Argonne NATIONAL LABORATORY

PHY Seminar

Physics Division Seminar

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Radiobiological Foundations of Ion Radiotherapy
Current Perspectives and Future Opportunities

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Cancer is the #2 killer in the US and is projected to overtake heart disease by 2030. More than 1.6 million new cancer cases and nearly 600,000 cancer deaths occur annually in the US. Radiotherapy is seeing increasing use in cancer treatment, largely because of improvements in dose distributions. The goal of radiotherapy is to deliver a lethal radiation dose to the tumor while sparing normal tissue. Most patients are treated with X-rays (photons) and in the US some receive proton (light ion) therapy. Following developmental work at Lawrence Berkeley National Laboratory in the 1970s and 1980s, the Japan National Institute of Radiological Sciences brought carbon ion radiotherapy (CIRT; heavy charged particles) to clinical practice in 1994. Today there are 9 CIRT facilities in operation including five in Japan, three in Europe, and one in China. There are physical and radiobiological reasons why CIRT provides superior treatment outcomes for the most challenging tumors, such as those near sensitive structures (e.g., head and neck and near the spinal cord) and hypoxic tumors which are resistant to photons and protons. Carbon ions and protons are similar in providing superior dose distributions vs. photons, but the larger mass and charge of carbon ions offer several other benefits. These include more effective tumor cell killing per unit dose reflecting more complex, clustered DNA damage that persists because it is difficult to repair, and more effective control of hypoxic tumors. The superior local tumor control with CIRT translates to improved patient survival that is particularly evident in longer term studies. There are outstanding opportunities to build on these successes, including development of additional ion species such as helium, silicon and oxygen, and by combining ion therapy with radiosensitizing drugs that target specific DNA repair and/or DNA damage signaling pathways and/or with the rapidly expanding arsenal of immunotherapies. A key question is: how can scientists, clinicians, and society promote research and further development of life-saving therapies? A case will be made that at least part of the answer lies with expanded clinical trials to treat spontaneous cancer in companion animals (dogs, cats), as this can promote more rapid translation of basic research in cell and small animal models to human clinical trials and human clinical practice, ultimately expanding patient access to advanced cancer therapies.