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RADIATION SAFETY AT SOLARIS 1.5 GeV STORAGE RING

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Abstract

Radiation measurements at Solaris are continuously performed by using 9 radiation monitor stations (RMS) located around the storage ring and the beamlines area. 4 of RMS are connected to the Personal Safety System (PSS) and in case of exceeding alarm levels, dump the electron beam or close beamlines' safety shutters. Moreover thermoluminescence dosimeters (TLDs) are used to register doses in the classified areas according to the Polish regulations. Measurements are performed since 2015 when the commissioning of the storage ring has started. Since that time several improvements to the radiation shielding were done to fulfill the ALARA principle and keep radiation level As Low As Reasonably Achievable (ALARA). Moreover the electron beam optimizations during the injection, ramping and operation were performed to decrease the electron losses and the radiation levels. This article reports on radiation measurements results obtained before and after the chopper installation. Additionally, problems with the radiation levels while the beam current is increasing to the designed 500mA value are presented.

SOLARIS FACILITY

The Solaris facility is a typical electron accelerator complex, which consists of a 600 MeV linac and a 1.5 GeV storage ring. To achieve the full electron energy the ramping mode in the storage ring is used. The high beam losses occur mainly during the injection process at the injection area. The synchrotron zone is classified as an accelerator laboratory and it has been divided into the following areas: unclassified, supervised and controlled [1-5]. The layout of Solaris facility with radiation protection areas and the location of the RMS stations are shown in Fig. 1.

Polish Regulations

All the Solaris activities concerning radiation protection are compatible with the requirements described in formal Polish regulations. We strictly follow the Principle of ALARA, which means making every reasonable effort to maintain exposures to ionizing radiation as far below the dose limits as practical [6]. Annual limits of effective dose per entire body are shown in the Table 1. According to the law a pregnant woman cannot work in conditions, in which the unborn child may receive the effective dose higher than 1mSv.

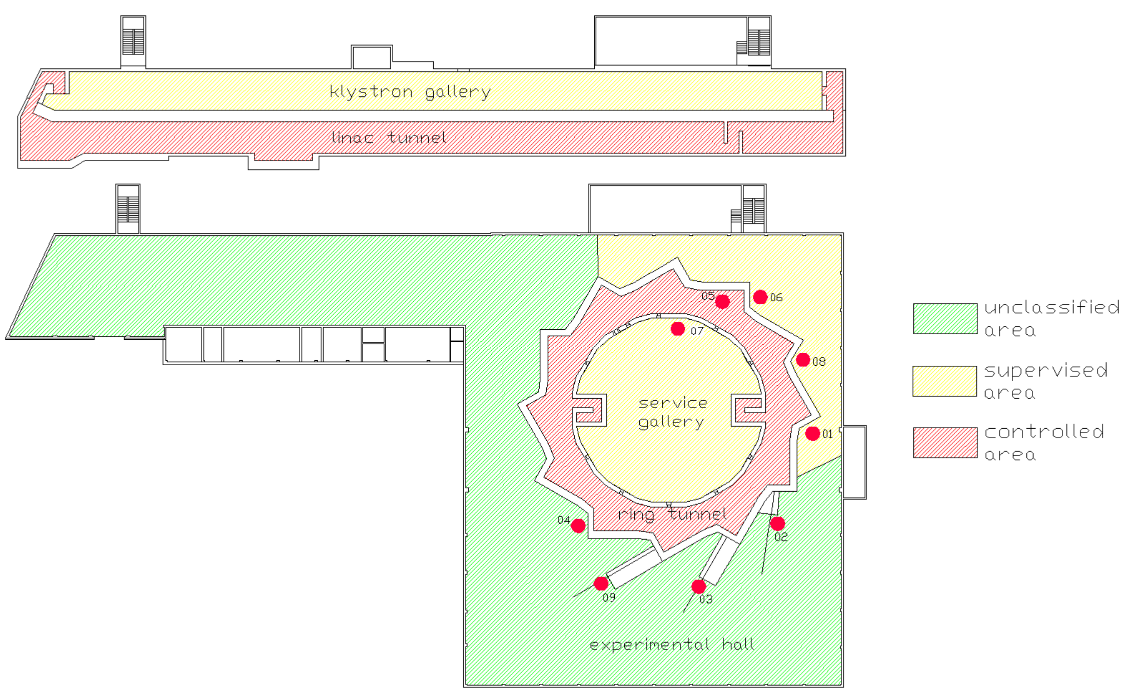

Figure 1: Layout of the Solaris facility.

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Table 1: Dose Limitations of Effective Dose (E) per Entire Body

Category	E	Who?
Radiation workers category A	20 mSv/y	No workers at Solaris
Radiation workers category B	6 mSv/y	Technical team of Solaris, Radiation Protection Officer
Public	1 mSv/y	Administrative and external workers, users, visitors

Machine Commissioning

Until December 2017 injection to the storage ring was performed without a chopper which means that the long (190 ns) train of 3 GHz bunches was injected into the 100 MHz buckets in the storage ring. This was one of the reasons for the high doses in the injection region. Additionally, the injector and storage ring optics had been optimized to increase the injection efficiency. During the commissioning some areas around the ring were fenced and closed for people (marked in yellow in Fig. 1).

How is Radiation Monitored at Solaris?

Radiation monitoring is classified into two categories:

- Personal dosimetry
- Environmental dosimetry

Thermoluminescence dosimetry (TLD) is used by the SOLARIS technical team to measure personal doses. The average annual dose for Solaris employees is about 0.66 mSv. A level of the natural radiation background is about 0.10 µSv/h. Solaris is also equipped with electronic personal dosimeters used by employees and visitors while accessing supervised areas.

The TLD dosimeters are also used for environmental measurements. They are placed in 40 points in the whole facility. Continuous measurements of accumulated doses are performed at selected points throughout the facility to assess radiation doses.

Currently, 9 RMS stations located around the storage ring tunnel have been installed. Thanks to these devices, the radiation level is monitored 24 hours a day. When any of the alarm thresholds is exceeded, acoustic and light alarms are released. Moreover, 2 RMS station located in the injection area are connected to the synchrotron PSS (marked in Fig. 1 as 05, 06) and they dump the electron beam in case of an alarm situation. The Solaris policy assumes that at each beamline there will be an RMS station connected to the beamlines PSS causing the safety shutters closure in case of exceeding radiation thresholds. In the near future another 2 RMS stations are planned to be installed in the areas of new beamlines under construction. For the cyclic measurements around the whole facility and also for the shutdown procedure the portable meters are used.

CHOPPER INSTALLATION

Before the chopper installation the radiation levels in the injection area were up to 5 µSv/h (illustrated in Fig. 2). In order to reduce losses of high-energy electrons along the injector and in the storage ring the 100 MHz chopper system right after the gun was installed and commissioned.

First measurement results after the chopper installation are shown in Fig. 3 - Signals from the RMS stations indicated doses up to 1µSv/h. Thanks to the chopper start-up, the radiation level was reduced five times. Moreover the injection efficiency was increased from 30% up to 60%.

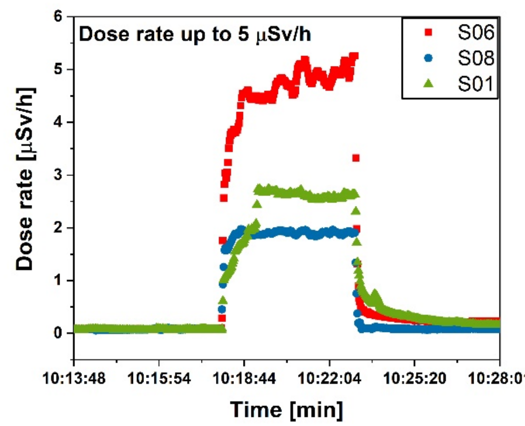

Figure 2: Radiation levels during injection before chopper start- up monitored by 3 RMS.

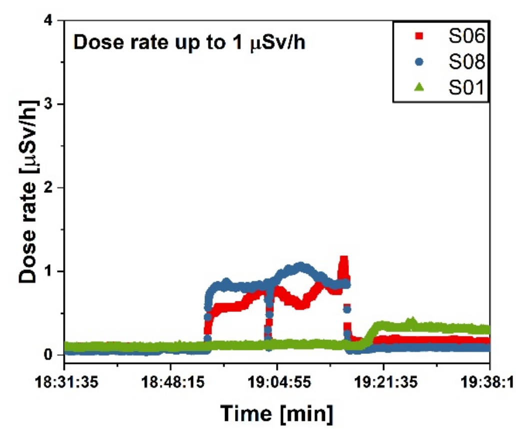

Figure 3: Dose rates during injection after chopper optimization.

Chopper Optimization

From a radiological point of view, the chopper installation was a very good option. Further optimization

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of the chopper is needed to go down with dose rates below 0.5 μSv/h.

ASSESEMENT OF RADIATION LEVELS

Initially, the results of the annual environmental doses qualified some areas as controlled areas (marked yellow in Fig. 1). In 2018, there has been a significant improvement and these places are classified as supervised areas.

As seen, starting-up the chopper decreased the radiation level significantly during the injection process. However, still the increased radiation level at the experimental hall was observed during storage ring operation with the beam current above 250 mA. For this reason, a number of measurements were made to assess dose rates. At the same time, beam optics, 3rd harmonic cavities tuning and orbit correction adjustments in the storage ring were done to obtain a stable beam.

Figure 4 shows as an example radiation measurements made with a portable meter to evaluate a radiation levels at 350 mA stored current. As seen, the increased radiation level is present at every ratchet wall at the 0 deg port (orange dots). Therefore those areas were fenced with the chains in order to separate it. Moreover the whole injection area is also separated as it is shown in Fig. 4. (a single dotted orange line). Currently Solaris is not operating with beam currents higher than 270 mA. However as the measurements indicate we need to design new shields to avoid radiological problems in presented areas. The entire experimental hall should be an unclassified area. In the near future additional lead walls in the most problematic places (around point 3 and 7 in Fig. 4) are planned to be installed.

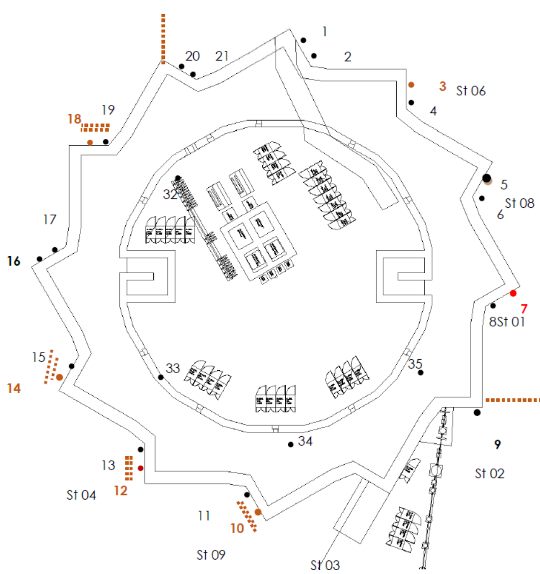

Figure 4: Assessment of radiation levels at higher currents (I=350 mA). Orange dotted lines indicates places where radiation levels are too high.

CONCLUSION

In Solaris facility the ALARA principle is strictly followed. The average dose received by employees is below 1 mSv/y. A number of training courses is provided so that employees, users and visitors are familiar with radiation safety and radiation protection. Plans for the nearest future are broad and refer to the commissioning of two new experimental beamlines, which will probably bring many topics and work in terms of radiological protection. Primarily Radiation Protection Officers daily work is just to ensure safe working conditions.

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