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Recent Developments in Proton Accelerators

Purpose:
Proton Beam Radiation Therapy has been clinically investigated for over 40 years. Despite obvious physical dose deposition advantages and compelling clinical results, the considerable financial cost of existing accelerator designs has hindered widespread use of this evidently superior treatment modality. Within the last few years however, materials have been developed that enable high concentrations of electromagnetic energy to be harnessed. These materials have opened the way for reducing the size and cost of accelerators for Proton Beam Radiation Therapy.

Method and Materials:
Two such materials, high current density superconducting wires and high field gradient dielectric elements, have led to the respective developments of compact superconducting cyclotrons and dielectric wall accelerators. Existing analytical tools for simulating the performance of circular accelerators and linear accelerators have been applied to guide the development of these designs in the new energy density regimes. These tools are essential for predicting the performance of accelerated proton beam dynamics in compact devices with high electromagnetic field gradients.

Results:
Each of these accelerators have been incorporated into single room proton therapy treatment system designs with a size and cost that are, or are projected to be, significantly below that of existing alternatives. Prototypes of these systems are now under construction and elemental prototype evaluation. Superconducting current density performance specifications have been met or exceeded in the development of the compact superconducting cyclotron. A working cyclotron has been prototyped and shown to accelerate an intense proton beam of more than 100 nA over the first stages of the cyclotron acceleration cycle. Likewise critical elements of the dielectric wall accelerator have met specifications for the final accelerator configuration, showing standoff fields in excess of 100 MeV / m.

Conclusion
At least one of these new systems is expected to be completed and being used for patient treatment before the end of 2008. With the significant reduction in complexity and cost the successful demonstration of these systems will likely lead to a more widespread adoption of Proton Beam Radiation Therapy.

Conflict of Interest
Kenneth Gall is a founder and Chief Technology Officer of Still River Systems Incorporated, a company involved in the design, production and clinical implementation of proton beam radiation therapy systems.