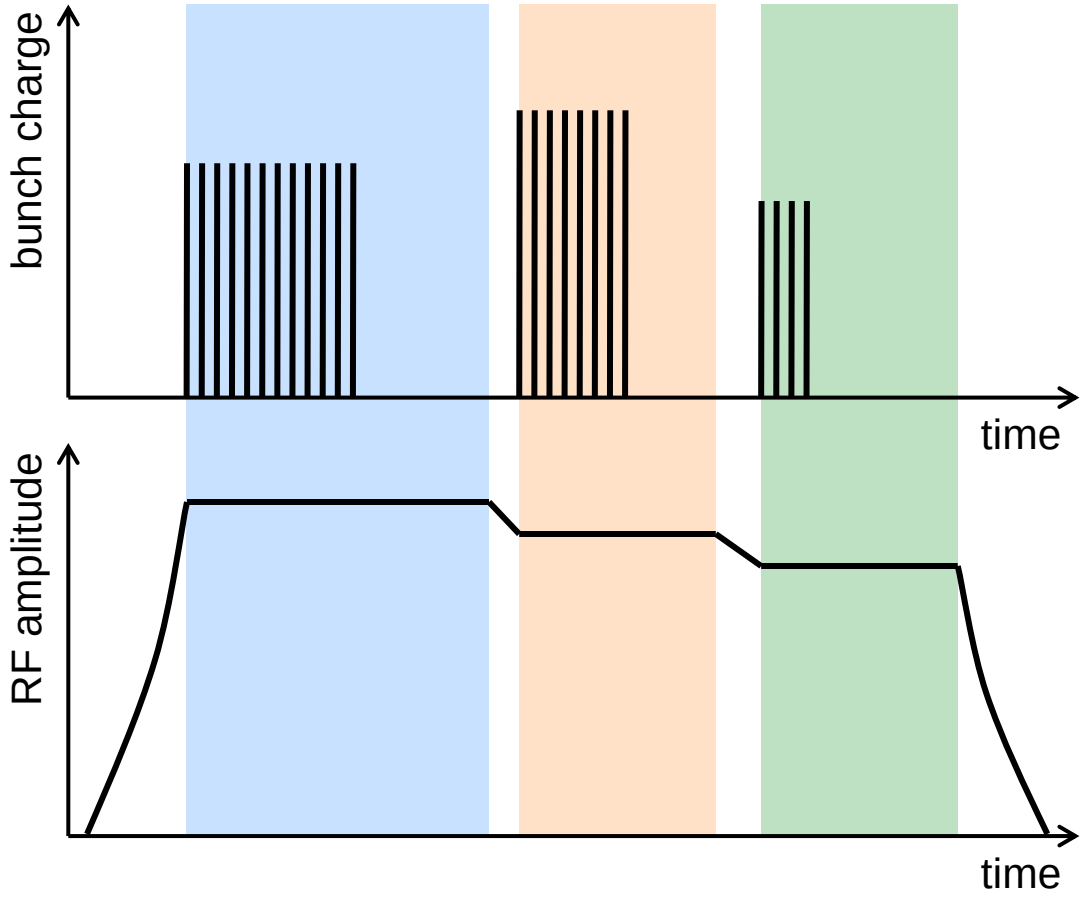
- What we will need to use in certain situations.
- Powerful.
- Complex.

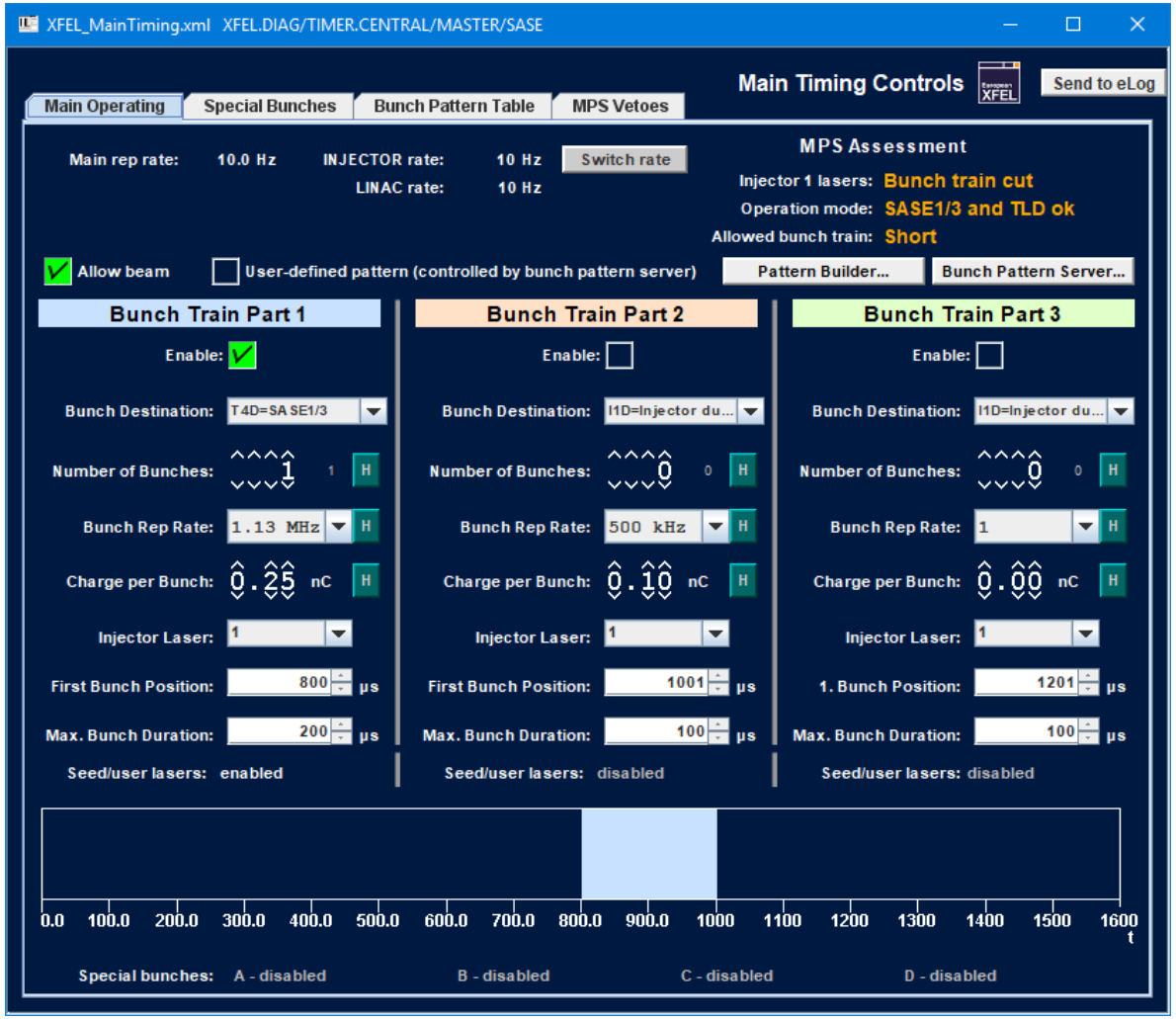


Legacy Mode

The Good Old Days

- There are up to three **separate** bunch train parts.

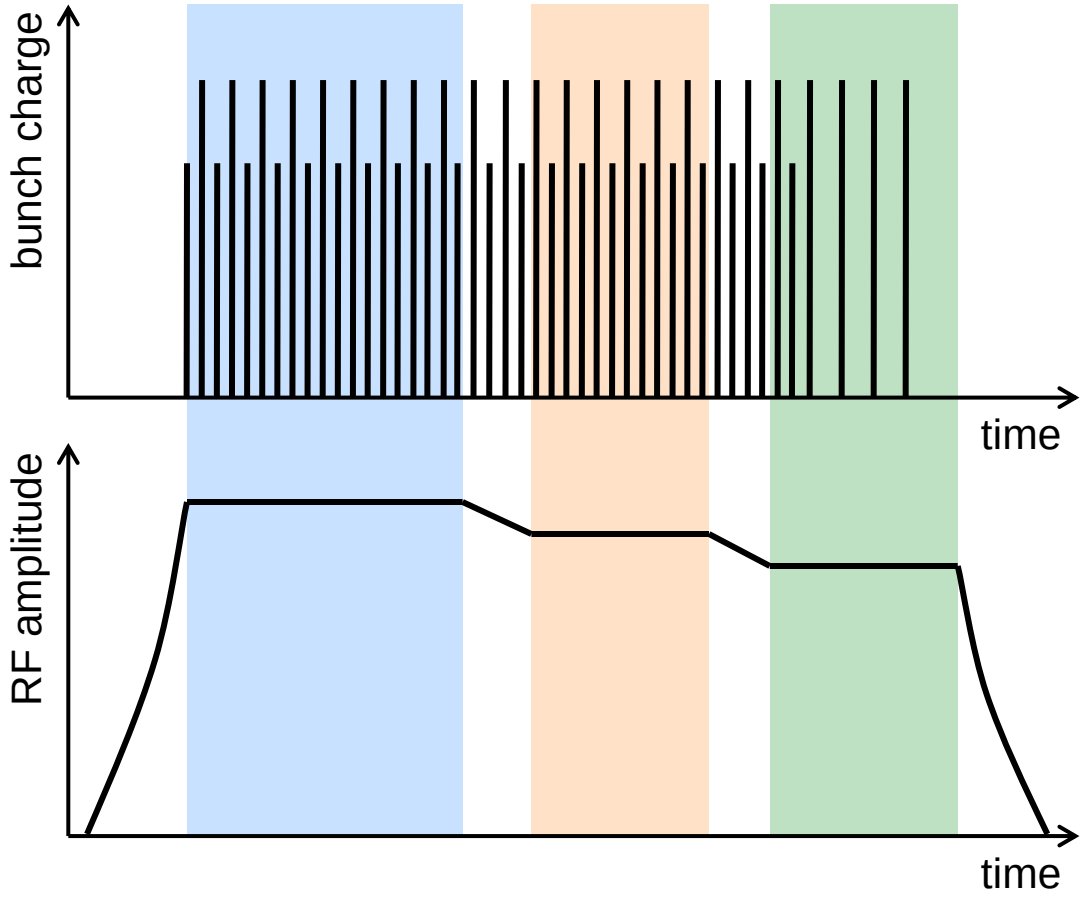


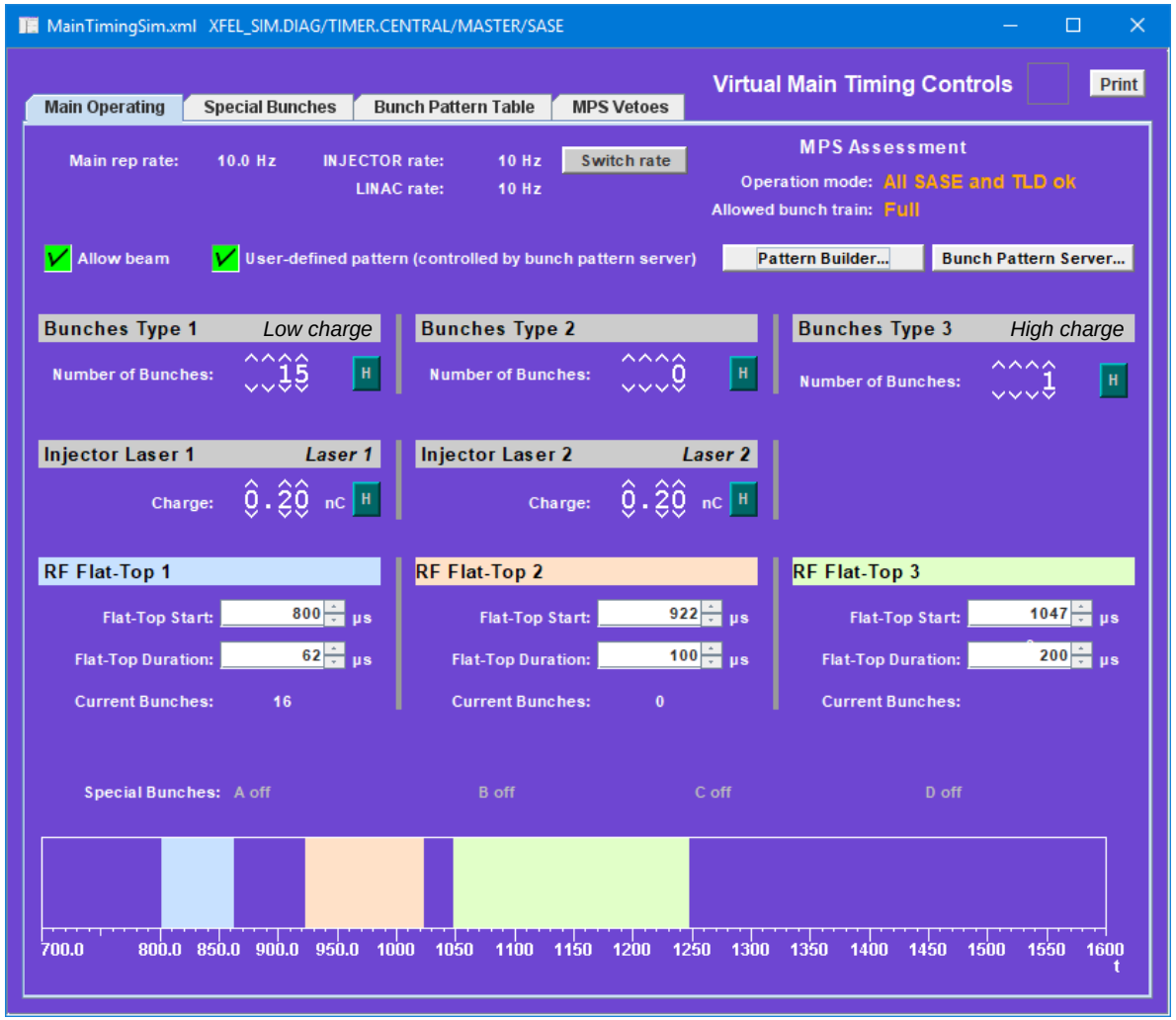


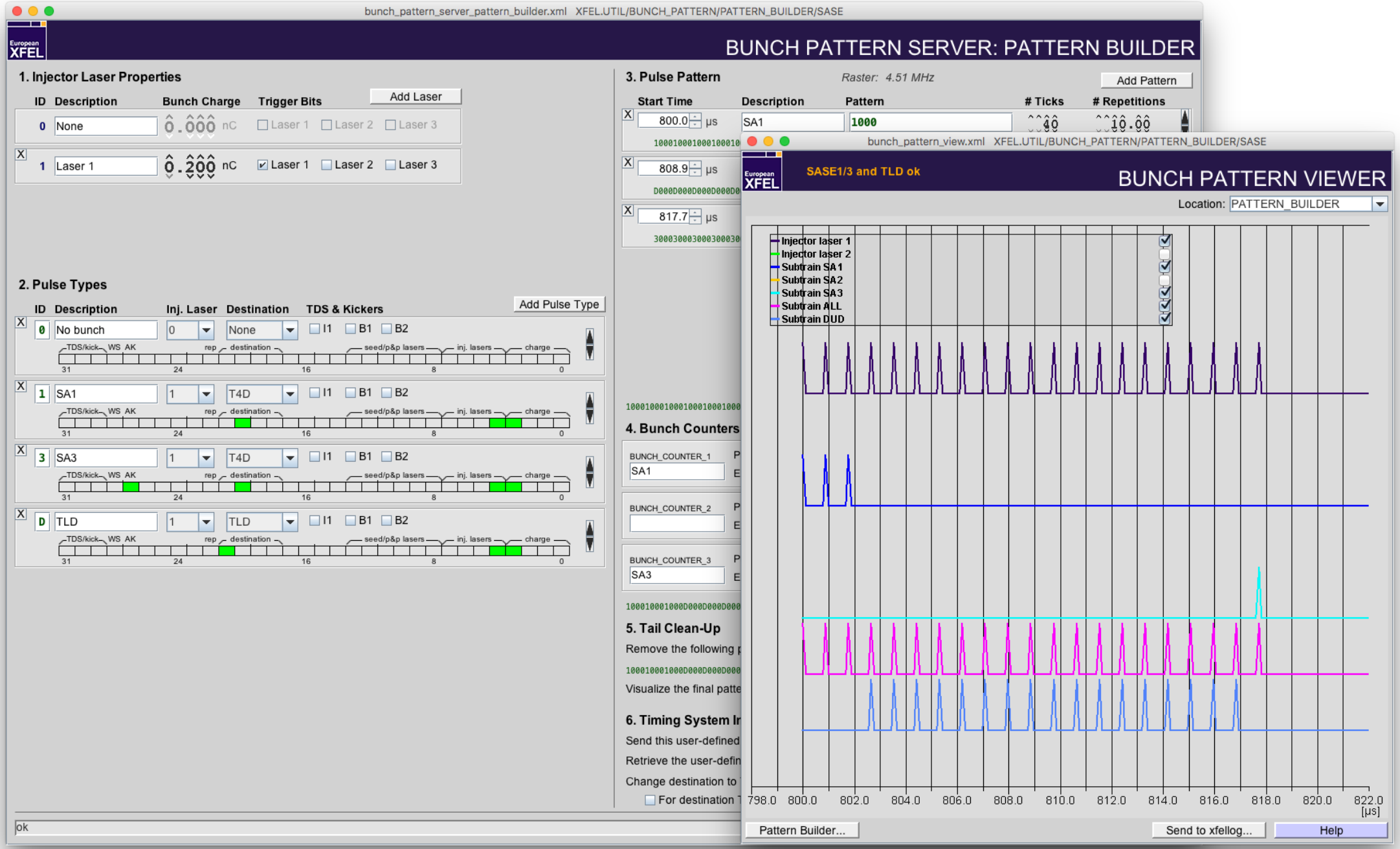
User-Defined Mode

Added Flexibility

- Bunch types, lasers, and RF flat-tops are decoupled





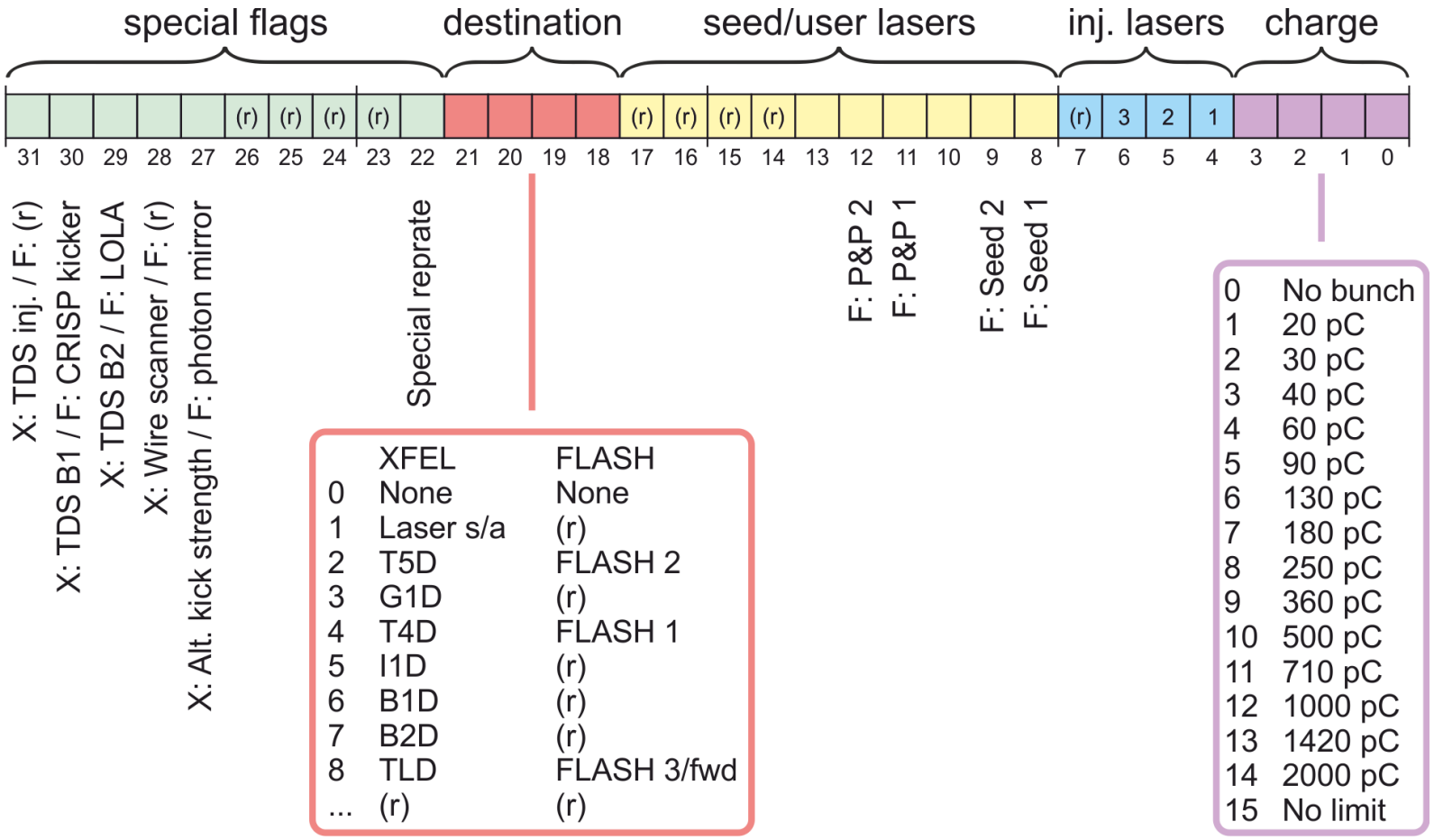

bunch_pattern_server_pattern_builder.xml XFEL.UTIL/BUNCH_PATTERN/PATTERN_BUILDER/SASE
BUNCH PATTERN SERVER: PATTERN BUILDER
1. Injector Laser Properties
Add Laser
ID Description Bunch Charge Trigger Bits
0 None 0.000 nC Laser 1 Laser 2 Laser 3
1 Laser 1 0.200 nC Laser 1 Laser 2 Laser 3
2. Pulse Types
Add Pulse Type
ID Description Inj. Laser Destination TDS & Kickers
0 No bunch 0 None I1 B1 B2
1 SA1 1 T4D I1 B1 B2
3 SA3 1 T4D I1 B1 B2
D TLD 1 TLD I1 B1 B2
TDS/kick WS AK rep destination seed/p&p lasers inj. lasers charge
31 24 16 8 0
3. Pulse Pattern
Raster: 4.51 MHz
Add Pattern
Start Time Description Pattern # Ticks # Repetitions
800.0 µs SA1 1000 40 10.00
808.9 µs
817.7 µs
4. Bunch Counters
BUNCH_COUNTER_1 SA1
BUNCH_COUNTER_2
BUNCH_COUNTER_3 SA3
5. Tail Clean-Up
Remove the following
Visualize the final patte
6. Timing System In
Send this user-defined
Retrieve the user-defin
Change destination to
For destination
ok
bunch_pattern_view.xml XFEL.UTIL/BUNCH_PATTERN/PATTERN_BUILDER/SASE
SASE1/3 and TLD ok
BUNCH PATTERN VIEWER
Location: PATTERN_BUILDER
Injector laser 1
Injector laser 2
Subtrain SA1
Subtrain SA2
Subtrain SA3
Subtrain ALL
Subtrain DUD
798.0 800.0 802.0 804.0 806.0 808.0 810.0 812.0 814.0 816.0 818.0 820.0 822.0
[µs]
Pattern Builder...
Send to xfellog...
Help

The Timing Pattern in Detail

- The timing pattern is an information block that is distributed by the timing system before each macropulse.
- Based on it, timing boards generate triggers.
- Based on it, hard- and software can classify bunches/pulses.

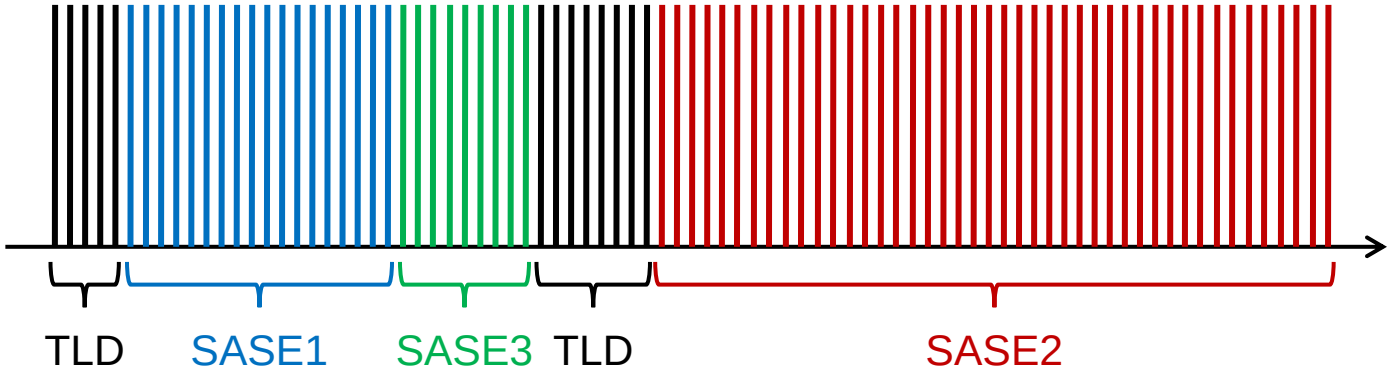
- Table with 7200 entries
- 9 MHz raster (111 ns step)
- Covers a time span of 800 µs (RF flat-top of FLASH)

- Each entry is described by a 32-bit number (integer/word).

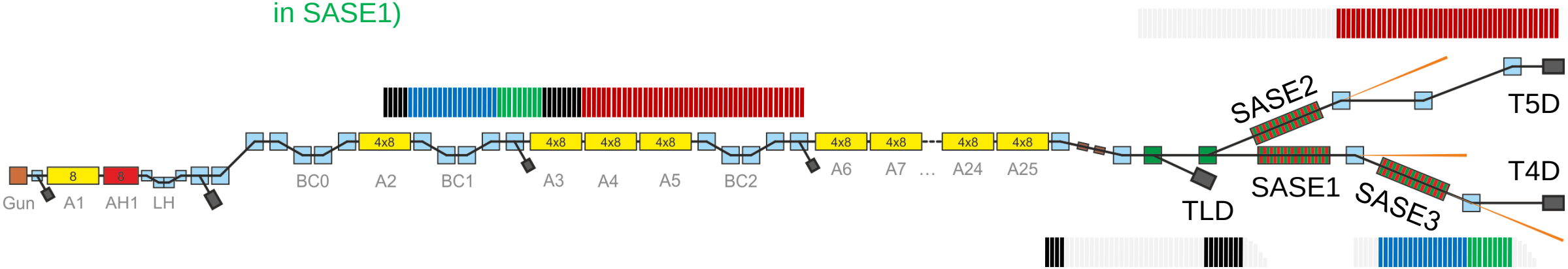


A Typical Pattern for User Operation

… driving SASE1, SASE2, and SASE3 simultaneously.



(kicked in TLD to suppress lasing in SASE1)



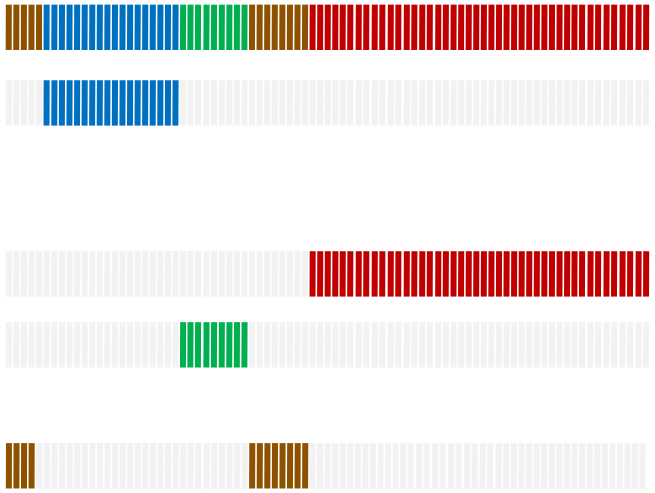
Subtrains

How is the timing pattern reflected in the control system?

A subtrain is the set of all bunches in a macropulse that share some common feature. Five of them are defined at the XFEL.

They appear mainly in property names:

X.**SA2**.TRAIN.MEAN_PKPK
the mean value and peak-to-peak variation over all bunches of subtrain **SA2**



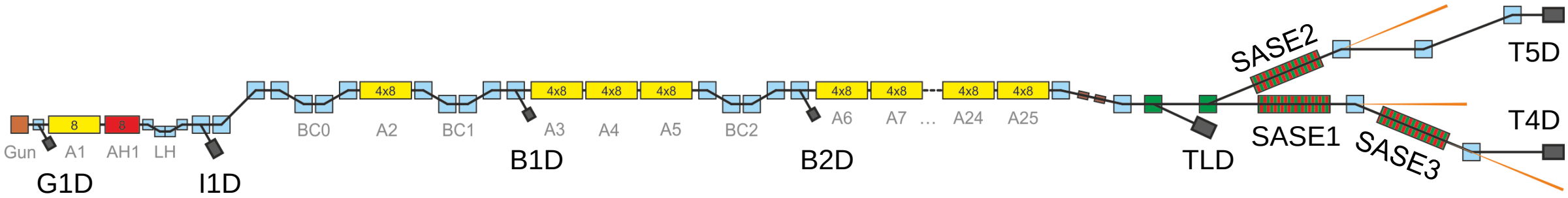
ALL contains all bunches.

SA1 contains all bunches with destination T4D that are *not* affected by a special excitation kick in TL.

SA2 contains all bunches with destination T5D.

SA3 contains all bunches with destination T4D that *are* affected by a special excitation kick in TL.

DUD (“Blindgänger”) contains all bunches that are not going through a SASE undulator, i.e. those with destination G1D, I1D, B1D, B2D, or TLD.



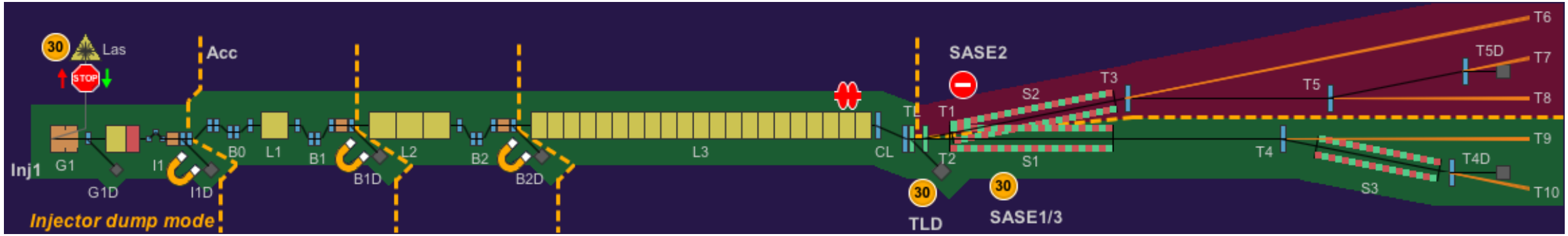
Machine Protection System

New Operation Mode Logics and How the MPS Interacts with the Timing System.

Operation Mode Detection

The MPS detects most of the operation modes by the status of the corresponding dump dipole magnet. The corresponding dump magnet power supply has to be run at a minimum current:

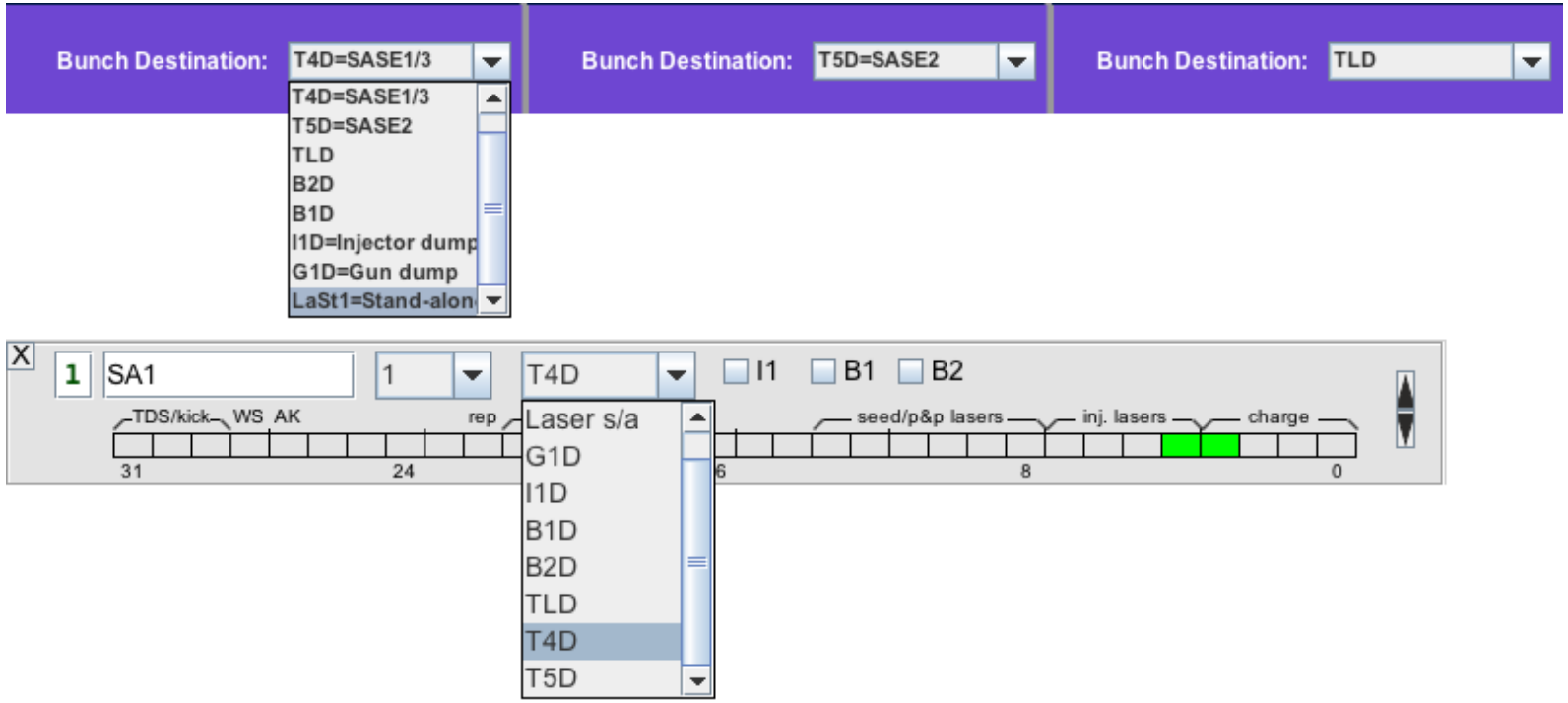
- Injector dump mode – BB.62.I1D – 95..102 A
- B1 dump mode – BB.229.B1D – 75..81 A
- B2 dump mode – BG.467.B2D – 177..185 A



Bunch Destination vs. Operation Mode

Selected *beam destinations* have to correspond to the current *operation mode* detected by the MPS.

Otherwise, the timing system does not trigger injector lasers even if they appear in the timing pattern.



Live Demo

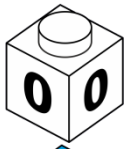
Building a User-Defined Timing Pattern with the Pattern Builder

Pattern Builder

1. **Define which injector lasers you want to use.**

   For example: Laser 1 at 200 pC and laser 2 at 500 pC

2. **Define pulse types** (your building blocks for a bunch pattern).



No bunch

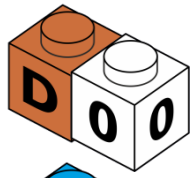
SASE1 bunch *(from laser 1, to T4D, no excitation kick)*

SASE2 bunch *(…)*

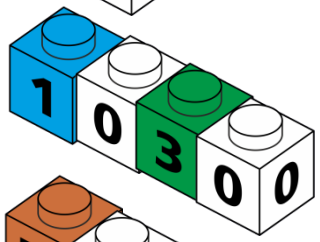
SASE3 bunch *(…)*

TLD bunch *(…)*

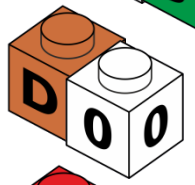
3. **Group pulse types into patterns and repeat them.**



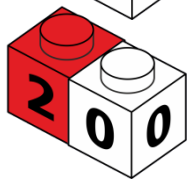
× 30



× 400

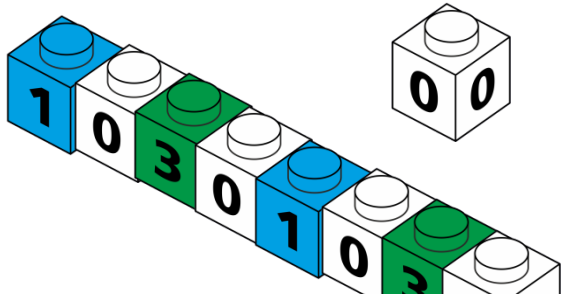


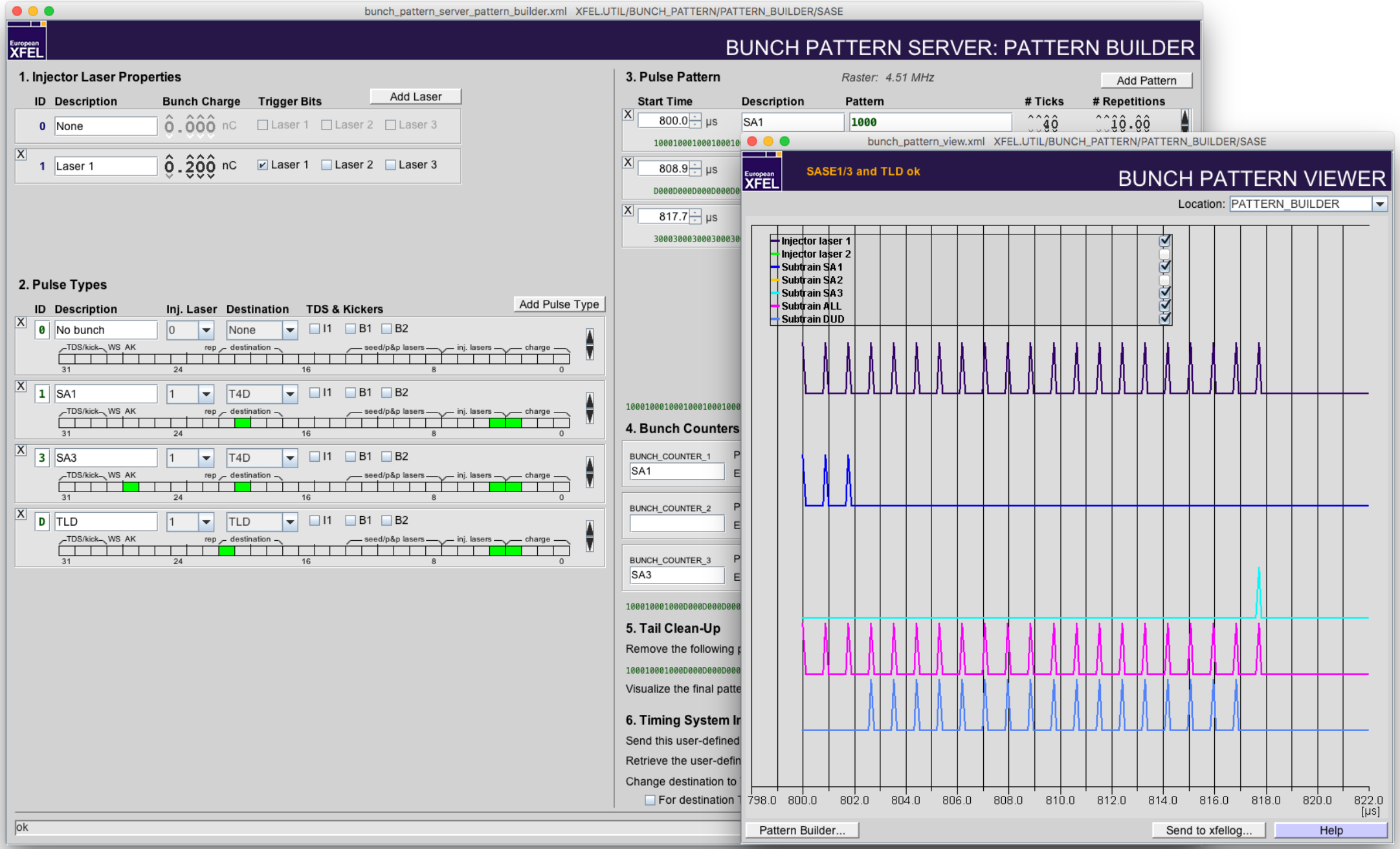
× 20



× 800

4. **Modify the assembled sequence.**




bunch_pattern_server_pattern_builder.xml XFEL.UTIL/BUNCH_PATTERN/PATTERN_BUILDER/SASE
European XFEL
BUNCH PATTERN SERVER: PATTERN BUILDER
1. Injector Laser Properties
Add Laser
ID Description Bunch Charge Trigger Bits
0 None 0.000 nC Laser 1 Laser 2 Laser 3
1 Laser 1 0.200 nC Laser 1 Laser 2 Laser 3
2. Pulse Types
Add Pulse Type
ID Description Inj. Laser Destination TDS & Kickers
0 No bunch 0 None I1 B1 B2
1 SA1 1 T4D I1 B1 B2
3 SA3 1 T4D I1 B1 B2
D TLD 1 TLD I1 B1 B2
TDS/kick WS AK rep destination seed/p&p lasers inj. lasers charge
31 24 16 8 0
3. Pulse Pattern
Raster: 4.51 MHz
Add Pattern
Start Time Description Pattern # Ticks # Repetitions
800.0 µs SA1 1000 40 10.00
808.9 µs
817.7 µs
4. Bunch Counters
BUNCH_COUNTER_1 SA1
BUNCH_COUNTER_2
BUNCH_COUNTER_3 SA3
5. Tail Clean-Up
Remove the following p
Visualize the final patte
6. Timing System In
Send this user-defined
Retrieve the user-defin
Change destination to
For destination
ok
bunch_pattern_view.xml XFEL.UTIL/BUNCH_PATTERN/PATTERN_BUILDER/SASE
European XFEL
SASE1/3 and TLD ok
BUNCH PATTERN VIEWER
Location: PATTERN_BUILDER
Injector laser 1
Injector laser 2
Subtrain SA1
Subtrain SA2
Subtrain SA3
Subtrain ALL
Subtrain DUD
798.0 800.0 802.0 804.0 806.0 808.0 810.0 812.0 814.0 816.0 818.0 820.0 822.0
[µs]
Pattern Builder...
Send to xfellog...
Help