STATUS REPORT ON THE SUPERCONDUCTING WIGGLER - INSERTION DEVICE ON ADONE

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Abstract

A new synchrotron light source generating a flux of $2.4x10^{12}$/sec mrad hard X-ray photons of 9 KeV critical energy (in 0.1% b.w.) by means of 6 Tesla S.C. Wiggler will be installed in the near future into one of the straight sections of the electron-positron storage ring Adone at Frascati. The paper describes the latest status of the facility.

The Magnet

A superconducting wiggler is currently being tested in cooperation between Laboratori Nazionali I.N.F.N. and ABB Ansaldo, to be used as an insertion device in the Adone storage ring. The facility consists of a superconducting wiggler, built by Ansaldo Componenti, and two warm magnets, home made, needed to compensate the field in such a way that the first integral of the vertical field component should vanish. The one pole superconducting wiggler has a measured magnetic field peak of 6.025 ± 0.003 Tesla. The two compensator magnets generate a maximum field of 0.85 Tesla. A 1430 S Koch liquefier/refrigerator on line with the s.c. magnet will keep it cooled at 4.6°K.

The aim of this facility is to shift the "universal" spectral curve of the synchrotron radiation from the Adone bending magnets towards higher energy photons. Table n. 1 shows the parameter list and the characteristic features of the radiation source.

Table 1

Parameter list and characteristic features of the radiation source

Electron energy (GeV)	1.5	
Electron current (mA)	100	
N of ph. at 9 Kev	2.4×10^{12}	/s/mrad $\left(0.1\% \frac{\Delta\lambda}{\lambda}\right)$
σ_x (mm)	2.3	
σ_z (mm)	0.16	
σ'_z (mrad)	0.3	
Brilliance	1.36×10^{12}	Nph/s/mm²/mrad² (0.1% $\Delta\lambda/\lambda$)

An important aspect is the structure of the synchrotron light source to be obtained, namely its horizontal phase space distribution (Fig. 1).

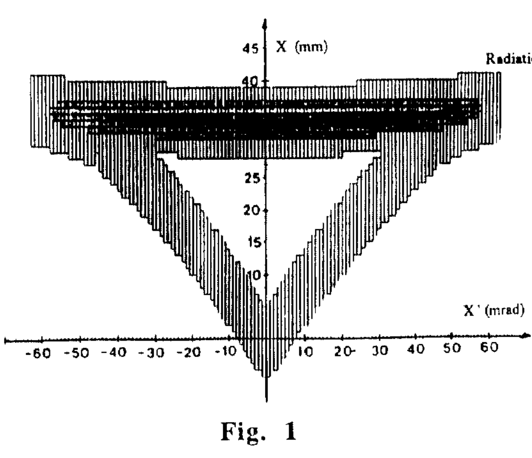

Fig. 1

The source created by a wiggler has a structure whose complexity depends on the number of the "wiggles" (electron orbit oscillations in the wiggler).

To be compatible with the storage ring optics, the wiggler must also fulfil the following conditions:

1) $\int B_z\, ds \sim 0$ (the first integral of the vertical field component should vanish)

2) The orbit parameters, displacement and angle, at the exit of the wiggler should be the same as those at the entrance. This imposes a symmetry on the field distribution along the beam trajectory, with a symmetry axis orthogonal to the straight section, lying on the orbit plane and passing through the wiggler center.

To reach the goal of having a very simple light source structure and a compensated magnetic field integral, a particular magnetic field pattern along the beam trajectory has been adopted: a sharp vertical field peak (- 6 T, 14 cm f.w.h.m., Fig. 2) placed at the straight section center, compensated by two side tails (both decreasing from about + 1T to zero in over 1 m of free straight section length).

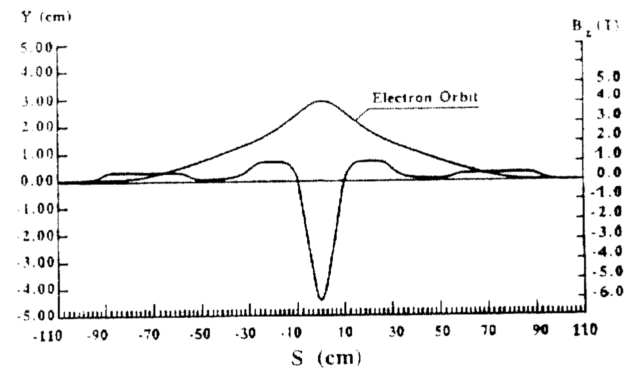

Fig. 2

The chosen field profile and symmetry, produce a single orbit bump in the horizontal plane, and the single "wiggle" gives rise to a single bright source spot in horizontal and vertical phase space.

Two runs of measurements have been made on the superconducting dipole [1, 2]. Fig. 3 shows the training diagrams and Fig. 4 the load line of the magnet.

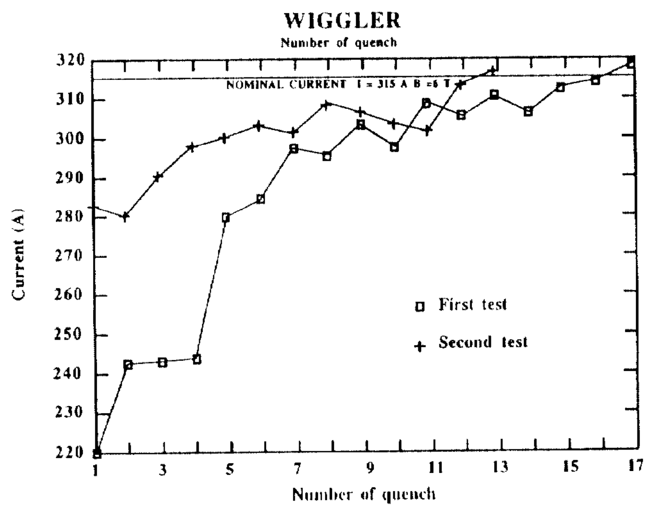

Fig. 3

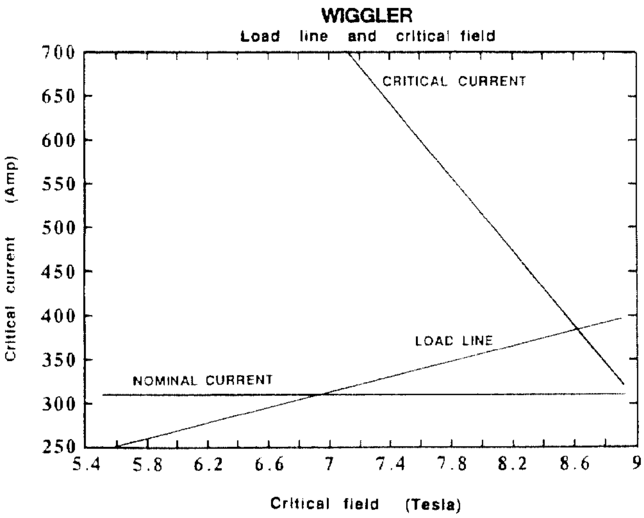

Fig. 4

The compensator Magnets [3] with a field of 0.85 Tesla, are made by Armco iron and H shaped to avoid quadrupolar gradients. They are 0.33 m long and are fed by two power supplies (22V, 1000A). Some tests have been carried out at 50% of their normal current and the results are compatible with the prevision made using the bidimensional code Magnet, the measured values being 0.85% lower than the forecast, while in the transversal direction a variation of ±1% in the plateau between -7.3 cm and + 7.15 cm with respect to the pole center, has been found. If the sextupole field term introduced by the wiggler has to be corrected, the compensator pole surfaces may be machined in such a way that a sextupole term having the opposite slope is obtained.

The Laboratory

The Fig. 5 shows the top view of the experimental area where the Laboratory has been erected. Three beam lines, each covering 8 mrad, are planned and one of them, dedicated to X-ray absorption spectroscopy of solids and gases, X-ray diffraction of amorphous solids, is almost ready.

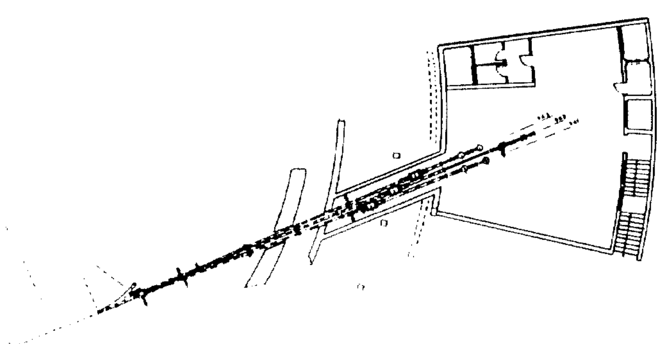

Fig. 5

The synchrotron light coming out from the vacuum chamber (see Fig. 6) through a beryllium window, will produce a high photon flux in a rather wide energy range. Due to the long distance (32 m) between the source and the sample, it will be necessary to focus the beam into a spot as small as possible. Simulations to study the performance of double curved crystal focusing monochromator, have been carried out with the ray tracing program "Shadow" [4], in order to fix the best position of the monochromator along the beam line.

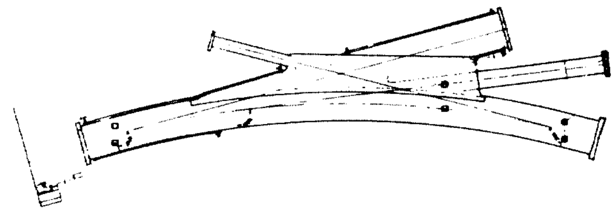

Fig. 6

On this base the geometry 1:3 for the monochromator position has been chosen because it will be possible to increase the photon flux in a small spot by at least two orders of magnitude.

Such a monochromator is being constructed by the Italian firm Contek,Varallo Sesia (VC).

The detector as well as the sample holder system will be purchased soon.

Magnetic Measurement System Design

Two kind of magnetic measurements will be carried out to determine the magnetic field profile along the beam direction :

- Point by point magnetic field map on the horizontal symmetry plane.
- Magnetic field integral measurement along the magnet axis.

Hall probes will be used for the point by point maps, while a long rotating coil will be used to measure the field integral and its integrated multipolar components.

The entire system to make the point by point measurements is described in this report. The system is made up of three parts : 1) the Hall probe; 2) the coordinatometer; 3) the computer driving the coordinatometer and performing the data acquisition.

The Hall Probe

The chosen Hall probe is a transverse Hall generator built by Lake Shore Cryotronics, model LHGT-321. It allows accurate field measurements up to ± 15 Tesla.

The current source for the Hall probe is the externally programmable Lake Shore Cryotronics model 120.

The Hall generator has been metal clad and put in an aluminium heatsink, heated by resistors. The temperature is controlled by means of a sensor and is maintained at a prefixed value between 40° and 60°C. A thermostat reads the temperature and acts on the resistor heating current in a regulation loop.

The coordinatometer

The Hall probe coordinatometer has been built by Contek (Varallo, Italy), it consists of a carriage pneumatically suspended in a reference, 3 m long, guide box. A bronze ribbon moves the carriage carrying the Hall probe and an encoder reads the longitudinal position during the field mapping. The probe can be manually moved laterally and vertically on the carriage to measure magnetic field maps outside the system axis. Longitudinal position can be reproduced to within 20 μm. The error on the vertical and horizontal position of the Hall probe, due to the reference box deflection, is less than 3/10 mm. At this stage the carriage movement is programmable by computer as described in the next section. Fig. 7 shows a schematic picture of the whole system.

The computer and its peripherals

A HP 98581 A computer of the HP 300 series using a Motorola 68010 micro-processor and Basic 5.11 as operating system has been purchased.

At the beginning of each measuring cycle, the computer program asks for some parameters, namely the currents of the three power supplies, the starting point, the length of each step the Hall probe must be moved, the speed, the acceleration and deceleration. Other parameters are fixed by software, like the permissible current variations, the Hall temperature change, the variation of the Hall current.

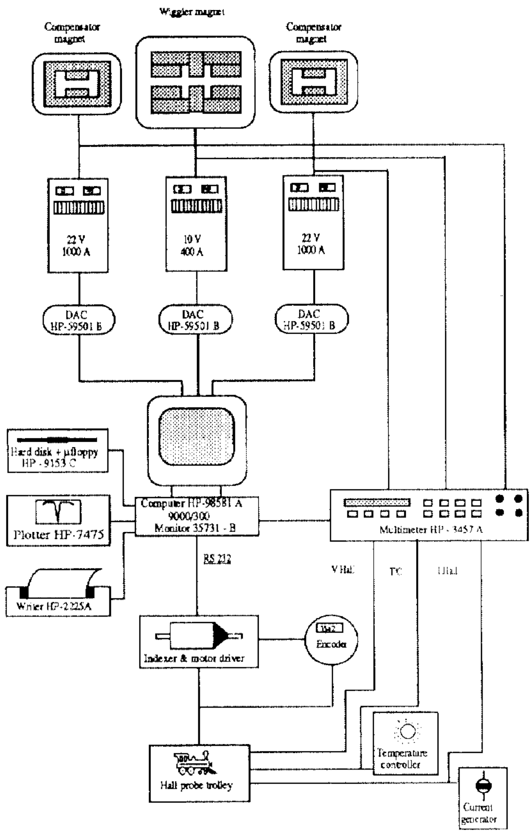

Fig. 7

There are two thresholds, the first one is an alarm with a graphical and acoustical signal, the second threshold stops the execution of the run because a parameter has exceeded the maximum acceptable variation.

The hardware configuration of the whole system is shown in fig. 8.

After the preliminary parameter set-up, the system starts the measurement through the interface RS 232 C, using a format of 7 data bits plus 2 stop bits and a parity mark and a baud rate of 9600. At this point the encoder reports the position reached and then the computer checks the three magnet currents, previously set through the HP 59501 B DAC, the temperature and the current of the Hall probe through the multimeter HP 3457 A. If everything is ready, the Hall voltage is read through the same multimeter and the data recorded are stored into a buffer. The Hall voltage is converted to Gauss to get the magnetic field value.

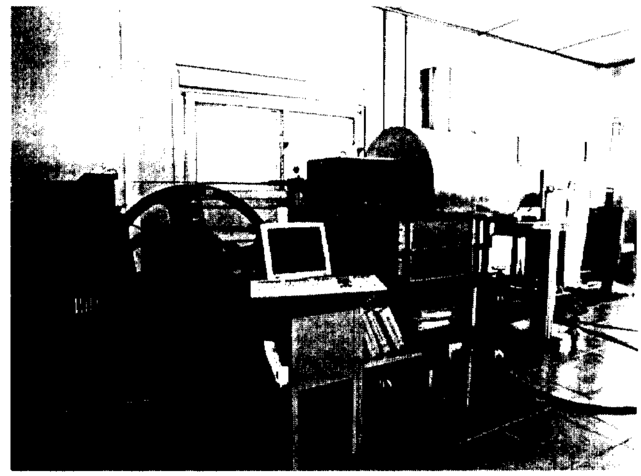

Fig. 8

At the end of the measuring cycle the Hall probe is returned automatically at the starting point and the data are stored on the Hard Disk, HP 9153 C. Another cycle can now start and/or the stored file can be analyzed. The analysis consists of printing, plotting the magnetic file values or computing the electron beam orbit parameters.

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