Events and Highlights

Since March 2023, we conducted 3 lecture series delivered by the YPG members and a brief description of the topics is described below.

Respiratory deposition models for dosimetric purposes

Ms. Riya Dey delivered a presentation on different respiratory deposition models, mainly ICRP 66 and ICRP 130 Human Respiratory Tract Models (HRTM) that are used widely for dosimetric purposes. The presentation addressed why we need a separate dosimetric model for respiratory tract and what the major parameters (both anatomical and physiological) are that govern the deposition in respiratory region. These models assume simplified cylindrical geometry of respiratory tract segmented into different compartments. The presentation also explained the theoretical and semi-empirical formula that are used to predict the effects of breathing behaviour and airway size on the deposition of particles in discrete anatomical regions of the lungs, i.e. in the extra thoracic (ET1 and ET2), trachea, bronchial (BB), bronchiolar (bb), and alveolar-interstitial (AI) airways, of various subjects. The aerosol deposition due to combined effects of gravitational settling, inertial impaction and Brownian diffusion were discussed.

Finally, the LUDEP and KDEP codes were explained. Lung Dose Evaluation Program (LUDEP) is a commercial software implementation of the ICRP model. It allows the user to calculate doses and dose rates to regions of the respiratory tract and to other body organs from intakes of radionuclides, using ICRP 66 model of the human respiratory tract. KDEP code was developed by John Klumpp & Luiz Bertelli in 2017 and it is an open-source implementation of LUDEP. It is able to reproduce the respiratory tract deposition tables generated by LUDEP and published in ICRP Publication 66 and ICRP Publication 130. One example of KDEP code output was discussed where the variation of aerosol deposition fraction with aerosol sizes in different respiratory region was plotted for a condition when an adult male is in sitting position and breathing normally. For aerosols with an AMAD (Activity Median Aerodynamic Diameter) below approximately 0.3 µm, deposition in the respiratory tract is found to be dominated by thermodynamic mechanisms (i.e. diffusion); as a result, deposition fractions are mainly dependent on the AMTD (Activity Median Thermodynamic Diameter). For aerosols with an AMAD above approximately 0.3 µm, deposition in the respiratory tract is dominated by impaction and gravitational settling, and so deposition fractions are mainly dependent on the AMAD. The presentation also highlighted the limitations of the above semi-empirical models. The talk ended with a note on the recent research domains and future scope of respiration deposition models based on computational fluid particle dynamics (CFPD) simulations.

Application of CFD aerosol coupled tools in radiation protection

Shri. Mayank delivered a presentation on application of Computational Fluid Dynamics (CFD) and Aerosol transport coupled tools in radiation protection. The OpenFOAM and

Aerosolved Codes were explained. OpenFOAM is a free, open source CFD software package which is written in C++ language. This framework consists of enormous groups of libraries for different mathematical and numerical physical model. The discretization of flow governing equations is based on Finite Volume Method (FVM). It is supplied with pre and post processing environments. AeroSolved code utilizes the OpenFOAM library for the fluid flow simulation and in addition to it, it can perform the simulation of multispecies evolving aerosols. AeroSolved was developed to study aerosol dynamics starting from the aerosol generation through its evolution, transport and deposition. The implemented aerosol physics is applicable to a wide range of practical applications, including the development of aerosol generators, inhalation devices, deposition in different industrial pipes etc. A brief overview of the aerosol deposition models and the possible application in radiation protection were highlighted in the presentation.

Radiation environments at low earth orbit: Study of cosmic rays for radiation protection of astronauts

Shri Sandipan Dawn delivered a comprehensive presentation addressing the impact of cosmic rays on spacecraft and astronauts in low Earth orbit (LEO). The challenges posed by cosmic rays in LEO, the region situated approximately 160 to 2,000 kilometres above Earth's surface, are significant for space exploration and satellite technology. Cosmic rays in this area consist of ions ranging from protons to iron, accompanied by electrons and photons. These high-energy particles, predominantly originating from beyond our solar system, have the potential to penetrate spacecraft, causing disruptions to electronic systems and posing a risk to sensitive components. It's noteworthy that solar cosmic rays also hold significance in terms of radiation safety during extravehicular activities.

The effects of cosmic rays in LEO are diverse, encompassing single-event upsets in electronic devices and the gradual degradation of solar panels and materials over the long term. The ionizing nature of cosmic rays presents a dual threat, impacting both human health during extended space missions and the reliability of satellite operations. Consequently, spacecraft designers and engineers must employ robust shielding and mitigation strategies to protect against these energetic particles. A profound understanding of the intricacies of cosmic ray interactions in LEO is paramount to fortifying the resilience of space-based technologies and ensuring the success of future space missions.

In the context of studying cosmic ray effects in LEO, Monte Carlo simulations emerge as a highly effective methodology. The presentation also elucidated on various Monte Carlo codes and their methodologies employed for evaluating cosmic ray effects in this specific space environment. Notably, solar weather plays a crucial role, as galactic cosmic ray doses to astronauts can reach up to 1 mSv/day based on prevailing conditions. Furthermore, a single solar event has the potential to impart doses of up to 67 mSv, underscoring the importance of understanding and addressing these radiation challenges in space exploration and satellite technology.