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4th Generation Light Source Instrumentation
Discussion Group #6, BIW'98
Alex Lumpkin: Chairman

This working group on 4th Generation Light Source (4GLS) Instrumentation was a follow-up to the opening discussion on Challenges in Beam Profiling. It was in parallel with the Feedback Systems session. We filled the SSRL Conference Room with about 25 participants. The session opened with an introduction by Lumpkin. The target beam parameter values for a few-angstrom, self-amplified spontaneous emissions (SASE) experiment and for a diffraction-limited soft x-ray storage ring source were addressed. Instrument resolution would of course need to be 2-3 times better than the value measured, if possible. The nominal targeted performance parameters are: emittance (1-2π mm mrad), bunch length (100 fs), peak-current (1-5 kA), beam size (10 μm), beam divergence (1 μrad), energy spread (2×10^{-4}), and beam energy (10's of GeV). These are mostly the SASE values, and the possible parameters for a diffraction-limited soft x-ray source would be relaxed somewhat. Beam stability and alignment specifications in the sub-micron domain for either device are anticipated.

Vinod B. (SLAC) then presented the specific design parameters for the Linac Coherent Light Source (LCLS) SASE project at 15 angstroms (0.8 keV) and 1.5 angstroms (8.2 keV) using beam energies of 4.5 and 14.4 GeV, respectively. Roger Carr (SLAC) then presented comments on the undulator and beam-based alignment techniques for the LCLS. Since the BIW'96 meeting, the strategy of steering and making position measurements every few meters between undulator sections has been accepted. Vinokurov pointed this out in the APS SASE design, and it was confirmed by adjusted calculations by Kim at LBNL for the LCLS. This revised strategy reduced the instrumentation challenges over the 100-m length undulator. The overlap of the beams should be held to about 5 μm over 10m.

Transverse beam size measurements were then discussed. Alex Lumpkin (APS) presented the results of using a 3.5-m-long diagnostics undulator with the 7-GeV beam to measure a particle-beam divergence of 3.3 μrad. The fundamental radiation was at 0.5 angstroms (26 keV), close to the 4GLS wavelength. The technique should scale to the 1-μrad regime and possibly to the single, few-nC micropulse charge. Lumpkin proposed such a device as one line of the array of undulators at an eventual 4GLS user facility. Additionally, the x-ray pinhole imaging technique with an x-ray streak camera was shown to measure 10's of microns with projected 1-ps (sigma) resolution in an earlier presentation. The issues related to signal strength for slices of the micropulse at sub-ps regimes remains an area for development, but the transverse size averaged over the micropulse seems solved.

The discussion moved to the measurement of sub-ps microbunches. In particular, the temporal profiles at the sub-100 fs regime are an issue. Most of the correlation methods using coherent transition radiation (CTR), coherent diffraction radiation (CDR), coherent Smith-Purcell Radiation (CSPR), or coherent synchrotron radiation (CSR) will provide a measure of pulse duration. The temporal profile is much more ambiguously determined and often relied on the "assumption" of the shape first. William Graves (BNL) commented on laser gating of a material's transmission or reflection property to provide sampling of converted visible radiation from the particle beam, e.g., an OTR signal. This could work at the 100-fs level with a ultra-fast laser probe. Other laser-based techniques have been suggested. As a side note, the differential optical gating technique has been demonstrated recently at the Stanford FEL by Schwettman, Smith, et. al. Temporal profiles on the sub-ps domain were obtained although not on a single pulse. Still, the

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technique avoids phase jitter averaging effects so it can be used over many pulses. There are still developments going on for the x-ray streak camera at the 100- to 200-fs (sigma) regime. This has the potential for longitudinal profiles with a spatial profile (submicropulse) as a complementary approach.

The discussion moved to the task of maintaining the photon beam and electron beam overlap to a few microns over a gain length of a few meters. (In the LCLS case this is 5 μm over 10 m). Suk Kim (APS) presented the rf BPM button configuration that is planned for the APS visible/UV SASE project. By rotating the axis of a pair of 4-mm-diameter buttons, very high sensitivity to motion in one plane is calculated which should scale to sub-micron resolution. Tests are expected in the coming year. An LCLS person brought up the combined electron and photon beam diagnostic based on the interactions with a single, 10- to 30-μm thick carbon wire. The photons are diffracted to an x-ray detector positioned off-axis at 26° to the particle beam direction, and the bremsstrahlung radiation is detected by another detector at a more forward angle.

As the session's allotted time was over, we adjourned to allow further discussion among small groups. The challenges in the spatial, temporal, charge, and position domain plus the preservation of beam quality were duly noted.