

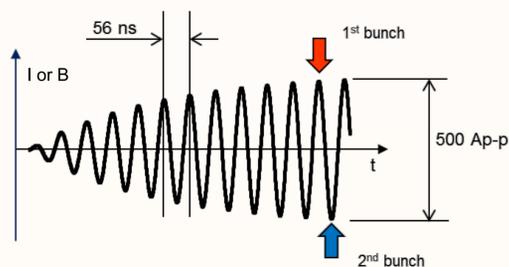
Commissioning and Stability Studies of the SwissFEL Bunch-separation System

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ABSTRACT

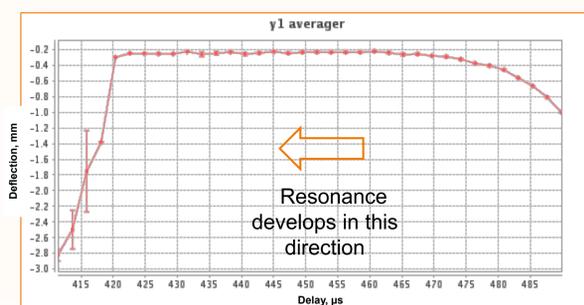
SwissFEL is a linear electron accelerator based, X-ray Free Electron Laser at the Paul Scherrer Institute, Switzerland. It is a user oriented facility capable of producing short, high brightness X-ray pulses covering the spectral range from 1 to 50 Å. SwissFEL is designed to run in two electron bunch mode in order to serve simultaneously two experimental beamline stations (hard and soft X-ray one) at its full repetition rate. Two closely spaced (28 ns) electron bunches are accelerated in one RF macro pulse up to 3 GeV. A high stability resonant kicker system and a Lambertson septum magnet are used to separate the bunches and to send them to their respective beamlines. With the advancement of the construction of the second beamline (Athos) the bunch-separation system was successfully commissioned. In order to confirm that the beam separation process is fully transparent a stability study of the electron beam and the free electron laser in the main beamline (Aramis) was done.

RESONANT KICKER (RK) SCHEME

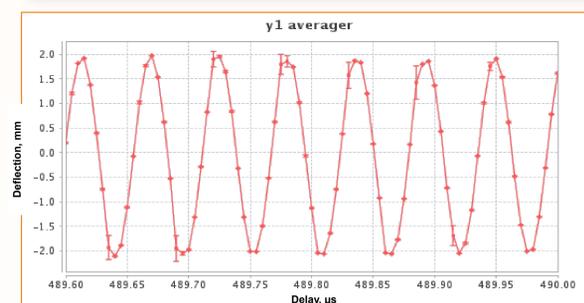


Deflecting current is slowly excited in the RKs. The two bunches arrive at the positive and negative maximum of the deflecting current or magnetic field.

ENVELOPE, PHASE SCAN AND BUNCH SEPARATION

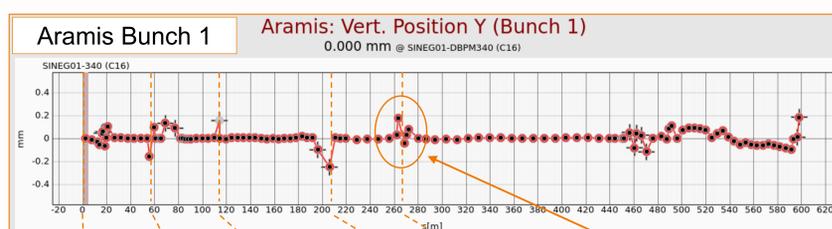


Finding rough position of the RKs' resonance. Resonance development appears backwards due to the increase in the relative delay between beam and RK macro-pulse in the scan.



Fine scan for phase determination. E-beam "probes" the sine wave of the RKs.

Vertical trajectory in the two electron beamlines (bunch separation).

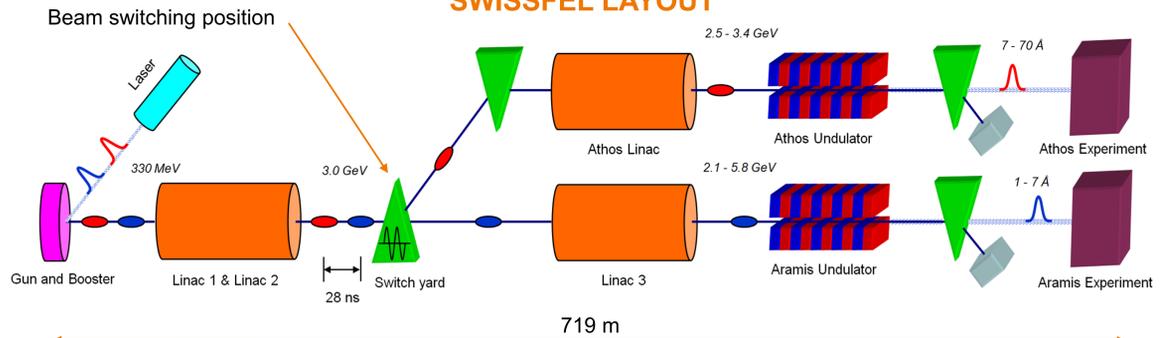


Switchyard

10 mm

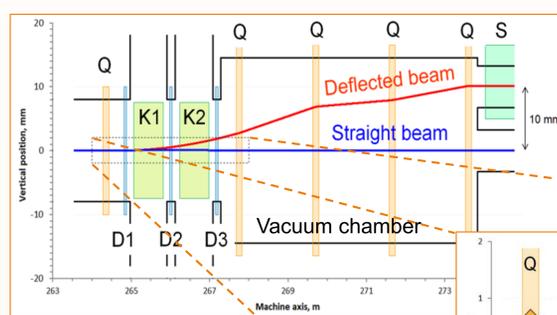
BPM No.

SWISSFEL LAYOUT



Schematic representation of SwissFEL double bunch operation scheme.

BEAM TRAJECTORIES



Beam trajectories of the straight and deflected beam. The color rectangles represent the corresponding magnets' field regions.

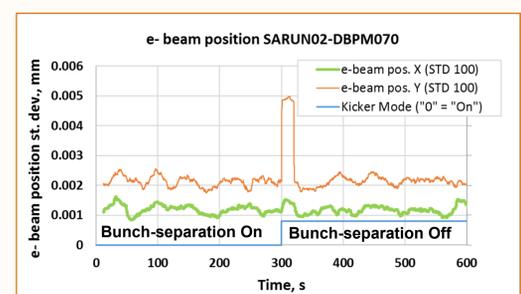
Enlarged view of the trajectories through K1 and K2 region. The arrows represent the direction of the electron deflection force.

Legend:
Kx – Kicker magnet
Dx – Dipole magnet
S – Septum magnet
Q – Quadrupole magnet

ELECTRON BEAM STABILITY

Electron beam position right before the FEL undulator section. Running standard deviation of 100 consecutive pulses.

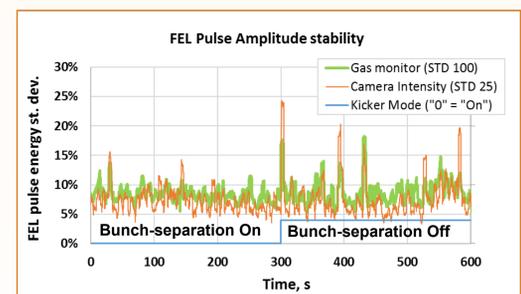
No visible difference in e-beam position stability with and without bunch-separation.



FEL PHOTON BEAM STABILITY

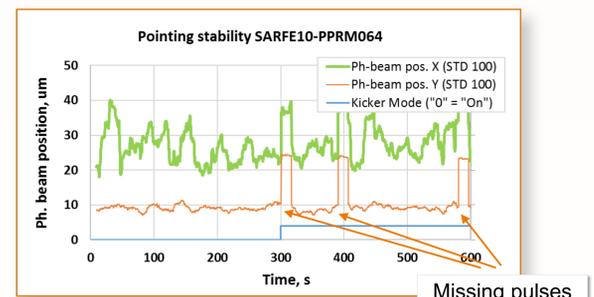
FEL photon beam pulse energy measured with gas monitor and photon beam-image camera. Running standard deviation of 100 consecutive pulses.

Pulse-to-pulse stability is not affected by bunch-separation system.



FEL photon beam horizontal and vertical position. Running standard deviation of 100 consecutive pulses.

FEL pointing stability is not changed by bunch-separation system.



CONCLUSION

Aramis beamline of SwissFEL is in regular user operation. Commissioning of the second beamline (Athos) is on its way. A fully transparent operation of the bunch-separation system is crucial to the efficient operation of SwissFEL. Number of tests were conducted to check its effect on the electron beam and FEL. It was confirmed that for the level of stability of the Aramis FEL beam present for our measurements, the bunch-separation system did not add any additional jitter to the FEL pointing and pulse energy.