FIRST RADIATION MONITORING RESULTS DURING ELETTRA BOOSTER COMMISSIONING

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Abstract

The new injection system for the Elettra storage ring is based on a 100 MeV linac and a booster synchrotron, where the electron energy can be raised up to 2.5 GeV.

The new machine is designed to perform full energy injection, also in top-up mode.

Outside the shielding, radiation monitoring is performed through a real-time network of gamma and neutron monitors as well as through TLD passive dosimeters. The radiation monitors placed next to the beamlines are interlocked with the machine operation and prevent injection into the storage ring if the alarm threshold is exceeded.

This paper reports the first results of the radiation monitoring performed during the new injector commissioning.

INTRODUCTION

The new injector has been designed to permit full energy injections, also in top-up mode, inside the 260 m long storage ring.

The electron beam is pre-accelerated in a 100 MeV linac (“Preinjector”), injected through a first transfer line from the preinjector to the 3.125 Hz booster (“preinjector to booster transfer line” or “PTB_TL”), accelerated inside the booster up to the target value and finally extracted towards the storage ring through a second transfer line (“booster to storage ring transfer line” or “BTS_TL”).

Outside the injector shielding, the only two areas accessible to personnel during machine operations are the “Preinjector Service Area” or “PSA” (pink coloured in Figure 1), located laterally to the preinjector tunnel and the ring Service Area or “ring SA” (yellow coloured in Figure 1), located beyond the ring internal shielding wall.

They both are classified as “supervised area”, which means that the radiation exposure risk for workers must be kept within 6 mSv/year. Personnel entering these areas must sign a register in the central control room and wear a dosimeter.

Three beamstoppers (BST_BTS1.1, BST_BTS1.2 and BST_BTS1.3) installed along the BTS_TL permit to operate the injector on local, independently from the ring working conditions. The first two (two for redundancy) consist of copper cylinders and can be used to intercept the electron beam. They are locally shielded with 15 cm polyethylene and 5 cm lead.

The third is made of tungsten and prevents the secondary radiation, produced by the interaction of the electrons with the previous beam stoppers, to channel along the vacuum chamber hole from the BTS_TL tunnel to the ring. It is interlocked with the previous beam stoppers and can be closed only if at least one of them is already closed.

Another copper beam stopper, called BST_BTS2.1, is located at the end of the BTS_TL, inside the ring tunnel and is interlocked with ring undulators, vacuum valves and flow-meters. It is locally shielded with 15 cm polyethylene and 15 cm lead.

SHIELDING WALL DESIGN

The layout of the injector and the concrete shielding wall thickness in the different parts of the accelerator is indicated in Figure 1.

The shielding wall is thicker around the estimated beam loss points (e.g. at the end of the PTB_TL and at the beginning of the BTS_TL, where the two beam stoppers BST_BTS1.1 and BST_BTS1.2 are installed).

During the injector commissioning the zone of major concern from a radiation protection point of view was the 50 cm internal shielding wall of the ring SA, which has been reinforced in the first part with a further wall (next to the injection point from the booster to the ring).

FIRST RESULTS OF RADIATION MONITORING

Taking into account the radiation protection issues, the new injector commissioning can be divided into three main phases.

The first phase started in September 2007 and was dedicated to the optimization first of the preinjector, then of the booster parameters. In this phase the booster was not connected to the storage ring yet, and was operated in local mode, while the existing 1.2 GeV linac was used to refill the ring until October 8th, 2007.

The second phase, which is now going on, started in January 2008 and was dedicated to the commissioning of the BTS_TL and of the ring. In March 3rd the 2.0 GeV users shift started as programmed, operating the booster as full energy injector. Nevertheless, from April 17th, due to a major fault on dipole power converters, it was not possible anymore to operate the booster at 2.0 GeV, but only at lower energies.

The third phase foresees to operate the new injector also in top-up mode and, for obvious reasons, has not started yet.

Radiation measurements were performed outside the accelerator shielding walls both with thermoluminescence dosimeters (GR200A TLDs for gamma radiation) and with double gamma/neutron monitors (pressurized ionization chambers + BF_3 rem counter) from the very beginning of the injector commissioning: the TLDs positions are indicated with green labels in Figure 1, the double monitors with red labels.

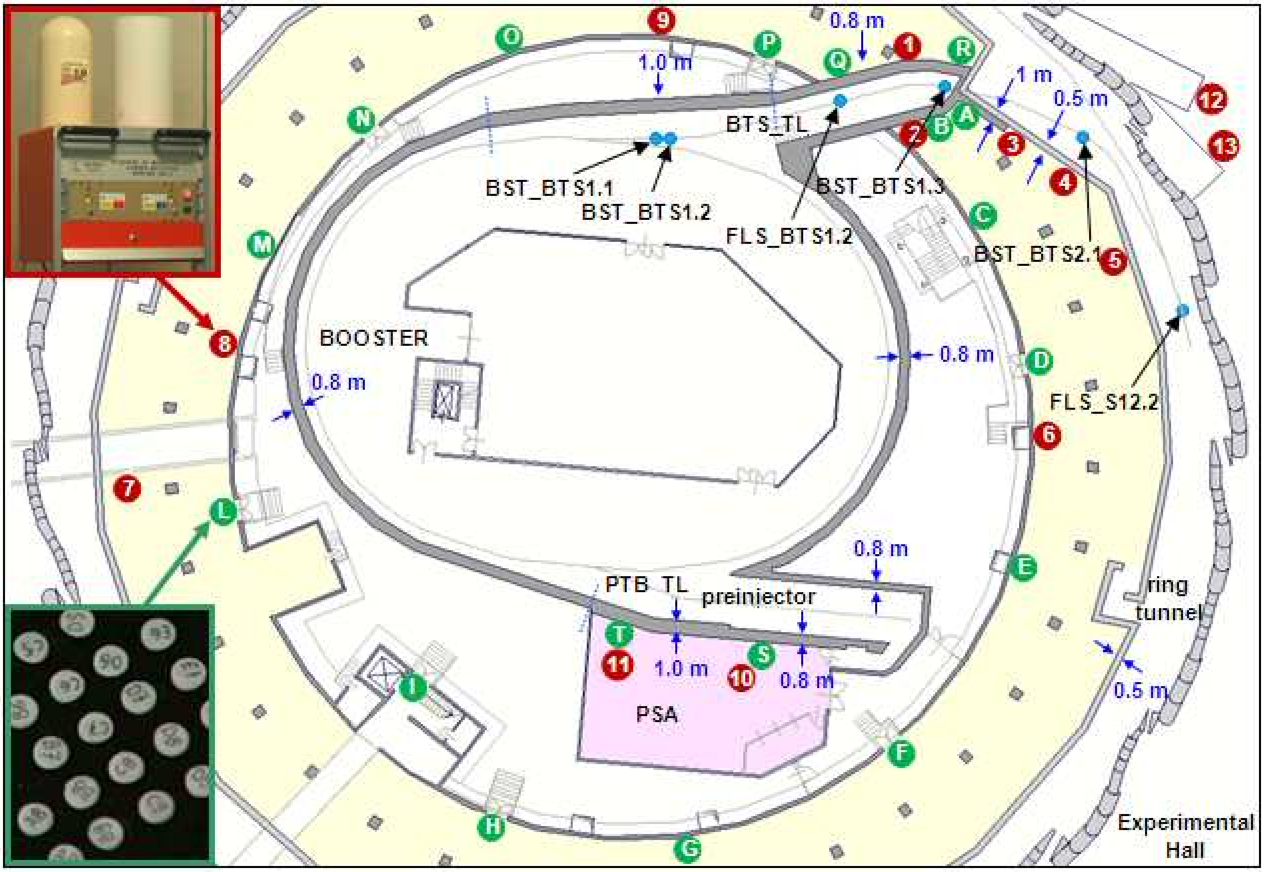

Figure 1: A plan of the new injector and the ring with the position of the TLDs (marked with “A”, “B”, etc. green labels) and of the active gamma/neutron monitors (marked with “1”, “2”, “3”, etc. red labels).

PSA and Ring SA Radiation Monitoring

The commissioning of the preinjector was carried out limiting as much as possible the permanence inside the PSA and operating the accelerator mostly from the central control room, which is an unclassified area.

The readings of the TLD labelled “S” and “T”, positioned inside the PSA on the preinjector shielding wall, are shown in Figure 2. As expected, the integrated doses were higher during the first months and decreased in the following period.

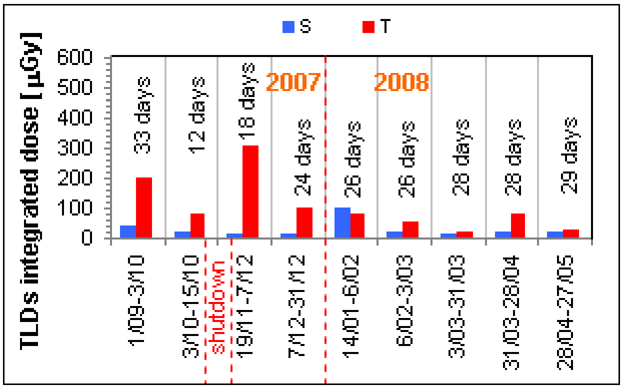

Figure 2: Integrated dose results from TLDs in PSA.

Once completed the preinjector commissioning, the booster optimization started.

Radiation dose rates in the ring SA were not of great concern as long as the beam was injected into the booster at 100 MeV. Then, in correspondence with the first tests of energy ramping inside the booster, radiation surveys were carried out with portable instruments to verify dose rate distribution in all the areas accessible to personnel.

In February 2008 the commissioning of the BTS_TL started and the access to the ring SA was precautionally forbidden.

A set of measurements was performed producing controlled 2 GeV beam losses along the BTS_TL at 1 Hz, with a booster pulse current of 2.5 mA and a bunch length of 120 ns. The losses were produced intercepting the beam with different devices installed along the BTS_TL (i.e. the fluorescent screen FLS_BTS1.2, the beam stopper BST_BTS2.1, the fluorescent screen FLS_S12.2) and measuring the radiation dose rate in the ring SA with the active monitors.

The most significant results are shown in Figure 4, compared with a regular injection beam loss distribution. For each position (“1”, “2”, etc.) the double monitor readings are reported, indicating with the letter “G” the gamma contribution and with “N” the neutron contribution.

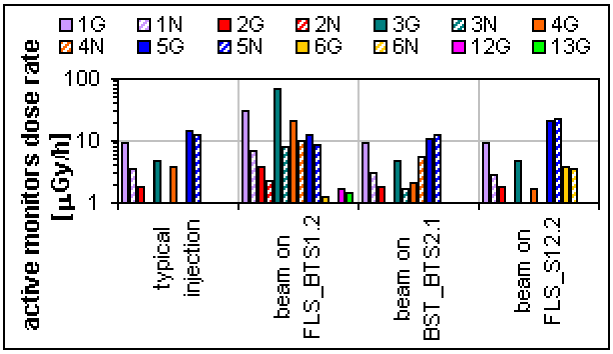

Figure 3: Active radiation monitors dose rate readings during controlled beam losses at 2.0 GeV.

TLDs dosimetry was carried out inside the ring SA during the entire commissioning. Data from September 2007 to the end of May 2008 are plotted in Figure 4 (at the bottom of the page) and show a dose increase starting from January. In February, in particular, during the BTS_TL optimization, the zone corresponding to “A”, “B” and “R” dosimeters was the most affected by radiation, as expected.

A similar trend resulted from the active monitors integrated dose readings. Figure 5 focuses on the period from February to the end of May 2008.

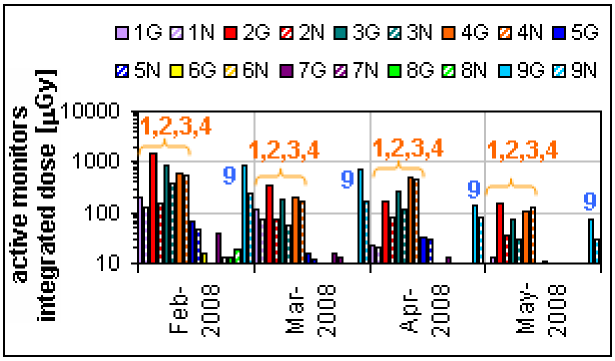

Figure 5: Active radiation monitors integrated dose.

The analysis of the data from active monitors permitted also to conclude that most of the dose was released during machine shifts and injection operations. As an example, the measurements recorded during the beam injection carried out on 7th March 2008 are plotted in Figure 6, together with the ring stored current.

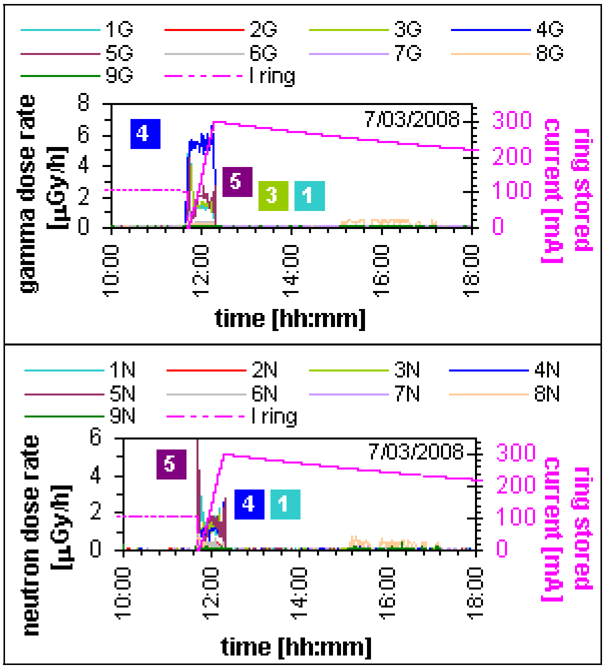

Figure 6: Gamma (above) and neutron (below) dose rate trends during the beam injection of 7th March 2008.

Experimental Hall Radiation Monitoring

Elettra Experimental Hall is not a radiation area, which means that radiation level must be kept within the limit provided by law for the public (1 mSv/year).

Mainly due to the fact that during beam injection the beamline beam stoppers are closed and locked, no significant dose rate increase was measured, exception done for a laboratory aligned with the BTS_TL where access was precautionally interdicted during machine shifts.

SUMMARY

First results of the radiation monitoring performed during the new Elettra injector commissioning have been reported and discussed.

Data are preliminary and must be integrated with further surveys in all areas around the new injector, to investigate beam losses distribution at 2.4 GeV, once the injector will be again fully operable at the end of the power converters refurbishment program.

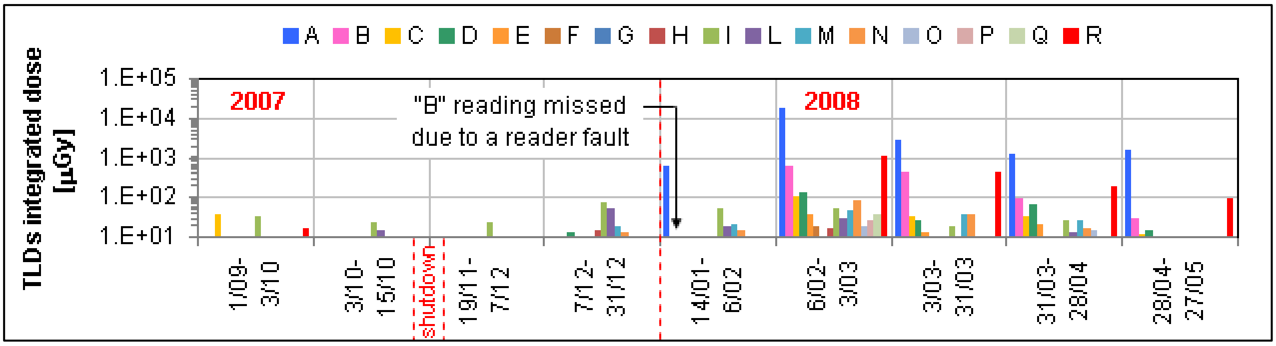

Figure 4: Integrated dose measured by the ring Service Area TLDs from September 2007 to May 2008.