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High accuracy detectors for medical applications and synchrotron radiation research

In the present report, we summarize our experience in development of high resolution position sensitive gas detectors for medicine and synchrotron radiation experiments in Budker Institute of Nuclear Physics during last years. We designed several modifications of Multistrip Ionisation Chamber with a pitch of channels from 0.4 down to 0.1 mm. Application of these detectors with high quantum efficiency (>65%) in a scanning system allowed to perform a high quality diagnostic imaging. The comparative parameters list of the detectors will be presented. The detector with 0.1 mm strip pitch and 20 atm pressure of Xe demonstrates the best possible DQE and spatial resolution for gaseous detectors in wide range of X-ray energies. Additionally the results of feasibility study of the detector for beam position monitoring for Heavy Ion Therapy System will be presented.

Summary (Additional text describing your work. Can be pasted here or give an URL to a PDF document):

In presented report, we summarize our experience in development of the detectors for medicine and synchrotron radiation experiments in Budker Institute of Nuclear Physics for last years. Since 1980th, in our institute the works on the detectors for medical applications were started. The first system (LDRD "Siberia") were designed based on Multiwire Proportional Chamber (MWPC) operating in photon counting mode. The scanning method has several intrinsic advantages over conventional two dimensional systems: huge image size in scan direction, significant rejection of radiation scattered in a patient body and simpler detector design. Initial application in the All-Union Center of Mother and Child protection (Moscow) shows that a using of technologies originally dedicated for nuclear physics lets dramatically reduces patient irradiation doses and improves diagnostics possibilities. In 1995, the installation passed the technical and clinical tests of the Ministry of Health of Russian Federation and was recommended for production and use in medicine. Industrial production of installations in Russia based on documentation developed by BINP stared since 1997. More than one hundred installation based on MWPC operated in hospitals. Early of 2000th, having experience of usage of MWPC based systems and following for increasing requirements of physicians, we introduce new detectors instead of MWPC –Multistrip Ionisation Chamber (MIC). The MIC working in charge integration mode allowed saving the same dose characteristics of the installation but it had 1.5 times better spatial resolution (0.4 mm), simpler design, more reliable and cheaper electronics. Moreover, the new detector allowed avoiding the problems of counting rate and gas aging. More than two hundred Multistrip Ionisation Chamber with 1024 registration channels were produced. In last years, based on MIC technology we designed several detectors having different parameters in dependence of application. For example, for installation intended for mass screening of healthy people we use a detector modification having 1536 independent channels with a pitch 0.26 mm, that lets to reach spatial resolution 2 lp/mm at an image plane. With unique design, the detector registers 100% of primary beam passed through patient body and significantly rejects scatter radiation. In this way, we get the lowest patient irradiation dose for chest radiography –4 ☒Sv. For comparison, the reported doses for routinely used in Europe systems - 10-32 ☒Sv (Eur Radiol (2006) 16: 333–341). For general-purpose radiography where higher resolution is required, we designed a detector with 2048 channels with a pitch of 0.2 mm. It lets to reach spatial resolution >2.5 lp/mm at an image plane. The technology of production of such detector were transferred to South Korea company and clinical studies of installations manufactured there show that scanning system provide better image quality at lower entrance dose (Korean J Radiol 10(1), February 2009, 51-57). At present moment, the first MIC detectors operate in hospitals almost 10 year and not show parameters degradation. It confirms the fact that properly made gas detector is robust one. The last modification of MIC is made for imaging at synchrotron radiation beam. This detector detomnstrates the limit of gaseous technology. It has 0.1 mm strip pitch and 20 atm of Xe pressure. Simulations show that further increase of pressure will not allow to improve the spatial resolution and DQE significantly.

Additionally, at present moment our institute develops the project of Heavy Ion Therapy System. While treatment, a tumor will irradiated by small high intensity pencil beam that will moves over target volume. Therefore, the beam position and intensity have to be controlled with high accuracy. The results of first studies of beam monitor prototype will be presented too.

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