NEW PROJECT OF 1.5 GEV ELECTRON LINAC AND PULSE STRETCHER.

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Abstract

A linac and pulse stretcher ring has been proposed for obtaining high duty factor, high current and high energy electron beams. A low duty factor electron beam is injected into a ring from which electrons are slowly extracted during the period between successive injections to realize the high duty factor.

The linac has quasi-constant gradient accelerating structures and generate an average current of 200 μA at 1.2 GeV. Each pulse beam from the linac is also injected into the pulse stretcher ring, a 160m circumference, with multiturn injection. The third integer resonance is used to extract electron beams of an average current of 90 μA, a duty factor $\geq$ 90% and an energy spread $\leq$ 0.1%.

The linac also supplies electron beams to the neutron diffraction experiments with a proper repetition rate and injects electrons into a storage ring, which is dedicated to generate synchrotron radiation.

Introduction

It has been widely admitted that the high duty factor, high current electron beams in the energy range over 1 GeV generate new kinds of nuclear physics experiments. Thus laboratories have begun to develop the new accelerators which meet these requirements.

The combination of a linac and a pulse stretcher has been considered to be the most promissing solution to realize high duty factor and high energy electron beams. Construction of such a linac is within well developed technologies and the pulse stretcher is also constructed by combining the existing techniques used for electron synchrotrons and storage rings. It is only needed to develop a rapid and high efficiency beam injection system. This has been solved by a small stretcher ring which was constructed in our laboratories as a test ring. No difficulty is anticipated to increase electron energies above 1.0 GeV.

General description

Fig.1 shows the general layout of accelerator and experimental halls. The experimental halls (EX1, EX2 and EX3) the linac housing and the stretcher housing are underground. At the exit of the linac, some parts of the electron beams are deflected by kicker magnets toward a neutron diffraction hall and a storage ring on the ground. Most of the beam pulses are deflected through 80 degrees toward the experimental halls for nuclear experiments.

When a continuous beam is required, a kicker magnet (K4) is excited to deflect electron beams into the stretcher ring (STR).

A high resolution electron spectrometer and a hadron spectrometer are set up in the electron scattering hall (EX1) these spectrometers are to be used for considence experiments such as (e,e'p) in addition to single arm experiments.

The linac consists of 32 accelerator wave quides. Each of them is connected to one of 32 klystrons. Electron beams are accelerated after being bunched at 2856 MHz by a prebuncher and a buncher. Since rf-cavity in STR operates at 476 MHz, the beam can be bunched at 476 MHz by a subharmonic buncher before the prebuncher. Parameters of the linac is listid in Table 1.

The pulse stretcher ring is about 160m in circumference and electrons are injected by three turn injection. Since the vertical emittance of the beam extracted from the ring is essentially the same as one of the stored beam, the use of betatron oscilation in the vertical direction is not desirable. Therefore multiturn injection uses only horizontal oscillations. Electrons rotating in the ring lose their energy, through synchrotron radiation so that we use an rf accelerating system to keep electrons in the ring in the energy range above 0.9 GeV. The maximum energy acceptance of the ring is limitted to 3%. Extraction is based on the third integer resonance. For energy lower than 0.9 GeV, monochromatic extraction is used. The electrons fallen into the extraction energy are forced to make the extraction resonance by the energy loss due to synchrotron radiation coupled to a non-zero chromatic factor of the ring. For energy above 0.9 GeV, an chromatic extraction method is employed in which a ramped sextupole system is used to reduce the stable area of the phase space. Table 2 shows the stretcher ring parameters.

The extracted electron beams are supplied to the experimental hall. In the electron scattering hall, two large magnetic spectrometers are installed as mentioned previously. Their parameters are listed in Table 3.

Table 1. Parameters of Electron Linac

Maximum rating	
energy	1.5 GeV
peak current	1 A
pulse width	3.0 μsec
pulse repetition rate	600 pps
Typical operation	
energy	1.2 GeV
peak current	200 mA
pulse repetition rate	300 pps
pulse width	3.0 μsec
average current	180 μA
energy spread	2 %
	0.2 % (ECS)
Accelerating wave guide	
no. of wave guides	32
rf input power	26 MW
(klystron output)	30 MW
rf frequency	2856 MHz
effective length	4.6 m
no. of cavities	131
filling time	0.57 - 0.73 μsec
attenuation constant	0.37 - 0.50 neper

Table 2. Parameters of Pulse Stretcher

Circumference	161.2 m
No. of bending magnets	16
Bending radius	8 m
Super periode	4
tune (horizontal)	7.3
(vertical)	7.2
Injection	
three turn injection	
injected beam	
peak current	200 mA
pulse width	1.5,0.7 μsec
repetion rate	300,600 pps
Extraction	
third integer (22/3) resonance	
extracted beam	
duty factor	≥ 90%
average current	90 μA
energy spread	≤ 0.1%
emittance (horizontal)	0.8 πmm·mr
(vertical)	≤ 0.3 πmm·mr
RF acceleration ($E_e \geq 0.9$ GeV)	
rf frequency	476 MHz

Table 3. Magnetic Spectrometers

	electron-spectrometer	proton-spectrometer
	QQDMD	QDD
maximum momentum	1.0GeV/c	0.7GeV/c
bending radius	2.2m	1.5m
maximum field	1.5T	1.5T
deflecting angle	120°	90°
focal plane angle	60°	53°
focal plane length	3.4m	1.6m
momentum acceptance	10%	40%
momentum resolution	$7 \cdot 10^{-5}$	$2 \cdot 10^{-4}$
solid angle	11msr	48msr
rotating angle	20°- 160°	20°- 160°
magnet weight	350ton	150ton
total weight	630ton	325ton

STR pulse stretcher
SOR storage ring
EX experimental halls
ND neutron diffraction hall
ECS energy compressing system
K kicker magnets

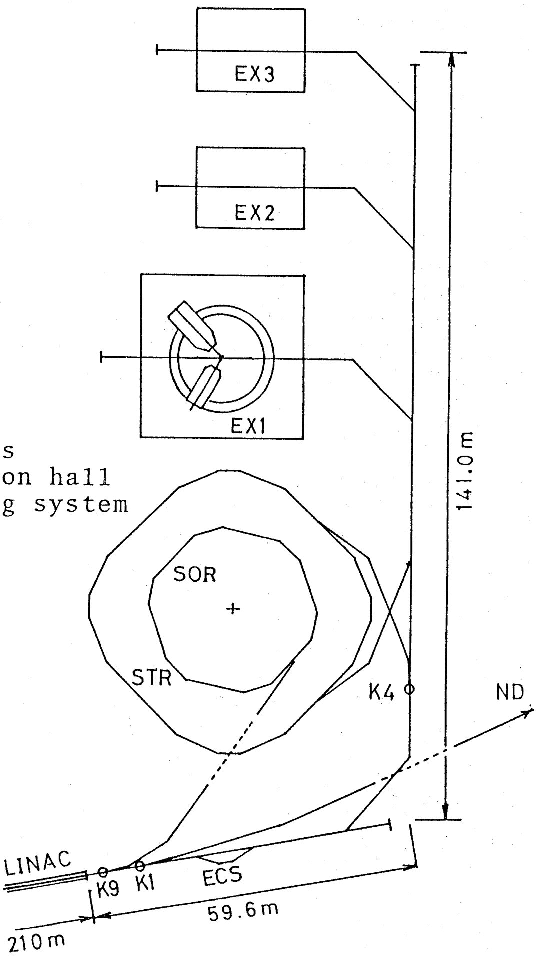

Fig. 1. Layout of the new accelerator