Timing System & Bunch Pattern Server

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

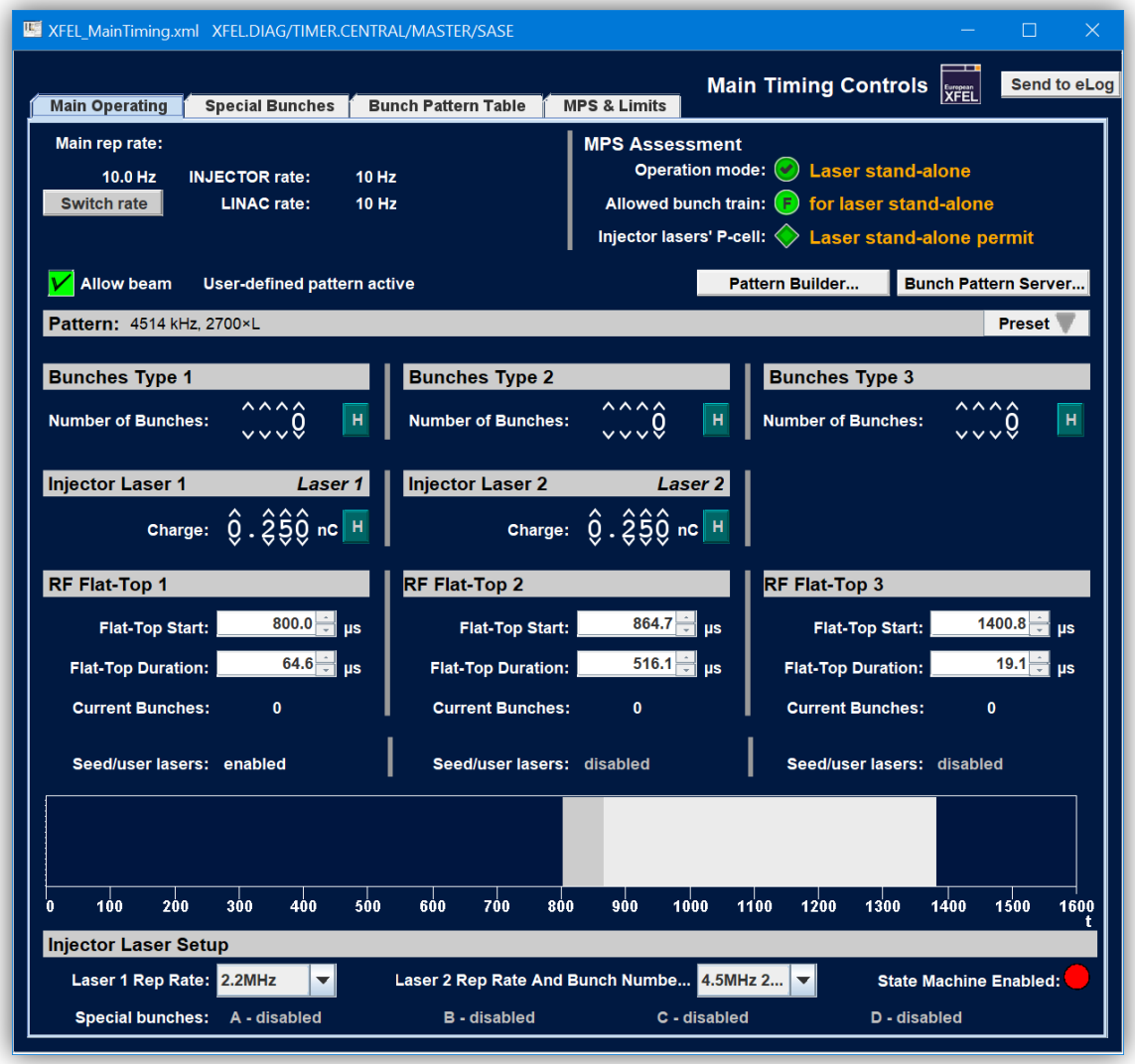
- x2timer & Bunch Pattern
- Beam Distribution at the XFEL
- Virtual XFEL Demo

x2timer & Bunch Pattern

The x2timer Timing Board

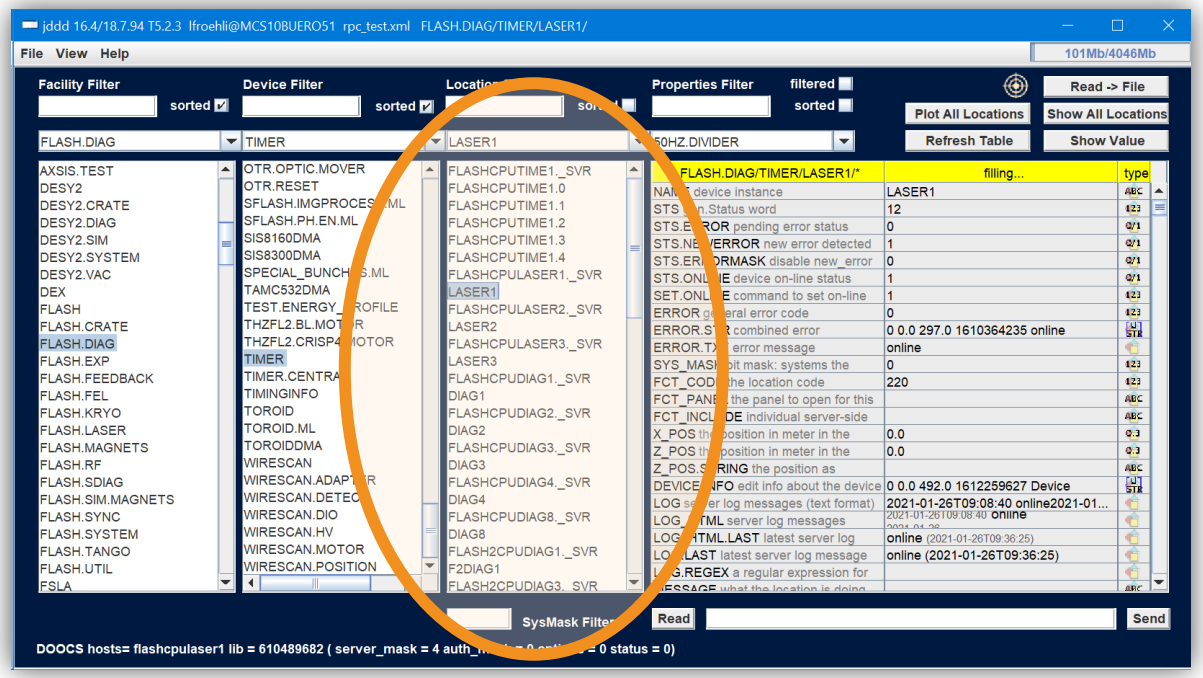
Generating the heartbeat for our facilities

- Generates precision clocks and triggers
- Can be transmitter or receiver (multi-star topology) or stand-alone
- Present in most MTCA crates
- Main DOOCS interface: x2timer server (Arthur Aghababyan, Olaf Hensler)



x2timer Servers in the DOOCS Namespace

Where to find x2timers in DOOCS



x2timer servers are ubiquitous:

SINBAD.DIAG/TIMER

SINBAD.DIAG/TIMER.CENTRAL

FLASH.DIAG/TIMER

FLASH.DIAG/TIMER.CENTRAL

XFEL.DIAG/TIMER

XFEL.DIAG/TIMER.CENTRAL

XFEL_SIM.DIAG/TIMER

XFEL_SIM.DIAG/TIMER.CENTRAL

KALDERA.DIAG/TIMER

TEST.DIAG/TIMER

TEST.XFEL/TIMER

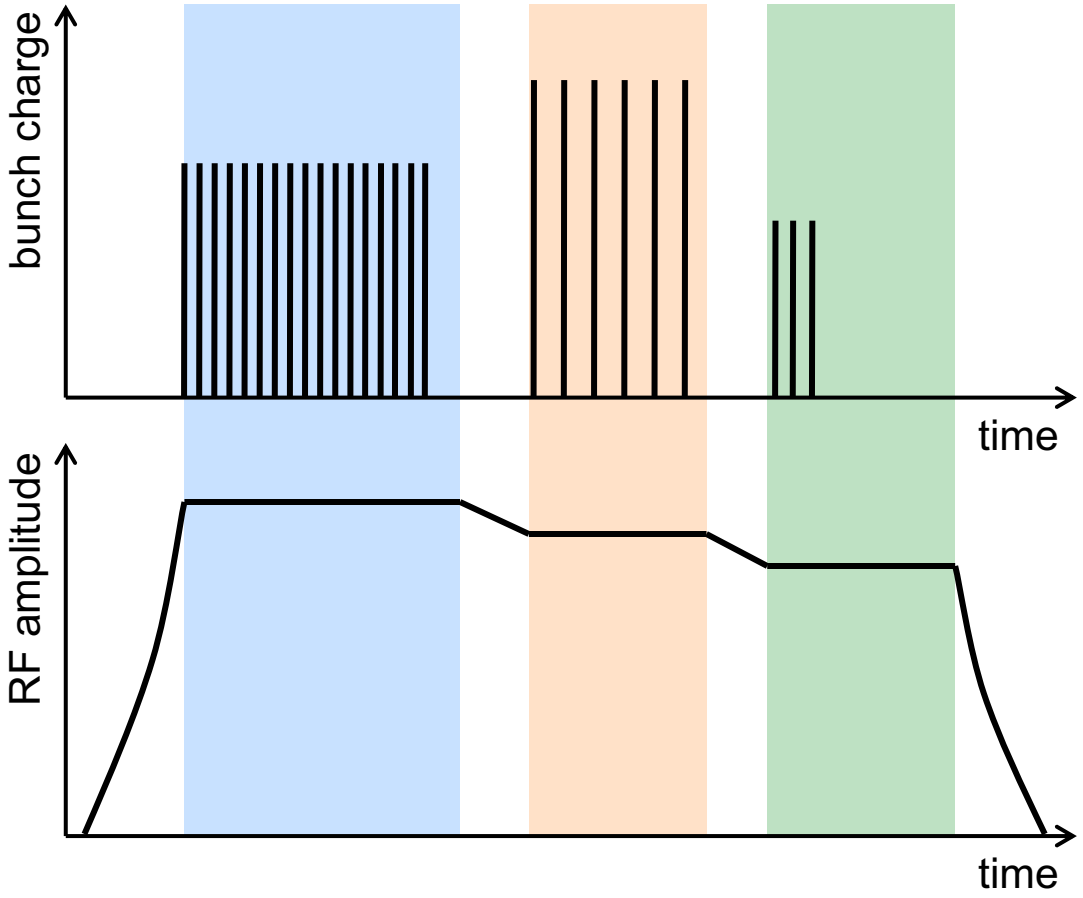
LAB.*/TIMER

…

x2timer Legacy Mode

Up to three beam regions

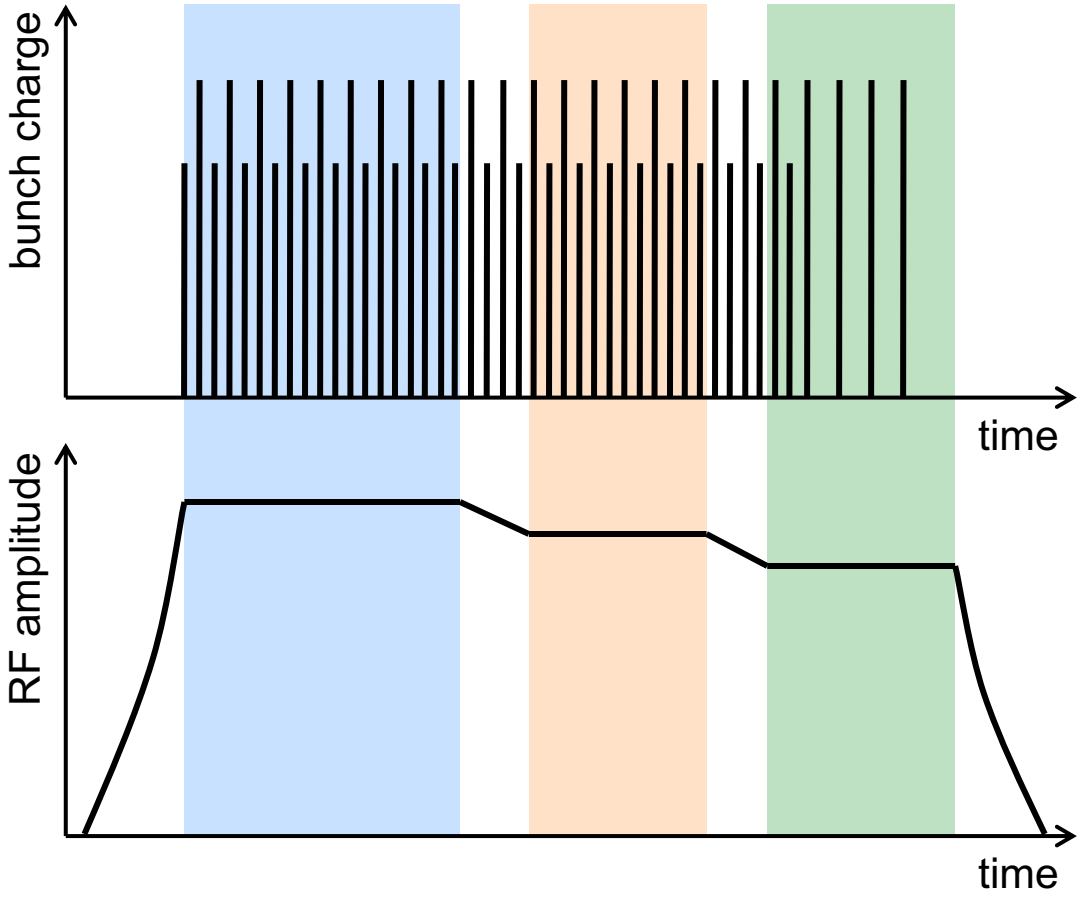
- Up to three beam regions (“flat-tops”)
- Between the beam regions, the LLRF may change amplitude & phase freely
- Bunches are only possible inside the beam regions
- Only one type of bunch per beam region (same injector laser, destination, charge, …)
- Simple → Can be used directly from x2timer server
- No longer supported



x2timer User-Defined Mode

Maximum flexibility

- (Almost) arbitrary number of beam regions
- Bunch types, lasers, destinations, and beam regions are decoupled
- Programmed via a huge pattern table
- New pattern tables are sent to the x2timer at 10 Hz by the bunch pattern server
- Used at FLASH, XFEL, PITZ, KALDERA, …

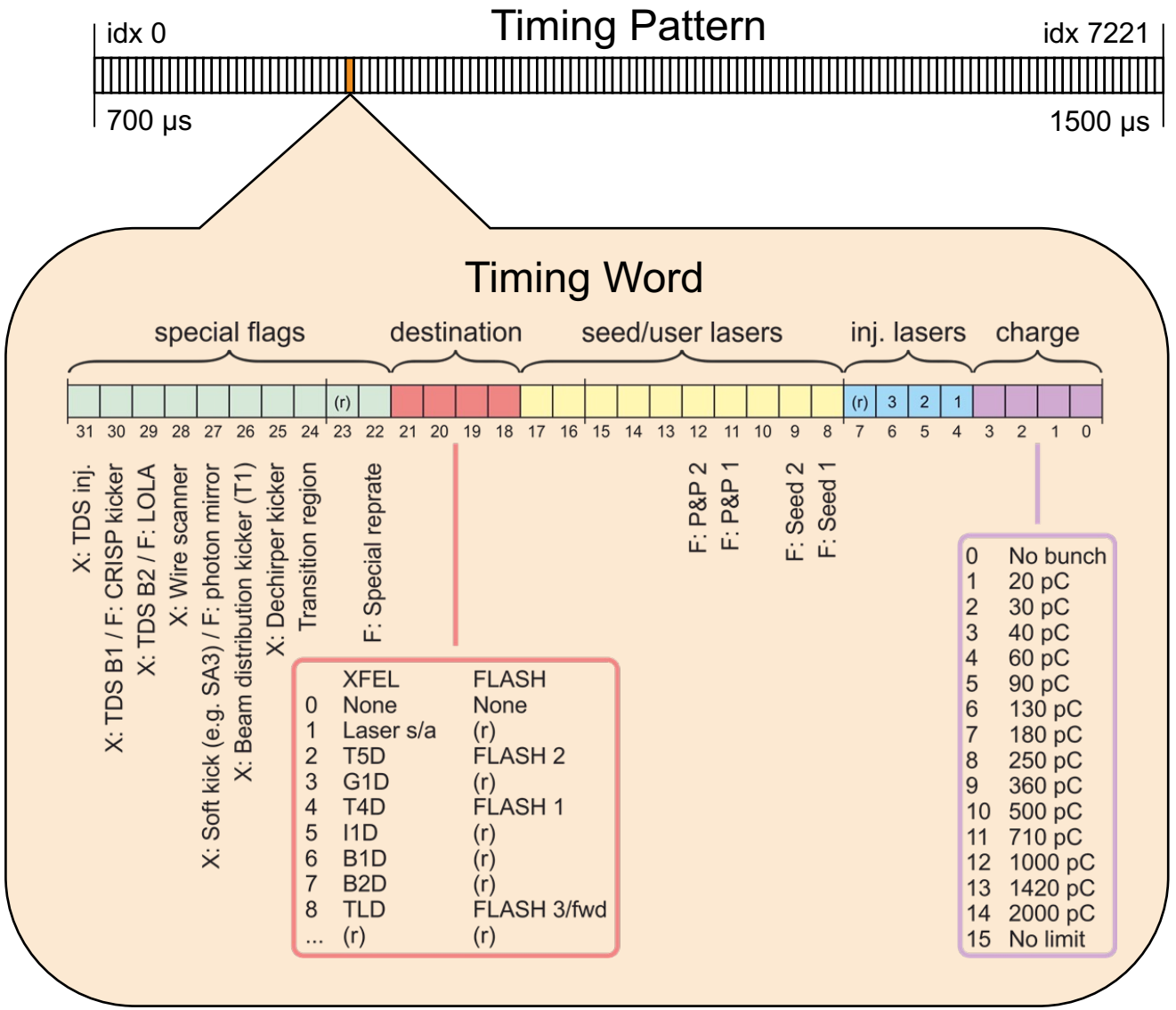


The Timing Pattern in Detail

An array of 7222 “timing words”.

- The timing pattern is an information block that is distributed by the timing system before each macropulse.
- Timing boards generate triggers from it.
- Hard- and software uses it to classify bunches/pulses.

- Table with 7222 [8192] entries
- 9.028 MHz raster (110.8 ns step)
- Covers a time span of 800 µs [910 µs]
- Each entry is described by a 32-bit integer (“timing word”)



Beam Distribution at the XFEL

Beam Distribution Scheme

TLD Kicker

- Fast (4.5 MHz)
- Horizontal kick (left)

Lambertson Septum

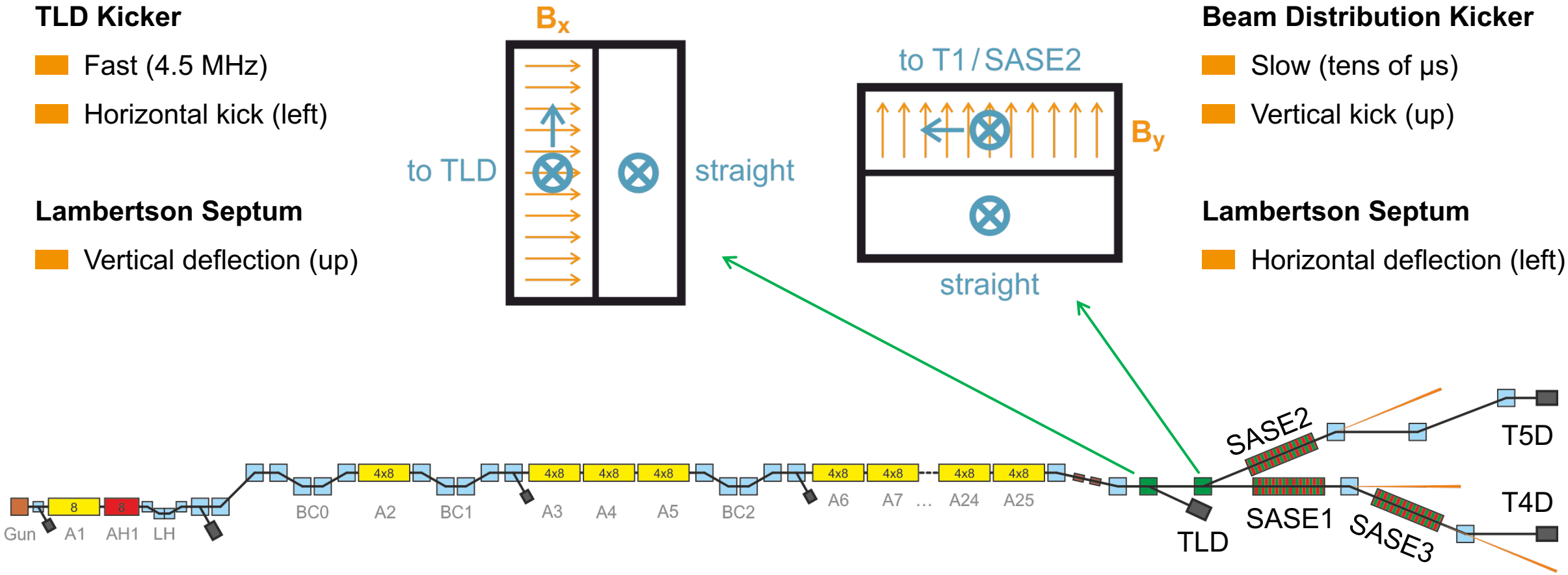
- Vertical deflection (up)

Beam Distribution Kicker

- Slow (tens of µs)
- Vertical kick (up)

Lambertson Septum

- Horizontal deflection (left)

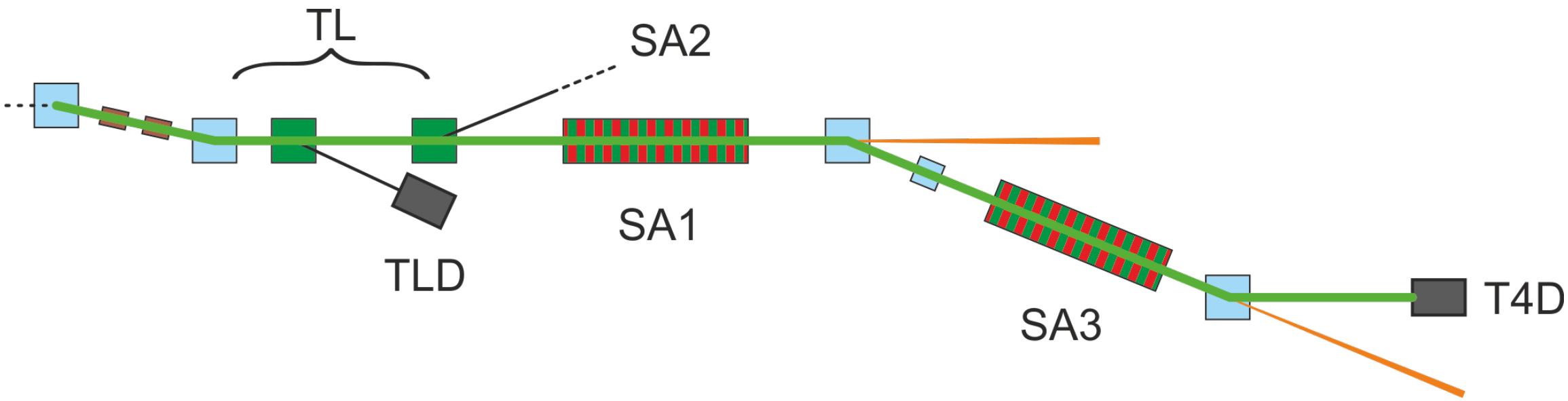


Fresh Bunch Mode: Implementation

Lasing in SA1 induces energy spread => less or no lasing in SA3

Lasing can be suppressed

- on individual bunches
- by exciting a trajectory oscillation with a fast kicker *(soft kick)*.



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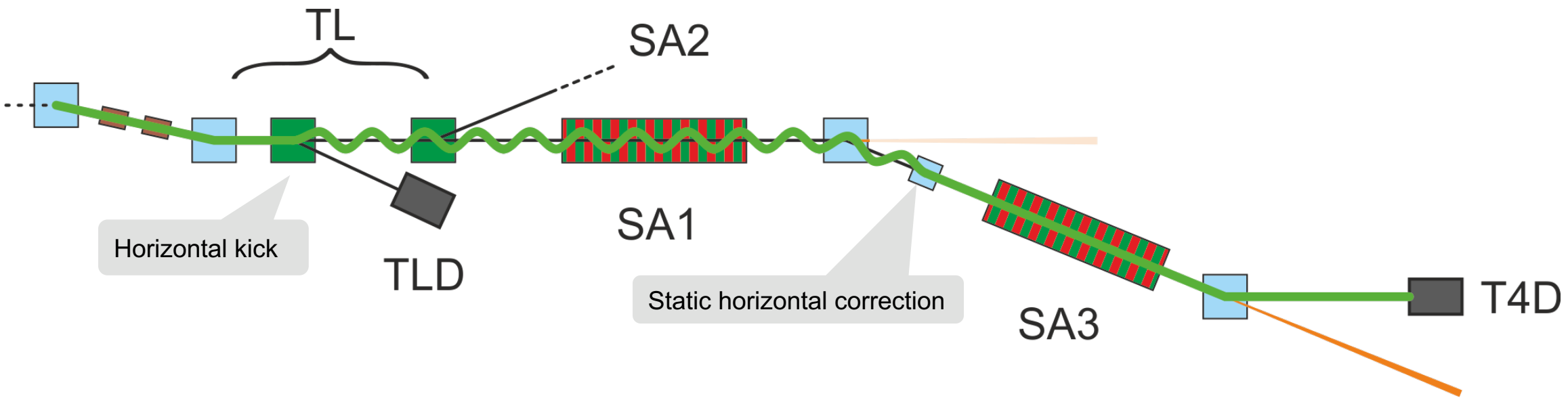

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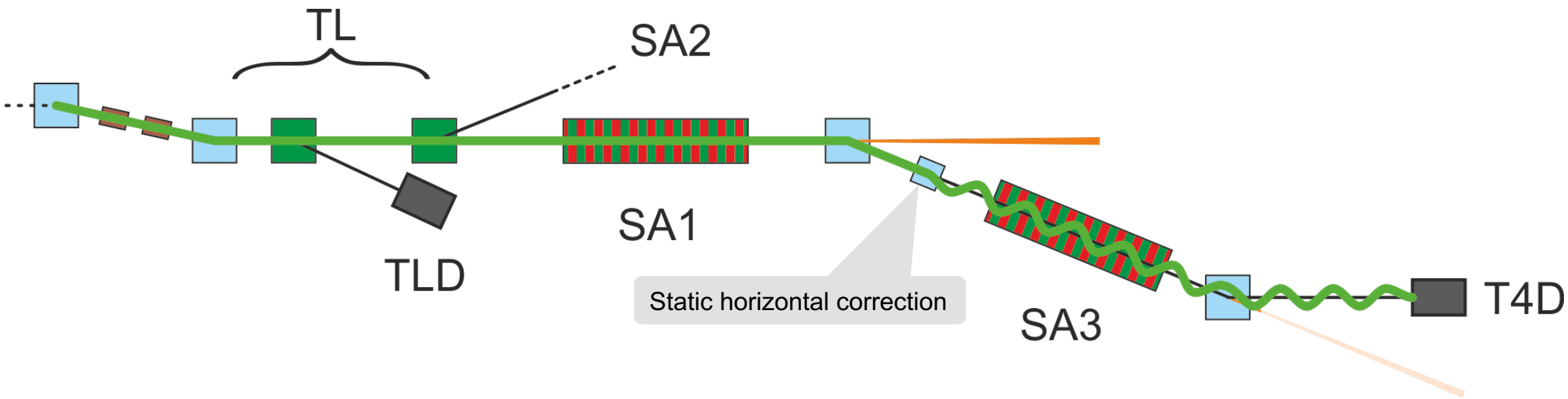
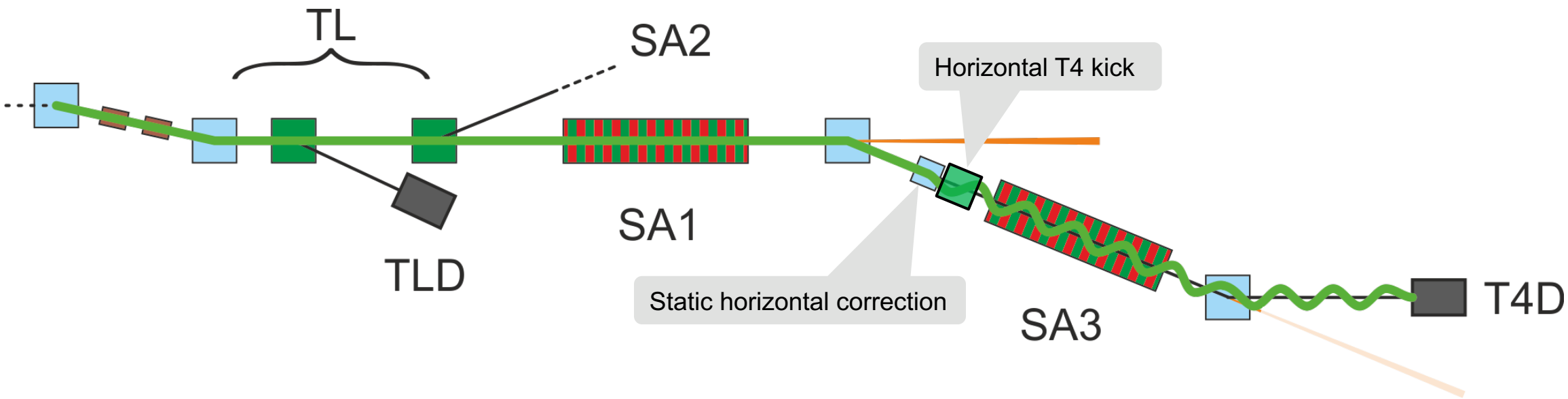


Fresh Bunch Mode: Additional Kick in T4

There is a “TLD-type” kicker in the T4 section, in front of SA3.
It is fired for SA1 bunches to increase the oscillation amplitude in SA3.

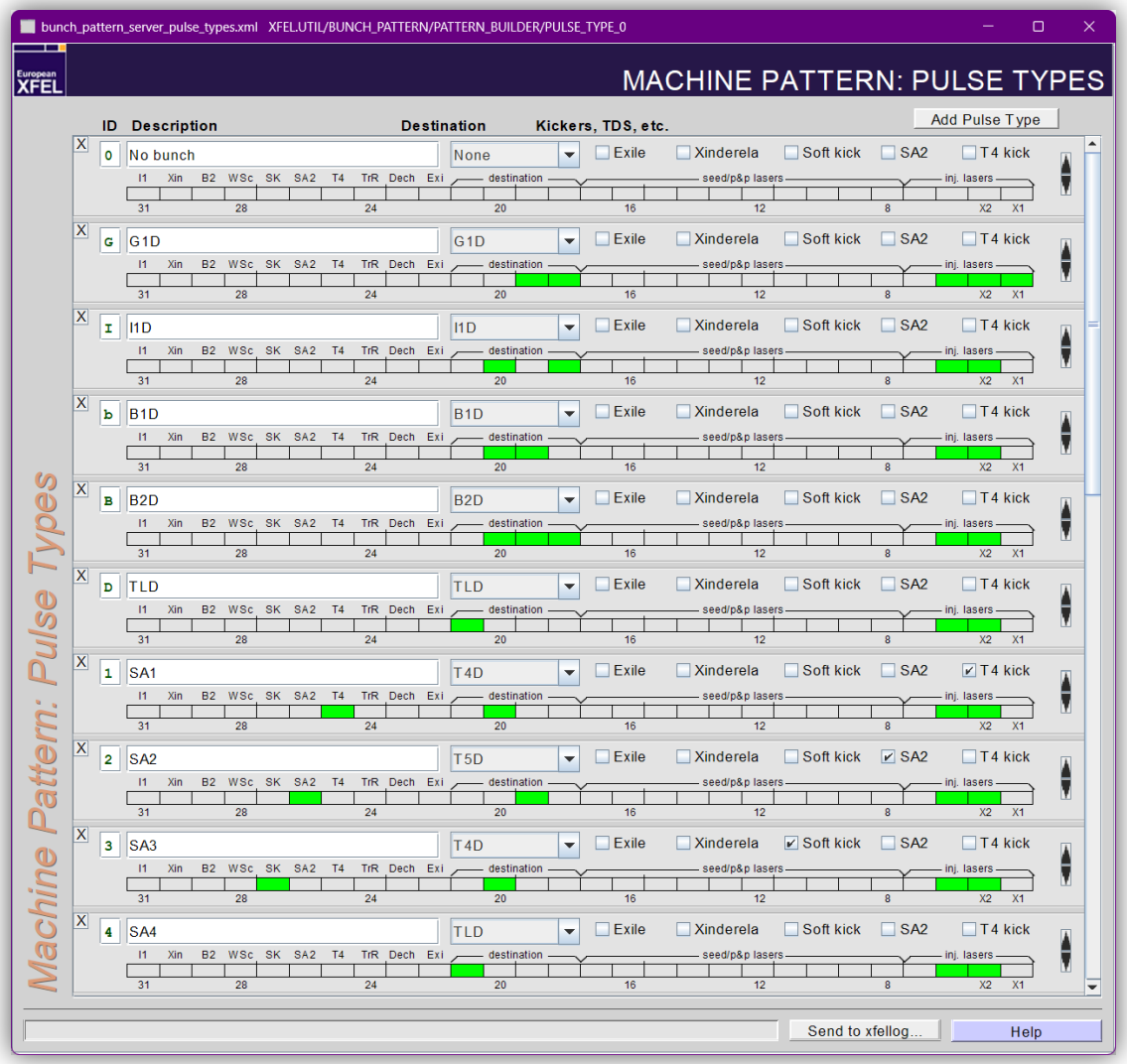


Beam Distribution: Get Your Kicks

(All four of them)

Four types of kicks can be triggered by the timing system:

- Kick to TLD (fast)
  Destination: TLD
- Kick to south branch/SASE2 (slow)
  Destination: T5D or Bit: “SA2”
- Soft kick (fast, one of the TLD kickers)
  Bit: “SK” (Soft Kick)
- T4 kick in front of SASE3 (fast)
  Bit: “T4”



Live from the Virtual XFEL

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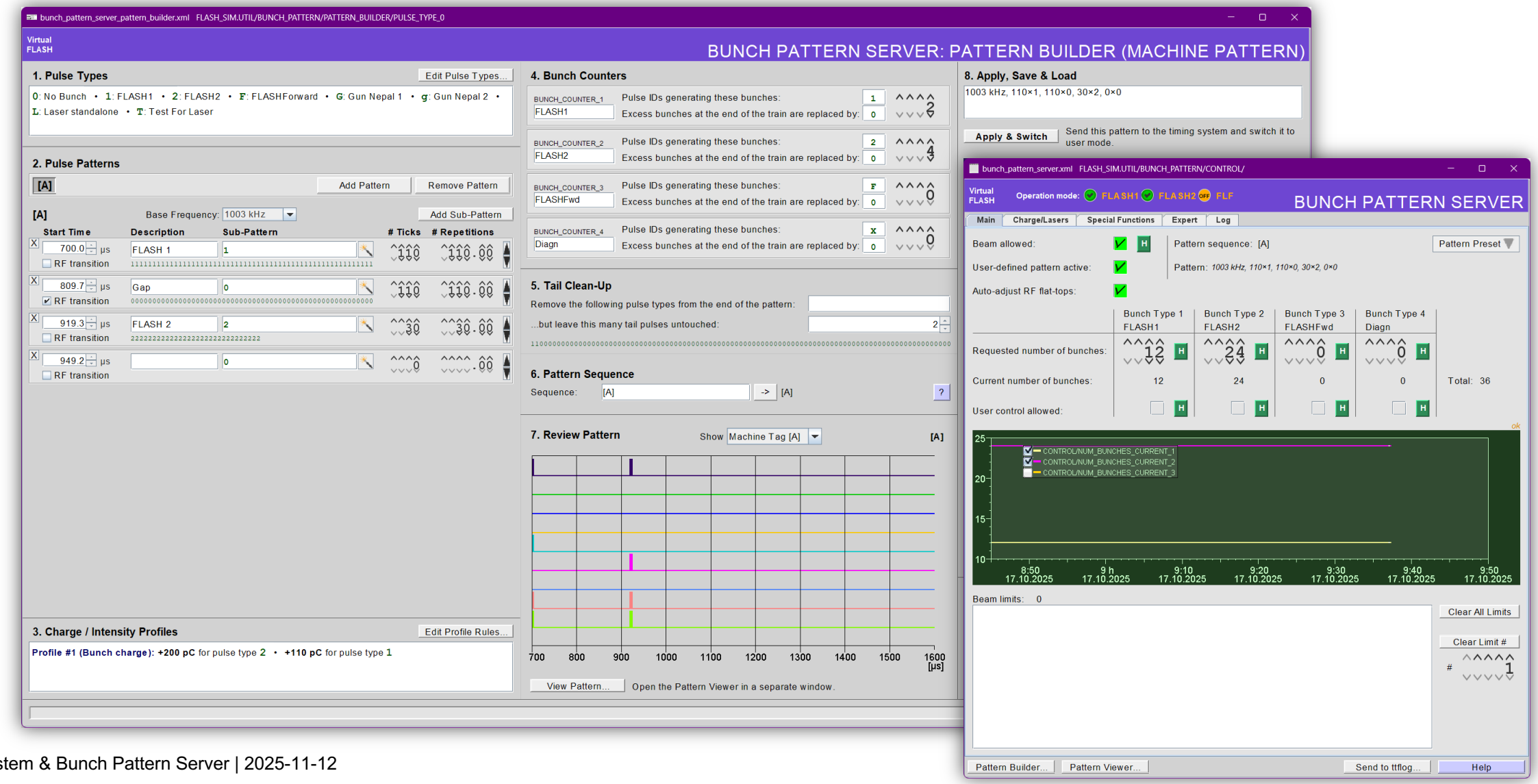
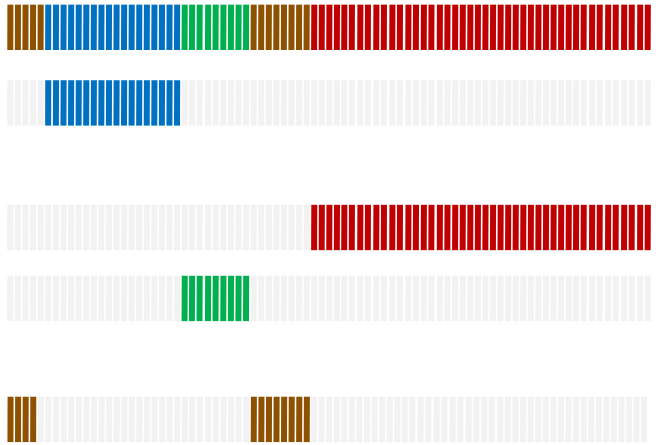


Subtrains – Reflecting the Pattern in the Control System

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

They appear mainly in property names:

X.**FLASH2**.TRAIN.MEAN_PKPK the mean value and peak-to-peak variation over all bunches of subtrain **FLASH2**



ALL contains all bunches.

FLASH1 contains all bunches with destination FLASH1

FLASH2 contains all bunches with destination FLASH2.

FLASH3 contains all bunches with destination FLASHfwd.

LASER1 contains all bunches produced by the first injector laser

LASER2 contains all bunches produced by the first injector laser

LASER3 contains all bunches produced by the fhird injector laser