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CONSTRUCTION AND TEST OF A CHANNELING-RADIATION SOURCE AT THE NEW DARMSTADT SUPERCONDUCTING ELECTRON ACCELERATOR[(1)]

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Abstract: - A source to produce channeling radiation has been set up immediately behind the injector of the new superconducting electron accelerator, which has gone into operation this summer. The electron beam energy at that stage of the machine can be varied between 3 and 10 MeV and the low value for its divergence (0.041-0.015 mrad) is suited to create monoenergetic, polarized photons of high intensity in the keV-region. It is projected that an electron beam of 20 μA and 10 MeV hitting a Si crystal produces a photon intensity of 10^{10}-10^{11} photons/s into 1 mrad solid angle with a band width of $\Delta E/E=0.1$ at an energy of about 45 keV. The first crystals under investigation will be a Si (111) and a diamond (110) crystal.

1. Introduction

The call for intense photon sources of high energy has come from many fields of basic and applied research. An alternative to synchrotron sources appears to be the channeling radiation which needs much smaller machines to produce tunable radiation that is of high energy, forward peaked and polarized. In connection with the new 130 MeV superconducting electron accelerator presently under construction at Darm-

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DARMSTADT SUPERCONDUCTING ELECTRON ACCELERATOR

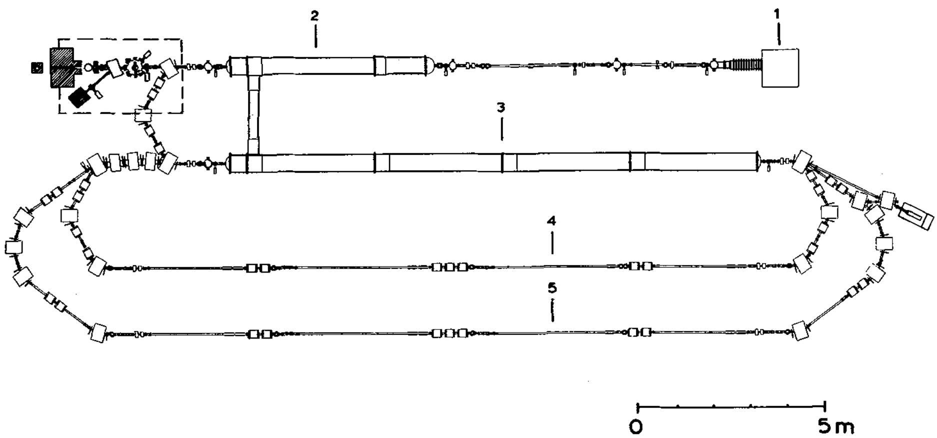

Fig.1 - Schematic layout of the 130 MeV accelerator: 1 - electron gun, 2 - super conducting injector linac, 3 - superconducting main linac, 4 - 1st recirculation for 50 MeV beam, 5 - 2nd recirculation for 90 MeV beam. The dotted area shows the channeling-radiation source set-up which is enlarged in Fig.2.

stadt we have set up the necessary gadgets to produce channeling radiation. The source will go into operation soon and its technical details are discussed in the following section. It is currently installed behind the injector (Fig.1) and will be moved behind the 130 MeV machine when an electron beam is provided.

2. Technical Data

The general layout of the 130 MeV accelerator (Fig.1) exhibits the main constituents with the electron gun, the superconducting injector and accelerator and the first and second recirculation. All parts displayed have been installed and the electron beam has already passed through the injector and reached an energy of about 6 MeV. The main features of the new superconducting accelerator will be described in detail elsewhere. A few for the channeling radiation source relevant parameters should be mentioned here already. The electron beam energy behind the injector will be variable between 3 and 10 MeV and behind the total accelerator between 10 and 130 MeV. The beam spread is designed to be ±13 keV , the divergence of the order of 0.015 mrad and the cw beam current up to 20 μA. The recirculation system consists of 22 dipole and 34 quadrupole magnets.

A schematic view of the channeling radiation source is shown in Fig.2. A goniometer to hold the crystals for the radiation production

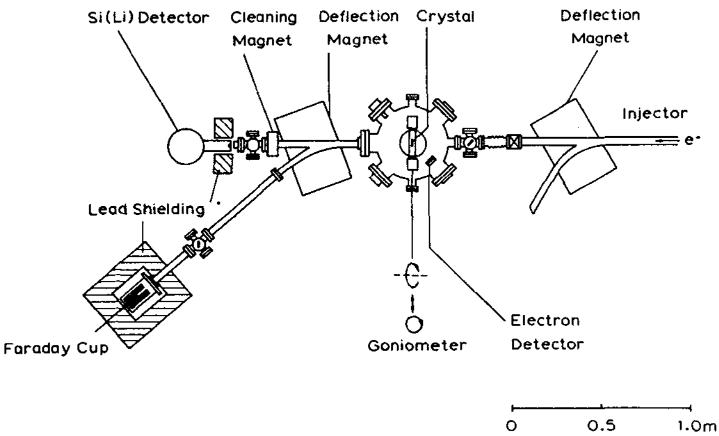

Fig.2 - Experimental set-up for the production of channeling radiation employing the 10 MeV electron beam of the superconducting injector

is housed in the center of a scattering chamber. The electron beam can pass through the crystal and is then deflected via a magnet into a Faraday cup. Before mounting the crystals on the goniometer they have to be prealigned. This is achieved by means of electron diffraction and the evaluation of the Laue spot patterns. The fine tuning will then be performed by recording channeled electrons and of course the channeling radiation, which will be detected by a Si(Li) detector placed outside the vacuum.

In order to estimate the expected spectral intensity distribution of the channeling radiation source and to enable a comparison with the according radiation at the electron accelerators at SLAC (Stanford) and BESSY (Berlin) , we have calculated this quantity [1,2] assuming for all machines the same electron beam current of 20 µA. The number of photons per s that is emitted into a horizontal angle of 1 mrad with 10% of the band width at the critical energy ε_c [SLAC 1: E_0=3 GeV, ρ=13 m,ε_c=5 keV; SLAC 2: E_0=3 GeV,ρ=1.4 m,ε_c=48 keV; BESSY I: E_0=1.5GeV ρ=3.8 m,ε_c=2 keV;BESSY II: E_0=0.75 GeV,ρ=1.8 m,ε_c=0.53 keV] is shown for the three cases in Fig.3. The curves denoted by S-DALINAC are based on the assumption that channeling radiation is created inside a Si (111) crystal by 2p - 1s and 3p - 1s transitions and electron bombarding energies up to 10 MeV (solid line) and up to 130 MeV (dashed line). From this representation it becomes apparent that a channeling radiation source in connection with a superconducting electron accelerator may become an important tool for the production of intense photon beams in the keV-region. It should be mentioned finally, that the dissipated power will be 0.2 and 0.5 W for an electron impact energy of 10 MeV and a

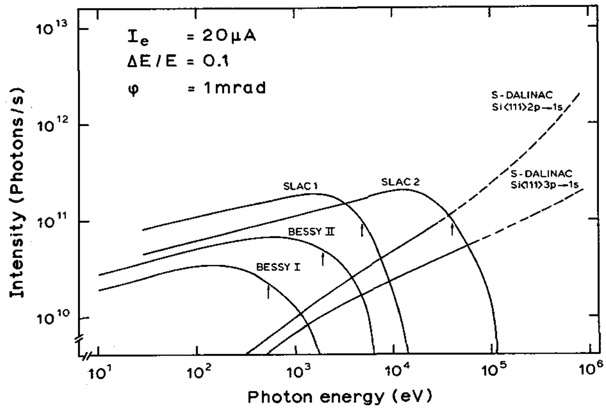

Fig.3 - Spectral intensity distribution of photon beams for equivalent experimental conditions for the machines at SLAC, BESSY and Darmstadt (solid curve for energies up to 10 MeV; dashed curve up to 130 MeV). A beam current of 20 µA is assumed and the photon intensity per s is emitted into an angle of 1 mrad at 10% of the band width at the critical energy ε_c (arrow).

current of 20 and 60 µA, respectively. Accordingly 2.0 and 5.2 W are anticipated at these currents, respectively, for 130 MeV electron energy. To obtain 60 µA at 130 MeV, however, the presently installed clystrons are not powerful enough. It is planned to modify the accelerator to supply a beam suitable for FEL experiments [3] which asks for a beam with a specific bunch lengt resulting in a peak current of 2.7 A.

For first experiments we plan to use Si and diamond crystals with a thickness of 10 µm for Si and 10 and 50 µm for the diamond. It is intended to extent former measurements, that determined the dependence of the photon energy from the electron impact energy, to higher energies [4,5]. The coefficients obtainable from such a relation enable a more reliable description of the continuum potential of the crystals.

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