Radiation Protection

Oral Presentations

0013

BioChroma - A new and patented technology for processing radioactive wastewater from nuclear medicine therapy facilities in hospitals and clinics.

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While undergoing nuclear medicine therapy using iodine-131 radioisotope at a hospital, patients generate wastewater with a considerable amount of radioactivity. Thus, contamination can reach levels of as much as 90% of the radioactive dose administered to the patient, depending on the type of therapy the patient underwent. Given its radioactive half-life of 8.02070 days, there is a significant risk of iodine-131 radioisotope accumulation after its discharge into the sewer network (through sanitary wastewater) and into the environment. Therefore, this effluent has to be collected in a separate system for its treatment prior to final discharge to the municipal sewer.

Delay and decay (natural decomposition of the isotope) is the most commonly used technical method of abating iodine-131, but it is frequently criticised as being complex and very expensive. While searching for alternatives to this old-fashioned technology, an alternative method called BioChroma has been developed and implemented in more than 20 hospitals in Germany and Austria.

This paper describes the technology and presents, as an example, a system that was installed and success-fully commissioned in 2008 in a nuclear medicine ward with 12 beds in Stuttgart (Germany). Based on exist-ing legislation, the responsible authorities and the company that operated the hospital agreed on a maximum activity level of 5 Bq/l at discharge point. By implementing the patented BioChroma process, the space requirements were reduced by 75% (compared with an expansion using delay and decay technology) and the nuclear medicine therapy facility was provided with a higher level of operation flexibility.

0022

Protecting Palestinian Children from Ionizing Radiation

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The biological effects of ionizing radiation are the combined result of **direct** absorption of energy at molecular level and the **indirect** oxidative damage produced by free radicals. Epidemiological studies have shown that moderate and high dose exposure to ionizing radiation leads to an increased risk of cancer (Leukemia, Thyroid, Brain), Considering the effects of radiation in the developing brain, and taking into account that the central nervous system is still under development during the first three years of life, frequent radiological examinations over short periods should be avoided early in life, particularly when other imaging techniques are available. This is especially important for computerized tomography (CT) scans, because of the potentially high exposure of the head of an infant during such procedures. We aim to reduce the use of computerized tomography (CT) by 30% in the next 3 years (2015-2018) in Palestine by applying strict referral criteria for radiological procedures, practical tools for justification of radiological procedures, special recommendations for the use of radiological procedures, communication between

pediatricians and radiologists, consider other modalities which do not use ionizing radiation (e.g. ultrasound). “One size does not fit al”. It is very important to scan only when necessary, Scan once, Reduce amount of radiation used and scan only the indicated region.

0029

DEVELOPMENT OF SOFTWARE FOR OCCUPATIONAL DOSE ASSESSMENT, ANALYSIS & REPORTING

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Software for occupational dose assessment & reporting was developed using visual basic programming language. All individual radiation dose information can be extracted from excel file and saved to a data base. Annual dose, average dose and standard deviation for each employee can be calculated, displayed and sent by e-mail. Maximum, minimum, average and standard deviation of radiation dose for each job categories in all departments can be calculated and displayed. Statistics for radiation dose distribution of all staff in each department can be calculated and displayed. The software can automatically find and send e-mails to employees exceeded certain ALARA levels. The software assists in assessment of effectiveness of radiation safety programs and impact on personal doses to staff.

0068

Physical properties of semiconductors radiation detectors by Ab initio study

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A lot of semiconductor materials are available fabrication of compound semiconductor radiation detectors such as Si and Ge. Our study, it is about Ab initio calculation of structural, electronic and optical proprieties of CdTe, CdSe, $Cd_{1-x}Mn_xTe$, $Cd_{1-x}Zn_xTe$ from group II–VI compounds of periodic table, these materials are using in radiation detectors of X-ray and ϒ-ray. We use calculation based on the density functional theory (DFT) within the generalized gradient approximation (GGA) and Local density approximation (LDA) by Abinit package. The first principal calculations study, it is an important experience for development and current progress of radiation Detection and measurements technologies. This research is an overview of different results of physical properties of some suitable materials which help researchers to realize good detectors, and in other hand to find new semiconductors materials in it.

0090

New Approach to Neutron Spectrometry with Multi-element Scintillators

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A recently developed scintillator has been investigated for possible use as a dual detector for neutron and gamma spectrometry. A ^{7}Li-enriched version of the scintillator has been investigated. The $^{35}Cl(n,p)^{35}S$ nuclear reaction provides a possibility for fast neutron detection. The sensor has been mounted on a photomultiplier tube controlled with a miniature electronics board and irradiated in different gamma and neutron radiation fields. A series of experiments has been carried out with different gamma energies as well as well with mono-energetic neutrons from a neutron generator and a KN Van de Graff accelerator. The pulse height spectra have been measured. To clarify different features observed on the response

functions of the detector, a Monte Carlo model of the scintillator has been built using MCNP6 and emitted charged particles have been tracked. The simulation data along with the experiments are analyzed, compared and reported

0093

Shielding Verification of Radiological Facilities in the newly Established King Abdullah Center for Oncology and Liver Diseases (KACO&LD)

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Six diagnostic radiology facilities are being constructed at the newly established King Abdullah Center for Oncology and Liver Diseases (KACO&LD) namely; 2 X-ray, 1 Angiography, 1 Fluoroscopy and 2 CT facilities. In October of 2015, a committee consisting of health and medical physicists along with the radiation safety officer performed a shielding verification of these facilities before the construction company initiated the finishing process. The objective of the shielding verification exercise was to confirm that the current facilities meet national and international recommendations from radiation protection point of view. NCRP Report No. 147 was used as the main guide in this shielding verification work. This study addresses four main issues; methodology applied in the shielding verification exercise, the impact of various parameters in the shielding verification process, the optimization of the measurement process and the calculations used to determine the thicknesses of the shielding barriers. This study also reports that the overall results of the performed shielding verification were found to be satisfactory from radiation protection perspective.

0100

The KFSH&RC Secondary Standard Dosimetry Laboratory Calibration and Measurements Capabilities

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The Secondary Standard Dosimetry Laboratories in ARASIA State Parties are either well established or still in the planning/implementation phase. The SSDLs of Syria and Saudi Arabia are the only members of the IAEA/WHO SSDL network. The SSDLs of Lebanon and Jordan are established but not members of the IAEA/WHO SSDL network, while the SSDLs of Iraq, Qatar, Oman, Yemen, Bahrain and the UAE are in the planning/implementation phase.

The Secondary Standard Dosimetry Laboratory (SSDL) of KFSH&RC, which joined the IAEA/WHO Network in June 1988, is the 1st and so far the only SSDL in the region having a full range of calibration capabilities covering radiation protection, diagnostic radiology and radiotherapy. Its calibration services, which extend throughout the Kingdom and the Gulf region, cover the following activities:

- calibration of ionization chambers in terms of absorbed dose to water in Co-60 gamma beams with an overall uncertainty of 1.2 % ;
- Calibration of ionization chambers used in radiotherapy in terms of air kerma in X-rays (T1 to T4 beam qualities);
- Calibration of radiation protection measuring instruments using ISO 4037 beam qualities ;
- Calibration of instruments used in diagnostic radiology (RQR2 to RQR10 beam qualities);
- Calibration of contamination meters and radioactivity measuring instruments using reference sources (Tc-99, Cl-36 and Sr-90);
- Reference irradiations in terms of air kerma, ambient and personal dose equivalent.

The SSDL best Calibration Measurement Capabilities (CMCs) are presented in this paper. The calibration and irradiation geometries as well as the established beam qualities and reference dose rates are described.

0102

Characterization of Neutron Field around a Neutron Generator

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Abstract:

Newly built neutron facility has been established at University of Ontario institute of Technology in 2012. The neutron facility consists of a (D, D) neutron generator and a high intensity gamma emitter source of 10Ci. Experiments have been carried out to measure neutron dose at different distances using bubble detector. Bubble detectors have been placed in three different distances of 20 cm, 50 cm and 110 cm away from the neutron generator. Dose has been evaluated using the known sensitivity of each bubble detector and has been found to be in the range from 104.5±0.4 to 1272.5±2.7 µSv/h. The facility description will be given and experimental data will be presented and discussed.

0106

Radiation Safety Training in Medicine

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The use of radiation in Medicine has been on the rise in many countries. A lot of diagnostic and therapeutic procedures may expose patients and staff to high radiation dose which can be reduced to low levels to ensure the safety and protection against the harmful effects of radiation exposures. The objective of this presentation is to ensure the following:

1. Implementing an effective radiation safety strategy

2. Examining the role of the hospitals in creating a radiation safety program

3. Enforcing radiation safety practice for patients, staff, physicians and visitors.

4. Providing regular radiation safety education to concerned staff

5. Identifying opportunities to improve radiation safety performance

By adhering to the principles and doctrines of radiation safety set forth by international organizations, the safety culture among radiation workers will be enhanced and the productivity as well as performance of the protocols will be optimized.

0127

PRACTICAL CONSIDERATIONS FOR EXPERIMENTAL NEUTRON DOSE ESTIMATION IN HIGH-ENERGY PHOTON FIELDS AT MEDICAL LINEAR ACCELERATORS

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Radiotherapy with photon still represents the most diffused technique to treat tumour diseases. One of the related risk extensively reported in literature is the generation of undesired fast neutron induced by photoneutron reaction, which may contaminate the therapeutic beam, and gives a non-negligible dose for a patient and personnel. It is important to accurately quantify this neutron fluence and corresponding dose equivalent, especially to healthy tissue surrounding the treatment volume, during X-ray radiotherapy. Experimental measurements of neutron doses are needed and require the use of several passive dosimeters in corresponding cavity locations inside an anthropomorphic physical phantom. These dosimeters must be previously calibrated using the adequate neutron source energy with appropriate quantities and dedicated conditions. In our previous works, many passive techniques for the evaluation of ambient neutron dose including activation detectors (P2O5), TLDs, CR-39 and bubble detectors have been investigated. Despite the detectors have been irradiated in the same location using the same conditions, the obtained results have shown some discrepancies but they remained in a similar order of magnitude with those published in literature indicating broad agreement. In this communication, a comparative study of the obtained results, taking into account advantages and inconvenient of each technique, has been performed in order to select the most promising dosimetric tool to be used for evaluating neutron organ dose out-off therapeutic beam. The calibration conditions and practical difficulties in the determination of appropriate dosimetric quantities are described and discussed and a reliable procedure to measure this neutron dose is presented.

0161

Decommessioning of radipharmaceutical production facility

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Many cyclotron facilities are installed and operated. At the end of the facility life, due to major change or need for replacement, decommissioning will be commenced, which is associated with problems and challenges. We will overview facility planning, construction and operation for smooth decommissioning, emphasizing on radiation protection and the difference between radiopharmaceuticals production facilities and other medical facilities using radiation or radioisotopes.

Posters

0028

Software for the Radiation Safety Training in Hospitals- Dvelopment and Impact

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Software for the radiation safety training in hospitals was developed. This software contains 14 modules presenting radiation safety aspects for nurses, technologists and physicians working in Radiology, Oncology, Cardiology, Surgery, Dentistry, Operating Rooms, Nuclear Medicine, Laboratory & Pathology, Endocrinology, Cyclotron, PET/CT and Endoscopy. In all modules, the radiation safety information is supported by a number of explanatory images. Each module ends with its specific test. The test is composed of random questions which cover both basic and job-related operational radiation safety information. The software overcomes the conventional class problems of temporary technologist/nurses staffing shortages resulting in a reduction of patient services or even the cessation of all routine patient services. This training software gives a better chance to evaluate the training outcomes for staff at any time. The user can print a certificate if he/she answers the test questions correctly. The software is interactive and maybe used to complement or replace the conventional training classes. The software was programmed by Health Physics in visual basic and SCORM (e-learning compatible format). The software was installed on the hospital iLearn portal to allow easy access of all KFSH&RC (Gen. Org.) staff.

Reduction of 43% in average radiation dose per staff was reached in KFSH&RC-Jeddah after 2 years of implementing the software. It is expected that patient dose significantly decreased (since staff dose is directly proportional to patient dose).

0041

ANNUAL DOSES RECEIVED BY THE WORKERS OF SOME MEDICAL PRACTICES (radiotherapy, nuclear medicine and diagnostic radiology) and comparing with occupational radiation doses of workers in non-destructive testing (NDT)

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This paper describes occupational radiation doses of workers in Industrial applications and some medical practices. The annual doses received by the workers of hospitals and NDT companies are presented in this work. The Department of personal monitoring in SAEC is facilitated with HARSHAW Reader model 6600 and assigned the rule of personal monitoring to contribute in controlling by Licensees and reducing the doses received by radiation workers. TLD cards with two TLD chips type LiF:Mg,Ti (TLD-100) were calibrated to measure the personal dose equivalent Hp(10). Around 150 medical radiation workers and 45 NDT radiation workers were monitored throughout the year. Each worker received a single TLD card worn on the chest received direct beam for medical and Industrial radiation workers and returned to laboratory for reading every two months.
The average annual doses received by the workers of radiotherapy, nuclear medicine, diagnostic radiology and NDT were evaluated. The annual doses for individual radiation workers ranged between 0.55 - 4.42 mSv, 0.48 - 1.86 mSv, 0.48 - 0.91, 8.86 - 0.47 mSv for the workers of radiotherapy, nuclear medicine and diagnostic radiology, respectively. The mean dose per worker was 1.29±1, 1.03±0.4, 0.69±0.2 and 1.57 ± 1.90 mSv, respectively. The results showed compliance with International dose limits. Our results reconfirm the importance of personal dosimetry service in assuring the radiation

protection of medical staff in developing countries. But we need more effort to manage radiation exposure aspect to reduced potential hazard in these practices.

0047

Patients Radiation dose and protection status in north kordofan state

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Diagnostic medical exposures make a large contribution to the public exposure to ionizing radiation. It was estimated that diagnostic radiology and nuclear medicine contributed 96% to the collective effective dose from man made source. The current study intended to measure the patients and ambient doses during conventional diagnostic X-ray examinations performed in four hospitals. A total of 299 patients were examined during four months. ESDs were calculated from patient exposure parameters using DosCal software. Effective doses were calculated using software from the National Radiological Protection Board (NRPB). Ambient dose was measured using survey meter (RDS-120). The mean patient ESD per procedure 0.3±0.1 mGy for the chest, 0.96±1.2 mGy for the skull, 0.85±0.2 mGy for the abdomen, 1.3±0.8 mGy for the spine and 0.43±0.2 mGy for the limbs. The mean ambient dose per department was 100µSv/h. patients doses showed wide variation between hospitals. Patient doses are higher than recommended diagnostic reference levels. The current study showed wide variation in ESAK between the four departments. This study showed that there is need optimize patient doses and departmental shielding in order reduces the dose to its minimum value. Regular quality control and staff training in radiation dose and image quality was adopted.

0056

Detection efficiency of NaI,CsI, RbI,KBr Detector in 662-1332KeV energy range

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Abstract

In the present work the simulated efficiencies were determined In part using a single-gamma emitter and radionuclide emitting. Gamma ray measurement can be used in a variety of different fields such as nuclear medicine, radiation and medical physics. In this paper the absolute and photo-peak detection efficiency and energy resolution of NaI,CsI detector were determined for 662, 835, 1173 and 1332 KeV photon energy. The measurements results are compared with the available theoretical and experimental data.

0079

Estimation of Radiation Dose Received in Knee Joint x-ray Examination

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Diagnostic X-ray examinations play an important role in the health care of the population. These examinations may involve significant irradiation of the patient and probably represent the largest manufactured source of radiation exposure for the population. This study performed to assess the effective dose (ED) received in lumbosacral radiographic examination in order to analyze effective dose distributions among radiological departments under study. The study was performed in Khartoum teaching hospital, covering two x-ray units and a sample of 50 patients. The following parameters were recorded age, weight, height, body mass index (BMI) derived from weight (kg) and (height (m)) and exposure factors. The dose was measured for knee joint x-rays examination. For effective dose calculation, the entrance surface dose (ESD) values were estimated from the x-ray tube output parameters for knee joint AP and lateral examinations. The ED values were then calculated from the obtained ESD values using IAEA calculation methods. Effective doses were then calculated from energy imparted using ED conversion factors proposed by IAEA. The results of ED values calculated showed that patient exposure were within the normal range of exposure. The mean ED values calculated were 2.49 +0.03 and 5.60 + 0.22 for knee joint AP and lateral examinations, respectively. Further studies are recommended with more number of patients and using more two modalities for comparison.

0080

Radiation Protection in Nuclear Medicine

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Abstract

In nuclear medicine, historically, radiopharmaceuticals are administered to patients either for the production of diagnostic images or with the intention to treat using the emitted radiation from the radiopharmaceutical.

The use of multimodality imaging system for molecular imaging like positron emission tomography (PET) and computed tomography (CT); has grown substantially in the last few years.

As compared with other radiologic examinations, CT delivers a relatively high radiation dose to the patient, which can be of particular concern when this is combined with the increased radiosensitivity of younger generation for carcinogenesis in life time.

Therefore, a need for new planning of radiation protection in nuclear medicine technology is required to keep the radiation dose as low as clinically practical.

In other hand the use of radionuclide therapy introduced higher activities and the radionuclides used are often different from those used in diagnostic nuclear medicine, hence it requires greater radiation protection.

In both diagnostic and therapeutic nuclear medicine, the patient becomes a source of radiation not only for him/herself but also for the staff, caregivers, and the general public.

All categories of staff members involved in nuclear medicine must have good knowledge of radiation protection. This is vital for patients' safety as well as for staffs' own security.

Objective

The aim of the project is to explore the concern of radiation dosimetry when using the multimodality systems and how health care providers and patients can protect themselves from the radiation and its harmful effects in nuclear medicine.

0095

Calibration of Radiation Instruments Used in Radiation Protection by the SSDL of KFSH&RC

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The SSDL of King Faisal Specialist Hospital and Research Center was established in 1982 and in 1988 became the only calibration laboratory in the kingdom that is a full member of the International Atomic Energy Agency/ World Health Organization SSDL network. The increased awareness of the need for accurate and reliable radiation protection instruments is the main cause for the rapid increase of the usage of radioactive materials in various industries throughout the Kingdom. The SSDL of KFSH&RC plays a vital role in fulfilling the national need for calibrating radiation protection instruments. Around one thousand instruments are routinely calibrated annually in terms of exposure or related quantities such as air kerma of ambient and personal dose equivalent. Recently the SSDL was revaluated and upgraded to further enhance its calibration capabilities. The results obtained from the re-evaluation are presented here. There were mainly three parameters in this revaluation; verification of the radiation safety, examining various physical and dosimetry parameters (timer error, verification of the source positioning, and beam profile) and the verification of the air kerma and dose rates. As part of the upgrade, a new Cs-137 irradiator was installed. The data from the commissioning of the new cs-137 irradiator is also presented in this paper. The impact of other upgraded ancillaries will also be presented. In 2014 the SSDL was subjected to an external audit by the IAEA to verify the accuracy of reference air-kerma rate. The results of the audit, which were satisfactory, are presented in this paper.

0101

The KFSH&RC Personal Monitoring Service:Calibration and validation of the TLD system

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The Personal Radiation Monitoring Service belonging to the Health Physics Section of the KFSH&RC's Biomedical Physics Department has been in continuous operation since 1990. This Service enables to evaluate the radiation doses received by more than 4500 people working with radiation due to their occupation.

The Thermoluminescent dosemeter (TLD) is the most commonly used in the kingdom with about 20.000 evaluated annually. The badge is comprised of a TLD card, which is placed in a holder that incorporates a filter system, allowing the radiation type and energy to be determined. This dosimeter is used to determine the whole body exposure of people who may be exposed to beta, gamma or X-rays. For the

reading of the TLD cards, our section is using two Harshaw 6600 TLD readers allowing an automatic evaluation of 200 cards organized in two trays with a rate of 2 cards/minute. Another Harshaw 5500 is also used as a backup system.

It is well known that the Reader should be calibrated periodically in order to evaluate the dose with better accuracy. For this purpose, the Thermoluminescent dosemeters are calibrated at the KFSHRC SSDL in terms of personal dose equivalent using a Cesium-137 gamma beam. The TLDs are irradiated on the surface of a tissue-equivalent phantom simulating the human trunk. Furthermore, The Calibration is validated by performing a blind test

The irradiation procedure at the SSDL and the calibration of TLDs and the reader are described in details in this paper.

0110

DOSE ASSESSMENT FOR NUCLEAR MEDICINE STAFF AT LAMINE DEBAGHINE UNIVERSTY HOSPITAL

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In nuclear medicine practice, the use of unsealed radioactive sources may be the cause of several radiation protection problems for staff. Extremity exposition can be high because the hands remain the closest external organ to the radioactive sources, and thus can receive high doses exceeding, in some cases, the dose limit for extremities especially when the workload is high. A pilot study has been conducted at the nuclear medicine service of Lamine Debaghine university hospital in order to assess actual dose received by the staff. In this study, several dosimeters have been used at the same times (film dosimeter, whole body photon and beta Harshaw TLD dosimeter and ring dosimeter for extremity). The ring dosimeter for extremity has been developed in our Dosimetry Laboratory. This dosimeter has been fully characterized according to the international standard specifications for extremity monitoring (ISO-12794), before its use in routine mode for extremity monitoring of nuclear medicine staff over a period of one year. In this communication, we present the main results of this study showing that, in some cases, the maximum skin dose limit is exceeded and for the same type of work, there is a wide range of exposures. The extremity recorded doses and the amount of radioactivity or the number of injected patients has been found to be correlated. Some recommendations have been made to personnel involved in the preparation or injection tasks in order to increase their awareness of risk and optimize the operating procedures and thus reduce their own exposure.

0140

Optimization of a Dual Monitor for A Class II Radiation Facility

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Abstract

As a part of the characterization of the class II radiation facility recently established at the University of Ontario Institute of Technology, a neutron/gamma monitor has been developed. The detector consists of a Lithium Iodide (LiI) scintillator to simultaneously detect moderate neutrons emitted from a (D, D) neutron generator and gamma rays from a high-intensity gamma irradiator. The detection unit uses a cylindrical shape moderator made of paraffin and a compact miniature data acquisition system for online neutron and gamma monitoring. A series of simulation has been performed to optimize the thickness of the

moderator using Monte Carlo N-Particle (MCNP) code. A set of experiments using an AmBe neutron source, G10 gamma irradiator and 60Co gamma source to test the performance the system has been carried out. This paper gives a description of the facility and the testing results of the developed detection monitor.

0151

Study of Neutron Dose Spectrum in High Energy Medical LINACs at 15MV along Maze Area

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Purpose: To evaluate the neutron equivalent dose (NED) along single/double bend maze centerline for different LINACs models at 15MV. The evaluation was based on measurements and comparison with Kersey's empirical formula.

Methods: For the assessment of NED along the single/double bend mazes, five hospitals with different accelerator machines and vault layouts were chosen to collect the data**.** These hospitals were named as Vault-A, Vault-B, Vault-C, Vault-D and Vault-E. Neutron dose rate was measured with calibrated Neutron Monitor 2222A for fully opened (40cm×40cm) and closed (0cm×0cm) collimators at 0º, 90º, 180º and 270º gantry angles along maze centreline at 1m from the floor. The measurement data were compared to semi empirical calculations (Modified Kersey Formula).

Results: When jaws are fully closed and gantry head is near to inner maze entrance, neutron equivalent dose reached its maximum value. Compared to the experimental results, the Modified Kersey method overestimated the NED by a factor of 1.35-1.82 at a point just before the outer maze entrance. In addition, double bend at outer maze entrance reduces NED up to 99% w.r.t dose at inner maze entrance.

Conclusions: Five LINAC treatment vaults were studied, this study shows that the Modified Kersey method overestimates the maze NED for Siemens Primus, Siemens Oncor Impression and Varian Clinac DHX accelerators. The modified Kersey Formula gives the closest estimation of NED along maze operating at 15 MV photon mode. A double bend maze replaces Borated Polyethylene Door with simple wooden door and economically cost effective.