SAW - A SUPERCONDUCTING ASYMMETRIC MULTIPOLE WIGGLER AT THE DELTA STORAGE RING*

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ABSTRACT

To satisfy the present need for the generation of intense synchrotron radiation with **C**ircular **P**olarisation in the **X-R**ay region (CPXR), a 5.5 Tesla **S**uperconducting **A**symmetric multipole **W**iggler (SAW) for the 1.5 GeV electron storage ring DELTA (**D**ortmund **EL**ectron **T**est **A**ccelerator) was developed and is now under construction. A special coil arrangement allows two operation modes of the wiggler. A symmetric mode with 10 periods of a sinlike field with a peak value of 2.75 Tesla and a asymmetric mode with 5 Periods and a peak value of 5.5 Tesla. The asymmetric mode generates circular polarised synchrotron radiation in the 1 Angstrom wavelength regime. The influences of the SAW on linear and nonlinear optic are calculated with canonical perturbation theory and optimized to reduce disturbing effects

1 THE SUPERCONDUCTING ASYMMETRIC MULTIPOLE WIGGLER

The wiggler design parameters are mainly defined by the SR properties determined by the user requirements. The users are interested in a hight photon flux in the 1 Anstrom wavelength regime. Furthermore, a high percentage of circularly polarized photons is disireable. So the magnet design was optimized to get an extremly short periodlength and a small gap height. The prinziple of the asymmetric wiggler field is the superposition of two axial shifted standard sinusoidial multipole wigglers of different period lengths [1]. The coil arrangement consists of 19 poles exited by racetrack coils in one half of the wiggler. Including two additional correction coils this leads to a number of 52 coils in the SAW. The dimensions of the field profile, the angular deflection and the particle trajectory for all periods are sketched in figure 1. The coils are arranged in three independed main circuits and one correction circuit. With the three main circuits it is possible to switch the wiggler operation between two modes. A standard sinusoidal mode and a asymmetric mode.

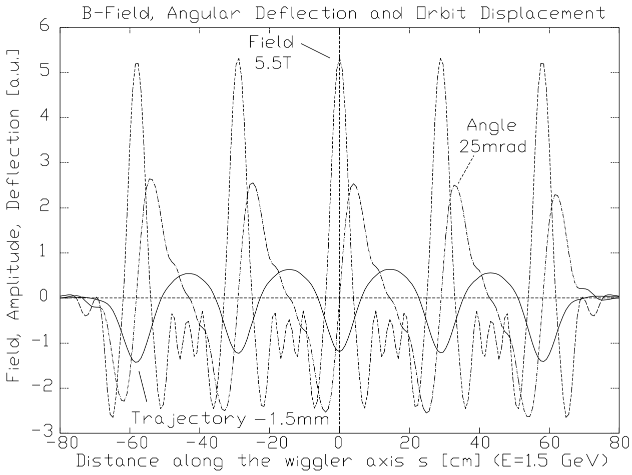

Figure 1: Magnetic field, angular deflection and orbit displacement along the wiggler axis (asymmetric mode)

The main parameters of the device are summarized in the table.

<u>Wiggler Parameter</u>

number of coils	52	
full magnetic gap	18 mm	
full vacuum gap	10 mm	
temperature of the chamber	20 K	
total magnetic length	1.44 m	
nominal electron energy	1.5 GeV	
	asymmetic	symmetric
peakfield	5.5 Tesla	2.75 Tesla
periodlength	28.8 cm	14.4 cm
number of periods	5	10
wiggler parameter k	149	37
opening of the ligth cone	25 mrad	13 mrad
critical photon energy	8.2 keV	4.1 keV

The synchrotron radiation spectra are calculated by the total numerical code **SpontLight** [6]. Figure 2 shows the Spektrum of the symmetric mode and figure 3 the spectrum of the asymmetric mode. The asymmetric mode spectrum is splitted of in right and left circularly polarised photons.

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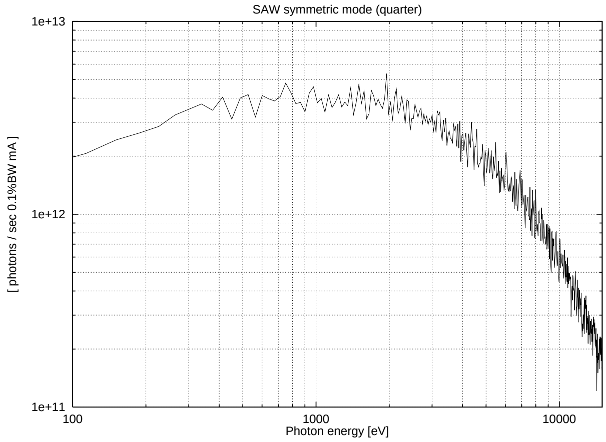

Figure 2: Spectrum of the symmetric mode

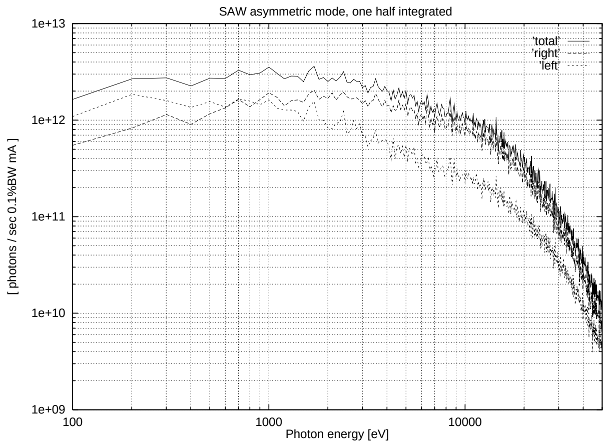

Figure 3: Spectrum of the asymmetric mode

2 STATUS OF THE SAW CONSTRUCTION

Since february 1995 the SAW is under construction by the german company ACCEL. In order to prove the design parameters a test module with 10 coils of the wiggler was build. This module was tested successfully in february 1996. The end of construction ist planed for december 1996 and so the start of operation is expected for spring 1997. The field measurements will be made with a pulsed wire method [7][8]. A wire in the wiggler chamber is pulsed with a short current pulse which exited mechanical waves on the wire. These waves can be measured and yields to a measurement of the field and the field integrals by one instantanus measurement. This method is much more reliable than the measurement by a moving hall probe in a vacuum chamber of a hight of 10 mm under vacuum conditions.

3 EFFECTS OF THE SAW ON THE STORED ELECTRON BEAM

The SAW will be installed in a dispersion free section of DELTA. A low vertical betafunktion in this section is necessary because the SAW field on linear optics (tune shifts) and nonlinear optics due to higher magnetic multipoles in the wiggler field can be minimized by low betafunktions. This guarantees also a small source point of SAW radiation. To simplify chromaticity compensation and to avoid intrabeam scattering the horizontal betafunction should not be choosen as low as the vertical. If the betafunction in the centre of the SAW amounts 0.4 m the averaged betafunction over the whole SAW magnet becomes minimal.

To compute betafunctions in DELTA real field shapes of dipoles, quadrupoles and of the SAW are taken into account by introducing effective magnet parameters. These parameters are calculated according to a method outlined in [4] which can be simplified for symmetric field shapes [5]. The vertical tune shift ΔQ_z generated by the maximal asymmetric wiggler field of 5.5 Tesla with the optimal vertical betafunction - 0.4 m in the centre of the SAW - is computed with these effectiv parameters to $\Delta Q_z = 0.02$. By adjusting some quadrupoles this small tune shift can be easily compensated.

Effects of sextupole components in the wiggler field are worked out with canonical perturbation theory [5]. The formula for amplitude dependent tune shifts is:

$$\Delta Q_x = T_{xx}\varepsilon_x + T_{xz}\varepsilon_z + o(\varepsilon^2_{x,z})$$
$$\Delta Q_z = T_{xz}\varepsilon_x + T_{zz}\varepsilon_z + o(\varepsilon^2_{x,z})$$

$\varepsilon_{x,z}$ is the horizontal and vertical emittance of a single particle. Sextupole magnets installed in the DELTA lattice compensate the chromaticity in order to avoid the head-tail instability and to enlarge the energy acceptance of DELTA . Because of these chromatic sextupoles the coefficients T become $T_{xx} = -434m^{-1}$, $T_{xz} = -3022m^{-1}$ and $T_{zz} = 525m^{-1}$. Another contribution to the coefficients T results on the assumption that each pole of the SAW generates sexupole components with the integrated strengths $\mathrm{m_w l}$:

$$\mathrm{T_{xx} = -1m|\,m_w l| + o(0.01m^3(m_w l)^2)}$$

$$\mathrm{T_{xz} = 7m|\,m_w l| + o(0.01m^3(m_w l)^2)}$$

$$\mathrm{T_{zz} = -1m|\,m_w l| + o(0.01m^3(m_w l)^2)}$$

Contributions of sextupole components in the wiggler field are negligibly small in comparison with contributions of chromatic sextupoles since the horizontal and vertical betafunction in the SAW is lower (horizontal 1.3 m and vertical 0.4 m in the SAW centre).

Therefore the influence of all higher multipoles in the SAW field is also nonrelevant. By introducing additional sextupoles in the dispersion free section around the SAW it is possible to reduce the contributions of chromatic sextupoles to the amplitude dependent tune shift. Thus a magnification of the dynamic aperture by a faktor 2 is possible as tracking calculations have shown [5].

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