TECHNIQUES AND TECHNOLOGIES FOR ULTRA BRIGHT SYNCHROTRON LIGHT SOURCES

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The designs of the latest generation of synchrotron light sources, both under construction and planned, have the objectives of ultra-low emittance and low energy spread, extreme beam stability and full exploitation of photon energies in the range of a few electron-volts to hard X-Rays with excellent coherence and time structure. Recent developments on lattice design have brought the electron beam emittance to sub nmrad values. As a consequence the adopted hardware and software technologies have to match requirements and guarantee continued performance. When designing a synchrotron radiation source based on a storage ring there is the need to take into account the strong interdependence between many parameters: the photon energy is related to beam energy and the type of insertion device; the brightness of the source is related to the beam energy, the emittance, the circulating current, beam stability and insertion devices; source stability is related to the circulating current and consequent beam instabilities, to transmitted vibrations and the ability to stabilise passively and actively; the time structure of the source is related to bunch lengths, bunch currents and to the type of accelerator or slicing technique used.

Ultra low emittance accelerator designs for ring based light sources benefit from the use of many magnets in an achromat structure and/or the use of damping wigglers. Optimal designs of the of the magnet lattice require many families of sextupole magnets to maximise the transverse and momentum dynamic apertures, often with the use of octupole magnets. The use of conventional separated function magnets is often not the most favourable solution and magnets that have a combination of multipoles are more appropriate to reach the desired emittances. Such magnets should be compact, with small apertures and strong fields and have a low cost, both in production and operation. Modern industrial techniques are available for the production of exotic magnets having exceptional field properties. The small apertures necessitate narrow gap vacuum chambers which in turn require state-of-the-art solutions for pumping given the low vacuum conductance of the chambers. The design of the vacuum chamber is strongly linked to the magnetic and mechanical design of the magnet. To reach a technologically feasible design, the adoption of Non-Evaporable Getter thin film technology is often the only means of pumping the vacuum chamber. Small bore vacuum chambers may in turn have adverse effects on the beam causing instabilities through generated wake-fields and will necessitate the implementation of Landau cavities and sophisticated feedback systems. Landau cavities additionally benefit machine operation by decreasing longitudinal bunch densities. This latter effect is particularly important given the very high electron bunch densities that can compromise the final emittance value because of intra-beam scattering.

Beam stability is of paramount importance in maintaining the ultra-bright characteristics of the photon beams. The accelerator and its housing have to be treated and designed together. Unavoidable cultural noise has to be isolated and damped. Care has to be taken in the design of all components of the infra-structure from magnet support stands to experimental floors, from water installations to the landscaping of areas around the facility. Ground vibration in the range of tens of nanometers can be amplified by supports and the magnetic lattice to levels that compromise facility performance. In addition to passive mechanisms towards beam stability many active systems are also required using state-of-the-art technology. Active systems can range from fast multibunch feedback systems (100's MHz) to top-up operations for thermal stability and improved feedback operational ranges. Top-up operation is essential to reach full performance and must be invisible to users. Operational ease of the facility is governed by the use of modern control systems that integrate a multitude of different systems and allow both operators and users transparent access to beam parameters and settings.

The talk will give a broad overview of state-of-the-art synchrotron light source design, both ring and linac based. Examples from on-going design and construction will be shown, together with examples of systems and solutions to technological requirements that guarantee performance.