DAΦNE Accumulator Kickers

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Abstract

The injection and extraction system for the DAΦNE accumulator and main rings is under study. Single-turn single-bunch injection has been adopted.

In the accumulator four symmetric kickers are used to inject and extract both electrons and positrons without changing field polarity.

A kicker prototype has been tested: design and realization of the magnet, HV pulser, control circuit, and measurements are presented.

1. INTRODUCTION

The injection scheme for the DAΦNE Frascati Φ-factory is fully described in [1,2].

In this report we present the injection and extraction kicker magnet prototypes and the pulsed power supply realized and tested for the DAΦNE accumulator.

The single-turn single-bunch injection scheme has been chosen for the accumulator and the idea to extract positrons from the electron injection channel and vice-versa has been adopted.

The maximum repetition rate from the LINAC to the booster is the inverse of the accumulator damping time (50 Hz); in the e^+ operation 45 shots are injected and accumulated in a single bunch; after 5 damping times the beam is extracted and sent to the main ring.

In the accumulator injection scheme four fast kickers are used with the same polarity for both electrons and positrons; three of them are fired for extraction: the required field values are shown in Table I.

Table I
Kicker magnetic fields

Integrated magnetic field (Gauss*m)	K1	K2	K3	K4
Positron injection	12	92	12	92
Electron injection	92	12	92	12
Positron extraction	110	107	68	0
Electron extraction	107	110	0	68

As shown in Fig. 1 the kickers are symmetrically inserted in two straight sections at ~3π/2 phase distance from the injection and extraction septa.

The accumulator injection and extraction timing system, synchronized with the Linac gun trigger and with the the DAΦNE accelerating RF, allows injection into any of the 120 RF buckets of each main ring.
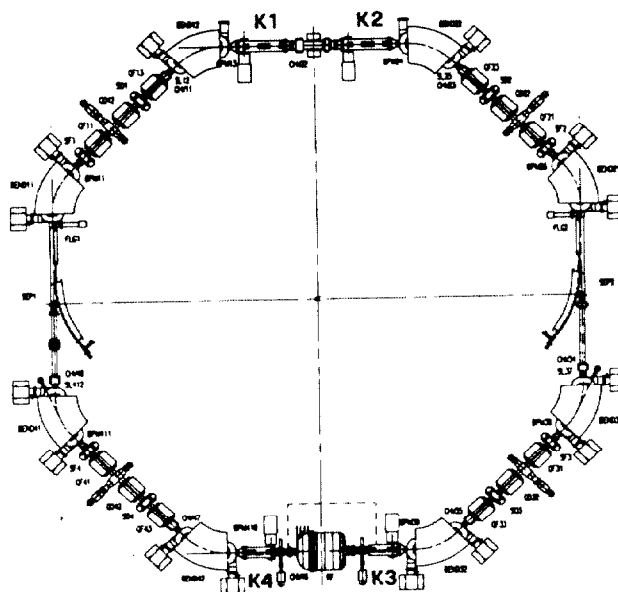

Figure 1. Accumulator Layout.

2. DESIGN CRITERIA

The nominal field in the kicker magnets at the injection energy of 510 MeV is shown in Table I.

The pulse length must be shorter than two revolution periods (218 nsec) to avoid particle losses from the injected beam on the septum wall.

The kicker design, described in the following, is derived from the experience gained in ADONE, where a similar device is running successfully since 1988 [3].

The kicker is realized with four rods inside the vacuum chamber, as shown in Fig. 2. The distance between the rods is dictated by aperture requirements. The vertical distance is determined by the injected beam emittance, while the horizontal one comes from field requirements.

The vacuum chamber inner diameter around the kicker coils must be the largest possible in order to minimize the reduction of the effective field due to the image currents in the surrounding wall. The proposed inner diameter, compatible with the current-voltage characteristic of our pulsed power supply, is ~200 mm: in this case the field reduction is less than 20%.

The kicker coils are paralleled to halve the self-inductance presented to the power pulser and hence the maximum voltage.

The transition from atmosphere to the accelerator vacuum is accomplished by means of two diametrically opposite ceramic feed-throughs: these are modified low profile insulators in order to minimize the parasitic inductance; a thoroidal current monitor is used to measure the current in the kicker coils.
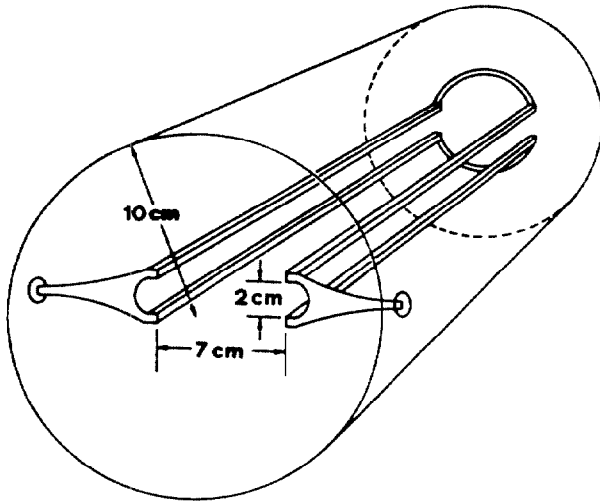

Figure 2. Kicker Magnet Artistic View.

In order to reduce the high voltage of the pulsers two different lengths are designed for the kicker: K1 and K2, which must deliver a higher magnetic field at extraction, are 75 cm long while K3 and K4 are 50 cm long. The measured inductance of the two kicker types is: 740 nH for K1 and K2, 610 nH for K3 and K4.

The connections from the large circular kicker vacuum chamber to the bending magnet one are tapered in order to reduce the longitudinal impedance to the beam.

3. POWER PULSER

The pulser scheme is shown in Fig. 3. Each kicker is powered by a thyratron switch pulser resonantly discharging a capacitor into the coils inductance.

The resulting waveform is almost half-sinusoidal as shown in Fig. 4.

As mentioned before, the pulse length must not exceed ~220 nsec. Then we use an EEV CX1154D thyratron with a 120 KA/μsec current rise rate and a 6 nF capacitor (Murata).
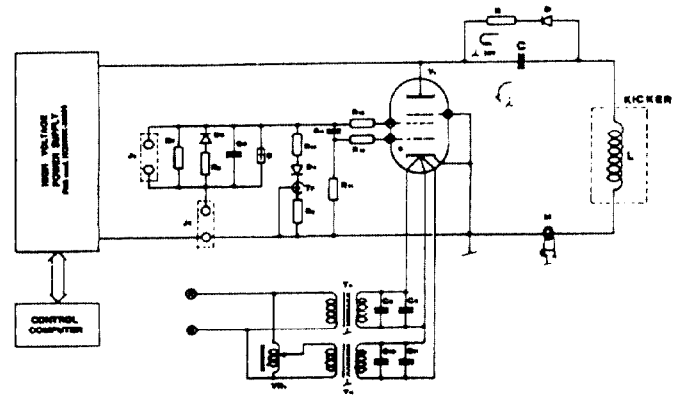

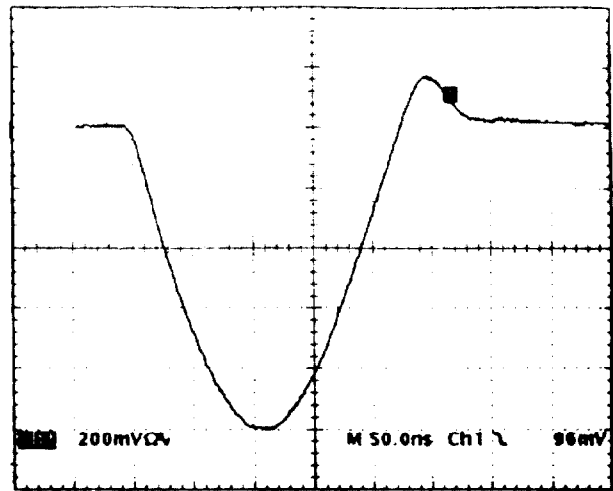Figure 3. Kicker Power Pulser Circuit.

Figure 4. Current Pulse Shape.

A series of fast solid-state diodes and resistances is paralleled connected to the capacitor to prevent high inverse voltage at the thyratron when this is switched off and to avoid the inverse current in the kicker coils.

It is necessary to continuously control the trigger delay to correct temperature-induced effects in the thyratron pulsers.

The pulser is located very close to each kicker section in order to reduce the wiring parasitic impedance. The current pulses are monitored and the power supplies are computer controlled from the control room.

The kicker prototype measurements show that the maximum power supply voltage needed should not exceed 35 KV.

4. MAGNETIC MEASUREMENTS

The magnetic field in the kicker prototypes is detected by a copper coil ($100*1.6$ mm^2) aligned on the mechanical axis of the coils and the induced voltage is measured at an oscilloscope after time integration by means of a passive circuit.

The measured field/current characteristic is 80.7 G/KA: we need therefore a maximum current of ~2700 A from the pulser (the coils are paralleled).

Fig. 5 shows the dependence of the vertical field normalized to its central values as a function of the distance from the axis: the measurement is performed by moving the probe coil in the transverse plane.

Figure 6 shows a tridimensional plot of the magnetic field as a function of both horizontal and vertical coordinates.
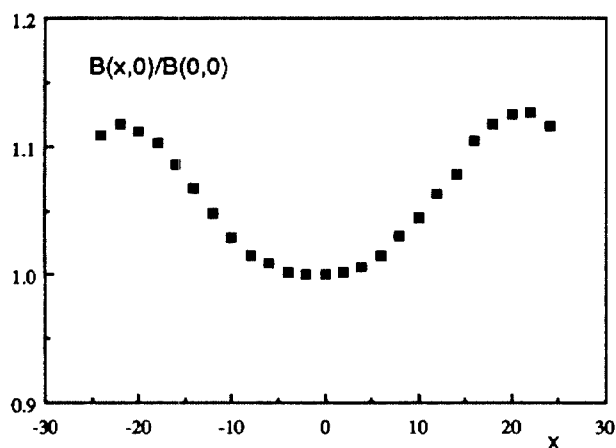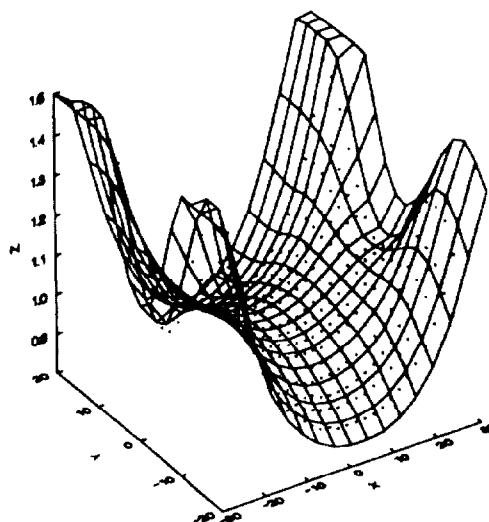

Figure 6. Tridimensional Plot of the Measured Magnetic Field.

5. ACKNOWLEDGMENTS

We would like to thank all members of the Mechanical and Electronic groups of the Accelerator Division for the work of construction of the kicker and power pulser prototypes, C. Milardi, M.A. Preger and M. Serio for the useful discussions, and P. Possanza for editing and fine-typing the manuscript.

Figure 5. Measured Ratio of the Centre Value Versus the Distance x from the Axis.

6. REFERENCES

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[2]   M. Masullo, C. Milardi and M.A. Preger: "DAΦNE Accumulator Update-3", DAFNE Technical Note I-8, Frascati, Rome, Italy, March 1992.

[3]   A.Aragona et al., "New Injection System for ADONE", EPAC1990 Proceedings, Nice, France, June 1990.