Summary of the Short-Pulse Workshop

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The primary purpose of the Short-Pulse Workshop held on May 6, 2005, was to present preliminary results of accelerator and optics calculations leading to the production of short (~1 ps) x-ray pulses from the Advanced Photon Source (APS) storage ring. In addition to presentations pertaining to the generation of short pulses, of equal import and interest, the workshop also afforded an opportunity to summarize the science driving this project. National and international experts were invited to hear the presentations and provide critical comments regarding all aspects of the proposal. Summaries of the presentations are not given here, as the full presentations are available on the Web. Rather, this summary deals with specific issues and comments that were brought up during the workshop.

A basic element of the short-pulse production scheme is a pair of special radio-frequency (rf) cavities at both ends of a section of the APS storage ring. The first cavity imparts a position-dependent vertical deflection (chirp) to the APS bunches, while the second cavity cancels the chirp. X-ray pulses from insertion devices between the deflecting cavities are compressed by x-ray optical components to 1-2 ps in duration. The design of the short-pulse system is constrained by the requirement that the beam property degradation in the rest of the APS ring (due to an imperfect cancellation of the deflection) be at an acceptable level. An extensive beam dynamics study has shown that this scheme can shorten APS pulses to 1-2 ps. The APS short-pulse project is estimated to last about three years.

Prior to this workshop, considerable effort was expended on developing a scheme whereby the rf cavities are operated in a continuous wave (CW) mode so that, when energized, all the bunches in the storage ring between the two cavities would be chirped. Such a CW system would almost certainly be based on a superconducting rf (SCRF) cavity technology due to power requirements.

Tremendous progress has recently been made in the area of SCRF technology, so that SCRF accelerating cavities are now operating successfully in accelerator facilities around the world. However, an SCRF cavity for transverse chirp is more challenging due to the need to remove the lower-order modes, as well as the higher-order modes, and because the cavity shape is not cylindrically symmetric. A project to install a 500-MHz deflecting cavity (known as a “crab” cavity in this context) is underway at the KEK B factory in Japan in order to raise the luminosity of colliding beams that cross at a slight angle rather than head on. A suggestion was put forth by the user community that a pulsed, room-temperature (RT) cavity might be consistent with the needs of users because in many (but not all) cases a laser is used as the pump beam for pump/probe experiments and lasers with adequate power typically have repetition rates of a few kHz (or perhaps a few 10’s of kHz at the maximum). In addition, a pulsed system may provide a larger chirp to the beam (yet to be determined), which could be of value in making development of the compression optics less daunting. Therefore, if a room-temperature cavity can be more quickly implemented, this may be an interesting short-term solution. Clearly, more work is required to sort out and weigh the advantages and disadvantages of a warm cavity versus a superconducting cavity. It was suggested that a compromise option would be to start the short-pulse project with an RT cavity, thereby learning the intricacies of the deflecting cavity and pulse compression optics, and later switch to an SCRF system.

Another concern brought forth at the workshop was that of focusing the centimeter-sized (in the vertical) chirped x-ray beam. Because high-speed mechanical choppers are often used to isolate a single x-ray pulse from the pulse-train of x-rays, small beams are needed–from 1 to 0.050 mm–depending on the required opening and closing time of the chopper window. While 1-mm-sized focal spots seem achievable (and would probably be compatible with isolating the lone bunch in our hybrid filling mode), the question remains: would we be able to produce beams of less than 100 µm for choppers that might be used in 24-bunch mode?

In conclusion, a special insertion at the APS for 1-2 ps x-ray pulses is not only feasible, but affords unprecedented opportunities for probing picosecond dynamics. The next step will be to decide between the SCRF or RT cavity options, as well as other parameters such as cavity frequency, gradient, and number of APS sectors to be included.