Design, Construction and Installation of the Elettra Injection System

M.Giannini, D.Corso, F.Daclon, R.Fabris, G. Loda, G.Pangon, N. Pangos, D.Tommasini
Sincrotrone Trieste, Padriciano 99, 34012 Trieste, Italy

Abstract

The design, construction and installation of the Elettra injection system is presented. Two pulsed septum magnets and four fast kickers are used to inject the 1.5-2.0 GeV electron beam into the storage ring. The septum magnets are housed in a common vacuum vessel, which provides the same UHV environment as the storage ring vacuum chamber, whereas the kickers operate in air with an internal ceramic vacuum chamber.

1 INTRODUCTION

The ELETTRA electron storage ring is filled from a full energy linac at the energy of 1.5 GeV. A possible upgrade of the linac up to 2 GeV asked for the injection system to be designed and built for this energy level.

Injection takes place in the horizontal plane, in a single straight section about 6 meters long (figure 1). Two septum magnets are used to deflect the electron beam coming from the transfer line into a direction which is parallel to that of the stored beam. The kickers allow the stored electron beam to be displaced close to the septum magnets during injection.

The design of the complete injection section layout and the detailed design of all the individual components has been carried out using a 3D CAD system (Euclid 3.1) which helped to fit all the components in the limited space available.

A photograph of the injection straight section before the installation of the pulsed power supplies is shown in figure 2. The pulsers have then been installed close to the individual magnets.

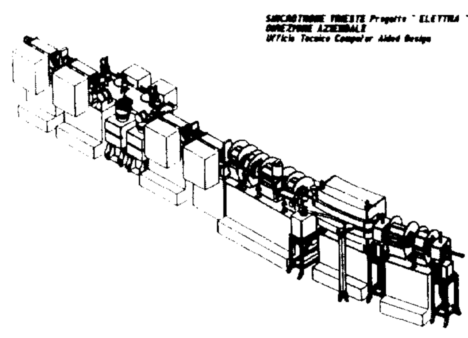

Figure 1. Layout of the ELETTRA storage ring injection.

Each couple of kickers has been placed on a single supporting plate. Due to the limited space available at each end of the injection section, the vacuum valves have been placed between two adjacent kickers.

2. SEPTUM MAGNETS

The two independent septum magnets are housed in a common vacuum tank which allows a radial displacement of the individual magnet.

The two magnets are identical, the conceptual design and the relevant tests made on prototypes have been described and discussed elsewere [1]. The mechanical design has been performed according to UHV criteria to guarantee the low outgassing of the laminations.

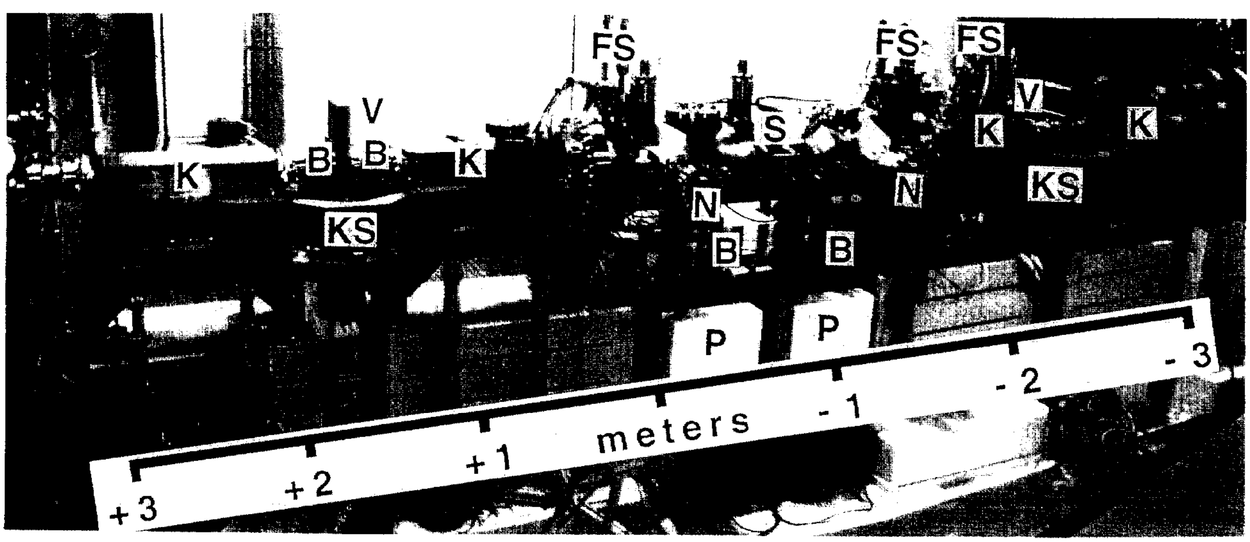

Figure 2. The ELETTRA injection section before the installation of the pulsed power supplies:

K	kicker magnet	**S**	septum magnets vacuum tank
V	vacuum valve	**P**	900 l/s ionic vacuum pump
B	bellow	**F S**	fluorescent screen
KS	kicker magnets support	**N**	NEG feedthrough

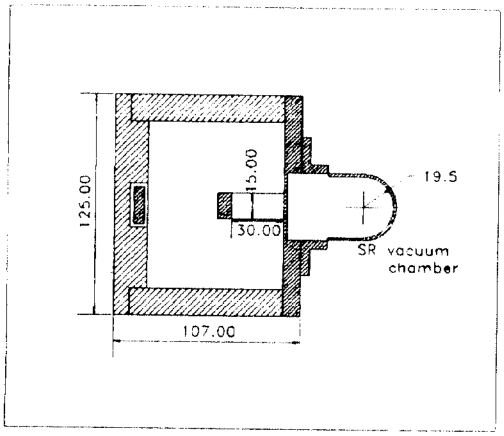

Figure 3. Septum magnet cross section.

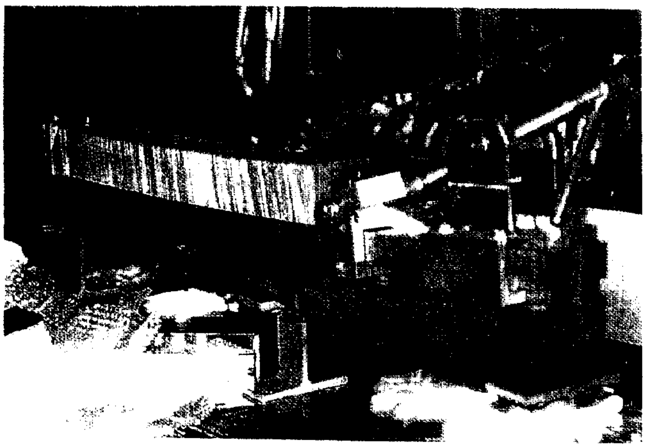

Figure 4. Stacking the septum magnet laminations.

The construction has been carried out completely in house in a cleaned area.

The magnet supporting plates have been washed in an ultrasonic bath with an alcalin detergent at the temperature of 60°C, then they have been rinsed under warm water (50°C) and finally under demineralized water. After being dryed with hot air, all the components have been packed in dry nitrogen.

The laminations have been washed in a ultrasonic bath with freon, then dryed in clean roomand packed in dry nitrogen.

The specific degassing rate has been measured on a short prototype according to PNEUROP specifications, obtaining:

$$q=6\cdot10^{-13}\text{mbar}\cdot\text{l/sec}\cdot\text{cm2}$$

The following assembling procedure was adopted:

- US cleaning of all the components and assembling tool.
- Assembly in clean room, with a grinded tool.
- 300 °C bake out in a vacuum oven for 40 hours at the pressure of 10^{-7} mbar obtained with a turbomolecular oil free pump.
- Dry N_2 protection in an envelope.

The 0.18 mm thick silicon-iron grain oriented laminations (figure 3) have been pressed with a force of 20 kg/cm^2 (figure 4) by means of a curved mandrin following the final shape of the magnet (curvature radius 12000 mm, total length of the laminated stack 720 mm), then enclosed in a stainless steel housing without the use of welded joints.

The back of the stainless steel housing was mounted with the back conductor already placed between the laminations and the steel plate.

The coil inside the septum channel has been placed afterwards. They are made up of three conductors which have been welded to the back conductor.

A copper plate, tapered along the injection section to a minimum thickness of 2.1 mm, acts as a shield for the stored beam against the pulsed magnetic field produced by the septa.

After the individual assembly (figure 5), the two magnets have been aligned on a stainless steel frame, then the copper shielding plates and the copper storage ring vacuum chamber have been placed in their final positions (figure 6). The frame also contains the slides for guiding the radial magnet mouvements from the external of the vacuum tank.

This mouvement is independent for each magnet to allow the optimization of their radial position.

The cooling of the magnets has been obtained by connectiong the copper screen and a cooled copper flange on the vacuum vessel by copper straps with a total cross sectional area of about 2000 mm^2 per magnet.

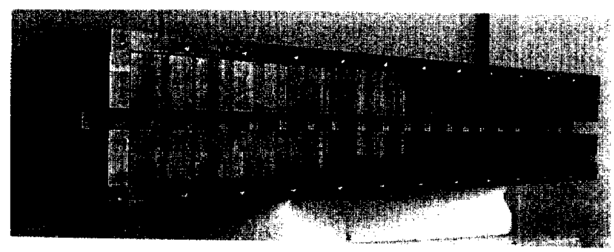

Figure 5. The septum magnet before placing the copper shield.The white spots inside the channel are ceramic isolators

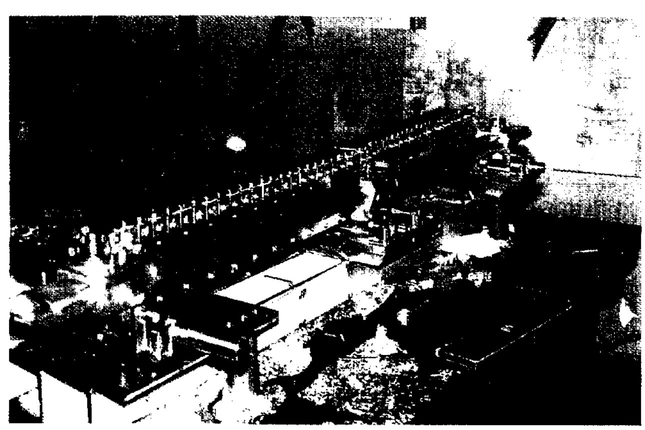

Figure 6. The septum magnets with the copper vacuum chamber on the supporting frame.

3. KICKER MAGNETS & CERAMIC CHAMBER

A description of the kicker magnets design and of the relevant tests can be found elsewhere [2,3]. The kickers are pulsed laminated magnets, which operate in air with an internal vacuum chamber. The magnets are splittable into two parts to allow the insertion of the vacuum chamber (figure 7).

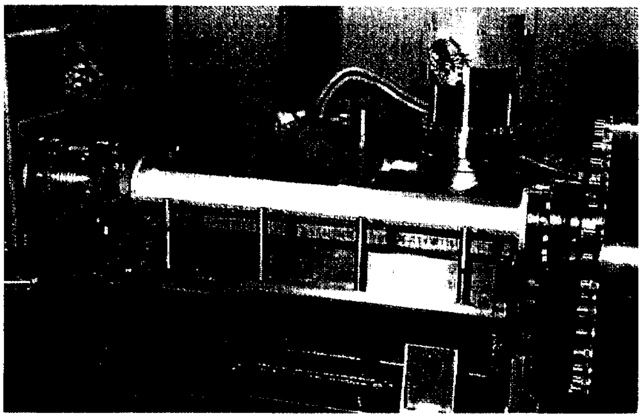

Figure 7. Installation of kicker magnet and ceramic chamber.

For the ceramic chamber a 97.5% Alumina grade was chosen to match mechanical strength and UHV properties with optimum metal-to-ceramic brazing procedures. The inside of the ceramic chamber is metallized with a 3 μm thick layer of titanium, in order to provide a conducting path for the wall currents. Copper beryllium RF contacts are used to connect the titanium layer to the stainless steel flanges (figure 8). To achieve a good and reliable contact the end parts of the tube corresponding to the contact region have been machined and coated with a 10 μm thick Nickel layer.

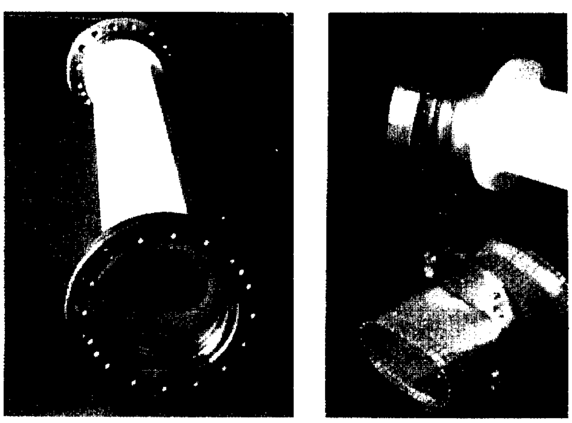

Figure 8. The ceramic vacuum chamber and the RF contacts.

The chamber is a monolithic tube 710 mm long with a minimum thickness of 3.5-5.0 mm, an internal width of 72 mm and height of 34 mm. Very tight tolerances have been imposed to the manufacturer. To achieve the highest mechanical strength the chamber was isostatically pressed. The external surface was grinded and the internal surface was as fired at the final roughness of 0.8 μm.

A covar ring was brazed directly to the ceramic with a substrate of molimanganese, then welded to a small bellows connected to the stainless steel flange. The small bellows are required to prevent the break of the ceramic during mounting, while bigger bellows have been foreseen in the injection section for linear dilatations during the bake-out.

4. VACUUM SYSTEM

The vacuum system is made by:
-one prevacuum turbomolecular oil free pump (500 l/sec).
-Two SIP 960 l/sec each.
-Two NEG modules 1000 l/sec each.
The "in situ" vacuum procedures were following:
a) Prevacuum
b) 200 °C bake out.
c) SIP activation
d) NEG activation.

Up to now the NEG have not been used as the machine is still under a commissioning phase. Anyway after the bakeout of the injection section without NEG activation the static vacuum pressure was in the range of $2 \cdot 10^{-9}$ mbar and after the completion of the bakeout on the whole machine the final static vacuum pressure was in the range of $6 \cdot 10^{-10}$mbar.

5. INSTALLATION

6.1 Septa Vacuum Vessel

All the internal components have been assembled and positioned inside the vessel with reference to external pins and to three Taylor spheres. The assembled vessel has been then installed using a three points supporting system, mounted on concrete blocks, using the Taylor spheres to align it with reference to the Transfer Line and the Storage Ring axis.

6.2 Kicker Magnets and Ceramic Chamber

The two kicker pairs have been prealigned, with a precision of 0.05 mm, on rigid girders which have been installed on a metallic supporting system, mounted on concrete blocks, and aligned using a three point regulation system. The ceramic vacuum chambers and the vacuum valves supports have been assembled on the metallic supporting system. Each vacuum component was independently positionned within 0.05 mm with reference to the septa vessel, the Taylor spheres and to the kicker magnets.

6.3 Bellows

All the vacuum components have been connected each other using hydroformed bellows with internal sliding RF-contacts to guarantee the electrical continuity of the vacuum chamber. The sliding RF-contact inside the first and the last bellow are also used to have a smooth transition from the romboidal shape of the metallic vacuum chamber to the rectangular shape of the ceramic chamber inside the kickers.

6. REFERENCES

[1] R.Fabris, A.Favari, D.Tommasini, "A high current passive septum magnet for Elettra", Proc. 1992 EPAC, Berlin 1992.

[2] D.Tommasini, "The ELETTRA fast magnets", Proc. 1992 EPAC, Berlin, March 1992.

[3] R.Fabris, D.Tommasini, P.Tosolini, "Test results of ...", Sincrotrone Trieste Internal Note ST/M-92/12, Sept. 1992.