FIRST RESULTS OF THE DAΦNE INJECTION SYSTEM COMMISSIONING

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Abstract

The injection system of DAΦNE, the Φ-Factory under construction at LNF in Frascati, consists of an S-band 800 MeV electron, 550 MeV positron Linac, an intermediate 510 MeV Accumulator and about 140 m long Transfer Lines. The whole system is designed to work at the operating energy of the double storage ring collider, in order to refill the rings frequently in a "topping up" mode. Construction and assembly of the Linac and Accumulator have been completed in fall 1995 and winter 1996 respectively. Results of commissioning and measurements of beam parameters are described.

1 INTRODUCTION

DAΦNE [1] is provided with a full energy injector [2]. Electron and positron beams are generated and accelerated up to the nominal energy of 510 MeV along the Linac and then stored and phase space damped in the Accumulator ring before the injection into the Main Rings. The injection rate is 50 Hz in the Accumulator and 1 Hz in the Main Rings. Phase adjustments between the rings RF's jointly with a proper timing will allow to fill each of the Main Rings 120 buckets. Positron and electron production and injection are not simultaneous and the design time to fill all of the Main Rings buckets is ~ 2 min for positrons and ~ 1 min for electrons. The overall injection time should be ≤ 10 min, including the time necessary for switching between positron and electron modes. The Main Rings beam life time is ~ 3 hours but considerations concerning integrated luminosity optimization, suggest to adopt a 'topping-up' scheme by injecting every hour approximately.

The Linac commissioning with electrons started at the beginning of the year and the up to date results are presented. The Accumulator electron injection has just started and the encouraging first results are described. Positron beam tests are scheduled for the next future.

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2 INJECTION SUB-SYSTEMS

2.1 Linac

The Linac, the first part of the injection chain, was assigned to the American company TITAN BETA on the base of a 'turn key' contract [3]. It is a ~ 60 m long linac able to deliver (50 pps) 800 MeV electron beam and 550 MeV positron beam with a FWHM bunch length of 10 ns. The positron conversion energy is 250 MeV.

Figure 1. DAΦNE-Linac low energy part view.

The RF scheme includes 4 S-band (2856 MHz) 45 MW klystrons each one equipped with a pulse compression device (SLED). The accelerating structure is composed by 15 SLAC type sections 3 m long, while the injector has a 120 keV thermoionic gun followed by a harmonic prebuncher and a five cells buncher. A pulsed solenoidal lens (SLAC flux concentrator) and ~ 7 m of 0.5 T DC solenoids compose the positron capture system. A positron separator downstream the positron converter allows to stop the secondary electron beam.

A portion of the Linac is shown in figure 1.

2.2 Accumulator

The Accumulator ring design has been based on the Orsay ring ACO [4,5]. The high values of the energy and emittance acceptances, ± 1.5% and 10 mm mrad @ 510 MeV respectively, allowed to relax the requirements on the Linac beams. Moreover the low values of the energy spread and emittance of the extracted beams, ± 0.1 % and 0.25 mm mrad @ 510 MeV respectively, permit the injection into the 'tight' buckets of the Main Rings.

Figure 2. Accumulator view.

The Accumulator length, 32.56 m and the RF, 73.65 MHz, are respectively 1/3 and 1/5 of the Main Rings ones, the RF harmonic number is 8.

The linear lattice periodicity is 4 and each period has 2 sextupoles for chromaticity correction. In the straight sections are placed the RF cavity [6] and the injection and extraction kickers [7] and septa [8]. The diagnostics scheme [9] distributed along the ring includes also 2 synchrotron radiation monitors.

Figure 2 shows a 'fish-eye' view of the Accumulator.

2.3 Transfer Lines

Linac, Accumulator and Main Rings are connected to each other by ~ 140 m of transfer lines [10].

Due to the requirement of using the pre-existing civil structures, the transfer lines have a fairly complex geometry that includes a section where the beams passes through, either during the Accumulator injection or in the extraction.

Downstream the Linac are placed the diagnostics for measuring the physical quantities of the out coming beam [11,12]. A Beam Test Facility, that can operate in parasitic mode with the Main Rings injection, is also present [13].

3 EXPERIMENTAL RESULTS

The Linac operation with the electron beam started on January 96. Since then the shifts have been shared between electron beam commissioning and the completion of the Linac control system integration. The latter is now completed and the electron commissioning is going ahead in parallel with the Accumulator electron injection first operation.

3.1 Linac Electron Beam Commissioning

Electron gun

It is a 150 keV (max) Pierce geometry triode gun with a 3 cm^2 dispenser cathode able to 8 A (max) output. Typical operation values are 6 A 120 keV in the positron mode and 0.5 A 120 keV in the electron one. Figure 3 shows an example of the gun pulse.

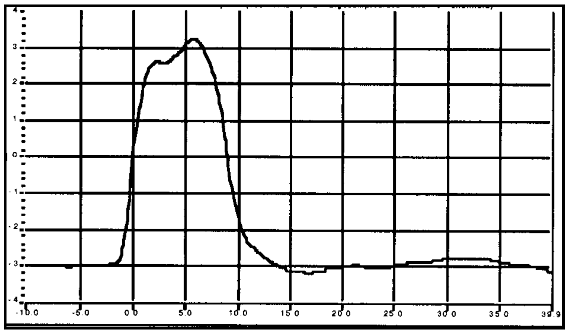

Figure 3. Typical Gun Pulse. The horizontal scale unit is 5 ns/div and the current peak value is 3.8 A. The monitor used is of the resistive wall type.

Current, energy and spot size at positron converter (PC).

With the design values for these quantities, 4 A, 250 MeV and 1 mm (sigma), the expected positron conversion efficiency is 0.9%. Concerning current, simulations showed that 7.3 A at the electron gun are required to obtain the design value. So far we did not operate in the positron mode, anyway during a preliminary test, 3 A at PC have been achieved with 7 A at gun. Finally it is worth to say that during the factory tests performed on May 1994 at TITAN BETA 4 A at PC have been reached with 6.2 A at gun.

Because of the RF structure geometry, the system spectrometer, placed downstream the Linac, cannot be used for measuring the beam energy at the PC position. Anyway an estimate has been done by using a steering coil and a flag placed just before the PC. The measured value was (200±20) MeV. This value is lower than the design one because one of the two klystrons that deliver the RF power to four of the five accelerating sections upstream the PC, saturates at a low power level (35 MW instead of 45 MW). In the factory tests, mentioned above, a value of (240±20) MeV was measured.

The spot size design value, 1 mm (σ), has been achieved either during the factory or in the actual test.

Current and energy at Linac end.

During the injection into the Accumulator, the Linac is running in the following configuration: 20 ÷ 300 mA electron bunches with energy (510±5) MeV at 1 pps.

Figure 4 shows an example of beam transverse spot size at the Linac end. The monitor used is a chrome-doped allumina flag viewed by a CCD camera connected to an image analyzer.

From the electron beam commissioning point of view we are doing a number of measurements necessary to characterize and optimize the Linac. Between these, it is worth to mention the one concerning the accelerating sections electrical field, a value of 17.8 MV/m has been measured against the design value of 18 MV/m.

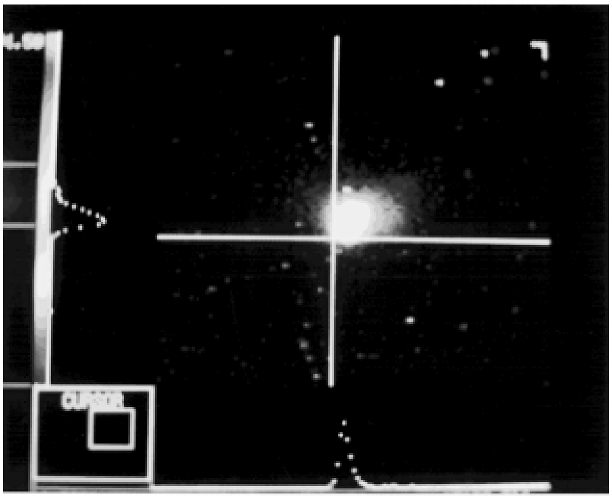

Figure 4. Electron beam spot at Linac end. The energy is 510 MeV and the sigma is ~ 1.5 mm.

3.2 Accumulator Electron Beam Injection

Transfer line set up.

The Linac is connected to the Accumulator by ~ 45 m of transfer line, which include 4 horizontal and 2 vertical bending magnets, two septa, 18 quadrupoles and 8 corrector magnets. A distributed scheme of diagnostics, including 7 strip lines, 3 beam charge monitors and 6 fluorescent screens, allowed us to transport the electron beam to the Accumulator in few hours.

Accumulator injection.

Four strip lines beam position monitors, one in each of the Accumulator periods, permit to follow the beam during the first turns. Simulations showed that with the nominal tunes and without firing the injection kickers, the beam must complete ~ 2.5 turns before hitting the vacuum chamber. The beam first turn was achieved in one shift and during the second shift the 2.5 turns were reached. In the following two shifts the kickers were tuned up and after minor adjustments to correct a small vertical orbit the beam was successfully circulated for more than 300 turns. The beam circulating in the Accumulator is presented in figure 5, where the electrode signals sum of one of the strip lines is shown. Several passages are clearly visible and the distance in frequency between two contiguous peaks is ~ 9.2 MHz which correspond to the Accumulator revolution frequency.

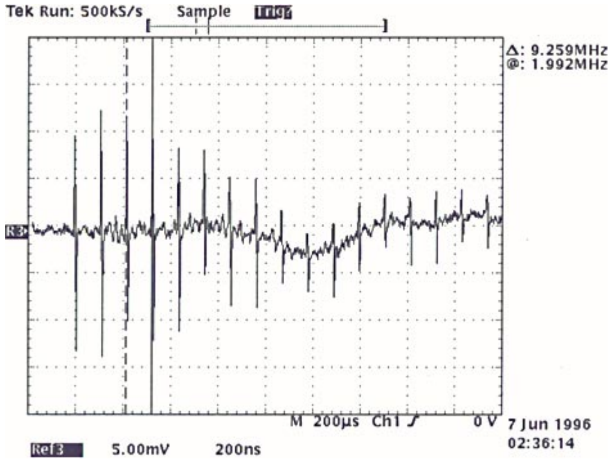

Figure 5. Circulating beam seen through one of the Accumulator strip lines.

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