2.3.6 Synchrotron - Acclerator Physics and Technology

Lecturer	Prof. Dr. Anke-Susanne Müller, Dr. E. Bründermann
Content	The course will introduce the basic operation principles of modern accelerators and synchrotrons, simulation tools, and comparison to other sources and detection methods
Course Objectives	The following selection of topics will be presented: ▪ Terahertz generation and detection ▪ Room temperature and cryogenic terahertz detectors (slow and fast), imaging systems, and operation principles ▪ Components of accelerators and synchrotrons (dipole, quadrupole, sextupole,…) ▪ Gaussian optics and magnet optics ▪ Design of a synchrotron with MAD-X ▪ Terahertz applications
Learning Targets/ Skills	After course completion, participants should be able to a) start designing magnet optics for accelerators; b) judge the technical complexity and feasibility; c) communicate effectively with electrical engineers and physicists; d) compare and transfer ideas from their field to other fields such as accelerator physics and technologies incl. fs lasers and detectors.
Pre-Requisites	Basic physics and electrodynamics, calculus, complex numbers, interest in electronics, lasers and technology
Duration	3 days
Teaching Method	Formal lectures, tutorial style discussion, group work, tours and hands-on operation of the synchrotron ANKA
Course Material	Lecture notes, simulation software via links
Literature	▪ H. Wiedemann, *Particle Accelerator Physics* 1&2, Springer Verlag, 1993 or newer edition. ▪ K. Wille: *Physik der Teilchenbeschleuniger und Synchrotronstrahlungsquellen*, Teubner, Studienbücher, 2. Aufl., 1996 (in German). ▪ E. Bründermann, H.W. Hübers, M.F. Kimmitt, *Terahertz Techniques*, Springer Verlag, 2012. ▪ A.-S. Müller et al., Experimental Aspects of CSR in the ANKA Storage Ring, *ICFA Beam Dynamics Newsletter* No. 57, pages 154–165 (2012), Link: http://www-bd.fnal.gov/icfabd/Newsletter57.pdf
Contact Lecturer	Deniz Birli: deniz.birli@kit.edu (assistant to Prof. Dr. Anke-Susanne Müller: anke-susanne.mueller@kit.edu), Dr. Erik Bründermann: erik.bruendermann@kit.edu

Schedule Synchrotron	
LAS / IBPT	**Content (accelerator physics, lasers, detectors, electronics, methods)**
Day 1: 26. July 2016 (Tu)	
ANKA (small) Seminarroom, Building 348, Northwest (NW) entrance of ANKA hall, upper floor, Campus Nord (CN) (KIT-Shuttle to Bldg. 605: 8:30 CS - 8:52 CN) **9:15 - 12:15 Lecture 1** **Lunch break: CN Casino** **13:15 - 16:15 Lecture 2** (KIT-Shuttle from Bldg. 605: 16:35 CN - 16:57 CS) Access to CN requires clearance at the entrance with a passport, prior contact: deniz.birli@kit.edu	Lecture 1 (3h) 9:15-12:15 by Dr. Erik Bründermann Basics, blackbody radiation, detection methods, figures of merit, terahertz detectors, diagnostics of synchrotron radiation, detectors made from semiconductors, superconductors, mixers, Schottky diodes, room-temperature micro-bolometers, cryogenic bolometers, cryogenic photodetectors, Golay cell, pyrorelectric detectors, optical diagnostics: e.g. streak camera, femtosecond lasers, electro-optical sampling (EOS), electro-optical decoding, time-stretch methods, pulse structures, frequency combs, near-field effects, antennas, microscopy, nanoscopy, terahertz generation, terahertz diagnostics. Lecture 2 (3h) 13:15-16:15 by Prof. Dr. A.-S. Müller Basics, light sources, acclerator physics, cyclotron, synchrotron, phase focusing, electron transport, Lorentz-Force, relativistic electrons, beam optics, synchrotron radition, magnets (dipole, quadrupole, sextupole), FODO-principle, equations of motion, particle trajectories, emittance, phase space lasers, tune and resonances, dispersion, chromaticity, time structure, insertion devices, wigglers, undulators, coherent synchrotron radiation, terahertz generation at ANKA, short bunches, low-alpha optics, comparison between Gaussian optics and magnet optics, streak camera, edge radiation, ultra-short bunches and pulses, bunch compression, linear accelerator FLUTE at KIT.
Day 2: 27. July 2016 (Wd)	
SCC-PC-Pool Bldg. 20.21, Poolraum G-119 **9:00 - 17:00 Practical work**	Simulation course with MAD-X: designing and simulating an accelerator such as ANKA for relativistic electron acceleration. It is encouraged to test MAD-X on own laptops: http://mad.web.cern.ch/mad/, see "Documentation": MAD-X tutorial, MAD-X primer. For further install recommendations contact erik.bruendermann@kit.edu
Day 3: 02. August 2016 (Tu)	
ANKA synchrotron control room Building 348 Meeting point 8:50 at entrance (Anmeldung) at CN **Practical work**	Hands-on synchrotron operation in the control room by the participants. Technology tours of synchrotron, terahertz technology, lasers and detectors.