A NEW ELECTRON LINAC FOR THE SACLAY STRETCHER RING PROJECT

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Abstract

The ALS-II project is an electron accelerator designed for a maximum energy of 1.7 GeV and nearly 100 % duty cycle. It consists in a low duty factor linac injecting a pulse stretcher ring. The existing linac (0.6 GeV, 1 % duty cycle) has to be transformed in keeping the same accelerating sections. It will use 23 new klystrons (25 MW, 25 KW, efficiency ≈ 60%) now under development by Thomson-CSF. In addition the beam will be bunched at 600 MHz ($f_0/5$), to match the RF frequency of the ring. A subharmonic prebunching system, including a 600 MHz chopper is described.

Introduction

The project of a CW electron machine using room temperature technique as described in [1], has been abandonned in early 1986 in favour of a superconducting linac for which studies are just starting. However we think useful to report on the way our present electron linac had to be transformed to become an injector for a 1.7 GeV stretcher ring.

General description

The injection of the beam into a 300 m circumference ring will take place over two turns. Therefore the pulse length has to be $\tau = 2$ µs. The repetition rate of the linac is limited by the maximum average RF power in the sections to f = 350 c/s. To produce an average current of 100 µA, the peak current has then to be I ≃ 140 mA. The main characteristics of the linac are summarized in table 1.

Table 1

Main characteristics of the linac	
Maximum energy	1.7 GeV
Energy at 100 µA	1.3 GeV
Nb of sections	23
Peak power per section	25 MW
Pulse length	2 µs
Repetition rate	350 c/s
Max. peak current	140 mA
Bunching frequency	600 MHz

A new klystron is under development by Thomson-CSF. It will deliver a peak power of 25 MW and an average power of 25 KW in one section of the linac. It will use a low perveance beam and is expected to have an efficiency of the order of 60 %.

To achieve a high efficiency at injection into the ring, the RF frequency of the cavity is a subharmonic of the RF frequency of the linac and the beam has to be bunched at that frequency. An odd subharmonic (600 MHz i-e. 1/5th the linac frequency) has been chosen since none of its harmonics falls in the pass band of the deflecting modes in the sections which includes 4500 MHz (3/2 the linac frequency). To avoid beam losses in the ring, satellites bunches have to be eliminated, leading to the use of a 600 MHz chopper at the linac injector. The system of prebunching and bunching has been computed taking into account space charge forces due to an equivalent peak current of 5 x 140 = 700 mA.

Description of the injector

Prebunching system.

Computer studies have been performed using a model in which the beam is decomposed into rigid disks surrounded by a conducting beam pipe. The formulation of space charge forces is the same as the one used in [2]. This study resulted in a system composed of two prebunching cavities : one at 600 MHz followed by a drift of 75 cm, the second at 3000 MHz followed by a drift of 10 cm for a gun high voltage of 150 KV. The peak voltage in the cavities are respectively 22 KV and 10 KV. (fig. 1).

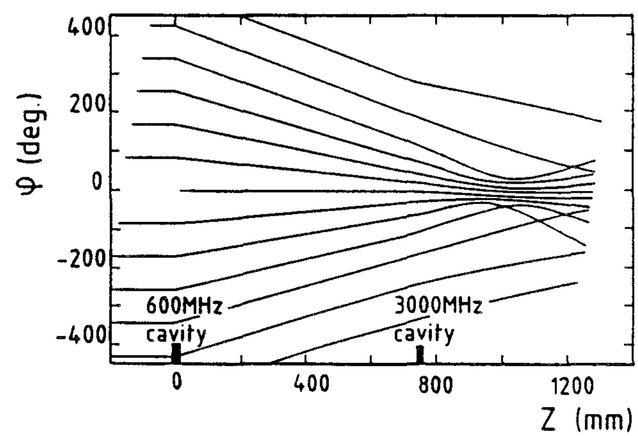

Fig. 1. Prebunching system : evolution of the disks phases.

An aluminium model has been built to study the characteristics of the 600 MHz prebunching cavity. It is a $\lambda/4$ coaxial cavity. We have determined the optimum dimensions and the shunt impedance of this cavity which are summarized in table 2.

Table 2

Characteristics of the 600 MHz prebunching cavity			
Inner diameter			48 mm
Outer			120 mm
Length	L	=	115.8 mm
Gap length	g	=	17.5 mm
Shunt impedance	$\frac{R}{Q}$	=	130 Ω
Frequency sensitivity :	df/dL	=	4 MHz/mm
	df/dg	=	10 MHz/mm

The computer code URMEL [3] has been used to compute this cavity and gave quite a good agreement with the measured characteristics. (fig. 2).

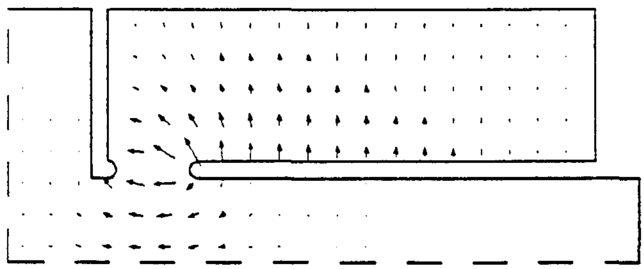

Fig. 2. URMEL plot of the 600 MHz prebunching cavity.

600 MHz chopping system.

In order to suppress all possible satellite bunches the chopping system has to deliver maximum 120° bunches of the subharmonic frequency. An RF chopping system (RF cavity plus collimator) has been designed. The choice of the cavity resulted from a study of different possible modes [4]. The TM_{110} mode of a rectangular cavity was chosen because of advantages like a high deflection coefficient $H/\sqrt{P}$ and a low Q. The dimensions are : 29.4 x 47.3 x 6 (in cm).(fig.3).

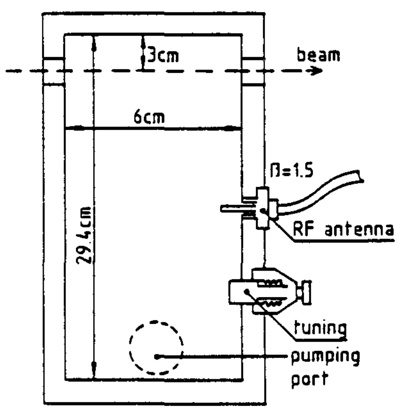

Fig. 3. Section of the 600 MHz deflecting cavity.

The theoretical Q_0 for a cavity made of aluminium is 13200 and the power needed is about 100 Watts. A prototype has been built to measure the RF characteristics. The loaded Q is about 4000.

The distance between the cavity and the chopping aperture is 50 cm. A magnetic lens is installed in between to focus the beam on the collimator. Figure 4 shows the result of a computer simulation of the system for an incoming beam of 50 keV, with an emittance of 30 π mm.mrd, and an RF power of 100 W in the cavity. Two beam envelopes are represented, one for zero deflection and one for maximum deflection. An aperture of 10 mm result in a chopping angle of 120°. For an initial beam emittance of 30 π mm.mrd we determined that the transmitted beam will have an emittance of 65 π mm.mrd. Estimation taking space charge into account shows that distances remain valid up to a current of 400 mA at 50 keV. The final cavity has to be built also in aluminium in using a rectangular "Helicoflex" [ref. 5] aluminium gasket for vacuum tightness.

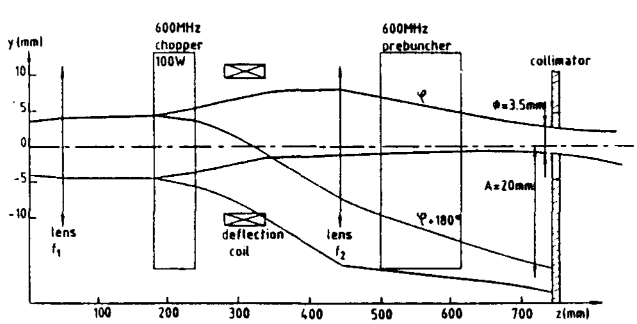

Fig. 4. Lay-out of the chopping prebunching system.

600 MHz modulated electron gun

An alternative way of chopping the beam consist in modulating the gun grid with a 600 MHz signal superimposed to the necessary grid bias. A low cathode-grid transconductance is required. Such a solution has been already reported in [6]. R.F. KOONTZ (from SLAC) proposed us a gun he has built, comprising a coaxial, λ/4 RF cavity suited for 600 MHz grid control. His design is suitable for 150 KV anode voltage and several amperes output current. It is clear that, if it can demonstrate an equivalent chopping capability, the use of such a gun would result in a much more simple and compact system than the use of the deflecting cavity.

References

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