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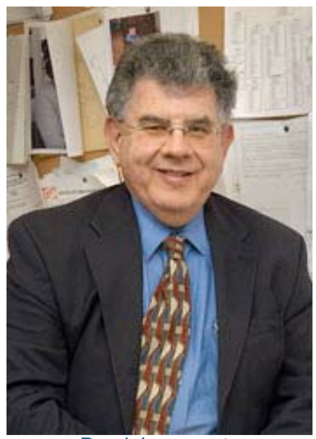
Synchrotron delivers full spectrum of ions

A collaboration between Brookhaven National Laboratory (Upton, NY) and Best Medical International (BMI) of Springfield, VA, has designed a unique synchrotron capable of delivering a full spectrum of ion species, from protons to carbon ions and potentially higher should this prove an effective treatment option. Work is continuing to finalize the design of the ion rapid cycling medical synchrotron (iRCMS), as well as to build some of the machine's key components, with the hope that installation can begin at Brookhaven within the next 12 months.

The ability to deliver multiple ion species is not the only thing that will make the iRCMS unique. With each cycle, the machine will deliver a spread-out Bragg peak (SOBP) across a longitudinal column of the target, instead of to a single voxel as is the current norm. Discussions are also ongoing to decide whether gantries are required, as radiation could potentially be delivered from fixed beams whilst the patient is rotated in the horizontal plane.



Derek Lowenstein

"Brookhaven can draw on many years of invention and accelerator expertise as well as technology that we have developed for the US Department of Energy (DoE) nuclear and particle physics programme and the NASA space programme," explained collaboration co-ordinator Derek Lowenstein, from Brookhaven's Collider-Accelerator Department. "What we have proposed is a state-of-the-art machine with distinguishing features that will result in the advancement of particle therapy."

When industry met academia

Brookhaven and BMI have been collaborating for around two years under a formal "collaborative research and development agreement" – otherwise known as a CRADA. This type of deal, which is promoted by the US DoE, is designed to foster interaction between industry and government research facilities such as Brookhaven.

Under the terms of the CRADA, BMI provides all of the funding to support the ongoing research and development at Brookhaven. "They supply the financing and the medical expertise and we supply the accelerator and operations expertise," explained Lowenstein. "At the end of the day, BMI will take ownership of the machine that we invent."

Proposed accelerator layout

Phase 1 of the CRADA saw Brookhaven supply BMI with a pre-conceptual design report at a cost of around $400,000. Phase 2 of the CRADA is the development of some of the key components and the completion of the design running to a cost of $5 million. The final step, phase 3, will see the machine being installed at Brookhaven for a period of time to ensure that it performs to the specifications outlined in the design. The machine would then be disassembled and sold by BMI.

Unique design features

The iRCMS features a 64 m particle racetrack and is a rapid-cycling machine that cycles at 15 Hz. The injector system will likely make use of a compact laser source that Brookhaven developed for NASA. According to Lowenstein, the laser ion source provides any ion species from protons to uranium and would generate fully stripped carbon ions for cancer therapy.

"The rapid cycling design requires only low-intensity particle beams to be accelerated," explained Lowenstein. "We plan to deliver dose as a SOBP over a full longitudinal column in one shot. With a rapid cycling machine, one knows exactly how much beam is in the machine and thus the maximum dose one can deliver, so it is a safer approach.

Another advantage of the rapid cycling is that the beam can be extracted at specific times. "You can gate the beam to coincide with organ motion," explained Lowenstein. "So, for example, if you are treating the lung with carbon you will gate the delivery of the beam to certain phases of the respiratory cycle."

One final, as yet undecided, aspect of the iRCMS design is the gantry system, and whether gantries are needed to deliver the millimetre-sized beam. "If the answer is not to have a gantry, we could provide fixed beams coming in at various angles and also rotate the patient horizontally," Lowenstein told *medicalphysicsweb*. "The medical community will have to decide on which approach to use."

If a gantry is adopted, Lowenstein is certain that the weight of the system would be significantly less than what is seen in current facilities thanks to the patented high efficiency combined function magnet structure developed at Brookhaven. "A gantry would be tens of tonnes, not the present structures of hundreds of tonnes," he said.

About the author

Jacqueline Hewett is a freelance science and technology journalist based in Bristol, UK.