# Real-Time Electron Beam Doses Monitoring System for Radiation Technologies

**by**

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## Category:
R&D/Lab Automation

## Products Used:
PXI-1025 Chassis
PXI-8176 PC
PXI-5112 High Speed Digitizer
PXI-2591 Switch
LabVIEW™ 6.1

**The Challenge:** To create a reliable and flexible real-time monitoring of electron beam doses absorbed in product for radiation technologies.

**The Solution:** To implement a new method for determination of electron beam doses absorbed in irradiated product based on beam energy measurements. This was accomplished by building a PXI system with high-performance National Instruments components and using LabVIEW graphical development environment to create an application to monitor and record electron beam absorbed doses in real-time.

## Abstract
The new real-time system for radiation technologies to monitor electron beam dose absorbed in product is considered. The system uses PXI modular instrumentation, including a PC running LabVIEW, an oscilloscope, switches, and a counter. The system features two modes of operation: monitoring accumulated or current doses during irradiation process. The system can be used with all types of industrial and research electron accelerators. This system was tested on a pulsed high current electron accelerator and on an industrial CW electron accelerator “Rhodotron”. Using all PXI hardware and LabVIEW software provides industrial strength, reliability, and performance. Applications of this system are discussed.

## Introduction
Electron beam radiation technologies have numerous industrial applications in sterilization, food irradiation, curing of polymers, degradation of polytetrafluoroethylene (PTEF), destruction of toxic gases and their components at electric power stations, etc. A radiation facility consists of an electron accelerator based irradiator with a radiation safety shield, a conveyor system for delivery of products to the area of treatment and a system for monitoring of doses absorbed in product. The latter is a critical component of a radiation complex (facility). The main requirement for a radiation technology is the ability to accurately measure dose absorbed in product. The efficiency of an irradiation process has direct dependence on this parameter which makes monitoring of absorbed doses an important component of any such process.

Currently, routine film dosimetry is used as the standard method for these purposes. This method has serious physical limitations with respect to the types of electron accelerators it can be used with and the levels of absorbed doses that can be measured with it. Designing a real-time system on the basis of this

method is impossible due to its very nature, because the measurement results can not be obtained before the exposed films are developed.

STERIS Corporation has patented a method for real-time measurements of electron beam absorbed doses using physical properties of electron beam. The new Real-Time (RT) system for monitoring of electron beam absorbed doses in a production environment is based on using absorbed energy sensors along with a National Instruments PXI measurement system. It can be used for all types of electron accelerators.

## System Description

The RT dose monitoring system includes absorbed beam energy sensors positioned after irradiated product on the beam path in the area of treatment, cable lines, and measurement instrumentation electronics based on a PXI-1025 Chassis: PC, switch and oscilloscope modules (Figure 1). The system allows working with all types of electron accelerators:

1. DC Linear Accelerator
2. Pulsed RF Linear Accelerator.
3. Continuous Wave (CW) RF Accelerator.
4. Pulsed High Current Accelerator.

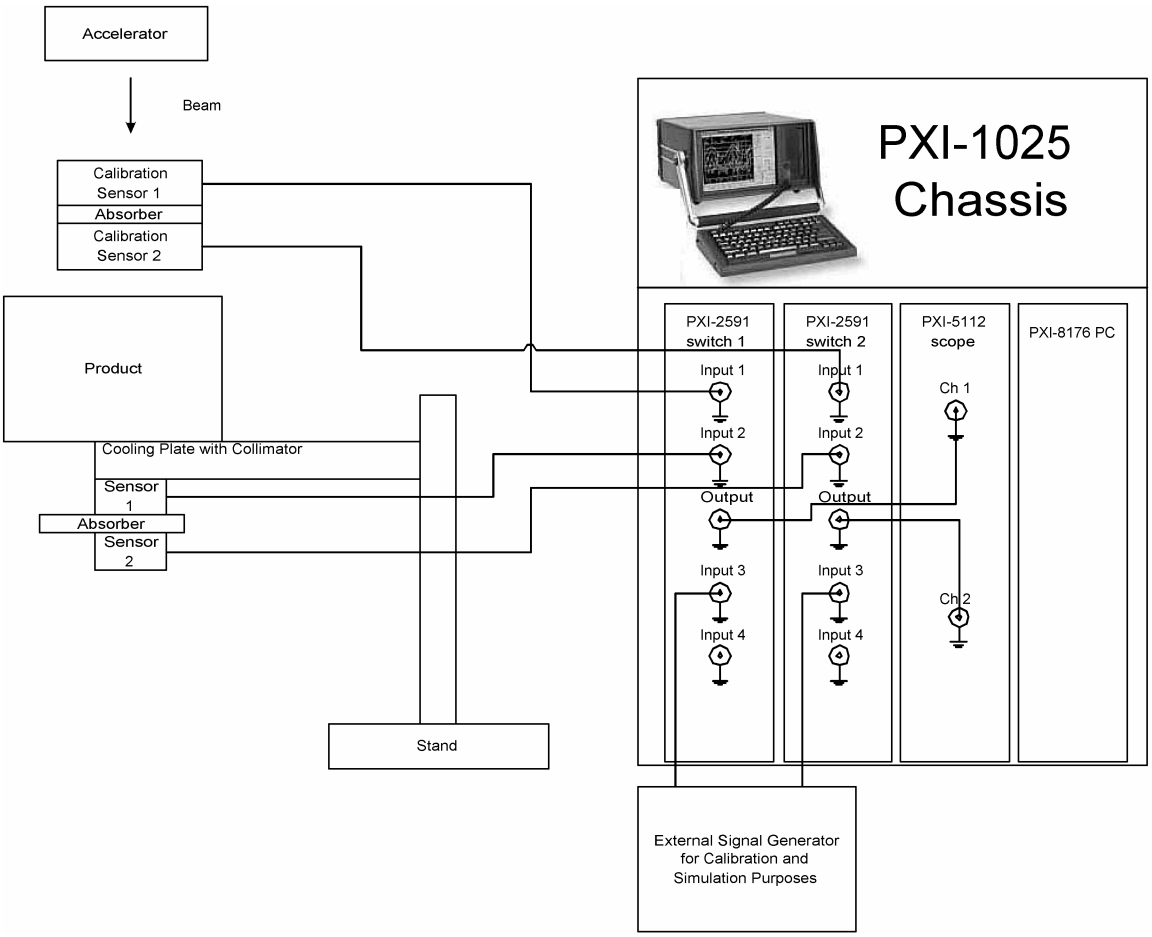


Figure 1. The block-diagram of real-time electron beam absorbed doses monitoring system.

The signals from sensors arrive to the two switch modules and are eventually registered by the oscilloscope card. The following processing of the data from the sensors is performed by a special algorithm in the developed LabVIEW application, “STERIS Doses On-line”.

Choosing LabVIEW as the development tool for the application allowed to easy implementation of a rather complex program architecture. Multithreading and synchronization tools in LabVIEW made it possible to create the software as a collection of components that have uniform structure but different purpose. Different components handle different areas of the application functionality on different levels: user interface, test logic, device server. They run simultaneously, asynchronously and independently of each other, providing services to each other and exchanging data via queued messages of a standard structure.

The operator enters the parameters of electron beam, sensors, conveyer and product on the Setup screen. The Monitoring screen is used for monitoring current beam signals from sensors and calculated absorbed doses (Figure 2). The program can perform two types of dose measurements: accumulated dose – for static irradiation, when conveyor is stopped, and current dose – for product moving on conveyor.

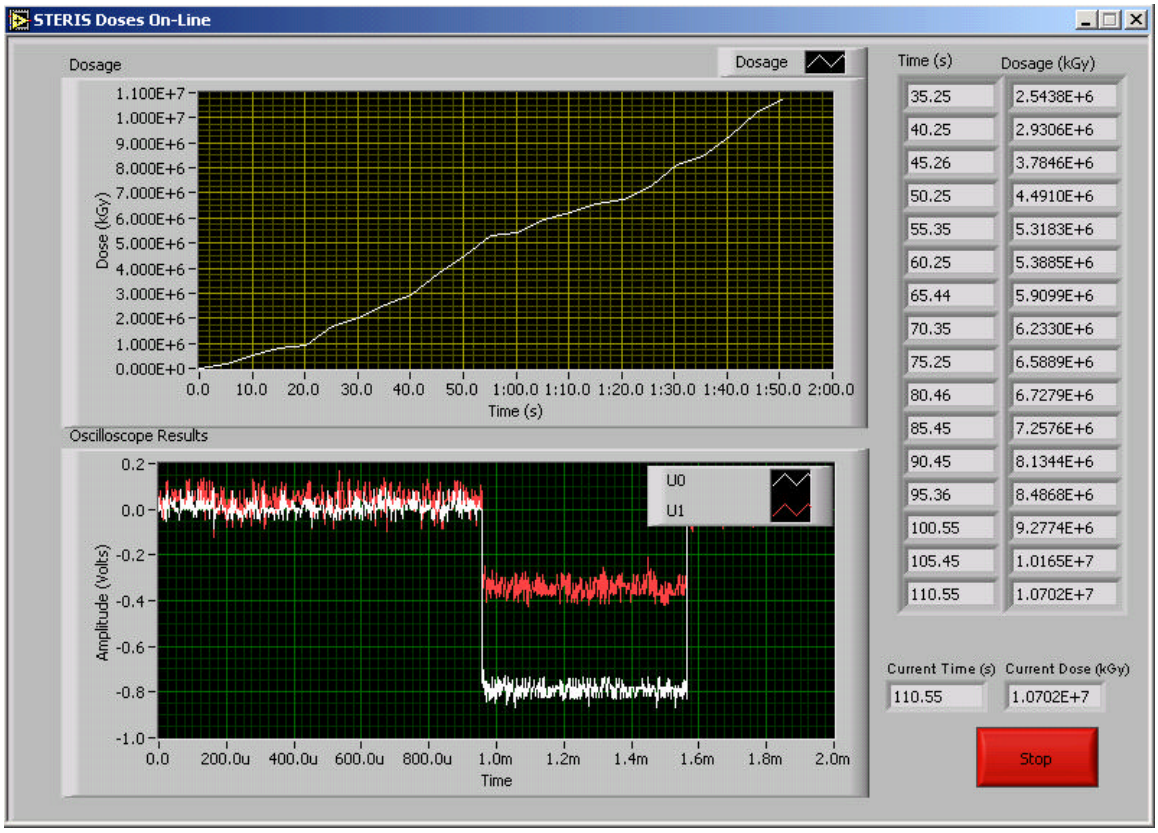


Figure 2: Monitoring Screen for Accumulated Doses Measurements.

This system has 3 modes of operations it can perform with data from sensors and electron beam parameters:

1. The Real-Time monitoring of absorbed doses.
2. Calibration of primary kinetic energy of electron beam.
3. Calibration of sensors with an external pulse generator.

In addition to logging measurement results to a file, the developed system features printing a protocol/log of the measured absorbed doses, which also includes the main information about the beam and product parameters. This simplifies for the manufacturer the government regulated process of qualification of a radiation process.

The system has been tested on the 2 types of electron accelerators:

1. CW “Rhodotron” electron accelerator with power of 80 kW and beam kinetic energy of 5 MeV.
2. Pulsed High Current Electron accelerator with beam current of 1 kA and beam kinetic energy of 200-400 keV and pulse duration of 300 nsec.

At the present time this system is used for irradiation of different products with these accelerators.

## System Benefits

The main summarized benefits are as follows:

1. A new technique for industrial radiation technologies has been developed on the basis of new physical principles.
2. It is a revolutionary method in the monitoring of absorbed doses in radiation technologies, compared to routine film dosimetry.
3. The real-time monitoring system built with National Instrument Products is more reliable, flexible and simple in the operation than the traditional methods, and, for the first time, it constitutes a finished product for industrial applications.
4. This system allows for autoimmunization of radiation process and increases the efficiency of radiation technologies.
5. The system greatly simplifies for manufacturers the government regulated qualification of radiation process for their products.

## Conclusion

The considered Real-Time Electron Beam Absorbed Doses Monitoring System for Radiation Technologies built with PXI and LabVIEW presents a new step in the progress of the radiation industry and opens a new market for National Instruments products.