DESIGN CONSIDERATION OF NEW INSERTION DEVICES OF HEFEI LIGHT SOURCE

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Abstract

To meet the requirements of users for higher brilliance and good transverse coherence VUV and soft X-ray synchrotron radiation, Hefei Light Source(HLS) will be upgraded. After upgrade HLS will have smaller beam emittance and install more insertion devices. In this paper the design considerations of new insertion devices are reported, they include one elliptically polarizing undulator, one quasi-periodic undulator, one in-vacuum undulator and one wiggler.

INTRODUCTION

Hefei Light Source (HLS) of National Synchrotron Radiation Laboratory (NSRL) is a dedicated second generation light source. In order to meet the increasing requirements of synchrotron radiation users for higher brilliance and good transverse coherence VUV and soft X-ray synchrotron radiation, an upgrade project of Hefei light source is undergoing. The Magnet Lattice focusing structure of the storage ring will be changed from 4 TBA to 4 DBA cells. The emittance of storage ring will be reduced from 166nm.rad to 36nm.rad. The number of straight section will be increased from the current four with 3. 36meter long to eight, in which the four straight sections are with available length of 3.4meter, and the other four shorter straight sections are with available length of 1.7meter. Except one longer straight section for injection system and one shorter straight section for RF system, there are six straight sections available for insertion devices. The existing insertion devices at HLS including an undulator and a superconductor wiggler will be used continually. In the upgrade project, four new insertion devices will be built.

The minimum pole gap is constrained by the beam dynamic aperture and vacuum chamber size. For the out vacuum undulator, the beam requires horizontal space ± 38 × ± 10mm at straight section, so the effective straight section vacuum chamber gap is ± 10mm. Consider the vacuum chamber wall thickness of 3 ~ 4mm, and deformation error, the minimum magnetic pole gap is taken as 30mm; For the in vacuum undulator, considering the impact on the beam lifetime of gas scattering and Touschek effect, the minimum pole gap is taken as 10mm.

The undulator period and deflection parameter K must satisfy the resonant relation on physics, and same time they are correlated technically. Figure 1 show the relations of them for our 800Mev electron beam case and different radiation wavelength

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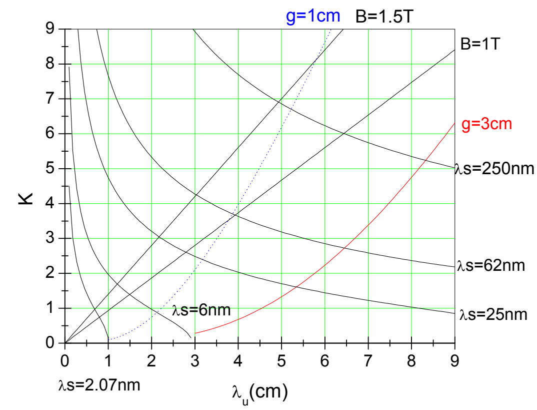

Figure 1: The relation of undulator period and deflection parameter K.

IN-VACUUM UNDULATOR

For the undulator of the Soft X-ray lithography beam-line and end-station user, the energy range of photon is 20-200ev, the corresponding wavelength is 62~6.2nmn, the user also hope can have fairly flux at 600ev. For the wavelength range required and existing magnet technology of undulator, from Figure1, even at the minimum pole gap 10mm (in-vacuum undulator) , the fundamental wavelength can't cover the wavelength range, the harmonic radiation must be used. The undulator is located at one of the shorter straight sections, the total length 1986 mm of the vacuum chamber includes both ends of the bore 8 angular CF100 standard interface flanges, bellows, and high-frequency shielding and water cooling and other auxiliary structural elements. In order to get as many periods, the length of auxiliary structural elements should be as short as possible. Considering various factors the parameters were given as Table 1. The corresponding photon fluxes are shown in Figure2.

Taking into account the requirements of the vacuum baking, the high Curie temperature of SmCo permanent magnetic materials is choose. The magnet pole, we choose vanadium permendur for its higher saturation field.

Table 1: Parameters of IVU40

Type	In vacuum，hybrid
Periods λ_u (*cm*)	40*mm*
Number of Periods *N*	~30
Gap rang (*mm*)	10～30*mm*
Peak field B_u(T)	1.01～0.18T
K	3.775～0.67

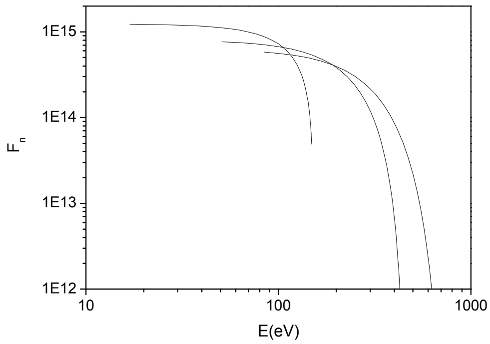

Figure 2: The photon flux of IVU4.0.

ELLIPTICALLY POLARIZING UNDULATOR

The elliptically polarizing undulator is designed for the users of ARPES beam-line and end station. The energy range of photon is 5-50ev, the corresponding wavelength is 248~24.8nm, and light flux demanded by users is about 10^{15} Ph./(sec*0.1%BW) , one order higher than the current. The undulator is located at a straight section of 3.4meter long. The APPLE-II type variable elliptical polarizing undulator was adopted. The parameters of the EPU are list in the Table 2. The corresponding photon flux are shown in Figure 3. The calculated transverse distributions of horizontal and vertical magnetic field for circular polarization mode are given in Figure 4.

Table 2: Parameters of EPU104

Type	EPU, ppm
Periods λ_u (*cm*)	104*mm*
Number of Periods *N*	31
Gap rang (*mm*)	30～80*mm*
Peak field (T)（linear）	0.65～0. 145 T
Peak field (T)（circular ）	0.34～0. 045 T

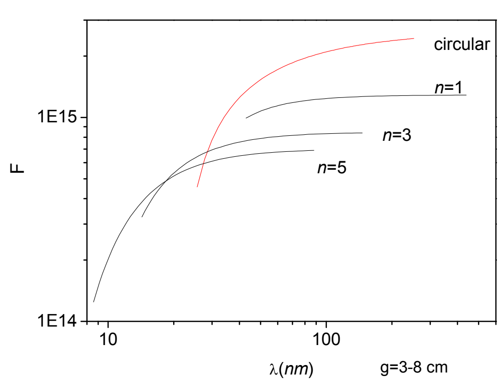

Figure 3: The photon flux of EPU104.

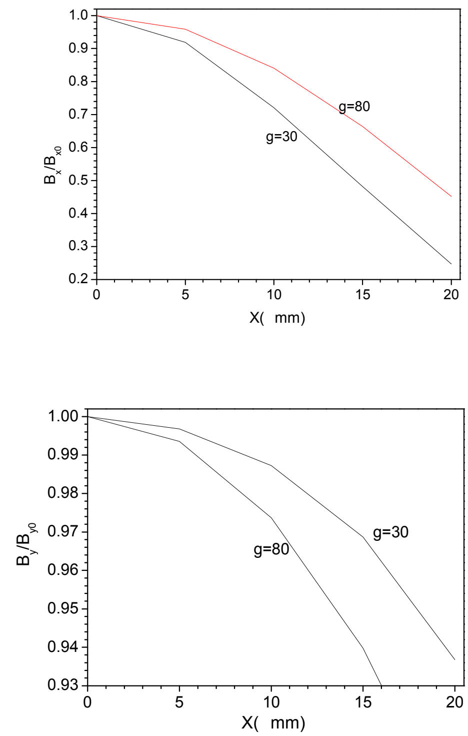

Figure 4: The transverse distribution of horizontal and vertical magnetic field for circular polarization mode.

QUASI-PERIODIC UNDULATOR

The quasi-periodic undulator is designed for the user of Combustion and Flame beamline and endstation. The energy range of photon is 5-20ev, the corresponding wavelength is 248~62nm. Users require high harmonic suppression, thus the quasi-periodic type undulator is adopted.

For a typical QPU, some H magnets (blocks magnetized horizontally) are retracted vertically by a value δ [1]. We propose and adopt a modified structure for QPU. We know that increasing the harmonic magnetic fields can enhance or suppress the harmonic undulator radiation [2], and the harmonic field can be enhanced by optimizing the magnetic blocks size [3].

We optimize the thickness ratio of V magnets (blocks magnetized vertically) and H magnets in the current QPU, to make the third harmonic field be enhanced with the same sign to the fundamental B_{u1}, then the third harmonic emission are suppressed more effectively[4]

The magnetic fields are calculated by using the RADIA code [5] and radiation spectrum are calculated by using the SPECTRA code [6]. The numerical results demonstrate that comparing the current QPU, the third harmonic emission are distinctly suppressed after the magnetic blocks size being optimized.

Table 3: Parameters of QPU88

Type	quasi-periodic
Periods λ_u (*mm*)	88
Number of Periods *N*	19
Gap rang (*mm*)	30~54
Peak field B_u(T)	0.62～0.26
η	$\sqrt{5}$
δ	5
H magnet(mm^3)	80×60×30
V magnets (mm^3)	80×60×14

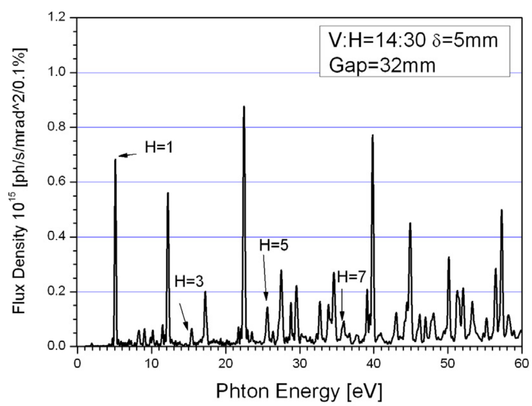

Figure 5: Flux of modified QPU88.

WIGGLER

The wiggler is designed for the user of surface physics beam-line and end-station. The energy range of photon is 200-600ev, the corresponding wavelength is 6.2~2.07*nm*. From the relationship of the period and deflection parameter K (Figure1), the required wavelength range can not be reached for the fundamental of an out vacuum undulator; it is difficult to cover even for a in vacuum undulator with minimum pole gap 10mm, therefore the wiggler mode is considered.

The characteristic energy, which corresponds to the maximum flux, of wiggler is $E_c=\hbar\omega_c$(eV)=$0.1738*10^{-3}\gamma^2B$(T). Users want to 520eV at the maximum flux, the corresponding magnetic field ~1.22T. Users also want the flux at 2.5Kev is as high as possible. To increase the photon flux of high energy side, the maximized magnetic field strength is requested. For this reason, the FeCoV pole and the permanent magnet with high remanence and high intrinsic coercivity were choose. Increasing the period length can increase the wiggler magnetic field strength, but the period length increase will reduce the number of the period that made the radiation flux of whole spectrum decline. Based on an overall consideration of various factors, the wiggler parameters were calculated and given in table 4.

Table 4: Parameters of WG156

Type	hybrid
Periods λ_u (*cm*)	156*mm*
Number of Periods	11
Gap rang (*mm*)	30 ～37*mm*
Peak field B_u(T)	1.393～1.160T

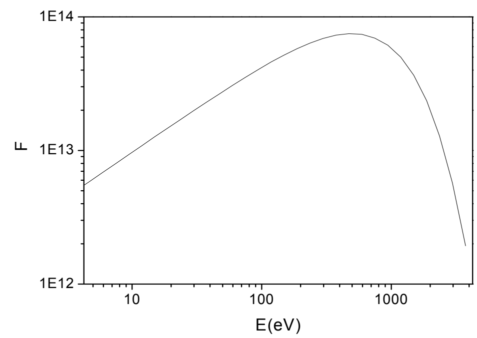

Figure 6: The photon flux of WG156.

For the four new insertion devices three are first special type ID for HLS. Now the detail technological designs of four ID are ongoing. The insertion devices will be completed and installed on the ring next year.

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