Advanced Photon Source: Focus on Time-Domain Capabilities

Storage Ring Properties

7 GeV, 100 mA, 3 nm-rad
1104 m circumference, 3.682 µs
64 beamlines, 5000 hrs/yr

Mean time between faults MTBF
median: 2009-2012: 85 hrs, best: 220 hr
Availability
median: 2009-2012: 98.3%, best: 99.6%
Source properties (rms size + dev 0.01-200 Hz)
X: 280 ± 5 µm, 11 ± 0.9µrad
Y: 11 ± 1.6 µm, 3.6 ± 0.8 µrad
Topup: 0.2% rms intensity fluctuation
Topup Interval: 2 min 24-bunch, 1 min hybrid singlet
Bunch charge: 15 nC 24-bunch, 60 nC hybrid-singlet

Fill patterns

24-bunch (65%): 80 ps (FWHM), 4.25 mA

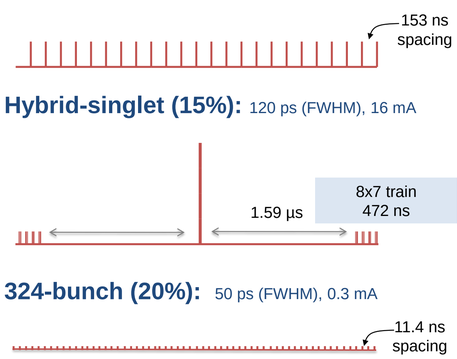
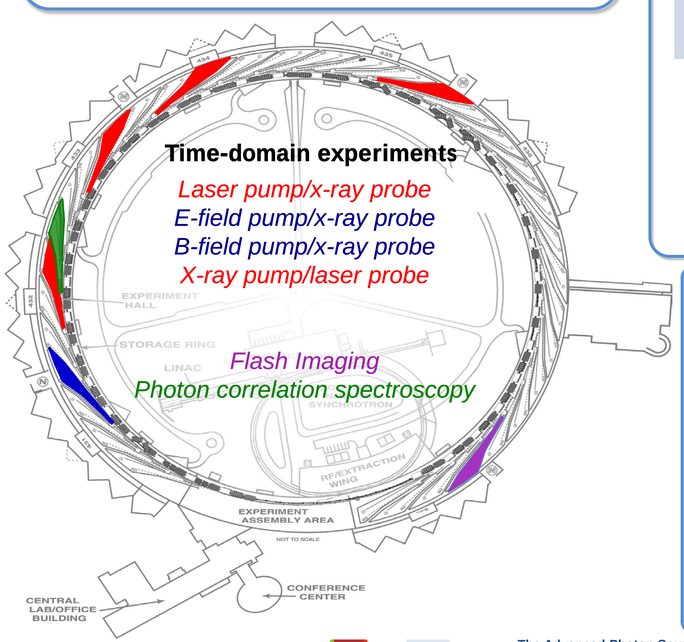


Fig 1. All patterns used in time-domain experiments. The 153 ns gap permits mechanical and electronic gating to provide variable repetition rate x-rays.

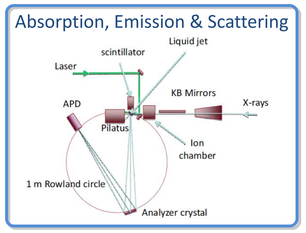


Pump-probe

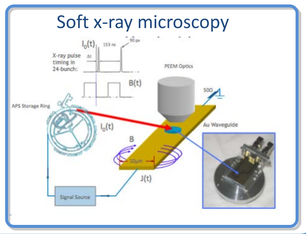
High-repetition-rate laser-pump x-ray probe – Sectors 7, 11 & 20

Sector	X-ray parameters	X-ray Techniques	Excitation Sources
7	6-25 keV, ΔE/E=5E-5 10^{13} x-rays/s 6x6 µm², 100 nm	Diffraction Absorption Emission Scattering Microscopy	Ti:sapphire CPA: 800, 400, 266 nm, 40 fs, 1 & 5 kHz, 3 W Ti:sapphire oscillator: 800 nm, 200 fs, 88 MHz, 1 W Nd: YAG: 1060 nm, 10 & 130 ps, 50 kHz – 6.5 MHz, 16 W (532, 355, 266 nm @ 9.5, 3.6, 2.5 W)
11	6-24 keV, ΔE/E=1E-4 10^{13} x-rays/s 30x450 µm²	XAFS/WAXS GIXAFS/WAXS	Ti:sapphire CPA: 800 nm, 100 fs, 3 & 10 kHz, 3 W TOPAS: 250-1600 nm, ~1W Nd:YLF: 1053, 527, 351, 263 nm, 5 ps, 1 & 2 kHz, 2 W
20	4-50 keV, ΔE/E=1E-4 & 2E-5 10^{13} x-rays/s 2x2 µm²	XAFS XRD XES	Ti: sapphire regenerative amplifier: 800 nm, 200 fs, 272 kHz, 1 W

Absorption, Emission & Scattering



Soft x-ray microscopy



B-field pump – Sector 4

0.5-2.8 keV, ΔE/E=5E-4, 100x100 µm, 1x10^{12} x-rays/s
PEEM (100 nm resolution), XMCD–FMR

Single-shot diffraction – Sector 14

12-17 keV, ΔE/E=2E-2, 10^{13}/xrays/s (10^{10} x-rays/pulse @ 1 kHz)
Laser: 780 nm, 1.2 ps, 5 mJ, 1 kHz
450-2000 nm, 1.2 ps, 150 µJ, 1 kHz

Flash imaging

~100 ps exposure
10^{10} photons/exposure
271 kHz frame rate
micron resolution
mm field of view

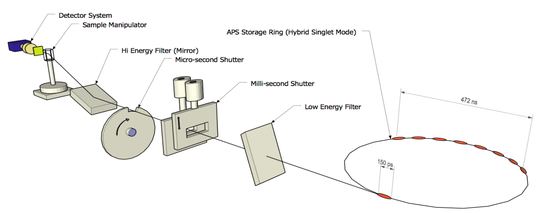


Fig 2. White beam is used for single-shot, phase contrast flash imaging. Either the 120 ps singlet or the 472 ns train can be used. Can be used in a no trigger mode to capture rogue events.

SPX: Short-Pulse X-ray Facility

World's first high-repetition rate, widely tunable, polarized short pulse x-ray synchrotron source

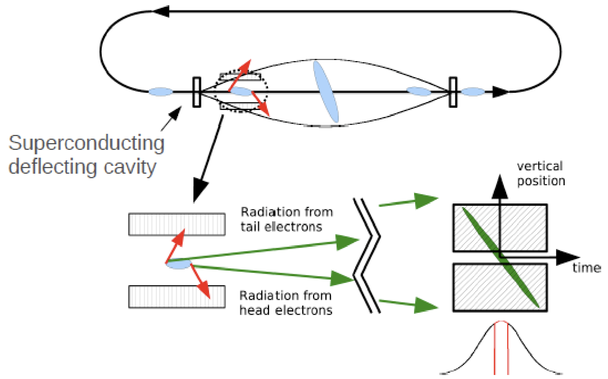
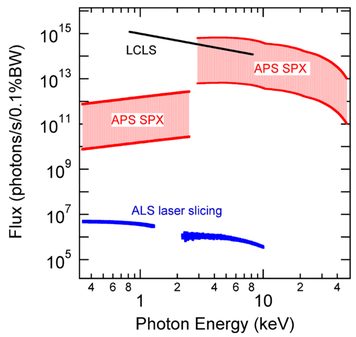


Fig. 3. Short-pulse x-ray generation by the Zholents transverse deflection scheme. A radio-frequency (rf) cavity imposes a chirp on the electron bunch such that there is a correlation between the longitudinal position of an electron within the bunch and its vertical momentum. A second cavity placed downstream restores the electron bunch to its original trajectory. Implementation at the APS incorporates superconducting rf-deflection cavities to produce short x-ray pulses at high repetition rate (6.5 MHz in standard 24-bunch mode) and high average flux.



	SPX	LCLS
Pulse duration (FWHM)	2, 10, 100 ps	100 fs (~5 fs)
Repetition rate	6.5 MHz	120 Hz
Photons/pulse (8 keV)	10^6 (10^8)	10^{12} (10^{11})
Energy range	0.2-40 keV	0.5-24 keV
Variable energy bandpass (FWHM)	2-3% Undulator A	~0.1%
Tunability	Variable undulator gap. Continuous.	Electron beam energy.
Average flux	6.5 x 10^{12}/s	1.2 x 10^{14}/s
Pulse-to-pulse reproducibility	Excellent	Limited by SASE

Fig 4. Usable fluence on target is a good figure-of-merit to evaluate x-ray probes operating in the linear response regime. The SPX is comparable to the LCLS for pulses of duration longer than ~ picosecond.

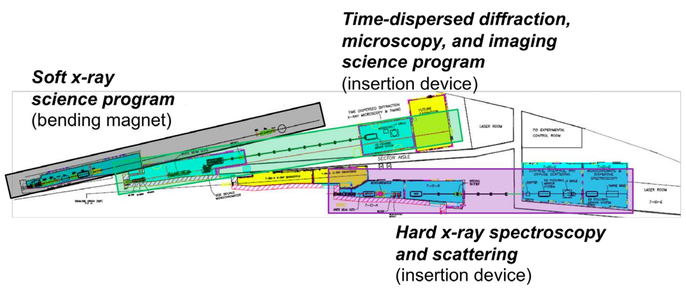


Fig 5. Three x-ray beamlines are planned for the SPX facility. They are flexible: variable x-ray photon energy, pulse duration, bandwidth, spot size on target and repetition rate. Co-located laser facilities to produce sub-picosecond radiation at high repetition rate are planned.

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