AbstractID: 11989 Title: Innovations in Hadron Beam Generation with Plasmas

Proton radiotherapy for cancer is growing in the US and around the world. This growth is due to the physical advantages of the improved ability to deposit most of the radiation dose in the tumor, as opposed to x-rays where most of the dose is deposited in normal tissues. In the US there are currently five proton therapy centers treating patients and over 2,300 x-ray based linear accelerator facilities. Limiting the widespread application of proton radiotherapy to the general cancer patient community is the capital, building and operating costs associated with proton radiotherapy that exceed $100 million per site, a substantial cost differential with x-ray based facilities. A compelling approach is to combine the physical advantages of proton therapy into a smaller, cheaper, gantry mountable system that can be widely disseminated. This requires a radical breakthrough in accelerator technology, however, as the size and mass of such an accelerator would have to be at least an order of magnitude less than those of conventional cyclotrons and synchrotrons.

The Plasma Physics Laboratory at Stanford has developed a novel particle accelerator that is based on a newly-understood second mode of operation in co-axial plasma accelerators. By processing a plasma instead of a pure ion gas, the proposed accelerator is fundamentally different from electrostatic accelerators, resulting in two important advantages. First, a plasma gas contains electrons and positive ions, making it macroscopically neutral. As a result, it can tolerate high ion densities in a very compact device. Second, a plasma can conduct very high currents and self-induce strong magnetic fields. This can be used to accelerate the plasma electromagnetically via the Lorentz force. The particle energy then becomes a function of the current to mass flow ratio rather than of the applied voltage. Eliminating the need for applying high voltages enables the generation of bursts of extremely energetic particles from a comparatively simple and inexpensive device. The recent identification and stabilization of a second mode of operation in coaxial plasma accelerators makes the advantages of plasma-based approaches accessible to proton radiotherapy. The distinct features of the proposed plasma-based accelerator may also result in attractive advantages when compared to alternative compact accelerator concepts that are currently under development.

This lecture will provide an overview of the differences between plasma and pure ion acceleration, as well as some of the limitations that have historically limited plasma accelerators to low beam energy applications. It will then summarize the advantages of operating in the second mode and describe the challenges that have to be overcome to scale and develop the existing proof of concept prototype into a viable therapy machine.