

# Option for High Rate Operation of LCLS-II

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### High Rate Operation of LCLS-II

#### Motivation:

The baseline maximum beam rate for LCLS-II is 928.6KHz = 1300MHz / 1400. To facilitate future upgrades, the linac is being designed to support maximum beam power of 1.2 MW of which corresponds to 300 pC at 1 MHz with an energy of 4 GeV. However, it is likely that the LCLS-II will want to deliver high-brightness, low-charge bunches to the various undulators instead of 300 pC. Such an option might be to operate at substantially higher beam rate with a corresponding lower bunch charge.

We consider an upgrade to a maximum rate of 7.428MHz or 8X the baseline rate with roughly 40 pC per bunch. This corresponds to:

- RF Frequency / 175
- Gun Frequency / 25
- Laser Frequency / 5 (assuming 37.14MHz (Frf / 35) laser.

The following changes / upgrades would be required:

#### Timing System:

The baseline timing system provides a pattern of 3200 bits at the baseline maximum beam rate of 928.6MHz. This upgrade would allocate 32 of those bits to managing the 8X higher rate beam, 4 bits (16 option) for each bunch. These bits would be used in the timing receivers to look-up pre-loaded data tables. Exact data to be worked out but for example.

0: bunch off

- 1: 100pC bunch, destination HXR
- 2: 80pC bunch destination SXR
- 3: 100pC bunch destination BSY dump
- 4: 50pC bunch to XFELO

Etc.

#### Limitations:

- Tables would need to be pre-loaded and not all possible beams could be supported by the accelerator hardware.
- MPS and other "veto" functions may need to operate on the entire set of 8 bunches, not individual bunches
- It may not be possible for the experiments to locally modify bit patterns with the flexibility provided by the low rate operation mode.

The baseline timing hardware can support this mode of operation, but significant additional firmware would be required. (low risk)

Diagnostics:

<u>Stripline BPMS</u>: The stripline BPM hardware is expected to function at this beam rate. Additional algorithm / firmware development may be required to eliminated effects from reflections of previous bunches. (low risk)

<u>Cavity BPMs</u>: The cavity BPM hardware is expected to function at this beam rate. Algorithm and firmware work is required to improve algorithms for measuring independent bunches in a train. (medium risk)

<u>Bunch Length Monitors</u>: The baseline bunch length monitors are already beyond the state of the art. This will substantially increase the difficulty. A new solution may need to be found (for example looking at CSR induced orbit changes in the bunch compressors). (medium risk)

<u>Wire Scanners</u>: The baseline wire scanners should operate. The wire scanner detectors will need <100ns response but this should be possible (medium risk).

Low rate diagnostics: The low rate diagnostics should operate without any changes. (low risk)

#### RF system

The baseline RF system is expected to operate correctly with only minimal firmware changes provided that the time average beam currents are within the baseline range. (low risk)

#### MPS / BCS Systems

The baseline BCS / MPS system is expected to operate with minimal changes. (low risk)

Kickers:

The kickers used for diagnostic lines will need to operate with 8X faster rise and fall times. This is a significant technical challenge; however substantially faster kickers have been demonstrated, but only for low duty factor operation: <u>https://accelconf.web.cern.ch/accelconf/p07/PAPERS/THPMN028.PDF</u>

Stripline kickers with high voltage (>1000V) drivers rather than ferrites will probably be required for the fast rise time pulses.

The BSY kicker / spreader will need to operate at a high average rate. This is beyond the current state of the art for kickers, but may be possible.

It may be possible to combine a lower rate kicker with a RF spreader. This needs study and would be fairly expensive and would limit operation to a limited set of pulse patterns.

Overall a significant R&D effort is required for kickers. (high risk).

Costs: The cost of upgrading the beam rate will be dominated by the kicker / spreader costs. These are probably on the order of \$10M - \$30M (depending on the technology chosen and the results of the R&D effort) for a 7.48MHz beam rate.