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# Precise Control is Key to Advanced Ion Therapy

**Scott L. Spencer**
**Publisher**

Readers of *High Frequency Electronics* are undoubtedly familiar with the Large Hadron Collider (LHC) located just outside of Geneva, Switzerland. Built 500 feet beneath the surface of the earth and being 17 miles in circumference, it is the biggest machine on the earth and likely the most complex. It was built by the European Organization for Nuclear Research (CERN). After an initial test run in 2008, in an interview conducted by *Computerworld UK,* Caltech physicist Harvey Newman referred to the LHC as “one of the great engineering milestones of mankind.” CERN’s main function was intended to provide the particle accelerators needed for fundamental high-energy physics research. The collider was designed to accelerate particles to nearly the speed of light for the purpose of allowing physicists to test the predictions of different theories of particle physics and in particular to prove or disprove the existence of the elusive Higgs-boson particle. The massive project has enlisted the collaboration of over 10,000 scientists and engineers from over 100 countries, as well as hundreds of universities and laboratories. Even the World Wide Web began as a CERN project. Research conducted at the site has resulted in the discovery of previously unobserved particles and yielded many other contributions to the field of high-energy physics.

About eight weeks ago I had the opportunity to attend a presentation given by CERN engineer Dr. Johannes Gutleber. The event was hosted by the Texas-based firm National Instruments. What I learned is that the same technology used by CERN engineers and scientists at the LHC is being put to use in a remarkable way—one that has the potential to significantly impact many of our lives and the lives of generations to come.

CERN engineers have been involved in the design of the MedAustron facility now under construction in Wiener Neustadt, Austria. Located over 600 miles from the LHC, it is a type of proton ion particle accelerator that will be used for a very advanced form of radio therapy known as ion therapy.

## How Ion Therapy Works

In an ion source, electrons are stripped away from carbon atoms, leaving positively charged nuclei which are then pre-accelerated and injected into a circular synchrotron and further accelerated to 80% of the speed of light and various levels of energy. The energy level determines the depth of penetration into the human body. The beam is extracted from the synchrotron and formed into what Gutleber described as similar to the shape of a pencil. This pencil-shaped beam can then be used to scan, at a very high rate of speed, cancerous tumors in three dimensions by varying the energy levels of the beam.

When construction of the football field-sized facility is completed the hadron accelerator will deliver proton and carbon ion beams to energy levels as high as 800 mega-electron-volts (MeV). According to Gutleber, these beams have an enormous advantage over traditional X-rays for destroying tumors deep inside the body. Heavy particles penetrate tissues with relatively little interaction until they reach a critical depth (again a function of their initial energy). At that point, known as the Bragg peak, they relinquish their energy. Heavier particles like carbon nuclei exhibit considerably sharper Bragg peaks than lighter protons, thus allowing for a more accurate application of their energy.

This precision has many benefits, allowing treatment of tumors in close proximity to critical parts of the body such as the brain, spine and eyes. It also lends itself to pediatric treatment where the use of conventional radio therapy is not an option due to inherent side effects.

What I found most thought-provoking is the level of synchronization and the control systems required to make everything work. A machine with hundreds of thousands of potential settings needs to be reconfigured every 250 milliseconds while extracting particles from ion sources. Hundreds of magnets need to be manipulated to boost the particles to within 0.1 percent of the precise energy required for treatment, then guide the particles so they irradiate a tiny tumor buried deep in human tissue. At the heart of the €150 million MedAustron installation are National Instruments' reconfigurable embedded I/O controllers and field-programmable gate array (FPGA) devices.

For his work Johannes Gutleber earned triple honors at this year's National Instruments Graphic Design System Achievement Awards: the Advanced Research Design Achievement Award, the Intel Intelligent Systems Award, and the Humanitarian Award. Kudos to Dr. Gutleber for his landmark achievements.

The MedAustron facility expects to begin treating patients and saving lives in 2015.